Chapter 5

Environmental Consequences of the Alternatives

TVA

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5.1 Introduction to Environmental Consequences

The Environmental Consequences of the Alternatives chapter consists of this overview and 24 individual sections that describe the potential impacts of the Base Case and the eight policy alternatives on each of the affected environmental resource areas. The sections are discussed in the same order as Chapter 4, Description of Affected Environment.

5.1.1 Organization of Resource Areas Sections

Each resource area section identifies the resource issues examined, explains the methods used to determine impacts, and describes the anticipated impacts under the Base Case and each policy alternative. Impacts identified for each policy alternative are based on the incremental change between the Base Case and the changes in each policy alternative. Impacts identified for the Base Case are based on changes associated with the existing environment plus future trends through the year 2030 and the projects and commitments made by TVA, as described in Chapter 3, Reservoir Operations Policy Alternatives.

5.1.2 Weekly Scheduling Model

The Weekly Scheduling Model (WSM) was a central tool in the analysis and impact assessment. This model was used to convert reservoir operations policy changes into predicted future changes in reservoir levels and discharges from each of the projects in the TVA water control system.

TVA developed the WSM to model major water control projects in the Tennessee and Cumberland River basins. Rainfall, runoff, and river flow data from the Tennessee River basin over the past 99 years (1903 through 2001) were used to develop and calibrate the model. The WSM output graphically depicts how elevation and flow would change under various scenarios. See Appendix C, Model Descriptions and Results, for additional details about the WSM and a presentation of modeling results for each of the reservoir policy alternatives.

It is important to note that the WSM is based on a weekly analysis. That is, the model provides predictions of average weekly reservoir levels, discharges, and power generation. The WSM does not predict how the reservoir levels, flows, or patterns of power generation would occur on an hourly or daily basis. For environmental analyses that required estimates of the effects of different alternatives on hourly and daily flows, a separate database was developed. This is described further in Section 5.4, Water Quality.

The WSM provided outputs for each alternative, for different reservoirs, and for different time periods. Depending on the output, a single week, groups of weeks, or an entire year (or years) can be selected. The various outputs that can be generated from the WSM include:

- Elevation and flow plots—show the elevation or flow of a reservoir over a defined period of time.

- Generation and turbine capacity plots—show the generation or turbine capacity of a reservoir release over a defined period of time.

- Probability elevation and flow plots—show the distribution of elevation or flow data over the 99-year record of a reservoir over any defined set of weeks (e.g., Labor Day or the month of June).

- Elevation and flow duration curves—show the percent of time an elevation or flow will occur at a reservoir over any defined set of weeks (e.g., Labor Day or the month of June).

The WSM is important for the ROS EIS because reservoir elevations and reservoir releases and tailwater flows are the drivers for most impacts. This tool quantitatively compares the effects of alternatives on the water control system.

Results of the WSM are presented in Appendix C.

5.2 Air Resources

5.2.1 Introduction

Potential changes in reservoir operations policy may result in changes in the quantity, timing, and location of hydropower generation. Decreases in hydropower generation could result in increased requirements on the thermal generation of electrical power. Increased thermal generation would result in increased fossil-fuel combustion and therefore more emissions of air pollutants. The opposite is true if hydropower generation is increased.

This section analyzes the changes in air pollutant emissions created by each policy alternative being evaluated for the ROS. The air resources analysis addressed potential changes on attainment of the National Ambient Air Quality Standards (NAAQS), Hazardous Air Pollutant (HAP) emissions, and air-quality-related values (AQRVs).

The timing of hydropower changes is important because of the seasonal nature of air pollution problems. The period of concern for ozone is April 1 to October 31 in much of the TVA region. Emissions of volatile organic compounds and nitrogen oxides (NO_x) usually create the most ozone during summer, which is also the season of most concern for fine particles, regional haze, and acidic deposition. The atmosphere is more chemically active in summer. Thus, increasing emissions during summer could result in more adverse air quality consequences than during the rest of the year.

5.2.2 Assessment Methodology and Results

TVA has a variety of methods for generating electricity. Reductions or seasonal shifts in hydropower generation can be replaced by nuclear, coal, or natural gas generation—or even by purchased power from other utilities, especially at times of peak demands. This analysis of air quality impacts required assumptions about which power generation sources would replace reductions or shifts in hydropower generation and which generation sources would be operated less if hydropower generation increased.

The steps in the methodology were as follows:

- Determine the increase or decrease in the monthly and annual hydropower generation for the alternative being considered as compared to the Base Case.
- Determine the likely generation, by fuel type (nuclear, coal, or gas) that would be affected by a change in hydropower generation (either substituting for or being displaced by), and calculate any associated change in air emissions. TVA used a computer code entitled PROSYM (see Appendix C-3) to make these calculations for both monthly and annual periods.
- Provide detailed results for pertinent emissions.

- Compare increases/decreases in emissions with Base Case emissions and present a percentage change.
- Discuss timing of monthly emissions increases/decreases and the effect on air quality.

The analysis of increases/decreases for annual emissions of each pollutant, based on the methodology described above is presented in Table 5.2-01. This shows the annual changes in emissions for each alternative and the percentage of TVA emissions that the increase represents for the maximum increase alternative.

The annual results shown in Table 5.2-01 and Figure 5.2-01 do not, however, adequately describe impacts on regional air quality resources. Using NO_x emissions as an example, Table 5.2-02 and Figure 5.2-02 show the seasonal pattern of NO_x emissions increases and decreases. For Figure 5.2-02, season is defined climatologically as winter being December, January, and February, for example. The seasonal differences for the other emissions are similar. The larger variation in emissions changes by season for the policy alternatives is masked by the annual emissions changes. The evaluations of each alternative examined both annual and seasonal changes.

Table 5.2-01 Summary of Annual Emission Increases/Decreases by Policy Alternative (Based on PROSYM Model Outputs for 2005) (in tons per year)

Alternative	Increase/ Decrease in Non-Hydro Generation (MW hours)	Sulfur Dioxide	Nitrogen Oxide	Particulate Matter	Mercury
Reservoir Recreation A	-89,310	-1,408	-447	-39	-.0028
Reservoir Recreation B	248,370	689	-7	18	.0007
Summer Hydropower	157,850	2,354	690	63	.0053
Equalized Summer/ Winter Flood Risk	906,350	4,172	1,163	113	.0080
Commercial Navigation	-90,930	-26	-109	-1	-.0006
Tailwater Recreation[1]	248,370	689	-7	18	.0007
Tailwater Habitat	298,810	-14,211	-4,700	-386	-.0362
Preferred [2]	Similar to Reservoir Recreation Alternative A				
Maximum Percentage Increase	0.52%	0.89%	0.58%	0.89%	0.49%

[1] Identical to Reservoir Recreation Alternative B, no separate PROSYM run was made for the Tailwater Recreation Alternative.

[2] The Preferred Alternative was assumed to be similar to the results of Reservoir Recreation Alternative A; no separate PROSYM run was made for the Preferred Alternative.

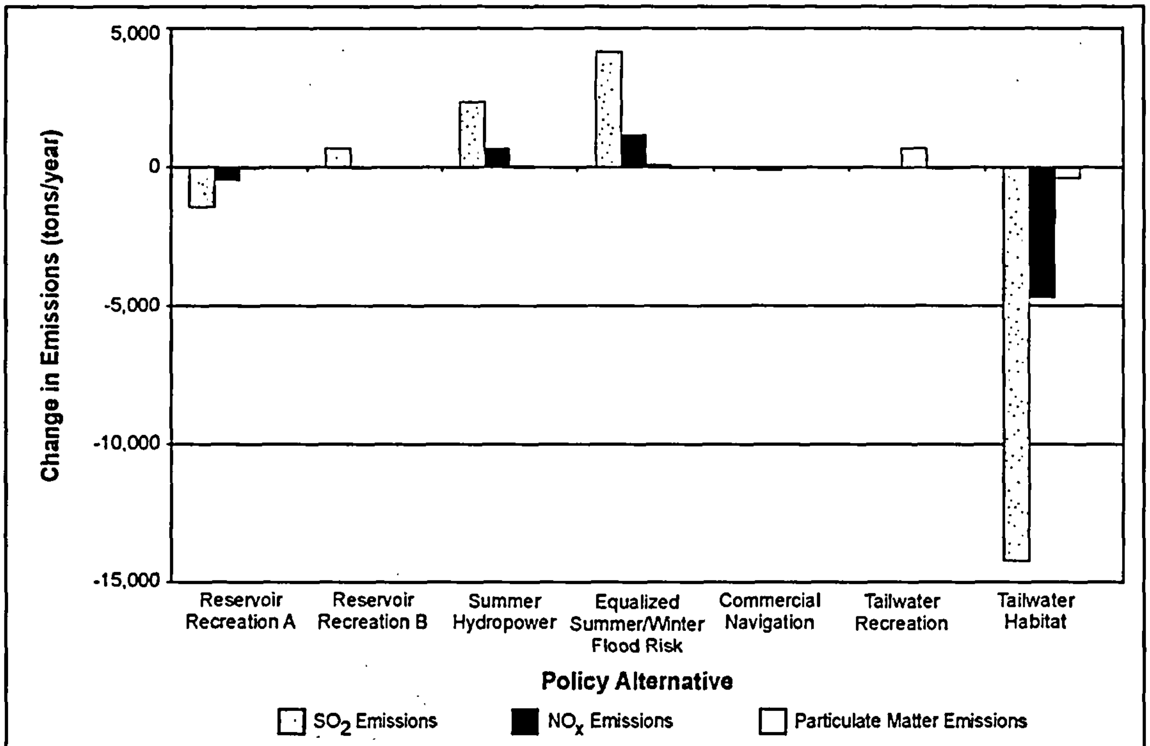
Table 5.2-02 Increases/Decreases of Nitrogen Oxides Emissions by Policy Alternative (in tons)

Alternative	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year	Comparison to Base Case (%)
Base Case	25,670	22,744	20,940	22,357	7,784	7,746	8,620	8,862	6,918	22,105	22,759	25,194	201,698	100%
Reservoir Recreation A	66	-315	-100	-49	-64	172	112	284	-254	-362	-55	117	-447	-0.22
Reservoir Recreation B	28	-499	-256	-101	-245	120	138	390	228	170	148	-128	-7	-0.00
Summer Hydropower	6	-320	-232	69	-121	-380	-188	-74	305	503	567	555	690	0.34
Equalized Summer/Winter Flood Risk	101	-622	-246	-416	-228	238	125	265	791	424	389	338	1163	0.58
Commercial Navigation	2	-61	-35	-32	-108	18	-1	-18	23	8	72	25	-109	-0.05
Tailwater Recreation[1]	28	-499	-256	-101	-245	120	138	390	228	170	148	-128	-7	-0.00
Tailwater Habitat	-644	-1075	-802	-712	-472	-2	98	201	546	-438	-919	-482	-4700	-2.33
Preferred[2]	Similar to Reservoir Recreation Alternative A													

[1] The Tailwater Recreation Alternative was assumed to be similar to the results of Reservoir Recreation Alternative B; no separate PROSYM run was made for the Tailwater Recreation Alternative.

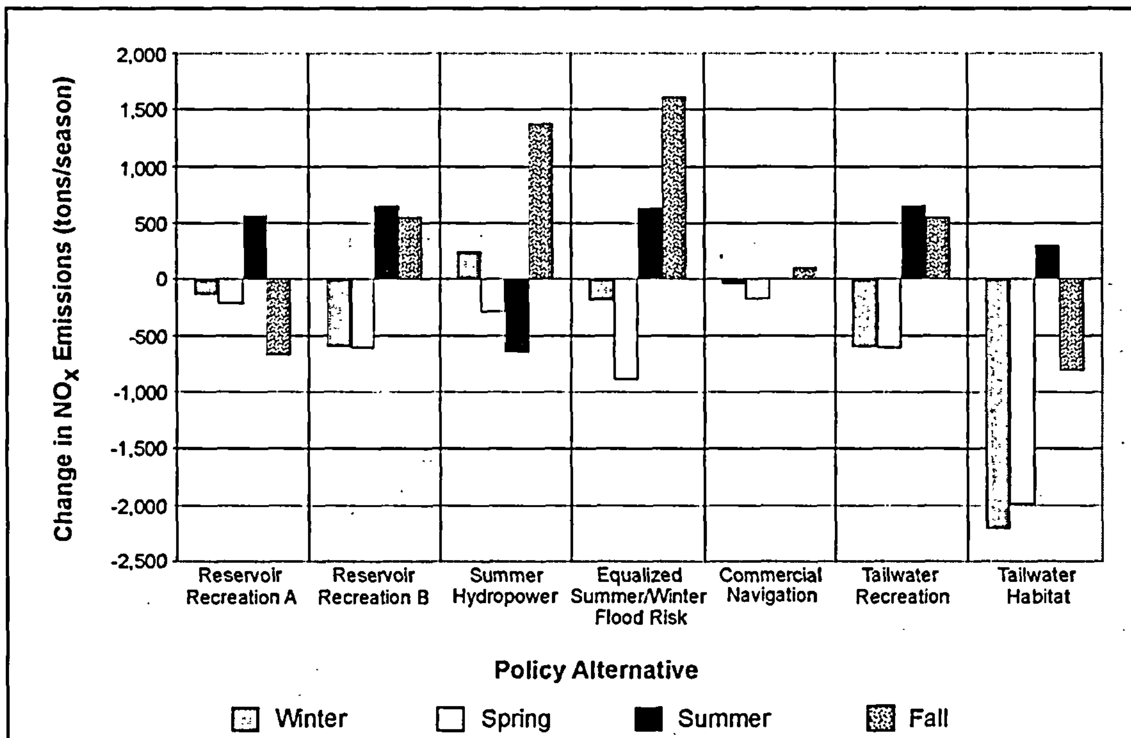
[2] The Preferred Alternative was assumed to be similar to the results of Reservoir Recreation Alternative A; no separate PROSYM run was made for the Preferred Alternative. The trends in hydropower generation would be similar to those under Reservoir Recreation Alternative A but with less hydropower generation shifted away from summer months. As a result, the summer increases would be similar to or less than the numbers provided for Reservoir Recreation Alternative A. Unlike Reservoir Recreation A, fall emissions would increase relative to the Base Case.

Source: TVA PROSYM model runs for 2005.



Source: TVA (based on PROSYM model results).

Figure 5.2-01 Comparison of Air Pollutant Emissions by Policy Alternative



Source: TVA (based on PROSYM model results).

Figure 5.2-02 Comparison of NOx Emissions by Policy Alternative by Season

Increases in emissions were generally assumed to result in a negative impact, and decreases were assumed to result in a positive impact. The year 2005 PROSYM computer program outputs were used for comparison because 2005 is the first full year of assumed implementation of alternatives.

5.2.3 Base Case

Under the existing reservoir operations policy, increases or decreases in air emissions occur due to annual variation of rainfall. These variations would continue to occur under the Base Case.

5.2.4 Reservoir Recreation Alternative A

For Reservoir Recreation Alternative A, the total annual hydropower generation on average would be slightly higher than the hydropower generation expected under the Base Case (see Section 5.23, Power). The amount of hydropower generation, however, would be reduced in summer and increased in the other seasons. In response to this shift in hydropower generation, other peaking generation resources, such as coal, combustion turbines, Raccoon Mountain Pumped Storage, and purchased power, would be dispatched to replace it. In addition, hydropower generation shifted to off-peak in other seasons would likely displace some coal generation.

Due to slightly higher total annual hydropower generation, Reservoir Recreation Alternative A would result in a reduction in annual emissions, with slight reductions in all pollutant emissions because of the shift of hydropower from summer. Reservoir Recreation Alternative A would result in an increase in summer emissions of all pollutants and decreases in the other seasons. Since the summer season is when ozone non-attainment and potential $PM_{2.5}$ non-attainment episodes could occur, Reservoir Recreation Alternative A could result in a potentially negative impact on NAAQS attainment.

Reservoir Recreation Alternative A would result in a slight decrease in mercury emissions, 5.6 pounds per year, although there would be a seasonal increase in the summer. Reservoir Recreation Alternative A would result in a very slight decrease in HAP emissions.

Reservoir Recreation Alternative A would result in an increase in nitrogen oxide, sulfur dioxide, and particulate matter emissions during summer. The alternative could result in a slight increase in acidic deposition and decrease in visibility in the Class I areas.

5.2.5 Reservoir Recreation Alternative B

The effect on hydropower generation under Reservoir Recreation Alternative B would be similar to Reservoir Recreation Alternative A, although more adverse. The total annual hydropower generation would be somewhat lower than the hydropower generation expected under the Base Case. The timing of the generation would shift from summer peak to other seasons similar to, although to a greater extent than, Reservoir Recreation Alternative A. TVA's response to this shift in hydropower generation would also be similar to Reservoir Recreation Alternative A.

Due to losses in annual hydropower, Reservoir Recreation Alternative B would result in slight increases in all NAAQS emissions (except nitrogen oxides) on an annual basis, similar to Reservoir Recreation Alternative A. On a seasonal basis, these increases would be disproportionately higher in summer and fall, as shown in Figure 5.2-02. Reservoir Recreation Alternative B would add 1.6 percent to TVA's nitrogen oxide summer emissions and similar percentages to the other emissions. Thus, this alternative could result in a negative impact on attainment of NAAQS.

Reservoir Recreation Alternative B could create an increase in mercury emissions of about 0.04 percent per year, or about 1.4 pounds.

Reservoir Recreation Alternative B would result in increases in summertime emissions of sulfur dioxide and nitrogen oxides, with air quality effects similar to those discussed for Reservoir Recreation Alternative A.

5.2.6 Summer Hydropower Alternative

Under the Summer Hydropower Alternative, hydropower generation would increase during the summer and winter peak demand periods and decrease in fall, relative to the Base Case. The total annual hydropower generation on average would be somewhat lower.

Because the Summer Hydropower Alternative would supply increased hydropower during summer, it would substantially decrease summer emissions of NAAQS emissions. Reduced hydropower generation in late September would increase emissions in fall. The Summer Hydropower Alternative might positively affect NAAQS attainment.

The Summer Hydropower Alternative could result in an increase in emissions of mercury of 10.6 pounds per year, or about a 0.33-percent increase from emissions under the Base Case.

The Summer Hydropower Alternative could, in general, benefit AQRVs in Class I areas because of its reduced emissions in summer.

5.2.7 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative would result in the most adverse effect on total annual hydropower generation, producing almost 5 percent less on an average annual basis. In addition, hydropower generation would shift relative to the Base Case, decreasing in summer and fall and increasing during winter. As in Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and to a greater extent, the Tailwater Recreation Alternative, other higher cost peaking generation units would need to be run to replace the shifted hydropower generation in summer and fall; and hydropower generation would likely displace coal generation in other seasons.

Due to the impacts on hydropower generation, the Equalized Summer/Winter Flood Risk Alternative would result in the largest increase in both annual and seasonal emissions of NAAQS pollutants. Annual emissions increases would be twice as large as under any other alternative, with increases of nearly 1 percent for sulfur dioxide and particulate matter, and nearly 0.5 percent for nitrogen oxide and mercury. The seasonal increases occur in summer and fall.

The Equalized Summer/Winter Flood Risk Alternative could result in an increase in mercury emissions of about 16 pounds annually, or about 0.49 percent of the Base Case emissions.

The Equalized Summer/Winter Flood Risk Alternative could also produce the highest negative impact on AQRVs, not only because of the higher annual total emissions but also because of their imbalance toward summer and fall.

5.2.8 Commercial Navigation Alternative

The Commercial Navigation Alternative would result in an increase in hydropower generation and thus a slight reduction in coal-fired emissions. This reduction is slightly skewed toward winter and spring, with fall emissions increasing slightly.

The Commercial Navigation Alternative could result in a slight decrease in mercury emissions.

The Commercial Navigation Alternative would result in a potential reduction in annual emissions and only a slight increase in fall.

5.2.9 Tailwater Recreation Alternative

The Tailwater Recreation Alternative could result in a slight increase in annual emissions similar to those under Reservoir Recreation Alternative B. The PROSYM results shown in the tables are identical to those under Reservoir Recreation Alternative B because the effects of the hydropower operation would be very similar to that of Reservoir Recreation B. However, a disproportionate amount of this increase would occur in summer and fall.

The Tailwater Recreation Alternative could lead to an increase in mercury emissions of approximately 1.4 pounds annually.

The Tailwater Recreation Alternative could result in a moderate annual increase in pollutants. The seasonal nature of the potential increases, mostly in summer, could increase the degree of negative impacts.

5.2.10 Tailwater Habitat Alternative

The effect on hydropower generation under the Tailwater Habitat Alternative would be similar to Reservoir Recreation Alternative B, although more adverse. The total annual hydropower generation would be somewhat lower, and the timing would shift from summer peak to other seasons similar to, although to a greater extent than, Reservoir Recreation Alternative B.

The Tailwater Habitat Alternative would result in an annual decrease of NAAQS emissions. This decrease is the consequence of displacing more coal generation than any other alternative. The Tailwater Habitat Alternative would shift the greatest amount of hydropower generation away from May through September, the period when coal and gas plant emissions are most costly. TVA's response to this shift in hydropower generation would be to reduce coal generation during the May through September period to avoid costly emissions and replace it with combustion turbines, pumped storage, or purchased power. The hydropower that is shifted out of the summer period would likely also displace coal generation. This alternative would, however, result in increased summer emissions due to greater combustion turbine generation during that time.

The Tailwater Habitat Alternative would result in a substantial decrease (72.4 pounds per year) in mercury emissions.

The Tailwater Habitat Alternative could negatively affect AQRVs in the Class I areas because its increase in emissions would occur in summer.

5.2.11 Preferred Alternative

For the Preferred Alternative, the total annual hydropower generation is expected to be slightly less than the Base Case. Hydropower would be slightly reduced in summer and fall, and increased in other seasons. In response to this shift in hydropower generation, other peaking generation resources, such as coal, combustion turbines, Raccoon Mountain Pumped Storage, and purchased power, would be dispatched to replace it. In addition, hydropower generation shifted to off-peak in other seasons would likely displace some coal generation.

The Preferred Alternative would result in a slight increase in summer emissions of all pollutants and decreases during the other seasons. Because ozone non-attainment and potential $PM_{2.5}$ non-attainment episodes are greatest in summer, the Preferred Alternative could result in a potentially negative impact on NAAQS attainment.

The Preferred Alternative would result in a slight increase in nitrogen oxide, sulfur dioxide, and particulate matter emissions during summer. The alternative could result in a slight increase in acidic deposition and a decrease in visibility in the Class I areas, compared to the Base Case.

The Preferred Alternative could result in a slight change in mercury and HAP emissions, as compared to the Base Case.

5.2.12 Summary of Impacts

The air quality resources of the TVA region could be negatively affected by decreases in hydropower generation due to changes in operations (Table 5.2-03). The Equalized Summer/Winter Flood Risk Alternative could result in the largest negative impact. Reservoir Recreation Alternative B, the Summer Hydropower Alternative, and the Tailwater Recreation Alternative would result in small annual impacts when compared to the Equalized Summer/Winter Flood Risk Alternative. The summer seasonal impacts of the Preferred Alternative, Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would be negative. However, Reservoir Recreation Alternative A, the Commercial Navigation Alternative, and the Tailwater Habitat Alternative would tend to result in positive impacts on an annual basis. The Commercial Navigation Alternative would be relatively neutral concerning overall impacts on air quality resources. The Preferred Alternative would result in no change to slightly adverse air quality impacts on an annual basis.

Table 5.2-03 Summary of Impacts on Air Resources by Policy Alternative

Alternative	Description of Impacts
Base Case	Under the existing reservoir operations policy, increases or decreases in air pollutant emissions would not occur.
Reservoir Recreation A	<u>Seasonal</u> Adverse in summer, otherwise beneficial <u>Annual</u> Slightly beneficial
Reservoir Recreation B	<u>Seasonal</u> Adverse in summer and fall, otherwise beneficial <u>Annual</u> Slightly adverse
Summer Hydropower	<u>Seasonal</u> Adverse in fall and winter, otherwise beneficial <u>Annual</u> Slightly adverse
Equalized Summer/ Winter Flood Risk	<u>Seasonal</u> Adverse in summer and fall, otherwise beneficial <u>Annual</u> Slightly adverse
Commercial Navigation	<u>Seasonal</u> Minimal change, but slightly adverse in fall and beneficial in spring <u>Annual</u> No change
Tailwater Recreation	<u>Seasonal</u> Adverse in summer and fall, otherwise beneficial <u>Annual</u> Slightly adverse
Tailwater Habitat	<u>Seasonal</u> Adverse in summer, otherwise beneficial <u>Annual</u> Beneficial
Preferred	<u>Seasonal</u> Slightly adverse in summer, otherwise beneficial <u>Annual</u> No change to slightly adverse

5.3 Climate

Because no direct link between greenhouse gas emissions and changes in regional climate has been demonstrated, impacts on regional climate cannot be estimated. Instead, changes in greenhouse gas emissions were used as a surrogate for potential impacts on the global climate. For the purposes of this analysis, TVA assumed that increases in greenhouse gas emissions would negatively affect climate. This could be untrue, however, especially for the Tennessee Valley region, which has been experiencing a cooling (not warming) trend.

5.3.1 Impact Assessment Methods

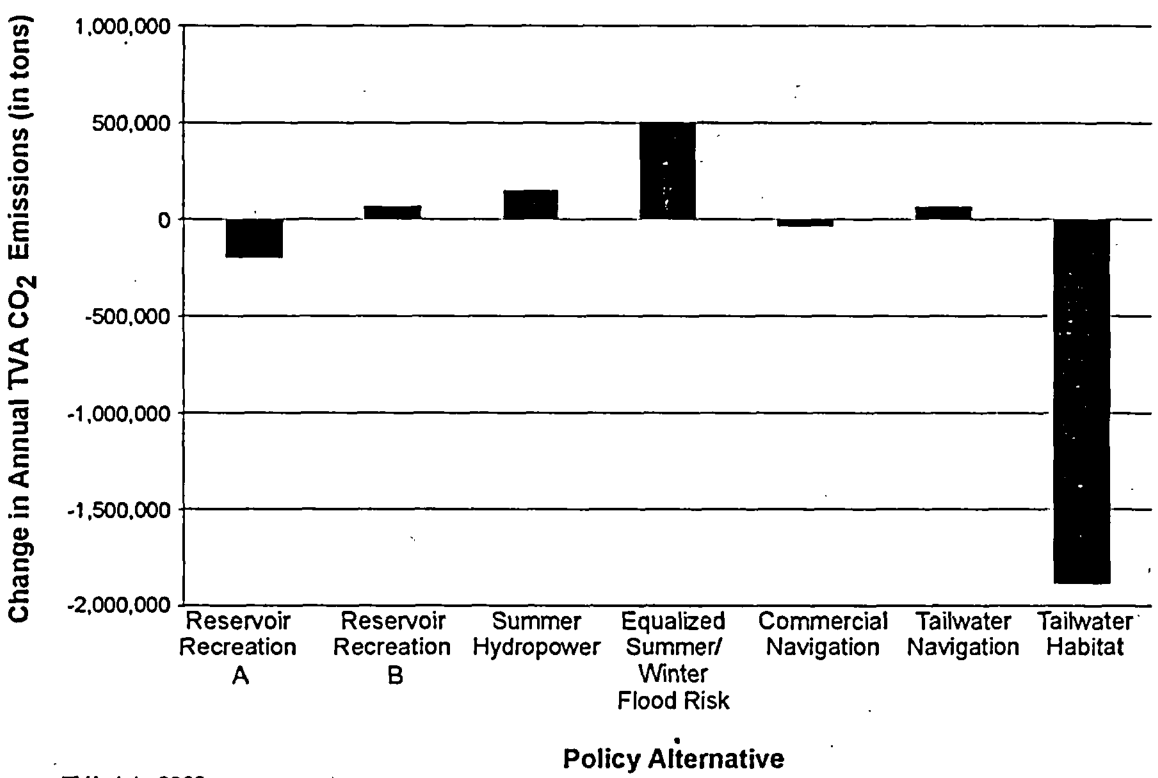
Because balancing among generation sources is both an economic decision (the marginal cost of power) and a physical decision (the availability of generation units to run), calculating the generation mix and related emissions is complex. TVA developed a computer model (PROSYM) that calculates the effect on fossil-fuel generation for each of the policy alternatives (see Appendix C-3). When hydropower is not available compared to existing operations (the Base Case), PROSYM identifies the most likely sources of replacement power. That portion of the replacement power provided by fossil-fired generation is then used to determine increases or decreases in CO_2 emissions.

The steps in the analysis methodology used to estimate changes in greenhouse gas emissions for the alternatives included:

- Determine the increase or decrease in the annual hydropower generation for the alternative being considered as compared to the Base Case. (Assumed to be 2005 consistent with the first full year for application of the policy alternatives).
- Determine the likely generation fuel (nuclear, coal, or gas) or mix of fuels to be used to satisfy the lost power or fuel to be reduced because of the gained hydropower. TVA has used a computer model, PROSYM, to make this analysis.
- Using PROSYM results, determine the number of MW hours of the increased or decreased non-hydropower requirement and the associated CO_2 emissions.
- Compare the increase or decrease in CO_2 emissions to the annual 2005 CO_2 emissions under the Base Case in order to arrive at a percentage change in TVA emissions. Extend the comparison to U.S. and global CO_2 emissions.
- Compare the increase or decrease in CO_2 emissions to expected reductions in CO_2 emissions over the study period, to 2030.

Figure 5.3-01 shows the changes in CO_2 annual emissions for each alternative. For this figure, the PROSYM model calculated impacts.

5.3 Climate



Source: TVA data 2003.

Figure 5.3-01 Comparison of Changes in Annual Total TVA CO_2 Emissions by Alternative

Table 5.3-01 contains numerical values for the increases and decreases in CO_2 emissions for each alternative. The table includes the change in MW hours; the change of CO_2 emissions (calculated by PROSYM); and the percentages of those changes compared to CO_2 emissions under the Base Case for TVA, 2000 emissions for the United States, and 1996 emissions for the 21 reporting countries.

5.3.2 Base Case

If TVA reservoir system operations are not changed, no consequent increases or decreases in CO_2 emissions would result. Increases and decreases in emissions would occur naturally due to annual variations of rainfall.

5.3.3 Reservoir Recreation Alternative A

Reservoir Recreation Alternative A would result in a minor increase in total annual hydropower production; thus, PROSYM calculates a minor decrease in CO_2 emissions (a decrease of 196,593 tons per year, or a reduction of approximately 0.18 percent). Of all the policy alternatives, Reservoir Recreation Alternative A would result in the second largest decrease in CO_2 emissions.

5.3.4 Reservoir Recreation Alternative B

Reservoir Recreation Alternative B would result in a decrease in hydropower production and therefore an increase in non-hydropower generation. Replacement of the lost hydropower generation was calculated by PROSYM to result in an average increase of 66,060 tons per year in CO_2 emissions. This amount represents an increase of approximately 0.06 percent of total annual TVA CO_2 emissions.

5.3.5 Summer Hydropower Alternative

While the Summer Hydropower Alternative would result in more hydropower generation in summer, hydropower generation for the entire year would decrease. The potential annual increase in CO_2 emissions calculated by PROSYM under the Summer Hydropower Alternative is 150,766 tons, representing approximately 0.14 percent of TVA CO_2 emissions.

5.3.6 Equalized Summer/Winter Flood Risk

The Equalized Summer/Winter Flood Risk Alternative would result in the largest decrease in hydropower production and increased CO_2 emissions of all the alternatives. Replacement of lost hydropower as calculated by PROSYM would result in an increase of 502,725 tons of CO_2 emissions. This amount represents an increase of approximately 0.47 percent.

5.3.7 Commercial Navigation Alternative

Because the Commercial Navigation Alternative would result in slightly increased hydropower production, there would be less need for fossil generation and thus corresponding potential decreases in emissions of CO_2. As calculated by PROSYM, the reduction would be 33,130 tons per year of CO_2 (or approximately 0.03 percent), representing a small positive benefit of the Commercial Navigation Alternative.

5.3.8 Tailwater Recreation Alternative

The Tailwater Recreation Alternative would result in a loss of hydropower production similar to that under Reservoir Recreation Alternative B and an increase in demand for fossil generation. PROSYM was not run specifically for this alternative because of its power production similarity to Reservoir Recreation Alternative B. As with Reservoir Recreation Alternative B, the annual increase in CO_2 emissions would be 66,060 tons (or 0.06 percent).

5.3.9 Tailwater Habitat Alternative

The PROSYM results for the Tailwater Habitat Alternative is a decrease of 1,884,347 tons per year of CO_2 emissions, representing an approximately 1.77-percent decrease. This alternative would result in the largest positive impact on climate resources.

5.3.10 Preferred Alternative

The Preferred Alternative would result in a minor decrease in total annual hydropower production. Thus, as for Reservoir Recreation Alternative A, a minor increase in CO_2 emissions is expected.

5.3.11 Summary of Impacts

Table 5.3-01 provides a summary of impacts on climate by policy alternative. Alternatives that would decrease hydropower generation could result in slightly adverse impacts on climate, but on a global scale the change at TVA in greenhouse gas emissions would have no noticeable effect. The severity of impacts associated with each alternative would depend on the amount of fossil-fuel generation used to replace lost hydropower: Implementation of the Equalized Summer/Winter Flood Risk Alternative could result in the largest potential adverse impact on climate. Reservoir Recreation Alternative B, the Summer Hydropower Alternative, and the Tailwater Recreation Alternative would result in lesser impacts on climate when compared to the Equalized Summer/Winter Flood Risk Alternative. The Preferred Alternative, Reservoir Recreation Alternative A, and the Commercial Navigation Alternative most likely would result in slightly beneficial impacts on climate, and the Tailwater Habitat Alternative would result in a beneficial impact on climate.

Table 5.3-01 Summary of Impacts on Climate by Policy Alternative

	Alternative								
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation[1]	Tailwater Habitat	Preferred[2]
Increase/decrease in non-hydropower generation (MW hours)	No change	-89,310	+248,370	+157,850	+906,350	-90,930	+248,370	+298,810	The Preferred Alternative is similar to Reservoir Recreation Alternative A
Change in CO_2 emissions (tons)	No change	-196,593	+66,060	+150,766	+502,725	-33,130	+66,060	-1,884,347	
Percent of total annual TVA CO_2 emissions	100	-0.18	+0.06	+0.14	+0.47	–0.03	+0.06	-1.77	
Percent of total annual U.S. CO_2 emissions	1.64	-0.003	+0.001	+0.002	+0.008	-0.001	+0.001	-0.029	
Percent of total annual CO_2 emissions for 21 reporting countries	0.934	-0.002	+0.001	+0.001	+0.004	–0.0003	+0.001	-0.017	

[1] The Tailwater Recreation Alternative was assumed to be similar to the results of Reservoir Recreation Alternative B; no separate PROSYM run was made for the Tailwater Recreation Alternative.

[2] The Preferred Alternative was assumed to be similar to the results of Reservoir Recreation Alternative A; no separate PROSYM run was made for the Preferred Alternative.

Source: TVA PROSYM model runs for 2005.

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5.4 Water Quality

5.4.1 Introduction

This section represents a summary analysis of the impacts of the policy alternatives on water quality. The primary evaluation tool was a numerical water quality model. A number of reservoir and riverine water quality metrics derived from the model formed the basis of this analysis. Effects of changes in water quality on aquatic resources, threatened and endangered species, water supply, and power (among other resources that are associated with water quality) are discussed in other sections of the EIS.

The representation of existing conditions used to quantify the impacts of the policy alternatives on water quality is called the Base Case. The Base Case is an integration of current conditions and currently scheduled changes to the system. In effect, the Base Case moves the current condition to a point in the future when all reasonably foreseeable, currently scheduled changes in the system have been implemented.

The alternatives under consideration generally vary in the timing and amount of water flow through the system. Changes in this timing may alter the retention times of the reservoirs, the degree and extent of thermal stratification, the temperatures of reservoirs and tailwaters, and DO concentrations in reservoirs and tailwaters. These characteristics and the metrics that describe them represent the majority of anticipated water quality changes associated with the alternatives considered and are the main focus of the water quality analysis. Many of the tailwaters have target DO concentrations set by the Lake Improvement Plan. These targets were incorporated into all of the alternatives because the Lake Improvement Plan targets will be maintained regardless of the policy alternative selected. Release targets and a list of projects included in the Lake Improvement Plan are presented in Appendix A, Table A-05.

Other water quality parameters that could be affected by reservoir operations (as described in Section 4.4) are closely related to residence time, temperature, and DO. Parameters in this category include manganese, sulfides, and ammonia, which are formed or move from reservoir sediments when DO concentrations are low. Analysis of very low DO concentrations (termed anoxia in this analysis) in the reservoirs captures these parameters. Phosphorus is released from sediments when DO concentrations are low—although the majority of the phosphorus in the system comes from sources in the watershed that would be unaffected by any of the policy alternatives under consideration. The relative contribution of sediment-released phosphorus to the total amount present throughout the TVA reservoir system would increase under any alternative that results in lower reservoir DO concentrations.

System-wide turbidity and sediment deposition attributable to reservoir operations are not expected to change substantially under any alternative. Localized erosion related to reservoir operations is discussed in Section 5.16, Shoreline Erosion. Likewise, the fate and transport of contaminants in the sediments throughout the TVA reservoir system are not anticipated to be influenced substantially by a change in reservoir operations, except for those compounds and contaminants mentioned above that are mobilized when DO concentrations are low. The occurrence of bacteria and pathogens in the system would not be substantially affected by any policy alternative.

5.4.2 Impact Assessment Methods and Data Summarization

TVA water quality monitoring has been conducted under various weather and reservoir flow conditions that have resulted in a wide range of water quality conditions. Understanding of the historical variability in water quality throughout the TVA reservoir system has fostered the development of models of water flow and quality. When combined with water quality data, these models are useful as tools to identify differences in water quality between the Base Case and alternative reservoir operations policies. Experience gained from TVA's monitoring program has substantiated the intuitive relationship between reservoir flows and water quality. Although quantifying the extent of these changes under various operating regimes is a job best suited for models, the real-world experience based on TVA's Reservoir Vital Signs Monitoring Program is essential for appropriate interpretation of modeling results. The following evaluation of various policy alternatives is based on this two-pronged approach.. The water quality models are used to evaluate flows, temperature, and DO concentrations as they relate to the policy alternatives. The relationship of algae (measured by chlorophyll-a) to water retention time in the reservoirs was evaluated using data from TVA's Vital Signs Monitoring Program.

Water Quality Modeling

TVA developed water quality models of 32 reservoirs and 12 tailwaters using computer programs TVARMS (Hauser et al. 1995), BETTER (Bender et al. 1990), and CE-QUAL-W2 (Cole and Buchak 1995) (Appendix C). The models simulate hydrodynamic and water quality conditions, such as water movement, temperature, thermal stratification, and DO concentrations.

The modeling approach used in this evaluation was to link models of individual reservoirs and tailwaters to simulate nearly the entire TVA river system—using the water quality model SysTempO. The models simulate the physical, chemical, and biological processes in sections of the system. TVARMS is used for the riverine sections, and CE-QUAL-W2 and BETTER are used for the reservoirs. SysTempO links the river and reservoir models. The methodology uses water quality data outputs from upstream waterbodies as input for the next tailwater or reservoir downstream. Existing water quality improvements were not included in models of reservoirs where in some cases aeration equipment injects compressed air or liquid oxygen immediately upstream of the dam. When SysTempO sets upstream inflow water quality for the next downstream dam, the Lake Improvement Plan DO targets are used. Release targets and a list of projects included in the Lake Improvement Plan are presented in Appendix A, Table A-05.

The individual elements in SysTempO were pre-calibrated for at least 1 year of data before being linked. After linking models together in SysTempO, 8 years (1987 to 1994) of modeled temperature and DO were compared to measured data. Calibrations were adjusted to closely approximate observed conditions. Generally, modeled temperatures were within 1 °F of those measured, and modeled DO was within 1 mg/L for most locations. The model was then used to simulate conditions under the Base Case and policy alternatives in order to examine the effects of changes in the existing reservoir operations policy.

The result was a set of tools that enabled the simultaneous evaluation of the policy alternatives on reservoir and tailwater water quality throughout the TVA reservoir system. To help focus evaluation on important water quality impacts associated with operational modifications linked to different alternatives, model results over a broad range of hydrometeorologic conditions represented in the 1987–1994 period were used to generate estimates of the water quality metrics described in Table 5.4-01 for all policy alternatives under consideration. A broad variety of hydrologic and weather conditions were experienced during this period. For example, certain years within this time period could be considered representative of normal conditions (1990), hot and dry conditions (1993), and cool and wet conditions (1994).

Table 5.4-01 Water Quality Metrics Used to Evaluate Policy Alternatives

Parameter	Metric	Target Use Potentially Affected
Reservoirs		
Hydrodynamics	Summer residence time from 6/1 to 9/30 (days)	General water quality
	Days that forebay surface-bottom temperature is ≥4 °C (# days)	General water quality
	Maximum forebay surface-bottom temperature difference (°C)	General water quality
	Sum of daily total reservoir volume (million m^3-days)	General water quality
Dissolved oxygen	Sum of daily volume DO ≤5 mg/L (million m^3-days)	General water quality
	Minimum reservoir volume DO ≥5 mg/L (million m^3-days) on worst-case day	Assimilative capacity
	Sum of daily volume DO ≤2 mg/L (million m^3-days) from 7/1 to 10/31	Tolerant aquatic life support
	Sum of daily volume DO ≤1 mg/L (million m^3-days)	Potential anoxia
Temperature	Sum of daily volume temperature >26 °C (million m^3-days)	Assimilative capacity
	Sum of daily volume temperature ≤10 °C (million m^3-days)	Cold water in storage
Algal activity	Chlorophyll-a concentration (micrograms/L)	Trophic status
Dam Releases		
Dissolved oxygen	Average annual minimum DO (mg/L)	General water quality
	Average number days/year DO <5 mg/L	General water quality
Temperature	Average annual maximum temperature (°C)	General water quality
	Average number of days/year temperature >10 °C	General water quality

Notes:

All results were derived from the water quality model, except for algal activity, which were assessed using Vital Signs Monitoring Program data.

DO = Dissolved oxygen.

This approach was used successfully and consistently for most alternatives. The Summer Hydropower Alternative resulted in flow and elevation conditions that prevented completion of successful model runs during certain dry years; therefore, water quality model results for the Summer Hydropower Alternative were based on 1990 to 1994 rather than the full 8-year period referenced above for the other alternatives. This situation did not allow full evaluation of effects on water quality of operations under the Summer Hydropower Alternative under all flow conditions. Consequently, evaluations of effects under this alternative must be viewed cautiously with this limitation in mind. Also, it is inappropriate to directly compare water quality effects of the Summer Hydropower Alternative to effects resulting from operations under the remaining policy alternatives because of the more limited set of weather and flow conditions used for the Summer Hydropower Alternative.

Use of Vital Signs Monitoring Results

The relationship of algae (measured by chlorophyll-a) to water retention time in the reservoirs was evaluated using Vital Signs Monitoring Program data and linear regression because the water quality model was not calibrated specifically for algal growth. A comparison of long-term average chlorophyll-*a* concentrations to 2002 data (a low-flow year similar to many of the alternatives) supplemented the evaluation, allowing an assessment of the impact of lower flow rates associated with many of the policy alternatives on algal growth.

Selection of Representative Reservoirs/Dam Releases

The integrated SysTempO model was run for 32 reservoirs and 12 tailwaters. Detailed water quality analyses and evaluations were compiled from a subset of reservoirs and dam releases that represent a variety of reservoir types and geographic regions. Specific water quality issues within certain reservoirs may not be reflected in this set of reservoirs; however, the overriding water quality issues appropriate for a programmatic evaluation are represented.

Representative reservoirs for three reservoir categories defined specifically for water quality analyses include:

- **Storage Tributary Reservoirs.** These reservoirs generally have long retention times and substantial winter drawdown for flood control. A total of 13 storage tributary reservoirs could be affected by policy alternatives. South Holston and Douglas Reservoirs initially were selected to represent tributary storage reservoirs. Hiwassee Reservoir was added to this group as a representative reservoir in response to comments received during review of the DEIS that suggested inclusion of a reservoir representative of the high-elevation reservoirs in the nutrient-poor Blue Ridge physiographic region.

- **Transitional Tributary Reservoirs.** This group of reservoirs did not fit with the other tributary reservoirs because the reservoirs have a relatively short retention, have nominal winter drawdown, or are much smaller. Five transitional reservoirs could be affected by policy alternatives. Boone and Melton Hill Reservoirs were selected to represent transitional tributary reservoirs.

- **Mainstem Reservoirs.** These reservoirs are typified by short retention times and nominal winter drawdown. Kentucky is the most downstream reservoir and represents the water quality that leaves the TVA reservoir system. Nine mainstem reservoirs would be potentially affected by policy alternatives. Three reservoirs were initially selected to represent mainstem reservoirs: Guntersville, Pickwick, and Kentucky. Watts Bar Reservoir was added as a representative mainstem reservoir following completion of the DEIS because one of the operational changes considered under the Preferred Alternative is delayed spring fill of three mainstem reservoirs (Fort Loudoun, Watts Bar, and Chickamauga), none of which had been included the initial set of representative reservoirs.

Summarization of Results

Appendix D1 provides detailed results from the water quality model for the Base Case and each policy alternative. In Appendix D1, Table D1-02 presents a compilation of metric results from the water quality model for reservoirs under the Base Case and all policy alternatives except the Summer Hydropower Alternative; Table D1-03 presents this information for the Summer Hydropower Alternative. Tables D1-04 and D1-05 present comparable information for dam releases.

Tables 5.4-02 and 5.4-03 summarize the detailed results from Tables D1-02–05 by using categories to describe the magnitude of relative change in water quality metrics between the Base Case and each policy alternative. Four categories were selected to quantify changes from the Base Case. These include; 0 to10 percent; 11 to 25 percent; 26 to 50 percent; and >50 percent.

In the following text, Section 5.4.3 summarizes Base Case conditions. Sections 5.4.4 through 5.4.11 use the quantitative changes in Tables 5.4-02 and 5.4-03 as the basis for discussion of relative changes for each policy alternative. Section 5.4.12 examines effects of policy alternatives on water quality under low-flow conditions. Flow conditions for 1993 were used in this analysis. The analysis in Section 5.4.12 is parallel to that in Sections 5.4.4 through 5.4.11 in that it provides a quantitative comparison of changes as they relate to the Base Case. A more thorough evaluation of impacts on assimilative capacity and the potential for formation of anoxic products is provided in Sections 5.4.15 and 5.4.16.

Table 5.4-03 reflects the effect and importance of TVA's commitment to maintain tailwater DO concentrations at or above targets set by the Lake Improvement Plan. Although Table 5.4-02 shows that larger volumes of low DO water would occur in some reservoirs (e.g., Hiwassee) under some policy alternatives, this would not be reflected in downstream tailwater releases. TVA would improve the lower DO levels by a corresponding increase in aeration methods. This explains why, in Table 5.4-03, reservoirs with downstream aeration facilities are listed as "LIP target."

Categories of change in Tables 5.4-02 and 5.4-03 were subjectively defined as follows:

- Not different from the Base Case = +/-10% of base (shown in these tables as "**o**").
- Increase compared to the Base Case = 11 to 25% change from conditions under the Base Case (shown in these tables as"↑").
- Decrease compared to the Base Case = 11 to 25% change from conditions under the Base Case (shown in these tables as"↓").
- An "*" is used in Tables 5.4-02 and 5.4-03 if changes from the Base Case were from 26 to 50%, and a double "**" is used if changes were >50% change from the Base Case.
- Note - The symbol "∞" is used in these tables to identify occurrences when both Base Case data and alternative data are infinitely small, causing nominal changes from the Base Case to appear quite large proportionally. Caution is needed in interpreting results in this situation, and the reader is urged to refer to tables in Appendix D1, where actual results for each water quality metric under the Base Case and each action alternative are provided.)

This approach facilitates a relative evaluation of each alternative compared to conditions under the Base Case. The up or down direction of arrows should not be construed to indicate improvement or degradation of water quality. The arrows only indicate change from conditions under the Base Case.

It should be noted that 13 tributaries, five transitional, and nine mainstem reservoirs were considered in this analysis. Mainstem and tributary reservoirs are more numerous in the system than transition reservoirs and collectively impound a much greater volume of water. Consequently, impacts on mainstem and tributary reservoirs should carry more weight than impacts on transitional reservoirs.

Table 5.4-02 Summation of Responses for Water Quality Characteristics in Representative Reservoirs by Policy Alternative

Alternative	Reservoir	Change in Reservoir Volume with Dissolved Oxygen Concentrations Compared to Base Case				Change in Reservoir Volume with Water Temperature Compared to Base Case	
		≤5 mg/L	≤2 mg/L	≤1 mg/L	≥5 mg/L	>26 °C	≤10 °C
Reservoir Recreation A	South Holston	o	o	o	↑	↑	o
	Douglas	o	↑	↑	↑*	o	↑
	Hiwassee	o	↑	↑**	o	o	↑
	Boone	↑*	↑∞	↑∞	↓	↑	o
	Melton Hill	↑**	↑∞	↑∞	o	↑*	o
	Watts Bar	o	↑*	↑**	o	o	o
	Guntersville	↑	↑**	↑*	o	o	o
	Pickwick	↑	↑*	↑*	o	o	o
	Kentucky	↑	↑	o	o	o	o
Reservoir Recreation B	South Holston	↑	o	o	↑	↑	↑
	Douglas	↑	↑*	↑	↑*	↑	↑*
	Hiwassee	↑	↑*	↑*	o	o	↑
	Boone	↑	↑**	↑∞	o	↑	o
	Melton Hill	↑**	↑∞	↑∞	o	↑**	↑
	Watts Bar	o	↑*	↑**	o	↑	o
	Guntersville	↑*	↑**	↑**	o	o	o
	Pickwick	↑	↑**	↑**	o	o	o
	Kentucky	↑*	↑**	↑**	o	o	↑
Summer Hydropower	South Holston	o	o	↑	↓	o	o
	Douglas	↓	↓*	↓	↑*	o	↑*
	Hiwassee	↓*	↓	↓	↓	↓*	o
	Boone	↓*	↑∞	↑∞	↓*	↓*	o
	Melton Hill	o	↑∞	↑∞	o	↓	↑
	Watts Bar	o	↓	↓*	↓*	o	o
	Guntersville	↓*	↓**	↓**	o	o	o
	Pickwick	↓*	↓**	↓**	o	o	o
	Kentucky	↓*	↓**	↓**	o	o	o

Table 5.4-02 Summation of Responses for Water Quality Characteristics in Representative Reservoirs by Policy Alternative (continued)

Alternative	Reservoir	Change in Reservoir Volume with Dissolved Oxygen Concentrations Compared to Base Case				Change in Reservoir Volume with Water Temperature Compared to Base Case	
		≤5 mg/L	≤2 mg/L	≤1 mg/L	≥5 mg/L	>26 °C	≤10 °C
Equalized Summer/ Winter Flood Risk	South Holston	o	o	o	o	o	o
	Douglas	↓*	↓*	↓*	o	o	o
	Hiwassee	o	o	↑	↓	o	o
	Boone	↑	↑∞	↑∞	↓	↓*	↑
	Melton Hill	↑**	↑∞	↑∞	↓	↑**	↑
	Watts Bar	o	↑*	↑**	o	↑*	o
	Guntersville	↑	↑*	↑	o	o	o
	Pickwick	↑	↑*	↑*	o	o	o
	Kentucky	↑	↑**	↑**	o	o	o
Commercial Navigation	South Holston	o	o	o	o	o	o
	Douglas	o	o	o	o	o	o
	Hiwassee	o	o	o	o	o	o
	Boone	o	↑∞	↑∞	o	o	o
	Melton Hill	o	o	o	o	o	o
	Watts Bar	o	o	o	o	o	o
	Guntersville	o	o	↓	o	o	o
	Pickwick	o	o	o	o	o	o
	Kentucky	o	↓*	↓*	o	o	↑
Tailwater Recreation	South Holston	↑	o	o	↑	↑	↑
	Douglas	↑	↑	↑	↑*	↑	↑*
	Hiwassee	↑	↑**	↑**	↓	o	o
	Boone	↑	↑∞	↑∞	o	↑	o
	Melton Hill	↑**	o	↓∞	o	↑*	↑
	Watts Bar	o	↑*	↑**	o	↑	o
	Guntersville	↑*	↑**	↑*	o	o	o
	Pickwick	↑	↑**	↑**	o	o	o
	Kentucky	↑	↑**	↑**	o	o	↑

Table 5.4-02 Summation of Responses for Water Quality Characteristics in Representative Reservoirs by Policy Alternative (continued)

Alternative	Reservoir	Change in Reservoir Volume with Dissolved Oxygen Concentrations Compared to Base Case				Change in Reservoir Volume with Water Temperature Compared to Base Case	
		≤5 mg/L	≤2 mg/L	≤1 mg/L	≥5 mg/L	>26 °C	≤10 °C
Tailwater Habitat	South Holston	↑	o	o	↑	↑	o
	Douglas	↑*	↑*	↑*	↑**	↑	↑*
	Hiwassee	↑*	↑**	↑**	↓	↓	↑
	Boone	↑	↑∞	↑∞	o	↑	o
	Melton Hill	↑**	↑∞	↑∞	↓	↑**	o
	Watts Bar	o	↑	↑*	o	↑*	o
	Guntersville	↑*	↑**	↑*	o	o	o
	Pickwick	↑	↑**	↑*	o	o	o
	Kentucky	↑**	↑**	↑**	o	o	o
Preferred	South Holston	o	o	o	o	o	o
	Douglas	o	o	o	↑*	o	↑
	Hiwassee	o	o	o	o	o	↑*
	Boone	↑	↑∞	↑∞	o	↑	o
	Melton Hill	↑**	↓∞	↓∞	o	o	o
	Watts Bar	↑	↑**	↑**	↓	o	o
	Guntersville	o	↓	o	o	o	o
	Pickwick	o	↑*	↑	o	o	o
	Kentucky	↑	↑	o	o	o	o

Notes:

Responses are relative to conditions under the Base Case.

Model results for each water quality metric under the Base Case and each policy alternative are provided in Table D1-02 for all alternatives other than the Summer Hydropower and are based on hydrometeorologic conditions that existed from 1987 to 1994. Table D1-03 provides water quality characteristics for the Base Case and the Summer Hydropower Alternative based on hydrometeorologic conditions that existed from 1990 to 1994.

- o = No appreciable change from conditions under the Base Case (+/- 10%).
- ↑ or ↓ = Used to identify changes (+/-) from conditions under the Base Case from 11 to 25%.
- * = Used to identified changes (+/-) from conditions under the Base Case from 26 to 50%.
- ** = Used to identify changes (+/-) from conditions under the Base Case >50%.
- ∞ = Used to identify occurrences when both Base Case data and policy alternative data are infinitely small, causing nominal changes from base to appear quite large proportionally.

Table 5.4-03 Summation of Responses for Water Quality Characteristics in Representative Dam Releases by Policy Alternative

Alternative	Reservoir	Dissolved Oxygen		Temperature	
		Annual Average Minimum DO	Average Number Days/Year DO <5 mg/L	Average Days/Year Temperature >10 °C	Annual Average Maximum Temperature
Reservoir Recreation A	South Holston	LIP target	LIP target	↑	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	↓	↑**	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	↑	o	o
	Pickwick	o	↑*	o	o
	Kentucky	↓	↑	o	o
Reservoir Recreation B	South Holston	LIP target	LIP target	↑*	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	↓	↑**	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	↑*	o	o
	Pickwick	o	↑*	o	o
	Kentucky	↓	↑	o	o
Summer Hydropower	South Holston	LIP target	LIP target	o	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	↑
	Melton Hill	o	o	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	↑	↓**	o	o
	Pickwick	↑	↓**	o	o
	Kentucky	↑	↓**	o	o
Equalized Summer/ Winter Flood Risk	South Holston	LIP target	LIP target	↑	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	↓	↑**	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	↑	o	o
	Pickwick	o	↑*	o	o
	Kentucky	↓	↑*	o	o

Table 5.4-03 Summation of Responses for Water Quality Characteristics in Representative Dam Releases by Policy Alternative (continued)

Alternative	Reservoir	Dissolved Oxygen		Temperature	
		Annual Average Minimum DO	Average Number Days/Year DO <5 mg/L	Average Days/Year Temperature >10 °C	Annual Average Maximum Temperature
Commercial Navigation	South Holston	LIP target	LIP target	o	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	o	o	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	o	o	o
	Pickwick	o	o	o	o
	Kentucky	↑	↓	o	o
Tailwater Recreation	South Holston	LIP target	LIP target	↑*	↓
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	↓	↑**	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	↑*	o	o
	Pickwick	o	↑*	o	o
	Kentucky	↓	↑	o	o
Tailwater Habitat	South Holston	LIP target	LIP target	↑*	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	↓*	↑**	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	↑**	o	o
	Pickwick	↓	↑**	o	o
	Kentucky	↓*	↑*	o	o

Table 5.4-03 Summation of Responses for Water Quality Characteristics in Representative Dam Releases by Policy Alternative (continued)

Alternative	Reservoir	Dissolved Oxygen		Temperature	
		Annual Average Minimum DO	Average Number Days/Year DO <5 mg/L	Average Days/Year Temperature >10 °C	Annual Average Maximum Temperature
Preferred	South Holston	LIP target	LIP target	o	o
	Douglas	LIP target	LIP target	o	o
	Hiwassee	LIP target	LIP target	o	o
	Boone	LIP target	LIP target	o	o
	Melton Hill	o	↑**	o	o
	Watts Bar	LIP target	LIP target	o	o
	Guntersville	o	↓*	o	o
	Pickwick	o	↑	o	o
	Kentucky	o	↑	o	o

Notes:

Responses are relative to conditions under the Base Case.

Model results for each water quality metric under the Base Case and policy alternatives are provided in Table D1-04 for all alternatives other than the Summer Hydropower Alternative and are based on hydrometeorologic conditions that existed from 1987 to 1994. Table D1-05 provides metric results for the Base Case and the Summer Hydropower Alternative based on hydrometeorologic conditions that existed from 1990 to 1994.

LIP = Lake Improvement Plan (TVA 1990).
o = No appreciable change from conditions under the Base Case (+/- 10%).
↑ or ↓ = Used to identify changes (+/-) from conditions under the Base Case from 11 to 25%.
* = Changes (+/-) from conditions under the Base Case from 26 to 50%.
** = Changes (+/-) from conditions under the Base Case >50%.

5.4.3 Base Case

The Base Case represents a continuation of existing reservoir operations throughout the system. The water quality represented by the Base Case is described in detail in Section 4.4, Water Quality.

Under the Base Case, water temperature in the TVA reservoirs would continue to vary depending on the season, the weather, the amount of rainfall and the amount and temperature of water entering each reservoir. Most tributary reservoirs would stratify in summer and surface water temperatures would approach or exceed 30 °C in late summer. Those reservoirs that stratify would mix in early to late fall in response to cooling weather and release of cooler water from deep levels in the reservoirs through the dams. Tailwater temperatures downstream from tributary reservoirs would fluctuate during the summer stratification period as turbines are cycled on and off, periodically releasing cold reservoir water that is subsequently warmed as it moves downstream. During dry years, stratification would be somewhat stronger and possibly persist longer into fall. During wet years, stratification would be weaker and break down earlier in the season. The mainstem reservoirs would not stratify thermally to the extent of the tributary reservoirs due to the mixing created by shallower depths, higher flows, and shorter residence times. Slight vertical temperature differences and weak thermal stratification would occur, particularly during dry years when the upstream water is held back to fill the tributary reservoirs. The stratification that does occur would typically be broken up when flows are increased progressively in June, July, and August.

The deeper strata of the tributary reservoirs would continue to have little or no DO during thermal stratification in summer and late fall. Dissolved oxygen concentrations in the mainstem reservoirs would remain generally higher than in the tributary reservoirs due to shorter residence times in the mainstem reservoirs. Nevertheless, reduced DO concentrations would occur in some mainstem reservoirs during hot, dry periods. The release of water from the lower depths of many reservoirs would result in low concentrations of DO in the releases and downstream in tailwaters without DO mitigation and associated DO targets (Appendix A, Table A-05).

Tributary reservoirs would continue to experience periodic increases in algal growth in response to nutrient inputs from runoff from heavy rainstorms. Mainstem reservoirs would continue to experience increases in algal growth during hot, dry years when flow through the reservoirs is diminished.

5.4.4 Reservoir Recreation Alternative A

Under Reservoir Recreation Alternative A, the mainstem reservoirs would experience an increase in volumes of water with low DO concentrations and essentially no change in the volumes of water with the temperatures examined in the analysis.

The transitional tributary reservoirs would exhibit an increase in the volumes of water with low DO concentrations and an increase in the volume of warm water. Presence of large proportional increases in the volume of water with particularly low DO concentrations (≤2 and ≤1 mg/L) must be interpreted cautiously because these volumes would be quite small under both the Base Case and Reservoir Recreation Alternative A.

The storage tributary reservoirs would tend to react differently to operating conditions under Reservoir Recreation Alternative A. For instance, Douglas and Hiwassee Reservoirs would tend to have an increase in the volume of cool water and little change in the volume of warm water, whereas South Holston would have an increase in the volume of warm water and little change in the volume of cool water. Douglas and South Holston Reservoirs would have an increase in the minimum volume of water available for assimilative capacity (i.e., an increase in the minimum volume of water with DO ≥5 mg/L), whereas Douglas and Hiwassee Reservoirs would have an increase in the volume of water with particularly low DO concentrations (i.e., ≤2 and ≤1 mg/L). The increase in volumes of cool/cold water would result both from higher pool levels in winter and summer, and the increase in volumes with low DO concentrations would result from higher pool levels and decreases in dam releases in late summer.

The operating conditions established under Reservoir Recreation Alternative A would increase the number of days each year in which discharges from the dams would have DO concentrations <5 mg/L for those representative reservoirs without aeration devices (i.e., Melton Hill, Guntersville, Pickwick, and Kentucky). The annual average minimum DO (i.e., the average of the lowest DO concentration that occurred each year in model runs) would be lower under Reservoir Recreation Alternative A than under Base Case conditions at Melton Hill and Kentucky Reservoirs but would be similar to the Base Case on Guntersville and Pickwick Reservoirs.

Generally, effects of Reservoir Recreation Alternative A on release temperature would be similar to those under the Base Case. However, releases at South Holston Reservoir would have fewer days each year when temperatures would exceed 10 °C (Table 5.4-03).

5.4.5 Reservoir Recreation Alternative B

The mainstem reservoirs would experience an increase in volumes of water with low DO concentrations under Reservoir Recreation Alternative B relative to the Base Case, particularly the volume with very low DO concentrations (≤2 and ≤1 mg/L). Changes in volumes of warm water and cool water would be minor on the mainstem reservoirs under Reservoir Recreation Alternative B.

The transitional tributary reservoirs would exhibit an increase in the volumes of water with low DO concentrations as well as an increase in the volume of warm water. As described before, presence of large proportional increases in the volume of water with particularly low DO concentrations (≤2 and ≤1 mg/L) must be interpreted cautiously because these volumes would be quite small in both Base Case and under Reservoir Recreation Alternative B.

The storage tributary reservoirs would exhibit more consistency in response to operational changes under Reservoir Recreation Alternative B than described above for Reservoir Recreation Alternative A. All three representative storage tributary reservoirs would experience an increase in the volume of water with low DO concentrations—Douglas and Hiwassee more so than South Holston. Also, these reservoirs would experience increases in not only volume of warm water but also volume of cool water—likely the result of higher pool levels in winter and in summer compared to the Base Case.

Similar to Reservoir Recreation Alternative A, operations under Reservoir Recreation Alternative B would increase the number of days each year in which dam releases would have DO concentrations <5 mg/L in releases from representative reservoirs that do not have aeration devices. It would reduce the annual average minimum DO in releases from Melton Hill and Kentucky Reservoirs but not those from Guntersville and Pickwick Reservoirs. Release temperatures under Reservoir Recreation Alternative B would be similar to those under Reservoir Recreation Alternative A. The annual average maximum temperature and the average number of days each year with release temperatures >10 °C would be similar to the Base Case except for releases from South Holston Reservoir, which would exhibit fewer days per year with releases above that temperature.

5.4.6 Summer Hydropower Alternative

As described in Section 5.4.2, the evaluation of effects of the Summer Hydropower Alternative on water quality is based on the set of hydrological conditions that existed in 1990–1994, whereas the evaluation for the other alternatives is based on a broader set of hydrological conditions that existed in 1987 to 1994.

The mainstem reservoirs would experience a substantial decrease in volumes of water with low DO concentrations under the Summer Hydropower Alternative. Effects on volumes of warm water and cool water at the temperatures examined for this evaluation would be minor on the mainstem reservoirs under the Summer Hydropower Alternative.

The transitional tributary reservoirs would exhibit an increase in the volumes of water with low DO concentrations under the Summer Hydropower Alternative as well as a decrease in the volume of warm water. As described before, presence of large proportional increases or decreases must be interpreted cautiously.

Response of the storage tributary reservoirs to operation under the Summer Hydropower Alternative would vary among reservoirs, although Douglas and Hiwassee would tend to respond similarly for most water quality characteristics. Douglas and Hiwassee Reservoirs would experience greater changes to water quality characteristics under the Summer Hydropower Alternative operation than would South Holston Reservoir. For example, Douglas and Hiwassee Reservoirs would tend to have a decrease in the volume of water with low DO at all concentrations examined, whereas South Holston Reservoir would have an increase in the volume with particularly low DO concentrations and no change in the volumes at the other concentrations. Douglas Reservoir would have an increase in the minimum volume of water available for assimilative capacity (DO ≥5 mg/L), while South Holston and Hiwassee Reservoirs would experience a decrease. Both Douglas and South Holston Reservoirs would have little change in the volume of warm water, but the volume of warm would decrease on Hiwassee

Reservoir. As for the volume of cool/cold water, South Holston and Hiwassee Reservoirs would be relatively unchanged, while Douglas Reservoir would experience a large increase.

The operating regime under the Summer Hydropower Alternative would increase the annual average minimum DO concentrations in releases from the mainstem reservoirs relative to the Base Case. The average number of days with release DO concentration >5 mg/L would be substantially lower in these same releases. DO concentrations in releases from tributary and transitional reservoirs would be similar to those under the Base Case. Release water temperatures under the Summer Hydropower Alternative would be similar to those under the Base Case.

5.4.7 Equalized Summer/Winter Flood Risk Alternative

The mainstem reservoirs would experience an increase in volumes of water with low DO concentrations and essentially no change in the volumes of warm or cool water under the Equalized Summer/Winter Flood Risk Alternative.

The transitional tributary reservoirs would also exhibit an increase in the volumes of water with low DO. As described above, presence of large proportional increases in the volume of water with particularly low DO concentrations ($\leq$2 and $\leq$1 mg/L) must be interpreted cautiously. The volume of cool water would be larger in these reservoirs under the Equalized Summer/Winter Flood Risk Alternative than under the Base Case; however, the impact on the volume of warm water would differ between the two reservoirs. Boone would have a smaller volume of warm water and Melton Hill a larger volume—most likely due to differing operations of upstream storage tributary reservoirs under the Equalized Summer/Winter Flood Risk Alternative, which is tailored to individual watersheds to equalize flood risk throughout the year.

Water quality characteristics in the storage tributary reservoirs under the Equalized Summer/Winter Flood Risk Alternative would vary depending on watershed-specific flood risks. There would be only nominal differences in water quality characteristics on South Holston Reservoir under this alternative compared to Base Case operations. Hiwassee Reservoir would experience an increase in the volume of anoxic water (as represented by the DO $\leq$1 mg/L metric) and a decrease in the minimum volume of water available for assimilative capacity. Douglas Reservoir would exhibit a decrease in the volume of water with low DO concentrations—most likely due to a decrease in reservoir volume during summer months (compared to the Base Case), when low DO concentrations occur.

Water quality conditions in dam releases under the Equalized Summer/Winter Flood Risk Alternative would be almost identical to those described above for Reservoir Recreation Alternatives A and B. This is true for both DO and temperature measures.

5.4.8 Commercial Navigation Alternative

Mainstem reservoirs would experience only nominal changes to DO and temperature conditions under the Commercial Navigation Alternative. The uncommon exceptions would be a decrease in the volumes of water with particularly low DO concentrations on Kentucky Reservoir and, to lesser extent, Guntersville Reservoir. The transitional tributary reservoirs would exhibit essentially the same temperature and DO conditions under the Commercial Navigation Alternative as under the Base Case. The storage tributary reservoirs would likewise be unchanged under the Commercial Navigation Alternative.

The operating regime under the Commercial Navigation Alternative would be similar to that under the Base Case with only a few changes. Most of the release water quality characteristics under the Commercial Navigation Alternative would be similar to the Base Case, as indicated in Table 5.4-03. The exception to this observation would be at Kentucky Reservoir, where the annual average minimum DO of releases would be increased and the number of days with DO concentrations <5 mg/L would be reduced under the Commercial Navigation Alternative operations.

5.4.9 Tailwater Recreation Alternative

Changes to DO and temperature conditions in reservoirs under the Tailwater Recreation Alternative are sufficiently similar to those described above for Reservoir Recreation Alternative B to not be repeated here.

The operating regime under the Tailwater Recreation Alternative would be similar to that under Reservoir Recreation Alternative B. Similar changes to DO and temperature would also occur. The number of days each year in which discharges would have DO concentrations <5 mg/L would increase, and the average annual minimum DO would be lower at Melton Hill and Kentucky Reservoirs but similar to the Base Case at Guntersville and Pickwick Reservoirs.

The average number of days per year with release temperature >10 °C as well as the average annual maximum temperature in releases would be similar to the Base Case under the Tailwater Recreation Alternative at all representative dams, except South Holston. Releases at South Holston Reservoir would exceed 10 °C for fewer days each year and have a lower average annual maximum temperature.

5.4.10 Tailwater Habitat Alternative

The mainstem reservoirs would experience an increase in volumes of water with low DO concentrations under the Tailwater Habitat Alternative. The increase in volume of water with low DO concentrations (≤2 and ≤1 mg/L) would be substantial, particularly for Kentucky Reservoir. Impacts on volumes of warm water and cool water would be minor on the mainstem reservoirs under the Tailwater Habitat Alternative.

The transitional tributary reservoirs would also exhibit an increase in the volumes of water with low DO concentrations as well as an increase in the volume of warm water. As described before, the presence of large proportional increases must be interpreted cautiously.

All three representative storage tributary reservoirs would experience increases in the volume of water with low DO concentrations under the Tailwater Habitat Alternative. South Holston

Reservoir would be affected the least and Hiwassee Reservoir the most. Douglas and South Holston Reservoirs would tend to have an increase in the minimum volume of water available for assimilative capacity, whereas Hiwassee Reservoir would experience a decrease. Likewise, Douglas and South Holston Reservoirs would have an increase in volume of warm water and Hiwassee a decrease. Douglas and Hiwassee Reservoirs would tend to have an increase in the volume of cool water.

The operating regime under the Tailwater Habitat Alternative would reduce the annual average minimum DO concentrations in releases from Melton Hill, Pickwick, and Kentucky Reservoirs relative to the Base Case. The average number of days each with release DO concentration <5 mg/L would be substantially greater in these same releases and those at Guntersville Reservoir. Temperature impacts would be minor except for South Holston Reservoir, which would experience fewer days, when release temperatures exceed 10 °C.

5.4.11 Preferred Alternative

Section 4.4 describes the relationships between the reservoir operations policy and water quality in reservoirs and in dam releases, particularly as operations affect reservoir flows and residence times. A common concern related to most of the policy alternatives described above is increased residence times resulting from reduced flows during summer months compared to the Base Case, particularly for mainstem reservoirs. The Preferred Alternative would reduce the residence time concern by including higher system minimum flows through Chickamauga Reservoir in June, July, and August compared to Reservoir Recreation Alternatives A and B and the Tailwater Recreation Alternative. These higher summer minimum flows would occur as long as the system minimum operations guide curves are met or exceeded. Table 5.4-04 lists the preferred minimum flows at Chickamauga Dam each week during summer and the frequencies those flows would be expected to be met or exceeded under the Base Case and the Preferred Alternative. Chickamauga Dam was used in this comparison because Chickamauga is the location chosen to measure weekly system-wide minimum flows (see Chapter 3).

Potential water quality effects of these lower-than-preferred flows were evaluated in two ways. First, several of the 8 years included in the analysis (1987–1994) had modeled flows at or below the preferred minimums. These years are identified in Table 5.4-05. Second, one of these years (1993) had low flows representative of near worst-case conditions and was evaluated separately in Section 5.4.12.

The increased summer minimum flows under the Preferred Alternative would provide summer residence times more similar to the Base Case than most of the other policy alternatives. Results for the full 8-year model period indicate that largest increases in average summer residence time under the Preferred Alternative would occur on storage tributary reservoirs, which already have extended residence times under the Base Case. South Holston would experience the greatest increase in summer residence time, with a calculated hydraulic residence time of 483 days under the Preferred Alternative compared to 436 days under the Base Case.

Table 5.4-04 Frequency of Meeting Preferred Minimum Flows at Chickamauga during Summer under the Base Case and the Preferred Alternative

Week	Approximate Date	Preferred Minimum Flow for Preferred Alternative (cfs)	Percentage of Years Flows Would Be Met or Exceeded under Base Case (%)	Percentage of Years Flows Would Be Met or Exceeded under Preferred Alternative (%)
23	1st Week of June	14,000	83	86
24	2nd Week of June	15,000	82	86
25	3rd Week of June	16,000	76	82
26	4th Week of June	17,000	79	77
27	1st Week of July	19,000	76	60
28	2nd Week of July	21,000	77	52
29	3rd Week of July	23,000	76	40
30	4th Week of July	25,000	77	48
31-35	August	29,000	74	50

Table 5.4-05 Water Quality Model Years with Modeled Flows at or below Preferred Minimum Flows under the Preferred Alternative

Week	Preferred Minimum Flow (cfs)	1987	1988	1989	1990	1991	1992	1993	1994
23	14,000		X					X	
25	16,000	X	X					X	
27	19,000	X	X		X			X	
29	23,000	X	X		X	X	X	X	
30	25,000	X	X		X	X	X	X	
31	29,000	X	X		X	X	X	X	
33	29,000	X	X	X	X	X	X	X	

Residence time for representative transitional tributary reservoirs would be increased by 4 days or less under the Preferred Alternative. Average summer residence time on representative mainstem reservoirs would be increased by only 1 or 2 days under Preferred Alternative operations. A noteworthy point about residence time is that, as shown in Table 5.4-05, the occurrence of reservoir flows above the preferred minimum is higher than the Base Case in early summer and lower in late summer. Hence, residence time under the Preferred Alternative is expected to be longer in late summer than under the Base Case.

5.4 Water Quality

Operational changes under the Preferred Alternative would result in only minor changes in volumes of either warm or cool water in mainstem reservoirs. However, compared to the Base Case, three of the four representative mainstem reservoirs would experience an increase in the volume of water with low DO concentrations under the Preferred Alternative. Of these three, Watts Bar would experience the greatest increases. There would be more water in Watts Bar Reservoir with DO $\leq$5, $\leq$2, and $\leq$1 mg/L. Additionally, there would be a decrease in the minimum volume of water available for assimilative capacity (i.e., minimum volume with DO $\geq$5 mg/L on a "worst-case" day). Guntersville Reservoir would differ from the other three representative mainstem reservoirs—with an apparent reduction in the volume of water with particularly low DO concentrations (i.e., $\leq$2 mg/L and $\leq$1 mg/L) under the Preferred Alternative and only nominal changes in the volume available for assimilative capacity. Modeling results indicate that low DO concentrations in Guntersville Reservoir occur primarily during low-flow (drought) conditions, such as those that occurred during 1988. Reservoir flows do not have to be that low for low DO concentrations to occur on the other mainstem reservoirs. For most years, the Preferred Alternative would have slightly lower reservoir flows during summer than under the Base Case. However, flows during particularly dry years like 1988 would be greater under the Preferred Alternative than under the Base Case—if the reservoir system is operated as specified during extreme drought conditions such as those that occurred in 1988.

The transitional tributary reservoirs would also vary in response to operations under the Preferred Alternative. Under the Base Case, Boone Reservoir has a fairly large volume of water with DO $\leq$5 mg/L yet quite small volumes of water with particularly low DO concentrations (i.e., $\leq$2 and $\leq$1 mg/L). Although volumes of all three of these concentrations would increase on Boone Reservoir under the Preferred Alternative, the volume of water with particularly low DO concentrations would still be relatively small. Operation under the Preferred Alternative would tend to increase the volume of warm water in Boone but would result in little change in the volume of cool/cold water. Melton Hill Reservoir also has only a small volume of low DO water under the Base Case. Model results indicate that the volume with very low DO concentrations (i.e., $\leq$2 and $\leq$1 mg/L) might be even less under the Preferred Alternative. The volume of water with DO $\leq$5 mg/l would increase under the Preferred Alternative, but the actual volume would still be small in comparison to total reservoir volume. Temperature characteristics of Melton Hill Reservoir, as well as the minimum volume of water available for assimilative capacity, would be essentially unaffected by Preferred Alternative operations.

Operation under the Preferred Alternative would produce few changes in DO and temperature characteristics for the three storage tributary reservoirs examined. Water quality metrics (both DO and temperature) for South Holston Reservoir under the Preferred Alternative would be similar to those that would exist under the Base Case. For Hiwassee Reservoir, DO metrics under the Preferred Alternative would be similar to those under the Base Case, but the volume of cool/cold water would increase—probably due to higher elevation (and volume) in winter. For Douglas Reservoir, the volume of water available for assimilative capacity would increase, with no measurable changes in volumes of water with low DO concentrations. There would be essentially no change in the volume of warm water, but the volume of cold water would increase—similar to the situation on Hiwassee Reservoir.

The average annual minimum DO concentrations in releases from representative reservoirs that do not have aeration devices (i.e., Melton Hill, Guntersville, Pickwick, and Kentucky) would be similar under the Preferred Alternative to those that would occur under the Base Case. The other DO metric (average number of days/year with DO <5 mg/L) would be increased by the Preferred Alternative for Melton Hill, Pickwick, and Kentucky Reservoir releases, yet decreased for Guntersville releases. The reason that Guntersville Reservoir differs is the dramatic effects of very low-flow conditions due to drought, as described above for 1988. The Preferred Alternative would have no appreciable effect on either of the water temperature metrics (average number of days/year with temperature >10 °C and average annual maximum temperature).

5.4.12 Impacts of Policy Alternatives on DO under Low-Flow Conditions

In evaluating the potential effects of reservoir operations policy alternatives on water quality, it is important to consider a broad range of weather and reservoir conditions. In particular, it is important to consider a situation approximating a scenario that would be expected to occur periodically under hot, low-flow conditions. For the 8 years modeled, the system inflows above Chickamauga Dam for 1988 were the lowest in the last 100 years. Instead of focusing on such a severe drought year, TVA chose to examine a less extreme event. System inflows above Chickamauga Dam for another modeled year (1993) were the seventh-lowest of the last 100 years. This situation can be expected to occur more frequently than the 1988 drought; consequently, modeled flows and water quality conditions for 1993 were used to examine potential effects of the various alternatives under low-flow conditions.

This analysis focuses on effects of low flows on DO because DO is the water quality parameter expected to be most affected under these conditions and because DO is critical to maintaining acceptable water quality conditions in reservoirs. The volume of water with a DO concentration ≤1 mg/l, the metric representing potential anoxic conditions, was selected as the basis of comparison. Table 5.4-06 provides predicted volumes of water with low DO concentrations under each policy alternative, including the Base Case, for 1993 flow conditions. It also expresses those volumes as a percentage of the total reservoir volume during the periods when water quality modeling results predicted this condition would occur.

These results are summarized for each category of TVA reservoir, comparing the effects of operation under the various policy alternatives to the Base Case. Any substantial increase in volume of water with low DO concentration is undesirable.

Table 5.4-06 **Predicted Water Volumes and Percentage of Total Reservoir Volume with Low DO Concentration by Policy Alternative (1993 Flows)**

Reservoir	Sum of Daily Volumes of Water with DO ≤1 mg/L (million m3-days) and Percent of Total Reservoir Volume with DO ≤1 mg/L (1993 Conditions)								
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
South Holston									
Volume	4,257	4,282	4,216	4,294	4,195	4,066	3,969	4,324	4,131
Percent of total volume	3.6%	3.6%	3.6%	4.1%	3.4%	3.5%	3.4%	3.7%	3.5%
Douglas									
Volume	33,948	33,084	39,551	14,259	19,942	33,983	39,275	45,089	33,032
Percent of total volume	19.8%	19.3%	20.7%	12.3%	17.0%	19.7%	20.6%	21.9%	19.4%
Hiwassee									
Volume	975	990	1,489	616	1,133	944	1,699	2,374	1,141
Percent of total volume	2.7%	2.7%	3.7%	2.7%	3.4%	2.6%	4.2%	5.9%	3.0%
Boone									
Volume	0	0	0	0	0	0	7	0	0
Percent of total volume	0%	0%	0%	0%	0%	0%	0.4%	0%	0%
Melton Hill									
Volume	10	141	61	0	79	11	4	261	28
Percent of total volume	0.6%	2.3%	0.9%	0%	1.1%	0.6%	0.1%	3.0%	0.5%
Watts Bar									
Volume	13,996	15,818	23,759	2,443	20,439	13,810	22,940	13,776	23,371
Percent of total volume	11.1%	12.2%	16.3%	2.7%	17.5%	11.1%	15.8%	11.2%	16.9%
Guntersville									
Volume	2,737	5,098	5,608	252	4,979	2,752	5,620	5,133	3,243
Percent of total volume	2.7%	4.9%	5.3%	0.3%	5.0%	2.7%	5.3%	4.7%	3.0%
Pickwick									
Volume	7,374	9,787	12,227	1,121	10,850	6,975	12,091	10,374	9,241
Percent of total volume	7.3%	9.3%	11.5%	1.3%	10.1%	6.9%	11. 4%	9.9%	8.8%
Kentucky									
Volume	863	2,702	3,341	237	3,118	319	3,332	9,890	1,648
Percent of total volume	0.3%	0.9%	1.1%	0.1%	1.0%	0.1%	1.1%	2.4%	0.4%

Storage Tributary Reservoirs

- Increase in low DO volume compared to the Base Case: Reservoir Recreation B, Tailwater Recreation Alternative, and Tailwater Habitat Alternative.
- Low DO volume similar to the Base Case: Reservoir Recreation Alternative A, Commercial Navigation Alternative, and Preferred Alternative.
- Decreased low DO volume compared to the Base Case: Summer Hydropower Alternative.
- Inconsistent response among reservoirs compared to the Base Case: Equalized Summer/Winter Flood Risk Alternative.

Transitional Tributary Reservoirs

- Model results indicate that volumes of water with low DO concentrations would be quite small relative to total reservoir volume under the Base Case and all the action alternatives.
- The largest increase in volume of low DO water would occur under the Tailwater Habitat Alternative, and a decrease would occur under the Summer Hydropower Alternative.

Mainstem Reservoirs

- The predicted volume of water with DO <1 mg/L and percentage of total reservoir volume would vary considerably among the representative mainstem reservoirs. Watts Bar Reservoir would have the largest low DO volume as well as the greatest proportion of total reservoir volume with DO <1 mg/L, and Kentucky would have the smallest volume and portion. Kentucky is the largest among all TVA reservoirs, with a total reservoir volume much greater than any of the other reservoirs.
- Increase in low DO volume compared to the Base Case: Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Equalized Summer/Winter Flood Risk Alternative, Tailwater Recreation Alternative, Tailwater Habitat Alternative, and the Preferred Alternative.
- Low DO volume similar to the Base Case: Commercial Navigation Alternative.
- Decrease in low DO volume compared to the Base Case: Summer Hydropower Alternative.

In summary, operation under the different policy alternatives under 1993 flow conditions would have varying effects on the volumes of low DO water, depending on alternative and reservoir.

Under the Commercial Navigation Alternative, the volume of low DO water in most reservoirs would be similar to those under the Base Case, and decreases would occur in most reservoirs under the Summer Hydropower Alternative. Under the other policy alternatives, low DO volumes appear to increase for most reservoirs—particularly the mainstem Tennessee River reservoirs.

Another important consideration is how alternatives affect summer hydraulic residence times, especially on mainstem reservoirs during low-flow years such as 1993. Table 5.4-07 shows the changes in summer residence times (days) for the representative mainstem reservoirs under each policy alternative.

Table 5.4-07 Summer Residence Time Changes for Representative Mainstem Reservoirs (1993 Flows)

Reservoir	Base Case (days)	Residence Time Changes Relative to Base Case (days)							
		Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Watts Bar	24.8	+3.9	+10.4	-7.9	+13.6	+0.1	+9.7	+17.0	+3.3
Guntersville	21.3	+2.8	+7.9	-6.0	+9.9	0	+7.8	+11.6	+3.0
Pickwick	19.8	+3.3	+8.2	-6.5	+11.6	-0.2	+8.1	+11.7	+3.7
Kentucky	46.5	+7.2	+17.7	-10.2	+12.6	-0.8	+17.5	+16.9	+3.2

Notes:

Summer represents June 1 through September 30.

+ = Indicates an increase in residence time relative to the Base Case.

5.4.13 Impacts of Policy Alternatives on Algae

Impacts of alternative operations policies on algal activity are not included in Table 5.4-02 or the discussion of each alternative. Absence of an appropriate, alternative-specific predictive tool prevents such a presentation of potential effects. The water quality models used in this evaluation were not specifically calibrated for algal activity. As a result, the evaluation of potential effects of various alternatives was based on an examination of Vital Signs Monitoring Program results. A regression analysis for chlorophyll-a (a measure of the amount of algae) concentrations predicted generally small increases in chlorophyll-a among the alternatives, with a maximum increase less than 10 percent. Based on past monitoring experience, a larger increase was expected in reservoirs with relatively short residence times because operation under most alternatives would result in increased residence time, which should be sufficient to result in increased chlorophyll-a concentrations. Further analysis compared chlorophyll-a concentrations in each representative reservoir in 2002 to their respective long-term averages. The basis of this comparison was that low flows, because of drought conditions in 2002, were generally similar to those that would occur under several alternatives. In effect, the long-term average represents the Base Case, and 2002 represents alternatives that result in decreased summer flows (Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative and, to a lesser extent, the Preferred Alternative). That comparison showed higher concentrations in all representative reservoirs in 2002 than the long-term average, with greatest increases in reservoirs with short retention times and least increases in reservoirs with long retention times. These results indicate that increased retention times due to lower flows associated with several alternatives could result in higher chlorophyll-a concentrations in several reservoirs, especially mainstem reservoirs. Based on 2002 results, some of the increases could be substantial.

5.4.14 General Water Quality Impacts

The water quality metrics described above provide a quantitative comparison among policy alternatives and are useful in determining the relative difference between the Base Case and the action alternatives. The focus of the analysis was on hydrodynamics, DO, and temperature. Of primary interest among these metrics are those that describe changes in DO concentrations. The presence, absence, and concentrations of DO in a reservoir both control and are controlled by many physical, chemical, and biological processes. Clearly, adequate DO concentrations are essential for many water uses such as support for a healthy and robust aquatic community and for assimilating oxygen demanding wastes.

The quantitative evaluation provided above for each policy alternative indicated that several of the operations policies would increase the volume of water with low DO concentrations. Potential implications of these increases could include loss of habitat for aquatic life, increased water treatment costs, loss in assimilative capacity, and increase in anoxic products. These changes would be expected to be of greater concern in reservoirs and tailwaters that never or rarely experience low DO concentrations than in those that experience such conditions routinely. Impacts of changes in water quality on aquatic resources are discussed in Section 5.7 (Aquatic Resources), impacts on threatened and endangered species are discussed in Section 5.13 (Threatened and Endangered Species), and impacts on water supply are discussed in Section 5.5 (Water Supply). Impacts of increases in volumes of water with low DO concentrations on assimilative capacity and the potential for anoxic products are described in Section 5.4.15.

5.4.15 Assimilative Capacity and Anoxic Products

The evaluation summarized in Table 5.4-08 uses the following criteria to describe relative impacts of alternatives on assimilative capacity and the extent of anoxia compared to the Base Case. These categories are similar in magnitude to those used previously, but include a judgment of whether the change would result in a beneficial or adverse impact on water quality. In addition to these quantitative changes, the evaluation considers other factors such as existence of low DO conditions under the Base Case, availability of an ample supply of water with adequate DO concentrations, and existence of aeration systems.

- Not different from the Base Case – +/-10% of Base Case (shown as No Change).
- Slightly Beneficial – 11 to 25% increase in the volume of water with DO $\geq$5 mg/L for assimilative capacity and 11 to 25% decrease in the volume of water DO $\leq$1 mg/L for evaluation of anoxia.
- Beneficial – 26 to 50% increase in the volume of water with DO $\geq$5 mg/L for assimilative capacity and 26 to 50% decrease in the volume of water DO $\leq$1 mg/L for evaluation of anoxia.
- Substantially Beneficial – >50% increase in the volume of water with DO $\geq$5 mg/L for assimilative capacity and >50% decrease in the volume of water DO $\leq$1 mg/L for evaluation of anoxia.
- Slightly Adverse – 11 to 25% decrease in the volume of water with DO $\geq$5 mg/L for assimilative capacity and 11 to 25% increase in the volume of water DO $\leq$1 mg/L for evaluation of anoxia.
- Adverse – 26 to 50% decrease in the volume of water with DO $\geq$5 mg/L for assimilative capacity and 26 to 50% increase in the volume of water DO $\leq$1 mg/L for evaluation of anoxia.
- Substantially Adverse – >50% decrease in the volume of water with DO $\geq$5 mg/L for assimilative capacity and >50% increase in the volume of water DO $\leq$1 mg/L for evaluation of anoxia.
- Note: The volume of water associated with certain metrics under certain alternatives for certain reservoirs could be quite small, causing nominal changes from the Base Case to appear quite large proportionally. Consequently, absolute volumes in Appendix D1 also were considered. Where this occurred, the judgment was labeled as Slightly Beneficial or Slightly Adverse regardless of the actual percentage change.

Assimilative Capacity

The analysis on impacts of reservoir operations on assimilative capacity was accomplished using the metric that measured the minimum volume of reservoir water that exceeded 5 mg/L oxygen on the "worst-case" day for each of the 8 years examined by the water quality model. It was assumed that this condition would provide a constraint on the amount of oxygen consuming waste a reservoir could accept. The analysis used this parameter as an indicator of the system-wide impacts of policy alternatives on the ability of the reservoirs to assimilate oxygen consuming wastes. The analysis did not evaluate specific discharges, it did not evaluate potential discharges to tailwaters or free-flowing sections, nor did it evaluate the ability of the system to assimilate other wastes that do not consume oxygen. A beneficial impact under this category of uses is defined as an increase in assimilative capacity while an adverse impact is defined as a loss in assimilative capacity.

Table 5.4-08 Summary of Impacts on Assimilative Capacity and Anoxia by Policy Alternative

Alternative	Assimilative Capacity	Potential for Anoxic Products
Reservoir Recreation A	This policy alternative would result in a slight increase in the minimum volume of water available to assimilate oxygen consuming wastes on tributary storage reservoirs (Slightly Beneficial). For the transitional tributary reservoirs, there would either be no change or a slight reduction in this volume (No Change – Slightly Adverse). This volume would be relatively unchanged from the Base Case for the mainstem reservoirs (No Change).	The volume of water with oxygen concentrations favoring development of anoxic products would increase somewhat on the storage tributary reservoirs and transitional tributary reservoirs compared to the Base Case (Slightly Adverse). Even greater proportional increases would occur on most representative mainstem reservoirs (Adverse).
Reservoir Recreation B	This policy alternative would result in essentially the same changes in representative reservoirs described for Reservoir Recreation A. The only difference is that the transitional tributary reservoirs would be rated No Change because the minimum volume available would be similar to the Base Case.	This policy alternative would result in essentially the same changes in storage tributary and transitional tributary reservoirs described for Reservoir Recreation A. For the mainstem reservoirs, the increase in volume compared the Base Case would be substantial for all representative reservoirs (Substantially Adverse).
Summer Hydropower	Changes under this alternative in the minimum volume of water available to assimilate oxygen-demanding materials were evaluated only for normal- to high-flow years. Impacts under low flows during dry years could not be evaluated because conditions created insufficient water availability for completion of model runs. For the flow conditions that could be evaluated, most representative reservoirs would have essentially the same volume of water with this characteristic as the Base Case or would have a slight reduction (No Change to Slightly Adverse).	Changes under this alternative in the volume of water with oxygen concentrations favoring development of anoxic products were evaluated only for normal- to high-flow years. Impacts under low flows during dry years could not be evaluated because conditions created insufficient water availability for completion of model runs. For the flow conditions that could be evaluated, volume reductions would occur more often than increases on the storage tributary reservoirs (Slightly Beneficial). Transitional tributary reservoirs would experience increases (Slightly Adverse). High summer flows through the mainstem reservoirs would result in large reductions compared to the Base Case (Substantially Beneficial).
Equalized Summer/ Winter Flood Risk	This policy alternative would result in essentially no change in the minimum water available to assimilate oxygen-demanding wastes in two of the storage tributary reservoirs and a slight reduction in the other (No Change to Slightly Adverse); a slight reduction in both transitional tributary reservoirs (Slightly Adverse); and similar volumes to Base Case operations for all representative mainstem reservoirs (No Change).	Changes under this alternative in the volume of water with oxygen concentrations favoring development of anoxic products would vary among storage tributary reservoirs from a slight increase to a decrease (overall rating Slightly Beneficial). The transitional tributary reservoirs would experience a slight increase under this alternative (Slightly Adverse). This volume would increase on all representative mainstem reservoirs, with proportional increases being substantial on some reservoirs (Adverse – Substantially Adverse).

Table 5.4-08 Summary of Impacts on Assimilative Capacity and Anoxia by Policy Alternative (continued)

Alternative	Assimilative Capacity	Potential for Anoxic Products
Commercial Navigation	The minimum volume of water available to assimilate oxygen-demanding wastes would be relatively unchanged compared to the Base Case for all representative reservoirs (No Change).	This policy alternative would result in about the same volumes of water with oxygen concentrations favoring development of anoxic products as the Base Case on storage tributary reservoirs (No Change). This volume would be slightly increased on some transitional tributary reservoirs and unchanged compared to the Base Case on others (No Change – Slightly Adverse). Mainstem reservoirs would either remain similar to the Base Case or experience a slight decrease in volume (overall rating Slightly Beneficial).
Tailwater Recreation	Effects of this policy alternative would be the same as those described for Reservoir Recreation B.	This policy alternative would result in either similar volumes of water with potential anoxic conditions on storage tributary reservoirs compared to the Base Case or a notable increase (No Change – Adverse). Some transitional tributary reservoirs would experience an increase, while others would experience a decrease (Slightly Adverse – Slightly Beneficial). Most mainstem reservoirs would encounter a large increase in this volume (Substantially Adverse).
Tailwater Habitat	Effects of this policy alternative would vary among the storage tributary reservoirs. There would be a notable increase in the minimum volume of water available to assimilate oxygen consuming wastes on one tributary storage reservoir and a slight decrease on another (overall rating Slightly Beneficial). For the transitional tributary reservoirs, there would either be no change or slight reduction in this volume (No Change – Slightly Adverse). This volume would remain relatively unchanged on the mainstem reservoirs (No Change).	The volume of water with oxygen concentrations favoring development of anoxic products would increase on almost all representative reservoirs. The increase would be sufficiently large as defined in this context to be rated Adverse on the storage tributary reservoirs; No Change to Slightly Adverse on transitional tributary reservoirs; and even larger increases on mainstem reservoirs would be rated Adverse to Substantially Adverse.
Preferred	This policy alternative would result in either an increase in the volume of water available for assimilating oxygen-demanding wastes or volumes similar to the Base Case for the storage tributary reservoirs (Slightly Beneficial). Volumes on the transitional tributary reservoirs would be similar to the Base Case (No Change). Volumes on three of the four mainstem reservoirs would be similar to the Base Case and slightly reduced compared to the Base Case on the other representative mainstem reservoir (overall rating No Change).	This policy alternative would result in about the same volumes of water with oxygen concentrations favoring development of anoxic products as the Base Case on storage tributary reservoirs (No Change). This volume would be slightly increased on some transitional tributary reservoirs and slightly decreased compared to Base Case on others (Slightly Adverse – Slightly Beneficial). Mainstem reservoirs would remain similar to the Base Case, experience a slight decrease in volume, or experience a large increase in volume (overall rating Slightly Adverse).

Anoxic Products

In addition to the direct impacts on aquatic life (discussed in Section 5.7, Aquatic Resources) low concentrations of DO approaching anoxia have the potential to introduce iron, manganese, sulfides, and ammonia into deeper strata of reservoirs. Because this process is so closely tied to DO concentrations, the potential for these compounds to be mobilized or formed was evaluated by looking at the volume of water in the reservoirs having a DO concentration less than 1 mg/L. A decrease in the potential for anoxic product formation or mobilization is designated as a beneficial impact while an increase is designated as an adverse impact.

5.4.16 Summary of Impacts

Table 5.4-04 identified relatively few changes in the minimum volume of water available to assimilate oxygen-demanding wastes compared to Base Case conditions. This metric was selected to be an indicator of system-wide impacts of policy alternatives on assimilative capacity. It was not intended to be a detailed evaluation of policy alternatives on assimilative capacity, nor was it intended to examine site-specific impacts. From this perspective, this analysis indicates that none of the alternative operations policies would result in substantial impacts on assimilative capacity.

Increases in anoxia and potential anoxic products are of particular concern, especially on mainstem reservoirs. Presence of anoxia on storage tributary reservoirs is an expected condition because of long residence times and thermal stratification. However, frequency, duration, and extent of anoxia are much less on most of the mainstem reservoirs than on the storage tributary reservoirs because of shorter residence times and lack of thermal stratification. This analysis shows that most policy alternatives would affect DO more in mainstem reservoirs than in storage tributary reservoirs.

Of the policy alternatives that were evaluated for the complete 8-year model period (i.e., all but the Summer Hydropower Alternative), several policy alternatives would result in a relative increase in the potential for anoxic products on most or all representative mainstem reservoirs and thus be considered an adverse to substantially adverse impact. Only one, the Commercial Navigation Alternative, would result in volumes of potential anoxic water either similar to or slightly less than the Base Case. The Preferred Alternative would affect each mainstem reservoir differently, ranging from a volume of potential anoxic water similar to the Base Case to a volume substantially larger than the Base Case. The increase would occur on Watts Bar Reservoir, which experiences relatively large volumes of low DO water on a more frequent basis than any of the other mainstem reservoirs. Watts Bar Reservoir presently has aeration equipment to maintain its Lake Improvement Plan target for the tailwater.

Analysis of the effects of policy alternatives on water quality under low-flow conditions acknowledged that the volume of water with low DO concentrations was greater on most representative reservoirs during dry years with low reservoir flows under the Base Case operations. Several policy alternatives would increase this volume beyond what would occur under the Base Case, especially on mainstem reservoirs. Flows for 1993 were used to represent low-flow conditions. Water quality model runs were completed for all policy alternatives under 1993 conditions. Results indicate that the Summer Hydropower Alternative would reduce the volume of low DO water on mainstem reservoirs compared to the Base Case; the Commercial Navigation Alternative would result in volumes similar to the Base Case; and all other alternatives would increase the volume of low DO water compared to the Base Case. Among the alternatives that would result in increased volume, the Preferred Alternative would create the smallest increase.

Conditions that exist under low flows are often a good predictor of future conditions under normal flow. This analysis indicates that most policy alternatives would tend to increase volumes of water with low DO concentrations, especially on mainstem reservoirs under low-flow conditions. The results of this analysis indicate that any operations policy that would reduce flows on mainstem reservoirs beyond those under the Preferred Alternative—whether one of the alternatives considered here or a future alternative—could compromise water quality in unacceptable ways.

5.5 Water Supply

5.5.1 Introduction

This assessment of environmental consequences focuses on whether implementation of a new reservoir operations policy would change reservoir elevations or tailwater minimum flows in a manner that would:

- Limit supply by constraining withdrawals for municipal and industrial uses;
- Increase the cost of obtaining supplies, as expressed in pumping costs or costs for new or modified intake structures; or
- Degrade water supply quality and thereby limit water supply through increased treatment requirements.

5.5.2 Impact Assessment Methods

The analysis for water supply is based on output from the WSM, which provided (among other things) changes in reservoir elevations, and output from the Water Quality Model, which provided data relative to changes in DO and algae formation. Using these data, the Base Case and action alternatives were evaluated using the methods of analysis described below.

Reservoir Elevations and Intake Structures

Changes in reservoir elevation were evaluated to determine whether:

- Alternative minimum reservoir elevations would fall below water supply intake structure elevations; or,
- Changes in elevations would affect the energy requirements for pumping water from the reservoirs and thereby constrain supply.

For all reservoirs with public supply and industrial water intakes, the proposed minimum reservoir elevations under each action alternative were compared to the TVA-published minimum reservoir elevation for the reservoir. A summary is shown in Table 5.5-01. All intakes in the reservoir were installed to be below the published normal minimum operating level. Footnoted entries in Table 5.5-01 indicate that five alternatives would result in elevations below the published minimum elevation. It should be noted that not all 35 reservoirs in the system were subjected to simulated elevations. Some, such as Fort Patrick Henry, Melton Hill, Apalachia, and the Ocoee Reservoirs, were not expected to experience elevation changes under any of the alternatives. The reservoirs that are discussed in the following pages were selected because their intakes were sufficiently large that mitigation costs could be substantial if an alternative would result in an adverse effect.

Table 5.5-01 Comparison of TVA-Published Minimum Reservoir Elevations to Existing and Proposed Elevations

Reservoir	TVA-Published Minimum Elevation (ft)	Base Case and Action Alternative Minimum Reservoir Elevations (ft)								
		Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/ Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Watauga	1,915	1,920.9	1,931	1,932	1,778.9[1]	1,913.4[1]	1,890.9[1]	1,924.9	1,936	1,913.8[1]
South Holston	1,675	1,681.3	1,688	1,694	1,676	1,676	1,676	1,698.1	1,679.7	1,676
Boone	1,330	1,355.7	1,355.7	1,355.7	1,354.9	1,361	1,355.7	1,355.7	1,355.7	1,361.2
Cherokee	1,020	1,026.6	1,027.6	1,029	981.0[1]	1,025.1	1,010.1[1]	1,029.4	1,030	1,020
Douglas	940	940	940	940	910.0[1]	940.5	932.8[1]	940	940	935[1]
Norris	960	970.8	974.6	978.3	900.0[1]	959.2	946.1[1]	977.5	973.2	960
Fontana	1,575	1,575	1,575	1,575	1,518.0[1]	1,575	1,553.4[1]	1,575	1,575	1,575
Chatuge	1,905	1,909.3	1,910.3	1,911.2	1,860.0[1]	1,906.4	1,893.3[1]	1,903.7[1]	1,904.9[1]	1,905
Nottely	1,735	1,741.1	1,742.6	1,743.9	1,690.0[1]	1,739	1,721.9[1]	1,733.5[1]	1,734.8[1]	1,735
Hiwassee	1,450	1,458.8	1,461.2	1,463.4	1,413.2[1]	1,451.3	1,438.5[1]	1,447.9[1]	1,450	1,450
Blue Ridge	1,590	1,639.6	1,642.5	1,646.7	1,611.7	1,626.6	1,644.8	1,647.5	1,618.5	1,644.8
Tims Ford	865	870	871.2	871	855.0[1]	864.6	863.1[1]	871	871.2	870
Fort Loudoun	807	808	809.5	809.5	808	807	809.5	809.5	809.5	808
Watts Bar	735	736	737.5	737.5	736	735	737.5	737.5	737.5	736
Chickamauga	675	676	677.5	677.5	676	675	677.5	677.5	677.5	676
Nickajack	632	632.5	632.5	632.5	632.5	632.5	632.5	632.5	632.5	632.5
Guntersville	593	593.3	593.3	593.3	593.3	593.3	593.3	593.3	593.3	593.3
Wheeler	550	551	552.5	552.5	551	551	552.5	552.5	552.5	551
Wilson	504.5	505.5	505.5	505.5	505.5	505.5	505.5	505.5	505.5	505.5
Pickwick	408	409	410.5	410.5	409	409	410.5	410.5	410.5	409
Kentucky	354	354.3	354.3	356	354.3	354.3	356	356	354.3	354.3

[1] Indicates elevations below the published minimum elevation.

Cherokee Reservoir

Morristown on Cherokee Reservoir has a municipal intake designed for operation with a minimum water level of 1,020 feet. Under both the Summer Hydropower Alternative and the Commercial Navigation Alternative elevations would be lower than 1,020 feet. Should reservoir elevations fall below 1,020 feet, an old intake at Morristown that is at the level of the original river channel could be used to supply some water when the reservoir level is as low as 1,000 feet.

Under the Summer Hydropower Alternative, the elevation of Cherokee Reservoir is predicted to be below elevation 1,020 feet for 125 weeks during 100 years and below elevation 1,015 feet for 94 weeks during 100 years. The minimum elevation during the 100-year period is expected to be 980 feet. The minimum elevation was found to occur during August and September, when peak demand conditions occur. Because of the frequency and duration of occurrence of elevations below the existing operating level, there is no practical way to modify the existing intake either on a permanent or temporary basis to provide the required water supply reliability. In these circumstances, it was assumed that a new intake would be required. Based on recent construction costs of other intakes similar to the existing Morristown design, the cost of a new intake would be about $5 million.

Under the Commercial Navigation Alternative, it is expected that the reservoir elevation would be below 1,020 feet for 16 weeks out of 100 years and below elevation 1,015 feet for 5 weeks out of 100 years. The approximate minimum elevation would be about 1,010 feet. Reservoir levels below 1,020 feet would all occur in the October–November time frame, when municipal demands are near or below the annual average demand. With the existing intake, it was assumed that approximately one-half of the projected 2030 demand of approximately 12 mgd could be produced under the Commercial Navigation Alternative. It was further assumed that the existing intake and pumps could be modified to provide the remaining 6 mgd. Installation of temporary pumps might also be required to pump into the existing intake wet well for a limited period of time. These modifications were estimated to cost approximately $1 million.

Norris Reservoir

The two alternatives with elevations below the published minimum elevation (960 feet) were the Summer Hydropower Alternative, with a minimum elevation of 900 feet, and the Commercial Navigation Alternative, with a minimum elevation of 946 feet. (Although the minimum elevation under the Commercial Navigation Alternative would be below the published minimum elevation, its minimum elevation would not affect Lafollette.) The Lafollette intake has a provision for the installation of a temporary pump should elevations go below 900 feet, the elevation of the City of Lafollette's intake. Therefore it was assumed that the Summer Hydropower Alternative would incur a cost of approximately $20,000 for temporary pumping for the period that the reservoir elevation reached elevation 900 feet.

Douglas Reservoir

The Sevier Water Board has an intake in Douglas Reservoir. According to plans approved by TVA for this intake, the lowest elevation for the intake was to be 926.5 feet. The Summer Hydropower Alternative has a minimum elevation of 910 feet. Because it is unlikely that the reservoir is sufficiently deep at the intake's location to allow the existing intake to be extended to a depth to accommodate an elevation of 910 feet, it was assumed that the intake would need to be moved approximately 2 miles and a new intake would need to be constructed. The total cost was expected to be $3 million. Under the Commercial Navigation Alternative, the minimum reservoir elevation was projected to be 932.8 feet, which is above the 926.5-foot elevation to which the intake was supposed to be functional. To allow for the uncertainty at which elevation the intake would continue to function, it was assumed that a cost of $26,000 would be incurred to connect temporary pumps and to modify private and commercial intakes. The Preferred Alternative has a minimum elevation of 935 feet, which is below the minimum published elevation. As for the Commercial Navigation Alternative, a $26,000 cost was assumed for potential temporary pumping and private/commercial intake modification to accommodate the minimum elevation event.

Chatuge Reservoir

The city of Hiawassee, Georgia has a floating intake on Chatuge Reservoir. Based on depth soundings beneath the intake, it was estimated that the reservoir level could drop to elevation 1,895 feet and the intake would still continue to function. Although elevations for the Tailwater Recreation and Tailwater Habitat Alternatives fall below the published minimum elevations, the minimum elevations for these alternatives are still above 1,895 feet. The minimum elevation for the Commercial Navigation Alternative is 1,893.3 feet, which is below the existing limitation of 1,895 feet. It was assumed that this elevation could be reached through a modification of the existing intake at a cost of $50,000. The existing intake cannot be modified to reach elevation 1,860 feet as required under the Summer Hydropower Alternative; therefore, it was assumed that a new intake must be constructed. The cost for the new intake in deeper water plus approximately 2.5 miles of pipeline to carry the water to the treatment plant was estimated at $2.2 million.

Nottely Reservoir

An intake tower for the Notla Water Company has been recently installed in the Nottely forebay. The lowest level from which water can be withdrawn is 1,733 feet. Both the Summer Hydropower and Commercial Navigation Alternatives resulted in minimum pool levels much below this level. Therefore, it was assumed that the intake would need to be reconstructed at a location farther out in the reservoir, at an estimated cost of $2.25 million.

Tims Ford Reservoir

An elevation of 855 feet at Tims Ford was recently experienced due to a drawdown necessary for dam repair. No adverse impacts were reported to TVA. Therefore, it was assumed that an elevation of 855 feet is possible without modification of any intakes.

Fontana and Hiwassee Reservoirs

Three alternatives would result in impacts on a few private or commercial intakes on these reservoirs.

Reservoir Elevations and Pumping Requirements

Table 5.5-02 shows the amount of water projected to be pumped from selected reservoirs in 2030. The difference in pumping energy required to lift water from the reservoir between the Base Case and each action alternative was computed. The computation was conducted by determining the difference in median elevation between each action alternative and the Base Case for each month for each reservoir.

Table 5.5-03 compares the difference in pumping energy required for each action alternative compared to the Base Case.

Table 5.5-02 2030 Total Average Water Supply Pumping Rates

Reservoir	Average 2030 Annual Water Pumping Affected by Reservoir Level (mgd)
South Holston	4.5
Chatuge	1.4
Cherokee	25.9
Douglas	5.1
Fort Loudoun	74.9
Norris	2.5
Watts Bar	50.0
Chickamauga	49.3
Nickajack	89.9
Guntersville	98.0
Wheeler	412.1
Wilson	53.0
Pickwick	92.2
Tims Ford	2.8
Nottely	1.0
Kentucky	136.1

Table 5.5-03 Change in Pumping Energy Required by Policy Alternatives

Action Alternative	Difference in Pumping Energy Compared to the Base Case (millions of KWh/yr)[1]
Reservoir Recreation A	-1.4
Reservoir Recreation B	-2.0
Summer Hydropower	0.9
Equalized Summer/Winter Flood Risk	-0.3
Commercial Navigation	-0.8
Tailwater Recreation	-2.0
Tailwater Habitat	-1.6
Preferred	-0.7

[1] A negative number indicates that the alternative requires less energy than the Base Case. A positive number indicates that the alternative requires more energy than the Base Case.

Water Supply Quality and Treatment

Water quality, in relationship to water supply, was analyzed for effects on water supply treatment requirements due to changes in algae concentrations, the potential for increased concentrations of soluble iron and manganese, and increased turbidity. The algal biomass concentrations in the photic zone (where light is available) were used to rate the alternatives; they represent a surrogate metric for dissolved organic matter (DOM), taste and odor impacts, and operational difficulties related to algae concentrations. Analysis of the water volume with DO less than 1 mg/L was used as a surrogate for the potential for soluble iron and manganese formation. Storm water runoff brings large amounts of sediment into the streams, rivers and reservoirs of the Tennessee River watershed. Storm events increase the cost of water treatment. However, none of the reservoir operational changes will affect the amount of sediment that enters the reservoir system. Operational changes that result in longer reservoir retention times might result in slightly more settling of suspended solids. However, experience with the water quality models used for the ROS evaluation indicated that suspended solids concentrations would vary by less than 10 mg/L among the alternatives (Shiao pers. comm.). Bohac (2003) showed that, for a change of 5 to 10 mg/L, the costs to water treatment systems in the Tennessee River watershed were insignificant. Therefore, no comparison of alternatives was made based on suspended solids.

<u>Algae</u>

Algae can cause taste and odor problems for water treatment plant operators, can contribute to the formation of DBPs, and can also contribute to operational problems such as reduced filter run times. Water quality modeling was used to investigate these potential effects by examining differences in algae concentrations between the alternatives. Reservoir maximum algae concentrations were calculated for the 8-year water quality simulation period (1987 to 1994), as shown in Table 5.5-04.

Table 5.5-04 Comparison of Maximum Algae Concentrations by Policy Alternative

Reservoir	Maximum Algae Concentration (mg/L)								Range between Alternatives (mg/L)
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred	
Cherokee	5.2	5.2	5.2	5.1	5.2	5.2	5.2	5.1	0.1
Douglas	3.5	3.8	3.8	3.4	3.5	3.8	3.8	3.4	0.4
Norris	1.3	1.3	1.4	1.5	1.3	1.5	1.4	1.4	0.2
South Holston	6.5	6.5	6.5	6.2	6.5	6.5	6.5	6.5	0.3
Watauga	3.5	3.8	4.9	5.0	3.5	4.8	4.6	5.1	1.6
Boone	6.4	6.8	6.5	6.8	6.5	6.5	6.7	6.7	0.4
Fort Patrick Henry	3.7	3.8	3.8	3.8	3.8	3.8	3.6	3.9	0.3
Melton Hill	6.0	6.0	6.0	6.3	5.9	5.8	6.2	5.7	0.6
Chickamauga	2.4	2.5	2.5	2.0	2.3	2.5	2.0	2.3	0.5
Fort Loudoun	5.1	5.2	5.2	4.7	4.6	5.0	4.9	5.1	0.6
Guntersville	8.3	8.6	8.6	8.0	8.3	8.6	8.3	7.1	1.5
Kentucky	3.4	3.4	3.4	3.4	3.4	3.5	3.4	3.2	0.3
Nickajack	2.6	2.7	2.6	2.1	2.4	2.7	2.4	2.5	0.6
Pickwick	6.8	6.5	6.6	6.5	6.7	6.4	6.5	6.3	0.5
Watts Bar	4.7	5.1	4.9	3.6	4.0	5.0	5.3	4.6	1.7
Wheeler	7.7	7.7	7.6	7.5	8.3	7.6	7.7	6.4	1.9

Even though there were slight differences between alternatives for any one reservoir, the differences in maximum concentrations were generally small on most reservoirs (Table 5.5-04). In addition, none of the alternatives exhibited a pattern of being consistently better or worse than any other alternative when all reservoirs were considered.

5.5 Water Supply

As discussed in Section 5.4.13, an analysis of chlorophyll-a concentrations and retention times suggested that all of the action alternatives except the Commercial Navigation Alternative could result in higher chlorophyll-a (algae) concentrations in some reservoirs.

Iron and Manganese

Reservoir water volumes with DO concentration below 1 mg/L were used as an indicator for the relative potential for soluble species of iron and manganese to form in reservoir bottoms; and they were used to rank each alternative on tributary, transitional, and mainstem reservoirs.

Based on the average rank, the Base Case and the Commercial Navigation Alternative appeared to have the lowest potential for soluble iron and manganese species formation across all reservoirs evaluated. The order of increasing potential for iron and manganese formation was the Preferred Alternative, followed by Reservoir Recreation Alternative A and the Equalized Summer/Winter Flood Risk Alternative. Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative have the highest potential for iron and manganese formation.

Because of volume differences between alternatives on tributary reservoirs, the ratios of water with DO less than 1 mg/L to total volume were investigated. It was determined that some of the effect of larger amounts of low DO water would be offset by more total water in the reservoir. As such, differences between alternatives based on ratios of low DO water to total water volume were less important than differences based only on low DO volume.

It is unclear to what degree water treatment plants could be affected by elevated concentrations of soluble iron and manganese. Many existing treatment plants have multiple-level intakes that allow iron- and manganese-rich water to be avoided. Therefore, even if some alternatives result in elevated soluble iron and manganese concentrations, treatment plants might be able to avoid potential impacts. Water treatment plant operators on South Holston, Cherokee, Douglas, Melton Hill, and Fort Loudoun Reservoirs stated that no treatment is presently required for iron and manganese. Treatment plant operators on Chickamauga, Nickajack, and Wheeler Reservoirs also confirmed that they do not now treat for iron and manganese.

The cost of chemicals to treat the differences in soluble iron and manganese that could arise if an alternative to the Base Case was implemented was estimated for Cherokee and Douglas, two reservoirs where the potential for soluble iron and manganese formation appeared to be the greatest. The additional cost for treatment was less than $5,000 per year, suggesting that any increase in soluble iron and manganese could be treated at little additional chemical cost, although some modification to process equipment might be required. However, because treatment plants presently do not routinely treat for soluble iron and manganese, initiating treatment for them would require process changes and increased operator attention. These changes might be more significant than the additional chemical costs would suggest. Implementing an alternative that would require a treatment plant to change from no treatment for soluble iron and manganese to treatment for these constituents could adversely affect some treatment plants.

Evaluation of tributary and mainstem reservoirs suggested that iron and manganese concentration differences between alternatives should be several times less on the mainstem than on the tributaries. The occurrence of low DO water in mainstem reservoirs also was cyclic over the summer, increasing in volume and then decreasing in volume only to increase again. It was also observed that the location of the water with DO below 1 mg/L typically occurred in the last few miles of the reservoir, in the forebay next to the dam. By contrast, the water with DO below 1 mg/L on tributary projects existed for most of the length of the reservoir. This also suggests that unless an intake was located in the forebay of a mainstem reservoir, water that could contain elevated iron and manganese concentrations could be avoided.

5.5.3 Base Case

Under the Base Case, the reservoirs would be operated to provide for the 2030 water demand and maintain minimum flows below reservoirs. In other words, no limitation is placed on water demand. However, there are existing intakes and there could be new intakes in tailwaters where minimum flows are provided. Because expansion of the withdrawal of the existing intakes or the additional withdrawal of the new intakes could affect the minimum flow, a case-by-case environmental analysis would be required for new intakes or expansion of existing ones. The water for future demand is available under the Base Case, but where it would be extracted from the system is an issue to be addressed on a case-by-case basis.

Elevations in reservoirs and tailwaters under the Base Case would be within the published minimum elevations for reservoirs and would not affect intake structures; pumping costs would not increase. Under the Base Case, water quality and related treatment requirements would not change.

5.5.4 All Action Alternatives

Under each action alternative, the reservoirs would also be operated to provide for the 2030 water demand and maintain minimum flows below reservoirs. As in the case of the Base Case, each action alternative places no limitation on water demand. However, where water can be extracted without substantially affecting minimum flows would remain an issue to be addressed for each alternative. Therefore, the water supply availability and the minimum flow issues would not be any different for any action alternative than they would be for the Base Case. Therefore, no specific analysis of these issues was performed, and they were not included in the following table. Table 5.5-05 shows the potential effects of the action alternatives on water supply delivery (cost) and water supply quality (treatment).

Table 5.5-05 Impacts on Water Supply by Action Alternative

Alternative	Water Supply Delivery (Cost)	Water Supply Quality (Treatment)
Reservoir Recreation A	Elevation changes under Reservoir Recreation Alternative A would not affect intake structures or require modifications to structures. Elevation changes would require less energy (1.4 million kWh/yr less) for pumping than under the Base Case.	Algae concentrations on some reservoirs could be higher than under the Base Case. Iron and manganese formations would be higher than under the Base Case.
Reservoir Recreation B	Reservoir Recreation Alternative B would not require modifications to intake structures and would require less energy for pumping (2.0 million kWh/yr less) than under the Base Case.	Algae concentration on some reservoirs under Reservoir Recreation Alternative B could be higher than under the Base Case. Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative have the highest potential for soluble iron and manganese formation.
Summer Hydropower	Elevation changes under the Summer Hydropower Alternative would result in seven reservoirs requiring modifications of their intake structures to ensure reliable supply. The cost of these modifications is estimated at $12.5 million dollars, the greatest increase in impact above the Base Case for all eight alternatives. The Summer Hydropower Alternative also has the greatest increase in energy demand for pumping (requiring 0.9 million kWh/year more) than under the Base Case.	Water quality modeling was not completed for the Summer Hydropower Alternative due to too little water in some reservoirs under dry conditions. In years for which simulations results were available, the potential for iron and manganese ranged from lowest to highest—depending on year and reservoir.
Equalized Summer/ Winter Flood Risk	Elevation changes under the Equalized Summer/Winter Flood Risk Alternative will not affect intake structures and will have lower pumping requirements (0.3 million kWh/yr) than under the Base Case.	Algae concentration on some reservoirs under the Equalized Summer/Winter Flood Risk Alternative could be higher than under the Base Case. The Equalized Summer/Winter Flood Risk Alternative has a higher potential for soluble iron and manganese formation than the Base Case and the Commercial Navigation Alternative.
Commercial Navigation	Elevations under the Commercial Navigation Alternative would require modifications to intake structures at seven reservoirs. Costs for these modifications are estimated at $3.4 million. This alternative would require less energy (0.8 million kWh/yr) for pumping than under the Base Case.	Algae concentration across the system under the Commercial Navigation Alternative would be the about the same as under the Base Case. The Commercial Navigation Alternative is similar to the Base Case in terms of potential for iron and manganese formations. The Commercial Navigation Alternative would not increase treatment costs above those for the Base Case.

Table 5.5-05 Impacts on Water Supply by Action Alternative (continued)

Alternative	Water Supply Delivery (Cost)	Water Supply Quality (Treatment)
Tailwater Recreation	Elevations under the Tailwater Recreation Alternative would require very minor modifications at three reservoirs to allow for limited temporary pumping. Estimated costs are $22,500. The Tailwater Recreation Alternative is equivalent to the Summer Hydropower Alternative, requiring less energy (2.0 million kWh/yr) for pumping than under the Base Case	Algae concentrations on some reservoirs under the Tailwater Recreation Alternative could be higher than under the Base Case. The Tailwater Recreation Alternative is similar to Reservoir Recreation Alternative B in terms of the potential for soluble iron and manganese formation.
Tailwater Habitat	Elevations under the Tailwater Habitat Alternative would require minimal temporary modifications to intake structures at two reservoirs, with an estimated cost of $21,000. Energy requirements are less (1.6 million kWh/yr) than under the Base Case.	Algae concentrations on some reservoirs under the Tailwater Habitat Alternative could be higher than under the Base Case. The Tailwater Habitat Alternative has the highest potential for soluble iron and manganese formation.
Preferred	Elevations under the Preferred Alternative would require minimal temporary modifications to intake structures on one reservoir, with an estimated cost of $26,000. Energy requirements are less (0.7 million kWh/yr) than under the Base Case.	Algae concentrations on some reservoirs under the Preferred Alternative could be higher than under the Base Case. The Preferred Alternative has slightly higher potential for soluble iron and manganese formation than the Base Case and the Commercial Navigation Alternative but less potential than Reservoir Recreation Alternative A.

Note: Water supply availability would not be affected under any action alternative and therefore was not included in the table.

5.5.5 Summary of Impacts

A summary of the alternative analysis is presented in Table 5.5-06. The alternatives were ranked from 1 to 8, with ties using the average rank. A "1" ranking is best, and an "8" ranking is worst. Algae concentrations showed little differences between alternatives. Chlorophyll-a concentrations and retention times suggested that the Base Case and the Commercial Navigation Alternative would have the lowest algae concentrations. The Base Case and the Commercial Navigation Alternative were also ranked best (lowest) in regard to iron and manganese formation. The rankings in Table 5.5-06 were based on the potential for soluble iron and manganese formation since the algae analysis did not help to distinguish between alternatives. The table also shows the sum of the intake modification costs and the present value of the difference in pumping costs, assuming a 30-year time horizon, 6-percent interest rate, and cost of power of $0.051/KWh. Because the Base Case and all the action alternatives are equal in terms of meeting the future water demand (water supply demand), this criterion was not summarized in Table 5.5-06.

Table 5.5-06 Summary of Impacts on Water Supply by Policy Alternative

Alternative	Water Supply Quality[1]	Water Supply Delivery
Base Case	No change 1.5	No change $0
Reservoir Recreation A	Slightly adverse 4.5	Slightly beneficial -$1 million
Reservoir Recreation B	Adverse 7	Slightly beneficial -$1.4 million
Summer Hydropower[2]	No change to adverse	Substantially adverse $13.1 million
Equalized Summer/Winter Flood Risk	Slightly adverse 4.5	Slightly beneficial -$0.2 million
Commercial Navigation	No change 1.5	Adverse $2.8 million
Tailwater Recreation	Adverse 7	Slightly beneficial -$1.4 million
Tailwater Habitat	Adverse 7	Slightly beneficial -$1.1 million
Preferred	No change to slightly adverse 3	Slightly beneficial -$0.5 million

1 Ranked on a scale of 1 to 8, where 1 is best and 8 is worst, with ties using the average rank of alternatives that tie. Three alternatives tied for 6th, 7th, and 8th place; therefore, each was assigned the average value of 7.

2 Water quality modeling could not be completed for the Summer Hydropower Alternative because of too little water in some reservoirs under dry conditions. In years for which simulations results were available, the potential for iron and manganese ranged from No Change to Adverse, depending on year and reservoir.

5.6 Groundwater Resources

5.6.1 Introduction

This section assesses the potential effects of future reservoir operations on groundwater resources in the Tennessee River watershed.

5.6.2 Impact Assessment Methods

Assessment of the surface water and groundwater interactions involved two phases: (1) an initial screening-level analysis to determine the zone of surface water influence on groundwater resources, and (2) a reservoir-specific analysis to determine potential effects on specific public groundwater wells situated within the zone of surface water influence identified in the screening-level analysis.

Screening-Level Analysis

A screening-level analysis was performed to determine the zone of surface water influence on groundwater resources adjacent to each TVA reservoir and tailwater. The calculation used an analytical model to represent the natural condition and assumed a sudden change in reservoir elevation that propagates through groundwater. (See Appendix D2 for additional information about the assessment of surface water and groundwater interactions.)

The furthest distance from the reservoirs where a change in reservoir elevation could be discerned in the groundwater zone was calculated. For this analysis, "no effect" represents a change in groundwater elevation less than or equal to 0.1 foot that was caused by a change in reservoir elevation. The screening-level analysis used January 1 (minimum pool) and June 1 (maximum pool) elevations and a duration of 150 days as inputs to the calculation. This range in elevation provided an upper bound for changes in groundwater levels. None of the reservoir operations policy alternatives would produce a greater change in groundwater levels than those predicted by the screening-level analysis.

Within the boundary of the screening-level analysis, the potentially affected groundwater resources were identified from the U.S. Geological Survey (USGS) database of public, commercial, agricultural, and industrial groundwater wells within the Tennessee River Valley region (Hutson et al. 2003, Bohac 2003). Any reservoir with potentially affected wells was further analyzed as described in the following sections.

In addition to the groundwater wells identified in Hutson et al. (2003) and Bohac (2003), there could be other private wells not included in these inventories that are close to Tennessee Valley reservoirs and tailwaters and could potentially be affected by changes in reservoir operations. The results of the analysis for public groundwater wells are expected to be generally representative of the effects to these private wells.

Table 5.6-01 Public Groundwater Wells within Zones of Influence of TVA Reservoirs

TVA Reservoir	Calculated Zone of Influence (feet)	Public Wells within Zone of Influence of Reservoir
Apalachia	1,050	0
Bear Creek	2,200	0
Blue Ridge	1,150	0
Boone	1,300	0
Cedar Creek	1,850	0
Chatuge	1,150	0
Cherokee	1,350	3
Chickamauga	1,140	0
Douglas	1,400	2
Fontana	1,325	0
Fort Loudoun	1,075	2
Fort Patrick Henry	1,050	0
Great Falls	1,870	0
Guntersville	1,600	0
Hiwassee	1,325	0
Kentucky	1,600	1
Little Bear Creek	1,820	0
Melton Hill	1,100	0
Nickajack	1,820	0
Normandy	1,800	0
Norris	1,350	1
Nottely	1,250	0
Ocoee #1	1,050	0
Ocoee #2	0	0
Ocoee #3	1,040	1
Pickwick	2,050	0
South Holston	1,330	0
Tellico	1,100	0
Tims Ford	1,875	1
Upper Bear Creek	2,090	0
Watauga	1,150	0
Watts Bar	1,100	2
Wheeler	1,650	0
Wilbur	1,150	0
Wilson	1,125	0

Note: The "zone of influence" is the zone of surface water influence on groundwater resources. No influence (0) is defined as changes in groundwater levels of less than 0.1 foot.

Table 5.6-01 gives the zone of groundwater influence for each TVA reservoir and the number of public wells located within this zone. For the following reservoirs, at least one public water supply well was located within the calculated zone of influence and was identified for further analysis: Cherokee, Douglas, Fort Loudoun, Kentucky, Norris, Ocoee #3, Tims Ford, and Watts Bar. Results were also used to identify wetlands potentially affected by reservoir and tailwater water level changes associated with the policy alternatives (see Section 5.8, Wetlands).

Reservoir-Specific Analysis

Reservoirs containing public wells within the zone of surface water influence on groundwater were further analyzed with respect to the reservoir operations policy alternatives. For each of the reservoir areas chosen for further analysis, the closest public well to the reservoir was designated as the most sensitive groundwater resource. The distances from these wells to the reservoirs were determined. In addition, median monthly changes in reservoir water levels were determined for all the alternatives. For all alternatives, the potential monthly change in groundwater levels at the wells closest to the reservoirs was calculated.

Any increase in groundwater levels resulting from a change in reservoir operations was considered a beneficial effect on groundwater resources. A decrease in groundwater levels of more than 3 feet resulting from a change in reservoir operations was considered an adverse effect on groundwater resources if the change occurred at or near reservoir minimum pool. This 3-foot threshold was based on the typical seasonal and annual changes in groundwater elevations attributable to non-reservoir influences and variation in groundwater use patterns.

5.6.3 Base Case

The Base Case would continue existing conditions to the year 2030. Since this alternative does not include a physical change and groundwater usage was assumed to remain fairly constant, there would be no adverse consequence to groundwater resources.

5.6.4 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Tailwater Recreation Alternative, and Tailwater Habitat Alternative—Reservoirs

Reservoir-specific analyses indicated that Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would most likely produce increases in water levels at public wells close to the reservoirs. The greatest increases would be at Cherokee, Douglas, and Norris Reservoirs under all four of these alternatives. The least amount of change would most likely occur at Watts Bar, Fort Loudoun, and Kentucky Reservoirs under all of these alternatives. As groundwater levels under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would increase, impacts on groundwater resources associated with these alternatives would be slightly beneficial.

5.6.5 Summer Hydropower Alternative, Equalized Summer/Winter Flood Risk Alternative, and Commercial Navigation Alternative—Reservoirs

Reservoir operations under the Summer Hydropower Alternative, Equalized Summer/Winter Flood Risk Alternative, and Commercial Navigation Alternative potentially could decrease groundwater levels from existing conditions near some reservoirs. For these alternatives, the greatest calculated decreases in groundwater levels at nearby public wells would be at Tims Ford under the Equalized Summer/Winter Flood Risk Alternative (7 feet) and at Fort Loudoun Reservoir under the Summer Hydropower Alternative (3 feet) and the Equalized Summer/Winter Flood Risk Alternative (2 feet). The predicted decreases at Fort Loudoun are under the 3-foot threshold and would have slightly adverse effects on groundwater resources. Further analysis of Tims Ford shows groundwater levels surrounding the reservoir to be higher than any potential water levels in the reservoir. The decreases in groundwater levels calculated for Tims Ford Reservoir are, therefore, highly unlikely to occur.

5.6.6 Preferred Alternative

The monthly difference from existing conditions in groundwater levels at the wells closest to those reservoirs identified in the screening-level analysis for further evaluation was calculated for the Preferred Alternative. According to the calculations, the Preferred Alternative would most likely produce an increase or no change in groundwater levels and water levels at public wells close to the reservoirs. The greatest increases would be at Cherokee, Douglas, and Norris Reservoirs. Consequently, impacts on groundwater resources associated with the Preferred Alternative would be slightly beneficial. The increases are slightly less than those for Reservoir Recreation Alternatives A and B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative.

5.6.7 All Policy Alternatives—Tailwaters

Rivers have a much narrower zone of influence on groundwater because of the substantial difference in the volume of water in any given river reach compared to that in a reservoir (Freeze and Cherry 1979). The preceding analysis concluded that effects on groundwater resources near all reservoirs would be slightly adverse to slightly beneficial. Furthermore, all the policy alternatives would maintain minimum levels of water in tailwaters for navigation and other beneficial uses. Therefore, tailwater impacts on groundwater resources would essentially not change under any policy alternative.

5.6.8 Summary of Impacts

Table 5.6-02 provides a summary of impacts on groundwater resources by policy alternative. The Preferred Alternative, Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would result in either a slightly beneficial or slightly adverse effect on public groundwater resources near TVA reservoirs, depending on the reservoir. The Summer Hydropower Alternative and Equalized Summer/Winter Flood Risk Alternative could potentially cause water levels at public wells close to Tims Ford and Fort Loudoun Reservoirs to decrease, although not substantially. Private or domestic wells not identified in Hutson et al. (2003) and Bohac (2003) that are within the zone of influence could also be adversely affected by changes in reservoir operations under all the policy alternatives. Essentially no change would occur on groundwater resources near tailwaters under any policy alternative.

Table 5.6-02 Summary of Impacts on Groundwater Resources by Policy Alternative

Alternative	All Reservoirs[1]	All Tailwaters
Reservoir Recreation A	Slightly beneficial	No change
Reservoir Recreation B	Slightly beneficial	No change
Summer Hydropower	Slightly adverse	No change
Equalized Summer/Winter Flood Risk	Slightly adverse	No change
Commercial Navigation	Slightly adverse	No change
Tailwater Recreation	Slightly beneficial	No change
Tailwater Habitat	Slightly beneficial	No change
Preferred	Slightly beneficial	No change

[1] Reservoirs that would be affected by alternatives would include Cherokee, Douglas, Fort Loudoun, Kentucky, Norris, Tims Ford, and Watts Bar. All other reservoirs would not be affected by the alternatives.

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5.7 Aquatic Resources

5.7.1 Introduction

The three main areas of concern for aquatic resources with regard to the ROS were biodiversity, sport fisheries, and commercial fisheries. The technical ability to accurately model direct impacts of environmental change on aquatic communities (e.g., numbers of species and numbers of individuals in a population) presently is limited and therefore impractical to apply across the TVA system. Instead, environmental conditions (e.g., DO, water temperature, and flow) that potentially affected aquatic communities under the various policy alternatives were modeled and used as surrogates of population and community responses. Responses of aquatic resources were discussed at a programmatic level, and anticipated change was indicated by the direction (e.g., beneficial or adverse) and magnitude (e.g., slight or substantial) of any change.

To provide a baseline for evaluation, aquatic resources responses to the policy alternatives were evaluated against the Base Case. The Base Case is described in Chapter 3, and its relationship to present operations related to aquatic resources is explained in Section 5.4, Water Quality. The estimated value of each surrogate environmental metric under the Base Case represents existing conditions that are expected to persist if no change is made to the reservoir operations policy.

Evaluation of aquatic resource issues was performed relative to waterbody type as described in this section. Surrogate measure results are presented by reservoir or tailwater. Biodiversity evaluations were made for individual reservoirs and warm-water tailwaters for fish and invertebrate communities. Biodiversity of cold-water tailwaters was not addressed because cold-water releases yield resident communities with little diversity; therefore, no alternative would change this general condition. Sport fish population conditions were assessed at reservoirs, including fish spawning conditions, and tributary tailwaters—cold-, cool-, and warm-water. Evaluation of commercial fisheries—both mussels and fishes—was conducted using metrics for mainstem reservoirs only, where most commercial activities occur.

5.7.2 Impact Assessment Methods

Based on scientifically established relationships of environmental variation and change in aquatic resources, surrogate metrics were identified to evaluate the potential change to aquatic resources under the policy alternatives (Table 5.7-01). Projected impacts on fish spawning conditions also were evaluated. Results of the evaluations of alternatives under other resource areas also were considered, including water quality analysis (see Section 5.4, Water Quality), aquatic plants (see Section 5.9, Aquatic Plants), and sediment and erosion (see Section 5.16, Shoreline Erosion).

Table 5.7-01 Environmental Factors Used to Evaluate Potential Changes among Species or Communities by Policy Alternative

Resource Issue	Category	Type	Condition Indicator	Representative or Modeled Years
General biodiversity	Reservoir	Mainstem	Dissolved oxygen (DO) water quality metrics (see Section 5.4, Water Quality)	
			Mean maximum percent of non-acceptable habitat (as percent of total daily reservoir volume)	1990,1993,1994
			Mean number of days of water volume with DO less than 1 mg/L	1990,1993,1994
		Tributary	DO water quality metrics (see Section 5.4, Water Quality)	
			Mean yearly volume of water with ammonia > 2 mg/L	1990,1993,1994
			Mean maximum percent of non-acceptable habitat (as percent of total daily reservoir volume)	1990,1993,1994
			Mean number of days of water volume with DO less than 1 mg/L	1990,1993,1994
	Tailwater	Warm-water fisheries	Mean summer (May to October) flow, DO, and temperature	1987–1994
			Mean daily range of summer (May to October) flow, DO, and temperature	1987–1994
			Mean August/September flow, DO, and temperature	1987–1994
			Mean daily range of August/September flow, DO, and temperature	1987–1994
			Hours of water temperature less than 16 °C and 20 °C	1987–1994
			Tailwater water quality indicators (see Section 5.4, Water Quality)	
		Cool-water fisheries	See general biodiversity, warm-water tailwater indicators (above)	
		Cold-water fisheries	See general biodiversity, warm-water flow, DO, and temperature metrics (above)	

Table 5.7-01 **Environmental Factors Used to Evaluate Potential Changes among Species or Communities by Policy Alternative (continued)**

Resource Issue	Category	Type	Condition Indicator	Representative or Modeled Years
Sport fisheries	Reservoir	Mainstem	Median number of weeks at summer pool elevation	1903–2001
			Median pool elevation in winter (week 2, January)	1903–2001
			Median first week stabilized at summer pool elevation	1903–2001
			See general biodiversity mainstem indicators (above)	
		Tributary	Median number of weeks at summer pool elevation	1903–2001
			Median pool elevation in winter (week 2, January)	1903–2001
			Median first week stabilized at summer pool elevation	1903–2001
			Mean volume of acceptable cool-water habitat (temperature < 24 °C and DO >3 mg/L)	1990,1993,1994
			Mean volume of suitable cool-water habitat (temperature < 24 °C and DO > 5 mg/L)	1990,1993,1994
			Mean volume of acceptable cool-water habitat (temperature < 20 °C and DO > 3 mg/L)	1990,1993,1994
			Mean volume of suitable cool-water habitat (temperature < 20 °C and DO > 5 mg/L)	1990,1993,1994
			See general biodiversity reservoir tributary indicators (above)	
	Tailwater	Warm-water fisheries	Hours of water temperature less than 16 °C	1987–1994
			See general biodiversity metrics, warm-water tailwater indicators (above)	
		Cool-water fisheries	See general biodiversity, warm-water tailwater indicators (above)	
		Cold-water fisheries	Hours of water temperature more than 20 °C	1987–1994
			See general biodiversity, cold-water tailwater indicators (above)	
			Tailwater water quality indicators (see Section 5.4, Water Quality)	
		Mainstem	Change in median discharge in spring (Week 13, April)	1987–1994
			Hours of no discharge from March through May	1987–1994
Commercial fisheries	Reservoir	Mainstem	See general biodiversity mainstem indicators (above)	

Reservoir Metrics

Increasing DO concentrations generally benefits aquatic life. Although very high levels of dissolved gases in water—a condition known as supersaturation—causes harm to aquatic animals, it has not been an issue for TVA reservoirs and only rarely has been an issue in tailwaters (downstream of the Kentucky Dam). Low DO concentrations not only are stressful to aquatic life; they can increase the potential for release of toxic substances (e.g., heavy metals, hydrogen sulfide, and ammonia) in the water (see Section 5.4, Water Quality). These impacts occur in reservoirs, which then can be transferred to tailwaters through discharge. Therefore, in addition to direct impacts of predicted low concentrations of DO, these estimates can be used as a surrogate measure of indirect impacts resulting from formation of toxic substances.

To evaluate changes to environmental conditions in reservoirs under the policy alternatives, the following DO and temperature metrics were used:

- Water quality metrics from Section 5.4, Water Quality:
  - Amount of water with DO < 1 milligrams per liter (mg/L)
  - Amount of water with DO < 2 mg/L
  - Amount of water with DO < 5 mg/L

Results for these metrics are presented in Section 5.4, Water Quality (Table 5.4-2). Estimates of DO < 1 mg/L were used to evaluate alternatives for the potential formation of toxic substances such as ammonia and presence of fatal concentrations of low DO. The DO < 2 mg/L metric served as an index of amount of stressful habitat, only habitable for short periods (hours or days). The final measure, DO < 5 mg/L, represented a DO concentration indicative of conditions not suitable for long-term survival and life function such as growth and feeding. Increased volumes of low DO water indicated decreasing habitat condition and increased potential of adverse impacts on aquatic biodiversity. With DO metrics, conditions representative of healthy biodiversity were also representative of conditions good for sport fish populations and commercial fisheries.

Changes in water temperature were also evaluated, especially with respect to sport fishes. Water temperature requirements for resident cold-water, cool-water, and warm-water sport fish were used to derive water temperature metrics. For cool- and cold-water species, higher temperatures decrease their potential growth or survival. For warm-water species, lower water temperatures decrease their potential growth, which indirectly lowers survival and, if temperature becomes extremely low, it may also cause direct stress or mortality. Cold-water species prefer maximum summer temperatures less than 20 °C. Cool-water species prefer temperatures less than 24 °C, and temperatures less than 16 °C during the summer/fall growth period can decrease the potential productivity of warm-water communities. Most policy alternatives would influence the volume of water in tributary reservoirs that is of a suitable temperature for cold-water and cool-water fishes with an adequate concentration of DO. Because water temperature strongly influences DO and many sport fishes have combined water temperature and DO preferences that reflect this relationship, habitat conditions for tributary sport fishes were evaluated with metrics combining temperature and DO preferences.

Metrics used to evaluate environmental changes on fishes in tributary reservoirs were estimated using the water quality model (Table 5.7-01):

- Cold-water habitat

  Critical

  Mean volume-days (million m^3) with water temperature less than 20 °C and DO > 3 mg/L for a dry, wet, and normal year.

  Preferable

  Mean volume-days (million m^3) with water temperature less than 20 °C and DO > 5 mg/L for a dry, wet, and normal year.

- Cool-water habitat

  Critical

  Mean volume-days (million m^3) with water temperature less than 24 °C and DO > 3 mg/L for a dry, wet, and normal year.

  Preferable

  Mean volume-days (million m^3) with water temperature less than 24 °C and DO > 5 mg/L for a dry, wet, and normal year.

While other fishes are more tolerant of warmer water, metrics for cool-water habitat were used to serve as general indices to changes in the environment for warm-water fishes.

The hydrodynamics of reservoirs are also important to biodiversity of communities, sport fishes, and commercial fishes. Certain aspects of reservoir hydrodynamics affect water quality, as described in detail in Sections 4.4 and 5.4, Water Quality. Reservoir hydrodynamic metrics specifically used in this section included the first week of attainment of summer pool levels, elevation of winter pool levels, and the number of weeks at full pool levels. Specific to tributary reservoirs, the date of attainment of summer pool levels relates to spawning success of sport fishes. When summer pool levels have been attained earlier in the year, spring flow (and dam discharge) has been higher. Reaching summer pool levels earlier allows important shoreline areas to be flooded, providing good spawning and important nursery habitat. Due to flood risk issues, early attainment of summer pool levels is not possible; therefore, use of the median first week at summer pool is not applicable. However, as noted in Section 4.7, it is also important that tributary reservoir water levels be stabilized as much as possible during the spawning period. These stabilizations would continue under each alternative, but the stabilization would be initiated at 60 °F instead of 65 °F.

In addition, early attainment of full pool increases recolonization of formerly dewatered habitat by aquatic insect communities (fish prey). Because there is a much smaller difference between summer and winter pool levels in mainstem reservoirs (Ploskey et al. 1984), the benefit to fishes in mainstem reservoirs is considerably less and has not been included in this analysis. Attaining summer pool levels earlier in tributary reservoirs, especially in conjunction with extending the drawdown dates, increases the duration of quality habitat for young fishes, hence increasing the growing season. Irwin et al. (1997) found that increased growth of young-of-year largemouth bass *(Micropterus salmoides)* led to increased winter survival of juveniles, which ultimately improved largemouth bass catch by anglers in later years. One concern of annual extended pool levels relates to existing available habitat. The existing available habitat would decrease with years of extended pool levels as exposed reservoir bottom areas would not be dewatered for sufficient time under adequate growing conditions to redevelop the desirable vegetative growth that provides the nutrient boost and good spawning and nursery habitat.

The final measure of reservoir hydrodynamics used as a metric for aquatic communities was winter pool elevations. Raising winter pool levels reduces the area dewatered annually to increase flood storage capacity in winter, thereby increasing the amount of area inundated year-round. This would benefit both fishes and macroinvertebrate communities in tributary reservoirs, but in mainstem reservoirs the effect would be minimal. During dry years, maintaining higher winter pool levels would also increase late winter and early spring discharges (February through March 15) because less inflow would be needed to fill reservoirs to summer pool levels. Increasing discharges during this period also would benefit tailwaters by resembling pre-dam conditions of higher late winter and early spring flows, which would benefit migratory spawning fish such as sauger *(Stizostedian canadense)*, white bass *(Morone chrysops)*, paddlefish *(Polyodon spathula)*, and most suckers.

Tailwater Metrics

To evaluate aquatic resources in tailwaters, the following environmental metrics were estimated using the TVA water quality model (Table 5.7-01):

- Mean flow (cubic feet per second [cfs]) in summer (May through October);
- Mean flow (cfs) during August and September combined;
- Mean DO (mg/L) in summer (May through October);
- Mean DO (mg/L) during August and September combined;
- Mean water temperature (°C) in summer (May through October);
- Mean water temperature (°C) during August and September combined; and,
- The mean daily maximum change of all metrics listed above.

For cold-water tailwaters:

- Hours of water temperature greater than 20 °C from May to October.

For cool-water/warm-water tailwaters:

- Hours of water temperature less than 16 °C from May to October.

For tailwaters, changes to water temperature, DO, and habitat were of primary interest for evaluating proposed operations. Flow is a controlling factor of river habitat. Because flow was more easily modeled than habitat condition, it was used as a surrogate to describe changes. For all metrics, both the mean level and the range of variation were important. Hydropower operations may cause large hourly fluctuations in all three metrics, which can disrupt important behaviors such as feeding or spawning activity and cause harmful stress on organisms.

Conditions of flow, water temperature, and DO concentrations are particularly important in flowing sections during spring, summer, and autumn. Spring and summer are important because this is when most reproduction of aquatic organisms occurs—especially spring. In early spring, some fishes migrate to spawning locations, with flow and temperature being important triggers. Appropriate flow levels during spring also help transport mussel larvae, maintain buoyant fish eggs in the water column, and keep fish nests free of suffocating fine sediments. Very low flows may limit available spawning habitat for species that require naturally clean-swept substrate for successful spawning, and very high flows may limit spawning—and even destroy eggs/larvae and nests of nest-building species. In late summer, a natural period of typically low flow, habitat and water quality become critical for aquatic organisms. Low flows limit habitat diversity, which limits the number of organisms (e.g., fishes and mussels). Low flows also result in higher water temperatures and lower DO concentrations. Therefore, higher mean flow is considered to increase available habitat. Generally, a decrease in daily flow fluctuations (less extreme variation) increases the health of aquatic communities, especially those that require stable or static conditions. The number of hours of no flow from March through May for mainstem dams was evaluated as a surrogate metric for spawning success of migratory sport and commercial fishes, such as walleye *(Stizostedion vitreum)*, sauger, paddlefish, and suckers in mainstem flowing areas.

Although late summer water quality is a critical issue, conflicts exist between requirements for cold-water and warm-water communities. Temperature changes that would benefit cold-water communities decrease potential of warm-water communities, and vice versa. Cold-water river communities primarily support trout fisheries and exhibit low biodiversity, while cool-water/warm-water rivers support more types of sport fish and show higher overall biodiversity. Cool-water communities respond to temperature changes in a mixed manner because the community contains some species that prefer colder water and others that prefer warmer water. Minor water temperature changes would simply shrink locations for one group and expand those of the other group (less cold-water habitat if water temperatures rise and less warm-water habitat if water temperatures decrease). Because cool-water communities are in the middle, the length of river classified as cool-water would not change unless temperature changes are substantial.

Basic changes in DO concentrations are evaluated in Section 5.4, Water Quality. More detailed metrics describing water quality changes specific to aquatic resources are listed in Table 5.7-01, and changes in their status under the policy alternatives are summarized in Tables 5.7-02 through 5.7-09. Dissolved oxygen in tributary and upper mainstem dam releases would be mitigated to Lake Improvement Plan targets through the RRI Program; therefore, no changes in minimum tailwater DO conditions were anticipated or addressed in these areas.

Representative Waterbodies

Representative waterbodies were selected to typify the affected environment and assess the policy alternatives for key issues. Waterbodies were selected based on several factors, including their importance to resource areas, potential for environmental change in the waterbody, available information, and location within the TVA system. Links among EIS components were integrated when possible.

Representative waterbodies were selected as follows:

Mainstem reservoirs	Kentucky, Guntersville, and Pickwick Reservoirs
Tributary reservoirs	Tims Ford, Douglas, Norris, Nottely, Hiwassee, South Holston, Watauga, Boone, and Melton Hill Reservoirs
Cool/cold tailwaters	South Fork Holston River (one location)
Cool-to-warm tailwaters	Elk River (one location), Holston River (one location)
Warm tailwaters	French Broad River (one location), Elk River (one location), Holston River (one location)

Water Quality Models

Metrics were estimated using one of two TVA models. The TVA Water Quality Model and the reservoir hydrodynamic, or Weekly Scheduling Model, are described in Appendix C. Metric values could not be calculated for the Summer Hydropower Alternative because drier years could not be successfully calibrated and run with the Water Quality Model. Water quality reservoir metrics for this section were evaluated using years classified according to annual rainfall amounts by TVA as normal (1990), dry (1993), and wet (1994). Metrics were averaged across these representative years. Reservoir hydrodynamic metrics were calculated as the statistic (e.g., mean) condition for a given week using a policy alternative simulated for years 1903 to 2001. For tailwaters, metrics for DO, water temperature, and flow were modeled on an hourly time step for the period from 1987 to 1994.

Change in each metric was evaluated against the Base Case. Metrics were classified by the percent of change and direction of change as follows:

- ↑** ↓** +/- greater or equal to 51 percent
- ↑* ↓* +/- 26.0-50.9 percent
- ↑ ↓ +/- 11.0-25.9 percent
- o +/- 0.0-10.9 percent
- ↑∞ ↓∞ Values for metrics were very small, causing artificially large change, or the baseline value was zero; arrows then indicate direction of change only.

Table 5.7-02 Comparison of Reservoir Dissolved Oxygen Metrics by Policy Alternative

Alternative	Reservoir	Mean Number of Days with Water Volume Having Dissolved Oxygen Less Than 1 mg/L	Peak Daily Volume of Non-Acceptable Habitat as Percent of Total Daily Volume
Reservoir Recreation A	Boone	↑∞	↑*
	Douglas	o	o
	Guntersville	↑	↑*
	Kentucky	↓*	↑**
	Pickwick	o	o
	South Holston	o	o
	Tims Ford	o	o
Reservoir Recreation B	Boone	↑∞	↑*
	Douglas	o	o
	Guntersville	↑**	↑*
	Kentucky	↓**	↑**
	Pickwick	o	o
	South Holston	o	o
	Tims Ford	o	o

Table 5.7-02 Comparison of Reservoir Dissolved Oxygen Metrics by Policy Alternative (continued)

Alternative	Reservoir	Mean Number of Days with Water Volume Having Dissolved Oxygen Less Than 1 mg/L	Peak Daily Volume of Non-Acceptable Habitat as Percent of Total Daily Volume
Equalized Summer/Winter Flood Risk	Boone	↑∞	o
	Douglas	o	o
	Guntersville	↑*	↑*
	Kentucky	↓**	↑**
	Pickwick	o	↑
	South Holston	↓	o
	Tims Ford	o	o
Commercial Navigation	Boone	↑∞	o
	Douglas	o	o
	Guntersville	o	o
	Kentucky	↓**	↑**
	Pickwick	o	o
	South Holston	o	o
	Tims Ford	o	o
Tailwater Recreation	Boone	↑∞	↑*
	Douglas	o	o
	Guntersville	↑*	↑*
	Kentucky	↓**	↑**
	Pickwick	o	o
	South Holston	o	o
	Tims Ford	o	o
Tailwater Habitat	Boone	↑∞	↑*
	Douglas	o	o
	Guntersville	↑**	o
	Kentucky	↓*	↑**
	Pickwick	o	↑
	South Holston	↑	o
	Tims Ford	o	o

Table 5.7-02 Comparison of Reservoir Dissolved Oxygen Metrics by Policy Alternative (continued)

Alternative	Reservoir	Mean Number of Days with Water Volume Having Dissolved Oxygen Less Than 1 mg/L	Peak Daily Volume of Non-Acceptable Habitat as Percent of Total Daily Volume
Preferred	Boone	↑∞	o
	Douglas	o	o
	Guntersville	↓*	o
	Kentucky	o	o
	Pickwick	↑	o
	South Holston	o	o
	Tims Ford	o	o

Note: See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-03 Comparison of Reservoir Hydrology Metrics

Alternative	Reservoir	Median Elevation for Week 2 (January)	Median First Week of Year at Summer Pool	Weeks at Summer Pool
Reservoir Recreation A	Douglas	↑∞	o	↑∞
	Guntersville	o	o	↑∞
	Kentucky	↑∞	o	↑∞
	Norris	↑∞	↓∞	↑∞
	Pickwick	↑∞	o	↑∞
	South Holston	↑∞	↓∞	o
	Tims Ford	↑∞	o	o
Reservoir Recreation B	Douglas	↑∞	o	↑∞
	Guntersville	o	o	↑∞
	Kentucky	↑∞	o	↑∞
	Norris	↑∞	↓∞	↑∞
	Pickwick	↑∞	o	↑∞
	South Holston	↑∞	↓∞	↑∞
	Tims Ford	↓∞	o	↑∞
Equalized Summer/Winter Flood Risk	Douglas	↑∞	↑∞	o
	Guntersville	o	o	↑∞
	Kentucky	↑∞	↑∞	↑∞
	Norris	↑∞	↑∞	↑∞
	Pickwick	↑∞	↑∞	↑∞
	South Holston	↑∞	↑∞	o
	Tims Ford	↓∞	↑∞	o
Commercial Navigation	Douglas	↑∞	o	o
	Guntersville	o	o	o
	Kentucky	↑∞	o	o
	Norris	↑∞	o	o
	Pickwick	↑∞	o	o
	South Holston	↑∞	o	o
	Tims Ford	↓∞	o	o
Tailwater Recreation	Douglas	↑∞	↑∞	↑∞
	Guntersville	o	o	↑∞
	Kentucky	↑∞	o	↑∞
	Norris	↑∞	↑∞	↑∞
	Pickwick	↑∞	o	↑∞
	South Holston	↑∞	↓∞	↑∞
	Tims Ford	o	o	o

Table 5.7-03 Comparison of Reservoir Hydrology Metrics (continued)

Alternative	Reservoir	Median Elevation for Week 2 (January)	Median First Week of Year at Summer Pool	Weeks at Summer Pool
Tailwater Habitat	Douglas	↑∞	↓∞	↑∞
	Guntersville	o	o	↑∞
	Kentucky	↑∞	o	↑∞
	Norris	↑∞	↓∞	↑∞
	Pickwick	↑∞	o	↑∞
	South Holston	↑∞	↑∞	↑∞
	Tims Ford	↑∞	o	o
Preferred	Douglas	↑**	o	↑∞
	Guntersville	o	o	↑**
	Kentucky	o	o	↓
	Norris	↑**	↑∞	↑**
	Pickwick	o	o	↑**
	South Holston	↑*	↓∞	↑∞
	Tims Ford	o	o	o

Note: See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-04 Comparison of Summer Tailwater Metric Values for Tailwaters by Policy Alternative

Alternative	River Segment (Upstream Reservoir)	Mean Flow in Summer (cfs)	Mean Daily Range of Flow in Summer (cfs)	Mean Dissolved Oxygen in Summer (mg/L)	Mean Daily Range of Dissolved Oxygen in Summer (mg/L)	Mean Summer Temperature (°C)	Mean Daily Range of Summer Temperature (°C)
Reservoir Recreation A	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	o	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓	↓	o	↓	o	o
	Holston River Mile 48 (Cherokee)	↓	↓	o	o	↓	o
	South Fork Holston River Mile 43 (South Holston)	↓	o	o	o	o	o
Reservoir Recreation B	Elk River Mile 125 (Tims Ford)	o	↓	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	↓	↓	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓	↓*	o	↓	↓	o
	Holston River Mile 48 (Cherokee)	↓	↓	o	↑	↓	o
	South Fork Holston River Mile 43 (South Holston)	↓	o	o	o	o	o
Equalized Summer/ Winter Flood Risk	Elk River Mile 125 (Tims Ford)	↓	↓**	o	o	↑	↓*
	Elk River Mile 73 (Tims Ford)	↓	↓*	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	↓	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓	↓*	o	↓	o	o
	Holston River Mile 48 (Cherokee)	↓	↓	o	↑	o	o
	South Fork Holston River Mile 43 (South Holston)	o	o	o	o	o	o
Commercial Navigation	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	o	o	o	o	o
	Holston River Mile 30 (Cherokee)	o	o	o	o	o	o
	Holston River Mile 48 (Cherokee)	o	o	o	o	o	o
	South Fork Holston River Mile 43 (South Holston)	o	o	o	o	o	o

Table 5.7-04 Comparison of Summer Tailwater Metric Values for Tailwaters by Policy Alternative (continued)

Alternative	River Segment (Upstream Reservoir)	Mean Flow in Summer (cfs)	Mean Daily Range of Flow in Summer (cfs)	Mean Dissolved Oxygen in Summer (mg/L)	Mean Daily Range of Dissolved Oxygen in Summer (mg/L)	Mean Summer Temperature (°C)	Mean Daily Range of Summer Temperature (°C)
Tailwater Recreation	Elk River Mile 125 (Tims Ford)	o	↓	o	o	↓	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	↓	o
	French Broad River Mile 18 (Douglas)	↓	↓	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓	↓	o	↓	o	o
	Holston River Mile 48 (Cherokee)	↓	↓	o	↑	o	o
	South Fork Holston River Mile 43 (South Holston)	↓	↓	o	o	o	o
Tailwater Habitat	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	↓	↓**	o	↓*	o	o
	Holston River Mile 30 (Cherokee)	↓*	↓**	↑	↓**	↓	↓
	Holston River Mile 48 (Cherokee)	↓*	↓**	o	↓*	↓	↓*
	South Fork Holston River Mile 43 (South Holston)	↓	o	o	o	o	o
Preferred	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	o	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓	↓	o	o	o	o
	Holston River Mile 48 (Cherokee)	↓	↓	o	o	o	o
	South Fork Holston River Mile 43 (South Holston)	o	o	o	o	o	o

Notes: Values could not be calculated for the Summer Hydropower Alternative because severely dry years dried portions of the system, crashing the water quality model. See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-05 Comparison of August–September Tailwater Metric Values by Policy Alternative

Alternative	River Segment (Upstream Reservoir)	Mean Flow for August and September (cfs)	Mean Daily Range of Flow in August and September (cfs)	Mean Dissolved Oxygen in August and September (mg/L)	Mean Daily Range of Dissolved Oxygen in August and September (mg/L)	Mean Temperature in August and September (°C)	Mean Daily Range of Temperature in August and September (°C)
Reservoir Recreation A	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	o	o	o	o	o
	Holston River Mile 30 (Cherokee)	o	o	o	↓	↓	↑
	Holston River Mile 48 (Cherokee)	o	o	↑	o	↓	o
	South Fork Holston River Mile 43 (South Holston)	↓*	o	o	o	o	↑
Reservoir Recreation B	Elk River Mile 125 (Tims Ford)	o	↓	o	o	o	↓
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	↓	↓	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓*	↓*	↑	↓	↓	↑
	Holston River Mile 48 (Cherokee)	↓*	↓*	↑	↑	↓*	o
	South Fork Holston River Mile 43 (South Holston)	↓*	↓	o	o	o	↑
Equalized Summer/ Winter Flood Risk	Elk River Mile 125 (Tims Ford)	↑	↓*	o	o	o	↓*
	Elk River Mile 73 (Tims Ford)	o	↓	o	o	o	o
	French Broad River Mile 18 (Douglas)	↓	↓	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓*	↓*	↑	↓*	↓	↑
	Holston River Mile 48 (Cherokee)	↓*	↓*	↑	↑	↓	↑
	South Fork Holston River Mile 43 (South Holston)	↓	o	o	o	o	↑
Commercial Navigation	Elk River Mile 125 (Tims Ford)	↑**	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	↑*	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	o	o	o	o	o
	Holston River Mile 30 (Cherokee)	o	o	o	o	o	o
	Holston River Mile 48 (Cherokee)	o	o	o	o	o	o
	South Fork Holston River Mile 43 (South Holston)	o	o	o	o	o	o

Table 5.7-05 Comparison of August–September Tailwater Metric Values by Policy Alternative (continued)

Alternative	River Segment (Upstream Reservoir)	Mean Flow for August and September (cfs)	Mean Daily Range of Flow in August and September (cfs)	Mean Dissolved Oxygen in August and September (mg/L)	Mean Daily Range of Dissolved Oxygen in August and September (mg/L)	Mean Temperature in August and September (°C)	Mean Daily Range of Temperature in August and September (°C)
Tailwater Recreation	Elk River Mile 125 (Tims Ford)	o	↓	o	o	o	↓
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	↓	↓*	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓*	↓*	↑	↓	↓	↑
	Holston River Mile 48 (Cherokee)	↓*	↓*	↑	↑	↓	o
	South Fork Holston River Mile 43 (South Holston)	↓*	↓	o	↓	o	o
Tailwater Habitat	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	↓*	↓**	↑	↓*	o	o
	Holston River Mile 30 (Cherokee)	↓**	↓**	↑*	↓**	↓*	o
	Holston River Mile 48 (Cherokee)	↓**	↓**	↑	↓	↓*	↓*
	South Fork Holston River Mile 43 (South Holston)	↓*	o	o	o	o	↑
Preferred	Elk River Mile 125 (Tims Ford)	o	o	o	o	o	o
	Elk River Mile 73 (Tims Ford)	o	o	o	o	o	o
	French Broad River Mile 18 (Douglas)	o	o	o	o	o	o
	Holston River Mile 30 (Cherokee)	↓	o	o	o	↓	o
	Holston River Mile 48 (Cherokee)	↓	o	o	o	↓	o
	South Fork Holston River Mile 43 (South Holston)	↓	o	o	↓	o	o

Notes: Values could not be calculated for the Summer Hydropower Alternative because severely dry years dried portions of the system, crashing the water quality model. See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-06 Comparison of Water Temperature Metric Values for Tailwaters by Policy Alternative

Alternative	River Segment (Upstream Reservoir)	Warm Tailwaters (Summer Hours of Water Temperature Less Than 16 °C)	Cool-to Warm-Tailwaters (Summer Hours of Water Temperature Greater Than 20 °C)	Cool/Cold Tailwaters (Summer Hours of Water Temperature Greater Than 20 °C)
Reservoir Recreation A	Elk River Mile 125 (Tims Ford)		o	
	Elk River Mile 73 (Tims Ford)	o		
	French Broad River Mile 18 (Douglas)	o		
	Holston River Mile 30 (Cherokee)	↑		
	Holston River Mile 48 (Cherokee)		↓*	
	South Fork Holston River Mile 43 (South Holston)			↑*
Reservoir Recreation B	Elk River Mile 125 (Tims Ford)		↑	
	Elk River Mile 73 (Tims Ford)	↑		
	French Broad River Mile 18 (Douglas)	o		
	Holston River Mile 30 (Cherokee)	↑		
	Holston River Mile 48 (Cherokee)		↓*	
	South Fork Holston River Mile 43 (South Holston)			↑**
Equalized Summer/Winter Flood Risk	Elk River Mile 125 (Tims Ford)		↑**	
	Elk River Mile 73 (Tims Ford)	↑		
	French Broad River Mile 18 (Douglas)	↓**		
	Holston River Mile 30 (Cherokee)	↓		
	Holston River Mile 48 (Cherokee)		↓*	
	South Fork Holston River Mile 43 (South Holston)			↑**
Commercial Navigation	Elk River Mile 125 (Tims Ford)		o	
	Elk River Mile 73 (Tims Ford)	o		
	French Broad River Mile 18 (Douglas)	o		
	Holston River Mile 30 (Cherokee)	o		
	Holston River Mile 48 (Cherokee)		o	
	South Fork Holston River Mile 43 (South Holston)			↑**

Table 5.7-06 Comparison of Water Temperature Metric Values for Tailwaters by Policy Alternative (continued)

Alternative	River Segment (Upstream Reservoir)	Warm Tailwaters (Summer Hours of Water Temperature Less Than 16 °C)	Cool-to Warm-Tailwaters (Summer Hours of Water Temperature Greater Than 20 °C)	Cool/Cold Tailwaters (Summer Hours of Water Temperature Greater Than 20 °C)
Tailwater Recreation	Elk River Mile 125 (Tims Ford)		↑	
	Elk River Mile 73 (Tims Ford)	↑		
	French Broad River Mile 18 (Douglas)	o		
	Holston River Mile 30 (Cherokee)	↑		
	Holston River Mile 48 (Cherokee)		↓*	
	South Fork Holston River Mile 43 (South Holston)			↓*
Tailwater Habitat	Elk River Mile 125 (Tims Ford)		o	
	Elk River Mile 73 (Tims Ford)	o		
	French Broad River Mile 18 (Douglas)	o		
	Holston River Mile 30 (Cherokee)	↑**		
	Holston River Mile 48 (Cherokee)		↓**	
	South Fork Holston River Mile 43 (South Holston)			↑*
Preferred	Elk River Mile 125 (Tims Ford)		o	
	Elk River Mile 73 (Tims Ford)	o		
	French Broad River Mile 18 (Douglas)	o		
	Holston River Mile 30 (Cherokee)	o		
	Holston River Mile 48 (Cherokee)		↓	
	South Fork Holston River Mile 43 (South Holston)			↓**

Notes: Values could not be calculated for the Summer Hydropower Alternative because severely dry years dried portions of the system, crashing the water quality model.

See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-07 Comparison of Cool-Water Habitat Reservoir Metrics by Policy Alternative

Alternative	Reservoir	Mean Percent Yearly Volume of Critical Cool-Water Habitat	Mean Percent of Yearly Volume of Preferable Cool-Water Habitat
Reservoir Recreation A	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	↑	o
	Nottely	o	o
	Tims Ford	o	o
Reservoir Recreation B	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	↑	o
	Nottely	o	o
	Tims Ford	o	o
Equalized Summer/Winter Flood Risk	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	↑	o
	Nottely	o	o
	Tims Ford	o	o
Commercial Navigation	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	↑	o
	Nottely	o	o
	Tims Ford	o	o

Table 5.7-07 Comparison of Cool-Water Habitat Reservoir Metrics by Policy Alternative (continued)

Alternative	Reservoir	Mean Percent Yearly Volume of Critical Cool-Water Habitat	Mean Percent of Yearly Volume of Preferable Cool-Water Habitat
Tailwater Recreation	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	↑	o
	Nottely	o	o
	Tims Ford	o	o
Tailwater Habitat	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	↑	↑
	Nottely	o	o
	Tims Ford	o	o
Preferred	Boone	o	o
	Douglas	o	o
	Hiwassee	o	o
	Melton Hill	o	o
	Norris	o	o
	Nottely	o	o
	Tims Ford	o	o

Note: See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-08 Comparison of Cold-Water Habitat Reservoir Metrics by Policy Alternative

Alternative	Reservoir	Mean Percent of Yearly Volume of Critical Cold-Water Habitat	Mean Percent of Yearly Volume of Preferable Cold-Water Habitat
Reservoir Recreation A	South Holston	o	o
	Watauga	o	o
Reservoir Recreation B	South Holston	o	o
	Watauga	o	o
Equalized Summer/Winter Flood Risk	South Holston	o	o
	Watauga	o	o
Commercial Navigation	South Holston	o	o
	Watauga	o	o
Tailwater Recreation	South Holston	o	o
	Watauga	o	o
Tailwater Habitat	South Holston	o	o
	Watauga	o	o
Preferred	South Holston	o	o
	Watauga	o	o

Note: See explanation on page 5.7-9 for metric symbols used in the table.

Table 5.7-09 Estimated Values for Flowing Mainstem Waterbodies

Alternative	Flowing Mainstem Reach (Upstream Reservoir)	Hours of No Discharge from March through May
Reservoir Recreation A	Fort Loudoun	o
	Guntersville	o
	Pickwick	o
Reservoir Recreation B	Fort Loudoun	↓
	Guntersville	↓
	Pickwick	o
Equalized Summer/Winter Flood Risk	Fort Loudoun	↓*
	Guntersville	o
	Pickwick	o
Commercial Navigation	Fort Loudoun	o
	Guntersville	o
	Pickwick	o
Tailwater Recreation	Fort Loudoun	↓
	Guntersville	↓
	Pickwick	o
Tailwater Habitat	Fort Loudoun	↓**
	Guntersville	↓**
	Pickwick	↓**
Preferred	Fort Loudoun	↓
	Guntersville	↓
	Pickwick	↓

Note: See explanation on page 5.7-9 for metric symbols used in the table.

5.7.3 Base Case

The status of aquatic resources under the Base Case is characterized for present operations and ongoing projects in the discussions below.

General Biodiversity

Reservoirs

In reservoirs, environmental conditions under the Base Case were generally more favorable for general biodiversity than under other policy alternatives—except the Commercial Navigation Alternative, which exhibited similar conditions to the Base Case. In tributary storage reservoirs, under the Base Case, the benthic aquatic insect and mussel communities would remain strongly affected by seasonal thermal stratification and resulting low DO concentration and large water level fluctuations. Aquatic insect communities would be low in diversity and comprised of only tolerant taxa. Reservoir Fish Assemblage Index values for tributary reservoirs were not projected to change more than the standard annual variation under the Base Case.

In mainstem reservoirs, aquatic insect communities would remain fair, and the status of mussels in flowing portions would remain poor for riverine mussel species and favorable for pool-adapted species. Reservoir Fish Assemblage Index values for mainstem reservoirs were not projected to change more than the standard annual variation under the Base Case.

Sport Fisheries

Reservoirs

Sport fishes in mainstem reservoirs would remain generally good under the Base Case. Recruitment would vary with reservoir hydrology as determined by climatic conditions; wet years produce more recruitment. Because mainstem pool levels have less fluctuation than tributary storage reservoirs, inter-annual changes in sport fish populations would vary less in mainstem reservoirs than in tributary reservoirs. Sport fish populations are also highly managed by state resource agencies, and Sport Fish Index scores could vary based on changes in management objectives.

Tailwaters

Variable recruitment for sport fishes in the flowing mainstem (e.g., sauger and white bass) would continue, largely related to flow during spring—with improved conditions during years with wet March-through-May periods. Achieving target DO concentrations in tailwater releases under the RRI Program would continue to benefit tributary tailwater fisheries. Late summer water quality (temperature) would continue to stress cold-water fisheries at some sites (e.g., below Hiwassee Dam) during dry years or warm summers.

Commercial Fisheries

Reservoirs

Commercial fisheries for fish and mussels occur primarily in mainstem reservoirs. Reservoirs benefit commercial fisheries by providing increased habitat for commercial fish species that are generally adapted to pool conditions. In dry years, with reduced flow through the mainstem, low DO may adversely affect mussel fisheries, but this impact would be determined more by climatic patterns than reservoir operations. Overall, commercial species should not vary more than changes currently experienced due to variation in climatic conditions.

5.7.4 Reservoir Recreation Alternative A

General Biodiversity

Reservoirs

In tributary reservoirs, results described in Section 5.4, Water Quality, indicated that Reservoir Recreation Alternative A would increase poor water quality in reservoirs. On the worst day for water quality, this alternative would increase the volume of water with poor quality for Boone Reservoir, with no changes in other tributary reservoirs (Table 5.7-02). Pool levels in winter would be raised, reducing the amount of bottom habitat dewatered during drawdown (Table 5.7-03), which would improve some benthic habitat conditions. In mainstem reservoirs, Reservoir Recreation Alternative A would increase the potential for reduced biodiversity because it would increase the volume of DO-depleted water and the potential amount of toxic substances in the water during summer. In tributary reservoirs, there was relatively no change relative to Base Case conditions in water quality metrics related to general biodiversity. Mainstem response would be slightly adverse.

Tailwaters

Summer flow decreased, except at sites below Tims Ford (Elk River) which did not change (Table 5.7-04). Conditions of summer DO and temperature would be similar to Base Case conditions. Mean August/September DO concentrations below Douglas (French Broad River), Cherokee (Holston River), and South Holston (South Fork Holston River) Dams increased, with no change observed at other sites (Table 5.7-05). Mean temperature during late summer dropped at both sites in the Holston River, with no change in temperature estimated for other rivers. Decreases in water temperature would slightly benefit cold-water sport fishes below Cherokee Dam (Table 5.7-06) but would be slightly adverse to downstream warm-water communities (potentially decreasing biodiversity). Therefore, the overall projected impact of Reservoir Recreation Alternative A on tailwater biodiversity is no change to slightly adverse.

Water temperature criteria for all years indicated similar trends. More cold water occurred in the Holston River, less in the South Fork Holston River, and no change at other sites. Again, cold-water sport fishes may benefit at some sites under this alternative, and conditions for warm-water species in cool-water rivers would be slightly adverse.

Sport Fisheries

Reservoirs

Under Reservoir Recreation Alternative A, conditions of water quality potentially influencing sport fisheries would not change from the Base Case in tributary reservoirs (Tables 5.7-07 and 5.7-08). On the other hand, if aquatic plants become more abundant in tributary reservoirs under this alternative (as projected in Section 5.9, Aquatic Plants), resident warm-water fish and aquatic insects would slightly benefit. Because there are more warm-water than cold- or cool-water fish in most tributary reservoirs, the overall influence of Reservoir Recreation Alternative A is no change to slightly beneficial.

Water quality conditions in mainstem reservoirs would decrease slightly over the Base Case as summer stratification would be extended for approximately 30 days. The increase in the number of weeks at summer pool levels would increase the volume of water with low DO during summer, possibly adversely influencing cool-water species such as white crappie *(Pomoxis annularis)*, sauger, and striped bass *(Morone saxatilis)* (Table 5.7-03). Growth and survival of warm-water fishes (e.g., bass [*Micropterus* sp.], catfish [*Ictalurus* sp.], and sunfish [mainly *Lepomis* sp.]) in mainstem reservoirs would benefit from longer pool levels because these species are tolerant of less suitable water quality. In mainstem reservoirs, the estimated response would be no change to slightly adverse.

Tailwaters

In the mainstem, there would be no change in discharge hours from mainstem dams (Table 5.7-09) from March through May. Water temperature criteria below most reservoirs indicate no change, except at the two sites in the Holston River below Cherokee (cool-to-warm and warm), where more cold-water would be present and the number of hours with water temperatures ≥20 °C below South Holston Dam would increase (Table 5.7-06). Cold-water fishes would slightly benefit from increased cold-water releases, but warm-water species would incur slightly adverse conditions. Cool/cold tailwaters are projected to incur slightly adverse impacts, no change was anticipated for other warm tailwaters, and cool-to-warm tailwaters would likely have variable responses.

Commercial Fisheries

All representative mainstem reservoirs—Pickwick, Guntersville, and Kentucky—were projected to be degraded by increased volume of water with poor quality. Kentucky Reservoir would see the most change. As a result, commercial fisheries, especially for freshwater mussels, would experience adverse habitat conditions under this alternative.

5.7.5 Reservoir Recreation Alternative B

General Biodiversity

Reservoirs

In tributary reservoirs, DO metrics showed more volume of water with low DO than under Reservoir Recreation Alternative A (Section 5.4, Water Quality). This would increase the potential for slightly adverse conditions in tributary reservoirs. For mainstem reservoirs, the number of days experiencing low DO varies by reservoir. Generally, the volume of water with DO concentrations less than 2 mg/L and 5 mg/L would increase, as well as the maximum volume of water with poor water quality on the most challenging day of the year. Biodiversity could be expected to decrease slightly under these conditions.

Tailwaters

Conditions for summer tailwater metrics showed relatively little change, except below Cherokee Dam (Holston River) (Table 5.7-04). In the Holston River, mean water temperature, flow, and range of flow exhibited slight decreases. During August and September, mean flow and range of flow decreased at all sites except those below Tims Ford (Elk River), which had no change (Table 5.7-05). Mean DO increased in the Holston River, with no change in DO or water temperature projected for other tailwaters assessed. Further, water quality metrics (see Section 5.4, Water Quality) indicated no change relative to the Base Case for DO in tailwaters due to Lake Improvement Plan targets. Therefore, due to projected decreases in water temperature in warm-water tailwaters and reductions in summer flow patterns, Reservoir Recreation Alternative B is projected to result in no change or a slightly adverse impact on biodiversity.

Sport Fisheries

Reservoirs

Reservoir Recreation Alternative B would increase the weeks at full pool level and increase winter pool levels but would not change the first week when full pool level was reached. These aspects would benefit aquatic insects and shoreline spawning sport fish, such as bass, crappie, and bluegill. More days at summer pool would increase the potential for establishment of aquatic vegetation. Release of only minimum flows from June 1 to Labor Day would increase the average volume of water with low DO and low water temperature in tributary reservoirs slightly more than projected under Reservoir Recreation Alternative A. This would have minimal impact on resident warm-water fish species due to their mobility and sufficient remaining volume of water with suitable water quality. Reductions in cool-water habitat (DO concentrations) would be more important for species such as white crappie, walleye, and white and striped bass. Overall, water quality conditions preferred by sport fishes showed minimal change under this alternative in tributary reservoirs. Reduced flow from tributary reservoirs would increase the volume of water with low DO in mainstem reservoirs, thus decreasing habitat availability.

A slightly beneficial change in sport fish populations of tributary reservoirs may be anticipated due to the longer period at summer pool. Due to decreased water quality, no change to slightly adverse change would be anticipated in mainstem reservoirs.

Tailwaters

Metric changes during August and September mostly indicated no change as discussed above for tailwater biodiversity. However, specific temperature metrics for tailwater sport fishes indicated that more temperatures above 20 °C would be experienced below Tims Ford (cool-to-warm) and South Holston (cool/cold) Dams (Table 5.7-06). The apparent conflict of metric results was due to the difference in the time frame of evaluation. Average temperatures would be cooler in the Elk River below Tims Ford during August and September. In cool-to-warm tailwaters, cold-water species would slightly benefit; but warm-water species would experience a slight adverse impact. In the South Fork Holston River, cold-water species would experience a slightly adverse impact. Warm-water species would experience some decrease in water temperature quality in downstream areas but would benefit from more stable flows while summer pool levels were maintained. Stable flows would be more important than the temperature changes for warm-water species. The hours of zero discharge from mainstem reservoirs in early spring would also decrease under this alternative, slightly benefiting sport fish spawning there. No change to slight benefits would be the impact on warm-water tailwaters.

Commercial Fisheries

Because of increased volume of water with low DO under Reservoir Recreation Alternative B, commercial fisheries—especially freshwater mussels—would experience adverse habitat conditions under this alternative. The limited ability of mussels to move out of affected areas increases their potential for decline.

5.7.6 Summer Hydropower Alternative

The Summer Hydropower Alternative would maximize summer hydropower. Water quality output for this alternative was not completed because under this alternative the model would not run for severely dry years (1986, 1987, and 1988). Therefore, outcomes for this alternative were subjective and should be accepted with caution.

General Biodiversity

Reservoirs

In mainstem reservoirs, a slight benefit may be achieved because this alternative increased mainstem flow, which would decrease the amount of water with low DO occurring during summer. For mainstem reservoirs, the number of days during summer the projected daily water volume had less than 1 and/or 2 mg/L DO decreased more than 50 percent. Increased mainstem flow would increase water levels in flowing mainstem areas, maintaining more habitats for fish, and especially aquatic insects and mussels. In tributary reservoirs, the

Summer Hydropower Alternative would decrease stratification, improving water quality, but water level fluctuation would adversely affect available shoreline habitat. Some reservoirs may reach extremely low pool levels under this alternative in very dry years. Overall, biodiversity would be adversely affected in tributary reservoirs.

Tailwaters

The Summer Hydropower Alternative would potentially extend the number of days under minimum flow targets from the Lake Improvement Plan; and unrestricted drawdown would mean more peaking flows, decreasing the stability of daily water elevations and water quality in warm-water tailwaters. The Summer Hydropower Alternative would adversely affect the potential for biodiversity.

Sport Fisheries

Reservoirs

Water quality results (Section 5.4, Water Quality) indicate that the Summer Hydropower Alternative was projected to reduce the volume of water with low concentrations of DO in some tributary reservoirs and increase it in others. Variation in suitable habitat available for cool-water and cold-water sport fish would result in variable responses by these sport fish populations in different reservoirs. The extended period of dewatering of the drawdown zone during the growing season (summer/early fall), would allow plants such as buttonbush *(Cephalanthus occidentalis)*, willows *(Salix sp.)*, and cockleburs *(Xanthium spinosum)* to thrive in the drawdown zone. This vegetation growth would enhance the potential for development of suitable habitat for spawning, a good media for aquatic insect production, and provide protection for enhanced juvenile survival and growth for warm-water species. If this habitat is not flooded for a sufficiently long period following inundation (through August), however, benefits would be generally reduced. The increased flow from tributary dams would tend to decrease the volume of water with low DO in mainstem reservoirs, which should increase the potential for better cool-water sport fish populations. Therefore, the potential for improvement for mainstem sport fish populations would slightly increase.

Tailwaters

Below mainstem dams, this alternative would not alter discharges in spring relative to the Base Case, and no change is expected for migratory fishes spawning below mainstem dams. Water temperatures from tributary reservoirs would be higher due to less cold water in storage in the late summer. Consequently, cold-water tailwater sport fishes would be adversely affected from decreasing water quality (raised water temperatures), and warm-water species would slightly benefit.

Commercial Fisheries

Increased flow through the mainstem reservoirs would improve water quality and benefit commercial fisheries.

5.7.7 Equalized Summer/Winter Flood Risk Alternative

General Biodiversity

Reservoirs

In tributary reservoirs, relatively no change in water quality condition for sport fishes was predicted (Tables 5.7-08 and 5.7-09). Mainstem DO conditions would be slightly degraded (see Section 5.4, Water Quality, and Table 5.7-02). The volume of water with critically low DO (<1 mg/L) is projected to increase considerably in Guntersville Reservoir and yet decline considerably in Kentucky Reservoir. Percent of non-acceptable habitat is projected to increase in both reservoirs. General biodiversity is expected to decrease slightly in mainstem reservoirs, with no appreciable change anticipated for tributary reservoirs.

Tailwaters

Relatively no change in late summer water temperatures is anticipated, except at sites in the Holston River, where temperature would decrease slightly. Dissolved oxygen in the Holston River below Cherokee Dam would increase slightly (Table 5.7-05). Reductions in temperature would result in a slightly adverse effect on biodiversity in the Holston River, but no change was estimated for other rivers. August/September flow under this alternative would be reduced slightly below Douglas, South Holston, and Cherokee Dams, but the daily mean range of flows, which provides more stable habitat and water quality, would be reduced— offsetting the loss of habitat from lower flows. No change in biodiversity is anticipated under this policy alternative.

Sport Fisheries

Reservoirs

Under the Equalized Summer/Winter Flood Risk Alternative summer pool levels would be achieved later in the year (Table 5.7-03) and, for most reservoirs, it would lower median summer pool levels. These aspects would result in negative impacts on shoreline species spawning and nursery habitat. Winter pool levels would be raised, except at Tims Ford, which would be lowered. Summer pool levels would be maintained longer than under the Base Case. In tributary reservoirs—except at Norris, where the mean percent of yearly volume of critical cool-water habitat would increase—relatively no change in water quality conditions for sport fishes was predicted (Table 5.7-07). Changes in pool levels under this alternative would result in a slightly adverse effect on tributary reservoir sport fisheries relative to the Base Case. As noted in Section 5.4, Water Quality, mainstem DO conditions would be degraded. Fort Loudoun Reservoir would decrease the hours of no discharge during spring, but no change was estimated for Kentucky and Pickwick Reservoirs (Table 5.7-09). This alternative would result in slightly adverse conditions for sport fishes in mainstem reservoirs.

Tailwaters

Metrics for sport fish concerns of tailwaters showed a mixed pattern of change (Tables 5.7-04 and 5.7-05). Both the cool-to-warm and warm-water tailwater sites in the Holston River below Cherokee Dam would be colder (Table 5.7-06) and with more DO, which would benefit the trout fishery immediately below the dam. Impacts on warm-water species would be slightly adverse. Estimated conditions for both the cool-to-warm and warm-water tailwater sites in the Elk River (Tims Ford) and the South Holston River cool/cold site showed a decrease in flow during August and September. No changes in summer flow or water temperature were projected. Number of hours with water temperature greater than 20 °C substantially increased in the cool/cold tailwater site below South Holston River, indicating adverse conditions. Fewer hours of water temperatures less than 16 °C are projected to occur below Douglas Dam (French Broad River), indicating improved conditions for warm-water fish species (Table 5.7-06). However, no change was projected in summer mean water temperatures or during the August/September period (Tables 5.7-04 and 5.7-05). Under this alternative, flow from mainstem reservoirs would not change from March through May (Table 5.7-09). The response of sport fishes in warm and cool-to-warm tailwaters would be variable, with slightly adverse conditions projected for cool/cold tailwaters.

Commercial Fisheries

Mainstem reservoirs would experience an increase in yearly volumes of water with poor DO concentrations. Conditions for mussels would decrease more than those for fishes because DO is depleted in benthic areas first and, because mussels are not mobile, they cannot escape. Impacts on commercial fisheries under the Equalized Summer/Winter Flood Risk Alternative are anticipated to be slightly adverse to adverse.

5.7.8 Commercial Navigation Alternative

Estimated conditions for the Commercial Navigation Alternative were similar to those under the Base Case. See the description of conditions for the Base Case for this alternative. The only anticipated difference is the potential for a slight benefit in biodiversity of mainstem reservoirs due to projections for substantially fewer days with DO <1 mg/L in Kentucky Reservoir. However, since the peak daily volume of non-acceptable habitat in this reservoir was projected to increase substantially, the overall projected impact on mainstem reservoirs is only slightly beneficial. This also may improve slightly the potential for sport fish in mainstem reservoirs. The slight increases in winter pool elevations (Table 5.7-03) in tributary reservoirs may also slightly aid sport fish populations in these systems.

5.7.9 Tailwater Recreation Alternative

Estimated conditions for the Tailwater Recreation Alternative were similar to those for Reservoir Recreation Alternative B (described in Section 5.7.5). For details on conditions under this alternative, see Reservoir Recreation Alternative B.

5.7.10 Tailwater Habitat Alternative

General Biodiversity

Reservoirs

Increasing volumes of water with low DO were estimated for some tributary and especially for mainstem reservoirs (Table 5.7-02). These conditions would reduce suitable habitat for cool-water and cold-water fish species, aquatic insects, and mussels. Consequently, this alternative is anticipated to incur slightly adverse effects on biodiversity in both tributary and mainstem reservoirs.

Tailwaters

The Tailwater Habitat Alternative lowered mean summer and August/September flows, substantially in the Holston River (Cherokee Dam), slightly in the French Broad River (Douglas Dam) and South Fork Holston River, and not at all in the Elk River (Tims Ford Dam) (Table 5.7-05). In fact, there was no change to conditions relative to the Base Case for Elk River sites for flow, DO, or water temperature. Mean water quality conditions for the French Broad and South Fork Holston Rivers also did not change. Temperature was slightly lowered in the Holston River (Tables 5.7-04 and 5.7-05). A drop in temperature in the Holston River (cool-water) would decrease the potential biodiversity at the most downstream site, but the site nearest the dam (Cherokee) already has low diversity due to cold-water releases. Reductions in the daily mean range of DO and temperature across rivers were relatively small. Results suggest no change to slightly adverse conditions for biodiversity under this alternative.

Sport Fisheries

Reservoirs

The Tailwater Habitat Alternative would not change the date of attainment of summer pool levels (Table 5.7-03). It would increase the weeks at full pool levels and would increase winter pool levels. These changes would improve conditions for sport fishes. However, tributary reservoirs would experience a substantial increase in low DO concentrations (see Section 5.4, Water Quality), and mainstem reservoirs would similarly experience decreases in water quality metrics. Tributary reservoirs would experience a slightly adverse impact under this alternative, and mainstem reservoirs would be adversely affected based on changes to DO concentrations (Section 5.4).

Tailwaters

Reductions of water temperature below Cherokee Dam (Holston River) would provide a slight benefit to the trout fishery in the cool-to-warm section of the tailwater close to the dam (Table 5.7-06); in downstream warm-water areas, however, impacts on resident species would be slightly adverse. No change was predicted to mean condition in either the cool-to-warm or warm sections of the Elk River (Tims Ford Dam) or the French Broad River (Douglas Dam—warm tailwater) (Table 5.7-06). In the cool/cold tailwater below South Holston River, summer hours of water temperature >20 °C (unsuitable for cold-water species) would increase (Table 5.7-06), but no change in mean summer or August/September metrics was indicated (Tables 5.7-04 and 5.7-05). A large portion of the decline occurred in summer months other than August and September (July and October) but not enough to affect the full summer (May to October). Mean flow in the South Fork Holston River was reduced slightly and could decrease habitat area. Under this alternative, hours of no discharge below mainstem reservoirs would be substantially reduced (Table 5.7-09), providing a substantial benefit to sport fishes spawning below mainstem reservoirs. However, poor mainstem reservoir water quality under the Tailwater Habitat Alternative may adversely affect the same sport fishes at later life stages. Overall, metrics under this alternative indicate an adverse response from cool/cold tailwater trout populations due to increased hours with water temperatures >20 °C. A variable environmental response for sport fishes is projected in warm (no change to slightly adverse for warm-water species) and cool-to-warm (cold-water species would benefit and warm-water species would be adversely affected) tailwater types.

Commercial Fisheries

Water quality indicators for mainstem reservoirs indicated adverse changes for the commercial fisheries. The amount of low DO present in the mainstem reservoirs would increase under this alternative.

5.7.11 Preferred Alternative

General Biodiversity

Reservoirs

For tributary reservoirs, results described in Section 5.4, Water Quality, indicate that the Preferred Alternative would marginally affect water quality. This alternative would slightly increase the volume of water with DO $\leq$ 1 mg/L and the volume of unacceptable habitat (DO < 2 mg/L) for Boone Reservoir, with relatively no changes in other tributary reservoirs (Table 5.7-02). Raising pool levels in winter in most tributary reservoirs (no change at Tims Ford Dam) would reduce the amount of bottom habitat dewatered during drawdown (Table 5.7-03), which would improve some benthic habitat conditions. However, low DO in summer would still affect these areas in most tributary reservoirs and would continue to restrict benthic communities. Tributary reservoir biodiversity is not anticipated to change under the Preferred Alternative.

In mainstem reservoirs, the Preferred Alternative, relative to Base Case conditions, would result in mixed impacts on the potential to reduce biodiversity, with no change in the volume of DO-depleted water in Kentucky Reservoir, a decrease in Guntersville Reservoir, and a slight increase in Pickwick Reservoir. As discussed in Section 5.4, Water Quality, Guntersville Reservoir results could have been overly influenced by the unusually dry conditions of 1988. No changes are projected for the mean peak daily volume of unacceptable habitat. Winter pool levels would not change on any of these representative mainstem reservoirs. Mainstem reservoir biodiversity impacts would be variable, with conditions in some reservoirs improving and declining in others.

Tailwaters

Summer flow would decrease at both the cool-to-warm and warm tailwater sites below Cherokee Dam. No change in flow relative to the Base Case is projected at other sites (Table 5.7-04). Conditions of summer DO and temperature would be similar to Base Case conditions. Late summer (August-September) water temperatures at both Holston River sites declined (~4 °C), which is projected to result in a slight adverse impact on these sites (Table 5.7-05). Water temperatures in other tailwaters are not projected to change. Therefore, the overall impact of the Preferred Alternative on tailwater biodiversity would be no change to slightly adverse.

Sport Fisheries

Reservoirs

Under the Preferred Alternative, conditions of water quality potentially influencing sport fisheries would not change from the Base Case in tributary reservoirs (Tables 5.7-07 and 5.7-08). On the other hand, if aquatic plants become slightly more abundant in tributary reservoirs under this alternative (as projected in Section 5.9, Aquatic Plants), resident warm-water fish and aquatic insects would slightly benefit. However, projected negative impacts on scrub/shrub plants such as buttonbush (as stated in Section 5.8, Wetlands), due to increased length of time covered by water, would result in slightly adverse impacts. Increasing the length of time at full pool under this alternative would provide additional shallow-water habitat, in the form of flooded vegetation such as grasses, during the first couple of years. This vegetation would result in additional cover, which is beneficial for survival of young fishes; however, this habitat would actually decrease with years of extended pool levels—except during dry years. Exposed reservoir bottom areas would not be dewatered for sufficient time under adequate growing conditions to redevelop the desirable vegetative growth that provides the nutrient boost and good spawning and nursery habitat. Summer pools would be extended at Douglas, Norris, and South Holston Reservoirs under this alternative, but not at Tims Ford. The volume of water with suitable cool-water habitat during summer was projected to not change in any of the representative reservoirs (Table 5.7-07). Increases in winter pool elevations (Table 5.7-03) in tributary reservoirs, except for Tims Ford, would also slightly aid sport fish populations in these systems. Overall, influence of the Preferred Alternative on tributary reservoir sport fisheries is projected to be no change to slightly beneficial.

Water quality conditions in most mainstem reservoirs would decrease slightly over Base Case conditions, as summer stratification would be extended for approximately 10 days. The number of weeks at summer pool levels would increase in Pickwick and Guntersville Reservoirs but decline slightly at Kentucky Reservoir (Table 5.7-03). Projected impacts on growth and survival of warm-water fishes (e.g., bass [*Micropterus* sp.], catfish [*Ictalurus* sp.], and sunfish [mainly *Lepomis* sp.]) in mainstem reservoirs would be variable. The increased duration at full pool would result in minimal increases in submersed aquatic vegetation (as noted in Section 5.9, Aquatic Plants). This would result in a slightly positive influence on benthic invertebrate and most fish species. Projected negative impacts on plants such as buttonbush (as stated in Section 5.8, Wetlands), due to increased length of time covered by water, would be slightly adverse in mainstem reservoirs.

Tailwaters

For cool/cold tailwaters, the number of summer hours with water temperatures greater than 20 °C (too warm for cold-water species) was projected to substantially decline below South Holston (South Fork Holston River Mile 43), suggesting a benefit at this location (Table 5.7-06). However, neither mean summer water temperature nor flows were projected to change relative to the Base Case at this site (Table 5.7-04). Most of the decline would occur in summer months other than August and September (June and July) but not enough to affect the full summer (May to October). During August/September, flows would slightly decrease, but water temperatures would not change from the Base Case (Table 5.7-05). Therefore, conditions for sport fish in cool/cold tailwaters are expected to be slightly beneficial.

A slight decrease in hours with water temperatures greater than 20 °C projected at the cool- to warm-water site in the Holston River below Cherokee Dam (Holston River Mile 48), with no change anticipated for the Elk River site below Tims Ford Dam (Table 5.7-06). This change would enhance the habitat for cold-water species (trout) but would negatively affect cool- and warm-water species. Mean summer water temperatures were not projected to change relative to the Base Case at either site (Table 5.7-04). During August/September, flows and water temperatures would slightly decrease at the Holston River site, but no change for either metric is projected at the Elk River site (Table 5.7-05). Conditions for cool- to warm-water tailwaters are predicted to vary, depending on the species group (cold-water species would slightly benefit, and cool- and warm-water species would experience slightly adverse conditions).

For warm tailwaters, no change in the number of summer hours (May through October) with temperatures less than 16 °C was projected for the lower Holston River, lower Elk River, or the French Broad River sites under this alternative (Table 5.7-06). Mean summer water temperatures also indicate no changes at any of these sites (Table 5.7-04). However, August/September mean water temperatures would decline at the lower Holston River site, creating slightly adverse conditions for warm-water species during this period (Table 5.7-05). Summer and August/September flows below Douglas (French Broad River Mile 18) and Tims Ford (Elk River Mile 125) Dams would not change relative to the Base Case. Flows at the lower Holston River site would decrease slightly in both summer and August/September periods (Tables 5.7-04 and 5.7-05). Mainstem reservoirs would have slightly less potential for hours of no discharge during March and April but marginally higher potential during May (Table 5.7-09). Overall, conditions for mainstem tailwater fisheries are expected to be no change to slightly beneficial. Therefore, conditions for sport fishes in warm tailwaters would be variable.

Commercial Fisheries

Based on water quality modeling, Guntersville Reservoir is projected to have fewer days with low DO (<1 mg/L) and thus improved conditions; no change at Kentucky and Douglas Reservoirs; and slight increases at Pickwick Reservoir, resulting in slightly degraded conditions under the Preferred Alternative compared to Base Case conditions (Table 5.7-02). Conditions for commercial mussels are not projected to change (the main harvest occurs in Kentucky Reservoir), while those for commercial fish are projected to vary under the Preferred Alternative.

5.7.12 Summary of Impacts

Assessment of conditions for each area of aquatic resources is summarized in Table 5.7-10. The amount of flow through the TVA system represents a driving factor on the status of aquatic organisms. In wet years, more flow through the system generally reduces the impacts of reservoir operations on aquatic organisms. In dry years, the condition of the environment is more challenging because reduced flow through the system exacerbates any adverse change induced by reservoir operations. Assessments of aquatic resources were made using the mean response of selected surrogate metrics. The response of metrics across years showed a similar pattern for the policy alternatives as the Base Case, which implies that the status of most metrics would be relatively worse in dry years and better in wet years for aquatic resources, as compared to the results stated in sections above. In many cases, however, the variations among mean metric values among policy alternatives was less than the inter-annual variation of metric values under the Base Case.

The biodiversity of mainstem reservoirs would be adversely or slightly adversely affected under all alternatives, except the Summer Hydropower Alternative and the Commercial Navigation Alternative, which would have slight benefits based on modeled changes in water quality. The Preferred Alternative would have variable results, with some reservoirs slightly benefiting from lower levels of unsuitable habitat and others experiencing slightly adverse increases in low DO conditions. Tributary reservoirs would experience no change or a slightly adverse change in metrics representing biodiversity; generally, however, no change in condition is expected because biodiversity was already affected under present operating conditions (see Section 4.7). Biodiversity in warm-water tailwaters would generally be adversely or slightly adversely affected under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Summer Hydropower Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative. No change is anticipated under the Equalized Summer/Winter Flood Risk Alternative or the Commercial Navigation Alternative. Cold-water tailwater biodiversity would not change from present conditions under any alternative. Overall, policy alternatives would result in minimal impacts on biodiversity over existing conditions.

Table 5.7-10 Summary of Impacts on Aquatic Resources by Policy Alternative

Alternative	Description of Impacts
Biodiversity – Tributary Reservoirs	
Base Case	No change – Benthic aquatic insect and mussel communities would still be affected by seasonal thermal stratification, low DO, and large water level fluctuations.
Reservoir Recreation A	No change – Benthic aquatic insect and mussel communities would still be affected by seasonal thermal stratification, low DO, and large water level fluctuations.
Reservoir Recreation B	Slightly adverse – Increased volume of water with low DO would reduce suitable habitat for cool-water species.
Summer Hydropower	Adverse – Shoreline fluctuation would adversely affect shoreline habitat.
Equalized Summer/ Winter Flood Risk	No change – Benthic aquatic insect and mussel communities would still be affected by seasonal thermal stratification, low DO, and large water level fluctuations.
Commercial Navigation	No change – Benthic aquatic insect and mussel communities would still be affected by seasonal thermal stratification, low DO, and large water level fluctuations.
Tailwater Recreation	Slightly adverse – Increased volume of water with low DO would reduce suitable habitat for cool-water species.
Tailwater Habitat	Slightly adverse – Increasing volumes of water with low DO in some reservoirs would reduce suitable habitat for cool-water and cold-water fish species, aquatic insects, and mussels.
Preferred	No change – Benthic aquatic insect and mussel communities would still be affected by seasonal thermal stratification, low DO, and large water level fluctuations.
Biodiversity – Mainstem Reservoirs	
Base Case	No change – Aquatic insect communities would remain fair; status of mussels in flowing portions would remain poor for riverine species and favorable for pool-adapted species.
Reservoir Recreation A	Slightly adverse – Increased volume of water with low DO would reduce suitable habitat.
Reservoir Recreation B	Slightly adverse – Increased volume of water with low DO would reduce suitable habitat.
Summer Hydropower	Slightly beneficial – Increased flow would decrease the amount of water with low DO during summer.
Equalized Summer/ Winter Flood Risk	No change to slightly adverse – Increase in volume of water with low DO in Guntersville Reservoir, yet considerable decrease in Kentucky Reservoir, would increase percent of non-acceptable habitat.
Commercial Navigation	Slightly beneficial – Although fewer days with DO <1 mg/L in Kentucky Reservoir, the peak volume of non-acceptable habitat in Kentucky is projected to increase substantially.

Table 5.7-10 Summary of Impacts on Aquatic Resources by Policy Alternative (continued)

Alternative	Description of Impacts
Biodiversity – Mainstem Reservoirs (continued)	
Tailwater Recreation	Slightly adverse – Increased volume of water with low DO would reduce suitable habitat.
Tailwater Habitat	Slightly adverse – Increased volume of water with low DO would reduce suitable habitat.
Preferred	Slightly adverse to slightly beneficial – Changes in DO concentrations and flows would result in some reservoirs improving (Guntersville), some staying the same (Kentucky), and some declining (Pickwick).
Biodiversity – Warm Tailwaters[2]	
Base Case	No change – Biodiversity would continue to be limited due to the restraints of a regulated system.
Reservoir Recreation A	No change to slightly adverse – Lower flow, DO concentrations, and temperature would result in slightly adverse conditions for Cherokee tailwater and no change in others.
Reservoir Recreation B	No change to slightly adverse – Decrease in water temperatures and reduced summer flow would adversely affect biodiversity, no change in water quality.
Summer Hydropower	Adverse – Decrease in the stability of daily water elevations and water quality would adversely affect biodiversity.
Equalized Summer/ Winter Flood Risk	No change – Biodiversity would continue to be limited due to the restraints of a regulated system.
Commercial Navigation	No change – Biodiversity would continue to be limited due to the restraints of a regulated system.
Tailwater Recreation	No change to slightly adverse – Decrease in water temperatures and reduced summer flow; no change in water quality.
Tailwater Habitat	No change to slightly adverse – Decrease in mean flows in Holston and French Broad, with no change in the Elk; slightly lower water temperatures in Holston; no other changes in water quality.
Preferred	No change to slightly adverse – Decreased flows and water temperatures in Holston River would adversely affect biodiversity; no change in Elk or French Broad Rivers.
Sport Fish – Tributary Reservoirs	
Base Case	No change – Conditions would continue to be stressful for cool-water species and favorable for warm-water species.
Reservoir Recreation A[2]	No change to slightly beneficial – Water quality would be similar to Base Case, but warm-water fish and aquatic insects would slightly benefit if aquatic plants become more abundant.
Reservoir Recreation B[2]	Slightly beneficial – Longer duration of high summer pool level and higher winter pool level would slightly increase aquatic habitat.

Table 5.7-10 Summary of Impacts on Aquatic Resources by Policy Alternative (continued)

Alternative	Description of Impacts
Sport Fish – Tributary Reservoirs (continued)	
Summer Hydropower	Slightly adverse to slightly beneficial – Volume of water with low DO would be reduced in some reservoirs and increased in others.
Equalized Summer/ Winter Flood Risk	Slightly adverse – Full summer pool level would be lower and achieved later in the year.
Commercial Navigation	No change to slightly beneficial – Slight increases in winter pool elevations may slightly aid sport fish populations.
Tailwater Recreation[2]	Slightly beneficial – Longer duration of high summer pool level and higher winter pool level would slightly increase aquatic habitat.
Tailwater Habitat	Slightly adverse – Low DO concentrations would increase.
Preferred	No change to slightly beneficial – Longer duration of high summer pool level would slightly increase potential for establishment of aquatic vegetation, which would increase aquatic habitat, as would increased winter pool levels.
Sport Fish – Mainstem Reservoirs	
Base Case	No change – Communities would continue to vary based on environmental conditions.
Reservoir Recreation A	No change to slightly adverse – Slight increase in volume of water with low DO during summer could adversely affect cool-water fish species; conditions for warm-water fish species would not change.
Reservoir Recreation B	No change to slightly adverse – Slight increase in volume of water with low DO in Guntersville would decrease cool-water fish habitat availability; no change in Pickwick, and slight decrease in Kentucky.
Summer Hydropower	No change to slightly beneficial – Slightly decreased volume of water with low DO would slightly increase suitable habitat.
Equalized Summer/ Winter Flood Risk	Slightly adverse – Slightly increased volume of water with low DO would slightly decrease suitable habitat.
Commercial Navigation	No change to slightly beneficial – Slightly fewer days with DO <1 mg/L.
Tailwater Recreation	No change to slightly adverse – Slight increase in volume of water with low DO in Guntersville would decrease cool-water fish habitat availability; no change in Pickwick, and slight decrease in Kentucky.
Tailwater Habitat	Adverse – Lower DO would result in less available habitat.
Preferred	Slightly adverse – Slightly increased volume of water with low DO would slightly decrease suitable habitat.
Sport Fish – Warm Tailwaters	
Base Case	No change – Communities would continue to vary based on environmental conditions.
Reservoir Recreation A	No change – Communities would continue to vary based on environmental conditions.

Table 5.7-10 Summary of Impacts on Aquatic Resources by Policy Alternative (continued)

Alternative	Description of Impacts
Sport Fish – Warm Tailwaters (continued)	
Reservoir Recreation B	No change to slightly beneficial – Decrease in hours of zero discharge from mainstem reservoirs in early spring would slightly enhance spawning conditions for migratory spawners.
Summer Hydropower	Slightly beneficial – Temperatures higher in tributary tailwaters due to less cold water storage in late summer would result in slightly adverse impact on cold-water fish species and slight benefit to warm-water species.
Equalized Summer/ Winter Flood Risk	Slightly adverse to slightly beneficial – Flows and temperatures would vary among reservoirs, benefiting cold-water fish species and resulting in slightly adverse impact on warm-water species.
Commercial Navigation	No change – Communities would continue to vary based on environmental conditions.
Tailwater Recreation	No change to slightly beneficial – Decrease in hours of zero discharge from mainstem reservoirs in early spring would slightly enhance spawning conditions for migratory spawners.
Tailwater Habitat	Slightly adverse to slightly beneficial – Decrease in water temperature would benefit cold-water fish species and result in slightly adverse impact on warm-water species.
Preferred	Slightly adverse to slightly beneficial – Slight decreases in water temperatures and flows below Cherokee Dam would result in slightly adverse impact on warm-water habitat; reduced hours of zero discharge from mainstem reservoirs in early spring would slightly enhance spawning conditions for migratory spawners.
Sport Fish – Cool-to-Warm Tailwaters	
Base Case	No change – Improvements would continue due to Reservoir Release Improvement (RRI) initiatives; warm-water species would continue to be limited.
Reservoir Recreation A	Slightly adverse to slightly beneficial – Fewer hours with water temperatures exceeding 20 °C would benefit cold-water fish species but would adversely affect warm-water species.
Reservoir Recreation B	Slightly adverse to slightly beneficial – Fewer hours with water temperatures exceeding 20 °C would benefit cold-water fish species but would adversely affect warm-water species.
Summer Hydropower	Slightly beneficial – Temperatures higher in tributary tailwaters due to less cold water storage in late summer would result in slightly adverse impact on cold-water fish species and slight benefit to warm-water species.
Equalized Summer/ Winter Flood Risk	Slightly adverse to slightly beneficial – Fewer hours with water temperatures exceeding 20 °C would benefit cold-water fish species but would adversely affect warm-water species.
Commercial Navigation	No change – Improvements would continue due to RRI initiatives; warm-water species would continue to be limited.

Table 5.7-10 Summary of Impacts on Aquatic Resources by Policy Alternative (continued)

Alternative	Description of Impacts
Sport Fish – Cool-to-Warm Tailwaters (continued)	
Tailwater Recreation	Slightly adverse to slightly beneficial – Fewer hours with water temperatures exceeding 20 °C would benefit cold-water fish species but would adversely affect warm-water species.
Tailwater Habitat	Slightly adverse to slightly beneficial – Decrease in water temperature would benefit cold-water fish species and result in slightly adverse impact on warm-water species.
Preferred	Slightly adverse to slightly beneficial – Fewer hours with water temperatures exceeding 20 °C would benefit cold-water fish species but would adversely affect warm-water species.
Sport Fish – Cool/Cold Tailwaters	
Base Case	No change – Improvements would continue due to RRI initiatives.
Reservoir Recreation A	Slightly adverse – Slightly increased number of hours with water temperatures exceeding 20 °C would be slightly adverse for trout.
Reservoir Recreation B	Slightly adverse – Slightly increased number of hours with water temperatures exceeding 20 °C would be slightly adverse for trout.
Summer Hydropower	Adverse – Increased hours with temperatures greater than 20 °C would be undesirable for trout.
Equalized Summer/ Winter Flood Risk	Slightly adverse – Slightly increased number of hours with water temperatures exceeding 20 °C would be slightly adverse for trout.
Commercial Navigation	No change – Improvements would continue due to RRI initiatives.
Tailwater Recreation	Slightly adverse – Slightly increased number of hours with water temperatures exceeding 20 °C would be slightly adverse for trout.
Tailwater Habitat	Adverse – Increased hours with temperatures greater than 20 °C would be undesirable for trout.
Preferred	Slightly beneficial – Decrease in number of hours with water temperatures greater than 20 °C would be slightly beneficial for trout.
Commercial Fisheries – Reservoirs	
Base Case	No change – Communities would continue to vary based on environmental conditions.
Reservoir Recreation A	Adverse – Volume of water with poor water quality would increase due to delayed summer drawdown.
Reservoir Recreation B	Adverse – Volume of water with poor water quality would increase due to delayed summer drawdown.
Summer Hydropower	Beneficial – Increase of flow through mainstem reservoirs would increase the water quality.
Equalized Summer/ Winter Flood Risk	Slightly adverse to adverse – Yearly volumes of water with poor DO conditions would increase.

Table 5.7-10 Summary of Impacts on Aquatic Resources by Policy Alternative (continued)

Alternative	Description of Impacts
Commercial Fish – Reservoirs (continued)	
Commercial Navigation	No change – Communities would continue to vary based on environmental conditions.
Tailwater Recreation	Adverse – Volume of water with poor water quality would increase due to delayed summer drawdown.
Tailwater Habitat	Adverse – Volume of water with low DO would increase in mainstem reservoirs.
Preferred	Slightly adverse to slightly beneficial – Number of days with DO <1 mg/L would decrease in Guntersville, increase in Pickwick, and not change in Kentucky and Douglas Reservoirs.

[1] Cold-water tailwaters are not included because resident communities are minimal due to the cold-water releases, and no alternative would change this general condition.

[2] Slight increase in volume of water with low DO during summer/fall would result in slightly adverse conditions for reservoir cold-water and cool-water species.

For sport fish concerns, there was no expected change or slight improvement in tributary reservoirs under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation Alternative, the Tailwater Recreation Alternative, and the Preferred Alternative. Under the Summer Hydropower Alternative, results for tributary reservoirs would be more variable, depending on species, and slightly adverse under the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative. Mainstem reservoirs would experience slightly adverse impacts on sport fish under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Preferred Alternative. Slightly beneficial results are anticipated under the Summer Hydropower Alternative and the Commercial Navigation Alternative, and adverse impacts are projected under the Tailwater Habitat Alternative. Overall, response of sport fish in tributary and mainstem reservoirs differs, and results depend more on water temperature preference in tributary reservoirs and DO requirements in mainstem reservoirs. Variable results were achieved when metrics indicated change, but changes were not consistent across all reservoir waterbodies assessed.

Metrics for warm-water tailwaters indicated that no change in status is anticipated under Reservoir Recreation Alternative A and the Commercial Navigation Alternative. No change to slightly beneficial results may occur under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, with variable results under the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative. The Summer Hydropower Alternative would adversely affect warm-water sport fish. Cool/cold tailwaters would experience no change or slight benefits under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation Alternative, the Tailwater Recreation Alternative, and the Preferred Alternative from decreasing water temperatures in cool-water waterbodies during late summer. Impacts under the Tailwater Habitat Alternative would be variable, as metric responses were mixed across waterbodies. Under the Summer Hydropower and Tailwater Habitat Alternatives, impacts on cold-water tailwaters would be adverse, and slightly adverse under the Equalized Summer/Winter Flood Risk Alternative. In cool-to-warm tailwaters, the Commercial Navigation Alternative is projected to result in no change in sport fisheries, while Reservoir Recreation Alternative B, the Summer Hydropower Alternative, and the Tailwater Recreation Alternative would result in no change to a slightly beneficial change in status. Reservoir Recreation Alternative A, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would cause variable results as cold-water species (trout) slightly benefit from cooler water temperatures in the late summer that would cause slightly adverse conditions for warm-water species.

Commercial fisheries would experience no change under the Commercial Navigation Alternative. Adverse or slightly adverse conditions may be achieved under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative from water quality changes in mainstem reservoirs, particularly Kentucky Reservoir. Under the Summer Hydropower Alternative, commercial fisheries would benefit from increased mainstem flow and improved summer water quality. Under the Preferred Alternative, conditions for commercial mussels are not projected to change, while those for commercial fish are projected to vary. Some areas are projected to experience slight improvements to water quality (DO concentrations), and others slight declines.

In conclusion, no policy alternative represents a clear benefit to aquatic resources. Metrics indicated that the Commercial Navigation Alternative would cause little change from the Base Case, with possibly some benefits. Biodiversity would generally not benefit under any alternative. Sport fish would experience the most potential benefits under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative. The Preferred Alternative projects some benefits to tributary reservoir and cool/cold tailwater sport fish. Variable results are anticipated for mainstem reservoir biodiversity, warm and cool-to-warm tailwaters, and commercial fishing. Commercial fisheries would generally experience adverse impacts under most alternatives due to decreased water quality (DO concentrations) and spring flows in mainstem reservoirs. Generally, impacts on commercial fisheries would be concentrated on mussels, as commercial fish species are mobile while mussels cannot behaviorally escape decreasing water quality conditions. Under the Preferred Alternative, no change is projected for commercial mussels. Commercial fish species in some areas would slightly benefit; in other areas, habitat conditions (DO concentrations) would decline slightly.

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5.8 Wetlands

5.8.1 Introduction

This section evaluates impacts on wetland locations, types, and functions for the Base Case and the policy alternatives. Because the individual alternatives would not affect all reservoirs in the same way, each policy alternative would not affect all wetlands associated with the reservoir system. Over time, changes in the timing and duration of surface water and soil saturation could change the locations, types, and functions—and as a result, the extents and distributions—of wetlands and the social, environmental, and economic values they provide.

Changes in wetland extent, distribution, and habitat connectivity would occur as conditions become wetter or drier. These changes include both short-term changes (changes that may occur within a decade or two) and long-term changes (changes that may continue over many decades or even centuries). Where increasing duration of water is an effect, there may be no place for wetlands to shift or expand into due to shoreline development or topography. In these areas, certain types of wetlands may be lost permanently.

Wetland vegetation types are generally adapted to particular water regimes; either too much or too little water can adversely affect all types of wetland vegetation. For example, flats and aquatic beds would be affected by changes in the timing and duration of exposure to water. Increased periods of exposure may reduce the extent of aquatic bed vegetation. Decreased periods of exposure may reduce the period of time available for the annual plant species that colonize flats (non-persistent emergents) to complete their lifecycles and set seed for subsequent generations.

The woody vegetation of forested and scrub/shrub wetlands is particularly sensitive to increased duration of water, which may result in loss of existing shrubs and trees, or slow attrition when seeds are prevented from germinating and establishing within the community to replace older individuals that have died. Some of these woody wetland vegetation types (particularly buttonbush scrub/shrub wetlands) may not be able to shift into new locations because current management regimes and climatic conditions are no longer favorable for their establishment. On the other hand, reduction in the level and duration of water may allow wetland vegetation to be invaded by upland or non-native species, changing vegetation composition and function.

The effects on water regimes were considered separately from the effects on wetland vegetation types, because the effects in many cases are different. Increased availability of water was assumed to enhance all wetland water regimes, and decreasing availability of water was assumed to diminish all wetland water regimes.

5.8.2 Impact Assessment Methods

Potentially affected wetlands were identified based on their occurrence within a projected groundwater area of influence. The groundwater area of influence was projected based on geologic modeling of the distance at which reservoir water levels cease to affect groundwater levels in each physiographic region in the study area (see Section 5.6 [Groundwater Resources] and Appendices D2 and D4a). In karst areas (limestone geology), this groundwater area of influence may fail to include a small number (statistically insignificant) of wetlands associated with affected springs and seeps that occur at a great distance from the reservoirs and tailwaters.

In general, the policy alternatives would affect mainstem and tributary systems differently. Different types of wetlands would be affected differently under each policy alternative, and these different types of wetlands are not distributed evenly among the individual reservoirs and tailwaters. For the purpose of comparison, reservoirs and tailwaters were assessed individually; and changes in mainstem reservoirs, tributary reservoirs, mainstem tailwaters, and tributary tailwaters, were compared separately.

Existing research and data did not permit quantification of potential changes in wetland extents (size and location) that might occur during the study period. Therefore, levels of impact were assessed according to the number of existing acres of wetlands that would be enhanced in function versus the number of acres that would be diminished in function. This method of assessment measures changes that would occur in the immediate future (in 1 to 5 years). The effects of the alternatives were compared by using the acreages of the affected types of wetlands weighted with a measure of the magnitude of the change caused by each alternative, and with the direction of the change (positive, zero, or negative impact) based on the alternative and the type of wetland.

For each alternative, mean changes in summer pool levels (duration and maximum elevation) and winter pool (maximum elevation) levels were compared with conditions under the Base Case to determine the magnitude of change each alternative would cause on water availability in wetlands. Changes in mainstem and tributary reservoirs were assessed separately. This magnitude of change was used to assess the degree to which proposed changes might affect wetland types and wetland functions. Changes in filling dates to reach summer pool were also evaluated. The Base Case was assigned a magnitude of zero for comparison.

For tailwaters, data generated by the water quality model was used to determine the magnitude of change each alternative would cause on water availability in wetlands. Relevant data from this analysis included minimum surface water elevations that are expected to occur during 90 percent of the year in tailwaters below dams. Mainstem and tributary tailwaters were evaluated separately because this modeling indicated that proposed changes in tailwaters would vary considerably between these two groups.

5.8.3 Base Case

Under the Base Case, wetlands would continue to follow existing trends. Overall, there would be minor but steady changes in wetland extents and distributions, shifts in wetland types, and a slow decline in wetland functions.

Wetland Location. Minor but steady declines in the extents and distributions of wetlands would continue, as discussed in Section 4.8. This decline in wetland extents and distributions also would result in a decrease in habitat connectivity.

Wetland Type. Wetland vegetation types are expected to follow existing trends. In general, acreage of scrub/shrub wetlands would increase, and the habitat quality and acreage of persistent emergent and forested wetlands would decline. National trend data for aquatic beds and flats are not available; however, TVA data show cyclical fluctuations in aquatic beds (see Section 4.9, Aquatic Plants) with large increases in coverage since the early 1960s following the introduction and establishment of Eurasian watermilfoil and more recently other invasive species such as hydrilla.

All wetland water regimes, shoreline wetlands, and surface-isolated wetlands are expected to follow existing trends. More than 22,000 acres of wetlands with controlled water levels on several reservoirs are expected to follow existing trends influenced by routine reservoir fluctuations (Table 4.8-02).

Wetland Function. Loss or degradation of wetland extents, distributions, and types would result in a general decline in all wetland functions. This would adversely affect wetland functions related to water quality, floodwater and stormwater storage, shoreline/bank stabilization and erosion control, carbon storage, wetland-upland community interspersion, and public use.

5.8.4 Reservoir Recreation Alternative A and Tailwater Habitat Alternative

Reservoir Recreation Alternative A would generally increase the availability of water by 4 to 7 weeks during the growing season, relative to the Base Case. This could cause slight shifts in the extents and distributions of wetlands and wetland types. The changes in the timing of the presence of water would adversely affect flats, scrub/shrub, and some forested wetlands. There would be a slight decrease in wetland functions. The Tailwater Habitat Alternative would result in some effects similar to those described for Reservoir Recreation Alternative A, especially on mainstem reservoirs. However, changes in water availability and wetland types would be more pronounced on tributaries under the Tailwater Habitat Alternative, where the duration of summer pool levels on affected reservoirs would increase up to 24 weeks longer than conditions under the Base Case and up to 16 weeks longer than under Reservoir Recreation Alternative A (see Appendix D4b for additional details).

Wetland Location. Over time, changes in the timing and duration of surface water and soil saturation under Reservoir Recreation Alternative A and the Tailwater Habitat Alternative would lead to slight increases in the extents and distributions of wetlands. Similar increases in wetland habitat connectivity would occur.

Wetland Type. Under Reservoir Recreation Alternative A, the extended duration of summer pool levels would positively affect aquatic bed and emergent wetlands, because more water would be available during the growing season to wetlands on affected mainstem and tributary reservoirs and tailwaters. Aquatic beds may experience some decline in deeper water zones, but this loss may be offset by expansion of submersed aquatic plants into the drawdown zone. The additional time that water is present in the wetland during the growing season would negatively affect flats, scrub/shrub, and some forested wetlands. Some already stressed forested wetlands would be stressed beyond existing conditions. Overall, Reservoir Recreation Alternative A would result in a negative effect on wetland vegetation types. The types of impacts resulting from the Tailwater Habitat Alternative would generally be the same as those for Reservoir Recreation Alternative A, but the magnitude of adverse impacts would be greater compared to those under Reservoir Recreation Alternative A.

The extended duration of summer pool levels on affected mainstem and tributary reservoirs and tailwaters would increase availability of water in all wetland water regimes, shoreline wetlands, and surface-isolated wetlands in the groundwater influence zone.

The increase in winter pool elevations could interfere with controlled wetlands on Wheeler and Douglas Reservoirs. Increases in winter pool elevations could interfere with dewatering efforts in managed wetlands on affected reservoirs. Late-season flooding on these reservoirs could also jeopardize crops planted for wildlife. Adverse impacts could increase costs to invested agencies, including maintenance and replacement costs of associated infrastructure (such as access roads, signage, levees, pumps, and monitoring equipment) (see Section 4.8.3 for more details).

Wetland Function. Systemwide, Reservoir Recreation Alternative A and the Tailwater Habitat Alternative would result in a net moderate decrease in wetland functions related to floodwater and stormwater storage and water quality because of changes in wetland extents, distributions, and types. A moderate increase in wetland functions related to shoreline/bank stabilization and erosion control, carbon storage, wetland-upland community interspersion, and all other general functions provided by all wetland types may result from changes in wetland extents, distributions, and types.

5.8.5 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Reservoir Recreation Alternative B and the Tailwater Recreation Alternative would cause a major increase in the availability of water from 9 to 11 weeks during the growing season; this could cause moderate shifts in the extents and distributions of wetlands and wetland types (Appendix D4b). The changes in the timing of the presence of water would adversely affect flats, scrub/shrub, and forested wetlands. Changes would occur faster than wetland plant communities could adapt. There would be an overall decrease in wetland functions.

Wetland Location. Over time, changes in the timing and duration of surface water and soil saturation could lead to minor increases in the extents and distributions of wetlands. Similar increases in habitat connectivity would occur.

Wetland Type. Under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, the extended duration of summer pool levels would positively affect aquatic bed and emergent wetlands because more water would be available during the growing season to wetlands on affected mainstem and tributary reservoirs and tailwaters. The additional time that water is present in the wetland during the growing season would negatively affect flats, scrub/shrub, and forested wetlands. Many affected scrub/shrub and forested wetlands would die back faster than they would expand into new suitable habitat. In areas where expansion could occur, scrub/shrub communities might develop within 5 to 10 years; forests would require a period of decades to reach maturity. Overall, Reservoir Recreation Alternative B and the Tailwater Recreation Alternative would negatively affect wetland vegetation types.

The extended duration of summer pool levels on affected mainstem and tributary reservoirs and tailwaters would increase availability of water in all wetland water regimes, shoreline wetlands, and surface-isolated wetlands in the groundwater influence zone.

The increase in winter pool elevations could interfere with those wetlands with controlled water levels on Kentucky, Wheeler, and Douglas Reservoirs.

Wetland Function. Systemwide, Reservoir Recreation Alternative B and the Tailwater Recreation Alternative would result in a net moderate decrease in wetland functions related to floodwater and stormwater storage and water quality due to changes in wetland extents, distributions, and types. A moderate increase in wetland functions related to shoreline/bank stabilization and erosion control, carbon storage, wetland-upland community interspersion, and all other general functions provided by all wetland types may result from changes in wetland extents, distributions, and types.

5.8.6 Summer Hydropower Alternative

The Summer Hydropower Alternative would decrease the mean summer pool duration on reservoirs for about 10 weeks (range -4 to -25 weeks), thus reducing the availability of water in wetlands during the growing season (Appendix D4b). This would result in major shifts or losses in wetland extents and distributions, degradation of most vegetated wetlands, and major loss of wetland functions. Changes would occur faster than wetland plant communities could adapt. Overall, the Summer Hydropower Alternative would result in the most adverse effects on wetlands of all of the alternatives.

Wetland Location. Over time, changes in the timing and duration of surface water and soil saturation would lead to substantial decreases in the extents and distributions of wetlands. Similar decreases in habitat connectivity also would occur.

Wetland Type. The reduction in summer pool levels would adversely affect aquatic beds and persistent emergent, scrub/shrub, and forested wetlands of all affected reservoirs and tailwaters. Overall, the Summer Hydropower Alternative would adversely affect wetland vegetation types.

The reduction in water availability during spring and summer would potentially positively affect flats because they would be exposed earlier in the year. However, too much exposure of flats could dry them out so that insufficient moisture remains for germination of seeds of nonpersistent emergent plants. On mainstem and tributary reservoirs, the decreased water availability would negatively affect aquatic bed, emergent, and forested wetlands, because there would not be enough water during the growing season to support these wetland plants. Potential effects on scrub/shrub wetlands could be either positive or negative depending on drawdown rates and summer pool management in reservoirs. If drawdown rates proceed slowly, these vegetation types may expand into the drawdown zone. If drawdown rates increase too quickly or erratically, these important wetlands could lose their most important source of water and dry up before they could migrate into other suitable habitat.

The earlier drawdown and shorter summer pool duration on affected mainstem and tributary reservoirs would decrease availability of water in all wetland water regimes, shoreline wetlands, and surface-isolated wetlands in the groundwater influence zone. The increase in winter pool elevations could interfere with wetlands with controlled water levels on Douglas Reservoir.

Wetland Function. Systemwide, the Summer Hydropower Alternative would result in a substantial increase in summer floodwater and stormwater storage function of wetlands, because less water would be stored in affected reservoirs during summer months. A major decrease in wetland functions related to water quality, shoreline/bank stabilization and erosion control, carbon storage, wetland-upland community interspersion, and other general functions provided by all wetland types may result from changes in wetland extents, distributions, and types.

5.8.7 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative would change the mean summer pool duration by -11 to +8 weeks on affected reservoirs compared to the Base Case. On mainstem reservoirs, summer filling dates would be delayed from 4 to 7 weeks. On tributary reservoirs, summer pool elevations would change from -21 to +3 feet relative to the Base Case (Appendix D4b). These changes in water availability would greatly alter the timing and availability of water during the growing season for most wetlands. This would result in damage to scrub/shrub and forested wetlands, particularly on tributary reservoirs where these wetland types are already limited in abundance and extent. Changes would occur faster than wetland plant communities could adapt.

Wetland Location. Over time, changes in the timing and duration of surface water and soil saturation would lead to major decreases in the extents and distributions of wetlands. Similar decreases in habitat connectivity would occur.

Wetland Type. By delaying summer pool filling dates on both mainstem and tributary reservoirs and having lower summer pool elevations on tributary reservoirs, aquatic beds, scrub/shrub, and forested wetlands on all affected reservoirs and tailwaters would be adversely affected.

The impact analysis methodology shows potential enhancement to flats in mainstem reservoirs and tailwaters and tributary reservoirs under the Equalized Summer/Winter Flood Risk Alternative. In general, lower summer water levels, especially on tributary reservoirs, would expose flats more during the year; but there is valid concern that too much summer drying would deplete the soil moisture necessary for seed germination and growth of non-persistent emergent plants. Higher winter pool elevations would drown out plants that were able to begin establishing themselves on exposed flats. The increased exposure of flats might also increase the opportunity for upland or invasive plants to colonize exposed flats. Because of these factors, the overall effect for flats would be adverse, and the overall effect for aquatic beds would be variable on tributary reservoirs under the Equalized Summer/Winter Flood Risk Alternative.

Impacts on scrub/shrub and forested wetlands would be especially harmful on tributary reservoirs where these vegetation types are somewhat uncommon. The decrease in summer pool elevations on tributary reservoirs would isolate these wetlands from their most important source of water, resulting in a net loss of these wetlands on affected reservoirs. Changes in water regimes would occur faster than these wetland types could adapt to new conditions.

The reduction in water availability during spring and early summer would negatively affect aquatic bed, flats, emergent, scrub/shrub, and forested wetlands because there would not be enough water during the growing season to support these wetland plants. Overall, effects of the Equalized Summer/Winter Flood Risk Alternative would result in negative system-wide impacts on wetland vegetation types.

On affected mainstem and tributary reservoirs and tailwaters, the reduced availability of water in all wetland water regimes would adversely affect shoreline wetlands and surface-isolated wetlands in the groundwater influence zone. The increase in winter pool elevations on Wheeler and Douglas Reservoirs could interfere with wetlands having controlled water levels on these reservoirs.

Wetland Function. Loss or degradation of wetland extents, distributions, and types would result in a major decrease in all wetland functions. This would adversely affect wetland functions related to water quality, floodwater and stormwater storage, shoreline/bank stabilization and erosion control, carbon storage, wetland-upland community interspersion, and public use.

5.8.8 Commercial Navigation Alternative

The Commercial Navigation Alternative would increase winter pool levels up to 2 feet over Base Case conditions on seven mainstem reservoirs (Appendix D4b). This increase would cause minor changes in water availability. Effects on wetland extents, distributions, types, and functions would be minor. The increase in winter pool levels on affected reservoirs would primarily reduce exposure of flats during winter months. Higher winter pools would also have slightly adverse effects on scrub/shrub and forested wetland types. The Commercial Navigation Alternative would not affect flood and stormwater storage, carbon storage, wetland-upland community interspersion, and all other general wetland functions

5.8.9 Preferred Alternative

The Preferred Alternative would extend the duration of summer pool on most reservoirs and delay spring fill dates on three mainstem reservoirs (Chickamauga, Watts Bar, and Fort Loudoun). The Preferred Alternative would generally increase the availability of water by 4 to 9 weeks during the growing season on affected reservoirs. This could cause slight shifts in the extents and distributions of wetlands and wetland types. Changes in the timing of the presence of water would adversely affect vegetated flats, scrub/shrub, and certain forested wetlands. There would be a slight decrease in wetland functions. The Preferred Alternative would result in effects that are similar to but less than those described for Reservoir Recreation Alternative A and the Tailwater Habitat Alternative (see Appendix D4b for additional details).

Wetland Location. Over time, changes in the timing and duration of surface water and soil saturation under the Preferred Alternative could lead to slight increases in the extents and distributions of wetlands. There could be some opportunities for new wetlands to develop as a result of the extension of summer pools. These opportunities for increases would be limited, because the capillary fringe would not extend much beyond its current extent. Other limiting factors for new wetland formation are the availability of suitable soils, topography, and suitable landforms. Any increase in extent of wetlands could lead to similar increases in wetland habitat connectivity.

Wetland Type. The additional time that water is present in wetlands during the growing season would adversely affect flats, scrub/shrub, and many forested wetlands and would positively affect aquatic bed and persistent emergent wetlands. Many flats, especially those supporting nonpersistent emergent wetlands, would be limited in their exposure and development. Many nonpersistent emergent communities could revert to unvegetated flats, because they could not complete their growth cycles and produce viable seed. Eventually these nonpersistent wetland communities could die off and be replaced by upland species or exotic, invasive pest plants.

Scrub/shrub and forested wetlands that are currently under extreme environmental stress (e.g., buttonbush swamps) would not respond well to prolonged flooding. Many scrub/shrub communities could die off and be replaced by aquatic beds in the drawdown zone and emergent communities in drier habitat.

Increased availability of water during the growing season could stress trees in temporarily and seasonally flooded or saturated forested wetlands to the point that they begin to die. Dominated tree species in these wetland types are not adapted to prolonged flooding or soil saturation. Many temporarily and seasonally flooded or saturated forested wetlands could convert to scrub/shrub and emergent communities in the ROS planning period to year 2030. Eventually, more water-tolerant tree species may colonize these wetter sites, but new forested wetlands would require many decades to develop and mature.

Changes in aquatic beds would likely be positive because of longer summer pools, but the health and vigor of aquatic beds depend on many environmental factors in addition to water levels (see Section 5.9, Aquatic Plants). Persistent emergent wetlands would likely adapt well to the extension of summer pool conditions due to their ability to withstand prolonged flooding and/or soil saturation and adaptations that allow them to reproduce vegetatively as well as by seed dispersal.

Over time, the Preferred Alternative could produce some major shifts in distribution of wetland types. Negative effects on flats, scrub/shrub, and forested wetlands would persist. Overall, the Preferred Alternative would result in a negative effect on wetland vegetation types. Effects would be negative on vegetation types of mainstem reservoirs, mainstem tailwaters, and tributary reservoirs, and neutral on tributary tailwaters.

Because winter pool levels would not change relative to the Base Case, wetlands with artificially controlled water levels would not be affected by the Preferred Alternative.

Wetland Function. Systemwide, the Preferred Alternative would result in a net moderate decrease in wetland functions related to floodwater and stormwater storage and water quality due to changes in wetland extents, distributions, and types. A moderate increase in wetland functions related to shoreline/bank stabilization and erosion control, carbon storage, wetland-upland community interspersion, and all other general functions provided by all wetland types may result from changes in wetland extents, distributions, and types.

5.8.10 Summary of Impacts

The largest impacts of the proposed alternatives are the potential effects on wetland extents and wetland vegetation types (Table 5.8-01). These changes in wetland extents and types would result in corresponding changes in wetland functions and the social, environmental, and economic values they provide. Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would increase the availability of water to wetlands. The changes in the availability of water to wetlands would improve opportunities for some new wetlands to develop in suitable habitat. However, the same changes that would encourage new wetland formation would adversely affect existing wetland vegetation types, in particular flats, scrub/shrub, and forested wetlands. Wetland vegetation types dominated by woody plants (scrub/shrub and forested wetlands) would require decades to recover from these changes. Forested wetlands would be particularly slow to recover, because trees require decades to become established and reach maturity.

The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would result in negative impacts on both wetland extents and types. Both of these alternatives would result in an overall decrease in availability of water to wetlands during the growing season. Under the Equalized Summer/Winter Flood Risk Alternative, the decrease in summer pool elevations on tributary reservoirs would isolate these wetlands from their most prevalent source of water. This hydrologic isolation would effectively eliminate scrub/shrub and forested wetlands from tributary reservoirs. Both the Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would adversely affect scrub/shrub and forested wetland communities on tributary reservoirs.

5.8 Wetlands

The Base Case and the Commercial Navigation Alternative would result in the least adverse impacts on wetlands on both mainstem and tributary reservoirs and tailwaters.

Overall, Reservoir Recreation Alternative A, Reservoir Recreation Alternative B; the Summer Hydropower Alternative, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would result in negative effects on wetlands. The Summer Hydropower Alternative would result in the most adverse impacts compared to the other alternatives. The Base Case and the Commercial Navigation Alternative would result in the greatest possible net positive impacts on wetlands.

Table 5.8-01 **Summary of Impacts on Wetland Resources by Policy Alternative**

Alternative	Description of Impacts
Base Case	No change – Wetlands would continue to follow existing trends. There would be minor but steady changes in wetland extents and distributions, shifts in wetland types, and a slow decline in wetland functions overall.
Reservoir Recreation A	Slightly adverse – The availability of water would generally increase during the growing season. This would cause slight shifts in the extents and distributions of wetlands and wetland types. The changes in the timing of the presence of water would adversely affect flats, scrub/shrub and forested wetlands. However, there would be positive effects on aquatic bed and persistent emergent wetlands. There would be a slight decrease in wetland functions overall.
Reservoir Recreation B	Adverse – The major increase in the availability of water during the growing season would cause moderate shifts in the extents and distributions of wetlands and wetland types. The changes in the timing of the presence of water would adversely affect flats, scrub/shrub and forested wetlands. Changes would occur faster than wetland plant communities could adapt However, there would be positive effects on aquatic bed wetlands. There would be a moderate decrease in wetland functions overall.
Summer Hydropower	Substantially adverse – The availability of water would be greatly decreased in wetlands during the growing season. This would result in major shifts or losses in wetland extents and distributions and the degradation of most vegetated wetlands, resulting in a major loss in wetland functions.
Equalized Summer/Winter Flood Risk	Substantially adverse – The timing and availability of water would be reduced in wetlands during the growing season for most wetlands. This would result in adverse effects on flats, scrub/shrub and forested wetlands, particularly on reservoirs where they are already limited in abundance. Changes would occur faster than wetland plant communities could adapt. There would be a major decrease in wetland functions overall.
Commercial Navigation	No change – There would be minor changes in water availability. Effects on wetland extents, distributions, types, and functions would be similar to the Base Case. The Commercial Navigation Alternative would affect wetlands at the least number of reservoirs.
Tailwater Recreation	Adverse – There would be a major increase in the availability of water during the growing season that would cause moderate shifts in the extents and distributions of wetlands and wetland types. Changes in the timing of the presence of water would adversely affect flats, scrub/shrub and forested wetlands. Changes would occur faster than wetland plant communities could adapt. However, there would be positive effects on aquatic bed wetlands. There would be a moderate decrease in wetland functions overall.
Tailwater Habitat	Slightly adverse – The availability of water would generally increase during the growing season. This would cause slight shifts in the extents and distributions of wetlands and wetland types. The changes in the timing of the presence of water would adversely affect flats, scrub/shrub and forested wetlands. However, there would be positive effects on aquatic bed and persistent emergent wetlands. There would be a slight decrease in wetland functions overall.
Preferred	Slightly adverse – The availability of water would generally increase during the growing season. This would cause slight shifts in the extents and distributions of wetlands and wetland types. The changes in the timing of the presence of water would adversely affect flats, scrub/shrub and forested wetlands. However, there would be positive effects on aquatic bed wetlands. There would be a slight decrease in wetland functions overall.

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5.9 Aquatic Plants

5.9.1 Introduction

Changes in water elevation or duration have the potential to affect the following factors related to aquatic plants: area of total plant coverage, area of invasive species coverage, and composition of plant communities. However, the effects of environmental factors beyond human control and prediction, such as weather and the hydrologic cycle, are overriding factors in determining increases or decreases in coverage of aquatic plants and invasive aquatic plants. These factors cannot be managed and would transcend most changes in water management or drawdown regime. Thus, while the following discussion of reservoir operations policy alternatives is based on qualitative metrics, these estimates must be viewed in the context of natural event cycles.

The primary qualitative metric used for impact comparison was a change in coverage (in acres), although community composition changes are also discussed. A change in coverage includes either an increase or a decrease in the vegetated acres. Change can be seen as adverse or beneficial, depending on the reader's perspective. For example, increases in plant coverage are generally considered beneficial by bass anglers and fisheries and wildlife managers. These same increases may be viewed as undesirable by shoreline property owners and recreational boaters. Consequently, the impacts discussed below are not described as adverse or beneficial. Due to their dominance, any increase or decrease in aquatic plant coverage discussed below was assumed to be mostly a change in invasive species coverage.

5.9.2 Impact Assessment Methods

The policy alternatives were divided into groups based on similar changes in water elevations and durations. Table 5.9-01 (see Section 5.9.10) lists generalized operational changes in the reservoirs (for example, higher winter pool elevations and more rapid water drawdown), and their potential effects on the aquatic plants in the mainstem and tributary reservoirs. However, a majority of these impacts, particularly those on the mainstem reservoirs, would be overridden by the natural hydrologic and climatic variability in the system. Some of the impacts anticipated on the tributary reservoirs may fall outside the range of natural variability; nevertheless, they still would be relatively small scale.

Both storage and run-of-river reservoirs have been included in the analyses below. Because of operational differences, the potential for impacts on aquatic plants on storage reservoirs would be greater than on run-of-river reservoirs. Impacts occurring on storage reservoirs could result from changes in water elevations and durations. Run-of-river reservoirs would not undergo substantial changes in water elevations or durations. On these reservoirs, therefore, aquatic plant and aquatic invasive plant coverage would continue to increase or decrease based primarily on the natural fluctuation associated with hydrologic and climatic events and hydrogeneration schedules.

5.9 Aquatic Plants

All impacts caused by the proposed alternatives and discussed below are ranked "low" in terms of substantially affecting the Tennessee River watershed because all impacts would be overridden by the natural variability in the system or the small scale of any measurable impact.

Substantial increases in algal biomass have the potential to decrease the amount of light available for aquatic plant growth. As discussed in detail in Section 5.4, Water Quality, regression analysis for chlorophyll-a concentrations indicated that the proposed alternatives are not anticipated to substantially alter the algal biomass of either the mainstem or tributary reservoirs. Changes in algal biomass that can be attributed to the proposed alternatives are anticipated to be less than 10 percent, which is within the range of the present natural variation of the system. Chlorophyll-a concentration in samples collected in 2002, a year when flows approximated those of several of the alternatives, indicated higher levels of chlorophyll-a than predicted by the regression analysis for several mainstem reservoirs. Coverage of aquatic macrophytes slightly increased or remained stable in all mainstem reservoirs in 2002 (Table 4.9-02); indicating no clear short-term inverse relationship between chlorophyll-a concentrations and aquatic macrophyte coverage. As discussed in Section 4.9.3, data were not available for trends in coverage of riverine plants of the Tennessee Valley. Although some of the alternatives may substantially change the velocity and duration of water flow, which could lead to scouring of habitat areas, community species shift, or reductions of light due to increased sediment load, these changes could not be measured with available information and were not included in the alternatives analyses below.

Impacts for each of the policy alternatives on overall populations of most emergent, invasive, or nuisance species listed in Table 4.9-01 are expected to be similar to changes in emergent wetlands discussed in Section 5.8, Wetlands. An exception is American lotus, where changes are likely to be more similar to those of submersed and floating-leaved aquatic plants. Historically, many of the emergent, invasive plants (e.g., purple loosestrife, common reed, and reed canary grass) in Table 4.9-01 have not been a widespread nuisance on TVA reservoirs. However, emergent invasive plants could become more abundant in situations where propagule sources (e.g., seeds, rhizomes, and fragments) are readily available and in additional areas of suitable habitat that become available for colonization. Invasive emergent species with existing large, established populations—such as alligatorweed, Uruguayan waterprimrose, water smartweed, and giant cutgrass—would likely have the highest potential for expansion, especially on mainstem reservoirs.

Few changes in invasive and nuisance emergent plant populations are expected for the Commercial Navigation Alternative compared to the Base Case. Several of the alternatives (e.g., Reservoir Recreation Alternative A, the Tailwater Habitat Alternative, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Preferred Alternative; and the Equalized Summer/Winter Flood Risk Alternative on mainstem reservoirs) may allow expansion of emergent wetlands (see Section 5.8) and would maintain and possibly enhance habitat for the expansion of invasives. These same policy alternatives that positively affect emergent communities would adversely affect shrub/scrub and forested wetlands by increasing the duration of surface water and soil saturation. This could provide additional opportunities for expansion of invasive emergents into "open" habitats caused by the decline of these wetland types. The remaining alternatives (the Summer Hydropower Alternative and Equalized Summer/Winter Flood Risk Alternative on tributary reservoirs) that negatively affect emergent wetlands by decreasing the duration of surface water and soil saturation could reduce populations of emergent and nuisance invasive plants. However, some emergent invasive species (e.g., purple loosestrife, common reed, reed canary grass, and alligatorweed) that sometimes colonize drier sites might expand into the upper drawdown zone under the Summer Hydropower Alternative on both mainstem and tributary reservoirs as the water recedes. In the short term, these same species might also colonize the habitat opened by the lower summer pool elevations on tributary reservoirs und the Equalized Summer/Winter Flood Risk Alternative. In the long term, these species would likely be replaced by terrestrial plants that would colonize this zone.

5.9.3 Base Case

The Base Case would continue existing water drawdown regimes. As shown in Figure 4.9-01, plant coverage has widely fluctuated naturally under existing operations. Under the Base Case, therefore, aquatic plant and aquatic invasive plant coverage on all mainstem and tributary reservoirs would continue to increase or decrease based primarily on the natural fluctuation associated with hydrologic and climatic events.

5.9.4 Commercial Navigation Alternative

The Commercial Navigation Alternative is similar to the Base Case but differs by raising winter pool levels where possible on the mainstem storage reservoirs. Aquatic plant and aquatic invasive plant coverage on mainstem and tributary storage reservoirs would continue to increase or decrease based primarily on the natural fluctuation associated with hydrologic and climatic events. Higher winter levels on mainstem storage reservoirs could favor the establishment and expansion of species such as Eurasian watermilfoil and hydrilla into areas of the drawdown zone that are presently colonized primarily by spinyleaf naiad and other annuals.

5.9.5 Reservoir Recreation Alternative A and Tailwater Habitat Alternative

Under Reservoir Recreation Alternative A and the Tailwater Habitat Alternative, summer or near-summer pool elevations would be held for a longer duration and winter pool elevations would be raised where possible. On the tributary storage reservoirs, summer pool levels under the Tailwater Habitat Alternative would be held longer than those under Reservoir Recreation Alternative A. Little change in plant coverage is expected on mainstem storage reservoirs for either alternative. Coverage of Eurasian watermilfoil and hydrilla colonies could decrease slightly on the deep-water side of the colonies due to a reduction in light penetration. Aquatic plants in the drawdown zone could slightly increase due to longer summer pools. Higher winter water levels on the mainstem storage reservoirs could favor the establishment and expansion of species such as Eurasian watermilfoil and hydrilla into some areas of the drawdown zone that are presently colonized primarily by spinyleaf naiad and other annuals. Because of longer summer pool levels, aquatic plant coverage could slightly increase in tributary storage reservoirs in flatter areas with suitable substrate, especially if the increase in winter water elevation is sufficient to dampen the drawdown amplitude to less than 10 feet. Under the Tailwater Habitat Alternative, the potential for slightly larger increases in plant coverage on tributary storage reservoirs could occur because of summer pool levels extending longer into fall. Invasive aquatic plants such as spinyleaf naiad and other annuals could colonize these areas.

5.9.6 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Reservoir Recreation Alternative B and the Tailwater Recreation Alternative would fill storage reservoirs to summer pool elevations and hold the water at these elevations until Labor Day—later in the year than existing operating guidelines but not as late as under the Tailwater Habitat Alternative. Winter water elevations would be increased, where possible. Little change in plant coverage on mainstem storage reservoirs is anticipated. Coverage of Eurasian watermilfoil and hydrilla colonies could decrease slightly on the deep-water side of the colonies due to a reduction in light penetration. Aquatic plants in the draw down zone could slightly increase due to longer summer pools. Higher winter water levels on mainstem storage reservoirs could favor the establishment and expansion of species such as Eurasian watermilfoil and hydrilla into some areas of the drawdown zone that are presently colonized primarily by spinyleaf naiad and other annuals. A slight increase in coverage could occur on tributary storage reservoirs with a large drawdown (over 10 feet). On a few tributary storage reservoirs (for example, the Chatuge and South Holston), where the amplitude of drawdown is reduced to less than 10 feet, slightly larger increases in coverage could occur where suitable substrate exists. Invasive aquatic annuals such as spinyleaf naiad could have the highest potential for establishment.

5.9.7 Summer Hydropower Alternative

Under the Summer Hydropower Alternative, drawdown would begin in June to increase power production. On mainstem storage reservoirs, the potential exists for substantial decreases (estimated at 10 to 40 percent reduction) in total plant coverage (primarily spinyleaf naiad and other annuals) growing in the upper portion of the drawdown zone. Decreases in total coverage would be greater in reservoirs such as Chickamauga with a large drawdown (about 7 feet) and less in reservoirs like Guntersville with a small drawdown (2 feet). A slight expansion of Eurasian watermilfoil and hydrilla into deeper areas could occur because of increased light penetration (due to less water to filter light through). In most tributary storage reservoirs where higher winter water levels would occur, a slight decrease in overall coverage is anticipated because water levels would not be elevated long enough during summer for annual plants to complete their seed cycle.

5.9.8 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative would result in lower summer pool water elevations and higher winter pool elevations on the tributary storage reservoirs, and later-filling, longer summer pool water elevations that are reduced quickly on the mainstem storage reservoirs (similar to Reservoir Recreation Alternative B but with a faster drawdown). This modification may result in a wide variety of effects, depending on how much the water levels vary from the existing regime. A slight decrease in plant coverage on mainstem reservoirs is anticipated. Coverage of Eurasian watermilfoil and hydrilla colonies could decrease slightly on the deepwater side of the colonies due to a reduction in light penetration. Aquatic plants in the drawdown could decrease slightly due to the delayed fill, although extended pool to later in the growing season could offset some of the decrease. Decreases under the Equalized Summer/Winter Flood Risk Alternative likely would be greater than under the remaining alternatives, except for the Summer Hydropower Alternative. Lower summer water elevations on tributary storage reservoirs could slightly decrease existing small populations of plants by dewatering the upper contours. The longer summer pool levels and decreased drawdown could slightly increase submersed and floating-leaved plants in flatter areas with suitable substrate, particularly in some reservoirs (for example, Chatuge) where the drawdown is less than 10 feet.

5.9.9 Preferred Alternative

The Preferred Alternative would result in a delayed fill in Chickamauga and upstream mainstem reservoirs, and extended summer pool elevations on several mainstem reservoirs. Summer pool levels would extend to Labor Day on tributary reservoirs, and winter water levels would be raised where possible. Little change in plant coverage on mainstem reservoirs is anticipated. In reservoirs with extended summer pool elevation, coverage of Eurasian watermilfoil and hydrilla colonies could decrease slightly on the deep-water side of the colonies due to a reduction in light penetration. Aquatic plants in the upper portion of drawdown zone could decrease slightly in reservoirs with delayed fill. This decrease could be offset by the extended summer pool levels.

The extended summer pool elevations and decreased drawdown in tributary reservoirs could slightly increase submersed and floating-leaved plants in flatter areas with suitable substrate, particularly in some reservoirs (for example, Chatuge) where the drawdown is reduced to less than 10 feet. Invasive aquatic annuals such as spinyleaf naiad could have the highest potential for establishment.

5.9.10 Summary of Impacts

Table 5.9-01 describes impact analysis considerations related to aquatic and invasive aquatic plants by operating option. Table 5.9-02 provides a summary of impacts on aquatic plants in mainstem and tributary reservoirs by policy alternative. Except for the Summer Hydropower Alternative, the policy alternatives would not cause aquatic plant and aquatic invasive plant coverage to change substantially from the Base Case on all the mainstem reservoirs and a majority of the tributary reservoirs. Potential coverage changes on mainstem reservoirs for alternatives other than the Summer Hydropower Alternative would be slight, and during most years natural environmental factors, such as weather and the hydrologic cycle, would override the effects of these alternatives in determining aquatic plant and invasive aquatic plant growth or decline. An exception is the Equalized Summer/Winter Flood Risk Alternative, where a slight decrease in coverage might occur during some years. Some of the impacts anticipated on the tributary reservoirs may fall outside the range of natural variability during some years; nevertheless, they still would be relatively small scale.

Table 5.9-01 Impact Analysis Considerations Related to Aquatic Plants by Operating Characteristic

Operating Characteristic	Impacts on Aquatic Plants in Mainstem Reservoirs	Impacts on Aquatic Plants in Tributary Reservoirs
Summer pool elevations held past present drawdown date	Because these plants have already completed their life cycle, little increase or decrease in coverage is expected; slight decrease or no expansion of Eurasian watermilfoil and hydrilla into deeper contours because of light limitations; slight increase in drawdown zone coverage due to longer growing season, and possibly more Eurasian watermilfoil/hydrilla in drawdown zone during summer.	Not many exist here; potential slight increase in coverage in flatter areas where habitat and substrate exist—primarily the annual/naiad mix, which can complete seed production before dewatering.
Higher winter pool elevations	In some mainstem reservoirs, potential to increase coverage of Eurasian watermilfoil and hydrilla because not dewatered; reducing area of drawdown zone would result in decreased coverage of annual/naiad mix.	Decreased amplitude of fluctuation to 10 feet or less in higher winter pool levels would increase potential for plants to colonize suitable habitat areas, which could increase coverage.
Lower summer pool elevations	Potential to decrease coverage in upper contours by reducing inundated habitat; increased light levels would allow expansion of Eurasian watermilfoil and hydrilla into deeper contours.	Not many exist here; reducing inundated habitat in upper portion of drawdown zone may result in slight decreases in the few existing populations.
Faster drawdowns, dewatering earlier in year	Shorter growing season could decrease coverage, especially in drawdown zone; annual species such as naiads and pondweeds may not be able to complete their seed cycles; may see species shift to perennial species with growth from underground propagules or to species that can complete their life cycles; possible expansion of hydrilla and Eurasian watermilfoil due to increased light penetration.	Not many exist here; decrease in the few existing populations and decrease in potential for establishment of additional populations.

Note: This table is applicable to storage reservoirs; run-of-river reservoirs would not experience large water elevation fluctuations under the policy alternatives.

Table 5.9-02 Summary of Impacts on Aquatic and Invasive Aquatic Plants by Policy Alternative

Alternative	Description of Impacts
Base Case	Aquatic and invasive aquatic plant coverage on mainstem and tributary reservoirs would continue to increase or decrease based primarily on natural fluctuation associated with hydrologic and climatic events.
Reservoir Recreation A	Little change in plant coverage is expected on mainstem reservoirs; a species shift could occur between increasing and decreasing communities of invasive plant species. Due to longer summer pool levels, aquatic plant coverage could increase slightly in some tributary reservoirs, especially if increase in winter water elevation is sufficient to reduce the drawdown to less than 10 feet.
Reservoir Recreation B	Little change in plant coverage on mainstem reservoirs is anticipated; however, a species shift could occur between increasing and decreasing communities of invasive species. A slight increase in coverage could occur on tributary reservoirs with a large drawdown (over 10 feet). On tributary reservoirs (for example, Chatuge and South Holston), where the drawdown is reduced to less than 10 feet, larger increases in coverage could occur.
Summer Hydropower	On mainstem reservoirs, there is potential for large reductions in plants growing in upper portion of drawdown zone. A slight expansion of Eurasian watermilfoil and hydrilla into deeper areas could occur because of increased light penetration. In most tributary reservoirs where higher winter water levels would occur, a slight decrease in overall coverage is anticipated because water levels would not be elevated long enough during summer for annual plants to complete their seed cycle.
Equalized Summer/Winter Flood Risk	This alternative may result in a wide variety of effects, depending on how much water levels vary from current regime. A slight decrease in plant coverage on mainstem reservoirs is anticipated during some years. Lower summer water elevations on tributary reservoirs could decrease existing populations of plants; however, longer summer pool levels and decreased amplitude of drawdown could increase submersed and floating-leaved plants—particularly in some reservoirs (for example, Chatuge) where the drawdown is less than 10 feet.
Commercial Navigation	Coverage on the mainstem and tributary reservoirs would continue to increase or decrease based primarily on natural fluctuation associated with hydrologic and climatic events. Higher winter water levels on mainstem reservoirs could favor establishment and expansion of perennial invasive species into some areas of drawdown zone currently colonized by annuals.
Tailwater Recreation	Little change in plant coverage on mainstem reservoirs is anticipated; however a species shift could occur between increasing and decreasing communities of invasive species. A slight increase in coverage could occur on tributary reservoirs with a large drawdown (over 10 feet). On tributary reservoirs (for example, Chatuge and South Holston), where drawdown is reduced to less than 10 feet, larger increases in coverage could occur.

Table 5.9-02 Summary of Impacts on Aquatic and Invasive Aquatic Plants by Policy Alternative (continued)

Alternative	Description of Impacts
Tailwater Habitat	Little change in plant coverage is expected on mainstem reservoirs; however, a species shift could occur between increasing and decreasing communities of invasive species. Due to summer pool levels extending later into fall, potential for increases in plant coverage on tributary reservoirs could be greater than under Reservoir Recreation Alternative A, especially if increase in winter water elevation is sufficient to reduce the drawdown to less than 10 feet.
Preferred	Little change in plant coverage is expected on mainstem reservoirs; however, a species shift could occur between increasing and decreasing communities of invasive species. A slight increase in coverage could occur in some tributary reservoirs, with the highest potential in reservoirs (for example, Chatuge) where the increase in winter elevation is sufficient to reduce the drawdown to less than 10 feet.

Note: Most anglers and waterfowl hunters would consider increases in aquatic plants to be beneficial, while most recreational boaters and shoreline property owners would consider such increases adverse.

5.10 Terrestrial Ecology

5.10.1 Introduction

Much of the terrestrial plant and animal life occurring in the vicinity of TVA reservoirs has adjusted to the established dynamic conditions associated with management of the many reservoirs and stream reaches. Changes in reservoir operations would change the seasonal timing and duration of water levels. The following discussion describes potential impacts of such changes on the upland and lowland plant communities, including those that are globally imperiled, and the associated wildlife communities described in Section 4.10.

Changes in the seasonal timing and duration of water levels could affect the species composition of plant and animal communities in the study area by changes to the structure of riparian habitats and the resulting gain or loss of specific community types. Factors such as increased shoreline erosion, residential development, and the spread of invasive species could substantially affect the distribution and quality of terrestrial habitats throughout the water control system.

5.10.2 Impact Assessment Methods

Data on the terrestrial ecology of the study area were gathered from field interviews with subject matter experts, published reports, TVA land use plans, environmental impact studies, and biological data collection centers. These data were used to identify plant and animal communities that could be affected by changes in reservoir operations.

Impacts on the terrestrial ecology of the study area were analyzed by summarizing effects described in various sections within this EIS. Results of analyses for wetlands and aquatic plants were used to identify potential effects on terrestrial resources. Analyses for other resource areas, such as invasive species, shoreline erosion, and land use were also used to identify potential effects on terrestrial plant and animal communities. The effects identified in these chapters were summarized for each alternative. This analysis used a qualitative approach to analyze the effects of each alternative on the terrestrial plant and animal resources in the study area.

Using the Base Case as a reference benchmark, the alternatives were grouped according to their similarities of impact on terrestrial ecology. Although the effects from potential changes in reservoir operations would vary widely, this analysis attempted to capture effects of the greatest magnitude on the resource.

The analysis of impacts in this section pertains only to mainstem storage and tributary storage reservoirs. Run-of-river reservoirs were initially investigated for elevation changes associated with each policy alternative. Because pool elevations for these reservoirs would not change under any of the alternatives, terrestrial ecology would not be affected around these reservoirs.

5.10.3 Base Case

Lowland Plant Communities

Most lowland terrestrial plant communities have adjusted to current operating conditions. Some communities, such as stands of water tupelo (*Nyssa aquatica*) on Guntersville and Wheeler Reservoirs and buttonbush (*Cephalanthus occidentalis*) on Kentucky Reservoir, are notable exceptions. Several stands of these species show signs of stress from prolonged periods of inundation under existing water regimes.

The Base Case would continue to provide lower winter pool elevations than any of the policy alternatives and thus would allow more opportunity for seed germination and establishment of vegetation in scrub/shrub and flats. As described in the SMI EIS, a long-term reduction in native shoreline plant communities would occur.

In areas where currents are sufficiently strong, headwater erosion of islands and toe accretion of deposits would continue under the Base Case, with consequent potential minor losses of bottomland hardwood or upland forest communities and some globally rare wetland communities. Slight increases in flats and scrub/shrub communities are expected under the Base Case.

Upland Plant Communities

Under the Base Case, continued rates of erosion would lead to additional loss of upland habitat adjacent to mainstem and tributary reservoirs (see Section 5.16, Shoreline Erosion). Existing successional patterns in upland communities would continue except where disrupted by shoreline development.

Wildlife Communities

Under the Base Case, most TVA reservoirs would continue to be operated at levels that are favorable to gulls, shorebirds, waterfowl, and other reservoir-dependent wildlife. Species associated with upland and lowland habitats would continue to derive benefits from the river system, and no adverse impacts on terrestrial wildlife are expected. The continuation of existing operations would result in limited effects on waterfowl and other migratory birds, as they have adapted to present conditions.

5.10.4 Commercial Navigation Alternative

The effects of the Commercial Navigation Alternative on lowland and upland terrestrial communities are expected to be similar to those described for the Base Case. Most plant communities would persist with little change. Impacts on vegetation under the Commercial Navigation Alternative would be minor.

Under the Commercial Navigation Alternative, higher winter pools would affect lowland wildlife species primarily through the net reduction of flats and changes in shallow-water habitats. Overall, available flats would be reduced as they are flooded by higher reservoir levels, resulting in a decrease in foraging areas for waterfowl (primarily geese) and roosting areas for gulls and other species. Areas inundated during winter would increase, shifting shallow-water foraging habitat for waterfowl and wading birds to higher elevations.

5.10.5 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Tailwater Recreation Alternative, and Tailwater Habitat Alternative

Lowland Plant Communities

Under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative, summer pool levels would be extended to or later than Labor Day, and winter pool levels would be raised by 2 feet. The prolonged periods of inundation under these alternatives would stress species in the bottomland hardwood, scrub/shrub, and flats communities. Over time, large acreages of scrub/shrub community would likely convert to aquatic beds or marshes dominated by wetland emergent species. Species least tolerant to prolonged flooding would be adversely affected within a few years, particularly those in presently stressed bottomland hardwoods and scrub/shrub communities (Hall and Smith 1955).

Annual plant species that make up the flora of flats communities require sufficient exposure to air in order to germinate and grow to reproductive condition (Webb 1988, Gunn 2003). Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would considerably decrease the areas occupied by annually vegetated flats communities, especially on Kentucky, Barkley, Pickwick, and Douglas Reservoirs.

The composition of globally imperiled communities would change to favor species that are more tolerant of prolonged flooding. The magnitude of the impact cannot be evaluated because the regional extent of various imperiled communities is unknown. Overall, impacts on lowland plant communities are expected to be detrimental in localized areas under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative.

Upland Plant Communities

Extending summer pool levels and raising winter pool levels would maintain existing groundwater levels adjacent to waterbodies, with minimal short-term and long-term effects on the terrestrial ecology of the region over the next 30 years. Saturation of surface soils would result in a minor loss of upland plant species and replacement by species more tolerant to flooding. Overall, impacts on upland terrestrial communities are expected to be minimal under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative.

Wildlife Communities

A variety of changes to wetland habitats are possible under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative (see Sections 5.8.4 and 5.8.5 in Wetlands). Effects on wildlife communities resulting from higher winter pools would be the same as those described for the Commercial Navigation Alternative. Extended summer pools would affect wildlife primarily by extending the period that summer flats and pools, aquatic beds, and wetlands are inundated. Extended pool levels under these alternatives would delay exposure of flats habitats, resulting in adverse impacts on shorebirds and teal as they migrate through the area (see Table 5.10-01). Eventually flats would develop later in fall but might not have adequate exposure time to allow vegetation to become established. This could result in adverse impacts to waterfowl (primarily geese) that forage on these areas in early winter months.

Table 5.10-01 Dates That Shorebird Habitat (Flats) Would Be Exposed during Summer Drawdown by Policy Alternative

Alternative	Reservoir (elevation [feet])				
	Kentucky (356.6)	Pickwick (411.5)	Wheeler (554)	Chickamauga (679)	Douglas (987)
Base Case	08/25	09/10	09/01	10/20	08/10
Reservoir Recreation A	10/07	11/01	10/07	11/05	09/05
Reservoir Recreation B	11/15	11/05	10/20	11/05	09/25
Summer Hydropower	07/25	07/25	07/25	07/25	07/25
Equalized Summer/Winter Flood Risk	09/15	10/15	10/15	10/15	NA
Commercial Navigation	08/25	09/10	09/01	10/20	08/10
Tailwater Recreation	11/25	11/05	10/20	11/05	09/25
Tailwater Habitat	10/05	11/01	10/05	11/05	11/01
Preferred	08/25	10/15	10/05	10/20	08/20

Notes: Dates were derived from the Weekly Scheduling Model for each alternative.

NA = Not applicable; summer pool levels are not projected to reach this elevation during years with normal levels of rainfall.

Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative could result in increases in aquatic vegetation, a food base for some waterfowl and aquatic turtles, on the tributary reservoirs. The increased vegetative biomass is likely to result in an increase in aerial aquatic insects that provide food for wildlife foraging on and adjacent to the river system.

Under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative, upland and some lowland species of wildlife would continue to derive benefits from the river system. Changes in operations under these alternatives would result in limited effects on semi-aquatic mammals and non-game wildlife, as they would adapt to changing conditions. Due to the anticipated decrease in flats habitats, shorebirds and early fall migrant waterfowl would be adversely affected during fall migration periods under these alternatives.

5.10.6 Summer Hydropower Alternative

Lowland Plant Communities

The Summer Hydropower Alternative has the potential to greatly expand or shrink the extent of the flats community, depending on how reservoirs are managed. Prolonged exposure and resultant drying of flats would reduce their extent, while slow drawdown at the appropriate time would allow extensive germination of seeds and establishment of associated plant communities. The Summer Hydropower Alternative could greatly reduce the extent of the scrub/shrub community (because of the severely reduced period of summer pool levels) and could initiate widespread changes in the composition of species found in bottomland hardwood forests.

Under the Summer Hydropower Alternative, delaying summer pool levels and shortening the duration of summer pool levels would allow upland species to displace existing bottomland hardwoods—resulting in adverse impacts on this community type. Impacts on scrub/shrub communities would be similar, although the shortened duration of summer pool levels might allow expansion of this community into new locations over the long term. The shortened duration of summer pool levels would result in loss of water from some globally imperiled plant communities listed in Table 4.10-01 (those with species more tolerant to flooding), triggering consequent changes in species composition and loss of community character.

Upland Plant Communities

The short duration of summer pool levels under the Summer Hydropower Alternative would not promote development of adjacent wetlands. Therefore, impacts on upland terrestrial communities are expected to be minimal under this alternative.

Wildlife Communities

Effects on terrestrial ecology resulting from higher winter pool levels under the Summer Hydropower Alternative are the same as those described for the Commercial Navigation

Alternative. Effects on wildlife under the Summer Hydropower Alternative would vary by reservoir. Shorter summer pool levels would affect wildlife primarily through changes in the availability of flats, aquatic beds, and wetlands. Early migrant shorebirds could benefit from the increase in the amount of exposed flats; however, flats may dry before shorebirds arrive, allowing vegetation to become established on these areas. While this could be detrimental to shorebirds, wintering waterfowl could benefit as these vegetated flats become flooded in winter. Decreases in aquatic beds may result in a reduction of food available to waterfowl and other species that feed in or adjacent to the river system. Overall, the Summer Hydropower Alternative would result in a negative change in wetland community types due to the loss of habitat for the variety of lowland, non-game animals that rely on these communities—including numerous Neotropical songbirds and semi-aquatic mammals.

Because of the instability of reservoir levels and the projected negative changes in wetland communities, the Summer Hydropower Alternative would also result in localized adverse impacts on wildlife that depend on lowland communities.

5.10.7 Equalized Summer/Winter Flood Risk Alternative

Lowland Plant Communities

Under the Equalized Summer/Winter Flood Risk Alternative, higher winter pool levels and lower summer pool levels may stress bottomland hardwood species (which are least tolerant of flooding from winter water levels). Some new species may move into bottomland hardwood forests under the Equalized Summer/Winter Flood Risk Alternative. The same rationale applies to imperiled communities. The management regime would likely eliminate some existing scrub/shrub communities but might allow for its reestablishment in different places. Development of nonpersistent vegetation on flats is likely to be severely restricted or eliminated as lower summer pool levels and higher winter pool levels would narrow the drawdown zone where this vegetation currently exists. Overall, selection of the Equalized Summer/Winter Flood Risk Alternative would result in adverse impacts on lowland plant communities, especially flats communities on tributary reservoirs.

Upland Plant Communities

The Equalized Summer/Winter Flood Risk Alternative is not expected to result in impacts on upland plant communities, because this alternative would not promote development of adjacent wetlands.

Wildlife Communities

Under the Equalized Summer/Winter Flood Risk Alternative, terrestrial ecology effects resulting from higher winter pool levels would be similar to those described for the Commercial Navigation Alternative. Lower summer pool levels would affect wildlife primarily through changes in wetlands and the ability to flood crops in dewatering units. Adequate water may not be available in the emergent and scrub/shrub wetland habitats to provide foraging and cover for waterfowl, such as wood ducks. Resident geese are very adaptable and would probably eventually start nesting in the drawdown zone. The persistence of aquatic beds would benefit the species that depend on these habitats. Raising summer pool levels later could alleviate spring crop flooding on mainstem waterfowl impoundments (see Section 4.14 [Managed Areas and Ecologically Significant Sites]).

Under the Equalized Summer/Winter Flood Risk Alternative, upland and lowland species of wildlife would continue to derive benefits from the river system. Changes in operations would result in limited effects on waterfowl, semi-aquatic mammals, and non-game wildlife, as they would adapt to changing conditions. The projected negative effects on flats habitat could adversely affect shorebirds during fall migration periods.

5.10.8 Preferred Alternative

Lowland Plant Communities

Under the Preferred Alternative, summer pool levels could be extended to Labor Day on 10 tributary and five mainstem reservoirs. The impacts on the lowland plant communities would be similar to those described for Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternatives—but to a lesser degree (see Table 5.10-01). Impacts on the lowland communities on Kentucky and Barkley Reservoirs would be similar to those under the Base Case; operations on these reservoirs would not be modified under the Preferred Alternative.

Upland Plant Communities

Impacts on the upland plant communities are expected to be similar to those described for Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative. Impacts on these resources are expected to be minimal under the Preferred Alternative.

Wildlife Communities

Raising winter pool levels on Wheeler and tributary reservoirs would result in effects similar to those described for the Commercial Navigation Alternative; however, impacts are expected to be of lesser magnitude. Extending summer pool levels on selected mainstem and tributary reservoirs under the Preferred Alternative would result in effects on terrestrial wildlife similar to those described for Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative. The delayed exposure of flats on Wheeler, Pickwick and, to a lesser extent, Douglas during late summer would adversely affect waterfowl and shorebirds (see Table 5.10-01). Under the Preferred Alternative, these resources would not be affected on Kentucky and Barkley Reservoirs because these reservoirs would continue to be operated as they are under the Base Case. System-wide adverse changes to bottomland hardwood forests, scrub/shrub wetlands, and flats communities (see Section 5.8, Wetlands) would result in changes in the distribution, abundance, and diversity of wildlife species that use these areas.

5.10.9 Summary of Impacts

The Base Case would result in fewer impacts on plant and wildlife resources than any of the action alternatives. Each policy alternative is expected to result in shifts in community types that will benefit some plant and animal species and adversely affect others. Table 5.10-02 identifies the impacts expected under each policy alternative on the issues of concern related to terrestrial ecology. Alternatives that would result in loss or change in species composition of wetland habitat types or communities would also result in the greatest potential impacts.

Except for the Summer Hydropower Alternative, changes in operations under all remaining policy alternatives would result in limited effects on semi-aquatic mammals and many non-game wildlife species, as they would adapt to changing conditions. Under several of the policy alternatives, shorebirds and waterfowl potentially would be adversely affected during fall migration periods, due to the decrease in the availability of flats along the reservoirs. Likewise, these same alternatives are expected to result in a loss of bottomland hardwood, flats, and scrub/shrub communities and changes in the composition of species in imperiled plant communities. Such changes in wetland communities are likely to result in shifts in species and numbers of local waterfowl.

Compared to the other policy alternatives, the Preferred Alternative and the Commercial Navigation Alternative are expected to result in a lower level of impacts on plant and animal populations; however, these impacts would be greater than those under the Base Case. Due to the instability of reservoir levels and the projected negative changes in wetland communities, the Summer Hydropower Alternative would result in the greatest impacts on the terrestrial ecology of the region.

Table 5.10-02 Summary of Impacts on Terrestrial Ecology by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Wildlife population trends would continue to mirror national trends; some bottomland hardwood communities would continue to be stressed.
Reservoir Recreation A	Adverse – Aquatic beds would persist longer, benefiting a wide variety of wildlife. Reduction of flats during late summer would affect migrating shorebirds and waterfowl. Some bottomland hardwood and scrub/shrub communities would be lost; and the composition of species in imperiled plant communities would change.
Reservoir Recreation B	Adverse – Aquatic beds would persist longer, benefiting a wide variety of wildlife. Reduction of flats during late summer would affect migrating shorebirds and some waterfowl. Some bottomland hardwood and scrub/shrub communities would be lost; and the composition of species in imperiled plant communities would change.
Summer Hydropower	Substantially adverse – Wetland habitats would be more adversely affected than under other alternatives. Reduction of flats and aquatic beds would adversely affect many dependent species of wildlife. Distribution and extent of scrub/shrub, bottomland hardwood, and imperiled plant communities potentially could be altered.
Equalized Summer/Winter Flood Risk	Adverse – Aquatic beds would persist longer, benefiting a wide variety of wildlife. Reduction of flats during late summer would affect migrating shorebirds and some waterfowl. Loss of scrub/shrub communities and changes in bottomland hardwood and imperiled plant communities would result.
Commercial Navigation	Slightly adverse – Minor benefits to some wetland types and associated wildlife. Decrease in flats on mainstem reservoirs would affect migrating shorebirds and some waterfowl; some bottomland hardwood communities would continue to be stressed.
Tailwater Recreation	Adverse – Aquatic beds would persist longer, benefiting a wide variety of wildlife. Reduction of flats during late summer would affect migrating shorebirds and some waterfowl. Loss of bottomland hardwood and scrub/shrub communities and species shifts in imperiled plant communities would occur.
Tailwater Habitat	Adverse – Aquatic beds would persist longer, benefiting a wide variety of wildlife. Reduction of flats during late summer would affect migrating shorebirds and some waterfowl. Loss of some bottomland hardwood and scrub/shrub communities and species shifts in imperiled plant communities would result.
Preferred	Slightly adverse – Aquatic beds would persist longer, benefiting a wide variety of wildlife. Reduction of flats during late summer would adversely affect migrating shorebirds and some waterfowl on select mainstem and tributary reservoirs. Loss of some bottomland hardwood and scrub/shrub communities and species shifts in imperiled plant communities would result.

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5.11 Invasive Plants and Animals

5.11.1 Introduction

Changes in reservoir operations have the potential to affect habitat suitability for invasive terrestrial and aquatic animals and terrestrial plants. Changes in habitat suitability would affect species abundance or their ability to colonize new areas.

5.11.2 Impact Assessment Methods

To determine impacts on invasive species, each policy alternative was evaluated to determine whether revised operation of the water control system would produce consistent support for conditions critical to the life history of the identified species. When changes in operations would consistently produce more favorable conditions, an increase in the abundance of invasive species was assumed. Factors considered in the analysis included:

- Increased development of open spaces;
- Changes to water quality;
- Increased reservoir elevations over longer duration; and,
- Changes to reservoir and tailwater flows.

Proposed changes to the reservoir operations policy under each alternative were evaluated for these four factors to determine how the alternatives would affect the population abundance and spread of invasive terrestrial and aquatic plants and animals.

5.11.3 Base Case

Invasive Terrestrial Animals and Plants

Under the Base Case, suitable habitat for invasive terrestrial animals and their populations is expected to continue to increase due to reasonably foreseeable actions in the Valley. Similarly, invasive terrestrial plant populations are expected to continue to increase as native habitats are altered to accommodate population growth and subsequent development pressures. This alternative is therefore not expected to directly affect the present or future rate of the establishment or spread of invasive terrestrial animals or plants.

Invasive Aquatic Animals

The Base Case would not affect habitat suitability for common carp, grass carp, or rusty crayfish; because these species tolerate a wide range of environmental conditions, their populations are expected to continue to increase. The feeding habits of the three species adversely affect the habitats and populations of other more desirable fish species. Alewives and blueback herring, on the other hand, prefer cool, well-oxygenated water, which may become limited in certain reservoirs during late summer under the Base Case. Asiatic clam densities fluctuate from year to year but would likely remain high, and zebra mussel populations would likely continue to increase and expand.

5.11.4 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Equalized Summer/Winter Flood Risk Alternative, and Tailwater Recreation Alternative

Invasive Terrestrial Animals and Plants

Under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, and the Tailwater Recreation Alternative, summer pool elevations would be extended and winter pool elevations would be altered, depending on the climate. These alternatives are not expected to modify habitat suitability for most invasive terrestrial animals or most invasive terrestrial plants. Their present rate of establishment or spread is not expected to be affected by extending the summer reservoir elevations and decreasing the length of time that the flats are exposed, because these species do not depend on the flats. Changes in winter elevations are not anticipated to influence invasive plants or animals beyond expectations for the Base Case.

Invasive Aquatic Animals

Habitat suitability for common carp, grass carp, and rusty crayfish would be unaffected by all policy alternatives. Because these species tolerate a wide range of environmental conditions, their populations are expected to continue to increase. Alewives and blueback herring prefer cool, well-oxygenated water, which may restrict their expansion downstream regardless of the selected alternative. As under the Base Case, densities of Asiatic clam would likely remain high, and zebra mussel populations would likely continue to increase and expand regardless of the selected alternative.

5.11.5 Summer Hydropower Alternative

Invasive Terrestrial Animals and Plants

Under the Summer Hydropower Alternative, drawdown would begin in June to increase power production. This modification would change the length of time that the flats are exposed and the extent of their exposure. Exposure of the flats for longer periods of time could result in the establishment of invasive plant species such as common privet and Japanese knotweed, increasing their distribution. Invasive terrestrial animals do not rely on flats or summer water levels; therefore, this alternative is not expected to affect their rate of establishment or spread. Raising water levels would cause invasive terrestrial plants that presently inhabit the shoreline to move inland; therefore, their population levels would be maintained.

Invasive Aquatic Animals

Habitat suitability for alewives, blueback herring, common carp, grass carp, rusty crayfish, Asiatic clams, and zebra mussels would be unaffected by all policy alternatives (see Section 5.11.4).

5.11.6 Commercial Navigation Alternative

Invasive Terrestrial Animals and Plants

Under the Commercial Navigation Alternative, winter reservoir elevations would be raised in the mainstem reservoirs. Increased winter reservoir elevations could reduce the spread of some invasive terrestrial plant species along mainstem reservoirs and cause other species (such as Japanese knotweed and common privet) to move inland as water levels are extended, which would maintain present population levels of these species.

Invasive Aquatic Animals

Habitat suitability for alewives, blueback herring, common carp, grass carp, rusty crayfish, Asiatic clams, and zebra mussels would be unaffected by all policy alternatives (see Section 5.11.4).

5.11.7 Tailwater Habitat Alternative

Invasive Terrestrial Animals and Plants

The Tailwater Habitat Alternative involves fill dates and drawdown levels that differ from present operations for some reservoirs, depending on annual precipitation patterns. Reservoir levels generally would be higher than those under the Base Case. The spread of some invasive terrestrial plant species could be reduced but, if winter levels exceed maximum summer elevations (Great Falls), suitable habitat may be created for the inland expansion of common privet and Japanese knotweed—as well as other invasive plants.

Invasive Aquatic Animals

Habitat suitability for alewives, blueback herring, common carp, grass carp, rusty crayfish, Asiatic clams, and zebra mussels would be unaffected by all policy alternatives (see Section 5.11.4).

5.11.8 Preferred Alternative

Invasive Terrestrial Animals and Plants

Under the Preferred Alternative, summer pool elevations would be extended and winter pool elevations would be altered. These changes are not anticipated to affect the current rate of most invasive terrestrial plant, terrestrial animal, or aquatic animal establishment or spread. As described in Reservoir Recreation A Alternative, a slight reduction in the spread of some invasive terrestrial plant species could result due to increased winter reservoir elevations. Invasive terrestrial animal species are expected to respond to this alternative as under the Base Case.

Invasive Aquatic Animals

Habitat suitability for alewives, blueback herring, common carp, grass carp, rusty crayfish, Asiatic clams, and zebra mussels would be unaffected by all policy alternatives (see Section 5.11.4).

5.11.9 Summary of Impacts

Table 5.11-01 provides a summary of impacts on invasive terrestrial and aquatic animals and terrestrial plants by policy alternative.

Habitat suitability for most invasive terrestrial animals would be unaffected by all policy alternatives because the species tolerate a wide range of environmental conditions. Their present trends relative to rate of establishment or spread would override the effects of any of the alternatives. Similarly, population abundance and spread of invasive terrestrial plants would be unaffected by any of the alternatives, except for the Summer Hydropower Alternative, where exposure of the flats for longer periods of time could result in the establishment of certain invasive plant species, thus increasing their distribution.

Habitat suitability for alewives, blueback herring, common carp, grass carp, and rusty crayfish would be unaffected by all policy alternatives. Because these species tolerate a wide range of environmental conditions, their populations are expected to continue to increase. Alewives prefer cool, well-oxygenated water, which may restrict their expansion downstream regardless of the alternative selected. Asiatic clam densities likely would remain high, and zebra mussel populations likely would continue to increase and expand regardless of the alternative selected.

Of all alternatives evaluated, only the Summer Hydropower Alternative is expected to increase the abundance of invasive terrestrial plants or animals or invasive aquatic animals (Table 5.11-01). However, because natural variability would likely result in potential impacts as great, or greater than, the impacts associated with this alternative, a measurable increase in impacts would not be expected.

Table 5.11-01 Summary of Impacts on Invasive Terrestrial and Aquatic Animals and Terrestrial Plants by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Habitat suitability and populations of terrestrial animals and plants would continue to increase. Populations of common carp, grass carp, rusty crayfish, and zebra mussel would continue to increase. Asiatic clam densities would remain high. Alewife populations would remain the same. Blueback herring would continue downstream habitation of cool-water environments below Hiwassee Reservoir.
Reservoir Recreation A	No change – Habitat suitability of terrestrial animals and plants, and their present rate of establishment or spread would not change due to extending summer reservoir elevations. Impacts on aquatic animals would be the same as those for the Base Case.
Reservoir Recreation B	No change – Impacts would be the same as those for the Base Case.
Summer Hydropower	Slightly adverse – Distributions of some invasive plant species would increase; distributions of terrestrial animals would not change. Impacts on aquatic animals would be the same as those for the Base Case.
Equalized Summer/ Winter Flood Risk	No change – Impacts would be the same as those for the Base Case.
Commercial Navigation	No change – Impacts would be the same as those for the Base Case.
Tailwater Recreation	No change – Impacts would be the same as those for the Base Case.
Tailwater Habitat	No change – Impacts would be the same as those for the Base Case.
Preferred	No change – Impacts would be the same as those for the Base Case.

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5.12 Vector Control

5.12.1 Introduction

As described in Section 4.12, changes in reservoir operations policy may affect the breeding success of mosquitoes in both permanent and temporary pools (floodwaters) created within water control system reservoirs. Of principal importance are changes in water elevations and their persistence or duration on the landscape. The following analysis assumed that the water management techniques to control mosquitoes (see Section 4.12.2, Regulatory Programs and TVA Management Activities) would remain in place under all the reservoir operations policy alternatives.

5.12.2 Impact Assessment Methods

To estimate the potential increase in mosquito populations and the associated increased risk of disease, projected water elevation forecasts prepared with the Weekly Scheduling Model were reviewed for each alternative. These forecasts were compared to the outputs for existing operations under the Base Case. Water elevations held higher or longer were the criteria for determining that higher mosquito populations and the associated risk of disease would result.

Policy alternatives that would increase water elevations or extend the area and duration of inundation may increase mosquito breeding habitat and populations, depending on temperature and rainfall during the mosquito season (March through October). The effects of these modifications depend primarily on weather (temperature and rainfall) and the resulting water levels. During a dry year, there would be little to no effect on the mosquito populations. An extension of summer pool would also increase the potential for floodwater mosquitoes if a major rain event occurred. Since the water is already high, the floodplain would drain less efficiently.

Representative tributary reservoirs were chosen for analysis because of their mosquito history; the selected tributary reservoirs historically had more mosquito activity than other tributary reservoirs. All of the mainstem reservoirs were evaluated except Nickajack Reservoir; Nickajack Reservoir is a run-of-river reservoir for which no water elevation modeling data were available. Changes in levels that result from the alternatives are expected to be minimal.

The potential of a policy alternative to increase mosquito breeding habitat and populations was considered an adverse impact relative to the Base Case. The potential of a policy alternative to decrease mosquito breeding habitat and populations was considered a beneficial impact relative to the Base Case.

5.12.3 Base Case

The Base Case would continue TVA's present operations schedule and would not affect existing mosquito breeding habitat or population abundance for permanent pool or floodwater mosquitoes. Although many unknowns or poorly understood influences are associated with mosquito-vectored diseases; the Base Case is not anticipated to affect the present rates or trends for disease occurrence.

5.12.4 Summer Hydropower Alternative

The Summer Hydropower Alternative would reduce the water elevations and duration of inundation, and thus the mosquito breeding habitat in both mainstem and tributary reservoirs. Depending on weather—which could dominate the effect of reduced water elevations for a particular year or for a period of years—this alternative would result in diminished mosquito populations for both permanent pool and floodwater species. The associated risk of mosquito-vectored diseases would also be reduced under the Summer Hydropower Alternative.

5.12.5 Commercial Navigation Alternative

The Commercial Navigation Alternative would result in very little or no change from existing operations. Depending on weather—which could dominate the effect of proposed modifications for a particular year or for a period of years—this alternative would not substantially affect mosquito population abundance. The associated risk of mosquito-vectored diseases is also not anticipated to change under the Commercial Navigation Alternative.

5.12.6 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Equalized Summer/Winter Flood Risk Alternative, Tailwater Recreation Alternative, and Tailwater Habitat Alternative

Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative to some degree would increase the water elevations or duration of inundation in mainstem and tributary reservoirs. These alternatives would result in an increase in mosquito breeding habitat and populations for both permanent pool and floodwater species, and an increased risk of mosquito-vectored diseases. The individual effects of these alternatives would differ slightly. Due to the complexity of the natural system and the dominating effects of weather, these differences cannot be described in a meaningful way. Potential effects associated with Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would be greater on tributary reservoirs because the operations changes for tributary reservoirs under these alternatives would deviate more from existing operations (the Base Case). Historically, water levels in tributary reservoirs have fluctuated more than those in mainstem reservoirs. Some of the alternatives would no longer allow the amount of historical fluctuation in tributary reservoirs, thus resulting in more substantial changes for tributary reservoirs than for mainstem reservoirs.

5.12.7 Preferred Alternative

The Preferred Alternative would increase the water elevations and/or duration of inundation in some mainstem and some tributary reservoirs. Mosquito populations on Kentucky Reservoir would not change from the Base Case. The delayed fill on Chickamauga, Watts Bar, and Fort Loudoun Reservoirs could decrease mosquito populations in April and May. Extension of summer pools on Chickamauga, Guntersville, Wheeler, and Pickwick Reservoirs could result in an increase in mosquito breeding habitat and populations for both permanent pool and floodwater species. An increased risk of mosquito-borne diseases in late summer would result. Potential effects associated with the Preferred Alternative would vary on tributary reservoirs. Historically, water levels in tributary reservoirs have fluctuated more than those in mainstem reservoirs. Mosquito populations could increase on Norris and Fontana Reservoirs, and the mosquito season could be extended on these reservoirs. Water levels of these tributaries would be higher and longer than in the past. During the first few years, this increase in mosquitoes could be worse because the vegetation along the shore line would be inundated, creating more mosquito habitat. This effect should lessen over the years, as this vegetation begins to die because of the inundation.

5.12.8 Summary of Impacts

Tables 5.12-01 and 5.12-02 provide a summary of impacts on mosquito population abundance by policy alternative. Alternatives that would increase water elevations or extend the area and duration of inundation may increase mosquito breeding habitat and populations, depending on temperature and rainfall during the mosquito season (March through October). The effects of these modifications depend primarily on weather (temperature and rainfall) and the resulting water levels.

The Base Case and the Commercial Navigation Alternative are not anticipated to affect present rates or trends for mosquito population abundance or disease occurrence. Depending on weather, which could dominate the effect of reduced water elevations in a particular year or for a period of years, the Summer Hydropower Alternative would result in diminished mosquito populations for both permanent pool and floodwater species, and a corresponding reduced risk of mosquito-borne diseases.

Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would result in an increase in mosquito breeding habitat and populations for both permanent pool and floodwater species, and an increased risk of mosquito-vectored diseases. The individual effects of these alternatives probably would differ slightly but cannot be described in a meaningful way because of the complexity of the natural system and the dominating effects of weather. Potential effects associated with Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would be greater on tributary reservoirs because the operations changes for tributary reservoirs would deviate more from existing operations on those reservoirs.

In general, the Preferred Alternative would increase mosquito populations and extend the mosquito season for both permanent pool and floodwater species on some mainstem and tributary reservoirs. The effects would vary by reservoir. An increase in mosquito populations or an extension of the mosquito season would increase the risk of mosquito-vectored diseases.

Table 5.12-01 Summary of Impacts on Mosquito Population Abundance at Selected Reservoirs by Policy Alternative

Reservoir	Alternative							
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Mainstem Reservoirs								
Fort Loudoun	No change	No change	Decrease	No change	No change	No change	No change	Decrease
Watts Bar	No change	Increase	Decrease	No change	No change	Increase	No change	Decrease
Chickamauga	Increase	Increase	Decrease	Increase	No change	Increase	Increase	Increase
Guntersville	Increase	Increase	Decrease	Increase	No change	Increase	Increase	Increase
Wheeler	Increase	Increase	Decrease	Increase	No change	Increase	Increase	Increase
Wilson	No change	No change	Decrease	Increase	No change	No change	No change	No change
Pickwick	Increase	Increase	Decrease	Increase	No change	Increase	Increase	Increase
Kentucky[1]	Increase	Increase	Decrease	Increase	No change	Increase	Increase	No change
Tributary Reservoirs								
Cherokee	Increase	Increase	No change	Increase	No change	Increase	Increase	No change
Douglas	Increase	Increase	Decrease	Decrease	Increase	Increase	Increase	No change
Hiwasee	Increase	Increase	Decrease	Increase	No change	Increase	Increase	No change
South Holston	Increase	Increase	No change	Increase	No change	Increase	Increase	Increase
Fontana	Increase	Increase	Decrease	Decrease	No change	Increase	Increase	Increase
Tims Ford	No change	Increase	Decrease	Decrease	No change	Increase	No change	No change
Norris	Increase	Increase	Decrease	Increase	No change	Increase	Increase	Increase

Notes:

"Decrease," "increase," and "no change" indicate the effect of a particular alternative on mosquito breeding habitat and the consequent effect on mosquito population abundance and the associated risk of disease.

The selected tributary reservoirs were chosen for analysis because of their mosquito and aquatic plant history.

[1] The effects of increasing the water level on Kentucky Reservoir are amplified because TVA does not fluctuate water levels to control mosquito populations on that reservoir.

Table 5.12-02 Summary of Impacts on Vector Control by Policy Alternative

Alternative	Description of Impacts
Base Case	No change to the number of days mosquito breeding habitat would be present.
Reservoir Recreation A	Adverse – Extending summer pools would extend the number of days mosquito breeding habitat would be present.
Reservoir Recreation B	Adverse – Extending summer pools would extend the number of days mosquito breeding habitat would be present.
Summer Hydropower	Beneficial – Drop in elevations earlier would provide less mosquito breeding habitat.
Equalized Summer/Winter Flood Risk	Slightly adverse – The equalization of flood risk would slightly increase the number of days mosquito breeding habitat would be present.
Commercial Navigation	No change to the number of days mosquito breeding habitat would be present.
Tailwater Recreation	Adverse – Extending summer pools would extend the number of days mosquito breeding habitat would be present.
Tailwater Habitat	Adverse – Extending summer pools would extend the number of days mosquito breeding habitat would be present.
Preferred	Adverse – Extending summer pools would extend the number of days mosquito breeding habitat would be present.

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5.13 Threatened and Endangered Species

5.13.1 Introduction

The information about endangered, threatened, and other types of protected species presented in Section 4.13 and Appendix D6a indicates that 526 protected species are known from within the 1-mile buffers around the reservoir and stream waterbodies covered by the scope of the ROS evaluation. Of that total, 172 species are known from within the 200-foot buffers around the waterbodies. The remainder of the discussion presented in Section 4.13 provides two general conclusions about the occurrence of protected species as they relate to the evaluation of the policy alternatives. Most protected species known from within or immediately adjacent to the waterbodies where ROS activities could occur typically exist in aquatic habitats along the least-modified stream reaches (warm tributary tailwaters, flowing mainstem reaches, some pooled mainstem reaches, and cool-to-warm tributary tailwaters). Relatively few protected species exist in or adjacent to any tributary reservoir, in any cool/cold tributary tailwaters, or in the drier terrestrial habitats that exist within 200 feet of any waterbody. These observations indicate that warm tributary tailwaters, flowing mainstem reaches, some pooled mainstem reaches, and cool-to-warm tributary tailwaters are the waterbody categories where most of the direct effects of the policy alternatives on protected species could occur. The information presented in Section 4.13 also suggests that at least a few of the 526 protected species known from the ROS waterbody areas can occur in just about any habitat present within 1 mile around almost any reservoir or tailwater included in this evaluation. This observation indicates that the evaluation of indirect and cumulative effects associated with the policy alternatives should consider all of the protected species known from the 1-mile buffers around the potentially affected waterbodies. These conclusions form the basis for the evaluation of threatened and endangered species described in this section.

The information presented in the following discussion is a general summary of the evaluation that has been conducted with regard to threatened and endangered species. Details of the evaluation concerning protected species living in flowing-water habitats are presented in Appendix D6b. Results of the species-specific evaluation concerning federal-protected animals and plants are presented in the USFWS Biological Opinion (Appendix G).

5.13.2 Impact Assessment Methods

Direct Effects

The information presented in Section 4.13 indicates that 172 protected species are known from within the 200-foot buffers around the ROS waterbodies—the area where any direct effects of the policy alternatives would be most likely to occur. Information about the typical habitats and known occurrences of these species was used to associate them into clusters that would be affected in similar ways by various operational changes. The seven evaluation clusters are identified in Table 5.13-01, along with the numbers of species in each major taxonomic group that were assigned to them. The species included in each cluster are identified in the following paragraphs. In addition, the "Direct Effects Analysis" column in Appendix D6a presents the evaluation cluster in which each species is addressed.

Excluded Areas

Information presented in Section 3.4.1 indicates that none of the alternatives would include changes in the operations policy at Normandy Dam in the Duck River watershed or at any of the four dams in the Bear Creek watershed (Bear Creek, Upper Bear Creek, Little Bear Creek, and Cedar Creek Dams). Therefore, the following evaluation excludes any discussion about the 23 protected species that occur only within the 200-foot buffers around the 13 waterbodies in the Duck River and Bear Creek watersheds. Each of these excluded species is identified in the "Direct Effects Analysis" column in Appendix D6a. Any potential for the various alternatives to affect these species is discussed below under Indirect Effects.

Flowing-Water Habitats

The largest cluster of protected species identified in Table 5.13-01 consists of 58 species that typically occur in flowing-water habitats, including at least some parts of the impounded mainstem Tennessee and Cumberland Rivers. Nearly all of these species are mollusks and fish; however, the flowing-water habitats cluster also includes two turtles and a large, completely aquatic, salamander (the hellbender). All of these species are typically found in habitats out in the river or stream, where the water is obviously moving.

Holding water in reservoirs can modify habitat conditions important to flowing-water species because temperature and DO concentrations stratify in reservoirs during late spring, summer, and early fall, and those changes affect the water released from the dams. As described in Section 3.3, the various types of changes that could be made in the reservoir operations policy focus on when reservoir elevations would be raised or lowered, and when and how much water would be released from the dams. TVA aquatic biologists used these basic concepts to help identify specific evaluation measures (metrics) that would indicate any differences in direct effects between the Base Case and each policy alternative. The metrics were designed to focus on specific locations and specific times of the year that are important to the reproduction and survival of species living in flowing-water habitats. Metrics were developed for each of the four waterbody categories in which direct effects of the alternatives could affect protected species populations (warm tributary tailwaters, flowing mainstem reaches, pooled mainstem reaches, and cool-to-warm tributary tailwaters). These metrics are listed in Table 5.13-02. Details about why each metric is pertinent to specific waterbody types and the results of the comparisons between various alternatives and the Base Case are presented in Appendix D6b.

Table 5.13-01 Number of Protected Species Included in Each Part of the Direct Effects Evaluation

Direct Effects Analysis Category	Numbers of Species within Major Taxonomic Groups								Category Totals
	Plants	Mollusks	Arthropods	Fish	Amphibians	Reptiles	Birds	Mammals	
Excluded areas	8	5	0	11	0	0	0	0	23
Flowing-water habitats	0	44	0	11	1	2	0	0	58
Shoreline and lowland habitats	29	0	0	2	1	1	4	0	37
Upland habitats	30	0	0	0	0	0	1	0	31
Apalachia Bypass reach	4	3	0	1	0	0	0	0	8
Wide-ranging species	0	0	0	0	0	0	3	4	7
Reservoir inflow areas	1	1	0	2	0	0	0	0	4
Cave aquifers	0	0	1	2	0	0	0	0	3
Group totals	**72**	**53**	**1**	**29**	**2**	**3**	**8**	**4**	**172**

Note: The part of this evaluation in which each individual protected species is addressed is indicated in the "Direct Effects Evaluation" column in Appendix D6a.

Table 5.13-02 Flowing-Water Habitat Evaluation Metrics

Metric No.[1]	Waterbody Category and Metric Description
Pooled Mainstem Waterbodies	
1	The total volume of water in a reservoir with dissolved oxygen (DO) < 2 mg/L during the year
Flowing Mainstem Waterbodies	
2	The amount of time when the water downstream from a dam would contain DO < 2 mg/L during the summer period (July through October)
3	The minimum water level that would be achieved 90 percent of the time during the year at a given point downstream from a dam
Warm Tributary Tailwaters (4–9) and Cool-to-Warm Tributary Tailwaters (10–15)	
4 & 10	The minimum water level achieved 90 percent of the time during the year at the selected sites
5 & 11	The difference between the 90- and 10-percent instantaneous flow rates at the selected sites during the second and third weeks in June
6 & 12	The average water temperature at the selected sites during the second and third weeks in June
7 & 13	The difference between the 90- and 10-percent instantaneous water temperatures at the selected sites during the second and third weeks in June
8 & 14	The average water temperature at the selected sites during the third and fourth weeks in August
9 & 15	The difference between the 90- and 10-percent instantaneous water temperatures at the selected sites during the third and fourth weeks in August

[1] These metrics are specific evaluation measures developed by TVA aquatic biologists to compare the effects of the policy alternatives at specific locations and during specific times of the year that are important to the reproduction and survival of species living in flowing-water habitats.

Results of the three metric comparisons concerning the effects of the policy alternatives on protected species living in mainstem reservoirs and tailwaters (pooled mainstem reaches and flowing mainstem reaches, respectively) are summarized in Table 5.13-03. Most of the policy alternatives would produce substantially higher minimum water elevations (substantially more potential habitat for protected aquatic species) downstream from the mainstem dams (Metric # 3). The exceptions to this pattern are the Equalized Summer/Winter Flood Risk Alternative and the Preferred Alternative, both of which would typically produce minimum water elevations similar to those produced under the Base Case. Few of the policy alternatives would produce any differences in the number of hours with DO < 2 mg/L released from the mainstem dams (Metric # 2). The major exception to this pattern was the expectation of more hours of low DO discharges (substantially adverse habitat conditions) downstream from Watts Bar Dam under the Preferred Alternative; however, TVA has committed to providing a minimum of 4 mg/L DO in the discharge from this dam.

Table 5.13-03 Summary of Direct Effects on Threatened and Endangered Species for Mainstem Reservoirs and Tailwaters

Metric No.	Affected Waterbody	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower[1]	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Mainstem Reservoirs									
1	Kentucky	N	N		N	N	N	SA	N
1	Guntersville	N	N		N	N	N	N	N
1	Chickamauga	N	N		N	N	N	SA	N
Mainstem Tailwaters									
2	Pickwick discharge	N	SA		N	N	N	N	N
2	Wilson discharge	N	N		N	N	N	SA	N
2	Guntersville discharge	SA	N		N	N	N	N	N
2	Watts Bar discharge	N	N		N	N	N	N	SSA
3	Pickwick—RM 190	SB	SSB		N	SSB	SSB	SSB	N
3	Wilson—RM 256	SSB	SSB		N	SSB	SSB	SSB	N
3	Guntersville—RM 349	SB	SB		N	N	SB	SB	N
3	Watts Bar—RM 530	SSB	SSB		SA	SB	SSB	SSB	N

Notes:

RM = River mile.

Evaluation abbreviations:

A = Adverse changes with regard to protected aquatic species.
B = Beneficial changes with regard to protected aquatic species.
N = Not statistically different from the Base Case.
S = Slightly (80 – 95 percent confidence level).
SS = Substantially (95 percent confidence level or higher).

[1] No statistical analysis data are available for this alternative.

Other exceptions were more hours of low DO discharges (slightly adverse conditions) downstream from Guntersville Dam under Reservoir Recreation Alternative A, downstream from Pickwick Dam under Reservoir Recreation Alternative B, and downstream from Wilson Dam under the Tailwater Habitat Alternative. Only the Tailwater Habitat Alternative would result in more water volume with DO < 2 mg/L in at least some of the downstream reservoirs (Metric # 1); that alternative yielded indications of more water with low DO (slightly adverse habitat conditions) in Kentucky and Chickamauga Reservoirs.

Overall, only the Tailwater Habitat Alternative would result in decreased DO concentrations in mainstem reservoirs (slightly adverse habitat conditions) in comparison to what would occur under the Base Case, and only the Equalized Summer/Winter Flood Risk Alternative and the Preferred Alternative would result in minimum water levels as low as what would occur under the Base Case. All of the other alternatives would yield higher minimum water levels (providing slightly or substantially more habitat for protected aquatic species). The Preferred Alternative could result in more hours of low DO water downstream from Watts Bar Dam (substantially adverse habitat conditions); however, TVA would ensure that the discharge from Watts Bar Dam continued to meet its existing 4 mg/L DO target.

Table 5.13-04 summarizes the results of the 12 metric comparisons concerning the effects of the policy alternatives on protected species living in warm and cool-to-warm tributary tailwaters. With regard to the minimum water level metrics (Metrics # 4 and # 10), only the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative would produce effects different from what would occur under the Base Case. The Equalized Summer/Winter Flood Risk Alternative would result in higher minimum water levels (slightly more minimum wetted area) at the (warm) French Broad River site. The Tailwater Habitat Alternative would result in higher minimum water levels at the site on the French Broad River (slightly beneficial habitat conditions) and at both sites on the Holston River (substantially beneficial conditions).

With regard to the mid-June flow range metrics (Metrics # 5 and # 11), only the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative would produce effects different from what would occur under the Base Case. The Equalized Summer/Winter Flood Risk Alternative would produce less variation in mid-June flow ranges at both sites on the Holston River (substantially beneficial habitat conditions for protected species) and at the cool-to-warm site on the Elk River (slightly beneficial conditions for protected species). The Tailwater Habitat Alternative would produce less variation in flow ranges (substantially beneficial conditions) at the sites on the Holston, French Broad, and Hiwassee Rivers but would not result in flow ranges any different from those under the Base Case at either site on the Elk River.

The four average temperature metrics (Metrics # 6 and # 12 concerning mid-June and Metrics # 8 and # 14 concerning late August) tend to follow consistent patterns—at least on the individual rivers. All of the policy alternatives would produce higher (substantially beneficial) average temperatures than under the Base Case at the Hiwassee River site during both time periods. All of the policy alternatives except the Commercial Navigation Alternative would produce lower (substantially adverse) average temperatures than under the Base Case at both Holston River sites in late August (Metric # 14). The Equalized Summer/Winter Flood Risk Alternative would produce higher (substantially beneficial conditions) average temperatures at the cool-to-warm site on the Elk River during both time periods, higher (slightly beneficial) average temperatures at the warm site on the Elk River in mid-June, and higher (substantially beneficial) average temperatures at both Holston River sites in mid-June.

Table 5.13-04 Summary of Direct Effects Metrics Related to Protected Species for Warm and Cool-to-Warm Tributary Tailwaters

Metric	Location	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower[1]	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Warm Tributary Tailwaters									
4	Holston RM 30	N	N		N	N	N	SSB	N
4	Fr. Broad RM 18	N	N		SB	N	N	SB	N
4	Elk RM 73	N	N		N	N	N	N	N
5	Holston RM 30	N	N		SSB	N	N	SSB	N
5	Fr. Broad RM 18	N	N		N	N	N	SSB	N
5	Elk RM 73	N	N		N	N	N	N	N
6	Holston RM 30	N	N		SSB	SB	N	N	N
6	Fr. Broad RM 18	N	N		SSB	N	N	N	N
6	Elk RM 73	N	N		SB	N	N	N	N
7	Holston RM 30	N	N		N	N	N	SB	N
7	Fr. Broad RM 18	N	N		SSA	N	N	N	N
7	Elk RM 73	N	N		N	N	N	N	N

Metric	Location	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower[1]	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Cool-to-Warm Tributary Tailwaters									
10	Holston RM 48	N	N		N	N	N	SSB	N
10	Hiwassee RM 48	N	N		N	N	N	N	N
10	Elk RM 125	N	N		N	N	N	N	N
11	Holston RM 48	N	N		SSB	N	N	SSB	N
11	Hiwassee RM 48	N	N		N	N	N	SSB	N
11	Elk RM 125	N	N		SB	N	N	N	N
12	Holston RM 48	N	N		SSB	N	N	N	N
12	Hiwassee RM 48	SSB	SSB		SSB	SSB	SSB	SSB	SSB
12	Elk RM 125	N	N		SSB	N	N	N	N
13	Holston RM 48	N	N		SSA	N	N	N	N
13	Hiwassee RM 48	N	N		N	N	N	SB	N
13	Elk RM 125	N	N		SSB	N	N	N	N

Table 5.13-04 Summary of Direct Effects Metrics Related to Protected Species for Warm and Cool-to-Warm Tributary Tailwaters (continued)

Metric	Location	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower[1]	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred	Metric	Location	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower[1]	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Warm Tributary Tailwaters (continued)										Cool-to-Warm Tributary Tailwaters (continued)									
8	Holston RM 30	SSA	SSA		SSA	N	SSA	SSA	SSA	14	Holston RM 48	SSA	SSA		SSA	N	SSA	SSA	SSA
8	Fr. Broad RM 18	N	N		SSB	N	N	N	N	14	Hiwassee RM 48	SSB	SSB		SSB	SSB	SSB	SSB	SSB
8	Elk RM 73	N	N		N	N	N	N	N	14	Elk RM 125	N	SB		SB	N	SB	N	N
9	Holston RM 30	N	N		N	N	N	SSB	N	15	Holston RM 48	SB	SSB		SB	N	SSB	SSB	N
9	Fr. Broad RM 18	N	N		SB	N	N	N	N	15	Hiwassee RM 48	N	N		N	N	N	N	N
9	Elk RM 73	N	N		N	N	N	N	N	15	Elk RM 125	N	SSB		SSB	N	SSB	N	N

Notes:

Fr = French.
RM = River mile.

Evaluation abbreviations:

A = Adverse changes with regard to protected aquatic species.
B = Beneficial changes with regard to protected aquatic species.
N = Not statistically different from the Base Case.
S = Slightly (80 – 95 percent confidence level).
SS = Substantially (95 percent confidence level or higher).

[1] No statistical analysis data are available for this alternative.

Concerning the four temperature range metrics, the policy alternatives would produce very few differences from the ranges under the Base Case at the warm tailwater sites during either mid-June (Metric # 7) or late August (Metric # 9). Two of the exceptions to this pattern would occur under the Tailwater Habitat Alternative, which would produce less temperature variation at the warm reach site on the Holston River during both mid-June (slightly beneficial habitat conditions) and in late August (substantially beneficial conditions). The other exceptions would occur at the French Broad River site under the Equalized Summer/Winter Flood Risk Alternative, which would produce more temperature variation (substantially adverse conditions) in mid-June and less variation (slightly beneficial conditions) in late August than would occur under the Base Case.

In the cool-to-warm tailwater reaches, the effects of the alternatives on the temperature range metrics would differ, depending on which month was being examined. During mid-June (Metric # 13), the Tailwater Habitat Alternative would produce less variation (slightly beneficial conditions) at the Hiwassee River site. Also during mid-June, the Equalized Summer/Winter Flood Risk Alternative would produce more temperature variation (substantially adverse habitat conditions) at the Holston River site and less temperature variation (substantially beneficial conditions) at the Elk River site. During late August (Metric # 15), none of the alternatives would produce temperature variations different from the Base Case at the Hiwassee River site. At the Elk River site, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, and the Tailwater Recreation Alternative would produce less temperature variation (substantially beneficial conditions) during this period. At the Holston River site, five of the alternatives would produce less temperature variation during late August (slightly beneficial habitat conditions under Reservoir Recreation Alternative A and the Equalized Summer/Winter Flood Risk Alternative; substantially beneficial conditions under Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Preferred Alternative).

The Summer Hydropower Alternative is not included in the metric evaluation of the flowing-water habitats because the Water Quality model could not provide output data for low-flow years (such as 1987 to 1989) when that alternative would result in discharging virtually all of the water in several tributary reservoirs. The general impressions about the effects of the Summer Hydropower Alternative on protected aquatic species that can be derived from its description (see Section 3.3.4) suggest that summer flow and, probably, water temperatures in the tributary tailwaters would be more variable than under the Base Case (less natural conditions for protected aquatic species). In mainstem reservoirs and tailwaters during the summer months, the Summer Hydropower Alternative probably would provide higher flows and, possibly, higher DO concentrations (more natural conditions for protected aquatic species) than would occur under the Base Case.

Shoreline and Lowland Habitats

The shoreline and lowland habitats that exist along the margins of the reservoirs and regulated stream reaches included in the ROS study area are inhabited by many types of animals and plants, some of that are protected at the federal or state level. The cluster of species covered by this part of the protected species evaluation includes a total of 39 species: 30 plants, five birds, two fish, an amphibian, and a reptile. Each of these species is identified in the "Direct Effects Analysis" column in Appendix D6a. Some of these species spend their entire lives submersed in springs, ponds, or other bodies of water (such as largeleaf pondweed and spring pygmy sunfish) but most of the others live in and around wetland habitats at the edges of the waterbodies. Changes in summer and winter pool levels, and when the reservoirs would be filled and drawn down under the various policy alternatives, could substantially affect the protected species living in these shoreline and lowland habitats. The general aspects of those effects are discussed in Section 5.8 (Wetlands) and Section 5.10 (Terrestrial Ecology). The following paragraphs focus on the ways various policy alternatives could affect the protected species living in these habitats.

Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would involve holding reservoir pool levels higher until, or later than, Labor Day. Under these alternatives, large areas on the mainstem reservoirs now occupied by scrub/shrub or bottomland hardwood communities would become aquatic beds; however, the Preferred Alternative would not involve any pool level changes or impacts on shoreline habitats on Kentucky Reservoir. Protected plants and animals now living in scrub/shrub or bottomland hardwood communities (such as lamance iris and green treefrog) would be adversely affected by the loss of suitable habitat. Other protected species (such as the great egret and wood stork) might benefit from the additional foraging habitat; however, they also might lose present roosting and potential nesting sites. Spring and seep habitats harboring protected aquatic species adjacent to the full-pool reservoirs would not be adversely affected and might increase in size as the scrub/shrub habitats declined. Overall, these alternatives would adversely affect protected species living in shoreline and lowland habitats, primarily because of the unreplaced loss of the scrub/shrub habitats.

Under the Summer Hydropower Alternative, reservoir pool levels would be held at high levels for much shorter time periods during the year than would occur under the Base Case. Under the Summer Hydropower Alternative, large areas of mainstem and tributary reservoirs now occupied by various types of wetland habitats would lose water more quickly during the growing season, and upland species would encroach on those habitats. Protected species that require wetland habitat conditions (such as sweetflag) would be adversely affected. This alternative also would result in adverse impacts on protected species living in shoreline and lowland habitats, again because of habitat loss.

The changes in reservoir pool levels that would occur under the Equalized Summer/Winter Flood Risk Alternative would result in continual changes in reservoir pool elevations. These pool level changes would occur throughout the growing season and would essentially prevent the establishment of stable wetland communities (see Section 5.8, Wetlands). As with the previous two sets of alternatives, protected species that require relatively stable wetland habitat conditions would be adversely affected by the Equalized Summer/Winter Flood Risk Alternative, although, once again, different operations policy would be responsible.

The Commercial Navigation Alternative would involve only minor modifications in pool levels during summer. During winter, the higher mainstem pool levels would serve to stabilize some wetland habitats, perhaps as slightly different communities than presently exist. Higher winter mainstem pool levels also could result in less foraging habitat for protected shorebirds such as the piping plover. Overall, this alternative probably would result in slightly beneficial impacts on protected shoreline and lowland species when compared to the Base Case.

Upland Habitats

The upland habitats cluster of protected species includes 30 plants (identified in the "Direct Effects Analysis" column in Appendix D6a) and one bird (Swainson's warbler). All of these species have been encountered within the 200-foot buffers around one or more ROS waterbodies; however, they typically occur in drier upland habitats that are not influenced by manipulation of the reservoirs or tailwaters. As indicated for all upland plant and animal communities (see Section 5.10, Terrestrial Ecology), these protected species would not be affected (directly or indirectly) by any of the policy alternatives. None of the alternatives would include raising summer pool levels any higher than under the Base Case; none of the alternatives would involve changes in the loss of land by wave action, erosion, or mass wasting (see Section 5.16, Shoreline Erosion); and none of the alternatives would result in changes in the locations or rates of conversion of open land to residential or commercial developments (see Section 5.15, Land Use).

Apalachia Bypass Reach

The eight protected species included in the Apalachia Bypass Reach cluster consist of four plants, two freshwater mussels, an aquatic snail, and a fish. These species are being evaluated together mostly because one of the habitats in which they all occur would be affected by a flow modification that is proposed as part of each of the policy alternatives.

During all times of the year, except when spilling is required from Apalachia Dam, nearly all of the flow at this dam is diverted through a tunnel to the powerhouse. The river channel in this bypassed stream reach receives leakage flow from the dam and unregulated inflow from several small tributary streams. Terrestrial vegetation along the bypass reach includes some species adapted to life in and along the river channel, along with trees and other woody vegetation that can survive infrequent but substantial flooding and scouring. These eight protected species include two plants (Ruth's golden aster and gibbous panic-grass) that are only found in rock crevices along scoured streambeds; two aquatic or semi-aquatic plants (creekgrass and a pondweed) that occur in the water; and three mollusks and a fish (knotty elimia snail, Cumberland bean, tan riffleshell mussels, and tangerine darter) that occur on, in, or not far from the stream bottom.

TVA may augment minimum flow in the 13-mile reach of the Hiwassee River between Apalachia Dam and the Apalachia Powerhouse to enhance the diversity of aquatic species in that waterbody. The present concept is to release a continuous flow of approximately 25 cfs from Apalachia Dam into the bypass reach between June 1 and November 1. The additional flow would be intended to increase the wetted area down the length of the bypass channel and provide additional flow and habitat stability for native aquatic species. This modification in the flow pattern downstream from Apalachia Dam is included in each of the policy alternatives (see Section 3.4.1).

The additional minimum flow would increase the amount of, and improve the quality of, the habitats for the protected mollusks and fish, and, potentially, for other protected aquatic species that exist or could be introduced into this part of the Hiwassee River. With regard to the plants, however, the infrequent but substantial spilling events control whether these protected species can continue to survive along this river channel. Previous observations have suggested that submersal for more than 10 consecutive days during the growing season (March through September) probably would have adverse effects on at least some of these plant species. Analysis of the actual flow data; however, indicates that spills exceeding 10 days duration have occurred routinely during the 60-year period since Apalachia Dam was built. Adoption of the proposed additional flow down this bypass channel would not result in more days of spilling or longer duration spills than would occur under the Base Case. These results indicate that the proposed change would not likely result in adverse effects on the protected plants or animals in this area.

Wide-Ranging Species

This cluster of six species includes two birds (peregrine falcon and bald eagle) and four mammals (eastern big-eared bat, gray bat, eastern small-footed bat, and Indiana bat). All six of these species have specific breeding, feeding, and roosting requirements; however, they all also range over wide areas on a daily or a seasonal basis, typically including some time over or along reservoirs and larger streams. Peregrine falcons and eastern small-footed bats would continue to forage, roost, and reproduce unaffected by the types or extent of changes involved in the policy alternatives.

Bald eagles and gray bats could be benefited by Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative to the extent that each alternative would increase the size of reservoir pools and increase the numbers of food items (mostly fish and waterfowl for the eagles and adult aquatic insects for gray bats). The Summer Hydropower Alternative could have the opposite effect on these species because it would decrease the size of mainstem reservoir pools and might decrease the number of food items for these species. Results of the Aquatic Resources evaluation indicate that Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would likely result in degraded biodiversity but increases in the number of warm-water fishes (see Section 5.7, Aquatic Resources). That evaluation also indicated that the Commercial Navigation Alternative would result in similar effects on aquatic life to what would occur under the Base Case.

In contrast, eastern big-eared bats and Indiana bats could be adversely affected by Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation

Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative to the extent that each alternative would increase the size of reservoir pools and decrease the number of suitable roosting trees in forested wetlands (see Section 5.8 [Wetlands] and Section 5.10 [Terrestrial Ecology]). Under any of these alternatives, both of these species would be able to find other suitable roosting trees in adjacent areas and would be able to adapt to the habitat changes without any long-term adverse effects.

Reservoir Inflow-Related Areas

This evaluation cluster includes only four species; however, these species represent a variety of relationships that may be pertinent across many parts of the river systems. One of these species, Cumberland rosemary, lives on seasonally inundated banks and bars along swift Cumberland Plateau streams—including a site on the Emory River just upstream from the full pool level on Watts Bar Reservoir. The second species, the Appalachian elktoe, is known from unimpounded stream reaches just upstream from Fontana and Calderwood Reservoirs. The third, bluemask darter, occurs in unimpounded stream reaches just upstream from Great Falls Reservoir. And the fourth, sicklefin redhorse (a fish), is known from impounded and unimpounded reaches upstream from Mission and Fontana Reservoirs. In all four of these cases (and, potentially at least, in several others), the flowing-water habitats in which these species occur extend downstream to the limits of or, occasionally, into the impoundments. The present status of these species (and, in effect, the Base Case) includes the fact that the impoundments were built and the habitats within those reservoirs may not be suitable for the protected species. Each of the policy alternatives calls for the reservoirs to be filled to present summer pool levels at some point during the year, and none of the policy alternatives includes raising summer pool levels any higher than they would be under the Base Case. Those facts support the conclusion that none of the policy alternatives would result in additional impacts on protected aquatic species living upstream from the affected reservoirs. The same facts also support the conclusion that none of the policy alternatives would likely provide any long-term benefits to upstream populations of protected aquatic species because any flowing-water habitat restored by lowering a reservoir pool during part of the year would be re-impounded at other times during the year.

Cave Aquifers

Three protected species are known from pools or flowing water in caves within the 200-foot buffer areas around the ROS waterbodies. These three protected aquatic cave species are an un-described cave shrimp, the Alabama cavefish, and the southern cavefish. In each of the locations where these species occur adjacent to ROS waterbodies, the underground aquifer systems exist at a higher elevation than the full pool level of the adjacent reservoir or regulated stream reach and do not appear to fluctuate when the reservoir pool levels are changed. Given that none of the policy alternatives would include raising pool levels higher than the elevations already reached under the Base Case, none of the policy alternatives would directly affect these protected cave aquatic species.

Indirect Effects

As indicated in Section 4.13, Table 4.13-02, and the introduction to this section, at least a few of the 526 protected species know from within the 1-mile buffers around the ROS waterbodies could occur in virtually any habitat present in those corridors. On that basis, the possibility exists that one or more of the policy alternatives could result in secondary or indirect effects on some protected species even though the operational changes at the dams associated with the alternatives would not directly affects those species.

While secondary and indirect effects on protected species might occur under some of the policy alternatives, information presented in other sections of this EIS indicates that no indirect effects on these species would occur. As indicated for all the terrestrial plant and animal communities (see Section 5.10, Terrestrial Ecology), none of the alternatives would include raising summer pool levels any higher than would occur under the Base Case; none of the alternatives would involve more than minor changes in the loss of land by wave action, erosion, or mass wasting (see Section 5.16, Shoreline Erosion); and none of the alternatives would result in changes in the locations or rates of conversion of open land to residential developments (see Section 5.15, Land Use). If none of the alternatives would affect the locations or rates of residential shoreline development, they also would not lead to any indirect effects on waterbodies included in this evaluation or any stream segments further upstream from the tributary reservoirs.

5.13.3 Base Case

Under the Base Case, existing trends would continue with regard to the status of endangered, threatened, and other protected species in the ROS study area. As indicated in Section 4.13, 526 of the species that occur in the TVA region have been provided additional protection by the federal and state governments because their original habitats had been severely degraded by human development of the land and the water. The variety of monitoring, habitat improvement, and enhancement activities that have been started in recent years are likely to continue and perhaps would be expanded. Laws and regulations would continue to provide some level of protection for these species. Future trends for the protected species in the ROS study area are likely to include a few successes, more failures, and many unknowns. The following summaries indicate the likely trends for the seven clusters of protected species discussed in Section 5.13.2 under the Base Case.

Flowing-Water Habitats. As indicated in Section 4.7, Aquatic Resources, the flowing-water habitats in the tributary tailwaters are beginning to show signs of improvement following the addition of minimum flows and DO augmentations identified in the Lake Improvement Plan. Except for the expanding snail darter populations in the tailwaters downstream from Cherokee and Douglas Dams, monitoring data do not yet indicate that protected aquatic species are responding to these improvements. Some protected species are being reintroduced into the tributary and mainstem tailwaters on the assumption that they should survive and reproduce there. Populations of most protected freshwater mussel species living in mainstem waterbodies do not include many young individuals and appear to be declining toward extirpation in those habitats.

Shoreline and Lowland Habitats. Information presented in Section 4.8 (Wetlands) and Section 4.10 (Terrestrial Ecology) indicates that most shoreline and lowland plant and animal communities appear to have adapted to the present operations policy; however, the spread of invasive wetland species and continuing pressure to develop shoreline property are reducing the size and number of these habitats. Unrelated to the TVA reservoir operations policy, the continuation of existing trends along shorelines and other lowland habitats would include the gradual loss of suitable habitat and populations of protected species that occur in those areas.

Upland Habitats. Protected species living in upland areas around the reservoirs and regulated streams are not directly affected by the present operations policy. Given the presence of the reservoirs, the continuation of existing trends would include the gradual loss of natural upland habitats to invasive species and development. More than likely, some protected upland species would benefit from ongoing and future enhancement activities; however, many others would continue to remain unknown to the general public and could be adversely affected by increasing development pressures.

Other Protected Species. Under the Base Case, the other clusters of protected species discussed in Section 5.13.2 also would continue to follow existing trends. Most of the wide-ranging birds and bats would continue to expand in numbers and distribution as ongoing management activities fulfill their goals, while the Indiana bat would continue to decline. Protected species living in caves or free-flowing stream reaches upstream from impoundments would not be affected by the reservoir operations policy but could be affected by localized pollution events or development pressures.

5.13.4 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and Tailwater Recreation Alternative

Under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Recreation Alternative, summer pool levels would be extended on most tributary reservoirs to Labor Day but would vary from each other in the amounts and the timing of releases from the dams. Concerning protected species, the variety of monitoring, habitat improvement, and enhancement activities that have been started in recent years are likely to continue and perhaps would be expanded. Laws and regulations would continue to provide some level of protection for these species, and future trends for the protected species in the ROS study area would likely be similar to the patterns described for the Base Case. The following summaries indicate how impacts on habitat clusters of protected species under these alternatives would differ from those described in the Base Case.

Flowing-Water Habitats. Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Recreation Alternative would result in relatively few changes in the habitats of protected aquatic species in the regulated river system. In tributary tailwaters, Reservoir Recreation Alternative A and the Tailwater Recreation Alternative would result in more natural summer water temperatures in some cool-to-warm waterbodies than the Base Case, while all three of these alternatives would result in less natural water temperatures in others. In the Tennessee River mainstem, all three alternatives would result in higher minimum water levels in tailwaters, which could provide some additional habitat for protected aquatic species. Reservoir Recreation Alternative A also might result in less DO than the Base Case in the releases from some mainstem dams.

Shoreline and Lowland Habitats. The longer duration of summer pool levels on tributary reservoirs that would occur under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Recreation Alternative would result in losses of scrub/shrub habitats along the margins of those waterbodies. Protected species that depend on scrub/shrub habitats would be adversely affected by these changes.

Upland Habitats. Like the Base Case, Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Recreation Alternative would not affect protected species living in upland habitats.

Other Protected Species. Under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Recreation Alternative, the longer duration of summer pool levels could benefit populations of bald eagles and gray bats foraging over the affected reservoirs. Under these alternatives, impacts on other wide-ranging protected species, protected species occurring upstream from impoundments or living in caves, or protected species living in the Hiwassee River between Apalachia Dam and the Apalachia Powerhouse would not differ from what would occur under the Base Case.

5.13.5 Equalized Summer/Winter Flood Risk Alternative and Tailwater Habitat Alternative

Although the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative have different purposes, both would involve operating the dams based on the amount of runoff coming into the river system. Under these alternatives, reservoir pool levels and flows in the tailwaters would vary in response to how much water was flowing down the rivers. Laws and regulations would continue to provide some level of protection for protected species in the ROS study area, and future trends for those species would likely be somewhat similar to the patterns described for the Base Case. The variety of monitoring, habitat improvement, and enhancement activities that have been started in recent years also would be likely to continue and perhaps would be expanded within the context of either of these alternatives.

Flowing-Water Habitats. Both the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative would tend to provide more natural flow and temperature regimes in mainstem tailwaters than the Base Case; however, the Tailwater Habitat Alternative also could provide more stressful DO conditions in mainstem waterbodies. In the tributary tailwaters, these alternatives would lead to more natural summer flow and water temperature conditions.

Shoreline and Lowland Habitats. The Equalized Summer/Winter Flood Risk Alternative would lead to adverse changes in the habitats of shoreline and wetland protected species because reservoir pool levels would be continually changing throughout the year. The Tailwater Habitat Alternative would lead to adverse changes in the habitats of some shoreline and wetland protected species because tributary reservoir pool levels would remain higher during parts of the year than they would under the Base Case.

Upland Habitats. The Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative would not affect protected species living in upland habitats.

Other Protected Species. Under the Tailwater Habitat Alternative, the longer duration of summer pool levels on tributary reservoirs could benefit populations of bald eagles and gray bats foraging over those areas. Impacts under the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative would not differ from those described under the Base Case for other wide-ranging protected species, protected species occurring upstream from impoundments or living in caves, or protected species living in the Hiwassee River between Apalachia Dam and the Apalachia Powerhouse.

5.13.6 Commercial Navigation Alternative

The operational changes included in the Commercial Navigation Alternative would focus on improving the reliability of the mainstem Tennessee River for commercial navigation. Impacts on protected species related to the changes in winter pool levels and minimum flows downstream from the mainstem dams associated with this alternative would be similar to those described for the Base Case. The variety of monitoring, habitat improvement, and enhancement activities that have been started in recent years would likely continue and perhaps would be expanded under this alternative. Laws and regulations would continue to provide some level of protection for these species, and the future trends for the protected species in the ROS study area would remain unchanged from what would occur under the Base Case.

Flowing-Water Habitats. Impacts on the habitats of protected aquatic species under the Commercial Navigation Alternative would be similar to those described for the Base Case. In tributary tailwaters, the only differences in impacts from those described for the Base Case would be a few more examples of more natural average summer water temperatures. In mainstem habitats, the only differences would be increases in minimum water elevations. None of the flowing-water metrics indicated more adverse impacts than would occur under the Base Case.

Shoreline and Lowland Habitats. The higher winter pool levels and only minor modifications in summer pool levels on mainstem reservoirs that would occur under the Commercial Navigation Alternative would slightly benefit protected species living in shoreline and wetland habitats.

Upland Habitats. The Commercial Navigation Alternative would not affect protected species living in upland habitats.

Other Protected Species. The relative stability in mainstem pool levels provided by the Commercial Navigation Alternative would result in potential benefits to bald eagles and gray bats. This alternative would not have effects any different from the Base Case on other wide-ranging protected species, protected species occurring upstream from impoundments or living in caves, or protected species living in the Hiwassee River between Apalachia Dam and the Apalachia Powerhouse.

5.13.7 Summer Hydropower Alternative

Operation of the reservoir system under the Summer Hydropower Alternative would focus on maximizing power production at the dams. Daily and seasonal changes in dam operations would result in a variety of differences from the Base Case. Although monitoring activities on the river system would likely continue, some habitat improvement and enhancement activities that have been started in recent years might not be continued because of the decrease in tailwater habitat stability. Laws and regulations would continue to provide some level of protection for endangered and threatened species; future trends for the protected species in the ROS study area would be the same as described for the Base Case.

Flowing-Water Habitats. As indicated in Section 5.13.2, the Summer Hydropower Alternative could not be included in the metric evaluation because no water quality modeling data were available. General impressions about the effects of the Summer Hydropower Alternative on protected aquatic species that can be derived from its description suggest that summer flow and probably water temperatures in the tributary tailwaters would be more variable than would occur under the Base Case (less natural conditions for protected aquatic species). In mainstem reservoirs and tailwaters during summer, the Summer Hydropower Alternative probably would provide higher flows and possibly higher DO concentrations (more natural conditions for protected aquatic species) than the Base Case.

Shoreline and Lowland Habitats. The early lowering of summer reservoir pool levels under the Summer Hydropower Alternative would reduce the amount of wetland habitats and would result in adverse changes for protected species that occur in those areas.

Upland Habitats. The Summer Hydropower Alternative would not affect protected species living in upland habitats.

Other Protected Species. The early lowering of summer reservoir pool levels under the Summer Hydropower Alternative would reduce the size of mainstem reservoir pools, which could lead to decreases in the numbers of prey species for bald eagles and gray bats. Impacts under the Summer Hydropower Alternative would not differ from those described under the Base Case for wide-ranging protected species, protected species occurring upstream from impoundments or living in caves, or protected species living in the Hiwassee River between Apalachia Dam and the Apalachia Powerhouse.

5.13.8 Preferred Alternative

Under the Preferred Alternative, tributary reservoir drawdown would be restricted from June 1 through Labor Day, summer operating zones would be maintained through Labor Day at four additional mainstem projects, and higher winter pool operating ranges would be established at 10 tributary reservoirs. Base Case minimum flows and the DO targets adopted following completion of the Lake Improvement Plan would continue to be met and, subject to flood control operations or extreme drought conditions, scheduled releases would be provided at five additional tributary projects to increase tailwater recreational opportunities. No changes in operations policy would occur on Kentucky Reservoir under the Preferred Alternative.

Concerning protected species, the variety of monitoring, habitat improvement, and enhancement activities that have been started in recent years are likely to continue and perhaps would be expanded. Laws and regulations would continue to provide some level of protection for these species, and future trends for the protected species in the ROS study area would likely be similar to the patterns described for the Base Case.

Flowing-Water Habitats. The Preferred Alternative would result in relatively few changes in the habitats of protected aquatic species in the regulated river system. In tributary tailwaters, this alternative would result in more natural summer water temperatures in some cool-to-warm waterbodies and less natural water temperatures in others than would occur under the Base Case. In the Tennessee River mainstem, adoption of the Preferred Alternative would not degrade present habitat quality downstream from the dams; however, additional effort would be required to continue to provide a minimum of 4 mg/L DO downstream from Watts Bar Dam.

Shoreline and Lowland Habitats. The longer duration of summer pool levels on tributary and some mainstem reservoirs that would occur under the Preferred Alternative would result in losses of scrub/shrub habitats along the margins of those waterbodies. Protected species that depend on scrub/shrub habitats would be adversely affected by these changes. These effects would not occur on Kentucky Reservoir because no changes in operations policy would occur in that reservoir under the Preferred Alternative.

Upland Habitats. Like the Base Case, the Preferred Alternative would not affect protected species living in upland habitats.

Other Protected Species. Under the Preferred Alternative, the longer duration of summer pool levels could benefit populations of bald eagles and gray bats foraging over the affected reservoirs. Under this alternative, impacts on other wide-ranging protected species, protected species occurring upstream from impoundments or living in caves, or protected species living in the Hiwassee River between Apalachia Dam and the Apalachia Powerhouse would not differ from what would occur under the Base Case.

5.13.9 Summary of Impacts

Table 5.13-05 provides a summary of the results of the analysis of impacts on threatened, endangered, and other protected species.

In general, these results indicate that the Commercial Navigation Alternative would not result in any adverse effects on protected species and would provide beneficial effects on summer water temperatures for protected species in comparison to the Base Case. The Preferred Alternative would also provide beneficial effects on summer water temperatures for protected aquatic species in some tailwaters but would result in adverse summer temperature effects in other tailwaters. Both the Equalized Summer/Winter Flood Risk Alternative and the Tailwater Habitat Alternative would lead to some adverse effects on scrub/shrub habitats along reservoir shorelines but would also provide beneficial temperature effects for protected species in tributary tailwaters. The Tailwater Recreation Alternative, Reservoir Recreation Alternative A, and Reservoir Recreation Alternative B would result in some adverse effects on scrub/shrub habitats along reservoir shorelines and some adverse summer temperature effects on protected aquatic species in tributary tailwaters. The Summer Hydropower Alternative probably would result in adverse effects on summer water temperature ranges in tailwaters and on scrub/shrub habitats along reservoir shorelines.

Table 5.13-05 Summary of Impacts on Endangered, Threatened, and Other Protected Species by Policy Alternative

Alternative	Evaluation Cluster							
	Flowing-Water Mainstem Reservoirs and Tailwaters	Flowing-Water Tributary Reservoirs and Tailwaters	Shorelines and Lowland Habitats	Uplands Habitats	Apalachia Bypass Reach	Wide-Ranging Species	Reservoir Inflow Areas	Cave Aquifers
Base Case	No change – Continuation of existing trends could lead to eventual loss of some mussel species from these habitats.	No change – Continuation of existing trends would include increasing diversity and reintroductions of protected species in these tailwaters.	No change – Continuation of existing trends would include the gradual loss of habitats and species populations.	No change – Existing trends would continue.	No change – Existing trends would continue.	No change – Existing trends would continue.	No change – Existing trends would continue.	No change – Existing trends would continue.
Reservoir Recreation A	Slightly beneficial – Higher minimum water levels on tailwaters; less DO in releases from some dams.	Variable – Less natural water temperatures in some tailwaters, more natural in others; less late summer temperature variation in some tailwaters.	Slightly adverse – Unreplaced loss of scrub/shrub habitats due to higher summer pool levels.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Slightly beneficial – Potential benefits to eagles and gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.
Reservoir Recreation B	Slightly beneficial – Higher minimum water levels on tailwaters; less DO in releases from some dams.	Variable – Less natural water temperatures in some tailwaters, more natural in others; less late summer temperature variation in some tailwaters.	Slightly adverse – Unreplaced loss of scrub/shrub habitats due to higher summer pool levels.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Slightly beneficial – Potential benefits to eagles and gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.

Table 5.13-05 Summary of Impacts on Endangered, Threatened, and Other Protected Species by Policy Alternative (continued)

Alternative	Evaluation Cluster							
	Flowing-Water Mainstem Reservoirs and Tailwaters	Flowing-Water Tributary Reservoirs and Tailwaters	Shorelines and Lowland Habitats	Uplands Habitats	Apalachia Bypass Reach	Wide-Ranging Species	Reservoir Inflow Areas	Cave Aquifers
Summer Hydropower	Beneficial – Probably higher flows and DO concentrations.	Adverse – Probably more variable summer flows and water temperatures.	Adverse – Unreplaced loss of wetland habitats due to shorter duration of summer pool levels.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Adverse – Potential adverse effects to gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.
Equalized Summer/ Winter Flood Risk	No change – Lower tailwater level at one site.	Beneficial – Less variation in June flow rates and less summer temperature variation in some tailwaters; more natural summer water temperatures in most tailwaters.	Adverse – Unreplaced loss of wetland habitats due to frequent changes in pool levels.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	No change – Existing trends would continue.	No change – Existing trends would continue.	No change – Existing trends would continue.
Commercial Navigation	Beneficial – Higher minimum water levels on most tailwaters.	Slightly beneficial – Very similar to Base Case; more natural summer water temperature in some tailwaters.	Slightly beneficial – Increased stability of slightly modified wetlands.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Slightly beneficial – Potential benefits to eagles and gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.

Table 5.13-05 Summary of Impacts on Endangered, Threatened, and Other Protected Species by Policy Alternative (continued)

Alternative	Evaluation Cluster							
	Flowing-Water Mainstem Reservoirs and Tailwaters	Flowing-Water Tributary Reservoirs and Tailwaters	Shorelines and Lowland Habitats	Uplands Habitats	Apalachia Bypass Reach	Wide-Ranging Species	Reservoir Inflow Areas	Cave Aquifers
Tailwater Recreation	Beneficial – Higher minimum water levels on tailwaters.	Variable – Less natural water temperatures in some tailwaters, more natural in others; less late summer temperature variation in some tailwaters.	Slightly adverse – Unreplaced loss of scrub/shrub habitats due to higher summer pool levels.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Slightly beneficial – Potential benefits to eagles and gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.
Tailwater Habitat	Variable – Higher minimum water levels on tailwaters; larger volume of low DO water; longer time of low DO discharges at one dam.	Beneficial – More natural summer water temperatures and late summer temperature ranges in some tailwaters.	Adverse – Unreplaced loss of scrub/shrub habitats due to higher summer pool levels.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Slightly beneficial – Potential benefits to èagles and gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.
Preferred	No change – Longer time of low DO discharges at one dam (would be corrected).	Few changes from Base Case – Less natural water temperatures in some tailwaters; more natural in others.	Slightly adverse – Unreplaced loss of scrub/shrub habitats due to higher summer pool levels; no change from Base Case on Kentucky Reservoir.	No change – Existing trends would continue.	Slightly beneficial – Increased minimum flow would benefit aquatic species; no effects on terrestrial species.	Slightly beneficial – Potential benefits to eagles and gray bats.	No change – Existing trends would continue.	No change – Existing trends would continue.

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5.14 Managed Areas and Ecologically Significant Sites

5.14.1 Introduction

Changes in reservoir operations are not likely to eliminate or alter the boundaries of managed areas and ecologically significant sites. Reservoir operations changes, however, could affect the resources that managed areas were established to address, thereby affecting their integrity. As described in Section 4.14, the most frequently cited management objectives for potentially affected managed areas and ecologically significant sites are protection of state- and federal-listed species, water-dependent bird habitat management, and recreation use. Habitat protection is an underlying objective of most managed areas and ecologically significant sites. Managed areas on reservoir or tailwater shorelines are most vulnerable to direct impacts, while upland and headwater areas are less vulnerable and therefore were eliminated from further assessment.

Potential indirect effects of increased shoreline development—including habitat fragmentation, the spread of invasive species, the presence of feral animals, increased visitor pressure, sedimentation, and erosion—were considered negligible, because only the rate of development may vary among alternatives (see Section 5.15, Land Use), and not, ultimately, the location or amount of developed acreage.

5.14.2 Impact Assessment Methods

The effects of each policy alternative on managed area resources and uses, including wetlands, terrestrial ecology, endangered and threatened species, and recreation, are addressed in Sections 5.8 (Wetlands), 5.10 (Terrestrial Ecology), 5.13 (Threatened and Endangered Species), and 5.24 (Recreation), respectively.

The evaluation in Section 5.8, Wetlands, included wetland attributes such as location, type, and function, as well as managed wetlands such as those subimpoundments that are seasonally drained and flooded for waterfowl management purposes. The integrity of some of the largest managed areas relies on the ability to raise and lower water levels in these managed wetlands. Many managed areas and ecologically significant sites also protect "unmanaged" wetlands for wildlife or endangered species habitat; therefore, all wetland types and functions are critical to the integrity of managed areas and ecologically significant sites.

The most likely effects of changes in reservoir operations on terrestrial ecology (see Section 5.10, Terrestrial Ecology) would be to lowlands and reservoir-associated wildlife. Particularly vulnerable resources include bottomland hardwood forests, scrub/shrub wetlands, annual flats plant communities, and globally rare wetland communities—many of which are protected within managed areas and ecologically significant sites.

Many threatened and endangered species occur in managed areas and ecologically significant sites, some of which were established to conserve these species. Those most likely to be affected by changes in the reservoir operations policy are the aquatic species along the least modified stream reaches, including warm tributary tailwaters, flowing mainstem reaches, some pooled mainstem reaches, and cool-to-warm tributary tailwaters (see Section 5.13, Threatened and Endangered Species). Alternatives that alter water temperature, DO, and quantity of water may produce conditions more or less similar to the natural conditions in which threatened and endangered species thrive.

For each policy alternative, the combined effects on the resources described above were evaluated for significance to the operational integrity of managed areas and ecologically significant sites as a group, because many of these sites fulfill multiple and varied management objectives. The evaluations focused on wetlands and managed subimpoundments, the managed area resources with the greatest potential to be affected by the policy alternatives.

5.14.3 Base Case

Under the Base Case, managed areas and ecologically significant sites would remain in their current state of management, subject to natural fluctuations. In general, these sites meet their management objectives under existing operating conditions and would continue to do so. The general trend of slight shifts in wetland location, type, and function (see Section 5.8, Wetlands) would have little effect on managed area integrity. The stress exhibited in some bottomland hardwoods, particularly water tupelo, from excessive periods of inundation under the current water regime (see Section 5.10, Terrestrial Ecology) could affect the integrity of a few sites such as the 281-acre Muddy Bottoms TVA HPA on Wheeler Reservoir and portions of the 34,500-acre Wheeler NWR.

5.14.4 Commercial Navigation Alternative

Conditions under the Commercial Navigation Alternative would be generally similar to those for the Base Case. The greatest change affecting managed areas would be the higher winter pools and slight increases in the duration of water cover over flats and shoreline. This would adversely affect management of migratory shorebirds while slightly benefiting other wildlife. Management of waterfowl subimpoundments in refuges and waterfowl management areas on Kentucky, Barkley, and Wheeler Reservoirs may be adversely affected if higher late-winter and spring water levels hinder their dewatering.

5.14.5 Reservoir Recreation Alternative A and Tailwater Habitat Alternative

Under Reservoir Recreation Alternative A and the Tailwater Habitat Alternative, mean summer pool duration and winter pool elevations would increase on many mainstem reservoirs and selected tributary reservoirs. This increase in water availability would benefit aquatic bed wetlands but would result in slightly adverse effects on other wetland types (primarily flats, scrub/shrub, and forested wetlands, and associated wildlife), and adverse effects on late-summer and early-fall migrating shorebirds targeted by many of the state and federal wildlife refuges. Higher winter water levels on Wheeler and Douglas Reservoirs could adversely affect the management of waterfowl impoundments as described for the Commercial Navigation Alternative. Overall, Reservoir Recreation Alternative A and the Tailwater Habitat Alternative would result in slightly adverse to beneficial effects on managed areas and ecologically significant sites.

5.14.6 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, mean summer pool duration would extend several weeks longer than under Reservoir Recreation Alternative A, and winter pool elevations would increase on many mainstem reservoirs and selected tributary reservoirs. The timing of the increase in water would slightly benefit some wetlands and wildlife habitat functions but would adversely affect flats, scrub/shrub, and forested wetlands, hindering protection of these wetland types in areas such as Rankin Bottoms. These alternatives also would increase the risk of crop flooding in waterfowl subimpoundments on Kentucky, Wheeler, and Douglas Reservoirs. The overall effects of these two alternatives on managed areas and ecologically significant sites would be slightly adverse.

5.14.7 Summer Hydropower Alternative

Under the Summer Hydropower Alternative, summer pool duration would be shorter than under the Base Case due to increased power production, and winter pools would be higher on tributary reservoirs. The resulting shifts in reservoir-dependent wetlands would occur too quickly for adaptive changes (Section 5.8, Wetlands), resulting in a substantially adverse effect on wetlands in managed areas. The delayed filling and early drawdown on mainstem reservoirs could have a beneficial effect on waterfowl subimpoundments by facilitating spring dewatering and reducing summer flood risk and subsequent crop loss. Invasive species may become problematic in managed areas. Bottomland hardwoods and some globally imperiled plant communities could be substantially adversely affected by the prolonged drawdown that would allow upland plants to invade and alter community composition. Overall, the Summer Hydropower Alternative would adversely affect many managed areas and ecologically significant sites.

5.14.8 Equalized Summer/Winter Flood Risk Alternative

The higher winter pools and lower but extended summer pools of the Equalized Summer/Winter Flood Risk Alternative would result in slightly adverse impacts on lowland plant communities, including flats, scrub/shrub, and forested wetlands, and associated shorebirds and protected species within managed areas. Low summer pools and delay in filling could hinder waterfowl management by reducing cover and foraging habitat in shoreline wetlands and by reducing late-season flooding opportunities on croplands managed for waterfowl. Higher winter water levels would impair habitat for migrating shorebirds. However, the risk of premature flooding of cropland for wildlife may be reduced by the delayed spring fill associated with this alternative (see Section 5.10, Terrestrial Ecology). The overall combined effects of the Equalized Summer/Winter Flood Risk Alternative on managed areas and ecologically significant sites would be adverse, but slightly less adverse than those for the Summer Hydropower Alternative.

5.14.9 Preferred Alternative

Under the Preferred Alternative, mean summer pool duration and winter pool elevations would increase on many mainstem reservoirs and selected tributary reservoirs. The increase in summer pool duration would result in the same variable impacts on wetlands, migrating shorebirds, and waterfowl subimpoundments as described for the Reservoir Recreation Alternative A and the Tailwater Habitat Alternative. The 0.5-foot increase in winter pool elevations on Wheeler Reservoir would likely have minimal effects on Wheeler NWR subimpoundments. Due in part to concerns over impacts on wildlife refuges, operating guide curves on Kentucky Reservoir would not be changed. Consequently, there would be no material changes in the operation of Kentucky and Barkley Reservoirs and thus no effects on managed areas and ecologically significant sites, including the Tennessee and Cross Creeks NWRs. Overall, the Preferred Alternative would result in slightly adverse effects on managed areas and ecologically significant sites.

5.14.10 Summary of Impacts

Reservoir operations that extend full pool into the fall migration season and increase winter water levels (Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative) would generally hamper management of waterfowl and/or shorebird habitat in managed areas on reservoirs. These alternatives also would affect some imperiled plant communities, scrub/shrub, and forested wetlands in managed areas and ecologically significant sites. For Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, these effects would result in slightly adverse impacts on managed area integrity. For Reservoir Recreation Alternative A, the Commercial Navigation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative, these impacts may be partially offset by beneficial effects on some wetland types, associated wildlife, and other managed area resources. The resulting overall effects under these alternatives would be slightly adverse to slightly beneficial. The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would result in the greatest adverse effects on managed areas, affecting wetland/waterfowl management efforts and other resources.

Table 5.14-01 Summary of Impacts on Managed Areas and Ecologically Significant Sites by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Continued difficulty in protecting integrity of bottomland hardwoods (e.g., Muddy Bottoms TVA HPA and Wheeler NWR) and some aquatic endangered species sites.
Reservoir Recreation A	Slightly adverse to slightly beneficial – Effects on certain wetlands; adverse effects on waterfowl subimpoundments and migratory shorebird habitat.
Reservoir Recreation B	Slightly adverse – Effects on waterfowl subimpoundments, habitat for some migratory birds, and scrub/shrub and forested wetlands, beneficial effects on aquatic bed wetlands and associated wildlife.
Summer Hydropower	Adverse – Substantially adverse effects on wetlands; no change to beneficial effects on waterfowl sub-impoundments.
Equalized Summer/Winter Flood Risk	Adverse – Adverse effects on waterfowl subimpoundments, flats, scrub/shrub, and forested wetlands and on some associated wildlife; slight benefits to some wildlife on tributary reservoirs.
Commercial Navigation	Slightly adverse to slightly beneficial – Generally similar to Base Case; continued difficulty protecting integrity of some bottomland hardwoods (e.g., Muddy Bottoms TVA HPA and Wheeler NWR).
Tailwater Recreation	Slightly adverse – Adverse effects on waterfowl sub-impoundments and some other migratory bird habitat, and on protection of scrub/shrub and forested wetlands; slightly beneficial effects on aquatic bed wetlands and associated wildlife.
Tailwater Habitat	Slightly adverse to slightly beneficial – Effects on certain wetlands and lowland habitats; beneficial effects on aquatic bed wetlands; and adverse effects on managed subimpoundments and migratory shorebird habitat.
Preferred	Slightly adverse – Effects on migratory shorebird habitat; variable impacts on wetlands and waterfowl subimpoundments; and overall slightly adverse effects.

HPA = Habitat Protection Area.
NWR = National Wildlife Refuge.

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5.15 Land Use

5.15.1 Introduction

The land use analysis examines the effects of policy alternatives on the rates of residential shoreline development for selected reservoirs (Table 4.15-02), both mainstem and tributary storage. The selected reservoirs were chosen because their respective rates of residential development may be affected by the alternatives to the existing reservoir operations policy that are being considered in the ROS. Some reservoirs may see a slight acceleration or deceleration of buildout, thereby reaching planned capacity somewhat before or after the currently projected buildout date of 2023. As discussed in Section 4.15, residential development is the predominant land use change occurring in the shoreline (primary) and secondary zones of influence around the reservoirs. Consequently, this analysis concentrates on potential impacts from changes in the rate of residential development. Impacts from commercial or industrial development were considered in the Shoreline Management Initiative (SMI) EIS and are expected to be relatively minor in comparison to residential development. Any proposals for such developments requiring TVA approval would be subject to separate environmental review.

Each reservoir is unique, in that the Land Management Plant (LMP) and the SMI govern the available shoreline for residential development (see Section 4.15.2). Consequently, the amount of shoreline available for development varies widely among reservoirs, from as little as 8 percent to as much as 88 percent of total shoreline (Table 4.15-02).

Population in the region is expected to continue to grow, with urbanization applying pressure to some counties more than others. This anticipated growth would continue to create demand for shoreline residential property. Due to the limited availability of developable shoreline property, all reservoir land where residential access is allowed would eventually be fully developed to its planned capacity.

The factors that affect residential development are both external and internal and differing reservoir levels that result from a change in the TVA reservoir operations policy are only one of several factors of influence to be considered when analyzing rates of shoreline residential development.

5.15.2 Impact Assessment Methods

The land use analysis is based on the following information from the SMI:

- The residential development projection (e.g., 38 percent of total shoreline, or 4,192.2 miles) is the maximum system-wide reservoir shoreline property available for residential development. Actual buildout is expected to be less than 38 percent because of environmental safeguards and maintain and gain exchanges, as required by the SMI.

- Sixty-seven percent, or 2,809 miles, of the shoreline property available for residential development is undeveloped.

- The pattern for development is defined for a reservoir on an individual basis by its LMP and varies widely between reservoirs.

- The full residential buildout within the primary zone of influence (the 0.25-mile shoreline band) is likely to occur within 25 years, or approximately 2023.

- The Shoreline Management Policy requires that environmental impacts due to residential development be mitigated according to applicable regulations. Each proposed development is reviewed independently, and the mitigation requirements imposed are project specific.

- The land use analysis used the same population growth and buildout assumptions concluded in the SMI—full buildout is likely to yield 83,000 new lakefront lots, 91,000 new backlots, and an estimated population increase of 396,000 persons.

- Urbanization was identified as a population growth trend that causes some counties to grow faster than others; therefore, population growth is not evenly distributed throughout the region. Localized areas of faster growth were identified in reservoir counties near Knoxville, Tennessee; Huntsville, Alabama; the Nottely and Chatuge Reservoirs in North Georgia; and the Watts Bar area in East Tennessee.

The descriptions of positive and negative factors that influence the rate of shoreline development came from the Lake Improvement Plan (TVA 1990). Interviews with TVA land management specialists indicate that the factors identified in the Lake Improvement Plan continue to be pertinent to this analysis. For example, growth, infrastructure (transportation and utility) improvements, good-quality commercial recreation and reservoir access, scenic beauty, water quality, and property value are some of the factors that are attractive to prospective buyers. Conversely, remoteness, lack of infrastructure and urban amenities, steepness of the land, lack of commercial recreation, and large reservoir fluctuations were considered detractors for prospective buyers. The land use analysis has examined these factors and additional external factors, such as the general state of the economy, attractive mortgage rates, and real estate marketing efforts in order to understand the relationship to shoreline residential development.

TVA land management specialists have been directly involved in the planning process and the development of the specific LMPs. Having the dual role of process participants and long-term observers, these technical specialists were interviewed to obtain their understanding of the relationship between the factors discussed above and the relative rates of development seen at different reservoirs.

This land use analysis assumed that a correlation exists between the management of reservoir elevations and the duration of reservoir water levels, and the perceived desirability of reservoir shoreline for residential development. Table 4.15-02 quantifies the magnitude (in acres and shoreline miles) of shoreline to be converted to residential use within the primary zone. Potential impacts on the rate of shoreline residential development associated with the alternative reservoir operations policies are expected to be indirect, requiring a qualitative approach. The policy alternatives were compared to the Base Case to evaluate the likely effect of each alternative in causing the rate of shoreline residential development to increase or decrease. For this analysis, an increase in the rate of development means that buildout likely would occur sooner than expected under the Base Case; a decrease in the rate of development means that buildout would occur later than expected under the Base Case.

The impacts of the anticipated changes in the rate of development can be viewed as positive or negative, depending on point of view. An increase in the rate of development can result in a beneficial economic impact or an adverse impact on the natural condition of the reservoir shorelines, and the inverse relationship is also true. The terms adverse and beneficial used to describe the impacts of the alternatives pertain to potential effects on the natural condition surrounding the reservoirs. Via several survey instruments, the SMI (TVA 1998) identified that visual quality and the natural aesthetics of the reservoir shorelines are important to large percentages of residents and recreational users.

The criteria for comparing the alternatives included the metrics cited in Section 4.15.3 and were supplemented where possible by the findings of other study teams, and observations derived from reservoir LMPs, TVA Watershed Management Teams, and others. Indirect effects of shoreline residential development on other resource areas are described in the sections for those resources.

5.15.3 Base Case

The Base Case was established as the reference against which to compare the rates of conversion to residential land use affected by each policy alternative. Assuming no change in reservoir operations policy and practice, the buildout projected by the SMI may be regarded as a reasonable basis on which to expect future land use conversion to residential shoreline development to reach planned capacity.

5.15.4 Reservoir Recreation Alternative A

The improved recreational opportunities and visual quality under Reservoir Recreation Alternative A could result in a slight increase in the rate of residential shoreline development. This increase could be slightly adverse to the natural condition of the land surrounding the reservoirs.

5.15.5 Reservoir Recreation Alternative B

The effects on land use under Reservoir Recreation Alternative B would be similar to those described for Reservoir Recreation Alternative A. The slight increase in the rate of residential shoreline development could be slightly adverse to the natural conditions of the land surrounding the reservoirs.

5.15.6 Summer Hydropower Alternative

The effects on land use under the Summer Hydropower Alternative could be slightly beneficial to the natural condition of the land surrounding the reservoirs. A decrease in the rate of residential shoreline development may result from reduced recreational opportunities and visual quality.

5.15.7 Equalized Summer/Winter Flood Risk Alternative

The likely effects on land use under the Equalized Summer/Winter Flood Risk Alternative could be no change or a slight benefit to the natural condition of the land surrounding the reservoirs. A slight decrease in the rate of residential shoreline development may result from reduced recreational opportunities and visual quality.

5.15.8 Commercial Navigation Alternative

No change to the natural condition of the land surrounding the reservoirs is anticipated under the Commercial Navigation Alternative. No change in the rate of residential shoreline development on the affected reservoirs is anticipated, because summer recreation levels would not change from the Base Case.

5.15.9 Tailwater Recreation Alternative

The effects on land use under the Tailwater Recreation Alternative would be similar to those described for Reservoir Recreation Alternative B. A slightly adverse effect on the natural condition of the land surrounding the reservoirs is anticipated for the same reasons.

5.15.10 Tailwater Habitat Alternative

The effects on land use under the Tailwater Habitat Alternative could range from no change to a slightly adverse effect on the natural condition of the land surrounding the reservoirs, similar to those described for Reservoir Recreation Alternative B.

5.15.11 Preferred Alternative

The effects on land use under the Preferred Alternative would be similar to those described for Reservoir Recreation Alternative A. The improved recreational opportunities and visual quality could result in a slight increase in the rate of residential shoreline development. This increase could be slightly adverse to the natural condition of the land surrounding the reservoirs.

5.15.12 Summary of Impacts

A number of factors influence the rate of shoreline residential development, such as the overall condition of the economy and the attractiveness of mortgage rates. These factors are broad based and would apply to development at all reservoirs. Other factors, such as urbanization, developed infrastructure and recreation, and reservoir fluctuation are apt to be reservoir specific—with attributes at certain reservoirs more likely to attract development. Those reservoirs are likely to develop faster than other reservoirs. In all cases, all of these factors apply to all of the alternatives being considered to varying degrees.

The land use analysis concluded that the reservoir operations policy can influence the rate of shoreline residential development but is not a determining factor when compared to other factors, such as urbanization and the health of the economy. Table 5.15-01 summarizes anticipated impacts on land use by policy alternative. Shoreline development is expected to occur as projected in the SMI, and none of the alternatives would affect the identified 38-percent total buildout. The land use analysis did find that some alternatives, including the Preferred Alternative, could contribute to a slight increase in the rate of residential shoreline development. Increased summer pool durations and winter flood guide levels, as described in the Preferred Alternative, would provide for an overall increase in reservoir recreational opportunities and visual quality. Improvements to these public values could result in a slight increase in the rate of shoreline development. Both the planning and management processes ensure that the environmental impacts of future development are addressed by the appropriate regulations in place for each proposed project.

Table 5.15-01 Summary of Impacts on Land Use by Policy Alternative

Alternative	Description of Impacts
Base Case	Buildout to 38% would occur as projected in the Shoreline Management Initiative (by 2023).
Reservoir Recreation A	Slightly adverse effects on natural conditions would occur because of a slight increase in the rate of residential shoreline development.
Reservoir Recreation B	Slightly adverse effects on natural conditions would occur because of a slight increase in the rate of residential shoreline development.
Summer Hydropower	Slightly beneficial effects on natural conditions would occur because a decrease in the rate of residential shoreline development may result in a slight benefit to the natural condition of land surrounding the reservoirs.
Equalized Summer/Winter Flood Risk	No change to slightly beneficial effects on natural conditions would occur because of a slight decrease in the rate of residential shoreline development.
Commercial Navigation	No change to natural conditions would occur.
Tailwater Recreation	Slightly adverse effects on natural conditions would occur because of a slight increase in the rate of residential shoreline development.
Tailwater Habitat	No change to slightly adverse effects on natural conditions would occur because of a slight increase in the rate of residential shoreline development.
Preferred	Slightly adverse effects on natural conditions would occur because of a slight increase in the rate of residential shoreline development.

5.16 Shoreline Erosion

5.16.1 Introduction

Erosion caused by TVA system operations occurs in both the reservoirs and the tailwater riverine sections. This section analyzes the impacts of reservoir operation alternatives on erosion in reservoirs and tailwaters, and provides a relative ranking of the impacts of the alternatives.

5.16.2 Impact Assessment Methods

Erosion in reservoirs is primarily influenced by wave energy affecting the shoreline and dislodging soil particles. Wave energy is derived from two sources: wind-generated waves and boat-generated waves. Wind waves are a function of the wind velocity and the fetch, the open distance, across the reservoir along which waves can build energy. Boat-generated waves in TVA reservoirs are due to recreational boat traffic and commercial activities, such as barge traffic. In general, commercial boat traffic is more prominent on TVA mainstem reservoirs than on tributaries.

In reservoirs, the area that is subject to wave action at the highest normal reservoir elevations is of the most interest. This zone is now subject to modification by water, whereas areas down slope have been subject to wave action and exposure to weather for decades. This zone has property than can be affected by erosion, and is of most concern for cultural resources (see Sections 4.18 and 5.18, Cultural Resources). For this analysis, the shoreline erosion zone is defined as the elevations between the June 1 flood guide elevation and 3 feet below the June 1 flood guide.

Wave energy is particularly important in the shoreline erosion zone; boat waves are more frequent due to summer recreational use and there are known critically eroded areas in the shoreline erosion zone (see the description of TVA ALIS data in Section 4.16). Much of the shoreline considered "poor" in the ALIS data set has a vertical or steep bank that is vulnerable to wave action. Relatively gentle slopes distribute wave energy over a large area, while steep banks absorb all of the energy in a small area. If a reservoir is not held at a higher water elevation for as long, these areas do not see as much wave action, and the wave energy is generally distributed over less abrupt slopes. If the reservoir is not filled as full, these areas never see wave action, and the waves generally only affect areas that have already eroded to a flatter slope. Conversely, if the reservoir surface elevation is held in the shoreline erosion zone longer, erosion effects are exacerbated. Shoreline shape (convex vs. concave, and radius of curvature) and the angle of wave action relative to the shoreline can have a large affect on local rates of erosion. Combined with the wind exposure, this factor makes islands and peninsulas more prone to erosion than coves or straight shore lines.

Another form of erosion of concern in reservoirs is mass wasting. Mass wasting is the slumping, sliding, or toppling of sections of bank, caused by structural failure. An example of this is the slumping of cohesive, saturated soils from a steep embankment when water levels are dropped. Mass wasting is usually caused by erosion of the shoreline at the toe of the slope or by undercutting of steep slopes. The resulting slope failure may occur after drawdown, but is not caused by drawdown.

Raindrops that land on exposed, unvegetated soils can initiate the erosion process by dislodging soil particles from the force of raindrop impact on the ground. This process is of concern to the TVA reservoir shorelines in the drawdown zone between maximum pool elevation and winter pool elevation. This drawdown zone has been exposed to raindrop impacts for many decades. It is likely that where there is rocky soil or shallow soil over bedrock, most of these soils have already eroded. Erosion in the drawdown zone may cause minor water quality impacts, but there is generally less concern about this erosion because usable land is not lost by this process. Reservoir storage capacity is not lost because eroded material generally originates within the pool. Unlike the shoreline erosion zone, erosion conditions of the drawdown zone have not been surveyed.

At winter pool elevations, wave energy also affects the shore, which are often unvegetated bare soils. The lowest pool levels can expose the areas around the original stream banks, which are frequently more subject to erosion than thinner, stonier upland soils. On the other hand, boat traffic typically is considerably less in winter than in summer. As with the drawdown zone, the winter pool shoreline conditions have not been surveyed.

Another factor affecting shoreline erosion is potential removal of vegetative cover from the shoreline. As discussed in the SMI EIS, healthy stands of woody and herbaceous vegetation around a riparian zone of a reservoir provide substantial protection of the shoreline from erosion. Development of the shoreline that would modify the shoreline vegetative cover would adversely affect erosion. Modification of shoreline vegetative covers from development was not a major consideration in this analysis for the following reasons. As described in Section 4.16, TVA has permit authority through Section 26a of the TVA Act to require erosion control measures for any shoreline development. In addition, TVA has designated a finite amount of shoreline land that is available for development. Although each of the policy alternatives may slightly modify the anticipated buildout date of the land available for development (see Section 4.15, Land Use), this change is not anticipated to affect the overall erosion conditions of the reservoirs.

Erosion in tributary tailwaters generally takes two forms. Surface erosion is the detachment and transport of surface material by flowing water that affects both the bed and the banks of a stream when they are exposed to flowing water. Mass wasting, as described above, can also occur in tailwaters when shoreline soils are saturated and water levels are dropped, especially where banks are steep.

Because mainstem tailwaters are essentially the upstream end of the next downstream reservoir, erosion in both reservoirs and mainstem tailwaters are influenced more by wave energy, whereas tributary tailwaters are primarily influenced by the forces of flowing water. Therefore, separate analyses were conducted for reservoir and mainstem tailwater shorelines and for tributary tailwater shorelines.

The analysis conducted for this EIS considered the following elements to evaluate potential impacts of reservoir operations policy alternatives. Three primary factors were evaluated:

- Duration of reservoir elevations in the shoreline erosion zone. Longer periods at high pool levels would cause wave energy to exacerbate existing erosion.
- Changes in boat-wave energy from recreational boat activity and commercial barge operations. Longer periods at high pool levels would result in higher recreational boat traffic, which would accelerate the rate of erosion.
- Cumulative shear stress hours over a year. None of the alternatives would increase existing maximum tailwater flows; so peak shear stresses would remain the same. However, some alternatives would change the duration and balance between the annual peak flows and secondary peak flows and could result in higher net cumulative shear stress over the annual cycle, potentially resulting in increased erosion.

Other potential contributing factors that were considered include:

- Erosion of the drawdown zone between maximum pool elevation and winter pool elevation due to raindrop impact forces on bare unvegetated soils and from mass wasting of saturated soils from the drawdown action;
- Erosion of the shorelines at winter pool elevations, which may erode bare unvegetated shorelines;
- Development of the shoreline—removal of vegetation on the shoreline—can accelerate erosion; however, existing TVA policies and land management practices were anticipated to eliminate or render unsubstantial any differences in development-related erosion potential between the policy alternatives; and,
- Changes in reservoir surface area—higher reservoir levels create longer distances for wind energy to build up. None of the policy alternatives were anticipated to modify the surface areas of the reservoirs to the degree that a change in wind fetch would be measurable; therefore, this metric was not considered in the analysis.

Data used to evaluate the potential changes in erosion from the policy alternatives are summarized in the tables below.

Table 5.16-01 provides the percent change in the duration of reservoir pool levels in the shoreline erosion zone compared to the Base Case that is projected for each representative reservoir. The number of days at shoreline erosion zone elevations is an indicator of the relative impacts from wave energy affecting shorelines; higher values show a higher relative risk of increase in shoreline erosion.

Table 5.16-01 **Comparison of Duration of Reservoir Surface Elevations in the Shoreline Erosion Zone of Policy Alternatives to Base Case for Representative Reservoirs**

	Alternative							
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Watauga	66.7%	241.7%	41.7%	166.7%	0.0%	75.0%	141.7%	33.3%
S. Holston	77.8%	111.1%	-22.2%	-22.2%	0.0%	155.6%	111.1%	77.8%
Boone	0.0%	-4.8%	-66.7%	-52.4%	0.0%	-4.8%	0.0%	4.8%
Cherokee	133.3%	200.0%	-16.7%	-100.0%	0.0%	200.0%	233.3%	50.0%
Douglas	27.3%	63.6%	-54.5%	-100.0%	0.0%	63.6%	127.3%	-9.1%
Fontana	71.4%	128.6%	-42.9%	-100.0%	0.0%	128.6%	171.4%	57.1%
Norris	100.0%	144.4%	-22.2%	-100.0%	0.0%	122.2%	166.7%	66.7%
Chatuge	42.9%	64.3%	-14.3%	-100.0%	0.0%	50.0%	114.3%	14.3%
Nottely	100.0%	137.5%	-12.5%	-75.0%	0.0%	100.0%	212.5%	50.0%
Hiwassee	33.3%	77.8%	-55.6%	-100.0%	0.0%	44.4%	122.2%	22.2%
Blue Ridge	53.8%	53.8%	-38.5%	-100.0%	0.0%	53.8%	153.8%	7.7%
Tims Ford	0.0%	15.8%	-57.9%	-100.0%	0.0%	15.8%	0.0%	0.0%
Ft Loudon	3.0%	3.0%	-45.5%	-27.3%	0.0%	3.0%	3.0%	0.0%
Watts Bar	3.0%	3.0%	-45.5%	-9.1%	-6.1%	3.0%	3.0%	0.0%
Chickamauga	7.4%	7.4%	-44.4%	-11.1%	3.7%	7.4%	7.4%	3.7%
Nickajack	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Guntersville	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wheeler	32.1%	28.6%	-32.1%	-3.6%	3.6%	28.6%	32.1%	10.7%
Wilson	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pickwick	33.3%	29.6%	-29.6%	0.0%	0.0%	29.6%	33.3%	14.8%
Kentucky	22.7%	136.4%	-22.7%	0.0%	136.4%	136.4%	22.7%	-4.5%
Mean tributary	**58.9%**	**102.8%**	**-30.2%**	**-65.2%**	**0.0%**	**83.7%**	**129.5%**	**31.2%**
Mean mainstem	**11.3%**	**23.1%**	**-24.4%**	**-5.7%**	**15.3%**	**23.1%**	**11.3%**	**2.7%**
Mean overall	**38.5%**	**68.7%**	**-27.7%**	**-39.7%**	**6.6%**	**57.7%**	**78.9%**	**19.0%**

The number of cumulative shear stress hours over a median year in tailwaters is an indication of the degree that shear stress forces may dislodge soil particles from streambanks. Table 5.16-02 compares the cumulative shear stress hours calculated from projected median flows of the policy alternatives to the Base Case. The days exhibiting highest flows are typically in spring, with minimal flows in late spring-early summer, and some high-flow periods in fall, but the alternatives change the relative duration of the spring and fall peak discharges. Because maximum generator discharge capacity does not change, the cumulative shear stress calculated from the projected flow curves did not show substantial variability among the alternatives (many are probably within the uncertainty of the models used), and some decrease the potential for erosion compared to the Base Case.

Table 5.16-02 Change in Cumulative Shear Stress of Policy Alternatives Compared to Base Case for Representative Reservoirs

Reservoir	Alternative							
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Tributary Reservoirs								
Chatuge	-0.6%	-3.6%	-2.2%	-3.7%	NC	-2.2%	-4.3%	-2.0%
Cherokee	2.8%	-3.5%	16.5%	-1.4%	NC	-3.4%	-1.2%	-5.8%
Douglas	-0.1%	-2.0%	0.4%	-1.0%	NC	-1.3%	-3.9%	+0.1%
Nottely	2.3%	-2.8%	-0.3%	-5.1%	NC	-0.2%	-1.5%	-3.4%
Mainstem Reservoirs								
Pickwick	+1.0%	+1.4%	-3.5%	+0.2%	-0.4%	+1.4%	+0.6%	-0.4%

Notes:

NC = No change.

Positive entries designate increase in cumulative shear stress (higher erosion) for this alternative compared to the Base Case; negative entries designate a decrease.

As this analysis developed, it became clear that the reservoirs chosen to represent the affected environment in Chapter 4 did not fully represent the changes in operations in the proposed alternatives. Reservoirs were added to the analysis to fully illustrate the range of impacts from the alternatives.

Projected changes in recreational use of the TVA reservoir system are discussed in Section 4.24, Recreation. Table 5.24-01 provides forecasted recreational use numbers in user-days over the 35 TVA projects, and Table 5.24-02 provides an overall summery of the forecasts. The recreation analysis did not consider projections for each individual reservoir. The main recreational factor of interest for the erosion analysis is the overall projected changes in recreation use from the Base Case. Also of interest are the projected changes in recreational use below the dams (tailwaters). This information is summarized in Table 5.16-03.

Table 5.16-03 Summary of Change from Base Case in Recreation Use by Policy Alternative (August, September, and October)

	Alternative							
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Public access use below dams	No change	Slight increase	Slight decrease	Slight decrease	No change	Slight increase	No change	No change
Overall projected change	Large increase	Large increase	Moderate decrease	Slight increase	Slight decrease	Large increase	Large increase	Moderate increase

5.16.3 Base Case

The Base Case would result in continued erosion of reservoir shorelines and implementation of treatments and BMPs by TVA and others to improve shoreline conditions. Reservoir shorelines would continue to erode at their present rate, or potentially at a slightly accelerated rate due to projected increased recreational use.

As with reservoir shorelines, tributary tailwater streambanks would continue to erode under the Base Case at their present rate or potentially at a slightly accelerated rate due to projected increased recreational use.

5.16.4 Reservoir Recreation Alternative A

Duration of pool levels in the shoreline erosion zone under Reservoir Recreation Alternative A would be substantially longer in most reservoirs compared to the Base Case, thereby increasing the existing rate of erosion. Increased recreational boating would also contribute to erosion of the shoreline. Higher winter levels would decrease exposure of any sediment deposits formed since impoundment and the original stream channel and floodplains. This would reduce erosion in these areas. Overall the effect of Reservoir Recreation Alternative A on reservoir shoreline erosion is projected to be adverse.

Under Reservoir Recreation Alternative A, the higher winter pool increases discharges during the early spring, already the highest-discharge period. This is mitigated during drawdown in fall, when discharges are generally a little lower than Base Case for a longer period than the spring peak. The net effect is that there is likely to be little change in potential for tailwater erosion under this alternative.

5.16.5 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Reservoir Recreation Alternative B would substantially increase the duration in the shoreline erosion zone in most reservoirs, especially tributary reservoirs. A large increase in boat activity is also projected. Therefore, this alternative has high erosion potential. The Tailwater Recreation Alternative would also increase shoreline erosion zone durations at most reservoirs, but not to the degree of Reservoir Recreation Alternative B in the tributaries. Large increases in boat wave energy are also projected for the Tailwater Recreation Alternative. Higher winter levels would decrease exposure of any sediment deposits formed since impoundment and the original stream channel and floodplains. This would reduce erosion in these areas.

Under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, there would be longer periods of high flows during the early spring, already the highest-discharge period in the tailwaters of the representative reservoirs. This is mitigated during drawdown in fall, when discharges are generally a little lower than Base Case for a longer period than the spring peak. The net effect is that there is likely to be little change in potential for tailwater erosion under this alternative.

5.16.6 Summer Hydropower Alternative

The Summer Hydropower Alternative would result in shorter periods of wave impact in the shoreline erosion zone than the Base Case and a consequent decrease in existing reservoir shoreline erosion. There would also be a large decrease in erosion from a corresponding decrease in recreational boating. Higher winter levels would decrease exposure of any sediment deposits formed since impoundment and the original stream channel and floodplains. This would reduce erosion in these areas.

Tailwater cumulative shear stress results were highly variable for this alternative. The largest impact for any of the cases calculated occurred for the Cherokee tailwater, where there was a 17 percent increase in cumulative shear stress, suggesting the potential for a slight increase in erosion rates there if this alternative were chosen. Other tailwaters would see increases small enough that they are unlikely to be noticeable.

5.16.7 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative generally would result in substantially shorter durations of high pool elevations than the Base Case except at Watauga. A slight increase in recreational boating activities is projected. The lower duration at shoreline erosion zone elevations and higher winter pool elevations would reduce the area of the exposed drawdown zone to rainfall impacts. Except in Tims Ford, higher winter levels would decrease exposure of the sediment deposits formed since impoundment and the original stream channel and floodplains. This would reduce erosion in these areas; lower winter elevations in Tims Ford would increase erosion in these areas. Overall, this alternative would likely result in less erosion than the Base Case.

Cumulative shear stress analysis indicates that there is likely to be little change in potential for tailwater erosion under this alternative.

5.16.8 Commercial Navigation Alternative

The Commercial Navigation Alternative is the only policy alternative that would result in substantial changes to commercial boat traffic. This alternative, which enhances navigation in the mainstem by deepening the channel, would allow for barges to be loaded more fully. The heavier barges would have a deeper draft, which would send more wave energy to the shorelines. However, fewer trips are projected under this alternative. The reduction in trips would likely offset the increased wave energy from the heavier barges, and no substantial change in erosion from the Base Case would be caused by commercial boat traffic.

Other erosion impacts under the Commercial Navigation Alternative would be similar to those described for the Base Case, particularly for tributary reservoirs, where this alternative makes little or no change in operation. There is only slight change in cumulative sheer stress. The duration at high-pool elevation for each representative reservoir would be similar to the Base Case, and no change in recreational use is projected for the Commercial Navigation Alternative.

5.16.9 Tailwater Habitat Alternative

Summer water levels under the Tailwater Habitat Alternative would be in the shoreline erosion zone for substantially longer durations than under the Base Case, especially on tributary reservoirs, resulting in more erosion. A large increase in recreational boating would result in a corresponding increase in erosion.

Tailwater cumulative sheer stress shows little change.

5.16.10 Preferred Alternative

The Preferred Alternative would increase the duration of pool levels in the shoreline erosion zone in most tributary reservoirs and would increase the erosion in these areas. There would be little change on mainstem reservoirs. Higher winter levels on tributary reservoirs would decrease exposure of any sediment deposits formed since impoundment and the original stream channel and floodplains reducing erosion rates in these areas. The overall result on reservoir shoreline erosion would be slightly adverse.

Changes in potential for tributary tailwater erosion would vary between reservoirs. Because the amount of change is small, the net impact of this alternative would be minimal.

5.16.11 Summary of Impacts

Table 5.16-04 provides a summary of impacts on erosion by policy alternative. The Base Case would result in continued erosion of reservoir and tailwater shorelines, and implementation of treatments and BMPs by TVA and others to improve shoreline conditions. Recreational use of the TVA system is projected to increase under the Base Case; therefore, erosion could accelerate. As described in the table, Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative are anticipated to increase the rate of erosion compared to the Base Case. The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative are anticipated to decrease the rate of erosion, while the Commercial Navigation Alternative is anticipated to cause similar erosion effects as the Base Case. Based on an analysis of cumulative shear stress in tailwaters, there would not be substantial impacts from any of the alternatives.

Table 5.16-04 Summary of Impacts on Shoreline Erosion by Policy Alternative

Alternative								
Base Case	**Reservoir Recreation A**	**Reservoir Recreation B**	**Summer Hydropower**	**Equalized Summer/ Winter Flood Risk**	**Commercial Navigation**	**Tailwater Recreation**	**Tailwater Habitat**	**Preferred**
Reservoir Effects								
No change – Shoreline erosion would continue at existing rates.	Adverse – Longer reservoir pool durations at summer levels and large increases in recreational boat waves would increase reservoir shoreline erosion.	Adverse – Longer reservoir pool durations at summer levels and large increases in recreational boat waves would result in an increase in existing erosion.	Beneficial – Shorter reservoir pool durations at summer levels and a large decrease in recreational boat waves would decrease existing erosion.	Beneficial, especially on tributary reservoirs – Shorter reservoir pool durations at summer levels and a smaller drawdown zone affected by raindrop impact would result in less reservoir shoreline erosion.	No change – Shoreline erosion would continue at existing rates.	Adverse – Longer reservoir pool durations at summer levels and large increases in recreational boat waves would increase reservoir shoreline erosion.	Substantially adverse – Substantially longer reservoir pool durations at summer levels and large increases in recreational boat waves would result in an increase in existing erosion.	Slightly adverse – Longer reservoir pool duration at summer levels in some reservoirs would result in an increase in erosion on some reservoirs.
Tailwater Effects								
No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.	No change – Shoreline erosion would continue at existing rates.

5.17 Prime Farmland

Farmland conversion, primarily to residential and commercial development, was considered the major factor in the loss of prime farmland. In addition, soil erosion was considered a by-product of land use change.

The impact analysis focused on the lands extending from the reservoir shoreline out to 0.25 mile. These lands could be indirectly affected by farmland conversion and soil erosion due to land use changes brought about by changes in the reservoir operations policy. As appropriate, more detailed analysis using criteria established by the FPPA (7 CFR 658.1 et. seq.) will be conducted at the county level as LMPs for specific reservoirs are written and updated.

Soil erosion along the shoreline, which is discussed in more detail in Section 5.16, Shoreline Erosion, initially was thought to affect prime farmland. After preliminary investigation, shoreline erosion was not considered a substantial impact on prime farmland and is not considered further in this section.

5.17.1 Impact Assessment Methods

Impacts on prime farmland by soil erosion were analyzed qualitatively by using the following guidelines:

- Reservoir operations that would increase the rate of development along the shoreline of the reservoirs and rivers would result in the loss of farmland.
- Factors influencing erosion include changes in land use that result in the removal of vegetation, changes in vegetative cover, and exposure of soil.

An assessment of the general extent of prime farmland within the TVA region was conducted using data provided by county offices of the NRCS. Farmland conversion was estimated by qualitatively looking at how land use changes, as described in Section 5.15, Land Use, would affect prime farmland around the reservoirs. The impact analysis focused on the backlands (lands extending from the shoreline out to 0.25 mile), which would be indirectly affected by changes in TVA operations.

The erosion assessment considered forestland to be the least susceptible to erosion while herbaceous cover, such as lawns and cropland (particularly row crops), were considered more vulnerable to erosion (Brady 1990). In addition, the anticipated increase in foot and vehicle traffic associated with roads and trails was assumed to result in additional areas of exposed soils.

Anticipated impacts by alternatives were assessed relative to the Base Case, which includes ongoing impacts as a result of existing operations, as well as impacts resulting from adjacent land uses related to commercial/industrial business, farming, and residential activities outside the control of TVA. The Base Case had established under the SMI a total residential buildout of 38 percent for the entire TVA system shoreline, which was projected to occur by 2023. The proposed alternatives, which also would be required to comply with the SMI, would differ from the Base Case by influencing the rate of development (see Section 4.15, Land Use).

5.17.2 Base Case

Based on farmland conversion data, the loss of farmland outlined in Section 4.17 is expected to continue under the Base Case. Farmland conversion at the county level ranged from a decline in acreage of 29 percent to an increase of 3.6 percent (Table 4.17-03). The total loss of prime farmland under the Base Case is considered minimal compared to the prime farmland resources within the counties bordering the Tennessee River watershed. In addition, the loss of prime farmland within the study area (0.25 mile from reservoir shorelines) is minimal compared to the total area (counties that surround TVA reservoirs). The loss would be attributed to factors outside the control of TVA, including proximity of reservoirs to large urban populations.

The erosion potential on prime farmland was assumed to involve the conversion of farmland to non-farm uses, which would affect erosion. The erosion potential of soils in the backlands was estimated to be moderate based on data available from the NRCS. Present TVA standards for soil stabilization and vegetation management under Section 26a regulations minimize the impact of erosion. The major difference in the erosion rate between the Base Case and the policy alternatives would result from a change in the rate of development in areas outside TVA jurisdiction, where county soil erosion and stabilization regulations are variable to non-existent. Sections 4.16 and 5.16, Shoreline Erosion, provide a detailed discussion of shoreline erosion.

5.17.3 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Tailwater Recreation Alternative, and Tailwater Habitat Alternative

The rates of farmland conversion and soil erosion under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative may be slightly higher than under the Base Case. The amount of farmland conversion under the Base Case was considered minimal, and the additional conversion under these alternatives is small.

5.17.4 Summer Hydropower Alternative and Equalized Summer/Winter Flood Risk Alternative

Under the Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative, the rate of land use changes resulting in conversion of prime farmland is not expected to change, and the amount of land use conversion is expected to be the same as under the Base Case. Land use conversion rates may diminish slightly due to the decrease in summer recreation opportunity.

The rate of soil erosion is expected to decrease compared to the Base Case, as a result of a reduced rate of development.

5.17.5 Commercial Navigation Alternative

The Commercial Navigation Alternative would result in similar impacts on prime farmland and soil erosion as described for the Base Case.

5.17.6 Preferred Alternative

The Preferred Alternative would result in increased conversion of prime farmland and soil erosion, similar to the effects of Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative, as this alternative provides increased recreation opportunities and related development compared to the Base Case.

5.17.7 Summary of Impacts

Because the land use buildout rate described in the SMI would occur under all alternatives, including the Base Case, the conversion of prime farmland to 2030 would be similar under all alternatives. Development may be accelerated under certain alternatives, however, resulting in an accelerated rate of prime farmland conversion. Erosion controls in the backlands would continue to depend on county-specific regulations, which govern land development and erosion from construction sites.

Table 5.17-01 provides a summary of impacts on prime farmland and soils by policy alternative. Under the Base Case and the Commercial Navigation Alternative, farmland conversion and soil erosion were considered minimal within 0.25 mile of the TVA shoreline. Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would increase the rates of farmland conversion and soil erosion. Because the Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would result in slower rates of farmland conversion, impacts on prime farmland and soils would be less than under the Base Case. Under all alternatives, the total amount of prime farmland converted is expected to be minimal compared to the total acreage within the counties that border the TVA reservoir system.

5.17 Prime Farmland

Table 5.17-01 Summary of Impacts on Prime Farmland and Soils by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Farmland conversion is considered minimal compared to overall resources of counties bordering the TVA system. Section 26a regulations would minimize erosion on land bordering shoreline. Erosion controls in backlands depend on county regulations, which are variable.
Reservoir Recreation A	Slightly adverse – Farmland conversion and resultant soil erosion are projected to increase at a slightly faster rate than under the Base Case, but the total amount of farmland conversion through 2030 is expected to be similar to the Base Case.
Reservoir Recreation B	Slightly adverse – Farmland conversion and resultant soil erosion are projected to increase at a faster rate than under Reservoir Recreation Alternative A, but the total amount of farmland conversion through 2030 is expected to be similar to the Base Case.
Summer Hydropower	Slightly beneficial – Farmland conversion and resultant soil erosion are projected to be slower than under the Base Case. The total amount of farmland conversion through 2030 may be less than the Base Case.
Equalized Summer/Winter Flood Risk	Slightly beneficial – Farmland conversion and resultant soil erosion are projected to be slower than under the Base Case. The total amount of farmland conversion through 2030, however, maybe less than the Base Case.
Commercial Navigation	No change – Farmland conversion and resultant soil erosion are projected to be at a similar rate to the Base Case, and the total amount of farmland conversion through 2030 is expected to be similar to the Base Case.
Tailwater Recreation	Slightly adverse – Farmland conversion and resultant soil erosion are projected to increase at a faster rate than under Reservoir Recreation Alternative B, but the total amount of farmland conversion through 2030 is expected to be similar to the Base Case.
Tailwater Habitat	Slightly adverse – Farmland conversion and resultant soil erosion are projected to increase at a slightly higher rate than under the Base Case, but the total amount of farmland conversion through 2030 is expected to be similar to the Base Case.
Preferred	Slightly adverse – Farmland conversion and resultant soil erosion are projected to increase at a higher rate than under the Base Case, but the total amount of farmland conversion through 2030 is expected to be similar to the Base Case.

5.18 Cultural Resources

5.18.1 Introduction

Reservoir operations have the potential to result in both direct and indirect impacts on historic properties (archaeological sites and historic structures). The primary direct impact of reservoir operations on historic properties, in particular on archaeological sites, is soil erosion by rainfall, streamflow, and wave action from wind and recreational boat traffic. Another direct impact is exposure by elevation fluctuations that result in saturation or alternate saturation/drying of archaeological deposits and historic structures. Indirect impacts include development of the shoreline and back-lying lands, changes to the view shed, and looting/vandalism or disturbance from recreational activity at historic properties. To address these concerns, the analyses of three other resource areas (Shoreline Erosion, Land Use, and Visual Resources) were used in conjunction with a quantitative assessment of known historic property location data.

Consultations with the seven State Historic Preservation Officers (SHPOs) and other consulting parties under the requirements of Section 106 of the NHPA have resulted in agreement(s) stipulating the actions TVA will take to avoid or reduce the adverse effects of the selected alternative on historic properties. The agreement(s) developed through this process are provided in Appendix H.

5.18.2 Impact Assessment Methods

The shoreline erosion analysis evaluated the potential for a change in erosion, which can disturb or destroy intact archaeological deposits—resulting in a loss of site integrity and adversely affecting site significance (i.e., its eligibility for listing in the NRHP). Three erosion zones concern historic properties: the summer pool shoreline, the winter pool drawdown, and the tailwater streambanks. Alternatives with greater potential for erosion along the shoreline and streambanks were considered to be adverse for historic properties. Conversely, alternatives that may reduce erosion in those areas were expected to be beneficial for historic properties. Alternatives with longer durations at summer pool elevation decrease erosion in the winter pool drawdown zone and were considered beneficial for historic properties in those areas.

Results of the land use analysis were included in the assessment because of the relationship between shoreline development and the destruction of archaeological sites and historic structures and landscapes. Alternatives with higher water levels for longer periods of time encourage shoreline development. These alternatives are anticipated to result in the most adverse impact on historic properties, while alternatives with lower water levels for longer periods of time are expected to have less impact.

Results of the visual resources studies were included because scenic integrity or attractiveness can promote development, and development can adversely affect historic properties. Alternatives that would result in less overall fluctuation in pool levels would improve scenic integrity and overall scenic attractiveness, and are anticipated to result in the most adverse impact on historic properties.

In addition to the results of these three analyses, a quantitative assessment of the number of archaeological sites located between June 1 pool level and winter pool at each reservoir was used to rank the alternatives (Table 5.18-01). Historic properties located in the winter pool drawdown are directly affected by reservoir operations through saturation and drying of archaeological materials and erosion of historic foundations. Indirectly, they are affected by site vandalism and looting or disturbance from recreational activity. Except for the Commercial Navigation Alternative, under all alternatives fewer archaeological sites would be located in the drawdown. Consequently, the project effects for these alternatives would be decreased compared to the Base Case. The number of archaeological sites at June 1 pool level and from June 1 pool level to 2 km above June 1 pool level was the same for all alternatives and therefore has no comparative value.

Table 5.18-01 NRHP Archaeological Sites by Zone and Policy Alternative

Alternative	Zone				Total[1]
	Below Winter Pool Level	Between Winter Pool and June 1 Pool Levels	At June 1 Pool Levels	June 1 Pool Level to 2 km above June 1 Pool Level	
Base Case	74	1,400	75	235	1,784
Reservoir Recreation A	290	1,184	75	235	1,784
Reservoir Recreation B	495	979	75	235	1,784
Summer Hydropower	391	1,083	75	235	1,784
Equalized Summer/ Winter Flood Risk	293	1,181	75	235	1,784
Commercial Navigation	74	1,400	75	235	1,784
Tailwater Recreation	442	1,032	75	235	1,784
Tailwater Habitat	529	945	75	235	1,784
Preferred	329	1,145	75	235	1,784

NRHP = National Register of Historic Places.

[1] These numbers do not match those in Tables 4.18-01 and 4.18-03, because the approximately 200 sites for which no elevation data were available were not included in the impacts analysis. Locating the data was not feasible and would not affect the conclusions.

5.18.3 Base Case

Shoreline Erosion. The Base Case would result in continued erosion of reservoir shorelines and tailwater streambanks.

Exposure by Elevation Fluctuations. The largest number of NRHP-eligible archaeological sites would be located between summer and winter pools under the Base Case and the Commercial Navigation Alternative.

Land Development. Under the Base Case, reservoir elevations and drawdown schedules would not change. Development of mainstem and tributary reservoir shorelines would continue at the same rate.

Visual Impacts. The existing scenic integrity would continue; changes in viewsheds would be related to continued trends in increased shoreline development and shoreline erosion.

5.18.4 Reservoir Recreation Alternative A

Shoreline Erosion. Longer duration at higher summer pool levels and an anticipated increase in recreational boating under Reservoir Recreation Alternative A would increase existing shoreline erosion. Longer durations at full summer pool would decrease runoff erosion in the drawdown zone. Reservoir releases would generally be at higher flows for longer durations than under the Base Case under this alternative. Because there would also be more periods of low flow, the overall change in tailwater shoreline erosion potential would be minimal. Impacts on archaeological site erosion rates are projected to be adverse under Reservoir Recreation Alternative A due to the increases in reservoir shoreline erosion.

Exposure by Elevation Fluctuations. Reservoir Recreation Alternative A has 1,184 NRHP-eligible archaeological sites located between summer and winter pool elevations. This alternative would slightly decrease the number of archaeological sites in the drawdown zone that are exposed to saturation and drying compared to the Base Case. Indirectly, this alternative would slightly decrease impacts from exposure to vandalism, looting, and disturbance from recreational activity.

Land Development. Reduced summer pool drawdowns and higher winter pools under Reservoir Recreation Alternative A could induce a slight acceleration in the rate of development, which would slightly increase impacts on historic properties.

Visual Impacts. Reservoir Recreation Alternative A would moderately improve scenic integrity because of less overall fluctuations in pool levels and generally higher pool levels. Improvements to visual integrity could accelerate the rate of shoreline development, which could slightly increase impacts on historic properties.

5.18.5 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Shoreline Erosion. Longer duration at higher summer pool levels and an anticipated increase in recreational boating under Reservoir Recreation Alternative B would increase existing shoreline erosion. Longer durations at full summer pool would decrease runoff erosion in the drawdown zone. As noted in Section 5.16, Shoreline Erosion, the Tailwater Recreation Alternative would increase summer pool erosion to a higher degree than under Reservoir Recreation Alternative B. Under both of these alternatives, reservoir releases would generally be at higher flows for longer durations than under the Base Case. Because there would also be more periods of low flow, the overall change in erosion potential would be minimal. Impacts on archaeological site erosion rates are projected to be adverse under Reservoir Recreation Alternative B and substantially adverse under the Tailwater Recreation Alternative due to the increases in reservoir shoreline erosion.

Exposure by Elevation Fluctuations. Reservoir Recreation Alternative B and the Tailwater Recreation Alternative have 979 and 1,032 NRHP-eligible archaeological sites, respectively, located between summer and winter pool elevations. They have the second and third lowest number of archaeological sites that can be exposed the changing water levels. These alternatives would reduce the number of sites in the drawdown that are exposed to saturation and drying compared to the Base Case. Indirectly, this alternative would decrease the effects resulting from exposure to vandalism, looting, and disturbance from recreational activity because fewer sites would be exposed.

Land Development. Reservoir Recreation Alternative B and the Tailwater Recreation Alternative are expected to increase the rate of open space development. An increase in development would increase impacts on historic structures and archaeological sites.

Visual Impacts. Under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, there would be an overall much greater reduction in pool level fluctuations, longer duration of pool levels at higher elevations, and higher winter pool levels. These alternatives would provide the greatest improvement of scenic integrity. Improvement to visual integrity could encourage development, which is anticipated to increase impacts on historic properties.

5.18.6 Summer Hydropower Alternative

Shoreline Erosion. Shorter periods of higher summer pool levels under the Summer Hydropower Alternative would slightly decrease existing erosion. Earlier drawdowns would result in shorter periods at higher flows and less erosion of the shoreline and tailwater streambanks. Longer periods of winter drawdown would increase runoff erosion in the drawdown zone.

Exposure by Elevation Fluctuations. The Summer Hydropower Alternative has 1,083 NRHP-eligible archaeological sites located between summer and winter pool elevations. This alternative would slightly decrease the number of archaeological sites and historic structures in the drawdown zone that are exposed to saturation and drying compared to the Base Case. Indirectly, this alternative would slightly decrease the effects resulting from exposure to vandalism, looting, and disturbance from recreational activity.

Land Development. Increased summer drawdowns under the Summer Hydropower Alternative could slow the rate of land use conversion. A decrease in development would be slightly beneficial to historic properties.

Visual Impacts. Under the Summer Hydropower Alternative, the overall reduction of the duration when pool levels are at higher levels would slightly decrease scenic integrity and may reduce the rate of development, which would decrease impacts on historic properties.

5.18.7 Equalized Summer/Winter Flood Risk Alternative

Shoreline Erosion. Shorter reservoir pool durations at summer levels and a smaller drawdown zone affected by rainfall would result in slightly less erosion and would decrease impacts on historic properties in these areas. Longer periods of winter drawdown may increase erosion in the winter pool drawdown zone and may increase impacts on historic properties located in these areas.

Exposure by Elevation Fluctuations. The Equalized Summer/Winter Flood Risk Alternative has 1,181 NRHP-eligible archaeological sites located between summer and winter pool elevations. This alternative would slightly reduce the number of archaeological sites and historic structures in the drawdown zone that are exposed to saturation and drying compared to the Base Case. Indirectly, slightly fewer sites under this alternative would be exposed to vandalism, looting, and disturbance from recreational activity, compared to the Base Case.

Land Development. The Equalized Summer/Winter Flood Risk Alternative would result in no change to a slight decrease in the rate of shoreline development, which would result in a slightly beneficial impact on historic properties.

Visual Impacts. The Equalized Summer/Winter Flood Risk Alternative would reduce elevation fluctuations and maximum reservoir levels would be lower. Low water levels might decrease the scenic integrity of the shoreline and reduce development, which could slightly decrease impacts on historic properties.

5.18.8 Commercial Navigation Alternative

Shoreline Erosion. The Commercial Navigation Alternative would result in continued erosion of reservoir shorelines and tailwater streambanks similar to the Base Case.

Exposure by Elevation Fluctuations. The Commercial Navigation Alternative, along with the Base Case, has the largest number (1,400) of NRHP-eligible archaeological sites located between summer and winter pool elevations. The effects of site exposure would be the same as the Base Case.

Land Development. Reservoir elevations and drawdown schedules would not change under the Commercial Navigation Alternative, resulting in continued development of the shorelines on mainstem and tributary reservoirs.

Visual Impacts. Scenic integrity would be slightly improved under the Commercial Navigation Alternative, primarily for the mainstem reservoirs. Mainstem reservoirs would have less pool level fluctuations. Tributary reservoirs would be the same as under the Base Case. Slightly improved scenic integrity along the mainstem reservoirs could affect the rate of shoreline development and might slightly increase impacts on historic properties.

5.18.9 Tailwater Habitat Alternative

Shoreline Erosion. Summer levels would be at high elevations for longer durations than under the Base Case, resulting in substantially more potential for shoreline erosion. As stated in Section 5.16, Shoreline Erosion, reservoir releases would generally be at higher flows for longer durations than under the Base Case. Because there would also be more periods of low flow, the overall change in erosion potential would be minimal.

Exposure by Elevation Fluctuations. The Tailwater Habitat Alternative has 945 NRHP-eligible archaeological sites located between summer and winter pool elevations. This alternative has the fewest number of sites in the area that would be affected by changing water levels and would decrease the number of archaeological sites and historic structures in the drawdown that would be exposed to saturation and drying compared to the Base Case. Indirectly, this alternative would decrease the effects resulting from exposure to vandalism, looting, and disturbance from recreational activity.

Land Development. The Tailwater Habitat Alternative could induce acceleration in the rate of development around affected reservoirs but would not increase the total amount of land developed adjacent to the reservoir shoreline. Therefore, slightly increased impacts on historic properties could occur.

Visual Impacts. The Tailwater Habitat Alternative generally would provide the longest duration of high pool elevations of all the alternatives. The greatly increased scenic integrity under this alternative could promote development, which could increase the rate of shoreline development but not the overall amount of development due to restrictions outlined in TVA's SMI. Therefore, impacts on historic properties would be slightly adverse.

5.18.10 Preferred Alternative

Shoreline Erosion. Archaeological site erosion rates along reservoir shorelines would increase slightly at those reservoirs with a slightly longer duration of pool elevation in the shoreline erosion zone due to increased exposure to wind- and boat-driven wave action.

Archaeological site erosion rates in the winter drawdown zone would slightly decrease at those reservoirs with longer summer pool durations, because the duration of exposure would decrease. In addition, fewer sites would be exposed to winter drawdown erosion at those reservoirs with higher winter pool elevations.

As noted in Section 5.16, Shoreline Erosion, shoreline erosion would not increase in tributary tailwaters under this alternative. Therefore, no substantial change in impacts on archaeological sites in these areas is anticipated. On the mainstem reservoirs, tailwater archaeological site erosion rates depend more on pool elevations than on flow rates and cumulative shear stress. Slightly adverse impacts are anticipated in these areas.

Exposure by Elevation Fluctuation. On most tributary reservoirs, the zone in which archaeological resources are subjected to exposure by elevation (i.e., the drawdown zone) would be decreased because of higher winter pool elevations. The exceptions are those reservoirs where no operational changes would occur. On mainstem reservoirs, the size of the fluctuation zone would remain the same; but the duration of exposure to looting, vandalism, and recreational activity would be decreased on those reservoirs with summer pool durations.

Land Development. As noted in the assessment methods, land development is considered to have an adverse effect on historic properties of all types. Because total development buildout is expected to eventually occur at all reservoirs, only the rate of adverse impact on historic properties would be affected. On most tributary reservoirs the rate of impact is expected to increase because of longer summer pool durations and/or higher winter pool elevations. The rate of impact on mainstem reservoirs would not change appreciably because of the relatively small difference between summer and winter pool elevations (less than 5 feet at all except Chickamauga Reservoir). Pickwick Reservoir may be an exception because of a substantial increase (64 percent) in the duration of the summer pool.

Visual Impacts. The setting/visual landscape is considered an important aspect of some kinds of historic properties (for example, historic structures). On those reservoirs where land development rates are expected to increase (most of the tributary reservoirs and Pickwick), the visual integrity of such resources could be compromised. (Also see the discussion in Chapter 6, Cumulative Impacts).

5.18.11 Summary of Impacts

All alternatives, including the Base Case, would result in adverse impacts on NRHP-eligible archaeological sites and historic structures through erosion from rainfall, streamflow, and wave action resulting from wind and recreational boat traffic. Another direct impact under all alternatives is the exposure of archaeological deposits and historic structures to saturation and drying in the drawdown zone.

Changes in the existing reservoir operations policy could affect archaeological sites and historic structures indirectly. These impacts include exposure of historic properties in the drawdown to vandalism, looting, and disturbance from recreational activity. Other indirect impacts are development along the shoreline and in back-lying lands, and changes to visual or scenic integrity that may influence development.

Considering the relative consequences and impacts of potential effects related to the policy alternatives, a ranking based on an increase or decrease of effects compared to the Base Case was derived (Table 5.18.02).

The Base Case would result in adverse effects on historic properties, as discussed in Section 4.18. All the policy alternatives would continue to adversely affect historic properties. Compared to the Base Case, the Commercial Navigation Alternative would result in little or no change to ongoing impacts. The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would decrease direct and indirect impacts, resulting in a slight benefit for historic properties compared to the Base Case. The remaining five policy alternatives would increase direct and indirect impacts on historic properties and were considered slightly adverse to adverse.

Table 5.18-02 **Relative Ranking of Impacts on Cultural Resources by Policy Alternative**

Alternative	Direct Effects					Indirect Effects			
	Erosion[1]			Exposure by Elevation Fluctuations[2]	Overall Ranking of Direct Effects[3]	Shoreline and Back-Lying Land Development[4]	Visual Impacts	Exposure by Elevation Fluctuations[2]	Overall Ranking of Indirect Effects
	Reservoir Erosion Shoreline Zone	Winter Pool Drawdown	Tailwater Streambanks						
Base Case	No change	No change	No change	No change	No change – Impacts would continue at existing rates due mainly to erosion.	No change	No change	No change	No change – Impacts would continue at existing rates due to land development.
Reservoir Recreation A	Increase	Decrease	No change	Slight decrease	Adverse – Shoreline erosion would increase.	Slight increase	Increase	Slight decrease	Slightly adverse – Land development would increase.
Reservoir Recreation B	Increase	Decrease	No change	Decrease	Adverse – Shoreline erosion would increase.	Slight increase	Increase	Decrease	Slightly adverse – Land development would increase.
Summer Hydropower	Decrease	Decrease	No change	Slight decrease	Beneficial – Shoreline erosion would decrease.	Slight decrease	Decrease	Slight decrease	Slightly beneficial – Slight decrease in land development.
Equalized Summer/ Winter Flood Risk	Decrease	Decrease	No change	Slight decrease	Beneficial – Shoreline erosion would decrease.	No change to slight decrease	Decrease	Slight decrease	Slightly beneficial – Slight decrease in land development.

Table 5.18-02 Relative Ranking of Impacts on Cultural Resources by Policy Alternative (continued)

Alternative	Direct Effects					Indirect Effects			
	Erosion[1]								
	Reservoir Erosion Shoreline Zone	Winter Pool Drawdown	Tailwater Streambanks	Exposure by Elevation Fluctuations[2]	Overall Ranking of Direct Effects[3]	Shoreline and Back-Lying Land Development[4]	Visual Impacts	Exposure by Elevation Fluctuations[2]	Overall Ranking of Indirect Effects
Commercial Navigation	No change	Slight decrease	No change	No change	No change	No change	Slight increase	No change	No change
Tailwater Recreation	Increase	Decrease	No change	Decrease	Adverse – Shoreline erosion would increase.	Slight increase	Increase	Decrease	Slightly adverse – Land development would increase.
Tailwater Habitat	Large increase	Decrease	No change	Decrease	Substantially adverse – Large increase in shoreline erosion.	No change to slight increase	Increase	Decrease	Slightly adverse – Slight increase in land development.
Preferred	Slight increase	Decrease	No change	Decrease	Slightly adverse – Slight increase in shoreline erosion.	Slight increase	Increase	Slight decrease	Slightly adverse – Slight increase in land development.

[1] From rainfall, streamflow, and wave action (wind and recreational boat traffic).

[2] Saturation/drying of archaeological deposits and historic structures in the drawdown; vandalism, looting, and disturbance from recreational activity.

[3] Based on the assumption that all impact concerns are equally important.

[4] See Section 5.15, Land Use.

5.19 Visual Resources

5.19.1 Introduction

The elements of scenic attractiveness, landscape visibility, and scenic integrity that were used to inventory and describe visual resource conditions also provided the framework and guidelines for completing an assessment of potential impacts for the alternatives considered. Of these elements, scenic integrity is the primary element as it categorizes the important visual changes related to each alternative and ultimately indicates the extent to which existing scenic attractiveness would be affected.

5.19.2 Impact Assessment Methods

For this analysis, it was assumed that minimizing exposed reservoir bottoms and shoreline ring effects resulting from lower pool levels would help maintain or enhance the positive scenic character and attractiveness of the reservoirs. The duration of views and the season in which different degrees of contrast occur were also considered when evaluating potential impacts. For example, less contrast during the primary viewing period of late spring through late fall would provide the greatest benefit to the visual resources in the project area. Based on these factors, potential impacts on visual resources were evaluated using the following criteria:

- The difference in pool level fluctuations compared to the Base Case reservoir operations;
- The number of days that reservoir level is within 3 feet of the highest median pool elevation and the period in which this occurs; and,
- The late October median pool level elevation.

The first criterion provides a framework for determining whether the overall shoreline ring effect would remain the same or be reduced in maximum contrast compared to the Base Case condition and indicates the degree to which reservoir bottoms and flats would be exposed. The second criterion indicates the duration and period in which reservoir levels would remain at an elevation that maintains the natural appearance of the shoreline and, conversely, the amount of time that the effects of lower pool levels would be evident. The third criterion provides a comparison of reservoir elevations during the fall foliage viewing period and the resulting degree of contrast that would occur during this important viewing period, when tributary reservoir levels are under unrestricted drawdown conditions.

This information was extracted from the WSM and is listed by policy alternative for each representative reservoir used in the visual resources assessment. Tables 5.19-01 through 5.19-03 provide summaries of the comparison data for each of the evaluation criteria. The data were then compared to determine the effect on visual integrity for each alternative. Results were characterized according to whether visual integrity would remain the same, be reduced, or be improved in comparison to conditions under the Base Case.

Table 5.19-01 Water Level Fluctuations for Representative Reservoirs by Policy Alternative

Reservoir	Policy Alternative								
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Tributary Reservoirs									
Boone	26.0	26.0	26.0	26.0	21.0	26.0	26.0	26.0	20.0
Cherokee	40.1	29.9	19.7	29.2	18.7	40.3	19.7	25.0	27.1
Fontana	71.7	77.5	49.0	51.6	32.0	73.5	49.0	59.0	52.5
Tims Ford	17.5	13.0	17.0	17.0	19.1	18.0	17.0	13.0	18.0
Watagua	21.0	13.1	4.6	15.4	9.0	21.4	10.8	7.4	8.2
Mainstem Reservoirs									
Chickamauga	6.2	4.7	4.7	6.3	7.2	4.7	4.7	4.7	6.2
Guntersville	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Kentucky	5.3	5.3	3.0	4.7	5.3	3.0	3.0	5.3	4.7
Wheeler	4.7	3.2	3.2	4.8	4.7	3.2	3.2	3.2	4.7

Note: Values represent the difference in feet between the highest and lowest median elevation points.

Source: TVA file data.

Table 5.19-02 Duration at High-Pool Elevations for Representative Reservoirs by Policy Alternative

Reservoir	Policy Alternative								
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Tributary Reservoirs									
Boone	147	147	147	49	70	147	147	147	147
Cherokee	49	98	126	35	91	49	126	133	70
Fontana	49	84	112	28	42	49	112	133	84
Tims Ford	133	133	154	56	91	133	154	133	133
Watagua	84	140	182	126	112	84	210	203	133
Mainstem Reservoirs									
Chickamauga	196	210	210	105	168	203	210	210	196
Guntersville	364	364	364	364	364	364	364	364	364
Kentucky	154	189	364	126	154	364	364	189	154
Wheeler	196	364	364	133	189	364	364	364	217

Note: Values indicate the number of days that median pool levels would be within 3 feet of the highest pool elevation.

Source: TVA file data.

Table 5.19-03 Late October Median-Pool Level for Representative Reservoirs by Policy Alternative

Reservoir	Policy Alternative								
	Base Case	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Tributary Reservoirs									
Boone	1,372.9	1,372.9	1,369.8	1,356.0	1,375.6	1,372.9	1,369.8	1,372.9	1,372.9
Cherokee	1,037.9	1,047.6	1,060.5	1,042.7	1,066.1	1,037.9	1,060.7	1,058.4	1,048.9
Fontana	1,653.3	1,658.0	1,681.7	1,652.5	1,666.4	1,652.7	1,681.6	1,684.8	1,664.3
Tims Ford	881.3	881.3	880.8	871.0	869.7	881.3	880.8	881.3	881.3
Watagua	1,940.0	1,948.6	1,955.8	1,943.3	1,953.7	1,940.0	1,946.5	1,956.5	1,951.1
Mainstem Reservoirs									
Chickamauga	678.5	679.4	679.3	676.0	676.4	678.5	679.3	679.4	678.7
Guntersville	593.6	593.6	593.9	593.3	593.6	593.6	593.9	593.6	593.9
Kentucky	354.7	355.6	357.1	354.3	354.7	356.0	357.1	355.6	354.7
Wheeler	552.0	553.5	553.7	551.0	551.9	552.5	553.7	553.5	552.8

Note: Values indicate elevation in feet for the median pool levels during the last week in October.

Source: TVA file data.

It is important to note that review of all the probable elevation data developed for the project confirmed that the representative reservoirs selected for this analysis are illustrative of the visual changes that would occur under each of the alternatives for all mainstem and tributary reservoirs in the TVA system. Run-of-river reservoirs were also investigated for elevation changes associated with each policy alternative. Pool elevations for these reservoirs would not change under any of the alternatives; therefore, visual integrity would not be affected.

Other qualitative measures used in the assessment of visual resources were based on indirect visual effects resulting from erosion factors, land use patterns, and development that may result from the alternatives (see Sections 4.15 and 5.15 [Land Use], and Sections 4.16 and 5.16 [Shoreline Erosion]).

5.19.3 Base Case

Under the Base Case, the existing scenic integrity levels would continue to be a component of the viewed landscape. The only changes that would occur would be related to continued trends in increased residential development and the resulting impacts on shoreline aesthetics. Implementation of the guidelines identified in the SMI (TVA 1998) would help to reduce or eliminate some of the factors contributing to lower scenic integrity levels that are associated with shoreline development. Actions to reduce the effects of exposed structures or other elements that cause visual discord when pool levels are lower would increase visual integrity. Erosion factors associated with existing reservoir operations may also contribute to reduced scenic integrity, especially for mainstem reservoirs.

5.19.4 Reservoir Recreation Alternative A

Reservoir Recreation Alternative A would improve the overall scenic integrity for both tributary and mainstem reservoirs. For the representative tributary reservoirs, Boone would remain the same while the others would be slightly to moderately improved. All mainstem representative reservoirs would see some level of improvement in scenic integrity, with the most noticeable changes at Chickamauga Reservoir and Wheeler Reservoir.

Changes in reservoir operations under Reservoir Recreation Alternative A would result in less overall fluctuation in pool levels, higher pool levels during the primary viewing period, higher winter levels for most reservoirs, and higher October water levels. These changes would reduce the contrast in the ring effect and the amount of exposed reservoir bottoms and flats.

Overall, Reservoir Recreation Alternative A would moderately improve visual integrity, with a resulting improvement in overall scenic attractiveness.

5.19.5 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Reservoir Recreation Alternative B and the Tailwater Recreation Alternative would result in similar effects as those described for Reservoir Recreation Alternative A but would result in a higher level of improvement of scenic resources. Overall, there would be a much greater reduction in pool level fluctuations, a longer duration of pool levels at higher elevations, and higher October reservoir levels. Winter pool elevations also would be viewed at higher levels than under Reservoir Recreation Alternative A.

Based on direct effects, Reservoir Recreation Alternative B and the Tailwater Recreation Alternative would provide the greatest improvement of scenic integrity and overall scenic attractiveness compared to all other alternatives.

5.19.6 Summer Hydropower Alternative

Although the Summer Hydropower Alternative would result in overall lower fluctuation levels for tributary reservoirs that would be similar to results under Reservoir Recreation Alternative A, the Summer Hydropower Alternative would also result in an overall reduction of the duration when pool levels are at higher elevations. This reduction would be substantial for some tributary reservoirs, such as Boone and Tims Ford. A shorter duration of higher water levels also was noted for the mainstem reservoirs when compared to the Base Case. The shorter duration would result in lower reservoir levels being observed for a longer time during the primary viewing period. It was also noted that the minimum pool levels reached under abnormal rainfall years for some of the tributary reservoirs under the Summer Hydropower Alternative would be extremely lower than those under the Base Case. Overall, late October reservoir levels would tend to be lower under the Summer Hydropower Alternative when compared to the other alternatives.

The Summer Hydropower Alternative would moderately decrease scenic integrity, with a resulting decrease in overall scenic attractiveness.

5.19.7 Equalized Summer/Winter Flood Risk Alternative

Although the Equalized Summer/Winter Flood Risk Alternative would include very favorable reductions in fluctuation levels (some equal to or better than those for Reservoir Recreation Alternative B and the Tailwater Recreation Alternative), the reductions would be accomplished at the expense of overall lower maximum reservoir levels. For some tributary reservoirs (such as Fontana), maximum reservoir levels would be 21 feet lower than under Base Case operations. This modification will create a short-term year-round shoreline ring effect. Natural succession is expected to re-establish vegetation in this area. However, the affected zone would most likely require several years to be restored to a fully vegetated shoreline. The visual effects on mainstem reservoirs under the Equalized Summer/Winter Flood Risk Alternative would be similar to those under the Summer Hydropower Alternative.

The Equalized Summer/Winter Flood Risk Alternative would decrease scenic integrity, with a resulting decrease in overall scenic attractiveness.

5.19.8 Commercial Navigation Alternative

The Commercial Navigation Alternative is similar to the Base Case for the tributary reservoirs. There would be some improvement for mainstem reservoirs, resulting in an overall slight improvement in scenic integrity levels.

5.19.9 Tailwater Habitat Alternative

The Tailwater Habitat Alternative would blend many of the positive attributes of Reservoir Recreation Alternative A and Reservoir Recreation Alternative B. While the degree of fluctuation levels lies between these two alternatives, the Tailwater Habitat Alternative generally would provide the longest duration of high pool elevations of all the alternatives. Fall pool level elevations also generally would be higher.

The Tailwater Habitat Alternative would result in greatly improved scenic integrity, with a resulting increase in overall scenic attractiveness.

5.19.10 Preferred Alternative

The Preferred Alternative would improve the overall scenic integrity for tributary reservoirs. Visual resources at mainstem reservoirs would be similar to those under the Base Case, although scenic integrity would be slightly improved for selected reservoirs such as Wheeler.

Visual resources at all representative tributary reservoirs, except Tims Ford, would be improved in the form of less overall fluctuation in pool levels, longer duration of higher pool levels during the primary viewing period, and higher October reservoir levels. Winter levels would also be higher. Visual resources at Tims Ford would be similar to those under the Base Case. The Preferred Alternative is the only alternative that would result in less pool level fluctuation for Boone Reservoir.

Overall, the Preferred Alternative would moderately improve visual integrity, with a resulting improvement in overall scenic attractiveness.

5.19.11 Summary of Impacts

Table 5.19-04 provides a summary of the direct effects on scenic integrity levels for the representative reservoirs associated with each of the alternatives. Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative would provide the greatest degree of improvement in scenic integrity and overall scenic attractiveness. Reservoir Recreation Alternative A and the Preferred Alternative would moderately improve scenic integrity. Effects under the Commercial Navigation Alternative would be similar to those under the Base Case. The Summer Hydropower Alternative and Equalized Summer/Winter Flood Risk Alternative would reduce scenic integrity.

Table 5.19-04 Summary of Impacts on Scenic Integrity by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Current scenic integrity levels would continue to be a component of the viewed landscape. The only changes that would occur would be related to continued trends in increased residential development and the resulting impacts on shoreline aesthetics. Erosion factors associated with current reservoir operations may also contribute to additional reduction in scenic integrity.
Reservoir Recreation A	Beneficial – Overall scenic integrity for both tributary and mainstem reservoirs would be moderately improved with a resulting improvement in scenic attractiveness. Changes in reservoir operations would result in less overall fluctuations in pool levels, higher pool levels during the primary viewing period, higher winter levels for most reservoirs, and higher October water levels.
Reservoir Recreation B	Substantially beneficial – Overall scenic integrity for both tributary and mainstem reservoirs would be greatly improved with a resulting improvement in scenic attractiveness. Changes in reservoir operations would result in much greater reductions in pool level fluctuations, a longer duration of pool levels at higher elevations, and higher October reservoir levels. Winter pool elevations also would be viewed at higher levels.
Summer Hydropower	Adverse – Overall scenic integrity for both tributary and mainstem reservoirs would be moderately reduced, with a resulting decrease in scenic attractiveness. Overall lower fluctuation levels. For tributary reservoirs, favorable reductions in fluctuation levels would be offset by an overall reduction of the duration when pool levels are at higher elevations. This reduction is substantial for some reservoirs. A shorter duration of higher water levels will also occur with the mainstem reservoirs.
Equalized Summer/Winter Flood Risk	Slightly adverse – Overall scenic integrity for both tributary and mainstem reservoirs would be slightly reduced with a resulting decrease in scenic attractiveness. Favorable reductions in fluctuation levels would be accomplished at the expense of overall lower maximum reservoir levels. These modifications would result in a short-term year-around shoreline ring. The affected zone would most likely take several years to be restored to a fully vegetated shoreline.
Commercial Navigation	Slightly beneficial – Overall scenic integrity would be slightly improved. There would be some improvement for mainstem reservoirs while tributary reservoirs would be similar to the Base Case.
Tailwater Recreation	Substantially beneficial – Overall scenic integrity for both tributary and mainstem reservoirs would be greatly improved with a resulting improvement in scenic attractiveness. Changes in reservoir operations would result in much greater reductions in pool level fluctuations, a longer duration of pool levels at higher elevations, and higher October reservoir levels. Winter pool elevations also would be viewed at higher levels.
Tailwater Habitat	Substantially beneficial – Overall scenic integrity for both tributary and mainstem reservoirs would be greatly improved with a resulting improvement in scenic attractiveness. Changes in reservoir operations would result in less overall fluctuations in pool levels, a much longer duration of pool levels at higher elevations, and higher October reservoir levels. Winter pool elevations also would be viewed at higher levels.
Preferred	Beneficial – Overall, scenic integrity for tributary reservoirs would be moderately improved, with a resulting improvement in scenic attractiveness. Changes in reservoir operations for tributary reservoirs would result in less overall fluctuation in pool levels, longer duration of higher pool levels, and higher October reservoir levels. Winter pool elevations would also be viewed at higher levels for the tributary reservoirs. Visual resources at mainstem reservoirs would be similar to the Base Case, with only slight improvement evident in selected reservoirs due to a slightly longer duration of higher pool levels during summer and slightly higher October pool levels.

5.20 Dam Safety

5.20.1 Introduction

This assessment of environmental consequences focuses on whether implementation of a new reservoir operations policy would change reservoir elevations in a manner that would affect the structural stability of the dams and their appurtenant structures.

5.20.2 Impact Assessment Methods

An assessment of the effect of the alternatives on reservoir levels was performed. Maximum simulated reservoir levels were reviewed and the reservoir levels under the alternatives were compared to those seen in the Base Case. Simulated maximum levels predicted to exceed those under the Base Case were evaluated. If the increase was small relative to the total head or if the duration of higher head was limited, the alternatives were considered to not result in an adverse effect on dam safety. Maximum design flood levels for each alternative were determined as a part of the flood risk studies and were compared with the design flood elevations under the Base Case.

Limits on reservoir drawdown rates were included in each alternative and were not violated.

For those reservoirs where leakage is a function of reservoir levels, the review of the reservoir levels described above was also applied to evaluate the impact of the alternatives on leakage. If the increase in reservoir levels was small relative to the total head and/or the duration of higher head was limited, the effect on leakage would be considered acceptable.

5.20.3 Base Case

With respect to dam safety, the Base Case is the existing condition. Geology and seismology, reservoir levels, reservoir drawdown rates, and leakage would not be affected under the Base Case.

5.20.4 All Action Alternatives

The simulated peak reservoir levels for 99 years of historical inflows indicated that no reservoir operations policy alternative would pose an adverse affect on dam safety relative to the Base Case. The flood risk studies indicated that, for all alternatives, design flood maximum pool levels would increase only slightly with respect to the Base Case, and would not adversely affect the stability of the dams and their appurtenant structures.

Reservoir Drawdown Rates

Because limits on reservoir drawdown rates would be included in each alternative and would not be violated, no impacts are associated with reservoir drawdown rates under the policy alternatives. Table 4.20-01 provides the reservoir rate drawdown limits.

Leakage

Table 4.20-03 lists the projects where leakage is monitored. For those reservoirs where leakage is a function of reservoir levels, the range of reservoir levels would not be affected by any of the policy alternatives.

5.20.5 Summary of Impacts

Reservoir-triggered seismicity does not appear to be a primary factor for TVA dams. The simulated peak reservoir levels for 99 years of historical inflows indicated that no reservoir operations policy alternative would adversely affect dam safety relative to the Base Case. The flood risk studies indicated that, for all alternatives, design flood maximum pool levels would increase only slightly with respect to the Base Case, and would not adversely affect the stability of the dams and their appurtenant structures.

Because the reservoir drawdown rates under the alternatives would not exceed those under the Base Case, a determination of no impact can be made without additional review.

The future effects on leakage at TVA dams and rims due to proposed changes in the operation of its reservoirs would vary. Leakage and seepage at most reservoirs vary with headwater, but not at all reservoirs. Those dams with leaks that vary with headwater and without trends would probably not be affected by reservoirs being maintained at elevations for normal summer pool for longer periods of time than under the Base Case. Also, the dams with leakage that does not fluctuate with headwater elevations should not be affected by extended periods of summer pool.

Dams with leakage that fluctuates with headwater and with existing increasing trends may, over time, be affected by pools being held at summer levels longer. Most likely, the effects would be either a change in the rate of the trends, or some sudden increases with or without a change in the discharge rate.

Table 5.20-01 provides a summary of impacts on dam safety by policy alternative.

Table 5.20-01 Summary of Impacts on Dam Safety by Policy Alternative

Alternative	Description of Impacts
Base Case	Current seismic conditions, leakage, and reservoir levels would continue.
Reservoir Recreation A	Alternative reservoir operations would not affect the range of normal reservoir levels, leakage, or seismicity; design flood maximum pool levels would increase only slightly with respect to the Base Case, and would not adversely affect the stability of the dams and their appurtenant structures.
Reservoir Recreation B	Impacts would be the same as those described for Reservoir Recreation Alternative A.
Summer Hydropower	Impacts would be the same as those described for Reservoir Recreation Alternative A.
Equalized Summer/Winter Flood Risk	Impacts would be the same as those described for Reservoir Recreation Alternative A.
Commercial Navigation	Impacts would be similar to those described for the Base Case.
Tailwater Recreation	Impacts would be the same as those described for Reservoir Recreation Alternative A.
Tailwater Habitat	Impacts would be the same as those described for Reservoir Recreation Alternative A.
Preferred	Impacts would be the same as those described for Reservoir Recreation Alternative A.

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5.21 Navigation

5.21.1 Introduction

A change in the depth of navigation channels could affect the Tennessee River navigation system. Changes in the depth of navigation channels introduced by implementation of any of the policy alternatives may alter movements of bulk cargoes on the Tennessee River, affecting the cost to shippers. The following section analyzes potential changes in shippers costs as influenced by policy alternatives.

5.21.2 Impact Assessment Methods

To assess the impacts of the policy alternatives on navigation, the alternatives were grouped into three categories: (1) the alternative would not change navigation channel pool levels from the existing reservoir operations policy (same as the Base Case), (2) the alternative would increase navigation channel pool levels (a 2-foot increase, when possible, to a 13-foot navigation channel with a 2-foot overdraft protection is a common component of five of the policy alternatives), and (3) the alternative would decrease navigation channel pool levels.

To assess potential impacts on navigation, TVA developed and applied a methodology that used movement surveys of 2,270 origin-destination pairs. These pairs were based on the actual commodity movements of calendar year 2000.

Because of the flexibility created by surface transportation deregulation, it is sometimes difficult to determine the exact rate charged by a carrier on shipments moving under contract. Barge rates are a matter of negotiation between shipper and barge line operator, and these rates are not published in tariff form. Each carrier's rates are based on individual costs and specific market conditions; therefore, rates vary considerably among regions, across time, and from one barge line to another.

The rates for moving grains are a notable exception to negotiated contract rates for barge transport. Contract rates for the movement of grains appear to have peaked in 1986, when approximately 40 percent of all grain was shipped under contract. Since that time, a number of carriers have returned to the use of traditional tariffs as the basis for rate calculations.

Contract rates are also common in pipeline, rail, and motor carrier transportation; like barge rates, they may be maintained in complete confidentiality. In other cases (particularly for grain), tariff rates are still applied; nevertheless, there is seldom any dependable means for determining whether a contract rate or a tariff rate should be used to price a particular movement. A further complication is the use of rebates and allowances by carriers as an incentive to shippers in order to induce higher traffic volumes.

For this study, actual rates, as provided by shippers, receivers, or river port operators, were used whenever possible. All other rates were obtained from published sources or, when this was not possible, were estimated by TVA based on the mode of transportation, the tonnage, and other shipment characteristics. The methodologies used to estimate unobservable rates were developed through extensive contacts with shippers, railroads, motor carriers, and the barge industry. This information was often integrated with confidential federal data and the output of computerized simulation and costing models. The process was both guided and augmented by in-house TVA rating and costing expertise developed through decades of experience as a major shipper of coal and other bulk commodities, and through the implementation of navigation-based economic development programs throughout the Tennessee River basin. Except for grain and feed ingredients, unobservable barge rates were calculated through the application of a computerized barge-costing model developed by TVA.

Three points should be noted regarding the methodological standards applied in this study. First, the standards reflect essentially the same processes TVA has applied (or will apply) in developing transportation rates for other recent (or ongoing) USACE studies. Specifically, the outlined methodology was used in the Ohio River Mainstem Study (USACE 1999) and the Upper Mississippi Navigation Improvement Project Rate Study (USACE 1997), and is being applied in the Missouri River Master Water Control Manual Review and Update (USACE 2002) and the Bayou Sorrel Lock Improvement Plan (USACE 1998) assessment. This uniform approach has facilitated inter-project comparisons. Second, recent methodological improvements enable TVA to produce transportation rate/cost materials that are, simultaneously, more complete and more reliable than the transportation data TVA (or any other agency) has produced for similar studies in the past. Each rate study for each District of the USACE is integrated into a series of databases for quick accessibility and data manipulation. Third, the forecasted rates do not include the water-compelled rate effect. This effect infers that rail rates are lower when water transportation is available to the shipper due to competitive factors and the need of the railroads to maximize utility. The water-compelled rate effect is captured by the model used to estimate the total economic effects of the policy alternatives.

5.21.3 Base Case

Existing and future predicted commodity (2030) movements were compared, and the changes in shipper savings due to continued operation of the water control system under the existing reservoir operations policy were determined. These savings are listed in Table 5.21-01.

Under the Base Case, 2030 tonnage on the regional navigation system is estimated to increase from 38.3 million to 56.5 million tons. Total annual shipper savings is estimated to be $597 million, with an average per-ton increase in shipper savings of $0.45.

The impacts on a per-ton savings are shown in Table 5.21-01.

Table 5.21-01 Tennessee River Shipper Savings under the Base Case

Group	Commodities	Existing Average Per-Ton Savings	2030 Average Per-Ton Savings	Impact Average Per-Ton Savings
1	Coal and coke	$ 8.07	$ 8.03	$ -0.04
2	Aggregates	$10.30	$10.05	$ -0.25
3	All other	$ 6.45	$ 6.12	$ -0.33
4	Iron and steel	$ 8.19	$ 8.18	$ -0.01
5	Grains	$ 8.59	$ 8.29	$ -0.30
6	Chemicals	$19.59	$19.84	$ 0.25
7	Ores and minerals	$10.67	$ 8.95	$ -1.72
8	Petroleum fuel	$ 6.48	$ 7.88	$ 1.40
Average all commodities		$ 9.24	$ 9.69	$ 0.45

5.21.4 Summer Hydropower Alternative

Under the Summer Hydropower Alternative, drawdown of mainstem reservoirs would begin on June 1 and reach normal winter pool levels by mid-September. The spring fill policy would not change. This would result in lower reservoir elevations during 5 months of the year, adversely affecting navigation. Losses in shipper savings would range from approximately $11 million in 2004 to over $17 million in 2030 compared to the Base Case.

5.21.5 Equalized Summer/Winter Flood Risk Alternative

Under the Equalized Summer/Winter Flood Risk Alternative, there is a potential for drawdown for each reservoir above River Mile 649 that would result in a 7-foot channel depth during some months. Two docks at Knoxville could be affected, with a resulting impact of approximately $1.0 million in reduced annual shipper savings compared to the Base Case. Because this potential reduction represents less than 0.05 percent of the RED shipper savings on the river navigation system, the impact was considered insignificant.

5.21.6 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Commercial Navigation Alternative, Tailwater Recreation Alternative, and Tailwater Habitat Alternative

Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Commercial Navigation Alternative, the Tailwater Recreation Alternative, and the Tailwater Habitat

Alternative would result in increasing channel depth to 13 feet where possible. Compared to the Base Case, changes in shipper savings would occur only under the Commercial Navigation Alternative. Model results for shipper savings under these alternatives are listed in Table 5.21-02.

Table 5.21-02 Tennessee River Shipper Savings under the Commercial Navigation Alternative

Group	Commodities	Base Case 2030 Average Per-Ton Savings	Commercial Navigation Alternative 2030 Average Per-Ton	Impact Average Per-Ton Savings
1	Coal and coke	$ 8.03	$ 8.97	$ 0.94
2	Aggregates	$10.05	$11.03	$ 0.98
3	All other	$ 6.12	$ 6.67	$ 0.55
4	Iron and steel	$ 8.18	$10.11	$ 1.93
5	Grains	$ 8.29	$ 9.62	$ 1.33
6	Chemicals	$19.89	$20.12	$ 0.23
7	Ores and minerals	$ 8.95	$11.36	$ 2.41
8	Petroleum fuel	$ 7.88	$ 7.88	0
Average all commodities		**$ 9.69**	**$10.75**	**$ 1.06**

Table 5.21-02 shows the impacts on a per-ton savings. Shipper savings would increase under the Commercial Navigation Alternative. The increases would range between $2.41 per ton for ores and minerals and $0.23 per ton for chemicals. By 2030, the average per-ton shipper savings increase over the Base Case would be $1.06 per ton. These savings would result in a total additional shipper benefit of $37.7 million annually by 2030, an 8.2-percent increase, under the alternatives with a 13-foot channel depth. These savings also include a reduction of over $10 million from potential 13-foot channel benefits that would accrue due to the constraints of the Chickamauga tailwater and Kentucky Reservoir. Without these constraints, total benefits by 2030 under alternatives with a 13-foot channel depth are estimated at $507 million, an increase of 10.5 percent.

In accordance with RED evaluation policy, these savings are regional, including only shipments originating or destined for Tennessee River system facilities. They do not include additional shipper savings accruing to shippers or receivers outside the system, such as on the Ohio or Mississippi Rivers.

Modal diversion is the shifting of cargoes from barge to the rail or truck mode. Interest exists regarding impacts on modal diversion that would result under various alternatives. At issue is the behavior of shippers to change modes or increase barge shipments for an average gain of $0.45 per ton. Elasticity of modal choice was explored in interviews with shippers. Operators demonstrated highly inelastic modal selection, citing three primary reasons: (1) typically, capital investment to implement modal change is not recoverable; (2) many shippers are captive to the barge mode; and (3) shipment quantities are based on factors other than channel depth.

5.21.7 Preferred Alternative

Under the Preferred Alternative, Kentucky Lock and Dam tailwater would be maintained at an elevation of 301 feet by increasing releases from the Kentucky Reservoir as needed, and Pickwick Landing Lock and Dam tailwater would be adjusted by releases from Pickwick Reservoir when requested by towboat operators. The impact on navigation of this alternative is to allow for 10-foot draft barges on Kentucky, Pickwick, and Barkley Reservoirs during the traditional pool drawdown periods for those docks that can accommodate deeper draft equipment. As with the previous alternative analysis, the shipper saving benefit to non-utility industries in the region was estimated at $0.3 million, and the shipper saving benefit to power plants in the region was estimated at $2.1 million in the first year of implementation.

5.21.8 Summary of Impacts

Table 5.21-03 contains a summary of impacts on navigation by policy alternative. Under the Base Case, total shipper savings in 2030 is estimated at $597 million, with an average per-ton increase in shipper savings of $0.45. Future increased tonnage under the Base Case would result in more barge trips that in turn would result in more fuel consumption and greater air quality impacts.

Under the Summer Hydropower Alternative, drawdown of mainstem reservoirs would begin on June 1 and reach normal winter pool levels by mid-September. The spring fill policy would not change. This would result in lower reservoir elevations during 5 months of the year, adversely affecting navigation. Losses in shipper savings would range from approximately $11 million in 2004 to over $17 million in 2030 compared to the Base Case. Under the Equalized Summer/Winter Flood Risk Alternative, there is a potential drawdown for each reservoir above River Mile 649 that would result in a 7-foot channel depth during some months. Two docks at Knoxville could be affected, with a resulting regional economic impact of approximately $1.0 million in reduced shipper savings compared to the Base Case. Because this potential reduction represents less than 0.05 percent of the RED shipper savings on the river navigation system, the impact was considered insignificant.

Under the Commercial Navigation Alternative, the average per-ton shipper savings increase over the Base Case would be $1.06 per ton. These savings would result in a total additional shipper benefit of $37.7 million annually by 2030, an 8.2-percent increase, under the alternatives with a 13-foot channel depth. These savings are regional, including only shipments originating or destined for Tennessee River system facilities. They do not include additional shipper savings accruing to shippers or receivers outside the system, such as on the Ohio or Mississippi Rivers.

The increased tonnage per barge under the Commercial Navigation Alternative would result in fewer tows for the equivalent tonnage under the Base Case. This would result in smaller impacts on emission shifting and air quality.

Under the Preferred Alternative, Kentucky Lock and Dam tailwater would be maintained at an elevation of 301 feet by increasing releases from Kentucky Reservoir as needed, and Pickwick Landing Lock and Dam tailwater would be adjusted by releases from Pickwick Reservoir when requested by towboat operators. This would allow for 10-foot draft barges on Kentucky, Pickwick, and Barkley Reservoirs during the traditional pool drawdown periods for those docks that can accommodate deeper draft equipment. Shipper savings benefits during the first year of implementation for this alternative were estimated at $0.3 million for non-utility industries in the region and $2.1 million for power plants in the region.

Table 5.21-03 Summary of Impacts on Navigation by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Regional shipper savings of approximately $378 million are expected to increase at an average annual rate of 1.5 to 2.0 percent, to $597 million by 2030.
Reservoir Recreation A	No changes in shipper savings compared to the Base Case.
Reservoir Recreation B	No changes in shipper savings compared to the Base Case.
Summer Hydropower	Slightly adverse – Mainstem reservoir levels would be lower than under the Base Case during 5 months of the year. Losses in shipper savings would range from approximately $11 million in 2004 to over $17 million in 2030.
Equalized Summer/Winter Flood Risk	Slightly adverse – Potential for drawdown for each reservoir that would result in a 7-foot channel depth during some months. Losses in shipper savings are expected to range from $1.2 million in 2004 to $1.9 million in 2030.
Commercial Navigation	Slightly beneficial – Shipper savings would increase by $17 million under the 13-foot channel option. Increased tonnage per barge would result in fewer impacts related to emission shifting and air quality.
Tailwater Recreation	No changes in shipper savings compared to the Base Case.
Tailwater Habitat	No changes in shipper savings compared to the Base Case.
Preferred	Slightly beneficial – Shipper savings would increase by approximately $2.4 million in 2004 due to changes that would allow for 10-foot draft barges on Kentucky, Pickwick, and Barkley Reservoirs during the traditional pool drawdown periods for those docks that can accommodate deeper draft equipment.

5.22 Flood Control

5.22.1 Introduction

The factors used to describe the existing flood risk condition, peak discharge, and potential flood damage were again used to assess the impact of each alternative considered.

5.22.2 Impact Assessment Methods

The analysis described in Section 4.22.3 was performed for each alternative. The RiverWare model used to predict discharges was reconfigured to mimic the various alternative operations policies to predict flows at each of 48 critical locations. The critical locations include dams and damage centers (Table 5.22-01).

Table 5.22-01 Critical Locations for Evaluation of Flood Risk Potential

Dams	
Apalachia	Little Bear Creek
Bear Creek	Melton Hill
Blue Ridge	Nickajack
Boone	Normandy
Calderwood	Norris
Cedar Creek	Nottely
Chatuge	Ocoee #1
Cheoah	Ocoee #3
Cherokee	Pickwick
Chickamauga	South Holston
Chilhowee	Tellico
Douglas	Tims Ford
Fontana	Upper Bear Creek
Fort Loudoun	Watauga
Fort Patrick Henry	Watts Bar
Great Falls	Wheeler
Guntersville	Wilson
Hiwassee	
Damage Centers	
Chattanooga, TN	Huntsville, AL
Clinton, TN	Kingsport, TN
Copperhill, TN/McCaysville, GA	Knoxville, TN
Decatur, AL	Lenoir City, TN
Elizabethton, TN	Savannah, TN
Fayetteville, TN	South Pittsburg, TN
Florence, AL	

5.22 Flood Control

The impact of each alternative was measured by changes in:

- The peak flows predicted for the 99 years of historical inflows;
- The peak flows predicted for the design storms; and,
- The potential damage due to flooding from historical inflows.

The downstream limit of TVA's detailed flood risk simulation model was Savannah, Tennessee. The analysis at Savannah was comprehensive and included both period-of-record flow frequency curves and analysis of a large number of hypothetical design storms.

Separate from its modeling of flood risks, TVA did consider flooding effects downstream from Savannah. For Kentucky Reservoir, TVA conducted a detailed investigation of the effect of different operations alternatives on the volume of water discharged from Pickwick Landing Dam. This investigation included the identification of the 10 largest annual and seasonal volumes discharged over 1–, 3–, 7–, 10–, 15–, and 30–day durations in the 99–year simulated period of record. For each of these events, the incremental volumes discharged into Kentucky Reservoir under each alternative were compared to the Base Case. This analysis showed that for these large storms it is reasonable to expect that the difference between Pickwick discharge under the Base Case and under any of the action alternatives, including the Preferred Alternative, can be temporarily stored in the Kentucky pool.

The intent of the flood risk study was to define the range of operating policy modifications that could be made without unacceptably increasing flood risk at any critical location, including Savannah and Kentucky Reservoir.

TVA developed a flood risk evaluation criterion for the ROS. As compared to Base Case, no acceptable policy alternative should increase overall flood risk and associated flood damages for those flood events with a recurrence interval of 500 years or less. Overall flood risk and associated damage considers offsetting increases and decreases of flood risk and damage in localized areas. Policy alternatives that did not meet this criterion were deemed unacceptable from a flood risk perspective. The evaluation was based on:

- A 99-year period of record continuous simulation (1903–2001), for which recurrence intervals of annual and seasonal peak discharges were assigned using a standard hydrologic formula, and

- Discrete simulations for a series of hypothetical events (design storms), for which recurrence intervals were estimated based on the volume-duration-frequency characteristics of total inflow upstream of the point in question.

Because of the uncertainty associated with the recurrence interval of regulated, hypothetical design storms, TVA considered those events with recurrence intervals up to 700 years. The hypothetical events are scaled replicas of the largest flood events observed across the Tennessee Valley within the 99-year period of record. A total of 138 separate design storms were developed in an effort to capture the watershed flood potential of events with a wide variation in the spatial and temporal distribution of runoff.

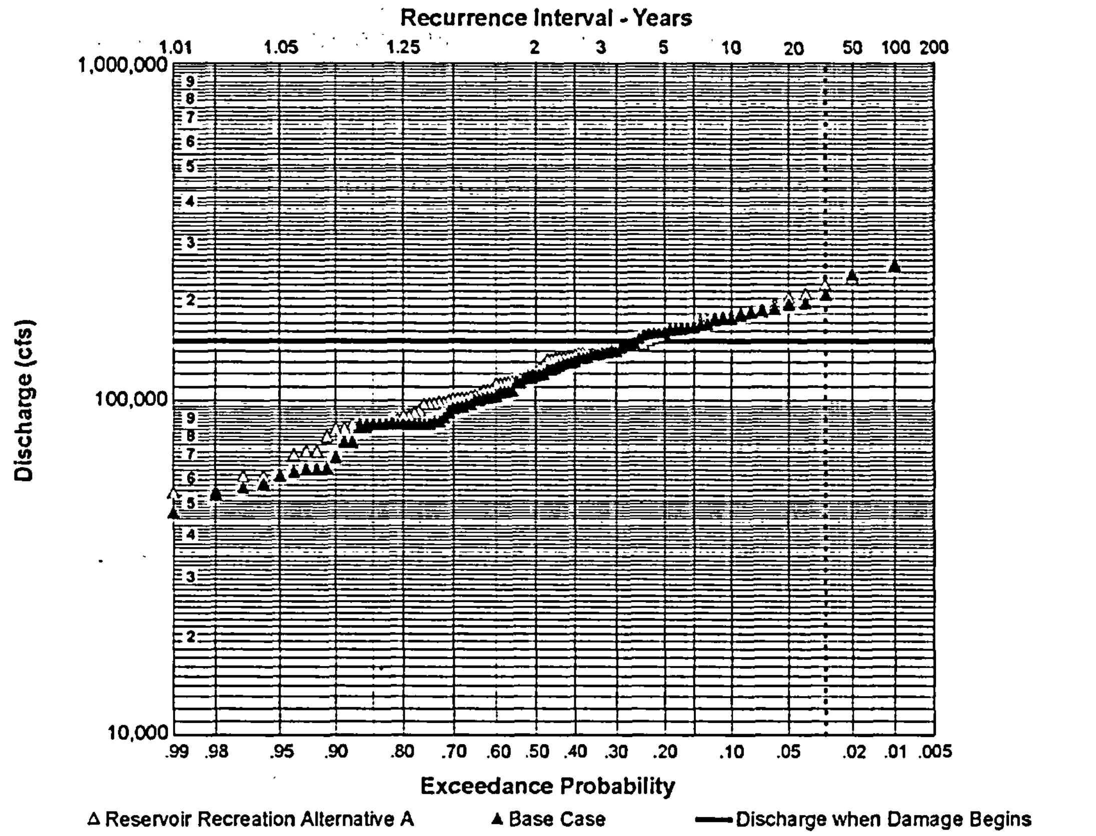
All of the alternatives investigated, with the exception of Base Case, can be characterized by a reduction in flood storage allocation at certain projects during certain seasons of the year. Any reduction in flood storage allocation must, by definition, be accompanied by an increase in flood risk, since the volume available to temporarily store large runoff volumes is reduced. For an alternative to be judged to satisfy the flood risk evaluation criteria described above, this increase in flood risk must be limited to those events with recurrence intervals larger than the 500-year event. The 500-year event was judged to be a reasonable standard that would allow TVA to investigate meaningful modifications to the reservoir operations policy while maintaining consistency with TVA's historical flood control mission.

Peak Flow

As described in Section 4.22.3, the annual and seasonal peak discharge at each critical location was identified for each year in the 99-year simulation of the Base Case. The peak discharges were sorted in descending order, assigned a recurrence interval using a standard hydrologic formula, and then plotted on probability paper to estimate the relationship between the magnitude of a peak discharge at a given location and the probability of occurrence of that discharge. A similar analysis was performed for each alternative. The impact of each alternative on flood flow frequency was determined by comparing the plotted flood flow frequency data for each policy alternative with the data from the Base Case.

The impact of Reservoir Recreation Alternative A on annual peak discharges from Chickamauga Dam is shown in Figure 5.22-01. This figure shows that operation of the reservoir system under Reservoir Recreation Alternative A would increase the annual peak discharges over those in the Base Case at this location across much of the range of recurrence intervals represented. At Chickamauga Dam, discharges in excess of about 150,000 cfs are of particular concern because of the immediate potential for downstream flooding in Chattanooga. This flow is indicated by the horizontal line labeled "Discharge When Damage Begins" in Figure 5.22-01. Any instances for which the alternative peak discharges are higher than the corresponding Base Case discharges in that region of the flood flow frequency plot at or above 150,000 cfs would therefore be an indication that increased flooding could be expected under that alternative.

As shown in Figure 5.22-01, an increase in peak discharge from Chickamauga Dam under Reservoir Recreation Alternative A can be expected for discharges with an annual probability of exceedance of between 0.05 (corresponding to a recurrence interval of 20 years) and 0.03 (corresponding to a recurrence interval of about 33 years; this recurrence interval is shown by a dashed vertical gridline in Figure 5.22-01). For this range of recurrence intervals, peak discharges are above the "damage begins" threshold. The increases in peak discharge evident under Reservoir Recreation Alternative A for events with exceedance probabilities larger than about 0.25 (recurrence intervals less than 4 years) would not be associated with increased flooding damage at Chattanooga. Flood flow frequency plots at other locations were evaluated in a similar manner, with each evaluation performed relative to an appropriate "damage begins" threshold discharge, based on consideration of potential damage to habitable residential, commercial, and industrial structures, and other areas such as farmlands.

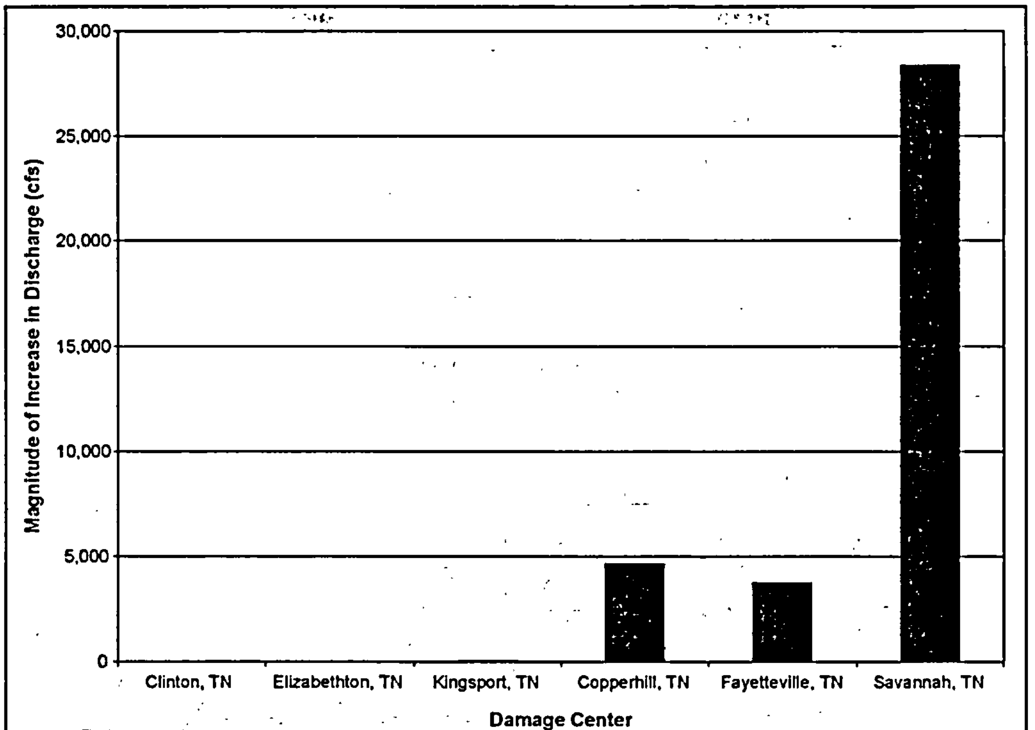


Source: TVA data 2003.

Figure 5.22-01 Simulated Annual Flood Flow Frequency for Chickamauga Dam (1903 to 2001)

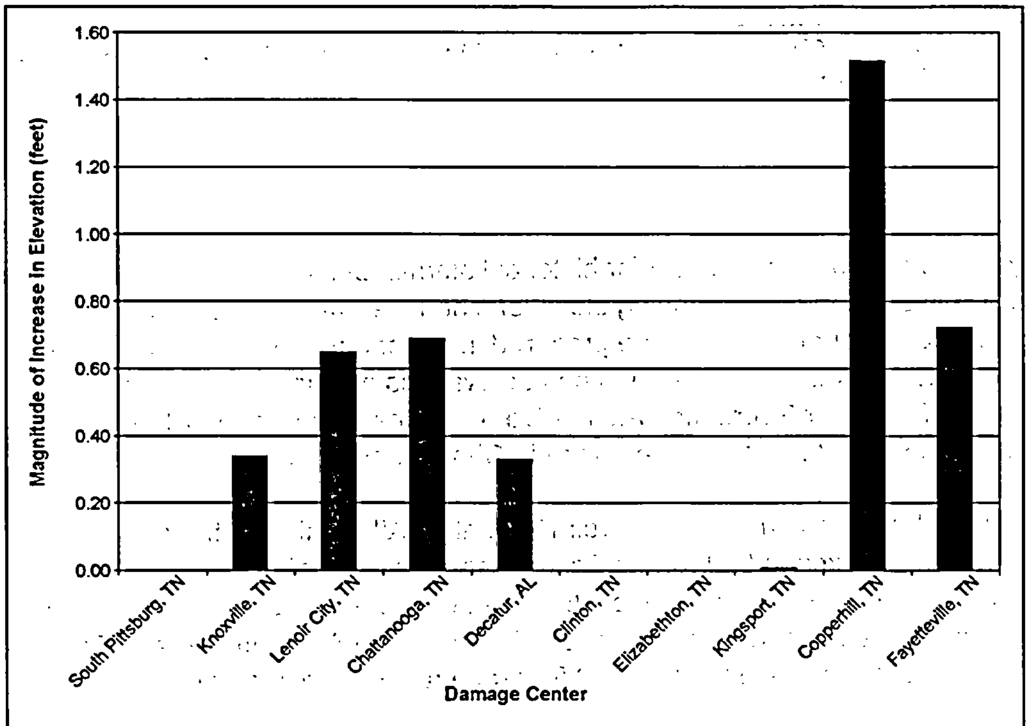
Annual and seasonal flood flow frequency plots were thus developed at each critical location to reflect the effects of each policy alternative. Figures 5.22-02 (a) and (b) show the incremental increase (with respect to the Base Case) in the largest of the simulated peak flows and/or elevations under Reservoir Recreation Alternative A for some of the 13 damage centers.

For the design storms, the scaled-up historical inflows were modeled in a series of discrete (as opposed to continuous) RiverWare simulations. The peak discharge for each storm event was then plotted versus the month and day of the historical storm peak, overlaying the policy alternative and the Base Case peak flows for comparison. Figure 5.22-03 illustrates the impact of Reservoir Recreation Alternative A in terms of peak discharge at Chickamauga for each design storm (based on historical inflows increased by a factor of 1.5). In some cases, such as the design storm that peaked on April 6 (1977), the impact is measurable as the peak discharge increases from 274,000 cfs under the Base Case to 296,000 cfs under Reservoir Recreation Alternative A. In the design storm that peaked on May 9 (1984), however, no measurable increase in the peak discharge is seen.



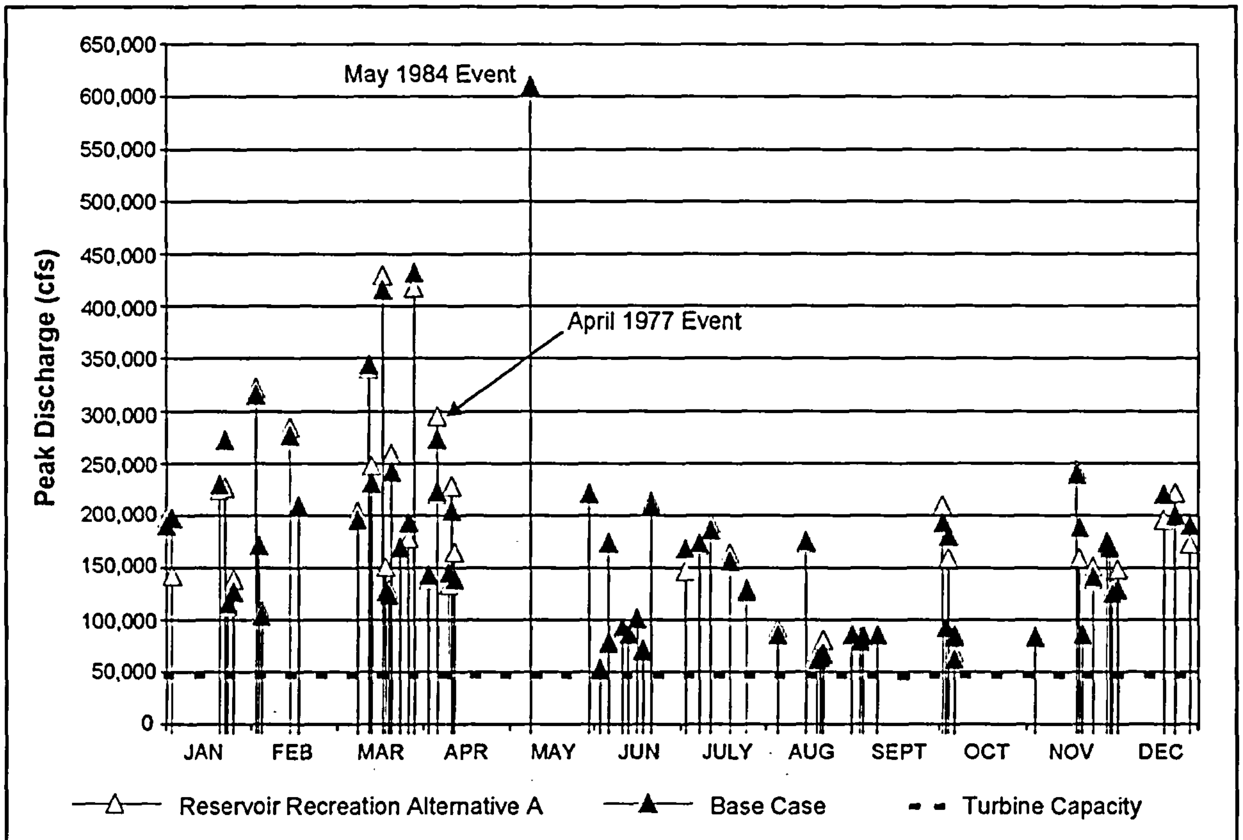
Source: TVA data 2003.

Figure 5.22-02a Increase in Simulated Peak Flow for Largest Event in 99-Year Period of Record for Six Flood Damage Centers in the Tennessee Valley Region under Reservoir Recreation Alternative A



Source: TVA data 2003.

Figure 5.22-02b Increase in Simulated Peak Elevation for Largest Event in 99-Year Period of Record for 10 Flood Damage Centers in the Tennessee Valley Region under Reservoir Recreation Alternative A



Source: TVA data 2003.

Figure 5.22-03 Peak Discharges from Hypothetical Design Storms for Chickamauga Dam (Scaling Factor 1.50)

Potential Damage

After identifying the change in peak flow for historical storms, peak flows at damage center locations were converted to corresponding elevations and the effect of the change was evaluated. Elevation frequency plots were prepared in a manner similar to the flood flow frequency plots. As an example, the annual peak elevations at Chattanooga are presented in Figure 5.22-04 for Reservoir Recreation Alternative A and the Base Case. Also identified in Figure 5.22-04 is the elevation at which damage in Chattanooga begins.

Figure 5.22-04 illustrates that, under Reservoir Recreation Alternative A, the annual peak water elevation is expected to exceed that for the Base Case over most of the range of recurrence intervals shown in the figure. For those elevation frequency points above the "damage begins" line, the elevation difference between the Reservoir Recreation Alternative A and Base Case points ranges from less than zero to about 1.3 feet (at a recurrence interval of 25 years).

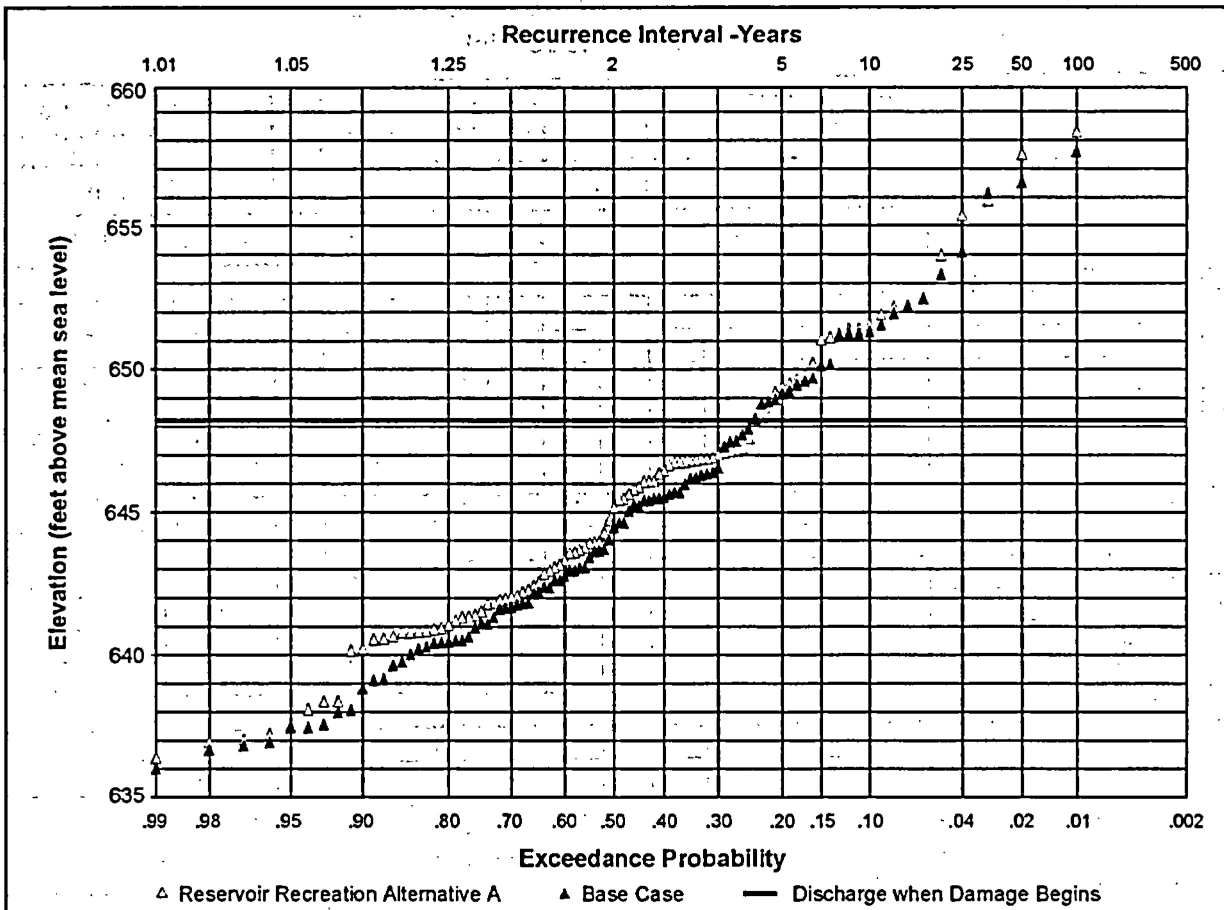


Figure 5.22-04 Simulated Annual Elevation Frequency in Chattanooga, Tennessee (1903 to 2001)

Next, the expected effects of those alternatives for which detailed flood risk simulations were completed were evaluated and summarized at each of 48 locations in the Valley, noting the locations and seasons where the effect of the alternatives would be to cause additional damage. If peak levels (flows and/or elevations) either did not increase or remained at non-damaging levels, the alternative was considered to cause no additional damage. If the alternative would increase peak levels from non-damaging levels to damaging levels, or from lower to higher damaging levels, it was considered to cause additional damage. This process was completed for each alternative compared to the Base Case for both the 99 years of historical inflows and the design storms. The results of the evaluation of flood risk simulations are summarized in the matrix formats contained in Tables 5.22-02 through 5.22-07.

5.22 Flood Control

Table 5.22-02 Summary Matrix Evaluation of the Effect of Reservoir Recreation Alternative A on Flood Risk

Location	Period of Record – 99 Years						Design Storms with 1.5 Multiplier						Design Storms with 2.0 Multiplier				
	Season						Season						Season				
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5
Tributary Dams																	
South Holston																	
Watauga																	
Cherokee									2	3						1	
Douglas									2	1	1				4	1	1
Fontana								1	2	1	2			1	2		1
Norris									1						1		
Chatuge							1		2		1		1	1	1		1
Nottely							2		1	1	1		2		2		3
Hiwassee											2				1		1
Blue Ridge							1	1	2	2	1				1		2
Tims Ford								2									
Great Falls																	
Mainstem Dams																	
Fort Loudoun								1	2						5	1	1
Watts Bar							2		6				1	1	7		
Chickamauga							3	1	2	2			4	1	5		
Nickajack							3	2	3	1			3	2	8		
Guntersville							4	1	1				3	2	5		
Wilson							3	1	2				3	4	4		
Pickwick							3	2	1				2	3	3	1	
Damage Centers																	
Kingsport									1								
Clinton									2						3		
Copperhill									2		1				3		
Elizabethton											1					2	1
Fayetteville														1			
Knoxville							3	2	4	3	1		4		6	3	3
Lenoir City								1	4	1					5		2
Chattanooga							2	1	3	2			3	3	8		
Decatur							1	2	1					1	4		
Florence							4	2	1				3	4	4	3	
Savannah							2	2	1				3	2	3	1	

Notes:

An unshaded cell indicates that, for a given alternative, no increase in peak discharge in the zone above the "damage begins" line was observed in that season for that location relative to the Base Case; a shaded cell indicates that a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line.

The numbers indicate that the number of hypothetical events for which an increase in peak discharge was observed, that the peak discharge is above the "damage begins" line, and that the approximate recurrence interval of the event falls between 100 and 700 years.

Table 5.22-03 Summary Matrix Evaluation of the Effect of Reservoir Recreation Alternative B on Flood Risk

Location	Period of Record – 99 Years					Design Storms with 1.5 Multiplier					Design Storms with 2.0 Multiplier				
	Season					Season					Season				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Tributary Dams															
South Holston							1	1							
Watauga															
Cherokee								1	3				1		
Douglas						1		2	1	2	1		3		2
Fontana						3	1	3	1	2	2	2	2		1
Norris								1					1		
Chatuge						1	1	2		1	3	1	2		1
Nottely						2	2	1	1	1	2		3		3
Hiwassee							2			2			1		1
Blue Ridge						1			1	1			1		2
Tims Ford								1			2				
Great Falls															
Mainstem Dams															
Fort Loudoun							1	4					5		1
Watts Bar						1	2	6				1	8		
Chickamauga						3	2	3	2		3	2	6		
Nickajack						3	3	4	1		3	3	9		
Guntersville						3	3				3	3	6	1	
Wilson						4	2				3	4	4		
Pickwick						3	2				2	3	3	1	
Damage Centers															
Kingsport								2							
Clinton						1		2					1		
Copperhill										1			1		
Elizabethton														2	
Fayetteville											2			1	
Knoxville						3	1	5	3	1	3		2	3	3
Lenoir City							1	5	1		1		6		2
Chattanooga						4	2	3	2		3	4	7		
Decatur						1	4	1			1	1	5		
Florence						3	2				3	4	4	3	1
Savannah						3	2				3	2	3	1	

Notes:

An unshaded cell indicates that, for a given alternative, no increase in peak discharge in the zone above the "damage begins" line was observed in that season for that location relative to the Base Case; a shaded cell indicates that a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line.

The numbers indicate that the number of hypothetical events for which an increase in peak discharge was observed, that the peak discharge is above the "damage begins" line, and that the approximate recurrence interval of the event falls between 100 and 700 years.

Table 5.22-04 Summary Matrix Evaluation of Effect of the Equalized Summer/Winter Flood Risk Alternative on Flood Risk

Location	Period of Record – 99 Years					Design Storms with 1.5 Multiplier					Design Storms with 2.0 Multiplier				
	Season					Season					Season				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Tributary Dams															
South Holston								1							
Watauga															
Cherokee															
Douglas															
Fontana												2	1		
Norris															
Chatuge							1				3	1			1
Nottely							1	1			1		2		2
Hiwassee															
Blue Ridge							2								1
Tims Ford															
Great Falls															
Mainstem Dams															
Fort Loudoun													3		
Watts Bar							2				1	1	2		
Chickamauga						1	2	2			2	2	2		
Nickajack							3	2			2	3	5		
Guntersville						1	6	1		1	1	3	7		
Wilson						1	3	1			2	4	2		
Pickwick							3	1			1	3	3		
Damage Centers															
Kingsport															
Clinton						2		1							
Copperhill								1							
Elizabethton								2		1			1	1	1
Fayetteville															
Knoxville						1	1	3	2	1	2		2	1	4
Lenoir City								4					3		
Chattanooga						1	2	2			2	3	3		
Decatur							5	1				1	4		
Florence						1	4	1			2	4	3	2	1
Savannah							3	1			2	2	3		

Notes:

An unshaded cell indicates that, for a given alternative, no increase in peak discharge in the zone above the "damage begins" line was observed in that season for that location relative to the Base Case; a shaded cell indicates that a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line.

The numbers indicate that the number of hypothetical events for which an increase in peak discharge was observed, that the peak discharge is above the "damage begins" line, and that the approximate recurrence interval of the event falls between 100 and 700 years.

Table 5.22-05 Summary Matrix Evaluation of Effect of the Commercial Navigation Alternative on Flood Risk

Location	Period of Record – 99 Years					Design Storms with 1.5 Multiplier					Design Storms with 2.0 Multiplier				
	Season					Season					Season				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Tributary Dams															
South Holston															
Watauga															
Cherokee															
Douglas															
Fontana							1					2			
Norris															
Chatuge															
Nottely															
Hiwassee													1		
Blue Ridge															
Tims Ford															
Great Falls															
Mainstem Dams															
Fort Loudoun								2					5		
Watts Bar								5				1	6		
Chickamauga						1	1	3	1		3	2	5		
Nickajack							2	3			2	2	4		
Guntersville						2	3	1		1	3	2	5		
Wilson						2	2	1			2	2	4	1	
Pickwick						2	3	1				3	3	1	
Damage Centers															
Kingsport															
Clinton															
Copperhill															
Elizabethton															
Fayetteville															
Knoxville						4	2	4	4	1	3		5		2
Lenoir City								3					5		
Chattanooga						1	1	3	1		3	3	4		
Decatur						1	6				1	1	4		
Florence						4	4	1			3	4	4	2	
Savannah						2	2	1			1	2	3	1	

Notes:

An unshaded cell indicates that, for a given alternative, no increase in peak discharge in the zone above the "damage begins" line was observed in that season for that location relative to the Base Case; a shaded cell indicates that a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line.

The numbers indicate that the number of hypothetical events for which an increase in peak discharge was observed, that the peak discharge is above the "damage begins" line, and that the approximate recurrence interval of the event falls between 100 and 700 years.

Table 5.22-06 Summary Matrix Evaluation of Effect of the Tailwater Habitat Alternative on Flood Risk

Location	Period of Record – 99 Years					Design Storms with 1.5 Multiplier					Design Storms with 2.0 Multiplier				
	Season					Season					Season				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Tributary Dams															
South Holston															
Watauga															
Cherokee								2	3					2	
Douglas						1		2	1	2	1		4		2
Fontana						2	2		2	2	1	2	2	1	1
Norris								2					1		
Chatuge						1	1	2		1	4	1	2	1	1
Nottely						2		1	1	1	3		4		3
Hiwassee										2	1		2	1	1
Blue Ridge						1	5	3	2	1	4	1	2		2
Tims Ford							2								
Great Falls															
Mainstem Dams															
Fort Loudoun							1	3	2		1		5		1
Watts Bar						2		7			1	1	7		
Chickamauga						3	1	3	2		5	3	7		
Nickajack						3	2	3	1		3	2	7	1	
Guntersville						4	3	1			3	3	4		
Wilson						4	2	1			3	3	4		
Pickwick						4	2	1			2	3	3	1	
Damage Centers															
Kingsport								1							
Clinton						1		2					2		
Copperhill							2	2		1	3		4		
Elizabethton										1				2	1
Fayetteville												1			
Knoxville						4	1	4	1	1	4		6	4	2
Lenoir City							1	4	1		1		5		2
Chattanooga						2	1	3	2		5	4	8		
Decatur						1	5					1	4		
Florence						4	2	1	2		3	4	4	2	1
Savannah						3	2	1			3	2	3	1	

Notes:

An unshaded cell indicates that, for a given alternative, no increase in peak discharge in the zone above the "damage begins" line was observed in that season for that location relative to the Base Case; a shaded cell indicates that a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line.

The numbers indicate that the number of hypothetical events for which an increase in peak discharge was observed, that the peak discharge is above the "damage begins" line, and that the approximate recurrence interval of the event falls between 100 and 700 years.

Table 5.22-07 Summary Matrix Evaluation of Effect of the Preferred Alternative on Flood Risk

Location	Period of Record – 99 Years					Design Storms with 1.5 Multiplier					Design Storms with 2.0 Multiplier				
	Season					Season					Season				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Tributary Dams															
South Holston															
Watauga															
Cherokee															
Douglas								1							
Fontana									1				1		1
Norris								1							
Chatuge													1		
Nottely									1				1	2	
Hiwassee										1			2		1
Blue Ridge								1			1		1	1	
Tims Ford															
Great Falls															
Mainstem Dams															
Fort Loudoun								2					3		
Watts Bar							1	2				1	2		
Chickamauga						2	1	2	1			1	2	2	
Nickajack						1	1	1	1			3	2		
Guntersville						2	1	4				2	3		
Wilson						2	2	2				1	1		
Pickwick						2	2					1	1		
Damage Centers															
Kingsport								1	1						
Clinton								1					1		
Copperhill								2					2		
Elizabethton							1			1			1	1	1
Fayetteville															
Knoxville							2	3	1	1	2		1		1
Lenoir City								3			1		1	1	
Chattanooga						2	1	2	1			2	1		
Decatur							3	2					4		
Florence						2	2	3				3	1		
Savannah						1	3				1	1	1	2	

Notes:

An unshaded cell indicates that, for a given alternative, no increase in peak discharge in the zone above the "damage begins" line was observed in that season for that location relative to the Base Case; a shaded cell indicates that a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line.

The numbers indicate that the number of hypothetical events for which an increase in peak discharge was observed, that the peak discharge is above the "damage begins" line, and that the approximate recurrence interval of the event falls between 100 and 700 years.

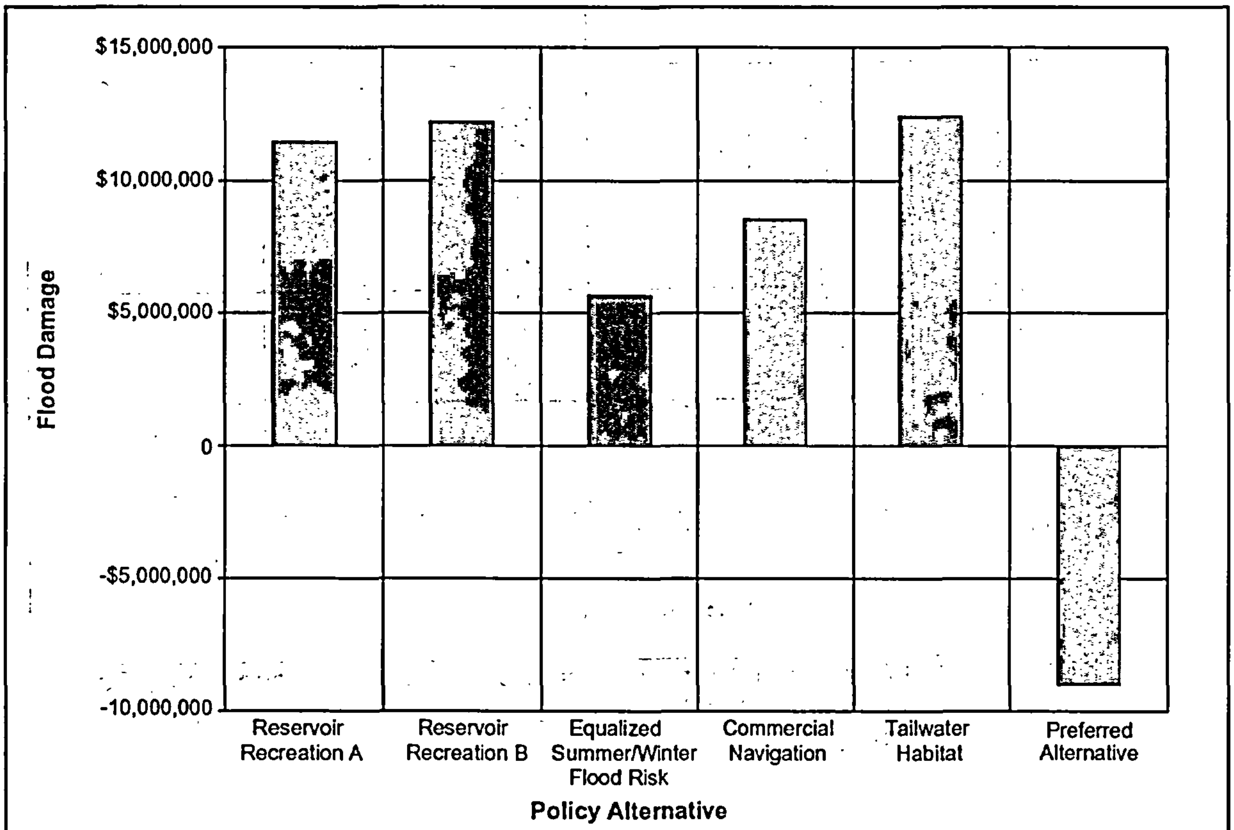
Detailed flood risk simulations were not conducted for the Summer Hydropower Alternative or the Tailwater Recreation Alternative. As discussed in Section 5.22.4, these alternatives were judged to be sufficiently similar to Reservoir Recreation Alternative B to allow meaningful conclusions concerning their impacts on flood risk. Reservoir Recreation Alternative B specifies a greater reduction in available flood storage with respect to the Base Case than either the Summer Hydropower Alternative or the Tailwater Recreation Alternative.

Tables 5.22-02 through 5.22-07 each include a list of selected locations, with a series of columns either shaded or unshaded to the right of the locations. The columns are in three main groups, and each group consists of five columns. These columns are labeled 1 through 5 and indicate the seasons used in the analysis. Column 1 corresponds to the season of October and November, column 2 to December through February, column 3 to March through May, column 4 to June and July, and column 5 to August and September. The left-hand column grouping is for the period of record 99-year continuous simulation. The center column grouping is for the design storms generated using a scaling factor of 1.5, and the right-hand column grouping is for the design storms generated using a scaling factor of 2.0.

An unshaded cell indicates that no increase in peak discharge for a given alternative relative to the Base Case in the zone above the "damage begins" line was observed in that season for that location. A shaded cell indicates the opposite: a given alternative produced an increase in peak discharge for one or more points in the zone above the "damage begins" line. Note that any observed increases in peak discharge above the "damage begins" line for a specific recurrence interval (from the period of record simulation analysis) or a specific hypothetical event (from the analysis of discrete design storms) result in a cell being shaded. In many instances, decreases in peak discharges for other recurrence intervals or hypothetical events were also observed; these instances are not noted in Tables 5.22-02 through 5.22-07.

The numbers in the design storm summary column groupings indicate the number of hypothetical events for which an increase in peak discharge was observed and for which the following conditions were satisfied: the peak discharge for the given alternative is above the "damage begins" line and the approximate recurrence interval of the event falls between 100 and 700 years (approximate recurrence intervals were computed based on considerations of the sum of all upstream local inflow volumes prior to any translation in space or time). While precise recurrence intervals have not been established for any hypothetical design storms, the adopted approach was intended to allow consideration of those flood events with inflow volumes for which a reasonable degree of regulation could be expected.

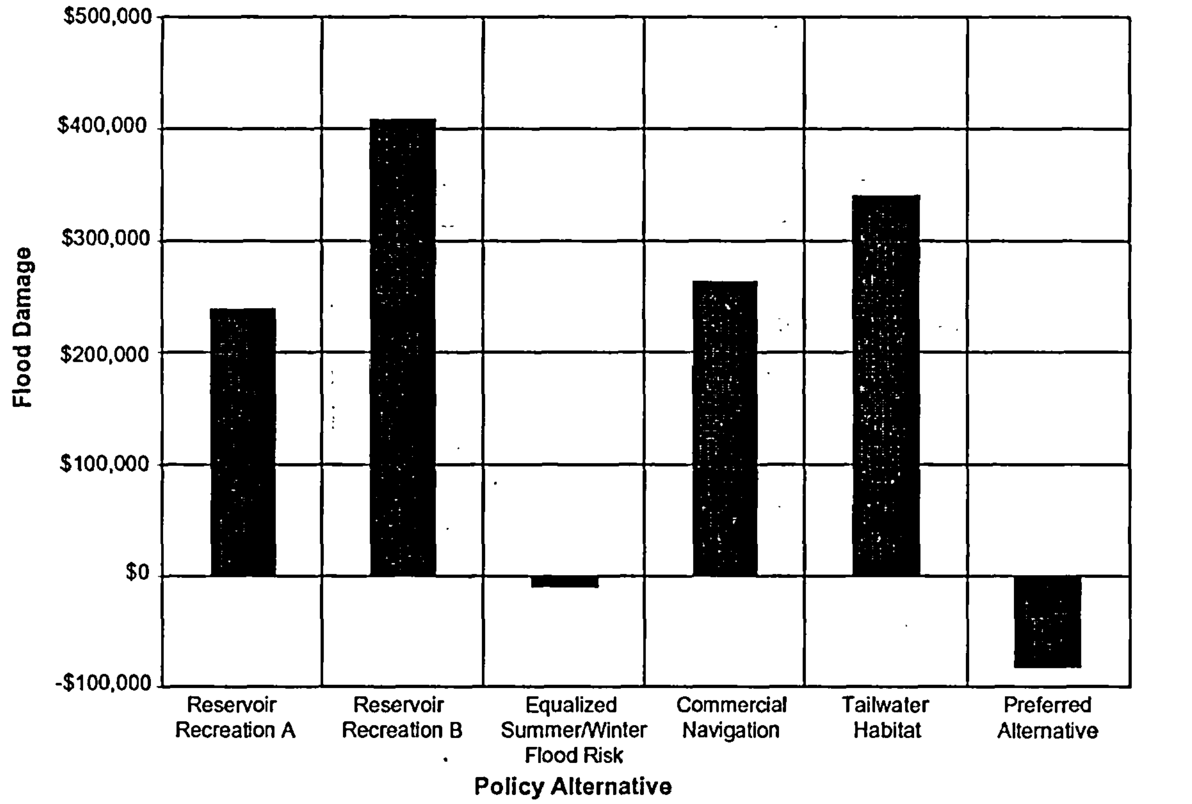
The extent of each alternative's impact was estimated by determining the increase in flood damage at Chattanooga above that expected under the Base Case due to the largest historical event within the 99-year period of record. As described in Section 4.22.4, the basis for the estimate was the inventory of the properties located in the floodplain and included the value of the structures and their contents plus an estimate of 20 percent of the direct loss to account for the indirect losses. The additional damage expected at Chattanooga from the largest historical event is presented in Figure 5.22-05. The increases in expected damage shown, range from $6 million under the Equalized Summer/Winter Flood Risk Alternative to over $12 million under Reservoir Recreation Alternative B and the Tailwater Habitat Alternative. These increases would be similar to the level of damage experienced in Chattanooga in the recent May 2003 storm (where flood damage was estimated at $18 million) (TVA 2003).). Figure 5.22-05 shows that the Preferred Alternative would result in a reduction of damage at Chattanooga of over $9 million.



Source: TVA data 2003.

Figure 5.22-05 Expected Additional Dollar Damage at Chattanooga by Policy Alternative Evaluated in Detail Relative to the Base Case for the Largest Event in 99-Year Period of Record

To rank each alternative according to its overall impact on expected damage, it is more appropriate to evaluate the cumulative flood damage, or average annual damage, rather than damage from a single storm. This average annual damage accounts for how frequently an area is damaged. Total flood damage for the 99-year period of record was calculated for each alternative and averaged over the 99 years. The increase in average annual damage relative to the Base Case presented in Figure 5.22-06 illustrates that the Preferred Alternative would result in the least impact, reducing average annual damage by about $ 82,000 at Chattanooga. Reservoir Recreation Alternative B and the Tailwater Habitat Alternative would result in the greatest adverse impact.



Source: TVA data 2003.

Figure 5.22-06 Expected Change in Average Annual Damage at Chattanooga by Policy Alternative Evaluated in Detail Relative to the Base Case for the 99-Year Period of Record

5.22.3 Base Case

Under the Base Case, the only expected changes to flood risk would be related to continued trends in land use and development in the floodplain, and their impacts on watershed runoff characteristics and potential damage.

Peak Flow. Peak discharges that result from operation of the reservoir system under the Base Case are expected to be no different from those under the existing policy.

Potential Damage. Although the peak discharges are not expected to change under the Base Case, the potential damage expected may change from existing conditions because of changes in development in the floodplain (see Section 4.22.4).

Flood Recovery Policy. The flood recovery policy under the Base Case is the existing policy; therefore, no impacts would occur.

5.22.4 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Summer Hydropower Alternative, Tailwater Recreation Alternative, and Tailwater Habitat Alternative

Within this grouping of alternatives, detailed flood risk simulations were performed only for Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Habitat Alternative.

The Summer Hydropower Alternative and the Tailwater Recreation Alternative were not included in detailed flood risk simulations. These alternatives were judged to be sufficiently similar to alternatives that were evaluated in detail to allow drawing meaningful conclusions about their impact on flood risk. Reservoir Recreation Alternative B specifies a more aggressive reduction in available flood storage (with respect to the Base Case) than either the Summer Hydropower Alternative or the Tailwater Recreation Alternative. Increases in flood risk under these alternatives can reasonably be expected to be bounded by any increases evidenced under Reservoir Recreation Alternative B.

These alternatives all specify a reduction in flood storage associated with a combination of extending current summer pool levels and raising winter pool levels, both on tributary and mainstem projects. They form a logical grouping and exhibit similar results, as shown in Tables 5.22-02, 5.22-03, and 5.22-06. The analysis of impacts was performed on a seasonal basis.

For Season 1 (October and November), the Tailwater Habitat Alternative demonstrates the greatest increases in flood risk, particularly in the North Georgia tributary projects and on the mainstem. Reservoir Recreation Alternative A shows the least increase in flood risk, with the majority of the tributary projects showing no increases in flood risk throughout the range of historical and hypothetical flood events investigated.

For Season 2 (December through February), Reservoir Recreation Alternative B and the Tailwater Habitat Alternative demonstrate similar increases in flood risk, with Reservoir Recreation Alternative B causing more increased risk in the Holston River projects and the Tailwater Habitat Alternative increasing risk on the Ocoee and Elk Rivers. Reservoir Recreation Alternative A generally shows the smallest increase in flood risk in this season.

For Season 3 (March through May), Reservoir Recreation Alternative B shows the smallest increases in flood risk on the tributary projects, with Reservoir Recreation Alternative A and the Tailwater Habitat Alternative showing approximately equal, larger increases in risk on these projects. All three alternatives show relatively uniform increases in flood risk throughout almost all of the mainstem projects.

Seasons 4 (June and July) and 5 (August and September) are almost identical for the three alternatives, with increases in flood risk primarily in the North Georgia tributary projects and at the upper and lower ends of the mainstem.

All of the damage centers show increases in flood risk throughout the year, particularly in Seasons 2 and 3. The increase in risk is smallest at Clinton, Kingsport, and Fayetteville. The mainstem damage centers are most affected during the late fall to spring period of October through May. The increases in flood risk, in general, are smallest in the summer months of June through September throughout the system.

With respect to flood risk, the Tailwater Recreation Alternative is nearly identical to Reservoir Recreation Alternative B. The Tailwater Recreation Alternative includes a provision for recreation flows between June 1 and Labor Day at some projects that is not included in Reservoir Recreation Alternative B. Otherwise, the alternatives are the same. For the purposes of this analysis, the impacts of the Tailwater Recreation Alternative were assumed to be identical to those of Reservoir Recreation Alternative B.

The Summer Hydropower Alternative was developed to enhance summer hydropower production and would result in summer reservoir pool levels lower than under the other policy alternatives at most, but not every, project. Increases in flood risk in summer would therefore be generally less under this alternative. However, this alternative is identical to Reservoir Recreation Alternative B with respect to winter pool levels for tributary projects (no changes are proposed to mainstem winter pool levels under the Summer Hydropower Alternative). The winter flood risk impacts at tributary projects and damage centers noted for Reservoir Recreation Alternative B would therefore also apply to the Summer Hydropower Alternative.

The Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Summer Hydropower Alternative, Tailwater Recreation Alternative, and Tailwater Habitat Alternative would result in unacceptable flood risk.

5.22.5 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative is unique in that it was developed with the intention of providing approximately equal flood protection throughout each season. In general, implementation of this alternative would involve raising winter pools and lowering summer pools for both tributary and mainstem projects. Because it is unique, impacts with respect to flood risk under this alternative were evaluated independently of the other alternatives. Table 5.22-04 summarizes the results of this evaluation.

Increases in flood risk on the tributary projects would primarily be limited to Season 2. On the mainstem projects, increases in flood risk would be more generally distributed through the winter months, with increases in most locations for Seasons 1 through 3. The damage centers of Kingsport and Elizabethton associated with tributary projects show increased flood risk; the risk at Elizabethton would be increased throughout the year. Damage centers on the mainstem from Knoxville through Savannah show increased flood risk under this alternative, primarily in Seasons 2 and 3.

The Equalized Summer/Winter Flood Risk Alternative would result in unacceptable flood risk.

5.22.6 Commercial Navigation Alternative

The Commercial Navigation Alternative was also evaluated independently. This alternative was developed to enhance navigation, with operational changes being limited to mainstem reservoirs. Table 5.22-05 summarizes the results of this evaluation.

As expected, Table 5.22-05 shows very little increase in flood risk on any of the tributary projects and damage centers. Minor increases in flood risk at Fontana and Hiwassee reflect changes in operations associated with enhancing navigation and most likely could be readily mitigated.

Increases in flood risk on the mainstem would be more widespread and primarily would occur in Seasons 1 through 3. This increase in risk is associated with the increase in winter mainstem pool levels, which are a fundamental aspect of the Commercial Navigation Alternative. All mainstem damage centers show an increase in flood risk in Season 3, and all but Lenoir City an increase in Season 2.

The Commercial Navigation Alternative would result in unacceptable flood risk.

5.22.7 Preferred Alternative

The Preferred Alternative was developed to address the flood damage issues associated with each of the policy alternatives evaluated in the DEIS, as documented in Tables 5.22-01 through 5.22-06. The alternative was developed by modifying flood guide curves and regulating zones for a wide range of tributary and mainstem projects such that the increases in peak flood discharges and associated damages evident in the policy alternatives evaluated in the DEIS were effectively eliminated. Changes to individual project guide curves and regulating zones were made to address flood damage issues immediately downstream of that project as well as at downstream damage centers such as Knoxville or Chattanooga. Table 5.22-07 summarizes the results of this evaluation.

The Preferred Alternative is characterized by higher winter flood guides for most tributary storage projects (including Watauga, South Holston, Boone, Cherokee, Douglas, Chatuge, Nottely, Hiwassee, Fontana, and Norris), slightly lower summer flood guides for several tributary storage projects (including Cherokee, Douglas, Nottely, Hiwassee, and Blue Ridge), and a delayed fill for the mainstem projects above Chattanooga. The effect of these changes on the tributary projects, as compared to the Base Case, would be generally higher winter pool levels, slightly lower June 1 pool levels, and generally higher median Labor Day pool levels. For the mainstem projects, this alternative would produce generally higher median Labor Day pool levels.

The increase in flood risk associated with the Preferred Alternative, while limited to relatively rare events, is a necessary outcome of the reduction in flood storage at certain projects. However, this increase was deemed acceptable, based on the criteria developed to determine flood risk acceptability (see Section 5.22.2).

5.22.8 Summary of Impacts

The change in flood risk for the alternatives evaluated in detail as compared to the Base Case is summarized in Tables 5.22-02 through 5.22-07. Table 5.22-08 presents a summary of impacts on flood control by policy alternative. For some areas within the reservoir system, the policy alternatives evaluated in the DEIS would increase flood risk to an extent that additional structural or other damage would occur as compared to the Base Case. The increase in flood risk is primarily attributable to the reduction in available flood storage in the tributary and mainstem reservoirs. All of the policy alternatives except for the Preferred Alternative would result in unacceptable flood risk.

The flood risk evaluation indicates that, compared to Base Case, all policy alternatives are characterized by a slight increase in flood risk at the PMF level, which is the largest event that can reasonably be expected to occur. TVA has not evaluated the range of recurrence intervals over which a change in flood risk associated with a given policy alternative may occur.

The Preferred Alternative satisfies the flood damage criterion established for this study. While Table 5.22-07 shows that some increases in peak discharge were noted at a few locations in some seasons, these increases were generally offset by similar reductions in peak discharge for other events in the same season.

Table 5.22-08 Summary of Impacts on Flood Control by Policy Alternative

Alternative	Description of Impacts
Base Case	No change – Under the Base Case, the only changes to flood risk that are expected would be related to continued trends in land use and development in the floodplain and the related effects on watershed runoff characteristics and increased potential for damage. Average annual flood-related damages under this alternative would be approximately $1,460,000.
Reservoir Recreation A	Adverse – Reservoir Recreation Alternative A would increase flood risk with respect to the Base Case. Average annual damage would be higher than under the Base Case. Average annual flood-related damages under this alternative would be approximately $1,880,000, an increase of about 29% relative to the Base Case. This alternative would result in unacceptable flood risk.
Reservoir Recreation B	Substantially adverse – Reservoir Recreation Alternative B would increase flood risk to an extent similar to Reservoir Recreation Alternative A, although more adverse. Average annual flood-related damages under this alternative would be approximately $2,180,000, the highest of the policy alternatives and an increase of about 49% relative to the Base Case. This alternative would result in unacceptable flood risk.
Summer Hydropower	Adverse – Detailed flood risk simulations for the Summer Hydropower Alternative were not performed. However, the level of impact relative to flood risk is expected to be bounded by the alternatives evaluated in detail. Average annual flood-related damages under this alternative are estimated at approximately $1,830,000, an increase of about 25% relative to the Base Case. This alternative would result in unacceptable flood risk.
Equalized Summer/Winter Flood Risk	No change – The Equalized Summer/Winter Flood Risk has the second fewest number of areas within the system where, for certain times of the year, additional damage would occur. The alternative would have a lower expected average annual damage than under the Base Case. Average annual flood-related damages under this alternative would be approximately $1,500,000, an increase of about 3% relative to the Base Case. This alternative would result in unacceptable flood risk.
Commercial Navigation	Adverse – The Commercial Navigation Alternative would result in the fewest number of areas within the system where, for certain times of the year, additional damage would occur. Nevertheless, average annual damage expected would be higher than under Reservoir Recreation Alternative A. Average annual flood-related damages under this alternative would be approximately $2,000,000, an increase of about 37% relative to the Base Case. This alternative would result in unacceptable flood risk.
Tailwater Recreation	Substantially adverse – Detailed flood risk simulations for the Tailwater Recreation Alternative were not performed. The level of impact on flood risk is expected to be similar to that of Reservoir Recreation Alternative B. Average annual flood-related damages under this alternative are estimated at approximately $2,050,000, an increase of about 40% relative to the Base Case. This alternative would result in unacceptable flood risk.

Table 5.22-08 Summary of Impacts on Flood Control by Policy Alternative (continued)

Alternative	Description of Impacts
Tailwater Habitat	Substantially adverse – The Tailwater Habitat Alternative would increase flood risk to an extent similar to Reservoir Recreation Alternative A, although more adversely. Average annual flood-related damages under this alternative would be approximately $2,110,000, an increase of about 44% relative to the Base Case. This alternative would result in unacceptable flood risk.
Preferred	No change – No overall increase in peak flood discharges is expected for any location for floods falling within the range of recurrence intervals adopted for this study. Average annual flood related damages under this alternative are approximately $1,370,000, a decrease of about 6% relative to the Base Case.

5.23 Power

5.23.1 Introduction

Changes to TVA's reservoir operations policy may cause changes in the cost of hydropower and non-hydropower production, and in power system reliability. To assess these effects, the impact of each alternative was determined by calculating generation, capital improvement, and other power system costs predicted for each policy alternative, and then comparing those costs to the Base Case.

As previously noted, TVA performs power system studies semi-annually to forecast the future 20-year energy demand. To maintain consistency with the balance of TVA's power system studies, the scope of the power generation studies performed in support of this EIS spans the 19-year period from 2004 through 2022. The 20-year forecast was extrapolated to estimate the forecast through 2030.

5.23.2 Impact Assessment Methodology

The impact of each alternative was measured by the increase or decrease in the power cost expected under the Base Case and that predicted for each policy alternative. For the Base Case, TVA's total power sales revenue was estimated for each year from 2004 to 2030 based upon the January 2003 power supply planning forecast. Then for each policy alternative, the change in power supply cost was estimated. The effects of each alternative were represented as an equivalent potential rate increase or the change in power supply cost as a percentage of total power sales revenue. This analysis was performed as follows:

- **Power Supply Analysis.** TVA performed an analysis to determine the effect on power supply costs of changes in hydropower and non-hydropower power production under each alternative. This analysis included the production cost of power; a reliability analysis; and costs associated with derate of coal and nuclear units, ancillary services, and other non-generating costs.
- **Economic Analysis.** The direct effects of the alternatives on power generation, as modeled by an equivalent potential rate increase, were used as inputs to the REMI model to evaluate their impact on the regional economy.

Power Generation Dispatch and Reliability

The power supply analysis included the use of three computer models: (1) the WSM for TVA's hydrological and hydroelectric system, (2) the RELY capacity planning model, and (3) the PROSYM power production costing model. The data and methodology used to estimate the impact on its system-wide power supply cost were the same data and models that TVA uses for operations and planning. A summary description of each of these models can be found in Appendix C, Model Descriptions and Results.

5.23 Power

The evaluation process included five steps as follows:

Step 1. Hydropower Generation

Weekly water releases are scheduled to provide for benefits such as navigation, system minimum flows, and flood control. Hydropower generation is dispatched to most efficiently generate power using these releases. The WSM was used to simulate weekly hydropower generation production for each alternative based on hydrologic conditions, considering the various constraints on water releases for other purposes. TVA then subtracted the weekly hydroelectric power production predicted by the WSM from the total system demand.

Step 2. Reliability

For each alternative, TVA then evaluated the power system's ability to reliably meet the "hydro-adjusted" summer and winter peak loads using the RELY model. RELY is a generation reliability model used to determine the capacity needed to maintain the reliability of the power system. RELY calculated the TVA system loss of load probability (LOLP) hourly for the summer and winter peak load seasons through 2022. The results were based on generating resource capacity, power purchases, expected equivalent forced outage rates, planned outages, the hourly load forecast, contract load available for interruptions and load forecast uncertainty. The impact of the hourly dispatch was analyzed weekly to determine the changes in capacity needs under each alternative and to compare them to the capacity needs of the Base Case. If necessary to maintain acceptable reliability with respect to meeting the "hydro-adjusted" summer and winter load peaks, the additional fixed (capital) and variable (operations and maintenance, and fuel) cost of new generation resources, whether owned by TVA or contracted by TVA with other generators, was determined. For the purpose of this analysis, TVA has assumed that any new capacity would be gas-fired combined-cycle (baseload) or simple-cycle (peaking). Implementation of any alternative could affect the environment and would require environmental review and other studies to select the preferred type of new capacity.

Step 3. Dispatch of Non-Hydropower Generation

The PROSYM dispatch model was then used to determine the most efficient combination of non-hydropower generation assets to meet the "hydro-adjusted" power demand. PROSYM, combined with TVA's power generation system data, was used to determine which generating resources should be operated to meet demand at the lowest cost. The PROSYM model scheduled all of TVA's other power resources on an hourly basis and estimated the effects of the alternatives on power supply cost. These effects include the associated re-dispatch in fossil units, purchase and sale of power outside TVA power system, ancillary services, emissions, the incremental nuclear outages associated with essential cooling water temperature limitations, and the operating costs of existing cooling towers to reduce the amount of thermal plant discharges in order to avoid coal and nuclear unit derates.

TVA currently operates cooling towers at Watts Bar, Browns Ferry, and Sequoyah Nuclear Plants and the Paradise Fossil Plant. Watts Bar Nuclear Plant condenser cooling water is cooled continuously by its towers, while the others use the cooling towers for some period of time each year to supplement their once-through cooling systems. Cooling tower use reduces the amount of heat discharged to the Tennessee River by these plants, which helps TVA comply with water temperature limits (see Section 2.3.3). The costs to operate these cooling towers are a part of the cost of power.

Step 4. Coal Unit Derates

TVA used its water quality models to simulate operations for each of the alternatives and predict water temperatures at the coal and nuclear plant discharge structures. These predicted water temperatures were compared with NPDES permit and NRC license limitations, and units were derated or shut down to maintain compliance. The potential nuclear unit derates and shutdowns due to essential cooling water temperature limitations were accounted for in the PROSYM model, using thermal-forced outage rates during the appropriate seasons. The effect of each alternative on coal unit derates, however, was not included in the PROSYM analysis and was estimated separately.

The cost of generation losses due to coal unit derates was valued differently for peak and off-peak power. The value of energy lost during peak periods was assumed to be the cost of replacing it with power purchased on an hourly basis in the bulk power market. Energy lost off-peak was valued by assuming replacement with energy from the most likely source, the next higher cost TVA coal units. The net cash impact off-peak was computed as the difference between the generating cost of the derated plant and the average generating costs of the replacement energy. For those periods when the replacement energy was expected to be at or below costs at the derated plants, the net cash impact was assumed to be zero.

Step 5. Other Non-Generation Costs

Other factors that affect the cost of meeting the power demand include the cost of aeration required to maintain DO concentrations in tailwaters, additional capital costs for construction of new cooling towers if necessary to reduce thermal plant derates, and the cost of shipping coal on the Tennessee River to fuel some of TVA's coal plants.

To maintain water quality below 16 of TVA's hydropower dams (see Appendix A, Table A-05), TVA currently supplements the DO concentrations by various methods, including auto-venting turbines, surface water pumps, oxygen injection systems, aerating weirs, and blowers (see Section 2.3.6). The cost includes purchase, installation, and operation and maintenance of aeration equipment.

The analysis of the alternatives revealed that, although the additional use of existing cooling towers would be needed at times, no new cooling towers would be warranted. Only the cost of additional use of existing cooling towers is included in the power cost impacts.

Coal that fuels TVA's coal-fired power plants is currently shipped via barge to some plants; rail and truck transport are also used for coal deliveries in some cases. Depending on location, barge transport is often the lowest-cost method of transport (see Section 5.21, Navigation). The cost of shipping coal is also a part of the fuel cost and therefore a part of the total cost of power.

5.23.3 Base Case

Under the Base Case, the power system would be operated to provide for the changing power demand from 2004 through 2030 at the lowest cost, based on current and forecast conditions. The Base Case also differs from existing conditions as a result of capacity additions from the HMOD projects and at Browns Ferry Nuclear Plant, and increased operational flexibility provided by the Hydro Automation Program (as described in Section 3.3.1).

Power Generation Dispatch and Reliability

The mix of generation dispatched to meet demand under the Base Case would remain similar to current conditions, with hydropower generation dispatched primarily to meet peak power needs. Planned nuclear and hydropower capacity additions would support a portion of the changing demand. The shift from industrial to residential and commercial load forecast for the period through 2030 would mean a greater need for on-peak energy supplied by hydropower and other peaking resources. Additional peaking capacity would be needed to maintain acceptable system reliability. Since hydropower resources would grow very little, this need for additional on-peak energy would be met by first shifting any hydropower that is currently off-peak to on-peak. The balance of on-peak generation required would be provided by increased operation of TVA's combustion turbine and pumped storage units and generation purchased from non-TVA generators.

Although no nuclear plant shutdowns have occurred historically as a result of the essential cooling water temperature limitations of the NRC license, severe meteorological conditions (hot, dry summers) similar to those experienced in the summer of 1993, could result in forced shutdowns of one or more TVA nuclear units for several days every 10 years on average under the Base Case. The effects of these conditions were included in the reliability and power supply analyses and factored into the power supply costs for the Base Case.

Coal Unit Derates

Under the Base Case, some derate of the coal units would be necessary to maintain compliance with NPDES temperature limits, similar to existing conditions.

Other Non-Generation Costs

Existing aeration facilities would continue to be operated similar to present levels in order to achieve existing DO targets.

The restart and operation of Browns Ferry Unit 1 will require construction of an additional cooling tower. Use of cooling towers would increase to ensure that the maximum cooling water discharge temperature and the temperature rise between intake and discharge, as measured by stations in the reservoir, remain within approved regulatory limits.

Coal shipping costs would be similar to existing costs.

Power Supply Costs

The total power sales revenue for the Base Case was estimated for each year from 2004 to 2030 based on the January 2003 power supply planning forecast. This forecast included the consideration of all the power supply and non-generating costs described for the Base Case.

5.23.4 Reservoir Recreation Alternative A

Power Generation Dispatch and Reliability

As detailed in Table 5.23-01 and Table 5.23-02, the timing of hydropower generation would be shifted under Reservoir Recreation Alternative A from late summer, (when the peak demand is highest and, therefore, replacement energy is most costly), to early winter (when replacement energy is less costly). The total annual hydropower generation on average would be similar to, although slightly higher than, the hydropower generation expected under the Base Case (Table 5.23-02). In response to the shift in hydropower generation, other more costly peaking generation resources, such as coal, combustion turbine units, Raccoon Mountain pumped storage, or purchased power, would be dispatched to replace the reduced hydropower generation during these times. In addition, because hydropower is shifted off peak, it could displace some coal-fired generation.

Similar to (although more often than) the Base Case, severe meteorological conditions like those experienced in summer 1993, could result in forced nuclear plant shutdowns of one or more TVA nuclear units for several days every 10 years on average. These shutdowns could be required to comply with the essential cooling water temperature limitations of the NRC license. The effects of these conditions were included in the reliability and power supply analyses, and were factored into the power supply costs for Reservoir Recreation Alternative A.

Table 5.23-01 Effect of Policy Alternatives on Hydropower Generation Relative to the Base Case

Alternative	January–March (Weeks 1–12)	April–May (Weeks 13–21)	June–July (Weeks 22–30)	August–Labor Day (Weeks 31–35)	Labor Day–December (Weeks 36–52)
Reservoir Recreation A	Somewhat higher generation due to higher winter levels		Much lower generation due to releases of only minimum flows	Much lower generation; hydro releases are still restricted, but increased minimum flows would reduce losses	Somewhat higher generation as unrestricted drawdown resumes
Reservoir Recreation B and Tailwater Recreation	Much higher generation due to higher winter levels		Much lower generation due to releases of only minimum flows		Slightly lower; unrestricted drawdown resumes but only to higher winter levels
Summer Hydropower	Somewhat higher generation due to higher winter levels		Much higher generation due to unrestricted drawdown		Much lower; unrestricted drawdown resumes but only to higher winter levels
Equalized Summer/ Winter Flood Risk	Much higher generation due to higher winter levels		Much lower due to generally lower summer levels and releases of only minimum flows unless additional is necessary to maintain flood storage	Much lower; releases are still restricted, but increased minimum flows would reduce losses	Much lower due to higher winter reservoir levels
Commercial Navigation	Hydropower generation is very similar to the Base Case				
Tailwater Habitat	Much higher generation due to higher winter levels		Much lower due to releases of only minimum flows		Similar generation
Preferred	Somewhat higher generation due to higher winter levels		Much lower generation; hydro releases are still restricted, but increased minimum flows through this period would reduce losses		Slightly lower; unrestricted drawdown resumes but only to higher winter levels

Table 5.23-02 Effect of Policy Alternatives on Shift of Hydropower Generation Relative to the Base Case

Alternative	Increase/Decrease in Hydropower Generation as a Percentage of Base Case Hydropower Generation					
	January–March (Weeks 1–12) (%)	April–May (Weeks 13–21) (%)	June–July (Weeks 22–30) (%)	August–Labor Day (Weeks 31–35) (%)	Labor Day–December (Weeks 36–52) (%)	Annual (%)
Reservoir Recreation A	6	7	-19	-16	6	0.5
Reservoir Recreation B	14	13	-19	-39	-2	-1.3
Summer Hydropower	9	7	30	6	-30	-0.9
Equalized Summer/ Winter Flood Risk	14	26	-24	-19	-22	-4.9
Commercial Navigation	1	7	-1	0	-1	0.5
Tailwater Recreation	Similar to Reservoir Recreation B					
Tailwater Habitat	11	13	-19	-37	-1	-1.6
Preferred	6	8	-11	-12	-2	-0.4

Note: A negative number indicates that hydropower generation under the alternative would be less than under the Base Case. A positive number indicates that hydropower generation under the alternative would be more than under the Base Case.

Source: TVA Weekly Scheduling Model.

Coal Unit Derates

The reduction in summer hydropower production would be offset to some extent by maintaining the average weekly 25,000-cfs flow at Chickamauga Reservoir to provide cooling water for power plants and minimize summer power plant derates. Even with these higher minimum flows under Reservoir Recreation Alternative A, additional derates of the coal units relative to the Base Case would be necessary to maintain compliance with NPDES temperature limits. The estimated cost of these additional derates is presented in Table 5.23-03.

Other Non-Generation Costs

Aeration costs under Reservoir Recreation Alternative A would be higher than under the Base Case and would include a capital cost expenditure for additional equipment in 2004 and an annual operations and maintenance cost for each year from 2004 through 2030. There would be no change in coal shipping rates (Table 5.23-03).

Power Supply Costs

The effect of power generation dispatch, generation losses at coal and nuclear plants due to water temperature limits, and cost for additional cooling tower use on power supply costs was estimated for each year from 2004 to 2030. The average change in power cost for Reservoir Recreation Alternative A could be represented by a hypothetical rate increase of 0.3 percent, as shown in Table 5.23-03.

Table 5.23-03 Impacts on Power Generation—Annual Production Costs (2010) (dollars in millions)

Alternative	Power Supply Costs	Coal Unit Derate Costs	Aeration Equipment Costs	TVA Coal Shipping Costs	Total Costs	Hypothetical Rate Increase[1] (percent)
Base Case	$0	$0	$0	$0	$0	0%
Reservoir Recreation A	$28	$1.1	$0.6	$0	$30	0.3%
Reservoir Recreation B	$65	$1.3	$0.8	$0	$67	0.6%
Summer Hydropower	-$4	$0.8	$0.4	$6	$3	0.0%
Equalized Summer/ Winter Flood Risk	$104	$3.8	$0.7	$0	$108	1.2%
Commercial Navigation	-$4	$0.4	$0.6	-$9	-$11	-0.1%
Tailwater Recreation	$65	$0.2	$0.7	$0	$66	0.6%
Tailwater Habitat	$294	-$0.2	$0.7	$0	$295	3.3%
Preferred	$13	-$0.2	$1.2	$0	$14	0.2%

Note: Projected costs for 2010 are indicative of trends.

[1] The total costs are expressed as a percentage of total annual TVA power sales revenues each year for the period 2004 through 2030, and the hypothetical rate increase is the 27-year average of these percentages.

Source: TVA Power Planning Group.

5.23.5 Reservoir Recreation Alternative B and Tailwater Recreation Alternative

Power Generation Dispatch and Reliability

Under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, the effect on hydropower generation would be similar to Reservoir Recreation Alternative A although more adverse. The total annual hydropower generation on average would be about 1 percent less than the hydropower generation expected under the Base Case (Table 5.23-02). The timing of the generation would be shifted under Reservoir Recreation Alternative B and the Tailwater Recreation Alternative from late summer to early winter (Table 5.23-02), reducing the availability of hydropower to meet summer peak loads. As in Reservoir Recreation Alternative A, although to a greater extent, other higher marginal cost peaking generation units would need to be run to replace the shifted hydropower generation.

Similar to (although more often than) Reservoir Recreation Alternative A, forced nuclear plant shutdowns of one or more TVA nuclear units for several days every 10 years on average would be necessary to comply with the essential cooling water temperature limitations of the NRC license. The effects of these conditions were included in the reliability and power supply analyses, and were factored into the power supply costs for Reservoir Recreation Alternative B and the Tailwater Recreation Alternative.

Coal Unit Derates

Continuation of releases from Chickamauga Reservoir at the present 13,000-cfs level, coupled with the shift of hydropower generation from summer to fall, would increase slightly the frequency of derating coal units under Reservoir Recreation Alternative B over that expected under Reservoir Recreation Alternative A. Under the Tailwater Recreation Alternative, the additional releases for tailwater recreation would almost eliminate additional coal unit derates as compared to the Base Case.

Other Non-Generation Costs

Aeration costs under Reservoir Recreation Alternative B would be slightly higher than under Reservoir Recreation Alternative A; under the Tailwater Recreation Alternative, costs would be slightly lower than under Reservoir Recreation Alternative B. There would be no change in coal shipping rates.

Power Supply Costs

The average change in power cost could be represented by a hypothetical rate increase of 0.6 percent for both Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, as shown in Table 5.23-03.

5.23.6 Summer Hydropower Alternative

Power Generation Dispatch and Reliability

Under the Summer Hydropower Alternative, the effect on hydropower generation relative to the Base Case would be to decrease hydropower generation in fall when generation is less valuable and increase hydropower generation during the summer and winter peak demand periods (Table 5.23-01). Although the total annual hydropower generation on average would be about 1 percent lower than the hydropower generation expected under the Base Case (Table 5.23-02), availability of the hydropower generation during the peak demand periods offsets somewhat the use of higher cost generation, leaving the overall power supply costs essentially the same as the Base Case.

5.23 Power

The Summer Hydropower Alternative would reduce the number of days that one or more nuclear units would need to be shutdown once every 10 years on average to comply with the essential cooling water temperature limitations of the NRC license. The effects of these conditions were included in the reliability and power supply analyses, and were factored into the power supply costs for the Summer Hydropower Alternative.

Coal Unit Derates

Reservoir releases to maximize summer hydropower generation would not be sufficient to avoid additional coal unit derates; the costs are indicated in Table 5.23-03.

Other Non-Generation Costs

Aeration costs for the Summer Hydropower Alternative would be lower than under Reservoir Recreation Alternative A but similarly include a capital cost expenditure for additional equipment in 2004, and an annual operations and maintenance cost for each year from 2004 through 2030. Reservoir operations under the Summer Hydropower Alternative would also hamper navigation and increase the shipment cost of coal for TVA's coal units.

Power Supply Costs

Under the Summer Hydropower Alternative, there would be essentially no change in average power cost, as shown in Table 5.23-03.

5.23.7 Equalized Summer/Winter Flood Risk Alternative

Power Generation Dispatch and Reliability

Under the Equalized Summer/Winter Flood Risk Alternative, the effect on hydropower generation relative to the Base Case would be a decrease in hydropower generation in summer and fall and an increase during winter (Table 5.23-02). As under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, and the Tailwater Recreation Alternative, although to a greater extent, other higher marginal cost peaking generation units would need to be run to replace the shifted hydropower generation. In addition to the shift in hydropower, the net average annual hydropower generation loss under the Equalized Summer/Winter flood Risk Alternative relative to the Base Case would be almost 5 percent (Table 5.23-02) due to lower reservoir levels and the resulting lower head on the hydropower units. This loss in total annual generation is large enough to necessitate the purchase of additional baseload energy in addition to the peaking generation to offset shifts.

Under the Equalized Summer/Winter Flood Risk Alternative, similar to (although more often than) Reservoir Recreation Alternative B and the Tailwater Recreation Alternative, additional nuclear plant shutdowns would be necessary to comply with the essential cooling water temperature limitations of the NRC license. The effects of these conditions were included in the reliability and power supply analyses, and were factored into the power supply costs for the Equalized Summer/Winter Flood Risk Alternative.

Coal Unit Derates

The generally lower summer reservoir levels maintained for flood storage under the Equalized Summer/Winter Flood Risk Alternative would reduce the volume of water available for release in late summer, when water temperatures are highest. Of all alternatives, consequently, the Equalized Summer/Winter Flood Risk Alternative would cause the greatest losses due to coal unit derates.

Other Non-Generation Costs

Increased aeration costs for the Equalized Summer/Winter Flood Risk Alternative include a capital cost expenditure for additional equipment in 2004 and an annual operations and maintenance cost for each year from 2004 through 2030. These costs under the Equalized Summer/Winter Flood Risk Alternative would be similar to those under the Tailwater Recreation Alternative. Coal shipping rates would not change.

Power Supply Costs

The average change in power cost under the Equalized Summer/Winter Flood Risk Alternative could be represented by a hypothetical rate increase of 1.2 percent, as shown in Table 5.23-03.

5.23.8 Commercial Navigation Alternative

Power Generation Dispatch and Reliability

Hydropower generation under the Commercial Navigation Alternative would be very similar to the Base Case, with little shift in hydropower generation. Net average annual hydropower generation would be less than 1 percent higher than the Base Case (Table 5.23-02), reflecting a minimal gain due to higher winter levels on the mainstem reservoirs. Power generation dispatch would generally not change under the Commercial Navigation Alternative relative to the Base Case.

Under the Commercial Navigation Alternative, the nuclear plant shutdowns necessary to comply with the essential cooling water temperature limitations of the NRC license would be similar to those under the Base Case.

Coal Unit Derates

Reservoir releases for commercial navigation would not be sufficient to avoid all additional coal unit derates under the Commercial Navigation Alternative.

Other Non-Generation Costs

Increased aeration costs under the Commercial Navigation Alternative would be similar to those for the Base Case. The Commercial Navigation Alternative would increase water levels in the mainstem reservoirs to improve navigation and decrease the shipment cost of coal for TVA's coal units.

Power Supply Costs

The average change in power cost for the Commercial Navigation Alternative could be represented by an equivalent potential rate decrease of 0.1 percent, as shown in Table 5.23-03.

5.23.9 Tailwater Habitat Alternative

Power Generation Dispatch and Reliability

Under the Tailwater Habitat Alternative, reservoir releases would produce variable flows, water depths, and velocities throughout the year that would be more similar to the seasonal variability of runoff and would reduce hourly and daily variability of flows in tailwaters. Actual releases would be determined by the inflow conditions. Peaking hydropower operations would not occur unless the low flow falls below the level needed to operate one unit; then peaking would occur only to the extent necessary to peak one unit at its most efficient setting.

The effect on hydropower generation relative to the Base Case would be a decrease in hydropower generation in summer and fall and an increase during winter and spring (Table 5.23-01). The Tailwater Habitat Alternative would shift the greatest amount of hydropower generation away from May through September. As with all of the alternatives, TVA's response to this shift in hydropower generation would be to replace it with the lowest marginal cost alternative generation resource. Depending on the marginal costs of replacement generation during the May-to-September period, the shifted hydropower generation could be replaced by coal, combustion turbines, pumped storage, or purchased generation. The hydropower that is shifted out of summer would likely also displace coal generation.

Net average annual hydropower generation would be 1.6 percent lower than the Base Case (Table 5.23-02) but would not be large enough to warrant purchase of additional baseload generation.

The nuclear plant shutdowns necessary to comply with the essential cooling water temperature limitations of the NRC license under the Tailwater Habitat Alternative would be similar to those under the Base Case.

Coal Unit Derates

Reservoir releases under the Tailwater Habitat Alternative would improve water temperatures sufficiently to reduce the generation losses due to coal unit derates relative to those expected under the Base Case.

Other Non-Generation Costs

Increased aeration costs under the Tailwater Habitat Alternative would include a capital cost expenditure for additional equipment in 2004 and an annual operating and maintenance cost for each year from 2004 through 2030. These costs under the Tailwater Habitat Alternative would be similar to those under the Tailwater Recreation Alternative. Coal shipping rates would not change.

Power Supply Costs

The Tailwater Habitat Alternative would result in the greatest adverse impact on power costs, with an average change in power cost represented by a hypothetical rate increase of 3.3 percent, as shown in Table 5.23-03.

5.23.10 Preferred Alternative

Power Generation Dispatch and Reliability

For the Preferred Alternative, the total annual hydropower generation on average would be similar to (although slightly lower than) the hydropower generation expected under the Base Case (Table 5.23-02). As detailed in Table 5.23-01 and Table 5.23-02, the timing of hydropower generation would be shifted under the Preferred Alternative from summer (when the peak demand is highest and, therefore, replacement energy is most costly) to winter and early spring (when replacement energy is generally less costly). In response to the shift in hydropower generation, other more costly peaking generation resources (such as coal, combustion turbine units, Raccoon Mountain pumped storage, or purchased power) would be dispatched to replace the reduced hydropower generation during these times. In addition, because hydropower is shifted off peak, it could displace some coal-fired generation.

Similar to (although more often than) Reservoir Recreation Alternative A, nuclear plant shutdowns of one or more TVA nuclear units for several days every 10 years on average would be necessary to comply with the essential cooling water temperature limitations of the NRC license. The effects of these conditions were included in the reliability and power supply analyses, and were factored into the power supply costs for the Preferred Alternative.

Coal Unit Derates

Reservoir releases under the Preferred Alternative would improve cooling water availability or temperatures sufficiently to reduce somewhat the frequency of generation losses due to coal unit derates as compared to those expected under the Base Case.

Other Non-Generation Costs

Under the Preferred Alternative, aeration costs would be substantially higher than under the Base Case and all alternatives considered. The costs would include a capital cost expenditure for additional equipment, expended over a 3-year period from 2004 through 2006 due to the larger costs, and an annual operations and maintenance cost for each year from 2004 through 2030. Coal shipping rates would not change (Table 5.23-03).

Power Supply Costs

The average change in power cost under the Preferred Alternative could be represented by a hypothetical rate increase of 0.2 percent, as shown in Table 5.23-03.

5.23.11 Summary of Impacts

Table 5.23-04 presents a summary of impacts on power by policy alternative. Under each alternative, the use of hydropower generation would shift among the seasons, with hydropower generation during each season either higher or lower than that expected under the Base Case, as presented in Table 5.23-01 and Table 5.23-02. Under all alternatives except the Summer Hydropower Alternative, hydropower generation would generally decrease in summer when the peak demand is highest and replacement energy is most costly, and increase in winter and spring when energy is less valuable. The Commercial Navigation Alternative would shift the least amount of hydropower generation away from summer, followed in order of increasing effect by the Preferred Alternative, Reservoir Recreation Alternative A, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Habitat Alternative, and Reservoir Recreation Alternative B. Under the Summer Hydropower Alternative, hydropower generation would shift from fall, when peak demand is lowest, to the summer and winter peak periods.

The change in dispatch of other power resources in response to hydropower generation shifts would result in the use of more (or in the case of the Summer Hydropower Alternative less) costly generation resources. At times, additional generation capacity would be needed to ensure acceptable system reliability. Under all alternatives except the Summer Hydropower Alternative, the shift in hydropower generation would create the need for increased use of combustion turbines, pumped storage, and purchased power for peaking. The hydropower that is shifted out of summer would likely also displace coal generation. In addition to the shift in hydropower generation away from periods of peak demand, requiring the acquisition of additional peaking generation, the Equalized Summer/Winter Flood Risk Alternative would cause a net annual loss in hydropower generation large enough to necessitate the purchase of additional baseload capacity.

Alternatives that reduce reservoir releases in late summer when water temperatures are highest would also increase the generation lost due to coal and nuclear unit derates. Additional derate of coal units would be necessary under all alternatives except the Preferred Alternative and the Tailwater Habitat Alternative, which show a slight reduction in the cost of coal unit derates.

A third impact on the cost of power production arises from alternatives that would decrease reservoir DO levels. To maintain current targets for tailwater DO levels, additional aeration would be required under all alternatives.

Finally, under those alternatives that would change water levels and flows in the mainstem reservoirs to the extent that navigation would be affected (the Summer Hydropower Alternative and the Commercial Navigation Alternative), the shipment cost of coal for TVA's coal units would change.

The Commercial Navigation Alternative is expected to slightly reduce power costs relative to the Base Case by 0.1 percent over the 2003 through 2030 period. The Summer Hydropower Alternative is expected to result in essentially no effect on power costs relative to the Base Case. The remaining six policy alternatives are expected to increase power costs. Of these six, the greatest increase in power costs relative to the existing operations policy is expected under the Tailwater Habitat Alternative, which is estimated to increase power costs by an average of 3.3 percent over the 2003-through-2030 period. The least increase in power costs relative to the existing operations policy is expected under the Preferred Alternative, which is estimated to increase power costs by an average of 0.2 percent over the period from 2003 through 2030.

5.23 Power

Table 5.23-04 Summary of Impacts on Power by Policy Alternative

<table>
<tr><th>Alternative</th><th>Description of Impacts</th></tr>
<tr><td>Base Case</td><td>Power generation would continue to follow existing trends; the annual energy load is expected to increase 1.6 percent on average from 2004 through 2020.

The industrial load growth is expected to slow, reducing the demand from the industrial client base and increasing the demand by the commercial and residential clients; this shift would require more peaking and less baseload capacity throughout the 2003 to 2030 period.</td></tr>
<tr><td>Reservoir Recreation A</td><td>Total power cost would increase $30 million annually (2010).

The total annual hydropower generation would be similar to the Base Case; however, the timing would be shifted from late summer, when the peak demand is highest and replacement energy is most costly, to early winter when energy is less costly. Other more costly generation, such as coal or combustion turbine units, would be dispatched to replace the shifted hydropower generation.
Hydropower generation similar to Base Case
Additional coal derates
Additional nuclear shutdowns
Additional aeration costs
No additional coal shipping costs</td></tr>
<tr><td>Reservoir Recreation B</td><td>Total power cost would increase $67 million annually (2010).

The effect on hydropower generation would be similar to Reservoir Recreation Alternative A, although more adverse.
Hydropower generation slightly lower than Base Case
Additional coal derates
Additional nuclear shutdowns
Additional aeration costs
No change to coal shipping costs</td></tr>
<tr><td>Summer Hydropower</td><td>Total power cost would increase $3 million annually (2010).

The effect on hydropower generation relative to the Base Case would be to decrease hydropower generation in fall and increase hydropower generation during the summer and winter peak demand periods. Availability of the hydropower generation during the peak demand periods offset the use of higher cost generation, leaving the overall power supply costs essentially the same as the Base Case.
Hydropower generation slightly lower than Base Case
Additional coal derates·
Fewer nuclear shutdowns
Additional aeration costs
Higher coal shipping costs</td></tr>
</table>

Table 5.23-04 Summary of Impacts on Power by Policy Alternative (continued)

Alternative	Description of Impacts
Equalized Summer/Winter Flood Risk	Total power cost would increase $108 million annually (2010). The effect on hydropower generation relative to the Base Case would be to decrease hydropower generation in summer and fall and increase hydropower generation during the winter and spring runoff periods. Other more costly generation, such as coal or combustion turbine units, would be dispatched to replace the shifted hydropower generation. • Greatest loss in hydropower generation of all alternatives • Additional coal derates • Additional nuclear shutdowns • Additional aeration costs • No additional coal shipping costs
Commercial Navigation	Total power cost would decrease $11 million annually (2010). The effect on hydropower generation would be very similar to the Base Case with little shift in hydropower generation. • Hydropower generation similar to the Base Case • Additional coal derates • No additional nuclear shutdowns • Additional aeration costs • Lower coal shipping costs
Tailwater Recreation	Total power cost would increase $66 million annually (2010). The effect on hydropower generation would be similar to Reservoir Recreation Alternative B. • Hydropower generation slightly less than Base Case • Additional coal derates but much less than Reservoir Recreation Alternative B • Additional nuclear shutdowns • Additional aeration costs • No additional coal shipping costs
Tailwater Habitat	Total power cost would increase $295 million annually (2010). The effect on hydropower generation would be similar to Reservoir Recreation Alternative A although much more adverse. Peaking hydropower operations would be very limited. • Hydropower generation slightly less than Base Case • No additional coal derates • No additional nuclear shutdowns • Additional aeration costs • No additional coal shipping costs

Table 5.23-04 Summary of Impacts on Power by Policy Alternative (continued)

Alternative	Description of Impacts
Preferred	Total power cost would increase $14 million annually (2010). The total annual hydropower generation would be similar to the Base Case; however, the timing would be shifted from late summer, when the peak demand is highest and replacement energy is most costly, to early spring when energy is less costly. Other more costly generation, such as coal or combustion turbine units, would be dispatched to replace the shifted hydropower generation. • Hydropower generation similar to Base Case • Fewer coal derates • Additional nuclear shutdowns • Additional aeration costs • No additional coal shipping costs

5.24 Recreation

5.24.1 Introduction

Recreation use of TVA reservoirs and below-dam areas would be affected to varying degrees by changes in reservoir and tailwater management under all policy alternatives except the Base Case. Estimated changes in recreation use in response to operating scenarios under the policy alternatives were evaluated. Estimates represent reservoir and tailwater recreation use of the 35 TVA projects studied in the ROS for the late-summer and early-fall period (August through October). As discussed in Section 4.24, use estimates are presented for those users of public recreational facilities and commercially provided recreational facilities, and users who have private residential access to project reservoirs.

5.24.2 Impact Assessment Methods

Behavioral response models were used to assess potential changes in recreation use in reservoirs and areas downstream in response to policy alternatives. Recreation area users were asked survey questions to ascertain how their use might change with changes in reservoir levels and corresponding tailwater flows. Responses were then used in behavioral models to quantitatively predict changes in recreation use during the August to October period. During this period, the policy alternatives were expected to reflect their primary impacts on levels and flows. Model predictions for changes in recreation use by policy alternative were made relative to the recreation use for the August to October period under the Base Case. Models assumed that the only factors to change would be reservoir levels, while other factors affecting recreation (e.g., the number of facilities) would remain the same. Changes in recreation use during other times of the year were qualitatively evaluated using survey response indicators that allowed generalization on recreation use changes during these other times.

The Base Case is described below specifically for the August through October period (as also described in Section 4.24). The quantitative impacts of the other policy alternatives were compared to the Base Case for the same 3-month period. Changes in recreation use were evaluated for public site users, commercial site users, and private access recreation users.

5.24.3 Base Case

The total annual recreation use under the Base Case is 21.8 million user days (see Section 4.24). During the August through October 2002 period, which is the basis for quantitatively comparing the impacts of the policy alternatives, recreation use is about 6.6 million user days (Table 5.24-01) (also see Appendix D8, Table D8-07).

Table 5.24-01 Recreational Use by Policy Alternative for 2002 (August through October)

Alternative	Total Recreational Use	Total Public Use (Reservoirs and Tailwaters)	Public Reservoir Use	Public Tailwater Use	Commercial Use	Private Use
Base Case	6,569,334	873,924	670,561	203,363	3,844,556	1,850,854
Reservoir Recreation A	7,907,800	896,484	692,160	204,324	3,997,786	3,013,530
Reservoir Recreation B	8,114,041	920,321	711,123	209,198	4,103,949	3,089,770
Summer Hydropower	5,300,096	849,185	655,920	193,265	3,725,224	725,687
Equalized Summer/Winter Flood Risk	6,813,723	859,883	667,534	192,349	3,891,437	2,062,403
Commercial Navigation	6,449,369	873,048	669,945	203,104	3,847,202	1,729,119
Tailwater Recreation	8,115,039	918,551	710,362	208,189	4,107,702	3,088,786
Tailwater Habitat	8,009,471	916,430	712,761	203,669	4,104,229	2,988,812
Preferred	7,735,922	894,110	689,524	204,586	3,950,983	2,890,828

Public recreation use of reservoirs and tailwaters totaled about 874,000 user days during August, September, and October, comprising 13 percent of the total recreation use by all user types during that period. Public recreation use on reservoirs totaled about 671,000 user days, while public use of tailwater areas totaled about 203,000 user days (Table 5.24-01).

Survey results from public access site users showed that air temperature (either too hot or too cold) was reported to be the most important reason for not recreating at TVA reservoirs or below-dam areas during winter (November through February), early spring (March and April) and fall (September and October). Low water levels were listed as the second most important reason for not recreating during these months and were cited as the most important reason for not using the projects during June and July. Results also showed that approximately 40 percent of all individuals surveyed at public access sites stated that nothing could be done to increase their recreation use of ROS projects; approximately 30 percent of respondents indicated that increasing water levels during low use months (typically late fall through early spring) would result in higher use.

Commercial recreation use at the 35 projects totaled over 3.8 million user days during August through October, comprising 59 percent of the total recreation use by all user types (Table 5.24-01). Surveys of commercial operators showed that their services are least likely to be used during December and January due to colder air temperatures. Operators indicating lower use of their facilities during March, April, August, September, and October cited low water levels as the primary reason. Approximately 67 percent of all commercial operators surveyed indicated that increasing water levels would result in an increased number of days that people would use their recreational facilities at ROS projects. Approximately 18 percent indicated that nothing could be done to increase patronage of their facilities.

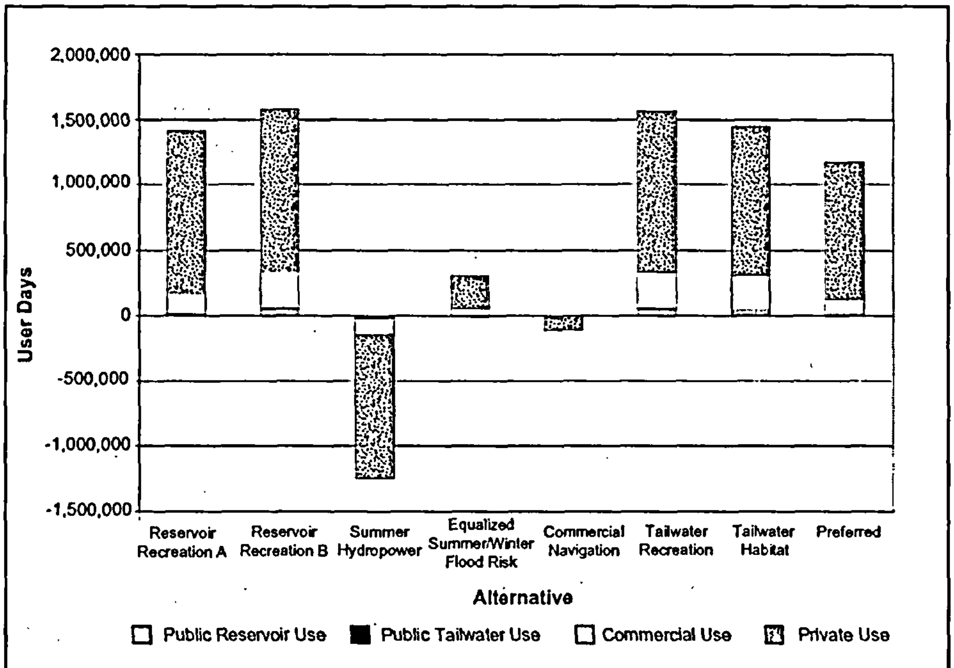
Private recreation use totaled about 1.9 million user days, comprising 28 percent of the total recreation use by all user types (Table 5.24-01). Results of surveys of private property owners adjacent to TVA reservoirs showed that this user group attributes their lack of participation in recreation to be primarily due to water levels, regardless of time of year, even for those months during which water levels are typically at full summer pool levels. Approximately 66 percent of property owners stated that increasing water levels would increase their use of the ROS projects during the periods of low use. Approximately 14 percent stated that nothing could be done to increase their recreation use of the projects.

5.24.4 Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, Tailwater Recreation Alternative, Tailwater Habitat Alternative, and Preferred Alternative

Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative all show similar expected results, with recreation use during August through October expected to total between 7.7 and 8.1 million user days (Table 5.24-01). Public access use on reservoirs and tailwaters is expected to total between 894,000 and 920,000 user days, or about 11 percent of total recreation use under these alternatives. Reservoir public use is expected to total between 689,000 and 713,000 user days, or 9 percent of the total recreation use. Public use below project dams is expected to total between 204,000 and 209,000 user days, or 2 percent of all recreation use.

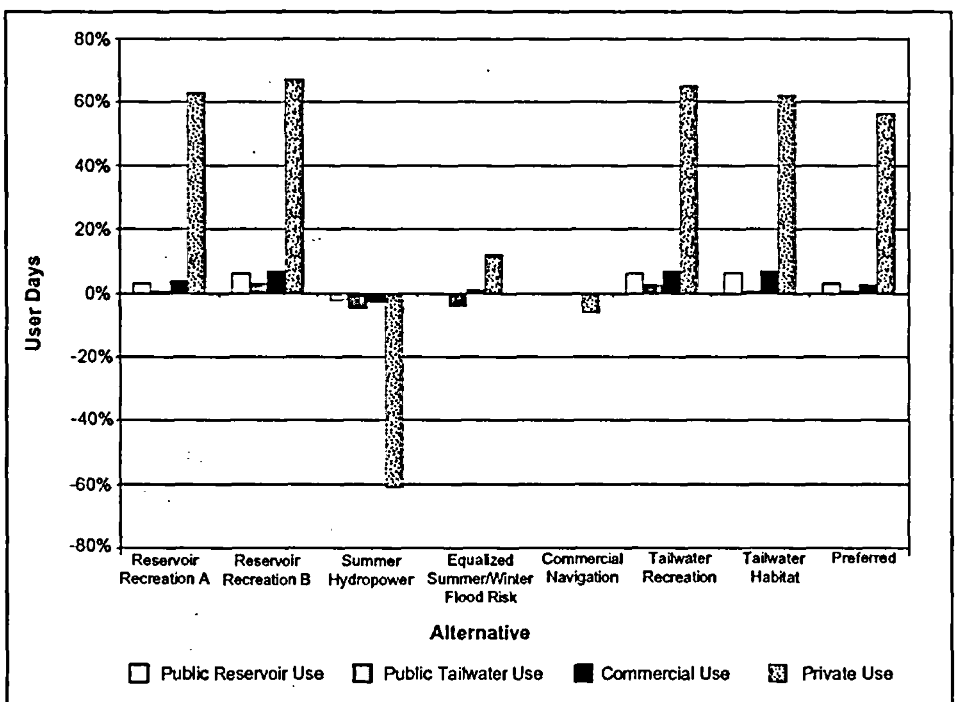
Commercial recreation use under these alternatives is expected to total between 4.0 and 4.1 million user days, or 51 percent of the total recreation use (Table 5.24-01). Private access recreation use under these alternatives is expected to total between 2.9 and 3.1 million user days, or about 37 to 38 percent of all recreation use.

Total recreation use under these alternatives is expected to increase between 1.2 and 1.5 million user days (or about 20 to 23 percent) compared to the Base Case during the August through October period (Figure 5.24-01). The majority of this expected increase is due to an expected increase in private access recreation use of about 61 to 67 percent, or about 1.0 to 1.2 million user days (Figure 5.24-02). All other recreation use types show increases in use but were not as dramatic as the private use increase. Commercial site recreation use is expected to increase by between 2.8 and 7 percent under these alternatives, while public use on tailwaters is expected to increase by 0.2 to 3 percent and public reservoir use is expected to increase by between 3 and 6 percent under these alternatives (Figure 5.24-02).



Note: User day = All or part of one day by one person at one reservoir.
Source: TVA data 2003.

Figure 5.24-01 Changes in Recreation Use during August through October (2002) by Policy Alternative



Note: User day = All or part of one day by one person at one reservoir.
Source: TVA data 2003.

Figure 5.24-02 Percent Changes in Recreation Use by Recreation User Type during August through October (2002) by Policy Alternative

Recreation use of reservoirs and below-dam areas may increase slightly during the remaining months of the year (November through July) as some people take advantage of the overall higher reservoir elevations that would be available. Changes in use would probably occur more during months with good weather and less during colder winter months. Use of riverine areas could decrease slightly during mid-summer due to lower releases but would likely stay about the same during fall. Riverine use attributed to scheduled recreation flow releases would remain the same under Reservoir Recreation Alternative A and Reservoir Recreation Alternative B, would increase appreciably for the Tailwater Recreation Alternative, and would decrease under the Tailwater Habitat Alternative. Because of the cold water and air temperatures during late winter and early spring, use of riverine areas is not expected to change appreciably.

5.24.5 Summer Hydropower Alternative

Recreation use during August through October is expected to total about 5.3 million user days (Table 5.24-01) under the Summer Hydropower Alternative. Public access use on reservoirs and tailwaters is expected to total about 849,000 user days, or about 16 percent of recreation use by all user types. Reservoir public use is expected to total about 656,000 user days, or about 12 percent of the total recreation use under this alternative. Public use below project dams is expected to total about 193,000 user days, or 4 percent of the total recreation use.

Commercial site recreation use under this alternative is expected to total about 3.7 million user days, or 70 percent of the total recreation use (Table 5.24-01). Private recreation use is expected to total about 726,000 user days, or 14 percent of the total recreation use.

In contrast to the previous four alternatives, recreation use under the Summer Hydropower Alternative is expected to decrease during August through October by about 1.3 million user days (or about 19.3 percent) compared to the Base Case (Figure 5.24-01). The majority of this expected decrease is due to an expected decrease in private access recreation use of about 1.1 million user days, or about 61 percent (Figure 5.24-02). Other types of recreation use are also expected to decrease, with commercial site use expected to decrease by 3 percent, public reservoir use expected to decrease by about 2 percent, and public use below project dams expected to decrease by about 5 percent.

Generally, recreation use of project reservoirs and below-dam areas during the remaining months of the year (November through July) would likely experience a decrease due primarily to the much lower water levels occurring during the warm weather months. With respect to the riverine areas, overall boating activity is expected to decrease primarily because the only scheduled recreational release would be below Ocoee #2. If the increased water releases occur on weekdays, boating activity on the tributaries may decrease in locations where scheduled releases do not typically occur. If the increased water releases occur on weekends, a slight increase in boating activity may result. Lower releases on the weekend could lead to an increase in wade fishing on cold-water tributary rivers where trout fishing occurs. Mainstem riverine areas would probably not be affected.

5.24.6 Equalized Summer/Winter Flood Risk Alternative

Recreation use during August through October is expected to total about 6.8 million user days (Table 5.24-01) under the Equalized Summer/Winter Flood Risk Alternative. Public access use on reservoirs and tailwaters is expected to total about 860,000 user days, or about 13 percent of recreation use by all user types. Reservoir public use is expected to total about 668,000 user days, or about 10 percent of the total recreation use under this alternative. Public use below project dams is expected to total about 192,000 user days, or 3 percent of the total recreation use.

Commercial recreation use under this alternative is expected to total about 3.9 million user days, or 57 percent of the total recreation use (Table 5.24-01). Private recreation use is expected to total about 2.1 million user days, or 30 percent of the total recreation use.

Changes in recreation use under this alternative are expected to be relatively minor, with expected increases during August through October of about 244,000 user days (or about 4 percent) compared to the Base Case (Figure 5.24-01). The majority of this expected increase is due to an expected increase in private recreation use of about 212,000 user days, or about 11 percent (Figure 5.24-02). Public reservoir recreation use and commercial recreation use would remain relatively unchanged, with expected changes of -0.5 to 1 percent respectively. Public use of projects tailwaters is expected to decrease by about 5 percent, or 11,000 user days (Figures 5.24-01 and 5.24-02).

In general, the Equalized Summer/Winter Flood Risk Alternative would likely result in overall lower levels of recreation use during spring and summer on reservoirs and below-dam areas due to lower reservoir levels and discharges during the warm-weather seasons. Use during late fall and winter (November through February) may be slightly greater due to the expected higher reservoir elevations during this period. Recreation use of riverine sections would not change for areas where and times when scheduled recreation releases occur, but may decrease slightly during summer and fall as releases would be typically lower than under the Base Case.

5.24.7 Commercial Navigation Alternative

Recreation use during August through October is expected to total about 6.4 million user days under the Commercial Navigation Alternative (Table 5.24-01). Public access use on reservoirs and tailwaters is expected to total about 873,000 user days, or about 13 percent of recreation use by all user types. Reservoir public use is expected to total about 670,000 user days, or about 10 percent of the total recreation use. Public use below project dams is expected to total about 203,000 user days, or 3 percent of the total recreation use.

Commercial site recreation use under the Commercial Navigation Alternative is expected to total about 3.8 million user days, or 60 percent of the total recreation use (Table 5.24-01). Private recreation use is expected to total about 1.7 million user days, or 27 percent of the total recreation use.

Similar to the Equalized Summer/Winter Flood Risk Alternative, changes in recreation use under the Commercial Navigation Alternative are expected to be relatively minor—with an expected decrease of less than 120,000 user days during August through October (or about 2 percent) compared to the Base Case (Figure 5.24-01). The expected decrease is driven by the expected decrease in private access recreation use of about 122,000 user days, or about 7 percent (Figure 5.24-02). Public reservoir recreation use, public use below project dams, and commercial site recreation use would remain relatively unchanged, with expected changes of less than 1 percent.

During the remaining months of the year (November through July), this alternative would likely result in very small changes in use of project reservoirs and downstream areas. The reservoir and below-dam area elevations would be similar to those experienced under the Base Case. Changes in riverine use would also be small, as there would be little change in flow releases and no change in scheduled recreation releases.

5.24.8 Summary of Impacts

Table 5.24-02 provides a summary of the expected changes in recreation by policy alternative. An overall rating is also indicated for each alternative. Four of the alternatives are expected to result in large increases in recreation use: Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, and the Tailwater Habitat Alternative. These alternatives are expected to result in increases in use of between 1.3 and 1.5 million user days. In contrast, the Summer Hydropower Alternative is expected to result in a moderate decrease in recreation use of about 1.3 million user days, and the Preferred Alternative would result in a moderate increase in recreation use of about 1.2 million user days. The Equalized Summer/Winter Flood Risk Alternative and the Commercial Navigation Alternative are expected to result in a slight increase or little change in recreation use.

Table 5.24-02 Summary of Changes in Recreational Use by Policy Alternative (August through October)

Alternative	Recreation Use Types				
	Public Use In Reservoirs	Public Use In Tailwaters	Commercial Use[1]	Private Use	Overall Rating
Reservoir Recreation A	Slightly beneficial (3.0%)	No change (0.5%)	Slightly beneficial (4.0%)	Substantially beneficial (63.0%)	Substantially beneficial (20.4%)
Reservoir Recreation B	Slightly beneficial (6.0%)	Slightly beneficial (3.0%)	Slightly beneficial (7.0%)	Substantially beneficial (67.0%)	Substantially beneficial (23.5%)
Summer Hydropower	Slightly adverse (-2.0%)	Slightly adverse (-5.0%)	Slightly adverse (-3.0%)	Substantially adverse (-61.0%)	Adverse (-19.3%)
Equalized Summer/ Winter Flood Risk	No change (-0.5%)	Slightly adverse (-5.5%)	Slightly beneficial (1.2%)	Beneficial (11.0%)	Slightly beneficial (3.7%)
Commercial Navigation	No change (-0.1%)	No change (-0.1%)	No change (0.1%)	Slightly adverse (-6.0%)	Slightly adverse (-1.8%)
Tailwater Recreation	Slightly beneficial (5.9%)	Slightly beneficial (2.5%)	Slightly beneficial (7.0%)	Substantially beneficial (67.0%)	Substantially beneficial (23.5%)
Tailwater Habitat	Slightly beneficial (5.9%)	No change (-0.1%)	Slightly beneficial (7.0%)	Substantially beneficial (61.0%)	Substantially beneficial (21.9%)
Preferred	Slightly beneficial (2.8%)	No change (0.6%)	Slightly beneficial (2.8%)	Substantially beneficial (56.0%)	Beneficial (17.8%)

Note: An increase in recreational use ranging from 0 to 1% was considered No Change, from >1 to 8% was considered Slightly Beneficial, from >8 to 20% was considered Beneficial, and >20% was considered Substantially Beneficial. A decrease in recreational use ranging from 0 to 1% was considered No Change, from >1 to 8% was considered Slightly Adverse, from >8 to 20% was considered Adverse, and >20% was considered Substantially Adverse.

[1] Commercial whitewater rafting activity on Ocoee #2 and Ocoee #3 was considered in this summary. Under the Summer Hydropower Alternative and the Tailwater Habitat Alternative, commercial whitewater releases would be suspended on Ocoee #3. For purposes of this summary, it was assumed that these alternatives would result in the closure of commercial whitewater operations on Ocoee #3. The expected increase in use overall is expected to occur for reservoir use.

5.25 Social and Economic Resources

5.25.1 Introduction

This section considers the potential social and economic effects of implementing an alternative reservoir operations policy, as well as the Base Case. Section 4.25 provides a discussion of the five pathways influencing total economic effects, as well as their respective trends through 2030. The five pathways are navigation, power, water supply, recreation, and property values. An assessment of potential damages associated with flooding is not included in the economic analysis.

This section presents the changes in direct effects and total economic effects resulting from the Base Case and the policy alternatives for each year of the forecast period. The economic model used to estimate the total economic effects of policy alternatives is also briefly discussed.

5.25.2 Impact Assessment Methods

The discussion of impact assessment methods includes a description of the pathways for direct effects, the REMI economic forecasting model, and the total economic effects of policy alternatives.

Pathways for Direct Effects

TVA's operations are linked to the regional level of economic activity by five direct pathways. Changes in the reservoir operations policy would directly affect these five sectors in the following ways:

- Increased (decreased) consumer expenditures from new money coming into (leaving) the region;
- Changes in the cost of production in the region; and,
- Wealth-induced changes in consumer spending.

For any given policy alternative, direct effects associated with all five pathways would occur simultaneously. Direct effects can be either positive or negative. For instance, a policy alternative that extends the summer reservoir levels for an extra month may induce new or additional trips from outside visitors into the region, generating an increase in new money coming into the region. Simultaneously, this alternative policy may increase the costs of production to industries using the TVA system for navigation, water supply, or power generation purposes. Further, the value of shoreline properties may rise as the aesthetic and recreational benefits of living by the reservoirs increase. The implied rise in property-owner wealth may then result in an increase in consumer spending.

The direct economic effects of changes in the reservoir operations policy would then act as stimuli to enhance or decrease the economic growth in the regional economy, which was measured in this EIS as changes to population, employment, gross regional product (GRP), and total personal income (PI). Direct effects that increase new money coming into the region or wealth-induced consumer spending would increase the growth rate of regional employment, GRP, and income. This increase would induce in-migration to the region. Direct effects that change production costs would generally affect the regional economy in both demand-side and supply-side effects. An increase in production costs would increase the cost of doing business in the region and reduce market share, raising prices of final goods and services, and reducing regional consumer spending through a fall in disposable income. On the supply side, increases in production costs would affect local business operating margins. In either case, the region would experience a decline in business sales volume, employment, and income levels.

Changes in these economic variables would then generate further rounds of spending as the effects of the direct stimuli ripple through the economy—a phenomenon known as the multiplier effect. Each additional round of spending would have a smaller effect on the economy than the previous one, as part of the change in spending leaks from the region in the form of imports. The additional rounds of spending and the associated changes in the regional economy are termed secondary effects. These effects were calculated using the REMI economic model, which is discussed later in this section.

The final changes to employment, population, GRP, and PI are the total economic effects of a policy alternative. Total economic effects to the region are therefore the sum of direct and secondary effects. Both the direct effects associated with each of the five direct pathways and the total economic effects to the regional economy under the policy alternatives, including the Base Case, are reported in this section.

The direct effects of a change in the reservoir operations policy include changes in costs or expenditure levels within each of the five regional pathways. The following discussion addresses the direct effects of each policy alternative (including the Base Case), by year, for power supply, navigation, water supply, recreation, and property values.

Power Supply

Operational changes that alter the water availability and timing of hydropower generation would affect the cost of both fuel and generating capacity, changing electricity prices in the region (see Section 5.23, Power).

The direct effects of each alternative were measured by the difference between the power cost under the Base Case and the cost predicted under each policy alternative. TVA performed an analysis for each alternative to assess the effect of changes in demand, timing, and amount of generation by assessing the effect of the change on the current TVA power supply plan and financial forecast.

The power supply analysis used three computer models: the Weekly Scheduling Model (WSM) of TVA's hydrological and hydroelectric system; the PROSYM power production costing model; and RELY, a generation reliability model that is used to determine the capacity needed to maintain the reliability of the power system. The data and methodology used to estimate an impact on TVA's system-wide power supply cost were the same that TVA uses for operations and planning, as discussed in Section 5.23, Power.

Changes in power cost by alternative are presented for 2004 to 2030 (Table 5.25-01) as a percentage of TVA's total revenues. The Commercial Navigation Alternative is expected to slightly reduce power costs relative to the Base Case by 0.1 percent over the 2004 through 2030 period. The Summer Hydropower Alternative is expected to result in essentially no effect on power costs relative to the Base Case. Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative are each expected to increase power costs. The greatest increase in power costs relative to the Base Case would occur under the Tailwater Habitat Alternative, which is expected to increase power costs by an average of 3.3 percent for the period from 2004 to 2030.

Table 5.25-01 Power Cost Change as a Percent of TVA Total Revenue (2004 to 2030) (percent)

Alternative	2004	2005	2006	2007	2008	2009	2010	2030
Reservoir Recreation A	0.9	0.5	0.6	0.6	0.5	0.4	0.4	0.1
Reservoir Recreation B	1.3	0.8	0.9	0.9	0.9	0.7	0.8	0.5
Summer Hydropower	-0.3	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0
Equalized Summer/ Winter Flood Risk	1.5	1.2	1.5	1.2	1.3	1.2	1.3	1.1
Commercial Navigation	0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Tailwater Recreation	1.2	0.8	0.9	0.8	0.9	0.7	0.8	0.5
Tailwater Habitat	3.3	3.5	3.3	3.4	3.2	3.3	3.5	2.8
Preferred	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1

<u>Navigation</u>

Navigation of the reservoir system is a key component to the operating costs of industries using the system for waterborne transportation. Navigable waterways reduce the cost of shipping bulky commodities such as grain, gravel, chemicals, coal, and petroleum products that are not transported by pipeline. Changes in channel depths would alter effective delivery loads and generate changes in transportation costs.

The direct effects are shown as shipper savings. For the navigation component of the reservoir operations policy, each alternative was expressed in terms of channel depth for each section of the Tennessee River. Knowing channel depth and shipper savings per-foot depth for each section of the river allowed the estimation of total shipper savings by commodity. Under the 11-foot navigation component in the Base Case, shipper savings were forecast to increase to $597 million by 2030 (Table 5.25-02). Raising the channel depths to 13 feet was forecast to increase shipper savings by $60 million by 2030, increasing shipper savings to $657 million. Conversely, decreasing the channel depths to 10 feet would reduce shipper savings by $55 million to a new level of $542 million over the same period. Four of the policy alternatives would alter channel depths and therefore change shipper savings (Table 5.25-03). The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative were forecast to reduce shipper savings by $17 million and $2 million by 2030, respectively, relative to the Base Case. Conversely, the Commercial Navigation Alternative and the Preferred Alternative were forecast to increase shipper savings by $24 million and $0.5 million, respectively, over the same period. Estimates of shipper savings do not include savings associated with the water-compelled rate effect. These effects are captured in the model used to estimate the total economic effects of the policy alternatives.

Table 5.25-02 Forecast Shipper Savings under the Base Case (2004 to 2030) (2002 dollars in millions)

Channel Depth	Shipper Savings	2004	2005	2006	2007	2008	2009	2010	2030
11-foot channel	Existing	$378.5	$386.1	$393.8	$401.7	$409.7	$417.9	$426.3	$597.1

Table 5.25-03 Changes in Shipper Savings by Policy Alternative (2004 to 2030) (2002 dollars in millions)

Alternative	2004	2005	2006	2007	2008	2009	2010	2030
Reservoir Recreation A	$0	$0	$0	$0	$0	$0	$0	$0
Reservoir Recreation B	$0	$0	$0	$0	$0	$0	$0	$0
Summer Hydropower	-$11.0	-$11.2	-$11.4	-$11.7	-$11.9	-$12.1	-$12.4	-$17.3
Equalized Summer/ Winter Flood Risk	-$1.2	-$1.2	-$1.2	-$1.3	-$1.3	-$1.3	-$1.3	-$1.9
Commercial Navigation	$15.3	$15.6	$15.9	$16.3	$16.6	$16.9	$17.3	$24.2
Tailwater Recreation	$0	$0	$0	$0	$0	$0	$0	$0
Tailwater Habitat	$0	$0	$0	$0	$0	$0	$0	$0
Preferred	$0.3	$0.3	$0.4	$0.4	$0.4	$0.4	$0.4	$0.5

Note: Numbers shown are for the non-utility industry. Utility shipper savings were included in the power analysis.

Water Supply

There are potentially two direct effects of changes to the reservoir operations policy within the water supply pathway. The first is the impact on intake costs. If changes in the policy reduce the minimum reservoir elevations below the level necessary for both public supply and industrial water intakes, capital expenditure would be required to alter the intakes. For each policy alternative, a hydrologic model using 100 years of historical data was used to estimate the occurrence, frequency, and duration of minimum elevation levels below the TVA-published minimum elevation levels for each reservoir where water intakes are located. The cost of restoring the existing reliability under the Base Case was then estimated for each policy alternative and was treated as an increase in the cost of local government, for input into the REMI model.

Under the Summer Hydropower Alternative (Table 5.25-04), the elevation of Cherokee Reservoir was predicted to be below the minimum elevation level of 1,020 feet for 125 weeks during the 100-year period and below 1,015 feet for 94 weeks of the 100 years. Based on the frequency and duration of these elevations, existing intakes could not be modified to provide water supply reliability. New intakes therefore would be required, estimated to cost about $5 million in capital expenditures. Four of the eight policy alternatives would require capital expenditures. The Summer Hydropower Alternative would incur the largest total intake costs of $12.5 million. The Commercial Navigation Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative would require expenditures of approximately $3.4 million, $22,500, $21,000, and $26,000, respectively.

The second potential impact would affect industries directly dependent on river flows in order to discharge wastewater. When river flow is too low or too high, affected industries would then need to curtail or shut down their operations, incurring lost production time. One TVA industry was also identified as being affected by changing reservoir operations. Hourly flow simulations were constructed for an 8-year period (1987 to 1994). The 8-year record contained dry, wet, and normal flow years and therefore represented the range of flows likely to be encountered in 100 years of flow record. According to these simulations, the annual average number of days the plant's wastewater storage capacity would be exceeded (and therefore production time would be lost) was estimated under each alternative. These estimates were transformed and entered into the REMI model as changes in output based on the number of days of production gained or lost under each policy alternative relative to the Base Case.

Water supply demands were projected into the future to identify those areas in the Valley where existing impoundments may not support future development and where water withdrawals could result in insufficient water for waste assimilation under low-flow conditions. These are discussed in the "Water Supply Inventory and Needs Analysis" report generated in support of the ROS. Areas of the Valley that are currently growth limited, or are projected to become growth limited in the future, are not expected to change as a result of modified reservoir operations.

Table 5.25-04 Cost to Modify Intakes on Reservoirs with Pool Levels below TVA-Published Minimum Elevations by Policy Alternative (2002 dollars in thousands)

Reservoir	Alternative							
	Reservoir Recreation A	Reservoir Recreation B	Summer Hydropower	Equalized Summer/ Winter Flood Risk	Commercial Navigation	Tailwater Recreation	Tailwater Habitat	Preferred
Watauga	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Cherokee	$0.0	$0.0	$5,000.0	$0.0	$1,000.0	$0.0	$0.0	$0.0
Douglas	$0.0	$0.0	$3,000.0	$0.0	$26.0	$0.0	$0.0	$26.0
Norris	$0.0	$0.0	$77.0	$0.0	$57.0	$0.0	$0.0	$0.0
Fontana	$0.0	$0.0	$4.5	$0.0	$4.5	$0.0	$0.0	$0.0
Chatuge	$0.0	$0.0	$2,200.0	$0.0	$69.5	$19.5	$19.5	$0.0
Nottely	$0.0	$0.0	$2,250.0	$0.0	$2,250.0	$1.5	$1.5	$0.0
Hiwassee	$0.0	$0.0	$1.5	$0.0	$1.5	$1.5	$0.0	$0.0
Tims Ford	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Total	**$0.0**	**$0.0**	**$12,500.0**	**$0.0**	**$3,400.0**	**$22.5**	**$21.0**	**$26.0**

Note: The numbers shown in Table 5.25-04 do not directly correspond with those in Table 5.5-06. Table 5.5-06 includes changes in intake modification capital costs and pumping costs. Table 5.25-04 includes only the capital costs of intake modification. The input to the REMI model to predict economic impacts also includes lost days of production to meet wastewater discharge requirements, which is not included in Table 5.25-04.

Recreation

Changes in the reservoir operations policy are expected to alter water-based recreational use across the TVA region. Water-based recreational expenditures resulting from proposed changes in operations in the TVA reservoir system were estimated for the forecast period (see Section 5.24, Recreation). Three user groups were included in the recreation analysis: public access site users, commercial patrons, and shoreline property owners. The economic analysis is concerned with "new" or external money, either brought into the economy by individuals who live outside the TVA region or by permanent residents of the region who reallocated travel days normally spent outside the TVA region. Any transfers of spending from one use to another within the TVA region, resulting in zero net benefit to the region, were not considered in the analysis. For each alternative, changes in recreational expenditures in August through October were estimated. The changes are shown in Figure 5.25-01.

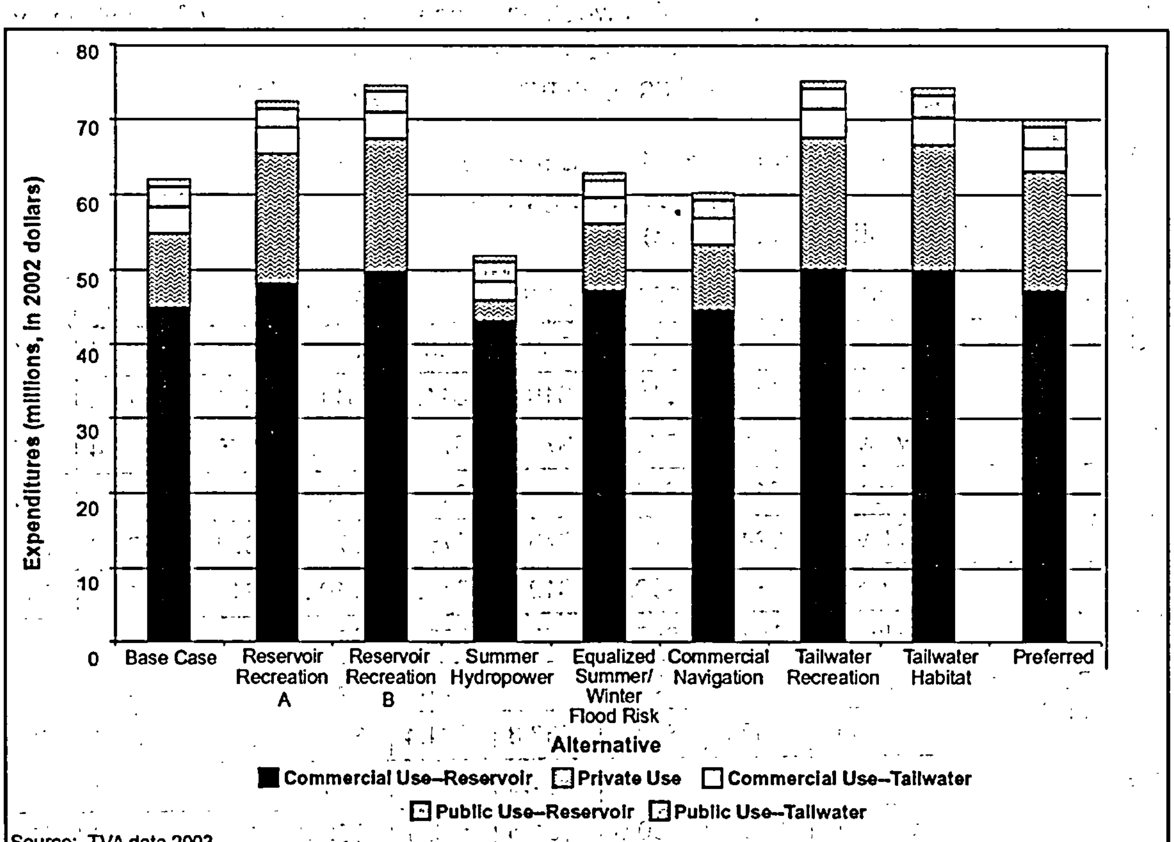


Figure 5.25-01 Projected External Recreation Expenditures by Policy Alternative (August through October 2004)

A constructed on-site survey scheme, involving mail surveys to commercial providers and shoreline property owners on 13 reservoirs, was used to estimate a baseline of recreation visitor days. Variables from these analyses were used to estimate changes in recreation visitor days based on the various alternatives. TVA's population projections for 2003 to 2030 were then used to forecast trends in recreational use from 2003 to 2030. Estimates of percent change in the number of visitor trips or days lived at a TVA reservoir or tailwater residence in response to proposed changes in the reservoir operations policy were used to forecast changes in recreational use from 2003 to 2030. Mean expenditures per person, per user day were then applied to the projected changes in recreational use in order to calculate the projected change in expenditures from 2003 through 2030 as a result of changes in operations.

Projected changes in recreational expenditures by alternative are presented for the years 2004 to 2030 (Table 5.25-05). Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, and the Preferred Alternative are expected to provide greater total expenditures than under the Base Case. The Summer Hydropower Alternative and the Commercial Navigation Alternative are expected to result in reduced external recreational expenditures. The greatest increase in external expenditures is expected for the Tailwater Recreation Alternative, which would increase expenditures by $17 million by 2030. The Summer Hydropower Alternative would generate the largest decline in external recreational expenditures, reducing spending by almost $13 million by 2030.

Table 5.25-05 Changes in Recreational Expenditures from outside the TVA Region (August through October) (2002 dollars in millions)

Alternative	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Base Case	Existing	$61.2	$61.9	$62.5	$63.2	$63.8	$64.5	$65.1	$79.6
Reservoir Recreation A	Change	$10.6	$10.7	$10.9	$11.0	$11.1	$11.2	$11.3	$14.0
	New level	$71.9	$72.6	$73.4	$74.1	$74.9	$75.7	$76.4	$93.6
Reservoir Recreation B	Change	$12.9	$13.1	$13.2	$13.3	$13.5	$13.6	$13.8	$17.0
	New level	$74.2	$74.9	$75.7	$76.5	$77.3	$78.1	$78.9	$96.6
Summer Hydropower	Change	-$9.8	-$9.9	-$10.0	-$10.1	-$10.2	-$10.3	-$10.4	-$12.8
	New level	$51.5	$52.0	$52.5	$53.1	$53.6	$54.2	$54.7	$66.8
Equalized Summer/ Winter Flood Risk	Change	$1.3	$1.3	$1.3	$1.3	$1.3	$1.3	$1.3	$1.4
	New level	$62.5	$63.2	$63.8	$64.4	$65.1	$65.7	$66.4	$81.1
Commercial Navigation	Change	-$1.0	-$1.0	-$1.0	-$1.0	-$1.1	-$1.1	-$1.1	-$1.3
	New level	$60.2	$60.9	$61.5	$62.1	$62.8	$63.4	$64.0	$78.3
Tailwater Recreation	Change	$13.2	$13.3	$13.4	$13.6	$13.7	$13.9	$14.0	$17.3
	New level	$74.4	$75.2	$76.0	$76.8	$77.6	$78.3	$79.2	$97.0
Tailwater Habitat	Change	$12.2	$12.4	$12.5	$12.6	$12.8	$12.9	$13.0	$16.2
	New level	$73.5	$74.2	$75.0	$75.8	$76.6	$77.4	$78.2	$95.8
Preferred	Change	$8.6	$8.7	$8.7	$8.8	$8.9	$9.0	$9.1	$11.3
	New level	$69.8	$70.5	$71.3	$72.0	$72.8	$73.5	$74.2	$90.9

Property Values

Changes in the reservoir operations policy have the potential to affect the value of waterfront properties on TVA reservoirs. Recreational and aesthetic benefits of living adjacent to the TVA reservoirs are capitalized into the values of property adjacent to the water. Changes in the existing policy that alter pool levels would alter amenities at reservoir properties and, thus, change property values. For instance, policy alternatives that would maintain summer pool levels for an additional month would increase the amenity benefits of living by the water. Adjacent property values should then rise in response.

A hedonic valuation model used to estimate the effect of reservoir levels on property values postulated that the value of residential property would be higher on lots where the winter drawdown exposes less area between the summer high pool and winter low pool elevations. In the hedonic model, the implicit price of each characteristic of the property was embedded in the market price of the property. A statistical model was used to estimate the value of the aesthetic and recreational benefits of living by the water. Changes in property values resulting from changes in reservoir elevations could then be measured.

An important relationship for the economic impact analysis concerns how changes in property values (a form of wealth) translate into changes in consumer spending. Direct economic effects in the regional economy occur via the estimate that 3 percent of the increase in household wealth is spent on "high-end" durable goods, holding constant the level of annual income. This assumption is consistent with both economic theory and empirical research. A central implication of economic theory is that people smooth consumption over their lifetime, and wealth is a key component of this consumption plan. A change in wealth will cause a rearrangement of the desired profile of consumption over time. Empirical research suggests that increases in wealth result in increases in consumer spending of between 3 and 5 percent. In this EIS, an increase in consumer spending of 3 percent of property value changes was assumed.

The results of the total change in spending for each alternative across the TVA region are presented in Table 5.25.06. Reservoir Recreation Alternative B would result in the largest increase in spending, with an estimated increase in property values leading to over $10 million annually by 2005 in additional spending on durable goods by residents in the region. Conversely, the Summer Hydropower Alternative, which would result in lower summer pool levels than under the existing policy, would cause an estimated decrease in property values, and therefore a decline in spending on durable goods of almost $12 million annually by 2005.

The REMI Model

The existing conditions and future trends through 2030 were forecast by TVA, using a system of models and forecasting processes of which the REMI model is an integral part (see Appendix C). REMI is a model widely used by federal agencies such as the USEPA and state governments such as Florida and Texas. TVA provided projections of total economic effects under the Base Case for 2004 to 2030. The direct effects within the five pathways were then used as inputs into the REMI model. Total economic effects were estimated and represented as changes in GRP, PI, employment, and population levels.

Table 5.25-06 Estimated Impacts of Changes in Property Values on Consumer Spending across the TVA Region by Policy Alternative (2004 to 2030) (2002 dollars in millions)

Alternative	2004	2005	2006	2007	2008	2009	2010	2030
Reservoir Recreation A	$3.8	$7.7	$7.7	$7.7	$7.7	$7.7	$7.7	$7.7
Reservoir Recreation B	$5.1	$10.2	$10.2	$10.2	$10.2	$10.2	$10.2	$10.2
Summer Hydropower	-$5.9	-$11.8	-$11.8	-$11.8	-$11.8	-$11.8	-$11.8	-$11.8
Equalized Summer/ Winter Flood Risk	-$2.3	-$4.5	-$4.5	-$4.5	-$4.5	-$4.5	-$4.5	-$4.5
Commercial Navigation	$2.8	$5.6	$5.6	$5.6	$5.6	$5.6	$5.6	$5.6
Tailwater Recreation	$5.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0	$10.0
Tailwater Habitat	$4.2	$8.4	$8.4	$8.4	$8.4	$8.4	$8.4	$8.4
Preferred	$0.9	$1.8	$1.8	$1.8	$1.8	$1.8	$1.8	$1.8

Total Economic Effects of Policy Alternatives

Tables 5.25-07 through 5.25-14 show the total economic effects for the policy alternatives. The results are presented by year for the first 7 years (2004 to 2010) of the forecast period. The economic effects throughout this period show the developing trend in the regional economy as the region adjusts to the direct effects of each policy alternative. Results for 2030 are also presented; however, any results after 2020 are subject to greater uncertainty.

Direct effects ripple across the economy to differing degrees, dependent on the interactions generated within the economy and the length of time that secondary impacts affect the region. The effects of the economic drivers do not occur in isolation; they occur simultaneously due to the system-wide linkage in TVA operations. For instance, a decision to hold water in upstream reservoirs to Labor Day in order to enhance recreation in those reservoirs could also reduce water releases for hydropower generation and channel depths for navigation. The cumulative effects of the changes in each pathway are of interest due to the dynamic and interconnected nature of the economy as expressed in the REMI model.

Direct effects, in terms of their impact on the economy, are shown in Table 5.25-15. For instance, under Reservoir Recreation Alternative A, an increase in recreation spending would result in a slightly beneficial effect on the economy whereas an increase in power costs would result in a slightly adverse effect on the economy. The magnitude of the impacts on the regional economy would be very small relative to the size of the regional economy as a whole. For example, a policy alternative that reduces GRP by $10 million in a given year would represent a decrease of less than one hundredth of a percent in the value of regional output.

Table 5.25-07 **Total Economic Effects under Reservoir Recreation Alternative A (2004 to 2030 in 2002 dollars)**

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$7.3	$1.1	-$9.1	-$10.3	-$14.4	-$14.6	-$13.6	-$3.7
	Percent change	-0.0024%	0.0004%	-0.0028%	-0.0031%	-0.0042%	-0.0041%	-0.0036%	-0.0005%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$2.1	$0.8	-$2.8	-$3.1	-$4.7	-$4.7	-$4.4	$2.1
	Percent change	-0.0008%	0.0003%	-0.0010%	-0.0011%	-0.0016%	-0.0016%	-0.0015%	0.0004%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	-.073	.067	-.049	-.047	-.081	-.066	-.043	.123
	Percent change	-0.0013%	0.0012%	-0.0009%	-0.0008%	-0.0014%	-0.0011%	-0.0007%	0.0016%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-.139	-.180	-.251	-.314	-.365	-.392	-.408	-.200
	Percent change	-0.0014%	-0.0019%	-0.0026%	-0.0032%	-0.0036%	-0.0039%	-0.0040%	-0.0016%

Table 5.25-08 Total Economic Effects under Reservoir Recreation Alternative B (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$15.8	-$8.4	-$21.8	-$22.0	-$29.3	-$28.7	-$32.5	-$32.2
	Percent change	-0.0052%	-0.0027%	-0.0068%	-0.0066%	-0.0085%	-0.0080%	-0.0087%	-0.0046%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$5.1	-$2.7	-$7.6	-$7.7	-$10.4	-$10.2	-$11.5	-$5.3
	Percent change	-0.0020%	-0.0010%	-0.0028%	-0.0028%	-0.0036%	-0.0035%	-0.0038%	-0.0010%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	-.179	-.039	-.190	-.164	-.229	-.193	-.220	.012
	Percent change	-0.0032%	-0.0007%	-0.0033%	-0.0028%	-0.0039%	-0.0032%	-0.0036%	0.0002%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-.206	-.296	-.424	-.525	-.627	-.690	-.769	-.821
	Percent change	-0.0021%	-0.0031%	-0.0043%	-0.0053%	-0.0063%	-0.0068%	-0.0075%	-0.0066%

Table 5.25-09 Total Economic Effects under the Summer Hydropower Alternative (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$21.3	-$24.3	-$36.2	-$34.7	-$45.3	-$42.6	-$43.2	-$69.8
	Percent change	-0.0071	-0.0078%	-0.0112%	-0.0104%	-0.0131%	-0.0119%	-0.0116	-0.0100%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$4.8	-$4.3	-$10.6	-$10.4	-$14.7	-$14.1	-$14.6	-$23.7
	Percent change	-0.0019%	-0.0017%	-0.0040%	-0.0038%	-0.0052%	-0.0048%	-0.0048	-0.0045%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	-.186	-.171	-.376	-.346	-.460	-.417	-.413	-.496
	Percent change	-0.0033%	-0.0030%	-0.0066%	-0.0060%	-0.0078%	-0.0069%	-0.0068	-0.0025%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-.004	-0.34	-.111	-.178	-.251	-.307	-.372	-.922
	Percent change	0.0000%	-0.0004%	-0.0011%	-0.0018%	-0.0025%	-0.0030%	-0.0036	-0.0074%

Table 5.25-10 Total Economic Effects under the Equalized Summer/Winter Flood Risk Alternative (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$40.7	-$46.5	-$59.8	-$64.9	-$73.1	-$80.9	-$76.5	-$127.6
	Percent change	-0.0135%	-0.0149%	-0.0186%	-0.0195%	-0.0212%	-0.0226%	-0.0205%	-0.0184%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$14.9	-$17.8	-$23.3	-$25.7	-$29.1	-$32.5	-$31.1	-$39.8
	Percent change	-0.0059%	-0.0068%	-0.0087%	-0.0093%	-0.0102%	-0.0110%	-0.0103%	-0.0075%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	-.574	-.594	-.728	-.733	-.791	-.835	-.745	-.664
	Percent change	-0.0103%	-0.0105%	-0.0127%	-0.0126%	-0.0134%	-0.0139%	-0.0122%	-0.0089%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-.317	-.550	-.816	-1.024	-1.231	-1.409	-1.571	-2.755
	Percent change	-0.0033%	-0.0057%	-0.0083%	-0.0103%	-0.0123%	-0.0139%	-0.0154%	-0.0221%

Table 5.25-11 Total Economic Effects under the Commercial Navigation Alternative (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	$22.3	$37.7	$36.3	$42.1	$47.0	$49.2	$54.0	$87.4
	Percent change	0.0074%	0.0121%	0.0113%	0.0126%	0.0136%	0.0137%	0.0145%	0.0126%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	$3.2	$9.4	$8.8	$11.2	$13.0	$14.0	$15.8	$24.0
	Percent change	0.0013%	0.0036%	0.0033%	0.0041%	0.0046%	0.0048%	0.0052%	0.0045%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	.111	.320	.263	.320	.361	.369	.408	.466
	Percent change	0.0020%	0.0057%	0.0046%	0.0055%	0.0061%	0.0061%	0.0067%	0.0062%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	.023	.112	.161	.220	.285	.344	.405	.974
	Percent change	0.0002%	0.0012%	0.0016%	0.0022%	0.0028%	0.0034%	0.0040%	0.0078%

Table 5.25-12 Total Economic Effects under the Tailwater Recreation Alternative (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$14.5	-$7.2	-$20.5	-$20.7	-$27.9	-$27.1	-$30.8	-$29.7
	Percent change	-0.0048%	-0.0023%	-0.0064%	-0.0062%	-0.0081%	-0.0076%	-0.0083%	-0.0043%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$4.6	-$2.2	-$7.0	-$7.1	-$9.7	-$9.5	-$10.9	-$4.4
	Percent change	-0.0018%	-0.0008%	-0.0026%	-0.0026%	-0.0034%	-0.0032%	-0.0036%	-0.0008%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	-.162	-.023	-.173	-.147	-.211	-.174	-.201	.030
	Percent change	-0.0029%	-0.0004%	-0.0030%	-0.0025%	-0.0036%	-0.0029%	-0.0033%	0.0004%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-.200	-.287	-.410	-.510	-.608	-.671	-.745	-.784
	Percent change	-0.0021%	-0.0030%	-0.0042%	-0.0051%	-0.0061%	-0.0066%	-0.0073%	-0.0063%

Table 5.25-13 Total Economic Effects under the Tailwater Habitat Alternative (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$46.3	-$78.2	-$100.3	-$115.8	-$123.8	-$141.3	-$160.8	-$335.2
	Percent change	-0.0154%	-0.0251%	-0.0311%	-0.0347%	-0.0358%	-0.0394%	-0.0431%	-0.0482%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$17.2	-$30.2	-$39.4	-$45.8	-$49.4	-$56.2	-$63.7	-$105.3
	Percent change	-0.0068%	-0.0116%	-0.0147%	-0.0166%	-0.0173%	-0.0191%	-0.0210%	-0.0199%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	-.700	-1.027	-1.196	-1.291	-1.277	-1.390	-1.522	-1.699
	Percent change	-0.0126%	-0.0182%	-0.0209%	-0.0222%	-0.0216%	-0.0232%	-0.0250%	-0.0227%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-.592	-1.168	-1.704	-2.224	-2.659	-3.086	-3.518	-7.273
	Percent change	-0.0062%	-0.0120%	-0.0174%	-0.0224%	-0.0265%	-0.0305%	-0.0344%	-0.0583%

Table 5.25-14 Total Economic Effects under the Preferred Alternative (2004 to 2030 in 2002 dollars)

Variable	Spending	2004	2005	2006	2007	2008	2009	2010	2030
Gross regional product	Base Case (millions)	$301,338.1	$311,985.2	$322,356.6	$333,267.3	$345,346.3	$358,597.7	$372,681.4	$694,732.7
	Change (millions)	-$2.2	-$5.8	-$5.6	-$8.3	-$9.0	-$7.3	-$6.0	-$4.5
	Percent change	-0.0007%	-0.0019%	-0.0018%	-0.0025%	-0.0026%	-0.0020%	-0.0016%	-0.0007%
Total personal income	Base Case (millions)	$253,806.0	$260,528.1	$268,255.1	$276,114.6	$285,081.1	$294,394.1	$303,333.6	$529,834.9
	Change (millions)	-$0.4	-$1.8	-$1.8	-$2.7	-$3.0	-$2.3	-$1.9	$0.5
	Percent change	-0.0002%	-0.0007%	-0.0007%	-0.0010%	-0.0010%	-0.0008%	-0.0006%	0.0001%
Employment	Base Case (thousands)	5,553.8	5,648.3	5,727.8	5,811.8	5,909.4	6,000.4	6,095.2	7,483.0
	Change (thousands)	0.002	-0.027	-0.016	-0.044	-0.043	-0.016	0.002	0.061
	Percent change	0.0000%	-0.0005%	-0.0003%	-0.0008%	-0.0007%	-0.0003%	0.0000%	0.0008%
Population	Base Case (thousands)	9,595.4	9,701.5	9,806.4	9,911.0	10,015.4	10,121.4	10,227.2	12,476.3
	Change (thousands)	-0.063	-0.101	-0.130	-0.163	-0.184	-0.189	-0.191	-0.116
	Percent change	-0.0007%	-0.0010%	-0.0013%	-0.0016%	-0.0018%	-0.0019%	-0.0019%	-0.0009%

Table 5.25-15 Direct Effects by Policy Alternative

Alternative	Recreation Spending	Expenditures Associated with Property Values	Water Supply	Navigation Costs	Power Costs
Reservoir Recreation A	Slightly beneficial	Slightly beneficial	Slightly adverse	No change	Slightly adverse
Reservoir Recreation B	Slightly beneficial	Slightly beneficial	No change	No change	Slightly adverse
Summer Hydropower	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Equalized Summer/ Winter Flood Risk	Slightly beneficial	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Commercial Navigation	Slightly adverse	Slightly beneficial	Slightly adverse	Slightly beneficial	Slightly beneficial
Tailwater Recreation	Slightly beneficial	Slightly beneficial	Slightly beneficial	No change	Slightly adverse
Tailwater Habitat	Slightly beneficial	Slightly beneficial	Slightly adverse	No change	Adverse
Preferred	Slightly beneficial	Slightly beneficial	Slightly adverse	Slightly beneficial	Slightly adverse

Notes:

The narrative under the Water Supply column in Table 5.25-15 is not directly comparable to the figures presented in Table 5.25-04. Table 5.25-15 takes into account the combined impact of changes in costs to modify intakes and changes in lost days of production to industries affected by low river flow. Table 5.25-04 represents only the former.

Effects are based on the year 2010.

Tables 5.25-07 through 5.25-14 present the results for all policy alternatives as forecast changes in total economic effects relative to their forecast levels under the Base Case. The percentage of changes in total economic effects is also shown.

5.25.3 Base Case

Under the Base Case, TVA would maintain the existing reservoir operations policy. Under this policy, reservoir levels are generally held up as high as possible until August, when reservoirs are drawn down for power generation and are held low through the winter to provide flood storage for spring rains. In late spring, the reservoirs are filled to reach their peak volumes for the year in April or May for the mainstem reservoirs, and in June for the tributaries. Maintaining existing operations implies no impact on the forecast trend of existing conditions.

5.25.4 Reservoir Recreation Alternative A

Reservoir Recreation Alternative A would increase recreational opportunities in the TVA region. Summer tributary reservoir levels would be maintained for an additional month through Labor Day. This alternative would increase recreation spending in the region as well as wealth-induced consumer spending by property owners on TVA reservoirs. This would positively affect the economy; however, power costs would rise, increasing the costs of production for many industries across the TVA region. Table 5.25-07 shows that the increase in power costs would more than offset the gains to the economy arising from the local areas of the reservoirs. All economic variables show an increasingly negative trend over the first 7 years of the forecast, with GRP decreasing by $14 million (0.0036 percent) by the year 2010 relative to its level under the Base Case. By 2030, GRP is forecast to have decreased by $4 million relative to the Base Case. Further, by 2030 both PI ($2 million) and employment (123 workers) would have recovered to positive levels relative to their levels under the Base Case.

5.25.5 Reservoir Recreation Alternative B

Reservoir Recreation Alternative B also would increase recreational opportunities in the region. This alternative would extend tributary and mainstem summer pool levels to Labor Day, and winter levels would be held higher. Again, recreation spending and wealth-induced spending would rise while higher power costs would result in a counteracting impact. The resulting impacts on the economy would be similar to those under Reservoir Recreation Alternative A, as there is a clear negative trend in the economic effects between 2004 and 2010; however, the magnitude of these effects under Reservoir Recreation Alternative B would be greater than under Reservoir Recreation Alternative A. GRP is forecast to decrease by $33 million by 2010 relative to its level under the Base Case (Table 5.25-08). Similarly, PI is forecast to decrease by $11.5 million, employment levels by 220 workers, and the population by 769 people. By 2030, the GRP is forecast to remain approximately $32 million below that forecast under the Base Case.

5.25.6 Summer Hydropower Alternative

The Summer Hydropower Alternative would maximize hydropower production by beginning an unrestricted drawdown of the tributary and mainstem reservoirs by June 1. This would leave summer pool levels lower than under the Base Case, and winter and spring levels would be higher. This alternative would not lower power costs measurably and would result in a neutral impact on the economy. The other direct effects would negatively affect the economy; navigation and water supply costs would rise, and spending levels would fall. Table 5.25-09 shows that forecast in economic activity measures continually decline relative to the Base Case. By 2030, the GRP and PI would have decreased by $70 million and $24 million, respectively, relative to their levels under the Base Case. Employment and population levels were also forecast to decrease under this alternative, with 496 fewer workers and 922 fewer residents.

5.25.7 Equalized Summer/Winter Flood Risk Alternative

The Equalized Summer/Winter Flood Risk Alternative would change flood guides so that tributary reservoirs would be generally higher in spring and winter but lower in summer compared to the Base Case. Power costs and selected waterborne freight costs would be raised, while reservoir recreational activity would be increased by a small amount. As a result, GRP (-$128 million) and PI (-$40 million) would show a continuing negative trend compared to their forecast levels under the Base Case (Table 5.25-10). Regional employment and population levels would also be below the forecast for the Base Case, with the level of employment shrinking by 664 workers and the population by 2,755 residents.

5.25.8 Commercial Navigation Alternative

The Commercial Navigation Alternative would enhance navigation. As expected, navigation costs would decrease as deeper channels relate to more efficient loads, providing a positive impact on the economy. Decreasing power costs would magnify this effect. Recreation spending levels would decrease but, as Table 5.25-11 shows, the economy would be positively affected by this policy alternative. All economic variables show an increasing trend over the 27-year forecast period relative to the Base Case. By 2030, the GRP and PI were forecast to increase by $87 million and $24 million, respectively, while 466 additional workers would be hired and 974 residents would migrate to the region.

5.25.9 Tailwater Recreation Alternative

The Tailwater Recreation Alternative would increase tailwater recreational opportunities by maintaining summer pool levels through Labor Day. Accordingly, recreation spending and wealth-induced spending would increase, but there are offsetting forces in the form of increasing power costs. Overall, the regional economy was forecast to contract compared to the Base Case. The GRP was forecast to decrease by $31 million by 2010 relative to the Base Case, while PI would decline by $11 million (Table 5.25-12). Employment and population levels were also forecast to be below their levels under the existing policy. Between 2010 and 2030, the economy (as measured by GRP) was forecast not to deviate further from its level under the Base Case, remaining at approximately $30 million under its forecast for the Base Case, while PI shows a recovery over this period toward its long-run growth rate.

5.25.10 Tailwater Habitat Alternative

The Tailwater Habitat Alternative would mimic natural flow conditions. The most substantial impact would result from an increase in power costs, caused by reduced peaking hydropower availability. As a result, TVA would need to replace the low-cost hydropower with higher cost purchased and generated power. The negative impact on the economy would be only partially offset by increased consumer spending driven by enhancements to recreational activities. This alternative has the most adverse implications for the regional economy. Table 5.25-13 shows the forecast trend in the economic variables being increasingly negative relative to the economic conditions under the Base Case. By 2030, relative to the forecast for the Base Case, the GRP would have declined by $335 million and PI by $105 million; there would be 1,699 fewer employees, and out-migration would lead to 7,273 fewer residents.

5.25.11 Preferred Alternative

Under the Preferred Alternative, reservoir and tailwater recreation opportunities would increase. As a result, recreation spending and wealth-induced spending would increase under this alternative. Shipper savings would also increase, but rising water supply and power costs would offset this benefit. As Table 5.25-14 shows, under this alternative, the regional economy is expected to contract slightly compared to the Base Case. By 2010, GRP and PI are forecast to decrease by $6 million and $1.9 million, respectively. Population levels are forecast to fall by 191 residents, while little impact is expected on regional levels of employment. Between 2010 and 2030, the trend in decreasing levels of economic activity would be mitigated. By 2030, GRP is forecast to decline by $4.5 million, while personal income levels are forecast to increase by $0.5 million relative to their levels under the Base Case. Population levels are expected to decrease by 116 residents, and the impact on the level of regional employment is expected to be negligible.

5.25.12 Environmental Justice

Across the TVA region as a whole, none of the policy alternatives would likely raise environmental justice issues (i.e., adverse and disproportionate environmental or human health impacts on minority or low-income populations). Population demographics rule out disproportionate impacts on minorities or low-income populations when the point of comparison is the percentage of the population comprised of minorities and low-income individuals within the seven states in which TVA operates, or the nation as a whole. It is conceivable that disproportionate impacts on minorities could occur at a sub-regional level in the Mississippi and Western sub-regions and at isolated, local locations. With regard to low-income populations, demographics also allow for the possibility of a very slight disproportionate impact across the TVA region as whole. The greatest potential for disproportionate sub-regional impacts exists in the Mississippi sub-region because of the high proportion of those living below the poverty level in that area. However, the region-wide nature of TVA's proposed action makes it unlikely that, if disproportionate impacts occurred, they would be substantial.

Although not substantial, disproportionate impacts on property values and recreation could occur. While lake-front residential property values would rise under some of the alternatives, it would unlikely adversely affect low-income populations–given that those living below the poverty level are unable to purchase lake-front property at existing prices. Minority individuals who are in the market for lake-front property would be adversely affected by increased property values; however, it is unlikely that such adverse impacts would be borne disproportionately by minorities. This would require that minorities in the market for lake-front property represent a greater percentage of the population of individuals in this market than the minority population percentage as a whole, and there is no evidence of this.

Some of the alternatives would adversely affect recreation opportunities. However, recreation survey data indicate that any such adverse impacts would not be borne disproportionately by minorities or low income populations. Those living below the poverty level likely would not be adversely affected by the loss of boating and other high-cost recreational opportunities that might occur under some of the alternatives. It is also unlikely that minorities would be disproportionately affected by the loss of such opportunities. The greatest potential for adverse and disproportionate impacts exists with regard to informal recreational opportunities, such as fishing, under some of the alternatives. The risk of such impacts under TVA's Preferred Alternative is remote because this alternative would enhance recreational opportunities.

Adverse health impacts on subsistence anglers are not anticipated, given that no increase in contaminates that accumulate in fish flesh and could potentially cause human health concerns is expected to occur under any of the alternatives (see Section 5.4.1).

5.25.13 Summary of Impacts

All of the alternatives would entail tradeoffs. None of the alternatives would be uniformly beneficial or adverse for all economic pathways or output measures.

The results of the impact analysis show that only the Commercial Navigation Alternative would produce a positive economic impact on the region. Under this alternative, more efficient waterborne transportation loads and lower electricity prices would ripple across the region, creating both lower production costs for regional industries and higher levels of disposable income for consumers. These direct effects would translate into an expanding economy; therefore, the Commercial Navigation Alternative would be the most beneficial alternative with regard to social and economic resources. Under this alternative, the positive impact on the economy would be a small change in the aggregate, raising GRP levels by only less than one-tenth of a percent in any given year.

The Tailwater Habitat Alternative represents the least beneficial alternative in terms of impacts on social and economic resources. Designed to mimic natural flows, the alternative would substantially reduce TVA's peaking hydropower availability, raising electricity prices for industry and households. This impact would overwhelm rising recreation spending and would create a contraction in the regional economy relative to the Base Case. The Equalized Summer/Winter Flood Risk Alternative also would result in adverse effects on the economy. Designed to enhance flood protection, the alternative would result in negative regional impacts associated with higher electricity and waterborne transportation costs.

Reservoir Recreation Alternative A and Reservoir Recreation Alternative B were designed to increase recreational activity, but both would create higher production costs that would offset these gains. The Summer Hydropower Alternative proposes to maximize hydropower availability but simultaneously would incur rising waterborne transportation costs and falling recreation spending. The Preferred Alternative would incur positive regional impacts of increased recreational activity, wealth-induced spending, and increased shipper savings; but these benefits would be more than offset by rising water supply and power costs. Under all these alternatives, the direct effects would contract the regional economy relative to its forecast performance under the Base Case. Of these alternatives, the Preferred Alternative would result in the smallest deviation from the Base Case.

Table 5.25-16 provides a qualitative summary of the total economic effects by policy alternative and emphasizes that impacts under all alternatives would be very small relative to the Base Case.

Different standards can be used to summarize and evaluate the total economic effects of each alternative. For instance, the impact of each alternative could be measured as an average across the whole 27-year period, by the impact at the end of the forecast period (2030), or by impacts in some representative year. After careful consideration, the economic effect in 2010 was chosen to evaluate the impact of each alternative. The year 2010 was chosen because, by then, adjustments in the economy to the effects of each alternative would have largely been made; effects in 2010 are quite similar to those taken as an average; and use of 2010 is more accurate, avoiding the uncertainties associated with long-term projection to 2030.

Concerning environmental justice, demographics suggest the possibility of a very slight disproportionate impact for low-income populations across the ROS analysis area as a whole, with the greatest potential disproportionality occurring in the Mississippi sub-region.

Table 5.25-16 Summary of Economic Effects by Policy Alternative

Alternative	Variable			
	Gross Regional Product	Personal Income	Employment[1]	Population
Base Case	No change	No change	No change	No change
Reservoir Recreation A	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Reservoir Recreation B	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Summer Hydropower	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Equalized Summer/Winter Flood Risk	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Commercial Navigation	Slightly beneficial	Slightly beneficial	Slightly beneficial	Slightly beneficial
Tailwater Recreation	Slightly adverse	Slightly adverse	Slightly adverse	Slightly adverse
Tailwater Habitat	Adverse	Adverse	Adverse	Adverse
Preferred	Slightly adverse	Slightly adverse	No change	Slightly adverse

[1] Employment is summarized as having incurred "no change" under the Preferred Alternative because by 2010 the slight increase in regional employment is considered to be negligible.

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Chapter 6

Cumulative Impacts

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6.1 Introduction

Cumulative impacts are defined as the effects of the proposed action when considered together with other past, present, and reasonably foreseeable future actions. Chapter 4, Description of the Affected Environment, presents information about past and present environmental conditions—including future trends, where appropriate. This chapter addresses the cumulative impacts of the reservoir operations policy alternatives and other reasonably foreseeable actions.

The ROS EIS is a programmatic evaluation of the potential consequences of changing TVA's policy for operating its integrated reservoir system. The study's broad geographic scope is the entire Tennessee River watershed and adjacent areas, including where TVA-generated electricity is consumed (TVA's Power Service Area). Consistent with the programmatic approach of this EIS and broad scale of the ROS, the cumulative impact analysis addressed cumulative impacts of the reservoir operations policy when added to future trends and future projects. Because of the time frame and geographic scope of the evaluation, predicting future resource conditions involves substantial uncertainty. Future cumulative impacts can result not only from possible actions of TVA but also from those of other agencies and the public. This increases the uncertainty. Nevertheless, existing conditions and trends provide a basis for broad assumptions for this cumulative impact analysis.

- **Future Trends.** The planning time frame of the ROS EIS is the period from 2003 to 2030. Over this three-decade period, existing conditions in many resource areas are expected to change. The amount and rate of change would vary by resource. For each resource, potential impacts were assessed for the resource conditions expected to exist over this period. The cumulative change in existing conditions between the present and 2030 was assessed as part of the resource-specific analyses in Chapter 5, Environmental Consequences of the Alternatives. This chapter summarizes the potential for cumulative impacts of each policy alternative when added to future trends, for each resource for which adverse impacts are expected to occur.

- **Future Projects.** Specific projects that would be undertaken and come into operation during the planning period were identified and evaluated. The impacts from these projects may result in regional-scale impacts when considered together with resource impacts resulting from the implementation of policy alternatives.

In addition to future trends for resources and future projects, regulatory programs—especially those that affect environmental quality—would substantially affect the occurrence of cumulative impacts. State regulatory programs, such as those implementing the Clean Air and Clean Water Acts, are designed to improve environmental conditions. While their precise effects cannot be accurately predicted, their regional or statewide application is expected to affect a positive change in the environment. Such positive environmental changes could not be fully accounted for in TVA's cumulative impact analysis. Consequently, the analysis was generally conservative; and any projected adverse cumulative impacts are likely to have been overstated.

6.2 Cumulative Impacts Associated with Future Trends

As appropriate in each resource area, relevant future trends were identified and evaluated along with the effects of policy alternatives, and were examined for potential cumulative impacts. The following sections provide a summary of these trends and their potential cumulative impacts. No material cumulative impacts are expected to result in the areas of Dam Safety, Invasive Plants and Animals, Aquatic Plants, Groundwater Resources, or Prime Farmland. The potential consequences of changes in the operations policy on Power and Navigation were determined to be primarily economic changes, and the modeling of economic changes integrated these cumulative effects. Changes in TVA's operations policy could affect Land Use, but these effects are also primarily economic and are captured in TVA's economic analyses. The cumulative effects of shoreline development are also presented in TVA's earlier programmatic EIS assessing shoreline development, the SMI (TVA 1998).

6.2.1 Air Resources/Climate

TVA evaluated potential impacts on air resources and climate based on changes in air emissions and air quality. Air quality is currently good and improving in the TVA region, as measured by EPA's national health and environmental standards for air quality, the NAAQS. Emissions of air pollutants in the region are likely to decrease in the future due to emissions reductions by TVA (see Section 4.2, Air Resources) and others. Pollution from increased motor vehicle trips and other new air pollution stationary sources (such as factories and power plants) are expected to offset some of these decreases. The overall trend, however, should be positive—with continued air quality improvements—especially as more stringent NAAQS for ozone levels and particulates are implemented by the states. On a regional basis, the Southern Appalachian Mountain Initiative has recommended an eight-state strategy designed to improve current air quality and mitigate the effects of future expected increases in cumulative air emissions from utility and other regional air emission sources. Chief among these strategies is the installation of emissions control equipment on existing and new emission sources, including energy generation facilities.

Implementation of the Tailwater Habitat Alternative or Summer Hydropower Alternative is expected to improve air quality and regional visibility because non-emitting generation either would increase or increase in summer months compared to the Base Case. These alternatives would reduce the potential for cumulative air quality effects. Reservoir Recreation Alternatives A and B, the Equalized Summer/Winter Flood Risk Alternative, and the Tailwater Recreation Alternative would adversely affect air quality because emissions from fossil-fuel electric generating units are expected to increase in order to offset the small reduction in total hydropower generation. Most alternatives also would result in a seasonal shift in emissions, resulting in increased emissions in summer, when the atmosphere is more chemically active and air quality problems like ozone levels are more severe. Overall, net annual increases in emissions under Reservoir Recreation Alternatives A and B, the Equalized Summer/Winter Flood Risk Alternative, and the Tailwater Recreation Alternative would be small and would not substantially increase the potential for cumulative impacts related to air quality. The Preferred Alternative is also expected to adversely affect the amount and timing of hydropower generation but to a lesser extent than the other action alternatives, except for the Tailwater Habitat Alternative and the Summer Hydropower Alternative.

Changes in CO_2 emissions were also evaluated as an indicator of potential climate change effects. Under four alternatives (the Preferred Alternative, Reservoir Recreation Alternative A, the Commercial Navigation Alternative, and the Tailwater Habitat Alternative), CO_2 emissions would be slightly reduced. All other alternatives would cause a potential increase in CO_2 emissions, but at very low levels—less than 1 percent of current TVA emissions. To the extent that a relationship exists between CO_2 emissions and climate change, increases or decreases in greenhouse gas emissions caused by implementation of any policy alternative would be so small that they are not likely to result in noticeable or measurable cumulative impacts.

6.2.2 Water Quality

Changes in water quality would directly affect the beneficial use of water in the Valley. Dissolved oxygen and temperature are critical to maintaining suitable habitat for aquatic organisms, including threatened and endangered species. Dissolved oxygen concentrations, the formation of toxic compounds, and the growth of algae are important to aquatic life and can affect water supply treatment costs. Water temperature is important to sport fisheries and the operation of power plants. Cumulative impacts on water quality could occur in several ways. These include the interaction of water quality changes caused by watershed development and changes in the reservoir operations policy, the potential for accumulated downstream change in water quality within the TVA system, and changes in the Valley-wide amount of reservoir or tailwater areas with anoxic conditions. Land use changes within the watershed, as well as uses of water that add nutrients and other pollutants to reservoir water, can reduce DO and increase temperature.

The interaction between future trends in water quality resulting from watershed development and changes in TVA's system-wide reservoir operations policy is difficult to predict. Future water quality throughout the Valley would depend largely on political, regulatory, and economic factors that cannot be reliably or reasonably predicted. Increased population growth would likely increase development pressure in the watershed, resulting in higher levels of nutrients and sediment loading to the TVA system. This would likely be balanced, in part, through water quality regulatory programs—including the development and implementation of targeted water quality improvement plans, such as TMDLs. These programs are expected to improve water quality in impaired segments by reducing inputs of pollutants over time.

Within reservoir systems, decreasing water quality in a downstream direction can result when releases from one dam result in worse conditions in a downstream reservoir than might otherwise occur. The following discussion focuses on the development of low concentrations of DO (anoxia) and related water quality issues, such as levels of manganese, ammonia, and nutrients, because this is the primary impact on water quality predicted by TVA's analyses.

The potential for cumulative impacts from low DO (anoxia) accumulating in a downstream direction has been considerably reduced by TVA's implementation of measures to increase oxygen in waters below hydropower dams. Starting in the 1980s, under its Reservoir Release Improvement (RRI) Program, TVA developed methods to increase oxygen in the water below hydropower dams. These methods included auto-venting turbines, surface water pumps, oxygen injection systems, aerating weirs, and blowers. In 1991, under the Lake Improvement Plan, TVA adopted efforts to increase DO concentrations in the releases from 16 dams using these techniques (see Appendix A, Table A-05). TVA also committed to provide minimum flows from a number of dams.

Water quality improvements resulting from the RRI have resulted in increases in the number and diversity of fish and aquatic insects in the tailwaters at Apalachia, Blue Ridge, Boone, Chatuge, Cherokee, Douglas, Fontana, Fort Patrick Henry, Hiwassee, Norris, Nottely, South Holston, Tims Ford, and Watauga Reservoirs. These are tributary reservoirs. TVA is committed to not reversing any of the improvements that have been made under the RRI Program and to maintaining the DO targets and minimum flows established in the Lake Improvement Plan.

The RRI Program improvements have effectively reduced and mitigated the potential for cumulative water quality problems related to anoxia accumulating or growing in a downstream direction by improving the DO balance at points along the major tributary rivers and on the upper mainstem. Under some of the alternatives, however, the potential exists for cumulative water quality impacts along the lower mainstem reservoirs. Under all of the action alternatives, except the Commercial Navigation Alternative, there is the potential for cumulative impacts related to anoxia in the waters of the mainstem reservoirs. The Commercial Navigation Alternative would maintain sufficient flow through the reservoir system to avoid such cumulative impacts. The Summer Hydropower Alternative and Preferred Alternative would also provide sufficient flows to reduce cumulative impacts on DO, except during dry years when the potential for cumulative impacts would increase during a few weeks in late July and August compared to the Base Case.

TVA's Preferred Alternative was designed in part to address the residence time of waters in the reservoirs and thereby reduce the volume of anoxia in reservoirs compared to other alternatives that would enhance recreation. The Preferred Alternative includes somewhat higher system minimum flows through mainstem reservoirs in June, July, and August than other policy alternatives that would enhance recreation in order to reduce these potential anoxic conditions. Nevertheless, water quality modeling indicated that anoxic conditions occurring seasonally in some representative mainstem reservoirs under the Preferred Alternative would worsen in the reservoirs and in some dam releases as compared to the Base Case.

For mainstem reservoirs, modeling indicates that the predicted magnitude of changes in anoxia under the Preferred Alternative was generally smaller than almost all other action alternatives. The potential does exist, however, for increased cumulative anoxic conditions in the lower mainstem reservoirs during dry years for a limited time under the Preferred Alternative.

A final potential cumulative impact on water quality is the change in the total system-wide volume of anoxic water. Such changes could affect the diversity of aquatic habitats by producing a directional change in the suitability of aquatic habitat within the system. Water quality modeling results for representative reservoirs indicate that all the policy alternatives, except for the Summer Hydropower Alternative and Commercial Navigation Alternative, would increase the total volume of anoxic water in the TVA system. The Preferred Alternative would reduce this potential cumulative impact compared to some of the action alternatives but would not eliminate it.

6.2.3 Water Supply

Although demand on water supply would increase for a variety of uses in the Valley through 2030, all of the alternatives would satisfactorily meet future water demand, and no materially adverse cumulative impacts are expected. The reservoir operations policy alternatives do differ in terms of water supply delivery costs. The Commercial Navigation Alternative and Summer Hydropower Alternative would yield adverse and substantially adverse impacts, respectively, related to water supply delivery costs. No other factors systematically affecting water supply delivery costs in the Valley were identified, and no resultant cumulative impacts on water supply delivery costs are expected under any alternative.

Some alternatives may result in increased anoxia in certain reservoirs, and water treatment costs would increase from the need to address soluble iron and manganese. The only other factor identified with a potential future impact on treatment costs was changing regulatory standards. Changing standards and their treatment cost implications could potentially interact with impacts of operational changes to produce a small cumulative impact at certain water treatment facilities under Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Preferred Alternative, and the Tailwater Habitat Alternative.

6.2.4 Aquatic Resources

Each action alternative would result in variable effects on aquatic resources throughout the reservoir system. Changes in water quality variables, including DO and temperature, would affect the quality and suitability of aquatic habitat in a different manner in each reservoir type. Reservoir sport fish would experience the most potential benefits under the Summer Hydropower Alternative, the Commercial Navigation Alternative, or the Tailwater Recreation Alternative. The Preferred Alternative is anticipated to benefit tributary reservoir and cool/cold tailwater sport fish. Small and variable changes are anticipated in mainstem reservoir biodiversity, warm and cool-to-warm tailwaters, and commercial fishing—resulting in little potential for cumulative effects.

Implementation of Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Equalized Summer/Winter Flood Risk Alternative, or the Commercial Navigation Alternative would result in minor effects on aquatic resources and thus would have little potential for additional cumulative impact. TVA has instituted programs to improve biodiversity through selected improvements in water quality.

The primary potential cumulative impact on aquatic resources would result from alternatives that would increase water retention times in reservoirs. Increased residence time lowers water quality in summer and fall, and reduces spring flows in the mainstem reservoirs. Commercial fisheries in reservoirs would experience adverse effects under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Equalized Summer/Winter Flood Risk Alternative, and the Tailwater Habitat Alternative due to increased amounts of water with low DO concentrations. Generally, impacts on commercial fisheries would be concentrated on mussels, as commercial fish species are mobile and can escape decreasing water quality conditions as long as other suitable habitat is available. The long-term effect of these changes is anticipated to be variable, as water temperatures in some dam releases would limit the effectiveness of TVA programs intended to improve biodiversity.

The Preferred Alternative would reduce the potential for cumulative effects on commercial fish. Under this alternative, flows through the mainstem reservoirs would be maintained at levels slightly lower than under the Base Case during summer and early fall. Under the Preferred Alternative, no change is projected for commercial mussels. Commercial fish species in some areas would slightly benefit; in other areas, reservoir habitat conditions (DO concentrations) would decline slightly.

6.2.5 Wetlands

Wetlands are extensive in the TVA reservoir system and are experiencing a minor but continuous decline that is expected to continue under the existing reservoir operations policy. This decline is cumulative because wetland succession, a slowly evolving process, is not maintaining present wetland diversity and function. Through the SMI and its permitting authority under the TVA Act, TVA manages impacts on development of shoreline water-use facilities, and federal regulation (the Clean Water Act) requires mitigation for disturbance of jurisdictional wetlands. To some extent, both of these programs would reduce the potential for long-term cumulative impacts resulting from interactions between changes in the TVA reservoir system operations policy and other impacts on wetlands resulting from construction and development in the Valley.

The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would result in an overall decrease in availability of water to wetlands during the growing season, isolating these wetlands from their most prevalent source of water. This would result in negative impacts on both wetland extent and type, including substantial adverse effects on scrub/shrub and forested wetlands around tributary reservoirs. Because of the geographic extent and importance of some wetland resources, this could constitute an adverse cumulative impact on scrub/shrub and forested wetlands; but these changes may be partially offset by cumulative increases in the coverage of other wetland types.

Implementation of Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, or the Preferred Alternative would increase the availability of water to wetlands but could result in overall negative effects on wetlands. These alternatives would likely increase the formation of new wetlands but potentially would result in conversion and replacement of existing wetland types (e.g., scrub/shrub to emergent wetlands and forested wetlands to scrub/shrub), and would result in other adverse effects on existing wetland functions. Some wetland habitats would be converted in a way that would make recovery a long process or unlikely (e.g., loss of forested wetlands and loss of buttonbush swamps). Because of the geographic extent and importance of these wetland resources, this could constitute a substantial adverse cumulative impact. Under the Preferred Alternative, potential impacts on wetlands have been substantially reduced compared to the other action alternatives; but there could still be an adverse cumulative impact on wetland resources in the Tennessee Valley region. To the extent practicable, potential impacts on wetlands may be mitigated using the approaches described in Chapter 7, thereby reducing their potential for long-term cumulative impacts. The effectiveness of the mitigation measures may be limited, however, and long-term cumulative impacts could continue.

6.2.6 Terrestrial Ecology

TVA evaluated lowland and upland plant and wildlife communities in areas along TVA reservoirs and tailwaters. The analysis found that these communities have adapted to the current operations of the water control system. Long-term changes in these communities are expected as a result of natural succession and changes in wetlands (see wetland discussion above), and from other construction and development activities as well as recreational pressures. These impacts would be slow and may be offsetting; therefore, broad cumulative effects may not occur. Cumulative effects are possible, at least in the short term, on shorebirds and migratory waterfowl and the plant communities of flats habitats—in addition to the potential loss of control of gravity-maintained dewatering units on wildlife refuges on affected reservoirs. Impacts would be of greatest concern if they occurred during critical migratory periods. Cumulative effects may result from adverse impacts on managed areas and wetland habitats—both important habitats for these bird populations. The Preferred Alternative and the Commercial Navigation Alternative are expected to result in a lower level of impacts on plant and animal populations than the other action alternatives; however, impacts under both these alternatives would be greater than those observed under the Base Case. Due to the instability of reservoir levels and the projected negative changes in wetland communities, the Summer Hydropower Alternative would result in the most extensive adverse cumulative impacts on the terrestrial ecology of the region.

6.2.7 Vector Control

The annual cycle of reservoir mosquito populations is a long-term, persistent issue throughout the Valley. The mosquito is a pest species with disease-transmission potential, and management to minimize mosquito populations is ongoing in the region. Management programs and natural variation in the availability of breeding habitat are expected to control mosquito populations at existing levels, and cumulative impacts are unlikely. Implementation of any action alternative, except the Summer Hydropower Alternative or the Commercial Navigation Alternative, is expected to increase the availability of mosquito breeding habitat—allowing some potential increase in mosquito populations. These increases would be small and are not expected to be cumulative. (See Chapter 7 for potential mitigation actions.)

6.2.8 Threatened and Endangered Species

A number of federal- and state-listed threatened and endangered species inhabit areas in and adjacent to the reservoirs and stream reaches of the water control system. Most of these species are found in aquatic habitats, including warm tributary tailwaters, flowing mainstem reaches, some pooled reservoirs, and some cool-to-warm tributary tailwaters. As indicated by their classification as threatened and endangered, many of these species are in a state of long-term decline and require protection. Plans to protect their habitat and assist in their recovery have been implemented for some species and are being developed for others. Cumulative impacts on such species are usually related to further degradation of habitat from development and disturbance.

Because construction of new facilities and additional land disturbance are not proposed under any policy alternative, direct or incremental cumulative impacts on terrestrial habitat would not occur. Changes to reservoir operations under policy alternatives may alter reservoir levels, water flows, and some water quality parameters—especially temperature and DO. These changes have the potential to result in adverse impacts on federal-listed threatened and endangered species; however, the level of impact would be small and not enough to jeopardize the continued existence of these species. Potential cumulative impacts on federal-listed species should be reduced because the Endangered Species Act requires that federal agencies not take actions that would jeopardize the continued existence of listed species and prohibits the "taking" of listed species by individuals.

6.2.9 Managed Areas and Ecologically Significant Sites

Managed areas and ecologically significant sites are designated to protect and manage sensitive resources that are typically linked with wetlands, bottomland hardwood forests, and other important habitats. As protected areas, they are managed to preserve the resource value for which they were designated. TVA's evaluation of these areas did not identify long-term trends in their condition. Implementation of either the Summer Hydropower Alternative or the Equalized Summer/Winter Flood Risk Alternative would likely cause some adverse impacts on a number of areas. Implementation of any of the other policy alternatives, including the Preferred Alternative, would result in slightly adverse to slightly beneficial impacts on managed areas. Because of the minimal nature of these changes and because these areas are affirmatively protected, future cumulative impacts are unlikely.

6.2.10 Shoreline Erosion

TVA's evaluation found that natural erosion processes (rain, wind, runoff, and streamflow), recreational boating, fluctuating reservoir levels, and shoreline land development would continue the present trend of erosion of reservoir and tailwater shorelines. TVA management programs may reduce these rates in some areas, while increased recreational activities and land development may increase erosion in other areas. The contribution of land development to overall cumulative impacts would be limited, as the SMI is designed to limit the maximum extent of residential shoreline development to 38 percent or less. The continuing effects of shoreline erosion may include further loss of shoreline habitat, changes to water quality, and impacts on cultural resources and visual integrity. Together, these impacts could be considered cumulative.

Implementation of Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, or the Tailwater Habitat Alternative has the potential to substantially increase reservoir shoreline erosion system wide, with more extensive impacts on the tributaries than on the mainstem reservoirs. These alternatives would result in potential adverse impacts that, together with erosion of backlands and land development, may result in some cumulative erosion impacts. Shoreline erosion resulting from changes in the operations policy is expected to be a minor contribution to total land erosion. These potential impacts may be mitigated using the approaches described in Chapter 7, thereby avoiding or reducing their potential for long-term cumulative effects.

In contrast, the Summer Hydropower Alternative and Equalized Summer/Winter Flood Risk Alternative would substantially decrease shoreline erosion, resulting in cumulative beneficial effects on shoreline erosion. The Commercial Navigation Alternative is expected to have little impact on shoreline erosion. The Preferred Alternative would result in minor increases in erosion, contributing in a small way to adverse cumulative impacts.

6.2.11 Cultural Resources

The integrity of cultural resources (archaeological sites and historic structures) is affected by a number of factors directly and indirectly related to the reservoir operations policy, resulting in the potential for cumulative effects. These factors include soil erosion by rainfall, streamflow, and wave action from wind and recreational boat traffic; exposure by elevation fluctuations; development of the shoreline and back-lying lands; changes to the viewshed; and looting/vandalism or disturbance from recreational activities. TVA's evaluation of cultural resources found that ongoing shoreline land development and shoreline erosion are expected to continue long-term potentially cumulative adverse impacts on the integrity of cultural resources on shoreline and near-shore reservoir bottom areas. These impacts are anticipated to occur regardless of the reservoir operations policy alternative selected.

Implementation of Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, the Tailwater Habitat Alternative, or the Preferred Alternative would cause additional adverse impacts—which would increase the potential for cumulative impacts compared to the Base Case. Among the preceding alternatives, the potential for cumulative impacts would be least under the Preferred Alternative. Potential adverse impacts would be reduced using the approaches described in Chapter 7, thereby reducing their potential for long-term cumulative effects.

Because they would reduce shoreline erosion, the Commercial Navigation Alternative, Summer Hydropower Alternative, and Equalized Summer/Winter Flood Risk Alternative would result in neutral to beneficial impacts on cultural resource sites and would reduce the potential for long-term adverse cumulative effects.

6.2.12 Flood Control

Requirements for storage of flood waters in TVA reservoirs to minimize flood damage during flood events were determined from evaluation of potential floodflows, based on a 99-year historical record and additional consideration of very large storm events. Except for the Base Case, detailed analyses indicated that all of the action alternatives evaluated in the DEIS would result in unacceptable increases in the risk of flooding at one or more critical locations in the Valley. A central component in formulating the Preferred Alternative was risk of flood damages. By modifying individual project flood guides and/or regulating zones, the overall potential for increased flood damage was reduced immediately downstream from each project as well as downstream at damage centers.

Extensive land development has the potential to change the volume and rate of runoff from rainfall in the Tennessee River basin. Localized areas of rapid development could result in changes to local runoff characteristics. The changes in basin-wide land use anticipated through 2030, however, are not expected to result in watershed runoff characteristics that would change the outcome of future flood events. Therefore, no cumulative impacts related to flood risk are expected under the Preferred Alternative.

6.2.13 Visual Resources

Cumulative impacts on visual resources of the TVA reservoir system could result from interaction among shoreline erosion, shoreline development, and the effects of a reservoir operations policy that may interact to degrade scenic integrity. Continued development along TVA reservoirs and tailwaters would generally affect scenic quality regardless of the policy alternative implemented. Development standards and controls may reduce such impacts, but continued development of shorelines would result in visual resource impacts that are considered unavoidable and cumulative. Scenic quality is also affected by shoreline erosion and the exposure of reservoir bottoms during periods of lower reservoir pool levels, but this is already occurring under the existing operations policy.

The interplay among these variables produces little potential for cumulative impacts on visual resources under any alternative because the directions of the impacts do not correspond. For example, the Tailwater Habitat Alternative—the alternative with the highest potential for increasing shoreline erosion and related impacts on visual integrity—also would result in a substantially beneficial effect on scenic integrity due to longer duration at higher pool levels and less fluctuation in pool levels. Except for the Summer Hydropower Alternative and the Equalized Summer/Winter Risk Alternative, all of the action alternatives, including the Preferred Alternative, were found to benefit scenic quality by reducing the size of the shoreline ring effect and amount of exposed reservoir bottoms.

The Summer Hydropower Alternative has the greatest potential to cause cumulative adverse effects on visual resources because it would generally result in the greatest exposure of reservoir bottoms, flats, and the shoreline ring throughout the reservoir system.

6.2.14 Recreation

Recreation and use of recreation resources are generally expected to increase in the future, in relation to regional population growth. All action alternatives except the Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative would result in increased recreational use, primarily as a result of higher reservoir levels or more predictable tailwater releases. Increases in recreation use under Reservoir Recreation Alternative A, Reservoir Recreation Alternative B, the Tailwater Recreation Alternative, or the Tailwater Habitat Alternative would be greater than under the Summer Hydropower Alternative or Preferred Alternative. The Preferred Alternative is expected to enhance recreation uses but to a lesser extent than the other alternatives that would enhance recreation use. The Summer Hydropower Alternative and the Equalized Summer/Winter Flood Risk Alternative are expected to reduce recreation use due to reduced summer and fall reservoir levels and tailwater flows, and could contribute to adverse cumulative effects on recreation uses.

6.3 Cumulative Impacts Associated with Future Projects

The preceding future trends discussion addresses the cumulative impacts that could result from implementing various operations policy alternatives and activities generally occurring throughout the TVA region. At the regional level, specific projects or actions could contribute to cumulative effects.

6.3.1 Identification of Future Projects

A three-step process was used to identify future projects to be included in the cumulative impact analysis. This process included:

- **Identification of Reasonably Foreseeable Projects (Actions).** Candidate projects were identified by reviewing published notices related to the preparation of environmental documents. The USEPA clearinghouse for NEPA compliance and state agency administrative dockets for the period from 1995 to 2002 were searched for: Notices of Intent to Prepare an Environmental Review, Notices of Availability of Draft and Final Environmental Documents, Findings of No Significant Impact, and Notices of No Practical Alternative to Impacting Wetlands or Floodplains. These lists were searched to identify reasonably foreseeable projects with potential cumulative effects in the Tennessee River watershed. This search identified 161 listings, which were reviewed and evaluated for their relevance. From this review, 31 candidate projects were selected based on their location, size, and status.

- **Review of Candidate Cumulative Projects.** Abstracts for candidate projects were reviewed and evaluated to determine whether a project met criteria for potential regional cumulative impact. Projects were considered that had been approved and not yet implemented or constructed, and projects for which a notice to proceed with environmental review had been issued. Projects in construction or that had completed construction but not yet begun operation were also considered. Projects being discussed but for which no action had yet been taken were considered speculative and were not included.

- **Selection of Projects for Cumulative Analysis.** Based on the scope, status, and potential cumulative effect of those projects reviewed, TVA selected the following projects for evaluation of potential cumulative effects:

- TVA land management plans
- Other land development programs
- U. S. Forest Service land and resource management plans
- TVA hydro modernization projects
- Hydroelectric projects licensed by the Federal Energy Regulatory Commission (FERC)

The specific projects identified for cumulative impact analysis are listed in Table 6.3-01. This table also summarizes the types of impacts that may be associated with each project.

6.3.2 Cumulative Impacts Associated with TVA Land Management Plans

TVA has developed and implemented reservoir land management plans (LMPs) for the areas surrounding a number of its reservoirs. To the extent these plans have been adopted and implemented by TVA, they were considered part of the existing environment and were included in the Base Case.

As part of the review of future projects, plans for 13 TVA reservoirs were identified (see Table 6.3-01). These plans include management of areas ranging from 66,651 acres at Kentucky Reservoir and 40,236 acres at Guntersville Reservoir to 880 acres on Boone Reservoir and 2,578 acres on Melton Hill Reservoir. Generally, these are multi-use plans designating areas for resource conservation and management, and for residential and commercial/industrial access and development. In all of the LMPs, except those for Kentucky and Wheeler Reservoirs, approximately 75 percent of the TVA land evaluated by the reservoir land planning process has been allocated for resource management and conservation. Allocations for specific uses have not yet been made in the Kentucky and Wheeler Reservoir plans. To the extent that the development occurs along reservoir shorelines, it was included in the SMI assessment of maximum buildout (see Section 4.15, Land Use). In addition, adopted SMI policies, including amendments to TVA's Section 26a permitting regulations, would substantially reduce the potential for cumulative impacts. Although implementation of the LMPs would result in some loss of habitat, these plans also would provide a cumulative increase in the availability of regional recreational facilities and enhanced protection of natural resources, including sensitive resources.

Table 6.3-01 Summary of Projects Included in the Cumulative Analysis

No.	Project	Description of Location	Resources Affected
1	Guntersville Reservoir Land Management Plan	Land Management Plan for 40,236 acres on Guntersville Reservoir. The plan includes 5,079 acres for project operations, 32,584 acres for resource management and conservation, 327 acres for industrial access or commercial use, 1,704 acres for recreational uses (such as campgrounds and parks), and 543 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
2	Tellico Reservoir Land Management Plan	Land Management Plan for 12,643 acres of TVA land on Tellico Reservoir. The plan designates 635 acres for project operations, 9,320 acres for resource management and conservation, 332 acres for industrial access or commercial use, 1,804 acres for recreational uses (campgrounds, parks, and public access areas), and 552 acres for residential lake access. Also includes designation of greenway and river corridor areas for resource protection.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
3	Tims Ford Reservoir Land Management Plan	Land Management Plan for 6,453 acres of state and federal lands on Tims Ford Reservoir. The plan designates 386 acres for project operations, 4,573 acres for resource management and conservation, 67 acres for industrial/commercial development, 573 acres for recreational uses (campgrounds, parks, and public access areas), and 864 acres for residential access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources

Table 6.3-01 Summary of Projects Included in the Cumulative Analysis (continued)

No.	Project	Description of Location	Resources Affected
4	Boone Reservoir Land Management Plan	Land Management Plan for 880 acres of TVA land on Boone Reservoir. The plan designates 209 acres for project operations, 594 acres for resource management and conservation, 76 acres for recreational uses (campgrounds, parks, and public access areas), and 1 acre for residential access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
5	Melton Hill Reservoir Land Management Plan	Land Management Plan for 2,578 acres of TVA land on Melton Hill Reservoir. The plan designates 294 acres for project operations, 1,890 acres for resource management and conservation, 22 acres for industrial/commercial development, 221 acres for recreational uses (campgrounds, parks, and public access areas), and 151 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
6	Bear Creek Reservoirs Land Management Plan (Upper Bear Creek, Bear, Little Bear Creek, and Cedar Creek Reservoirs)	Land Management Plan for 9,178 acres of TVA land on the four Bear Creek Reservoirs. The plan designates 851 acres for project operations, 7,456 acres for resource management and conservation, 14 acres for industrial/commercial development, 616 acres for recreational uses (campgrounds, parks, and public access areas), and 241 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources

Table 6.3-01 Summary of Projects Included in the Cumulative Analysis (continued)

No.	Project	Description of Location	Resources Affected
7	Norris Reservoir Land Management Plan	Land Management Plan for 27,927 acres of TVA land on Norris Reservoir. The plan designates 934 acres for project operations, 23,776 acres for resource management and conservation, 1,744 acres for recreational uses (campgrounds, parks, and public access areas), and 1,473 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
8	Cherokee Reservoir Land Management Plan	Land Management Plan for 8,026 acres of TVA land on Cherokee Reservoir. The plan designates 542 acres for project operations, 6,615 acres for resource management and conservation, 601 acres for recreational uses (campgrounds, parks, and public access areas), and 268 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
9	Pickwick Reservoir Land Management Plan	Land Management Plan for 19,238 acres of TVA land on Pickwick Reservoir. The plan designates 2,861 acres for project operations, 13,431 acres for resource management and conservation, 534 acres for industrial/commercial development, 1,327 acres for recreational uses (campgrounds, parks, and public access areas), and 1,085 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources

Table 6.3-01 **Summary of Projects Included in the Cumulative Analysis (continued)**

No.	Project	Description of Location	Resources Affected
10	Chickamauga Reservoir Land Management Plan	Land Management Plan for 12,862 acres of TVA land on Chickamauga Reservoir. The plan designates 337 acres for project operations, 8,653 acres for resource management and conservation, 46 acres for industrial/commercial development, 899 acres for recreational uses (campgrounds, parks, and public access areas), and 2,927 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
11	Watts Bar Reservoir Land Management Plan	Land Management Plan for 11,121 acres of TVA land on Watts Bar Reservoir. The plan designates 586 acres for project operations, 7,394 acres for resource management and conservation, 142 acres for industrial/commercial development, 644 acres for recreational uses (campgrounds, parks, and public access areas), and 2,355 acres for residential lake access.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources
12	Kentucky Reservoir Land Management Plan	The Kentucky Reservoir Land Management Plan designated 66,651 acres for multiple uses. This reservoir has not been allocated into specific zones.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion
13	Wheeler Reservoir Land Management Plan	Wheeler Reservoir Land Management Plan designated 28,004 acres for multiple uses. This reservoir has not been allocated into specific zones.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion
14	Use of Columbia Dam Project Lands	On the Duck River, upstream of the former Columbia Dam site, approximately 13,000 acres of TVA land was transferred to the State of Tennessee for management. Up to 2,000 acres are available for residential development; 3,800 acres for a possible water supply reservoir; remaining acreage was set aside for resource protection, wildlife management, and recreation.	Ecological Resources—direct impacts on resources from development of 2,000 acres but protection of natural resources on remaining 7,200 acres and possibly 3,800 more acres if water supply reservoir not developed Visual Resources – protection of visual resources

Table 6.3-01 Summary of Projects Included in the Cumulative Analysis (continued)

No.	Project	Description of Location	Resources Affected
15	U.S. Forest Service Land and Resource Management Plans	Land and resource management plans are being revised or proposed for the six national forests that are in proximity to the Tennessee Valley. Draft plans for Cherokee and Chattahoochee-Oconee National Forests and all national forests in Alabama, including Bankhead, indicate that a greater emphasis will be placed on forest restoration, recreation, and wildlife while allowable timber harvest acreage will be decreased. The proposed forest plan for Daniel Boone reflects similar goals of improved habitat biodiversity, riparian areas, fire management, and old-growth forest stands while reducing timber harvest volumes. Revision of land management plans for Land between the Lakes and Nantahala/Pisgah are still in the planning stages.	Ecological Resources – protection of natural resources and restoration of habitat biodiversity Aquatic Resources – increased protection of watersheds, reduced sediment loads, and increased abundance of local aquatic species Recreation – increased backcountry recreation, trails and dispersed recreation areas Visual Resources – protection of scenic areas, corridors, and sensitive viewsheds
16	TVA Hydro Modernization Projects	Hydro modernization efforts were initiated in 1992 to upgrade hydropower units in the TVA power system (see Section 3.3.1). Modification projects would address several types of upgrades, including increased efficiency and electrical output, and modifications to improve DO concentrations.	Power – increased generation capacity in the region Water Quality – management of low DO levels in hydro unit discharge Ecological Resources – benefits to downstream habitat from changes in water quality
17	Hydroelectric Projects Licensed by the Federal Energy Regulatory Commission	Hydroelectric projects are now in the relicensing process in the upper Tuckaseegee, Nantahala, and Little Tennessee Rivers. Duke Power's Nantahala Area Projects include the Bryson Project (FERC No. 2601), Dillsboro Project (FERC No. 2602), Franklin Project (FERC No. 2603), Mission Project (FERC No. 2619), East Fork Project (FERC No. 2698), West Fork Project (FERC No. 2686), and Nantahala Project (FERC No. 2692). Tapoco's Tapoco Project (FERC No. 2169) is a four-development hydroelectric project located on the Little Tennessee and Cheoah Rivers in eastern Tennessee and western North Carolina that includes Santeetlah, Cheoah, Calderwood, and Chilhowee.	Land development acreage is limited by SMI policy, with reduced potential for increased erosion Ecological Resources – protection of species/habitat in areas designated for resource management Recreation – increased recreation access and facilities Visual Resources – protection of visual resources

Notes: FERC = Federal Energy Regulatory Commission. SMI = Shoreline Management Initiative. DO = Dissolved oxygen.

Because none of the action alternatives proposes development or preservation of any land areas, direct cumulative impacts of policy alternatives in concert with implementation of TVA LMPs is not expected to occur. To the extent that both implementation of policy alternatives and any of the LMPs would indirectly affect an environmental resource, cumulative effects may occur. The loss of terrestrial and shoreline habitat from development under an LMP and increased impacts on wildlife resources from implementation of a policy alternative may result in a small cumulative effect on wildlife species. Many of these potential cumulative impacts are likely to be reduced by the resource protection benefits of TVA's reservoir LMPs.

6.3.3 Cumulative Impacts Associated with Other Land Development Programs

Continuing development and urbanization throughout the Valley would occur over the planning period. Where and when these activities would occur cannot be predicted, but they are certain to occur in light of population growth trends in the Southeast. In aggregate, this development may result in regional cumulative impacts, such as reduction in habitat, changes in surface water runoff, increased water use, and increased wastewater for disposal. None of the policy alternatives proposes the development of any new facilities; therefore, no direct impacts associated with development and urbanization would occur that could be considered cumulative. In addition, new development that may be expected to occur adjacent to TVA reservoirs has been included as part of the Base Case and was considered in the impact analyses for relevant resources.

The review of future projects identified one large land development program that is located upstream of TVA 's former Columbia Dam site. This 12,800-acre site was transferred to the State of Tennessee for management. Under the State's plan, approximately 2,000 acres are planned for residential development. The remaining area would be primarily set aside for wildlife management. While implementation of this development plan would remove as much as 2,000 acres of natural habitat, it would preserve other natural areas that are very important habitats for a number of sensitive resources, including species listed as threatened or endangered. No materially adverse cumulative impacts are expected to occur from implementation of any policy alternative in concert with this land development program.

6.3.4 Cumulative Impacts Associated with U.S. Forest Service Land Management Plans

Because national forest lands comprise large blocks of undeveloped acreage proximate to the Tennessee Valley region, management plans for nearby forests were reviewed for potential cumulative impacts. These federally managed lands include Cherokee National Forest in Tennessee, Nantahala/Pisgah National Forests in North Carolina, Chattahoochee-Oconee National Forests in Georgia, Bankhead National Forest in Alabama, Daniel Boone National Forest in Kentucky, and Land between the Lakes National Recreation Area in Tennessee and Kentucky.

The National Forest Management Act (NFMA) requires national forests to be managed under forest or land management plans that must be periodically revised. Three of the above national forests (Cherokee; Chattahoochee-Oconee; and all national forests in Alabama, including

Bankhead) are currently undergoing land management plan revisions. This is part of a collaborative effort among five forests to develop a more consistent management approach to improving forest health, productivity, and public enjoyment of national forests in the Southern Appalachians. This new approach to developing forest plans will use the findings of the Southern Appalachian Assessment (USDA Forest Service 1996) to identify common issues and management prescriptions across all Southern Appalachian forests. These common goals will be incorporated into each proposed management plan, along with any unique issues specific to individual forests. Drafts of management plans and DEIS documents for these three forests were released in March 2003; maintaining and restoring healthy forests was identified as the most significant goal of the revised plans (USDA Forest Service 2003a). Although these management documents are still being developed, they include such changes as more focus on ecological habitat protection and restoration, protection of old-growth forests, watershed health, and wilderness benefits while decreasing annual timber harvests. The proposed changes represent a shift from balanced-age timber management to an emphasis on the health of existing forest stands and restoration of forest ecosystems (USDA Forest Service 2003b, 2003c, 2003d).

The Daniel Boone DEIS and Proposed Revised Land and Resource Management Plan that was released in April 2003 reflects a similar shift in goals and management direction, including new prescriptions for habitat biodiversity and riparian areas, reduction in timber harvest volume, better understanding of fire habitat needs, and increased progression to old-growth stands (USDA Forest Service 2003e). New land and resource management plans are proposed to be released in 2004 for Land between the Lakes and in 2008/2009 for Nantahala/Pisgah National Forests. Current trends indicate a positive impact on regional land and water resources from U.S. Forest Service management activities, and no substantial adverse cumulative impacts relating to TVA's proposed action are anticipated.

6.3.5 Cumulative Impacts Associated with Hydro Modernization Projects

TVA is in the process of modernizing its hydropower facilities throughout the water control system. The potential impacts of these activities were addressed in TVA's Energy Vision 2020 EIS (1995). HMOD projects that were designed and funded, implemented, or completed on or before October 2001 are considered in this EIS as part of the Base Case (see Appendix A, Table A-09). The projects considered but not designed or implemented as of October 2001 are considered in the cumulative impacts analysis. These projects are listed in Table 6.3-02. The purpose of the HMOD projects is to increase the effective output and operational flexibility of these units; nevertheless, in most circumstances, an increase in discharge flow rate would occur during operations (as noted in Table 6.3-02).

The direct impact of modernized units would be increased flows. This may cause changes in river hydrology at run-of-river projects during operation of upstream hydropower units. These projects would include the reaches below Wheeler, Ocoee #3, Watauga, Blue Ridge, and Wilbur Reservoirs. The increased flows are not expected to be outside the range of flows that would otherwise occur at these projects; therefore, the direct impacts related to flows would not cumulatively be greater than impacts already assessed in each relevant resource area under the Base Case.

Table 6.3-02 Hydro Modernization Projects Considered in Cumulative Impact Analysis

Power Plant	Status in October 2001	Receiving Water	Planned Changes	Flow Increase
Cherokee (Units 1–4)	Phase 1	Mainstem storage	High efficiency, low flow	Yes
Wheeler (Units 1–8)	Phase 1	Mainstem run-of-river	High efficiency, low flow	Not expected
Wilson (Units 19–21)	Phase 1	Mainstem storage	Increased efficiency/capacity	Expected
Fort Loudoun (Units 1–2)	Not started	Mainstem storage	Increased efficiency/capacity	Mix
Wilson (Units 1–4)	Not started	Mainstem storage	High efficiency	Yes
Wilson (Units 5–8)	Not started	Mainstem storage	High efficiency	Yes
Ocoee #3 (Unit 1)	Not started	Tributary run-of-river	Increased efficiency/capacity	Yes
Nickajack (Units 3–4)	Not started	Mainstem storage	Increased efficiency/capacity	Yes
South Holston (Unit 1)	Not started	Tributary storage	Increased efficiency/capacity	No
Melton Hill (Units 1–2)	Not started	Mainstem storage	Increased efficiency/capacity	No
Watauga (Units 1–2)	Not started	Tributary run-of-river	Increased efficiency/capacity	Yes
Blue Ridge (Unit 1)	Not started	Tributary run-of-river	Increased efficiency/capacity	Yes
Wilbur (Units 1–4)	Not started	Tributary run-of-river	Increased efficiency/capacity	Insignificant

Increased flows for modernized hydropower units discharging to mainstem and tributary storage reservoirs could affect water quality (principally by changes in temperature in the receiving waters). The incremental increase in discharge volume from modernized units would be small when compared to overall discharge volume and would be within the normal range of variation for release volumes, such that water quality is unlikely to be changed and no cumulative impact is likely to result.

Increased power generation capacity would allow production of additional electrical energy with the same amount of water. The TVA reservoir system currently has approximately 3,842 MW of hydropower capacity (not including Raccoon Mountain). Although this capacity would be increased through modernization efforts; actual hydrologic conditions and operations of the water control system in any given year would determine the cumulative increase in electrical production. Because TVA hydropower units are often operated during periods of peak demand, increased electrical output from hydropower production could reduce the requirements for energy from fossil-fired peaking units on the TVA power system. The cumulative effects of this offset could be to displace some peak fossil production. Displacing peak fossil production with incremental hydropower production could reduce air emissions from power production. The incremental offset of fossil generation is likely to be small, however, and would occur only if no long-term increase in overall peak energy growth occurs. It is unlikely that a cumulative reduction in air emissions from incremental hydropower production as a result of modernization would occur.

6.3.6 Cumulative Impacts Associated with Hydroelectric Projects Licensed by the FERC

A number of hydroelectric projects in the Tennessee Valley are operating under licenses authorized by the FERC. Some of these projects are now in the process of being relicensed, a multi-year process that includes engineering and operations review of the project; consultation with relevant federal and state natural resources agencies, Indian tribes, and state water quality agencies; resource studies; and environmental and economic analyses. The process culminates with the submittal of a license application to the FERC, development of a NEPA compliance document (EA or EIS), and a decision by the Commission as to the term and operating conditions of the license. The relicensing process typically results in the issuance of a new license for operation of the project for the next 30 to 50 years under new operating conditions and with new operations and other measures for the protection, mitigation, and enhancement of environmental resources.

Several hydroelectric projects are now in the relicensing process in the upper Tuckaseegee and Nantahala Rivers, two major tributaries of Fontana Reservoir, and in the Little Tennessee River downstream of Fontana Reservoir.

- **Nantahala Area Projects.** Duke Power is relicensing its Nantahala Area projects, including 10 hydroelectric stations and 12 reservoirs on the Hiwassee, Nantahala, Oconaluftee, and Tuckasegee Rivers in western North Carolina. These include the Bryson Project (FERC No. 2601), Dillsboro Project (FERC No. 2602), Franklin Project (FERC No. 2603), Mission Project (FERC No. 2619), East Fork Project (FERC No. 2698), West Fork Project (FERC No. 2686), and Nantahala Project (FERC No. 2692).

- **Tapoco Project.** Tapoco, a division of the Alcoa Power Generating Inc (APGI), is relicensing its Tapoco Project (FERC No. 2169), a four-development hydroelectric project located below Fontana Reservoir on the Little Tennessee and Cheoah Rivers in eastern Tennessee and western North Carolina. The four developments that comprise the project are Santeetlah, Cheoah, Calderwood, and Chilhowee.

These hydroelectric projects are well along in the licensing process, and the licensing process for these projects has included the development of draft settlement agreements with the resource agencies and other participants. These settlement agreements are not yet finalized, and the FERC must make its own independent analysis and issue the licenses. Based on the draft settlement agreements to date and the history of recent relicensing process at other hydroelectric projects, the new licenses for the Nantahala Area and Tapoco Projects would likely contain protection, mitigation, and enhancement measures. These would include such measures as improvement and enhancement of recreational access and opportunity, new minimum flows that would improve aquatic habitat and benefit fish and wildlife, protection of historical and cultural resources, and other environmental enhancements. Consequently, the relicensing of these projects would contribute in a positive way to beneficial cumulative impacts.

Duke Power and Tapoco projects are both located in the headwaters of the TVA region, and their total water storage volume is very small relative to the TVA reservoir system. Due to their size and location, there is limited potential for adverse cumulative effects on TVA's operations or flood risk.

Chapter 7

Potential Mitigation Measures

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7.1. Introduction

The National Environmental Policy Act and its implementing regulations require that an EIS identify appropriate mitigation measures for the adverse impacts potentially resulting from a proposed action. Mitigation measures are actions that could be taken to avoid, offset, reduce, or compensate for adverse effects to the environment.

The purpose of this chapter is to describe the programmatic framework within which mitigation measures would be implemented and to identify and describe the mitigation measures that TVA may implement if the Preferred Alternative is implemented. After issuance of the FEIS, reviewing public comments on the FEIS, and a decision from the TVA Board, TVA will identify those mitigation measures to be implemented in its Record of Decision for this action.

MITIGATION

NEPA defines mitigation as actions taken to avoid, reduce the severity of, or eliminate an adverse impact. Mitigation can include:

- Avoiding impacts;
- Minimizing impacts by limiting the degree or magnitude of the action;
- Restoring or rehabilitating the affected environment;
- Reducing or eliminating impacts over time; and,
- Compensating by providing offsetting resources or environments.

Because the ROS is a programmatic action that takes place over a multi-state region covering the entire integrated reservoir system, TVA's mitigation approach also is appropriately scaled to a programmatic, reservoir-system level. TVA will rely heavily on its existing resource management programs to detect and track environmental changes that may occur and to implement identified mitigation measures.

This chapter is organized into three parts. Section 7.2 describes the need and context for a programmatic approach to mitigation. Section 7.3 presents an overview of TVA's management programs, which provide a framework for mitigation, monitoring, reporting, and enforcement. Section 7.4 describes the steps that TVA has taken during development of the Preferred Alternative to avoid and minimize environmental effects. That section also outlines the actions TVA may take to detect and track environmental changes and to mitigate adverse resource impacts if the Preferred Alternative is implemented.

7.2. Programmatic Approach to Mitigation

Mitigation for a policy action differs considerably from mitigation for a specific project. This is especially true for an operations policy that affects a large geographic area and the large number of waterbodies in the TVA reservoir system. In contrast with project-specific impacts, which may be readily delineated and quantified, some policy impacts can be diffuse, difficult to predict, may or may not occur as anticipated, and may develop over a long period of time. The prediction of environmental impacts, always an inexact science, is even more difficult for large-scale actions such as reservoir operations. Consequently, monitoring and an adaptive response can be important components of a programmatic mitigation plan.

TVA's reservoir operations policy permits an adaptive response that has included substantial monitoring of environmental parameters, evaluation of ongoing environmental impacts, and mitigation of impacts. Under the Reservoir Release Improvement (RRI) Program, TVA has restored concentrations of DO in over 300 miles downstream of 16 projects. TVA has also established minimum flow requirements at 25 sites. Required structural modifications were completed in 1996, but ongoing operational aspects of the program could be modified to help mitigate low DO concentrations and flow problems in project releases.

In addition, the numerous statutes and implementing regulations that are presented in Chapter 4, Description of Affected Environment, can substantially affect the impacts relating to alternative reservoir operations policies. Chapter 5, Environmental Consequences of the Alternatives, provides the impact analysis and conclusions concerning compliance with these regulations and statutes; these are summarized in this chapter, as appropriate.

7.3. TVA Management Programs—Providing a Framework for Mitigation

TVA has developed numerous policies and programs to protect and enhance natural resources; these programs are the logical institutional framework for implementing mitigation actions. TVA presently manages and administers a wide variety of programs, initiatives, public outreach, and other individual measures designed to monitor, protect, maintain, and enhance the quality of the environment within the TVA reservoir system (Table 7.3-01). These activities range from monitoring programs such as the Vital Signs Reservoir Ecological Health Monitoring Program, to the development of reservoir land management plans and implementation of the Clean Water Initiative. As impacts are identified, existing TVA programs can be changed to better address substantive adverse impacts. Table 7.3-01 outlines a number of TVA program elements and activities relevant to monitoring and mitigation activities. These programs and activities were considered in the development of mitigation measures for the Preferred Alternative.

Table 7.3-01 TVA Program Elements and Activities Relevant to Mitigation

TVA Program or Activity	TVA Programs and Activities Relevant to Mitigation Strategies
Section 26a permitting process – Requires obtaining TVA approval before putting obstructions on or along Tennessee River system	• This process addresses construction, maintenance, and operation of facilities and activities on, over, or along the Tennessee River and its tributaries. This includes residential shoreline structures, non-navigable houseboats, and intakes and outfalls. • TVA Watershed Teams are responsible for implementation of Section 26a. • Permit recipients are required to follow the construction procedures and environmental protection measures specified. • For non-routine projects or actions, Environmental Assessments (EAs) or Environmental Impact Statements (EISs) are completed in addition to the Section 26a permitting process.
Reservoir Land Management Planning – Defines allowable areas for residential, commercial, and industrial shoreline development on TVA property	• Land Management Plans (LMPs) are approved by the TVA Board of Directors and implemented by the Watershed Teams. • Each LMP includes provisions for shoreline management, land use, protection, and monitoring. The whole reservoir is considered in the plan. • Each LMP is developed with extensive interagency and public review.
Reservoir Release Improvement Program – TVA's Program, completed in 1996, to improve dissolved oxygen (DO) and increase water levels in tailwaters from minimum flows	• TVA uses a wide range of methods to improve DO concentrations. In some cases, more than one approach is necessary to reach oxygen targets (6 milligrams per liter of water in cold-water tailwaters, and 4 milligrams per liter in warm-water tailwaters), which include turbine venting, surface water pumps, oxygen injection systems, aerating weirs, and air compressors and blowers. • TVA uses three different technologies to maintain minimum water level in the riverbed below tributary dams, including turbine pulsing, weirs, and small hydroelectric units.

Table 7.3-01 TVA Program Elements and Activities Relevant to Mitigation (continued)

TVA Program or Activity	TVA Programs and Activities Relevant to Mitigation Strategies
Vital Signs Reservoir Ecological Health Monitoring Program – TVA's program to systematically monitor the ecological condition of its reservoirs	• This monitoring program provides the necessary information from five key indicators (chlorophyll-a, DO, fish assemblage, benthic macroinvertebrates, and sediment contaminants) to evaluate conditions in reservoirs and to target detailed assessment studies if significant problems are found. In addition, this information establishes a baseline for comparing future water quality conditions in TVA's reservoirs. • TVA monitors ecological conditions at 69 sites on 31 reservoirs. Each site was monitored initially for 4 to 5 consecutive years to establish baseline data. Monitoring continues on an every-other-year basis unless a substantial change in the ecological health score occurs during a 2-year cycle. If that occurs, the site is monitored the next year to confirm that the change was not temporary. Roughly half the sites are sampled each year on an alternating basis. • In 1999, TVA began physical and chemical water quality monitoring annually on 32 reservoirs at 59 locations. Physical and chemical water quality monitoring is conducted monthly from April through September on mainstem reservoirs and from April through October on tributary reservoirs. Sampling includes temperature, DO, pH, and conductivity profiles; and photic zone composite samples for chlorophyll and nutrients (Total P, NH_3, NO_x, organic N, TKN, TSS, and TOC). • TVA performs biological sampling (fish and/or benthic macroinvertebrates) of tailwaters for 18 tailwaters at 47 sites. Reservoir fish and benthic assemblages are sampled once in late fall/early winter. The condition of these biological communities is evaluated using multi-metric indices. Sediment samples are collected in July or August of each year and analyzed for PCBs, pesticides, and metal contaminants. The monitoring program is based on sampling protocols following EPA Level III fish and Level III benthic bioassessment protocols.
Shoreline Management Policy – A comprehensive management policy developed out of the Shoreline Management Initiative that controls residential development along TVA reservoir shorelines	• TVA Watershed Teams are responsible for implementation of the Shoreline Management Policy. • The goal is to balance shoreline development, recreation use, and resource conservation needs. • Under this policy, a Residential Access Shoreland Inventory is being conducted, which includes an ongoing baseline inventory of resource conditions along TVA-owned residential access shoreland and flowage easement shoreland. Residential shoreline is placed into at least three categories: shoreline protection, residential mitigation, and managed residential. • New construction of residential water use facilities on waterbodies is limited to 1,000 square feet. • Shorelands not open for residential development can be opened only if offset by closing other shorelands that are open to residential development (a maintain-and-gain policy). • A 50-foot shoreline management zone (or greenbelt) is retained on TVA land that adjoins newly developed residential areas where practicable.

Table 7.3-01 TVA Program Elements and Activities Relevant to Mitigation (continued)

TVA Program or Activity	TVA Programs and Activities Relevant to Mitigation Strategies
Shoreline Management Policy (continued)	• Vegetation Management Plans are required for new developments under this policy and are designed to improve or enhance the vegetative cover of the property. Use of native vegetation is encouraged. • Best management practices for the construction of docks, management of vegetation, stabilization of shoreline erosion, and other shoreline alterations are promoted to protect water quality.
Shoreline Treatment Program – A program for rating the condition of shorelines within TVA reservoirs and identifying those to be restored through stabilization and revegetation	• TVA has conducted Shoreline Condition Assessments on all TVA reservoir shorelines. These assessments rate the shoreline conditions based on two parameters: erosion condition and vegetation condition. Shorelines are rated as good, fair, or poor based on the combined score for the two parameters. Each year, TVA selects 35 to 40 sites (approximately 8 miles of reservoir shoreline) that are rated as poor to be restored through stabilization and revegetation. The shoreline rating criteria, used to rank potential sites in order of treatment priority, provides a higher rating to those sites where archaeological resources are threatened, all other criteria being equal.
Hydro Automation Program – A TVA Program to automate the control of TVA's hydropower generating units	• The Hydro Automation Program will link a majority of all 109 units to a centralized computer system so turbines can be managed individually on a system-wide scale.
TVA's Natural Areas Programs – TVA's cooperative management of publicly owned lands with significant natural features.	• In managing the publicly owned land in and around its facilities and reservoirs, TVA has developed a land use designation system under which 82 sites on 10,700 acres have been classified as TVA natural areas. The sites are identified as habitat protection areas, small wild areas, ecological study areas, or wildlife observation areas. Their management includes restrictions on activities that might endanger significant natural features.
Natural Heritage Project – TVA's project to inventory and monitor sensitive natural resources, including protected species, geological features, natural areas, and other sensitive natural resources	• In cooperation with other federal, state, and non-governmental organizations, TVA identifies, monitors, and assists in protecting threatened and endangered species and environmentally sensitive sites. In addition, it maintains databases of these protected species, geological features, natural areas, and other sensitive natural resources. The Natural Heritage Project staff also uses this information to provide environmental input on TVA activities that range from transmission line construction to economic development. TVA and the U.S. Fish and Wildlife Service routinely share information on the location of listed species.
Riparian Restoration – Activities to protect and restore riparian vegetation	• Riparian restoration is designed to help owners of streambank or shoreline properties create landscaping plans that not only enhance their property but also protect water resources. The program identifies ways of using trees and other vegetation to help reduce erosion by holding soil in place, protect water quality by filtering sediments and pollutants, provide wildlife habitat and cover for fish, and enhance scenic beauty along the water's edge.

Table 7.3-01 TVA Program Elements and Activities Relevant to Mitigation (continued)

TVA Program or Activity	TVA Programs and Activities Relevant to Mitigation Strategies
Cultural Resources Management – TVA's program to manage cultural and archaeological resources	• Cultural resources management includes various actions to address requirements of the National Historic Preservation Act and the Archaeological Resource Protection Act. • Archaeological resources in need of treatment/protection are identified from data obtained during archaeological surveys of reservoir shorelines and TVA reservoir lands, and through additional field evaluations of site conditions. The most critically impaired sites are submitted to the Shoreline Treatment Program for consideration in that program's rating process. For each site selected for treatment, consultation is conducted with the appropriate State Historic Preservation Office and other stakeholders, such as Indian tribes.
Clean Water Initiative – A program started in 1992 as a result of the Lake Improvement Plan; TVA partnerships with community residents, businesses, and government agencies to promote watershed protection	• TVA's Watershed Teams are responsible for carrying out the program. They focus on improving water quality and shoreline conditions. Among other accomplishments, these community coalitions: —Monitor stream and aquatic community conditions; —Institute agricultural and urban management practices that reduce water pollution; —Treat eroded land and stabilized streambanks; —Plant vegetation and installed structures intended to improve aquatic habitat; and, —Collect waste and litter from streambanks and shores.

7.4. Potential Impacts and Mitigation for the Preferred Alternative

Mitigation follows a sequence of avoiding impacts; minimizing impacts by limiting the degree or magnitude of the action; and then, if needed, restoring or rehabilitating the affected environment, reducing or eliminating impacts over time, or compensating by providing offsetting resources or environments. Monitoring is often included to verify anticipated outcomes or identify unanticipated impacts. TVA has implemented the first steps of this mitigation process by avoiding and minimizing potential impacts in the design of its reservoir operations policy alternatives and especially in the formulation of the Preferred Alternative.

In developing the Preferred Alternative, TVA combined the desirable features of the alternatives identified in the DEIS to create a more feasible, publicly responsive preferred alternative. Through detailed analysis in this FEIS, TVA has determined that most changes under the Preferred Alternative would result in beneficial to slightly adverse impacts. The Preferred Alternative would result in a few types of effects, however, that would cause adverse impacts on the environment.

7.4.1 Avoidance and Minimization in the Preferred Alternative

The Preferred Alternative was formulated purposefully to avoid or reduce the adverse impacts associated with the action alternatives presented in the DEIS, especially the substantially adverse impacts related to flood damages, water quality, power costs, aquatic resources, wetlands, and migratory waterfowl and shorebirds. The elements of the Preferred Alternative that were added or modified specifically to avoid or minimize potential adverse impacts include the following:

- Except for the Base Case, detailed analyses indicated that all of the alternatives evaluated in the DEIS would result in unacceptable increases in the risk of flooding at critical locations in the Tennessee Valley. To address this issue, operating guides and regulating zones for individual projects were modified so that there would be no increase in flood damages for flood events with a frequency of 500 years or less.

- Most of the alternatives that included extension of summer pools further into summer and fall than under the Base Case would result in longer residence time of water in the reservoirs and consequent adverse or substantially adverse impacts on water quality. The Preferred Alternative focuses on achieving certain flows from the reservoirs from June 1 through Labor Day. Consequently, impacts on water quality would be only slightly adverse and variable among the reservoirs under the Preferred Alternative. However, some of these variable impacts could be adverse and may justify mitigation. This balancing of additional recreation benefits with water quality impacts is also important for aquatic resources, because water quality is a major factor that influences the health of fisheries and the quality of aquatic habitat.

- Habitat quality in many tailwaters would be maintained by ensuring that minimum flow commitments and DO targets in the Lake Improvement Plan would continue to be met. In addition, TVA would provide seasonal releases into the Apalachia Bypass to enhance aquatic habitat in that river reach.

- Most of the alternatives that extended summer pool levels could result in substantial adverse effects on wetlands. Under the Preferred Alternative, pools would be maintained at levels more similar to the Base Case than other policy alternatives. Although adverse impacts on wetland extent, distribution, and habitat connectivity would be reduced compared to most other policy alternatives, adverse impacts may still occur.

- No changes would be made in the operating guide curves for Kentucky Reservoir. This would substantially reduce the potential for adverse effects on flats habitats, interference with the operation and integrity of managed areas, and impacts on adjacent forested wetlands that could occur under alternatives that extend summer pool levels further into summer and fall.

7.4.2 Mitigation for the Preferred Alternative

The Preferred Alternative does not avoid all potential impacts on environmental resources; some adverse impacts could still occur. In particular, implementation of the Preferred Alternative could result in slightly adverse to adverse impacts on certain wetland types and locations, water quality and aquatic resources in some reservoirs, and other resource areas. In some cases, the extent of the impacts may vary from year to year—depending on the reservoir, annual rainfall conditions, and other factors.

Potential mitigation measures for TVA's Preferred Alternative are identified in Table 7.4-01 for adverse impacts on water quality, aquatic resources, and vector (mosquito) control. These mitigation measures are based on incremental impacts compared to the Base Case and are scaled to resource importance and extent as well as to the severity of the potential impact. For each mitigation measure proposed, TVA has provided a description of the need for the mitigation; the mitigation measure or monitoring activity; and the anticipated result in terms of follow-up activities for resource management, protection, enhancement, or replacement.

Table 7.4-01 Mitigation for Potential Adverse Impacts Associated with the Preferred Alternative

Need	Description	Results and Follow-Up Activities
Water quality and aquatic resources could be adversely affected at some locations. If analysis or monitoring indicates that dissolved oxygen (DO) concentrations are declining below DO target levels, increase TVA aeration efforts (see Table 7.4-02).	Upgrade aeration equipment and operations at appropriate locations as necessary to meet the DO target levels established by the Lake Improvement Plan (see Appendix A, Table A-05.) This could include increased oxygenation, upgrading existing equipment, or installing additional equipment. Such measures shall be initiated and completed within 1 year at Watts Bar, and within 3 years at other locations where established targets are not being met.	Share information about enhanced aeration efforts with interested agencies. Continue monitoring to determine whether efforts are successful. If DO targets cannot be maintained, investigate additional mitigation approaches with interested agencies.
Holding mainstem reservoir levels up longer could increase the number of days that reservoir mosquito breeding habitat exists. Mitigate if this is confirmed through monitoring (see Table 7.4-02).	Extend the duration of reservoir level fluctuations for mosquito control, consistent with holding mainstem reservoir levels up longer.	Continue to monitor mosquito levels. If extending the duration of the fluctuations does not offset the increase in reservoir mosquitoes, investigate other mitigation methods—including additional changes in fluctuation efforts.

7.4.3 Mitigation and Monitoring

Given the inherent uncertainties with any environmental analyses, monitoring should be conducted before a substantial investment is made in mitigation—not only to avoid wasting money but also to ensure that the appropriate mitigation is used at the most important locations. A mix of monitoring and adaptive response is an important component of TVA's programmatic mitigation plan. Tables 7.4-02 and 7.4-03 describe the activities that could be taken to verify TVA's projection of impacts for a number of important resource areas.

Tables 7.4-02 and 7.4-03 identify those activities that could be undertaken to mitigate adverse impacts that could not be avoided in the formulation of the Preferred Alternative. Activities that could be taken to address other resource areas are also identified.

Table 7.4-02 Monitoring for Potential Adverse Impacts Associated with the Preferred Alternative

Need	Description	Results and Follow-Up Activities
Decreases in concentrations of dissolved oxygen (DO) are predicted in water released from some mainstem and tributary dams due to increase in volumes of water with low DO concentrations in the reservoirs. This could adversely affect water quality and aquatic resources.	Continue existing monitoring activities under the Reservoir Release Improvement and Vital Signs Reservoir Ecological Health monitoring programs to look for water quality and ecological changes. Conduct additional DO and temperature sampling at selected tailwater locations as determined by Vital Signs monitoring.	Share data with other interested agencies. If DO concentrations lower than the established targets are observed, mitigate appropriately (see Table 7.4-01).
Holding mainstem reservoir levels up longer could increase the number of days that reservoir mosquito breeding habitat exists.	Continue existing monitoring activities throughout the extended time the mainstem reservoir levels are held up.	Share data with interested agencies. If reservoir mosquito nuisance levels increase, mitigate appropriately (see Table 7.4-01).

Table 7.4-03 Monitoring for Other Resource Areas

Need	Description	Results and Follow-Up Activities
The rate of erosion on reservoir shorelines could increase, further affecting sensitive cultural resource sites.	Continue monitoring sensitive cultural resource sites along the shoreline.	If the rate of shoreline erosion at sensitive cultural resource sites increases, increase stabilization efforts commensurate with the rate of increase.
One population of the endangered green pitcher plant on Chatuge Reservoir could be affected by changes in the local hydrology. Detailed hydrologic studies have not been conducted at this site.	Work with the landowner, the U.S. Fish and Wildlife Service, and other interested agencies to conduct a hydrologic study to determine whether the changes in reservoir levels would affect this population. The study and results are to be completed within 1 year. Then, periodically monitor the status of green pitcher plant populations around Chatuge Reservoir and share data with interested agencies.	If results of the study indicate that changes resulting from implementation of the Preferred Alternative are likely to adversely affect the green pitcher plant, take appropriate action to avoid or mitigate those adverse effects.
The results of the Reservoir Operations Study indicate that there is a need to develop a Drought Management Plan for the Tennessee River system.	Work with state and federal agencies in a cooperative manner to develop a Drought Management Plan within a reasonable period of time. This plan would be implemented during extreme drought conditions.	Suspend the reservoir operations policy during severe drought to allow implementation of the Drought Management Plan.
The availability of water would generally increase during the growing season. This could cause slight shifts in the extents and distributions of wetlands and wetland types. The changes in the timing of the presence of water could adversely affect flats, scrub/shrub, and forested wetlands. There could be a slight decrease in wetland functions overall.	Develop a monitoring program to determine whether extended pool levels cause shifts of wetland plant communities. Perform monitoring activities on a 3- to 5-year basis for 15 years to establish effects.	If substantial shifts of wetland plant communities occur, take appropriate action to mitigate adverse effects.

Table 7.4-03 Monitoring for Other Resource Areas (continued)

Need	Description	Results and Follow-Up Activities
The results of the Reservoir Operations Study indicate that there is a need for more cooperative efforts to determine habitat requirements and potential enhancements for shorebirds.	Work with state and federal agencies in a cooperative manner to determine habitat requirements and opportunities for enhancements to shorebirds. This will include better identification of information gaps and cataloguing the federal and state programs that address these habitats and species.	Share data with other interested agencies and investigate with other agencies actions that could be taken to enhance these habitats and species.
The results of the Reservoir Operations Study indicate that there is a need for more cooperative efforts to determine habitat requirements and potential enhancements for important sport fish.	Work with state and federal agencies in a cooperative manner to determine habitat requirements and opportunities for enhancements to sports fish. This will include better identification of information gaps and cataloguing the federal and state programs that address these habitats and species.	Share data with other interested agencies and investigate with other agencies actions that could be taken to enhance these habitats and species.

Chapter 8

List of Preparers

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8.1 TVA Staff

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Position: Environmental Scientist, Science Applications International Corporation
Education: M.S., Forestry; B.S., Natural Resources
Background: 23 years of experience in natural resource management and environmental impact assessment; 13 years of experience in NEPA compliance and wetlands ecology, management, and restoration

Richard K. Grady

Position: Executive Vice President, Applied Geographics, Inc.
Education: M.B.A., Management; B.S., Resource Economics
Background: 25 years of experience in computer mapping, systems integration, and GIS

Ernest B. Griggs

Position: Assistant Project Manager, PB Power, Inc.
Education: B.S., Management
Background: 30 years of experience in bulk power (hydro) generation and transmission

8 List of Preparers

Amy H. Haas

Position: GIS Analyst, Applied Geographics, Inc.
Education: B.S., Earth Sciences
Background: 4 years of experience in environmental sciences and GIS

Melissa Hetrick

Position: Assistant Staff Environmental Scientist, ENTRIX, Inc.
Education: B.S., Integrative Biology
Background: 3 years of experience in environmental impact assessment and environmental policy and permitting

Gale Hoffnagle

Position: Senior Vice President and Technical Director, TRC Environmental Corporation
Education: M.S. and B.S., Meteorology
Background: 34 years of experience in air quality consulting

Paul M. Jakus

Position: Associate Professor, Utah State University
Education: Ph.D., Economics; M.Sc. and B.Sc., Agricultural and Natural Resource Economics
Background: Faculty member at University of Tennessee with extensive experience in trip response modeling in the TVA region

Angela Johnson

Position: Biologist, Science Applications International Corporation
Education: B.S., Biology
Background: 5 years of experience in ecological risk assessment and wildlife biology

Margaret W. (Peg) Johnson

Position: Supervising Planner, Associate Vice President, Parsons Brinckerhoff, Inc.
Education: M.S., Economics; B.A., English
Background: 24 years of experience in ports and waterway planning and economic analysis

Deborah Joy

Position: Archaeologist, Legacy Research Associates, Inc.
Education: M.A., Native American History; B.A., Anthropology
Background: 22 years of experience in archaeology; 18 years of experience in cultural resource management

Nancy Ellen Keene

Position: Wetlands Biologist, ADECCO Technical
Education: Ph.D., Ecology; M.Ed., Outdoor Education; B.S., Biology
Background: 11 years of experience in teaching, researching, and performing environmental assessments

Carrie Koenig

Position: Consultant Analyst, PA Government Services, Inc.
Education: B.B.A., Business Management and Marketing
Background: 5 years of experience in survey research

Thomas Kokx

Position: Principal, Thomas Kokx Associates
Education: B.S., Landscape Architecture
Background: 30 years of experience in visual resource inventory, assessment, and management

Karl Krcma

Position: Supervising Engineer, Parson Brinckerhoff, Inc.
Education: B.S., Agricultural Engineering
Background: 23 years of experience in ports, waterways, and marine facilities

Donald Kretchmer

Position: Senior Water Resources Scientist, Normandeau Associates, Inc.
Education: M.S., Water Resources Management; B.S., Natural Resources
Background: 22 years of experience in water resources planning and management

Gabriela Landau-Gabbai

Position: GIS Analyst, Applied Geographics, Inc.
Education: M.S., Urban and Regional Planning; B.A., Geography
Background: 1 year of experience in urban planning; 2 years of experience in GIS

Paul Leonard

Position: Senior Project Manager, ENTRIX, Inc.
Education: M.S., Fisheries Science/Statistics; B.S., Aquatic Science/Biology
Background: 20 years of experience in managing and performing environmental assessments related to hydroelectric power and other water resource development projects

Elisa Aylin Lewallen

Position: Project Scientist, ENTRIX, Inc.
Education: M.S., Environmental Science; M.P.A., Public Affairs; B.S., Natural Resources
Background: 6 years of experience in watershed assessments, water quality monitoring, stream assessments, endangered species surveys, and environmental permitting

Joan Lynn

Position: President, egret, inc.
Education: 6 years of undergraduate studies in Latin and Greek
Background: 20 years of experience in writing and editing environmental documents

Dennis Magee

Position: Vice President, Normandeau Associates, Inc.
Education: M.S., Botany/Forestry; B.S., Zoology/Wildlife
Background: 31 years of experience in managing a wide range of environmental assessment projects

Richard Masters, P.E.

Position: Director of Engineering, Normandeau Associates, Inc.
Education: M.A., Environmental Planning; B.S., Civil Engineering
Background: 22 years of experience in environmental planning and water resources engineering

Ian K. McDonough

Position: Economics Graduate Student, Utah State University
Education: B.Sc., Information Systems
Background: Expertise in developing and maintaining electronic databases

Bryce Mochrie

Position: Senior Principal Engineer, PB Power, Inc.
Education: M.S. and B.S., Civil Engineering
Background: 25 years of experience in addressing the structural aspects of dam design, stability, and safety

April Montgomery

Position: Preservation Planner, Legacy Research Associates, Inc.
Education: M.A., Urban and Regional Planning; B.A., History
Background: 5 years of experience in historic preservation planning

Marcia B. Montgomery

Position: Project Historian, ENTRIX, Inc.
Education: M.A. and B.A., History
Background: 12 years of experience in historic research for environmental compliance

Ash Morgan

Position: Senior Staff Scientist, ENTRIX, Inc.
Education: Ph.D. and M.A., Economics; B.A., Accounting and Finance
Background: 5 years of experience in economic modeling and analysis

Nicholas Nitka

Position: Consultant Analyst, PA Government Services, Inc.
Education: B.S., Marketing
Background: 5 years of experience in managing large-scale surveys for government and private clients

Kelly O'Brien

Position: Staff Recreation Analyst/Planner, Kleinschmidt Associates
Education: M.S., Resource Economics; B.S.S., Environmental Policy
Background: 3 years of experience in survey research and statistical applications; 8 years of experience in the recreation industry

Kimberly R. Peace

Position: Wetlands Scientist, Normandeau Associates, Inc.
Education: M.S. and B.S., Marine Science
Background: 8 years of experience in the field of environmental consulting, including wetlands delineation and mitigation, endangered species surveys, NEPA compliance and EIS preparation

Marcia L. (Marty) Phillips

Position: Senior Resource Economist, Kleinschmidt Associates
Education: M.S., Agricultural and Resource Economics; B.S., Natural Resources; A.A., Liberal Arts
Background: 15 years of experience in resource economics and survey research in the field of outdoor recreation

Cindy Potter

Position: Document Coordinator, ENTRIX, Inc.
Education: B.A., Liberal Arts
Background: 6 years of experience in public outreach and coordinating production of environmental documents

Paul W. Rasmussen

Position: Statistician, Wisconsin Department of Natural Resources
Education: M.S., Statistics; M.S. and B.A., Biology
Background: 22 years of experience in environmental and biomedical statistics

Pamela R. Rathbun

Position: Principal Consultant, PA Government Services, Inc.
Education: M.S., Sociology (Research and Analysis); B.S., Rural Sociology
Background: 20 years of experience in designing and conducting survey research for clients in the public and private sectors

John Robinson

Position: Senior Project Manager, ENTRIX, Inc.
Education: Masters Studies in Urban Design and Economics; B. Arch., Architecture
Background: 33 years of experience in energy facility development, permitting, and environmental performance evaluation (NEPA compliance) for thermal, nuclear, combustion turbine, pipeline, transmission line, and alternative energy facilities

Barbara Rosensteel

Position: Wetlands Biologist, ADECCO Technical
Education: M.S. and B.S., Environmental Science
Background: 14 years of experience in wetlands assessment and delineation

Jeffrey G. Royal

Position: Archaeologist, Legacy Research Associates, Inc.
Education: Ph.D., M.A., and B.A., Anthropology; B.A., Economics
Background: 12 years of experience in archaeological research, analysis, and publication

Cynthia Audrey Saine

Position: Senior GIS Analyst, Applied Geographics, Inc.
Education: B.A., Economics and Environmental Science
Background: 8 years of experience in GIS

John Shuman

Position: Senior Water Resources Planner, Kleinschmidt Associates
Education: Ph.D., Environmental Science; B.A., Biology
Background: 20 years of experience in fisheries, aquatic ecology, reservoir limnology, environmental science, and watershed planning

Heidi K. Singletary

Position: Senior GIS Analyst/Project Manager, Applied Geographics, Inc.
Education: M.S. and B.S., Environmental Science
Background: 5 years of experience in data development and mapping with GIS

Theresa Tennant

Position: Administrative Assistant, PA Government Services, Inc.
Background: 1 year of experience in administration in a survey research firm

Daniel R. Tormey

Position: Senior Management Consultant, ENTRIX, Inc.
Education: Ph.D., Geology and Geochemistry; B.S., Civil Engineering; B.S., Geology
Background: 14 years of experience as a hydrologist, geologist, geochemist, civil engineer, environmental scientist, environmental engineer, and project manager

William W. Wade

Position: President, Energy and Water Economics
Education: Ph.D., Agricultural and Resource Economics; M.S., Agricultural and Resource Economics; B.S., English
Background: 30 years of experience in conducting regional economic impact analyses and resource economic analyses

Calvin Wenzel

Position: Wildlife Ecologist, Science Applications International Corporation
Education: B.S., Biology
Background: 28 years of experience in NEPA compliance, natural resource management, and environmental impact assessment

Jennifer West

Position: Soil Scientist, Normandeau Associates, Inc.
Education: M.S., Plant Science; B.S., Natural Resource Management
Background: 17 years of experience in environmental consulting, including permitting, site review, and mapping of soils and wetlands

Shirley Marie Williamson

Position: Project Manager, PB Power, Inc.
Education: M.S., Civil Engineering; B.S., Civil Engineering
Background: 22 years of experience in water resources projects and hydrologic analyses

8 List of Preparers

Roberta Willis

Position: Senior Consultant, ENTRIX, Inc.
Education: M.S., Ecology/Forestry; B.S., Landscape Design/Biology
Background: 25 years managing and performing environmental assessments related to environmental planning and natural resource programs and projects

Michael W. Wright

Position: Senior Management Consultant, Water Resources, ENTRIX, Inc.
Education: M.A. and B.A., Geography
Background: 32 years of experience in NEPA assessments for major water resource management and infrastructure projects

Bryan Zent

Position: Consultant, PA Government Services, Inc.
Education: M.A., Industrial/Organizational Psychology; B.S., Psychology
Background: 8 years of experience in survey design, data collection, data management, and data analysis

Chapter 9

Distribution List

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9.1 Federal Agencies

Bureau of Indian Affairs, Franklin Keel, Eastern Agency
Bureau of Indian Affairs, Ross Mooney, Washington, DC
Bureau of Indian Affairs, Mike Smith (Acting)
Bureau of Indian Affairs, J. Mannis, Regional Director, Eastern Oklahoma Regional Office
Economic Development Administration, William J. Day, Jr., Regional Director, Atlanta Region
Economic Development Administration, John Ogden, Atlanta Region
Economic Development Administration, Paul M. Raetsch, Regional Director, Philadelphia Region
Environmental Protection Agency, Heinz J. Mueller, Chief, Office of Environmental Assessment
Environmental Protection Agency, Thomas Welborn, Region 4
Federal Emergency Management Agency, Mark A. Viera, Atlanta, GA
Federal Emergency Management Agency, Mohammad Waliullah, Atlanta, GA
National Park Service, John Conoboy, Trail of Tears National Historic Trail, Long Distance Trails Group Office
National Park Service, Jeff Duncan, Hydropower Assistance
National Park Service, Phil Francis, Superintendent (Acting), Great Smoky Mountain National Park
National Park Service, Woody Harrell, Superintendent, Shiloh National Military Park
National Park Service, Patrick Reed, Superintendent, Chickamauga-Chattanooga National Military Park
National Park Service, Wendell Simpson, Superintendent, Natchez Trace National Scenic Trail
National Park Service, Rich Sussman, Planning and Compliance Division
National Weather Service, Jerry McDuffie, Weather Forecast Office, Morristown, TN
National Weather Service, Dave Reed, Lower Mississippi River Forecast Center
National Weather Service, Ben Weiger, Southern Regions
U.S. Army Corps of Engineers, Larry Banks, Mississippi Valley Division
U.S. Army Corps of Engineers, Bill Barron, Nashville District
U.S. Army Corps of Engineers, Dave Buelow, Great Lakes and Ohio River Division
U.S. Army Corps of Engineers, David K. Baker, Asheville Regulatory Field Office
U.S. Army Corps of Engineers, Col. Frederick L. Clapp, Jr., Commander, Vicksburg District
U.S. Army Corps of Engineers, Patty Coffey, Nashville District
U.S. Army Corps of Engineers, Gary Craig, North Area Section
U.S. Army Corps of Engineers, Col. James W. DeLony, Commander, Wilmington District
U.S. Army Corps of Engineers, Brigadier General Edwin J. Arnold, Jr., Mississippi Valley Division
U.S. Army Corps of Engineers, Ron Gatlin, Regulatory Branch
U.S. Army Corps of Engineers, Lt. Col. Steve Gay, Commander, Nashville District
U.S. Army Corps of Engineers, Col. Roger A. Gerber, Commander, Savannah District
U.S. Army Corps of Engineers, W. Chris Hinton-Lee, Director, Military and Technical Directorate
U.S. Army Corps of Engineers, Brigadier General Robert Griffin, Director of Civil Works
U.S. Army Corps of Engineers, Elizabeth S. Guynes, Chief, Regulatory Branch, Vicksburg District
U.S. Army Corps of Engineers, Col. David I. Hansen, PE, Commander, Norfolk District
U.S. Army Corps of Engineers, Brigadier General Steven R. Hawkins, Commander, Great Lakes and Ohio River Division
U.S. Army Corps of Engineers, Robert Johnson
U.S. Army Corps of Engineers, Col. Robert B. Keyser, Commander, Mobile District
U.S. Army Corps of Engineers, Ron Krizman, Chief, Regulatory Branch, Mobile District

U.S. Army Corps of Engineers, Brigadier General Peter T. Madsen, Commander, South Atlantic Division
U.S. Army Corps of Engineers, Brigadier General M. Stephen Rhoades, Commander, Atlantic Division
U.S. Army of Engineers, Brigadier General Don T. Riley, President Designee, Mississippi River Commission
U.S. Army Corps of Engineers, Col. Jack V. Scherer, Commander, Memphis District
U.S. Army Corps of Engineers, Col. Robert E. Slockbower, Commander, Louisville District
U.S. Army Corps of Engineers, Tom Swor, Nashville District
U.S. Army Corps of Engineers, Dennis Williams, Nashville District
U.S. Coast Guard, Commander Patrick T. Keane, Marine Safety Office
U.S. Coast Guard, Josh McTaggart, Marine Safety Office
U.S. Coast Guard, Lt. Commander Paul Thorne, Marine Safety Detachment
U.S. Department of Agriculture - National Resources Conservation Service, Mary K. Combs, State Conservationist
U.S. Department of Agriculture - National Resources Conservation Service, Denise Doetzer, State Conservationist
U.S. Department of Agriculture - National Resources Conservation Service, John Dondero, Regional Strategic Planner
U.S. Department of Agriculture - National Resources Conservation Service, James W. Ford, State Conservationist
U.S. Department of Agriculture - National Resources Conservation Service, Robert N. Jones, State Conservationist
U.S. Department of Agriculture - National Resources Conservation Service, Leonard Jordan, State Conservationist
U.S. Department of Agriculture - National Resources Conservation Service, David G. Sawyer, State Conservationist
U.S. Department of Agriculture - National Resources Conservation Service, Vic Simpson, Regional Technology Specialist
U.S. Department of Agriculture - National Resources Conservation Service, David Thackeray, Director, Water Management Center
U.S. Department of Agriculture - National Resources Conservation Service, Homer L. Wilkes, State Conservationist
U.S. Department of the Interior, Office of Environmental Policy and Compliance, Stephen R. Spencer
U.S. Department of the Interior, Office of Environmental Policy and Compliance, Gregory Hogue, Regional Environmental Officer
U.S. Department of the Interior, Office of Environmental Policy and Compliance, Willie R. Taylor, Director
U.S. Forest Service, Terry Bowerman, District Ranger, Nolichucky/Unaka District
U.S. Forest Service, Cassius Cash, Toccoa Ranger District
U.S. Forest Service, Jack Holcomb
U.S. Forest Service, Bob Jacobs, Regional Forester, Region 8
U.S. Forest Service, Ray Johnston
U.S. Forest Service, Don Kinnerson, Ocoee/Hiwassee District
U.S. Forest Service, Bill Lisowsky, Area Supervisor, Land between the Lakes
U.S. Forest Service, John Ramey, Forest Supervisor, National Forests in North Carolina
U.S. Forest Service, Anne Zimmerman, Forest Supervisor, Cherokee National Forest
U.S. Fish and Wildlife Service, Steve Alexander, Cookeville Field Office
U.S. Fish and Wildlife Service, V. Lee Andrews, Jr., Field Supervisor, Kentucky Field Office

U.S. Fish and Wildlife Service, Ray Aycock, Jackson Field Office, Field Supervisor
U.S. Fish and Wildlife Service, Lee Barclay, Field Supervisor, Cookeville Field Office
U.S. Fish and Wildlife Service, Brian Cole, State Supervisor, Asheville Field Office
U.S. Fish and Wildlife Service, Dwight Cooley, Manager, Wheeler National Wildlife Refuge
U.S. Fish and Wildlife Service, Larry Goldman, Daphne Field Office, Field Supervisor
U.S. Fish and Wildlife Service, Robin Goodloe, Supervisory Biologist, North Georgia Sub-Office
U.S. Fish and Wildlife Service, Sam D. Hamilton, Regional Director, Region 4, Southeast Region
U.S. Fish and Wildlife Service, Roberta Hylton, Field Supervisor, Southwest Virginia Field Office
U.S. Fish and Wildlife Service, Karen L. Mayne, Virginia Ecological Services Field Office
U.S. Fish and Wildlife Service, John Taylor, Manager, Tennessee National Wildlife Refuge
U.S. Fish and Wildlife Service, Sandy Tucker, Field Supervisor, Georgia Field Office
U.S. Geological Survey, Athena P. Clark, Montgomery, AL
U.S. Geological Survey, Mr. Leonard R. Frost, Jr., District Chief, Water Resources Division, Pearl, MS
U.S. Geological Survey, W. Scott Gain, Nashville, TN
U.S. Geological Survey, Robert M. Hirsch, National Center, Reston, VA
U.S. Geological Survey, Edward H. Martin, Atlanta, GA
U.S. Geological Survey, Gerald L. Ryan, Raleigh, NC

9.2 American Indian Nations

Alabama Indian Affairs Commission, Michael C. Gilbert, Executive Director, Montgomery
Poarch Creek Indians, Eddie L. Tullis, Chairman
Seminole Indian Tribe, Dr. Patricia Wickman, Tribal Historic Preservation Office
Georgia Council on American Indian Concerns
Band of Choctaw Indians, Christine Norris
Mississippi Band of Choctaw Indians, Kenneth Carleton
Eastern Shawnee Tribe of Oklahoma, Charles D. Enyart, Chief
North Carolina Historic Preservation Officer, Eastern Band of the Cherokee Indians, Leon Jones, Principal Chief
North Carolina Eastern Band of Cherokee Indians, Michael Bolt, Tribal Utilities
North Carolina Eastern Band of Cherokee Indians, Michelle Hamilton, Tribal Historic Preservation Officer
North Carolina Commission of Indian Affairs, Gregory Richardson, Executive Director
Absentee-Shawnee Tribe of Oklahoma, James "Lee" Edwards, Jr., Governor
Alabama Quassarte Tribal Town, Mekko Tarpie Yargee, Chief
Cherokee Nation of Oklahoma, Honorable Chadwick Smith, Chief
Chickasaw Nation, Bill Anoatubby, Governor
Choctaw Nation of Oklahoma, Olin Williams, Tribal Historic Preservation Office, Terry Cole, Cultural Resources Director
Kialegee Tribal Town, Honorable Lowell Wesley
Muscogee (Creek) Nation of Oklahoma, Honorable R. Perry Beaver, Principal Chief
Seminole Nation of Oklahoma, Ted Underwood
Shawnee Tribe, Ron Sparkman, Chairman
Thlopthlocco Tribal Town, Honorable Bryan McGrett
United Keetoowah Band, Honorable Dallas Proctor, Chief
Bureau of Indian Affairs, Kurt Chandler, Eastern Agency

Alabama-Coushatta Tribe, Walter Celestine, Program Director

9.3 State Agencies

Alabama

Alabama Department of Environmental Management, James E. McIndoe, Chief, Water Division
Alabama Historical Commission, Elizabeth Brown, Acting Executive Director
Alabama Office of Water Resources, Tom Littlepage
Department of Economic and Community Affairs, Onis "Trey" Glenn III, Office of Water Resources
Alabama Department of Conservation and Natural Resources, James D. Martin, Commissioner
Alabama Department of Conservation and Natural Resources, M. N. Pugh, Director, Wildlife and Fisheries Division
Alabama Department of Environmental Management, James W. Warr, Director
Geological Survey of Alabama, Danny Moore
Top of Alabama Regional Council of Governments, Jeff Perkins, Clearinghouse Coordinator

Georgia

Georgia Department of Natural Resources, Lonnice Barret, Commissioner
Georgia Department of Natural Resources, Ray Luce, State Historic Preservation Office
Georgia Department of Natural Resources, Denise P. Messick, Environmental Review Historian
Georgia Department of Natural Resources, David Waller, Director, Wildlife Resources Division
Georgia Environmental Protection Division, Harold Reheis, Director
Georgia Department of National Resources, Jeff Durniak, Regional Fisheries Supervisor, Wildlife Resources Division
Georgia State Clearinghouse, Barbara Jackson, Office of Planning and Budget

Kentucky

Kentucky Department for Environmental Protection, Alex Barber, Executive Staff Advisor
Kentucky Department for Environmental Protection, John Lyons, Division of Air Quality,
Kentucky Department of Fish and Wildlife Resources, C. Thomas Bennett, Commissioner
Federal Highway Administration, Paul Toussaint, Division Administrator
Kentucky Division of Water, Jeffrey W. Pratt
Kentucky Division of Water, Terry Anderson
Kentucky Division of Water, Leon Smothers
Kentucky Division of Water, Robert W. Ware
Kentucky Heritage Council, David L. Morgan, Executive Director
Kentucky State Clearinghouse, Ronald W. Cook, Department of Local Government

Mississippi

Mississippi Department of Environmental Quality, Charles Chisolm, Executive Director
Mississippi Department of Finance and Administration, Cathy Mallette, Clearinghouse Officer
Office of Pollution Control, Phil Bass, Director,
Mississippi Department of Transportation, Kenneth I. Warren, Executive Director
Natchez Trace Parkway, Gary Mason
Mississippi State Department of Health, Public Water Supply Program

Mississippi Department of Wildlife, Fisheries and Parks, Dr. Sam Polles, Executive Director
Mississippi Department of Environmental Quality, Barry Royals, Chief, Surface Water Division
Mississippi Department of Environmental Quality, Dwight K. Wylie, Chief, Air Division, Office of Pollution Control
Mississippi Department of Economic and Community Development, James C. Burns, Jr., Executive Director
Mississippi Department of Archives and History, Elbert R. Hilliard, Executive Director
Mississippi Museum of Natural Science, Department of Wildlife, Ken Gordon, Coordinator, Mississippi Natural Heritage Program, Fisheries and Parks

North Carolina

North Carolina Division of Archives and History, David Brook, State Historic Preservation Officer
North Carolina Division of Archives and History, David Morgan, Western Area
North Carolina Division of Water Quality, J. Todd Kennedy
North Carolina Division of Water Quality, Mary Kiesau
North Carolina Division of Water Quality, Collen Sullins
North Carolina Division of Water Resources, Steve Reed
Hiwassee State Scenic River, Jamie Nicholson, Manager
North Carolina Department of Environment and Natural Resources, Melba McGee, Environmental Review Coordinator
North Carolina State Clearinghouse, Chrys Baggett, Environmental Policy Act Coordinator
North Carolina Wildlife Resources Commission, Fred A. Harris, Chief, Division of Inland Fisheries
North Carolina Wildlife Resources Commission, Micky Clemmons
North Carolina Wildlife Resources Commission, Chris Goudreau
North Carolina Wildlife Resources Commission, Scott Loftis
North Carolina Wildlife Resources Commission, Frank McBride, Program Manager

Tennessee

Tennessee Department of Transportation, Glen Beckwith, Planning Division Director
Tennessee Division of Solid Waste, Mike Apple
Tennessee Division of Water Pollution Control, Paul Davis, Director
East Tennessee Development District, Robert Freeman, Executive Director
Tennessee Commission on Indian Affairs, Luvenia H. Butler, Director
Tennessee Department of Economic and Community Development, Wilton Burnette
Tennessee Department of Environment and Conservation, Paul Davis, Water Pollution Control
Tennessee Department of Environment and Conservation, Andrew Barrass, Division of Natural Heritage
Tennessee Department of Environment and Conservation, David Draughon, Division of Water Supply
Tennessee Department of Environment and Conservation, Nick Fielder, Archeological Reviews
Tennessee Department of Environment and Conservation, Joe Garrison, Historical Reviews
Tennessee Department of Environment and Conservation, Alan Leiserson, Director of Policy
Tennessee Department of Environment and Conservation, Barry Stephens, Division of Air Pollution
Tennessee Department of Environment and Conservation, Reggie Reeves, Division of Natural Heritage
Tennessee Division of Archeology, Jennifer Bartlett
Tennessee Historical Commission, Herbert L. Harper, Executive Director

Tennessee Wildlife Resources Agency, David McKinney
Tennessee Wildlife Resources Agency, Gary T. Myers
Tennessee Wildlife Resources Agency, Dan Sherry

Virginia

Virginia Department of Environmental Quality, Teresa Frazier
Virginia Department of Environmental Quality, Michael P. Murphy, Director, Division of Environmental Enhancement
Virginia Office of Environmental Impact Review, Ellie L. Irons, Program Manager
Virginia Department of Historic Resources, Cara Metz, Division of Resource Services and Review
Virginia Department of Transportation, Tracey E. Harmon, Aquatic Ecology Section
Virginia Department of Transportation, George B. Young, Assistant District Environmental Manager

Washington, D.C.

Appalachian Regional Commission, Thomas M. Hunter, Executive Director

9.4 Libraries

Alabama

Decatur Public Library, Decatur
Guntersville Public Library, Guntersville
Huntsville-Madison County Public Library, Huntsville
Muscle Shoals Public Library, Muscle Shoals

Georgia

LaFayette-Walker County Library, LaFayette
Catoosa County Library, Ringgold
Mountain Regional Library, Young Harris

Kentucky

Marshall County Public Library, Benton
Bowling Green Public Library, Bowling Green
Calloway County Public Library, Murray

Mississippi

Starkville-Oktibbeha County Public Library System, Starkville
Lee-Itawamba Library System, Tupelo

North Carolina

Marianna Black Library, Bryson City
Murphy Public Library, Murphy

Tennessee

Sullivan County Public Library, Blountville
Chattanooga-Hamilton County Bicentennial Library, Chattanooga
Clinton Public Library, Clinton
Putnam County Library, Cookeville
Johnson City Public Library, Johnson City
Lawson McGhee Library, Knoxville
Lenoir City Public Library, Lenoir City
Loudon County Public Library, Loudon
Memphis-Shelby County Public Library and Information Center, Memphis
Morristown-Hamblen County Public Library, Morristown
Main Nashville Public Library, Nashville
Betty Anne Jolly Norris Community Library, Norris
W. G. Rhea Public Library, Paris
Hardin County Library, Savannah
Coffee County Lannom Memorial Public Library, Tullahoma

9.5 Individuals and Organizations

Alabama

The Honorable Robert Aderholt, U.S. House of Representatives
Richard Alfiero
Eddie Allen
The Honorable Spencer Bachus, U.S. House of Representatives
Bill Beautjer
Larry Bennich, Morgan County Commission
Ron Boyd
James D. Brackin
Edwin D. Breland, Jr.
Chuck Brown
Doris Cooley Edmonds
The Honorable Robert E. "Bud" Cramer, U.S. House of Representatives
John Crowder
The Honorable Arthur Davis, U.S. House of Representatives
Buddy Denton
Michael Dudley, Tennessee Valley Indian Trail Association
Doris Cooley Edmonds
Carol English, Amcor
Terry and Jane Ewing
Keith B. Floyd
Horace H. Freeman
Kimberly Ann Garrard
William R. Gates
Stacy Lee George, Morgan County Commission
Gary W. Gray, City of Guntersville
Kerry Grissett
Hardie Haley
Paul Hargrove
Sam Harvey
Wendell Hathorn
H. A. Henderson
Richard Holst, North Alabama Council of Local Governments
William D. Hudson
William M. Hudson
Howard Hutcheson
James Loew, Florence Lauderdale Port Authority
Teresa M. Lucas, Blount County Water Authority
David Lyle
Angela Mack
Dennis Mack
D. L. Marshall
John McBride
Stanley Menafau, Limestone County Commissioner
Bruce Metts
Vicky Mitchell, Tennessee Valley Resource Conservation and Development
Nancy Muse
Larrandi Nichols
Ed Ortow
George M. Patrick, Jr.
Stuart Peck
Edwin L. Quigley
Alex Rawleigh
Harvey Reimer, U.S. Gypsum Company
James E. Rich
Jerry Rich, TAC Alloys
Juanita Riddle
Dr. Carl E. Rodenburg
The Honorable Mike Rogers, U.S. House of Representatives
Charles L. Rose
E. Carl Rudolph, Rudolph Marine & Salvage
Emilio Sahurie
Duane Sammons
Mike Scudamore, Alabama B.A.S.S. Federation
David Seibert, Commissioner, Limestone County
J. Wayne Sellers, City of Guntersville
The Honorable Jeff Sessions, United States Senate
The Honorable Richard Shelby, United States Senate
Claude H. Smith
G. David Smith
Ida Will Smith
Waylon Spurgeon
Robert Stansell, Pier Post River Journal
Roy K. Stepp Sr., Delphi
Mike Terry
Rick Terry, Port of Decatur
Robert N. Tidmore

Harold Webb
Richard J. Wells
Al Westlake
Clyde T. White
Victoria White
Andy Whitt
Duncan Wilkinson
Gary Wolfskill
Troy M. Wyers

Arizona

Curtis Davis
Harold Dehart

Florida

Mary P. Kitchen

Georgia

Denise Adams
Neal M. Allen
Bradley Arnold
Rainer Arnold
Russell Baggett
Ken Baker
Brenda Baldridge
Don Baldridge
Dick Bell
Hank Blackwood
Cecil G. Boland, President, Lake Nottely Improvement Association
Dorren Boroemeister
Patti Bransford
Steve Bratton
Donald C. Breslin
Carolyn and Mike Brock
Renai Brock
Charles Butler
C. Calder
F. C. Campbell
Mary Anne Camphell
Robert Canaan
Aif Candell
Alton and Penny Candler
Roy Cardell
Jim Carlin
Kelly Carlin
Tom Carlton
Beverly Caroell
Anne E. Caron
The Honorable Saxby Chambliss, United States Senate
John Chitwood
Julie A. Clancy
Carolyn Clarkson
Frazier Coffie
Terry Coil
Marvine Cole
Michael A. Cole
Patricia Cole
Syd and Toni Cole
Chris Collins
Fred L. Cone, Jr.
Doug Conlin
David R. Cook
Don Cope
Carry Corl
John Cory
Evelyn Crossley
Jean Crothers
Diane Daige
Mike Darnell
Robert Davies
Susan Davis
Emory Debord
The Honorable Nathan Deal, U.S. House of Representatives
Viki E. Dial
Raymond W. Doucette
Ronald and Lena Dycus
Myron Engebretson
Judy Enzman
Richard Ernstes
Randall W. Ertzbercer
Jack C. Etheridge
Phillip H Fauver
Arneta H. Ferguson
James D. Ferguson
Paul Filer
Lamar Franklin
Julia Franks
Shelia Garrison
Marie Geesa
Lynn Gill
Robert Gill
Henry L. Glove
Bobby Gordon
Eddie Graham
Richard Guenthen
Jan Hackett

Kevin Harris
Philip D. Hartley
Charles Hebert
William P. Hennells
Shirley Hennels
Roger Hutchison
Mary S. Johnson
Joseph L. Johnson, Jr.
Mr. and Mrs. Ray Johnston
Mike Jollen
Jerry Kehoe
Patricia Kehoe
Jack Kilgore
Judy King
Mike King
Robert A. Klein
Charlos Kraus
Charles Krick
Anthony Lagratta
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Chapter 10

Supporting Information

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10.2 Glossary

26a permit—written approval required under Section 26a of the TVA Act, which must be obtained from TVA prior to construction, operation, or maintenance of boat docks, piers, boathouses, rafts, buoys, floats, boat-launching ramps, fills, nonnavigable houseboats, or other such obstructions which may affect navigation, flood control, public lands, or reservations along or in the Tennessee River or its tributaries.

100-year floodplain—that area inundated by the 100-year flood.

100-year flood—the level of flooding with a 1-percent chance of being equaled or exceeded in any given year; does not indicate a time period of 100 years between floods of this magnitude.

access rights—property rights across TVA-owned shoreland held by some adjacent landowners. These rights provide ingress to and egress from the water and allow the landowner to request TVA permits for proposed docks and other water-use facilities.

adaptive management—regarding this EIS, includes environmental monitoring and the process by which TVA may adjust its reservoir system operations policy after implementation to further address effects of operations.

aeration—the mixing of air and water, usually by bubbling air through water or by contact of water to air.

algae—small (generally microscopic) plants that live either floating in the water or attached to submerged objects.

alluvium—material such as earth, sand, gravel, or other rock or mineral materials, transported by and laid down by flowing water.

anaerobic—oxygen-deficient conditions.

ancillary services—those services necessary to support the transmission of electric power from seller to purchaser, to maintain reliable operations of the transmission system; includes system control, reactive supply and voltage control, regulation, and spinning and supplemental operating reserve.

aquatic—typically living in water.

aquatic invasive plants—those species of plants that spread at a prolific rate and can crowd or out-compete other species with such speed and thoroughness that the ecosystems become negatively affected. This definition includes those plants that are exotic, or non-native, to the southeastern United States, as well as some native species that are capable of growing at levels sufficiently high to substantially alter the environment.

aquatic macrophytes—larger, generally rooted or floating aquatic plants.

aquifer—a geological formation that contains water, especially one that supplies the water for wells and springs.

archaeological resources—material remains of past human activity.

backlands—the land extending beyond 0.25 mile from the TVA system shoreline.

10.2 Glossary

backwater—locations along a river where the water level depends on the level at a downstream dam rather than strictly on the rate of flow in the stream channel.

balancing guide—the elevation defining the bottom of the normal operating zone that is used to help maintain relative balance among tributary storage projects for the Preferred Alternative.

bank stabilization—the physical strengthening of a streambank or shoreline to resist erosion. Typical stabilization techniques include placing of riprap, timbers, tires, or vegetation along the eroding area.

Base Case—serves to document TVA's existing reservoir operations policy. For purposes of this EIS, it is the No-Action Alternative. Under the Base Case, TVA would continue operating individual projects in accordance with existing guidelines as defined by guide curves, priorities, and project commitments and constraints.

benthic—refers to the bottom of a stream, river, or reservoir and the organisms that live there.

best management practices—construction or maintenance practices that have been shown to be the most effective and practical ways of preventing impacts environmental resources.

biodiversity—the number and types of species in the TVA region.

Board of Directors (Board)—TVA's three-member board. Members are appointed by the President of the United States and confirmed by the Senate. The President also determines which Board member will serve as Chairman. Each member serves a term that lasts 9 years.

buildout—a term used by TVA in this EIS when referring to the estimated maximum amount (percentage) of shoreline that could eventually be developed for residential uses.

carbon dioxide (CO_2)—a colorless, odorless nonpoisonous gas that results from fossil fuel combustion and is normally a part of the ambient air.

carbon monoxide (CO)—a colorless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

census block group—the smallest geographic area, usually containing 600 to 3,000 people, for which the Bureau of the Census collects and publishes sample data.

cfs—cubic foot per second; typically used as a measure of flow in a stream. A cubic foot is equivalent to about 7.5 gallons.

channel capacity—the maximum rate of flow that may occur in a stream or river without causing it to flood its banks.

Clean Water Act (CWA)—an Act passed in 1972 to protect the Nation's water quality. The CWA is the primary law for regulating discharges of pollutants into the waters of the United States by enforcing water quality standards that are defined in Section 301 of the Act.

commercial (barge) waterway—a marked, 9-foot-draft navigation channel suitable for barge transportation, that exists on the Tennessee River and its tributaries.

consumptive use—the difference between water withdrawals from and returns back to the river system. It is the water that may be evaporated in industrial cooling, released from plants to the atmosphere, consumed by humans or livestock, or otherwise used and not returned to surface water or groundwater.

contiguous—adjacent, touching.

Council on Environmental Quality (CEQ)—the council responsible for developing environmental policy and advising federal agencies concerning implementing the National Environmental Policy Act (NEPA). Congress created the CEQ specifically to administer NEPA. Congress intended that each federal agency assume responsibility for meeting NEPA requirements, with guidance from the CEQ.

critical-period, 500-year storage—the maximum storage volume required to store the inflow from a storm with a recurrence interval of 500 years, or the probability of occurring in any give year of 0.002. The storage volume required for a specific reservoir also takes into account the reservoir's natural inflow/discharge and inflows from upstream projects.

croplands—lands used for growing agricultural crops, such as soybeans and corn, and for pasture.

cubic yard—a measure of volume used in many construction activities; the amount of material that would fill a space 1 yard (3 feet) on each side (27 cubic feet); equals 0.00062 acre-foot.

cultural resources—any historic structure, historic site, or archaeological site that is protected by the National Historic Preservation Act (NHPA) or other preservation legislation.

cumulative impacts—impacts that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions, regardless of what agency or person undertakes such actions (40 CFR 1508.7).

derates/derating—a temporary or permanent reduction in a power plant's capacity to generate electricity caused by, among other things, age, loss of efficiency in, loss of availability of, or loss of reliability of the unit due to a number of impacts—including cooling water temperature.

designated uses—categories of beneficial uses of water in a stream that have been specifically identified by the Tennessee Department of Environment and Conservation (TDEC).

detention space—see "flood storage space."

dewatering areas—low-lying areas that are isolated from a mainstem river channel by a series of dikes allows those areas to be pumped out or "dewatered" during spring and summer. These lands can then be used for agricultural or wildlife management purposes; mosquito production is also controlled and timber resources are protected.

10.2 Glossary

direct impacts—effects that are caused by the action and occur at the same time and place (40 CFR 1508.4).

discretionary operating zone—for tributary reservoirs, the storage space between the flood guide and minimum operations guide.

dissolved oxygen (DO)—the oxygen dissolved in water, necessary to sustain aquatic life; usually measured in milligrams per liter (mg/L) or parts per million (ppm).

draft—the depth below the water surface that a towboat and barge extends when fully loaded.

drawdown—the process of lowering reservoir levels. Drawdown usually is measured in feet or units of storage volume.

drawdown zone—fluctuation of pool levels, in combination with the steeper slopes of the tributary reservoirs, exposes what is referred to as a "bath tub ring" or barren drawdown zone around the shoreline.

dredging—the removal of material from an underwater location, primarily for deepening harbors and waterways.

easement—an interest in land owned by one party that allows another party to have specific, limited use of the land.

ecosystem—a community of organisms in a region and their surrounding physical resources and conditions.

edge—the junction of two different habitats, such as forest and grassland.

effluent—contaminated water, treated or untreated, discharged through a pipe from a wastewater source; generally applies to municipal and industrial wastewaters but can include wastewaters from other sources such as mining operations, yard drainage from industrial operations, and drainage from landfills.

EIS—Environmental Impact Statement—the most detailed type of environmental assessment document identified in NEPA.

embayment—a bay or arm of the reservoir.

emergent wetland—wetlands dominated by erect, rooted herbaceous plants such as cattails and bulrush.

emission shifting—the change in fuel emissions resulting from either a change in mode of transportation or a change in the number of trips of the existing mode.

endangered species—an animal or plant that is in danger of extinction throughout all or a significant part of its range.

Endangered Species Act—a federal law, first passed in 1973, leading to federal lists of endangered and threatened wildlife and plants, that requires federal agencies to ensure that actions they proposed to authorize, fund, or carry out are not likely to jeopardize the continued existence of listed species or adversely modify critical habitat.

Energy Vision 2020—a combined integrated resource plan and Programmatic EIS. In Energy Vision 2020 (TVA 1995), TVA identified and proposed to select short- and long-range strategies that would enable TVA to meet the additional needs of its customers for electricity from 1996 to 2020. TVA identified a portfolio of energy resource options from seven alternative strategies that best met TVA's evaluation criteria regarding costs, rates, environmental impacts, debt, and economic while meeting customer energy needs. Energy Vision 2020 identified short-term and long-term actions to provide flexible, competitive energy choices.

erosion—natural processes by which soil or rocks are moved from one location to another. Typical examples include streambank or shoreline erosion in which soil particles are washed away by the forces of water.

eutrophication—the nutrient enrichment and response in productivity of a water body (i.e., relatively high levels of aquatic plant life); this is a natural aging process that can be accelerated by nutrients added by humans.

Executive Order 11988—an order to federal agencies signed by the President requiring them to avoid taking or supporting siting actions in floodplains and to minimize the effects of such actions if they cannot be practically avoided.

Executive Order 11990—an order to federal agencies signed by the President requiring them to avoid new construction in wetlands and to minimize the effects of such actions if they cannot be practically avoided.

Executive Order 12898—an order to federal agencies signed by the President that requires some federal agencies to consider potential disparate effects of proposed actions on minority and low-income populations.

Executive Order 13112—an order to federal agencies signed by the President that requires federal actions to address invasive species ("alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health").

farmland conversion—shifting the use of land to non-farm uses, with irretrievable losses occurring when the land is developed.

fill period—the spring period of lessening runoff, when reservoirs are filled at a rate designed to maintain flood storage and reach targeted summer pool elevations

flats—includes mudflats as well as flats of other natural and artificial substrate types, such as various mixtures of sand, silt, cobble and gravel.

floodplain—the part of a stream valley that is covered with water during a flood event; typically associated with a flood that could occur at a given frequency.

floodway—the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that a specific recurrence interval flood (typically a 100-year flood) can be passed without substantial increases in flood heights. Minimum federal standards limit increases to 1.0 foot, provided that hazardous water velocities are not produced.

10.2 Glossary

flood storage—the volume within an elevation range on a TVA reservoir that is reserved for the storage of floodwater.

flood crest—the highest (peak) water level in a stream or river during a flood.

flood guide—a curve defining the seasonal allocation of flood storage. It represents the elevation of the reservoir above which the space is reserved for temporary and intermittent storage of water to help reduce flows at downstream locations.

foraging habitat—an area where an animal or select group of animals search for and obtain food.

forb—a nonwoody plant other than a grass.

fossil fuels—any organic fuel, such as coal, oil, and natural gas.

geographic information system (GIS)—a collection of computer hardware and software that helps people efficiently capture, store, update, manipulate, analyze, and display information about the location of the Earth's natural, cultural, economic, and human resources, and the human-made environment. Location is normally shown on maps with associated textual and numeric information that describes the characteristics of those resources.

global warming –the theory that certain gases, such as carbon dioxide (CO_2), methane (CH_4), and chlorofluorocarbon (CFC) in the earth's atmosphere effectively restrict radiation cooling, thus elevating the earth's ambient temperatures.

grasslands—an area dominated by grasses; includes lawns, pastures, and hayfields.

greenhouse effect—the buildup of carbon dioxide and other trace gases that allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

greenhouse gases—emissions that are thought to be associated with global warming (also referred to as greenhouse emissions). The term "greenhouse gases" includes CO_2 (generally a product of combustion), methane (generally a product of natural gas and decomposition of organic material), nitrous oxide (a product of combustion), and chlorofluorocarbons (freons). Because emissions of CO_2 from combustion represent the largest quantity of greenhouse gas emissions, CO_2 often is used as a gauge of total greenhouse gas emissions. (See "global warming.")

gross regional product (GRP)—the sum dollar value of goods and services created in the region; because the GRP measures the sum of wages income and corporate profit, it is a broad measure of full economic effects.

groundwater—water that is located under the surface of the earth.

guide curves—see specific guide curve definitions (e.g., minimum operations guide and flood guide).

habitat—the combined physical and biological features of a particular location that provide conditions necessary for the survival of one or more species.

habitat suitability model—a model developed to describe the suitability of an area to a particular species or group of species. It normally includes measurements of many of the species' requirements, such as food or nest sites, and is useful in describing how the species will be affected by changes to an area.

headwater—the upstream portion of a watershed.

hydric soil—soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic (oxygen deficient) conditions in the upper part.

hydrology—the field of study of the distribution and movement of water.

hydroturbine—a wheel with attached blades mounted to a shaft. Water released from a reservoir pushes against these blades, causing the turbine to spin, which powers the generating unit.

impoundment—in this EIS, another term for reservoir.

indirect impacts—effects that are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable (40 CFR 1508.4).

Interagency Team and Public Review Group (IAT/PRG)—individuals from the six Valley states, including 13 members of the public and representatives from 12 federal agencies, who were involved in review and development of the Reservoir Operations Study.

inter-basin transfer (IBT)—when water is moved from one watershed to another watershed. In 2000, the 13 IBTs from the Tennessee River watershed diverted 5.61 million gallons per day.

invasive species—an organism that successfully establishes itself, proliferates, and displaces native organisms in an ecosystem to the detriment of that ecosystem. Invasive species may include organisms referred to as non-native, exotic, alien, weeds, and pests, and may also include native species capable of rapid population expansion.

invertebrates—animals without backbones; used to refer to all animals except fish, amphibians, reptiles, birds, and mammals (the vertebrates).

karst—an irregular limestone region with sinks, underground streams, and caverns.

kilowatt hour (kWh)— the amount of energy equal to 1,000 watt-hours; common measure for use of electricity over time.

Lake Improvement Plan—the Tennessee River and Reservoir Operations and Planning Review (TVA 1990), commonly referred to as the Lake Improvement Plan. The Lake Improvement Plan proposed changes in TVA reservoir operations to maintain minimum flows below dams at critical times and locations, to increase dissolved oxygen (DO) below 15 dams by aerating releases, and to delay unrestricted summer drawdown until August 1 on 10 tributary reservoirs. These actions were proposed to recover over 170 miles of aquatic habitat lost from intermittent drying of the river bed below TVA tributary dams and improve levels of DO in over 300 miles of river where water quality was impaired in late summer and fall by releases through TVA dams.

landscape visibility—a combination of several factors that include the context of those viewing the landscape and the concern they have toward the scenic value of the lands under study. Other factors include duration of view, number of viewers, viewing distance, and discernable details that can be influenced by light/shadow, atmospheric conditions, and air quality.

load—the amount of electric power that is drawn from TVA's electric system at a given point in time.

lock—an enclosed dam chamber with gates at each end that allows water to be admitted and released; the change in water levels allows vessels to be raised and lowered so they can pass over unnavigable parts of a river. The locks in the dams on the Tennessee River make navigation possible for 652 miles—from Knoxville, Tennessee, to Paducah, Kentucky.

loess—a type of soil consisting of windblown silt.

macroinvertebrates—aquatic insects, snails, and mussels whose species and genus can be determined with the naked eye.

macrophytes—aquatic plants large enough to be seen by the naked eye.

mainstem or mainstream storage reservoirs—reservoirs located along the Tennessee River between Fort Loudoun Reservoir and the Ohio River. These reservoirs are managed with seasonal lowering (typically less than 5 to 10 feet) of water levels to provide storage for flood control and were designed to serve multiple purposes, especially commercial navigation and hydropower production.

managed area—specific, defined, land in public, institutional, or private ownership that has been established and is operated to protect significant features or resources.

mass wasting— the slumping, sliding, or toppling of sections of bank, caused by structural failure.

megawatt hour (MWh)— the amount of energy equal to 1 million watt-hours; common measure for use of electricity over time.

minimum flow—a release from one or more dams provided to meet downstream water needs (e.g., aquatic habitat, water supply, and waste assimilation), hydropower production, reservoir level targets, and other commitments; a minimum flow does not represent the lowest flow rate that TVA can pass from a dam or dams. Project minimum flows are the minimum flow required to be released from a specific dam over a specific time period. System minimum flows are minimum flows needed at some point in the system to meet certain specific needs for power, waste assimilation, navigation, and other beneficial uses.

Minimum Operations Guide (MOG)—a seasonal elevation guide for some tributary storage projects that denotes a level below which only minimum flows should be released. The system MOG is a seasonal storage guide based on the sum of the storage in 10 tributary storage projects.

minimum pool—the lowest planned water elevation set by TVA for a mainstem reservoir.

mitigation—an action that either would result in avoidance of an effect or lessen adverse effects on a resource.

modal diversion—shifting of cargoes from barge to the rail or truck mode.

modeling—for this study, use of computers to predict the effects of altered reservoir operations.

multi-purpose reservoirs—reservoirs which were constructed and are operated to accommodate multi-purposes.

National Environmental Policy Act (NEPA)—a 1970 federal law that requires federal agencies to determine the environmental impacts of proposed actions, to consider alternatives to those actions, and to include a consideration of the environmental impacts when deciding which actions to conduct. The federal agency must prepare an EIS for actions "significantly affecting the quality of the human environment" (42 USC 4332).

National Historic Preservation Act (NHPA)—a 1966 federal law that requires agencies to avoid or mitigate impacts on significant archaeological or historic resources.

National Wetlands Inventory (NWI)—a program of the U.S. Fish and Wildlife Service that maps and categorizes wetlands of the United States based on "Classification of Wetlands and Deepwater Habitats of the United States."

native species—a species, not introduced from another location, which historically occurred or currently occurs in a particular ecosystem or habitat.

navigable waterway—the Tennessee River and tributaries of the Tennessee River having a marked, 9-foot-draft navigation channel suitable for barge transportation.

Neotropical migrant birds—birds that nest in the United States or Canada and migrate to spend the winter in Mexico, Central America, the Caribbean, or South America.

nonpoint source pollution—pollution such as nutrient increases, fecal wastes, and siltation occurring from sources such as agriculture or general urban development of an area.

normal operating zone—the operating space between the flood guide and the balancing guide for the Preferred Alternative.

nutrient enrichment—the addition of excessive nutrients above those naturally found in a water system.

nutrient loading—the addition of nutrients such as phosphorus or nitrogen from various sources in a watershed.

objectives—reflect the public and TVA's range of preferences for emphasizing selected benefits from reservoir operations (such as improving recreation, reducing flood risk, and increasing tailwater aquatic habitat conditions).

operating guidelines—a set of guidelines that include guide curves, minimum flow requirements, water release requirements, and other requirements to meet system operating objectives.

option—one of many possible distinct types of water control operations or practices (such as maintaining specified winter or summer pool elevations and releasing minimum flows) that could be conducted at reservoir projects as part of one or more system-wide alternatives.

oxygen injection—a technique to improve dissolved oxygen levels in tailwaters, in which liquid oxygen is turned into gaseous form and then injected into the water before it enters a dam's turbine.

peaking capacity—a generating unit's or system's maximum output, generally applied to power resources whose output can be quickly changed to meet changing power requirements.

peaking power—supplying additional power quickly when daily power demands are highest.

permit for shoreline use—approval of proposed uses of TVA shoreline areas that can vary from the construction of water-use facilities or shoreline stabilization to the use of TVA lands for a variety of purposes, including vegetation management, recreational use, and agricultural use. These activities may be covered by a 26a permit or a TVA land use permit, depending on the type of activity.

personal income (PI)—wages and salary income, including transfer payments, dividend interest, and rent less personal social security payments.

physiographic regions—general divisions of land; each area has characteristic combinations of soil materials and topography.

point source pollution—pollution that typically comes from an identifiable source, such as industrial and municipal discharges.

policy alternative—a set of operational changes that would rebalance system operations to emphasize certain operating objectives, such as increased power production or opportunities for recreation. A policy alternative may emphasize several operating objectives at the same time.

pool recovery zone—the operating space below the balancing guide. Operations within this zone are usually made at minimum flow rates to try to fill the reservoirs back to within their normal operating zones.

Power Service Area—in this EIS, the area that receives its electricity from TVA sources. The Power Service Area includes 170 counties in much of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia.

Preferred Alternative—the policy alternative that TVA staff would prefer to implement in order to achieve the overall project purpose.

prime farmland soils—types of soils with physical and chemical properties that economically can sustain high crop yields.

programmatic review—a type of environmental review that is appropriate when a decision involves a policy or program, or a series of related actions by an agency over a broad geographic area, as compared to a specific project or action.

project minimum flow—see minimum flow.

protected species—in the context of this EIS, any plant or animal species that is on a state or federal list of endangered, threatened, or special concern or in need of management of some form.

pumping station—a structure housing pumps used to move water through a pipeline from one location to another over some higher elevation.

qualitative—analysis based on professional judgment and/or limited data.

quantitative—analysis based on hard data or numbers that can be substantiated from observations or modeled data.

ramping rate—how many hydropower turbines are simultaneously brought online or taken offline at a hydropower plant. The term ramping rate also indicates an increase or decrease in generation by an individual hydro turbine unit.

raptors—birds of prey such as hawks, eagles, and owls.

recreation period—see summer pool elevation.

recreation trip—engaging in one or more recreation activities at one or more recreation sites for an unspecified amount of time but generally more than 3-4 hours. Several recreation visits could be made during one recreation trip (i.e., a person could go camping, fishing, and boating, which would be counted as three visits to different recreation sites during one trip). (See "recreation visit" below.)

recreation visit—the visit to an area or site to engage in some form of recreation activity. Although no timeframe is associated with a visit, it generally is approximately equal to a visitor hour. A person could enter different recreation sites during a day or could make multiple visits to the same site in one day, which would be counted as more than one visit. (See "recreation trip" above.)

Regional Resource Stewardship Council—a 20-member council first convened in March 2000. The council is a formally authorized Federal Advisory Committee. The members of the Regional Council represent public and private stakeholders who benefit from TVA's management of the river system. Members are nominated by the governors of the seven states in the TVA power service area, the distributors of TVA power, and TVA's directly served customers. They serve 2-year terms. Representatives of other interested groups are chosen by TVA.

regulating zone(s)—regulating zones provide guidance for the temporary storage of floodwaters and for the effective recovery of flood control space at each project. Each regulating zone is associated with a discharge rate at which flood storage recovery efforts should be made.

regulating zone guide—this curve represents the reservoir elevation at which the flood storage recovery policy changes, usually resulting in higher discharge rates when the pool is above the guide.

reregulation weir—same as weir.

reserve margin—extra standby power generation capacity that is maintained to ensure power system reliability.

reservoir (pool) level—the elevation of the water in a reservoir at a given time.

Reservoir Operations Study (ROS)—a study and Programmatic EIS. The purpose of this ROS is to determine whether changes in TVA's reservoir operating policies would produce greater overall public value. TVA is using the EIS process to elicit and prioritize the values and concerns of stakeholders; identify issues, trends, events, and tradeoffs affecting reservoir operating policies; formulate, evaluate, and compare alternative reservoir operating policies; provide opportunities for public review and comment; and ensure that any decision to change its operating policies reflects a full range of stakeholder input.

reservoir-triggered seismicity (RTS)—the initiation of earthquakes by the impoundment or operation of a reservoir; reservoir-triggered earthquakes can be identified by a change in the pattern of earthquake activity in the immediate vicinity of a reservoir that usually begins during or shortly after (days to a few years) initial filling of the reservoir; rapid reservoir elevation changes can also trigger earthquakes.

residence time—the amount of time on average that water remains in a reservoir.

restricted drawdown—a lowering of reservoir pool levels that is limited by one or more restrictions on the rate of change.

riparian zone—an area of land with vegetation or physical characteristics that reflect permanent water influence; typically, a streamside zone or shoreline edge.

riprap—stones placed along the shoreline for bank stabilization and other purposes.

riverine—having characteristics similar to a river.

run-of-river reservoir—a project that relies on the flow of a stream or river to produce hydropower, with little or no capacity to store water; one of two major categories of projects, the other being storage. These projects pass water through a dam at nearly the same rate it enters the reservoir, so they are managed with minimal changes in seasonal reservoir levels.

runoff—rain that flows off from the land into streams. About 40 percent of rainfall in the drainage area of the Tennessee River system becomes runoff.

scenic attractiveness—a measure of scenic quality and its importance based on the perception of natural beauty that is expressed in the landscape.

scenic integrity—the measure of disturbance to a landscape and the degree to which the landscape deviates from the character and quality that are desired and valued for its scenic attractiveness. Scenic integrity is influenced by both the type and degree of shoreline development and pool-level elevations.

scope—range of operation; extent of activity or influence.

scoping—for this EIS, the process by which TVA gathered and analyzed comments from the public and government agencies on reservoir operating policies and then used that information to identify critical issues and subsequently develop alternative operating policies.

scrub/shrub—woody vegetation less than 20 feet tall, under the Cowardin et al. (1979) wetland classification system. Species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

sediment—material that is moved and deposited by wind and/or water.

shoreland—same as shoreline area.

shipper savings—costs that shippers avoid by moving cargo via barge versus rail or highway. Shipper savings are realized when navigation channels are deepened, or when available depth is sustained at consistent levels.

shoreline—the line where the water of a TVA reservoir meets the shore when the water level is at the normal summer pool elevation. This area is measured in miles in the SMI EIS.

Shoreline Aquatic Habitat Index (SAHI)—the index used to determine the quality of shoreline aquatic habitat, based on seven characteristics important to support good populations of sport and commercial fish.

shoreline area—the surface of land lying between the minimum winter pool elevation of a TVA reservoir and the maximum shoreline contour or TVA backlying property line (whichever is further). This area is measured in acres in the SMI EIS.

Shoreline Management Initiative (SMI)—An Assessment of Residential Shoreline Development Impacts in the Tennessee Valley (TVA 1998), known as the Shoreline Management Initiative, or SMI. In the SMI, TVA reviewed existing permitting practices and established a policy that better protects shoreline and aquatic resources, while accommodating reasonable access to the water by adjacent residents. The SMI document represents a review of alternative actions as well as an EIS. Seven alternatives for managing residential development were analyzed. This action affected 30 reservoir projects where TVA (under Section 26a of the TVA Act) has approval authority over proposed obstructions (such as docks, bank stabilization, and vegetation management). In 1998, 13 percent of the total shorelines miles on TVA's reservoirs was developed for residential uses, and lake front property owners had access rights along an additional 25 percent of the shoreline that was undeveloped. The SMI projected that up to 38 percent of TVA shoreline would eventually be developed for residential uses.

spillways—structures designed to allow relatively high flows of water over the top of a dam or through a separate structure. Spillways can be gated or uncontrolled.

storage reservoir—a reservoir that is capable of seasonally adjusting streamflow patterns to accomplish a variety of purposes.

stratification—the seasonal layering of water within a reservoir due to differences in temperature or chemical characteristics of the layers. (See "temperature stratification" below.)

substrate—the base or material to which a plant is attached and from which it receives nutrients.

summer operating zone—a zone that allows for fluctuations in reservoir levels for power production, flood control, and mosquito control.

surcharge zone—the area of the guide curve above the Top-of-Gates line. It represents the operating space above top of gates. It is available on reservoirs where TVA owns either flowage easements or fee simple land to an elevation several feet above the Top-of-Gates level.

surface water—water visible on the surface of the ground or in a stream, in contrast to groundwater.

suspended load—fine particles that move along in the mass of flowing water. Cloudy or muddy water typically includes suspended sediment.

system minimum flow—see minimum flow.

tailwater—the part of a river downstream from a dam; in this area, the flow and quality of the water are substantially affected by the dam discharge.

temperature stratification—the variation of water temperature with depth in a reservoir. The coldest water is typically the densest and is found on the bottom of the reservoir, whereas the warmest water is at the surface. In the Tennessee Valley, reservoirs usually begin stratifying in spring and become very stratified in May and June. Stratification disappears by winter.

Tennessee River system—the Tennessee River and its tributaries, the drainage area of which covers about 41,000 square miles, including 125 counties within much of Tennessee and parts of Alabama, Kentucky, Georgia, Mississippi, North Carolina, and Virginia.

Tennessee Valley 201-county region—the combined TVA Power Service Area and the Tennessee River watershed, comprising 201 counties within a 58-million acre area.

terrestrial—typically found on land.

thermal plant—a power plant that produces electricity from heat energy released by combustion of a fossil fuel (coal, oil, or gas) or consumption of a fissionable material (nuclear).

threatened species—an animal or plant that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

tiering—refers to the coverage of general matters in broader EISs with subsequent narrower EISs or Environmental Assessments incorporating by reference the general discussions from the programmatic EIS and concentrating solely on the issues specific to the subsequent project-specific action.

Top of Gates—this is the elevation at which spilling must occur to accommodate any additional inflow to the reservoir. The "Top of Gates" line indicates the elevation of the reservoir at the dam when the spillway gates are fully seated on the spillway crest.

tributary—a river or stream flowing into a larger stream; in this EIS, refers to the streams and rivers that eventually flow into the Tennessee River.

tributary storage reservoirs—storage reservoirs located on tributaries to the Tennessee River.

turbid—the clouded appearance of water because of the fine sediment it contains.

turbidity—all the organic and inorganic living and nonliving materials suspended in a water column. Higher levels of turbidity affect light penetration and typically decrease productivity of water bodies.

turbine pulsing—the operation of a hydroturbine for a short duration (from 15 to 60 minutes), often at regular intervals from 2 to 24 hours apart for the purpose of maintaining a minimum flow at some downstream location.

turbine venting—a technique to improve dissolved oxygen levels in tailwaters, in which air is drawn into hydroturbines and mixed with water as power is generated.

unrestricted drawdown—lowering of reservoir levels with no restrictions on the rate of change.

upland—the higher parts of a region, not closely associated with streams or lakes.

vascular plants—plants with specialized tissues that conduct water and synthesized foods.

vector—an insect (such as a mosquito) or other organism that can transmit a disease.

waste assimilation—the process by which a river accepts and dilutes wastewater.

wastewater—spent or used water from agricultural, residential, or industrial sources that contains dissolved or suspended matter.

wastewater discharge—water released into a stream or reservoir after being processed through a wastewater (sewage) treatment plant.

water column—the vertical section of water in a reservoir from its surface to its bottom.

water-compelled rates—a concept inferring that costs (rates) of shipping goods by rail are lower when water transportation is available to the shipper due to competitive factors and the need for the railroads to maximize utility.

water control system—the interconnected system of dams and reservoirs, tailwaters, navigation locks, and hydropower generation facilities on the Tennessee River and its tributaries.

water intake—a pipe or more complex structure designed and used to withdraw water from a stream or reservoir.

water quality—the physical, chemical, and biological characteristics of water compared to recognized standards of quality necessary to maintain certain uses.

water supply—water removed from a stream or reservoir for municipal or industrial use.

Weekly Scheduling Model (WSM)—the TVA reservoir system simulation model used to estimate reservoir elevations, discharges, and hydropower generations over a period of time.

weirs—structures (could be considered as low dams) placed in a river to temporarily back up or divert water. Generally, these structures are less than 10 feet high.

wetlands—areas inundated by surface or groundwater often enough to support a prevalence of vegetation or aquatic life that requires saturated or seasonably saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, mud flats, and natural ponds.

winter drawdown elevation—the planned winter elevation for a reservoir.

winter operating zone—a zone that denotes normal reservoir level fluctuations in the December-through-March period on mainstem projects.

10.3 Index

10.2 Glossary

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