Arkansas

AQUATIC RESOURCE QUESTIONS
ATTACHMENT 1

FORM AR731-791
REV 11 70

ARKANSAS POWER & LIGHT COMPANY

INTRA COMPANY CORRESPONDENCE

Arkansas Nuclear One
Russellville, Arkansas
April 25, 1988

ANO-88-04380

MEMORANDUM

TO: Chris Longinotti

FROM: Richard Gillespie

SUBJECT: Arkansas Nuclear One
Oil Discharge To Lake Dardanelle
Due To Cooler Tube Leak

On April 14 operations personnel noticed oil in the auxiliary cooling when checking cooler flow from E-33 cooler. The plant chemists were contacted to take a sample for oil analysis. One sample contained 41 mg/l and one sample contained 70 mg/l.

After confirming oil in the auxiliary cooling water which is discharged to Lake Dardanelle, valve ACW42 was closed preventing discharge to the lake, and the discharge was diverted through the turbine building sump to the oil and water separator.

At approximately 7:00 a.m. the discharge was surveyed for oil buildup. No oil was visible in the immediate discharge area form shore. While surveying the discharge embayment by boat, an oil sheen was observed in two areas. The area of largest concentration was northwest of the boathouse, a sheen was visible in one spot approximately 50 yards long and 25 yards wide. This sheen was very thin. Other small spots of sheen were west of the plant in the discharge bay. These areas were thin and breaking up when they were discovered. the oil sheen was very thin and was not visible when contacting the shore or shoreline vegetation. No adverse environmental damage was observed. It was determined that clean-up efforts on the sheen would not be effective.

This incident was reported as an oil spill to governmental agencies per our Oil Spill Prevention Control and Countermeasure Plan. Please find attached report of oil spill and notification record.

RDG:CRA:lab

Attachments

cc: ANO-DCC

ARKANSAS POWER & LIGHT COMPANY
Arkansas Nuclear One

TITLE REPORT OF OIL SPILL	FORM NO. 1072.05A
	REV. 0 PC 0

REPORT OF OIL SPILL

DATE/TIME OF NOTIFICATION 4-14-88

I. Description of Spill

A. Spill Date: 4-14-88 Time: 0215

B. General Weather Conditions:

Temperature 50° °F

Wind Speed 9 miles/hr & / / gusty or /X/ steady

Wind Direction N (direction wind is from)

Lake Surface Condition (rippling, choppy, whitecapping) Calm

C. Location of Spill (intake canal, discharge canal, etc.)
discharge

D. Movement of spilled material:
No movement Localized near boathouse And discharge

E. Material Spilled (#2 Diesel oil, turbine lube oil, etc.)
Turbin Lube oil 10W oil

F. Quantity Spilled (gallons, barrels, etc.)
5-10 gal (estimation)

G. Source of Spill (barge, truck, oil cooler leak, etc.,)
~~[illegible]~~ 4-15-88 CRA Coler leak E-33 unit 1

H. Operation in Progress (unloading oil, transferring oil, etc.)
Normal Plant ~~[illegible]~~ CRA operation

I. Corrective Action taken Isolated Cooler ACW49 closed, routed discharge Through oil and Water Separator unit.

J. Name of Personnel that discovered spill. Mike McAllister unit 1 AO (Crue C)

K. Name of Personnel to contact at scene of spill: Tom Baker

ARKANSAS POWER & LIGHT COMPANY
Arkansas Nuclear One

TITLE NOTIFICATION RECORD | FORM NO. 1072.05B

REV. #1

USCG National Response Center Report # 4778

AGENCY	PERSON CONTACTED	PHONE	DATE/TIME CONTACTED
USCG National Response Center	Ensign Farreau	•1-800-424-8802•	4-14-88/1005
State Dept. Pollution Control & Ecology	June Walters Alan Price	562-7444 (24 Hr) 329-1201	4-14-88/1014
Corp of Engineers (Russellville)	Tommy Spincer	968-5008	4-14-88/1020
AP&L ES Technical Analysis	Chris Longinotti ~~•Tom Reed•~~	Office •~~370~~ 753-8870• ~~Home •247-4856•~~	4-14-88/1031
AP&L ES Technical Analysis	•Edward I. Green•	Joint Call Office •370-8874• Home •332-6115•	
AP&L ES Technical Analysis	•Firdina C. Hyman•	Office •~~370~~ 753-8962• Home •224-6859•	4-14-88/1031

For information purposes, the following numbers are provided:

U.S. Coast Guard (Memphis) weekdays	1-901-521-3941
Emergency-nights, weekends holidays	1-901-521-3912
EPA, Dallas 24-Hour Emergency	1-214-655-2666
Corps of Engineers (Little Rock) (Russellville)	 •378-5739• 968-5008

Other Agencies Notified:

AGENCY	PERSON CONTACTED	PHONE	DATE/TIME CONTACTED

Person Making Notification:

Thomas C. Baker [signature]

THE MATERIAL CONTAINED WITHIN THE SYMBOLS (•) IS PROPRIETARY OR PRIVATE INFORMATION.

U.S. Nuclear Regulatory Commission

Operations Center
September 23, 1985
Page 1 of 2

EVENT NOTIFICATION WORKSHEET

Notification Time	Facility or Organization	Unit	Caller's Name	Telephone Number (For call back)
10:50 a.m.	Arkansas Nuclear One	1	Don Lomax	(501) 964-3215

EVENT CLASSIFICATION		Y	N	EVENT CATEGORY	INITIATION SIGNAL		CAUSE OF FAILURE
	General Emergency N/A		✓	Reactor Trip/Scram	None	✓	Mechanical (Apparent Cooler Leak)
	Site Area Emergency N/A		✓	ESF Actuation			Electrical N/A
	Alert N/A		✓	ECCS Actuation			Personnel Error N/A
	Unusual Event N/A		✓	Safety Injection Flow			Procedure Inadequacy N/A
1 hr	50.72 Non-Emergency		✓	LCO Action Statement			Other N/A
4 hr	50.72(b)(2)(vi)	✓		Other Notification of other government agencies			
1 hr / 24 hr	Security/Safeguards N/A			System: Turbine Lube Oil Cooler			
	Transportation Event N/A			Component: E-33			
	Other: N/A						

Event Time	Zone	Event Date (1988)	Month	Day
2:15 a.m.	CST		04	14

EVENT DESCRIPTION

A small oil spill to Lake Dardenelle (via the plant discharge) occurred in the early morning hours of 4/14/88, apparently due to a leak in turbine lube oil cooler E-33. At approximately 2:15 a.m., plant operators discovered the presence of oil in the ACW side of E-33 (this cooler is checked each shift for the purpose of checking for oil leaks from the high pressure oil side to the low pressure ACW side of the cooler). It is estimated that only 5 to 10 gallons of lube oil (10W type oil) were discharged to the lake. The spill resulted in a thin film, i.e., sheen, of oil in a localized area (eddy) at the discharge canal to lake area interface. As the volume spilled was small and is "breaking up", no containment or cleanup is planned. Normal plant operation will continue except the E-33 ACW discharge will now be isolated from the plant discharge. The ACW discharge will be routed to the plant oil and water seperator, via the turbine building sump, to allow seperation of oil from any water to be discharged.

Power Prior To Event (%): 80%	Did all systems function as required?	YES —	If NO, Explain above. —
Current Power or Mode: 80%	Anything "unusual" or not understood?	NO —	If YES, Explain above. —

Outside Agency or Personnel Notified By Licensee

State(s): Department of Pollution Control and Ecology

Local: None

Resident	Yes	No	Will Be
Bob Haag	✓		

Other: See (1) below

Press Release: No

CORRECTIVE ACTION(S)

ACW flow from turbine lube oil cooler E-33 has been isolated from plant discharge to oil and water seperator via turbine building sump.

Mode of Operation Till Correction:	Estimate Time To Restart:
No effect on Unit 1 Operation	N/A

Additional Information On Back: N/A

(1) U.S. Coast Guard National Response Center (Report # 4778)
U.S. Army Corp of Engineers
These notifications occurred between 10:05 a.m and 10:35 a.m.

FORM 731-791
REV 11-70

ARKANSAS POWER & LIGHT COMPANY

INTRA COMPANY CORRESPONDENCE

Arkansas Nuclear One
Russellville, Arkansas
April 19, 1984

ANO-84-4067

MEMORANDUM

TO: Dale Swindle

FROM: Richard Gillespie

SUBJECT: Arkansas Nuclear One
Oil Spill

On April 7, 1984, at approximately 6:00 a.m., oil was observed in the discharge canal. The Oil Spill Team Leader was notified and the oil containment boom was deployed by approximately 8:00 a.m. The leak was found and isolated at approximately 8:20 a.m. The leaking component was a hydrogen seal oil cooler on Unit 1. The oil (Gulfcrest 32, Turbine Lube Oil) was leaking into cooling water which discharges directly to the discharge flume. The quantity of oil discharged was estimated at between 5 to 10 gallons. See attached forms 1903.24A and B for weather conditions and notification record.

On April 11, 1984, oil was discovered on the Unit 1 Turbine Building roof near the Hydrogen Vent. There was some oil on the roof and evidence that oil had run into the roof drain system. Roof drains in this area discharge into the discharge flume. Oil on the roof was removed using oil sorbent. The roof drain was flushed with water to remove any remaining oil. The oil containment boom was still deployed when the oil leak on the roof was found.

Clean-up of oil from the surface of the discharge canal was accomplished by using oil sorbent material specifically designed to absorb oil from the surface of water. See attached list of type and quantity of oil sorbent used. Oil sorbent was placed on water containing oil and left overnight and removed the next day. This action was repeated until oil was absorbed from water. Clean-up of oil was confined to oil contained by the oil containment boom and two small pockets of oil at each end of the boom. The oil containment boom was removed from the discharge canal on April 13, 1984 at approximately 2:30 p.m. after clean-up operations were completed.

RDG/CA/mil
Attachments
cc: Early Ewing
Tom Baker
Basil Baker
Edward Green, Little Rock
Sharon Tilley, Little Rock
ANO-DCC

Attachment List

Oil Sorbent Used at ANO During Oil Clean-up in the Discharge Canal

(1) 6 boxes of Sorbent 5 Booms, 4 per box 5" x 10'
(2) 3 Type T-126 (3M) Sweeps 17" x 100' x 3/8"
(3) 5 rolls of T-100 (3M) 36" x 150' x 3/8"
(4) 6 bales of Type T-156 sheets (3M) 18" x 18" x 3/8", 100 sheets per bale

ARKANSAS POWER & LIGHT COMPANY
Arkansas Nuclear One

TITLE: ~~REPORT OF OIL SPILL~~	FORM NO. 1903.24A
	REV. # 2 PC #

REPORT OF OIL SPILL

DATE/TIME OF NOTIFICATION 4-7-84 0615

I. Description of Spill

A. Spill Date: 4-7-84 Time: ~0600

B. General Weather Conditions:

Temperature 58° °F

Wind Speed 6 miles/hr & / / gusty or /✓/ steady

Wind Direction 65° (direction wind is from)

Lake Surface Condition (rippling, choppy, whitecapping) rippling

C. Location of Spill (intake canal, discharge canal, etc.)

discharge canal

D. Movement of spilled material:

In an west bay of discharge canal toward lake

E. Material Spilled (#2 Diesel oil, turbine lube oil, etc.)

~~undetermined~~ (SB) Hydrogen seal oil (Gulfcrest 32 Turbine lube oil about same as SAE 10W)

F. Quantity Spilled (gallons, barrels, etc.)

~~undetermined~~ (SB) 5-10 gal.

G. Source of Spill (barge, truck, oil cooler leak, etc.,)

~~undetermined~~ (SB) Internal Hydrogen seal oil Cooler leak

H. Operation in Progress (unloading oil, transferring oil, etc.)

Normal operations - no unloading or transferring of oil in progress.

I. Corrective Action taken: Oil Spill Response Team Leader notified. Began searching for source of oil. Notified D.E.C. Oil boom [illegible] in response. Source of leakage was isolated @ 0830

J. Name of Personnel that discovered spill: Sally Burris

K. Name of Personnel to contact at scene of spill: Charles Adams 3367 3121

FORM AE731-J91
REV 11 78

ARKANSAS POWER & LIGHT COMPANY

INTRA COMPANY CORRESPONDENCE

Arkansas Nuclear One
Russellville, Arkansas
January 28, 1985

ANO-85-01122

MEMORANDUM

TO: J. M. Levine

FROM: R. D. Gillespie

SUBJECT: Arkansas Nuclear One
Oil Spill on January 25, 1985

On January 25, 1985 at 1900 while plant startup was underway (after 1R6, with the startup boiler running) the Unit One AOs notified the control room of an oil spill in progress on the S/U boiler room roof. The S/U boiler day tank (T-28) in the S/U boiler room was overflowing out its vent onto the S/U boiler room roof. The fuel oil transfer pump (P74A) used to fill T-28 from the diesel oil storage tank T-25 was immediately stopped, which in turn stopped T-28 from overflowing on the roof.

About an hour earlier a fire watch on 335' elevation of the auxiliary building near the circ. water flume called with notification of a strong smell of diesel fuel. The control room dispatched the WCO to the scene. He confirmed the odor and notified the AOs to look around for diesel fuel oil leaks. Shortly thereafter the AOs discovered the problem on the S/U boiler room roof.

The problem on the S/U boiler roof was magnified by the fact that the roof drains go straight to the circ. water flume which discharges directly to the discharge canal and subsequently Lake Dardanelle.

The reason for the overflow of the S/U boilder day tank (T-28) was a stuck level gage. At the time, the S/U boiler was running, taking fuel from T-28, and also P74A was running filling T-28. The AOs had no reason to not believe the level gage, which read approximately 65% at the time of overflow.

The DEC was notified at 1905 and the Plant Manager at 1907. The AOs found traces of fuel oil in the discharge canal at 1910, and the control room started calling out the oil spill response team. At 1935 the Technical Analysis Manager was notified, and at 1950 the Chemistry and Environmental Supervisor was notified. At 2025 the US coast guard was notified, and at 2040 the floating oil boom was in place across the surface of the discharge canal, basically terminating the release of any more fuel oil to Lake Dardanelle.

The night time conditions prevented the oil spill team from being able to take any further action. They were released at 2230 and asked to return the next morning.

On 1/26/85 at approximately 0700 the oil spill team leaders and the Chemistry and Environmental Supervisor went out on the lake to evaluate the conditions of the spill. At that time they observed a thin layered oil slick covering an approximate 40-acre area west of the ANO discharge canal to the main channel of the river. A slight odor from the spilled diesel fuel could also be detected. During their investigation of the oil spill, they observed a boat with three fishermen in the area. The fishermen flagged the AP&L boat down and began to question them about the oil spill. The AP&L representatives assured the fisherman that the oil was not radioactive and that they were going to do everything possible to clean up the oil. One of the fishermen became very upset and made mention of the number of small fish he had seen killed in the area and that he was going to notify the newspapers and television about the spill. The AP&L representatives tried to explain to them that the state people (i.e., Department of Pollution and Control and Coast Guard) had already been contacted. The fishermen left stating that they were still going to notify the newspaper and television stations.

The fish that the fishermen had seen were Threadfin shad which are killed each year during the winter months when the lake water temperature drops to 42°F or below. During the last week or so, the water temperature had been 36°F or lower and a large number of these fish had been drawn into our intake canal by the water current. When this happens, the dead fish become trapped on our traveling intake screens. Most of the fish are removed by the screens. However, some of the small fish are sucked into the plant intake and travel through the plant and out the discharge canal where they float to the surface and drift to the shoreline. Normally about 80 to 90% of the entire Threadfin shad population on Lake Dardanelle die each year because of the low water temperatures. The oil spill had nothing to do with the fish kill that the fishermen had seen.

After completing the evaluation of the oil spill it was decided that AP&L would seek the aid of a professional oil spill cleanup contractor to determine what additional effort could be done to clean up the spill. The Acme Product Company of Tulsa, Oklahoma, was contacted around 0900 on 1/26/85 for this purpose. Their company resprsentative, Mr. James G. Duncan, arrived on site around noon and went out on the lake with the ANO Plant Manager, the Plant Biologist and Chemistry and Environmental Supervisor to evaluate the spill. After a very thorough investigation of the area affected by the spill and amount of oil seen, Mr. Duncan stated that there was no danger to the lake environment from this amount of oil. He stated that the oil slick was so thin that there was nothing available that would pick it up. He recommended that we continue to monitor the lake shoreline for pockets of oil that might be cleaned up later.

The Plant Biologist monitored the shoreline on 1/27/85 and 1/28/85 and have not seen any pockets of oil that can be cleaned up. They will continue to monitor for areas where oil might accumulate and can be cleaned up.

RDG/cmc
cc: ANO-DCC

ARKANSAS POWER & LIGHT COMPANY
Arkansas Nuclear One

TITLE NOTIFICATION RECORD — FORM NO 1903.24B — REV. # 3 PC #

AGENCY	PERSON CONTACTED	PHONE	DATE/TIME CONTACTED
USCG National Response Center	WALLACE	•1-800-424-8802•	2025
State Dept. Pollution Control & Ecology	———	562-7444	———
AP&L ES Technical Analysis	•Dale L. Swindle•	Office •370-8870• Home •455-1341•	2045
AP&L ES Technical Analysis	•Edward L. Green•	Office •370-8874• Home •332-6115•	N/A*
AP&L ES Technical Analysis	•Firdina C. Hymd. •	Office •370-8962• Home •224-9456•	N/A
AP&L ES Technical Analysis	•Sharon R. Tilley•	Office •370-8883• Home •776-2699•	N/A

For information purposes, the following numbers are provided:

U.S. Coast Guard (Memphis) 24-Hour Emergency	•1-901-521-3172•
EPA, Dallas 24-Hour Emergency	•1-214-767-2666•
Corps of Engineers	•378-5739•

Other Agencies Notified:

AGENCY	PERSON CONTACTED	PHONE	DATE/TIME CONTACTED
CES	JAMES GRAY	329-5601	2120
DICK KALE		455-4883	2145

Person Making Notification:

JERRY SHINN

THE MATERIAL CONTAINED WITHIN THE SYMBOLS (•) IS PROPRIETARY OR PRIVATE INFORMATION.

* N/A PER DALE SWINDLE

ARKANSAS POWER & LIGHT COMPANY
Arkansas Nuclear One

TITLE: REPORT OF OIL SPILL — FORM NO. 1903.24A — REV. # 3 PC #

REPORT OF OIL SPILL

DATE/TIME OF NOTIFICATION 25 JAN 85

I. Description of Spill

A. Spill Date: 25 JAN 85 Time: 1530 hrs 1900

B. General Weather Conditions:

Temperature 30 °F

Wind Speed 8 miles/hr & / ⊘ / gusty or / ✓ / steady

Wind Direction NNE (direction wind is from)

Lake Surface Condition (rippling, choppy, whitecapping) CHOPPY

C. Location of Spill (intake canal, discharge canal, etc.)
DISCHARGE CANAL

D. Movement of spilled material:

E. Material Spilled (#2 Diesel oil, turbine lube oil, etc.)
DIESEL FUEL OIL

F. Quantity Spilled (gallons, barrels, etc.)
~200 GAL

G. Source of Spill (barge, truck, oil cooler leak, etc.)
RELIEF VENT INTO ROOF DRAIN

H. Operation in Progress (unloading oil, transferring oil, etc.)
TRANSFERRING FUEL OIL

I. Corrective Action taken: CONTACTED TEAM MEMBERS, OPS TO BEGIN BOOM STRETCH

J. Name of Personnel that discovered spill:
MICHAEL McALLISTER

K. Name of Personnel to contact at scene of spill: DENNIS CALLOWAY

ARKANSAS NUCLEAR ONE
NPDES PERMIT AR0001392
HISTORY OF CHANGES AND MODIFICATIONS

September 13, 1974

EPA issues a proposed NPDES permit. This permit became effective November 21, 1974 and expired November 20, 1979.

November 16, 1974

EPA issues a final permit. The effective date was December 16, 1974 and the expiration date was December 15, 1979. Changes from the proposed permit were:

1. Once through cooling water discharge was authorized for the entire period of the permit.

2. Free available chlorine in once through cooling water was limited to 0.2 mg/l daily average and 0.5 mg/l daily maximum.

3. Effluent limitations for low-volume waste water, metal cleaning waste water, and boiler blowdown were revised to total suspended solids of 30 mg/l daily average and 100 mg/l daily maximum; oil and grease of 15 mg/l daily average and 20 mg/l daily maximum; total iron of 1 mg/l daily average and daily maximum; and total copper of 1 mg/l daily average and daily maximum

4. Limitations were deleted for total suspended solids and phosphorus in cooling tower blowdown effluents; and for total manganese, oil and grease, and phosphorus in boiler blowdown effluents.

May 23, 1979

EPA issues a proposed permit. The effective date was December 1, 1979 and the expiration date was September 30, 1980. Changes from the previous final permit were:

1. Renumbering of the outfalls as follows:

   Outfall 001, once through cooling water
   Outfall 01A, low-volume wastewater
   Outfall 01B, cooling tower blowdown
   Outfall 002, treated sanitary sewage effluents

2. A daily average flow reporting requirement was established at the low volume wastewater outfall.

3. A daily average flow reporting requirement was established at the cooling tower blowdown outfall.

4. A daily average flow reporting requirement was placed on treated sanitary sewage effluent.

5. Monitoring requirements for Fecal Coliform were deleted at the treated sanitary sewage effluent outfall.

6. No schedule of compliance.

7. Part II of permit extended to include definition for metal cleaning wastes and modification for the definition of flow weighted average temperature.

July 20, 1979

EPA issues final permit. Permit contents are same as proposed permit (including effective and expiratory dates) dated May 23, 1979.

June 5, 1981

EPA issues final permit. The effective date was July 6, 1981, with expiration on July 5, 1986. Changes from the previous permit were:

1. For Outfall 001, the daily average flow limitation is increased to 1123 MGD.

2. For Outfall 002, totalized flow monitoring is deferred until July 1, 1984.

3. For Outfall 004, daily average flow is changed to 0.15 MGD and daily maximum flow is changed to 0.3 MGD. For total suspended solids the daily average mass discharge limitation is changed to 37.5 lbs/day and the daily maximum mass discharge limitation is removed. For oil and grease the daily average mass discharge limitation is changed to 18.8 lbs/day and the daily maximum mass discharge limitation is removed.

4. For Outfall 005, daily average flow is changed to 0.025 MGD.

5. For Outfall 001, effective July 1, 1984, total residual chlorine limits are changed to 0.5 mg/l daily maximum.

6. Effective July 1, 1984, no discharge of total residual chlorine is allowed from Outfall 001, once through cooling water.

7. Effective July 1, 1984 chlorine discharge from Outfall 002, cooling tower blowdown, is limited to 0.14 mg/l total residual chlorine.

February 11, 1983

EPA issues a proposed permit. The permit had no effective date, but expired July 5, 1986. The following modifications were made to the permit:

1. For Outfall 001, once through cooling water and previously monitored effluents, effective July 1, 1984, chlorine limits are changed to 0.2 mg/l daily maximum for total residual chlorine in accordance with BAT (best available technology economically achievable) under Part 423.13 (b) (1) and (2). Associated mass limitations are applied at a daily maximum flow of 1145 MGD and two hours per day of chlorination.

2. For outfull 002, cooling tower blowdown, effective July 1, 1984, chlorine limits are retained at 0.2 mg/l daily average and 0.5 mg/l daily maximum for free available chlorine in accordance with BAT under Part 423.13(d) (1) and (2). Associated mass limitations are retained based on a daily average flow of 20 MGD, a daily maximum flow of 25 MGD, and two hours per day of chlorination.

May 6, 1983

EPA issued a final permit. The permit became effective June 6, 1983 and expired July 5, 1986. The following changes were made to the proposed permit dated February 11, 1983:

1. The daily average discharge at Outfall 001, once-through cooling water was modified to 1145 MGD. The mass limitations for FAC were revised to 159 lbs/day daily discharge and 398 lbs/day daily discharge maximum.

2. The PH limitations at Outfall 005, sanitary waste stream were deleted.

November 22, 1985

EPA issues proposed permit. There was no effective or expiration date. The changes from the previously issued permit were:

1. Flow limitations were deleted from Outfall 003, 004, and 005. Mass limitations were deleted from Outfalls 003 and 004. The free available chlorine mass limitations for Outfall 002 were changed from 33 lb/day to 3 lb/day (daily average) and from 83 lbs/day to 7 lb/day (daily maximum).

January 31, 1986

EPA issues final permit. The permit became effective March 1, 1986 with expiration on March 1, 1991. Changes were as follows:

1) A new Outfall, 006, wastewater holding pond discharge was added.

April 27, 1988

EPA issued a draft permit. There was no effective date, but expiration was March 1, 1991. The changes from the previously issued permit were the addition of two new outfalls: 007-metal cleaning wastewater and 008-reverse osmosis wastewater (blowdown).

August 26, 1988

EPA issued a final permit. The effective date was August 28, 1988 with expiration March 1, 1991. Changes to the permit included:

1. Authorization to periodically discharge maintenance chemicals from the ultra pure water processing system through either Outfall 002 (cooling tower blowdown) or Outfall 005 (sanitary sewage discharge).

2. EDTA was added to monitoring requirements at Outfall 002.

Arkansas

AQUATIC RESOURCE QUESTIONS
ATTACHMENT 2

ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

ARKANSAS NUCLEAR ONE
GENERATING STATION

Dardanelle Reservoir
Environmental Monitoring Program

Summary Report

of

Environmental Impact of Thermal Discharge

October 30, 1984

Both units intake cooling water from the Illinois Bayou and discharge into a cove on the northern shore of Dardanelle Reservoir. Unit 1 utilizes a once-through cooling water system, while Unit 2 utilizes a natural draft cooling tower. The temperature distribution survey consisted of a pre-operational survey and a series of 13 monthly post-operational surveys. Data was collected along a cross-section of the reservoir in the area of the reservoir receiving the maximum impact of the discharge plume. This survey indicated that plume behavior was affected by air temperature, wind and reservoir flow-through. Analysis also showed compliance with the water quality criteria of 95°F maximum and 5°F maximum increase.

A second, continuing program implemented in 1973, before operation, involves monthly physio-chemical water sampling at a number of locations and quarterly sampling of benthos and plankton. Monthly water samples are collected upstream, through the discharge area, and downstream of the plant. These samples are analyzed for a wide range of parameters, including temperature. As expected, the cooling water discharge does cause an increase in temperature over the ambient temperature indicated by the upstream sampling station. Sampling locations in the area of discharge routinely show temperatures in excess of 90°F during the summer months of June, July, and August. Based on monthly sampling, the highest recorded of ANO. Sampling is conducted at various locations to compare unaffected areas with the discharge area. The fish population in Dardanelle Reservoir consists of more than 50 species. The first nine years of data has been subjected to statistical analysis to determine the correlation of temperature in the discharge area with the level of spawning activity. The conclusion of the analysis is that no significant correlation exists. The mean weight of adult fish collected in the discharge area was not significantly different from those collected in other areas. The species composition in the discharge area is not significantly different from other sample locations. In conclusion, the thermal discharge does not have a significant impact on the fishery use of Dardanelle Reservoir.

AP&L has been conducting an environmental survey program on Dardanelle Reservoir beginning prior to actual operation of ANO, and analysis has been made of nine years of data collected during operation. This data demonstrates that the cooling water discharge causes a temperature increase approaching 5°F during the colder winter months. In summer months, the maximum temperature approaches 95°F. The water quality criteria of a 95°F maximum temperature and a 5°F maximum increase are indicative of actual conditions in Dardanelle Reservoir. Concurrent with this temperature data, data has been collected on plankton, benthos, and fish. Analysis has shown that the species diversity and populations are not significantly different in the discharge

BIBLIOGRAPHY

Geo-Marine, Inc., "The Distribution of Temperature and Dissolved Oxygen in the Vicinity of Arkansas Nuclear One Dardanelle Reservoir," December 17, 1976

John D. Rickett, "Dardanelle Reservoir - Illinois Bayou Embayment Survey," UALR Department of Biology, 1973-1982.

Sharon Tilley, "A Summary of the Dardanelle Reservoir Fishery Survey Annual Reports," 1983.

"Attachment 2"

ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

ARKANSAS NUCLEAR ONE
GENERATING STATION

Lake Dardanelle Environmental Monitoring Program

Summary Reports
of
Environmental Impacts of Thermal Discharge

1. Dardanelle Reservoir - Illinois Bayou Embayment Survey

2. A Summary of the Dardanelle Reservoir Fishery Surveys

September 20, 1984

DARDANELLE RESERVOIR-ILLINOIS BAYOU EMBAYMENT SURVEY

PROGRESS REPORT NO. 26

Introduction

According to specifications of contract between the University of Arkansas at Little Rock and Arkansas Power & Light Company, this report is respectfully submitted.

Progress Report No. 21 under this title filed with AP&L in February 1979 contains the standard field and laboratory procedures for this project, and subsequent reports contain any changes in procedure and data for the previous year. This report contains data and a superficial analysis for the year 1982, and the reader is referred to Report No. 21 for specific procedures.

Procedural Changes

There were no modifications of project operation during 1982. Table 1 is a summary of our standard collection procedures, and Figure 1 is a map of the lake with sampling stations designated.

Plant Operation

Unit I of ANO was shut down or in the process of being shut down at trip time in April, August, November and December. These shut-downs involved refueling and safety modifications.

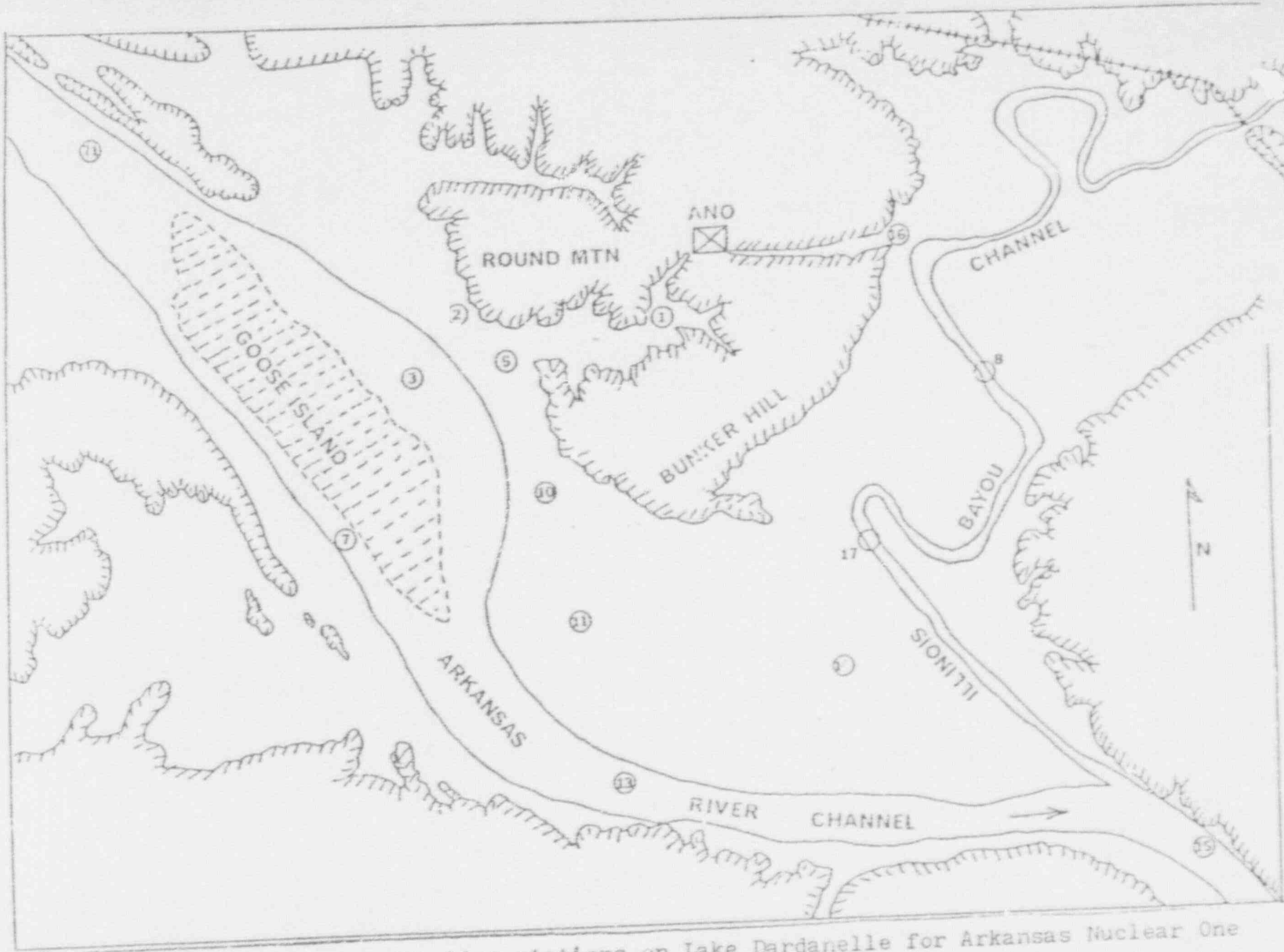


Figure 1. Locations of sampling stations on Lake Dardanelle for Arkansas Nuclear One (ANO) project, 1982.

Table 2. Meteorological data for vicinity of ANO, Lake Dardanelle, Arkansas, 1982.

Month	Air Temp. (F)	BTU	Wind	Clouds
JAN	47-60	0-15	SE,NE,E 0-15	50-100%
'FEB'	33-65	10-105	NE,NW,E 0-17	10-50 %
MAR	47-52	110-295	SE,NE,E 0-7	0-75 %
APR	54-62	40-260	SW,ENE,E,W 0-10	10-70 %
MAY	71-81	80-285	SW,S,W 0-10	20-70 %
JUN	85-89	100-310	SE,SW,S 0-8	10-90 %
JUL	87-98	95-295	S,W 0-8	0-20 %
AUG	68-85	30-185	ESE,ENE,SE,E 0-10	10-80 %
SEP	70-76	60-255	NE,E 3-7	10-75 %
OCT	55-76	50-245	NW,NE,W,N 0-14	0-20 %
NOV	64-68	50-200	NE,SE,S,E 0-10	0-60 %
DEC	47-62	5-65	SE,E 3-10	10-90 %

Table 4. Monthly ranges of 12 physico-chemical parameters, Lake Dardanelle, Arkansas, 1982.

Month	pH	Total hardness (mg/l as $CaCO_3$)	Turbidity (FTU)	Iron (mg/l)	Chloride (mg/l)	Copper (mg/l)
JAN	7.4-8.1	118-180	4-19	.04-.11	103-208	.09-.17
'FEB'	6.9-7.3	84-152	35-42	.13-.36	49-91	.09-.12
MAR	6.9-8.2	92-186	14-45	.10-.32	72-160	.05-.14
APR	7.7-8.3	82-174	12-50	.12-.31	84-106	.05-.10
MAY	7.3-8.1	106-146	17-120	.16-.70	68-108	.04-.17
JUN	7.2-8.5	84-162	12-90	.12-.75	51-73	.16-.15
JUL	7.1-8.8	94-148	14-102	.05-.70	70-78	.00-.05
AUG	7.3-8.5	136-184	16-54	.11-.35	89-110	.00-.11
SEP	7.7-8.2	84-230	18-60	.13-.38	85-105	.00-.08
OCT	7.7-8.0	122-220	21-45	.08-.29	99-118	.03-.40
NOV	7.9-8.0	138-292	2-22	.04-.19	101-121	.04-.10
DEC	7.1-7.4	44-106	36-62	.04-.41	24-56	.00-.12

than in 1981. The lowest iron readings were observed in the early winter months, whereas the highest were in the early summer months. Chloride was too variable to reveal any seasonal trends with the lowest value occurring in December and the highest in January. Copper test results were quite uniform throughout the year, as were sulfate values.

During April through July, phosphate readings were highest (off the scale; estimated in excess of 3 mg/l). Suspended solids were noticeably lower in September, slightly higher in May and June, but otherwise quite uniform. Lowest nitrate values were seen during summer and early autumn, whereas highest values were obtained in winter. Other than very high readings in January, nitrite values were fairly uniform. Conductivity values were lowest in December and highest in January, corresponding to chloride, but otherwise rather uniform. Tables 9-20 (Appendix I) give all physico-chemical data for January through December, respectively.

Table 5 gives weights of plankton, while Table 6 gives numbers and phytoplankton/zooplankton ratios. Total numbers were highest in July, but zooplankton was most abundant in April. The largest P/Z ratio occurred in January, whereas the lowest was seen in April. Phytoplankton was more numerous at close stations in January and April, whereas zooplankton was more numerous at close stations in January, July and October (Table 7). The combined mean for the year showed 3.9% more phytoplankton and 5.8% more zooplankton at the close stations.

In January, Melosira was the dominant phytoplankton taxon at nine of the ten stations while Polyarthra was the dominant

Table 6. Numbers of plankton (per liter) and phy/zoo ratios, Lake Dardanelle, Arkansas, 1982. (Total numbers are averages of strip count and field count methods, and zooplankton numbers are adjusted to reflect that proportion of the average totals which the actual counts reflect of the strip count total).

	JANUARY			APRIL		
Station	Total	Zoopl.	phy/zoo	Total	Zoopl.	phy/zoo
1	4411	703	5.27	3700	770	3.80
2	4588	501	8.16	5278	1843	1.86
3	7251	858	7.45	5178	2555	1.03
5	3467	502	5.91	sample missing		
10	5074	811	5.26	5466	1461	2.74
11	2968	604	3.91	4328	1272	2.40
14	5601	870	5.44	3444	2583	0.33
15	3037	650	3.67	4792	1[illegible]73	2.25
16	3280	577	4.68	5007	1623	2.08
21	4001	362	10.05	4907	1364	2.60
MEAN	4368	644	5.98	4678	1660	2.12
S.D.	1343	168	2.00	708	591	2.10
	JULY			OCTOBER		
1	6732	940	6.16	2590	455	4.69
2	5752	979	4.88	3510	682	4.15
3	7140	1211	4.90	2952	777	2.80
5	4968	2198	1.26	3025	638	3.74
10	5928	1012	4.86	3435	1094	2.14
11	6845	1678	3.08	3386	636	4.32
14	5130	1270	3.04	2277	735	2.10
15	6914	1332	4.19	2418	464	4.21
16	7759	1031	6.52	2587	377	5.86
21	8258	908	8.09	4436	640	5.93
MEAN	6543	1256	4.70	3062	650	3.99
S.D.	1081	406	1.96	652	264	1.35

zooplankton taxon at all stations. In April, Cyclotella was the dominant phytoplankton taxon at five of ten stations (others varied), whereas the dominant zooplankton taxon varied among Polyarthra, Bosmina, Keratella, Diaptomus and Asplanchna. In July, the dominant phytoplankton taxon was Oscillatoria, while the dominant zooplankton taxon varied among Polyarthra, Hexarthra, Asplanchna and Brachionus. In October, Cyclotella was the dominant phytoplankton taxon at eight of ten stations (Ankistrodesmus at the other two), whereas the dominant zooplankton taxon varied among Polyarthra, Brachionus, Keratella and others. Tables 21-24 (Appendix II) contain complete phytoplankton data, whereas Tables 25-28 (Appendix III) give complete zooplankton data.

Table 8 is a summary of the abundance of benthic organisms at close versus distant stations. There were more Chaoborus at close stations in April and October, whereas numbers of Chironomidae at close stations were less except in October when close and distant stations had the same. Oligochaeta were more abundant at close stations in January a April, whereas Hexagenia and Sphaeriidae were more abundant at close stations in July and October. Corbicula were present only at close stations in July and October. Chironomidae was the most abundant taxon in January, April and July, and Chaoborus was the most abundant in October. Tables 29-32 (Appendix IV) give complete benthic data.

A SUMMARY OF THE

DARDANELLE RESERVOIR FISHERY SURVEY

ANNUAL REPORTS

Sharon Tilley
Environmental and Technical Services

Arkansas Power & Light Company

1983

Four sampling areas were used. The one control area, Backwater Area A, is located eight miles upstream away from expected ANO influence. The other three areas are located in the general vicinity of ANO. Sample station Discharge Area C is located in the discharge embayment of ANO, station Channel Area D is located in the main river channel downstream of the discharge embayment, and station Intake Area B is located in the Illinois Bayou arm of the reservoir. This area is the least influenced by the Arkansas River, and has slightly better water quality.

Data and Discussion

The fishery survey was designed to characterize the species composition and growth of fish in Dardanelle Reservoir. Its purpose was to assess significant impact on the fishery due to the operation of ANO. Several concerns were raised in the Final Environmental Statement issued by the United States Atomic Energy Commission (later called the United States Nuclear Regulatory Commission). Among the concerns identified were: (1) what affect would impingement have on the fishery and (2) what affect would the thermal discharge have on the species composition in the discharge area and on the reservoir as a whole. Would thermally-tolerant species of fish such as Carp, Drum, Bowfin and Gar assume an unreasonable percentage of the population?

I cannot find this concern in the FES extract we are using!

Impingement affects are discussed in the impingement summary of this report. Basically, it does not appear that impingement is having a significant impact on the fishery.

The fish population consists of more than 50 species. One migratory species, the American Eel, was identified (Table 1).

areas. Catfish species were never collected in any of the samples. Use of the mid-water trawl yielded Clupeidae species as the dominant species as well. However, greater species diversity was noted in this type sample gear, probably due to the larger fish it is designed to catch, and change of habitat as they grow. Actual data analysis and literature searches indicated that survival of larval fish was usually less than 5%. Natural factors such as disease and predation exert a powerful influence on survival of larval fish.

Abnormalities and parasites found on larval and juvenile fish consisted of growths of unknown origin, Lorodosis (humpback or crooked spine), Henneguya and Ichthyophthirus. Fish with growths were found in all the sample areas with the least number of growths being found in the Discharge Area C. Henneguya and Ichthyophthirus were found intermittently on Channel Catfish, Freshwater Drum, and the Clupeidae species. The incidence of Lorodosis has declined to very small numbers since the use of toxaphene, a herbicide, was banned for agricultural use.

A study of the mean length of juvenile fish caught in the mid-water trawl over the nine-year survey period revealed that the Clupeidae species, unidentifiable to species, ranged from 27.1 mm in Backwater Area A to 35.6 mm in Discharge Area C. Gizzard Shad juvenile mean lengths ranged from 60.5 mm in Discharge Area C to 80.6 mm in Intake Area B. Threadfin Shad juvenile mean lengths ranged from 50.0 mm in Discharge Area C to 58.4 mm in Channel Area D.

Channel Catfish ranged from 128.0 mm in Backwater Area A to 169.4 mm in Discharge Area ~~D~~ C; Blue Catfish ranged from 139.8 mm in Intake Area B to

Pre-operational and operational rotenone data was the only information compatible with the survey, and was used to determine species composition and give a more accurate assessment of weight trends. Backwater Area A was sampled consecutively from 1973 through 1982, and Discharge Area C from 1971 through 1982.

All but one species of fish exhibited a tendency toward random weight distribution. Threadfin Shad in Discharge Area C tended toward nonrandom clustering (P=.0529). Mean weights tended to be somewhat higher in Discharge Area C for Gizzard Shad, River Carpsucker, Channel Catfish, Warmouth and Largemouth Bass. Condition factors

The predator-to-prey ratio by weight in both areas appeared to be randomly distributed with the ratio in Discharge Area C higher than Backwater Area A (Table 2).

Species composition in the two areas (Table 3) showed randomness. The only exception was found in an increase in Striped Bass numbers in Backwater Area A for the last four years (P=.0167). Drum could be the only identified thermally-tolerant species to have exhibited a significant increase. However, this trend showed up prior to operation of ANO, and a similar trend was seen in Backwater Area A.

Conclusion

Species composition in Dardanelle Reservoir has not reached equilibrium in the more than 15 years of impoundment, and the data suggests that it is unlikely to do so. The number of larval, juvenile and adult fish in

Table 1. Some of the species of fish collected in Dardanelle Reservoir from 1974 through 1982.

Lepisosteus productus	Spotted Gar
Lepisosteus osseus	Longnose Gar
Lepisosteus platostomus	Shortnose Gar
Dorosoma cepedianum	Gizzard Shad
Alosa chrysochloris	Skipjack Herring
Dorosoma petenense	Threadfin Shad
Carpiodes forbesi	River Carpsucker
Ictiobus bubalus	Smallmouth Buffalo
Ictiobus cyprinellus	Bigmouth Buffalo
Ictiobus niger	Black Buffalo
Ictalurus natalis	Yellow Bullhead
Ictalurus punctatus	Channel Catfish
Ictalurus furcatus	Blue Catfish
Pylodictis olivaris	Flathead Catfish
Roccus chrysops	White Bass
Roccus saxatilis	Striped Bass
Micropterus punctulatus	Spotted Bass
Chaenobryttus coronarius	Warmouth
Lepomis cyanellus	Green Sunfish
Lepomis humilis	Orangespotted Sunfish
Lepomis macrochirus	Bluegill
Lepomis megalotis	Longear Sunfish
Lepomis microlophus	Redear Sunfish
Micropterus salmoides	Largemouth Bass
Pomoxis annularis	White Crappie
Pomoxis nigromaculatus	Black Crappie
Stizostedion canadense	Sauger
Aplodinotus grunniens	Freshwater Drum
Notropis lutrensis	Red Shiner
Menidia audens	Mississippi Silverside
Labidesthes sicculus	Brook Silverside
Notemigonus crysoleucas	Golden Shiner
Notropis atherinoides	Emerald Shiner
Notropis volucellus	Mimic Shiner
Notropis venustus	Blacktail Shiner
Notropis amoenus	Silverband Shiner
Pimephales vigilax	Bullhead Minnow
Gambusia affinis	Mosquitofish
Amia calva	Bowfin
Percina caprodes	Logperch
Anguilla rostrata	American Eel
Hiodon alosoides	Goldeye
Hiodon tergisus	Mooneye
Moxostoma carinatum	River Redhorse

(continued)

Table 2 Predator to prey ratio by weight for two areas in Dardanelle Reservoir using rotenone sampling data.

DATE	BACKWATER AREA A	DISCHARGE AREA C
1971	-	1:6.4
1972	-	1:3.9
1973	1:8.6	1:8.6
1974	1:6.8	1:8.1
1975	1:11.7	1:10.2
1976	1:11.3	1:9.0
1977	1:9.7	1:9.3
1978	1:8.4	1:11.9
1979	1:11.0	1:15.1
1980	1:5.5	1:12.5
1981	1:8.2	1:9.5
1982	1:6.6	1:11.7

FORM 731-791
REV 11 70

ARKANSAS POWER & LIGHT COMPANY

INTRA COMPANY CORRESPONDENCE

May 6, 1985

CL-85-171

MEMORANDUM

TO: Mr. Paul N. Mears

FROM: Edward L. Green *Edward L. Green /st*

SUBJECT: Arkansas Nuclear One Water Quality - Use Attainability

Attached, you will find an appendix to the October 30, 1984 Summary Report of Environmental Impact of Thermal Discharge submitted to the Arkansas Department of Pollution Control and Ecology, and Environmental Protection Agency by AP&L.

Mr. Larry Champagne, EPA coordinator, in his letter of January 10, 1985, raised a few questions about the data requiring an explanation. In a telephone conversation between Mr. Champagne and Ms. Sharon Tilley, AP&L Technical Analysis, May 3, 1985, Mr. Champagne was satisfied with the verbal explanation to his questions, and is looking forward to the written reply. He was also most complimentary of AP&L's report and data summaries.

Please forward copies of this appendix to ADPC&E for them to file with EPA. If you have any questions, please let me know.

ELG/SRT/tlw

Attachment

cc: Dr. D. L. Swindle
Ms. S. R. Tilley ✓

This appendix to the Summary Report of the Environmental Impact of Thermal Discharge is being submitted to clarify several questions raised by the Environmental Protection Agency in their letter of January 10, 1984, to the Arkansas Department of Pollution Control and Ecology.

The specific questions were as follows:

Item 4. It was unclear how affected and unaffected areas were determined (Dardanelle Reservoir Fishery Survey). A brief explanation of the method of delineation should be included.

Item 5. Table 3, the thermal loading table (Dardanelle Reservoir - Illinois Bayou Embayment Survey), is confusing. How are the data in this table used to determine areas in the lake which are affected and unaffected by the thermal discharge?

In response to Item 4, the location of the sampling stations was briefly discussed in the report under the section heading SAMPLING. The attached Figure 2 shows the location of the four sample stations. Station A is the control station, and is located upstream beyond influence of the thermal discharge. Station C is located in the discharge canal, and Station D is located downstream of the confluence of the thermally-heated discharge water and the main body of the reservoir. Both stations were predicted to be impacted by the thermal plume. Station B is located near the mouth of the intake canal, and is a part of the study to determine impingement and entrainment impacts. It was also predicted in the early days of study design that the thermal plume might spread around Bunker Hill, and loop back to the intake area. This phenomenon has not been observed to occur.

Therefore, affected areas for the fishery study were determined to be Stations B, C, and D, and the unaffected area would be Station A.

In response to Item 5, the affected and unaffected areas of the reservoir survey as it relates to physicochemical parameters were determined by thermal impact studies performed before plant operation, and were characterized by river flow at various times of the year. It was predicted that the discharge canal, Stations 1 and 5, would receive the most significant thermal impact. At the confluence of the discharge and the Arkansas River, it was predicted that the plume would extend out to Stations 3, 10, and 11, and, at times, might extend around Goose Island, Station 7 (Figure 1). Actual data supports most of the predicted areas of impact.

The heated effluent is fairly evenly mixed in the water column at Station 1. The maximum temperature difference between the intake water and that discharged in 1982 was 15°F in January. Actual data indicates that the thermally-heated water rapidly rises to the top few feet by the time it reaches Station 5 near the mouth of the discharge bay. When mixed with the Arkansas River, there is rapid dissipation of the plume, and it usually becomes undefined by the time it reaches Stations 3, 10, and 11 (Table 1).

To clarify the question concerning Table 3, the thermal loading table, proportions were calculated by dividing the station of interest by the intake temperature, Station 16. The proportion could also be expressed as a percent. For example, in January, Station 1, the immediate area of discharge

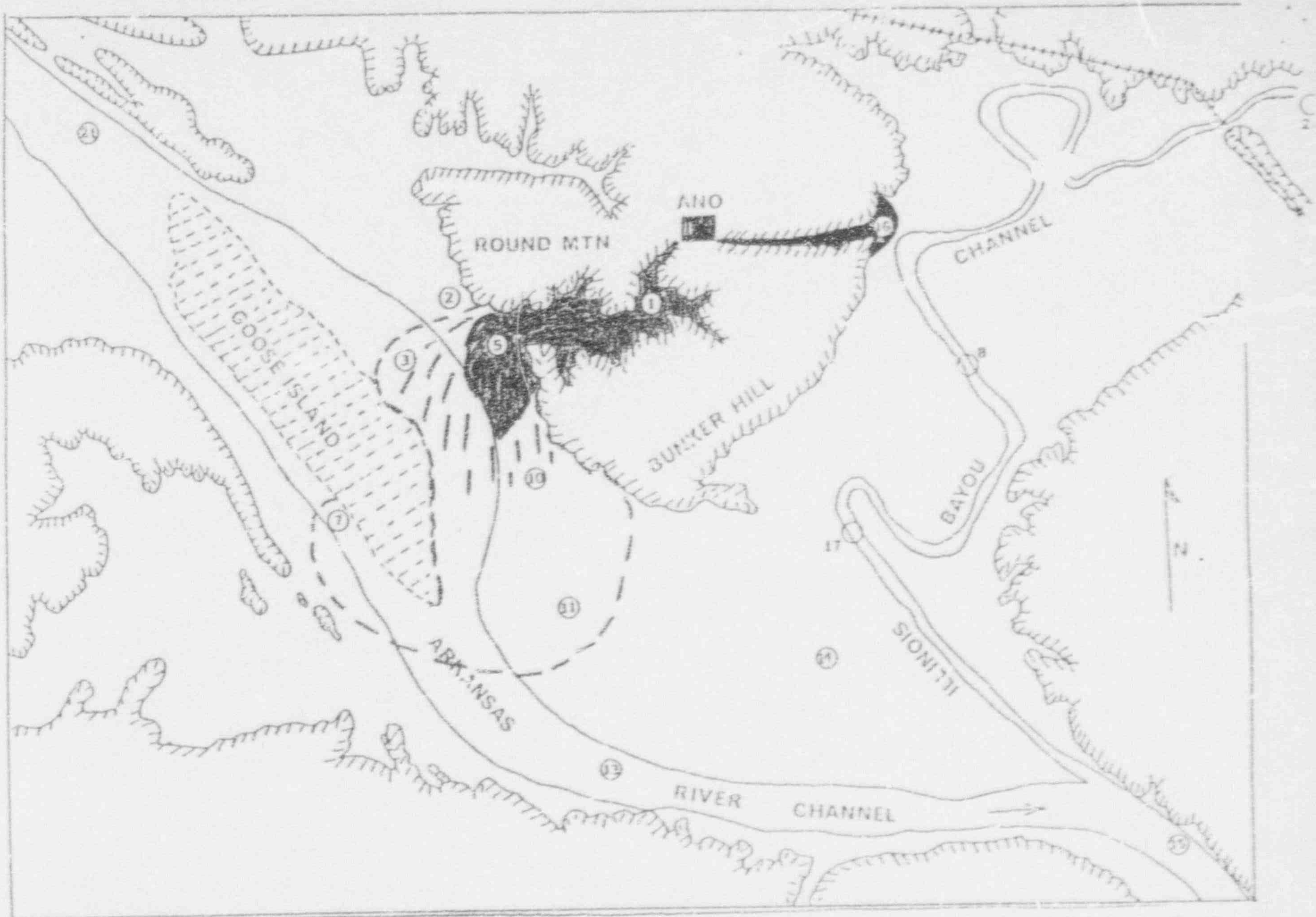


Figure 1. Locations of sampling stations on Lake Dardanelle for Arkansas Nuclear One (ANO) project, 1982.

TABLE 1. THERMAL LOADING AND DISPERSAL IN THE UPPER TWO FEET (0.61 m) AT THE SAMPLE STATIONS IN DARDANELLE RESERVOIR, ARKANSAS, 1982.

TEMPERATURE AT EACH STATION, AND THE PROPORTION OF THE TEMPERATURE COMPARED TO STATION 16 (INTAKE)

		INTAKE	AFFECTED AREAS						UNAFFECTED AREAS						
		STATION 16	STATION 1	STATION 5	STATION 3	STATION 10	STATION 11	STATION 7	STATION 8	STATION 13	STATION 14	STATION 15	STATION 17	STATION 20	STATION 21
JANUARY	TEMPERATURE	39.3	54.3	53.2	41.0	41.1	40.9	40.8	-	-	40.8	40.3	40.6	-	40.9
	PROPORTION		1.38	1.35	1.04	1.05	1.04	1.04	-	-	1.04	1.03	1.03	-	1.04
FEBRUARY*	TEMPERATURE	49.0	58.8	57.4	52.5	50.8	48.2	47.1	49.9	48.2	49.7	49.5	49.6	50.9	47.2
	PROPORTION		1.20	1.17	1.07	1.04	.98	.96	1.02	.99	1.01	1.01	1.01	1.04	.96
MARCH	TEMPERATURE	58.6	69.9	68.1	65.2	63.6	62.8	61.7	58.0	61.7	59.5	60.4	58.9	58.2	60.5
	PROPORTION		1.19	1.16	1.11	1.09	1.07	1.05	.99	1.05	1.02	1.03	1.01	.99	1.04
APRIL	TEMPERATURE	56.4	57.3	58.4	55.9	57.2	57.1	56.3	57.0	55.7	55.9	55.9	56.1	55.9	55.0
	PROPORTION		1.02	1.04	.99	1.01	1.01	1.00	1.01	.99	.99	.99	.99	.99	.98
MAY	TEMPERATURE	76.8	82.9	83.0	75.5	79.8	75.1	76.1	74.9	73.4	75.1	[illegible]	75.9	79.6	76.0
	PROPORTION		1.08	1.08	.98	1.04	.98	.99	.98	.96	.98	.99	.99	1.04	.99
JUNE	TEMPERATURE	81.1	92.2	90.7	78.8	82.6	79.1	80.4	82.0	79.0	81.1	80.2	80.9	83.8	80.4
	PROPORTION		1.14	1.12	.97	1.02	.98	.99	1.01	.97	1.00	.99	1.00	1.03	.99
JULY	TEMPERATURE	91.6	103.4	100.6	95.1	91.0	90.8	92.1	91.7	89.4	91.2	90.6	89.9	91.4	87.7
	PROPORTION		1.13	1.10	1.04	.99	.99	1.01	1.00	.98	.99	.99	.98	1.00	.96
AUGUST	TEMPERATURE	82.9	84.1	83.9	85.6	85.6	83.7	85.6	86.1	86.1	85.9	84.1	87.4	84.7	83.8
	PROPORTION		1.01	1.01	1.03	1.03	1.01	1.03	1.04	1.04	1.04	1.01	1.05	1.02	1.01
SEPTEMBER	TEMPERATURE	84.6	94.7	89.4	86.7	83.0	82.6	82.8	81.3	82.4	81.9	81.8	82.0	82.5	84.7
	PROPORTION		1.12	1.06	1.02	.98	.98	.98	.96	.97	.97	.97	.97	.98	1.00
OCTOBER	TEMPERATURE	70.5	81.5	80.0	72.7	71.0	69.5	69.6	71.1	72.1	71.3	71.2	70.6	69.8	70.0
	PROPORTION		1.16	1.13	1.03	1.01	.95	.99	1.01	1.02	1.01	1.01	1.00	.99	.99
NOVEMBER	TEMPERATURE	56.8	57.4	57.0	58.2	57.2	57.4	57.3	56.5	57.0	57.0	57.0	56.7	56.1	59.0
	PROPORTION		1.01	1.00	1.02	1.01	1.01	1.01	[illegible]	1.00	1.00	1.00	1.00	.99	1.04
DECEMBER	TEMPERATURE	48.1	48.4	48.4	47.5	46.4	46.9	46.5	46.5	47.2	47.1	47.4	47.1	46.1	47.8
	PROPORTION		1.01	1.01	.99	.96	.98	.97	.97	.98	.98	.99	.98	.96	.99

* DUE TO BAD WEATHER, FEBRUARY MEASUREMENTS WERE TAKEN THE FIRST OF MARCH

FORM AP731-2510
REV 11 70

ARKANSAS POWER & LIGHT COMPANY

INTRA COMPANY CORRESPONDENCE

Little Rock, Arkansas
June 26, 1985

RECEIVED
JUN 28
ARKANSAS POWER & LIGHT CO
TECHNICAL ANALYSIS SECTION

MEMORANDUM

TO: Mr. Charles L. Steel
Mr. Jack King

FROM: Ray F. Cox

SUBJECT: ANO - Lake Dardanelle Water Quality Standards

In 1984, EPA made major revisions to the Water Quality Standards Regulations. Part of these revisions required all existing exceptions to State Water Quality Standards to be re-justified. In order to use once-through cooling water on Unit 1 at ANO, AP&L obtained a variance to the temperature standards for Lake Dardanelle. To comply with the new regulations AP&L, and anyone else operating under an exception, was required to re-justify the basis for the variance. A failure to retain this variance would have required the construction of a cooling tower at Unit 1.

AP&L and approximately 15 other businesses and municipalities made the necessary filings to retain their variance. As indicated by the attached letter, EPA accepted our justification and approved a continued variance to the temperature standards on Lake Dardanelle. As a point of interest, EPA rejected all other applications for a variance from the state of Arkansas.

Ray F. Cox

RFC:PNM:kjs

Attachment

cc: Mr. Paul N. Means
Ms. Sharon Tilley
Dr. Dale Swindle

6-21-85
#2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VI
INTERFIRST TWO BUILDING, 1201 ELM STREET
DALLAS, TEXAS 75270

June 18,1985

Mr. James R. Shell
Chief, Water Division
Arkansas Department ollution
Control and Ecology
8001 National Drive
Little Rock, Arkansas 72209

Dear Mr. Shell:

We have reviewed the Arkansas Power and Light Company's response to our comments on their use attainability analysis (UAA), transmitted with your letter of May 31, 1985. The concerns stated in our letter of January 10, 1985, have been adequately addressed, thus the UAA is fully approved. The exception to the Arkansas Water Quality Standards in water temperature for Dardanelle Reservoir is now fully justifiable.

Thank you for your cooperation in this matter. If you have any questions, please do not hesitate to contact us.

Sincerely,

Myron O. Knudson
Director, Water Management Division, 6W

TEMPERATURE AND DISSOLVED OXYGEN PROFILES IN LAKE DARDANELLE, 1971-1980

John D. Rickett, Dept. of Biology, University of Arkansas at Little Rock, Little Rock, AR 72204.

A variety of sampling sites were chosen in Lake Dardanelle; some would undoubtedly be affected by the construction and operation of ANO, Unit I (Arkansas Power & Light Co.), other sites would be marginally affected, while still others would probably not be affected. Contrary to what was expected, dissipation of the heated effluent in summer did not require more time or lake area. Since the plant is regulated to a maximum effluent temperature, very high ambient temperatures (e.g. the summer of 1980) forced a partial shut-down. In general the thermal load was confined to the upper two feet (0.61 m) of the lake and dissipated within 7000 ft (approx. 2.1 km) of the point of discharge. Dissolved oxygen content was not greatly influenced by thermal loading. Stations receiving heated effluent commonly had slightly greater D.O. content probably because of an elevated rate of photosynthesis. The lake never truly stratified, but a few deeper areas revealed some stagnation and oxygen depletion. Normal seasonal change accounted for most of the variation in D.O. content.

Name and Address for Correspondence:

Dr. John D. Rickett

Dept. of Biology

University of Arkansas at Little Rock

Little Rock, AR. 72204

PHONE: 501 569-3270

Senior XX or Collegiate ______

Type of Projection Equipment: ______

35 mm Carousel Projector

Time needed for presentation 15
[Not to exceed 15 min]

ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

June 14, 1985

CL-85-245

MEMORANDUM

TO: Mr. Jim LeBlanc, MSS

FROM: Mr. Edward L. Green

SUBJECT: EPA Proposed Ambient Water Quality Criteria for Dissolved Oxygen

This letter is in response to your letter of May 16, 1985, requesting comments on the EPA proposed ambient water quality criteria for dissolved oxygen. A general review of the proposed criteria does not indicate a significant impact on the operation of AP&L's power plants. We operate under the non-salmonid water criteria and the 5 mg/l dissolved oxygen criteria has not changed.

The State of Arkansas standard specifies not less than 5 mg/l dissolved oxygen except where lower values occur as a result of natural factors. Our data from Dardanelle Reservoir on the Arkansas River indicates that dissolved oxygen frequently goes below 5 mg/l under natural conditions as well as going below the EPA proposed 3 mg/l acute mortality limit under extreme climatic conditions such as occurred in 1979 and 1980. There was no evidence of significant impact on the fishery during these extreme conditions.

Our data collection at Arkansas Nuclear One (ANO) on Dardanelle Reservoir during the 1970's and earl, 1980's was quite extensive due to the non-radiological environmental monitoring requirements of the Nuclear Regulatory Commission. The sampling included all life-stages fishery monitoring, physico-chemical, zoo/phytoplankton, and benthic monitoring.

You will find attached some figures, graphs and table giving the location of sample stations for the different studies and the dissolved oxygen measurements over a period of years.

Figure 1 is a map of the location of the physico-chemical sample stations located in Dardanelle Reservoir in the vicinity of ANO. As indicated by the dashed lines, stations 1, 3, 5, 7, 10, and 11 are areas of predicted

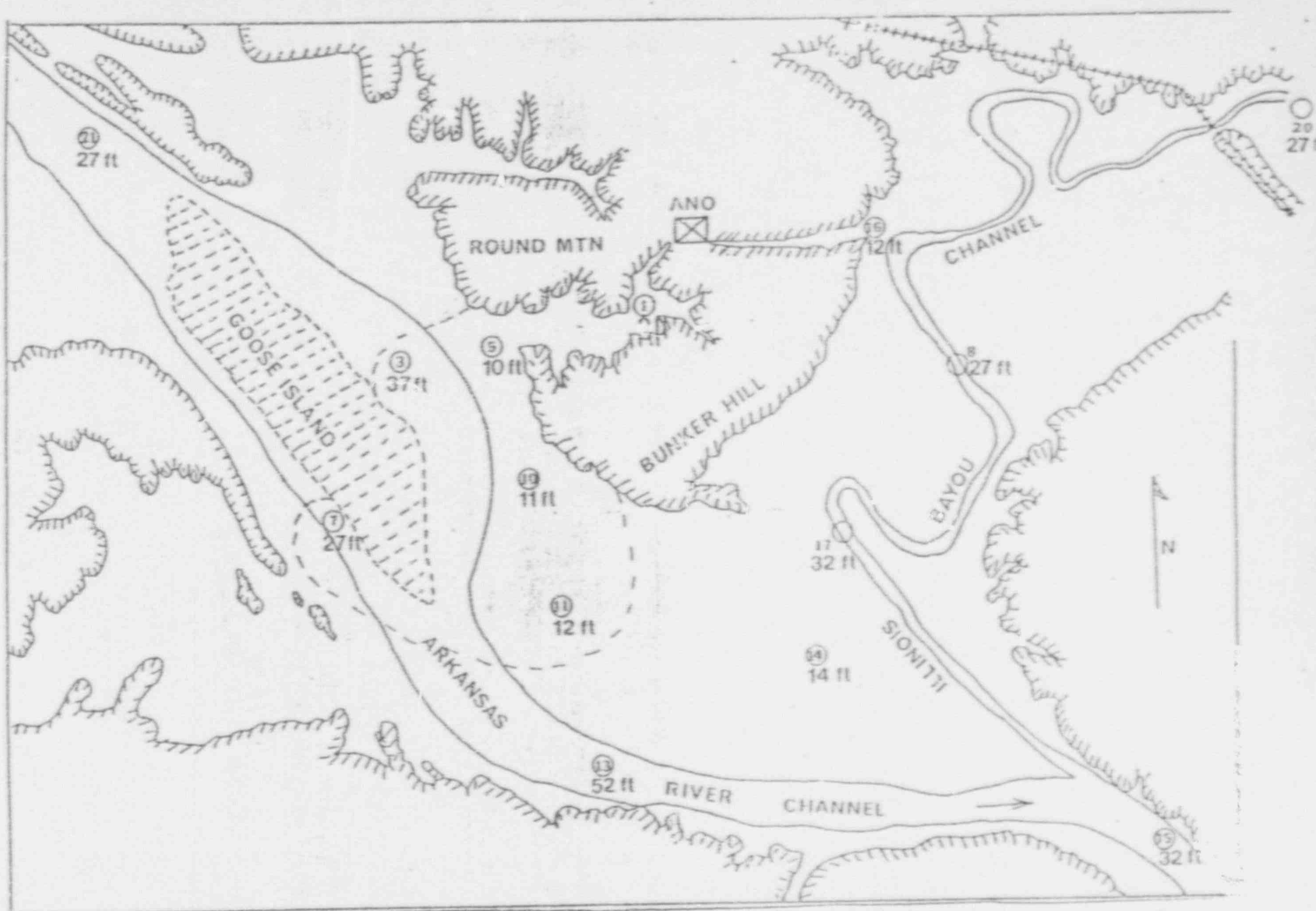
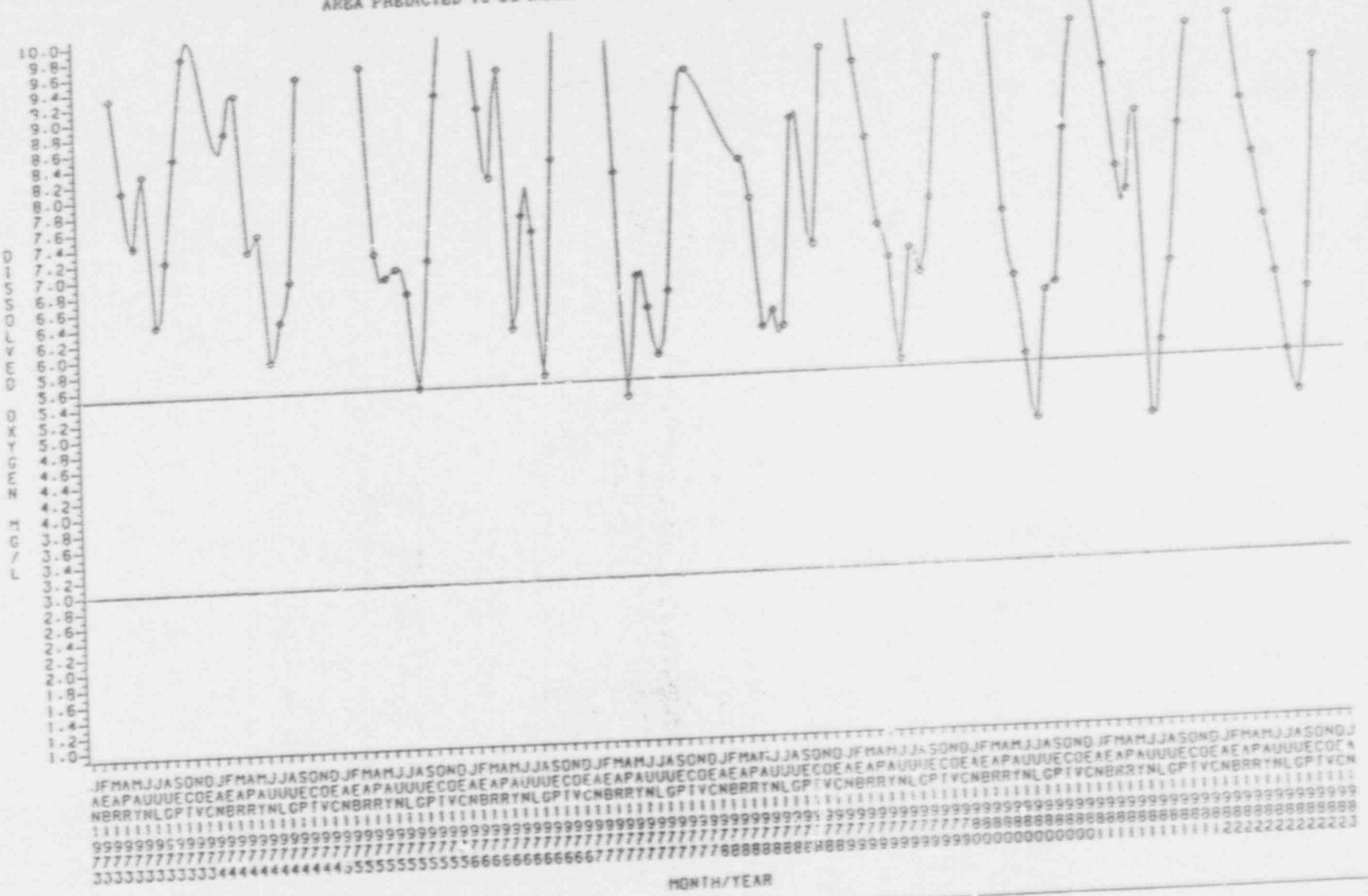


Figure 1. Locations of sampling stations on Lake Dardanelle for Arkansas Nuclear One (ANO) project.

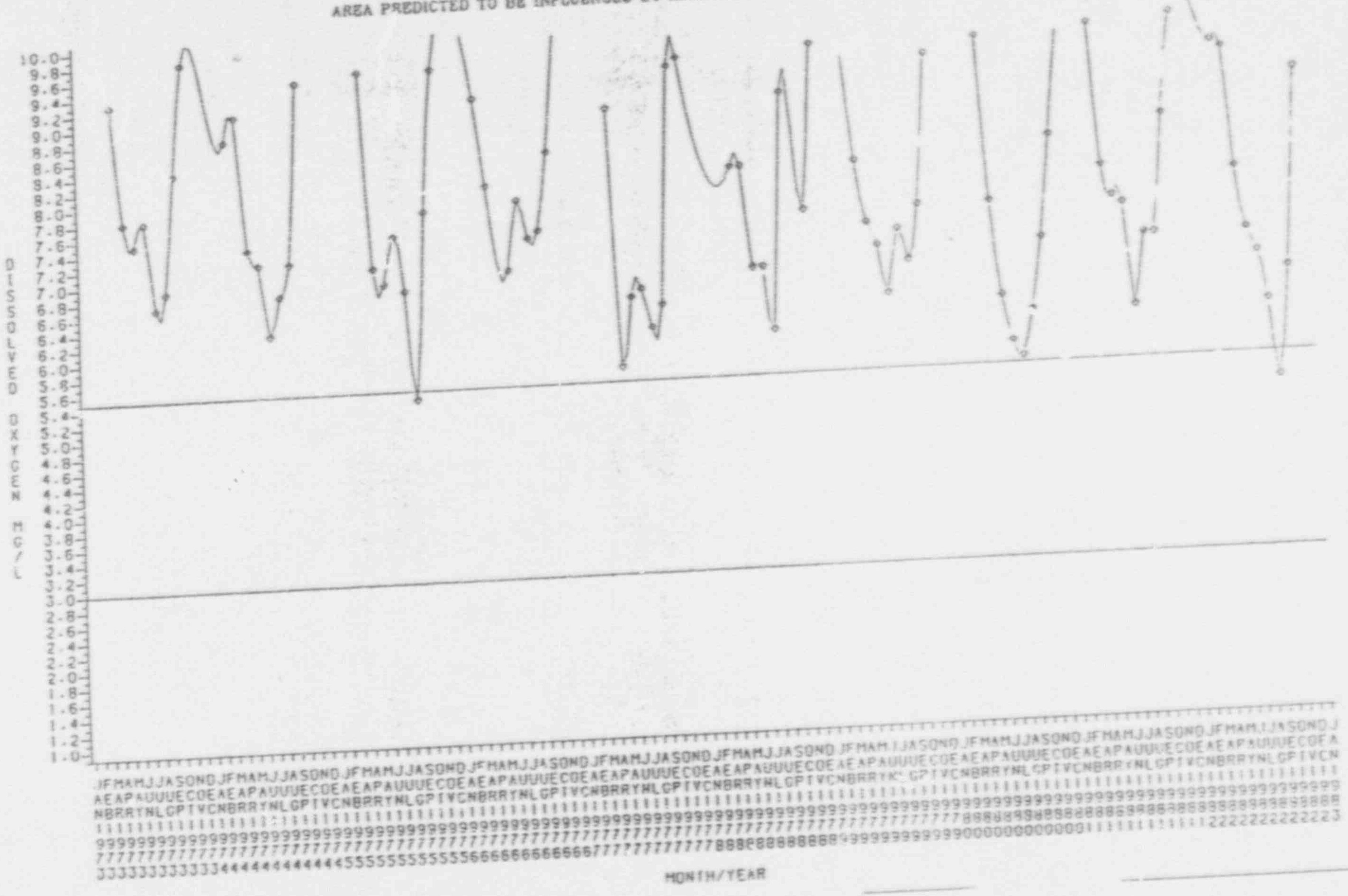
Graph 2

DISSOLVED OXYGEN AT STATION 3, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1983
AFFECTED AREA
AREA PREDICTED TO BE INFLUENCED BY ARKANSAS NUCLEAR ONE THERMAL DISCHARGE



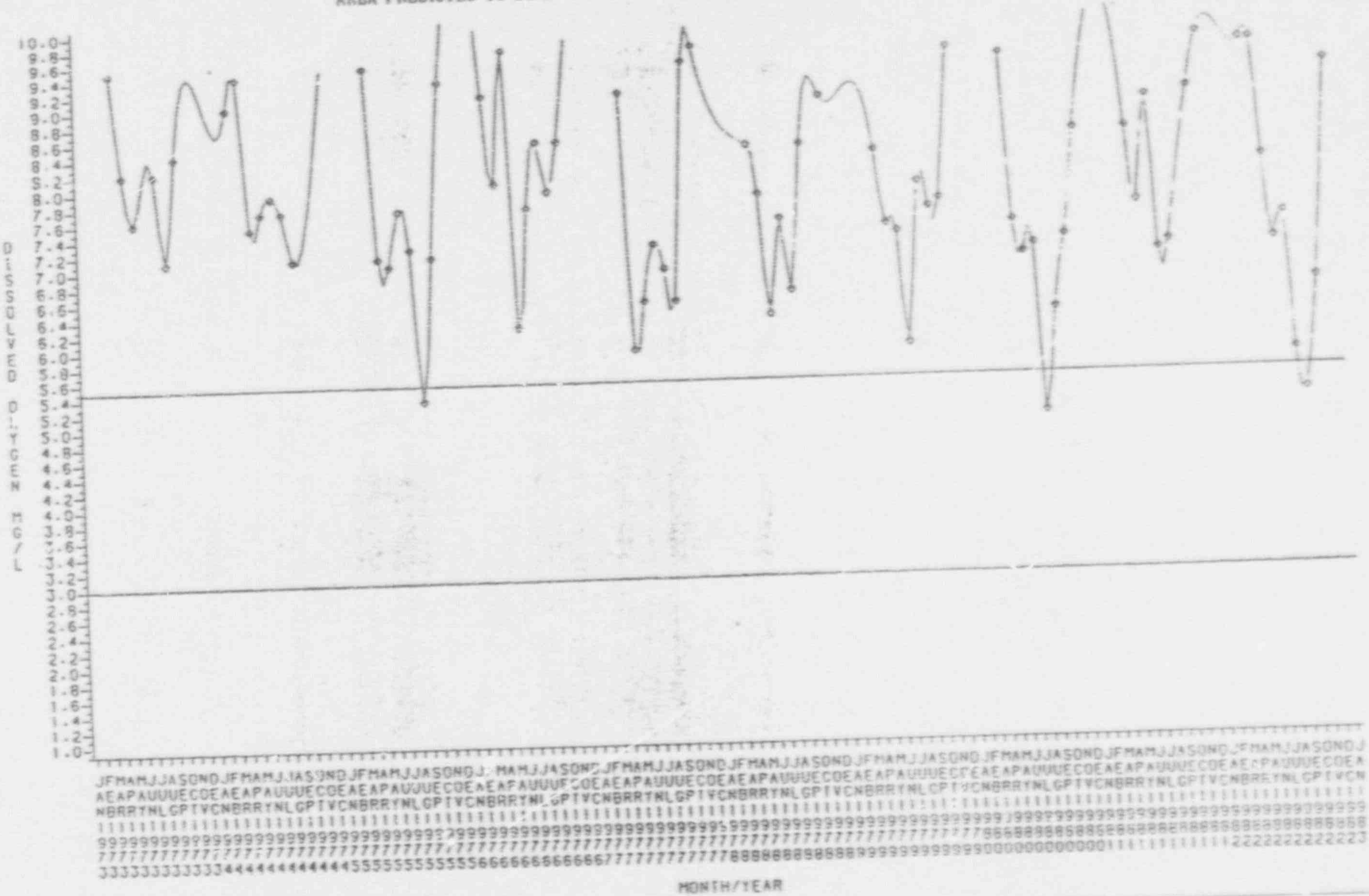
Graph 4

DISSOLVED OXYGEN AT STATION 7, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1982
AFFECTED AREA
AREA PREDICTED TO BE INFLUENCED BY ARKANSAS NUCLEAR ONE DISCHARGE CANAL



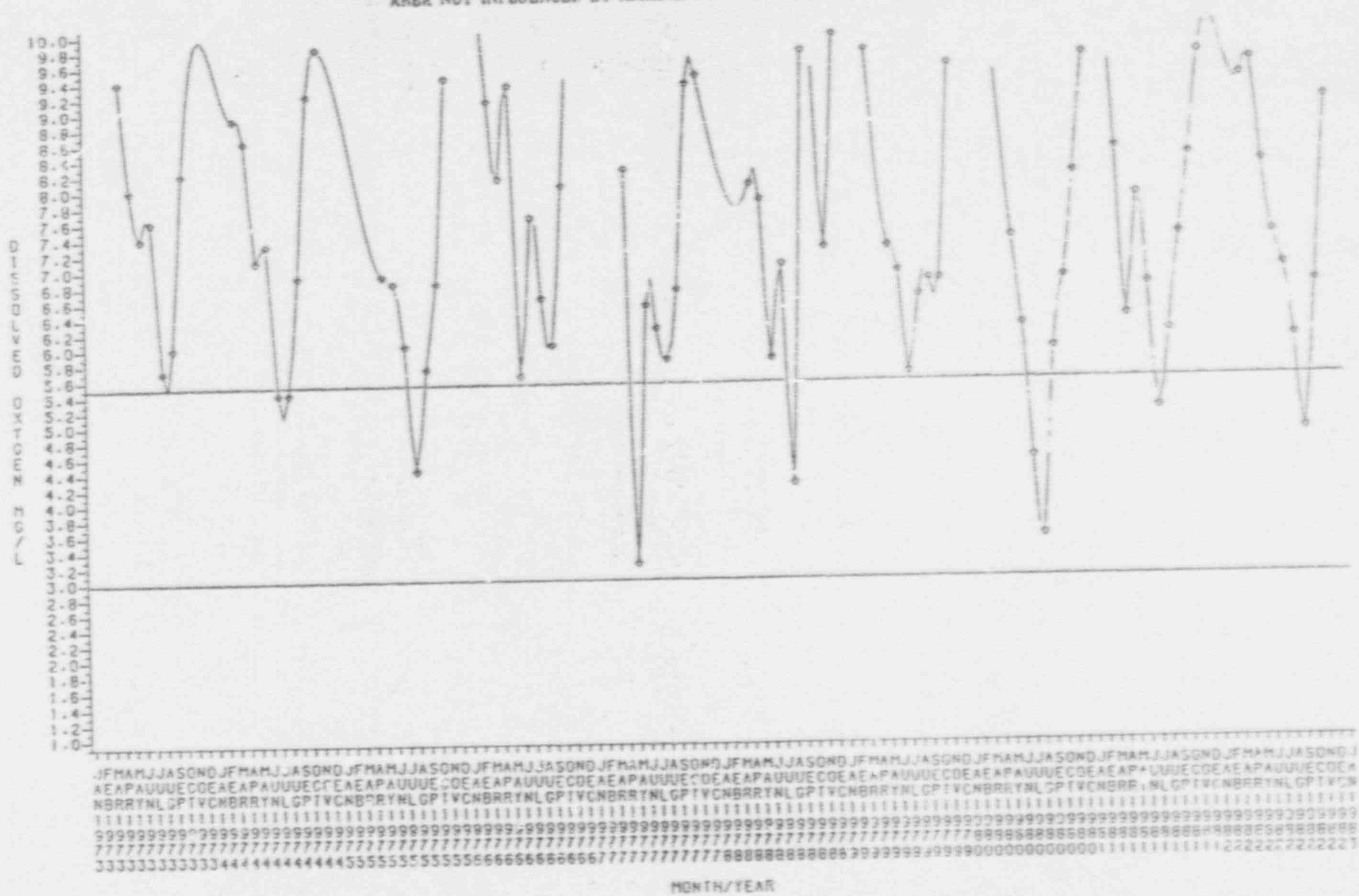
Graph 6

DISSOLVED OXYGEN AT STATION 11, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1982
AFFECTED AREA
AREA PREDICTED TO BE INFLUENCED BY ARKANSAS NUCLEAR ONE DISCHARGE CANAL



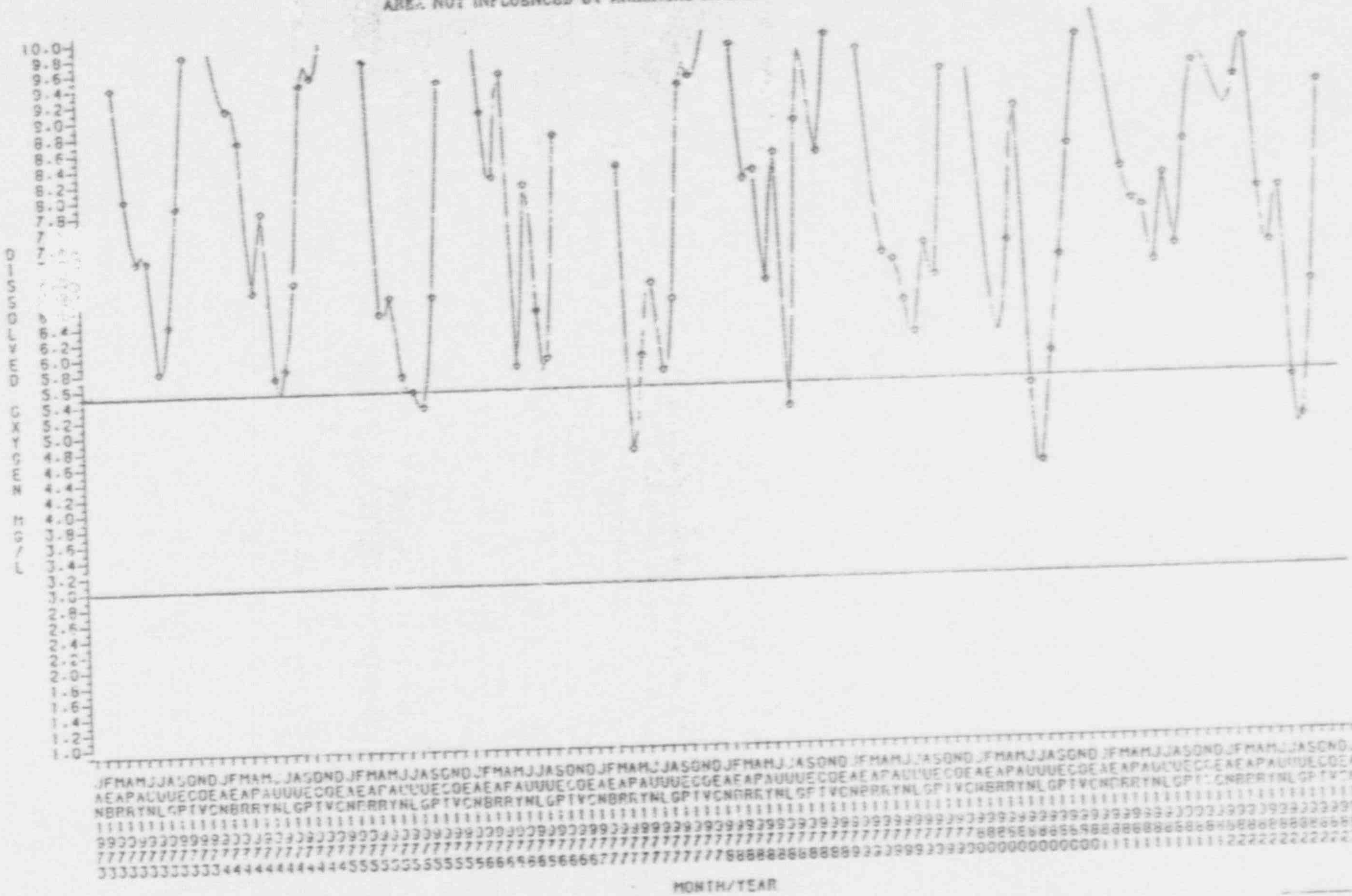
Graph 8

DISSOLVED OXYGEN AT STATION 13, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1982
UNAFFECTED AREA
AREA NOT INFLUENCED BY ARKANSAS NUCLEAR ONE THERMAL DISCHARGE



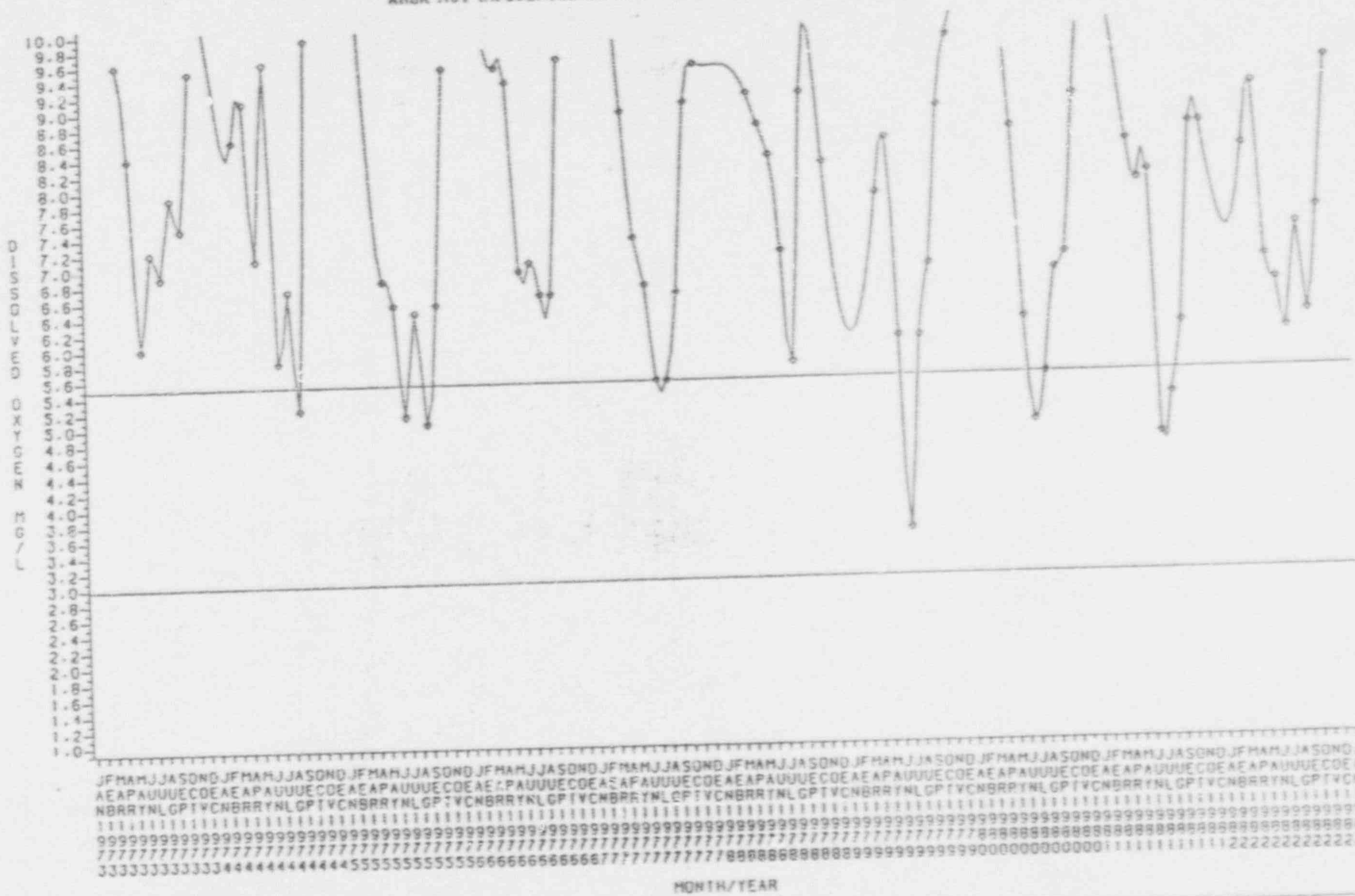
Graph 10

DISSOLVED OXYGEN AT STATION 15, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1982
UNAFFECTED AREA
AREA NOT INFLUENCED BY ARKANSAS NUCLEAR ONE THERMAL DISCHARGE

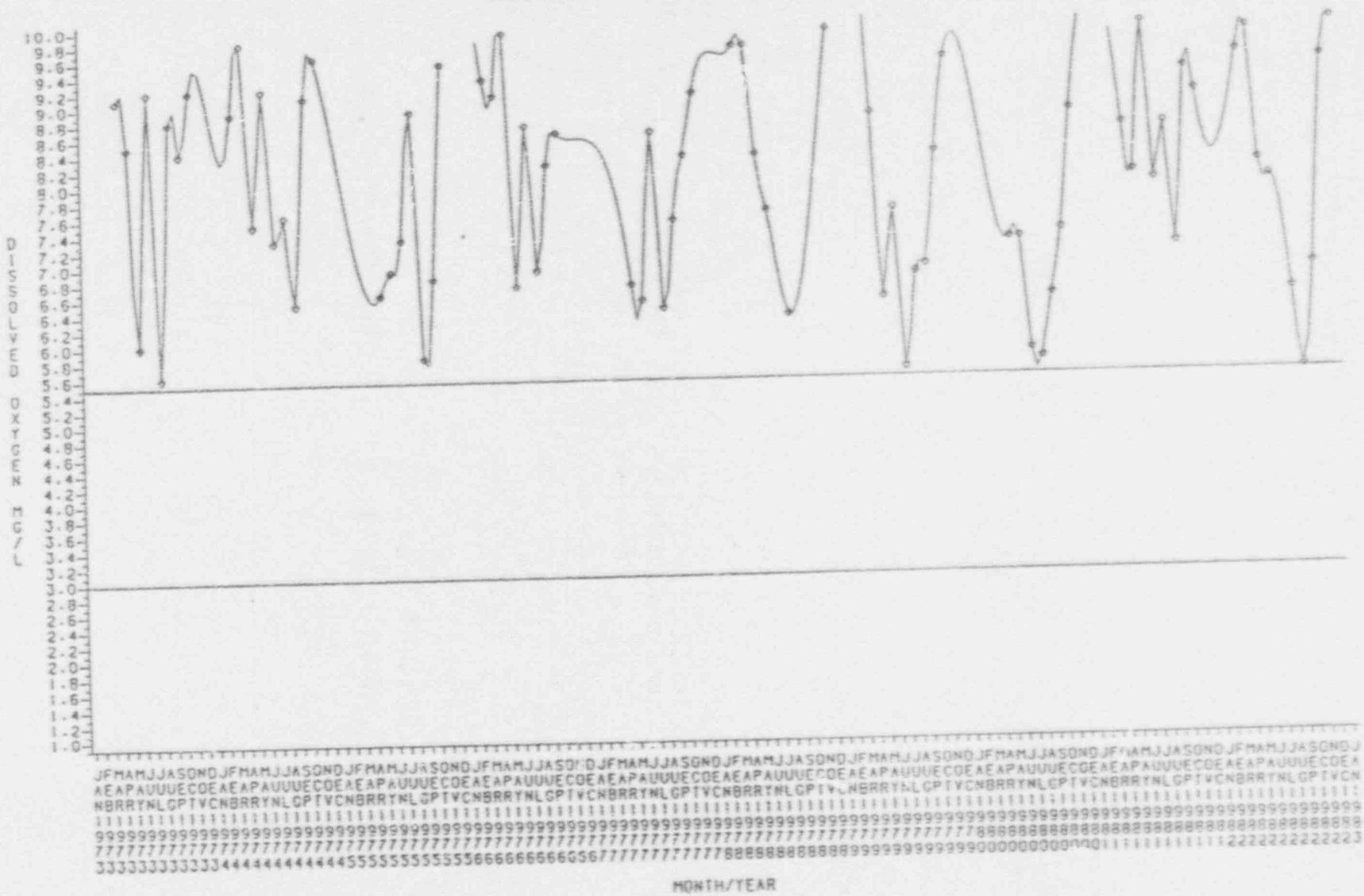


Graph 12

DISSOLVED OXYGEN AT STATION 20, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1982
UNAFFECTED AREA
AREA NOT INFLUENCED BY ARKANSAS NUCLEAR ONE THERMAL DISCHARGE



DISSOLVED OXYGEN AT STATION 16, DARDANELLE RESERVOIR
JANUARY 1973 THROUGH DECEMBER 1982
UNAFFECTED AREA
AREA OF ARKANSAS NUCLEAR ONE INTAKE CANAL



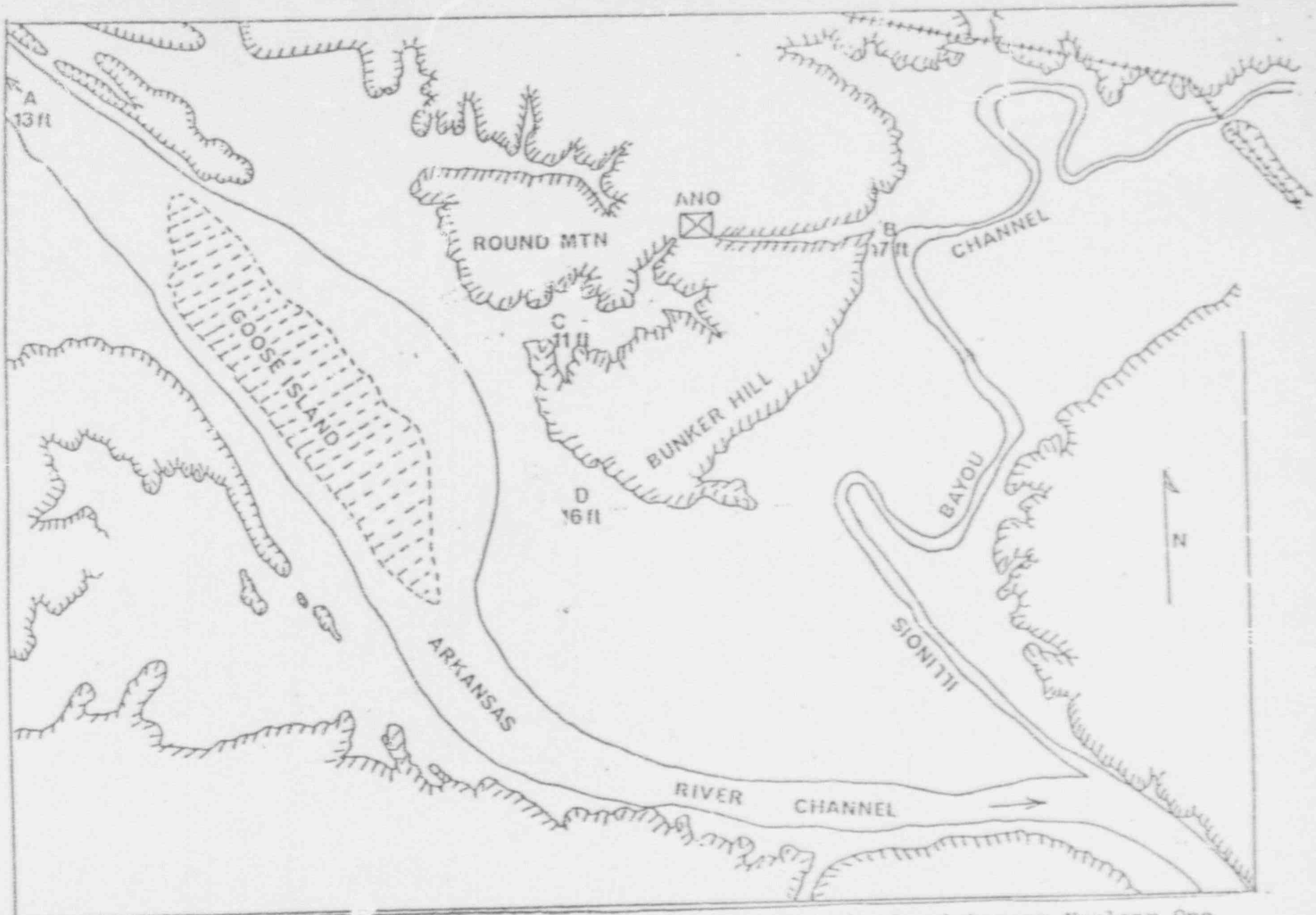
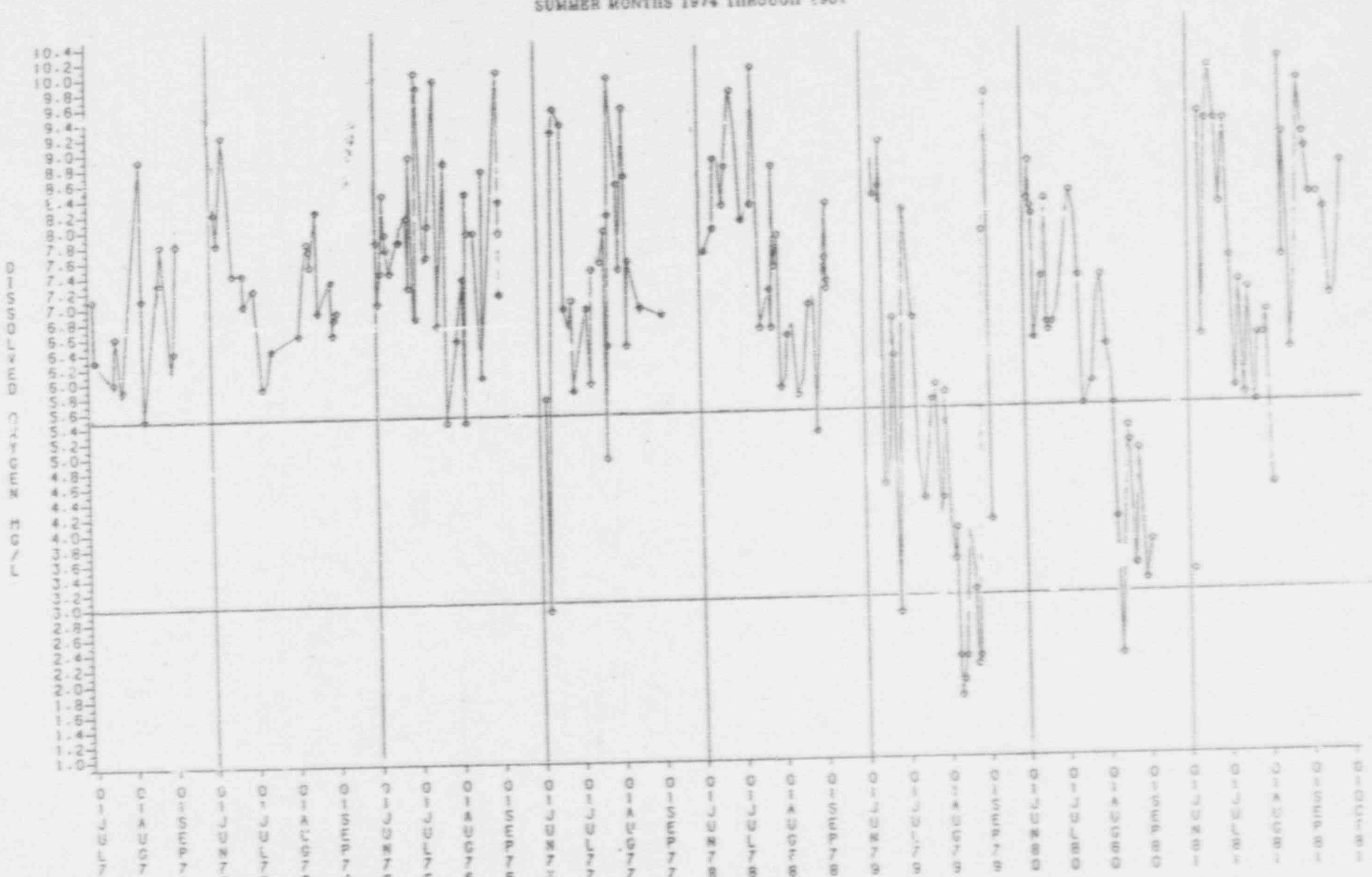


Figure 2. Locations of sampling stations on Lake Dardanelle for Arkansas Nuclear One (ANO) project.

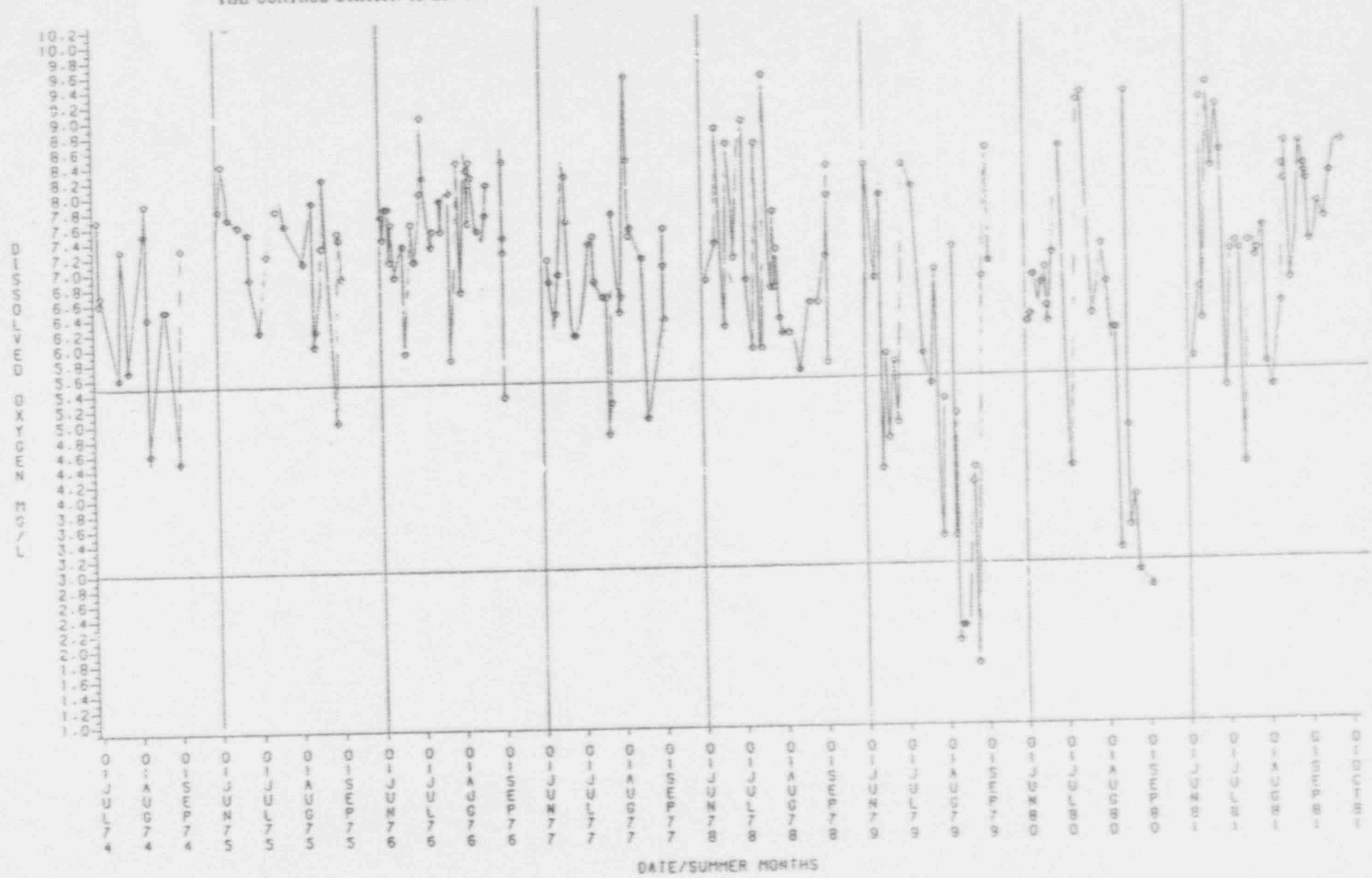
Graph 16

DISSOLVED OXYGEN AT THE INTAKE AREA OF ARKANSAS NUCLEAR ONE
SUMMER MONTHS 1974 THROUGH 1981



Graph 18

DISSOLVED OXYGEN AT THE UPRIVER CONTROL STATION, DARDANELLE RESERVOIR
SUMMER MONTHS 1974 THROUGH 1981
THE CONTROL STATION IS LOCATED UPRIVER OUTSIDE OF THE AREA OF ARKANSAS NUCLEAR ONE THERMAL DISCHARGE



FORM 731-291
REV 11-70

ARKANSAS POWER & LIGHT COMPANY

INTRA COMPANY CORRESPONDENCE

August 27, 1984

CL-84-372

MEMORANDUM

TO: Mr. Edward L. Green

FROM: Sharon R. Tilley *Sharon Tilley*

SUBJECT: Water Temperatures in Dardanelle Reservoir at Selected Stations as Recorded by the University of Arkansas at Little Rock (UALR) for 1980 Through 1983

As you requested, I have reviewed the temperature data in Dardanelle Reservoir for the years 1980 through 1983.

Average water temperatures (F°) were recorded for Station 5 located at the mouth of the discharge bay; Stations 3, 7, 10, and 11 located in the vicinity of the discharge confluence and considered areas of potential mixing; Station 16 located near the intake canal; and Station 21 located upriver from the discharge confluence, and represents near-characteristic ambient water temperature (see Attachment A and Attachment B).

across all of these stations???

The highest average water temperature for the four-year period was 89.1°. The ambient water temperature at Station 21 in July, 1980, was 92.6° and was the highest recorded for the four-year period. It should be noted that the sampling is performed once a month and temperatures greater than 90° could have occurred during any of the years reviewed.

10/10 not — what does this mean. Many rows have averages > 89.1; no column has an average this high. (See last page)

All stations in the mixing zone (Stations 3, 7, 10, and 11) were less than 3° above ambient during the four years, with the exception of the following:

Station 10	5.3°	February, 1980
Station 10	4.7°	April, 1980
Station 11	4.6°	May, 1981
Station 10	3.1°	August, 1981

As discussed with you earlier, the affect of temperature on the condition of fish depends on the species of fish and the presence of toxic chemicals and metals. It is, also, an established fact that high water temperatures cause oxygen depletion. However, our monitoring studies, particularly the Arkansas Tech project, have not indicated any adverse affect on fish age and growth, spawning activity, species density, or distribution. These findings were reported in the annual reports to the NRC.

Based on the temperatures in the mixing zone areas (Attachment A) for the summer months, it appears that Arkansas Nuclear One would experience no difficulty with the 90° maximum temperature proposed by the Arkansas Departcent of Pollution Control and Ecology. However, this conclusion is based on once-a-month sampling, and ADPC&E should be made aware that excursions could occur based on the high ambient temperature in 1980. ??

SRT/twr

Attachments (2)

I do not understand - how is this possible?? Ambient temperatures exceed 90° already - or maybe the standard is in terms of an average

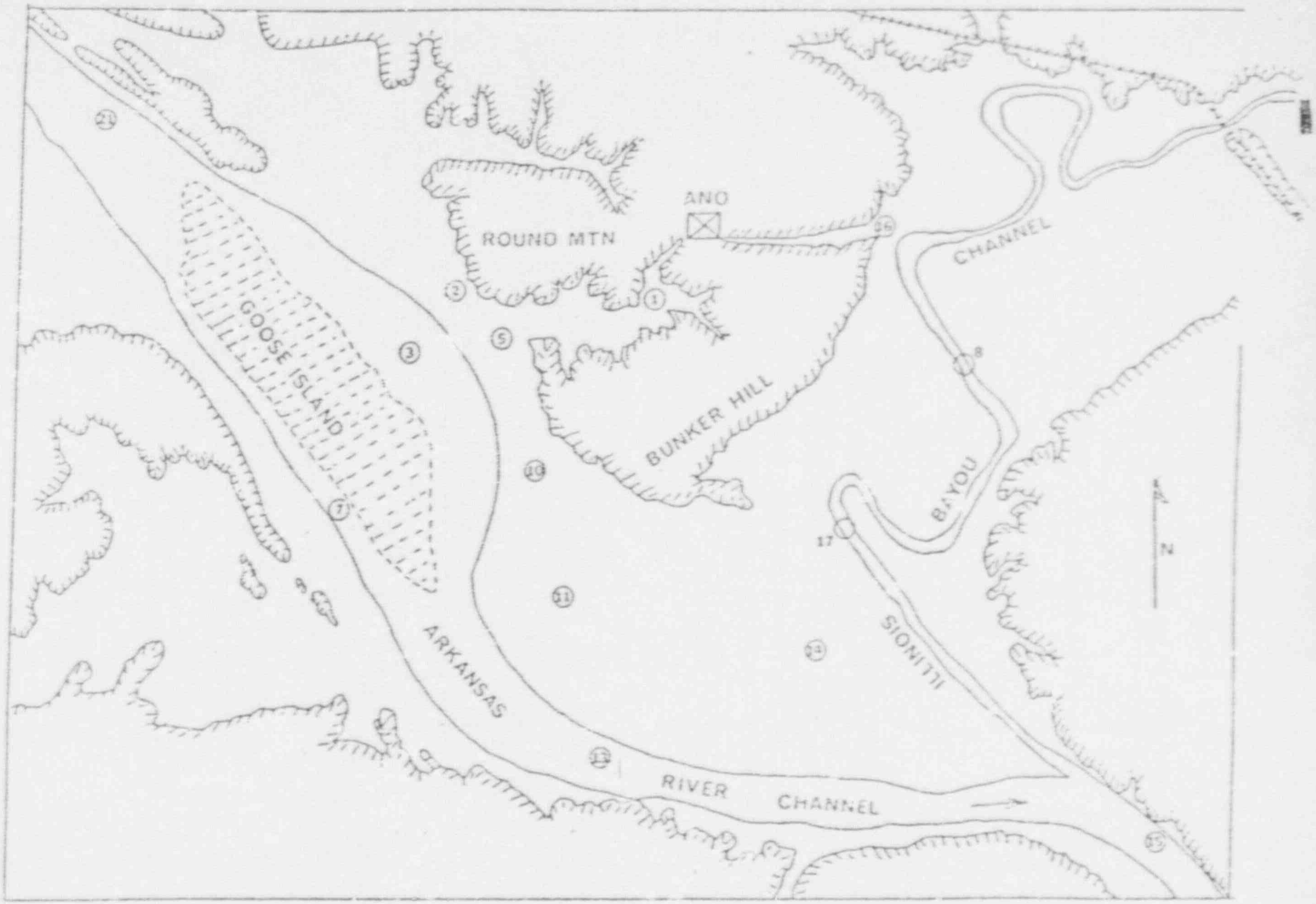


Figure 1. Locations of Sampling Stations on Lake Dardanelle for Arkansas Nuclear One (ANO) Project

Average water temperatures (F°) at stations in Dardanelle Reservoir located in the vicinity of Arkansas Nuclear One. Depths are 1, 2, 5, 7, and every 5 feet thereafter to the bottom. Station 5 is located at the mouth of the discharge; Stations 3, 7, 10, and 11 are located in the reservoir near the discharge bay; and Station 16 is located near the intake canal in the Illinois Bayou area. Station 21 is located upstream of the discharge and should represent near characteristic ambient water temperatures. See map for station locations.

MONTH/YEAR	STATION 5 TEMPERATURE	STATION 3 TEMPERATURE	STATION 7 TEMPERATURE	STATION 10 TEMPERATURE	STATION 11 TEMPERATURE	STATION 16 TEMPERATURE	STATION 21 TEMPERATURE
January - 1980	45.6	44.6	43.0	44.3	43.7	44.5	45.7
February - 1980	46.9	37.7	.	44.6	38.9	37.8	39.3
March - 1980	58.7	50.8	47.9	49.4	48.8	48.1	48.9
April - 1980	66.2	61.1	58.7	62.5	60.1	58.6	57.8
May - 1980	72.4	70.0	70.3	71.3	70.6	70.1	70.6
June - 1980	90.1	82.9	81.2	82.5	82.0	80.6	81.9
July - 1980	93.2	91.1	91.4	91.1	92.0	89.7	92.6
August - 1980	92.5	88.9	87.6	86.5	86.6	85.9	88.9
September - 1980	80.7	80.2	80.3	80.8	80.4	81.2	80.2
October - 1980	74.8	71.2	69.8	70.1	69.1	69.6	69.6
November - 1980	60.7	56.6	55.2	55.4	55.3	53.1	55.8
December - 1980	56.8	52.4	50.4	53.5	51.8	49.8	51.1
January - 1981	44.4	41.7	41.9	42.3	42.2	42.5	41.1
February - 1981	46.3	42.8	43.2	45.3	44.9	45.3	43.9
March - 1981	62.4	57.2	55.9	57.0	55.9	55.2	57.6
April - 1981	75.7	67.0	66.2	66.0	66.1	64.9	68.2
May - 1981	71.3	66.6	66.7	67.9	71.0	67.1	66.4
June - 1981	91.2	84.0	81.7	85.3	83.7	83.9	82.7
July - 1981	91.1	88.2	88.6	90.0	89.4	90.3	88.4
August - 1981	83.8	81.4	82.1	84.3	82.0	82.9	81.2
September - 1981	80.9	77.1	76.9	76.7	78.9	73.3	76.9
October - 1981	68.2	64.7	62.4	62.2	.	64.0	61.9
November - 1981	64.1	59.1	58.2	60.3	58.4	57.3	57.5
December - 1981	51.7	44.0	42.0	43.0	42.9	41.0	41.1
January - 1982	47.2	40.9	39.9	40.9	40.6	39.1	39.1
February - 1982	54.0	48.9	47.5	49.8	48.2	48.6	47.6
March - 1982	65.1	61.8	60.5	62.1	61.6	58.7	60.3
April - 1982	57.3	55.7	55.7	56.5	56.4	56.2	55.1
May - 1982	79.3	73.8	73.6	76.5	74.2	75.8	73.9
June - 1982	86.4	78.0	79.0	80.6	78.7	79.9	79.4
July - 1982	94.0	88.4	88.1	88.2	[illegible]	89.4	85.9
August - 1982	84.[illegible]	85.3	85.3	85.6	83.7	83.4	84.0
September - 1982	86.7	83.5	82.6	82.5	82.2	84.6	84.0
October - 1982	76.3	71.2	69.9	71.1	69.8	70.1	69.7
November - 1982	56.6	56.2	56.1	56.4	56.7	56.3	56.7
December - 1982	47.9	46.6	46.4	46.4	46.6	47.7	46.7
January - 1983	41.2	41.1	41.0	41.1	41.1	41.4	41.3
February - 1983	47.9	46.3	46.2	46.8	46.5	47.8	46.2
March - 1983	55.7	55.5	55.6	55.4	55.2	53.6	55.6
April - 1983	56.2	54.6	54.6	54.9	54.6	56.2	54.9
May - 1983	69.1	66.6	.	66.7	66.5	67.8	.
June - 1983	78.8	76.4	76.3	75.6	75.6	76.5	76.8
July - 1983	84.0	83.6	84.2	83.8	83.8	84.2	83.2
August - 1983	94.0	90.1	89.0	88.8	88.8	87.8	89.5
September - 1983	88.9	84.5	83.7	84.4	85.0	80.2	84.7
October - 1983	75.0	72.2	71.5	69.8	69.6	71.3	71.0
November - 1983	62.8	57.4	55.6	56.7	55.9	56.7	56.3
December - 1983	.	.	.	.	.	.	.

FISH POPULATION HISTORY
for
Dardanelle

Date	09/31/1985	09/09/1986	09/08/1987	09/12/1988	09/11/1989
Location	Effluent Bay	Effluent Bay	Effluent Bay	Effluent Bay	Effleuent Bay
Samp_Num	7324	7327	7332	7336	7340
COMMON NAME	KGS PER HA				
Largemouth Bass	9.679	9.796	9.992	14.154	7.475
White Bass	1.595	4.297	0.313	7.217	1.001
Striped Bass	0.050	0.241	0.064	0.181	0.042
Blue Catfish	0.462	1.399	14.147	11.276	0.236
Channel Catfish	21.159	28.490	25.537	44.516	43.605
Flathead Catfish	0.415	1.066	2.468	1.850	3.352
White Crappie	1.461	0.673	0.125	0.853	0.072
Black Crappie	0.865	0.037	0.117	0.222	0.000
Spotted Gar	0.000	0.132	0.000	0.000	0.214
Longnose Gar	3.262	0.182	0.275	0.000	0.448
Shortnose Gar	0.000	0.000	0.000	0.593	0.050
Freshwater Drum	28.437	35.051	45.038	40.457	34.356
Skipjack Herring	0.393	2.212	0.068	1.649	0.150
Sauger	0.017	0.015	0.000	0.000	0.099
Green Sunfish	0.350	0.763	0.976	1.728	1.356
Warmouth	1.580	0.639	0.968	1.982	1.813
Orangespotted Sunfish	0.085	0.099	0.100	0.000	0.000
Bluegill	12.736	14.670	34.671	37.646	18.061
Longear Sunfish	8.071	5.581	17.439	23.436	10.488
Redear Sunfish	0.000	0.000	0.023	0.000	0.000
Black Bullhead	0.000	0.000	0.000	0.000	0.096
Yellow Bullhead	0.000	0.335	0.012	0.273	0.159
Fathead Minnow	0.000	0.000	0.007	0.026	0.000
Bluntnose Minnow	0.000	0.000	0.000	0.000	0.279
Bullhead Minnow	0.000	0.000	0.126	0.000	0.000
Minnows (Unid)	0.415	0.083	0.000	0.345	0.000
Golden Shiner	0.000	0.000	0.007	0.006	0.012
Emerald Shiner	0.000	0.000	0.013	0.012	0.000
Gizzard Shad	121.247	73.279	75.680	226.307	276.057
Threadfin Shad	0.135	3.395	87.954	39.547	29.287
Topminnows (Unid)	0.000	0.000	0.000	0.081	0.000
Mosquitofish	0.000	0.000	0.000	0.031	0.000
Inland Silverside	0.000	0.196	0.101	1.938	0.005
Smallmouth Buffalo	76.461	63.586	87.051	101.686	79.165
Bigmouth Buffalo	8.602	1.750	10.077	9.001	12.355
Black Buffalo	6.310	2.093	2.014	1.741	0.000
Common Carp	29.257	29.842	22.185	18.833	20.579
Israeli Carp	0.000	0.000	0.000	0.000	0.642
Spotted Sucker	0.000	0.159	0.000	0.000	0.000
Golden Redhorse	0.004	0.000	0.000	0.000	0.000
River Carpsucker	65.553	52.176	39.809	23.738	28.752
Highfin Carpsucker	0.000	0.000	0.000	0.000	0.101
Grass Carp	0.000	0.000	1.026	2.426	0.000
TOTAL	398,606	332,437	478,383	613,751	570,507

number caught??

Comparative Age, Growth, and Condition of Channel Catfish from Lake Dardanelle, Arkansas

THOMAS M. FREEZE AND BUFORD TATUM

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Vol. 38, Nos. 3–4, September 1977

Comparative Age, Growth, and Condition of Channel Catfish from Lake Dardanelle, Arkansas

THOMAS M. FREEZE[1] AND BUFORD TATUM
Department of Fisheries and Wildlife Management, Arkansas Polytechnic College, Russellville, Arkansas 72801

ABSTRACT
Pectoral spines were collected from 112 channel catfish *Ictalurus punctatus* from Lake Dardanelle, Arkansas, during 1973–1975 for purposes of calculating age and growth of different year classes. A length–weight relationship, determined using the equation log W = −4.3297 + 2.7216 log L, indicated that an average channel catfish from Lake Dardanelle weighs about 165 g when it reaches a harvestable size of 255 mm. Lake Dardanelle channel catfish were characterized by a large first year's growth with greater lengths similar to those from nearby states. Condition factors tended to decrease with increased age.

INTRODUCTION

In order to evaluate the ecological effects of the heated water effluent from Arkansas Power and Light Company's nuclear electric generating plant, Arkansas nuclear One, on Lake Dardanelle, it was necessary to establish baseline data on the aquatic fauna prior to the commercial operation of the plant. A ten-year study was initiated in 1973 by Arkansas Polytechnic College with funding from Arkansas Power and Light Company to accomplish that evaluation. While the populations of many organisms were sampled, this paper deals with the age, growth, and condition of Lake Dardanelle channel catfish.

ACKNOWLEDGMENTS

Acknowledgments are expressed to Mr. Edward L. Green, Project Head; Mr. Larry Rider, District Biologist for the Arkansas Game and Fish Commission; and student assistants: Dennis Calloway, Ron Goddard, Sam Henry, Larry Sanders, and Bruce Shackleford.

DESCRIPTION OF STUDY AREA

Lake Dardanelle (Fig. 1) is an impoundment of the Arkansas River in west-central Arkansas near the town of Russellville. It is a flow-through reservoir created by the U. S. Army Corps of Engineers as a part of the Arkansas River navigation project. The Arkansas River has its headwaters in the Rocky Mountains of Colorado and flows through Kansas, Oklahoma, and Arkansas before emptying into the Mississippi River approximately 150 km southwest of Memphis, Tennessee. The reservoir has a drainage area of 398,090 km², a conservation pool of 13,880 ha, and a shoreline length of 507 km. Completed in 1969, the reservoir is managed primarily for flood control and navigation (McGee 1972).

MATERIALS AND METHODS

A total of 112 channel catfish spines was collected from Lake Dardanelle during 1973–1975 utilizing gill nets, trammel nets, and rotenone. Total lengths of the fish were recorded in inches, and weights were measured either in grams on dietetic scales or in tenths of pounds on suspension dial scales. All English units of measurements were converted to metric units before computation of data.

Left pectoral spines were disarticulated by means of the procedure outlined by Sneed (1951) and placed in numbered scale envelopes. As the spines were free of all tissue except a thin layer of skin, they received no special treatment or preservation in accordance with DeRoth (1965). The spines were sectioned using a small

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[1] Present address: Department of Biological Sciences, Murray State University, Murray, Kentucky 42071.

FIG. 1. Location of Lake Dardanelle, an impoundment of the Arkansas River.

power saw on a stationary platform, similar to the apparatus of Witt (1961). Unreadable sections were ground by hand on a fine carborundum stone to increase their transparency.

The distal end of the basal recess served as a reference point to ensure consistency in the location of each section (Marzolf 1955, Sneed 1951). That reference point resulted in more readable spine sections and permitted comparisons with previous studies utilizing the same method. One disadvantage in its use is that the body–spine relationship is curvilinear instead of linear (DeRoth 1965).

Approximately one-fourth of the sections were stained with alizarin red S for 3–5 sec before being rinsed with distilled water, but the procedure was discontinued as no apparent advantages in aging the sections were observed.

Spine sections were read with a binocular microscope equipped with an ocular micrometer. Measurements were made from the center of the spine lumen to the annuli and to the edge of the expanded posterior radius.

Measurements of the pectoral spine annuli were used to calculate an average rate of growth utilizing the Dahl–Lea direct proportion method (Carlander 1969). This equation may be stated as:

$$L_n = (S_n)L/S$$

where L_n = length at annulus n, S_n = spine radius at annulus n, S = total spine radius, and L = total body length.

The length–weight relationship was determined using the formula:

$$\text{Log } W = \log a + n \log L$$

where W = weight in grams, L = total length in millimeters, and a and n are empirical constants. The value of the constant n usually is above 3.0 for larger species of catfish such as the channel catfish (Carlander 1969).

The coefficients of condition (K) were computed using the formula:

$$K = 10^5 \times W/L^3$$

where W = weight in grams and L = total length in millimeters. The coefficients provided indexes for comparative analyses of plumpness or well-being of the catfish. Such calculations are based on the premise that the body form of a fish varies with the cube of increasing length provided the shape and specific gravity remain the same (Carlander 1969).

RESULTS AND DISCUSSION

The growth of Lake Dardanelle channel catfish, as determined by the Dahl-Lea equation, and the annual lengths for the 1966–1974 year classes are shown in Table 1. The average annual increments decreased gradually from 140 mm the first year to 25 mm the sixth year of life and then gradually increased to 56 mm in the ninth year. The average annual increment for the first year is approximately twice that for any of the following years. While it is normal for channel catfish to attain large percentages of their total lengths during their first 2 years of life, the unusu-

TABLE 1.—CALCULATED TOTAL LENGTHS (MM) OF 112 CHANNEL CATFISH FROM LAKE DARDANELLE, ARKANSAS, 1973–1975

Year class	Number of individuals	Year 1	2	3	4	5	6	7	8	9
1966	5	121	227	292	333	379	406	444	469	533
1967	10	143	229	283	326	374	414	453	482	
1968	13	155	230	277	330	378	427	410		
1969	28	139	207	269	322	385	374			
1970	25	144	215	276	332	348				
1971	14	145	226	289	328					
1972	12	124	195	230						
1973	4	90	163							
1974	1	102								
Average Lengths		140	213	274	328	371	396	432	477	533
Average Annual Increments		140	73	61	54	43	25	36	45	56

ally large first year's growth has resulted in greater lengths of Lake Dardanelle channel catfish than those in several nearby states for their first 4 years of life (Table 2). After the fourth year of life, the growth was approximately equal to or below that of catfish in the other lakes.

All of the studies in Table 2 were conducted on man-made reservoirs. Many of the 16 reservoirs that made up the Oklahoma study are in the same watershed as Lake Dardanelle but are closer to the headwaters of the Arkansas River. Thus, their location relative to the headwaters might result in their being less fertile than Lake Dardanelle. Each of those 16 reservoirs had been impounded more than 4 years and was labeled as old by Finnell and Jenkins (1954), and age was cited by them as the reason for the below average growth of channel catfish as compared to other Oklahoma waters.

The Lake of the Ozarks is farther north than any of the other reservoirs and that may account for the poor growth of channel catfish there. Other environmental factors undiscussed by Marzolf (1951) such as age, turbidity, and extent of reproductive success may also have acted to depress the rate of growth.

Both Norris Lake, in the eastern mountains of Tennessee, and Kentucky Lake, bordering the Jackson Purchase Area of Kentucky, were considerably older than Lake Dardanelle when they were sampled. Those conditions, plus differences in lati-

TABLE 2.—CALCULATED TOTAL LENGTHS (MM) OF CHANNEL CATFISH FROM LAKE DARDANELLE, ARKANSAS, 1973–1975 COMPARED WITH DATA FROM OTHER STUDIES

Location	Number of individuals	Calculated total lengths at end of year 1	2	3	4	5	6	7	8	9
Dardanelle Reservoir	112	140	213	274	328	371	396	432	477	533
16 Oklahoma Reservoirs (Finnell and Jenkins 1954)	3,291	91	178	249	305	363	417	472	531	577
Norris Reservoir, Tenn. (Carroll and Hall 1964)	87	99	175	272	325	373	424	457	541	
Lake of the Ozarks, Mo. (Marzolf 1951)	434	53	109	155	196	234	264	292	330	
Kentucky Lake, Ky. (Matthai 1972)	615	89	188	259	310	356	404	455		

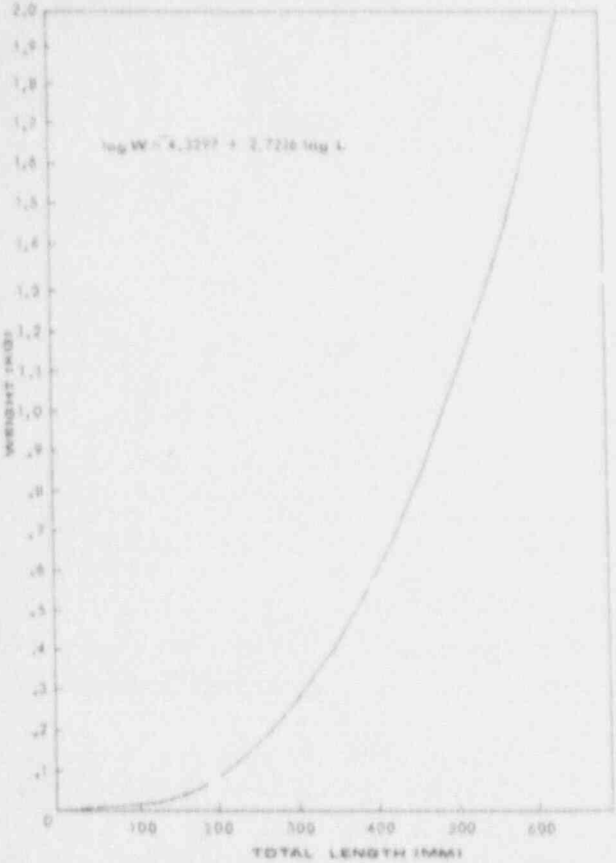

FIG. 2. Length–weight relationship of channel catfish from Lake Dardanelle.

tudes, may account for some of the variations in length attainments. While the channel catfish from Norris Lake came from a balanced population (Finnell and Jenkins 1954), the fish from Kentucky Lake were stunted as evidenced by the retardation in growth reported by Matthai (1972). Also, Lake Dardanelle being a very recently formed body of water, is experiencing what fishery biologists refer to as "peak growing conditions" due to the increased fertility of the water associated with the decay of inundated vegetation.

The length–weight relationship (Fig. 2) was calculated from 112 channel catfish

TABLE 4.—AVERAGE CONDITION FACTORS (K) OF CHANNEL CATFISH IN LAKE DARDANELLE, ARKANSAS, FOR 1973–1975

Age (years)	K
1	1.17
2	1.07
3	0.99
4	0.94
5	0.85
6	0.88
7	0.83
8	0.86
9	0.82

ranging from 102 to 533 mm. This relationship can be expressed by the equation:

$$\text{Log } W = -4.3297 + 2.7216 \log L.$$

Channel catfish from Lake Dardanelle weighed approximately 165 g upon reaching a harvestable size of 255 mm. At 380 mm, they weighed about 500 g and at 510 mm approximately 1,080 g (Table 3).

Average coefficients of condition (K) for fish from Lake Dardanelle (Table 4) tended to decrease with an increase in age except between the fifth and sixth and between the seventh and eighth years of life. It is believed those discrepancies are due to the small sample size of older fish. The slope in the length–weight regression was less than 3.0 indicating that a decrease in condition should occur with an increase in length as observed here, since length is related to age (Carlander 1969).

In comparison, the average coefficient of condition of channel catfish from Norris Lake was erratic, while that of Kentucky Lake decreased with an increase in age until the third year of life and then increased steadily. Average coefficients of condition for channel catfish were not

TABLE 3.—AVERAGE TOTAL LENGTHS (MM) AND WEIGHTS (G) OF CHANNEL CATFISH FROM LAKE DARDANELLE, ARKANSAS, 1973–1975

	Age								
	1	2	3	4	5	6	7	8	9
Average length	102	163	230	328	348	374	410	482	533
Average weight	12	46	121	332	358	460	572	963	1,235
No. of individuals	1	4	12	14	25	28	13	10	5

reported by Finnell and Jenkins (1954) or Marzolf (1951).

In conclusion, the channel catfish population of Lake Dardanelle, prior to commercial operation of Arkansas Nuclear One generating plant, exhibited a large first year's growth, other length attainments comparable to studies from nearby states, and condition factors that tended to decrease with an increase in age. In most aspects, the channel catfish of Lake Dardanelle could be considered normal. However, it should be noted that the lengths of Lake Dardanelle catfish may decrease with the natural aging of the reservoir and the resultant decrease in nutrients over an extended period of time.

More recent data on the aquatic fauna of Lake Dardanelle including the channel catfish are being collected by Mr. Buford Tatum.

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ZOOPLANKTON COMMUNITY STRUCTURE IN DARDANELLE RESERVOIR, ARKANSAS, 1975-1982

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ABSTRACT

Zooplankton was collected at 10 stations in Dardanelle Reservoir from 1975 to 1982. Current data were compared to a five-year preoperational study phase. Rotifer taxa strongly dominated the community. Overall abundance was higher, variety about the same and diversity lower than those of comparable studies. Thermal discharges caused a dominance shift between two rotifer taxa, slightly depressed abundance and variety, did not noticeably affect diversity and elevated the phytoplankton/zooplankton ratio. Heated effluent also stimulated stronger fluctuations in abundance and variety. Other studies indicate that in upper sections of the Arkansas River drainage, microcrustaceans dominate lake habitats whereas rotifers dominate river habitats. In similar northern and eastern habitats, microcrustaceans were generally dominant.

INTRODUCTION

Much of the basic descriptive work in Arkansas with zooplankton was done under the auspices of the Water Resources Research Center (Schmitz, 1974, 1975, 1978). Sinclair and Watson (1978) conducted a five-year survey of the zooplankton community composition in Dardanelle Reservoir prior to the beginning of power generation by Arkansas Nuclear One (ANO) Unit 1. Palko (1970) collected and identified zooplankton from two stations in the upper Illnois Bayou arm of Dardanelle Reservoir during the summer and autumn of 1969. Numerous reports attempting to describe and quantify the impacts of thermal discharges have come from other states (Carlson, 1974; Gehrs, 1974; Anderson and Lenat, 1978; Miller et al., 1976; Edmondson, 1965). Analysis of the structure of zooplankton communities should receive much more research effort than in the past. This report is a general examination of data collected over an eight-year period, 1975-1982, during which ANO Unit 1 was operative. We will attempt to describe basic community structure and relate such to thermal discharges. Main points to be addressed in this report are (1) seasonality or periodicity of community diversity, (2) which taxa are dominant and when, (3) changes in abundance and diversity related to season and location with respect to power plant discharge, and (4) evidence of long-term trends or shifts in community structure.

MATERIALS AND METHODS

Zooplankton samples were collected in January, April, July and October of the years 1975-1982 by straining 10 l. of water through a standard No. 20 Wisconsin-style plankton net. The water column was sampled by taking 2 l. of water each from near the bottom, mid-depth and 0.6 m. plus 4 l. from the surface. Ten stations were sampled quarterly and the samples preserved in Meyer's Fixative. Figure 1 is a line map of the reservoir showing the locations of the sampling stations. Close stations (1,2,3,5,10) were those affected by effluent from the power plant as determined by thermal measurements, however not all five stations were necessarily affected at any one time. For example, a southeast wind tended to move the effluent toward Sta. 2 away from Sta. 10. Distant stations (11,14,15,16,21) were not measurably affected by the discharge.

In the lab a 1 ml. aliquot was transferred to a Sedgwick-Rafter counting cell, and quantitative evaluation was made by counting randomly-spaced strips across the counting cell until approximately 40 percent of the area was examined. Organisms were identified to genus where possible and reported as organisms per liter. Statistical procedures included calculation of the number of taxa (genera), number of individuals, mean number of individuals per taxon and community diversity at the genus level. Diversity was calculated with the Shannon Index, $d = -\Sigma(\frac{n_i}{N})\ell n(\frac{n_i}{N})$, where ni is the number of organisms in

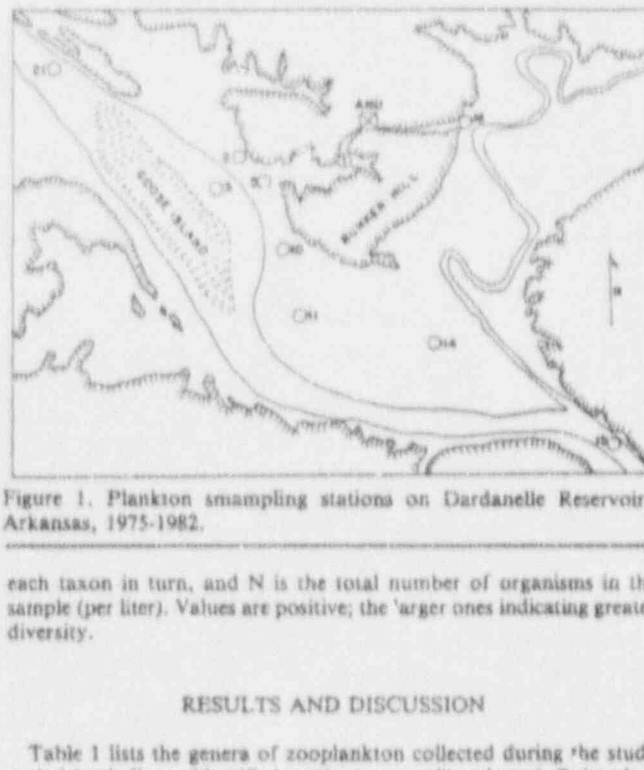

Figure 1. Plankton smampling stations on Dardanelle Reservoir, Arkansas, 1975-1982.

each taxon in turn, and N is the total number of organisms in the sample (per liter). Values are positive; the larger ones indicating greater diversity.

RESULTS AND DISCUSSION

Table 1 lists the genera of zooplankton collected during the study period (excluding unidentified specimens, nauplii and eggs). Quite often the nauplii and/or eggs counted comprised a significant proportion of the sample. Twenty-six genera representing 22 families in three phyla were identified. Rotatoria contained 46.2 percent of the genera and 40.9 percent of the families. Wilhm et al. (1977) collected 27 genera in the Arkansas River near Ponca City, Oklahoma (excluding unidentified taxa). They obtained three genera of Protozoa, seven of Rotatoria and four of microcrustacea not obtained in our study, whereas our study obtained eight genera of Protozoa, three of Rotatoria and two of microcrustacea not obtained in theirs. Palko (1970) reported three genera of Protozoa (all Ciliata), one genus of Cladocera *(Diaphanosoma)* and 11 genera of rotifers not recorded in this study.

Table 2 contains mean numbers of organisms and taxa, number per taxon and diversity values grouped by season. Although there was considerable fluctuation from year to year within a given season, the means show the greatest overall abundance occurred in July and the lowest in October. That close stations had more organisms than distant stations in January and April was probably due to the heated water which elevated metabolism allowing them to take greater advantage of available

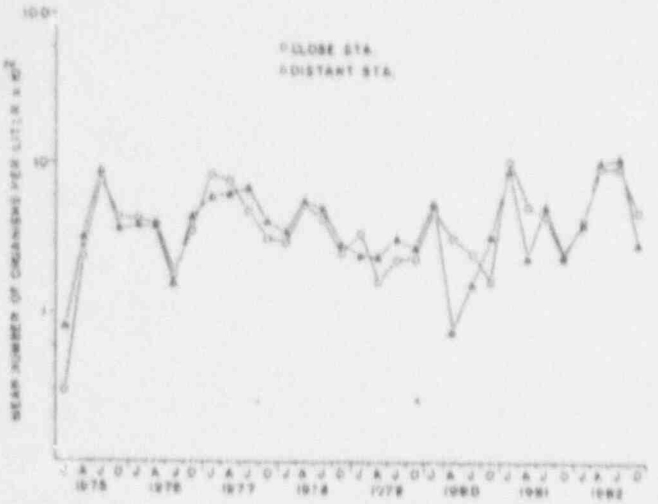

Figure 2. Mean number of zooplankton organisms for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

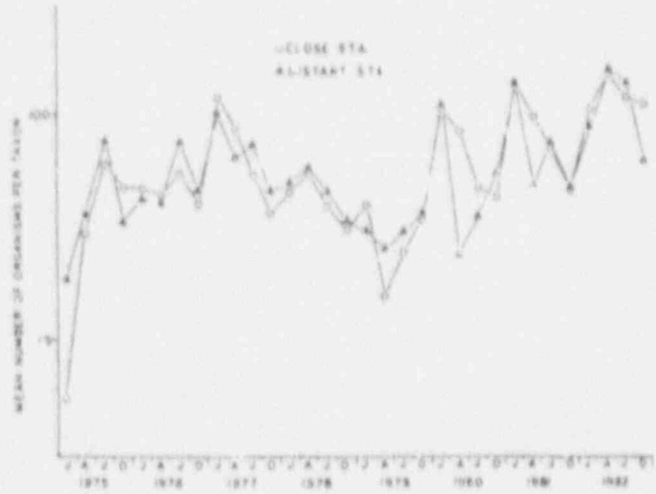

Figure 4. Mean number of zooplankton organisms per taxon for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

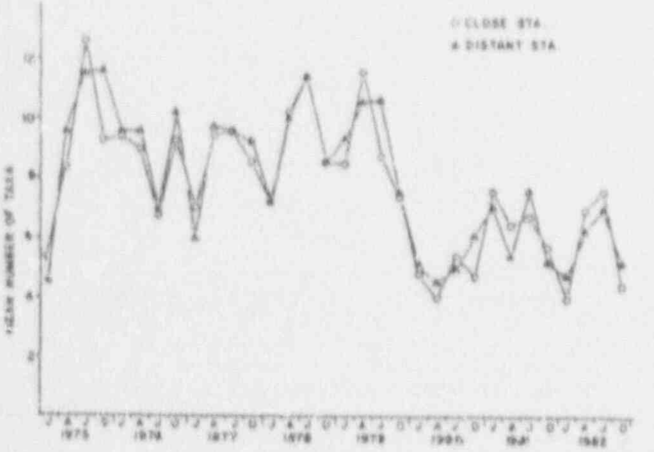

Figure 3. Mean number of zooplankton taxa for close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

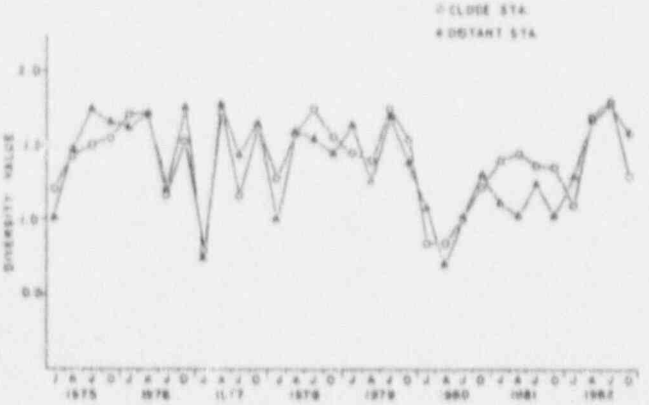

Figure 5. Diversity values of zooplankton fo. close vs. distant stations in chronological sequence in Dardanelle Reservoir, Arkansas, 1975-1982.

dication that the warm water stimulated fluctuations or patchiness of distribution.

Figure 5 shows the chronological sequence of diversity values. Six of eight peaks at close stations occurred in April and July (three each), whereas seven of 11 peaks (three and four, respectively) occurred in these two months at distant stations. Smith et al. (1979) also obtained greater diversity in the summer months. Diversity values apparently vary more in rivers than in riverine reservoirs (Wilhm et al., 1977). Kochsiek et al. (1971) obtained values from 2.45 to 2.61 near the dam in Keystone Reservoir, Oklahoma, and Prather and Prophet (1969) obtained values from 2.39 to 3.02. Dardanelle zooplankton diversity ranged from 0.71 to 1.82.

In the upper Arkansas drainage apparently rotifers dominate river zooplankton but microcrustaceans dominate in lakes (Hynes, 1972; Kochsiek et al., 1971; Yacovino, 1970). In the Arkansas River within Arkansas, rotifers are dominante in lakes as well as the river sections (Williams, 1963). In Dardanelle Reservoir, rotifers were strongly dominant. Considering individual sampling stations quarterly during the study period, *Polyarthra* was dominant 105 times, *Keratella* 70, *Brachionus* 66 and *Asplanchna* 24 (Table 3). *Polyarthra* was strongly dominant in January, *Keratella* was dominant in April, *Brachionus* and *Polyarthra* shared dominance in July, and *Keratella* and *Polyarthra* shared in October. Palko (1970) also gives data indicating that rotifers were strongly dominant in Dardanelle.

That most phytoplankton is directly used as food by most zooplankton is generally agreed. Therefore, the comparative concentrations of

Table 3. Number of times each taxon was dominant, by quarter, in Dardanelle Reservoir, Arkansas, 1975-1982.

	Number of times dominant in:				
Taxon	January	April	July	October	Total
Polyarthra	48	7	28	22	105
Keratella	10	32	1	27	70
Brachionus	7	13	33	13	66
Asplanchna	5	8	2	9	24
Rotifer sp.	0	9	3	3	15
Miscellaneous (includes other rotifer genera)	6	22	15	21	64

moved from third to first). Heated effluent also slightly suppressed overall abundance and variety but had no obvious effect on diversity. Other studies have shown that slight temperature increases stimulated zooplankton, but they dealt with communities in which microcrustaceans were dominant. Similar data on rotifer-dominated communities were unavailable. In Dardanelle Reservoir the P/Z ratios were generally greater at close stations indicating the phytoplankton was stimulated or zooplankton was depressed or both. The phytoplankton data indicated both phenomena occurred.

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FLUCTUATIONS AND RELATIONSHIPS OF SELECTED PHYSICOCHEMICAL PARAMETERS IN DARDANELLE RESERVOIR, ARKANSAS, 1975-1982

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ABSTRACT

Annual and seasonal fluctuations and relationships are described for discharge, turbidity, chloride, total hardness, conductivity and suspended solids over an eight-year period in Dardanelle Reservoir. The parameters fluctuated rather widely primarily in response to seasonal patterns of rainfall. Chloride and conductivity were related and generally fluctuated together as did turbidity and suspended solids. Hardness appeared to vary independently of the others prior to 1979 then varied more closely with chloride after March 1979. Inherent differences between the Illinois Bayou arm and the main Arkansas River sections complicated the precise identification of any overall impact of power plant operation. No significant long term changes were seen, but chloride declined gradually whereas hardness and conductivity increased slightly. Suspended solids exhibited a significant rise in 1982.

INTRODUCTION

Dardanelle Reservoir is located in west-central Arkansas on the main stem of the Arkansas River near the city of Russellville. The reservoir was constructed approximately 20 years ago by the U.S. Army Corps of Engineers as a part of the Kerr-McClellan Arkansas River Navigation System. The lake has a surface area of approximately 13,720 ha, a shoreline of 510 km, a volume of 656 million m³ and a mean depth of 4.3 m (range to 16.5 m). The normal pool level stands at 103.3 m (339 ft) above MSL, and the rate of fall is approximately 0.2 m/km. The mean long term river discharge (Q) at this point is 1103 cubic meters/sec (cms) making the average residence time 6.9 days. However, during this study period the average Q was 773.4 and 770.4 cms if calculated from monthly means and sample day means, respectively (USGS 1975-1982). The watershed of the reservoir proper comprises approximately 40,000 ha and contains a variety of natural and man-made environments including areas of mature hardwood, coniferous and mixed forest, row cropping, cattle farming, orchards, timber removal, light industry and limited urban development.

In the late 1960's Arkansas Power and Light Company began construction on a two-unit nuclear generating facility. In conjunction an environmental monitoring program was begun in 1969. Unit I, which began commercial operation in December 1974, utilizes an 875 megawatt dynamo which uses once-through circulation of lake water for condenser cooling at a rate exceeding 48 cms. The primary goal of this project was to identify and quantify any physicochemical or biological changes, especially those caused or accelerated by the operation of Unit I. Other than USGS Water Data (1975-1982), few literature sources are available that report general survey characteristics. Chittenden (1979, 1980) and Chittenden and McFadden (1978) reported on radionuclides, total dissolved solids and selected cations in Dardanelle Reservoir.

METHODS

Although there have been minor changes in procedures over the years, the general protocol of this project involved monthly sampling at stations 1 (discharge), 5 (mouth of discharge bay into the main part of the lake), 16 (intake) and 21 (upstream control) (Figure 1). The average depths at these stations were 3 m, 3 m, 3.5 m and 12 m, respectively. The water level fluctuated 0.3 m up or down in response to runoff and channel dredging. Water samples from 0.6 m and near the bottom at each station were tested. Turbidity was measured on site, whereas the others were measured in the laboratory. The samples were transported on ice and refrigerated continuously until analyzed within three days after collection. All chemical tests were performed according to methods recommended by Standard Methods (1975) as adapted by Hach Chemical Company.

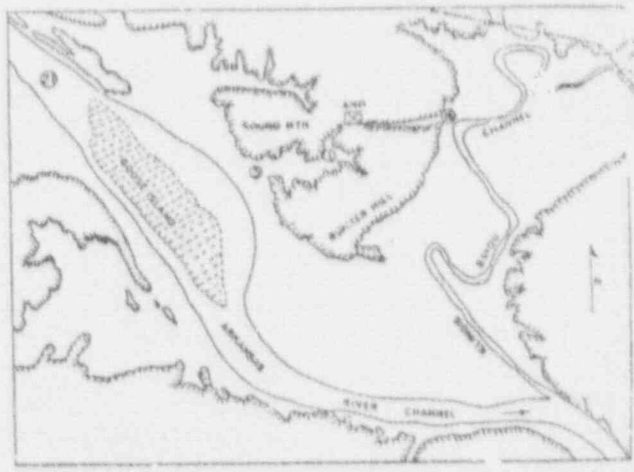

Figure 1. Outline map of Dardanelle Reservoir with key sampling stations, 1975-1982.

RESULTS AND DISCUSSION

The individual data collected during this project were too numerous to list in this report. After monthly means and ranges were determined for the six parameters, the months were ranked from highest to lowest by station and test, assigned a rank value from 1 to 12, and the rank values were summed (Tables 1-3). Our data compare favorably with periodic but incomplete readings of conductivity, turbidity and suspended solids reported at the USGS gauging station immediately below the Dardanelle Dam.

Discharge readings (Q) on sampling dates from USGS (1975-1982) data were averaged by month (Table 1). The years 1977 and 1981 experienced dry springs and wet autumns, whereas the other years followed the more expected trend of wet springs and dry autumns. Perhaps the most astonishing fluctuation occurred in 1975 between June and legends are reversed

Table 3. Cumulative Ranking Values for Months Listed from Highest to Lowest Physicochemical Concentrations, Dardanelle Reservoir, Arkansas, 1975-1982.

Variables	1975 n	1975 r	1975 p	1976 n	1976 r	1976 p	1977 n	1977 r	1977 p
Q vs T	12	.899	.0001	12	.332	.1457	11	.135	.3467
Q vs SS	12	.561	.0228	12	.326	.1505	11	-.179	.3015
Q vs Cl	12	-.561	.0278	12	.271	.2015	11	.554	.0324
Q vs H	12	-.049	.4366	12	.103	.3735	11	.529	.0459
Q vs C	12	-.510	.0439	12	.107	.3697	11	.494	.0600
T vs SS	-	-	-	36	.842	.0001	29	.092	.3175
T vs Cl	37	-.572	.0002	36	.459	.0016	32	.030	.4356
T vs H	34	.136	.2260	36	.077	.3050	32	.285	.0305
T vs C	36	-.344	.0189	36	.254	.0554	28	.021	.4548
SS vs Cl	-	-	-	37	.471	.0018	32	-.150	.2190
SS vs H	-	-	-	36	.252	.0675	32	-.034	.4268
SS vs C	-	-	-	36	.405	.0068	28	-.044	.4056
Cl vs H	33	-.091	.3096	40	.138	.2024	32	.616	.0003
Cl vs C	38	.64[illegible]	.0001	40	.727	.0001	28	.881	.0001
H vs C	34	.289	.0469	40	.431	.0018	28	.744	.0001

Variables	1978 n	1978 r	1978 p	1979 n	1979 r	1979 p	1980 n	1980 r	1980 p
Q vs T	11	.680	.0102	12	.925	.0001	12	.704	.0052
Q vs SS	11	.623	.0196	12	.973	.0001	12	.759	.0022
Q vs Cl	11	-.555	.0374	12	-.802	.0010	12	.050	.4358
Q vs H	11	-.475	.0688	12	-.877	.0002	12	-.569	.0257
Q vs C	11	-.658	.0134	11	-.884	.0003	12	-.413	.0901
T vs SS	34	.841	.0001	46	.890	.0001	48	.778	.0001
T vs Cl	34	-.406	.0081	46	-.690	.0001	48	.251	.0408
. vs H	43	.285	.0305	47	-.727	.0001	48	-.269	.0307
T vs C	31	-.366	.0206	42	-.750	.0001	48	-.094	.2651
SS vs Cl	34	-.116	.2593	46	-.599	.0001	48	.113	.2250
SS vs H	34	.179	.1554	46	-.646	.0001	48	-.221	.0637
SS vs C	31	-.162	.1974	42	-.673	.0001	48	-.118	.2158
Cl vs H	34	.249	.0759	45	.950	.0001	48	.406	.0022
Cl vs C	31	.737	.0001	42	.964	.0001	48	.661	.0001
H vs C	31	.315	.0404	42	.971	.0001	47	.759	.0001

Variables	1981 n	1981 r	1981 p	1982 n	1982 r	1982 p
Q vs T	12	.413	.0901	12	.592	.0205
Q vs SS	12	.519	.0406	12	.366	.1202
Q vs Cl	12	.268	.2067	12	-.394	.1016
Q vs H	12	.044	.4432	12	-.398	.0989
Q vs C	12	.146	.3265	12	-.339	.1403
T vs SS	48	.434	.0012	48	.606	.0001
T vs Cl	48	-.099	.2553	48	-.428	.0014
T vs H	48	-.271	.0291	48	-.339	.0088
T vs C	48	-.300	.0180	48	.051	.3648
SS vs Cl	48	.179	.1103	48	-.202	.0828
SS vs H	48	.272	.0290	48	-.408	.0021
SS vs C	48	.073	.3147	48	-.302	.0173
Cl vs H	48	.794	.0001	48	.704	.0001
Cl vs C	48	.909	.0001	48	.918	.0001
H vs C	48	.893	.0001	48	.789	.0001

The intensity of this layering was regulated by the volume of water pumped through the plant, the direction of wind and the discharge of the river (Rickett and Watson, 1982). Turbidity at station 21 was greater than at station 16 10 of 12 months by a mean of 12.9 FTU's. Turbidity at station 1 was greater than at station 16 all months by a mean of 3.2 FTU's, which was probably not caused by current disturbance of the bottom sediment. Shortly after the plant began commercial operation, we began experiencing great difficulty obtaining a benthos sample at station 1 because the current had scoured the loose silt away leaving hard gray clay.

The greatest average concentration of suspended solids was measured in March with May showing a close second, whereas November had the lowest (Table 1). The late winter and spring months had the highest values, while the late fall and winter months had the lowest. Again station 21 had larger values than station 16 10 of 12 months by a mean

Table 4. Pearson Correlation Tests on Physicochemical Data, Dardanelle Reservoir, Arkansas, 1975-1982. Q = discharge; T = turbidity; SS = suspended solids; Cl = chloride; H = hardness; C = conductivity.

Q	Turb	S.S.	Chloride	Hard	Cond
Mar 12	May 48	Mar 42.5	Jun 42	Sep 46	Sep 47
Jun 11	Mar 40	May 40	Sep 40	Aug 43	Oct 41
May 10	Apr 39	Feb 38	Aug 38	Nov 42	Jul 36
Apr 9	Jun 39	Apr 36	Oct 37	Jul 35	Aug 36
Jul 8	Oct 27	Oct 30.5	Nov 33	Oct 34	Jun 35
Feb 7	Feb 25.5	Jun 26.5	Jul 29	Jun 26	Nov 32
Jan 6	Jul 24	Jul 26.5	Apr 24	Dec 22	Dec 23
Aug 5	Dec 20	Sep 18	Dec 22	May 20	Jan 21
Nov 4	Aug 17	Aug 17.5	Jan 17.5	Jan 15	Feb 16
Dec 3	Nov 11.5	Dec 13	Feb 14	Mar 13	Mar 10
Sep 2	Jan 11	Jan 13	Mar 10	Feb 12	May 9
Oct 1	Sep 10	Nov 10.5	May 5.5	Apr 4	Apr 8

of 7.6 mg/l. There was no significant difference between stations 1 and 16 with respect to suspended solids. Pearson correlation analysis showed a strong positive correlation between turbidity and suspended solids (Table 4).

Chloride concentrations were highest in June and lowest in May, but there was much inconsistent variation month by month. Apparently the spring rainfall diluted the chloride concentration, which quickly recovered during the next month. There was more chloride at station 21 than 16, eight months out of 12 by a mean of 53.6 mg/l. There was no real difference between stations 16 and 1; the concentration was greater at station 1 five months out of 12 by a mean of 13.9 mg/l. Sinclair and Watson (1978) reported a somewhat stronger correlation between Q and chloride than our data, which show a weak positive correlation in 1976 and 1981, a significant positive correlation in 1977 and zero or negative correlations during the other years (Table 4). The location of a storm might help explain this fluctuating correlation. A localized heavy rain in western Arkansas should dilute the river water giving a negative correlation, whereas a rainfall in the major chloride source areas of eastern and northeastern Oklahoma would result in more chloride with the heavier discharge showing a positive correlation. The zero correlations would be observed with a generalized rainfall or a storm located in an intermediate area.

The greatest conductivity readings occurred in September, whereas the lowest values were obtained in April with May and March showing very low values. Conductivity values increased rather steadily between April and August and declined rather steadily between October and March. Station 21 had greater conductivity than 16 only seven months out of 12, but the mean difference was 109.4 micromhos. Station 16 had higher conductivity readings than station 1 during 11 of 12 months and was greater by a mean of 45.7 micromhos. Apparently the passage through the condenser circuit removed some of the ions. Pearson correlation tests showed a rather strong positive correlation between chloride and conductivity (Table 4). Generally minimum conductivity measurements were observed during the periods of greatest Q because of dilution, although the highest conductivity readings did not necessarily coincide with periods of lowest Q but occurred generally within two or three months following a peak Q reading.

Total hardness was also greatest in September and lowest in April, but the months between were arrayed differently than for conductivity. Station 21 showed higher values than station 16 11 of 12 months by a mean of 21.6 mg/l, but there was no significant difference between stations 1 and 16. Pearson correlations showed a moderate positive correlation between hardness and conductivity (Table 4).

Correlation may also be tested non-statistically using a rank matching technique. If two datasets are positively correlated perfectly, the rank-

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Arkansas

AQUATIC RESOURCE QUESTIONS
ATTACHMENT 3

COMPARISON OF NUMBER AND WEIGHT IMPINGED TO ESTIMATED RESERVOIR TOTAL
OF SOME OF THE MORE IMPORTANT COMMERCIAL AND SPORT FISH AND FORAGE FISH
FOR 1981

SPECIES	CALCULATED NUMBER IMPINGED FOR 1981	CALCULATED NUMBER IN RESERVOIR FOR 1981	PERCENT IMPINGED FROM RESERVOIR	CALCULATED WEIGHT (LB) IMPINGED FOR 1981	CALCULATED WEIGHT (LB) IN RESERVOIR FOR 1981	PERCENT WEIGHT IMPINGED FROM RESERVOIR
CHANNEL CATFISH	2,012	8,710,800	0.02	222	1,354,200	0.01
FLATHEAD CATFISH	53	65,880	0.06	0	109,800	0.00
BLUE CATFISH	4,598	695,400	0.66	286	146,400	0.19
LARGEMOUTH BASS	50	988,200	0.00	50	242,800	0.02
STRIPED BASS	2,394	606,828	0.39	335	402,600	0.08
WHITE BASS	2,938	292,800	1.00	554	109,800	0.50
BLACK CRAPPIE	20	50,508	0.04	3	10,797	0.03
WHITE CRAPPIE	943	622,200	0.16	262	67,710	0.39
LONGEAR SUNFISH	422	13,249,200	0.00	30	366,000	0.01
BLUEGILL SUNFISH	2,377	22,069,800	0.01	279	805,200	0.03
FRESHWATER DRUM	34,040	24,176,130	0.14	2,108	2,013,000	0.10
GIZZARD SHAD	1,288,917	51,606,000	2.50	27,745	4,318,800	0.64
THREADFIN SHAD	6,750,280	53,106,600	12.71	64,926	512,400	12.67

How estimated?
Avail. for other years?

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED OVER THE NINE YEAR PERIOD, 1974 THROUGH 1982

OBS	SPECIES	MEAN_WT	MIN_WT	MAX_WT
1	ARKANSAS RIVER SHINER	0.01603	0.01412	0.01857
2	BULLHEAD MINNOW	0.01000	0.01000	0.01000
3	CHANNEL CATFISH	0.08263	0.00077	1.38000
4	CHESTNUT LAMPREY	0.10644	0.03000	0.18000
5	EMERALD SHINER	0.00863	0.00333	0.01[illegible]0
6	EUROPEAN CARP	1.45945	0.01000	4.38000
7	FLATHEAD CATFISH	0.04076	0.00333	0.65000
8	FRESHWATER DRUM	0.08220	0.00142	1.51300
9	GIZZARD SHAD	0.04102	0.00022	0.62500
10	GOLDEN SHINER	0.01023	0.00154	0.04024
11	BLACK BULLHEAD	0.11215	0.00200	3.56000
12	GOLDFISH	0.01000	0.01000	0.01000
13	GOLDEYE	0.54792	0.04333	1.25000
14	GREEN SUNFISH	0.03617	0.00250	0.34000
15	LARGEMOUTH BASS	0.55746	0.00667	4.44000
16	LARGEMOUTH BUFFALO	3.56000	2.64000	5.25000
17	LOGPERCH	0.01500	0.01000	0.03000
18	LONGEAR SUNFISH	0.06810	0.00333	0.23000
19	LONGNOSE GAR	0.28878	0.01000	2.50000
20	MADTOM	0.01000	0.01000	0.01000
21	MISSISSIPPI SILVERSIDE	0.01053	0.00073	0.06600
22	BLACK CRAPPIE	0.14275	0.01000	0.72000
23	MOONEYE	0.35083	0.28000	0.44000
24	ORANGESPOTTED SUNFISH	0.01410	0.00235	0.07000
25	PADDLEFISH	0.31714	0.01000	2.13000
26	RED SHINER	0.01000	0.01000	0.01000
27	REDEAR SUNFISH	0.04577	0.01000	0.14000
28	RIVER CARPSUCKER	1.28004	0.00824	3.51000
29	RIVER SHINER	0.01317	0.00167	0.04000
30	SAUGER	0.31808	0.00500	2.00000
31	SHORTNOSE GAR	1.52344	1.08000	2.46750
32	BLUE CATFISH	0.11052	0.00200	2.37250
33	SHOVELNOSE STURGEON	0.01000	0.01000	0.01000
34	SKIPJACK HERRING	0.11411	0.00250	1.03000
35	SMALLMOUTH BUFFALO	2.02301	0.00421	3.44000
36	SPOTTED GAR	0.16000	0.16000	0.16000
37	STRIPED BASS	0.25002	0.00250	3.56000
38	THREADFIN SHAD	0.01416	0.00156	0.08000
39	TILAPIA	0.24387	0.25108	0.33667
40	WHITE BASS	0.14370	0.00071	1.44000
41	BLUEGILL SUNFISH	0.07604	0.00165	0.46000
42	WHITE CRAPPIE	0.17840	0.00200	2.59833
43	WARMOUTH	0.04166	0.00235	0.20000
44	YELLOW BULLHEAD	0.04800	0.01000	0.16000
45	FATHEAD MINNOW	0.01000	0.01000	0.01000
46	BLUNTNOSE MINNOW	0.00631	0.00630	0.00632
47	DARTER	0.01000	0.01000	0.01000
48	JOHNNY DARTER	0.01000	0.01000	0.01000
49	SPOTTED SUNFISH	0.01000	0.01000	0.01000
50	SLIM MINNOW	0.00842	0.00417	0.01000
51	BLACK BUFFALO	1.82333	0.47000	2.31000
52	AMERICAN EEL	0.67431	0.01000	2.50667
53	GRASS PICKEREL	0.07176	0.07176	0.07176
54	RIVER DARTER	0.01146	0.01000	0.01333
55	STONEROLLER	0.10000	0.10000	0.10000
56	BROOK SILVERSIDE	0.00837	0.00333	0.06000

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED AT AND BY YEAR FROM 1974 THROUGH 1982

OBS	YR	SPECIES	MEAN_WT	MIN_WT	MAX_WT
1	1976	ARKANSAS RIVER SHINER	0.01603	0.01412	0.01667
2	1975	BULLHEAD MINNOW	0.01000	0.01000	0.01000
3	1976	BULLHEAD MINNOW	0.01000	0.01000	0.01000
4	1977	BULLHEAD MINNOW	0.01000	0.01000	0.01000
5	1980	BULLHEAD MINNOW	0.01000	0.01000	0.01000
6	1974	CHANNEL CATFISH	0.03259	0.00421	0.09367
7	1975	CHANNEL CATFISH	0.04366	0.00314	0.72000
8	1976	CHANNEL CATFISH	0.06738	0.00375	0.83286
9	1977	CHANNEL CATFISH	0.10402	0.00333	1.08000
10	1978	CHANNEL CATFISH	0.04000	0.00077	1.27333
11	1979	CHANNEL CATFISH	0.06011	0.00187	1.07333
12	1980	CHANNEL CATFISH	0.06431	0.00333	1.38000
13	1981	CHANNEL CATFISH	0.11014	0.00600	0.40857
14	1982	CHANNEL CATFISH	0.09699	0.00818	0.79500
15	1975	CHESTNUT LAMPREY	0.12125	0.11000	0.17000
16	1976	CHESTNUT LAMPREY	0.12175	0.04500	0.18500
17	1977	CHESTNUT LAMPREY	0.09875	0.05000	0.16000
18	1978	CHESTNUT LAMPREY	0.09312	0.03000	0.13500
19	1980	CHESTNUT LAMPREY	0.10712	0.07000	0.18000
20	1981	CHESTNUT LAMPREY	0.09000	0.09000	0.09000
21	1982	CHESTNUT LAMPREY	0.09500	0.08000	0.10500
22	1976	EMERALD SHINER	0.01000	0.01000	0.01000
23	1977	EMERALD SHINER	0.01000	0.01000	0.01000
24	1978	EMERALD SHINER	0.00833	0.00333	0.01000
25	1979	EMERALD SHINER	0.00809	0.00500	0.01000
26	1980	EMERALD SHINER	0.00822	0.00333	0.01000
27	1981	EMERALD SHINER	0.00885	0.00667	0.01000
28	1982	EMERALD SHINER	0.01000	0.01000	0.01000
29	1974	EUROPEAN CARP	1.08333	1.08333	1.08333
30	1975	EUROPEAN CARP	1.35312	0.53000	2.61000
31	1976	EUROPEAN CARP	2.00817	1.13000	3.89000
32	1977	EUROPEAN CARP	0.92333	0.01000	2.31000
33	1978	EUROPEAN CARP	1.40090	0.65000	2.50000
34	1979	EUROPEAN CARP	1.20754	0.02789	2.88000
35	1980	EUROPEAN CARP	1.58848	0.31000	2.81500
36	1981	EUROPEAN CARP	2.51611	1.08500	4.38000
37	1982	EUROPEAN CARP	0.78969	0.01000	3.06000
38	1975	FLATHEAD CATFISH	0.03900	0.00333	0.17667
39	1976	FLATHEAD CATFISH	0.07272	0.00500	0.65000
40	1977	FLATHEAD CATFISH	0.02255	0.00333	0.08000
41	1978	FLATHEAD CATFISH	0.04356	0.00667	0.27667
42	1979	FLATHEAD CATFISH	0.02575	0.00909	0.10000
43	1980	FLATHEAD CATFISH	0.02137	0.00836	0.05000
44	1981	FLATHEAD CATFISH	0.07167	0.00833	0.18000
45	1982	FLATHEAD CATFISH	0.07339	0.00714	0.25000
46	1974	FRESHWATER DRUM	0.04336	0.00367	0.34560
47	1975	FRESHWATER DRUM	0.07089	0.00192	1.38000
48	1976	FRESHWATER DRUM	0.05028	0.00575	0.41200
49	1977	FRESHWATER DRUM	0.04316	0.00823	0.29955
50	1978	FRESHWATER DRUM	0.07936	0.00880	0.47062
51	1979	FRESHWATER DRUM	0.04566	0.00833	1.51300
52	1980	FRESHWATER DRUM	0.08031	0.00444	0.56800
53	1981	FRESHWATER DRUM	0.14259	0.01714	0.60385
54	1982	FRESHWATER DRUM	0.10002	0.00960	1.17500
55	1974	GIZZARD SHAD	0.01596	0.00022	0.03579
56	1975	GIZZARD SHAD	0.05903	0.00903	0.27000

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED AT ANO BY YEAR FROM 1974 THROUGH 1982

INUED)

OBS	YR	SPECIES	MEAN_WT	MIN_WT	MAX_WT
57	1976	GIZZARD SHAD	0.06265	0.00300	0.10680
58	1977	GIZZARD SHAD	0.03759	0.00432	0.13152
59	1978	GIZZARD SHAD	0.03172	0.00419	0.07463
60	1979	GIZZARD SHAD	0.03225	0.00621	0.62500
61	1980	GIZZARD SHAD	0.02759	0.00432	0.05273
62	1981	GIZZARD SHAD	0.02909	0.00478	0.10000
63	1982	GIZZARD SHAD	0.05482	0.00526	0.06424
64	1974	GOLDEN SHINER	0.00333	0.00333	0.00333
65	1975	GOLDEN SHINER	0.01062	0.00273	0.04500
66	1976	GOLDEN SHINER	0.00842	0.00250	0.01000
67	1977	GOLDEN SHINER	0.01072	0.00154	0.04424
68	1978	GOLDEN SHINER	0.01069	0.00500	0.02000
69	1979	GOLDEN SHINER	0.01123	0.00455	0.04000
70	1980	GOLDEN SHINER	0.00845	0.00222	0.02000
71	1981	GOLDEN SHINER	0.00970	0.00250	0.03000
72	1982	GOLDEN SHINER	0.01308	0.00500	0.03000
73	1974	BLACK BULLHEAD	0.01333	0.01333	0.01333
74	1975	BLACK BULLHEAD	0.09227	0.01000	0.60000
75	1976	BLACK BULLHEAD	0.10125	0.01000	0.14000
76	1977	BLACK BULLHEAD	0.11600	0.00667	0.83000
77	1978	BLACK BULLHEAD	0.04025	0.00200	0.14000
78	1979	BLACK BULLHEAD	0.07432	0.00324	0.32750
79	1980	BLACK BULLHEAD	0.01919	0.01000	0.06000
80	1981	BLACK BULLHEAD	0.07600	0.02000	0.24000
81	1982	BLACK BULLHEAD	0.24404	0.01500	3.56000
82	1977	GOLDFISH	0.01000	0.01000	0.01000
83	1975	GOLDEYE	1.15500	1.06000	1.25000
84	1976	GOLDEYE	0.10000	0.10000	0.10000
85	1978	GOLDEYE	0.09333	0.09333	0.09333
86	1979	GOLDEYE	0.23625	0.23625	0.23625
87	1974	GREEN SUNFISH	0.00872	0.00333	0.03000
88	1975	GREEN SUNFISH	0.03781	0.00500	0.14000
89	1976	GREEN SUNFISH	0.04060	0.00500	0.20000
90	1977	GREEN SUNFISH	0.04427	0.00500	0.26000
91	1978	GREEN SUNFISH	0.03373	0.00333	0.13000
92	1979	GREEN SUNFISH	0.01979	0.00250	0.13200
93	1980	GREEN SUNFISH	0.02937	0.00333	0.12000
94	1981	GREEN SUNFISH	0.04279	0.00250	0.13500
95	1982	GREEN SUNFISH	0.04407	0.00417	0.34000
96	1974	LARGEMOUTH BASS	0.24333	0.09333	0.39333
97	1975	LARGEMOUTH BASS	0.60143	0.01000	2.88000
98	1976	LARGEMOUTH BASS	0.35311	0.01000	4.04000
99	1977	LARGEMOUTH BASS	0.35567	0.01000	2.13000
100	1978	LARGEMOUTH BASS	0.91214	0.01000	1.88000
101	1979	LARGEMOUTH BASS	0.69447	0.01222	4.13000
102	1980	LARGEMOUTH BASS	1.08667	0.00667	3.31000
103	1981	LARGEMOUTH BASS	0.61442	0.01000	2.31000
104	1982	LARGEMOUTH BASS	0.14611	0.01000	0.43000
105	1976	LARGEMOUTH BUFFALO	2.64000	2.64000	2.64000
106	1977	LARGEMOUTH BUFFALO	3.84000	3.84000	3.84000
107	1980	LARGEMOUTH BUFFALO	3.06000	3.06000	3.06000
108	1982	LARGEMOUTH BUFFALO	5.25000	5.25000	5.25000
109	1975	LOGPERCH	0.01000	0.01000	0.01000
110	1977	LOGPERCH	0.01667	0.01000	0.03000
111	1974	LONGEAR SUNFISH	0.03333	0.00333	0.06333
112	1975	LONGEAR SUNFISH	0.04438	0.01000	0.14000

IED)

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED AT AND BY YEAR FROM 1974 THROUGH 1982

OBS	YR	SPECIES	MEAN_WT	MIN_WT	MAX_WT
113	1976	LONGEAR SUNFISH	0.06026	0.003333	0.19000
114	1977	LONGEAR SUNFISH	0.06119	0.005000	0.18000
115	1978	LONGEAR SUNFISH	0.06595	0.010000	0.18000
116	1979	LONGEAR SUNFISH	0.06233	0.003333	0.14000
117	1980	LONGEAR SUNFISH	0.06536	0.010000	0.13000
118	1981	LONGEAR SUNFISH	0.07054	0.003750	0.14000
119	1982	LONGEAR SUNFISH	0.07157	0.005000	0.23000
120	1975	LONGNOSE GAR	1.25500	0.010000	2.50000
121	1976	LONGNOSE GAR	0.16450	0.020000	0.26750
122	1978	LONGNOSE GAR	0.76000	0.210000	1.41000
123	1980	LONGNOSE GAR	0.28500	0.015000	0.81000
124	1981	LONGNOSE GAR	0.12000	0.120000	0.12000
125	1982	LONGNOSE GAR	0.03485	0.025000	0.05500
126	1976	MADTOM	0.01000	0.010000	0.01000
127	1977	MADTOM	0.01000	0.010000	0.01000
128	1978	MADTOM	0.01000	0.010000	0.01000
129	1974	MISSISSIPPI SILVERSIDE	0.01108	0.000732	0.06333
130	1975	MISSISSIPPI SILVERSIDE	0.00957	0.003333	0.06000
131	1976	MISSISSIPPI SILVERSIDE	0.00824	0.003333	0.02000
132	1977	MISSISSIPPI SILVERSIDE	0.00883	0.003333	0.02000
133	1978	MISSISSIPPI SILVERSIDE	0.01175	0.005000	0.06600
134	1979	MISSISSIPPI SILVERSIDE	0.01106	0.005000	0.02000
135	1980	MISSISSIPPI SILVERSIDE	0.01156	0.000909	0.02000
136	1981	MISSISSIPPI SILVERSIDE	0.01205	0.005000	0.02667
137	1982	MISSISSIPPI SILVERSIDE	0.01111	0.002308	0.02000
138	1974	BLACK CRAPPIE	0.13307	0.012500	0.22000
139	1975	BLACK CRAPPIE	0.10957	0.020000	0.27000
140	1976	BLACK CRAPPIE	0.33000	0.150000	0.53000
141	1977	BLACK CRAPPIE	0.16563	0.010000	0.64600
142	1978	BLACK CRAPPIE	0.13067	0.050000	0.25000
143	1979	BLACK CRAPPIE	0.23628	0.080000	0.42750
144	1980	BLACK CRAPPIE	0.13074	0.046667	0.30000
145	1981	BLACK CRAPPIE	0.18125	0.040000	0.27000
146	1982	BLACK CRAPPIE	0.43917	0.093333	0.72000
147	1978	MOONEYE	0.28000	0.280000	0.28000
148	1979	MOONEYE	0.44000	0.440000	0.44000
149	1981	MOONEYE	0.33250	0.332500	0.33250
150	1974	ORANGESPOTTED SUNFISH	0.00333	0.003333	0.00333
151	1975	ORANGESPOTTED SUNFISH	0.01136	0.002727	0.05000
152	1976	ORANGESPOTTED SUNFISH	0.00981	0.005000	0.02000
153	1977	ORANGESPOTTED SUNFISH	0.01191	0.003333	0.02000
154	1978	ORANGESPOTTED SUNFISH	0.01583	0.005000	0.03000
155	1979	ORANGESPOTTED SUNFISH	0.00830	0.002353	0.02000
156	1980	ORANGESPOTTED SUNFISH	0.01681	0.002500	0.07000
157	1981	ORANGESPOTTED SUNFISH	0.01925	0.002500	0.05000
158	1982	ORANGESPOTTED SUNFISH	0.01878	0.005000	0.07000
159	1975	PADDLEFISH	0.71667	0.010000	2.13000
160	1976	PADDLEFISH	0.01000	0.010000	0.01000
161	1977	PADDLEFISH	0.02000	0.020000	0.02000
162	1982	PADDLEFISH	0.02000	0.020000	0.02000
163	1975	RED SHINER	0.01000	0.010000	0.01000
164	1980	RED SHINER	0.01000	0.010000	0.01000
165	1981	RED SHINER	0.01000	0.010000	0.01000
166	1975	REDEAR SUNFISH	0.04000	0.040000	0.04000
167	1976	REDEAR SUNFISH	0.01000	0.010000	0.01000
168	1979	REDEAR SUNFISH	0.03269	0.015385	0.05000

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED AT AND BY YEAR FROM 1974 THROUGH 1982

OBS	YR	SPECIES	MEAN_WT	MIN_WT	MAX_WT
169	1980	REDEAR SUNFISH	0.04000	0.04000	0.04000
170	1981	REDEAR SUNFISH	0.02500	0.02500	0.02500
171	1982	REDEAR SUNFISH	0.14000	0.14000	0.14000
172	1974	RIVER CARPSUCKER	0.00829	0.00829	0.00829
173	1975	RIVER CARPSUCKER	1.34889	0.25000	2.00000
174	1976	RIVER CARPSUCKER	1.33600	0.46000	2.19000
175	1977	RIVER CARPSUCKER	1.15934	0.04000	2.24000
176	1978	RIVER CARPSUCKER	0.42111	0.10000	1.44000
177	1979	RIVER CARPSUCKER	1.08961	0.60333	2.[illegible]6000
178	1980	RIVER CARPSUCKER	1.24000	0.10000	2.77000
179	1981	RIVER CARPSUCKER	2.27500	1.10000	3.51000
180	1982	RIVER CARPSUCKER	1.38458	0.59500	2.19000
181	1975	RIVER SHINER	0.01159	0.00500	0.02000
182	1976	RIVER SHINER	0.01650	0.01000	0.04000
183	1977	RIVER SHINER	0.01917	0.01000	0.03000
184	1978	RIVER SHINER	0.01125	0.01000	0.02000
185	1979	RIVER SHINER	0.01378	0.01200	0.01556
186	1980	RIVER SHINER	0.00937	0.00500	0.01000
187	1981	RIVER SHINER	0.01000	0.01000	0.01000
188	1982	RIVER SHINER	0.01292	0.00167	0.02000
189	1975	SAUGER	0.28000	0.00500	1.00000
190	1976	SAUGER	0.60000	0.50000	0.70000
191	1977	SAUGER	0.22784	0.01000	2.00000
192	1978	SAUGER	0.10714	0.02000	0.35000
193	1979	SAUGER	0.70111	0.01000	1.50000
194	1980	SAUGER	1.21000	1.21000	1.21000
195	1981	SAUGER	0.77000	0.75000	0.79000
196	1982	SAUGER	0.66000	0.01000	1.31000
197	1975	SHORTNOSE GAR	1.13000	1.13000	1.13000
198	1976	SHORTNOSE GAR	1.96375	1.46000	2.46750
199	1977	SHORTNOSE GAR	1.19000	1.19000	1.19000
200	1979	SHORTNOSE GAR	1.06000	1.06000	1.06000
201	1980	SHORTNOSE GAR	1.25000	1.25000	1.25000
202	1981	SHORTNOSE GAR	2.38000	2.38000	2.38000
203	1974	BLUE CATFISH	0.01703	0.00568	0.04333
204	1975	BLUE CATFISH	0.04789	0.00607	0.19000
205	1976	BLUE CATFISH	0.14327	0.00750	1.73500
206	1977	BLUE CATFISH	0.19160	0.00200	1.17500
207	1978	BLUE CATFISH	0.10966	0.00333	0.74000
208	1979	BLUE CATFISH	0.10748	0.00750	0.79167
209	1980	BLUE CATFISH	0.10451	0.00500	1.56500
210	1981	BLUE CATFISH	0.12813	0.00600	2.37250
211	1982	BLUE CATFISH	0.10110	0.00423	0.39500
212	1975	SHOVELNOSE STURGEON	0.01000	0.01000	0.01000
213	1974	SKIPJACK HERRING	0.05000	0.05000	0.05000
214	1975	SKIPJACK HERRING	0.10415	0.01000	0.65000
215	1976	SKIPJACK HERRING	0.06098	0.01000	0.33500
216	1977	SKIPJACK HERRING	0.11948	0.01000	1.00250
217	1978	SKIPJACK HERRING	0.06444	0.01963	0.45000
218	1979	SKIPJACK HERRING	0.13660	0.05294	0.45750
219	1980	SKIPJACK HERRING	0.04915	0.01667	0.29000
220	1981	SKIPJACK HERRING	0.24973	0.00250	1.03000
221	1982	SKIPJACK HERRING	0.17779	0.02083	0.83000
222	1974	SMALLMOUTH BUFFALO	0.01351	0.00421	0.03132
223	1975	SMALLMOUTH BUFFALO	1.38700	0.34000	2.83000
224	1976	SMALLMOUTH BUFFALO	2.29389	1.80000	2.63000

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED AT AND BY YEAR FROM 1974 THROUGH 1982

OBS	YR	SPECIES	MEAN_WT	MIN_WT	MAX_WT
225	1977	SMALLMOUTH BUFFALO	2,03500	1,63000	2,44000
226	1978	SMALLMOUTH BUFFALO	1,66646	0,01000	2,58000
227	1979	SMALLMOUTH BUFFALO	1,44000	1,44000	1,44000
228	1980	SMALLMOUTH BUFFALO	2,61659	1,48000	3,70000
229	1981	SMALLMOUTH BUFFALO	2,69167	2,13000	3,30000
230	1982	SMALLMOUTH BUFFALO	2,55667	1,19000	3,94000
231	1977	SPOTTED GAR	0,16000	0,16000	0,16000
232	1975	STRIPED BASS	0,04516	0,01000	0,34000
233	1976	STRIPED BASS	0,09405	0,01000	1,34000
234	1977	STRIPED BASS	0,45218	0,00500	2,06000
235	1978	STRIPED BASS	0,15611	0,00400	2,25000
236	1979	STRIPED BASS	0,08496	0,01000	0,32500
237	1980	STRIPED BASS	0,10052	0,00250	0,60000
238	1981	STRIPED BASS	0,24394	0,01667	1,66667
239	1982	STRIPED BASS	0,66662	0,00500	3,56000
240	1974	THREADFIN SHAD	0,01250	0,00158	0,01933
241	1975	THREADFIN SHAD	0,01766	0,00333	0,03636
242	1976	THREADFIN SHAD	0,01436	0,00201	0,02955
243	1977	THREADFIN SHAD	0,01469	0,00231	0,08000
244	1978	THREADFIN SHAD	0,00743	0,00200	0,03875
245	1979	THREADFIN SHAD	0,01158	0,00333	0,02430
246	1980	THREADFIN SHAD	0,01478	0,00200	0,04000
247	1981	THREADFIN SHAD	0,01279	0,00333	0,05000
248	1982	THREADFIN SHAD	0,01612	0,00360	0,07000
249	1974	TILAPIA	0,29367	0,25108	0,33667
250	1974	WHITE BASS	0,03791	0,01538	0,15667
251	1975	WHITE BASS	0,11943	0,00250	0,75000
252	1976	WHITE BASS	0,07892	0,00333	0,55500
253	1977	WHITE BASS	0,14188	0,00516	1,02000
254	1978	WHITE BASS	0,20904	0,00071	1,15667
255	1979	WHITE BASS	0,16013	0,01000	1,26545
256	1980	WHITE BASS	0,27635	0,00379	1,44000
257	1981	WHITE BASS	0,26363	0,01333	1,27000
258	1982	WHITE BASS	0,30962	0,04437	1,03000
259	1974	BLUEGILL SUNFISH	0,02411	0,00185	0,11167
260	1975	BLUEGILL SUNFISH	0,05526	0,00286	0,19000
261	1976	BLUEGILL SUNFISH	0,07073	0,00333	0,30333
262	1977	BLUEGILL SUNFISH	0,08676	0,00333	0,24667
263	1978	BLUEGILL SUNFISH	0,08248	0,00286	0,32000
264	1979	BLUEGILL SUNFISH	0,07013	0,00264	0,42625
265	1980	BLUEGILL SUNFISH	0,06329	0,00250	0,20000
266	1981	BLUEGILL SUNFISH	0,10884	0,00333	0,21167
267	1982	BLUEGILL SUNFISH	0,08363	0,00444	0,46000
268	1974	WHITE CRAPPIE	0,05670	0,00372	0,29222
269	1975	WHITE CRAPPIE	0,16043	0,00318	2,00000
270	1976	WHITE CRAPPIE	0,15617	0,00500	0,80400
271	1977	WHITE CRAPPIE	0,15097	0,00368	1,85600
272	1978	WHITE CRAPPIE	0,17312	0,01000	1,69000
273	1979	WHITE CRAPPIE	0,12512	0,00333	1,00013
274	1980	WHITE CRAPPIE	0,28188	0,00200	2,59833
275	1981	WHITE CRAPPIE	0,23717	0,00667	0,92000
276	1982	WHITE CRAPPIE	0,16268	0,00375	0,74000
277	1975	WARMOUTH	0,06143	0,01000	0,16000
278	1976	WARMOUTH	0,06667	0,01000	0,14000
279	1977	WARMOUTH	0,04655	0,01000	0,19000
280	1978	WARMOUTH	0,03500	0,02750	0,04000

MEAN WEIGHT OF EACH SPECIES OF FISH IMPINGED AT AND BY YEAR FROM 1974 THROUGH 1982

OBS	YR	SPECIES	MEAN_WT	MIN_WT	MAX_WT
281	1979	WARMOUTH	0.00976	0.00235	0.02667
282	1980	WARMOUTH	0.03260	0.01000	0.16750
283	1981	WARMOUTH	0.05156	0.02000	0.20000
284	1982	WARMOUTH	0.03425	0.00600	0.20000
285	1975	YELLOW BULLHEAD	0.04000	0.04000	0.04000
286	1976	YELLOW BULLHEAD	0.01000	0.01000	0.01000
287	1978	YELLOW BULLHEAD	0.06500	0.01000	0.16000
288	1980	YELLOW BULLHEAD	0.02000	0.02000	0.02000
289	1976	FATHEAD MINNOW	0.01000	0.01000	0.01000
290	1977	FATHEAD MINNOW	0.01000	0.01000	0.01000
291	1974	BLUNTNOSE MINNOW	0.00631	0.00630	0.00632
292	1976	DARTER	0.01000	0.01000	0.01000
293	1976	JOHNNY DARTER	0.01000	0.01000	0.01000
294	1975	SPOTTED SUNFISH	0.01000	0.01000	0.01000
295	1977	SLIM MINNOW	0.01000	0.01000	0.01000
296	1978	SLIM MINNOW	0.00750	0.00500	0.01000
297	1979	SLIM MINNOW	0.00458	0.00417	0.00500
298	1980	SLIM MINNOW	0.01000	0.01000	0.01000
299	1978	BLACK BUFFALO	1.58000	0.97000	2.19000
300	1979	BLACK BUFFALO	2.31000	2.31000	2.31000
301	1977	AMERICAN EEL	0.38357	0.10000	0.67000
302	1979	AMERICAN EEL	0.60375	0.02000	2.25000
303	1980	AMERICAN EEL	0.01000	0.01000	0.01000
304	1981	AMERICAN EEL	1.94333	1.36000	2.50667
305	1979	GRASS PICKEREL	0.07176	0.07176	0.07176
306	1980	RIVER DARTER	0.01000	0.01000	0.01000
307	1982	RIVER DARTER	0.01292	0.01250	0.01333
308	1982	STONEROLLER	0.10000	0.10000	0.10000
309	1974	BROOK SILVERSIDE	0.00530	0.00431	0.00630
310	1975	BROOK SILVERSIDE	0.00916	0.00500	0.01077
311	1976	BROOK SILVERSIDE	0.00750	0.00500	0.01000
312	1977	BROOK SILVERSIDE	0.00500	0.00333	0.00667
313	1978	BROOK SILVERSIDE	0.01000	0.00400	0.06000
314	1979	BROOK SILVERSIDE	0.00506	0.00333	0.00723
315	1980	BROOK SILVERSIDE	0.00911	0.00333	0.02000
316	1981	BROOK SILVERSIDE	0.00744	0.00667	0.01000

ANO Entrainment
Species/Family Entrained 1982 Through 1987

Clupeidae
Gizzard Shad
Threadfin Shad
Skipjack Herring
Dorosoma Species
Carp
Striped Bass
Morone Species
Cyprinidae
Catostomidae
Freshwater Drum
Black Crappie
Pomoxis Species
Samllmouth Buffalo
Brook Silverside
Atherinidae
Mississippi Silverside
Percidae
Mosquitofish
Centrarchidae
Lepomis Species
Channel Catfish

Entrainment
Total Density of Fish Entrained Per Sample Date
1984 through 1987

1984		1985		1986		1987	
Date	Number	Date	Number	Date	Number	Date	Number
		4- 8	37	4-17	1252		
4-25	53	4-29	1714	4-28	84	4-20	20
5- 9	18	5-15	33472	5-13	7387	5-7	2125
5-24	40344	5-30	5173	5-29	26910	5-21	21580
6-14	172867	6-10	38844	6-12	74825	6-2	37349
6-27	116609	6-25	2298	6-26	48637	6-23	17079
7-10	2662	7- 9	2596	7-10	4795	7- 9	99048
7-24	503	7-31	506	7-22	4573	7-22	16183
8-14	222	8-13	207	8- 7	2395	8- 3	674
8-30	79	8-28	252	8-21	590	8-19	1072
9-10	46	9- 9	647	9- 4	298	9-10	364
9-19	32	9-25	125			9-29	50
Total	334435		85871		171746		195544

Density or numbers?
What units?

ANO Entrainment

Density By Species/Family Entrained From 1984 Through 1987

Species	1984	1985	1986	1987
Clupeidae	315312	73776	156909	189662
Gizzard Shad	12231	1241	679	179
Threadfin Shad	1521	441	2090	2095
Skipjack Herring	30	185	0	19
Carp	0	49	16	0
Striped Bass	0	34	0	0
Cyprinidae	1304	354	427	0
Black Crappie	0	16	0	0
Catostomidae	0	655	16	111
Brook Silverside	0	17	0	0
Channel Catfish	31	0	17	0
Centrarchidae	18	0	0	0
Morone Species	261	5123	891	736
Mosquitofish	16	0	0	0
Lepomis Species	540	603	1330	718
Pomoxis Species	16	459	454	129
Freshwater Drum	2998	2610	8272	1841
Atherinidae	0	111	118	0
Mississippi Silverside	156	195	525	34
Percidae	0	0	0	20

Do numbers for Family _include_ numbers for species? or are they exclusive? Presumably they could not or did not identify each fish?

Arkansas

AQUATIC RESOURCE QUESTIONS
ATTACHMENT 4

HELPING BUILD ARKANSAS

ARKANSAS POWER & LIGHT COMPANY

9TH & LOUISIANA STREETS • LITTLE ROCK, ARKANSAS 72203 • (501) 372-4311

January 21, 1977

1-017-7

Director of Nuclear Reactor Regulation
ATTN: Mr. Dennis L. Ziemann, Chief
Operating Reactors Branch #2
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Arkansas Nuclear One-Unit 1
Docket No. 50-313
License No. DPR-51
August 30, 1976, Semi-Annual
Environmental Monitoring Report
(File: 0900)

Gentlemen:

Your December 14, 1976, letter identified 3 so called "abnormalities" pointed out in the subject report and requested additional information on each. In addition Jim Wilson of Mr. B. K. Grimes staff has verbally requested detailed discharge temperatures for startups and shutdowns during the Spring 1976 period in relation to the same topic. Attached find the requested information.

Very truly yours,

Donald A. Rueter

Donald A. Rueter
Manager, Licensing

DAR:DHW:ay

Attachment

ATTACHMENT 1

RESPONSE TO "QUESTIONS CONCERNING ABNORMALITIES REPORTED IN ARKANSAS NUCLEAR ONE-UNIT 1 SEMI-ANNUAL ENVIRONMENTAL REPORT"

1. On page 47 it is stated that "Large hydra were found feeding on larval fish in Area C (Discharge Cove) during May 1976."

   A. Is this unusual for Southern reservoirs?

RESPONSE

This is not common in Southern reservoirs but it is certainly not unheard of and it is not peculiar to Southern reservoirs. "Occasionally hydras become a [Fish] hatchery nuisance by killing fish fry."[1] Hydra have been observed in the nest of black basses attaching to eggs and to hatching fry in two northern Arkansas reservoirs.[2] Zooplankton have been observed feeding on hatchery fish larvae.[3] Hydra have been observed in large numbers on a transient basis in an Iowa nursery lake.[4] This is far from an exhaustive list of such observations.

   B. If it is, could the fish populations of the reservoir be affected?

RESPONSE

Not applicable.

   C. Is it because of plant operations?

RESPONSE

When this observation was made the plant had been shutdown continuously for about 2 months. The discharge bay is a natural hydra habitat. Connection to plant operation is improbable.

2. On page 47 it is stated that "The June 1976 meter net samples from all areas of the reservoir produced 30 percent to 60 percent larval fish with raised areas or growths over the body or spinal curvature".

   A. Is this abnormality likely to be due to plant operation and if so, what plant-related factors have caused it? If not, what other factors have caused it?

RESPONSE

The 30 to 60 percent figure was an estimate based on visual observation. Actual numbers developed later by inspection revealed that only

6.9% of all fish sampled had raised areas or growths over the body or spinal curvature. Approximately 1/4% of the sampled fish had spinal curvature, all restricted to the discharge canal. No individuals were affected by both abnormalities. Therefore the two abnormalities are considered to be completely independent. There is a possibility that the spinal curvature is associated with plant operation since it appears to be a phenomenom unique to the discharge embayment. However, we have been unable to identify any connection. It is very unlikely that the growths or raised areas are caused by plant operation. The first specimen collected with this feature was taken from the control area upstream of the plant in a recessed cove.

Jim Wilson of the NRC staff has suggested the possibility of toxaphene effects causing both these abnormalities. The symptoms identified with toxaphene poisoning[5] do not coincide with the abnormalities we have identified, i.e. the raised areas or growths cannot be characterized as hemorrhaging and the "broken back syndrome" does not appear to correspond to lordosis as identified in our report. In addition, as previously stated, no individuals exhibited both features.

We offer no explanation for the identified abnormalities. We simply have not been able to identify any causes.

B. Is this abnormality likely to significantly affect the populations of the reservoir?

RESPONSE

No. As indicated earlier the frequency of occurrence is much lower than previous visual estimates indicated.

C. Does this observation invalidate previous analyses made by you concerning the impact of Unit 1 on the reservoir?

RESPONSE

No.

5. On page 50 it is stated that "On almost every collection trip from mid-May through June, dead but not deteriorated mussels were observed floating in every area of the reservoir".

A. Is this abnormality likely to be due to plant operation, and if so, what plant-related factors have caused it? If not, what other factors have caused it?

RESPONSE

During the period in which the dead mussels were identified the plant had been shut down for 2 months or more and some floating mussels were observed upstream of the plant. Therefore, it is highly unlikely that plant operation could have affected the mussels in the manner identified.

No cause has been identified. The only possibility theorized thus far has been suffocation due to shifting sand, silt and debris in the wake of high water. As indicated in the August 30, 1976, Semi-Annual Operating Report (page 31) flood level conditions with much trash existed immediately preceding the first observations of the dead mussels.

B. Is this abnormality likely to significantly affect the mussel populations of the reservoir?

RESPONSE

This question cannot be answered because the extent of the dieoff is not known, the population is indeterminate and whether the mussels died in the reservoir or in tributaries is unknown.

C. Is this related to the larval fish abnormality?

RESPONSE

We have been unable to postulate any relationship.

D. Does this observation invalidate previous analyses made by you concerning the impact of Unit 1 on the reservoir?

No.

REFERENCES FOR ATTACHMENT 1

1. Pennak, R. W.; Fresh-Water Invertebrates of the United States, p.99, 1953.

2. Houser, Al; South-Central Reservoir Investigations Group, U. S. Fisheries and Wildlife Service.

3. Beavers, Berry; Arkansas Game and Fish Commission, Lonoke Fish Hatchery.

4. Moon, Thomas; "Hydra in an Iowa Nursery Lake", Iowa Academy of Science. Vol. 58, 1951.

5. Mehrle, Paul and Mayer, Jr., Foster, "Toxaphene Effects on Growth & Bone Composition of Fathead Minnows Pimephales Promelas", Journal of the Fisheries Research Board of Canada, Vol. 32, No. 5, 1975.

ATTACHMENT 2

Discharge Temperature Fluctuations
For Spring 1976
During Shutdowns and Startups

Continuous operation near full power until March 19 when shutdown.

	TIME	°F*	
March 19	1600	67	
	1700	67	
	1800	67	
	1900	67	
	2000	66	
	2100	60	
	2200	57	
	2300	57	← non-critical at 2217
March 20	000	57	
	100	57	
	200	57	
	300	57	

Continuously shutdown until June 19 when started up.

	TIME	°F*	
June 19	1000	79	
	1100	79	
	1200	79	
	1300	79	
	1400	79	← critical at 1353
	1500	79	
	1600	79	
	1700	79	
	1800	79	
	1900	79	
	2000	79	
	2100	79	
	2200	79	
	2300	80	
June 20	000	80	
	100	80	
	200	80	
	300	80	
	400	81	
	500	81	
	600	81	
	700	81	
	800	81	

	TIME	°F*
	900	81
	1000	80
	1100	80
	1200	81
	1300	81
	1400	82
	1500	82
	1600	84
	1700	85
	1800	87
	1900	87
	2000	86
	2100	86
	2200	86
	2300	86
June 21	000	86
	100	85
	200	85
	300	86
	400	86
	500	87
	600	86
	700	87
	800	78 ← tripped at 0729
	900	Not available
	1000	Not available
	1100	78
	1200	78
	1300	79
	1400	79

Continuously shutdown until June 28 when started up.

June 28	TIME	°F*
	1700	79
	1800	79
	1900	79
	2000	79
	2100	81
	2200	83 ← critical at 2115
	2300	84
June 29	000	84
	100	89
	200	Not available
	300	88
	400	88

* as measured in the discharge flume.

SUMMARY OF ENTRAINMENT
AT
ARKANSAS NUCLEAR ONE
FROM
1977 THROUGH 1982

INTRODUCTION

Entrainment at Arkansas Nuclear One is defined as the passive movement of organisms in water through the plant's condenser cooling system. Of particular interest are larval fish entrained, and the impact their loss has on Dardanelle Reservoir. Mortality of these organisms is assumed to be 100% due to sudden water temperature increases, pressure, and turbulence.

Approach velocity at the confluence of the intake canal and the reservoir is less than or equal to 0.3 ft./sec., and increases to 3.0 ft./sec. at the most narrow point. It then reduces to approximately 1.5 ft./sec. along the remainder of the canal to the intake forebays. Each forebay is protected from trash, fish, etc. by a vertical traveling screen constructed of 3/8" wire mesh. Very small organisms are able to pass through the screens and enter the ANO condenser cooling system.

METHODS

Entrainment monitoring at ANO has been conducted since the spring of 1977. Nuclear Regulatory Commission technical specifications for this monitoring required once-a-month sampling, three times in a 24-hour period, at three depths, with each sample replicated. In other words, there were 18 five-minute stationary samples in a 24-hour period at the most narrow point in the intake canal (Figure 1).

Meter net data, obtained by Arkansas Tech University, was used for impact assessment. These samples were taken in the daylight hours, at the surface, and were replicated. Sampling was once a week from mid-March through June, and biweekly from July through mid-September. See Figure 1 for meter net sample areas.

Nets probably different?

DATA AND DISCUSSION

Of the six years of entrainment sampling, three years met minimal technical specifications (1978-1980). The other three years were sampled more frequently, usually twice a month in May and June. Peak spawning occurred in May and June in the meter net samples. Comparison of meter net data and entrainment data (Graphs 1-6) indicates that several peak spawning periods were missed when entrainment sampling was performed once a month. As a result, estimated entrainment losses may have been underestimated for some of the years.

As shown by meter net data, the intake bay area is one of the least productive areas of the four reservoir areas sampled (Table 1). The larvae in the intake area varied randomly from year to year ($P>.05$), as did the number of larvae entrained.

Entrainment samples were taken three times per day (8 a.m., 4 p.m., and 12 midnight), at three depths (surface, mid-depth, and near bottom), and were replicated. Therefore, meter net numbers for fish larvae as reported in past annual reports should be carefully applied to impact assessment of entrainment.

Over the six-year period, larval densities in the entrainment samples were greatest at night at 90.2%, 4.5% in the morning, and 5.3% in the afternoon. A further breakdown indicates .65% of the fish larvae were at the surface in the morning, 1.44% at mid-depth, and 2.41% at the bottom. Larvae in the afternoon samples were distributed throughout the water column with .69% at the surface, 2.22% at mid-depth, and 2.36% on the bottom. At night, there were 57.35% at the surface, 17.55% at mid-depth, and 15.33% at the bottom.

If the distribution of fish larvae in the water column and time of day for the entrainment samples was indicative of what one would find in the intake bay area, then meter net fish larvae densities reported in the meter net data were an extremely small portion of the larvae present during a 24-hour period, probably around .69%.

With the above entrainment percentages as a guide to calculate what might have been seen in the meter net samples had they been taken three times per day at three depths, an estimate of fish larvae densities for the intake bay area can be made. The average density per trawl (How are nets suspended?) over the six-year period for entrainment, and the estimated average density per trawl for meter net is found on Table 2. Use of these densities allows calculation of average entrainment losses for the six-year period. Approximately .07% of the estimated density of fish larvae in the intake bay area were entrained.

Night samples consistently had the greatest number of larval fish in the entrainment samples (Table 3). There does appear to be both a spatial and temporal distribution of fish larvae over a 24-hour period (top-right corner, Graphs 1-6). However, in the sample years 1978-1980, where sampling was less frequent, the spatial distribution was not that apparent. The surface area contained the greatest density of larval fish, while mid-depth and the bottom showed fewer larvae, and little difference between each other.

All species of fish except carp were entrained in the greatest densities in the night samples. Carp were most numerous in the morning samples (Table 4).

The Clupeidae species usually first appeared in the intake bay area around mid-to-late-April, and usually first appeared in the entrainment samples a week or so later, from mid-April to mid-May. Peak larval density in the bay occurred early in May, and lasted through late June. Entrainment peaks occurred at approximately the same time. Both meter netting and entrainment indicated two spawns for the Clupeidae species in 1980; the latter one began the first of August, and lasted into the first of September. The probable cause for the second spawn might have been due to an extended spawning season caused by an unusually long, hot, dry summer. No other obvious second spawn has been observed for the Clupeidae species during the six-year period.

Entrainment data showed the species to be concentrated at mid-depth and the bottom during the daylight hours, then coming to the surface at night (Graph 7). The greatest density was at the surface, and the least at mid-depth and the bottom (Graph 9).

What % of ent. samples?

Morone species, usually white bass, first appeared in the bay area around mid-April and were found in the entrainment samples in late April. The peak spawning period was mid-April through mid-June. Entrainment peaks were in late April to late May. The larvae of this species was not seen in the meter net samples after mid-June.

Morone species made up less than 1% to 12% of the entrainment samples, and were more prevalent in the entrainment samples (Graphs 19-21). >?

Entrainment data showed the species to be concentrated at mid-depth and the bottom in the daylight hours, and coming to the surface at night (Graph 7). There appeared to be a significant spatial distribution, with the surface usually containing the greatest density (Graph 9).

Pomoxis species usually first appeared in mid-April in the meter net samples, and were usually first seen in the entrainment samples late April into May. Peak densities usually occurred in May, but varied from late April to mid-June. Only two peaks were observed in the entrainment samples, in 1977 and 1982. These were in late April through early June, and mid-May, respectively. The larvae of this species was not seen after late June in the meter net samples. No *Pomoxis* species was observed in the entrainment samples in 1979 or 1980.

Pomoxis species made up from less than 1% to 1% of the species composition in both the meter net samples and the entrainment samples (Graphs 19-21). They were usually found at the surface in both the daylight hours and at night. The greatest density was observed at night (Graph 7). They were not observed in the entrainment samples from 1978 through 1980. When they were observed in the other years, they were most numerous at the surface, and rarely observed at the bottom (Graph 13).

Lepomis species usually first appeared in the meter net samples around late April into late May. They were first observed in the entrainment samples in late May to early June. Peak densities occurred June through mid-August in the meter net samples, while peak entrainment occurred mid-June to mid-July. The larvae of this species was not observed in the meter net samples after August.

Lepomis species made up from less than 1% to 3% of the meter net samples and less than 1% to 4% of the entrainment samples. They were slightly more prevalent in the entrainment samples (Graphs 19-21).

The larvae were found exclusively at the surface during the daylight hours, then mixed throughout the water column at night (Graph 7). They were most numerous at the surface (Graph 12).

Cyprinidae species usually first appeared in the entrainment samples, rather than the meter net samples. Their first appearance in the entrainment samples varied from late April through July; they first appeared in the meter net samples late April to June. Peak densities in the meter net samples occurred in early June. There were only two entrainment peaks, one in late May, 1978, and late June through mid-July in 1980. No *Cyprinidae* species were observed in the entrainment samples in 1979.

They made up less than 1% to 1% of the species composition in the meter net samples and the entrainment samples. They were slightly more prevalent in the entrainment samples (Graphs 19-21).

Cyprinidae species were most often observed at night at the surface (Graph 7). They showed great diversity of distribution throughout the water column in the entrainment samples. In four out of five years they were observed, they were 100% at some particular depth. With the data available, it was impossible to determine whether they dominated any level in the water column (Graph 13).

Freshwater drum larvae usually first appeared in the entrainment samples around mid-May, then were usually observed in the meter net samples in late May to early June. They were usually observed each year in the entrainment samples, but were not observed in the meter net samples in 1978, 1980, and 1981. They reached peak spawning densities in the meter net samples around late May to early June, and were present for a very short period of time. Entrainment peak densities occurred early-to-late June, sometimes at the last of July. Larvae of this species were usually not seen after July in the meter net samples. No freshwater drum were observed in the entrainment samples in 1978.

Freshwater drum made up less than 1% of the meter net samples, and from less than 1% to 7% of the entrainment samples (Graphs 19-21). They were observed exclusively at mid-depth and the bottom during the daylight hours, then mixed in the water column, with the greatest density at night at the surface (Graph 8). They were found 100% at the surface in 1981, and 1982.

Atherinidae species, usually Mississippi silversides, varied greatly in their first appearance in the meter net samples. They were observed as early as late April, and as late as the last of July. They first appeared in the entrainment samples in late April to late June. No Atherinidae species were observed in the entrainment samples in 1978, and 1982. Peak densities in the meter net samples occurred anywhere from May to early August. Only two entrainment peaks were observed, one in late June, 1977, and the other in mid-May, 1981. The time at which the species was last observed in the meter net samples varied from early June to September.

The Atherinidae larvae made up less than 1% of the species composition for both meter net and entrainment samples (Graphs 19-21). They were not observed in the morning entrainment samples, some were observed in the afternoon samples, and none were found at the bottom. They were most numerous at night at the surface. At night, no larvae were observed at mid-depth, but were collected from the bottom (Graph 7).

When entrainment sampling was performed more than once per month, Atherinidae species were observed at the greatest densities at the surface (Graph 15).

Catostomidae species were usually first observed in the meter net samples in mid-April, and as late as mid-June. When they did appear in the entrainment samples, it was usually in mid-May. Peak densities occurred late in May through June, while they peaked in the entrainment samples in mid-June. No Catostomidae species were observed in the entrainment samples in 1977, 1978, 1979, and 1981. They were not observed in the meter net samples after mid-July.

The Catostomidae species made up less than 1% of the species composition of the entrainment samples, and from less than 1% to 7% of the meter net samples. They were more prevalent in the meter net samples (Graphs 19-21).

The larvae were observed at the bottom of the water column in the daylight hours, and rising to the surface at night. They were most numerous at the surface at night (Graph 8). When present, they were more prevalent at the surface than at mid-depth and the bottom (Graph 17).

Carp were never identified in the meter net samples, and were only observed twice in the entrainment samples, 1978, and 1982. Their first appearance was late in May, 1978, and late June, 1982. Carp larvae were never observed after June.

They made up less than 1% to 1% of the species entrained (Graphs 19-21). They were never observed in the bottom entrainment samples, nor were they observed at any level in the water column in the afternoon. They were most numerous in the morning at the surface, and when observed at night, they were found exclusively at the surface (Graph 8). The larvae were most prevalent at the surface (Graph 16).

Channel catfish were never observed in the meter net samples, and were only observed once on June 13, 1977, in the entrainment samples. They were located at mid-depth at night (Graphs 8 and 18).

Micropterus species were never observed in the entrainment samples, and were not observed in the meter net samples in 1977, 1978, and 1981. The larvae first appeared in mid-April to early May, and were present for less than a week. They were never observed after early May.

Percidae species were never observed in any of the entrainment samples. They were observed in the meter net samples every year except 1981. They usually first appeared in mid-April. Peak densities occurred in mid-April to the first of May. They were not observed after early June.

In the summer of 1983, a few meter net trawls were performed at night at the surface at all four sample stations. The few samples confirmed the assumption that there were significantly more larvae present at night than during the daylight hours.

CONCLUSION

Since the *Clupeidae* species were the most entrained fish larvae, and since the species has been able to reestablish itself in the intake area and the reservoir each year, it does not appear that entrainment is having a significant impact on the *Clupeidae* species, nor is there any evidence that entrainment losses have had a significant impact on the other species of fish observed.

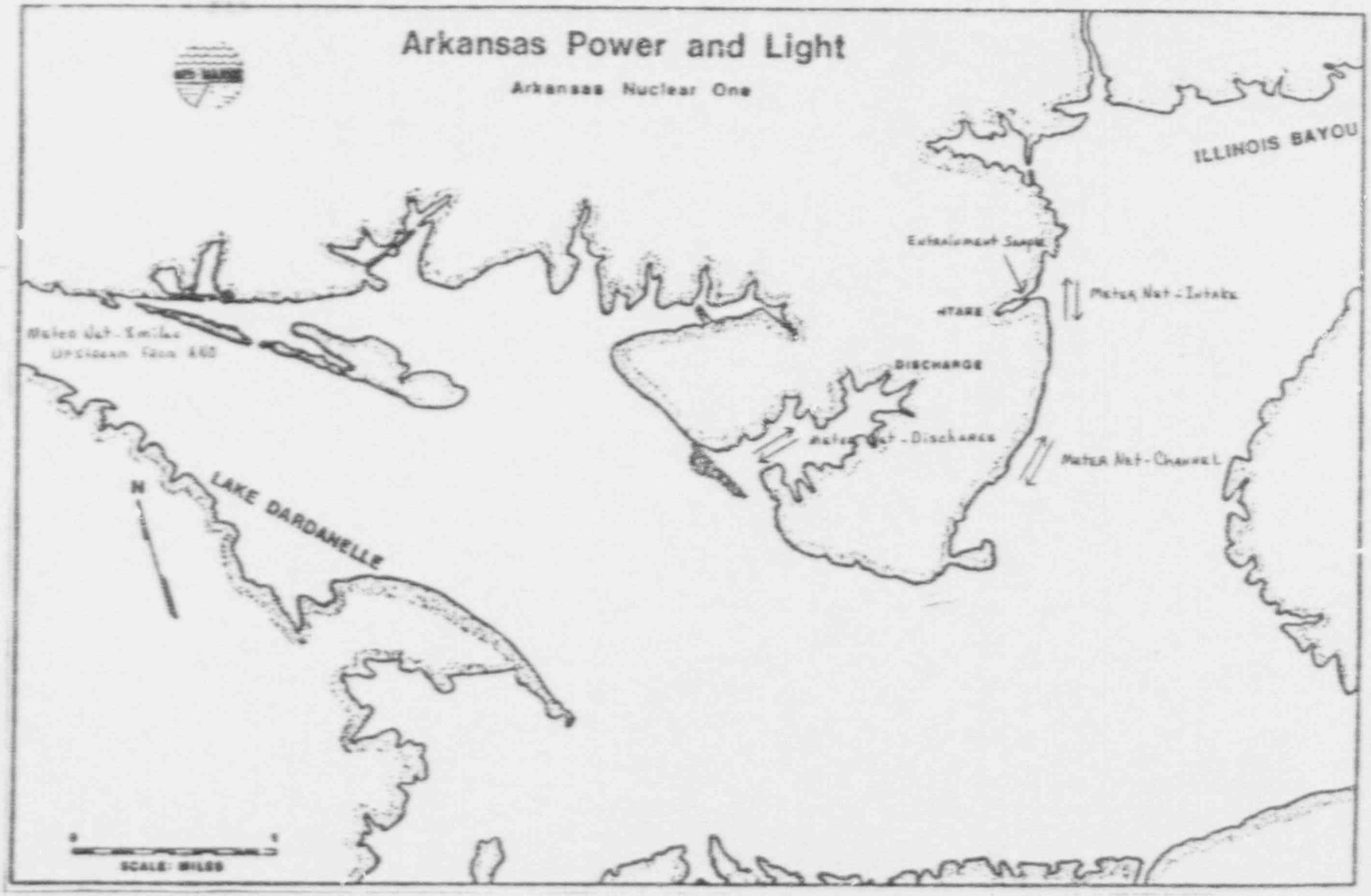


FIGURE 1: MAP SHOWING LOCATION OF ENTRAINMENT SAMPLE AND THE FOUR METER NET SAMPLE AREAS.

TABLE 1: LIST OF LARVAL FISH CAUGHT EACH YEAR FOR ENTRAINMENT SAMPLES AND THE FOUR SAMPLE AREAS IN DARDANELLE RESERVOIR. REPLICATES ARE COMBINED.

YEAR	ENTRAINMENT	INTAKE	DISCHARGE	CHANNEL	BACKWATER
1974		1551	3558	1975	6052
1975		3717	4496	4880	38201
1976		5774	8815	9546	23581
1977	1088	5769	4455	11970	14807
1978	1212	6318	7134	13363	102137
1979	218	6864	12027	13734	60481
1980	554	10763	9692	234896	142937
1981	836	3073	1782	15053	18681
1982	2478	29135	9492	8607	29752

$\Sigma = 6386$

$\bar{x} = 1064.33$

Are these total #'s of all species caught, in a standard amount of sampling effort?

TABLE 2: AVERAGE NUMBER OF LARVAE/1000M³ FOR ENTRAINMENT SAMPLES (1977-1982 COMBINED) AND THE ESTIMATED NUMBER OF LARVAE/1000M³ FOR METER NET SAMPLES (1977-1982 COMBINED) IN THE INTAKE BAY AREA.

	8 A.M.			4 P.M.			12 MIDNIGHT		
	SURFACE	MID-DEPTH	BOTTOM	SURFACE	MID-DEPTH	BOTTOM	SURFACE	MID-DEPTH	BOTTOM
METER NET	81575	180721	302456	86595	278611	296181	7197446	2202531	1923921
ENTRAINMENT	56	124	207	59	191	202	4955	1506	1316
PERCENT OF TOTAL	.65%	1.44%	2.41%	.69%	2.22%	2.36%	57.35%	17.55%	15.33%

— Σ = 8,616 (across)

Σ %, 757.33

= close to previous page

— In each case, the "entrainment" number is ≈ 0.0006 of the "meter net" samples.

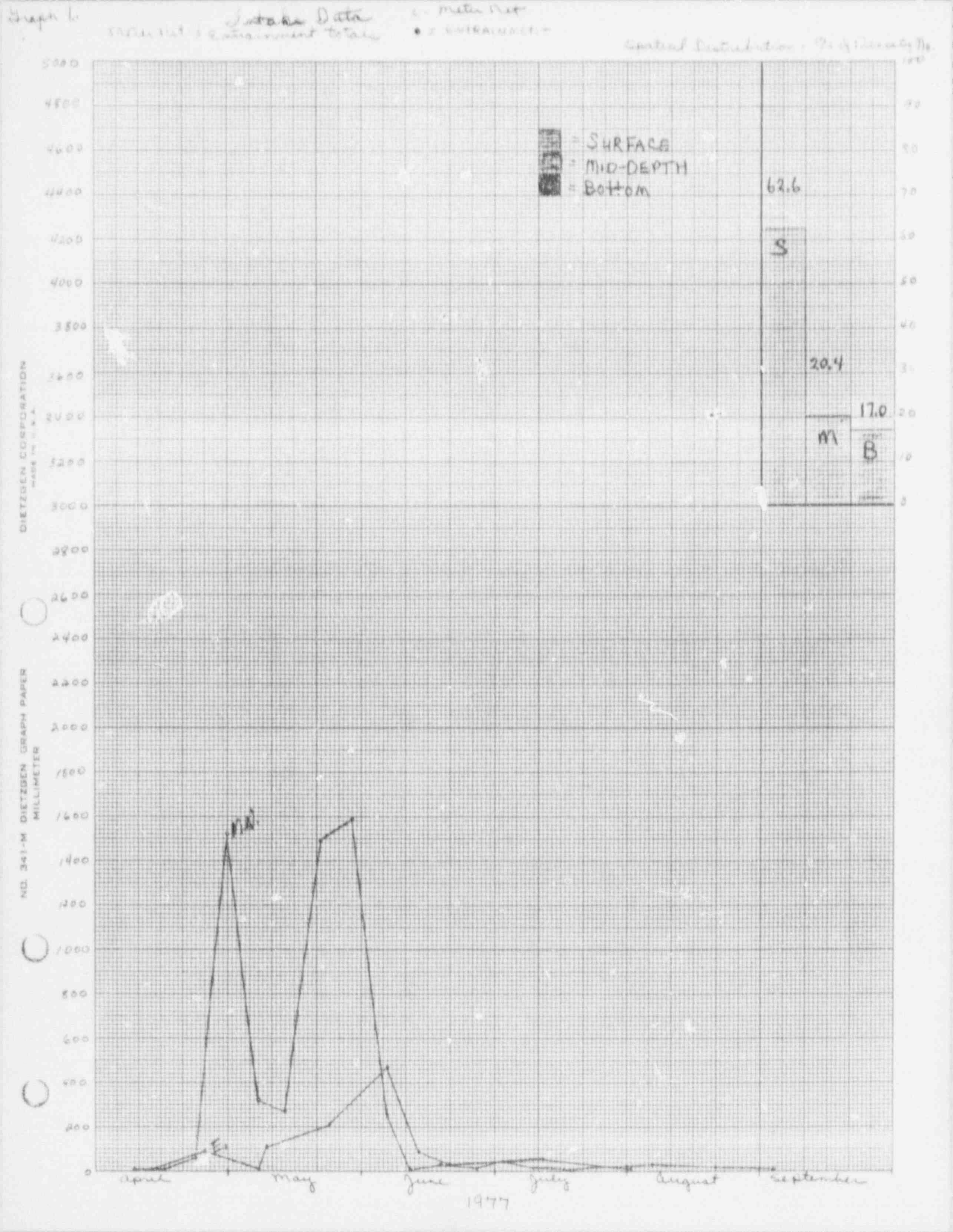
Apparently, meter net samples have been synthesized from entrainment samples, assuming a constant ratio of densities apparently derived from some comparisons of ent. vs trawl densities for the few samples taken at the same time of day.

TABLE 3: PERCENT OF LARVAL FISH DENSITIES ENTRAINED BY TIME OF DAY AND YEAR.

YEAR	8 A.M.	4 P.M.	12 MIDNIGHT
1977	4.11%	9.45%	86.44%
1978	14.63%	16.93%	68.44%
1979	4.86%	1.78%	93.36%
1980	8.09%	8.31%	83.60%
1981	2.30%	1.57%	97.54%
1982	3.95%	3.94%	92.11%

TABLE 4: EACH SPECIES PERCENT DENSITY DURING THE THREE TIME PERIODS WITHIN 24 HOURS AVERAGED OVER THE SIX-YEAR PERIOD OF ENTRAINMENT SAMPLING (1977-1982).

SPECIES	8 A.M.	4 P.M.	12 MIDNIGHT
CLUPEIDAE SPECIES	4.5%	6.8%	88.7%
CYPRINIDAE SPECIES	6.0%	30.0%	64.0%
CHANNEL CATFISH	0.0%	0.0%	100.0%
MORONE SPECIES	12.3%	5.6%	82.1%
LEPOMIS SPECIES	4.2%	1.3%	94.5%
POMOXIS SPECIES	9.0%	2.8%	88.2%
FRESHWATER DRUM	3.7%	2.2%	94.1%
ATHERINIDAE SPECIES	0.0%	11.8%	88.2%
CATOSTOMIDAE SPECIES	16.5%	1.8%	81.7%
CARP	82.3%	0.0%	17.7%

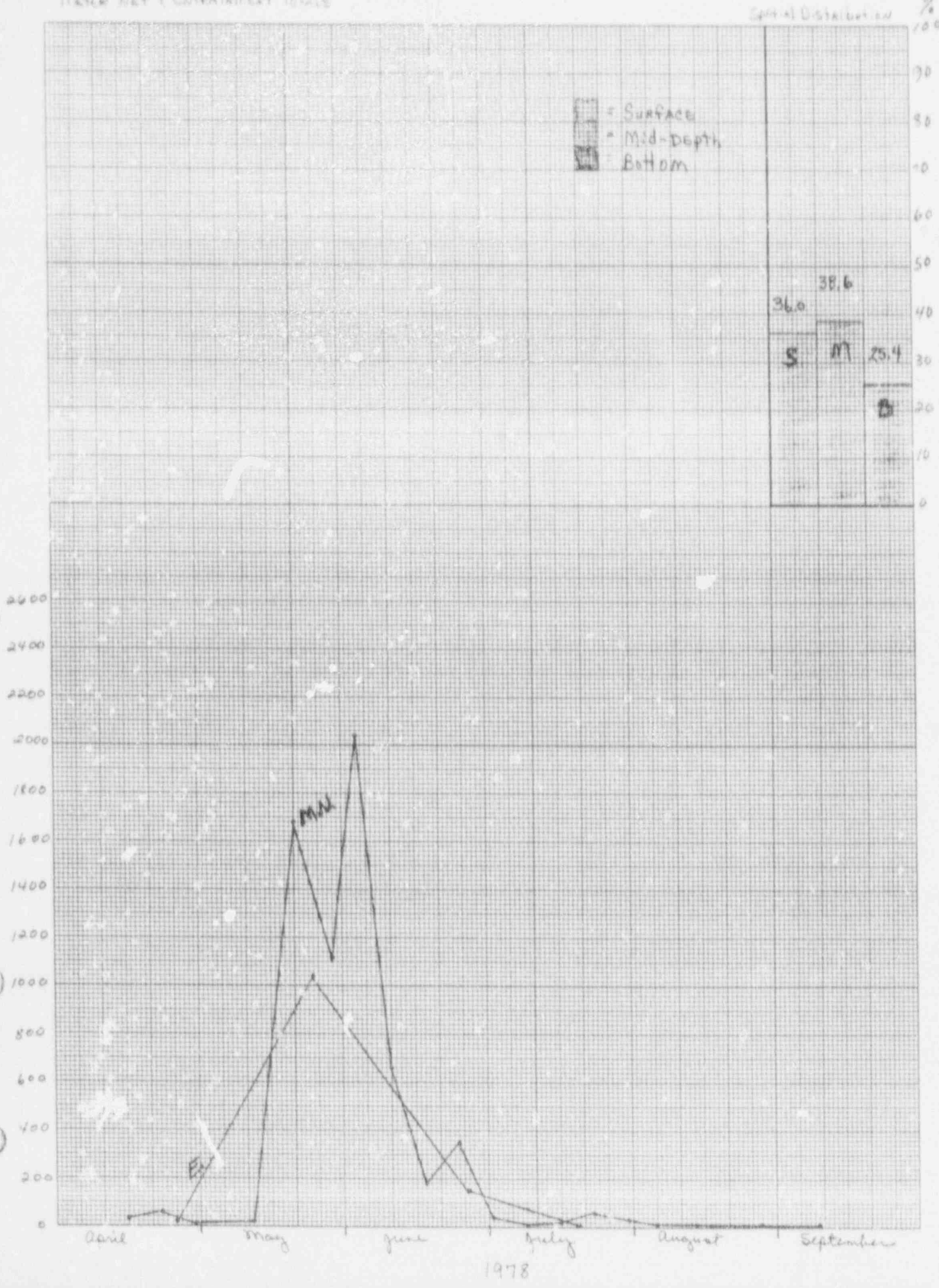


Graph 6
Intake Data
= SURFACE
= MID-DEPTH
= BOTTOM
62.6
S
20.4
M
17.0
B
NO. 341-M DIETZGEN GRAPH PAPER
MILLIMETER
DIETZGEN CORPORATION
April
May
June
July
August
September
1977

Graph 2. Intake Data

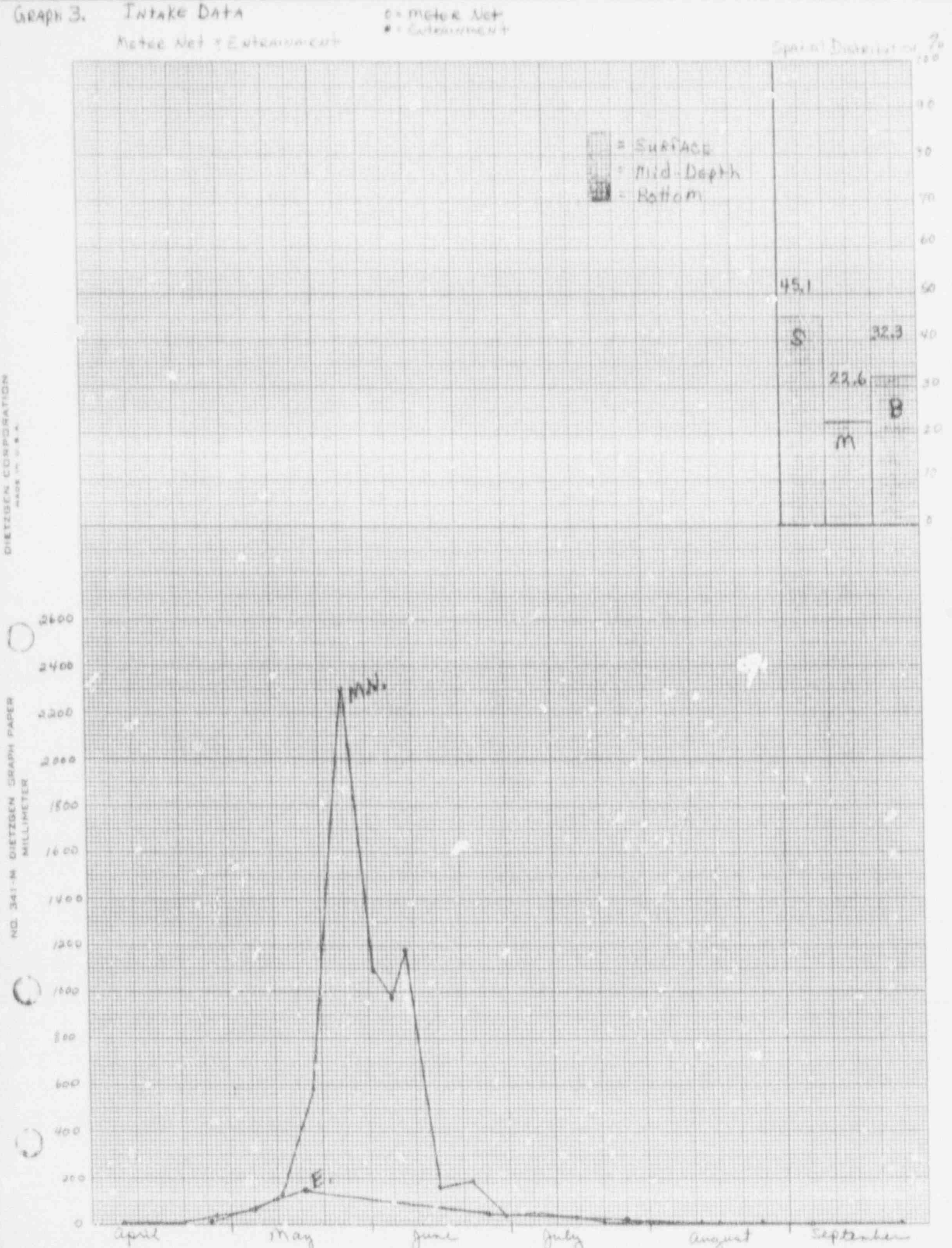
Meter Net & Entrainment Totals

o = Meter Net
• = Entrainment

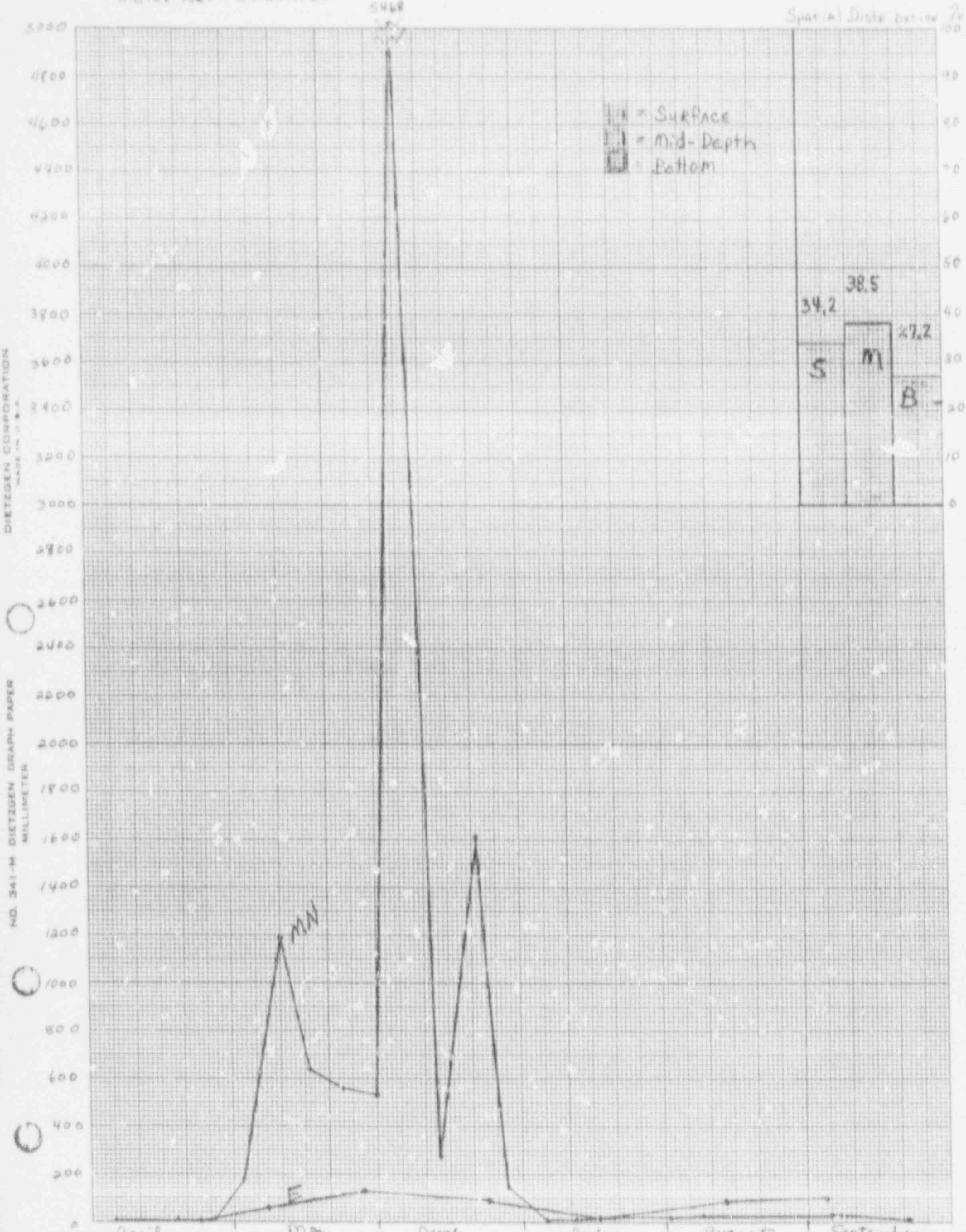


GRAPH 3. INTAKE DATA

Meter Net + Entrainment

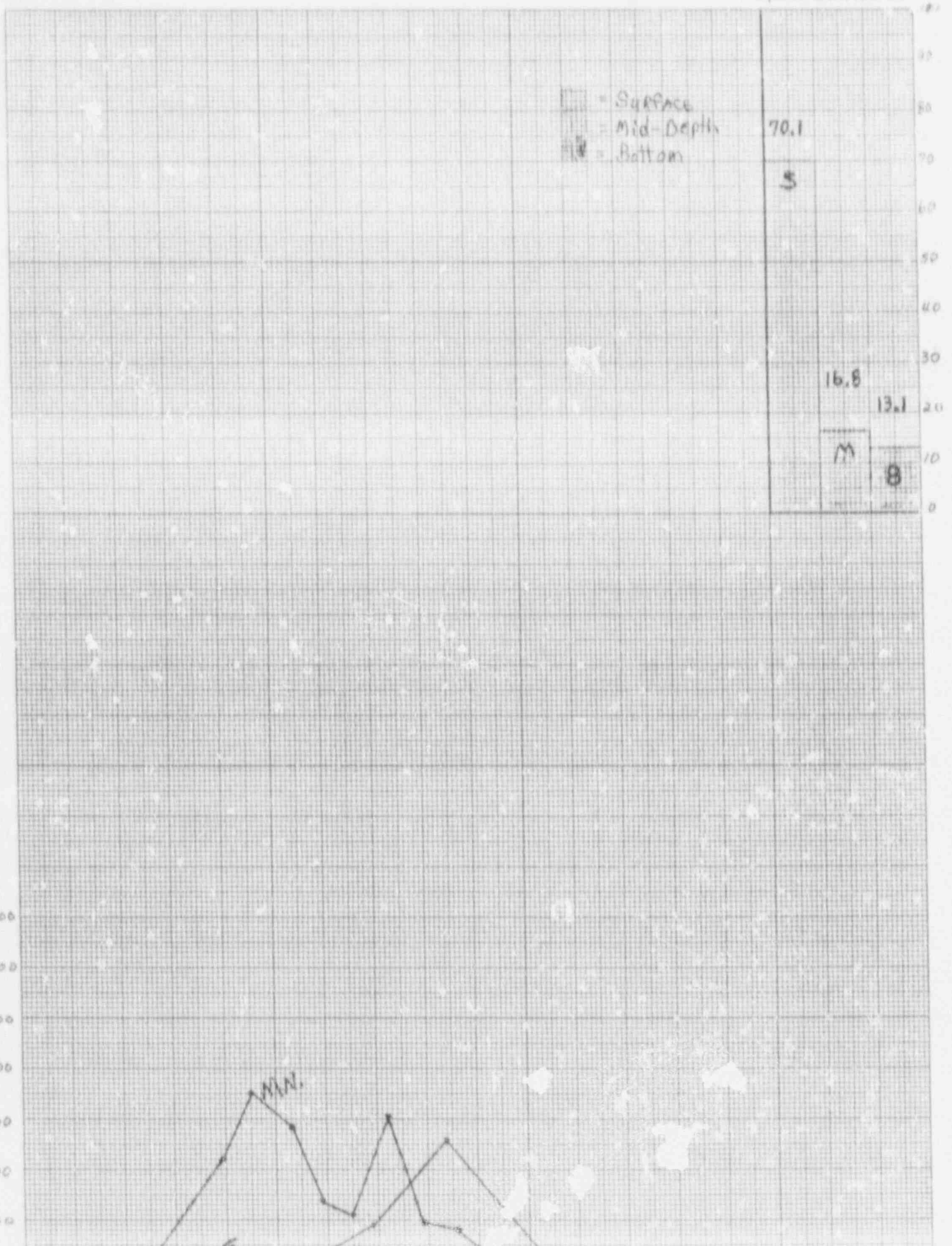


GRAPH 4 INTAKE DATA
Meter Net + Entrainment

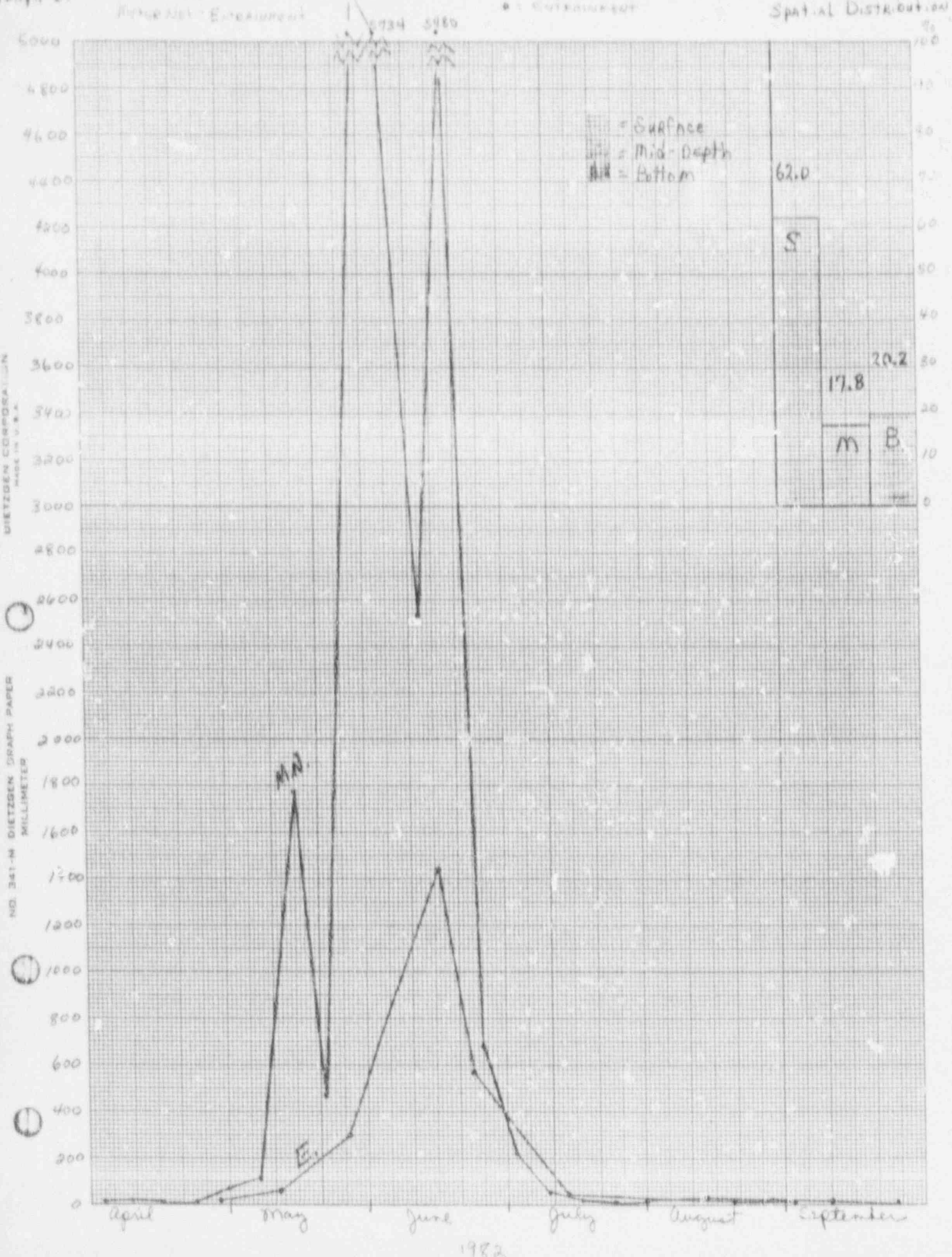


GRAPH 5. Intake Data

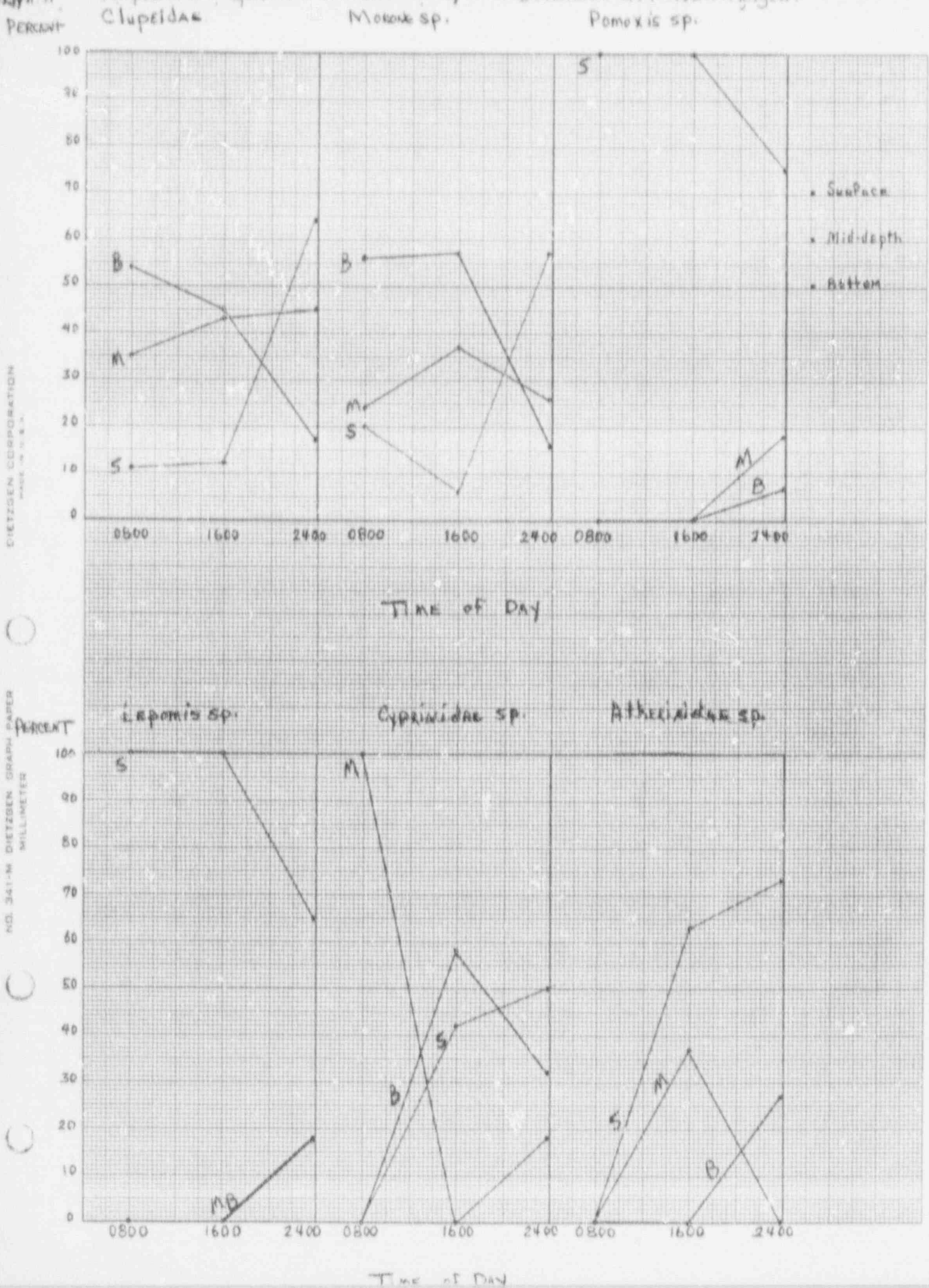
o = Meter Net



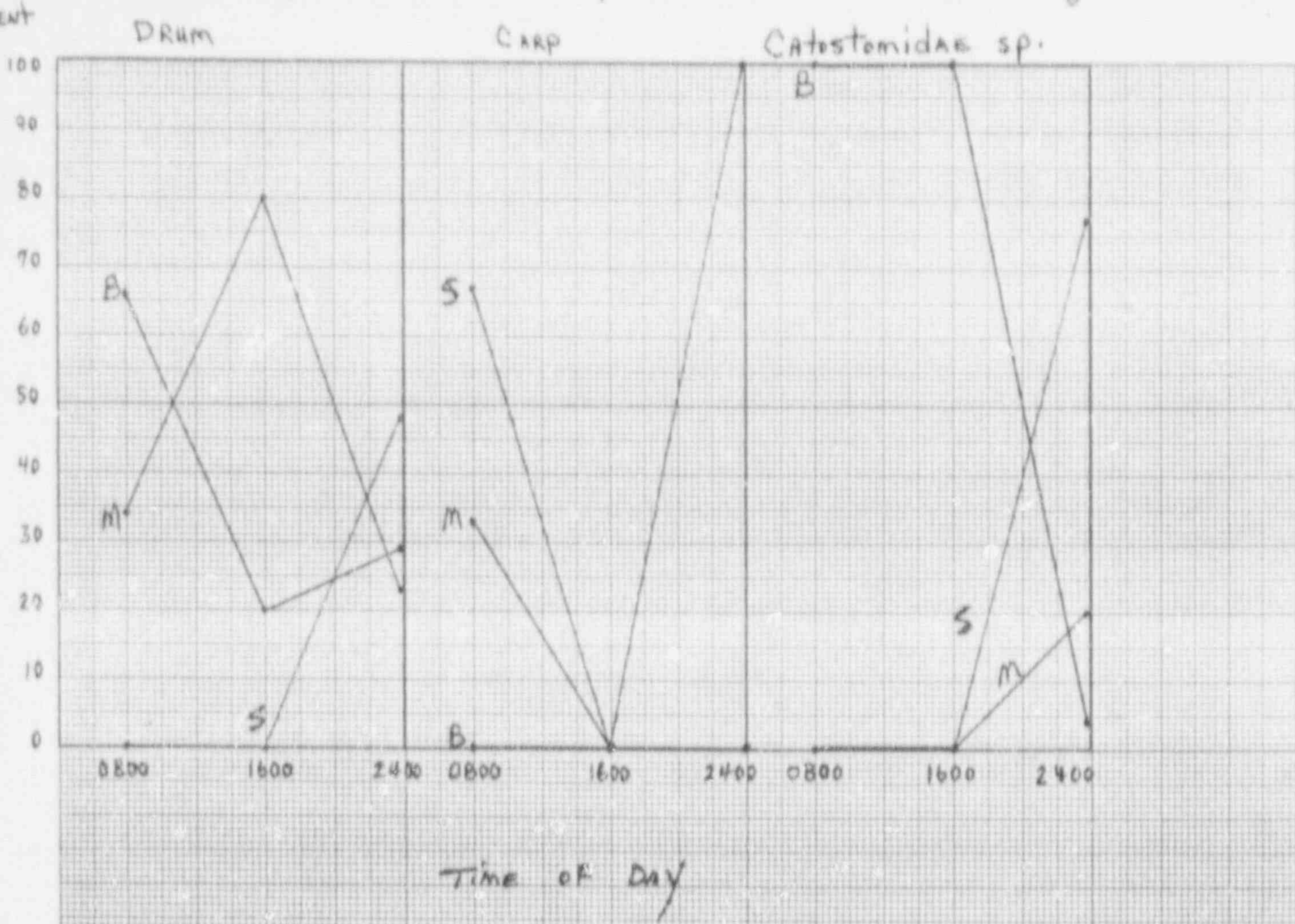
Graph 6. Intake Data

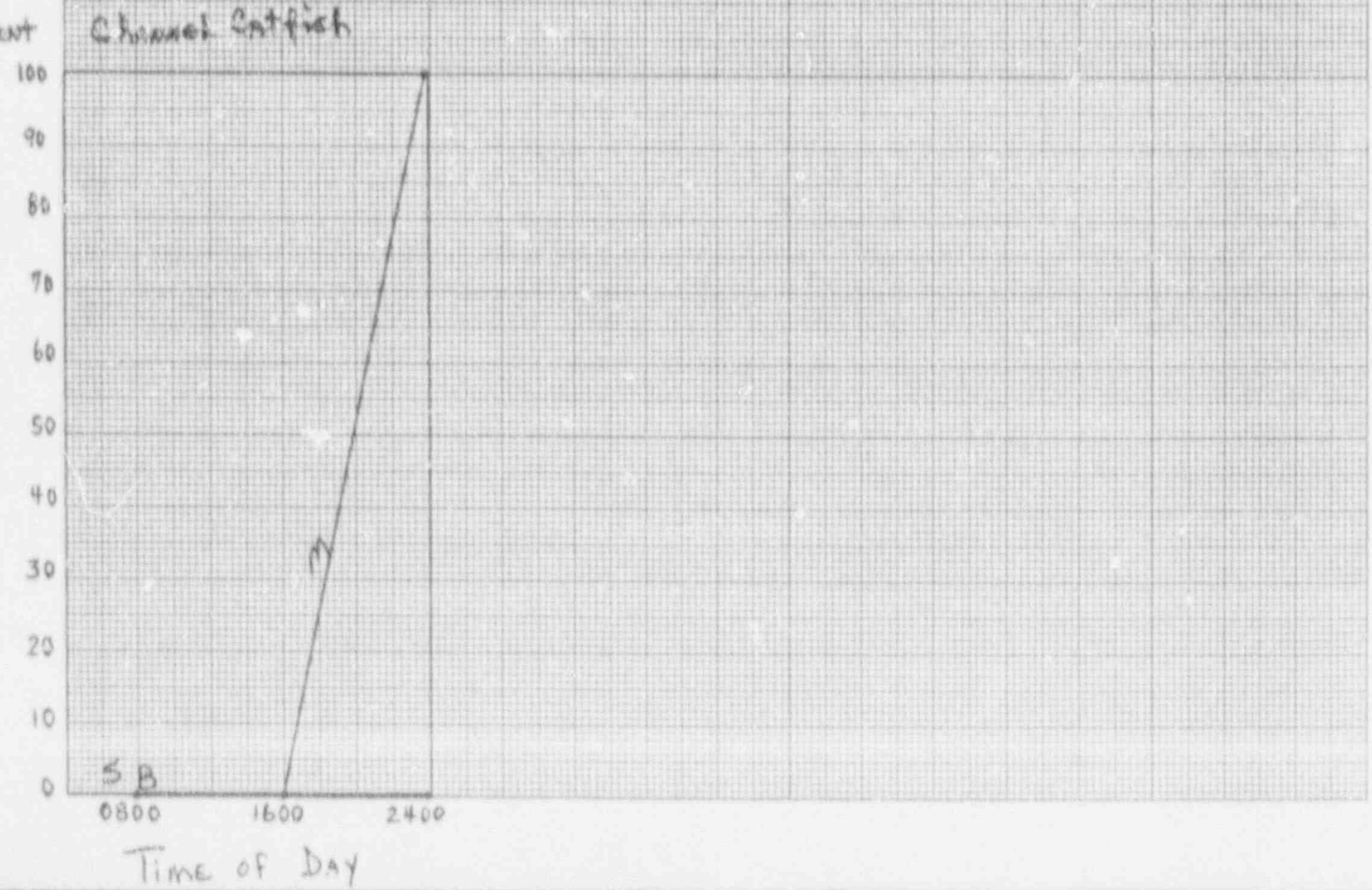


GRAPH 7. Temporal and Spatial Distribution of Species Entrained 1977-1982 Averaged.

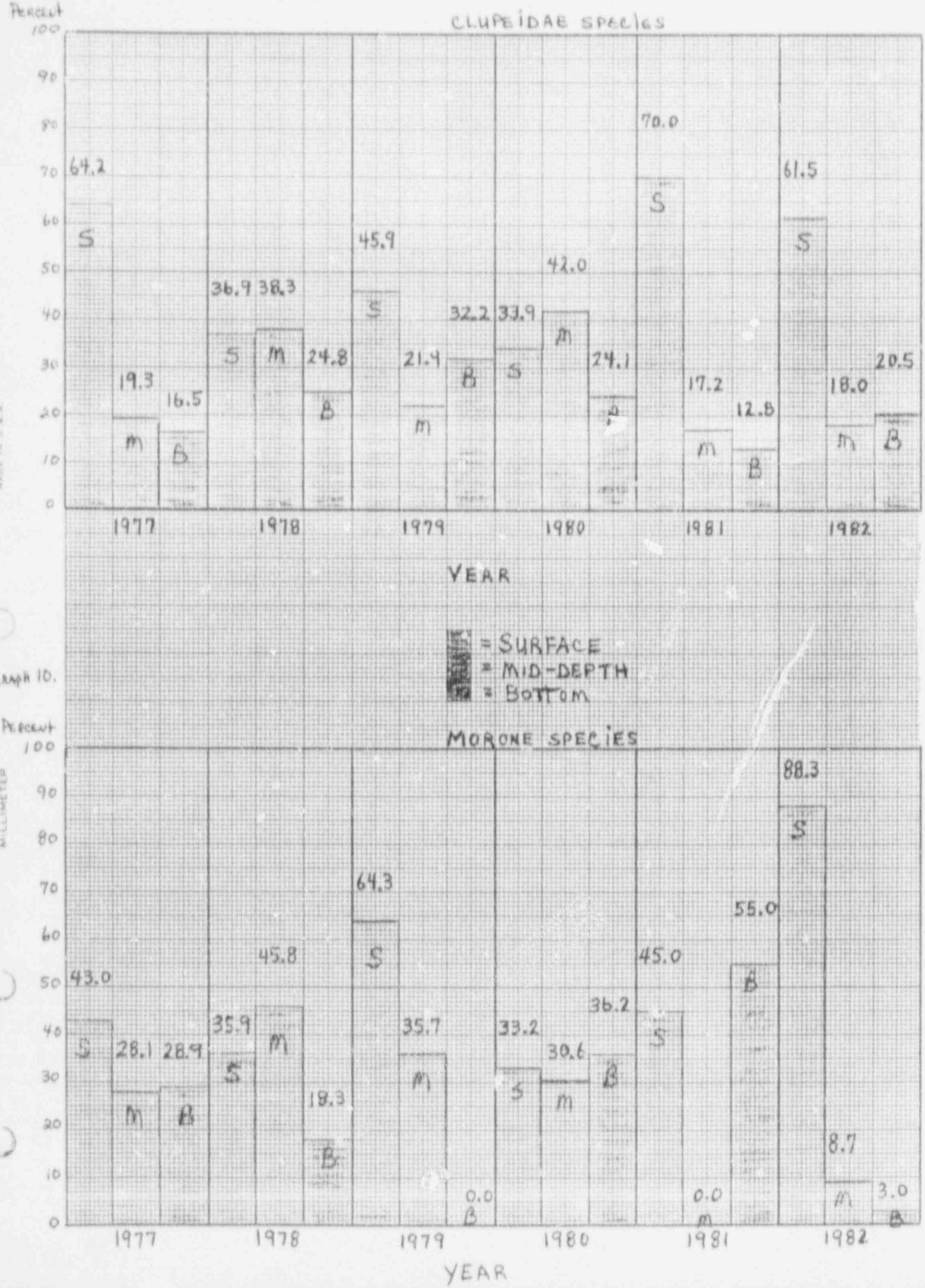


Graph 8. Temporal and spatial Distribution of species Entrained 1977-1982 averaged.



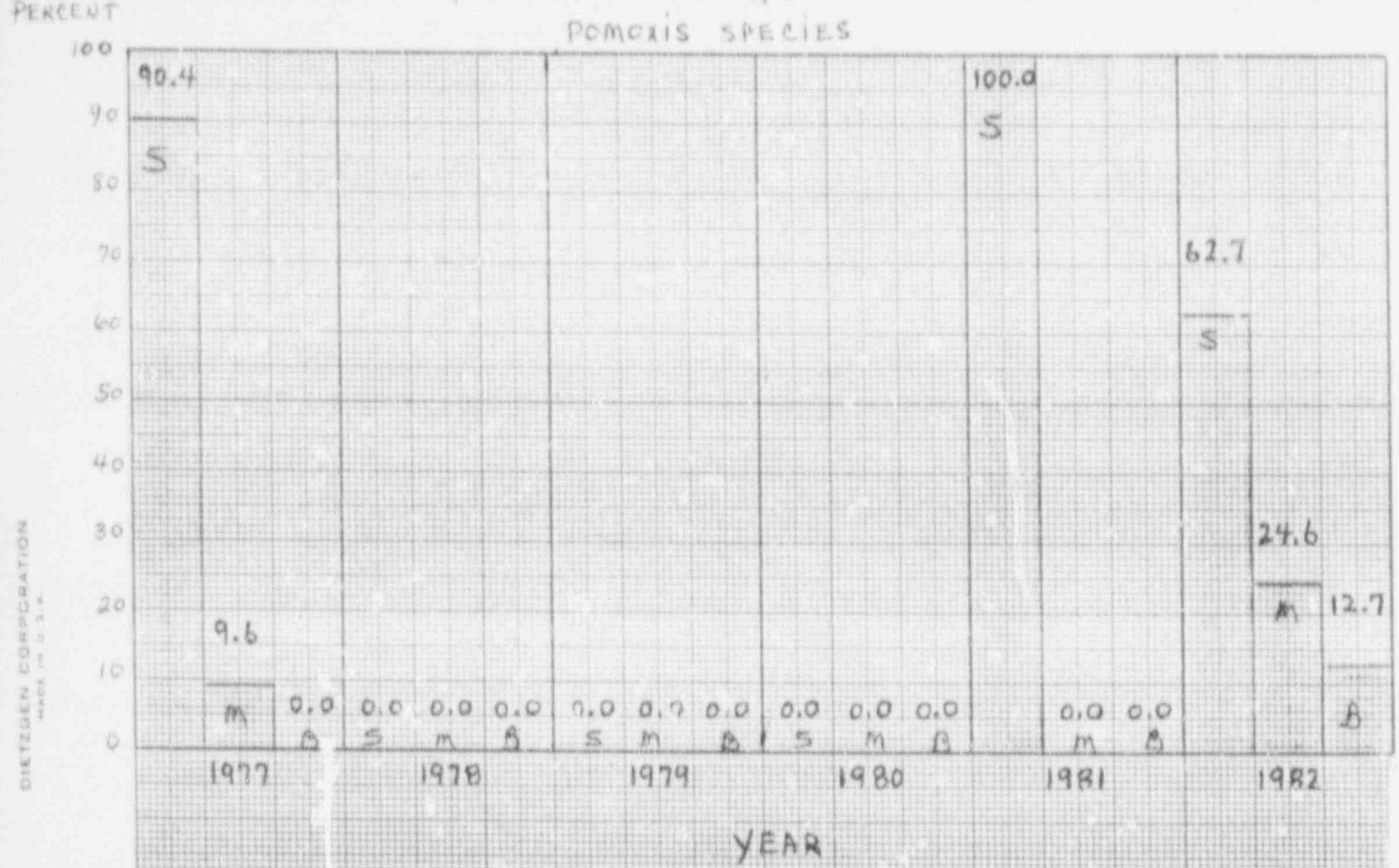


Spatial distribution by year for each family/species of fish entrained.

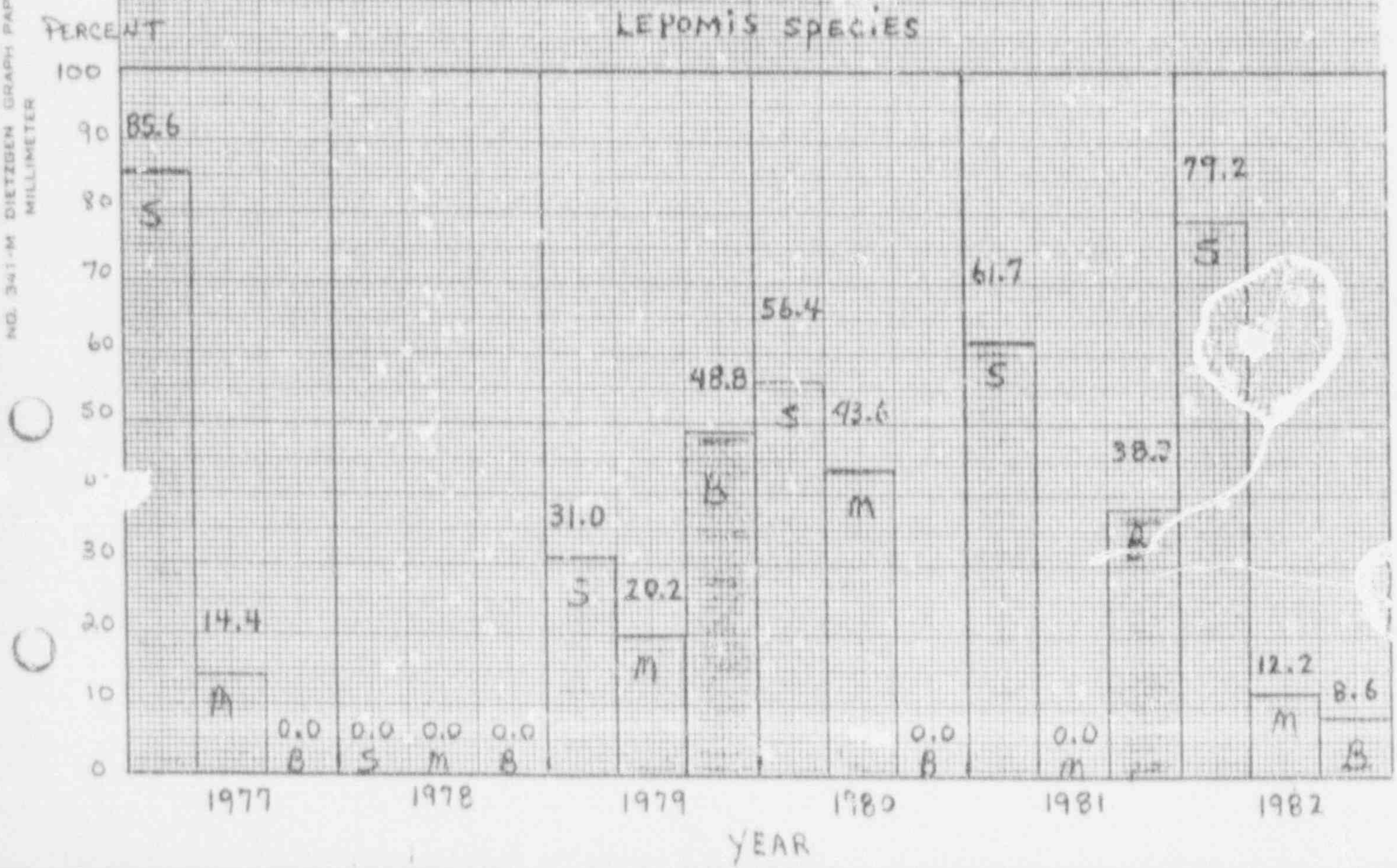


Graph 10.

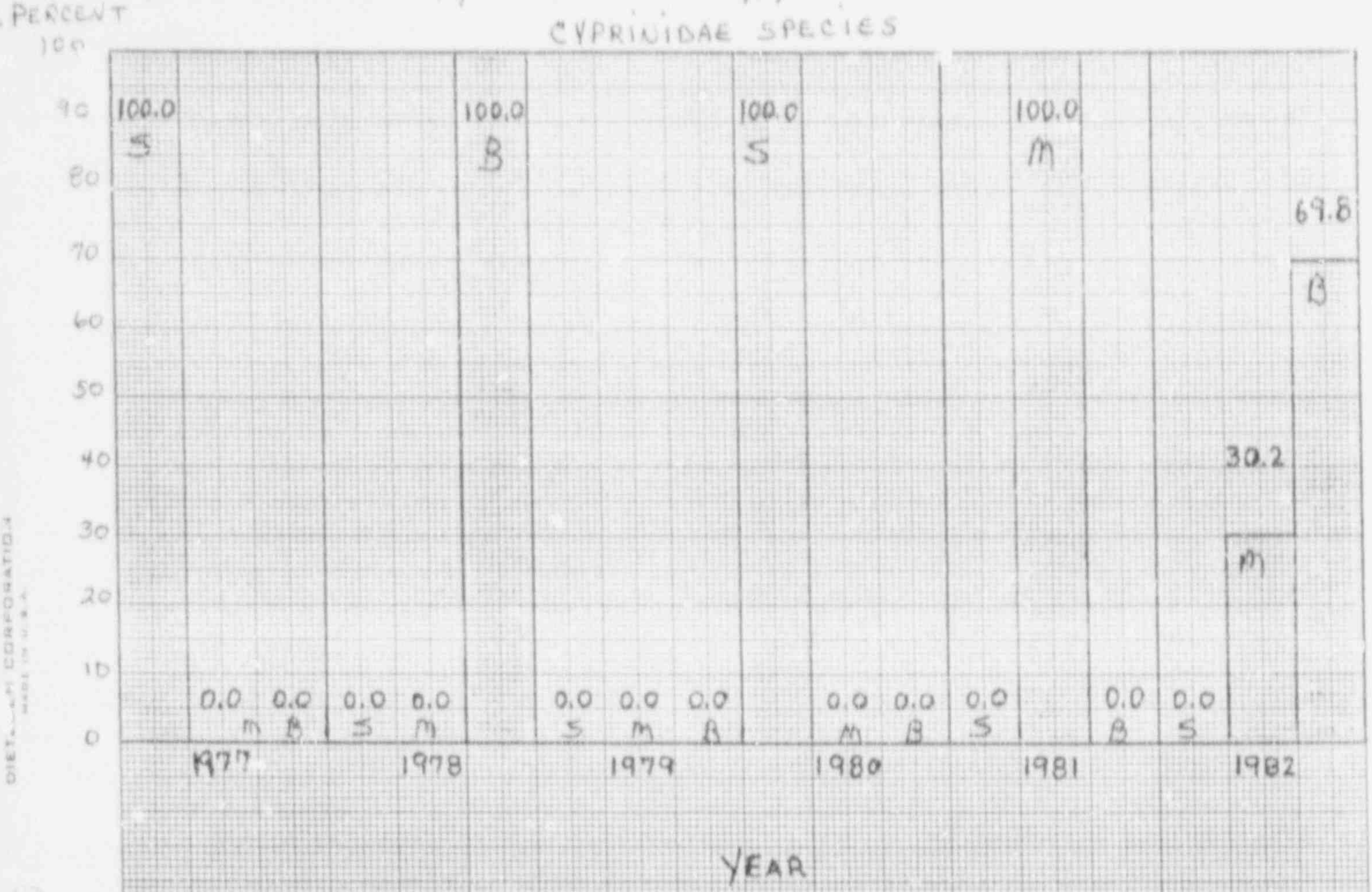
Graph 11. Spatial distribution by year for each family/species of fish Entrained.



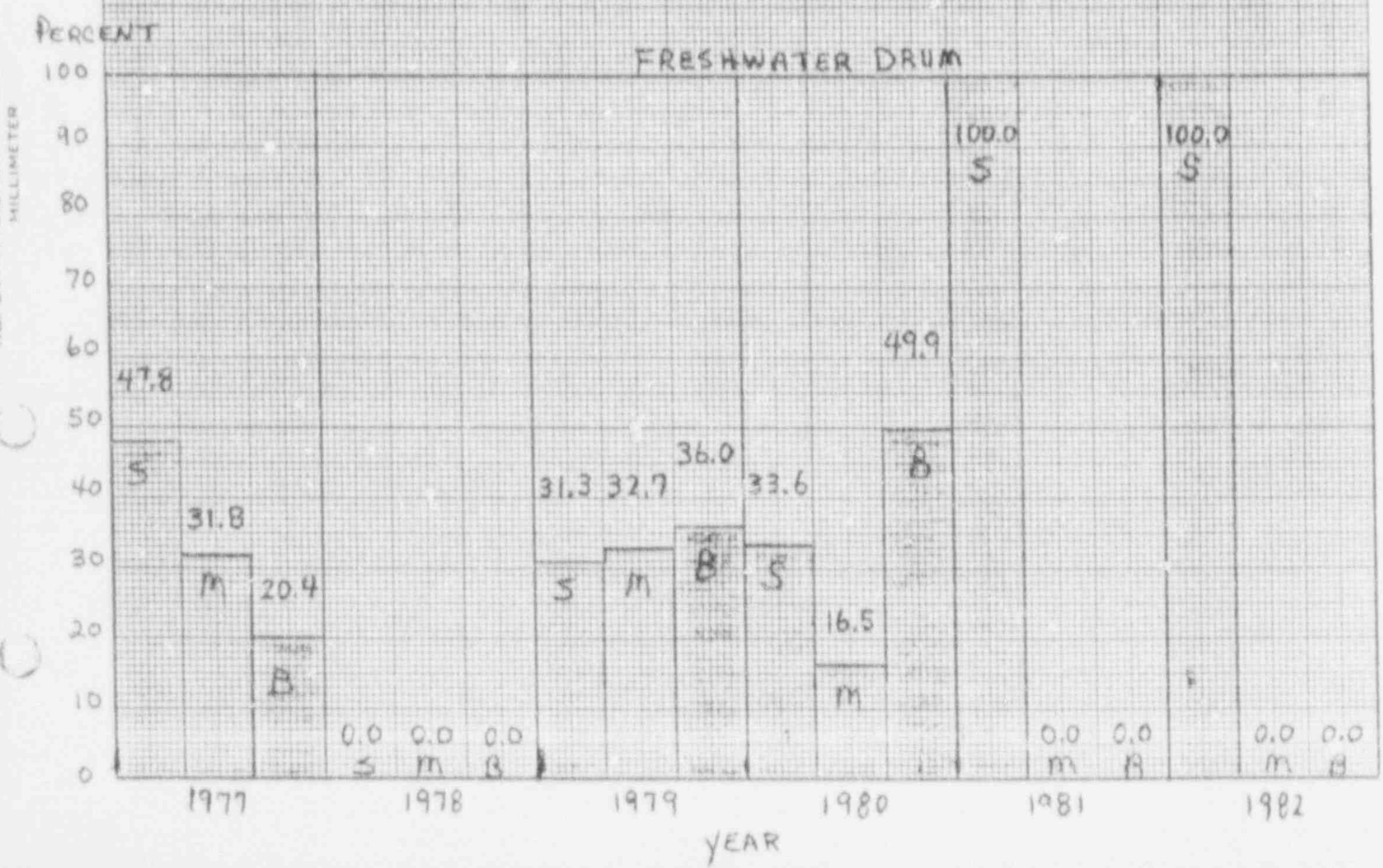
Graph 12.



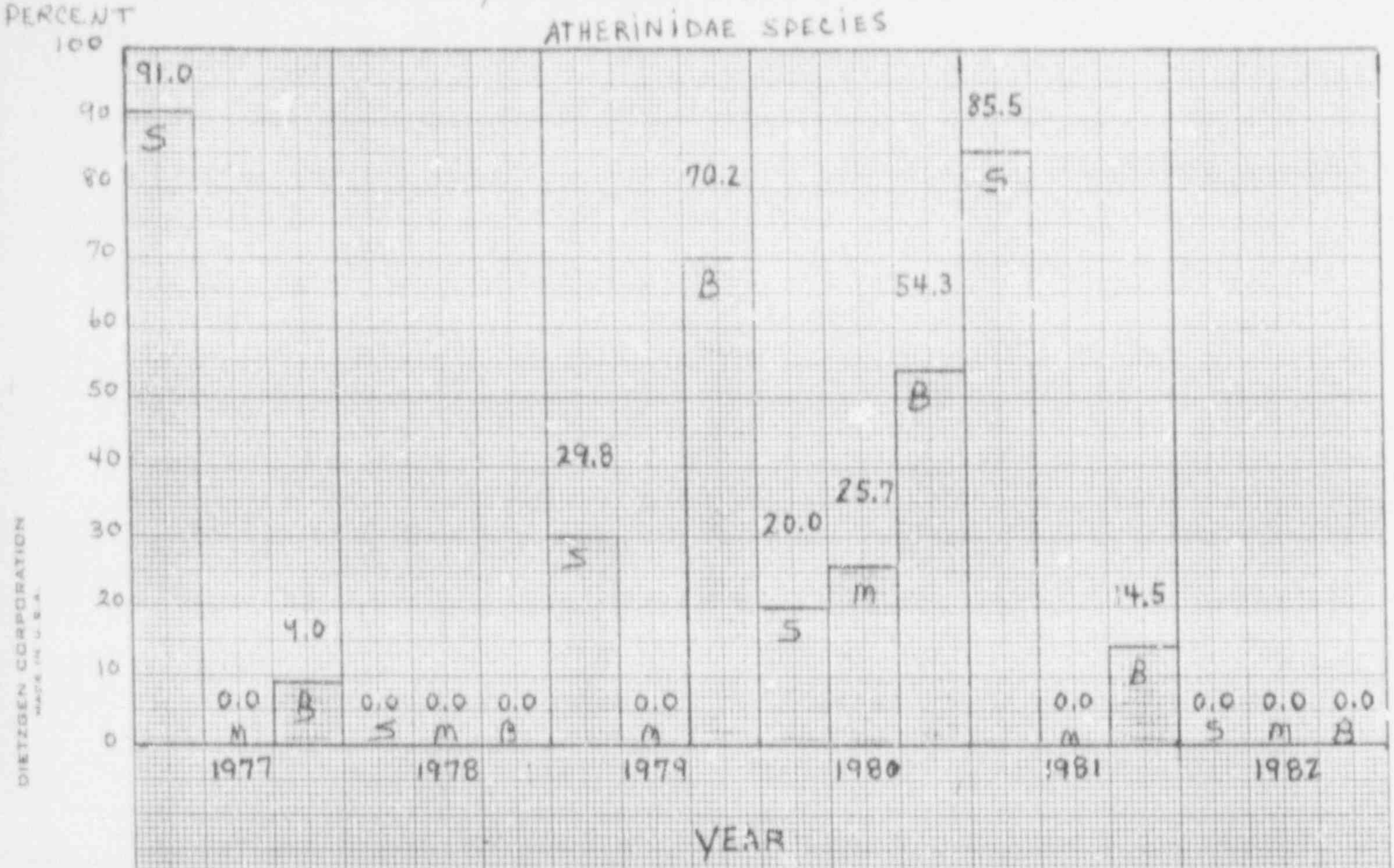
GRAPH 13. Spatial distribution by year for each family/species of fish Entrained.



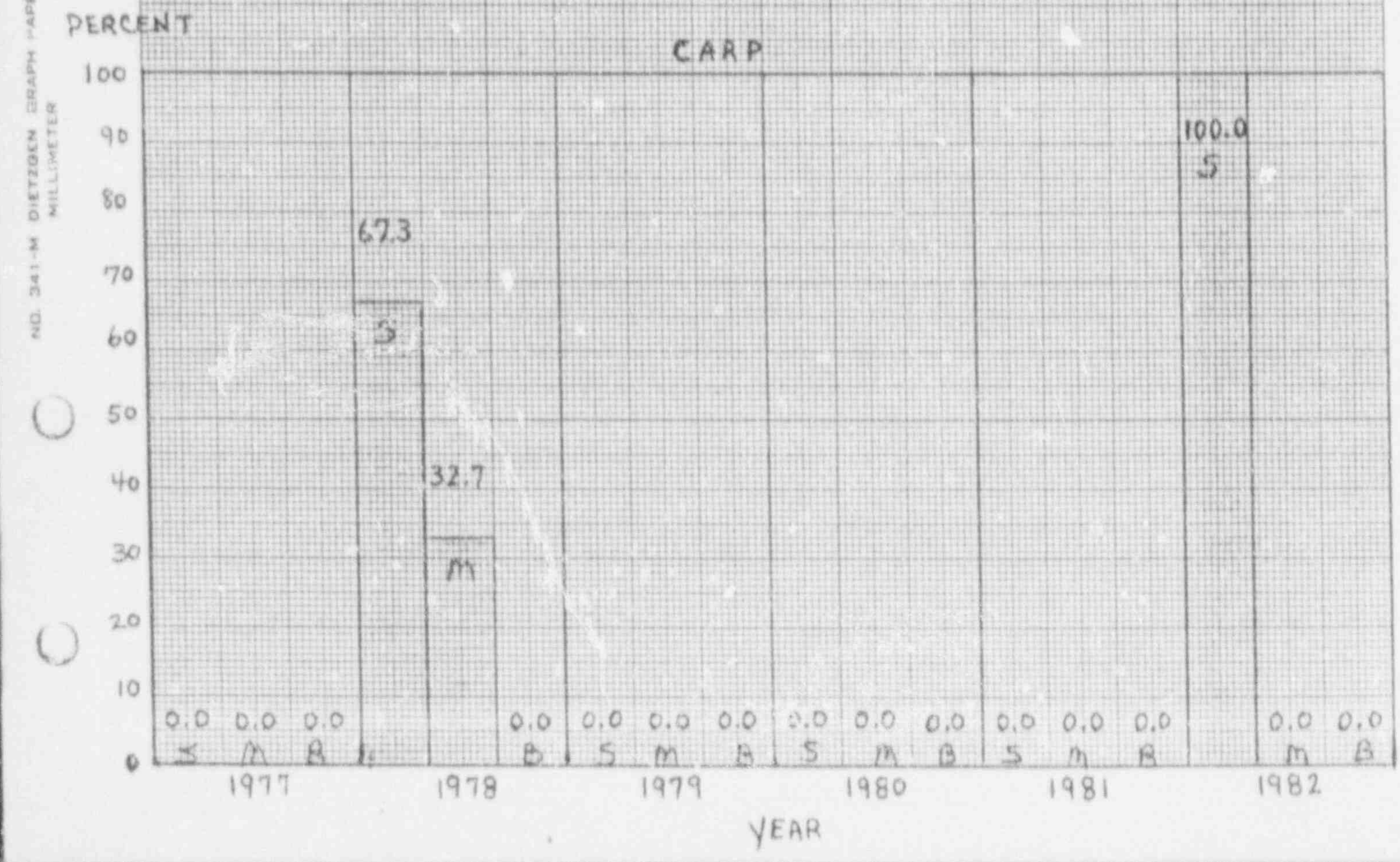
Graph 14.



Graph 15 Spatial distribution by year for each family/species of fish entrained.



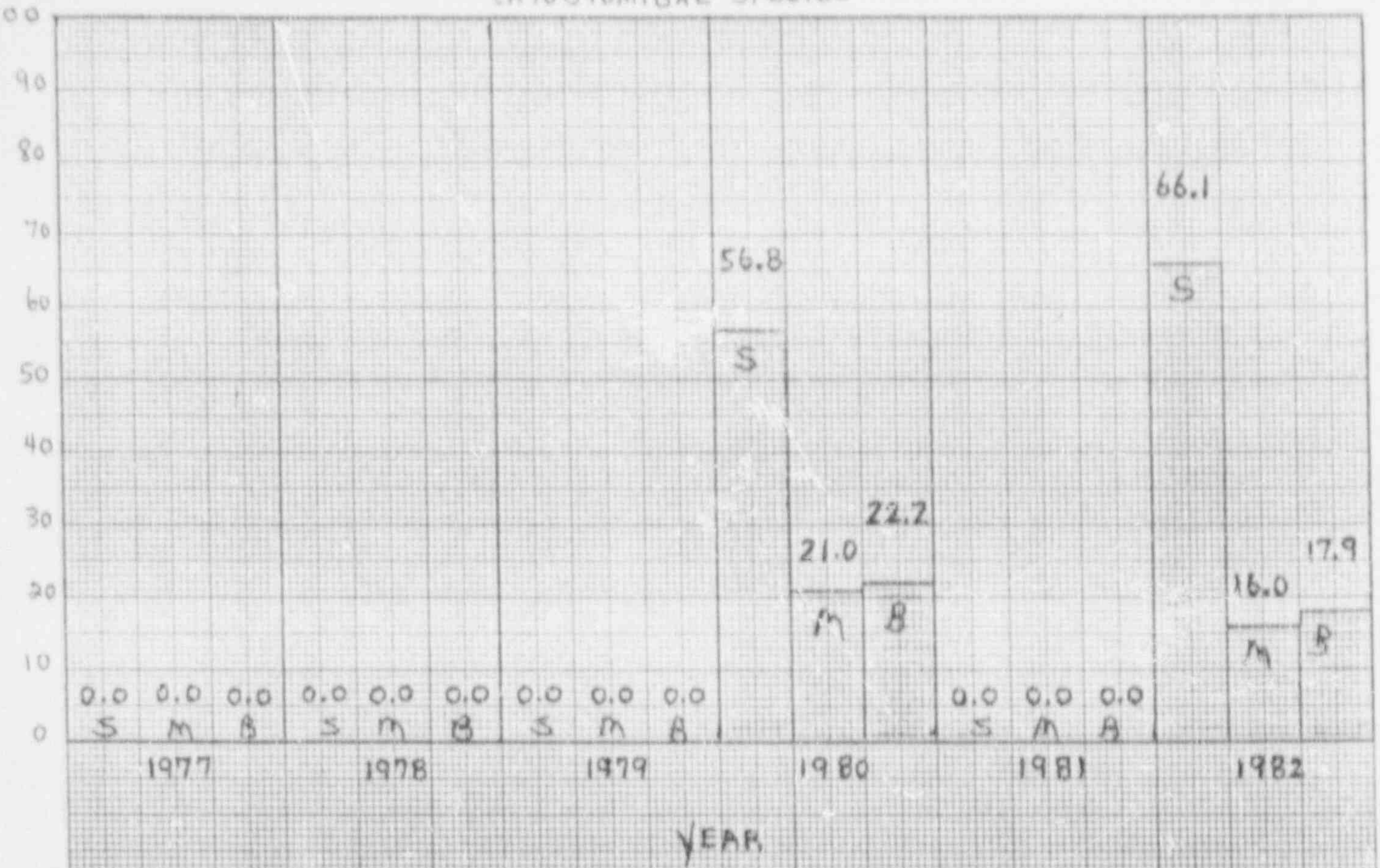
Graph 16.



Graph 17. Spatial distribution by year for each Family/species of Fish Entrained.

PERCENT

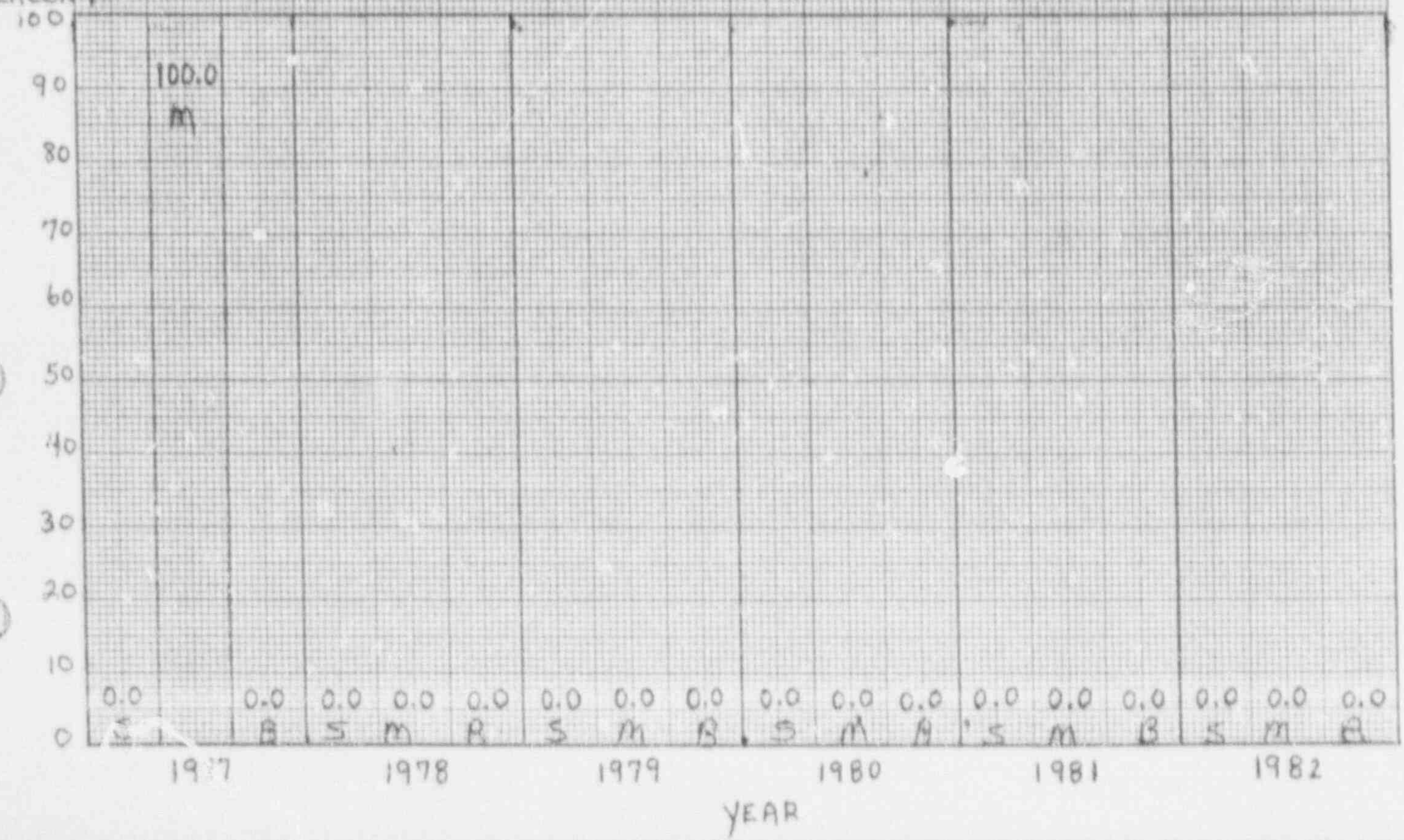
CATOSTOMIDAE SPECIES



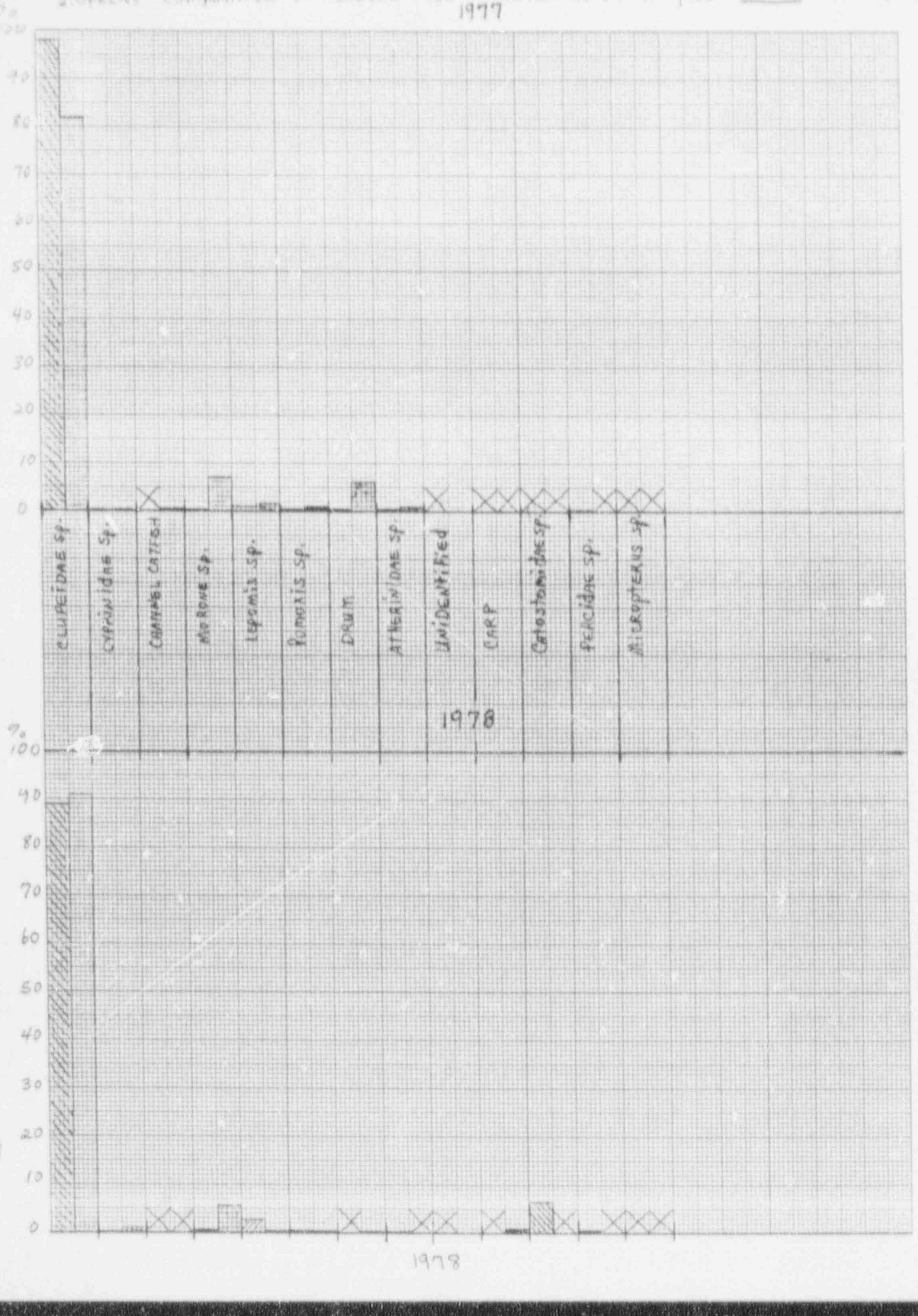
Graph 18.

CHANNEL CATFISH

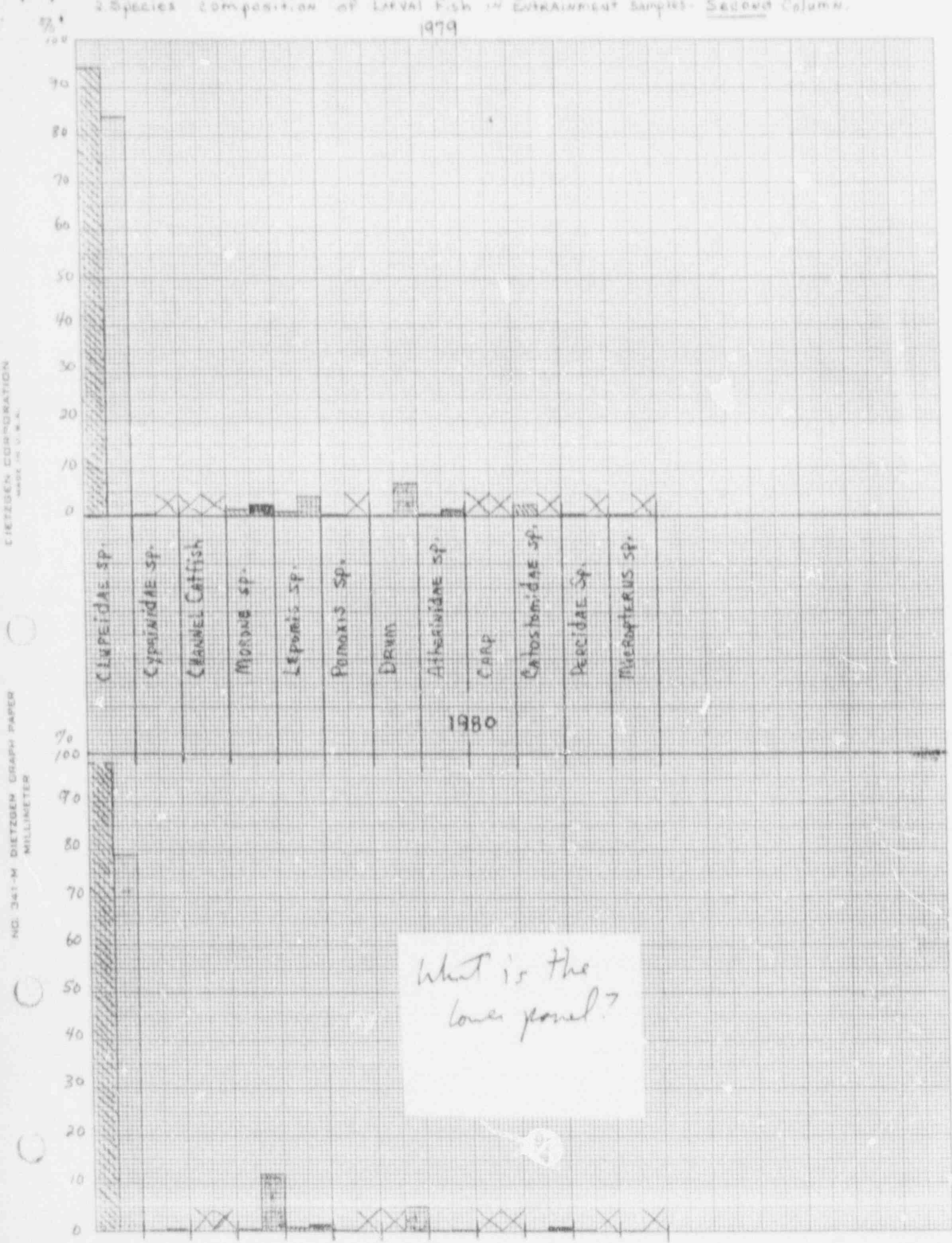
PERCENT



GRAPH 19. 1. Species composition of Larval fish in Intake Bay Area - First Column
2. Species composition of larval fish in Entrainment samples - Second Column.

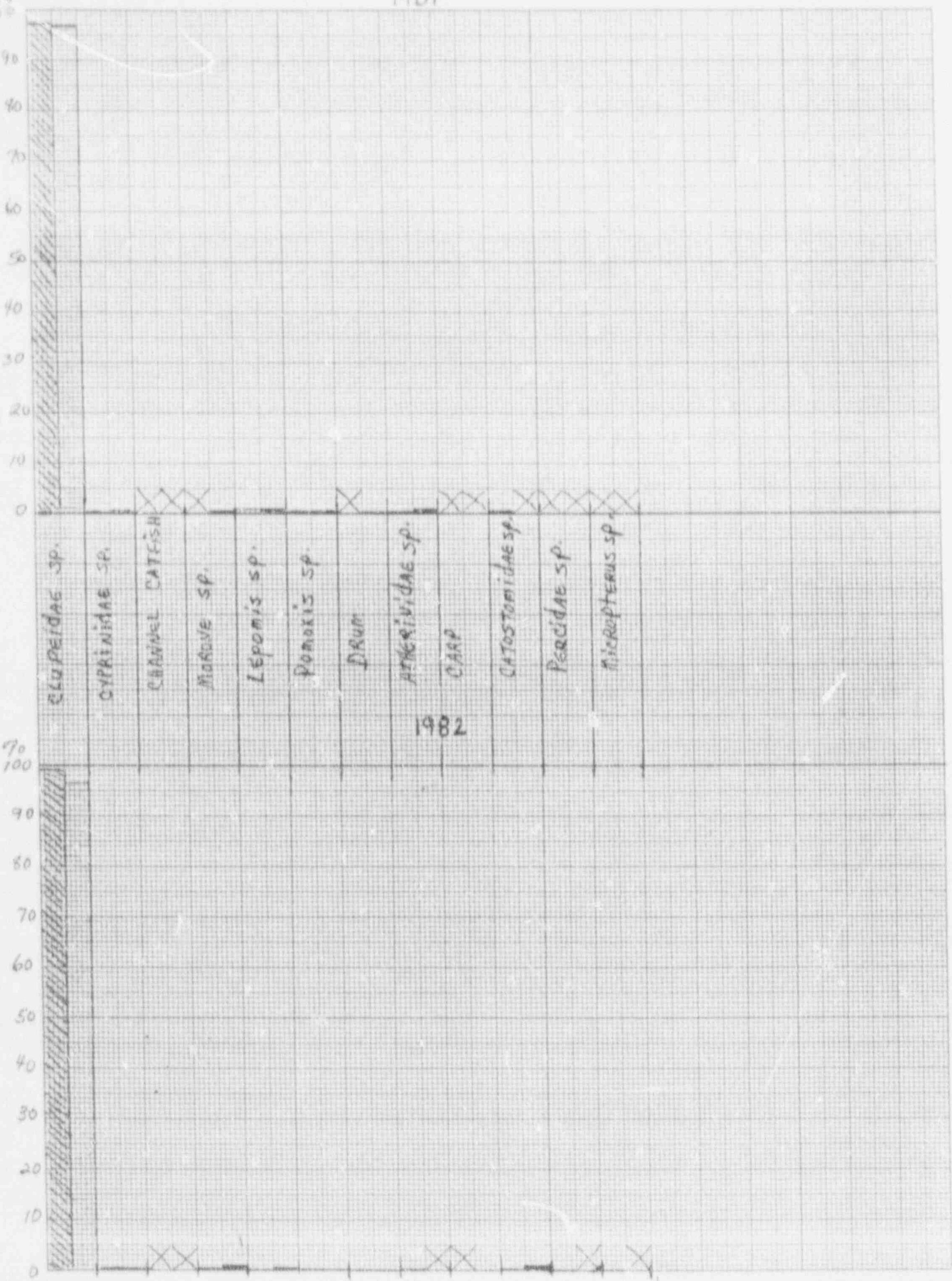


GRAPH 20. 1. Species composition of Larval Fish in Intake Bay Area - First Column.
2. Species composition of Larval Fish in Entrainment samples - Second Column.



GRAPH 21. 1. Species composition of Larval Fish in Intake Bay Area — First column.
2. Species composition of Larval Fish in Entrainment Samples — Second column

1981



Arkansas

AQUATIC RESOURCE QUESTIONS
ATTACHMENT 5

THE DISTRIBUTION OF TEMPERATURE AND DISSOLVED OXYGEN IN THE VICINITY OF ARKANSAS NUCLEAR ONE

Final Report - Volume I

Conducted for

ARKANSAS POWER AND LIGHT COMPANY

By

Geo-Marine, Inc.

17 December 1976

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List of Figures

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Forward

The distribution of the Arkansas Nuclear One (ANO) thermal effluent in Lake Dardanelle is affected by a complex interaction of natural and man-made factors. The extent of the lake provides a large fetch upon which winds can act. Reservoir throughflow varies from a high steady flow to one that is negligible. Inflow via Illinois Bayou, from past history, is highly irregular and for the study period unknown. Meanwhile, the pumping rate of the ANO facility remains, for the most part, constant. The extent and configuration of the ANO plume as these conditions varied over a 13-month period was the subject of Geo-Marine's 14-part temperature and dissolved oxygen survey program at Lake Dardanelle, and the findings of that program are the subject of this report.

I. INTRODUCTION

On 25 February 1976, Geo-Marine, Inc. completed a program of three-dimensional thermal and dissolved oxygen surveys in the vicinity of Arkansas Power and Light's Arkansas Nuclear One power plant at Lake Dardanelle. The program, as originally proposed, included one pre-operational survey and a series of 12 monthly post-operational surveys. As conducted, the program consisted of a pre-operational survey in October 1973 and 13 post-operational surveys that spanned January 1975 through February 1976. Of these 13 surveys, the April 1975 survey was conducted while the plant was shut down and the remainder were done on a monthly basis with the following exceptions: no survey in July 1975; two surveys in August 1975; and no survey in October 1975. This final report presents the results of the thermal and dissolved oxygen monitoring program in two volumes. Volume I contains a discussion of the complete survey program. Volume II contains the individual survey reports.

II. BACKGROUND

Arkansas Nuclear One (ANO), a facility of Arkansas Power and Light, is located near Russellville, Arkansas, on Dardanelle Reservoir (Figure 1). Occupying a headland that separates the submerged Arkansas River channel from Illinois Bayou, ANO intakes its cooling water from Illinois Bayou at a rate of 1700 cubic feet per second and discharges the effluent into a cove on the northern shore of Lake Dardanelle. ANO is a base-load generating facility designed for a maximum cooling water temperature rise of 15°F across the condensers. In actual practice the temperature rise across the condenser is usually less.

Dardanelle Reservoir is formed by the impoundment of the Arkansas River by the U. S. Army Corps of Engineers (COE) Lock and Dam #11, located at Arkansas River navigation mile 205.5. The mouth of the ANO discharge cove lies at navigation mile 212 and the Arkansas River enters the upper reaches of the Lake Dardanelle regime at approximately mile 224.[1] Upstream of Lake Dardanelle, the Arkansas River is regulated by the COE Lock and Dam #11 at Ozark, Arkansas, river mile 257.

Throughflow from Lake Dardanelle through Lock and Dam #10 is regulated so as to provide a pool elevation that remains between 336-338 feet above mean sea level, with consideration given to both navigational and hydroelectric requirements. During periods of extremely low inflow to the lake, no water may be released through turbines or spillway and the throughflow is in the form of lock operation and leakage only, estimated by the Corps of Engineers at 50 cfs (cubic feet per second). If inflow is sufficient to re-establish pool elevation, power is generated at peak-load hours only. At an inflow rate of approximately 36,000 cfs continuous, maximum power generation is possible while little, if any, change in pool elevation occurs. At inflows in excess of 36,000 cfs power is continuously generated, while excess water passes through the spillway. Thus, depending on the rate of inflow, Dardanelle Reservoir throughflow may be essentially non-existent, occur for only a few hours, or be essentially steady-state. The throughflow regime during each survey is taken up in the next section.

[1] Source: Personal communication, River Regulation Branch, COE, Vicksburg, Mississippi. Based on a prior river mile numbering system, Dardanelle Lock and Dam was at 265.9 and the Arkansas River entered the upper reaches of the Lake at mile 285, or approximately 19 miles upriver.

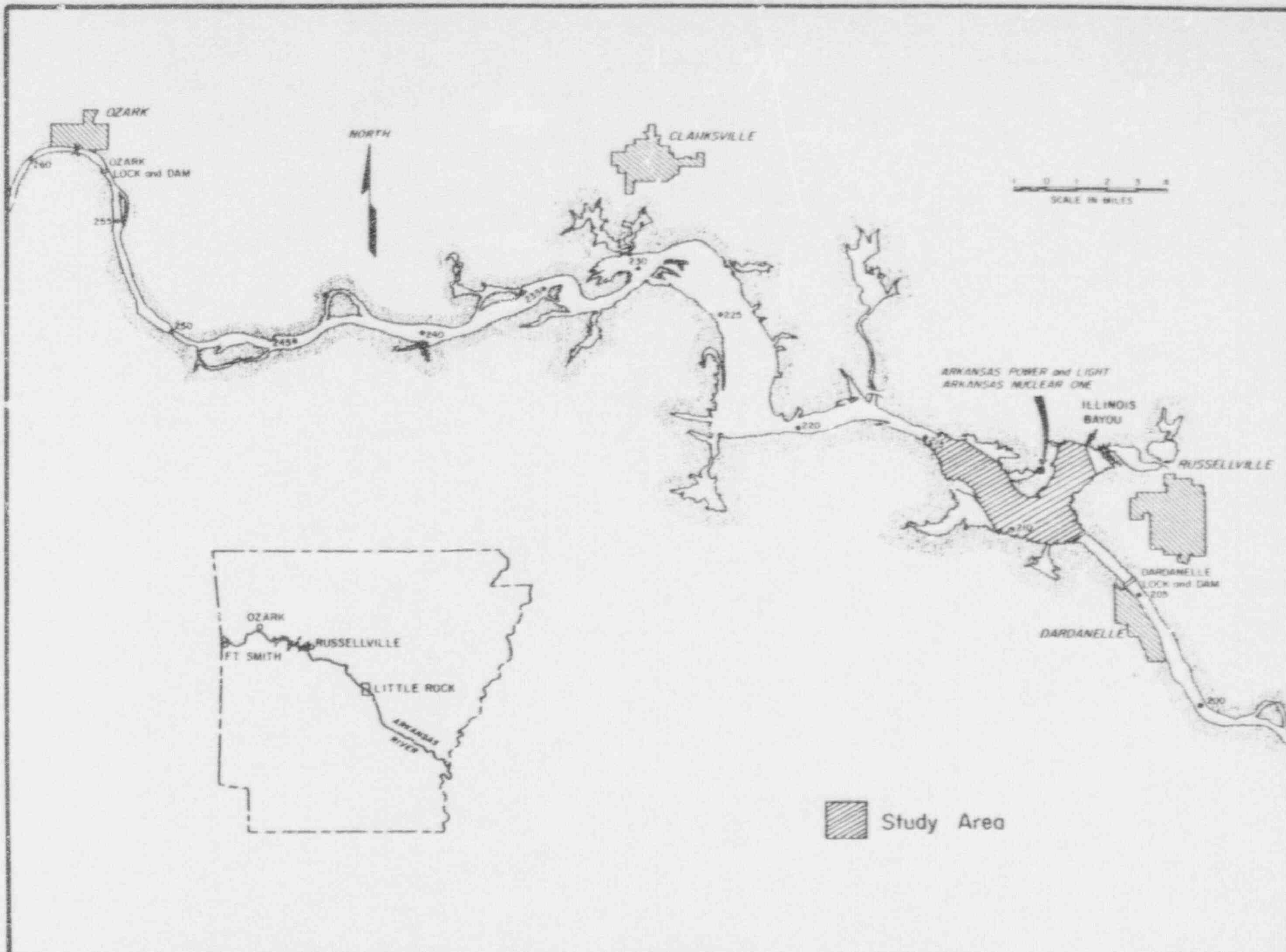

Figure 1. Location of Arkansas Nuclear One, near Russellville, Arkansas.

III. DARDANELLE RESERVOIR THROUGHFLOW

In order to better understand the behavior patterns of the thermal plume as it leaves the discharge area, the quantity of throughflow in the Dardanelle Reservoir is examined. Throughflow for Dardanelle Reservoir is presented in two ways in this report: as mean daily averages and as hourly flows.

A. Mean Daily Averages

To place the river flows during each of the 13 post-operational surveys in perspective with historical data, percentile curves taken from the mean daily flows for the Arkansas River at Dardanelle, Arkansas, for the period October 1969 through September 1975 were constructed.[2] The curves presented are the 16-2/3, 50 and 83-1/3 percentiles with each curve representing the percent of throughflow values for each day of the year that were equal to or below the curve. In other words, from each six mean daily flow values (1969-1975) on a given day, the lowest, the third highest and the fifth highest were selected which then are points on the 16-2/3, 50 and 83-1/3 percentile curves, respectively.

Figure 2 illustrates each of the three percentile curves for the six-year period. These percentile curves are used as references to compare the mean daily flow curve for the study period January 1975 through February 1976 which is also displayed in this figure. Mean daily flows for the survey dates are labeled by dots.

A comparison of the mean daily flows with the percentile curves shows that from January through September 1975 Dardanelle Reservoir throughflow was relatively high--for the most part being equal to and at times exceeding the 83-1/3 percentile curve. By October 1975, flows are generally below the 50 percentile curve. In January and February 1976, the daily value plot becomes generally a new low-flow curve. Thus during the period during which the series of surveys were performed, measurements were made through the full spectrum of throughflow regimes.

[2] River flows for this period were obtained from the U. S. Geological Survey Water Resources Division in Little Rock, Arkansas. Flow data from 1 October 1975 to 28 February 1976 is "provisional" and subject to future revision by USGS.

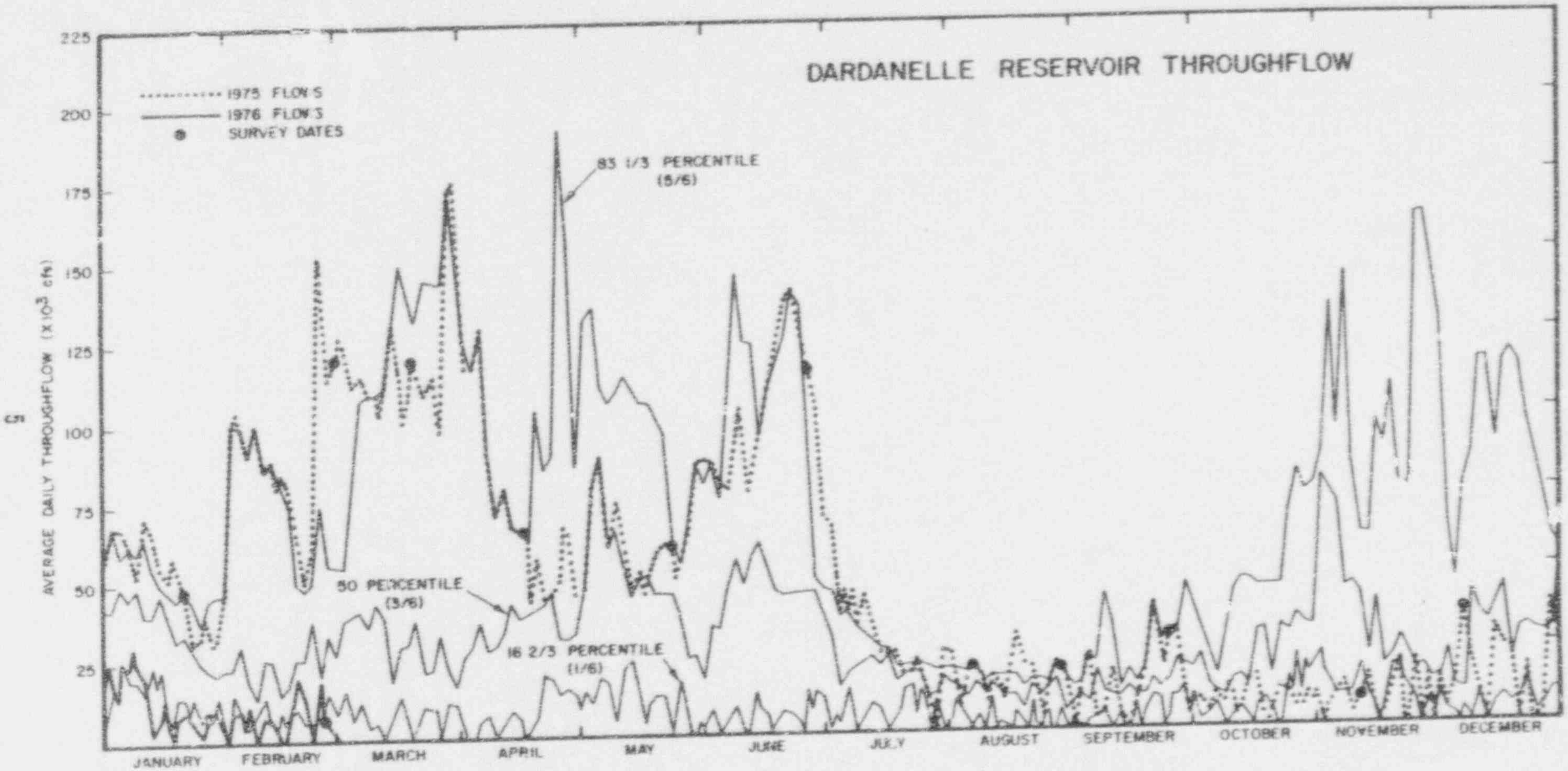

Figure 2. Percentile curves for the period October 1969 through September 1975 and daily mean flows for the period January 1975 through February 1976.

B. Hourly Flows

Mean daily averages were presented in each survey report for a 5-day period bracketing the survey day. As the average throughflow figures continued to generally decline during the thirteen month study, a change in the plume configuration was noticed from month to month. As an aid in understanding the impact of Lock and Dam #10 releases on the reservoir, an attempt was made to differentiate between the actual hours and quantities of release and the hours of pooling.

The Corps of Engineers maintains daily operation logs for Lock and Dam #10. Among other information, these logs provide a breakdown of the flow quantities through the locks, the spillway and the turbines. With respect to the turbines, their hours of operation are also given. Generally, when inflow is below the threshold value of 36,000 cfs, reservoir water is released only through the turbines or the locks, with the latter amount being of the same order as the estimated leakage rate; i.e., about 50 cfs, or negligible. From these considerations the hourly values of throughflow can be calculated by pro-rating the quantity of water released through each turbine against its hours of operation. More simply, the various patterns of reservoir throughflow can be presented schematically by plotting the number of turbines generating each hour of the survey day, as water is being pooled when no turbines are operating. This plot is shown in Figure 3. From this figure and the knowledge of the mean daily flows presented in the previous section, it can be seen that Dardanelle Reservoir changes its characteristics not only day to day, but several times within a single day.

IV. ILLINOIS BAYOU FLOWS

Illinois Bayou, near its confluence with the Arkansas River, is regulated by two dams. About 20 miles distant is a dam at Scottsville, Arkansas. Somewhat closer is the Russellville City water works dam, about 6 miles upstream. Since the intake for ANO is located on Illinois Bayou, it is desirable to know the daily flows throughout the survey period.

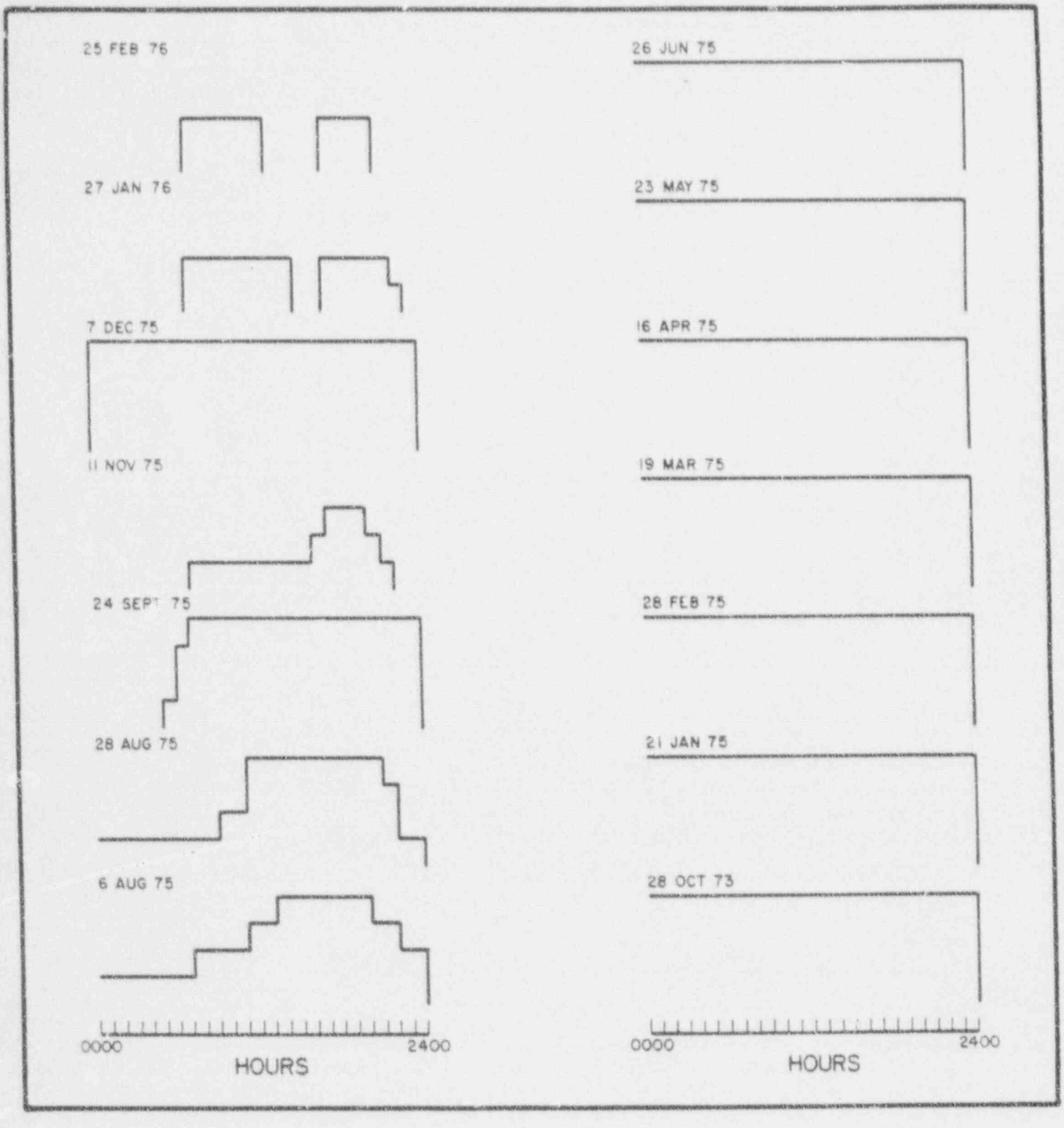

Figure 3. Schematic of relative changes of turbine flow releases during survey days.

The USGS in Little Rock kept daily records from 1948-1970 on the Scottsville gauge. After September 1970 use of that gauge was discontinued and a record of peak flows only was made. Thus, daily records for the period spanned by the surveys covered herein were not available, although those for the period of October 1947 to September 1970 were obtained. This flow data showed extreme variability from year to year and as such could not be meaningfully extrapolated to the present study.

Records for the City of Russellville water works dam in Illinois Bayou were kept for local use only. The gauge at this site is not in current operation and historic records remain unlocated.

Thus, quantitative information concerning Illinois Bayou flows is unavailable for the period of this survey program. Qualitatively, it can be stated that the flows are highly variable and at times have been negligible as evidenced by the USGS report of flows as low as 5 cfs on 22-23 August 1967.[3]

V. WEATHER

The sources for the weather data contained in the monthly reports vary. In the pre-operational report (October 1973) and in the first three post-operational reports (January, February, March 1975) weather data from the ANO 10-meter reporting station were used. When difficulty was encountered in obtaining meteorological data from the ANO facility, data from the National Weather Service in Little Rock, Arkansas, were presented in the remaining reports. Now that ANO meteorological data are again readily recoverable, they are presented in the Appendix as a basis for comparison of local meteorological factors with plume characteristics.

Little Rock is approximately 70 miles southeast of Lake Dardanelle and though in most cases there is close agreement between the Little Rock National Weather Service meteorological data and that of the ANO facility, there are cases of notable variation in conditions of which one should be aware when using meteorological data from the more remote source. Examples of this are provided by comparison of the wind

[3] Sullivan, John N. Thermal Survey of Dardanelle Reservoir. USGS. open-file report, p. 7.

parameters and temperatures for 6 August 1975. In Little Rock the wind from midnight to 0900 was generally out of the west and south at 4-5 mph. At the same time, the ANO facility reported winds at half that speed out of the north and east. Temperatures also varied widely between the two stations, with ANO reporting 106°F at 1600 while Little Rock reported 89°F, a difference found generally throughout the day.

Meteorological data from the ANO 10-meter reporting station appear in the Appendix for all survey dates except for the one in late August 1975. For 28 August 1975 the appropriate data were unrecoverable. Also, in some cases where 10-meter wind data were unavailable, 57-meter data were used and that is duly noted.

VI. INDIVIDUAL MONTHLY SURVEYS

A. Introduction

This volume is not intended to replace the individual monthly reports but rather to summarize the study and compile data which addresses applicable state regulations. For this reason, the individual monthly survey reports, presented in their entirety in Volume II, should be reviewed for in-depth information on a particular survey before the corresponding portion of this section is studied. For weather information as reported by the ANO 10-meter station for each of the survey days, the reader is referred to the Appendix.

The new presentations of data contained in this section for each of the surveys include two cross-sections, a determination of ambient water temperature, and the extent of a water temperature zone in excess of ambient plus 5°F.

The two cross-sections (one for temperature, one for dissolved oxygen) are based upon the isothermal contour charts and isopleth charts for dissolved oxygen presented in the monthly reports. The orientation of the cross-sections is along a line from the northeast to southwest from the mouth of the discharge cove to the southern shore of Lake Dardanelle.

The applicable criteria for water quality are given in the State of Arkansas, Arkansas Department of Pollution Control and Ecology, Regulation No. 2 as amended. Section 5 (a) states the following:

> *Temperature--During any month of the year, heat shall not be added to any stream in excess of the amount that will elevate the temperature of the water more than 5 F, based upon the monthly average of the maximum daily temperatures as measured at mid-depth or 5 feet, whichever is less. In lakes and reservoirs, the temperature shall not be raised more than 3 F above that which existed before the addition of heat or artificial origin, based upon the average of temperatures taken from surface to bottom, or from surface to thermocline, if present. The maximum temperature due to man-made causes shall not exceed 58 F in trout waters, 86 F in smallmouth bass waters, or 90 F in all other waters except for the following:*
>
> 1. *Red River - 93 F*
> 2. *Kelley Bayou - 91 F*
> 3. *Bayou Dorcheat - 91 F*
> 4. *Quachita River (state line to Remmel Dam) - 91 F*
> 5. *Lake Catherine - 93 F*
> 6. *Bayou Macon - 91 F*
> 7. *Arkansas River - 93 F*
> 8. *Dardanelle Reservoir (segment 3E) - 95 F with 5 F maximum increase.*
> 9. *White River (mouth to Lock and Dam #1) - 93 F*
> 10. *Spring River (mouth to mouth of South Fork) - 93 F*
> 11. *Little Missouri River (mouth to mouth of Muddy Fork) - 93 F*
> 12. *McKinney Bayou - 93 F*

See p 34 - is the Max a monthly average or not?

Based on the above, the 5°F delta for each survey was determined as explained in the next two paragraphs.

The ambient temperature for each survey was determined by first seeking an area of Lake Dardanelle upstream of the discharge cove that was outside the influence of the plume. In this area temperatures were measured for all five depths at which the sensors were towed. Since the area of the lake receiving the maximum impact of the plume averaged about 10-12 feet in depth and since the lowest sensor (at 9 feet) generally described the lower reaches of the plume, the ambient temperature was determined as the average of the surface, 3, 5, 7 and 9-foot temperatures in the area outside the influence of the plume.

Exactly what constitutes a violation is unclear. Any [illegible] over ambient, monthly-averaged [illegible] the plant? Whole reservoir, plume?

The presence and extent of a water temperature zone in excess of ambient plus 5°F was also determined using the average of readings at the near-surface, 3, 5, 7 and 9-foot levels. From the temperature cross-section presented for each survey, the average at the mouth of the cove (far left hand side of the cross-section) was used to determine if such a zone was present. If it was, then the extent was determined from the near-surface through the 9-foot isothermal contour charts presented as part of the original survey reports (see Volume II).

The temperature and dissolved oxygen cross-sections along with pertinent discussion for each survey follow in this section.

B. 28 October 1973 (Pre-Operational Survey)

The conditions under which the pre-operational survey was conducted were as follows: winds were generally out of the west at from 2.0-7.5 knots, air temperature was about 47°F, and reservoir throughflow was continuous at an average rate of 84,810 cfs. The full report on this survey appears in Volume II.

The cross-sections for temperature (Figure 4) and dissolved oxygen (Figure 5) show little lateral or vertical variation in values.

C. 21 January 1975

The conditions under which this survey was conducted were as follows: winds were generally out of the east at from 5-10 knots, air temperatures ranged from 35-60°F, ANO generation was about 870 MW gross, and reservoir throughflow was continuous at an average rate of 48,000 cfs. The full report appears in Volume II.

The temperature cross-section appears in Figure 6. Ambient temperature for this survey was 39.9°F. Along the cross-section the zone of water temperature exceeding ambient plus 5°F (referred to as the 5°F delta and equal to 44.9°F) extended approximately 2480 feet out from the mouth of the discharge cove. The areal extent of the 5°F delta is indicated in Figure 7. The area within the shading is about 166 acres.

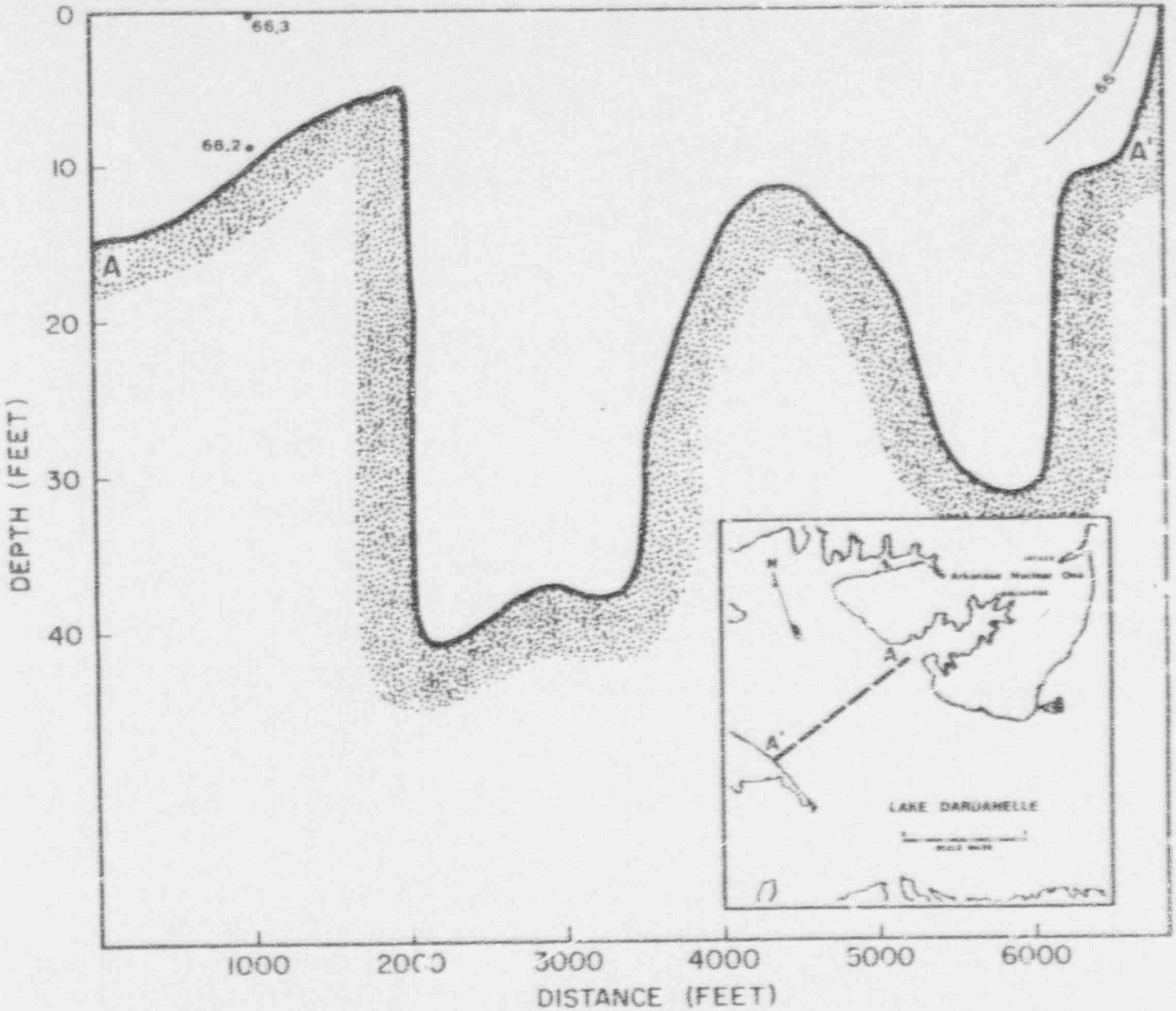

Figure 4. Temperature cross-section, 28 October 1973 (pre-operational survey).

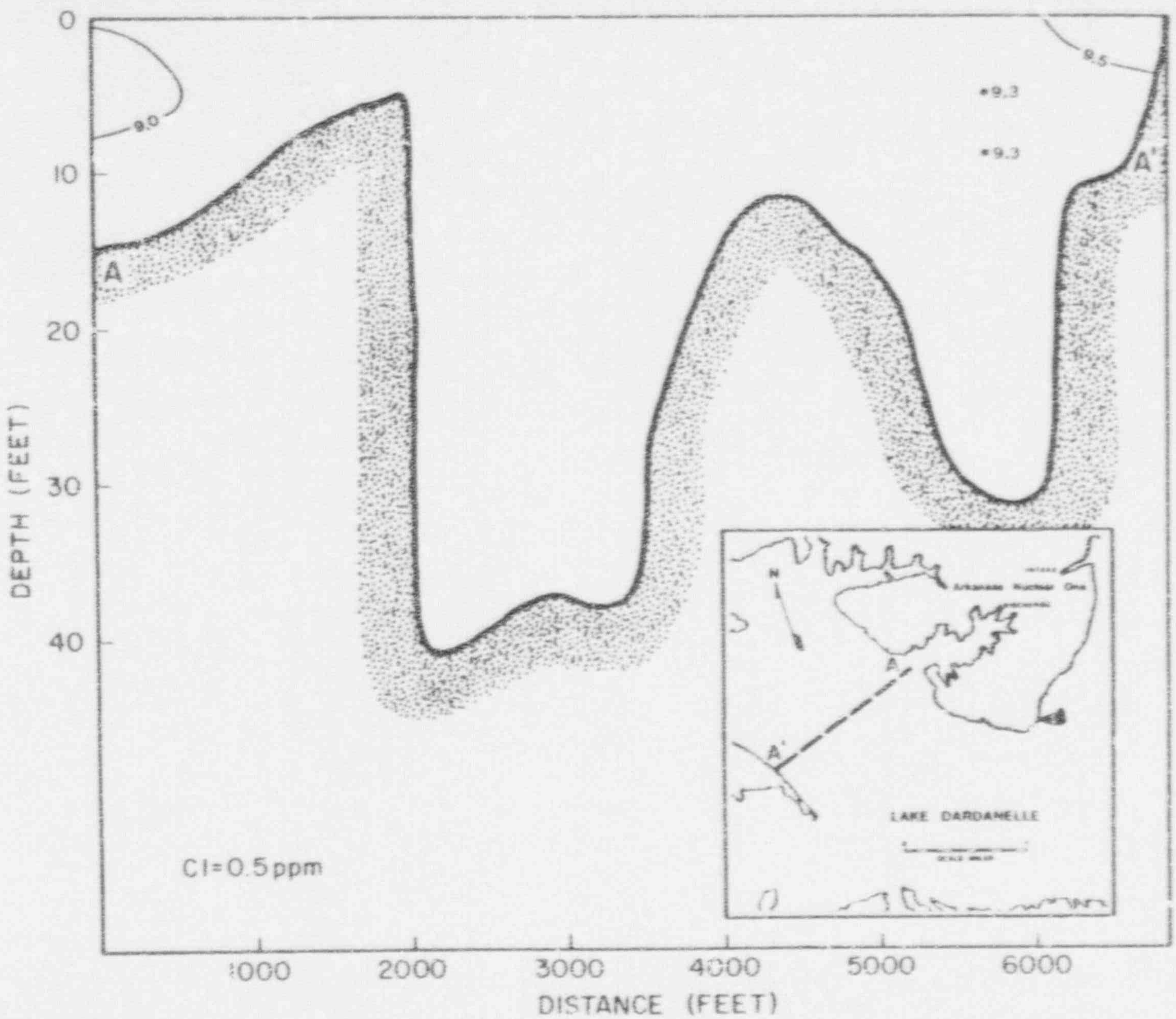

Figure 5. Dissolved oxygen cross-section, 28 October 1973 (pre-operational survey).

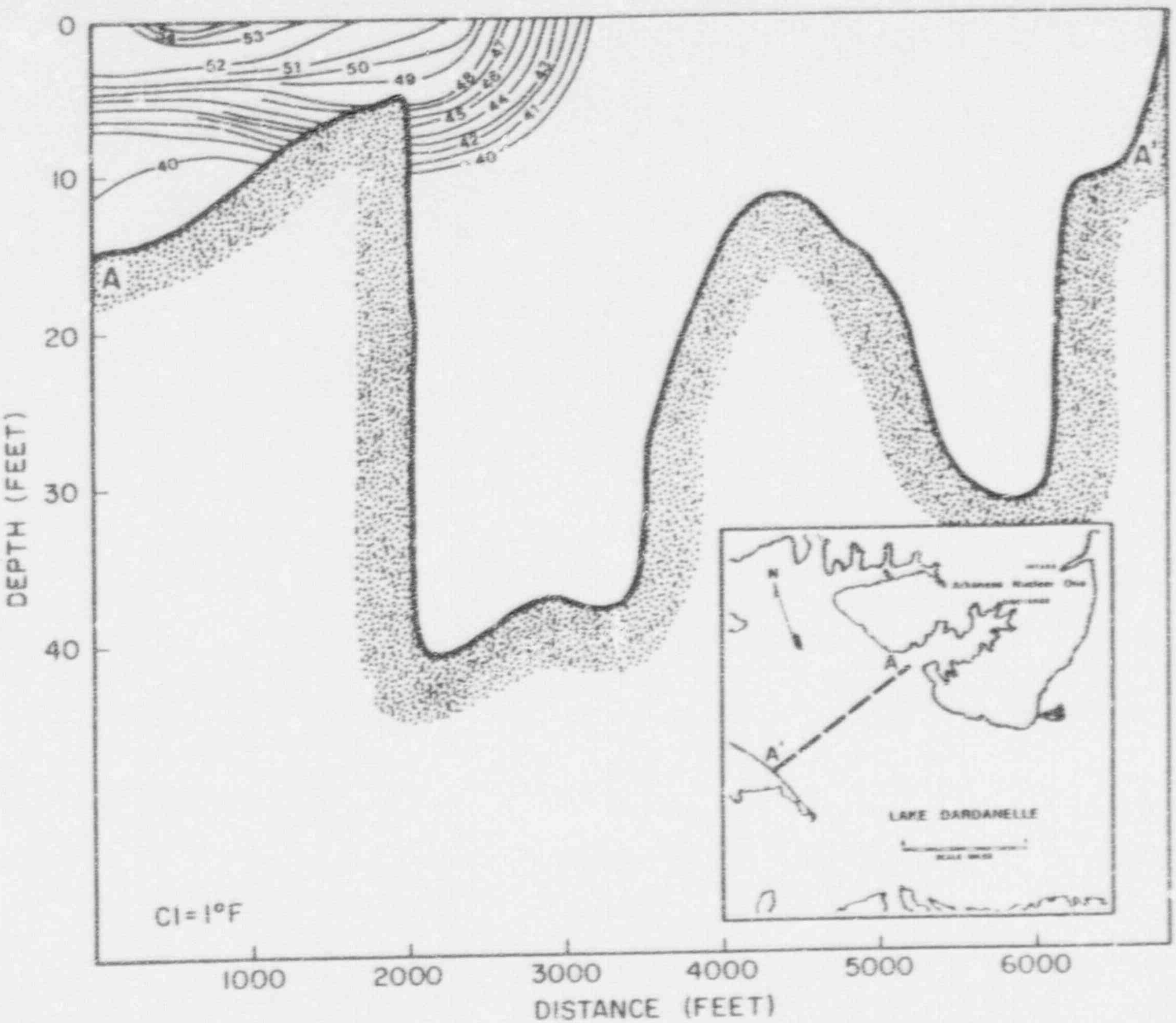

Figure 6. Temperature cross-section, 21 January 1975.

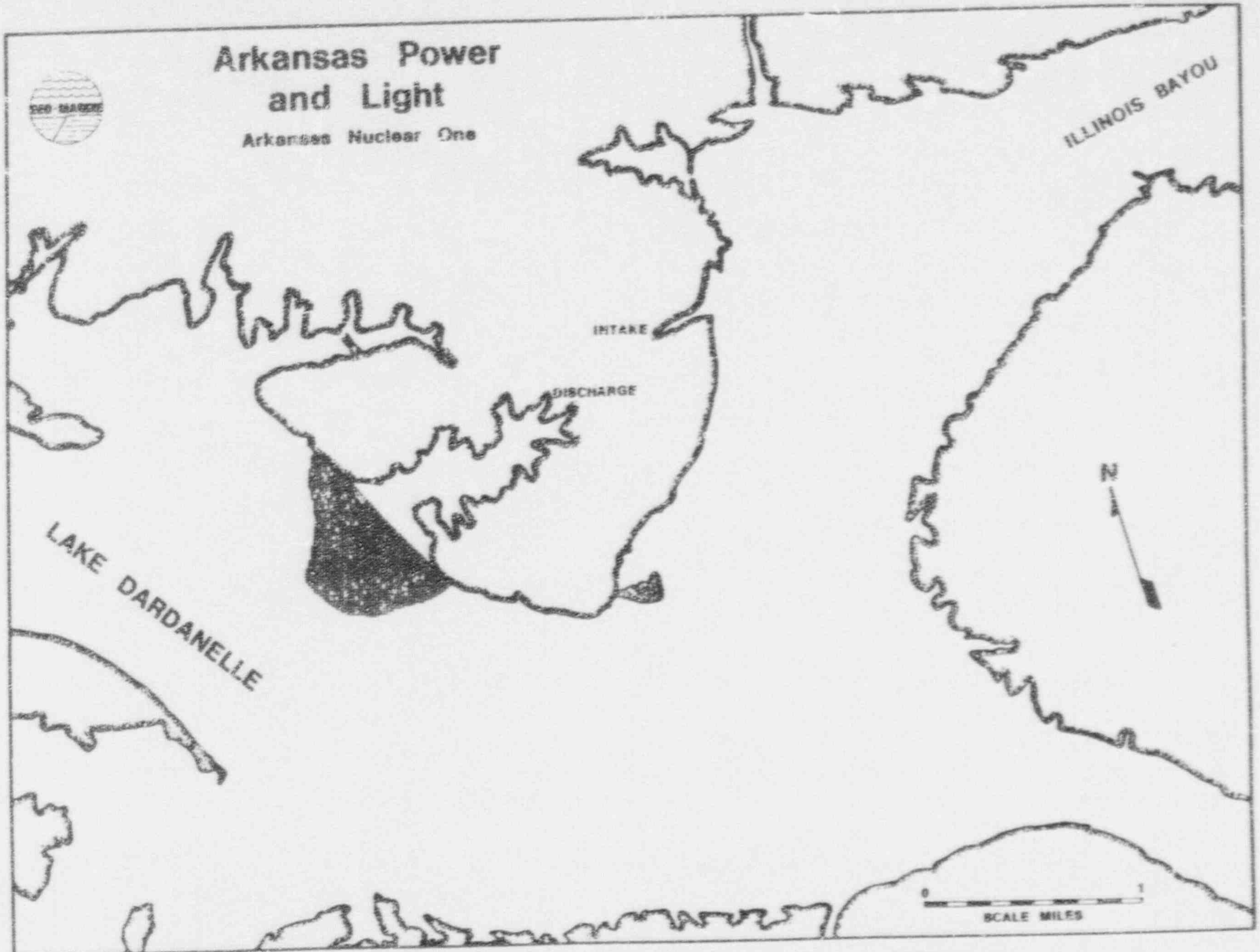

Figure 7. Areal extent of 5°Δ temperature, 21 January 1975.

The cross-section of dissolved oxygen values is shown in Figure 8. Concentrations vary only slightly laterally, while a general increase is seen vertically from the near-surface down to seven feet.

D. 28 February 1975

This survey was conducted under the following conditions: winds were light and variable throughout the night but by mid-morning were generally out of the west at increasing speeds up to nearly 9 knots by mid-afternoon; air temperatures ranged from 40-64°F; ANO generation varied from 428-440 MW gross; and reservoir throughflow was continuous at an average rate of 121,300 cfs, far above the 83-1/3 percentile value for that day (Figure 2). The full report appears in Volume II.

The temperature cross-section appears in Figure 9. Ambient temperature for this survey was 42.2°F, making the 5°F delta value 47.2°F. Along the cross-section, the zone of water temperature exceeding plus 5°F extended approximately 160 feet out from the mouth of the discharge cove. The areal extent of the 5°F delta is indicated in Figure 10. The area within the shading is about 36 acres.

The cross-section of dissolved oxygen appears in Figure 11, and exhibits an increase in concentrations outward from the discharge cove. It should be noted, however, that on the isopleth charts of dissolved oxygen in the monthly report (Volume II) the levels of dissolved oxygen at the intake in Illinois Bayou are the same as those at the mouth of the discharge cove.

E. 19 March 1975

The following conditions existed when this survey was conducted: from midnight on, winds were steady out of the west at from 4-7 knots, air temperatures ranged from 44-69°F; ANO generation was decreasing from a midnight output of 493 MW gross to a 0500 value of 209 MW gross about which it varied little until after the survey was completed; reservoir throughflow averaged 121,000 cfs and as such was continuous throughout the day. The full survey report appears in Volume II.

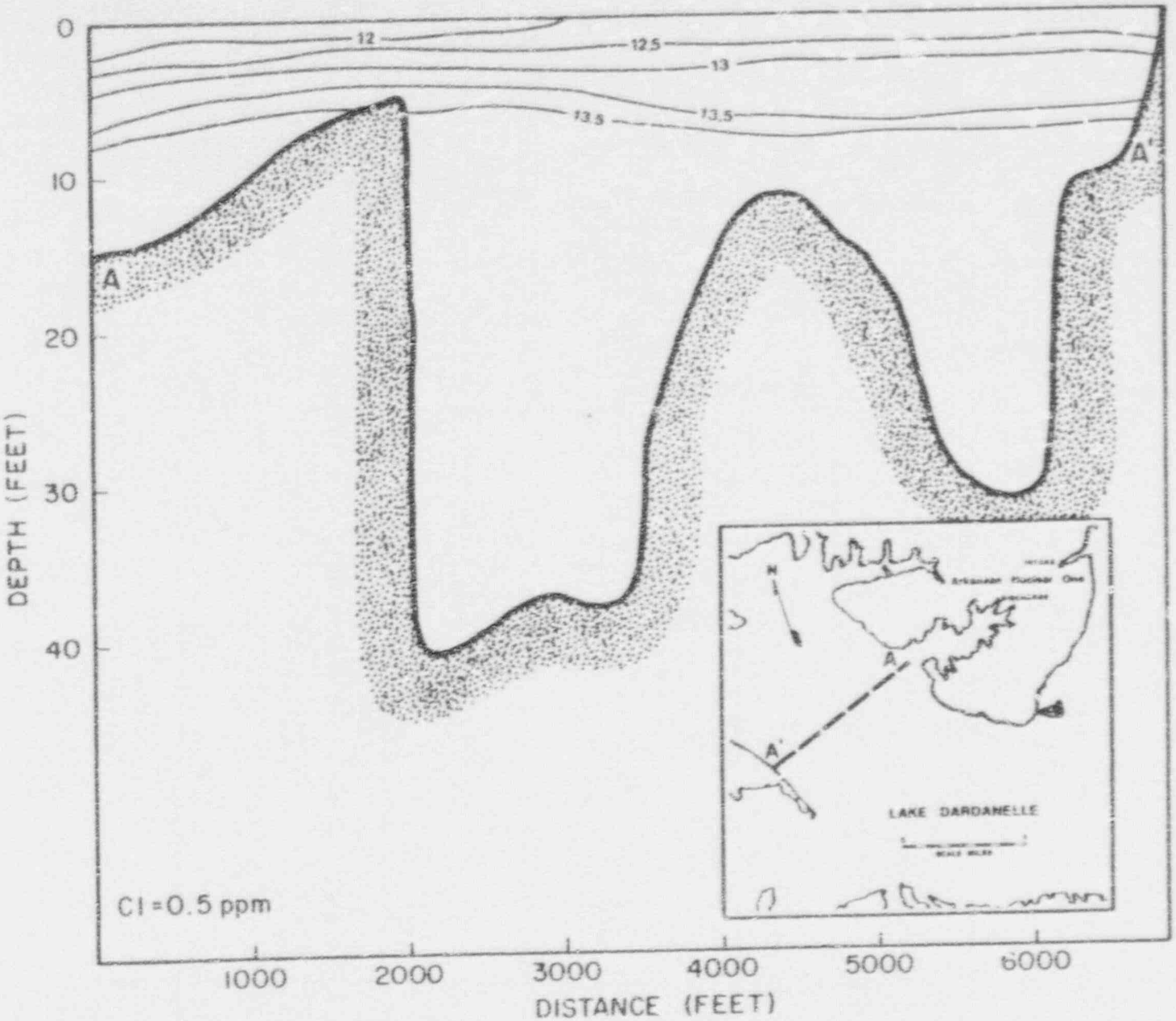

Figure 8. Dissolved oxygen cross-section, 21 January 1975.

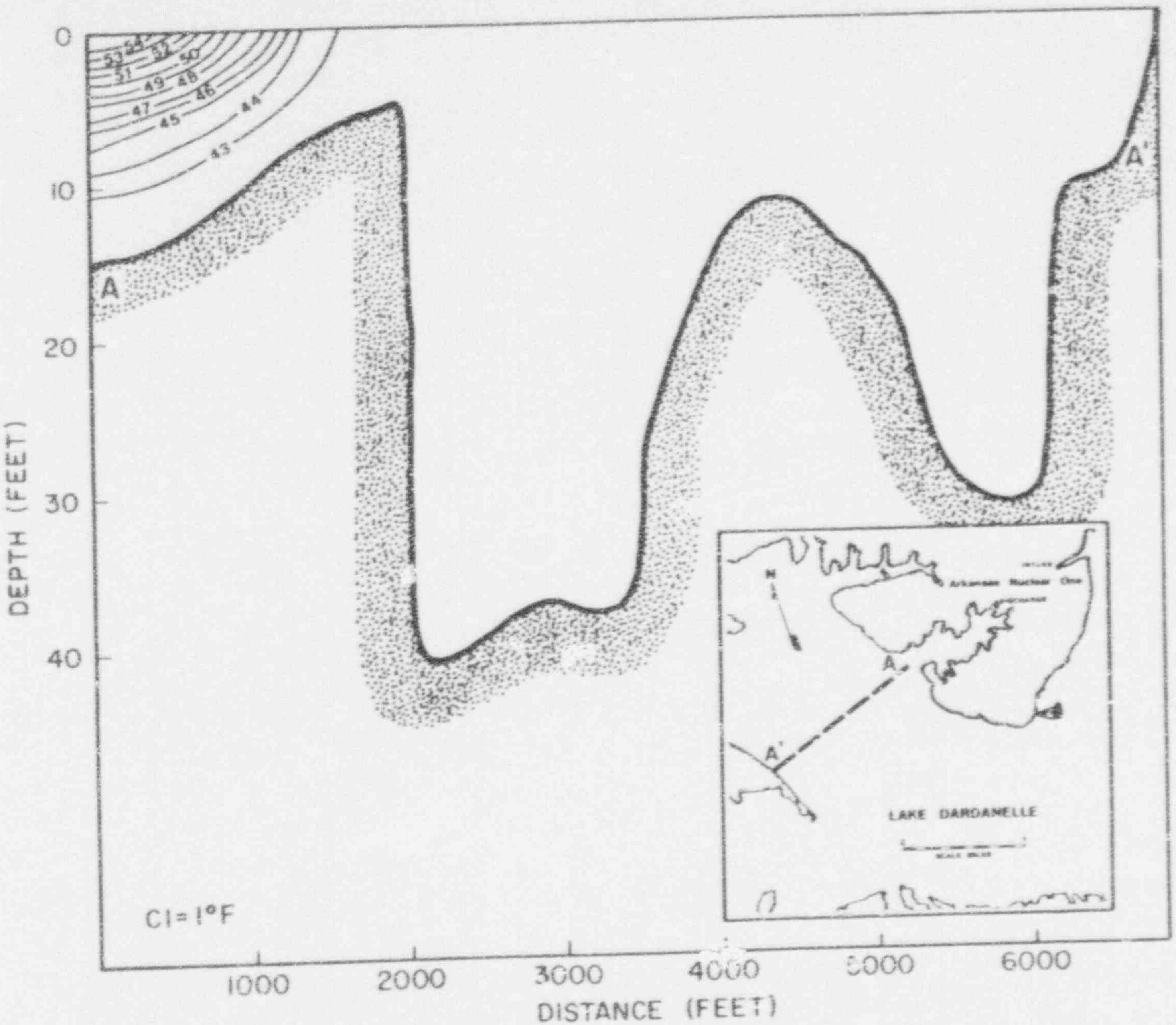

Figure 9. Temperature cross-section, 28 February 1975.

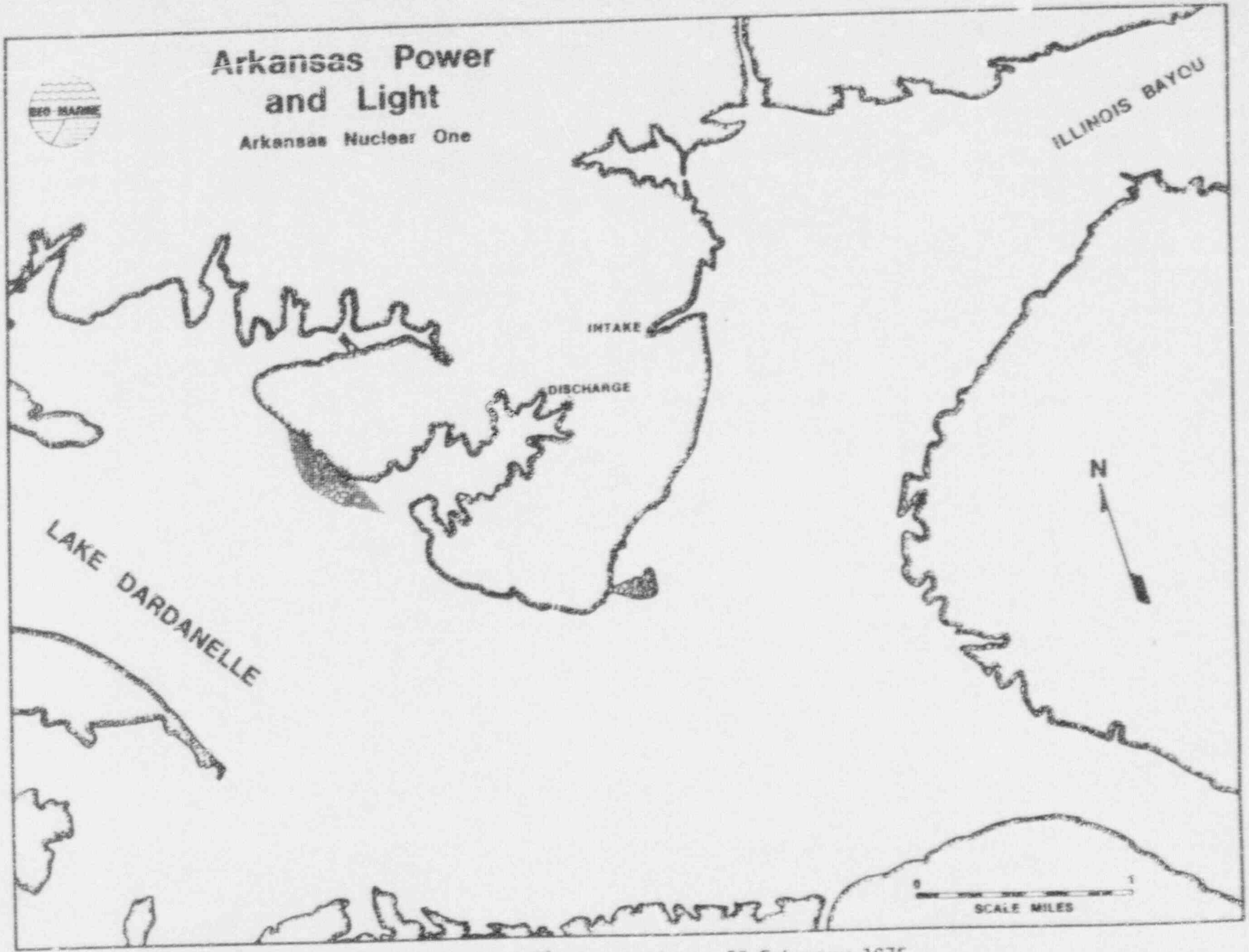

Figure 10. Areal extent of 5°Δ temperature, 28 February 1975.

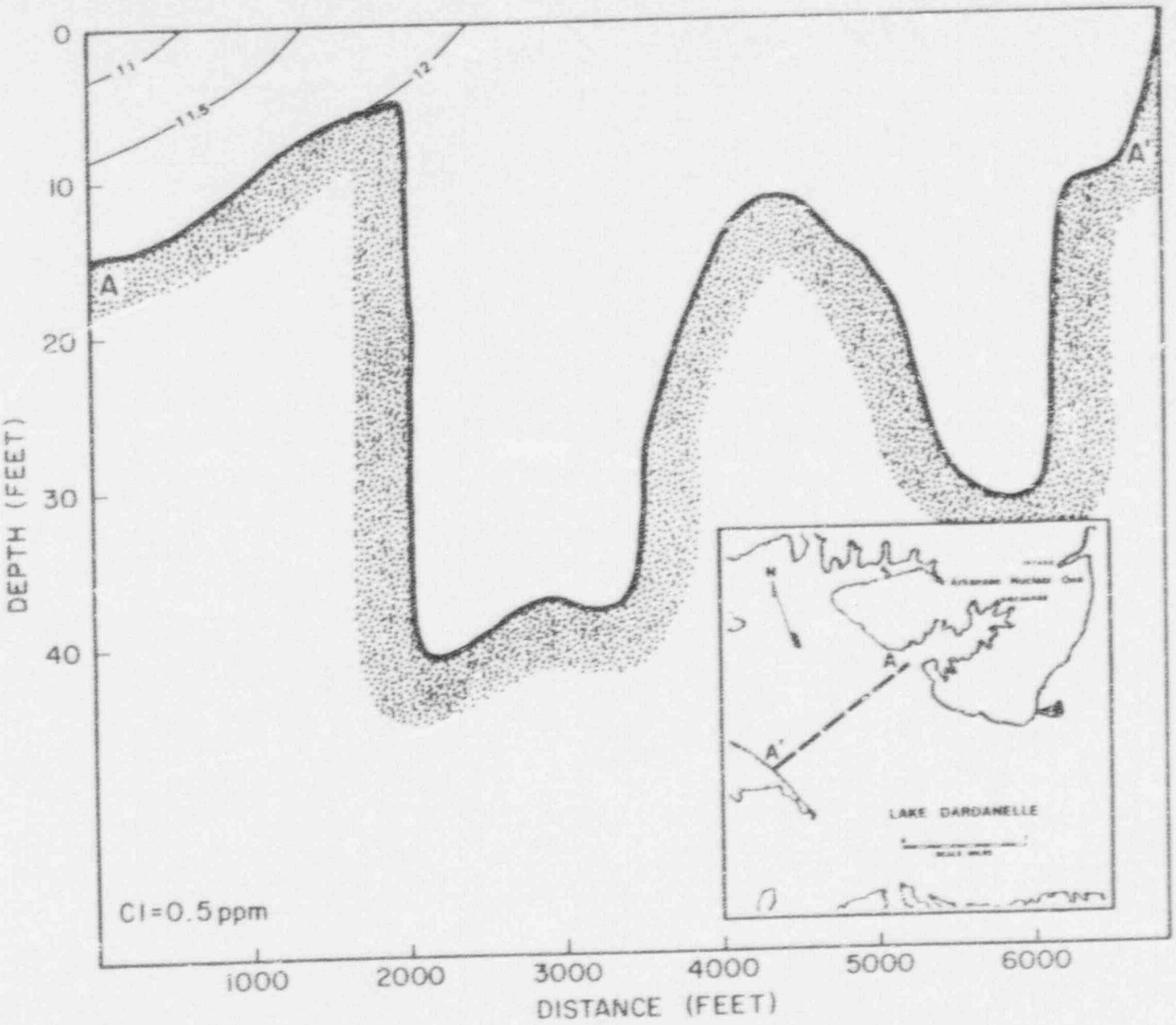

Figure 11. Dissolved oxygen cross-section, 28 February 1975.

The temperature cross-section appears in Figure 12, and shows the plume to be essentially confined to the upper two feet of the reservoir. Ambient temperature for this survey was 44.7°F, making the 5°F delta equal to 49.7°F. The zone of water temperatures exceeding the 5°F did not reach the mouth of the discharge cove.

The cross-section of dissolved oxygen appears in Figure 13, showing concentrations to decrease approximately 2 ppm from the surface down to 9 feet. This is fairly representative of the trend seen throughout the survey area in Lake Dardanelle and Illinois Bayou (refer to Volume II).

F. 16 April 1975

This survey was conducted during a period when ANO was shut down. The other conditions under which this survey was done were as follows: winds changed from the east to the west and south in mid-morning, increasing in speed from about 3 knots to around 9 knots; temperatures ranged from 65-100°F, the high being reached about 1600; reservoir throughflow averaged 70,000 cfs. The full survey report appears in Volume II.

The temperature cross-section appears in Figure 14. Ambient temperatures for the survey was 56°F. The cross-section for dissolved oxygen appears in Figure 15. Due to the small range of dissolved oxygen concentration, a contour interval of 0.2 ppm is used.

G. 2? May 1975

The conditions under which this survey was conducted were as follows: winds which were at 2-4 knots out of the east around midnight were out of the south by mid-morning and continued out of that direction at 4-9 knots through the afternoon; air temperatures rose from 75°F to 90°F by 1500; ANO generation was about 820 ± 20 MW gross; and reservoir throughflow was continuous averaging 64,500 cfs. The full survey report appears in Volume II.

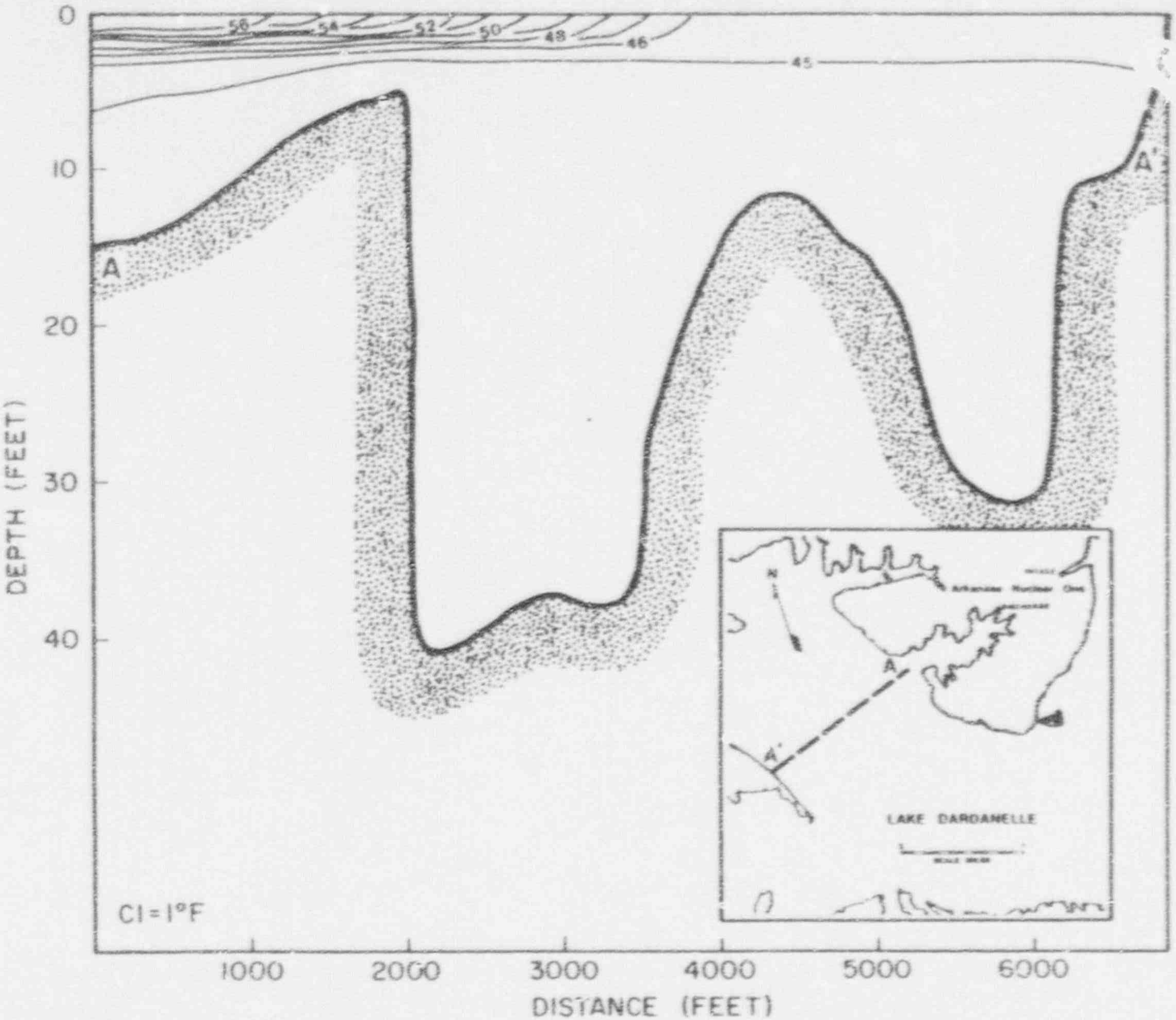

Figure 12. Temperature cross-section, 19 March 1975.

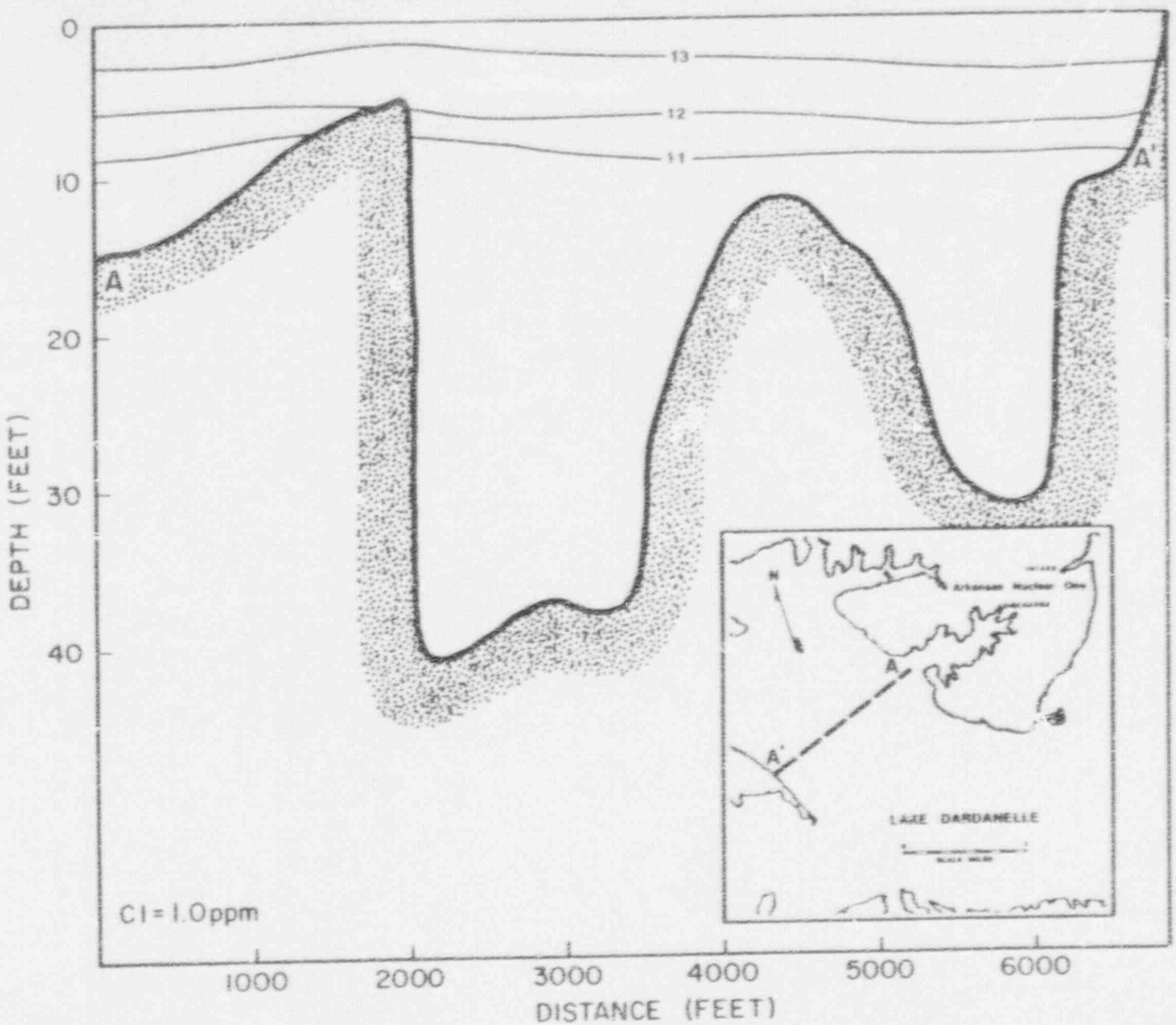

Figure 13. Dissolved oxygen cross-section, 19 March 1975.

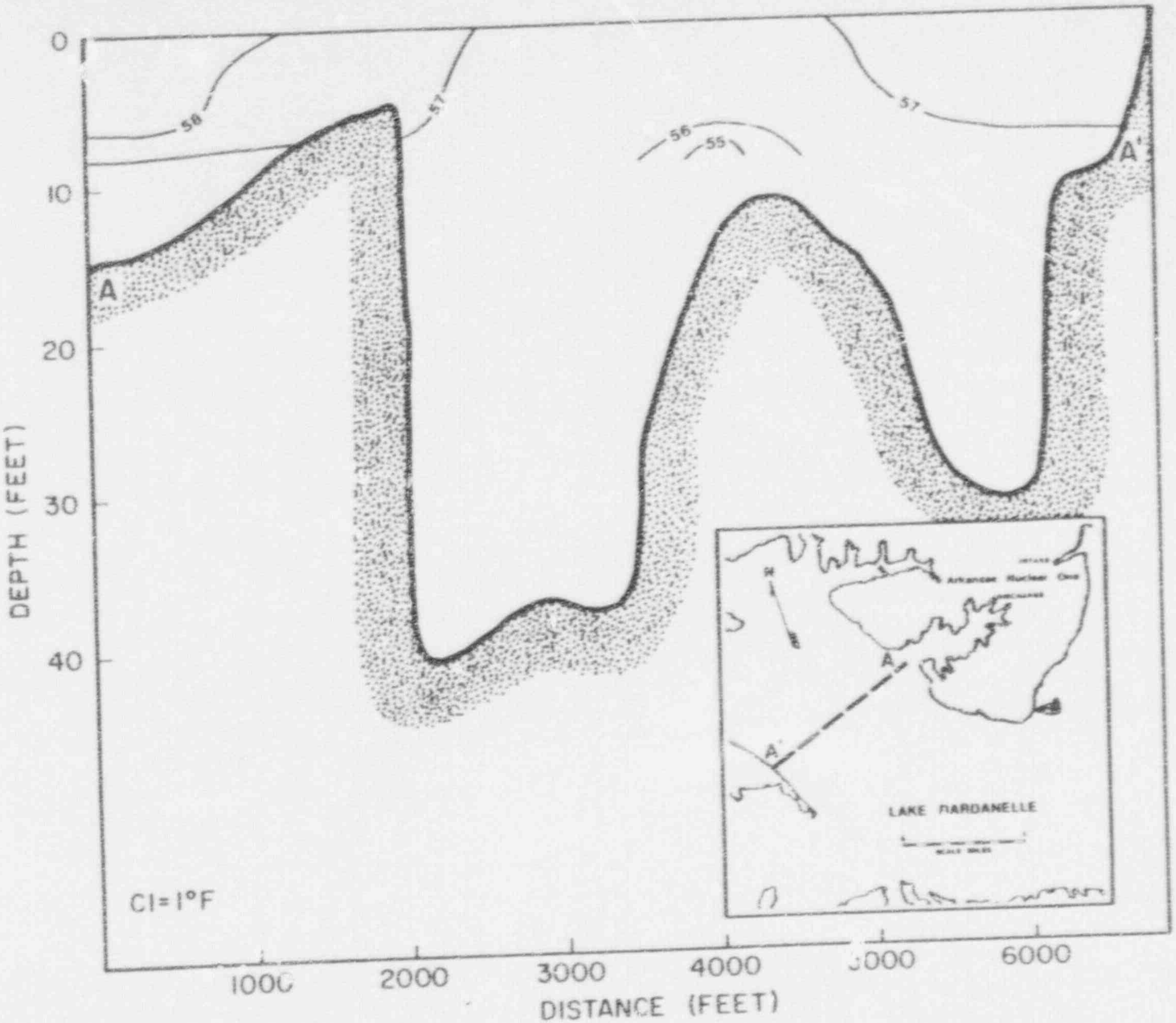

Figure 14. Temperature cross-section, 16 April 1975.

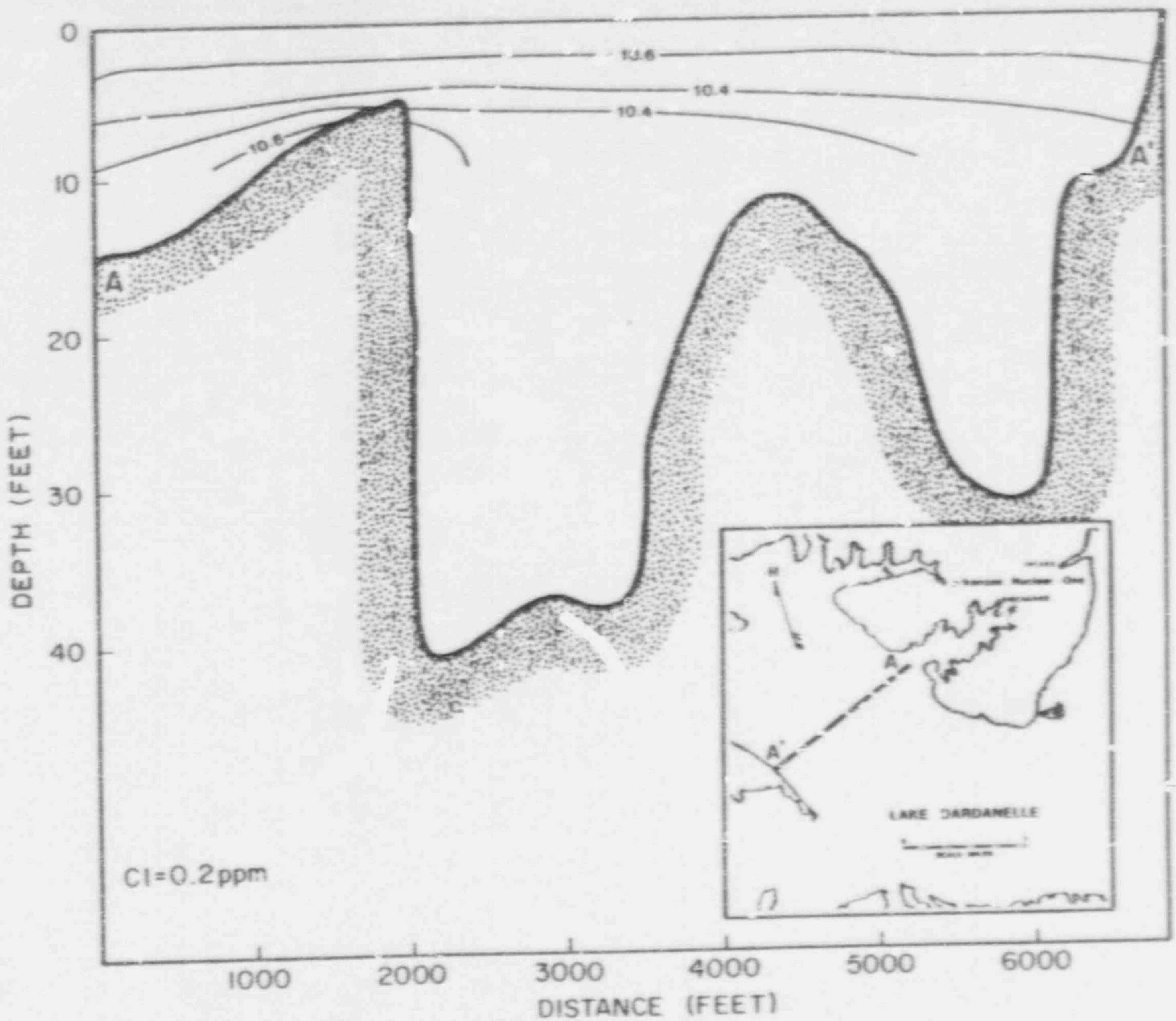

Figure 15. Dissolved oxygen cross-section, 16 April 1975.

Figure 16 shows the temperature cross-section. Ambient temperature for the survey was 76.7°F, making the 5°F delta equal to 81.7°F. The average of the surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 82.4°F, indicating the presence of a zone of water temperatures exceeding the 5°F delta. This zone extended approximately 1800 feet out from the mouth of the discharge cove along the line of cross-section (A-A'). The areal extent of the 5°F is shown as the shaded area in Figure 17, which represents about 113 acres.

The cross-section for dissolved oxygen appears in Figure 18.

H. 26 June 1975

This survey was conducted under the following conditions: winds were out of the east at from 3-7 knots throughout the day; air temperatures ranged from 75-92°F; ANO generation range was 815 ± 10 MW gross; and reservoir throughflow was continuous averaging 123,000 cfs. The full survey report appears in Volume II.

The cross-section of temperature from the mouth of the discharge cove to the south shore of the lake is shown in Figure 19. Ambient temperature for the survey was 80.5°F, making the 5°F delta 85.5°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 86°F, indicating the presence of a zone of water temperature exceeding the 5°F delta. This zone extended approximately 1580 feet out from the mouth of the discharge cove along the line of cross-section (A-A'). The areal extent of the 5°F delta is shown as the shaded area in Figure 20, which represents about 82 acres.

The dissolved oxygen cross-section appears in Figure 21. As explained in detail in the monthly report (refer to Volume II), no near-surface values for dissolved oxygen were measured.

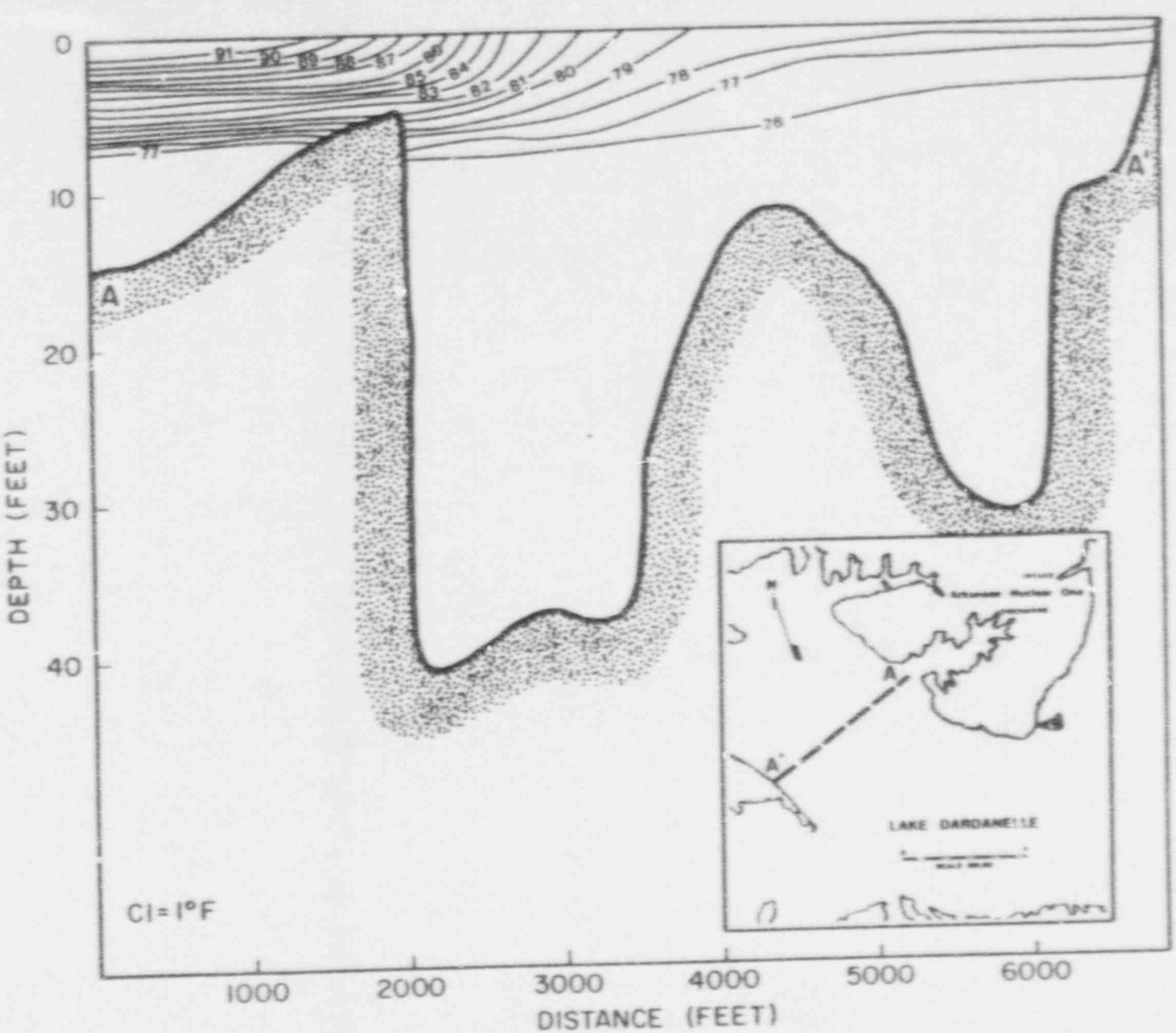

Figure 16. Temperature cross-section, 23 May 1975.

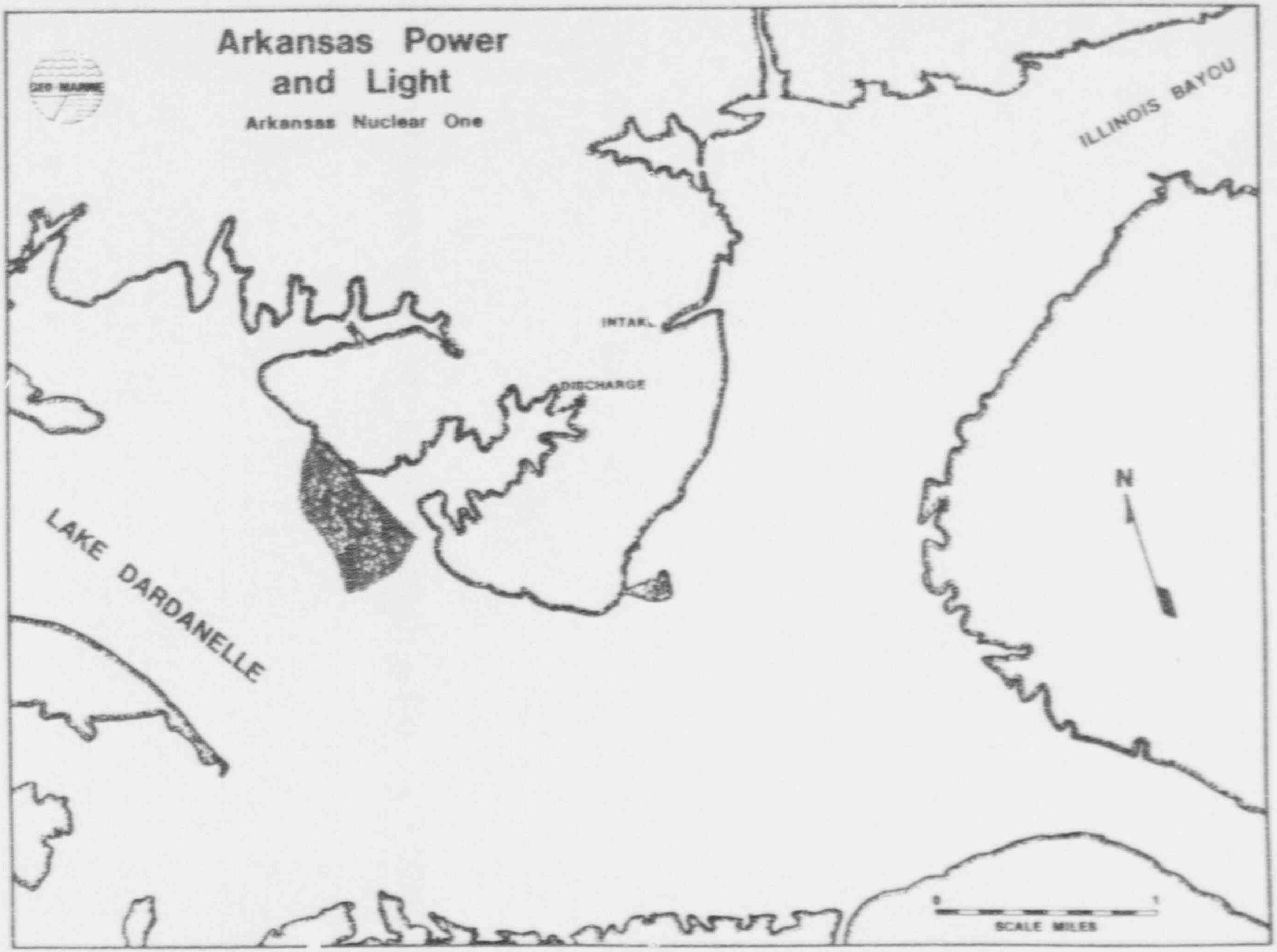

Figure 17. Areal extent of 5°Δ temperature, 23 May 1975.

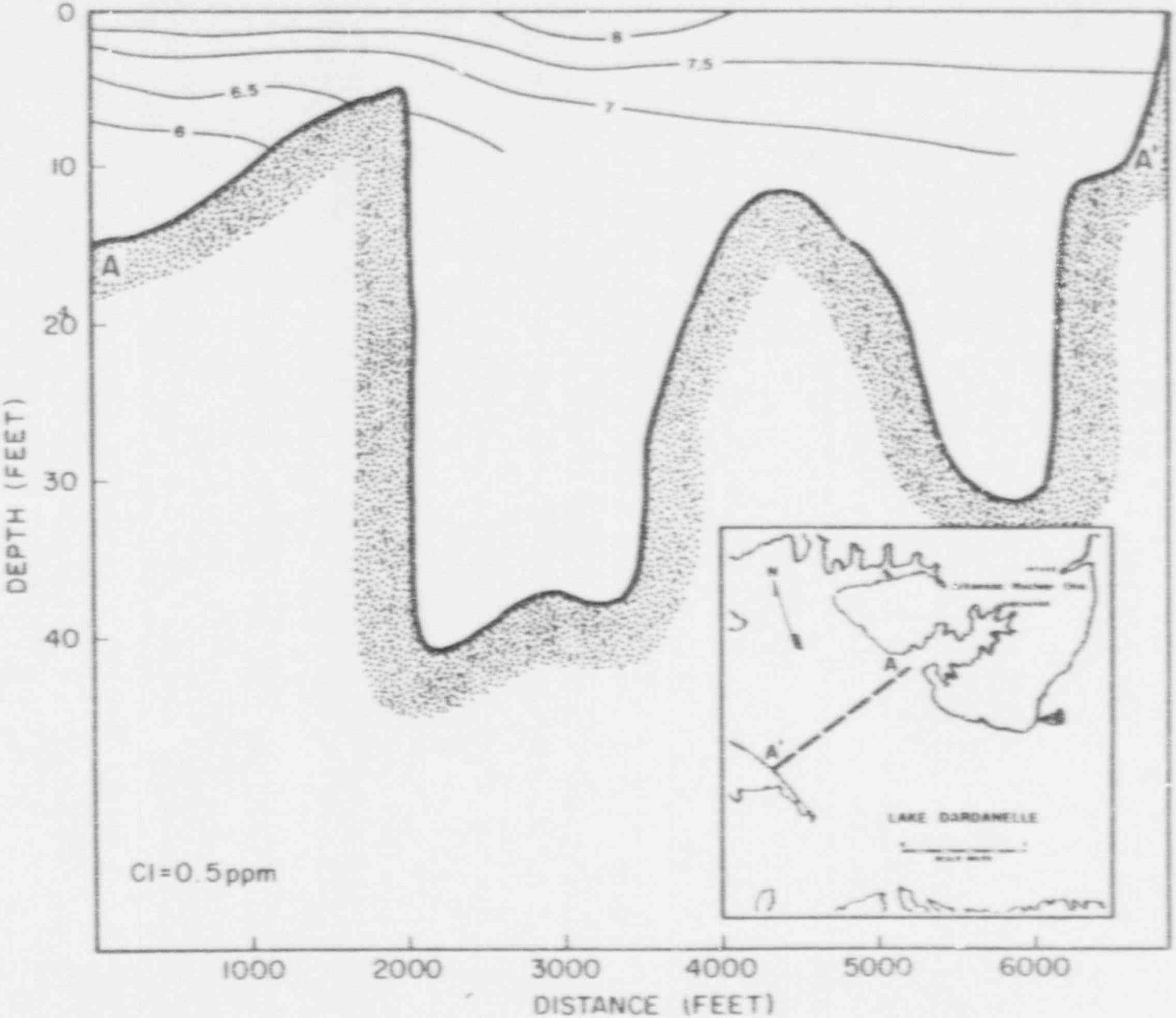

Figure 18. Dissolved oxygen cross-section, 23 May 1975.

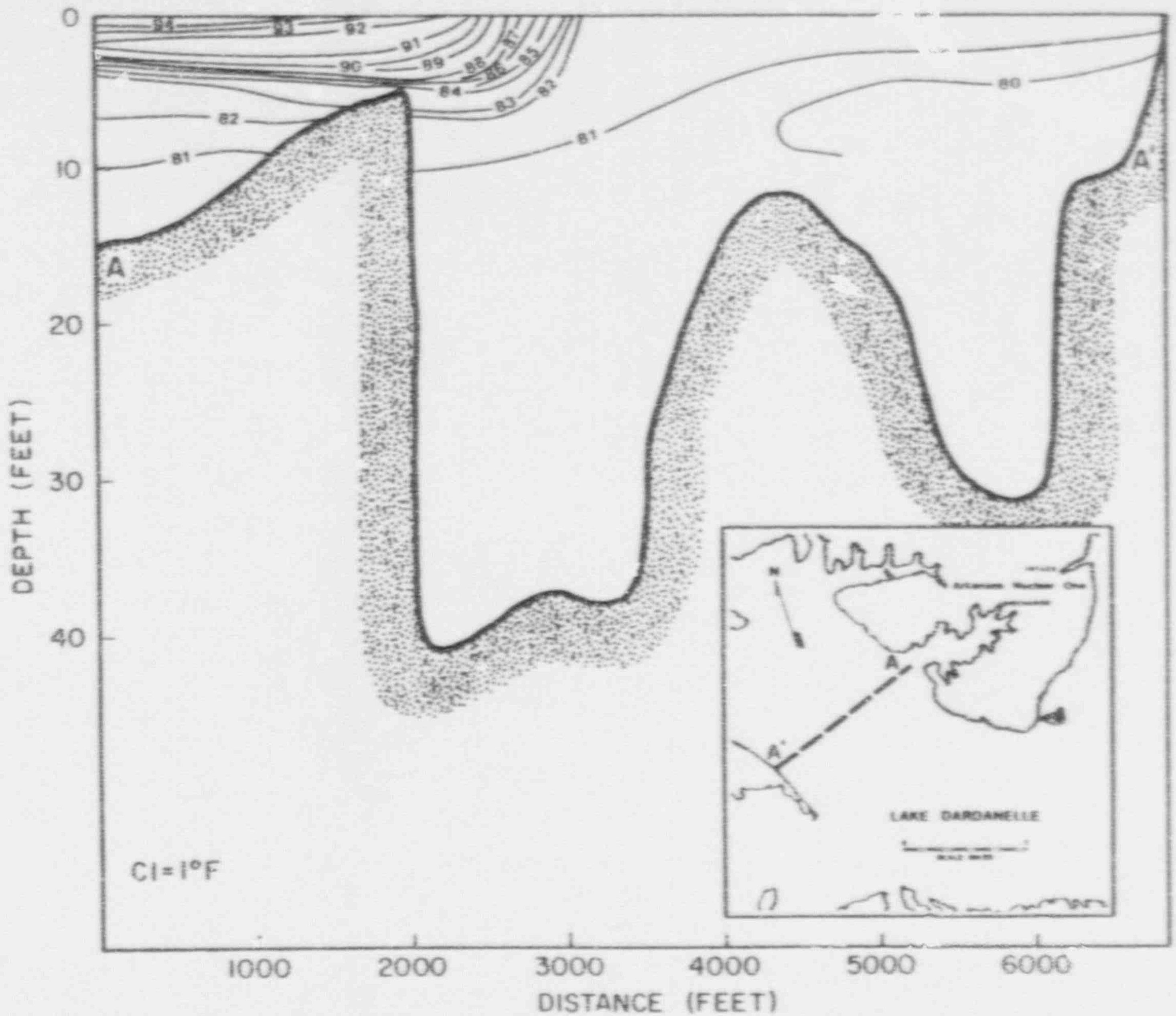

Figure 19. Temperature cross-section, 26 June 1975.

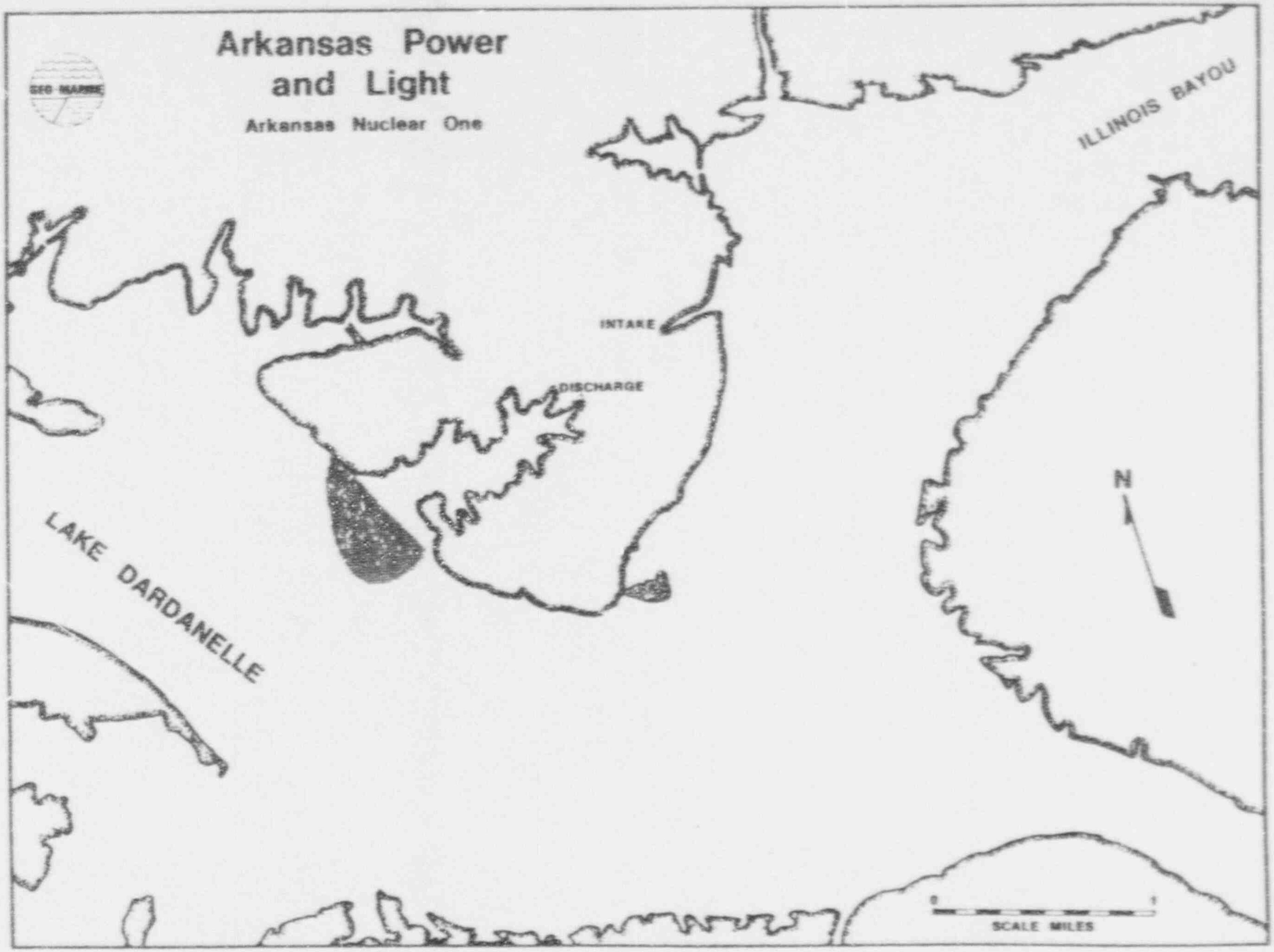

Figure 20. Areal extent of $5^{\circ}\Delta$ temperature, 26 June 1975.

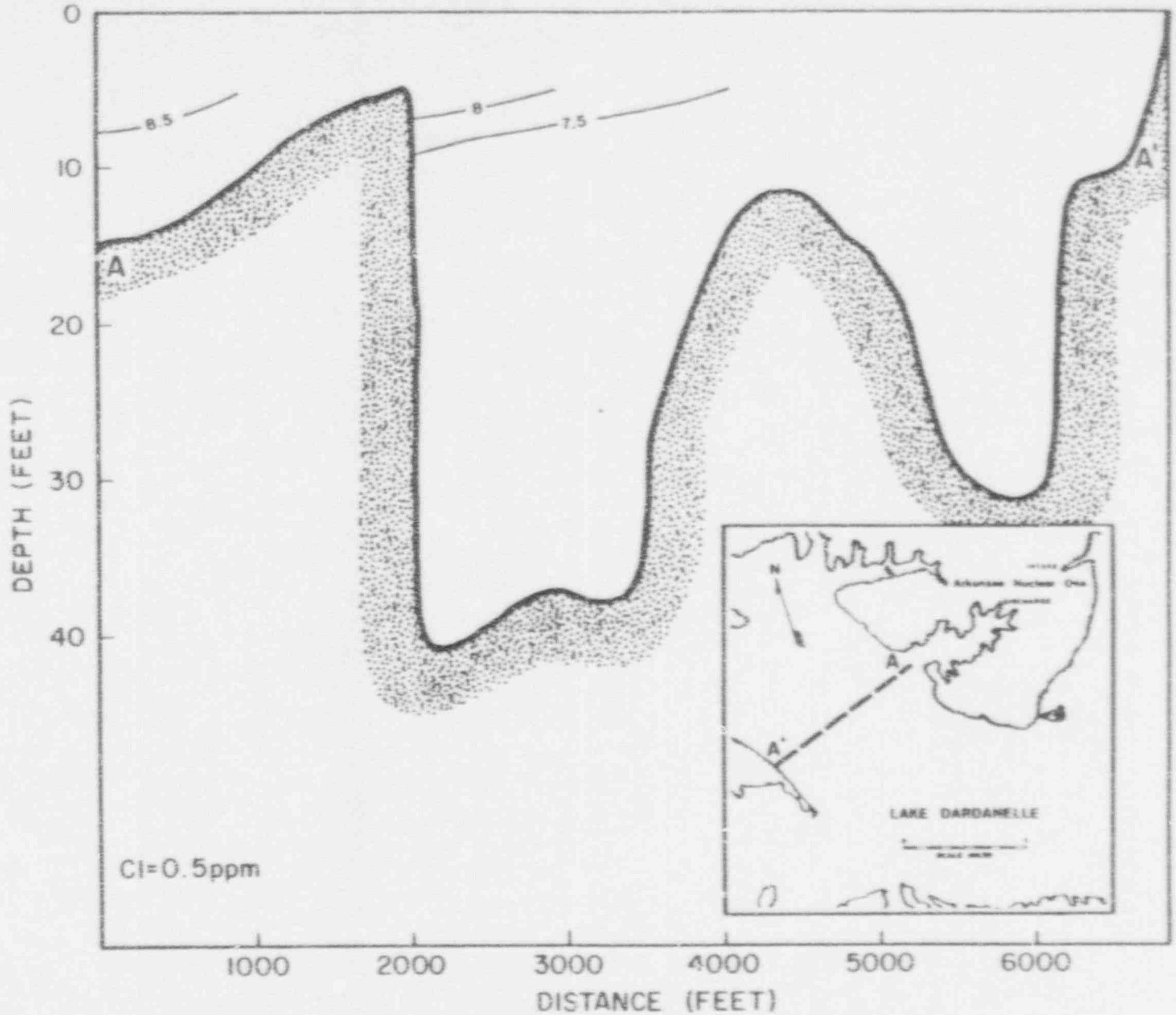

Figure 21. Dissolved oxygen cross-section, 26 June 1975.

I. 6 August 1975

The conditions under which this survey was conducted were as follows: winds reversed direction at mid-morning, having been out of the northeast at about 2 knots and changing to the southwest at 3-6 knots; air temperatures ranged from 78°F to 106°F at 1600; ANO generation was within the range of 785 $\pm$ 15 MW; reservoir throughflow, though continuous, varied considerably throughout the day (refer to Figure 3) and averaged 20,100 cfs. The full survey report appears in Volume II.

The cross-section of temperature is shown in Figure 22. Ambient temperature for the survey was 86.6°F, making the 5°F delta 91.6°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 89°F, indicating that the zone of water temperatures exceeding the 5°F delta did not extend out beyond the discharge cove.

Why so little increase? Evaporative cooling?

The cross-section for dissolved oxygen appears in Figure 23.

J. 28 August 1975

This survey was conducted under the following conditions: winds at 4-5 knots in the early morning hours that gave way to stronger southerly winds at 5-12 knots; air temperatures ranged from 70-92°F; ANO generation ranged about 775 $\pm$ 10 MW; while the reservoir throughflow pattern was similar to the 6 August pattern, continuous but varying considerably throughout the day (Figure 3) and averaged 19,600 cfs. The full survey report appears in Volume II.

The cross-section of temperature is presented in Figure 24. Ambient temperature for the survey was 84.5°F, giving a 5°F delta temperature of 89.5°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 90°F, indicating the presence of a zone of water temperatures exceeding the 5°F delta. This zone extended approximately 690 feet out from the mouth of the discharge cove along the line of the cross-section (A-A'). The areal extent of the 5°F delta, as shown by the shaded area in Figure 25, represents about 83 acres.

'c - SRC - QA Subcommittee

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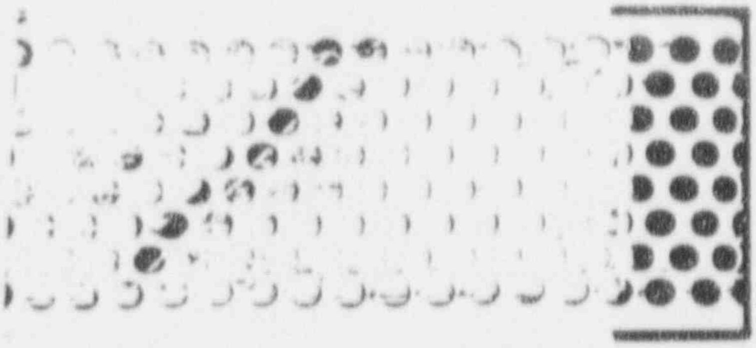

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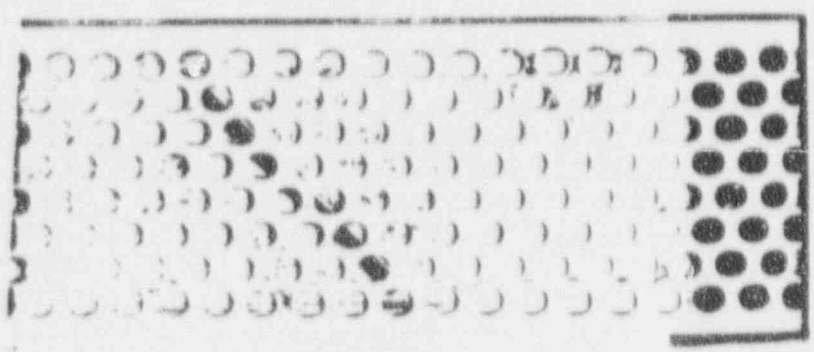

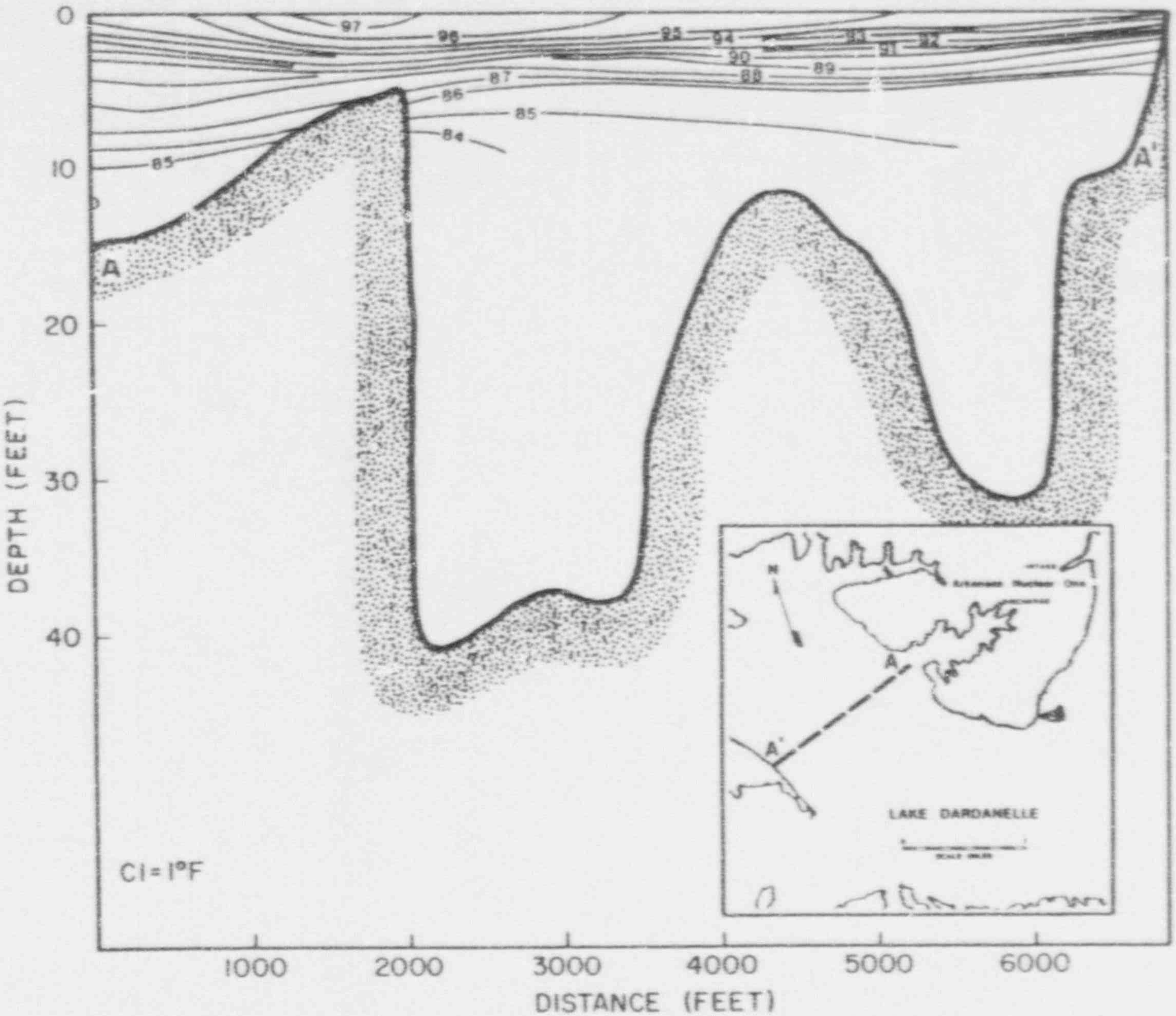

Figure 22. Temperature cross-section, 6 August 1975.

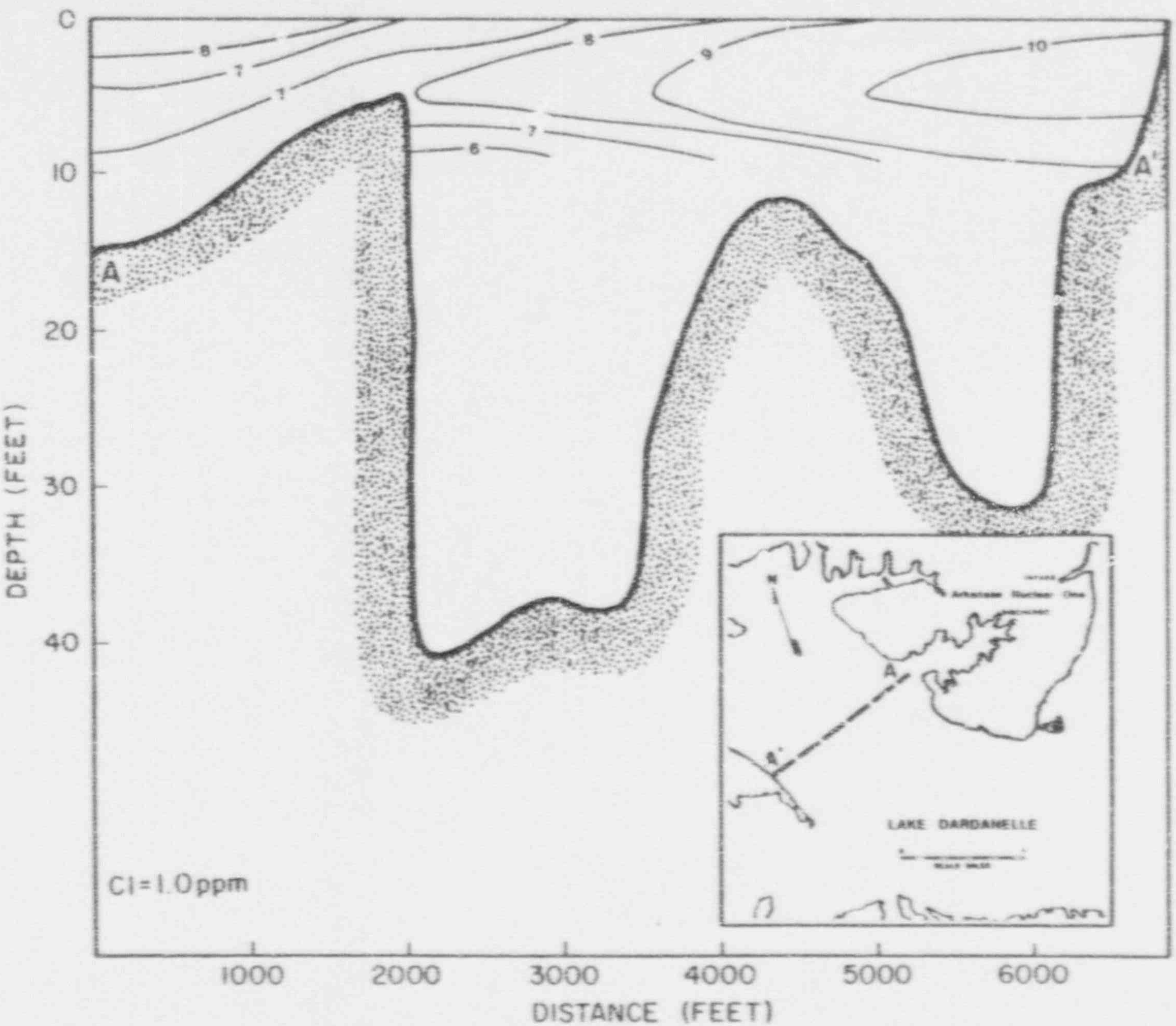

Figure 23. Dissolved oxygen cross-section, 6 August 1975.

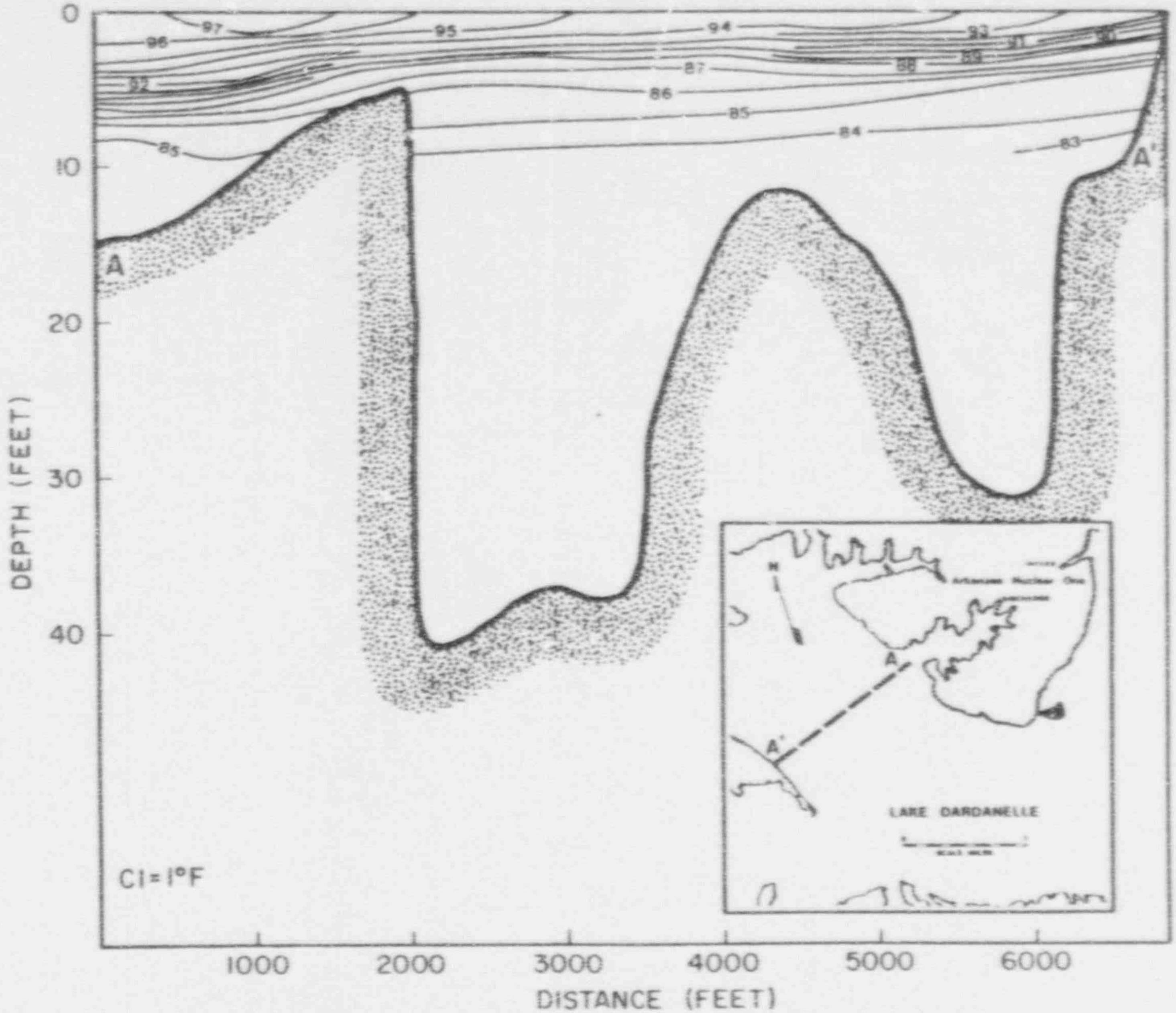

Figure 24. Temperature cross-section, 28 August 1975.

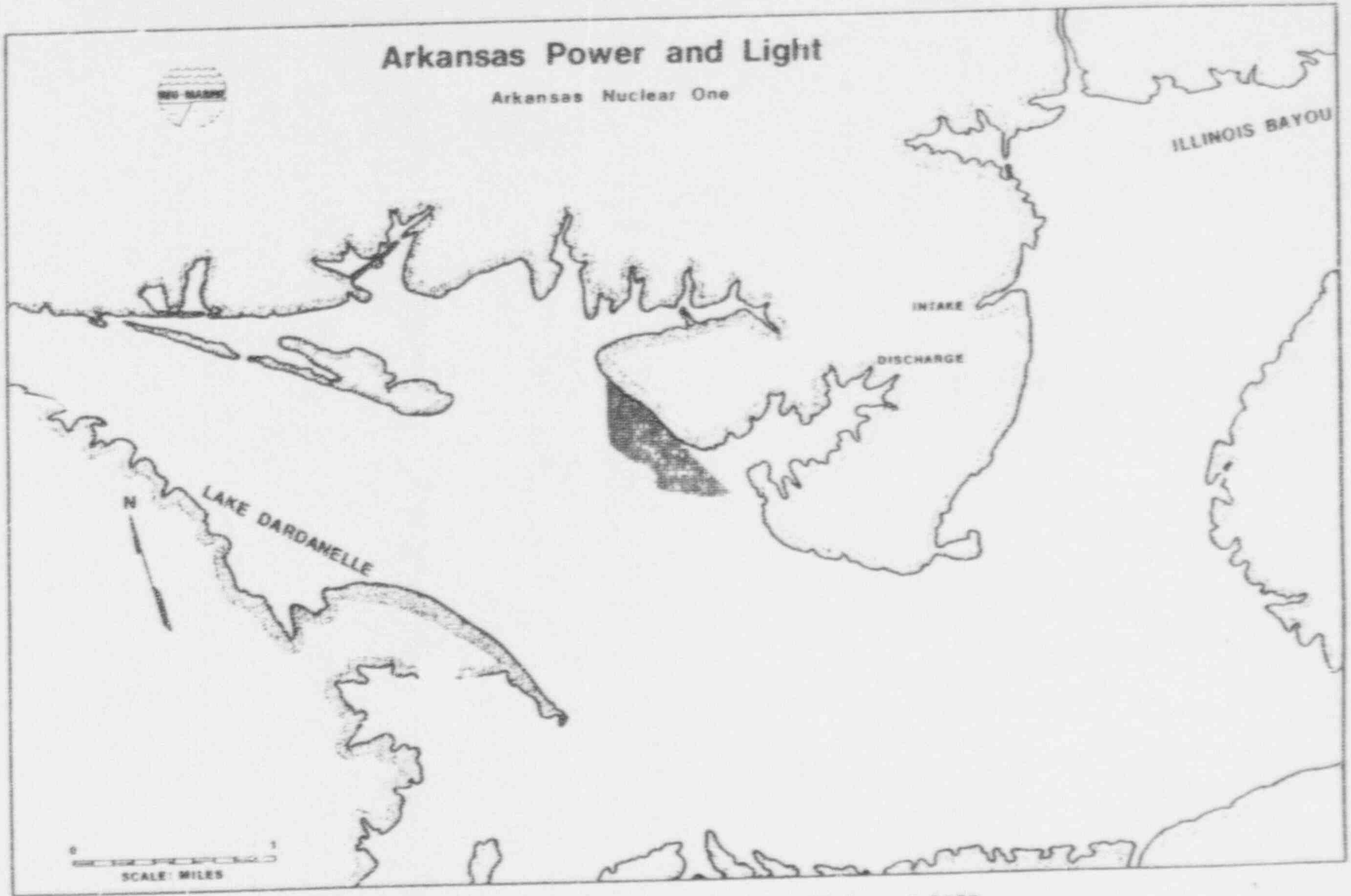

Figure 25. Areal extent of 5°Δ temperature, 28 August 1975.

The dissolved oxygen cross-section appears in Figure 26. No surface values for dissolved oxygen were measured in the area within 2500 feet along the line of the cross-section. A full explanation is included in the monthly report in Volume II.

K. 24 September 1975

The following conditions prevailed on the day of this survey: winds were generally out of the north at from 3-9 knots; air temperatures ranged from 55-68°F; ANO generation was 835 ± 5 MW; and reservoir throughflow was discontinuous, ranging from near-zero from midnight to 0400 to about 40,000 cfs most of the remainder of the day, the average being 29,800 cfs. This survey was the first of this program that was conducted when pooling had occurred for part of the survey day. The full survey report appears in Volume II.

The temperature cross-section appears in Figure 27. Ambient temperature for the survey was 68°F, making the 5°F delta 73°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 74.6°F, indicating the presence of a zone of water temperature exceeding the 5°F delta. This zone extended approximately 630 feet out from the mouth of the discharge cove along the line of the cross-section (A-A'). The areal extent of the 5°F delta, as shown by the shaded area of Figure 28, represents about 10 acres.

The cross-section for dissolved oxygen appears in Figure 29.

L. 11 November 1975

On the day of the survey the following conditions prevailed: winds during the early hours of the day were generally out of the west ranging from calm to 3 knots, but by afternoon became more southerly at from 3-7 knots; air temperatures ranged from 36-69°F; ANO generation from midnight to 1800 was 720 ± 5 MW; and reservoir throughflow was discontinuous, ranging from near-zero from midnight to 0700 to about 8000 cfs from 0700-1600. Greater throughflow occurred in the early evening hours, pooling again commenced at 2200, and the average discharge for the day was about 8000 cfs. The full survey report appears in Volume II.

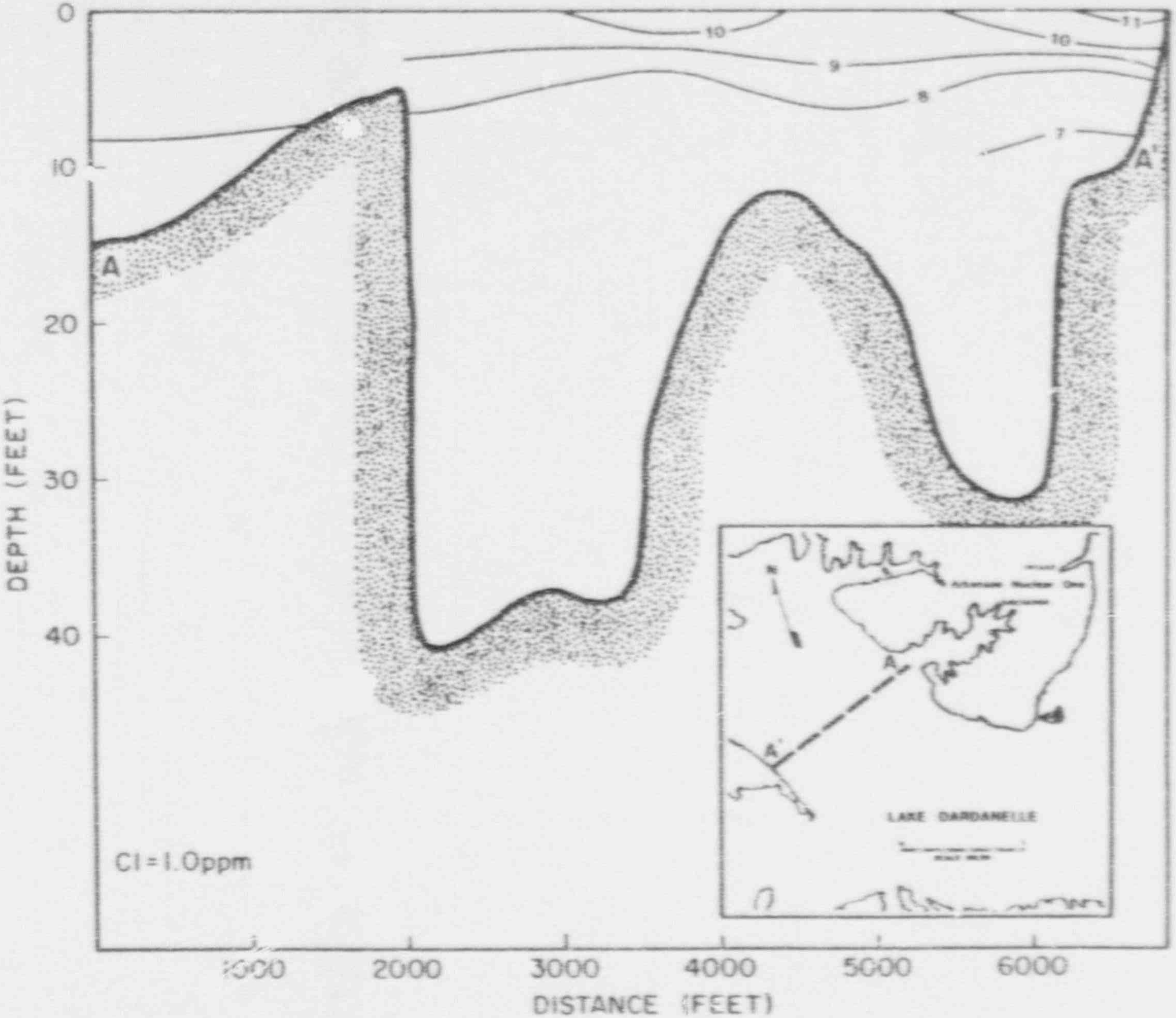

Figure 26. Dissolved oxygen cross-section, 28 August 1975.

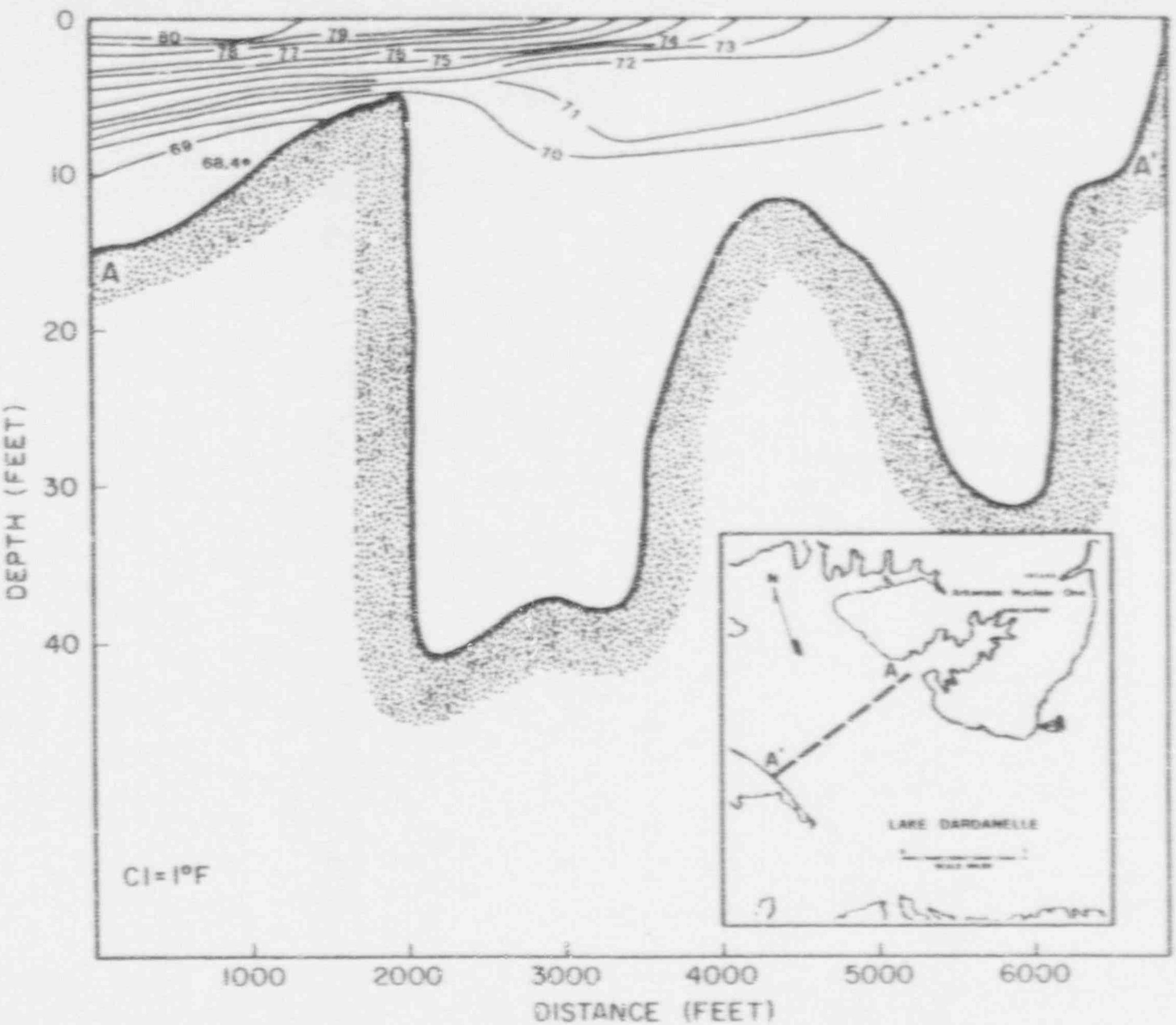

Figure 27. Temperature cross-section, 24 September 1975.

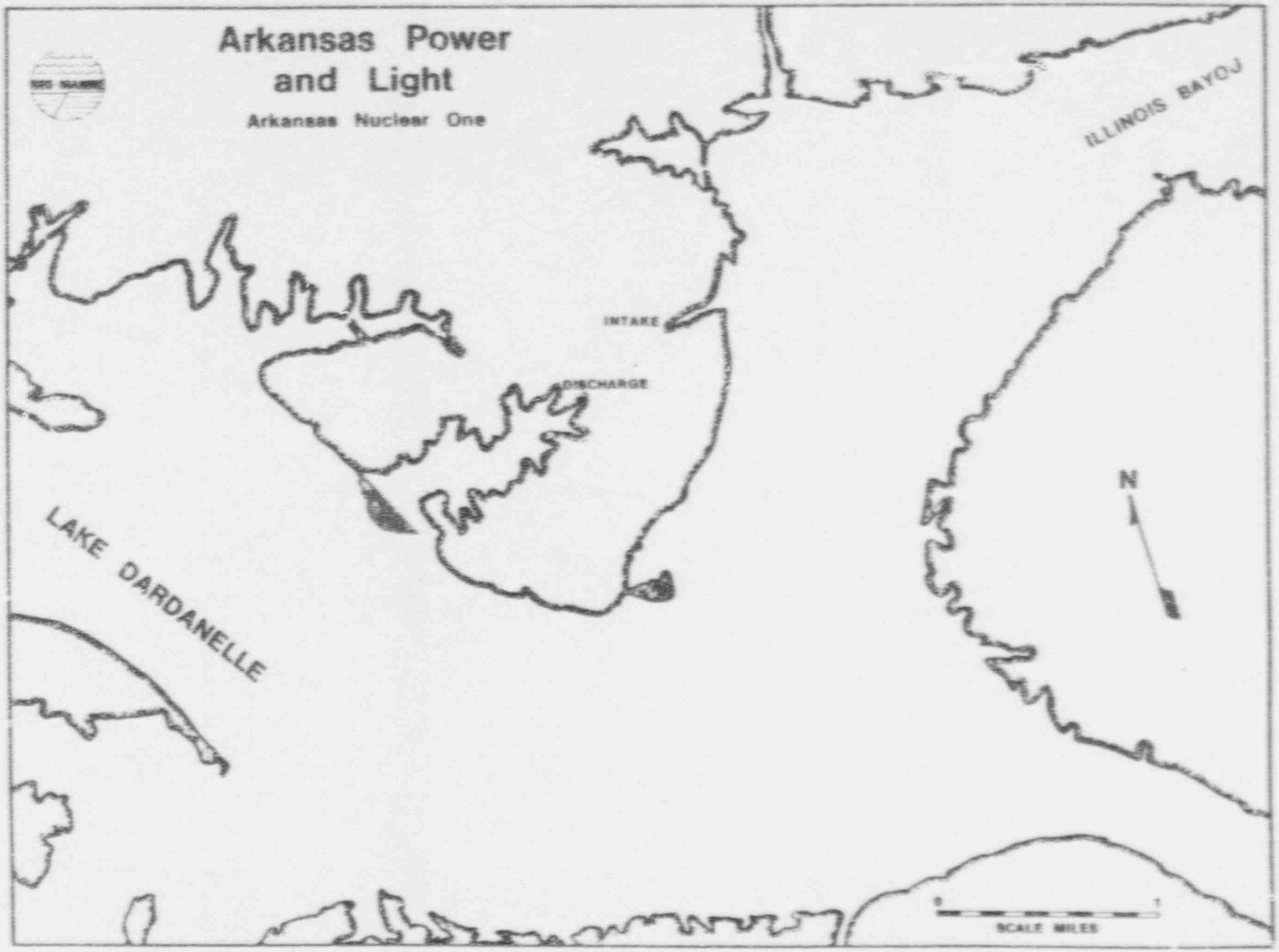

Figure 28. Areal extent of 5°Δ temperature, 24 September 1975.

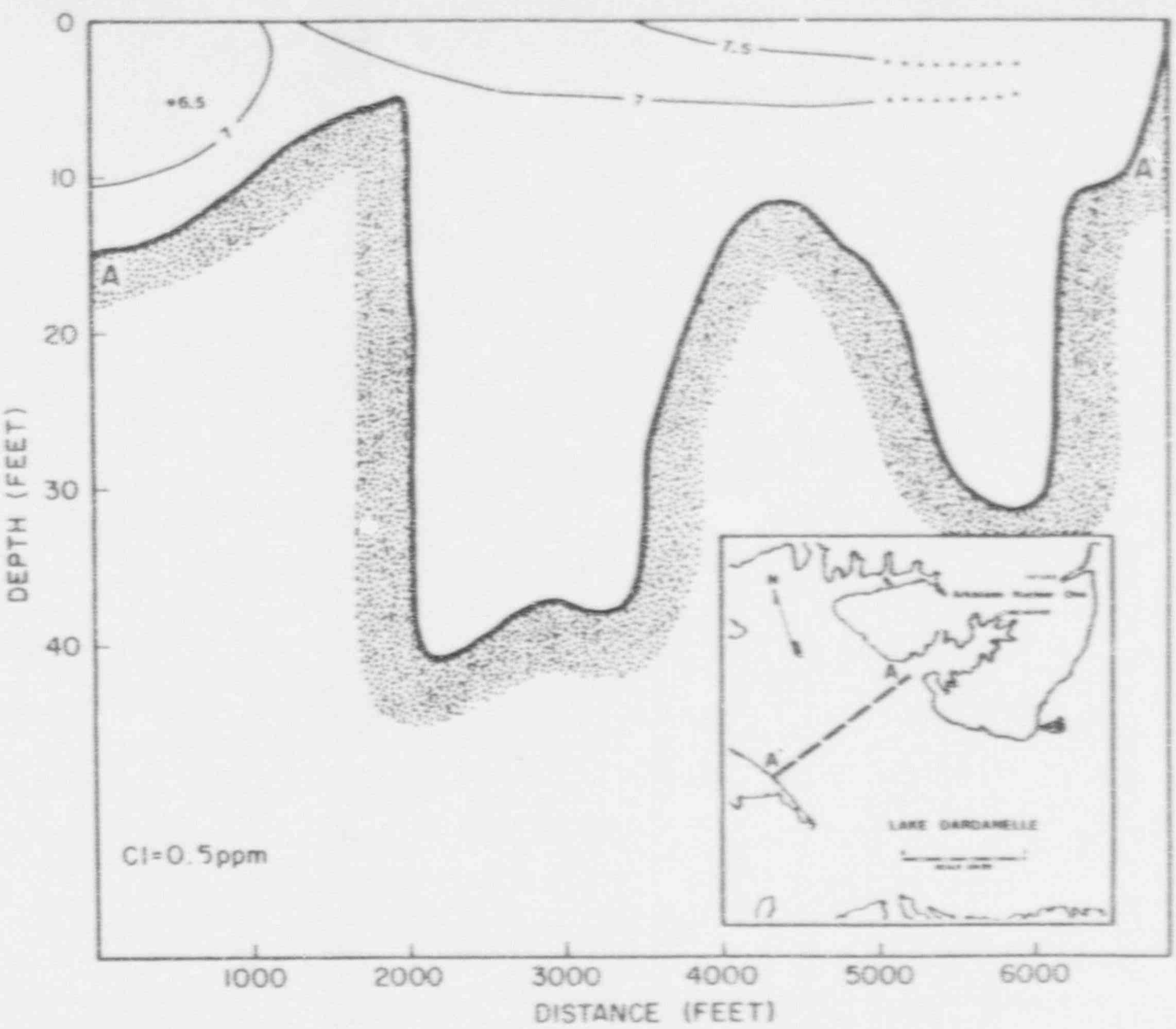

Figure 29. Dissolved oxygen cross-section, 24 September 1975.

The temperature cross-section appears in Figure 30. Ambient temperature for the survey was 65.5°F, making the 5°F delta 70.5°F. The average of the surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 71.2°F, indicating the presence of a zone of water temperature exceeding the 5°F delta. This zone extended approximately 370 feet out from the mouth of the discharge cove along the line of the cross-section (A-A'). The areal extent of the 5°F delta, as shown in Figure 31 by shading, represents approximately 14 acres.

The dissolved oxygen cross-section appears as Figure 32.

M. 7 December 1975

This survey was conducted under the following conditions: winds were 3-6 knots, predominantly out of the north; air temperatures ranged from 39-45°F, ANO generation was 705 ± 5 MW from midnight to 1400, then increased over the next several hours to [illegible] ± 2 MW from 1700 through the remainder of the day; and, unlike conditions during the previous two surveys, throughflow was essentially continuous and averaged 36,200 cfs. The full survey report appears in Volume II.

The cross-section of temperature is presented in Figure 33. Ambient temperature for the survey was 47.9°F, giving a 5°F delta temperature of 52.9°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 56.6°F, indicating the presence of a zone of water temperature exceeding the 5°F delta. This zone extended approximately 2100 feet out from the mouth of the discharge cove along the line of the cross-section (A-A'). The areal extent of the 5°F delta, as shown by the shaded area of Figure 34, was about 171 acres.

The cross-section for dissolved oxygen appears in Figure 35.

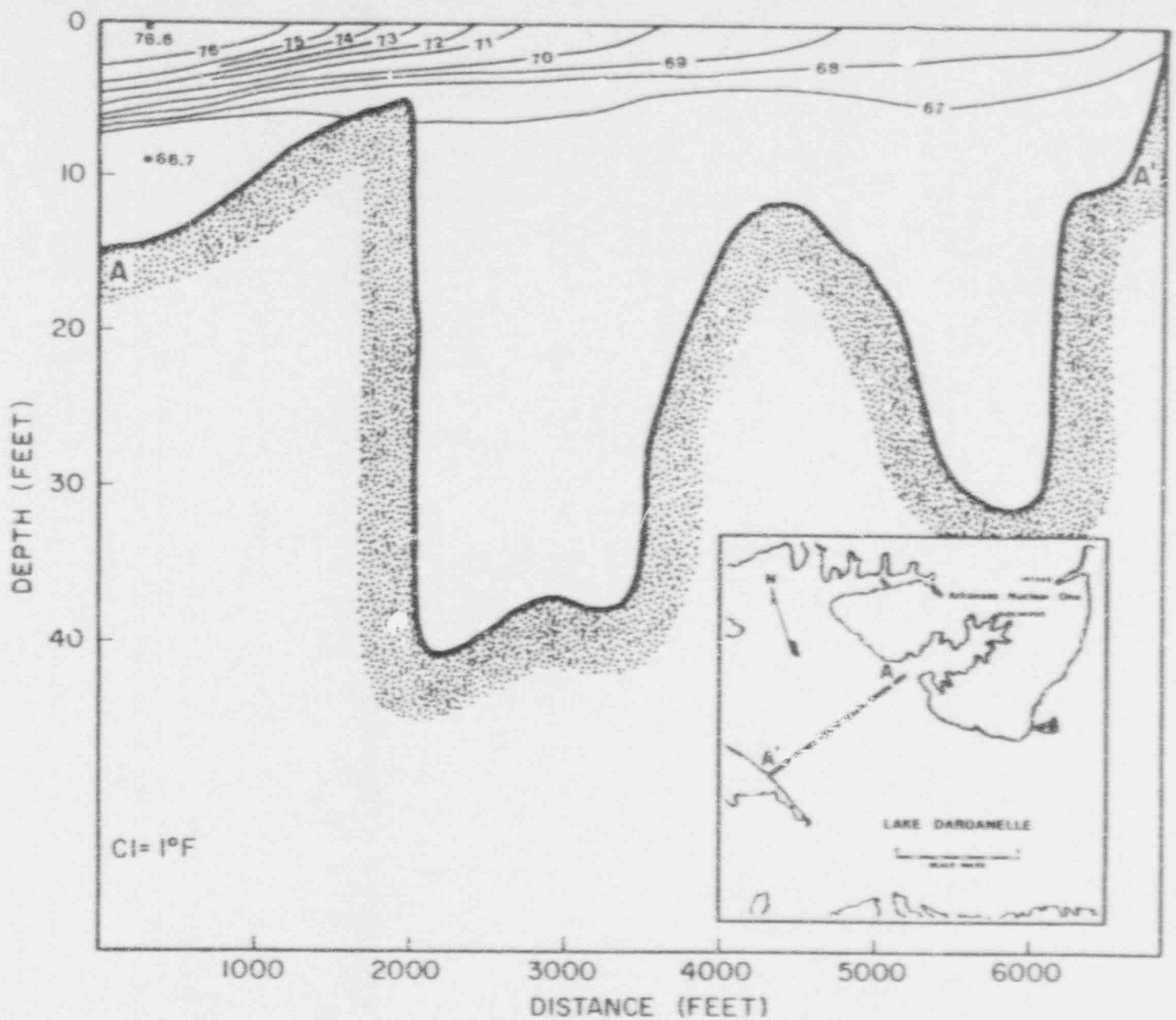

Figure 30. Temperature cross-section, 11 November 1975.

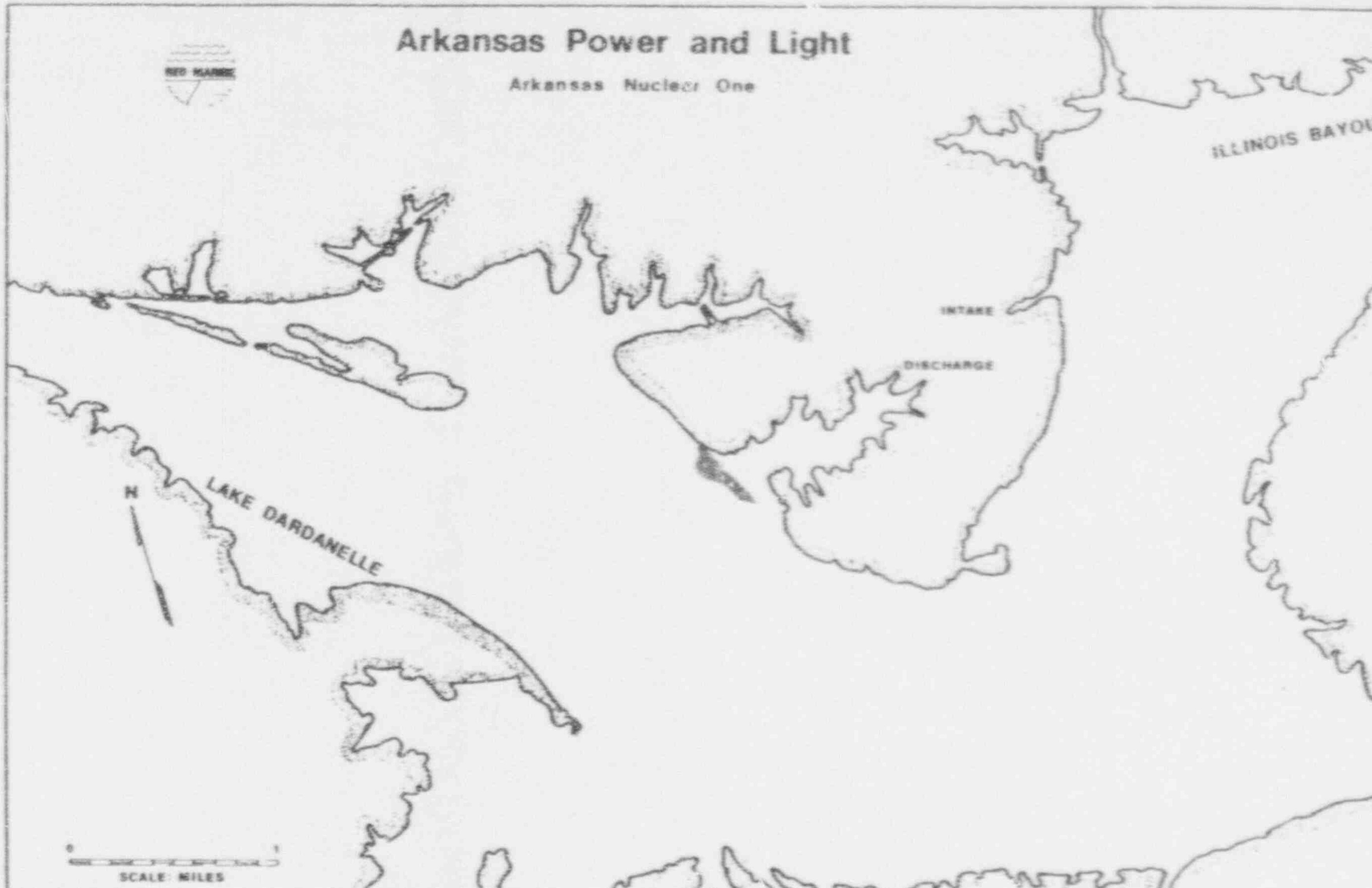

Figure 31. Areal extent of 5°Δ temperature, 11 November 1975.

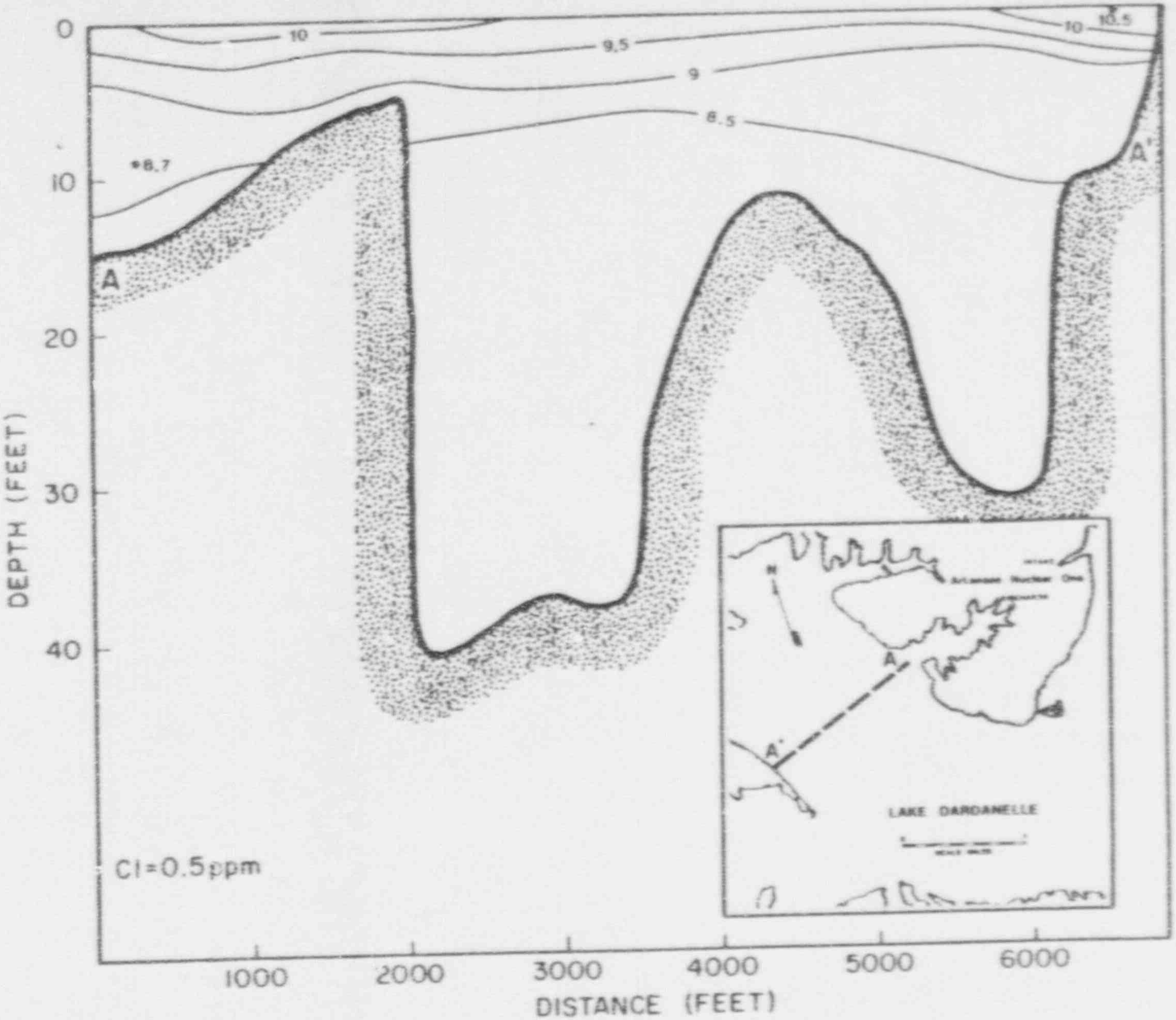

Figure 32. Dissolved oxygen cross-section, 11 November 1975.

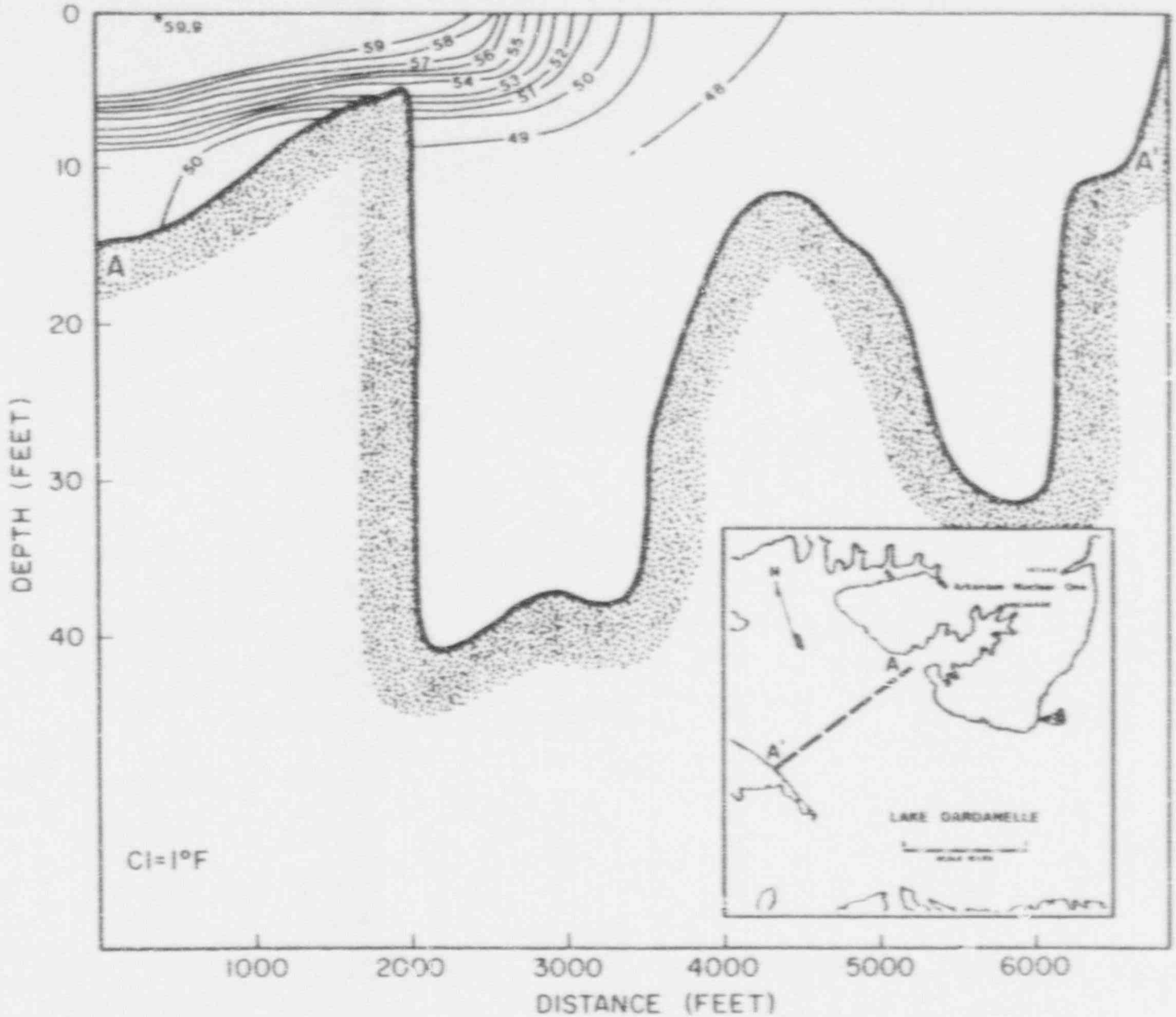

Figure 33. Temperature cross-section, 7 December 1975.

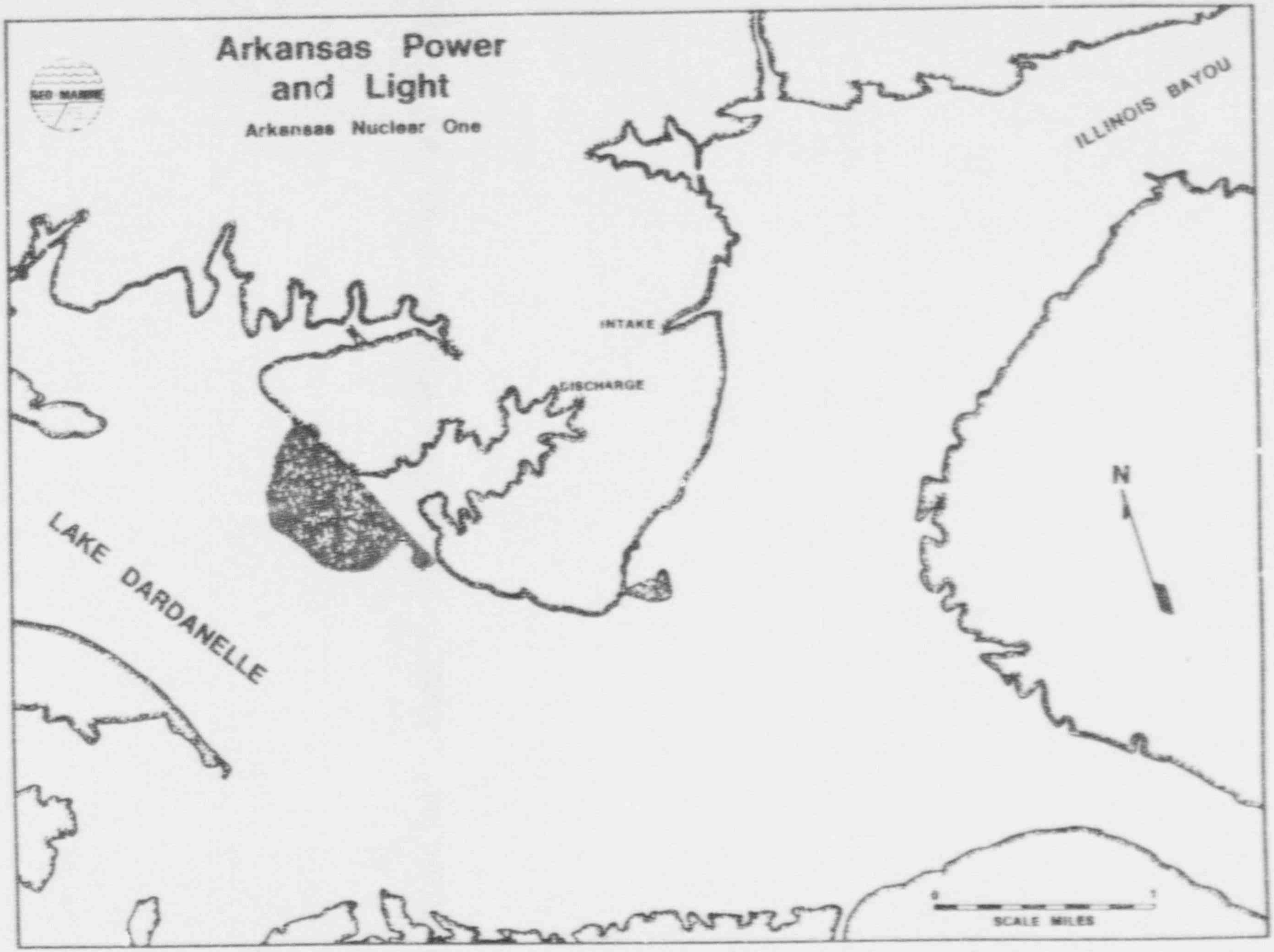

Figure 34. Areal extent of 5°Δ temperature, 7 December 1975.

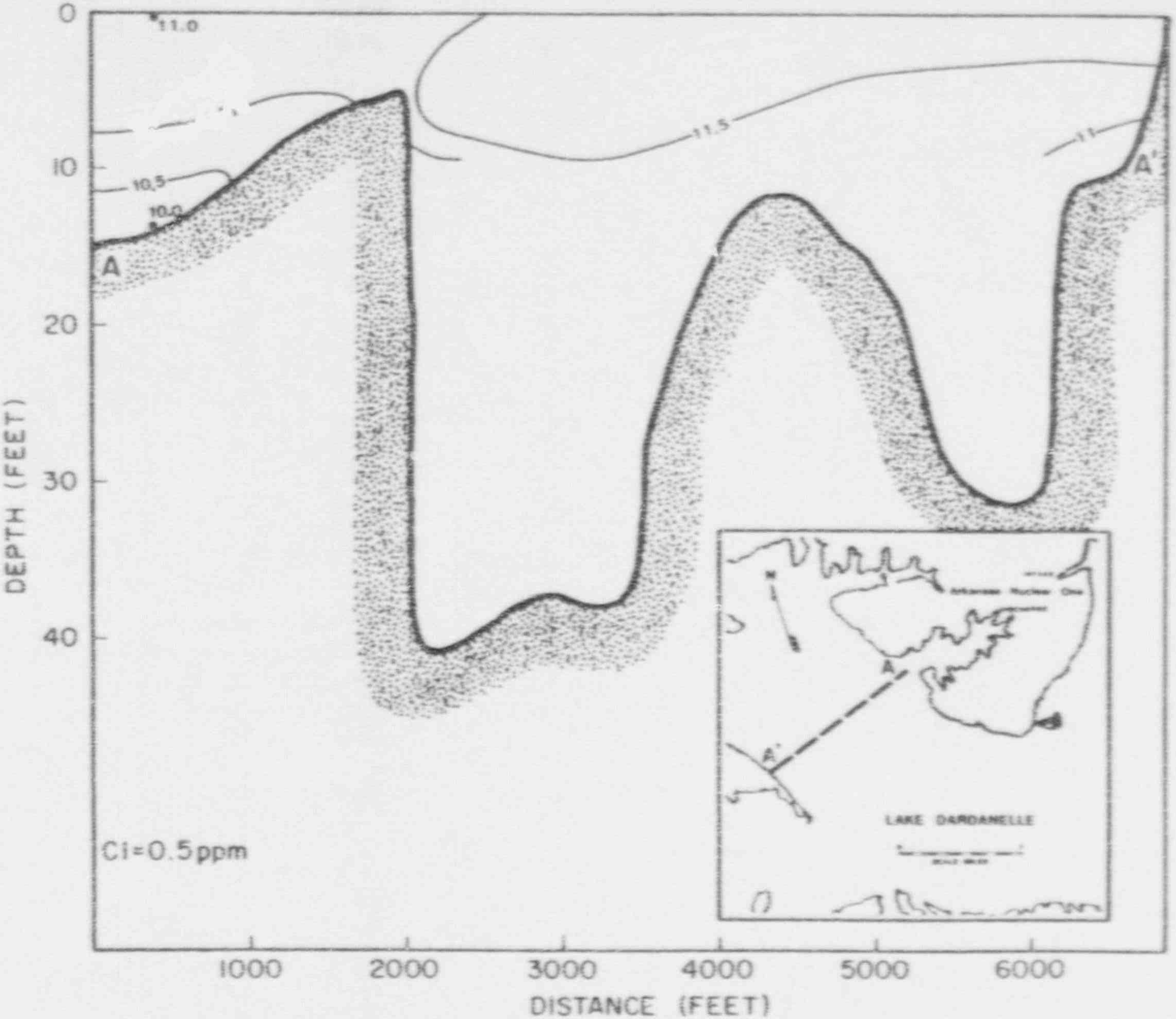

Figure 35. Dissolved oxygen cross-section, 7 December 1975.

N. 27 January 1976

The following conditions prevailed on the day of the January survey: winds throughout the morning hours were northerly at 4-7 knots, shifting in the afternoon to easterly at 1-4 knots; air temperatures ranged from 21-40°F; ANO generation was 862 ± 7 MW; and reservoir throughflow was discontinuous--being near-zero from midnight to 0700, 14,000 cfs from 0700-1500, near-zero again from 1500-1700, returning to 14,000 cfs from 1700-2200, with pooling again occurring by 2300. (Average throughflow for the day was 7800 cfs). The full survey report is contained in Volume II.

The cross-section of temperature is presented in Figure 36. Ambient temperature for the survey was 41°F, giving a 5°F delta temperature of 46°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 52°F, indicating the presence of a zone of water temperatures exceeding the 5°F delta. Along the line of the cross-section this zone extended approximately 4170 feet out from the mouth of the discharge cove, which the areal extent, as shown by the shaded area in Figure 37, was about 525 acres.

The cross-section for dissolved oxygen appears in Figure 38.

O. 25 February 1976

On the day of the survey, the following conditions prevailed: southerly winds at 5-10 knots throughout the day; air temperatures from 48-62°F, ANO generation at 862 ± 7 MW, and discontinuous reservoir throughflow, with releases occurring between the hours of 0700-1300 and again from 1700-2100 at a rate of 16,400 cfs, while flow was near-zero the remainder of the day. The full survey report appears in Volume II.

The temperature cross-section appears in Figure 39. Ambient temperature for the survey was 51.6°F, giving a 5°F delta temperature of 56.6°F. The average of the near-surface, 3, 5, 7 and 9-foot temperatures at the mouth of the discharge cove was 64°F, indicating the presence of a zone of water temperatures exceeding the 5°F delta. Along the line of the cross-section this zone extended approximately 2900 feet out from the mouth of the discharge cove, while its areal extent, as shown by the shaded area in Figure 40, was about 573 acres.

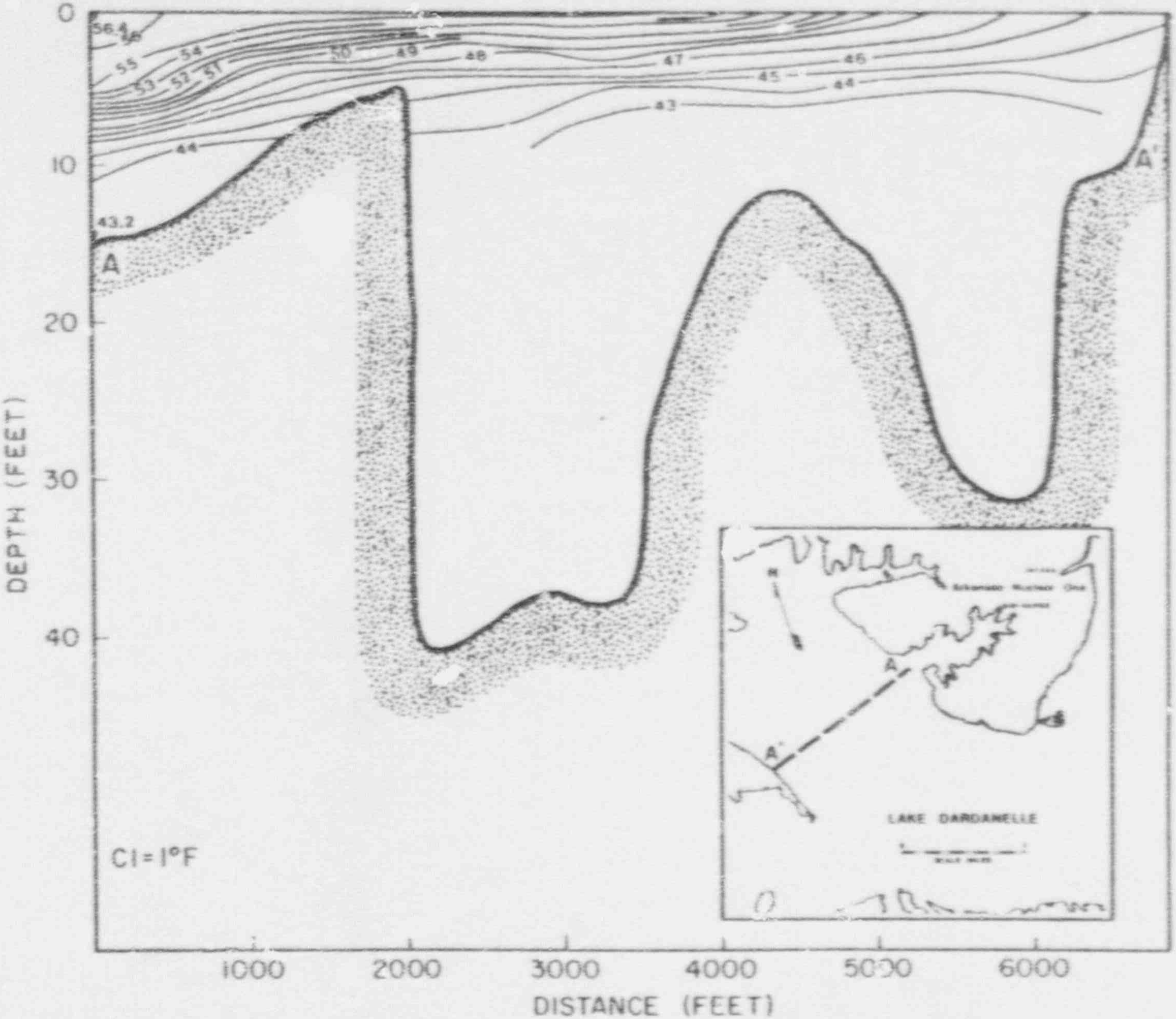

Figure 36. Temperature cross-section, 27 January 1976.

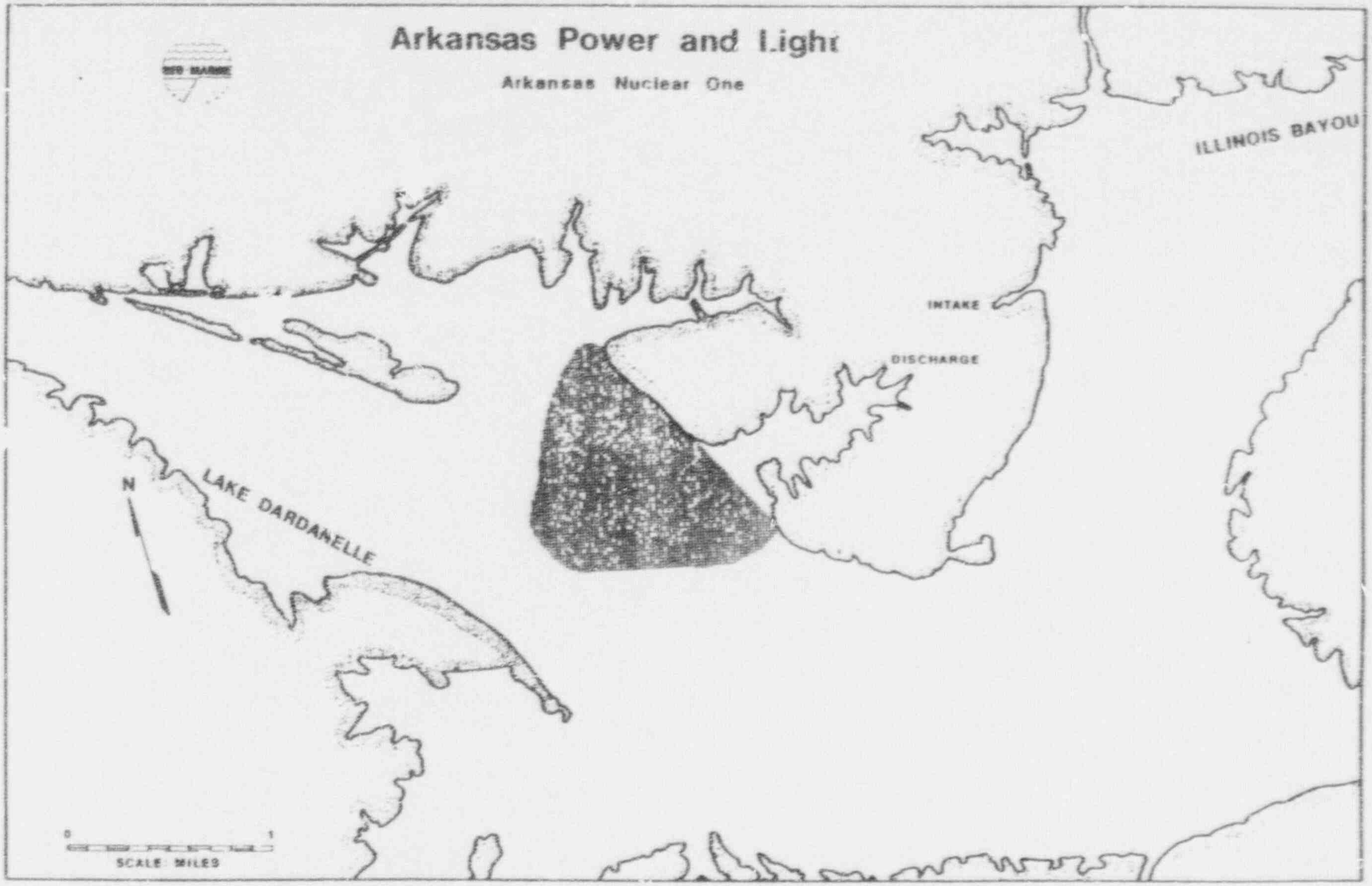

Figure 37. Areal extent of 5°Δ temperature, 27 January 1976.

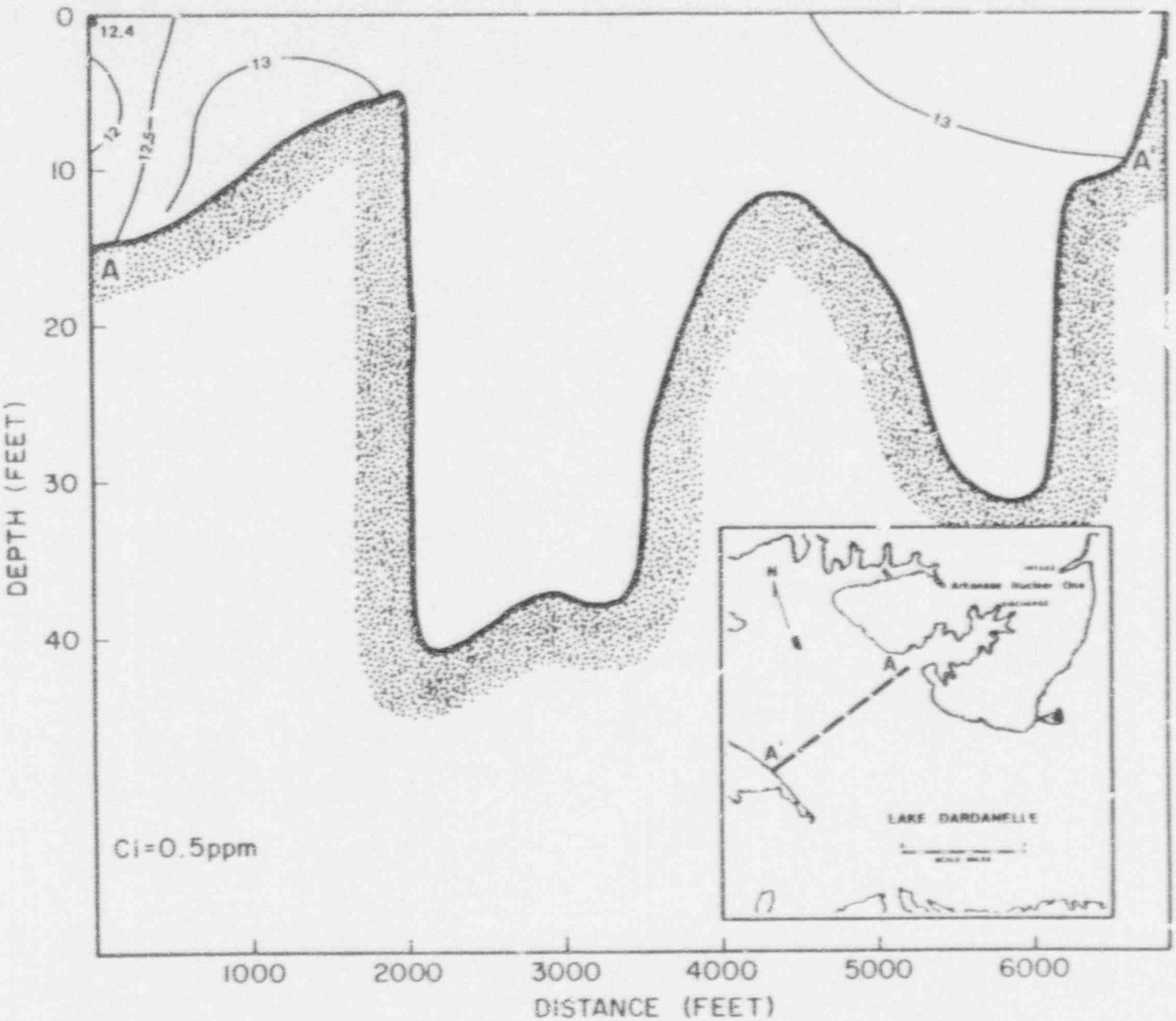

Figure 38. Dissolved oxygen cross-section, 27 January 1976.

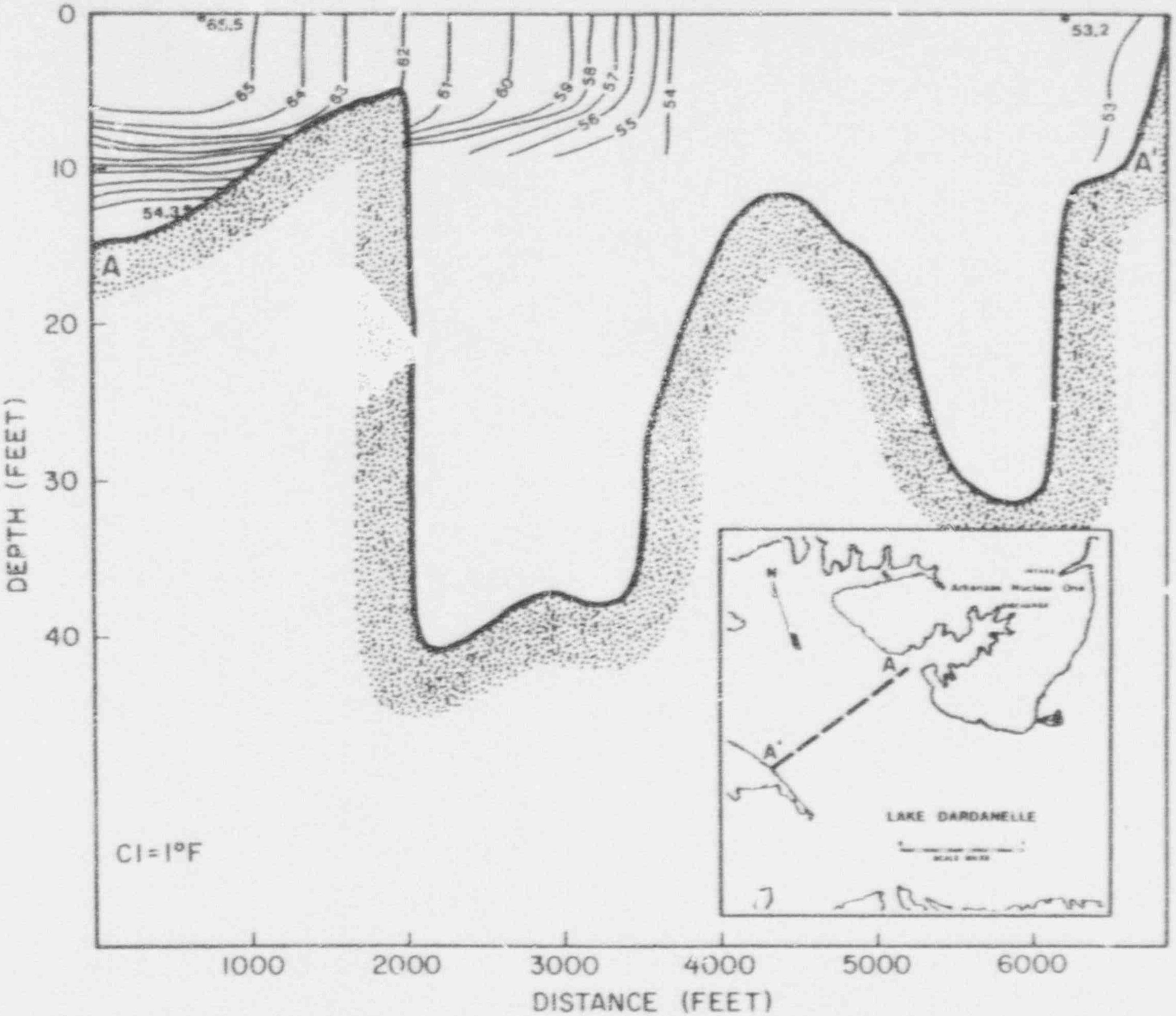

Figure 39. Temperature cross-section, 25 February 1976.

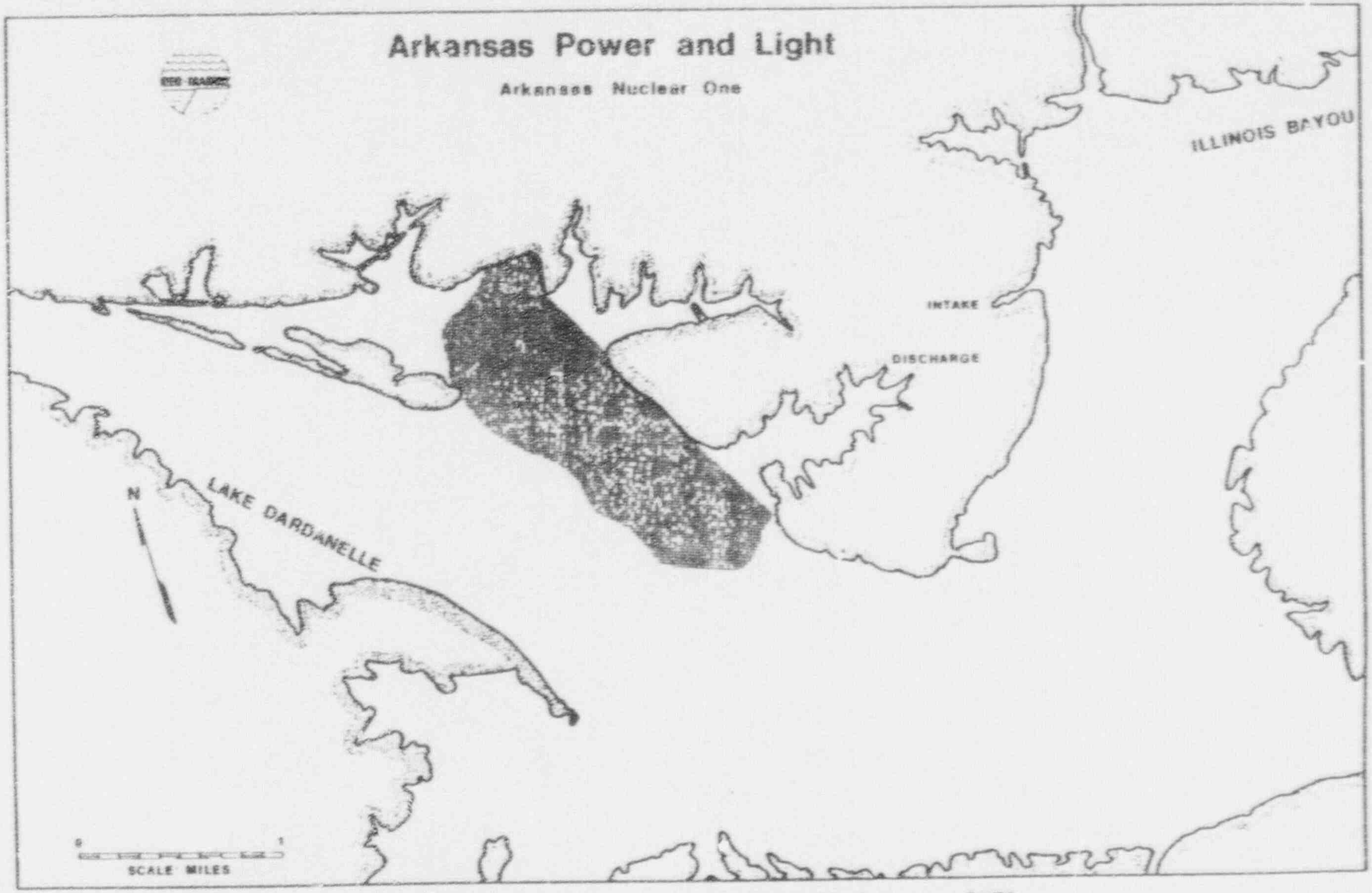

Figure 40. Areal extent of 5°Δ temperature, 25 February 1976.

The cross-section for dissolved oxygen appears in Figure 41.

VII. SUMMARY

The conditions of Lake Dardanelle and the generation of the ANO facility varied considerably throughout the course of this survey program. As a result, the appearance and distribution of the plume also changed markedly. Generally, with all other factors being equal, the most significant factor regulating the extent of the plume was the reservoir throughflow.[4] Once throughflow became intermittent or low, winds became an important factor.[5]

There are three additional plume effects that require comment. These are the questions of recirculation of discharge waters up Illinois Bayou to the intake; depression of dissolved oxygen concentrations in the area of the discharge cove; and an apparent anomaly in vertical profiles of dissolved oxygen for the area immediately northwest of the discharge cove.

Since current flow information for Illinois Bayou is not available, the question of recirculation must be approached by analyzing the isothermal contour charts and by examining other possible explanations for the trends found on them. This approach is complicated by the fact that the pre-operational survey indicated that the characteristics of Illinois Bayou water differed from that of the main body of Lake Dardanelle.[6]

[4] For example, compare the isothermal contour charts (high throughflow--Figures 6-10, pages 15-19) from the January 1975 report with those from the November 1975 report (low intermittent throughflow--Figures 7-11, pages 17-21). These reports are in Volume II.

[5] This is demonstrated by comparing the isothermal contour charts from September 1975 (northerly winds--Figures 6-10, pages 14-18) with those for November 1975 (winds light and variable--Figures 7-11, pages 17-21), and with those for February 1976 (strong, steady winds--Figures 6-10, pages 13-17). These individual survey reports are contained in Volume II.

[6] See paragraph 1, page 6 of the October 1973 report in Volume II.

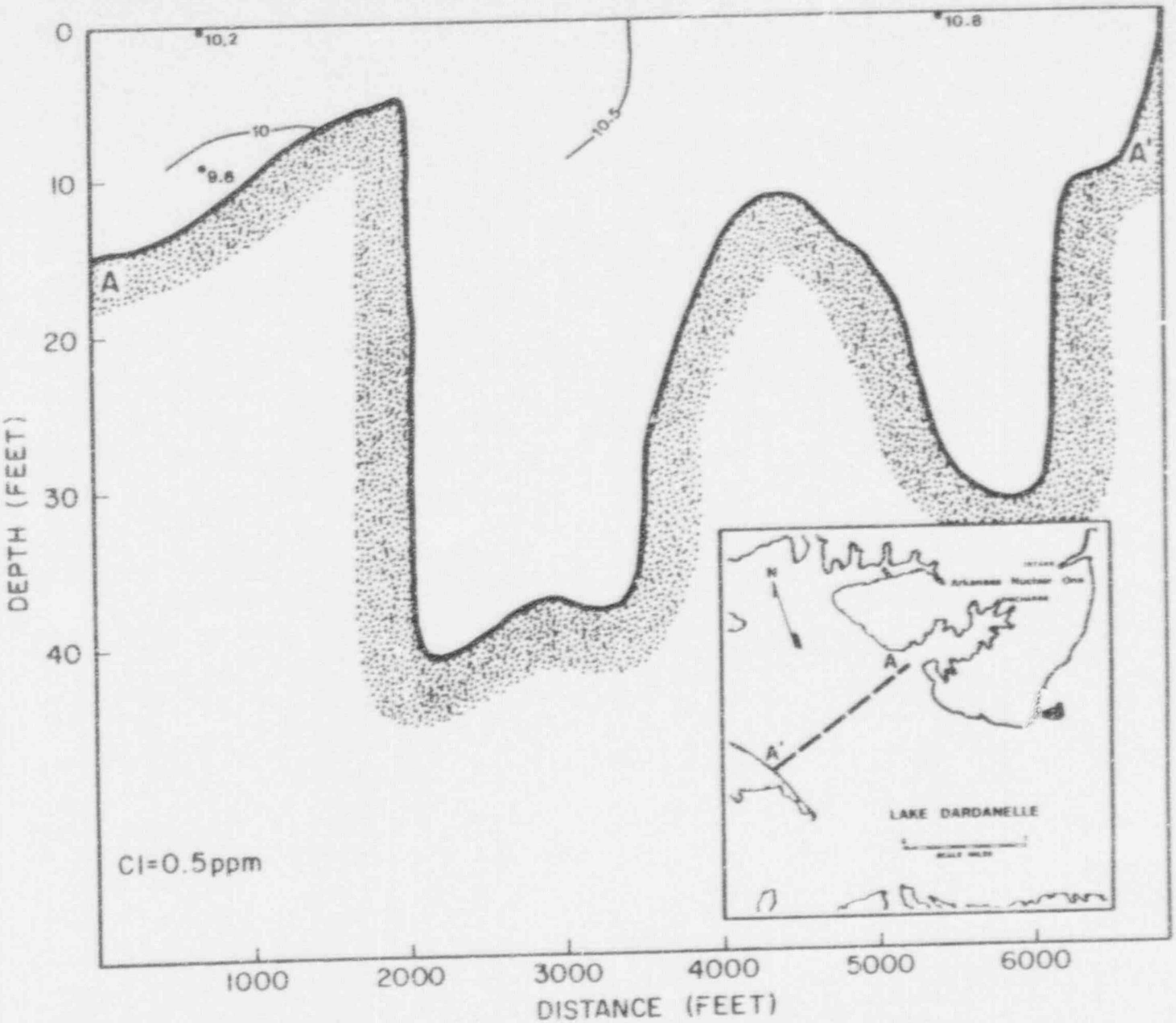

Figure 41. Dissolved oxygen cross-section, 25 February 1976.

The February 1975 survey report stated that:

> *"The waters of Illinois Bayou are warmer than ambient open lake waters at all measured depths. This temperature elevation is as much as 5.8F at the near-surface and 1.6F at a depth of 9 feet. Although we would expect some recirculation of discharge waters, this seems to be the case only at the near-surface. At the 3- and 9-foot depths, the presence of a temperature minimum near where Illinois Bayou joins the main lake body suggests that these deeper waters are moving southward..."*[7]

The first quarterly summary contained in the March 197[illegible] [illegible] summarized the findings of the first three post-operational surveys as [illegible]

> *"Temperatures in Illinois Bayou ranged from 1-5F above the measured ambient in the main body of the lake. There are indications in the February and March survey of some surface recirculation, whereas, all surveys at all measured depths show warmer water northeast of the intake, indicating that flow is in a southerly direction."*[8]

These post-operational surveys were conducted under conditions of relatively high, continuous reservoir throughflow and seemed to indicate a possibility of some recirculation in the upper few feet. The survey in June was done under similar reservoir throughflow conditions but seemed to indicate that no recirculation was occurring.

> *"... The surface temperature contour chart (Figure 5) shows that Illinois Bayou water, ranging in temperature from 81.5F to 86.6F is generally warmer than the ambient open lake waters that are 82F and cooler. A general 5F increase in water temperature is seen at all depths to nine feet as one moves across Illinois Bayou from the southeast to the northwest. Also seen in this survey is the existence of nearly isothermal water in a vertical column from the surface down to the 9-foot depth. Recirculation of discharge water into Illinois Bayou appears to be denied at all depths to nine feet by the existence of water at the Bayou mouth that is, in general, cooler than that which is apparently moving southward (see Figures 5 through 9)".*[9]

[7] February 1975 report (paragraph 3, page 4) of Volume II.

[8] Quarterly summary and March 1975 report (paragraph 3, page 5), Vo[illegible]me II.

[9] June 1975 report (paragraph 5, page 3), Volume II.

The January 1976 survey was done under low, intermittent reservoir throughflow conditions. As a result of that survey, the following observations were reported:

> *"... The near-surfa[illegible] tem[illegible]ature measured at the mouth of the intake cov[illegible] 44F contour does extend from the southeast[illegible]ake into Illinois Bayou and the intake ar[illegible]inues past the intake into the north [illegible] This seems to belie the initial in[illegible]*
>
> *At the 3-f[illegible] depth, the temperatures at the mou[illegible]tured nearly the same as the near-su[illegible] levels, unlike at the near-surf[illegible]enerally decreased in the area of th[illegible]*
>
> *At the 7-foot [illegible] temperature in Illinois Bayou to the nor[illegible]take cove were generally equal to those at the [illegible] Bayou, though the central portion was co[illegible] of lower temperatures.*
>
> *Generally, then, there is a decrease in temperature northward from the mouth of Illinois Bayou toward the intake cove. Were this the only trend observed, recirculation would be indicated. Contraindication comes from the presence of warmer water to the northeast of the cove that appears to be moving down Illinois Bayou toward the intake."*[10]

The last paragraph of the above quote points up the crux of the problem in making a definitive statement concerning recirculation. Are the contours that indicate recirculation the result of waters of a different temperature regime moving down Illinois Bayou or a result of the mixing of recirculating discharge water with Bayou waters? The following pattern was seen in Illinois Bayou during the April 1975 survey which was conducted when ANO was shut down.

> *"Water temperatures in Illinois Bayou are warmer than those in the main body of the lake ...*
>
> *The temperature pattern in Illinois Bayou follows closely that of the January and March 1975 surveys. There are*

[10] January 1976 report, beginning with paragraph 2 of page 20 and continuing through paragraph 1, page 21, Volume II.

generally warmer waters on both shores with cooler waters in the center. The temperature elevations seen in Illinois Bayou during this underway survey were not as pronounced as on the three prior operational measurement programs. A surface reconnaissance during the morning of 16 April did show a similarity to the previous surveys, with surface temperatures across the main body of the lake ranging from 55.7F to 57.6F, and surface temperatures along Illinois Bayou (to above the railroad bridge) ranging from 55.2F to 60.6F. However, during the morning, winds were moderate to 4 knots. In the afternoon, when the underway data were taken, the winds had increased to 10 knots, which enhanced surface cooling and mixing. It can be concluded that some of the temperature elevation in Illinois Bayou seen during plant operational surveys was due to natural conditions."[11]

An explanation for this temperature elevation in Illinois Bayou may lie upstream. The area behind the railroad bridge over Illinois Bayou upstream of the intake cove is wide and shallow. Water is trapped there by the causeway that blocks the Bayou almost to the north shore. Bayou water may circulate slowly in this area, experience solar heating, then move downstream toward the intake. This would explain the temperature range and distribution measured in the April (natural condition) survey as well as in the operational surveys.

The results of this survey program do not, therefore, provide conclusive evidence for or against recirculation.

The effects of the ANO discharge on the levels of dissolved oxygen in Lake Dardanelle are summarized in Figure 42. In this figure, three individual dissolved oxygen concentration plots appear for each survey. The first plot presents the calculated saturation level for the ambient temperature of the survey. The second plot presents the calculated saturation values for the range of temperatures in cross-section A-A', the same cross-section from the mouth of the discharge cove to the southern shore of Lake Dardanelle as has been used throughout this report (see

[11] April 1975 report of Volume II (paragraphs 2 and 3 of page 3).

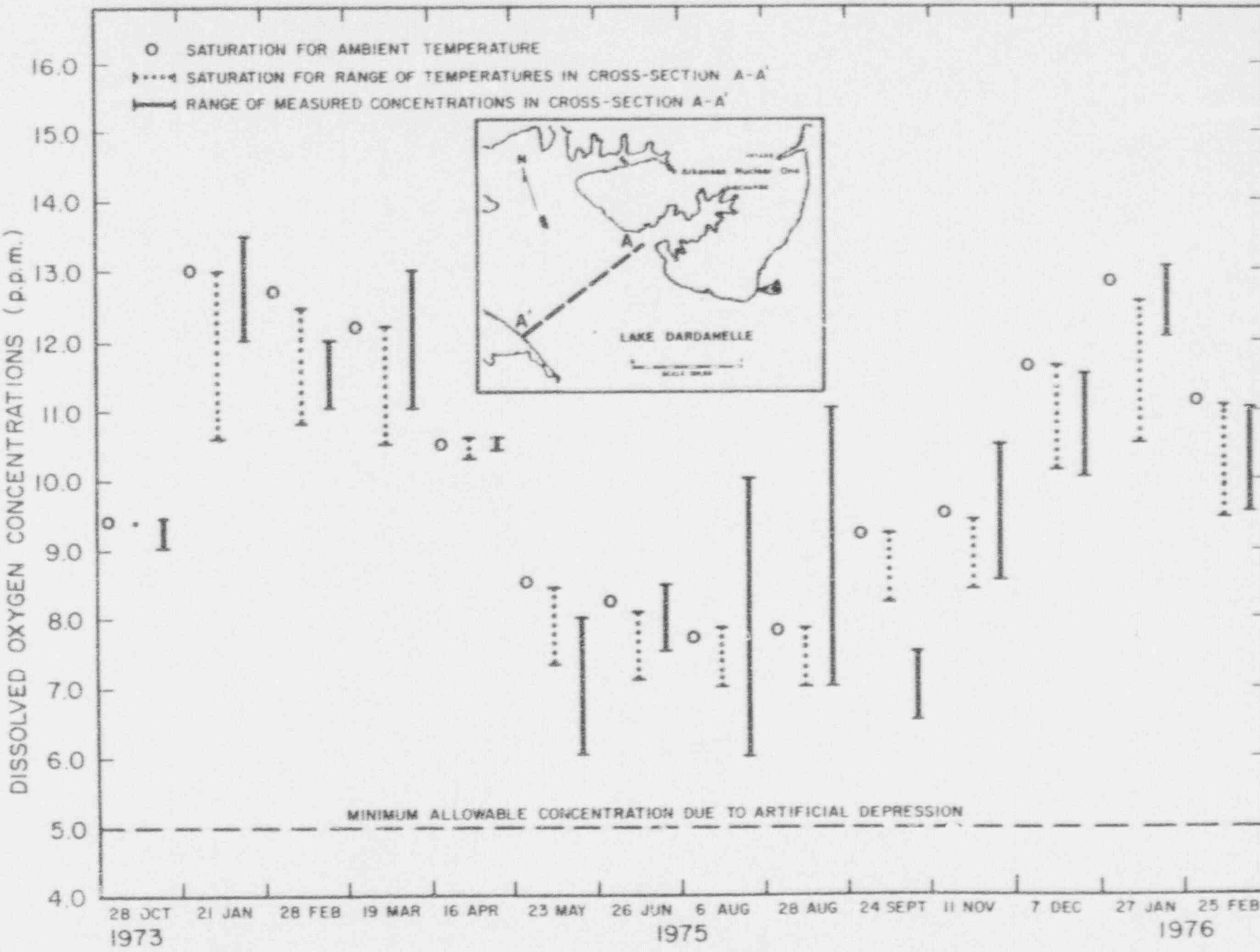

Figure 42. Dissolved oxygen levels along cross-section A'-A for calculated saturation at ambient temperatures, calculated saturation for minimum-maximum temperatures, and measured minimum-maximum dissolved oxygen.

insert, Figure 42).[12] The third plot is of the measured range of dissolved oxygen concentrations in cross-section A-A' for each survey.

Arkansas regulations prescribe that dissolved oxygen concentrations shall not be artifically depressed below 5 ppm. In Figure 42 the 5 ppm ordinate has been enhanced and labeled for comparison with the levels measured during the various surveys. All measured concentrations are seen to be above this minimum-value line. Also, except for the 28 February and 24 September surveys, the measured dissolved oxygen concentrations were shown to range generally right around saturation [illegible]es not only for the temperature range of the cross-section, but also for ambient.

[illegible]pparent anomaly in the dissolved oxygen profiles for the area immediately [illegible] the discharge cove first appeared in the Early August survey report.[13] [illegible] general decrease of dissolved oxygen concentrations with depth, values began increasing after a certain depth, then again showed a decreasing trend. With little variation, vertical profiles of dissolved oxygen for September,[14] November,[15] December,[16] and January[17] showed the same anomaly. The fact that the anomaly showed up repeatedly in the same limited area and nowhere else throughout the survey area suggests that it is indeed real and the result of some highly localized phenomenon. No source for it was located during the surveys, and no comprehensive explanation can be offered for the repeated appearance of this anomaly.

[12] The determination of saturation concentrations of dissolved oxygen at the various ambient temperatures and cross-section temperatures ranges is based upon Table 218(1): "Solubility of Oxygen in Water Exposed to Water-Saturated Air" found on page 480 of Standard Methods for the Examination of Water and Wastewater (13th edition, 1971). Maximum corrections for saturated water vapor pressure at a given water temperature, for the elevation of Lake Dardanelle above sea level and for the range of barometric pressures to be expected vary tabular values for saturated dissolved oxygen by at most $\pm$ 4 percent.

[13] See dissolved oxygen vertical profile for V_1, Figure 2, page 11 of the Early August 1975 report in Volume II.

[14] V_1, Figure 2, page 10 and V_6, Figure 4, page 12 of the September 1975 report in Volume II.

[15] V_5, Figure 4, page 14 and V_8, Figure 5, page 15 of the November 1975 report in Volume II.

[16] V_5 and V_6, Figure 4, page 13 of the December 1975 report in Volume II.

[17] V_3, Figure 3, page 4 of the January 1976 report in Volume II.

Appendix

This Appendix contains meteorological data from the records of the ANO 10-meter reporting station. In cases where 10-meter wind records were missing, 57-meter readings were used and are so indicated.

Mention must be made concerning the units in which the various meteorological parameters were recorded by different weather stations. All temperatures are presented here in degrees Fahrenheit. Where the original data was in Centigrade, the appropriate conversions were made. Various modes for the presentation of wind parameters also used. The NWS at Little Rock reported wind direction in 10 degree increments from 0 -360 and wind speed in knots. The monthly survey reports (Appendix A) followed this convention for the most part. Wind parameters from the ANO station were received in two modes: (1) wind direction to the nearest 0.1 and wind speed in meters per second; and (2) wind direction expressed as the 16 points of the compass (N, NNE, NE, . . ., NNW) and wind speed in miles per hour. For consistancy throughout this appendix, all wind directions are presented with reference to the 16 points of the compass (presentation in degrees, though more desirable, is not obtainable as each "point" describes a direction within a 22.5 arc).

Wind speeds are presented in knots. The following conversions were used in preparing the Appendix:

1 meter per second = 2.24 miles per hour

1 knot = 1 nautical mile per hour = 1.15 statute mile per hour

Compass Point	Corresponding Range of Degrees
N	348-11
NNE	11-34
NE	34-56
ENE	56-78
E	78-101
ESE	101-124
SE	124-147
SSE	147-169
S	169-192
SSW	192-214
SW	214-236
WSW	236-258
W	258-282
WNW	282-304
NW	304-326
NNW	326-348

Appendix

Meteorological Data
ANO 10-meter Station*
28 October 1973

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
1200	WNW	2	47	-
1300	W	7.5	-	-
1400	W	7.0	46	-
1500	NNW	10	-	-
1600	NW	15	-	-

*Further data for this date is unavailable.

Appendix

Meteorological Data
ANO 10-meter Station
21 January 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	ENE	5.1	35	25
0200	ENE	5.5	35	25
0300	ENE	6.3	35	25
0400	E	5.5	35	25
0500	ENE	5.5	35	25
0600	ENE	5.5	34	25
0700	ENE	5.7	35	26
0800	E	7.3	38	30
0900	ENE	6.7	42	32
1000	E	7.0	46	34
1100	E	9.4	53	39
1200	E	6.5	53	36
1300	E	5.9	56	37
1400	E	6.7	58	37
1500	ESE	5.0	60	36
1600	E	4.7	59	35
1700	ENE	4.3	57	37
1800	ENE	3.6	53	37

Appendix

Meteorological Data
ANO 10-meter Station
28 February 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	ESE	1.2	43	30
0200	E	1.4	43	29
0300	NE	0.6	42	29
0400	-	-	41	30
0500	WSW	0.4	41	30
0600	N	0.6	41	31
0700	NW	1.0	39	30
0800	NE	2.2	40	31
0900	ESE	2.3	43	34
1000	W	3.6	50	36
1100	WNW	5.9	55	34
1200	WNW	5.1	58	32
1300	W	7.0	60	30
1400	WNW	8.9	62	28
1500	WNW	8.5	63	29
1600	W	7.3	63	29
1700	W	5.1	64	29
1800	WSW	3.6	64	28

Appendix

Meteorological Data
AND 10-meter Station
19 March 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	WNW	4.9	49	40
0200	WNW	4.5	48	39
0300	WNW	4.5	47	38
0400	WNW	6.9	46	38
0500	WNW	5.9	46	37
0600	W	3.6	45	36
0700	WNW	5.3	44	36
0800	WNW	5.1	45	38
0900	W	5.7	49	38
1000	W	4.7	53	36
1100	W	4.5	56	37
1200	WSW	5.3	61	35
1300	WSW	3.9	63	34
1400	WSW	5.7	65	31
1500	SW	7.5	68	31
1600	WSW	6.5	69	29
1700	WSW	2.5	68	31
1800	SW	1.7	68	33

Appendix

Meteorological Data
ANO 10-meter Station
16 April 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	E	5.7	73	45
0200	ENE	2.8	70	44
0300	ENE	2.5	70	43
0400	E	3.1	67	43
0500	E	4.3	66	42
0600	E	2.8	65	42
0700	E	2.2	66	44
0800	E	3.1	71	46
0900	ESE	3.7	77	48
1000	SSE	7.0	83	49
1100	SW	7.8	90	49
1200	WSW	10.6	93	45
1300	SW	9.4	94	44
1400	SSW	9.2	97	41
1500	SSW	9.0	98	41
1600	SSW	8.1	100	42
1700	S	9.9	99	43
1800	S	9.2	97	43

Appendix

Meteorological Data
ANO 10-meter Station
23 May 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	E	2.5	79	64
0200	E	3.9	78	63
0300	ENE	3.5	77	63
0400	WSW	1.6	76	62
0500	E	1.9	75	62
0600	S	2.3	77	62
0700	SSE	4.7	78	63
0800	ESE	3.9	79	63
0900	SSE	4.3	81	63
1000	SSE	6.7	83	62
1100	SSE	5.5	84	62
1200	SSE	6.9	86	62
1300	S	7.7	88	61
1400	S	8.9	89	61
1500	S	7.0	90	62
1600	S	7.0	90	63
1700	SSW	6.5	89	62
1800	SSW	4.2	87	61

Appendix

Meteorological Data
ANO 10-meter Station
26 June 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	E*	5.3*	77	67
0200	ENE*	5.3*	75	65
0300	E*	5.0*	75	65
0400	E*	6.1*	76	65
0500	E*	5.0*	75	64
0600	E*	6.7*	75	64
0700	E*	4.5*	78	65
0800	ENE*	3.7*	79	66
0900	E*	3.3*	82	67
1000	ESE	3.7	86	69
1100	E*	4.7*	88	69
1200	ESE	4.7	90	69
1300	SE	5.0	91	68
1400	ESE	6.9	92	68
1500	S	6.3	87	66
1600	SW	3.1	87	68
1700	SSE	1.9	88	68
1800	ESE	2.3	90	70

* 57 meter reading; 10 meter not available

Appendix

Meteorological Data
ANO 10-meter Station
6 August 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	ENE	2.2	83	63
0200	NE	1.9	82	62
0300	ENE	1.7	80	61
0400	NE	2.3	79	61
0500	NE	1.9	79	60
0600	NE	1.0	78	60
0700	NNE	1.9	80	62
0800	NNW	2.2	84	65
0900	W	1.7	89	68
1000	W	3.0	93	69
1100	WSW	3.3	98	68
1200	SW	5.0	100	64
1300	SW	4.3	102	61
1400	SW	4.5	104	64
1500	WSW	4.5	105	64
1600	WSW	5.9	106	61
1700	WSW	4.2	106	61
1800	S	2.5	103	65

Appendix

Meteorological Data
ANO 10-meter Station
24 September 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	W	2.7	52	50
0200	NW	2.7	56	51
0300	NW	5.4	57	52
0400	NW	5.1	57	52
0500	-	-	57	52
0600	-	-	56	52
0700	-	-	55	51
0800	N	5.9	57	52
0900	NNW	5.6	59	53
1000	N	6.3	60	54
1100	N	6.5	63	54
1200	NNE	7.5	65	55
1300	NNE	8.5	68	56
1400	N	7.4	66	54
1500	N	7.2	67	54
1600	N	6.4	68	55
1700	N	8.7	67	53
1800	NNE	7.6	65	51

Appendix

Meteorological Data
ANC 10-meter Station
11 November 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	-	0.6	38	36
0200	-	0.8	38	36
0300	SW	1.3	37	35
0400	-	0.8	36	35
0500	W	1.2	37	35
0600	WSW	1.6	36	35
0700	NNW	1.8	38	36
0800	WSW	2.0	42	38
0900	SW	3.0	49	44
1000	W	3.3	55	45
1100	WSW	2.5	59	46
1200	SW	2.6	64	48
1300	SW	4.9	66	49
1400	SSW	6.7	69	52
1500	SW	7.1	69	52
1600	SSW	6.8	68	52
1700	S	4.4	65	52
1800	SW	4.6	61	51

Appendix

Meteorological Data
ANO 10-meter Station
7 December 1975

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	NNE	5.9	41	37
0200	N	6.0	41	35
0300	N	4.5	41	35
0400	N	5.6	40	35
0500	ENE	5.4	40	35
0600	ENE	4.7	39	35
0700	N	4.9	40	36
0800	NNE	5.0	41	37
0900	N	4.2	42	37
1000	N	3.7	43	38
1100	NNE	4.3	45	39
1200	N	4.2	45	39
1300	ENE	2.8	44	39
1400	N	2.5	43	39
1500	ENE	3.0	43	39
1600	N	3.3	42	39
1700	N	3.5	38	38
1800	ENE	4.5	36	37

Appendix

Meteorological Data
ANO 10-meter Station
27 January 1976

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	NNW	5.6	27	20
0200	NNW	5.1	25	20
0300	NNW	6.3	24	19
0400	NNW	4.4	23	19
0500	NNW	4.3	23	19
0600	N	6.3	22	19
0700	NNW	6.0	21	18
0800	N	5.9	23	19
0900	N	6.1	27	20
1000	N	5.8	29	21
1100	NNE	4.6	31	21
1200	NNE	3.3	33	22
1300	NE	1.8	36	23
1400	NE	0.8	38	23
1500	ENE	1.1	40	24
1600	ENE	2.3	40	24
1700	E	3.9	37	25
1800	ESE	4.3	33	25

Appendix

Meteorological Data
ANO 10-meter Station
25 February 1976

Time	Wind		Air Temperature (F)	Dew Point Temperature (F)
	Direction	Speed (kts)		
0100	SSW	7.5	51	32
0200	S	7.0	50	32
0300	S	5.5	51	33
0400	S	4.5	49	32
0500	S	5.1	49	32
0600	S	5.6	48	32
0700	S	7.4	50	33
0800	S	7.2	51	33
0900	SSW	8.3	52	34
1000	SSW	8.6	53	36
1100	S	8.5	56	36
1200	SSW	7.7	59	37
1300	SSW	8.0	61	37
1400	SW	6.6	62	37
1500	SW	6.3	61	38
1600	SW	5.8	61	39
1700	SSW	6.7	60	41
1800	SW	7.0	59	42