LOUISIANA POWER & LIGHT

Demonstration Under Section 316(b) of the Clean Water Act

WATERFORD STEAM ELECTRIC STATION

UNIT NO. 3

LOUISIANA POWER & LIGHT COMPANY

DEMONSTRATION UNDER SECTION 316(b) OF THE CLEAN WATER ACT

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April, 1979

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SECTION 1

1.0 PURPOSE AND SCOPE

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), Section 316(b), require cooling water intake structures to reflect the best technology available for minimizing adverse environmental impact. This document is submitted by Louisiana Power & Light Company to demonstrate its compliance with this requirement for the intake structure serving the Waterford Steam Electric Station, Unit No. 3.

In this report, relevant aspects of the design and operation of the Waterford 3 Circulating Water System are described. The characteristics of the Mississippi River near Waterford 3 are discussed, based on the information gathered during a comprehensive aquatic survey conducted in the area. A quantitative prediction of the extent of the entrainment and impingement of aquatic organisms is made, and the methodology to derive each estimate is detailed. The anticipated environmental effects of the predicted entrainment and impingement are evaluated.

SECTION 2

2.0 INTRODUCTION

The Waterford Steam Electric Station, Unit No. 3, owned by the Louisiana Power & Light Company (LP&L), is being constructed adjacent to the Mississippi River on a site previously dedicated to power generation. The site is the location of Waterford 1 and 2, which began operation in 1975. Directly across the Mississippi River from Waterford 3 is Louisiana Power & Light's Little Gypsy Steam Electric Station.

This report has been prepared in support of LP&L's application for a National Pollutant Discharge Elimination System permit for Waterford 3 filed pursuant to 40 CFR 125 with the U S Environmental Protection Agency, Region VI, on October 16 , 1978. The report evaluates the Waterford 3 Circulating Water System and demonstrates that this system complies with the requirements of the 1972 amendments to the Federal Water Pollution Control Act, Section 316(b), which state that the location, design, construction and capacity of cooling water intake structures shall reflect the best technology available for minimizing adverse environmental impact.

This report analyzes existing information on the biological communities of the Mississippi River near Waterford 3 and predicts the entrainment and impingement effects of its Circulating Water System on these communities. Beginning in 1970 with studies of the Mississippi River near the site, LP&L has been evaluating the relationship of these generating units to the river water quality, thermal and ecological characteristics of this section of the river. A comprehensive analysis and discussion of these studies is contained in the Construction Stage Environmental Report (CPER) and the Operating License Stage Environmental Report (OLER). Other specific documents related to thermal analysis and biological monitoring have also been prepared (Ebasco, 1974), (LP&L, 1972), (Geo-Marine, 1977).

Entrainment effects for Waterford 3 are predicted by comparison of the ratios of river flow to water use. Impingement estimates are based on those described in the literature for other plants on the Mississippi,

Ohio and Missouri Rivers, site-specific baseline monitoring results, and impingement mortality estimates from existing cooling water intakes in the vicinity of Waterford 3.

CITATIONS - SECTION 2

1. Ebasco Services, Inc., 1974 "Waterford Steam Electric Station, Summary of Hydrologic Studies Performed in the Mississippi River for Louisiana Power & Light".

2. Geo-Marine, Inc., 1977 "First Operational Hydrothermal Study, Waterford S.E.S.", Sept-Oct, 1976. Conducted for Louisiana Power & Light Co.

3. Louisiana Power & Light Company, 1972 Environmental Report - Construction Permit Stage, for Waterford Steam Electric Station, Unit 3.

SECTION 3

3.0 SITE AND PLANT DESCRIPTION

This section contains information concerning the environmental characteristics of the area surrounding Waterford 3, as well as a description of the Circulating Water System.

3.1 SITE LOCATION

Waterford 3 is a 1154 MWe (Net) nuclear generating unit located on the west (right descending) bank of the Mississippi River at River Mile 129.6, between Baton Rouge, and New Orleans, Louisiana. The site is in the northwestern section of St. Charles Parish, Louisiana, near the towns of Killona and Taft. The Mississippi River is the most prominent natural water body near Waterford 3; other important natural features include Lac des Allemends, about 5.5 miles southwest of the site, and Lake Pontchartrain, about 7 miles northeast of the site. Figure 3-1 shows the area within 10 miles of Waterford 3.

Waterford 3 is located adjacent to the Waterford 1 and 2 generating station and directly across the Mississippi River from the Little Gypsy generating station. The Waterford 3 site and plot plan with major station structures is shown in Figure 3-2.

3.2 METEOROLOGY

Table 3-1 presents a summary of monthly and annual average meteorological data for the site area. Mean temperatures range from 53.6°F in January to 79.8°F in July. Average annual precipitation at New Orleans is 53.9 inches, varying from an average of 2.84 inches in October to 6.72 inches in July.

3.3 HYDROLOGY

Of the regional surface water hydrologic characteristics, the flow regime of the lower Mississippi River is considered the principal concern, on a regional scale, to the description and evaluation of the Waterford 3 in-

take withdrawal. In the area of the site, the river's bathymetry, current patterns, and thermal characteristics are important.

3.3.1 FLOW VOLUME IN THE LOWER MISSISSIPPI RIVER

Flow records have been maintained on the lower Mississippi at Red River Landing (1900-1963) and Tarbert Landing (1964-1976). Because there are no major tributaries below these points, these flows are characteristic of the lower reach of the river and the Waterford 3 site. For a 77 year period of record, starting in 1900, the mean annual discharge is 494,000 cfs. Flood season is from mid December to July, and typically, flows are generally above the mean from February to June, and below the mean for the remainder of the year.

3.3.2 LOW FLOWS

The flow in the Mississippi River has substantial variations throughout the course of the year. Figure 3-3, based on 45 years of combined monthly data from Tarbert Landing and Red River Landing, shows the percent of the time that various river flows are exceeded. This figure indicates that, for approximately 85 percent of the time, flows are above 200,000 cfs. This is a typical low flow, which is estimated to occur about every four years during the summer and fall seasons. If all months of the year are considered, the typical low flow would have a recurrence interval of about 6.7 years. This flow may be compared to seasonal average flows which have been calculated to be 580,000, 650,000, 280,000 and 240,000 cfs for winter, spring, summer and fall, respectively.

3.3.3 BATHYMETRY

The Waterford 3 site is located on the outside bank of a bend in the Mississippi River. The lowest elevation of the bottom, in this reach of the Mississippi, is approximately -119 ft MSL. Bathymetry for the Mississippi River in the vicinity of the Waterford 3 site is presented in Figure 3-4.

3.3.4 RIVER CURRENT AT THE WATERFORD 3 SITE

The 39-year average current velocity calculated at the Waterford 3 site is 2.3 fps and the minimum is 1.1 fps, as given in Table 3-2. These values are cross-sectionally averaged velocities. The actual velocity distribution is controlled by the channel geometry. It can be expected to vary along the cross-section; however, these approximations fall within the range previously recorded. The details of velocity calculations and actual velocity measurements are given in the Waterford 3 OLER, Section 2.2.3.4.

3.3.5 THERMAL CHARACTERISTICS

Temperatures in the Mississippi River below St Francisville vary seasonally. Seasonal variations in the thermal characteristics, including monthly minimum, average and maximum temperatures are included in Table 3-3 and Figure 3-5.

3.3.6 SEDIMENT

Sediment is transported by the Mississippi River as either a bed load or a suspended load. The amount of material in suspension is generally a function of river discharge, turbulence, and particle size. Whether or not the flow is increasing or decreasing also appears to influence suspended sediment concentrations. During high flow, the sediment concentration generally increases downstream. The converse is true for low flows. Figure 3-6 gives the duration curve for suspended sediment concentration at Red River Landing, Louisiana. Table 3-4 presents typical suspended sediment levels at several river discharge levels. Sediment size varies with depth, river mile, and discharge. In general, the percentage of coarser particles increases with increasing depth and river discharge. At a given discharge rate and depth, particle size decreases with increasing distance downstream (LP&L, 1978).

3.4 ECOLOGY OF THE MISSISSIPPI RIVER

The Mississippi River is a highly turbid waterbody, with high current velocity and low habitat diversity. The productivity of the system is limited by light penetration and the high suspended solids concentration, as well as the stability and habitability of the substrate. The Mississippi River food chain is considered to be detrital based, because phytoplankton occur in low densities and do not seem to be the major energy source that they constitute in more lake-like environments. This is typical of larger southeastern and midwestern rivers.

In April, 1973, the Waterford 3 Environmental Surveillance Program, an intensive aquatic ecological sampling program to study the Mississippi River in the vicinity of Waterford 3, was initiated in order to establish baseline data characterizing the site area. Five sampling stations representing low-current, soft-bottomed, shallow areas, and high-current, dense clay sediment areas, were established between River Miles 132 and 126, as shown in Figure 3-7. (A sixth station was established to replace an earlier station in the second year of sampling). A description of the sampling areas is presented in Table 3-5. Appendix A (attached) presents a detailed description of the sampling methodologies utilized in the aquatic portion of the Environmental Surveillance Program. A detailed compilation of the data collected in these programs is contained in the Waterford 3 OLER Section 2.2.2.1 and Appendix 2-4.

The discussion below is divided into four sections, describing four biotic communities which may be affected due to river water withdrawal by Waterford 3. These are:

- phytoplankton
- zooplankton
- macroinvertebrates
- fish and ichthyoplankton

3.4.1 PHYTOPLANKTON

In the lower Mississippi River, turbidity, turbulence and suspended solids limit the productivity of the primary producers (e.g. phytoplankton). High river suspended solids concentrations, as indicated by Figure 3-6, and turbidity limit light penetration to very shallow depths. Also, shallow areas with substrate suitable for benthic (attached) algae production are rare. Therefore, production of "tychoplankton" (ie, algae which find their way into the plankton community by sloughing off of various substrates on which they grow) is limited. The system may be considered a detrital based one, typical of large, commercially travelled rivers such as the Mississippi. Recent estimates of primary productivity suggest that the Mississippi River in the vicinity of Waterford is less productive than other rivers which have been studied and substantially less productive than most lakes (Geo-Marine, 1979).

A list of phytoplankton species collected at the Waterford 3 site is presented in Table 3-6. The dominant plankton genera found in the Mississippi near Waterford 3 are generally similar to those listed by Hynes (1972) as being the most frequently encountered true plankton in larger rivers. The genera present also are similar to those found in other studies on the Mississippi River (U.S. Army Corp. of Eng. 1976), (Bryan, et al, 1973).

During the period 1973 through 1976, phytoplankton densities measured in the Environmental Surveillance Program ranged from 24.6 to 1,446.8 cells/ cm^3 in the Mississippi River near Waterford. The mean (average) and median (50th percentile) densities were 260 and 150 cells/cm^3, respectively. These densities, given in Tables 3-7, 3-8, 3-9, can be compared to those found in lakes, where phytoplankton usually occur in much higher densities and consequently make a more significant contribution to the food web than in rivers. For example, phytoplankton densities typically range from 500-8000 cells/cm^3 in some lakes which have been studied.

3.4.2 ZOOPLANKTON

An inventory of the zooplankton species found during the Waterford 3 Environmental Surveillance Program is presented in Table 3-10.

Average densities of the dominant zooplankton taxa sampled from 1973 through 1976 are shown in Table 3-11. Rotifers, usually numerically dominant in river systems (Bryan et al, 1973) were poorly represented in samples of zooplankton taken near the Waterford site. In view of the large number of rotifers sampled elsewhere in the lower Mississippi River, (Bryan, et al, 1973) and the small mesh-sized net normally required to sample members of this phylum (Likens and Gilbert, 1970), it is suspected that the densities found during the Environmental Surveillance Program were biased downwards because of the relatively large mesh-size (0.243 mm) utilized.

Nevertheless, the 0.243 mm mesh aize is well suited for sampling zooplankton large enough to serve as prey for many juvenile and adult fish. Galbraith (1967) found that yellow perch and rainbow trout usually fed on zooplankton larger than 1.3 mm. Lyakhnovich, et al, (1975) found that similarly-sized zooplankton were preferred by carp. Also, Vineyard, et al, (1975) found that bluegill sunfish responded towarda daphnids ranging from 0.75 mm to 3.75 mm with a preference exhibited for the larger sizes. Allan (1974) reported that yellow perch were most interested in prey 1.3 mm or larger, and least interested in prey less than 0.5 mm; comparable values for rainbow trout were 1.6 mm and 0.9 mm.

Alewives, which are planktivores, showed most and least interest, respectively , in zooplankton 0.7 mm and 0.2 mm in length. Thus, the above findings suggest that estimates of zooplankton abundance presented in this document provide a measure of the potential contribution of zooplankton as forage for the fish community near Waterford.

The significance of this contribution can be assessed by comparing the densities of large zooplankton in the Mississippi River to densities reported for other ecosystems. Zooplankton are generally regarded to be an important component of quiet water systems. Zooplankton were reported to range

between 2000 and 24,000/m^3, 2000 and 55,000/m^3, and 200,000/m^3 in Lakes Huron, Ontario and Erie, respectively (Watson, 1974). In a survey of 340 lakes and ponds in the Canadian Rockies, Anderson (1974) found a mean density of crustacean zooplankton in "sparsely populated" water bodies to be 28,000/m^3, and the mean of "densely populated" water bodies to be 170,500/m^3. The densities of cladocerans and calanoid copepods sampled by Lane (1975) in Gull Lake, Michigan; Cranberry Lake, New York; and Lake George, New York were 6,000 to 13,000/m^3, 20,000 to 26,000/m^3 and 15,000/m^3 respectively. In contrast to these reported values, average annual zooplankton densities at Waterford 3 did not exceed 2500/m^3 and the average monthly density over all stations, as shown in Table 3-12, did not exceed 3500/m^3.

3.4.3 PELAGIC MACROINVERTEBRATES

The river shrimp, Macrobrachium ohione, has been consistently found in high numbers at the Waterford site during the Environmental Surveillance Program and during impingement sampling at Waterford 1 and 2 (Epsey-Huston, 1977). Both females "in berry" and decapod larvae, probably river shrimp, were observed during the Waterford 3 sampling program indicating that spawning takes place near the site.

3.4.4 FISH AND ICHTHYOPLANKTON

3.4.4.1 Fish

A listing of the fish species collected, and the numbers and weights of each species caught during each of the 3 years of sampling near the Waterford site, are given in Table 3-13 and 3-14, respectively. A summary of the numbers and weights of common species and total fish collected each month per unit effort (per 48 hr gill net set, per 1 hr electrofishing effort) is given in Tables 3-15 and 3-16. The number and weight of the dominant fish and all fish captured per unit effort during each year, at each station utilized, is given in Table 3-17.

Sixty-one species of fish were collected during the 3 year study at Waterford. The number of species represented in fish collections during Years I, II, and III was 45, 34, and 49, respectively. Dominant species (among the fish most abundant in at least 2 out of 3 sample years) were the gizzard shad, threadfin shad, blue catfish, freshwater drum and the striped mullet. These were similar to the dominant species collected during other studies of the lower Mississippi River.

Table 3-16 presents the number of fish caught per unit effort by month, by station for each of the five dominant species given above. Seasonal trends in the abundance of gizzard shad, freshwater drum, and striped mullet were either nonexistent, or were obscured by high month-to-month variability in the numbers of these species caught by gill netting and electroshocking. In two of the three sampling years, the number of blue catfish caught by electroshocking was usually higher during the fall and winter months than during the spring and summer. This trend was consistent among all stations. In the other year, blue catfish were in low abundance throughout the year. The number of threadfin shad caught by electroshocking appeared to decrease during the winter months.

Differences in the catch of fish among stations and between years were tested for statistical significance using Friedman's two-way analysis of variance (Siegel, 1956). Friedman's two-way analysis of variance is a statistical test which analyzes the variability in observations between types of stations in relation to the variability within a single type of station. For this, ranks were assigned from one through five to the five sampling stations according to the yearly catch per unit effort for a given species of that station. Five such sets of ranks were assigned, one for each of the five common species: blue catfish, freshwater drum, gizzard shad, threadfin shad and striped mullet. For the purpose of Friedman's analysis of variance, the five species were considered independent trials and the stations were considered treatments. The hypothesis that differences among stations in Year I were not significant could not be rejected. The same test for Year II data yielded similar results (Table 3-18 and 3-19). Again, the hypothesis that the abundance of dominant fish species does not differ spatially could not be rejected. These results imply that

there is either no difference in fish abundance between stations in the river near Waterford, or that differences could not be detected from the samples taken.

Thermal data suggest that sampling station A_t experienced, during Year III, elevated temperatures due to Waterford 1 and 2. However, the application of Friedman's test to data from this station suggests that it did not experience a change in the abundance of fish relative to other stations between Year I and Year III.

This hypothesis of no difference between Years I and III at Station A_t was examined using the sign test (Siegel, 1956). Catch per unit effort for Year I was subtracted from that for Year III at Station A_t for each of the five common species. Given that no difference between Years I and III existed, the occurrence of plus and minus signs were equally likely. These signs did occur in approximately equal numbers, suggesting no difference in the abundance of common species between Year I and III; that is the hypothesis of no difference between Years I and III could not be rejected at accepted levels of significance.

In summary, significant differences in the distribution of dominant fish species among stations within years could not be detected. The relationship between stations did not vary between Years I and III. Catch per unit effort at Station A_t was not found to vary significantly between Years I and when the station had experienced thermal influences by Year III.

3.4.4.2. Ichthyoplankton

The Mississippi River at Waterford does not provide habitat suitable for spawning by many fish species. It lacks the riffle areas preferred for spawning by many catfish (ictalurids) and most suckers (catastomids), the shallow back-waters and flood areas preferred by pikes (esocids) and some of the shads (clupeids) and sunfishes (centrarchids), and the vegetated areas preferred by other sunfishes and perch (percids) (see Table 3-20). To the extent that sheltered locations are available (including cans, snags, etc), a limited number of catfish may spawn near Waterford. Other

species that may be capable of spawning in this portion of the river include freshwater drum, gizzard shad, threadfin shad, river carpsucker and shipjack herring. However, the spawning habitat appears not to be optimal even for these species. This is supported by the low ichthyoplankton densities found.

Average densities for all stations ranged from a low of $0.002/m^3$ to $0.106/m^3$ over the three years of sampling (see Tables 3-21 and 3-22). No ichthyoplankton were found in the period September to February. Spatial variation by station in total ichthyoplankton concentration was examined by Friedman's two-way analysis of variance using Year III data, since they were the most complete. For each date, ranks are assigned to each station according to the average ichthyoplankton concentration observed there (Table 3-23). These ranks are then summed, and an overall rank is assigned to each station. It was found that the five stations did not differ significantly. Therefore, these data indicated no significant spatial differences in ichthyoplankton densities in the Mississippi in the Waterford vicinity.

At St. Francisville, Louisiana, 10 species of ichthyoplankton were found to be common in the Mississippi River mainstem. These included Dorosoma sp (March - July), Cyprinus capio (May - August), Poxomis sp (April - June) and Aplodinotus grunniens and Hybopsis sp. Ichthyoplankton were found only in the mainstem. Densities during May, June and early July are ranged from 0.5 to $0.9/m^3$ in the main channel of the Mississippi near St. Francisville. Densities were generally lower in the Waterford area, probably because the backwater areas present at St. Francisville, which provide spawning habitat, are not available at Waterford.

3.4.4.3 Commercial Fisheries

Commercial fish species in the lower Mississippi River include buffalo fish, freshwater catfish, freshwater drum and gar. The commercial catches from the Mississippi River from Baton Rouge to the mouth are shown in Table 3-24 (in both pounds and dollar values) for the period 1971 to 1975. This information shows that freshwater catfish had the highest dollar value of

all commercial species, reaching a high of $401,903 in 1975. The only commercial species which were common in the Waterford area were the freshwater catfish and freshwater drum. Commercial catches of river shrimp in the lower Mississippi River from 1971 to 1975 are shown (Table 3-24) to have ranged from 900 to 4,200 pounds to be valued from $297 to $2,940.

3.4.4.4 Sport Fisheries

Fish sought by sport fishermen in the River Bend area of the Mississippi River include blue catfish, channel catfish, flathead catfish, white bass, yellow bass, white crappie, sauger and freshwater drum (U S Atomic Energy Commission, 1974). Although all these species are present in the Waterford area, the only ones that can be considered common (more than 200 collected during any sampling year during the Waterford study) are blue catfish and freshwater drum. Largemouth bass, another valued sport fish, was collected only occasionally during the Waterford 3 Environmental Surveillance Program.

3.4.4.5 Endangered Species

None of the fish species actually found in the area sampled in the Waterford study, or expected to be present in the Waterford area, are included in the January 1979 Fish and Wildlife Service's List of Endangered and Threatened Wildlife and Plants (USDI, 1979).

There are some species which were found in the Waterford area which may be considered locally rare, or whose number have been recently decreasing. These include the pallid sturgeon, shovelnose sturgeon and paddlefish. The Louisiana Wildlife and Fisheries Commission (1977) has indicated, however, that the shovelnose sturgeon and paddlefish are still relatively common in the State of Louisiana. Of the species listed by Miller (1972) as threatened and/or rare in the State of Louisiana, only the brown bullhead, pallid sturgeon and suckermouth minnow were found in the Waterford area. However, the suckermouth minnow and brown bullhead do not appear to be endangered when their entire range, and not just the State of Louisiana, is considered.

3.4.4.6 River Habitat Utilization in the Waterford Area

From the life histories information of the fish species that occur in the Waterford area (Table 3-20), it appears that most species spawn in shallow areas, sheltered areas, smaller streams, backwaters, areas of aquatic vegetation, or over gravel and sand bottoms. The only abundant (A), commercial (C), sport (S), or threatened (T) species that might spawn over the clay or mud substrate in the waters found in the vicinity of the Waterford area are threadfin shad (A), gizzard shad (A) and possibly blue catfish (C). These were the most abundant groups of ichthyoplankton captured during the Waterford 3 Environmental Surveillance Program.

Based on the length distribution of the abundant, commercial, sport or threatened fish species collected in the Waterford area, it would appear that blue catfish, freshwater drum, gizzard shad and threadfin shad juveniles utilize the area as a nursery area during specific times of the year.

Life history information on sport (S), commercial (C), abundant (A), or threatened (T) species in the Waterford area suggests that some species may undertake spring or summer migrations through the Waterford area. These include longnose gar (C), gizzard shad (A), bigmouth buffalo (C), channel catfish (C), and striped mullet (A). Actual data collected in the Waterford area indicated, however, that longnose gar and bigmouth buffalo apparently do not pass though the area in sizeable numbers.

Comparison of Waterford data to other studies of fishery resources in the lower Mississippi River and fish collected in the area, suggests that the Mississippi River at Waterford is not unique fish habitat.

3.5 Pre-Existing Environmental Stresses

The populations of aquatic organisms in the lower Mississippi River appear to be limited mainly by the poor spawning habitats and the effects of high turbidity, high concentrations of total suspended solids, high current velocities, and fluctuating water levels.

The high turbidities (49-625 JTU during the Waterford study) restrict phytoplankton and periphyton growth due to very limited light penetration. Productivity of the phytoplankton is further limited by the high turbulence and mixing in the Mississippi, which may prevent phytoplankton from remaining in the zone of light penetration for sufficient lengths of time to effectively photosynthesize. High concentrations of suspended solids (reaching values as high as 345 ppm in the Waterford study) and high current velocities (2.78 to 7.01 fps in the April 1973 to September 1976 study period) result in scouring of fish eggs and larvae (in nests or attached to submerged objects), scouring of benthic and periphyton communities, clogging of fish gills and filter-feeding mechanisms of invertebrates, and shifting bottom sediments. Resultant sediment deposition in areas with slower currents smother fish eggs and larvae as well as benthic organisms (both fauna and flora), further limiting their composition and density.

The variation of the flow regime in the lower Mississippi River appears to make it a difficult habitat for fish. (The total river discharge during the Waterford Environmental Surveillance Program excluding those values reached during the spring 1973 flood, ranged from 222,000 to 1,086,000 cfs). High water after spawning may lead to the displacement or mortality of eggs and larvae.

Other stresses placed on the aquatic organisms in this reach of the Mississippi include the effects of waste water discharges. According to a 1969-1971 Environmental Protection Agency study of the lower Mississippi River (US EPA, 1972) sixty industrial plants between St. Francisville, Louisiana and Venice, Louisiana (Figure 3-8) discharged wastes containing quantities of heavy metals and organics into the river.

As a result of its unstable substances, high turbidity, high concentrations of suspended solids, high current velocities, and industrial discharges along its banks, the lower Mississippi River mainstream would be expected to be an area with relatively low productivity. The Waterford studies seem to support this assumption of low productivity for certain communities. The Waterford Environmental Surveillance Program has found extremely low concentrations of phytoplankton and attached algae, low zooplankton

densities, and an absence of macrophytes. The dominant benthic invertebrates collected, i.e., Corbicula and oligochaetes, are prey for fish and also play a role in processing organic matter. However, their numbers are so low as to make their contribution minimal, although river shrimp (Macrobrachium ohione), is probably an important pelagic forage species (Williams, 1965).

3.6 The Waterford 3 Circulating Water System

Below is a description of the Waterford 3 Circulating Water System structure and operation, including the intake canal, intake structure and discharge structure. Velocities, residence times, and temperature changes are also presented.

The Circulating Water System withdraws water from the river though an intake canal, and intake structure which contains the travelling water screens and the circulating water pumps. Water is transported from the pumps through the condenser and to the discharge structure. The circulating water is then returned to the river through a discharge canal. A plan view of the system is shown in Figure 3-9. The system is a once-through system, and has negligible consumptive water loss (i.e. evaporation).

3.6.1 System Operation

The equipment specifications for the circulating water pumps were developed from an estimated operating schedule, based on optimum steam cycle conditions. The operation of the Circulating Water System, described in this section, is predicted from this preliminary schedule.

Water is withdrawn from the Mississippi River at a design summer rate of 1,003,404 gpm, which includes 1,003,200 gpm of circulating water. Of the 1,003,200 gpm, 975,100 gpm passes through the main condenser where its temperature is raised about 16.4° F. The Turbine Closed Cooling Water System heat exchangers and the Steam Generator Blowdown System heat exchangers use the remaining 28,100 gpm, which undergo a temperature increase of about

7.6° F. The resultant temperature rise of the combined flow of 1,003,200 gpm is approximately 16.1° F. Therefore, during full load and design flow conditions, the circulating cooling water discharged to the river is an average of approximately 16.1° F above the intake water temperature.

When the station is operating, it is anticipated that all four circulating water pumps will be utilized whenever the intake water temperature exceeds 70°F. This is estimated to occur approximately 34 percent of the time on an annual basis. The system design flow rate for four pump operation is 1,003,200 gpm, with a temperature rise at this rate of 16.1°F.

Three pump operation will occur during approximately 25 percent of the time, when the intake water temperature ranges between 55°F and 70°F. The flow rate during this condition is approximately 84 percent of the design four-pump flow rate. The full load temperature rise at this flow rate is about 19.2°F. When the intake water temperature is below 55°F, it is anticipated that two circulating water pumps will be utilized. This condition is expected to occur about 30 percent of the time. The flow rate during this mode is about 62 percent of the design flow rate when four pumps are operating , and this mode has a corresponding temperature rise of approximately 26°F. The remaining 11 percent of the time, the unit is shut down.

There are no provisions for backflushing or de-icing anywhere within the Circulating Water System.

3.6.2 Intake Canal

Water is drawn from the river through a sheet pile formed intake canal, which is illustrated in Figure 3-10. The overall length of the canal is about 162 ft. At the river end of the canal, its width is approximately 37 ft and the bottom elevation is at -35.0 ft MSL. Average low water level (ALWL) and average high water level (AHWL) in the river are 0.90 ft and 18.60ft MSL, respectively. The canal width increases uniformly over the first 122 ft to approximately 120 ft. That width is maintained over the last 40 ft to the intake structure. The bottom of the canal slopes upward

over the first 52 ft to an elevation of -24.0 ft MSL, which is maintained for the remaining 110 ft. At the river entrance to the canal, a skimmer wall extends down to elevation -1.0 ft to prevent the entrance of large debris and to draw water from a depth below the surface of the river.

3.6.3 Intake Structure

The dimensions of the intake structure base are approximately 120 ft in width and 73 ft in length. The bottom of the base slab is set at -28.0 ft MSL and the slab is 4.0 ft thick at the river face. The top of the deck is at 27.0 ft MSL. The intake structure is illustrated in Figure 3-11.

A skimmer wall is provided at the river face of the intake structure to prevent the entrance of large debris. This wall on the intake structure extends down to -4.0 ft MSL, leaving a clear opening 20 ft high.

Water entering the intake passes through a coarse screen (trash rack) of 1/2 in. diameter bars on six inch centers and enters into eight bays, each equipped with a travelling water screen with 1/4 in. clear openings. Each bay is 11 ft. 2 in. wide. Slots are provided for inserting a fixed screen of similar mesh downstream of any travelling screen which may fail. Fish and other organisms removed from the cooling water by the travelling screens will be washed to a trough and then sluiced to the river at a point downstream of the Waterford 3 intake.

3.6.4 Zone of Intake Withdrawal

The opening of the intake canal to the river is set at -35.0 ft MSL. At the entrance to the canal a skimmer wall extends down to elevation -1.0 ft. Water withdrawal for Waterford covers essentially the whole water column between these depths. Below this, river depth drops off sharply to an elevation of -119 ft MSL, as indicated in Figure 3-4. Therefore, withdrawal of intake water for Waterford 3 will be concentrated within the upper portion of the river water column with very little influence in the deeper offshore river portions. During periods of high river flow, when stage height is above +16.0 ft, the entire intake canal sheet piling and

skimmer wall will be below high water level (AHWL) of 18 ft. At this stage, withdrawal will also include withdrawal from the river surface.

3.6.5 Piping and Condenser

Four steel pump discharge lines run below the intake deck horizontally to a common, cast-in-place, concrete transition block. These lines have an external diameter of 8 ft.

From the transition block, two steel pipes of 11 ft external diameter cross over the levee, beneath Louisiana Highway 18, and join two reinforced concrete pipes, with internal diameters of 11 ft. The concrete pipes are installed below grade and carry the flow from the end of the 11 ft steel pipes to the cast-in-place, concrete condenser intake block within the Turbine Building.

The condenser is connected to both the condenser intake block and discharge block by six, 7 ft diameter vertical steel pipes. A three-shell, single pass, divided water box condenser is provided with tubes at right angle to the turbine generator. These stainless steel tubes are 52 ft long, one inch outer diameter and 22 Bwg.

From the cast-in-place condenser discharge block, two, 11 ft internal diameter reinforced concrete pipes, installed below grade, carry the flow to a cast-in-place concrete transition block.

Four, 9 ft external diameter steel pipes convey the water from the transition block in the Turbine Building, under Louisiana Highway 18, over the levee, and into the discharge structure. The levee is crossed with steel lines in accordance with requirements previously applied by the Corps of Engineers.

3.6.6 Discharge Structure and Canal

The discharge structure, illustrated in Figure 3-12, consists of a concrete seal well with outer dimensions approximately 52 ft by 45 ft. Cooling

water enters the seal well from four 9 ft diameter steel pipes. It leaves the seal well by overflowing about 95 ft of weirs which run around three of the four sides of the discharge structure. The height of water above the weirs at full design flow is about 3.4 ft. Elevation of the weir crests (highest point) is adjustable between elevations 6.0 ft and 11.0 ft. The elevation selected at a given time depends on the Mississippi River water level. The discharge structure design selected is typical of those presently in use at other LP&L plants on the Mississippi River.

A sheet pile formed discharge canal carries the water from the discharge structure to the river. The bottom is constructed at elevation -5.0 ft MSL. At the shore end, the discharge canal is 81 ft wide. The width is constant over the first 81 ft of the canal length. From this point, the width contracts symmetrically over a distance of about 95 feet, to a width of 50 feet at the river end. The discharge canal is concrete lined to prevent erosion. The design criteria are for a discharge velocity into the river of about 7 ft per second at ALWL during four pump operation. The purpose of this high discharge velocity is to promote rapid mixing of the discharge with ambient river water. The top of the sheet pile is at elevation 15.0 ft where the canal is 81 ft wide and at elevation 10.0 ft where the canal is contracting.

3.6.7 System Velocity and Residence Times

Average velocities at selected locations within the intake canal and intake structure have been calculated for high and low river stages during various pumping modes. The results are summarized in Table 3-25. This table shows that the velocity varies under the skimmer wall at the entrance of the intake canal, from a maximum of 1.78 feet per second, during operation of all four pumps, to a minimum of 1.09 feet per second when two pumps are operating. The average velocity through the travelling screens, based on net clear openings, ranges from a maximum during low river flow of 1.82 feet per second, to a minimum of 1.06 feet per second at high river stages. The velocity through the travelling screens does not depend upon the number of pumps operating because each pump is served separately by two travelling screens.

Travel times have been calculated for the various portions of the Circulating Water System for high and low river stages during various pumping modes. The times and corresponding average velocities are presented in Table 3-26. During operation of all four pumps, the total travel time of the circulating water after the addition of heat varies from 330 seconds to 238 seconds at AHWL and ALWL, respectively. With two pumps operating, the travel times after heat addition are 532 seconds with AHWL and 383 seconds with ALWL.

3.6.8 Chemical and Biocide Systems

During operation of Waterford 3, several classes of chemical wastes will be generated from systems and processes such as water treatment, corrosion control, and the sanitary water system. These additions may affect the ability of entrained planktonic organisms to survive passage through the Waterford 3 Circulating Water System, although the increases in the concentrations in the circulating water are extremely slight when compared to the concentrations occurring in the river, as indicated in Table 3-27.

The major impact of chemical treatment to the ability of entrained organisms to survive is likely to come from chlorine applications to the Circulating Water System. Although the chlorination facilities will be available at Waterford 3 if needed, it has been found at Waterford 1 and 2 and Little Gypsy that the high suspended solid levels scour the condensers to such a degree that chlorination is not routinely necessary.

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TABLE 3-1

AVERAGE MONTHLY TEMPERATURE AND PRECIPITATION FOR SELECTED STATIONS IN THE NEW ORLEANS AREA

New Orleans, La - New Orleans International Airport

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Temp (°F)	54.6	57.1	61.4	67.9	74.4	80.1	81.6	81.9	78.3	70.4	60.0	55.4	68.6
Precip (in.)	3.84	3.99	5.34	4.55	4.38	4.43	6.72	5.34	5.03	2.84	3.34	4.10	53.90

New Orleans, La - Audubon Station

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Temp (°F)	55.5	57.7	62.1	68.9	75.7	81.1	82.6	82.5	78.9	71.1	61.0	56.6	69.5
Precip (in.)	4.29	4.35	5.91	5.54	4.86	5.59	8.12	6.64	6.41	3.15	3.51	4.59	62.96

Reserve, La - Cooperative Observer

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Temp (°F)	53.8	55.9	60.6	67.8	75.1	80.0	82.5	82.3	78.7	70.4	59.8	54.6	68.5
Precip (in.)	4.49	5.16	5.64	4.92	4.90	5.31	7.00	5.74	5.14	2.96	3.77	5.54	60.57

TABLE 3-2

AVERAGE MONTHLY CROSS-SECTIONAL VELOCITY AT THE WATERFORD 3 SITE

Month	Flow*		Stage (ft)		Cross Sectional Area**		Velocity	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
January	455	116	7.6	0.2	18.4	16.2	2.5	0.7
February	577	118	10.25	1.6	18.9	16.7	3.1	1.1
March	700	296	12.9	4.3	19.5	17.6	3.6	1.7
April	773	302	14.6	4.3	19.7	17.6	3.9	1.7
May	590	303	10.6	4.3	19.0	17.6	3.1	1.7
June	474	247	8.2	3.3	18.5	17.2	2.6	1.4
July	384	198	6.3	2.2	18.0	16.8	2.1	1.2
August	243	154	3.1	1.1	17.2	16.5	1.4	0.9
September	194	133	1.9	0.6	16.8	16.4	1.2	0.8
October	212	93	2.4	0.1	16.9	16.2	1.3	0.6
November	225	95	2.7	0.1	17.0	16.2	1.3	0.6
December	294	105	4.3	0.2	17.6	16.2	1.7	0.7
Average							2.3	1.1

*Flow (Q) in 1,000 cfs
**Cross sectional area (CA) in 10,000 sq. ft.

TABLE 3-3

MONTHLY WATER TEMPERATURE DATA FROM THE MISSISSIPPI RIVER NEAR WESTWEGO, LOUISIANA*
(1951-1969)

Month	Temperature (°F)		
	Maximum	Minimum	Mean
January	50	41	46
February	50	40	46
March	56	46	51
April	63	57	59
May	78	67	71
June	83	77	79
July	87	81	84
August	90	81	86
September	87	76	83
October	78	71	74
November	71	57	63
December	57	47	52

*Measurements taken at Ninemile Point Generating Station, 25.6 miles downstream from Waterford 3.

Source: Louisiana Power & Light Company, Environmental Report Operating License Stage, Waterford Steam Electric Station, Unit 3, 1978.

TABLE 3-4

SEDIMENT CONCENTRATIONS IN THE MISSISSIPPI RIVER AT LULING FERRY, LA.

Discharge at Red River Landing cfs x 1,000	Date	Total Suspended Sediment (mg/l)	Silt (mg/l)	Sand (mg/l)
602	April 7, 1976	386	290	96
304	June 19, 1976	135	122	13
221	Aug. 18, 1976	58	49	9
174 (2/10)	Feb. 9, 1977	68	61	7
420 (5/5)	May 4, 1977	250	232	18

Source: Personal Communication, US Geological Survey, Baton Rouge, La. 1977.

Preliminary Data, Subject to Revision.

TABLE 3-5

SAMPLING STATIONS FOR
PREOPERATIONAL ENVIRONMENTAL SURVEILLANCE PROGRAM
FOR SURFACE WATERS

Station Identification	Location	Rationale for Location
A_c	Behind an island on the west bank (right hand descending) of the Mississippi River, in a shallow back-water area upstream of Waterford 1 and 2.	Station is not expected to be directly affected by discharges from Waterford 1, 2, or 3; and therefore, has been designated as a control station.
A_t	On the west bank of the Mississippi River, in a shallow area characterized by low-velocity currents. Immediately upstream of Waterford 1 and 2, in a back eddy current.	Back eddy current results in transportation of heated discharge from Waterford 1 and 2 upstream to this station.
B_c	On the east bank of the Mississippi River opposite Waterford 1, 2, and 3. It is also upstream of LP&L's Little Gypsy Power Plant.	Intended as unaffected control station for deep, fast velocity current environment.
B_t	Immediately downstream of Waterford 3 discharge.	Station located in area of river influenced by heat discharge from Waterford 3.
B_{t1}	Along the west bank, near River Mile 127.	Abandoned after first year of sampling, and replaced by Station B_{t1*}.
B_{t1*}	On the west bank near River Mile 127.8.	Replaced Station B_{t1} in second year of sampling. Location is just upstream of an adjacent thermal discharge, and further downstream from the discharge of Waterford 3 than Station B_t.

TABLE 3-6

SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE MISSISSIPPI RIVER IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 TO SEPTEMBER 1976

(Sheet 1 of 5)

Chlorophyta

Chlorophyceae

Volvocales

Volvocaceae

Eudorina

Pandorina

Gonium pectorale

Chlorococcales

Cocystaceae

Ankistrodesmus

Ankistrodesmus falcatus

Scenedesmaceae

Actinastrum

Actinastrum hantzschii

Coelastrum

Scenedesmus sp

Scenedesmus acuminatus

Scenedesmus armatus

Scenedesmus dimorphus

Scenedesmus obliquus; *Scenedesmus quadricauda*

Tetrastrum

Hydrodictyaceae

Pediastrum

Pediastrum duplex

TABLE 3-6 (Cont'd)

SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE MISSISSIPPI RIVER IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 TO SEPTEMBER 1976

(Sheet 2 of 5)

Chlamydomonadaceae

Chlamydomonas sp

Chrysophyta

Chrysophyceae

Chrominales

Chrysococcaceae

Chrysococcus

Ochromonadales

Dinobryaceae

Dinobryon

Bacillariophyceae

Centrales

Coscinodiscaceae

Coscinodiscus

Coscinodiscus rothu

Melosira

Melosira distans

Melosira granulata

Melosira herzogii

Melosira ambigua

Melosira variens

Melosira islandica

Cyclotella

Cyclotella meneghiniana

TABLE 3-6 (Cont'd)

SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE MISSISSIPPI RIVER IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 TO SEPTEMBER 1976

(Sheet 3 of 5)

Stephanodiscus

Stephanodiscus astrea

Pennales

Cymbellacea

Amphora

Cymbella

Fragilariaceae

Fragilaria

Synedra

Diatoma sp

Asterionella formosa

Eunotiaceae

Eunotia

Achnanthaceae

Achnanthes

Cocconeis

Naviculaceae

Gyrosigma sp

Gyrosigma kutziingii

Navicula

Navicula exigua

Pinnularia sp

Pleurosigma

Stauroneis

TABLE 3-6 (Cont'd)

SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE MISSISSIPPI RIVER IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 TO SEPTEMBER 1976

Gomphonemaceae

Gomphonema

Gomphonema constrictum

Nitzschiaceae

Nitzschia

Surirellaceae

Surirella

Cyanophyta

Chroococcales

Chroococcaceae

Anacystis

Merismopedia

Oscillatoriales

Oscillatoriaceae

Oscillatoria sp

Nostocales

Nostocaceae

Anabaena

Euglenophyta

Euglenales

Euglenaceae

Euglena sp

Euglena acus

Trachelomonas

TABLE 3-6 (Cont'd)

SPECIES LIST OF PHYTOPLANKTON COLLECTED IN THE MISSISSIPPI RIVER IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 TO SEPTEMBER 1976

(Sheet 5 of 5)

Trachelomonas hispida

Trachelomonas lacustris

Trachelomonas volvocina

TABLE 3-[illegible]

AVERAGE PHYTOPLANKTON DENSITIES IN SAMPLES COLLECTED IN THE MISSISSIPPI RIVER IN THE WATERFORD VICINITY FROM JUNE 1973 THROUGH MAY 1974 (YEAR I)

Month	Avg Total Density (No./Liter)	Dominant Taxa *	Number of Genera
June, 1973	27,200	Cyclotella, Melosira	4
July, 1973	57,800	Cyclotella, Melosira, Scenedesmus	5
August, 1973	299,200	Coscinodiscus	15
September, 1973	719,100	Coscinodiscus, Melosira	11
October, 1973	59,500	Coscinodiscus, Scenedesmus, Cyclotella, Melosira	4
November, 1973	52,700	Coscinodiscus, Cyclotella, Melosira	5
December, 1973	34,000	Cyclotella, Melosira	3
February, 1974	40,800	Cyclotella, Melosira	4
March, 1974	51,000	Cyclotella, Melosira	5
April, 1974	45,960	Melosira, Trachelomonas	5
May, 1974	28,900	Cyclotella, Melosira	3
Average	128,742		

*20% or greater of average total density or most abundant

Source: Waterford 3 Environmental Surveillance Program

TABLE 3-8

AVERAGE PHYTOPLANKTON DENSITIES IN SAMPLES COLLECTED IN THE MISSISSIPPI RIVER IN THE WATERFORD VICINITY FROM JUNE 1974 THROUGH FEBRUARY 1975 (YEAR II)

Month	Avg Total Density (No./Liter)	Dominant Taxa *	Number of Genera
June 1974	230,814	Chrysococcus Melosira	13
August 1974	479,417	Coscinodiscus	15
April 1975	348,098	Chrysococcus	9
February 1975	501,201	Chrysoccoccus	12
AVERAGE	389,882		

*20% or greater of average total density or most abundant.

Source: Waterford 3 Environmental Surveillance Program

TABLE 3-9

AVERAGE PHYTOPLANKTON DENSITIES IN SAMPLES COLLECTED IN THE MISSISSIPPI RIVER IN THE WATERFORD VICINITY FROM OCTOBER 1975 THROUGH SEPTEMBER 1976 (YEAR III)

Month	Avg. Total Density (No./Liter)	Dominant Taxa*	Number of Genera
October 1975	56,751	Melosira	12
November 1975	24,541	Coscinodiscus; Melosira, Scendesmus quadricauda	9
December 1975	59,816	Coscinodiscus	6
January 1976	152,349	Coscinodiscus; Melosira	7
February 1976	119,636	Coscinodiscus; Melosira	11
March 1976	162,574	Coscinodiscus; Melosira	8
April 1976	1,446,815	Melosira	19
May 1976	320,548	Coscinodiscus; Melosira	9
June 1976	326,699	Melosira	15
July 1976	440,189	Coscinodiscus	12
September 1976	608,919	Coscinodiscus; Cyclotella; Melosira:	14
September 1976	162,579	Melosira; Cyclotella	14
AVERAGE	323,451		

* 20% or greater of average total density or most abundant.

Source: Waterford 3 Environment Surveillance Program

TABLE 3-10

ZOOPLANKTON COLLECTED IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 THROUGH SEPTEMBER 1976
(Sheet 1 of 3)

Hydrozoa

Rotifera

Class Monogononta

Order Ploima

Asplanchna sp.

Brachionus sp.

Keratella sp.

Platyias quadricornis

Platyias sp.

Nematoda

Arthropoda

Class - Crustacea

Subclass - Brachiopoda

Order - Anostraca

Order - Cladocera

Sub Order - Calyptomera

Daphnia longiremis

Daphnia magna

Daphnia sp.

Ceriodaphnia recticulata

Ceriodaphnia sp.

Moina brachiata

Moina sp.

TABLE 3-10 (Cont'd)

ZOOPLANKTON COLLECTED IN THE VICINITY OF WATERFORD 3 FROM JUNE 1973 THROUGH SEPTEMBER 1976

Bosmina longirostris

Bosmina coregoni

Bosmina sp.

Alona sp.

Alonella rostrata

Alonopsis sp.

Camptocercus rectirostris

Chydorus sp.

Diaphanosoma branchyurum

Diaphanosoma sp.

Subclass - Ostracoda

Subclass - Copepoda

Order - Eucopepoda

Suborder - Calanoida

Eurytemora affinis

Diaptomus pallidus

Diaptomus siciloides

Diaptomus stagnalis

Diaptomus sicilis

Diaptomus sp.

Suborder - Cyclopoida

Cyclops bicuspidatus

Cyclops vernalis

Order - Harpacticoida

TABLE 3-10 (Cont'd)

ZOOPLANKTON COLLECTED IN THE VICINITY OF
WATERFORD 3 FROM JUNE 1973 THROUGH SEPTEMBER 1976
(Sheet 3 of 3)

Subclass - Malacostraca

Order - Decapoda

Larvae

Order - Amphipoda

Family - Gammaridae

Class - Arachnida

Order - Acarina

Family - Pionidae

Order - Hydracarina

Class - Insecta (Larvae)

Order - Ephemeroptera

Order - Coleoptera

Order - Odonata

Order - Plecoptera

Order - Diptera

Source of data: Waterford 3 Environmental Surveillance Program

AVERAGE DENSITIES*, NUMBERS PER M^3, OF DOMINANT ZOOPLANKTON TAXA IN SAMPLES COLLECTED IN THE VICINITY OF WATERFORD 3

ZOOPLANKTON GROUP

YEAR	DATE	BOSMINA SP.	CERIODAPHNIA SP.	DAPHNIA SP.	DECAPODA LARVAE	DIAPHANOSOMA SP.	MOINA SP.	SUBORDER CALANOIDA	SUBORDER CYCLOPOIDA
I	73 JUN 08**	85.278	101.692	228.935	9.091	.000	.000	820.476	862.410
	73 JUL 17	.000	1.025	.993	33.027	.000	.000	39.033	68.962
	73 AUG 22**	.000	.000	.000	7.771	.000	.000	66.486	60.195
	73 SEP 28	591.511	109.854	259.865	.720	.000	.000	185.701	412.575
	73 OCT 25**	1.770	.360	2.446	.000	.000	.000	220.801	34.682
	73 NOV 30	44.785	8.145	29.868	.000	.000	.000	99.607	62.183
	73 DEC 19	44.423	12.975	44.842	.000	.000	.000	79.727	70.577
	74 FEB 13	68.815	38.909	103.283	.000	.000	.000	214.031	325.845
	74 MAR 27	119.268	56.026	84.571	.000	.000	.000	680.059	585.786
	74 APR 20	61.025	4.881	9.588	.000	.000	.000	81.812	220.428
	74 APR 23	138.744	37.867	48.577	.000	.000	.000	323.532	722.367
	74 MAY 17	299.345	15.592	237.192	1.212	.000	.000	848.203	1006.413
II	74 JUN 04	.000	1.798	7.425	11.990	.000	.000	97.714	99.979
	74 JUN 24	.860	.687	38.277	2.873	.000	.000	37.397	19.223
	74 AUG 22	139.324	232.268	135.890	.867	.000	.000	13.804	2961.953
	74 NOV 13	146.515	11.969	19.369	.000	10.627	.000	2207.900	402.447
	75 FEB 26	88.771	70.821	6.903	.000	.187	.000	88.171	270.836
	75 APR 23**	37.728	57.007	9.475	.000	2.083	.000	31.052	94.815
	75 AUG 08	1.609	7.158	.000	1.516	36.442	.000	56.724	205.923
III	75 OCT 30	127.194	1.146	6.023	.000	1.284	.000	39.736	32.127
	75 NOV 20	7.937	.459	7.056	.000	.000	.000	16.861	22.429
	75 DEC 22	13.409	.003	4.230	.000	.000	.000	16.166	41.009
	76 JAN 30	.000	.000	4.131	.000	.000	.000	3.208	.402
	76 FEB 26	.040	.165	.447	.000	.000	.000	.486	.656
	76 MAR 25	41.992	7.526	27.146	.000	.567	.000	62.310	133.386
	76 APR 29**	39.660	.145	7.656	.000	.000	.000	18.877	33.791
	76 MAY 27	7.941	1.137	5.631	.000	.410	.000	18.921	135.513
	76 JUN 24	.000	1.581	.213	.000	11.551	.000	57.615	49.072
	76 JUL 29	.000	4.552	1.539	.000	6.403	456.646	17.088	31.480
	76 SEP 10	124.016	.274	9.861	.000	2.436	164.476	25.917	1093.319
	76 SEP 26	413.466	2.247	45.346	.000	2.158	155.645	12.567	111.096

* Densities do not include exoskeletons
** Samples on more than one sampling day

Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-12

AVERAGE ZOOPLANKTON DENSITIES*, NUMBER PER M^3, BY STATION BY DATE IN SAMPLES COLLECTED IN THE VICINITY OF WATERFORD 3

YEAR	DATE	STATION Ac	At	Bc	Bt	Bt1	Average Density
I	73 JUN 08**	2151.734	1580.130	1803.907	2005.236	2679.522	2044.106
	73 JUL 17	126.281	140.528	97.441	214.526	158.607	147.477
	73 AUG 22**	62.817	99.730	73.826	295.303	272.853	160.906
	73 SEP 28	647.594	1385.887	1944.685	2087.479	1901.405	1593.410
	73 OCT 25**	210.468	77.352	460.079	336.389	223.060	261.469
	73 NOV 30	201.474	314.514	239.250	221.261	248.244	244.949
	73 DEC 19	250.441	229.720	314.981	225.287	252.158	254.518
	74 FEB 13	980.525	744.519	701.260	873.192	459.180	751.735
	74 MAR 27	1475.952	1528.514	1384.779	1806.556	1448.072	1528.774
	74 APR 20	478.675	227.956	319.404	391.012	488.194	381.048
	74 APR 23	1181.860	1284.395	1576.604	1214.239	1118.899	1275.199
	74 MAY 17	3890.018	1991.789	743.248	3291.852	2133.284	2410.038
Average Year I		971.487	800.420	804.96	1080.194	948.623	
II	74 JUN 04	282.044	229.545	223.501	225.018	150.570	222.136
	74 JUN 24	95.196	100.219	148.189	79.112	77.409	100.025
	74 AUG 22	1727.880	4398.961	2395.663	7689.520	928.038	3428.012
	74 NOV 13	483.673	1189.501	508.609	7873.902	2774.520	2566.041
	75 FEB 26	756.809	247.172	399.953	416.015	825.766	529.143
	75 APR 23**	100.409	263.693	160.395	439.766	214.347	235.722
	75 AUG 08	268.163	168.986	297.409	443.718	380.032	311.662
Average Year II		530.596	942.582	590.531	2452.436	764.383	
III	75 OCT 30	123.350	52.613	436.986	314.618	38.785	193.270
	75 NOV 20	62.821	83.003	44.854	20.066	75.966	57.342
	75 DEC 22	32.400	108.214	59.537	28.711	208.136	87.400
	76 JAN 30	5.173	18.819	5.151	9.339	3.593	8.415
	76 FEB 26	.000	5.505	1.033	3.156	1.746	2.288
	76 MAR 25	327.820	233.666	402.086	407.337	7.238	275.629
	76 APR 29**	19.055	132.969	109.459	83.841	141.732	97.411
	76 MAY 27	113.404	225.532	197.259	153.344	182.504	174.408
	76 JUN 24	68.690	150.226	157.960	103.963	150.243	126.217
	76 JUL 29	225.149	69.174	632.122	925.233	504.507	471.237
	76 SEP 10	1434.406	527.145	1985.596	1571.616	1297.066	1363.166
	76 SEP 26	622.113	528.958	792.617	706.768	951.573	720.406
Average Year III		252.865	177.985	402.055	360.666	296.921	

* Densities do not include exoskeletons or fish larvae

** Sampled on more than one sampling day

Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-13

SPECIES OF FISH COLLECTED IN THE VICINITY OF WATERFORD 3 APRIL 1973 THROUGH SEPTEMBER 1976

Osteichtyes

Acipenseriformes

Acipenseridae

Scaphirhynchus albus (Pallid Sturgeon)
Scaphirhynchus platorynchus (Shovenlose Sturgeon)

Polyodonitidae

Polyodon spathula (Paddlefish)

Semionotiformes

Lepisosteidae

Lepisosteus oculatus (Spotted Gar)
Lepisosteus osseus (Longnose Gar)
Lepisosteus platostomus (Shortnose Gar)
Lepisosteus spatula (Alligator Gar)

Amiiformes

Amiidae

Amia calva (Bowfin)

Elopiformes

Elopidae

Elops saurus (Lady Fish)

Anguilliformes

Anguillidae

Anguilla rostrata (American Eel)

Clupeiformes

Clupeidae

Alosa chysochloris (Skipjack Herring)
Brevoortia patronus (Gulf Menhaden)
Dorosoma cepedianum (Gizzard Shad)
Dorosoma petenense (Threadfin Shad)

TABLE 3-13 (Cont'd)

SPECIES OF FISH COLLECTED IN THE VICINITY OF WATERFORD 3 APRIL 1973 THROUGH SEPTEMBER 1976
(Sheet 2 of 4)

Engraulidae

Anchoa mitchilli (Bay Anchovy)

Osteoglossiformes

Hiodontidae

Hiodon alosoides (Goldeye)
Hiodon tergisus (Mooneye)

Cypriniformes

Cyprinidae

Cyprinus carpio (Carp)
Hybognathus nuchalis (Silvery Minnow)
Hybopsis aestivalis (Speckled Chub)
Hybopsis amblops (Bigeye Chub)
Hybopsis storeriana (Silver Chub)
Notemigonus crysoleucas (Golden Shiner)
Notropis atherinoides (Emerald Shiner)
Notropis blennius (River Shiner)
Notropis emiliae (Pugnose Minnow)
Notropis fumeus (Ribbon Shiner)
Notropis shumardi (Silverband Shiner)
Notropis venustus (Blacktail Shiner)
Pimephales vigilax (Bullhead Minnow)

Catostomidae

Carpiodes carpio (River Carpsucker)
Carpiodes cyprinus (Quillback)
Ictiobus bubalus (Smallmouth Buffalo)
Ictiobus cyprinellus (Bigmouth Buffalo)

Siluriformes

Ictaluridae

Ictalurus furcatus (Blue Catfish)
Ictalurus melas (Black Bullhead)
Ictalurus natalis (Yellow Bullhead)
Ictalurus nebulosus (Brown Bullhead)
Ictalurus punctatus (Channel Catfish)
Pylodictis olivaris (Flathead Catfish)

Atheriniformes

TABLE 3-13 (Cont'd)

SPECIES OF FISH COLLECTED IN THE VICINITY OF WATERFORD 3 APRIL 1973 THROUGH SEPTEMBER 1976
(Sheet 3 of 4)

Poeciliidae

Gambusia affinis (Mosquito Fish)

Atherinidae

Menidia audens (Mississippi Silverside)

Perciformes

Percichthyidae

Morone chrysops (White Bass)
Morone mississippiensis (Yellow Bass)
Morone saxatilis (Striped Bass)

Centrarchidae

Elassoma zonatum (Banded Pygmy Sunfish)
Lepomis cyanellus (Green Sunfish)
Lepomis gulosus (Warmouth)
Lepomis macrochirus (Bluegill)
Lepomis megalotis (Longear Sunfish)
Lepomis microlophus (Redear Sunfish)
Micropterus punctulatus (Spotted Bass)
Micropterus salmoides (Largemouth Bass)
Pomoxis annularis (White Crappie)
Pomoxis nigromaculatus (Black Crappie)

Percidae

Percina sciera (Dusky Darter)
Stizostedion canadense (Sauger)

Sciaenidae

Aplodinotus grunniens (Freshwater Drum)

Mugilidae

Mugil cephalus (Striped Mullet)

Pleuronectiformes

Bothidae

TABLE 3-13 (Cont'd)

SPECIES OF FISH COLLECTED IN THE VICINITY OF WATERFORD 3 APRIL 1973 THROUGH SEPTEMBER 1976
(Sheet 4 of 4)

Paralichthys lethostigma (Southern Flounder)

Soleidae

Trinectes maculatus

(Sheet 1 of 2)

TABLE 3-14

TOTAL NUMBERS AND WEIGHTS OF FISH COLLECTED BY ALL GEARS DURING YEARS I, II, AND III, IN THE VICINITY OF WATERFORD 3

COMMON NAME	YEAR I		YEAR II		YEAR III	
	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
ALLIGATOR GAR	2	856.1	0	.	2	9,706.2
AMERICAN EEL	7	3,444.3	2	276.3	2	363.3
BAY ANCHOVY	1	2.5	0	.	133	301.4
BIGEYE CHUB	3	3.7	0	.	0	.
BIGMOUTH BUFFALO	5	2,755.2	7	3,415.0	1	1,866.0
BLACK BULLHEAD	1	33.8	6	552.4	0	.
BLACK CRAPPIE	10	871.6	6	763.3	12	2,324.2
BLACKTAIL SHINER	0	.	0	.	1	.6
BLUE CATFISH	553	66,320.4	76	20,708.1	1451	142,947.8
BLUEGILL	40	1,305.4	20	1,045.7	42	1,024.8
BOWFIN	1	1,918.0	0	.	0	.
BROWN BULLHEAD	5	2,202.8	0	.	0	.
BULLHEAD MINNOW	1	3.4	0	.	1	1.7
CARP	17	12,933.6	34	50,575.6	20	37,230.1
CRANNEL CATFISH	82	12,140.2	15	2,984.8	41	9,192.8
DUSKY DARTER	1	259.6	0	.	0	.
EMERALD SHINER	0	.	1	6.1	2	4.9
FLATHEAD CATFISH	10	7,468.4	8	2,528.4	11	6,948.3
FRESHWATER DRUM	368	9,336.9	24	2,624.9	403	25,381.3
GIZZARD SHAD	2451	97,214.6	799	75,096.6	1111	199,627.3
GOLDEYE	10	320.7	3	763.7	5	647.9
GREEN SUNFISH	0	.	35	764.4	0	.
GULF MENHADEN	6	168.1	0	.	91	3,163.1
HOGCHOKER	0	.	0	.	3	9.5
IMMATURE SUCKER	0	.	0	.	2	1.2
LADYFISH	0	.	1	86.4	4	675.8
LARGEMOUTH BASS	8	1,957.7	9	4,000.8	7	3,873.9
LONGEAR SUNFISH	1	13.9	0	.	5	162.1
LONGNOSE GAR	5	1,481.3	5	2,647.2	5	5,951.7
MISSISSIPPEE SILVERSIDE	0	.	2	6.4	1	4.7
MOONEYE	1	4.1	0	.	0	.
MOSOUITOFISH	0	.	1	.7	0	.
PADDLEFISH	6	261.1	0	.	1	1,289.1
PALLID STURGEON	3	360.4	0	.	1	144.4
PUGNOSE MINNOW	0	.	0	.	1	0.7
PYGMY SUNFISH	1	0.1	0	.	0	.
QUILLBACK CARPSUCKER	0	.	0	.	1	274.2
REDEAR SUNFISH	1	45.0	0	.	0	.
RIBBON SHINER	0	.	0	.	3	2.9
RIVER CARPSUCKER	50	9,918.6	7	1,758.5	13	5,567.1
RIVER SHINER	0	.	0	.	3	4.0
SAUCER	8	683.8	0	.	3	1,238.8
SHORTNOSE GAR	3	3,371.0	3	1,816.5	3	1,620.5

TABLE 3-14 (Cont'd)
TOTAL NUMBERS AND WEIGHTS OF FISH COLLECTED BY ALL GEARS
DURING YEARS I, II, AND III, IN THE VICINITY OF WATERFORD 3

COMMON NAME	YEAR I NUMBER	YEAR I WEIGHT*	YEAR II NUMBER	YEAR II WEIGHT	YEAR III NUMBER	YEAR III WEIGHT
SHOVELNOSE STURGEON	22	1,954.3	2	2.0	5	1,796.310
SILVER CHUB	20	92.4	1	9.9	7	43.800
SILVERBAND SHINER	3	4.8	0	.	1	2.000
SILVERY MINNOW	0	.	0	.	3	5.230
SKIPJACK HERRING	130	13,697.4	48	5,364.0	71	9,227.530
SMALLMOUTH BUFFALO	24	7,802.2	14	10,229.0	10	12,950.270
SOUTHERN FLOUNDER	0	.	0	.	10	7,157.790
SPECKLED CHUB	3	4.1	0	.	1	.400
SPOTTED BASS	0	.	1	1.9	0	.
SPOTTED GAR	4	4,237.7	5	1,991.9	8	3,837.600
STRIPED BASS	20	3,589.7	6	3,685.5	10	10,626.680
STRIPED MULLET	233	49,229.2	497	75,656.2	467	84,013.085
THREAD FIN SHAD	1058	6,434.5	387	2,078.7	222	2,796.610
WARMOUTH	0	.	1	38.6	1	6.770
WHITE BASS	10	782.0	7	1,044.1	14	4,036.290
WHITE CRAPPIE	19	2,200.2	4	226.6	1	156.670
YELLOW BASS	2	94.7	2	203.7	1	111.900
YELLOW BULLHEAD	1	1.3	0	.	0	.

* Expressed in grams

Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-15

TOTAL NUMBERS AND WEIGHTS OF FISH COLLECTED PER UNIT EFFORT* EACH MONTH DURING YEARS I, II AND III IN THE VICINITY OF WATERFORD 3

YEAR AND MONTH	AVERAGE NUMBER**	AVERAGE WEIGHT***
73 APR(1)	1.0	379.7
73 JUN	14.3	9,741.8
73 JUL(2)	12.6	897.1
73 AUG	25.4	4,875.9
73 SEP	92.4	12,754.4
73 OCT	32.2	3,955.6
73 NOV	62.7	9,119.4
73 DEC	27.1	5,968.7
74 JAN	19.5	4,687.8
74 FEB	11.8	2,637.6
74 MAR(1)	34.3	8,791.2
74 APR	96.6	10,572.5
74 JUN	41.4	8,209.7
74 AUG	33.4	11,743.6
74 NOV	139.4	16,274.4
75 FEB	100.4	14,158.5
75 JUN	10.2	1,423.1
75 AUG	8.4	2,210.0
75 OCT	48.2	9,845.2
75 NOV	25.0	6,699.7
75 DEC	57.1	15,681.8
76 JAN(2)	14.0	4,038.4
76 FEB	65.2	16,922.2
76 MAR	80.4	15,330.1
76 APR	42.5	11,375.3
76 MAY	26.1	5,945.5
76 JUN	15.1	5,953.5
76 JUL	21.9	6,301.9
76 AUG	54.6	12,150.0
76 SEP	40.1	8,143.3

* In 2 hours of electroshocking and 48 hours of gill netting
** Number of individuals
*** Expressed in grams

Source of data: Waterford 3 Environmental Surveillance Program

(1) 48 hrs gill netting only

(2) 2 hrs electroshocking only

TABLE 3-16

PART I

AVERAGE NUMBER AND WEIGHT PER UNIT EFFORT* OF REPRESENTATIVE SPECIES OF FISH COLLECTED EACH MONTH DURING YEARS I, II AND III IN THE VICINITY OF WATERFORD 3

YEAR and MONTH	BLUE CATFISH		FRESHWATER DRUM		GIZZARD SHAD		STRIPED MULLET		THREADFIN SHAD	
	AVERAGE NUMBER**	AVERAGE WEIGHT**	AVERAGE NUMBER	AVERAGE WEIGHT	AVERAGE NUMBER	AVERAGE WEIGHT	AVERAGE NUMBER	AVERAGE WEIGHT	AVERAGE NUMBER	AVERAGE WEIGHT
73 APR(1)	1.0	379.7	. (3)	.	.	.	.	.	.	.
73 JUN	4.0	926.4	.3	26.4	4.0	476.8	.7	23.7	1.3	11.4
73 JUL(2)	.8	1.2	.8	3.0	3.0	254.0	2.6	253.3	2.4	5.1
73 AUG	.5	457.9	1.5	832.6	12.0	1,387.5	4.0	827.0	1.6	7.7
73 SEP	3.0	741.2	.4	120.6	53.4	3,926.1	19.4	4,680.4	6.0	48.3
73 OCT	6.6	322.6	.8	122.7	9.8	637.2	3.6	1,039.8	2.0	12.6
73 NOV	1.8	692.9	.3	46.6	49.6	4,952.4	4.0	983.4	.2	.9
73 DEC	8.3	3,200.9	.2	.2	15.4	2.584.0	1.2	55.4	.4	1.3
74 JAN	5.2	1,134.8	.	.	12.3	2,306.7	.6	81.3	.2	.7
74 FEB	2.4	475.7	.	.	7.4	1,239.0	.	.	.4	1.3
74 MAR(1)	2.0	542.8	.	.	1.7	288.6	.	.	16.3	1,033.1
74 APR	5.0	2,269.8	1.0	36.3	47.5	2,010.3	13.0	2,382.5	15.2	274.3
74 JUN	.4	799.2	.8	118.0	17.4	837.6	12.0	2,300.3	1.8	29.8
74 AUG	.8	1,251.3	.6	116.3	3.8	206.6	20.2	5,996.4	1.6	4.7
74 NOV	7.2	1,055.6	1.0	96.1	67.6	4,433.7	38.8	4,931.2	4.4	33.3
75 FEB	.2	45.3	1.0	99.2	65.0	9,264.1	26.4	1,633.1	.	.
75 JUN	.8	298.0	.2	46.3	1.0	86.4	1.6	227.7	4.8	27.2
75 AUG	2.4	625.1	.	.	1.6	155.5	.4	42.4	.4	4.7
75 OCT	1.6	669.5	.	.	27.6	5,475.5	11.0	3,104.8	1.8	24.7
75 NOV	1.2	601.9	.	.	15.4	1,849.1	2.2	365.5	.	.
75 DEC	10.2	4,473.1	1.4	196.3	30.6	4,534.3	5.8	1,366.7	.2	1.5
76 JAN(2)	.3	270.1	.	.	13.8	3,768.3	.	.	.	.
76 FEB	7.2	2,838.0	.8	227.8	50.6	11,932.1	.2	117.8	1.0	6.9
76 MAR	9.0	4,480.6	.6	204.1	56.2	7,834.2	2.6	304.9	7.2	129.2
76 APR	4.3	2,661.6	1.9	619.7	8.3	727.3	15.0	2,008.6	6.9	124.9
76 MAY	1.4	65.4	1.3	331.6	4.0	672.9	6.6	705.3	6.2	63.7
76 JUN	2.5	2,174.5	.2	50.3	3.7	569.1	6.2	789.0	.5	.3
76 JUL	1.7	1,621.5	.5	88.8	1.7	253.6	12.0	1,801.1	2.8	26.9
76 AUG	3.2	2,855.4	1.0	421.8	4.4	1,340.4	23.2	4,812.6	4.2	58.2
76 SEP	4.3	2,065.1	2.0	462.0	5.4	2,045.4	12.0	1,830.1	3.0	78.9

*In 2 hours of electroshocking and 48 hours of gill netting
**Number of individuals
***Expressed in grams

(1) 48 hrs gill netting only
(2) 2 hrs electroshocking only
(3) Species not found during sampling

Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-16 (Cont'd) (Sheet of 2 of 2)

PART 2

NUMBER AND WEIGHT OF REPRESENTATIVE FISH SPECIES CAPTURED PER UNIT EFFORT* AT EACH STATION DURING YEARS I, II AND III IN THE VICINITY OF WATERFORD 3

		BLUE CATFISH YEARLY AVERAGE		FRESHWATER DRUM YEARLY AVERAGE		GIZZARD SHAD YEARLY AVERAGE		STRIPED MULLET YEARLY AVERAGE		THREADFIN SHAD YEARLY AVERAGE	
STATION	YEAR	NUMBER**	WEIGHT***	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT	NUMBER	WEIGHT
Ac	I	5.4	898.3	.5	141.4	24.5	1974.0	2.4	527.3	1.5	16.5
	II	.3	138.2	.2	35.2	7.2	452.7	9.8	2465.4	1.0	16.6
	III	5.0	1612.6	.4	76.2	20.1	1911.8	9.0	1901.0	3.0	40.7
At	I	5.2	1050.0	.3	84.7	15.4	1814.4	4.1	974.3	7.8	224.7
	II	2.3	601.8	.8	113.7	14.5	1646.4	10.2	1239.2	4.0	28.5
	III	7.4	4979.7	.9	296.5	10.6	2484.5	2.5	989.8	3.9	39.4
Bc	I	4.1	1768.5	.3	67.5	25.9	2681.8	3.6	712.9	3.6	42.1
	II	.7	463.9	.(1)	.	63.3	5342.5	12.3	2707.1	1.7	17.8
	III	.9	561.5	.5	164.4	37.2	8346.1	9.9	1470.0	3.6	82.9
Bt	I	2.4	958.1	1.0	311.8	23.4	2140.8	12.0	2457.3	4.3	193.7
	II	5.7	1657.6	.7	73.1	28.0	2780.8	30.8	3245.7	3.0	12.8
	III	6.0	2444.0	.9	223.5	14.8	2320.8	11.1	1779.9	3.1	45.0
Bt_1	I	1.7	218.2	.5	2.6	21.6	1737.5	3.1	645.6	2.9	94.6
	II	.8	534.0	1.3	174.6	17.3	2264.3	19.7	2952.0	1.2	7.5
	III	1.8	1936.5	1.6	420.3	11.4	2748.4	7.6	1194.9	.9	6.8

*In 2 hours of electroshocking and 48 hours of gill netting
**Number of individuals
***Expressed in grams

(1) Species not found at this station

Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-17

TOTAL NUMBER AND WEIGHT OF ALL FISH SPECIES CAPTURED PER UNIT EFFORT*

AT EACH STATION DURING YEARS I, II AND III IN THE VICINITY OF WATERFORD 3

STATION	YEAR	YEARLY AVERAGE NUMBER**	YEARLY AVERAGE WEIGHT***
Ac	I	43.7	6,924.4
	II	25.3	8,243.7
	III	50.6	10,585.1
At	I	39.5	5,202.1
	II	35.5	5,014.6
	III	37.4	11,071.2
Bc	I	46.8	8,562.3
	II	95.5	11,981.2
	III	55.6	12,051.5
Bt	I	47.9	9,229.0
	II	74.0	9,731.7
	III	39.3	7,893.9
Bt_1	I	34.0	3,463.2
	II	47.3	10,044.8
	III	26.7	9,198.6

*In 2 hours of electroshocking and 48 hours of gill netting
**Number of individuals
***Expressed in grams

Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-18

FRIEDMAN'S TWO-WAY ANALYSIS OF VARIANCE;

TESTING THE NULL HYPOTHESIS (H_0) OF

EQUAL CATCH/EFFORT* AT 5 WATERFORD STATIONS

(YEAR I)

Catch/Effort*

	STATION				
	Ac	At	Bc	Bt	Bt_1
Blue Catfish	5.429	5.233	4.089	2.375	1.700
Freshwater Drum	.486	.322	.322	1.042	.500
Gizzard Shad	24.543	15.411	24.944	23.403	21.550
Striped Mullet	2.443	4.100	3.600	12.000	3.075
Threadfin Shad	1.500	7.800	3.600	4.431	2.900

Rank**

	Ac	At	Bc	Bt	Bt_1
Blue Catfish	5	4	3	2	1
Freshwater Drum	3	1.5	1.5	4	5
Gizzard Shad	4	1	5	3	2
Striped Mullet	1	4	3	5	2
Threadfin Shad	1	5	3	4	2
Sum of Ranks	14	15.5	15.5	19	11
Sum of Ranks Squared	196	240.25	240.25	361	121

$X_r^2 = 2.68$

Fail to reject H_0; ie, stations were not significantly different with respect to catch/effort

*Per 48 hour gill net set and 1 hour electroshocking effort

**Stations ranked according to catch/effort for species listed (ties were averaged).

Source: Siegel S. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill Book Company, Inc. 1956.

TABLE 3-19

FRIEDMAN'S TWO-WAY ANALYSIS OF VARIANCE;

TESTING THE NULL HYPOTHESIS (H_0) OF

EQUAL CATCH/EFFORT* AT 5 WATERFORD STATIONS

YEAR III

Catch/Effort

	STATION				
	Ac	At	Bc	Bt	Bt_1
Blue Catfish	5.015	7.389	.875	6.000	1.773
Freshwater Drum	.432	.889	.458	.917	1.573
Gizzard Shad	20.697	10.622	37.167	14.845	11.355
Striped Mullet	9.030	2.456	9.917	11.083	7.600
Threadfin Shad	3.008	3.900	3.583	3.083	.909

Rank**

	Ac	At	Bc	Bt	Bt_1
Blue Catfish	3	5	1	4	2
Freshwater Drum	1	3	2	4	5
Gizzard Shad	4	1	5	3	2
Striped Mullet	3	1	4	5	2
Threadfin Shad	2	5	4	3	1
Sum of Ranks	13	15	16	19	12
Sum of Ranks Squared	169	225	256	361	144

$X_r^2 = 2.40$

Fail to reject H_0; ie, Stations were not significantly different with respect to catch/effort.

*Per 48 hour gill net set and 1 hour electroshocking effort

**Stations ranked according to catch/effort for species listed (ties were averaged)

Source: Siegel S. Nonparametric Statistics for the Behavorial Sciences. McGraw-Hill Book Company, Inc. 1956

TABLE 3-20

HABITATS, SPAWNING AREAS, MIGRATION ROUTES AND FOODS OF SOME FISH SPECIES PRESENT IN THE VICINITY OF WATERFORD 3*

Species	Habitat	Spawning Area and Egg Type	Migration Routes	Foods
Bigmouth Buffalo	Widely distributed but most commonly found in larger rivers, lakes, oxbows and sloughs.	Shallow bays; sloughs; wait until water levels rise in the spring. Eggs are adhesive and are deposited in dead vegetation on the bottom.	Move into shallow bays and up tributary streams to spawn.	Bottom feeder; also filter feeder on plankton
Blue Catfish**	Prefer large lakes and deeper portions of major rivers where a noticeable current is present	Construct Nests		Zooplankton (for fish under 125 mm); larger fish feed on insect larvae (benthic), organic, detritus and fish
Bowfish	Usually found in clear, sluggish waters of bayous, borrow pits and backwaters of rivers where aquatic vegetation is present.	Shallow weedy areas; a depression is built in 2-3 feet of water. Eggs are adhesive. Young cling to vegetation at the bottom of the nest for 7-9 days post hatching.		Adults feed on fish, crustaceans; young feed on insects, small shrimp, vegetable matter.
Brown Bullhead	Clear, weedy lakes, muddy pools of intermittent drainageways, slow moving streams with abundant vegetation and sand to mud bottoms.	Build nexts adjacent to stones, logs, or other shelter, on sand or mud bottoms in water up to 2 feet deep. Eggs are adhesive.		Fish up to 75 mm feed on zooplankton and chiromids; adults eat insects, fish, fish eggs, molluscs and plants
Carp	Widely distributed but prefers quiet shallow waters of rivers and impoundments.	Shallow areas - Eggs are adhesive and are scattered at random over plant beds, debris and rubble.	There is frequently a migration to the shallow water spawning areas.	Bottom fauna, chiromids plant material, small molluscs, small crustaceans, organic detritus

* All information and sources can be found in the Life Histories of Important Species, Appendix 2-3.

** Dominant species

TABLE 3-20 (Cont'd) (Sheet 2 of 3)

HABITATS, SPAWNING AREAS, MIGRATION ROUTES AND FOODS OF SOME FISH SPECIES PRESENT IN THE VICINITY OF WATERFORD 3*

Species	Habitat	Spawning Area and Egg type	Migration Routes	Foods
Channel Catfish	Found in streams, rivers, lakes and ponds but prefer moderate to swiftly flowing streams with warm water and bottom of sand, gravel or rubble. During daytime, in streams, adults inhabit pool areas and remain near cover; at night they move into stronger, deeper, riffle areas for feeding.	Under overhanging ledges, hollow logs or in similarly sheltered areas. Also spawn in lakes and ponds: They will not spawn in clear ponds. Eggs deposited in a gelatinous mass.	Migration into rivers during spawning periods.	Omnivorous - feed on aquatic insects or other fish. In the River Bend study *** they were found to feed on detritus, oligochaetes, microcrustacea, crayfish, mayfly larvae, caddisfly larvae and dipteran larvae.
Freshwater Drum**	Lakes and large rivers, especially in the shallow areas of the Red and Mississippi Rivers.	Spawn on mud and sand bottom generally in areas where aquatic vegetation is present. Eggs are buoyant.		Bottom feeding foods include mayflies, amphipods, fish, crayfish, small molluscs and detritus ***.
Gizzard Shad**	Successful in both streams and lakes.	Pond bottoms; shallow water. Eggs are demersal and adhesive.	There may be a spawning migration upstream in the lower Mississippi River.	Young feed on zooplankton and later on bottom organisms. Adults are filter feeders - Strain detritus from the bottom and plankton from the water.
Largemouth Bass	All types of freshwater bodies from small creeks to large lakes but is most common in non-flowing water characterized by abundant aquatic vegetation and soft bottoms.	Sheltered bays among aquatic vegetation in 6 inches to 6 feet of water over bottoms which vary from gravelly sand to marl and soft mud.		Young feed on zooplankton. Adults feed on insects, crawfish, small turtles and frogs. Cannibalism is common.
Longnose Gar	Sluggish pools, backwaters, oxbows; adults usually found in large deep pools. Often inhabit brackish water and sometimes saltwater.	Shallow open sloughs and backwaters. Eggs are adhesive; larvae attach themselves to stones and other objects by means of a sucking disc.	Spawning is often preceded by upstream migrations into smaller streams.	Young feed at the surface on small insects, crustaceans and fish; adults are piscivorous.
Paddlefish	Seem to be generally confined to large rivers and impoundments.	Over sand and pebbles and gravel bars in strong currents; generally spawn in schools.	In the Osage River, an upstream migration follows the warming of the waters to 50°F.	Plankton, fish, insects (mayfly naiads).

** Dominant species

*** Bryan CF, JV Conner, and DJ Demont, "An Ecological Study of the Lower Mississippi River and Alligator Bayou near St. Francisville, Louisiana" In: Environmental Report, River Bend Station Units 1 and 2, Construction Permit Stage, Volume III, Appendix E, Gulf State Utilities Company, 1973

TABLE 3-20 (Cont'd)

HABITATS, SPAWNING AREAS, MIGRATION ROUTES AND FOODS OF SOME FISH SPECIES PRESENT IN THE VICINITY OF WATERFORD 3*

Species	Habitat	Spawning Area and Egg Type	Migration Routes	Foods
Pallid Sturgeon	Largest, muddiest rivers of the Missouri-Mississippi System. Bottom inhabitant, usually living in strong currents over firm sandy bottoms.			
River Carpsucker	Streams and rivers. Preferred habitat is quiet silt-bottomed pools, backwaters, and oxbows or large streams	1-3 feet of water in lakes and reservoirs over a firm sand bottom; in silty shoals; in shallow silty bays; on silt deltas at the mouth of tributaries extending upstream; and over tree roots and vegetation in moderately deep water.		Indiscriminate omnivore; bottom feeder.
Shortnose Gar	Lakes, oxbows, backwaters but prefer the mainstreams of large muddy rivers.	Eggs deposited in small masses held together by a clear gelatinous substance which attaches to weeds.	Doesn't appear to be any particular spawning migration.	Young feed on ostracods, worms and aquatic insects; adults are piscivorous but sometimes feed on crawfish and shrimp.
Shovelnose Sturgeon	Larger rivers of Mississippi Basin and Rio Grande. Lives on the bottom in areas characterized by strong currents.	Rocky bottoms in swift water.	Upstream migrations precede spawning. Enters tributaries for spawning when water is high.	Insects, algae, aquatic vegetation (bottom feeder).
Skipjack Herring	Deep swift waters - usually avoiding high turbidities.		In Louisiana-spring migration when it travels to the headwaters or larger streams and into connecting lakes.	Other fish; invertebrates.
Smallmouth Buffalo	Oxbow lakes, backwater areas of large rivers, swift shallow riffles, creeks.	Areas of aquatic vegetation or innundated terrestrial plants, and sloughs.		Bottom feeder, indiscriminate omnivore.
Striped Mullet**	Marine waters - sometimes come up into waters of the Gulf States and California and up the Mississippi River.	They do not seem to spawn in fresh water.	Schools of mullet are known to come up the Atchafalaya River in the spring as far as Avoyelles Parish.	Miscroscopic organisms including diatoms and formanifera, detritus.
Threadfin Shad**	Prefers large bodies of water and is most abundant where strong current is found - Pelagic	Open water; under brush and floating logs. Spawns in schools. Eggs are adhesive		Plankton, <u>Chaoborus</u>, Tendipedids.

** Dominant Species

TABLE 3-21

AVERAGE DENSITIES* BY STATION OF ICHTHYOPLANKTON IN SAMPLES COLLECTED IN THE VICINITY OF WATERFORD 3

DATE	STATION Ac	At	Bc	Bt	Btl	Average
74 NOV 13	.000	.122	.000	.000	.000	.024
75 FEB 26	.000	.000	.000	.000	.000	.000
75 APR 24	.000	.000	.000	.000	.010	.002
75 AUG 08	.000	.000	.005	.054	.077	.027
75 OCT 30	.000	.000	.000	.000	.000	.000
75 NOV 20	.000	.000	.000	.000	.000	.000
75 DEC 22	.000	.000	.000	.000	.000	.000
76 JAN 30**	.000	.000	.000	.000	.000	.000
76 FEB 26	.000	.000	.000	.000	.000	.000
76 MAR 25	.000	.010	.009	.023	.004	.009
76 APR 30**	.000	.081	.007	.026	.015	.026
76 MAY 27	.020	.009	.069	.000	.007	.021
76 JUN 08	.127	.176	.030	.139	.058	.106
76 JUN 24	.000	.000	.000	.000	.008	.002
76 JUL 07	.003	.034	.013	.017	.017	.017
76 JUL 29	.000	.000	.000	.011	.000	.002
76 AUG 12	.000	.000	.006	.000	.007	.003
76 SEP 10	.000	.000	.000	.000	.000	.000
76 SEP 27	.000	.000	.000	.000	.000	.000

*Densities expressed in number/m^3
**Samples collected over two sampling days

Source of Data: Waterford 3 Environmental Surveillance Program

TABLE 3-22

AVERAGE ICHTHYOPLANKTON DENSITIES* BY SPECIES IN SAMPLES COLLECTED IN THE VICINITY OF WATERFORD 3

Date	Unidentifiable	Centrarchidae	Clupeidae	Cyprinidae	Esocidae	Ictaluridae	Sciaenidae
Nov 13 74	-	-	.019	-	-	-	-
Feb 26 75	-	-	-	-	-	-	-
Apr 24 75	-	-	-	.002	-	-	-
Aug 8 75	-	.015	.005	.004	-	.004	-
Oct 30 75	-	-	-	-	-	-	-
Nov 20 75	-	-	-	-	-	-	-
Dec 22 75	-	-	-	-	-	-	-
Jan 30 76	-	-	-	-	-	-	-
Feb 26 76	-	-	-	-	-	-	-
Mar 25 76	-	-	.002	.008	-	-	-
Apr 30 76	.004	.008	-	.005	.002	.002	.003
May 27 76	.003	.007	-	.012	-	-	-
Jun 8 76	.002	.003	.065	-	-	-	.029
Jun 24 76	-	.002	-	-	-	-	-
Jul 7 76	-	-	.004	-	-	-	.012
Jul 29 76	.003	-	-	-	-	-	-
Aug 12 76	-	-	-	-	-	-	.003
Sep 10 76	-	-	-	-	-	-	-
Sep 27 76	-	-	-	-	-	-	-

* Densities expressed in number/m^3
Source of data: Waterford 3 Environmental Surveillance Program

TABLE 3-23

FRIEDMAN'S TWO-WAY ANALYSIS OF VARIANCE;
TESTING THE NULL HYPOTHESIS (H_0) OF EQUALITY OF
ICHTHYOPLANKTON CONCENTRATIONS (NUMBER PER CUBIC METER)
AT 5 WATERFORD STATIONS DURING YEAR III

NUMBER PER CUBIC METER

	STATION				
Date	Ac	At	Bc	Bt	Bt_1
March 25, 1976	.000	.010	.009	.023	.004
April 30, 1976	.000	.081	.007	.026	.015
May 27, 1976	.020	.009	.069	.000	.007
June 8, 1976	.127	.176	.030	.139	.058
June 24, 1976	.000	.000	.000	.000	.008
July 7, 1976	.003	.034	.013	.017	.107
July 29, 1976	.000	.000	.000	.011	.000
August 12, 1976	.000	.000	.006	.000	.007

RANKS*

March 25, 1976	1	4	3	5	2
April 30, 176	1	5	2	4	3
May 27, 1976	4	3	5	1	2
June 8, 1976	3	5	1	4	2
June 24, 1976	2.5	2.5	2.5	2.5	5
July 7, 1976	1	5	2	3.5	3.5
July 29, 1976	2.5	2.5	2.5	5	2.5
August 12, 1976	2	2	4	2	5
Sum of Ranks	17	29	22	27	25
Overall Rank	1	5	2	4	3

$X^2_r = 4.40$

Fail to Reject H_0; ie, Stations were not significantly different with respect to ichthyoplankton densities.

*Stations ranked according to ichthyoplankton densities (ties were averaged)

Source: Siegel S. Nonparametric Statistics for the Behavioral Sciences McGraw-Hill Book Company, Inc. 1956.

TABLE 3-24

COMMERCIAL CATCHES FROM MISSISSIPPI RIVER
BETWEEN BATON ROUGE, LOUISIANA AND THE MOUTH OF RIVER, 1971 - 1975
(IN POUNDS, ROUND OR LIVE WEIGHT AND DOLLAR VALUE)

	1971		1972		1973		1974		1975	
Species	Pounds	$ Value	Pounds	$ Value	Pounds	$ Value	Pounds	$ Value	Pounds	$ Value
Bowfin	-		-		1,000	60	1,000	60	900	63
Buffalofish	10,700	1,317	28,900	3,749	60,800	8,289	88,400	13,054	138,600	20,992
Carp	10,200	836	10,900	1,064	9,300	8,079	7,300	474	16,200	944
Catfish, F W	227,500	71,372	190,200	56,428	360,000	111,883	818,000	259,504	1,198,400	401,903
Garfish	13,500	1,746	34,000	4,479	53,700	6,385	42,900	4,572	42,800	6,755
Paddlefish	-		-		3,000	295	200	19	200	14
Gaspergou (Freshwater drum)	3,500	392	11,600	1,364	57,600	7,341	46,700	5,986	80,300	11,763
Crawfish	14,100	2,826	16,700	3,725	45,600	11,400	35,000	11,200	54,200	16,260
River Shrimp	900	297	1,900	855	2,700	1,005	3,500	1,400	4,200	2,940
Drum:										
Black	200	18	-		-		-		-	
Red	1,400	291	-		-		-		-	
Sea Trout:										
Spotted	2,300	569	-		-		-		-	
White	100	11	-		-		-		-	
Turtle, Snapper	4,100	885	400	176	-		700	258	200	70

Source: Personal Communication, Dept. of Commerce,
National Oceanic and Atmospheric Admin., 1976

TABLE 3-25

VELOCITIES IN CIRCULATING WATER SYSTEM*

Location	Water Level	Velocity - Feet per Second: 4 Pump Operation	3 Pump Operation	2 Pump Operation
Intake Canal				
Entrance (under Skimmer)	AHWL	1.78	1.52	1.09
	ALWL	1.78	1.52	1.09
Narrow Section (River End)	AHWL	1.13	0.96	0.69
	ALWL	1.69	1.44	1.03
Wide Section (Intake Structure End)	AHWL	0.45	0.38	0.27
	ALWL	0.76	0.65	0.46
Intake Structure**				
Entrance (under Skimmer)	AHWL	1.25	1.25	1.25
	ALWL	1.25	1.25	1.25
Unobstructed Bay	AHWL	0.59	0.59	0.59
	ALWL	1.01	1.01	1.01
Through Trash Racks	AHWL	0.64	0.64	0.64
	ALWL	1.10	1.10	1.10
Through Traveling Water Screens	AHWL	1.06	1.06	1.06
	ALWL	1.82	1.82	1.82

*Average velocities based on cross-sectional flow area.

**Velocity is zero in bays in which no pumps are running.

TABLE 3-26

AVERAGE VELOCITIES AND TRAVEL TIMES IN CIRCULATING WATER SYSTEM*

(V in Feet per Second, T in Seconds)

		4 Pump Operation		3 Pump Operation		2 Pump Operation	
		V	T	V	T	V	T
Intake Canal	AHWL	.59	275	.50	325	.37	443
	ALWL	1.00	163	.83	195	.62	261
Intake Structure	AHWL	.59	101	.59	101	.59	101
	ALWL	1.0	60	1.0	60	1.0	60
Piping Upstream of Condenser	AHWL	11.80	99	9.94	117	7.37	158
	ALWL	11.80	99	9.94	117	7.37	158
Condenser	AHWL	8.0	7	6.7	8	4.9	11
	ALWL	8.0	7	6.7	8	4.9	11
Piping Downstream of Condenser	AHWL	11.1	189	9.31	226	6.92	304
	ALWL	11.1	189	9.31	226	6.92	304
Discharge Structure and Canal	AHWL	1.43	134	1.21	159	.88	217
	ALWL	4.57	42	3.84	50	2.82	68
Total Time After Addition of Heat	AHWL		330		393		532
	ALWL		238		284		383

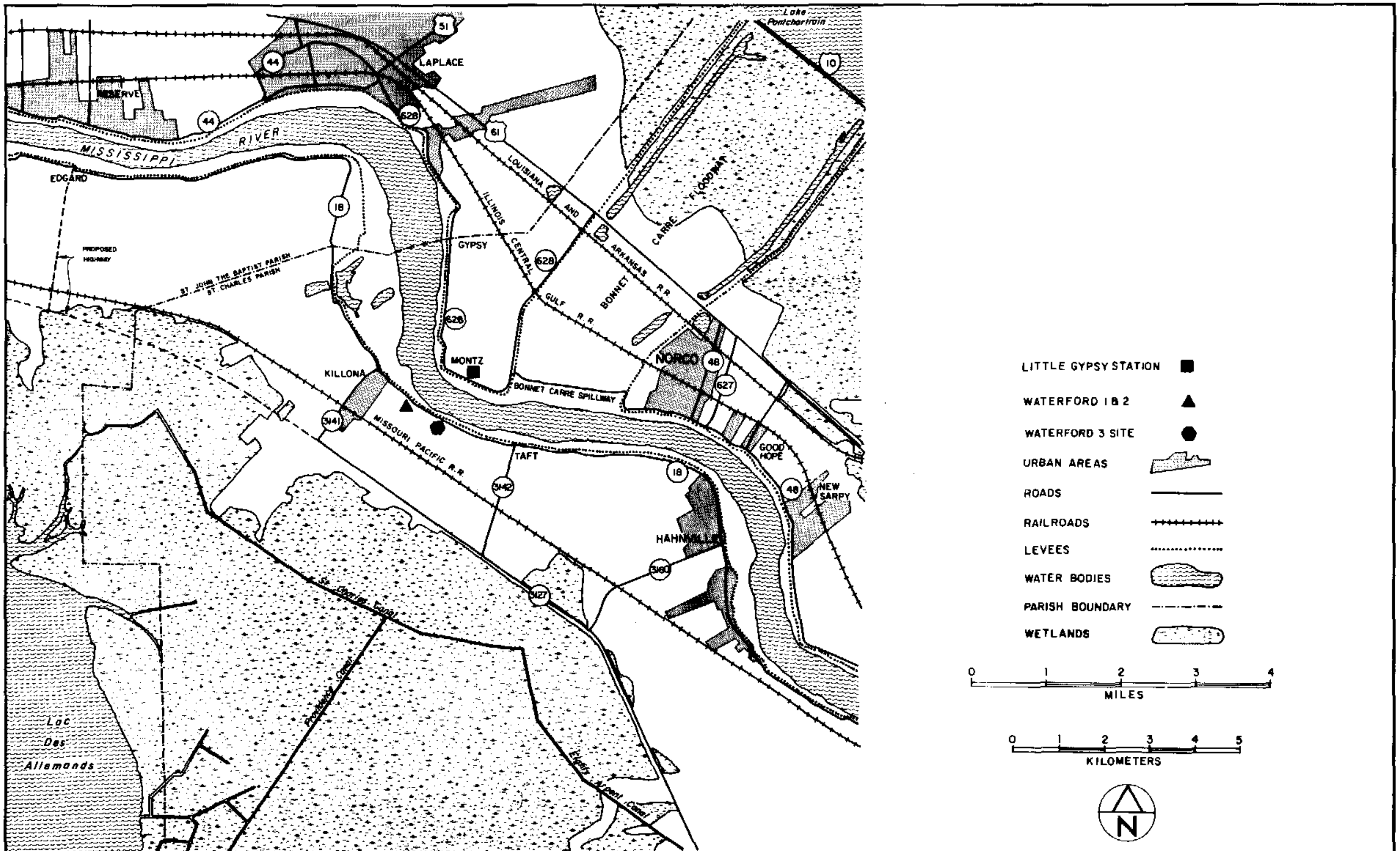
* Averages based on volume and length of each portion of the system.

TABLE 3-27

SUMMARY OF CHEMICAL WASTE CONCENTRATIONS ABOVE AMBIENT CONCENTRATIONS IN THE MISSISSIPPI RIVER FOR AVERAGE SUMMER FLOW CONDITIONS*
FROM DISCHARGE BY WATERFORD 3

Waste Source	Chemical and Pollutant Content	Applicable EPA Effluent Limitations or State Water Quality Standards	Estimated Increase in Average Concentration of Circulating Water (ppm)	Estimated Increase in Avg. Concentration at 10 F above Ambient Temperature Isotherm (Dilution Factors: 0.526[a], 0.621[b]) (ppm)	Estimated Increase in Avg. Concentration at 5 F above Ambient Temperature Isotherm (Dilution Factors: 0.263[a], 0.311[b]) (ppm)	Estimated Increase in Avg. Concentration at 3.6 F above Ambient Temperature Isotherm (Dilution Factors: 0.190[a], 0.224[b]) (ppm)
Boron Management System	Boron	–	$1.3x10^{-5}$	$8.1x10^{-6}$	$4.0x10^{-6}$	$2.9x10^{-6}$
Waste Management System	Detergent, Dirt	TSS-Avg-30	$7.6x10^{-6}$	$4.7x10^{-6}$	$2.4x10^{-6}$	$1.7x10^{-6}$
Laundry, Showers	Detergent, Dirt	TSS-Avg-30 Max-100	$2.5x10^{-4}$	$1.6x10^{-4}$	$7.8x\ 10^{-5}$	$5.6x10^{-5}$
	Hydrazine[c]	–	$4.2x10^{-8}$	$2.6x10^{-8}$	$1.3x10^{-8}$	$9.4x10^{-9}$
Steam Generator Blowdown System Regenerative Solutions	Total Dissolved Solids	–	4.6	2.4	1.2	0.9
	Sulfates	–	2.3	1.2	0.6	0.4
	pH	6.0-9.0	No Change	No Change	No Change	No Change
Steam Generator Blowdown System Electromagnetic Filter Flush	Total Suspended Solids	30	$6.9-10^{-3}$	$3.6x10^{-3}$	$1.8x10^{-3}$	$1.3x10^{-3}$
Condenser Feedwater Drains	Ammonia	–	$1.2x10^{-7}$	$7.5x10^{-8}$	$3.7x10^{-8}$	$2.7x10^{-8}$
Demineralizer Makeup	Total Dissolved Solids	–	3.8	2.0	1.0	0.7
	Sulfates	–	1.9	1.0	0.5	0.4
Pretreatment System	pH	– 6.9	6-9	No Change	No Change	No Change
	Residual Chlorine	Cl-Avg-0.2 Max-0.5	$1.5x10^{-4}$	$9.3x10^{-5}$	$4.7x10^{-5}$	$3.4x10^{-5}$
Sewage Treatment System	Residual Chlorine	–	$7.9x10^{-6}$	$4.2x10^{-6}$	$2.1x10^{-6}$	$1.5x10^{-6}$
	BOD	Avg-30	$4.7x10^{-4}$	$2.5x10^{-4}$	$1.2x10^{-4}$	$8.9x10^{-5}$
	TSS	Max-45	$7.1x10^{-4}$	$3.7x10^{-4}$	$1.9x10^{-4}$	$1.3x10^{-4}$
HVAC Cooling Tower Blowdown	TSS	Avg-30 Max-100	$4x1x10^{-4}$ Avg $1.4x10^{-3}$ Max	$2.2x10^{-4}$ $7.4x10^{-4}$	$1.1x10^{-4}$ $3.7x10^{-4}$	$7.8x10^{-5}$ $2.7x10^{-4}$

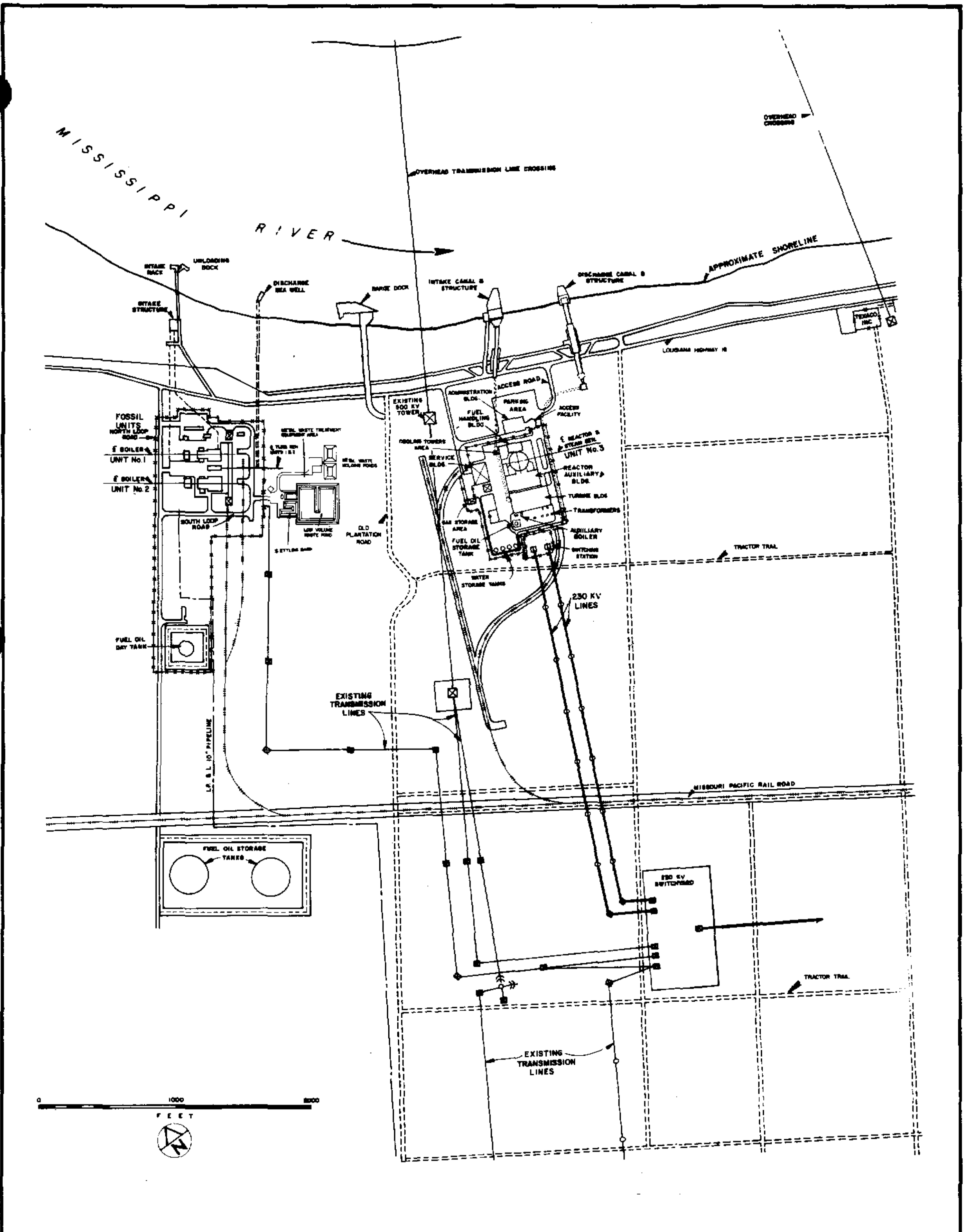
* River flow 280,000 cfs.
(a) Dilution factor for Waterford 1 and 2 point discharge. (b) Dilution factor Waterford 3 point discharge.
(c) Hydrazine originates from radioactive equipment machine shop drains.



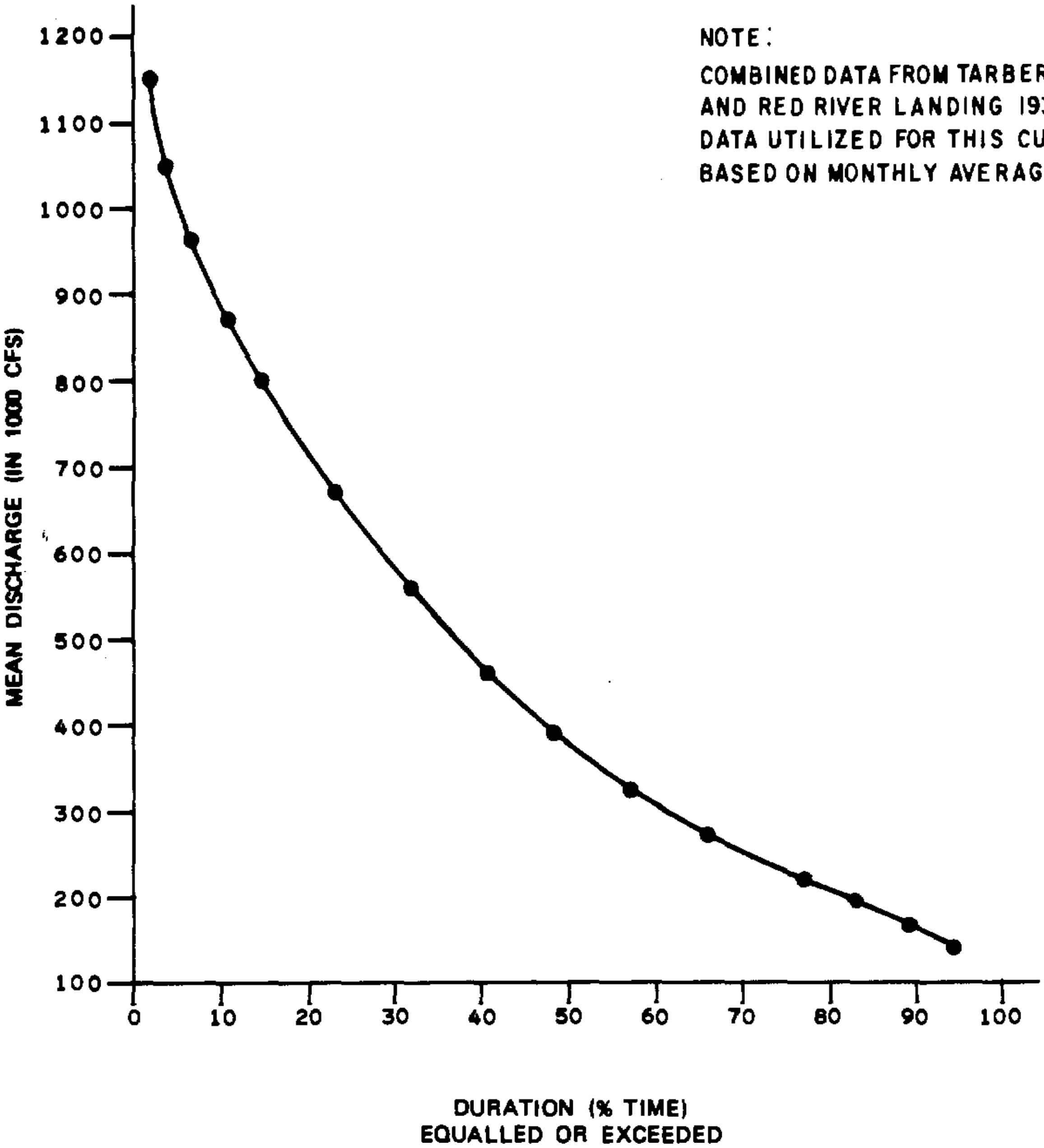
LOUISIANA POWER & LIGHT Co.
Waterford Steam Electric Station

THE REGION WITHIN 5 MILES OF WATERFORD 3

FIGURE 3-1



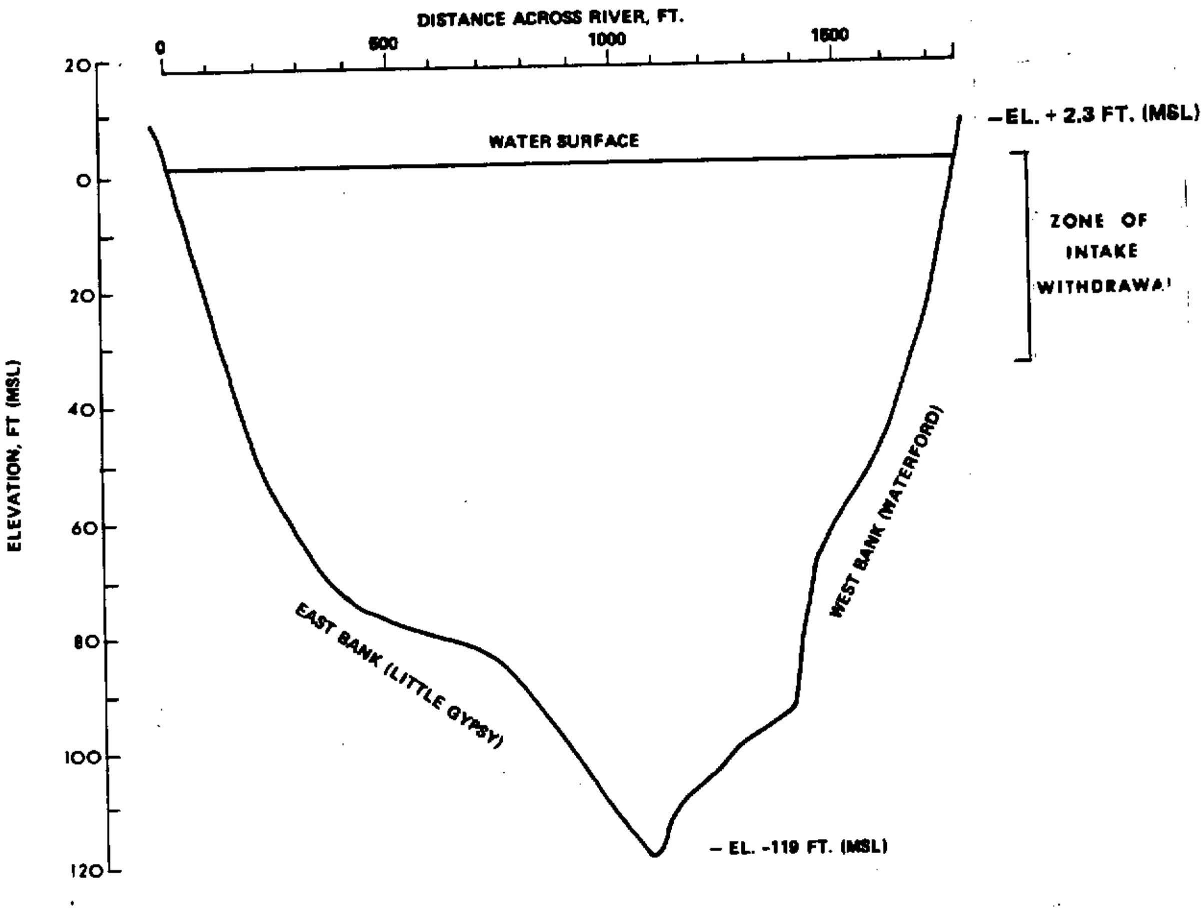
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	WATERFORD 3 SITE AND NEARBY STRUCTURES	Figure 3-2



NOTE:
COMBINED DATA FROM TARBERT LANDING AND RED RIVER LANDING 1930 - 1975 DATA UTILIZED FOR THIS CURVE IS BASED ON MONTHLY AVERAGE FLOWS

SOURCE:
UNPUBLISHED PRELIMINARY DATA - SUBJECT TO REVISION
U.S. GEOLOGICAL SURVEYS, BATON ROUGE, LA. 1977

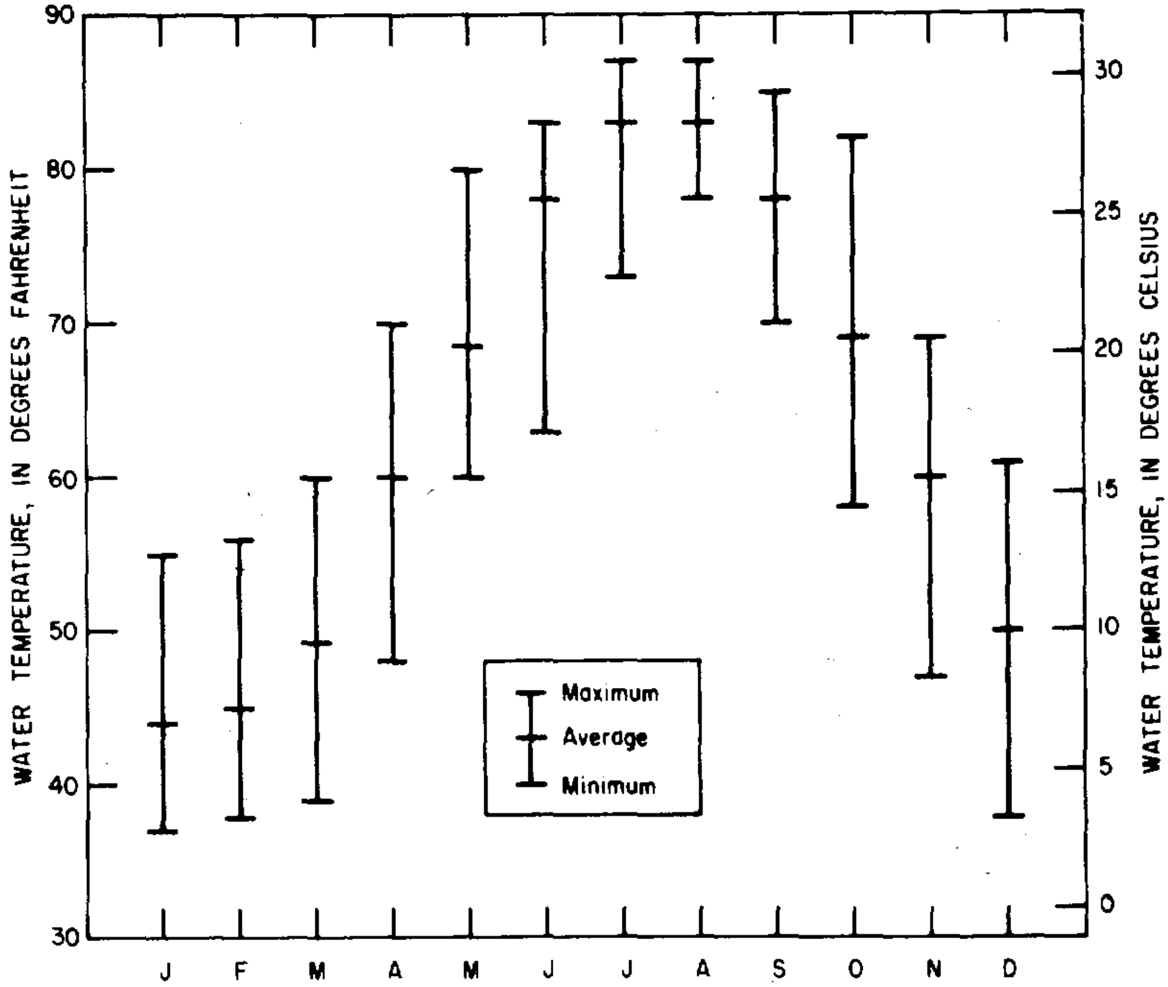
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	MISSISSIPPI RIVER FLOW DURATION CURVE	Figure 3-3



RIVER FLOW: 200,000 cfs

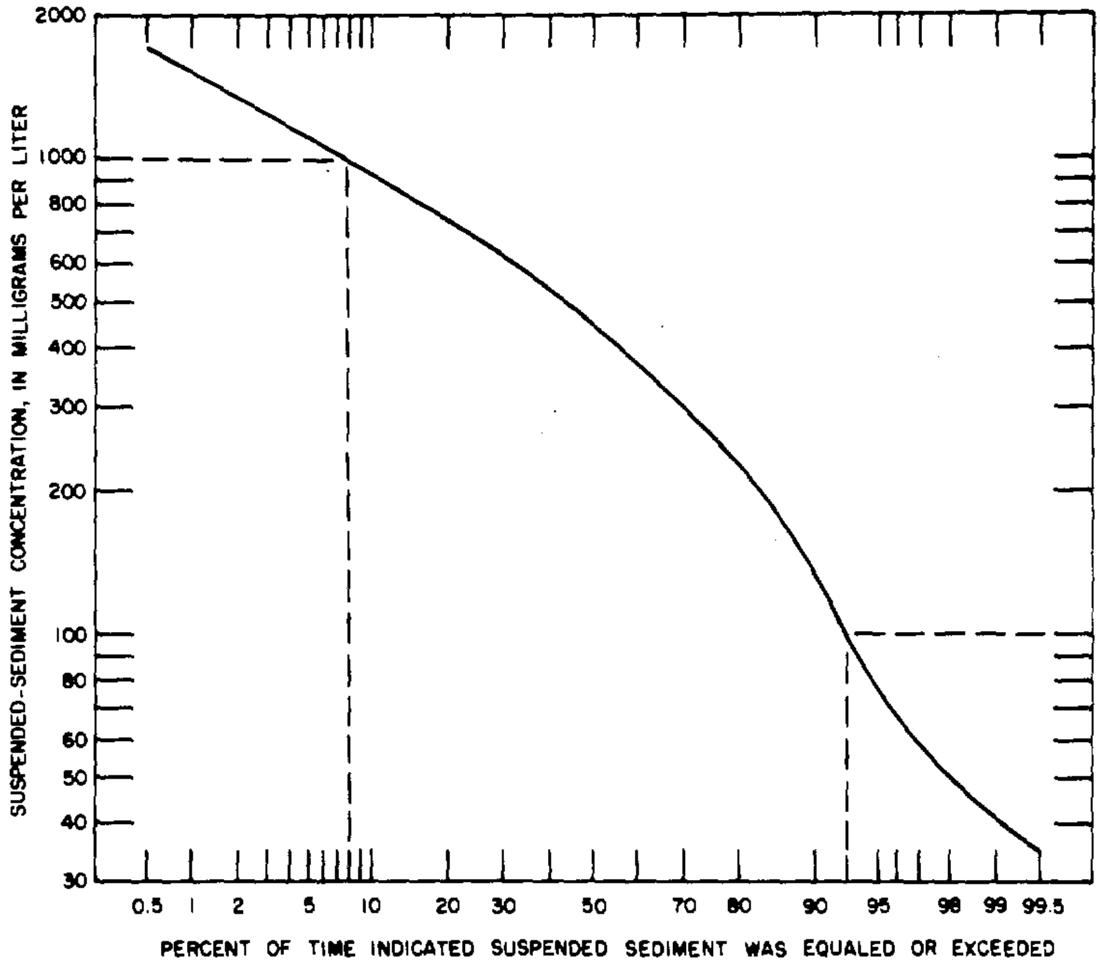
SOURCE:
RIVER CROSS-SECTION CONSTRUCTED FROM CONTOUR MAP FROM U.S. CORPS OF ENGINEERS, NEW ORLEANS, LA. "MISSISSIPPI RIVER HYDROGRAPHIC SURVEY – 1973-1975 BLACK HAWK LA. TO HEAD OF PASSES LA. 1976

LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	MISSISSIPPI RIVER CROSS-SECTION AT LITTLE GYPSY GENERATING STATION	Figure 3-4



SOURCE:
EVERETT, D. "HYDROLOGIC AND QUALITY CHARACTERISTICS OF THE LOWER MISSISSIPPI RIVER," TECHNICAL REPORT NO. 5, LOUISIANA DEPARTMENT OF PUBLIC WORKS, 1971

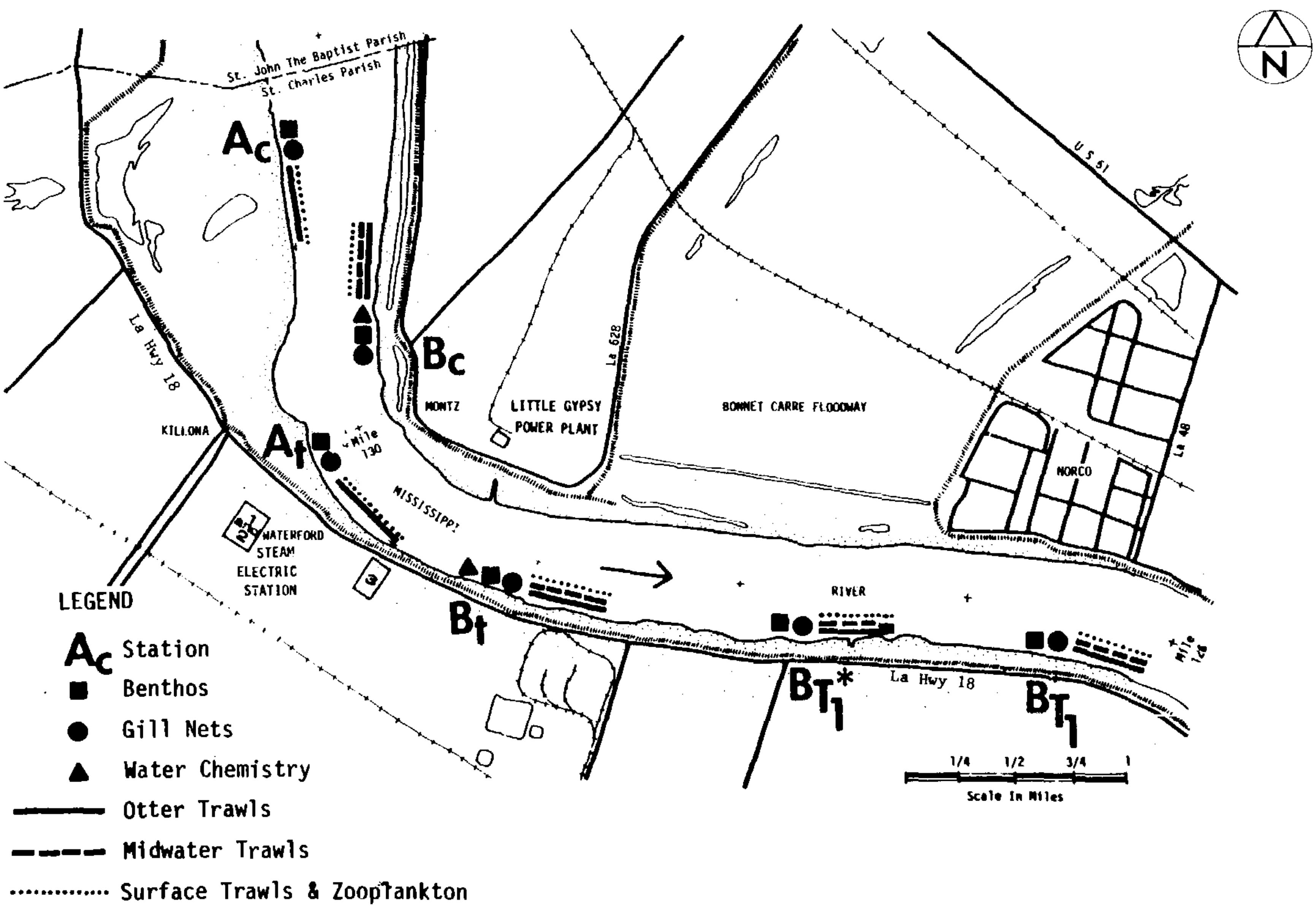
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	MONTHLY VARIATIONS IN WATER TEMPERATURE IN THE MISSISSIPPI RIVER NEAR ST. FRANCISVILLE, LA., 1954-68.	Figure 3-5



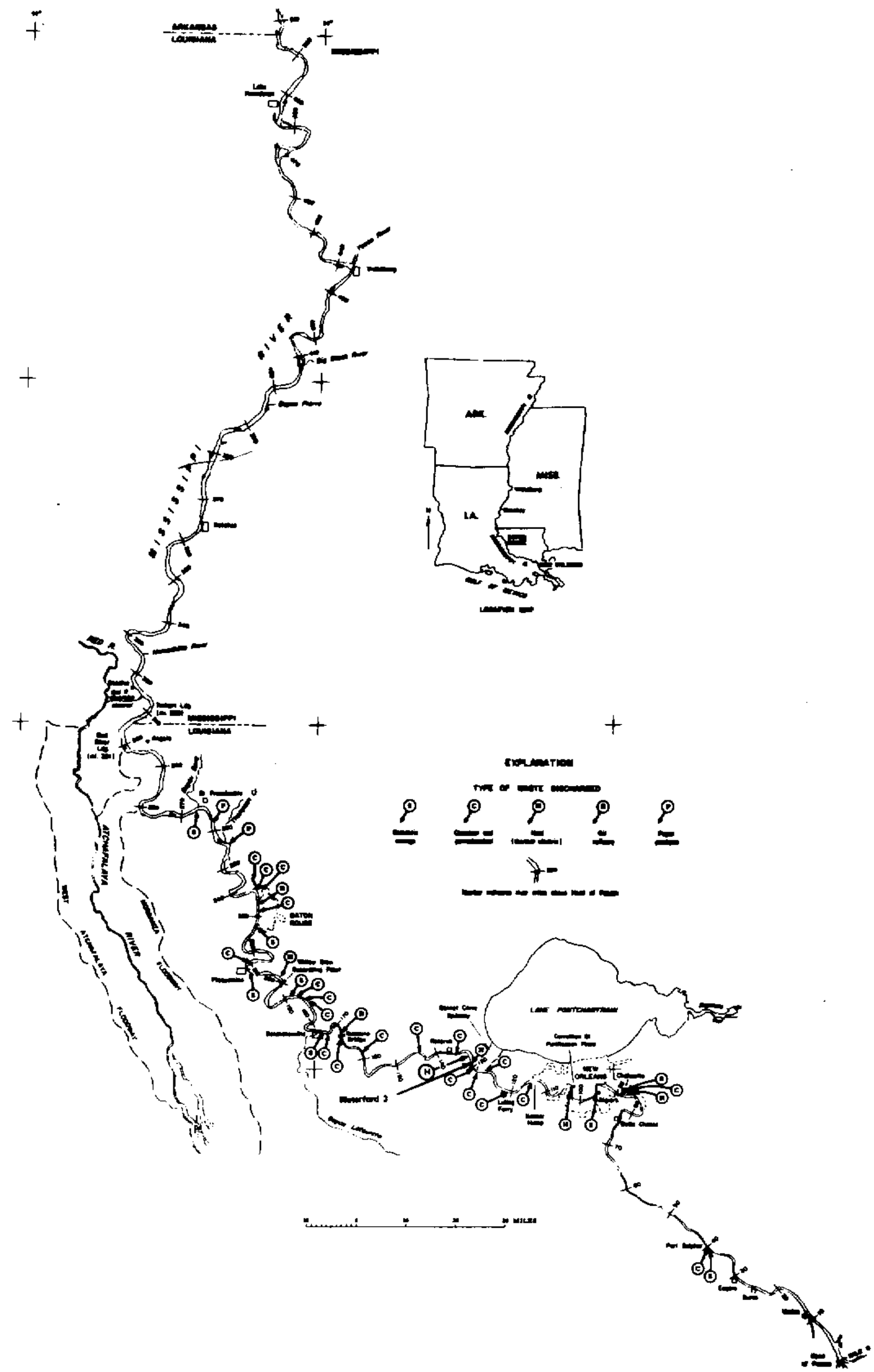
SOURCE: SMITH, A. S. "CHANNEL SEDIMENTATION AND DREDGING PROBLEMS, MISSISSIPPI RIVER AND LOUISIANA GULF COAST ACCESS CHANNELS." PROCEEDINGS OF THE FEDERAL INTER-AGENCY SEDIMENTATION CONFERENCE.

U.S. DEPT. OF AGRICULTURE, MISC. PUBLICATION 970. pp. [illegible]. [illegible]

LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	DURATION CURVE OF SUSPENDED-SEDIMENT CONCENTRATION MISSISSIPPI RIVER AT RED RIVER LANDING, LA., 1949-63	Figure 3-6

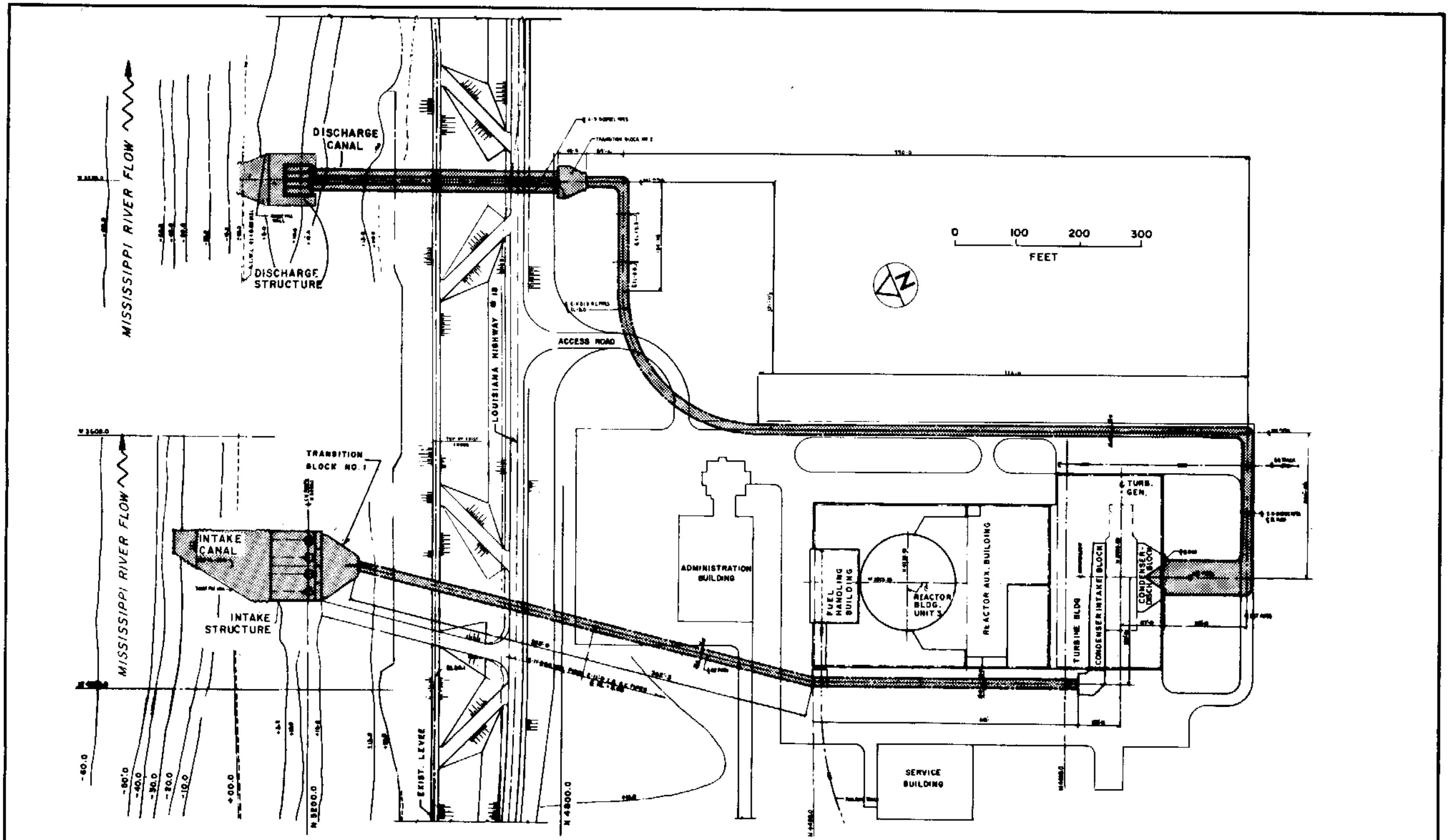


LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	SAMPLING AREAS IN THE MISSISSIPPI RIVER NEAR WATERFORD 3	Figure 3-7



MODIFIED FROM:
EVERETT, D. "HYDROLOGIC AND QUALITY CHARACTERISTICS OF THE LOWER MISSISSIPPI RIVER," TECHNICAL REPORT NO. 5, LOUISIANA DEPARTMENT OF PUBLIC WORKS, 1971.

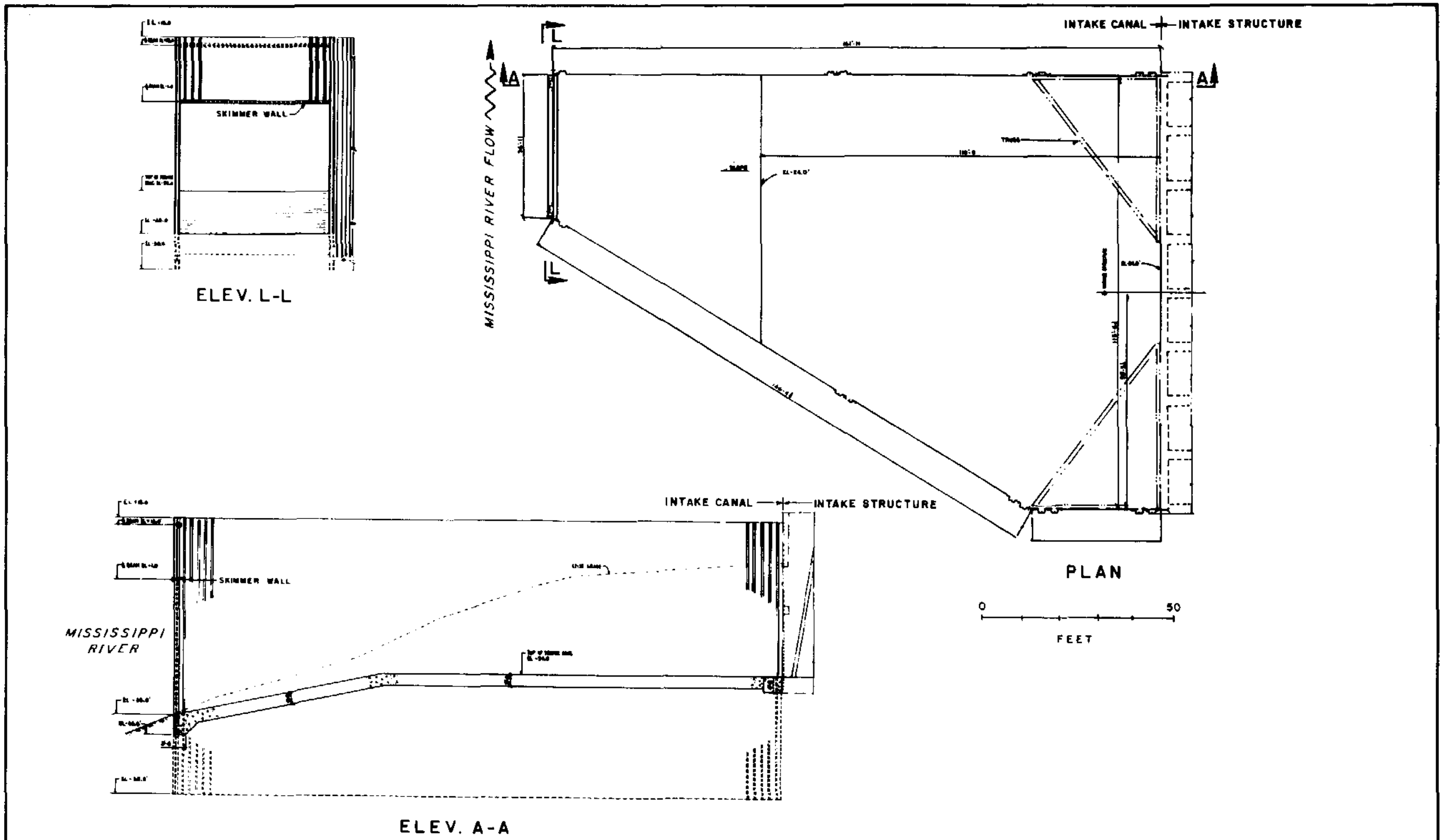
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	WASTE SOURCES IN THE LOWER MISSISSIPPI RIVER	Figure 3-8



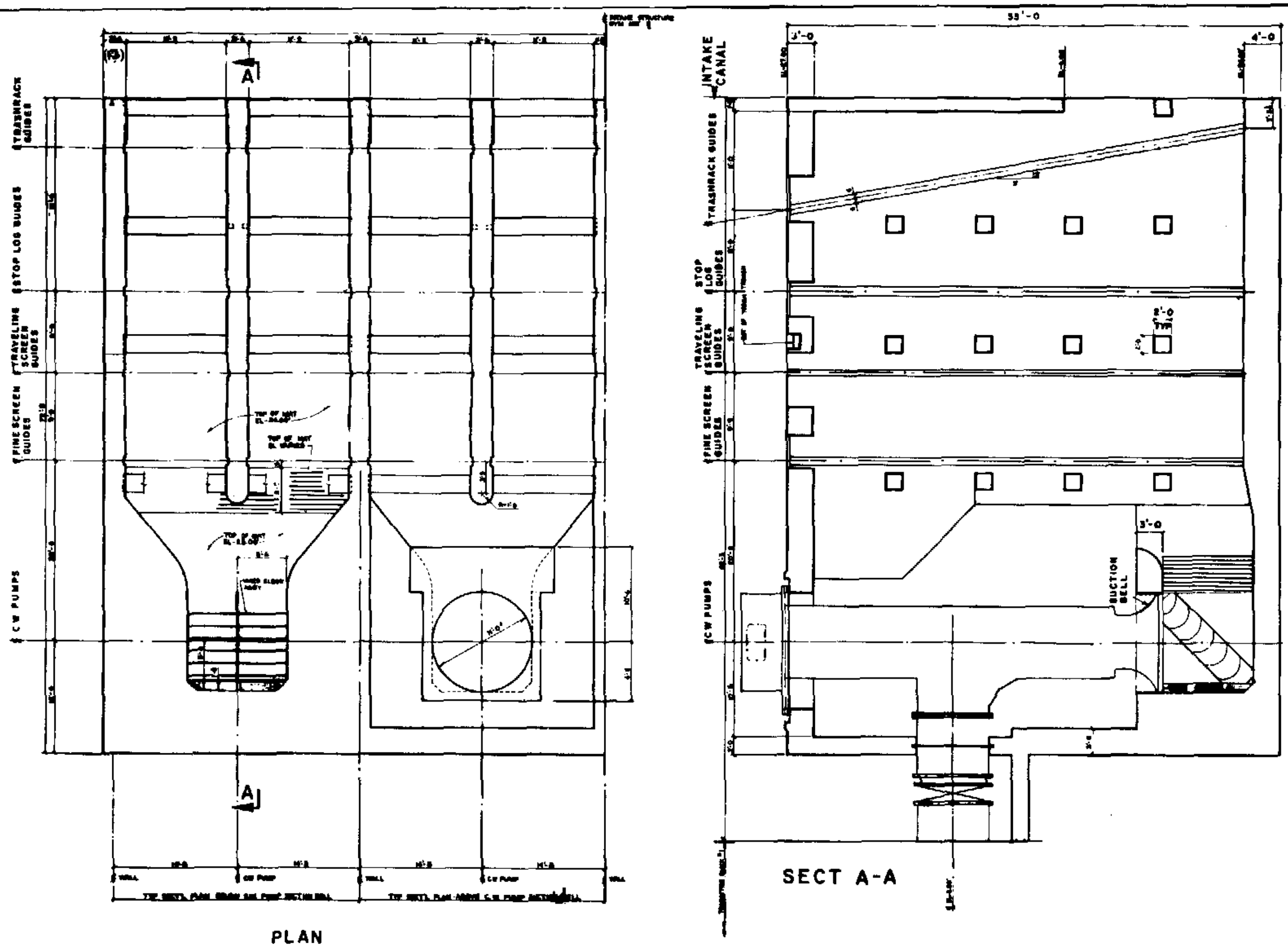
LOUISIANA POWER & LIGHT Co.
Waterford Steam Electric Station

CIRCULATING WATER SYSTEM
GENERAL PLAN

FIGURE
3-9

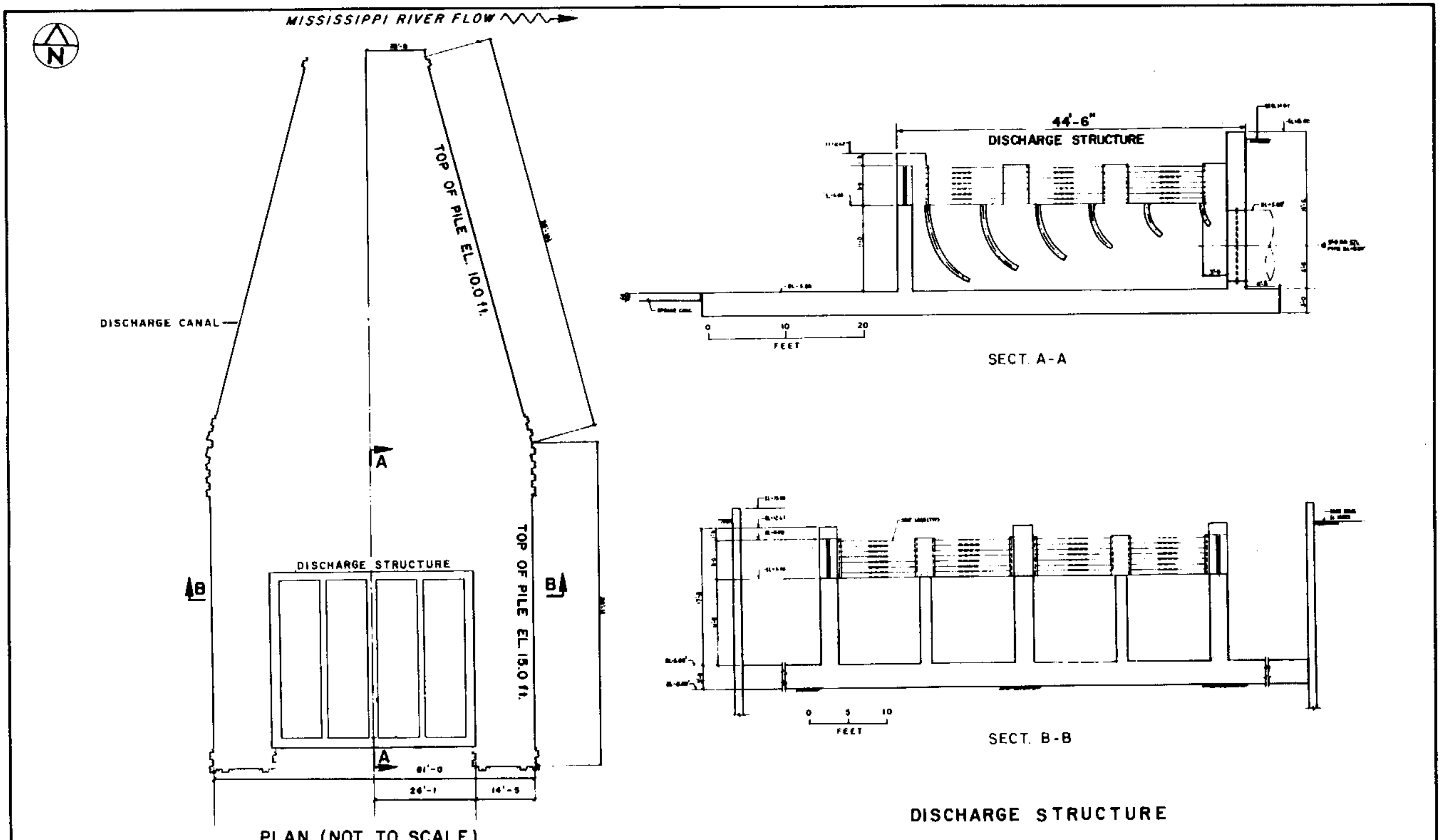


LOUISIANA POWER & LIGHT Co. Waterford Steam Electric Station	CIRCULATING WATER SYSTEM INTAKE CANAL	FIGURE 3-10



NOTE: TWO OF THE FOUR INTAKE PUMPS SHOWN

LOUISIANA POWER & LIGHT Co. Waterford Steam Electric Station	CIRCULATING WATER SYSTEM INTAKE STRUCTURE	FIGURE 3-11



LOUISIANA POWER & LIGHT Co.
Waterford Steam Electric Station

CIRCULATING WATER SYSTEM
DISCHARGE STRUCTURE AND CANAL

FIGURE 3-12

SECTION 4

4.0 BIOLOGICAL COMMUNITY IMPACT POTENTIAL

Based on the site aquatic ecology description presented in Section 3.4 and the operating characteristics of the Circulating Water System presented in Section 3.6, it is believed that there is a low potential for significant impact to the aquatic communities of the lower Mississippi River due to intake water withdrawal by Waterford 3. The considerations used in this evaluation include the low biological productivity and value associated with this section of the river, and the very low percentage of the river discharge which is withdrawn by the Waterford 3 Circulating Water System. This percentage is usually less than 1 percent of the annual average flow (see Section 5.0). The combined total withdrawals for Little Gypsy and Waterford 1 and 2, and Waterford 3 do not exceed 3 percent of the typical low flow of 200,000 cfs.

This section contains a community-by-community rationale for the conclusion that there is a low potential for impact from water withdrawal.

4.1 PHYTOPLANKTON

Turbidity, turbulence and suspended solids limit the phytoplankton community of the lower Mississippi River. A major portion of the phytoplankton community present in the river is probably washed out of tributaries rather than originating within the mainstream itself. Primary production is low. The river food chain is detrital based; therefore phytoplankton are not the major energy source in the Mississippi that they are in more lake-like systems. The percentage of the community subjected to withdrawal is low, and percent survival of the species found at Waterford after passage through the condenser is expected to be substantial during most periods of the year (Gurtz and Weiss, 1974).

4.2 ZOOPLANKTON

Zooplankton densities are low in the Mississippi, and the community is probably dominated by rotifers which are not a major food source for the fish species present in the Mississippi. The percentage of the community

subjected to intake withdrawal is low. No commercially important or endangered species of zooplankton were found in the Waterford area. The relative importance of the zooplankton to the aquatic biological systems of the river as well as low relative volume of river flow entrained by Waterford 3, leads to the conclusion of a low potential for impact to this community.

4.3 SHELLFISH/MACROINVERTEBRATES

The species likely to be affected by intake withdrawal of Waterford 3 is the river shrimp, *Macrobrachium ohione*. The river shrimp supports a small fishery in the Mississippi and Atchafalya Rivers. River shrimp are found in high numbers throughout the lower Mississippi River and the Waterford 3 site is not unique in terms of habitat. River shrimp has a low potential for impact due to the low volume of river water involved, the non-uniqueness of the Waterford habitat, and the relatively insignificant commercial fishery for this species. No threatened or endangered species of macroinvertebrates are found in the Waterford area.

4.4 FISH

Species captured during the Environmental Surveillance Program were found in low numbers except for gizzard and threadfin shad, fresh water drum, striped mullet and blue catfish. None of the fish species found in the Mississippi River at the Waterford site are listed by the Fish and Wildlife Service as threatened or endangered.

Several species found have commercial value. Between Baton Rouge and the river mouth freshwater drum, blue and channel catfish, and carp were taken from the Mississippi by commercial fisherman. The value of the regions commercial fishery is discussed further in Section 3.4. Sport fishing in the lower Mississippi River is not common (USAEC 1973).

4.4.1 FISH SPAWNING AND NURSERY POTENTIAL

The Mississippi River at Waterford does not provide habitat suitable for spawning of many fish species. It lacks the riffle areas preferred for spawning by many catfish (ictalurids) and most suckers (catastomids), the shallow backwaters and flooded areas preferred by pike (esocids) and some of the shads (clupeids) and sunfishes (centrarchids), and the vegetated areas preferred by other sunfishes and perch (percids) (see Table 3-20).

Some of the fish larvae sampled during the Environmental Surveillance Program must have been produced upstream of Waterford 3, since the habitat at Waterford does not meet their spawning requirements (e.g., sunfishes and pikes). Most of these washed out eggs and larvae are not adapted to the turbid, turbulent, and high velocity river conditions, and therefore, few would be expected to survive, regardless of entrainment by Waterford 1 and 2, Waterford 3, and Little Gypsy. However, increased mortality of freshwater drum eggs, which are buoyant, might occur. In view of the low numbers of drum eggs and larvae collected in the river and the high fecundity of this species (approximately 200,000 to 350,000 eggs per female), no significant reduction in the number of adults is expected.

With the exception of freshwater drum, the eggs of those species expected to spawn near the Waterford site are demersal and/or adhesive. This tendency to adhere to substrates or to sink will eliminate them from possible entrainment by the Waterford 3 surface withdrawal.

Summarizing the above information, it is concluded that impact potential is low because:

a) Presence of commercial fish is not unique to the area and their importance as a resource will not be impaired by Waterford 3.

b) No special spawning habitat is available in the Mississippi at Waterford 3.

c) The intake withdrawal affects only a small portion of the typical low flow river discharge.

d) Threatened or endangered species were not found.

CITATIONS - SECTION 4

1. Gurtz, M.E. and C.M. Weiss, 1974 "Response of Phytoplankton to Thermal Stress," in Cooling Water Studies for Electric Power Research Institute-RP-49. Proceedings of the Second Workshop on Entrainment and Intake Screening - Jones Hopkins University.

2. U.S. Atomic Energy Commission, 1973 "Final Environmental Statement Related to Construction of Grand Gulf Nuclear Station Units 1 and 2. Mississippi Power and Light Company." Docket Nos. 50-416, 50-417.

SECTION 5

5.0 ENTRAINMENT EFFECTS

The organisms subject to entrainment by the Waterford 3 Circulating Water System include phytoplankton, zooplankton, ichthyoplankton, and juvenile fish and invertebrates small enough to pass through the 1/4 inch clear openings of the traveling screens. These communities have been described in Section 3.4 and their potential for significant impact has been discussed in Section 4.0.

In the following analysis of entrainment effects, it has been assumed, for purposes of conservatism, that the organisms entrained in the Circulating Water System do not survive. In reality, mortality of entrained organisms will vary, with some groups of organisms experiencing 100 percent mortality, and others experiencing significantly less mortality. Mortality factors contributed by the Circulating Water System include thermal, chemical, and mechanical stresses.

5.1 STRESSES DURING ENTRAINMENT

Temperature elevation (Δ T) in the Circulating Water System will range from 29^{o}F at two-pump operation to 16.1^{o}F at four-pump operation. The frequency of these operating modes is described in Section 3.6.1. The total retention time of river water in the system, depending on the number of pumps operating and river water level, ranges from 238 to 532 seconds (4 to 9 minutes) after the addition of heat. The total retention time of river water in the Circulating Water System varies from 337 to 690 seconds.

Stresses on entrained organisms from the chemicals placed in the circulating water from the operation of Waterford 3 are expected to be most significant from the addition of chlorine, which will not be used routinely, as described in Section 3.6.9. The proportion of total entrained organisms exposed to chlorine over the course of a year is therefore expected to be very small. The chemicals added periodically for water treatment and from other plant systems will occur in very dilute concentrations following dilution within the circulating water, as shown in Table 3-27. These would

be anticipated to be relatively insignificant chemical stresses to entrained organisms when compared to other sources of stress.

Mechanical stresses to entrained organisms consist of damages from the circulating water pumps, pressure changes within the system, abrasion, and other stress effects.

The effects of the thermal, chemical, and mechanical stress can vary according to the organism entrained. However, in view of the simplifying assumption of complete mortality that is utilized in this analysis, the resultant influence of entrainment losses to the biological communities of the Mississippi is the criterion by which entrainment effects of Waterford 3 should be evaluated. The assessment of these effects is included in the following section.

5.2 WATERFORD 3 ENTRAINMENT EFFECTS

As discussed in Section 3.4, phytoplankton, zooplankton and ichthyoplankton are present in relatively low numbers in the lower Mississippi River. Section 3.4 also identified the low primary productivity that has been found to occur in the river, and that energy flow in this aquatic system is detrital based. These factors are indicative of the low biological productivity of the Mississippi River in this area. When this is considered in combination with the low percentage of river flow to be utilized by Waterford 3, it is indicated that the capacity of the Circulating Water System is suitable for minimizing the potential for significant adverse effects to the aquatic communities of the Mississippi.

Assuming that entrainment is nonselective and the distribution of organisms in the river is homogeneous, then the relative number of organisms withdrawn from the community will be directly proportional to the amount of water withdrawn. This assumption is reasonable in view of the generally high current velocity and turbulence which occurs in the Mississippi, and the lack of differences in the distribution of organisms among the sampling stations utilized, which is described in Section 3.4. Therefore, the rates

of organisms entrainment have been calculated based on the average densities of phytoplankton, zooplankton, and ichthyoplankton from samples collected in each month of the year.

Tables 5-1, 5-2, and 5-3 contain the calculated numbers of phytoplankton, zooplankton, and ichthyoplankton, respectively, that are estimated to be entrained each month. The number of phytoplankton estimated to be entrained ranges from 183 x 10^3 cells/second in November, to 4720 x 10^3 cells/second in September. The number of zooplankton entrained range from 331/second in January to 113,596/second in August. Average ichthyoplankton entrainment ranges from a low of 0.35/sec in March, to a high of 3.42/second in June over the period of March to August when ichthyoplankton are present.

While these entrainment numbers are considered only an approximation, their significance to the Mississippi River can only be determined by considering the portion of the aquatic communities actually entrained, and their ability to reproduce. The percent of the Mississippi River monthly average flow entrained by Waterford 3 is given in Table 5-4. This table shows that Waterford 3 will typically withdraw the highest percentage of river flow during the month of September. But, even during this month, Waterford 3 will only utilize about 1.0 percent of the river's average monthly flow, and only about 1.2 percent of the monthly minimum average flow. The low percentage of total river flow withdrawn by Waterford 3, even in view of the conservative assumption of 100 percent mortality to entrained organisms, indicates that there will be a correspondingly low percentage of the phytoplankton, zooplankton, and ichthyoplankton communities affected.

Most groups of plankton have an innate capacity to reproduce quickly. Phytoplankton have particularly short generation times. For example, the doubling time for Coscinodiscus sp is approximately 30 hours at 18°C (64.4°F) and the doubling time for Asterionella formosa is 9.6 hours at 20°C (68°F) (Fogg, 1965). Although these generation times are sufficiently long to preclude creation of blooms in the thermal plume (as discussed in 316(a) Demonstration for Waterford 3), they are short enough to anticipate that entrainment losses would be compensated for within a

short distance of the Waterford 3 discharge. This combination of small percentages of river water withdrawn and high phytoplankton reproductive potential, suggests no adverse impact.

Zooplankton populations also have generally high reproductive capabilities. The relatively short generation times of most planktonic invertebrates allow populations to recover rapidly from a stress such as entrainment. For example, studies conducted under natural conditions indicated relative rates of increase for rotifers of 8 percent per day by Karatella aculeata and 35 percent per day by Asplanchna pridodonta (Colditz (1914) and Ahlstrom (1933), cited by Edmondson et al, (1962) and Hall (1964), cited by Lauer, et al (1974)).

The reproductive characteristics of the species of fish found in the Mississippi near Waterford 3 gives perspective to the significance of the predicted effect from entrainment of approximately 1 percent maximum of the ichthyoplankton community. The fish population of this area is not likely to be noticeably affected by this small loss of ichthyoplankton because of the characteristics of the eggs of the species expected to spawn near Waterford 3 and their relative fecundity (discussed in Section 4.4). Furthermore, in spring, when most fish spawn, river flows are at a maximum. The river flow used by Waterford 3, and consequently the estimated portion of the ichthyoplankton population, would be approximately 0.2 to 0.4 percent for April through June under average monthly flow conditions, as shown in Table 5-4. This is the period when the highest number of ichthyoplankton are present in the river, as shown in Tables 3-21 and 3-22. During September, when the ratio of withdrawal to river flow is highest, these tables indicate that no ichthyoplankton are likely to be present.

In view of these factors, no adverse effects to the Mississippi River ichthyoplankton community are expected from entrainment by Waterford 3.

CITATIONS - SECTION 5.0

1. Edmondson, W.T., 1946 "Factors in the Dynamics of Rotifer Populations". Ecol Mongr 16.

2. Fogg, G.E., 1965 Algal Cultures and Phytoplankton Ecology. The University of Wisconsin Press.

3. Lauer, G.R., et al, 1974 "Entrainment Studies on Hudson River Organisms". Cooling Water Studies for Electric Power Research Institute RP-49. Proceedings of the Second Workshop on Entrainment and Intake Screening, Report No. 15 - John Hopkins University.

TABLE 5-1

ESTIMATED PHYTOPLANKTON ENTRAINMENT BY WATERFORD 3

Month	Average Total Density Year I*	Average Total Density Year II*	Average Total Density Year III*	Average Total Density #/liter	$\#/ft^3 \times 10^4$	Waterford 3 Intake cfs	Phytoplankton cells/sec Entrained $\times 10^3$
January	------	-------	152,349	152,349	432	1388	600
February	40,800	501,201	119,636	220,545	625	1388	867
March	51,000	-------	162,574	106,787	302	1388	419
April	45,960	348,098	1,446,815	613,624	1738	1756	305
May	28,900	-------	320,548	174,724	494	1997	986
June	27,200	230,814	326,699	194,904	551	2236	1232
July	57,800	-------	440,189	248,994	705	2236	1576
August	299,200	479,417	-------	389,308	1103	2236	2466
September	719,100	-------	385,749	745,299	2111	2236	4720
October	59,500	-------	56,751	58,125	164	2118	347
November	52,700	-------	24,541	38,620	109	1683	183
December	34,000	-------	59,816	49,908	133	1388	185

*Average total density derived from Tables 2.2-3, 2.2-4, and 2.2-5 of Waterford 3 OLER. Year I extends from June, 1973-May, 1974; Year II from June, 1974-August, 1975; and Year III from October 1975-September, 1976. Densities expressed as numbers per liter.

TABLE 5-2

ESTIMATED AVERAGE NUMBER OF ZOOPLANKTON ENTRAINED BY WATERFORD 3

Month	Average Total $\#/M^3$ All Years*	M^3/sec Intake Waterford 3	Average # Zooplankton Entrained/sec
January**	8.4	39.30	331
February	250	39.30	9825
March	901.8	39.30	35440
April	386.6	49.72	19221
May	1292	56.55	73062
June	777	63.32	49199
July	309	63.32	19565
August	1794	63.32	113596
September	1118	63.32	70791
October	227	59.98	13615
November	956	47.66	45563
December	170.7	39.30	6708

*Average $\#/M^3$ for each month sampled. Three years pooled data.

**Only one year sampled

TABLE 5-3

ESTIMATED ICHTHYOPLANKTON ENTRAINMENT BY WATERFORD 3

Month	#/M^3 Average Total Density All Stations All Years	Most Abundant Family	Intake M^3/sec	Total Ichthyoplankton Entrained/sec
January	.000	--------	39.30	------
February	.000	--------	39.30	------
March	.009	Cyprinidae	39.30	0.4
April	.014	Centrarchidae	49.72	0.7
May	.021	Cyprinidae	56.55	1.2
June	.054	Clupeidae	63.32	3.4
July	.009	Sciaenidae	63.32	.6
August	.015	Sciaenidae	63.32	.9
September	.000	--------	63.32	------
October	.000	--------	59.98	------
November	.000	--------	47.66	------
December	.000	--------	39.30	------

TABLE 5-4

PERCENT OF MISSISSIPPI RIVER FLOW ENTRAINED BY WATERFORD 3

Month	Average Monthly Station Intake Flow* cfs	Average of Monthly Averages: River Flow** 1,000 cfs	Average of Monthly Averages: Station Intake Flow as % River Flow	Average of Monthly Minimums: River Flow 1,000 cfs	Average of Monthly Minimums: Station Intake Flow as % River Flow
Jan	1,388	501	0.277	349	0.398
Feb	1,388	602	0.231	449	0.309
Mar	1,388	708	0.196	543	0.256
Apr	1,756	780	0.225	648	0.271
May	1,997	715	0.279	561	0.356
Jun	2,236	540	0.414	427	0.524
Jul	2,236	407	0.549	295	0.758
Aug	2,236	279	0.801	219	1.021
Sep	2,236	218	1.026	180	1.242
Oct	2,118	233	0.909	179	1.183
Nov	1,683	258	0.652	191	0.881
Dec	1,388	366	0.379	275	0.505

*Station flows based on pumping modes described in Section 3.4.

**Flows based on 35 year record at Red River Landing (1942-1976).

SECTION 6

6.0 IMPINGEMENT EFFECTS

6.1 INTRODUCTION

This section describes the anticipated impingement of aquatic organisms on the travelling screens of the Waterford 3 Circulating Water System intake. Organisms will become impinged because they are too large, or otherwise unable to pass through the 1/4 inch openings in the screen. Once impinged, the organisms are removed by washing to a trough and sluiced to the river downstream of the Waterford 3 intake. Details concerning the intake structure and the operation of the Circulating Water System are given in Section 3.6.

Because the Waterford 3 Circulating Water System will not be placed into operation until 1981, actual measurements of the rates of impingement which occur are not possible. Therefore, in order to develop a predicted rate of impingement and an evaluation of its effect on the Mississippi River environment, it has been necessary to derive a method to calculate, as closely as possible, the rate of impingement which can be expected when Waterford 3 becomes operational.

The conclusions which can be drawn from predictive studies such as this one have inherent limitations when compared to those based on actual measurements obtained at an operating intake. This report utilizes, however, an approach to the quantitative prediction of impingement that is based on conservative assumptions and presents an analysis of both the estimated maximum and average rates of impingement that can be expected at Waterford 3. The use of this range of anticipated effects and the conservatism in underlying assumptions can be expected to overcome the greatest limitations to a predictive study.

This section presents the analysis of impingement by Waterford 3. A description of the factors affecting impingement analysis is included and the general methodology utilized to calculate impingement rates is

detailed. The actual impingement expected to occur at Waterford 3 is described for each important species likely to be affected. A discussion of the influence of this impingement to the lower Mississippi River fisheries resources as a whole, is included.

This study has shown that the predicted environmental effects to the lower Mississippi River due to impingement by the Waterford 3 Circulating Water System, as presently designed, will be insignificant. Therefore, because of this insignificant effect and the demonstrated lower productivity of this portion of the Mississippi, the Waterford 3 intake can be considered to represent best available technology.

6.2 FACTORS AFFECTING THE ANALYSIS OF IMPINGEMENT

Impingement can be significantly influenced by the location, design and capacity of intake structures (EPA, 1976). The variability in these influences to the expected rate of impingement have had an effect on the analysis that has been utilized to predict impingement by Waterford 3, and therefore should be noted.

The most important locational factor influencing the effect of an intake is the nature of the water source from which the supply is taken (EPA, 1976). For purposes of this analysis, the ecological characteristics of the river have been shown to have significance on impingement rates and patterns. The combination of the species of organisms susceptible to impingement which are present, their abundance, and their behavior patterns can be very influencial to the analysis of impingement rates.

The Waterford 3 Environmental Surveillance Program indicated that there were no differences in fish abundance between the stations sampled, as discussed in Section 3.4.4, and that the specific intake location selected for Waterford 3 appears to be optimal for this area, based on observations during sampling (Geo-Marine, 1979). However, when comparing the Waterford 3 intake to other intakes, it should be noted that variability in abundance of fish, in rivers such as the Mississippi, can be due, in part, to the configuration of the river in the location from which water is withdrawn.

The placement of an intake on a meander, oxbow, shoal, etc, because of variations in fish abundance, can affect rates of impingement when compared to withdrawals from relatively staight shoreline or channelized rivers.

The physical structure of an intake is another major factor in predicting impingement rates. One principle aspect for this analysis is the manner in which water is withdrawn from the water column. An intake relying upon withdrawal through a pipeline will remove water from a relatively restricted area, typically near the bottom. A structure utilizing a more open canal or shoreline intake withdraws water from a larger portion of the water column. The zone of withdrawal is considered to be significant in the analysis of impingement when some of the fish species present will have variable distribution by depth in the water column.

Other physical factors influence the rate of impingement and consequently any prediction of the effects. Factors such as the direction of the inflow current at the point of withdrawal, the current velocity within the structure, and other design features should be considered in an analysis of impingement (EPA, 1976).

6.3 GENERAL METHODOLOGY UTILIZED FOR PREDICTION OF IMPINGEMENT

This section describes the general method which was utilized to derive a quantitative prediction for the number of aquatic organisms expected to be impinged by Waterford 3. Specific methods for predictions by species are included in the discussion in Section 6.4.

6.3.1 BASIC METHODOLOGY

The principle limitation on a predictive analysis of impingement is the availability of sufficient existing data which can be utilized as directly applicable to the intake being studied. The Waterford 3 Environmental Report, Operating License Stage presented an initial quantified estimate of impingement which was developed through analysis of species impingement data gathered at Waterford 1 and 2. Recent investigations have shown that the prediction of impingement rates from similarly designed and proximally

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located intakes are valid in some situations, but that any great deviation in design or localized fish productivity may invalidate the comparison (Gross, 1977; Astor, 1978). Because of this potential limitation to the use of data from Waterford 1 and 2, the methodology utilized in this analysis was a continuation of the approach taken in the Environmental Report, but with a further refinement of these earlier estimates through evaluation of additional data from other intakes. It was felt that a continuation and refinement of the impingement prediction developed through comparison with impingement rates at other intakes withdrawing from the same types of biological communities would be more effective than the use of a biological or eco-system model. Biological models for impingement prediction are considered to be difficult to develop, use and test, to require very substantial data taken over long periods of time, and too frequently produce unrealistic results (EPA, 1977).

6.3.2 COMPARISON OF INTAKE

To complete the predictive study for Waterford 3, existing intakes for which impingement data were available were identified and the data obtained. These intakes could be placed into two categories developed in reference to the applicability of their data to Waterford 3. The first was those intakes which located reasonably close to Waterford 3 in the lower Mississippi River. These intakes were assumed to be withdrawing water from essentially identical aquatic environments, as would Waterford 3.

Because of limitations on the applicability of the data from the first group of intakes, as discussed below, the second category was developed. These were intakes of basically similar design to Waterford 3's, with existing data and located in the central Mississippi River Basin, but unavoidably a very substantial distance from the Waterford 3 site. Nevertheless, it was felt that the dominant fish species present in this area were the same ones subject to impingement by Waterford 3.

The intakes utilized in this analysis were obtained through a computerized search of the "Power Database", developed by the Atomic Industrial Forum, Inc. (AIF, 1978). The data utilized were derived from published impinge-

ment studies, intake evaluations, and 316(b) documents. This data search yielded information on two power plants in the lower Mississippi and eight in the central basin which had sufficient data and information to use in this study. These ten power plants utilized a total of twelve intakes for which data was available. The general location of these power plants within the Mississippi River Basin is given in Figure 6-1.

The design, operational and locational characteristics of interest to this analysis were the following:

1) Intake location

2) Plant intake type

3) Stream morphology at the intake

4) Operational data

5) Intake temperature, including discharge recirculation

This information is displayed in Table 6-1 for all of the intakes utilized in the analysis.

Because the differences in these intakes, in either physical structure or location, have influence to the impingement prediction for Waterford 3, the capabilities of the two major categories to benefit or limit the analysis should be noted.

6.3.2.1 Lower Mississippi River Intakes

The operating intake closest to the Waterford 3 intake for which impingement data are available is Waterford 1 and 2. As indicated in Table 6-1, Waterford 1 and 2 uses submerged, siphon pipes located offshore and operates with smaller cooling water volumes than does Waterford 3. The principle benefit to the analysis from the use of impingement data from Waterford 1 and 2 is their location relatively close to Waterford 3, as indi-

cated in Figure 3-2. Although Waterford 1 and 2 withdraw water from an area which has different current patterns than those occurring at the Waterford 3 intake, as well as withdrawing water from the edge of a shoal, the fish community was found to be generally similar by the Waterford 3 Environmental Surveillance Program. This similarity is described in detail in the Waterford 3 Environmental Report.

However, there are substantial physical differences between the Waterford 1 and 2 intake and that designed and under construction for Waterford 3. These differences have a limiting effect on the direct extrapolation of data from Waterford 1 and 2 to Waterford 3, and they are explored in detail in the Waterford 3 Environmental Report. In summary, actual impingement at Waterford 3 could be higher because of: 1) the potential for fish to gather in the low current velocity area within the intake canal; 2) the potential withdrawal of heated water from the Waterford 1 and 2 discharge by Waterford 3, and; 3) the higher intake volume of Waterford 3. Waterford 3 could have lower impingement due to: 1) its withdrawal over the water column rather than from the bottom layers exclusively; 2) the greater potential for fish to escape the intake canal after their entrance, and; 3) the greater capabilities of fish to escape the horizontal current patterns of the Waterford 3 withdrawal. The Waterford 1 and 2 intake is also an offshore intake, compared to Waterford 3's shoreline position.

The second nearest plant to Waterford 3 studied is Willow Glen, several miles upstream of Waterford 3, as shown in Figure 6-1. The Willow Glen station has two intakes, designated Willow Glen 1 and Willow Glen 4. These are placed on the outer bank of a meander in the Mississippi, as indicated in Table 6-1, and withdraw water via pipeline. Willow Glen 1 has an offshore, inverted pipe intake with an average intake capacity of 200 cfs. Willow Glen 4 is similar, but with a horizontal pipe and an average capacity of 400 cfs. Neither Willow Glen 1 and 4 nor Waterford 1 and 2 recirculate heated discharge water for ice control in the intake.

These three intakes on the lower Mississippi River are most useful to this analysis for their location and consequently their withdrawal from the same general aquatic community. However, the physical and operation-

al dissimilarities with Waterford 3, as well as differences in pipeline withdrawal from the more restricted bottom area of the Mississippi River habitat, indicated that additional data were needed from intakes of similar design to Waterford 3's.

6.3.2.2 Central Mississippi Basin Intakes

The attempt to secure additional data from intakes with a more similar range of operating and design parameters identified eight power plants in the central Mississippi basin. These plants are the Sioux, Meramec, Wood River and Riverside stations, located on the Mississippi River; the Gallagher Generating Station on the Ohio River; and the Council Bluffs, Hawthorne, and Labadie Stations on the Missouri River. Locational, design and operational parameters for these plants are given in Table 6-1. The location of these stations is shown in Figure 6-1. These stations were located from the "Power Database" (AIF, 1978) on the basis of their withdrawal from the river system (the Mississippi or a major tributary) and the availability of impingement data. Two plants with data had to be eliminated from further use because of their intake withdrawal from saltwater and lake environments. One riverine plant was eliminated from use due to the incompatibility of the data with the format of that from the other plants. While no attempt was purposely made to locate other plants in the areas more distant from Waterford 3 solely on the basis of similarities in design and operational characteristics, the central basin plants located did offer this benefit to the analysis. These eight plants, with nine operating intakes, were the only central Mississippi River basin intakes with impingement data available for this analysis. There was no reasonable method which could enlarge the data base beyond this without a corresponding decrease in the applicability of the data to Waterford 3.

The intakes located in the central basin benefited the analysis not only because of the design and operation but also because of their withdrawal of water from the Mississippi. This assured that, generally, the major fish communities would be similar to that of the lower Mississippi River, and indicative of the susceptability predicted of these species at Waterford 3.

However, the use of intakes at such a substantial distance from Waterford 3 (i.e., at least 1,000 river miles) does have inherent limitations. This distance results in different environmental conditions, such as climate, water temperature and quality, as well as resulting dissimilarities to the lower basin in terms of relative fish abundance and seasonal dissimilarities in susceptability to impingement. Section 6.4 discusses these differences further.

The impingement data from the eight central basin plants with similar intakes and the information from those plants in the lower Mississippi offered a substantial data base for this predictive study of the Waterford 3 intake. The Waterford 3 Environmental Surveillance Program also provided significant information on the aquatic community at Waterford which was critical to the evaluation. These two major sources of data, when used with a conservative predictive approach, provided a satisfactory basis upon which to estimate impingement by Waterford 3.

6.3.3 DATA ANALYSIS

The operating and design variables from the intakes analyzed all required some standardization to allow for comparisons. Average intake velocities on impingement sampling dates were obtained directly from source documents for the Gallagher, Sioux and Meramec stations and were expressed in feet per second. Intake velocities at the other plants were calculated by dividing the intake flow (in cfs) by the cross-sectional area of the intake opening. Table 6-1 gives the results of this analysis for each intake. As this table indicates, the intake velocity of Waterford 3 is slightly below the average velocity of all the intakes evaluated. Because there was not significant variability in the range of velocities among the plants, a correlation between rates of impingement and velocity could not be drawn in this analysis. Therefore, velocity information did not affect the prediction of impingement by Waterford 3.

Impingement samples were all scaled to reflect a 24-hour sampling period. On dates when there were multiple samples at the intake, daily rates were calculated for each sample and averaged to yield one daily rate for that

date. Numbers of organisms impinged per unit volume of water withdrawn were also used to account for differing operating levels among the plants and to provide a basis for predicting impingement rates at the average Waterford 3 intake flow.

Impingement rates were, therefore, expressed in two forms: average numbers impinged per day and average numbers impinged per 100,000 gallons of water withdrawn. Average daily rates were used primarily to express the results of the analyses, and to calculate annual losses, as well as biomass losses, to the Mississippi River.

The analysis established a list of dominant species, which in total, compromised greater than 90 percent of the number of organisms collected during sampling. After an initial range for overall impingement at Waterford 3 was determined, impingement rates were estimated separately for each of the dominant species. When applicable, differences between impingement collections and baseline monitoring collections were considered to establish judgements of species susceptibility to impingement.

To overcome the limitations inherent in a prediction based on comparison with other intakes, two estimates of impingement by Waterford 3 were developed. The first, reflecting conservative underlying assumptions, is the likely expected maximum rate. The second is a rate judged to be more likely to actually occur. This range of impingement rates can be anticipated to envelop a reasonable and realistic rate which can then be used to analyze the effect on the Mississippi River resources. The assumptions utilized for a particular species are discussed in the following section.

6.4 PREDICTION OF IMPINGEMENT AT WATERFORD 3

This section describes the estimated range of impingement which can be predicted to result from the operation of the Waterford 3 Circulating Water System.

6.4.1 AN OVERVIEW OF IMPINGEMENT ON THE MISSISSIPPI RIVER

An indication of the rate of impingement throughout the study area can be derived from the data gathered from the other Mississippi River generating stations used in this report. The number of fish impinged per day is shown in relation to the sampling period in Figure 6-2 for each of the generating stations studied. It is evident from this figure that impingement varies considerably over time and among stations. The only trend which is suggested is that stations in the Ohio Basin and central Mississippi Basin experience their highest impingement during the colder portions of the year, from October through March (days 280-0-80); whereas lower Mississippi River stations have relatively more constant impingement rates. Since impingement at the more northerly - located plants is dominated by shad, as discussed below, this may be explained by relatively greater susceptibility of the fish to impingement during the winter (Union Electric Company, 1979, and Loar, et al, 1978). Winter recirculation of heated water for de-icing purposes at the northern plants may also play a role in increasing impingement by attracting fishes to the intake.

For purposes of estimating impingement at Waterford 3, as well as placing such estimates in perspective with actual impingement at other plants, the average number of fish and crustaceans impinged per day and per 100,000 gallons of water entrained were calculated for each plant. These are shown in Figures 6-3 and 6-4. These figures show that impingement ranges from about 2 to 3500 organisms per day, and between 0.00 and 1.03 fish per 100,000 gallons of water. The figures also indicate that some of the plants with high capacities, i.e., Waterford 1 and 2, Hawthorn , Labadie, do not necessarily have the highest impingement rates. It is believed that local abundance of fish, i.e. higher productivity, is largely responsible for the greater rates of impingement at Sioux, Riverside, Meramic, and Wood River (Upper Mississippi River Conservation Comm. 1979). The greater presence of sloughs, oxbows, shoals and backwaters in this portion of the Mississippi Basin is considered to contribute to this increase in productivity in comparision with the lower basin. These factors, in addition to plant design and capacity, are considered later in estimating impingement at Waterford 3.

In the Waterford 3 Environmental Report, Operating License Stage, it was estimated that the organisms which should dominate impingement samples at Waterford 3 would be: (1) blue and channel catfish; (2) freshwater drum; (3) gizzard and threadfin shad, and; (4) river shrimp. That appraisal was based on their abundance at Waterford, and their impingement by Waterford 1 and 2, and, in general, their susceptibility to impingement at power plant intakes.

It may be noted that striped mullet was identified as being a dominant species in the river at Waterford 3, as discussed in Section 3.4. It was not, however, impinged in high numbers at Waterford 1 and 2, which may be due, in part, to its greater abundance in the surface waters and, in part, by its strong swimming ability and tendency to respond effectively to intake water currents (Rulifson and Huish, 1975). In situations where generating stations, utilizing once-through cooling from surface water intakes, are located in areas of very high mullet abundance, this species has been found to comprise very small percentages of the impingement collections (Hogarth, 1979, MacPherson, 1977, Southwest Research Association, 1977). Therefore, because of its very low susceptibility to impingement, striped mullet is not considered to be a dominant species in this analysis although it occurs in relatively high abundance in the river.

Table 6-2 presents point (mean) and interval (standard deviation) estimates of volumetric rates (per 100,000 gal) of impingement of the four susceptible groups over all stations studied in this document. This table shows that, as an initial first approximation, impingement rates could be expected to be approximately 700 organisms per day, plus or minus 600, for a plant located somewhere within these river systems. This would appear to be an oversimplification; however, as developed in the following analysis, the predicited impingement at Waterford 3 is estimated to average about 900 organisms per day as a reasonable estimate, and range upward to probable maximum of about 2000 organisms per day.

6.4.2 ESTIMATED IMPINGEMENT AT WATERFORD 3

This section describes the prediction of impingement rates for fish and

shell fish species, and includes discussion of the characteristics of each species which were considered in deriving the predictions.

6.4.2.1 Methods of Estimation

The method of estimating impingement is based on appraisals of where, in a range of possible volumetric impingement rates, Waterford 3 impingement would be expected to lie. This has been done for each of the important species identified in the previous section, with total impingement representing the sum of these species-rates, plus an amount of impingement expected to be associated with all "other species". These "other species," including striped mullet have been taken to compromise an average of 5% of the expected Waterford 3 impingement rate, based on Waterford 1 and 2 experience, baseline data presented in the Waterford 3 Environmental Report, and knowledge of a species susceptibility to impingement.

In order to predict the percent composition of impingement at Waterford 3 based on experience at other generating stations, it was first necessary to look at each of the other generating stations impingement rates as though the shads (gizzard and threadfin) were not present. This is because a species such as shad may be impinged in such high and variable numbers that it completely obscures patterns among other species. Figure 6-5 presents volumetric rates of shad impingement, versus impingement of all other species, at the stations studied. Table 6-3 presents similar information; in particular the percentages of shads impinged relative to the percentage of other species impinged at these stations.

From Figure 6-5 and Table 6-3 it can be seen that the lower Mississippi stations impinge relatively much lower numbers of shad, compared to other species, than the central Mississippi and Ohio stations. As pointed out earlier, this is attributed to the greater susceptibility of shad in more northern waters, the design of the intakes (lower Mississippi River intakes draw primarily from bottom waters), and a greater productivity of the more northern waters, with the exception of the Missouri which is channelized significantly.

It is estimated that the impingement of the shad species will be about 45% of the total impingement by Waterford 3. Forty-five percent is significantly higher than that experienced at the lower Mississippi Basin intakes (Waterford 1 and 2 and Willow Glen 1 and 4), which indicate shad to be impinged at a level of about 15%. However, it is within the lower end of the range of percent composition of shad by the remaining stations studied as shown in Table 6-3. This table shows that the other stations had a range of 37% to 93%. The estimate of 45% shad impingement by Waterford 3 is based on two assumptions:

1) Shad will be more susceptible to impingement by Waterford 3 than Waterford 1 and 2 or Willow Glen 1 and 4 because the Waterford 3 intake will draw from a geater portion of the water column, however;

2) Shad will be less susceptible to impingement at Waterford 3 than at the more northern stations due to higher water temperatures in the winter and a generally lower productivity of shad in the lower Mississippi.

In the following analysis, the blue catfish, channel catfish, and drum impingement rates were estimated independently on the basis of volumetric rates of impingement experienced at other stations. This estimate was modified by judgements about these species susceptibility to impingement by the Waterford 3 intake because of its design and because of the lower productivity of the Mississippi River in this area. This analysis leads the conclusion that these three species would account for approximately 50% of the total impingement by Waterford 3. This conclusion is based principally on the fact that Waterford 3 will not draw river water solely from bottom layers, as does the Waterford 1 and 2 intake.

The 50% proportion of the total impingement expected to be drum and catfish can then be added to the estimated 45% proportion for shad. The postulated ratio of 5% of the total for all "other species" can then be added to account for the total impingement by Waterford 3. Through the development of these ratios, calculation of the predicted impingement rate for catfish

and drum will allow the derivation of the impingement rate for the remaining species. Impingement rates for river shrimp are determined independently.

6.4.2.2 Fish Impingement Rates

1) Blue Catfish

Blue catfish were the most abundant species found in the Waterford 1 and 2 impingement study. Excluding shad, blue catfish comprised 55% of the total remaining specimens collected at Waterford 1 and 2; and 23% and 8% of the total remaining specimens at the two Willow Glen intakes. At the more northern intakes, it comprised only about 1% of the remaining specimens.

These percentages suggest that similarities in the design and/or location of the lower basin intakes account for the relatively higher impingement rates for blue catfish. Blue catfish are more abundant in the lower reaches of the basin then they are further north, and they generally dwell on or near the river bottom. Therefore, as the comparison of the percentages impinged indicate, blue catfish are relatively more susceptible to impingement by intakes of the design (inverted pipes) and locational characteristics of Waterford 1 and 2 and Willow Glen 1 and 4.

The volumetric rates of impingement of blue catfish are given for all of the study stations in Figure 6-6. Averages are shown to be 0.034 fish per 100,000 gallons for Waterford 1 and 2, 0.003 for Willow Glen 1 and 0.002 for Souix. A conservative rate of impingement for Waterford 3 can be predicted as 0.030 fish per 100,000 gallons, based solely on its close proximity to Waterford 1 and 2. This rate can be anticipated to be a likely maximum rate of impingement of blue catfish by Waterford 3, due to the lack of consideration of the design differences. At this rate, a likely maximum of 131,000 blue catfish per year can be predicted for Waterford 3, assuming an average withdrawal rate of 8.3 $x10^5$ gpm. When the design differences between Waterford 1 and 2 and Waterford 3 are considered, it is more likely that Waterford 3 will impinge approximately 0.02 blue catfish per 100,000 gallons withdrawn. This lower rate can be assumed to be due to the greater

susceptibility of blue catfish to withdrawal and impingement by the upward extraction of bottom waters through the inverted pipe of the Waterford 1 and 2 intake.

If the average weight of 0.02 pounds per fish is assumed, based on data from the study at Waterford 1 and 2, the intake serving Waterford 3 will impinge an expected maximum of approximately 2600 lb/yr of blue catfish; however, a more likely rate is 1700 lb/yr. These estimates are shown in Table 6-4.

2) Channel Catfish

The average rates of channel catfish impinged per 100,000 gallons entrained for the stations studied is shown in Figure 6-7. The rate for this species experienced at Waterford 1 and 2 was 0.003 fish per 100,000 gallons, which is too small to be indicated on the scale utilized in this figure. This low rate of impingement of channel catfish, given the assumption that the Waterford 1 and 2 intake would be selective for this species because of its design, indicates that channel catfish are relatively much less abundant in this area of the river.

The prediction for the range of impingement of this species by Waterford 3 can be derived in the same manner as the range for blue catfish. A conservatively predicted maximum rate for Waterford 3 would be 0.003 fish per 100,000 gallons, or 13,100 fish per year. Using the average weight per fish, gained from the Waterford 1 and 2 study, a likely maximum weight of 650 lb/yr of channel catfish would be impinged by Waterford 3. A more realistic average rate can be expected to be approximately 0.002 fish per 100,000 gallons or 8700 fish per year. This would be equivalent to about 400 lb/yr, based on an average size of 0.05 pounds per fish. Table 6-4 includes these estimates.

3) Freshwater Drum

The average numbers of freshwater drum impinged per 100,000 gallons at each of the stations studied is given in Figure 6-8. The relatively higher

rates of drum impingement which occurred at the Riverside intakes, when viewed in light of their relatively lower withdrawal (as shown in Table 6-1) indicate that a much higher abundance of drum occurs in the Mississippi near this station than at the others. Given this assumption , a likely maximum rate of drum impingement was predicted for Waterford 3 based on the average of all stations except Riverside. This average is 0.02 fish per 100,000 gallons of water, or 87,000 drum per year. The actual drum impingement rate observed at Waterford 1 and 2, which can be expected to be selective for drum because of its withdrawal from near the river bottom, is 0.01 fish per 100,000 gallons. The maximum rate predicted for Waterford 3 is greater than this, which is not likely to occur. A more realistic level of impingement of drum by Waterford 3 would be estimated to be 44,000 per year. At an average fish size of 0.09 pounds per fish, it can be predicted that Waterford 3 will impinge 4000 lb/yr under average circumstances. These figures are also given in Table 6-4.

4) Shad

It has been assumed that shad would comprise 45% of the total impingement by Waterford 3, and that combined catfish and drum impingement will constitute 50%. The sum of the maximum volumetric rates estimated above for catfish and drum is 0.053 fish per 100,000 gallons. Utilizing simple ratios, the maximum likely rate of shad impingement is predicted to be 0.048 shad per 100,000 gallons. This rate is derived as follows:

$$\frac{0.053}{50} = \frac{x}{45}$$

$$50(x) = (0.053)\ (45)$$

$$x = 0.0477$$

A similar computation for predicting the likely average rate for shad impingement results in 0.029 shad per 100,000 gallons withdrawn, given a likely average combined rate of 0.032 fish per 100,000 gallons for catfish and drum.

The predicted likely maximum and average rates for shad impingement by Waterford 3 are higher than the 0.01 to 0.02 shad per 100,000 gallons calculated for Waterford 1 and 2 and Willow Glen. It can be anticipated that Waterford 3 will impinge shad at this higher rate due to its withdrawal from the entire water column. However, the Waterford 3 predicted rates are lower for shad than those experienced at the more northern stations, because of the warmer winter water temperatures and resultant lower susceptibility of shad to impingement during this portion of the year.

Table 6-4 shows that the impingement of shad can be conservatively predicted to be between a maximum of 210,000 fish per year and an average of 125,000 fish per year. This would imply an estimated maximum annual loss of 17,000 pounds of shad or an average loss of 10,000 pounds, based on an average weight of 0.08 pounds per fish. This poundage of shad is based on an assumed impingement of equal proportions of gizzard and theadfin shad, with average weights of 0.15 and 0.01 pounds per fish, respectively.

5) Other Fish Species

The method utilized to derive the volumetric impingement rate for shad can be applied to this group of species. This yields a prediction of an estimated maximum of 0.005 fish per 100,000 gallons and a more likely rate of 0.003 fish per 100,000 gallons. Table 6-4 presents the range of annual impingement rates for these species, as well as the number per year and the pounds per year which can be predicted.

6.4.2.3 River Shrimp Impingement Rates

The river shrimp is a species of crustacean which is abundant at Waterford and in other areas of the lower Mississippi River. Impingement of river shrimp was not reported by any facilities other than Waterford 1 and 2 and Willow Glen, but its range is quite wide. Thus the prediction of impingement for river shrimp at Waterford 3 is based upon a limited data base and upon the biology of the species.

Average impingement of river shrimp was found to be less than 0.005 organims per 100,000 gallons at Willow Glen 4, about 0.08 per 100,000 gallons at Willow Glen 1, and approximately 0.08 per 100,000 gallons at Waterford 1 and 2. These rates are shown in Figure 6-9. These intakes draw water from near the bottom, where shrimp are more likely to occur, and are expected to result in higher rates of impingement than Waterford 3.

Nevertheless, a likely maximum rate of impingement of 0.06 shrimp per 100,000 gallons by Waterford 3 has been postulated from the average of the rates of Waterford 1 and 2 and Willow Glen 1 and 4. This rate, expressed on an annual basis, is equivalent to 260,000 shrimp per year or 1040 pounds per year, using an average weight of 0.004 pounds per shrimp.

A more realistic rate of shrimp impingement can be estimated to be 0.01 individual per 100,000 gallons, which is equivalent to 44,000 shrimp or 180 pounds per year. This information is also included in Table 6-4.

6.4.3 TOTAL IMPINGEMENT BY WATERFORD 3

From these estimates, a likely maximum rate of impingement by Waterford 3 can be predicted to be 0.106 fish per 100,000 gallons, or 463,000 fish per year, and 0.60 shrimp per 100,000 gallons, or 260,000 shrimp per year. Thus a total maximum impingement of approximately 720,000 organisms per year can be expected. This prediction has been based on conservative assumptions, explained above, and can be considered to be an upper limit to the rate of impingement which can be expected.

The more likely rate of impingement by Waterford 3 is anticipated to be 0.064 fish per 100,000 gallons, or 277,000 fish per year. River shrimp are predicted to be impinged at 0.010 shrimp per 100,000 gallons, or 44,000 pounds per year.

This range of impingement will not necessarily result in permanent loss of this weight of organisms from the Mississippi River each year. The sluice return system, incorporated into the intake structure design, can be anticipated to return some of the organisms to the river in a condition which

would result in their survival. It should also be noted that, as discussed in Section 3.6.1, Waterford 3 is not expected to operate about 11% of the time on an annual basis. Nevertheless, to be consistent with the conservative approach utilized above, the following analysis of the effects of impingement on the environment will utilize the rates predicted and assume that the organisms are lost to the Mississippi River.

6.5 THE EFFECT ON THE MISSISSIPPI RIVER OF IMPINGEMENT BY WATERFORD 3

To evaluate the effect of the predicted range of impingement of aquatic organisms by Waterford 3 to the Mississippi River as a whole, the poundage estimated to be lost because of impingement can be compared to the commercial fish landings. This is one of the few measures available to quantifiably place the economic value of impingement losses in perspective, and has been utilized in other analyses of this type (Equitable Environmental Health, Inc, 1976a and 1976b). This comparison could be done both in terms of poundage and dollar value. However, the comparison of poundage of fish impinged to poundage of commercial catch is misleading. The average weight of each organism impinged is likely to be significantly below that of a commercial-sized specimen. Direct comparison of poundage of the smaller, younger impinged fish to the poundage of commercial landings overlooks the the natural and man-made mortality to the population that occurs as the fish mature. It is necessary, therefore, to establish a measure by which the value of the fish impinged can be effectively compared to commercial use of this resource.

The American Fisheries Society has calculated the costs of raising an individual fish of a designated species to a specified size (AFS, 1975). This value may be termed the "replacement cost" for an individual fish, and has been utilized to determine the compensation for the loss of fish due to water pollution. For consistency, these costs are compared to the value of commercial landings for 1975.

Utilizing the average length of the individual impinged fish measured during the Waterford 1 and 2 impingement study, and the number per year of that species expected to be impinged, the total replacement cost for the species can be calculated. Table 6-5 lists these values for catfish, drum, and shad, which together, have been predicted to constitute 95% of the total fish impinged by Waterford 3. The remaining 5% in the impingement of "other species" of fish, and the replacement cost for this group is taken at 5% of the total costs for the catfish, drum and shad. A replacement cost for river shrimp, by length, could not be located. Therefore, to complete Table 6-5, the cost for shrimp was calculated from the 1975 dollar per pound value reported for shrimp taken in the Inland District of the State of Louisiana (NOAA, 1976). The fishing districts of the state are shown in Figure 6-10. Table 6-5 reports these costs for both the predicted likely maximum and coverage rate of impingement by Waterford 3.

Table 6-5 indicates that the total costs of the fish and shellfish expected to be impinged ranges from a high of approximately $19,000 per year to an average of $10,000 per year. These values may be compared to the 1975 total value for the Inland District for fish and shellfish of $2.95 million (NOAA, 1976). Therefore, at the maximum predicted rate, the annual replacement costs for impingement is less than 0.7% of the value of this districts commercial landings. The replacement costs at the average rate would be less than 0.4% of this value. If the 1975 data included in Table 3-24 (Mississippi River between Baton Rouge and the mouth) are used for comparison, the maximum replacement cost for impingement losses is only about 4.5% of the 1975 catfish, drum and shrimp commercial value alone.

In evaluating the significance of this comparison, it is important to note that the fisheries resources of the Mississippi River make a very small contribution to the commercial landings in the Inland District. The Atchafalaya River and the surrounding bayous are the source of the great majority of the districts' commercial landings (National Marine Fisheries Ser., 1979).

Therefore, even at the expected maximum rate, it is apparent that, impingement by Waterford 3 will represent an insignificant economic effect to the fisheries resources of Louisiana and the Inland District. The loss contributed by Waterford 3 is also from a water source which has minimal contribution to these resources. The maximum replacement cost of less than 0.7% of the commercial value is easily obscured by the annual variation in the economic values of the district's landings, which between 1972 and 1977, ranged from an annual dollar increase of 43% to a decrease of 18% from the preceeding year.

An evaluation of the ecological effect of the predicted rate of impingement is much more difficult than an analysis of effect to the commercial fisheries resources. Sufficient information is not available to quantitatively define the fish population which occurs in this reach of the Mississippi, or to identify accurately the method of recruitment to that population. Therefore a quantified estimate of changes to the population is not possible. Even if a quantification of the change were possible, it would be highly speculative to predict the long-term effects to the entire ecosystem.

The volumetric impingement rate predicted for Waterford 3 varies between 0.106 to 0.064 fish per 100,000 gallons. As can be seen from Figure 6-4, this range is within the lower rates that were determined for the other stations studied. In view of this, there is no reason to assume that the ecological effects of impingement by Waterford 3 will be significant.

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LE 6-1

LOCATION, DESIGN AND OPERATION OF INTAKES AT THE ELEVEN STUDY STATIONS AND AT WATERFORD 3

Facility	Intake Type	Location of Intake	Average Intake Capacity (cfs)	Average Intake Velocity (fps)	Water Recirculated For Ice Control
Waterford 1 and 2	Offshore (inverted pipe)	Outer edge of shoal	870	1.3	No
Waterford 3	Shoreline	Straight shoreline	1840	1.3	No**
{ Willow Glen 1	Offshore (inverted pipe)	Outer bank of Meander	200	1.6	No
{ Willow Glen 4	Offshore (horizontal pipe)	"	400	1.2	No
Wood River	Shoreline	Straight shoreline	600	1.0	Yes
Meramec	Shoreline	"	760	1.4	Yes
Sioux	Canal	"	830	1.4	Yes
{ Riverside Old	Shoreline	"	20	1.4	Yes
{ Riverside New	Shoreline	"	50	1.4	Yes
Labadie	Shoreline	Pooled River	1610	3.0	Yes
Hawthorn	Shoreline	Straight River	580	0.3	Yes
Council Bluffs	Shoreline	Outer bank of Meander	140	1.3	Yes
Gallagher	Shoreline	Outer bank of Meander	410	0.9	Yes

** Under influence of discharge from Waterford 1 and 2

TABLE 6-2

MEAN ($\bar{x}$) IMPINGEMENT PER 100,000 GALLON WITH STANDARD DEVIATION (S.D.) AND STANDARD ERROR ($SD/\sqrt{n}$) OF ESTIMATE BY SPECIES

	$\bar{x}$	S.D.	$SD/\sqrt{N}$
Blue Catfish	.003	.010	.003
Freshwater Drum	.030	.038	.021
Channel Catfish	.005	.013	.004
River Shrimp*	.041	.040	.023
Shad	.236	.290	.087
Total Organisms	.30	.33	.10
Average Numbers/24 Hrs. (all stations)	676	1030	286

Mean Number/24 Hrs $\pm$ 2 $SD/\sqrt{N}$ = 104 to 1248/24 Hrs.

* Not recorded at all stations

TABLE 6-3

NUMBER OF SHAD IMPINGED AS A PERCENTAGE OF TOTAL IMPINGEMENT

River Basin	Plant	Capacity (cfs)	Avg Daily Impingement	Shad* (%)
Ohio	Gallagher	412	321	71
Missouri	Council	137	2	75
	Hawthorn	580	14	37
	Labadie	1609	81	81
Central Mississippi	Wood River	515	1481	78
	Sioux	826	3521	91
	Riverside (old)	17	52	68
	Riverside (new)	47	364	85
	Meramec	756	1708	93
Lower Mississippi	Willow Glen 1	197	70	15
	Willow Glen 4	395	14	15
	Waterford 1 and 2	869	921	13

*Gizzard and/or threadfin

TABLE 6-4

ESTIMATED NUMBER OF ORGANISMS TO BE IMPINGED AT WATERFORD 3

FISH - LIKELY MAXIMUM

Species	Vol. Rate per 100,000 Gal	No./Yr*	Lbs/Yr**
Blue Catfish	.030	131,000	2,600
Channel Catfish	.003	13,000	650
Drum	.020	87,000	8,000
Shad	.048	210,000	17,000
Other	.005	22,000	-
TOTAL	.106	463,000	28,250

FISH - LIKELY AVERAGE

Species	Vol. Rate per 100,000 Gal	No./Yr*	Lbs/Yr**
Blue Catfish	.020	87,000	1,700
Channel Catfish	.002	8,700	400
Drum	.010	44,000	4,000
Shad	.029	125,000	10,000
Other	.003	13,100	-
TOTAL	.064	277,800	16,100

Shrimp

Species	Vol. Rate per 100,000 Gal	No./Yr*	Lbs/Yr**
Likely Maximum	.060	260,000	1,040
Likely Average	.010	44,000	180

* At average intake rate of 8.3×10^5 gpm

**At average weights of individual commercially important fish impinged at Waterford 1 and 2.

TABLE 6-5

ECONOMIC COSTS OF PREDICTED IMPINGEMENT BY WATERFORD 3

Species	Average Length per Specimen*	Replacement Cost per Specimen**	No/Yr Predicted to be Impinged	Total Replacement Cost
LIKELY MAXIMUM				
Blue Catfish	3.3 in.	$0.05	131,000	$ 6,550
Channel Catfish	2.9 in.	$0.05	13,100	$ 655
Drum	2.7 in.	$0.06	87,000	$ 5,220
Shad	2.9 in.	$0.02	210,000	$ 4,200+
Other Fish Species+	-	-	-	$ 831
Shrimp++	-	$1.43/lb++	1,040 lb++	$ 1,487++
			TOTAL	$18,943
LIKELY AVERAGE				
Blue Catfish	3.3 in.	$0.05	87,000	$ 4,350
Channel Catfish	2.9 in	$0.05	8,700	$ 435
Drum	2.7 in	$0.06	44,000	$ 2,640
Shad	2.9 in	$0.02	125,000	$ 2,500+
Other Fish Species+	-	-	-	$ 496
Shrimp++	-	$1.43/lb++	180 lb++	($ 257++
			TOTAL	10,704

* From Waterford 1 and 2 impingement study.

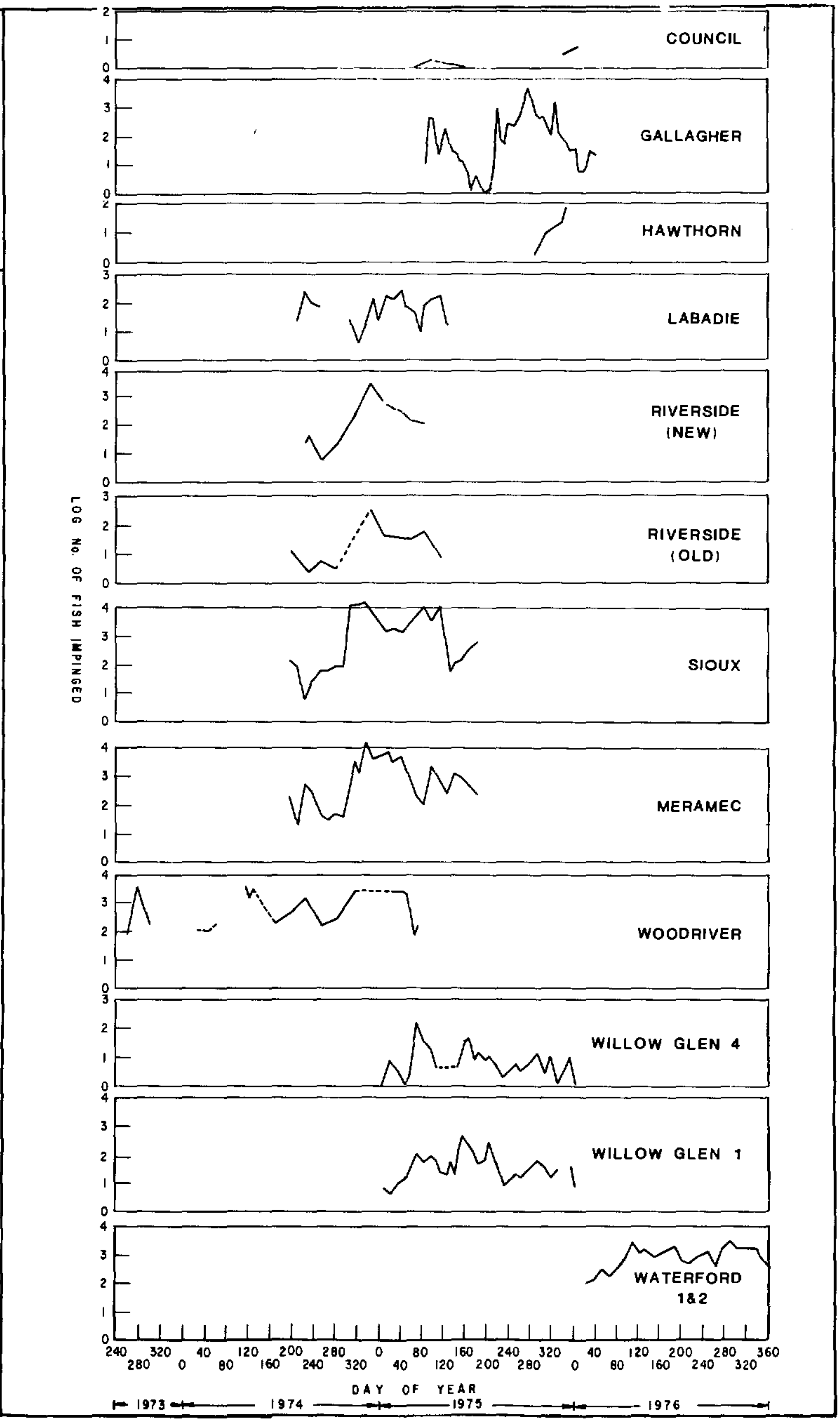
** Based on hatchery costs given in: American Fisheries Society, The Pollution Committee, Southern Division, "Monetary Values of Fish". 1975.

+ Calculated value as 5% of total replacement costs of catfish, drum, and shad; based on proportion of total fish predicted to be impinged.

++ A hatchery cost per shrimp is not available. Costs, therefore, are calculated on basis of 1975 values per pound for shrimp from the Inland District of Louisiana.
National Marine Fisheries Service, "Current Fisheries Statistics No. 6922, Louisiana Landings, Annual Summary 1975".

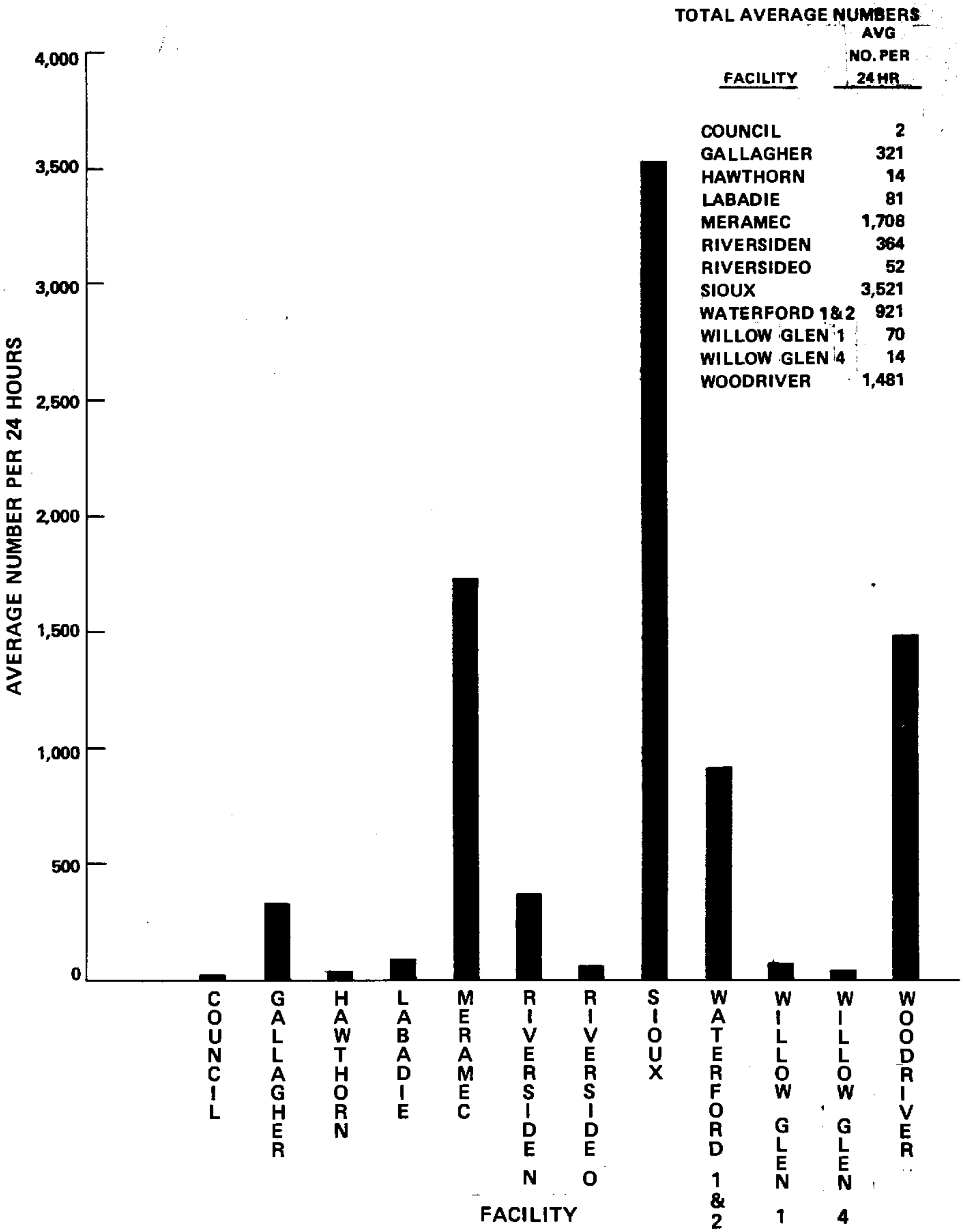
LOUISIANA POWER & LIGHT Co. Waterford Steam Electric Station	LOCATION OF ELECTRIC GENERATION FACILITIES INCLUDED IN IMPINGEMENT ANALYSIS	FIGURE 6-1

LOUISIANA POWER & LIGHT Co
Waterford Steam Electric Station



NUMBER OF FISH AND CRUSTACEANS IMPINGED PER 24 HOURS AT ALL STATIONS

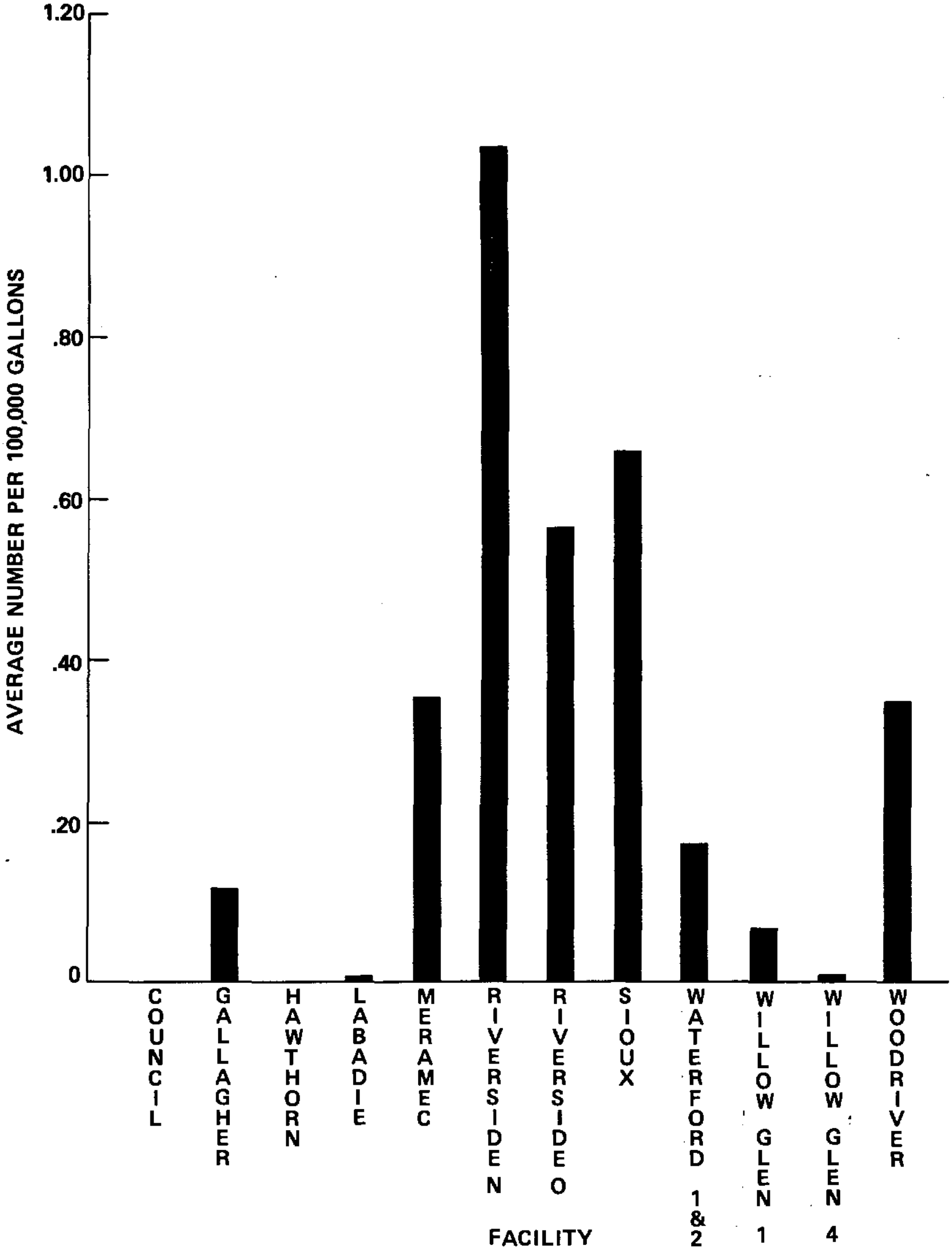
Figure 6-2



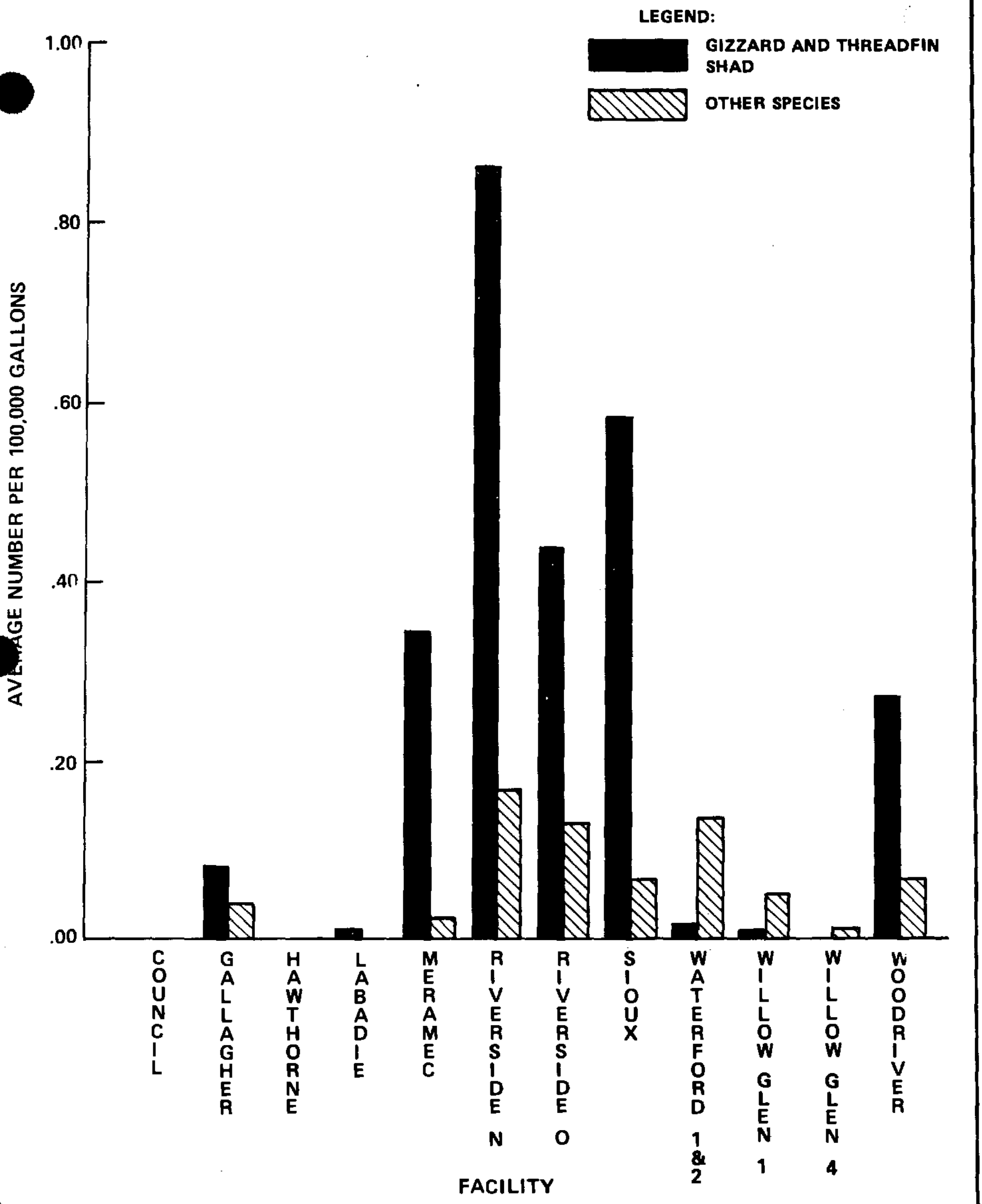
TOTAL AVERAGE NUMBERS

FACILITY	AVG NO. PER 24 HR
COUNCIL	2
GALLAGHER	321
HAWTHORN	14
LABADIE	81
MERAMEC	1,708
RIVERSIDEN	364
RIVERSIDEO	52
SIOUX	3,521
WATERFORD 1&2	921
WILLOW GLEN 1	70
WILLOW GLEN 4	14
WOODRIVER	1,481

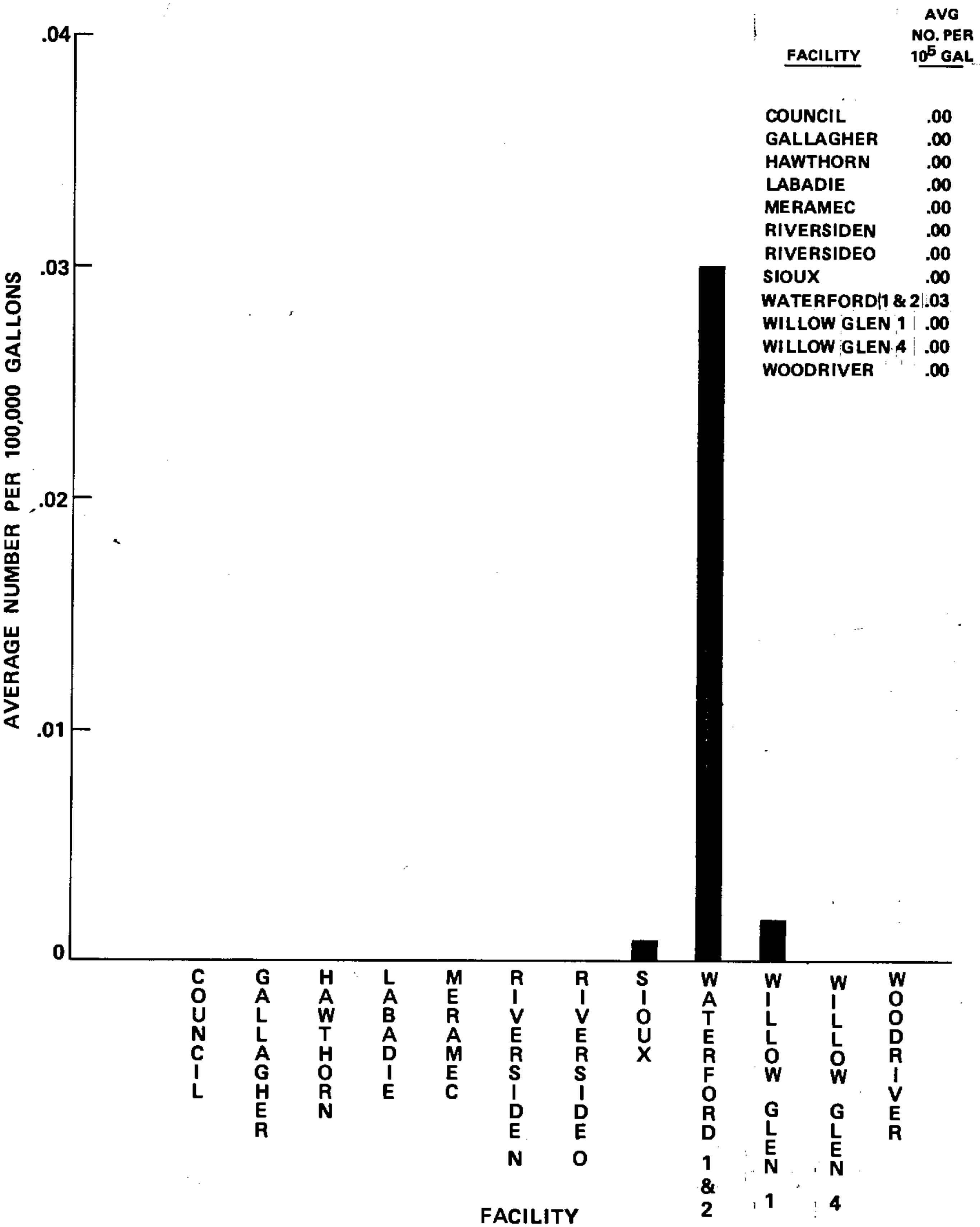
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF FISH AND CRUSTACEANS IMPINGED PER 24 HOURS	Figure 6-3



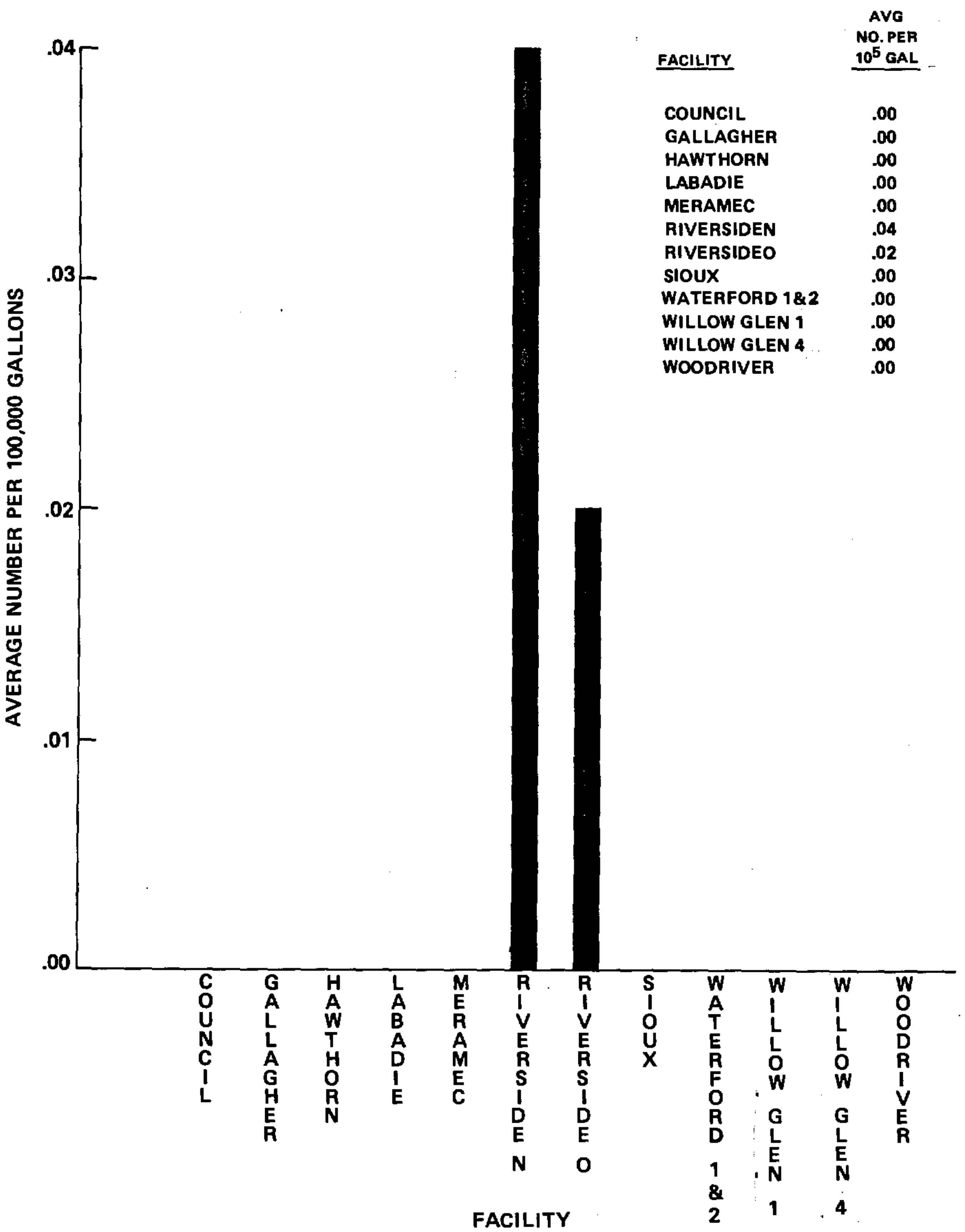
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF FISH AND CRUSTACEANS IMPINGED PER 100,000 GALLONS OF WATER ENTRAINED	Figure 6-4



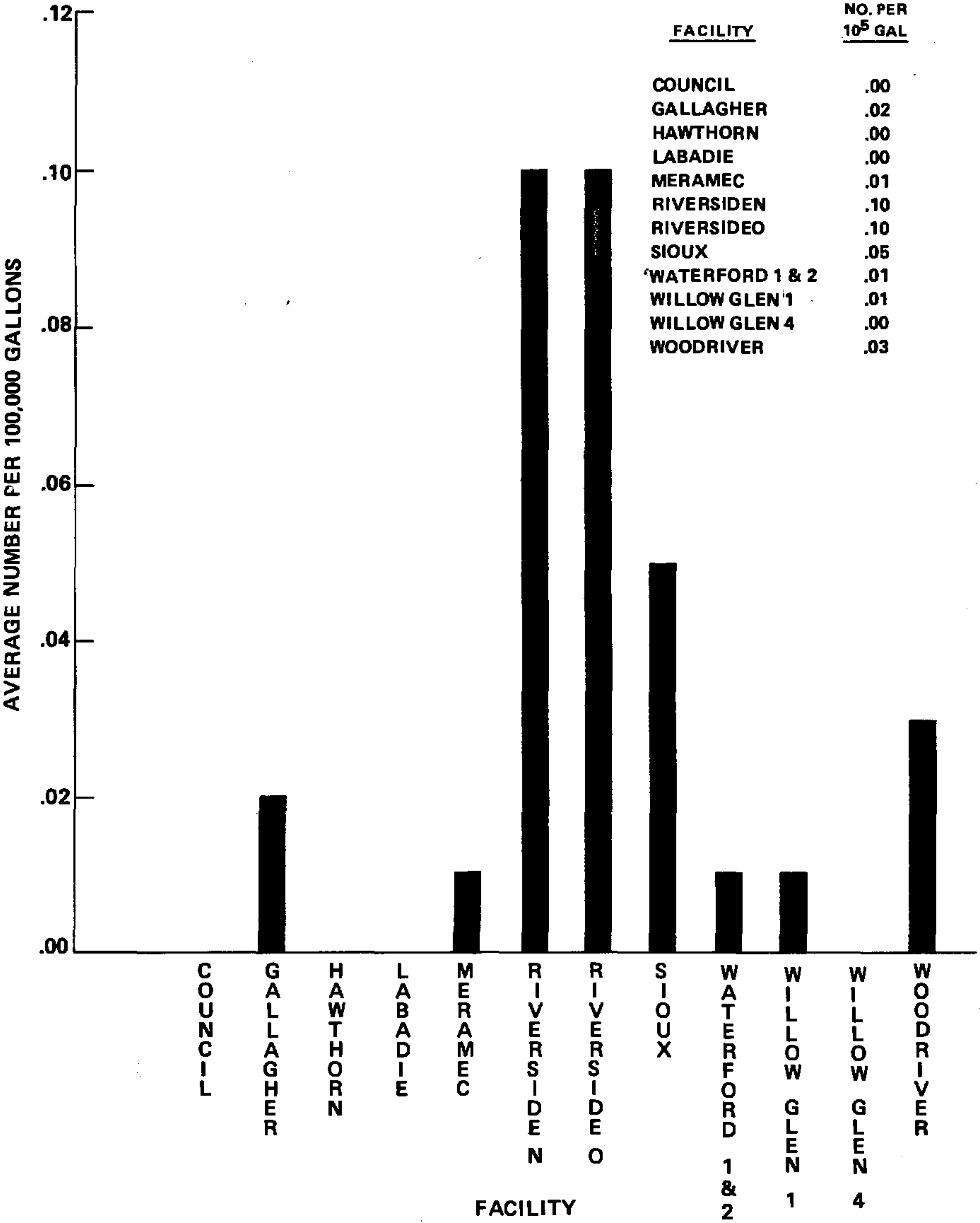
LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF GIZZARDS & THREADFIN SHAD IMPINGED PER 100,000 GALLONS OF WATER ENTRAINED, RELATIVE TO IMPINGEMENT OF OTHER SPECIES	Figure 6-5



LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF BLUE CATFISH IMPINGED PER 100,000 GALLONS OF WATER ENTRAINED	Figure 6-6

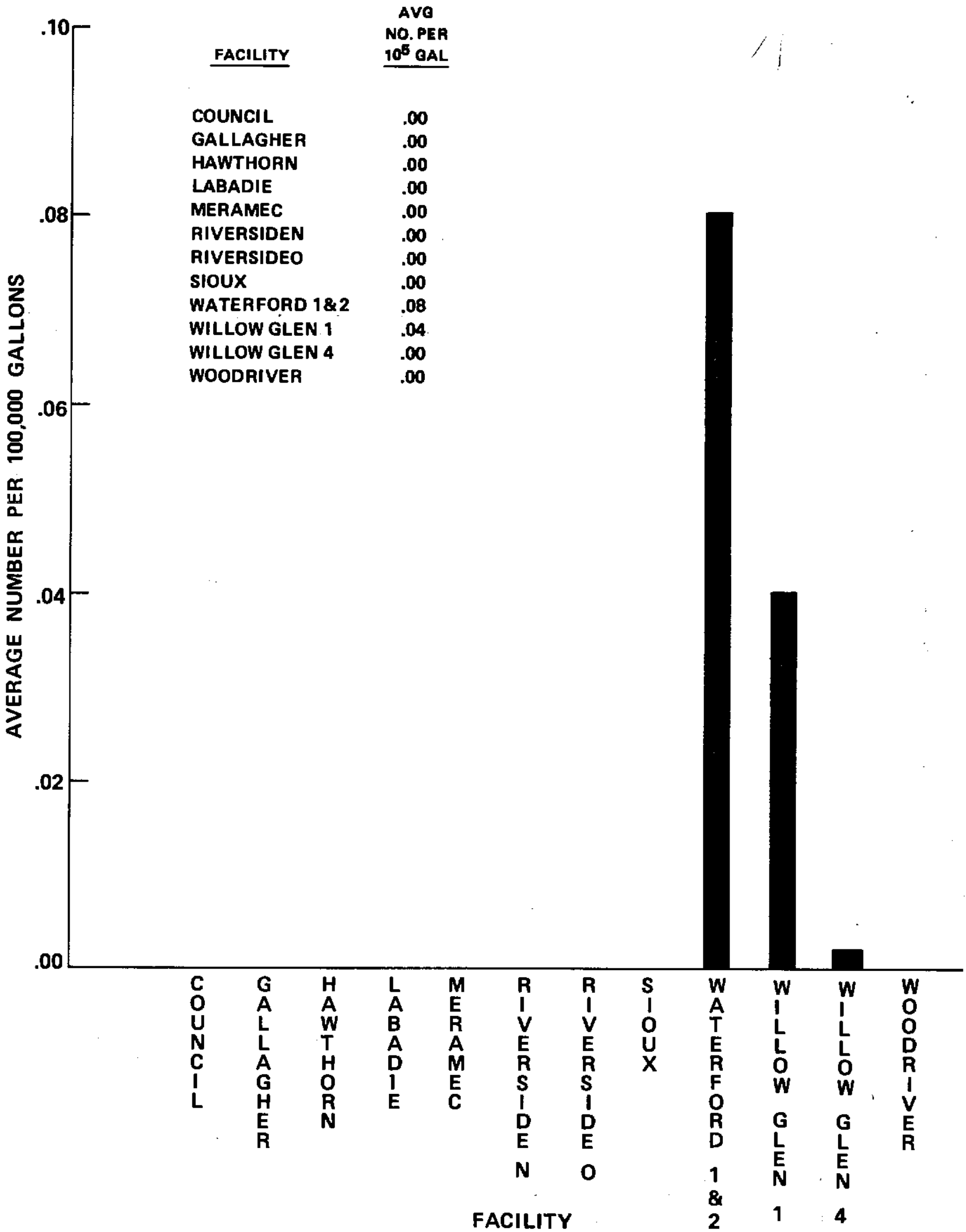


LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF CHANNEL CATFISH IMPINGED PER 100,000 GALLONS OF WATER ENTRAINED	Figure 6-7



FACILITY	AVG NO. PER 10^5 GAL
COUNCIL	.00
GALLAGHER	.02
HAWTHORN	.00
LABADIE	.00
MERAMEC	.01
RIVERSIDEN	.10
RIVERSIDEO	.10
SIOUX	.05
WATERFORD 1 & 2	.01
WILLOW GLEN 1	.01
WILLOW GLEN 4	.00
WOODRIVER	.03

LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF FRESHWATER DRUM IMPINGED PER 100,000 GALLONS OF WATER ENTRAINED	Figure 6-8



LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	AVERAGE NUMBER OF RIVER SHRIMP IMPINGED PER 100,000 GALLONS OF WATER ENTRAINED	Figure 6-9

Source: U S Dept of Commerce, National Oceanic and Atmospheric Administration National Marine Fisheries Service

In cooperation with the Louisiana Wild Life and Fisheries Commission, Division of Oyster and Water Bottoms and Commercial Seafood, New Orleans, Louisiana 70130

LOUISIANA POWER & LIGHT Co. Waterford Steam Electric Station	FISHING DISTRICTS OF LOUISIANA	FIGURE 6-10

APPENDIX A

APPENDIX A

Methods-Preoperational Environmental Monitoring Program

Prior to beginning the Preoperational Environmental Surveillance Program, the effects of the operation of Waterford 3 on aquatic life were initially predicted on the basis of a literature review and a pilot sampling program which is described in the Construction Permit Environmental Report. The Environmental Surveillance Program is a more intensive sampling and analysis of the aquatic communities of the Mississippi River near Waterford 3, and is providing additional data necessary for a more accurate assessment of baseline conditions and environmental impact.

This section describes the Preoperational Environmental Surveillance Program, conducted by Gulf South Research Institute, New Iberia, La., between April 1973 and September 1976.

Sampling Schedule and Locations

Preoperational aquatic ecology data were collected on a monthly basis from April, 1973 to May, 1974 (Year I), and from October, 1975 to September, 1976 (Year III), and on a seasonal basis from June, 1974 to August, 1975 (Year II).

The sampling locations are given in Figure A-1 which also summarizes the type of biological sampling conducted at each station. A description of each station and the rationale for its selection is given in Table A-1. The important characteristics of each station, relative to the aquatic biology portion of the Environmental Surveillance Program, can be further described as follows:

a) Station A_c - Habitat characterized by shallow depths and low velocity currents; used as control station

b) Station A_t - Habitat characterized by shallow depths and low velocity currents; affected by heated discharge from Waterford 1 and 2

c) Station B_c - Habitat characterized by deep, fast-current water; used as control station

d) Station B_t - Habitat characterized by deep, fast-current water; to be affected by heated discharge of Waterford 3

e) Station B_{t1} or Btl* - Habitat characterized by deep, fast-current water; to be affected by heated discharge of Waterford 3 (small temperature changes). In discussions of Years II and III data, Btl* is referred to as B_{t1}.

Sampling Methodologies and Statistical Analysis for Years I-III

The methodologies described below have been used in the sampling program completed to date. The schedule and methodologies of the aquatic ecological portion of the Environmental Surveillance Program are summarized in Table A-2.

a) Algae

1) Attached Algae

The benthic and attached algae were surveyed seasonally. Attached algae were collected from naturally occurring solid substrates at each station, while the benthic forms were taken from shallow water sediments. The algae obtained from these collections were preserved, labeled, and transported to the laboratory for identification.

2) Phytoplankton

To sample phytoplankton, a 100 ml subsample was extracted from each of three whole water samples and a 300 ml composite was formed from these subsamples. Samples were preserved with 3 percent buffered formalin.

In the laboratory, slides were prepared from the samples using the method described by Sanford et al [3]. Each slide was divided into forty fields, each with a diameter of 0.41 mm. Phytoplankton were identified and counted using a Zeiss RA research microscope. Keys used for the identification of the algae included:

Hustedt, F - 1930. Bacillariophyta (Diatomeae). In Pascher, A. ed. Die Susswasser. Flora Mittleuropas Heft, 10. G Fischer, Jena, 466 p.

Patrick, R and Reimer, C W - 1966. "The diatoms of the United States, exclusive of Alaska and Hawaii, Vol. I. Fragilariaceae, Eunotiaceae, Achmanthaceae, Naviculaceae". Acad Nat Sci Phil Monogr 13, 688 p.

Patrick, R and Reimer, C W - 1975. "The diatoms of the United States, exclusive of Alaska and Hawaii, Vol. II. Entomoneidaceae, Cymbellaceae, Gomphonemaceae, Epithemiaceae". Acad Nat Sci Phil Monogr 13, 213 p.

Numerically dominant organisms were identified to genus and/or species whenever feasible.

Algae and phytoplankton identifications were verified by Dr. Richard A. Pecora, Univ. of Southwestern Louisiana, Lafayette, La.

3) Productivity

Productivity was measured using the C14 method [4]. The primary productivity bottles were incubated in the laboratory for four hours under high intensity light and ambient water temperature, which probably overestimated actual productivity in the Mississippi River.

b) Zooplankton

Five-minute tows to sample zooplankton were taken at surface, mid-depth and near the river bottom with a metered number six net, which has mesh openings of 0.243 mm. Until February 1975, a net with a mouth diameter of 0.3 meter was used; thereafter a 1/2 meter diameter net was used.

A General Oceanics Model 2030 digital flowmeter, mounted eccentrically on the net, was used beginning in December 1974. However, since flowmeter data from the initial months were unavailable, the average reading for the other months sampled during 1973-1974 was applied to those initial samples.

Each sample was preserved in a solution of 5 percent buffered formalin, labeled and transported to the laboratory. The analysis was conducted by examining ten 1/2 ml aliquots from each sample in Sedgwick-Rafter cells using a Wild compound microscope (12 Power magnification). Determinations of the density of the zooplankton in the samples were made.

Identifications were made using the following references:

Hyman, L H - 1940. The Invertebrates: Protozoa Through Ctenophora .Vol 3. McGraw Hill Book Co., NY. 726 p.

Meglitsch, P A - 1972. Invertebrate Zoology. Oxford Univ Press, NY. 834 p.

Pennak, Robert W - 1953. Freshwater Invertebrates of the United States. The Ronald Press Co., NY. 769 p.

c) Benthic Invertebrates

Beginning in June, 1973, benthic invertebrates were sampled with a Shipek sediment sampler (samples an area 0.04 m^2). A Smith-McIntyre grab sampler (samples an area of 0.1 m^2) was used in addition to the Shipek during the Year II sampling program (June, 1974 - August, 1975). The Smith-McIntyre was only used in August and November 1974, and in April and August 1975. In general, on each sampling date, six benthic samples were taken at each station. However, during August and November 1974, and in April and August 1975, 12 samples were taken (six with each sampler).

The samples were preserved with 10 percent buffered formalin solution, labeled and then transported to the laboratory. The macroinvertebrate samples were filtered through a number 10 and/or 30 sieve, which have openings of 2 mm and 0.595 mm, respectively. Some samples were also filtered through a number 80 sieve (mesh openings of 0.177 mm) and used for microbenthic analysis. Invertebrate organisms were presorted with the aid of a dissecting microscope. Organisms were preserved in a 40 percent solution of isopropyl alcohol. They were then classified to the lowest identifiable taxon using the following references:

Hyman, L H - 1940. <u>The Invertebrates: Protozoa Through Ctenophora</u>. Vol. 3. McGraw Hill Book Co., NY. 726 p.

Meglitsch, P A - 1972. <u>Invertebrate Zoology</u>. Oxford Univ Press, NY. 834 p.

Pennak, Robert W - 1953. <u>Freshwater Invertebrates of the United States</u>. The Ronald Press Co., NY. 769 p.

In those cases where positive identification could not be made, the organisms were shipped for verification to Dr. H. Dickson Hoese, a taxonomic specialist at the University of Southwestern Louisiana, Lafayette, La.

The density of the benthic organisms in each sample was also determined and the results were expressed as numbers per square meter.

d) Fish

Fish populations at each station were sampled by surface trawl, otter trawl, electrofishing and gill net. Midwater (mid-depth) trawls were conducted at all stations, except A_t and A_c, because at these stations, during most seasons, the water was too shallow.

In general, three five-minute otter (bottom), surface and midwater trawls were conducted at each sampling station (except at midwater depths at A_c and A_t) on each sampling date. In July, 1973, however, because fewer fish were being collected, the number of surface and otter trawls was increased to five trawls per station. Other exceptions in sampling frequency are noted in the OLER, Table 6.1.1-7.

The surface trawl was conducted using a circular net having a five foot opening. A 16 foot semi-balloon net was used for the otter trawl. The midwater trawl had a 64.56 ft^2 opening and was 47.2 ft. long. The body of the net had a 1 inch bar mesh (1.5 inch stretch mesh) and the bag had 0.25 inch bar mesh and a 1 inch stretch mesh.

Experimental gill nets, consisting of five 25 foot panels of 1 inch, 1.5 inch, 2 inch, 3 inch and 4 inch bar mesh, were set for 48 hours at each station. Experimental gill nets, which trap different size fish by snagging their gill covers or other body parts with appropriately sized mesh openings, use panels of different mesh sizes to catch a representative sample of fish living in the area being sampled. Electrofishing, which sends an electrical current through the water, thereby shocking fish and permitting their collection, was conducted using a high-voltage, pulsating, D C electric shocker. The actual shocking time, 2 hours, was controlled by a timer that is an integral part of the unit.

Each specimen was weighed to the nearest tenth of a gram and measured to the nearest millimeter. The data were recorded on survey sheets.

e) Ichthyoplankton

During the 1973-1974 study (Year I), ichthyoplankton (drifting fish eggs and larvae) were collected in the zooplankton samples.

However, during Year II and Year III sampling, ichthyoplankton were also collected using a number zero (0.571 mm mesh opening) plankton net with a 1/2 meter diameter mouth opening. Five minute tows were conducted at the surface and bottom of stations A_c and A_t, and at the surface, bottom and mid-depth of stations Bc, Bt and B. Additional ichthyoplankton sampling was conducted twice monthly from June-August 1976. The samples were preserved and the densities of the ichthyoplankton in the samples were determined in the same manner as were zooplankton densities.

Identifications of ichthyoplankton were made using:

> A preliminary Key to the Identification of Larval Fishes of Oklahoma, with Particular Reference to Canton Reservoir, Including a Selected Bibliography. Oklahoma Department of Wildlife Conservation. 42 pp.

This was one of the few readily available keys at that time for identifying freshwater ichthyoplankton. Identification was made to the family level.

Impingement Study at Waterford 1 and 2

In order to determine which species would be subject to impingement at Waterford 3 and to develop a first approximation of numbers and biomass of organisms which might be impinged there, a screen wash study was conducted

at Waterford 1 and 2, which are operative. The study was done from February 1976 to January 1977. It involved semi-monthly monitoring at the intake screening structures of Waterford 1 and 2.

A 24-hour period was sampled on each sampling date. The screens were rotated, washed and cleared at the outset of each period. Baskets were then placed in series within the sluiceway carrying impinged organisms back to the waterbody, as shown in Figure A-2. Two 1/4" expanded metal baskets were placed closest to the screens; a 1/2" hardware cloth basket was placed behind them as a backup. Collections were made when one or more screens were in operation during the 24-hour sampling period.

All organisms collected during each sampling period were identified to species level, except when the organism's physical condition precluded identification. Physical injuries were noted. All fish and crustaceans were individually weighed and measured, with the exception of some bay anchovy and river shrimp samples. These were subsampled; i.e., measurements were taken on 25 randomly selected individuals. Total weights were computed for all species. Weights were measured on an O Haus Dial-O-Gram balance, with a precision of ± 0.1 gram.

Lengths of organisms were measured to the nearest millimeter. Fish were measured in standard length; shrimp were measured from the tip of the rostrum to the tip of the telson; blue crab were measured by the carapace width.

During the sampling periods, physical and chemical data were collected from the Unit 1 West and the Unit 2 East intake pump screen wells at approximately six-hour intervals. Dissolved oxygen, water temperature and conductivity were measured <u>in situ</u>. Water samples were collected from the appropriate wells, and pH was measured within 30 minutes of sample collection.

Methodology of Sampling - Program Continuation (1977-1979)

During 1977, 1978 and 1979, the Environmental Surveillance Program of the aquatic ecology of the Mississippi River was and will be continued, utilizing essentially the same sampling locations, techniques, and methodologies that are described above. However, there are some slight modifications in order to comply more closely with the sampling program described in Supplement 6 to the Construction Permit Environmental Report for Waterford 3, which has been accepted by the Nuclear Regulatory Commission.

TABLE A-1

SAMPLING STATIONS FOR PREOPERATIONAL ENVIRONMENTAL SURVEILLANCE PROGRAM FOR SURFACE WATERS

Station Identification	Location	Rationale for Location
A_c	Behind an island on the west bank (right hand descending) of the Mississippi River, in a shallow back-water area upstream of Waterford 1 and 2.	Station is not expected to be directly affected by discharges from Waterford 1, 2, or 3; and therefore, has been designated as a control station.
A_t	On the west bank of the Mississippi River, in a shallow area characterized by low-velocity currents. Immediately upstream of Waterford 1 and 2, in a back eddy current.	Back eddy current results in transportation of heated discharge from Waterford 1 and 2 upstream to this station.
B_c	On the east bank of the Mississippi River opposite Waterford 1, 2, and 3. It is also upstream of LP&L's Little Gypsy Power Plant.	Intended as unaffected control station for deep, fast velocity current environment.
B_t	Immediately downstream of Waterford 3 discharge.	Station located in area of river influenced by heat discharge from Waterford 3.
B_{t1}	Along the west bank, near River Mile 127.	Abandoned after first year of sampling, and replaced by Station B_{t1*}.
B_{t1*}	On the west bank near River Mile 127.8.	Replaced Station B_{t1} in second year of sampling. Location is just upstream of an adjacent thermal discharge, and further downstream from the discharge of Waterford 3 than Station B_t.

TABLE A-2

PREOPERATIONAL MONITORING PROGRAM - AQUATIC ECOLOGY SAMPLING SCHEDULE

Community Sampled	1973 - 1974 Frequency Of Sampling	1973 - 1974 Sampling Gear	1974 - 1975 Frequency Of Sampling	1974 - 1975 Sampling Gear	1975 - 1976 Frequency Of Sampling	1975 - 1976 Sampling Gear
FISH	Monthly (April-April); five minute trawls Monthly; 48 hours at each station	Otter Trawl (all stations), mid-water trawl (Bt, Bt_1, B_c), surface trawl (all stations), gill net (all stations)	Once during the months of June, August, November, February, April and August-same as 1973-1974	Same as 1973-1974	Monthly (October - September); same as 1973-1974	Same as 1973-1974
	Monthly; 2 hours at each station	Electroshocking (all stations)				
BENTHOS	Monthly (June-April); 6 grab samples at each station	Shipek Sampler All stations	The Shipek was used during the months of June, August, November, February, April and August. Smith-McIntyre was used only in August, November, April and August.	Shipek Sampler (all Stations) Smith Mc-Intyre (all stations)	Monthly (October - September)	Shipek Sampler
ZOOPLANKTON	Monthly (June-Dec. and Feb-May); 2 samples were taken in April. Samples taken at surface, mid-depth and bottom	0.3 meter diameter #6 (0.243 mm mesh) plankton net	Once during the months of August, November, February, April and August and 2 times in June	Until February 1975 a 0.3 meter diameter net was used. From February 1975 on, a 1/2 Meter diameter #6 (0.243) mm mesh) plankton net	Monthly (October - September); A stations - S and B B stations - S,M,B	Same as 1973-1974

TABLE A-2

PREOPERATIONAL MONITORING PROGRAM - AQUATIC ECOLOGY SAMPLING SCHEDULE

	1977 - 1978*		1978 - 1979*		1979 - 1980*	
Community Sampled	Frequency Of Sampling	Sampling Gear	Frequency Of Sampling	Sampling Gear	Frequency Of Sampling	Sampling Gear
FISH	Once during the 3rd week of each of the following months, July, September, January, April; five minute trawls for all trawls	Trawls same as 1973 - 1974	Same as 1977 - 1978	Same as 1973-1974	Monthly	Same as 1973 - 1974
	Two 24 hour periods at each station during each sampling period	Gill net (all stations)				
	Two hours at each station during each sampling period	Electroshocking (all stations)				
BENTHOS	Once a month during the following months: July, September, January and April	Smith McIntyre Grab				
	At least 4 samples taken at each sampling station on each sampling date		Same as 1977 - 1978	Same as 1977-1978	Monthly	Same as 1977 - 1978
ZOOPLANKTON	Once a month during the following months: July, September, January and April A stations - S and B B stations - S, M, B	1/2 meter diameter #6 (0.243 mm mesh) plankton net (same as 1974 - 1975)	Same as 1977-1978	Same as 1974-1975	Monthly	Same as 1974-1975

*Not finalized at date of printing.

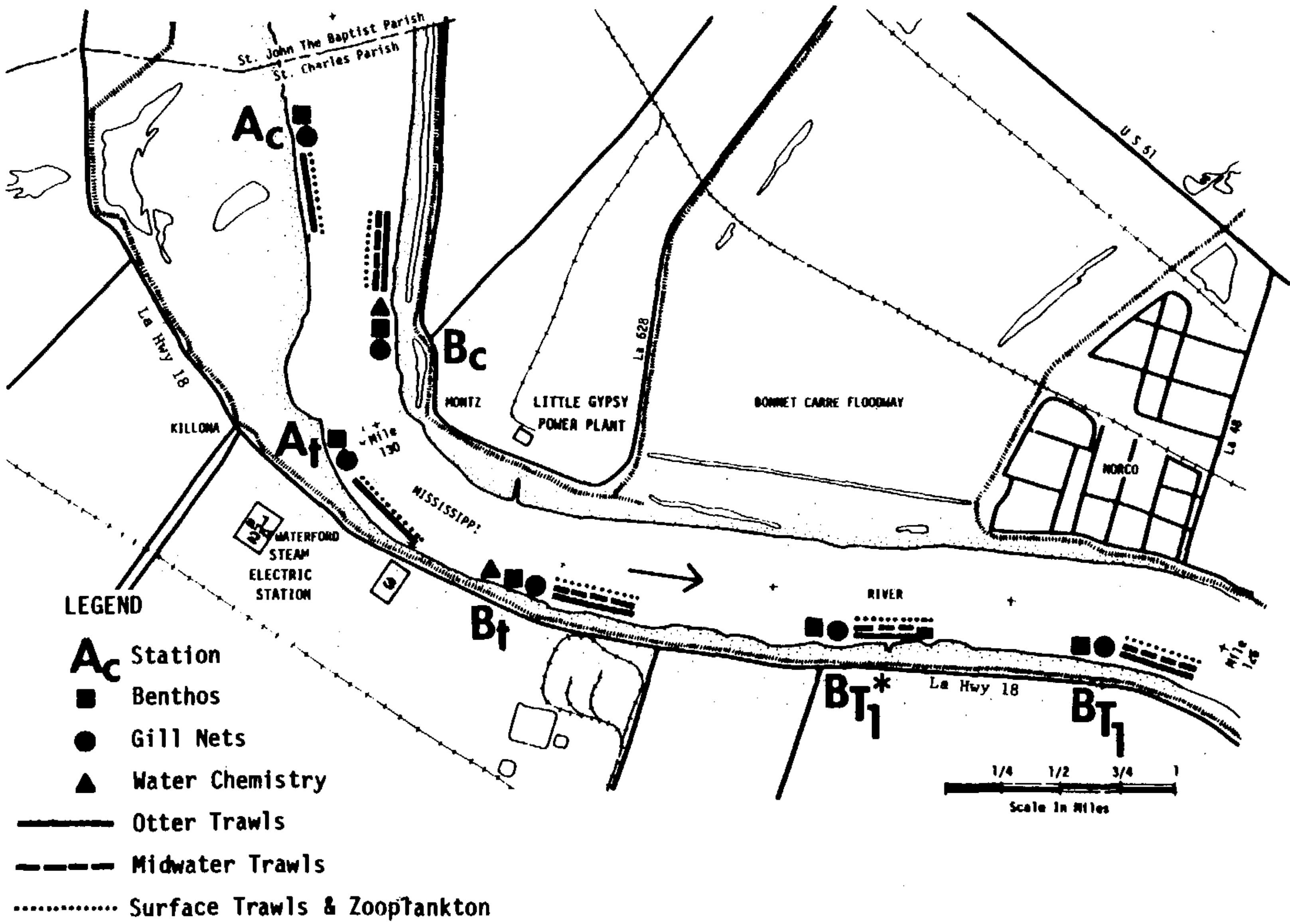
TABLE A-2

PREOPERATIONAL MONITORING PROGRAM - AQUATIC ECOLOGY SAMPLING SCHEDULE

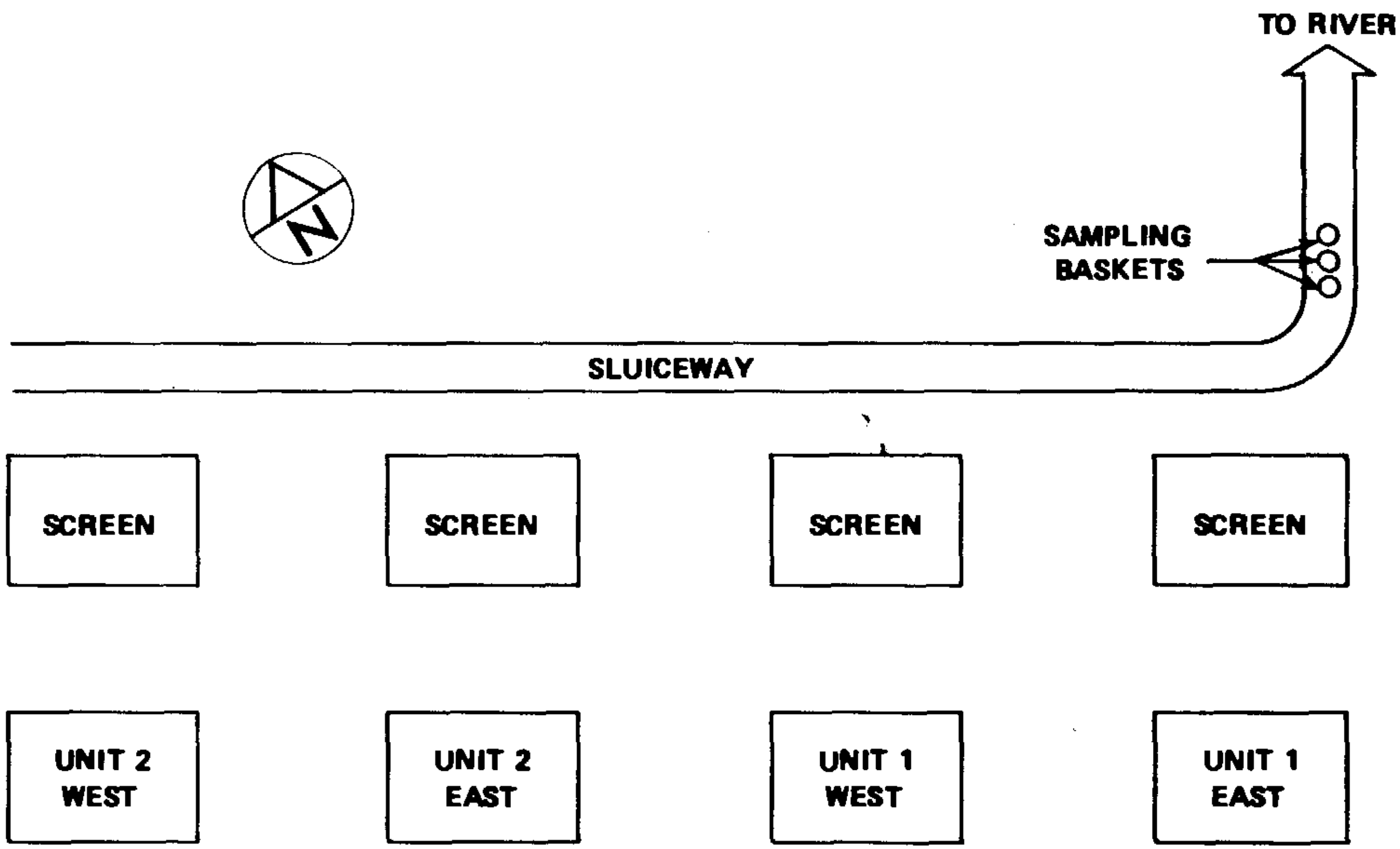
	1973 - 1974		1974 - 1975		1975 - 1976	
Community Sampled	Frequency Of Sampling	Sampling Gear	Frequency Of Sampling	Sampling Gear	Frequency Of Sampling	Sampling Gear
PHYTOPLANKTON	Monthly except January, 1974 and April, 1974 - near surface of each station; productivity also run (*in vitro*)	Whole water samples	Once during the months of June, August, February, April. Productivity also run (*in vitro*)	Whole water samples	Monthly (October - September	Same as 1973 - 1974
ATTACHED ALGAE	Seasonal	Collected from natural substrates and sediment	Same as 1973 - 1974	Same as 1973 - 1974		
ICHTHYOPLANKTON	See zooplankton (1973 - 1974)	See zooplankton (1973-1974)	November, February April and August	1/2 meter diameter #0 (0.571 mm mesh) plankton net	Monthly except June, July and August when 2 monthly samples were taken	Same as 1974 - 1975

TABLE A-2
PREOPERATIONAL MONITORING PROGRAM - AQUATIC ECOLOGY SAMPLING SCHEDULE

Community Sampled	1977 - 1978 Frequency Of Sampling	1977 - 1978 Sampling Gear	1978 - 1979 Frequency Of Sampling	1978 - 1979 Sampling Gear	1979 - 1980 Frequency Of Sampling	1979 - 1980 Sampling Gear
PHYTOPLANKTON	Once a month during the following months: July, September January and April just below the surface Productivity also run (*in vivo* and *in vitro*)	Same as 1973 - 1974	Same as 1977 - 1978		Monthly Productivity *in vivo* and *in vitro*	Same as 1973 - 1974
ATTACHED ALGAE	Same as 1973 - 1974		Same as 1973 - 1974		Same as 1973 - 1974	
ICHTHYOPLANKTON	Once a month during the following months: July, September, January and April A stations - S and B B stations - S, M, B each tow at least 20 minutes duration	One meter diameter #0 (0.57 mm mesh) plankton net	Same as 1977 - 1978		Monthly	Same as 1977 - 1978



LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	SAMPLING AREAS IN THE MISSISSIPPI RIVER NEAR WATERFORD 3	Figure A-1



SOURCE: ESPEY, HUSTON & ASSOCIATES, INC, "ANNUAL DATA REPORT—WATERFORD POWER STATION UNITS 1 AND 2 SCREEN IMPINGEMENT STUDIES—FEBRUARY 1976—JANUARY 1977".

LOUISIANA POWER & LIGHT CO. Waterford Steam Electric Station	LOCATION OF SCREEN IMPINGEMENT SAMPLE SITES AT WATERFORD 1 AND 2	Figure A-2