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Harris Nuclear Plant

1996 Environmental Monitoring Report

Environmental Services Section

HARRIS NUCLEAR PLANT
1996 ENVIRONMENTAL MONITORING REPORT

November 1997

Environmental Services Section

CAROLINA POWER & LIGHT COMPANY

New Hill, North Carolina

This copy of the report is not a controlled document as detailed in the *Environmental Services Section Biology Program Procedures Manual and Quality Assurance Manual*. Any changes made to the original of this report subsequent to the date of issuance can be obtained from:

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Harris Energy & Environmental Center
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New Hill, North Carolina 27562-0327

Table of Contents

List of Appendices

Metric-English Conversion and Units of Measure

Length

1 micron (µm) = 4.0 x 10^{-5} inch
1 millimeter (mm) = 1000 m = 0.04 inch
1 centimeter (cm) = 10 mm = 0.4 inch
1 meter (m) = 100 cm = 3.28 feet
1 kilometer (km) = 1000 m = 0.62 mile

Area

1 square meter (m^2) = 10.76 square feet
1 hectare (ha) = 10,000 m^2 = 2.47 acres

Weight

1 microgram (µg) = 10^{-3} mg or
10^{-6} g = 3.5 x 10^{-8} ounce
1 milligram (mg) = 3.5 x 10^{-5} ounce
1 gram (g) = 1000 mg = 0.035 ounce
1 kilogram (kg) = 1000 g = 2.2 pounds
1 metric ton = 1000 kg = 1.1 tons
1 kg/hectare = 0.89 pound/acre

Volume

1 milliter (ml) = 0.034 fluid ounce
1 liter = 1000 ml = 0.26 gallon
1 cubic meter = 35.3 cubic feet

Temperature

Degrees Celsius (°C) = 5/9 (°F-32)

Specific conductance

µS/cm = Microsiemens/centimeter

Turbidity

NTU = Nephelometric Turbidity Unit

EXECUTIVE SUMMARY

Harris Reservoir supplies makeup water to the closed-cycle cooling system for the Harris Nuclear Plant. The Harris Nuclear Plant discharges primarily cooling tower blowdown along with low volume waste discharges into the reservoir near the main dam.

Total phosphorus concentrations remained stable for the reporting period (1992-1996) at concentrations within an acceptable range for a productive reservoir in this area. Reservoir wide total nitrogen concentrations had remained stable during 1993 through 1995 but increased in 1996.

No nuisance algal blooms (i.e., when chlorophyll *a* concentrations are $\geq$ 40 μg/liter) were observed in Harris Reservoir during 1995 or 1996. Algal blooms have been a concern in previous years because blooms indicate increased nutrient loading which can degrade water quality.

Monitoring of biofouling organisms continued in 1996. Asiatic clams were found in low to moderate numbers in the main reservoir service water system, the cooling water makeup system, and the emergency service water system. No clams were found in the power plant's fire protection system. The presence of Asiatic clams in the main reservoir service water system, the cooling water makeup system, and the emergency service water system did not affect power plant operations. Zebra mussels, another potential biofouling organism, were not collected in the main or the auxiliary reservoirs. To date, this organism has not been found in North Carolina waters.

Hydrilla continued to be widespread throughout Harris Reservoir and in the auxiliary reservoir during 1996. The attempt to control hydrilla in the auxiliary reservoir by releasing grass carp in the fall of 1994 was only partially effective. A supplemental stocking of grass carp in the auxiliary reservoir was conducted during the fall of 1996. Depending on the hydrilla control achieved from these two releases, an additional grass carp stocking may occur in 1997.

RESERVOIR DESCRIPTION

The main body of Harris Reservoir has a surface area of 1680 ha; the auxiliary reservoir has a surface area of 130 ha (Appendix 1). The main reservoir has a maximum depth of 18 m, a mean depth of 5.3 m, a volume of 8.9×10^7 m^3, a full-pool elevation of 67.1 m National Geodetic Vertical Datum (NGVD), and an average residence time of 28 months. The reservoir began filling in December 1980, and full-pool elevation was reached in February 1983. The 64.5-km shoreline is mostly wooded, and the 183.9-km^2 drainage area is mostly rolling hills with land used primarily for forestry and agriculture. The conversion of areas from forestry or agricultural purposes to residential uses continues in many areas of the drainage.

Harris Reservoir has a "Class C" water quality classification (NCDEM 1994a). Class C waters are suitable for aquatic life propagation and maintenance of biological integrity (including fishing and fish), wildlife, secondary recreation, agriculture, and any other usage except for primary recreation or as a source of water supply for drinking, culinary, or food processing purposes (NCDEM 1994b).

HISTORICAL OVERVIEW

Harris Reservoir was constructed to supply cooling tower makeup and auxiliary reservoir makeup water to the 900-MW Harris Nuclear Plant which began commercial operation in May 1987. In 1986 the bottom waters of the reservoir near the main dam began receiving National Pollutant Discharge Elimination System (NPDES)-permitted wastewater discharges from the power plant cooling tower. Tributaries also receive NPDES-permitted discharges from the Harris Energy and Environmental Center and from wastewater treatment plants at Apex and Holly Springs.

The environmental monitoring programs that were conducted after Harris Nuclear Plant initiated commercial operation determined that Harris Reservoir was a typical southeastern, moderately productive reservoir with seasonal oxygen-deficient subsurface waters, elevated nutrient and algal concentrations, an abundance of rooted shallow-water aquatic plants, and a productive sport fishery.

Throughout its history, the reservoir has increased in biological productivity. Increased nutrient loadings from point and nonpoint sources increased the algal biomass of Harris Reservoir from a low/moderate range to a moderate/high range within the period 1986-1989. In 1994, Harris Reservoir was described as "support-threatened" because of elevated nutrient levels (primarily total nitrogen) (NCDEM 1995). Support-threatened reservoirs are those that fully support their designated uses but may not fully support uses in the future (unless pollution control action is taken) because of anticipated sources or adverse pollution trends (NCDEM 1994a). The annual mean total nitrogen concentration increased through 1993, but from 1993 to 1995 concentrations remained similar. Total phosphorus concentrations remained stable during 1991 through 1995 and at levels acceptable for southeastern, productive reservoirs.

With the increase in nutrients, an increase in algal biomass (as estimated by chlorophyll *a* concentrations) was observed throughout much of the reservoir. On at least one occasion each year from 1989 to 1994, the chlorophyll *a* concentration was above the North Carolina water quality standard (40 µg/liter) in Harris Reservoir. During 1995 no measured chlorophyll *a* concentration exceeded 40 µg/liter. Chlorophyll *a* concentrations above 40 µg/liter implies nuisance algal blooms and potential water quality degradation.

In 1984 the reservoir was colonized by the Asiatic clam (*Corbicula fluminea*). This nonnative organism has the potential to block power plant pipes and tubes in raw-water systems. Although densities remained at low levels during 1991 and 1992, the presence of shells along the shoreline in many areas has indicated that the clam has continued to spread throughout the main reservoir. Mean number and density estimates for Asiatic Clams for 1995 continued to increase above estimates for 1994 but remained at relatively low levels. Asiatic clams have not interfered with power plant operations at the Harris Nuclear Plant.

The aquatic plant hydrilla (*Hydrilla verticillata*) was initially found in 1988 growing in the White Oak Creek arm. Within a two-year period, this nonnative species had displaced native species and become the dominant littoral zone plant species. Since 1990 creeping water primrose (*Ludwigia uruguayensis*) has also increased its littoral zone coverage in the main reservoir. Hydrilla and water primrose were observed in the auxiliary reservoir in 1993 and by 1994 they were widespread. The distribution and abundance of hydrilla and water primrose in 1995 was similar to 1994 distribution and abundance patterns. Despite these shifts in the structure of the aquatic macrophyte community, the community has not impacted Harris Nuclear Plant operations.

OBJECTIVES

The primary objective of the 1996 Harris Nuclear Plant nonradiological environmental monitoring program was to provide an assessment of the effect of power plant operations on the water quality in Harris Reservoir. Secondary objectives of the program were to document any other environmental factors impacting water quality and to document the introduction and expansion of nonnative plant and animal populations in the reservoir. These objectives have also been addressed in previous reports (e.g., CP&L 1991, 1992, 1994a, 1994b, 1996a, 1996b).

METHODS

Key indicators of the water quality of Harris Reservoir were assessed at various locations in the reservoir (Appendices 1 and 2). These key indicators were used to describe and interpret the environmental quality of the reservoir and were included if there was an occurrence or the potential for a significant change, trend, or an abnormal event. Other items were included as key indicators when there was environmental, public, or regulatory interest.

The 1996 environmental program included monitoring: (1) the reservoir's limnological characteristics (water quality, water chemistry, and chlorophyll *a*), (2) the Asiatic clam populations, (3) the distribution of aquatic vegetation, and (4) the possible introductions of the zebra mussel and the quagga mussel. Sampling methods in 1996 were similar to those used in 1995 (CP&L 1996b) (Appendix 3). No largemouth bass fishing tournaments were monitored.

Supporting data summaries and appropriate statistical analyses were used to describe and interpret the environmental quality of the reservoir. Monthly precipitation data from Sanford, North Carolina during 1992 to 1996 are presented as a reference to interpret the environmental data (Appendix 4).

All analytical testing, except total phosphorus analyses, completed in support of the Harris Reservoir environmental monitoring program was performed by testing laboratories that are certified by North Carolina Division of Water Quality's (NCDWQ) Laboratory Certification Program to perform water and wastewater testing. The validity of these data was assured through CP&L's quality control program. For calculation of means in this report, concentrations of less than the reporting limit were assumed to be at one-half the reporting limit.

RESULTS AND DISCUSSION

Limnology

Annual precipitation

- Annual precipitation at Sanford, North Carolina, during 1996 (141.7 cm) was less than during 1995 (161.2 cm). During both years annual precipitation was greater than the thirty-year average. Two major storms, Hurricane Bertha (July 12, 1996) and Hurricane Fran (September 5-6, 1996) increased total monthly precipitation during July, and September, 1996 above the respective monthly 30-year average (Appendix 4).

Temperature and Dissolved Oxygen

- During 1996, Harris Lake surface water temperatures ranged from 4.1°C to 28.3°C (Appendix 5). The waters at the deeper reservoir Stations E2 and H2 were stratified during May, July, and September while waters were stratified at Station P2 during May and July only. Waters at these stations were freely circulating during January, March, and November. Portions of the hypolimnion were anoxic (i.e., conditions where dissolved oxygen concentrations are less than 1 mg/ liter) from May through September with the greatest volume of anoxic water occurring during July (Appendix 6). This bottom-water oxygen decline is typical during the warm summer months in Harris Reservoir and in other southeastern productive water bodies when well-defined thermoclines develop and block bottom waters from mixing with the upper, more oxygenated waters.

Water Clarity

- Secchi disk transparency (a water clarity indicator) annual mean value was significantly less in the upper reservoir compared to the other stations (S2 < P2 = E2 = H2) during 1996. Except for an increased annual mean Secchi disk transparency value during 1995, Secchi disk transparency values remained similar from 1992 through 1996. There were no significant spatial trends for solids (i.e., total solids, total dissolved solids, and total suspended solids), or turbidity during 1996 for surface waters at Stations E2, H2, P2, and S2 nor were there statistically significant temporal trends for the period 1992-1996 (Appendices 7 and 8).

Algal Biomass

- During 1996, no measured mean chlorophyll *a* concentration exceeded the North Carolina water quality standard of 40 µg/liter (NCDEM 1992) (Appendices 7 and 8). No nuisance algal blooms have been observed in Harris Reservoir during 1995 and 1996.

- There were no significant spatial differences in mean chlorophyll *a* concentrations during 1996 primarily due to the continued high variability among the monthly mean concentrations at each station. Monthly mean chlorophyll *a* concentrations have remained below 40 µg/liter since January 1994. Annual mean chlorophyll *a* concentrations were significantly less in 1996 compared to 1992 and 1993 annual mean concentrations but similar to 1994 and 1995 annual mean chlorophyll *a* concentrations (Appendices 7, 8, and 9).

Nutrients (surface waters)

- During 1996, annual mean total phosphorus concentrations were significantly greater at Station E2 compared to concentrations at Stations H2 and P2 (Appendix 7). Annual mean total phosphorus concentrations were not significantly different between Stations E2 and S2. There were no significant differences among stations for most mean nitrogen (i.e., ammonia-N, nitrate + nitrite-N, and total nitrogen) concentrations in Harris Reservoir during 1996 (Appendix 7). The annual mean total nitrogen concentrations were significantly greater during 1996 compared to 1992, 1993, and 1995 annual mean concentrations (Appendix 8).

Ions (surface waters)

- Except for annual mean magnesium and sodium concentrations which were significantly greater at the station near the dam (Station E2) than the upstream Station S2, there were no spatial differences in ion concentrations during 1996 (Appendix 7).

- The annual mean calcium concentrations for 1996 increased compared to the 1992-1994 period but remained at a low level (3.9 mg/liter). No consistent temporal trends were indicated for the other ion concentrations during the 1992-1996 comparison period (Appendix 8).

Other surface water chemical constituents

- In 1996, concentrations of total organic carbon and hardness were not statistically different among stations. The annual mean total alkalinity concentrations at Stations E2, H2, and

P2 were significantly greater than the annual mean concentrations at Station S2. These spatial differences in total alkalinity were relatively small and were not expected to influence biological communities (Appendix 7).

- There were no consistent significant temporal trends in annual mean total organic carbon, total alkalinity, or hardness concentrations during the 1992 through 1996 comparison period (Appendix 8).

Trace Metals and Metalloids (surface waters)

- Excluding mercury, and a copper concentration (Station E2, September, 1996) all metal and metalloid concentrations measured in 1996 continued to be less than the respective North Carolina water quality standard (Appendices 7). All mercury concentrations were below the laboratory detection level of 0.20 µg/liter. During 1996, aluminum ranged from <50 to 1140 µg/liter with the greater value recorded in a headwater region where aluminum concentrations may have been influenced by watershed sources located upstream of the reservoir (Appendix 7).

- There were no consistent temporal trends in aluminum or copper concentrations during the 1992 through 1996 comparison period (Appendix 8).

Chemical Constituents in the Bottom Waters at Station E2

- The concentrations of most chemical constituents in the bottom waters remain within a range expected for productive, southeastern reservoir waters and were not considered detrimental to the biological community.

- Except for calcium concentrations, there were no consistent significant temporal differences for the ion constituents in the bottom waters at Station E2. The annual mean calcium concentrations for 1995 and 1996 were significantly greater than concentrations from 1992-1994 (Appendix 10).

- In the bottom waters at Station E2, there were no significant differences among years (1992-1996) for solids (total, dissolved, and suspended solids), turbidity, nutrients (total nitrogen, nitrate + nitrite-N, ammonia-N, and total phosphorus), total organic carbon, total alkalinity, hardness, and metals (Appendix 10). The extreme variability in the concentrations between periods of stratification and periods of uniform mixing throughout the water column were the probable cause for being unable to detect any significant temporal differences in the chemical constituents in the bottom waters.

Biofouling Monitoring Surveys

Asiatic Clam

- Asiatic clams caused no operational problems for the Harris Nuclear Plant during 1996. No Asiatic clams were collected in 1996 from the fire protection system.

- During 1996, Asiatic clam mean density estimates in the main reservoir service water system and the cooling water makeup system mean densities were lower than densities observed in 1995. Mean clam densities in the auxiliary reservoir emergency service water system increased ten-fold during 1996 over 1995 levels (Appendix 11). The 1996 mean clam densities in the auxiliary reservoir emergency service water system were at moderate levels. All Asiatic clams collected during 1996 were approximately 2-4 years old based on their size ranges.

Zebra Mussel and Quagga Mussel

- No Zebra mussels (*Dreissena polymorpha*) or quagga mussels (*D. bugensis*), potentially serious biofouling organisms to power plant operations, were found in Harris Reservoir or the auxiliary reservoir during 1996. Zebra mussels and quagga mussels are not expected to thrive in Harris Reservoir because concentrations of alkalinity, calcium, total hardness, and pH are suboptimal for mussel growth and reproduction (Claudi and Mackie 1993).

Aquatic Vegetation

- A visual survey made during 1996 revealed that hydrilla (*Hydrilla verticillata*), a non-native submersed plant, and creeping water primrose (*Ludwigia uruguayensis*) were established in the littoral zone (< 3 m deep) throughout Harris Reservoir except for those areas lacking suitable substrate (i.e., rocks and hard-packed clay). Although these aquatic plants were well established in all regions of the reservoir, no impacts to the Harris Plant have occurred nor are they expected because of the low velocity of water drawn from the main reservoir into the cooling tower makeup water intake structure.

- Hydrilla was also established in the littoral zone of the auxiliary reservoir with an almost continuous band of plants covering the littoral zone in the discharge arm (north side of the reservoir) and a patchy distribution of plants in the littoral zone of the intake arm (south side) of the reservoir. The distributions and abundance of hydrilla in the Harris Reservoir and the auxiliary reservoir during 1996 were similar to distributions and abundance observed in 1995.

- During the fall of 1996, approximately 800 grass carp (*Ctenopharyngodon idella*) were released in the auxiliary reservoir with 400 released on the north side of the dike separating the intake and discharge sides of the auxiliary reservoir and 400 released on the south side of the dike at the boat ramp. These fish and the 800 stocked in 1994 were released to control the growth and spread of aquatic vegetation. In the proximity of the 1994 release site, including the area at the intake canal, control was evident during 1996. The fish released in 1994 apparently did not emigrate in sufficient numbers to the discharge side of the reservoir as evidence by limited control of hydrilla in this area.

CONCLUSIONS

During 1996 Harris Reservoir continued to show characteristics of a typical southeastern, biologically productive reservoir with seasonally occurring oxygen-deficient subsurface waters, elevated nutrient concentrations, and an abundance of rooted shallow-water aquatic plants.

The environmental monitoring program conducted in 1996 continued to provide an assessment of the effects of the Harris Nuclear Plant's operation on the various components of the aquatic environment. Most key indicators of the environmental quality in Harris Reservoir were unchanged from the previous five years. Nutrient concentrations have been a concern in Harris Reservoir since phosphorous and nitrogen concentrations increased rapidly in the late 1980s and early 1990s. Water quality assessments determined that total phosphorus concentrations have remained stable since 1992 and at levels acceptable for southeastern, productive reservoirs. The annual mean total nitrogen concentration continued to increase in 1996, with concentrations significantly greater than concentrations during the 1992-1993 comparison period.

The frequency and severity of nuisance algal blooms, as indicated by chlorophyll *a* concentrations, continued to lessen in recent years. For the second consecutive year since 1988, no measured chlorophyll *a* concentration exceeded the North Carolina water quality standard of 40 µg/l in 1996. Reservoir wide chlorophyll *a* concentrations have remained similar for the 1994-1996 period and no nuisance algal blooms were observed.

The presence of Asiatic clams in the Harris Nuclear Plant emergency service water system did not impact plant operations in 1996 and no clams were observed in the fire protection system. During 1996, Asiatic clam mean density estimates in the main reservoir service water system and the cooling water makeup system remained similar to densities observed in 1995 while clam densities increased in the auxiliary reservoir service water system.

Neither the zebra mussel nor the quagga mussel were found in the main reservoir or the auxiliary reservoir during 1996. These biofouling organisms have yet to be found in North Carolina. Due to potential biofouling impact to Harris Nuclear Plant operations monitoring was continued.

Based on surveys conducted during 1996, the aquatic plants hydrilla and creeping water primrose were well established in the littoral zone throughout the entire main reservoir. Hydrilla has also become well established along the shoreline throughout most of the auxiliary reservoir, especially in the northern region. The control of aquatic vegetation by the grass carp released in the fall of 1994 in the auxiliary reservoir was only evident near and around the release site in the southern region. A supplemental stocking of 800 grass carp was conducted during October, 1996. These fish are expected to further control the proliferation of aquatic vegetation in the auxiliary reservoir. No operational impacts have occurred at the Harris Nuclear Plant because of aquatic vegetation biofouling.

REFERENCES

CP&L. 1991. Shearon Harris Nuclear Power Plant 1990 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

______. 1992. Shearon Harris Nuclear Power Plant 1991 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

______. 1994a. Shearon Harris Nuclear Power Plant 1992 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

______. 1994b. Shearon Harris Nuclear Power Plant 1993 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

______. 1996a. Shearon Harris Nuclear Power Plant 1994 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

______. 1996b. Shearon Harris Nuclear Power Plant 1995 annual environmental monitoring report. Carolina Power & Light Company, New Hill, NC.

Claudi, R., and G. L. Mackie. 1993. Practical manual for zebra mussel monitoring and control. Lewis Publishers, Boca Raton, FL.

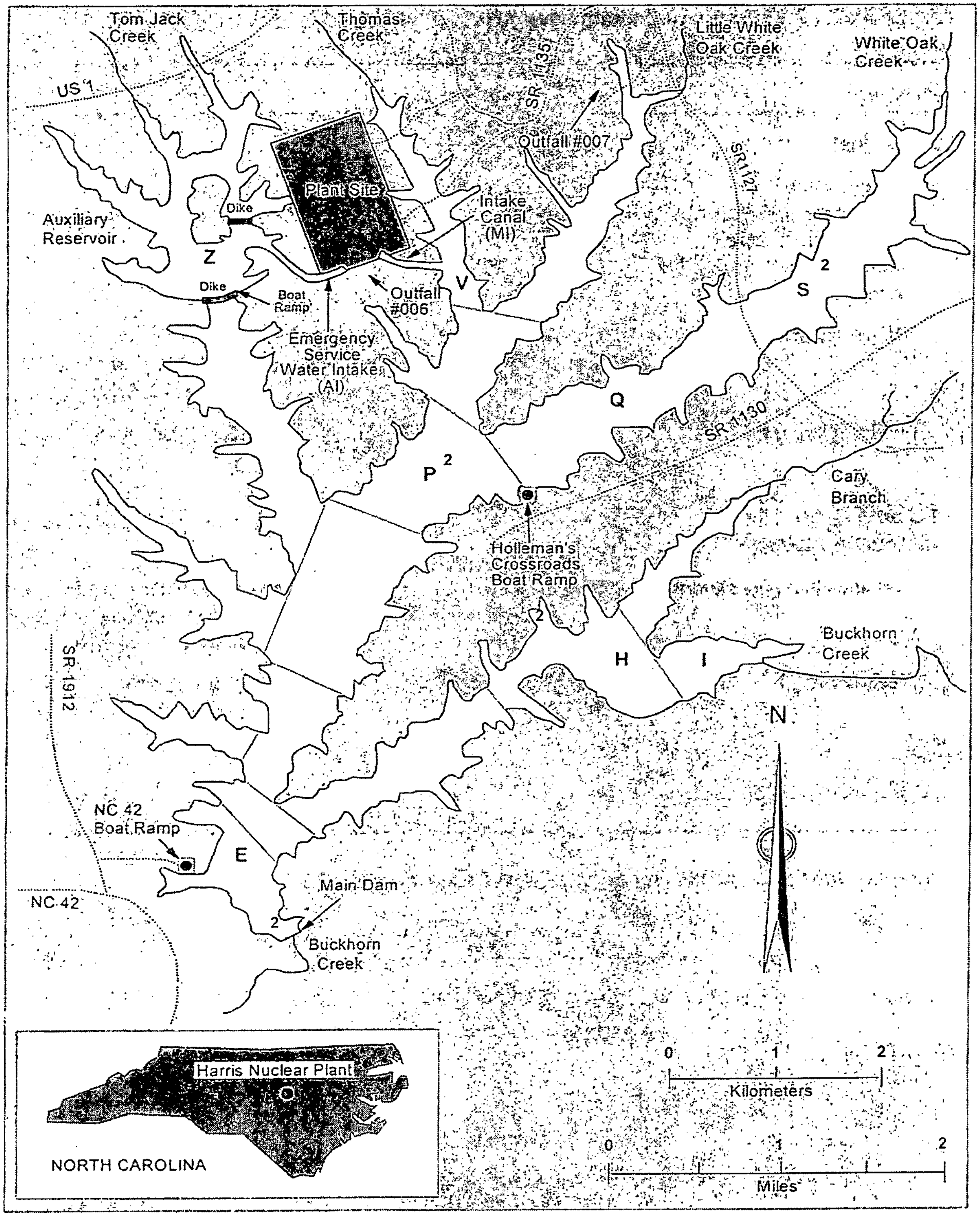
NCDEM. 1992. North Carolina lake assessment report. Report No. 92-02. Water Quality Section, Division of Environmental Management, North Carolina Department of Environment, Health, and Natural Resources, Raleigh, NC.

______. 1994a. Water quality progress in North Carolina, 1992-1993, 305 (b) report. Report No. 94-07. Water Quality Section, Division of Environmental Management, North Carolina Department of Environment, Health, and Natural Resources, Raleigh, NC.

______. 1994b. Administrative code. Classifications and water quality standards applicable to surface waters of North Carolina. North Carolina Department of Environment, Health, and Natural Resources. North Carolina Division of Environmental Management. Raleigh, NC.

______. 1995. Executive summary (draft). Cape Fear River basinwide water quality management plan. May 10, 1995. Water Quality Section, Division of Environmental Management, North Carolina Department of Environment, Health, and Natural Resources, Raleigh, NC.

Strickland, J. D. H., and T. R. Parsons. 1972. A practical handbook of seawater analysis. Bulletin No. 167 (2nd ed.). Fisheries Research Board of Canada.



Appendix 1. Sampling areas and stations at Harris Reservoir during 1996.

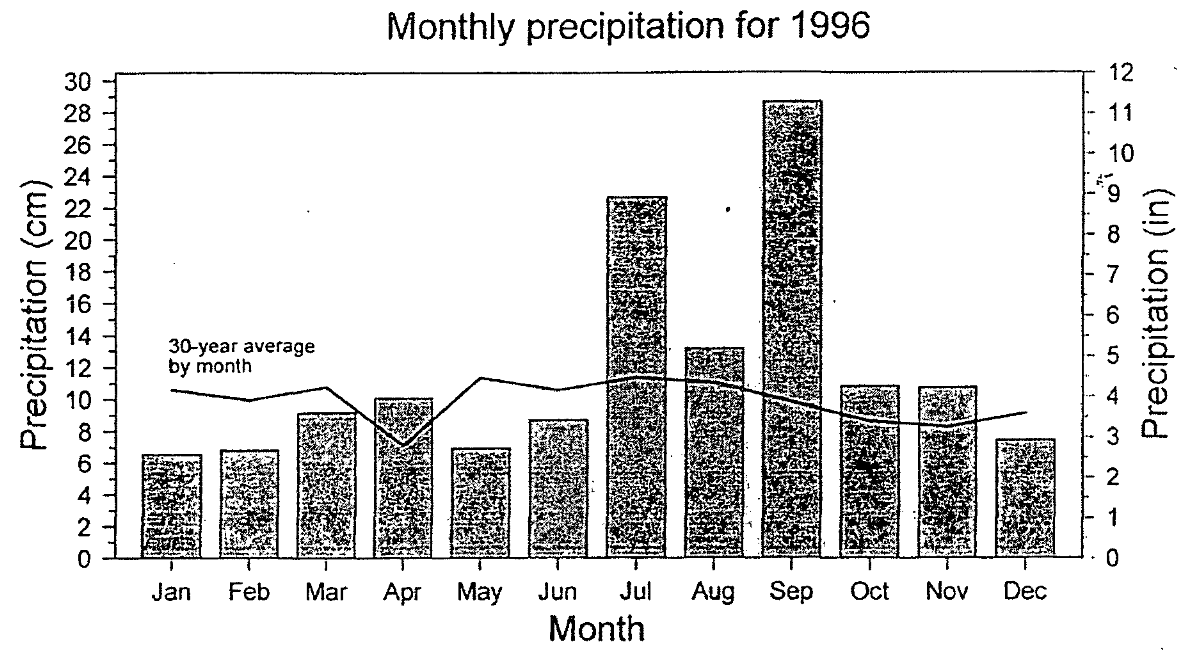
Appendix 2. Environmental monitoring program at Harris Reservoir for 1996.

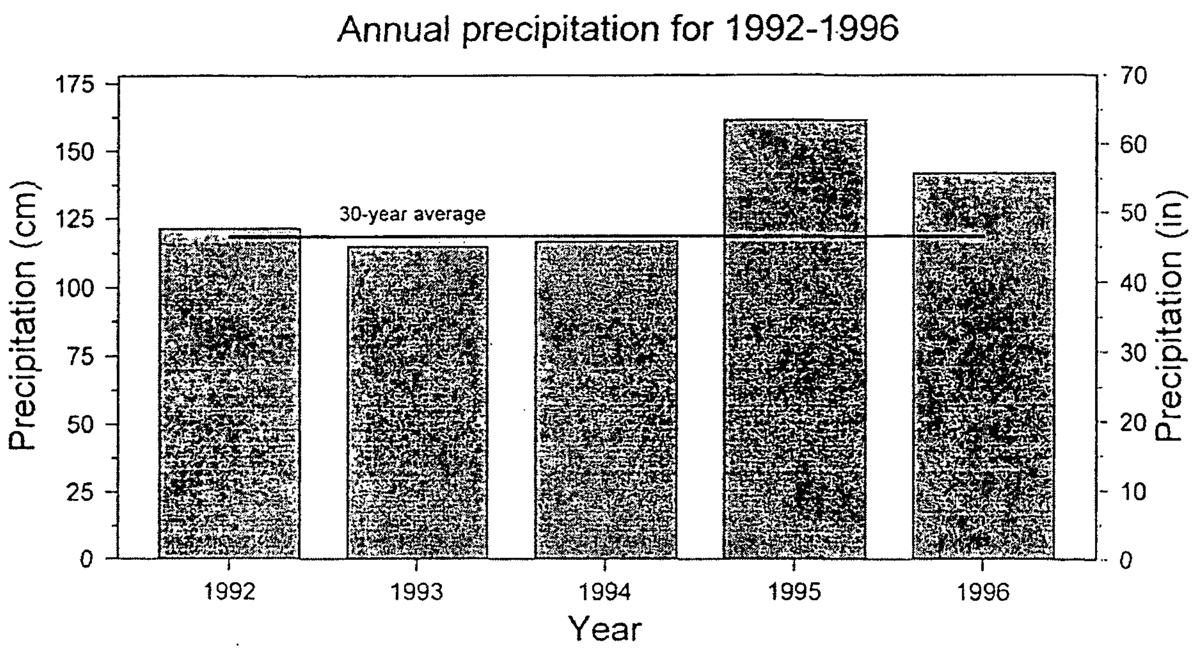
Program	Frequency	Location
Limnology		
Water quality (temperature, dissolved oxygen, pH, specific conductance, Secchi disk transparency)	Jan, Mar, May, Jul., Sept., Nov.	Stations E2, H2, P2, and S2 (surface to bottom at 1-m intervals)
Water chemistry	Jan, Mar, May, Jul., Sept., Nov.	Stations E2, H2, P2, and S2 (surface samples at all stations, bottom sample at E2 only)
Chlorophyll *a*	Jan, Mar, May, Jul., Sept., Nov.	Stations E2, H2, P2, and S2
Biofouling monitoring surveys		
Asiatic clam (*Corbicula*)	May, Nov.	Emergency service water and cooling tower makeup system intake structures
Zebra mussel	Jan, Mar, May, Jul., Sept., Nov.	Areas E, P or Q, and V
Aquatic vegetation survey	Nov.	Areas I, E, P, Q, S, V, and Z

+Alternate months were January, March, May, July, September, and November.

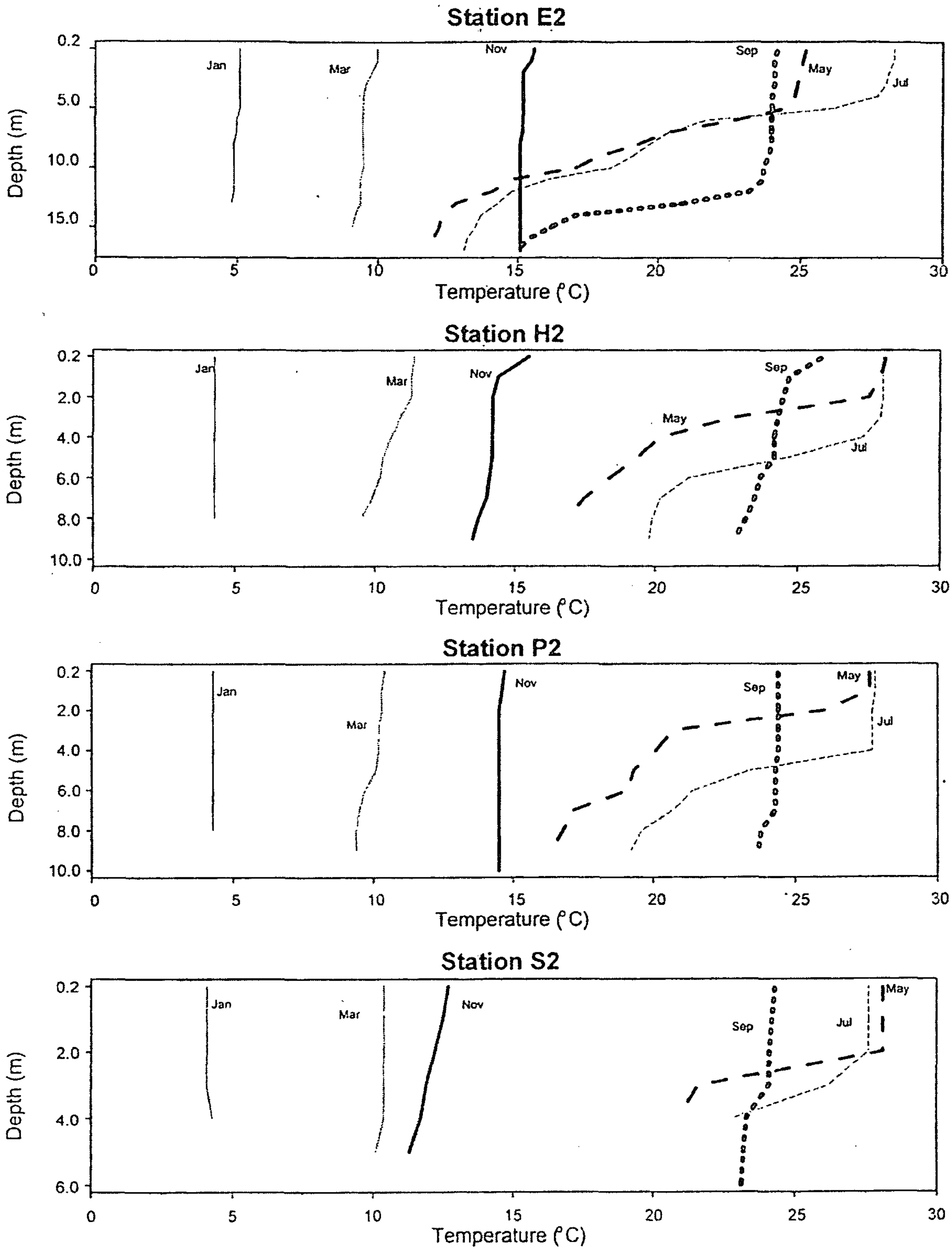
Appendix 3. Field sampling and laboratory methods followed in the 1996 environmental monitoring program at Harris Reservoir.

Program	Method
Water quality	Temperature, dissolved oxygen, pH, and specific conductance were measured with calibrated Martek Mark XV® and YSI® instruments. Measurements were taken from surface to bottom at 1-m intervals. Water clarity was measured with a Secchi disk.
Water Chemistry	Surface (Stations E2, H2, P2, and S2) and bottom samples (Station E2) were collected with a nonmetallic Van Dorn sampler, transferred to appropriate containers, transported to the laboratory on ice, and analyzed according accepted laboratory methods.
Phytoplankton	Equal amounts of water from the surface, the Secchi disk transparency depth, and twice the Secchi disk transparency depth were obtained with a Van Dorn sampler and mixed in a plastic container. A 250-ml subsample was taken and preserved with 5 ml of "M3" fixative.
Chlorophyll *a*	During January, March, May, July, and September, 1000-ml samples were collected from the surface, the Secchi disk transparency depth, and twice the Secchi disk transparency depth with a Van Dorn sampler, and placed in dark bottles. During November, equal amounts of water from the surface, the Secchi disk transparency depth, and twice the Secchi disk transparency depth were obtained with a Van Dorn sampler, placed in a plastic container and mixed, then a 1000-ml subsample was collected in a dark bottle. All samples werre placed on ice and returned to the laboratory. In the laboratory, a 250-ml subsample from each depth was analyzed according to Strickland and Parsons (1972) and APHA (1992).
Asiatic clam	Seven samples were collected with a petite Ponar from the emergency service water and cooling tower makeup intake structures. Sampling of the main and auxiliary reservoir intake canals was discontinued during 1996. Samples were preserved with 5% formalin and returned to the laboratory where they were elutriated through 1000-, 500-, and 300-μ mesh sieves. Asiatic clams were counted, measured, and preserved.
Zebra mussel	An artificial substrate sampler, constructed of a PVC frame and fitted with removable PVC plates, was placed near the cooling tower makeup intake structure. This sampler, the dock at the Holleman's boat ramp, or the water quality station marker buoys were visually inspected for the presence of mussels during routine water quality or Asiatic clam survey monitoring.
Aquatic Vegetation Survey	Portions of the shoreline and/or littoral zone of the reservoir and auxiliary reservoir were systematically surveyed by boat to document the presence of aquatic vegetation (specifically hydrilla and creeping water primrose)

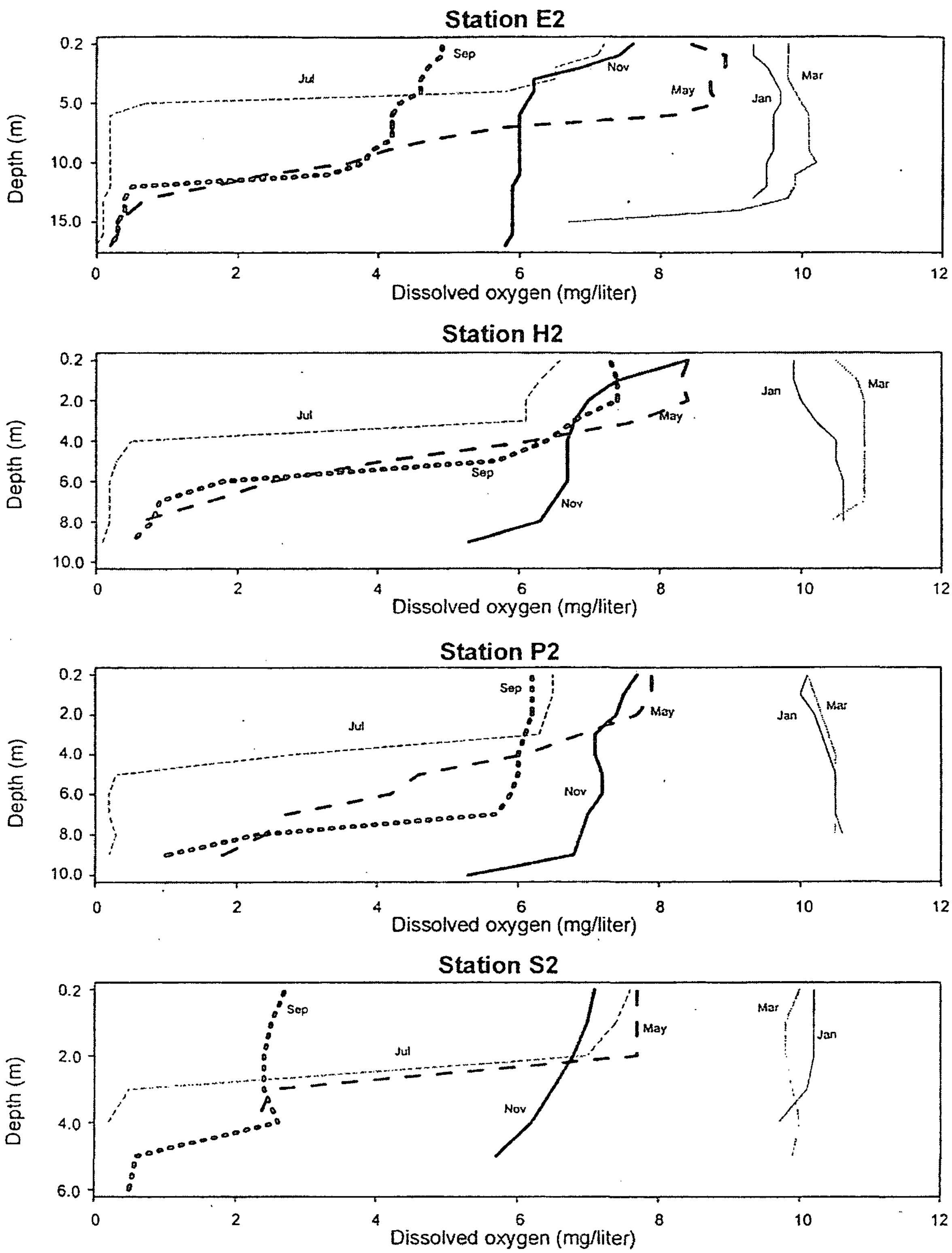




Appendix 4. Monthly and yearly precipitation recorded at Sanford, North Carolina, 1992-1996 (Source: The State Climatologist, North Carolina State University).



Appendix 5. Water temperature profiles at Harris Reservoir during 1996. Note: The maximum depth is different for each station.



Appendix 6. Dissolved oxygen profiles at Harris Reservoir during 1996. Note: The maximum depth is different for each station.

Appendix 7. Means, ranges, and spatial trends of selected limnological variables from the surface waters of Harris Reservoir during 1996.+

Variable	Station E2	Station H2	Station P2	Station S2
Solids (mg/liter)				
Total	103 (85-123)	78 (56-86)	89 (52-117)	74 (43-95)
Total dissolved	85 (70-148)	71 (18-121)	73 (62-80)	73 (25-99)
Total suspended	< 6	< 6	< 6 (< 6-9)	9 (< 6-19)
Turbidity (NTU)	5.8 (1.3-18)	3.2 (1.6-6.6)	3.7 (2.0-8.0)	11 (2.6-34)
Secchi disk transparency (m)	1.5 a (1.0-2.0)	1.7 a (1.3-2.0)	1.5 a (1.0-1.9)	1.1 b (0.3-1.7)
Chlorophyll *a* (µg/liter)	11.0 (3.0-22.8)	13.3 (5.4-24.5)	12.1 (3.6-26.3)	8.1 (4.8-12.9)
Nutrients (mg/liter)				
Ammonia-N	< 0.07 (< 0.07-0.10)	< 0.07 (< 0.07-0.10)	< 0.07 (< 0.07-0.09)	< 0.07 (< 0.07-0.12)
Nitrate + Nitrite-N	0.05 (< 0.02-0.10)	< 0.05 (< 0.02-0.09)	0.03 (< 0.02-0.08)	0.05 (< 0.02-0.13)
Total nitrogen (TN)	0.9 (0.5-2.3)	0.5 (0.2-0.7)	0.6 (0.5-0.7)	0.7 (0.6-1.0)
Total phosphorus (TP)	0.046a (0.026-0.083)	0.030 b (0.022-0.048)	0.029 b (0.025-0.043)	0.040ab (0.022 -0.060)
TN:TP	23 (9-61)	18 (10-24)	22 (16-26)	30 (12-85)
Total organic carbon (mg/liter)	6.8 (5.3-8.8)	6.6 (5.6-8.8)	6.8 (5.9-7.4)	6.9 (5.4-9.5)
Ions (mg/liter)				
Calcium¶	4.0 (3.7-4.2)	3.7 (3.4-3.9)	3.9 (3.4-4.7)	3.8 (3.4-4.8)
Chloride	9.3 (8.1-10)	9.6 (8.5-11)	10 (9.0-14)	8.5 (7.7-9.8)
Magnesium¶	1.8 a (1.6-2.0)	1.7ab (1.6-1.9)	1.7 a (1.6-1.9)	1.6 b (1.4-1.9)
Sodium¶	9.6a (8.2-11)	8.9a (7.9-9.9)	9.3a (7.8-10)	7.9b (6.7-9.9)
Sulfate	14 (13-17)	13 (11-15)	13 (11-14)	12 (8.6-15)
Total alkalinity (mg/liter as $CaCO_3$)	13a (13-14)	13a (12-14)	13a (12-14)	12 b (8.1-15)
Hardness ¶ (calculated as mg equivalents $CaCO_3$/liter)	17 (17-18)	16 (16-17)	17 (15-19)	16 (15-19)
Specific conductance (µS/cm)	84a (65-93)	81a (68-88)	83a (65-91)	76b (69-87)

Appendix 7 (continued)

Variable	N.C. water quality standard	Station			
		E2	H2	P2	S2
Metals (µg/l)					
Aluminum	None	69 (<50-155	58 (<50-189)	60 (<50-202)	304 (<50-1140)
Arsenic	50	< 1 (< 1-2)	< 1 (< 1-2)	< 1 (< 1-1)	< 1 (< 1-2)
Cadmium	2	< 0.5	< 0.5	< 0.5	< 0.5
Copper	7[§]	4.3 (1.2-13[£])	1.4 (1.0-2.2)	2.2 (1.2-5.9)	1.7 (1.2-2.5)
Mercury	0.012	< 0.20	< 0.20	< 0.20	< 0.20
Selenium	5	< 1	< 1 (< 1-1)	< 1	< 1

[+]Fisher's protected least significant difference test was applied only if the overall f test for the treatment was significant. Means followed by the same superscript were not significantly different ($P > 0.05$). Sample size equaled 6 for all variables unless otherwise noted. The variable TN:TP was not subjected to statistical analyses.

[¶]Mean values calculated using n = 5 at Station H2. Calcium, magnesium, and sodium concentrations for Station H2 during March, 1996 were considered outliers and intentionally omitted from data analyses.

[§]This value is an action level not a water quality standard. An action level is for toxic substances which are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics, or associated waste characteristics (NCDEM 1994b).

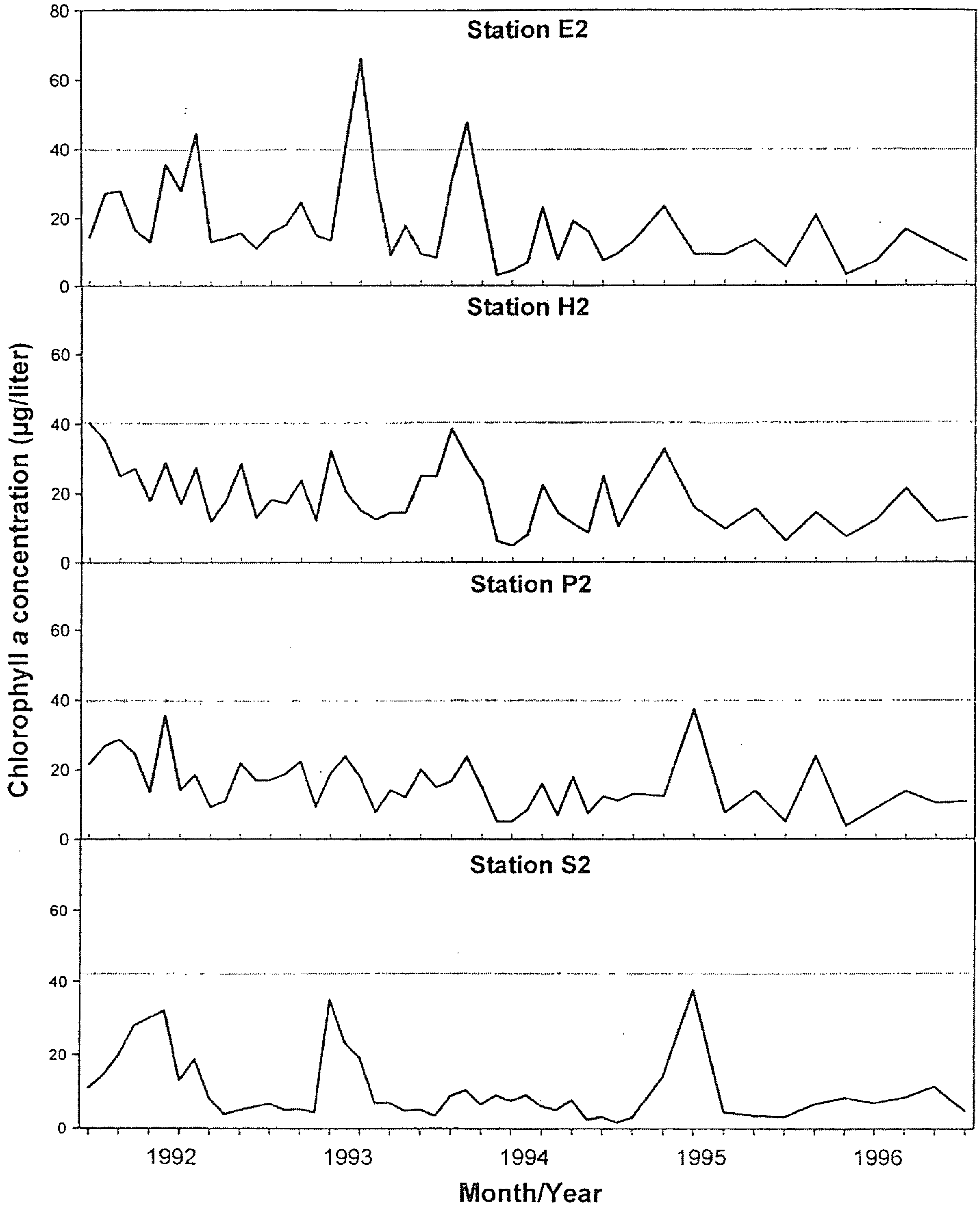
[£]Copper concentration for Station E2 during September, 1997 was an outlier but was not omitted from data analyses.

Appendix 8. Temporal trends of selected limnological variables from the surface waters of Harris Reservoir at Stations E2, H2, and P2, 1992-1996.+

Variable	Year				
	1992	1993	1994	1995	1996
Solids (mg/liter)					
Total	78[ab]	64[c]	73[bc]	76[ab]	86[a]
Total dissolved	56[bc]	52[c]	67[ab]	68[a]	75[a]
Total suspended	5.3	5.3	4.0	4.3	4.5
Turbidity (NTU)	2.9	4.9	5.4	4.4	6.1
Secchi disk transparency (m)	1.3[b]	1.3[b]	1.4[b]	1.8[a]	1.4[b]
Chlorophyll *a* (µg/liter)	18.7[a]	18.3[ab]	14.9[abc]	13.6[bc]	11.0[c]
Nutrients (mg/liter)					
Ammonia-N	0.06[a]	0.03[c]	0.03[bc]	0.03[bc]	0.05[ab]
Nitrate + nitrite-N	0.05[a]	0.05[a]	0.04[ab]	0.03[b]	0.04[ab]
Total nitrogen	0.43[c]	0.60[bc]	0.67[ab]	0.61[b]	0.80[a]
Total phosphorus	0.038	0.031	0.032	0.034	0.037
TN:TP[¶]	12	21	25	20	23
Total organic carbon (mg/liter)	7.0	7.2	6.5	6.9	6.8
Ions (mg/liter)					
Calcium	3.4[b]	3.5[b]	3.6[b]	4.0[a]	3.9[a]
Chloride	9.1[b]	7.8[c]	9.3[ab]	9.8[a]	9.4[ab]
Magnesium	1.9[a]	1.8[b]	1.8[b]	1.9[a]	1.7[b]
Sodium	11[a]	8.9[b]	11[a]	12[a]	9.9[ab]
Sulfate	14[a]	11[c]	14[ab]	14[a]	13[b]
Total alkalinity (mg/liter as $CaCO_3$)	11[c]	11[c]	13[b]	14[a]	13[b]
Hardness (mg equivalents $CaCO_3$/liter)	16[b]	16[b]	16[b]	18[a]	17[b]
Specific conductance (µS/cm)	94[a]	61[c]	91[a]	94[a]	81[b]
Metals (µg/liter)					
Aluminum	159	137	120	87	123
Copper	2.1[ab]	2.1[ab]	1.3[bc]	1.0[c]	2.4[a]

+Fisher's protected least significant difference test was applied only if the overall F test for the treatment was significant. Means followed by the same superscript were not significantly different ($P > 0.05$). Data were rounded to conform to significant digit requirements. The mean separation technique may yield separations which are obscured by data rounding. Since alternate month sampling was conducted during 1996, only odd months were included in analysis.

¶Variable was not subjected to statistical analyses.



Appendix 9. Chlorophyll *a* concentrations by station in Harris Reservoir, 1992-1996. Note: The North Carolina water quality standard is 40 µg/liter.

Appendix 10. Temporal trends of selected limnological variables from the bottom waters of Harris Reservoir at Station E2, 1992 1996.[+]

Variable	Year				
	1992	1993	1994	1995	1996
Solids (mg/liter)					
Total	94	83	84	84	99
Total dissolved	82	71	77	83	98
Total suspended	7	7	5	4	5
Turbidity (NTU)	8.2	7.9	5.9	4.1	6.2
Nutrients (mg/liter)					
Ammonia-N	1.2	0.78	0.36	0.22	0.38
Nitrate + nitrite-N	0.09	0.07	0.06	0.05	0.14
Total nitrogen	2.0	1.1	1.1	0.8	1.5
Total phosphorus	0.21	0.29	0.11	0.08	0.15
TN:TP[§]	10	4	10	10	12
Total organic carbon (mg/liter)	8.2	8.0	6.8	7.4	7.6
Ions (mg/liter)					
Calcium	4.1[b]	4.2[b]	4.2[b]	4.7[a]	4.8[a]
Chloride	9.7[bc]	8.7[c]	10[b]	12[a]	9.7[bc]
Magnesium	2.3[a]	2.1[b]	2.0[b]	2.1[ab]	2.0[b]
Sodium	12[a]	10[b]	12[a]	13[a]	10[b]
Sulfate	12	11	14	15	12
Total alkalinity (mg/liter as $CaCO_3$)	30	24	22	20	27
Hardness (mg equivalents $CaCO_3$/liter)	20	19	19	21	20
Metals (µg/liter)					
Aluminum	82	72	73	52	61
Copper	3.7	3.5	2.4	2.2	2.1

[+]Fisher's protected least significant difference test was applied only if the overall F test for the treatment was significant. Annual means followed by the same superscript were not significantly different ($P > 0.05$).

[§]Variable was not subjected to statistical analyses.

Appendix 11. **Mean density (clams/m²) and range of Asiatic clams collected from the Harris Nuclear Plant emergency service water system (e.g., intake canals and structures and the fire protection system), 1992-1996.**

Location	Mean density of live clams[+]				
	1992	1993	1994	1995	1996
Main reservoir					
Intake canal	7 (0-14)	4 (0-14)	7 (0-14)	14 (0-14)	NS
Service water system	0	0	25 (0-86)	371 (0-948)	97 (0-388)
Cooling water makeup	0	0	22 (0-86)	280 (0-1121)	11 (0-43)
Auxiliary reservoir					
Intake canal	0	0	22 (0-86)	75 (0-201)	NS
Service water system	0	0	7 (0-29)	43 (0-216)	431 (129-2026)
Fire protection system	0	0	0	0	0

[+]Density estimates were calculated by multiplying the number of live clams collected by the expansion factor of 43.1.

NS = Not Sampled