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June 10, 2003

State of Tennessee
Department of Environment and Conservation
Division of Water Pollution Control
Enforcement & Compliance Section
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Nashville, Tennessee 37243-1534

Attention: Mr. Chip Hannah

Dear Mr. Hannah:

SEQUOYAH NUCLEAR PLANT - NONRADIOLOGICAL AQUATIC MONITORING PROGRAM BIOLOGICAL MONITORING

Please find enclosed the report, "Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge, 2002." This report is submitted in accordance with Part III, Section F of the TVA - Sequoyah Nuclear Plant NPDES Permit No. TN0026450.

Please contact me at (423) 843-6700 if you have any questions or comments.

Sincerely,

Stephanie A. Howard

Stephanie A. Howard
Acting Environmental Supervisor
Signatory Authority for
Richard T. Purcell
Site Vice President
Sequoyah Nuclear Plant

Enclosure
cc (Enclosure):

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IE25

Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge 2002

by
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June 2003
Final

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Acronyms

BIP	Balanced Indigenous Population
NPDES	National Pollutant Discharge Elimination System
PSD	Proportional Stock Density
QA	Quality Assurance
RFAI	Reservoir Fish Assemblage Index
RSDM	Relative Stock Density of Memorable-sized

Acronyms
(Continued)

RSDP	Relative Stock Density of Preferred-sized
RSDT	Relative Stock Density of Trophy-sized
SFI	Sport Fishing Index
SQN	Sequoyah Nuclear Plant
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
VS	Vital Signs
Wr	Relative Weight

Introduction

Section 316(a) of the Clean Water Act specifies that industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. Industries responsible for point-source dischargers of heated water can obtain a variance from state water quality standards if the industry can demonstrate compliance with thermal criteria by documenting the maintenance of balanced indigenous populations (BIP) of aquatic life in the vicinity of its discharge. Sequoyah Nuclear Plant's (SQN) current National Pollutant Discharge Elimination System (NPDES) permit number TN0026450 states, "For Section 316(b), the permittee shall summarize previous data and indicate whether significant changes have occurred in plant operation, reservoir operations or in stream biology that would necessitate that significant changes to the permitted variance." The permittee shall use the Reservoir Fish Assemblage Index (RFAI) to assess Chickamauga Reservoir fish community health. Any apparent declines in the fish community health will be further investigated to discover whether the decline is a valid conclusion and if the decline is real to identify possible sources for the fish community decline. As part of the identification of potential sources for the decline, the instream effects of the discharges made under this permit will be investigated (TDEC 2000). In response to this requirement, Tennessee Valley Authority's (TVAs) Vital Signs (VS) monitoring program (Dycus and Meinert 1993) will be used to evaluate areas of Chickamauga Reservoir upstream and downstream of SQN discharge. The purpose of this document is to briefly summarize and provide Tennessee Department of Environment and Conservation the results of comparisons between current and historical monitoring data.

Prior to 1990, the TVA reservoir studies focused on reservoir ecological assessments to meet specific needs as they arose. In 1990, the TVA instituted a Valley-wide VS monitoring program which is a broad-based evaluation of the overall ecological conditions in major reservoirs. Data is evaluated with a multi-metric monitoring approach utilizing five environmental indicators: dissolved oxygen, chlorophyll, sediment quality, benthic macroinvertebrate community, and the fish community. When this program was initiated, specific evaluation techniques were developed for each indicator, and these techniques were fine-tuned to better represent ecological conditions. The outcome of this effort was development of multi-metric evaluation techniques for the fish assemblage (i.e., RFAI) and the benthic community, as described below. These multi-metric evaluation techniques have proven successful in TVA's monitoring efforts as well as other federal and state monitoring programs. Therefore, they will form the basis of evaluating these monitoring results. For consistency, only RFAI analyses between 1993 and 2002 will be utilized.

In the past, the Sport Fishing Index (SFI) was used in support of a thermal variance request at SQN (TVA 1996) and during Supplemental Condenser Cooling Water monitoring. The SFI was developed to quantify sport fishing quality for individual sport fish species. The SFI provides biologists with a reference point to measure the quality of a sport fishery. Comparison of the population sampling parameters and creel results for a particular sport fish species with expectations of these parameters from a high quality fishery (reference conditions) allows for the determination of fishing quality. Indices have been developed for black bass (largemouth,

smallmouth and spotted bass), sauger, striped bass, bluegill, and channel catfish. Each SFI relies on measurements of quantity and quality aspects of angler success and fish population characteristics.

In recent years, SFI information has been used to describe the quality of the resident fishery in conjunction with compliance monitoring, thermal variance requests, and other regulatory issues at TVA nuclear plants in Tennessee. Similar NPDES compliance monitoring programs using the methodologies described above are also being performed at Colbert and Widows Creek Fossil Plants in Alabama.

SFI analyses will be used in this document to support the findings of the other indices used. However, 2002 Tennessee Wildlife Resources Agency (TWRA) data, necessary to complete the SFI analyses for Chickamauga Reservoir, will not be available in time to incorporate into this document, so 2001 results will be used in the analysis.

Methods

Fish Community

Reservoirs are typically divided into three zones for VS Monitoring – inflow, transition and forebay. The inflow zone is generally in the upper reaches of the reservoir and is riverine in nature; the transition zone or mid-reservoir is the area where water velocity decreases due to increased cross-sectional area, and the forebay is the lacustrine area near the dam. The Chickamauga Reservoir inflow zone is located at Tennessee River Mile (TRM) 529.0; the transition zone is located at TRM 490.5, and the forebay zone is located at TRM 472.3. The VS transition zone, which is located approximately 7.2 river miles upstream of the SQN discharge (TRM 483.3), will be used to provide upstream data for the 316(a) thermal variance studies performed in sample years between 1993 and 2002. An additional transition station was later added downstream of the SQN discharge to more closely monitor Chickamauga Reservoir aquatic communities in close proximity to the SQN thermal effluent. This station is located at TRM 482.0 and will be used for downstream comparisons of aquatic communities for the 1999 through 2002 sample seasons. The forebay zone, will serve as the downstream station for 1993 through 1995 and 1997 sample seasons.

Fish samples consisted of fifteen 300-meter electrofishing runs (approximately 10 minutes duration) and ten experimental gill net sets (five 6.1 meter panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm) per station. Attained values for each of the 12 metrics were compared to reference conditions for transition zones of mainstream Tennessee River reservoirs and assigned scores based upon three categories hypothesized to represent relative degrees of degradation: least degraded -5; intermediate -3; and most degraded -1. These categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment. Individual metric scores for a station are summed to obtain the RFAI score.

Comparison of the attained RFAI score from the potential impact zone to a predetermined criterion has been suggested as a method useful in identifying presence of normal community structure and function and hence existence of a BIP. For multi-metric indices, two criteria have

been suggested to ensure a conservative screening for a BIP. First, if an RFAI score reaches 70 percent of the highest attainable score (adjusted upward to include sample variability), and second, if fewer than half of RFAI metrics potentially influenced by thermal discharge receive a low (1) or moderate (3) score, then normal community structure and function would be present indicating that a BIP existed. Under these conditions, the heated discharge would meet screening criteria and no further evaluation would be needed.

The range of RFAI scores possible is from 12 to 60. As discussed in detail below, the average variance for RFAI scores in TVA reservoirs is 6 ($\pm$ 3). Therefore, any location that attains an RFAI score of 45 (42 + our sample variance of 3) or higher would be considered to demonstrate a BIP. It must be stressed that scores below this endpoint do not necessarily reflect an adversely impacted fish community. The endpoint is used to serve as a conservative screening level; for example, any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this level would require a more in-depth look to determine if a BIP exist. If a score below this criterion is obtained, an inspection of individual RFAI metric results would be an initial step to help identify if SQN operation is a contributing factor. This approach is appropriate if a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

Upstream/downstream stations comparisons can be used to identify if SQN operation is adversely affecting the downstream fish community as well. A similar or higher RFAI score at the downstream station compared to the upstream (control) station is used as one basis for determining presence/absence of SQN operational impacts on the resident fish community. Definition of "similar" is integral to accepting the validity of these interpretations.

The Quality Assurance (QA) component of VS monitoring deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15-20 percent of the stations each year. Experience to date with the QA component of VS shows that the comparison of RFAI index scores from 54 paired sample sets collected over a seven year period ranged from 0 to 18 points, the 75th percentile was 6, the 90th percentile was 12. The mean difference between these 54 paired scores is 4.6 points with 95 percent confidence limits of 3.4 and 5.8. Based on these results, a difference of 6 points or less is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score, the communities will be considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (25 percent of the QA paired sample sets exceeded that value). When this occurs, a metric-by-metric examination will be conducted to determine what caused the difference in scores and the potential for the difference to be thermally related.

As mentioned in the introduction, modifications to the metrics used in RFAI are continually being evaluated in order to make the index better reflect reservoir conditions. For the 2002 sampling season, some RFAI metrics were changed. In addition, several years of RFAI and water quality data have revealed that largemouth bass, in the Tennessee Valley, are actually quite tolerant of poor water quality. The species has shown a tolerance for low dissolved oxygen,

warm water temperatures, and highly eutrophic conditions. Therefore, its water quality tolerance rating has been changed to "Tolerant." Previous years' scores have been adjusted in this report to reflect these changes so as not to affect year-to-year comparisons and averages. Comparisons will be made between present and improved RFAI scores. Future versions of the RFAI will likely include more iterations as this analysis technique is continually fine tuned.

Benthic Macroinvertebrate Community

Ten benthic grab samples were collected at equally spaced points along the upstream and downstream transects. A Ponar sampler was used for most samples but a Peterson sampler was used when heavier substrate was encountered. Collection and processing techniques followed standard VS procedures. Bottom sediments were washed on a 533μ screen and organisms were then picked from the screen and remaining substrate and identified to Order or Family level in the field using no magnification. Benthic community results were evaluated using seven community characteristics or metrics. Results for each metric were assigned a rating of 1, 3, or 5 depending upon how they compared to reference conditions developed for VS sample sites. The ratings for the seven metrics were summed to produce a total benthic score for each sample site. Each reservoir section (inflow, transition, or forebay) differs in their maximum potential for benthic diversity; thus, the criteria for assigning metric ratings were adjusted accordingly such that the total benthic scores from sites on different reservoir sections are comparable. Potential scores ranged from 7 to 35. Ecological health ratings ("Poor," "Fair," or "Good") are then applied to scores. A similar or higher benthic index score at the downstream site compared to the upstream site is used as basis for determining if SQN's thermal discharge is having no effect on the Chickamauga Reservoir benthic community.

The QA component of VS monitoring shows that the comparison of benthic index scores from 49 paired sample sets collected over a seven year period ranged from 0 to 14 points, the 75th percentile was 4, the 90th percentile was 6. The mean difference between these 49 paired scores is 3.1 points with 95 percent confidence limits of 2.2 and 4.1. Based on these results, a difference of 4 points or less is the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if the downstream benthic score is within 4 points of the upstream score, the communities will be considered similar and it will be concluded that SQN has had no effect. Once again, it is important to bear in mind that differences greater than 4 points can be expected simply due to method variation (25 percent of the QA paired sample sets exceeded that value). When this occurs, a metric-by-metric examination will be conducted to determine what caused the difference in scores and the potential for the difference to be thermally related.

Sport Fishing Index

Calculations described by Hickman (2000) were used to compare SFI values for selected quantity and quality parameters from creel and population samples to expected values that would occur in a good or high quality fishery. Quantity parameters include angler success and catch per unit effort from standard population samples (electrofishing, trap and experimental gill netting). Population quality is based on measurement of five aspects of each resident sport fish community. Four of these aspects address size structure (proportional number of fish in each length group) of the community, Proportional Stock Density (PSD), Relative Stock Density of

Preferred-sized fish (RSDP), Relative Stock Density of Memorable-sized fish (RSDM), and Relative Stock Density of Trophy-sized fish (RSDT) (Figure 1). Relative weight (Wr), a measure of the average condition of individual fish makes up the fifth population quality aspect. As described by Hickman (2000), observed values were compared to reference ranges and assigned a corresponding numerical value. The SFI value is calculated by adding up the scores for quantity and quality from existing data and multiplying by two when only creel or population data are available. Species received a low score when insufficient numbers of individuals were captured to reliably determine proportional densities or relative weights for particular parameters. SFI scores are typically compared to average Tennessee Valley reservoir scores; however, Valley-wide scores are unavailable from natural resource agencies. Therefore, Chickamauga Reservoir fish species scores will be compared to previous years.

Results and Discussion

Fish Community

In the autumn of 2002, the SQN downstream station scored 43 (Good) and the upstream station scored 51 (Excellent) using the new RFAI analysis methodology (Tables 1 and 2). In addition, the downstream, SQN transition station (closest to the SQN discharge) received lower scores than the forebay downstream station for the following RFAI metrics, 1) percent dominance by one species, 2) percent omnivores, and 3) average number per run (Table 1). However, RFAI scores obtained from VS monitoring stations located upstream and downstream of the SQN discharge over the past several years have revealed consistently good fish community results (Tables 3a and 3b and Figure 2). Regardless of analysis methodology or which downstream station was used, the upstream station rating remained in the "Good" range and the downstream continued in the "Good" range, on average (Tables 3a and 3b and Figure 2). As indicated in Table 3b, between 1993 and 2002, the average RFAI score for the upstream station was 47 (78.0 percent of the maximum score). The two downstream stations (i.e., SQN transition and forebay) both averaged 46 (76.6 percent of the maximum score).

The 2002 upstream and downstream RFAI stations have a difference greater than 6 points which does not meet one of the criteria identified in the Methods section as indicative of a BIP. However, as you will note in the following benthic community discussion, the downstream benthic station (TRM 482) scored better than the upstream station which does not support the RFAI findings. Since the 2002 RFAI data only represents one year, further investigation may be warranted in the future, if the trend continues, to determine if method variation can account for the change or if it is water quality related.

Based on the average upstream and downstream RFAI scores, 2002 macroinvertebrate community data, and the defining characteristics for a BIP, it can be concluded that SQN operation has had no impact on the Chickamauga Reservoir resident fish community, on average, for eight sampling seasons. Electrofishing and gill netting catch rates for individual species from the downstream station are listed in Table 4 and 5.

Benthic Macroinvertebrate Community

Table 6 provides ratings for each metric as well as the overall benthic index score for both monitoring sites. Table 7 summarizes density by taxon at the upstream (TRM 490.5) and downstream (TRM 482) collection stations. In the 2002 sampling season, the upstream station produced a benthic index score of 23 (Fair) and the downstream station scored 27 (Good). Therefore, it appears that SQN has had no adverse effect on the benthic macroinvertebrate community immediately downstream from the plant. Table 8 provides benthic index scores from VS monitoring at the forebay (TRM 472.3) and transition zone stations from 1994 to 2002. The Chickamauga forebay zone sample station is of sufficient distance downstream (11 miles) that results would not be expected to reflect plant effects. The similar scores from TRM 472.3 and TRM 482 also indicate that SQN has had no effect on the macroinvertebrate community immediately downstream from the plant.

Sport Fishing Index

In the autumn of 2001, Chickamauga Reservoir's black bass, largemouth, and spotted bass, bluegill, and sauger received lower SFI scores than they did in 2000 and smallmouth bass received a higher score (Table 9 and Figure 3). The score for largemouth was the lowest it has been since 1997 when this analysis technique was implemented by TVA. Here again, this is only one year's dataset, and a reservoir-wide analysis (rather than upstream, downstream comparison), so it is not necessarily indicative of a trend. Historical data indicates that SFI scores typically vary across years. However if future scores would continue to decline, further investigation would be warranted. Smallmouth bass and striped bass received their highest SFI scores to date and walleye were not collected in sufficient numbers to analyze (Table 9 and Figure 3). Tables 10 and 11 illustrate sport fish index scoring criteria for population metrics and creel quantity and quality.

Sauger population estimates based on rotenone data have increased annually since 1988 in Wheeler Reservoir. The 1994 sauger population estimate (38 fish/ha) and the estimated number of young-of-year (35 fish/ha) were the second highest reported for each category during the 1969-1997 time period. In 1997, the last year rotenone data was available, Wheeler Reservoir sauger population averaged 5.6 fish/ha (Baxter and Buchanan 1998).

Hickman et al., (1990) noted that sauger populations across the Tennessee Valley declined during the mid- to late-1980's due to a prolonged drought. The Tennessee Valley is currently in another drought cycle and populations may decline further. Maceina et al., (1998) described population characteristics and exploitation rates of sauger during 1993-1995 in the tailraces of Guntersville, Wheeler and Wilson Dams. Maceina reported that total annual mortality between age-1 and age-2 fish was high (64 percent-83 percent) and that saugers were harvested at high rates before reaching their full growth potential.

Sauger, striped bass, and channel catfish are easily caught during their spring migration to preferred spawning habitats. Fishing creel surveys conducted in the spring would better describe and evaluate these species compared to only using autumn fisheries surveys.

Watts Bar Sauger Spawning Study, 2003 Update

While no SQN operational impacts on sauger spawning have been identified, TVA has found that reservoir releases from Watts Bar Dam during April significantly influence success of sauger spawning in Chickamauga Reservoir. Relative failures of sauger yearclasses were documented during the drought period of the late 1980's, a time during which instantaneous minimum flows were not provided (Yeager and Shiao 1992; Hickman and Buchanan 1996). A continuous minimum release of about 8,000 cfs from Watts Bar Dam during April is usually sufficient to produce an adequate sauger yearclass. However, under dry conditions, a release of 8,000 cfs cannot be sustained.

In April 1999 only 4,000 cfs were provided (Figure 4), and that failed to produce a good yearclass (Hickman 2003). The next year adequate water was available to maintain at least 8,000 cfs during April. However, during the dry spring of 2001, the specified minimum flows were again unobtainable. Since 4,000 cfs were found to be inadequate in 1999, special releases for sauger were modified in 2001 to provide 6,000 cfs for the three week period from April 9 to April 30, the period of greatest spawning activity. The success of this spawning flow regime was to be determined by a series of hourly gill net samples collected during the late winter of 2002 and compared to historical sample results.

Unfortunately, high flows beginning in mid-March 2002 (Figure 4) negated our ability to safely collect gill net samples downstream from Watts Bar Dam. When the flows subsided in mid-April, water temperatures had already risen beyond the sauger spawning peak, and very few sauger were collected in the gill nets. What few that were collected had already spawned, so it was presumed that the bulk of sauger spawning activity had occurred during the high flows when gill netting was not possible. Although we were unable to assess the success of the 2001 spawn, the likelihood of a good 2002 yearclass was strong.

Plans were made to return to Watts Bar Tailwater in the winter of 2003 to again attempt sampling of the 2001 sauger yearclass. However, those plans were jeopardized by the fire at the Watts Bar Dam powerhouse and subsequent loss of hydroturbine operation in the fall of 2002. While the turbines were inoperable, all the water passing the dam was via the spillways. Additional hindrances to sampling in the late winter of 2003 were high flows (Figure 4), especially since they were over the spillway, making it impossible to sample the area below dam safely. Flows subsided briefly during the first week of April, and a few samples were collected, but not enough sauger were captured before high flows returned.

Because insufficient numbers of sauger were collected in gill net samples below Watts Bar Dam during 2002 and 2003, inferences from TWRA creel surveys on Chickamauga Reservoir were drawn to evaluate sauger abundance and yearclass strength (Table 12).

Sauger fishing is highly seasonal, beginning in December and ending in March, when sauger migrate to the headwaters of Chickamauga Reservoir below Watts Bar Dam before the spring spawning season. Most sauger are caught during January and February, as in 1992 (TWRA 1993). To help maintain the fishery, TWRA enforces a 15" minimum size limit, which allows them at least one spawning season before being harvested. Most fish are in their third growing

season when they reach legal size. Since sauger are sought mostly for food, as opposed to a catch-and-release fishery, the majority of those released are under legal size. The percentage of caught fish released (Table 12) gives an approximation of one and two-year old fish in the Chickamauga Reservoir sauger fishery. Average weight of harvested sauger also indicates the yearclass composition of the fishery among years.

Creel statistics for 2000 and 2001 are somewhat similar in total number caught, total number harvested, percent of caught fish released, and average weight. This indicates that the yearclass composition of harvested sauger from Chickamauga Reservoir were basically the same, although the abundance may have been slightly more in 2000. Nearly two-thirds of the sauger caught were released, implying they were of sub-legal size (i.e., one and two-year old fish). The abundance of sub-legal sauger caught indicates relative spawning success during the previous two years.

But in 2002, creel statistics show a change in yearclass composition and a decline in recruitment of smaller, younger fish to the fishery. That decline can be largely traced to the relative weakness of the 1999 yearclass of sauger, which was attributed to the minimum April 1999 flows of 4,000 cfs from Watts Bar Dam (Figure 4). The total 2002 catch was approximately half those of the previous two years, and the average size was larger. Furthermore, the lower percentage of caught and released fish in 2002 implies a decline in abundance of sub-legal sauger, which would include the 2001 yearclass. If future data confirm this to be true, then the 6,000 cfs maintained for the last three weeks in April 2001 was insufficient to produce a strong sauger yearclass.

One cautionary note on using creel data to evaluate sauger abundance is necessary. Since sauger are primarily harvested during the two month period preceding their spawning season, inclement weather or flow conditions (such as high, muddy discharges) at that time could hinder sauger fishing and produce creel statistics that do not accurately reflect the true abundance of sauger in Chickamauga Reservoir. Also note that flows in February 2002 were not excessive (Figure 4), and the creel statistics for that year, as discussed above, should be accurate. The same is not true for Watts Bar Dam discharges in 2003, however, but those data are not yet available from TWRA.

Additional gill net samples will be collected during the winter of 2004, hopefully in the absence of uncontrolled discharges from Watts Bar Dam. With adequate numbers of sauger collected next year, length and yearclass analysis should be sufficient to determine the adequacy of reduced minimum flows of 6,000 cfs during three weeks of April in years when rainfall is low.

In summary, assessment of 2001 sauger spawning success during three weeks of 6,000 cfs minimum flows during the spawning season was not possible using gill net information collected in 2002 or 2003 due to unusual flow conditions. Instead, inferences were made on the relative success of the 2001 spawn using TWRA creel information. Those data indicate the 2001 spawn was poor. However, creel data in 2000-2002 indicate that even during the recent drought, the fishery did not crash, as it did during the drought years of the late 1980's, before April minimum flows were maintained at Watts Bar Dam (Hickman and Buchanan 1996). Better understanding of the 2001 yearclass of sauger should be available following gill netting data collected next year.

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Table 1. Scoring Results for the Twelve Metrics and Overall Reservoir Fish Assemblage Index for Chickamauga Reservoir at the Sequoyah Downstream Sampling Station, 2002.

		Forebay TRM 472.3		Transition TRM 482.0 *Downstream Station*	
Metric		**Obs.**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		25	3	24	3
2. Number of centrachid species		7	5	7	5
3. Number of benthic invertivores		3	1	3	1
4. Number of intolerant species		5	5	5	5
5. Percent tolerant species	electrofishing	52.5	1.5	70.3	0.5
	gill netting	16.6	1.5	6.2	2.5
6. Percent dominance by one species	electrofishing	27.1	1.5	30.6	1.5
	gill netting	28.0	1.5	42.0	0.5
7. Number non-native species	electrofishing	0.4	2.5	0.5	2.5
	gill netting	2.3	2.5	3.7	2.5
8. Number of top carnivore species		8	5	10	5
B. Trophic composition					
9. Percent top carnivores	electrofishing	8.1	1.5	14.3	2.5
	gill netting	76.0	2.5	67.9	2.5
9. Percent omnivores	electrofishing	10.3	2.5	33.5	1.5
	gill netting	12.0	2.5	17.3	1.5
C. Fish abundance and health					
11. Average number per run	electrofishing	45.3	0.5	38.8	0.5
	gill netting	17.5	1.5	8.1	0.5
12. Percent anomalies	electrofishing	1.0	2.5	0.9	2.5
	gill netting	0	2.5	0	2.5
RFAI			**46 Good**		**43 Good**

Table 2. Scoring Results for the Twelve Metrics and Overall Reservoir Fish Assemblage Index for Chickamauga Reservoir at the Upstream Sampling Station, 2002.

		Transition TRM 490.5 *Upstream Station*		Inflow TRM 529.0	
Metric		**Obs.**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		30	5	26	3
2. Number of centrachid species		8	5	7	5
3. Number of benthic invertivores		5	3	5	3
4. Number of intolerant species		6	5	6	5
5. Percent tolerant species	electrofishing	57.9	1.5	37.5	3
	gill netting	9.8	2.5	0	0
6. Percent dominance by one species	electrofishing	32.0	1.5	29.4	3
	gill netting	34.8	0.5	0	0
7. Number non-native species	electrofishing	0.8	2.5	0.8	5
	gill netting	2.3	2.5	0	0
8. Number of top carnivore species		10	5	7	5
B. Trophic composition					
9. Percent top carnivores	electrofishing	16.3	2.5	12.1	3
	gill netting	81.1	2.5	0	0
9. Percent omnivores	electrofishing	18.0	2.5	13.2	5
	gill netting	11.4	2.5	0	0
C. Fish abundance and health					
11. Average number per run	electrofishing	75.3	0.5	85.7	3
	gill netting	13.2	1.5	0	0
12. Percent anomalies	electrofishing	0.6	2.5	0.5	5
	gill netting	0	2.5	0	0
RFAI			**51 Excellent**		**48 Good**

Table 3a. Recent (1993-2001) RFAI Scores Collected as Part of the Vital Signs Monitoring Program Upstream and Downstream of Sequoyah Nuclear Plant.

Station	Reservoir	Location	1993	1994	1995	1997	1999	1993-1999 Average	2000*	2001	1993-2001 Average
Upstream	Chickamauga	TRM 490.5	51	43	50	40	41	45 (Good)	44	45	45 (Good)
Sequoyah Transition	Chickamauga	TRM 482.0					43	43 (Good)	49	47	48 (Good)
Forebay	Chickamauga	TRM 472.3	45	41	47	38	39	42 (Good)	43	42	43 (Good)

*The 2000 sample year was not part of the VS monitoring program, however the same methodology was applied.

Table 3b. Recent (1993-2002) RFAI Scores Developed Using the New (2002) RFAI Metrics.

Station	Reservoir	Location	1993	1994	1995	1997	1999	1993-1999 Average	2000*	2001	2002*	1993-2002 Average
Upstream	Chickamauga	TRM 490.5	49	40	46	39	45	44 (Good)	46	45	51	47 (Good)
Sequoyah Transition	Chickamauga	TRM 482.0					41	41 (Good)	48	46	43	46 (Good)
Forebay	Chickamauga	TRM 472.3	44	44	47	39	45	44 (Good)	45	48	46	46 (Good)

*The 2000 and 2002 sample years were not part of the VS monitoring program, however the same methodology was applied.

Table 4. Species Listing and Catch Per Unit Effort for the Embayment and Sequoyah Transects During the Fall Electrofishing and Gill Netting on Chickamauga Reservoir, 2002 (Electrofishing Effort = 300 Meters of Shoreline and Gill Netting Effort = Net-Nights).

	Forebay TRM 472.3			Transition TRM 482.0		
Common Name	**Electrofishing Catch Rate Per Run**	**Electrofishing Catch Rate Per Hour**	**Gill Netting Catch Rate Per Net Night**	**Electrofishing Catch Rate Per Run**	**Electrofishing Catch Rate Per Hour**	**Gill Netting Catch Rate Per Net Night**
Skipjack herring	.	.	2.4	.	.	0.3
Gizzard shad	3.27	18.01	1.2	11.33	71.13	0.3
Threadfin shad	8.33	45.96	0.1	.	.	.
Common carp	0.2	1.1	0.1	0.2	1.26	.
Golden shiner	1.13	6.25	0.1	0.07	0.42	.
Emerald shiner	4.27	23.53	.	1.27	7.95	.
Spotted sucker	0.27	1.47	0.8	0.33	2.09	0.3
Blue catfish	.	.	0.5	0.53	3.35	0.2
Channel catfish	0.07	0.37	0.2	0.87	5.44	0.9
Flathead catfish	.	.	0.1	0.2	1.26	0.3
White bass	.	.	.	0.07	0.42	.
Yellow bass	.	.	1.7	0.07	0.42	0.1
Striped bass	.	.	0.3	.	.	0.3
Warmouth	0.07	0.37	.	0.27	1.67	0.1
Redbreast sunfish	4.67	25.74	0.1	1.67	10.46	.
Green sunfish	0.33	1.84	.	.	.	.
Bluegill	12.27	67.65	0.2	11.87	74.48	.
Longear sunfish	1.07	5.88	.	0.53	3.35	.
Redear sunfish	1.93	10.66	0.5	3.33	20.92	0.2
Smallmouth bass	0.47	2.57	0.3	0.53	3.35	0.2
Spotted bass	1.2	6.62	4.9	2.33	14.64	3.4
Largemouth bass	1.93	10.66	1.2	2.13	13.39	.
White crappie	.	.	.	.	.	0.2
Black crappie	0.07	0.37	2.3	0.2	1.26	0.1
Logperch	0.27	1.47	.	0.13	0.84	.
Sauger	.	.	0.1	.	.	0.6
Freshwater drum	0.07	0.37	0.4	0.13	0.84	0.6
Brook silverside	3.4	18.75	.	0.73	4.6	.
Chestnut lamprey	0.07	0.37	.	.	.	.
Total	**45.36**	**250.01**	**17.5**	**38.79**	**243.54**	**8.1**
Number Samples	**15**		**10**	**15**		**10**
Number Collected	**680**		**175**	**582**		**81**
Species Collected	**21**		**20**	**22**		**16**

Table 5. Species Listing and Catch Per Unit Effort for the Forebay, Transition, and Inflow Transects During the Fall Electrofishing and Gill Netting on Chickamauga Reservoir, 2002 (Electrofishing Effort = 300 Meters of Shoreline and Gill Netting Effort = Net-Nights).

	Transition TRM 490.5			Inflow TRM 529.0	
Common Name	**Electrofishing Catch Rate Per Run**	**Electrofishing Catch Rate Per Hour**	**Gill Netting Catch Rate Per Net Night**	**Electrofishing Catch Rate Per Run**	**Electrofishing Catch Rate Per Hour**
Skipjack herring	.	.	1.5	.	.
Gizzard shad	10.87	61.51	1.2	9.2	51.49
Threadfin shad	8.93	50.57	.	25.2	141.04
Common carp	0.47	2.64	.	0.47	2.61
Golden shiner	1.07	6.04	.	0.2	1.12
Emerald shiner	3.6	20.38	.	0.13	0.75
Spotfin shiner	0.47	2.64	.	1.87	10.45
Bullhead minnow	0.07	0.38	.	0.4	2.24
Northern hog sucker	0.07	0.38	.	0.07	0.37
Spotted sucker	0.27	1.51	.	0.53	2.99
Black redhorse	.	.	.	0.13	0.75
Golden redhorse	0.07	0.38	0.1	0.47	2.61
Channel catfish	1.13	6.42	0.3	1.47	8.21
Flathead catfish	0.13	0.75	0.3	0.4	2.24
White bass	.	.	0.4	0.6	3.36
Yellow bass	1.2	6.79	4.6	2.33	13.06
Striped bass	.	.	0.2	0.07	0.37
Hybrid striped x white	.	.	0.1	.	.
Warmouth	1.6	9.06	.	0.33	1.87
Redbreast sunfish	2.67	15.09	.	1.27	7.09
Green sunfish	0.27	1.51	.	0.27	1.49
Bluegill	24.07	136.23	.	16.27	91.04
Longear sunfish	0.93	5.28	.	0.53	2.99
Redear sunfish	4.73	26.79	0.6	14.73	82.46
Smallmouth bass	1.93	10.94	0.2	1.07	5.97
Spotted bass	4.07	23.02	2.1	2.07	11.57
Largemouth bass	3.73	21.13	.	2.6	14.55
White crappie	.	.	0.1	.	.
Black crappie	1.13	6.42	0.8	1.2	6.72
Yellow perch	0.13	0.75	.	0.13	0.75
Logperch	0.07	0.38	.	.	.
Sauger	0.07	0.38	0.4	.	.
Freshwater drum	0.47	2.64	0.3	0.4	2.24
Brook silverside	0.87	4.91	.	1.33	7.46
Chestnut lamprey	0.2	1.13	.	.	.
Total	**75.29**	**426.05**	**13.2**	**85.74**	**479.86**
Number Samples	**15**		**10**	**15**	
Number Collected	**1129**		**132**	**1286**	
Species Collected	**29**			**29**	

*Only Young-of-Year Collected

Table 6. Individual Metric Ratings and the Overall Benthic Community Index Score for Upstream and Downstream Stations near Sequoyah Nuclear Plant, Chickamauga Reservoir, Novembei 2002.

	TRM 490.5 Upstream		TRM 482 Downstream	
Metric	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	5.4	3	4.8	3
2. Proportion of samples with long-lived organisms	100%	5	100%	5
3. Average number of EPT taxa	0.4	1	0.4	1
4. Average proportion of oligochaete individuals	10%	5	21%	3
5. Average proportion of total abundance comprised by the two most abundant taxa	83.8%	3	78.5%	5
6. Average density excluding chironomids and oligochaetes	200	1	383.3	5
Zero-samples - proportion of samples containing no organisms	0	5	0	5
Benthic Index Score		**23 Fair**		**27 Good**

*Scored with transition criteria.

Table 7. Average Mean Density Per Square Meter of Benthic Taxa Collected at Upstream and Downstream Stations near Sequoyah Nuclear Plant, Chickamauga Reservoir, November 2002.

	Chickamauga Reservoir	**TRM 490.5 Upstream**	
	Species	**Mean Density**	**Occurrence per site**
Phylum	Annelida		
Subclass	Oligocheata		
Family	Tubificidae	77	6
	Branchiura sowerbyi	2	1
	Limnodrilus hoffmeisteri	20	5
Class	Hirudinea		
Family	Glossiphoniidae		
	Placobdella pediculata	2	1
	Crustacea		
	Amphipoda		
	Talitridae		
	Hyalella azteca	2	1
Phylum	Insecta		
Order	Ephemeroptera		
Family	Ephemeridae		
	Hexagenia limbata <10mm	2	1
	Hexagenia limbata >10mm	5	2
Order	Trichoptera		
Family	Leptoceridae		
	Oecetis sp.	2	1
Order	Diptera		
Family	Chironomidae		
	Ablabesmyia annulata	7	4
	Chironomus sp.	23	5
	Coelotanypus tricolor	507	10
	Acari		
	Parasitengonia		
	Acariformes		
	Unionicola sp.	2	1
Phylum	Mollusca		
Class	Gastropoda		
Order	Mesogastropoda		
Family	Viviparidae		
	Viviparus Georgianus	2	1

Table 7. (continued)

	Chickamauga Reservoir	**TRM 490.5 Upstream**	
	Species	**Mean Density**	**Occurrence per site**
Class	Bivalvia		
	Veneroida		
Family	Corbiculidae		
	Corbicula fluminea		
	<10mm	8	2
	Corbicula fluminea		
	>10mm	68	10
Family	Sphaeriidae		
	Musculium transversum	108	9
	Number of samples	**10**	
	Sum	**835**	
	Number of taxa	**13**	
	Number of EPT taxa	**2**	
	Sum of area sampled	**0.60**	

	Chickamauga Reservoir	**TRM 482 Downstream**	
	Species	**Mean Density**	**Occurrence per site**
Phylum	Annelida		
Subclass	Oligocheata		
Family	Enchytraeidae		
Family	Lumbricidae	3	1
Family	Tubificidae	105	6
	Branchiura sowerbyi	3	1
	Limnodrilus hoffmeisteri	18	4
Class	Hirudinea	18	3
Phylum	Insecta		
Order	Ephemeroptera		
Family	Ephemeridae		
	Hexagenia limbata		
	>10mm	57	4
Order	Diptera		
Family	Chironomidae		
	Branchiura sowerbyi	3	1
	Ablabesmyia annulata	17	4

Table 7. (continued)

	Chickamauga Reservoir	TRM 482 Downstream	
	Species	**Mean Density**	**Occurrence per site**
	Axarus sp.	5	2
	Unionicola sp.	2	1
Phylum	Mollusca		
Class	Gastropoda		
Order	Mesogastropoda		
Family	Viviparidae		
	Campeloma sp.	2	1
	Viviparus Georgianus	22	6
Class	Bivalvia		
	Veneroida		
Family	Corbiculidae		
	Campeloma sp.	2	1
	Viviparus Georgianus	22	6
Class	Bivalvia		
	Veneroida		
Family	Corbiculidae		
	Corbicula fluminea <10mm	77	6
	Corbicula fluminea >10mm	108	9
Family	Dressenidae		
	Dreissena polymorpha	8	1
Family	Sphaeriidae		
	Musculium transversum	90	7
	Number of samples	**10**	
	Sum	**644**	
	Number of taxa	**15**	
	Number of EPT taxa	**1**	
	Sum of area sampled	**0.60**	

Table 8. Recent (1994-2002) Benthic Index Scores Collected as Part of the Vital Signs Monitoring Program at Chickamauga Reservoir Transition (TRM 490.5 and TRM 482) and Forebay Zone (TRM 472.3) Stations.

			Year									
Site	**Reservoir**	**Location**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**Average**
Upstream	Chickamauga	TRM 490.5	33	29		31		31	23	25	**23**	**27.8**
Downstream	Chickamauga	TRM 482							23	31	**27**	**27**
Downstream	Chickamauga	TRM 472.3	31	27		29		25	27	27	**23**	**27**

Table 9. Sport Fishing Index Results for Chickmauga Reservoir, 2002

	Years					
Species	**1997**	**1998**	**1999**	**2000**	**2001**	**1997-2001 Average SFI Score**
Black bass		40.5	24.5	34.5	30.5	26
Bluegill			32	33	32	19.4
Channel catfish				29	30	11.8
Crappie	30		31	31	32	25
Hybrid striped x white bass				26	34	12
Largemouth bass	39	37	34	32	28	34
Spotted bass	25	37	24	40	26	30
Sauger	27	36	26	39	30	32
Smallmouth bass	25	20	24	22	40	26
Striped bass			30	30	40	20
Walleye	20			20		8
White bass			31	30	30	18

Table 10. Sport Fish Index Population Quantity and Creel Quantity and Quality Metrics and Scoring Criteria.

Metrics	Scores		
	5	10	15
Black bass			
Population (quantity)			
TVA electrofishing catch/hour	< 15	15-31	> 31
State electrofishing (catch/hour)	< 62	62-124	> 124
Creel (quantity)[a]			
Anglers (catch/hour)	< 0.3	0.3-0.6	> 0.6
BAIT and BITE data	< 1.1	1.1-2.3	> 2.3
Creel (quality)			
Pressure (hours/acre)	< 8	8-16	> 16
Largemouth bass			
Population (quantity)[b]			
TVA electrofishing catch/hour	< 13	13-25	> 25
State electrofishing (catch/hour)	< 53	53-106	> 106
Creel (quantity)			
Anglers (catch/hour)	< 0.29	0.29-0.58	> 0.58
Creel (quality)			
Pressure (hours/acre)	< 8	8-16	> 16
Smallmouth bass			
Population (quantity)			
TVA electrofishing catch/hour	< 4	4-8	> 8
State electrofishing (catch/hour)	< 8	8-15	> 15
Creel (quantity)			
Anglers (catch/hour)	< 0.1	0.1-0.3	> 0.3
Creel (quality)			
Pressure (hours/acre)	< 8	8-16	> 16
Spotted bass			
Population (quantity)			
TVA electrofishing catch/hour	< 5	5-11	> 11
State electrofishing (catch/hour)	< 14	14-27	> 27
Creel (quantity)			
Anglers (catch/hour)	< 0.07	0.07-0.13	> 0.13
Creel (quality)			
Pressure (hours/acre)	< 8	8-16	> 16

Table 10. (Continued)

Metrics	Scores 5	10	15
Sauger			
Population (quantity)			
Experimental gill net (catch/net night)	< 9	9-17	> 17
Creel (quantity)			
Anglers (catch/hour)	< 0.5	0.5-1	> 1
Creel (quality)			
Pressure (hours/acre)	< 5	5-10	> 10
Channel catfish			
Population (quantity)			
Experimental gill net (catch/net night)	< 2	2-4	> 4
Creel (quantity)			
Anglers (catch/hour)	< 0.3	0.3-0.7	> 0.7
Creel (quality)			
Pressure (hours/acre)	< 9	9-19	> 19

[a]Each worth 2.5, 5.0, and 7.5 points if both data sets are available.
[b]TVA electrofishing only used when state agency electrofishing data is unavailable.

Table 11. Sport Fish Index Population Quality Metrics and Scoring Criteria.

	Scores		
	5	**10**	**15**
Metrics			
Population (quality)	1	2	3
PSD	< 20 or > 80	20-39 or 61-80	40-60
RSDP (preferred)	0 or > 60	1-9 or 41-60	10-40
RSDM (memorable)	0 or > 25	1-4 or 11-25	5-10
RSDT (trophy)	0	< 1	≥ 1
W_r (Stock-preferred size fish)	< 90	> 110	90-110

Table 12. Estimated Sauger Harvest from Chickamauga Reservoir, 2000-2002 (TWRA data).

Year	**Total number caught**	**Total number harvested**	**Percent of caught fish released**	**Average weight (lbs.)**
2000	18,784	7,160	61.9	1.46
2001	15,265	5,518	63.9	1.45
2002	8,245	4,071	50.6	1.65

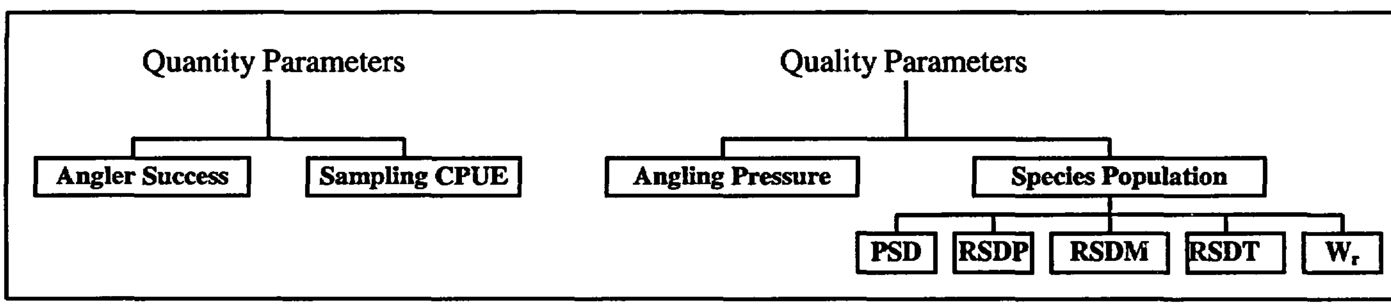

Figure 1. Parameters used to calculate the Sport Fishing Index (SFI).

Annual RFAI Scores for Chickamauga Reservoir

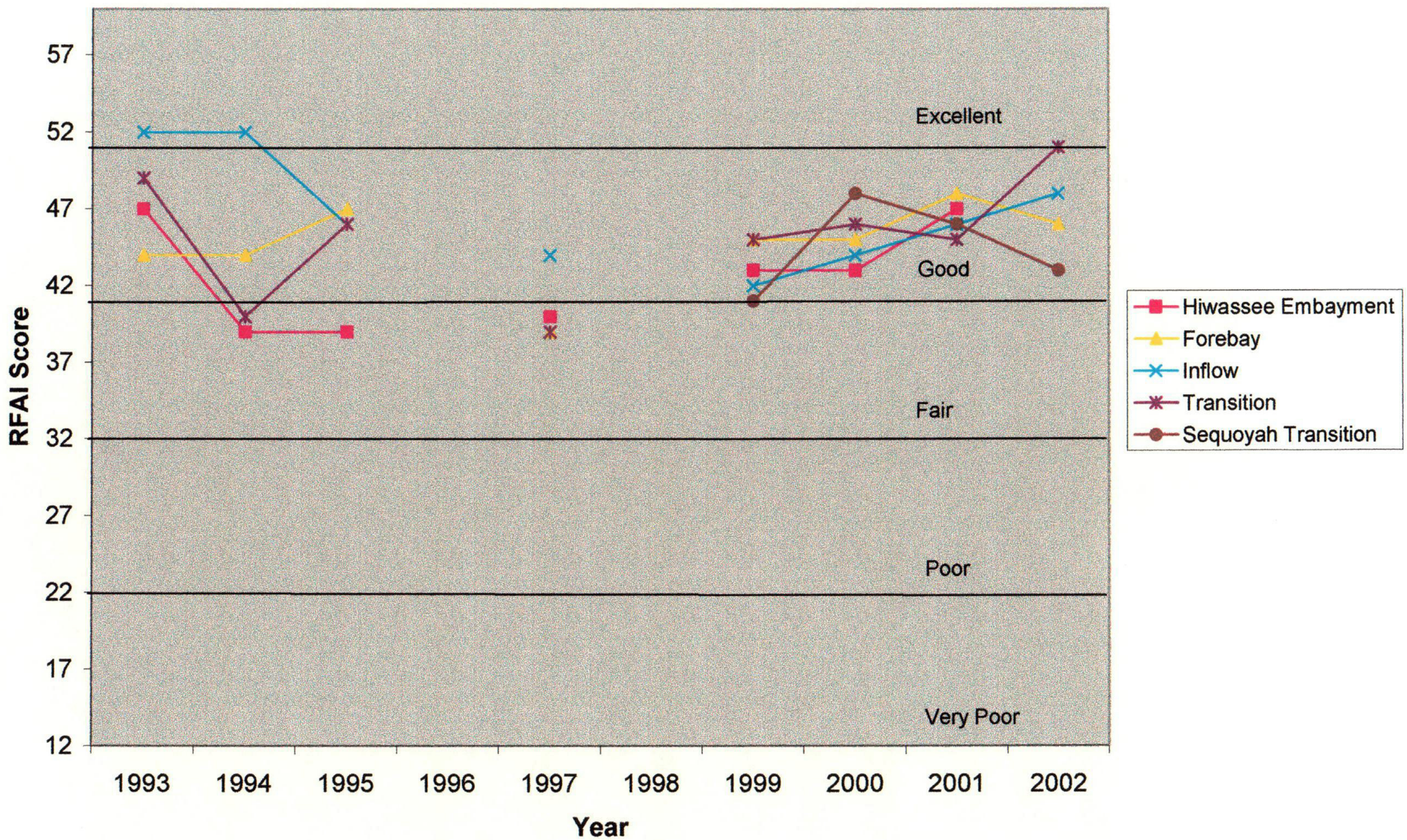

Figure 2. RFAI scores from sample years between 1993 and 2002.

C01

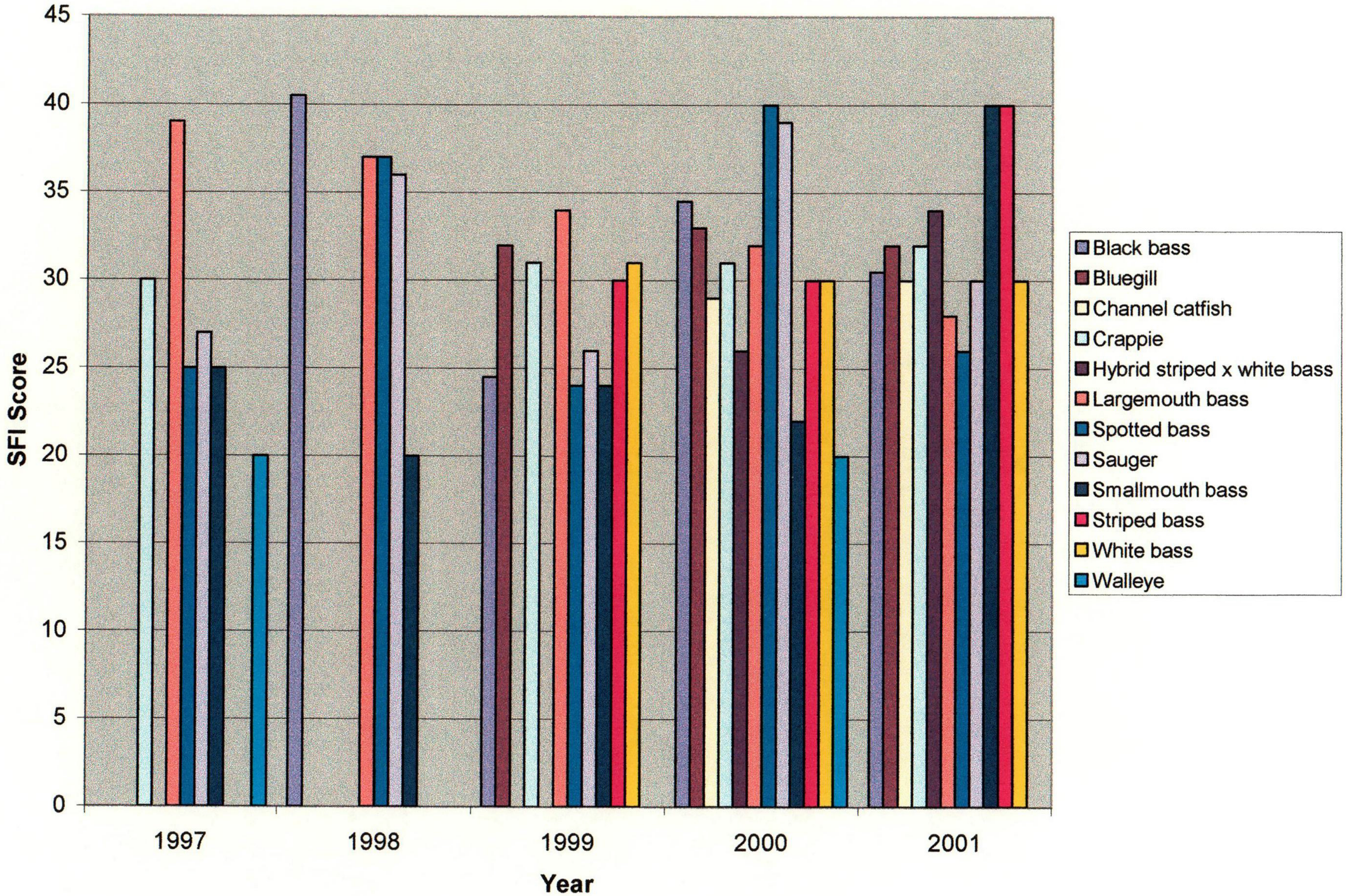

Figure 3. Sport Fishing Index results for Chickamauga Reservoir between 1997 and 2001.

C02

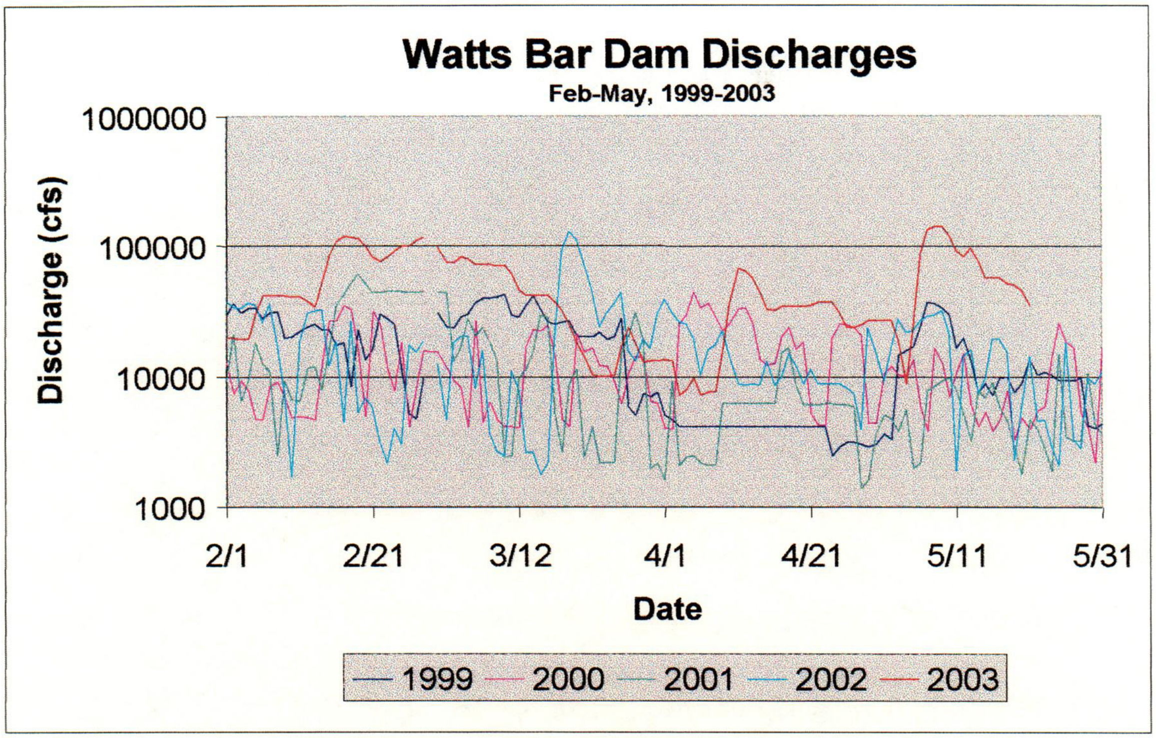

Figure 4. Watts Bar Dam discharges during late winter-early spring, 1999-2003.

C03