Chlorine Concentration And Exposure Time Necessary For Macroinvertebrate (*Corbicula*) Control At Farley Nuclear Plant

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ABSTRACT

Section 423.13(b)(2) of the Environmental Protection Agency's Steam Electric Effluent Guidelines as well as Farley Nuclear Plant's NPDES Permit No. AL0024619 Part I; page I-1b ***footnote for discharge points 001 and 002, states total residual chlorine may not be discharged from any single generating unit for more than two hours per day unless the discharger demonstrates to the permitting authority that more than two hours/day is required for macroinvertebrate control. Alabama Power Company received approval from the Alabama Department of Environmental Management (ADEM) to conduct an extended service water chlorination study at Farley Nuclear Plant. The objective of the study was to determine the minimum combined chlorine concentration and exposure time necessary for macroinvertebrate (Corbicula) control.

Continuous chlorination treatments, utilizing sodium hypochlorite, were conducted from the Fall of 1986 through the Winter of 1988. Sodium hypochlorite was metered into one unit's service water system such that total residual chlorine (TRC) levels would not exceed the effluent guidelines of 0.20 mg/l at the river discharge structure. Biomonitoring tanks containing adult Asiatic clams, located upstream and downstream of the heat exchangers, were utilized to determine the minimum treatment duration. Treatments were terminated when we achieved greater than 90% mortality of Corbicula indicator organisms or an eight week period of chlorination whichever occurred first. Results from the treatments have shown that chlorine levels of 0.20-0.30 mg/l TRC within the service water system (maintaining less than 0.20 mg/l TRC at the river discharge structure) are adequate for Corbicula control within eight weeks when water temperatures exceed 62°F. Seasonal change in the service water temperature was the primary factor affecting the treatment durations. Most significantly, this study demonstrated lower chlorine concentrations than previously documented were adequate for Corbicula control at Farley Nuclear Plant.

Based on the results of this study, Alabama Power Company requests the Alabama Department of Environmental Management approve a permanent chlorination program for macroinvertebrate control, outlined in the recommendations section, which allows for a chlorine discharge of more than two hours per day at Farley Nuclear Plant.

INTRODUCTION

The Environmental Protection Agency's Steam Electric Effluent Guidelines and Farley Nuclear Plant's NPDES permit Part I, page I-1b ***footnote for DSN 001 and 002 indicate total residual chlorine may not be discharged from any single generating unit for more than two hours/day unless the discharger demonstrates more than two hours/day of chlorination is necessary for macroinvertebrate control. Alabama Power Company found it necessary to demonstrate the need for a variance from the length of chlorination period and requested approval on October 22, 1986 from the ADEM to perform a study to determine chlorine concentration and exposure time necessary for adequate macroinvertebrate control (Enclosure 1). Approval was granted by the ADEM on October 28, 1986 with four additions to the study program (Enclosure 2). Enclosures 3 through 9 provide additional modifications which were made as the study progressed.

The Environmental Affairs Department of Alabama Power Company has therefore conducted a study to determine the necessary chlorine concentration and duration required for adequate macroinvertebrate control. The primary objective of this study was to develop a permanent chlorination schedule which minimizes the amount of chlorine needed to prevent observable fouling of service water system components, as opposed to total eradication of Corbicula.

The chlorination study was primarily based on Corbicula information surveys, literature research and monitoring programs conducted as listed in Table 2. The purpose of the Corbicula information surveys was to determine the density of Corbicula in the service water pond, to determine the length of the spawning season and determine their growth rates. This was the basis for knowing when the chlorination treatment would be necessary. The purpose of the literature research was to know what chlorination amount and duration were necessary to adequately control the Corbicula. The purpose of the monitoring programs was to determine site specific information on the minimum amount of chlorination and contact time necessary to kill an acceptable percentage of Corbicula (greater than 90%) which would not cause biofouling problems in the service water system.

STUDY BACKGROUND

Corbicula Life History and Service Water Infestation

The exotic freshwater clam Corbicula was imported to the western United States from Asia in the early 20th centur. (Neitzel et al. 1984). The infestation of virtually all river systems in the southern United States can be attributed to the clam's reproductive characteristics. Unlike native North American bivalves, the immature stage of Corbicula does not require an intermediate host, and the sexually mature adults are usually monoecious (i.e., a single individual possesses both male and female sexual organs at the same time). Each adult clam can produce up to 700 larvae per day. The juvenile clams (less than 48 hours old) are easily transported by current away from the adult population.

Service water systems in generating facilities provide ideal habitat for Corbicula. Adjacent areas within the service water system with variable flow patterns of high- and low-velocity are conducive to the transporting and settling of juvenile clams. These areas also provide a continuous source of food and oxygen. Some plant operators have reported that the intake structure provides an ideal environment for the clam (Neitzel et al. 1984). The free-living juvenile clams range in size from 0.2 to 0.5 mm and are pumped into the service water system through screen and strainer openings of approximately 4.7 mm. After the young clams settle in a suitable habitat they use a sticky mucus (the byssus) to secure themselves until the 5 mm stage is reached. After this stage, flow velocity will again influence their movement and deposition. Neitzel et al. (1984) also provided a list of locations within nuclear generation service water systems that are susceptible to clam biofouling. These locations within Farley Nuclear Plant (FNP) include the following:

1 - branch headers supplying water to intermittent-flow cooling loops;

2 - auxiliary-building room coolers to: low-pressure safety-injection pumps, high-pressure safety-injection pumps, electric equipment rooms, and other pump rooms;

3 - other components such as containment cooling units; diesel generator coolers; service-water strainers; control-room and computer-room air coolers; generator seal oil coolers; hydrogen coolers; and component cooling-water heat exchangers.

Control of Corbicula

The control of Corbicula is complicated by their remarkable ability to survive environmental stress and their reproductive characteristics. The survival of Corbicula exposed to air depends on the relative humidity and can range from 7 to 27 days at temperatures of 30 to 20°C, respectively (NRC 1981). Bioassay studies at Commonwealth Edison utilizing mature clams show that regardless of whether the toxic agent was a high level of chlorine (1.0 or 5.0 mg/l free available chlorine, FAC) or anoxia (no dissolved oxygen), 100% mortality was achieved in six to twelve days at temperatures of 29 and 18°C, respectively (EEI 1986). McMahon and Williams (1986) have reported that during overwintering periods and periods of environmental stress Corbicula may close its valves tightly and partially or completely respire anaerobically, leading to shell dissolution, erosion of the shell edge and degrowth. These facts clearly demonstrate this clam's ability to survive periods of stress.

Historically FNP has used "good housekeeping" of the service water (SW) components and intermittent chlorination to control clam biofouling. Intermittent chlorination of three treatments per day at concentrations of less than 0.5 mg/l total residual chlorine (TRC) is used primarily to control microfouling (slime, fungus, etc.) and was believed to also control the Asiatic clam. During the Summer of 1986 the accumulation of sediment and Corbicula resulted in a high temperature alarm being received from a reactor coolant system charging pump oil cooler. This event precipitated the need to re-evaluate the Corbicula control program.

The Pacific Northwest Laboratory has recently completed a number of extensive reviews of biofouling control in SW systems (Neitzel et al. 1984, Daling and Johnson 1985, and Johnson and Neitzel 1987). Basically, three types of control are considered in the literature: heat shock, physical control and chemical control. The use of heated water to control juvenile Corbicula would require a 2-minute exposure at 120°F (49°C) (NRC 1981). The combination of heat shock with chlorination as a control method has been suggested by Sappington et al. (1986). Either of these options would exceed the 95°F (35°C) operational criterion for the FNP SW system during the summer and, therefore, are not viable control options at this time. Due to the operating restrictions of the FNP SW system and the complexities of the clam's life history, Corbicula control will require a combination of enhanced physical control along with chemical control.

Physical control is an essential aspect of a comprehensive management scheme designed to minimize Corbicula infestations. Physical control involves the routine inspection and cleaning of susceptible piping, which monitors the effectiveness of the initial screening and chemical control process. Routine dredging of the entire intake structure area is also necessary in order to eliminate a potentially large population of spawning clams which prefer this habitat upstream from the chlorinator. Alabama Power Company uses commercial divers and a submersible trash pump with a flexible hose to remove the accumulated adult clams in this area.

Chlorine is currently used as a biocide by the industry, however, regulatory restrictions on chlorine discharge have become increasingly stringent over the past decade. The EPA published new effluent limitations for utilities in November 1982. The use of intermittent chlorination with total residual chlorine (TRC) discharge limitations of 0.20 mg/l has been found to be ineffective in controlling larvae and adult Corbicula (Johnson and Neitzel 1987).

Chlorine Minimization

A variance from the 2 hour - 0.2 mg/l TRC state (ADEM) and federal (EPA) guideline requires Alabama Power Company to determine the minimum amount of chlorine necessary to control Corbicula in the FNP SW system. Daling and Johnson (1985) recommend a site-specific evaluation of the proper chlorine concentration because of water quality differences. They also recommend establishing a chlorination schedule which incorporates an optimum frequency and a minimum target concentration. Various aspects of the chlorination schedule would be determined from site-specific life history information and chlorine minimization testing using biomonitoring tanks.

Study Objectives

The primary objective of this study was to develop a chlorination schedule which minimizes the amount of chlorine needed to maintain a level of control which would prevent observable fouling of SW components, as opposed to total eradication of Corbicula. Specific objectives of this study included the following:

1. Determine the density of Corbicula in the SW supply pond and intake structure.
2. Determine the extent of the Corbicula spawning season.
3. Determine Corbicula young of the year growth rates.
4. Determine if TRC concentrations lethal to adult Corbicula can be maintained in the SW system without exceeding 0.20 mg/l at the river discharge monitoring point.
5. Determine the time necessary to obtain a desired mortality of greater than 90% for adult Corbicula at the concentrations previously determined.
6. From the above information establish a permanent chlorination program that will control Corbicula infestations while minimizing chlorine discharges to the environment.

MATERIALS AND METHODS

Description of the Study Area

Service water for the 1,720 MW nuclear generating plant is drawn from the Chattahoochee River and pumped to a 95 acre service water supply pond. Service water within the plant is used in the turbine building heat exchangers, auxiliary heat exchangers, as dilution water and as make-up for the circulating water before being discharged back into the Chattahoochee River. Water from the supply pond is pumped separately to each of two units at a typical rate of 35,000 GPM.

Collection of Life History Information

The density of *Corbicula* in the service water pond was determined during October 1986. Adults were collected using a Ponar dredge (23 X 23 cm) at random points and depths along four transects (Figure 1). Samples were also taken in front of the intake screens and in the wet pit area. Samples were sieved through a U. S. No. 8 screen, and *Corbicula* greater than 5 mm were counted. The density of adult clams collected during the Fall of 1986 are compared with those collected during the Fall of 1983.

The length of the spawning season was estimated by periodically determining the density of juvenile *Corbicula* in the service water. Juvenile *Corbicula* were collected by filtering 100 gallons of service water on a weekly basis beginning in October of 1986 and continuing through December 1987. Service water was filtered at two points within each unit. One point within the turbine building was located upstream from the heat exchangers and another was located at the Main Discharge Surge Tank (MDST) downstream from the heat exchangers and prior to the merging of the once through service water from both units. Juvenile clams were counted by microscopic examination with the aid of a Sedgwick-Rafter cell.

Corbicula growth rates within the service water system were determined by collecting sediment samples from 4 in-plant side-stream biomonitoring tanks tapped into the SW system at the same points from which juvenile clams were collected. Clams retained in a U. S. #30 (greater than 0.6mm) screen were measured and counted in order to provide length-frequency information on clams recruited into the side-stream tanks.

Minimization Testing

Efficiency of continuous low-level chlorination was determined by exposing adult Asiatic clams housed in the previously mentioned biomonitoring tanks. During each treatment period one of the two service water systems was treated with sodium hypochlorite (NaOCl), exposing two biomonitoring tanks (located in the turbine building and at the MDST) to continuous low levels of chlorine. Unit One was treated four times beginning in the Fall of 1986 and ending in the Winter of 1988. Unit Two was treated three times beginning in the Spring of 1987 and ending in the Spring of 1988. The NaOCl was injected into the treated unit with the use of a positive displacement piston pump. The two biomonitoring tanks tapped into the untreated service water system were used as controls. Each biomonitoring tank housed at least 8 plastic trays, each containing 20 adult clams. Adult clams (greater than 0.5 inches) used to stock tanks were manually collected from the service water pond. Flows through the the 30 gallon biomonitoring tanks were maintained between 4 - 5 GPM.

Clam mortalities were determined by periodically removing trays of clams throughout each treatment period. Mortality was determined by manual twisting of the clam valves or by obvious gaping. Treatment ceased when greater than 90% mortality was achieved in both of the treated tanks. Any trays remaining in the biomonitoring tank contributed toward the final mortality estimate. Each group (i.e., tray) of clams was considered a within - treatment replication. Statistical analyses were performed using oneway, Duncan multiple range and ANOVA procedures (SPSS 1986).

Total residual chlorine (TRC) and free available chlorine (FAC) were measured using the amperometric method (ASTM 1986). Accuracy was routinely checked using standard chlorine additions. Daily samples were also taken from each of the treated biomonitoring tanks. Chlorine concentrations were determined in accordance with ADEM's approval for the chlorination study.

Water Quality

Temperature and dissolved oxygen concentrations for biomonitoring tank water were determined weekly with the use of a YSI meter.

RESULTS AND DISCUSSION

Corbicula in the Service Water Pond

The densities of sexually mature (greater than 0.5 inches) adults collected during the Fall of 1983 and 1986 in the service water pond, intake structure, and wet pit are presented in Figure 2. Densities of adult Corbicula at the mouth of the intake structure (prior to intake screening) were 7 - 20 times greater than those found in the service water pond and the densities in the wet pit (after intake screening) were 106 - 248 times greater than those found in the pond. Adults associated with the intake structure and wet pit area take advantage of the variable flow patterns, plankton-rich waters, and protection from predation. The presence of numerous immature clams in the wet pit area suggests that Corbicula upstream from the screen are affected by natural predations. The high density of clams inhabiting the intake structure suggests that they have been the primary source of contaminating spawn (juveniles and veligers) entering the FNP service water system. Clams in the intake structure were removed during the Winter of 1986 with the use of divers and a submersible pump. Approximately 40 cubic yards of clams and debris were removed. The existence of approximately 19 million clams in the service water supply pond (approximately 95 acres) guarantees the potential for contaminating spawn in the future operation of the plant.

Corbicula Spawn

Means and ranges for monthly juvenile clam densities in the service water system are presented in Figure 3. Mean monthly temperatures within the turbine building service water are also presented.

The density of spawn within the service water system indicates that the infestation of juvenile clams is constantly occurring during the eight warmer months of the year, with a major and minor spawning peak occurring during spring and fall, respectively. Minimal recruitment of juveniles occurs during the four months of late winter and early spring. Spawning was not detected in January of 1987, when service water temperatures in the turbine building dropped to 64°F (18°C) and resumed in May when temperatures rose to 72°F (22°C). The biannual pattern of reproduction with suppressed activity during the late summer has been reported by Dreier and Tranquilli (1977), Sickel (1977), Aldridge and McMahon (1978), Cherry et al. (1986), and McMahon and Williams (1986). Optimum temperatures of 71-80°F (22-27°C) for juvenile release agree with those reported by Aldridge and McMahon (1978). The minimal amount of spawn during the winter and early spring at both the turbine building and MDST indicates that no significant spawning by adults occurs within the service water system during this period. Water temperatures at the MDST averaged 5°F higher than those at the turbine building during this period. There were no significant differences (P greater than 0.05) in the amount of spawn between the turbine building and MDST during the eight month spawning period.

Corbicula Growth

Growth rate and length-frequency information pertaining to clams recruited into the two turbine building biomonitoring tanks during the spring spawning period of 1987 is presented in Figures 4 and 5. Sediment deposited in the bottom of these tanks was collected 6, 33 and 62 days after recruitment began in the Unit 1 turbine building tank and 20, 41, 68, and 98 days after recruitment began in the Unit 2 turbine building tank.

Maximum clam size in the two turbine building biomonitoring tanks exceeded 0.13 inches (3.1 mm) in 33 days, 0.25 inches (6.2 mm) in 62 days and 0.50 inches (12.5 mm) in 98 days. The minimum heat exchanger tubing diameter in the FNP service water system is 0.25 inches. Based on the information from the clam populations in the biomonitoring tanks (clams retained by a number 30 sieve, greater than 0.6 mm) the average clam size in the FNP service water system would reach 0.25 inches within 6 to 10 weeks after the initiation of the spring spawn. This growth rate is greater than those reported from Georgia and Texas. Data from McMahon and Williams (1986) showed that clams from Trinity River, Texas spawned in the spring had mean generation lengths of 6 - 7 mm in August of that same year. Clams spawned in the spring from the Altamaha River, Georgia appear as the 4 mm length class in August. The greater rate of growth for clams in the FNP SW system reflects the favorable characteristics of the habitat. Sickel (1977) has documented differences in growth characteristics between Corbicula populations from the Mud River, West Virginia and the Altamaha River, Georgia.

Efficiency of Low Level Chlorination

Average TRC levels of 0.20 to 0.37 mg/l at the MDST were possible without exceeding 0.20 mg/l at the river discharge. Table 1 presents the total residual (TRC) and free available (FAC) chlorine from the first six treatments at the two biomonitoring tanks, MDST, and river discharge. Chlorine concentrations within the SW system were similar during five of the six treatments. Treatment number three maintained a significantly (P less than 0.05) greater TRC concentration at the MDST when compared with the other five treatments.

TRC levels of greater than 0.30 mg/l were purposely maintained at the MDST during treatment three in order to determine what maximum chlorine levels were achievable without exceeding the 0.20 mg/l TRC limit at the river discharge. Chlorine levels were purposely maintained between 0.20-0.30 mg/l during the other five treatments.

The TRC level at the river discharge varied from 32% to 55% of the levels maintained at the MDST. This variation in reduction of TRC at the river discharge is positively related to SW temperature, with the greatest reduction possible during the summer months when chlorine demand is greatest. Average TRC levels at the river discharge for each treatment were maintained at or below 0.14 mg/l. Incidental TRC levels were greater than 0.20 mg/l during treatments 1 and 2. Experience with the NaOCl feedrate additions kept all incidental TRC levels below 0.20 mg/l during treatments three through six.

The clams in the biomonitoring tanks were exposed to TRC levels similar to TRC levels at the MDST. Therefore, the 4 - 5 gpm flow rate through the 30 gallon biomonitoring tank is considered sufficient for maintaining the same level of chlorine that is found in the service water. There were no significant differences (P greater than 0.05, paired t-test) in the TRC concentrations between the MDST valve (weighted daily average TRC) and the MDST biomonitoring tank (daily TRC). Daily concentrations of TRC in the turbine building biomonitoring tank were significantly less (P less than 0.05, paired t-test) by 0.06 - 0.08 mg/l TRC than the weighted daily values from the MDST valve during treatments 3 and 4. These differences are likely due to the chlorine demand within the samples from the turbine building during transport prior to analysis. Average chlorine values from the MDST valve should be considered more precise than those values from the biomonitoring tanks because there were no discernible differences between chlorine values from the MDST valve and tank and the frequency of measurements from the MDST valve was much greater than from the biomonitoring tank.

Variation in treatment durations (8-56 days), dictated by the 90% clam mortality - 8 week limit criteria, were primarily due to seasonal changes in SW temperature. Increased water temperature would increase the metabolic rate of the clam, improving the efficiency of the biocide. Table 2 presents the average Corbicula mortality on the last day of each treatment along with the Unit treated, date of treatment, treatment days and SW temperature. Figure 6 presents the relationship between Corbicula mortality, SW temperature and treatment days. A greater than 90% mortality is not achievable within an eight week period at temperatures less than 62°F (17°C). As temperatures approach 90°F (32°C), a 90% mortality is achievable within a week. Final control mortalities for each treatment averaged 6% or less at both the MDST and turbine building, with the exception of the turbine building biomonitoring tank during treatment 4. Average mortality in this tank reached 29%. A possible reason for this unexplained mortality may be natural mortality due to disease.

In their recent bulletin (Improving the Reliability of Open-Cycle Water Systems, Volume 2) Johnson and Neitzel (1987) state that "continuous chlorination at 0.60 ppm or greater is required during spawning seasons to control Asiatic clams." Our results have shown that chlorine levels of 0.20-0.30 mg/l TRC are adequate for controlling Corbicula within eight weeks at temperatures greater than 62°F.

Water Quality

With the exception of one occasion when valves were accidentally shut off, dissolved oxygen levels in the biomonitoring tanks were maintained above 4.9 mg/l during each treatment. Information from the in-line temperature monitors reveals that no unusual water temperature spikes occurred in the service water system during the treatments. The service water at FNP is considered soft for biological purposes, with total alkalinity ranges of 12 - 27 mg/l and total hardness ranges of 18 - 27 mg/l.

Conclusions

The following conclusions are a result of the previous life history and toxicology information and are proposed as a permanent chlorination program:

1. Total Residual Chlorine (TRC) levels during the treatment periods will not exceed 0.20 mg/l at the river discharge. A Free Available Chlorine (FAC) level of at least 0.20 mg/l is desired at the furthermost point of concern in the system (i.e., Main Discharge Surge Tank) during each treatment. However, the TRC limit at the river discharge will be the controlling factor.
2. Annually the treatments will begin with the initiation of spawning activity, or on May 1, whichever occurs first. The initiation of spawning activity will be determined through biomonitoring. The SW of each unit will be scheduled for treatment at a nominal frequency of eight weeks between treatments. Subsequent rounds of chlorination will commence approximately eight weeks after terminating the last previous

treatment of the subject unit. All treatments will continue for eight weeks, or until greater than 90% mortality is indicated in each treated biomonitoring tank, whichever occurs first.

3. Initiation of treatments will continue, as necessary, through December 31 each year. All treatments commenced will continue until the 90% mortality/eight week criterion is achieved. Any spawn from the winter will experience low growth rates and be controlled the following year.
4. The side-stream biomonitoring tanks will be used during treatment periods to insure that the duration of every chlorination treatment has been minimized and the desired mortality level is achieved (i.e., 90% mortality).
5. During the chlorination of a unit's SW for Corbicula control; the opposite unit will receive the current chlorination program of three intermittent treatments per day in order to control microfouling (slimes, fungus, etc.).

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FARLEY NUCLEAR POWER PLANT SERVICE WATER POND

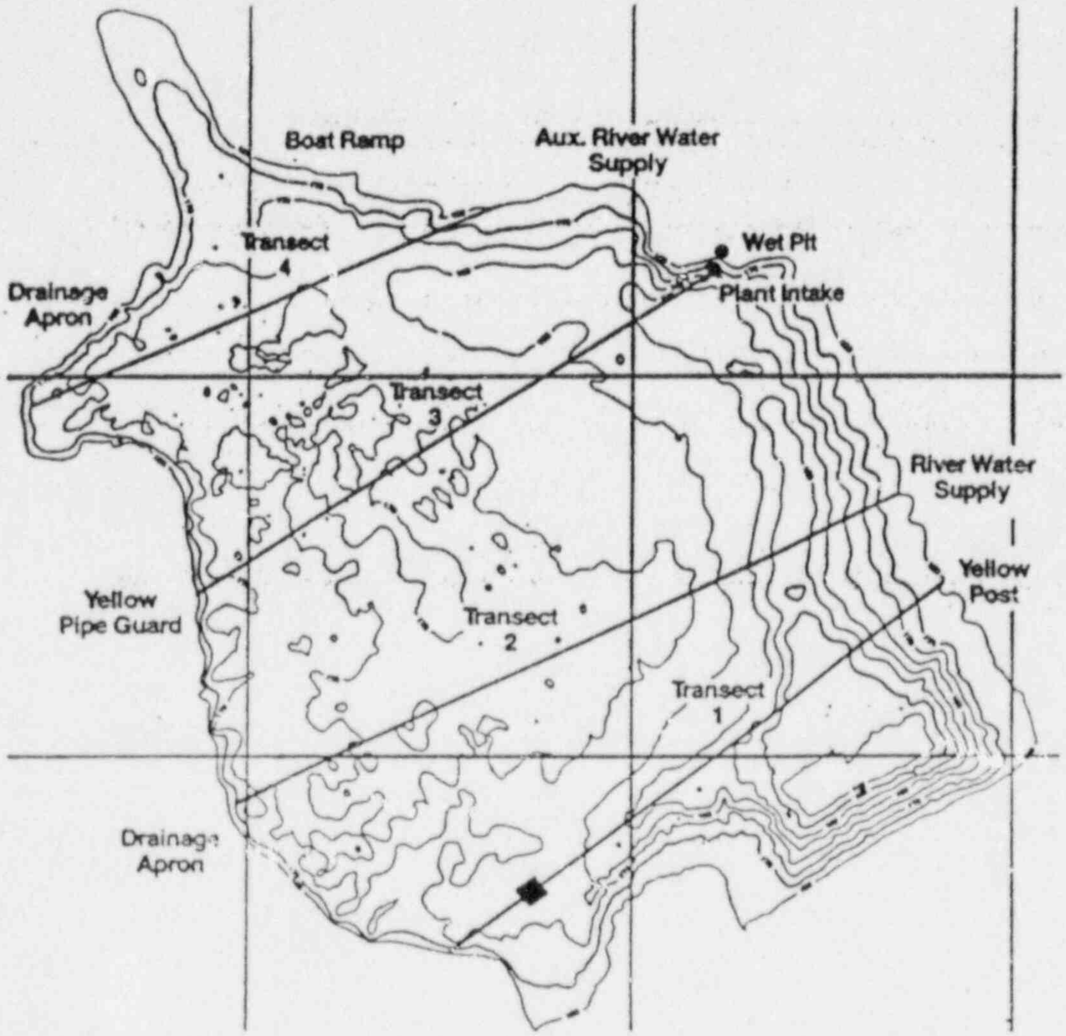

Figure 1. Service water supply pond for the Farley Nuclear Plant near Ashford, Alabama.

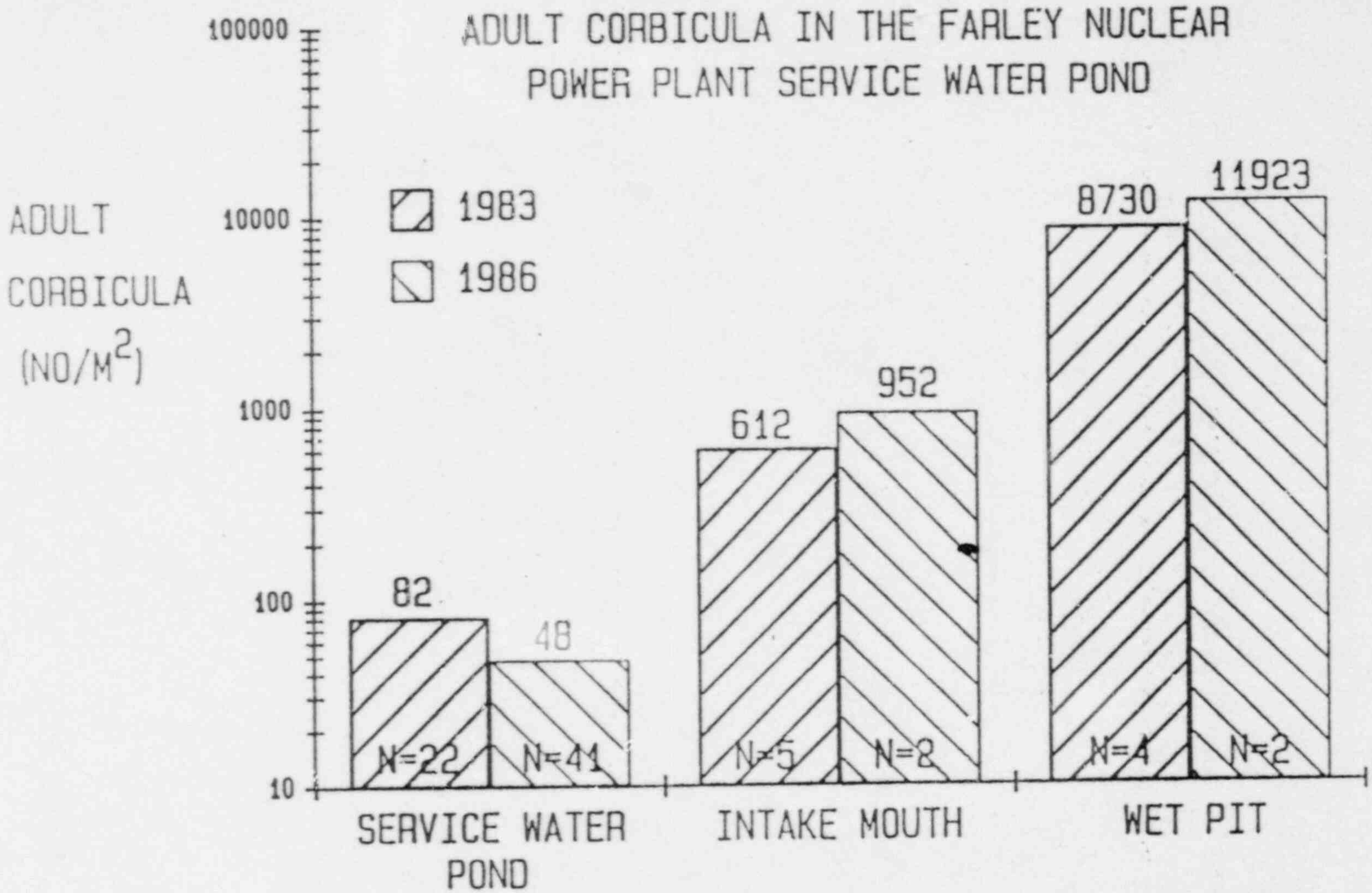

Figure 2. Number of Asiatic clams in the Farley Nuclear Plant service water pond during the Fall of 1983 and 1986. Samples were taken within the pond, at the mouth of the intake structure prior to screening, and after screening in the wet pit of the intake structure (N = number of samples).

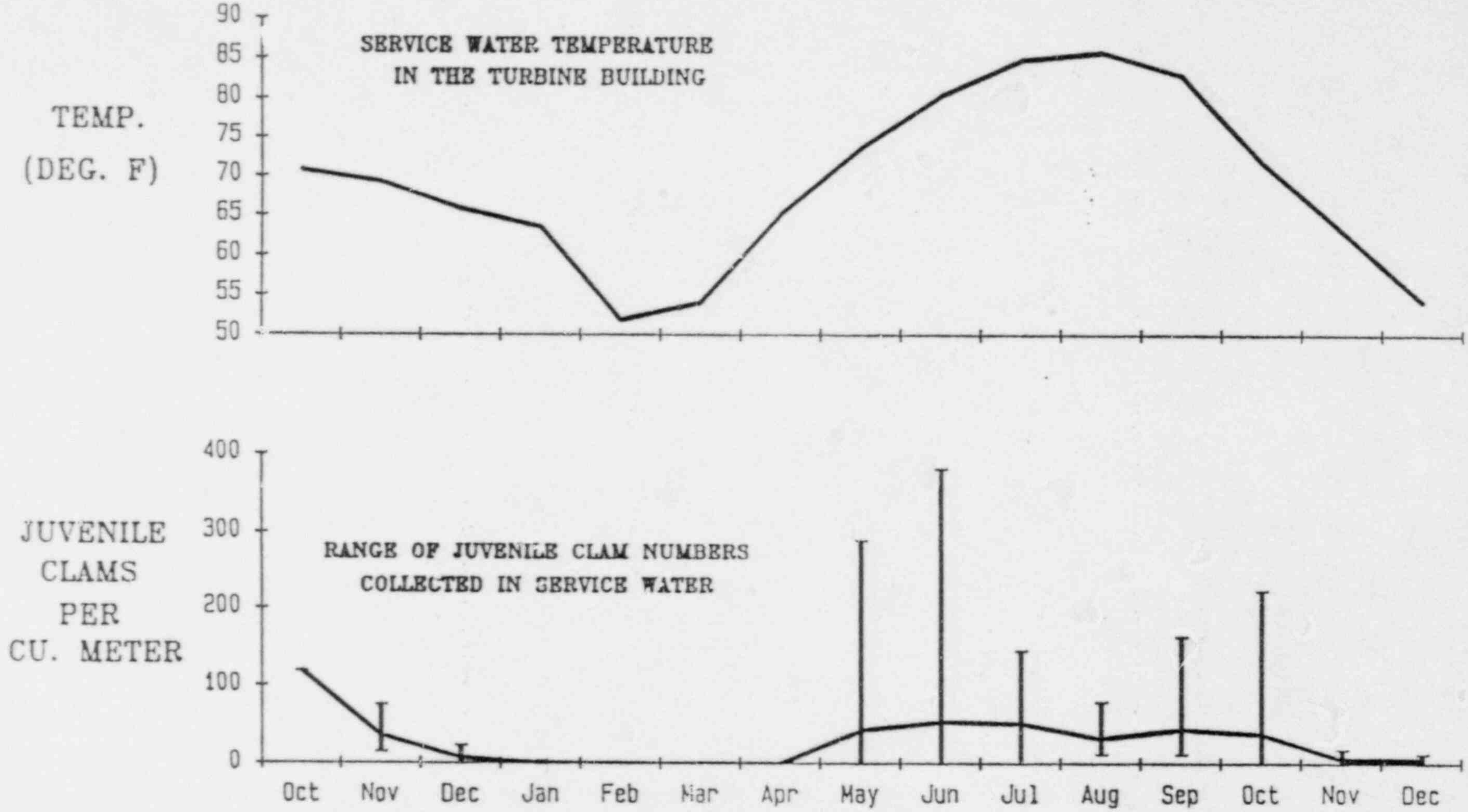

Figure 3. Mean monthly service water temperatures in the turbine building along with the means and ranges for monthly juvenile clam densities found in the service water system from October 1986 to December 1987.

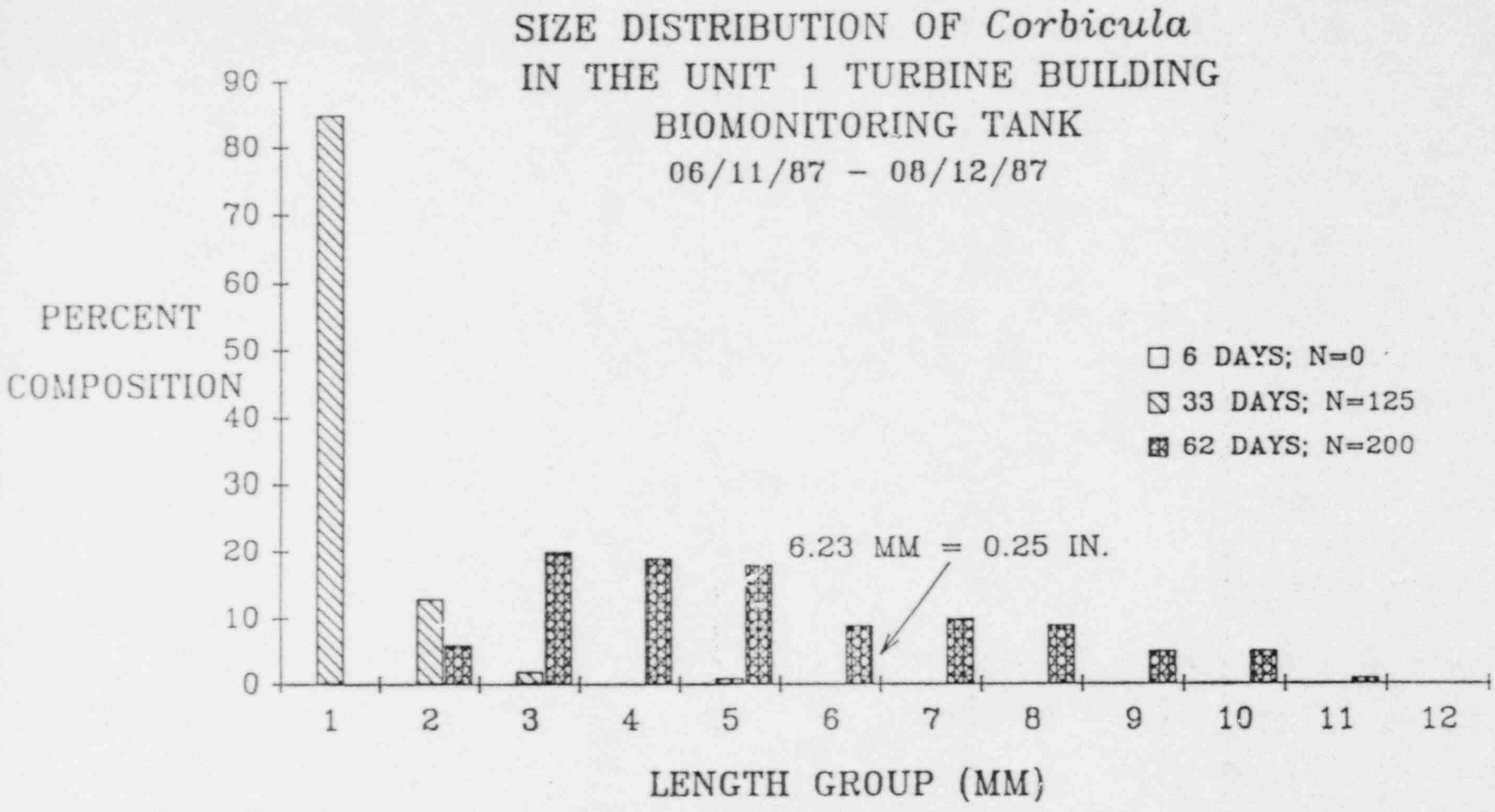

Figure 4. Percent composition of various length groups for Corbicula collected from the Unit 1 turbine building biomonitoring tank. Samples were taken 6, 33, and 62 days after recruitment from the service water began on June 11, 1987 (N = number of live clams collected).

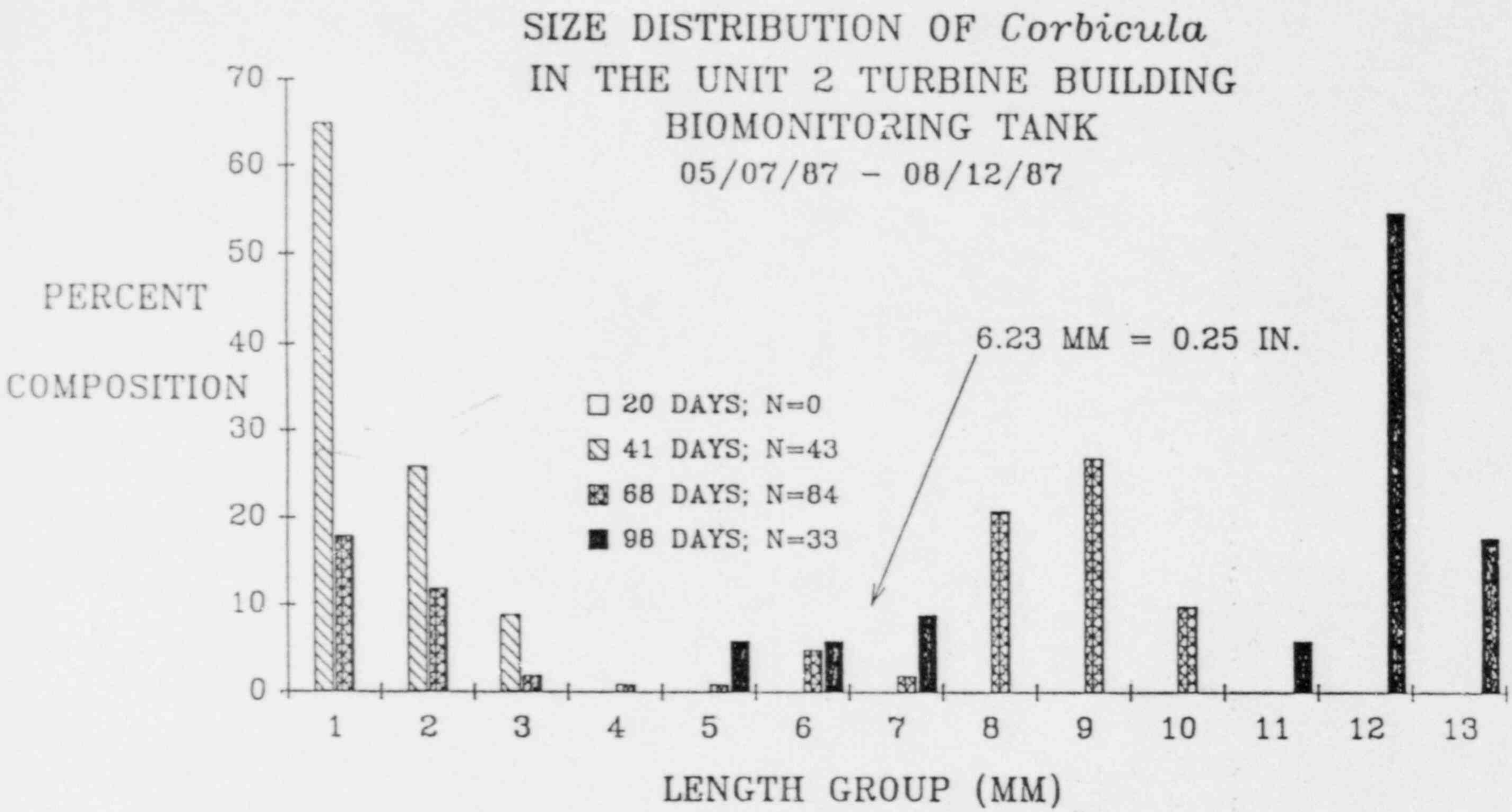

Figure 5. Percent composition of various length groups for Corbicula collected from the Unit 2 turbine building biomonitoring tank. Samples were taken 20, 41, 68, and 98 days after recruitment from the service water began on May 7, 1987 (N = number of live clams collected).

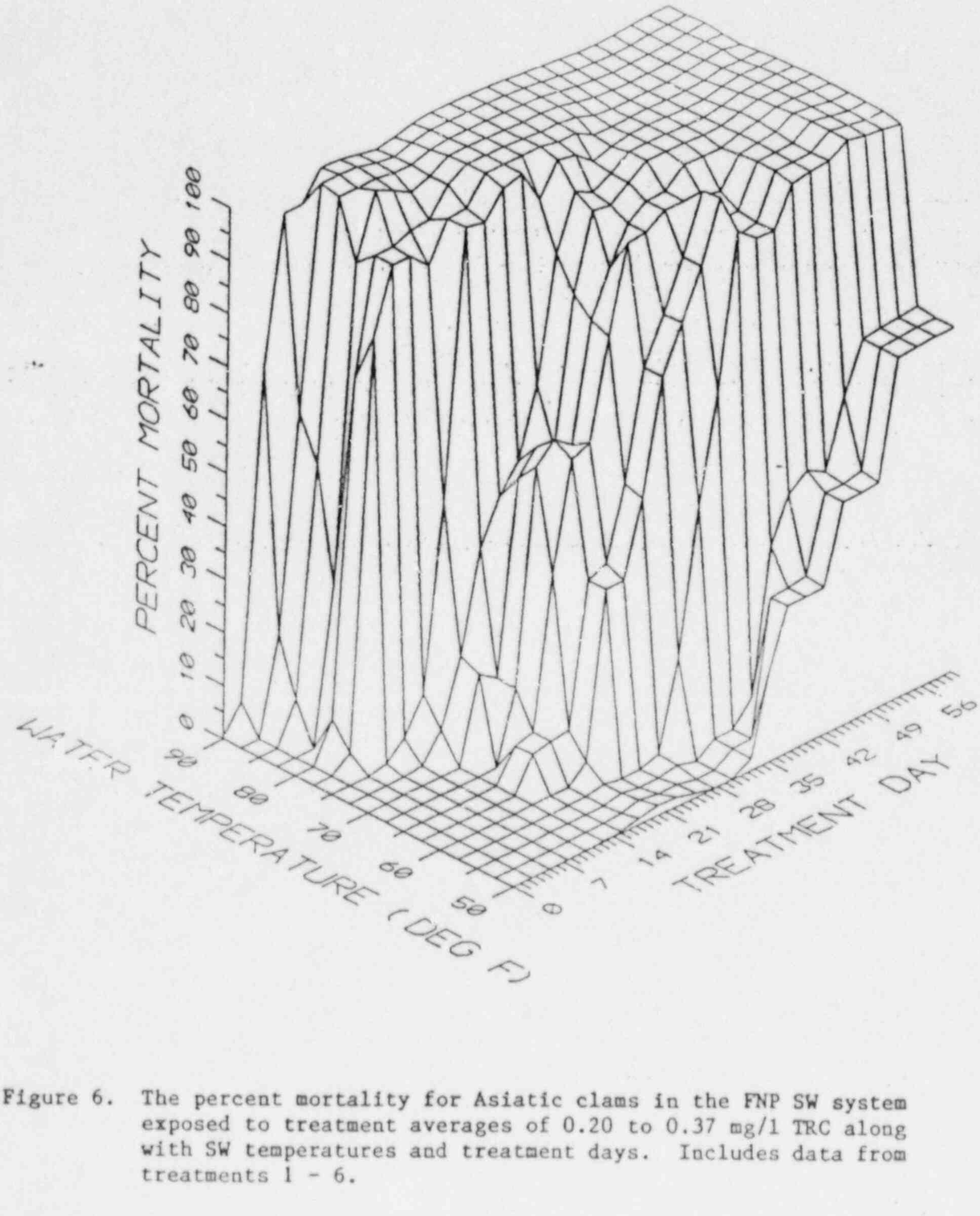

Figure 6. The percent mortality for Asiatic clams in the FNP SW system exposed to treatment averages of 0.20 to 0.37 mg/l TRC along with SW temperatures and treatment days. Includes data from treatments 1 - 6.

Table 1. Means and ranges for daily average total residual and free available chlorine measurements* from the two biomonitoring tanks, surge tank valve and river discharge during the six treatment periods. Mean values at the surge tank and river discharge were weighted according to the time of previous measurement.

	TEST						Total
	1	2	3	4	5	6	
TOTAL RESIDUAL CHLORINE							
Turbine Bldg., Biomonitoring Tank							
Mean	.26	.23	.29	.14	.24	.18	.22
Minimum	.20	.01	.09	.07	.14	.09	.01
Maximum	.34	.39	.40	.23	.40	.32	.40
Surge Tank, Biomonitoring Tank							
Mean	.29	.24	.34	.19	.21	.26	.26
Minimum	.20	.01	.10	.12	.10	.14	.01
Maximum	.37	.38	.50	.24	.30	.37	.50
Surge Tank, Service Water Valve							
Mean	.20	.26	.37	.22	.24	.26	.25
Minimum	.11	0.0	.10	.17	.19	.18	0.0
Maximum	.27	.37	.53	.33	.29	.35	.53
River Discharge							
Mean	.11	.11	.12	.08	.12	.14	.12
Minimum	.06	.05	.03	.04	.09	.05	.03
Maximum	.16	.18	.16	.11	.14	.18	.18
FREE AVAILABLE CHLORINE							
Turbine Bldg., Biomonitoring Tank							
Mean	.11	.14	.14	.07	.12	.09	.11
Minimum	.07	.01	.07	.04	.10	.02	.01
Maximum	.16	.25	.20	[illegible]	.14	.17	.25
Surge Tank, Biomonitoring Tank							
Mean	.12	.13	.18	.10	.12	.14	.13
Minimum	.08	.01	.07	.06	.05	.07	.01
Maximum	.16	.24	.25	.12	.20	.18	.25
Surge Tank, Service Water Valve							
Mean	.14	.17	.20	.11	.14	.14	.15
Minimum	.06	0.0	.06	.08	.12	.08	0.0
Maximum	.23	.26	.29	.15	.17	.18	.29
River Discharge							
Mean	.09	.06	.07	.04	.07	.07	.07
Minimum	.04	.03	.02	.02	.06	.03	.02
Maximum	.14	.11	.10	.07	.10	.09	.14

*Values less than 0.05 mg/l were calculated as 0.0 mg/l.

**Chlorine concentrations determined using DPD ferrous titrimetric method, all other measurements conducted using the amperometric titration method.

Table 2. Treatment information along with final clam mortalities and water temperature ranges for the biomonitoring tanks.

Treatment Number	Unit Treated	Beginning Date	Ending Date	Exposure (Days)	Biomonitoring Tank Location	Final Mortality with 95% CI	Water Temperature (°F)
1	1	10-28-86	12-04-86	38	Turbine Bldg. (Treated)	97.5	60.8 - 72.0
					MDST (Treated)	97.5	70.7 - 72.0
					Turbine Bldg. (Control)	5.0	-----------
					MDST (Control)	-----	-----------
2	2	04-07-87	05-07-87	30	Turbine Bldg. (Treated)	95.8	59.0 - 72.0
					MDST (Treated)	99.2	59.4 - 77.4
					Turbine Bldg. (Control)	0.0	-----------
					MDST (Control)	0.0	-----------
3	1	06-01-87	06-11-87	11	Turbine Bldg. (Treated)	91.3	78.8 - 79.9
					MDST (Treated)	98.8	84.6 - 85.3
					Turbine Bldg. (Control)	0.0	-----------
					MDST (Control)	0.5	-----------
4	2	07-15-87	07-22-87	8	Turbine Bldg. (Treated)	83.9	83.8 - 86.2
					MDST (Treated)	93.9	89.4 - 92.8
					Turbine Bldg. (Control)	29.3	-----------
					MDST (Control)	6.1	-----------
5	1	09-08-87	09-18-87	11	Turbine Bldg. (Treated)	100.0	82.4 - 83.3
					MDST (Treated)	99.5	84.2 - 86.9
					Turbine Bldg. (Control)	3.0	-----------
					MDST (Control)	2.5	-----------
6	1	11-11-87	01-05-88	56	Turbine Bldg. (Treated)	64.8	50.7 - 64.8
					MDST (Treated)	98.6	59.9 - 68.9
					Turbine Bldg. (Control)	0.0	-----------
					MDST (Control)	0.0	-----------

ENCLOSURE 1

Alabama Power Company
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291
Telephone 205 250-1000

Alabama Power
the southern electric system

October 22, 1986

Mr. James P. Martin
Alabama Department of
Environmental Management
1751 Federal Drive
Montgomery, AL 36130

Dear Mr. Martin:

As discussed during our phone conversation of October 22, 1986, we are requesting your approval to conduct a study to determine chlorine concentrations and exposure time necessary for Corbicula control in service water systems at the Farley Nuclear Plant. The study will consist of the following:

I. Three Week Study

   A. Maintain chlorine concentrations at the service water intake (for one unit) necessary to provide a free available chlorine (FAC) level of 0.20 mg/l at the furthermost point of concern in the system.

   B. Maintain prescribed chlorine level for a period of three (3) weeks.

   C. Evaluate effectiveness of chlorination on Corbicula control (larvae and adult forms)

II. Long Term Study to Evaluate Corbicula Control

   A. Implement continuous chlorination program for the FNP service water system, which will preclude simultaneous chlorination of units 1 and 2.

   B. Evaluate long-term chlorination levels necessary to control Corbicula larvae.

   C. Maintain chlorination levels at the service water intake (for one unit) necessary to provide a FAC level equal to or less than 0.20 mg/l at the furthermost point of concern in the system.

D. Evaluate effectiveness of chlorination on <u>Corbicula</u> larvae control for a period of one year.

If you should have any questions concerning this request, please contact me.

Sincerely,

John D. Grogan, Manager
Environmental Compliance

:dy

ENCLOSURE 2

ADEM

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

George C. Wallace
Governor

Leigh Pegues, Director

1751 Federal Drive
Montgomery, AL
36130
205/271-7700

Field Offices:

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2204 Perimeter Road
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36615
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October 28, 1986

Mr. Willard Bowers
Manager
Environmental Compliance
Alabama Power Company
P.O. Box 2641
Birmingham, AL 35291

Dear Mr. Bowers:

Re: Farley Nuclear Plant

We have received and reviewed John Grogan's October 22, 1986 letter relating to corbicula control at the above referenced plant. We understand that the control of these organisms has been inadequate with the present level of chlorination and that operational and regulatory concerns have arisen as a result of this problem.

We believe that your proposed methodology for the study is acceptable, with the following conditions:

1. Total residual chlorine (TRC) discharge levels of less than detectable are maintained at the main discharge line, just prior to discharge to the river, during the three week and long term studies.

2. During the period of chlorination ramp-up, chlorine monitoring is performed at DSN001(or 002) at hourly intervals until detectable levels are found, hourly intervals thereafter at the point referenced in 1., then once per 30 minute intervals until the system reaches equilibrium at no greater than the limitation levels. Thereafter, unless flows, chlorine feed rates or other considerations could impact chlorine, levels TRC and FAC shall be monitored daily at both points. If conditions do change, TRC and FAC shall be monitored once per 30 minutes until equilibrium is again reached.

3. Results from all TRC/FAC monitoring shall be submitted on the quarterly discharge monitoring reports, as appropriate, and also under separate cover on a monthly basis within 30 days after the end of each month, during the duration of the three week and long term studies.

4. At the end of the long term study, a reprot shall be submitted assessing the minimum level of chlorination possiɒle for corbicula control.

Sincerely,

James P. Martin

James P. Martin, P.E.
Chief
Industrial Branch
Water Division

ATTACHMENT 4

Revised ADEM Conditions For FNP
Service Water Chlorination

Discussions with Mr. J. P. Martin, Alabama Department of Environmental Management, on October 29, 1986 have resulted in a revision to ADEM conditions associated with the modified chlorination program. In accordance with these discussions, Item 1 of Attachment 3 (Letter from John D. Grogan to W. C. Carr, dated October 23, 1986) should be amended to read as follows:

> Total residual chlorine discharge levels are not to exceed 0.20 ppm at the river discharge structure during the three week study and long-term program.

ENCLOSURE 4

Alabama Power Company
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291
Telephone 205 250-1000

Alabama Power
the southern electric system

November 3, 1986

Farley Nuclear Plant
NPDES Permit No. AL0024619

Mr. James P. Martin
Alabama Department of
Environmental Management
1751 Federal Drive
Montgomery, AL 36130

Dear Mr. Martin:

As discussed during our phone conversations, we are providing additional information regarding our request to modify chlorination of the service water system at the above referenced facility.

Potential biofouling problems associated with Corbicula were first noted in 1978 at the referenced facility. Various control practices including physical, biological and chemical means have been utilized. Some of the more recent methods are as follows:

1. Stop log maintenance in the service water intake structure.

2. Clam removal from the intake structure and systems within the plant.

3. Strainer Maintenance Programs

4. Utilization of both chlorine gas and chlorine dioxide biocide treatment programs

5. Placement of fishes known to use Corbicula as a food source in the service water pond

In 1986, Corbicula were collected at both the intake structure and throughout the service water pond. These investigations showed a significant increase since 1983. During the current outage of Unit 1, a large number of live clams have been collected in piping throughout the service water system.

The Nuclear Regulatory Commission (NRC) is aware of biofouling conditions which can exist in generating facilities. This problem has been noted in NRC's IE Bulletin No. 81-03 with requirements to access and correct problems associated with Corbicula of blockage safety system components.

Based on the above information, modifications to the chlorination program were deemed necessary. Elevated chlorine levels within piping systems cause significant corrosion, thus our goal is to achieve the minimum amount of chlorination required to control Corbicula while maintaining requirements to operate our system in a safe and efficient manner.

Past chlorination practices utilizing chemicals noted in Item 4 have been structured such that time restraint conditions in the NPDES permit for DSN 001 and 002 were met. However, we will be chlorinating on a continuous basis during both the three week and long-term studies as outlined in my letter of October 22, 1986. Following evaluation of past results and results obtained from this study, we will submit a request to your office as described in the *** Footnote for DSN 001 and 002 which will demonstrate that a chlorine discharge of greater than two hours is required for macroinvertebrate control. As noted in the two studies, it will be necessary to exceed the present two (2) hour limit for unit chlorination in order to obtain data for our demonstration.

As discussed in our phone conversation of October 29, 1986, we will be maintaining a total residual chlorine level of 0.2 mg/l or less at the river discharge structure. It is requested that you amend Item 1 of your October 28, 1986 letter to reflect the change in approved total residual chlorine levels at the river discharge structure.

Should you have any questions or require additional information, please contact me.

Sincerely,

John D. Grogan, Manager
Environmental Compliance

JMG:dy

Alabama Power Company
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291
Telephone 205 250-1000

ENCLOSURE 5

Alabama Power
the southern electric system

November 17, 1986

Farley Nuclear Plant
NPDES Permit No. AL0024619

Mr. James P. Martin
Alabama Department of
Environmental Management
1751 Federal Drive
Montgomery, AL 36130

Dear Mr. Martin:

As discussed during our November 7, 1986 phone conversation, we are providing additional information regarding the condition contained in Item 1 of your October 28, 1986 letter. A change in this condition to a level of 0.20 ppm Total Residual Chlorine (TRC) or less at the river discharge structure was necessary to successfully conduct the two phase study to determine proper levels of chlorination for Corbicula control in the service water system.

Our requests of October 22, 1986 and November 3, 1986 were based on three items in the NPDES permit. The first, *** Footnote for DSN's 001 and 002 states, "Total residual chlorine may not be discharged from any single generating unit for more than two hours per day unless the discharger demonstrates to ADEM that discharge for more than two hours is required for macro invertebrate control..." Evidence of Corbicula in plant systems demonstrates that discharges for more than two hours will be necessary to control this macro invertebrate. The study outlined in our letter of October 22, 1986 is designed to determine the necessary level.

The second, Part II.A.4, provides conditions for bypassing. Part c.1 and 2 indicates a bypass is not prohibited and need not meet permit limits if necessary to prevent severe property damage and there are no feasible alternatives. Our phone conversations and previous correspondence addressed existing conditions in the service water system and alternatives attempted to control Corbicula. We are bypassing our normal treatment to meet chlorine limits at DSN's 001 and 002 during this period in order to find the necessary level needed for Corbicula control.

Part II.B.7 addresses temporary suspension of a part of the NPDES permit when cause exists for such suspension. As discussed previously, current conditions existing in the service water system meet the necessary cause requirements which would allow for a temporary suspension of the effluent limitations and monitoring requirements for DSN's 001 and 002.

As noted in our phone conversations and previous correspondence, we are only chlorinating the service water system of one unit at a time and are monitoring the levels of TRC in the river in the vicinity of the discharge. These measures are to insure that the impact on the river will be minimized as a result of these activities.

Should you require additional information, please contact me.

Sincerely,

John D. Grogan

John D. Grogan, Manager
Environmental Compliance

JMG:dy

ATTACHMENT 5

Revised ADEM Conditions for FNP
Service Water Chlorination

The discussion with Mr. J. P. Martin, Alabama Department of Environmental Management, on November 25, 1986 has resulted in a revision to ADEM conditions associated with the modified chlorination program. In accordance with these discussions the following items should be amended.

Section I and I.B of Attachment 2 (letter dated October 22, 1986 from John D. Grogan to Mr. J. P. Martin) should be amended to read as follows:

I. Four Week Study

B. Maintain prescribed chlorine level for a period of four (4) weeks or 100% mortality of Corbicula indicator organisms whichever occurs first.

Item 1 of Attachment 3 (Mr. John D. Grogan's letter to Mr. W. C. Carr dated October 23, 1986) should be amended to read as follows:

1. Total residual chlorine discharge levels are not to exceed 0.20 ppm at the river discharge structure during the four week study and long-term program.

The extension of seven days does not alter the Non-Radiological Environmental Impact Evaluation made concerning Service Water Chlorination which was submitted to Mr. W. C. Carr on November 3, 1986.

Alabama Power Compan,
600 North 18th Street
Post Office Box 2641
Birmingham, Alabama 35291
Telephone 205 250-1000

ENCLOSURE 7

Alabama Power
the southern electric system

November 26, 1986

Farley Nuclear Plant
NPDES Plant No. AL 0024619

Mr. James P. Martin
Alabama Department of
Environmental Management
1751 Federal Drive
Montgomery, AL 36130

Dear Mr. Martin:

This letter is to confirm changes discussed in our phone conversation on November 25, 1986 to the service water chlorination study for the above referenced facility. As stated, we will extend the three week study to a four week study or 100% mortality of Corbicula indicator organisms whichever occurs first. We will contact your office on December 1, 1986 and report whether additional time is necessary.

Should you have any questions, please contact me.

Sincerely,

Mike Godfrey / for

John D. Grogan, Manager
Environmental Compliance

JMG:dy

Attachment 3

Revised ADEM Conditions for FNP
Service Water Chlorination

Discussions with Mr. J. P. Martin, Alabama Department of Environmental Management (ADEM), have resulted in revisions to ADEM's conditions associated with the approved modified chlorination program. They are as follows:

* Continuous chlorination for Unit 2 may continue for eight weeks or until greater than 90% mortality of Corbicula control indicator organisms is achieved whichever occurs first.

* Total residual chlorine discharge levels are not to exceed 0.20 ppm at the river discharge structure during each chlorination period.

The ADEM will make a decision regarding approval of our desired long term chlorination procedure following completion of the one year program approved by the ADEM on October 28, 1986.

Attachment III

Revised ADEM Conditions for FNP
Service Water Chlorination

Discussions with Mr. Jim Moore (ADEM) have resulted in an extension and revisions to ADEM's conditions associated with the currently approved chlorination program scheduled for completion on October 28, 1987. They are as follows:

* The October 28, 1987 deadline has been lifted to allow one more chlorination for Corbicula control on each unit. This will allow for control of the Corbicula produced from the Fall spawn.

* Continuous chlorination for either unit may continue for eight weeks or until greater than 90% mortality of Corbicula indicator organisms is achieved, whichever occurs first.

* While chlorinating one unit for Corbicula control the opposite unit may be chlorinated (i.e., 3 periods/day with chlorine dioxide) as per "normal" procedures for service water chlorination.

* Total residual chlorine levels are not to exceed 0.20 ppm at the river discharge structure during each chlorination period.