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	

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.

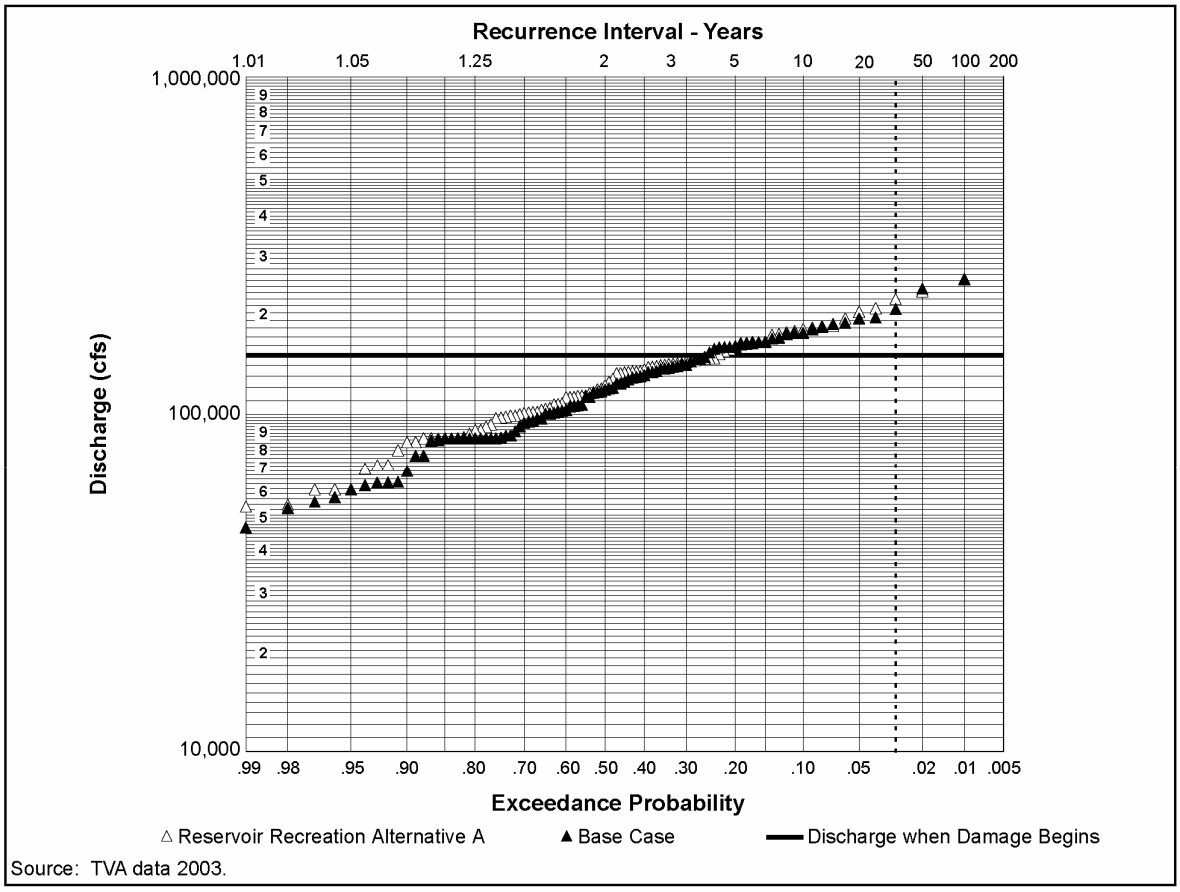


Figure 5.22-01 Simulated Annual Flood Flow Frequency for Chickamauga Dam (1903 to 2001)

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.

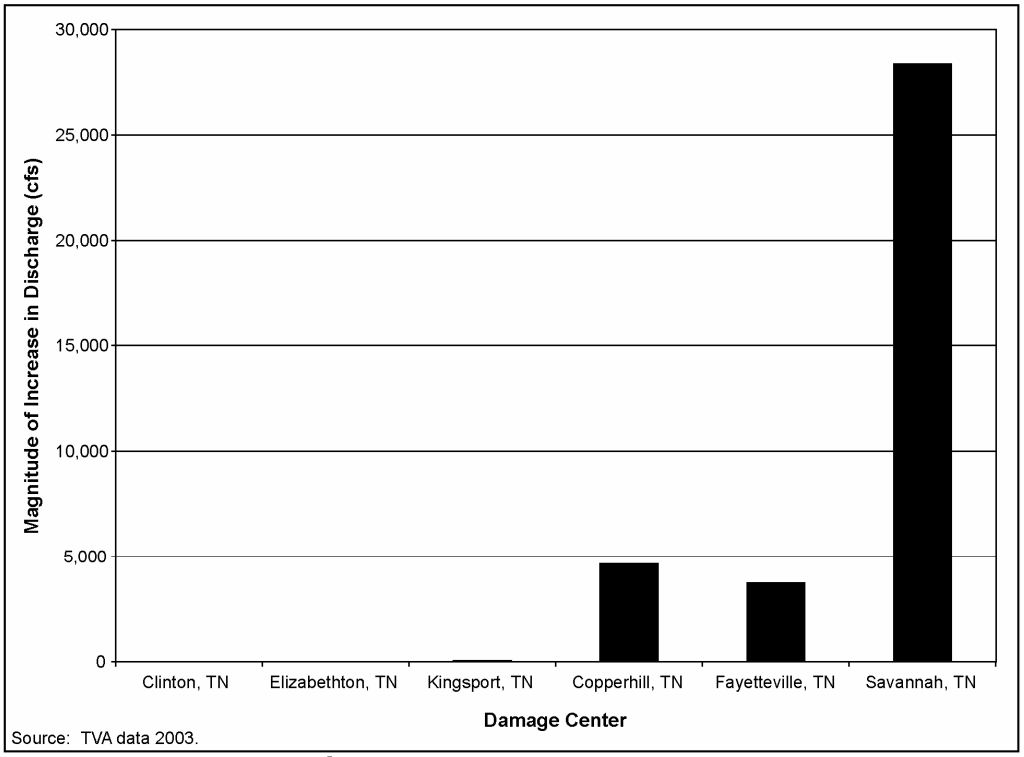


Figure 5.22-02a Increase in Simulated Peak Flow for Largest Event in 99-Year Period of Record for Six Flood Damage Centers in the Tennessee Valley Region under Reservoir Recreation Alternative A

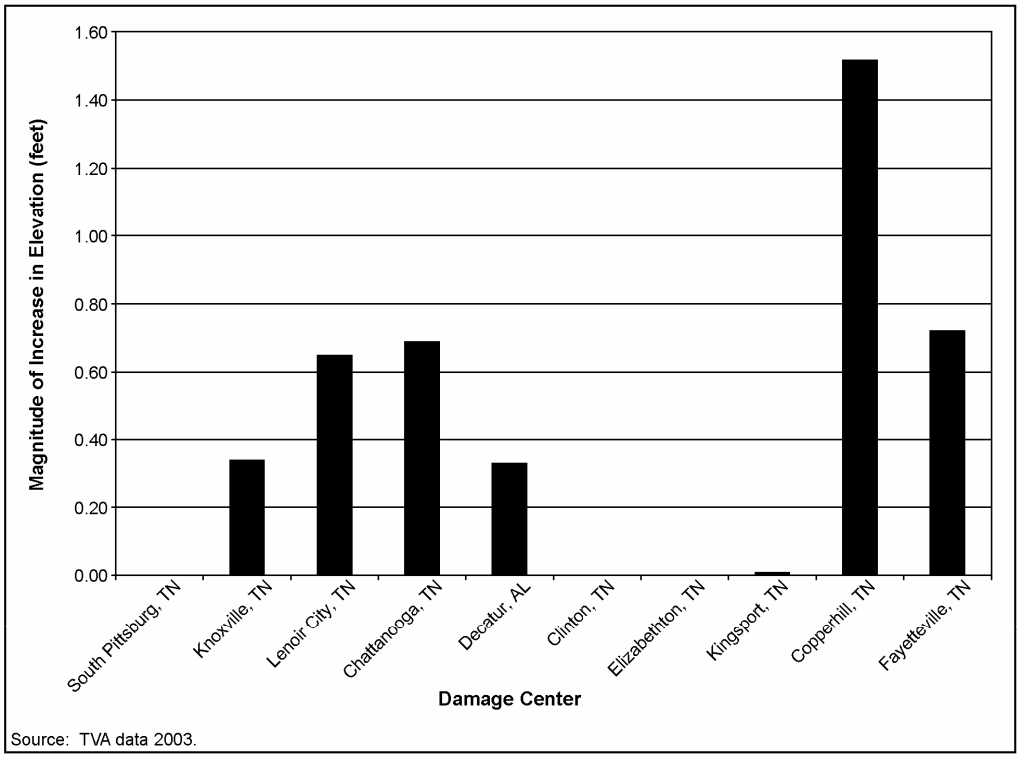


Figure 5.22-02b Increase in Simulated Peak Elevation for Largest Event in 99-Year Period of Record for 10 Flood Damage Centers in the Tennessee Valley Region under Reservoir Recreation Alternative A

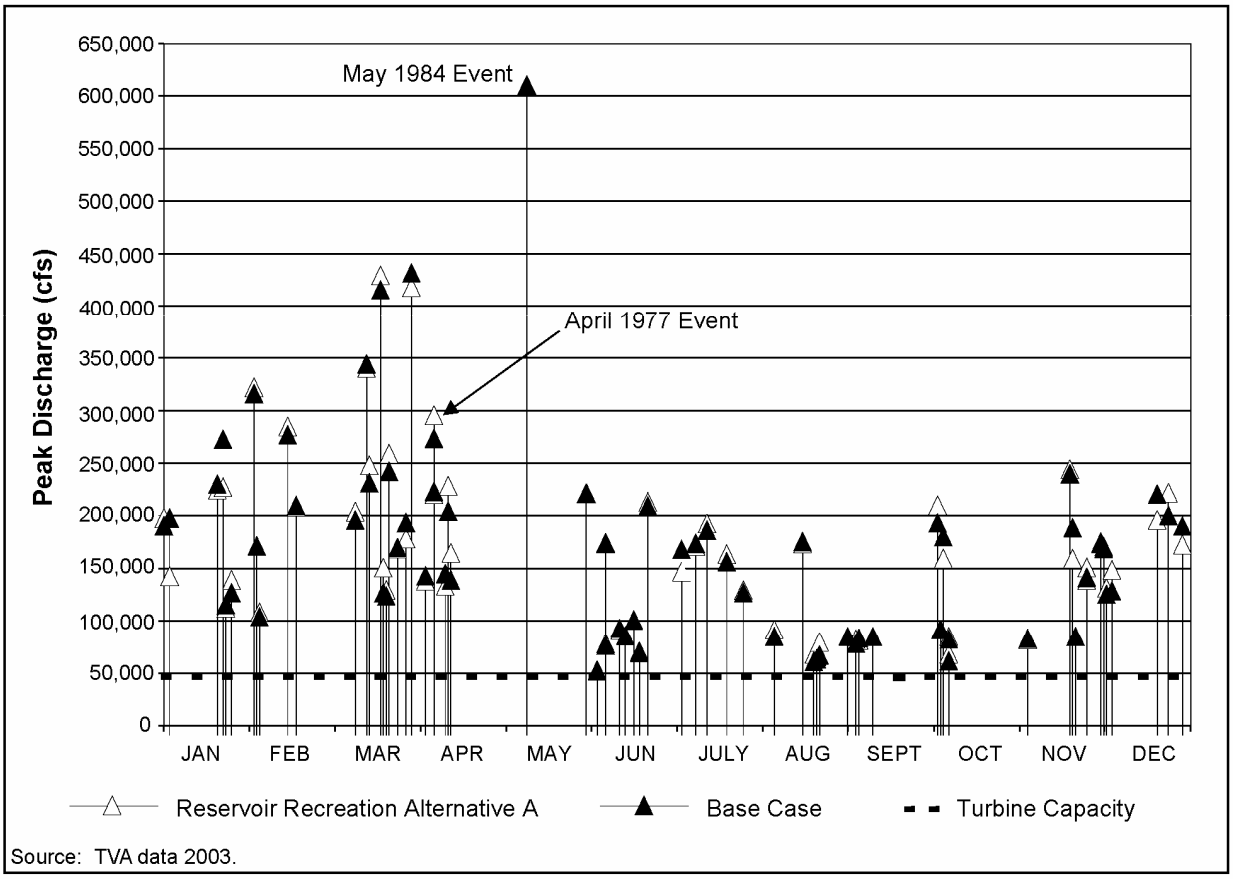


Figure 5.22-03 Peak Discharges from Hypothetical Design Storms for Chickamauga Dam (Scaling Factor 1.50)

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).

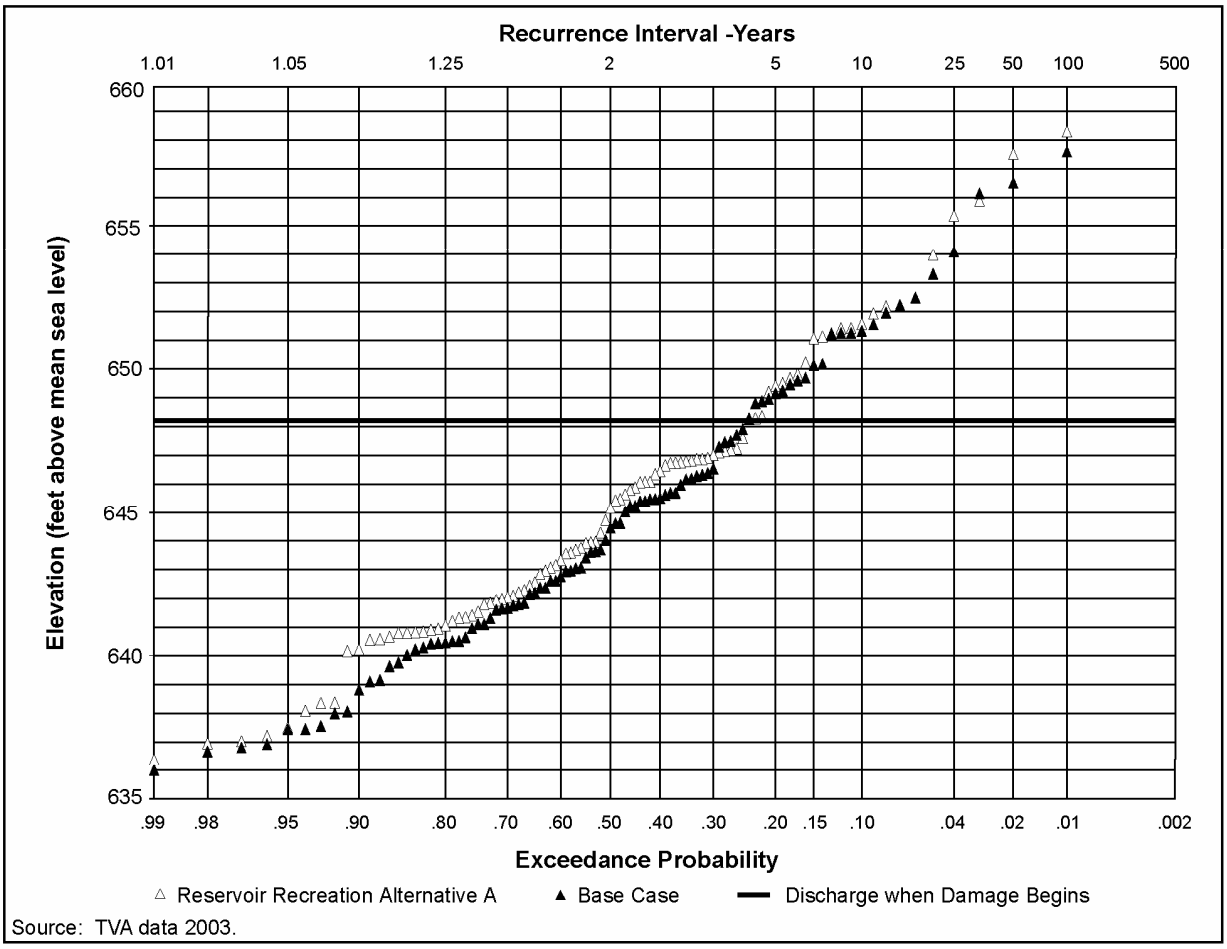


Figure 5.22-04 Simulated Annual Elevation Frequency in Chattanooga, Tennessee (1903 to 2001)

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.

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.

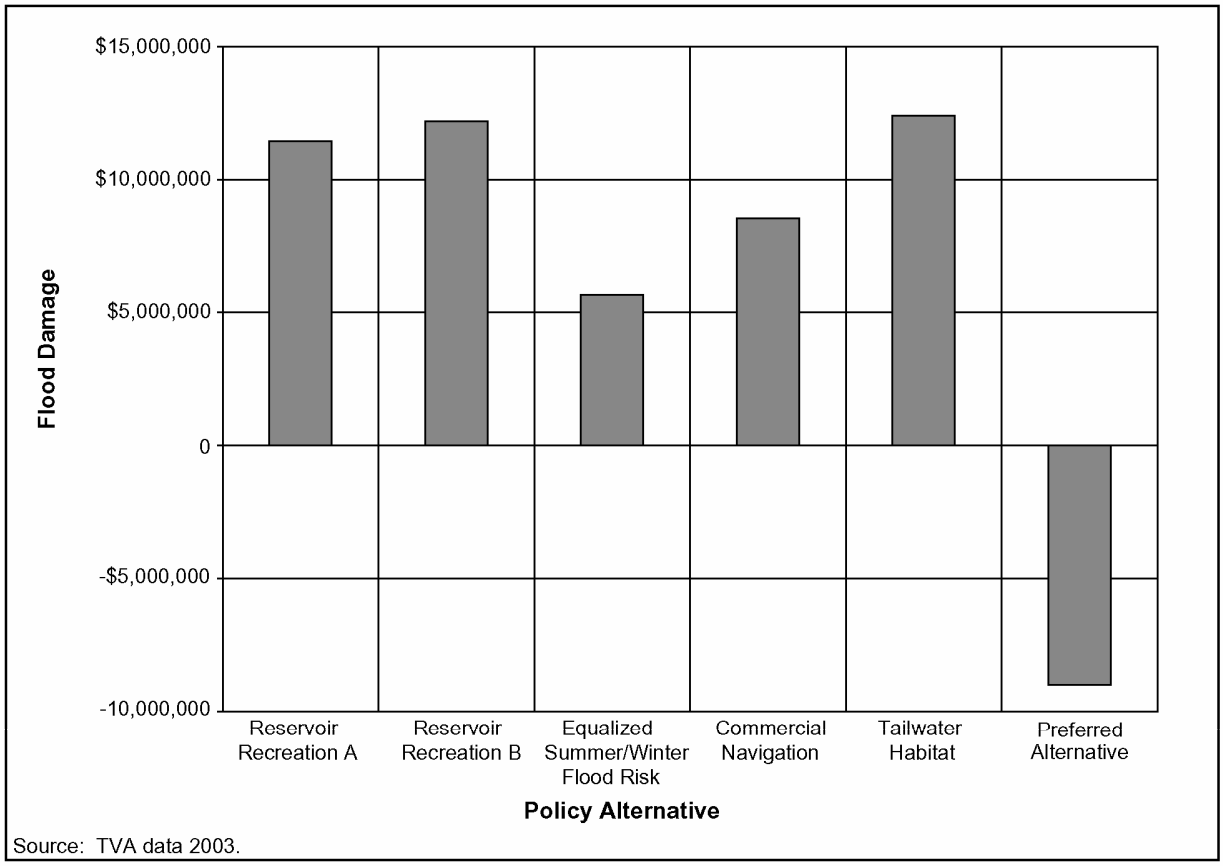
Tables 5.22-02 through 5.22-07 each include a list of selected locations, with a series of columns either shaded or unshaded to the right of the locations. The columns are in three main groups, and each group consists of five columns. These columns are labeled 1 through 5 and indicate the seasons used 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 <u>any</u> 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.

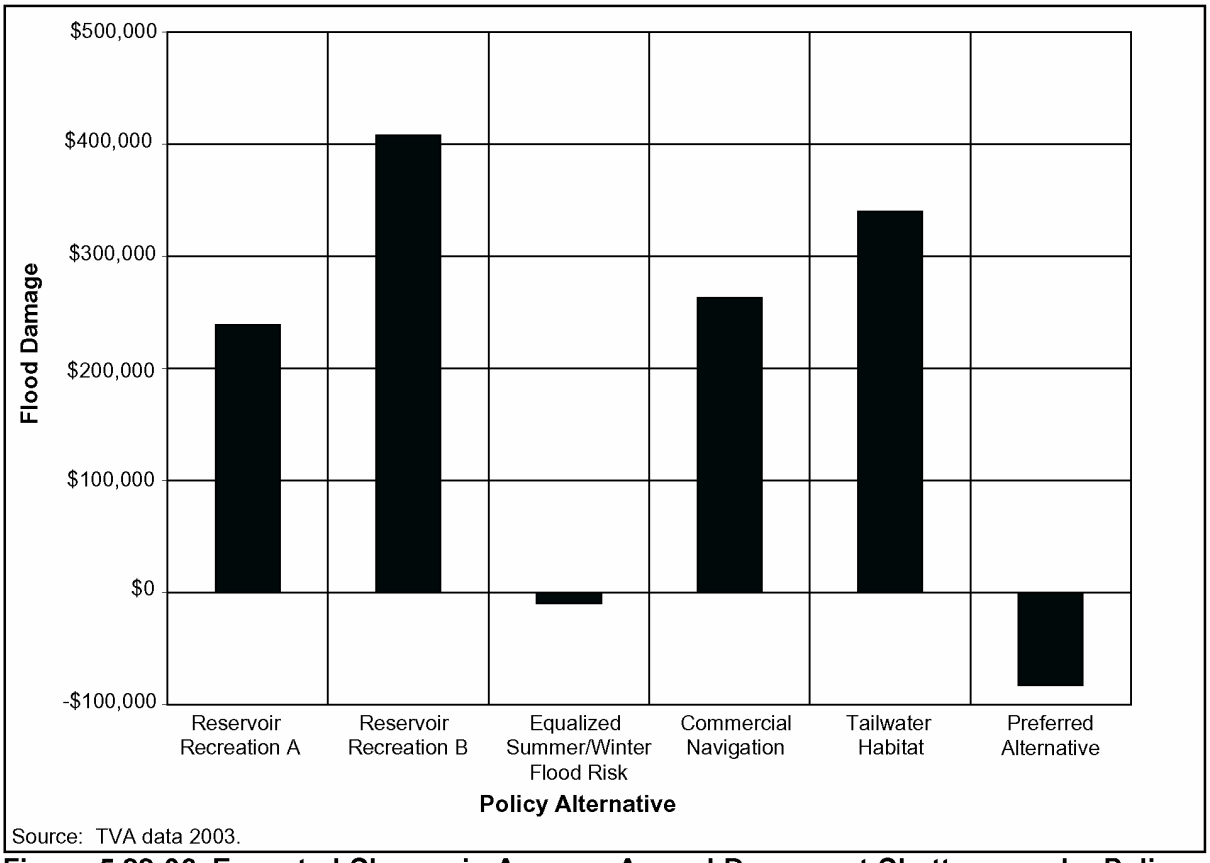


Figure 5.22-06 Expected Change in Average Annual Damage at Chattanooga by Policy Alternative Evaluated in Detail Relative to the Base Case for the 99-Year Period of Record

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.