BEFORE THE ILLINOIS POLLUTION
CONTROL BOARD

RECEIVED

POLLUTION CONTROL BOARD

In the matter of:

PROPOSED DETERMINATION OF)
NO SIGNIFICANT ECOLOGICAL)
DAMAGE FOR THE QUAD CITIES)
GENERATING STATION)

No. PCB 75-61

PETITION FOR DETERMINATION
UNDER RULE 203(i)(5)

Commonwealth Edison Company (the "Company), hereby requests, pursuant to Rule 203(i)(5) of Chapter 3 of the Rules and Regulations of the Illinois Pollution Control Board, that the Board make a determination that discharges from the Company's Quad Cities Generating Station have not caused and cannot be reasonably expected to cause significant ecological damage to the receiving waters, namely the Mississippi River.

1. Attached hereto is the "REPORT OF PETITIONER COMMONWEALTH EDISON COMPANY IN SUPPORT OF PETITION FOR DETERMINATION UNDER RULE 203(i)(5)." This Report contains the information specified in Rule 602 of Chapter 1, Procedural Rules, of the Board's Rules and Regulations.

2. The Company waives its right to a hearing herein. In the event a hearing is held, however, the Company requests that it be held in Cook County pursuant to Rule 605(a) of Chapter 1.

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2. The Company waives its right to a hearing herein. In the event a hearing is held, however, the Company requests that it be held in Cook County pursuant to Rule 605(a) of Chapter 1.

WHEREFORE, the Company prays that the Board determine:

That the discharges from the Company's Quad Cities Generating Station have not caused and cannot be reasonably expected to cause significant ecological damage to the Mississippi River within the meaning of Rule 203(i)(5) of Chapter 3 of the Board's Rules and Regulations.

COMMONWEALTH EDISON COMPANY

By ______________________
One of Its Attorneys

ISHAM, LINCOLN & BEALE
One First National Plaza
Suite 4200
Chicago, Illinois 60603
(312) 786-7500

RECEIVED
POLLUTION CONTROL BOARD
PCB 75-[illegible]

REPORT OF COMMONWEALTH EDISON COMPANY IN SUPPORT OF ITS PETITION FOR A DETERMINATION UNDER RULE 203(i)(5)

GENERAL PLANT DESCRIPTION AND HISTORY OF STATION OPERATION

The Quad Cities Station is a nuclear fueled steam electric generating facility owned jointly by Commonwealth Edison Company and Iowa - Illinois Gas & Electric Company. The station is located at Cordova, Illinois on Pool 14 of the Mississippi River about 21 miles north of the Davenport - Bettendorf-- Moline - Rock Island area (Figure 1).

The station consists of two boiling water reactor units each with an output of 2,511 megawatts thermal (MWt) and 809 megawatts net electrical (MWe). Quad Cities Station began commercial operation in early 1972. Unit 1 began commercial operation in April, 1972 and was followed by Unit 2 in May, 1972.

For the first three months of operation, the station operated with once through cooling utilizing a side jet discharge system. During this period, the station was limited to power production of 50% plant capacity. Meanwhile, installation of two 16 ft. diameter diffuser pipes in the river bed of the Mississippi River was proceeding. The diffuser system began operation in August, 1972 and was the interim cooling method used while a closed-cycle, spray canal system was designed and constructed. After start-up and operation of the diffuser system, operational constraints were lifted and the station began operating near 100% capacity. The station operated in this condenser cooling configuration until May, 1974. From May 1974 to October 1975, the station discharged about one-half of its wasteheat to the closed cycle spray canal, with the remainder going to the river.

Since October, 1975 the station has operated primarily in the closed-cycle mode utilizing the spray canal for cooling water heat dissipation. Pursuant to the terms of an agreement the Attorney General of Illinois, the station may operate open cycle with the diffuser cooling system when instances of unusually high system demand requiring the purchase of power from other utilities or endangerment to the health and safety of the public, such as fog formation and icing, arise.

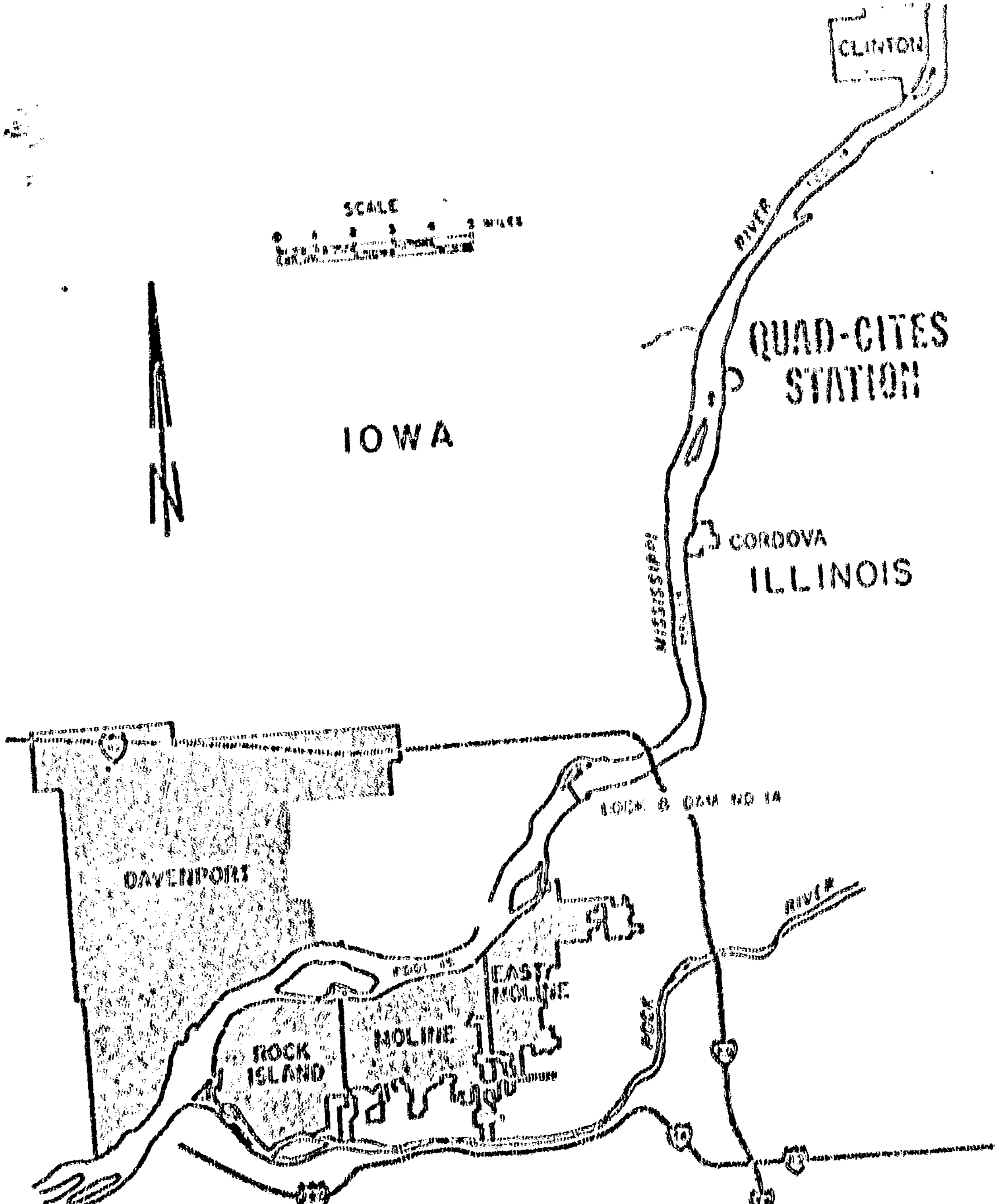
The station capacity factor which is defined as the fraction: station net generation (MWHR) ÷ station winter net capacity (MW) x hours in period, and expressed as a percentage is shown in Table 1 for the period 1972-76. During this period the highest and lowest capacity factors were 59.5% and 37.0% experienced in 1976 and 1975, respectively.

TABLE 1

Quad-Cities Station - Historical Capacity Factor

Year	Plant Capacity Factor - %
1972	58.3
1973	58.4
1974	43.8
1975	37.0
1976	59.5

Capacity factors in the range of 60-65% are expected with future operation. Although no specific plans have been made



LOCATION MAP OF QUAD CITIES STATION

regarding retirement of the station, using an average 35-year operating life of a generating unit, retirement in the year 2007 may be anticipated. There are no plans for additional units at the plant. Quad Cities Station on several occasions has been shut down. Shutdown durations have ranged from a matter of minutes to several months. In most instances, shut-down periods of extended duration (longer than one month) are caused by unit refueling or scheduled maintenance overhauls. Unit shutdowns for shorter periods are generally caused by equipment malfunction.

A history of unit shutdowns for the period 1972-1976 are shown in Figures 2-6. The shutdown periods depicted in these figures reflect unit outages of 7 days and longer. Instances of complete plant shutdown for this same period are listed in Table 2.

The projected and planned unit shutdowns resulting from scheduled refueling and maintenance outages for the period 1978-1982 are similarly shown in Figures 7-11. It can be seen that no periods of complete plant shutdown are scheduled. These are scheduled outages and do not include forced outages caused by equipment malfunction or other unplanned reason.

A projected forced outage factor has been estimated for the station by the Company's System Planning Department. During the next five years, it has been projected that the two Quad Cities units will be forced out of service approximately 10% of the time.

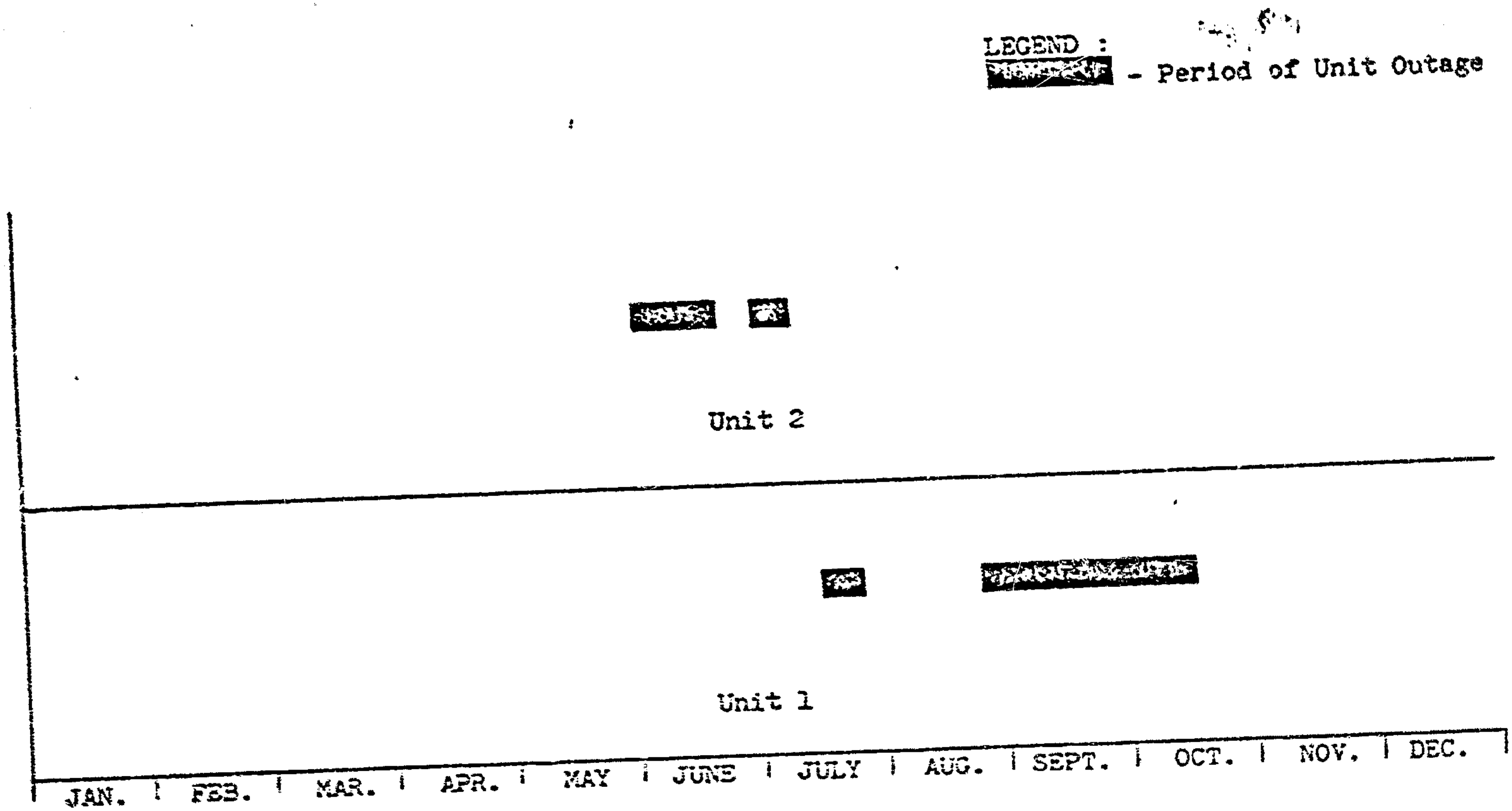


Figure 2. Unit outages of 7 days duration or longer at Quad Cities Station for the year 1972.

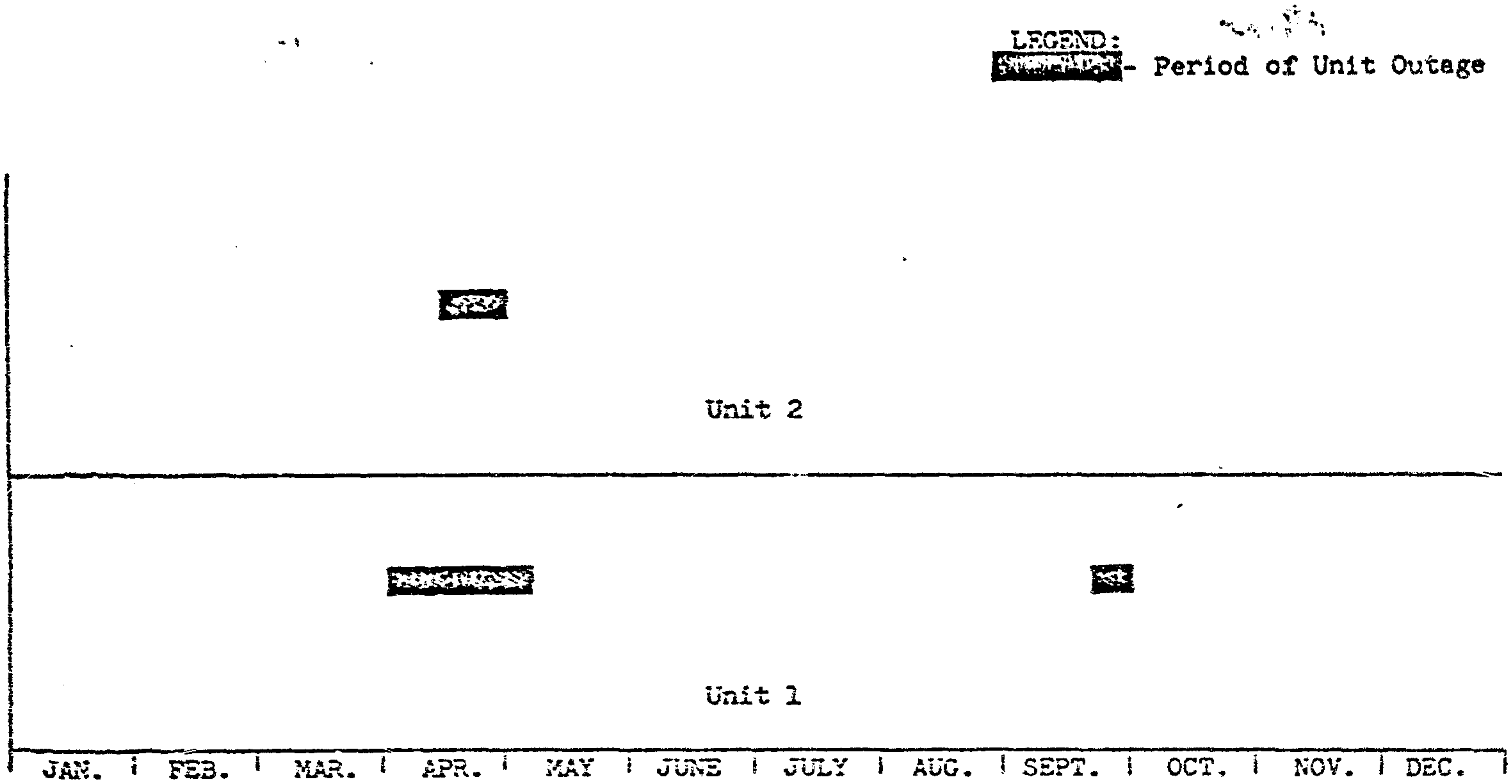


Figure 3. Unit outages of 7 days duration or longer at Quad Cities Station for the year 1973.

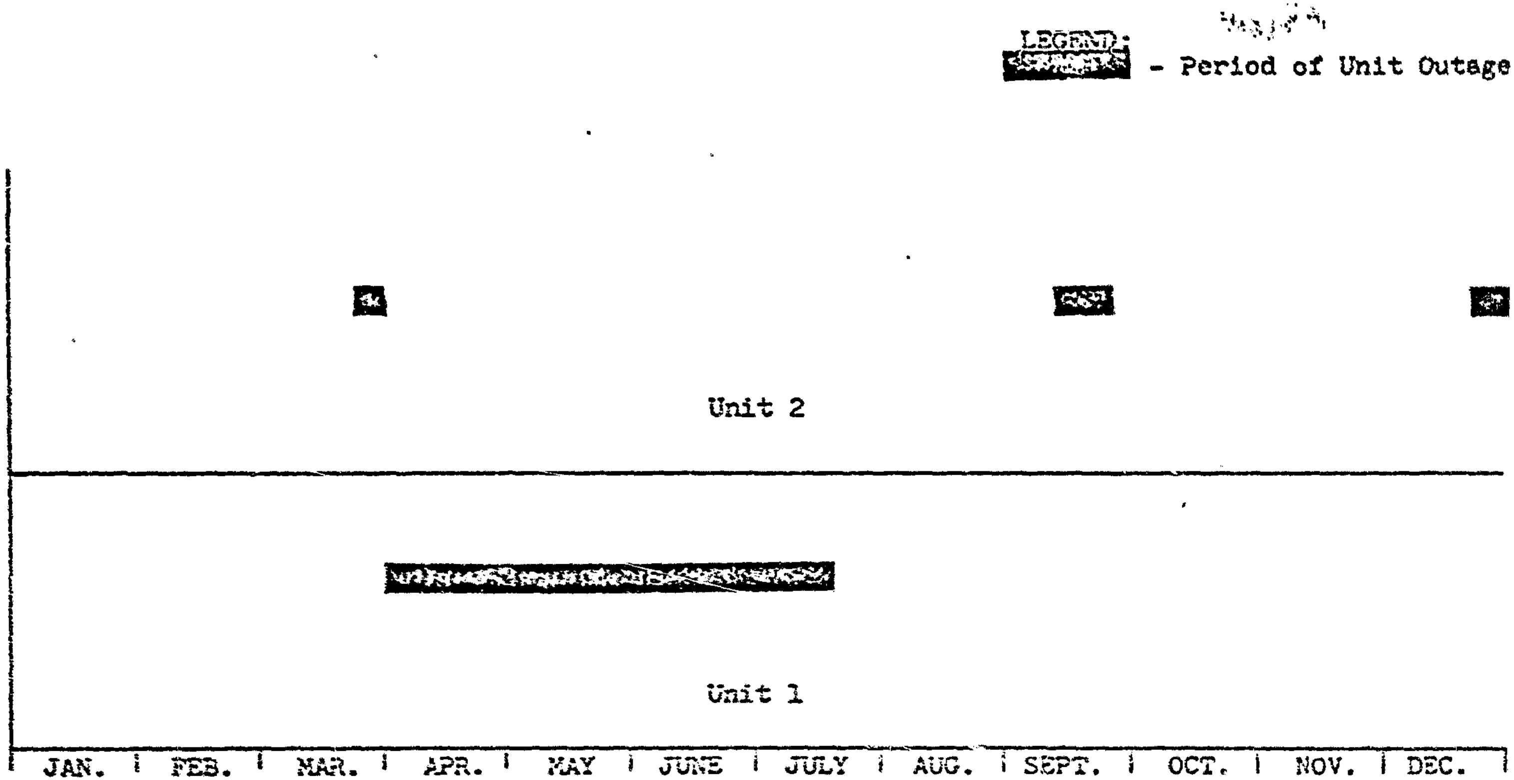


Figure 4. Unit outages of 7 days duration or longer at Quad Cities Station for the year 1974.

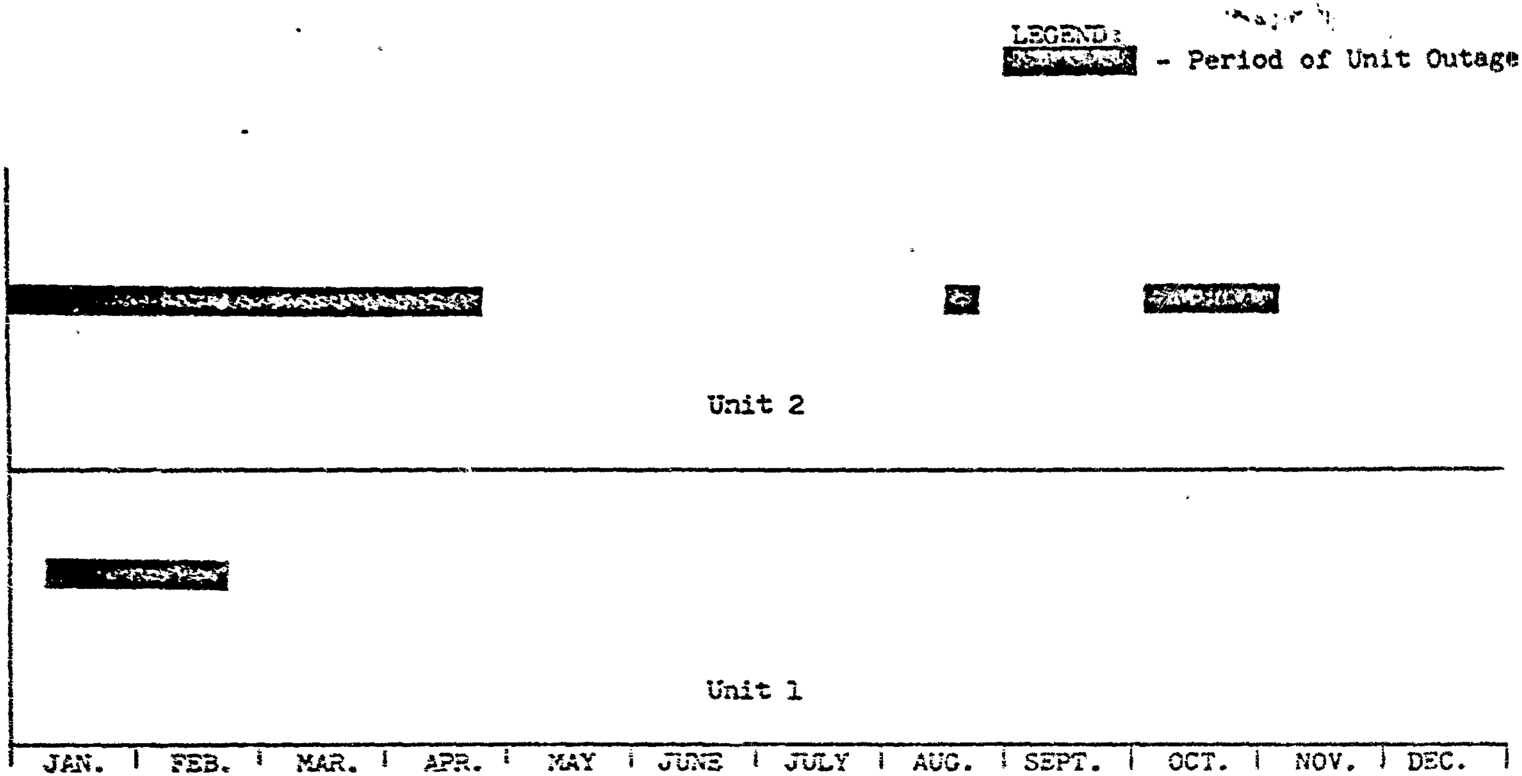


Figure 5. Unit outages of 7 days duration or longer at Quad Cities Station for the year 1975.

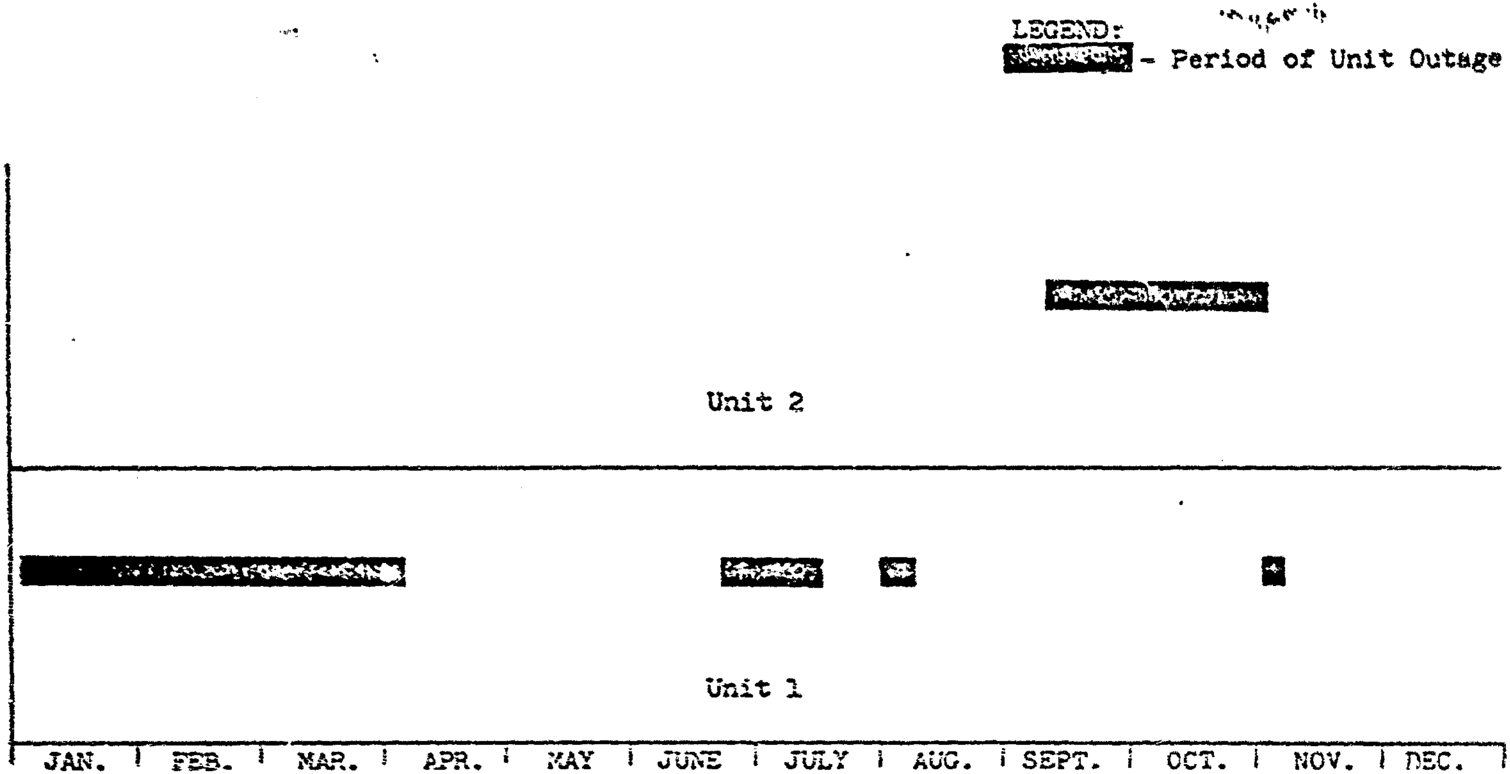


Figure 6. Unit outages of 7 days duration or longer at Quad Cities Station for the year 1976.

Table 2

INSTANCES AND DURATIONS OF COMPLETE PLANT SHUTDOWN AT QUAD CITIES STATIONS FOR THE PERIOD 1972-1976

Date of Plant Shutdown	Duration of Shutdown - Days
May 2, 1972	5
June 2, 1972	1
June 10, 1972	2
June 16, 1972	2
September 23, 1972	5
December 28, 1972	2
April 21, 1973	9
August 2, 1973	3
April 12, 1974	2
June 10, 1974	6
June 19, 1974	3
January 9, 1975	43
February 7, 1976	2
February 10, 1976	2
October 9, 1976	1
November 2, 1976	4

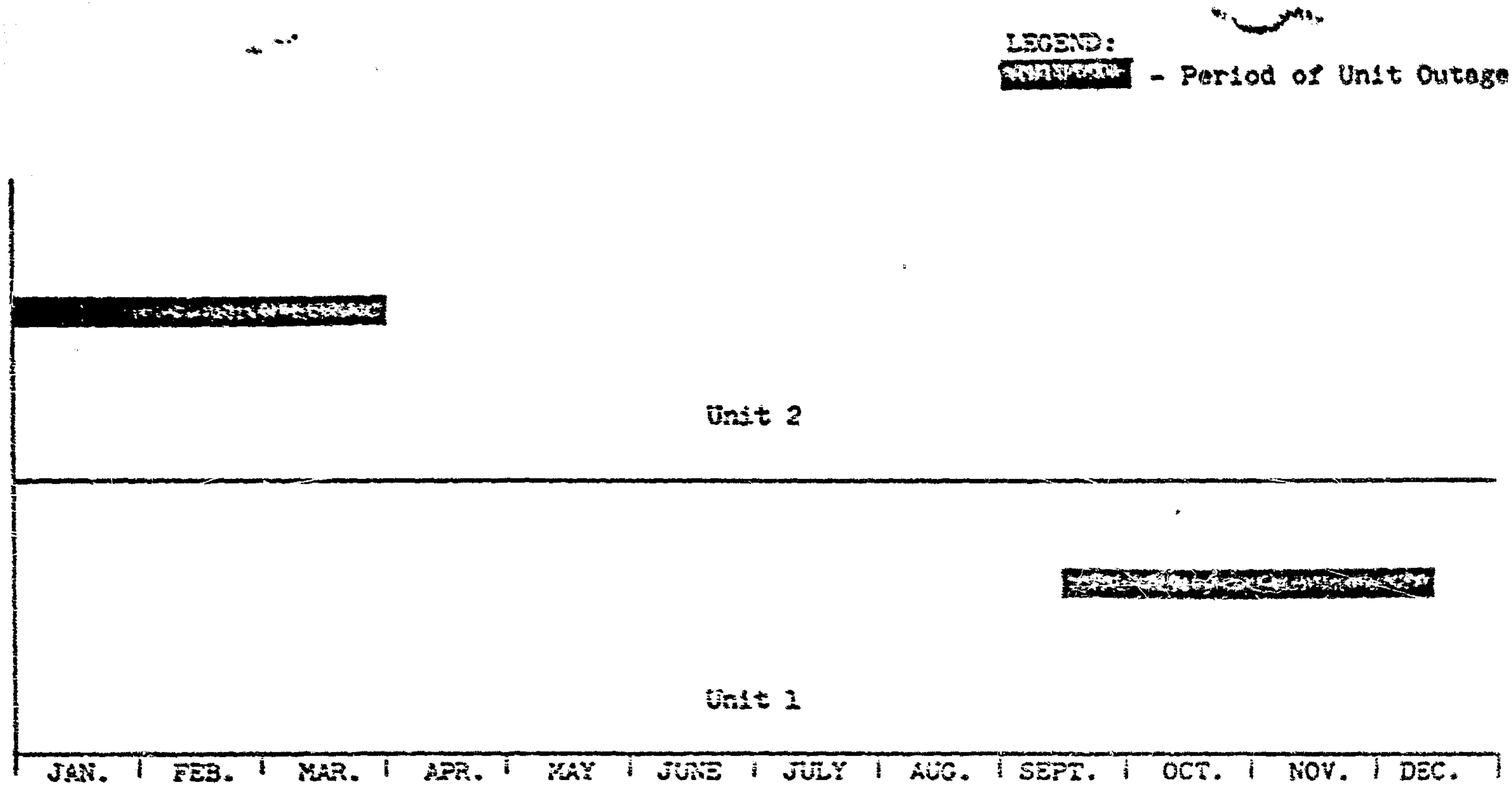


Figure 7. Projected unit outages of 7 days duration or longer at Quad Cities Station for the year 1978.

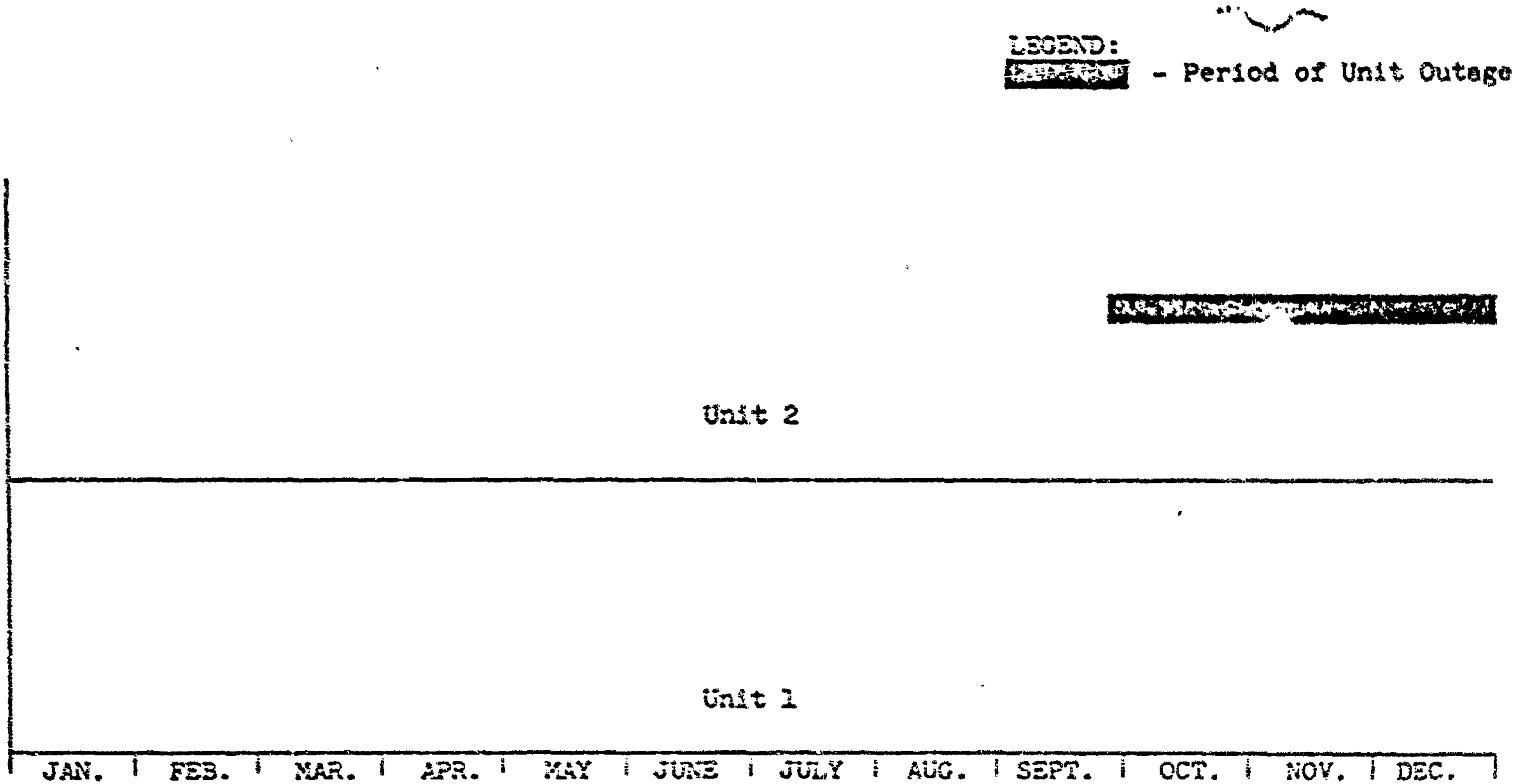


Figure 8. Projected unit outages of 7 days duration or longer at Quad Cities Station for the year 1979.

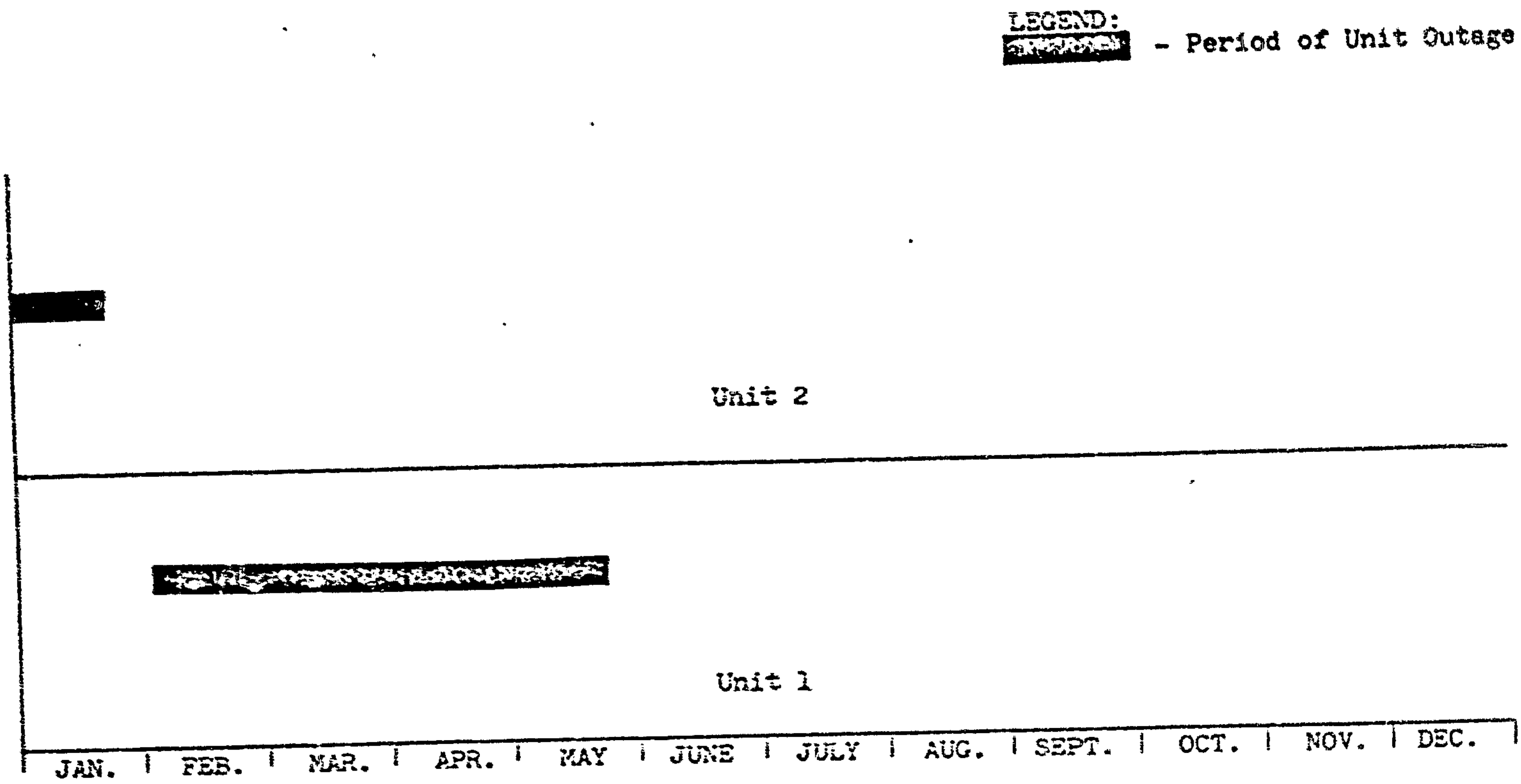


Figure 9. Projected unit outages of 7 days duration or longer at Quad Cities Station for the year 1980.

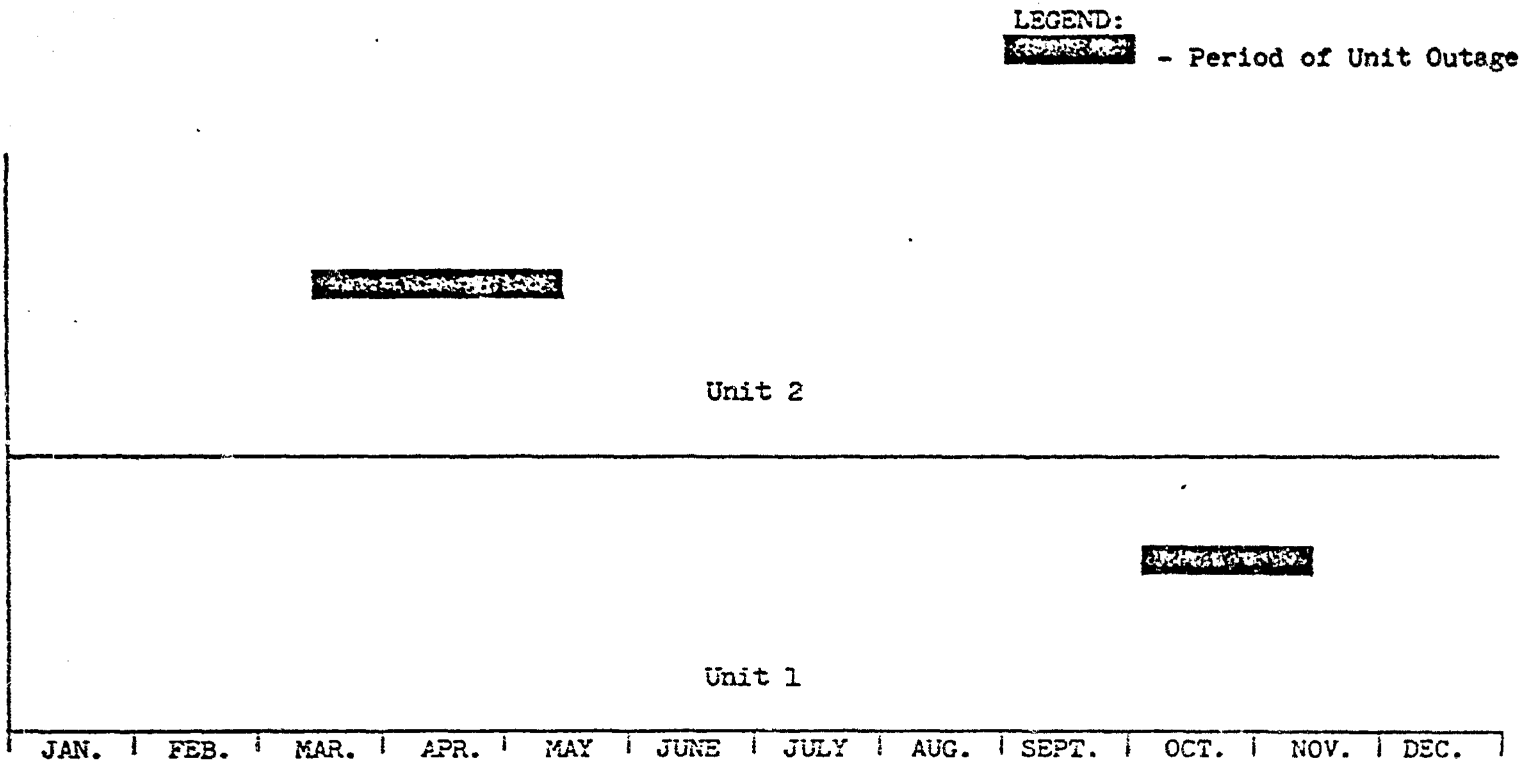


Figure 10. Projected unit outages of 7 days duration or longer at Quad Cities Station for the year 1981.

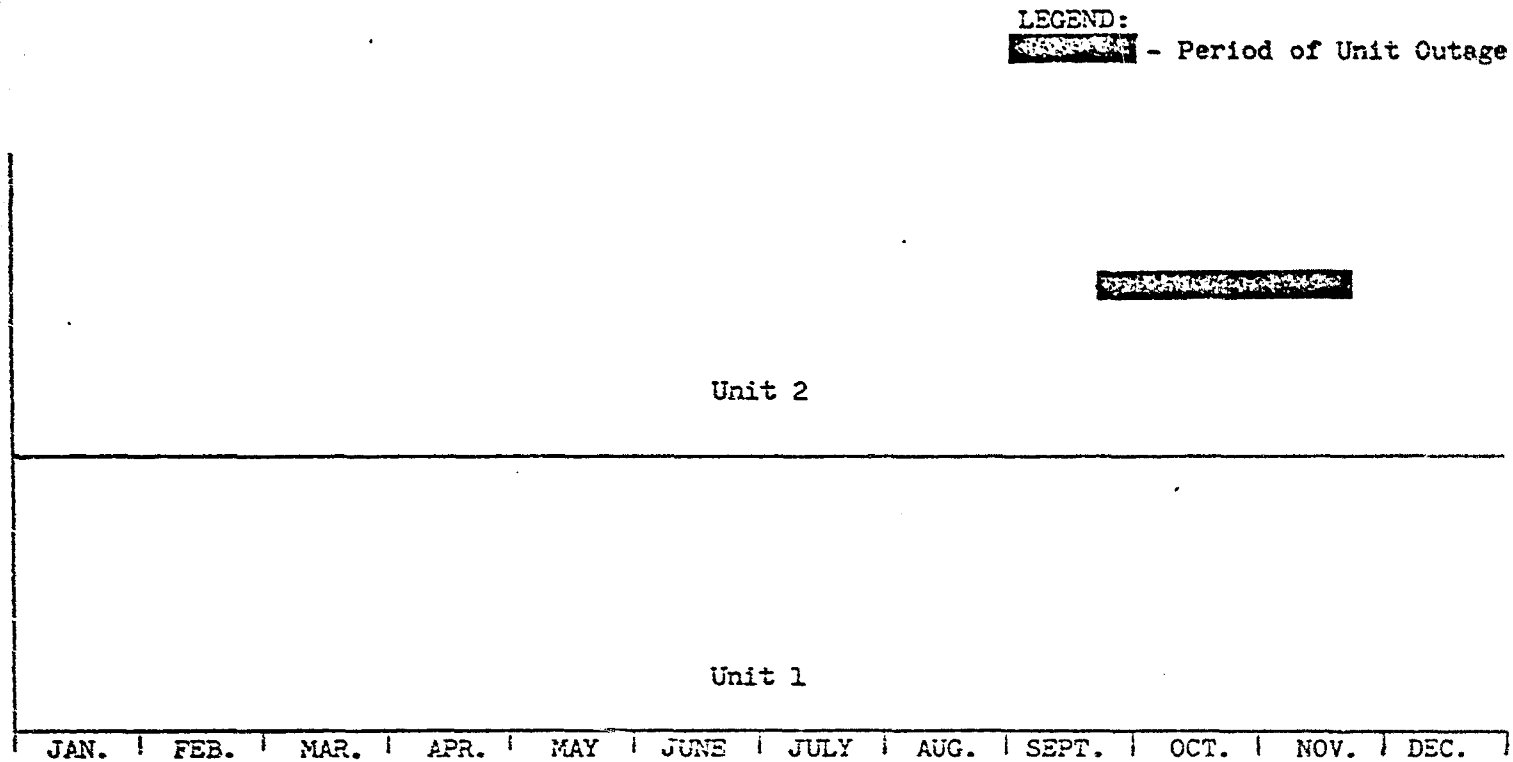


Figure 11. Projected unit outages of 7 days duration or longer at Quad Cities Station for the year 1982.

PLANT COOLING SYSTEM

Heated condenser effluent is cooled by an off stream spray canal system. The spray canal is approximately 14,000 feet long, 185 feet wide and nine feet deep, and is designed to accommodate a flow of about one million gallons per minute (gpm). Six lift pumps, each with a capacity of 167,000 gpm, move the heated water from the discharge bay into the canal where water is cooled by the evaporative action of approximately 300 floating spray modules. The cooled water returns to the intake bay and is recirculated through the condensers. Figure 12 depicts the major components of the Quad Cities cooling water system.

Blowdown from the canal is discharged to the Mississippi River through a 4 foot dia. 1000 foot long diffuser pipe at an annual average rate of 50 cfs. The location and position of the blowdown diffuser is also shown in Figure 12.

Prior to use of the spray canal (April 1972 - May 1974) the station operated with an open-cycle condenser cooling system. With the exception of a short period of time (April - July 1972) when an interim side-jet discharge was utilized, all of the heated condenser water was discharged into the river through a diffuser system.

The diffuser system is now used on a back-up or emergency basis. The open-cycle diffuser system consists of two 16-foot diameter multi-port pipes in the bottom of the main channel of the river. The two diffuser pipes extend approximately 2000 ft. across the main channel and lie below the 18 foot maximum depth required for navigation. The location and position of these diffuser pipes are shown in Figure 12.

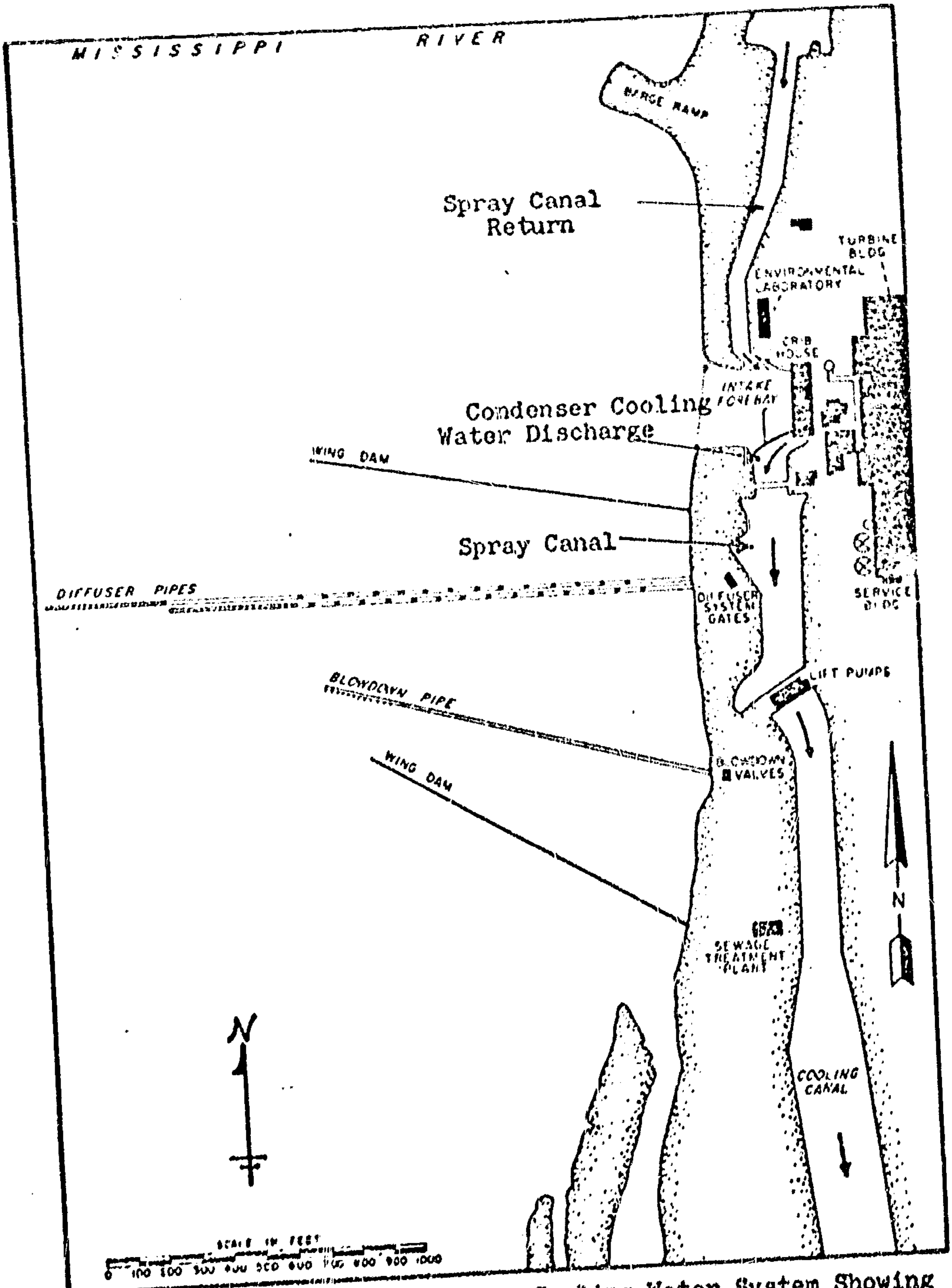


Figure 12. Quad Cities Station Cooling Water System Showing Spray Canal and Diffuser Discharge Pipes

Effluent from the diffuser pipes is discharged as jets from a series of risers that are spaced along the pipes. Beginning approximately 840 ft. from the Illinois shore, ten 24 inch risers are spaced at intervals of 39 feet across the remainder of the shallow water region and extend 400 feet into the navigation channel. Forty 36 inch diameter ports are spaced at intervals of 20 feet across the deep water region spanning the next 780 feet. No heated water is discharged to the shallow off-channel portions of the river, since the lower velocity in the shallows does not provide effective mixing and dilution. Each riser is inclined at an angle of 20 degrees with the port pointing in the downstream direction. The design of the diffuser system is illustrated in Figure 13. Discharge velocity from the jets is approximately 10 feet per second at full load.

HYDROLOGICAL CHARACTERISTICS OF THE RECEIVING STREAM

The Mississippi River in the vicinity of the Quad-Cities Station has a drainage area of approximately 85,600 square miles. The flow distribution in the river is distinctly seasonal. Annual high flows usually occur between April and June and the annual low flows occur between December and February. A minimum daily flow of 6,500 cfs. was reported in December of 1933. The average flow for the period of record (1864 to 1969) is 47,000 cfs. The seven day 10-year low flow as determined by the U.S. Geological Survey at Clinton, Iowa, a short distance upstream from the Quad-Cities Station, for the period 1864 to 1969 was 9,400 cfs. Following the construction of navigation dams which resulted in a leveling of river flow, the seven day 10-year low increased

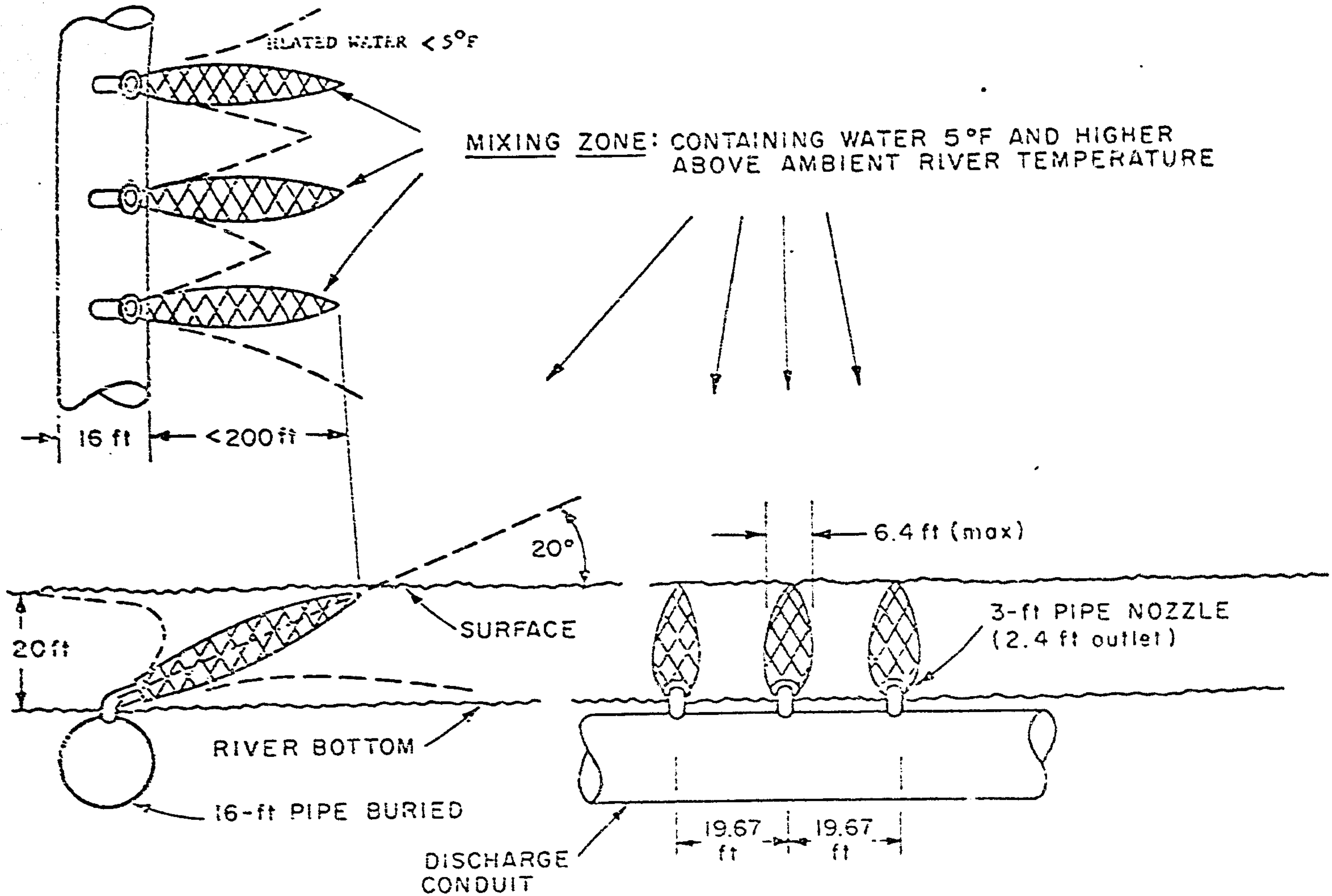


Figure 13. Diffuser Pipe System and Thermal Plumes (not to scale)

slightly. During the period 1939 to 1970 the seven day 10-year low flow was 13,970 cfs. Maximum, minimum and average monthly flows for the period of record (1864 to 1969) are given in Table 3.

CURRENT DATA

Current velocities in the Mississippi River in the vicinity of the Quad-Cities Station vary both spatially and temporally. In general, maximum current velocities occur in the main channel with substantially lower velocities occurring in channel edge and side-channel areas. Little or no water movement occurs in slough areas.

Current velocities in the main channel are influenced primarily by river stage. In general, greatest current velocities occur during the April-June period when river flow is at a maximum. Maximum current velocities of 1.7 meters/sec have been observed at mid-channel locations during this period. Lowest current velocities usually occur during the fall and winter months. The minimum monthly and maximum monthly current velocities observed in the river channel edge areas during the period February 1973-July 1974 were 0.1 meters/sec and 1.7 meters/sec, respectively. The average monthly velocities during this period ranged from 0.1 meters/sec to 1.0 meters/sec.

STRATIFICATION CHARACTERISTICS OF THE RECEIVING STREAM

With the exception of the slough areas which may exhibit pronounced thermal and chemical stratification during the summer months, little stratification occurs in the river in the vicinity of the Quad-Cities Station. Intermittent thermal stratification

Table 3

Summary of 1864-1969 Mississippi River Discharges*

Month	Average Flow (cfs)	Max. Daily Flow (cfs)	Min. Daily Flow (cfs)
Jan.	24,185	107,000	8,000
Feb.	26,375	100,000	9,000
Mar.	47,289	164,400	7,000
Apr.	86,563	307,000	17,400
May	79,662	284,000	18,100
June	69,421	250,000	14,600
July	55,463	215,000	11,900
Aug.	36,791	116,000	10,500
Sept.	36,733	176,000	10,500
Oct.	39,508	237,000	12,500
Nov.	36,570	213,000	10,000
Dec.	25,443	90,400	6,500

*U.S.G.S. Data from Clinton, Iowa

has been observed on the Iowa side of the river due to inflow from the Wapsipinicon River and upstream discharges in the vicinity of Clinton, Iowa. However, temperature differentials were transitory and rarely exceeded 2°F. Little evidence of thermal stratification has been observed in the main river channel.

AMBIENT TEMPERATURE OF THE RECEIVING STREAM

Continuous monitoring of water temperature upstream and 600 feet downstream from the Quad Cities Station was initiated in October 1971. Prior to this time only limited information concerning ambient river temperature in the vicinity of the station was available. However, a good deal of long-term temperature data are available from the Davenport, Iowa Water Plant, located approximately 22 miles downstream from the station. These data are believed to be representative of the thermal characteristics of Pool 14.

Monthly maximum, and monthly average water temperatures recorded at the Davenport water plant during the period 1962 to 1970 are given in Table 4. Maximum temperatures generally occur during July and have not been reported as exceeding 86°F in the main channel. Ryckman, Edgerley, Tomlinson & Associates reported that the river temperature at Davenport has been 85°F or higher, only about 1/10th of 1 percent of the time.

In general, average ambient river temperatures monitored at the station have been comparable to subsequent seasonal temperatures recorded at the Davenport plant. With several exceptions, maximum monthly temperatures at the station were lower than those recorded at Davenport. During the October 1971 - July 1974 period,

Table 4

Monthly Average and Monthly Maximum Temperatures
in the Mississippi River at the Davenport
Water Treatment Plant - July 1962 - February 1971*

Month	Maximum Observed Temp.	Average Temp.
Jan.	37	33.1
Feb.	38	33.3
Mar.	54	37.0
Apr.	63	49.2
May	73	62.5
June	81	72.8
July	85	77.8
Aug.	83	76.6
Sept.	80	68.9
Oct.	69	57.4
Nov.	55	44.0
Dec.	42	34.3

*Compiled by RETA 1971

a maximum ambient temperature of 83.3°F was recorded at the station's upstream river sensor.

THERMAL PLUME CHARACTERISTICS OF HEATED DISCHARGE ONCE THROUGH UTILIZING DIFFUSER PIPES

The cooling water discharge at the Quad-Cities Station is discharged into the Mississippi River either by means of a blowdown diffuser pipe or two large diffuser pipes. Both systems are designed to distribute discharged water across the river more or less in proportion to the transverse distribution of the ambient river discharge in such a way that complete mixing is achieved within a short distance. Numerous temperature surveys have been conducted to determine the distribution of the temperature rise in the river. Temperature monitors were installed 600 ft. downstream from the diffusers to determine compliance with thermal standards. At the 600 ft. distance, the thermal plume area is less than 26 acres and the radius of the plume no larger than 600 ft.

To determine the temperature rise due to the discharge, ambient temperatures 200 ft. upstream from the diffuser pipe were measured, both before and after the 600 ft. downstream survey. Thus, the temperature rise at a point in the river was estimated as the difference between the measured temperature at a point in the 600 ft. downstream cross-section and the ambient temperature at the corresponding point in the 200 ft. upstream cross-section.

The diffuser system was designed and laboratory tested at the Iowa Institute of Hydraulic Research (IIHR), of the University of Iowa. Subsequent to diffuser installation and operation, field measurements of river velocity and temperature distributions near the Quad-Cities Station have been taken by IIHR. The purpose of these studies was to verify laboratory simulations and plume models derived to predict plant output - river flow - thermal plume relationships.

A predictative model developed using laboratory simulators and field monitoring data, indicates that with the plant operating at full load in the completely open-cycle mode, the maximum temperature rise 500 ft. downstream from diffusers (this distance across the entire width of the river equals an area roughly equal to 25 acres, an area far larger than the expected plume area, although for purposes of discussion a conservative estimate of the potential plume) will be less than 5°F for all flows greater than about 15,000 cfs. Further, the model indicates that the zone of passage will be greater than 75 per cent for all river flows greater than about 15,300 cfs. This situation is for complete open-cycle cooling.

Actual field monitor data is available for river flows down to 19,000 cfs. At those flows with full power output compliance with all thermal limits was attained.

Heat dissipated to the river during closed-cycle operation will meet thermal limits for all recorded river flow conditions. This is due to the comparatively small heat rejection rate for closed-cycle rather than once-through cooling (approximately 2×10^9 BTU/hr versus 12×10^9 BTU/hr).

ACTUAL TEMPERATURE MONITORING DATA

As discussed earlier, numerous factors influence the configuration of thermal plumes. The more significant factors include: river flow conditions, station output, and the type of cooling system employed. The latter two factors essentially determine the heat rejection rate. Accordingly, it is incomplete to describe a thermal plume without including such supportative information.

An overall perspective of the operational history of Quad Cities Station for the period 1972-1976 is shown on a daily basis in Figures 14-18. Depicted in these figures are data indicating: the type of cooling system used, the daily station power output as a percent of theoretical capacity, the daily mean river flows, and the daily mean and maximum temperature rise in the river at the edge of the standard 600 ft. mixing zone for the station's thermal discharge. These graphs can readily be used to determine compliance with applicable Illinois thermal standards as downstream temperature recorders were set at distances designed to detect thermal plumes with radii 600 ft. or larger.

Figures 14-18 present in graphical form, four sets of data assembled in three levels. The lowermost set of curves graph both station output and the mean daily river flow. The abscissa axis, common to all three levels, indicates the time scale on a daily basis. The middle curve depicts compliance with state thermal standards by indicating the mean and maximum temperature increases at the edge of the allowable mixing zone. The upper curve indicates the type of cooling system employed at the station for any given day of operation.

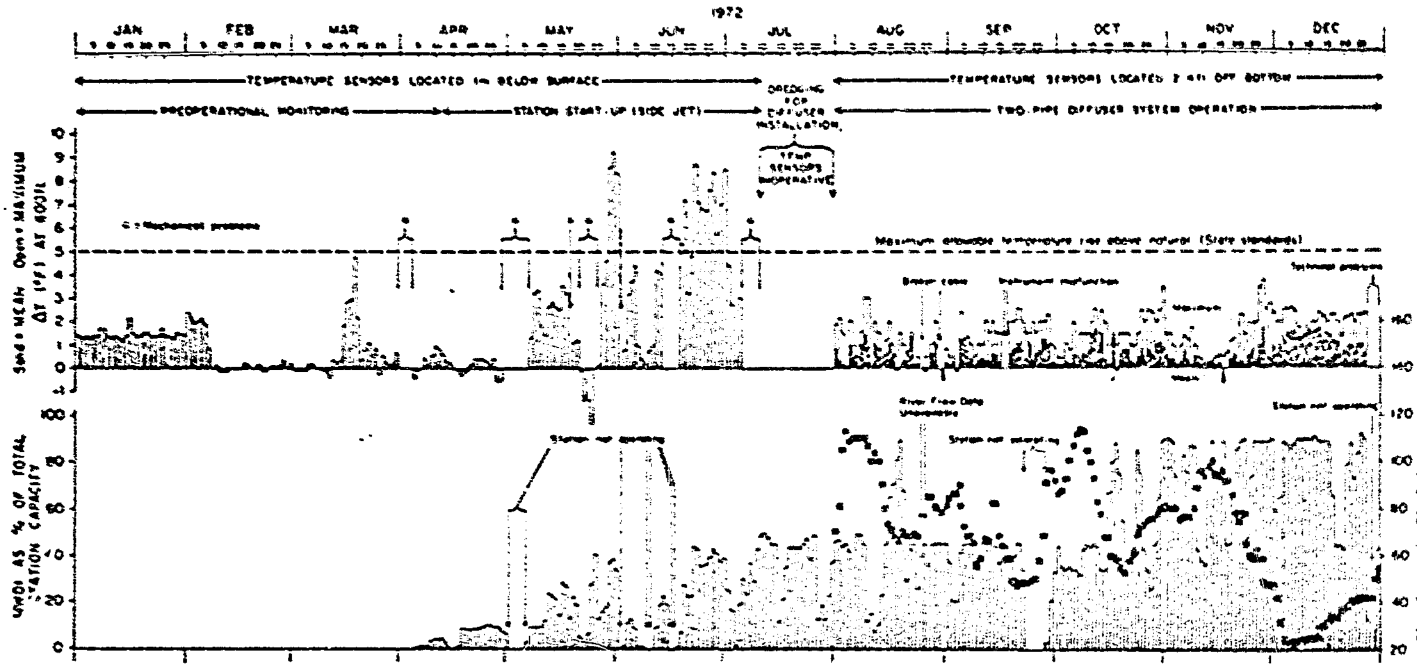


Figure 14. Time line; daily operational history of the Quad-Cities Station; power output; river flow; and mean and maximum temperature rise in the river at the edge of the 600 foot mixing zone below the station's diffuser system, January through December 1972.

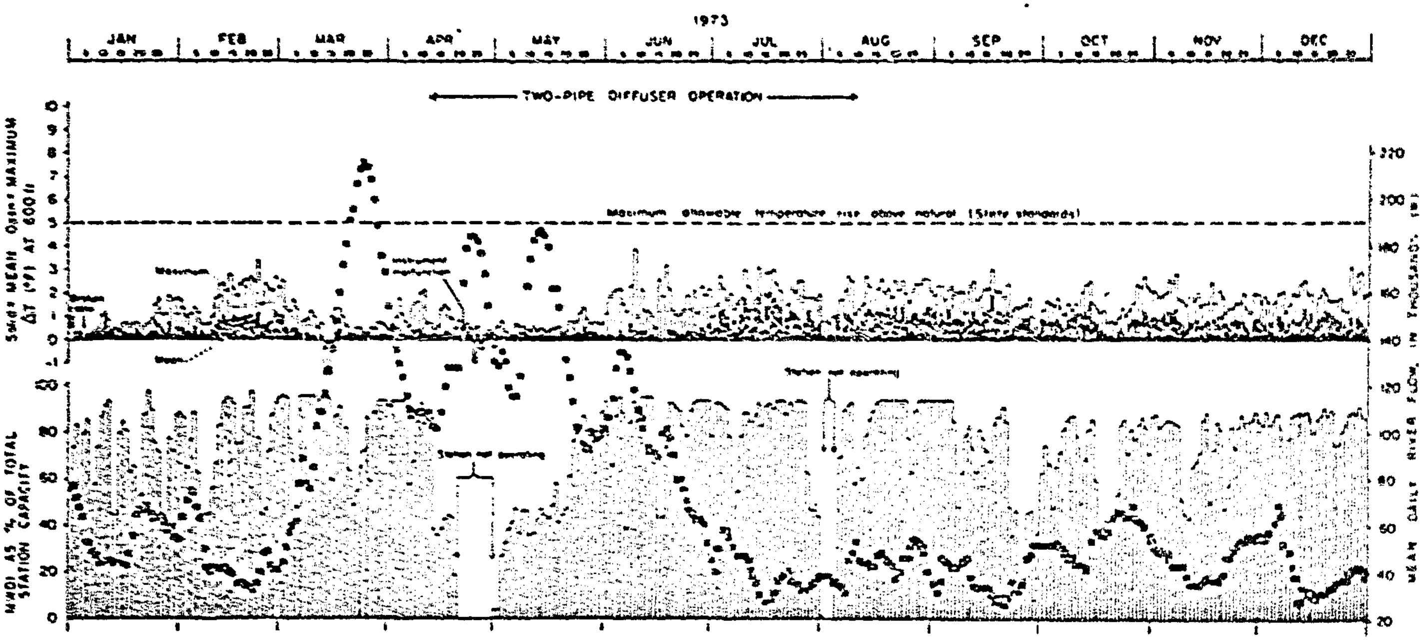


Figure 15. Time line; daily operational history of the Quad-Cities Station; power output; river flow; and mean and maximum temperature rise in the river at the edge of the 600 foot mixing zone below the station's diffuser system, January through December 1973.

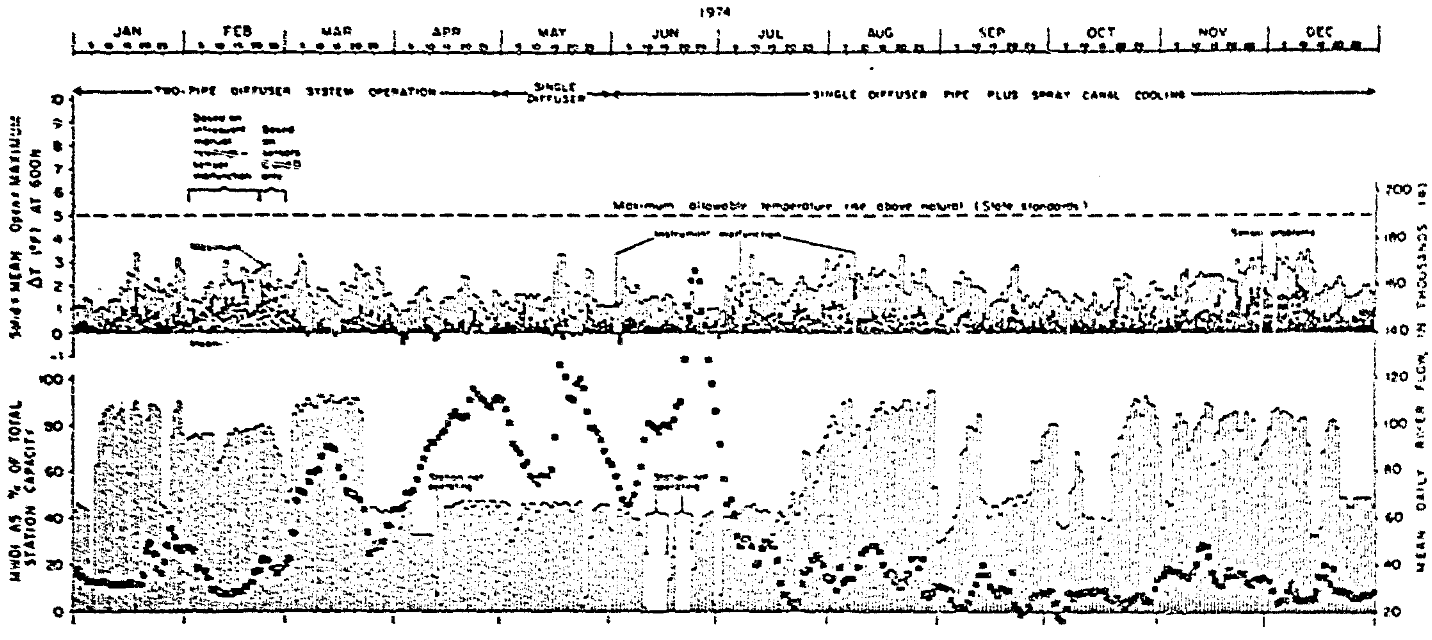


Figure 16. Time line; daily operational history of the Quad-Cities Station; power output; river flow and mean and maximum temperature rise in the river at the edge of the 600 foot mixing zone below the station's diffuser system, January through December 1974.

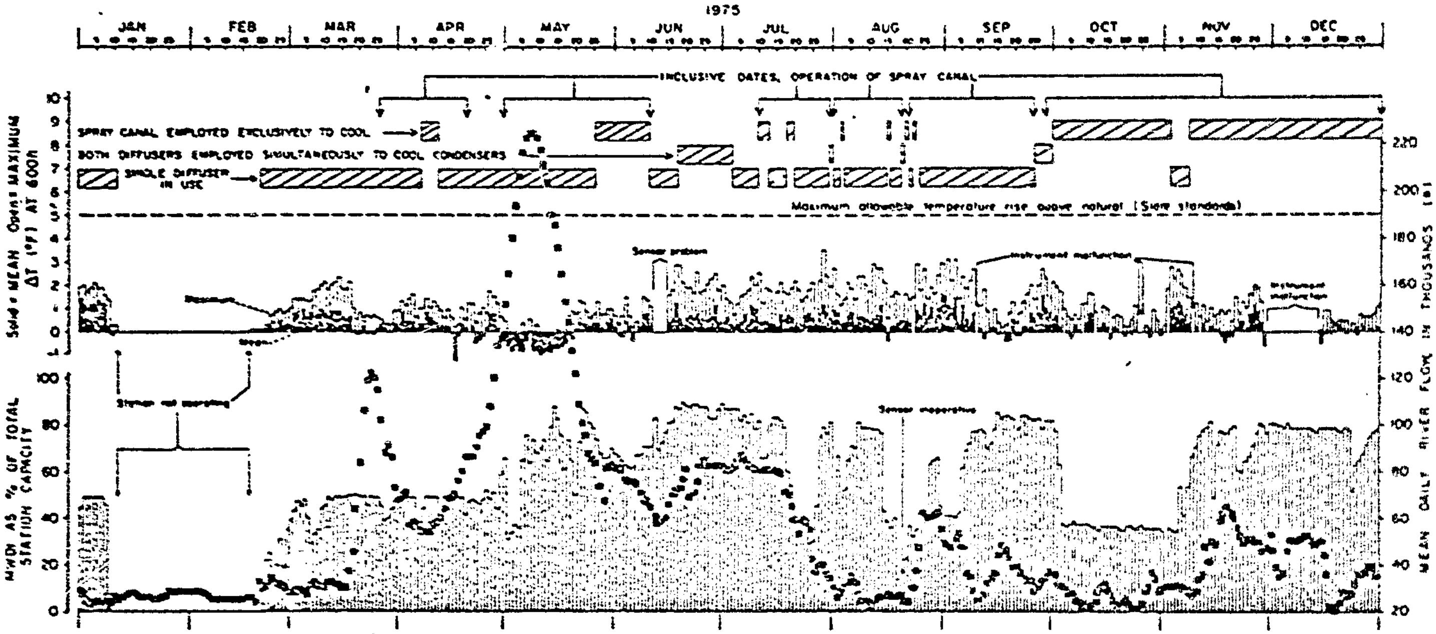


Figure 17: Time line; daily operational history of the Quad-Cities Station; power output; river flow; and mean and maximum temperature rise in the river at the edge of the 600 foot mixing zone below the station's diffuser system, January through December 1975.

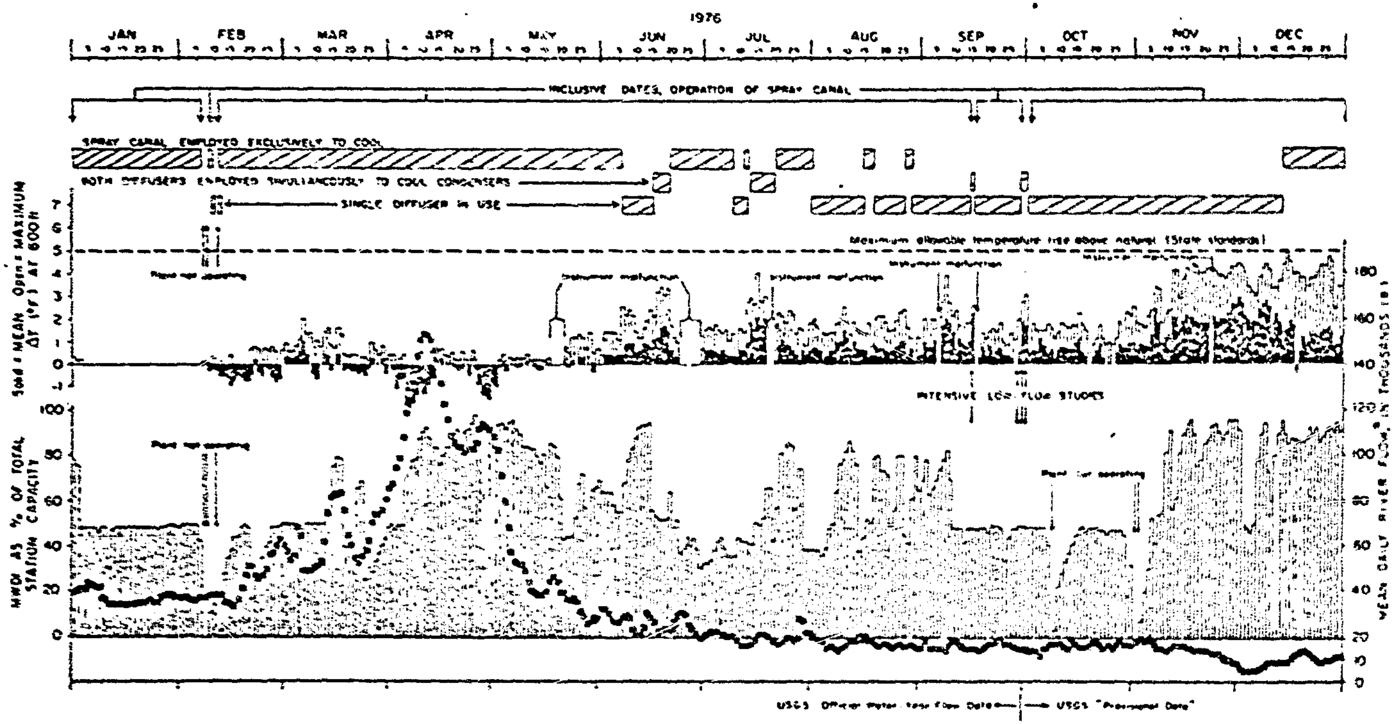


Figure 18. Time line; daily operational history of the Quad-Cities Station; power output; river flow; and mean and maximum temperature rise in the river at the edge of the 600 foot mixing zone below the station's diffuser system, January 1976 through December, 1976.

It is evident from these figures that except for the first two months of operation when the side jet discharge system was used, heat discharged from the station for the five year period 1972-1976 always complied with state thermal standards. Uncompiled data for 1977 suggest no variation from this condition. It can be concluded that the heated discharge from either diffuser pipe is rapidly mixed with the river water and, that because the diffuser discharge ports span only approximately 1200 ft. of the 2200 ft. width of the river, that only a small portion of the river is subject to temperature increases of 5°F or more above the ambient.

Based upon the generally recognized assumption that temperature increases of less than 5°F above ambient do not constitute a thermal barrier for the migration of aquatic forms, the zone of passage between diffuser ports was in excess of 86% throughout the entire period of once-through operation. When the entire width of the river is considered, the zone of passage is considerably greater due to the absence of diffuser ports in the shallow water areas on each side of the river as well as the spaces of unaffected water between diffuser ports.

TOTAL HEAT DISCHARGE AS A FUNCTION OF TIME

Figure 19 shows heat rejection from the diffuser pipes to the Mississippi River at full load during open cycle cooling. The figure is based on the maximum design heat rejection rate discharged to the Mississippi River over a 24-hour period. Because the station is a baseload nuclear facility, power production generally remains virtually constant throughout a 24-hour period.

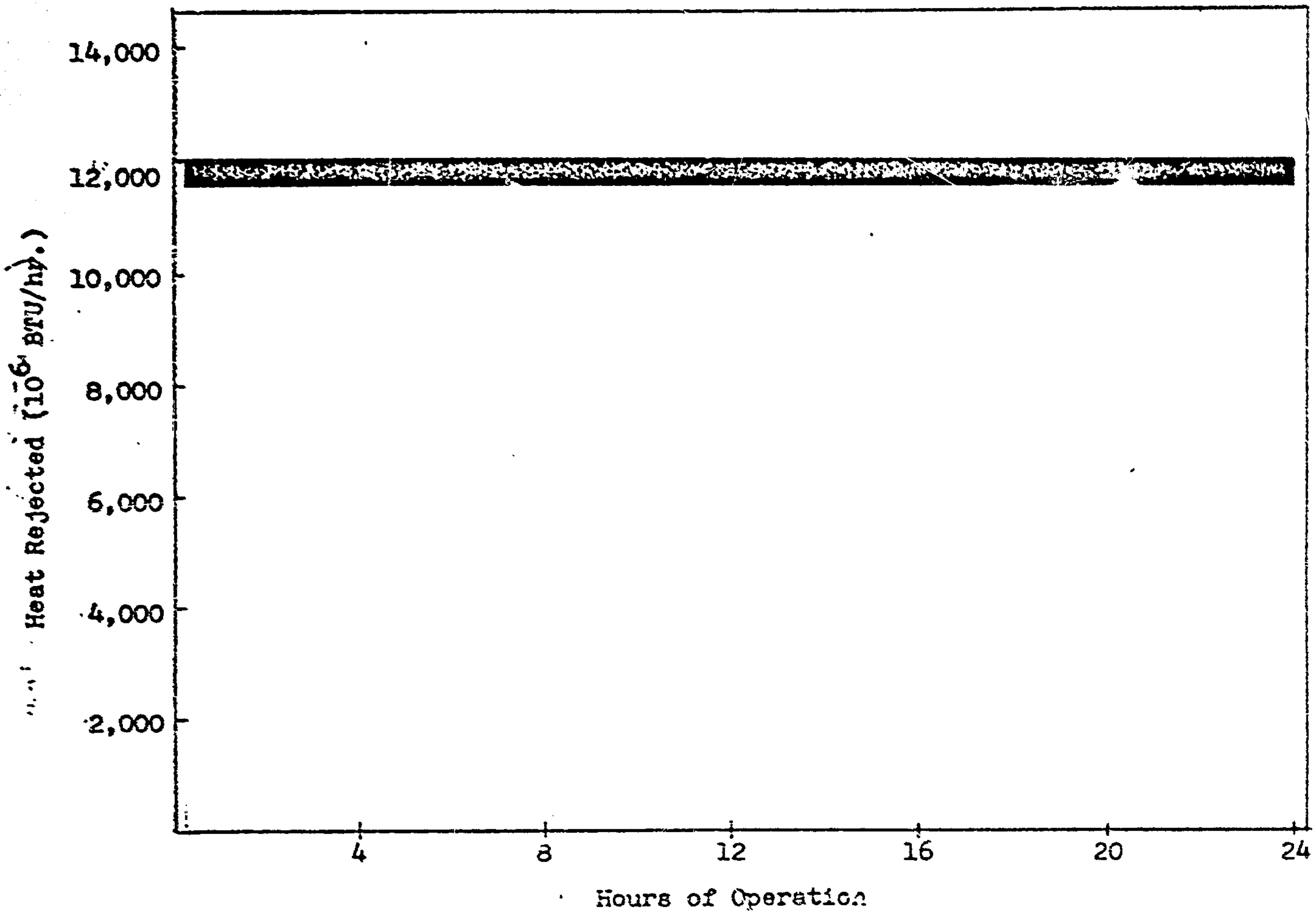


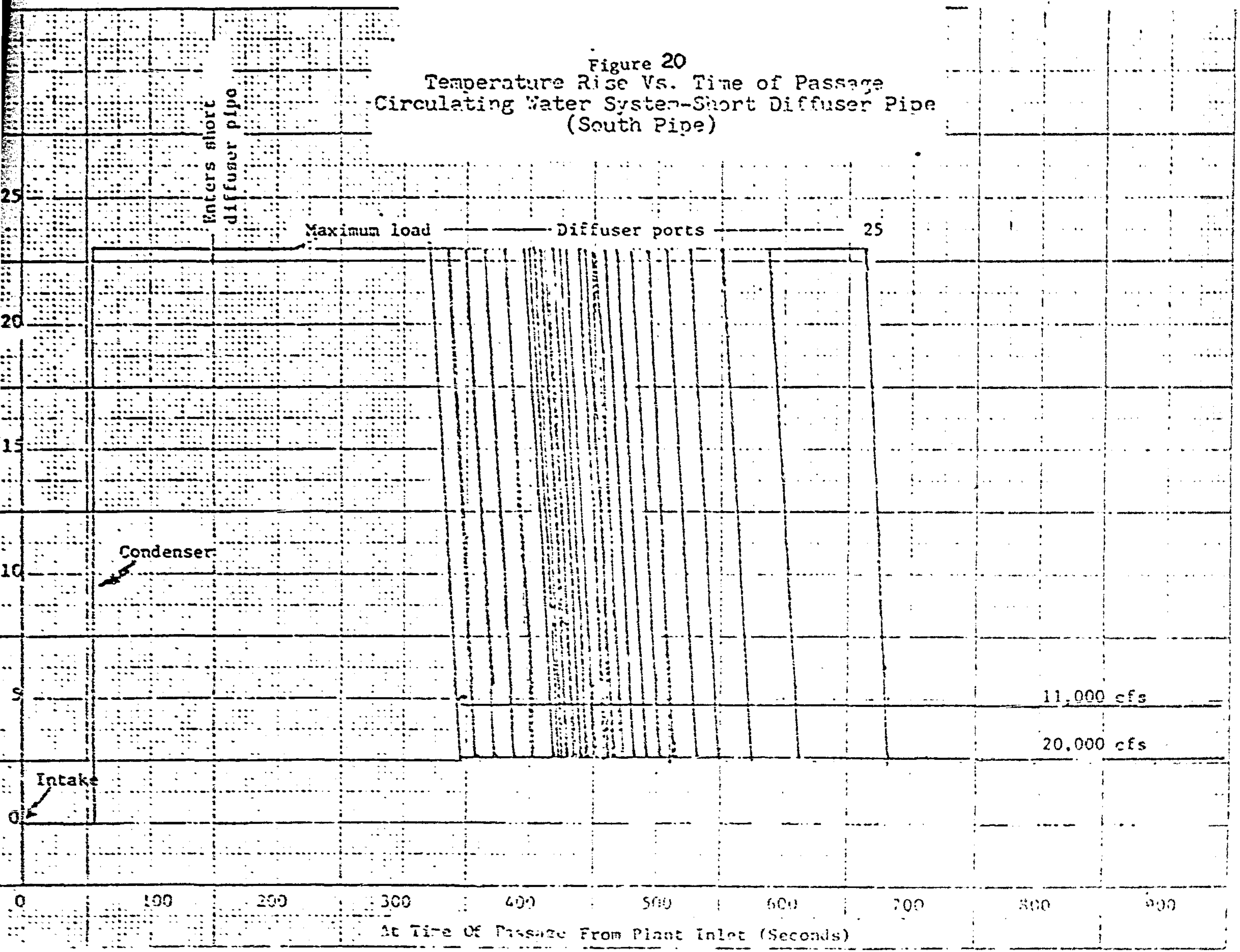
Figure 19. Heat Rejected to Mississippi River via Diffuser Discharges at Full Load During Open-Cycle Cooling.

This situation is reflected in Figure 19 by a constant heat rejection rate of approximately 12×10^9 BTU/hr.

TIME TEMPERATURE DATA

The circulating water temperature rise versus time of passage is shown for each of the two open-cycle diffuser pipes in Figures 20 and 21. The two figures depict the time required for a slug of river water to enter the station intake, traverse the cooling water system, and exit through either diffuser at full station load. Readily apparent is the heating-cooling profile beginning with heat addition in the condenser and terminating when water temperature has cooled to within 5°F above ambient river temperature. For either diffuser this process takes from approximately 300 to 650 seconds, depending on the diffuser and the travel time from the point where heat is introduced (condenser) to the particular diffuser port. Once discharged from a diffuser port, heated water takes approximately 22 seconds to cool to within 5°F of river ambient temperature.

Figure 20
Temperature Rise Vs. Time of Passage
Circulating Water System-Short Diffuser Pipe
(South Pipe)



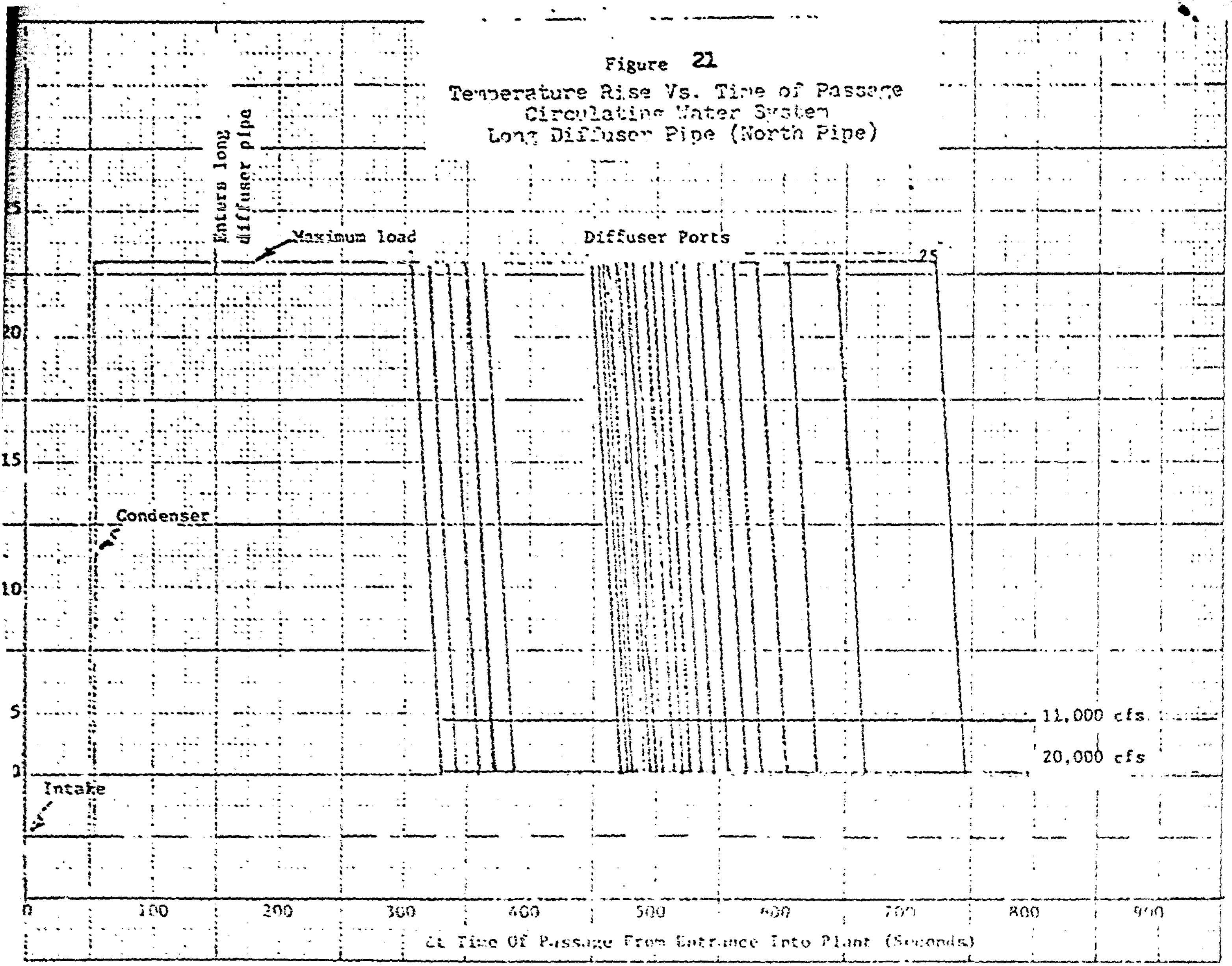


Figure 21
Temperature Rise Vs. Time of Passage
Circulating Water System
Long Diffuser Pipe (North Pipe)

Summary of Biological Data

Introduction

The evidence presented are based on the results of studies conducted in the Mississippi River near the plant site since 1968. Intensive preoperational studies were first undertaken in July, 1970 and continued until the station began operational testing in January, 1972 and are continuing. During the entire preoperational and operational period, intensive studies of all important aquatic trophic levels of the biota upstream and downstream of the station have been conducted. Relevant publications to date are listed in Attachment A.

The Quad Cities Station operated with an open cycle condenser cooling system from April 1972 until May 1974. With the exception of a short period of time (April to July 1972) when an interim side jet discharge was utilized, condenser water was discharged into the river through a multiport diffuser system consisting of two 16 foot diameter manifolds buried in the river bed. From May to December 1974 the station was operated in a combination open and closed cycle mode utilizing a simple diffuser plus the spray canal for cooling. The year 1975 was a period of intensive engineering testing in which most relevant combination of spray canal (closed loop cooling) and diffuser system (open cycle, once-through cooling) was employed. Since the end of 1975 the station, for the most part, has been operated in the closed loop mode utilizing the spray canal system for condenser cooling, (pg. 2, 7-17 Annual Report 1976).

The predominant fact which emerges from all the information collected during the studies is that there has been no change in the relative abundance of important species in Pool 14 of the Mississippi River as a result of heated water discharges from the operation of Quad Cities Station. There has been no increase in abundance of pollution-tolerant or undesirable species attributable to station operations. There has been no decline in game or commercially valuable species or of species indigenous to the area attributable to station operation.

This fact is borne out consistently and uniformly by all of the reports and data. It is borne out by the NALCO intensive monitoring reports from pre-operational status, April, 1971, through January, 1977, which show consistent patterns of the presence and relative abundance of the same species. In particular, the 1976 NALCO Report presents analysis of species populations based on electroshocking, trawling, and seining as well as standing crop data for the full period, all of which show no change in relative species abundance attributable to station operation. It is also borne out by the Pool 14 creel survey analysis conducted by the Iowa State Conservation Commission, who concluded that "there has been no measurable change in the fishing attributable to the operations of the plant." It is also borne out by the reports on commercial fish catches in the Pool, and by comparison with literature on species abundance in this stretch of the Mississippi River. (See pp. 372-381, in February 1976-January 1977 Annual Report.) The fluctuations which have been observed are all fully consistent with normal biological "wobble" in population cycles and relative abundance at anytime, particularly considering the change in River flow and other environmental conditions in the river over time. Nothing has been observed which was inconsistent with these patterns, although it certainly would have been if in fact station operations were having any material impact on the biota in the River.

The underlying reasons that no plant related effects have been observed are clear. The Station's operations do not have an adverse impact on water quality in the River. See Sections on Water Quality Evaluation in the 1975 and 1976 monitoring reports as well as in the prior semi-annual monitoring reports. The thermal effluent does not alter or destroy any existing habitats or create any undesirable new ones. On the contrary; the Mississippi River in Pool 14 represents a huge, immensely complicated and everchanging ecosystem which is subject to a great many natural influences, including weather, river flows, solar radiation and many others. It is influenced to some extent by upstream industrial and municipal dishcarges and non-point source contributions. By comparison, the environmental impact of the station's thermal input is miniscule.

For example, the thermal discharges from the station's diffuser's pipes mix almost instantaneously with the river's current, resulting in practically no thermal "plume" in the ordinary sense.

Summary of Monitoring Results

The detailed results of monitoring programs which justify the earlier conclusions have been presented in numerous publications. These reports consist of 13 reports covering a period of eight years (the reports are listed in Appendix A).

As a result of the various cooling modes utilized at the Quad Cities Station, these studies cover periods of full open cycle operation during which all of the waste heat was discharged to the river via the side jet discharge of the two diffuser pipes; one diffuser plus spray canal operation during which roughly half the waste heat was discharged to the river and full closed cycle operation during which virtually no waste heat was discharged to the river. Recognizing that the period during which greatest stress to the river environment could occur is during the lowest river flow period, studies conducted during the summer and fall of 1976 and 1977 encompassed periods of extremely low flow, falling below the seven day ten year low flow of 13,200 cfs and reaching a minimum of 10,800 cfs in September 1977. The studies conducted during these periods revealed no significant ecological damage to the receiving waters of the Mississippi River. (See chapter 2, p. 19, Annual Report covering the period February 1976 through January 1977).

Temperature Determinations Conducted

During the period of interim side jet operation, data indicate that plume temperatures as measured at the edge of the 600 foot mixing zone were as much as 12.5 F greater than ambient river temperatures and temperatures in the Illinois island area immediately downstream from the side jet discharge were as much as 15.1°F higher than ambient. A maximum temperature of 91°F was observed in this area during the period of side jet operation.

Following the startup of the diffuser pipe system in July 1972, numerous temperature surveys were conducted in the River, downstream from the diffuser pipes. During the period July 1972 to October 1975, when the station operated both full open and half open cycle, downstream river temperatures never exceeded 85°F. The maximum local temperature increases measured 600 feet downstream of the diffuser pipes never exceeded 3.8°F, well below the allowable 5° maximum. It is important to point out that during the period of complete open cycle, the thermal standards for both Illinois and Iowa were always met. This occurred because unlike conventional plumes which stratify and do not mix with the surrounding water, the heated effluent is diffused as jets from a series of ports spaced along the length of the buried diffuser pipes. This results in rapid mixing with the river water, and thus only a small section of the river in the immediate area of the jets is subjected to temperature increases.

During the period May 1975 through July 1977 when river flows were low and the station was operating in closed cycle or combination open and closed cycle cooling modes, mean monthly differences between water temperatures downstream and upstream of the station (Δ T) ranged from 4.9°F to - 1.3°F. Larger differences (up to 6.9°F) were observed in January 11, 1977. Maximum downstream water temperatures did not exceed 87°F during this period.

In addition, chemical characteristics of the river and all the important aquatic communities present in the Mississippi River, above and below the Quad Cities Station, were studied. In order to insure that the study was capable of identifying significant differences in the ecology in the river which were related to station operation, an experimental design was developed for the study plan, and various statistical procedures were used to analyze data.

Monitoring of water quality in the Mississippi River near the Quad Cities Station was carried out at regular intervals since 1969. Sampling was initially conducted on a quarterly basis. This was increased to twice monthly in August of 1971 and then to weekly in February of 1972. Dissolved oxygen has been monitored continuously on an hourly basis since 1973. In order to determine the effects of station operation on the water quality of the river, samples have been taken at locations upstream and downstream of the station as well as in the intake and discharge bays. Results of the operational water quality studies indicate that with the exception of oxygen saturation, which is slightly higher in the discharge bay than in the river, station operation has had no effect on the chemical water quality of the river. Values of the parameters tested remained essentially unchanged between sampling locations upstream and downstream during all sampling periods. Similarly, chlorination of the Quad Cities condenser cooling water for slime control did not result in measurable concentrations of chlorine in the river following the start-up of the diffuser pipe system. Although chlorine concentrations in excess of 1 mg/l have been observed in the discharge bay, all samples taken from the river during the period of diffuser pipe operation have been below the analytical limit of detection (0.01 mg/l) throughout the course of the study.

Comparisons of total phytoplankton, major algal divisions and dominant species at locations upstream and downstream from the side-jet discharge or the diffuser pipe system indicated that neither mode of heat discharge had any detectable effect upon phytoplankton numbers or community composition. Statistically significant differences ($P = >.05$) between sample locations tested were rarely found. The occasional small differences observed were random in nature and relatable to variability within the river plankton and were not indicative of the effect of station operation. No changes in the phytoplanktonic community structure have been noted. Examination of the data revealed no consistent differences between upstream and downstream locations.

Comparisons of zooplankton and the three major groups of zooplankters prior to and during all phases of operation at locations upstream and downstream of the station from early 1971 to the present time did not reveal any differences attributable to plant operation.

Statistically significant differences between zooplankton numbers upstream and downstream of the diffuser pipe system were occasionally observed but highest counts did not consistently occur at either upstream or downstream locations. It can be concluded that the changes in numbers of zooplankton reflect natural variations rather than effects of station operation. Similarly, no changes in the structure of the zooplankton community were observed that could be attributed to station operation.

Periphyton (attached organisms) populations and production rates upstream and downstream of the station were generally equivalent throughout the period of study. Periphyton productivity as indicated by species diversity, biomass and chlorophyl a concentrations were significantly reduced in the Illinois Island area, 600 feet below the station only during the short period of interim side-jet operation (April-July 1972) at a time when temperatures in this area were as much as 12.5°F greater than ambient river temperatures. However, periphyton populations rapidly recovered to their baseline level following start-up of the diffuser pipe system and no consistent differences between upstream and downstream periphyton colonies on the artificial substrates have been observed that are attributable to diffuser pipe operation. All changes in periphytic algae communities were related to seasonal fluctuations and hydrological conditions and were not a result of the operation of the Quad Cities Station.

Extensive studies of the benthic (bottom dwelling) community indicate that these organisms are primarily affected by the nature of the substrate and hydrological conditions rather than the operation of the Quad Cities Station. The only discernible effect of the Quad Cities Station on benthic populations occurred during ther period of dredging for the installation of the diffuser pipe system. At that time increased numbers of tubificids (sludge worms) and Chironomid (midge) larvae were observed in the Illinois Island area directly downstream from the station in conjunction with the deposition of new sediment from the dredging operation. Following start-up of the diffuser pipe system, however, these organisms declined and population structure returned to the conditions observed pre-operationally. Similarly, no consistent effects to the drifting macroinvertebrate populations have occurred that are attributable to the operation of the diffuser pipe mode of heat dissipation.

The Mississippi River in the vicinity of the Quad Cities Station has historically supported a diverse and productive warm water fishery. Because of the importance of this community, thorough fisheries studies have been conducted within the vicinity of the Quad Cities Station between river mile 504 and river mile 509 since April of 1971. The fish sampling techniques employed in this study were designed to yield the most representative sample under the environmental conditions within the study area. The use of the several techniques employed (seining, trawling, trammel netting and electro-fishing) gave a reasonable and practical representation of the fish population. These studies have indicated that the distribution of fish taxa and numbers, both above and below the Quad Cities Station, appear to be most strongly influenced by the river flow, season and habitat type. Catch per unit effort among locations upstream and downstream from the diffuser pipe were similar during the operation of the differ pipe system as well as prior to its use. During the three month period of side-jet discharge when the heated effluent tended to hug the Illinois shore as far as 6.3 miles downstream of the station and plume temperatures as measured at the end of the 600 foot mixing zone were as much as 15.1°F higher than ambient river temperatures, several species of fish were displaced from the Illinois Island area downstream of the station. The abundance of crappie and bluegill decreased and no largemouth bass were collected, although these species were previously common in the Island area. Similar decreases in numbers of those fishes were not observed at other sampling locations and with this exception, station operation had no influence on the fishery of the river. Following start-up of the diffuser pipe system, the Illinois Island area was reinhabited by displaced species when river temperatures in this area again returned to ambient levels.

In order to assess the effects of diffuser pipe discharge on fish migration, tagging of selected sport and commercial fish species was implemented in September of 1971 and has continued during the various modes of condenser cooling. There is no evidence from these studies that diffuser pipe operation has resulted in a thermal barrier to fish migration. This is not suprising considering that a large zone of passage is present between the shoreline and beginning diffusee port, as well as the wide spacing between diffuser ports.

In addition to the routine investigations which have been conducted, two intensive short term studies were conducted in September of 1976 during studies of very low flows (12,000 and 10,800 cfs) when the station was operating on one diffuser and about 50% of the waste heat was being discharged to the river. These studies included determinations of water quality, zooplankton, phytoplankton, and fish distribution above and below the diffuser pipe. Although the results of these studies have not been fully analyzed, they show no evidence of any significant differences between data taken above and below the diffuser pipes.

A creel census of Pool 14 was conducted in cooperation with the Iowa Conservation Commission during the period 1972 to 1972. Data from this study was submitted to Mr. Donald Klein of the Iowa Conservation Commission and was analyzes by Mr. Klein and his staff. He concluded that "The original purpose for conducting the creel survey was to see if any changes in the fishery resulted from the operation of the nuclear power plant at Cordova. From the data we have assembled, I conclude that there has been no measurable change in the fishing attributable to the operation of the plant."

In summary, the ecological studies of the Mississippi River at Quad Cities Station have been of a sufficient magnitude and of a sufficient duration to assess the ecological characteristics of the area, and to identify any significant effects of station operation, if they occurred. This is evidenced by the fact that effects attributable to the station effluents were detected during the period of side jet operation and that ecological effects relate to changes related in seasonal and hydrological conditions or those upstream discharges which are routinely observed and identified. In spite of this sensitivity, no effects attributable to station operation have been apparent during the period of diffuser pipe operation. Similarly, the discharges of heated water via the intake plume and/or the blowdown pipe to the river that are associated with spray canal operation have resulted in no significant changes to the ecology of the river.

APPENDIX A

Quad-Cities Station Reference List

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