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Tennessee Valley Authority
River Basin Operations
Water Resources

WATER RESOURCES REVIEW:
WHEELER RESERVOIR
1990

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CONTENTS

TABLES

TABLES

(Continued)

FIGURES

EXECUTIVE SUMMARY

TVA is preparing a series of reports that provide technical information on the characteristics and condition of individual TVA reservoirs. These reports present a summary of (1) reservoir purpose and operation; (2) physical characteristics of the reservoir and watershed; (3) water quality conditions; (4) aquatic biological conditions; (5) designated, actual, and potential uses of the reservoir and impairments of those uses; and (6) ongoing or planned reservoir management activities. This report is for Wheeler Reservoir.

Wheeler Reservoir was formed on the Tennessee River with the closing of TVA's Wheeler Dam in 1936. TVA operates the dam for navigation, flood control, and power production. Wheeler Dam has 11 hydropower units with a total capacity of 378 MW. The dam provides about 11 percent of the total hydropower capacity of the TVA system.

The reach of the Tennessee River impounded in Wheeler Reservoir (Guntersville Dam at TRM 349.0 to Wheeler Dam at TRM 274.9) flows generally northwesterly through northern Alabama. The watershed is primarily mixed hardwood forests and small to large farms, many on prime farmland. Cotton and soybeans are the most important crops in the area, and some of the subwatersheds draining to the reservoir have the most intensive row-cropping in the state. Several of the counties bordering Wheeler Reservoir rank in the top ten counties in Alabama in production of dairy and beef cattle, hogs and pigs, broiler chickens, and eggs.

Of the nine mainstem Tennessee River reservoirs, Wheeler ranks third in area and fourth in volume. There are 1,063 miles of shoreline around Wheeler Reservoir. It has a total drainage area of 29,590 square miles but only 5,140 square miles of that total is downstream of Guntersville Dam. Its largest tributary is the Elk River, which has a drainage area of 2,249 square miles. None of its other tributaries exceed 600 square miles in drainage area.

Like the other mainstem Tennessee River reservoirs, thermal stratification in Wheeler Reservoir is weak and infrequent. A strong dissolved oxygen gradient is sometimes apparent even when there is no thermal stratification, however, and dissolved oxygen concentrations near the surface during the summer are sometimes only marginally greater than the 5 mg/l water quality criteria. Limited data suggest that concentrations of lead and copper may occasionally exceed applicable criteria.

Light penetration in Wheeler Reservoir is relatively shallow due to turbidity. Nutrient concentrations and alkalinity are high enough to support abundant plant growth, but both phytoplankton and macrophyte populations appear to be limited by the shallow depth of the photic zone.

Wheeler Reservoir supports a variety of aquatic organisms typical of mainstem Tennessee River reservoirs. Although mussels occur throughout the reservoir, populations have been depleted or reduced by commercial overharvesting as well as by the change in habitat created by the inundation of their original riverine environment. There is little evidence of mussel reproduction in the riverine area of Wheeler Reservoir.

Wheeler Reservoir supports a diverse fish community (81 species) dominated by warmwater species. A substantial commercial fishery has been adversely impacted for several years due to contamination of the fish flesh with DDT. Channel and blue catfish and buffalo are the most important commercial species. Important sport fishes include largemouth and smallmouth bass, white crappie, sunfishes, white and yellow bass, and sauger.

In recent years several TVA reservoirs including Wheeler appear to have experienced a significant decline in sauger populations. The cause(s) of this decline is not known but it is believed to be related to the drought that began in 1985.

In the TVA system, Wheeler Reservoir is exceeded only by Guntersville Reservoir in terms of total acreage of aquatic macrophytes. In 1988 about 9,843 acres (14 percent of the reservoir's surface area) had been colonized. Hydrilla was discovered in the reservoir in 1987. Mosquito populations associated with aquatic macrophytes are considered a significant problem. In comparison to other TVA reservoirs, Wheeler ranks about third in severity of mosquito problems.

Wheeler Reservoir provides habitat for several aquatic organisms with state or federal protected status. Four endangered mussel species (pink mucket, orangefooted, rough pigtoe, and fanshell) are present. A single threatened fish species, the snail darter, may occur in the reservoir. An amphibian (the eastern hellbender) and the American alligator are the only other aquatic organisms with protected status known to occur in the reservoir.

Alabama has classified the waters of all or parts of Wheeler Reservoir for public water supply, swimming and other whole body contact sports, and fish and wildlife. Aside from these and TVA's operational uses, some other important uses of Wheeler Reservoir waters include boating, sport and commercial fishing, wastewater assimilation, industrial water supply, and shoreline usage.

In assessing the condition of state waters for the period 1986-1987, ADEM indicated that Wheeler Reservoir did not support its designated uses. This rating did not necessarily include the entire reservoir, but does indicate that a portion or all of the reservoir is or has the potential to be adversely impacted. Nonpoint sources of both toxic and conventional pollutants were identified as causes of impairments.

Some important causes of impairments to the uses of Wheeler Reservoir aquatic resources include:

- <u>aquatic macrophyte colonization</u>: impairs or has the potential to impair industrial water supply, boating, shoreline usage, aesthetic quality of the environment, and power production. Associated mosquito populations are a nuisance.

- <u>fish flesh contamination with DDT</u>: potential effect on human health limits interstate commerce for commercial catch and may impair the sport fishing experience for some.

- <u>fecal coliforms</u>: potential for adverse effect on human health may limit the use of reservoir waters in certain areas for swimming and other whole body contact sports.

- <u>drought</u>: may have contributed to the recent continuous decline of sauger populations.

- <u>low flows with high BOD loading rates</u>: intermittently results in lowered ambient DO, which impairs wastewater assimilation capacity of the reservoir.

- <u>high ambient water temperature</u>: seasonally impairs use of reservoir for cooling water supply.

- <u>commercial overharvesting of mussel stocks</u>: result has been the depletion of large populations of mussels once present in the reservoir.

WATER RESOURCES REVIEW:
WHEELER RESERVOIR
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INTRODUCTION

Protection and enhancement of water quality is essential for attaining the full complement of beneficial uses of TVA reservoirs. The responsibility for improving and protecting TVA reservoir water quality is shared by various federal, state, and local agencies, as well as the thousands of corporations and property owners whose individual decisions affect water quality. TVA's role in this shared responsibility includes collecting and evaluating water resources data, disseminating water resources information, and acting as a catalyst to bring together agencies and individuals that have a responsibility or vested interest in correcting problems that have been identified.

This report is one in a series of status reports that will be prepared for each of TVA's reservoirs. The purpose of this status report is to provide an up-to-date overview of the characteristics and conditions of Wheeler Reservoir, including: (1) reservoir purposes and operation; (2) physical characteristics of the reservoir and the watershed; (3) water quality conditions: (4) aquatic biological conditions: (5) designated, actual, and potential uses of the reservoir and impairments of those uses; (6) ongoing or planned reservoir management activities.

Information and data presented here are from the most recent reports, publications, and original data available. In cases where no recent data were available, historical data were summarized or if data were completely lacking, environmental professionals with special knowledge of the resource being discussed were interviewed. Literature and reports cited in text are listed at the end of the report. Interviewees are acknowledged within the text.

PURPOSES AND OPERATION OF WHEELER DAM AND RESERVOIR

Wheeler Reservoir was formed on the Tennessee River in north Alabama with the closing of TVA's Wheeler Dam in 1936. Consistent with Section 9a of the TVA Act, TVA operates the dam for navigation, flood control, and, to the extent consistent with the primary purposes, for power production.

Wheeler Reservoir provides 349,000 ac-ft of flood storage capacity--about three percent of the total for the TVA system. Normal operation for flood control involves initiating reservoir filling on March 15 to achieve full pool (elevation 556.0 feet above msl) by April 15, initiating drawdown July 1, and reaching normal winter operating range (elevation 550.0 to 552.0) by late fall. To guarantee a minimum navigable channel depth of at least 11 feet, the winter pool elevation is not dropped below elevation 550 unless sufficient releases are being made at Guntersville Dam upstream to provide minimum depth in the upper reaches of Wheeler Reservoir (figure 1).

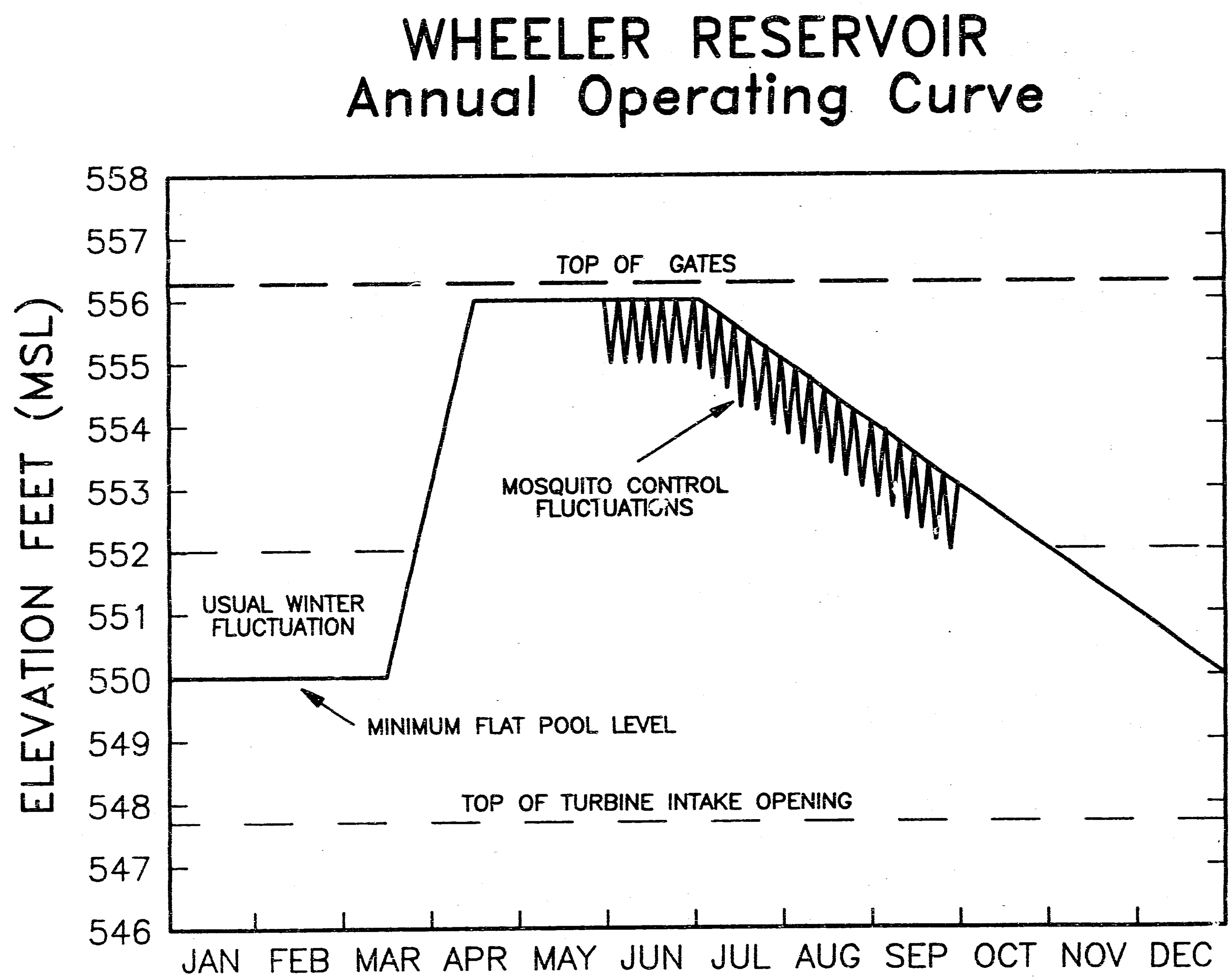

Figure 1. Rule curve for multipurpose use of Wheeler Reservoir.

After navigation and flood control constraints are met, Wheeler Dam is operated to meet power system demands as economically as possible. With a generating capacity of 378 MW, Wheeler Dam provides 11 percent of the total hydropower capacity of the TVA system. Because hydropower generation is the most economical, versatile, and dependable power source in the TVA system, it is used to provide peaking power quickly for those times of day when power demands are highest. Hydropower generation is also scheduled for high demand times of the week (generally during the 5-day workweek) and high demand times of the year (June through August and December through February), depending on the availability of water from upstream regulation.

When consistent with the three primary purposes of flood control, navigation, and power production, water levels in Wheeler Reservoir are regulated to achieve secondary purposes. In recent years, full pool has been maintained through July for two of every three years to provide enhanced pool levels consistent with reservoir maintenance activities, including rebrushing (figure 2). Every third year, drawdown is initiated earlier to allow for mowing of shoreline vegetation to assist in vector control. Between mid-May and mid-September, water levels are fluctuated for mosquito control by raising and lowering pool elevation about one foot on a weekly cycle.

TVA is conducting a comprehensive review of its policies for managing and operating the Tennessee River reservoir system and has released a draft environmental impact statement (EIS) (TVA 1990). The draft EIS evaluates changes in operational objectives (such as maintaining higher summer pool levels in the tributary reservoirs, or providing minimum flows at critical points) that would modify typical flow conditions throughout the Tennessee River system, including Wheeler Reservoir. Changes in typical flow conditions are discussed under "Reservoir Characteristics" on page 8. No modifications in the seasonal pattern of pool elevation for Wheeler Reservoir are being considered at this time.

DESCRIPTION OF WHEELER RESERVOIR AND SURROUNDING AREA

Watershed Characteristics

The reach of the Tennessee River impounded in Wheeler Reservoir (from Guntersville Dam at TRM 349.0 to Wheeler Dam at TRM 274.9) flows generally northwesterly through northern Alabama. The upper end of the reservoir receives drainage from the Cumberland Plateau and Mountains Major Land Resource Area (MLRA) to the north and the Sand Mountain MLRA to the south. The mid- to lower-reservoir receives drainage from the North Alabama Limestone Valley MLRA. Several tributaries to the reservoir drain known coal reserve areas.

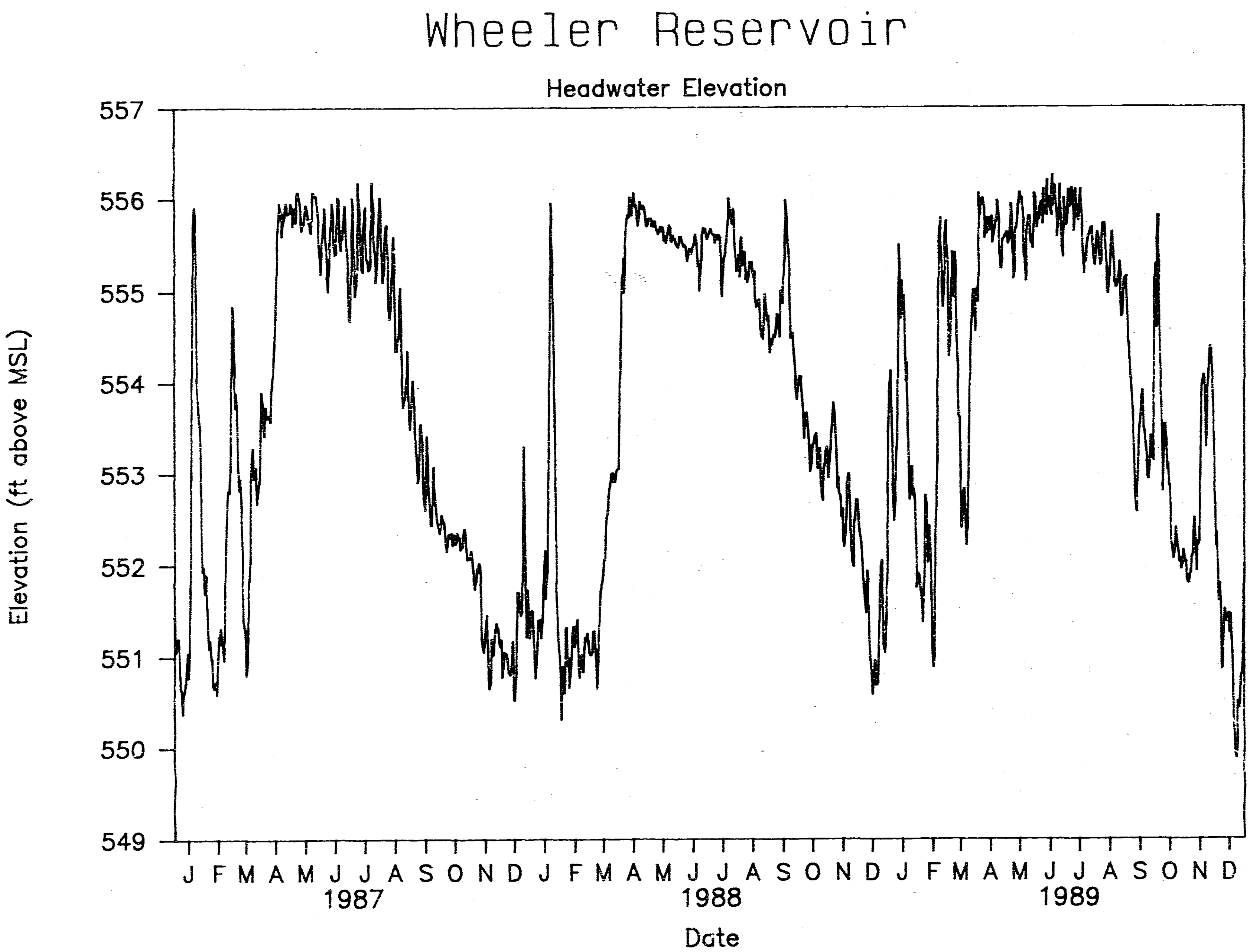

Figure 2. Water levels in Wheeler Reservoir during the period 1987–1989.

The watershed is primarily mixed hardwood forests and small to large farms, many on prime farmland. Cotton and soybeans are the most important crops in the area, and some of the subwatersheds draining to Wheeler Reservoir have the most intensive row-cropping in the state. Cropland erosion rates in the counties bordering Wheeler Reservoir range from 11 to 30 percent above the state average, and about 40 percent of the cropland in the area is eroding at a rate greater than twice the soil loss tolerance (T). Because of these high erosion rates and the extensive use of pesticides and fertilizer on intensively row-cropped lands, the Tennessee River watershed has been identified by several sources as especially prone to water quality degradation from agricultural nonpoint sources. Several tributaries to Wheeler Reservoir are known to be impacted by cropland erosion, including Piney Creek, Limestone Creek, Flint River, Beaverdam Creek, Round Island Creek, Swan Creek, Flat Creek, and Paint Rock River (Cox 1990).

Several of the counties bordering Wheeler Reservoir rank in the top ten counties in Alabama in production of dairy and beef cattle, hogs and pigs, broiler chickens, and eggs. Tributaries to the reservoir that have been identified as impacted by runoff of animal waste include Piney Creek, Limestone Creek, Flint River, Round Island Creek, Flint Creek, and Flat Creek (Cox 1990).

Wheeler Reservoir receives drainage from a total of 29,590 square miles; only 5,140 square miles of that total is downstream of Guntersville Dam, and only 4,611 square miles is uncontrolled drainage downstream of both Guntersville Dam and Tims Ford Dam (Elk River). The largest tributary to Wheeler Reservoir, the Elk River (table 1), has a total drainage area of 2,249 square miles (1,720 square miles downstream of Tims Ford Dam). The next largest tributaries are Flint River, Paint Rock River, and Flint Creek with drainage areas of 568, 458, and 455 square miles, respectively.

Over one-half million people live in the counties surrounding Wheeler Reservoir. The most populated area, Huntsville/Madison County, is expected to grow from 242,700 to 275,000 by 1995. The Decatur/Morgan County area is second most populated with 98,000 residents and an expected growth of 1.4 percent by 1995. The remaining five counties adjoining the reservoir have a total population of 170,000 (TVA 1990).

Shoreline Characteristics

There are 1,063 shoreline miles around Wheeler Reservoir. Of 115 miles of privately owned property, 37 percent is developed. The upper third of Wheeler Reservoir shoreline is mostly composed of undeveloped tracts that once belonged to TVA and narrow strips of undeveloped TVA property. Developments in the area include the U. S. Army's Redstone Arsenal and Huntsville's marina and public use area. Huntsville is only a few miles north of the Tennessee River, at about TRM 333, and the Redstone Arsenal complex occupies most of the north bank from Huntsville downstream to

Table 1. Major tributaries (>100 square miles drainage area) of Wheeler Reservoir.

Tributary	Location of confluence (TRM)	Drainage area (square mile)
Elk River	284.3	2,249
Flint Creek	308.4	455
Limestone Creek	310.7	286
Cotaco Creek	319.1	243
Indian Creek	320.9	193
Flint River	339.1	568
Paint Rock River	343.2	458

about TRM 321. Decatur and its large waterfront industrial complex stretch along the south bank from about TRM 309 to TRM 298, and TVA's Browns Ferry Nuclear Plant (BFN) is located on the north bank at TRM 294.0. Wheeler National Wildlife Refuge (WNWR), a wintering ground for migratory waterfowl, occupies both sides of roughly the middle third of Wheeler Reservoir east of Decatur (from TRM 305 to TRM 324). The westernmost edge of the refuge is within the city limits of Decatur, and its easternmost edge borders the city limits of Huntsville. Two state wildlife management areas are also located near Decatur. Private residential development has occurred along the lower portion of the reservoir and in the Elk River area. Joe Wheeler State park is located along the north bank of the reservoir near the dam. The remaining lower reservoir lands have either been sold or are retained by TVA in forestry or agricultural production.

A plan currently being prepared for managing TVA lands along Wheeler Reservoir is projected to be complete in 1991.

Reservoir Characteristics

Physical Characteristics

Of the nine mainstem Tennessee River reservoirs, Wheeler Reservoir ranks third in area and fourth in volume. The main channel of Wheeler Reservoir varies from 20 to 50 feet deep. Throughout much of the length of the reservoir, the main channel is bounded by shallow overbank areas (floodplain inundated when the reservoir was impounded). Additional physical features of Wheeler Reservoir are summarized in table 2.

Table 2. Physical characteristics of Wheeler Reservoir.

Location: TRM[a] 349.0 (Guntersville Dam) to TRM 274.9 (Wheeler Dam)

Reservoir length: 74.1 miles

Shoreline: 1,063 miles at normal maximum pool

Shoreline development[b]: 29

Elevation (msl): normal maximum pool: 556.0
normal minimum pool: 550.0

Area[c]: normal maximum pool: 67,070 ac
normal minimum pool: 45,450 ac

Volume[c]: normal maximum pool: 1,050,000 ac-ft
normal minimum pool: 720,000 ac-ft

Mean depth: normal maximum pool: 15.7 ft
normal minimum pool: 15.8 ft[d]

Percent of reservoir $\leq$5 m (16 ft) deep at normal maximum pool: 58

Theoretical average hydraulic retention time[e]: 9 days

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a. TRM = Tennessee River mile

b. Ratio of reservoir shoreline length at average pool to circumference of a circle with equal area.

c. Includes dewatering projects.

d. Apparent discrepancy reflects draining of shallow overbank areas at minimum pool.

e. Assuming 49,500 cfs and pool elevation 553 msl.

Hydrologic Characteristics

During normal operation of Guntersville and Wheeler Dams, flow in the riverine section of the reservoir upstream from Decatur is turbulent and has velocities ranging from 0.8 to 2.0 feet per second (fps) (TVA 1983). Velocities in the lacustrine portion of the reservoir downstream from BFN at TRM 294.0 are about 0.1 to 0.15 fps, and velocities in the overbank areas near BFN are about 0.24 to 0.4 fps. Flows in the main channel can be well defined, and during times of heavy rainfall and runoff, entrainment of turbid overbank water into the clearer, deeper main channel is evident (Cox 1990).

Average monthly discharges from Wheeler Dam vary from a high of 78,000 cfs in March to a low of 32,400 cfs in September (figure 3). The estimated average unregulated flow is 49,500. On average, 83 percent of the total inflow of Wheeler Reservoir originates as discharges from Guntersville Dam and 17 percent originates from local tributaries. Guntersville's average contribution to the total inflow to Wheeler varies from a low of 74 percent in March to a high of 90 percent in September. The estimated natural 7Q10 of the Tennessee River is 6,630 cfs at Guntersville Dam and 7,570 cfs at Wheeler Dam.

In January 1990, TVA issued a draft environmental impact statement addressing the Tennessee River and Reservoir System Operation and Planning Review (TVA 1990). In that document, TVA proposes to delay summer drawdown in ten tributary reservoirs to enhance their recreational use, and to provide minimum flows at critical points within the TVA system. If that proposal is implemented, typical flow conditions in Wheeler Reservoir are expected to change. Actual flow projections will depend on the specific operational constraints and objectives throughout the TVA system, but in general, maintaining higher pool elevations in the tributary reservoirs during the summer months would result in decreased weekly average flows through the mainstem Tennessee River reservoirs, including Wheeler Reservoir. For instance, preliminary analyses indicate that maintaining the tributary reservoirs at recreational pool elevation through the end of July would decrease the 90th percentile for average weekly flows at Wheeler Dam from 16,000 cfs to 12,000 cfs in May; from 26,500 cfs to 17,000 cfs in June; and from 27,000 cfs to 19,000 cfs in July (personal communication, J. Ruane, Water Quality Department, TVA). Decreases in average daily flow could be even more marked as the hydropower system is operated for peaking with less flow available throughout the system. However TVA would guarantee minimum flows necessary for operation of BFN: 10,000 cfs daily average for July through September; 8,000 cfs for December through February; and 5,000 cfs March through June and October through November (Cox 1990).

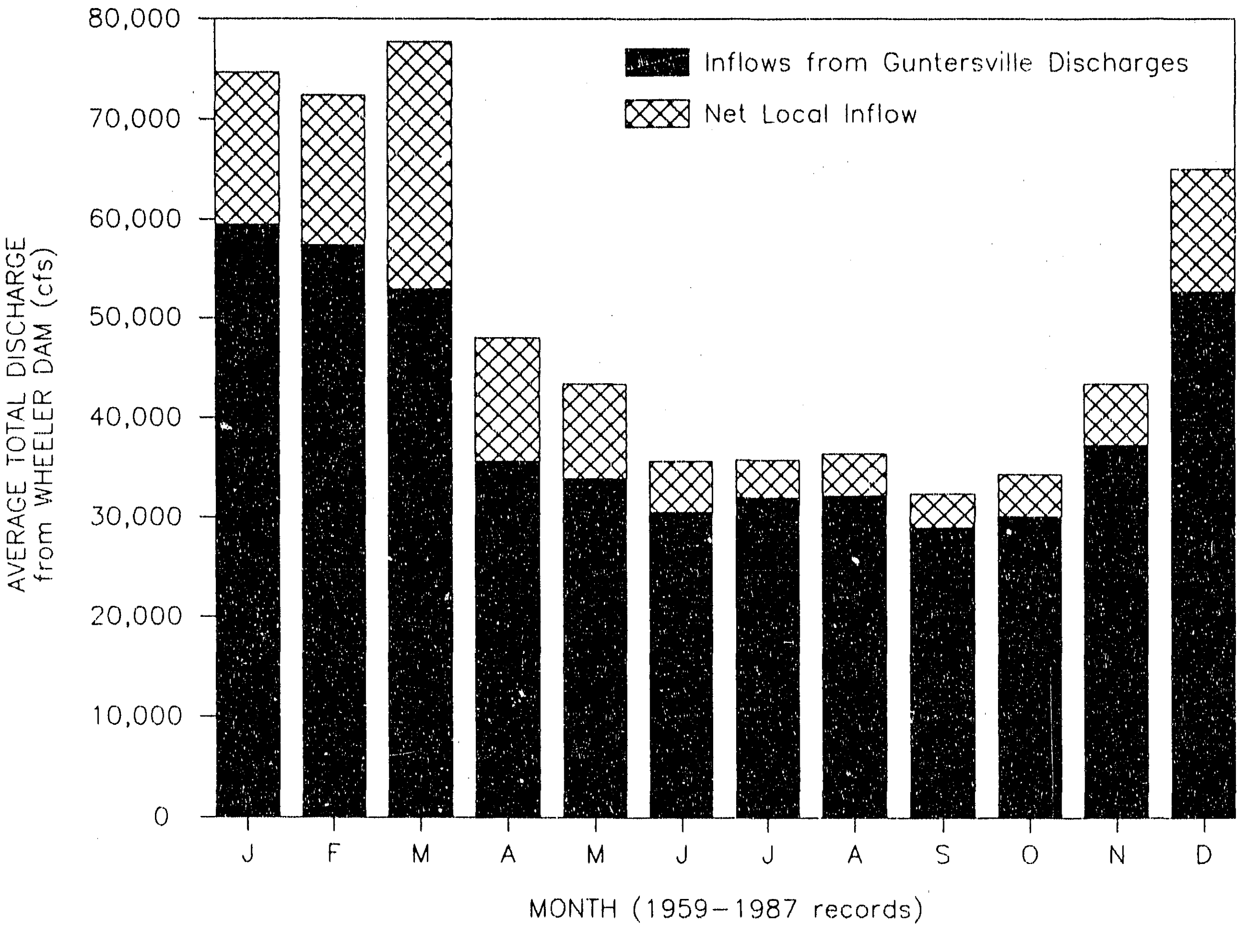

Figure 3. Long–Term Average Monthly Inflows and Discharges from Wheeler Reservoir, by Month

WATER QUALITY CONDITIONS

Status of Database

The most extensive source of water quality data for Wheeler Reservoir is preoperational and operational monitoring conducted by TVA in support of operation of the BFN at Tennessee River mile (TRM) 294. Quarterly sample sites for that work extend from the forebay at TRM 278 upstream to Decatur at TRM 307.5. There are essentially no recent TVA data for the upstream reach of the reservoir. In 1990, TVA initiated a systemwide monthly reservoir "Vital Signs" monitoring project that includes two sites in Wheeler Reservoir (TRMs 307.5 and 277). Data from that project will be incorporated into future Wheeler Reservoir status reports. At present there are no Alabama Department of Environmental Management (ADEM) or U.S. Geological Survey (USGS) ambient water quality monitoring sites in Wheeler Reservoir.

The reservoir water quality database available for the period 1985 to the present is essentially restricted to the following elements:

1. Until January 1990, TVA monitored temperature and dissolved oxygen (DO) of Guntersville and Wheeler Dam discharges biweekly from May through October, then monthly for the remainder of the year. Monitoring of the discharges for other parameters has been conducted only sporadically in recent years.

2. Champion International at Courtland, Alabama, collects weekly data from May through November at eight reservoir stations from TRM 286.2 to TRM 276. Parameters collected at 5-ft depth include pH, DO, biochemical oxygen demand (BOD_5), temperature, and apparent color.

3. TVA conducted intensive monitoring for fecal coliform concentrations at seven recreation sites on the reservoir in 1986, and at ten sites in 1990.

4. In May and August, 1989, ADEM sampled five stations on Wheeler Reservoir as part of the Alabama Lake Water Quality Assessment as required by Section 314(a)(1) of the Water Quality Act of 1987. The data include temperature, DO, conductivity and pH profiles, nutrients, turbidity, suspended solids, Secchi depth, total organic carbon, and chlorophyll a.

5. During drought conditions in the summer of 1988, TVA conducted approximately weekly temperature, DO, and pH profiles in Wheeler Reservoir forebay (TRM 275.1), Elk River embayment (Elk River mile 2.7), and Spring Creek embayment (Spring Creek mile 1.5).

6. Water treatment plants withdrawing water from the reservoir normally sample daily (or even hourly, in some cases) for raw water quality parameters that affect treatment, including pH, alkalinity, carbon dioxide, temperature, and turbidity. Huntsville Utilities also samples raw water on an approximately monthly basis for several dozen organic and inorganic parameters listed in the Safe Drinking Water Act.

7. Since 1981, routine reservoir water quality monitoring in support of operation of the BFN has been limited to temperature measurements. However, TVA conducted a special short-term water quality/ phytoplankton study in the vicinity of the plant in September 1989.

Physical and Chemical Characteristics

Temperature and Dissolved Oxygen Patterns

Under normal flow conditions, the riverine section of Wheeler Reservoir tends to be fully mixed with intermittent periods of thermal stratification lasting only hours or a few days (TVA 1983). The lacustrine section of the reservoir sometimes exhibits thermal stratification with as much as a 10 F gradient top to bottom, but under normal flow conditions such periods are generally short-lived and restricted to the spring when surface waters are rapidly warming while inflow temperatures remain low. Stable stratification during the summer is normally precluded by warm inflows, short retention time, and turbine intake withdrawals from essentially the entire vertical depth of the forebay.

Although thermal stratification is weak and infrequent, DO concentrations in Wheeler Reservoir are sometimes marginal even under normal flow conditions. In August 1980, TVA documented DO concentrations in the 5 to 6 mg/l range at all depths from mid-reservoir to forebay although average daily discharge was nearly 30,000 cfs (Cox et al. 1990). Similar DO conditions were noted in ADEM's August 1989 survey near TRMs 298, 305, and 321 (ADEM 1989) (figure 4). Environmental staff at Champion International have noted that during the summer, DO concentrations generally improve later in the day, presumably due to phytoplankton photosynthetic activity and unsteady flows associated with power production at Guntersville and Wheeler Dams in response to peak demand.

During low flow (daily average discharge <10,000 cfs) conditions in the summer of 1988, the thermal gradient in the forebay was relatively weak, but there was a strong and persistent decline in DO with depth (figure 5). Although the surface waters were often supersaturated with oxygen, DO concentrations below 5 mg/l occurred at depths as shallow as 20 feet. For several weeks during the summer of 1988, surface water temperatures in the forebay exceeded Alabama's water quality criterion of 86° (30°C). Surface water temperatures of up to 30°C have been noted under more typical flow conditions as well.

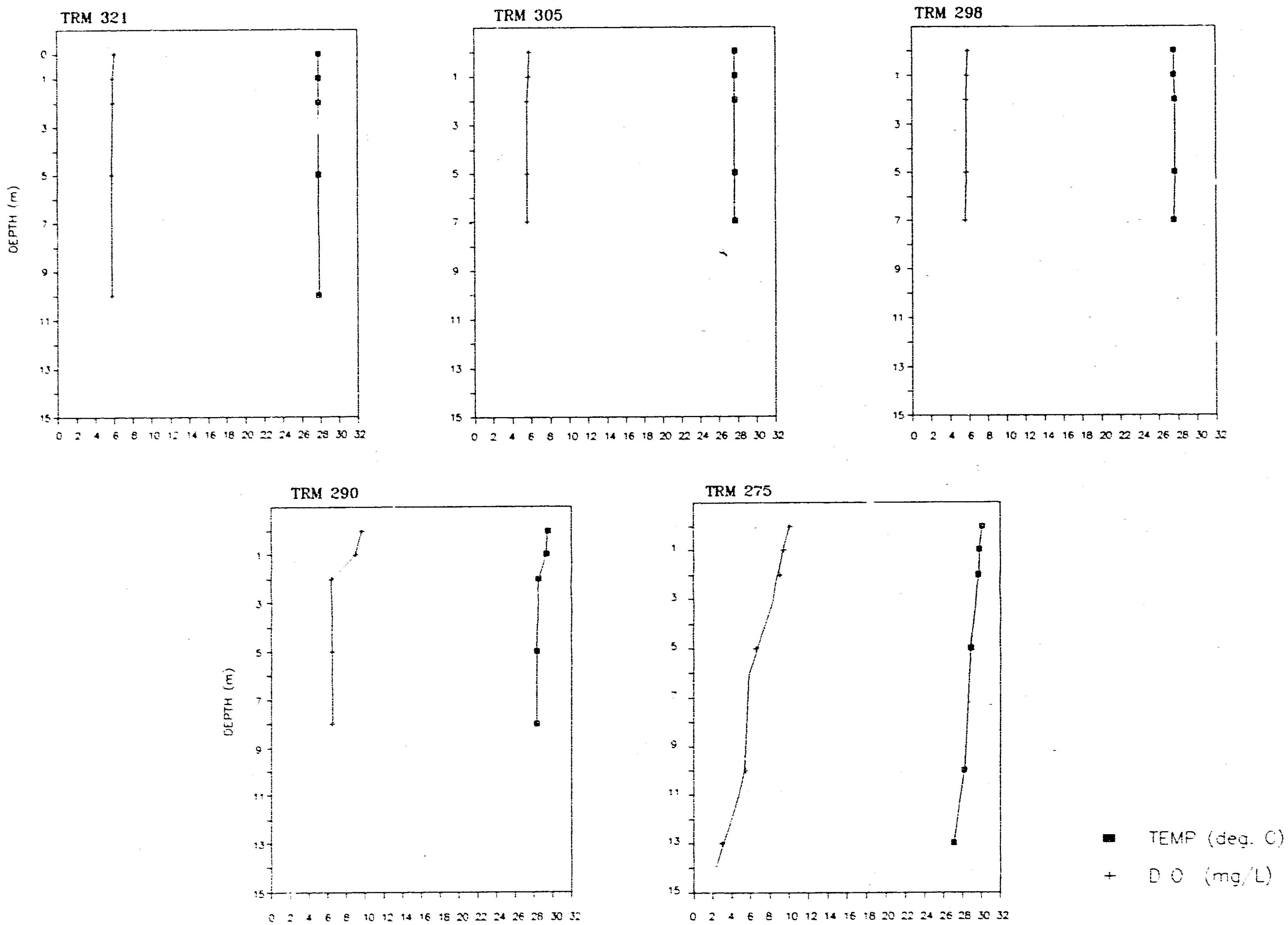

FIGURE 4. Temperature and DO Profiles in Wheeler Reservoir
August 1, 1989 (ADEM, 1989)

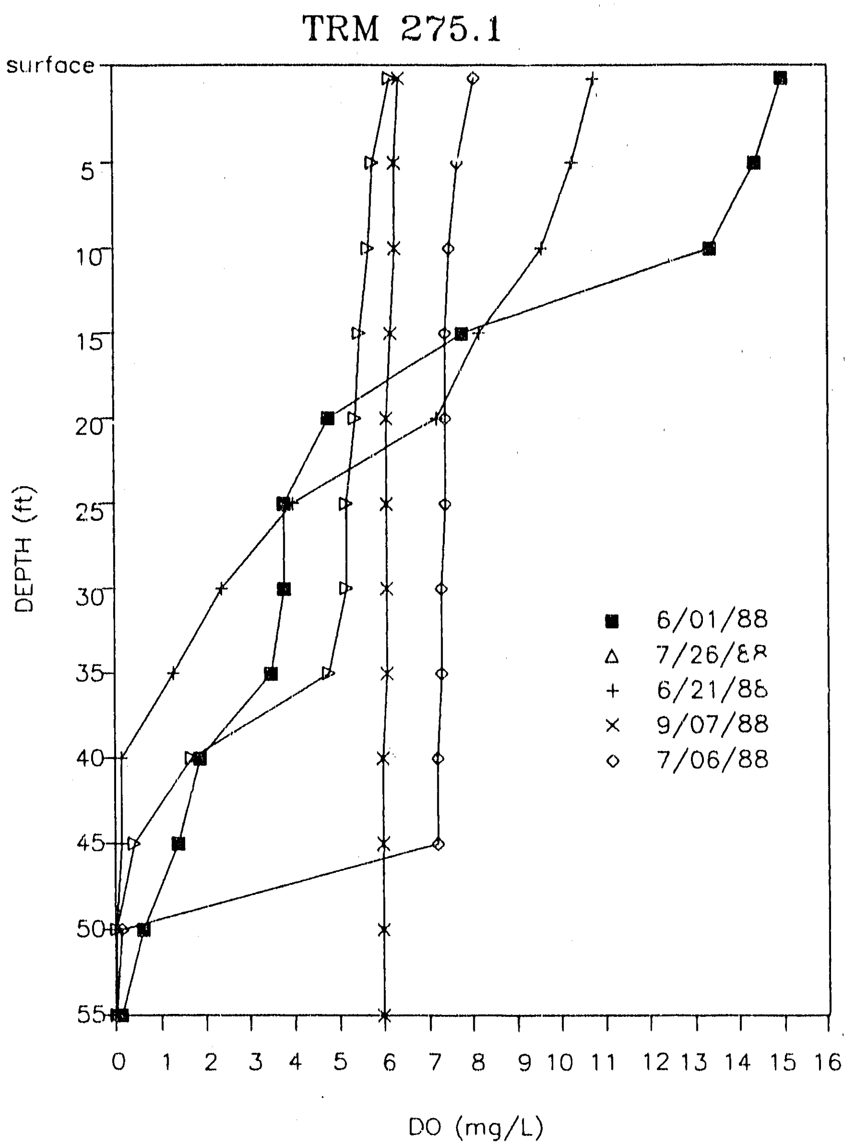

Figure 5. DO profiles in Wheeler Reservoir forebay in 1988

Studies near BFN indicate temperatures in overbank areas tend to b: similar to temperatures in the main channel, although the overbanks are more responsive to changing meteorologic conditions. There are relatively few temperature and DO profiles available for embayment areas. During the summer 1988 drought study, profiles made at Elk River mile 2.7 showed only a slight thermal gradient but a strong DO gradient with DO concentrations less than 5 mg/l at depths as shallow as 10 feet. Profiles in Spring Creek embayment at mile 1.5 showed a stronger thermal gradient but slightly less marked declines in DO with depth.

BOD_5 and Total Organic Carbon (TOC)

Essentially all the recent BOD_5 data available have been collected by Champion International, which collects weekly data from May through November. Champion's instream monitoring data from 1989 show mean values for BOD_5 ranging from a low of 1.5 mg/l at TRM 286.2 (upstream from the discharge) to a high of 3.5 in the mouth of the Elk River (also upstream from the discharge (table 3). The ranges in the Champion data indicate marked variations in BOD_5 at all stations.

Until 1981, TVA collected quarterly BOD_5 data at several sites between TRMs 295.9 and 283.9 in support of BFN operations. Mean values were similar to values for Champion's upstream station, and the ranges in the TVA data also indicate a great deal of variability at each station (table 3). Mean TOC values were within the range commonly seen in TVA reservoirs, although individual values occasionally exceeded 9 mg/l.

Anomalously high TOC values were recorded by ADEM in their survey in May 1989 (table 3). Values in August 1989 samples were much lower, but were still in the upper end of the range of values collected by TVA.

TVA's Vital Signs monitoring in Wheeler Reservoir will not include measurement of BOD_5, but will include both total and dissolved organic carbon.

Alkalinity, Hardness, and pH

Wheeler Reservoir waters range from slightly soft to moderately hard, and are well buffered to a typical pH of 7.5. High pH values (i.e., >9.0) occur occasionally, and are probably attributable to photosynthetic activity of phytoplankton and macrophytes.

Turbidity, Total Nonfiltrable Residue, Secchi Depth, and Color

Light penetration in Wheeler Reservoir is relatively shallow, as is the case in most of TVA's mainstem reservoirs. Total nonfiltrable residue

Table 3. BOD_5 and total organic carbon (TOC) data for Wheeler Reservoir.

	BOD_5 (mg/l)			TOC (mg/l)		
Station	Mean	Range	N	Mean	Range	N
TRM 295.87[a]	1.4	<1.0–2.8	60	[illegible].7	0.9–9.6	80
TRM 291.76[a]	1.5	<1.0–8.2	109	2.9	0.9–9.4	125
TRM 283.94[a]	1.6	<1.0–5.4	246	3.0	0.4–8.8	237
TRM 286.2[b]	1.6	0.6–4.2	26	N/C[d]	–	–
TRM 283.0[b]	2.5	1.1–4.5	26	N/C	–	–
TRM 282.0[b]	2.4	1.0–5.0	26	N/C	–	–
TRM 281.5[b]	2.5	0.7–6.0	26	N/C	–	–
TRM 280.0[b]	2.3	1.0–4.6	26	N/C	–	–
TRM 278.0[b]	2.4	0.9–3.7	26	N/C	–	–
Elk River at TRM 284.3[b]	3.5	0.6–7.2	25	N/C	–	–
TRM 276.0[b]	2.5	1.2–4.5	26	N/C	–	–
TRM 321[c]	N/C	–	–	17.3	8.03–26.63	2
TRM 305[c]	N/C	–	–	18.1	8.72–27.46	2
TRM 298[c]	N/C	–	–	24.7	10.20–39.11	2
TRM 290[c]	N/C	–	–	16.0	11.24–20.77	2
TRM 275[c]	N/C	–	–	21.7	6.45–39.16	4

a. TVA data, 1975–81.

b. Champion International data, 1989.

c. ADEM data, 1989.

d. N/C = not collected.

(TNFR) and turbidity values average about 10 mg/l and 10 JTU, respectively, but TNFR values greater than 200 mg/l and turbidity values greater than 100 JTU occur occasionally (table 4). There are relatively few recent measurements of Secchi depth available, but values exceeding 2.0 meter are relatively uncommon. Weekly Secchi depth measurements in Wheeler forebay during drought sampling in 1988 were atypical: the mean value between April and November was 1.5 m and several values were 3 m or greater (Cox 1990). Values recorded by ADEM during the summer of 1989 were more similar to historical data (table 4).

True color measurements from TVA's operational monitoring for BFN indicate levels that would be barely noticeable to a casual observer but that could require treatment before some sensitive industrial uses (textiles, food processing, etc.). Apparent color data are available from both Champion's instream monitoring and TVA's operational monitoring for BFN. The Champion 1989 data show a significant amount of apparent color both upstream and downstream from their discharge, with a maximum in the Elk River embayment.

Major Dissolved Constituents

Conductivity in Wheeler Reservoir waters is moderate, with values averaging 170 μmhos/cm. Calcium is the predominant cation (mean 20 mg/l), followed by sodium (mean 5.5 mg/l), silica (mean 4.4 mg/l), magnesium (mean 3.8 mg/l), and potassium (mean 1.3 mg/l). Carbonate and bicarbonate dominate the anions (mean alkalinity 50 mg/l); sulfate averages 13 mg/l, and chloride averages 6.8 mg/l.

Nutrients

Total nitrogen concentrations in Wheeler Reservoir near BFN are typically in the range of 0.5 to 0.6 mg/l, although ADEM (1989) reports NO_3-N concentrations averaged 1.47 mg/l for their two sampling dates in 1989 (table 5). The nitrate plus nitrite fraction normally comprises about half the total nitrogen. Based on the limited data available, nitrogen concentrations in the Elk River inflow to Wheeler may be substantially higher than concentrations in the main body of the reservoir. Total phosphorus concentrations in the main body of Wheeler Reservoir are typically 0.03 to 0.04 mg/l, and the limited data available indicate the dissolved ortho-phosphate component of the total is always above the detection limit of 0.01 mg/l. Phosphorus concentrations in the Elk River inflow to the reservoir, like nitrogen concentrations, appear to be higher than typically found in the main body of the reservoir. ADEM (1989) reports total phosphorus averaged 0.09 mg/l for the two sampling dates in 1989 with individual values as high as 0.143 mg/l.

Nutrient concentrations in Wheeler Reservoir waters are unlikely to be limiting to either algal or macrophyte growth.

Table 4. Summary of data on factors limiting light penetration in Wheeler Reservoir.

Station	Apparent color (Pt-Co U)			True color (Pt-Co U)			Total nonfiltrable residue (mg/l)			Turbidity[d] (JTU)			Secchi depth (m)		
	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range	N
TRM 295.87[a]	26	12-58	54	11	1-25	58	8	<1-27	59	9	2-22	53	0.95	0.9-1.0	2
TRM 291.76[a]	30	9-220	100	12	5-55	104	13	1-340	104	11	2-120	95	0.73	0.7-0.75	2
TRM 283.94[a]	30	8-220	271	11	3-28	275	16	<1-210	281	16	1-130	222	0.95	0.9-1.0	2
TRM 286.2[b]	124	59-186	26	N/C	-	-	9	2-17	26	N/C	-	-	N/C	-	-
TRM 283.0[b]	109	8-186	26	N/C	-	-	-	-	-	N/C	-	-	N/C	-	-
TRM 282.0[b]	113	44-186	26	N/C	-	-	7	2-12	26	N/C	-	-	N/C	-	-
TRM 281.5[b]	116	44-186	26	N/C	-	-	7	2-13	26	N/C	-	-	N/C	-	-
TRM 280.0[b]	109	49-186	26	N/C	-	-	6	2-12	26	N/C	-	-	N/C	-	-
TRM 278.0[b]	110	54-196	26	N/C	-	-	6	2-11	26	N/C	-	-	N/C	-	-
Elk River at TRM 284.3[b]	207	98-999	25	N/C	-	-	15	4-57	26	N/C	-	-	N/C	-	-
TRM 276.0[b]	106	35-243	26	N/C	-	-	6	0-17	26	N/C	-	-	N/C	-	-
TRM 321[c]	N/C	-	-	N/C	-	-	5.0	3.0-7.0	2	4.7	3.2-6.2	2	1.9	1.75-2.09	2
TRM 305[c]	N/C	-	-	N/C	-	-	4.6	2.8-6.3	2	2.9	2.8-3.0	2	1.8	1.61-2.00	2
TRM 298[c]	N/C	-	-	N/C	-	-	9.4	4.5-14.3	2	8.0	6.2-9.8	2	1.0	0.79-1.19	2
TRM 290[c]	N/C	-	-	N/C	-	-	6.3	4-8.5	2	4.6	4.2-4.9	2	1.1	0.91-1.37	2
TRM 275[c]	N/C	-	-	N/C	-	-	2.0	0-3.5	4	2.3	1.9-2.6	2	2.0	1.83-2.22	4

a. TVA data, 1975-81.

b. Champion International data, 1989.

c. ADEM data, 1989.

d. Units are JTU for TVA data, NTU for ADEM data.

Table 5. Nutrient data for Wheeler Reservoir collected by TVA since 1975.

Parameter (mg/l)		Guntersville discharge (inflow)	TRM 307.52 (mid-reservoir)	Elk River mile 20.55 (inflow to Elk River embayment)	TRM 277.98 (forebay)	Wheeler discharge (outflow)
Organic N	mean	0.23	0.14	0.19	0.16	0.31
	range	0.08–0.66	<0.01–0.52	<0.01–0.51	0.04–0.38	0.13–0.65
	no. obs.	4	69	9	69	4
NH_3+NH_4–N	mean	0.065	0.08	0.06	0.06	0.11
	range	0.05–0.08	<0.01–0.41	0.01–0.13	<0.01–0.21	0.06–0.16
	no. obs.	4	70	9	70	7
NO_2+NO_3–N	mean	0.24	0.37	0.75	0.35	0.20
	range	0.02–0.73	0.11–0.68	0.03–1.10	0.01–1.00	0.02–0.75
	no. obs.	13	70	9	70	18
Mean total N (calculated)		0.54	0.59	1.0	0.57	0.62
Total P	mean	0.07	0.03	0.23	0.04	0.05
	range	<0.01–0.56	0.01–0.80	0.06–0.62	0.01–0.13	<0.01–0.08
	no. obs.	13	69	9	70	18
Dissolved ortho-P	mean	0.03	N/C	0.12	N/C	0.045
	range	<0.01–0.05	–	0.01–0.24	–	0.04–0.05
	no. obs.	4	–	8	–	2

Trace Inorganic Constituents

Data on trace inorganic constituents collected during monitoring activities for BFN from 1975-81 are summarized in table 6. Most of the means are well below levels of concern.

Mean concentrations of lead exceed the EPA and Alabama water quality criterion for protection of aquatic life from chronic toxicity, while mean concentrations of copper exceed the EPA and Alabama water quality criteria for protection of aquatic life from both acute and chronic toxicity. Because the available data are for total (particulate plus dissolved) metal concentrations, exceedance of the criteria does not necessarily indicate any significant toxicity in situ.

Calculated mean concentrations of mercury exceed the EPA and Alabama water quality criterion for protection of aquatic life from chronic toxicity and calculated mean concentrations of silver exceed the EPA and Alabama instantaneous water quality criterion for protection of aquatic life. However, the calculated means are biased upward by many values actually below the analytical detection limit.[1]

Mean in-reservoir arsenic concentrations are significantly less than the Alabama water quality criterion for protection of aquatic life (190 µg/l, chronic trivalent arsenic) and the National Interim Primary Drinking Water Regulation value of 50 µg/l, but they are significantly higher than the 22 nanogram/l drinking water concentration corresponding to a lifetime incremental cancer risk level of 10^{-5}.[2] Mean in-reservoir beryllium concentrations are less than concentrations generally considered toxic to aquatic life, but they are significantly higher than th 68 nanogram/l drinking water concentration corresponding to a lifetime incremental cancer risk level of 10^{-5}.[3]

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1. In calculation of means, the STORET program assumes values less than the detection limit are equal to the detection limit. Therefore, when several individual values are below detectable levels, calculated means are significantly biased.

2. Arsenic is an EPA Group A carcinogen (i.e., sufficient evidence of human carcinogenicity from epidemiologic studies). No Maximum Contaminant Level (MCL) has yet been established for arsenic, but the Maximum Contaminant Level Goal (MCLG) is zero. ADEM has proposed promulgation of human health criteria for water quality at the 10^{-5} incremental lifetime cancer risk level.

3. Beryllium is an EPA Group B2 carcinogen (i.e., sufficient evidence in animals, inadequate data in humans) with an MCLG of zero and a tentative MCL of 1 µg/l. ADEM has proposed promulgation of human health criteria for water quality at the 10^{-5} incremental lifetime cancer risk level.

Table 6. Trace inorganic constituent data for Wheeler Reservoir collected by TVA during the period 1975-81.

Parameter	TRM 283.94			TRM 291.76			TRM 295.87		
	Mean	Range	N	Mean	Range	N	Mean	Range	N
Aluminum, µg/l	577	78-8,100	196	612	<100-10,000	101	487	<100-1200	54
Arsenic, µg/l[a]	3.1	<2-15	196	3.0	1-12	100	3.1	<1-8	54
Barium, µg/l[a]	107	21-370	195	105	23-310	101	113	23-370	54
Boron, µg/l	74.3	8-500	154	71.5	9-250	84	81.6	9-460	42
Cadmium, µg/l[a]	0.89	<0.1-2	188	0.98	<0.1-9.0	100	0.88	<0.1-2	54
Chromium, µg/l[a]	4.9	<1-50	188	4.7	1-29	101	4.5	1-12	54
Copper, µg/l	28.3	<1-350	188	28	<1-490	101	58.4	<1-1,400	53
Total iron, µg/l	616	48-18,000	196	675	80-12,000	101	425	<50-1,100	54
Dissolved iron, µg/l[a]	64	<5-280	189	65	9-270	96	68	12-320	52
Lead, µg/l[a]	9.0	<1-28	188	9.4	<1-26	101	9.8	<1-53	54
Total manganese, µg/l	68	<10-2,900	196	63	<10-1,000	101	49	10-140	53
Dissolved manganese, µg/l[a]	28	<5-1,600	189	12	<5-50	96	15	<5-100	51
Nickel, µg/l[a]	43	<10-<100	188	43	<10-100	101	44	<10-<100	53
Silver, µg/l[a]	10.2	<10-20	195	10.4	<10-20	101	10.6	<10-30	54
Zinc, µg/l	29	<5-250	196	31	<5-300	101	44	<5-470	53
Lithium, µg/l[a]	<10	<10	154	10.2	<10-20	86	<10	<10	44
Selenium, µg/l[a]	1.2	<1-2	188	1.2	<1-2	101	1.8	<1-30	54
Titanium, µg/l[a]	746	<5-<1,000	154	740	<5-<1,000	86	763	<5-<1,000	43
Mercury, µg/l[a]	0.22	<0.2-1.6	194	0.24	<0.2-1.4	101	0.28	<0.2-3.0	54
Beryllium, µg/l[a]	9.0	<0.5-10	196	8.9	<0.5-<10	101	8.9	<0.5-<10	54

a. In calculation of means, the STORET program assumes values less than the detection limit are equal to the detection limit. Therefore, calculated means for these parameters are biased because most values were below detectable levels. Detectable levels for individual parameters varied during the reported period.

In the absence of any information on how well conventional treatment processes would remove the arsenic and beryllium in raw water from Wheeler Reservoir, no particular significance can be assigned to these values.

Toxic Organics

Data indicating DDT, PCB, and dioxin contamination of the Wheeler Reservoir fishery are available. The extent and ramifications of this contamination are discussed in the Use Impairments section of this report.

Radiological Characteristics

TVA monitors radioactivity levels in reservoir water, commercial and game fish tissue, *Corbicula* tissue, and bottom sediment from Wheeler Reservoir in the area of BFN. Radioactivity levels in water, fish, and *Corbicula* are consistent with background (either naturally occurring or levels commonly found throughout the environment as a result of atmospheric fallout from historical nuclear weapons testing (TVA 1989).

Small amounts of Cs-137, Co-60, and Cs-134 have been identified in sediment samples downstream from BFN, but the activities encountered would result in no measurable increase over background in the dose to the general public (TVA 1989).

Sediment Quality

TVA sampled sediment from Wheeler Reservoir forebay at TRM 275.0 in 1982 and at TRM 275.1 in 1984 for analysis of particle size distribution and concentrations of metals and PCBs. The results of analyses of the top three centimeters of sediment cores are shown in table 7. Except for beryllium, all values for Wheeler Reservoir sediments were within the range of values seen in the other eight mainstem Tennessee River reservoirs. With the exception of manganese, values for Wheeler Reservoir sediments did not exceed the range of values reported by Forstner and Wittmann (1983) for 87 remote lakes.

TVA will be collecting sediments for analysis again in 1990 as part of the reservoir Vital Signs monitoring project.

Bacteriological Water Quality

TVA conducted intensive (10 samples within 30 days) monitoring for fecal coliform concentrations at seven sites in Wheeler Reservoir in 1986 (table 8). Although high (>1000/100 ml) values were noted sporadically

Table 7. Sediment data for Wheeler Reservoir forebay.

Parameter	Wheeler Reservoir TRM 275.1	Wheeler Reservoir TRM 275.0	Range of values for the other eight mainstem Tennessee River reservoirs
Clay (<2 μ)	N/C	74.7%	24.7-83.0%
Silt (2-63 μ)	N/C	24.9%	14.6-40.8%
Sand (63 μ-2 mm)	N/C	0.4%	0-44.9%
Gravel (>2 mm)	N/C	0.0%	0-6.0%
Iron	N/C	43,000 ppm	26,000-46,000 ppm
Manganese	N/C	2,400 ppm	1,500-4,900 ppm
Zinc	150 ppm	240 ppm	87-500 ppm
Lead	48 ppm	52 ppm	25-77 ppm
Copper	34 ppm	41 ppm	14-63 ppm
Chromium	32 ppm	35 ppm	17-50 ppm
Nickel	25 ppm	30 ppm	14-30 ppm
Arsenic	12 ppm	12 ppm	6-16 ppm
Beryllium	2.0 ppm	1.4 ppm	<1-1.9 ppm
Selenium	0.44 ppm	0.5 ppm	<0.2-0.9 ppm
Mercury	0.12 ppm	0.22 ppm	0.10-0.77 ppm
Cadmium	<0.5 ppm	<1 ppm	<1 ppm
Silver	<1 ppm	<1 ppm	<1 ppm
PCBs	0.23 ppm	<1 ppm	<1 ppm

Table 8. Fecal coliform data collected in Wheeler Reservoir by TVA in 1986 and 1990.

Site	Date	Geometric mean (number/100 ml)	Maximum (number/100 ml)
Joe Wheeler State Park			
TRM 277.0	June 1986	24	124
Beach	May-June 1990	12	82
Marina	May-June 1990	11	64
Lauderdale County Park			
Elk River mile 5.0	June 1986	18	92
Round Island Recreation Area			
TRM 298.0	June 1986	24	330
TRM 297.2	May-June 1990	22	690
Madison County Park			
Hobbs Island	June 1986	54	120
TRM 334.5[a]	May-June 1990	26	530
Ditto Landing Marina			
TRM 333.7[a]	May-June 1990	19	45
Decatur Boat Harbor	June 1986	155	2160
TRM 305.0	July 1986	19	70
Point Mallard Park			
Flint Creek Embayment			
opposite TRM 308.5[a]	June 1986	49	1440
Flint Creek mile 2.0[a]	May-June 1990	59	1400
Mallard Creek			
opposite TRM 298.8	June 1986	24	90
Mallard Creek mile 0.8[a]	May-June 1990	8	18
Limestone County Park			
TRM 286.7	May-June 1990	29	220
Sharps Ford Bridge			
Cotaco Creek mile 1.85	May-June 1990	115	2300
Grantland Bridge			
Cotaco Creek mile 6.07	May-June 1990	212	7500

a. Site is not classified for whole body contact recreation.

at Decatur Boat Harbor (TRM 305.0) and Point Mallard Park (TRM 308.5), none of the sites exceeded the Alabama water quality criterion for waters classified for body contact recreation (geometric mean of ≤200/100 ml). However, because these data were collected under drought conditions, it was not clear how well they might reflect more typical flow or runoff conditions.

TVA repeated intensive (12 samples within 24 days) monitoring for fecal coliform concentrations at ten sites in Wheeler Reservoir and its tributaries in 1990 (table 8). Two of the twelve samples were collected following rainfall. With the exception of Grantland Bridge at Cotaco Creek mile 6.1, all sites met Alabama's geometric mean criterion. However, high (>1000/100 ml) values were noted sporadically at Point Mallard Park and at Sharps Ford Bridge on Cotaco Creek. At all ten sites, fecal coliform concentrations following rainfall were greater than during baseline conditions. These differences were marked (tenfold or greater) at the Round Island Creek, Point Mallard Park, Madison County Boat Harbor, and Cotaco Creek sites.

Trophic Status

Eutrophication in the TVA mainstem reservoirs results in abundant production of macrophytes and floating algal mats along shorelines, and in abundant phytoplankton in the main channel. Nitrogen and phosphorus are generally present in excess of demand and do not limit production. Growth of macrophytes and associated floating algal mats is controlled primarily by availability of substrate, light penetration, pool elevation fluctuation, and herbicide application. Phytoplankton growth in the main channel is limited primarily by shallow light penetration relative to the mixed depth and by hydraulic washout.

Placke (1983) devised a trophic state index specifically for use on the TVA mainstem reservoirs that incorporated the following variables: mean summer chlorophyll a, percent of reservoir surface area with macrophyte or algal mat infestation, reservoir retention time, Secchi depth, percent of reservoir surface area with depth less than five feet at full pool, and mean annual pool drawdown. Using that index, Wheeler Reservoir was ranked the second most eutrophic of the mainstem Tennessee River reservoirs, preceded only by Guntersville Reservoir. Macrophyte infestation has presumably changed more in the past several years than any of the other variables used to calculate the 1983 index values. Recalculating index values incorporating macrophyte infestation data from 1987 does not change Wheeler's rank as second most eutrophic (Cox 1990).

Reservoir Releases

TVA monitors temperature and DO of Guntersville and Wheeler Dam discharges biweekly during May through October, then monthly for the remainder of the year. Dissolved oxygen in Guntersville Dam discharges (the principal inflow to Wheeler Reservoir) seldom falls below 5 mg/l (table 9). However, Wheeler discharge DO drops below 5 mg/l for an average of several weeks per year.

Monitoring of Wheeler and Guntersville discharges for other parameters has been conducted only sporadically in recent years. A summary of discharge water quality data over the period of record is given in table 10.

Table 9. Historical dissolved oxygen of discharges from Wheeler and Guntersville Reservoirs.

	Wheeler		Guntersville	
Year[a]	Weeks <5 mg/l	Minimum mg/l	Weeks <5 mg/l	Minimum mg/l
1975	0	5.0	0	6.0
1985	4	3.7	0	5.5
1986	10	3.2	3	4.5
1987	2	4.1	0	6.4
1988	1	4.4	1	4.4
1989	0	5.5	0	6.4

a. Data collected from 1976-84 is considered by TVA to be invalid due to problems with sample bottles.

Table 10. Water quality summary of discharges from Gunterville and Wheeler Reservoirs, 1980-89.

	Guntersville Dam discharge			Wheeler Dam discharge		
	Mean	Range	Number of observations	Mean	Range	Number of observations
Instantaneous streamflow, cfs	38,374	0-162,000	381	48,676	0-296,200	389
Turbidity, JTU	6.5	4.2-7.9	4	7.2	3.8-17.0	6
Color, Pt-Co U	10.3	4-14	4	12.6	6-21	9
Conductivity, µmhos/cm	177	77-223	28	204	79-236	29
Dissolved oxygen, mg/l	7.8	3.2-13.6	383	7.3	2.6-14.8	397
BOD_5, mg/l	1.5	<1.0-2.5	4	1.8	1.0-2.8	7
BOD_{20}, mg/l	-	-	-	3.2	2.9-3.7	4
pH, s.u.	7.6	7.2-8.1	32	7.3	6.6-8.1	36
Total alkalinity, mg/l	61	50-86	4	55.4	50-61	8
Total hardness, mg/l	58.8	54-62	4	66.6	59-77	7
Organic nitrogen, mg/l	0.23	0.08-0.66	4	0.31	0.13-0.65	4
NH_3+NH_4-N, mg/l	0.065	0.05-0.08	4	0.11	0.06-0.16	7
NO_2+NO_3-N, mg/l	0.24	0.02-0.73	13	0.20	0.02-0.75	18
Total phosphorus, mg/l	0.07	<0.01-0.56	13	0.05	<0.01-0.08	18
Dissolved ortho-phosphorus, mg/l	0.03	<0.01-0.05	4	0.045	0.04-0.05	2
Chloride, mg/l	5.0	4-6	4	6.3	5-9	7
Sulfate, mg/l	11.8	10-13	4	12.6	10-14	7
Total cadmium, µg/l	0.80	0.2-1	4	0.48	<0.1-1.0	5
Total chromium, µg/l	-	-	-	<1	-	1
Total copper, µg/l	12.5	10-20	4	13	<5-20	5
Total iron, µg/l	-	-	-	320	-	1
Dissolved iron, µg/l	115	60-200	4	75	<50-130	4
Total lead, µg/l	13.5	2-32	4	5.2	<1-10	5
Total manganese, µg/l	-	-	-	72	-	1
Dissolved manganese, µg/l	35	<10-80	4	37.5	<10-90	4
Total zinc, µg/l	12.5	<10-20	4	35.0	<5-120	5
Total coliforms, number/100 ml	-	-	-	4,501	55-11,000	6
Fecal coliforms, number/100 ml	53	<10-120	4	72	<10-250	5

BIOLOGICAL CONDITIONS

Aquatic Life

Much of the aquatic life information from Wheeler Reservoir has come from studies conducted during and subsequent to the construction, licensing, and permitting of BFN (TRM 294).

Plankton

Diverse communities of both phytoplankton and zooplankton occur in Wheeler Reservoir. Channel plankton communities are normally transported through Wheeler Reservoir in one to two weeks. Residence time in overbank areas is typically longer. Wheeler Reservoir is typical of other mainstream reservoirs in that productivity and abundance of phytoplankton and zooplankton generally increase in pooled downstream areas where velocities are low.

Phytoplankton. Detailed information for eight stations between TRMs 307.5 and 278 is available in the most recent operational monitoring report for BFN (TVA 1981). Because phytoplankton abundance, biomass, and productivity tend to increase in a downstream direction between mid-reservoir and forebay, data on phytoplankton dynamics for the most upstream and downstream stations give an idea of the range of values in the BFN database (table 11). About 50 percent of total abundance values are less than one million cells/liter, and only a relatively few values exceed ten million cells/liter. Primary productivity is at a minimum during winter and increases one to two orders of magnitude during the summer. A similar trend in abundance and biomass is evident, but less marked. Chrysophytes are numerically dominant in winter and spring and sometimes in the fall (figure 6). On average, chlorophyte abundance is 20-30 percent of the total abundance throughout the year. Cyanophytes reach their peak in summer and fall, and are sometimes--but not always--dominant at that time. Mid-reservoir to forebay variations in community composition tend to be of smaller magnitude than year-to-year variations at individual stations.

Both TVA and ADEM collected limited phytoplankton data in Wheeler Reservoir during 1989. The TVA data, which were collected in the BFN area, show moderate chlorophyll levels and low phytoplankton abundance with dominance by Cyanophyta (table 12). The ADEM data, which were collected at five sites along the length of the reservoir in May and August, show some high chlorophyll values with one value (28.2 µg/l) outside the range of historical data (table 13).

Table 11. Summary of mid-reservoir and forebay phytoplankton data collected from Wheeler Reservoir during monitoring at BFN.

Quarter	Location	Primary productivity[a] ($mgC/m^2/day$)		Chlorophyll *a*[b] (µg/l)		Abundance[b] (10^6 cells/l)	
		Mean	Range	Mean	Range	Mean	Range
Winter	TRM 277.98	70	16–304	2.8	0.4–8.4	0.68	0.03–2.40
	TRM 307.52	83	18–446	3.7	0.7–11.1	0.81	0.04–2.74
Spring	TRM 277.98	695	22–2604	5.6	0.0–14.8	2.69	0.11–6.25
	TRM 307.52	198	37–524	2.0	0.3–4.3	0.94	0.65–1.36
Summer	TRM 277.98	3295	1661–5728	12.9	10.6–16.2	16.75	3.95–32.90
	TRM 307.52	529	89–1358	1.3	0–3.8	1.57	0.16–5.07
Fall	TRM 277.98	1332	279–5559	6.2	1.0–14.0	2.82	0.84–5.82
	TRM 307.52	332	16–1534	2.0	0–4.0	1.19	0.19–3.03

a. 1972–1980 TVA data

b. 1973–1980 TVA data

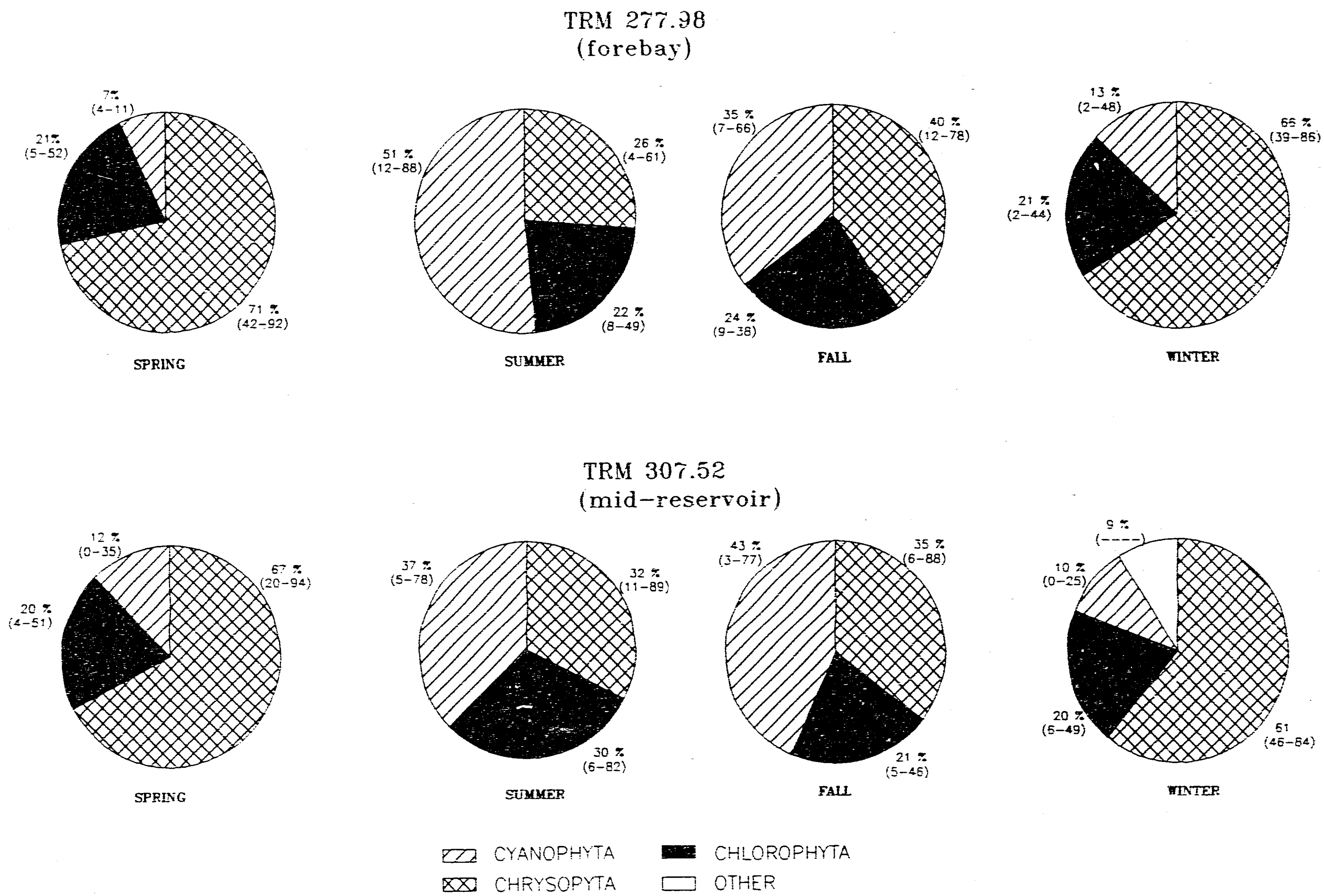


Figure 6. Means and ranges in phytoplankton composition in Wheeler Reservoir during the period 1969 – 1980.

Table 12. Phytoplankton data collected by TVA in a BFN special study, September 1989.

Location	Depth (m)	Chlorophyll, µg/l a	Chlorophyll, µg/l b	Chlorophyll, µg/l c	Total abundance 10^6 cells/l	Dominant division and percent of total
TRM 296, overbank	0–3	4.0	<1	<1	0.04	Cyanophyta (57%)
TRM 296, channel	0–5	4.8	<1	<1		Cyanophyta (60%)
TRM 294	0–7	4.7	<1	<1	0.04	Cyanophyta (58%)
TRM 292.8	0–9	5.6	<1	<1	0.03	Cyanophyta (41%)

Table 13. Chlorophyll data collected in ADEM's 314(a) lake assessment study.

Station[a]	Chlorophyll a µg/l	
	May 3, 1989	August 1, 1989
TRM 275	6.6	9.8
TRM 290	8.0	14.5
TRM 298	28.2	2.2
TRM 305	6.5	0.7
TRM 321	3.6	0.7

a. Surface samples only.

Zooplankton. Zooplankton collections in Wheeler Reservoir between TRMs 307.5 and 278 include 38 cladoceran, 30 copepod, and 59 rotifer species or genera. Zooplankton abundance at individual stations appeared highly variable year to year (table 14), possibly due to the inadequacies of attempting to characterize an extremely dynamic community with a quarterly sampling program. As is apparent in figure 7, differences in community composition between stations can be marked, especially during summer and fall.

Table 14. Summary of mid-reservoir and forebay zooplankton abundance data collected from Wheeler Reservoir during monitoring for BFN, 1974-80.

Quarter	Location	Abundance (organisms/m^3)	
		Mean	Range
Winter	TRM 277.98	8,952	782-34,988
	TRM 307.52	9,362	1,245-37,636
Spring	TRM 277.98	46,950	735-242,928
	TRM 307.52	5,587	918-25,018
Summer	TRM 277.98	306,686	104,263-694,950
	TRM 307.52	17,012	3,682-57,810
Fall	TRM 277.98	52,588	8,895-110,568
	TRM 307.52	4,107	1,042-9,326

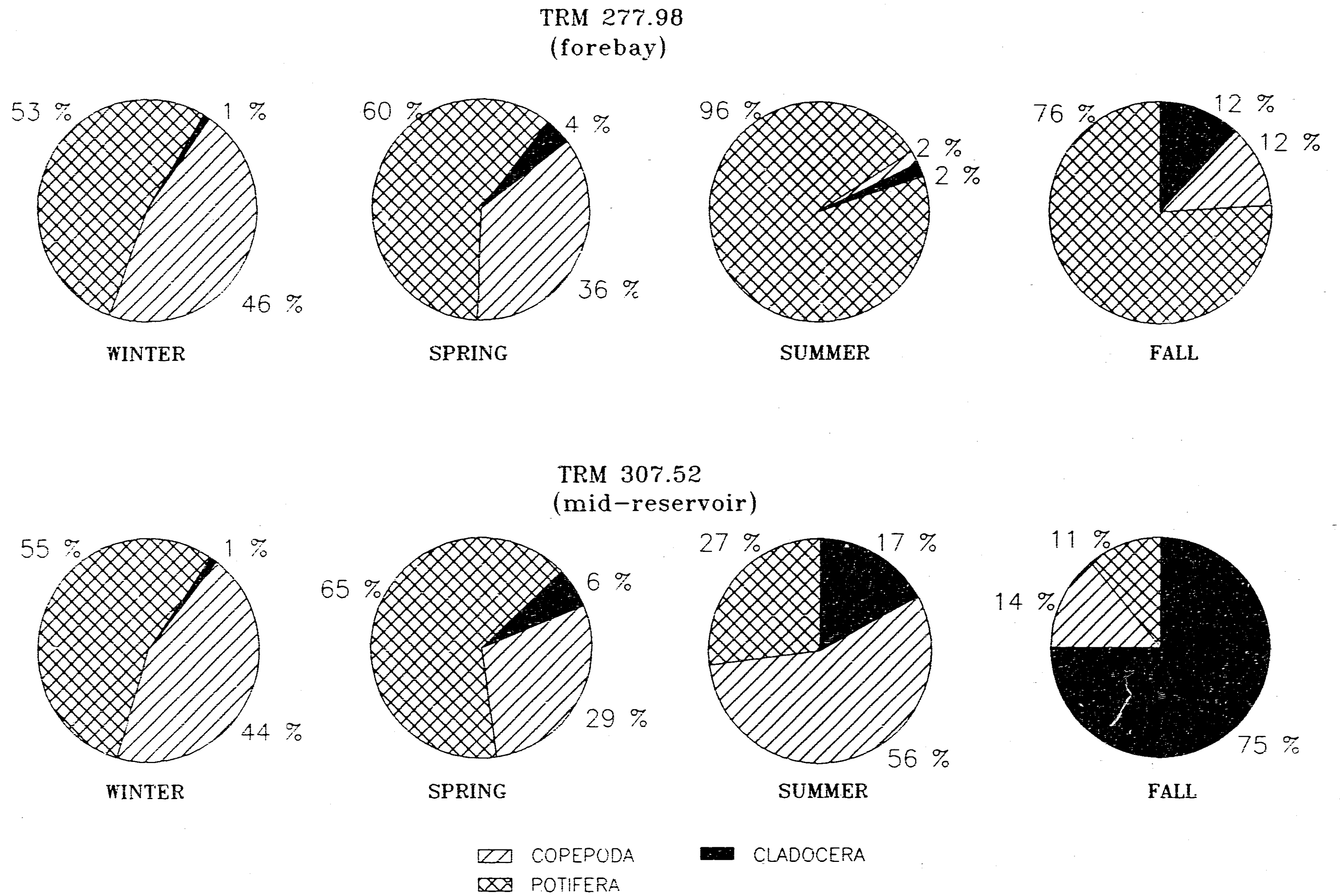


Figure 7. Zooplankton community composition at mid-reservoir and forebay in 1980

Macrophytes

Macrophyte colonization in Wheeler Reservoir has fluctuated substantially over the last ten years. From 1979 to 1988, the number of acres colonized increased from 100 to 9,843. For the most part, this pattern of increase is because most of these plants are not native to the Tennessee Valley and there are no effective natural population control mechanisms in TVA reservoirs. Drought conditions between 1984 and 1988 brought lower flows and increased water clarity that also markedly accelerated colonization. As of 1989, only 5,991 acres (a decline of 39 percent from 1988) were colonized (table 15). This decline is believed to be due to flood conditions during the spring and summer of 1989. Presently, Wheeler Reservoir ranks second among TVA reservoirs in terms of number of acres colonized and fourth in terms of percent of reservoir surface area colonized.

Table 15. 1988 and 1989 acreages of aquatic plants, by species, in Wheeler Reservoir.

Species	Acres 1988	Acres 1989
Eurasian watermilfoil *Myriophyllum spicatum*	6,767	3,780
Spinyleaf and Southern naiads (*Najas minor* and *Najas guadalupensis*)	850	74
Mixed milfoil and naiads	278	84
American lotus *Nelumbo lutea*	929	819
Pondweed (*Potamogeton* spp.)	30	2
Coontail *Ceratophyllum demersum*	9	0
Hydrilla *Hydrilla verticillata*	65	266
Algae (*Chara zeylandica* and unidentified filamentous species)	320	8
Mixed (milfoil, naiads, coontail, *Egeria densa*, etc.) and other	595	942
Total	9,843	5,991

Most of the macrophyte colonization is between TRMs 293 and 310, and in the Spring Creek and Flint Creek embayments. The predominant species is Eurasian watermilfoil. Colonies of the macrophyte hydrilla were discovered in Wheeler Reservoir in 1987 and now cover 266 acres, primarily around Decatur. The successful establishment of this aggressive and prolific plant may lead to more serious and frequent interference with reservoir uses in the future for several reasons: (1) hydrilla can colonize deeper areas than most of the other macrophyte species found in the TVA system, (2) hydrilla is more difficult to control than many of the other macrophyte species, and (3) hydrilla colonies tend to be very dense and can seriously impair boat traffic and other recreation.

The objective of TVA's Aquatic Plant Management Program is to manage macrophyte colonization and minimize impacts on other desirable reservoir uses. Complete eradication of macrophyte colonization is not desirable or feasible. Macrophyte management activities on Wheeler Reservoir include water level manipulation and herbicide treatment at high priority areas. Winter pool drawdown for flood control benefits macrophyte management by exposing macrophyte colonies to freezing and drying. Herbicides (primarily 2,4-D) were used on 88 acres of priority areas in 1989, generally around industrial intakes and along developed shorelines with high recreational usage.

Mosquitoes

Two major groups of mosquitoes present serious problems on Wheeler Reservoir--the floodwater-complex and the permanent-pool types. Permanent-pool mosquitoes breed continuously during the season and TVA monitors population levels weekly during the summer at specific sites on Wheeler Reservoir. Anopheles punctipennis, Anopheles quadrimaculatus, and Culex erraticus are the dominant species recorded in larval and adult samples. Primary larval habitat is submersed aquatic weed beds and production has increased measurably with the increased growth of submersed aquatic macrophytes in the reservoir.

Presence of floodwater mosquitoes is unpredictable. This group of mosquitoes generally deposits their eggs on damp soil in grassy or wooded depressions of the floodplain that are intermittently flooded. Primary species of concern are Aedes vexans and Aedes sticticus.

The most extensive areas of permanent pool and floodwater mosquito habitat are from TRM 291.0 upstream to TRM 320.0, and along several tributaries, including the Elk River, Flint Creek, Beaverdam Creek, and Cotaco Creek. Portions of the Wheeler National Wildlife Refuge are also problem areas.

Principal methods of mosquito control consist of mechanical control of marginal vegetation, drainage maintenance, water level management, and insecticide applications (larvicidal and adulticidal). In comparison to other TVA reservoirs, Wheeler ranks about third in severity of mosquito problems, and in comparison with other mosquito breeding areas outside TVA that fall under the jurisdiction of abatement programs, it would be considered to have a significant problem.

Benthic Macroinvertebrates

Abundant macroinvertebrates near BFN (TRM 308-278) include Asiatic clams (Corbicula sp.), oligochaetes, Hexagenia sp., Caenis sp., chironomids, snails, sponges, bryozoans, a few mussel species, and crayfish. Abundant macroinvertebrates in the upstream portion of Wheeler Reservoir nearer Guntersville Dam include a number of rheophyllic taxa including several trichopteran species.

Historically, Asiatic clams (Corbicula) were collected without difficulty for the BFN radiological sampling program. However, sampling at TRM 307.5, 297.0, 293.7, 288.8, and 278.0 during the past 10 years has shown a steady decline in clam populations. There have also been numerous reports of Corbicula dieoffs. In more than 150 dredge samples at each location during November 1987, no clams were found at TRM 276.8 and only two clams were found at TRM 288.8.

Freshwater Mussels

Several locations on Wheeler Reservoir provided habitat for large populations of mussels that supported a fairly important, but declining, commercial fishery. An evaluation of mussel stocks in the Tennessee River (Scruggs 1960) identified a large population (more than 24 million) of Pleurobema cordatum in Wheeler Reservoir on the Triana bed upstream from Decatur, Alabama (TRM 306 to 316). Mussel harvest between Decatur and Indian Creek (TRM 304.1 and 320.8, which included the Triana bed) was heavy in 1956 and 1957; however, recruitment to the population was less than 1 percent, and harvesting had ceased on the Triana bed within four years after Scruggs' study. Only one live specimen was collected from this area in 1963 (Isom 1969). Decline of this bed was attributed to "high rate of exploitation," unfavorable environmental conditions, sediment effects, and industrial wastes entering the Tennessee River by way of Indian Creek.

There have been no recent surveys of mussel resources in Wheeler Reservoir. Existing information indicates these animals occur throughout much of the length of the reservoir. In the upstream part of the reservoir (essentially from Decatur upstream to Guntersville Dam), most mussels are found in the old river channel and an almost continuous mussel bed in the Guntersville Dam tailwater (TRM 331-348.4) best represents the preimpoundment mussel fauna. Isom (1969) identified 16 species from collections made in this area in 1963-64. His collections were dominated (in decreasing order of abundance) by Obliquaria reflexa, Pleurobema cordatum, and Quadrula pustulosa. Collections in the same tailwater area in 1976-78 also showed a large, diverse (23 species) mussel fauna (tables 16 and 17). Elliptio crassidens was the predominant species identified in the 1976-78 study, comprising from 52.7 to 60.8 percent of the mussel fauna. The three most abundant species from the 1963-64 collections represented a relatively small proportion of the total fauna in 1976-78, except for Pleurobema cordatum which comprised 23.3 percent of the assemblage. Differences between the two studies may have resulted from different sampling techniques (a Petersen-type dredge in 1963-64 and scuba in 1976-78). Many of the mussels found in the Guntersville tailwater were present before the reservoir was filled and very few young mussels have been found in this area.

Downstream from Decatur, most mussels are found on the overbanks. These mussel stocks include many young individuals and a different mix of species from those found in the old river channel upstream. The former river channel in this downstream part of the reservoir is covered with

Table 16. Mussel species collected by TVA from the Guntersville tailwater, Browns Ferry Nuclear Plant, and Spring Creek embayment areas of Wheeler Reservoir.

Species	Common name	Guntersville tailwater	BFN	Spring Creek
Fusconaia ebena	ebony shell	x		
Megalonaias nervosa	washboard	x	x	x
Amblema plicata	three ridge	x	x	x
Quadrula quadrula	mapleleaf		x	x
Quadrula pustulosa	pimpleback	x	x	x
Quadrula metanevra	monkeyface	x		
Tritigonia verrucosa	pistolgrip	x	x	x
Cyclonaias tuberculata	purple wartyback	x		
Plethobasus cyphyus	sheepnose	x		
Plethobasus cooperianus	orange-foot pimpleback	x		
Pleurobema coccineum	round pigtoe	x		
Pleurobema oviforme	Tennessee clubshell	x		
Pleurobema cordatum	Ohio pigtoe	x	x	
Pleurobema pyramidatum	pyramid pigtoe	x		
Elliptio crassidens	elephant-ear	x	x	
Elliptio dilatata	spike	x		
Lasmigona complanata	white heelsplitter		x	x
Anodonta grandis	giant floater		x	x
Anodonta imbecillis	paper pondshell			x
Anodonta suborbiculata	flat floater		x	x
Obliquaria reflexa	threehorn wartyback	x	x	x
Cyprogenia stegaria	fanshell	x		
Ellipsaria lineolata	butterfly	x		
Truncilla donaciformis	fawnsfoot		x	x
Leptodea fragilis	fragile papershell	x	x	x
Potamilus alatus	pink heelsplitter	x	x	x
Toxolasma parvus	lilliput			x
Toxolasma lividus	purple lilliput			x
Ligumia recta	black sandshell	x		
Lampsilis teres	yellow sandshell			x
Lampsilis ovata	pocketbook	x		
Lampsilis abrupta	pink mucket	x		

Table 17. Composition of mussel communities at selected locations in Wheeler Reservoir.

	Tennessee River miles											
	345.8-346.5		339.1-339.2		336.5-336.6		297.2-298.9		292.7-294.5		Spring Creek Embayment	
Species	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Megalonaias nervosa	25	2.8	15	2.7	57	9.3	60	39.7	49	39.8	22	4.1
Amblema plicata	21	2.3	8	1.4	1	0.2	7	4.6	4	3.3	17	3.2
Quadrula quadrula	-	-	-	-	-	-	9	6.0	6	4.9	172	32.1
Quadrula pustulosa	71	7.9	38	6.9	7	1.1	1	0.7	-	-	11	2.0
Quadrula metanevra	30	3.3	24	4.4	18	2.9	-	-	-	-	-	-
Tritigonia verrucosa	4	0.4	-	-	1	0.2	-	-	1	0.8	-	-
Cyclonaias tuberculata	69	7.6	29	5.3	17	2.8	-	-	-	-	-	-
Plethobasus cyphyus	-	-	1	0.2	-	-	-	-	-	-	-	-
Plethobasus cooperianus	1	0.1	-	-	-	-	-	-	-	-	-	-
Pleurobema coccineum	-	-	1	0.2	-	-	-	-	-	-	-	-
Pleurobema oviforme	-	-	-	-	1	0.2	-	-	-	-	-	-
Pleurobema cordatum	68	7.5	128	23.3	95	15.4	2	1.3	-	-	-	-
Pleurobema pyramidatum	-	-	-	-	1	0.2	-	-	-	-	-	-
Elliptio crassidens	549	60.8	289	52.7	356	57.9	3	2.0	1	0.8	-	-
Elliptio dilatata	1	0.1	-	-	-	-	-	-	-	-	-	-
Lasmigona complanata	-	-	-	-	-	-	-	-	1	0.8	6	1.1
Anodonta grandis	-	-	-	-	-	-	12	7.9	7	5.7	-	-
Anodonta imbecillis	-	-	-	-	-	-	-	-	-	-	126	23.6
Anodonta suborbiculata	-	-	-	-	-	-	1	0.7	1	0.8	139	26.0
Obliquaria reflexa	8	0.9	1	0.2	-	-	3	2.0	6	4.9	5	0.9
Cyprogenia stegaria	2	0.2	-	-	-	-	-	-	-	-	-	-
Ellipsaria lineolata	46	5.1	14	2.5	48	7.8	-	-	-	-	-	-
Truncilla donaciformis	-	-	-	-	-	-	-	-	12	9.8	3	0.6
Leptodea fragilis	1	0.1	-	-	2	0.3	2	1.3	19	15.4	4	0.7
Potamilus alatus	6	0.7	-	-	-	-	51	33.8	16	13.0	22	4.1
Toxolasma parva	-	-	-	-	-	-	-	-	-	-	1	0.2
Toxolasma lividus	-	-	-	-	-	-	-	-	-	-	6	1.1
Ligumia recta	-	-	-	-	1	0.2	-	-	-	-	-	-
Lampsilis teres	-	-	-	-	-	-	-	-	-	-	1	0.2
Lampsilis ovata	2	0.2	-	-	3	0.5	-	-	-	-	-	-
Lampsilis abrupta	1	0.1	-	-	7	1.1	-	-	-	-	-	-
Total	905		545		615		151		123		535	

silt and is, generally, unsuitable mussel habitat. Isom (1969), sampling in 1963-64 in an area between TRM 289 and 300 (downstream from Decatur, upstream and downstream from BFN) identified populations of Pleurobema cordatum, Megalonaias nervosa, and Amblema plicata. Approximately 200 tons of shells were harvested from this area in 1963 and the population was expected to decline because no evidence of recruitment was observed. Siting evaluations in 1982 identified 14 species still present near BFN, predominantly Megalonaias nervosa and Potamilus alatus (table 17).

Four mussels (Lampsilis abrupta pink mucket, Plethobasus cooperianus orangefoot, Pleurobema plenum rough pigtoe, and Cyprogenia stegaria fanshell) that occur in the reservoir are listed as endangered both federally and by Alabama (note--the fanshell was listed by the USFWS in 1990 and its status by Alabama is unknown at this time). All four of these species are known to occur in the river channel upstream from Decatur (table 18). The pink mucket pearly mussel is also known from the lower Paint Rock River.

Fish

The Wheeler Reservoir fish community is diverse (81 species) and dominated by warmwater species (table 19). It includes important game and commercial warmwater species and also the coolwater species sauger and walleye. Dominant prey species are gizzard and threadfin shad.

The fish community of Wheeler Reservoir is monitored annually by TVA by means of three cove rotenone surveys, which provide data on standing stock of game, rough, and forage species. Between 1969 and 1984, total standing stock averaged 51,573 fish per hectare (ha) weighing 711 kilograms (kg) per hectare. More recent estimates in 1985 and 1986 were 90,147 fish/ha weighing 703 kg/ha and 28,588 fish/ha weighing 613 kg/ha, respectively. Approximately 96 percent by number and 64 percent by weight were prey species (primarily gizzard shad). Game species comprised 4 percent of the total number and 11 percent of the total biomass. Estimates of abundance since 1969 have been cyclic, with a generally increasing trend over the 16-year period. Maximum abundance occurred in 1982.

The snail darter Percina tanasi, listed as a threatened species both federally and by Alabama, is the only fish species of sensitive status likely to occur in Wheeler Reservoir. Snail darters have been found in the Paint Rock River. In other streams young of this species are known to drift downstream into the Tennessee River during their first summer. Adult snail darters return to gravel shoals in tributary streams each year to spawn (Hickman and Fitz 1978).

The extension of the range of yellow perch Perca flavescens into Wheeler Reservoir and apparent establishment of a reproducing population is noteworthy. This species was stocked in the upper Hiwassee River in the early 1950s and has since slowly extended its range in the Tennessee River system. Adult yellow perch first occurred in Wheeler Reservoir rotenone samples in 1977 and larvae were identified from yearly ichthyoplankton samples collected near BFN during the period 1985-88.

Table 18. Endangered, threatened, or special concern aquatic species that occur or are suspected to occur in Wheeler Reservoir.

Species	Common name	Status[a] U.S	Status[a] AL	Wheeler area occurrences (since 1974)[b]
Freshwater mussels				
<u>Lampsilis</u> <u>abrupta</u>	pink mucket	E	E	Tennessee River miles 334.3L, 336.5R, 336.6C, 344.0C, 345.6C, 346.5C (all 1978)
				Paint Rock River mile 13.0 (1983)
<u>Plethobasus</u> <u>cooperianus</u>	orange-foot pimpleback	E	E	Tennessee River mile 345.8C (1978)
<u>Pleurobema</u> <u>plenum</u>	rough pigtoe	E	E	unknown upstream sites on Wheeler impoundment of Tennessee River (1982)
<u>Cyprogenia</u> <u>stegaria</u>	fanshell	E	?	collected in late 1970s from Guntersville tailwater (TRM 346)
Fish				
<u>Percina</u> <u>tanasi</u>	Snail darter	T	T	Paint Rock River miles 15.8, 16.9, 19.3 (1981)
Amphibians				
<u>Cryptobranchus</u> <u>alleganiensis</u> <u>alleganiensis</u>	Eastern hellbender	C	T	clear streams throughout area and Guntersville Dam tailwater
Reptiles				
<u>Alligator</u> <u>mississippiensis</u>	American alligator	T	SC	Wheeler National Wildlife Refuge area

a. Status abbreviations: E--legally protected as an endangered species; T—legally protected as a threatened species; C--candidate; SC--special concern.

b. Distribution abbreviations: C—center of river width; L—near left (descending) shore; R—near right (descending) shore.

Table 19. Fish species known to occur in Wheeler Reservoir. Abundance rating based on historical occurrence (1949 to present) in TVA rotenone samples is indicated by: (R)--rare, occurring in less than 10 percent of all samples; (C)--common, occurring in 10 to 90 percent of all samples; or (A)--abundant, occurring in more than 90 percent of all samples.

Common name	Scientific name	Abundance
Sport species		
Grass pickerel	Esox americanus	R
White bass	Morone chrysops	C
Yellow bass	M. mississippiensi	A
Rock bass	Ambloplites rupestris	R
Redbreast sunfish	Lepomis auritus	R
Warmouth	L. gulosus	A
Green sunfish	L. cyanellus	A
Orangespotted sunfish	L. humilis	C
Bluegill	L. macrochirus	A
Longear sunfish	L. megalotis	A
Redear sunfish	L. microlophus	A
Spotted sunfish	L. punctatus	R
Smallmouth bass	Micropterus dolomieui	C
Spotted bass	M. punctulatus	C
Largemouth bass	M. salmoides	A
White crappie	Pomoxis annularis	C
Black crappie	P. nigromaculatus	C
Yellow perch	Perca flavescens	C
Sauger	Stizostedion canadense	C
Walleye	S. vitreum	R
Commercial species		
Paddlefish[a]	Polyodon spathula	R
River carpsucker	Carpiodes carpio	R
Quillback carpsucker	C. cyprinus	R
Highfin carpsucker	C. velifer	R
Smallmouth buffalo	Ictiobus bubalus	A
Bigmouth buffalo[a]	I. cyprinellus	C
Black buffalo[a]	I. niger	R
Blue catfish[a]	Ictalurus furcatus	C
Channel catfish	I. punctatus	A
Flathead catfish	Pylodictis olivaris	A
Other species		
Chestnut lamprey	Icthyomyzon castaneus	R
Bowfin	Amia calva	R
Spotted gar	Lepisosteus oculatus	C
Longnose gar	L. osseus	C
Shortnose gar	L. platostomus	R
American eel	Anguilla rostrata	R

Table 19 (Continued)

Common name	Scientific name	Abundance
Other species (Continued)		
Skipjack herring[a]	Also Chrysochloris	C
Gizzard shad	Dorosoma cepedianum	A
Threadfin shad	D. petenense	A
Mooneye	H. tergisus	R
Common carp	Cyprinus carpio	C
Central stoneroller	Campostoma anomalum	C
Goldfish	Carrasius auratus	R
Bigeye chub	Hybopsis amblops	R
Silver chub[a]	H. storeriana	C
Golden shiner	Notemigonus crysoleucas	C
Emerald shiner	N. atherinoides	C
Ghost shiner[a]	N. buchanani	R
Striped shiner	N. chrysocephalus	R
Whitetail shiner	N. galacturus	R
Spotfin shiner	N. spilopterus	C
Mimic shiner	N. volucellus	R
Steelcolor shiner[a]	N. whipplei	R
Pugnose minnow[a]	N. emiliae	R
Suckermouth minnow	Phenacobius mirabilus	R
Bluntnose minnow	Pimaphales notatus	R
Fathead minnow	P. promelas	R
Bullhead minnow	P. vigilax	C
Northern hog sucker	Hypentelium nigricans	C
Spotted sucker	Minytrema melanops	A
Silver redhorse	Moxostoma anisurum	C
Shorthead redhorse	M. macrolepidotum	R
River redhorse	M. carinatum	R
Black redhorse	M. duquesnei	C
Golden redhorse	M. erythrurum	C
Black bullhead	I. melas	R
Yellow bullhead	I. natalis	R
Brown bullhead	I. nebulosus	R
Slender madtom	Noturus exilis	R
Tadpole madtom	N. gyrinus	R
Blackstripe topminnow	F. notatus	C
Blackspotted topminnow	F. olivaceus	C
Mosquitofish	Gambusia affinis	C
Brook silverside	Labidesthes sicculus	C
Fantail darter	E. flabellare	C
Stripetail darter	E. kennicotti	C
Logperch	Percina caprodes	C
Dusky darter	P. sciera	R
River darter[a]	P. shumardi	C
Freshwater drum	Aplodinotus grunniens	A

a. Species generally restricted to mainstream Tennessee River.

The reservoir is used for both sport and commercial fishing. The substantial commercial fishery in Wheeler Reservoir has been adversely impacted for several years due to levels of DDT. Channel catfish, blue catfish, and buffalo are the most important commercial species.

Important sport fishes include largemouth bass, smallmouth bass, white crappie, bluegill, redear sunfish, white bass, yellow bass, and sauger. Also, the Alabama Department of Conservation and Natural Resources has stocked more than 600,000 striped bass and more than 2.5 million hybrid striped bass x white bass fry in Wheeler Reservoir to provide additional sport fish species. Some general information about important sport species follows:

Largemouth bass. Fishermen consider this fishery excellent on Wheeler Reservoir as evidenced by the number of bass tournaments held on the reservoir from early spring through late fall. Area clubs and bass anglers attribute recent improvements in the fishery to the increase of aquatic vegetation. The milfoil around Decatur has become a "hot spot" for largemouth bass fishing. Data from rotenone samples since 1982 show a minimum of 40 harvestable bass per acre. In 1988 electrofishing samples taken by TVA as part of the TVA Reservoir Biomonitoring Program, catch rates of largemouth bass were over twice the average historical catch rate (table 20) and relative weight analysis indicated that largemouth bass were heavier than expected for Tennessee River reservoirs (table 21). PSD/RSD analysis (table 22) indicated a fair largemouth bass fishery, as 28 percent of the fish collected electrofishing were of quality size. However the proportion of larger fish was small, as preferred (RSD1) and memorable (RSD2) fish only amounted to 3 and 1 percent, respectively, of the bass collected. No trophy-sized bass were collected in 1988.

Smallmouth bass. Rocky bluffs and gravel bars abound in the lower end of Wheeler Reservoir. Deep water and current adjacent to those areas provide prime smallmouth bass habitat. Recent cove rotenone surveys have shown an increase in numbers of all sizes of smallmouth bass, but catch rates in electrofishing samples in 1988 were less than the historical average (table 20).

Table 20. Comparison of electrofishing catch rates (number per hour) of selected species in Wheeler Reservoir, 1988, to historical catch rates for Tennessee River mainstream reservoirs (TVA 1989).

Common name	Present[a] CPUE	Historical CPUE
Bluegill	66.22	170.30
Redear sunfish	2.67	1.02
Smallmouth bass	3.11	11.57
Largemouth bass	92.67	37.36
Yellow bass	42.00	8.60

a. CPUE = catch per unit effort

Table 21. Relative weight (Wr) analysis[a] of largemouth bass in Wheeler Reservoir, 1988, compared to standard weights established for Tennessee River mainstream reservoirs (TVA 1989).

Common name	Mean Wr	Minimum Wr	Maximum Wr	Standard error	N
Largemouth bass	108.51	88.57	136.28	0.9408	122

a. Relative weight analysis involves the calculation of standard weight tables based on historical length-weight data, which projects "expected" weights of fish at observed lengths in present surveys (Anderson 1978). Fish having expected weights will have Wr values of 100, while those heavier than expected will have Wr values greater than 100.

Table 22. Proportional (PSD) and relative stock density (RSD)[a] of selected species in Wheeler Reservoir, 1988 (TVA 1989).

Common name	Quality (PSD)	Preferred (RSD)	Memorable (RSD2)	Trophy (RSD3)
Bluegill	36.00	0.45	0.45	0.00
Largemouth bass	28.00	3.06	0.77	0.00
Yellow bass	30.00	4.75	0.00	0.00

a. PSD/RSD analysis compare the number of fish attaining various lengths with the total number of catchable-sized individuals of a given species (Anderson 1978). Size categories are based on percentages of maximum attainable lengths of selected species (Gabelhouse 1984). Catchable length includes all individuals measuring 25 percent or more of the maximum attainable length of the species. Quality fish are 37 percent or more of the maximum attainable length, preferred fish are 45 percent or more, memorable 59 percent or more, and trophy 74 percent or more.

Panfish (white crappie, bluegill, redear sunfish). Results of a creel survey in 1980 indicated that white crappie was the dominant species harvested from Wheeler Reservoir in terms of number (62 percent) and biomass (54 percent). Bluegill ranked second in number. Although catch rates of bluegill were less than the historical average (table 20), they were the most abundant sunfish in TVA electrofishing collections in 1988 and 36 percent of those collected were quality fish (table 22). Catch rates of redear sunfish were over twice the historical catch rate (table 20). Fishing for these species is heaviest during early spring through midsummer, particularly in the lower half of the reservoir. Numerous tributaries, coves, and expansive overbank areas provide prime spawning and nursery areas for these species.

Sauger. In recent years, several TVA reservoirs including Wheeler appear to have experienced a significant decline in sauger populations (Hevel 1988). Cove rotenone sampling in Wheeler Reservoir in 1987 and 1988 failed to collect any sauger; they previously had been collected every year since 1969 (Buchanan 1989). Recent larval fish sampling in Wheeler also suggests a decline in the population. The exact cause(s) of the sauger decline is not known but is believed to be related to the drought that began in 1985. Water temperature fluctuations, flow rates and turbidity--all factors known to influence the success of sauger spawning--were atypical throughout the system during the drought (Cox 1990). Possible effects of the operation of BFN on sauger distribution and reproduction are currently under study. Fishing for this species is heaviest January through March in the Guntersville Dam tailwater and around tributary mouths in the upper end of the reservoir.

White and yellow bass. Schools of white bass provide angling action spring through early fall. The yellow bass population in Wheeler Reservoir is increasing. In 1988 electrofishing catches, the species was about five times more abundant than in historical catches (table 20).

Threatened, Endangered, and Other Special Concern Aquatic Species

Wheeler Reservoir and its local watershed provide habitat for a variety of organisms with state or federal protected status (Cox 1990). Aside from the possible occurrence of the snail darter and the presence of the four mussel species previously discussed, the only other listed aquatic species known to occur in Wheeler Reservoir are the eastern hellbender and the American alligator (table 18). Fifty alligators were stocked in Wheeler National Wildlife Refuge by the U.S. Fish and Wildlife Service (USFWS) in 1979. An attempt was made the following year to remove them from the reservoir. Consequently, status of the alligator population in the reservoir is questionable.

Wildlife

Wheeler National Wildlife Refuge, the easternmost National Wildlife Refuge on the lower Mississippi Flyway, is a wintering area for about 30,000 Canada geese and 50,000 to 70,000 ducks. Established in 1938, the refuge was the first national demonstration of operation of a power reservoir for waterfowl resources. Prior to the establishment of the refuge, the area wintered only 3 to 4 thousand waterfowl; the refuge now boasts the southeast's highest concentrations of Canada geese. Although most waterfowl that winter on Wheeler Reservoir nest far to the north, many wood ducks and some mallards and black ducks nest on the refuge each spring (Cox 1990). Although waterfowl are the most spectacular visitors, a wide variety of other wildlife is present. Many species of shorebirds stop briefly in early fall and again in the spring. Quail and mourning doves are numerous. In all, the list of birds around Wheeler Reservoir includes 304 species. Beaver, muskrats, mink, otters, and other mammals also occur throughout the reservoir. Peregrine falcons, listed as threatened by Alabama and endangered federally, pass through the Wheeler National Wildlife Refuge during migration.

RESERVOIR USES AND USE IMPAIRMENTS

Designated Uses

The Alabama water quality criteria and use classification regulations have assigned use classifications to Wheeler Reservoir and its tributaries "based on existing utilization, uses reasonably expected in the future, and uses not now possible because of correctable pollution" (table 23). These use classifications determine the water quality criteria that ADEM applies to the reservoir (table 24). The Tennessee River is classified for use as a public water supply from Wheeler Dam to the Elk River, from U.S. Highway 31 to Flint Creek, and from Cotaco Creek to the Flint River. Except for the immediate vicinity of the discharge from Decatur's sewage treatment plant and the reach from Indian Creek to Flint River, the Tennessee River from Wheeler Dam to Guntersville Dam is classified as suitable for swimming and other whole body water-contact sports. The entire reservoir and most of its tributaries are classified for fish and wildlife.

In assessing the condition of state waters for the period 1986-87, ADEM indicated that Wheeler Reservoir did not support its designated uses (ADEM 1988). Nonpoint sources of toxic and conventional pollutants were identified as causes of impairments. An impaired status rating by Alabama "does not necessarily include the entire reservoir, but does indicate a portion or all of the reservoir is or has the potential to be adversely impacted" (ADEM 1988).

Existing and Potential Uses

TVA reservoirs often have existing and potential uses that are not specifically recognized in the designated stream use classifications issued by the various states with regulatory authority over the water. Reservoir uses that may not be adequately protected under designated use classification systems with their associated water quality criteria (i.e., providing fish for human consumption, providing habitat for sensitive threatened or endangered species, providing capacity to assimilate wastewaters, and various other uses) are discussed below. Identification of this broad range of potential uses and evaluation of the suitability of the water resource for each use is an essential first step in managing the resource for the protection and enhancement of all beneficial uses.

For the purpose of this report, a use impairment is defined as any physical, chemical or biological characteristic of the water that prevents or constrains use of the water, diminishes the value of a use, or makes a use inadvisable. For designated uses, there are numerical water quality criteria that permit objective evaluation of whether a

Table 23. Water use classifictions for Wheeler Reservoir (ADEM 1988).

From	To	Classifications[a,b,c]
Wheeler Dam	Elk River	PWS/S/F&W
Elk River	U.S. Highway 31	S[d]/F&W
U.S. Highway 31	Flint Creek	PWS/S/F&W
Flint Creek	Cotaco Creek	S/F&W
Cotaco Creek	Indian Creek	PWS/S/F&W
Indian Creek	Flint River	PWS/F&W
Flint River	Guntersville Dam	S/F&W

a. PWS = public water supply; S = swimming and other whole body water-contact sports; F&W = fish and wildlife.

b. With the exception of those segments in the "Public Water Supply" classification, every segment, in addition to being considered acceptable for its designated use, is also considered acceptable for any other use with less strintent associated criteria.

c. Those segments not included by name are considered acceptable for a "Fish and Wildlife" classifiction unless it can be demonstated that such a generalization is inappropriate in specific instances.

d. That portion of Wheeler Reservoir in the immediate vicinity of the discharge from the city of Decatur's sewage treatment plant is not considered suitable for swimming and other whole body water-contact sports.

Table 24. Selected numerical water quality criteria applicable to Wheeler Reservoir.

Parameter	Criterion	Remarks
pH	6.0–8.5	–
Temperature	maximum 86°F maximum rise 5°F	Thermal variance granted for BFN permits maximum of 90°F and maximum rise of 10° at edge of diffuser mixing zone.
Dissolved oxygen	$\geq$5 mg/l; $\geq$4 mg/l for extreme conditions due to natural causes	Measured at 5-ft depth in waters $\geq$10-ft deep; measured at middepth for water <10-ft deep.
Fecal coliforms	(1) GM $\leq$2,000 and maximum 4,000 for areas classified for public water supply (2) GM $\leq$200 for areas classified for swimming (3) GM $\leq$1,000 and maximum 2,000 for areas classified for fish and wildlife	Geometric mean (GM) calculated from no less than five samples collected over a 30-day period at intervals not less than 24 hours.
Turbidity	$\leq$50 JTU over background	Turbidity from "natural runoff" included in establishing background values.
Arsenic (III)	(1) 360 µg/l acute (2) 190 µg/l chronic	
Beryllium	–	ADEM has not yet promulgated criteria.
Copper	(1) $e^{(0.9422 \ln H - 1.464)}$ acute (2) $e^{(0.8545 \ln H - 1.465)}$ chronic (3) 1,000 µg/l for protection of human health	Hardness (H)-dependent, H in mg/l as $CaCO_3$; criterion in µg/l.

Table 24 (Continued)

Parameter	Criterion	Remarks
Dioxin (2,3,7,8-TCDD)	0.0000012 µg/l for protection of human health	ADEM has not yet promulgated criteria for protection of aquatic life from acute or chronic toxicity.
Lead	(1) $e^{(1.273 \ln H - 1.460)}$ acute (2) $e^{(1.273 \ln H - 4.705)}$ chronic (3) 50 µg/l for protection of human health	Hardness (H)-dependent, H in mg/l as $CaCO_3$; criterion in µg/l.
Mercury	(1) 2.4 µg/l acute (2) 0.012 µg/l chronic	ADEM has not yet promulgated criteria for protection of human health.
PCBs	0.014 µg/l chronic	ADEM has not yet promulgated criteria for protection of aquatic life from acute toxicity or for protection of human health.
Silver	(1) $e^{(1.72 \ln H - 6.52)}$ acute (2) 50 µg/l for protection of human health	Hardness (H)-dependent, H in mg/l as $CaCO_3$; criterion in µg/l. ADEM has not promulgated a citerion for protection of aquatic life from chronic toxicity.

body of water is suitable for a particular use. However, the designated uses of TVA reservoirs and the associated water quality criteria vary somewhat from one state to another. Consequently, water quality criteria promulgated by the U.S. Environmental Protection Agency (EPA 1986), are also cited to provide a broader perspective.

For evaluation of fish flesh contamination, this report uses EPA guidance, Food and Drug Administration (FDA) criteria, and, where available, state policy. The EPA guidance criteria, which were developed pursuant to Section 304(a) of the Clean Water Act, are based solely on human health considerations and are generally the most stringent of the criteria available. The EPA criteria have no regulatory impact, but were derived to provide guidance to the states. The FDA criteria, on the other hand, are based on human health considerations, estimation of economic impact on interstate commerce, and analytical detection limits. The FDA criteria have regulatory impact only in the realm of interstate commerce. In practice, the individual states may use the EPA guidance criteria, the FDA criteria, or develop original criteria to advise the public on the consumption of fish from intrastate waters.

One purpose of this report is to summarize causes of impairments or potential impairments to the uses of the aquatic resources of Wheeler Reservoir (table 25). In some cases, there are no numerical criteria for evaluating use impairments. Examples include evaluating the aesthetic quality of the water, assessing interference of mosquitoes or aquatic weeds with recreational use, or protecting the habitat of sensitive threatened or endangered aquatic species. In these instances, evaluation of whether a particular use is impaired is made by technical judgment of TVA water resource professionals, coupled with acknowledgment of concerns expressed by the public.

Navigation

Wheeler Dam has navigation locks, and TVA maintains an 11-ft navigable channel in Wheeler Reservoir upstream to Guntersville Dam. Barge traffic on Wheeler Reservoir increased from 6.6 million tons in 1970 to 9.5 million tons in 1986. During 1986, grains and grain products made up 42 percent of the total tonnage, 23 percent was coal and coke, and 7 percent was chemicals. Recent increases in tonnage are partly the result of opening of the Tennessee-Tombigbee Waterway in January 1985. Further increases are predicted over the next few years because the waterway provides a direct connection between the Port of Mobile, the Tennessee River, and 16,000 miles of inland navigable waterways (Cox 1990).

Power Production

Wheeler Dam has 11 hydropower units with a total capacity of 378 mw (11 percent of the total for the TVA reservoir system). This use has been impaired when turbine intakes clogged with aquatic vegetation and debris during high flow conditions.

Table 25. Summary of impairments or potential impairments to the uses of the aquatic resources of Wheeler Reservoir.

Cause	Uses(s) affected	Effects(s)	Frequency	Extent	Severity	Documentation[a]
Aquatic macrophyte colonization	(1) power production	(1) clogging of turbine intakes results in turbine shutdown	infrequent	occurs during high flows	precludes use	3
	(2) industrial water supply	(2) clogging of intakes results in modification of plant operations	seasonal	localized	increases cost of use	3
	(3) swimming	(3) colonization of shoreline areas in coves, residential areas, and public access areas makes swimming impossible or unpleasant	seasonal	localized	increases use in some areas, limits use overall	3
	(4) boating	(4) colonization prohibits boat access to some coves and other shallow shoreline areas	seasonal	localized	limits or precludes use	3
	(5) aesthetic quality	(5) infestations mar beauty of the environment and create nuisance factor	seasonal	localized	affects quality of use	3
	(6) commercial shoreline usage	(6) infestations may clog intakes and/or block use of water by boats	seasonal	localized	may limit or preclude use	3
	(7) residential shoreline usage	(7) infestations mar beauty of residential and may limit or preclude boat access areas (especially in coves)	seasonal	localized	affects quality of use, may limit or preclude use	3
	(8) public shoreline usage	(8) infestations block use of shoreline areas area for boat access, boating, swimming, wading, etc.	seasonal	localized	affects quality of use, may limit or preclude use	3
Mosquitoes	(1) recreation	creates a nuisance factor	seasonal	localized	affects quality of use	3
	(2) shoreline usage	creates a nuisance factor	seasonal	localized	affects quality of use	3
High ambient water temperature	industrial water supply	high ambient temperatures at cooling water intakes may result in modification of plant operations	seasonal	localized	increases cost of use	3
Low flows with high BOD loading rates	wastewater assimilation	condition results in low ambient DO, potentially impairing assimilative capacity of the reservoir	Intermittent	localized	limits further use	3

Table 25 (Continued)

Cause	Uses(s) affected	Effects(s)	Frequency	Extent	Severity	Documentation[a]
Fish flesh contamination with DDT, PCBs, dioxins	(1) consumption of aquatic life	(1) potential effect on human health	continuous	widespread	may be limiting use	2-A (DDT) 2-L (PCBs, dioxins)
	(2) sport fishing	(2) if catch deemed nonconsumbable, may partiially or fully spoil fishing experience	continuous	widespread	affects quality of use, may limit or preclude use for some	2-L
	(3) support for biological communities	(3) DDT in food chain possibly contributed to decline in piscivorous bird population at WNWR; may preclude recovery	continuous	distribution unknown	unknown	4
	(4) commercial fishing (fish)	(4) DDT contamination resulted in FDA ban on interstate sale of fish	continuous	widespread	precludes use	1-A
Fecal coliforms	swimming and other whole body contact sports	potential effect on human health	intermittent to continous	localized	use inadvisable in some areas	4
Drought	(1) support for biological communities	(1) conditions may have contributed to recent decline in sauger population	recent	continuous, widespread	limits, may preclude use	3
	(2) sport fishing	(2) decline in sauger fishery	recent	continuous, widespread	limits, may preclude use	3
Commercial overharvest	support for aquatic life	large populations of mussels once present in the reservoir have been depleted	continous until resource was depleted	localized	precludes use	3
Reservoir environment	support for aquatic life (mussels)	no evidence of reproduction of riverine mussel species present before impoundment	continous	widespread	precludes use	3

Table 25 (Continued)

Cause	Uses(s) affected	Effects(s)	Frequency	Extent	Severity	Documentation[a]
Unknown	(1) potable water supply	(1) taste and odor	seasonal, infrequent	localized	affects quality of use	3
	(2) support for aquatic life	(2) decline of Asiatic clam population	continuous	widespread	precludes use	3

a. 1 = data exceed regulatory criteria; 1-A = adequate database; 1-L = limited database; 2 = data exceed recommended levels; 2-A = adequate database; 2-L = limited database; 3 = impairment verified, but no standards available or standards are inadequate to protect use; 4 = impairment not verified, assessment based on professional judgment.

Flood Control

Wheeler Reservoir provides 349,000 ac-ft of flood capacity--about three percent of the total for the TVA reservoir system.

Public Water Supply

There are four municipal water supply intakes located on Wheeler Reservoir (figure 8 and table 26). In many cases, the municipal systems also supply potable and process water to nearby industries.

Sporadic problems with taste and odor (T/O) have been reported in water supplies drawn from Wheeler Reservoir. A problem with the potable water supply at Champion International during the summer of 1988 was never traced to a specific cause but may have been associated with backflows of effluent to the intake location. The cause of occasional T/O problems in the Huntsville water supply has not been established.

Industrial Water Supply

Nine industrial water intakes are located on Wheeler Reservoir (figure 8 and table 26).

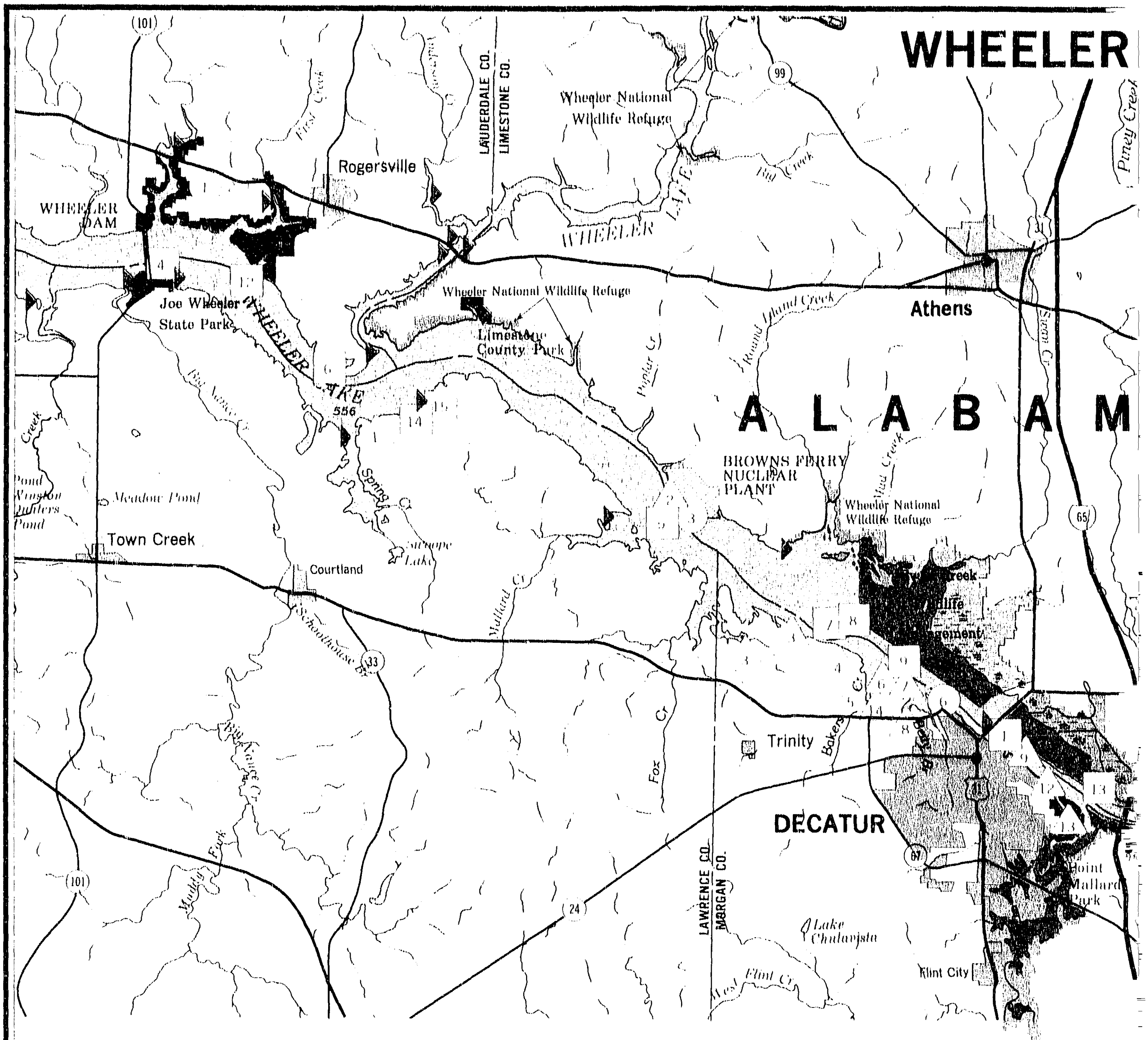
In recent years, the Monsanto plant at Decatur has experienced recurring problems with aquatic macrophyte debris clogging their intake structure wastewater discharge (downstream at TRM 282.5). Because of low flows in the Tennessee River during the drought, there was a possibility of backflows that could carry discharged water upstream. TVA recommended that Champion reduce their effluent flows at night and increase the discharge during the day when Wheeler Dam turbines were operating for peak power production (Cox 1990).

Agricultural Water Supply

There are two agricultural water supplies on Wheeler Reservoir (figure 8 and table 26).

Wastewater Assimilation

Permitted discharges of treated municipal and domestic wastewater are listed in table 27 and shown in figure 8. The majority of treatment plants in the Wheeler Reservoir area are small facilities that discharge to tributary streams rather than directly to the reservoir. The principal industrial wastewater discharges into Wheeler Reservoir are located at the Decatur waterfront complex and downstream (table 28).



☐ SURFACE WATER SUPPLY INTAKES

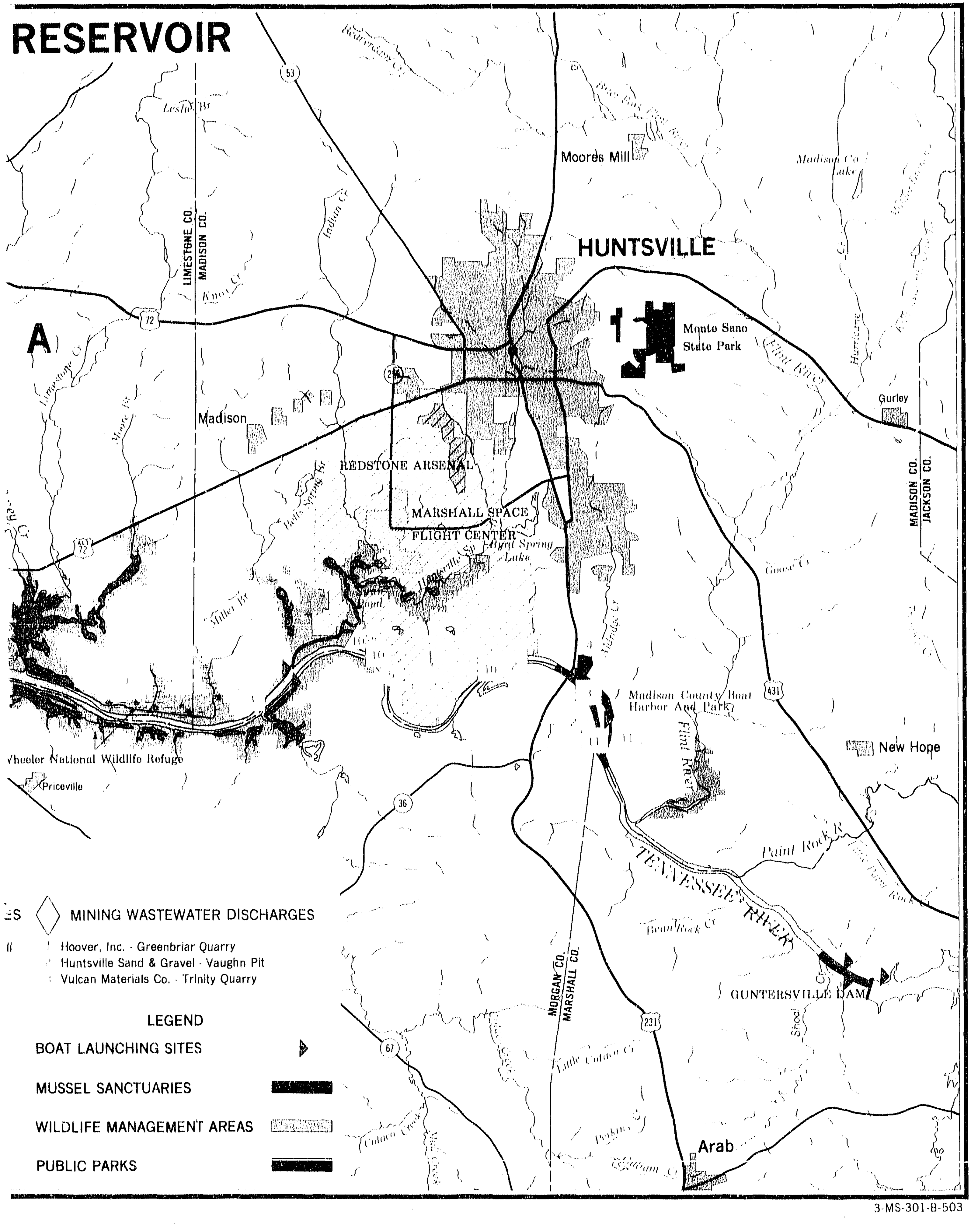
1 Decatur
2 Northeast Morgan County Water and Fire Protection Authority
3 Huntsville
4 TVA - Wheeler Dam Hydro
5 TVA - Browns Ferry Nuclear Plant
6 Champion International
7 Amoco Chemicals Corporation
8 3M Company
9 Monsanto Textile Company
10 Redstone Arsenal
11 Norton Company, Inc.
12 Joe Wheeler State Park
13 City of Decatur - Point Mallard Park Golf Course
14 Joe Wheeler Estate
15 Clancy Lumber Company

○ MUNICIPAL & DOMESTIC WASTEWATER TREATMENT FACILITIES

1 Joe Wheeler State Park
2 Rogersville
3 TVA - Browns Ferry Nuclear Plant
4 Huntsville - Aldridge Creek Plant
5 Huntsville - West
6 Decatur

△ INDUSTRIAL WASTEWATER DISCHARG

1 Champion International Corporation - Courtland M
2 TVA - Browns Ferry Nuclear Plant
3 Amoco Chemicals Corporation
4 Minnesota Mining & Manufacturing (3M)
5 Prestolite Co. - Electronics Division
6 American Fructose
7 Monsanto Co., Inc.
8 Fruehauf Corporation
9 Wolverine Tube, Inc.
10 Redstone Arsenal
11 Norton Company
12 Bunge Corporation
13 General Electric
14 Liquid Air Corporation


RESERVOIR
A
HUNTSVILLE
Moores Mill
Monte Sano State Park
Madison
REDSTONE ARSENAL
MARSHALL SPACE FLIGHT CENTER
Gurley
Madison County Boat Harbor And Park
New Hope
Wheeler National Wildlife Refuge
Priceville
GUNTERSVILLE DAM
TENNESSEE RIVER
Flint River
Paint Rock R
Arab
LIMESTONE CO.
MADISON CO.
MADISON CO.
JACKSON CO.
MORGAN CO.
MARSHALL CO.
MINING WASTEWATER DISCHARGES
Hoover, Inc. - Greenbriar Quarry
Huntsville Sand & Gravel - Vaughn Pit
Vulcan Materials Co. - Trinity Quarry
LEGEND
BOAT LAUNCHING SITES
MUSSEL SANCTUARIES
WILDLIFE MANAGEMENT AREAS
PUBLIC PARKS

3-MS-301-B-503

Table 26. Surface water supply intakes in Wheeler Reservoir.

Water supply	Intake location	Average daily use (mgd)
Municipal		
Decatur, Alabama	TRM 306.0	21.3
Northeast Morgan County Water and Fire Protection Authority	TRM 331.1	0.98
Huntsville, Alabama	TRMs 319.4 and 334.2	4.0 and 17.0, respectively
Industrial		
TVA--Wheeler Dam Hydro	TRM 274.9	32,026.5
TVA--BFN	TRM 293.6	639.1
Champion International	TRM 282.6	54.0
AMOCO Chemicals Corporation	TRM 299.5	4.6
3M Company	TRM 299.7	10.0
Monsanto Textile Company	TRM 301.9	85.0
Redstone Arsenal	TRM 330.2 and 324.2	19.3
Norton Company, Inc.	TRM 335.3	2.35
Independence Tube--proposed	(TRM 297.0)	-
Irrigation		
Joe Wheeler State Park	TRM 278.5	0.36
City of Decatur--Point Mallard Park Golf Course	TRM 308.2	included in Decatur, Alabama above

and pump station at the cooling water intake. Two episodes of milfoil clogging of intake screens have occurred at BFN that were severe enough to reduce flow through the plant and force reductions in power generations (Cox 1990).

In recent years, Monsanto has also had difficulty with elevated temperatures (up to 92-93°F) at their cooling water intake. The elevated temperatures, which have tended to persist for several weeks in August, have necessitated operational changes at the plant (Cox 1990). Ambient water temperatures in excess of ADEM's 86°F criterion are not uncommon during the summer months, and could necessitate installation of cooling towers by industries for compliance with thermal effluent limits.

During the summer of 1986, Champion International expressed concern about potential contamination of their intake (TRM 282.8) by their

Table 27. Municipal and domestic wastewater discharges to Wheeler Reservoir.

County	Owner or municipality	Design capacity (mgd)	Level or type of treatment	Discharge location
Lauderdale				
	Joe Wheeler State Park	0.264	nonaerated stabilization lagoon, 3 cells	TRM 277.8
	Rogersville	0.180	nonaerated stabilization lagoon, 3 cells	TRM 277.8
	TVA--BFN	0.125	secondary (lagoon)	TRM 294.0
	Huntsville			
	(1) Huntsville Spring[a] Branch No. 1	10	activated sludge	TRM 332.1
	(2) Huntsville Spring[a] Branch No. 1A	20	activated sludge	TRM 332.1
	(3) Huntsville-Aldridge Creek Plant	8.4	trickling filter, oxidation ditch	TRM 332.1
	(4) Huntsville-West	10	activated sludge	TRM 333.4
	Decatur	24	secondary	TRM 303.4 (Dry Branch embayment)

a. To be consolidated to one activated sludge facility.

Table 28. Industrial wastewater discharges into Wheeler Reservoir.

Discharger	Type discharge	Average discharge flow	Outfall location
Champion International Corp.-Courtland Mill	process	55 mgd	TRM 282.3
TVA--BFN[a]	cooling	2378 to 2814 mgd for 3-unit operation	TRM 294.0
Vulcan Materials Co.	mining (quarry)	-	unnamed tributary to Fox Creek embayment
Amoco Chemicals Corp.	process, noncontact cooling	24 mgd	TRM 299.4
Minnesota Mining and Manufacturing (3M)	process, sanitary, cooling	12.5 mgd	TRM 301.0
Prestolite Co.-Electronics Division	noncontact cooling	0.086 mgd	Bakers Creek mile 1.2 (to TRM 301.1)
American Fructose	noncontact cooling	1.7 mgd	TRM 301.4
Monsanto Co., Inc.	cooling, process, sanitary	89 mgd	TRMs 301.3, 301.5, 301.8, 302.2
Fruehauf Corp.	noncontact cooling	0.10-1.15 mgd	Betty Rye Branch mile 0.8 (to TRM 302.8)
Wolverine Tube, Inc.	noncontact cooling	0.5-1.0 mgd	TRMs 306, 307

Table 28 (Continued)

Discharger	Type discharge	Average discharge flow	Outfall location
General Electric	primarily noncontact cooling	0.036 mgd	unnamed tributary to Tennessee River at Decatur
Hoover, Inc.	mining (quarry)	-	Goosepond, Wheeler National Wildlife Refuge
Redstone Arsenal	primarily sanitary	2.71 mgd	TRM 323.4
Huntsville Sand and Gravel	mining	-	unnamed tributary upstream from U.S. Highway 231 bridge
Norton Company	cooling	3 mgd	near TRM 335.3
Bunge Corporation	artesian well onsite, site runoff, and cooling tower blowdown	varies with rainfall	Tennessee River at Decatur

a. BFN has been offline since 1985 and is not expected to return to power production before 1991.

Available data indicate the assimilative capacity of Wheeler Reservoir is occasionally marginal or inadequate for existing discharges (Cox 1990). This concern was intensified during the unusually low flows of the 1985-88 drought. However, predrought data, coupled with planned increases in net wasteload to the reservoir and potential changes in reservoir operation, make this a continuing concern.

Recreation

Wheeler Reservoir receives an estimated 3.4 million visits per year at its various developed recreation areas. There are approximately 22 sites with either boat docks or boat launch ramps, five sites with developed swimming areas, and 14 sites with lakeshore camping (table 29). Pleasure boating and water skiing are popular in the summer months. Most overnight campgrounds are full during June, July, and August.

Swimming/Whole Body Water Contact Sports. There are no routine monitoring programs by TVA, Alabama, individual counties, or the various state and local parks bordering the reservoir to assure compliance with applicable sanitary water quality criteria. Short term sampling at several sites by TVA in 1986 and 1990 (see table 8 above) found all sites to be in compliance with the geometric mean criterion for fecal coliforms. However, excessive concentrations (greater than 1000/100 ml) were occasionally noted at Decatur Boat Harbor and in Flint and Cotaco Creek embayments.

Because of the possibility of contamination by enteroviruses that are not inactivated by effluent chlorination, swimming and other whole body contact sports are inadvisable near sewage treatment plant discharges regardless of fecal coliform concentrations. Consequently, this recreational use of Wheeler Reservoir is technically impaired immediately downstream from the discharges listed in table 27.

Boating. Submersed aquatic vegetation impairs the use of some cove areas for boating activities.

Sport Fishing. The reservoir is open to year-round fishing, subject to state regulations. The principal sport species harvested are crappie, largemouth and smallmouth bass, sunfish, catfish, and sauger. Both black and white crappie are harvested, and bluegill and redear comprise most of the sunfish harvest. Blue and channel catfish are the most abundant catfish in the sport harvest. The estimated annual sport fish harvest on Wheeler Reservoir is 188,000 pounds taken during 100,000-120,000 sport fishing trips. The total maximum annual expenditure by these sport fishermen is estimated to be between $11,500,000 and $13,000,000.

The inadvisability of frequent consumption of fish from the reservoir because of flesh contamination reduces the quality of the fishing experience for some people.

Table 29. Boat docks, launches, and recreation areas on Wheeler Reservoir.

Facility	Location	Boat dock	Launching ramp	Public swimming	Camping
Joe Wheeler State Park	TRM 275.2 (R)	x	x	x	x
Second Creek Dock	Second Creek mile 3.5	x			x
Spring Creek Dock	TRM 283.0 (L)	x	x	x	x
Elk River Lodge	Elk River mile 5.0		x		x
Blue Springs Camp	Elk River mile 0.8	x	x		x
Elk River Mills Dock	Elk River mile 14.5	x			
Elk River Rest Area	Elk River embayment		x		x
Limestone County Park	TRM 286.0 (R)	x	x		x
Mallard Creek Boat Dock	TRM 294.8 (L)	x	x		x
Decatur Boat Harbor	TRM 305.0 (R)	x	x	x	x
Flint Creek Boat Dock	Flint Creek embayment	x			
Madison County Boat Harbor and Park	TRM 334.0 (R)	x	x		x
TVA--Wheeler Dam Reservation	TRM 275		x		x
TVA--Round Island Creek Recreation Area	TRM 298 (R)		x	x	x
TVA--Mallard Creek Recreation Area	TRM 293 (L)		x	x	x
TVA--Guntersville Dam Reservation	TRM 348		x		
Lake Shore Marina	TRM 302.8 (L)	x	x		
Point Mallard Park	TRM 308.5 (L)			x	x
Ditto Landing Marina	TRM 333.4 (R)	x			
Limestone Creek Boat Launch	Limestone Creek embayment		x		
Cotaco Creek Boat Launch	Cotaco Creek embayment		x		
Triana Recreation Area	TRM 320.9 (R&L)		x		
Hobbs Island Boat Launch	TRM 336.7 (R)		x		

NOTE: Facilities and services subject to change without notice.

Sources: Recreation on TVA Lakes, TVA/ONRED/LER-84/7; Wheeler and Wilson Lakes Recreation Map, and TVA Mapping Services Branch, 1985.

Aesthetic Quality. The aesthetic quality of reservoir shorelines, especially in residential areas, can be marred by submerged aquatic vegetation. Increases in mosquito populations resulting from increased infestations of submersed aquatic vegetation present a nuisance factor that affects all aspects of recreation on the reservoir.

Support For Biological Communities

Wildlife. Populations of piscivorous birds in the Wheeler National Wildlife Refuge (WNWR) area underwent noticeable declines during the 1950s and 1960s (USACE 1986). Although the cause of the decline has not been established, it is assumed that DDT contamination played a role. Data indicating significant DDT contamination of the Wheeler Reservoir fishery has been available since 1970 (WAR 1980). The degree and geographic extent of contamination was not well characterized, however, until nearly ten years later when the Department of the Army initiated engineering and environmental studies focusing on impacts of past DDT manufacturing activities by Olin Corporation and its predecessors at Redstone Arsenal.

Olin Corporation completed remedial activities to isolate the source of the contamination in 1988 and is now conducting long-term environmental monitoring in the Huntsville Spring Branch-Indian Creek (HSB-IC) area. According to the 1983 Consent Decree, Olin's remedial actions must achieve a performance standard of ≤ 5 ppm DDTr (DDT+DDD+DDE) in channel catfish, smallmouth buffalo, and largemouth bass from specified reaches of the HSB-IC system by 1998 (ten years after completion of remedial actions). However, fish tissue DDtr concentrations of up to 5 ppm may still adversely impact the recovery of piscivorous bird populations. Egg shell thinning and poor reproductive success occur in some freshwater waterfowl at dietary levels of 3 ppm DDT (USACE 1986). EPA's freshwater ambient water quality criterion for protection of piscivorous wildlife is based on prevention of bioaccumulation in fish to levels greater than 0.15 ppm (EPA 1980). Therefore, DDTr concentrations of up to 5 ppm may not be sufficient to permit recovery of the local wildlife.

Aquatic life. Wheeler Reservoir provides habitat for a variety of organisms necessary for a balanced aquatic environment. In most cases the reservoir supports its use by aquatic life but impairments to the use by sauger, mussels, and Asiatic clams are obvious. The recent continuous decline of the sauger population in the reservoir may be due in part to recent drought conditions and may possibly be tied to the operation of BFN. The reservoir environment does not support the continuation of riverine mussel species as evidenced by lack of reproduction. Existing populations have been commercially over-exploited and impacts of waste water discharges and sedimentation are possible contributors to the decline of mussel stocks in the reservoir. Cause(s) of the widespread disappearance of the exotic Asiatic clam are unknown.

Threatened, Endangered, and Other Special Concern Species. Three mussel species, possibly one fish species, an amphibian, and a reptile are the only aquatic species of protected status known to occur in the reservoir (table 18). There is concern that peregrine falcons, listed as threatened by Alabama and endangered federally, could possibly be affected by DDT in the food chain of the reservoir. They feed primarily on waterfowl and shorebirds and pass through the Wheeler National Wildlife Refuge during migration.

Human Consumption of Aquatic Life and Wildlife

There are no quantitative estimates available, but because Wheeler Reservoir has a popular sport fishery and a significant intrastate commercial fishery, consumption of fish tissue is probably substantial. Contamination of the fishery with DDT, PCBs, and dioxin threatens this use.

DDT Contamination. The most recent Wheeler Reservoir channel catfish data (collected by TVA in 1988 from areas other than the HSB-IC system) found DDTr (DDT + DDD + DDE) concentrations less than 2 ppm in composite samples. In 1985, DDTr concentrations marginally greater than the 5 ppm FDA temporary tolerance had been detected in channel catfish fillets from TRM 343. Most of the difference between the 1985 and 1988 samples is attributable to a decline in DDD residues. There are no recent reservoir-wide data on DDTr concentration in other fish species, but historical data indicate that DDTr contamination of channel catfish is generally as great or greater than DDTr contamination of most other species in this reservoir.

Legitimate concerns remain about the potential impact on human health of consumption of fish with DDTr levels of up to 5 ppm (i.e., the FDA temporary tolerance and the Olin remedial activity performance standard). Although no advisories to limit consumption have been issued, Cox (1990) noted that the incremental lifetime cancer risk associated with consumption at a contamination level of 5 ppm DDTr exceeds 1 in 10,000 for the average consumer (EPA has assumed that the national average for fish consumption is 5.2 pounds per year over a 70-year lifetime), and would be even greater for atypical consumers like sports fishermen and subsistence fishermen.

PCB Contamination. In 1985, TVA analyzed channel catfish fillets from Wheeler Reservoir for polychlorinated biphenyls (PCBs) as a follow-up to finding contamination above the FDA 2.0 μg/g tolerance in catfish from Wilson Reservoir, directly downstream from Wheeler. Four of 27 composite samples from Wheeler, each collected from TRM 339 or TRM 343, equaled or exceeded the FDA tolerance. Two five-fish channel catfish composites were collected at TRMs 300 and 339 in 1988. Total PCBs in both composites were less than the 2.0 μg/g for tolerance. However, as noted by Cox (1990) the incremental lifetime cancer risk associated with consumption at a contamination level of 0.5 ppm exceeds 1 in 10,000 for the average consumer.

Dioxin Contamination. Dioxin contamination of fish flesh in waters receiving bleached kraft paper mill effluent has become a significant concern in several areas of the Tennessee Valley. As part of the National Fish Bioaccumulation Study, EPA analyzed smallmouth bass and smallmouth buffalo fillet composites collected in November 1986 from the Tennessee River in the vicinity of the Champion International discharge. The analyses showed no contamination above the detection limit of 1.2 to 1.9 parts per trillion (ppt) of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (Cox 1990). Data collected by Champion in 1989 showed the following concentrations: carp, 0.46 ppt in fillet, 1.1 ppt whole body; bass, 0.07 to 1.2 ppt in fillets, 3.6 to 7.7 ppt whole body; and buffalo, 2.4 ppt in fillets, 5.3 ppt whole body (Cox 1990). There are no dioxin criteria for fish tissue available. However, as noted by Cox (1990), the incremental lifetime cancer risk associated with consumption at a contamination level of 1 ppt is approximately 1 in 10,000 for the average consumer.

Commercial Fishing

Fishes. Wheeler Reservoir supports an extensive commercial fishery for fish. The estimated annual commercial harvest is 1,400,000 pounds, comprised mostly of buffalo (932,000 pounds) and catfish (468,000 pounds). Smallmouth buffalo and blue, channel, and flathead catfish comprise most of the harvest, although other species including carp, gar, redhorse, drum, and paddlefish are also marketed. The total value of the annual fin fish harvest is estimated to be $510,000.

Because of DDTr concentrations greater than 5 ppm, FDA has banned interstate sale of fish from one or more commercial fish markets in the area. Because most of the commercial catch harvested from Wheeler Reservoir had been sold in other states, the FDA restrictions are reported to have adversely affected the commercial market. Local fishermen and market operators have expressed concern over decreased local sales as well.

Mussel Fishery. The mussel harvest on Wheeler Reservoir is limited. Habitat of mussels native to the Tennessee River has been altered by impoundment except in the Guntersville Dam tailwater. This area, extending from Guntersville Dam downstream to the mouth of Shoal Creek (TRM 347) has been designated a mussel sanctuary by the State of Alabama. A second sanctuary has been designated from TRM 337 to TRM 333. A few mussel fishermen (15 or fewer) operate brail boats part time in the upper reaches of the reservoir, and limited diving for mussels occurs where shells are found to be abundant. In the late 1970s, a large population of washboards (Megalonaias nervosa) was found from Round Island Creek to just above the causeway at the U.S. Highway 20 bridge. Approximately 50 to 70 divers worked this area for about two years until the harvestable shells were depleted. Many small shells were also taken as stock for a pearl culture venture in Tennessee. Since this bed was depleted, a few divers (fewer than 30) work the reservoir part time. Although the annual mussel harvest from Wheeler Reservoir was as much as 4,800 tons in 1953, at present the harvest is probably less than

80 tons. The approximate value of the current harvest is $80,000 to $95,000, depending on shell quality. Various sources have attributed the decline of the fishery to high rate of exploitation, unfavorable environmental conditions, sediment effects, and industrial wastes (Cox 1990).

Shoreline Usage

Commercial and Residential Shoreline Usage. Much of the Wheeler Reservoir shoreline is utilized by municipalities and industries, and for agriculture. Residential development is important in the lower end of the reservoir.

The presence of WNWR on either side of the middle third of Wheeler Reservoir is the most significant limit on increased use of the shoreline for residential and commercial development. Increased infestation by submersed aquatic vegetation affects access (especially in coves) and aesthetics of residential areas of the reservoir and poses a potential impact to commercial water intakes. Access to marinas and boat ramps located in coves may also be impacted by increased aquatic vegetation. Increased mosquito populations associated with aquatic plants create an annoyance in shoreline areas utilized by man.

Public Shoreline Usage. Numerous sites along the reservoir support aquatic recreation, including marina areas with boat docks and ramps, swimming areas, lakeshore camping areas, as well as other public access areas (table 29). Aquatic plant infestation and the potential for bacteriological contamination may constrain further development of some shoreline areas for public use.

RESERVOIR MANAGEMENT ACTIVITIES

Management of Wheeler Reservoir to achieve all feasible beneficial uses is a multidisciplinary task that involves the participation of a variety of agencies, corporations, and institutions. Ongoing or planned activities, as well as activities completed within the past five years, are identified below.

Monitoring Programs

Project: Valleywide Fish Tissue Screening Study

Principal Contact: Don Dycus
Phone Number: (615)-751-3722
Organization: TVA

Project Description: Screening study of contaminants in channel catfish flesh with samples collected approximately every three years.

Project: Water Resources and Ecological Monitoring--Reservoir "Vital Signs" Monitoring

Principal Contact: Neil Carriker
Phone Number: (615)-751-7330
Organization: TVA

Project Description: Monitoring to provide information on the "health" or integrity of the ecosystem within each TVA reservoir and provide screening level information to describe how each reservoir meets the fishable and swimmable goals of the Clean Water Act.

Project: Environmental Radiological Monitoring--BFN

Principal Contact: Neil M. Woomer
Phone Number: (615)-751-7307
Organization: TVA

Project Description: Aquatic biological radiological monitoring to detect and measure radioactive isotope concentrations contained in clams, sediment, and fish samples collected semiannually. Samples from Wheeler Reservoir are collected in May and November each year.

Project: Browns Ferry Nuclear Plant Thermal Variance Monitoring

Principal Contact: Johnny P. Buchanan
Phone Number: (615)-632-1797
Organization: TVA

Project Description: Annual cove rotenone fish stock assessments; sauger reproduction monitoring (1985-89); studies of the distribution and temperature selection by sauger beginning in 1991; an algal dynamics study of the effects of BFN on blue-green algae growth beginning in 1991.

Project: Champion International Compliance Monitoring

Principal Contact: Charles Black
Phone Number: (205)-637-6894
Organization: Champion International

Project Description: Weekly temperature, DO, BOD, pH, and apparent odor monitoring at eight reservoir stations from May through November.

Project: Drought Monitoring
Principal Contact: Bruce Brye
Phone Number: (615)-751-7297
Organization: TVA

Project Description: Weekly temperature and DO monitoring at the Wheeler Reservoir forebay, Elk River embayment, and Spring Creek embayment during the drought conditions of the summer of 1986.

Project: Temperature and DO Monitoring Network

Principal Contact: Neil Carriker
Phone Number: (615)-751-7330
Organization: TVA

Project Description: Monthly to weekly monitoring of TVA reservoir releases. Data for Guntersville and Wheeler dams available for the period 1983-89; both sites discontinued in 1990.

Problem Mitigation

Project: Aquatic Plant Management Program

Principal Contact: A. Leon Bates
Phone Number: (615)-386-2278
Organization: Tennessee Valley Authority

Project Description: TVA's Aquatic Plant Management Program uses aerial photography, helicopter reconnaissance, and field surveys to assess distributions and area cover of various aquatic macrophytes on Tennessee River reservoirs. Acreages are determined from aerial photography made after priority areas have been treated with herbicides. Herbicide treatments are used to control aquatic weeds in high priority areas where they conflict with reservoir use. Generally, commercial marinas, public use areas, campgrounds and resorts, residential areas, industrial raw water intakes, and areas with dense weed infestations associated with high mosquito production are considered high priority areas.

Project: Vector Control

Principal Contact: Joseph C. Cooney
Phone Number: (205)-386-2277
Organization: TVA

Project Description:

Resource Assessment and Planning

Project: Wheeler Reservoir Assessment and Management Plan Development

Principal Contact: Don Anderson
Phone Number: (615)-751-7329
Organization: TVA

Project Description: To begin in FY 1991; will include calibration of BETTER model, etc.

Project: Wheeler Reservoir Land Management Plan

Principal Contact: Spencer Boardman
Phone Number: (615)-494-9800
Organization: TVA

Project Description: Develops reservoir-specific objectives for management, protection, and enhancement of beneficial uses of lands under TVA stewardship and control. To be completed in 1991.

Project: 1989 Water Quality Assessment of Alabama Lakes

Principal Contact: Robert Cooner
Phone Number: (205)-271-7700
Organization: Alabama Department of Environmental Management

Project Description: Limited survey of 34 publicly owned reservoirs to provide data on water quality and trophic condition to satisfy Section 314(a)(1) requirements and provide information for 1990 305(b) report.

Project: Recreation Site Assessment

Principal Contact: Joe Fehring
Phone Number: (615)-751-7308
Organization: TVA

Project Description: Intensive sampling (10 samples within one month) from each of 10 sites on Wheeler Reservoir in 1990. In anticipation of regulatory agencies changing bacteriological indicator criteria from fecal coliform to E. coli, data for both indicators were collected from Wheeler Reservoir in 1990.

Project: Water Resources Issues Analysis

Principal Contact: Janice Cox
Phone Number: (615)-751-7337
Organization: TVA

Project Description: Evaluate available information to identify water resource problems and issues that should be addressed by TVA and/or others. An issues analysis for the Wheeler Reservoir Watershed Region will be available in 1990.

Project: Browns Ferry Algal Dynamics Study

Principal Contact: Wayne Poppe
Phone Number: (615)-751-7333
Organization: TVA

Project Description: Limited scope 1989 study of algal dynamics upstream and downstream of BFN while BFN was offline.

Regulatory Compliance

Alabama Department of Environmental Management, Water Division, 1751 Federal Drive, Montgomery, Alabama 36130

- Industrial Branch: John Pool, Chief (205) 271-7852
- Municipal Branch: Truman Green, Chief (205) 271-7800
- Water Supply Branch: Joe Power, Chief (205) 271-7774

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