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PEACH BOTTOM ATOMIC POWER STATION

Materials Prepared For The Environmental Protection Agency

316 (a) Demonstration
for PBAPS Units No. 2 & 3
on Conowingo Pond

Prepared By

PHILADELPHIA ELECTRIC COMPANY

July 1975

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SUMMARY

This document presents the technical information in support of Philadelphia Electric Company's (hereafter "Company") request pursuant to Section 316(a) of the Federal Water Pollution Control Act for alternative thermal effluent limitations for its Peach Bottom Atomic Power Station (hereafter "PBAPS") which is located on Conowingo Pond, a run of the river impoundment on the Susquehanna River. As detailed herein, on the basis of over 175 man-years of effort carried on by Ichthyological Associates on behalf of the Company by approximately 125 biologists, chemists and other specialists (including 29 full-time scientists and support personnel who are presently working on the studies), the Company has concluded that the operation of PBAPS with the present cooling system (open cycle cooling with three helper towers to cool approximately half of the condenser effluent prior to discharge to the Pond) will assure the protection and propagation of a balanced indigenous, community of shellfish, fish and wildlife in and on the Conowingo Pond. Other alternatives are presented, the construction of two additional helper towers, and the construction of a return channel in conjunction with the two additional towers, allowing the discharge of heat to the Pond to be variable (the variable cycle cooling system).

The Conowingo Pond has been under study by the Company's consultant, Ichthyological Associates, since 1966 to determine baseline ecological conditions, which included determination of water quality and the species composition, distribution and fluctuations in abundance of the biota prior to the operation of PBAPS. This report contains the results of pertinent experimental studies conducted to determine the swimming speed of fishes and the thermal preference, avoidance as well as effects of sudden decrease and increase in temperature on fishes; results of pertinent experimental work and literature searches regarding the selected representative species; engineering data concerning the various alternative cooling systems; and predictions of the isotherms for various river flow and meteorological conditions. The limnological and fishery studies in the Pond are based on a large number of collections (over 16,000). Baseline conditions are derived from the data from monitoring stations which have existed from the initial sampling date to the present.

Data collected from the preoperational program have been compared to those collected from the postoperational program. No deleterious effects have been observed and no deleterious effects are predicted on the abundance and distribution of the biota in the Pond.

TABLE OF CONTENTS

SECTION	NARRATIVE DISCUSSION	PAGE
	ACKNOWLEDGEMENTS	iii
	SUMMARY	v
1.0	INTRODUCTION.	1-1
1.1	JUSTIFICATION FOR THE CONCLUSION THAT THE PRESENT COOLING SYSTEM AT PEACH BOTTOM ATOMIC POWER STATION IS SUFFICIENT TO ASSURE THE PROTECTION AND PROPAGATION OF A BALANCED, INDIGENOUS COMMUNITY IN CONOWINGO POND. . . .	1-10
1.2	EXPECTED EFFECTS OF OPERATION OF THE PEACH BOTTOM ATOMIC POWER STATION UNITS NO. 2 AND NO. 3	1-14
1.2.1	Water Temperature	1-14
1.2.1.1	Natural Water Temperature	1-14
1.2.1.2	Model Predictions of "Worst Case" Water Temperature Conditions.	1-14
1.3	DISSOLVED OXYGEN AND WATER CHEMISTRY.	1-15
1.4	PHYTOPLANKTON COMMUNITY	1-16
1.5	ZOOPLANKTON COMMUNITY	1-17
1.6	BENTHIC COMMUNITY	1-17
1.7	FISHES.	1-18
1.7.1	Introduction.	1-[illegible]
1.7.2	Temperature Requirement of Fishes	1-
1.7.3	Fishes and Heated Plumes.	1-20
1.7.4	Reproduction.	1-21
1.7.5	Growth	1-22
1.7.6	Food Habits	1-22
1.7.7	Movement of Fishes.	1-23
1.8	TROPICAL STORM AGNES.	1-24
1.9	PREDICTED WINTER FISHERY.	1-24
1.10	CONCLUSIONS	1-26
	PRESENTATION OF SPECIFIC DATA	
2.0	PLANT OPERATING DATA.	2-1
2.2	UNIT LOADING.	2-1
2.2.1	Intake.	2-1
2.2.2	Cooling	2-2
2.2.3	Outfall	2-2
2.2.4	Transit Times	2-3
2.3	CHEMICAL AND WATER QUALITY DATA	2-15
2.3.1	Chlorine.	2-15
2.3.2	Other Chemicals	2-15
3.0	PLANT OPERATIONAL EXPERIENCE TO DATE.	3-1

SECTION		PAGE
3.1	GENERATION & SHUTDOWNS.	3-1
3.2	BIOLOGICAL EFFECTS OF SHUTDOWNS	3-1
4.0	SUSQUEHANNA RIVER HYDROLOGY	4-1
4.1	RIVER FLOW.	4-1
4.2	WATER TEMPERATURES.	4-2
4.3	CURRENTS.	4-2
4.4	DEPTH CONTOURS.	4-2
4.5	FLOW TEMPERATURE RELATIONSHIPS.	4-2
5.0	METEOROLOGY	5-1
6.0	THERMAL PLUME CHARACTERISTICS	6-1
6.1	Predicted Isotherms	6-1
6.2	Observed Isotherms.	6-1
6.3	Plume Velocity Distribution	6-1
6.4	Other Thermal Effluents	6-2
7.0	AQUATIC COMMUNITY DESCRIPTION	7.1-1
7.1.0	LIMNOLOGY OF CONOWINGO POND	7.1-1
7.1.1	INTRODUCTION	7.1-1
7.1.2	WATER QUALITY	7.1-1
7.1.2.1	Temperature	7.1-1
7.1.2.2	Light Penetration	7.1-1
7.1.2.3	Oxygen	7.1-2
7.1.2.4	Biochemical Oxygen Demand	7.1-2
7.1.2.5	Chemical Parameters	7.1-3
7.1.2.6	Statistical Analysis.	7.1-3
7.1.3	PHYTOPLANKTON COMMUNITY	7.1-13
7.1.3.1	Species Composition	7.1-13
7.1.3.2	Plant Pigments.	7.1-13
7.1.3.3	Statistical Analysis.	7.1-14
7.1.3.4	Aquatic Vascular Plants	7.1-15
7.1.4	ZOOPLANKTON COMMUNITY	7.1-29
7.1.4.1	Species Composition	7.1-29
7.1.4.2	Abundance	7.1-29
7.1.4.3	Statistical Analysis.	7.1-29
7.1.5	BENTHOS	7.1-43
7.1.5.1	Species Composition	7.1-43
7.1.5.2	Species Diversity and Equitability.	7.1-43
7.1.5.3	Distribution and Abundance.	7.1-45
7.1.5.4	Faunal Similarity	7.1-46
7.1.5.5	Biomass	7.1-46
7.2.0	ABUNDANCE AND DISTRIBUTION OF FISHES.	7.2-1
7.2.1	INTRODUCTION.	7.2-1
7.2.2	SPECIES COMPOSITION	7.2-1
7.2.2.1	Distribution.	7.2-2

SECTION		PAGE

7.2.2.2	Abundance	7.2-2
7.2.3	FISHES IN THE THERMAL PLUME	7.2-19
7.2.3.1	Trap Net Catches.	7.2-19
7.2.3.2	Trawl Catches	7.2-20
7.3.0	BIOLOGY OF FISHES	7.3-1
7.3.1	WHITE CRAPPIE (*Pomoxis annularis*)	7.3-2
7.3.1.1	Food Habits	7.3-2
7.3.1.2	Reproduction.	7.3-2
7.3.1.3	Age and Growth.	7.3-3
7.3.1.4	Year Class Fluctuations	7.3-5
7.3.1.5	Survival Rates.	7.3-5
7.3.2	CHANNEL CATFISH (*Ictalurus punctatus*)	7.3-25
7.3.2.1	Food Habits	7.3-25
7.3.2.2	Reproduction.	7.3-25
7.3.2.3	Age and Growth.	7.3-25
7.3.2.4	Year Class Fluctuations	7.3-26
7.3.3	BLUEGILL (*Lepomis Macrochirus*	7.3-33
7.3.3.1	Food Habits	7.3-33
7.3.3.2	Reproduction.	7.3-33
7.3.3.3	Age and Growth.	7.3-33
7.3.4	SPOTFIN SHINER (*Notropis spilopterus*)	7.3-37
7.3.4.1	Food Habits	7.3-37
7.3.4.2	Reproduction.	7.3-3[illegible]
7.3.4.3	Age and Growth.	7.3-[illegible]
7.3.5	BLUNTNOSE MINNOW (*Pimephales Notatus*)	7.3-41
7.3.5.1	Reproduction.	7.3-41
7.3.6	GIZZARD SHAD (*Dorosoma cepedianum*)	7.3-41
7.3.6.1	Reproduction.	7.3-41
7.3.7	WALLEYE (*Stizostedion vitreum*)	7.3-43
7.3.7.1	Food Habits	7.3-43
7.3.7.2	Reproduction.	7.3-43
7.3.7.3	Age and Growth.	7.3-43
7.3.8	LARGEMOUTH BASS (*Micropterus salmoides*) . . .	7.3-45
7.3.8.1	Food Habits	7.3-45
7.3.8.2	Reproduction.	7.3-45
7.3.8.3	Age and Growth.	7.3-45
7.3.9	SMALLMOUTH BASS (*Micropterus dolomieui*) . . .	7.3-47
7.3.9.1	Food Habits	7.3-47
7.3.9.2	Reproduction.	7.3-47
7.3.9.3	Age and Growth.	7.3-47
7.3.10	MOVEMENT OF FISHES.	7.3-49
7.3.10.1	Movement of Fishes in Conowingo Pond. . . .	7.3-49
7.3.10.2	Movement of Fishes in the Plume	7.3-49
7.3.11	NATURAL MORTALITIES OF FISHES IN CONOWINGO POND.	7.3-50
7.3.12	RECREATIONAL FISHERY.	7.3-53

SECTION PAGE

7.4.0 TEMPERATURE EXPERIMENTS WITH FISHES 7.4-1
7.4.1 TEMPERATURE PREFERENCE. 7.4-1
7.4.1.1 Spotfin shiner. 7.4-2
7.4.1.1.1 Falling Field Temperatures. 7.4-2
7.4.1.1.2 Rising Field Temperatures 7.4-2
7.4.1.2 Channel catfish 7.4-2
7.4.1.2.1 Falling Field Temperatures. 7.4-2
7.4.1.2.2 Rising Field Temperatures 7.4-2
7.4.1.3 Pumpkinseed 7.4-2
7.4.1.3.1 Falling Field Temperatures. 7.4-2
7.4.1.3.2 Rising Field Temperatures 7.4-3
7.4.1.4 Bluegill 7.4-3
7.4.1.4.1 Falling Field Temperatures. 7.4-3
7.4.1.4.2 Rising Field Temperatures 7.4-3
7.4.1.5 White crappie 7.4-3
7.4.1.5.1 Falling Field Temperatures. 7.4-3
7.4.1.5.2 Rising Field Temperatures 7.4-3
7.4.1.6 Other Species 7.4-4
7.4.2 TEMPERATURE AVOIDANCE 7.4-7
7.4.2.1 Spotfin shiner. 7.4-7
7.4.2.1.1 Falling Field Temperatures. 7.4-7
7.4.2.1.2 Rising Field Temperatures 7.4-7
7.4.2.2 Channel catfish 7.4-7
7.4.2.2.1 Falling Field Temperatures. 7.4-7
7.4.2.2.2 Rising Field Temperatures 7.4-7
7.4.2.3 Pumpkinseed 7.4-8
7.4.2.3.1 Rising and Falling Field Temperatures . . 7.4-8
7.4.2.4 Bluegill. 7.4-8
7.4.2.4.1 Falling Field Temperatures. 7.4-8
7.4.2.4.2 Rising Field Temperatures 7.4-8
7.4.2.5 White crappie 7.4-8
7.4.2.5.1 Falling Field Temperatures. 7.4-8
7.4.2.5.2 Rising Field Temperatures 7.4-8
7.4.2.6 Other Species 7.4-8
7.4.3 TEMPERATURE SHOCK 7.4-11
7.4.3.1 Spotfin shiner 7.4-11
7.4.3.2 Channel catfish 7.4-11
7.4.3.3 Pumpkinseed 7.4-12
7.4.3.4 Bluegill 7.4-12
7.4.3.5 White crappie 7.4-12
7.4.4 DISCUSSION 7.4-13

8.0 ALTERNATIVE #1 - FIVE "HELPER" COOLING TOWERS 8-1
8.1 Applicable Effluent Limitation. 8-1
8.2 System Description. 8-1
8.3 Schedule and Costs. 8-1
8.4 Resultant Isotherms 8-2
8.5 Biological Impact 8-3

SECTION		PAGE
9.0	ALTERNATIVE #2 - FIVE "HELPER" COOLING TOWERS WITH STUDIES	9-1
9.1	Applicable Effluent Limitations	9-1
9.2	System Description.	9-1
9.3	Schedule and Costs.	9-1
9.4	Resultant Isotherms	9-2
9.5	Biological Impact	9-2
10.0	ALTERNATIVE #3 - FIVE COOLING TOWERS, VARIABLE BLOWDOWN	10-1
10.1	Applicable Effluent Limitations	10-1
10.2	System Description.	10-1
10.3	Schedule and Costs.	10-1
10.4	Resultant Isotherms	10-2
10.5	Biological Impact	10-2
11.0	LITERATURE CITED	11-1

LIST OF TABLES

SECTION 2.0 PLANT OPERATING DATA

Table		Page
2.2-1	Seasonal Variation of Discharge Delta T . .	2-5
2.2-2	Seasonal Variation of Rate of Evaporative Loss	2-6
2.2-3	Circulating Water Transit Times.	2-7
2.3-1	Chemical Discharges in Cooling Water. . . .	2-17

LIST OF FIGURES

SECTION 2.0 PLANT OPERATING DATA

Figure		Page
2.2-1	Closeup of Peach Bottom Complex.	2-9
2.2-2	Condenser Delta T vs. Unit Load	2-10
2.2-3	Submerged Discharge Facility	2-11
2.2-4	Path of Cooling Water Through Plant. . . .	2-12
2.2-5	July Temperature - Time Profile.	2-13
2.2-6	November Temperature - Time Profile. . . .	2-14

LIST OF TABLES

SECTION 3.0 PLANT OPERATIONAL EXPERIENCE TO DATE

Table		Page
3.1-1	PBAPS Average and Monthly Generation by Month, February 1974 through May 1975 .	3-3

SECTION 4.0 SUSQUEHANNA RIVER HYDROLOGY

4.2-1	Summary of Susquehanna River Water Temperatures (1936-1966)	4-3
4.5-1	7-Day Low Flows and Corresponding Temperatures	4-5
4.5-2	Median 7-Day Low Flows and Temperatures. .	4-6
4.5-3	Joint Probability Distribution Between Temperature and Flow	4-7

LIST OF FIGURES

SECTION 4.0 SUSQUEHANNA RIVER HYDROLOGY

Figure		Page
4.1-1	Susquehanna River Basin.	4-9
4.1-2	Lower Susquehanna River Hydro Plants . . .	4-10
4.1-3 to 4.1-5	Inflow and Discharge at Conowingo Pond . .	4-11
4.1-6	Flow Duration Curves	4-14
4.1-7 to 4.1-10	7-Day Low Flow Recurrence Interval (monthly).	4-15
4.2-1	Range of Water Temperatures.	4-19
4.4-1 to 4.4-7	Bottom Contours of Conowingo Pond.	4-20

LIST OF TABLES

SECTION 5.0 METEOROLOGICAL DATA

Table		Page
5.0-1	Monthly Meteorological Data.	5-1

SECTION 6.0 THERMAL PLUME CHARACTERISTICS

6.4-1	Thermal Generating Stations between Harrisburg and Peach Bottom.	6-3

LIST OF FIGURES

SECTION 6.0 THERMAL PLUME CHARACTERISTICS

Figure		Page
6.2-1 to 6.2-8	Selected Observed Isotherms and Associated Data	6-4
6.3-1	Surface Discharge Isotherms.	6-20
6.3-2	Surface Plume Velocity	6-21
6.3-3	5 Ft. Depth Discharge Isotherm	6-22
6.3-4	5 Ft Depth Plume Velocity.	6-23
6.3-5	10 Ft. Depth Discharge Isotherm.	6-24
6.3-6	10 Ft. Depth Plume Volocity.	6-25
6.3-2	Centerline Plume Velocity vs. Distance from Discharge and	6-26

LIST OF TABLES

SECTION 7.1.0 LIMNOLOGY OF CONOWINGO POND

Table		Page
7.1.2-1	Comparison of the monthly mean values of Water quality parameters measured during the preoperational (1967-1973) and post-operational (1974) periods in Conowingo Pond	7.1-5
7.1.2-2 to 7.1.2-3	Maximum and minimum weekly water temperatures measured at Holtwood Dam, 1966-1974.	7.1-8
7.1.2-4	Comparison of the seasonal vertical distribution of dissolved oxygen during the preoperational (1967-1973) and postoperational (1974) periods in stations in and outside the thermal plume in Conowingo Pond.	7.1-9
7.1.2-5	Monthly values of biochemical oxygen demand from samples collected at Conowingo Dam, 1960-1967. Data supplied by Storet System of the Environmental Protection Agency	7.1-10
7.1.3-1	List of Genera of algae collected in Conowingo Pond, 1967-1969.	7.1-17
7.1.3-2	Monthly variations in the percentage composition of the major groups of algae in Conowingo Pond, 1967-1969	7.1-18
7.1.3-3	Comparison of the monthly mean plant pigments concentrations during the pre-operational (1971-1973) and post-operational (1974) periods in Conowingo Pond	7.1-19
7.1.3-4	Values of Chlorophyll a (mg/m^3), nitrates, phosphates (ppm), water temperature, daily river flow (x 1,000 cfs) and zooplankton densities during the pre-operational (1971-1973) and post-operational (1974) periods in Conowingo Pond	7.1-20

Table		Page
7.1.3-5	Regression statistics for the concentration of total chlorophyll a (mg/m³) and physiochemical parameters in Conowingo Pond, 1973	7.1-21
7.1.3-6	List of macrophytic aquatic plants found in Conowingo Pond.	7.1-22
7.1.4-1	Zooplankton taxa collected from Conowingo Pond	7.1-33
7.1.4-2	Annual species composition of zooplankton in Conowingo Pond, 1967-1974	7.1-34
7.1.4-3	Comparison of the monthly density of common taxa of zooplankton (no./liter) during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond	7.1-35
7.1.4-4	Comparison of the monthly density of total zooplankton (no./liter) during the preoperational (1967-1973) and post-operational (1974) period in Conowingo Pond	7.1-3
7.1.4-5	Total chlorophyll a (mg/m³), nitrates, phosphates (ppm), water temperature, daily river flow and zooplankton density during the preoperational (1971-1973), and postoperational (1974) periods in Conowingo Pond	7.1-36
7.1.4-6	Regression equations for predicting zooplankton densities at Stations 602-611 in Conowingo Pond.	7.1-37
7.1.4-7	Regression equations between the total zooplankton density at Station 601-611 and average water temperature, river flow and degree days in Conowingo Pond . .	7.1-38
7.1.5-1	List of benthos taxa collected in Conowingo Pond, 1967-1974.	7.1-47

Table		Page
7.1.5-2	Mean number (per 81 in.^{2}) and percentage composition of benthic organisms collected during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.	7.1-49
7.1.5-3	Percentage composition of bottom sediments in terms of particle size at limnological stations in Conowingo Pond, 27 July 1972	7.1-52
7.1.5-4 to 7.1.5-5	Species diversity and equitability indices by month and by station for benthic organisms collected at limnological stations during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.	7.1-53
7.1.5-6	Mean number (per 81 in.^{2}) of the selected representative species of benthic organisms collected at Stations 601-611 during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond	7.1-55
7.1.5-7	Spearman rank correlation (rs) test between years indensities of the selected representative taxa of benthos at Stations 601-611 in Conowingo Pond	7.1-56
7.1.5-8	Percentage similarity of Stations 601-611 between years in Conowingo Pond, 1967-1974	7.1-57
7.1.5-9	Comparison of the monthly mean biomass (mg/dry weight) per 81 in.^{2} at stations during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond	7.1-58

LIST OF FIGURES

SECTION 7.1.0 LIMNOLOGY OF CONOWINGO POND

Figure		Page
7.1-1	Distribution of limnological stations in Conowingo Pond	7.1-11
7.1.3-1 to 7.1.3-4	Average total chlorophyll a (mg/m³) concentrations at Stations 601-605 in Conowingo Pond, 1971-1974.	7.1-23
7.1.3-5	Plot of total chlorophyll a (mg/m³), nitrates and phosphates (ppm) in Conowingo Pond, 1971-1974.	7.1-27
7.1.3-6	Map of Conowingo Pond showing distribution of aquatic macrophytes. . . .	7.1-28
7.1.4-1	Plot of total zooplankton density (no./liter), average daily river flow and water temperature in Conowingo Pond, 1971-1974	7.1-39
7.1.4-2 to 7.1.4-4	Confidence limits of the observed vs. estimated values of total zooplankton density at Stations 602-611	7.1-40
7.1.5-1	Plot of number of taxa (species richness), species diversity and equitability indices for benthic organisms in Conowingo Pond, 1967-1974	7.1-59
7.1.5-2 to 7.1.5-5	Relative densities of the selected representative taxa of benthos at stations in Conowingo Pond, 1967-1974	7.1-60

LIST OF TABLES

SECTION 7.2.0 ABUNDANCE AND DISTRIBUTION OF FISHES

Table		Page
7.2.2-1	List of scientific and common names of fishes collected in Conowingo Pond and tributary streams	7.2-5
7.2.2-2	Catch per effort for fishes collected by various gears in Conowingo Pond	7.2-6
7.2.2-3 to 7.2.2-8	Comparison of catch per effort for fishes collected by various gears during the preoperational (1966-1973) and post-operational (1974) periods in Conowingo Pond	7.2-7
7.2.3-1	Comparison of the monthly mean bottom water temperature at Trap Net Stations in and outside the thermal plume of Peach Bottom Station Units No. 2 and 3 in Conowingo Pond, July 1974-March 1975	7.2-23
7.2.3-2	Comparison of catch per effort (number per 24-hour) for fishes collected by trap net at the monitoring stations, discharge canal and plume stations in Conowingo Pond, July 1974-March 1975 . . .	7.2-24
7.2.3-3 to 7.2.3-4	Comparison of the catch per effort (number per 24-hour) of selected representative fishes collected in the discharge canal and at Station 110 during the preoperational (1967-1973) and postoperational (1974), periods in Conowingo Pond.	7.2-25
7.2.3-5	Bottom water temperature, delta T, percentage power of Units No. 2 and 3, daily river flow at trawl stations in and outside the thermal plume Peach Bottom Station Units 2 and 3 in Conowingo Pond	7.2-27

Table		Page
7.2.3-6	Catch per effort (number per 10-min. haul) for fishes collected by trawl at stations in and outside the thermal plume of Peach Bottom Station Units No. 2 and 3 in Conowingo Pond.	7.2-29

LIST OF FIGURES

SECTION 7.2.0 ABUNDANCE AND DISTRIBUTION OF FISHES

Figure		Page
7.2.1-1 to 7.2.1-5	Map of Conowingo Pond showing the distribution of Trap Net, Trawl Transect, Trawl Zone, Seine and Meter Net Stations in Conowingo Pond	7.2-13
7.2.3-1	Map showing the location of Trap Net Stations in the thermal plume of Peach Bottom Station Units No. 2 and 3	7.2-31
7.2.3-2	Location of trawl stations in and outside the thermal plume of Peach Bottom Station Units No. 2 and 3 in Conowingo Pond	7.2-32

LIST OF TABLES

SECTION 7.3.0 BIOLOGY OF FISHES

Table		Page
7.3.1-1	Catch of larval fishes (≤25mm) at various locations during the pre-operational (1967-1973) and post-operational (1974) periods in Conowingo Pond	7.3-7
7.3.1-2	Catch of larval fishes (≤25mm) at stations on the west shore, mid-pond and east shore during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond	7.3-8
7.3.1-3	Comparison of the fecundity data on white crappie from various studies	7.3-9
7.3.1-4	Growth indices for white crappie, *Pomoxis annularis* collected by trap net during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond	7.3-10
7.3.1-5	Time of annulus formation of I, II, and III year old crappie, *Pomoxis annularis*, collected from Conowingo Pond 1967-1970. .	7.3-11
7.3.1-6	A comparison of calculated growth rate for white crappie, *Pomoxis annularis*, from various parts of the country.	7.3-13
7.3.1-7	Estimates of survival rates of various year classes of white crappie, *Pomoxis annularis* in Conowingo Pond	7.3-14
7.3.1-8	Catch per effort (number per 24-hr) for various age groups of the 1966-1974 year classes of the white crappie, *Pomoxis annularis*, collected by trap net in Conowingo Pond	7.3-15
7.3.1-9	Estimates of survival rates between two successive age groups of individual year classes of white crappie, *Pomoxis annularis* in Conowingo Pond	7.3-15

Table		Page
7.3.2-1	Comparison of growth rates for the channel catfish, *Ictalurus punctatus* from various parts of the country	7.3-27
7.3.3-1	Comparison of growth rates for the bluegill, *Lepomis macrochirus* from various parts of the country	7.3-35
7.3.4-1	Food of the spotfin shiner, *Notropis spilopterus* in Conowingo Pond, 1967-1968 .	7.3-39
7.3.7-1	Comparison of growth rates of the walleye, *Stizostedion vitreum* from various parts of the country	7.3-44
7.3.8-1	Comparison of growth rates of largemouth bass, *Micropterus salmoides*, from various parts of the country	7.3-46
7.3.9-1	Comparison of growth rate for the smallmouth bass, *Micropterus dolomieui*, from various parts of the country	7.3-48
7.3.11-1	Species composition of dead fishes observed during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond	7.3-51
7.3.12-1	Species composition of fishes caught by anglers during the winter (Januray-March) creel sensus of Conowingo Pond, 1973 and 1974	7.3-55

LIST OF FIGURES

SECTION 7.3.0 BIOLOGY OF FISHES

Figure		Page
7.3.1-1	Seasonal variations in mean gonosomatic index of the white crappie, *Pomoxis annularis*, and water temperature during the preoperational (1971-1973) and postoperational (1974) periods in Conowingo Pond	7.3-17
7.3.1-2	Range of surface water temperatures at which larvae (≤25mm) of the selected representative fishes were collected in Conowingo Pond, 1969-1973	7.3-18
7.3.1-3	Distribution of larvae of the white crappie, *Pomoxis annularis*, at plankton net stations in Conowingo Pond, 1969-1973 . .	7.3-19
7.3.1-4	Abundance of various age groups of the white crappie, *Pomoxis annularis*, collected by trap net during the pre-operational (1966-1973) and post-operational (1974) periods in Conowingo Pond	7.3-20
7.3.1-5	Growth of the 1966-1974 year classes of the white crappies, *Pomoxis annularis* in Conowingo Pond.	7.3-21
7.3.1-6 to 7.3.1-9	Monthly growth of the 0, I, II, and III year old white crappie, *Pomoxis annularis*, collected during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.	7.3-22
7.3.1-10	Year class strength of the white crappie *Pomoxis annularis* in Conowingo Pond, 1966-1974	7.3-24
7.3.2-1 to 7.3.2-2	Calculated growth curve and growth history of the 1958-1968 year classes of the channel catfish, *Ictalurus punctatus* in Conowingo Pond.	7.3-29

Figure		Page
7.3.2-3	Plot of the monthly growth rates of young and yearling channel catfish *Ictalurus punctatus* and mean monthly water temperatures in Conowingo Pond . . .	7.3-30
7.3.2-4	Distribution of larvae (≤25mm) of the channel catfish, *Ictalurus punctatus* at Plankton net stations in Conowingo Pond	7.3-31
7.3.2-5	Year class strength of the channel catfish *Ictalurus punctatus* in Conowingo Pond, 1966-1974	7.3-32
7.3.3-1	Distribution of larvae (≤25mm) of the bluegill, *Lepomis macrochirus* at plankton net stations in Conowingo Pond	7.3-36
7.3.4-1	Distribution of larvae (≤25mm) of the spotfin shiner, *Notropis spilopterus* at plankton net stations in Conowingo Pond	7.3-40
7.3.6-1	Distribution of larvae (≤25mm) of the gizzard shad, *Dorosoma cepedianum* at plankton net stations in Conowingo Pond. .	7.3-42

LIST OF TABLES

SECTION 7.4.0 TEMPERATURE EXPERIMENTS WITH FISHES

Table		Page
7.4.1-1	Regression equations of the preferred temperatures (Y), acclimation temperature (X1) and mean total length (X2) for the spotfin shiner, channel catfish, pumpkinseed, bluegill, and white crappie for falling and rising field temperatures	7.4-5
7.4.1-2	Summary of temperature preference data on other selected representative species .	7.4-6
7.4.2-1	Regression equations of the avoidance temperature (Y), acclimation temperature (X1), and mean total length (X2) for the spotfin shiner, channel catfish, bluegill and white crappie for falling and rising field temperatures	7.4-9
7.4.2-2	Summary of temperature avoidance data on other selected representative species .	7.4-1
7.4.4-1	Preference, avoidance and uppper temperature (F) tolerance limits of the selected representative fish acclimated to high summer temperatures common to Conowingo Pond	7.4-15
7.4.4-2	Preference and avoidance temperatures of selected representative fishes acclimated to 33, 40, and 55 F	7.4-16

LIST OF FIGURES

SECTION 7.4.0 TEMPERATURE EXPERIMENTS WITH FISHES

Figure		Page
7.4.1-1 to 7.4.1-5	Relationship between rapid temperature increase (shock) and preference and avoidance temperatures (95% confidence intervals of the population mean) during falling and rising field temperatures for the spotfin shiner, channel catfish, pumpkinseed, bluegill and white crappie	7.4-17
7.4.4-1 to 7.4.4-5	Plot of rapid temperature decrease test (shock) in relation to water quality criteria (maximum increase in delta T = 5 F) and delta T = 15 F for the spotfin shiner, channel catfish, pumpkinseed, bluegill, and white crappie.	7.4-22

LIST OF TABLES

SECTION 8.0 ALTERNATIVE # 1

Table		Page
8.2-1	Seasonal Variation of Discharge Delta T	8-3
8.2-2	Seasonal Variation of Rate of Evaporative Loss	8-4

SECTION 10.0 ALTERNATIVE # 3

10.2-1	Seasonal Variation of Blowdown	10-3
10.2-2	Seasonal Variation of Evaporative Loss	10-4

LIST OF FIGURES

SECTION 8.0 ALTERNATE # 1

Figure		Page
8.2-1	Closeup of Peach Bottom Complex	8-5
8.4-1 to 8.4-6c	Peach Bottom Model Study, Predicted Conowingo Pond Temperature Rise Above Ambient Water Temperature	8-6

SECTION 10.0 ALTERNATIVE # 3

10.2-1	Proposed Mixing Zone for Alternative # 3	10-5
10.2-2	Closeup of Peach Bottom Complex	10-6

NARRATIVE DISCUSSION

1.0 INTRODUCTION

This document was prepared in support of Philadelphia Electric Company's (hereafter "Company") application to the Environmental Protection Agency for the imposition of effluent limitations for its Peach Bottom Atomic Power Station, Units 2 and 3 (designated hereafter as PBAPS) which are less stringent than would be produced by a closed cycle cooling system, but yet sufficiently stringent to assure the protection and propagation of a balanced indigenous community of shellfish, fish and wildlife in and on Conowingo Pond.

By letter dated December 5, 1974, the Company had requested a determination pursuant to Section 316(a) of the Federal Water Pollution Control Act and suggested to EPA that certain species be designated representative species to be utilized in a demonstration pursuant to that section. On December 17, 1974, the Company met with representatives of EPA, the Commonwealth of Pennsylvania and the State of Maryland at Ichthyological Associates' Muddy Run Laboratory to discuss the planned demonstrations and to view the facility and Conowingo Pond. On May 27, 1975, the Company submitted to EPA a preliminary description of the desired alternative effluent limitations with several contingent alternatives including a schedule for construction of equipment associated with the contingent alternatives. The following is a statement of the effluent limitations requested together with the proposed alternatives thereto and associated Schedule for Completion.

Effluent Limitation Requested

The Company's preferred alternative effluent limitation is one which corresponds to the facility as presently designed, constructed, and operated. The present design of the facility with regard to the thermal component of the discharge is sufficient to assure the protection and propagation of a balanced indigenous population (community) of shellfishes, fishes, and wildlife in and on the body of water into which the discharge is made, i.e., Conowingo Pond ("Pond"). The present design consists of an open cycle cooling system utilizing three mechanical draft "helper" cooling towers cooling 58 percent of the flow which is mixed with the remaining 42 percent of the flow being discharged via a submerged jet discharge to the Pond. The discharge to the Pond would average 12×10^9 Btu/hr.

Should the ultimate determination under Section 316(a) as to this alternative be that it is not stringent enough to satisfy the Section 316(a) standard in lieu of applicable effluent limiations, water quality standards or other requirements, if any, the Company would propose the next following and correspondingly more stringent effluent limitations:

Contingent Alternative 1

After obtaining all necessary regulatory approvals, the Company would commence the installation of two additional helper cooling towers which would provide sufficient capacity to accommodate the total circulating water flow and thus cool all of the circulating water before discharging it to the Pond. The total five tower system would about double the cooling capacity of the present three tower system, in that essentially 100 percent of the flow through the condensers would pass through the cooling towers instead of about 58 percent with the present system. The discharge to the Pond would average 8.5×10^9 Btu/hr. A further description of this system and its operation is contained herein (see Section 8). A schedule for construction of these facilities is discussed, *infra*. During the construction of the facilities, the Company would propose that the Section 316(a) standard would be satisfied by a schedule of compliance corresponding to the construction schedule and certain agreed upon interim operating conditions.

Contingent Alternative 2

In the event the determination should be made that the evidence submitted in support of Contingent Alternative 1 is not sufficient to clearly demonstrate its suitability as a means of satisfying the requirements of Section 316(a), the Company would propose the following measures. The Company would construct two additional helper cooling towers as described in Contingent Alternative 1 and undertake a comprehensive biological monitoring program to verify the adequacy of the system. If, after one year of full power operation and monitoring with the five tower system, it were determined that Section 316(a) was not being satisfied, the Company would construct a sheet-pile return channel (or other suitable return) which in conjunction with the five tower system and other plant modifications, could be operated over a range of discharge (blowdown) modes from open cycle to closed cycle. The system would have the capability of regulating blowdown rates such that the discharge may be in amounts which, although perhaps greater than "blowdown" as defined in 40 CFR Section 423.11(e), would nonetheless be controlled so as to assure the protection and propagation of a

balanced indigenous population (community) of shellfishes, fishes, and wildlife in and on the Pond. The measures required to complete this system and its mode of operation are discussed in Sections 9 and 10. During installation of the return channel and performance of other necessary modifications or for the longer term, the system would be operated such that thermal discharges are controlled in accordance with certain agreed upon operating conditions.

Contingent Alternative 3

Should it be determined, on the basis of the information submitted pursuant to 40 CFR Section 122.5(b)(1), and other appropriate record evidence that the proposed alternative effluent limitation or Contingent Alternatives 1 or 2 would not produce effluent limitations which were sufficiently stringent to assure the protection and propagation of a balanced indigenous community in the Pond, the Company would propose to concurrently install two additional helper cooling towers and install a return channel, which in conjunction with other plant modifications would provide a system which could be operated over a range of discharge modes from open cycle to closed cycle. (See Section 10.) This combination amounts to Contingent Alternative 3. The determination of the operating mode would proceed as in Contingent Alternative 2. A schedule for the installation of this equipment is provided, infra.

It may be noted that since the variable blowdown system described herein could be operated as a closed cycle one with minor blowdown, in the unlikely event it were ultimately determined that the foregoing alternatives and corresponding effluent limitations did not satisfy Section 316(a), the facility, assuming the schedules set forth herein, could be operated in substantial compliance with 40 CFR Section 423.13(1) by July 1, 1981, the date for meeting national thermal effluent limitations for plants of the class of Peach Bottom, i.e., existing sources.

Denial of Alternatives

Should it ultimately be determined that the imposition of alternative, less stringent effluent limitations are not warranted, the Company would nevertheless request that a Schedule of Compliance be established under Section 316(a) or otherwise to allow interim operation under such conditions as may be justified, pending completion of the closed cycle system, as mandated by 40 CFR Section 423.13(1), by July 1, 1981, or such later date as may be in accordance with law, but in any event no

earlier than the schedule proposed in conjunction with Contingent Alternative 3.

Because of the nature of certain of the contingent alternative effluent limitations outlined above and because of the time necessary for installation of equipment necessary to meet those contingent effluent limitations, and the test and monitoring program which may have to be conducted upon the completion of the installation of such equipment, should the Regional Administrator decide that the information submitted herewith is not sufficient to make a final determination, it may be necessary that the Administrator's final determination of alternative effluent limitations be deferred pursuant to 40 CFR Section 122.5(c).

The information which would be submitted as part of such a deferred plan of study and demonstration would be the results of (and an analysis thereof) a continuation of the type of monitoring done to date and discussed herein. In addition, information concerning the isotherms observed during the additional study period and other physical data taken would be submitted. The type of information would be responsive to any requirement which might reasonably be imposed by the Regional Administrator as part of his decision.

Should such a plan of study and demonstration be required, the Company would request that it be allowed to gather and analyze one year's data subsequent to completion of the required equipment which would be installed in accordance with the schedule below:

SCHEDULE FOR COMPLETION

Effluent Limitation Requested
No additional construction or equipment is required.

Contingent Alternative 1 - After receipt of last regulatory approval, it would take approximately 30 months to construct two additional cooling towers, assuming completion of engineering and availability of long lead time items.

Contingent Alternative 2 - (if required to install return channel after analysis of operation with five towers). After receipt of

last regulatory approval necessary for commencement of construction, the construction and modifications necessary would take approximately 23 months to complete.

Contingent Alternative 3 - After receipt of last regulatory approval it would take approximately 30 months to complete necessary construction and modifications, assuming completion of engineering and availability of long lead time items.

This document is generally organized in accordance with EPA Region III guidance contained in "316(a) Technical Guidance -- Thermal Discharges" dated September 30, 1974. Section 1 contains a narrative description of the impact expected to occur to the indigenous biological communities due to the thermal effluent from PBAPS and the expected effects of operation of PBAPS on the Pond. Section 2 presents a description of the facility and its operation. Section 3 describes plant operating experience to date and the biological effects of plant shutdowns. Section 4 discusses Susquehanna River hydrology and the Conowingo Pond. Section 5 describes the meteorology that was utilized in cooling tower and pond thermal performance studies. Section 6 describes the thermal plume characteristics of the plant as designed. Section 7 provides a detailed description of the aquatic community and analysis of the effect of operations to date. Sections 8, 9, and 10 describe in further detail the contingent alternatives. Chapter 11 contains citation to the literature. The primary and three contingent alternative cooling systems are presented and their impact upon the biota are discussed.

The environmental and biological studies of Conowingo Pond for both the preoperational and the postoperational periods, have been reported in detail in Robbins and Mathur (1974a, b and 1975a, b, c). Based on these and other extensive ecological studies, Raney (1973) predicted an overall enhancement in the recreational values of the Pond. It is the applicant's belief that the "representative, important species" will not be harmed as a result of the designed operation of PBAPS and that "the protection and propogation of a balanced, indigenous community of shellfish, fish and wildlife" will be assured. The designated species and/or biological communities evaluated are, for fishes: gizzard shad, *Dorosoma cepedianum*, channel catfish, *Ictalurus punctatus*, bluegill sunfish, *Lepomis macrochirus*, white crappie, *Pomoxis annularis*, walleye pike, *Stizostedion vitreum*, spotfin shiner, *Notropis spilopterus*, bluntnose minnow, *Pimephales notatus*, largemouth bass, *Micropterus salmoides*, smallmouth bass, *Micropterus dolomieui*; for benthic invertebrates: *Procladius* sp. or *Chironomus* sp., *Chaoborus punctipennis*, *Limnodrilus*

hoffmeisteri, Hexagenia limbata; and for biological communities: evaluation of the thermal discharge effect on the phyto- and zooplankton communities.

Conowingo Pond is a main stream impoundment on the lower Susquehanna River in southeastern Pennsylvania and northern Maryland. It is approximately 14 miles long and one mile wide. Pond depths vary from 15 ft to approximately 90 ft. at Conowingo Dam. Normal Pond elevation is 108.5 ft CD (Conowingo Datum; 0.72 ft. above MSL) with a maximum operational drawdown elevation of 98.5 ft CD.

Biological studies were initiated in June 1966 at the Muddy Run Pumped Storage Power Station as a result of Federal Power Commission License No. 2355, Article 40, to determine the design of fish protective facilities as may be needed at the project. Initially the study included only the northern half of the Pond in the vicinity of the Muddy Run Station. In the spring of 1967 the study was expanded to include the entire Pond because of the planned construction of Units No. 2 and 3 of the Peach Bottom Atomic Power Station.

From 1966 to the present, studies were made on the ecology of the Pond and connecting waters by Ichthyological Associates. Approximately 125 biologists, chemists and other specialists participated and have contributed more than 175 man-years of investigations. Presently, 29 full-time scientists and support personnel are working on the studies. To date about 20 man-years (combined personnel of Ichthyological Associates and Philadelphia Electric Company) have been expended to establish a computer data base containing the ecological information.

The objective of the study of the Pond was to determine baseline ecological conditions, which included determination of water quality and the species composition, distribution and fluctuations in abundance of the biota prior to the operation of PBAPS. Experimental studies were conducted to determine the swimming speed of fishes and the thermal preference, avoidance and effects of sudden decrease and increase in temperature on fishes.

The limnological and fishery studies in the Pond are based on a large number of collections (over 16,000). Baseline conditions are derived from the data from monitoring stations which have existed from the initial sampling date to the present.

Beginning in September 1973 PBAPS operated at varying power loads reaching full power of Unit No. 2 in June 1974.

Since June 1974, PBAPS began operating on a regular schedule. All data taken from the various environmental monitoring program during 1974 is considered to be postoperational. Data collected from the peroperational period (1966 to 1973) are compared with those from the postoperational period. No deleterious effects were observed on the abundance and distribution of the biota in the Pond during the postoperational period.

All information contained in this document has been supplied in summary form so the review can be conducted without supplemental reports. Each section contains references to the particular documents where detailed data can be obtained. In a similar manner, only the results of analysis are contained herein. References are given for the detailed documents.

Ichthyological Associates has provided in Section 7.0 sufficient analysis of raw data to enable the fundamental relationships to be understood. Statistical analysis has been provided by Philadelphia Electric Company personnel and is presented as reference documents. All analysis is directed toward detecting changes in the ecology of Conowingo Pond in the postoperational period.

The reports prepared by Philadelphia Electric Company covering the statistical analyses of the data collected by our consultants are listed below by subject with brief comments as to content:

AMBIENT WATER TEMPERATURE

1 - Analysis of Ambient Water Temperatures in Conowingo Pond, pre-op versus Post-op - hourly confidence limits are utilized to detect exceptions to present water quality criteria.

2 - Station 13 versus Station 2

3 - Station 2 versus Station 18

4 - Station 13 versus Station 18

Station 13 is located slightly above Pa./Md. State Line; Station 2, about one mile upriver of PBAPS Station 18 is located slightly below Holtwood Dam, about six miles upriver of PBAPS.

DISSOLVED OXYGEN

Analysis of dissolved oxygen in Conowingo Pond - Pre-op versus Post-op.

5 - Average of samples from top ten feet.

6 - Bottom samples

Predictive equations are developed based on the preoperational data and the utilization of a control station which are the foundation for distinguishing PBAPS effects from natural varation in the post-operational period.

The justification to determine effects of PBAPS operation by developing dissolved oxygen predictive equations for top ten feet and bottom depth is also provided. Also, each report includes an estimate of the cause and effect relationship between Conowingo Pond water temperature and dissolved oxygen.

PLANT PIGMENT - CHLOROPHYLL A (TOTAL)

Analysis of chlorophyll a (TOTAL in Conowingo Pond - Pre-op versus Post-op.

Predictive equations are developed based on preoperational data and the utilization of a control station which are the foundation for distinguishing PBAPS effects from natural variation in the post-operational period.

8 - Relationship between chlorophyll (TOTAL) in Conowingo Pond and Water flows and temperatures at Holtwood Dam - Pre-op versus Post-op. This report provides an estimate of the cause and effect relationship between Conowingo Pond water temperature and chlorophyll a (TOTAL).

9 - Analysis of Plant Pigments and Water Chemistry

The justification for using the average of chlorophyll a (TOTAL) samples from surface, 5 feet, 10 feet, and bottom depths is provided in this report. This report also includes the analysis of variance to detect difference in stations and depths for 7 plant pigment parameters and 16 water chemistry parameters.

ZOOPLANKTON

Analysis of total zooplankton densities in Conowingo Pond - Pre-op versus Post-op.

10 - June - October

11 - January - December

Again, predictive equations are developed based on preoperational data and utilization of a control station which are the foundation for distinguishing PBAPS effects from natural variation in the post-operational period.

Relationship between Total Zooplankton Densities, Diversity, Biomass, and Equitability - Preoperational Period

12 - June - October

13 - January - December

No meaningful predictive equations could be developed for the Diversity Biomass and Equitability Index parameters which would be used as the foundation for distinguishing PBAPS effects from natural variation. This report records the efforts to date.

Relationship between total zooplankton densities in Conowingo Pond and water flows and temperatures at Holtwood Dam - Preoperational Period.

14 - June - October

15 - January - December

These reports provide an estimate of the cause and effect relationship between Conowingo Pond water temperature and total zooplankton densities.

BENTHOS

Analysis of Benthos Densities and Biomass in Conowingo Pond - Preoperational versus Postoperational

16 - June - October

17 - January - December

Covariance analysis, station rankings and Duncan New Multiple Range Test compare preoperational with postoperational benthos communities for total densities and biomass as well as for density and biomass of selected species.

1.1 JUSTIFICATION FOR THE CONCLUSION THAT THE PRESENT COOLING SYSTEM AT PEACH BOTTOM ATOMIC POWER STATION, IS SUFFICIENT TO ASSURE THE PROTECTION AND PROPAGATION OF A BALANCED, INDIGENOUS COMMUNITY IN CONOWINGO POND.

In Section 7.0 which describes the aquatic communities in Conowingo Pond, it is demonstrated that:

(1) Aquatic organisms present in Conowingo Pond show great seasonal and annual fluctuations in abundance under natural conditions. No rare or endangered species exist in the Pond. No species are commercially harvested for bait or food.

(2) The organisms are adapted to living within a wide range of temperatures (32 to 94 F).

(3) The organisms can recover from a catastrophic environmental deviation (caused by Tropical Storm Agnes) which indicates that any short term "appreciable harm" is not irreversible. Even if there were to be any short term appreciable harm (none is predicted), it would not be irreversible.

(4) No thermal stratification has been observed in the Pond since 1966. The water chemistry of the Pond has not been altered as a result of PBAPS operation.

(5) Variation in the abundance of the phytoplankton community (as measured by chlorophyll a) is positively related to water temperature and negatively related to river flow, i.e., an increase in abundance is associated with an increase in water temperature and a decrease in river flow. Water temperature alone accounted for 60.8% of the variation in phytoplankton density. The availability of nutrients increases as the phytoplankton population decreases; nutrients are available year-round.

(6) Total zooplankton densities are low (average less than 3 animals per liter) from November through May. From June through October, the monthly average density has exceeded 100 animals per liter. A statistical analysis indicated no change in density due to operation of the Station. Variation in the abundance of the zooplankton community is

related to water temperature and river flow, i.e., an increase in abundance is associated with a increase in water temperature and decrease in river flow. More than 75% of the variation in density of zooplankton is explained by water temperature and river flow. The production of zooplankton and phytoplankton decreases substantially at temperatures less than 60°F. Post-operational studies have indicated that no changes have occured in phytoplankton populations.

(7) Macrophytic aquatic plants are not common in the Pond. A small bed of water willow (*Justicia americana*) which is located about 3/4 mile downstream from the Station is the only bed of aquatic macrophytes which is contacted by the thermal plume. No deleterious effects have been observed on this bed since the start of operations.

(8) The benthic community in the Pond is sparse. A small number of species account for most of the individuals. The common benthic types are oligochaetes and chironomids. Of the selected representative taxa, *Hexagenia limbata* is infrequently collected; its density never averaged more than 0.01 per 81 in.^{2} at any monitoring station in any month. The other selected taxa, *Procladius* sp., *Chironomus* sp., *Chaoborus punctipennis* and *Limnodrilus hoffmeisteri* are widely distributed in the Pond. Their densities have varied between stations and years. The density of *C. punctipennis* decreased at Station 605, immediately downstream from the jet discharge after PBAPS began operating. *L. hoffmeisteri* and *Procladius* sp. increased in abundance at Station 605. Postoperational studies have indicated that no changes have occurred in benthic populations with the exception of the immediate vicinity of the discharge.

(9) The common fishes in Conowingo Pond are the white crappie, channel catfish, bluegill, pumpkinseed, and spotfin shiner. Game fishes such as the walleye, largemouth bass, and smallmouth bass are uncommon. The gizzard shad was accidently introduced in 1972 and may become a serious competitor with the desirable fishes. The bluntnose minnow is not common in the areas which

may be impacted by Station operation. The common fishes are widely distributed. Variations in year class strength have been noted for the common species since 1966. This has been determined by the use of many types of gear at a number of monitoring stations.

(10) The selected representative species feed, grow and reproduce over a wide range of temperatures. Most growth and feeding activity occurs from June through October. Reproduction occurs primarily from May through July. No differences were noted in the feeding habits, growth and reproduction in the postoperational period.

(11) The preference and avoidance behavior of fishes is a very important factor which will govern their distribution in relationship to the heated discharge. Upper temperatures tolerance limits are not applicable since fishes will not be trapped in the thermal plume or the discharge canal.

(12) Fishes were collected in the thermal plume; 29 species were taken in the plume by trap net in the period July 1974-March, 1975. Samples were taken when PBAPS was operating at various power levels up to full power. Fifteen species were taken in the discharge canal where the fishes were subjected to the highest delta T, the highest water velocity and the greatest fluctuations in temperature which have occurred during the operation, shutdown and start-up of PBAPS. Fishes were subject to a delta T as high as 14°F in the plume close to the jet discharge and slightly higher in the discharge canal.

Between July and December, 1974, 31 species were captured in the plume by trawl. More species were collected in the plume at stations where there was an increase in temperature than those where both the temperature and flow increased. The catch per effort in the plume was twice as great as that at the periphery and five times greater than that at a control station (located upstream). Fishes were taken in the plume in all months. Fishes were trawled at a delta T as high as 14°F.

(13) Natural mortality of fishes has been observed in the Pond since the study began in June, 1966. Primarily channel catfish and white crappie were observed. Mortality is attributed to the bacteria, Aeromonas sp.

(14) Experimental studies have shown that fishes found in the Pond can withstand a sudden decrease or increase in temperature of up to 15-17°F.

See p. 1-21 pp. 7-3-50

(15) No fish kills have occurred in the discharge canal or thermal plume from PBAPS operation at any time including shutdown and start-up.

(16) The winter fishery is restricted to a small portion of the Pond at the mouth of Broad, Conowingo creeks and Funks Run. It is anticipated that this winter fishery will expand to include the area of the Pond heated by the thermal plume.

Extensive field and experimental studies of the organisms in Conowingo Pond have shown the relationships between water temperatures and their effect on biological activity. Increases in temperature result in increased productivity. The organisms in the Pond have experienced the temperature range predicted (Elder, et. at., 1973) under the "worst case" conditions in summer. The fishes and other organisms found in the Pond have, primarily, a more southern geographic distributio and throughout their range may be exposed to natural water temperatures in excess of 93°F. In winter, production in the Pond will be enhanced by extension of the growing season.

Experimental studies supported by field observations at PBAPS have shown that fishes in the Pond can withstand the predicted increases and descreases resulting from start-up and shutdown of the Peach Bottom Station Units No. 2 and 3. No mortalities are expected and none have been observed to occur due to thermal shock in the plume or discharge canal. The effects of increased temperature on the biology of fishes will be determined primarily by their behavioral response (preference and avoidance) to various isotherms.

It is the conclusion of Ichthyological Associates that the findings which are summarized in Section 7 provide the basis for predicting that the operation of PBAPS on an open loop cooling system with 3 'helper' cooling towers will assure the protection and propagation of a balanced, indigenous community. The findings to date support predictions made by Raney (1973)

relative to the effects of the operation of the Station as designed (with an open cooling system). The expected effects of the operation of the Peach Bottom Station are given in Section 1.2.

1.2 EXPECTED EFFECTS OF OPERATION OF THE PEACH BOTTOM ATOMIC POWER STATION UNITS NO. 2 AND 3

1.2.1 Water Temperature

1.2.1.1 Natural Water Temperature

Examination of natural water temperature illustrate the wide range of temperatures experienced by the biota in the Pond. If they were not adapted to living under such variation they could not survive. None of the biota needs to experience temperatures in the range of 32°F or slightly higher in order to satisfy the needs of their life cycle. All of the species found in freshwater in the latitude of Conowingo Pond are able to exist at winter temperatures of 32°F. Some fishes which are normally found in the shallows in summer become inactive in winter; in early April or May when the water again reaches approximately 40-50°F they enter shallows.

Temperatures as high as 90°F have been recorded during the pre-operational monitoring period at the surface in Conowingo Pond (July, 1966). In a pool located in the shallows below Holtwood Dam a temperature as high as 94°F was measured on 4 July, 1966 when the river flow was 5,700 cfs. The maximum bottom temperatures recorded in Conowingo Pond during the pre-operational period was 85.2°F in July.

The 7 day average maximum natural temperature for Conowingo Pond (31 years record at Holtwood Dam) for June through August is 87-88°F (Moyer and Raney, 1969. p. 1133). The average temperature of water entering Conowingo Pond over a 31-year period at Holtwood Dam was: 36.0°F in December, 35.2 in January, 35.8 in February and 39.8 in March. In April, temperatures ranged from 37°F to 70°F (average 49.9). During the same period, November temperatures ranged from a minimum of 33 to a maximum of 64°F (average 47.7).

1.2.1.2 Model predictions of "Worst Case" Water Temperature Conditions

Model studies were conducted by Alden Research Laboratories and analysed by Bechtel Corporation, Elder, et. al, (1973) to predict the thermal conditions in the Pond as a result

of the operation of PBAPS. The "worst case" conditions, occur when river flow is low (1675-3350 cfs). These "worst case" conditions are based on a theoretical model and have not been verified. These predictions are presented as references to this document to be used as an upper limit on the magnitude of the thermal impact which might occur under normal operation of PBAPS during various meteorological and hydrological conditions.

The predicted "worst case" summer condition would be when the average flow is 2500 cfs in July and the average weekly incoming temperature at Holtwood is 85°F. At this time a delta T of 8°F may occur at the surface, 5°F may occur at 10 ft and 2°F may occur at 20 ft. Under these conditions the maximum temperature predicted at the surface may be 93°F and a maximum at depth of 20 ft may be approximately 87°F. The volume of the total pond water above 87°F under these conditions would be approximately 20%. It should be emphasized that based on 30 years of temperature and flow records only 2.8% of the time was a flow less than 5000 cfs experienced with temperatures greater than 80°F (Section 4.5).

During the period from November through March, should a low flow occur, the model predicts much of Conowingo Pond downstream from the discharge to a depth of approximately 20 feet may have a temperature increase of at least 10°F. From late February through early October the delta T in Conowingo Pond will be less and the plume will be smaller. These increases delta are due to reduced cooling tower efficiencies during winter months.

From November through January increases in temperature of more than 5°F may occur over a large portion of the Pond. When the ambient is 35°F, a temperature of 50-55°F might be expected at the surface and a temperature of approximately 45°F may occur at the bottom. When ambient is 45°F the temperature in a large area of the Pond may be as high as 60-63°F at the surface. In March, with an ambient of 40°F, the predicted increase in temperature in the Pond is less. At an ambient higher than 50°F, the delta T throughout the Pond is expected to be much less than at lower ambient temperatures and the plume will be considerably reduced in size. Thus the biota will not be exposed to temperatures unusually higher than those which they have experienced as normal annual variation.

1.3 DISSOLVED OXYGEN AND WATER CHEMISTRY

The dissolved oxygen concentration in the intake water from Conowingo Pond is at or near the saturation level. The

heated water that is discharged is aerated as it passes through the cooling towers and into the discharge canal. The available BOD data indicate that large amounts of organic wastes are not found in the water.

Studies in 1974 during partial operation of PBAPS detected no change in oxygen concentration. The values for the other water quality parameters measured were also within the range of the preoperational experience.

In a study supported by the Environmental Protection Agency to determine the effects of thermal discharges on water quality and eutrophication, Lee and Veith (1971) suggested that intake water would have to contain large amounts of municipal and/or industrial wastes and be exposed to elevated temperatures for periods of many hours to days before the exertion of BOD would critically deplete the dissolved oxygen in the receiving water. They also stated that "where the intake waters do not contain large amounts of organic wastes or are already at critically low oxygen levels, the effect of using the water for cooling purposes probably would have little or no effect on the amount of dissolved oxygen in the water". The operation of the Peach Bottom Station will have little effect on the concentration of dissolved oxygen and BOD under the "worst case" temperature conditions.

Thermal stratification (a decrease in temperature of 1°C per meter) will not occur in Conowingo Pond as a result of the operation of PBAPS. Stratification will not occur because of the large amount of water exchange (turnover time) as a result of the operation of the Conowingo Hydro-electric Station and the Muddy Run Pumped Storage Generating Station. With the lack of thermal stratification oxygen will not be depleted in the water column because no thermocline will be formed.

The discharge of chlorine to the Pond will be less than 0.1 ppm or less. This level would be immediately reduced in the plume so that the amount of chlorine would be miniscule. No significant effect on production of fishes or zooplankton will occur.

1.4 PHYTOPLANKTON COMMUNITY

Studies show that temperature accounts for much of the variability observed in the phytoplankton community (as measured by chlorophyll a concentrations). The analysis of the relationship of the effect of nutrients, river flow and water temperature indicates that temperature is an important factor in

the production of phytoplankton. As water exceeds 60°F phytoplankton production is enhanced. This will occur betwee November and April at times when PBAPS is operating. The nutrients are available to support the predicted increase in production during these months.

1.5 ZOOPLANKTON COMMUNITY

Zooplankton production in the Pond reaches a maximum at the time of maximum water temperature. There is no evidence that summer maximum temperature is a limiting factor. A comparison of density during preoperational and postoperational periods shows no significant effects of the operation of PBAPS on the zooplankton community. No significant differences in the density were noted at monitoring stations within the plume when PBAPS was operated at full power.

A statistical analysis indicates that an increase in water temperature (along with increase in phytoplankton) stimulates production of zooplankton and an increase in river flow would depress zooplankton (and phytoplankton) abundance.

Since sharp decreases in zooplankton density occur at temperatures less than 60°F, it is expected that when the water temperature exceeds 60°F zooplankton production will be enhanced. At a water temperature less than 60°F, no deleterious effects on zooplankton community are expected since the density is normall low (less than 3 organisms/liter).

1.6 BENTHIC COMMUNITY

The benthic community consists mostly of chironomid larvae and oligochaetes which make up over 93% of the population by number. The species in the Pond can live within a temperature range of 32 to 90°+F and tolerate wide temperature fluctuations. Samples from the discharge canal revealed the presence of the following selected taxa: Hexagenia limbata, Limnodrilus hoffmeisteri, and Procladius sp. (complex). The temperature in the canal was 79°F and at the intake (60.5°F). The fact that these taxa are present in the canal suggests that they can withstand high delta T (18.5°F). Their distribution is not restricted by the thermal discharge.

Published information on the temperature tolerance of the benthos common to Conowingo Pond is sparse. Langford (1972, p. 331-332) reviewed the effects of power stations in Great Britain and reported that few benthic species are restricted by warm water discharges. He reported that Limnodrilus hoffmeisteri

can reproduce successfully over a temperature range of 5-30°C (41 to 84°F). He found a large number of sexually mature specimens of L. hoffmeisteri downstream from a heated discharge (in Great Britain) where the average temperature increment downstream was 10°C (18°F).

In the summer, the plume will not impinge on the bottom of the Pond except over a few acres for a short period under the "worst case" condition (2500 cfs flow and average weekly incoming temperature of 85°F at Holtwood). The temperature increase alone will not harm the benthos in summer. Some change in benthos has occurred in the immediate scoured area near the discharge in 1974. Chaoborus punctipennis which was commonly taken here before PBAPS operation, was not taken in the latter half of 1974. Chemautopsyche sp. which was not taken in the Pond earlier was taken for the first time after operation began.

Expected increases in temperature in winter will not have a deleterious effect on benthos. Observations indicate that emergence takes place at temperatures as low as 49°F in November for two of the most common emergent forms, Procladius sp. (complex) and Coelotanypus concinnus (Robbins, et al., 1974, p. 13). For Chaoborus punctipennis, emergence does not occur until the water temperature reaches 66°F and takes place mostly from July through August. Small shifts in emergence time will not be disruptive to the life cycle of the common emergent benthic taxa. Any decrease in availability of benthic organisms as food for fishes would be compensated for by an increase in zooplankton productivity.

1.7 FISHES

1.7.1 Introduction

It has been demonstrated that "worst case" summer temperature conditions are not an unseasonable temperature regime for fishes and other aquatic organisms in the Pond. However, in the winter fishes and other organisms may be exposed to unseasonable increases in temperature.

The biology of organisms over a temperature range of 50-60°F (November through February) is the important consideration in the operation of PBAPS during the winter. It is expected that this will be the thermal regime when the temperature of water entering the Pond from Holtwood is between 32 and 50°F. At this time such a temperature regime may occur over a large portion of the Pond. A synopsis of the findings on the relationship between temperature and fishes in Conowingo Pond follows. It is based on

the findings reported herein and supporting documents. Robbins, Euston, Wahl and Mathur (1974) have documented the relationship between abundance of food organisms, fish food habits, and water temperature.

The fishes which are found in Conowingo Pond are, for the most part, classified as warm water fishes and have a wide distribution from south-eastern United States to Canada. They are capable of living and prospering under the various water temperature regimes found through hundreds of miles of their geographic range. The channel catfish and white crappie which are the two most common fishes in the Pond have been (along with largemouth bass, smallmouth bass, bluegill, pumpkinseed, walleye, yellow perch, white crappie, brown bullhead, yellow bullhead, and golden shiner) transferred to warm water reservoirs in California (Calhoun, 1966, p. 312, 332, 354, 375, 402, 423, 426, 440, 463, 479 and 488) where they have adapted to a winter temperature regime which is warmer than that expected in Conowingo Pond with the full operation of the Peach Bottom Units 2 and 3. Most are native to or were introduced in reservoirs in Alabama and elsewhere in the TVA system.

1.7.2 Temperature Requirement of Fishes

Fishes are "cold-blooded". The body tissues quickly change to the temperature of the surrounding water because the gills must be exposed to permit the passage of oxygen and carbon dioxide. Fishes can perceive minute differences in temperature of much less than 1°F.

Lethal temperatures are avoided by motile aquatic organisms. Thus, fishes avoid the hotter part of plumes. Fishes have a lower and an upper lethal temperature limit or tolerance. The lethal temperature is specific for each species. These limits permit adjustment to differences in seasonal temperatures as well as of those of 5 degrees F or more locally, from place to place, from day to day, or night and day.

The lethal temperature is that temperature at which a fish dies after a given time. Fishes acclimate to a given temperature, within the lethal limits, and do so regularly with temperature changes accompanying the seasons. A fish, when permitted to acclimate, chooses a final preferred temperature. A species, which is acclimated to a given water temperature may move toward, or away from, a higher or lower temperature.

Once acclimated to a given temperature, fishes acclimate more readily to an increase than to a decrease in temperature.

The rate of activity of fishes usually increases with a rise in temperature. However, the relationships may be reversed.

It has been shown that fishes can and will follow a temperature gradient. They normally follow this gradient to or toward their preferred temperature. The behavior of a given species often depends on the magnitude of change of temperature to which it may be exposed. It may be attracted to a higher or lower temperature, or it may avoid higher or lower temperature, or it may not react.

Obviously lethal maximum temperatures for motile organisms are inappropriate to predict the effects when such species encounter higher temperatures (plumes) because such a measure ignores the behavior of the organisms and the time which an organism might be in contact with such a temperature. It is proper to use such a measure only for organisms which cannot avoid and which remain in the increased temperatures. A far more appropriate measure is the upper avoidance temperature.

Fishes do not normally react to the change of water temperature up to 5°F. Changes of more than 7-8°F may and often elicit an avoidance reaction (see Section 7.3 herein). When a fish approaches warm water and if it is not in the direction of its preferred temperature, it turns and follows the gradient which must lead to cooler waters.

1.7.3 Fishes and Heated Plumes

Observations at large power stations discharging relatively large volumes of heated water into rivers and lakes confirm the absence or rarity of thermal fish kills or serious biological change. The effect of the heated effluent at Hanford on the Columbia River was observed on salmon and trout over a 25-year period. No thermal kills of any significance were observed. See recent reviews by Nakatani (1969). In England, Alabaster (1969) made studies of fish mortalities, both in the laboratory and in the field. He reported that kills under field conditions are extremely rare and insignificant. Nor have thermal kills or other harmful ecological effects to fishes been observed on the lower Connecticut River in extensive studies of the operations of the Connecticut Yankee Nuclear Power Plant (Merriman, 1970). Kills are absent even where lethal temperatures are present, at the base of a plume, because fishes under most circumstances will shun these areas.

In winter, fishes will be attracted to the Peach Bottom plume because they will be going toward their preferred

temperature. During operation of Peach Bottom Units No. 2 and 3 in winter the water in most of Conowingo Pond will be a approximately 40°F when the temperature of the water entering from Holtwood is 39°F or lower. Fresh water reaches its maximum density at approximately 40°F. In the plume (near the end of the effluent canal but outside a small zone of rapid mixing) the water temperature may be as much as 54 to 56°F. If both Units 2 and 3 should suddenly cease operations the water temperature would fall slowly to the ambient water temperature of 40°F or less.

Studies were made on the effects of rapid increases and decrease of temperature on fishes. The basic design of the studies was to simulate a complete shutdown of PBAPS. The potential rate of temperature decrease in the plume during a shutdown will be less than those decreases used in the shock tests conducted in the laboratory. Thus the estimates of the effects from shock studies are conservative and they demonstrate only a very low potential for mortality.

During the actual operation of PBAPS the temperature decreases due to unscheduled shut downs will not be rapid. It is expected that at least one of the two units will remain operating and no shock will result. In 1974 no fish kills were observed in the Pond or the discharge canal at times of Station shutdown.

1.7.4 Reproduction

A combination of temperature and photoperiod is important in timing of the reproduction in fishes. The peak spawning for the common fishes in Conowingo Pond occurs when the water temperature exceeds 70°F.

Most of the fishes found in Conowingo Pond build nests. Of the selected representative species only the walleye and gizzard shad do not build nests. The eggs of both species are demersal and develop on or near the bottom rather than in the water column. Spawning occurs throughout the Pond and primarily along the shoreline. Large areas suitable for spawning for the selected representative fishes and others are available outside that encompassed by the thermal plume. One of the primary spawning areas (Broad Creek) would not be affected by the heated discharge. Fishes will avoid areas within the plume which may not be suitable for spawning. The peak of the spawning period is earlier than the period when the predicted "worst case" summer maximum conditions will exist. These facts provide evidence that the heated discharge will not adversely effect eggs and larvae.

Observations on the spawning of the channel catfish in ponds at Auburn University indicate that minimum water temperature of 70°F for five consecutive days is needed before spawns occurs (Prather, personal communication). Bennett and Gibbons (1975, p. 82) found that thermal effluent in Par Pond (Georgia) did not grossly alter the reproductive cycles of largemouth bass from heated areas, as compared to cycles of bass from unheated waters. The heated area had a maximum temperature of 38.3°C (101°F) and the unheated area a maximum of 27.2°C (81°F). Temperatures of this magnitude are not expected to occur in the pond.

The predicted winter conditions in Conowingo Pond are not expected to affect reproduction. When water entering the Pond is 50°F in April the rise in temperature may be approximately 5-10°F in a relatively small area and primarily at the surface along the west shore just downstream from the discharge. The study of the development of the ovaries (GSI;gonadosomatic index) in the channel catfish and white crappie in Conowingo Pond indicates that at 60°F in the spring development is not at a peak. If some early development of gonads takes place and spawning is advanced by several weeks, food will be available for larvae (see effects of temperature on zooplankton abundance below).

1.7.5 Growth

Studies of the white crappie and channel catfish indicate that growth normally ceases between November through May when the water temperature is below approximately 60°F. Depending on age, growth may resume in the white crappie as early as late May when water temperature exceeds 70°F.

Merriman (1970) reported that large numbers of "skinny" brown bullhead were found in the canal at the Connecticut Yankee Atomic Power Plant, Connecticut River. These fish maintained themselves in a fast current and at a high delta T. Thus, the metabolic requirements were greatly increased and the food supply was limited. In Conowingo Pond the above situation will not exist because of the restricted entrance to the jet discharge and the relatively few fish found in the discharge canal.

1.7.6 Food Habits

No specific feeding areas for fishes are present in Conowingo Pond; the fishes feed throughout the Pond. The effects of the thermal plume on feeding of the fishes under the predicted "worst case" conditions in the Pond will be minimal. This

activity occurs over the entire Pond and fishes will move to their preferred temperature where food will be available.

Studies of the seasonal food habits of the channel catfish, white crappie, bluegill, walleye and largemouth bass indicate, except for the walleye, a dependence on zooplankton from May through October. The walleye were observed to feed predominantly on fishes. Changes in food habits, food availability or both occur when the water temperature is between 50 and 60°F. The diet of the above species and brown bullhead, yellow bullhead, white catfish, black crappie and rock bass is primarily made up of benthic organisms and fish from November to April. The feeding rate decreases in most fishes as water temperature decreases. The total number and volume of organisms per stomach is decidedly less in the winter than in the summer.

Sharp decreases in the density of zooplankton occur at a water temperature less than 60°F. Benthic organisms and small fishes are then the primary available food but fishes feed primarily on benthos. The change to a benthic diet appears to be obligatory rather than facultative. Fishes are expected to continue to feed on benthos in winter except at times when zooplankton production is enhanced by the operation of PBAPS.

1.7.7 Movement of Fishes

Tagging studies indicate that the channel catfish show little seasonal movement within Conowingo Pond. The whit crappie moves seasonally. Crappie have been observed to move into the upper portion of Conowingo Pond in the spring but by winter have moved downstream to the mouth of Broad and Conowingo creeks. Fishes tagged in the lower portion of Conowingo Pond in November have remained there through the winter. These were tagged when the water temperature was approximately 50-55°F. It appears that the white crappie which move downstream have started or completed their movement by the time the temperature in the upper portion of the Pond is 60°F or less.

The expected increase in temperature in winter as a result of the discharge will tend to attract fishes to the heated plume since they will be moving toward their preferred temperature. Some fish which normally move into the lower portion of the Pond may remain in the upper part in winter.

No anadromous fishes are found in Conowingo Pond and there is little expectation that they will ever be present in large numbers. If the American shad is present in the future it will move freely during its normal spring and fall migrations.

Experiments and observations with the American shad and other anadromous fishes have shown they readily move under or around heated plumes. Experimental studies by Moss (1970) on the American shad were confirmed by field studies in the Connecticut River by Marcy, et al., (1972).

1.8 TROPICAL STORM AGNES

The biota of the Pond experienced sudden substantial increases in turbidity, decreases in temperature and increase in river flow when Tropical Storm Agnes (mid-June 1972) wrought devastating effects. The effects have been documented in Sections 2 through 4 of this report. Decreases in the abundance of organisms were noted in the period shortly following the high flows (more than 900,000 cfs) and are attributed to the heavy silt load, scouring, and swift currents. The populations of organisms have recovered from this natural catastrophe. The zooplankton and phytoplankton populations were observed to recover somewhat shortly after the flood and by 1974 the seasonal pattern of abundance was similar to earlier years. The fishes have recovered at a somewhat slower rate but year classes of the common fishes in 1973 and 1974 have in some cases exceeded the strength of those prior to 1972. One obvious effect of the reduction of the fish population as a result of Agnes was an increase in growth rate of the white crappie in 1974. This is attributed to the decrease in overall population which occurred as the result of the destruction of the 1972 year class. An increase in growth may have occurred in other species but has not yet been documented. The recovery of the population is evidence that should the operation of the Station be detrimental to the biota in the Pond (such detrimental effects are not predicted), the biota has the capacity to recover and detrimental effects would not be irreversible.

1.9 PREDICTED WINTER FISHERY

Large numbers of fishes may be attracted to the heated plume in the winter. For all the warm water fishes the preferred temperature is above the water temperature that will exist in the discharge between November and February. The resulting concentration of fishes could serve as a source of an important winter fishery in Conowingo Pond. This prediction is based on our knowledge of the present winter fishery in the Pond and on studies which report that angling in the vicinity of warm water discharges from steam plants is among the best fishing available. For example, the Tennessee Valley Authority studies (1969, n.p.) of fish and fishing at five steam generating plants (John Sevier, Kingston, Bullrun, Colbert and Johnsonville) have confirmed the

presence of large concentrations of fishes and good winter fishing. Channel catfish and white crappie are among those taken in the fall, winter and spring in large numbers. These are the two most common fishes in the Pond.

Moore and Frisbie (1972) reported on a sport fishing survey which was conducted from January through April 1970 along a one mile discharge canal of a steam electric station located at Chalk Point, Maryland. In 20,000 fishing trips, 58,000 fishes representing nine species were captured. This excellent catch was made in the canal at a time when sport fishing on the Patuxent River was negligible. The fact that more fishing was found in the canal in the winter than in summer and fall indicates the value of an unseasonable sport fishery which can be produced by a warm water discharge. Marcy (1971) reported on a substantial winter-spring sport fishery in the heated canal leading from the nuclear power plant on the Connecticut River at Haddam, Connecticut. A total of 18 species was caught. For additional examples of winter sport fisheries which have been established in heated effluents see Elser (1963 and 1965), Shearer, Ritchie and Frisbie (1962) and Walker (1954).

1.10 CONCLUSIONS

We conclude that there has been none and will be no appreciable harm to the balanced, indigenous community, or to community components which results in such phenomena as the following:

- Substantial increase in abundance or distribution of any nuisance species or heat tolerant community not representative of the highest community development achievable in receiving waters of comparable quality.

- Substantial decrease of formerly indigenous species, other than nuisance species.

- Changes in community structure to resemble a simpler successional stage than is natural for the locality and season in question.

- Unaesthetic appearance, odor or taste of the waters.

- Elimination of an established or potential economic or recreational use of the waters.

- Reduction of the successful completion of life cycles of indigenous species, including those of migratory species.

- Substantial reduction of community heterogeneity or trophic structure.

PRESENTATION OF SPECIFIC DATA

2.0 PLANT OPERATING DATA

2.1 Unit Loading

Peach Bottom Units 2 and 3 are base loaded and operated at their full load, 1065 MWe each, as much as possible. These units generally are operated at lesser loads only during the startup or shutdown processes. A normal startup or shutdown sequence will typically take about six days.

Scheduled shutdowns for each unit will be made for maintenance and refueling. For planning purposes, scheduled maintenance shutdowns may be expected at the rate of one week every two months. The first refueling outage, which will last about five weeks, should occur about 22 months after initial full power operation. This initial refueling outage for Unit 2 is scheduled to begin in February of 1976. This is somewhat longer than the scheduled 22 months. Subsequent refueling outages should be expected at 14-month intervals. For planning purposes, forced outages may be expected to shutdown the units a total of one week per four-month period. The estimated average yearly capacity factor for these units is 80%. The capacity factor will range between 85% for the summer months and 60% for the winter months.

2.2 Circulating Water System

The locations of all features of the Peach Bottom circulating water system are indicated on Figure 2.2-1. Cooling water for Units 2 and 3 is provided by three 250,000 gpm (557 cfs) pumps per unit, for a total of six pumps with a capacity of 1,500,000 gpm (3350 cfs). The operation of these units, as designed, will meet an effluent limitation which provides that discharge to Conowingo Pond of an average of 12 x 10^9 Btu/hr. and a maximum of 16 x 10^9 Btu/hr."

2.2.1 Intake

Water is withdrawn directly from Conowingo Pond through an intake structure approximately 500 ft. in length and parallel to the pond. The intake is protected from heavy debris and ice flows by 32 sets of vertical steel trash bars. Approximately 40 ft. behind the trash bars are 24 vertical traveling screens of 3/8 in. mesh. The total intake area was designed to be large enough to maintain a maximum velocity through the screens of .75

fps at the lowest pond level normally attained, 104.5 ft. elevation (Conowingo Datum).

The cooling water enters two separate intake basins, one for each unit, and travels to the pump intake facility where it is again screened by 3/8 inch mesh traveling screens before being pumped through the condensers. During its passage through the condensers the water temperature is increased by 20.8° F, at full load, and is discharged into a common basin. The amount of heat rejected to the cooling water, and therefore the condenser temperature rise, is approximately proportional down to about the 20% power level (approx. 200 MWe). This relationship is illustrated on Figure 2.2-2.

2.2.2 Cooling

Approximately 876,000 gpm of the cooling water is pumped to the three forced-draft helper cooling towers. The remainder of this warm water passes directly into the 4700 ft. discharge canal where it mixes with the water cooled by the towers.

The performance of the helper towers, and therefore the discharge temperature rise, is dependent on meteorological conditions. The monthly variation in discharge temperature rise is indicated on Table 2.2-1. Table 2.2-2 illustrates the resultant variation in evaporative losses from the cooling towers and the water body surface.

2.2.3 Outfall

The total circulating water flow is discharged to Conowingo Pond via the PBAPS discharge structure located at the end of the discharge canal. The discharge structure contains one rectangular nonregulated opening and three regulating gates. Details of this structure are presented in Figure 2.2-3. The automatic operation of the three regulating gates maintains the velocity of the submerged jet discharge between five and eight feet per second.

The design of the discharge canal and structure was based on the results of hydraulic and thermal model studies performed at the Alden Research Laboratories. The intent of these studies was to find a configuration that would minimize recirculation and maximize entrailment of the surrounding water in order to limit the heat affected area of the Pond.

A fishnet is deployed over the non-regulated opening when less than three circulating water pumps are operating.

2.2.4 Transit Times

Transit times of the cooling water through the plant are given in Table 2.2-3. Numbers in the first column of this table refer to marked locations on Figure 2.2-4. The relationship between these times and the temperature rise of the water above ambient is illustrated on Figures 2.2-5 and 2.2-6 for average July and November conditions respectively. The time required for the discharged water to return to ambient does not lend itself to simple analysis due to the complexity of the hydraulics of Conowingo Pond. The pertinent information can be inferred for a particular set of operating parameters - operation of the hydroelectric stations meteorology, river flow, etc. - from the isotherms submitted herewith.

Table 2.2-1
Peach Bottom, Units 2 and 3
Three "Helper" Cooling Towers
Seasonal Variation of Discharge ΔT *

	Ambient Water Temp. (°F)	Condenser ΔT (°F)	Cooling Twr. Range (°F)	Heat Rejected via Discharge (10^9 Btu/hr.)	Discharge ΔT (°F)
January	35.0	20.8	6.0	13.0	17.3
February	36.0	20.8	5.0	13.4	17.9
March	39.5	20.8	5.5	13.1	17.5
April	48.5	20.8	6.0	13.0	17.3
May	64.0	20.8	9.5	11.4	15.2
June	72.5	20.8	10.5	11.0	14.7
July	80.0	20.8	13.0	9.8	13.0
August	79.5	20.8	13.5	9.6	12.9
September	70.5	20.8	10.5	11.0	14.7
October	60.0	20.8	8.5	11.8	15.8
November	45.0	20.8	6.0	12.9	17.2
December	35.5	20.8	4.5	13.7	18.2
Average Annual during Operation				12.0	16.0

* based on average monthly meteorological conditions.

Table 2.2-2

Peach Bottom Units 2 and 3

Seasonal Variation of Rate of Evaporative Loss*

	Evaporative Loss from C. Twrs. (cfs)	Receiving Water** Evap. (cfs)	Total Evaporative Loss (cfs)
January	6.1	19.5	25.6
February	6.1	18.8	24.9
March	5.5	22.3	27.8
April	7.3	26.0	33.3
May	15.5	26.2	41.7
June	17.1	30.8	47.9
July	21.2	28.4	49.6
August	22.0	27.8	49.8
September	17.1	29.7	46.8
October	13.8	29.5	43.3
November	6.1	25.8	31.9
December	5.5	23.3	28.8
Average Annual Rate during Operation	11.9	25.7	37.6

* based on average monthly meteorology conditions.

** calculated using formulae developed in Brady, Edinger, and Geyer; Heat Exchange and Transport in the Environment; EPRI Publication No. 74-049-00-3.

Table 2.2-3

Circulating water transit time through plant cooling system

Flow distance[a]	Description	Flow directly to discharge canal	Flow through cooling tower system
1-2	Retention in intake structure	24.3 min	24.3 min
2-3	Circulating water piping to condenser	0.7 min	0.7 min
3-4	Condenser	14 sec	14 sec
4-5	Condenser to cooling tower pond	1.3 min	1.3 min
5-6	First cooling tower pond		24.3 min
6-7	Second cooling tower pond		16.3 min
7-8	Piping from pond to cooling tower		22 sec
8-9	Retention in cooling tower		64 sec
9-10	Cooling tower discharge to canal		87.5 sec
10-11	Transit in discharge canal	38.9 min	38.9 min
5-10	Bypassing of cooling tower, time in discharge canal	22.6 min	
Total		88 min	109 min

[a]Points 1 through 10 are labeled on Fig. 2.2-4

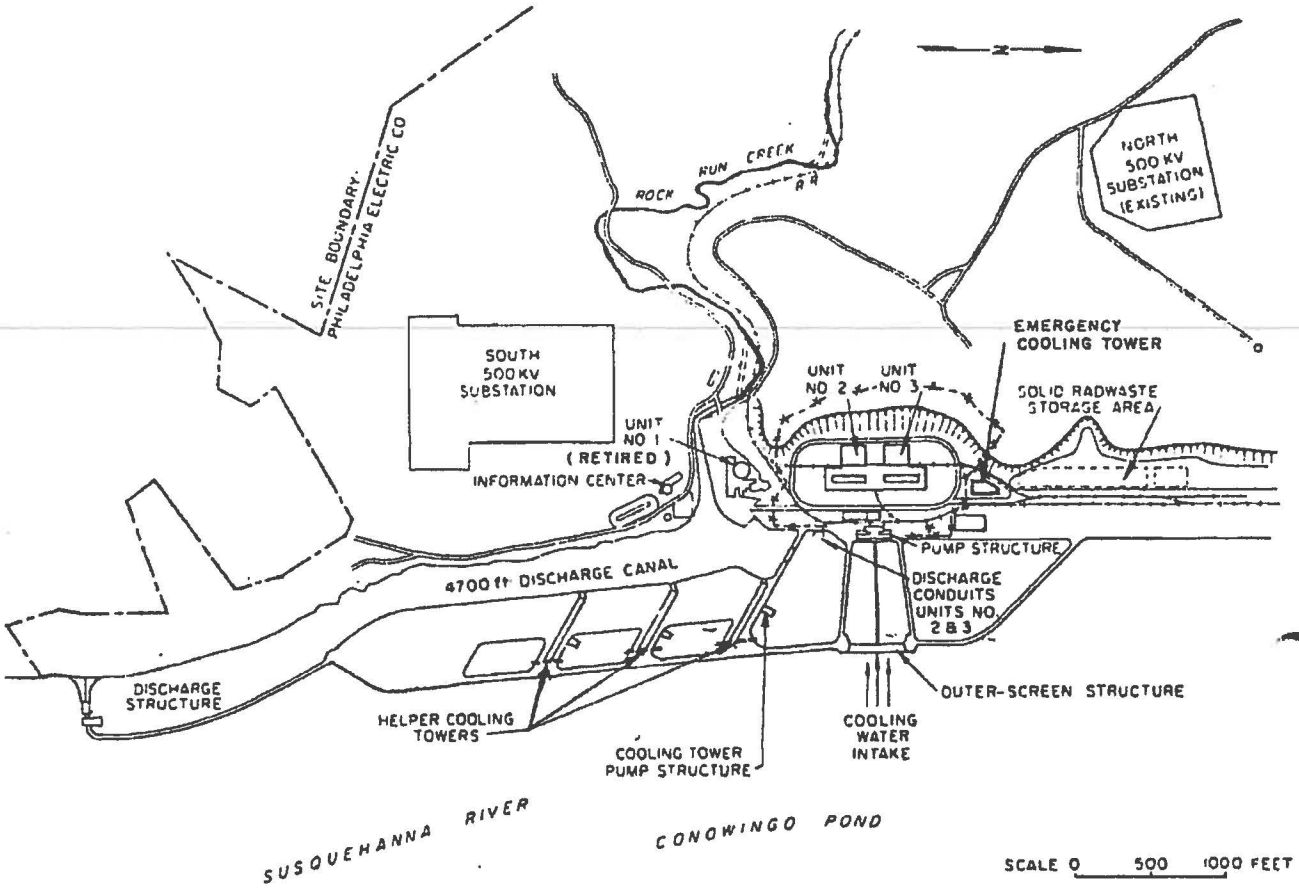


FIGURE 2.2-1 CLOSEUP OF PEACH BOTTOM COMPLEX

PEACH BOTTOM UNITS 2 AND 3

Condenser ΔT VS. Unit Load

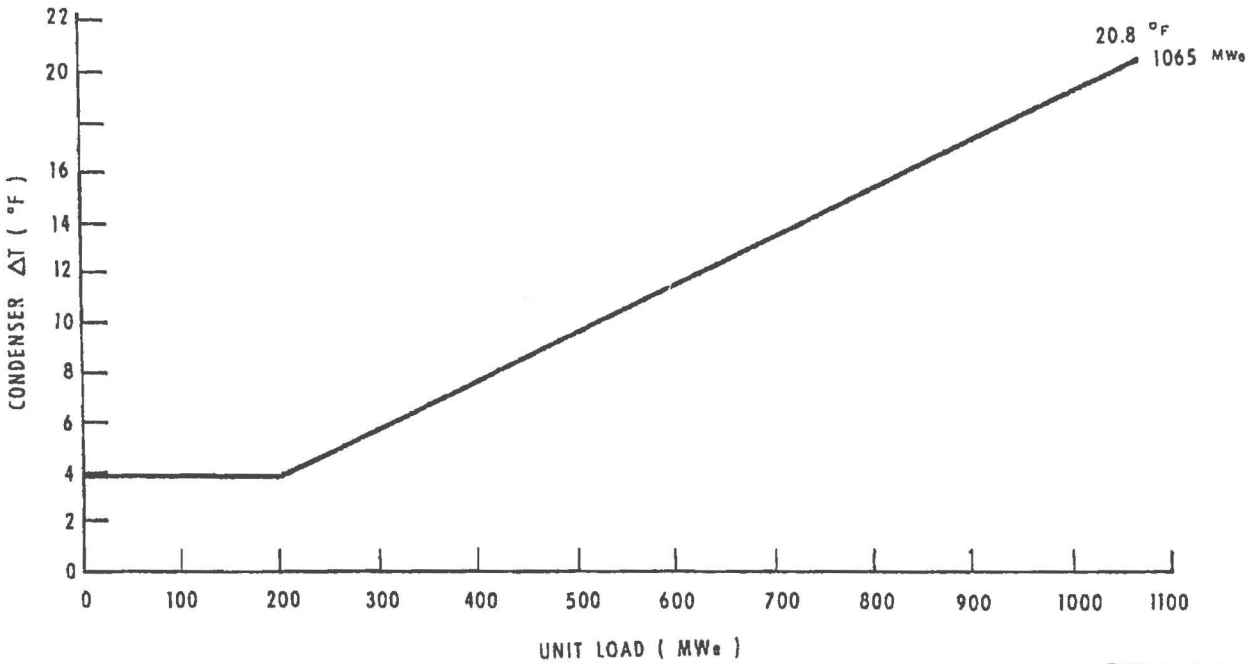


FIGURE 2.2-2

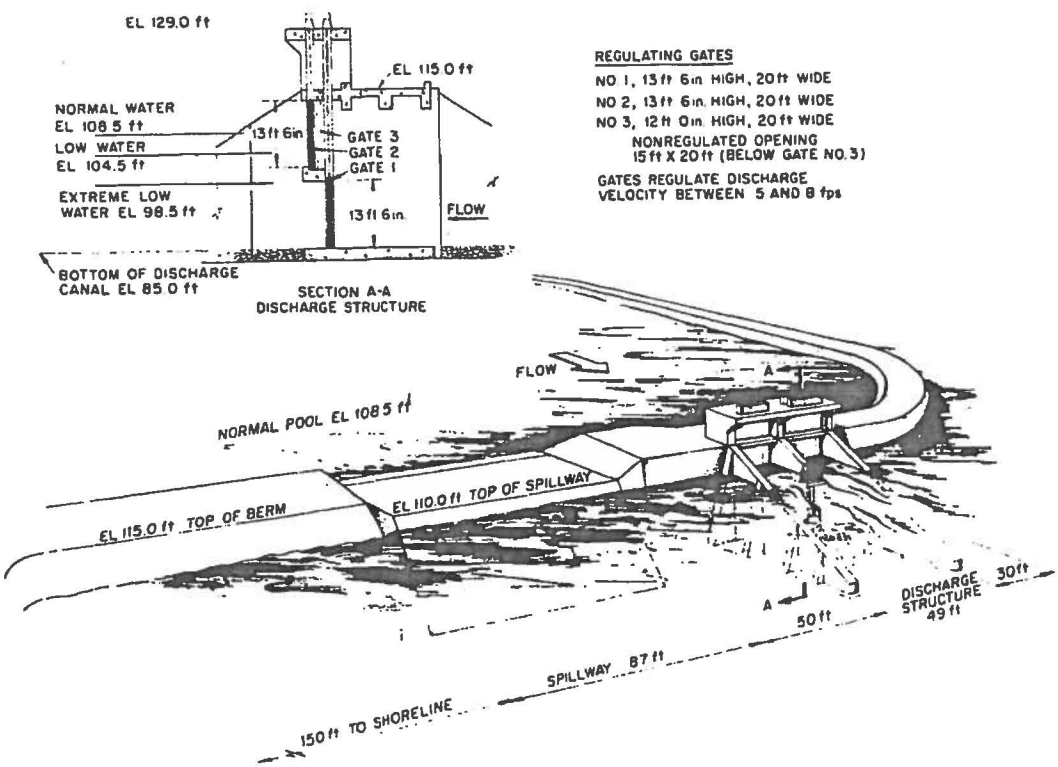


FIGURE 2.2-3 Submerged discharge facility, with details of movable gates.

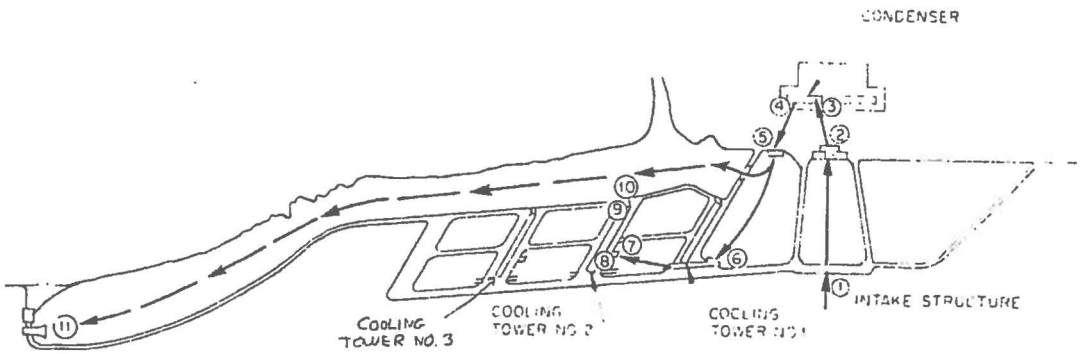


Figure 2.2-4 Path of cooling water from Conowingo Pond through the Peach Bottom Station. Transit times are given in Table 2.2-3.

PEACH BOTTOM UNITS 2 AND 3

Temperature - Time Plot Average July Conditions

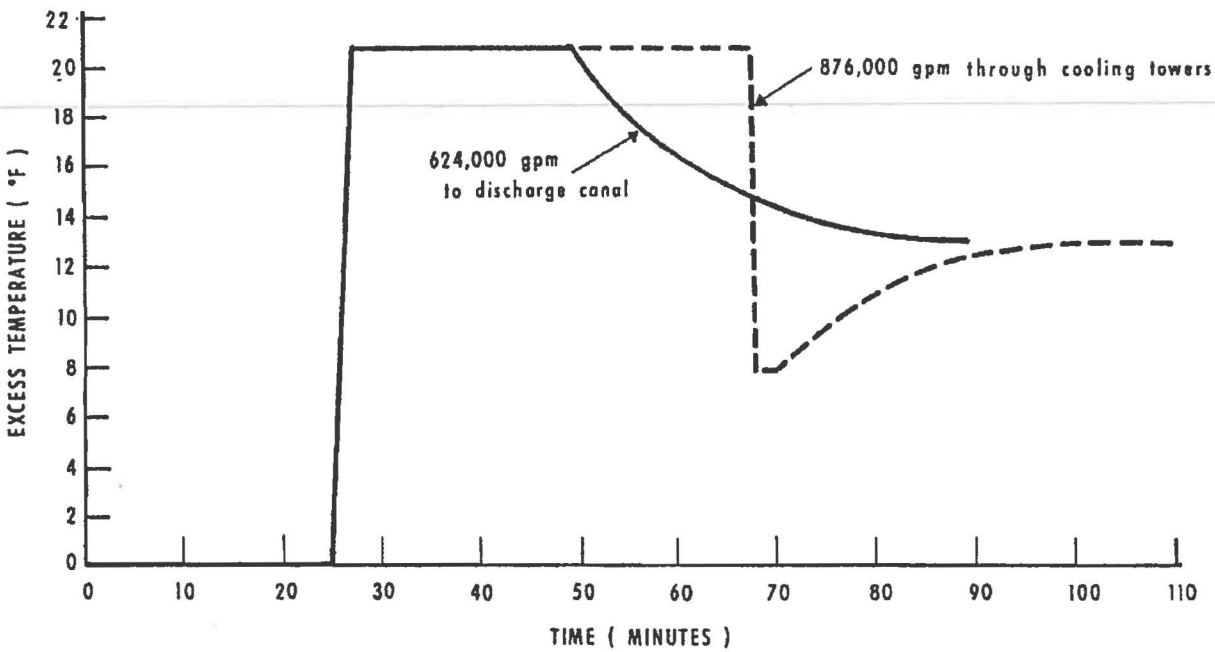


Figure 2.2-5

PEACH BOTTOM UNITS 2 AND 3

Temperature - Time Plot for Average November Conditions

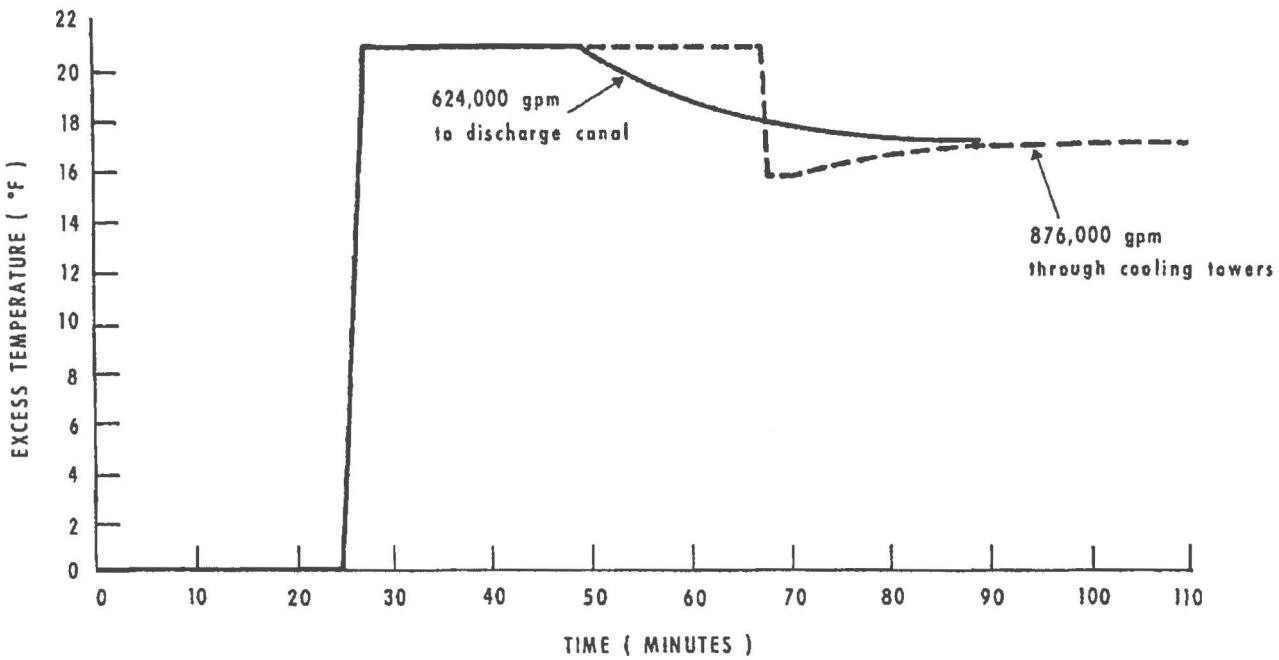


Figure 2.2-6

2.3 Chemical and Water Quality Data

2.3.1 Chlorine

The major portion of chlorination will take place in the condenser cooling water system (1,500,000 gpm total water flow for both units) but chlorine will also be added to the service water system (50,000 gpm).

There are six circulating water pumps and each condenser of the two generating units is divided into three sections. Chlorination will be scheduled to add chlorine to one section at a time.

Basically, the amount of chlorine periodically added is determined by checking the effluent from a condenser section to maintain a free residual chlorine of 0.5 ppm. Maximum rate of chlorination is expected to result in 5 ppm initial charge (to result in 0.5 ppm residual) or a rate of 3,840 lbs/day total chlorine added to both condenser cooling and service water. This is based on chlorinating each condenser section three times per day for 20 minutes per time plus proportional chlorination of the service water. At 0.5 ppm residual, the free chlorine to the plant discharge canal and ultimately to the Conowingo Pond equals 385 lbs/day total. However, due to programming the chlorination, the quantity of chlorine added at any one time equals approximately 210 lbs. (based on 5 ppm) or at 0.5 ppm residual, about 21 lbs. to the discharge canal. This residual is mixed with the total circulating water of 3,450 cfs for a resultant concentration of less than 0.1 ppm to the pond at any time. Our consulting biologists, Ichthyological Associates, has recommended this chlorination schedule to achieve maximum dilution and foresees no adverse effect on the Pond due to this discharge.

Normally, the plant would chlorinate at a rate of 2 ppm instead of 5 ppm which would reduce all chlorine quantities to 40% of values shown above.

There is no data available for chlorine demand of the intake water; we estimate it to be about 1 ppm.

2.3.2 Other Chemicals, etc.

Other chemicals, additives or other discharges which are contained in the cooling water are listed in Figure 2.3-1.

These releases, which occur on a frequent batch basis (several times/day, are to the discharge pond or the discharge canal and are sufficiently mixed such that they may be considered to be continuous discharges.

Sodium sulfate is the major constituent of the total dissolved solids and therefore was used in the following calculation; concentration of other constituents are insignificant.

$$\frac{330{,}000 \text{ pounds/year}}{365 \text{ days/year}} = 904 \frac{\text{pounds}}{\text{day}}$$

Using the condenser circulating water flow rate of 1.5×10^6 GPM (18×10^9 pounds/day) the concentration of sodium sulfate in the plant discharge is:

$$\frac{904 \text{ pounds/day}}{18 \times 10^9 \text{ pounds/day}} = 0.0502 \text{ ppm}$$

TABLE 2.3-1

CHEMICAL DISCHARGES IN COOLING WATER

CHEMICAL	USE	ESTIMATED RELEASES (Pounds/Year)	REMARKS
Calcium Hypochlorite	Sewage Plant	3,000	Includes chlorides
Lime	Waste Water Treatment	10,000	-
Unidentified Chemical Wastes	-	4,200	Laboratory Drains Including Water
Soda Ash	Waste Water Treatment	30,000	-
Sodium Hypochlorite	Sewage Treatment	6,000	Includes Chlorides
Sodium Phosphate	Auxiliary Boilers	500	
Sodium Sulfite	-	330,000	Product of Demineralizer Regeneration
Sodium Sulfite	Auxiliary Boilers	500	-

3.0 PLANT OPERATIONAL EXPERIENCE TO DATE

3.1 Generation and Shutdowns

Since September of 1973, there has been power produced at PBAPS. In February of 1974 the initial checkout of Unit No. 2 was completed and the unit began producing power at significant levels (>10%) up to 100%. In August of 1974, Unit No. 3 began producing power at significant levels. For this reason, thermal surveys conducted in the Pond from February 1974 to the present are discussed in this document.

Table 3.1-1 contains a listing of this maximum and approximate average power generated (200% indicates full power of Units No. 2 and 3) by month beginning with February 1974. PECo monthly report nos. 8 through 23 on the thermal and biological monitoring programs have been included with this submittal as references to provide detailed plant operating data.

3.2 Biological Effects of Shutdowns

There have been no mortalities observed in Conowingo Pond or in the PBAPS discharge canal due to (during or after) shutdowns. Section 7.2.3 provides a detailed discussion of the biological monitoring programs conducted in the thermal plume.

TABLE 3.1-1

PBAPS AVERAGE AND MAXIMUM GENERATION BY MONTH
FEBRUARY, 1974 THROUGH MAY, 1975

MONTH, YEAR	PBAPS POWER (in percent)* AVERAGE	MAXIMUM
February, 1974	11%	34%
March, 1974	13	40
April, 1974	43	79
May, 1974	55	95
June, 1974	65	100
July, 1974	88	100
August, 1974	96	100
September, 1974	91	125
October, 1974	105	175
November, 1974	120	190
December, 1974	135	195
January, 1975	86	200
February, 1975	110	200
March, 1975	191	200
April, 1975	177	200
May, 1975	137	200

*200% equals maximum power for both Units 2 and 3

4.0 SUSQUEHANNA RIVER HYDROLOGY

4.1 River Flow

The watershed of the Susquehanna River, Figure 4.1-1, encompasses an area of about 27,500 square miles. The main stem, which has its headwaters in New York State, is joined by the West Branch at Sunbury, Pa. and then flows southeast 123 miles to the Cnesapeake Bay.

The river is regulated by twelve existing flood control dams on its major tributaries and by the York Haven, Safe Harbor, Holtwood, and Conowingo Dams and the Muddy Run Pumped Storage Station. The lower portion of the Susquehanna River, with the locations of these major dams, is shown in Figure 4.1-2. Peach Bottom Atomic Power Station is located on the westerly shore of Conowingo Pond just north of the Pennsylvania-Maryland border.

River flow statistics for any particular location in the lower Susquehanna River are normally based upon flows measured at the USGS gage at Harrisburg. These flows closely approximate the daily inflow to the Safe Harbor reservoir which is located about 38 miles downriver. Below Safe Harbor the natural river flows are affected by the operation of the hydro-electric dams. The operation of the four hydro plants on the Lower Susquehanna (Safe Harbor, Holtwood, Muddy Run and Conowingo) is coordinated to obtain the best overall use of the water available. Based on predicted flows at Harrisburg, the Conowingo Hydro Plant is scheduled to operate so that Conowingo Pond will be full on Monday morning and lowered by intermittent operation through the week to such a point that it will refill over the following weekend. During an average week the pond may be drawn down 3.0 to 3.5 ft. Figures 4.1-3, 4.1-3 to 4.1-5 show graphically the mass flow patterns in the Conowingo Pond resulting from optimized operations at 2,500, 5,000 and 15,000 cfs. The volume of water entering Conowingo Pond during a week of operation is, in effect, the area under the inflow curves on these figures. In addition, "natural river flows" are computed daily at the Conowingo Station based on the past day's operating records. These calculated values account for all aspects of the operation of Conowingo and Muddy Run but are slightly affected by the limited storage at Safe Harbor and Holtwood.

Flow Duration and 7-Day Low Flow Frequency Curves are presented on Figures 4.1-6 to 4.1-10.

4.2 Water Temperatures

Monthly means and extremes of the average daily water temperature measured at the Safe Harbor Hydroelectric Station, for the period 1936 to 1966 are tabulated on Table 4.2-1. The range of these temperatures is illustrated on Figure 4.2-1.

4.3 Currents

Currents in the Conowingo Pond are governed by the operation of the three hydro-electric plants (Holtwood, Muddy Run and Conowingo) which either discharge into, or withdraw from, the Pond. A preoperational Current Velocity Measurements survey was undertaken in April, May and August 1972. Environmental Devices Corporation. January 1974.

4.4 Depth Contours

Conowingo Pond is approximately 13.5 square miles in surface area and is about 14 miles long. Its width varies from 0.5 to 1.5 miles, and is 1.3 miles wide at the site. The total volume of the Pond is about 310,000 acre-ft. of which about 81,000 acre-ft. are in the top 10 ft. and are usable for generation at Conowingo Hydro Plant. Pond depths vary from 10 to 20 ft. near the site to about 90 ft. at the Conowingo Dam.

Bottom contours of Conowingo Pond in the vicinity of the Peach Bottom site and vertical profiles at the intake and discharge are presented on Figures 4.4-1 and 4.4-2. Bottom contours of all but the upper reaches of the Pond are presented on Figures 4.4 3 through 4.4-6. The silting rate of the Pond has amounted to about 7 ft. in 20 years.

4.5 Flow - Temperature Relationships

The river flow and temperature data previously presented indicate that, in general, the highest water temperatures occur in July whereas the lowest flow rates occur in September. Yearly 7-day low flows and the corresponding average water temperatures, are presented in Table 4.5-1 for the period 1936 to 1966. Median 7-Day Low Flows and temperatures during the low flows for each month are listed in Table 4.5-2.

A more conclusive analysis of the coincident relationship between temperature and flow is presented in Table 4.5-3, a joint probability distribution. The probability of occurrence for any chosen range of temperature and flow can be found directly from this table. This analysis indicates that while daily water temperatures greater than 80° F occurred 12.7% of the time these were coincident with flows less than 2,500 cfs only .06% of the time and coincident with flows less than 5,000 cfs only 2.8% of the time.

TABLE 4.2-1

SUMMARY OF SUSQUEHANNA RIVER TEMPERATURES

(Average Daily River Temperatures at Safe Harbor Hydro Station, 1936 to 1966)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1936	Max.			51.0	58.0	73.0	78.0	87.0	84.0	76.0	67.0	50.0	39.0
	Avg.			38.5	48.5	69.8	74.1	80.6	80.5	72.7	60.9	42.4	33.7
	Min.			32.0	43.0	62.0	68.0	73.0	75.0	68.0	49.0	34.0	32.0
1937	Max.			43.0	55.0	77.0	81.0	87.0	84.0	82.0	71.0	49.0	43.0
	Avg.			37.9	47.7	63.9	77.4	79.8	79.7	70.5	61.4	43.4	34.4
	Min.			33.0	42.0	51.0	74.0	73.0	72.0	64.0	53.0	36.0	32.0
1938	Max.			54.0	66.0	70.0	81.0	84.0	86.0	79.0	65.0	57.0	42.0
	Avg.			41.1	53.3	65.3	75.8	79.9	83.3	70.9	60.7	48.9	36.4
	Min.			32.0	39.0	59.0	67.0	74.0	78.0	62.0	53.0	33.0	32.0
1939	Max.			50.0	59.0	79.0	81.0	82.0	84.0	78.0	69.0	53.0	40.0
	Avg.			40.3	47.8	67.6	78.0	78.6	81.6	73.6	61.0	44.4	36.6
	Min.			36.0	40.0	55.0	75.0	76.0	78.0	70.0	54.0	40.0	32.0
1940	Max.			41.0	54.0	69.0	79.0	88.0	86.0	74.0	64.0	51.0	44.0
	Avg.			34.3	43.9	63.0	73.7	80.0	79.3	70.3	58.3	45.2	35.6
	Min.			32.0	37.0	55.0	64.0	70.0	72.0	64.0	50.0	36.0	33.0
1941	Max.			40.0	66.0	77.0	83.0	84.0	84.0	78.0	72.0	55.0	43.0
	Avg.			34.4	54.0	67.9	74.4	79.8	78.1	74.6	64.7	47.3	37.8
	Min.			32.0	41.0	64.0	67.0	77.0	72.0	70.0	55.0	43.0	33.0
1942	Max.			45.0	62.0	71.0	79.0	82.0	83.0	79.0	64.0	52.0	48.0
	Avg.			39.1	51.5	65.8	74.4	79.1	77.1	74.4	59.2	45.7	34.7
	Min.			33.0	43.0	59.0	68.0	75.0	72.0	63.0	49.0	39.0	32.0
1943	Max.			46.0	54.0	67.0	87.0	85.0	84.0	78.0	64.0	52.0	40.0
	Avg.			38.1	46.1	60.8	77.7	80.7	80.7	71.6	57.8	43.6	35.0
	Min.			32.0	41.0	52.0	65.0	76.0	77.0	65.0	48.0	37.0	32.0
1944	Max.			43.0	52.0	75.0	79.0	84.0	85.0	77.0	66.0	52.0	37.0
	Avg.			36.5	46.3	65.8	73.5	81.1	80.4	72.1	58.6	45.5	33.0
	Min.			32.0	40.0	55.0	69.0	78.0	74.0	67.0	48.0	38.0	32.0
1945	Max.			59.0	64.0	65.0	83.0	86.0	80.0	79.0	66.0	60.0	39.0
	Avg.			43.1	56.7	58.1	72.4	77.8	76.4	72.2	55.5	46.8	35.8
	Min.			32.0	52.0	50.0	59.0	72.0	68.0	61.0	50.0	38.0	32.0
1946	Max.			56.0	63.0	68.0	80.0	83.0	80.0	78.0	68.0	61.0	43.0
	Avg.			43.9	54.5	62.6	69.2	80.6	76.0	74.0	60.8	49.5	36.3
	Min.			32.0	48.0	57.0	61.0	79.0	74.0	72.0	57.0	41.0	32.0
1947	Max.			43.0	54.0	69.0	78.0	81.0	84.0	79.0	65.0	61.0	37.0
	Avg.			35.0	49.6	60.0	70.6	76.5	79.7	73.0	61.9	45.9	33.6
	Min.			32.0	40.0	49.0	66.0	70.0	76.0	60.0	58.0	36.0	32.0
1948	Max.			48.0	58.0	65.0	82.0	82.0	87.0	79.0	68.0	57.0	43.0
	Avg.			40.0	51.0	60.2	73.9	80.2	77.9	74.8	58.6	50.6	37.4
	Min.			34.0	46.0	54.0	64.0	78.0	73.0	68.0	51.0	44.0	32.0
1949	Max.			57.0	60.0	72.0	82.0	88.0	86.0	79.0	70.0	55.0	39.0
	Avg.			42.6	52.7	66.4	76.9	82.4	82.0	70.9	63.6	46.5	35.5
	Min.			36.0	48.0	59.0	66.0	80.0	78.0	63.0	56.0	36.0	33.0
1950	Max.			43.0	55.0	67.0	81.0	80.0	83.0	81.0	64.0	61.0	41.0
	Avg.			35.5	46.4	61.2	73.2	78.9	78.0	69.0	59.2	46.8	35.0
	Min.			32.0	39.0	52.0	67.0	77.0	73.0	56.0	54.0	37.0	32.0
1951	Max.			48.0	62.0	71.0	81.0	83.0	83.0	79.0	69.0	56.0	47.0
	Avg.			41.2	50.7	66.4	73.8	80.7	79.7	73.4	61.7	42.2	36.1
	Min.			38.0	44.0	60.0	64.0	76.0	77.0	68.0	57.0	35.0	32.0
1952	Max.			46.0	61.0	64.0	84.0	87.0	85.0	79.0	70.0	52.0	43.0
	Avg.			40.1	51.4	60.3	75.9	83.6	80.2	74.0	57.9	46.1	37.7
	Min.			36.0	45.0	55.0	65.0	79.0	76.0	69.0	48.0	41.0	32.0

TABLE 4.2-1
SUMMARY OF SUSQUEHANNA RIVER TEMPERATURES (Continued)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1953	Max.			52.0	59.0	70.0	79.0	81.0	82.0	83.0	72.0	64.0	45.0
	Avg.			42.6	51.1	64.4	71.7	78.8	79.0	74.5	66.5	49.8	38.0
	Min.			37.0	44.0	56.0	58.0	76.0	77.0	69.0	64.0	43.0	32.0
1954	Max.			50.0	66.0	74.0	82.0	85.0	85.0	78.0	75.0	54.0	39.0
	Avg.			41.9	54.7	61.3	75.8	79.6	77.9	73.0	63.0	44.3	33.9
	Min.			36.0	45.0	53.0	68.0	77.0	73.0	68.0	52.0	41.0	32.0
1955	Max.			47.0	61.0	77.0	81.0	88.0	86.0	78.0	68.0	54.0	38.0
	Avg.			41.5	53.8	68.2	73.4	85.0	80.6	73.7	60.0	44.8	34.7
	Min.			38.0	43.0	58.0	66.0	79.0	75.0	67.0	50.0	36.0	34.0
1956	Max.			43.0	59.0	70.0	84.0	82.0	81.0	82.0	63.0	61.0	43.0
	Avg.			39.3	46.5	61.3	76.0	77.0	77.3	70.2	59.0	47.8	40.7
	Min.			35.0	42.0	57.0	68.0	73.0	73.0	59.0	54.0	36.0	36.0
1957	Max.			47.0	68.0	73.0	88.0	85.0	86.0	79.0	66.0	50.0	46.0
	Avg.			42.3	50.5	67.1	79.0	80.5	78.9	74.7	58.2	46.3	37.6
	Min.			36.0	42.0	61.0	72.0	77.0	75.0	67.0	50.0	40.0	32.0
1958	Max.			45.0	60.0	70.0	78.0	84.0	81.0	77.0	63.0	52.0	43.0
	Avg.			39.7	49.2	61.5	71.7	80.8	79.3	72.2	58.2	47.3	34.2
	Min.			34.0	41.0	51.0	66.0	75.0	75.0	66.0	50.0	36.0	34.0
1959	Max.			44.0	60.0	81.0	86.0	86.0	86.0	83.0	76.0	52.0	39.0
	Avg.			39.1	50.8	67.6	76.3	82.4	82.3	76.4	64.1	44.3	35.8
	Min.			33.0	43.0	55.0	67.0	80.0	78.0	69.0	52.0	37.0	32.0
1960	Max.			50.0	70.0	67.0	77.0	82.0	82.0	82.0	68.0	52.0	48.0
	Avg.			37.4	52.9	61.2	73.0	79.3	80.5	72.5	60.6	47.3	36.2
	Min.			34.0	41.0	53.0	65.0	77.0	79.0	65.0	50.0	43.0	34.0
1961	Max.			49.0	59.0	66.0	82.0	86.0	84.0	84.0	73.0	59.0	39.0
	Avg.			41.5	46.8	60.0	75.3	81.2	80.2	78.7	62.7	49.6	35.0
	Min.			36.0	41.0	52.0	63.0	76.0	77.0	72.0	55.0	39.0	32.0
1962	Max.			50.0	67.0	81.0	81.0	81.0	80.0	80.0	65.0	49.0	41.0
	Avg.			39.2	48.6	69.3	78.4	78.7	77.9	71.9	61.4	43.9	35.7
	Min.			32.0	41.0	60.0	76.0	76.0	76.0	64.0	50.0	40.0	34.0
1963	Max.			46.0	61.0	68.0	83.0	86.0	83.0	76.0	65.0	56.0	45.0
	Avg.			36.2	52.6	62.9	74.1	79.6	76.7	70.2	63.8	50.3	35.1
	Min.			32.0	44.0	53.0	68.0	75.0	73.0	64.0	57.0	46.0	32.0
1964	Max.			47.0	59.0	74.0	83.0	86.0	83.0	79.0	67.0	55.0	41.0
	Avg.			41.1	49.4	65.6	75.9	82.2	77.5	74.6	58.9	51.6	36.3
	Min.			34.0	41.0	50.0	68.0	77.0	74.0	68.0	55.0	41.0	33.0
1965	Max.			43.0	55.0	74.0	79.0	81.0	83.0	78.0	69.0	51.0	41.0
	Avg.			39.6	49.4	67.5	74.0	78.4	79.2	73.6	59.7	46.5	38.1
	Min.			33.0	42.0	58.0	69.0	75.0	73.0	70.0	51.0	42.0	35.0
1966	Max.			47.0	58.0	70.0	83.0	85.0	82.0	82.0	60.0	52.0	44.0
	Avg.			41.2	48.2	59.2	74.2	81.0	78.8	71.5	57.4	46.3	36.4
	Min.			37.0	42.0	51.0	65.0	77.0	76.0	60.0	53.0	40.0	33.0
Total Period	Max.	37.5*	38.0*	59.0	70.0	81.0	88.0	88.0	87.0	84.0	76.0	64.0	48.0
	Avg.	35.2*	35.8*	39.5	50.2	63.9	74.6	80.1	79.3	72.9	60.5	46.5	35.9
	Min.	32.0*	32.0*	32.0	37.0	50.0	58.0	70.0	68.0	56.0	48.0	33.0	32.0

* from Table V of Peach Bottom Units 2 and 3 Design Engineers Report; Sept. 16, 1968; daily data for Jan. and Feb. is not presently available.

TABLE 4.5-1

7-DAY LOW FLOWS AND CORRESPONDING TEMPERATURES

SUSQUEHANNA RIVER

Year	Date	7-Day Low Flow (cfs)*	Average Temperature (°F)**
1936	September 19-25	3204	72.6
1937	October 5-11	5960	62.4
1938	September 7-13	3751	74.4
1939	September 23-29	2051	70.6
1940	August 21-27	4409	75.9
1941	September 27-October 3	2493	70.7
1942	September 4-10	6260	76.6
1943	September 24-30	2653	66.4
1944	September 6-12	3400	73.7
1945	August 18-24	7467	78.4
1946	September 12-18	5306	74.6
1947	October 22-28	3850	64.1
1948	September 23-29	3193	70.6
1949	August 23-29	4251	78.7
1950	August 13-19	5889	77.4
1951	September 27-October 3	3619	68.7
1952	November 6-12	3323	44.9
1953	August 28-September 3	2840	81.9
1954	September 13-19	3714	72.7
1955	August 2-8	2821	85.0
1956	October 17-23	9964	60.3
1957	September 3-9	3211	76.4
1958	October 17-23	6976	58.4
1959	September 24-30	2583	71.9
1960	September 5-11	4830	80.3
1961	October 26-November 1	3069	56.4
1962	August 2-8	2783	78.7
1963	October 19-25	2163	63.6
1964	September 22-28	1786	70.1
1965	July 25-August 1	2636	80.1
1966	August 28-September 3	2383	81.0

* flows at USGS gage in Harrisburg.

** average 7-day temperature at Safe Harbor Hydro Station.

TABLE 4.5-2

MEDIAN 7-DAY LOW FLOWS AND TEMPERATURES

SUSQUEHANNA RIVER

Month	7-Day Low Flow (cfs)* Median/Lowest	Ave. Temperature during ** 7-Day Low Flow (°F) Median/Highest
January	13910 3240	
February	14400 4410	
March	26030 6500	36.6 57.0
April	31940 13460	54.9 64.6
May	19790 8080	67.9 77.7
June	11430 4220	78.7 83.9
July	7610 2640	81.0 86.6
August	5120 2470	78.7 85.0
September	4690 1790	71.9 82.4
October	5770 2010	63.3 73.0
November	10400 2030	49.9 63.7
December	12210 2190	34.0 42.7

* based on flows at the USGS gage in Harrisburg (1891-1973)

** based on temperatures at Safe Harbor Hydro Station (1936-1966). daily temperatures for January & February are not presently available.

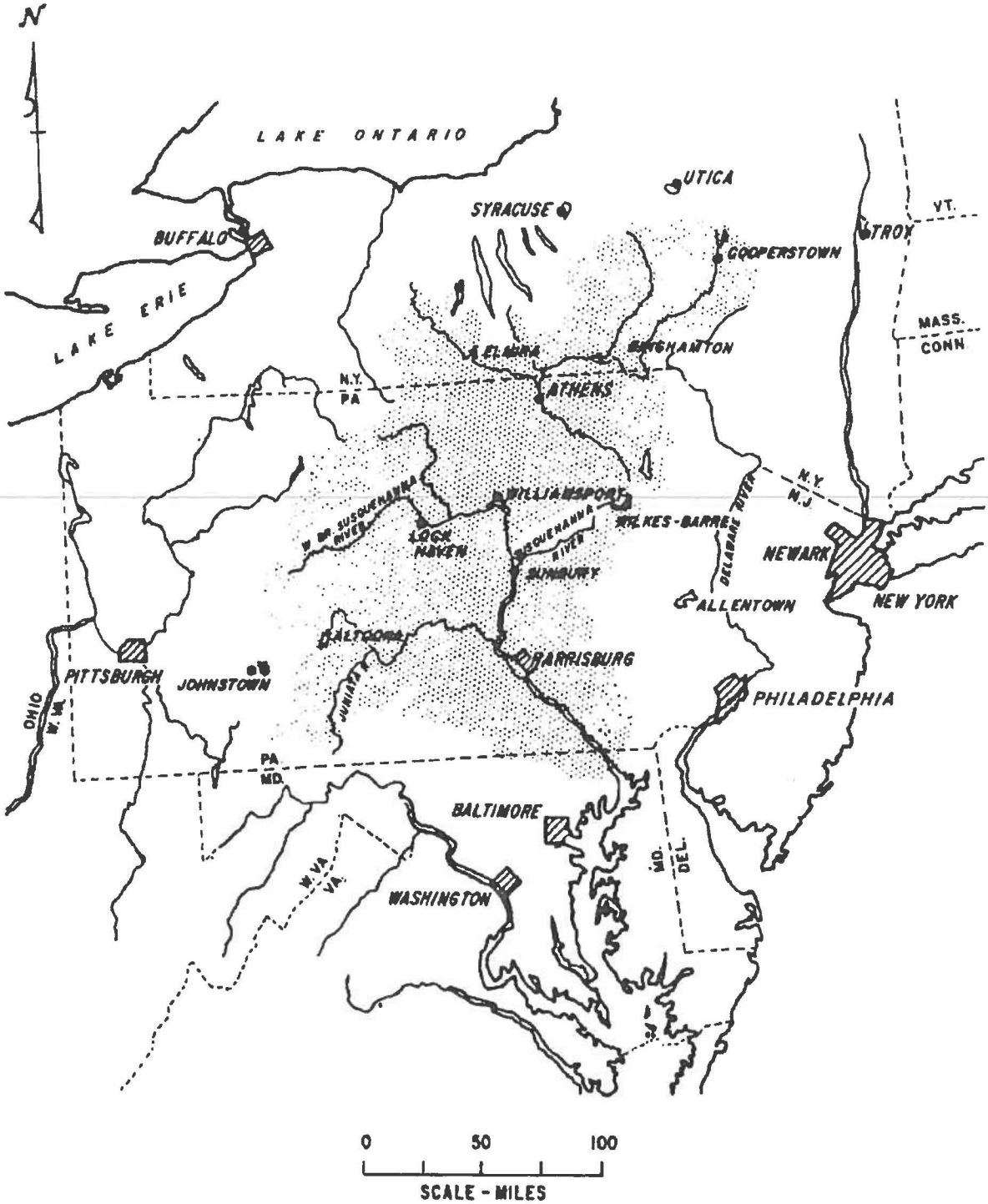
TABLE 4.5-3

JOINT PROBABILITY DISTRIBUTION FOR 7-DAY AVERAGE FLOWS AND TEMPERATURES*

SUSQUEHANNA RIVER

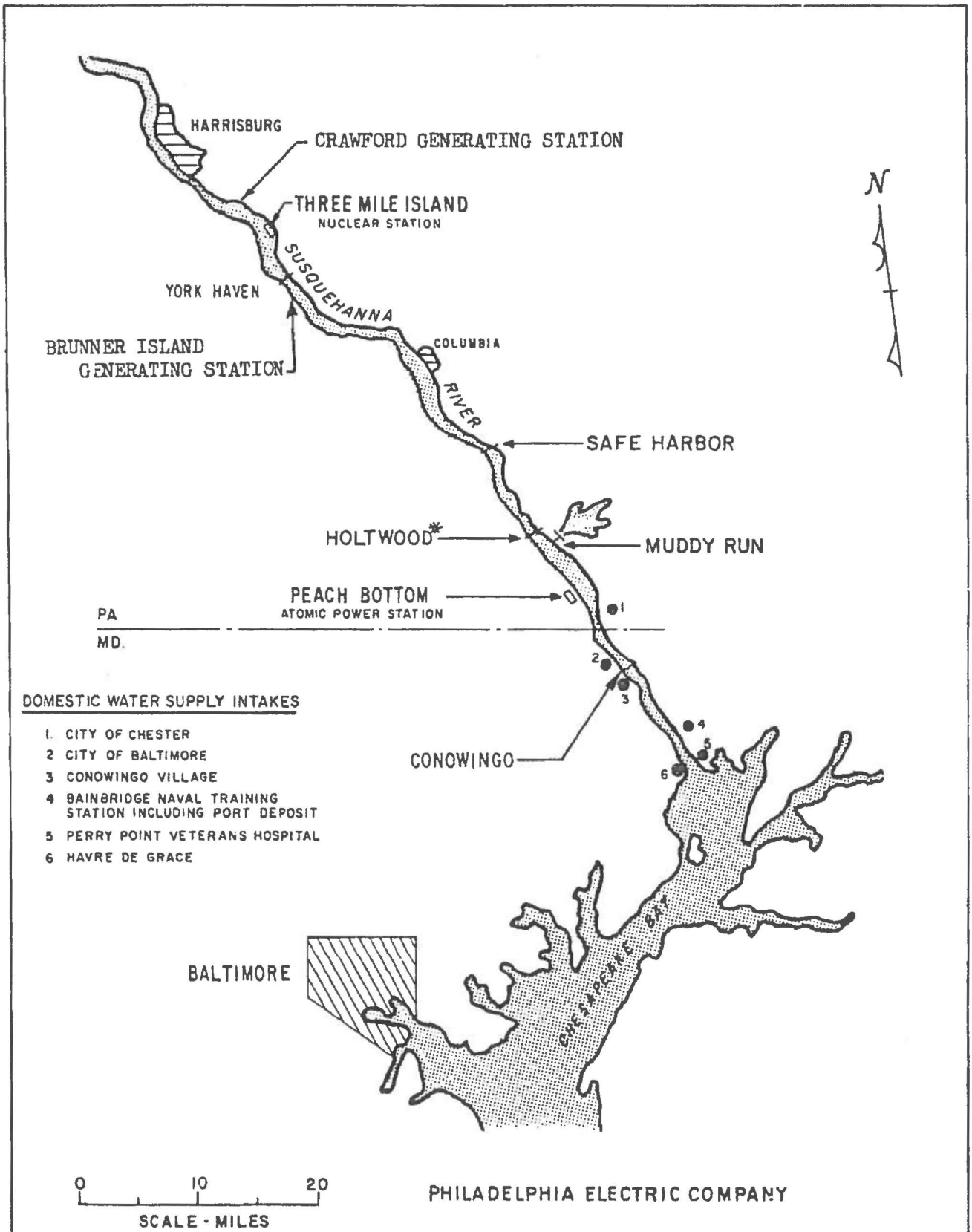
River Flow - cfs	Temperature - °F: 30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 85	>85	7-Day Average Flow Distribution
< 2,500	0	.309	.451	.283	.371	.044	0	1.458%
2,500 - 4,999	.080	.592	1.175	2.165	5.276	1.856	.177	11.321%
5,000 - 9,999	2.589	1.688	2.033	2.307	5.647	3.889	.247	18.400%
10,000 - 14,999	4.216	1.441	.831	.954	4.278	1.821	.283	13.824%
15,000 - 19,999	3.818	.919	.486	1.025	2.846	.725	.009	9.829%
20,000 - 29,999	4.940	1.865	1.131	2.165	2.430	.327	0	12.856%
30,000 - 39,999	3.526	1.494	.981	1.821	1.087	.018	0	8.927%
40,000 - 49,999	2.333	1.370	1.228	.999	.362	0	0	6.292%
50,000 - 74,999	4.030	2.961	2.678	1.326	.194	0	0	11.189%
≥ 75,000	2.015	2.298	.972	.583	.027	0	0	5.895%
7-Day Ave. Temp Distribution	27.547%	14.937%	11.966%	13.628%	22.518%	8.662%	.716%	

* based on average daily USGS river flows for Harrisburg and average daily temperatures at Safe Harbor Hydro Station (1936-1966).



PHILADELPHIA ELECTRIC COMPANY

SUSQUEHANNA RIVER BASIN
FIGURE 4.1-1

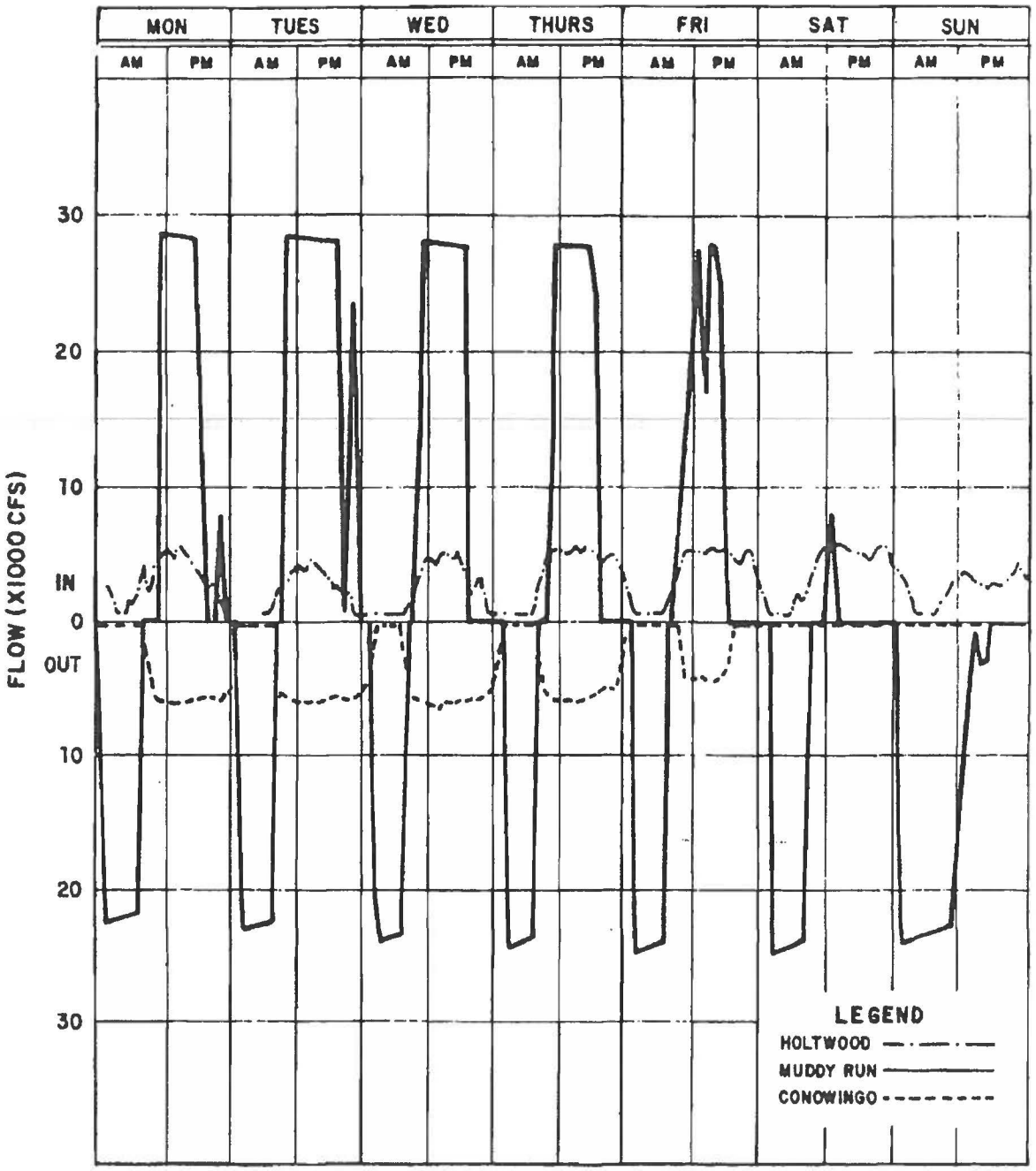


PHILADELPHIA ELECTRIC COMPANY

LOWER SUSQUEHANNA RIVER HYDRO PLANTS AND OTHER WATER UTILIZING FACILITIES

FIGURE 4.1-2

*(includes thermal generation)



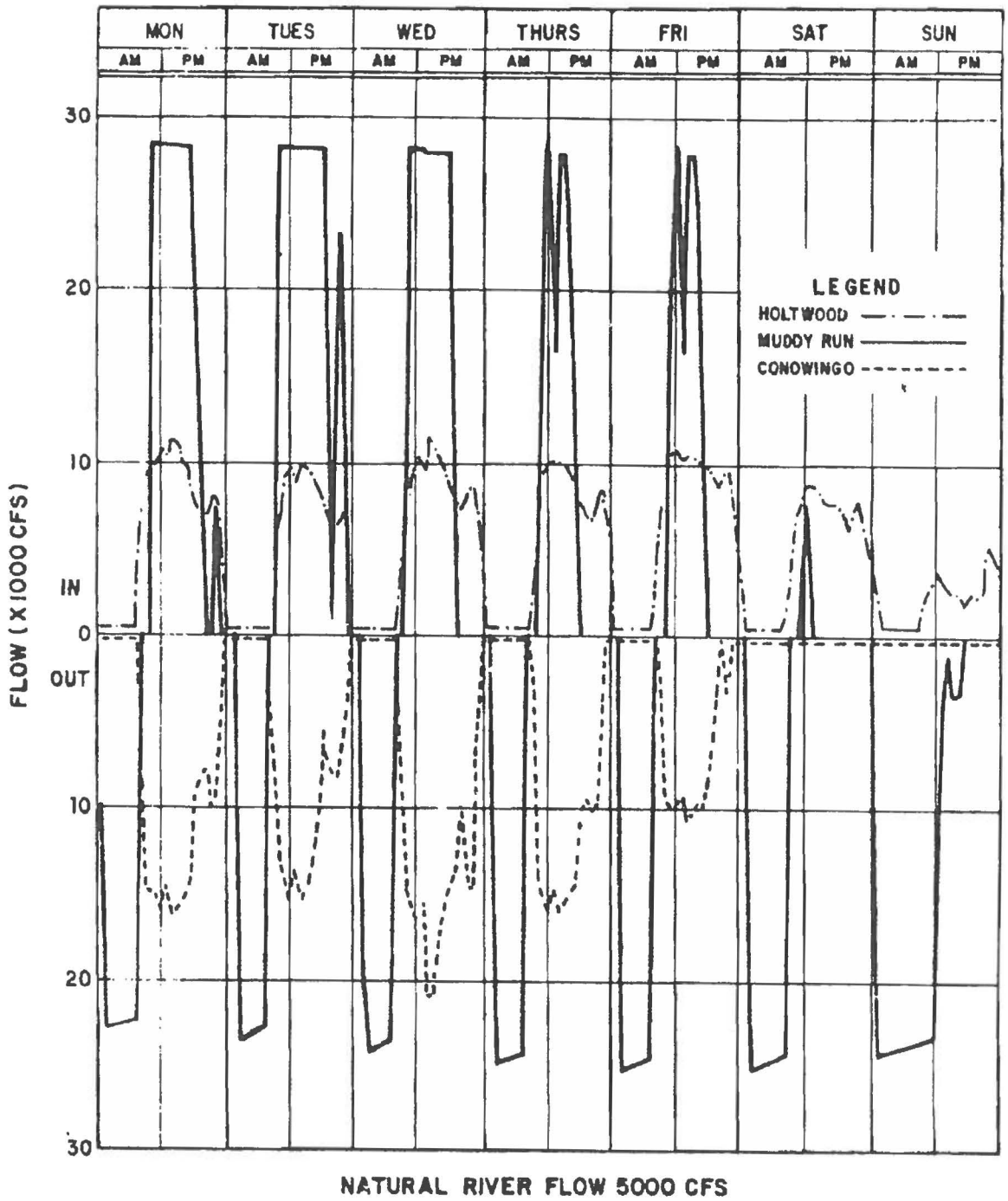
NATURAL RIVER FLOW 2500 CFS

PHILADELPHIA ELECTRIC COMPANY

NOTE: THIS IS A TYPICAL SCHEDULE BASED ON NATURAL RIVER FLOW

INFLOW AND DISCHARGE AT CONOWINGO POND

FIGURE 4.1 – 3

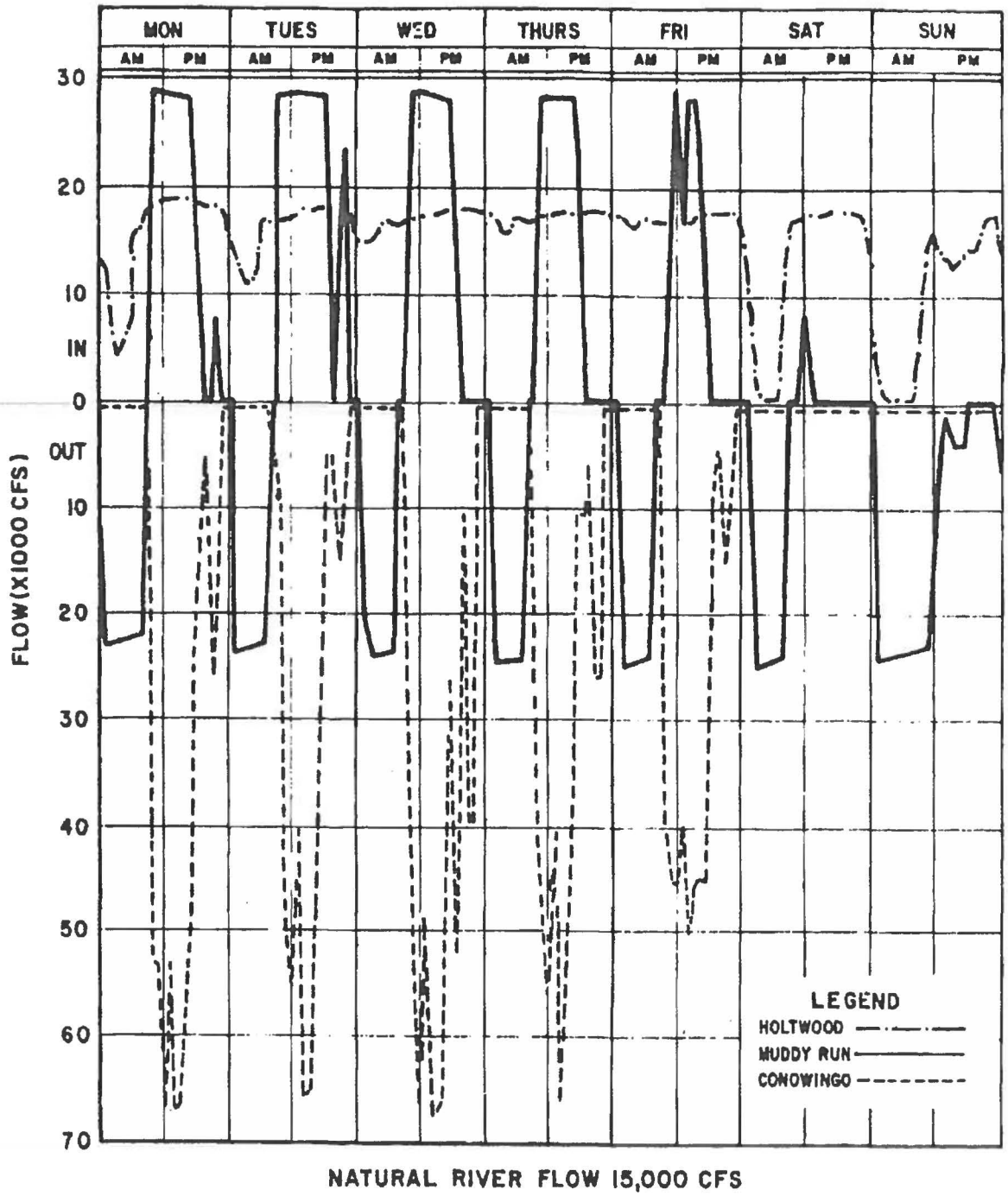


PHILADELPHIA ELECTRIC COMPANY

NOTE: THIS IS A TYPICAL SCHEDULE BASED ON NATURAL RIVER FLOW

INFLOW AND DISCHARGE AT CONOWINGO POND

FIGURE 4.1-4

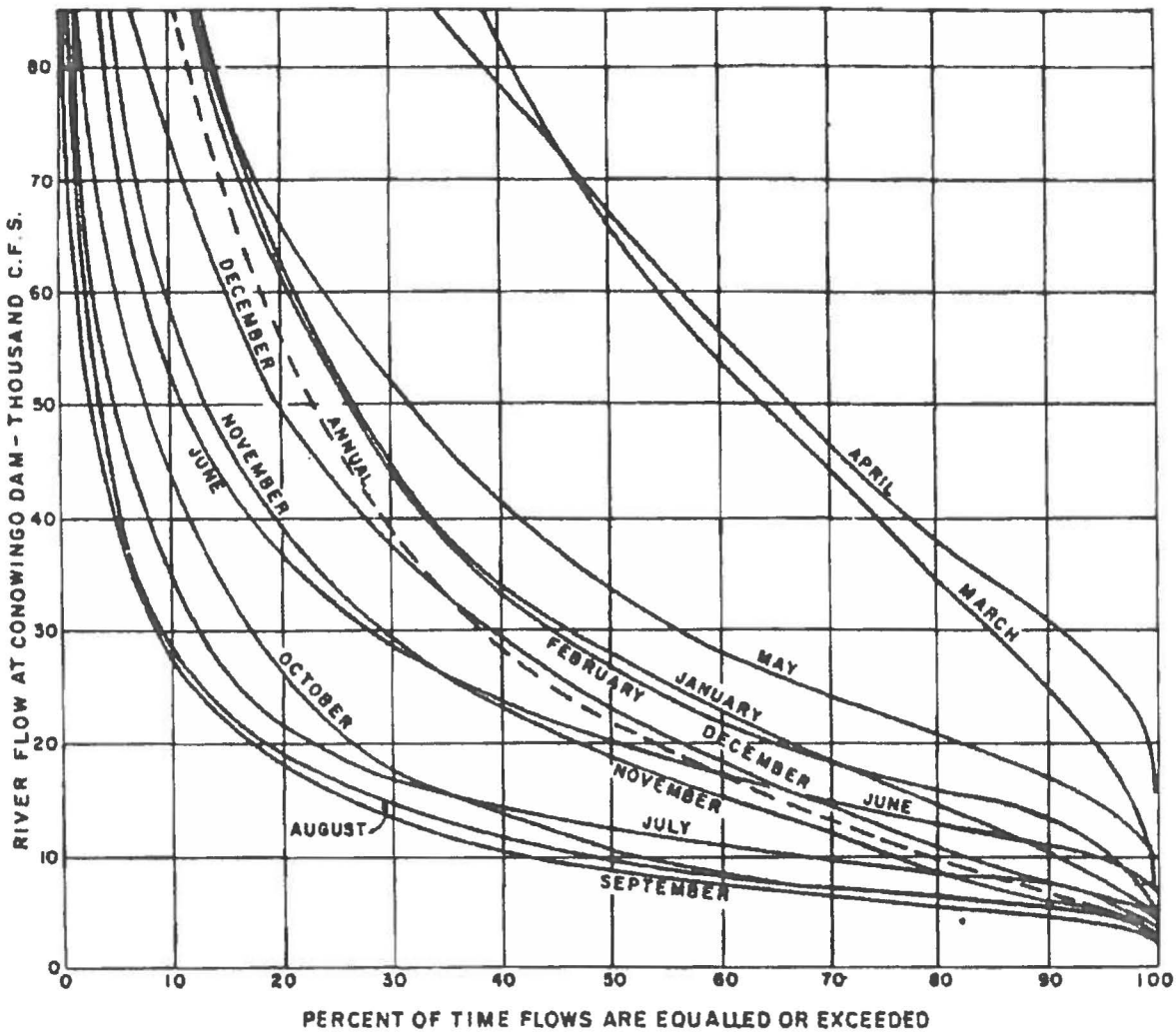


PHILADELPHIA ELECTRIC COMPANY

NOTE: THIS IS A TYPICAL SCHEDULE BASED ON NATURAL RIVER FLOW

INFLOW AND DISCHARGE AT CONOWINGO POND

FIGURE 4.1-5



PERIOD: 1929-1969

PHILADELPHIA ELECTRIC COMPANY

FLOW DURATION CURVES
SUSQUEHANNA RIVER
AT CONOWINGO DAM

FIGURE 4.1-6

SOURCE: CONOWINGO HYDRO PLANT

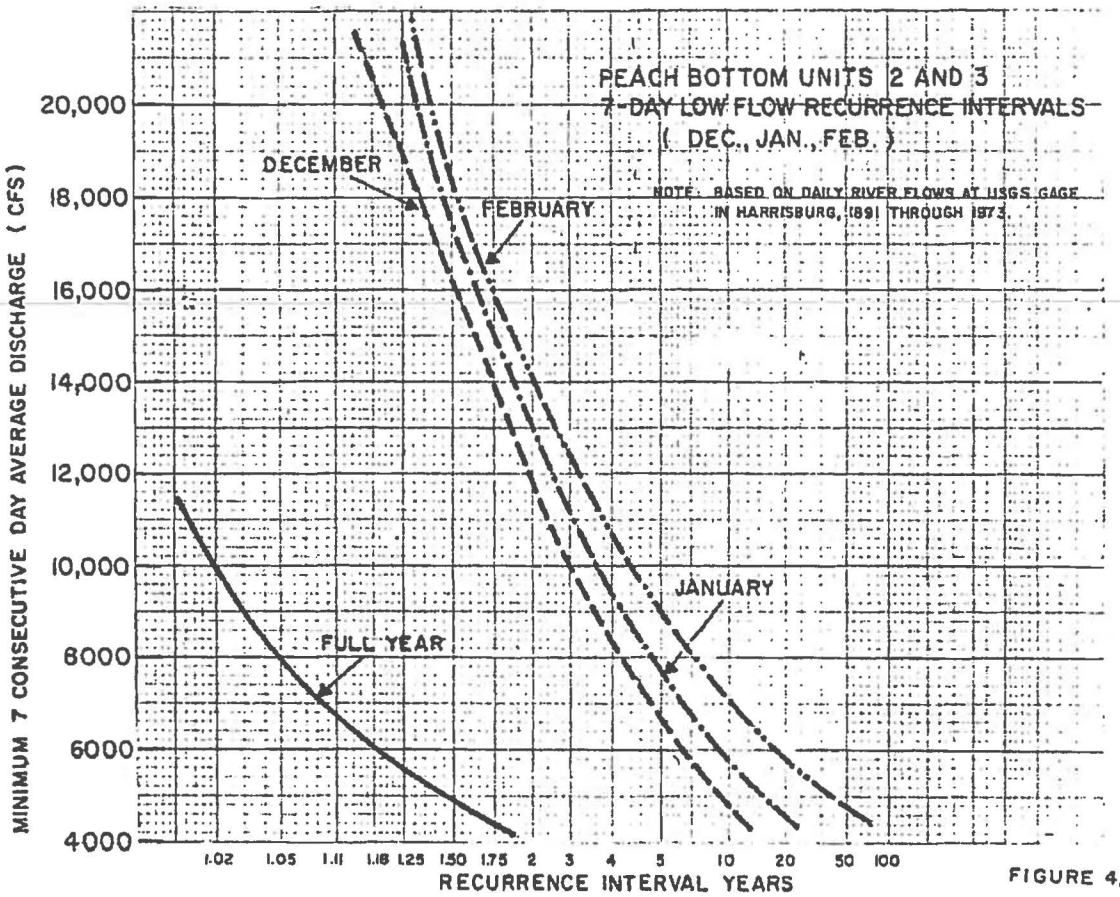

PEACH BOTTOM UNITS 2 AND 3
7-DAY LOW FLOW RECURRENCE INTERVALS
(DEC., JAN., FEB.)
NOTE: BASED ON DAILY RIVER FLOWS AT USGS GAGE IN HARRISBURG, 1891 THROUGH 1973.
DECEMBER
FEBRUARY
JANUARY
FULL YEAR
MINIMUM 7 CONSECUTIVE DAY AVERAGE DISCHARGE (CFS)
20,000
18,000
16,000
14,000
12,000
10,000
8000
6000
4000
1.02
1.05
1.11
1.18
1.25
1.50
1.75
2
3
4
5
10
20
50
100
RECURRENCE INTERVAL YEARS

FIGURE 4.1-7

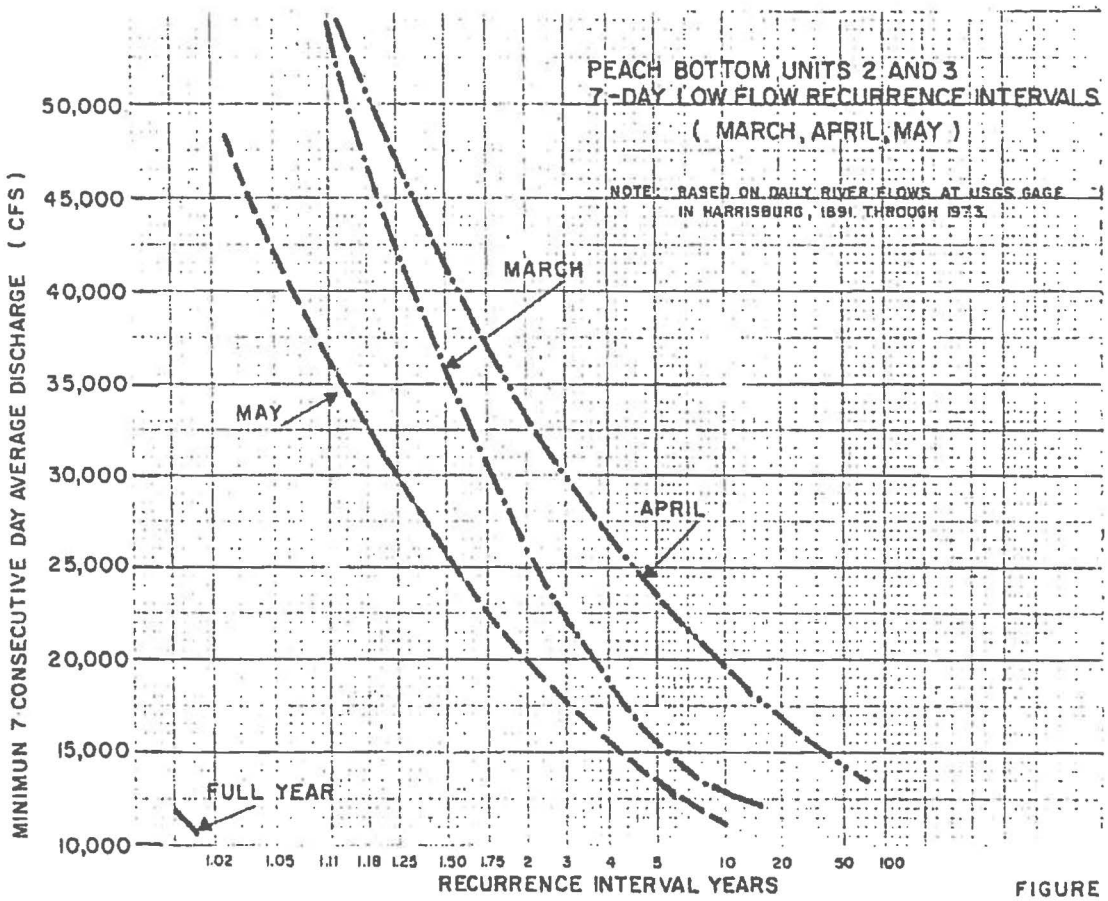

PEACH BOTTOM UNITS 2 AND 3
7-DAY LOW FLOW RECURRENCE INTERVALS
(MARCH, APRIL, MAY)
NOTE: BASED ON DAILY RIVER FLOWS AT USGS GAGE IN HARRISBURG, 1891 THROUGH 1973
MARCH
MAY
APRIL
FULL YEAR
MINIMUN 7-CONSECUTIVE DAY AVERAGE DISCHARGE (CFS)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
1.02
1.05
1.11
1.18
1.25
1.50
1.75
2
3
4
5
10
20
50
100
RECURRENCE INTERVAL YEARS

FIGURE 4.1-8

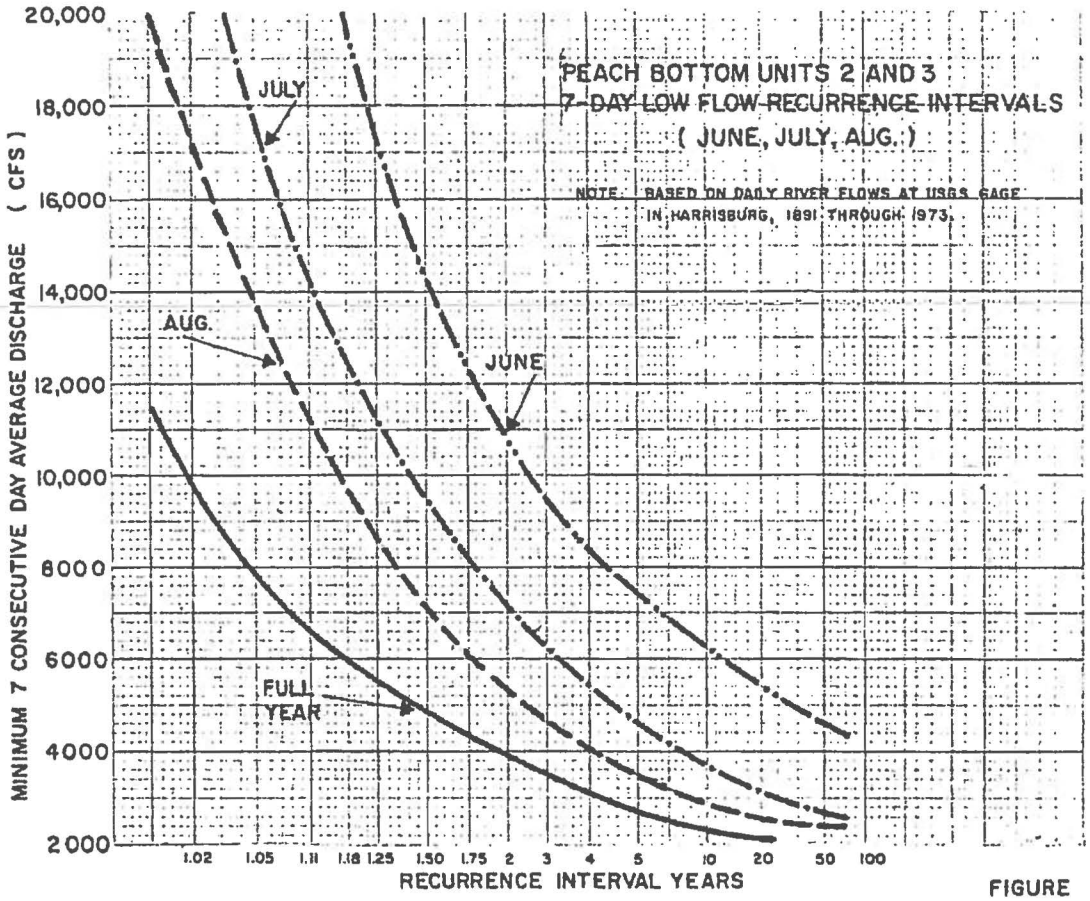

PEACH BOTTOM UNITS 2 AND 3
7-DAY LOW FLOW RECURRENCE INTERVALS
(JUNE, JULY, AUG.)
NOTE: BASED ON DAILY RIVER FLOWS AT USGS GAGE IN HARRISBURG, 1891 THROUGH 1973.
JULY
AUG.
JUNE
FULL YEAR
MINIMUM 7 CONSECUTIVE DAY AVERAGE DISCHARGE (CFS)
20,000
18,000
16,000
14,000
12,000
10,000
8000
6000
4000
2000
1.02
1.05
1.11
1.18
1.25
1.50
1.75
2
3
4
5
10
20
50
100
RECURRENCE INTERVAL YEARS

FIGURE 4.1-9

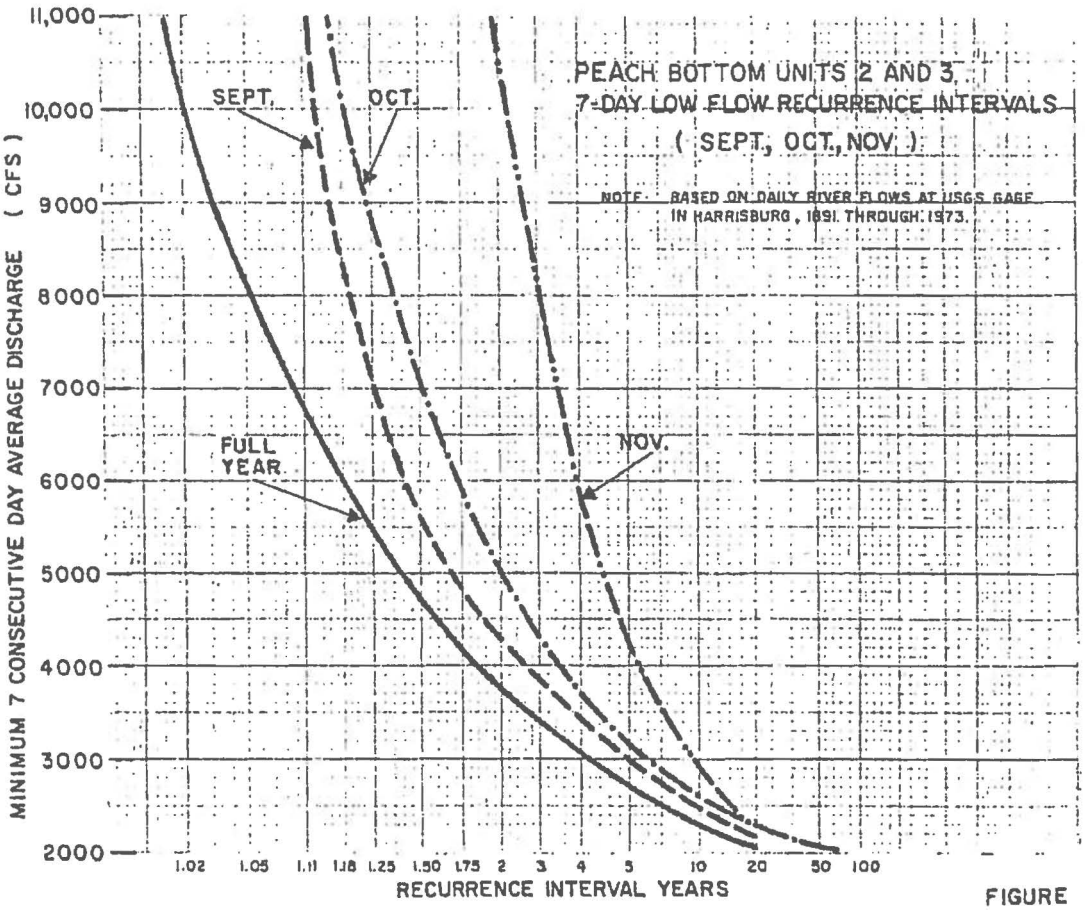

PEACH BOTTOM UNITS 2 AND 3
7-DAY LOW FLOW RECURRENCE INTERVALS
(SEPT., OCT., NOV.)
NOTE: BASED ON DAILY RIVER FLOWS AT USGS GAGE IN HARRISBURG, 1891 THROUGH 1973.
SEPT.
OCT.
NOV.
FULL YEAR
MINIMUM 7 CONSECUTIVE DAY AVERAGE DISCHARGE (CFS)
11,000
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1.02
1.05
1.11
1.18
1.25
1.50
1.75
2
3
4
5
10
20
50
100
RECURRENCE INTERVAL YEARS

FIGURE 4.1-10

RANGE OF AVERAGE DAILY RIVER TEMPERATURES

Susquehanna River at Safe Harbor Hydro Station
(1936 - 1966)

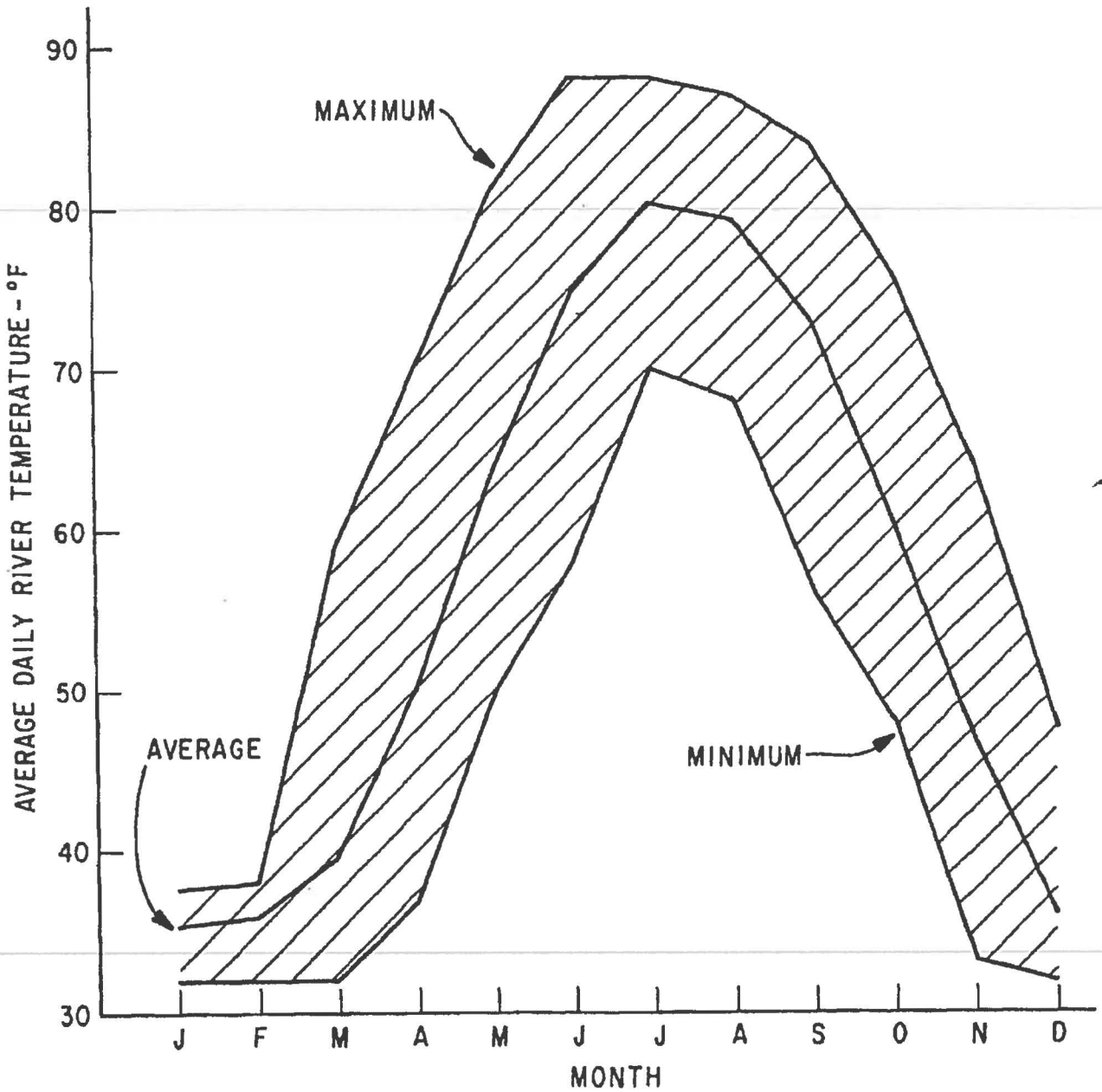


FIGURE 4.2-1

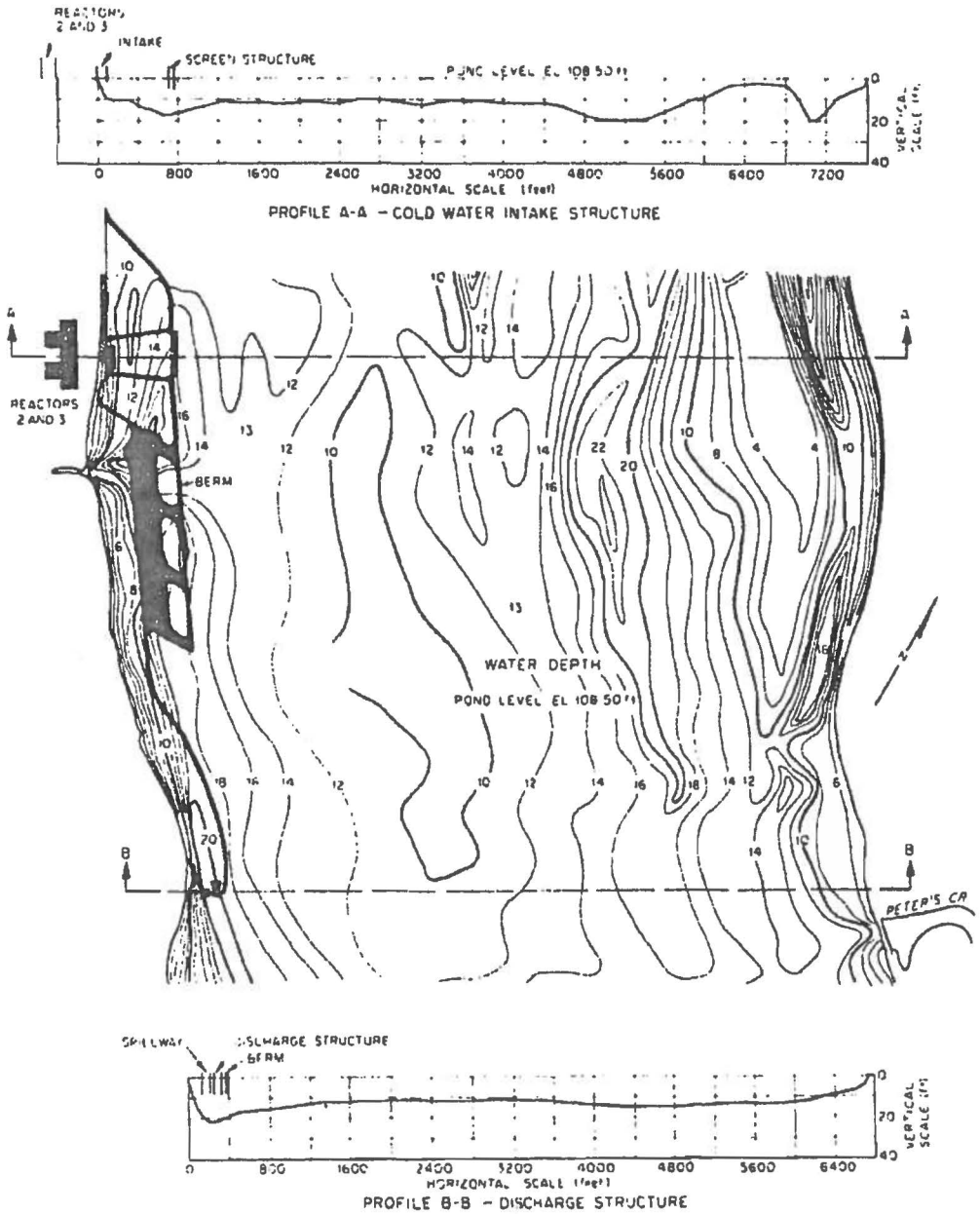
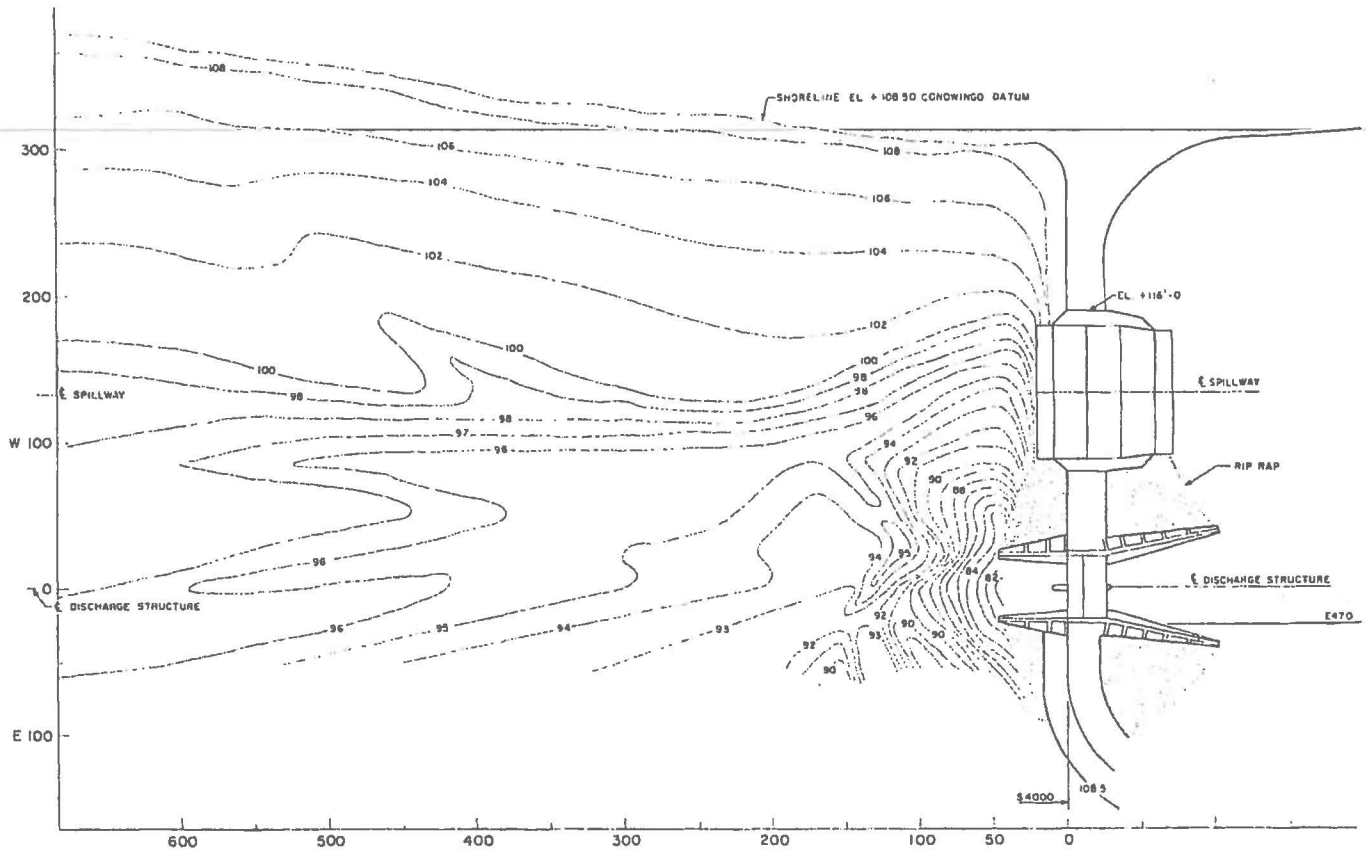


Fig 4.4-1 Bottom contours of Conowingo Pond at the Peach Bottom site, with vertical profiles shown for the points of intake and discharge.

Note: based on 1967 survey.



TOPOGRAPHY
VICINITY OF PEACH
BOTTOM ATOMIC POWER
STATION DISCHARGE STRUCTURE
NOVEMBER 19 - 1973

300 200 100 50 0
SCALE: 1" = 50'

FIGURE 4.4-2

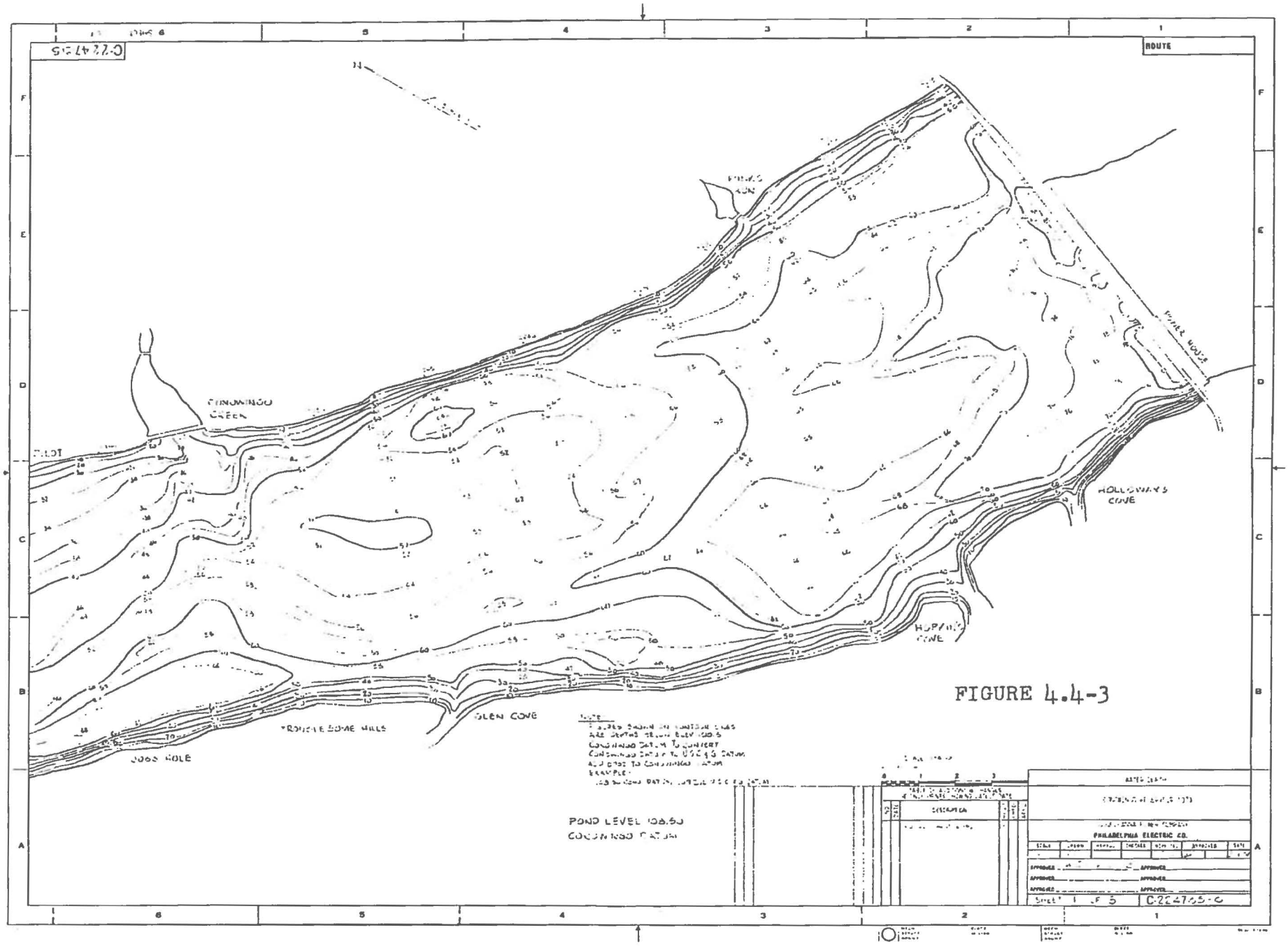

ROUTE
CONOWINGO CREEK
HOLLOWAYS COVE
GLEN COVE
POND LEVEL 108.50
PHILADELPHIA ELECTRIC CO.

FIGURE 4.4-3

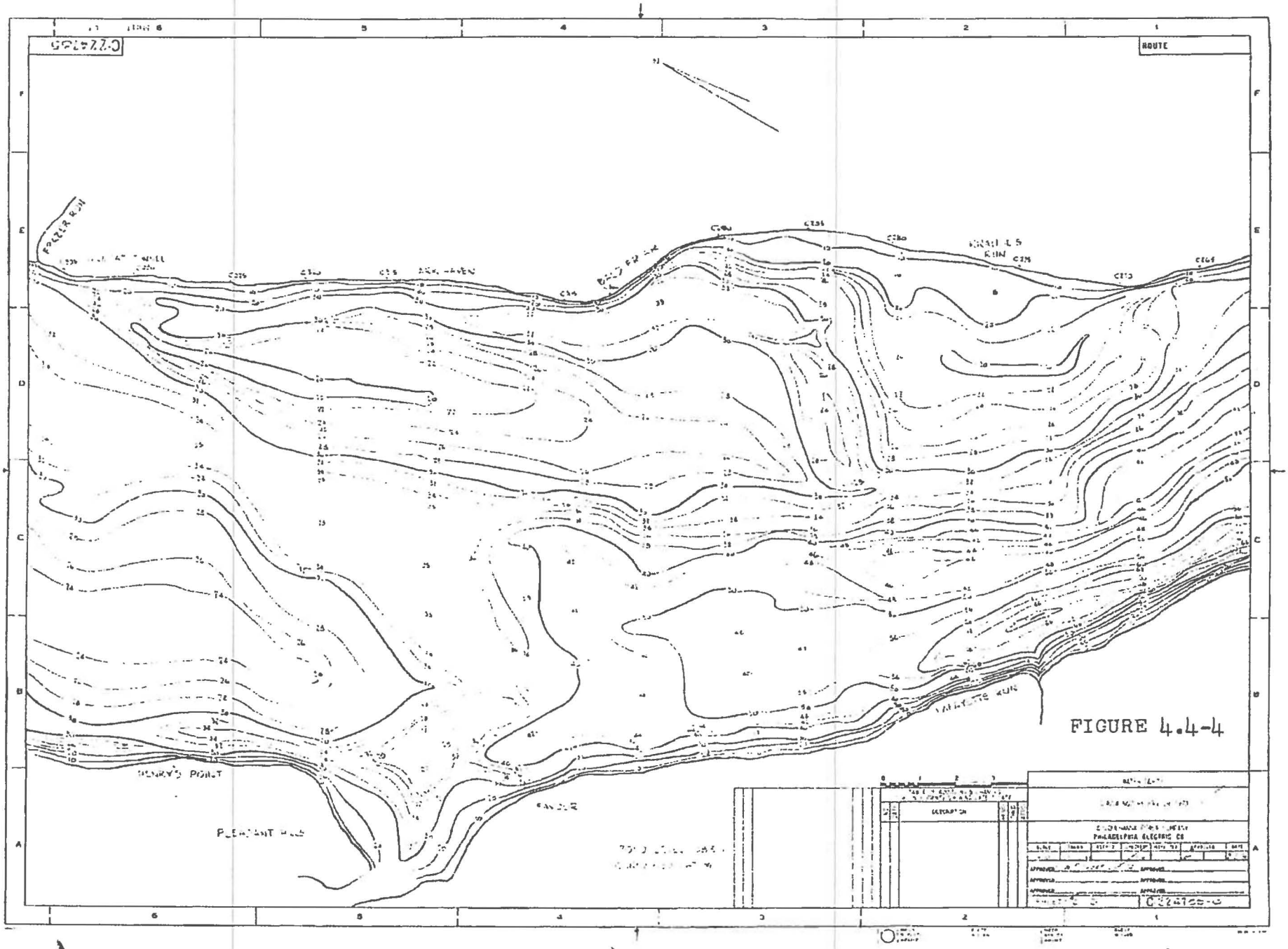

ROUTE
FRAZER RUN
HENRY'S POINT
PLEASANT HILL
FRAZER
CHARLES RUN
VALLEYSTONE RUN
PHILADELPHIA ELECTRIC CO

FIGURE 4.4-4

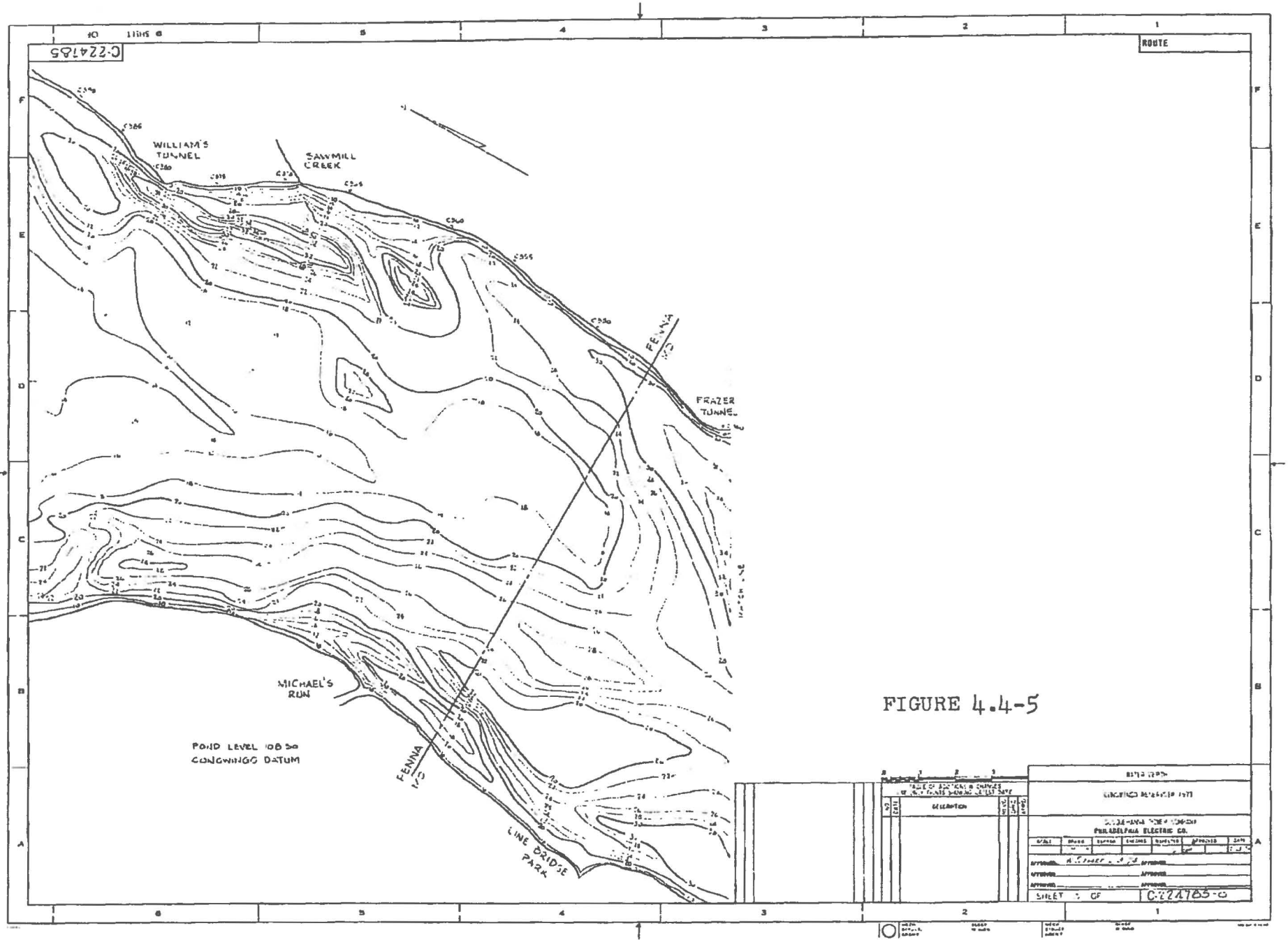

ROUTE
C-224185
WILLIAM'S TUNNEL
SAWMILL CREEK
FENNA
FRAZER TUNNEL
MICHAEL'S RUN
POND LEVEL 1085
CONOWINGO DATUM
FENNA
LINE BRIDGE PARK
PHILADELPHIA ELECTRIC CO.
SHEET 1 OF
C-224185-0

FIGURE 4.4-5

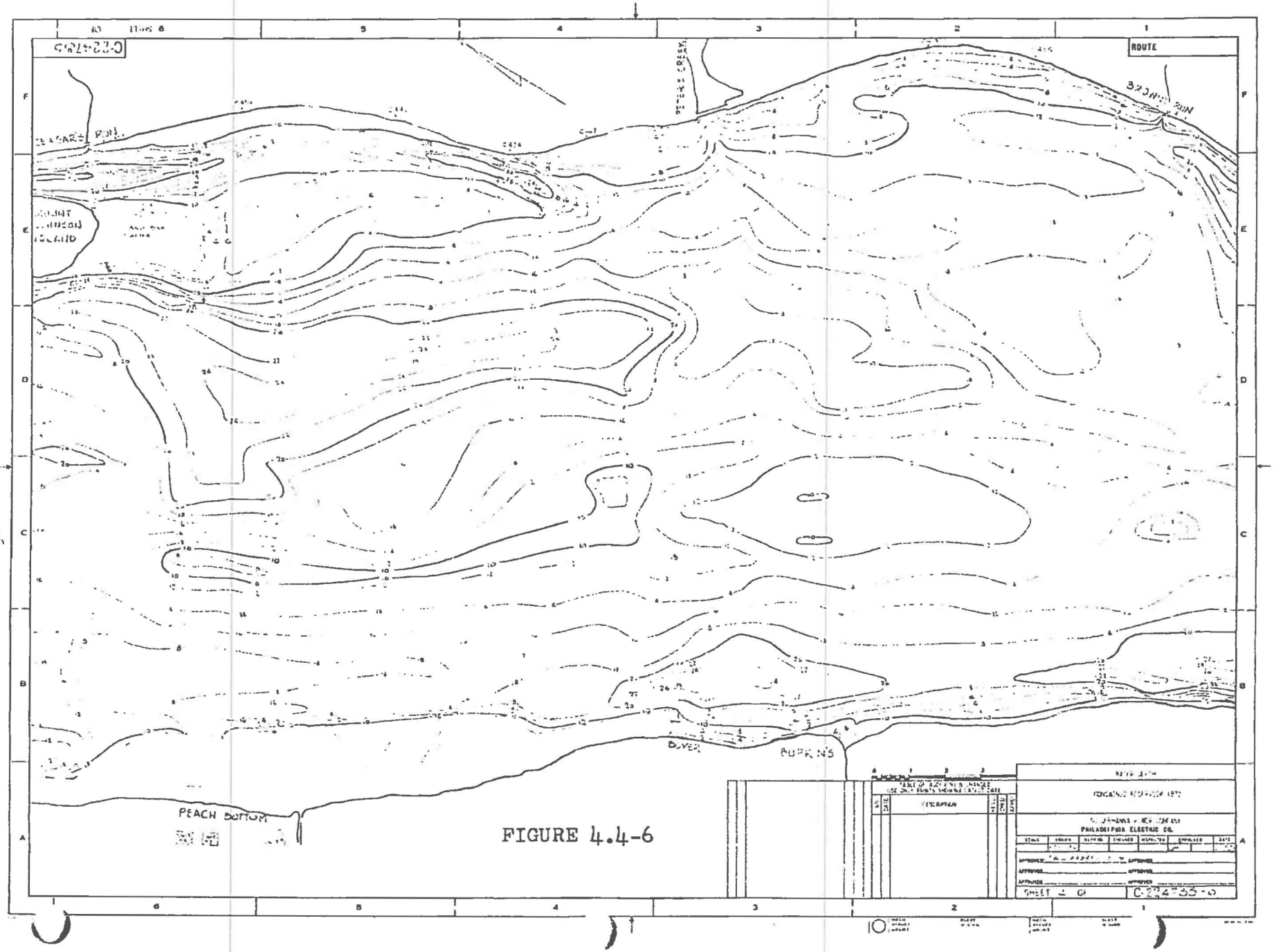

ROUTE
PEACH BOTTOM
BURKINS
DYER
PHILADELPHIA ELECTRIC CO.
SHEET 1 OF
C-224-55-0

FIGURE 4.4-6

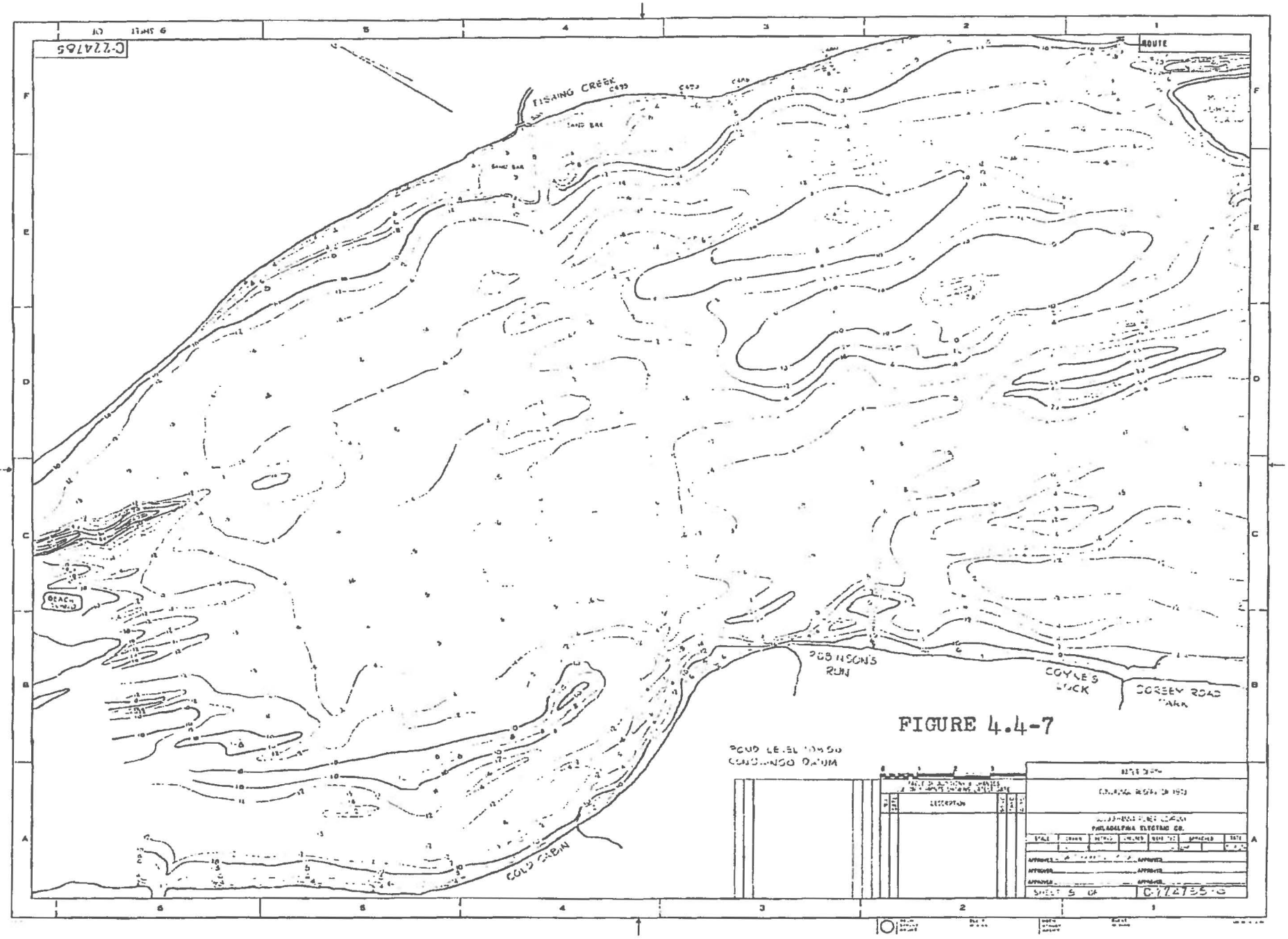

C-772765
ROUTE
TISAING CREEK
SAND BAR
BEACH
ROBINSON'S RUN
COYLE'S LOCK
SCREEN ROAD
COLD CABIN
POND LEVEL 104.50
CONSTANT DATUM
PHILADELPHIA ELECTRIC CO.
SHEET 5 OF
C-772765-G

FIGURE 4.4-7

5.0 METEOROLOGICAL DATA FOR ENERGY BUDGET CALCULATIONS

The basic meteorological data used for the analysis of cooling tower and pond thermal performance studies were developed from data taken at the site, with the exception of solar radiation which was taken from Climatic Atlas of the United States. Dry-bulb temperatures, relative humidity, wet-bulb temperatures, and wind speed data were analyzed for the period from August 1967 through March 1972 for several locations and elevations. The data used for these performance studies are shown in Table 5.0-1.

Table 5.0-1

Peach Bottom Units 2 and 3

Monthly Meteorological Data

Month	Occurence	Dry Bulb Temp.(°F)	Relative Humidity (%)	Wet-Bulb Temp.(°F)	Wind Speed (mph) at 50 ft.	Wind Speed (mph) at 25 ft.	Solar Radiation (Langleys/day)
January	ave.	27.0	75.0	25	8.5	6.7	160
	50%			30			
	5%			40			
February	ave.	30.0	70.2	27	7.6	6.0	225
	50%			30			
	5%			44			
March	ave.	38.1	68.5	34.5	8.2	6.5	315
	50%			35			
	5%			51			
April	ave.	50.0	67.9	45	8.3	6.6	400
	50%			45			
	5%			62			
May	ave.	60.0	76.2	56	6.7	5.3	480
	50%			55			
	5%			68			
June	ave.	70.9	81.8	67	6.3	5.0	525
	50%			65			
	5%			73			
July	ave.	75.3	82.1	71	5.5	4.3	510
	50%			68			
	5%	76.0	89.0	74		3.4	610
August	ave.	71.8	84.1	68	4.5	3.5	450
	50%			68			
	5%			74			
September	ave.	62.8	86.7	60.5	5.1	4.0	380
	50%			61			
	5%			73			
October	ave.	54.3	84.4	52	5.7	4.5	270
	50%			50			
	5%			65			
November	ave.	42.9	81.5	40.5	6.0	4.7	160
	50%			40			
	5%			56			
December	ave.	34.9	78.5	32.5	8.2	6.5	130
	50%			30			
	5%			47			

6.0 THERMAL PLUME CHARACTERISTICS

6.1 Predicted Isotherms

Temperature distributions in the Conowingo Pond resulting from the heat rejection from Peach Bottom Units 2 and 3 have been predicted based on the analysis of physical model studies conducted at Alden Research Laboratories of Worcester Polytechnic Institute. Tests were conducted to simulate various river flows and associated pond operating schedules, river temperatures and plant operating conditions. A detailed description of the studies and the resultant predicted isotherms is contained in Elder, et.al. (1973). Studies of the effect of a sudden plant shutdown are included.

The state-of-the-art in physically modeling and theoretically analyzing thermal problems such as associated with the Peach Bottom project makes exact predictions of temperature patterns impossible. The ambient pond temperature will vary with fluctuating meteorological and flow conditions, however, the predicted excess temperature distributions should still be representative of those that will be experienced for the range of conditions studies.

6.2 Observed Isotherms

In order to obtain an overall analysis of the extent and magnitude of the thermal plume, boat surveys are conducted on a regular basis. Selected isotherm maps of the thermal conditions in the Pond during PBAPS operation are provided in Figures 6.2-1 to 6.2-8. These figures were selected from each season at times when the river flow was lowest and PBAPS power levels were the highest. In this manner an overview of the "worst case" conditions can be obtained.

All isotherm survey plots have been provided on a monthly basis to the U.S. Nuclear Regulatory Commission, the Commonwealth of Pennsylvania Department of Environmental Resources and the State of Maryland Department of Natural Resources. For convenience, they have been resubmitted with this document as supporting references, PECo, Monthly Report Nos. 8 through 23, thermal and Biological Monitoring Programs. Monthly report No. 13 begins address the biological effects due to the measured thermal impact.

6.3 Plume Velocity Distribution

Typical surface plume velocity measurements taken at the surface, 5 ft and 10 ft depths are shown on Figures 6.3-2, 6.3-4 and 6.3-6 respectively. In order to provide an indication of the

location of the thermal plume, isotherm plots, taken at the same time are given on Figures 6.3-1, 6.3-3 and 6.3-5. Centerline plume velocity vs. distance from the jet discharge is plotted on Figure 6.3-7.

6.4 Other Thermal Effluents

There are four thermal generating stations on the Susquehanna River between Harrisburg and Peach Bottom (Crawford, Three Mile Island, Brunner Island, Holtwood). The locations of these stations are shown on Figure 4.1-2 and their rates of thermal discharge are listed in Table 6.4-1.

The excess temperature caused by the thermal effluents of the Crawford, Three Mile Island, and Brunner Island Generating Stations is entirely dissipated by the time the water reaches Peach Bottom even during the 7-Day, 10-Year recurrence low flow. The Holtwood Steam Generating Station is located adjacent to the Holtwood Hydro Electric Station, about 4 miles upstream from Peach Bottom. Under steady-state low flow conditions, without Muddy Run operating, the thermal discharge from Holtwood could account for as much as 0.5° F temperature increase at Peach Bottom. However, in reality, the operating cycles of Muddy Run complicate the flow patterns in the upper reaches of the Pond and serve to dissipate this excess temperature before it reaches Peach Bottom.

At low river flows when Muddy Run is pumping (24,000 cfs) river flows are toward Muddy Run from both upstream and downstream. When Muddy Run is generating (28,000 cfs), the remaining excess temperature in the Conowingo Pond from upstream is effectively being diluted by flows several times greater than the natural river flow. Figure 4.1-3 illustrates the order of magnitude of these flows and the scheduling of hydroelectric station operations for 2500 cfs river flow. Because of the complicated hydraulics and its interrelationship with holding time and dilution, it is impossible to accurately predict what temperature excess caused by Holtwood could be expected at Peach Bottom. A conservative estimate would be considerably less than the 0.5° F mentioned above.

TABLE 6.4-1

THERMAL GENERATING STATIONS BETWEEN

HARRISUBRG, PA. AND PEACH BOTTOM

Station	Distance above P.B. (miles)	Generating Capacity (MW_e)	Heat Rejected (10^6 Btu/hr.)
Crawford	39.8	117	831
Three Mile Island	35.8	1770	54
Brunner Island	31.8	1454	6836
Holtwood (thermal generation only)	4.0	73	674

SMALL BOAT SURVEY SUMMARY SHEET

DATE: Tues. (Day) August (Month) 20 (Date) 1974 (Year) TIME: Start 0900 Hours (E.S.T.)
Finish 1445 Hours (E.S.T.)

HYDRAULIC DATA

Pond Elevation:
Start 107.45 CFS Finish 108.18 CFS

Average (24 Hr) Flows:
Natural River 5,300 CFS Conowingo Inflow 5,125 CFS

Conowingo Dam Draft 9,650 CFS

Daily Mean Temperature:
Holtwood 27.1 °C (80.8 °F) Muddy Run 26.0 °C (78.8 °F)

Mid Survey Temperature:
Holtwood 26.5 °C (79.7 °F) Muddy Run 26.1 °C (79.0 °F)

SMALL BOAT SURVEY DATA

Peach Bottom Atomic Power Station: Discharge Water 30.2 °C (86.4 °F)*

Intake Water 26.0 °C (78.8 °F)*

ΔT 4.2 C (7.6 F°)

PBAPS Power: Thermal 3285.5 Megawatts

Electrical 1098.1 Megawatts

Surface Temperature: (Max) 30.2 °C (86.4 °F) Sta. No. 9

(Min) 25.9 °C (78.6 °F) Sta. No. 68

Bottom Temperature: (Max) 30.2 °C (86.4 °F) Sta. No. 9

(Min) 25.6 °C (78.1 °F) Sta. No. 68

METEOROLOGICAL DATA

Time: 0900 - 0915 E.S.T. Location: Sta. 7

Air Temperature: 78 °F Wind Speed: 2.8 mph

Relative Humidity: 71 % Wind Direction: N

Precipitation: 0 Inches (24 Hr Total) Cloud Cover: Partly Cloudy

COMMENTS: Survey begun at North end of Pond.
Cooling towers operating = 3

* Average of 5 foot depth increment readings

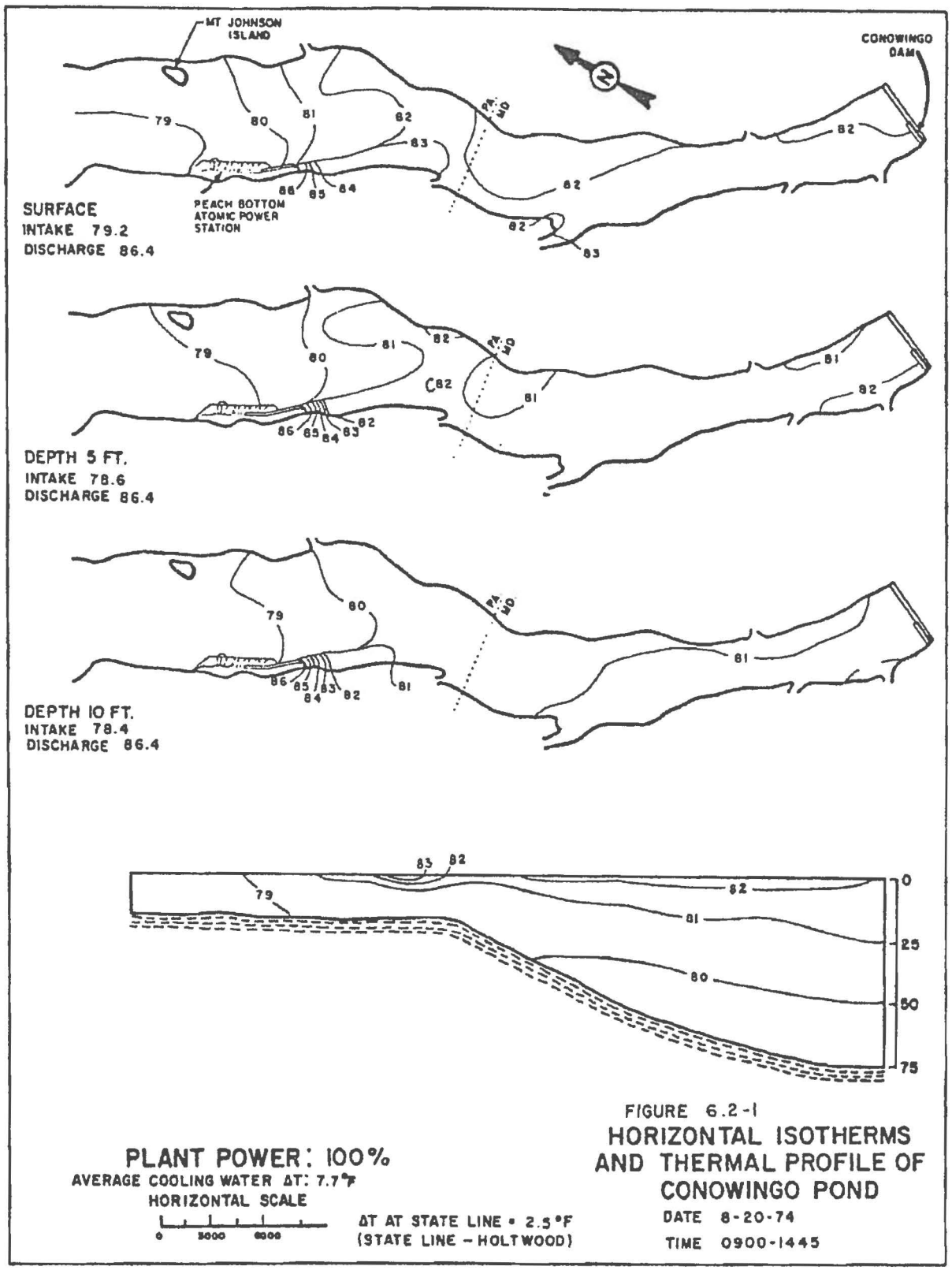


FIGURE 6.2-1
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND
DATE 8-20-74
TIME 0900-1445

BOAT SURVEY SUMMARY

DATE: Sun. October 27, 1974
day month date year

TIME: Survey Start: 1240 Hours (EST)

State Line: _____ Hours (EST)

Survey Finish: 1730 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 106.97 Feet

Finish: 106.95 Feet

Average (24 Hour) Flows:

Natural River 9300 CFS

Conowingo Inflow 4875 CFS

Conowingo Dam Draft 50 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 2993.3 Megawatts

Electrical 898.0 Megawatts

Unit 3: Thermal 2683.3 Megawatts

Electrical 805.0 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood - °C (- °F)

Muddy Run 10.8 °C (51.4 °F)

Mid Survey: Holtwood - °C (- °F)

Muddy Run 10.9 °C (51.6 °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 20.0 °C (68.0 °F)

Intake 13.6 °C (56.5 °F)

ΔT 6.4 C° (11.5 F°)

			Station
Pond Surface:			
Maximum	20.0 °C	(68.0 °F)	9
Minimum	12.4 °C	(54.3 °F)	1
Pond Bottom:			
Maximum	20.0 °C	(68.0 °F)	9
Minimum	12.0 °C	(53.6 °F)	27

METEOROLOGICAL DATA

Time: 1240 - 1255 EST

Air Temperature: 60 °F

Relative Humidity: 58 Percent

Precipitation: 0 Inches (24 Hour Total)

Wind Speed: 12.0 MPH

Cloud Over: Clear

Location: Boat Station 7

Wind Direction: North

Comment:

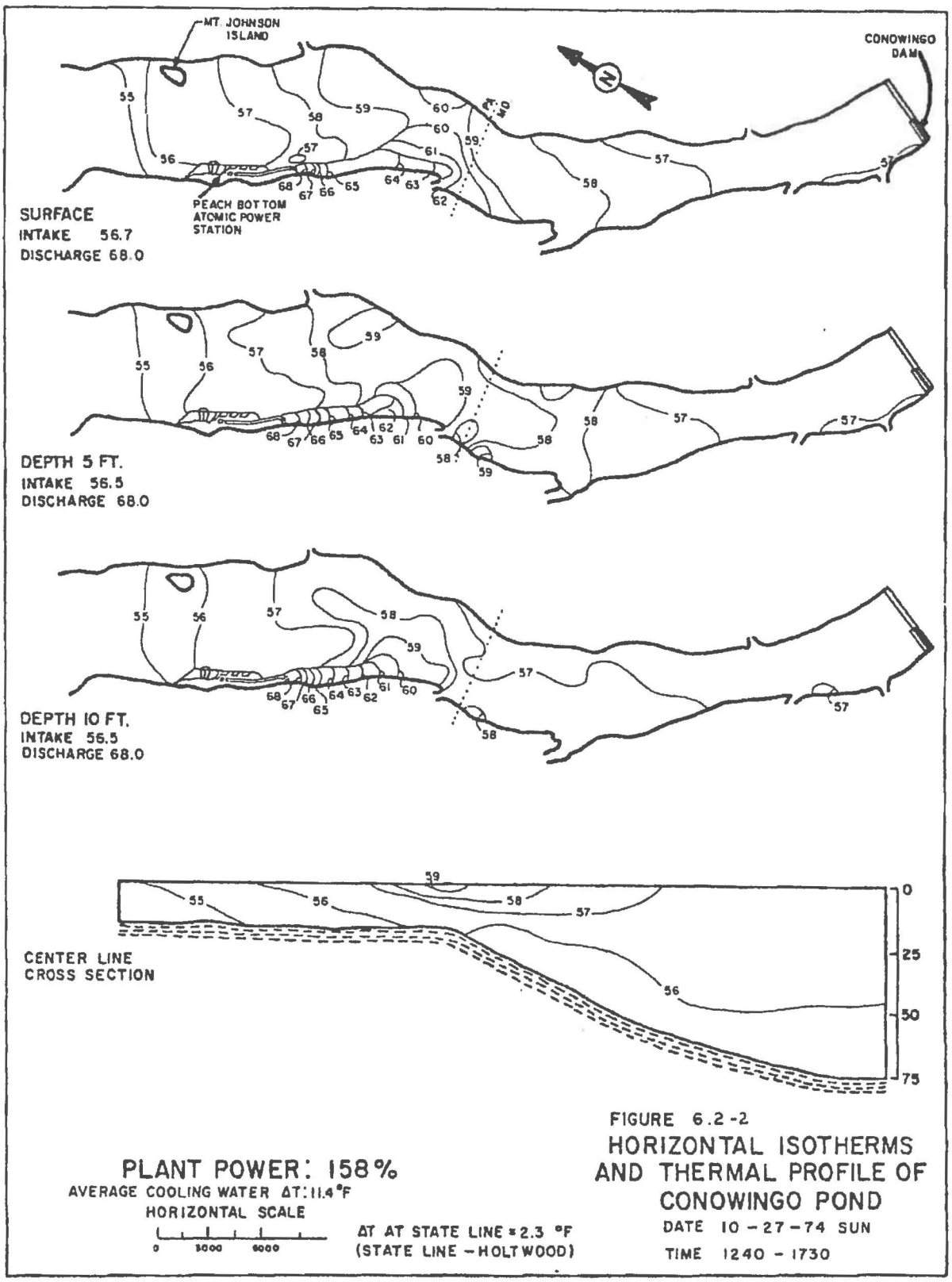


FIGURE 6.2-2
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND
DATE 10-27-74 SUN
TIME 1240 - 1730

BOAT SURVEY SUMMARY

DATE: Fri. November 15, 1974
day month date year

TIME: Survey Start: 1200 Hours (EST)

State Line: _____ Hours (EST)

Survey Finish: 1705 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 106.11 Feet

Finish: 104.66 Feet

Average (24 Hour) Flows:

Natural River 21,600 CFS

Conowingo Inflow 22,825 CFS

Conowingo Dam Draft 30,660 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 3,230 Megawatts

Electrical 1,070 Megawatts

Unit 3: Thermal 2,845 Megawatts

Electrical 990 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood 9.8 °C (49.6 °F)

Muddy Run 10.4 °C (50.7 °F)

Mid Survey: Holtwood 9.9 °C (49.8 °F)

Muddy Run 11.0 °C (51.8 °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 18.3 °C (64.9 °F)

Intake 10.3 °C (50.5 °F)

ΔT 8.0 C° (14.4 F°)

Pond Surface: Station

Maximum 18.3 °C (64.9 °F) 9

Minimum 9.8 °C (49.6 °F) 2,6

Pond Bottom:

Maximum 18.3 °C (64.9 °F) 9

Minimum 9.8 °C (49.6 °F) 2,6

METEOROLOGICAL DATA

Time: 1200 - 1215 EST

Air Temperature: 42 °F

Relative Humidity: 77 Percent

Precipitation: 0.20 Inches (24 Hour Total)

Wind Speed: 11.6 MPH

Cloud Over: partly cloudy

Location: Boat Station 7

Wind Direction: north west

Comment:

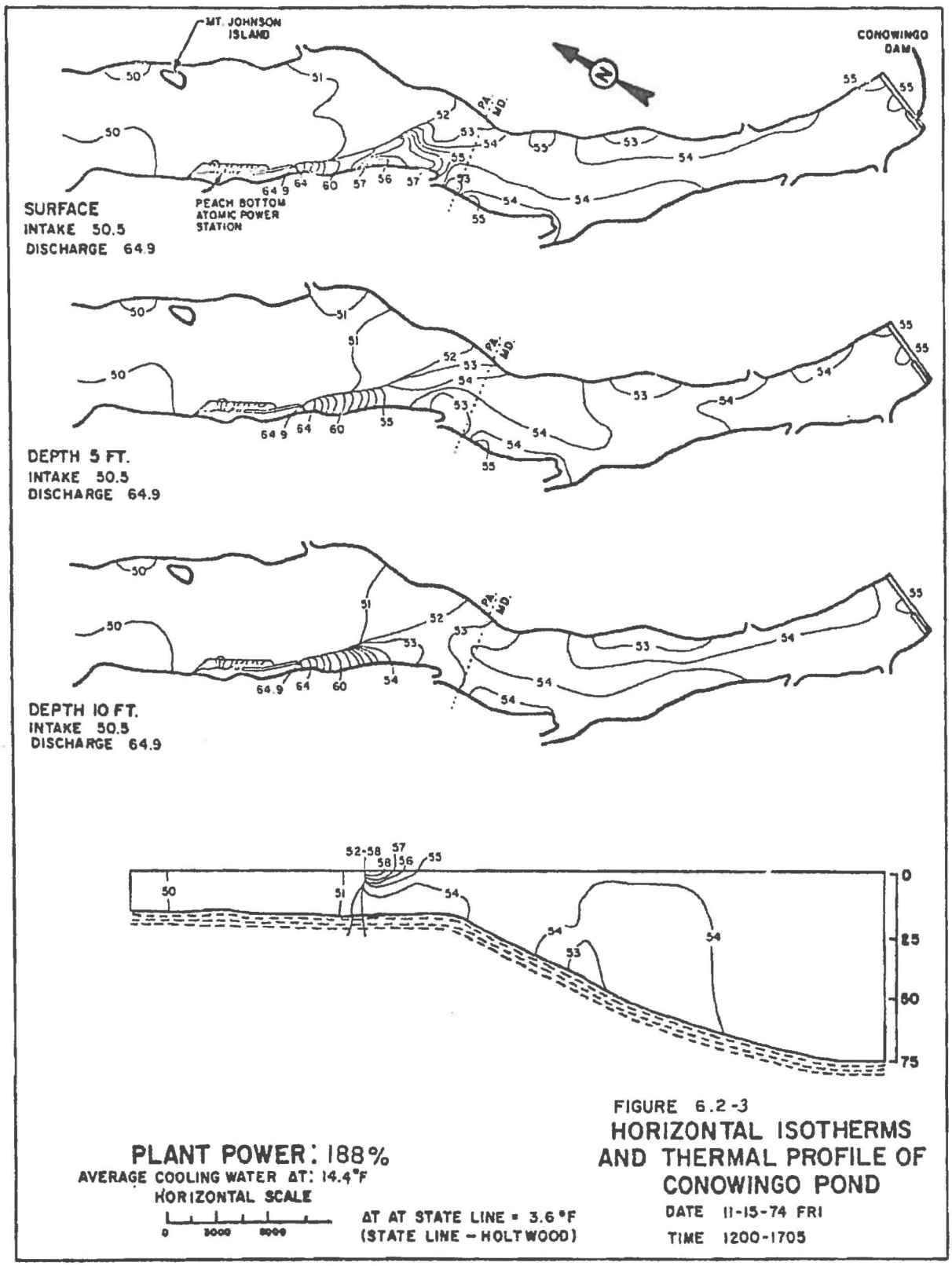


FIGURE 6.2-3
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND
DATE 11-15-74 FRI
TIME 1200-1705

BOAT SURVEY SUMMARY

DATE: Thurs. December 26, 1974
day month date year

TIME: Survey Start: 1100 Hours (EST)

State Line: 1255 Hours (EST)

Survey Finish: 1530 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 107.04 Feet

Finish: 106.35 Feet

Average (24 Hour) Flows:

Natural River 33,100 CFS

Conowingo Inflow 30,975 CFS

Conowingo Dam Draft 33,100 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 3,300 Megawatts

Electrical 1,100 Megawatts

Unit 3: Thermal 3,250 Megawatts

Electrical 1,050 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood 3.4 °C (38.1 °F)

Muddy Run 3.0 °C (37.4 °F)

Mid Survey: Holtwood 3.4 °C (38.1 °F)

Muddy Run 3.1 °C (37.6 °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 11.9 °C (53.4 °F)

Intake 3.0 °C (37.4 °F)

ΔT 8.9 C° (16.0 F°)

			Station
Pond Surface:			
Maximum	11.9 °C	(53.4 °F)	9
Minimum	2.9 °C	(37.2 °F)	20,21,58,64
Pond Bottom:			
Maximum	11.9 °C	(53.4 °F)	9
Minimum	2.8 °C	(37.0 °F)	20

METEOROLOGICAL DATA

Time: 1100 - 1115 EST

Air Temperature: 34 °F

Relative Humidity: 71 Percent

Precipitation: 0.00 Inches (24 Hour Total)

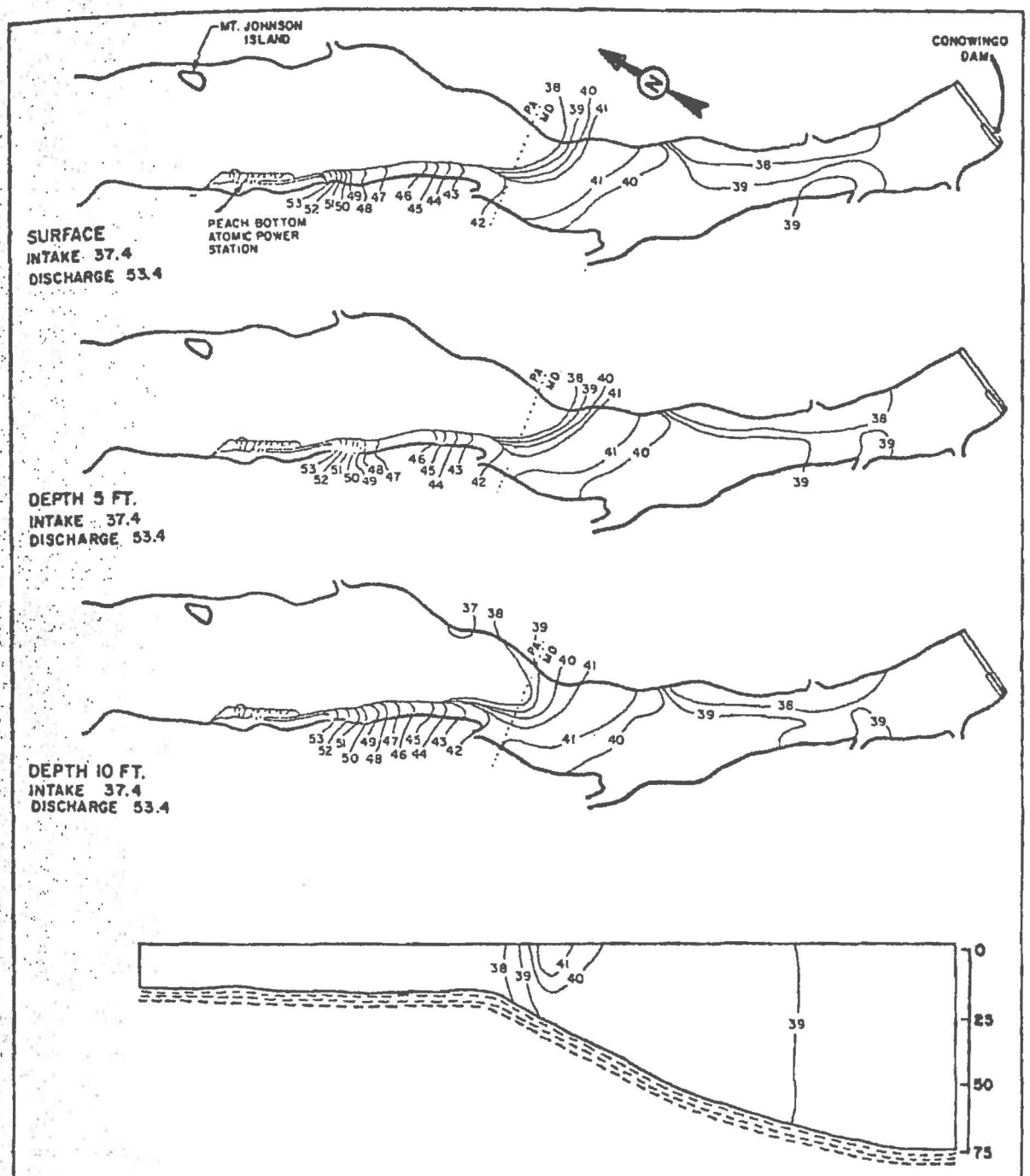
Wind Speed: 12.4 MPH

Cloud Over: cloudy

Location: Boat Station 7

Wind Direction: north

Comment:



PLANT POWER: 197 %
AVERAGE COOLING WATER ΔT: 16.0 °F
HORIZONTAL SCALE
0 3000 6000

ΔT AT STATE LINE = 4.3 °F
(STATE LINE – HOLTWOOD)

FIGURE 6.2-4
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND
DATE 12-26-74 THUR
TIME 1100 - 1500

BOAT SURVEY SUMMARY

DATE: Tues. 02 11 1975
day month date year

TIME: Survey Start: 1005 Hours (EST)

State Line: 1140 Hours (EST)

Survey Finish: 1440 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 107.42 Feet

Finish: 106.43 Feet

Average (24 Hour) Flows:

Natural River 32,300 CFS

Conowingo Inflow 32,000 CFS

Conowingo Dam Draft 29,125 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 3,280 Megawatts

Electrical 1,100 Megawatts

Unit 3: Thermal 3,260 Megawatts

Electrical 1,080 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood 0.9 °C (33.6 °F)

Muddy Run 1.3 °C (34.3 °F)

Mid Survey: Holtwood 0.6 °C (33.1 °F)

Muddy Run 1.7 °C (35.1 °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 10.0 °C (50.0 °F)

Intake 0.7 °C (33.3 °F)

ΔT 9.3 C° (16.7 F°)

			Station
Pond Surface:			
Maximum	10.0 °C	(50.0 °F)	9
Minimum	0.5 °C	(32.9 °F)	2,3,4,5,6,7,8 61,68,70
Pond Bottom:			
Maximum	10.0 °C	(50.0 °F)	9
Minimum	0.4 °C	(32.7 °F)	2,3,6

METEOROLOGICAL DATA

Time: 1005 - 1020 EST

Air Temperature: 33 °F

Relative Humidity: 90 Percent

Precipitation: 0.0 Inches (24 Hour Total)

Wind Speed: 2.8 MPH

Cloud Over: Overcast

Location: Boat Station 7

Wind Direction: SSE

Comment:

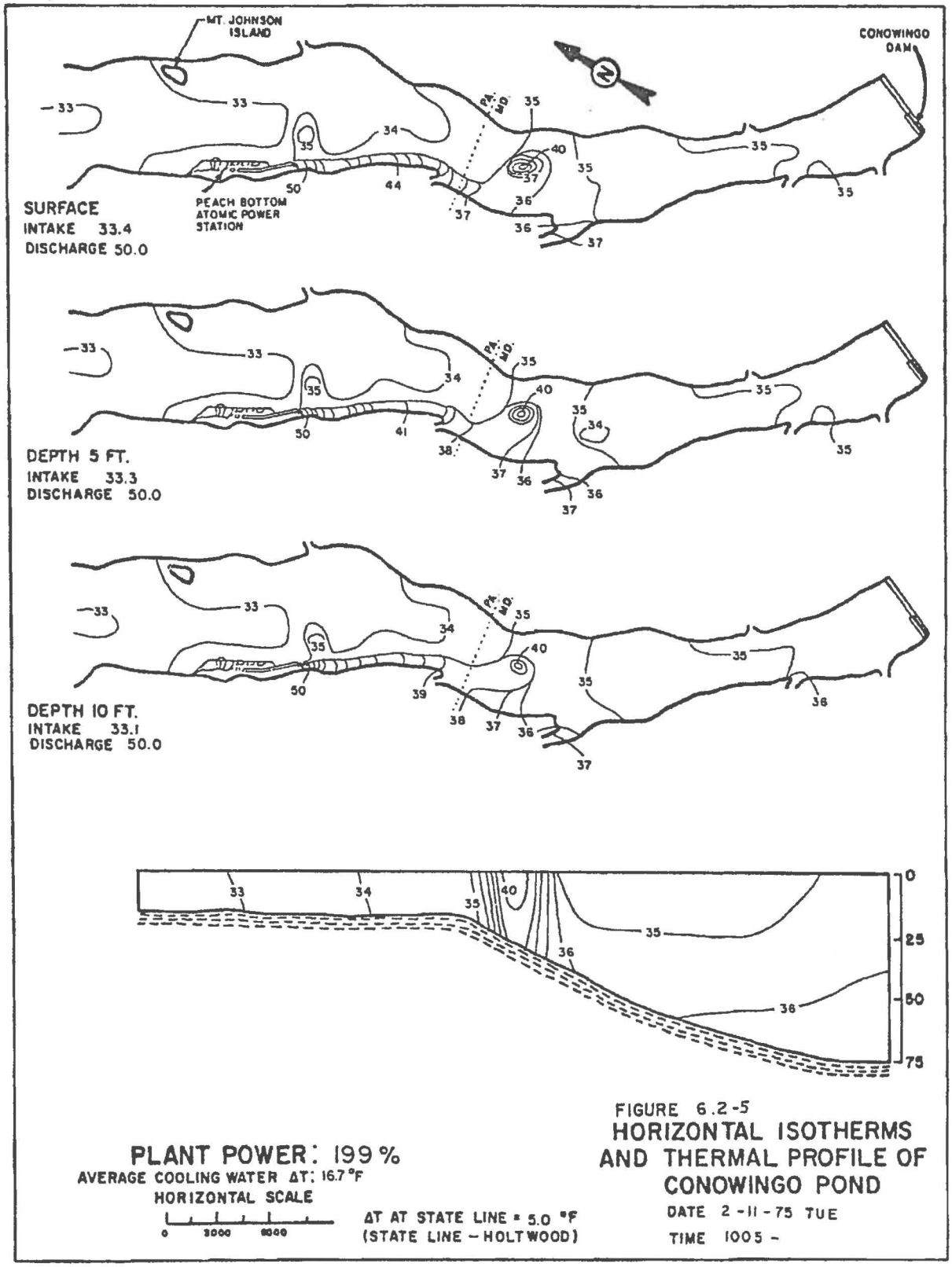


FIGURE 6.2-5
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND
DATE 2-11-75 TUE
TIME 1005 -

BOAT SURVEY SUMMARY

DATE: Wed. March 12 1975
day month date year

TIME: Survey Start: 0915 Hours (EST)

State Line: 1045 Hours (EST)

Survey Finish: 1425 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 108.02 Feet

Finish: 107.82 Feet

Average (24 Hour) Flows:

Natural River 39,000 CFS

Conowingo Inflow 38,800 CFS

Conowingo Dam Draft 39,950 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 3,280 Megawatts

Electrical 1,100 Megawatts

Unit 3: Thermal 3,260 Megawatts

Electrical 1,100 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood 3.0 °C (37.4 °F)

Muddy Run - °C (- °F)

Mid Survey: Holtwood 2.9 °C (37.2 °F)

Muddy Run - °C (- °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 12.4 °C (54.3 °F)

Intake 2.9 °C (37.2 °F)

ΔT 9.5 C° (17.1 F°)

			Station
Pond Surface:			
Maximum	12.4 °C	(54.3 °F)	9,3-1
Minimum	2.8 °C	(37.0 °F)	3,6,7,8,11,12, 13,19,58,61,62, 63,65,68,70,16A, 3-3,5-4
Pond Bottom:			
Maximum	12.4 °C	(54.3 °F)	9
Minimum	2.8 °C	(37.0 °F)	3,6,7,8,11,12,13, 19,58,61,62,63,65, 68,70,71,16A,3-3, 54

METEOROLOGICAL DATA

Time: 0915 - 0930 EST

Air Temperature: 38 °F

Relative Humidity: 100 Percent

Precipitation: 0.34 Inches (24 Hour Total)

Wind Speed: 7.2 MPH

Cloud Over: Overcast

Location: Boat Station 7

Wind Direction: South

Comment:

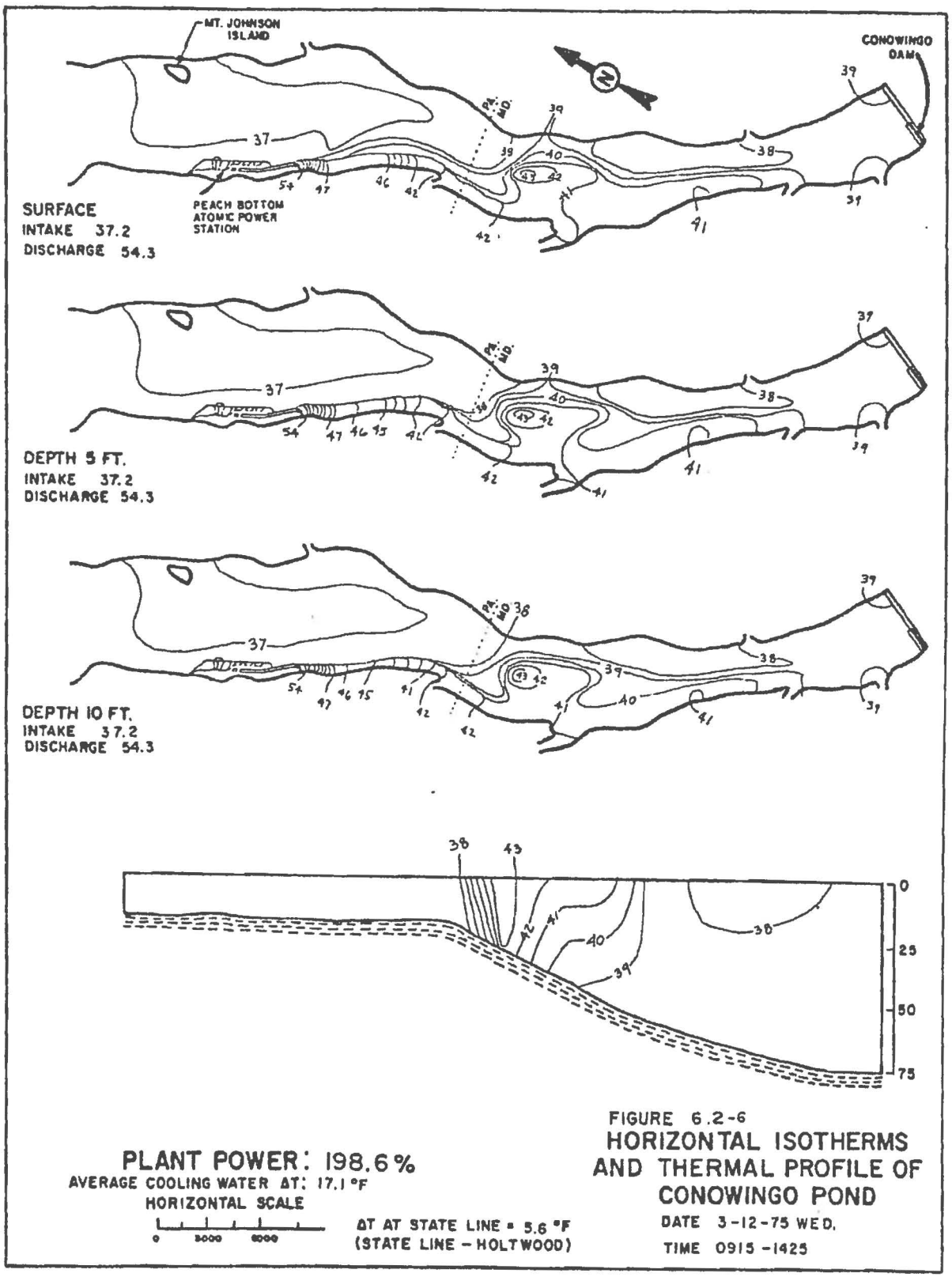


FIGURE 6.2-6
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND

BOAT SURVEY SUMMARY

DATE: Tues. April 22, 1975
day month date year

TIME: Survey Start: 0820 Hours (EST)

State Line: 1035 Hours (EST)

Survey Finish: 1230 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 108.28 Feet

Finish: 107.35 Feet

Average (24 Hour) Flows:

Natural River 30,300 CFS

Conowingo Inflow 30,325 CFS

Conowingo Dam Draft 32,625 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 3250 Megawatts

Electrical 1100 Megawatts

Unit 3: Thermal 3250 Megawatts

Electrical 1100 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood 11.7 °C (53.1 °F)

Muddy Run 10.7 °C (51.3 °F)

Mid Survey: Holtwood 11.8 °C (53.2 °F)

Muddy Run 9.9 °C (49.8 °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 20.0 °C (68.0 °F)

Intake 11.6 °C (52.9 °F)

ΔT 8.4 C° (15.1 F°)

			Station
Pond Surface:			
Maximum	20.0 °C	(68.0 °F)	9
Minimum	11.1 °C	(52.0 °F)	6,62
Pond Bottom:			
Maximum	20.0 °C	(68.0 °F)	9
Minimum	10.7 °C	(51.3 °F)	6

METEOROLOGICAL DATA

Time: 0820-0835 EST

Air Temperature: 45 °F

Relative Humidity: 64 Percent

Precipitation: 0.0 Inches (24 Hour Total)

Wind Speed: 1.2 MPH

Cloud Over: Clear

Location: Boat Station 7

Wind Direction: Variable

Comment:

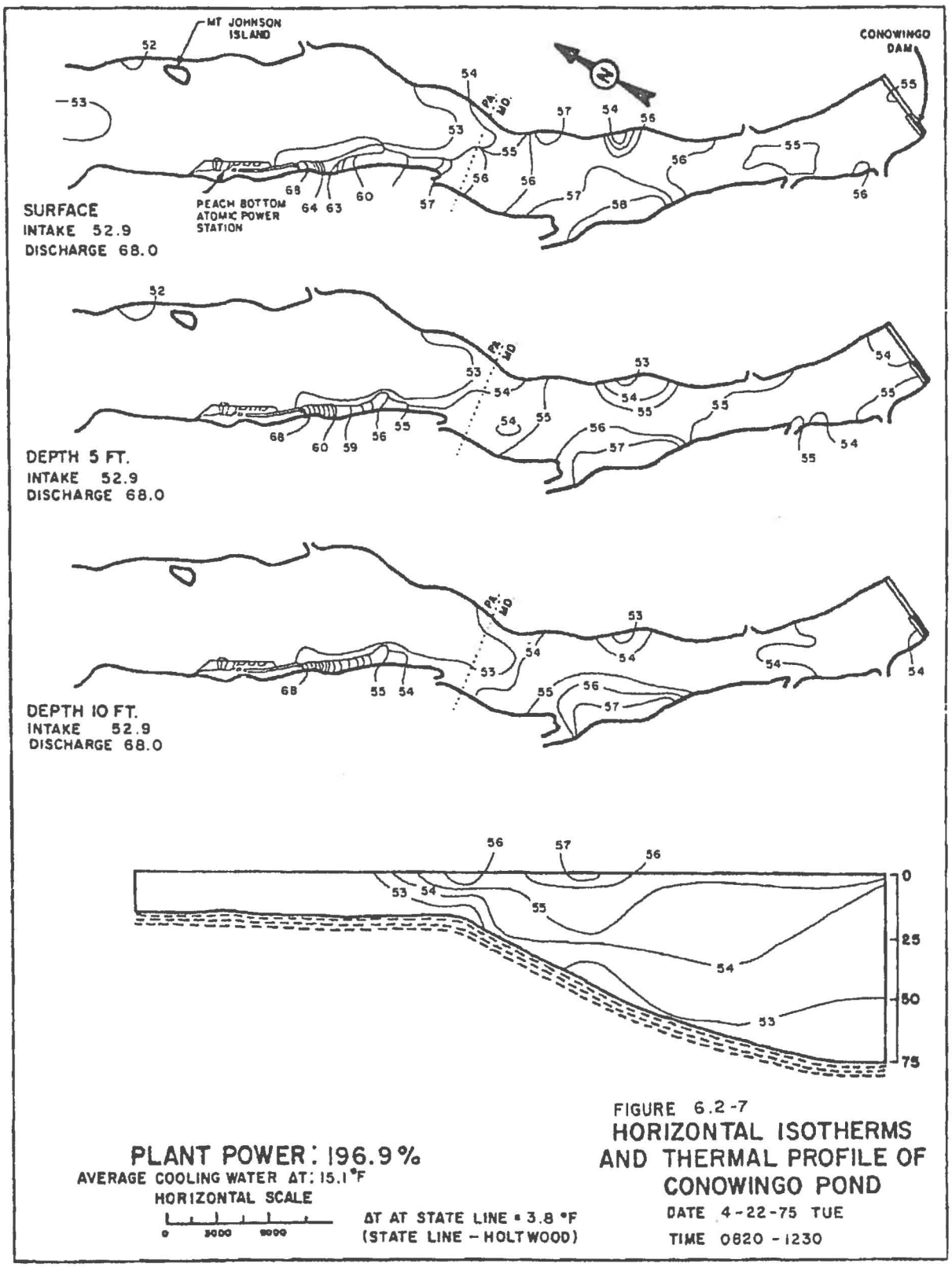


FIGURE 6.2-7
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND
DATE 4-22-75 TUE
TIME 0820 - 1230

BOAT SURVEY SUMMARY

DATE: Fri. May 2, 1975
day month date year

TIME: Survey Start: 1030 Hours (EST)

State Line: 1240 Hours (EST)

Survey Finish: 1530 Hours (EST)

HYDRAULIC DATA

Pond Elevation Start: 107.73 Feet

Finish: 106.91 Feet

Average (24 Hour) Flows:

Natural River 39,600 CFS

Conowingo Inflow 39,750 CFS

Conowingo Dam Draft 45,625 CFS

PBAPS POWER OUTPUT

Unit 2: Thermal 3200 Megawatts

Electrical 1060 Megawatts

Unit 3: Thermal 3280 Megawatts

Electrical 1100 Megawatts

WATER TEMPERATURE (THERMOGRAPH)

Daily Mean: Holtwood 12.1 °C (53.8 °F)

Muddy Run 12.8 °C (55.0 °F)

Mid Survey: Holtwood 12.1 °C (53.8 °F)

Muddy Run 12.7 °C (54.9 °F)

WATER TEMPERATURE (SURVEY)

PBAPS: Discharge 20.3 °C (68.5 °F)

Intake 11.9 °C (53.4 °F)

ΔT 8.4 C° (15.1 F°)

			Station
Pond Surface:			
Maximum	20.3 °C	(68.5 °F)	9
Minimum	11.8 °C	(53.2 °F)	2
Pond Bottom:			
Maximum	20.3 °C	(68.5 °F)	9
Minimum	11.8 °C	(53.2 °F)	2

METEOROLOGICAL DATA

Time: 1030-1045 EST

Air Temperature: 52 °F

Relative Humidity: 87 Percent

Precipitation: 0.32 Inches (24 Hour Total)

Wind Speed: 8 MPH

Cloud Over: Overcast

Location: Boat Station 7

Wind Direction: North

Comment:

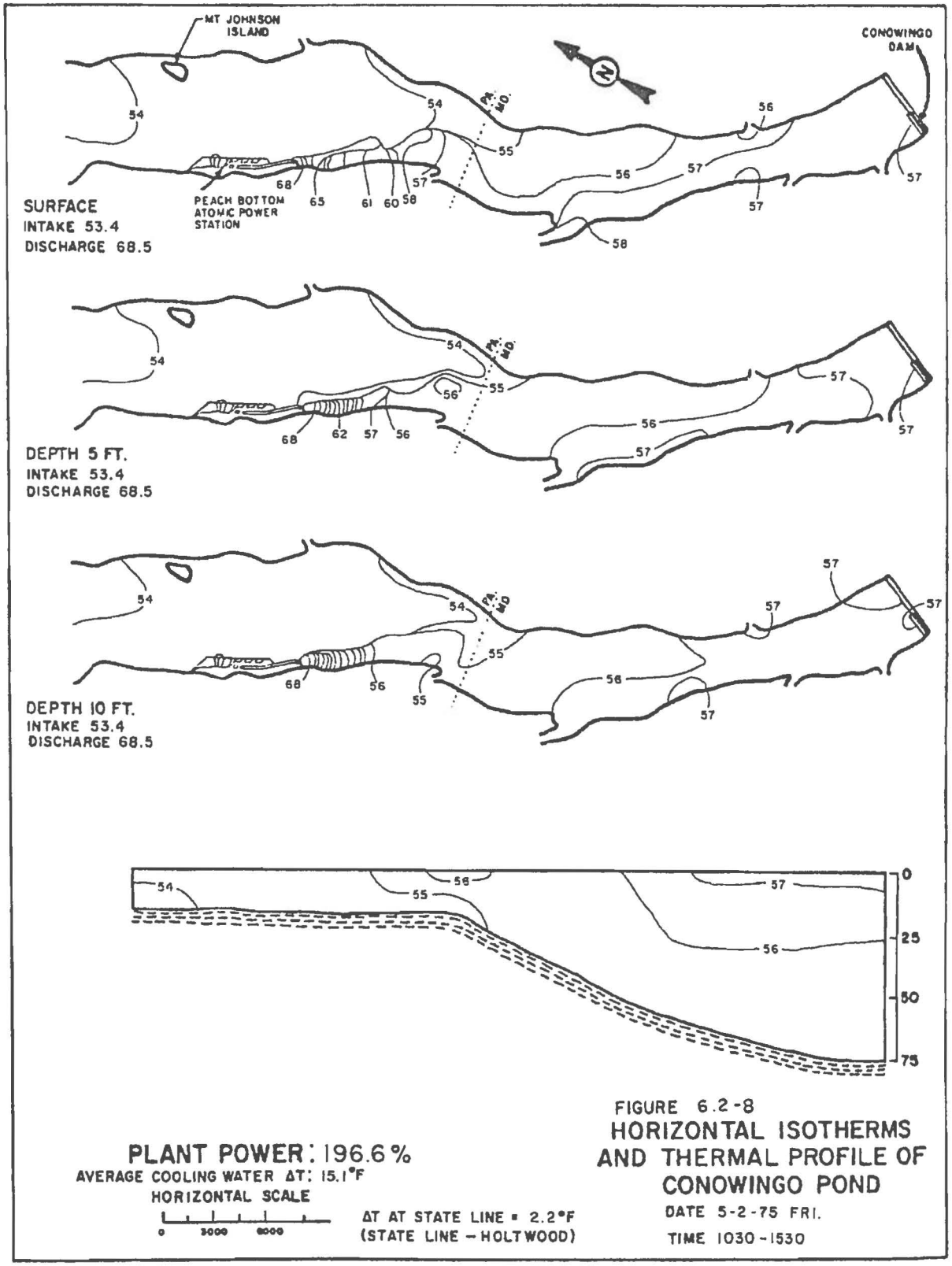


FIGURE 6.2-8
HORIZONTAL ISOTHERMS AND THERMAL PROFILE OF CONOWINGO POND

DATE 5-2-75 FRI.
TIME 1030-1530

PLANT POWER: 196.6%
AVERAGE COOLING WATER ΔT: 15.1°F
HORIZONTAL SCALE
0 3000 6000

ΔT AT STATE LINE = 2.2°F
(STATE LINE – HOLTWOOD)

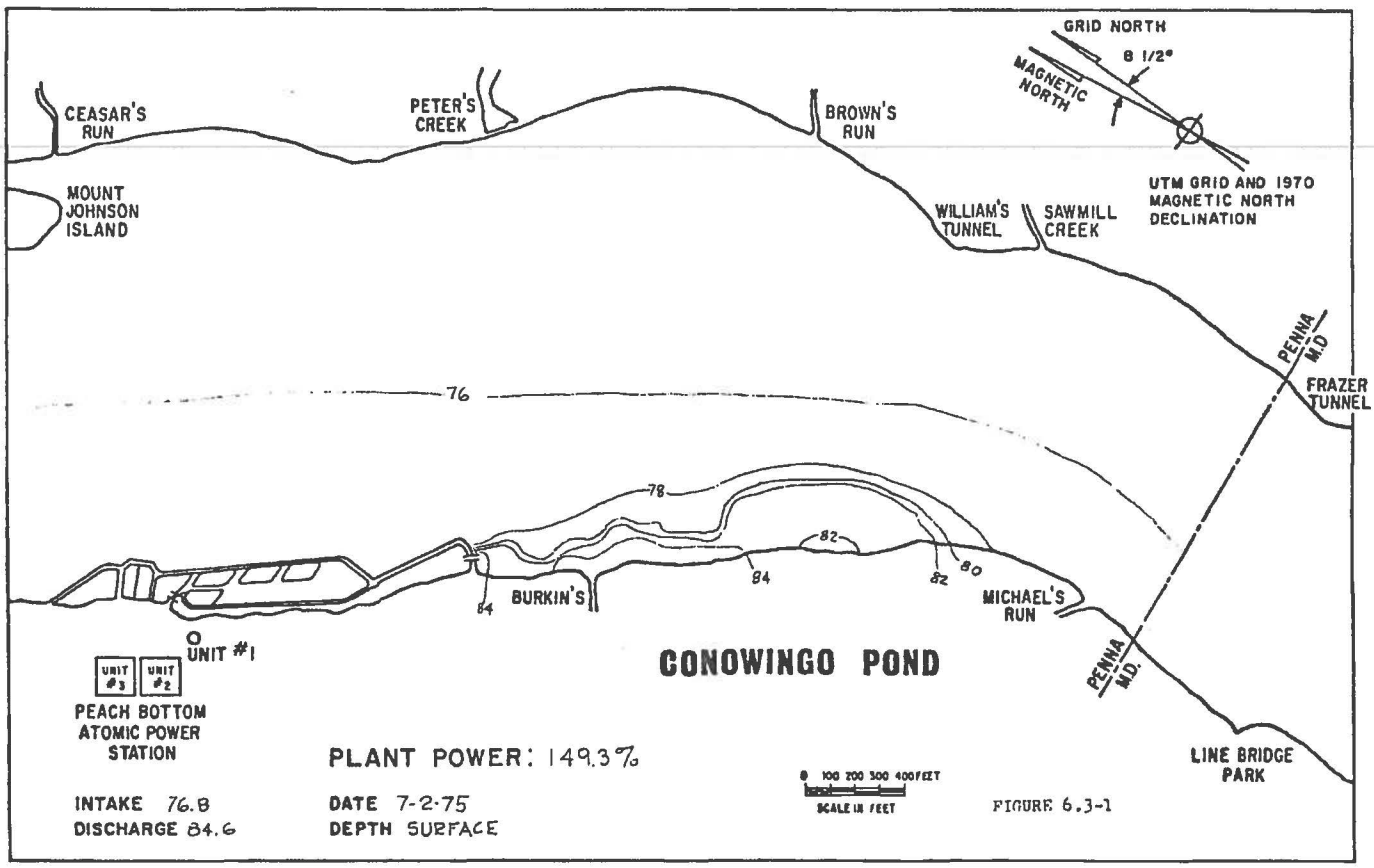

GRID NORTH
8 1/2°
MAGNETIC NORTH
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION
CEASAR'S RUN
PETER'S CREEK
BROWN'S RUN
MOUNT JOHNSON ISLAND
WILLIAM'S TUNNEL
SAWMILL CREEK
PENNA
MD
FRAZER TUNNEL
76
78
82
80
84
82
84
BURKIN'S
MICHAEL'S RUN
UNIT #1
UNIT #3
UNIT #2
PEACH BOTTOM ATOMIC POWER STATION
CONOWINGO POND
PENNA
MD.
LINE BRIDGE PARK
PLANT POWER: 149.3%
INTAKE 76.8
DISCHARGE 84.6
DATE 7-2-75
DEPTH SURFACE
0 100 200 300 400 FEET
SCALE IN FEET

FIGURE 6.3-1

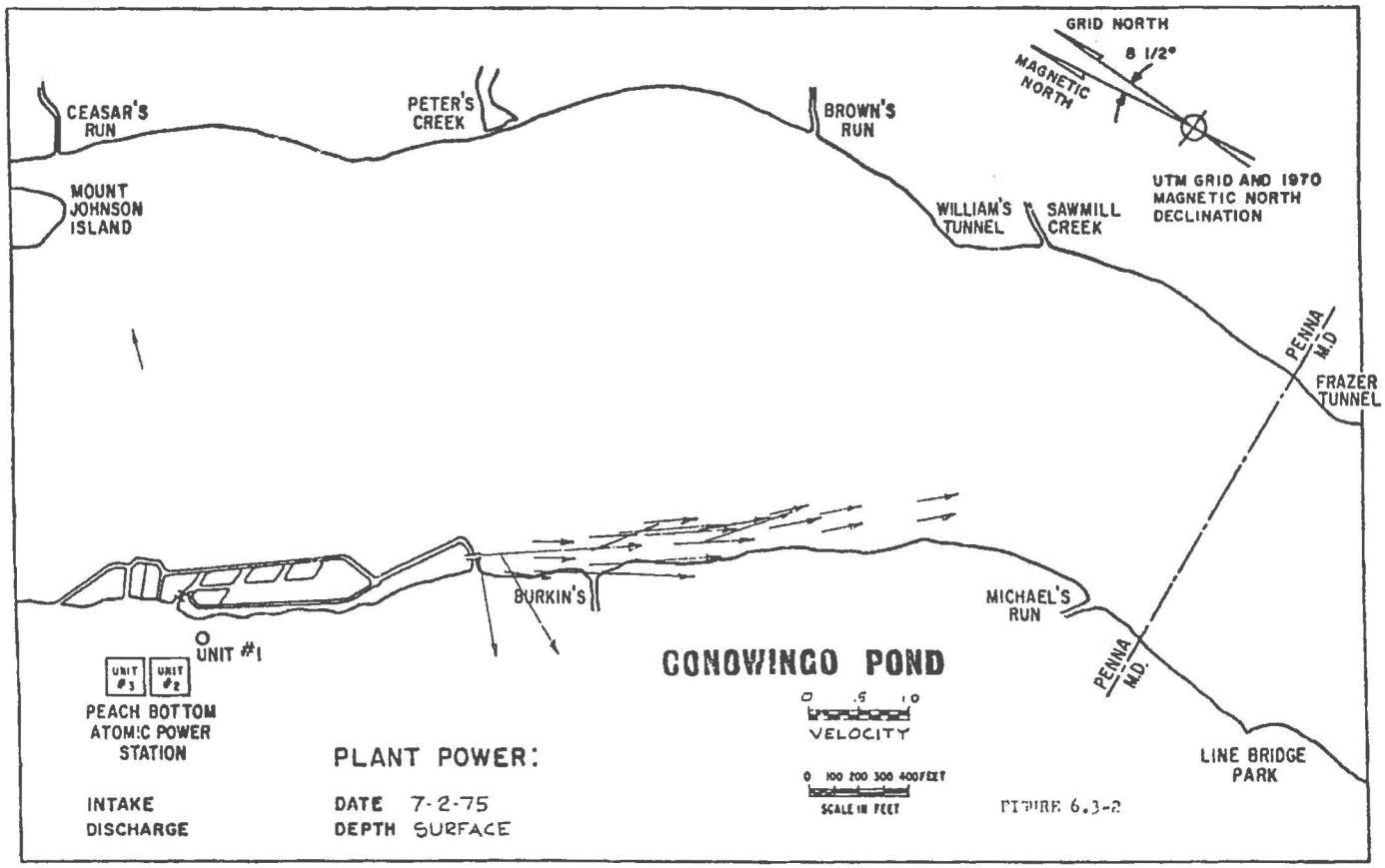

GRID NORTH
8 1/2°
MAGNETIC NORTH
CEASAR'S RUN
PETER'S CREEK
BROWN'S RUN
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION
MOUNT JOHNSON ISLAND
WILLIAM'S TUNNEL
SAWMILL CREEK
PENNA M.D
FRAZER TUNNEL
BURKIN'S
MICHAEL'S RUN
UNIT #1
UNIT #3
UNIT #2
PEACH BOTTOM ATOMIC POWER STATION
CONOWINGO POND
0 .5 1.0
VELOCITY
PENNA M.D.
LINE BRIDGE PARK
PLANT POWER:
0 100 200 300 400 FEET
SCALE IN FEET
INTAKE
DISCHARGE
DATE 7-2-75
DEPTH SURFACE

FIGURE 6.3-2

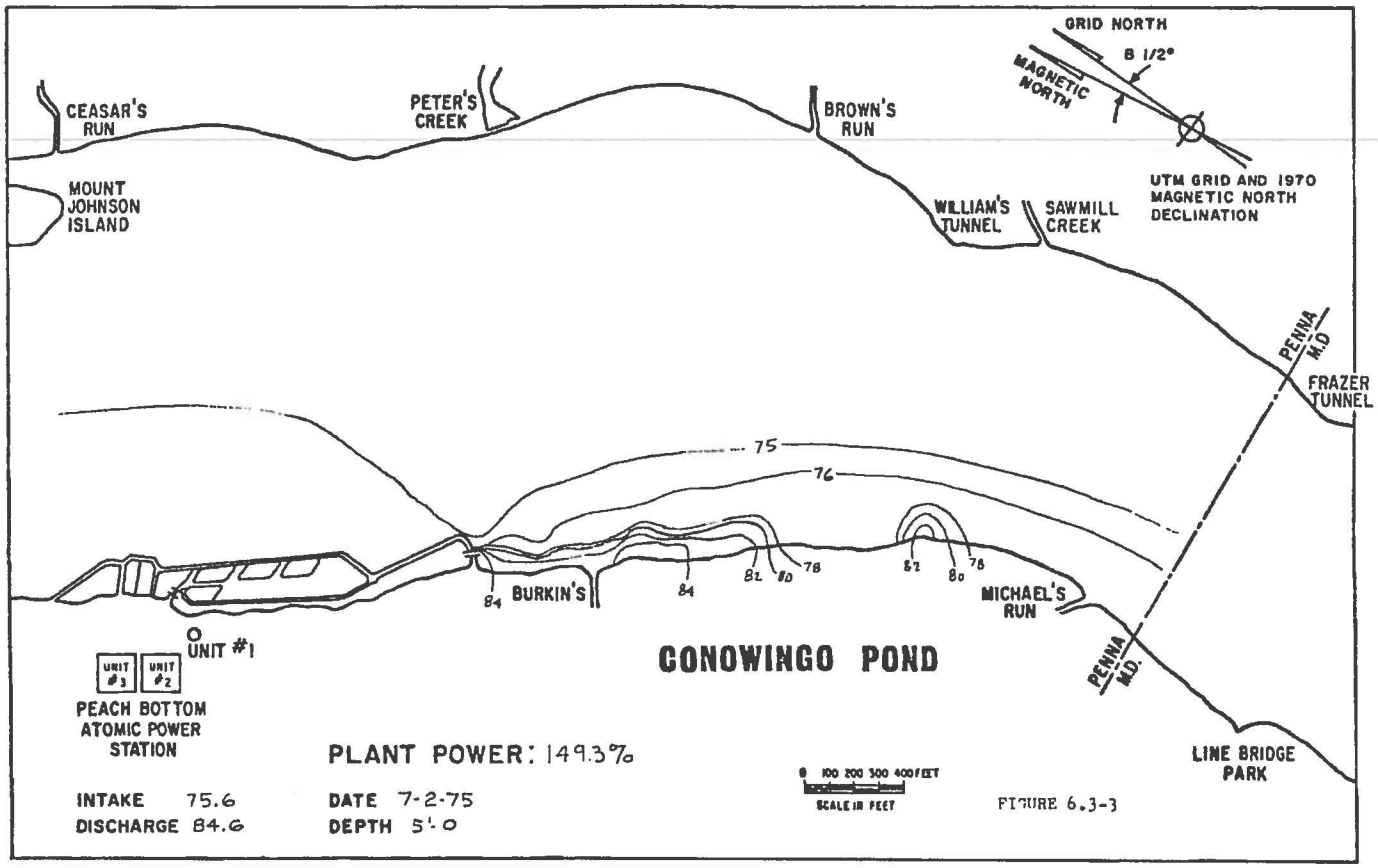

GRID NORTH
8 1/2°
MAGNETIC NORTH
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION
CEASAR'S RUN
PETER'S CREEK
BROWN'S RUN
MOUNT JOHNSON ISLAND
WILLIAM'S TUNNEL
SAWMILL CREEK
PENNA M.D
FRAZER TUNNEL
75
76
84
BURKIN'S
84
82
80
78
82
80
78
MICHAEL'S RUN
UNIT #1
UNIT #3
UNIT #2
PEACH BOTTOM ATOMIC POWER STATION
CONOWINGO POND
PENNA M.D.
LINE BRIDGE PARK
PLANT POWER: 149.3%
INTAKE 75.6
DISCHARGE 84.6
DATE 7-2-75
DEPTH 5'-0
0 100 200 300 400 FEET
SCALE IN FEET

FIGURE 6.3-3

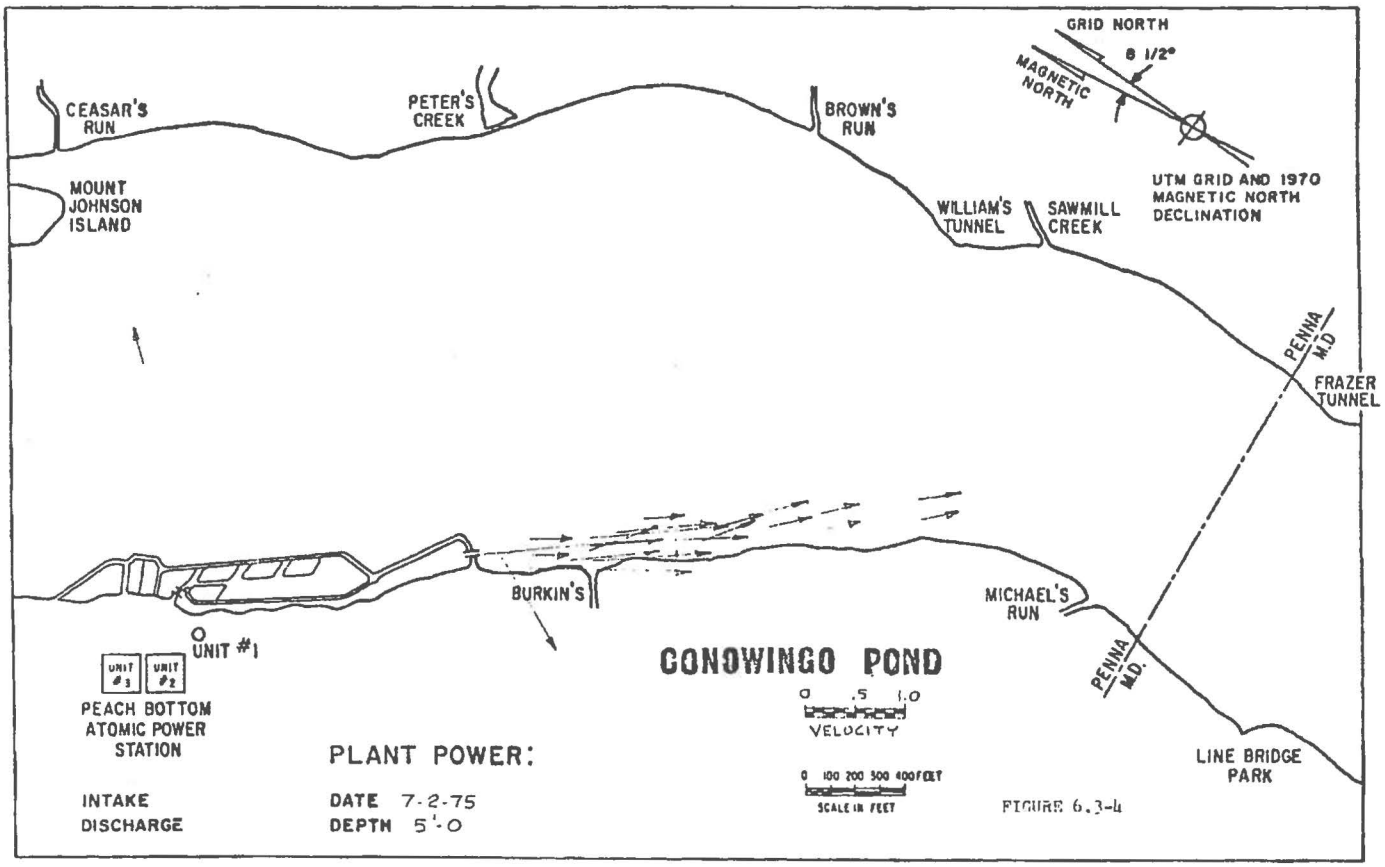

GRID NORTH
8 1/2°
MAGNETIC NORTH
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION
CEASAR'S RUN
PETER'S CREEK
BROWN'S RUN
MOUNT JOHNSON ISLAND
WILLIAM'S TUNNEL
SAWMILL CREEK
PENNA MD
FRAZER TUNNEL
BURKIN'S
MICHAEL'S RUN
UNIT #1
UNIT #3
UNIT #2
PEACH BOTTOM ATOMIC POWER STATION
CONOWINGO POND
0 .5 1.0
VELOCITY
PENNA MD.
LINE BRIDGE PARK
PLANT POWER:
INTAKE
DISCHARGE
DATE 7-2-75
DEPTH 5'-0
0 100 200 300 400 FEET
SCALE IN FEET

FIGURE 6.3-4

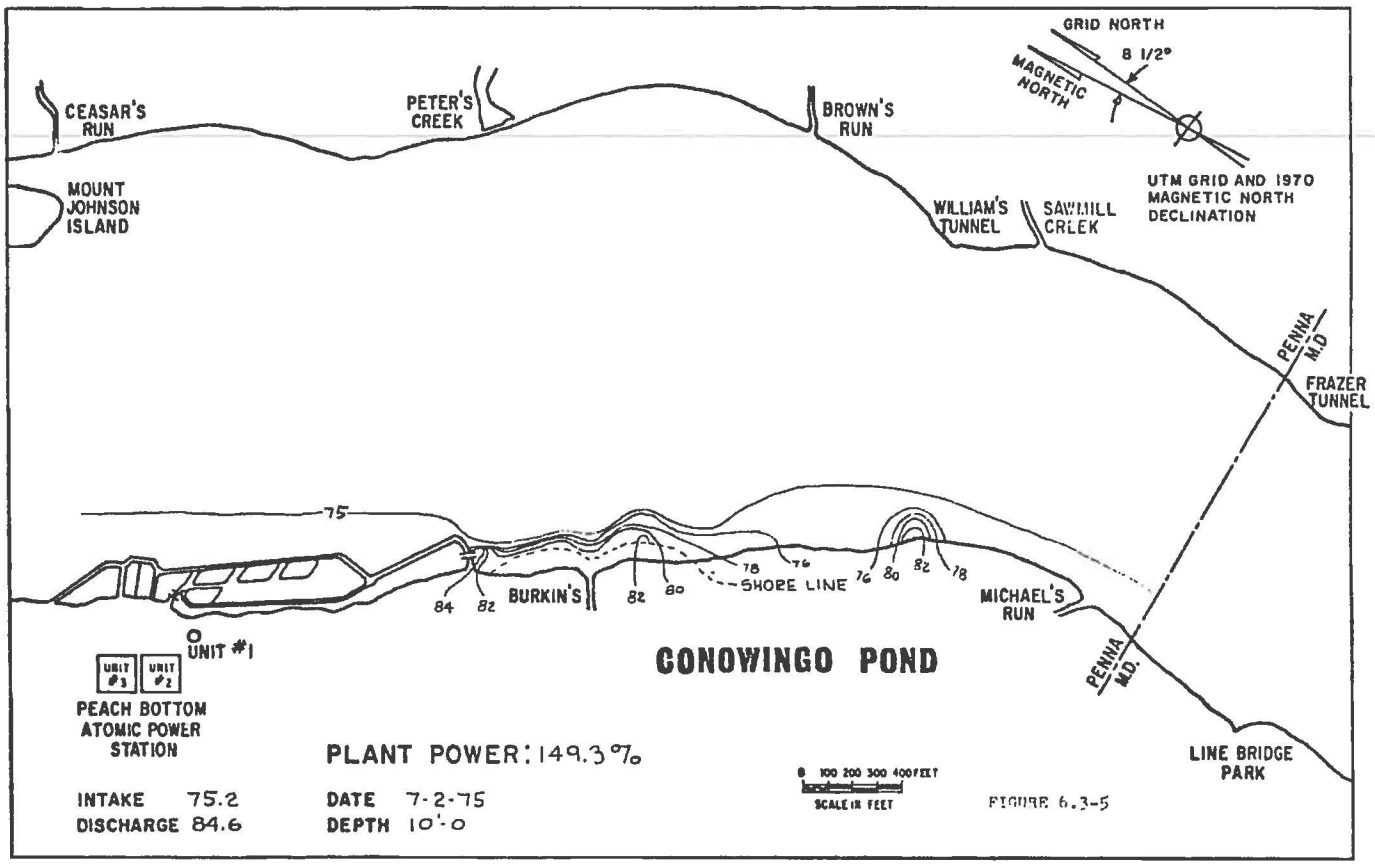

GRID NORTH
8 1/2°
MAGNETIC NORTH
CEASAR'S RUN
PETER'S CREEK
BROWN'S RUN
MOUNT JOHNSON ISLAND
WILLIAM'S TUNNEL
SAWMILL CREEK
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION
PENNA M.D
FRAZER TUNNEL
75
84
82
BURKIN'S
82
80
78
76
SHORE LINE
76
80
82
78
MICHAEL'S RUN
PENNA M.D.
UNIT #1
UNIT #3
UNIT #2
PEACH BOTTOM ATOMIC POWER STATION
CONOWINGO POND
LINE BRIDGE PARK
PLANT POWER: 149.3%
INTAKE 75.2
DISCHARGE 84.6
DATE 7-2-75
DEPTH 10'-0
0 100 200 300 400 FEET
SCALE IN FEET

FIGURE 6.3-5

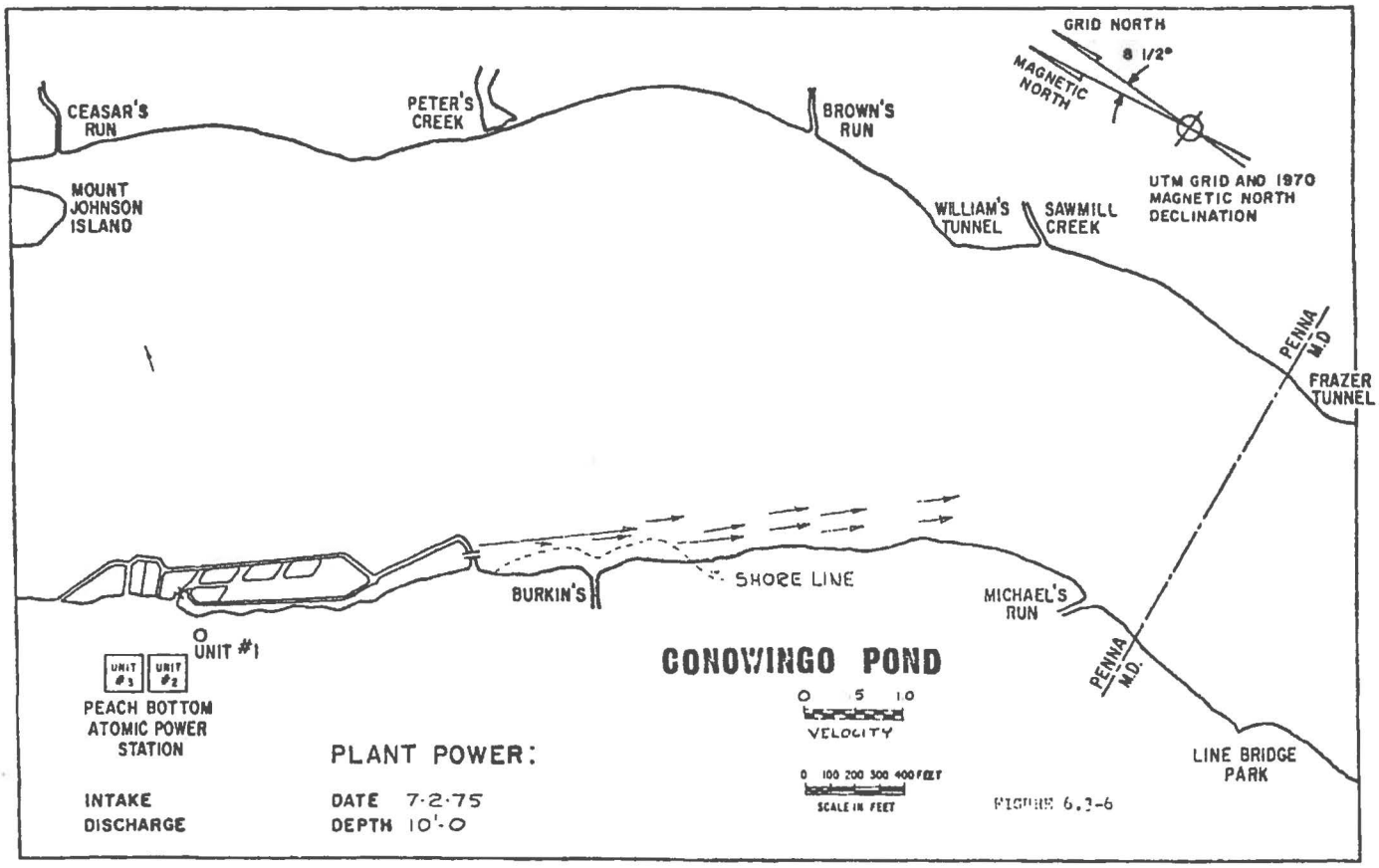
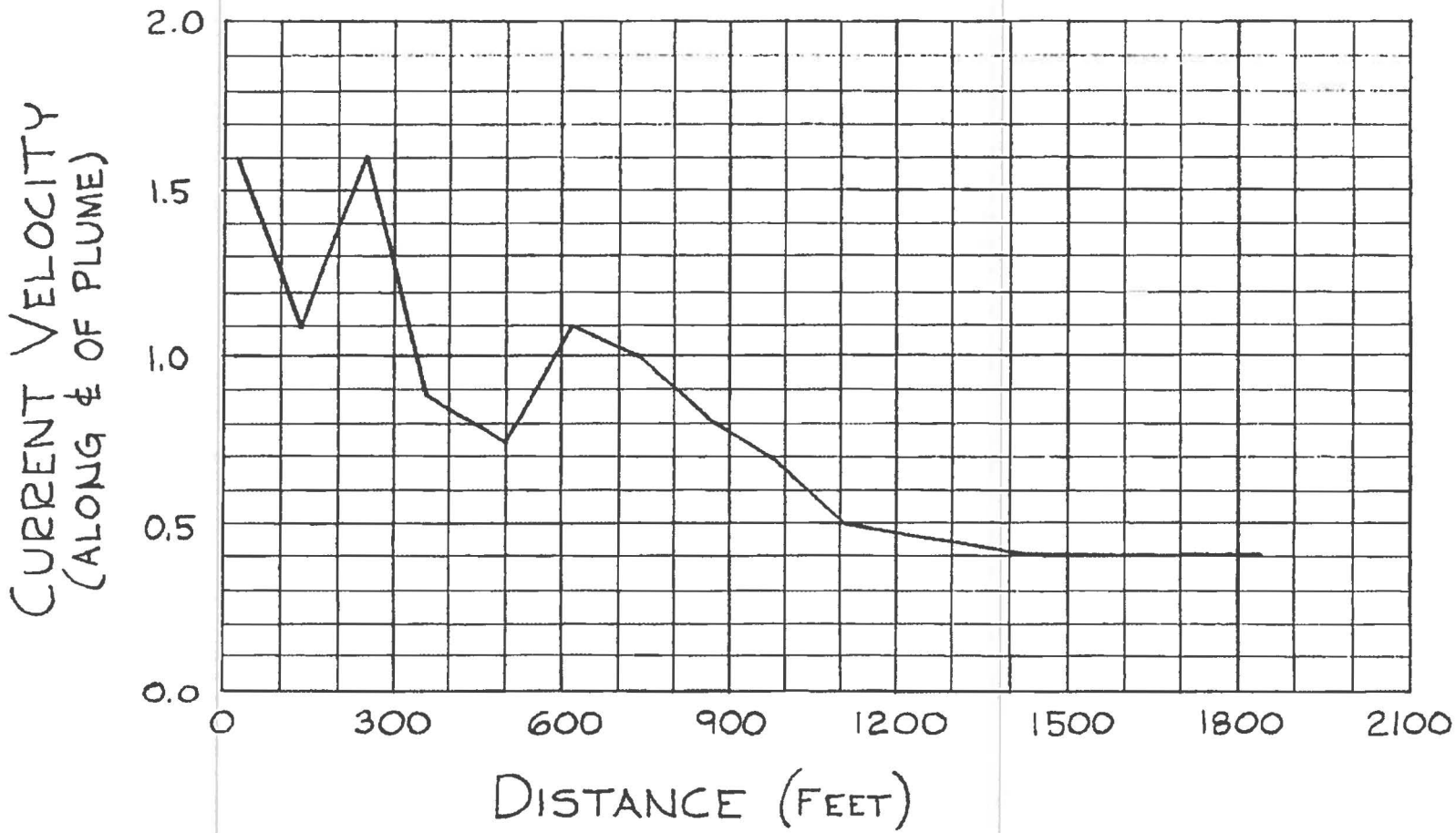

GRID NORTH
8 1/2°
MAGNETIC NORTH
UTM GRID AND 1970 MAGNETIC NORTH DECLINATION
CEASAR'S RUN
PETER'S CREEK
BROWN'S RUN
MOUNT JOHNSON ISLAND
WILLIAM'S TUNNEL
SAWMILL CREEK
PENNA
M.D
FRAZER TUNNEL
SHORE LINE
BURKIN'S
MICHAEL'S RUN
UNIT #1
UNIT #3
UNIT #2
PEACH BOTTOM ATOMIC POWER STATION
CONOWINGO POND
0 5 10
VELOCITY
PENNA
M.D.
LINE BRIDGE PARK
PLANT POWER:
0 100 200 300 400 FEET
SCALE IN FEET
INTAKE
DISCHARGE
DATE 7-2-75
DEPTH 10'-0

FIGURE 6.3-6



DATE : 7-2-75
DEPTH: SURFACE

FIGURE 6.3-7

7.0 AQUATIC COMMUNITY DESCRIPTION

7.1.0 LIMNOLOGY OF CONOWINGO POND

7.1.1 INTRODUCTION

Studies of zooplankton and benthic communities began in June 1967. In 1970 the limnology program was expanded to include detailed studies of the water chemistry and phytoplankton community (as measured by plant pigments). The location of the stations sampled are shown in Figure 7.1-1.

The objectives of the studies are: (1) to quantitatively and qualitatively monitor the phytoplankton, zooplankton and the benthic communities, and the physicochemistry of the Pond (2) to determine the biomass of zooplankton and benthos (3) to determine the effects of natural phenomena on the phytoplankton, zooplankton, benthos and physicochemistry and (4) to document the effects, if any, of the operation of the Station.

A summary of the limnological findings is given below. Comparisons of the preoperational (June 1967 to December 1973) and postoperational (January to December 1974) conditions are included to support the premise that no "appreciable harm" has occurred. See Robbins and Mathur (1974a, b, and 1975a, b) Section 2.2 for supporting data on water chemistry, Section 2.3 for plant pigments, Section 2.4 for zooplankton and Section 2.5 for benthos. The raw data from which the summary tables are prepared are given in a limnological data report prepared by Robbins and Mathur (1975c).

7.1.2 WATER QUALITY

7.1.2.1 Temperature

Monthly mean temperatures between the preoperational and postoperational periods were similar (Table 7.1.2-1). Thermal stratification (a decline of 1°C (1.8°F) or more per meter in a thermocline) did not occur in the Pond in either period.

The monthly maximum weekly average water temperatures and minimum weekly average winter water temperatures measured at Holtwood Dam from 1966 through 1974 are given in Tables 7.1.2-2 and 7.1.2-3. The highest weekly temperatures occurred in July and August. A maximum weekly average temperature of 88.4°F occurred in July 1966. Maximum weekly average temperatures in the summer usually are in the range of 81 to 86°F. Minimum weekly average winter temperatures in January and February are less than 33°F. The Pond usually has ice over in January and February depending on the meteorological conditions. For the

period 1966 through 1974, the period of ice cover usually has been brief, i.e., usually less than four consecutive weeks.

A more detailed discussion of water temperature covering the period of 1936 to 1966, prior to the start of the biological monitoring program is provided in Section 3.2.

7.1.2.2 Light Penetration

The maximum average light penetration (37-46 inches) in the Pond usually occurs in August through October at a time of relatively low river flow (Table 7.2-1). Maximum light penetration is usually observed in the lower part of the Pond where depth is 50-90 feet. Depth of light penetration is lowest in the upper half of the Pond. Individual measurements have varied from 1 to 140 inches in the period 1967-1974.

7.1.2.3 Oxygen

No distinct seasonal vertical or horizontal stratification of dissolved oxygen occurred in the Pond in the preoperational or postoperational periods. Average values given in Table 7.1.2-4 during both periods were lowest in summer (4.1-7.8 ppm) and highest in winter (12.0-15.6 ppm). Compared to the preoperational period, oxygen values for the Pond were lower in winter, spring and fall and higher in summer in the postoperational period. These differences are considered natural variations because values at Station 601 (upstream control) followed the same trend. Oxygen values at Station 605 (located in the discharge) were similar to those observed for the entire Pond.

7.1.2.4 Biochemical Oxygen Demand

Biochemical oxygen demand (5 day BOD) determinations were made by the Baltimore Bureau of Water Supply on samples collected at Conowingo Dam in 1960-1967 (Table 7.1.2-5). Additional data have been collected but these were not available at the time of this writing. The monthly mean BOD values ranged from 1.5 to 2.1 mg/l with an overall mean of 1.7 mg/l. No distinct difference in monthly mean values was observed. The low BOD values indicate that no large amounts of organic wastes were present in the water leaving Conowingo Pond.

No appreciable amounts of untreated municipal or industrial wastes are discharged directly into the Pond other than from upstream sources. Because of recent stringent state and federal regulations requiring municipalities and industries to treat wastes before discharge into streams, the amount of wastes entering the Pond from upstream should have been reduced after 1967. For these reasons, the BOD values for Conowingo Pond

since 1967 are probably similar to or less than those reported above.

7.1.2.5 Chemical Parameters

Except for the concentrations of the total phosphates and seston (suspended solids), which are generally higher at the bottom, the values of other parameters are either homogeneously distributed or vary slightly with depth in the Pond (Table 7.1.2-1). The monthly mean concentrations of parameters other than nitrates, filterable iron, reactive silica, total phosphates and seston (suspended solids) are generally higher in summer and early fall. Nitrates (maximum average 8.77 ppm) and filterable iron concentrations (maximum average 0.33 ppm) are usually higher in late fall and winter. Reactive silica concentrations (maximum average 2.69 ppm) are higher in winter and early spring. From 1971 through 1973 total phosphates (maximum average 0.43 ppm) were higher in late fall through early spring. In 1974 they were higher in late spring through early summer and late fall (maximum average 0.38 ppm). The data show that the nutrients (phosphates, nitrates and silicates) are available in the late fall, winter and early spring.

Monthly variation was observed in mean concentrations of most parameters between the preoperational and postoperational periods. However, the range of variation in the postoperational period was within the range of that observed in the preoperational period (Table 7.1.2-1). The fluctuations in the concentration of most physicochemical parameters in the Pond coincide with variation in the mean daily river flow. The concentrations of most decrease as the river flow increases due to dilution.

7.1.2.6 Statistical Analysis

The 1971 through 1973 water quality data were analyzed using a factorial analysis of variance to detect differences between stations and depths In 1971, Stations 601, 605 and 611; in 1972 Stations 601, 604, 605 and 611; and in 1973, Stations 601, 604, 605, 607 and 611, were tested. In each year, three depths, surface 5 ft and bottom were tested. Data included in the analysis were those available from all stations and depths on a given date. If some values appeared "spurious" due to sampling error, two separate analyses were run; one including and the other excluding these values. We believe that the sampling error was caused by the presence of sediments in the water samples taken at the bottom.

Significant differences ($P < 0.05$) between stations were noted for phosphates in 1972 when data with "spurious" values were analyzed. However, when these values were excluded from the

analyses, significant differences between depths were noted. The concentrations of seston in 1971 were significantly different ($P < 0.05$) between stations. Other parameters did not differ spatially. Tukey's w-test indicated that the mean concentration (0.15 ppm) of total phosphates was significantly higher ($P < 0.05$) at Stations 601 and 604 than at Stations 605 and 611 (0.10 ppm). The mean seston was significantly higher at Station 611 than at other stations.

Only the concentrations of total phosphates in 1972 and 1973 and seston in 1971 and 1972 were significantly different ($P < 0.05$) between the three depths. The concentrations of the other parameters did not differ significantly ($P > 0.05$) between depths. The mean values of seston at bottom in 1971 (19.26) and 1972 (27.49) were significantly higher than at other depths. No significant differences were noted in 1973.

The above analyses indicate that even though some parameters reveal significant differences in spatial and vertical distribution, the differences are not consistent in all years. Also, the difference between means was small and is hardly of any biological significance.

TABLE 7.1.2-1

Comparison of the monthly mean values of water quality parameters measured during the preoperational (1971-1973) and postoperational (1974) periods in Conowingo Pond. Values are expressed in mg/l unless otherwise specified. Dash indicates parameter not measured. River flow data supplied by Pennsylvania Power and Light Company at Holtwood Dam. Temperature data taken at monitoring stations on the day of sampling.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Parameter													
							1967-73						
Water Temp. (F)	Surface	34.9	36.5	43.4	49.6	60.3	73.5	79.7	79.8	74.6	63.8	47.9	41.7
	Bottom	35.0	36.5	43.3	48.7	59.5	73.6	79.0	78.8	74.5	63.4	49.1	41.5
							1974						
	Surface	39.0	38.4	42.6	52.7	65.1	73.3	78.9	81.6	71.6	58.7	52.5	38.8
	Bottom	38.5	-	41.8	51.2	63.2	72.0	77.8	79.7	70.3	57.5	51.6	38.2
Dissolved Oxygen							1967-73						
	Surface	15.5	15.4	13.4	12.8	10.8	8.5	6.4	6.2	6.8	8.3	10.2	14.3
	Bottom	15.7	15.6	13.7	13.0	11.9	8.5	5.6	5.4	6.5	8.7	11.2	14.4
							1974						
	Surface	11.2	-	12.6	10.8	10.5	8.5	7.1	6.5	9.2	9.4	10.0	11.6
	Bottom	11.4	-	12.9	11.3	10.2	7.5	6.5	4.9	9.2	9.4	9.8	11.6
Secchi Disk							1967-73						
Reading (in.)		54	32	34	26	27	29	34	42	46	37	28	15
							1974						
		14	-	23	16	28	35	38	47	39	42	45	20
River Flow							1967-73						
(x 1000 cfs)		29.5	48.3	71.8	75.7	53.0	49.4	22.7	14.2	10.7	12.8	39.3	58.9
							1974						
		72.7	47.6	61.4	92.4	39.7	19.4	21.4	10.6	21.2	11.8	23.0	53.5
pH							1971-73						
	Surface	7.40	7.10	7.17	7.20	7.39	7.36	7.42	7.60	7.40	7.43	7.33	7.10
	Bottom	7.16	6.85	7.17	7.05	7.40	7.23	7.30	7.40	7.33	7.46	7.33	7.08
							1974						
	Surface	6.98	6.87	7.05	7.05	7.84	7.72	7.56	7.45	7.66	7.75	7.36	7.26
	Bottom	6.92	-	7.06	6.98	7.66	7.45	7.30	7.28	7.53	7.68	7.30	7.25
Conductivity							1971-73						
(umhos/cm at 20C)	Surface	200.68	187.22	178.44	158.20	156.60	168.40	230.22	282.71	312.83	332.87	245.26	155.79
	Bottom	213.43	120.58	215.84	156.33	152.81	152.50	220.83	279.83	307.64	321.68	233.43	141.45
							1974						
	Surface	168.50	175.90	147.80	147.80	179.50	219.70	178.60	254.00	230.01	247.03	260.49	154.30
	Bottom	173.90	-	146.60	140.30	176.30	220.30	178.70	251.94	232.49	246.27	255.06	152.37
Bicarbonate							1971-73						
(HCO_3)	Surface	36.83	34.81	36.22	34.08	35.81	41.95	54.34	59.15	59.32	59.75	51.84	32.68
	Bottom	37.49	23.86	42.28	33.67	33.73	37.35	54.21	58.63	45.36	57.14	51.61	28.90
							1974						
	Surface	34.17	28.07	28.17	32.24	40.60	53.76	44.28	59.04	45.26	53.43	56.25	35.59
	Bottom	32.39	-	28.13	29.90	40.80	54.60	44.76	58.25	45.48	54.07	56.54	34.92
Carbonate							1971-73						
(CO_3)	Surface	0.61	0.00	0.00	0.00	0.00	0.10	0.04	0.01	0.00	0.00	0.00	0.00
	Bottom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
							1974						
	Surface	0.00	0.00	0.00	0.00	0.07	0.00	0.15	0.00	0.26	0.09	0.00	0.00
	Bottom	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

continued

TABLE 7.1.2-1

Continued.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Parameter													
Sodium (Na)							1971-73						
	Surface	7.90	8.43	6.23	5.72	5.58	5.81	6.21	6.47	9.18	8.53	6.09	5.02
	Bottom	8.32	5.06	6.36	5.68	5.24	5.44	6.44	6.56	8.70	8.62	6.59	4.21
							1974						
	Surface	6.57	6.43	4.56	3.53	4.39	6.78	5.21	7.59	6.70	7.74	8.37	4.80
	Bottom	7.57	-	4.66	3.37	4.39	6.99	5.24	7.82	6.75	7.87	8.42	4.85
Potassium (K)							1971-73						
	Surface	3.30	3.11	2.86	2.93	2.92	3.47	3.96	4.06	5.73	7.54	6.08	3.23
	Bottom	2.99	2.57	2.88	2.57	2.88	2.92	3.82	3.90	5.41	6.82	5.36	2.53
							1974						
	Surface	3.15	2.37	2.43	2.18	2.14	3.57	3.65	4.38	3.65	3.91	4.36	3.30
	Bottom	3.12	-	2.30	2.18	2.17	3.68	3.70	4.48	3.61	3.93	4.26	3.26
Calcium (Ca)							1971-73						
	Surface	25.0	21.6	21.1	17.1	20.3	21.4	29.7	33.3	34.9	35.9	30.7	21.3
	Bottom	24.8	14.0	24.8	19.1	23.8	23.4	29.0	33.5	34.5	35.3	29.7	19.1
							1974						
	Surface	21.9	23.3	16.3	17.5	22.1	27.9	22.1	28.5	27.6	29.7	30.5	20.1
	Bottom	21.4	-	15.8	16.5	22.5	28.5	22.2	27.1	27.7	29.7	29.9	20.3
Magnesium (Mg)							1971-73						
	Surface	4.7	5.3	6.7	5.2	6.2	6.8	7.1	11.6	10.1	17.6	8.8	3.2
	Bottom	5.2	4.0	7.0	5.3	7.2	5.6	6.0	10.2	10.5	17.4	8.6	2.8
							1974						
	Surface	4.6	5.3	4.8	4.6	4.9	6.6	5.5	9.8	7.8	8.7	8.3	4.2
	Bottom	4.8	-	4.8	4.4	5.0	6.5	5.7	10.6	7.3	9.2	8.3	3.9
Chloride (Cl)							1971-73						
	Surface	10.53	10.71	9.65	7.04	7.11	7.89	11.17	12.41	13.78	16.79	12.38	8.75
	Bottom	10.43	6.74	9.59	6.42	6.91	7.13	9.96	11.91	13.74	16.26	11.72	7.64
							1974						
	Surface	8.28	8.40	6.97	5.90	8.18	15.02	6.75	12.37	9.65	11.16	11.42	6.93
	Bottom	8.01	-	6.79	5.07	8.19	14.93	6.69	12.25	9.52	11.56	11.49	6.93
Sulfate (SO_4)							1971-73						
	Surface	44.64	42.73	48.98	36.88	37.24	47.60	58.93	73.19	92.04	91.43	75.53	37.42
	Bottom	45.40	28.88	59.17	41.17	37.61	43.37	58.39	72.45	92.28	93.13	67.42	33.74
							1974						
	Surface	41.22	44.89	36.42	35.24	42.23	50.11	40.87	67.25	61.36	70.07	64.94	38.04
	Bottom	43.35	-	35.31	32.93	40.35	50.75	38.60	62.26	59.94	70.11	60.48	37.17
Nitrite (NO_2)							1971-73						
	Surface	0.05	0.13	0.05	0.04	0.04	0.05	0.07	0.12	0.14	0.10	0.06	0.05
	Bottom	0.06	0.20	0.06	0.04	0.03	0.07	0.12	0.14	0.14	0.12	0.06	0.05
							1974						
	Surface	0.04	0.04	0.03	0.04	0.03	0.05	0.06	0.14	0.07	0.05	0.03	0.03
	Bottom	0.03	-	0.03	0.04	0.03	0.05	0.07	0.16	0.07	0.04	0.02	0.03
Nitrate (NO_3)							1971-73						
	Surface	7.14	8.17	6.25	5.58	5.49	5.08	5.61	5.31	7.13	8.60	6.54	5.42
	Bottom	6.92	4.87	4.75	4.71	5.10	4.70	5.64	4.82	6.67	7.59	6.23	4.84
							1974						
	Surface	7.89	5.56	5.48	4.43	3.50	1.98	1.68	2.08	2.68	2.44	2.58	3.14
	Bottom	8.77	-	5.62	4.39	3.30	1.90	1.69	2.19	2.59	2.55	2.32	3.19

continued

TABLE 7.1.2-1

Continued.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Parameter													
Filterable Iron (Fe)							1971-73						
	Surface	0.30	0.06	0.13	0.11	0.06	0.03	0.03	0.02	0.04	0.12	0.09	0.12
	Bottom	0.08	0.07	0.11	0.10	0.05	0.02	0.02	0.02	0.04	0.17	0.09	0.18
							1974						
	Surface	0.20	0.03	0.07	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.05	0.18
	Bottom	0.33	-	0.09	0.03	0.04	0.01	0.02	0.02	0.03	0.02	0.05	0.13
Silica (SiO_3-Si)							1971-73						
	Surface	1.12	1.46	1.23	0.79	1.20	0.67	0.84	0.84	0.66	0.41	0.84	0.94
	Bottom	1.25	2.44	1.65	1.05	1.20	0.85	1.01	0.90	0.76	0.50	1.05	1.24
							1974						
	Surface	2.69	2.40	2.11	2.10	0.82	0.34	1.17	0.82	1.31	0.28	0.70	1.99
	Bottom	2.68	-	2.11	2.14	0.92	0.39	1.19	0.85	1.34	0.30	0.75	1.98
Phosphate (PO_4)							1971-73						
	Surface	0.14	0.26	0.16	0.15	0.14	0.11	0.11	0.11	0.10	0.09	0.21	0.19
	Bottom	0.16	0.43	0.12	0.17	0.16	0.15	0.19	0.13	0.16	0.14	0.16	0.25
							1974						
	Surface	0.13	0.11	0.10	0.20	0.23	0.22	0.24	0.16	0.20	0.18	0.16	0.25
	Bottom	0.14	-	0.11	0.27	0.38	0.38	0.29	0.20	0.24	0.26	0.20	0.25
Seston (Suspended Solids)							1971-73						
	Surface	16.8	96.8	23.2	18.0	19.4	26.8	23.8	12.8	14.2	13.5	28.6	43.1
	Bottom	6.3	216.6	28.1	15.5	25.6	38.4	45.7	27.3	20.3	17.4	28.1	44.3
							1974						
	Surface	21.9	13.4	8.7	28.8	18.4	15.0	11.4	7.4	11.8	10.3	7.8	17.3
	Bottom	37.3	-	21.9	45.5	44.1	70.7	17.0	13.1	16.7	25.5	14.4	20.8

TABLE 7.1.2-2

Maximum weekly average water temperatures (F) measured at Holtwood Dam, January-December, 1966-1974.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1966	37.1	37.4	48.1	55.7	69.0	86.0	88.4	85.4	84.5	64.8	56.7	40.2
1967	36.0	33.5	44.9	57.2	65.5	80.9	83.1	80.2	75.5	65.2	47.0	39.6
1968	32.5	32.6	54.0	62.6	62.9	75.7	85.9	85.1	*	64.8	55.1	42.4
1969	32.3	32.5	44.6	58.4	69.7	83.3	82.5	80.3	77.7	66.1	51.8	35.4
1970	32.2	33.3	41.3	58.6	71.5	77.0	83.6	85.1	80.6	68.9	53.2	37.6
1971	32.5	37.3	43.6	54.6	64.0	84.7	85.3	82.2	82.7	72.0	46.6	42.0
1972	36.7	37.1	41.0	58.6	71.0	71.5	83.6	81.1	79.0	64.0	53.0	39.4
1973	40.0	37.3	48.4	61.4	60.1	79.5	81.7	82.7	83.3	67.8	49.0	45.1
1974	39.9	37.7	43.6	63.0	71.2	79.5	83.5	85.4	77.8	63.7	61.9	38.3

* Temperature not available

TABLE 7.1.2-3

Minimum weekly average winter water temperature (F) (December-March), measured at Holtwood Dam, 1966-1974.

Year	Month			
	Jan	Feb	Mar	Dec
1966	32.2	32.2	38.4	32.4
1967	32.5	32.4	34.8	35.2
1968	32.2	32.3	33.1	32.1
1969	32.1	32.2	32.9	32.1
1970	32.1	32.3	35.6	33.5
1971	32.3	32.6	37.3	37.6
1972	32.8	32.4	35.8	34.4
1973	32.9	32.6	43.1	33.9
1974	32.5	32.8	41.7	

TABLE 7.1.2-4

Comparison of the seasonal vertical distribution of dissolved oxygen (ppm) during the preoperational (1967-1973) and postoperational (1974) periods for Conowingo Pond (all stations), Station 601 (located upstream from Peach Bottom Atomic Power Station), Station 605 (located in the discharge from Peach Bottom Atomic Power Station) and Station 611 (located downstream from Peach Bottom Atomic Power Station near Conowingo Dam).

Season Period		Winter (Jan-Mar) 1967-1973	Winter (Jan-Mar) 1974	Spring (Apr-Jun) 1967-1973	Spring (Apr-Jun) 1974	Summer (Jul-Sep) 1967-1973	Summer (Jul-Sep) 1974	Fall (Oct-Dec) 1967-1973	Fall (Oct-Dec) 1974
	Depth								
Conowingo Pond	0	14.6	12.2	10.2	9.9	6.6	7.4	10.9	10.3
(all stations)	5	14.8	12.9	10.8	9.9	6.6	7.6	11.1	10.3
	10	14.9	12.6	10.9	9.8	6.6	7.2	11.6	10.3
	*15	15.2	12.8	10.5	9.7	6.4	6.8	11.7	10.6
Station 601	0	14.6	13.1	9.6	9.5	5.7	6.3	10.8	10.1
(upstream	5	14.9	13.5	10.4	9.5	5.7	6.5	11.2	10.1
control)	10	14.8	-	10.8	9.4	5.4	6.3	11.7	10.6
	*15	15.3	12.7	10.8	9.9	6.8	6.5	13.0	10.1
Station 605	0	14.8	11.4	9.8	10.0	6.7	7.5	11.1	9.9
(discharge)	5	15.0	12.4	10.1	10.0	6.4	7.8	11.1	10.0
	10	15.0	12.3	10.2	10.0	6.4	7.5	11.2	10.1
	*15	15.0	12.0	9.6	10.2	5.7	7.4	10.6	10.3
Station 611	0	15.1	12.8	9.8	10.5	6.7	7.7	10.6	10.0
(downstream)	5	15.2	12.7	10.1	10.5	6.6	7.7	10.7	10.0
	10	15.2	12.8	10.0	10.4	6.2	6.8	10.7	10.0
	15	15.3	13.4	10.2	10.4	6.5	6.6	10.8	10.6
	20	15.4	13.4	10.2	10.0	6.7	6.6	10.9	10.6
	30	15.5	13.5	10.4	9.8	6.5	6.4	11.1	10.7
	40	15.6	13.6	10.5	9.9	6.4	6.2	11.4	10.5
	50	15.3	13.8	10.4	9.4	5.9	6.0	11.4	10.9
	60	15.3	13.6	10.6	9.1	5.3	5.1	11.5	10.2
	*65	15.1	13.2	10.0	9.1	4.1	4.8	11.1	9.4

* Mean bottom depth

TABLE 7.1.2-5

Monthly mean, minimum and maximum biological oxygen demand (5-day B.O.D.) values (mg/l) from samples collected at Conowingo Dam by the Baltimore Bureau of Water Supply, 1960-1967. Data supplied by the STORET System of the Environmental Protection Agency. N represents the number of determinations made.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Grand Values
N	21	20	24	22	22	25	30	27	21	23	27	16	278
Mean	1.5	2.0	2.1	1.6	1.6	1.9	1.6	1.9	1.8	1.5	1.8	1.6	1.7
Min	0.4	0.5	0.7	0.6	0.6	0.1	0.0	0.0	0.0	0.5	0.8	0.8	0.0
Max	3.2	3.3	4.1	2.8	3.0	4.1	3.3	4.4	3.5	2.9	3.6	2.6	4.4

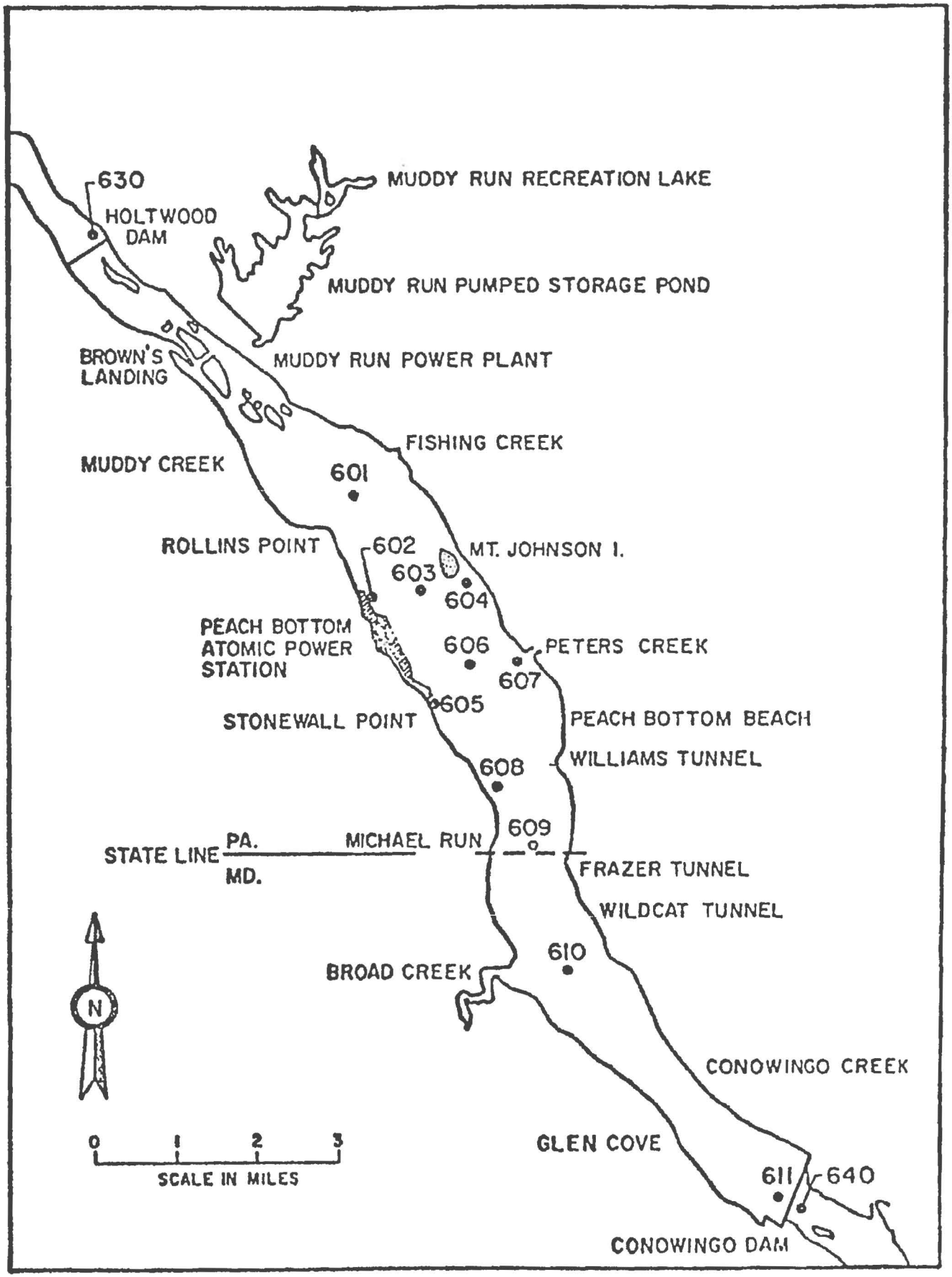


FIGURE 7.1-1 Distribution of limnological stations in Conowingo Pond.

7.1.3 PHYTOPLANKTON COMMUNITY

7.1.3.1 Species Composition

Populations of algal cells retained by a #20 mesh plankton net in June through October were enumerated and identified to genera in 1967 through 1969. A list of genera of algae collected in the Pond is given in Table 7.1.3-1. Common genera collected were Pandorina, Pleodorina, Pediastrum, Melosira, Asterionella, Anacystis, Gomphosphaeria and Anabaena.

The abundance of groups of algae differed monthly; green algae were common in August and September, brown algae in October, diatoms in June and July and blue-green algae in September and October (Table 7.1.3-2). Overall, diatoms were dominant and constituted 49% of the algal population. Although blue-green algae were common in September and October, they were not the dominant group in the Pond.

7.1.3.2 Plant Pigments

The concentrations of chlorophyll a (total and active), b, c, phaeo-pigments and carotenoids have been measured at selected monitoring stations since 1971 to indicate the standing crop of algae in the Pond. Comparison of the monthly mean pigment concentrations in the preoperational (1971-1973) and postoperational (1974) periods is given in Table 7.1.3-3. No substantial differences were noted.

No distinct vertical stratification of any plant pigment occurs in the Pond (Table 7.1.3-3). Most plant pigment concentrations are low in late fall through early spring, increase in mid and late spring and peak in summer and early fall. Variation in monthly mean concentrations occurred between the preoperational and postoperational periods. However, the range of variation between periods was similar.

Concentrations of total chlorophyll a at Stations 601 (upstream control), 605 (discharge), and 611 (downstream from discharge) on each sampling date in 1971 through 1974 are shown in Figures 7.1.3-1 to 7.1.3-4. The overall Pond averages are also shown for comparison. The pattern of chlorophyll a distribution at the selected stations is similar to that in the entire Pond. The peaks occur at the same time at all stations. However, the occurrence of these peaks within seasons can vary between years. The general pattern is one of small peaks in late spring and fall and a maximal peak in the summer. The concentrations are lower in November through May. There is little evidence of spatial differences in chlorophyll concentrations. The postoperational values at Station 605 are

within the range of variation observed in the preoperational period.

The relationship between concentration of chlorophyll a (total), nitrates, phosphates in 1971-1974 is shown in Figure 7.1.3-5. Data for this figure are given along with water temperature, river flow and zooplankton density in Table 7.1.3-4. The concentrations of nitrates and phosphates are usually higher in the fall and winter months while the chlorophyll a concentrations are generally low in late November through early April. However, the fluctuations in the concentration of phosphates are less than those for the nitrates. The values for phosphates ranged from 0.08 to 0.36 ppm but for the nitrates the range was 0.83 to 15.19 ppm. It is important to note that the nutrients and phytoplankton are present throughout the year and are never completely depleted.

7.1.3.3 Statistical Analysis

The relationship between the concentration of total chlorophyll a and the water temperature, average daily river flow, nitrates, phosphates, reactive silica and depth of light penetration (Secchi disk measurements) was examined by stepwise multiple regression analysis. The data collected in 1973 were used for this analysis.

The six independent variables accounted for 66.6% of the total variation in chlorophyll a concentrations (Table 7.1.3-5). The water temperature alone accounted for 60.8% of the variation. The depth of light penetration, reactive silica and phosphates accounted for an additional 5.2% of the variation.

Examination of the simple correlations and signs of the regression coefficients indicated that the water temperature is positively related while the nutrient elements and the river flow are negatively related to the total chlorophyll a. That is, as the water temperature increases chlorophyll a increases and as river flow increases the chlorophyll a values decrease. An increase in nutrients coincides with a decrease in the phytoplankton. The water temperature had the highest correlation ($r = 0.779$) with chlorophyll a. The standardized partial regression coefficients revealed that the water temperature is about four times more important than the depth of light penetration or concentration of phosphates in predicting the concentrations of chlorophyll a. The reason that the water temperature is more important in the Pond than the nutrients is because the nutrient levels do not fluctuate widely and they are generally available throughout the year.

7.1.3.4 Aquatic Vascular Plants

Macrophytic aquatic plants are not common in the Pond. A list of species observed is given in Table 7.2.3-6. A few macrophytes occur from Holtwood Dam along the shallow rocky areas of the west shore to a point approximately one mile below the Dam (Figure 7.1.3-6). The common species is the water willow (*Justicia americana*). Small isolated beds of macrophytes are found in Hopkins Cove and at the mouth of tributary streams such as Peters Creek and Wissler Run.

A small bed of water willow, located at Burkins Run, is the only bed of aquatic macrophytes which is impacted by the thermal plume. No deleterious effects have been observed since PBAPS began operation in January 1974.

TABLE 7.1.3-1

A list of genera of algae collected in Conowingo Pond, 1967-1969.

Green Algae

- Chlamydomonas
- Eudorina
- Pandorina
- Pleodorina
- Volvox
- Haematococcus
- Sphaerocystis
- Golenkinia
- Micractinium
- Errerella
- Dictyosphaerium
- Coelastrum
- Hydrodictyon
- Pediastrum
- Oocystis
- Ankistrodesmus
- Closteriopsis
- Kirchneriella
- Selenastrum
- Actinastrum
- Scenedesmus
- Closterium
- Cosmarium
- Staurastrum
- Spirogyra

Yellow-green Algae

- Gloeobotrys

Yellow-brown Algae

- Mallomonas
- Synura
- Dinobryon

Diatoms

- Melosira
- Stephanodiscus
- Asterionella
- Fragilaria
- Gyrosigma
- Navicula
- Nitzschia

Brown Algae

- Ceratium
- Peridinium

Blue-green Algae

- Anacystis
- Coccochloris
- Gomphosphaeria
- Anabaena
- Aphanizomenon
- Nostoc
- Rivularia
- Oscillatoria
- Spirulina

TABLE 7.1.3-2

Monthly variation in the percentage composition of the major groups of algae in Conowingo Pond, 1967-1969.

Group of Algae	Jun	Jul	Aug	Sep	Oct	Average
Green	16.3	21.3	40.5	31.4	5.0	27.4
Yellow-brown	0.0	0.6	0.6	0.4	0.0	0.6
Brown	0.7	1.2	1.5	1.6	15.0	5.1
Diatoms	75.0	63.8	31.4	31.6	46.0	49.0
Blue-green	4.0	9.5	17.8	30.0	32.0	19.7

TABLE 7.1.3-3

Comparison of the monthly mean plant pigment concentrations (mg/m^3) during the preoperational (1971-1973) and postoperational (1974) periods in Conowingo Pond. Dash indicates pigment not measured.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Chlorophyll a (Total)						
						1971-1973						
Surface	1.56	0.88	2.18	5.22	17.29	25.91	16.01	21.59	17.64	16.84	13.37	3.60
Bottom	0.62	1.75	1.89	3.51	14.51	22.88	16.10	16.36	15.48	13.93	10.66	4.47
						1974						
Surface	1.64	1.57	1.46	4.73	33.22	28.43	23.54	15.00	28.83	23.18	14.74	4.36
Bottom	1.41	-	2.20	2.86	35.63	27.18	24.44	12.40	27.31	24.93	11.50	4.84
						Chlorophyll a (Active)						
						1971-1973						
Surface	1.58	0.80	2.38	2.46	11.41	15.61	10.08	13.05	9.10	9.31	8.38	2.49
Bottom	0.60	0.80	0.56	2.58	10.87	14.71	10.63	9.33	9.97	9.61	6.32	2.40
						1974						
Surface	1.11	0.40	0.85	2.90	27.05	20.16	17.05	10.60	19.85	15.22	11.62	1.71
Bottom	1.12	-	0.88	1.76	27.15	16.10	14.42	8.45	17.78	15.78	7.21	1.20
						Chlorophyll b						
						1971-1973						
Surface	0.23	0.43	0.39	0.89	0.74	1.02	1.42	2.71	9.10	2.27	1.55	1.01
Bottom	0.28	0.79	1.08	1.28	0.74	1.15	2.06	3.29	4.35	3.30	1.82	1.75
						1974						
Surface	1.71	2.53	0.34	0.90	1.32	2.15	2.02	2.04	3.35	2.05	1.34	2.96
Bottom	1.35	-	1.09	1.28	0.93	3.40	2.43	2.01	3.19	1.29	1.56	2.72
						Chlorophyll c						
						1971-1973						
Surface	1.19	1.31	1.09	1.63	5.68	4.19	3.62	5.54	4.80	4.65	4.44	2.57
Bottom	0.76	2.46	2.98	1.44	5.77	5.73	5.25	4.35	4.30	5.95	3.86	3.58
						1974						
Surface	3.60	5.81	0.85	3.16	14.26	9.23	7.36	8.21	11.42	7.30	6.62	7.85
Bottom	2.70	-	3.61	3.60	13.98	14.10	6.41	4.57	8.34	5.97	6.04	6.68
						Phaeopigments						
						1971-1973						
Surface	0.39	0.37	1.05	4.11	7.56	14.29	8.36	12.14	11.70	10.02	5.67	2.32
Bottom	0.56	1.44	2.55	2.15	5.75	13.62	9.08	11.68	10.37	6.94	8.09	3.91
						1974						
Surface	1.19	2.21	1.05	3.12	9.33	13.30	10.27	7.30	14.67	12.94	4.96	4.77
Bottom	0.64	-	2.59	1.94	13.01	18.33	16.16	6.43	15.58	14.78	7.09	5.81
						Carotenoids (Min.)						
						1971-1973						
Surface	0.36	0.45	0.57	1.01	5.03	7.03	4.76	5.49	4.50	4.06	3.86	1.38
Bottom	0.23	0.12	0.35	0.76	4.44	6.20	5.42	5.22	4.48	4.85	3.49	1.66
						1974						
Surface	0.14	0.38	0.01	1.09	10.86	8.73	7.47	3.53	7.25	6.15	4.33	0.08
Bottom	0.00	-	0.36	0.58	11.30	8.27	8.03	3.31	8.28	7.49	3.72	0.28
						Carotenoids (Max.)						
						1971-1973						
Surface	0.91	1.14	1.41	2.53	12.58	17.34	11.89	13.72	11.24	10.16	9.66	3.45
Bottom	0.58	0.30	0.87	1.90	11.10	15.49	13.56	13.04	11.20	12.12	8.72	4.16
						1974						
Surface	0.35	0.95	0.02	2.72	27.16	21.83	18.66	8.82	18.13	15.36	11.31	0.19
Bottom	0.00	-	0.90	1.44	28.26	20.67	20.07	8.27	20.70	18.72	9.30	0.69

TABLE 7.1.3-4

Chlorophyll a (mg/m^3) nitrates, phosphates (ppm), water temperature (F), daily river flow (x 1000 cfs) and zooplankton density (no./liter) data during the preoperational (1971-1973) and postoperational (1974) periods in Conowingo Pond.

Date	Chlorophyll a	NO_3	PO_4	Water Temp. (F)	River Flow	Avg. Total Zooplankton Density
		1971				
19 Mar-22 Mar	1.74	-	-	39.2	173.4	0.1
18 May	5.44	8.92	-	60.0	61.9	0.7
9 Jul	12.46	6.08	0.08	86.0	7.7	184.3
21 Jul	16.20	3.60	0.08	82.3	6.7	124.9
4 Aug	16.36	4.12	0.29	76.7	39.4	67.8
18 Aug	22.46	2.97	0.09	82.4	7.3	166.8
1 Sep	10.79	6.04	0.14	78.6	7.7	151.1
15 Sep	13.26	5.07	0.06	82.1	13.1	142.9
29 Sep	10.57	8.36	0.16	70.4	13.2	31.6
13 Oct	11.58	8.72	0.10	64.1	10.2	28.7
27 Oct	9.29	13.42	0.09	62.5	16.3	11.5
10 Nov	13.50	10.74	0.25	48.2	17.8	1.2
24 Nov	10.96	7.08	0.06	44.3	12.0	1.3
13 Dec	4.37	7.44	0.34	42.5	107.0	2.0
		1972				
10-11 Jan	0.55	6.95	0.21	34.7	39.4	0.1
31 Jan-3 Feb	0.52	8.21	0.26	32.2	31.6	0.1
13 Apr	1.39	4.97	0.11	50.9	49.5	0.1
28 Apr	2.13	4.04	0.24	53.3	71.0	0.3
10 May	4.74	6.23	0.22	58.1	91.2	0.4
24 May	18.75	4.25	0.09	70.7	58.3	0.6
8 Jun	32.64	4.47	0.19	71.1	44.6	2.6
21 Jun	11.37	7.31	0.02	73.8	54.8	6.4
6 Jul	3.79	9.26	0.21	68.9	76.3	0.9
19 Jul	31.81	6.75	0.06	79.9	57.6	2.8
2 Aug	13.88	5.34	0.02	77.9	16.5	59.2
16 Aug	18.22	7.97	0.05	78.6	14.0	86.2
30 Aug	21.65	7.00	0.05	81.5	9.4	110.6
13 Sep	16.39	15.19	0.06	75.4	6.7	81.9
27 Sep	13.22	5.57	0.08	71.6	8.0	41.8
16 Oct	-	-	-	64.4	8.0	70.7
25 Oct-31 Oct	22.87	7.71	0.14	52.7	7.1	32.9
9 Nov-10 Nov	19.99	7.20	0.16	51.3	62.7	2.1
16 Nov	3.41	6.31	0.28	-	-	-
5 Dec	1.74	5.42	0.13	39.2	50.5	0.2
14 Dec	1.32	5.05	0.17	-	-	-
		1973				
25 Jan	1.09	5.43	0.10	33.1	55.7	0.1
7 Feb	1.29	4.97	0.36	37.4	117.8	0.1
7 Mar	2.38	5.29	0.08	38.3	60.5	0.1
28 Mar	1.58	4.25	0.12	46.6	51.2	0.1
12 Apr	1.89	4.55	0.16	46.3	117.6	0.3
24 Apr	10.31	5.31	0.13	63.5	37.4	0.2
8 May-9 May	22.56	4.10	0.13	57.4	40.2	0.3
22 May	16.49	3.61	0.09	58.1	62.6	1.0
5 Jun	22.77	4.12	0.09	69.5	45.1	1.0
20 Jun	29.22	3.15	0.12	72.2	24.5	26.8
4 Jul	19.14	5.48	0.25	77.9	50.0	7.7
18 Jul	10.09	4.41	-	79.4	13.2	66.1
31 Jul	14.17	3.39	0.12	82.1	17.0	95.1
15 Aug	12.56	2.70	0.09	83.0	10.1	68.0
29 Aug	18.34	2.90	0.13	78.5	11.3	39.4
12 Sep	11.10	2.22	0.12	79.2	8.9	51.6
26 Sep	26.31	5.45	0.17	66.2	17.7	4.3
24 Oct	10.91	4.03	0.10	59.0	8.9	16.3
12 Nov	4.54	3.42	0.10	43.7	22.4	0.2
28 Nov	-	4.77	0.09	50.4	29.3	0.3
12 Dec	8.45	2.48	0.12	39.2	105.2	0.8
		1974				
24 Jan	1.32	8.68	0.13	38.4	123.2	0.1
15 Mar	1.34	5.27	0.09	40.3	69.5	0.1
26 Mar	2.22	5.85	0.11	43.2	51.9	0.1
9 Apr	6.85	3.78	0.23	46.8	119.4	0.3
25 Apr	5.07	4.96	0.28	56.2	43.3	0.3
8 May	38.11	3.86	0.28	58.3	29.5	0.8
22 May	33.38	2.91	0.28	70.9	40.3	3.2
5 Jun	36.80	2.36	0.25	70.7	22.6	41.0
19 Jun	21.82	1.38	0.27	76.1	26.0	244.4
10 Jul	36.00	2.57	0.27	83.2	26.5	20.5
24 Jul	15.53	0.83	0.24	83.5	10.5	34.4
14 Aug	15.77	2.10	0.19	82.4	8.4	60.8
29 Aug	12.88	2.11	0.15	86.6	6.1	104.1
11 Sep	32.33	2.45	0.21	70.6	21.0	10.7
24 Sep	22.38	2.76	0.23	71.6	20.0	100.1
9 Oct	39.90	2.32	0.23	60.3	12.6	30.6
23 Oct	12.96	2.74	0.18	57.1	11.4	29.0
6 Nov	16.94	2.42	0.21	61.6	7.6	12.1
20 Nov	9.57	2.28	0.14	43.9	28.7	0.4
5 Dec	4.05	3.04	0.23	36.5	32.2	0.4
15 Dec-16 Dec	4.31	3.27	0.23	38.3	59.9	0.3

TABLE 7.1.3-5

Regression statistics for the concentration of total chlorophyll a (mg/m^3) and physicochemical parameters in Conowingo Pond, 1973.

Order of entry of Variables	R^2	$s_{y.x}$	Simple Correlation	Standarized Partial Regression Coefficient
Water Temperature (F)	0.608	0.296	0.779**	0.951
Secchi disk (inches)	0.622	0.292	0.118 NS	-0.259
Phosphates (ppm)	0.644	0.285	-0.118 NS	-0.241
Reactive silica (ppm)	0.664	0.279	-0.299 **	0.175
River Flow (100 x cfs)	0.665	0.279	-0.493**	-0.068
Nitrates (ppm)	0.666	0.281	-0.298**	-0.044

$r_{98df,\ 0.05} = 0.197$

$r_{98df,\ 0.01} = 0.253$

TABLE 7.1.3-6

List of macrophytic aquatic plants found in Conowingo Pond.

Species
Swamp milkweed - *Asclepias incarnata*
Bur marigold - *Bidens* sp.
Turtlehead - *Chelone glabra*
Sedge - *Cyperus strigosus*
Three-way sedge - *Dulichium arundinaceum*
Spike rush - *Eleocharis acicularis*
Spike rush - *Eleocharis* spp.
Joe-Pye weed - *Eupatorium dubium*
Boneset - *Eupatorium perfoliatum*
Halberd leaved rose - *Hibiscus militaris*
Blue flag - *Iris versicolor*
Rush - *Juncus scuminatus*
Soft rush - *Juncus effusus*
Water willow - *Justicia mericanan*
Cardinal flower - *Lobelia cardenalis*
Great lobelia - *Lobelia siphilitica*
Seedbox - *Ludwigia alternifolia*
Yellow loosetrife - *Lysimachia terrestris*
Spiked loosetrife - *Lythrum salicara*
Monkey flower - *Mimulus ringens*
Yellow pond lily - *Nuphar advena*
False dragonhead - *Physostegia virginiana*
Smartweed - *Polygonum densiflorum*
Pickerelweed - *Pontedaria cordata*
Broad leaved arrowhead - *Sagittaria latifolia*
Engelmanns arrowhead - *Sagittaria engelmanniana*
Swordgrass - *Scirpus americanus*
Soft stem bulrush - *Scirpus validus*
Bur reed - *Sparganium* sp.
Slough grass - *Spartina pectinata*
Common cattail - *Typha latifolia*
Water celery - *Vallisneria americana*

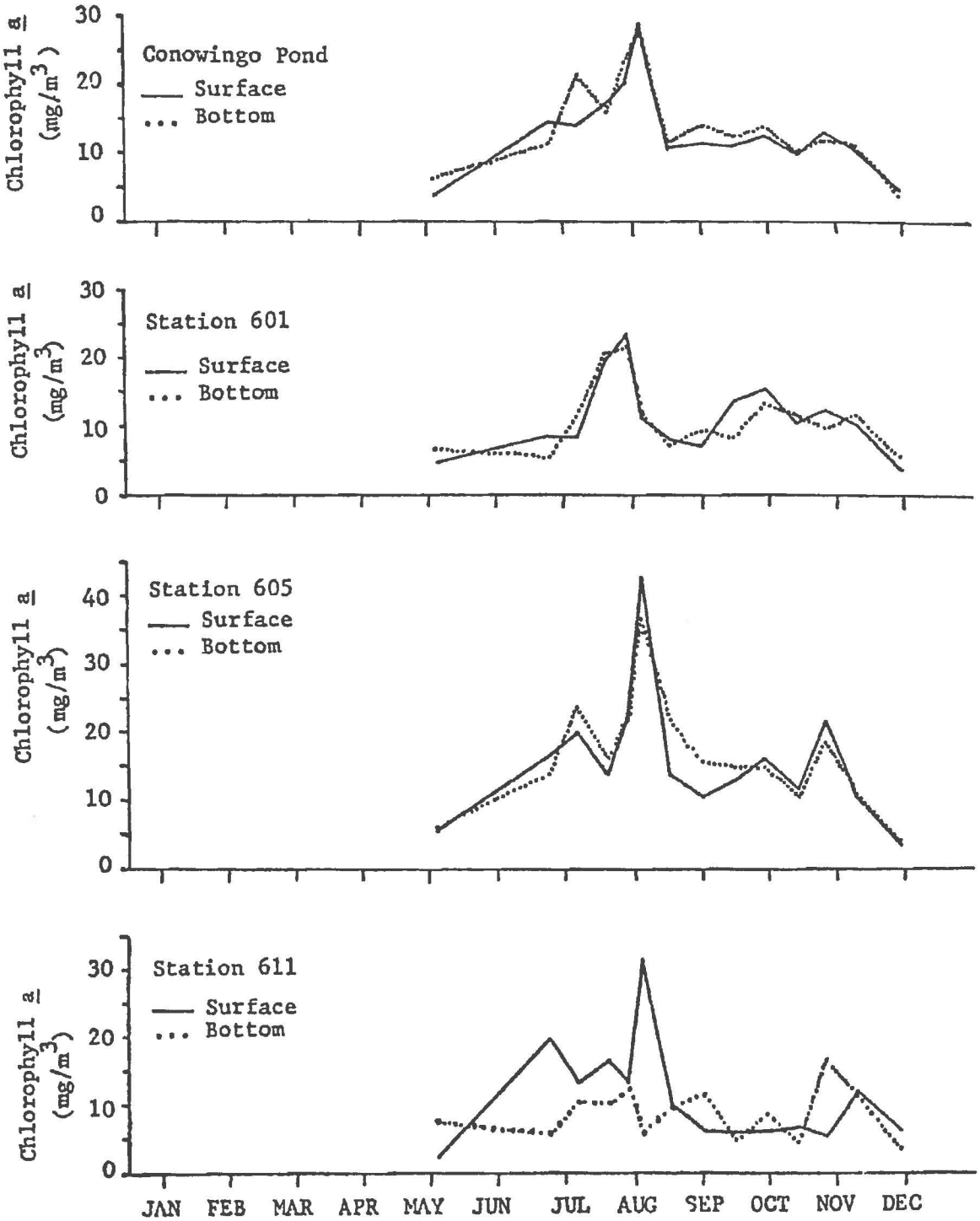


FIGURE 7.1.3-1

Average chlorophyll a (mg/m^3) concentrations in Conowingo Pond and at Station 601 (control), 605 (discharge) and 611 (downstream) in 1971.

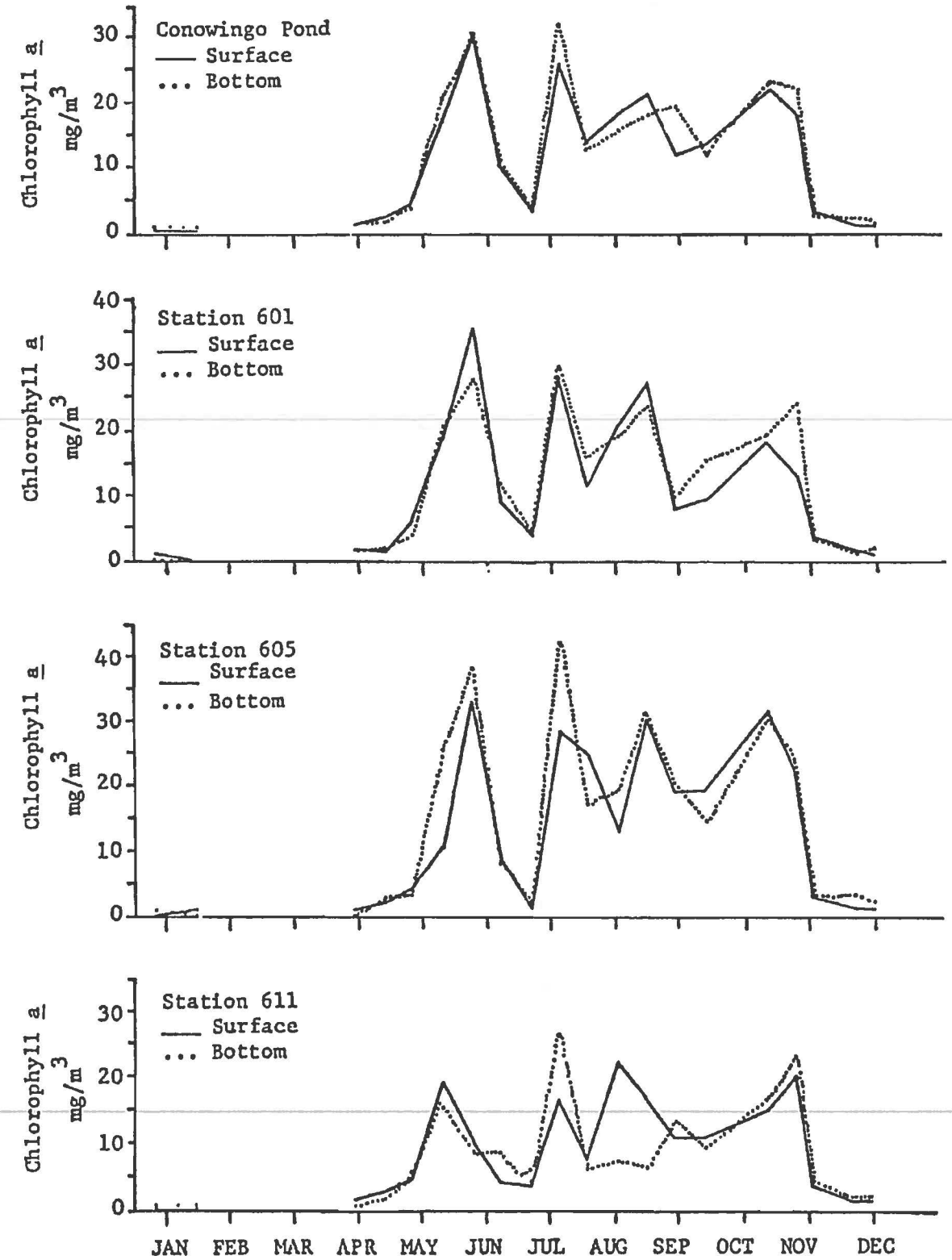


FIGURE 7.1.3-2

Average chlorophyll a (mg/m^3) concentrations in Conowingo Pond and at Station 601 (control), 605 (discharge) and 611 (downstream) in 1972.

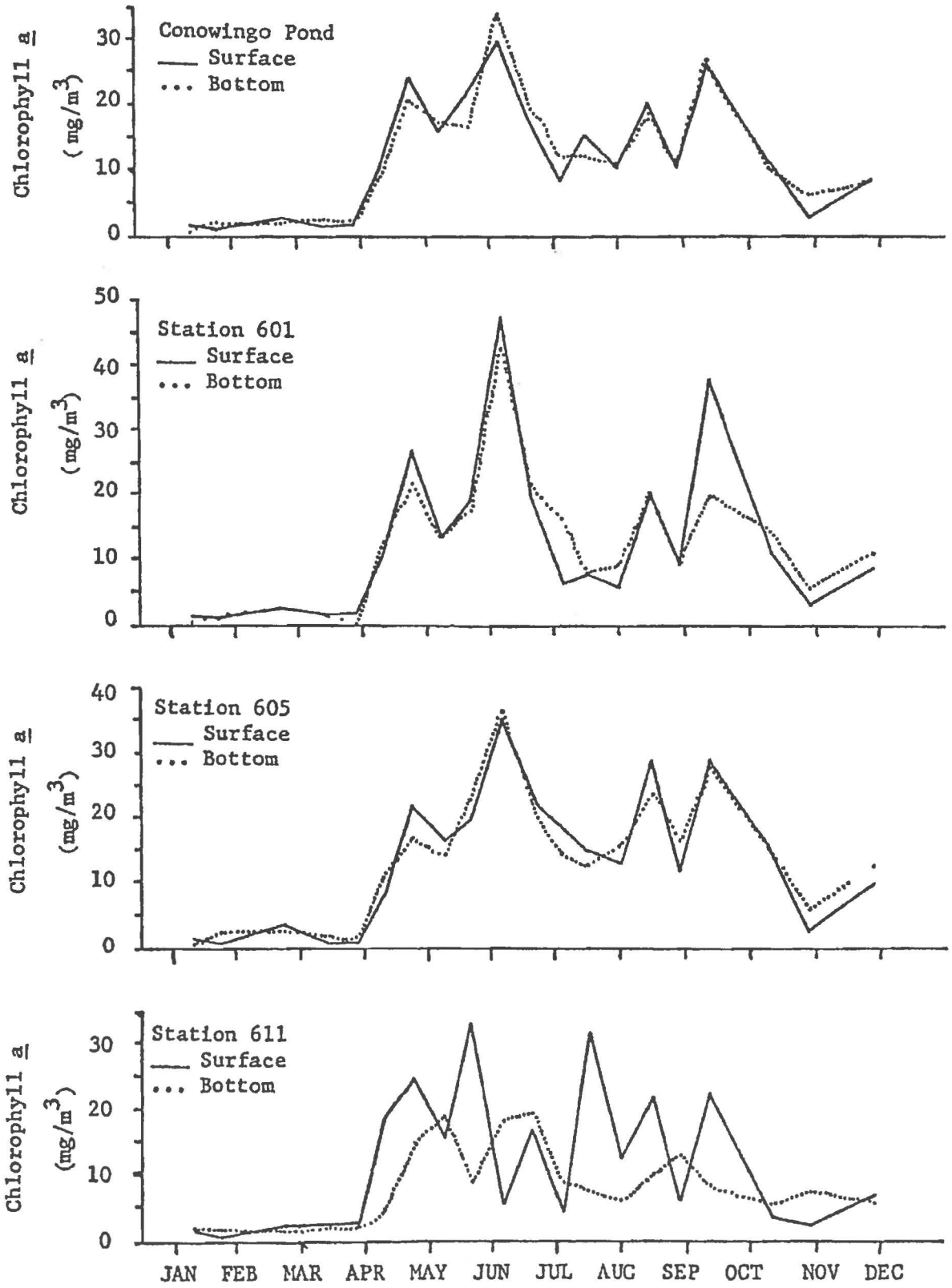


FIGURE 7.1.3-3

Average chlorophyll a (mg/m^3) concentrations in Conowingo Pond and at Station 601 (control), 605 (discharge) and 611 (downstream) in 1973.

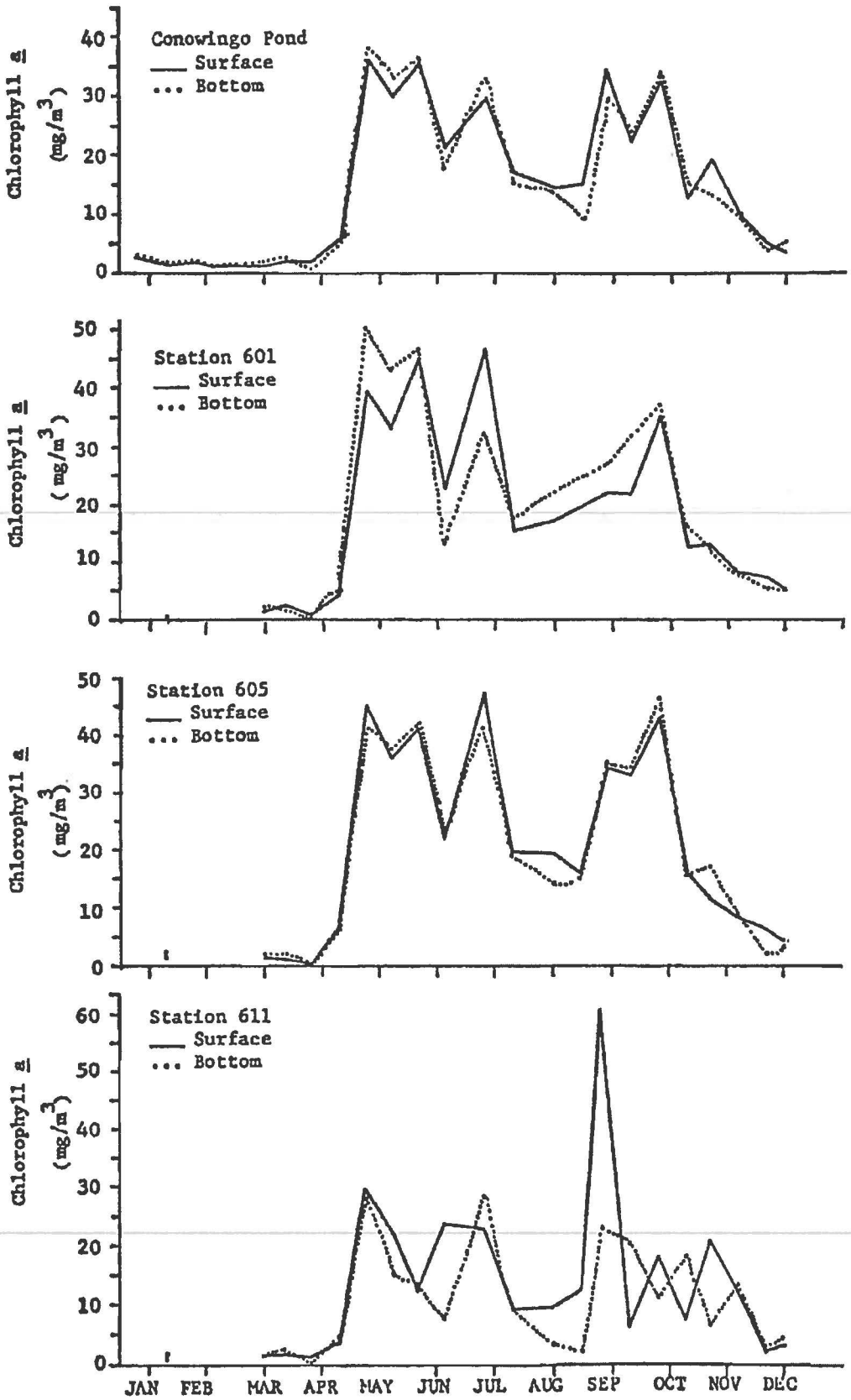


TABLE 7.1.3-4

Average chlorophyll a (mg/m^3) concentrations in Conowingo Pond and at Station 601 (control), 605 (discharge) and 611 (downstream) in 1974.

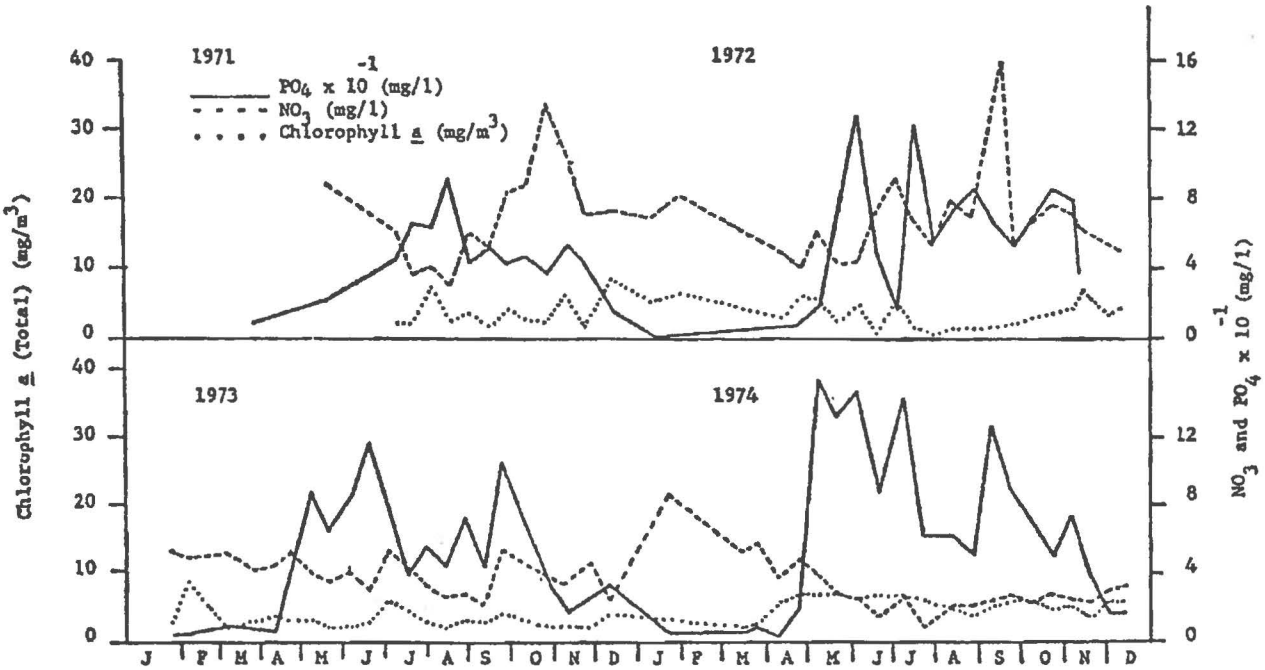


FIGURE 7.1.3-5

Plot of total chlorophyll a (mg/m^3), nitrates and phosphates (ppm) in Conowingo Pond, 1971-1974.

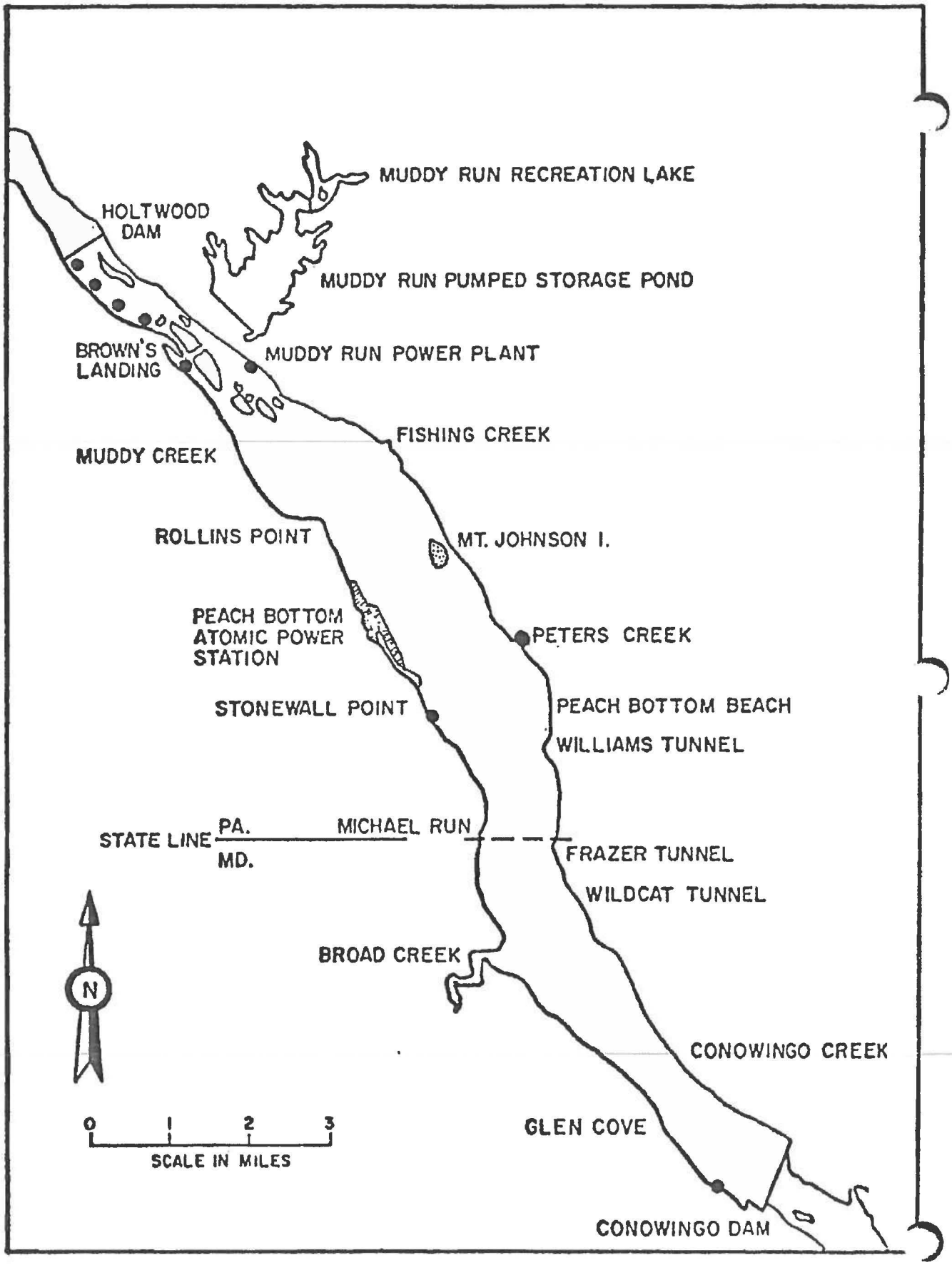


FIGURE 7.1.3-6 Map of Conowingo Pond showing distribution of aquatic macrophytes.

7.1.4 ZOOPLANKTON COMMUNITY

7.1.4.1 Species Composition

The crustacean zooplankton community of the Pond is comprised of 53 species (Table 7.1.4-1). Six taxa have dominated the community from 1967 through 1974 (Table 7.1.4-2). In order of decreasing abundance the common taxa are: nauplii, cyclopoid copepodids, daphnia sp., Bosmina longirostris, Diaphanosoma leuchtenbergianum, and Cyclops vernalis. The abundance of these taxa has varied between stations, months and years. No differences were noted in abundance of these taxa between the preoperational and postoperational periods (Table 7.1.4-3).

7.1.4.2 Abundance

Total zooplankton densities are low (average less than 3 animals per liter) from November through May (Table 7.1.4-4). From June through October, the monthly average density may exceed 100 animals per liter. Generally, two peaks of abundance occur, usually in July or August and again in September (Table 7.1.4-5 and Figure 7.1.4-1). Peaks occur at times of high temperature (July and August) and low river flow (< 25,000 cfs). The density of zooplankton decreases sharply when the water temperature is below 60 F. Production increases sharply in the spring when the water temperature exceeds 60 F.

It should be noted that a rather abrupt decrease in zooplankton production coincided with the flooding associated with Tropical Storm Agnes in June 1972 (Figure 7.1.4-1). Record high flows were recorded in the June 1972 flood. The Pond was flushed rapidly and water temperature was depressed for three weeks following the storm. The temperature decreased from 75 F on 21 June to 58 F on 25 June. It reached 75 F again on 14 July. Zooplankton production did not recover until August; consequently, zooplankton densities for 1972 never reached the peaks observed in other years. Cowell (1967) reported that water exchange rate in a reservoir or stream like system must be greater than 18 days to permit significant development of zooplankton. The production is considerably greater when flushing time is more than 15 days.

7.1.4.3 Statistical Analysis

In order to detect the effects, if any, of the operation of PBAPS on the zooplankton community in the Pond, a simple regression model was developed to isolate the thermal effects that may be localized or widespread, from those due to natural causes. The technique is based on the hypothesis that if ambient Pond conditions change due to natural causes than locations

within and outside the thermal plume should be similarly affected. The model provides a quick method of "flagging" values, with a given level of confidence, that are beyond the range of natural variations in the postoperational period.

It is assumed that (1) some unique relationship (predictive) exists between the density of zooplankton at a control station (Station 601) and the other 10 stations (Stations 602-611). That is, if the density of zooplankton, water temperature, and flow conditions are known at the control station, the densities at other stations can be predicted within specified variation (90% confidence interval in this case). These predicted densities should agree well with the observed values within the specified variation unless significant changes have occurred in the zooplankton community. In which case, the values may fall outside the confidence limits set on the relationship between the observed and the predicted values. However, one would expect up to 10% of the values to fall outside the confidence limits on a random chance alone.

The data from 1967-1971 and 1973 were analyzed by a stepwise multiple regression technique for a model run. The following generalized model was used for each station,

$$Y_i = a + b_1 X_j + b_2 X_k + b_3 X_l + b_4 X_m$$

where Y_i = log of density at a Station i, i = 602, 603, ..., 611

X_j = log of density at Station 601 (control)

X_k = average daily water temperature for past days j = 1, 2, ..., 15

X_l = average daily river flow for the past l days l = 1, 2, ..., 15

X_m = total degree days for past m days m = 1. 2, ..., 15

A total of 46 independent variables was available for regression analysis for each of the 10 dependent variables (Stations 602-611). The water temperature and daily river flow data were obtained from Holtwood Dam and were provided by the Pennsylvania Power and Light Company. All calculations were performed using the Statistical Analysis System (SAS) package

(August 1972) and supplementary procedures, edited by A. J. Barr, and J. H. Goodnight, Department of Statistics, North Carolina State University, Raleigh, N.C. These calculations and all the equations are given in Purdy, et. al, (1975a, b, c, d).

The computer program selected the best combination of variables from the 45 available. Each of the resulting equations explained a large proportion of the variance (R^2) and had the smallest standard error (sy.x). The density data were substituted in the equations and densities estimated for each station. These estimated densities were plotted against the observed values and a regression equation was obtained. The agreement was good between the observed and the predicted densities. The 90% confidence intervals were obtained around the points on this regression line. If a significant number of observed densities deviate from the predicted in any year they should fall outside the confidence limits and thus be readily detectable.

The data from 1972 were used to verify the applicability of the above regression technique. The year 1972 was chosen for verification because a natural catastrophe due to Tropical Storm Agnes had occurred. The densities at Station 602-611 in 1972 were predicted from the densities, water temperature and flow conditions at Station 601 using the above equations. A good agreement was noted between the observed and estimated values. Nearly all the values fell within the 90% confidence interval (Figures 7.1.4-2 to 7.1.4-11). It is assumed that the high flows associated with Tropical Storm Agnes (over 900,000 cfs) affected all the stations proportionally and the relationship between the control and other stations remained stable in this period.

After the model was verified, a new set of equations using the entire preoperational data base from 1967-1973 was developed (Table 7.1.4-5). The 90% confidence intervals set on the observed and the estimated values from these equations serves as the "flagging" system for values that may deviate significantly.

The densities at each station in 1974 were estimated using the regression equations between the observed and estimated values at each station. A plot of the observed versus the predicted densities showed a good agreement and nearly all the values were within the 90% confidence band (Figures 7.1.4-12 to 7.1.4-21). Thus, it may be concluded that; (1) a significant change in the density of zooplankton did not occur at any station due to the operation of Units No. 2 and 3; and (2) the observed variations in zooplankton densities were due to natural causes.

The regression model discussed above helps detect the changes in density at each station. However, it is important

also to know if the ranks of the stations changed between the two periods. The Spearman Rank correlation test was used to determine this. A significant positive correlation indicated that the ranks did not change significantly and the stations that yielded high or low densities in the preoperational period also showed a corresponding high or low production in the postoperational period. The Spearman rank correlation test also showed that the Stations that yielded high or low species diversity maintained the same trend in the postoperational period.

The zooplankton data from each station were further analyzed by stepwise multiple regression procedure to determine which physical factors affect the zooplankton density at each station. The water temperatures, daily river flow and 'degree days' (temperature divided by river flow) were used as the independent variables. In all cases (Table 7.1.4-6) a large proportion of the variance was explained by the variables. However, the density of zooplankton at each station was affected differently by each variable. For example, at Station 601 (upstream control) degree day one and average temperature for the preceding five days were important. In contrast, at Station 611 (farthest downstream station) degree day five and the average water temperature of the preceding fifteen days contributed significantly to the variation in zooplankton density. In all cases average water temperature had a positive effect (note sign of regression coefficients) indicating an increase in average temperature should enhance zooplankton production.

TABLE 7.1.4-1

Zooplankton taxa collected from Conowingo Pond, 1967-1974.
Habitat designations assigned according to Edmondson (1966).

Crustacea
- Cladocera
  - Leptodoridae: *Leptodora kindtii* - limnetic-lakes
  - Sididae: *Diaphanosoma leuchtenbergianum* - limnetic-lakes
    - *Sida crystallina* - littoral, weedy areas
    - *Latona setifera* - littoral-benthic
  - Daphnidae: *Daphnia parvula* - ponds, small lakes
    - *D. retrocurva* - limnetic-lakes
    - *D. galeata mendotae* - limnetic-lakes
    - *D. pulex* - ponds, lakes
    - *D. catawba* - ponds, lakes
    - *D. ambigua* - ponds, deep water of stratified lakes
    - *Moina affinis* - ponds, pools
    - *M. macrocopa* - ponds
    - *Ceriodaphnia lacustris* - limnetic-lakes
    - *C. quadrangula* - limnetic or littoral-lakes, pools
    - *C. reticulata* - limnetic
    - *Scapholeberis kingi* - weedy water - pools, lakes
    - *S. aurita* - weedy pools, margins of lakes
    - *Simocephalus vetulus* - pools, weedy ponds
  - Bosminidae: * *Bosmina longirostris* - limnetic - ponds, lakes
    - *B. coregoni coregoni* - limnetic - ponds, lakes
    - *Bosminopsis deitersi* - limnetic - ponds, lakes
  - Macrothricidae: *Ilyocryptus spinifer* - benthic-pools, ponds
    - *I. sordidus* - benthic-pools, ponds
    - *Macrothrix laticornis* - marshy pools, lake margins
    - *M. rosea* - littoral-marshy pools, lake margins
  - Chydoridae: *Pleuroxus hamulatus* - littoral, weedy water
    - *P. denticulatus* - littoral, weedy water
    - *Alona affinis* - margins of lakes, ponds - weedy water
    - *A. quadrangularis* - margins of lakes, ponds - weedy water
    - *A. guttata* - margins of lakes, ponds - weedy water
    - *A. costata* - margins of lakes, ponds - weedy water
    - *Leydigia quadrangularis* - weedy lake margins
    - *Chydorus sphaericus* - littoral, limnetic at times
    - *C. globosus* - lakes, ponds - weedy margins
    - *Camptocercus rectirostris* - weedy margins of lakes
    - *Kurzia latissima* - pools or weedy margins of lakes
    - *Eurycercus lamellatus* - pools or weedy margins of lakes
    - *Alonella excisa* - pools or weedy margins of lakes

Copepoda
- Cyclopoida
  - *Cyclops varicans rubellus* - debri, weedy areas, ponds
  - *Cyclops vernalis* - limnetic, mainly warm water
  - *C. bicuspidatus thomasi* - limnetic, mainly cold water
  - *C. scutifer* - limnetic - cold water
  - *Mesocyclops edax* - limnetic, warm water
  - *Eucyclops agilis* - littoral
  - *E. speratus* - littoral
  - *Tropocyclops prasinus* - limnetic
  - *Paracyclops fimbriatus poppei* - littoral-benthic-lakes, pools
  - *Macrocyclops albidus* - littoral, benthic-lakes, pools
- Calanoida - Diaptomidae: All limnetic - lakes, ponds
  - *Diaptomus pallidus*
  - *D. pygmaeus*
  - *D. siciloides*
- Harpacticoida - littoral-benthic
  - None identified

TABLE 7.1.4-2

Annual species composition of zooplankton (number per liter) in Conowingo Pond, 1967-1974.

Year	1967	1968	1969	1970	1971	1972	1973	1974	Total
Species									
Leptodora kindtii	-	0.174	0.050	0.036	0.085	0.017	0.037	0.051	0.450
Diaphanosoma leuchtenbergianum	5.331	13.380	4.908	9.667	8.727	1.794	4.016	2.394	50.217
Sida crystallina	-	-	-	*	*	*	*	-	*
Latona setifera	-	-	*	*	*	*	-	*	*
Daphnia spp.	9.099	10.008	7.192	9.812	7.913	1.955	1.690	5.813	53.482
Moina spp.	19.378	1.883	2.286	1.457	1.429	1.178	0.342	0.185	25.138
Ceriodaphnia spp.	0.005	0.056	0.165	0.415	0.762	0.033	0.010	0.040	1.486
Scapholeberis kingi	-	-	0.005	0.001	-	-	-	-	0.006
S. aurita	-	-	-	*	-	-	-	-	*
Simocephalus vetulus	-	-	-	*	*	*	-	-	*
Bosmina longirostris	5.659	1.804	5.891	5.450	7.127	2.975	0.844	3.668	33.418
Bosmina coregoni	-	-	0.071	0.007	1.006	0.022	0.054	0.490	1.650
Bosminopsis deitersi	-	-	-	0.012	-	-	-	-	0.012
Ilyocryptus spp.	0.075	0.014	0.031	0.024	0.010	0.007	0.012	0.003	0.176
Macrothrix spp.	-	-	0.025	0.003	0.007	0.019	0.003	*	0.057
Pleuroxus spp.	-	-	0.021	0.013	0.003	0.002	0.001	0.001	0.041
Alona spp.	0.093	0.037	0.041	0.008	0.010	0.003	0.002	0.002	0.196
Leydigia sp.	0.040	-	0.011	0.013	0.004	0.001	0.003	0.002	0.074
Chydorus spp.	0.073	-	0.016	0.003	0.022	0.009	0.004	0.006	0.133
Camptocercus rectirostris	-	-	0.002	0.001	*	*	-	*	0.003
Kurzia latissima	-	-	-	-	*	-	-	*	216.713
Eurycercus lamellatus	-	-	-	-	*	*	-	*	59.197
Alonella excisa	-	-	-	*	-	-	-	*	16.393
Nauplii	40.630	56.771	29.130	24.629	33.349	13.334	8.172	10.698	0.006
Cyclopoid copepodids	10.432	10.164	7.611	6.416	7.171	3.748	1.982	5.673	*
Cyclops vernalis	5.479	2.960	1.604	2.187	1.214	0.783	0.621	1.545	*
C. bicuspidatus thomasi	-	-	-	0.001	0.001	0.001	0.001	0.002	*
C. varicans rubellus	-	-	-	-	-	-	-	*	*
C. scutifer	-	-	-	-	-	-	*	*	*
Mesocyclops edax	0.321	0.442	0.284	0.879	0.717	0.243	0.061	0.094	3.041
Eucyclops agilis	-	-	*	0.001	0.003	0.001	0.001	*	0.006
E. speratus	-	-	0.001	*	0.002	0.001	0.001	*	0.005
Tropocyclops prasinus	-	-	0.012	0.017	0.018	0.006	0.001	0.001	0.055
Macrocyclops albidus	-	-	-	*	*	*	*	0.012	0.012
Paracyclops fimbriatus poppei	-	-	-	*	0.001	*	*	*	0.001
Orthocyclops modestus	-	-	-	-	*	-	-	-	*
Calanoid copepodids	0.419	2.368	0.125	0.082	0.554	0.121	0.058	0.067	3.794
Diaptomus spp.	0.312	1.544	0.011	0.045	0.204	0.055	0.020	0.035	2.226
Harpacticoida	-	-	0.001	0.002	0.005	0.003	0.002	0.002	0.015
TOTAL	97.346	101.605	59.494	61.181	70.344	26.311	17.938	30.784	465.003

* Less than .001

TABLE 7.1.4-3

Comparison of the monthly density of common taxa of zooplankton (number of organisms per liter) during the preoperational (1967-1973) and postoperational periods (1974) in Conowingo Pond.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
						Nauplii							
1967-1973	0.06	0.04	0.07	0.14	0.25	11.04	33.32	52.60	40.30	19.70	0.55	0.30	13.20
1974	0.06	-	0.07	0.19	0.43	71.89	3.92	23.10	16.85	8.32	1.63	0.24	11.52
						Cyclopoid copepodids							
1967-1973	0.01	0.02	0.02	0.03	0.07	5.40	7.07	11.45	8.73	5.57	0.24	0.13	3.23
1974	0.03	-	0.01	0.05	0.49	43.81	2.85	9.00	4.71	2.67	0.93	0.03	5.87
						Cyclops vernalis							
1967-1973	0.00	0.00	*	*	*	1.24	2.68	3.28	2.43	1.01	0.18	*	0.90
1974	0.00	-	*	-	0.02	6.09	1.75	6.53	1.40	0.62	0.31	*	1.52
						Daphnia spp.							
1967-1973	*	*	*	*	0.01	4.54	8.43	10.58	12.56	3.63	0.05	*	3.32
1974	*	-	*	*	0.13	14.05	9.82	23.57	8.17	7.33	0.68	*	5.80
						Bosmina longirostris							
1967-1973	0.01	0.01	*	0.03	0.22	3.31	2.13	7.31	11.54	4.59	0.16	0.17	2.46
1974	0.03	-	*	0.01	0.87	4.95	1.81	2.09	18.08	8.50	1.94	0.07	3.49
						Diaphanosoma leuchtenbergianum							
1967-1973	*	0.00	*	*	*	2.15	12.59	14.80	8.41	0.93	*	*	3.24
1974	*	-	0.00	0.00	*	0.68	6.97	13.62	3.12	0.02	0.06	*	2.22

* Less than 0.01

TABLE 7.1.4-4

Comparison of the monthly total zooplankton density (number of organisms per liter) during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1967-1973	0.11	0.08	0.11	0.23	0.61	33.59	72.79	106.04	89.15	37.07	1.19	0.95	28.49
1974	0.16	-	0.10	0.30	2.02	143.16	27.43	82.45	55.39	29.75	6.26	0.37	31.58

TABLE 7.1.2-5

Chlorophyll a (mg/m^3) nitrates, phosphates (ppm), water temperature (F), daily river flow (x 1000 cfs) and zooplankton density (no./liter) data during the preoperational (1971-1973) and postoperational (1974) periods in Conowingo Pond.

Date	Chlorophyll a	NO_3	PO_4	Water Temp. (F)	River Flow	Avg. Total Zooplankton Density
		1971				
19 Mar-22 Mar	1.74	-	-	39.2	173.4	0.1
18 May	5.44	8.92	-	60.0	61.9	0.7
9 Jul	12.46	6.08	0.08	86.0	7.7	184.3
21 Jul	16.20	3.60	0.08	82.3	6.7	124.9
4 Aug	16.36	4.12	0.29	76.7	39.4	67.8
18 Aug	22.46	2.97	0.09	82.4	7.3	166.8
1 Sep	10.79	6.04	0.14	78.6	7.7	151.1
15 Sep	13.26	5.07	0.06	82.1	13.1	142.9
29 Sep	10.57	8.36	0.16	70.4	13.2	31.6
13 Oct	11.58	8.72	0.10	64.1	10.2	28.7
27 Oct	9.29	13.42	0.09	62.5	16.3	11.5
10 Nov	13.50	10.74	0.25	48.2	17.8	1.2
24 Nov	10.96	7.08	0.06	44.3	12.0	1.3
13 Dec	4.37	7.44	0.34	42.5	107.0	2.0
		1972				
10-11 Jan	0.55	6.95	0.21	34.7	39.4	0.1
31 Jan-3 Feb	0.52	8.21	0.26	32.2	31.6	0.1
13 Apr	1.39	4.97	0.11	50.9	49.5	0.1
28 Apr	2.13	4.04	0.24	53.3	71.0	0.3
10 May	4.74	6.23	0.22	58.1	91.2	0.4
24 May	18.7[illegible]	4.25	0.09	70.7	58.3	0.6
8 Jun	32.6	4.47	0.19	71.1	44.6	2.6
21 Jun	11.3	7.31	0.02	73.8	54.8	6.4
6 Jul	3.7	9.26	0.21	68.9	76.3	0.9
19 Jul	31.8	6.75	0.06	79.9	57.6	2.8
2 Aug	13.8	5.34	0.02	77.9	16.5	59.2
16 Aug	18.22	7.97	0.05	78.6	14.0	86.2
30 Aug	21.65	7.00	0.05	81.5	9.4	110.6
13 Sep	16.39	15.19	0.06	75.4	6.7	81.9
27 Sep	13.22	3.57	0.08	71.6	8.0	41.8
16 Oct	-	-	-	64.4	8.0	70.7
25 Oct-31 Oct	22.87	7.71	0.14	52.7	7.1	32.9
9 Nov-10 Nov	19.99	7.20	0.16	51.3	62.7	2.1
16 Nov	3.41	6.31	0.28	-	-	-
5 Dec	1.74	5.42	0.13	39.2	50.5	0.2
14 Dec	1.52	5.05	0.17	-	-	-
		1973				
25 Jan	1.09	5.43	0.10	33.1	55.7	0.1
7 Feb	1.29	4.97	0.36	37.4	117.8	0.1
7 Mar	2.38	5.29	0.08	38.3	60.5	0.1
28 Mar	1.58	4.25	0.12	46.6	51.2	0.1
12 Apr	1.89	4.55	0.16	46.3	117.6	0.3
24 Apr	10.31	5.31	0.13	63.5	37.4	0.2
8 May-9 May	22.56	4.10	0.13	57.4	40.2	0.3
22 May	16.49	3.61	0.09	58.1	62.6	1.0
5 Jun	22.77	4.12	0.09	69.5	45.1	1.0
20 Jun	29.22	3.15	0.12	72.2	24.5	26.8
4 Jul	19.14	5.48	0.25	77.9	50.0	7.7
18 Jul	10.09	4.41	-	79.4	13.2	66.1
31 Jul	14.17	3.39	0.12	82.1	17.0	95.1
15 Aug	12.56	2.70	0.09	83.0	10.1	68.0
29 Aug	18.34	2.90	0.13	78.5	11.3	39.4
12 Sep	11.10	2.22	0.12	79.2	8.9	51.6
26 Sep	26.31	5.45	0.17	66.2	17.7	4.3
24 Oct	10.91	4.03	0.10	59.0	8.9	16.3
12 Nov	4.54	3.42	0.10	43.7	22.4	0.2
28 Nov	-	4.77	0.09	50.4	29.3	0.3
12 Dec	8.45	2.48	0.12	39.2	105.2	0.8
		1974				
24 Jan	1.32	8.68	0.13	38.4	123.2	0.1
15 Mar	1.54	5.27	0.09	40.3	69.5	0.1
26 Mar	2.22	5.85	0.11	43.2	51.9	0.1
9 Apr	6.85	3.78	0.23	46.8	119.4	0.3
25 Apr	5.07	4.96	0.28	56.2	43.3	0.3
8 May	38.11	3.86	0.28	58.3	29.5	0.8
22 May	33.38	2.91	0.28	70.9	40.3	3.2
5 Jun	36.80	2.36	0.25	70.7	22.6	41.0
19 Jun	21.82	1.38	0.27	76.1	26.0	244.4
10 Jul	36.00	2.57	0.27	83.2	26.5	20.5
24 Jul	15.53	0.83	0.24	83.5	10.5	34.4
14 Aug	15.77	2.10	0.19	82.4	8.4	60.8
29 Aug	12.88	2.11	0.15	86.6	6.1	104.1
11 Sep	32.33	2.45	0.21	70.6	21.0	10.7
24 Sep	22.38	2.76	0.23	71.6	20.0	100.1
9 Oct	39.90	2.32	0.23	60.3	12.6	30.6
23 Oct	12.96	2.74	0.18	57.1	11.4	29.0
6 Nov	16.94	2.42	0.21	61.6	7.6	12.1
20 Nov	9.57	2.28	0.14	43.9	23.7	0.4
5 Dec	4.05	3.04	0.23	36.5	32.2	0.4
15 Dec-16 Dec	4.31	3.27	0.23	38.3	59.9	0.3

TABLE 7.1.4-6

Regression equations for predicting zooplankton densities at Stations 602-611 (dependent variables) in Conowingo Pond. Equations based on data from Jan-December, 1967-1973.

Equation	R^2	$s_{y.x}$
L 602 = -0.0948 + 1.0779 L 601	0.8842	0.2826
L 603 = -0.0563 + 0.8744 L 601 + 0.0443 D 3	0.9114	0.2445
L 604 = -.3485 + 0.9676 L 601 - 0.0052 F 1	0.8991	0.2727
L 605 = -0.1812 + 0.8838 L 601 + 0.0191 T 13	0.8936	0.2689
L 606 = 0.0091 + 0.8145 L 601 + 0.0201 D 8	0.9158	0.2312
L 607 = 0.4195 + 0.7489 L 601 - 0.0056 F 1 + 0.1937 D 1	0.8910	0.3062
L 608 = -0.0127 + 0.8740 L 601 + 0.1590 D 1	0.8956	0.2750
L 609 = -0.1942 + 0.4946 L 601 + 0.0271 T 13 + 0.2349 D 1	0.8809	0.3090
L 610 = 0.1102 + 0.4325 L 601 + 0.0523 T 15 - 0.0059 F 10	0.9214	0.2659
L 611 = -0.3046 + 0.4129 L 601 + 0.0649 T 15	0.9118	0.2607

L 602 = log of zooplankton density at Station 602
" "
" "
L 611 = log of zooplankton density at Station 611

Dependent variables

L 601 = log of zooplankton density at Station 601
F 1 = average daily river flow on the day of sample taken
F 10 = average daily river flow for 10 days before sample was taken
D 1 = degree day 1
D 3 = degree day 3
D 8 = degree day 8
T 13 = average of 13 days water temperature before sample was taken
T 15 = average water temperature of 15 days before sample was taken

Independent variables

TABLE 7.1.4-7

Regression equations between the total zooplankton density (log (x+1) at Stations 601-611 and average water temperature and degree days (water temerapture divided by average river flow) in Conowingo Pond, 1967-1973.

Equation	R^2
L 601 = -0.0485 + 0.0879 D5 + 0.0194 T1	0.7895
L 602 = -0.1139 + 0.1241 D4 + 0.0174 T4	0.7454
L 603 = -0.1439 + 0.1613 D3 + 0.0216 T4	0.7814
L 604 = -0.1204 + 0.1688 D3 + 0.0253 T15	0.8102
L 605 = -0.2247 + 0.0455 D8 + 0.0378 T4	0.7960
L 606 = -0.1629 + 0.0528 D7 + 0.0327 T12	0.7890
L 607 = -0.1690 + 0.4117 D1 + 0.0427 T14	0.8021
L 608 = -0.1920 + 0.2249 D2 + 0.0306 T15	0.7701
L 609 = -0.2066 + 0.2101 D2 + 0.0383 T11	0.8426
L 610 = -0.3403 + 0.0641 T14 + 0.0205 D14	0.8715
L 611 = -0.3104 + 0.0709 T15 + 0.0386 D5	0.8857

L 601 = log density of total zooplankton at Station 601

D 5 = degree day five $\left(\frac{\text{average daily temperature (C)}}{\text{average daily river flow (cfs)}}\right)$

T 1 - average daily water temperature (C) on day 1

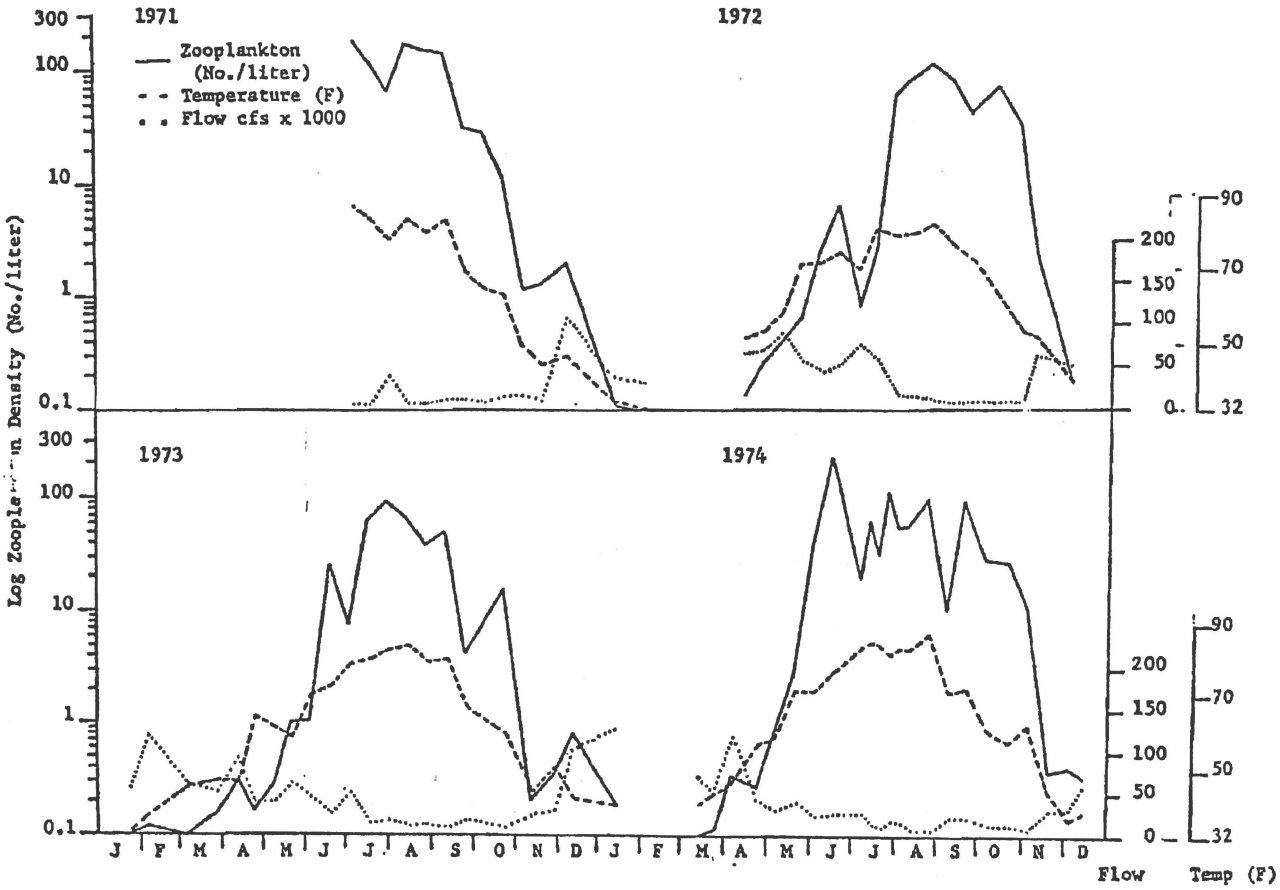


FIGURE 7.1.4-1

Plot of total zooplankton density (number per liter), average daily river flow (1000 x cfs) and water temperature (F) in Conowingo Pond, 1971-1974.

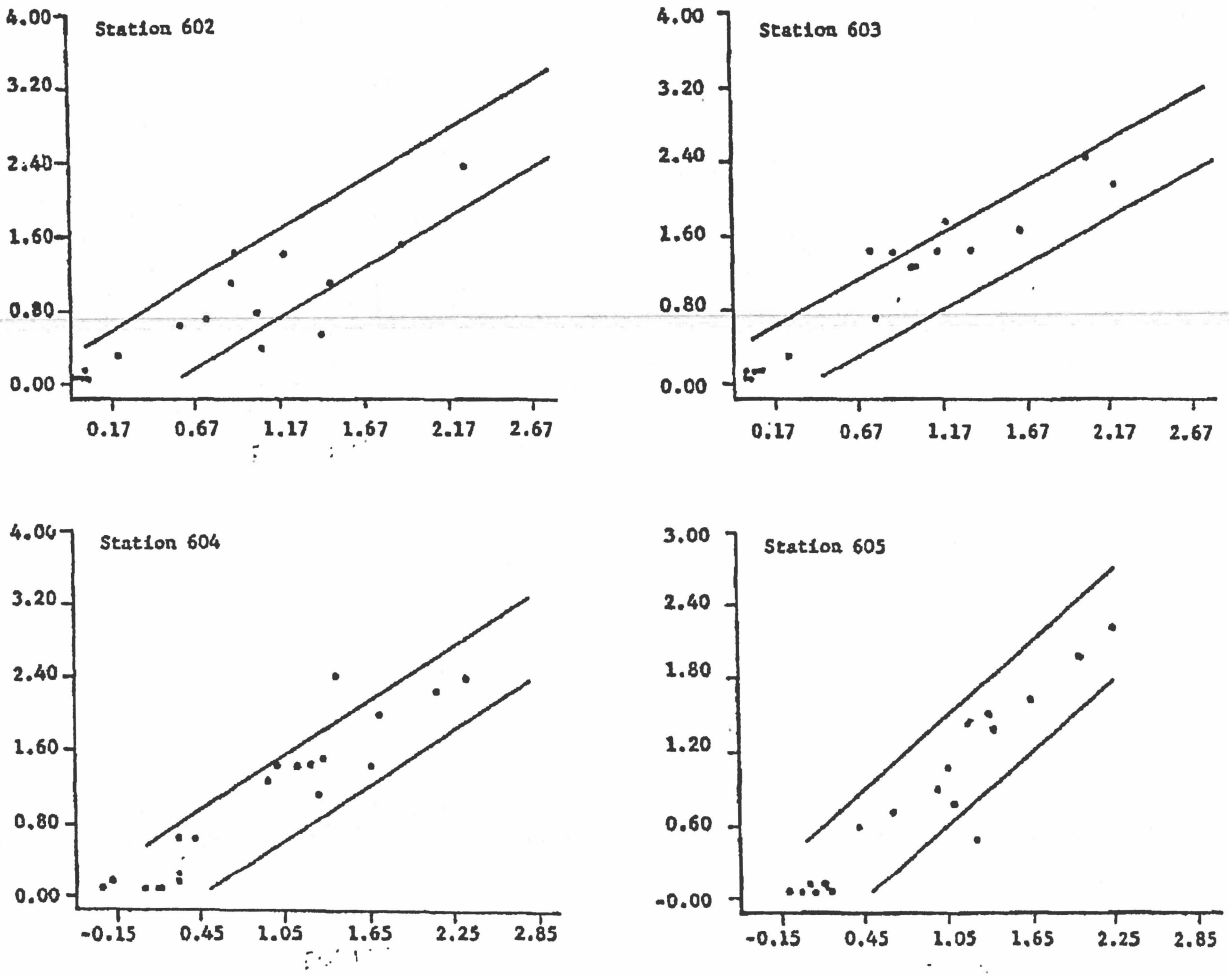


FIGURE 7.1.4-2

The 90% confidence intervals on the observed vs estimated densities of total zooplankton at Stations 602-605 in Conowingo Pond.

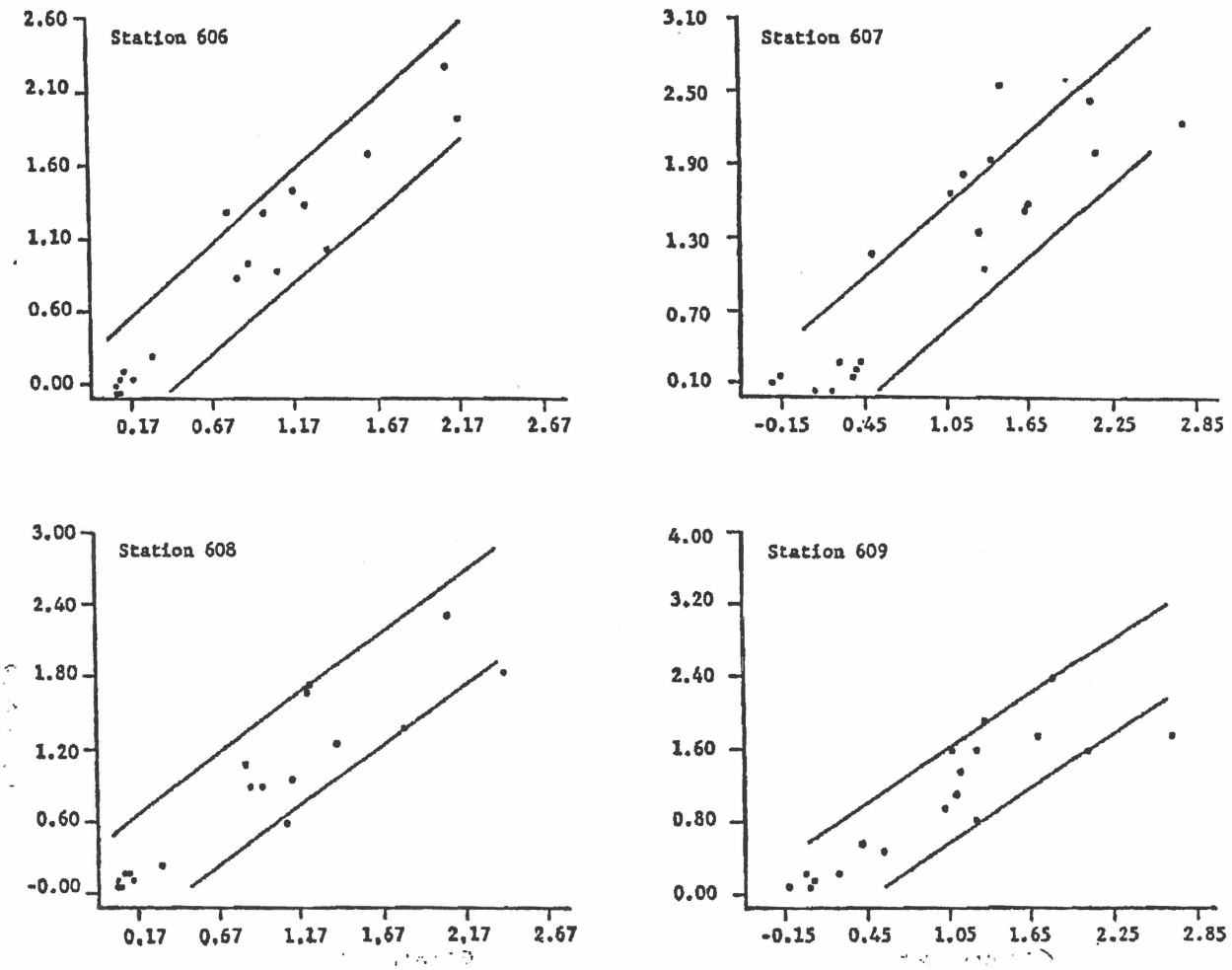


FIGURE 7.1.4-3

The 90% confidence intervals on the observed vs estimated densities of total zooplankton at Stations 606-609 in Conowingo Pond.

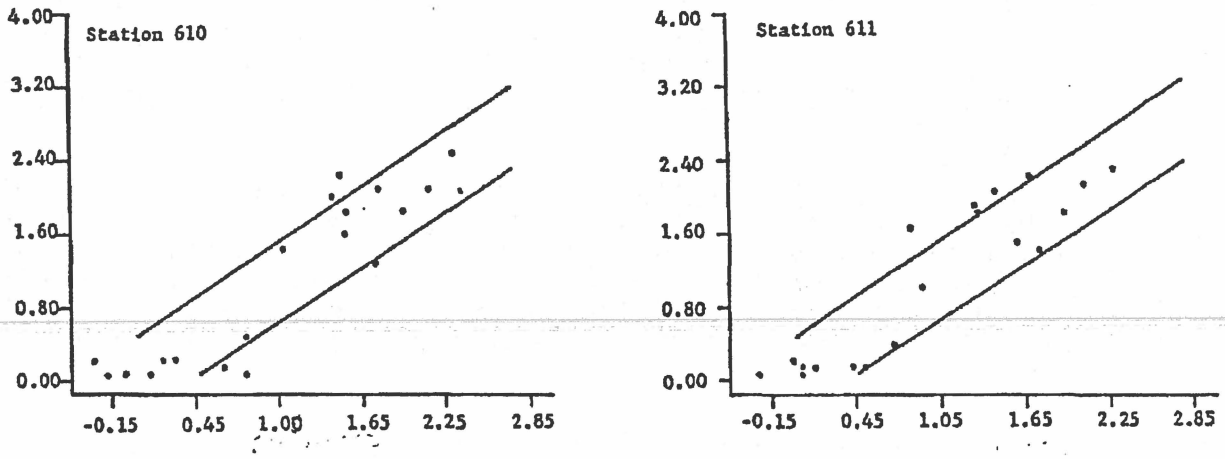


FIGURE 7.1.4-4

The 90% confidence intervals on the observed vs estimated densities of total zooplankton at Stations 610-611, in Conowingo Pond.

7.1.5 BENTHOS

7.1.5.1 Species Composition

From 1967 through 1974 (Table 7.1.5-1), 61 taxa were collected from the Pond. The major types are oligochaetes and chironomids. The common taxa are Limnodrilus hoffmeisteri, Procladius sp. (complex), Chaoborus punctipennis, Chironomus attenuatus, Coelotanypus consinnus and Ilyodrilus templetoni (Table 7.1.5-2).

These taxa comprised 94 to 98% of the total individuals collected in various years. Hexagenia limbata is infrequently collected and its density never averaged more than 0.01/81 in.^{2} at any station or in any month. Few fresh water mussels are present. No rare or endangered species of macro-invertebrates exist in the Pond, nor do species commercially harvested for food or bait.

7.1.5.2 Species Diversity and Equitability

The benthic community in the Pond is characterized by a small number of species which account for most of the individuals. This may be due to the bottom types. Two major substrate types are present in the Pond, sand-coal fines and silt (particles≥u500) (Table 7.1.5-3).

The species diversity ($\bar{D}$) was calculated from the following expression,

$$\bar{D} = - \sum_{i=1} p_i \log_2 p_i$$

where p_i = proportion of the ith taxon. The benthic community is sparse as indicated by the low species diversity ($\bar{D}$) indices (Table 7.1.5-4 and 7.1.5-5). Most values (over 90%) of D were less than 2.5 throughout the year and at a given station. No substantial differences were noted in $\bar{D}$ values between the preoperational (1967-1973) and postoperational (1974) periods.

The diversity values are influenced by the proportion of the common taxa. The importance of the number of taxa in the index of diversity was determined by plotting values of $\bar{D}$ and corresponding number of taxa in the samples (Figure 7.1.5-1). The monthly species diversity data given in Table 7.1.5-5 were used. The correlation coefficient was nonsignificant (r = 0.098, P≥0.05). Although the range in number of taxa

collected was large, its influence was not discernible. We conclude from this analysis that if any additional uncommon taxa are collected they will have little or no effect on diversity, which is determined primarily by the abundance of the most common taxa.

The equitability index (E) was calculated from the following expression,

$$E = \frac{\bar{D}}{\text{Log}_2 S}$$

Where $\bar{D}$ = species diversity, S = number of taxa, E = equitability (evenness of the species). The values of E can range from 0 to 1. A value of one indicates that all the taxa occur in equal proportions in the samples while a value of zero would indicate extreme inequality. Overall, the equitability component has remained similar between years; the values ranged from 0.42 to 0.53 (Table 7.1.5-4). However, some seasonal differences were noted (Table 7.1.5-5. The values appear to be higher in the fall through spring (more evenness) and lower in the summer (less evenness). The values also varied with stations (Table 7.1.5-4). Species appeared to be somewhat evenly distributed at all stations only in 1967 and 1973. In other years variation was large.

The influence of the number of taxa on the equitability was determined by plotting the number of taxa against the equitability index (Figure 7.1.5-1). The plot shows that the relationship is negative ($r = -0.505$, $P \leq 0.01$). That is, the equitability increases with a decrease in number of species, particularly the uncommon ones. This is expected since the additional species in samples are lower in abundance and thus decrease the equitability but do not increase the species diversity. Addition of uncommon species simply increases the denominator log2 S.

In general, the analysis indicates that the species diversity index is inadequate and insensitive to the occurrence of uncommon species and is influenced more by the relative proportions of the dominant species. Consequently, the addition or elimination of an uncommon species would not be reflected in the D values unless a change has also occurred in the proportion of the dominant species. Changes of small magnitude in the equitability component may not be interpreted as real changes in the community due to any environmental deviations. A high correlation exists ($r = 0.881$, $P \leq 0.01$) between the species diversity and equitability.

7.1.5.3 Distribution and Abundance

Although the common taxa (selected representative indigenous species) are widely distributed in the Pond, their densities vary between stations and years (Table 7.1.5-6 and Figures 7.1.5-2 to 7.1.5-5). Overall the density of Procladius was highest at Station 611 in the preoperational years (1967-1973) but in 1974 its density was highest at Station 601 (upstream from the PBAPS discharge). At Station 605, which is located in the plume, no changes were observed. The densities increased at all stations except 605 after 1972. The density of L. hoffmeisteri decreased considerably in 1972 and 1973 at all stations. However, in 1974 the densities were close to or higher than those in 1967-1971. The density of Chaoborus was higher at Stations 610 and 611 and lower at Stations 602 and 606. However, its density appeared to have increased at Station 608 and decreased at Station 605 (located in the thermal plume). Hexagenia were collected too infrequently and in low numbers to reveal any trend. None have been collected from Stations 610 and 611 (Figure 7.1.5-5).

The Spearman rank correlation test was used to determine if the ranks of the stations with respect to the abundance of Limnodrilus hoffmeisteri, Procladius sp. (complex) and Chaoborus punctipennis had changed between years (Table 7.1.5-7). Since the eleven monitoring stations were not sampled in all years, the data used for the analysis were those from years when all stations were sampled (1968, 1970-1974). The test was not run for Hexagenia limbata because its distribution is limited and its abundance is low. Only one significant ($P<0.05$) correlation was noted for Limnodrilus hoffmeisteri (between 1972 and 1973) and for Procladius sp. (between 1970 and 1974). Ranks of stations varied greatly in other years and no trend was apparent. A positive significant correlation for L. hoffmeisteri indicated that stations that had high or low abundance in 1972 maintained the same trend in 1973. A significant negative correlation for Procladius sp. indicated that the stations that yielded high or low abundance in 1970 generally were reversed in their ranking in 1974.

Although more positive significant correlations were observed for Chaoborus punctipennis, no consistent trend was apparent. The postoperational year (1974) was significantly correlated only to 1968 and 1973. The lack of a consistent pattern in the case of C. punctipennis and large amounts of variation for L. hoffmeisteri and Procladius sp. may be partly attributed to the lack of samples at all stations in each month in each year.

7.1.5.4 Faunal Similarity

The faunal associations at each station were similar in all years. The percent similarity indices (PSc) between years at a station showed that the stations maintained similar faunal associations through 1971 (Table 7.1.5-8). They showed less similarity with previous years in 1972 and 1973. However, PSc values were similar between 1972 and 1973. Station 607 and 611 remained relatively similar in all years. Station 605 (located in the thermal plume) showed intermediate to high similarity in all years.

7.1.5.5 Biomass

The biomass varied between months during the preoperational (1967-1973) and postoperational (1974) periods (Table 7.1.5-9). No consistent trend was evident. The postoperational biomass was higher only in January and April and was within the range observed in other months of the preoperational periods.

TABLE 7.1.5-1

List of benthos collected in Conowingo Pond, 1967-1974.

Scientific Name
Platyhelminthes
Planariidae
Dugesia sp.
Plagiostomidae
Hydrolimax grisea
Nematoda
Bryozoa
Plumatellidae
Plumatella sp. (Statoblasts observed)
Lophopodidae
Lophopodella carteri (Statoblasts observed)
Pectinatella magnifica (Statoblasts observed)
Mollusca
Pelecypoda
Sphaeriidae
Pisidium sp.
Sphaerium sp. ✓
Unionidae
Utterbackia imbecilis
Gastropoda
Lymnaeidae
Stagnicola sp.
Physidae
Physa sp.
Annelida
Oligochaeta
Tubificidae
Branchiura sowerbyi
Limnodrilus hoffmeisteri
Ilyodrilus templetoni
Polychaeta
Hirudinea
Arthropoda
Crustacea
Isopoda
Asellidae
Asellus militaris
Amphipoda
Gammaridae
Gammarus sp.
Talitridae
Hyalella azteca
Arachnoidea
Hydracarina

continued

TABLE 7.1.5-1 Continued.

Scientific Name
Insecta
Ephemeroptera
Baetidae
Baetis sp.
Ephemeridae
Hexagenia sp.
H. limbata
Caenidae
Caenis sp.
Odonata
Libelluilidae
Gomphidae
Gomphus sp.
Hemiptera
Mesoveliidae
Mesovelia mulsanti
Megaloptera
Sialidae
Sialis sp.
Trichoptera
Leptoceridae
Oecetis sp.
Psychomyiidae
Hydropsychidae
Cheumatopsyche sp.
Coleoptera
Elmidae
Dytiscidae
Hydrophilidae
Diptera
Culicidae
Chaoborus pupae
C. punctipennis
Ceratopogonidae
Chironomidae
Pupae
Procladius sp (complex)
P. riparius
P. culiciformis
P. rubellus
Anatopynia sp. (1)
Tanytarsus sp. (1)
Chironomus sp.
C. attenuatus
C. (Dicrotendipes) sp.
Tribelos sp.
Cryptochironomus nr *fulvus*
C. nais
Harnischia sp.
H. nr *nais*
H. amachaerus
Pentaneura sp. E
Pentaneura sp.
Polypedilum halterale
P. fallax
Coelotanypus concinnus
Limnochironomus sp. (1)
L. fumidus
L. modestus
Calopsectra sp. 5
Glyptotendipes sp.
Orthocladius sp.
Microtendipes sp.
Psectrocladius sp.
Anthomyiidae

TABLE 7.1.5-2

Mean number (per 81 in.^{2}) and percentage composition of benthic organisms collected during preoperational (1967-1973) and postoperational (1974) periods, in Conowingo Pond.

Year		1967	1968	1969	1970	1971	1972	1973	1974
No. Samples		82	98	75	198	142	233	242	231
Taxa									
Procladius sp. (complex)	Mean No.	1.56	3.53	8.25	3.18	1.75	5.44	14.95	27.41
	% No.	5.6	10.5	14.7	8.2	5.8	22.7	41.9	29.4
Limnodrilus hoffmeisteri	Mean No.	16.45	14.86	26.85	24.72	16.99	8.00	7.74	29.58
	% No.	58.8	44.1	48.0	64.0	56.4	33.4	21.7	31.7
Chaoborus punctipennis	Mean No.	0.56	5.97	2.25	1.24	5.44	2.51	2.63	11.45
	% No.	2.0	17.7	4.0	3.2	18.0	10.5	7.4	12.3
Ilyodrilus templetoni	Mean No.	0.52	0.95	2.44	1.52	0.71	1.24	0.25	2.26
	% No.	1.9	2.8	4.4	3.9	2.4	5.2	0.7	2.4
Coelotanypus concinnus	Mean No.	7.12	6.34	11.63	5.75	4.53	0.91	2.80	5.91
	% No.	25.4	18.8	20.8	14.9	15.0	3.8	7.8	6.3
Chironomus attenuatus	Mean No.	0.27	0.11	1.84	1.45	0.30	5.27	6.00	13.68
	% No.	1.0	0.3	3.3	3.8	1.0	22.0	16.8	14.7
Polypedilum halterale	Mean No.	0.04	0.06	0.09	0.00	0.00	0.03	0.18	0.30
	% No.	0.1	0.2	0.2	0.0	0.0	0.1	0.5	0.3
Cryptochironomus nr *fulvus*	Mean No.	0.33	0.23	0.43	0.29	0.01	0.14	0.28	0.48
	% No.	1.2	0.7	0.8	0.7	TR	0.6	0.8	0.5
Chironomid pupae	Mean No.	0.30	0.03	0.16	0.02	0.01	0.04	0.07	0.18
	% No.	1.1	0.1	0.3	0.1	TR	0.2	0.2	0.2
Sphaerium sp.	Mean No.	0.21	0.29	0.07	0.00	0.00	0.01	0.00	0.01
	% No.	0.7	0.8	0.1	0.0	0.0	TR	0.0	TR
Oecetis sp.	Mean No.	0.07	0.02	0.00	0.00	0.00	*	0.09	0.04
	% No.	0.3	0.1	0.0	0.0	0.0	TR	0.2	TR
Elmidae	Mean No.	0.01	0.15	0.00	0.02	0.01	*	*	0.03
	% No.	TR	0.5	0.0	TR	TR	TR	TR	TR
Hydracarina	Mean No.	0.18	0.12	0.15	0.00	0.00	*	*	0.04
	% No.	0.7	0.4	0.3	0.0	0.0	TR	TR	TR
Branchiura sowerbyi	Mean No.	0.01	0.00	0.00	0.02	0.01	0.04	0.02	0.04
	% No.	TR	0.0	0.0	0.1	TR	0.2	0.1	TR
Chaoborus pupae	Mean No.	0.21	0.24	0.27	0.00	0.22	*	0.12	0.04
	% No.	0.7	0.7	0.5	0.0	0.7	TR	0.3	TR
Tanytarsus sp.	Mean No.	0.02	0.08	0.53	0.00	0.00	*	0.02	0.06
	% No.	0.1	0.2	0.9	0.0	0.0	TR	0.1	0.1
Hydrolimax sp.	Mean No.	0.01	0.37	0.28	0.01	0.00	0.00	0.07	0.76
	% No.	TR	1.1	0.5	TR	0.0	0.0	0.2	0.8
Gammarus sp.	Mean No.	0.06	0.14	0.01	0.03	0.00	0.01	0.22	0.15
	% No.	0.2	0.4	TR	0.1	0.0	TR	0.6	0.2
Caenis sp.	Mean No.	0.02	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.1	0.0	0.0	0.0	0.0	0.0	0.0	TR
Hexagenia limbata	Mean No.	0.01	0.10	0.35	0.00	0.02	0.00	0.01	0.03
	% No.	TR	0.3	0.6	0.0	0.1	0.0	TR	TR
Nematoda	Mean No.	0.00	0.01	0.03	0.01	0.01	0.01	0.07	0.11
	% No.	0.0	TR	TR	TR	TR	TR	0.2	0.1
Trichoptera	Mean No.	0.00	0.01	0.01	0.00	0.01	0.01	*	*
	% No.	0.0	TR	TR	0.0	TR	TR	TR	TR
Pentaneura sp. E	Mean No.	0.00	0.01	0.00	0.00	0.00	0.00	0.06	0.01
	% No.	0.0	TR	0.0	0.0	0.0	0.0	0.2	TR
Coleoptera	Mean No.	0.00	0.01	0.25	0.00	0.01	*	*	0.00
	% No.	0.0	TR	0.5	0.0	TR	TR	TR	0.0
Harnischia sp.	Mean No.	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00
	% No.	0.0	0.1	TR	0.0	0.0	0.0	0.0	0.0

continued

TABLE 7.1.5-2

Continued.

Year		1967	1968	1969	1970	1971	1972	1973	1974
No. Samples		82	98	75	198	142	233	242	231
Taxa									
Pelecypoda	Mean No.	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
	% No.	0.0	0.0	TR	0.0	0.0	0.1	0.0	0.0
Calopsectra sp. 5	Mean No.	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
	% No.	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Pisidium sp.	Mean No.	0.00	0.00	0.00	0.11	0.01	*	0.00	0.00
	% No.	0.0	0.0	0.0	0.3	TR	TR	0.0	0.0
Hexagenia sp.	Mean No.	0.00	0.00	0.00	0.20	0.06	0.03	0.00	0.00
	% No.	0.0	0.0	0.0	0.5	0.2	0.1	0.0	0.0
Gastropoda	Mean No.	0.00	0.00	0.00	0.02	0.02	0.02	0.01	*
	% No.	0.0	0.0	0.0	TR	0.1	0.1	TR	TR
Procladius riparius	Mean No.	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
	% No.	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Procladius culiciformes	Mean No.	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	% No.	0.0	0.0	0.0	TR	0.0	0.0	0.0	0.0
Baetis sp.	Mean No.	0.00	0.00	0.00	0.00	0.01	*	0.00	0.00
	% No.	0.0	0.0	0.0	0.0	TR	TR	0.0	0.0
Sphaeriidae	Mean No.	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00
	% No.	0.0	0.0	0.0	0.0	0.1	TR	0.0	0.0
Cryptochironomus nais	Mean No.	0.00	0.00	0.00	0.00	0.00	0.47	0.01	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.2	TR	0.0
Limnochironomus fumidus	Mean No.	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Glyptotendipes senilis	Mean No.	0.00	0.00	0.00	0.00	0.00	*	0.01	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	TR	TR	0.0
Glyptotendipes sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.12	0.02	0.05
	% No.	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0.1
Stagnicola sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	*	0.00	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	TR	0.0	0.0
Dytiscidae	Mean No.	0.00	0.00	0.00	0.00	0.00	*	0.01	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	TR	TR	0.0
Pentaneura sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
	% No.	0.0	0.0	0.0	0.0	0.0	TR	0.0	TR
Chironomus (Dicrotendipes) sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	0.02
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	TR
Hyalella sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	0.0
Chironomidae	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	0.0
Polypedilum fallax	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	0.0
Chironomus (Tribelos) sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	TR
Ceratopagonidae	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	TR
Anthyomyiidae	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	TR
Harnischia or nais	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	0.0
Mesovelia mulsanti	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	0.0
Chironomus sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Hydrophilidae	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	*	0.00
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	TR	0.0

continued

TABLE 7.1.5-2

Continued.

Year No. Samples		1967 82	1968 98	1969 75	1970 198	1971 142	1972 233	1973 242	1974 231
Taxa									
Microtendipes sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Hydropsychidae	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Physa sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Polychaeta	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Orthocladius sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Cheumatopsyche sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Paectrocladius sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Caenis sp.	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Libellulidae	Mean No.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*
	% No.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	TR
Totals	Mean No.	27.96	33.65	55.99	38.64	30.15	24.34	35.70	93.16
	% No.	99.9	99.8	100.0	99.9	100.1	100.1	100.0	99.6

* = < 0.01/81 in.^{2}
TR = < .10%

TABLE 7.1.5-3

Percentage composition of particle size (microns) in bottom sediments at limnological stations in Conowingo Pond, 27 July 1972.

	Particle size (micron)							
	3360	2000	1000	500	250	125	63	<63
Station								
601	0.4	0.9	5.6	36.8	21.4	14.4	5.2	15.3
602	Tr	Tr	Tr	0.1	0.2	1.3	7.8	90.5
603	1.9	2.6	10.7	49.9	24.2	1.2	0.8	8.6
604	0.2	0.5	19.3	29.8	17.7	23.6	3.6	5.4
605	Tr	Tr	Tr	0.1	0.4	2.7	7.4	89.5
606	Tr	0.1	1.3	13.5	52.6	30.2	0.9	1.4
607	0.1	Tr	0.5	8.1	23.6	41.8	15.9	10.0
608	0.1	0.1	0.1	0.4	1.8	5.4	6.5	85.6
609	0.1	0.1	0.2	0.3	1.8	5.3	7.7	84.5
610	0.1	0.2	1.8	9.6	9.7	13.6	19.9	48.4
611	Tr	Tr	Tr	Tr	0.6	9.7	16.9	72.7

Tr = less than 0.1 percent

TABLE 7.1.5-4

Species diversity ($\bar{D}$) and equitability (E) indices for benthic organisms at Stations 601-611 during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

		601	602	603	604	605	606	607	608	609	610	611	Weighted Mean
1967	$\bar{D}$	1.75	1.55	1.53	1.74	1.67	1.70	2.04	1.50	-	-	-	1.80
	E	0.51	0.45	0.44	0.46	0.47	0.51	0.61	0.43				0.42
1968	$\bar{D}$	2.56	2.43	2.49	2.32	2.30	1.93	2.28	1.63	1.97	1.87	2.10	2.40
	E	0.67	0.77	0.67	0.65	0.62	0.56	0.64	0.47	0.62	0.66	0.70	0.53
1969	$\bar{D}$	2.15	1.92	1.45	-	2.00	1.89	2.71	1.26	1.79	2.26	-	2.35
	E	0.68	0.61	0.46	-	0.51	0.48	0.68	0.42	0.54	0.80	-	0.53
1970	$\bar{D}$	1.92	1.70	1.64	1.04	2.48	1.52	1.99	1.45	1.95	1.82	1.27	1.77
	E	0.55	0.49	0.58	0.31	0.72	0.48	0.54	0.44	0.56	0.57	0.45	0.42
1971	$\bar{D}$	1.68	1.76	1.48	2.06	1.82	1.27	1.89	1.77	2.05	1.84	1.42	1.82
	E	0.47	0.63	0.49	0.60	0.55	0.42	0.57	0.56	0.79	0.79	0.55	0.42
1972	$\bar{D}$	2.58	2.29	2.22	2.20	2.29	2.43	2.57	2.33	2.44	2.39	1.69	2.10
	E	0.70	0.60	0.62	0.58	0.64	0.70	0.66	0.74	0.64	0.72	0.49	0.42
1973	$\bar{D}$	1.86	2.00	2.23	2.50	1.91	2.21	2.54	2.12	2.08	2.05	1.70	2.35
	E	0.45	0.56	0.58	0.55	0.55	0.55	0.60	0.54	0.60	0.57	0.54	0.45
1974	$\bar{D}$	2.01	2.00	1.95	2.08	1.93	2.00	2.52	2.36	2.16	2.24	1.73	2.45
	E	0.46	0.46	0.50	0.47	0.41	0.54	0.59	0.59	0.54	0.65	0.52	0.46

$$\bar{D} = -\sum_{i=1}^{S} p_i \log_2 p_i$$

p_i = proportion of ith taxon by number

$$E = \frac{\bar{D}}{\log_2 S}$$

S = No. of taxa

TABLE 7.1.5-5

Monthly species diversity ($\bar{D}$) and equitability (E) indices for benthic organisms collected during the preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Weighted Mean
1967	$\bar{D}$	-	-	-	-	-	0.98	1.44	1.75	1.96	2.03	2.23	2.35	1.80
	E	-	-	-	-	-	0.27	0.45	0.47	0.55	0.64	0.64	0.68	0.42
1968	$\bar{D}$	-	-	-	2.80	2.54	1.65	1.45	1.76	2.06	1.80	-	-	2.40
	E	-	-	-	0.76	0.69	0.43	0.46	0.51	0.65	0.60	-	-	0.53
1969	$\bar{D}$	-	-	-	-	-	1.35	1.29	1.45	2.16	2.57	2.63	2.92	2.35
	E	-	-	-	-	-	0.41	0.34	0.42	0.58	0.77	0.76	0.77	0.53
1970	$\bar{D}$	-	-	2.38	2.41	-	1.83	1.39	1.49	1.43	1.84	2.00	-	1.77
	E	-	-	0.92	0.73	-	0.48	0.36	0.42	0.55	0.55	0.63	-	0.42
1971	$\bar{D}$	-	-	-	-	2.00	-	0.98	1.66	1.78	1.35	2.22	2.19	1.82
	E	-	-	-	-	0.51	-	0.31	0.55	0.51	0.58	0.79	0.73	0.42
1972	$\bar{D}$	2.37	-	-	1.94	1.42	1.06	1.60	2.25	2.06	2.18	1.79	2.19	2.10
	E	0.71	-	-	0.58	0.43	0.35	0.57	0.52	0.59	0.63	0.47	0.63	0.42
1973	$\bar{D}$	2.23	2.49	2.04	1.98	1.90	1.90	1.66	1.91	2.35	2.42	2.44	2.18	2.35
	E	0.64	0.78	0.59	0.50	0.49	0.48	0.46	0.49	0.62	0.68	0.68	0.66	0.45
1974	$\bar{D}$	1.88	-	1.64	1.52	1.39	1.37	1.37	1.42	1.37	1.72	1.84	1.76	2.43
	E	0.48	-	0.36	0.34	0.32	0.33	0.33	0.38	0.33	0.42	0.43	0.45	0.46

$$\bar{D} = -\sum_{i=1}^{S} p_i \log_2 p_i$$

p_i = proportion of ith taxon by number

$$E = \frac{\bar{D}}{\log_2 S}$$

S = No. of taxa

TABLE 7.1.5-6

Mean number (per 81 in.^{2}) of the selected representative species of benthic organisms at Station 601-611 during preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond. Dashes indicate sampling not conducted.

Station		601	602	603	604	605	606	607	608	609	610	611	Mean
Taxa	Year												
Procladius sp. (complex)	1967	1.70	2.40	1.27	1.45	2.36	1.82	0.33	0.89	-	-	-	1.56
	1968	3.42	7.12	1.80	4.30	4.11	4.22	2.66	2.75	4.62	2.14	0.66	3.53
	1969	6.00	8.90	3.44	-	4.62	7.11	18.21	8.00	6.00	3.25	-	8.25
	1970	1.61	4.50	1.06	0.89	5.05	3.74	2.80	2.35	4.44	6.06	2.00	3.18
	1971	1.38	2.00	1.46	2.31	1.08	1.31	1.61	1.54	3.23	1.92	1.46	1.75
	1972	5.43	4.48	2.19	4.05	6.09	6.67	8.86	1.81	5.00	8.67	7.29	5.44
	1973	25.45	6.45	6.00	16.50	5.50	5.27	15.09	19.32	17.36	23.82	23.73	14.95
	1974	59.67	22.94	29.59	44.78	5.96	10.69	28.79	29.65	26.73	24.98	20.57	27.41
Limnodrilus hoffmeisteri	1967	12.00	21.20	11.54	17.45	19.54	20.36	7.89	19.00	-	-	-	16.45
	1968	9.75	19.38	5.90	16.10	15.78	15.33	9.00	18.37	26.87	13.12	24.17	14.86
	1969	16.75	25.20	36.55	-	32.00	40.11	21.43	42.25	29.71	14.62	-	26.85
	1970	13.56	29.28	9.59	32.78	14.11	28.53	21.65	34.12	20.83	23.25	44.56	24.72
	1971	17.08	14.31	14.54	11.69	21.33	24.15	12.85	16.61	13.92	14.15	24.00	16.99
	1972	4.57	5.66	4.29	6.67	10.50	6.48	9.57	7.33	3.19	7.90	17.57	8.00
	1973	4.36	4.41	5.73	5.90	16.86	5.86	6.73	3.86	4.00	6.00	21.50	7.74
	1974	39.93	26.27	40.57	29.82	36.17	23.18	31.19	18.50	21.89	9.04	32.94	29.58
Chaoborus punctipennis	1967	0.50	0.30	0.27	0.45	0.64	0.45	1.11	0.89	-	-	-	0.56
	1968	4.00	1.00	2.00	6.50	2.00	1.44	1.55	0.50	10.25	30.29	16.83	5.97
	1969	0.25	2.20	1.22	-	1.75	0.89	0.57	2.00	3.00	9.37	-	2.25
	1970	0.39	1.06	0.18	0.11	1.68	1.37	0.20	1.24	0.67	4.38	2.78	1.24
	1971	1.92	0.15	1.00	3.69	17.08	1.46	2.46	5.46	5.85	11.69	6.31	5.44
	1972	1.62	0.62	1.86	0.95	5.33	0.86	2.90	2.05	1.43	5.43	4.76	2.51
	1973	0.32	0.14	0.14	1.41	0.82	0.04	1.50	1.63	2.12	10.04	10.77	2.63
	1974	0.52	0.35	1.42	2.65	0.11	0.34	1.62	10.00	6.16	13.39	13.24	11.45
Hexagenia limbata	1967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	-	-	-	0.01
	1968	0.00	0.00	0.00	0.00	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.13
	1969	0.00	0.10	0.00	-	2.87	0.11	0.07	0.00	0.00	0.00	0.00	0.35
	1970	0.00	0.06	0.00	0.22	1.63	0.00	0.15	0.00	0.06	0.00	0.00	0.20
	1971	0.00	0.00	0.23	0.31	0.16	0.08	0.00	0.08	0.00	0.00	0.00	0.08
	1972	0.00	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.03
	1973	0.00	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.01
	1974	0.05	0.05	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03

TABLE 7.1.5-7

Spearman rank correlation (r_s) test on densities of common taxa at Stations 601-611 between years in Conowingo Pond.

	1970	1971	1972	1973	1974
			Limnodrilus hoffmeisteri		
1968	0.61	0.04	0.41	-0.17	-0.43
1970		0.05	0.33	0.11	-0.50
1971			0.02	0.22	0.25
1972				0.59*	-0.18
1973					0.27
			Chaoborus punctipennis		
1968	0.20	0.56*	0.41	0.61*	0.54*
1970		0.57*	0.50	0.37	0.20
1971			0.75**	0.76**	0.45
1972				0.62*	0.42
1973					0.87**
			Procladius sp. (complex)		
1968	0.24	0.36	-0.31	-0.32	-0.05
1970		0.03	0.44	-0.15	-0.68*
1971			-0.19	0.28	0.37
1972				0.10	-0.47
1973					0.50

* Significant at 95% level, r_s (0.05, 11) = 0.54
** Significant at 99% level, r_s (0.01, 11) = 0.73

TABLE 7.1.5-8

Index of percent similarity of species composition between years at Stations 601-611 during preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

						68	1968	66						
	601				76	72	1969	79	86				602	
				78	66	81	1970	76	72	83				
			82	74	69	72	1971	78	81	85	87			
		42	47	50	54	39	1972	40	57	57	51	45		
	59	27	35	39	36	29	1973	31	46	44	41	34	86	
62	80	46	54	60	57	47	1974	44	58	57	54	46	85	83
1973	1972	1971	1970	1969	1968	1967		1967	1968	1969	1970	1971	1972	1973
76	77	53	54	51	58	54	1974	53	57	-	49	57	50	75
	68	51	54	50	56	48	1973	40	46	-	32	44	55	
		43	39	37	54	39	1972	38	41	-	32	42		
			80	81	70	89	1971	76	83	-	65			
				92	71	75	1970	82	56	-				
	603				70	76	1969	-	-				604	
						68	1968	70						

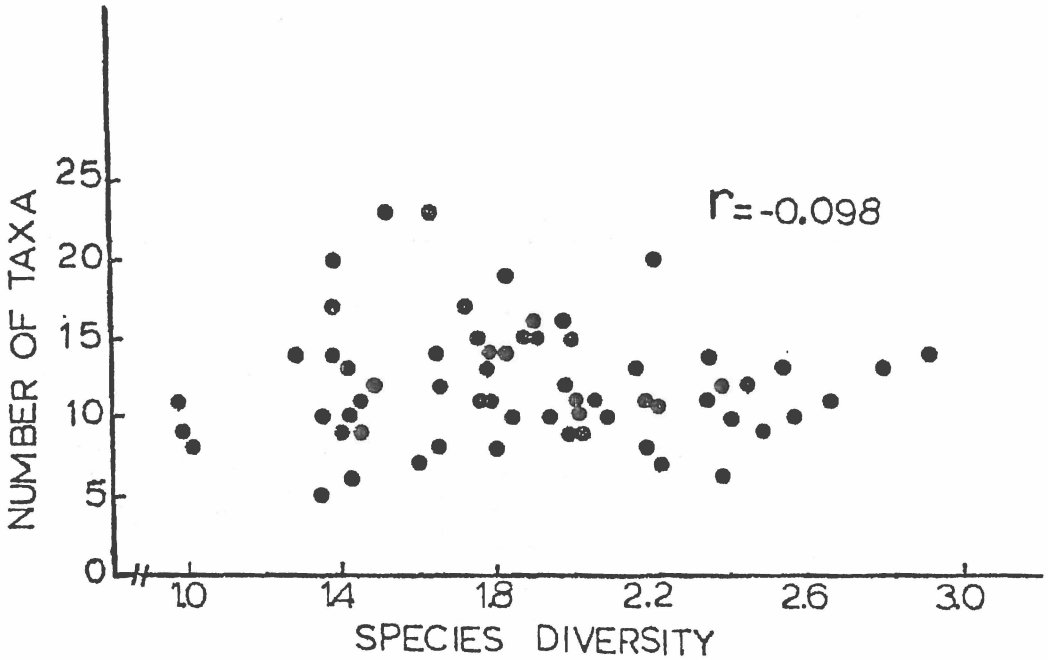
						80	1968	85						
	605				86	90	1969	89	90				606	
				76	82	73	1970	84	85	88				
			68	67	70	65	1971	79	79	78	86			
		70	71	58	66	55	1972	50	58	51	51	45		
	70	52	70	72	74	70	1973	40	50	46	47	38	79	
88	64	51	67	74	74	75	1974	51	61	57	58	49	82	87
1973	1972	1971	1970	1969	1968	1967		1967	1968	1969	1970	1971	1972	1973
84	77	54	61	83	56	51	1974	47	52	47	47	59	60	73
	73	48	54	82	50	46	1973	31	36	34	33	34	48	
		55	55	77	52	48	1972	53	58	60	59	65		
			85	55	64	87	1971	80	81	71	80			
				61	66	86	1970	87	87	86				
	607				57	51	1969	80	84				608	
						67	1968	90						

						-		-						
						-	1968	-						
	609				87	-	1969	-	68				610	
				82	71	-	1970	-	52	62				
			77	82	90	-	1971	-	79	71	73			
		66	66	60	59	-	1972	-	56	63	64	63		
	61	38	40	38	36	-	1973	-	46	47	47	47	76	
75	76	61	65	69	59	-	1974	-	54	59	53	52	78	85
1973	1972	1971	1970	1969	1968	1967		1967	1968	1969	1970	1971	1973	1973
87	89	72	59	-	65	-	1974							
	77	62	47	-	59	-	1973							
		80	69	-	64	-	1972							
			80	-	70	-	1971							
				-	63	-	1970							
	611				-	-	1969							
						-	1968							

TABLE 7.1.5-9

Comparison of the monthly mean biomass (mg dry weight) per 81 in.^{2} at Stations during preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond. Dashes indicate sampling not conducted.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year												
1967	-	-	-	-	-	11.890	12.509	12.693	12.994	9.002	10.753	16.164
1968	-	-	-	10.579	8.687	6.782	14.609	6.828	14.814	15.060	-	-
1969	-	-	-	-	-	27.488	23.054	14.099	32.256	15.605	34.752	43.016
1970	-	-	39.472	9.239	-	16.672	23.172	10.811	9.118	15.097	10.823	-
1971	-	-	-	-	37.201	-	18.285	14.988	12.626	8.483	10.148	8.352
1972	10.590	-	-	10.155	11.080	11.254	8.645	2.831	5.689	7.333	12.922	9.105
1973	14.732	13.002	12.700	9.049	5.478	3.192	5.210	3.841	6.614	12.871	13.686	15.111
1974	15.895	-	15.611	19.106	16.809	21.154	19.976	14.646	17.388	22.451	32.209	40.024



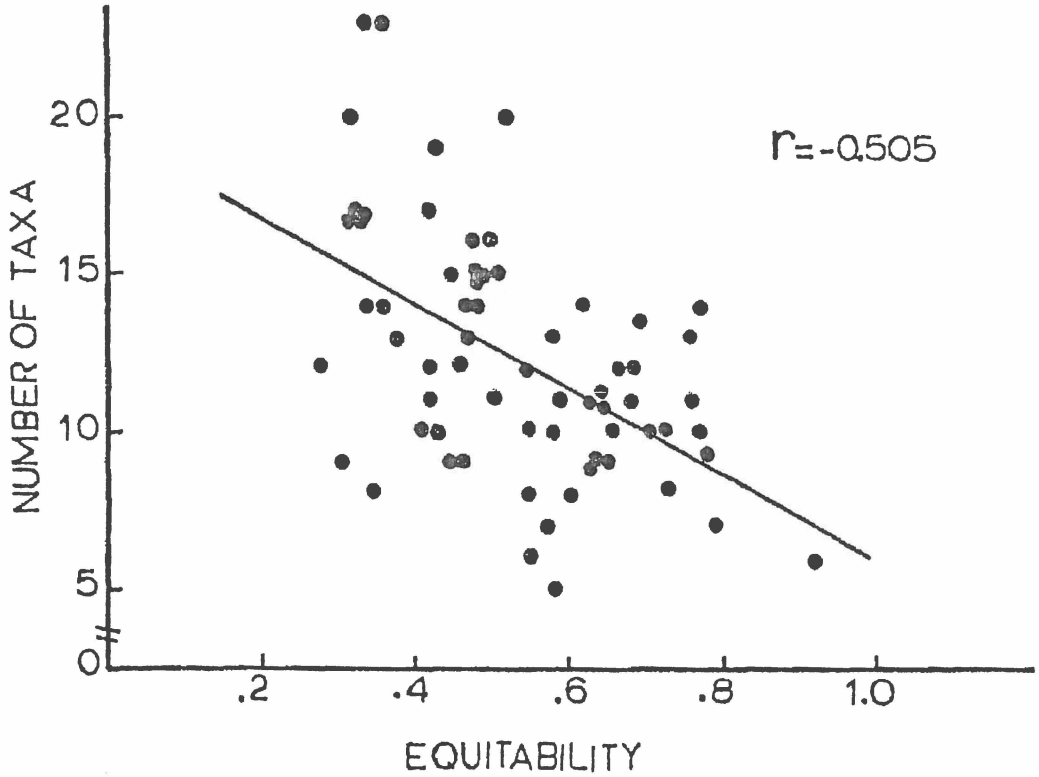


FIGURE 7.1.5-1

Plot of number of taxa (species richness) and species diversity (upper) and equitability (lower) indices for benthic organisms in Conowingo Pond, 1967-1974.

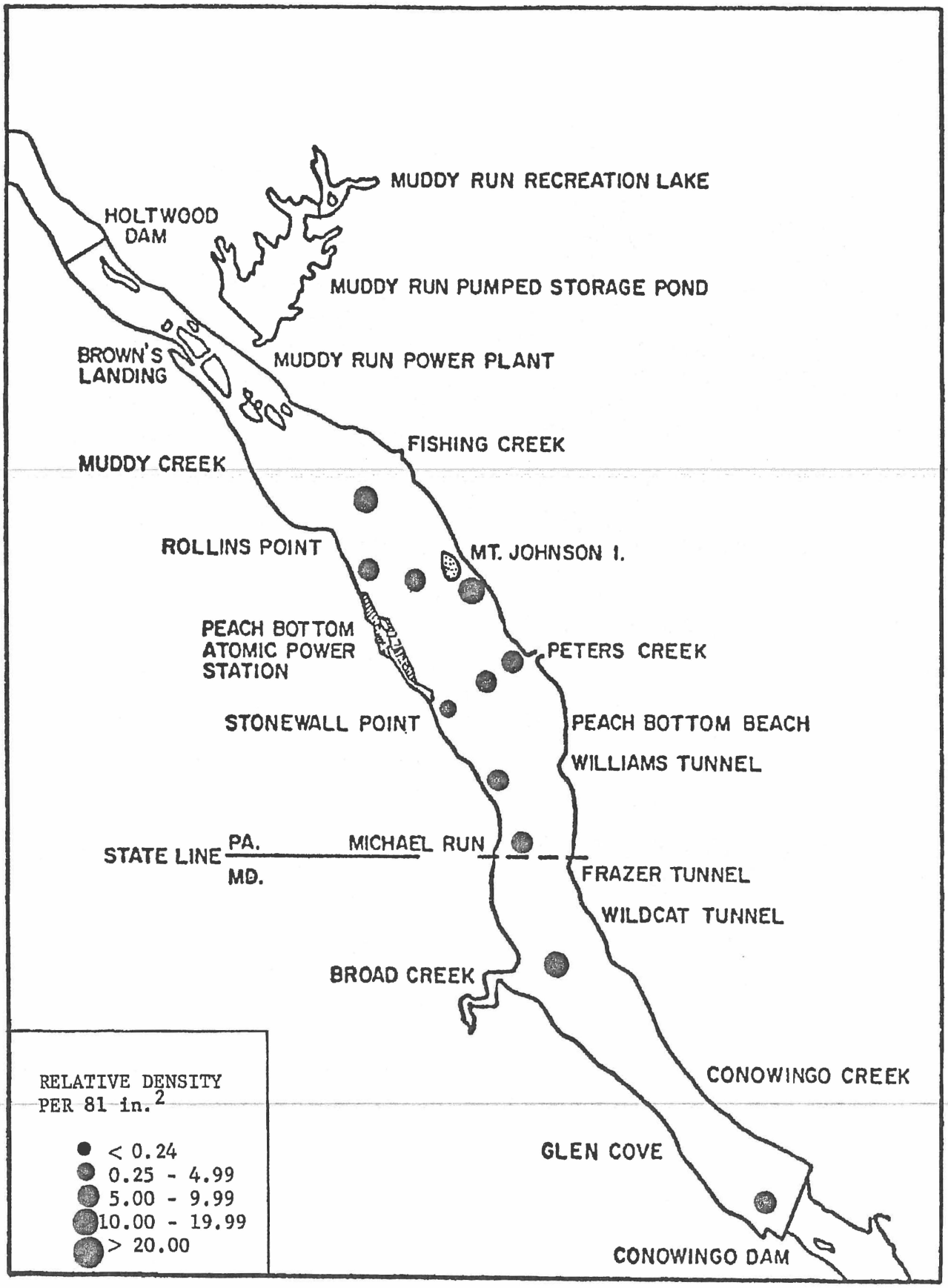


FIGURE 7.1.5-2

Relative densities of Procladius sp. at various stations in Conowingo Pond, 1967-1974.

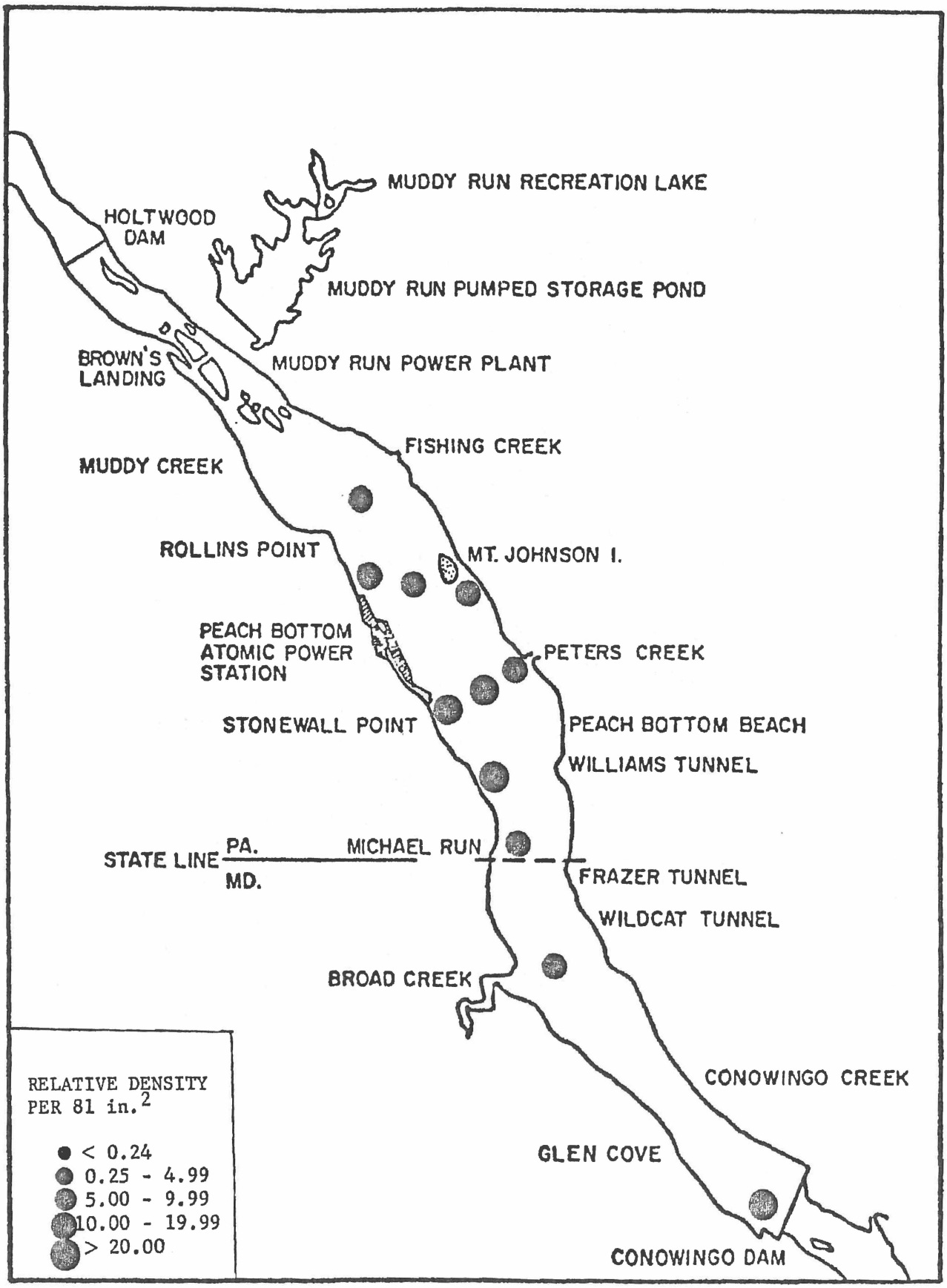


FIGURE 7.1.5-3

Relative densities of Limnodrilus hoffmeisteri at various stations in Conowingo Pond, 1967-1974.

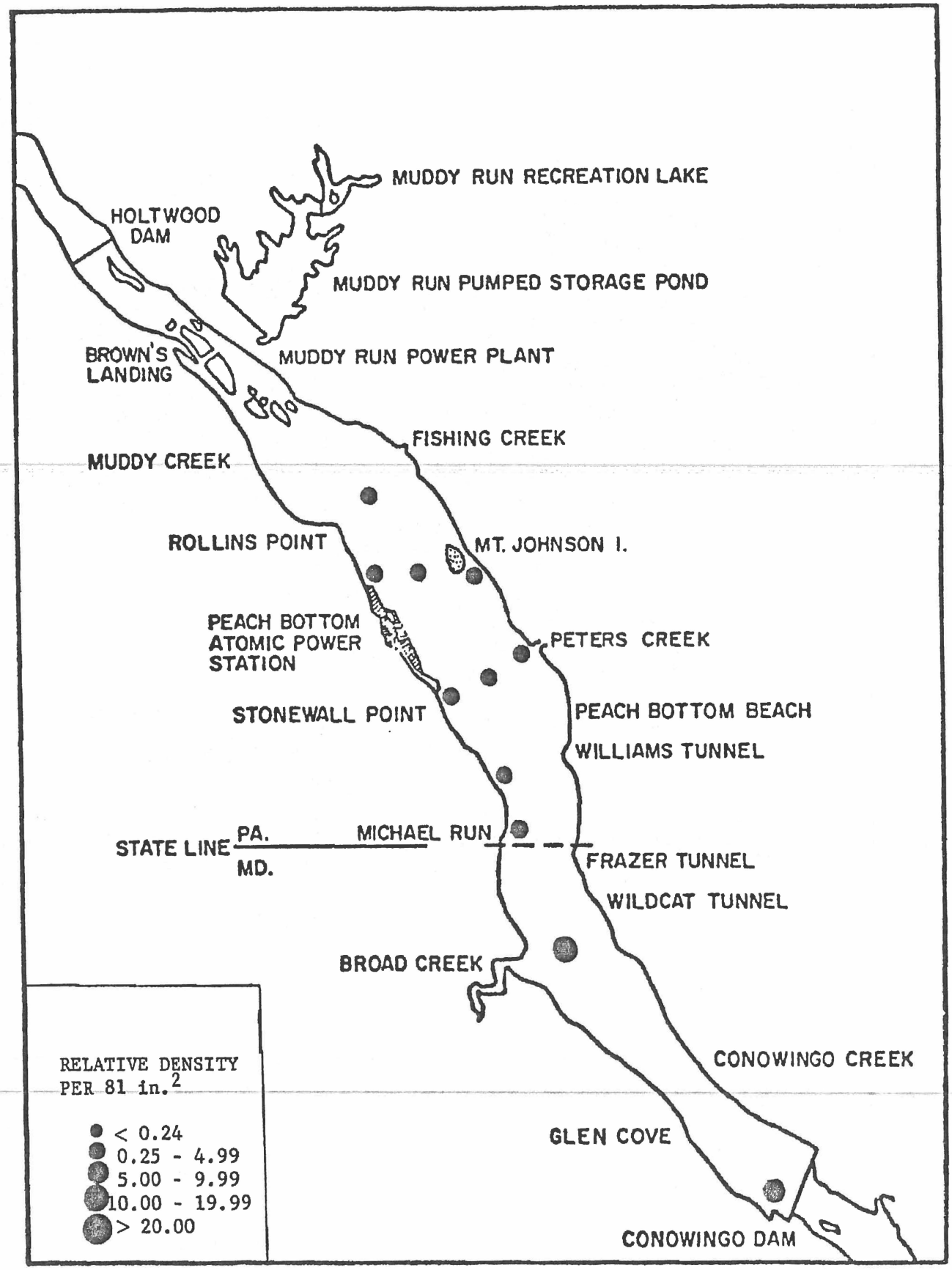


FIGURE 7.1.5-4

Relative densites of Chaoborus punctipennis at various stations in Conowingo Pond, 1967-1974.

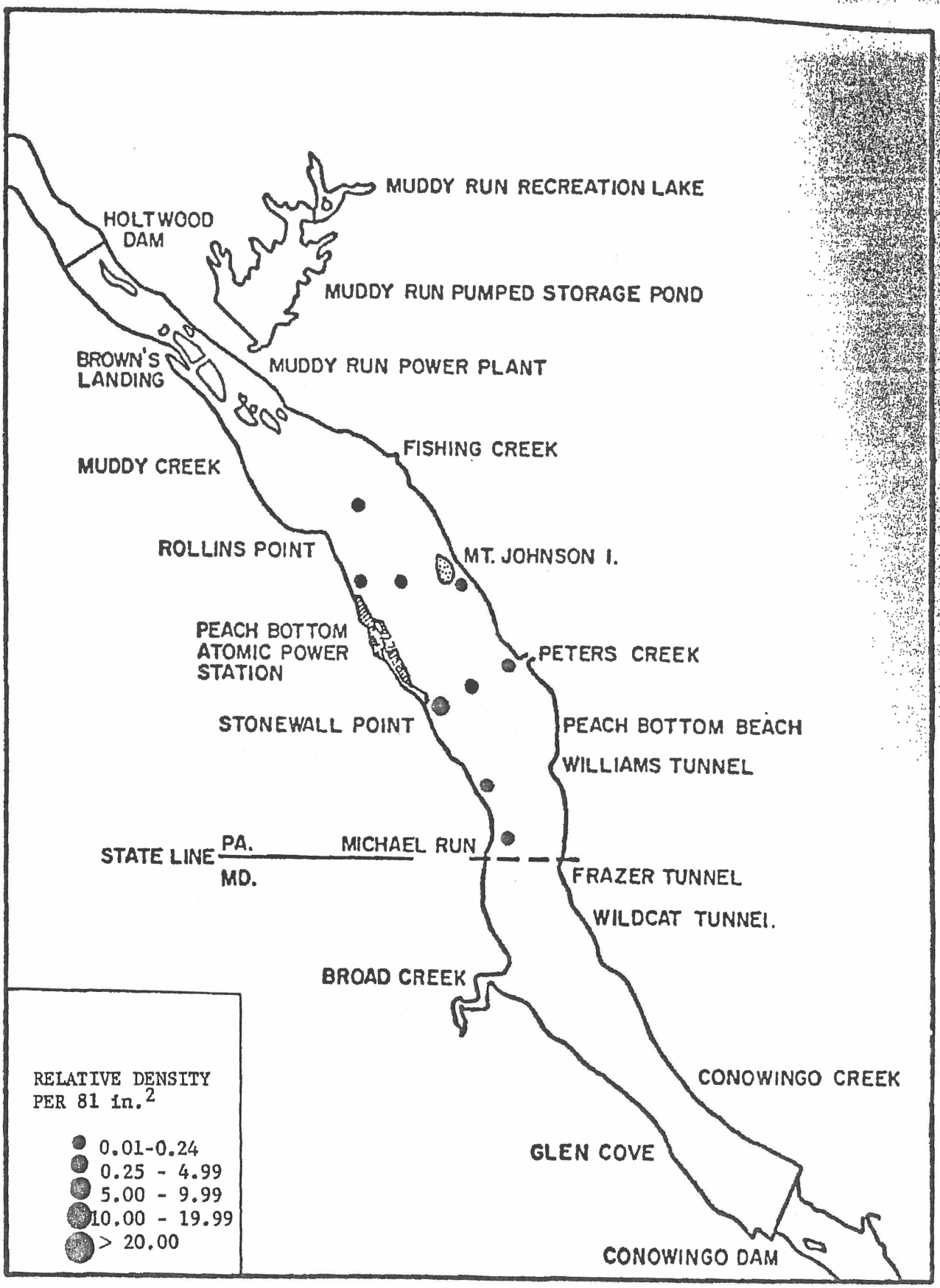


FIGURE 7.1.5-5

Relative densities of Hexagenia limbata at various stations in Conowingo Pond, 1967-1974.

7.2.0 ABUNDANCE AND DISTRIBUTION OF FISHES

7.2.1 INTRODUCTION

The study of fishes in Conowingo Pond is based on over 12,000 collections made by meter net, trap net, trawl and seine from 1966 to 1974. Monitoring stations for each gear were located on the basis of available habitats, physical constraints imposed by topography and the location of the Station. Stations were located upstream and downstream from PBAPS and in areas expected to be within the heated plume. Twelve Trap Net Stations (Figure 7.2.1-1), 18 Trawl Zone Stations (Figure 7.2.1-2), 13 Trawl Transects Stations (Figure 7.2.1-3), 12 Seine Stations (Figure 7.2.1-4) and 13 Plankton Meter Net Stations (Figure 7.2.1-5) are sampled. Collections are made twice a month. When PBAPS Unit No. 2 operated at 100% power consistently, in July 1974, an additional nine trawl stations and eight trap net stations were established inside and outside of the thermal plume (Figures 7.2.3-1 and 7.2.3-2). Trawl samples were taken three times a week and trap net Stations were sampled twice a month. Samples were replicated.

The abundance and distribution of fishes at the various stations has been well documented (see Section 3 in Robbins and Mather, 1974a, b; 1975a, b). Comparisons between the catch of fishes in the pre- and postoperational periods are also given in the above reports. A summary of these findings is given below. It is impractical to delineate the abundance of fishes on the basis of a 2 C (3.6 F) isotherm because the plume will vary in size with season and perhaps within a day.

7.2.2 SPECIES COMPOSITION

The fishes in the Pond are, for the most part, classified as warm water fishes. Some 56 species were taken in the Pond and the tributary streams from 1966 through 1974 (Table 7.2.2-1). The spotfin shiner, bluegill, pumpkinseed, bluntnose minnow and spottail shiner are the common forage fishes. The white crappie and channel catfish are the most important pan fishes. The game fishes such as the smallmouth bass, largemouth bass, yellow perch and walleye are uncommon. No rare or endangered, commercially harvested or migratory anadromous fishes are present in the Pond. The relative abundance differs as measured by a given sampling gear but the dominant species are the white crappie, channel catfish, pumpkinseed, bluegill and spotfin shiner (Table 7.2.2-2).

The alewife, American shad, blueback herring and striped bass were introduced at various times in the last 10 years, but none were taken in the Pond in the present study. Although the

walleye was stocked by the State of Maryland, it is relatively uncommon. The Pennsylvania Fish Commission has stocked muskellunge upstream in the vicinity of Falmouth, Pennsylvania and a few adult muskellunge are taken in the Pond. The gizzard shad was inadvertently introduced in 1972 from below Conowingo Dam (during the American shad study). Young gizzard shad were taken in Conowingo Pond in 1972 and in subsequent years and may be considered as being established. The white perch also was introduced. Several adults were taken in 1974. The extent to which the white perch may become established remains to be seen.

7.2.2.1 Distribution

The five common species (white crappie, channel catfish, pumpkinseed, bluegill and spotfin shiner) are widely distributed in the Pond. The distribution of many of the less common fishes, such as the walleye, smallmouth bass, largemouth bass and many cyprinids including the bluntnose minnow, is more limited. The largemouth bass is more common in the southern part of the Pond whereas the smallmouth bass, walleye and bluntnose minnow are found near the northern part, primarily between Holtwood Dam and the Muddy Run Station.

The depth and temporal distribution of larval fishes were statistically analyzed using a 2 x 2 factorial analysis of variance. Larvae of channel catfish and tessellated darter were found primarily at the bottom both in day and night. Those of carp and quillback were concentrated near the bottom in the day and at the surface at night. Larvae of the bluegill larger than 13 mm appeared to remain near the bottom. Larvae of the bluegill and other *Lepomis* (≤ 13 mm) were most abundant at the surface both in the day and night. Larvae of channel catfish and *Lepomis* were found mainly near shore, while those of carp, quillback and tessellated darter were distributed throughout the Pond.

7.2.2.2 Abundance

Some 48 fishes were collected by seine (Table 7.2.2-3). The common species in order of decreasing abundance are the spotfin shiner, bluegill and bluntnose minnow but annual and seasonal fluctuations in abundance occur. Annual species diversity ranged from 1.12 (1970) to 2.79 (1969). Species composition was similar at most stations.

In trap nets, 43 species were caught. The most common in order of decreasing abundance are the white crappie, channel catfish, bluegill and pumpkinseed (Table 7.2.2-4). Game fishes such as the smallmouth bass, largemouth bass and walleye are uncommon. Fluctuations were observed between years and months in catch per effort of the common species. Much of this variation was associated with differences in year class strength.

Abundance of most species was low in 1972, the year of Tropical Storm Agnes. One exception was the catch of the carp which increased substantially in 1972.

Some 31 species were taken in Trawl Zone 405 (off PBAPS) and 32 species were taken in Trawl Zone 408 (off Peters Creek) (Tables 7.2.2-5 and 7.2.2-6). The most common fish in Zone 408 was the white crappie and in Zone 405 it was the channel catfish. The third and fourth most common fishes in both zones were the bluegill and pumpkinseed. Both seasonal and annual fluctuations in abundance were noted. More young channel catfish were taken in Zone 405 while more young white crappie were taken in Zone 408. A considerable decrease in catch per effort of fishes was noted in July 1972 following Tropical Storm Agnes.

Of the 34 fishes taken at Trawl Transect Stations, the common species in order of decreasing abundance are the channel catfish, white crappie, bluegill, pumpkinseed, tessellated darter and spottail shiner (Table 7.2.2-7). Their abundance varies between years and stations. The white crappie, pumpkinseed and bluegill are most abundant along the east shore. The channel catfish is more abundant along the west shore between an area just north of the Station south to Michael Run and along the east shore off Fishing Creek and Wildcat Tunnel. No consistent trends are evident in the distribution of the spottail shiner and tessellated darter.

Some 30 fishes were collected by meter net (Table 7.2.2-8). The larvae of tessellated darter, quillback, carp, channel catfish and bluegill were the most common. Together they comprised about 90% of all larvae collected. Yearly fluctuations occurred in the abundance of these larvae. Except for the great abundance of the larvae of quillback; other species were scarce in 1972. The decrease in abundance of larvae of other species was due to the catostrophic flooding caused by Tropical Storm Agnes in June 1972.

TABLE 7.2.2-1

List of scientific and common names of fishes collected in Conowingo Pond and tributary streams. (According to Bailey, et al., 1970).

Scientific Name	Common Name
Family - Amiidae	Bowfins
Amia calva	Bowfin
Family - Clupeidae	Herrings
Dorosoma cepedianum	Gizzard shad
Family - Salmonidae	Trouts
Salmo gairdneri	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
Family - Esocidae	Pikes
Esox niger	Chain pickerel
Esox lucius	Northern pike
Esox masquinongy	Muskellunge
Family - Cyprinidae	Minnows and carps
Campostoma anomalum	Stoneroller
Carassius auratus	Goldfish
Clinostomus funduloides	Rosyside dace
Cyprinus carpio	Carp
Exoglossum maxillingua	Cutlips minnow
Nocomis micropogon	River chub
Notemigonus crysoleucas	Golden shiner
Notropis amoenus	Comely shiner
Notropis analostanus	Satinfin shiner
Notropis cornutus	Common shiner
Notropis hudsonius	Spottail shiner
Notropis procne	Swallowtail shiner
Notropis rubellus	Rosyface shiner
Notropis spilopterus	Spotfin shiner
Pimephales notatus	Bluntnose minnow
Pimephales promelas	Fathead minnow
Rhinichthys atratulus	Blacknose dace
Rhinichthys cataractae	Longnose dace
Semotilus atromaculatus	Creek chub
Semotilus corporalis	Fallfish
Ericymba buccata	Silverjaw minnow
Family - Catostomidae	Suckers
Carpiodes cyprinus	Quillback
Catostomus commersoni	White sucker
Erimyzon oblongus	Creek chubsucker
Hypentelium nigricans	Northern hog sucker
Moxostoma macrolepidotum	Shorthead redhorse
Family - Ictaluridae	Freshwater catfishes
Ictalurus catus	White catfish
Ictalurus natalis	Yellow bullhead
Ictalurus nebulosus	Brown bullhead
Ictalurus punctatus	Channel catfish
Noturus insignis	Margined madtom
Family - Anguillidae	Freshwater eels
Anguilla rostrata	American eel
Family - Cyprinodontidae	Killifishes
Fundulus diaphanus	Banded killifish
Fundulus heteroclitus	Mummichog
Family - Percichthyidae	Temperate basses
Morone americana	White perch
Family - Centrarchidae	Sunfishes
Ambloplites rupestris	Rock bass
Lepomis auritus	Redbreast sunfish
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie
Family - Percidae	Perches
Etheostoma olmstedi	Tessellated darter
Etheostoma zonale	Banded darter
Perca flavescens	Yellow perch
Percina caprodes	Logperch
Percina peltata	Shield darter
Stizostedion vitreum	Walleye

TABLE 7.2.2-2

Catch per effort for fishes collected by various gears in Conowingo Pond, 1966-1974.

Station	Trawl Zone 405	Trawl Zone 408	Trawl Transect	Trap Net	Seine	Meter Net
No. Collections	1209	1167	1499	2893	1567	2961
No. Species	31	33	34	43	48	31
Species						
A. calva	-	-	-	*	-	-
A. rostrata	*	*	*	0.05	-	-
D. cepedianum	0.01	0.50	0.01	0.05	-	0.08
S. gairdneri	-	-	-	*	-	-
S. trutta	-	-	-	*	*	-
S. fontinalis	-	-	-	*	*	-
E. niger	-	-	-	*	-	-
E. lucius	-	-	-	*	-	-
E. masquinongy	-	-	*	0.01	-	-
C. anomalum	-	-	-	-	0.08	-
C. auratus	*	*	*	*	-	-
C. funduloides	-	-	-	*	0.04	-
C. carpio	1.02	1.28	0.96	1.30	0.04	3.50
E. buccata	-	-	-	-	*	-
E. maxillingua	-	-	-	-	0.03	-
N. micropogon	-	-	-	*	0.08	-
N. crysoleucas	0.04	0.16	0.05	0.38	0.17	0.01
N. amoenus	*	0.01	-	*	0.49	*
N. analostanus	-	-	*	-	*	-
N. cornutus	-	*	-	-	0.25	-
N. hudsonius	1.13	2.43	1.64	0.02	1.49	0.02
N. procne	*	*	*	*	0.18	*
N. rubellus	-	*	-	*	0.12	*
N. spilopterus	0.01	0.04	0.02	0.04	56.31	0.11
P. notatus	0.01	0.08	0.02	*	2.50	*
P. promelas	-	-	-	-	0.01	-
R. atratulus	-	-	-	-	0.84	-
R. cataractae	-	-	-	-	0.06	-
S. atromaculatus	*	-	-	-	0.26	-
S. corporalis	-	-	*	-	0.02	*
C. cyprinus	0.01	0.03	0.02	0.02	1.50	5.46
C. commersoni	0.01	0.03	0.02	0.14	0.23	0.04
E. oblongus	-	-	*	-	-	-
H. nigricans	-	*	*	*	0.14	-
M. macrolepidotum	0.01	0.01	0.01	0.04	0.02	-
I. catus	0.04	0.02	0.06	0.22	*	0.01
I. natalis	*	*	0.01	0.62	0.01	0.01
I. nebulosus	0.31	0.68	0.49	1.61	0.01	*
I. punctatus	38.63	28.94	45.42	7.28	0.08	2.10
N. insignis	-	-	-	*	*	-
F. diaphanus	-	-	-	-	0.01	-
F. heteroclitus	-	-	-	*	0.02	-
A. rupestris	*	*	-	0.20	0.01	0.01
L. auritus	*	*	*	0.28	0.07	0.01
L. cyanellus	*	0.01	*	0.02	*	*
L. gibbosus	1.13	3.39	1.15	2.46	1.93	0.14
L. macrochirus	2.18	8.88	4.01	3.79	7.66	0.82
Lepomis spp.	-	-	-	-	-	0.95
M. dolomieui	0.02	0.08	0.03	0.01	0.29	0.02
M. salmoides	0.01	0.08	0.01	0.02	0.87	*
P. annularis	21.42	46.91	23.14	55.73	0.69	0.61
P. nigromaculatus	0.01	0.03	0.02	0.12	0.01	*
E. olmstedi	1.62	1.56	1.66	*	1.90	8.64
E. zonale	-	-	-	-	0.01	-
P. flavescens	0.02	0.12	0.07	0.06	*	0.02
P. caprodes	*	0.01	*	*	0.02	*
P. peltata	-	-	*	-	*	0.11
S. vitreum	0.03	0.02	0.02	0.03	0.09	0.03
Total	67.72	95.34	78.48	74.53	78.57	22.73

* Less than 0.01

TABLE 7.2.2-3

Catch per effort of fishes (number per collection) collected by 10- and 15 x 4 ft seine at stations during the preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
No. Collections	67	82	115	124	177	245	256	236	265	1567
No. Species	30	26	34	28	33	38	39	34	37	48
Species										
S. trutta	-	-	-	-	-	-	-	-	0.01	*
S. fontinalis	-	-	-	-	0.01	*	-	-	-	*
C. anomalum	0.01	0.05	0.94	0.03	0.06	0.23	0.02	0.05	0.02	0.08
C. funduloides	0.01	0.01	0.21	-	0.08	0.04	0.08	0.01	0.02	0.04
C. carpio	-	-	0.15	0.05	-	0.04	0.11	0.03	0.02	0.04
E. buccata	-	-	-	-	-	0.01	-	-	-	*
E. maxillingua	-	-	0.03	0.01	0.01	0.02	0.06	0.02	0.08	0.03
N. micropogon	0.03	0.01	0.21	-	-	0.04	0.08	0.09	0.22	0.08
N. crysoleucas	0.31	0.24	1.62	0.10	0.26	0.16	0.18	0.06	0.06	0.17
N. amoenus	0.76	0.23	2.94	0.39	0.73	0.16	0.59	0.55	0.39	0.49
N. analostanus	-	-	-	-	-	-	0.01	*	-	*
N. cornutus	0.04	0.07	1.38	0.02	0.14	0.31	0.26	0.17	0.49	0.25
N. hudsonius	3.18	0.56	6.24	2.93	1.29	2.45	1.30	0.18	1.12	1.49
N. procne	0.42	0.05	0.64	0.08	0.12	0.07	0.12	0.26	0.37	0.18
N. rubellus	0.09	0.35	0.09	-	0.12	0.16	0.05	0.14	0.14	0.12
N. spilopterus	109.90	53.21	140.97	32.82	64.37	51.12	31.87	68.96	72.85	56.31
P. notatus	18.52	1.32	4.18	2.98	1.94	1.52	0.83	1.22	3.20	2.50
P. promelas	0.01	-	-	-	-	0.01	0.04	0.01	0.02	0.01
R. atratulus	0.01	0.04	0.35	-	0.28	0.35	2.03	1.90	0.77	0.84
R. cataractae	-	-	-	0.01	0.04	0.10	0.14	0.11	0.03	0.06
S. atromaculatus	-	-	0.41	-	0.06	0.59	0.41	0.11	0.42	0.26
S. corporalis	-	-	0.12	0.02	0.04	-	*	0.06	0.01	0.02
C. cyprinus	0.16	0.05	0.56	3.27	0.39	1.28	0.16	2.20	3.64	1.50
C. commersoni	0.01	-	0.15	-	0.08	0.64	0.05	0.06	0.61	0.23
H. nigricans	-	-	0.03	0.23	0.04	0.11	0.10	0.02	0.46	0.14
M. macrolepidotum	0.01	0.05	-	0.03	-	*	-	-	0.05	0.02
I. catus	0.01	-	-	-	-	-	-	-	-	*
I. natalis	-	-	0.03	-	-	*	-	-	0.03	0.01
I. nebulosus	0.07	-	0.06	0.09	-	-	-	-	0.01	0.01
I. punctatus	0.46	0.41	0.12	0.02	0.01	0.09	0.07	0.01	0.01	0.08
N. insignis	-	-	-	-	-	*	*	-	-	*
F. diaphanus	-	-	0.03	-	0.01	0.01	0.02	-	-	0.01
F. heteroclitus	-	-	0.03	-	0.09	0.02	0.03	0.01	0.01	0.02
A. rupestris	0.01	0.05	0.03	0.01	0.01	*	0.01	-	-	0.01
L. auritus	0.01	0.11	0.38	0.15	0.11	0.04	0.05	0.06	0.06	0.07
L. cyanellus	-	0.01	0.06	0.01	-	-	0.01	-	-	*
L. gibbosus	12.64	0.76	22.35	2.79	0.73	1.75	0.44	0.55	0.77	1.93
L. macrochirus	55.45	7.18	101.65	8.53	1.24	8.19	1.89	1.44	0.52	7.66
M. dolomieui	0.15	0.33	0.44	1.81	0.16	0.08	0.03	0.06	0.42	0.29
M. salmoides	0.31	0.58	1.82	3.00	0.28	1.25	0.12	0.55	1.32	0.87
P. annularis	5.40	0.28	1.32	0.98	0.12	1.22	0.69	0.04	0.08	0.69
P. nigromaculatus	0.10	0.01	-	0.02	0.01	*	0.01	-	-	0.01
E. olmstedi	0.67	1.34	2.82	3.59	0.91	2.02	0.58	0.56	5.05	1.90
E. zonale	-	-	-	-	-	-	-	0.01	0.02	0.01
P. flavescens	-	-	-	-	0.01	-	-	-	-	*
P. caprodes	0.01	0.04	-	0.04	-	0.01	*	0.01	0.03	0.02
P. peltata	0.03	-	-	-	-	-	*	-	0.02	*
S. vitreum	-	-	0.03	-	0.80	-	0.01	*	-	0.09
Total	208.86	67.35	292.35	64.01	74.56	74.10	42.46	79.54	93.33	78.57

* Less than 0.01

TABLE 7.2.2-4

Catch per effort (number per 24-hr) for fishes collected by 3 x 6 ft trap net at Trap Net Stations during preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
No. Collections	38	207	235	264	304	346	533	459	507	2893
No. Species	21	24	21	23	26	25	27	35	39	43
No. Hours	992	4416	6067	6206	7262	8028	12479	11220	12286	68956
No. Trap Days	41.33	184.00	252.79	258.58	302.58	334.50	519.96	467.50	511.91	2873.15
Species										
A. calva	-	-	-	-	-	-	-	-	*	*
A. rostrata	0.65	0.07	0.03	0.07	0.10	0.06	0.01	0.02	*	0.05
D. cepedianum	-	-	-	-	-	-	0.03	0.02	0.22	0.05
S. gairdneri	-	-	-	-	-	-	-	*	-	*
S. trutta	-	-	-	-	-	-	-	*	*	*
S. fontinalis	-	-	-	-	*	-	-	-	-	*
E. niger	-	-	*	-	-	-	-	-	-	*
E. lucius	-	-	-	-	-	-	-	-	*	*
E. masquinongy	-	-	0.01	-	*	0.01	*	*	0.01	0.01
C. auratus	-	-	0.01	-	-	-	0.01	0.01	*	*
C. funduloides	-	-	-	-	-	-	-	-	*	*
C. carpio	0.16	0.08	0.18	0.35	0.36	0.57	4.89	1.13	0.42	1.30
N. micropogon	-	-	-	-	-	-	-	-	*	*
N. crysoleucas	1.25	0.23	0.16	0.62	1.01	0.48	0.28	0.14	0.22	0.38
N. amoenus	0.02	-	-	*	-	-	*	*	0.01	*
N. hudsonius	0.04	0.01	-	*	*	-	0.01	0.01	0.06	0.02
N. procne	-	-	-	-	*	-	-	*	0.01	*
N. ruballus	-	-	-	-	-	-	-	-	*	*
N. spilopterus	-	0.16	0.01	0.12	*	*	*	0.05	0.07	0.04
P. notatus	-	0.01	-	-	-	-	-	*	*	*
C. cyprinus	0.02	0.01	0.02	*	*	*	0.03	0.01	0.01	0.02
C. commersoni	0.09	0.11	0.16	0.13	0.18	0.13	0.15	0.12	0.11	0.14
H. nigricans	0.02	-	*	0.01	*	*	*	*	*	*
M. macrolepidotum	0.04	0.07	0.07	0.03	0.07	0.02	0.05	0.02	0.01	0.04
I. catus	0.31	0.51	0.13	0.34	0.23	0.26	0.21	0.25	0.06	0.22
I. natalis	0.31	0.21	0.09	1.22	1.70	0.84	0.50	0.23	0.36	0.62
I. nebulosus	0.36	1.27	1.15	2.18	2.47	2.28	1.27	1.58	1.17	1.61
I. punctatus	8.73	10.83	2.43	17.72	12.35	9.10	4.85	4.83	3.55	7.28
N. insignis	-	-	-	-	-	*	-	-	*	*
F. heteroclitus	-	-	-	-	-	-	-	*	-	*
A. rupestris	0.38	0.45	0.22	0.40	0.25	0.19	0.09	0.12	0.15	0.20
L. auritus	0.02	0.16	0.14	0.54	0.34	0.53	0.28	0.05	0.28	0.28
L. cyanellus	-	0.01	-	0.06	0.02	0.03	0.01	0.01	0.02	0.02
L. gibbosus	1.50	2.95	1.42	3.87	4.93	3.24	1.45	1.27	2.31	2.46
L. macrochirus	3.38	1.34	2.61	6.75	5.63	5.27	2.77	3.21	3.30	3.79
M. dolomieui	-	-	*	0.01	-	*	-	*	0.01	0.01
M. salmoides	0.07	0.03	*	0.03	*	*	0.02	0.02	0.04	0.02
P. annularis	112.84	50.39	33.35	73.64	111.08	97.76	59.88	24.68	18.98	55.73
P. nigromaculatus	0.31	0.04	0.05	0.06	0.10	0.11	0.20	0.10	0.16	0.12
E. olmstedi	-	0.01	-	-	-	-	-	*	0.01	*
P. flavescens	-	0.04	0.08	0.13	0.10	0.06	0.07	0.03	0.03	0.06
P. caprodes	-	-	*	-	-	-	-	*	*	*
S. vitreum	0.02	0.03	0.04	*	0.01	0.01	0.06	0.07	*	0.03
Total	130.48	69.10	42.49	108.42	141.09	121.07	77.12	38.12	31.63	74.53

* Less than 0.01

TABLE 7.2.2-5

Catch per effort (number per 10 min haul) for fishes collected by 16 ft semi-balloon trawl in Trawl Zone 405 during preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
No. Collections	18	59	37	62	107	188	223	240	275	1209
No. Species	13	17	19	19	21	21	20	11	23	31
Species										
A. rostrata	-	-	-	-	-	-	-	-	*	*
D. cepedianum	-	-	-	-	-	-	0.01	0.05	0.01	0.01
C. auratus	-	-	-	-	0.01	-	-	0.40	-	*
C. carpio	0.22	0.36	0.43	0.81	0.38	2.19	1.84	-	0.67	1.02
N. crysoleucas	0.11	0.10	0.10	0.10	0.10	0.04	0.05	-	0.01	0.04
N. amoenus	-	-	-	-	-	-	0.01	-	0.01	*
N. hudsonius	0.94	0.78	0.78	3.66	3.69	2.46	0.34	0.09	0.32	1.13
N. procne	-	-	-	-	-	-	0.01	-	-	*
N. spilopterus	-	-	-	-	0.04	*	0.01	-	0.01	0.01
P. notatus	-	-	0.02	0.11	-	*	-	-	-	0.01
S. atromaculatus	-	-	-	-	-	*	-	-	-	*
C. cyprinus	0.06	0.03	0.02	-	0.02	0.02	0.01	*	0.01	0.01
C. commersoni	-	0.02	-	0.05	0.02	0.03	-	-	-	0.01
M. macrolepidotum	0.22	0.02	-	-	0.03	*	-	-	0.02	0.01
I. catus	0.50	0.50	0.05	0.23	0.07	0.05	*	-	0.01	0.04
I. natalis	-	-	-	0.05	0.02	-	0.07	-	*	*
I. nebulosus	0.67	0.73	0.86	1.39	0.69	0.38	-	0.02	0.13	0.31
I. punctatus	19.61	19.39	29.89	163.23	113.70	71.76	12.33	6.31	14.76	38.63
A. rupestris	-	-	0.02	-	0.01	-	-	-	-	*
L. auritus	-	-	0.02	0.02	0.02	*	-	-	-	*
L. cyanellus	-	-	-	0.05	-	-	-	-	-	*
L. gibbosus	4.00	0.83	1.72	5.61	0.93	2.77	0.21	0.03	0.58	1.13
L. macrochirus	7.72	1.76	7.21	7.90	1.28	6.57	0.21	0.09	0.68	2.18
M. dolomieui	-	0.02	0.02	0.27	-	-	*	-	0.02	0.02
M. salmoides	-	0.02	0.05	0.13	0.01	0.01	*	-	*	0.01
P. annularis	187.61	23.68	9.13	60.47	22.93	47.88	23.07	0.31	1.32	21.42
P. nigromaculatus	0.11	-	-	-	-	0.02	0.01	-	0.02	0.01
E. olmstedi	1.17	1.54	1.48	3.29	0.87	2.20	0.17	0.47	3.39	1.62
P. flavescens	-	0.02	0.16	0.08	0.05	0.01	*	-	0.02	0.02
P. caprodes	-	-	0.02	-	-	-	-	-	*	*
S. vitreum	-	0.05	0.05	0.06	0.04	0 07	*	*	01	0.03
Total	222.94	49.41	52.13	247.50	144.90	136.56	38.44	7.79	22.03	67.72

* Less than 0.01

TABLE 7.2.2-6

Catch per effort (number per 10 min haul) for fishes collected by a 16 ft semi-balloon trawl in Trawl Zone 408 during preoperational (1966-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
No. Collections	9	36	44	32	119	179	222	228	276	1167
No. Species	15	15	21	23	20	21	22	22	27	32
Species										
A. rostrata	0.11	-	-	-	-	-	-	-	-	*
D. cepedianum	-	-	-	-	-	-	0.10	2.43	0.05	0.50
C. auratus	-	-	-	-	-	-	-	-	0.01	*
C. carpio	0.11	0.56	0.59	1.50	0.77	1.90	2.19	1.00	0.91	1.28
N. crysoleucas	0.11	0.17	0.63	1.06	0.36	0.09	0.02	0.01	0.17	0.16
N. amoenus	-	-	-	-	0.02	-	0.01	-	0.02	0.01
N. cornutus	-	-	-	-	-	-	-	*	-	*
N. hudsonius	2.56	1.36	2.90	7.13	5.62	3.22	0.80	0.62	3.06	2.43
N. procne	-	-	-	-	-	-	*	-	-	*
N. rubellus	-	-	-	-	-	-	-	-	0.01	*
N. spilopterus	-	-	0.02	-	0.03	-	*	0.01	0.16	0.04
P. notatus	-	-	-	0.53	0.03	0.01	*	-	0.24	0.08
C. cyprinus	-	-	0.04	0.03	-	0.01	0.02	0.07	0.02	0.03
C. commersoni	0.22	0.03	0.09	0.03	0.07	0.07	-	0.02	0.02	0.03
H. nigricans	-	-	-	0.06	-	-	-	*	-	*
M. macrolepidotum	-	0.06	0.06	0.06	0.03	0.01	*	0.01	*	0.01
I. catus	0.22	0.11	0.04	0.06	0.04	0.02	-	0.01	*	0.02
I. natalis	-	-	-	-	-	0.01	-	*	-	*
I. nebulosus	0.67	1.19	1.47	2.31	1.65	1.55	0.39	0.16	0.13	0.68
I. punctatus	17.89	17.89	49.86	19.69	59.86	47.18	24.29	19.42	17.23	28.94
A. rupestris	-	-	0.04	0.03	-	-	-	-	-	*
L. auritus	0.11	-	0.02	0.03	0.01	-	-	-	*	*
L. cyanellus	-	0.03	-	-	-	-	0.01	-	0.01	0.01
L. gibbosus	5.56	2.36	9.11	12.66	2.53	6.77	0.34	1.35	4.04	3.39
L. macrochirus	5.33	4.92	77.86	41.75	4.33	12.54	0.18	3.78	6.11	8.88
M. dolomieui	-	-	0.02	0.44	-	0.03	*	-	0.26	0.08
M. salmoides	-	0.14	0.06	1.03	0.07	0.04	*	*	0.13	0.08
P. annularis	61.89	58.11	86.22	354.00	45.09	132.99	17.18	4.28	10.93	46.91
P. nigromaculatus	0.11	-	0.04	0.16	0.10	0.06	*	*	0.02	0.03
E. olmstedi	0.67	2.28	1.06	1.28	1.05	1.27	0.34	1.52	3.17	1.56
P. flavescens	-	0.03	0.36	0.63	0.14	0.06	0.01	*	0.25	0.12
P. caprodes	0.11	-	-	0.03	-	0.01	-	-	0.02	0.01
S. vitreum	-	-	0.06	0.06	0.02	0.04	0.02	0.01	0.04	0.02
Total	95.56	89.22	230.65	444.56	121.82	207.87	46.00	34.73	47.01	95.34

* Less than 0.01

TABLE 7.2.2-7

Catch per effort (number per 10-min haul) for fishes collected by 16 ft semi-balloon trawl at Trawl Transect Stations during preoperational (1967-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1967	1968	1969	1970	1971	1972	1973	1974	Total
No. Collections	93	183	151	145	159	234	268	266	1499
No. Species	18	20	26	23	18	18	18	22	34
Species									
A. rostrata	-	-	-	-	-	-	-	*	*
D. cepedianum	-	-	-	-	-	-	0.15	0.02	0.01
E. masquinongy	-	-	-	0.01	-	-	-	-	*
C. auratus	-	-	0.01	-	-	-	-	-	*
C. carpio	0.34	0.78	1.07	0.59	1.59	2.29	0.31	0.58	0.96
N. crysoleucas	0.02	0.09	0.13	0.11	0.06	-	0.01	0.0[illegible]	0.05
N. amoenus	-	-	-	0.01	-	-	0.01	0.0[illegible]	*
N. hudsonius	1.08	0.88	5.97	3.42	1.82	0.21	0.44	1.2[illegible]	1.64
N. procne	-	-	-	-	-	-	0.01	-	*
N. spilopterus	-	0.01	0.01	0.05	-	-	0.02	0.03	0.02
P. notatus	-	-	0.07	0.06	-	-	-	0.04	0.02
S. corporalis	-	-	-	0.01	-	-	-	-	*
C. cyprinus	0.03	0.01	0.04	-	0.02	0.04	*	0.02	0.02
C. commersoni	-	0.04	0.05	0.05	0.03	-	*	0.01	0.02
E. oblongus	-	0.03	0.01	-	-	-	-	-	*
H. nigricans	-	-	0.01	0.01	-	-	-	-	*
M. macrolepidotum	0.05	-	0.03	-	0.03	-	-	0.01	0.01
I. catus	0.09	0.04	0.20	0.14	0.06	0.02	0.01	0.04	0.06
I. natalis	-	-	0.08	0.01	0.03	*	-	-	0.01
I. nebulosus	0.95	0.85	1.16	0.86	0.60	0.18	0.06	0.16	0.49
I. punctatus	21.32	31.83	127.33	104.68	63.82	26.46	11.26	22.26	45.02
L. auritus	0.01	-	0.01	-	0.01	*	-	-	*
L. cyanellus	-	0.01	-	-	-	-	-	-	*
L. gibbosus	0.71	1.79	1.82	1.95	3.51	0.18	0.34	0.88	1.15
L. macrochirus	1.75	17.62	5.36	0.92	6.74	0.14	0.74	1.41	4.01
M. dolomieui	0.03	0.01	0.16	0.04	-	*	-	0.06	0.03
M. salmoides	0.02	0.01	0.05	0.04	0.01	*	-	0.01	0.01
P. annularis	16.26	14.13	113.90	31.59	41.30	5.97	1.15	2.04	23.14
P. nigromaculatus	0.04	0.02	0.04	0.02	-	0.01	*	0.02	0.02
E. olmstedi	2.53	0.96	1.71	0.77	1.53	0.19	0.69	4.64	1.66
P. flavescens	0.08	0.31	0.11	0.04	0.04	-	*	0.02	0.07
P. caprodes	-	-	0.01	-	-	*	-	-	*
P. peltata	-	-	-	-	-	*	-	-	*
S. vitreum	0.03	0.02	0.05	0.04	0.03	*	-	0.02	0.02
Total	45.34	69.43	259.33	144.37	121.21	35.76	15.21	33.59	78.48

* Less than 0.01

TABLE 7.2.2-8

Yearly comparison of the catch of larval fishes (≤ 25 mm) per 10-min tow at Transect Stations preoperational (1969-1973) and postoperational (1974) periods in Conowingo Pond.

Year	1969	1970	1971	1972	1973	1974	Total
No.	390	449	471	327	628	696	2961
No. Species	25	23	17	15	27	26	30
Species							
D. cepedianum	-	-	-	*	0.31	0.06	0.08
C. carpio	3.82	2.66	2.31	6.01	4.79	2.33	3.50
N. crysoleucas	0.01	0.01	0.04	-	*	*	0.01
N. amoenus	-	0.01	*	0.02	*	*	*
N. hudsonius	0.04	0.06	-	-	0.01	*	0.02
N. procne	0.01	0.01	-	-	-	-	*
N. rubellus	0.01	-	-	-	*	-	*
N. spilopterus	0.11	0.08	0.09	0.03	0.02	0.27	0.11
P. notatus	0.01	-	-	-	*	0.01	*
S. corporalis	-	-	-	*	-	-	*
C. cyprinus	2.53	4.83	1.10	16.52	7.11	3.76	5.46
C. commersoni	0.02	0.02	0.01	0.12	0.04	0.07	0.04
I. catus	0.05	*	-	-	0.01	*	0.01
I. natalis	0.04	0.01	-	-	0.01	0.02	0.01
I. nebulosus	0.02	-	-	-	*	*	*
I. punctatus	6.49	2.61	0.63	*	1.87	1.49	2.10
A. rupestris	0.03	0.02	-	0.01	*	0.01	0.01
L. auritus	0.05	*	0.01	-	*	0.01	0.01
L. cyanellus	*	*	-	-	-	*	*
L. gibbosus	0.20	0.04	0.53	0.17	0.01	0.02	0.14
L. macrochirus	3.04	0.39	2.07	0.03	0.03	0.08	0.82
Lepomis spp.	1.27	0.46	3.39	-	0.49	0.30	0.95
M. dolomieui	0.12	0.02	0.01	-	*	*	0.02
M. salmoides	*	0.01	0.01	-	*	*	*
P. annularis	1.97	0.24	1.42	0.09	0.12	0.23	0.61
P. nigromaculatus	0.01	*	-	-	0.01	-	*
E. olmstedi	17.75	7.12	5.33	2.11	0.55	17.12	8.64
F. flavescens	-	*	-	-	*	0.08	0.02
P. caprodes	*	-	*	-	*	0.01	*
P. peltata	0.11	0.14	0.05	0.08	0.13	0.13	0.11
S. vitreum	-	-	0.08	0.04	0.03	0.01	0.03
Total	37.73	18.64	17.08	25.23	15.54	26.33	22.73

* Less than 0.01

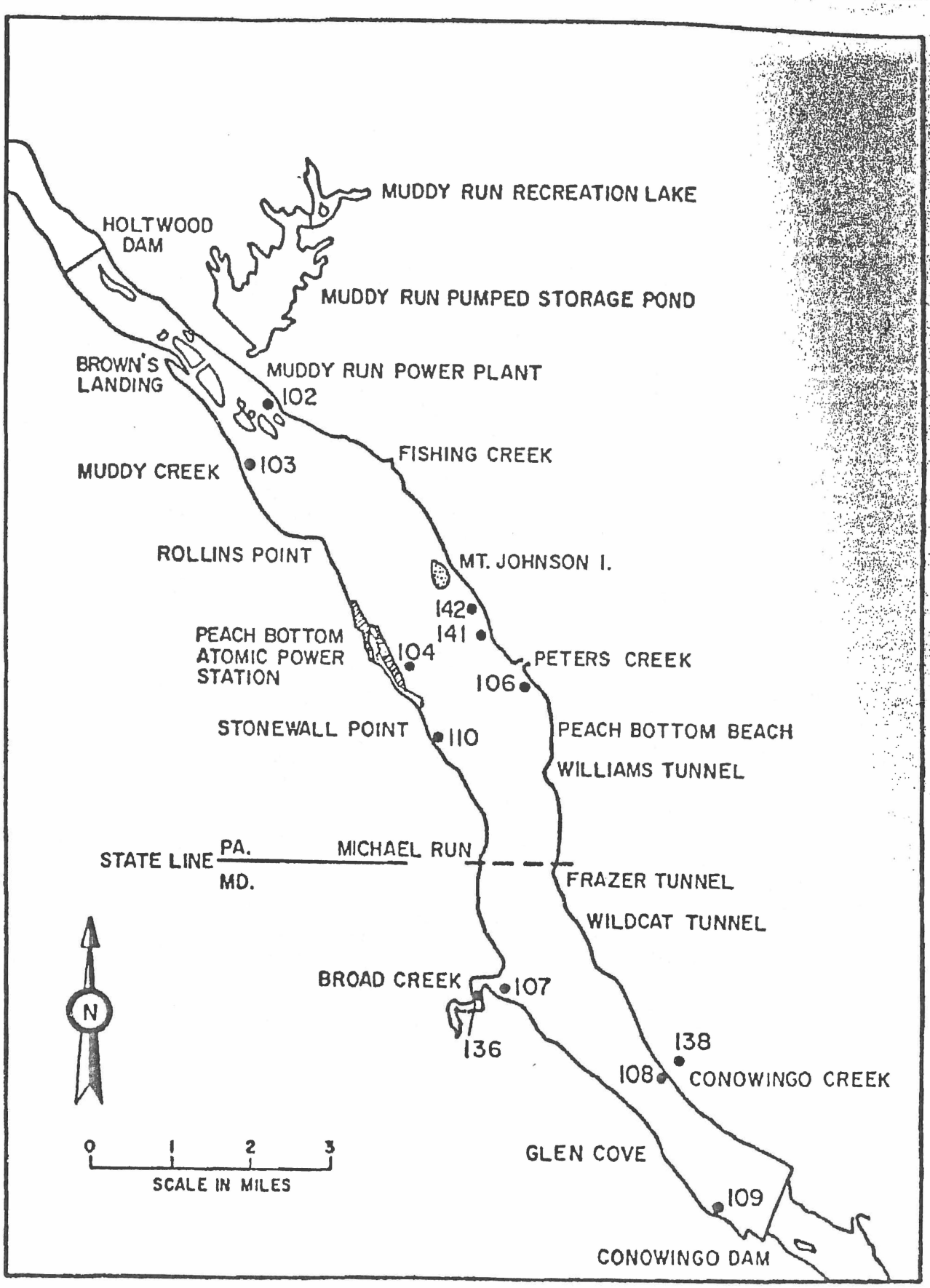


FIGURE 7.2.1-1 Map of Conowingo Pond showing the location of Trap Net Stations.