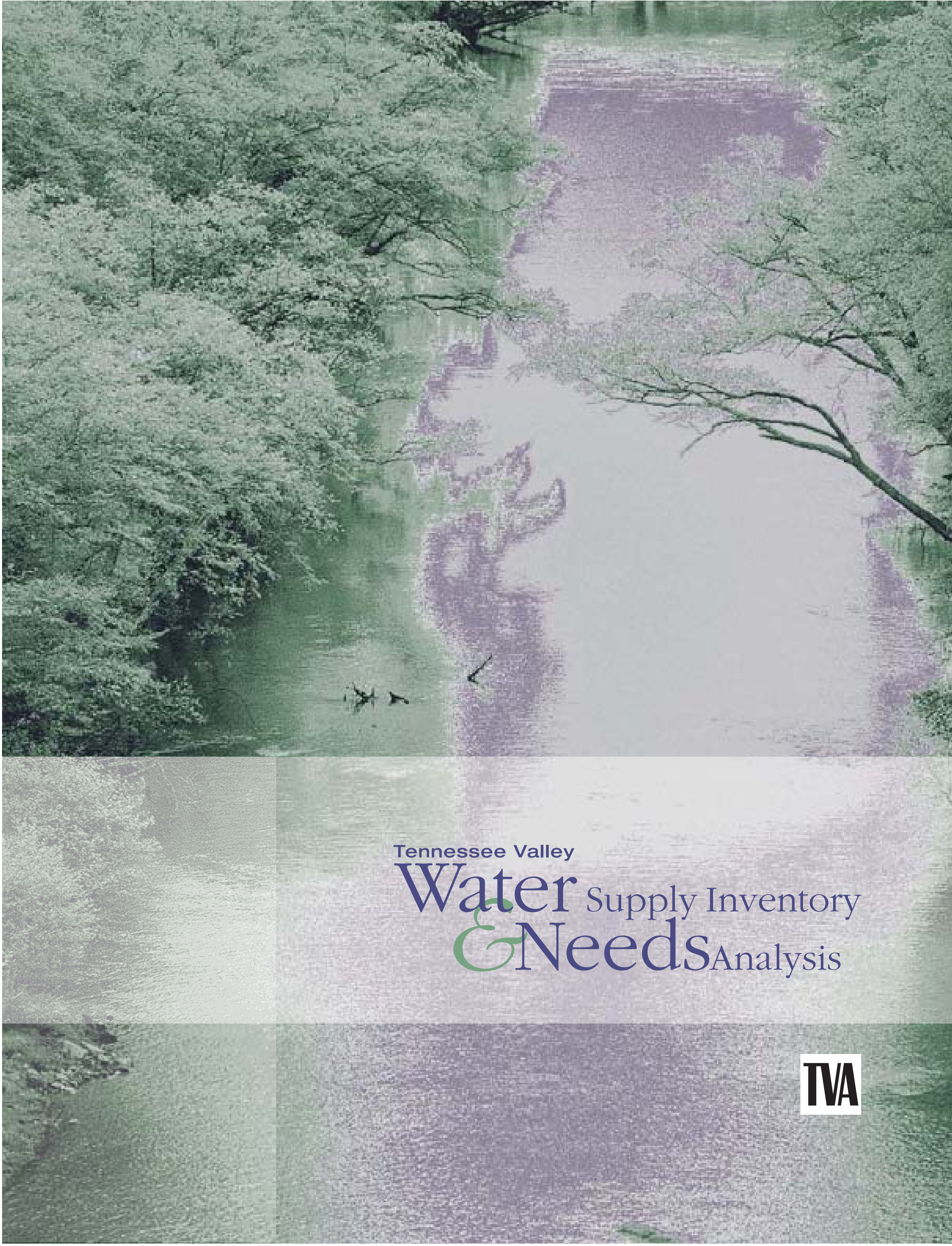

Tennessee Valley

Water Supply Inventory & Needs Analysis

TVA

TENNESSEE VALLEY AUTHORITY

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November 2004

Tennessee Valley Water Supply Inventory & Needs Analysis

TVA

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Executive Summary

Water Supply Inventory and Needs Analysis

Introduction

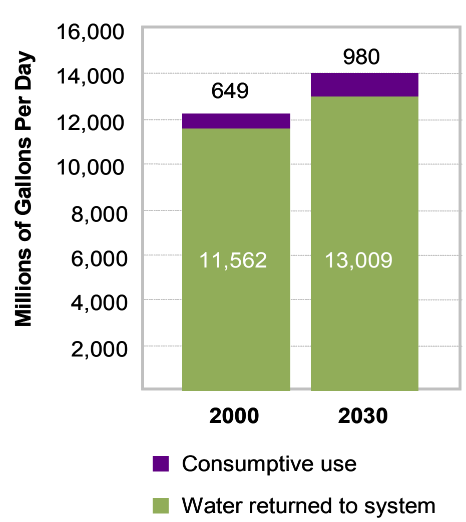
The primary objective of this report was to identify the critical water supply areas and issues that are expected to affect the Tennessee River watershed over the next 30 years. Other objectives were to supply the Tennessee Valley Authority's Reservoir Operations Study (ROS) with a forecast of 2030 water use, provide an estimate of potential Inter-Basin Transfers (IBTs) of water, and address issues concerning potential changes to water treatment and wastewater disposal resulting from possible changes in reservoir operation. Key questions addressed include:

- What is the current (2000) water use in the Tennessee River watershed?
- How much water will be used from streams and rivers in the watershed by 2030?
- Where is there insufficient stream flow and reservoir storage to support future water demand?
- Where and when will water withdrawals affect other beneficial uses (e.g. navigation, power generation, recreation, water quality, aquatic habitat)?
- Where and when will water withdrawals affect TVA's ability to meet minimum stream flow and reservoir level commitments?
- How might IBTs affect beneficial uses and TVA's operation of the river system?

Water Use

Figure ES–1 shows that by 2030, total water use in the Tennessee River watershed is forecast to increase by 15 percent, from 12,211 mgd to 13,989 mgd. However, by 2030, consumptive water use is forecast to increase by 51 percent, from 649 mgd to 980 mgd. Consumptive use is defined as withdrawals from the river system less returns to the river system. It is the part of the water withdrawn that is evaporated, transpired, incorporated into products or crops,

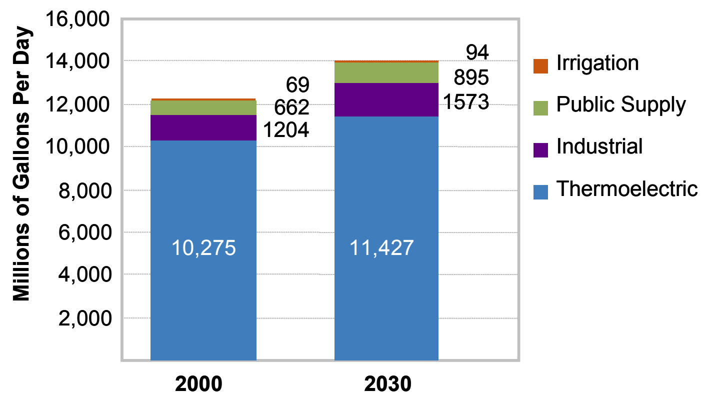
Figure ES–1: Total Water Use in 2000 and 2030



consumed by humans or livestock, or otherwise removed from the immediate water environment (Hutson and others, 2004).

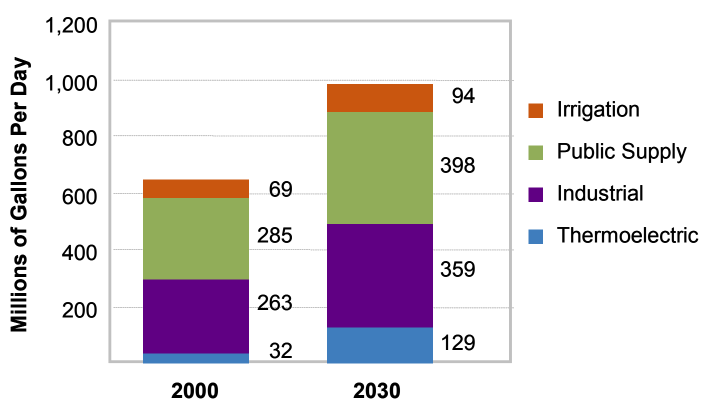
Thermoelectric power generation used about 84 percent of the water in 2000, industrial use accounted for 10 percent and public supply and irrigation used 5 percent and 1 percent, respectively. These percentages are expected to change only slightly by 2030. Total water use by category is shown in Figure ES–2.

Figure ES–2: Total Water Use by Category



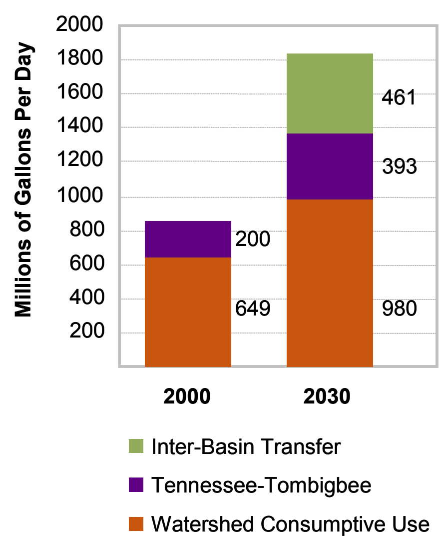
Consumptive use is expected to increase by 331 mgd or 51 percent in the next 30 years, as shown in Figure ES–3. Almost 29 percent of the increase in consumptive use is due to the increase in thermoelectric water use, an additional 29 percent of the increase is in the industrial sector, and 34 percent of the increase is due to increased demand in public supply.

Figure ES–3: Consumptive Water Use by Category



Flow from the Tennessee River to the Tennessee-Tombigbee Waterway in 2000 was about 200 mgd. The projected increase in flow by 2030 ranges from 36 to 193 mgd depending upon barge traffic assumptions. However, the increase could be as much as 600 mgd if traffic through the waterway were to reach design capacity. Should requests be submitted and approved for IBTs to areas such as northeast Mississippi, Birmingham, Alabama, and Atlanta, Georgia, it is estimated that an additional 461 mgd could be lost from the TVA system. The increased flows for the Tennessee-Tombigbee Waterway and IBTs are compared to the increase in watershed consumptive use, as shown in Figure ES–4.

Figure ES–4: Consumptive Use Plus Water Leaving the Tennessee River Watershed



Impacts of Supplying 2030 Water Demand

The increase in consumptive use within the Tennessee River watershed over the next 30 years could result in lower reservoir levels, less water in rivers under minimum flow conditions, and water scarcity in areas not served by reservoirs. The impacts are discussed below.

Reservoir Elevations

Simulations of reservoir operations using 100 years of hydrologic data were made during the course of conducting the River Operations Study (ROS), which was a study to determine if changes in TVA's reservoir system operating policies would produce greater overall public value. All the alternatives considered for the ROS included the increases for additional consumptive use and the Tennessee-Tombigbee Waterway for 2030. At the conclusion of the ROS, a preferred alternative was selected and implementation began in June 2004. An evalutation of the impacts of the growth in water demand and diversions to the Tennessee-Tombigbee Waterway was conducted for the implemented alternative. Results indicate that there will be no decrease in reservoir elevations to reservoir elevations during years when rainfall is at or above the historical median for the year. It is expected that during dry years, some decrease in reservoir elevations could be observed on tributary reservoirs. This impact might be on the order of as much as 4 feet every 1 year in 10.

Tailwaters

TVA provides minimum flow releases below 16 dams to insure that flow never drops below specified minimum values. New withdrawals located in stream reaches where minimum flows are provided might be large enough to significantly reduce the minimum flow volume. Areas where future water demand could affect minimum flow releases include the Watauga River below Wilbur Dam, South Fork Holston River below Fort Patrick Henry Dam, and possibly the French Broad River below Douglas Dam. In addition, there could be an impact to the Clinch River in the area of Bull Run Fossil Plant if significant amounts of water were used consumptively, such as for a merchant power plant.

Since future withdrawals could potentially impact minimum flows, aquatic life, and other instream beneficial uses, a case-by-case environmental evaluation would be required for new intakes. Potentially interested regulatory parties would include TVA, Valley states, and the U. S. Army Corps of Engineers.

Areas Not Supplied by TVA Reservoirs

Table ES–1 and Figure F–1 in Apprendix F summarize water supply issues relating to areas of the Tennessee River watershed which lie in the headwaters of the reservoirs and must rely on groundwater or unregulated stream flow for water supply sources. The issue for some of these communities is that additional sources of water might not be available if existing supplies run short. In addition, new water treatment regulations might cause some communities, particularly small systems or ones using groundwater, to seek new sources.

Effects of Water Quality Change on Water Supply

Variations in water quality require water treatment plants to alter treatment processes. These changes are most often in response to storm-generated changes in turbidity. An analysis of treatment costs as a function of turbidity in the Tennessee River system indicates that likely changes due to reservoir operation would not significantly change treatment costs associated with turbidity.

Reservoir operations could affect disinfection by-products (DBPs) and iron and manganese concentrations. Until recently, DBPs and iron and manganese were not significant considerations for most water treatment systems in the watershed. Taste and odor and DBPs are related, in part, to algae. Therefore, reservoir

Table ES–1: Summary of Existing and Potential Water Supply Shortages on Unregulated Streams

System	Issue
Upper Wise, Smyth, and Tazewell Counties, VA	Little opportunity to develop surface supplies if required due to location in headwater area where streams are small. Clinch River sensitive aquatic habitat well into Tennessee.
Lebanon, VA	Presently extracts about 30 percent of stream low flow. TVA projections indicate that an additional 10 percent of stream low flow might be required in next 30 years.
Duffield, VA	Presently takes about 20 percent of stream low flow, but future growth not expected to significantly increase impact on stream.
Washington County, VA	New water-treatment plant would double extractions from Middle Fork Holston River to 30 percent of low flow. Additional intake has been proposed on South Fork Holston River to lessen impact.
Gate City and Big Moccasin Creek, VA	Combined withdrawal appears to be about 30 percent of low flow in Big Moccasin Creek. Growth in demand is projected to be small.
Upper Johnson and Carter Counties, TN	Presently supplied by groundwater. Surface water sources appear limited for major switches to surface water if groundwater supplies are not adequate.
Newland, NC	North Carolina State Water Supply Plan (2001) expects Newland to exceed existing groundwater supply. If groundwater supply cannot be expanded, surface water might be available from the North Toe River.
Miller Ridge and Seven Devils, NC	North Carolina State Water Supply Plan expects communities to exceed existing groundwater supplies. If groundwater supply cannot be expanded, surface water might be available from the Elk River.
Woodfin, Biltmore Forest, Black Mountain, Laurel Park, Mars Hill, Junaluska, NC	North Carolina State Water Supply Plan expects communities to exceed existing supplies. Connection to other water systems likely.
Gatlinburg and Sevierville, TN	Demand expected to exceed supply. Douglas Reservoir/French Broad River could be considered for future supply.
Alcoa and Maryville, TN	Alcoa and Maryville already extract over half of the low flow from Little River. Future growth could result in as much as 75 percent of the low flow being extracted. However, Alcoa will soon build a new treatment plant. An intake on Fort Loudoun Reservoir for the new plant is possible to alleviate pressure on the Little River. In addtion, South Blount Utility District which currently purchases from Alcoa and Maryville, is constructing its own treatment plant which extracts from Tellico Reservoir. Maryville could obtain additional water from Alcoa.
Sweetwater, TN	Demand already consumes about 40 percent of low stream flow. Growth in demand is projected to consume 50 to 60 percent of low stream flow assuming spring supply remains reliable. Otherwise, even more of the stream low flow would be required.
Athens, TN	Groundwater supplies can be tight during dry periods. The interconnection with the Hiwassee Utility Commission which extracts from the Hiwassee River might be used to meet an increase in future demand or a shortfall in any of the groundwater sources.
Andrews and Marble, NC	North Carolina State Water Supply Plan indicates supply is limited during drought. Marble is exploring new groundwater sources.
Morgan County, TN	Surface water sources dry up during droughts.
Cumberland County Crossville, TN	Existing impoundments could be only marginally adequate to meet future demand according to recent investigation (Breedlove, Dennis, and Young, 2002).
Sequatchie River Valley, TN	Pikeville has severe problem with wells. Surface withdrawals for Valley communities could be limited in order to preserve river flow for wastewater assimilation. Investigation of other resources is underway. The Tennessee River has been proposed as a source.
Monteagle and Tracy City, TN	Communities have experienced water supply shortages in the past (Arcadis, 2001), but Monteagle has interconnected with other systems to provide additional sources and Tracy City is exploring the addition of wells.
Central Giles, Lawrence, and Wayne Counties, TN	Surface water extractions are currently greater than 25 percent of low stream flows. Growth in demand over the next 30 years might cause extractions to be as much as 40 to 60 percent of low stream flows.
Southern Henderson County, TN	Little opportunity to develop local surface supplies if existinging groundwater sources prove inadequate. Location is in headwater area where streams are small. Potential surface water sources are Beech River impoundments and Tennessee River.
Tennessee Ridge, TN	Groundwater supply is inadequate. Tennessee River being considered as possible source.

operating alternatives that significantly increase algae and total organic carbon (TOC) concentrations could be viewed as less favorable from a water supply quality perspective. Likewise, alternatives which deplete reservoir oxygen significantly more than other alternatives would be expected to result in higher iron and manganese concentrations at the raw water intake. Many treatment plants have multilevel intakes to avoid elevated reservoir iron and manganese concentrations, and some have processes for removing these species.

Flow and Ambient Water Quality Issues Associated with Wastewater Disposal

Minimum instream flows are used by state regulators as a basis for issuing wastewater discharge permits under the National Pollutant Discharge Elimination System (NPDES). Because the Reservoir Operations Study (ROS) considered no alternative which would decrease minimum flows, it was considered that no NPDES wastewater discharge permit holder would be adversely affected by a change in reservoir operation. However, an investigation was conducted to verify this assumption.

Industries, municipal wastewater treatment plant operators and state regulators were interviewed to determine if there were any wastewater discharge permits in the Tennessee River watershed that depended on more than just minimum river flow. Four instances of industrial discharge were found to depend on ambient water quality or river flow as a condition of their discharge permits. All four were pulp and paper manufacturing facilities. Some of the plants identified store wastewater during lower flows for release during higher flows. Should any of the plants exceed their wastewater storage capacities, the plants would have to shut down. The plants and wastewater discharge issues, which could be affected by changes in reservoir operations, are summarized in Table ES–2.

Table ES–2: Wastewater Discharges Potentially Affected by Changes in Reservoir Operations

Plant	Location	Wastewater Disposal Issue Potentially Affected by Reservoir Operations
Bowater	Hiwassee River near Calhoun, TN	Discharge must be diluted 20 to 1 by river flow
Packaging Corporation of America	Pickwick Tailwater near Counce, TN	Prohibited from discharging unless at least 1 turbine operating at Pickwick discharging at least 7000 cfs
Mead Corporation (Smurfit-Storm Container Corporation)	Guntersville Reservoir near Stevenson, AL	Prohibited from discharging unless reservoir DO is greater than 5 mg/L
International Paper	Wheeler Reservoir near Courtland, AL	Prohibited from discharging unless reservoir DO is greater than 5 mg/L

Summary

Total water demand in the Tennessee River watershed is expected to increase by 15 percent and consumptive use is expected to increase by 51 percent from 2000 to 2030. In 2000, the only significant transfer of water outside the watershed was through the Tennessee-Tombigbee Waterway. Water shortages outside the watershed might result in requests to transfer additional water outside the watershed in the coming years.

The Tennessee River watershed uses water more intensively than any other major watershed water resource region in the country and has the highest annual withdrawal per square mile than any other system. However, the percentage of consumptive use in the watershed is the lowest of any watershed water resource region (Hutson and others, 2004). Although much water is used, most of it is returned to the system. Nevertheless, there are communities in the watershed which are currently experiencing water supply problems, expect their future demand to exceed their current supply, or are already using a high amount of stream flow under low-flow conditions. There is also the potential for new water intakes or the expansion of existing ones to reduce minimum flow releases below dams.

Critical water supply issues identified in the preceding discussions are shown in Figure F–1 in Appendix F.

1
Introduction

Background

Extended dry periods during the last 15 years have heightened public interest in water supply and the availability of surface and groundwater resources in the Tennessee River watershed. Increasingly, water is seen as a scarce resource that must be protected and managed. An adequate and dependable water supply is a necessity for economic growth and regional development. Recognizing this situation, many cities, utilities, and states are taking steps to protect available water sources.

Efficient water management requires reliable information on existing and future demands relative to the available supplies. To assist in providing this information, TVA and the United States Geological Survey (USGS) cooperated in a two-year study of water supply needs in the region. The study area included the entire state of Tennessee and those counties in surrounding states that drain to the Tennessee River watershed as shown in Figure 1–1. The study involved an inventory of existing (year 2000) public and private water supplies and wastewater discharges, a projection of future demands, and a comparison of the future demands with the capacity of the available water resources.

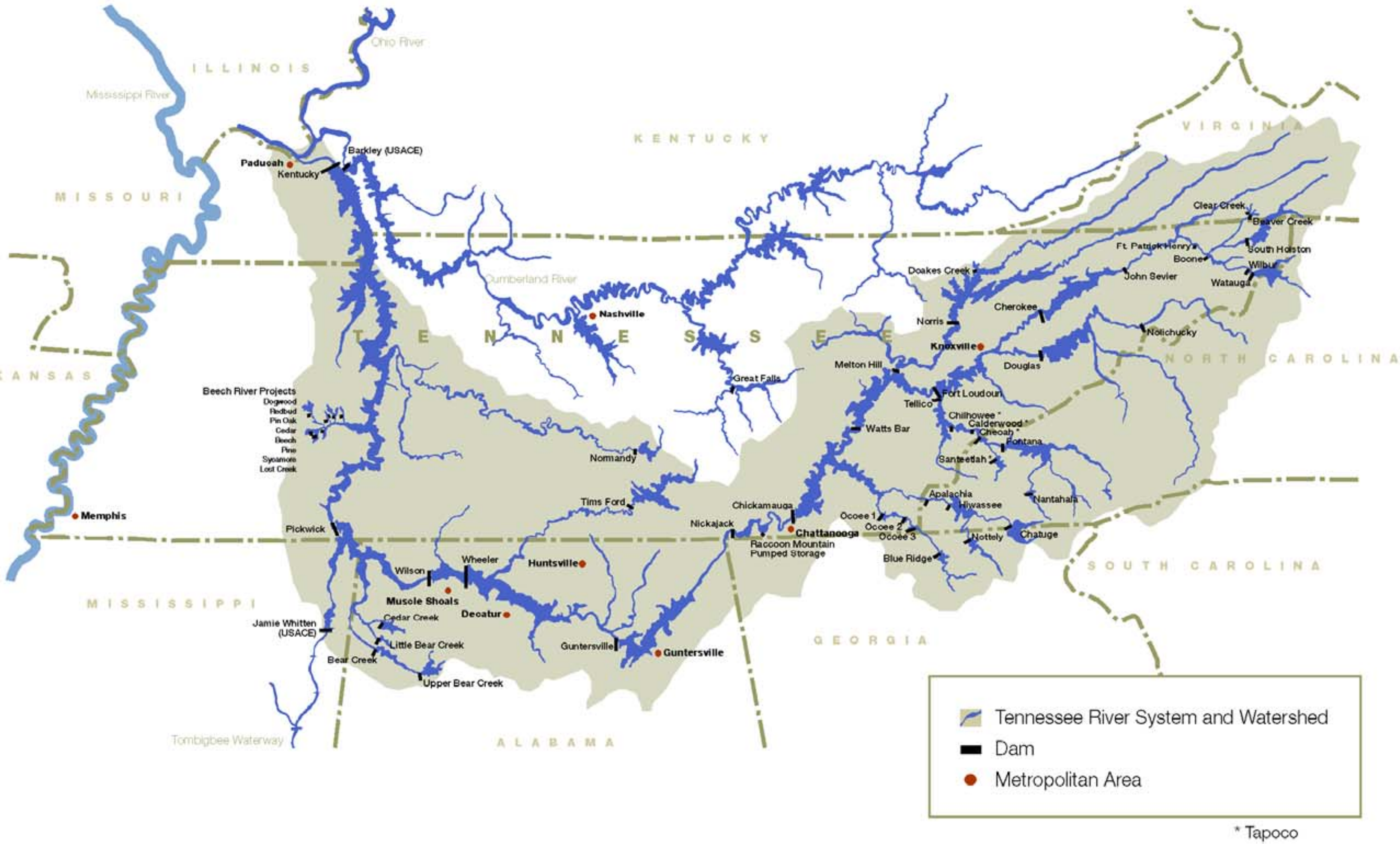
The results of this study were also used as input to TVA's ROS. The ROS is a formal reevaluation of TVA policies for operating the reservoir system, including an analysis of the costs and benefits of potential changes in these policies. In the course of conducting the ROS, several water supply issues, which are addressed in this report, were raised.

This report presents details concerning the 2030 water use projections, evaluates the potential water supply impacts of the 2030 water use projections, and addresses specific issues raised by the ROS.

Companion Report

The inventory of water use for 2000 and the projected water use for 2030 is presented in the report, "Estimated Use of Water in the Tennessee River Watershed and Projections of Water Use in 2030" (Hutson and others, 2004).

Figure 1–1: The Tennessee River and Major Tributaries



Water Supply and Wastewater Discharge Inventory Database

In 2001, a water use survey was completed for 2000 withdrawals from the Tennessee River watershed for four major water use categories: public supply, industrial, thermoelectric, and irrigation. TVA collected information on industrial and thermoelectric use, the USGS collected information on public supply. The USGS also obtained data from the U. S. Department of Agriculture (USDA) from which irrigation data were derived. For the municipal, industrial, and thermoelectric use categories, data relating to the water returned to the system in the form of treated wastewater and cooling water discharges were also obtained. A projection algorithm was developed to interface with the database to project water use for any year out to 2030.

Report Objectives

The primary objective of this report is to identify the critical water supply areas and issues that are expected to affect the Tennessee River watershed and the TVA reservoir system over the next 30 years.

Key questions to be addressed include:

- What is the current (2000) water use in the Tennessee River watershed area?
- How much water will be used from streams and rivers in the watershed by 2030?
- Where is there insufficient stream flow and reservoir storage to support future water demand?
- Where and when will water withdrawals affect other beneficial uses (e.g., navigation, power generation, recreation, water quality, aquatic habitat)?
- Where and when will water withdrawals affect TVA's ability to meet minimum stream flow and reservoir level commitments?
- How might inter-basin transfers affect beneficial uses and TVA's operation of the river system?

The analysis of supply and demand conflicts required three areas of analysis: reservoirs, streams below reservoirs (tailwaters), and unregulated streams.

Reservoirs

TVA reevaluated the operation of its reservoir system (see Interface with Reservoir Operations Study in this chapter) and implemented a new operating policy in June 2004. Meeting the projected increase in water demand and the increase in diversions to the Tennessee-Tombigbee Waterway was an objective of the new policy. Under some hydrologic conditions, reservoir elevations could be lower than they would be without the growth in demand and diversions.

Streams Below Reservoirs

TVA provides minimum flows below many reservoirs. A significant increase in withdrawals by intakes located in the tailwater section below these dams could reduce the minimum flow which is provided to maintain designated stream uses. Critical minimum flow river reaches are discussed in regard to increased withdrawals from the reaches.

Unregulated Streams

Many communities lie upstream of TVA reservoirs and obtain water from unregulated streams. During low-flow conditions, some streams might not support future growth resulting in potential water shortages. As water demands grow, some communities might turn to nearby reservoirs for additional supplies. Others might be too far from existing reservoirs to obtain water from them. Areas which may have to rely on unregulated streams for supply or possibly consider constructing small water supply reservoirs are identified and typical situations discussed.

Interface with Reservoir Operations Study

TVA recently conducted a comprehensive study of its reservoir operating policies to determine whether changes in those policies would produce greater public value. Because of the importance of water supply to the Tennessee Valley, water supply was included in the ROS. Specific requests for information relating to water supply were made in the course of conducting the ROS. The following information was supplied in this report in support of the ROS.

Water Supply Estimates for Alternative Analysis

The 2030 water demand forecast presented in Chapter 2 was utilized in the ROS for the analysis of alternatives.

Effect of Supplying Future Water Demands on Reservoir Levels

Supplying future water needs in the Tennessee River Watershed will result in reduced reservoir levels under some conditions. This is discussed in Chapter 3.

Analysis of Effect of Reservoir Operating Alternatives on Water Supply

Alternative ways of operating the reservoir system might impact existing water supply intakes, water treatment systems, and wastewater treatment systems. Should alternatives decrease minimum pool levels, some intakes might be affected. The effect of meeting future water supply demands on minimum reservoir elevations is discussed in Chapter 3. Water treatment and wastewater treatment issues are discussed in Chapters 6 and 7, respectively.

2
Estimated Water Use in 2000 and 2030

Introduction

The existing water use in the Tennessee River watershed for 2000, as well as the forecasted water use in 2030, are described in this chapter. Potential IBTs from the Tennessee River watershed are also addressed.

The companion report (Hutson and others, 2004) describes the sources, collection, verification, and database construction for 2000 water use. The Hutson report summarizes surface and groundwater withdrawals and wastewater returns. The use is categorized into thermoelectric, industrial, public supply, and irrigation. Summaries are presented by hydrologic cataloging unit, by state and county, and by reservoir catchment area and water-use tabulation area. The report characterizes the water data withdrawals as to the source of supply (surface or groundwater) and the type of use.

Data Collection and Storage

Data Source

The USGS collected and summarized public water supply data for the Tennessee River watershed counties in the seven valley states. Alabama, Kentucky, Georgia, and Virginia permit intakes and permit holders must report withdrawals annually. These reports serve as the basis for the 2000 data. In Tennessee, the EPA (Environmental Protection Agency) monthly operating reports supplied by public water supplies were used as the data source. Since North Carolina has no reporting requirement, the USGS conducted a survey of public water supplies to determine the withdrawal amounts. All of the counties in Mississippi are served by groundwater except Tupelo, which extracts about 8 mgd from lockages through the Tennessee-Tombigbee Waterway; therefore, only return flow data were collected.

A list of industrial water users, developed for a 1995 USGS survey, was supplied to TVA. A database of water-supply intakes, permitted under Section 26a of the TVA Act, is maintained by TVA. Using these two sources of information, TVA developed a list of industrial water users. A questionnaire relating to water use was sent to each industry on the list. Using those responses, TVA compiled the industrial water-use data. Other data sources, listed below, were also used.

- Irrigation data were provided by state USDA offices to the USGS.

- Thermoelectric data were provided by TVA.
- Wastewater discharge data were obtained by TVA from EPA. The data were then reviewed by the USGS to extract stormwater flows from the data set.

More detail concerning the collection of data is presented in Hutson and others (2004).

Database

Data were compiled in a Microsoft Access database. Key data fields include the following:

- State
- County
- Source or receiving water type—surface water or groundwater
- Source name—river, reservoir, or groundwater aquifer
- Withdrawal/discharge rate—average yearly and maximum daily (maximum daily withdrawals are currently available for Tennessee only)
- Use category—public supply, industrial, commercial, irrigation, mining, and thermoelectric
- Location—latitude and longitude
- User name
- 8-digit hydrologic unit
- Population served—public systems only

Data Record Assignment to Reservoir Catchment Areas

Each intake and discharge listed in the database and within the Tennessee River watershed was assigned a Hydrologic Unit based on its location. Intakes and discharges were also assigned to one of 30 reservoir catchment areas in order to model the combined effects of all the intakes and discharges on individual reservoirs and the TVA reservoir system. The assignment to a particular reservoir was based on the following criteria:

(1) The intake or discharge point was in the reservoir.

(2) The intake or discharge was in the river, or a tributary to the river, above the dam creating the reservoir.

(3) The intake was actually below the dam, but in close proximity to the reservoir such that future expansions of the water supply would likely be supplied by the upstream reservoir.

Wastewater discharges located below a dam were always assigned to the next downstream reservoir catchment area.

Judgment was used in assigning intakes under condition (3) as to where the future water supply would be provided. The conservative approach was to assume that the growth in water supply would come from the nearby upstream reservoir. In some cases, this assignment can be thought of as the influence of the upstream reservoir extending a short distance below the dam over a reach which would be dry without releases from the reservoir.

The details of these assignments appear in Appendix A. The 8-digit hydrologic units and the reservoir catchment areas are shown in Figure F–2 and F–3 in Appendix F.

Reservoir catchment areas were combined into water-use tabulation areas which were determined by the natural drainage. The water-use tabulation areas account for water availability and the water-use transactions (withdrawal, delivery, release, return flow, or transfer) that occur with the drainage area. The water-use tabulation areas account for the complete site-specific, water-use transactions between adjoining reservoir catchment areas and are used to determine consumptive use at a large scale.

2000 Water Use

Water Use Summary

Table 2–1 summarizes the total water use by source, reservoir catchment area, and water-use tabulation area. Table 2–2 summarizes total water use by water-use tabulation area and category and also shows the net water demand for each reservoir catchment area.

Although water is withdrawn from the river system, most of the water is returned in the form of wastewater. The net demand is computed as the amount of water withdrawn less the amount of water returned. In the aggregate of the Tennessee River watershed, the total net demand is the amount of water which is consumptively used. The net demand for each reservoir catchment area is the amount of water taken from each reservoir for water supply. The net demand is also the input parameter to the simulation of the effect of meeting the 2030 water supply demand on the reservoir system and is explained in Chapter 3. Please see the glossary for the definitions for net water demand, total net water demand, and consumptive use.

The total water withdrawals for 2000 were 12,211 mgd, of which 11,996 mgd was surface water or 98 percent of the total withdrawal. Approximately 6 percent of the water withdrawal was used consumptively. Table 2–3 summarizes water use by category.

Comparison of Net Water Demand to Evaporation Estimates

Estimates for evaporation from TVA reservoirs range from 36 inches/year to 44 inches/year (Tennessee Valley Authority, 1943). The range of variability is estimated to be about 6 inches/year. Using these evaporation rates, the net water demand for 2000 was about 30 percent of the present average evaporation volume from all the reservoirs.

Existing Inter-Basin Transfer Analysis

Inter-basin transfers are of concern because water is actually lost from the system. In addition, Tennessee recently enacted an Inter-Basin Transfer Act which requires a permit to be issued in order for water to be transferred from one river basin to another. Table 2–4 shows the existing inter-basin transfers into and out of the Tennessee River watershed.

Table 2–1: 2000 Water Use by Source, Water-Use Tabulation Area, and Reservoir Catchment Area (in Millions of Gallons per Day)

Water-Use Tabulation Area Reservoir Catchment Area	Surface Water	Groundwater	Total Water	Total Return Flow	Net Water Demand
Cherokee					
Watauga	12.40	9.40	21.80	2.85	18.95
South Holston	21.30	8.01	29.31	2.33	26.98
Boone	0.00	3.72	3.72	23.62	-19.90
Fort Patrick Henry	513.10	0.00	513.10	0.00	513.10
Cherokee	639.23	13.00	652.22	1103.66	-451.44
WUTA total	1186.02	34.13	1220.15	1132.46	87.69
Douglas					
Douglas	110.78	11.99	122.76	57.50	65.26
Fort Loudoun					
Fort Loudoun	77.52	1.60	79.12	56.39	22.73
Cumulative net demand					175.68
Fontana-Tellico					
Fontana	4.64	1.13	5.76	3.37	2.40
Santeetlah	0.44	0.00	0.44	0.00	0.44
Tellico	4.16	0.57	4.73	1.09	3.64
WUTA total	9.24	1.70	10.93	4.46	6.47
Norris					
Norris	29.88	3.42	33.30	10.69	22.61
Melton Hill	500.36	1.58	501.94	479.33	22.61
WUTA total	530.25	4.99	535.24	490.02	45.22
Hiwassee-Ocoee					
Chatuge	1.73	0.18	1.91	0.27	1.64
Nottely	0.60	0.55	1.15	0.24	0.91
Hiwassee	0.93	0.00	0.93	0.10	0.84
Apalachia	2.94	0.00	2.94	0.00	2.94
Blue Ridge	33.25	0.05	33.30	0.33	32.97
Ocoee	0.01	1.11	1.12	24.63	-23.51
WUTA total	39.46	1.90	41.36	25.57	15.79
Watts Bar-Chickamauga					
Watts Bar	1494.66	1.11	1495.77	1366.58	129.19
Chickamauga	1667.10	24.02	1691.12	1775.56	-84.44
WUTA total	3161.76	25.13	3186.89	3142.13	44.76
Cumulative net demand					287.92
Nickajack					
Nickajack	62.94	9.86	72.80	60.50	12.30
Cumulative net demand					300.23
Guntersville					
Guntersville	1594.42	7.86	1602.28	1585.93	16.35
Cumulative net demand					316.57
Tims Ford					
Tims Ford	58.57	2.80	61.37	40.50	20.87
Wheeler-Wilson					
Wheeler	2449.02	45.82	2494.84	2328.13	166.71
Wilson	53.77	3.36	57.31	27.81	29.32
WUTA total	2502.79	49.18	2551.96	2355.95	196.01
Cumulative net demand					533.46
Pickwick					
Pickwick	1308.23	5.41	1313.64	1291.56	22.08
Cedar Creek	3.00	1.13	4.13	0.00	4.13
Upper Bear Creek	2.81	0.16	2.97	0.00	2.97
WUTA total	1314.04	6.70	1320.74	1291.56	29.18
Cumulative net demand					562.64
Normandy					
Normandy	26.30	2.11	28.41	2.19	26.22
Kentucky					
Kentucky	1322.24	54.93	1377.17	1317.30	59.87
Watershed total	11996.32	214.86	12211.18	11562.45	648.73

Table 2–2: 2000 Water Use by Category, Water-Use Tabulation Area, and Reservoir Catchment Area (in Millions of Gallons per Day)

Water-Use Tabulation Area Reservoir Catchment Area	Thermoelectric		Industrial		Public Supply		Irrigation	Totals	
	Water Withdrawal	Water Return Flow	Water Withdrawal	Return Flow	Water Withdrawal	Return Flow	Water Withdrawal	Water Withdrawal	Return Flow
Cherokee									
Watauga			0.64	0.47	21.04	2.38	0.12	21.80	2.85
South Holston			0.83	0.47	26.25	1.86	2.23	29.31	2.33
Boone			0.00	0.04	3.72	23.58	0.00	3.72	23.62
Fort Patrick Henry			496.70	0.00	16.40	0.00	0.00	513.10	0.00
Cherokee	621.00	621.00	10.72	467.53	20.22	15.13	0.28	652.22	1103.66
WUTA total	621.00	621.00	508.89	468.51	87.63	42.95	2.63	1220.15	1132.46
Douglas									
Douglas	4.97		42.28	28.49	73.07	29.01	2.44	122.76	57.50
Fort Loudoun			0.00	0.00					
Fort Loudoun			5.02	1.37	72.42	55.03	1.68	79.12	56.39
Fontana–Tellico									
Fontana			1.94	1.36	3.83	2.01	0.00	5.76	3.37
Santeetlah			0.00	0.00	0.44	0.00	0.00	0.44	0.00
Tellico			0.00	0.00	4.68	1.09	0.05	4.73	1.09
WUTA total			1.94	1.36	8.94	3.10	0.05	10.93	4.46
Norris									
Norris	9.24	0.00	6.24	0.21	17.56	10.48	0.26	33.30	10.69
Melton Hill	469.00	469.00	1.48	0.90	31.41	9.43	0.05	501.94	479.33
WUTA total	478.24	469.00	7.72	1.11	48.97	19.91	0.31	535.24	490.02
Hiwassee–Ocoee									
Chatuge			0.04	0.00	1.88	0.27	0.00	1.91	0.27
Nottely			0.00	0.00	1.00	0.24	0.15	1.15	0.24
Hiwassee			0.08	0.00	0.75	0.10	0.11	0.93	0.10
Apalachia			0.00	0.00	2.89	0.00	0.05	2.94	0.00
Blue Ridge			31.77	0.00	1.47	0.33	0.07	33.30	0.33
Ocoee			0.00	24.37	1.11	0.26	0.01	1.12	24.63
WUTA total			31.89	24.37	9.09	1.20	0.39	41.36	25.57
Watts Bar–Chickamauga									
Watts Bar	1484.10	1345.00	0.03	0.24	9.53	21.34	2.12	1495.77	1366.58
Chickamauga	1571.40	1693.50	68.36	68.14	47.39	13.92	3.97	1691.12	1775.56
WUTA total	3055.50	3038.50	68.38	68.37	56.91	35.26	6.09	3186.89	3142.13
Nickajack									
Nickajack			23.66	15.30	48.78	45.19	0.35	72.80	60.49
Guntersville									
Guntersville	1546.00	1546.00	10.97	19.49	42.43	20.45	2.88	1602.28	1585.93
Tims Ford								0.00	0.00
Tims Ford			56.26	35.93	4.86	4.57	0.26	61.37	40.50
Wheeler–Wilson									
Wheeler	2108.00	2107.00	229.62	147.86	110.82	73.27	46.39	2494.84	2328.13
Wilson			30.31	21.01	23.16	6.80	3.96	57.12	27.81
WUTA total	2108.00	2107.00	259.63	168.87	133.98	80.07	50.35	2551.96	2355.94
Pickwick									
Pickwick	1251.00	1251.00	53.61	26.66	8.92	13.89	0.11	1313.64	1291.56
Cedar Creek			0.00	0.00	4.13	0.00	0.00	4.13	0.00
Upper Bear Creek			0.00	0.00	2.97	0.00	0.00	2.97	0.00
WUTA total	1251.00	1251.00	53.61	26.66	16.02	13.90	0.11	1320.74	1291.56
Normandy									
Normandy			1.45	0.00	26.26	2.19	0.69	28.41	2.19
Kentucky								0.00	0.00
Kentucky	1211.00	1211.00	133.17	82.55	32.35	23.74	0.65	1377.17	1317.30
Watershed total	**10275.71**	**10243.50**	**1204.87**	**942.38**	**661.73**	**376.56**	**68.87**	**12211.18**	**11562.44**

Table 2–3: 2000 Water Use Summary by Category (Millions of Gallons per Day)

Category	Water Use	Percent of Total Water Use	Consumptive Use	Percent of Total Consumptive Use
Thermoelectric	10,275	84	32	5
Industrial	1,204	10	263	41
Public Supply	662	5	285	44
Irrigation	69	1	69	10
Total	12,211	100	649	100

Table 2–4: Estimated Inter-Basin Transfers for 2000 (Millions of Gallons per Day)

System	City	Transfer from	Transfer to	Amount Transfers from TN Watershed (-)
City of Lexington	Lexington, TN	West Tennessee Basin	Mississippi River Basin	-0.10
Cleveland Utilities	Cleveland, TN	Conasauga River	Lower Tennessee Basin	1.04
Cleveland Utilities	Cleveland, TN	Lower Tennessee River Basin	Conasauga River	-0.18
Columbia Power & Water	Columbia, TN	Duck River River Basin	Lower Cumberland River Basin	-0.45
Cumberland Utility District	Harriman, TN	Clinch/Emory Rivers	Upper Cumberland River Basin	-0.09
Plateau Utility District	Wartburg, TN	Upper Tennessee River Basin	Upper Cumberland River Basin	-0.09
West Warren-Viola Utility District	Morrison, TN	Upper Cumberland River Basin	Tennessee Western Valley River Basin	0.26
Eastside Utility District	Chattanooga, TN	Lower Tennessee River Basin	Conasauga River	-3
Crossville Water Resources	Crossville, TN	Upper Cumberland Basin	Upper Tennessee Basin	1.19
Huntsville Utility District	Huntsville, TN	Upper Cumberland Basin	Upper Tennessee Basin	0.06
Fort Payne	Fort Payne, AL	Tennessee River	Little River Basin	-4
Hendersonville	Hendersonville, NC	French Broad River Basin	Broad River Basin	-0.15
Highlands	Highlands, NC	Little Tennessee River Basin	Savannah River Basin	-0.1
Halleyville	Halleyville, AL	Lower Tennessee River Basin	Buttahatchee River	-2.5
Albertville	Albertsville, AL	Lower Tennessee River Basin	Coosa River Basin	-2*
Arab	Arab, AL	Lower Tennessee	Coosa River Basin	-1*
Total				**-8.1****

Data from Simmons (2002) and North Carolina (2001), Greer (2004) *Estimated,
**Does not include estimated

Water Use Forecast in 2030

Forecast Approach

Projections of Future Public Supply, Industrial, and Irrigation Water Use

The 2000 water supply inventory serves as the base year for the water use projections (Hutson, and others 2004). Water use was projected for industry, public supply, and irrigation using county-level demographic and economic data for the future developed by Woods and Poole Economics, Inc. (2001). Manufacturing and mining earnings were used to project industrial withdrawals and return flows; number of households, for public supply withdrawals and wastewater releases; and, farm earnings for irrigation. The county-specific projection factor, or multiplier, was applied to each water use record in the database to produce estimates of the 2030 water use. The records of estimated use for 2030 were then aggregated to the reservoir catchment areas. The projections for the growth in thermoelectric power water use were based on TVA's projections for increased electrical demand in the TVA region.

Interface with Reservoir Operations Study

In order to ensure that all water use projections were consistent with ROS power and economic development projections, the approach based on the Woods and Poole multipliers described in the above section was compared to the methods for preparing the economic forecasts used in the ROS. Small adjustments were made to Woods and Poole-based industrial multipliers to make the approach consistent with other ROS economic forecasts. The adjustments were made primarily for rural counties where TVA believes there is additional information not captured in the Woods and Poole trends. More detail on the interface is presented in Appendix B.

Thermoelectric Forecast

The thermoelectric forecast details are presented in Appendix B, but important features of the forecast are summarized below.

The basis of the thermoelectric forecast for water use is the TVA load forecast for the TVA Power Service Area extrapolated to 2030. Other assumptions are as follows:

- TVA's Browns Ferry Nuclear Plant (BFN) Unit 1 is assumed to be returned to service using once-through cooling.
- All other new generation is assumed to use cooling towers rather than once-through cooling.
- There is a possibility that the growth in new generation will exceed the growth in electrical demand within the TVA Power Service Area resulting in the region being a net exporter of power.
- There is uncertainty concerning whether or not new generation within the TVA Power Service Area will utilize water from the Tennessee River watershed.

In order to account for these uncertainties, the forecast for water use is based on supplying all the growth in electrical demand within the TVA Power Service Area by power generated using water from the Tennessee River watershed. Also included in the forecast is the addition of scrubbers at Bull Run, Kingston, and Colbert Fossil Plants, which are scheduled to be operational by 2010.

Table 2–5 shows the increase in consumptive water use by 2030 for thermoelectric power production. Assigning water demand from new generation to reservoir catchment areas was based on consideration of pipeline locations, transmission line location, and the number of sites presently under some stage of development.

Table 2–5: Increase in Consumptive Use for Thermoelectric Power Production from 2000 to 2030 (Millions of Gallons per Day)

Reservoir-Catchment Area	New Generation	Scrubber	Nuclear Addition	Total
Melton Hill	5	3.4		8.4
Cherokee	10			10
Fort Loudoun	5			5
Watts Bar	5	5.1		10.1
Chickamauga	5			5
Nickajack	12			12
Wheeler	15		1.1	16.1
Wilson	5			5
Pickwick	13.1	1.9		15
Kentucky	11			11
Totals	**86.1**	**10.4**	**1.1**	**97.6**

Summary of Water Use Forecast for 2030

A summary of the 2030 water use forecast is presented in Table 2–6. Table 2–7 shows the percent of total water use in each sector for 2030. Comparing Table 2–3 to Table 2–7, total water use is expected to increase from 12,211 mgd to 13,989 mgd (about a 15 percent increase), and consumptive use is expected to increase from 649 mgd to 980 mgd (about a 51 percent increase). Industrial, public supply, and irrigation consumptive use is expected to increase by about 36 to 40 percent. Consumptive use in the thermoelectric industry is expected to increase from 32 mgd to 129 mgd—almost a 100 percent increase. This is due to new power plants using cooling towers rather than once-through cooling.

Future Groundwater Use

The median daily use of groundwater in the Tennessee River watershed over the past 35 years is 245 mgd and the range is 170 mgd to 305 mgd. Groundwater use has been declining for the past 10 years. Groundwater use was 215 mgd in 2000, which is about 2 percent of the total water use for 2000 (Hutson and others, 2004). Because it was uncertain whether groundwater use would decline any further in the future, the assumption was made to hold total groundwater use constant over the next 30 years.

Groundwater supplies are limited in many areas of the watershed and some are of very poor quality. In addition, new drinking water regulations will require significant capital improvements to be made to water supply systems. This is anticipated to cause the consolidation of small public water supply systems which are financially unable to make the capital improvements to meet the new requirements. It is anticipated that several of these consolidated systems will seek out surface water supplies. An example of this is the consolidation of a number of water utilities in the Elizabethton-Carter County area forming the Watauga River Regional Water Authority (WRRWA). It is anticipated that the WRRWA will soon apply for a permit to withdraw water from the Watauga River below Wilbur Dam. The result is that, although dependence on groundwater will grow for some systems, other systems will switch completely to surface water. The assumption of holding total public supply groundwater use constant means that about 30 percent of the existing public supply groundwater systems (including Elizabethton-Carter County) will switch to surface water in the next 30 years. Historically, it has taken about 10 or more years for water authorities such as the WRRWA to form, acquire funding, and build a new water treatment plant. At the present, there are only a few regional systems

Table 2–6: 2030 Water Use by Category, Water-Use Tabulation Area, and Reservoir Catchment Area (Millions of Gallons per Day)

Water-Use Tabulation Area Reservoir Catchment Area	Thermoelectric		Industrial		Public Supply		Irrigation	Totals	
	Water Withdrawal	Water Return Flow	Water Withdrawal	Return Flow	Water Withdrawal	Return Flow	Water Withdrawal	Water Withdrawal	Return Flow
Cherokee									
Watauga			1.08	0.81	28.08	3.07	0.09	29.25	3.88
South Holston			1.23	0.69	29.59	2.05	1.89	32.71	2.74
Boone			0.00	0.04	4.04	29.20	0.00	4.04	29.24
Fort Patrick Henry			602.49	0.00	18.93	0.00	0.00	621.42	0.00
Cherokee	631.00	621.00	11.70	567.48	26.04	18.25	0.24	668.97	1206.72
WUTA total	631.00	621.00	616.50	569.02	106.69	52.56	2.22	1356.40	1242.58
Douglas									
Douglas	4.97		57.23	34.34	100.80	37.03	1.97	164.96	71.37
Fort Loudoun									
Fort Loudoun	5.00	0.00	7.91	1.98	101.60	80.18	1.41	115.92	82.17
Fontana-Tellico									
Fontana			2.66	1.86	5.56	2.96	0.00	8.22	4.82
Santeetlah			0.00	0.00	0.53	0.00	0.00	0.53	0.00
Tellico			0.00	0.00	5.94	1.36	0.04	5.98	1.36
WUTA total			2.66	1.86	12.03	4.33	0.04	14.73	6.19
Norris	9.24	0.00	7.36	0.23	22.61	12.90	0.23	39.43	13.13
Melton Hill	477.40	469.00	2.47	1.49	40.32	12.80	0.04	520.23	483.29
WUTA total	486.64	469.00	9.83	1.73	62.92	25.69	0.27	559.66	496.42
Hiwassee-Ocoee									
Chatuge			0.06	0.00	4.15	0.43	0.00	4.21	0.43
Nottely			0.00	0.00	1.53	0.37	0.22	1.74	0.37
Hiwassee			0.12	0.00	0.94	0.17	0.14	1.20	0.17
Apalachia			0.00	0.00	3.32	0.00	0.07	3.39	0.00
Blue Ridge			39.56	0.00	4.72	0.46	0.11	44.38	0.46
Ocoee			0.00	30.33	1.38	0.33	0.01	1.40	30.65
WUTA total			39.73	30.33	16.04	1.75	0.55	56.32	32.08
Watts Bar-Chickamauga									
Watts Bar	1494.20	1345.00	0.03	0.37	14.75	28.92	3.90	1512.88	1374.29
Chickamauga	1576.40	1693.50	91.31	91.19	67.17	17.99	5.14	1740.03	1802.69
WUTA total	3070.60	3038.50	91.34	91.56	81.93	46.91	9.05	3252.91	3176.97
Nickajack									
Nickajack	12.00	0.00	28.25	18.02	59.02	54.84	0.27	99.54	72.86
Guntersville									
Guntersville	1546.00	1546.00	14.36	25.00	61.33	27.24	4.43	1626.12	1598.25
Tims Ford									
Tims Ford			102.81	66.11	5.88	6.44	0.40	109.09	72.55
Wheeler-Wilson									
Wheeler	3178.10	3161.00	327.35	210.01	159.24	100.72	65.24	3729.92	3471.73
Wilson	5.00	0.00	35.84	25.78	28.35	8.59	6.71	75.91	34.38
WUTA total	3183.10	3161.00	363.19	235.80	187.59	109.30	71.95	3805.83	3506.11
Pickwick									
Pickwick	1266.00	1251.00	67.12	28.59	9.93	16.53	0.12	1343.17	1296.12
Cedar Creek			0.00	0.00	5.46	0.00	0.00	5.46	0.00
Upper Bear Creek			0.00	0.00	4.17	0.00	0.00	4.17	0.00
WUTA total	1266.00	1251.00	67.12	28.59	19.57	16.53	0.12	1352.81	1296.12
Normandy									
Normandy			2.06	0.00	36.20	3.21	0.82	39.08	3.21
Kentucky									
Kentucky	1222.00	1211.00	170.08	110.22	43.49	30.95	0.62	1436.18	1352.17
Watershed total	**11427.31**	**11297.50**	**1573.06**	**1214.57**	**895.07**	**496.98**	**94.10**	**13989.54**	**13009.05**

Table 2–7: 2030 Water Use Summary by Category (In Millions of Gallons per Day)

Sector	Water Use	Percent of Total Water Use	Consumptive Use	Percent of Total Consumptive Use
Thermoelectric	11,427	82	129	13.2
Industrial	1,573	11	359	36.6
Public Supply	895	6	398	40.6
Irrigation	94	1	94	9.6
Total	13,989	100	980	100

under consideration. Therefore, a 30 percent switch from groundwater to surface water over 30 years is considered conservative in regard to the projected impact on surface water availability.

Potential Inter-Basin Transfers

Introduction

Local Transfers

Table 2–4 shows that the current estimate for local transfers is about 8 to 11 mgd. It is estimated that, by 2030, about 27 mgd of water will be sent outside the Tennessee River watershed by water supply entities residing inside the watershed. This will be water to supply areas immediately adjacent to the watershed, and essentially consists of suppliers meeting customer demands in their existing or slightly expanded service areas. These local transfers could possibly add about 8 percent to the growth in net water demand over the next 30 years.

New Inter-Basin Transfers

Although the local transfers are technically IBTs, IBTs discussed in this report are defined as new significant transfers of water into areas which have never been served by the Tennessee River watershed water and may not be directly bordering the watershed. A request for such an IBT will come from Northeast Mississippi. TVA has also been approached by Blount County, Alabama, concerning a transfer to supply Blount County and the Birmingham, Alabama, area. However, in an April 2004 veto of legislation requiring local approval of any IBT from Guntersville Reservoir, Governor Bob Riley stated that under current law and regulations, it is illegal in Alabama to make an inter-basin transfer from any river basin in Alabama to another river basin in Alabama (Riley, 2004). Another area of limited water supply is the 18-20 county area comprising the Atlanta metropolitan area and northern Georgia area. Georgia's law creating the Metropolitan North Georgia Water Planning District precludes any planning that involves inter-basin transfer of water to the District from outside the District (Jordan Jones and Goulding, 2003). Although IBTs in Alabama and Georgia are presently difficult to approve, a transfer scenario was developed in order to test what their effect would be upon the Tennessee River system were this outlook restricting IBTs to change.

The following sections describe the basis for the estimates. Figure F–4 in Appendix F shows the areas for which the IBT estimates were prepared.

Northeast Mississippi

Public and Industrial Demands

USGS 1995 water use data (Hutson, 2002a) were used with Woods and Poole industrial and public supply estimators to obtain 2000 and 2030 estimates for water use in Alcorn, Tishomingo, and Prentiss Counties. These estimates were compared to estimates prepared by Cook Coggin Engineers (1990) in a water supply study for the tri-county region. Recently, Cook Coggin (2001) revised the estimates for Alcorn County. The 2030 demand was based on the maximum of either the most current Cook Coggin estimate or the estimate based on the 1995 USGS data. The average annual 2030 projected demand is shown in Table 2-8.

Table 2–8: 2030 Water Demand Estimates for Tri-County Region, Mississippi (In Millions of Gallons per Day)

County	Estimate Source	Average Annual Demand
Alcorn	Cook Coggin (2001)	7.43
Tishomingo	Projection based on 1995 USGS data	5.06
Prentiss	Cook Coggin (1990)	4.07
Total		**16.56**

It is believed that eventually the tri-county area will construct a water treatment plant that will be supplied by water from Pickwick Reservoir. Because all of the current water use in the tri-county area is groundwater, switching the supply to the new treatment plant will mean a complete shift to surface water. Therefore, the total 2030 estimated demand will be used in the IBT forecast.

The 1995 USGS data and Woods and Poole multipliers were also used to estimate 2000 and 2030 demands for Itawamba and Lee Counties. These estimates were compared to Cook Coggin (1997) estimates for 2000 and 2020. The estimates using the USGS data were slightly higher than the Cook Coggin estimates. Therefore, the USGS-based estimates were selected for use in the IBT estimate and are shown in Table 2–9. The estimate for Union County was based on a recently completed water supply needs analysis for the county (Tennessee Valley Authority, 2000a).

Table 2–9: Water Demand for Northeast Mississippi Regional Water Supply District (In Millions Gallons per Day)

County	2000 Demand	2030 Demand
Itawamba	1.86	2.00
Lee	12.53	18.0
Union	2.96	4.0
Totals	**17.35**	**24.0**

The 2000 estimate of 17.35 mgd is estimated to contain about 8.9 mgd of surface water for Tupelo (Lee County) which is currently taken from the Tombigbee River. It is assumed that by 2030 all three counties shown in Table 2–9 will have converted to surface water. The additional amount of surface water needed by 2030 will be 24 minus 8.9, or 15.1 mgd. Recent discussions with Tupelo (Gibson, 2002) indicate that the city believes that new industrial development might require an additional 8 mgd.

There appears to be considerable interest in developing merchant power plants in northeast Mississippi. However, because of the assumptions made concerning new power-plant development, it is considered that sufficient water for new electrical generation including any new generation in northeast Mississippi is already in the thermoelectric forecast. Therefore, no additional water was added to the IBT for Mississippi.

The estimated 2030 public and industrial surface water demand for northeast Mississippi is summarized in Table 2–10.

Table 2–10: Potential Total Inter-Basin Transfers for Northeast Mississippi for 2030 (In Millions of Gallons per Day)

System	Average Annual Additional Surface Water Requirement
Alcorn, Tishomingo, Prentiss Counties	16.56
Itawamba, Lee, Union Counties	15.1
Lee County Industrial	8.0
Total	**39.66**

Diversions for the Tennessee-Tombigbee Waterway

In 2000, it was estimated that about 200 mgd of water was taken from Pickwick Reservoir for the operation of the Tennessee-Tombigbee Waterway. A series of four projections were made for the required amount of water to be taken from Pickwick Reservoir in 2030. The estimates ranged from 236 mgd to 393 mgd. The details of the estimate are presented in Appendix C.

In a 1982 supplement to the 1971 Environmental Impact Statement for the Tennessee-Tombigbee Waterway project, the USACE believed that the maximum use of 800 mgd was still valid (USACE Districts Mobile, Alabama, and Nashville, Tennessee, 1982).

Total Northeast Mississippi IBT

Only Alcorn, Tishomingo, and Prentiss Counties are likely to take water directly from Pickwick Reservoir. The other counties discussed above and shown in Table 2–10 are located farther south along the Tennessee-Tombigbee Waterway. Additional lockages over the next 30 years to support additional barge traffic on the waterway will result in an additional 36 to 193 mgd of flow through the waterway. The amount of additional water needed for the public and industrial supplies for Itawamba, Lee, and Union Counties is projected to be 23 mgd (39.7 less 16.7 mgd). The additional amount of water flowing through the waterway is so large compared to the public and industrial demand, it is assumed that the additional 23 mgd needed for public and industrial supply will be taken from the increased flow in the waterway. Therefore, the total IBT for northeast Mississippi will include the flow increase for the waterway and only the public and industrial demand for Alcorn, Tishomingo, and Prentiss Counties. Using the larger estimate for the waterway, the total IBT for northeast Mississippi is 210 mgd (193 mgd plus 17 mgd).

Blount County, Birmingham, Alabama

In January 2002, TVA representatives met with the Blount County Water Authority (BCWA) to discuss a possible IBT from Guntersville Reservoir to Blount County. The scale of the project was not clear, but seemed to be contingent upon whom in Alabama would join with BCWA in order to construct the project.

Participation of other Alabama water suppliers would be needed in order to make the project large enough so that it would be economically feasible. Recent correspondence with the BCWA indicates that a water supply needs analysis is near completion and will be submitted to TVA for review. The needs analysis will indicate a need for an additional 300 mgd by 2050. Based on an initial demand of 5 to 10 mgd when the first module of the project would go on line, it is estimated that the 2030 demand would be 180 mgd (Griffin, 2002 and Lucas, 2002). Although the transfer is currently claimed to be illegal (Riley, 2004), it was investigated should it not be deemed so in the future.

Northern Georgia and Atlanta

Counties Included in the 2030 Tennessee River Watershed Forecast

Dade, Walker, Catoosa, Fannin, and Union Counties are included in the Tennessee River watershed and their water demands are part of the 2000 base estimate and forecast for 2030. In addition, it is assumed that the increase in use between 2000 and 2030 in Gilmer, Towns, and Rabun Counties will be supplied from the Tennessee River watershed, and the 2030 forecast includes an allowance for this.

Northern Georgia

Because of rapid growth in the Atlanta area and northern Georgia, the USACE was asked to reallocate water in several northern Georgia reservoirs for water supply purposes. The reallocation prompted lawsuits by downstream water users, which in 1992 led to the initiation of comprehensive water studies conducted by Alabama, Florida, and Georgia. The water studies have involved the Alabama-Coosa-Tallapossa River Basin (ACT) and the Apalachicola-Chattahoochee-Flint River Basin (ACF). In 1997, the ACT River Basin Compact and the ACF River Basin compact were formed. As well as creating interstate administrative agencies, the compacts directed the parties to develop allocation polices for apportioning surface waters among the states subject to a multitude of federal laws (USACE, 1998a and 1998b).

A draft EIS was prepared for each compact to focus on the potential impacts of surface water allocation within the watersheds of the basins. The water allocations were determined by analyses of water demands, return flows, rainfall and runoff, and alternative reservoir operation (USACE, 1998a). A draft allocation formula for the ACT was negotiated, but was not signed. Litigation with Alabama, Georgia, and the USACE has resumed. Negotiations for the ACF allocation formula were terminated in 2003 (Farrell, 2004).

The Georgia Department of Natural Resources (Hawkins, 2002) supplied TVA with the estimates of current (2000) withdrawals and returns and projected 2030 withdrawals and returns for both the ACT and ACF. These are the estimates used in the water allocation studies. The net demand (withdrawals less returns) for both basins combined for 2000 is 360 mgd while the 2030 projection is 624 mgd. The difference in net demand is 264 mgd.

The metropolitan North Georgia water Planning District (District) was formed in order to address the future water needs of the 18-to-20 county area comprising the Atlanta metropolitan area and northern Georgia area. The district considered alternatives to meeting future water demand. Because Georgia law precludes planning that involves IBTs, none of the alternatives investigated by the District considered importation of water from the Tennessee River watershed. Alternatives considered reallocating reservoir storage and releases, construction of new reservoirs, and conservation measures to address demand issues. In 1998, prior to the formation of the District, Dalton Utilities (DU) discussed a possible intake location on Ocoee 1 Reservoir. At that time, DU discussed an IBT of approximately 10 to 20 mgd.

Even though IBTs are currently difficult to approve in Georgia, the ROS requested that a possible amount of water for a northern IBT Georgia be estimated to test that robustness of the alternatives considered in the ROS to uncertainties. Therefore, the possible IBT range for northern Georgia and Atlanta is 0 mgd based on the assumption that arrangements can be made for a sufficient amount of water within Georgia to 264 mgd, which is the higher estimate if satisfactory arrangements cannot be made.

IBT Summary

Table 2–11 summarizes the potential IBTs and where the IBT extractions could occur.

Table 2–11: Potential 2030 Inter-Basin Transfers (In Millions of Gallons per Day)

IBT to	Reservoir Where IBT Extracted	2000 IBT	Potential 2030 IBT
North Gerogia and Atlanta	Chickamauga	0	264
Blount County, Birmingham	Guntersville	0	180
Northeast Mississippi Public and Industrial	Pickwick	0	17
Tennessee-Tombigbee Waterway	Pickwick	200	393*

*The USACE maximum flow estimate for the waterway is 800 mgd.

Summary

Total water use in the Tennessee River watershed is forecast to increase by 15 percent, while consumptive use is forecast to increase from 649 mgd to 980 mgd, or 331 mgd, by 2030. This represents a 51 percent increase in consumptive use. Almost 29 percent of the increase in consumptive use is due to thermoelectric water use, an additional 29 percent increase is in the industrial sector, and 34 percent of the 331 mgd increase is due to the increased demand in public supply.

Flow through the Tennessee-Tombigbee Waterway might increase by about 96 percent or from 200 mgd to 393 mgd, although the increase could be as much as 600 mgd if traffic through the waterway were to reach design capacity. Potential IBT's excluding the Tennessee-Tombigbee Waterway might reach about 461 mgd.

In conclusion, it appears that although consumptive water use within the watershed will likely increase by 51 percent in 30 years, increase in flows for the Tennessee-Tombigbee Waterway, and possible IBTs, might double or triple this amount.

3

Water Supply Impact on Reservoir Levels

Introduction and Approach

Introduction

A key question raised in Chapter 1 was "Where and when will water withdrawals affect TVA's ability to meet minimum stream flow and reservoir level commitments?" This chapter describes how the future water demand was developed and input into the ROS for consideration in evaluating alternatives for future reservoir operations.

Approach

A portion of the water withdrawn from the Tennessee River watershed is returned to the watershed. The difference between the amount of water withdrawn and the amount of water returned on a reservoir catchment basis is called the net water demand. Data were collected for water withdrawals and returns to the system for 2000 and withdrawals and returns have been estimated for 2030, as described in Chapter 2. The net demand for each reservoir has been calculated for 2000 and 2030.

The impact of net water demand on reservoirs was determined by calculating the change in reservoir elevations, which would be observed solely on the basis of the increase in net water demand. The elevations were calculated using TVA's Weekly Scheduling Model (WSM), and OASIS.

The WSM is an integrated optimization program linking 42 reservoirs operated by TVA. TVA uses the model to evaluate the impact of new operating requirements, check reservoir system status to warn of possible future problems, forecast reservoir system operation, and develop new long-range operating policies. The WSM incorporates 100 years of historical hydrologic data for the Tennessee River system, the observation of important system operating constraints and priorities, extreme event analysis, and a linear programming structure that provides the flexibility to modify operating objectives, and analyze new types of long-range efficiency guides (Shane and Gilbert, 1982).

OASIS was used in part to examine water supply impacts on Normandy Reservoir. OASIS is a modeling system recently applied to Normandy and the Duck River by HydroLogics, Inc. (2002).

Weekly Scheduling Model Input

Periodically, the local inflow estimate for the WSM is adjusted to match the measured inflow and outflow. It is assumed that these periodic adjustments to the WSM local inflow terms have captured the current (year 2000) net demands for water supply. In other words, the WSM local inflow adjustments have accounted for the difference between the water withdrawn for off-stream use and the water returned to the system. Therefore, the data supplied for use by the WSM to estimate the effects of water supply on reservoir operations were the projected increases in net water demand for each reservoir over the next 30 years. The projected increases in net water demand for each reservoir were used to adjust the local inflow terms to simulate the effect of the 2030 net water demand.

Seasonal Adjustments to the Average Annual Estimate

The water use forecast was made on the basis of daily water use averaged over a year. Therefore, the difference in consumptive water use for 2000 and 2030, was also estimated on an average-annual basis. In order to apply a seasonal pattern to the net demand, the average-annual demand was distributed by month to account for seasonal variation in withdrawal. This was done by varying the thermoelectric-consumptive use according to the variation in TVA electrical demand, public supply variation was based on monthly water records of several large public water suppliers, industry was assumed to remain constant, and all irrigation was assumed to occur during June, July, and August.

Input Data and Model Runs

The model input to the WSM is shown in Table 3–1. The input is the difference between the net water demand for 2000 and 2030 as estimated for each reservoir catchment area (see Tables 2–1 and 2–6). IBTs and the increase for the Tennessee-Tombigbee Waterway as shown in Table 2–11 are not included in Table 3–1. WSM model runs to determine the impact on reservoir levels of the 2030 water demand included the design capacity of the Tennessee-Tombigbee Waterway of 800 mgd.

Impact of Meeting 2030 Water Demand to the Tennessee-Tombigbee Waterway

On May 19, 2004, the TVA Board approved the preferred alternative identified in the ROS. The impact on reservoir levels caused by the increase in water demand over the next 30 years and the maximum diversion to the Tennessee-Tombigbee Waterway was examined under TVA's newly implemented operating policy. WSM runs determined that the increase in consumptive water use (total net water demand) and Tennessee-Tombigbee Waterway diversions will not affect reservoir levels during years of average or above-average rainfall. Some lower pool levels would be expected on some tributary reservoirs under unusually dry conditions. No pool level decreases would be anticipated for the mainstem reservoirs even under drought conditions, although the mainstem reservoirs might take longer to fill. Perhaps every 1 year in 10, some tributary reservoirs might experience reservoir elevations up to 4 feet below what they would be without the growth in water demand. Under less frequent but drier conditions (e.g. 1 year in 20), the effect of the growth in water demand on reservoir levels becomes greater. However, even under extremely dry conditions, public supply intakes in reservoirs would still be below water. The detailed analysis is presented by Bohac (2004a). Impacts are summarized in Table 3–2.

Table 3–1: Weekly Scheduling Model Input (Million of Gallons per Day)

	Monthly Average											
Reservoir	**January**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**
South Holston	2.15	2.19	2.15	2.15	2.38	3.06	3.11	3.14	2.40	2.40	2.24	2.25
Watauga	14.23	14.52	14.26	14.24	15.83	16.40	16.72	16.97	15.95	15.95	14.87	14.93
Boone	-5.16	-5.26	-5.17	-5.16	-5.74	-5.87	-5.98	-6.07	-5.78	-5.78	-5.39	-5.41
Fort Patrcik Henry	107.66	107.72	107.67	107.66	108.01	108.08	113.19	108.20	108.03	108.03	107.80	107.81
Cherokee	-86.21	-86.30	-86.33	-86.39	-86.20	-85.95	-90.07	-85.83	-86.16	-86.23	-86.31	-86.20
Douglas	26.01	26.16	25.80	25.67	27.86	30.90	31.80	31.79	28.07	27.94	26.54	26.83
Fontana	0.87	0.88	0.87	0.87	0.94	0.96	0.99	0.99	0.95	0.95	0.90	0.90
Santeetlah	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09
Tellico	0.86	0.88	0.86	0.86	0.96	1.01	1.03	1.04	0.96	0.96	0.90	0.90
Fort Loudoun	9.72	9.89	9.74	9.73	10.63	13.11	13.38	13.43	10.70	10.70	10.09	10.12
Norris	3.58	3.37	3.33	3.21	3.44	3.71	3.98	3.90	3.51	3.37	3.32	3.53
Melton Hill	13.45	13.46	13.23	13.11	14.50	14.99	15.46	15.59	14.66	14.53	13.67	13.92
Watts Bar	10.19	8.73	8.62	7.90	8.52	10.40	11.70	11.32	8.88	8.03	8.22	9.54
Chatuge	1.99	2.03	1.99	1.99	2.21	2.26	2.31	2.34	2.23	2.23	2.08	2.09
Nottely	0.33	0.34	0.33	0.33	0.37	0.65	0.65	0.66	0.37	0.37	0.35	0.35
Hiwassee	0.16	0.16	0.16	0.16	0.17	0.28	0.28	0.29	0.17	0.17	0.16	0.16
Apalachia	0.41	0.41	0.41	0.41	0.45	0.50	0.51	0.52	0.46	0.46	0.42	0.43
Blue Ridge	10.77	10.79	10.77	10.77	10.90	11.05	11.54	11.10	10.91	10.91	10.82	10.83
Ocoee	-3.94	-4.37	-3.98	-3.95	-6.33	-7.98	-7.62	-8.83	-6.52	-6.52	-4.90	-4.99
Chickamauga	26.57	21.05	20.86	18.26	19.35	15.95	20.43	18.89	20.54	17.49	18.96	23.71
Nickajack	13.97	13.51	13.42	13.16	13.72	14.86	15.75	15.32	13.88	13.58	13.41	13.89
Guntersville	8.88	8.86	8.63	8.50	9.87	16.42	16.72	17.03	10.03	9.88	9.05	9.33
Wheeler	59.96	59.98	59.58	59.36	61.81	159.52	162.39	160.57	62.08	61.86	60.35	60.79
Wilson	13.23	13.13	13.01	12.90	13.61	21.80	22.44	22.16	13.71	13.59	13.19	13.41
Pickwick	27.77	26.96	26.98	26.63	26.49	27.15	28.99	27.45	26.63	26.21	26.61	27.25
Cedar Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Bear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tims Ford	15.26	15.25	15.26	15.26	15.23	16.13	16.87	16.11	15.22	15.22	15.25	15.24
Normandy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kentucky	31.80	31.60	31.49	31.34	32.02	33.31	34.88	33.70	32.13	31.96	31.62	31.91
Totals	**304.59**	**296.02**	**294.04**	**289.03**	**301.10**	**422.78**	**441.54**	**431.89**	**304.11**	**298.37**	**294.32**	**303.63**
Monthly Fraction	0.08	0.07	0.07	0.07	0.08	0.11	0.11	0.11	0.08	0.07	0.07	0.08
Dev. from Mean %	-8.20	-10.78	-11.38	-12.89	-9.25	27.42	33.08	30.17	-8.34	-10.07	-11.29	-8.49

Table 3–2: Reservoir Elevation Decreases Resulting from 2030 Water Demand and Tennessee-Tombigbee Waterway Diversion (in Feet)

Project	1 Year in 10		1 Year in 20		1 Year in 50	
	Maximum	Average	Maximum	Average	Maximum	Average
Watauga	3.7	1.0	5.2	1.2	6.2	2.0
South Holston	4.1	1.3	5.0	1.6	6.9	2.4
Cherokee	1.7	0.5	2.4	0.7	2.9	0.9
Douglas	2.3	0.6	2.7	0.9	4.7	1.5
Fontana	2.7	0.6	4.6	1.5	9.4	2.0
Norris	1.7	0.5	2.2	0.7	4.9	1.3
Chatuge	0.7	0.2	1.1	0.3	1.7	0.4
Nottely	1.5	0.3	2.2	0.5	4.2	0.7
Hiwassee	3.3	0.6	4.8	0.9	6.3	1.5
Blue Ridge	1.5	0.4	2.5	0.5	3.7	0.8
Tims Ford	1.4	0.1	1.8	0.1	2.1	0.2
Chickamauga	0.0	0.0	0.1	0.0	0.1	0.0
Guntersville	0.0	0.0	0.0	0.0	0.0	0.0
Wheeler	0.0	0.0	0.0	0.0	0.0	0.0

Duck River Below Normandy Dam

The Duck River is shown on Figure F–24 and Figure F–25 located in Appendix F.

Normandy Reservoir is currently operated during June through November to provide an instantaneous minimum flow of 165 cubic feet per second (cfs) (107 mgd) at Shelbyville, which is approximately 12 miles below Normandy Dam. Ten cfs, or 6.5 mgd, is provided for water supply and 155 cfs is provided for water quality control at the Shelbyville treatment plant wastewater discharge. December through May, the water quality control requirement is relaxed and releases from Normandy are regulated to provide for 80 to 120 cfs at the Shelbyville treatment plant discharge. Although there is no minimum-flow objective relating to Columbia, meeting the Shelbyville objective provides at least 135 cfs in the river at Columbia. In 1996, the Tennessee Division of Water Pollution Control established that the one-day average flow in the Duck River at Columbia, just below the Columbia water supply intake, should not fall below 100 cfs (Tennessee Valley Authority, 1998a).

In 1998, TVA published the results of a water supply needs analysis which compared the water supply in the Duck River under extremely dry conditions to the water demands from Normandy to Columbia. The needs analysis assumed that Normandy Reservoir would be operated to provide 165 cfs (107 mgd) at the Shelbyville water supply intake and that the minimum flow in the Duck River must not be less than 100 cfs (64.6 mgd) below the Columbia water supply intake. The results of the study showed that around 2025 to

2030, the demands along the river would cause the flow below the Columbia intake to drop below the minimum of 100 cfs (Tennessee Valley Authority, 1998a).

Withdrawals used in the needs analysis and the average-annual flows observed for 2000 are presented in Table 3–3. The 2000 net demand (withdrawals less wastewater return flows) projected for the needs analysis below the Columbia intake are approximately 29 percent higher than the net demand actually observed for 2000. Because the water demand from the river does not appear to be developing as rapidly as forecast, the 2025 to 2030 time frame for exhausting the currently available supply might be extended somewhat into the future.

Table 3–3: Water Withdrawals and Return Flows Along the Duck River Below Normandy Dam (Millions of Gallons per Day)

System	Needs Analysis 2000 Withdrawal Wastewater Return	Needs Analysis 2030 Withdrawal Wastewater Return	Needs Analysis 2000 Peak Withdrawal Wastewater Return	Needs Analysis 2030 Peak Withdrawal Wastewater Return	Observed 2000 Withdrawal Wastewater Return
Shelbyville Water Supply Intake	3.8	4.6	5.7	6.9	4.4
Shelbyville Wastewater Discharge	(1.8)	(3.1)	(2.7)	(4.6)	(3.1)
Bedford County Utility Intake	1.4	1.6	2.1	2.4	1.3
Lewisburg Water Supply Intake	2.8	5.0	4.2	7.5	2.8
Lewisburg Wastewater Discharge	(0.9)	(0.9)	(1.3)	(1.4)	(2.1)
Columbia Water Supply Intake	12.7	21.7	19	32.5	10.6
Subtotal	18.0	28.9	27.0	43.3	13.9
Spring Hill Wastewater Discharge	(0.2)	(1.2)	(0.3)	(1.8)	(0.4)
Columbia Wastewater Discharge	(3.9)	(7.7)	(5.8)	(11.5)	(6.9)
Totals	**13.9**	**20**	**20.9**	**30.0**	**6.6**

As a result of the perceived need for water in the future along the Duck River, TVA prepared a Programmatic Environmental Impact Statement (EIS) in which various alternatives for meeting the future water supply needs in the Upper Duck River Basin were evaluated. The alternatives for developing a new water supply were to construct a new water supply reservoir on Fountain Creek near Columbia, construct a water intake on the Duck River below the mouth of Catheys Creek with a 13-mile pipeline to pump water back to Columbia, increase the yield from Normandy Reservoir by increasing the height of the dam, or constructing an intake with a 20-mile pipeline from Tims Ford Reservoir to a point near Shelbyville. All the water supply alternatives were compared to the alternative of not developing a new source of water for the Duck River communities. TVA's preferred alternative was that one or more of the alternatives to develop a new water supply should be perused by the local water supply agencies of the region (Tennessee Valley Authority, 2000b).

In 2002, the Duck River Development Agency (DRA) contracted with HydroLogics, Inc. to analyze Normandy Reservoir's ability to meet projected water demands between the dam and Columbia, Tennessee. HydroLogics (2002) used their OASIS modeling system for the analysis. OASIS is a mass-balance model which incorporates withdrawals from the river and wastewater return flows, as well as 65 years of hydrologic record for the drainage area.

The following flow targets were used by HydroLogics:

Normandy	Minimum flow of 40 cfs (25.8 mgd)
Shelbyville	120 cfs (77.6 mgd) December 1–May 31 155 cfs (100 mgd) June 1–November 30
Columbia	130 cfs (84 mgd)

The projected withdrawals, which are considerably less than those used in the EIS described above, are presented in Table 3–4. Also shown in Table 3–4 are the current (2000) withdrawals and the projected 2030 withdrawals using the procedures outlined in Chapter 2. These are shown in Table 3–4 under the TVA heading.

Total current return withdrawals, based on the percent return columns shown in Table 3–4, are 11.5 mgd for the HydroLogics estimates and 14.6 mgd for the TVA estimates. The 2025 return for HydroLogics is 19.2 mgd and the 2030 TVA estimate is 20.1 mgd.

Table 3–4 suggests that the HydroLogics estimates are somewhat higher and the return estimates are somewhat lower than the estimates prepared by TVA for this report.

Simulations show that over the 65-year period of record, the Normandy Reservoir minimum elevation with the current demands would be 862.7 feet. The elevation is projected to be about 2 feet lower (elevation 860.5 feet) using the HydroLogics 2050 estimated demands. A "worst case" simulation assuming that demands were 150 percent of the 2050 demands and the flow target at Columbia was raised from 130 cfs to 155 cfs resulted in a minimum elevation of 855.4 feet.

Table 3–4: HydroLogics OASIS Model Input Compared to Current TVA Estimates (Millions of Gallons per Day)

	HydroLogics				TVA		
City	**Current**	**2025**	**2050**	**Percent Return**	**2000**	**2030**	**Percent Return**
Manchester	2	3.5	5	63			
Tullahoma	3	4.5	6	0			
DRUC				25	5.2	7.7	40
Shelbyville	4	5.5	7	45	4.4	5.4	70
Bedford County	1	1.7	2.4	0	1.3	1.6	
Lewisburg	3	4.5	6	72	2.8	3.8	75
Spring Hill	0	3	6	60			
Columbia	10.5	15.8	21	60	10.6	15.1	65
Totals	**23.5**	**38.5**	**53.4**		**24.3**	**33.6**	

For comparison, the original normal minimum pool level for the reservoir was 859 feet. An experimental program to hold the minimum pool level at 864 feet began in 1988 and continued for three years. In 1991, the reservoir operating curve was changed to reflect a minimum operating level of 864 feet. The minimum pool level on record is 853.1 feet on November 26, 1981.

Bear Creek Projects

Average monthly withdrawal for 2000 and the projected withdrawal for 2030 are show in Table 3–5. TVA's project planning report indicates that 11 mgd from Upper Bear Creek, 5 mgd from Bear Creek and 6 mgd from Cedar Creek, would be available for water supply (Tennessee Valley Authority, 1965).

Table 3–5: Net Water Demand for Bear Creek Projects (Millions of Gallons per Day)

Month	Upper Bear Creek 2000	Upper Bear Creek 2030	Bear Creek 2000	Bear Creek 2030	Cedar Creek 2000	Cedar Creek 2030
January	2.81	4.17	0	2.1	3.0	5.47
February	2.41	3.58	0	1.8	2.58	4.69
March	2.6	3.86	0	1.94	2.78	5.05
April	2.55	3.78	0	1.9	2.72	4.95
May	2.89	4.28	0	2.16	3.08	5.61
June	2.97	4.41	0	2.22	3.17	5.77
July	3.2	4.76	0	2.4	3.42	6.23
August	3.27	4.85	0	2.44	3.49	6.36
September	2.82	4.19	0	2.11	3.01	5.49
October	2.83	4.2	0	2.12	3.02	5.5
November	2.57	3.82	0	1.92	2.75	5.0
December	2.79	4.13	0	2.08	2.97	5.41
Average Annual	**2.81**	**4.17**	**0**	**2.1**	**3.0**	**5.46**

IBTs and Tennessee-Tombigbee Waterway

Model runs to determine the impact of the IBTs for north Georgia and Atlanta, Birmingham/Blount County, and Northeast Mississippi (total of 461 mgd) in addition to the 2030 water demand increase and diversions to the Tennessee-Tombigbee Waterway were investigated. Little to no effect was predicted in median or above median hydrologic conditions. Effects were observed under drier conditions, and elevation decreases for the IBTs are show in Table 3–6. The decreases shown in Table 3–6 would be in addition to these show in Table 3–2. Details are described by Bohac (2004a).

Table 3–6: Reservoir Elevation Decreases Resulting from Inter-Basin Transfers (in Feet)

Project	1 Year in 10		1 Year in 20		1 Year in 50	
	Maximum	Average	Maximum	Average	Maximum	Average
Watauga	1.2	0.2	1.6	0.4	5.1	1.6
South Holston	1.8	0.3	2.6	0.6	3.7	1.2
Cherokee	1.4	0.3	1.9	0.5	2.3	0.6
Douglas	1.5	0.4	2.2	0.6	2.9	0.9
Fontana	2.4	0.5	3.2	0.9	6.4	1.7
Norris	1.3	0.3	1.6	0.5	3.1	0.9
Chatuge	0.4	0.1	0.6	0.2	1.2	0.2
Nottely	0.8	0.2	1.4	0.4	2.6	0.5
Hiwassee	1.7	0.4	2.2	0.7	3.4	1.0
Blue Ridge	1.2	0.3	1.6	0.4	2.0	0.5
Tims Ford	0.3	0.0	1.0	0.0	2.1	0.0
Chickamauga	0.5	0.0	0.6	0.0	1.0	0.1
Guntersville	0.0	0.0	0.0	0.0	0.0	0.1
Wheeler	0.0	0.0	0.0	0.0	0.0	0.2

Summary

The increase in net water demand between 2000 and 2030 was used as input to the WSM which was used to model flow and reservoir elevations for the ROS. Under average rainfall conditions, little impact would be expected on reservoir levels due to the increase in total net water demand for the operating policy implemented by TVA in June 2004. Under drier conditions, the growth in water demand will result in lower tributary reservoir elevations.

An EIS prepared for the Duck River below Normandy Dam stated that under drought conditions in which there would be no local inflow below Normandy, the target flows at Shelbyville would not be sufficient to maintain the target flows at Columbia using the EIS projected demands by approximately 2025. However, current withdrawal and wastewater data suggest that the EIS projected demands were too high. A recent modeling study using lower projected demands and 65 years of hydrologic record, so that some local inflow could be included, indicated that the Normandy minimum pool level might be only 2 feet lower when the 2050 demands were considered than when the 2000 demands were modeled. The modeled 2050 minimum pool level would be about 860 feet or about 4 feet lower than the current normal minimum. The lowest reservoir elevation on record was about 853 feet.

4
Water Supply Impact on Streams Below Reservoirs

Introduction

In 1990, TVA prepared an Environmental Impact Statement on the Tennessee River and reservoir operating system. As a result of this process, TVA initiated a policy of providing minimum stream flows below selected dams to meet the objectives of improving water quality and aquatic life (Tennessee Valley Authority, 1990). In 2001 through 2004, TVA's ROS reevaluated the operation of the Tennessee River and its reservoirs. The ROS examined the potential impact of reservoir operations on beneficial uses such as water quality, aquatic life, hydropower, generation, navigation, and recreation on reservoirs. The ROS committed to maintain minimum flows at least as high as those established in 1990.

Two key questions raised in Chapter 1 are as follows:

- Where and when will water supply withdrawals affect other beneficial uses (e.g. navigation, power generation, recreation, water quality, aquatic habitat)?
- Where and when will water withdrawals affect TVA's ability to meet minimum stream flow and reservoir level commitments?

This chapter addresses the above questions in considering whether the minimum stream flows provided by TVA could be affected by future water supply withdrawals.

Analytical Approach

Water Demand—Minimum Flow Ratios

Table 4–1 shows the dams where TVA committed to providing minimum releases in 1990 (Tennessee Valley Authority, 1990). The approach used in the analysis is to compare minimum flow provided at the dam to the increase in anticipated extraction by existing and future intakes from the tailwater in order to meet the 2030 water demand in the areas served by the tailwater. Ratios are computed for 2000 extraction to the minimum flow and the projected 2030 extraction to the minimum flow. The increase in the 2030 ratio is then compared to the 2000 ratio. The assumption is that as the ratio of withdrawal to minimum low-flow increases, the potential for impacting the designated stream uses increase. Table 4–1 also lists the designated use for the streams under analysis. An additional important consideration for the analysis is the implication to future withdrawals if a stream is 303(d) listed.

Table 4–1: Tailwaters Where Minimum Flows are Provided (Millions of Gallons per Day)

Tailwater	Minimum Flow at Dam	River Reach	Designated Use	303(d) Listed
South Holston Dam @ South Fork Holston River Mile 49.8	58	Dam to Mile 35.1	TN—1–6 and 8	P—from Dam to Mile 45.4 Flow Alteration and Thermal Modifications
Wilbur Dam @ Watauga River Mile 34	69	Dam to Mile 25	TN—1–6 and 8	Not listed
Boone Dam @ South Fork Holston River MilE 18.6	259	Dam to Mile 5.7	TN—1–6 and 8	Not listed
Fort Patrick Henry Dam @ South Fork Holston River Mile 8.2	517	Dam to Mile 5.7 Mile 5.7 to Mile 0	TN—1–6 and 8 TN—2, 3, 4	P—Dam to Mile 5.8—Organic Enrichment, Low DO, Flow Alteration Thermal Modification Mile 5.8–Mile 0.3—Flow Alteration and Thermal Modification
Cherokee Dam @ Holston River Mile 52.32	210	Dam to Mile 0	TN—1–6	P—from Dam to Mile 25.4—Low DO and Flow Alteration
Douglas Dam @ French Broad River 32.3	378	Dam to Mile 0	TN—1–6	P—from Dam to Mile 27.4—Low DO, Thermal Modification, Flow Alteration
Norris Dam @ Clinch River Mile 79.8	129	Dam to Mile 66.2 Mile 66.2 to Mile 61.5 Mile 61.5 to Mile 0	TN—1–6 and 8 TN—1–6 TN—1–7	P—Dam to Mile 72.4 Thermal Modifications and Flow Alteration
Chilhowee Dam @ Little Tennessee River Mile 33.6	646			Not listed
Chatuge Dam @ Hiwassee River Mile 121	55	Dam to Mile 108 Mile 108 to Murphy	NC—C NC—WS IV	Not listed
Apalachia Dam @ Hiwassee River Mile 53.6	129 Apalachia + Ocoee = 388	Dam to Mile 34.4	TN 1–6 and 8	Not listed
Ocoee1 Dam @ Ocoee River Mile 11.9	90 Apalachia + Ocoee = 388	Dam to Mile 2.5	TN—1–6	P—Dam to Mile 0—Unknown Toxicity
Nottely Dam @ Nottely River Mile 21	35.5	Dam to state line state line to Hiwassee Reservoir	GA—Recreation NC—C	GA— Dam to Mile 19 Low DO Dam to Miile 15 Fecal Coliform
Blue Ridge Dam @ Taccoa River Mile 53	74.3	Dam to state line	GA—Recreation	Dam to Mile 46—Low DO
Tims Ford Dam @ Elk River Mile 133.3	51.7	Dam to Mile 90.5	TN—1–6 and 8	P—Dam to Mile 117.9—Thermal Modification and Flow Alteration
Chickamauga Dam @ Tennessee River Mile 471	1938	Dam to Mile 460.6 Mile 460.6 to Mile 448	TN—1–7 TN—2–7	P—Chickamauga Dam to Nickajack Dam—PCBs and Dioxins
Pickwick Dam @ Tennessee River Mile 206.7	5171	Dam to Mile 49.1	TN—1–-7	Not listed

Designated Uses

Tennessee
1—Domestic Water Supply
2—Industrial Water Supply
3—Fish & Aquatic Life
4—Recreation
5—Irrigation
6—Livestock Watering & Wildlife
7—Navigation
8—Trout Stream
P—Partially supporting designated uses in Tennessee

Georgia
Drinking Water, Recreation, Fish & Other Aquatic Life, Wild River, Scenic River

North Carolina
C—Aquatic Life, Secondary, Recreation, WS-IV— Water Supply Highly Developed

Designated Uses and 303(d) List

The 303d lists, compiled by state water-quality agencies, list streams that are "water quality limited" or are expected to exceed water quality standards in the next two years and will need additional pollution controls for wastewater discharge. Water quality limited streams are those that have one or more properties that violate water quality standards and are considered to be impacted by pollution and not fully meeting designated uses.

If a stream has been placed on the 303(d) list, the state water quality regulatory agency cannot allow additional loadings of the same pollutant(s). This can result in dischargers not being allowed to expand or locate on 303(d) listed streams until the sources of pollution have been controlled.

When a stream becomes listed, a priority is assigned for a Total Maximum Daily Load (TMDL), which is a specialized study of the stream. When the TMDL has been completed, a watershed plan is prepared which includes the proposed actions to be taken to insure that water quality standards will be met. Draft NPDES permits are issued and public hearings are held. Final permits are then issued after comment has been received on the draft permits (Tennessee Department of Environment and Conservation, 2002).

Some of the streams discussed in the tailwater analysis are already listed on the 303(d) list, and because of the listing, development along the stream might be limited. It is also possible that a significant increase in withdrawal by an existing intake might impact the designated use of the stream and possibly cause it to become listed if it is not already. Therefore, the analysis attempts to incorporate both the effect of an existing 303(d) listing and the potential for a future listing should a significant amount of additional water be withdrawn from the stream segment.

Analysis

Figures for this chapter appear in Appendix F.

South Holston

The South Holston tailwater is shown on Figure F–7 in Appendix F. Existing intakes in the South Holston tailwater include those for the Bristol, Tennessee, and the Bristol-Bluff City Utility District. Bristol's intake is in the upper reaches of the tailwater near the dam; while the Bristol-Bluff City Utility District intake is located at the end of the free-flowing river segment, almost in the Boone Reservoir.

The ratios of peak to minimum flow, shown in Table 4–2, indicate that the projected increase in the peak-day withdrawal for Bristol, Tennessee, will decrease the minimum flow in the river by about 2 percent. The increase in withdrawal by the Bristol-Bluff City Utility District is expected to reduce the minimum flow in the river by less than 1 percent. If other local water suppliers (Chinquapin Grove Utility District and Bluff City) were to switch away from groundwater and use the South Fork Holston River as a water supply, they might possibly extract another 1 percent of the minimum flow. It would appear that the increase in water demand will decrease the minimum flow in the river by possibly 2 to 3 percent.

Table 4–2: Water Withdrawal in South Fork Holston River Below South Holston Dam (Millions of Gallons per Day)

System	2000 Annual-Average Withdrawal	2030 Annual-Average Withdrawal	2000 Peak-Day Withdrawal	2030 Peak-Day Withdrawal	Minimum Flow	Ratio 2000 Peak-Day to Minimum Flow	Ratio 2030 Peak-Day to Minimum Flow
Bristol, Tennessee	5.86	6.76	8.79	10.1	58 at dam	0.15	0.17
Bristol-Bluff City Util Dist	1.69	1.95	2.53	2.92	70 estimated	0.04	0.04
Potential Groundwater Conversion to Surface Water	0.34	0.39	0.51	0.59	64 (mean of 58 and 70)	<0.01	0.01

A 4.4-mile segment from South Holston Dam appears on the 303(d) list. The causes for the listing are flow alterations and thermal modifications and their impact on the biological integrity of the stream. It is possible that withdrawal of an additional 2 to 3 percent of the minimum flow might contribute to a small warming of the water as it travels downstream under minimum flow conditions.

Watauga

The tailwater below Wilbur Dam is shown on Figure F–7 in Appendix F.

The only existing intake in the Wilbur tailwater is for Johnson City in the upper reaches of Boone Reservoir. In 2000, Elizabethton, the First Utility District of Carter County and the Hampton Utility District, also in Carter County, used a combined total of 7.41 mgd—all from groundwater. Recently, these entities have proposed abandoning their groundwater sources and forming a regional water authority (the Watauga River Regional Water Authority—WRRWA) which would take water from the Wilbur tailwater approximately 5 miles below Wilbur Dam and about 2.4 miles above the confluence with the Doe River. The projected 2030 demand for the combined utilities is 8.72 mgd on an average-annual basis and about 13 mgd on a peak-day basis. The steady-state minimum flow at the intake location is about 107 cfs (69 mgd) from Wilbur Dam, plus approximately 8 cfs (5 mgd) from Stony Creek. The peak demand for the WRRWA would be about 11 percent of the minimum flow from the dam, plus the Stony Creek flow. The WRRWA has requested that TVA consider increasing the minimum flows from Wilbur Dam to meet the increased water supply needs of the area. A high quality trout fishery has been established by the minimum flow.

The original application for the intake was submitted by the city of Elizabethton. Because of the controversy over the intake, Elizabethton has withdrawn its application. A new intake application is expected from the WRRWA. Table 4–3 shows the Elizabethton-Johnson City water withdrawal area.

The Johnson City water demand is expected to increase from 10.9 mgd in 2000 to 14.5 mgd by 2030. The 3.4 mgd (5.4 mgd on peak-day) increase will likely diminish the minimum flow by an additional 5 percent. The effect will be offset somewhat by the increase in wastewater flow from Elizabethton. The impact of the additional withdrawal is lessened because the intake is located at the upper end of Boone Reservoir where there is not much of the riverine portion of the Watauga River to be affected.

Table 4–3: Water Withdrawals in the Elizabethton-Johnson City Area (Millions of Gallons per Day)

System	2000 Annual-Average Withdrawal	2030 Annual-Average Withdrawal	2000 Peak-Day Withdrawal	2030 Peak-Day Withdrawal	Source
Elizabethton Water Department	5.39	6.34			Springs
First Utility District of Carter County	1.12	1.32			Wells
Hampton Utility District	0.90	1.06			Springs
Total above	7.41	8.72	11.11	13.08	
Johnson City	10.9	14.5	16.35	21.75	Watauga River

Boone

Presently, there are no intakes in the South Fork Holston River below Boone, as shown on Figure F–7. Significant development would have to occur in the area apart from either Johnson City or Kingsport before an intake large enough to significantly reduce the minimum release of 258 mgd would be expected.

Fort Patrick Henry

Figure F–7 in Appendix F shows the tailwater below Fort Patrick Henry Dam. Table 4–4 shows the existing water balance under minimum flow conditions for 2000. Average flows are used because of the large concentration of industrial water use in the stream reach to which little peaking factor has been applied. The minimum target flow from Fort Patrick Henry is 259 mgd (Tennessee Valley Authority, 1990). However, because of a contract with Eastman Chemical Company, the minimum flow is 517 mgd. The lowest weekly average flow in ten years for the North Fork Holston River is estimated to be about 137 mgd. This flow is added to the river flow after the confluence with the South Fork Holston River

Table 4–4 shows that the minimum flow conditions exist between Eastman Chemical's intake and discharge, where only 4 percent of the 517 mgd minimum flow exists. After the Eastman return, however, the river flow increases to about 90 percent of the minimum flow released from Fort Patrick Henry Dam.

Over the next 30 years, the net water demand for the Fort Patrick Henry-Cherokee Reservoir area is expected to increase by about 22.3 mgd, although the exact location of the withdrawal and return are unknown. A conservative analysis is presented by assuming that the net demand occurs at South Fork Holston River Mile 2.4, where the ratio of river flow to minimum at Fort Patrick Henry Dam is lowest. Results of the analysis are shown in Table 4–5. Because the Kingsport withdrawal is projected to increase by 3.8 mgd (28.4 less 24.6) and the wastewater return is expected to increase by 1.4 mgd (11 less 9.6), the 22.3 mgd net demand has been adjusted to account for the change in net demand (22.3 less 2.4) for Kingsport. Table 4–5 also shows the projected 2030 withdrawal and wastewater discharges for Kingsport.

A comparison of Tables 4–3 and 4–4 show that Kingsport would reduce the flow in the South Fork Holston River under minimum flow conditions by about 1 percent more by 2030. Concentrating the entire growth in net water demand at the lowest flow point in the South Fork Holston River would decrease flow by about 4 percent more in the South Fork Holston River and by about 6 percent more in the Holston River.

Table 4–4: Water Withdrawal for 2000 in South Fork Holston River and Holston River Below Fort Patrick Henry Dam (Millions of Gallons per Day)

Site	River Mile	(Withdrawal) or Discharge	River Flow	Ratio of Flow to Minimum Flow South Fork 517 Holston 654
Fort Patrick Henry Dam–South Fork Holston River	SFHM 8.2	517	517	1
Kingsport Water Plant Intake	SFHM 5.5	(24.6)	492	0.95
TN Eastman Intake	SFHM 5	(449)	43	0.08
TN Eastman Discharge	SFHM 4.5	421	464	0.90
Willamette Intake	SFHM 2.4	(10.7)	453.3	0.88
Willamette Discharge	SFHM 2.0	7.7	461	0.89
Kingsport Wastewater Discharge	SFHM 1.9	9.6	471	0.91
North Fork Holston River Confluence	HRM 142.2	137	608	0.93
Holston Army Ammunition Discharge	HRM 141.3	36	644	0.98
Holston Army Ammunition Intake	HRM 140.8	37	607	0.93

An important consideration for the tailwater below Fort Patrick Henry Dam is that it is 303(d) listed. The South Fork Holston River is listed for organic enrichment/low dissolved oxygen, flow alterations, and thermal modifications for the first 2.4 miles below Fort Patrick Henry Dam. This listing extends approximately to the Kingsport water intake. From that point until almost the confluence with the North Fork Holston River, the river is listed for flow alteration and thermal modifications. The comments provided in the 303(d) list are that "The river below Fort Patrick Henry Dam has been impacted by rapid temperature and flow fluctuations. TVA's tailwater improvements have helped, but have not eliminated the problem."

Table 4–5: Water Withdrawal for 2030 Analysis of the South Fork Holston River and Holston River Below Fort Patrick Henry Dam (Millions of Gallons per Day)

Site	River Mile	(Withdrawal) or Discharge	River Flow	Ratio of River Flow to Minimum Flow South Fork 517 Holston 654
Fort Patrick Henry Dam—South Fork Holston River	SFHM 8.2	517	517	1
Kingsport Water Plant Intake	SFHM 5.5	(28.4)	489	0.94
TN Eastman Intake	SFHM 5	(449)	40	0.08
TN Eastman Discharge	SFHM 4.5	421	461	0.89
Willamette Intake	SFHM 2.4	(10.7)	450	0.87
2000 to 2030 growth in net demand	SFHM 2.4	(19.9)	430.1	0.83
Willamette Discharge	SFHM 2.0	7.7	437.8	0.85
Kingsport Wastewater Discharge	SFHM 1.9	11	448.87	0.86
North Fork Holston River Confluence	HRM 142.2	137	585.8	0.90
Holston Army Ammunition Discharge	HRM 141.3	36	621.8	0.95
Holston Army Ammunition Intake	HRM 140.8	(37)	584.8	0.89

Because of the 303(d) listing, it is unclear whether or not additional discharge could take place along the rivers in the Kingsport area. The TMDL process would have to be completed, including the development of an implementation plan before such a determination could be made. However, the analysis in Table 4–4 probably does represent a "worst case" analysis from a water quantity standpoint. Should the new wastewater discharge permits result in the restriction of discharges in the tailwater, then the projected growth for Sullivan County will have to occur on the Holston River below the North Fork and South Fork confluence where the Holston River is not listed and presumably supports all designated uses.

Tables 4–4 and 4–5 show that between Eastman's intake and discharge points, flow in the river is limited. This suggests, should Eastman need additional water in the future, more water would have to be released from Fort Patrick Henry Dam to prevent depleting the water between Eastman's intake and discharge. Under its existing contract, Eastman can request additional water from TVA. Should additional water be provided, flows below Eastman would be increased, above what they are now, because of the expected additional return flow.

Cherokee

There are no intakes in the Holston River below Cherokee Dam for over 40 miles, as shown on Figure F–8. Because of the lack of large metropolitan areas along the river, no significant withdrawals occur before the Knoxville area. The increase in withdrawal from the Holston River, apart from the Knoxville area, over the next 30 years is not expected to be significant. By the time Knoxville is reached, local inflow adds approximately 100 mgd under low-flow conditions, which would offset projected increases in withdrawals prior to the formation of Fort Loudoun Reservoir.

Douglas

The minimum flow released from Douglas is 378 mgd. In addition, the Little Pigeon River enters the French Broad about 4 miles below Douglas Dam, as shown on Figure F–8. The lowest weekly average flow in ten years at Sevierville, about 5 or 6 miles from the mouth of the Little Pigeon, is 28 mgd—contributing to the minimum of 378 mgd released from Douglas Dam. This is shown on Figure F–8 in Appendix F.

Presently, there are no intakes or discharges on the French Broad River below Douglas Dam until almost the confluence of the French Broad and Holston Rivers—the beginning of the Tennessee River. There are two public supply intakes and two industrial discharges at the lower end of the river reach. The 2000 net demand for these facilities is about 3.8 mgd. Growth over the next 30 years (2030) could result in a net demand of 5.3 mgd or an increase of 1.5 mgd (2.2 mgd on peak-day). Since the increase in net demand is less than 1 percent of the minimum flow at Douglas Dam, no impact on tailwater quantity is expected from growth in withdrawals from existing intakes.

Figure F–8 shows significant population centers at Knoxville, Sevierville, and Pigeon Forge. It is believed that the increase in water demand for Knoxville will largely be supplied by the expansion of the existing large plants on Fort Loudoun Reservoir. The Douglas tailwater will likely be unaffected. Significant growth is projected for Sevierville and Pigeon Forge. As discussed in Chapter 5 of this report, Sevierville appears to lack sufficient water to meet future demands and has proposed an intake slightly above the confluence of the Little Pigeon River. Minimum flows on the French Broad are provided by turbine pulsing. Any intake in the river would have to be far enough below Douglas Dam to be unaffected by the turbine pulse.

Norris

The Norris tailwater begins at Norris Dam, at Clinch River Mile (CRM) 79.8, as shown on Figure F–8.

Melton Hill Dam, at CRM 23.1, impounds Melton Hill Reservoir which extends 44 miles upstream under normal maximum pool conditions. The free-flowing segment of the Clinch extends from Norris Dam to just north of Clinton at about CRM 68. Bull Run Fossil Plant, the largest water user on the river, is located at CRM 48. The analysis is conducted in three parts. The first is for the most riverine segment from CRM 68 to Norris Dam, the second is from CRM 68 to Bull Run Fossil Plant, and the third extends from Bull Run to Melton Hill Dam.

Table 4–6 shows the net demand (withdrawals less returns) for public supply, industrial, and thermoelectric sectors for various segments of the Clinch River from Norris Dam to Melton Hill Dam. Table 4–6 also shows the 2000 net demand for existing withdrawals and returns and the projected 2030 net demand. The assumption concerning the industrial net demand increase, is that it will increase at the same rate as industrial growth. In general, it is expected to increase in Anderson and Knox Counties, although the current specific industries located along the Clinch River might not grow. The increase in the net demand for thermoelectric was based on the installation of a scrubber at Bull Run.

With the exception of the expected increase in withdrawal for the North Anderson County Utility District, little, if any, additional increase in demand is expected in the tailwater. However, the Norris Water Commission could switch from groundwater to surface water. This switch would impose an additional 0.36 mgd average demand (0.54 mgd peak demand) on the river, which would still be less than 1 percent of the minimum flow of 129 mgd.

The growth in net water demand from Norris Dam to Bull Run is expected to only be 4 percent of the minimum flow in the river and most of this increase is also due to the new scrubber at Bull Run.

Consideration of the net demand below Bull Run Fossil Plant is included because, under some flow conditions, there can be a flow reversal in Melton Hill. Under these conditions, water withdrawals downstream of Bull Run can cause a decrease in cooling capacity for Bull Run. Table 4–6 indicates that when the

Table 4–6: Water Withdrawal from the Clinch River Below Norris Dam (Millions of Gallons per Day)

Stream Segment	2000 Public Supply Net Demand	2030 Public Supply Net Demand	2000 Industrial Net Demand	2030 Industrial Net Demand	2000 Thermoelectric Net Demand	2030 Thermoelectric Net Demand	Total 2030 Less Total 2000	Ratio Increase in Net Demand to Minimum Flow
Norris Dam to CRM 68	1.4	1.7					0.3 average 0.45 peak	<.01 average <.01 peak
Norris Dam to BRF @ CRM 48	5.0	6.1	0.6	0.8	0	3.4	4.7 average 5.25 peak	0.04 average 0.04 peak
Norris Dam to Melton Hill Dam	20.5	27.0	0.6	0.8	0	3.4	10.1 average 13.4 peak	0.08 average 0.10 peak

anticipated growth in all of the existing water use sectors is taken into consideration, the net withdrawals could increase the percentage of minimum flow extracted by 8 to 10 percent.

There is a potential for new withdrawals to influence the ability to cool Bull Run under low-flow conditions. The closer and larger the intake that would locate near Bull Run, the larger the potential impact. However, the Hallsdale Powell Utility District has proposed a new intake for Bull Run Creek approximately 2.4 miles from its mouth at Melton Hill Reservoir. The proposal was evaluated by TVA for its effect on Bull Run. At a withdrawal of 22 mgd, there was no perceived impact (Tennessee Valley Authority and U. S. Army Corps of Engineers, 2002).

Very little groundwater is supplied in the area. With the exception of the Norris Water Commission, the Hallsdale Powell Utility District is the only significant supplier of groundwater. Presently, Hallsdale Powell supplies about 1 mgd of groundwater. It is assumed that all of the demand in the area will be met by surface water.

A final consideration, which could raise the net withdrawal above the values shown in Table 4–6, is that of merchant power plant development. Melton Hill Reservoir lies at the intersections of electrical transmission lines, natural gas lines, and a water source. Therefore, it is possible that the net demands, shown in Table 4–6, could increase by another 5 to 10 mgd in 30 years. Such a withdrawal would have the impact of reducing the minimum flow by another 4 to 8 percent.

Chilhowee

A minimum flow of 646 mgd is provided below Chilhowee from May to October only. Figure F–9 shows that there are no intakes currently on the Little Tennessee River below Chilhowee. Because of the absence of population centers, no significant withdrawals are foreseen.

Chatuge

The only existing intake on the Hiwassee River below Chatuge Dam, as shown on Figure F–10, is at Murphy where the increase in peak-day withdrawal is estimated to be about 0.4 mgd. Since this increase is less than 1 percent of the minimum flow of 55 mgd at Chatuge Dam, the increase is expected to be insignificant. It also appears that there are few communities with the potential to develop water demand sufficiently to impact the minimum flow. In addition, it also appears that there would likely be little impact if the public supplies presently using groundwater were to switch to surface water. The Clay County Water Service District serves Clay County with groundwater. The Clay County supplied an estimated 0.17 mgd in 2000 and is projected to supply 0.23 mgd in 2030. If all of the water were supplied from the Hiwassee River, it would be less than 1 percent of the minimum flow on the peak-day demand.

Apalachia Powerhouse and Ocoee 1

The combined minimum flow from Apalachia and Ocoee 1 is 388 mgd. The minimum flow from Ocoee 1 is 90 mgd and the minimum flow from Apalachia is 129 mgd. Figure F–10 in the Appendix shows both tailwaters.

There is only one intake on the Hiwassee River which is at Etowah. Presently, the withdrawal for Etowah Utilities is an average of 2.55 mgd (3.84 mgd peak). By 2030, this withdrawal is expected to increase to an average of about 2.9 mgd (4.35 mgd peak). The ratio of 2000 withdrawal to the minimum flow at Apalachia is about 0.03. The 2030 ratio is expected to still be only about 0.03. Since there is little potential for withdrawal because of nearby development, no impact to the tailwater is foreseen from the growth of existing sources or nearby communities.

Although there are no intakes presently on the Ocoee River below Parksville Reservoir, the town of Benton could potentially switch from groundwater to surface water. The 2030 peak-water demand for Benton is projected to be about 0.7 mgd, or less than 1 percent of the minimum flow.

Because of the lack of development in the area along the Ocoee, there appears to be little potential that projected 2030 demands for the area would impact the minimum flow. However, Dalton Utilities has proposed an intake for an IBT for as much as 15 to 20 mgd, which would be about 9 to 12 percent of the minimum flow. Therefore, even though there is likely to be no significant development along the river which would use a substantial portion of the minimum flow, the Ocoee River is a possible location for a significant IBT which would potentially reduce the minimum flow .

Nottely

Presently, there are no intakes on the Nottely River below Nottely Dam and little development that would seek out the river for future supply. There are no significant groundwater users who could potentially switch to a surface water supply.

Blue Ridge

Growth in water demand along the Taccoa River (the river name changes to the Ocoee River at the Tennessee-Georgia state line) below Blue Ridge Dam to Ocoee 3 Reservoir is projected to be about 1.9 mgd over the next 30 years. This increase is only about 2.5 percent of the 74 mgd minimum flow at Blue Ridge. Since almost all of the increase is expected to occur at the lower end of the stream reach where the minimum flow is somewhat higher because of the addition of local inflow, there should be little additional impact on the minimum flow from growth in existing demands. There are no major population centers near the tailwater, nor are there significant amounts of groundwater being used in the area which could switch to surface water in the future.

Tims Ford

Figure F–11 in Appendix F shows there are few intakes in the Elk River below Tims Ford. Fayetteville is the nearest metropolitan area. The current peak-day withdrawal at Fayetteville is about 2 mgd or about 4 percent of the minimum flow at Tims Ford Dam. The 2030 peak-day demand would be about 2.46 mgd or about 5 percent of the minimum flow at Tims Ford Dam. Under low-flow conditions, TVA also provides for a 72 mgd minimum flow at Fayetteville. The ratios of withdrawal based on the 72 mgd minimum are about 3 percent for both 2000 and 2030.

Fayetteville also uses about 0.5 mgd of groundwater on an average-annual basis. If there is a complete switch from groundwater to surface water, the peak-day extraction from the river might be about 3.48 mgd by 2030, or about 5 percent of the minimum flow at Fayetteville.

Chickamauga

The Chickamauga tailwater is shown on Figure F–12. Table 4–7 shows current and projected withdrawals from the Tennessee River between Chickamauga Dam and the Moccasin Bend Wastewater Treatment Plant. The Moccasin Bend location is selected as the key analytical location because the NPDES permit is based on a minimum flow of 1939 mgd. If a significant amount of water were to be removed from the river prior to the treatment plant, Moccasin Bend's discharge permit might be affected.

Table 4–7: Water Withdrawals Below Chickamauga Dam (Millions of Gallons per Day)

Facility	2000 Average Withdrawal	2030 Average Withdrawal
BASF	6.09	
DuPont	7.79	
National Starch & Chemical	2.99	
Subtotal Industry	16.87	
Tennessee-American Water Company	44	53.3

The existing minimum flow is 1939 mgd and occurs during October through April. Assuming a 1.4 peaking factor for Tennessee-American Water Company during this time of year, the combined 2000 peak-day demand would be 78.5 mgd or about 4 percent of the minimum flow. Since the industries, listed in Table 4–7, return about 74 percent of their withdrawal in the form of wastewater, the net withdrawal in this river reach is about 3 percent. Industrial growth in Hamilton County, Tennessee, is projected to be about 21 percent over the next 30 years. Applying this growth rate to the industry subtotal, shown on Table 4–5, results in an industrial demand of about 20.5 mgd by 2030. This, combined with the expected Tennessee-American peak-day withdrawal of 74.6 by 2030, results in a total water demand of 95.1 or about 5 percent of the minimum flow. If the return flows are included, the net withdrawal by 2030 would only be about 4 percent of the minimum flow. Therefore, growth in water demand between Chickamauga Dam and Moccasin Bend Wastewater Treatment Plant is likely to increase by only 1 percent of the minimum flow in the next 30 years.

Guntersville

Figure F–13 in Appendix F shows the Guntersville tailwater. TVA does not provide a minimum flow below Guntersville. However, flow requirements past Browns Ferry Nuclear Plant generally have historically resulted in an average-daily flow of about 6500 mgd July through September, about 5200 mgd December through February, and about 3200 mgd otherwise.

Wheeler

Minimum flows are not provided at Wheeler. However, the Browns Ferry Nuclear Plant requirement generally applies for flows below Wheeler. Figure F–15 in Appendix F shows the Wheeler tailwater.

Pickwick

Figure F–16 shows that there are no significant withdrawals below Pickwick Dam. Only Packaging Corporation of America discharges wastewater in Pickwick tailwater. They can only discharge wastewater if there is at least one turbine flow from Pickwick Dam. This is discussed in Chapter 7. Minimum flows from Pickwick have historically bean about 9700 mgd June through August, 5800 mgd during May and September, and 7800 otherwise. Bohac (2004b) determined that TVA's new operating policy would require no change in PCA's wastewater disposal practice.

Summary and Conclusions

Since 1990, TVA has provided minimum stream flows to improve water quality and aquatic life. The ROS conducted during 2001 through 2004 reevaluated the minimum flows and their relation to other reservoir operating considerations such as reservoir levels, power generation, and navigation. The new operating policy implemented by TVA in June 2004 did not change the minimum flows established in 1990. This chapter considered whether the minimum flows provided by TVA could be affected by 2030 water supply withdrawals. The analysis compared future water demands to minimum flows in tailwaters by comparing the peak-day withdrawal to the minimum flow. Generally, this was done by computing the ratio of demand to the minimum flow in order to determine the fraction or percentage that the water withdrawal was taking from the minimum flow.

Calculations were performed for both 2000 and 2030, and the results compared. An additional factor in the analysis considered the possibility that nearby communities would develop regional water authorities and seek significant new sources of supply in tailwater areas.

The results indicate that it is possible that water supply withdrawal could potentially affect minimum flow releases for designated uses other than water supply. Particular areas of interest include the Watauga River below Wilbur Dam, the South Fork Holston River below Fort Patrick Henry Dam, and possibly the French Board River below Douglas Dam. The Clinch River in the area of Bull Run Fossil Plant might also be affected should significant amounts of water be used consumptively such as for a merchant power plant.

Since future withdrawals could potentially affect minimum flows, aquatic life, and other instream beneficial uses, a case-by-case environmental analysis would be required for new intakes. Potential regulatory parties would include TVA, states, the U. S. Army Corps of Engineers, and U. S. Fish and Wildlife Service. Under section 26a of the TVA Act, an application must be submitted to TVA in order to obtain a permit for a new intake. Generally, TVA reviews permits cooperatively with the U. S. Army Corps of Engineers who has specified regulatory authority for navigable rivers. State agencies also have regulations relating to water withdrawals, and these agencies might also review the potential impact on the minimum flows.

5
Water Supply Impact on Unregulated Streams

Introduction

Key questions asked in Chapter 1 included:

- How much water will be used from streams and rivers in the watershed by 2030?
- Where is there insufficient stream flow and reservoir storage to support future water demand?
- Where and when will water withdrawals affect other beneficial uses (e.g., navigation, power generation, recreation, water quality, aquatic habitat)?

This chapter addresses these questions for streams above reservoirs (unregulated streams) which do not rely on a TVA reservoir for water supply.

Many of the water supply intakes in the Tennessee River watershed are located in a reservoir so that water required during a dry period can be supplied from reservoir storage. Some intakes are located on a stream reach below a reservoir which receives water during a dry period because TVA is committed to providing minimum flows in the river. There are many intakes which are located in the headwaters of TVA reservoirs and are neither in a reservoir nor on a stream segment below a reservoir. Development of additional water supply intakes on these streams might exceed the ability of the stream to supply the intake during dry periods. Areas of particular interest include:

- Powell and Clinch Rivers above Norris Reservoir in Tennessee and Virginia
- North, Middle, and South Forks of the Holston River in Virginia
- Watauga and Doe Rivers in Tennessee and North Carolina above Watauga Reservoir
- Upper Nolichucky River in Tennessee and North Carolina
- Upper French Broad in North Carolina particularly around Asheville
- Pigeon River in Tennessee and North Carolina above Douglas Reservoir
- Tuckasegee and Little Tennessee Rivers in North Carolina above Fontana Reservoir
- Tellico River in Tennessee above Tellico Reservoir
- Oostanaula Creek above Calhoun, Tennessee
- Obed and Emory Rivers above Watts Bar Reservoir
- Sequatchie River in Sequatchie and Bledsoe Counties, Tennessee

- Southeast Tennessee Between the Duck and Tennessee Rivers
- Western edge of the Tennessee River watershed

The first step was to map the locations of the water intakes and to determine if the unregulated streams could supply the growth in water demand. Figures showing water withdrawal areas are presented in Appendix F. The next step was to compare the growth in water demand to statistics for low stream flow on either the stream on which the intake was located or, in some cases, a nearby stream. The USGS (Bradley, 2002) provided locations of stream gauges and low-flow statistics for gauges. The stream gauges and the low-flow statistics are shown in the figures in Appendix F.

The low-flow data are the 7Q10 and the 3Q20. The 7Q10 is the lowest average flow over a 7-day period which would be expected to occur once in 10 years (one would expect this low-flow condition to occur only one time in any 10-year period or the probability that it would occur in any one year would be 10 percent). The 3Q20 is the lowest average flow over a 3-day period that would be expected to occur no more than once every 20 years (probability of occurring in any one year would be 5 percent).

Peak-day flows were estimated by multiplying the average-annual flow by a peaking factor (1.5) to obtain the projected peak-day flow. The tables show both the estimated peak day for 2000 and the projected peak-day flow for 2030. The 2000 and 2030 peak flows are designated by either 2000 or 2030 appearing in parenthesis (00 for 2000 and 30 for 2030) next to the flow within the tables. The peak-day flow for each intake was compared to appropriate low-flow statistics for the intake's stream. This was done by calculating the ratio of the peak-day demand to either the 7Q10 or the 3Q20. Taking too much water out of the stream could impair the stream's designated uses. Therefore, when the ratio of peak-day demand was greater than 0.1 to 0.2, the intake was designated as a potential problem location. The ratio was based on discussions with wastewater permit writers who stated their reluctance to permit wastewater discharges where minimum flows were reduced by water withdrawals by about 10 to 20 percent (Baker, 2002). In addition, recent discussions concerning a new intake on the Watauga River below Wilbur Dam suggest that stream uses would potentially be impacted by withdrawals of this magnitude.

In the case of existing intakes, the difference in the ratios between 2000 and 2030 were often compared. In some cases, the ratio of 2000 peak flow to the 7Q10 or 3Q20 indicates that the intakes already withdraw a significant amount of water under low-flow conditions. In such cases, it might be concluded that the stream's designated uses have already been impacted. However, in many cases, the projected increase is only a small percent indicating that, although the stream might be impacted, the growth in water demand will not likely have a significant change on the impact.

Comments are made in the analysis concerning whether enough water is in a particular stream, under low-flow conditions, for communities to consider the stream as a potential surface water source if their groundwater source proves to be inadequate because of either quantity or quality (see Future Groundwater Use in Chapter 2). It is to be noted that these comments are for individual systems. The cumulative effect of multiple conversions of groundwater systems to surface water systems, all using the same stream, is not considered in this chapter.

Analysis

Powell River in Virginia and Tennessee above Norris Reservoir

The Powell River in Virginia and Tennessee above Norris Reservoir is shown on Figure F–17 in Appendix F.

The annual-average demand for 2000 and the projected demand for 2030 for the communities of Wise, Norton, Appalachia, and Big Stone Gap are given in Table 5–1. The peak-day demands are not shown because there are no low-flow statistics to compare to the peak-day demands. All of these communities are located in the headwaters of the Powell River, and all, with the exception of Big Stone Gap, are served to some degree by reservoirs. Growth in water demand in Wise County is projected to be about 20 percent in the next 30 years. Withdrawals from unimpounded streams might not provide a reliable water source, during

Table 5-1: Water Withdrawal in Wise and Lee Counties, Virginia, and Claiborne County, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of 7Q10 to Peak-Day Withdrawal	Ratio of 3Q20 to Peak-Day Withdrawal	Source
Wise County, Virginia								
Coeburn	0.175	0.211						Groundwater
Wise	0.799	0.965						Wise Reservoir
Wise	0.509	0.615						Bear Creek
Norton	0.872	1.054						Lower Lake
Norton	0.213	0.257						Robinette Branch
Appalachia	0.529	0.639						Guest River
Appalachia	0.381	0.46						Appalachia Reservoir
Big Stone Gap	1.7	2.054						South Fork Powell River
Lee County, Virginia								
Pennington Gap	0.778	0.946	1.17 (00) 1.42 (30)		9	0.13 (00) 0.16 (30)		Powell River
Ridgeview	0.01	0.012	0.018 (30)					Groundwater
Ridgeview potential surface supply			0.018 from above	24		<0.01 (30)		Powell River
Jonesville	0.409	0.497	0.745 (30)					Groundwater
Jonesville potential surface supply			0.745 from above	24		0.03 (30)		Powell River
Rose Hill	0.165	0.201						Groundwater
Claiborne County, Tennessee								
Lincoln Memorial University	0.218	0.311						Groundwater
Arthur-Shawnee Utility District	1.43	2.037	2.14 (00) 3.05 (30)	52	46	0.04 (00) 0.06 (30)	0.05 (00) 0.07 (30)	Powell River

(00) denotes year 2000 and (30) denotes year 2030

dry periods. Therefore, it is likely that if existing surface water sources are not adequate, new or expanded reservoirs would be investigated.

Pennington Gap presently has an intake on the Powell River. The 2000 withdrawal for Pennington Gap is estimated to be 13 percent (ratio of 0.13) of the 7Q10 flow. The projected 2030 peak-day demand is estimated to be about 16 percent of the 7Q10 flow. Although this might be a significant amount of the low river flow, the additional 3 percent increase might not cause significant additional impact to the river under low-flow conditions.

Ridgeview and Jonesville are served by groundwater. Should the groundwater sources prove to be unsatisfactory over the next 30 years, it appears that the Powell River would have sufficient water to meet the needs of these communities, as indicated by the low ratio of peak-day demand to 7Q10 flow shown in Table 5–1. A combined intake would remove about 4 percent of the low flow in the river by 2030.

Rose Hill is presently supplied by groundwater. Demand is expected to increase by approximately 20 percent over the next 30 years. If the existing groundwater source is unsatisfactory and additional groundwater is unavailable, it may not be practical to develop a surface water supply in the immediate area because of the community's headwater location. The closest source might be the Powell River approximately 10 miles away. Similarly, should Lincoln Memorial University need significant amounts of additional water, groundwater might be the only source because of the University's headwater location.

Table 5–1 shows that the Arthur-Shawnee Utility District currently extracts about 4 percent of the 7Q10 flow and about 5 percent of the 3Q20 flow from the Powell River. By 2030, it is expected that the district could take 1 to 2 percent more of the low flow under peak-day conditions.

Clinch River in Virginia and Tennessee above Norris Reservoir

The Clinch River in Virginia and Tennessee is shown on Figure F–17 and Figure F–18 in Appendix F. Tazewell through St. Paul are shown on Figure F–18, while Duffield and Sneedville are shown on Figure F-17 Table 5–2 shows water withdrawals along the Clinch River from its headwaters near Tazewell, Virginia, to its entry into Norris Reservoir, a few miles below Sneedville, Tennessee.

Current data for Tazewell and Claypool are not available, but the combined withdrawal for both communities, based on 1995 USGS data (Hutson, 2002b), might be about 2 mgd. Tazewell is supplied by several surface water sources including the Clinch River. The estimated 7Q10 in the Clinch River near Tazewell is on the order of 4 mgd. Claypool is supplied by both groundwater and a surface water supply on the Little River. A conservative analysis for the Claypool intake, and the combined withdrawal for Tazewell and Claypool, appears in Table 5–2. The relative ratio of 2000 and 2030 peak-day withdrawal compared to the 7Q10 flow near the Claypool intake indicates that the most Claypool's demand could reduce the Little River low flow would be 5 percent (0.3 less 0.25).

Jewel Ridge is supplied by an impoundment in the upper headwaters of the Clinch River. The impoundment's safe yield is unknown, but Jewel Ridge's demand is expected to increase less than 10 percent over the next 30 years. If the impoundment is not sufficient, the Clinch River would probably be the only source that could provide the needed water.

Table 5-2: Water Withdrawal in Tazewell, Russell, Wise, and Scott Counties, Virginia, and Hancock County, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	Ratio of 7Q10 to Peak-Day Withdrawal	Source
Tazewell County, Virginia						
Tazewell	No data					Clinch River & Cox Br. Reservoir
Claypool	0.044	0.082	0.12 (3)			Groundwater
Claypool	No data	No data	No data	12		Little River
Claypool-Tazewell potential surface supply	2 total estimated combined	2.4	3 (00) 3,6 (30)	12 near Claypool Little River intake	.25 (00) .30 (30)	
Jewel Ridge	0.038	0.046				Impoundment
Richlands	0.458	0.554	0.69 (99) 0.72 (30)	13	0.05 (00) 0.06 (30)	Clinch River
Raven	0.227	0.275	0.34 (00) 0.41 (30)	13	0.03 (00) 0.03 (30)	Clinch River
Russell County, Virginia						
Honaker	0.155	0.21	0.315 (3)			Groundwater
Honaker potential surface supply			0.315 from above	1	0.31 (3)	Flat Rock Creek
Appalachia Det Center	0.011	0.015				Groundwater
Cleveland	0.027	0.037	.056 (3)			Groundwater
Cleveland potential surface supply			0.056 from above	35	<0.01 (3)	Clinch River
Moss Mine	3.79					Chaney Creek
Dante	0.146	0.198				Groundwater
Lebanon	0.522	0.75	0.83 (00) 1.125 (3)	3	0.28 (00) 0.38 (30)	Big Cedar Creek
Castlewood	0.101	0.137	0.2 (30)			Groundwater
Castlewood potential surface supply			0.2 from above	>34 at St. Paul	<0.01 (30)	Clinch River
Wise County, Virginia						
St. Paul	0.293	0.354	0.44 (00) 0.53 (30)	>34 approximately 15 mi upstream	0.01 (00) 0.02 (30)	Clinch River
Scott County, Virginia						
Duffield	0.15	0.15	0.23 (00) 0.23 (30)	1	0.22 (00) 0.22 (30)	North Fork Clinch River
Speers Ferry (proposed)	0		3	64	0.05 (30)	Clinch River
Hancock County, Tennessee						
Sneedville	0.344	0358	0.52 (00) 0.54 (3)	92 Clinch River below	<0.01 (00) <0.01 (3)	Clinch River and Brier Creek

(00) denotes year 2000 and (30) denotes year 2030

Richlands' and Raven's projected 2030 withdrawal will only decrease the Clinch River's low flow by about an additional 1 percent.

Honaker is presently served by groundwater. Flat Rock Creek might be available as a surface water supply, but likely could not supply the entire demand without significantly depleting the creek during low flow (2030 peak-day withdrawal would be 31 percent of the 7Q10). The Appalachia Detention Center presently uses groundwater and, because only a small increase is projected for 2030, the existing supply might be sufficient. Cleveland, Virginia, presently uses groundwater. Cleveland's 2030 demand would take less than 1 percent of the 7Q10 if all its supply were provided by the Clinch.

The Moss Mine and Dante are located in the upper reaches of the drainage basin where there is little opportunity to develop a significant surface water source. Dante presently utilizes groundwater.

Castlewood uses groundwater presently, but the nearby Clinch River has ample water if a surface supply is needed. The 7Q10, measured about 14 miles from St. Paul on the Clinch River, is 34 mgd. Therefore, Castlewood's 2030 peak-day demand would be less than 1 percent of the Clinch River 7Q10. St. Paul's projected 2030 withdrawal from the existing intake on the Clinch River would only raise the withdrawal from the current (2000) 1 percent of the 7Q10, to about 2 percent of the 7Q10.

Lebanon is expected to extract about 30 to 40 percent of the 7Q10 in Big Cedar Creek by 2030. Russell County proposed to negotiate additional water purchases from Lebanon (Frazier, 2004).

Duffield's intake is located on the North Fork of the Clinch River. It appears that presently about 22 percent of the 7Q10 could be extracted from the river under peak-day conditions. However, the growth in water demand is expected to be small and little increase in the percentage of low river flow is expected by 2030.

A new 3 mgd intake is proposed at Spears Ferry (Frazier, 2004). This would be about 5 percent of the 7Q10. Sneedville, located on the Clinch River, is projected to withdraw less than 1 percent of the 7Q10 on a 2030 peak day.

Recent attempts to permit intakes on the Clinch River has revealed that the U.S. Fish and Wildlife Service is very concerned about threatened and endangered species in the Clinch River and locating new water intakes in the river might be problematic.

In summary, there generally appears to be adequate water in the Clinch River although surface withdrawals in the upper reaches of the river could remove a significant portion of the low flow under peak-day conditions. Communities in the upper reaches of the drainage area are limited in their potential to develop surface water sources. However, projected demand over the next 30 years is expected to grow less than 10 percent in the area which means that existing supplies for these communities might be adequate. Significant increased withdrawal from the Clinch might be difficult due to the aquatic-habitat issues.

North, Middle, and South Forks of the Holston River in Virginia

The study area is shown in Figure F–18, with the exception of Big Moccasin Creek and Gate City which are shown in F–17. As shown in Table 5–3, Rye Valley is supplied by four springs in the headwaters of the South

Fork of the Holston River. There would appear to be little opportunity to develop a surface water source in the immediate area. However, the growth in demand over the next 30 years is expected to be small (8 to 10 percent) and the existing spring-water supply might not be taxed much more heavily than at present.
The Thomas Brothers Water Company provides service in the Adwolf area using both groundwater and a surface water intake on the South Fork Holston River. The 7Q10 flow on the South Fork Holston River, a short distance downstream from the intake, is 13 mgd. Table 5–3 shows that the ratio of the 2000 peak-day demand to the 7Q10 low flow for just the surface water intake is about 0.04 and is not expected to be much different in 2030. Even if the 2030 groundwater and surface water supplies are combined into a single surface water supply, the ratio of peak-day demand to the 7Q10 river flow would still only be about 0.05. Both ratios are small, indicating that the surface water source is adequate for future needs even if the groundwater source is abandoned, and all the demand is met with water from the river.

Chilhowee is supplied by wells, located south of the South Fork Holston River. The projected demand increase is only about 8 percent over the next 30 years and the existing sources might have adequate supply. If there were a complete switch to surface water with an intake near Adwolf, the peak demand might be as much as 14 percent of the 7Q10, as reflected in Table 5–3. However, the 7Q10 on the Middle Fork Holston River near Chilhowee is 16 mgd. If an intake were developed on the Middle Fork, the ratio of demand to the 7Q10 would only be 0.12 or the withdrawal might be on the order of 12 percent of the 7Q10.

Marion has both a spring and an intake on the Middle Fork of the Holston River for water supply sources. The growth in water demand over the next 30 years is projected to be only about 0.2 mgd, or less than 10 percent of the 2000 withdrawal. The estimated 7Q10 flow at Marion is about 8 mgd. Both ratios of peak-day demand to 7Q10 flow are about the same, at 0.09, indicating that growth in water demand might have little impact on the river. However, a complete switch from groundwater to surface water would mean a peak-day demand of about 4.16 mgd, which would be over 50 percent of the 7Q10 flow. Because this demand represents such a high percentage of the low flow, it probably would not be possible to supply all of Marion’s water needs from the Middle Fork.

Washington County supplies water from two groundwater sources located south of the South Fork Holston River and from one surface water intake located on the Middle Fork Holston River. The peak-day demand for 2000 at the surface water intake on the Middle Fork is estimated to be less than about 14 percent of the 7Q10 and could rise to about 15 percent by 2030. The state of Virginia has proposed that Washington County’s withdrawal on the Middle Fork be limited to 10 percent of Middle Fork flow. Therefore, Washington County applied for an intake site that could withdraw water from the South Fork. Combining the peak-day demand for all of Washington County results in an estimate of about 9.15 mgd for 2030, which would be about 11 percent or less of the combined 7Q10 flows in both the Middle Fork and South Fork. Using Washington County’s 2030 projection of 12 mgd, the withdrawal would be somewhat less than 15 percent of the minimum flow. The ability to withdraw water from both the Middle and South Fork would lessen the impact on the Middle Fork.

Saltville is presently supplied by two wells and a spring. The projected increase in demand over the next 30 years is only 0.04 mgd, which might be met by existing sources. Should the existing sources prove to be unsatisfactory, it would appear that the North Fork Holston River has ample water. The 7Q10 at Saltville is estimated to be about 17 mgd and the 2030 total peak, public supply demand is only about 5 percent of the 7Q10.

Table 5–3: Water Withdrawal in Smyth, Washington, and Scott Counties, Virginia (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	Ratio of 7Q10 to Peak-Day Withdrawal	Source
South Fork Holston River—Smyth and Washington Counties						
Rye Valley near Sugar Grove	0.212	0.23	0.345 (30)			Four springs
Thomas Bros near Adwolf	0.09	0.1	0.15 (30)			Groundwater
Thomas Bros near Adwolf	0.321	0.348	0.48 (00) 0.52 (30)	13 near Adwolf	0.04 (00) 0.04 (30)	South Fork Holston River
Thomas Bros groundwater surface water combined			0.67 (30)	13	0.05 (3)	South Fork Holston River
Chilhowie	1.15	1.24	1.87 (30)			Gross & Jones Springs
Chilhowie			1.87 from	13 near Adwolf 16 near Chilhowie	1.87/13=0.14 1.87/16=0.12	South Fork Holston River (Adwolf) Middle Fork Holston River (Chilhowie)
Washington County	1.8	1.98	2.97 (30)			Cole Spring, Mill Creek
Washington County	0.86	0.94	1.41 (30)			Groundwater-Reservation Spring
Middle Fork Holston River—Smyth and Washington Counties						
Marion	2.1	2.276	3.41 (30)			Town Spring
Marion	0.463	0.502	0.69 (00) 0.75 (30)	8 Near Marion	0.09 (00) 0.09 (30)	Middle Fork Holston River
Marion switch to surface water			4.16 (30)	8	.52 (30)	Middle Fork Holston River
Washington County	2.89	3.13	4.34 (00) 4.77 (30)	>32	<0.14 <0.15	Middle Fork Holston River
Washington County single surface water source			9.15 (30) sum of above	>32 >79 combined Middle & South Fork	<0.28 <0.11	Middle Fork only Intakes in Middle & South Forks Holston River
North Fork Holston River—Smyth, Scott, and Washington Counties						
Saltville	0.543	0.589	0.88 (30)			Wells and Whitt Spring
Saltville potential surface water source			0.88 from above	17	0.05 (30)	North Fork Holston River
Gate City	0.492	0.488	0.74 (00) 0.73 (30)			Big Moccasin Creek
Big Moccasin Creek	0.413	0.409	0.62 (00) 0.61 (30)			Big Moccasin Creek
Gate City and Big Moccasin			1.36 (00) 1.34 (30)	4.5	0.30 (00) 0.30 (30)	Big Moccasin Creek

(00) denotes year 2000 and (30) denotes year 2030

The Gate City and Big Moccasin Creek water treatment plants are located on Big Moccasin Creek which has a 7Q10 of about 4.5 mgd. Presently, the combined peak-day extraction is about 30 percent of the 7Q10. Projections for the area supplied by these two plants are that growth will be minimal, which means that little increase in the peak-day extraction is expected by 2030.

Watauga and Doe Rivers in Tennessee and North Carolina above Watauga Reservoir

Table 5–4 and Figure F–19 in Appendix F show existing water users above Watauga Reservoir and in the upper reaches of the Doe River in Tennessee. Carderview Utility District and Peter's Hollow Water System are groundwater systems located in the upper reaches of small streams—with little opportunity to develop surface water sites in the immediate area. Because their growth is projected to be small, their existing groundwater sources might be sufficient.

Mountain City is served by a spring and a reservoir. Water demand is projected to increase by about 1 mgd over the next 30 years. If the existing sources are not sufficient, Roan Creek might be able to supply the increased demand. However, completely switching to Roan Creek would deplete the flow in the creek under low-flow conditions and, thus, would not be practical.

Table 5-4: Water Withdrawals in Johnson and Carter Counties, Tennessee for 2000 and 2030 (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of 7Q10 to Peak-Day Withdrawal	Ratio of 3Q20 to Peak-Day Withdrawal	Source
Johnson County								
Carderview Utility Dist	0.046	0.058	0.087 (30)					Wells
Cold Springs Utility Dist	0.085	0.106	0.159 (30)					Cole Spring
Mountain City	0.826	1.026	1.539 (30)					Springs
Mountain City	1.2	1.491	2.236 (30)					Silver Lake
Mountain City switch to Roan Creek for above intakes	1.33	2.30	3.45 (30)	3.7	3	0.93 (30)	1.15 (30)	Roan Creek
Carter County								
Peter's Hollow Water System	0.01	0.012	0.018 (30)					Well
Roan Mtn Utility	0.125	0.147	0.22 (30)					Wells
Roan Mtn potential switch to surface			0.22 from above	1.3	1	0.17 (3)	0.22 (3)	Buck Creek

(00) denotes year 2000 and (30) denotes year 2030

Roan Mountain is served by several groundwater wells. Water demand is projected to only increase by about 0.02 mgd during the next 30 years, so the groundwater sources might be sufficient. Buck Creek at Roan Mountain appears to have sufficient low flow to provide all of the Roan Mountain Utility District's flow should a switch to surface water become necessary. However, a significant portion of the low flow (17 to 22 percent) would be withdrawn.

Table 5–5 shows public water suppliers in Avery and Watauga Counties of North Carolina[1]. Beach Mountain is the only system supplied by surface water and utilizes an impoundment on the Watauga River. The yield from

Buckeye Lake appears to be sufficient to support the projected 2030 demand. Other systems in the counties rely on relatively low-yielding wells. The 2010 supply column shown in Table 5–5 is based on data from the North Carolina Water Supply Plan for the Watauga River Basin (North Carolina, 2001). No data were available for the 2030 water supply. Therefore, only the ratios of 2030 withdrawal to 2010 were calculated. North Carolina's Division of Water Resources criterion for critical water supply is a ratio of withdrawal to supply of 0.8 or more. It is assumed that the 2010 supply will be at least as much as the 2030 supply. Therefore, if the ratio of 2030 withdrawal to 2010 supply is less than 0.8, it is also assumed that the ratio of 2030 withdrawal to 2030 supply would be less than 0.8.

Based on the critical ratio of 0.8, it appears that Newland, Miller Ridge, and Seven Devils will need to develop additional water supplies by 2030. All of the systems are isolated by mountainous terrain, so none of the systems are presently interconnected (North Carolina, 2001). Because of the difficulty to interconnect the systems, it is possible that each system would have to develop its own new source of water rather than combining into a regional system.

Low-flow statistics at a gauge located on the North Toe River near Newland, indicate a 7Q10 flow of about 2 mgd suggesting that there could be an opportunity for surface water development in the area.

Miller Ridge and Seven Devils are located in the headwaters of the Elk River where surface water development might be limited. A gauge on the Elk River near Banner Elk, located several miles below the two communities, indicates a 7Q10 flow of about 4 mgd. Since the combined 2030 demand of Miller Ridge and Seven Devils on peak day would be about 0.36 mgd, or about 10 percent of the 7Q10, the Elk River might be a source of water for these communities.

Table 5–5: Water Withdrawal and Supply Comparison for Avery, Watauga, and Yancey Counties, North Carolina (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2010 Supply	Ratio 2030 Withdrawal to 2010 Supply	Source
Avery County, NC					
Elk Park	0.086	0.106	0.236	0.450	Groundwater
Newland	0.169	0.210	0.257	0.815	Groundwater
Banner Elk	0.210	0.260	0.488	0.533	Groundwater
Watauga County, NC					
Beach Mountain	0.276	0.457	1.00	0.457	Buckeye Lake
Miller Ridge	0.025	0.036	0.043	0.834	Groundwater
Seven Devils	0.135	0.194	0.216	0.899	Groundwater
Yancey County, NC					
Burnsville	0.570	0.747	1.98	0.377	North Fork Bowlens Creek

Data Source: North Carolina (2001)

Upper Nolichucky River in Tennessee and North Carolina

The Upper Nolichucky area is shown on Figure F–19 in Appendix F and Table 5–6 shows a comparison of major water withdrawals in the Nolichucky River drainage. Since Greenville and Jonesborough have intakes on the Nolichucky, the fraction of 2000 and 2030 demand to the 7Q10 and 3Q20 are small and only grow by about 1 to 2 percent in 30 years. This indicates that future demand increases would not significantly impact the river. Although Erwin is presently supplied by groundwater, future growth in demand or a switch to surface water would appear feasible given that the projected 2030 withdrawal would only reduce the low river flow by 3 to 4 percent.

The municipalities listed in Table 5–7 are also shown on Figure F–19 in Appendix F. Table 5–7 indicates that public water supply sources are adequate for the 2030 demands in Mitchell and Yancey Counties based on the ratio of 2030 withdrawal to 2010 supply being less than 0.8.

Table 5–6: Water Withdrawals in Greene, Unicoi, and Washington Counties, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2030 Peak-Day Withdrawal	7Q10	3Q20	Ratio of 7Q10 to Peak-Day Withdrawal	Ratio of 3Q20 to Peak-Day Withdrawal	Source
Greene County								
Zinc Products	3.35							Sinking Creek
Greenville Water & Light	7.65	8.39	11.5 (00) 12.59 (30)	141	97	<0.08 (00) <0.09 (30)	<0.12 (00 <0.13 (30)	Nolichucky River
North Green Utility	0.455	0.499	0.748 (30)					Lick Creek
Unicoi County								
Erwin Utilities	2.207	2.396	3.594 (30)					Groundwater
Erwin Utilities potential surface supply			3.594 from above	123	97	0.03 (30)	0.04 (30)	Nolichucky River near Erwin
Washington County								
Jonesborough	2.26	3.007	3.39 (00) 4.51 (30)	141	97	0.02 (00) 0.03 (30)	0.03 (00) 0.05 (30)	Nolichucky River

(00) denotes year 2000 and (30) denotes year 2030

Upper French Broad and Pigeon River Basins

Figure F–20 and Table 5–8 show the Upper French Broad and Pigeon Rivers unregulated stream area and the projected 2030 demands for Woodfin, Biltmore Forest, Black Mountain, and Laurel Park all exceed 80 percent of their 2010 supplies. Woodfin states that they will contract with Asheville or Weaverville for the required amount (North Carolina, 1997a). Asheville would be a likely source for Biltmore Forest and Black Mountain, although Black Mountain does have the option of looking for additional groundwater (North Carolina, 1997b).

Table 5–7: Water Withdrawal and Supply Comparison for Mitchell and Yancy Counties, North Carolina (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2010 Supply	Ratio 2030 Withdrawal to 2010 Supply	Source
Mitchell County					
Bakersville	0.087	0.090	0.114	0.793	Groundwater
Spruce Pine	1.296	1.338	3.073	0.436	Beaver Creek Res, N. Toe River, Groundwater
Yancey County					
Burnsville	0.57	0.747	1.98	0.377	N & S Forks Bowlens Creek, Cane River

Date Source: North Carolina, 2001

Table 5–8: Water Withdrawal and Supply Comparison for Buncombe, Henderson, and Madison Counties, North Carolina (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2010 Supply	Ration 2030 Withdrawal to 2010 Supply	Source
Buncombe County					
Woodfin	1.056	1.396	1.477	0.945	Sugar Camp Fork & Groundwater
Asheville	22.52	29.76	40	0.744	Burnette and Bee Reservoirs
Biltmore Forest	0.235	0.31	0.306	1.014	Asheville
Black Mountain	0.705	0.931	0.491	1.896	Groundwater
Montreat	0.204	0.270	0.398	0.678	Groundwater
Weaverville	0.443 1.0*	0.7	1.63	0.429	Ivy River & Asheville
Henderson County					
Hendersonville	7.5 12.0*	11.753	17.5	0.672	Mills & N. Fork Mills River
Laurel Park	0.149	0.208	0.186	1.119	Hendersonville
Madison County					
Marshall	0.154	0.181	0.241	0.75	Groundwater
Hot Springs	0.094	0.11	0.234	0.47	Cascade Branch
Mars Hill	0.35 0.8*	0.343	0.356	0.964	Poplar Cove & Carter Cove

* Design capacity
Data Source: North Carolina, 2001

Mars Hill is exploring groundwater possibilities and the possibility of connecting to Weaverville in order to meet their future water supply needs (North Carolina, 1997c).

Table 5–9 indicates that only Junaluska, which is interconnected to both Waynesville and Maggie Valley, is expected to have a water demand which will exceed 80 percent of the available supply by 2030. Since both Waynesville and Maggie Valley appear to have adequate supplies, Junaluska would appear to have the option of purchasing the needed water from either Waynesville or Maggie Valley. In Appendix F, Figure F–20 shows the locations of the communities.

Table 5–9: Water Withdrawal and Supply Comparison for Haywood and Transylvania Counties, North Carolina (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2010 Supply	Ratio 2030 Withdrawal to 2010 Supply	Source
Haywood County					
Maggie Valley	0.866	1.09	3.0	0.364	Jonathan Creek & Campbell Creek
Canton	2.335	2.942	6.8	0.433	Pigeon River
Clyde	0.197	0.248	1.0	0.248	Canton
Waynesville	3.924 8.0*	4.944	12.8	0.386	Allens Creek
Junaluska	0.398	0.502	0.482	1.041	Waynesville/Maggie Valley
Transylvania County					
Brevard	1.131 2.6*	1.6	2.6	0.615	Cathey's Creek
ECUSTA Development	0.15 0.8*				Davidson River
Rosman	0.065	0.087	0.171	0.511	Groundwater

* Design capacity
Data Source: North Carolina, 2001

Pigeon River Above Douglas Reservoir in Tennessee

Figures F–8 and F–20 in Appendix F show the Pigeon River unregulated stream area of Cocke and Sevier Counties of Tennessee. Table 5–10 shows Newport's intake on the French Broad River and appears to have an adequate water source for the future. The ratio of withdrawal to 7Q10 and 3Q20 flows is only 0.02 to 0.03 for both 2000 and 2030.

The East Sevier County Utility District is currently supplied by groundwater. Should additional sources be needed in the future, the Pigeon River might be investigated as a possible source.

Pigeon Forge in Sevier County will have an adequate supply because of its intake on Douglas Reservoir. No low-flow comparison is presented in Table 5–10 for Pigeon Forge because of the intake on Douglas. However, growth in water demand in other areas of Sevier County is projected to tax the current supplies. Both

Table 5–10: Water Withdrawals in Cocke and Sevier Counties, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of 7Q10 to Peak-Day Withdrawal	Ratio of 3Q20 to Peak-Day Withdrawal	Source
Cocke County								
Hunt Wesson	0.45							Groundwater
Newport Utilities	4.090	5.178	6.14 (00) 7.77 (30)	344	274	0.02 (00) 0.02 (30)	0.02 (00) 0.03 (30)	French Broad River
Sevier County								
Pigeon Forge	3.036	6.40						Walden's Creek & Douglas Reservoir
Gatlinburg	1.88	3.965	5.94 (30)	2.72	2	>1	>1	West Prong Little Pigeon River
Sevierville	2.37	4.999	7.5 (30)	3	2.2	>1	>1	East Prong Little Pigeon River
Sevierville potential new surface supply			7.5 from from above	10.8	8	0.72	0.94	Little Pigeon River near Sevierville
East Sevier County Utility	0.159	0.335						Groundwater

(00) denotes year 2000 and (30) denotes year 2030

Gatlinburg and Sevierville would appear to need additional sources of water to meet the projected 2030 demand. Douglas Reservoir or the French Broad River could be considered.

Should the groundwater source for the East Sevier County Utility District be found to be insufficient, the nearest possible stream might be Cosby Creek in Cocke County which has a 7Q10 of 5 mgd. Douglas Reservoir might also be considered.

Tuckasegee and Little Tennessee Rivers In North Carolina Above Fontana Reservoir

The Tuckasegee and Little Tennessee River areas and communities are shown on Figure F–21 in the Appendix, and Table 5–11 shows that none of the public supplies in the headwater areas are in danger of exhausting their supplies by 2030.

Tellico and Little River Areas of Tennessee

Figure F– 9 shows the Tellico and Little River, and Table 5–12 indicates that both Alcoa and Maryville already withdraw a significant amount of water from the Little River under low-flow conditions. Growth for both communities over the next 30 years could place an additional burden on the river. South Blount Utility's new water plant will reduce Alcoa demand, but additional water supply sources such as from Fort Loudoun Reservoir will likely be required by 2030.

The projected growth at Tellico Plains is only about 0.1 mgd, so existing groundwater sources might be sufficient. Should they not be sufficient, the Tellico River would support a complete switch to a surface supply.

Table 5-11: Water Withdrawal and Supply Comparison for Jackson, Macon, and Graham Counties, North Carolina (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2010 Supply	Ratio 2030 Withdrawal to 2010 Supply	Source
Jackson County					
Tuckasegee	0.904	1.219	15	0.076	Tuckasegee River
Macon County					
Franklin	1.129 2.2*	1.725	3.1	0.556	Cartoogechaue Creek
Highlands	0.556 2.0*	0.849	2	0.425	Big Creek
Graham County					
Robbinsville	0.432	0.53	1.1	0.482	Talula, Rock, Long & Burgen Creeks
Santeelah	0.022	0.026	0.147	0.18	Groundwater
Swain County					
Bryson City	0.762	1.008	2	0.504	Deep Creek
Whittier	0.037	0.049	0.144	0.34	Groundwater

* Design capacity
Data Source: North Carolina, 2001

Table 5–12: Water Withdrawals in Blount and Monroe Counties, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of 7Q10 to Peak-Day Withdrawal	Ratio of 3Q20 to Peak-Day Withdrawal	Source
Blount County								
Alcoa	10.5	15.445	15.75 (00) 23.2 (30)	30.6	20.1	0.51 (00) 0.76 (30)	0.78 (00) 1.15 (30)	Little River
Maryville	3.77	5.545	5.66 (00) 8.32 (30)	30.4	20.1	0.18 (00) 0.27 (30)	0.28 (00) 0.41 (30)	Little River
Monroe County								
Tellico Plains	0.502	0.627	0.94 (30)					Groundwater
Tellico Plains potential surface water supply			0.94 from above	20	17	0.05 (30)	0.06 (30)	Tellico River
Sweetwater	0.81	1.147	1.21(00) 1.72 (30)	3.1	2.6	0.39 (00) 0.55 (30)	0.46 (00) 0.66 (30)	Sweetwater Creek
Sweetwater	0.54	0.54	0.81 (00)					Cannon Spring
Tellico area services and Madisonville	3.66	4.574						Little Tennessee River Tellico Reservoir

(00) denotes 2000 and (30) denotes 2030

Sweetwater apparently already extracts a considerable amount of the water from Sweetwater Creek under low-flow conditions and peak-day demand (39 percent of the 7Q10 and 46 percent of the 3Q20). The projected peak-day demand for 2030 will withdraw even a greater percentage of Sweetwater Creek's low flow. The Tellico Area Services System, with an intake in Tellico Reservoir, will have a sufficient supply to meet future needs. No low-flow comparison is presented because the intake is supplied by Tellico Reservoir.

Oostanaula Creek Above Calhoun, Tennessee

The Oostanaula Creek area is shown on Figure F–9 in Appendix F. Athens presently obtains its water from three wells and a spring. All the water passes through a treatment plant with a capacity of approximately 4.1 mgd. In the past, Oostanaula Creek also supplied some water to the city, but the difficulty in treating it and upstream pollution caused the city to discontinue its use. During the summer of 2002, the city reported that they were only able to produce about 2.5 mgd from their wells and spring (Gentry, 2002). The city does have an interconnection with the Hiwassee Utility Commission, which supplies about 0.5 mgd of water from the Hiwassee River. The 7Q10 and 3Q20 values shown for Athens are for Oostanaula Creek near Athens. Although there would appear to be some water available in Oostanaula Creek to supplement Athens' groundwater supply, the ratios shown in Table 5–13, which reflect switching entirely from groundwater to surface water, indicate that there is not enough water in Oostanaula Creek at low flow to support a complete surface water supply for Athens. North Mouse Creek, which lies to the west of Athens, has low-flow values similar to Oostanaula Creek. Therefore, although there might be some water available in North Mouse Creek, it too would not support a complete switch from groundwater to surface water for Athens. As stated above, pollution issues, at least in regard to Oostanaula Creek, might limit the development of local sources. The Hiwassee River might be the best source for a new long-term supply.

Table 5–13: Water Withdrawals in McMinn and Bradley Counties, Tennessee, Near Oostanaula Creek (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of 7Q10 to Peak-Day Withdrawal	Ratio of 3Q20 to Peak-Day Withdrawal	Source
McMinn County								
Athens	2.354	2.706	4.05 (30)					Groundwater
			4.05 from above	4.5	3.9	1.1	0.96	Oostanaula Creek near Athens
Englewood	0.34	0.39	0.51 (00) 0.59 (30)	4	3.7	0.13 (00) 0.15 (30)	0.14 (00 0.16 (30)	Middle Creek
Etowah	2.55	2.931	4.54 (30)	TVA provides a minimum flow of 129 mgd at Apalachia—20 miles upstream from Etowah. Ratio of peak flow to minimum flow is <.03 in 2030.				Hiwassee River
Bradley County								
Hiwassee	3.6	4.48	6.72 (30)	743		.001 (30)		Hiwassee River

(00) denotes 200 adn (30) denotes 2030

The low-flow values for Englewood are for Chestuee Creek and not Middle Creek, because no values for Middle Creek are available. The ratios do indicate that there would be sufficient water in Chestuee Creek to support Englewood's growth if there is insufficient water in Middle Creek.

The growth in demand at Etowah (0.7 mgd on peak day) is not considered to be a problem since the Hiwassee minimum flow is 129 mgd at the Apalachia powerhouse, approximately 20 miles up river from the Etowah intake. The minimum flow at Etowah would certainly be greater than 129 mgd. The Hiwassee Utility Commission has an intake in Bradley County on the Hiwassee River. The commission supplies water to several communities in McMinn County including Calhoun, Niota, Riceville, and Athens. The treatment plant capacity is 7.61 mgd (Hutson, 1999). Under peak-day conditions, the withdrawal is expected to be about 0.1 percent of the Hiwassee River 7Q10 flow in 2030.

Hiwassee River Area Above Hiwassee Reservoir in North Carolina

As shown in Table 5–14, the 2030 demands for both Andrews and Marble exceed 80 percent of the available supply. Andrews recently cleaned Beaver Creek Reservoir in order to improve its yield and increase the town's water supply by 0.08 mgd. The town was under an expansion moratorium, as required by the North Carolina Division of Environmental Health, until an additional source of water was developed (North Carolina, 1997d). Marble has also been under a moratorium that bans new connections. Marble is exploring the possibility of developing groundwater as the source of additional supply (North Carolina, 1997e). The area is shown in Figure F–10 in the Appendix.

Table 5–14: Water Withdrawal and Supply Comparison for Cherokee and Clay Counties, North Carolina (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2010 Supply	Ratio 2030 Withdrawal by 2010 Supply	Source
Cherokee County					
Murphy	0.984 2.0*	1.231	13	0.095	Hiwassee River
Andrews	0.74 1.0*	0.869	0.88	0.94	Don Holland Reservoir and Bever Creek
Marble	0.099	0.124	0.154	0.805	Groundwater
Clay County					
Clay County	0.174	0.229	0.457	0.502	Groundwater

* Design Capacity

Northern Knox and Southern Union Counties, Tennessee

Figure F–8 in Appendix F shows the study area. South of Norris Reservoir is heavily dependent on springs, as shown in Table 5–15. The projected increase in demand over the next 30 years is about 0.4 mgd. Should this amount of water be unavailable from the existing sources, it is unclear whether or not there is a single surface water source capable of supplying the required increase. The gauging stations shown on Figure F-8 do not show a stream large enough to supply this amount of water without significantly impacting the low flow of the stream. However, the gauging station network does not cover all of the streams.

Table 5–15: Water Withdrawals in Northern Knox and Southern Union Counties, Tennessee (Millions of Gallons per Day)

System	2000 Average-Day Withdrawal	2030 Average-Day Withdrawal	Source
Union County			
Maynardville	0.169	0.265	Davis Spring
Maynardville	0.125	0.196	Lay Spring
Luttrell-Blaine-Corryton Utilities	0.276	0.432	Phipps, Booker, and Big Springs
Knox County			
Luttrell-Blaine-Corryton Utilities	0.225	0.312	Surface
Totals	**0.795**	**1.205**	

Obed and Emory Rivers Above Watts Bar Reservoir

The Obed and Emory Rivers are shown on Figure F-22, The Plateau Utility District serves the area around Wartburg. As Table 5–16 shows, it is projected that Crooked Fork Creek, with a 3Q20 of 0 mgd, might be unable to supply future water needs in the area. Surface water development is a problem for the area because the small streams are characterized by very low flow during dry periods. The Emory River, approximately 4 miles southwest of the present Plateau Utility District intake has some flow during dry periods, as shown by the 7Q10 and 3Q20 flows in Table 5–16. However, a complete switch to the Emory would take a very large portion of the flow in the river during minimum flow conditions.

Table 5–17 shows the major water supply providers in Cumberland County and their projected 2030 withdrawals (annual average in third column and peak-day in fourth column). The safe yield is from a water supply needs assessment conducted by Breedlove, Dennis, and Young (2002). The safe yield was computed based on a water balance for the reservoirs and calibrated for 1968, which was the driest period of record. Although the peak-day demands exceed the safe yield, the average daily withdrawal during the peak month is considered to be a more appropriate number for comparison to the safe yield for reservoirs. Table 5–17 suggests that Otter Creek Impoundment might not be adequate, but there may be enough water in all three reservoirs to meet the county's needs. It should be noted that the Breedlove, Dennis, and Young study also states that the safe yield numbers shown in Table 5–17 assume that the reservoir would be drawn down significantly to provide the required water. Other safe yield estimates limit the amount of reservoir drawdown from 5.4 mgd to 7.8 mgd. Breedlove, Dennis, and Young state that demand could be higher than projected as shown in Table 5–17. This increase in demand largely comes from an extrapolation of prior population growth, an assumption that per capita consumption will grow 88 percent over the next 30 years, and that leakage will increase. The TVA estimates account for population growth, but do not project an increase in per capita use or an increase in system leakage.

Table 5–16: Water Withdrawal in Morgan County, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	2030 Peak-Day Withdrawal	7Q10	3Q20	Ratio of Peak-Day Withdrawal to 7Q10	Ratio of Peak-Day Withdrawal to 3Q20	Source
Plateau Utility District	0.878	0.995	1.49		0 near Wartburg			Crooked Fork Creek
Plateau Utility District potential source			1.49 from above	2.6 2 miles below Crooked Fork Creek Confluence	2.4 2 miles below Crooked Fork Creek Confluence	0.57	0.62	Emory River

Table 5–17: Water Withdrawal in Cumberland County, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Average-Day Withdrawal	2030 Peak-Day Withdrawal	2030 Average-Day Withdrawal During Peak Month	Safe Yield	Source
Crab Orchard Utility District	1.41	2.376	3.56	2.8	2.1	Otter Creek Impoundment
Crossville	1.84	3.1	4.65	3.6	4.4	Holiday Hills Lake
Crossville	1.09	1.837	2.75	2.1	3.0	Meadow Park Lake
Total				**8.5**	**9.5**	

Sequatchie River

The Sequatchie Valley and part of Grundy County, Tennessee, are shown on Figure F–23 in Appendix F.

Withdrawals

Communities located along the Sequatchie River in Marion, Sequatchie, and Bledsoe Counties are shown in Table 5–18. Table 5–18 also shows the 2000 average annual withdrawals for groundwater and surface water, the projected 2030 demands, and the 2000 and 2030 return flows from the wastewater treatment plants to the Sequatchie River.

Withdrawals Compared to Low River Flows

Table 5–19 compares the cumulative net withdrawal from the Sequatchie River to low-flow statistics at various locations along the river. The cumulative net withdrawal is the accumulation of withdrawals minus wastewater returns along the river; it is essentially the consumptive use from the river. The low-flow data for Melville,

Table 5–18: Water Withdrawals and Returns Along the Sequatchie River (Millions of Gallons per Day)

Location	2000 Groundwater Withdrawal	2000 Surface Water Withdrawal	2030 Groundwater Withdrawal	2030 Surface Water Withdrawal	2000 Wastewater Return	2030 Wastewater Return	Source
Pikeville	0.39		0.49		0.18	0.26	Wells
Dunlap		0.65		0.89	0.47	0.65	Sequatchie River
Whitwell		0.59		0.79			Sequatchie River
Jasper	0.63	0.96	0.85	1.29	0.24	0.33	Blue Springs and Sequatchie River
South Pittsburg		1.09		1.46	0.56	0.75	Tennessee River

Pikeville, College Station, and Dunlap are from the USGS (1996). Data for Dunlap is from Arcadis (2001) and the low-flow statistics for Jasper are based on extrapolation of the data from both the USGS and Arcadis. Table 5–19 indicates that peak-day demand will possibly reduce the 7Q10 and 3Q20 low flows by 10 to 26 percent from Dunlap to possibly Jasper. In a study of the water demand and supply situation in the Sequatchie Valley, Arcadis (2001) stated that the 2000 severe drought brought failure of three of Pikeville's four wells. Five new wells were drilled, but only one has proven to be satisfactory. In August 2002, Pikeville's water supply was rated at 45 out of 100 by the Tennessee Department of Environment and Conservation (TDEC). A score of 70 is needed to be satisfactory. The problem was related to turbidity in the well water caused by extreme drawdown and rain. (Flessner, 2002). A short-term remedy of connecting the system to Dunlap has been implemented. If Pikeville were to switch from groundwater to surface water taken from the Sequatchie River, the 16 to 21 percent reduction in low flow (7Q10 and 3Q20 flows) would extend all the way to Dunlap. Arcadis states that if Grundy County were to look to the Sequatchie River for their water, the withdrawals would be an even larger percentage of the minimum flows on the Sequatchie. The city of Dayton plans to supply water to North Bledso County through an interconnection with North Bledsoe. Pikeville could receive water from Dayton (McCombs, 2003).

Table 5-19: Water Withdrawals Compared to Sequatchie River Low-Flow Statistics (Millions of Gallons per Day)

Location	2030 Peak-Day Withdrawal	2030 Peak-Day Wastewater Return	7Q10	3Q20	Cumulative Net Withdrawal	Ratio Cumulative Net Withdrawal to 7Q10	Ratio Cumulative Net Withdrawal to 3Q20
Melville			1.3	1.1			
Pikeville	0.74	0.26	4.5	3.6	0.74	0.16	0.21
College Station			8.4	7.0			
Dunlap	1.34	0.98	10.7	8.9	1.81	0.17	0.20
Whitwell	1.18		21	17.8	2.01	0.10	0.11
Jasper	3.21	0.49	>23	>20	5.22	0.23	0.26

In the analysis of the Sequatchie Valley water supply, Arcadis raised the issue of TDEC expressing a concern that water withdrawals along the river might endanger the designated uses as indicated by the high ratios of withdrawals to minimum flows. TDEC was reported to indicate that more stringent limitations on water withdrawal and wastewater discharges might become necessary.

Table 5–20 shows the major public supply sources in Grundy County. Arcadis reported that the Big Creek Utility District has already increased the height of the Ranger Creek Impoundment to provide additional storage, and they might be prevented from raising it again.

Table 5–20: Public Water Supplies in Grundy County (Millions of Gallons per Day)

Location	2000 Surface-Water Withdrawal	2030 Surface-Water Withdrawal	2030 Peak-Water Withdrawal	Source
Big Creek Utility District	0.89	1.15	1.73	Ranger Creek Impoundment
Monteagle	0.35	0.46	0.69	Laurel Lake
Tracy City	0.39	0.51	0.77	Big Fiery Gizard Creek Impoundment

Monteagle is supplied by water from Laurel Lake. Arcadis reported that Monteagle is concerned that the lake will not be sufficient to meet the expected growth in demand, but Monteagle has connected to other systems. Tracy City is supplied with water from an impoundment on Big Fiery Gizard Creek. Tracy City has experienced water supply shortages (Arcadis, 2001) and is investigating a groundwater source.

Sequatchie River Summary

A number of communities in the counties of Marion, Sequatchie, Bledsoe, and Grundy are reported to experience water supply shortages. Pikeville in particular has had difficulty developing a satisfactory source of groundwater and is expected to increasingly rely upon surface water. The additional demand from the Sequatchie River and other communities along the river could create difficulty in maintaining the designated uses of the river during times of low river flow. Other communities in Grundy County are also reportedly experiencing water supply shortages, and additional impoundments may be required to supply their future needs.

As an alternative to cities developing their own new water supplies, or for further tapping of the Sequatchie River, Arcadis has proposed a regional water system. The withdrawal point would be the Tennessee River. Should a regional system be adopted as a solution, the overall effect on the Tennessee River should be very insignificant. All of the existing systems, with the exception of Pikeville, are presently on surface water systems in the Tennessee River watershed area. Therefore, only the Pikeville demand would increase the level of withdrawal from the Tennessee River.

Giles, Lawrence, Wayne, and Lewis Counties, Tennessee

Figure F–28 shows Lincoln, Giles, Lawrence ,and portions of Wayne and Lewis Counties. Figure F–16 shows the remainder of Wayne County and Figure F–25 shows the southern portion of Dickson County which lies within the Tennessee River watershed. Table 5–21 shows the major water users in Giles, Lawrence, Wayne, and Lewis Counties. The major water users in Lincoln County, which is also shown on Figure F–28 were discussed in Chapter 4 as part of the Tims Ford tailwater analysis.

Table 5–21 shows that under low-flow conditions, Pulaski already extracts 45 percent of the 7Q10 flow and 54 percent of the 3Q20 flow from Richland Creek. The projected 2030 peak demand will result in the withdrawal of about 11 percent more of the 7Q10 flow and about 14 percent more of the 3Q20 flow.

Summertown is presently served by groundwater. If a surface water source was needed to meet future supply, Saw Creek might be a possible source. The 2030 withdrawal would take about 14 percent of the 7Q10 and about 16 percent of the 3Q20 flow.

Lawrenceburg is presently served by a combination of groundwater and surface water. The current peak surface water withdrawal is estimated to be about 25 percent of the 7Q10 flow and about 28 percent of the 3Q20 flow. If it is assumed that all the growth in water demand over the next 30 years will be supplied by surface water, the projected 2030 peak-day withdrawal would be about 48 percent of the 7Q10 flow and about 53 percent of 3Q20 flow. If surface water supplies all the 2030 demand, 65 percent of the 7Q10 and 71 percent of the 3Q20 flow from Shoal Creek would be required to meet the peak-day demand.

Leoma is supplied entirely by groundwater. Demand is expected to increase by about 34 percent over the next 30 years. Low-flow data do not exist in the area of Leoma to assess the availability of a surface water supply.

Loretto is presently served by groundwater. Table 5–21 indicates that Shoal Creek could supply the 2030 demand with only a 3 to 4 percent of the 7Q10 or 3Q20 flow required. St. Joseph and Iron City are both supplied by groundwater. Because both are close to Shoal Creek, the 2030 demand for both communities was combined and compared to the low-flow statistics for Shoal Creek. Table 5–21 shows that the demand for both communities could be supplied by only about 1 percent of the low flow from Shoal Creek.

Presently, Waynesboro needs about 32 percent of the 7Q10 and 39 percent of the 3Q20 of the Green River flow to meet the peak-day demand. By 2030, it is projected that these percentages will increase to 40 and 48 percent respectively. Geissler Spring might be an additional source.

Collinwood is currently served by groundwater with demand projected to increase by about 24 percent over the next 30 years. It appears that development of an alternative surface water supply would be difficult because Collinwood is located on top of a basin divide.

Both Hohenwald and the Farm Water System are supplied by groundwater. Low-flow, surface water data are not available in order to assess the potential for a surface water supply. The Buffalo River might be the nearest reliable surface water source.

Table 5–21: Water Withdrawals in Giles, Lawrence, Wayne, and Lewis Counties, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of Peak-Day Withdrawal to 7Q10	Ratio of Peak-Day Withdrawal to 3Q20	Source
Giles County								
Pulaski Water System	3.09	3.85	4.63 (00) 5.78 (30)	10.3	8.5	0.45 (00) 0.56 (30)	0.54 (00) 0.68 (30)	Richland Creek
Lawrence County								
Summertown	0.18	0.24	0.27 (00) 0.36(30)					Wells
Summertown possible surface source			0.36 (30)	2.5	2.19	0.14 (30)	0.16 (30)	Saw Creek near Barnesville
Lawrenceburg	1.27	1.27						Hope Spring
Lawrenceburg	1.9		2.85 (00)	11.3	10.3	0.25 (00)	0.28 (00)	Shoal Creek
Surface water supplies growth		3.62	5.43 (30)			0.48 (30) 0.65 (30)	0.53 (30) 0.71 (30)	
Surface water supplies all demand		4.89	7.35 (30)					
Leoma Utility	0.187	0.251	0.38 (30)					Big Oak Well
Loretto	0.446	0.599	0.89 (30)					Still House Spring
Loretto possible SW source			0.89 from above	25.8	22	0.03	0.04	Shoal Creek
St Joseph System	0.258	0.346	0.52 (30)					Spring
Iron City	0.043	0.058	0.087 (30)					City Srping
St Joseph + Iron City possible surface source			0.61 (30)	51.1	42.7	0.01	0.01	Shoal Creek
Wayne County								
Waynesboro Water System	0.422	0.521	0.63 (00) 0.78 (30)	1.94	1.61	0.32 (00) 0.40 (30)	0.39 (00) 0.48 (30)	Green River
Collinwood Water Dept	0.2	0.247	0.37 (30)					Wells
Lewis County								
Hohenwald Water System	1.48	1.89	2.84					Wells
Farm Water System	0.03	0.039	0.059					Wells

McNairy County, Tennessee

Figure F–16 in Appendix F shows the portion of McNairy County which lies within the Tennessee River watershed. Table 5–22 shows current and projected withdrawals for the Michie and Adamsville water systems. Both systems utilize groundwater, and demand is projected to increase by about 26 percent for both communities. Both communities are close to the watershed divide so the drainage area for streams near the communities are small. As such, low-flow statistics suggest that a nearby surface water source might not exist for either community. However, the Tennessee River is within 10 miles of both communities.

Table 5–22: Water Withdrawals in McNairy County, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	Source
Michie Water Dept	0.253	0.318	0.477	Wells
Adamsville Water System	0.721	0.906	1.36	Wells

Henderson, Decatur, Carroll, Henry, and Houston Counties Tennessee

Figure F–26 shows the counties of interest, and withdrawals and stream flows are compared in Table 5–23.

Both Sardis and Scotts Hill use groundwater. Demand or the next 30 years is expected to increase by about 44 percent. No low-flow statistics exist for nearby streams in order to assess the possibility of developing a nearby surface water source. However, both communities appear to be near the headwater areas of streams, and substantial low stream flows might not exist.

The Lexington Water System draws water from Beech Reservoir. The 7Q10 and 3Q20 on the Beech River are on the order of the 2030 peak-day demand. However, the reservoir provides 1560 acre-feet of water supply storage which would be about 70 days of withdrawal at the 2030 peak-day demand with zero inflow into the reservoir.

Decaturville presently is supplied by groundwater, but is within a few miles of the Beech River embayment on Kentucky Reservoir should a surface water source be needed in the future. Parsons is located north of the embayment and is supplied by water from the Beech River. Parsons is proposing to build a new water intake on the Tennessee River which might also serve Decaturville if it were built.

Clarksburg, Bruceton, and Hollow Rock are served by groundwater, but the Big Sandy River is located nearby should it become necessary to develop a surface water supply for any of these communities.

Paris, located on the western edge of the Tennessee River watershed, is supplied by groundwater. Demand is expected to increase by about 28 percent over the next 30 years. Because of its location on the edge of the watershed, it rests in the headwaters of area streams. Therefore local stream flow is quite low. Should a surface water supply become necessary, the nearest source would be the Tennessee River, a little over 10 miles to the east. Tennessee Ridge in Houston County is located on the eastern edge of the Tennessee River watershed. Like Paris on the western side, Tennessee Ridge is served by groundwater with little potential for development of a nearby surface source. Tennessee Ridge has experienced problems with their wells in the past. Although they have a connection with Erwin, Erwin does not have the capacity to adequately supply Tennessee Ridge. Therefore, Tennessee Ridge will likely propose an intake on the Tennessee River.

Table 5–23: Water Withdrawals in Henderson, Decatur, Carroll and Henry Counties, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of Peak-Day Withdrawal to 7Q10	Ratio of Peak-Day Withdrawal to 3Q20	Source
Henderson County								
Sardis Water System	0.072	0.104	0.156 (30)					Wells
Scotts Hill Water	0.293	0.422	0.633 (30)					Wells
Lexington Water	3.54	5.094	5.31 (00) 7.64 (30)	4.5	4.3			Beech Reservoir
Decatur County								
Decaturville Water	0.195	0.226	0.34 (30)					Wells
Parsons Water	0.914	1.061	1.59 (30)					Beech River
Carroll County								
Clarksburg Utility	0.12	0.148	0.22 (30)					Wells
Clarksburg possible water source			0.22 (30) from above	12.3	11.1	0.02	0.02	Big Sandy River
Bruceton Water	0.206	0.255	0.38 (30)					Wells
Hollow Rock Water	0.231	0.286	0.43 (30)					
Bruceton+Hollow Rock possible water source			0.81 (0.38 + 0.43) from above	23.3	21.1	0.03	0.04	Big Sandy River
Henry County								
Paris Board Utility	2.57	3.3	4.95 (30)					Wells
Houston County								
Tennessee Ridge Water	0.162	0.228	0.34 (30)					Wells

(00) denotes year 2000 and (30) denotes year 2030

Hickman and Dickson Counties, Tennessee

Hickman County is shown on Figure F–25 in Appendix F. A major potential water supply source for the county is the Duck River, which roughly divides the county in half. The water supply situation for counties up river from Hickman along the Duck River, is discussed in Chapter 3.

Table 5–24 shows demand and supply comparisons for the Bon Aqua-Lyles and Centerville water systems neither of which is located on the Duck River. Table 5–24 shows that the projected increase in demand by 2030 will use only about 1 percent more of the low flow from the existing sources. The southern end of Dickson County is also shown in Figure F–25. The Dickson County Water Department projected total 2030

Table 5–24: Water Withdrawals in Hickman and Dickson Counties, Tennessee (Millions of Gallons per Day)

System	2000 Withdrawal	2030 Withdrawal	Peak-Day Withdrawal	7Q10	3Q20	Ratio of Peak-Day Withdrawal to 7Q10	Ratio of Peak-Day Withdrawal to 3Q20	Source
Hickman County								
Bon Aqua-Lyles Utilities	0.763	0.999	1.14 (00) 1.5 (30)	23.27	20.7	0.05 (00) 0.06 (30)	0.06 (00) 0.07 (30)	Piney River
Centerville Water System	1.24	1.624	1.86 (00) 2.43 (30)	35.5	31.7	0.05 (00 0.07 (00)	0.06 (00 0.08 (30)	Big Swan Creek
Dickson County								
Dickson Water	1.06			3.8	3.3			W. Piney River
Dickson Water	0.47							City Lake
Dickson Total	1.53	2.4	2.3 (00) 3.6 (30)					

(00) denotes year 2000 and (30) denotes year 2030

peak-day demand (3.6 mgd) is on the order of the low flow from the West Piney River, indicating limited surface water development in southern Dickson County. Because of growth in water demand in Dickson County and problems with development of additional groundwater or surface water supplies, the Dickson County Water Authority was formed and plans were made to extract water from the Cumberland River to meet future demands. Dickson County recently began construction of an intake on the Cumberland River and a water treatment plant.

Kentucky

In Appendix F, Figure F–27 shows the Tennessee River watershed area in Kentucky, where several small water systems utilize groundwater. Should groundwater supplies become inadequate to meet future demands, the Tennessee River might be considered as a possible source.

Summary and Conclusions

The 7Q10 and 3Q20 low-flow statistics were used in combination with current and projected 2030 water demands to evaluate the potential for surface water to meet projected 2030 water-use needs in unregulated areas above reservoirs. The analysis focused on determining whether or not the increase in water demand would result in a significant decrease in water in the stream under 7Q10 or 3Q20 flow conditions.

The investigation resulted in the following general findings. For many areas, the increase in water withdrawal from streams, required to meet projected 2030 demands, is only a few percent of the 7Q10 or 3Q20 low flow. However, in some cases, water withdrawals already take a significant portion of the low flow from streams. As the result of groundwater supplies being inadequate to meet future needs, or because of water quality problems with groundwater, some groundwater systems might eventually have to rely more heavily on surface water or switch to surface water entirely. Where possible, the investigation tried to identify where adequate surface water supplies might exist if communities presently supplied by groundwater were to consider switching. It was found that several areas in the watershed are expected to grow so significantly that they could likely exhaust their current supplies and have to develop new supplies. Some areas in the watershed are already experiencing shortages and are looking for new sources of water. For some communities, new sources of water are hard to find. Table 5–25 summarizes the investigation.

Table 5–25: Summary of Existing and Potential Water Supply Shortages on Unregulated Streams

System	Issue	Comments	Reference Table
Upper Wise Smyth, and Tazewell Counties, VA	Little opportunity to develop surface supplies if needed	Much of Clinch River is sensitive habitat	5–1
Lebanon, VA	Takes significant portion of stream low flow, T&E species*	Future growth may need additional 10% of stream low flow	5–2
Duffield, VA	Takes significant portion of stream low flow, T&E species	Growth not expected to significantly increase impact on stream	5–2
Washington County, VA	New treatment plant taking water from two rivers	Ability to withdraw from Middle & South Forks could lessen impact on Middle Fork where withdrawal is expected	5–3
Gate City and Big Moccasin Creek, VA	Combined withdrawal appears to be significant amount of low flow in Big Moccasin Creek	Growth not expected to increase the impact	5–3
Upper Johnson and Carter Counties, TN	Surface water sources appear limited for major switch to surface water	Might not be an issue unless springs and groundwater supplies become inadequate	5–4
Newland, NC	Expect to exceed existing groundwater supply	If groundwater supply cannot be expanded, surface water might be available on the North Toe River	5–5
Miller Ridge and Seven Devils, NC	Expect to exceed existing groundwater supply	If groundwater supply cannot be expanded, surface water might be available on the Elk River	5–5
Woodfin, Biltmore Forest, Black Mountain, Junaluska, Laurel Park, Mars Hill	Demand expected to exceed existing supplies	Likely connect to other water system	5–8
Gatlinburg and Sevierville, TN	Demand expected to exceed supply	Local stream not likely to have sufficient water; Douglas Reservoir or French Broad River a possible sources	5–10
Alcoa and Maryville, TN	Appear to take significant amount of low flow from Little River	Growth in demand will require more low flow; Alcoa consider intake on Fort Loudoun Reservoir	5–12
Sweetwater, TN	Demand consumes significant amount of low flow	Growth in demand will take even more flow.	5–12
Athens, TN	Groundwater supplies are tight during dry periods	Not enough surface water to supply demand, and quality is poor. Interconnected to Hiwassee River intakes	5–13
Andrews and Marble, NC	Supplies already limited	Might look to Murphy if local groundwater is not available	5–14
Morgan County	Surface water sources dry during droughts	Emory River might be available as possible source	5–16
Cumberland County and Crossville, TN	Existing impoundments could be only marginally adequate to meet demand		5–17
Sequatchie River Valley, TN	Pikeville has severe problems with wells	Withdrawal from Sequatchie River could be limited for Pikeville and other communities due to insufficient flow to assimilate wastewater	5–18
Monteagle and Tracy City, TN	Experienced water supply shortages in the past	Monteagle now interconnected to other system and Tracy City exploring groundwater source	5–20
Central Giles, Wayne, and Lawrence Counties	Surface water extractions already a large portion of low stream flows	Growth in demand would require even larger portion of low stream flows	5–21
Southern Henderson County, TN	Local surface supply could be limited if groundwater not adequate	Tennessee or Beech Rivers possible sources	5–23
Tennessee Ridge, TN	Groundwater supply inadequate	Tennessee River is a possible source	5–23

*** Threatened and Endangered Species**

6
Water Quality Implications to Water Supply

Introduction

Overview

Alternatives evaluated as part of the ROS could result in some changes to reservoir water quality. A brief description of some of the processes and mechanisms at work in reservoirs, which affect water quality, is presented in this chapter. Changes in reservoir operation are described and how these changes might alter water quality is also discussed.

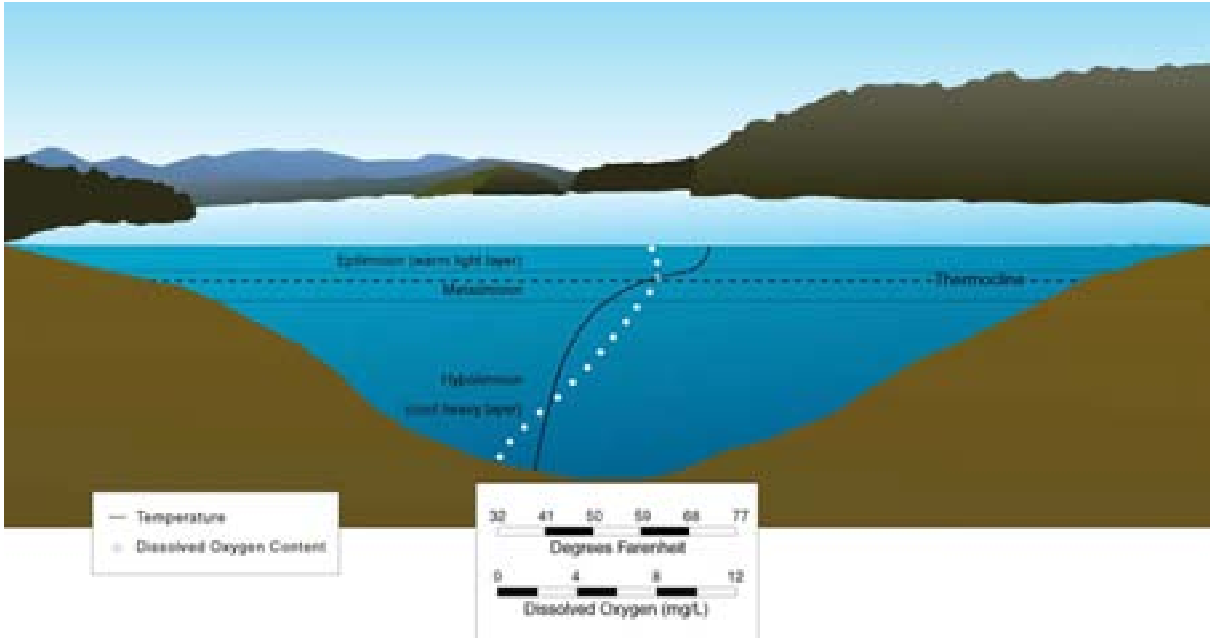
In order to determine whether the possible changes in water quality would affect public water supply systems and industries, key industries and public water treatment plants were contacted and their water treatment processes were discussed. Key water quality parameters that could potentially be affected by reservoir operational changes were identified. An additional review was made of the drinking water regulations to help identify key water quality parameters important to public treatment plants.

Thermal Stratification

One of the factors which affects water quality in reservoirs is thermal stratification. Reservoirs become thermally stratified in the summer when solar energy warms the surface water leaving the bottom portions of the reservoir cooler. The warmer surface layer (epilimnion) floats on the cooler and denser bottom layer (hypolimnion) isolating the hypolimnion from natural aeration processes. Biochemical processes consume oxygen throughout the water column, but only in the epilimnion can the oxygen be replenished. As the result of many factors, but primarily as the result of thermal stratification, many of TVA's reservoirs have low oxygen concentration near the reservoir bottom during summer and fall. Figure 6–1 illustrates how dissolved oxygen and water temperature drops near the bottom of the reservoir.

Reservoir sediments act as both sources and sinks for chemical species in reservoirs. Particulate matter wash into reservoirs or forms through chemical and biochemical reactions, then settles to the bottom of the reservoir where decomposition and chemical change takes place. Species important to the biochemical nature of a reservoir are iron, manganese, phosphorous, nitrogen, and carbon. It is generally the case that anoxic conditions favor the release of these species from bottom sediments. These species are essential nutrients for the biota in the reservoir, and their cycling from the reservoir bottom contributes to algae growth and changes in the chemistry of the water.

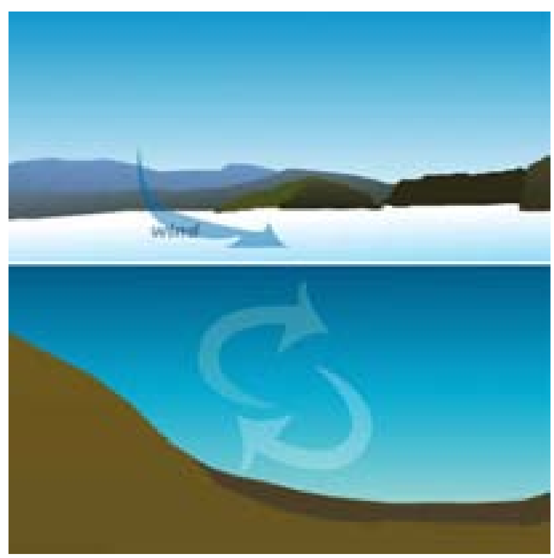
Figure 6–1: Dissolved Oxygen and Temperature Profile in a Thermally Stratified Reservoir



While a reservoir is stratified, there is little or no mixing of the epilimnion and hypolimnion which might have elevated concentrations of the above species due to anoxia at the reservoir bottom. During late fall, the reservoir surface cools and the density difference between the epilimnion and hypolimnion progressively diminishes until there is no longer any thermal stratification, and the water near the bottom is mixed into the upper layer of the reservoir. Wind speeds the mixing of the reservoir. The mixing of the bottom and top layers of the reservoir is called "turnover." Fall turnover is illustrated in Figure 6–2.

Reservoir Operation and its Effect on Thermal Stratification

Figure 6–2: Fall Turnover in a Typical Reservoir



Reservoir operation can effect thermal stratification. Summertime withdrawals from TVA reservoirs are pulled from the bottom of the reservoir and releases from dams will act to reduce the amount of cool water in the reservoir bottom and thereby reduces the size of the hypolimnion. Releasing less water in the summer would tend to make the hypolimnion more stable and keep the cooler water longer near the bottom in the reservoir. This could result in more water near the reservoir bottom being low in oxygen and possibly increase the release of the iron, manganese, phosphorous, and other species from the sediments.

Alternately, releasing more water in the summer might lessen the extent of anoxia in the reservoir. Releasing more water will also pull anoxic water from the more upstream part of the reservoir, where the reservoir is shallower. This action could cause the anoxic and nutrient-laden water, from the upper end of the reservoir, to be mixed into the upper layers of water in the more downstream part of the reservoir, where the nutrients might contribute to algal growth. Releasing more cool water, sooner, would also have the effect of causing the reservoir to turnover sooner.

Some of the reservoir operational changes being evaluated by the ROS involve releasing water from the reservoir at rates generally different than the release patterns presently in TVA's operational policy. These changes in release pattern will be mathematically modeled using TVA's reservoir water quality models, and the differences in water quality resulting from the change in release patterns will be compared.

Surface Water Withdrawals

Table 6–1 summarizes surface water withdrawals on the Tennessee River by Standard Industrial Classification (SIC) code. This report focuses on public supply systems (SIC code 4941) and 8 SIC industry codes which use 82 percent of the industrial water withdrawn from the Tennessee River. The industries are pulp mills (2611), paper mills (2621), paperboard mills (2631), inorganic pigments (2816), industrial inorganic chemicals (2819), plastics materials and resins (2821), organic fibers (2824), industrial organic chemicals (2869), and explosives (2892). The requirements for these 9 industrial groups were used as surrogates for industries in general. Typical treatment processes used to achieve the desired water quality, and the effect of changes in raw water quality on the treatment processes, are analyzed.

Thermoelectric (SIC 4911, Electric Services) water use is not included in Table 6–1, but is discussed under "Industrial Water Treatment" in this chapter.

Public Supply Systems

Regulations

Water quality requirements for public supply systems are driven by water quality regulations. The current Environmental Protection Agency (EPA) drinking water regulations, which are mirrored in the regulations for the Valley states, were reviewed (U. S. Environmental Protection Agency, 2002). Current regulations for public water supply cover four types of contaminants: inorganics, organics, microbial contaminants, and secondary contaminants which are not health related.

A review of the regulations suggests that changes in reservoir operations might affect the following parameters: turbidity, iron and manganese, and disinfection by-products (DBP), as the result of changes in Natural Organic Matter (NOM).

Interviews were conducted with six major public supply treatment plants. These plants treat about 152 mgd of water, which constitutes 29 percent of the public water supply in the Tennessee River. The locations ranged from Morristown, Tennessee, on Cherokee Reservoir, to Huntsville, Alabama, on Wheeler Reservoir. Plant sizes varied from 1.1 mgd to 44 mgd. The interviews were used to define the public supply treatment systems used to achieve the parameter limits specified in the regulations.

Table 6–1: Water Withdrawals by Standard Industrial Classification (SIC) North Carolina (Millions of Gallons per Day)

SIC	Title	Count	2000 Average-Annual Withdrawal	2030 Average-Annual Withdrawal
22	Textile Mill Products	4	2.470	3.182
286	Industrial Organic Chemicals	1	1.090	1.511
0921	Fish Hatcheries and Preserves	1	2.130	1.802
1031	Lead and Zinc Ores	2	10.004	12.812
1211		32	5.959	7.050
1222	Bituminous Coal-underground Mining	5	0.005	0.006
1422	Crushed and Broken Limestone	9	2.619	3.286
1423	Crushed and Broken Granite	16	0.461	0.650
1442	Construction Sand and Gravel	1	0.216	0.295
1446	Industrial Sand	4	22.100	29.020
1459	Clay and Related Minerals	2	3.835	7.407
2011	Meat Packing Plants	1	0.013	0.017
2015	Poultry Slaughtering and Processing	1	1.150	1.561
2033	Canned Fruits and Specialties	3	2.050	2.813
2077	Animal and Marine Fats and Oils	1	0.040	0.055
2085	Distilled and Blended Liquors	2	1.225	1.674
2221	Broadwoven Fabric Mills, Manmade	1	0.284	0.369
2257	Weft Knit Fabric Mills	1	0.450	0.585
2269	Finishing Plants, NEC	1	0.072	0.087
2273	Carpets and Rugs	1	0.180	0.255
2611	Pulp Mills	3	75.600	99.629
2621	Paper Mills	4	63.760	87.107
2631	Paperboard Mills	3	33.530	47.667
2812	Alkalies and Chlorine	2	6.480	9.086
2813	Industrial Gases	1	3.130	4.339
2816	Inorganic Pigments	2	67.000	76.581
2819	Industrial Inorganic Chemicals, NEC	6	33.870	37.027
2821	Plastics, Materials, and Resins	1	7.790	9.461
2824	Organic Fibers, Noncellulosic	2	142.600	194.940
2833	Medicinals and Botanicals	2	0.086	0.104
2843	Surface Active Agents	1	0.768	0.801
2869	Industrial Organic Chemicals, NEC	8	469.604	573.398
2892	Explosives	2	37.000	44.881
2899	Chemical Preparations, NEC	2	4.103	5.609
2951	Asphalt Paving Mixtures and Blocks	4	0.082	0.088
3052	Rubber and Plastics Hose and Beltings	1	0.085	0.092
3069	Fabricated Rubber Products, NEC	1	0.324	0.475
3079		2	0.124	0.201
3082	Unsupported Plastics Profile Shapes	1	0.014	0.018
3089	Plastics Products, NEC	2	1.454	1.725
3111	Leather Tanning and Finishing	1	0.030	0.040
3211	Flat Glass	1	0.300	0.506
3229	Pressed and Blown Glass, NEC	1	0.000	0.000
3241	Cement, Hydraulic	3	1.924	2.338
3275	Gypsum Products	13	0.000	0.000
3312	Blast Furnaces and Steel Mills	1	0.042	0.058
3313	Electrometallurgical Products	1	0.289	0.401
3341	Secondary Nonferrous Metals	3	3.431	4.256
3429	Hardware, NEC	1	0.003	0.005
3462	Iron and Steel Forgings	1	0.005	0.008
3531	Construction Machinery	1	0.000	0.000
3562	Ball and Roller Bearings	1	0.514	0.670
3621	Motors and Generators	2	0.019	0.025
3714	Motor Vehicle Parts and Accessories	1	0.196	0.255
3728	Aircraft Parts and Equipment, NEC	1	0.010	0.013
3861	Photographic Equipment and Supplies	2	1.030	1.256
4449	Water Transportation of Freight, NEC	2	19.850	25.216
4911	Electric Services	2	173.500	173.500
4941	Water Supply	432	548.803	715.119
7997	Membership Sports and Recreation Clubs	5	0.285	0.281
7999	Amusement and Recreation, NEC	1	0.007	0.007
8211	Elementary and Secondary Schools	1	0.000	0.000
8641	Civic and Social Associations	1	0.450	0.655
9223	Correctional Institutions	2	0.011	0.015
9512	Land, Mineral, Wildlife Conservation	1	0.001	0.001

Treatment Processes

Based on interviews with public supply treatment facilities, typical treatment processes for public supplies utilizing water from the Tennessee River watershed include the following unit operations:

- Chemical coagulant addition and mixing
- Flocculation
- Sedimentation
- Pre-filtration disinfection
- Filtration
- Post-filtration disinfection

The thrust of the treatment process was to remove suspended solids. Since turbidity is more easily measured than suspended solids, it is often used as a surrogate measure for process control. Since suspended solids include contaminants such as soil, algae, bacteria, and other species and chemicals which are adsorbed into the particulate matter, suspended solids removal is the key part of any treatment process. Disinfection is an important operation in killing pathogenic organisms.

Chemical coagulant is added to reduce the electrical charges on waterborne particulate matter which keep particles small because they are separated and dispersed. Reducing the electrical charges allows particles to grow in size in the flocculation step to facilitate their removal during sedimentation. In some cases, polymers are added prior to filtration. The polymers bind one particle to another so that the particles are easily removed during sedimentation and filtration. Often a disinfectant, such as chlorine, is added before filtration to reduce biological growth on the filter and to lengthen filtration runs. This step (pre-chlorination) also aids the effectiveness of final disinfection which follows filtration. Chlorine is commonly used for final disinfection as well.

NOM in the water can react with the chlorine used in the treatment process to produce chlorinated organics, collectively called DBPs. Because the concentration of DBPs is regulated in the finished drinking water, excessive NOM concentrations must be removed in the flocculation-sedimentation step and the concentrations of DBPs in finished water must not exceed specified limits. Generally, the surrogate measure of NOM is total organic compound (TOC). TOC is usually the regulated parameter.

All plant operators interviewed stated that their chemical addition was altered in response to varying raw water turbidity, resulting primarily from storms. Most water treatment plants measure turbidity, although some use a streaming current detector for process control. The streaming current detector measures the relative charges in the water after coagulant has been added. Coagulant and chlorine concentrations applied at the head of the treatment plant are varied as raw water turbidity (or streaming current) varies.

Industrial Water Treatment

Introduction

Interviews were conducted with 11 industries, representing 8 SIC codes and representing 80 percent of the industrial water taken from the Tennessee River. In addition, TVA combustion water treatment specialists were interviewed. The TVA personnel described typical processes used to make boiler feedwater for power plants (Payne, 2002). A discussion of boiler feedwater preparation is included because it is used to produce perhaps the highest quality water used in the watershed, and the treatment is most extensive.

General Industrial

Much of the water used in industry is used for noncontact cooling and is not treated. However, for water that is treated, the treatment processes of coagulant addition, flocculation, sedimentation, and filtration, which were discussed in relation to public water-supply systems, are common to industrial boiler feedwater and process water treatment systems as well. In cases where high water quality is required, such as for boiler feed, other processes, such as demineralization as discussed below, are employed. However, the processes which increase the degree of treatment above filtration are expected to be largely unaffected by any change in reservoir operation.

Thermoelectric

Almost all of the water currently used in thermoelectric generation is used for noncontact, once-through cooling and is not treated. However, a small portion of the water is treated to a very high degree for boiler water makeup. The treatment of this water is discussed in regard to a TVA fossil plant. The discussion provides insight into what factors affect water treatment, not only for power generation, but also for industries that use water to generate steam. The plant selected is Johnsonville, because the steam generated at that facility is not only used for power generation, but also for industrial use at the nearby DuPont facility.

The treatment process consists of sodium hypochlorite to control biological growth, followed by injection of polyaluminum chlorohydrate and organic polymer to flocculate the suspended solids (turbidity) in the water. Sedimentation then follows flocculation. A dual medial filter removes the remaining suspended solids and the residual chlorine. The water is then softened using zeolite ion exchange softeners, and then another filtration follows using fine-pore cartridge filters. Reverse osmosis is next in line to reduce the dissolved solids concentration. Next, carbon dioxide is removed. Then, another cartridge filter follows, as well as another reverse osmosis step. Finally, ion exchange is used to produce demineralized water.

Turbidity excursions caused by storms are handled by increasing the coagulant dose as required. Iron and manganese concentrations are not an issue and would be removed in the softening step if they were an issue. NOM might potentially affect the reverse osmosis membranes, but the process stages before the reverse osmosis step effectively removes all the organic carbon from the system.

Treatment Costs Related To Water Quality Changes

Public Supply and Industrial Treatment Plant Response to Changes in Turbidity

Because public supply treatment plants and industrial treatment plants utilize the same unit processes through the filtration step, the costs of treatment through filtration are comparable for both public supply and industries.

Turbidity and Chemical Addition

Treatment plant operators provided information concerning coagulant doses and chlorine addition as functions of turbidity levels. Typical costs for the chemicals used were obtained from chemical suppliers and the cost of chemical addition, as a function of change in turbidity, were computed for five representative treatment plants along the Tennessee River system from Morristown, Tennessee, to Huntsville, Alabama. The cost function is shown in Figure 6–3.

Figure 6–3: Turbidity and Chemical Costs

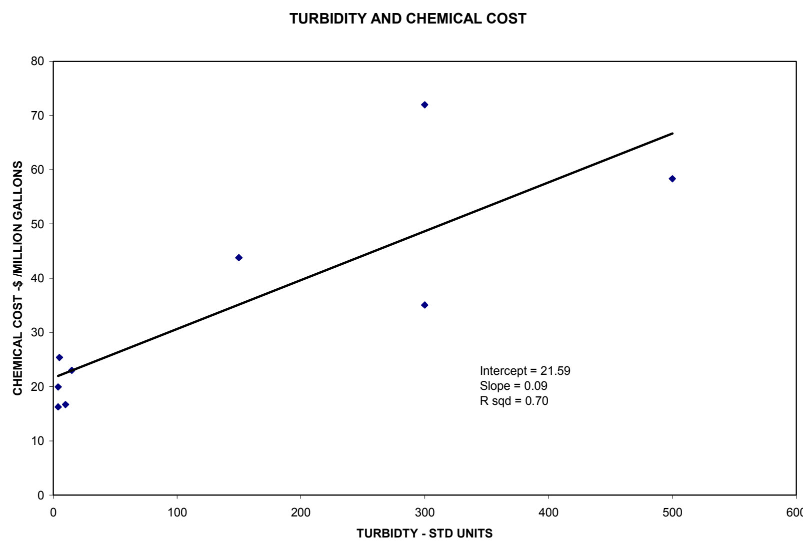


Figure 6–3 also shows that the chemical addition treatment costs related to turbidity removal, or affected by turbidity levels, range from about $16 per million gallons of water treated to about $25 per million gallons at the normal turbidity level of 5 to 10 standard turbidity units. As turbidity levels increase, the cost data become scattered because the chemical addition during storms is not as well documented as it is under normal conditions. Generally, the upper range for chemical dose is about three times that at normal operating conditions, yet the turbidity might vary by a factor of 10 to 200.

Figure 6–4: Nonfilterable Residue and Turbidity

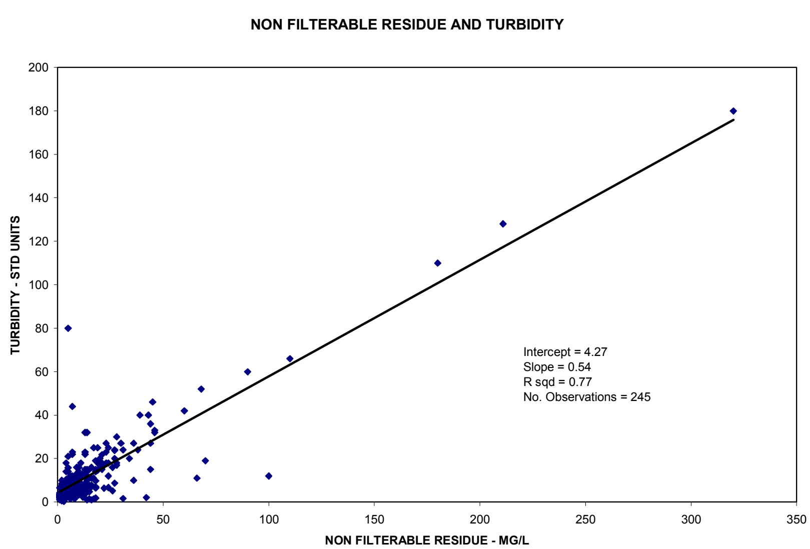


Figure 6–4 graphs nonfilterable residue (suspended solids) and turbidity for stations in Cherokee, Chickamauga, Nickajack, and Wheeler Reservoirs.

Combining the results of Figure 6–3 and Figure 6–4 suggests that a 1 mg/L change in nonfilterable residue will result in a change in treatment costs of $0.0486 per million gallons of water treated.

Sensitivity of Turbidity Change Resulting in Changes in Reservoir Operations

All of the industrial and treatment plant operators contacted, stated that turbidity changes caused by storms require them to change chemical addition. The water quality models used for analyzing the impacts of different reservoir operating alternatives for the ROS do not model storms. Since the influent suspended solids concentrations used in the models are likely to be monthly average values, the model results will be reflective of monthly values.

The alternatives which could result in a change in modeled suspended solids concentrations are those which hold pool levels up longer. It is possible that these changes could result in a slight change in suspended solids levels, perhaps on the order of about 5 to 10 mg/L (3 to 6 turbidity units), which is well below the change brought about by storms. Even for a change of 5 mg/L across the whole system over a three-month period when the higher pool levels might have an effect, the net benefit would only be on the order of $14,000 (assuming about 700 mgd of water is treated). Also, in the range of 5 to 10 mg/L of suspended solids where any change is expected to occur, suspended solids, turbidity, and treatment costs are largely random and not correlated. In other words, the modeled change will be within the noise of the existing treatment plant cost variability.

Additional Considerations for Public Supply Facilities

Natural Organic Matter

NOM is a concern to public supply water treatment plants because chlorine and NOM can react to form chlorinated organic compounds whose concentrations are regulated based on potential effects to public health. The chlorinated organics are collectively called DBPs. As mentioned earlier, an indicator that is used for NOM is TOC. Normal TOC values for six public supply water treatment plants from Morristown, Tennessee, to Huntsville, Alabama, reported a range of TOC values of 2 to 5 mg/L. For comparison, samples collected quarterly from Chickamauga Reservoir from 1978 through 1986 averaged 2.8 mg/L. The Chickamauga data show there was little seasonal variability, little variability with depth, but some variability between years. The minimum value was 1.2 mg/L and the maximum value was 10 mg/L.

TOC in reservoirs originates from runoff into streams, wastewater discharges, and from algae growth in which inorganic carbon is converted to organic carbon. Reservoirs can be either sources or sinks for TOC. Algae produced in the reservoir can remain suspended or settle to the bottom of the reservoir and accumulate in the reservoir sediments. Dissolution, diffusion, excretion, and decomposition of the algae can result in increased TOC concentrations in the reservoir. Reservoir TOC concentrations can be reduced by being adsorbed onto settling particles, by microbial uptake and oxidation to carbon dioxide during respiration, or by degradation by sunlight. In a study of Arizona reservoirs, Nguyen and others (2002), found that reservoirs were either net producers or consumers of TOC based on residence time and hydraulic loading.

The current DBP rule requires treatment plants, serving more than 10,000 people, to remove a specified amount of TOC through coagulation or softening and to meet concentration limits for DBPs (HDR Engineering, Inc, 2001). The concentration limits are 0.08 mg/L for total trihalomethanes and 0.06 mg/L for haloacetic acids. In 2004, small systems will also have to achieve the DBP limits. In 2005 or 2006, implementation of Stage 2 of the DBP rule is expected, which will no longer allow averaging samples in order to meet the DBP limit. The result is that changes will have to be made to water treatment plants in order to meet the limits.

Expected changes include elimination of chlorine feed at the front of the treatment plant and the use of alternative disinfectants such as chlorine dioxide. Coagulation will be enhanced, such as through the use of iron-based coagulants, especially during the summer, to remove the required amount of TOC. Additional processes, such as ozone injection or activated carbon addition, might be required for plants to achieve the DBP concentration limits (Foster, personal communication, 2002).

Because of the expected process changes and plant upgrades required for DBP compliance, even at today's levels of TOC, it is likely that almost all public water treatment plants using water from the Tennessee River watershed will soon have treatment systems for DBP control. Therefore, changing algae concentration through a modification of reservoir operation would likely change only the degree of treatment required and would not cause any plant to add a new DBP treatment system.

So far, only the larger treatment plants have dealt with the DBP issue, and there has been no quantification of the impacts to treatment costs brought about by the Stage 2 rules. In addition, there really have been no studies performed to quantify what factors in the source waters affect the portion of TOC which can give rise to DBP (Volk and others, 2002). Therefore, it is not possible to quantify the changes to treatment cost brought about by changes in algae concentration. It is also considered that much of the difficulty in meeting DBP concentration limits under Stage 2 will arise, not from the raw water TOC concentration, but from the amount of time that the treated water spends in the distribution system (Foster, 2002). Distribution systems are, of course, unaffected by reservoir operational changes.

Taste and Odor

Secretions from algae, particularly blue-green algae, are often the source of taste and odor problems at public water treatment plants. Several of the treatment plants interviewed either combine granular activated carbon in their filtration process or feed powdered activated carbon before the sedimentation step to remove the objectionable compounds. Other treatment plants add oxidants, such as potassium permanganate, to control taste and odor.

There have been no studies conducted by TVA to correlate reservoir operating conditions with the production of blue-green algae. Treatment plant operators interviewed also could not give guidance concerning when and how the blooms occur. There is some anecdotal evidence that stagnant water, during low-flow periods on isolated parts of the reservoirs and rivers feeding the reservoirs, might be the source of blooms. Treatment plant operators who add powdered activated carbon often trigger the start of the feeding season to water temperature. On this basis, reservoir alternatives which result in the threshold feeding temperature (78°F) being exceeded might cause water treatment plants to feed carbon longer each year. The estimated additional treatment cost is $7 per million gallons for adding powdered activated carbon.

Iron and Manganese

Iron and manganese in water supplies can cause taste and odor problems and also add color to water which can stain fixtures and laundry. Iron and manganese, which are trapped in reservoir sediments, can become soluble and enter the water column when the reservoir bottom becomes anoxic. Because the soluble iron and manganese come out of the sediments, the high concentrations are confined to the deep reservoir water. Therefore, many public supply intakes, which are located in reservoirs, draw water from multiple levels so that elevated reservoir iron and manganese concentrations can be avoided. Reservoir releases can contain iron and manganese, but the iron and manganese are oxidized in the stream below the dam and may not affect intakes in tailwaters—if they are sufficiently downstream from dams. None of the treatment plants interviewed specifically treated for iron and manganese. Several plants do add potassium permanganate which would oxidize iron and manganese if present in the water. Treatment plants which treat for iron and manganese, such as those at Upper Bear Creek and Normandy Reservoirs, experience the greatest problem during reservoir turnover when concentrations change rapidly. Reservoir operating alternatives where reservoir anoxic conditions are greater (less DO for greater periods of time), will likely have a greater possibility to experience elevated iron and manganese concentrations.

Bohac (2004b) investigated the likely effects of the new reservoir operating policy implemented by TVA in June 2004 in regard to the water quality issues identified above. He found that the potential for soluble iron and manganese formation was slightly elevated across the system compared to the operating policy in effect up until June 2004.

Summary and Conclusions

Changes in reservoir operation have the potential to alter reservoir water quality. Because of a concern that changes in water quality might affect water treatment costs for public supply and industrial water treatment plants, the potential impacts water quality changes would have on treatment costs were investigated.

Changing water quality may cause water treatment plants to alter their treatment process. Primarily, these changes are in response to storm-generated turbidity changes. Treatment costs, as a function of turbidity, indicate that the likely change in turbidity caused by a change in reservoir operation would result in an insignificant change in treatment costs. Treatment cost for treating taste and odor problems, could not be correlated with any measurable water quality parameter.

DBPs and iron and manganese are a potential problem, but the treatment costs as the result of reservoir operation changes could not be quantified. However, taste and odor and DBPs are related in some degree to algae. Therefore, the evaluation of the reservoir operating alternatives in the ROS identified alternatives which could cause large changes in algae and TOC concentrations as less favorable from a water quality perspective than others with insignificant change. Likewise, alternatives which could deplete reservoir oxygen significantly more than other alternatives would be expected to result in higher iron and manganese concentrations.

Many treatment plants are equipped with multiple-level intakes to avoid elevated reservoir iron and manganese concentrations. Although, TVA's new operating policy slightly raises the potential for soluble iron and manganese formation.

7

Water Supply for Assimilative Capacity Needs

Introduction

In 2000, industrial water discharges were 942 mgd and municipal wastewater discharges were 377 mgd. All of the discharges are permitted by state water pollution control agencies under the National Pollutant Discharge Elimination System (NPDES). Each state regulatory authority issues NPDES permits for each discharge. The permits contain limits on the amount of pollutant that can be discharged into the receiving stream. The permit limits are often determined based on a minimum flow condition in the receiving stream. Therefore, one of the most important instream uses of water in the Tennessee River watershed is for the discharge of wastewater.

Wastewater discharge permits are issued by the states and are based on a required level of pollution control technology for the type of waste or industry (technology based limits). In addition, states have established receiving water quality criteria based on preserving specified “designated uses” of the stream. In cases where the water quality criteria are not met, the stream segment is designated as “water quality limited” (i.e., the quality of water is not good enough to support its designated use). Water quality limited streams are identified in each state’s 303(d) list.

For water quality limited stream segments, state regulations must establish the Total Maximum Daily Load (TMDL) for the pollutant(s) causing the stream to violate the water quality criteria and not meet its designated use. The objective of the TMDL is to reduce the loading on the water quality limited segment so that it will be restored to its designated use. This TMDL is then allocated to all pollution sources in the watershed and subsequently defines the amount of pollutant that can be discharged by each pollution source. Discharges located in the water quality limited segments will then have water quality based (rather than technology based) effluent requirements. Additional treatment requirements are imposed on discharges in an effort to improve water quality and achieve the ambient water quality criteria.

In some cases, new discharges and additional connections to wastewater collection systems may be prohibited along water quality limited segments. In other cases, existing dischargers may be restricted from discharging when ambient water quality criteria are not being met (e.g., pulp mill discharges from International Paper at Courtland, Alabama are restricted when the receiving water DO is below 5 mg/L). Discharge permits may also restrict the amount of flow or pollutant that can be discharged during low-stream flow, low DO, or high temperature conditions. Bowater at Calhoun, Tennessee, and Packaging Corporation of America at Counce, Tennessee, must limit the amount of wastewater discharged if there is low river flow.

Minimum Flows

In general, the process, in which the permitting agency makes a determination concerning how much pollutant can be assimilated by the receiving stream, uses a specific flow in the stream. The specified river flow has commonly depended on the minimum flow released from the upstream dam. For the past 10 years, TVA has maintained minimum flows below its tributary projects and below most of the mainstem dams. As such, state permitting agencies have often used the minimum flows to determine the permit limits for the discharges.

If minimum flow or DO levels are decreased, water quality criteria may be violated, designated stream uses not met, and limits placed on growth and economic development. However, reducing minimum flows was not an ROS alternative. Likewise, the analytical approach presented here assumes that TVA will continue to comply with the previously established DO targets for reservoir releases (Tennessee Valley Authority, 1990).

Once state regulators determine the amount of allowable pollutant which can be discharged, limits are placed either in terms of maximum concentration limits (mg/L) or maximum loading limits (pounds/day) that can be discharged. Most permits do not specify any river conditions, although they might have been considered in preparing the permit. Since TVA did not consider changing either minimum flows or DO levels in its dam releases, most wastewater permits would be unaffected because the underlying assumptions of DO and minimum river flow upon which current permits are based would not change. However, permits, which specify discharge under specific ambient river conditions only, might be affected by alternative reservoir operation.

In some cases, however, the wastewater discharge permits do contain limits which are dependent upon the real-time river conditions. Therefore, a search of major industries, municipalities, and state agencies was conducted to determine if there were such existing permits, who the dischargers were, what the critical ambient water quality conditions were, and what the consequences were if the discharges were restricted.

Industrial and Municipal Survey

Interviews

Many of the same industries and municipalities contacted for the water supply treatment cost survey were contacted regarding their wastewater discharge permits. The industries and municipalities are listed in Table 7–1.

Nine industries, representing 74 percent of the industrial wastewater return flows and the four largest municipal dischargers, were contacted to discuss permit conditions.

In addition to talking to the industries and municipalities listed in Table 7–1, the wastewater permitting agencies in Alabama (Dean, 2002) and Tennessee (Qualls, 2002) were contacted. The permitting agencies were not only asked about permit holders whose discharge might be tied to ambient water quality or flow conditions, but also about significant new regulations expected in the future. Both Alabama and Tennessee regulators thought that nutrient removal might be the next requirement, although any change in permits to reflect this change might be years away.

Table 7–1: Municipalities and Industries Interviewed Concerning Wastewater Discharge Restrictions (Millions of Gallons per Day)

Name	Location	2000 Wastewater Flow	Wastewater Discharge Permit Tied to Ambient Water Quality Conditions
Municipalities			
Huntsville	Huntsville, AL	28.84	No
Decatur	Decatur, AL	16.6	No
Chattanooga	Moccasin Bend WWTP	36.1	No
Knoxville Utility Board	Kuwahee. WWTP Knoxville, TN	29.2	No
Total Municipal		**110.7**	
Industries			
DuPont	New Johnsonville, TN	54.1	No
Packaging Corporation of America	Counce, TN	19.9	Yes—Minimum release of 4524 mgd required from Pickwick Dam to discharge
International Paper	Courtland, AL	55.8	Yes—Discharge not permitted when reservoir DO is below 5 mg/L
Mead	Stevenson, AL	15	Yes—Discharge not permitted when reservoir DO is below 5 mg/L
Intertrade Holdings	Copperhill, TN	23	No
Bowater	Calhoun, TN	64.8	Yes—Limited by 20:1 dilution and BOD restricted when flow is below 646 mgd
Willamette	Kingsport, TN	7.7	No
Eastman Chemical	Kingsport, TN	421	No
Holston Army Ammunition	Kingsport, TN	36.5	No
Total Industry		**697.8**	

Results of Discussions with Dischargers

All the municipal wastewater treatment facilities in Huntsville, Decatur, Chattanooga, and Knoxville had no limits which were directly tied to river conditions. Four of the industries did have permit conditions which depended upon conditions in the river. The four industries are Bowater at Calhoun, Tennessee; International Paper at Courtland, Alabama; Mead Corporation (Smurfit-Stone Container) at Stevenson, Alabama; and Packaging Corporation of America at Counce, Tennessee. The four industrial situations are as follows:

Bowater

Bowater's wastewater discharge to the Hiwassee River must be diluted by at least 20 to 1 by river flow. Bowater also has a biochemical oxygen demand (BOD) permit limit of 29,000 pounds per day for flows above 1000 mgd (1540 cfs) and a lesser limit for flows below 1000 mgd. Presently, Bowater has the capability to discharge at a maximum rate of 50 mgd. In recent conversations with Bowater (O'Grady, 2002) the daily wastewater volume was reported to be about 40 mgd. Table 7–2 indicates that the discharge is about 65 mgd. The Table 7–2 value is the flow reported to Tennessee and EPA as part of Bowater's NPDES permit. However, it might contain some stormwater and the actual process water might be in the range of 40 to 50 mgd.

When river flows are above about 1000 mgd, the amount of river flow will dilute the maximum wastewater discharge by more than 20 to 1. When river flow is between 646 mgd and 1000 mgd, Bowater must control its discharge flow rate to prevent exceeding the 20-to-1 limitation. When river flow is below 646 mgd, Bowater must estimate the BOD concentration in the effluent wastewater and make an estimate of how much wastewater they can release to prevent violating either the 20-to-1 dilution requirement or the reduced BOD requirement. Because of the 5-day lag time on BOD analysis, Bowater is conservative in the estimate of BOD load to the river to prevent violating the permit. Bowater has determined that when the river flow drops below 388 mgd (600 cfs), they are unable to control the wastewater discharge to insure that it will not violate the BOD requirement. Therefore, when river flow is below 388 mgd, wastewater discharge is stopped.

When Bowater cannot discharge all or some of its wastewater, the portion that cannot discharged is diverted to storage lagoons where it is stored until river flow is sufficient to discharge the wastewater. Bowater has enough storage capacity for about 150 to 180 million gallons. In addition to this storage, Bowater also has about 235 acres of storage adjacent to Interstate 75, which they no longer use because of issues related to fogging conditions. Therefore, once the storage lagoons are full, Bowater will cease operating the mill until sufficient flow and wastewater discharge can resume.

Packaging Corporation of America

Packaging Corporation of America (PCA) is restricted from discharging unless the release from Pickwick Dam is at least 4524 mgd (7000 cfs). Presently, PCA's average wastewater generation is about 25 mgd. The current maximum wastewater discharge capacity is 36 mgd. Therefore, PCA requires at least a release from Pickwick of 4524 mgd for a significant part of the day in order to discharge their wastewater.

Because Pickwick Dam does not provide sufficient minimum flow for PCA to discharge all the wastewater generated during some days, PCA will store the excess portion of the wastewater. PCA stored an estimated 652 million gallons of wastewater during the summer of 2002. This is about 26 days of total plant wastewater production. PCA typically relies upon the traditional longer flow releases from Pickwick, which occur in the fall, in order to empty their storage lagoons.

PCA is examining options to relieve their wastewater discharge constraint. One option is to build more storage lagoons. Another option is to increase the maximum capacity of their discharge from 36 mgd to 54 mgd (Holland,2002).

International Paper

Ten years ago, International Paper's wastewater discharge permit was changed so as not to allow any discharge when the reservoir DO level, measured at the 5-foot depth, was below 5 mg/L. The change was in response to Wheeler Reservoir not supporting its designated uses due to low DO. In the summer of 1999, a low-DO condition was encountered resulting in the discharge being shut off for 4 to 5 hours, about 6 times during a 6- to 8-week period.

International Paper has enough storage capacity to store wastewater for 1 to 2 days with the mill running at full capacity. When the ponds are full, the mill has to shut down.

Recently, International Paper submitted an application for an NPDES permit renewal. Along with the application, modeling results were submitted showing that International Paper's discharge had very little effect on reservoir DO. Because the reservoir is no longer 303(d) listed for DO, International Paper requested that the DO limitation on discharge be eliminated. If the reservoir DO is too low to discharge, International Paper can store some wastewater.

International Paper believes that if summer discharge from Wheeler Dam does not drop below the 6460 mgd (10,000 cfs) minimum, they will not have difficulty with the reservoir DO limitation (McGee, 2002).

Mead (Smurfit-Stone Container)

Discussion with Mead personnel indicated that there was no limitation on discharge. Personnel did say that they had to monitor reservoir DO. However, discussion with the Alabama Department of Environmental Management (Dean, 2002) indicated that Mead was also required not to discharge wastewater when the DO level was below 5 mg/L at the 5-foot depth.

Apparently, the DO restriction has had no effect on Mead because no change in operation has occurred as a result of the reservoir DO conditions. In addition, Mead's effluent lagoons are designed to hold only wastewater during process upsets and are not designed to hold water based on reservoir DO.

Potential Mill Shut Down

Should it be necessary to idle any of these facilities, the following employees, shown in Table 7–2, would be affected.

Table 7–2: Plant Employment

Plant	Employment
Bowater at Calhoun, TN	1100
Mead at Stevenson, AL	540
International Paper at Courtland, AL	1283
Packaging Corporation of America at Counce, TN	550

Investigation and Impacts

Bohac (2004b) investigated the above concerns in relation to the operating policy implemented by TVA in June 2004. He found that PCA, International Paper, and Mead likely would be unaffected by TVA's change in operation. There was a slight increase in the number of days Bowater's storage ponds were predicted to be filled, however.

Summary and Conclusions

Industries, municipal wastewater treatment plant operators, and state regulators were interviewed to determine if there were any wastewater discharge permits in the Tennessee River watershed which depends on more than minimum river flow. Four instances of industrial discharge were found to depend on ambient water quality or river flow as conditions of their discharge. All were pulp and paper manufacturing facilities. Two of the plants routinely store wastewater during low flows for release during higher flows. One plant has stored wastewater for a few hours on a few days when reservoir DO concentration dropped below 5 mg/L, and one plant has apparently never stored any wastewater, although its discharge permit prohibits discharge when the reservoir DO concentration is below 5 mg/L. Should any of the plants exceed their wastewater storage capacities, the plants would have to shut down. Employment at the plants would be affected.

A

Appendix

Assigning Hydrologic Units and Reservoir Catchment Areas to Intake and Discharge Records

Intake and discharge information for the 2000 Water Use Survey for the Tennessee River watershed came from a variety of sources and with a varying amount of information beyond the source of the supply or point of discharge and the quantity of water involved. Location information ranged from the specific to the general; while many records had a latitude and longitude associated with a water supply source or discharge point, others only had a street address or a county name and state.

It was determined that, for reporting purposes, it would be desirable to assign each record to its corresponding hydrologic unit cataloguing number (HUC#), and for modeling purposes, it was necessary to assign each record to an appropriate reservoir. The methodology of making those assignments based on available location information is outlined below:

For records with a latitude and longitude (accuracy of reported latitude/longitude assumed):

- HUC assignments were made based on spatial coincidence using Geological Information System (GIS). In other words, water source points were displayed in the same map view as hydrologic units (HU) using GIS software. All points falling within the boundaries of each HU were selected and assigned that HUC#. All records in the data set were assigned a HUC#, including those outside of the Tennessee River watershed. Discharge points from the NPDES came with HUC numbers preassigned.

- Reservoir assignments for those records with latitude/longitude were made based on the HUC# assignment and a series of rules, with some exceptions noted below. Both GIS and hydrologic maps assisted in determining the correct reservoir assignment for each source or discharge record.

  Intakes

  Using a GIS display showing intake points, hydrologic units, the regulated river system and unregulated streams for the Tennessee River watershed, intake records were selected and assigned a reservoir, based on a 'geographic logic'. The first choice was to assign the name of the upstream reservoir to a record. If there was no upstream reservoir, then the nearest downstream reservoir was assigned.

Outfalls

Outfalls were assigned the nearest downstream reservoir.

For records with no latitude and longitude, both HUC#s and reservoirs were assigned using whatever clues were provided in the record. If there was an address for the record, the town or city name provided the best clue for location. The record was then assigned the HUC# of that hydrologic unit where the town lies, and the name of the closest reservoir.

If no address information was provided, the county name was used to determine the HUC# of the predominant hydrologic unit (by areal extent) in that county and the name of the local or nearest reservoir.

Again, intakes were assigned to the nearest upstream reservoir and outfalls to the nearest downstream reservoir.

Exceptions

Those intakes and outfalls falling within the HU 06040006 were not assigned a reservoir. This is the hydrologic unit located below Kentucky Dam and is subject to conditions on the Ohio River.

B

Appendix

Thermoelectric Forecast and Interface with Regional Economic Simulation Model

As part of TVA's Water Supply Inventory and Needs Analysis, a forecast of increased water use for electrical generation was prepared in terms of consumptive use. The water use forecast is based upon the TVA forecast of electrical energy demand within the TVA region.

It is assumed that all of the projected generation increase, with the exception of that supplied by the addition of Browns Ferry Nuclear Plant (BFN) Unit 1 and the power supplied by simple-cycle combustion turbines (SCCT), will be supplied by new power plants which have closed-loop water systems.

TVA will add scrubbers to five of its coal-fired units, and the increased water demand for the scrubber program was also estimated.

Electrical Demand

Recent Demand

Total TVA system output for 1997 through 2001 averaged 165,035 million kwh (Tennessee Valley Authority, 1997, 1998b, 1999, 2000c, 2001a). The average growth rate over these years was 0.5 percent per year. By comparison, electrical generation grew nationally at a rate of 0.74 percent from 1990 through 2000 and at about 0.2 percent from 1996 through 2000 (Energy Information Administration, 2001).

Future Demand

Table B–1 shows the projected future demand of electrical energy in the TVA region. The forecast for 2020, was compared to the projections made for Energy Vision 2020 (TVA, 1994). The Energy Vision estimates ranged from about 140 to 325 million MWh/yr, with a median forecast of about 220 million MWh/yr, which compares to this study's forecast of 212 million MWh/yr using the method described here. It should be noted that the growth rates used beyond 10 to 15 years in the future are considered little more than trends. Therefore, projections made beyond 10 to 15 years reflect only a trending-type analysis.

Table B–1: Projected Electrical Demand in the TVA Region (Millions of Megawatts Hours per Year)

Year	Demand
2001	165
2010	192
2020	212
2030	244
2050	326

Electrical Generation

Recent Generation

Table B–2 shows how the electrical demand within the TVA region was supplied for the fiscal year ending September 30, 2001.

Table B–2: 2000–2001 Electrical Generation in the TVA Region (Millions of Megawatt Hours per Year)

Generation Source	Generation
Hydro	9.5
Fossil	100
Nuclear	45.6
Combustion Turbine	1.1
Purchased	9.9
Total	**166.1**

Future Generation

Much of the future generation of electrical energy consumed in the TVA region could come from merchant power plants. Presently, there is 1453 MW of operational merchant plant capacity located in the TVA region that is SCCT. There is also 1383 MW of operational merchant plant capacity located in the TVA region that is combined-cycle combustion turbine (CCCT).

The EPA developed an Integrated Planning Model, which forecasts electric power generation and resulting air emissions (U.S. Environmental Protection Agency, 1998). The EPA base case scenario for air emissions projected little increase in coal and nuclear generation. By 2010, the dominant new generating technology is expected to be CCCT power plants. The Southeastern Electric Reliability Council (SERC) assessment states that approximately 30 percent of the new capacity installed between 2000 and 2010 will be simple-cycle combustion turbine (SCCT). However, SCCT only met less than 1 percent of the TVA demand in 2000–2001. It is believed that, with the exception of the addition of BFN Unit 1, no additional nuclear generation will be built in the forecast horizon. It is expected that most of the electrical demand will be met with CCCT plants, with some coal or coal/derived additions as well.

Although important for meeting peak demand, SCCT plants provide less than 1 percent of the TVA total generation in any year. Since the purpose of the energy demand forecast is to estimate future consumptive water use, the contribution of SCCT plants in meeting total new energy demand will be ignored. Water consumption of cogeneration facilities should lie within the range of the combined-cycle and coal-fired facilities. Since only 6 percent of the merchant plant capacity under development is cogeneration, the error in assuming that power from cogeneration facilities consumes water at the rate of a CCCT or coal-fired power plant should be small. Therefore, the forecast of future consumptive water use in the TVA region is based on the following. Future electrical demand will be met by the addition of BFN Unit 1. The rest of the demand will be met with a mixture of 68 percent CCCT and 32 percent coal-fired. These percentages were derived from Table B–3 ignoring the contribution of SCCT and cogeneration.

Table B-3: Merchant Power Plant Capacity Under Development

Generation Technology	Capacity MW	Percent of Total Capacity
SCCT	2150	12.6
CCCT	9457	55.5
Cogeneration	1024	6.0
Coal	4405	25.9
Total	**17,036**	**100**

Forecast of Consumptive Water Use on the Tennessee River System

Future Water Use From New Electrical Generation

New Generation

SCCT plants do not require cooling water. CCCT and coal plants, as well as most cogeneration facilities, will require cooling water. Almost all of TVA's thermal power plants presently rely on once-through cooling most of the time, with a few plants using cooling towers when the return flows would warm the river above water quality standards. Once-through cooling is simply extracting water from the river, passing it through the power plant condenser, and returning it to the river. Almost no water is lost. Cooling towers require less water from the river than once-through systems, but little water is returned since it evaporates in the cooling process. Once-through cooling discharges the waste heat to the river, while cooling towers discharge it to the atmosphere.

It is believed that current environmental regulations will make it very difficult for new generating plants to use once-through cooling with direct-heat rejection to the river or lake (Lee, 2002). Therefore, it is believed that all new generation, with the exception of BFN Unit 1, will require the use of cooling towers all the time. Since the new merchant power plants appear to be sited near the intersection of natural gas lines and transmission lines and not on rivers, the use of once-through cooling will also be precluded by the location of the new plants.

The consumptive use of water in cooling towers for combined-cycle plants is based upon calculations provided for TVA's Franklin County CCCT plant. The estimated consumptive use of 337 gallons/MWh was compared to other new CCCT plant water consumption rates which ranged from 250 to 320 gallons/MWh (Mekeel, 2002).

The reported consumptive use for coal-fired power plants, which includes evaporation from the cooling towers and some consumptive use for ash disposal, is 464 gallons/MWh (Meyers, 1983). It was assumed that all new coal plants would have scrubbers or another form of advanced gas cleanup system. Therefore, an additional 184 gallons/MWh, which is based on scrubber experience at Cumberland, was added to the water use by coal-fired plants.

BFN Unit 1 will operate with once-through cooling most of the time, but cooling towers will be used part of the time. In fact, the addition of BFN Unit 1 will require more use of cooling towers for the other two units. It is estimated that the addition of BFN Unit 1 will cause the cooling towers at the plant to be used an average of 176 hours more per year (Tennessee Valley Authority, 2001b). The estimated increase in consumptive use associated with this increase of cooling tower usage is about 1.09 mgd.

Addition of Scrubbers

TVA will be adding scrubbers at 4 plants. It is assumed that the units scrubbed are Bull Run (950 MW), Colbert 5 (550 MW), all units at Kingston (1456 MW), and Paradise Unit 3. Since Paradise is outside of the Tennessee River System, it will not be considered. Scrubber consumptive water use is estimated to be 3545 gallons per day/MW, based on experience at Cumberland. Table B–4 summarizes consumptive water use for the new scrubbers.

Water Use Summary for 2030

Total water use for new generation and scrubber addition on existing coal-fired fossil units is shown in Table B–4. It is to be noted that the water use forecast does not try to identify if TVA or merchant plants will be the providers of power to the TVA region; the water use will be the same no matter who provides the power.

Table B–4: Additional Consumptive Thermoelectric Water Use by 2030 (Millions of Gallons per Day)

Water-Use Component	Additional 2030 Consumptive Use
New fossil generation	86.1
Scrubber additions to existing coal-fired units	10.4
Additional loss from nuclear cooling towers	1.1
Total	**97.6**

Consumptive Use Estimate

Uncertainties

In addition to the uncertainty of how much electrical energy is needed in the TVA region in the future, there are other uncertainties which include the number of new facilities that will take water from the Tennessee River watershed and the amount of additional capacity which will export energy outside the Valley. For those plants that take water from the watershed, a determination must also be made concerning their likely withdrawal locations.

Presently, 66 percent of the water used for thermal power generation by TVA comes from the Tennessee River system. The rest of the water is provided from the Mississippi, Green, Cumberland, and Ohio Rivers.

Future Water Withdrawals from Reservoir Catchment Areas

Concern has been raised that the list of power plants in various stages of development within the TVA region (17,000 MW in April 2002) exceeded the needed new capacity to supply just the region's increased load in 2030. This imbalance between possible plant construction and needed capacity led to speculation that perhaps many merchant plants would be built in the TVA region solely for the purpose of exporting power outside the region. The question was raised that perhaps the thermoelectric water forecast should include an allowance for generation in addition to the generation required just to meet the energy needs of the TVA region.

In discussions with TVA's Power Resources and Operations Planning staff (Robinson, 2002), it was determined that the merchant power plant planning horizon is very short. Recently, it has not been much longer than the time it takes to get the plant built. Many plants now being constructed and coming on-line were justified on the perceived lack of capacity of a few years ago. Since so many plants were built, there is no longer a shortage of capacity. As a result, excess capacity in the immediate future is expected and a significant decline in merchant plant development is already being observed.

In April 2002, the list of plants under some stage of development within the TVA region totaled about 17,000 MW. In August, the total was about 14,000 MW. Nationwide about 100,000 MW of new capacity has been cancelled and another 100,000 MW of planned projects have been put on hold indefinitely. Some firms (e.g., Duke Energy, Teco Energy, Inc.) have walked away from plants already being built. Another reason for a drop off in development is that lenders for new power plant construction have significantly tightened their credit worthiness criteria and collateral requirements. Most of the pure merchant electricity generating firms have had their credit ratings downgraded to below investment grade (junk-bond status) due to liquidity fears. (*Investor's Business Daily*, 2002). Lenders now also require some assurance of transmission line adequacy as well.

It is expected that construction will stay slack until there is again a sharp increase in wholesale bulk prices during winter and summer peaks. This will bring about another boom in new plant development. The result will be a boom and bust industry (much as in the office space market) with construction starts for new generation cycling widely around the mean increase in regional demand. Because of the short planning horizon for merchant plants and the highly cyclic nature of the business, it was determined that it would be unwise to use the rate of present plant construction to determine if the TVA region will be an importer or exporter of merchant power 30 years in the future. It was considered that basing the thermoelectric forecast solely on the load demand forecast was perhaps the best that could be done presently.

The snapshot of merchant plant development, shown in Table B–3, was based on information available in April 2002. For the information shown in Table B–3, only 52 percent of the plants under various stages of development were located in the Tennessee River watershed. However, another snapshot taken in August 2002 showed that the number of plants under various stages of development had dropped to 32 percent (39 percent of the capacity) within the watershed. Although the percentage of generation planned for the watershed was decreasing, there was no clear reason why new generating plants would not locate along the Tennessee River system. In addition, there was always the possibility that new generating plants would build pipelines to the Tennessee River system to obtain water even though the plants were not constructed in the watershed. Therefore, the assumption of the amount of the regional demand that would be satisfied by using water from the watershed was considered to be highly uncertain. Because of these concerns and because of the high variability and the large uncertainty in merchant plant data as discussed above, it was decided not to base the amount of generation in the watershed on the merchant plant data.

The uncertainty concerning the possibility of the region being a net exporter of power and the uncertainty concerning the amount of generation to take water from the Tennessee River watershed were addressed as follows. The thermoelectric water use forecast assumes that all new generation to supply the TVA region's electrical energy will use water from the Tennessee River watershed. In reality of course, not all of the new power plants built in the TVA region will use water from the watershed. Historically, only 66 percent of the region's energy needs have used water from the watershed. Therefore, the 100 percent assumption will provide a safety factor in case the TVA region does become a net exporter of power, or if plants built outside the watershed still come inside the watershed to obtain water.

The forecast in water use for new electrical generation was assigned to the reservoirs as follows. The Tennessee River system, natural gas pipelines, and the power system transmission grid were mapped.

Intersections of the river, pipelines and the transmission system were viewed as likely locations for new generating facilities and an initial increase in withdrawal from the total increase in projected use was assigned to reservoirs at the intersections. Additional withdrawal was assigned to a reservoir if a new plant was being constructed on the reservoir, and a final increment of the total estimated increase in use was assigned based on the level of new generation being considered on each reservoir or its headwaters.

Table B–5 summarizes the projected consumptive water use for thermal generation of electrical energy in the TVA region and for the Tennessee River system.

Table B–5: Increase in Consumptive Use for Thermoelectric Power Production from 2000 to 2030 (Millions of Gallons per Day)

Reservoir-Catchment Area	New Generation	Scrubber	Nuclear Addition	Total
Melton Hill	5	3.4		8.4
Cherokee	10			10
Fort Loudoun	5			5
Watts Bar	5	5.1		10.1
Chickamauga	5			5
Nickajack	12			12
Wheeler	15		1.1	16.1
Wilson	5			5
Pickwick	13.1	1.9		15
Kentucky	11			11
Totals	**86.1**	**10.4**	**1.1**	**97.6**

2030 Forecast Interface with Regional Economic Simulation Model

The demographic and economic data provided by Woods and Poole, Inc., serve as the basis for the water use forecast. Economic data are used by other ROS activities. TVA's Regional Economic Simulation Model (RESM) regional economic forecast is input to the Regional Economic Models, Inc. (REMI) model forecasts for TVA economic subregions. These forecasts will serve as the base forecasts for the ROS. REMI model output on secondary economic effects of the ROS alternatives will be used in an iterative process to evaluate the monetary change in hydropower generation for the different ROS alternatives.

The four components of the water use forecast are public supply, industrial, irrigation, and thermoelectric. Public supply is based on demographic data. The RESM does not use Woods and Poole manufacturing earnings data because TVA believes that, at least for the near future, TVA industrial data are more accurate than the Woods and Poole trends. The irrigation forecast is based on farm earnings which RESM/REMI do not directly identify, but instead, lumps with forestry, fishing, and other agricultural services. Even though there are different definitions of agriculture used, the trends should be similar for both series since the part that is not farm earnings is a very small part of the total. Nevertheless, because of the way that RESM treats agriculture, it is only possible to approximately say how the agricultural RESM output differs from Woods and Poole. The thermoelectric, water use forecast uses TVA's load demand forecast, which is fully supported by the RESM/REMI economic forecasts. Based on the above comparison, it appeared that the underlying assumptions for the water use forecast might differ from those used by the RESM in the industrial area.

It was believed that the manufacturing component for the RESM/REMI economic forecasts would provide estimates that were most similar to Woods and Poole estimates in the county aggregates that included the large economically diversified metropolitan areas of the Valley (e.g., Chattanooga, Knoxville). The largest differences might be expected in the more rural areas.

In order to compare the Woods and Poole industrial forecast to a forecast using RESM output, the output from the RESM was disaggregated to the county level to develop projected county manufacturing earnings for 2020. The RESM model only went out to 2020; it had not yet been modified to provide a 2030 forecast. These earnings were then used in place of the Woods and Poole earnings to project industrial water use to 2020. An estimate was also made for 2020 using the Woods and Poole data only and the two results were compared. On the whole, the two estimates were very close, only varying by about 3 to 4 percent in total industrial water use. There was also good agreement when the results were compared on a reservoir-by-reservoir basis, except for two rural reservoirs, Tims Ford and Blue Ridge, where the deviations between the two estimates were larger. In order to make the water use forecast consistent with the RESM approach, the ratio of the two 2020 estimates, based on the disaggregated RESM output and the estimate based only on Woods and Poole data for reservoir catchment areas, were computed. These ratios were then used as an adjustment to the 2030 Woods and Poole calculations.

C

Appendix

Projection of Lockages through Jamie Whitten Lock

The results of 4 different approaches to projecting the number of lockages through the Jamie Whitten Lock in 2030 are shown in Table C–1. Based on the estimate of 200 mgd for 2000, the IBT associated with these projections ranges from 236 to 393 mgd (assuming the relationship between lockages and water transfers remains constant).

The first 3 methods were based on the historical trends in lockages. In the first, tugs, including light boats, were projected forward using the average-annual growth rate from 1989 to 2000. Other lockages, which accounted for a relatively small share of the total, did not appear to have a consistent pattern of growth or decline. Therefore, the mean of the historical data was used for the 2030 projection. The second method was the same, except all lockages were projected as one data series (an apparent dip in recreation lockages since 1999 accounts for most of the difference between this series and the first). The third method was time-series analysis, based on the least-squares approach. The fourth method used the rate of increase from the USACE's most recent traffic forecast for the Tennessee River system (telephone conversation with Dale Keltz, USACE). The USACE is in process of updating that forecast, which will probably be higher than the existing one. However, most of that increase is due to anticipated shipments of western coal to TVA, which should not impact Whitten Lock.

Regression analyses using national and regional forecasts were tried, but results appeared totally unreasonable.

In addition to the choice of projection to use, another issue is whether there would be less water lost per lockage as traffic increases. In theory, the increase in the number of pit dumps should be less than the increase in traffic, since there would be fewer occasions when the lock would dump water without a boat.

Table C–1: Lockages through Jamie Whitten Lock

	Up River	Down River	Total
1989	1,014	857	1,871
2000	1,194	1,077	2,271
2001	1,007	966	1,973
2002	1,146	827	1,973
2030			
Historical, Tugs Only (Mean for Other)	2,198	2,269	4,467
Historical, Total	1,867	2,009	3,876
Time Series	1,661	1,360	3,021
USACE Rate (1.1%)	1,557	1,123	2,680

D

Appendix

Interviews with Industrial and Public Water Supply and Water Treatment Plants

The following are summaries of interviews conducted with owners and operators of industrial water treatment plants.

Bowater, Calhoun, Tennessee

Process

Much of the water (5 to 30 mgd) is used for noncontact cooling and is not treated. The remaining water (35 to 40 mgd) is coagulated with alum and then sent to sedimentation and sand filters. It is chlorinated and an orthophosphate-corrosion inhibitor is added.

Chemicals Used

In addition to alum, chlorine is used.

Operational Notes

Operation of the treatment plant is steady unless there is a storm, then operation of the treatment plant would be changed (chemical addition changed) to adjust to the increase in turbidity. A big rain is the only thing that gives them problems. April river turbidity was in the range of 3.5 NTUs.

Intertrade Holdings, Copperhill, Tennessee

Process

The majority of the water (99.5 percent) used is for noncontact cooling for which there is little chlorine addition. The rest of the water (30 to 40 gpm) is treated by a conventional filter plant as a pretreatment for deionization. This water is used for boiler feed.

Operational Notes

The only issue is the turbidity in the water caused by a storm event.

BP Amoco, Decatur, Alabama

Process

Approximately 8 mgd is treated for BP's process. Calpine uses their intakes and takes another 6 mgd. The treatment plant is a conventional coagulation-sedimentation-filtration plant.

Chemicals Used

Custom-made polymers are used. Sodium hyperchlorite is added at the front of the process.

Apart from mechanical equipment failures, they experience difficulty in operating their plant once or twice a year. This is due to storm-related turbidity spikes. They have had aquatic weeds growing in the clarifier. Chlorine addition seems to take care of any algae problems.

Other

Minimum flow is important to them. They also depend on barge traffic. A 1- or 2-foot drop in winter pool elevation is not expected to affect them.

Holston Army Ammunition, Kingsport, Tennessee

Process

Most of the water is used for cooling and is not treated. Approximately 2.6 mgd is treated through coagulation, sedimentation, and filtration.

Chemicals Used

Liquid alum is fed for coagulation. Sodium hyperchlorite is used for disinfection.

DuPont, New Johnsonville, Tennessee

Process

Most of the water is used for noncontact cooling. Only chlorine is added to the water. About 6 to 8 mgd is treated through a conventional filter plant.

Chemicals Used

A polymer and a streaming current meter are used.   Chlorine is also used.

Solutia, Decatur, Alabama

Process

The water they take from the river is used for cooling and is not treated.

International Paper, Courtland, Alabama

Process

All of the water drawn from the river is treated using coagulation, flocculation, sedimentation, and filtration. Some of the water is then softened and deionized for boiler use.

Chemicals Used

Alum and chlorine are used.

Operational Notes

The Elk River is across the river from their intake and affects their treatment when there has been rain and the Elk is turbid. Operation of the water treatment plant is most touchy during the spring and fall when turbidity is the highest.

Algae in the process is controlled by chlorination when the water is removed from the river.

A 2-foot change in river elevation in the winter is not perceived to be a problem.

Dupont, Chattanooga, Tennessee

Process

Most of the water is used for cooling, with only about 2 mgd being treated. The process consists of coagulation, flocculation, sedimentation, and filtration. Some of the filtered water goes on to activated carbon treatment and then ion exchange.

Chemicals Used

Alum is used for coagulation, but they have no data on the dose. A streaming current meter automatically controls the process. Sodium hyperchlorite is used for disinfection.

Operational Notes

They have to backwash the sand filter more often during times of heavy rain. Organic material relating to the ion exchange system does not seem to be a problem.

A 2-foot lowering of reservoir operating level in the winter will not likely be a problem.

Williamette, Kingsport, Tennessee

Process

All the water extracted from the river is treated. The process is coagulation, flocculation, sedimentation, and filtration.

Chemicals Used
Polymer is used.

Operational Notes
Polymer varies as the turbidity in the raw water varies. Normally the turbidity is about 2.8 NTUs. Last week, during a rain, the turbidity was 50. Storm water is the only thing that routinely affects treatment.

In the fall, they sometimes have problems with leaves clogging things up.

Packaging Corporation of America (PCA), Counce, Tennessee

Process
Only about 2 mgd of water is treated and it is used primarily for boiler feed water. No treatment is needed for the rest of the water. The plant makes brown paper, so turbidity is generally not an issue as far as their process is concerned. However, heavy rains do produce increased turbidity levels. Some bromine and hyperchlorite are added for bacteriological control.

Pool Level Change
A pool-level decline of 1 or 2 feet would not cause a problem with the water intake.

Eastman Chemical, Kingsport, Tennessee

Process
About 23 mgd is processed through a conventional filter plant. The rest of the water (over 400 mgd) is used for noncontact cooling and returned to the river. Approximately half of the 23 mgd is demineralized and used for boiler feed and other process water. The demineralizer system is resin based.

Chemicals Used
Polymer and alum is used.

Operational Notes
The primary thing that drives a change in the treatment process is turbidity due to storms. No chlorine or other biocide is used in the treatment process, so there is some organic fouling of the demineralization resins. When the water in the river is low, the aquatic growth becomes heavy. During high flows, the growth is dislodged and causes problems with the intakes.

The following are summaries of interviews with public water supply treatment plant operators.

Tennessee-American Water Company, Chattanooga, Tennessee

Process

Chemical flocculent addition, chemical mixing, flocculation, sedimentation, filtration, fluoridation, corrosion inhibitor addition, pre and post chlorination

Chemicals Used

Aluminum chlorohydrate, nionic polymer, and chlorine are used.

Operational Notes

Plant operation varies the most during storms when North and South Chickamauga Creeks significantly increase sediment loading in the river. During storms, turbidity levels can rise to 300 NTUs or more. Normally turbidity is about 5. Normal raw water coliform concentrations are about 30 colonies/100 ml, but concentrations can increase to 10,000 or even 100,000 during storms.

TOC monthly samples average about 3 to 4 mg/L. Based on the raw water TOC and the alkalinity of the water, the required TOC removal is 25 to 35 percent. Effluent TOC averages about 1.8 mg/L.

No plant upgrades are expected over the next 5 years. The only effect that new regulatory changes might have would be that the Stage 2 Disinfectants/Disinfection by-products rule could require a switch to chloramine disinfection rather than using chlorine.

Pool Level Change

A reduction in pool level will decrease pump efficiency and increase pumping head.

Anderson County Utilities Board, Clinton, Tennessee

Process

Coagulation, flocculation, sedimentation, and filtration

Chemicals Used

Poly aluminum chloride and chlorine are used.

Operational Notes

Turbidity varies normally from 1.5 to 6 NTUs. A large storm can create turbidities of over 1000. They do not have to treat for iron and manganese. TOC in the raw water is about 2 mg/L.
Most of the difficulty in treating water comes during storms. The river velocities are high, so a storm above their intake, which would affect Coal Creek, could bring turbid water to their intake very soon They have no plans to upgrade their treatment plant. DBP limits are being met.

City of Morristown, Tennessee

Process

Conventional filtration plant (coagulation, flocculation, sedimentation, filtration), but granular activated carbon (GAC) used for filtration

Chemicals Used

Aluminum chlorohydrate, chlorine, and potassium permanganate are used.

Operational Notes

Normal raw water turbidity ranges from 2 to 10 NTUs. During rainfall events, the turbidity will be 25 to 40 and sometimes even higher. The higher range happens four to six times each year and is all storm-related. Low lake levels compound the turbidity problem because the exposed banks erode during storms.

Raw water TOC ranges from 2.4 to 5 mg/L. There is no apparent correlation with time of year except during reservoir turnover when the levels might elevate.

The GAC in the filters is replaced every three years.

The treatment plant's capacity will be expanded from 15 to 24 mgd. The treatment process will not be upgraded. This is only to gain hydraulic capacity.

They have had blue green algae blooms in the past which have caused taste and odor problems. This is one of the reasons for the GAC. The problem has occurred at low lake level.

The plant has a variable level intake to avoid any iron or manganese issues.

The biggest difficulty in plant operation comes from high turbidity during storms, high water demand because the plant is limited, and during reservoir turnover when raw water characteristics vary rapidly.

Pumping costs are affected by low-pool levels.

City of Huntsville, Alabama

Process

The city has two plants. One is located at Whitesburg, which is above Huntsville near the confluence with the Flint River, and the other is located below Huntsville near the airport. Both plants are conventional filtration plants. Powdered activated carbon (PAC) is fed at the front of the plants during the summer.

Chemicals Used

Alum, chlorine, and PAC is used.

Operational Notes

There was a big taste and odor problem last year (June and July), but they have not had much trouble so far this year. Last year, there were problems all along the river. The problem cleared up at Chattanooga and, several days later, it cleared up for them.

They often attribute taste and odor problems to Geosim/MIB. They think the Flint River is a big contributor to the problem. There is a lot of agricultural activity along the river.

Another problem concerning the Flint is that there is a lot of construction and development along the Flint. When it rains, the river gets very turbid. When it enters the Tennessee, the turbidity hugs the bank and affects the Whitesburg inlet.

TOC is typically 2 mg/L with a maximum of 2.5 mg/L. Presently, the city blends the surface water with well water so DBP limits have not been a problem. Starting in 2003, each source will have to stand on its own, and DBPs might be a problem. If it is, they will work on their coagulation. Potassium permanganate can be used to oxidize some of the influent organic matter.

There are no iron and manganese issues.

A drop in winter pool elevation could cause them to have to rebuild their inlet. The plants presently have marginal net positive suction head.

Most of the difficulty in operating the plants comes from coagulation, especially when it is very cold, taste and odor control, and low river levels.

City of Decatur, Alabama

Process

Conventional filtration using a dual media anthracite-sand filter.

Chemicals Used

Alum, polymer, and chlorine is used.

Operational Notes

Normal turbidity ranges from 8 to 12 NTUs. During a storm, the turbidity might become as high as 150.

TOC concentrations on the raw water range from 2 to 4 mg/L with little discernible seasonal variation. High concentrations of 8 to 9 mg/L have been observed, but these levels do not persist very long.

Iron and manganese are not an issue for the plant.

There have been taste and odor complaints in the past, but these have been attributed to the customer's reaction to elevated water temperatures in the distribution system.

They intend to move away from pre-chlorination, possibly switching to potassium permanganate. They might also start using polymer. This is in response to concerns about meeting their DBP limit.

They just finished a major expansion for capacity. The most difficulty they have is operating the plant during periods of high turbidity during the winter.

Pool Level Change

Since the intake is located in the bottom of the main channel, it is doubtful that a 1- to 2-foot pool level change would affect their operation. They have no plans to upgrade their treatment plant. DBP limits are being met.

Knoxville Utilities Board, Knoxville, Tennessee

Process

Coagulation, flocculation, sedimentation, and filtration.

Chemicals Used

Chlorine dioxide, alum, and ferrous chloride are used.

Operational Notes

Heavy rains cause changes to treatment operations. Treatment for iron and manganese is not required. A 1-or-2 foot drop in water level during the winter would not cause a problem.

E

Appendix

Interviews with Owners and Operators of Industrial and Municipal Wastewater Treatment Plants

The following are summaries of discussions held with wastewater treatment plant operators.

City of Huntsville

1. Company/Municipality Name—City of Huntsville
2. Location—Huntsville, Alabama
3. Date—9/19/02
4. Current Discharge—Discussed 5 permits in Huntsville area
5. Permit Limits—They have both load limits (pounds/day) and concentration limits. They have limits for BOD, TSS, Ammonia (report only), P (report only), pH, and DO.
6. Basis for Permit Conditions—what is the tie to river flow?—There is no direct tie to river flow or river conditions.
7. What happens if TVA does not bring the flows up on August 1?—Since discharge is not tied to flow, there is no impact
8. If you store wastewater, how long can you store it?—How much can you store?—There is no storage of wastewater.

DuPont

1. Company/Municipality Name—DuPont
2. Location—New Johnsonville, Tennessee
3. Telephone Number—931-535-7316
4. Date—9/19/02
5. Current Discharge—About 54 mgd—mostly cooling water

6. Permit Limits—They have limits for suspended solids, metals, and pH. They also have a periodic bioassay requirement. There is no organic waste. All their sewage goes to the city. There is no temperature limit on their discharge, but they do report temperature.

7. Basis for Permit Conditions—what is the tie to river flow?—There is no direct tie to river flow or river conditions.

8. What happens if TVA does not bring the flows up on August 1?—Since discharge is not tied to flow, there is no impact.

9. If you store wastewater, how long can you store it? How much can you store?—There is no storage of wastewater.

City of Decatur

1. Company/Municipality Name—City of Decatur

2. Location—Decatur, Alabama

3. Date—9/19/02

4. Current Discharge—The plant is rated for 36 mgd, but they discharge about 16 to 18 mgd.

5. Permit Limits—They have both load limits (pounds/day) and concentration limits. They have limits for BOD, TSS, pH, and chlorine minimum and maximum. The have no nutrient limits. Their waste stream is 70 percent industrial waste so they have low nutrient concentrations in the influent. Their permit will be renewed in 2004.

6. Basis for Permit Conditions—what is the tie to river flow?—There is no direct tie to river flow or river conditions.

7. What happens if TVA does not bring the flows up on August 1?—Since discharge is not tied to flow, there is no impact

8. If you store wastewater, how long can you store it? How much can you store?—There is no storage of wastewater.

International Paper

1. Company/Municipality Name—International Paper

2. Location—Courtland, Alabama

3. Date—9/18/02

4. Current Discharge—48 to 52 mgd

5. Permit Limits—They have both load limits (pounds/day) and concentration limits. They have limits for BOD, TSS, pH, and toxicity. They must monitor for nutrients. The storm water that is in contact with their process area goes through their wastewater treatment system. Other storm water releases have oil and grease limits. There is no temperature limit. They think they probably discharge below river temperature anyway because of their ponds.

6. Basis for Permit Conditions—what is the tie to river flow?—Ten years ago Wheeler Reservoir was impaired for DO. Therefore, the discharge permit restricted International Paper from discharging when the DO is less than 5 mg/L at the 5-foot depth as measured as follows. From the plant down to 1 mile

above the Elk River; one mile up the Elk River; from the plant up to 1 mile below Wheeler Dam. They sample April to November.

Three summers ago they had low DO and had to shut the discharge down for 4 to 5 hours about 6 times during a 6–to 8–week period.

7. What happens if TVA does not bring the flows up on August 1?—Experience has shown that if Wheeler is discharging 10,000 cfs, they don't have a problem.

8. If you store wastewater, how long can you store it? How much can you store?— Their ponds cover about 400 acres. They can store about 1 to 2 days of wastewater flow at full operation. Because they withdraw water from below the river water surface and they discharge from the pond bottom, they believe that the discharge water would be cooler than the river surface water.

9. Important Other—Wheeler has been 303(d) listed for pH (nutrients), temperature, and flow modifications. As such, a TMDL was developed for the reservoir. During the TMDL process, International Paper modeled DO using the WASP model (EPA model) and determined that their discharge does not significantly affect reservoir DO. They have supplied this information to Alabama with their new application for their NPDES permit application, which they submitted last month. They have asked Alabama to remove the reservoir DO restriction. They do not know when they will hear from the state, but they do expect an answer soon. They say that it is in the state's interest to act quickly on their request because the state wants to permit the facility under the Pulp and Paper Cluster Rule, which will give the state greater control over the use of chlorine in the plant.

Mead (Smurfit-Stone Container Corporation)

1. Company/Municipality Name—Mead

2. Location—Stevenson, Alabama

3. Date—

4. Current Discharge—6 mgd

5. Permit Limits —They have both load limits (pounds/day) and concentration limits. They have limits for BOD, TSS, pH, and DO. There is no temperature limit. In the summer, they monitor for nutrients. They also monitor for reservoir DO in the summer, but that has no direct impact on them.

6. Basis for Permit Conditions—what is the tie to river flow?—There is no direct tie to river flow or river conditions.

7. What happens if TVA does not bring the flows up on August 1?—Since discharge is not tied to flow, there is no impact

8. If you store wastewater, how long can you store it? How much can you store?—They have storage in their treatment ponds for treatment plant upsets.

Bowater

1. Company/Municipality Name—Bowater

2. Location—Calhoun, Tennessee

3. Date—9/19/02

4. Current Discharge—Listed as 64.8 mgd in the database, but process water is only about 40 mgd.

5. Permit Limits—The average BOD loading limit is 26,000 pounds per day with a maximum of 50,000 pounds per day. They think the actual average is about 8,000 pounds per day. However, if the river flow drops below 1000 cfs, the BOD limit drops. Bowater also has a dilution requirement of no more than 1 part of wastewater for each part of river water.

6. Basis for Permit Conditions—what is the tie to river flow?—When river flow drops below 600 cfs, Bowater stops discharging. At other times, they discharge proportionately to river flow according to the dilution requirement. The maximum volume they can discharge is about 50 mgd. When river flow gets above 20,000 cfs, the river is too high for them to discharge.

7. What happens if TVA does not bring the flows up on August 1?—Their problem does not occur in August; the problem occurs in January and February.

8. If you store wastewater, how long can you store it? How much can you store?—The storage is about 150 to 180 million gallons. If they can discharge at an average daily rate of about 20 mgd, they have a week to 10 days of storage. That is, they can operate at mill capacity for a week to 10 days if they can discharge at least 20 mgd. They do not want to use the ponds near the Interstate because of the fog issue. These ponds cover another 235 acres. If they run out of storage, they will cut production rather than use the ponds.

Intertrade Holdings

1. Company/Municipality Name—Intertrade Holdings

2. Location—Copperhill, Tennessee

3. Date—9/18/02

4. Current Discharge—31 mgd when acid plant running

5. Permit Limits—They have a small amount of wastewater. Most of the water is for indirect cooling. The temperature limit is the big thing.

6. Basis for Permit Conditions—what is the tie to river flow?—They are concerned that the new temperature limit will cause them a problem.

7. What happens if TVA does not bring the flows up on August 1?—It would depend on the temperature.

8. If you store wastewater, how long can you store it? How much can you store?—There is no storage of wastewater.

Holston Army Ammunition

1. Company/Municipality Name—Holston Army Ammunition

2. Location—Kingsport, Tennessee

3. Date—9/18/02

4. Current Discharge—The database lists 36.5. Most of the flow is noncontact cooling water. There is about 3 mgd of process/sanitary water.

5. Permit Limits—The limits for BOD are 30 mg/L average monthly and 45 mg/L maximum day. There is a temperature limit not to exceed 30.5 degrees C, and they can't raise the river temperature more than 3 degrees C.

They have both load limits (pounds/day) and concentration limits. They have limits for BOD, TSS, Ammonia (report only), P (report only), pH, and DO.

6. Basis for Permit Conditions—what is the tie to river flow?— Only the temperature limit, but they do not think it would ever be an issue except possibly at maximum plant capacity.

7. What happens if TVA does not bring the flows up on August 1?—Since discharge is not tied to flow, there is no impact.

8. If you store wastewater, how long can you store it? How much can you store?— There is no storage of wastewater.

Eastman Chemical

1. Company/Municipality Name—Eastman Chemical

2. Location—Kingsport, Tennessee

3. Date—9/20/02

4. Current Discharge—Database lists as 421 mgd

5. Permit Limits—They have both load limits (pounds/day) and concentration limits. They have limits for BOD, TSS, and pH. There is no temperature limit except that they can't discharge if the river is above 30.5 degrees C, unless the high temperature is caused by natural conditions.

6. Basis for Permit Conditions—what is the tie to river flow?—There is no direct tie to river flow or river conditions.

7. What happens if TVA does not bring the flows up on August 1?—If TVA provides the contractual amount of water, they won't have problems.

8. If you store wastewater, how long can you store it? How much can you store?—There is no storage of wastewater.

Willamette

1. Company/Municipality Name—Willamette

2. Location—Kingsport, Tennessee

3. Date—9/20/02

4. Current Discharge—Database lists as 7.7 mgd.

5. Permit Limits—Willamette has limits for TSS, TDS, CBOD, ammonia, and P. There is no temperature limit.

6. Basis for Permit Conditions— What is the tie to river flow?—There is no direct tie to river flow or river conditions.

7. What happens if TVA does not bring the flows up on August 1?—Nothing, as long as Eastman gets all the water they need.

8. If you store wastewater, how long can you store it? How much can you store?—There is no storage of wastewater.

9. Other—The plant process is presently being upgraded. After the upgrade, it will produce three times as much product with the same amount of pollutants being generated. The new paper machine has much less fiber loss than the old machine it is replacing.

Moccasin Bend

1. Company/Municipality Name—Moccasin Bend Wastewater Treatment Plant

2. Location—Chattanooga, Tennessee

3. Date—9/20/02

4. Current Discharge—Database lists as 36 mgd

5. Permit Limits—The plant has standard secondary limits. The BOD and SS concentration limits are 30 mg/L monthly average and 45 mg/L maximum day. The ammonia limit is 15 mg/L as N. The CBOD limit is 25 mg/L. There is also an effluent chlorine limit. They measure BOD, temperature, DO, and SS upstream and downstream of their discharge.

6. Basis for Permit Conditions—What is the tie to river flow?—There is no direct tie to river flow or river conditions. When the minimum flow was reduced from 6000 cfs to 3000 cfs, the plant had to reduce the chlorine in the effluent which required greater process control. Now the plant dechlorinates, so the issue of reducing the minimum flow no longer affects the plant operation.

7. What happens if TVA does not bring the flows up on August 1?— If TVA provides the 3000 cfs minimum flow, they won't have problems.

8. If you store wastewater, how long can you store it? How much can you store?—There is no storage of wastewater.

9. Other—About one-half mile downstream from the discharge, the DO sag is about 0.1 to 0.2 mg/L. Nothing unusual happened this summer when unusually low flows were provided.

Solutia

1. Company/Municipality Name—Solutia

2. Location—Decatur, Alabama

3. Date—9/23/02

4. Current Discharge—Database lists as 76.3 mgd

5. Permit Limits—All of the discharge is noncontact cooling except for 3 mgd. The temperature limit for the cooling water discharge is 110 degrees F. There is no other temperature limit. The process water treatment plant has limits for BOD, SS, and ammonia.

6. Basis for Permit Conditions—what is the tie to river flow?—There is no direct tie to river flow or river conditions.

7. What happens if TVA does not bring the flows up on August 1?—NA

8. If you store wastewater, how long can you store it? How much can you store?—There are equalization ponds with several days of holdup time, but there is no storage of wastewater.

Packaging Corporation of America

1. Company/Municipality Name—Packaging Corporation of America

2. Location—Counce, Tennessee

3. Date—9/24/02

4. Current Discharge—Database lists as 19.9 mgd—They said they average 25 mgd.

5. Permit Limits—The BOD limit is 14,000 pounds/day monthly average and the SS limit is 26,000 pounds/day monthly average. The daily maximum loads are about twice the monthly. They also have a pH limit and a color limit. They measure color above and below the discharge, and they can't change the color in the river by more than 50 color units. They have never had trouble meeting the color limit.

6. Basis for Permit Conditions—What is the tie to river flow?— PCA cannot discharge to the river unless the flow is a minimum of 7000 cfs. Above 7000 cfs there are no restrictions on their discharge. TVA's turbine improvement has changed the minimum turbine discharge to 6100 cfs. PCA currently has the capability to discharge at a rate of 36 mgd. They have proposed that they be allowed to discharge at a maximum rate of 57.6 mgd. The state has not objected to the increase.

7. What happens if TVA does not bring the flows up on August 1?—They must have 7000 cfs in order to discharge.

8. If you store wastewater, how long can you store it? They have 250 acres of ponds in which there is storage. They varied the water level 8 feet this year.

F Appendix

Endnotes

Chapter 5

[1]Data for North Carolina municipalities are largely based on 1997 Water Supply Plans. The demands listed in those plans were projected to 2000 and 2030 using Woods and Poole multipliers (see Chapter 2). In some cases, the Water Supply Inventory and Needs Analysis database had 2000 values and projected 2030 demands. The Water Supply Inventory 2000 and 2030 demands were compared to the demands projected from the Water Supply Plan demands, and the higher numbers were used in this analysis.

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Glossary

ACF Apalachicola-Chattahoochee-Flint River Basin

ACT Alabama-Coosa-Tallapossa River Basin

Anoxia Absence of oxygen

BCWA Blount County Water Authority (Alabama)

BFN Browns Ferry Nuclear Plant

BOD Biochemical oxygen demand

CCCT Combined-cycle combustion turbine

CFS Cubic feet per second (a rate of flow of water)

Consumptive Use Withdrawals from the river system less returns to the river system. It is part of the water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock or otherwise removed from the immediate water environment.

DBP Disinfection by-products

DO Dissolved oxygen

DU Dalton Utilities

DRA Duck River Development Agency

EIS Environmental Impact Statement

EPA U.S. Environmental Protection Agency

HUC Hydrologic Unit Code

IBT Inter-Basin Transfer

MGD Millions Gallons per Day (a rate of flow of water)

Net Cumulative Withdrawal Accumulation of withdrawals minus wastewater returns and equal to consumptive use on a large scale.

Net Water Demand Amount of water withdrawn less the amount of water returned for a reservoir catchment area

NPDES National Pollutant Discharge Elimination System

Once-through cooling	Water withdrawn from a waterbody that is used for noncontact cooling purposes and returned to the waterbody
NOM	Natural organic matter
OASIS	Mass balance model that incorporate withdrawals from river and wastewater return flow
PCA	Packaging Corporation of America
Population Centers	A concentration of people within a geographic area
ROS	Reservoir Operations Study (TVA)
REMI	Regional Economic Models, Inc.
RESM	Regional Economic Simulation Model
RiverWare	A software that simulates river flow and reservoir operation
Section 26a	An authorizing permit granted by TVA as stated through the TVA Act
SIC	Standard Industrial Classification
SCCT	Simple-cycle combustion turbine
Scrubber	Flue gas desulfurization systems that reduces sulfur dioxide emissions
SERC	Southeastern Electric Reliability Council
Tailwater	Area of a river downstream of a dam
TVA	Tennessee Valley Authority
TOC	Total organic carbon
TMDL	Total Maximum Daily Load (specialized study for 303d listed streams)
TDEC	Tennessee Department of Environment and Conservation
Total Net Water Demand	Sum of net water demand for all reservoir catchment areas and equal to the consumptive use for the watershed
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
USDA	U.S. Department of Agriculture
WSM	Weekly Scheduling Model—integrated optimization program linking 42 reservoirs that evaluate operating requirements, reservoir systems to warn of possible problems, forecast reservoir system operations, and develop new long-range operating policies
WRRWA	Watauga River Regional Water Authority
303(d) List	Comprehensive public accounting of all impaired water bodies
7Q10	Minimum 7-day flow with a recurrence interval of 10 years
3Q20	Minimum 3-day flow with a reoccurrence interval of 20 years