SS-0052

V. C. Summer Nuclear Station

Fish Kill Study

1994 Status Report

SCE&G Environmental Services

December 1994

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Executive Summary

Efforts undertaken by SCE&G to reduce the frequency and severity of thermally related fish kill events in the V.C. Summer Station circulating water discharge bay coincided with a reduced number of kills after 1990 and an absence of kills in 1994. Other factors identified as contributing to fish kill events were evaluated and found to be generally unchanged for most summer months from 1989 through 1992 and 1994. Evaluation of the fish habitat of the circulating water discharge bay bottom revealed a somewhat less volatile thermal environment in 1991 and 1992 (after shoal removal). Temperature comparisons showed a change to a relatively stable thermal environment in the summer of 1994 (after canal dredging). Data indicate that canal dredging was a prime factor responsible for the absence of fish kills in 1994 by creating a more stable thermal environment in the circulating water discharge bay.

1.0 Introduction

This report details the status of thermally related fish kill occurrences at the V. C. Summer Nuclear Station, Jenkinsville, South Carolina. The effectiveness of dredging the circulating water discharge canal as a way to eliminate fish kills in the circulating water discharge bay is examined. Dredging was conducted in July and August of 1993. June, July and August of 1994 were the first months where the effect of canal dredging on fish kills would have been seen. These months were compared with conditions from 1989 through 1992 to gauge the impact of this mitigation action.

2.0 Background

Factors were evaluated that contributed to or were associated with thermally related fish kill events from 1989 through 1992. Fish kill events were restricted to the V.C. Summer Station circulating water discharge bay which connects to Monticello Reservoir through the circulating water discharge canal (Figure 1). A report detailing the suspected mechanisms that triggered these fish kills was submitted to the South Carolina Department of Health and Environmental Control (SCDHEC) in November of 1991 (SCE&G, September 1991). Please refer to that report for the in-depth analysis which formed the basis for the conclusions and actions undertaken to mitigate the fish kill occurrences.

A formal program of fish kill investigation began in 1989. In general, fish kills were caused by a rapid increase in water temperature (~ 10°F) when temperatures already exceeded 90°F at the bottom of the bay. Temporary disruption of the cool water inflow from the reservoir into the bottom of the discharge bay caused the rapid temperature increase. Reservoir drawdowns were associated with the disruption of the cool water inflow into the bottom of the discharge bay.

SCE&G took several actions from 1991 through 1993 to reduce the frequency of fish kills. They included: 1) A shoal (an old roadbed) was dredged from the discharge canal bottom in April of 1991. 2) Monticello Reservoir drawdown was limited to 422.5′ mean sea level (msl) in September of 1992. and 3) The entire discharge canal was dredged in July and August of 1993. The objective of these actions was to prevent disruption of cool water into the discharge bay, thus providing a more stable thermal habitat for fish.

This report evaluates the effect of canal dredging by comparing the conditions in the bay after dredging (June through August of 1994) to conditions documented from June through August of 1989, 1990, 1991 and 1992. The June through August period is referred to as "summer" in the context of this report. Information from 1993 was not used for comparison because reservoir drawdown was limited to 422.5′ msl during the summer of 1993 and canal dredging activities

prevented data collection in the discharge bay in July and August of 1993. Both direct and indirect evidence were evaluated to determine the impact of canal dredging on conditions influencing thermally related fish kills in the discharge bay.

3.0 Direct Evidence of Fish Kill Mitigation

The direct evidence of successful mitigation of fish kill events was a reduction in the number and severity of fish kills. Summer Station personnel inspected the circulating water discharge bay from the shore at least once a day each summer from 1989 through 1994. Any dead fish seen floating at the surface were counted. The type of fish and estimated length were also determined if possible. Information was recorded in a log book. Ten or more dead fish observed in one day constituted a fish kill event for the purposes of this report. By procedure, not all of these events would have been reportable to regulatory agencies.

The number and severity of fish kills were examined for 1989, 1990, 1991, 1992 and 1994. This information is presented in Table I. A summary of fish kill events, including mitigation actions, is presented in chronological order in Table II. The number of events was reduced after shoal removal (April 1991). No fish kill events occurred after the entire canal was dredged (July - August 1993; Table I and II).

4.0 Other Factors Affecting Fish Kill Events

Several factors, independent of mitigation activities, have the potential to reduce the number of fish kill events reported. These factors include the ability to detect fish kills, cooler reservoir temperatures, lower Summer Station discharge temperatures and a reduced number of reservoir drawdowns from full pool (425.0′ msl) to below 422.5′ msl. These factors were evaluated for their potential effect on the lower number of fish kills reported after 1990 and the absence of fish kill events in 1994.

4.1 Ability to Detect Fish Kills

It was observed from documented fish kill events that the large majority of dead fish seen at the surface remained in the discharge bay and were not carried out to Monticello Reservoir. The counterclockwise flow pattern of water at the surface of the round discharge bay generally kept floating objects in the bay, where they eventually were deposited in the discharge structure. To confirm this, a test was conducted in the summer of 1990 by placing oranges (simulated dead fish) in the bay at the location where dead fish first appeared. A high percentage of the oranges were recovered from the bay after three days. This indicated that the majority of floating fish were held in the bay and not discharged to the reservoir.

Since shoal removal and canal dredging could have influenced surface flow patterns in the discharge bay, the test was repeated

in July of 1994. Twenty oranges were placed in the bay at the location where the first test was conducted. Eighteen oranges were recovered from the bay after three days. The results of this test showed that the surface flow pattern in the bay was not greatly altered by shoal removal and dredging. Since floating fish would remain in the bay, fish kill events were still able to be detected with the same level of effort in the summer of 1994. It is believed that any fish kill event occurring during the summer of 1994 would have been detected.

4.2 Cooler Reservoir Conditions

Cooler Monticello Reservoir temperatures could be caused by a mild summer or increased rainfall. A cooler reservoir would reduce the thermal stress on fish and possibly contribute to fewer fish kills independent of mitigation activities. To evaluate this possibility, reservoir temperatures were compared for the summers of 1989 through 1992 and 1994.

Circulating water inlet temperatures, reflecting reservoir conditions at approximately 20 feet, and reservoir ambient surface temperatures (recorded at the northern end of the reservoir) were used as indicators of the thermal condition of the reservoir each summer. Monthly average temperatures along with fish kill events are presented in Table III.

Lower monthly average temperatures reported in June and July of 1992 from the circulating water inlet may have been a factor in the reduced number of fish kill events reported for those months in 1992 (Table III). However, circulating water inlet and reservoir temperatures for June, July and August of 1994 were generally similar to the summer temperatures of 1989 through 1991 (Table III). This indicates that reservoir thermal conditions did not play a major role in either the reduction of fish kill events in 1991 or the absence of fish kill events in 1994.

4.3 Lower Summer Station Discharge Temperature

The temperature of the water discharged from the circulating water system has a direct impact on the potential for fish kills in the bay. If a change in Summer Station operation resulted in lower discharge temperatures than normally seen, this could have reduced the potential for a fish kill event. This effect would be independent of mitigation activities.

Monthly average circulating water outlet temperatures were compared for the summers of 1989 through 1992 and 1994 (Table IV). The average monthly temperature for June was lowest in 1989, corresponding to four fish kill events. June of 1994 had the highest monthly average temperature with no corresponding fish kills (Table IV). The monthly discharge temperature in July of 1994 was similar to other July years reported. No fish kills were seen in July of 1994, however (Table IV). The monthly discharge

temperature in August of 1994 was lower than other August years reported. This was the result of a 20% reduction in power generation from the Summer Station for most of August 1994.

Monthly average circulating water discharge temperatures indicate that these temperatures did not play a part in either the reduction of fish kills in 1991 or the absence of fish kills in June and July of 1994. The relatively lower average discharge temperature reported for August 1994 could have lessened the potential for fish kill events for that month.

4.4 Reservoir Drawdowns Below 422.5′ msl

It had been documented that reservoir level changes on Monticello Reservoir disrupted the inflow of cool water into the Summer Station circulating water discharge bay. A reservoir drawdown from full pool, 425.0′ msl, to below 422.5′ msl was identified as a major contributor to fish kill events (SCE&G, 1991). Fewer instances of reservoir level drawdown from full pool to below 422.5′ msl would allow fewer chances for fish kill events. The number of daily drawdowns below 422.5′ msl were examined for the summers of 1989 through 1992 and 1994 to identify any reduced chances for fish kill events. The summer of 1993 was not evaluated because reservoir level drawdowns were limited to 422.5′ msl as a temporary mitigation action. Information for June, July and August is presented in Tables V, VI, and VII, respectively.

The number of daily reservoir level drawdowns below 422.5′ msl in June of 1994 was greater than for all other years evaluated. It was more than twice the number reported for June of 1992 (Table V). The greater the drop in reservoir level, the greater the potential for flow disruption into the discharge bay and possible fish mortality. There were two instances in June of 1994 where the maximum routine drawdown occurred (420.5′ msl) with no resulting fish kill (Table V).

The number of drawdowns below 422.5′ msl in July of 1994 was greater than in 1989, 1990 and 1991 but less than the number seen in 1992 (Table VI). The number of drawdowns below 422.5′ msl in August of 1994 was greater than in 1991 and 1992 but fewer than in 1989 and 1990 (Table VII). Overall, the frequency of drawdown events in the summer of 1994 was approximately similar to the frequency of drawdowns for years when fish kill events were reported. Therefore, the overall frequency of drawdowns in 1994 did not lessen the potential for fish kill events.

5.0 Habitat Evaluation

It has been previously discussed that reservoir temperatures, Summer Station discharge temperatures and reservoir drawdowns were not greatly different over the years 1989, 1990, 1991, 1992 and 1994. With the exception of lower Summer Station inlet temperatures in June and July of 1992 and lower Summer Station discharge temperatures in August of 1994, none of these factors

were thought to have the potential to cool temperatures in the bay bottom and thereby reduce the chance of fish kills for the summers examined.

Temperatures monitored in the bottom of the circulating water discharge bay, prior to dredging, showed rapid temperature changes associated with reservoir drawdowns. In some instances this quickly rendered the fish habitat at the bottom of the bay unusable. The objective of the shoal removal in April of 1991 and the dredging of the entire discharge canal in the summer of 1993 was to eliminate the occurrence of rapid temperature increases in the bottom of the bay for the range of expected reservoir levels. Figures 2, 3 and 4 show hourly average temperatures versus time from the bottom of the discharge bay for June, July and August (respectively) to compare the years 1989 and 1990, before any dredging took place, with 1994, after canal dredging.

Temperature spikes of 8°F to 10°F were continually seen for all summer months in 1989 and 1990. There was a marked difference in the bay bottom temperatures recorded in 1994 (after canal dredging) as compared to those years. Temperatures were cooler in 1994 and showed little fluctuation (Figures 2, 3 and 4).

Figures 5, 6 and 7 show hourly average temperatures versus time from the bottom of the discharge bay for June, July and August (respectively) to compare the years 1991 and 1992, after shoal

removal, with 1994, after canal dredging. Bay bottom temperature spikes appeared less frequently and with less intensity in June and August of 1991 and 1992 (after shoal removal; Figures 5 and 7). There was a marked difference in the bay bottom temperatures recorded in 1994 (after canal dredging) as compared to these years (Figures 5, 6 and 7).

Temperatures recorded in the summer of 1994 were generally lower and without the repeated temperature spikes associated with fish mortality in previous years (Figures 2 through 7). Since all other known factors were accounted for, it appears that the dredging of the discharge canal successfully reduced and stabilized the temperatures at the bottom of the discharge bay in the summer of 1994. This allowed the bay bottom to remain a usable habitat for fish throughout the expected range of reservoir levels.

6.0 Summary and Conclusions

Efforts undertaken by SCE&G to reduce the frequency and severity of thermally related fish kill events in the V.C. Summer Station circulating water discharge bay coincided with a reduced number of kills after 1990 and an absence of kills in 1994. Other factors identified as contributing to fish kill events were evaluated and found to be generally unchanged for most summer months from 1989 through 1992 and 1994. Evaluation of the fish habitat of the circulating water discharge bay bottom revealed a somewhat less volatile thermal environment in 1991 and 1992 (after shoal

removal). Temperature comparisons showed a change to a relatively stable thermal environment in the summer of 1994 (after canal dredging). The change resulting in a thermally stable environment in the bay bottom in the summer of 1994 appears to be a direct result of the circulating water discharge canal dredging. A thermally stable habitat greatly reduces the potential for fish kills. Data indicate that canal dredging was a prime factor responsible for the absence of fish kills in 1994 by creating a more stable thermal environment in the circulating water discharge bay.

7.0 Recommendations for Future Action

Reduced Summer Station operation in August of 1994 prevented a worse case evaluation of the effect of canal dredging on fish habitat at the circulating water discharge bay bottom. A reduced scope temperature monitoring program and continued daily inspection of the bay in June, July and August of 1995 is recommended to further examine the effect of canal dredging.

In addition, it is recommended that velocity profile data be collected in the summer of 1995 in the circulating water discharge canal at low reservoir levels (below 422.5′ msl). This information will be used to calculate the flow of cool reservoir water entering the discharge bay at low reservoir levels. Flow data will be compared with information prior to 1993 to further evaluate the effect of canal dredging.

8.0 References

VCSNS Corporate Health Physics and Environmental Programs. V.C. Summer Nuclear Station Fish Kill Study, 1991 Status Report, SCE&G Environmental Services, File G015.1, Columbia, SC (September 1991).

FIGURE I

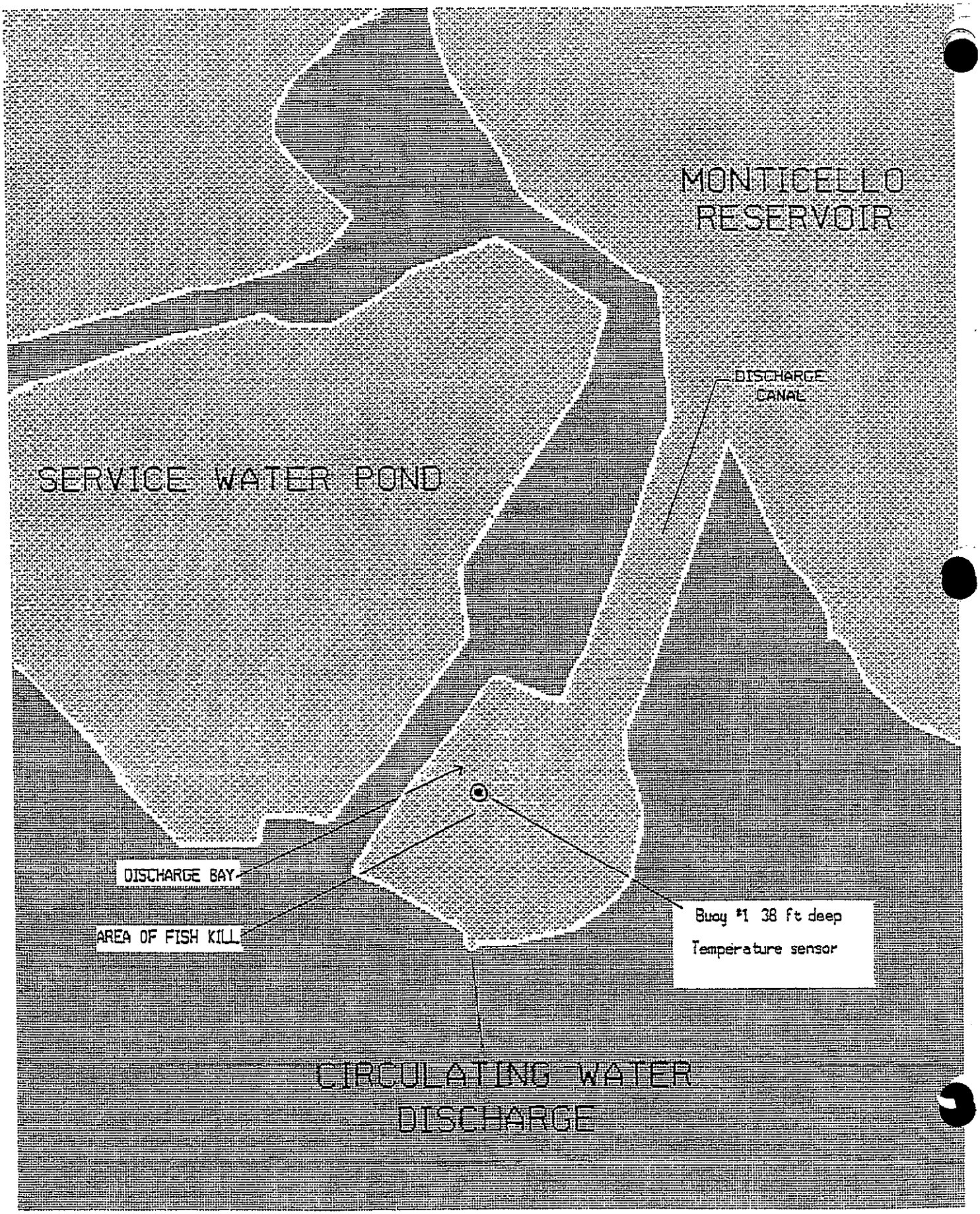
MONTICELLO
RESERVOIR
DISCHARGE
CANAL
SERVICE WATER POND
DISCHARGE BAY
AREA OF FISH KILL
Buoy #1 38 ft deep
Temperature sensor
CIRCULATING WATER
DISCHARGE

Figure 2. Temperature data from the bottom of the circulating water discharge bay of the V. C. Summer Nuclear Station. Temperatures are included for 1989 and 1990 (before dredging) and 1994 (after canal dredging). Temperatures were recorded as hourly averages. June 1989, 1990 and 1994.

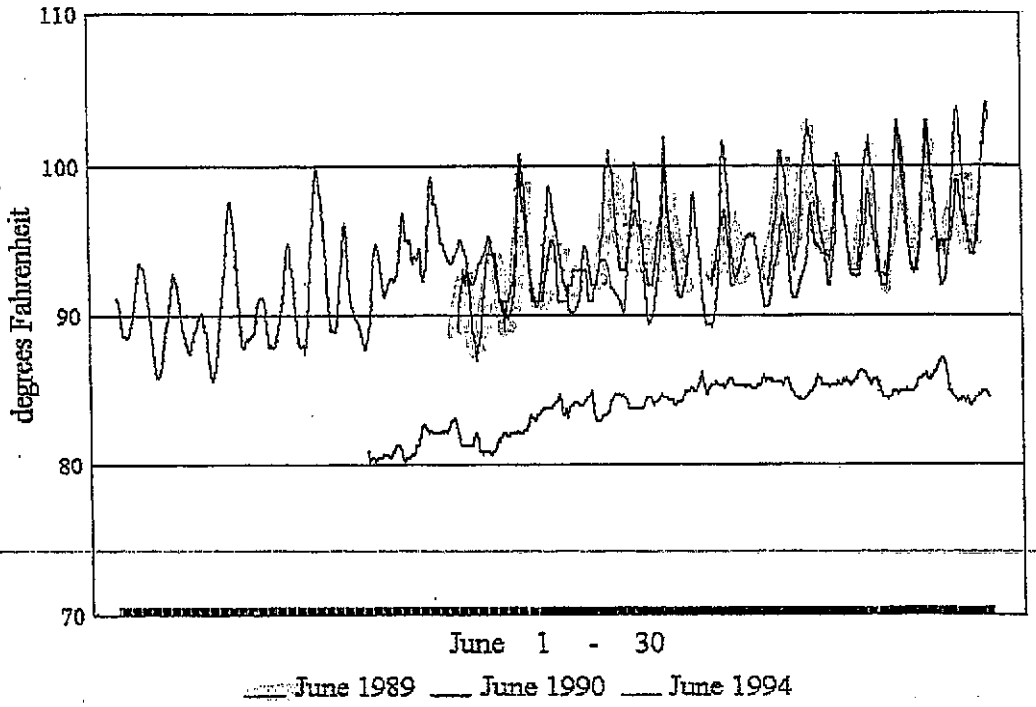

Figure 3. Temperature data from the bottom of the circulating water discharge bay of the V. C. Summer Nuclear Station. Temperatures are included for 1989 and 1990 (before dredging) and 1994 (after canal dredging). Low temperatures in 1989 and 1990 reflect reactor power reduction. Temperatures were recorded as hourly averages. July 1989, 1990 and 1994.

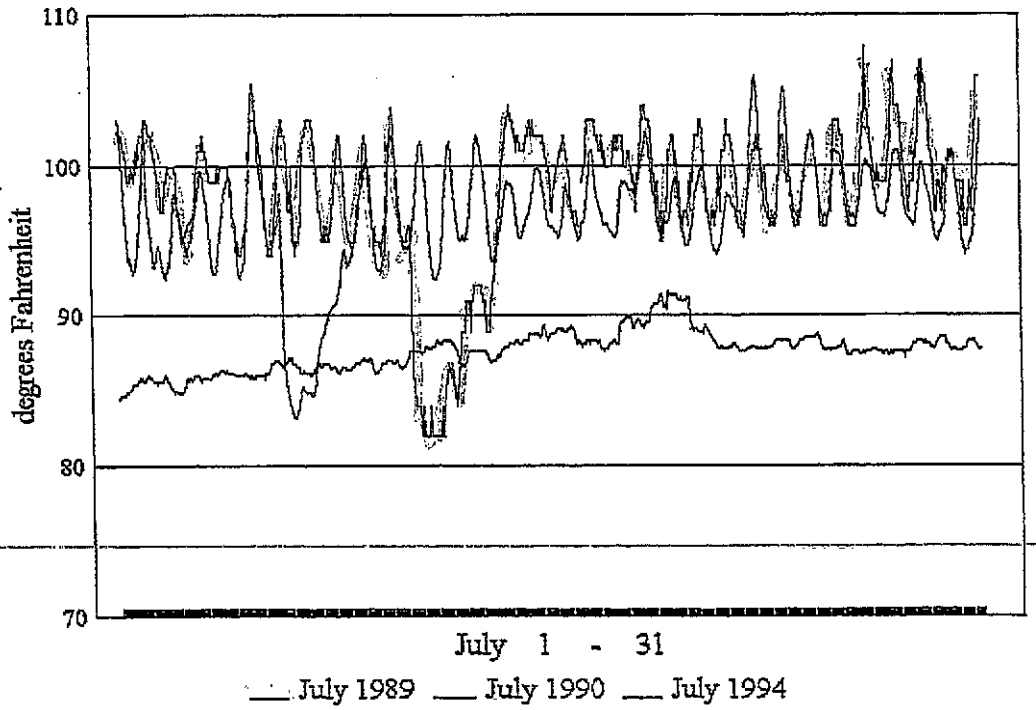

Figure 4. Temperature data from the bottom of the circulating water discharge bay of the V. C. Summer Nuclear Station. Temperatures are included for 1989 and 1990 (before dredging) and 1994 (after canal dredging). Temperatures were recorded as hourly averages. August 1989, 1990 and 1994.

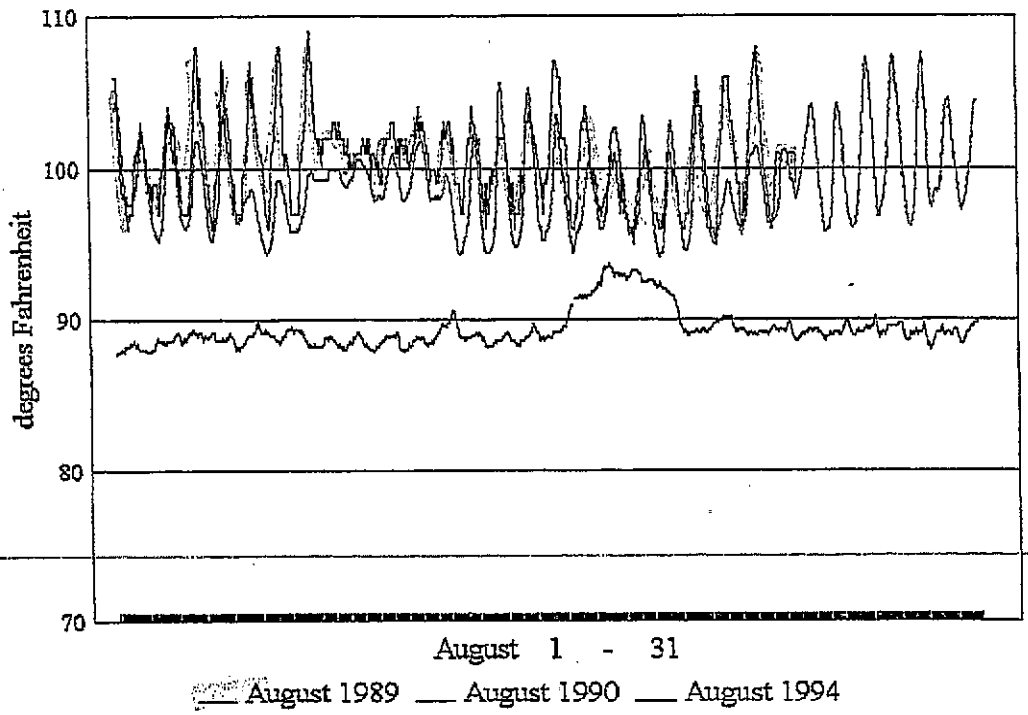

Figure 5. Temperature data from the bottom of the circulating water discharge bay of the V. C. Summer Nuclear Station. Temperatures are included for 1991 and 1992 (after shoal removal) and 1994 (after canal dredging). Temperatures were recorded as hourly averages. June 1991, 1992 and 1994.

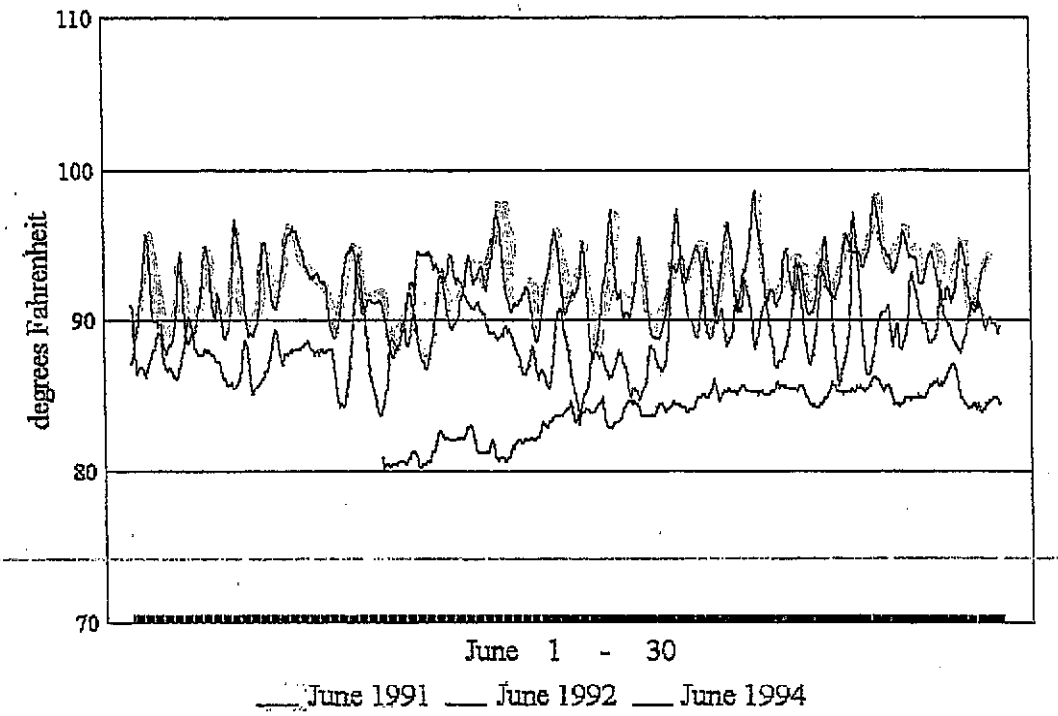

Figure 6. Temperature data from the bottom of the circulating water discharge bay of the V. C. Summer Nuclear Station. Temperatures are included for 1991 and 1992 (after shoal removal) and 1994 (after canal dredging). Temperatures were recorded as hourly averages. July 1991, 1992 and 1994.

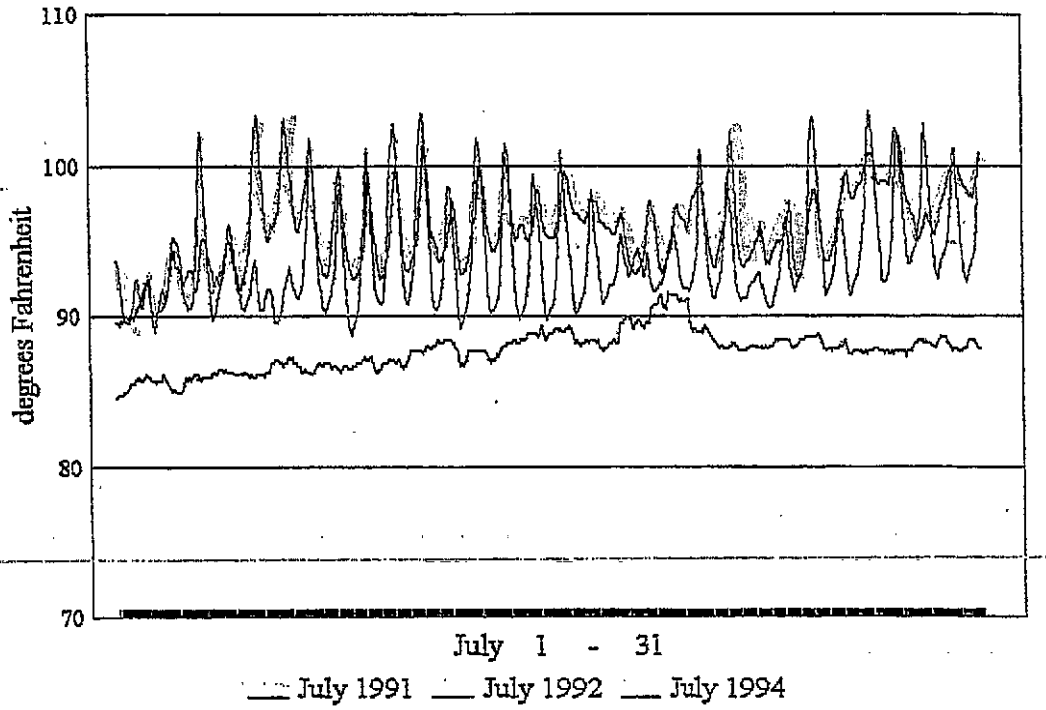

Figure 7. Temperature data from the bottom of the circulating water discharge bay of the V. C. Summer Nuclear Station. Temperatures are included for 1991 and 1992 (after shoal removal) and 1994 (after canal dredging). Temperatures were recorded as hourly averages. August 1991, 1992 and 1994.

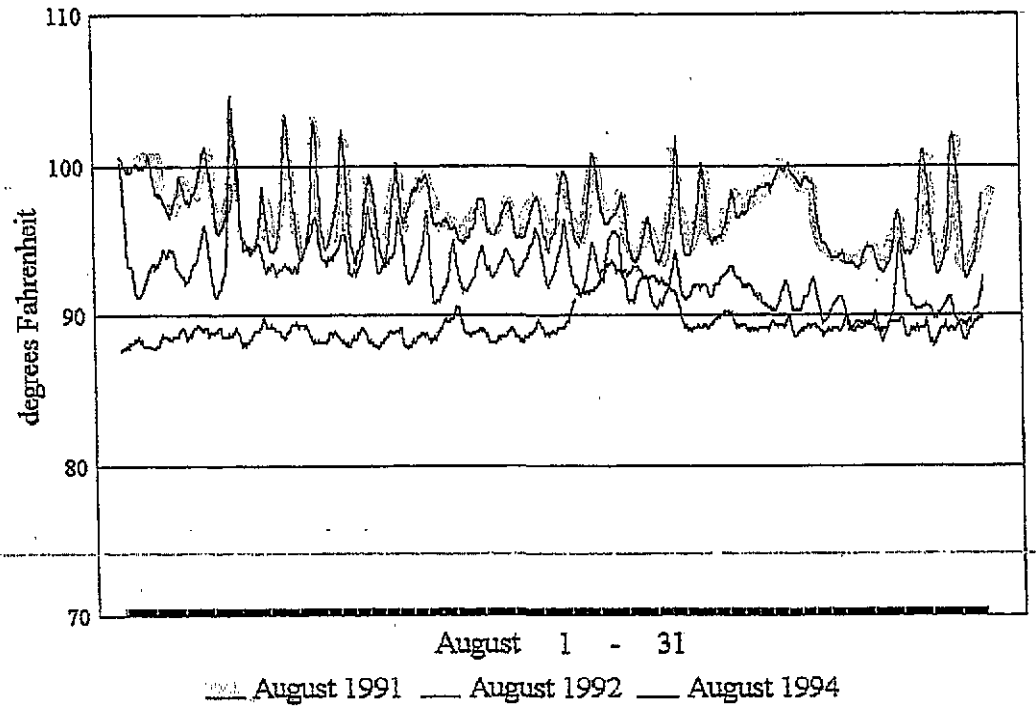

Table I. Number and severity of fish kill events that occurred in the circulating water discharge bay of the V. C. Summer Nuclear Station. June through August of 1989, 1990, 1991, 1992 and 1994

Month	Day	Year	Number of fish
June	25	1989	32
June	27	1989	18
June	28	1989	74
June	29	1989	13
July	5	1989	12
July	15	1989	354
August	1	1989	16
August	4	1989	96
August	17	1989	10
August	22	1989	56
June	7	1990	26
June	11	1990	25
June	19	1990	33
June	21	1990	36
July	5	1990	56
July	10	1990	55
July	23	1990	11
August	14	1990	279
August	15	1990	43
August	27	1990	10
August	28	1990	53
August	29	1990	107
August	30	1990	13
July	3	1991	52
July	5	1991	17
July	7	1992	94
August	4	1992	2544
summer		1994	no events

Table II. Summary of fish kill events with mitigation actions included. June 1989 through August 1994.

no mitigation action

June through August 1989 events = 10 Total fish = 681

no mitigation action

June through August 1990 events = 13 Total fish = 747

mitigation action - shoal removed from canal in April of 1991

June through August 1991 events = 2 Total fish = 69

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no additional mitigation action

June through August 1992 events = 2 Total fish = 2638

mitigation action - reservoir drawdown limited to 422.5' in August of 1992

mitigation action - entire canal dredged in July and August of 1993

June through August 1994 events = 0

Table III. Monthly average water temperatures for the circulating water inlet point of the V. C. Summer Nuclear Station and Monticello Reservoir surface ambient temperature location. Corresponding fish kill events are also included. June through August 1989, 1990, 1991, 1992 and 1994.

Month	Year	Monthly Average Circ Water Inlet Temperature (deg F)	Monthly Average Reservoir Temperature (deg F)	Fish kill events/ number of fish
June	1989	76.6	83.2	4/137
June	1990	75.7	71.9	4/120
June	1991	76.3	82.7	0
June	1992	73.5	83.1	0
June	1994	77.5	83.8	0
July	1989	80.6	86.9	2/366
July	1990	80.8	80.1	3/122
July	1991	81.3	85.6	2/ 69
July	1992	74.5	86.0	1/ 94
July	1994	80.9	86.1	0
August	1989	81.9	84.7	4/178
August	1990	82.0	85.4	6/505
August	1991	81.7	84.9	0
August	1992	81.0	83.2	1/2544
August	1994	81.2	84.8	0

Table IV. Monthly average water temperatures for the circulating water outlet point of the V. C. Summer Nuclear Station. Corresponding fish kill events are also included. June through August 1989, 1990, 1991, 1992 and 1994.

Month	Year	Monthly Average Circ Water Outlet Temperature (deg F)	Fish kill events/ number of fish
June	1989	97.8	4/137
June	1990	101.3	4/120
June	1991	101.9	0
June	1992	99.0	0
June	1994	103.9	0
July	1989	103.7	2/366
July	1990	104.4	3/122
July	1991	106.8	2/ 69
July	1992	105.4	1/ 94
July	1994	106.9	0
August	1989	105.4	4/178
August	1990	107.6	6/505
August	1991	107.1	0
August	1992	107.5	1/2544
August	1994	103.3	0

Table V. Daily minimum reservoir level drawdowns from full pool (425.0 feet) to below 422.5 feet for Monticello Reservoir. June of 1989, 1990, 1991, 1992 and 1994.

June

1989		1990		1991		1992		1994	
Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)
15	421.1	7	420.6	1	422.1	8	421.5	1	421.6
18	421.9	11	422.1	3	422.4	23	422.1	13	421.7
23	422.4	14	420.6	4	422.4	24	421.5	14	420.5
24	422.0	15	422.0	15	422.4	25	421.1	15	420.8
27	421.0	18	421.2	17	422.3			16	421.7
28	420.5	19	421.5	18	422.3			17	422.2
29	422.2	21	421.3					20	420.5
		27	421.2					21	420.9
		29	420.9					22	420.6
								23	421.7
								28	422.0
	1989		**1990**		**1991**		**1992**		**1994**
Total events	**7**		**9**		**6**		**4**		**11**

Table VI. Daily minimum reservoir level drawdowns from full pool (425.0 feet) to below 422.5 feet for Monticello Reservoir. July of 1989, 1990, 1991, 1992 and 1994.

July

1989		1990		1991		1992		1994	
Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)
1	421.3	1	422.2	3	421.4	8	421.7	9	421.9
6	420.3	5	420.8	5	421.3	9	421.2	10	422.3
7	421.4	9	422.2	9	422.1	10	420.7	11	421.6
9	422.4	10	421.9	10	422.2	11	420.6	12	422.2
11	422.4	11	422.0	11	422.0	12	421.9	13	421.4
27	422.2	23	421.2	14	422.0	13	421.1	14	421.4
28	421.8	24	421.5	22	421.4	14	421.0	16	421.4
29	421.9	31	421.9			15	421.7	17	421.3
30	421.9					16	421.2	18	421.7
						17	422.3	19	422.3
						21	421.4	20	422.1
						22	422.0	21	420.9
						27	420.8	23	422.1
						28	421.3	24	422.0
						29	420.9		
						30	421.3		
						31	421.6		

	1989	1990	1991	1992	1994
Total events	9	8	7	17	14

Table VII. Daily minimum reservoir level drawdowns from full pool (425.0 feet) to below 422.5 feet for Monticello Reservoir. Drawdowns were limited to 422.5 feet after the first week of August for the year 1992. August of 1989, 1990, 1991, 1992 and 1994.

August

1989		1990		1991		1992		1994	
Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)	Day	Minimum Reservoir Level (feet)
1	421.5	2	422.1	6	421.6	4	420.7	2	421.4
3	422.4	3	422.4	7	421.8			3	422.0
4	421.2	4	421.8	8	421.7			4	422.0
5	421.5	13	422.1					5	422.3
6	421.5	14	421.1					10	422.0
7	421.5	15	421.1					12	421.8
8	422.0	16	421.8					26	422.0
18	422.3	19	421.9					27	422.1
22	421.4	20	422.0					30	422.1
23	421.2	21	421.5					31	421.8
24	421.6	26	421.8						
29	422.1	27	420.9						
		28	420.7						
		29	421.1						
		30	421.6						
	1989		**1990**		**1991**		**1992**		**1994**
Total events	**12**		**15**		**3**		**1**		**10**