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Docket Nos. 50-259, 50-260
and 50-296

Mr. Howard D. Zeller, Deputy Director
Enforcement Division
U.S. Environmental Protection Agency
345 Courtland Street, N.E.
Atlanta, Georgia

Dear Howard:

We have reviewed fish impingement data collected at TVA's Browns Ferry Nuclear Plant through August of 1979. Our review was performed in response to TVA's request to terminate the impingement study required by the Environmental Technical Specifications (Appendix B to the licenses for each of the three units). Based on the review, we have concluded that the objective of the study has been achieved and that the request to terminate the study should be granted. In revising the Environmental Technical Specifications, we are indicating our reliance on the NPDES permit with regard to future requirements, if any, for monitoring and reporting of impingement.

A copy of the technical review, conducted by Dr. Charles W. Billups is provided by enclosure. We thought the information might be useful in EPA's review leading to the Section 316(b) determination for the Browns Ferry intake. If you have questions about the analysis, you may direct them to Charlie Billups on FTS 492-8209.

We would appreciate being kept informed of activities related to your review and determination under Section 316(b). If we can provide further assistance in those activities, please feel free to contact us.

Sincerely,

Original Signed by Robert D. Samworth

for Ronald L. Ballard, Chief
Environmental Engineering Branch
Division of Engineering

Enclosure:
As stated

cc: w/enclosure
C. Kaplan, EPA-Region IV
P. Frey, EPA-Region IV
w/o enclosure
S. Jankus, EPA-HQ

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SUMMARY REVIEW OF FISH IMPINGEMENT AT THE BROWNS FERRY NUCLEAR PLANT SEPTEMBER 1976 - AUGUST 1979

INTRODUCTION

Monitoring and reporting of fish impingement at Browns Ferry has been required by the Environmental Technical Specifications (ETS) since start-up of Unit 1 in August 1973. Detailed studies were initiated in February 1974 and have been continued (with some modifications) up to the present time.

This review summarizes impingement data collected over the 36-month period, September 1976 through August 1979. The period was selected for the following reasons:

(1) the plant was at "full" operation

(2) the data collection and reporting methods remained constant over the 36 months

(3) the 36 months allow for comparisons between three consecutive 12-month "study years"

This review does not address whether the Browns Ferry intake complies with Section 316(b) of the Clean Water Act; EPA has statutory authority for making that determination. TVA has submitted their Section 316 demonstration study results to EPA (TVA 1978, TVA 1980); however, EPA has not yet made a determination. Based on the data reviewed, we found that the purpose of the required ETS impingement program has been satisfied.

METHODS

The Environmental Technical Specifications (ETS) for Browns Ferry require estimation of fish impinged on each operating intake screen for a 24-hour collection period, once each week. Numbers impinged are recorded for the following taxa: shad and herring (Clupeids), catfish, bass (Micropterus spp.), crappies, sunfish (Lepomis spp.), freshwater drum, and other species. Results are submitted to the NRC in quarterly impingement reports and in the annual operating reports. These procedures for sampling and reporting of fish impingement were instituted in September 1976 (coincident with the start-up of Unit 3) and have remained unchanged for three-unit plant operation up to the present time; therefore, over three consecutive 12-month periods of fish impingement data, collected during "full" 3-unit plant operation and with the same procedures, are now available for comparative analysis. For purposes of discussion in this review, the three 12-month periods will be defined as follows:

Study Year 1 - September 1976 through August 1977
Study Year 2 - September 1977 through August 1978
Study Year 3 - September 1978 through August 1979

In their Section 316(b) report submitted in 1978, TVA has compared impingement during "Study Year 1" (i.e., September 1976 through August 1977) with impingement observed for two earlier periods: the first period with Unit 1 and start-up and initial operation of Unit 2 and the second period with reduced flow during plant outage following the fire which occurred in March 1975. We give no further consideration in this review to the two earlier periods of plant operation at less than 3 units.

RESULTS

Study Year 1: September 1976 - August 1977

A tabular summary of impingement for the period September 1976 through August 1977 has been presented by TVA in their Section 316(b) demonstration report to EPA (TVA, 1978). As shown in Table 1, the summary provides some information which is not required by the ETS program in that both estimated numbers and total weights are given for each impinged species. Recall that the ETS require an estimation of numbers impinged for seven taxonomic groups differentiated by numbers impinged on each of the intake screens in operation on the day of sampling.

In Table 2, we have summarized impingement for this same period using data reported in quarterly reports to the NRC. The change in format facilitates comparison with subsequent data from Study Years 2 and 3 which were only available in the quarterly reports. Some slight differences may be noted in comparing impingement totals as given in Table 1 and Table 2 even though the data are for the same study period. The differences result from TVA's use of 54 sampling days in their calculations whereas only 52 sampling days were reported in the quarterly reports and used in our calculations.

During Study Year 1, an estimated 6.7 million fish representing 61 species (TVA 1978, p. 14) were impinged. Of the total, 6.1 million (91%) were shad and herring (Clupeids) and 0.2 million (3.6%) were freshwater drum. The remaining 0.4 million impinged fish primarily consisted of bluegill, yellow bass, white bass, green sunfish, redear sunfish and channel catfish. Pump

operation for the sampling days averaged 7.2 pumps of the 9 pumps available (approximately 80% capacity).

The monthly estimates (Table 2) show the major impingement of Clupeids occurring over the three months, September through November. Figure 1 illustrates the relative contribution of monthly impingement to the 12-month totals for each of the three "study years". TVA has noted that, for this study period, peak impingement of clupeids occurred earlier than had been observed during the prior years of plant operation (ibid, p. 14). We found this early peak in the Fall of 1976 to be an exception from those observed in Study Years 2 and 3, also.

Peak impingement of catfish (primarily channel catfish) occurred in March and over 75% of the 12-month total estimated impingement of catfish occurred during the three months, February through April. Peak impingement of bass (primarily largemouth) and freshwater drum also occurred in March. The impingement of drum was more broadly spread over all 12 months with lowest levels in September-October 1976 and August 1977.

Crappie (mostly white crappie) impingement peaked in July with a broader secondary peak occurring in March-April. Impingement peaked for sunfish (mostly bluegill, green sunfish, and redear sunfish) in April. Over 90% of the 12-month total for sunfish occurred over the four months, January through April. Another 5% of the total sunfish were impinged in July. The yellow bass and white bass constituted over 75% of the 12-month impingement of "Other" taxa; peak levels occurred in March and July.

For "Study Year 1", 66% of the total estimated impingement of all taxa occurred during the three months, September through November; the clupeids (mostly threadfin shad) made up 99% of the total for these three months. March impingement added 16% to the 12-month total of which 84% were clupeids. Monthly impingement levels were lowest in May through August; impingement during these four months made up only 2.6% of the 12-month total. During this time of low impingement, "Other" taxa constituted a greater relative amount of the monthly impingement levels, i.e., 13% in May, 58% in June, 37% in July and 40% in August. The percent contribution of each species group to the total 12-month impingement is shown in the last row of Table 2 and, also, is compared with values for the two subsequent 12-month study periods in Table 5. Observed differences in the relative contributions are discussed later in this report.

Study Year 2: September 1977 - August 1978

Impingement for "Study Year 2" has been estimated from TVA's quarterly impingement reports to the NRC (Table 3). An estimated 4.2 million fish were impinged during this period with clupeids making up about 3.2 million (76%). Fishes in the category of "Other Species" made up about 0.5 million (11%) and freshwater drum about 0.3 million (7%) of the total estimated impingement. Pump operation for the days of sampling averaged 7.4 pumps of the 9 pumps available (~ 82% capacity).

Monthly estimates of impingement (Table 3 and Figure 1) show the major peak for clupeids to have occurred in December, with relatively high monthly values starting in October 1977 and continuing through March 1978.

Peak impingement of catfish occurred in April with a secondary peak in August. Impingement for the three months, March through May, made up 50% of the 12-month

total for catfish. Compared to "Study Year 1", both the primary and secondary peaks for catfish occurred one month later.

Impingement of basses during "Study Year 2" was at such low levels that monthly comparisons are probably meaningless. Highest impingement during "Study Year 2" appeared to shift about two months later than that observed in "Study Year 1".

Estimated impingement of crappies during "Study Year 2" was greater by nearly 20 times that of "Study Year 1". Of the total for crappies, 73% occurred in the three months, November through January. While crappie impingement increased between the two study years, sunfish impingement decreased by about 70% from "Study Year 1" to "Study Year 2". Peak monthly impingement of sunfish occurred in December as compared to the April peak observed in "Study Year 1".

Freshwater drum impingement continued at about the same level through "Study Year 2" and was broadly spread over all months as observed for the "Study Year 1". Three distinct peaks, of nearly equal magnitude, occurred in December 1977, March 1978, and May 1978; impingement for these three months made up about 50% of the total 12-month total impingement of freshwater drum.

Impingement of fishes in the category of "Other Species" increased during "Study Year 2" by nearly 3 times that estimated for "Study Year 1". Seasonally, impingement of "Other species" was highest during the fall months, September through November; impingement for these three months made up nearly 60% of the 12-month total. A secondary impingement peak for the "Other Species" occurred in July, as had occurred during "Study Year 1". Based on cove rotenone data (which are discussed later), white bass and yellow bass were probably the two dominant species appearing in this category, as had been documented by TVA for "Study Year 1".

For "Study Year 2", peak monthly impingement for all species combined occurred in December 1977. Impingement for the six-month period from October through March made up about 86% of the 12-month total. Clupeids contributed a greater relative percentage during these six months than during the full 12-month period, i.e., 83% versus 76.5%. Compared to the first 12-month period, both the total estimated numbers and the relative contribution of shad to the total showed a marked decline. The decline can be attributed to a reduced standing stock of threadfin shad as indicated by TVA's cove rotenone survey data (which are discussed later).

Study Year 3: September 1978 - August 1979

Impingement for the 12-month period, September 1978 - August 1979, has been estimated from TVA's quarterly impingement reports to the NRC (Table 4). An estimated 2.8 million fish were impinged during this period with clupeids making up about 2.1 million (77%). Of the total, freshwater drum made up about 0.2 million (8%), fishes in the category of "Other Species" made up 0.15 million (5%), crappies about 0.13 million (5%) and sunfishes about 0.1 million (4%). Pump operation for the days of sampling averaged 7.6 pumps of the 9 pumps available (~ 84% capacity).

Monthly estimates of impingement (Table 4 and Figure 1) show the major peak for impingement of clupeids to have occurred in March with relatively high impingement values spread over the 4-month period January through April 1979. Compared to the previous two 12-month periods, the peak impingement of clupeids in March was about three months and six months later than that observed in "Study Year 2" and "Study Year 1", respectively. Total estimated numbers of clupeids impinged during "Study Year 3" were about one million less than during the second period and about four million less than during the first period. This reduction in

impingement may be attributed to the continued low standing stock of threadfin shad as shown by TVA's cove rotenone survey data (discussed in the next section).

Impingement of catfish during this third period peaked in January as compared to the March peak during the first period and the April peak during the second period. Relative contribution of catfish to the total 12-month impingement was highest of the three study years but made up less than 1% of the total.

Impingement of bass was lower than for the two previous periods; only 161 bass were estimated to have been impinged over the 12-month period.

Crappie impingement was of the same order of magnitude as recorded for "Study Year 2". Recall that crappie impingement was almost 20 times greater during the second period than during the first 12-month period. For this third period, impingement of crappies was about 15 times greater than that for the first period. The peak monthly level occurred in February as compared to a November peak during the second period and a July peak during the first period. Impingement for the three months, January through March, made up 87% of the crappie impingement for this third period (September 1978 - August 1979). The relative contribution of crappies to the total 12-month impingement (of all species) was higher than during "Study Years 1 and 2" (Table 5).

The relative contributions of sunfish and freshwater drum to total impingement for this third period were, also (like crappie), highest of the three "study years" (Table 5). Sunfish impingement was about 2 times greater than during "Study Year 2" but 40% less than during "Study Year 1". The peak monthly impingement of sunfish during this third period occurred in January with a secondary peak in March. Impingement of sunfish for those two months made up 83% of the 12-month total for sunfish during Study Year 3.

Impingement of freshwater drum during this third period continued at the same levels observed over the two previous study years. The pattern of seasonal impingement also remained the same with intermediate to peak monthly levels spread over seven months, December 1978 through June 1979 and lower levels during September - November 1978 and July - August 1979. The peak for this period occurred in March - April which was similar in occurrence to that observed in "Study Year 1".

Impingement of "Other Species" was lowest of the three study years. Based on TVA's cove rotenone survey data, the white bass and yellow bass continued to contribute the major portion of impingement in this category of "Other Species".

For "Study Year 3", the peak monthly value for all species combined occurred in March 1979 (38% of the 12-month total). Over the four months, January through April, impingement made up 90% of the 12-month total. Total impingement continued downward in this third period, i.e., 2.8 million compared to 4.2 million in the second period and 6.7 million in the first period. The pattern of monthly impingement of all species for this third period and the decline in total impingement over the three periods, both reflect the impingement patterns for clupeids.

The relative contribution of clupeids (at 77%) to the 12-month total was essentially identical to that in "Study Year 2" (see Table 6). The contributions of catfishes, crappies, sunfishes, and freshwater drum were highest of the three study years while the contribution of basses was lowest of the three study years.

DISCUSSION

TVA found a positive relationship between levels of plant operation (i.e., intake pump usage) and fish impingement (total of all species) for three 12-month periods (TVA 1978, p. 39). In our current review, we found a negative relationship between pump usage rate and total impingement for three "study years".* These contrasting results are summarized in Table 6.

For the three 12-month periods analyzed by TVA, it may be noted in Table 6 that there were large differences (i.e., 90 and 200%) in pump usage rate between periods. In contrast, pump usage for the three "study years" which we reviewed was essentially constant with differences between years of only 2 to 6%.

Even though pump usage was essentially constant, the levels of total impingement declined significantly over the three "study years". We found that the decline might be explained on the basis of declining abundance of young-of-the-year (*y*-o-*y*) threadfin shad. Large reductions in threadfin shad stocks have been recorded through contemporaneous studies on other southern U.S. reservoirs (Logan and Masnik, 1979, and McLean et al., 1980). The reductions are attributed to cold stress during the severe winters of 1976-77, 1977-78, and 1978-79. In the latter study, the authors conclude that natural cold kills of threadfin and *y*-o-*y* gizzard shad mask any ecological effects of impingement and that most of the shad, had they not been impinged, would have died due to cold stress.

In the last two columns of Table 6, we have presented data on the standing stock abundance of *y*-o-*y* threadfin and gizzard shad for the years 1974-1978. These

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* Note that the third 12-month period considered in TVA's analysis (TVA 1978) is the same period defined as "Study Year 1" in our current review.

data are from TVA's cove rotenone surveys (TVA 1977, TVA 1978, TVA 1979) and describe the average concentrations (area-weighted mean number per hectare) of y-o-y shad from three coves in Wheeler Reservoir. The rotenone surveys are conducted annually by TVA during late August or early September. At this time of the year, the y-o-y of shad (and other species) have attained a size which makes them susceptible to being impinged on intake screens (rather than entrained and carried through the cooling system). Thus, it is convenient to select a "study year" for impingement analysis to cover the 12 months from September through August of the next year. This is particularly appropriate if the assessment of impacts due to impingement is based on calculating the fraction of the reservoir population (as estimated from the annual cove rotenone data) removed by impingement. TVA has used this analytical approach in their assessment (TVA 1978). However, it should be noted that each of the first two 12-month periods, which TVA analyzed, ran from late March through late March of the succeeding year. Large numbers of clupeids were impinged in March-April 1974 and March-April 1975 (Ibid., Figure 2). The majority of these impinged clupeids were likely y-o-y of the 1973 year class and 1974 year class, respectively. In TVA's analysis, these losses were included in the calculations of fractional losses of the standing stocks for 1974 and 1975, respectively. For these first two periods, it appears that TVA has overestimated the fractions of shad y-o-y standing stock removed by impingement (i.e., overestimated the potential impact). Potential impacts of impingement on the standing stocks of other species may be overestimated or underestimated depending on whether the standing stock concentrations between the years 1973 through 1975 were decreasing or increasing, respectively.

The third 12-month impingement period analyzed by TVA extends from September 1976 through August 1977. Impingement for this period has been compared appropriately (in our view) with the 1976 cove rotenone data. As previously noted, this period of analysis corresponds to "Study Year 1" in our summary review.

TVA's analysis of the data for this period is much more detailed than was possible from our review of the quarterly monitoring reports required by the Environmental Technical Specifications (ETS). For example, the ETS allow for reporting by species groups, whereas TVA has presented assessments by individual species. We acknowledge that the ETS-required reporting by species groups does not provide sufficient information to assess potential impacts on each species population. This condition in our ETS limits the comparison of data from subsequent "study years" with TVA's results.

We have reproduced TVA's results comparing impingement and 1976 standing stock estimates in Table 7. These results suggest that the potential impact of impingement, in terms of fractional reduction of the 1976 standing stocks, is negligible (< 1%) for the two shad species and for most of the other selected species.* Six species were represented in impingement collections but no y-o-y of these species were collected in the cove rotenone sampling; hence calculations of percent reduction for these y-o-y stocks were not possible. Impingement made up large percentages (> 10%) of the estimated y-o-y standing

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* The species, selected by TVA for comparison with standing stock abundance, were those impinged at an average rate of one or more per day over the 12-month period.

stocks for five species: white crappie, channel catfish, freshwater drum, skipjack herring, and yellow bass. Intermediate values (between 1% and 10%) were recorded for four species: green sunfish, white bass, spotted sucker and sauger. Potential impacts on these nine species are addressed, below, and to the extent possible, we compare these results with the impingement levels and standing stock estimates for the subsequent two "study years". As noted in the preceding paragraph, such comparisons are not possible for each species.

White crappie - TVA has indicated that low abundance of y-o-y white crappie in the 1976 cove samples resulted in the high relative impingement (62% of standing stock), and that white crappie were probably greatly underestimated by the cove sampling. For the subsequent two "study years", the impingement levels of crappie were greater by factors of 20X and 15X, respectively. Relative to the 1977 and 1978 standing stock estimates, impingement of crappies (primarily white crappie) was 266% in "Study Year 2" and 31% in "Study Year 3". The value of 266% would suggest that the white crappie population should have been decimated in "Study Year 2". However, both the 1978 cove data and the impingement level in "Study Year 3" indicate a healthy population of white crappie. As shown in Table 8, the 1978 year class of white crappie was 38X greater than the 1976 year class, based on cove data.

Channel catfish - TVA has indicated that the densities of channel catfish are poorly estimated by cove rotenone sampling since the species occurrence is more characteristic in the main stream portion. The ETS-reporting of impingement data does not allow for comparison of individual species of catfish. For catfish

as a species group, impingement levels were less in study years 2 and 3 than recorded in study year 1. The mean standing stocks of y-o-y channel catfish have increased over the three study years (2.9 per hectare in 1976, 15.2 in 1977, and 22.6 in 1978). From these results, we concur in TVA's opinion that the impingement of channel catfish cannot be assessed on the bases of standing stocks as calculated from cove rotenone data.

Freshwater drum - TVA has indicated that impingement of freshwater drum appears to be a function of reservoir abundance. Our review of the impingement and standing stock data for the three study years supports this conclusion (Table 9). Impingement levels were less relative to the standing stocks in the second and third study years.

Skipjack herring - TVA has indicated that since this species is pelagic and highly mobile, it might be more susceptible to impingement and its abundance would likely be underestimated by cove rotenone data. Because the ETS-reporting for skipjack herring combined its impingement with the two shad species, we were unable to make between year comparisons.

Yellow bass - TVA has indicated that although impingement of yellow bass was high in "Study Year 1", the large increase in standing stock the following year (i.e., in 1977) suggests that impingement did not have an adverse impact on this species. The ETS-reporting allows grouping of yellow bass in the category of "other species". Therefore, we cannot make comparisons between study years for this species. We do note that the y-o-y standing crops of yellow bass have continued to increase over the three years (i.e., 19.1 per hectare in 1976, 63.3 in 1977, and 334.0 in 1978). These data provide additional support for TVA's finding.

Impingement of the four species with intermediate values recorded in Table 7 (i.e., green sunfish, white bass, spotted sucker and sauger) were included in the category of "other species" by the ETS requirements rather than by individual species. Therefore, comparisons of impingement between study years is not possible. TVA concluded that the increase in standing stocks of green sunfish in 1977 indicates that impingement has not adversely affected the population. In the 1978 cove rotenone data, y-o-y green sunfish increased by more than 4X the 1977 level (Table 10), thus providing further support to TVA's assessment. The 1978 standing stocks of white bass, spotted sucker and sauger each declined between 1977 and 1978 (Table 10). We can provide no further assessments of potential impacts on these species because of the limitations of the ETS-required reporting method.

SUMMARY AND CONCLUSIONS

Our review of the Browns Ferry data for the 36-month period, September 1976 through August 1979, indicates that fish impingement has declined even though the intake pumping rate has remained essentially constant over the same period. Total impingement (all species combined) for the three successive 12-month "study years" within the 36-month period was 6.7 million, 4.2 million and 2.8 million fish. The average number of intake pumps in operation on sampling days within the corresponding "study year" was 7.2, 7.4, and 7.6 pumps of the 9 pumps available for full 3-unit plant operation.

The decline in total impingement primarily reflects the decline in impingement of shad and herring (Clupeidae) which were impinged at estimated levels of

6.1 million, 3.2 million and 2.1 million for the three successive "study years". Of the other six taxa studied, only the "basses" showed a similar pattern of declining impingement over the three study years. Impingement levels were highest for crappies, freshwater drum and "other" species in "Study Year 2" and highest for catfishes and sunfishes in "Study Year 1" (see Table 5).

As stated in the ETS, the objective of the required impingement study was to "detect and quantify" fish impingement. The detailed study has extended from early 1974 up to the present time. Impingement losses have been quantified (estimated) for various levels of plant operation including levels which are judged to be representative of continued three-unit plant operation.

TVA has analyzed impingement by individual fish species for three 12-month periods, the third period being with three-unit plant operation. We have summarized the impingement data, as reported quarterly to the NRC for a continuous 36-month period during which plant operation was at the three-unit level. [The third 12-month period analyzed by TVA is the same as the first 12-month period covered by our summary review.]

Major variations in impingement level between years (12-month periods) reflect the variations in the reservoir standing stock of young-of-the-year threadfin shad. Compared to the standing stock estimates, impingement of shad species appears to be a negligible loss to the reservoir populations. Due to the data reporting method specified by the ETS, we were unable to compare impingement losses and standing stock estimates for each fish species. Where such data

comparisons were possible, we found the results to be supportive of TVA's assessments of low impact potential due to impingement. Based on our review, we conclude that the objective of the impingement monitoring study has been achieved and that termination of the study is justified on the basis of low impact potential due to impingement.

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Table 1. Estimated impingement of all fish species at Browns Ferry Nuclear Plant during 12-month period, September 1976 - August 1977

Taxa	Total Est. Number Impinged in 54 samples	Total wt. (kg) Impinged in 54 samples	Total Est. No. Impinged	Total Est. wt. (kg) Impinged
Shad & Herring:				
Skipjack Herring	16,346	171.35	110,487	1,158.23
Gizzard shad	200,305	4,235.89	1,353,913	28,631.50
Threadfin shad	685,769	2,189.22	4,635,290	14,797.49
Catfish:				
Blue catfish	379	33.79	2,562	228.40
Black bullhead	88	1.80	595	12.15
Yellow bullhead	1	0.08	7	0.55
Brown bullhead	253	16.01	1,778	108.13
Channel catfish	3,657	175.22	24,719	1,184.36
Flathead catfish	328	9.91	2,217	67.01
Bass:				
Smallmouth bass	47	2.80	318	18.93
Spotted bass	50	1.53	338	10.36
Largemouth bass	262	17.42	1,771	117.75
Crappie:				
White crappie	1,003	23.04	6,780	155.75
Black crappie	86	4.69	581	31.69
Sunfish:				
Green sunfish	5,801	40.54	39,210	274.05
Warmouth	58	1.26	392	8.51
Orangespotted sunfish	2	0.03	14	0.20
Bluegill sunfish	12,572	295.70	84,977	1,951.13
Longear sunfish	1,374	10.68	9,287	72.18
Redear sunfish	4,087	184.93	27,625	1,249.96
Spotted sunfish	1	0.04	7	0.25
Freshwater drum	31,924	1,322.38	215,783	8,938.31

Source: TVA 1978, Table 4 (modified)

Table 1 (continued)

Taxa	Total Est. Number Impinged in 54 samples	Total wt. (kg) Impinged in 54 samples	Total Est. No. Impinged	Total Est. wt. (kg) Impinged
Other Species:				
Chestnut lamprey	12	0.61	81	4.10
Paddlefish	2	0.21	14	1.45
Spotted gar	19	10.93	128	73.85
Longnose gar	1	0.85	7	5.73
Shortnose gar	11	4.94	74	33.38
Mooneye	97	15.95	656	107.78
Chain pickerel	2	1.36	14	9.21
Stoneroller	1	.03	7	0.20
Goldfish	36	8.83	243	59.66
Carp	10	5.03	68	34.00
Speckled chub	4	0.08	27	0.51
Silver chub	1,115	24.42	7,537	165.07
River chub	2	0.12	14	0.72
Golden shiner	817	16.83	5,522	113.78
Emerald shiner	1,184	7.84	8,003	53.01
Ghost shiner	10	0.02	68	0.16
Mimic shiner	33	0.06	223	0.41
Bullhead minnow	182	1.80	1,230	12.82
Longnose dace	1	0.01	7	0.05
Quillback	11	0.11	74	0.75
Northern hog sucker	2	0.54	14	3.63
Smallmouth buffalo	125	48.95	845	330.86
Bigmouth buffalo	5	2.24	34	15.13
Spotted sucker	1,094	69.33	7,395	468.61

Table 1 (continued)

Taxa	Total Est. Number Impinged in 54 samples	Total Wt. (kg) Impinged in 54 samples	Total Est. No. Impinged	Total Est. Wt. (kg) Impinged
Other Species: (continued)				
Silver redhorse	15	5.94	101	40.16
Shorthead redhorse	1	0.60	7	4.04
Black redhorse	4	2.11	37	14.27
Golden redhorse	19	8.22	128	55.35
Black spotted topminnow	1	<0.01	7	0.01
Brook silverside	3	<0.01	20	0.03
White bass	7,498	131.19	50,581	886.71
Yellow bass	9,913	234.38	67,005	1,582.21
Striped bass	30	1.26	203	15.26
Rock bass	2	0.04	14	0.30
Logperch	256	1.70	1,730	11.49
Dusky darter	7	0.03	47	0.22
River darter	4	0.02	27	0.12
Sauger	375	52.74	2,535	356.48
Walleye	3	2.45	20	16.53
	987,310	9,390.88	6,673,488	63,[illegible].13

Table 2. Browns Ferry Nuclear Plant - Impingement Summary for 12-month period, September 1976 - August 1977

Month	Avg. No. of Pumps on Sample Days	Estimated Monthly Impingement (Numbers of Fish)								% of 12-month Total
		Shad	Catfish	Bass	Crappies	Sunfish	Drum	Other	All Species	
Sept. 1976	6.4	1,627,566	1,296	192	24	762	6,222	6,534	1,642,596	24.5
Oct. 1976	6.25	1,365,519	1,062	62	31	604	5,216	4,185	1,376,679	20.6
Nov. 1976	6.2	1,476,210	912	24	162	798	24,708	5,118	1,507,932	22.5
Dec. 1976	7.67	166,770	775	10	320	475	15,490	4,536	188,376	2.8
Jan. 1977	6.8	304,327	949	167	360	6,392	8,265	13,516	333,976	5.0
Feb. 1977	8.25	137,235	3,556	112	497	17,094	15,533	8,183	182,210	2.7
Mar. 1977	6.5	884,848	17,972	899	1,782	54,475	66,162	27,923	1,054,061	15.7
Apr. 1977	8.75	88,538	4,890	735	1,020	70,410	47,872	19,852	233,317	3.5
May 1977	7.0	1,736	713	0	25	1,531	11,935	2,480	18,420	0.3
June 1977	8.25	3,285	428	75	622	1,718	10,988	23,265	40,381	0.6
July 1977	6.75	25,188	1,256	225	2,402	8,517	17,716	32,023	87,327	1.3
Aug. 1977	8.4	10,410	701	50	781	1,283	4,129	12,214	29,568	0.4
12-Month Total	7.3*	6,091,632	34,510	2,551	8,026	164,059	234,236	159,829	6,694,843	
% by Species Group		91.0	0.5	0.04	0.1	2.4	3.5	2.4		

*Avg. pumps in operation on sampled days [Maximum = 9 pumps (3 pumps per unit)]

Table 3. Browns Ferry Nuclear Plant - Impingement Summary for 12-month period, September 1977 - August 1978

Month	Avg. No. of Pumps on Sample Days	Estimated Monthly Impingement (Numbers of Fish)								% of 12-month Total
		Shad	Catfish	Bass	Crappies	Sunfish	Drum	Other	All Species	
Sept. 1977	7.0	91,380	480	60	1,808	1,162	2,430	95,228	192,548	4.6
Oct. 1977	7.5	505,106	798	70	9,936	4,503	6,595	107,663	634,671	15.2
Nov. 1977	7.4	359,376	396	78	52,848	11,556	25,914	70,230	520,398	12.5
Dec. 1977	7.75	974,400	333	46	45,190	23,490	53,498	47,476	1,144,433	27.5
Jan. 1978	9.0	345,836	211	6	13,107	2,957	10,013	13,423	385,553	9.2
Feb. 1978	9.0	324,016	266	14	7,602	2,261	14,224	6,398	354,781	8.5
Mar. 1978	7.75	460,342	2,062	16	6,812	3,077	47,422	17,492	537,223	12.9
Apr. 1978	6.0	45,300	2,528	0	938	210	18,630	6,158	73,764	1.8
May 1978	6.4	2,238	1,023	12	1,655	887	49,774	3,379	58,968	1.4
June 1978	7.0	1,005	398	30	1,552	218	20,588	14,190	37,981	0.9
July 1978	7.2	26,654	508	112	6,901	484	28,154	53,996	116,809	2.8
Aug. 1978	7.5	51,607	2,240	93	3,441	1,457	11,858	37,386	108,082	2.6
12-Month Total	7.4*	3,187,260	11,243	537	151,790	52,262	289,100	437,619	4,165,211	
% by Species Group		76.5	0.3	<0.1	3.6	1.2	6.9	11.4		

*Avg. pumps in operation on sampled days [Maximum = 9 pumps (3 pumps per unit)]

Table 4. Browns Ferry Nuclear Plant - Impingement Summary for 12-month period, September 1978 - August 1979

Month	Avg. No. of Pumps on Sample Days	Estimated Monthly Impingement (Numbers of Fish)								% of 12-month Total
		Shad	Catfish	Bass	Crappies	Sunfish	Drum	Other	All Species	
Sept. 1978	7.75	10,118	1,005	8	622	218	3,510	4,192	19,673	0.7
Oct. 1978	6.2	27,664	1,668	19	961	211	3,404	11,327	45,254	1.6
Nov. 1978	7.0	54,660	1,132	0	2,212	300	4,110	5,310	67,724	2.4
Dec. 1978	6.75	72,904	1,488	16	5,534	4,363	9,889	6,921	101,115	3.6
Jan. 1979	7.4	294,543	15,488	56	35,055	46,717	42,960	61,919	496,738	17.9
Feb. 1979	9.0	395,649	355	0	42,625	1,568	8,671	9,165	458,033	16.5
Mar. 1979	9.?	854,974	719	19	33,499	36,394	77,822	37,684	1,041,111	37.5
Apr. 1979	8.0**	403,650	802	0	6,345	6,450	60,045	7,792	485,084	17.5
May 1979	5.75**	3,528	676	6	657	1,221	9,343	608	16,039	0.6
June 1979	7.5	1,988	180	15	255	1,050	10,920	1,050	15,458	0.6
July 1979	9.0**	7,601	211	6	192	682	4,166	2,951	15,809	0.6
Aug. 1979	8.0	11,702	519	16	140	604	1,488	512	14,981	0.5
12-Month Total	7.6*	2,138,981	24,243	161	128,097	99,778	236,328	149,431	2,777,019	
% by Species Group		77.0	).9	<.01	4.6	3.6	8.5	5.4		

*Avg. pumps in operation on sampled days
[Maximum = 9 pumps (3 pumps per unit)]
**Incomplete Data Reported (Preliminary value)

Table 5 Summary of Browns Ferry Nuclear Plant Impingement by Species Group and Study Year

Species Group	Study Year*					
	1		2		3	
	Number	(%)	Number	(%)	Number	(%)
Shad & Herring (Clupeidae)	6,091,632	(91.0)	3,187,260	(76.5)	2,138,981	(77.0)
Catfishes (Ictaluridae)	34,510	(0.5)	11,243	(0.3)	24,243	(0.9)
Basses (*Micropterus* spp.)	2,551	(0.04)	537	(0.01)	161	(0.006)
Crappies (*Pomoxis* spp.)	8,026	(0.1)	151,790	(3.6)	128,097	(4.6)
Sunfishes (*Lepomis* spp.)	164,059	(2.4)	52,262	(1.2)	99,778	(3.6)
Freshwater drum (*Aplodinotus grunniens*)	234,236	(3.5)	289,100	(6.9)	236,238	(8.5)
Other Species	159,829	(2.4)	473,019	(11.4)	149,431	(5.4)
Total of All Species	6,694,843		4,165,211		2,277,019	

*The three impingement "study years" are defined as follows: Study Year 1 - September 1976 - August 1977
Study Year 2 - September 1977 - August 1978
Study Year 3 - September 1978 - August 1979

Table 6. Browns Ferry Nuclear Plant: Levels of plant operation, total impingement and standing stock indices for shad species.

Twelve-Month Study Period	Plant Operation as Mean No. of Pumps Used on Sampled Days	Total Impingement[1] in Millions of Fish		Standing Stock in No. Per Hectare[2]	
		TVA Est.	NRC Est.	Threadfin Shad	Gizzard Shad
3/27/74-3/27/75	4.6	5.26	-	2,445	873
3/27/75-3/26/76	2.4	2.69	-	1,565	9
9/1/76-8/31/77	7.2	6.67	6.69	26,024	6,830
9/1/77-8/31/78	7.4	-	4.16	8	10,434
9/1/78-8/31/79	7.6	-	2.78	67	11,770

Notes: (1) Estimated impingement from TVA's Section 316(b) Demonstration Report to EPA and from our current review of Quarterly Impingement Monitoring Reports to NRC.

(2) Standing stocks estimates are as reported by TVA based on cove rotenone surveys conducted in late-August to early-September, each year. The five entries are for young-of-the-year threadfin and gizzard shad for the five years 1974 through 1978.

Table 7. Comparison of impingement over the period, September 1976 through August 1977, with 1976 standing stock estimates for selected species.

Species	Total No. Impinged	Mean standing stock (No/ha)		Percent of Standing[3] Stock Numbers	
		YOY[1]	Total[2]	YOY[1]	Total[2]
Skipjack herring	110,487	30.67	75.52	13.33	5.39
Gizzard shad	1,353,913	6,830.07	12,521.83	0.73	0.40
Threadfin shad	4,635,290	26,024.10	26,028.07	0.66	0.66
Mooneye	656	NC[4]	NC[4]	-[5]	-[5]
Silver chub	7,537	96.43	96.43	0.29	0.29
Golden shiner	5,522	39.80	39.80	0.51	0.51
Emerald shiner	8,003	63.82	63.82	0.46	0.46
Bullhead minnow	1,230	436.22	436.22	0.01	0.01
Smallmouth buffalo	845	NC[4]	38.66	-[5]	0.08
Spotted sucker	7,395	12.16	152.46	2.23	0.18
Blue catfish	2,562	NC[4]	0.26	-[5]	36.29
Black bullhead	595	NC[4]	NC[4]	-[5]	-[5]
Brown bullhead	1,778	NC[4]	NC[4]	-[5]	-[5]
Channel catfish	24,719	2.89	67.40	31.50	1.35
Flathead catfish	2,217	13.37	19.20	0.61	0.43
White bass	50,681	30.16	33.56	6.19	5.56
Yellow bass	67,005	19.08	21.06	12.93	11.72
Green sunfish	39,210	14.79	41.33	9.76	3.49
Bluegill	84,977	6,607.19	894.00	0.05	0.04
Longear sunfish	9,287	1,995.37	2,038.69	0.02	0.01
Redear sunfish	27,625	227.18	493.92	0.45	0.21
Largemouth bass	1,771	50.56	277.36	0.13	0.02
White crappie	6,780	0.40	2.68	62.42	9.32
Black crappie	581	NC[4]	NC[4]	-[5]	-[5]
Logperch	1,730	215.58	215.58	0.03	0.03
Sauger	2,535	7.20	72.12	1.30	0.42
Freshwater drum	215,783	52.41	239.52	15.16	3.32

1. Refers to young-of-year fish.
2. Refers to all ages collected in summer cove samples.
3. Based on a reservoir surface area of 27,150 ha.
4. Not collected on cove rotenone samples.
5. Calculation not possible.

Source: TVA 1978, Table 8, p. 33.

Table 8. Comparison of crappie impingement over three "study years" with standing stock estimates of white crappie (Brown's Ferry Nuclear Plant/Wheeler Reservoir)

Study Year[1]	Cove Rotenone Sampling Year	No. of Crappies Impinged	Mean Standing Stock (No/hectare)		Percent of Standing[2] Stock Numbers	
			Y-O-Y[3]	Total[4]	Y-O-Y	Total
1	1976	6,780	0.4	2.68	62.4	9.3
2	1977	151,790	2.1	88.8	266.2	6.3
3	1978	128,097	15.3	73.3	30.8	6.4

Notes:

1. Study years extend from September of the cove rotenone sampling year indicated in column 2 through August of the next year.

2. Based on estimate of population abundance equal to mean standing stock in number per hectare times the reservoir surface area of 27,150 hectares.

3. Refers to young-of-the-year white crappie.

4. Refers to all ages of white crappie collected in cove samples.

Table 9. Comparison of freshwater drum impingement over three study years with standing stock estimates (Browns Ferry/Wheeler Reservoir).

Study Year	Cove Rotenone Sampling Year	No. of Drum Impinged	Mean Standing Stock (No/hectare)		Percent of Standing Stock Numbers	
			YOY	Total	YOY	Total
1	1976	215,783	52.4	239.5	15.16	3.32
2	1977	289,100	199.7	348.1	5.3	3.0
3	1978	236,328	174.6	341.3	5.0	2.6

Table 10. Standing crop estimates for four selected species, Wheeler Reservoir, 1976-1978.

Cove Rotenone Sampling Year	Mean Standing Stock (Number per Hectare)							
	Green Sunfish		White Bass		Spotted Sucker		Sauger	
	YOY	Total	YOY	Total	YOY	Total	YOY	Total
1976	14.8	41.3	30.2	33.6	12.2	152.5	7.2	72.1
1977	72.6	126.3	63.3	66.4	15.8	168.3	55.4	60.0
1978	316.0	391.2	11.2	13.7	5.9	90.9	3.6	11.6

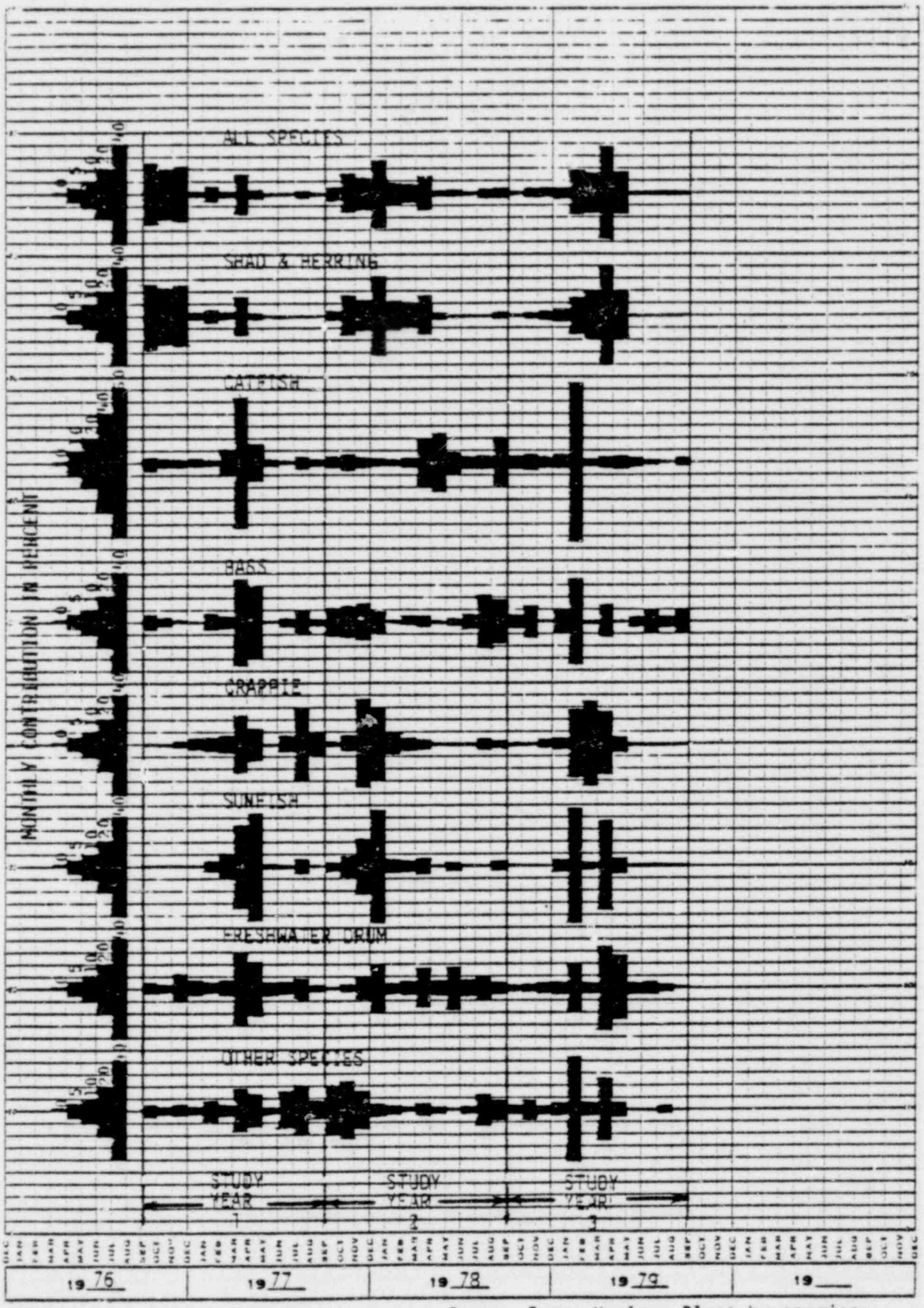

Figure 1. Variation in impingement at Browns Ferry Nuclear Plant by species group (monthly contribution to impingement for each study year).

ENCLOSURE 2

ETS Revisions Effected by the Current Action

The current action has resulted in the staff's recommendation to revise ETS Section 4.1.2(f), entitled "Fish Impingement on Intake Screens". Suggested wording for the revisions are provided on the following page which would replace page 17 of the existing ETS for each of the three units of the Browns Ferry Nuclear Plant. The location of revisions is indicated by the vertical bars on the right margin of the page.

Monitoring will be performed using standard accepted sampling procedures which are on file in the office of the Division of Forestry, Fisheries, and Wildlife Development, Norris, Tennessee.

Reporting Results

The results will be summarized annually in the annual reports of the nonradiological environmental monitoring program.

Bases

A significant proportion of the river flow will be routed through the plant for cooling purposes, and during periods when larval fish are abundant there is the potential for entrainment of large numbers of fishes.

The specified study will determine the numbers of fish eggs and larvae entrained in the cooling water system resulting from plant operation and identify the need for possible corrective action.

(f) Fish Impingement on Intake Screens

Objective

To detect and quantify fish impingement upon the intake screens.

Specification

Monitoring requirement deleted.

Reporting Requirements

The licensee shall submit to NRC copies of impingement study reports as now required by the NPDES Permit No. AL0022080 or as may be required as a result of EPA's determination pursuant to Section 316(b) of the Clean Water Act. Submittals to the NRC shall be on the same schedule as required by the NPDES permitting authority.

Bases

To avoid conflict or unnecessary duplication between the NRC monitoring program and the program imposed by the NPDES permit, this ETS requirement relies on the permit program. Submittal of copies of study results obtained under the NPDES permit will allow the NRC to maintain awareness of the consequences of our licensing action.