A REPORT FROM

The University Hygienic Laboratory

OAKDALE CAMPUS

THE UNIVERSITY OF IOWA
IOWA CITY, IOWA 52242

1986 Iowa Lakes* Study

Report No. 87-3

*Badger Lake - Webster County	Lake Wapello - Davis County
Bob White Lake - Wayne County	Nine Eagles Lake - Decatur County
Lake Geode - Henry County	Pierce Creek Lake - Page County
Lake Hendricks - Howard County	Red Haw Lake - Lucas County
Lake Icaria - Adams County	Rodgers Park Lake - Benton County
Lake Keomah - Mahaska County	Twelve Mile Lake - Union County
Lake Macbride - Johnson County	Volga Lake - Fayette County
Lake Miami - Monroe County	Yellow Smoke Lake - Crawford County

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Prepared for the Iowa Department of Natural Resources by the University of Iowa Hygienic Laboratory.

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CONTENTS

SUMMARY AND RECOMMENDATIONS

The physical characteristics, water quality and fisheries of sixteen Iowa lakes were evaluated during the summer of 1986. The major objectives of the study were to: collect similar information as collected during the 1979 Clean Lakes Classification Study and compare to 1986 data for trend analysis; provide additional information on the physical, chemical and biological quality of each lake; and increase the pre-project data base for each lake to provide support for selection and funding of non-point source control projects.

Results of the study include:

- Most of the lakes studied have significant siltation problems. The siltation problems can be minimized by the utilization of best land management practices in the watershed to reduce soil erosion.

- Water quality of most of the lakes was not much different than observed in 1979. In general the lakes studied were shallow (less than 40 feet), eutrophic and exhibited varying degrees of oxygen depletion during the summer months.

- Water and sediment samples for pesticide analysis were collected from five lakes. Although no pesticides were found in the sediment samples above the reporting limit, several pesticides were measured in lake water samples. The most common pesticide found was the herbicide atrazine.

- The quality of the fishery was lake dependent varying from excellent to poor. The water quality data are too limited to determine any valid relationship between measured water quality parameters and fish populations.

- Overall the 1986 Iowa Lakes Study has provided additional insight into evaluating lake water quality and met the objectives of the study.

Recommendations from the study are:

- Limited resources, study design and analytical methodology did not allow for the 1979 study to be duplicated. A standardized documented procedure should be developed for future lake water quality assessments.

- The lake mapping, utilizing the current methodology, does not provide the level of detail needed to determine changes in lake physical characteristics. For evaluating physical changes in lake morphometry over time a more accurate mapping procedure is needed.

- Information provided on prior and current soil conservation efforts in the lake watersheds lack consistency and was often incomplete. Future lake assessment reports need to incorporate accurate and detailed discussions of soil conservation practices both historical and current.

INTRODUCTION

In 1979, a study of Iowa's lakes (1) was performed to prioritize their public lakes in need of restoration and/or protection. The 1979 study was required in order to be eligible for assistance through the Federal Clean Lakes Program after January 1, 1982. One hundred seven publicly-owned Iowa lakes were selected for the survey. Data collection was initiated on each lake that included describing the physical features of the lakes, an assessment of pollution contributors, lake trophic state, and identifying major point and nonpoint pollution discharges. From this information, and using a criteria ranking system, a lake restoration priority list was developed for the 107 lakes.

During 1986, the Iowa Department of Natural Resources (IDNR) proposed to obtain current water quality data from the 107 lakes studied in 1979. Because of the lack of resources required to evaluate all 107 lakes, only 16 Iowa lakes were selected for review. The lakes were selected by the IDNR staff and represent lakes of varying size, location and quality.

The objectives of the 1986 Iowa Lakes Study as identified in the Work/Quality Assurance project plan (2) were:

1) to provide additional information on the physical, chemical and biological quality of each lake;

2) to prepare a use impact assessment on each lake to document non-point source impacts and other factors which have influenced general lake quality, and to document general lake quality;

3) to compile all available lake quality data for each lake and prepare an up-to-date report to be used as a reference document for demonstrating long-term lake quality changes;

4) to increase the pre-project database of each lake to provide support for the funding and selection of additional nonpoint source control projects;

5) to collect similar water quality information as was collected during the Clean Lakes Classification Study in 1979 and to compare the data and identify any apparent trends in lake quality; and

6) to establish the framework for future lake monitoring by making necessary improvements to the monitoring design used in this study.

SAMPLING AND ANALYTICAL METHODOLOGY

A comprehensive Work/Quality Assurance project plan for the study was written by personnel from the Iowa Department of Natural Resources (IDNR) and University Hygienic Laboratory (UHL). Quality assurance procedures for field and laboratory activites were followed as outlined in the project plan. All data presented in this report meet the quality assurance objectives specified in the Work/QA plan. A brief discussion of the field and laboratory activities follows. For more details of these activities, see the <u>1986 Iowa Lakes Study Quality Assurance/Work Plan</u> (2). Copies of the study plan are available from the IDNR or UHL.

Between May 1 and September 31, 1986, water samples were collected on three separate days, approximately 45 days apart, from the deepest part of the lake. The number of samples collected each day was dependent on the presence or absence of thermal stratification. If the lake was not thermally stratified, surface and near the bottom samples were collected. When the lake was thermally stratified an additional sample was collected from the stratified layer (usually about mid-depth) in the water column. To determine if stratification was present, a dissolved oxygen and temperature depth profile was recorded for each sampling date prior to sample collection.

At five of the sixteen lakes, water and sediment samples were also collected for pesticide analysis. The water samples were collected from the headwaters of each lake at the beginning of the sampling period (generally non-runoff conditions) and after two rainfall runoff events. Lake sediment samples were collected in mid-summer from areas of observed sedimentation and after more than 90% of the crops in the watershed had been planted.

All water samples were collected by IDNR staff and submitted to UHL for analysis. Sediment samples were collected by UHL staff.

Procedures used in sample collection, preservation and analysis are described in the Work/QA plan (2), Standard Methods (3), and Manual of Methods for Chemical Analysis of Water and Wastes (4).

Iowa Department of Natural Resources Fisheries staff have contributed significantly to this report by providing for each lake the fisheries assessment, lake impact assessment, 1986 bathymetric map, and additional pertinent information.

All the information and results obtained for each lake may be found in the following pages. The lakes, and DNR Fisheries staff contributing for each are acknowledged below.

Lake	DNR Field Staff
Badger Lake	L. Miller, D. Herrig
Bob White Lake	J. Bruce, D. Henley
Lake Geode	D. Kline, J. Golden
Lake Hendricks	G. Wunder
Lake Icaria	M. McGhee, G. Sobotka
Lake Keomah	J. Bruce, D. Henley
Lake Macbride	B. Middendorf, R. Gent
Lake Miami	J. Bruce, D. Henley
Lake Wapello	J. Bruce, D. Henley
Nine Eagles Lake	M. McGhee, G. Sobotka
Pierce Creek Lake	M. McGhee, G. Sobotka
Red Haw Lake	L. Mitzner
Rodgers Park Lake	B. Middendorf, R. Gent
Twelve Mile Lake	M. McGhee, G. Sobotka
Volga Lake	G. Wunder
Yellow Smoke Lake	L. Miller, D. Herrig

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa's Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Wnuk, M. 1986. 1986 Iowa Lakes Study - Work/QA Plan. Iowa Department of Natural Resources, Des Moines, Iowa.

3. American Public Health Association. 1980. Standard Methods for the Examination of Water and Wastewater. 15th Edition. American Public Health Association, Inc. Washington, D.C.

4. U.S. Environmental Protection Agency. 1979. Methods for Chemimcal Analysis of Water and Wastes. Cincinnati, Ohio.

BADGER LAKE

Physical and Lake Impact Data

Badger Lake is located in Webster county approximately 3.5 miles north of Ft Dodge, Iowa. Most of Badger Lake's 8,650 acre watershed is in cropland (92%) and pasture (3.5%). A map of Badger Lake developed from 1986 data may be found on page 5 . In addition a comparison of the lake's physical characteristics between 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussesd in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lake's physical characteristics. (See Appendix for lake mapping procedure.)

	1979	1986
Surface Area	45 acres	38 acres
Maximum depth	24 ft.	18 ft.
Volume	380 acre ft.	249 acre ft.

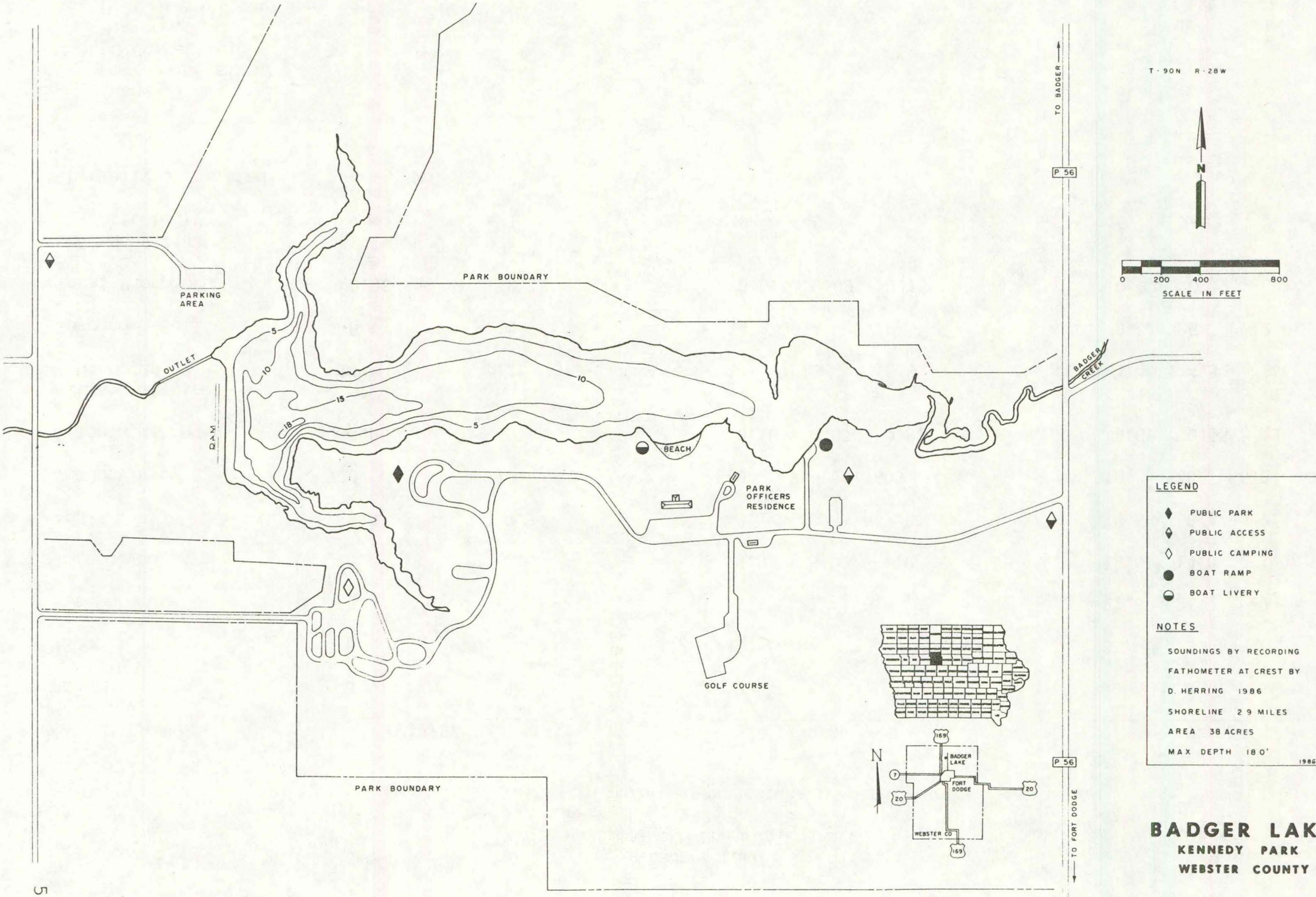
Based on 1986 data for Badger Lake, it is apparent that the lake has lost a large amount of water volume due to siltation. The east or inlet end of the lake has lost between two and three feet of water. The maximum water depth in 1979 was 24 feet while in 1986 the maximum depth was only 18 feet. Silt does not seem to suspend and cause water turbidity problems probably because of the sheltered position of the lake. The sources of the siltation problem need to be identified and corrective measures implemented at the earliest possible time. The lake cannot afford to lose any more water volume.

As was noted in the 1979 report (1), the city of Badger continues to discharge its wastewater lagoon effluent into a creek that enters Badger Lake. Although this discharge occurs only two or three times a year during relatively high water periods, the nutrient-enriched wastewater may be affecting Badger Lake water quality. The impact of this wastewater discharge to Badger Lake should be evaluated to determine if it should be eliminated.

Chemical Data

The physical and chemical data obtained in 1986 for Badger Lake are listed in the table on page 6 . Where possible, in the following brief discussion, 1979 data will be compared to 1986 data. All Badger Lake data for both 1979 and 1986 may be found in the Appendix.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 43 to 53 inches with a mean (N = 3) of 49 inches. The 1979 Secchi



BADGER LAKE
KENNEDY PARK
WEBSTER COUNTY

Badger Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/17/86		7/22/86			9/02/86		
*Depth [1]	0	18	0	8	16	0	6	16
*Secchi [2]	50		43			53		
*Temperature [3]	23	17	26	21	19	22.8	21.7	20
*Dissolved Oxygen	13.0	2.0	13.0	5.0	1.0	15.0	14.0	1.0
*pH [4]	8.3	7.3	8.1	NDA**	7.5	8.5	8.4	7.4
Conductivity [5]	720	720	680	730	7609	510	540	670
Ammonia Nitrogen	0.06	0.80	0.10	0.07	0.92	0.09	0.05	1.8
Nitrate-Nitrite Nitrogen	14	12	13	13	5.0	4.4	4.5	2.6
Suspended Solids	5	12	14	14	8	9	5	12
Total Phosphorus	0.06	0.15	0.01	0.09	0.15	0.07	0.12	0.14
Chlorophyll a (Corrected) [6]	7	1	9	40	19	15	28	7
Thermally Stratified	No			Yes			No	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site
**No Data Available

readings ranged from 16 to 35 with an average (N = 3) of 26 inches.

Badger Lake water temperature ranged from a low of 17°C in the June bottom sample to a high of 26°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with 1986 data.

Dissolved oxygen (DO) values ranged from 1.0 mg/L in several bottom samples to 15.0 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 8 , 9 and 10 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. The June profile reflects early summer conditions where both a temperature and DO gradient were beginning to develop in Badger Lake. That is, the values for both parameters gradually declined from top to bottom. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). In July, sharp DO and temperature gradients (stratification) were present between the 6.5 (2 meter) and 10 foot (3 meter) depth. The sharp temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom samples of 1 to 2 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with high organic content frequently have no dissolved oxygen in the lower water layer.

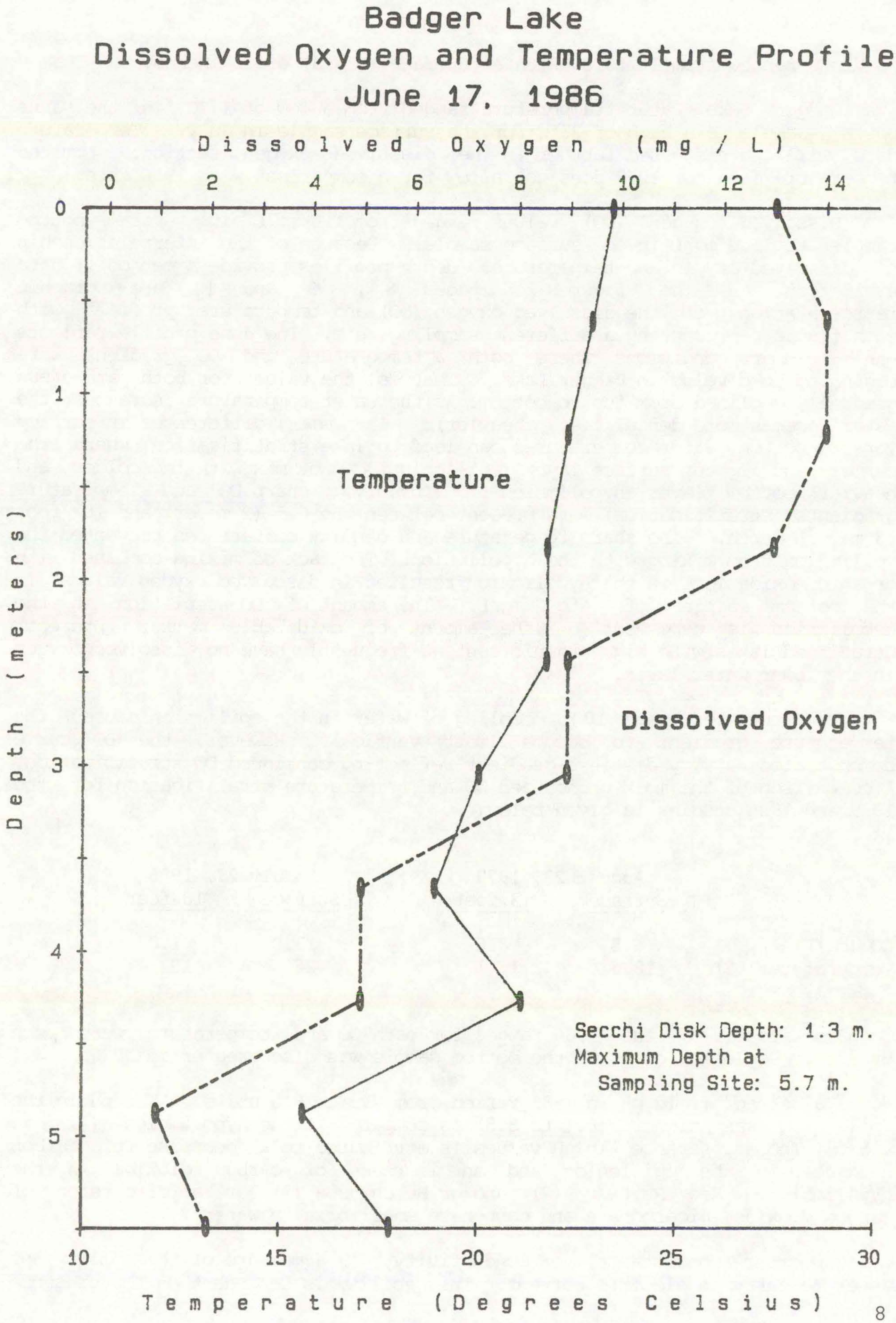
By September (page 10), cooling of water in the epilimnion caused the temperature gradient to become almost vertical. However, the DO curve demonstrated a very distinct gradient reflecting continued DO stratification. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

	August 23, 1979		July 27, 1986	
	Surface	13 feet	Surface	18 feet
DO (mg/L)	6.8	3.6	13.0	1.0
Temperature (°C)	18.6	17.1	26	19

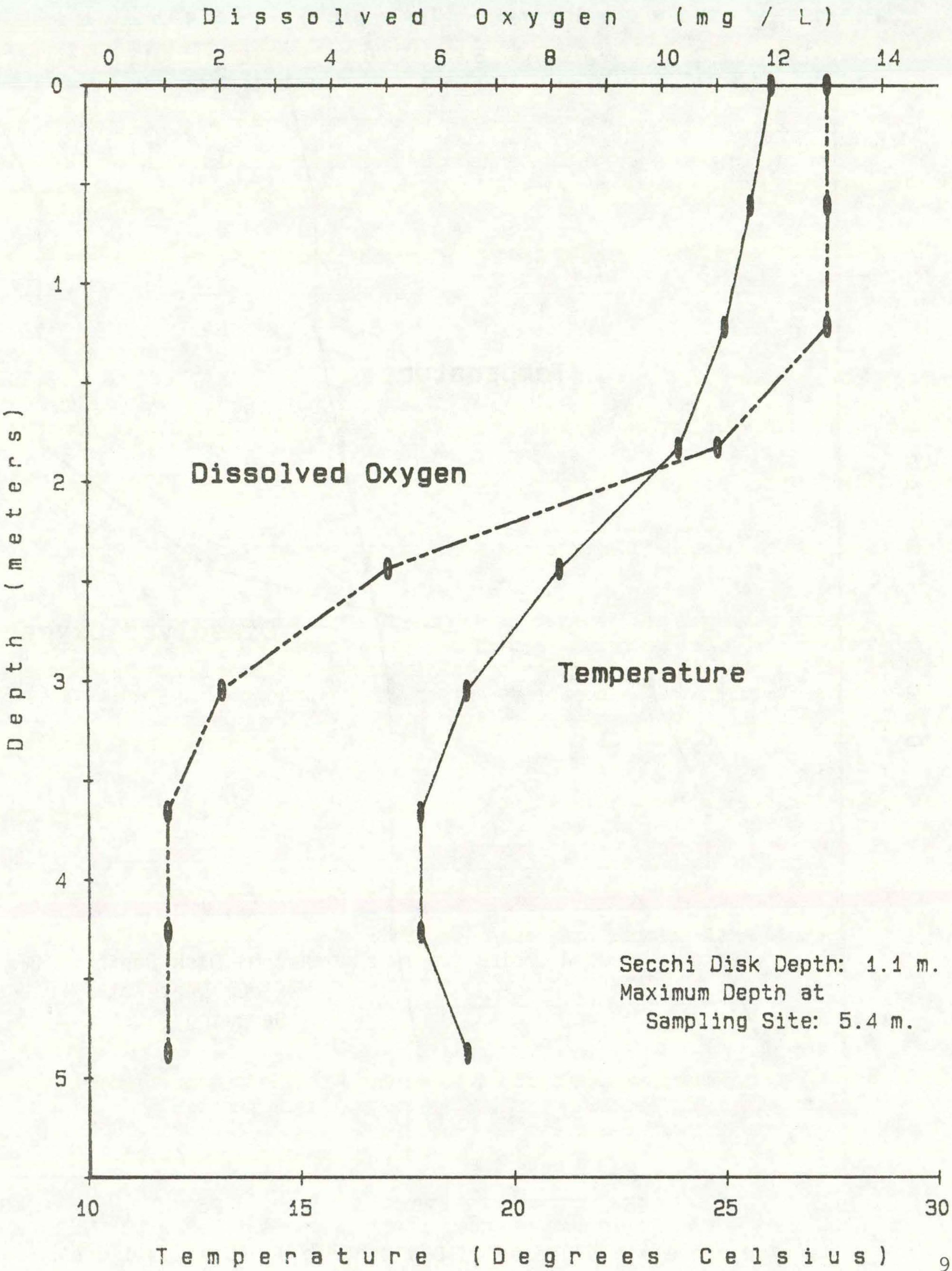
Compared to 1979, the 1986 ranges for both DO and temperature were much broader. Depletion of DO in the bottom sample was also greater in 1986.

Values for field pH in 1986 varied from 7.3 to 8.5 units. The pH in the epilimnion was higher (8.1 to 8.5) as compared to the hypolimnion (7.3 to 7.5). The difference in pH values is attributed to a decrease of carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.

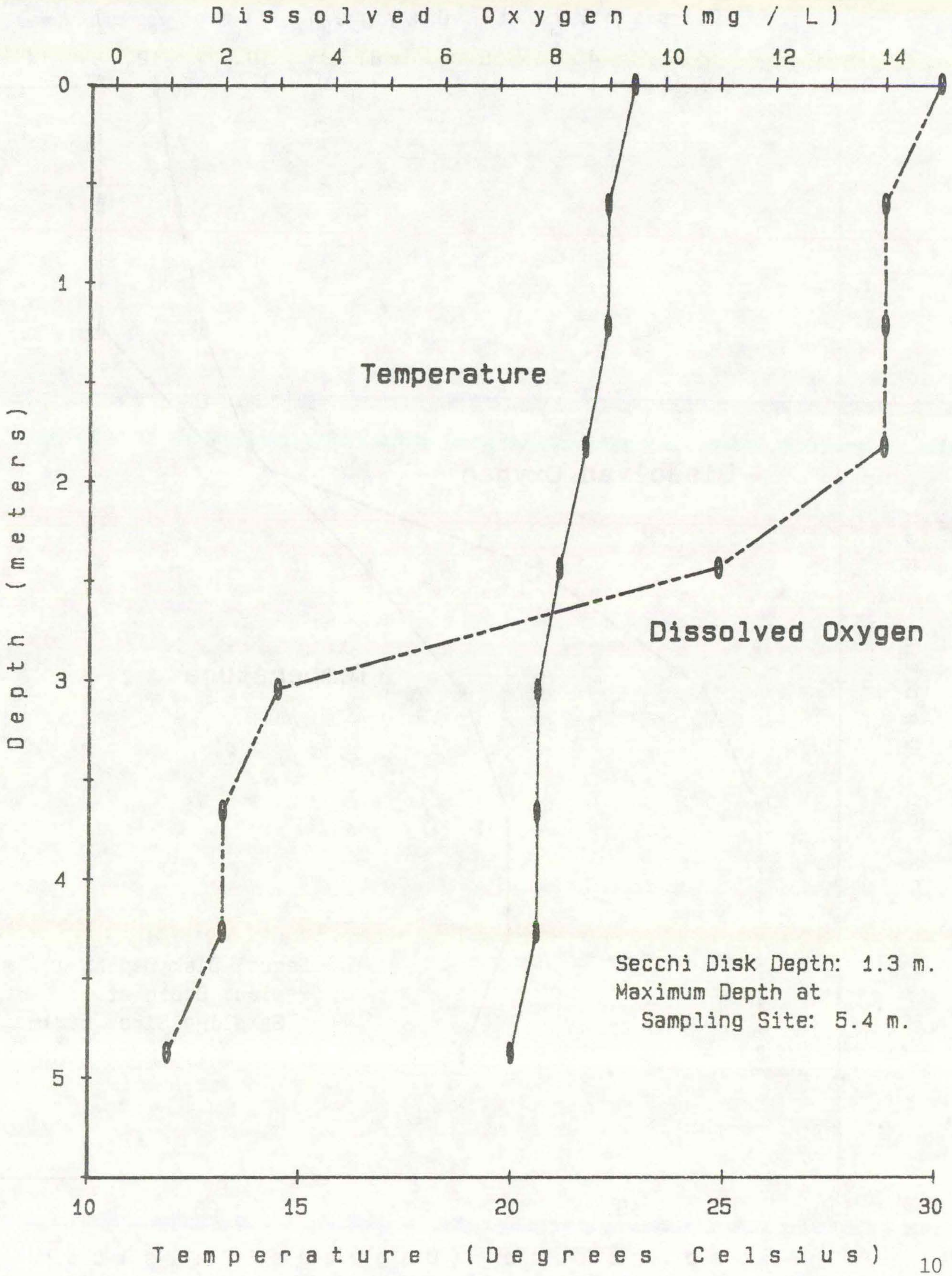
Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence


Badger Lake
Dissolved Oxygen and Temperature Profile
June 17, 1986
Dissolved Oxygen (mg / L)
0
2
4
6
8
10
12
14
Depth (meters)
0
1
2
3
4
5
Temperature
Dissolved Oxygen
Secchi Disk Depth: 1.3 m.
Maximum Depth at
Sampling Site: 5.7 m.
10
15
20
25
30
Temperature (Degrees Celsius)

Badger Lake
Dissolved Oxygen and Temperature Profile
July 22, 1986



Badger Lake
Dissolved Oxygen and Temperature Profile
September 2, 1986



of dissolved solids; i.e., the more dissolved solids the greater the conductance. In June, conductivity was similar throughout the water column (720 micromhos top and bottom). July values reflected a conductivity gradient developing with a surface value of 680 micromhos and a bottom value of 760 micromhos. By early September the surface conductivity was 510 micromhos while the bottom was 670 micromhos. The decline in conductivity is related to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). In June, phytoplankton populations were low (as indicated by the low chlorophyll values). As the phytoplankton populations increased in July and September, they began utilizing the dissolved nutrients causing a decline in dissolved solids hence a decline in conductivity. The upper water layer showed the greatest decrease because fewer phytoplankton existed at the lower depths. Conductivity data for the epilimnion in 1979 demonstrated the same general decline from 620 micromhos in July to 580 micromhos in September. Limited data for 1979 indicate conductivity in the hypolimnion was consistently higher than the epilimnion.

Ammonia nitrogen concentrations were similar for all three surface and mid-depth samples, ranging from 0.05 to 0.10 mg/L. Bottom samples, however, reflected a gradual increase from 0.80 mg/L in June to 1.8 mg/L in early September. This increase may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate levels in the surface water declined from 14 mg/L in June to 4.4 mg/L in September. The nitrate decline in the epilimnion may be attributed to nitrate assimilation by the phytoplankton. Hypolimnetic nitrate values declined from 12 mg/L in June to 2.6 mg/L in September. Hutchinson (3) believes declines of this type are due to nitrate being reduced to ammonia in the deoxygenated hypolimnion. The limited nitrogen data for 1979 does not allow comparison to 1986 data (one surface sample for ammonia of 0.11 mg/L and nitrate of 10.3 mg/L measured in September).

Suspended solids during 1986 ranged from 5 mg/L to 14 mg/L with no discernible pattern or trend. A similar range was measured in 1979 (8 to 18 mg/L) for suspended solids.

Total phosphorus concentrations in surface samples ranged from 0.01 to 0.07 mg/L as compared to 0.14 to 0.15 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The lower values of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. In the oxygen-deficient part of the hypolimnion phosphorus levels remained relatively constant. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. During the 1979 sampling, total phosphorus ranged from 0.07 to 0.21 mg/L with minor differences between the top and bottom samples (July ranged from 0.10 to 0.21 mg/L, August from 0.15 to 0.67 mg/L and September from 0.07 to 0.11 mg/L).

Chlorophyll values are an indirect measurement of the phytoplankton populations. The chlorophyll <u>a</u> values in the epilimnion ranged from 7 µg/L to 40 µg/L in 1986. The June epilimnion chlorophyll <u>a</u> value was lowest while exhibiting similar mean values (N = 2) for July ($\overline{25}$ µg/L) and September (21 µg/L). Hypolimnetic values ranged from 1 µg/L to 19 µg/L with the highest value occurring in July. Chlorophyll <u>a</u> values in the 1979 epilimnion averaged

38 µg/L for July, 7 µg/L for August and 56 µg/L for September.

Biological Data

A fisheries survey was conducted on Badger Lake on June 17-20, 1985. Five fyke nets were used for a total of 360 fyke net hours, and a 220 volt A.C. electrofishing unit was utilized for 70 minutes.

Species composition, relative abundance and average length and weight are shown below.

Species	No.	Ave. Length Inches	Ave. Weight Pounds	Range Inches	Percent of Total Number
W. Crappie	197	7.3	0.2	3.9-10.2	23.4%
Channel Catfish	38	13.3	0.9	6.6-25.7	4.5%
Bluegill	161	6.4	0.2	1.9-8.0	19.1%
Bullhead	95	9.0	0.4	6.9-11.0	11.3%
W. Sucker	260	14.8	1.3	11.7-18.1	30.8%
Carp	24	19.4	4.2	10.1-26.3	2.8%
Largemouth Bass	68	9.6	0.7	1.0-18.4	8.1%

Length-frequency graphs of the five major game fish species may be found in the Appendix.

Fish growth and population structure in general has improved greatly in the last five years. Bluegill mean length has increased from 3.5 inches in 1981 to 6.4 inches in 1985. Crappie length averaged 6.2 inches in 1981 and in 1985 averaged 7.3 inches. Largemouth bass numbers went from 17 sampled in 1981 to 68 sampled in 1985. More small bass were sampled in 1985, which indicates good reproduction.

SUMMARY

Although the data presented in this report are rather limited, it is possible to make several general statements about the data.

> Since 1979, the volume of water in Badger Lake has declined as a result of siltation. The possibility of sediment retention basins for the lake inlets or installation of other sediment control measures in the watershed should be evaluated.
>
> The city of Badger continues to discharge wastewater into the Badger Lake watershed. This source of nutrient loading to Badger Lake should be evaluated to determine its affect lake water quality.
>
> Although the 1986 dissolved oxygen and temperature profiles were more pronounced as compared to the 1979 profiles, no major changes in lake water quality appear to

have occurred from 1979 to 1986. Continued monitoring is necessary to determine long-term trends in water quality.

In general, fish growth and population structure has improved greatly since 1979. Continued assessment of the fisheries will allow for maximizing its potential.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00516 999400101000
42 35 00.0 094 11 00.0 5
DEEPEST PART OF BADGER LAKE-4.2MI N FT DODGE
19187 IOWA WEBSTER
DES MOINES RIVER BASIN 071100
DES MOINES-BADGER LAKE T090NR28WSC30
21IOWA 801004 07100004 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/26		WATER	0	.00		.90	620	8.50		8.00	10		
79/07/26		WATER	3				690	3.20		7.60	9		
79/07/26		WATER	6				700	2.10		7.50	8		
79/07/26		WATER	13				730	.30		7.40	12		
79/07/26 CP(1)- 79/07/26	REP	WATER	0	23.50		.80							
79/08/23		WATER	0	18.60		.40	620	6.80		7.80	18		
79/08/23		WATER	3				615	6.40		7.75	18		
79/08/23		WATER	6				615	6.20		7.73	18		
79/08/23		WATER	13				670	3.60		7.48	14		
79/08/23 CP(1)- 79/08/23	REP	WATER	0	.00		.40	620			7.83			
79/08/23 CP(1)- 79/08/23	REP	WATER	3					6.40					
79/09/26		WATER	0	.00		.70	580	15.00		8.20	12	.110	10.30
79/09/26		WATER	3				590	15.20		8.20	12		
79/09/26 CP(1)- 79/09/26	REP	WATER	0	19.60		.60						.100	10.20
86/06/17	1120	WATER	0	23.00	50.0		720	13.00	8.30	8.30	5	.060	14.00
86/06/17	1130	WATER	18	17.00			720	2.00	7.30	7.90	12	.800	12.00
86/07/22	1200	WATER	16	19.00			760	1.00	7.50	7.90	8	.920	5.00
86/07/22	1240	WATER	8	21.00			730	5.00		7.90	14	.070	13.00
86/07/22	1308	WATER	0	26.00	43.0		680	13.00	8.10	8.30	14	.100	13.00
86/09/02	1240	WATER	16	20.00			670	1.00	7.40	7.50	12	1.800	2.60
86/09/02	1315	WATER	6	21.70			540	14.00	8.40	8.40	5	.050	4.50
86/09/02	1335	WATER	0	22.80			510	15.00	8.50	8.40	9	.090	4.40

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00516 999400101000
42 35 00.0 094 11 00.0 5
DEEPEST PART OF BADGER LAKE-4.2MI N FT DODGE
19187 IOWA WEBSTER
DES MOINES RIVER BASIN 071100
DES MOINES-BADGER LAKE T090NR28WSC30
21IOWA 801004 07100004 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/26		WATER	0	.32			39.70						
79/07/26		WATER	3	.55			37.00						
79/07/26		WATER	6	.57			10.50						
79/07/26		WATER	13	.65			5.40						
79/07/26 CP(1)- 79/07/26	REP	WATER	13	.65									
79/08/23		WATER	0	.51			7.10						
79/08/23		WATER	3	.51			8.20						
79/08/23		WATER	6	.51			7.10						
79/08/23		WATER	13	.46			2.20						
79/08/23 CP(1)- 79/08/23	REP	WATER	13	.23									
79/09/26		WATER	0	.33			66.60						
79/09/26		WATER	3	.32			47.00						
79/09/29		WATER	0				62.10						
86/06/17	1120	WATER	0		.060	13.00	7.00						
86/06/17	1130	WATER	18		.150	7.00	1.00K						
86/07/22	1200	WATER	16		.150	21.00	19.00						
86/07/22	1240	WATER	8		.090	44.00	40.00						
86/07/22	1308	WATER	0		.010	14.00	9.00						
86/09/02	1240	WATER	16		.140	16.00	7.00						
86/09/02	1315	WATER	6		.120	42.00	28.00						
86/09/02	1335	WATER	0		.070	25.00	15.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

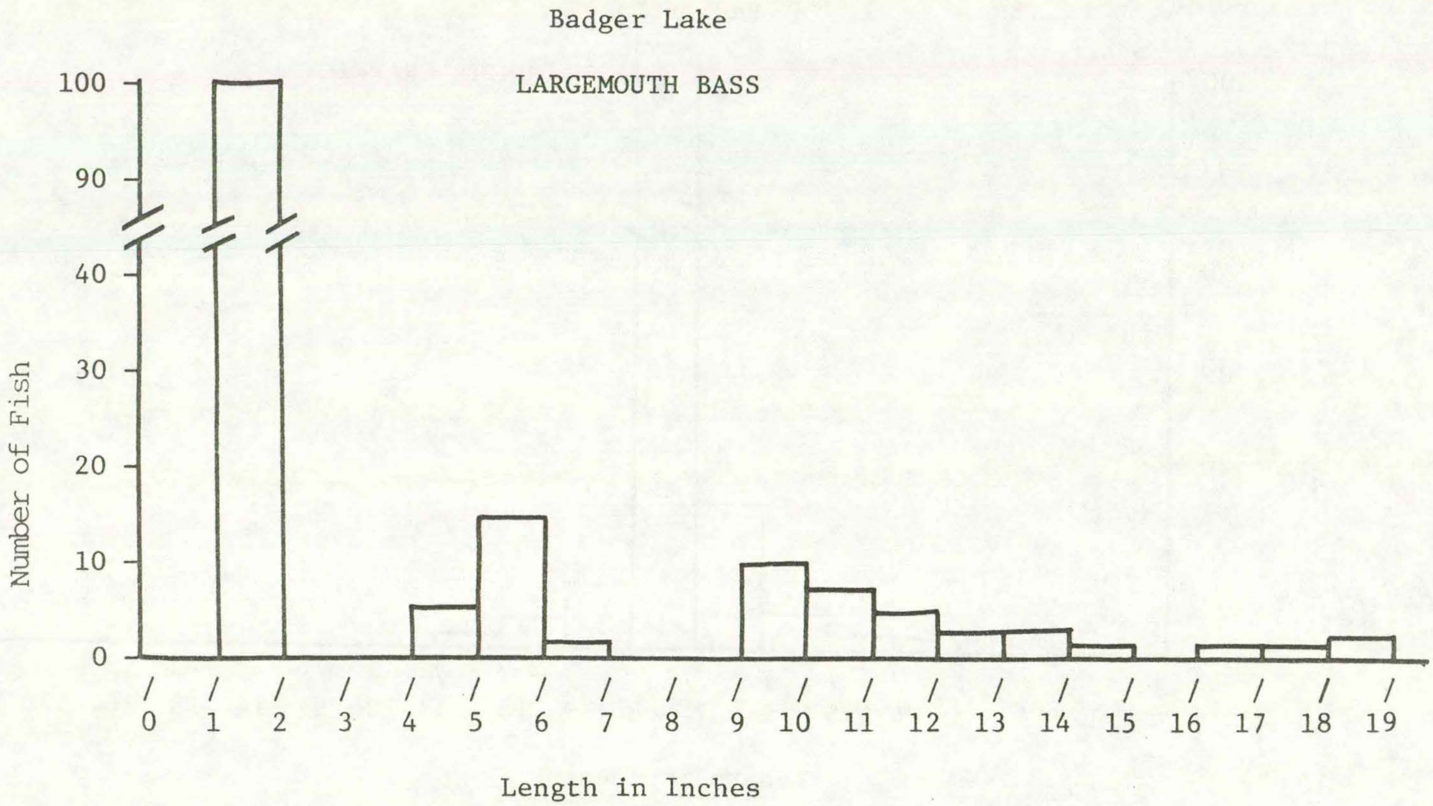


Figure 1. Length-frequency graph of largemouth bass in Badger Lake, 1986.

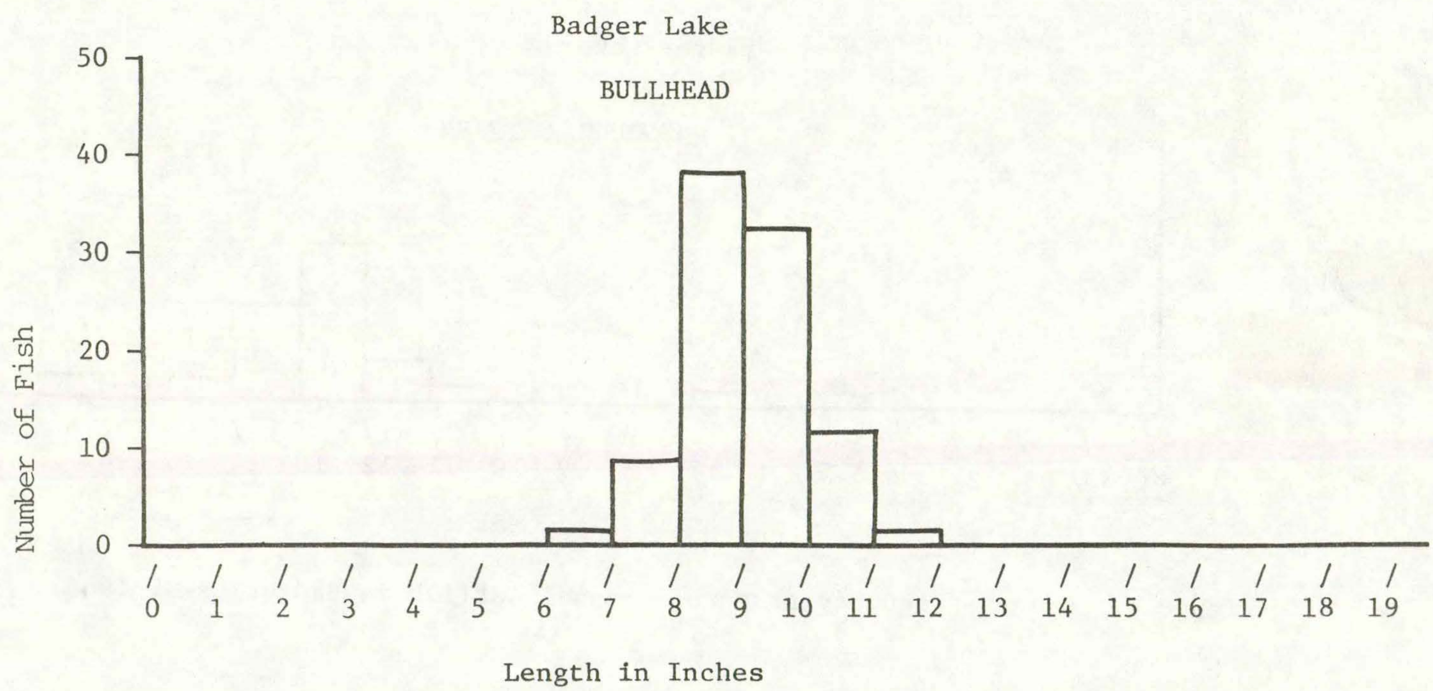


Figure 2. Length-frequency graph of bullhead in Badger Lake, 1986.

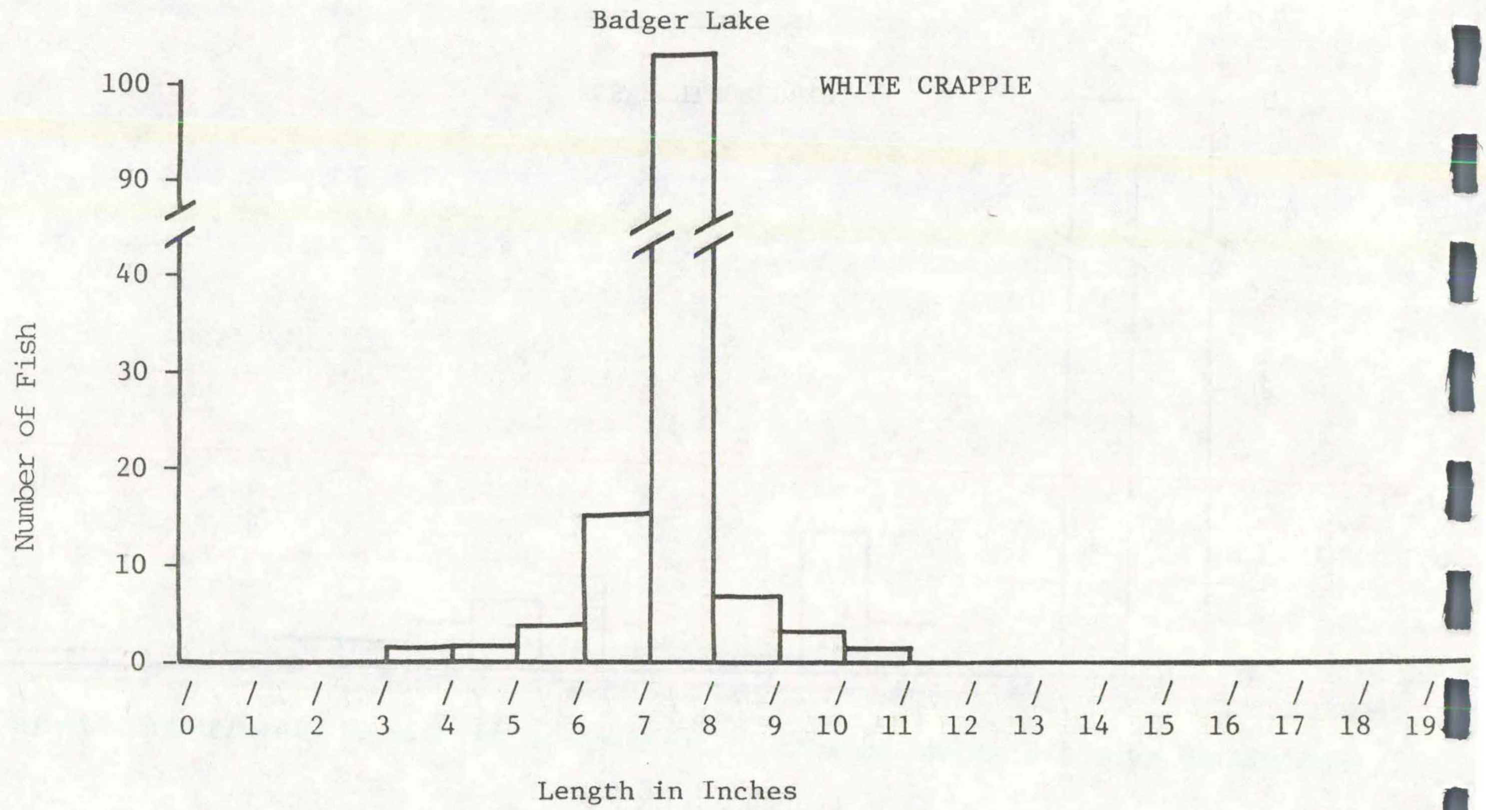


Figure 3. Length-frequency graph of white crappie in Badger Lake, 1986.

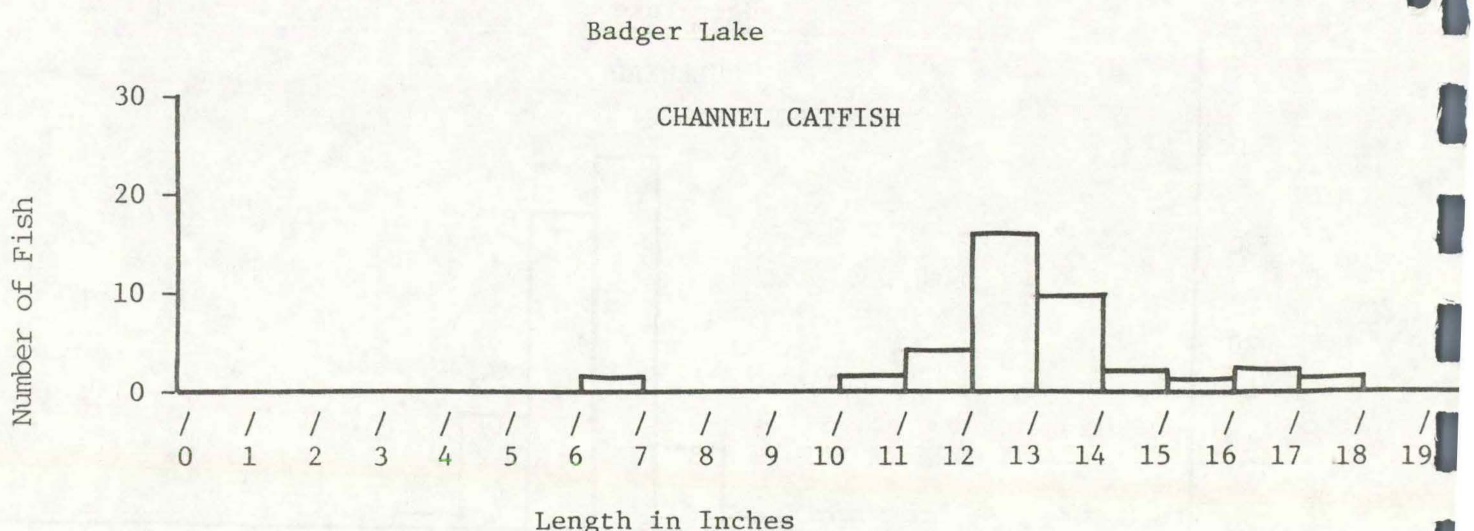


Figure 4. Length-frequency graph of channel catfish in Badger Lake, 1986.

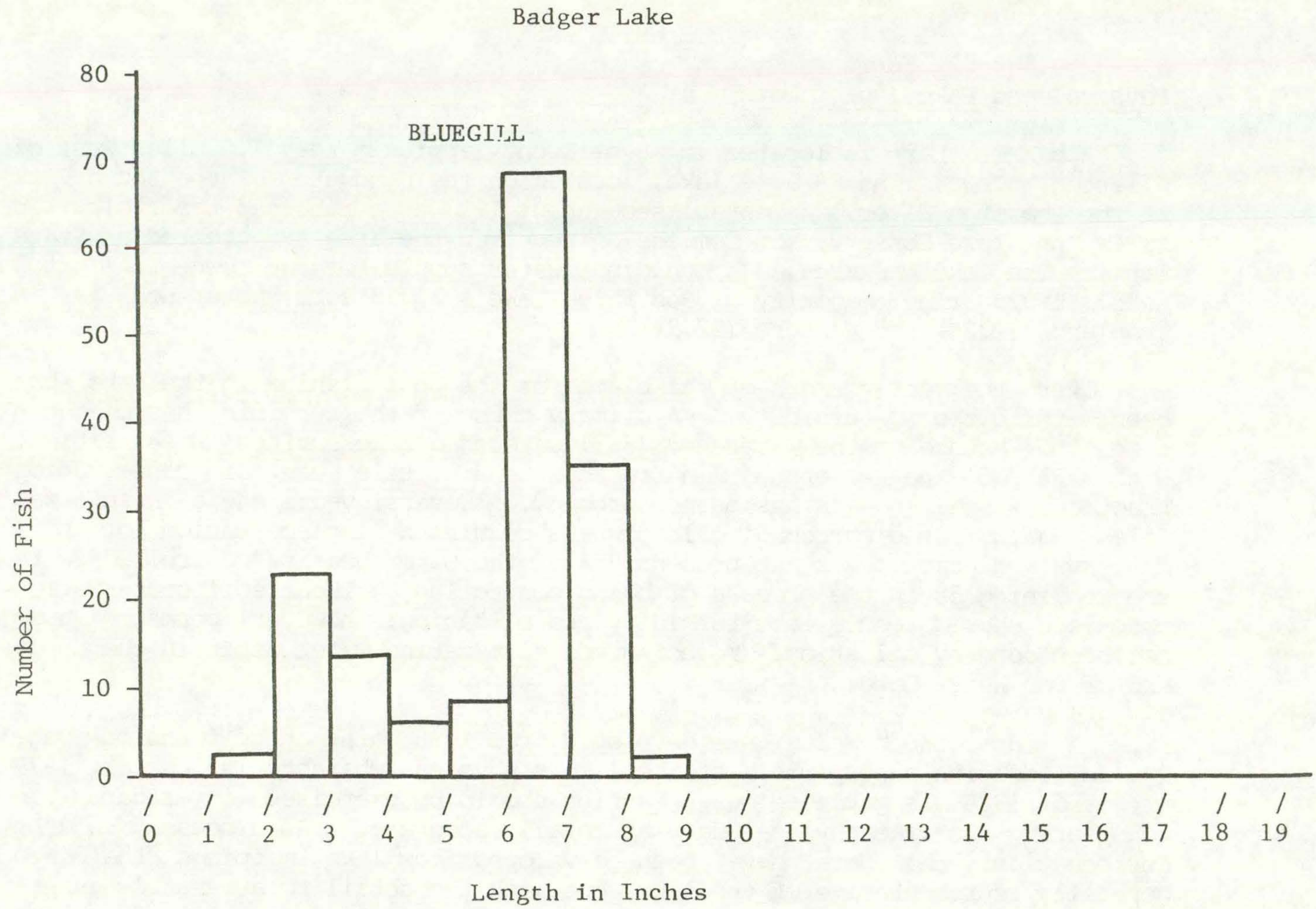


Figure 5. Length-frequency graph of bluegill in Badger Lake, 1986.

BOB WHITE LAKE

Physical and Lake Impact Data

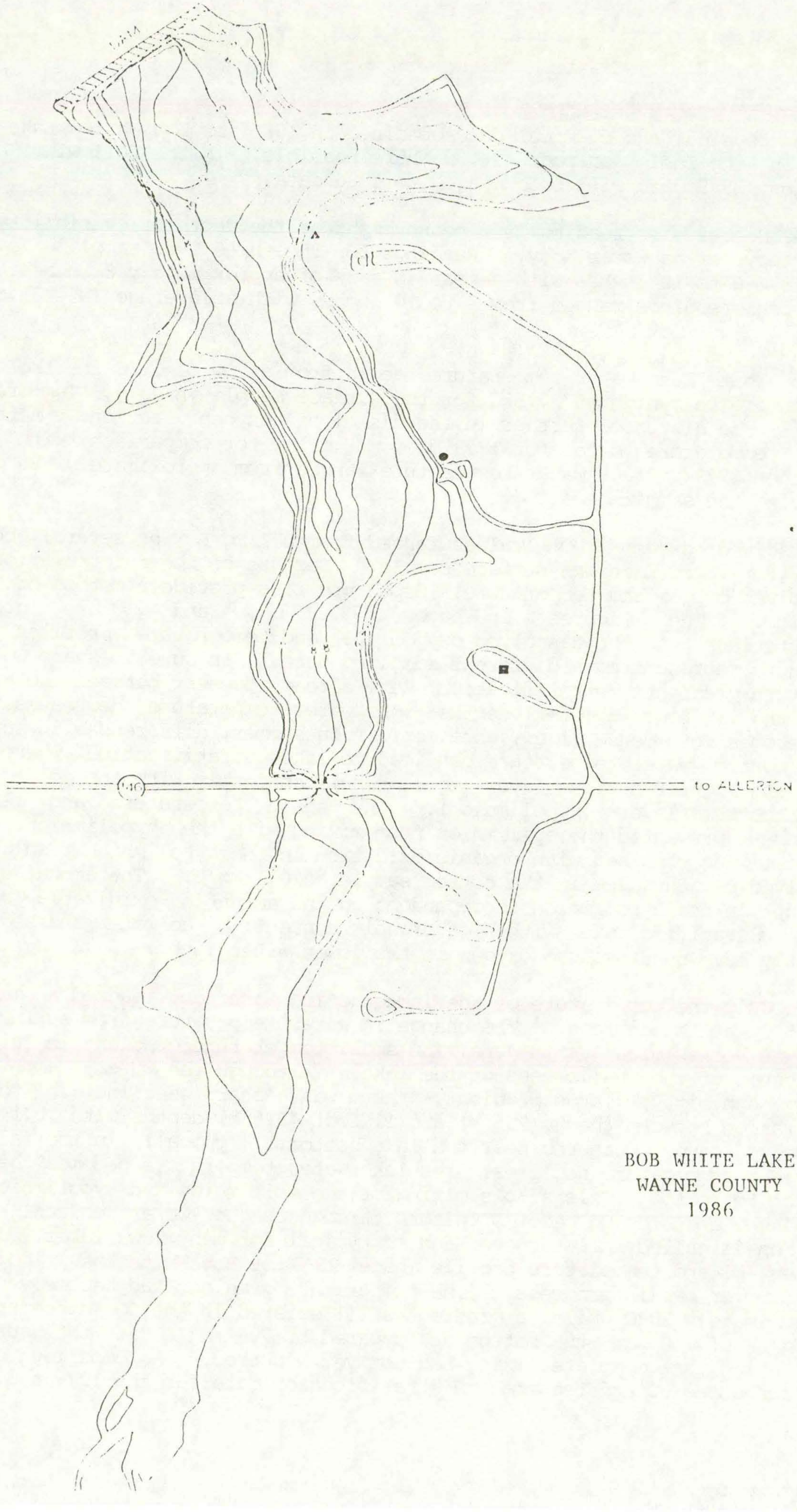
Bob White Lake is located in Wayne County approximately 1.5 miles west of Allerton, Iowa. The 89 acre lake, located on the headwater of the South Fork of the Chariton River, was established about 1913 as a railroad reservoir. In 1956 the Iowa Conservation Commission acquired the area and created a State Park. The lake was used as a municipal water supply for the town of Allerton until 1982. The majority of Bob White Lake's 3,398 acre watershed is in cropland (72.2%) and pasture (22.9%).

Over the years, much of the blame for the poor fishing in the lake has been attributed to turbidity. A primary cause of the turbidity has been the size and nature of the watershed (38:1 watershed/lake surface area ratio). With 72% of the watershed in rowcrops and little use of conservation practices, soil erosion has been a problem. Several years ago a lawsuit was filed against the surrounding landowners requiring implementation of soil conservation practices. At present 95% of the watershed is "controlled" with the remaining 5% in the process of being controlled. These soil conservation practices should reduce lake turbidity and siltation; however, permanent harm has been done by siltation, reducing and eliminating water depth in the upper end of Bob White Lake.

A map of Bob White Lake developed from 1986 data may be found on page 24. In addition a comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake, but lack the detail to accurately assess changes in the lake's physical characteristics. (See Appendix for lake mapping procedure.)

	1977*	1986
Surface Area	89 acres	90 acres
Maximum depth	14 ft.	13 ft.
Volume	444 acre ft.	456 acre ft.

Based on a comparison of the 1979 and 1986 data it is unclear whether the lake has lost any water volume. Although the maximum depth in 1979 was 14 feet as compared to the present maximum depth of 13 feet, both surface and volume have increased from 1977 to 1986. According to the Department of Natural Resources, lake usage in 1979 was below its potential because of poor fishing and high concentrations of suspended matter imparing its usage for swimming. Good soil conservation practices in the watershed should continue to be followed to slow the rate of siltation and thus lengthen the time until the lake's extinction.



BOB WHITE LAKE
WAYNE COUNTY
1986

Chemical Data

The physical and chemical data obtained in 1986 for Bob White Lake are listed in the Table on page 26. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 6 to 10 inches with a mean (N = 3) of approximately 8 inches. The 1979 Secchi readings ranged from 4 to 10 inches with an average (N = 3) of 7 inches.

Bob White Lake water temperature ranged from a low of 16°C in the June bottom sample to a high of 27.5°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Although limited temperature data for 1979 does not allow for comparison with 1986 data, the 1979 surface water temperature ranged from approximately 20°C to 29°C during the sampling period.

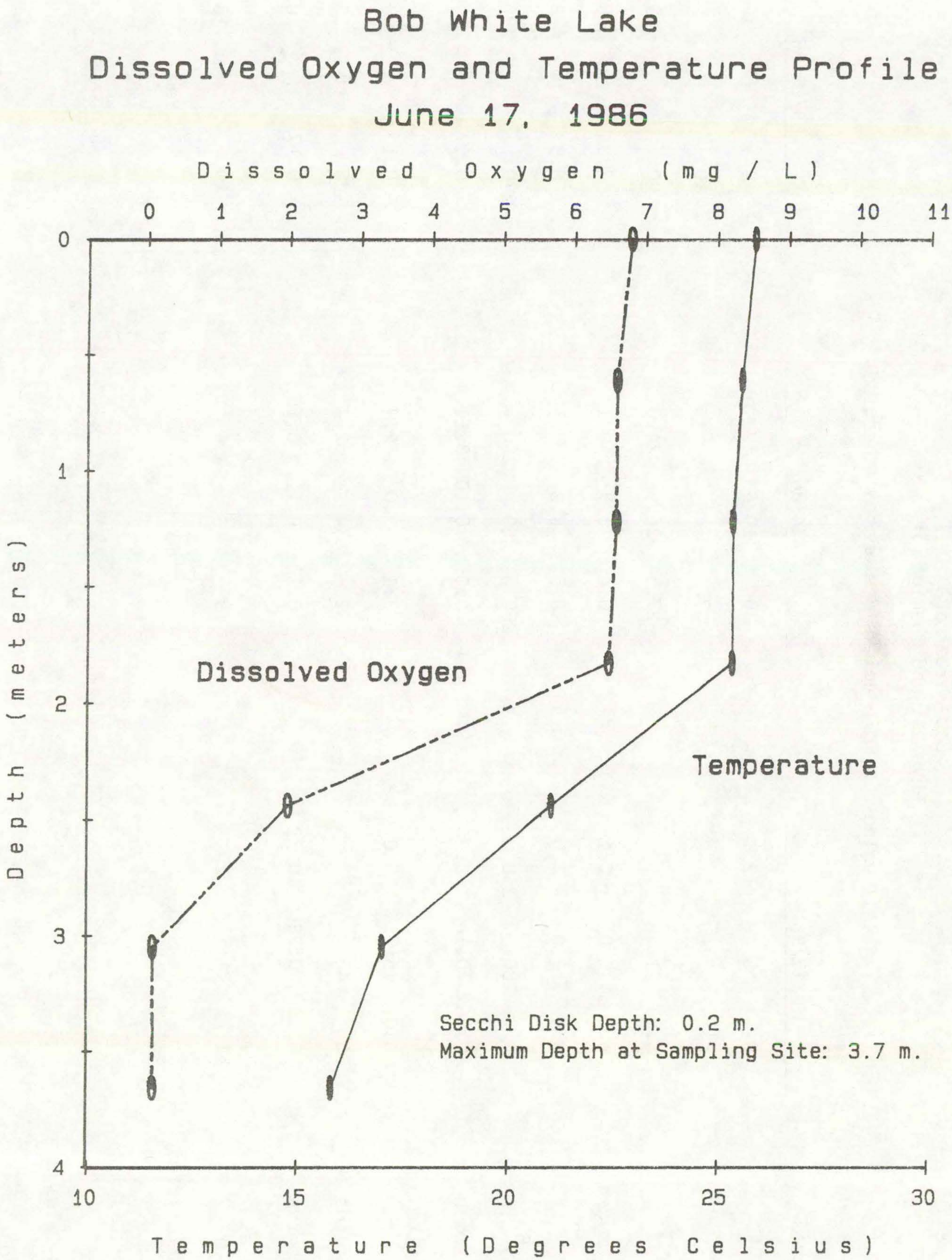
Dissolved oxygen (DO) values ranged from 0.1 mg/L in several bottom samples to 7.8 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 27 , 28 , and 29 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. In June, sharp DO and temperature gradients (stratification) were already present between the 6.0 (2 meter) and 10 foot (3 meter) depths. As water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperature can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The sharp temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in a dissolved oxygen value in the bottom sample of 0.1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with high organic content in the water and sediment frequently have no dissolved oxygen in the lower water layer.

In July the temperature of the lake had increased and reached a maximum of 27.5°C at the surface. The change in water temperature from surface to bottom was not as great as in June. The small temperature gradient in July may be a result of the shallowness of the lake. Although the water temperature did not exhibit a large gradient, there was a sharp decline in the DO concentration between the 8 (2.5 M) and 11 foot (3.5 M) depths with 0.1 mg/L of dissolved oxygen measured near the lake bottom. Typically in the fall, as the ambient temperature declines, the lake water temperature becomes the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 29) for Bob White Lake indicated fall turnover was in progress. The temperature gradient had become vertical at approximately 20°C while a gradient still existed in the DO concentration (3.0 mg/L of DO at the bottom as compared to 7.8 mg/L at the surface) demonstrating that complete mixing had not yet occurred. A comparison of the most pronounced DO and temperature stratification data for the 1979 and 1986

Bob White Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

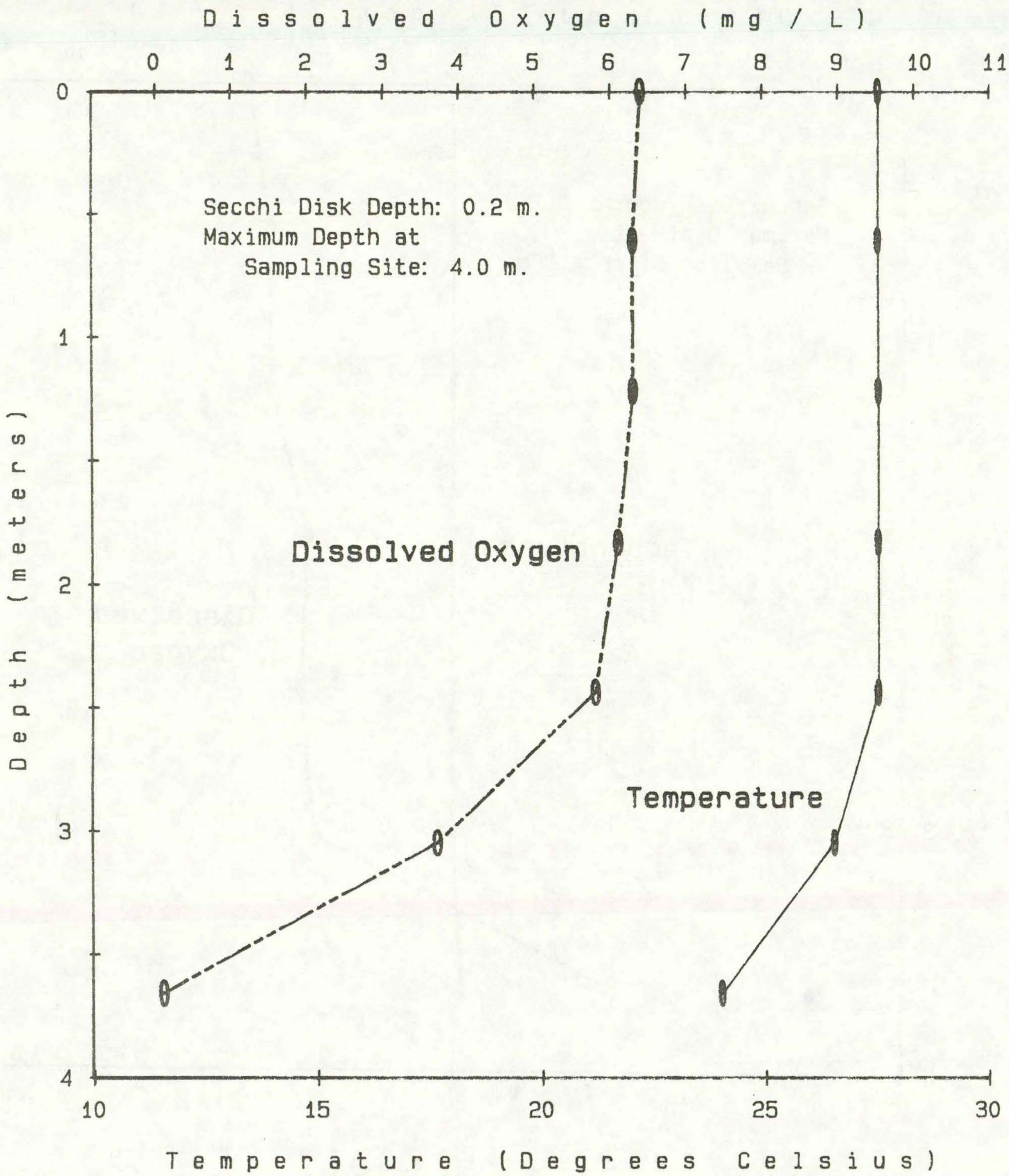
Date Collected	6/17/86			7/24/86			9/09/86	
*Depth[1]	0	8	12	0	10	12	0	12
*Secchi[2]	6			7			10	
*Temperature[3]	25.5	21	16	27.5	26.5	24.0	20	19.8
*Dissolved Oxygen	6.8	2.0	0.1	6.4	3.7	0.1	7.8	3.0
*pH[4]	8.5	7.0	7.0	8.5	8.2	7.5	8.5	8.5
Conductivity[5]	260	260	250	260	260	260	270	270
Ammonia Nitrogen	0.06	0.16	0.26	0.06	0.10	0.14	0.07	0.12
Nitrate-Nitrite Nitrogen	6.0	5.7	5.0	3.1	3.0	2.7	0.1	0.2
Suspended Solids	36	48	70	32	34	62	35	38
Total Phosphorus	0.25	0.28	0.32	0.11	0.11	0.15	0.17	0.21
Chlorophyll a (Corrected)[6]	<1	<1	2	9	4	4	10	13
Thermally Stratified	Yes			Yes			Yes	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

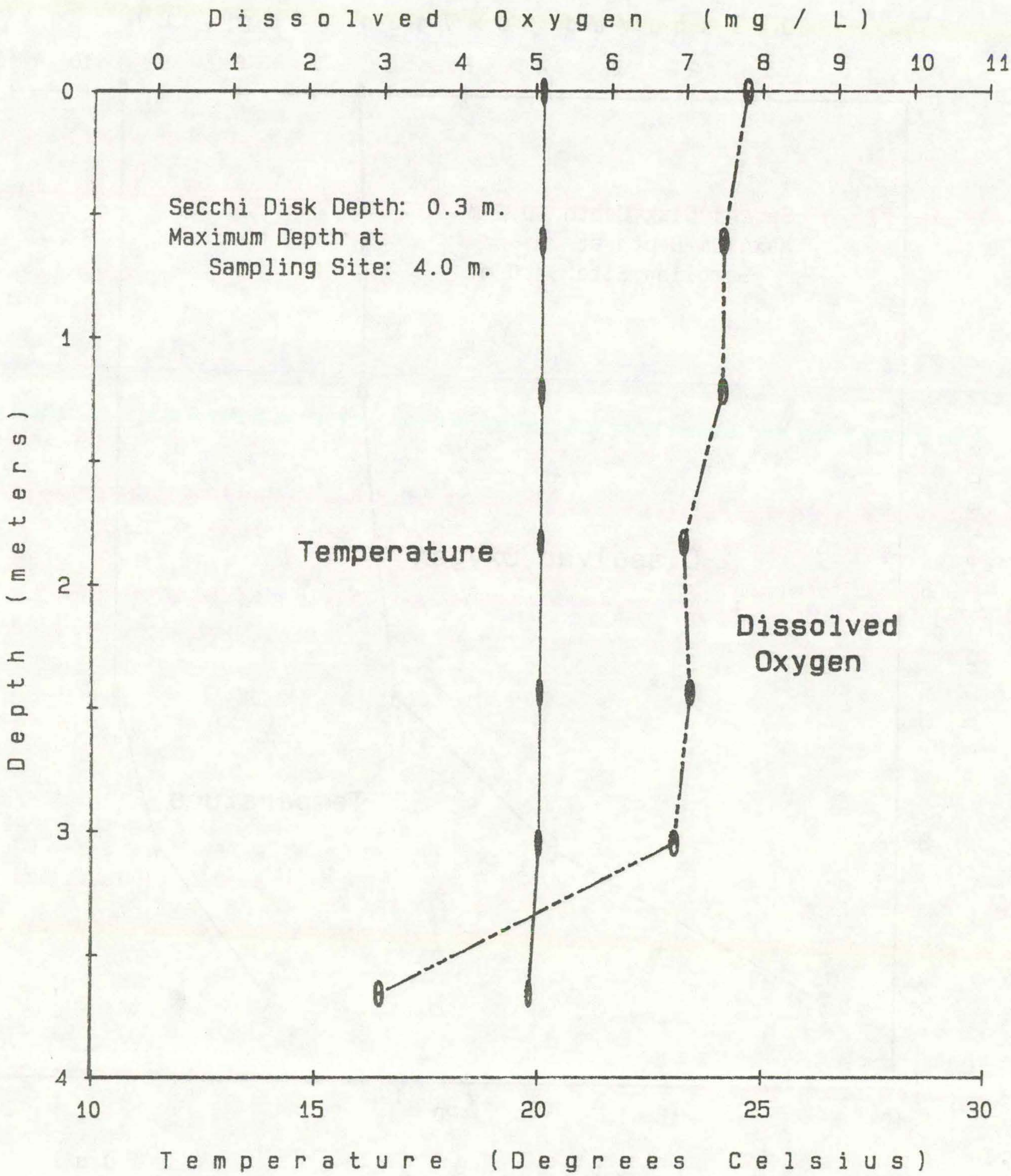


Bob White Lake
Dissolved Oxygen and Temperature Profile
June 17, 1986
Dissolved Oxygen (mg / L)
0 1 2 3 4 5 6 7 8 9 10 11
Depth (meters)
0 1 2 3 4
Dissolved Oxygen
Temperature
Secchi Disk Depth: 0.2 m.
Maximum Depth at Sampling Site: 3.7 m.
10 15 20 25 30
Temperature (Degrees Celsius)

Bob White Lake
Dissolved Oxygen and Temperature Profile
July 24, 1986



Bob White Lake
Dissolved Oxygen and Temperature Profile
September 9, 1986



studies is given below.

	21 August 1979 Surface	21 August 1979 10 feet	17 June 1987 Surface	17 June 1987 12 feet
DO (mg/L)	7.2	2.3	6.8	0.1
Temperature (°C)	26.8	22.2	25.5	16

Compared to 1979, the 1986 dissolved oxygen and temperature values were much lower in the bottom sample.

Values for pH in 1986 varied from 7.0 to 8.5 units. Except when fall turnover was in progress, the pH in the epilimnion was higher (8.5) as compared to the pH of the hypolimnion (7.0 to 7.5). The difference in pH values can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water).

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. Values for specific conductance in 1986 were very similar (ranging from 250 to 270 umhos) throughout the water column for all sampling periods. Conductivity data from the 1979 study (1) also reflected this uniformity between sampling periods and within the water column (ranging from 190 to 250 micromhos). The average Bob White Lake conductivity increased from 205 umhos in 1979 to 260 umhos in 1986. The cause and significance of this increase is not known.

During 1986, the ammonia nitrogen concentrations exhibited a relatively narrow range (from 0.06 mg/L to 0.26 mg/L) with an increase in concentration occuring with depth. The ammonia increase with depth may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate nitrogen levels in the water declined from a maximum of 6.0 mg/L (in June) to 0.1 mg/L (in September). This decline in the nitrate concentration can be attributed to assimilation by the phytoplankton and other plant life. The limited nitrogen data for 1979 do not allow for any comparison to the 1986 data (one surface sample for nitrate, (0.44 mg/L) and ammonia (0.33 mg/L).

Suspended solids in 1986 ranged from 32 mg/L to 70 mg/L with the higher values being found in the bottom samples. The higher solids values can be attributed to the settling of material from the upper water layers and include turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter. During the 1979 study suspended solids ranged from 28 to 167 mg/L and also generally increased with depth.

Total phosphorus concentrations in surface samples in 1986 ranged from 0.11 mg/L to 0.25 mg/L as compared to 0.15 to 0.32 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The slightly lower value of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part of the hypolimnion phosphorus levels were consistently higher than those of the epilimnion. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. The same general trends were found during the 1979 sampling of Bob White Lake. Total phosphorus in 1979 ranged from 0.08 to 0.52 mg/L with higher concentrations being found near the bottom during the July and August sampling.

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986 the corrected chlorophyll a values ranged from <1 µg/L to 13 µg/L. The average corrected chlorophyll a value was lowest in June (1 ug/L) while increasing in both July (6 µg/L) and September (12 µg/L). Chlorophyll a values in the 1979 study averaged 7 µg/L for July, 12 µg/L for August and 13 µg/L for September. Chlorophyll data for both 1979 and 1986 indicate relatively low phytoplankton populations.

Biological Data

A review of old (1948-56) fishery survey forms lists Secchi disk readings ranging from 4 to 48 inches with an average of 20 inches. Fish population sampling during this period indicated numerous bluegill in the eight inch size class. More recent (1973-82) surveys have Secchi disk readings ranging from 4 to 16 inches with an average of 7 inches. During this period only one bluegill over the 6 inch size class has been taken. The first notation of carp in the Bob White field surveys occurs in 1956. In recent years carp are considered to have been a contributing factor to the lake's elevated turbidity levels. Historically, much of the blame for the poor fishing has been attributed to the high turbidity levels in the lake.

Another factor which undoubtedly has contributed to reduced growth in the fish population was the use of copper sulfate (used as an algacide) by the town of Allerton in treatment of their water supply. Since the town no longer uses Bob White as a water supply, this treatment has stopped.

These factors combined with "natural" population tendencies, have resulted in a Bob White Lake fish population dominated by small panfish having little angling value.

A fisheries survey was performed during the fall of 1986. A table listing the species composition is presented below, other pertinent data may be found in the Tables and Figures on pages 39 to 42 .

BOB WHITE FISH POPULATION SAMPLE
10 and 11 September 1986

Species Composition - Collected with 6 pound nets (overnight) and shocker (129 minutes)

Species	Nets	Shocker	Total #	Total Percent
Bluegill	11	8	19	4
White Crappie	220	20	240	56
Black Crappie	1		1	<1
Largemouth Bass		22	22	5
Channel Catfish	46	21	67	16
Green Sunfish	5	14	19	4
Carp	34	20	54	13
Golden Shiner	3	2	5	1
Black Bullhead	1		1	<1
Total	321	107	428	

SUMMARY

Although the data presented in this report are rather limited, it is possible to make several general statements about the data.

> Since 1979, the volume of water in Bob White Lake has declined slightly as a result of siltation. The possibility of additional soil conservation practices for the near vicinity should be evaluated.

> Although the 1986 dissolved oxygen and temperature profiles were more pronounced as commpared to the 1979 data, and there was a slight increase in specific conductance values, no major changes in lake water quality appear to have occurred from 1979 to 1986. Continued monitoring is necessary to determine long term trends in water quality.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00231 999300103000
40 42 40.0 093 23 55.0 3
BOB WHITE SAMPLING SITE #2
19185 IOWA WAYNE
CHARITON RIVER BASIN 091300
BOB WHITE LAKE T068NR22WSC04
21IOWA 771123 10280201 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
76/07/15		WATER					210						
79/07/18		WATER	0	29.00		.25	225	7.30		7.60	31		
79/07/18		WATER	6				200	1.40		7.20	143		
79/07/18		WATER	9				190	.30		7.05	167		
79/07/18 CP(1)- 79/07/18	REP	WATER	0	.00		.20							
79/08/21		WATER	0	26.80		.10	200	7.20		7.91	27		
79/08/21		WATER	6				200	6.80		7.91	39		
79/08/21		WATER	9				200	2.30		7.45	82		
79/08/21 CP(1)- 79/08/21	REP	WATER	0	.00		.10		6.90					
79/08/21 CP(1)- 79/08/21	REP	WATER	9				200			7.45			
79/09/26		WATER	0	19.60		.20	210	8.00		8.10	28	.330	.44
79/09/26		WATER	3				210	8.00		8.10	26		
79/09/26		WATER	6				210	7.80		8.10	26		
79/09/26 CP(1)- 79/09/26	REP	WATER	0	.00		.20	210			8.10		.070	.40
86/06/17	1100	WATER	0	25.50	6.0		260	6.80	8.50	7.90	36	.060	6.00
86/06/17	1100	WATER	8	21.00			260	2.00	7.00	7.50	48	.160	5.70
86/06/17	1100	WATER	12	16.00			250	.10	7.00	7.40	70	.260	5.00
86/07/24	0930	WATER	0	27.50			260	6.40	8.50	7.80	32	.060	3.10
86/07/24	0930	WATER	10	26.50			260	3.20	8.25	7.70	34	.100	3.00
86/07/24	0930	WATER	12	24.00			260	.10K	7.50	7.30	62	.140	2.70
86/09/09	0900	WATER	0	20.00			270	7.80	8.50	7.60	35	.070	.10
86/09/09	0900	WATER	12	19.75			270	3.00	8.50	7.90	38	.120	.20

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00231 999300103000
40 42 40.0 093 23 55.0 3
BOB WHITE SAMPLING SITE #2
19185 IOWA WAYNE
CHARITON RIVER BASIN 091300
BOB WHITE LAKE T068NR22WSC04
21IOWA 771123 10280201 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
76/07/15		WATER				3.94							
76/07/28		WATER				4.53							
76/08/11		WATER				8.22							
76/08/18		WATER				22.15							
79/07/18		WATER	0	.48			4.30						
79/07/18		WATER	6	1.12			9.40						
79/07/18		WATER	9	1.58									
79/08/21		WATER	0	.55			12.00						
79/08/21		WATER	6	.60			16.50						
79/08/21		WATER	9	.91			6.70						
79/08/21 CP(1)- 79/08/21	REP	WATER	9	.83									
79/09/26		WATER	0	.29			14.20						
79/09/26		WATER	3	.30			12.70						
79/09/26		WATER	6	.24			10.50						
86/06/17	1100	WATER	0		.250	5.00	1.00K						
86/06/17	1100	WATER	8		.280	5.00	1.00K						
86/06/17	1100	WATER	12		.320	4.00	2.00						
86/07/24	0930	WATER	0		.110	12.00	9.00						
86/07/24	0930	WATER	10		.110	7.00	4.00						
86/07/24	0930	WATER	12		.150	6.00	4.00						
86/09/09	0900	WATER	0		.170	19.00	10.00						
86/09/09	0900	WATER	12		.210	19.00	13.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

BOB WHITE LAKE, 1986

BACK-CALCULATED TOTAL LENGTHS (INCHES)

LARGEMOUTH BASS

Age Group	N	Annulus 1	2	3	4	5	6
I	1	5.0					
II	6	6.1	9.1				
III	1	6.9	9.5	11.7			
IV	0						
V	0						
VI	2	6.1	9.3	11.6	14.7	16.4	17.3
Mean		6.1	9.2	11.7	14.7	16.4	17.3

BLUEGILL

Age Group	N	Annulus 1	2	3	4
I	1	2.8			
II	0				
III	11	2.4	3.3	4.1	
IV	5	1.7	3.0	4.1	4.7
Mean		2.2	3.2	4.1	4.7

CRAPPIE

Age Group	N	Annulus 1	2	3	4
I	20	3.6			
II	5	3.8	6.4		
III	0				
IV	1	4.4	6.2	8.7	10.2
Mean		3.7	6.4	8.7	10.2

BOB WHITE LAKE - RELATIVE WEIGHT SELECTED SPECIES - FALL 1986

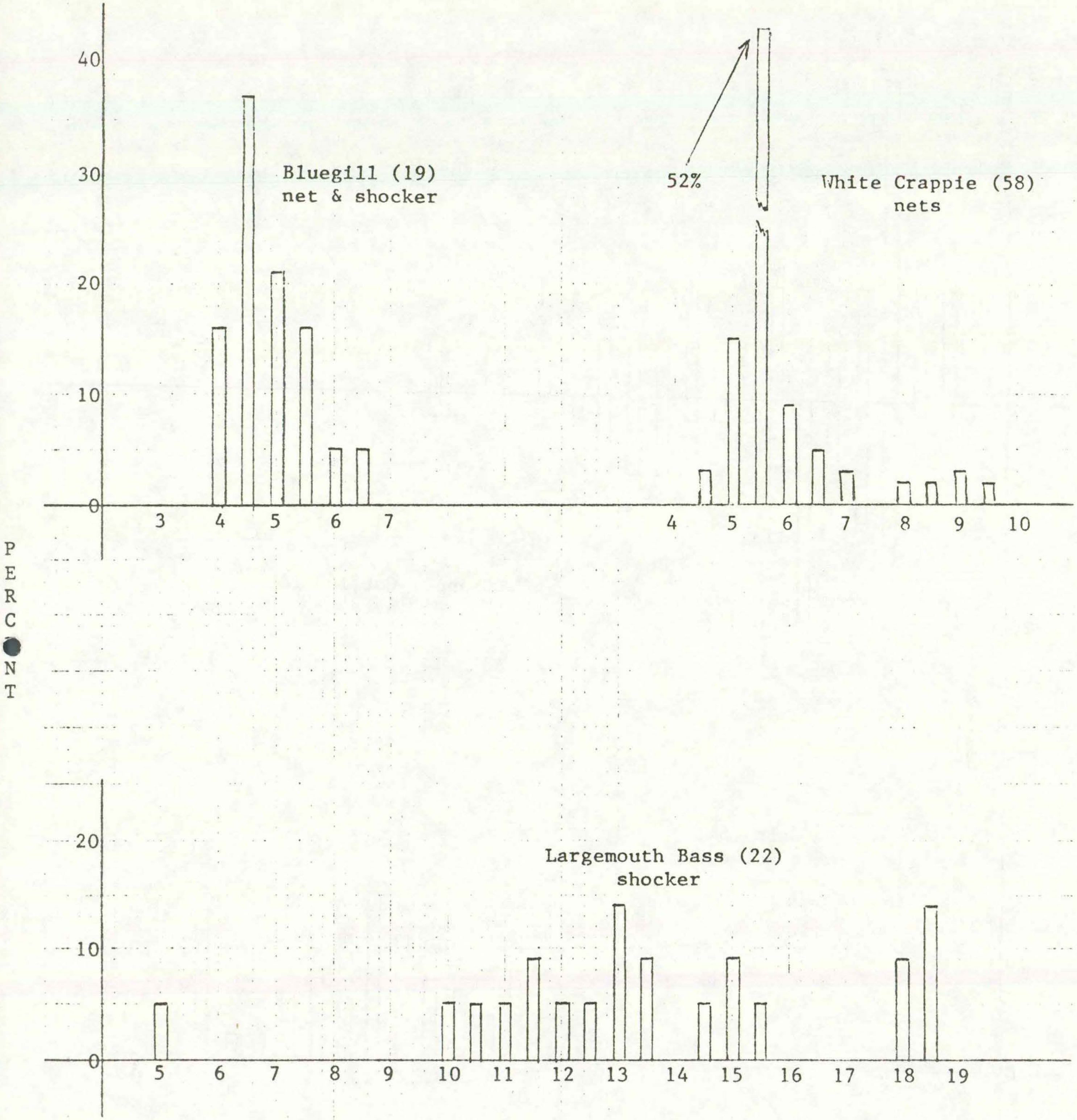
Species	Length	W_r
Channel Catfish	<11.0"	.91
Channel Catfish	11.0 - 15.9"	.75
Crappie	<5.0"	.80
Crappie	5.0 - 7.9"	.73
Crappie	≥8.0"	.77
Largemouth Bass	<12.0"	.95
Largemouth Bass	12.0 - 14.9"	.91
Largemouth Bass	≥15.0"	1.02
Bluegill	3.0 - 5.9"	.98
Bluegill	≥6.0"	.87

BOB WHITE LAKE AREA-CAPACITY CHART 1986 DATA

Elevation	Surface Area (Acres)	Capactiy (Acre Feet)
Spillway Crest	89.6	455.6
-2'	66.9	299.1
-4'	47.2	185.0
-6'	35.3	102.5
-8'	22.1	45.1
-10'	9.8	13.2
-12'	1.7	1.7

SIZE COMPOSITION, SELECTED SPECIES

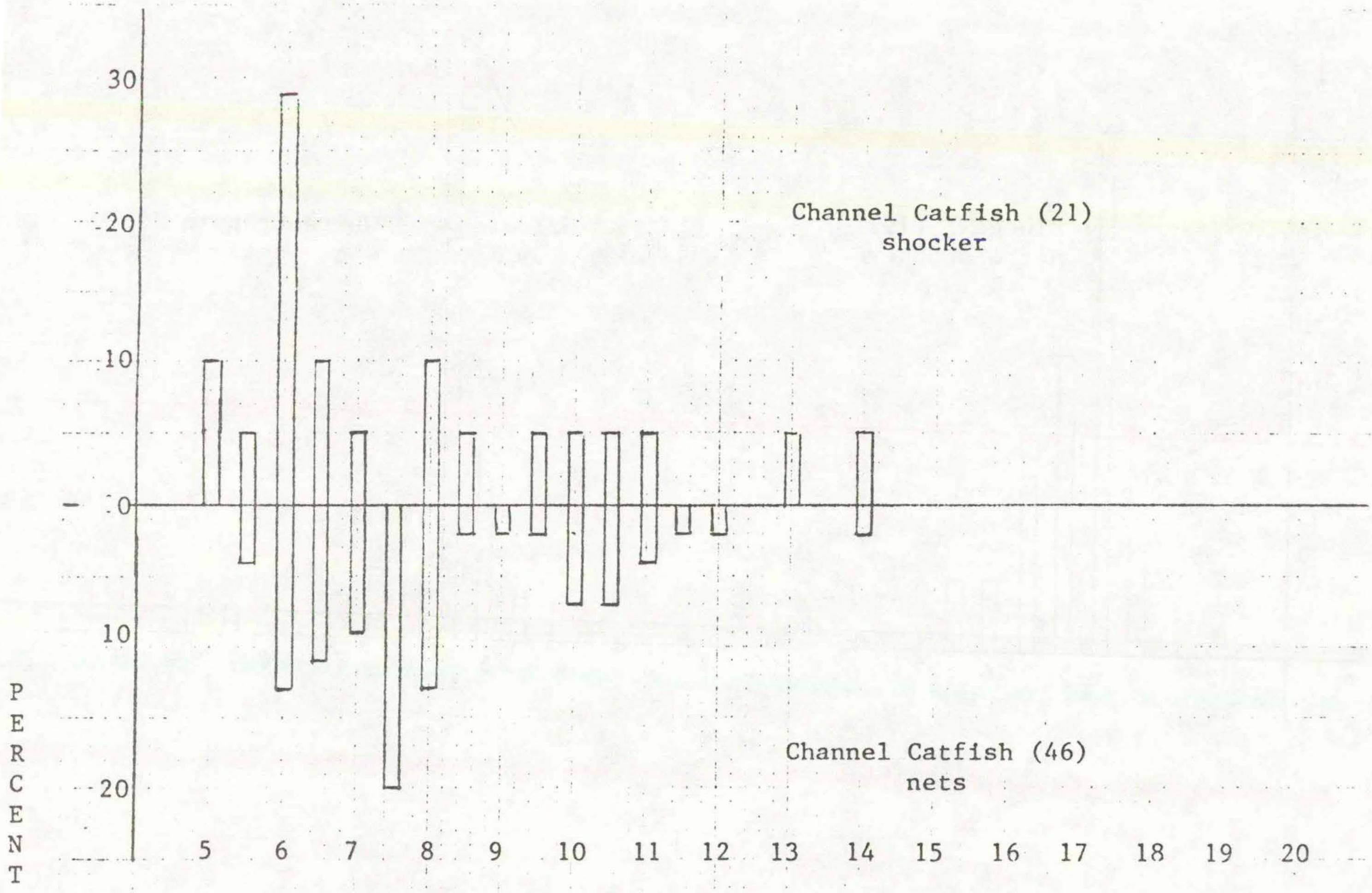
BOB WHITE LAKE 9/10/86, 9/11/86

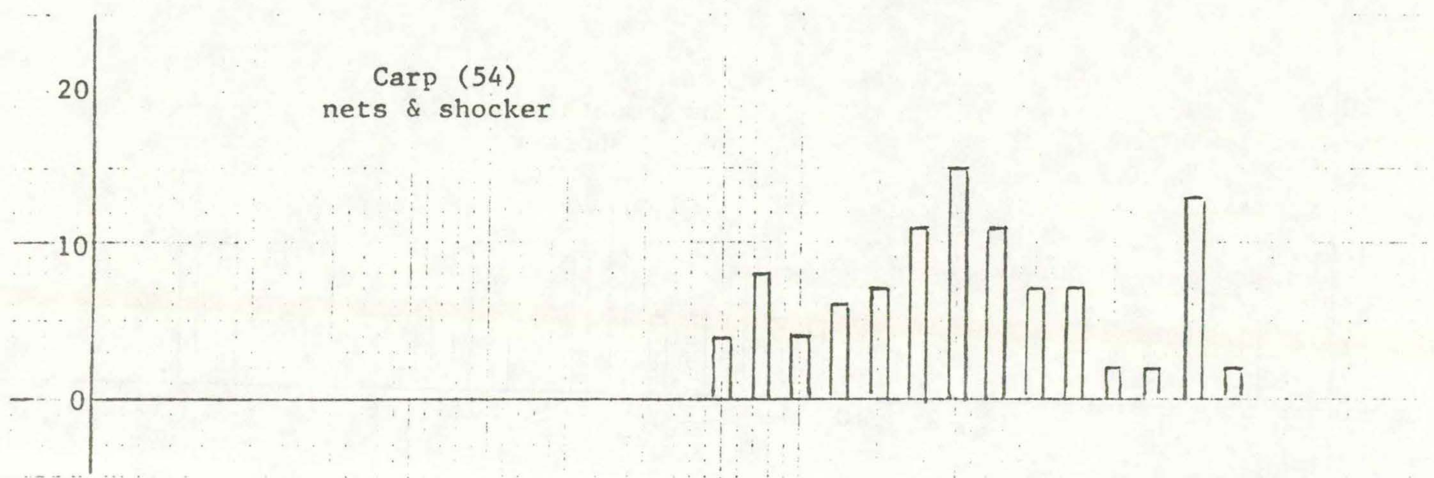


INCHES

SIZE COMPOSITION, SELECTED SPECIES

BOB WHITE LAKE 9/10/86, 9/11/86





INCHES

LAKE GEODE

Physical and Lake Impact Data

Lake Geode is located in Henry County approximately 8 miles south of New London, Iowa. The majority of the lake's 9,869 acre watershed is in cropland (68.4%), pasture (19.1%) and forest (9.9%). A map of Lake Geode developed from 1986 data may be found on page 44 .

During the 1970's, an increase in the rowcrop usage of tillable land in the watershed corresponded to an increase in turbidity, sedimentation and the dominance of blue-green algae in Lake Geode. The signs of siltation were first noticed during fish surveys conducted during 1975 to 1979, and when the lake was drained in the fall of 1981 the effects of siltation became obvious. The upper portion of the lake had layers of silt approximately six feet deep. The fisheries staff of the DNR have indicated in-lake restoration measures are needed and have proposed installing aerators for use during summer dissolved oxygen stratification in Lake Geode. A more detailed impact accessement can be found in the Appendix. A comparison of the lake's physical characteristics for 1973 (1) and 1986 are given below. Caution should be excercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lake's physical characteristics. (See Appendix for lake mapping procedure.)

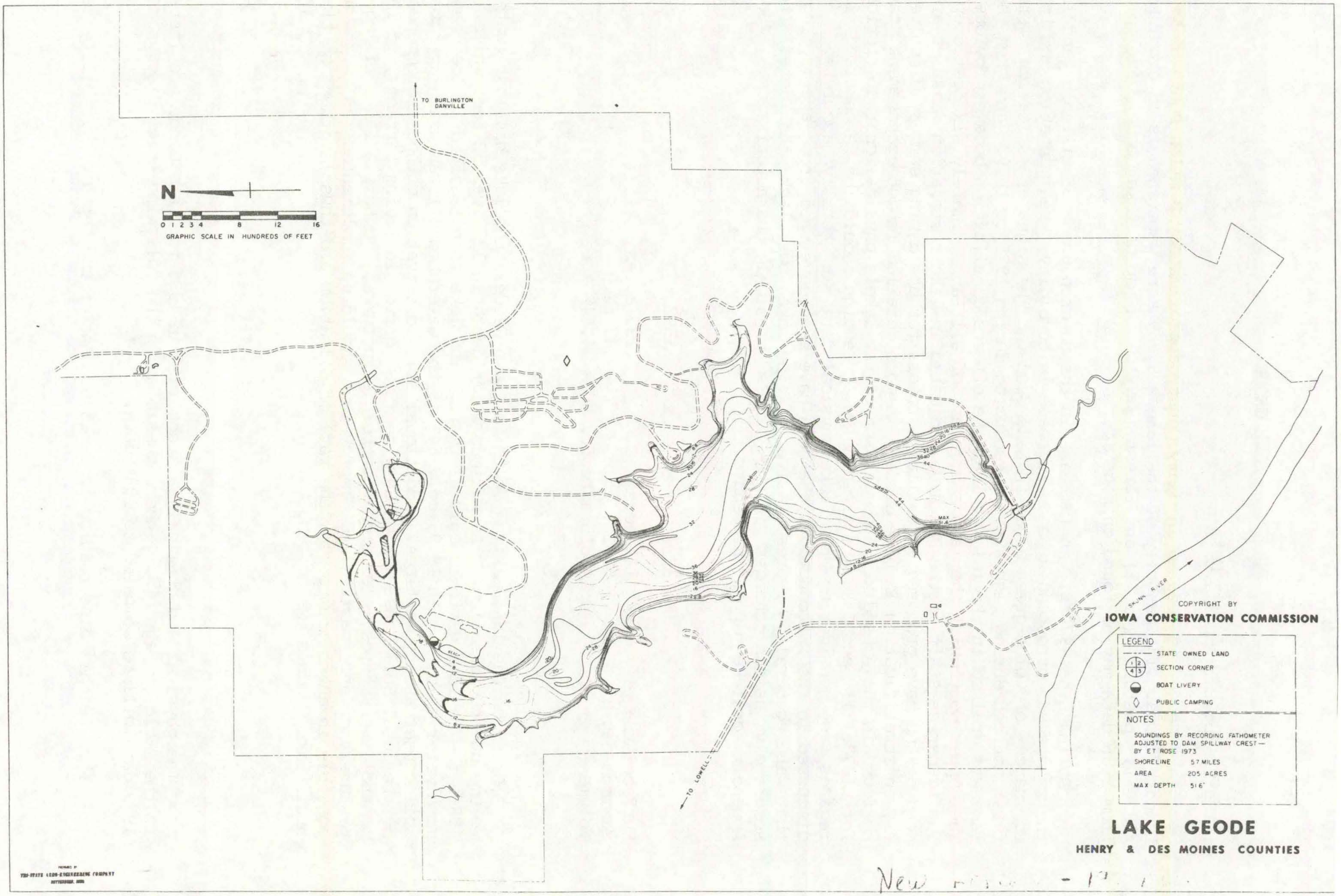
	1973	1986
Surface Area	181 acres	190 acres
Maximum depth	52 ft.	42 ft.
Volume	4,515 acre ft.	4,542 acre ft.

Based on the 1986 maximum depth for Lake Geode, the lake has lost water volume due to siltation. The maximum water depth in 1973 was 52 feet while in 1986 the maximum depth is only 42 feet. The lake cannot afford to lose any more water volume. In 1979, only 64% of the watershed (1) was using approved soil conservation practices. Additional soil conservation methods recommended by the local Soil Conservation Service (SCS) office including terraces, gulley control structures, erosion control structures, conservation tillage, pastureland and pastureland improvement should be implemented as soon as possible in an effort to slow the rate of siltation and thus lengthen the time until Lake Geode's extinction.

Chemical Data

The physical and chemical data obtained in 1986 for Lake Geode are listed in the Table on page 45 . Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or


TO BURLINGTON
DANVILLE
N
0 1 2 3 4 8 12 16
GRAPHIC SCALE IN HUNDREDS OF FEET
SKUNK RIVER
TO LOWELL
COPYRIGHT BY
IOWA CONSERVATION COMMISSION
LEGEND
STATE OWNED LAND
SECTION CORNER
BOAT LIVERY
PUBLIC CAMPING
NOTES
SOUNDINGS BY RECORDING FATHOMETER
ADJUSTED TO DAM SPILLWAY CREST—
BY E T ROSE 1973
SHORELINE 5.7 MILES
AREA 205 ACRES
MAX DEPTH 51.6'
LAKE GEODE
HENRY & DES MOINES COUNTIES

Lake Geode
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/16/86			8/15/86			9/11/86		
*Depth[1]	0	10	36	0	11	20	0	17	36
*Secchi[2]	81.5			28			32		
*Temperature[3]	25	20.5	9.0	23	23	14	21	18	10
*Dissolved Oxygen	9.6	2.8	2.0	9.4	3.7	0.0	7.2	2.1	0.0
*pH[4]	8.5	8.0	7.5	9.8	9.8	7.8			
Conductivity[5]	340	340	360	220	240	310	240	260	350
Ammonia Nitrogen	0.15	0.09	0.93	0.14	0.23	0.27	0.19	0.27	1.4
Nitrate-Nitrite Nitrogen	5.3	5.5	1.8	1.2	1.4	2.6	0.6	0.7	<0.1
Suspended Solids	6	4	10	10	8	8	8	12	11
Total Phosphorus	0.06	0.07	0.11	0.04	0.02	0.07	0.05	0.08	0.20
Chlorophyll a (Corrected)[6]	2	5	3	32	24	3	28	16	5
Thermally Stratified		Yes			Yes			Yes	

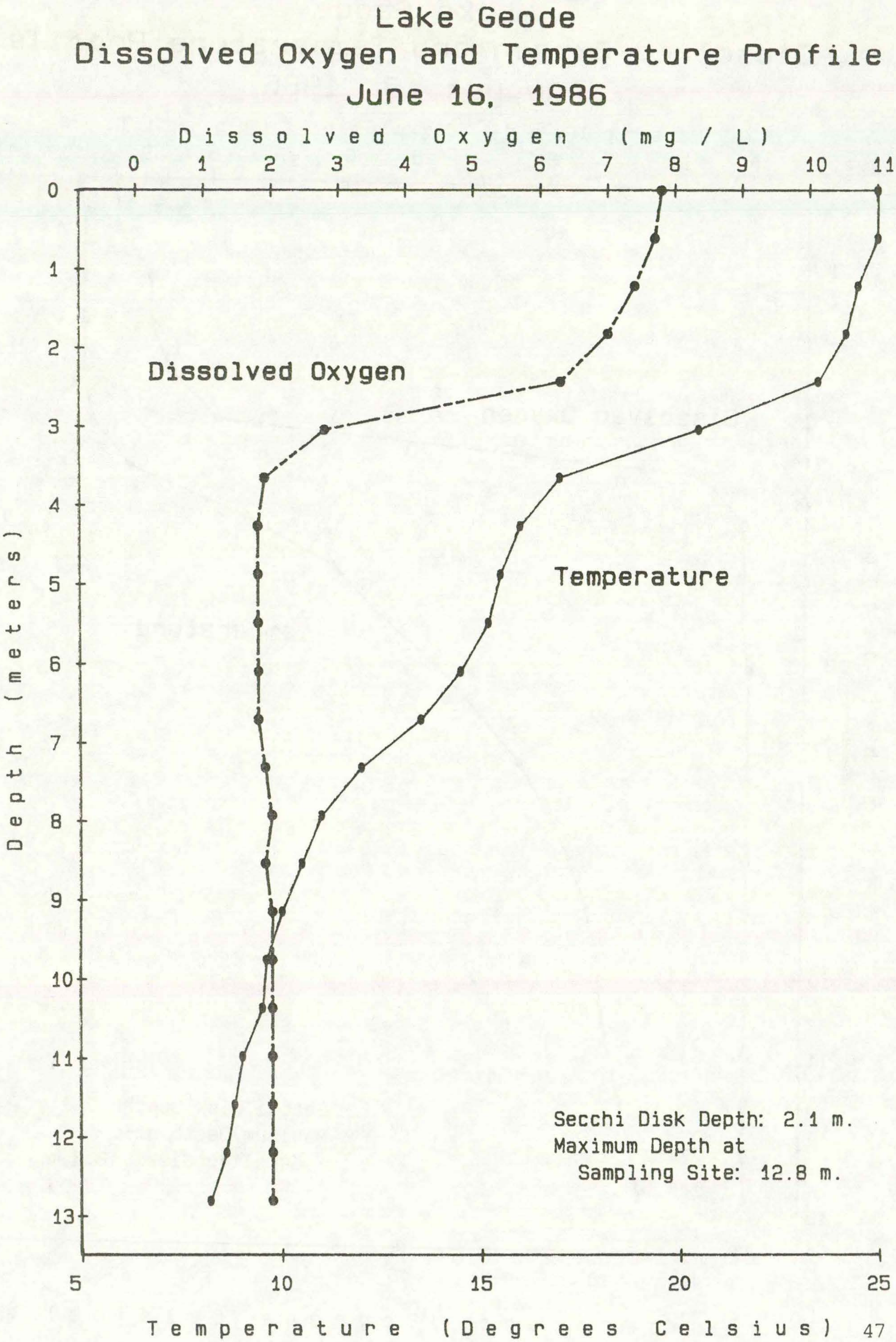
1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

transparency of a water body. Readings for the three 1986 sampling events ranged from 28 to 81.5 inches with a mean (N = 3) of 47 inches. The 1979 Secchi readings range from 27 to 51 with an average (N = 3) of 39 inches.

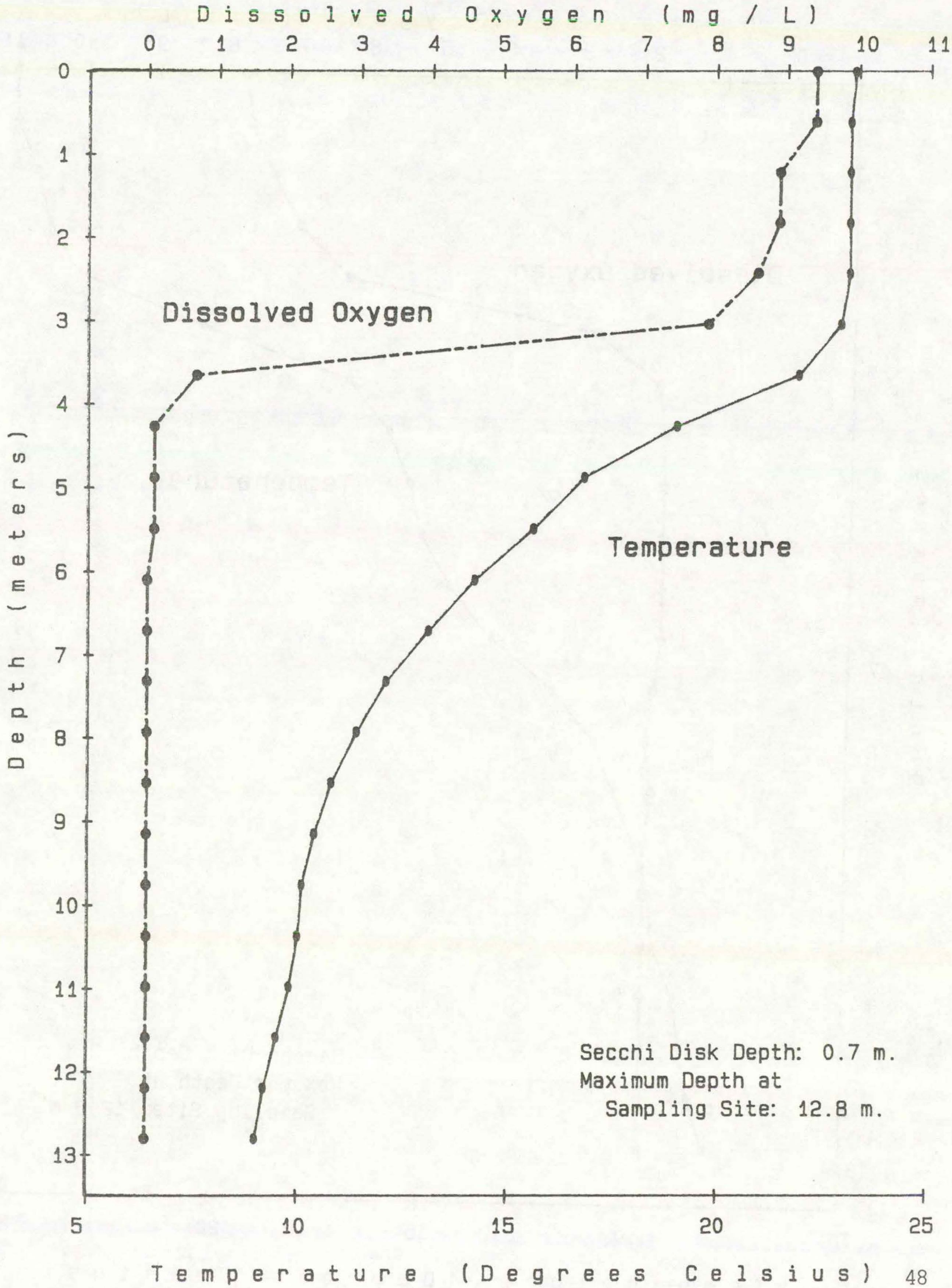
Lake Geode water temperature (in 1986) ranged from a low of 9°C in the June bottom sample to a high of 25°C for the surface sample in June. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with 1986 data.

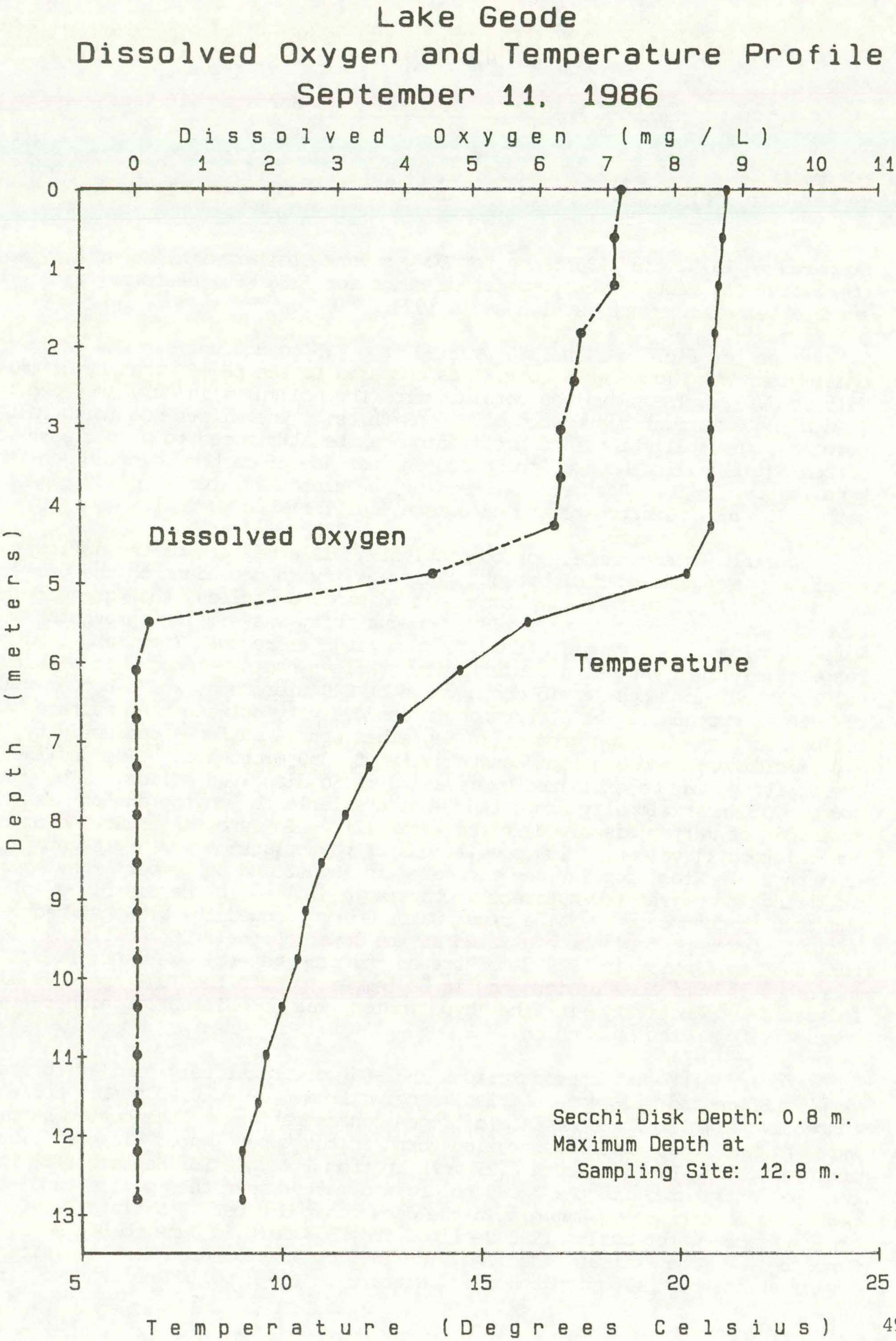
During 1986 dissolved oxygen (DO) values ranged from 0.0 mg/L in several bottom samples to 9.6 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 47, 48 and 49 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. The June profile indicates that Lake Geode already had moderately sharp DO and temperature gradients (stratification) that began at a depth of 8 ft. (2.5 meters). At a depth of about 12 feet, the DO had declined to approximately 2 mg/L and remained at that concentration to the bottom (42 feet). The profile for the August sampling period was very similar to the June profile except that the DO and temperature gradients were even sharper and the DO concentration below 13 feet (4 meters) was <1 mg/L. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom samples of from 0 to 2 mg/L. The amount of DO depletion in the hypolimnion is dependent upon the amount of oxidizable matter present. Stratified lakes with high organic content in water and sediment frequently have no dissolved oxygen in the lower water layer. The DO and temperature profiles for September 1986 (page 49) continued to demonstrate well-defined gradients from surface to the bottom. Compared to August, however, the zone of oxygen depletion had been reduced to between 18 to 42 feet.

Normally in the fall, as the ambient temperature declines, the lake water temperature becomes the same from top to bottom, mixing of the epilimnion and hypolimnion takes place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. As illustrated in the September profile, although the surface water temperature had begun to cool (21°C as compared to 23°C in August), the temperature gradient was still quite sharp indicating that fall turnover would not occur for some time. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.


Lake Geode
Dissolved Oxygen and Temperature Profile
June 16, 1986
Dissolved Oxygen (mg/L)
0 1 2 3 4 5 6 7 8 9 10 11
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Dissolved Oxygen
Temperature
Secchi Disk Depth: 2.1 m.
Maximum Depth at
Sampling Site: 12.8 m.
5 10 15 20 25
Temperature (Degrees Celsius)

Lake Geode
Dissolved Oxygen and Temperature Profile
August 15, 1986




Lake Geode
Dissolved Oxygen and Temperature Profile
September 11, 1986
Dissolved Oxygen (mg / L)
0 1 2 3 4 5 6 7 8 9 10 11
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10 11 12 13
Dissolved Oxygen
Temperature
Secchi Disk Depth: 0.8 m.
Maximum Depth at
Sampling Site: 12.8 m.
5 10 15 20 25
Temperature (Degrees Celsius)

	8 August 1979			15 August 1986		
	Surface	16 feet	40 feet	Surface	16 feet	40 feet
DO (mg/L)	11.7	0.2	0.1	9.4	0.1	0.0
Temperature (°C)	32	23	10	23	17	9

Compared to 1979, the 1986 range for DO was very similar with essentially no DO below 16 feet. The temperature range for 1986 was narrower with the surface temperature not as high as in 1979.

Values for field pH (in 1986) varied from 7.5 to 9.8 units. The pH in the epilimnion was higher (8.5 to 9.8) as compared to the pH of the hypolimnion (7.5 to 7.8). The pH values obtained from the ipilmnion in July exceeded the Iowa class B warmwater standard of 9.0 pH units. The difference in pH values between the epilimnion and hypolimnion can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. During June of 1986, conductivity was similar throughout the water column and ranged from 340 to 360 micromhos (top and bottom respectively). By August a conductivity gradient had developed with a surface value of 220 micromhos, a mid depth value of 240 micromhos, and a bottom value of 310 micromhos. The difference in conductivity between the surface and bottom samples was even greater in September with a surface conductivity of 240 micromhos, and a bottom conductivity of 350 micromhos. The decline in conductivity may be explained by relating it to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). In June, as indicated by the low chlorophyll values, low populations of phytoplankton were present. As the phytoplankton populations increased in August and September they began utilizing the dissolved nutrients, causing a decline in the dissolved solids and thus in conductivity. The upper water column showed the greatest decrease because fewer phytoplankton existed at the lower depths. Conductivity data for the epilimnion in 1979 demonstrated the same general decline from 320 micromhos in June to 250 micromhos in September. Both the 1979 and 1986 data indicate conductivity in the hypolimnion was consistently higher than conductivity in the epilimnion.

Ammonia nitrogen concentrations in 1986 were relatively similar for all three surface and mid-depth samples, ranging from 0.09 to 0.23 mg/L. For each respective sampling, the ammonia nitrogen concentrations in the bottom samples were higher than the concentration found in the upper water layers (i.e., surface 0.19 mg/L, mid-depth 0.27 mg/L, bottom 1.4 mg/L for September). This can be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate levels in the surface water during 1986 declined from 5.3 mg/L in June to 0.6 mg/L in September. The nitrate decline in the epilimnion is due to nitrate assimilation by the phytoplankton. Nitrate in the hypolimnion ranged from

<0.1 to 2.6 mg/L (August and September respectively). The low nitrate concentration (<0.1 mg/L) and somewhat elevated ammonia nitrogen concentration (1.4 mg/L) observed in the September bottom sample may be attributed to nitrate being reduced to ammonia in the deoxygenated hypolimnion (3). The limited nitrogen data for 1979 does not allow for any comparison to 1986 data (one surface sample for ammonia 0.08 mg/L and a nitrate of 0.08 mg/L measured in September).

Suspended solids (in 1986) ranged from 4 mg/L to 12 mg/L with no discernible pattern or trend. A similar range was measured in 1979 (4 to 18 mg/L) for suspended solids.

During 1986, total phosphorus concentrations in surface samples ranged from 0.05 to 0.20 mg/L as compared to 0.16 to 0.38 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. In the oxygen deficient part of the hypolimnion, phosphorus levels were lowest in June (0.16 mg/L) and relatively constant in August and September (0.38 and 0.32 mg/L respectively). It is not unusual for phosphorus to increase in the bottom waters from the decomposition of sinking phytoplankton and liberation from the sediment by reduction (3). During 1979, total phosphorus ranged from 0.02 to 0.62 mg/L and generally increased with depth.

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986, the corrected chlorophyll a values in the epilimnion ranged from 2 ug/L to 32 µg/L. The June epilimnion mean corrected chlorophyll a value was lowest (4 µg/L) while exhibiting relatively similar mean values (N = 2) for August (28 µg/L) and September (22 µg/L). Hypolimnetic values for corrected chlorophyll a ranged from 3 µg/L to 5 µg/L with the highest value occurring in September. Corrected chlorophyll a values in the 1979 epilimnion ranged from 8 µg/L to 39 µg/L with the highest conentration present in July. Chlorophyll data for both 1979 and 1986 indicate relatively low phytoplankton populations.

Pesticide Data

As described in the 1986 Iowa Lakes Study Work/QA plan, Lake Geode was one of five lakes in which samples for pesticide analysis were collected (4). One water sample was to be collected during non-rainfall runoff conditions (usually the first sample collected) and used for baseline data. Two water samples were to be collected after rainfall runnoff to demonstrate the impact of runoff on lake water quality. In addition, a composite (of at least 3 samples) sediment sample was also obtained from each lake. All samples were analyzed for nine common Iowa pesticides; i.e., the herbicides Atrazine, Cyanazine, Methlachlor, alachlor, Metribuzin and Dicamba; the chlorinated hydrocarbons dieldrin and chlordane; and the organophosphate Fonfos. The pesticide data for Lake Geode may be found in the table on page 52 . Reportable values were measured in all three water samples for Atrazine (range 2.6 to 15 µg/L), Cyanazine (range 1.1 to 5.7 µg/L), Methlachlor (range 2.2 to 5.6 µg/L), Alachlor (range 0.5 to 1.5 µg/L) and Metribuzin (range 0.16 to 0.56 µg/L). All of the other pesticides were less than the reporting limit.

Lake Geode
Pesticide Data - 1986
(all values in micrograms per liter or parts per billion)

Date Collected	6/06/86	7/03/86	8/15/86	7/11/86
Sample Matrix	Water	Water	Water	Sediment
Atrazine (AAtrex)	15	2.6	6.3	<100
Cyanazine (Bladex)	5.7	1.1	2.9	<100
Methlachlor (Dual)	5.6	2.2	2.5	<200
Alachlor (Lasso)	1.5	0.5	0.59	<200
Metribuzin (Sencor)	0.56	0.4	0.16	<100
Dicamba (Banvel)	<0.1	<0.1	<0.1	<50
Dieldrin (Dieldrin)	<0.05	<0.05	<0.05	<50
Fonfos (Dyfonate)	<0.1	<0.1	<0.1	<100
Chlordane (Chlordane)	<0.2	<0.2	<0.5	<100

The levels of these herbicides were generally highest in June and less in the samples obtained in July and August. This is not unexpected and can be explained when several factors are considered. Applications of herbicides generally occur in the late spring after the crops are planted. Herbicides (as a group) are generally more water soluble, less persistant and less toxic than other classes of pesticides. Although precipitation records were not available for the state park, data obtained from the National Oceanic and Atmospheric Administration (NOAA) indicate the city of Burlington (located approximately 15 miles from Lake Geode) received over 5.5" of rain during the first two weeks of June. Therefore, although the first set of water samples were not collected under rainfall runoff conditions, the recent application of herbicide to crops, the solubility of the herbicides, the lack of persistance of herbicides in general, and the abundant precipitation during the first two weeks of June combined to make the levels of herbicides found higher in the June samples than the samples collected in July and August. No reportable values for pesticides were found in the sediment sample obtained from Lake Geode. During 1979 no samples were collected for pesticide analysis and comparison to 1986 is not possible.

Biological Data

A fisheries survey was conducted from October 1-3, 1986, using pound nets, gill nets and an electroshocker. The predominent species included black bullhead, bluegill, black crappie, channel catfish and largemouth bass. This differs from fish surveys performed during 1978 to 1981 when Lake Geode eventually became dominated by gizzard shad. To eradicate these fish, the lake eventually had to be drained in September of 1981. A detailed summary of fisheries surveys (from 1952 to 1986) may be found in the Appendix.

Summary

Although the data presented in the report are rather limited, it is possible to make several general statements.

> Since 1979, the volume in Lake Geode has declined as a result of siltation. The best possible land use practices should be applied to the area in an effort to slow the rate of siltation. Although the 1986 dissolved oxygen and temperature profiles were not as pronounced as compared to 1979, no major changes in lake water quality appeared to have occurred from 1979 to 1986. Reportable pesticide values were measured in lake water throughout the summer reflecting the affect of agriculture runoff. Continued monitoring is necessary to determine long term trends in water quality.

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2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

4. Wnuk, M. 1986. 1986 Iowa Lakes Study - Work/QA Plan. Iowa Department of Natural Resources, Des Moines, IA.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00204 994400101000
40 49 29.0 091 26 30.0 3
LAKE GEODE SAMPLING SITE #1
19087 IOWA HENRY
SKUNK RIVER BASIN 071100
LAKE GEODE T070NR05WSC36
21IOWA 771123 07080107 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
76/07/15		WATER					290						
79/07/05		WATER	0	24.50		.70	320	10.70		8.90	9		
79/07/05		WATER	6				320	10.50		8.90	10		
79/07/05		WATER	13				320	8.20		8.70	9		
79/07/05		WATER	19				340	.50		8.10	8		
79/07/05		WATER	20								9		
79/07/05		WATER	26				340	.30		8.20	8		
79/07/05		WATER	32				340	.20		8.10	9		
79/07/05		WATER	39				360	.10		8.10	7		
79/07/05 CP(1)- 79/07/05	REP	WATER	19					.80					
79/08/08		WATER	0	32.10		.80	285	11.70		9.21	4		
79/08/08		WATER	3				290	11.60		9.31	18		
79/08/08		WATER	6				300	13.80		9.21	11		
79/08/08		WATER	16				375	.20		7.70	8		
79/08/08		WATER	29				390	.10		7.54	5		
79/08/08		WATER	39				400	.10		7.40	12		
79/08/08 CP(1)- 79/08/08	REP	WATER	39				400			7.40			
79/09/05		WATER	0	.00		1.20	250	8.60		9.00	4	.080	.08
79/09/05		WATER	3				250	9.30		9.00	4		
79/09/05		WATER	6				250	8.70		9.00	5		
79/09/05		WATER	19				300	.10		7.70	12		
79/09/05		WATER	29				320	.10		7.60			
79/09/05		WATER	36								6		
79/09/05		WATER	39				330	.40		7.30	7		
79/09/05 CP(1)- 79/09/05	REP	WATER	0	8.50		1.30	250			9.00		.050	.06
79/09/05 CP(1)- 79/09/05	REP	WATER	6					8.50					
86/06/16	1220	WATER	0	25.00	81.5		340	9.60	8.50	8.50	6	.150	5.30
86/06/16	1225	WATER	10	20.50			340	2.80	8.00	8.45	4	.090	5.50
86/06/16	1230	WATER	36	9.00			360	2.00	7.50	7.70	10	.930	1.80
86/08/15	1325	WATER	0	23.00			220	9.40	9.75	8.90	10	.140	1.20
86/08/15	1330	WATER	11	23.00			240	3.70	9.75	8.80	8	.230	1.40
86/08/15	1335	WATER	20	14.00			310	.00	7.75	7.30	8	2.600	
86/09/11	1305	WATER	0	21.00	32.0		240	7.20		8.80	8	.190	.60
86/09/11	1310	WATER	17	21.00			260	2.10		8.50	12	.270	.70

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00204 994400101000
40 49 29.0 091 26 30.0 3
LAKE GEODE SAMPLING SITE #1
19087 IOWA HENRY
SKUNK RIVER BASIN 071100
LAKE GEODE T070NR05WSC36
21IOWA 771123 07080107 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
86/09/11	1315	WATER	36	10.00			350	.00		7.30	11	1.400	.10K

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00204 994400101000
40 49 29.0 091 26 30.0 3
LAKE GEODE SAMPLING SITE #1
19087 IOWA HENRY
SKUNK RIVER BASIN 071100
LAKE GEODE T070NR05WSC36
21IOWA 771123 07080107 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
76/07/15		WATER				10.99							
76/07/28		WATER				16.74							
76/08/11		WATER				80.45							
76/08/18		WATER				38.50							
79/07/05		WATER	0	.13			36.30						
79/07/05		WATER	6	.13			3.40						
79/07/05		WATER	13	.13			38.90						
79/07/05		WATER	19	.10			8.20						
79/07/05		WATER	26	.37			3.40						
79/07/05		WATER	32	.54			1.10						
79/07/05		WATER	39	.89									
79/07/05													
CP(1)-	REP	WATER	32	.52									
79/07/05													
79/08/08		WATER	0	.11			19.80						
79/08/08		WATER	3	.10			15.70						
79/08/08		WATER	6	.12			27.70						
79/08/08		WATER	16	.12			15.00						
79/08/08		WATER	29	.53			4.10						
79/08/08		WATER	39	1.89			9.00						
79/08/08													
CP(1)-	REP	WATER	0	.11									
79/08/08													
79/09/05		WATER	0	.09			8.00						
79/09/05		WATER	3	.10			9.90						
79/09/05		WATER	6	.11			21.30						
79/09/05		WATER	19	.15			13.10						
79/09/05		WATER	29	.37									
79/09/05		WATER	39	1.48			.00						
86/06/16	0000	WATER	0							15.000	.200U		5.60
86/06/16	1220	WATER	0		.080	3.00	2.00						
86/06/16	1225	WATER	10		.060	5.00	5.00						
86/06/16	1230	WATER	36		.160	4.00	3.00						
86/07/03	0000	WATER	0							2.600	.200U		2.20
86/07/11	0000	WATER	0					50.000U	200.000U			100.00U	
86/08/15	0000	WATER	0							6.300	.500U		2.50
86/08/15	1325	WATER	0		.050	35.00	32.00						
86/08/15	1330	WATER	11		.050	25.00	24.00						
86/08/15	1335	WATER	20		.380	5.00	3.00						
86/09/11	1305	WATER	0		.200	35.00	28.00						
86/09/11	1310	WATER	17		.170	18.00	16.00						
86/09/11	1315	WATER	36		.320	5.00	5.00						

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00204 994400101000
40 49 29.0 091 26 30.0 3
LAKE GEODE SAMPLING SITE #1
19087 IOWA HENRY
SKUNK RIVER BASIN 071100
LAKE GEODE T070NR05WSC36
21IOWA 771123 07080107 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	39380 DIELDRIN TOTUG/L	39383 DIELDRIN SEDUG/KG DRY WGT	39631 ATRAZINE MUD UG/KG	46317 LASSO WHL SMPL UG/L	77780 BLADEX TOTAL UG/L	81294 DYFONATE TOT UG/L	81407 ALACHLOR SED DRY WGTUG/KG	81408 MTRBUZIN TOT UG/L	81409 MTRBUZIN SED DRY WGTUG/KG	82052 BANVEL TOTAL UG/L
86/06/16	0000	WATER	0	.050U			1.50	5.700	.100U		.560		
86/07/03	0000	WATER	0	.050U			.50	1.100	.100U		.400		
86/07/11	0000	WATER	0		50.00U	100.00U				200.000U		100.000U	
86/08/15	0000	WATER	0	.050U			.59	2.900	.100U		.160		

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00204 994400101000
40 49 29.0 091 26 30.0 3
LAKE GEODE SAMPLING SITE #1
19087 IOWA HENRY
SKUNK RIVER BASIN 071100
LAKE GEODE T070NR05WSC36
21IOWA 771123 07080107 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	82502 IRON INS OL DRYDP UG/KG	82543 BLADEX DRY WT. MG/KG	82544 DYFONATE DRY WT / MG/K
86/06/16	0000	WATER	0	.1U		
86/07/03	0000	WATER	0	.1U		
86/07/11	0000	WATER	0		.10U	.10U
86/08/15	0000	WATER	0	.1U		

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

Lake Impacts from Nonpoint Sources or other Observed influences to Lake Quality

Lake Geode

Sedimentation:

The first signs that the upper end of the lake was filling up was noticed in the period 1975-1979. Previously we had been able to utilize a large flat bottom boat and 20 hp motor to set nets within 100 yds of the mouth of the creek entering the East end of the lake. We first noticed that we had to reduce speed and there was a noticeable brown trail behind the boat as the motor's shaft dragged in the silt bottom. We still use this net site, but the two foot frame and hoops now stand out of the water by about six inches. We also noticed that the entrance to the large shallow pool on the south side of the creek became narrower and finally we could not motor across it. A boat ramp located on the east shore of this pool had been abandoned, before 1972, because the pool had filled and access to the lake was difficult. The spit of land along the north and side of the creek continued to extend westward out into the lake, and is now past the entrance to the south pool mentioned above.

It was easy to notice the effect of siltation, which had occurred since 1950, when the lake was drained in the fall of 1981. The creek cut down through the layers of silt about six feet deep near the entrance to the large pool. The old creek had been covered with silt and could not be recognized until it passed the beach area. All the other small creek entrances showed similar silt deposits and creek cutting. Each of the small creeks now have silt deltas formed at the upper ends. These covered areas were excellent bluegill and redear spawning sites. The lower two thirds of the lake, from the dam to the corner south and west of the beach showed little signs of sedimentation. Old tire tracks, stumps, and the original creek could be seen, in front of the dam, on the bottom of the lake.

Turbidity:

This lake was known for its excellent water clarity from 1950 through the early 1970's. Several people have commented about the water lilies which used to cover the upper reaches near the main creek and the small bays throughout the lake, but these no longer exist. Also missing are the loose, scattered beds of coontail and Milfoil which were in evidence during the early 1970's. The lake became riled, with a brown color, during spring rains beginning in 1972. By 1975, most submerged aquatic vegetation was gone from around the shore line, and only a few sprigs have been seen since that time. Water willow, an emergent, began to increase its prominence along the shoreline, and seemed to replace the submerged plants between 1975 and the present. Water willow has now established a dominant ring around the edge, extending out about 15 feet to a water depth of two feet. The upper end of the lake, especially east of the beach, is always more turbid, brown colored, than the other three fourths. See map.

Algae:

The dominance of blue-green algae has been the most noticeable change since the early 1970's. Only the small, quiet bays used to show a heavy bloom of blue-green, and then only in late summer. A problem with nuisance levels of blue-green have been noted during the last few years. An especially heavy bloom started in late spring and continued through fall during 1985. The lake appeared to have a green scum floating on the surface, which was described as "pea soup". Both anglers and swimmers complained about the green water and its effect on their activities. The long duration and extremely heavy levels of blue-green were attributed to the lack of significant rain fall during the summer of 1985, which resulted in the lake being below the spillway until late fall. Blue-green was again noticed in 1986, but at a reduced level.

Nutrients:

Most of the tillable land in the watershed was converted to cash crops (corn and soybeans) during the 1970's. This conversion corresponds with the increased turbidity and sedimentation. At the same time, each acre of tilled land received additional agricultural nutrients. The result of more tilled acres and added nutrients was an increase in the nutrient load in the lake water. Unfortunately, we do not have empirical data to back up this statement. Hog confinement operations also became more numerous in the watershed. One operator was cited for dumping the stored effluent in one charge, which resulted in a fish kill in the main stream entering the east end of the lake. Dead fish were found from the point of the spill down the stream to the lake.

General Comments:

Geode Henry County

Watershed Acreage = 9869 Acres

	Contour	Acres	Inches	Feet	Depth	Mean Depth
Lake Acreage =	590	189.49		30640	48	24.0
	586	183.07		25173	44	
	582	160.08		22133	42	
	578	146.47		19973	36	
	574	128.37		18960	32	
	570	111.62		17760	28	
	566	88.41		14280	24	
	562	75.55		13720	20	
	558	58.50		12133	16	
	554	46.91		11040	12	
	550	28.48		9400	8	
	546	17.71		9333	4	
	542			1960	0	

Contour	Watershed ratio	Mean Slope	Shore Development	Volume Acre/Feet	Volume Development	Shoreline Length
590	52.08 to 1	8.51%	3.01	745	1.5	5.8
586	53.91 to 1	7.46%	2.51	686	0.0	4.8
582	61.65 to 1	7.59%	2.36	613	0.0	4.2
578	67.38 to 1	6.64%	2.23	549	0.0	3.8
574	76.88 to 1	6.24%	2.26	480	0.0	3.6
570	88.42 to 1	5.74%	2.27	399	0.0	3.4
566	111.63 to 1	5.68%	2.05	328	0.0	2.7
562	130.63 to 1	5.04%	2.13	267	0.0	2.6
558	168.70 to 1	4.62%	2.14	210	0.0	2.3
554	210.38 to 1	3.70%	2.18	149	0.0	2.1
550	346.52 to 1	3.23%	2.38	92	0.0	1.8
546	557.26 to 1	1.46%	3.00	24	0.0	1.8
542	0.00 to 1		0.00	0	0.0	.4
				4542		

Biological (Fisheries) Monitoring Lake Geode 1952 through 1986

Period #1 1952 - 1955 Fisheries Personnel: Moen
Initial stocks of fish had reproduced and angling began in June 1953. Minnow species (stocked and natural) disappeared from the fishery. Water level was intentionally held below spillway level during 1953 and 1954. The water quality was excellent with secchi disk readings of 8' and 3' in 1953 and 1954, respectively. This lake was considered the best candidate for smallmouth bass in southern Iowa, because of its steep rocky shoreline and clear water, so they were included in the original stockings. Narrow leaf pondweed and water lily are noted in the upper end where the main creek enters. The first boat ramp was located in a shallow embayment next to where the main creek enters the lake. Bullhead and smallmouth bass stocking was recommended. Growth and condition of the major sport fishes, largemouth bass, bluegill, and crappie was above the average for lakes in Iowa. Green sunfish and bullhead were present as young of the year in the first survey, conducted in July 1952.

Period #2 1956 - 1960 Fisheries Personnel: Mayhew
Major game species (largemouth bass, bluegill, and crappie) showed excellent reproduction and growth. Water quality was excellent. Bullhead, channel catfish, largemouth bass, and walleye stocking was recommended. Vegetation control at the boat ramp and angler access areas was needed. Vegetation noted was coontail and pondweed. Algae was noted as rare during August 1958 and 1959 surveys. A few nine inch walleye were caught by anglers in 1959, but no walleye were found in surveys.

Period #3 1961 - 1965 Fisheries Personnel: Mayhew, Morrison, Helms
Fish populations continued to be rated as good to excellent in body condition and growth. Crappie were caught in large numbers during 1964. A single channel catfish was captured with the shocker in May 1961, but no more were recorded for several years. Water quality continued to be excellent. The thermocline was found near the 30 foot depth in the spring, and from 14 to 18 feet deep in a July survey. Walleye fry were being stocked as advanced fry (11,000 - June, 1963) or fingerlings (15,000 - June, 1964, and 10,000 - June, 1965), while recommendations asked for 500,000 fry. Several walleye (4,7, and 9 in May 1961, September 1961, and May 1964, respectively) were being captured in the fish surveys. Bullhead, walleye, and experimental smallmouth bass stockings were recommended. A special request was made for largemouth fingerlings, because the fish surveys showed poor recruitment, and 10,785 fingerlings were stocked in October, 1965. Vegetation growth control near the boat ramp and angler access areas was considered the number one priority.

Period #4 1966 -1969 Fisheries Personnel: Mitzner, Golden
The fish populations showed good biological balance and good body condition. Redear sunfish were captured in the September 1966 survey, for the first time, confirming the success of the October 1963 (5,000 fingerling) and 1964 (7,200 fingerling) stockings. Redear sunfish rapidly became one of the most significant panfishes in the surveys, by 1969. No other redear were stocked until after the lake drainage in 1982. A recommendation to stop the smallmouth bass stocking was made in 1966, since none were captured in the surveys and no reports were made by anglers. Walleye fingerling stocking continued in 1966, 1967, and 1969 with 20,000, 10,000, and 7,500, respectively. Adult bullhead were stocked in 1967 (4,500) and 1968 (2,000). No other records of bullhead stocking have been found. Bullheads were not

captured in large numbers in any of the surveys. The boat ramp was moved, from the shallow upper end, about two-thirds of the way down the lake to its present location. Therefore, ending the notations about weed control at the boat access in the field notes.

Period #5 1970 - 1973 Fisheries Personnel: Mitzner, Golden, Kline
Largemouth bass, bluegill, redear, and crappie dominated the sport fishery, while white sucker, green sunfish, and golden shiner dominated the non sport portion of the fishery. The first carp was recorded in September 1970, and this species contributed no more than two percent of the catch in any survey. Water clarity varied from a 4.5 feet secchi in September 1971 to a 3.5 inch secchi in May 1973. Secchi readings by August 1973 were 3.5 feet. Thermocline records range from 10 to 18 feet down from the surface. Siltation in the upper end, where the main creek enters, was noted in the field records. Vegetation (coontail and leafy pondweed) was dense in the upper end and was noted as "scattered beds" at most places around the shoreline during 1971. The scattered weed beds were considered excellent fishing habitat. Heavy rains in June 1971 made the lake turbid, and by September 1971 algae growth was heavy, and described as "pea soup". That year was the first year that submerged vegetation was noted as "under control". Bluegreen algae was dominant during 1972, with a thick layer again described as "pea green soup" being found throughout the lake. A creel survey in 1972 found bluegill harvest at the highest level (34,581) during creels in 1972, 1977, 1978, 1979, and 1981. Bluegill accounted for 78.5 percent of the total harvest. Although, large numbers of bluegill (ranging from four to eight inches) were being harvested, anglers were expressing dissatisfaction with the size of the fish they were catching. Many remembered eight and nine inch bluegill. Largemouth bass (1,402), crappie (5,732), and redear (1,684) were the other major species harvested. Walleye stocking continued during this period with 25,000 fingerlings, 15,000 fingerlings, and 500,000 fry being stocked in 1970, 1972, and 1973, respectively. It was noted that the May 1973 walleye stocking took place at the time of the heaviest turbidity. Water the color of hot chocolate was seen. The lake was mapped by E. T. Rose in 1973.

Period #6 1974 - 1977 Fisheries Personnel: Kline, Golden
This was a period of recovery when water quality was good, fish growth and condition were excellent, and harvest was good. Again largemouth bass, crappie, redear, and bluegill dominate the sport catch, while green sunfish, white sucker, golden shiner, and carp dominated the nonsport catch. Carp increased in importance in the survey catches reaching 16 percent in a net survey in September 1975. The years 1974 and 1975 were noted as two of the best overall fishing years within the last ten years. Bluegill harvest was still high contributing about 79 percent of the catch (234,292) in the 1977 creel. Crappie harvest increased significantly from 12 percent in 1972 to 33 percent (12,492) in 1977, and remained near this level through 1981. Largemouth bass (437), and redear (229) harvest declined, while green sunfish (500), and bullhead (1,052) increased in the harvest estimates between 1972 and 1977. The entry of channel catfish into the fishery is documented by the 1977 creel, when 373 fish were taken. Stocking of channel catfish began in 1966 and continued in 1977 and 1978, when 1,000, 2,000, and 2,000 fish were stocked, respectively. Vegetation was absent or much reduced during this period. Leafy pondweed was found in shallow water and in the upper end. A secchi disk reading in May 1975 showed visibility down to 13 feet from the surface. Bluegreen algae was prevalent during late summer and fall each year.

The thermocline in August 1977 was between 14 and 17 feet deep. What would turn out to be one of the most significant records of the period was the capture of one gizzard shad in September 1975. By August 1977, gizzard shad would surpass bluegill numbers in the survey.

Period #7 1978 -1981 Fisheries Personnel: Kline, Golden
The sport fishery was dominated by largemouth bass and crappie, while bluegill and redear declined. Creel surveys conducted during 1978, 1979, and 1981 show the harvest of bluegill dropped to around 40 percent of the total harvest (7,240, 7,230, and 7,421 - 1978, 1979, and 1981). Redear virtually disappeared from the harvest with only 22, 28, and 28 fish estimated in 1978, 1979, and 1981, respectively. Channel catfish harvest increased from zero in 1977 to a high of 459 in 1979. The last walleye were recorded in shocker surveys in the spring of 1978, and none were reported in the creel surveys of 1978, 1979, and 1981. Carp numbers in the shocker and net surveys stayed about the same throughout this period, but the harvest of 12 fish in 1979 was the largest of all creels.

The most noticeable change in the fishery survey data was the eventual domination by gizzard shad. The species they replaced were bluegill and redear. The growth and body condition of bluegill and redear also declined. Largemouth bass and crappie on the other hand showed good growth and body condition. Aquatic vegetation changes took place during this and the preceding period, and was noted by the complete dominance by water willow, in 1980. Only scattered stand of pondweed or coontail were noted, but heavy stands of water willow invaded most of the water, less than two feet deep, from the beach to the dam. Heavy rain in September 1980, May 1981, and June 1981 kept the lake water turbid during this period of time. Dead fish were seen, by the creel clerk, after the June rains. The lake was drained in September 1981 to eradicate the gizzard shad, so that the bluegill fishery could be reestablished.

Period #8 1982 - 1986 Fisheries Personnel: Kline, Golden

1982

The lake was renovated in the Fall of 1981 by drainage and rotenone treatment. Heavy rains put ten feet of water back into the lake by late fall, and the lake was full by June of 1982. Fish stocking began in October of 1981 with 187,000 bluegill fingerlings. Channel catfish were stocked as seven inch fish (1,870) and three inch fish (18,700) in June 1982. Redear adults (129) and largemouth bass fingerlings (6,500) were also stocked in June 1982. Tiger musky fingerlings (713) where stocked in July 1982. The first fisheries survey of the new lake was made in early June 1982. The water was clear with some coontail stands and water willow along the edge. Bluegill from the previous year's stocking dominated the catch as two to four inch fish. Fathead minnow, bluegill-green sunfish crosses, and bullhead were common, while channel catfish, golden shiner, green sunfish, and creek chub were rare. Largemouth bass and bluegill were both abundant by September 1982. The largemouth bass ranged from six to nine inches in length. Bluegill ranged from four to six inches in length, and their young of the year ranged from one to two inches in length.

1983

The water level was down about one foot during the summer of 1983, because of drought conditions. A heavy bluegreen algae bloom dominated the lake. No submerged rooted aquatic vegetation was noted, but water willow dominated the shallow areas. Black crappie adults (124), largemouth bass advanced fingerlings (10,080), and tiger musky fingerlings (185) were stocked in June and July 1983. Channel catfish (4,670) were stocked in September 1983. Bluegill again dominated the September 1983 fishery survey. Growth of the original stocked bluegill had virtually stopped, showing the same range from four to six inches in length. The young of the year bluegill were still in the size range of one and a quarter to three inches in length. Channel catfish, black bullhead, and redear were common in the catch. Two tiger musky stocked as six inch fish the previous year now measured 17 and 19 inches in length.

1984

Channel catfish, bullhead, and largemouth bass dominated the catch during the July 1984 fishery survey. Length frequency graphs of the channel catfish population showed two distinct modes, one ranged from nine to twelve and one quarter inches and the other from fourteen to eighteen inches. The largest individual was twenty three and one quarter inches in length. Bullheads ranged from six to 12 inches, but most were between six and eight inches. Most of the largemouth bass captured ranged from 11 to 13 inches in length, with only a few fish between seven and nine inches, and young of the year were rare. Bluegill were again compressed into the size range of three and one half to six and one quarter inches. More adult black crappie (410) were added in April 1984. Tiger musky fingerlings (157) were stocked in August 1984.

1985

Low water level and very heavy bluegreen algae growth were prominent features of the lake in 1985. Fishery surveys in August and September 1985 revealed a similar pattern of fish growth and abundance, as in the previous survey. The mode of the largemouth bass size frequency centered on 14 inches, with young of the year rare. The first reproduction of black crappie from 1984 were captured at a length range of five to six inches, and one white crappie at six and one quarter inches was captured. Bluegill languished in the same size range, and were in an emaciated body condition. Tiger musky fingerlings (130) were stocked in July 1985. Channel catfish (4,680) and large fingerling largemouth bass were added in October 1985. The largemouth bass were stocked to supplement the lack of adequate natural reproduction, and the tiger musky were stocked to provide a trophy species.

1986

Bullhead, channel catfish, and redear sunfish dominated both net and shocker catches in fishery surveys conducted during the period April through September 1986. However, population estimates for April 1987 showed that bluegill, black bullhead, black crappie, redear sunfish, and channel catfish made up 57%, 18%, 16%, 7%, and 2%, respectively, of the 109,809 fish estimated for this group. Bluegill size remained between the range from three to six inches in length, which has not changed since the 1982 survey. Bullhead size ranged from eight to eleven inches in length, with an average of nine inches. Black crappie had grown to an average of seven inches after three growing seasons. One tiger musky had reached 35 inches length and weighed seven pound ten ounces, after 5 growing seasons. Channel catfish had a wide distribution of sizes ranging from seven inches to 22 inches in length, with most between 11 and 16 inches. With the addition of white amur, white sucker, and drum in the 1986 survey, the species list now includes largemouth bass, white crappie, black crappie, tiger musky, bluegill, redear, green sunfish, channel catfish, yellow bullhead, black bullhead, golden shiner, and crosses between bluegill, redear, and green sunfish. Only largemouth bass, bluegill, black crappie, channel catfish, redear, and tiger musky were officially stocked. All species are showing acceptable growth, except bluegill. Carp are the notable exception from the species list.

Extensive testing for temperature and Oxygen, during 1986, revealed that a thermocline had developed between eight and 10 feet down from the surface by June 16, 1986, and varied between eight and 15 feet until the end of August. Oxygen levels below 14 feet were less than one part per million between the period June 30 and August 28.

Species *Black Bullhead* Date *Oct. 1-3 1986*

Location *Lake Geode* Gear *Pound Nets - Gill Nets*

in.	mm	Tally	in.	mm	Tally
	0- 15		20	506-515	
1	16- 25			516-525	
	26- 35		21	526-535	
	36- 45			536-545	
2	46- 55			546-555	
	56- 65		22	556-565	
	66- 75			566-575	
3	76- 85		23	576-585	
	86- 95			586-595	
4	96-105			596-605	
	106-115		24	606-615	
	116-125			616-625	
5	126-135		25	626-635	
	136-145			636-645	
6	146-155			646-655	
	156-165		26	656-665	
	166-175			666-675	
7	176-185			676-685	
	186-195	|	27	686-695	
8	196-205	||		696-705	
	206-215	||||	28	706-715	
	216-225	卌 卌 ||||		716-725	
9	226-235	卌 卌 卌 卌 卌 卌		726-735	
	236-245	卌 卌 ||||	29	736-745	
10	246-255	卌 |||		746-755	
	256-265		30	756-765	
	266-275			766-775	
11	276-285	|		776-785	
	286-295		31	786-795	
12	296-305			796-805	
	306-315		32	806-815	
	316-325			816-825	
13	326-335			826-835	
	336-345		33	836-845	
	346-355			846-855	
14	356-365		34	856-865	
	366-375			866-875	
15	376-385			876-885	
	386-395		35	886-895	
	396-405			896-905	
16	406-415		36	906-915	
	416-425			916-925	
17	426-435			926-935	
	436-445		37	936-945	
	446-455			946-955	
18	456-465		38	956-965	
	466-475			966-975	
19	476-485			976-985	
	486-495		39	986-995	
	496-505			996-	

Species Black Crappie Date Sept. 3, 1986

Location Lake Geode Gear Pound Nets

in.	mm	Tally
	0- 15	
1	16- 25	
	26- 35	
	36- 45	
2	46- 55	
	56- 65	
	66- 75	
3	76- 85	
	86- 95	
4	96-105	
	106-115	
	116-125	
5	126-135	
	136-145	
6	146-155	
	156-165	I
	166-175	卌 卌 卌 卌 IIII
7	176-185	卌 卌 卌 IIII
	186-195	卌 卌
8	196-205	
	206-215	
	216-225	
9	226-235	
	236-245	
10	246-255	
	256-265	
	266-275	
11	276-285	
	286-295	
12	296-305	
	306-315	
	316-325	
13	326-335	
	336-345	
	346-355	
14	356-365	
	366-375	
15	376-385	
	386-395	
	396-405	
16	406-415	
	416-425	
17	426-435	
	436-445	
	446-455	
18	456-465	
	466-475	
19	476-485	
	486-495	
	496-505	
20	506-515	
	516-525	
21	526-535	
	536-545	
	546-555	
22	556-565	
	566-575	
23	576-585	
	586-595	
	596-605	
24	606-615	
	616-623	
25	626-635	
	636-645	
	646-655	
26	656-665	
	666-675	
	676-685	
27	686-695	
	696-705	
28	706-715	
	716-725	
	726-735	
29	736-745	
	746-755	
30	756-765	
	766-775	
	776-785	
31	786-795	
	796-805	
32	806-815	
	816-825	
	826-835	
33	836-845	
	846-855	
34	856-865	
	866-875	
	876-885	
35	886-895	
	896-905	
36	906-915	
	916-925	
	926-935	
37	936-945	
	946-955	
38	956-965	
	966-975	
	976-985	
39	986-995	
	996-	

Species Bluegill Date Oct 1-2 1986

Location Lake Geode Gear Shocker - Pound Nets

in.	mm		in.	mm	
	0- 15		20	506-515	
1	16- 25			516-525	
	26- 35		21	526-535	
	36- 45			536-545	
2	46- 55	|||		546-555	
	56- 65	卌	22	556-565	
	66- 75				566-575	
3	76- 85			23	576-585	
	86- 95			586-595	
4	96-105			596-605	
	106-115	||||	24	606-615	
	116-125	卌 ||		616-625	
5	126-135	卌 卌 ||||	25	626-635	
	136-145	卌 卌 卌			636-645	
6	146-155	卌 |||		646-655	
	156-165			26	656-665	
	166-175			666-675	
7	176-185			676-685	
	186-195		27	686-695	
8	196-205			696-705	
	206-215		28	706-715	
	216-225			716-725	
9	226-235			726-735	
	236-245		29	736-745	
10	246-255			746-755	
	256-265		30	756-765	
	266-275			766-775	
11	276-285			776-785	
	286-295		31	786-795	
12	296-305			796-805	
	306-315		32	806-815	
	316-325			816-825	
13	326-335			826-835	
	336-345		33	836-845	
	346-355			846-855	
14	356-365		34	856-865	
	366-375			866-875	
15	376-385			876-885	
	386-395		35	886-895	
	396-405			896-905	
16	406-415		36	906-915	
	416-425			916-925	
17	426-435			926-935	
	436-445		37	936-945	
	446-455			946-955	
18	456-465		38	956-965	
	466-475			966-975	
19	476-485			976-985	
	486-495		39	986-995	
	496-505			996-	

Species Channel Catfish Date Oct 1-3 1986

Location Lake Geode Gear Pound Nets - Gill Nets

in.	mm	in.	mm
	0- 15	20	506-515
1	16- 25		516-525
	26- 35	21	526-535
	36- 45		536-545
2	46- 55		546-555
	56- 65	22	556-565
	66- 75		566-575
3	76- 85	23	576-585
	86- 95		586-595
4	96-105		596-605
	106-115	24	606-615
	116-125		616-625
5	126-135	25	626-635
	136-145		636-645
6	146-155		646-655
	156-165	26	656-665
	166-175		666-675
7	176-185		676-685
	186-195	27	686-695
8	196-205		696-705
	206-215	28	706-715
	216-225		716-725
9	226-235		726-735
	236-245	29	736-745
10	246-255		746-755
	256-265	30	756-765
	266-275		766-775
11	276-285		776-785
	286-295	31	786-795
12	296-305		796-805
	306-315	32	806-815
	316-325		816-825
13	326-335		826-835
	336-345	33	836-845
	346-355		846-855
14	356-365	34	856-865
	366-375		866-875
15	376-385		876-885
	386-395	35	886-895
	396-405		896-905
16	406-415	36	906-915
	416-425		916-925
17	426-435		926-935
	436-445	37	936-945
	446-455		946-955
18	456-465	38	956-965
	466-475		966-975
19	476-485		976-985
	486-495	39	986-995
	496-505		996-

Species: *LargeMouth Bass* Date: *Oct 2 1986*

Location: *Lake Geode* Gear: *Shocker*

in.	mm	Tally
	0- 15	
1	16- 25	
	26- 35	
	36- 45	
2	46- 55	
	56- 65	
	66- 75	
3	76- 85	|
	86- 95	
4	96-105	
	106-115	
	116-125	||
5	126-135	
	136-145	|
6	146-155	
	156-165	|
	166-175	|
7	176-185	
	186-195	
8	196-205	
	206-215	
	216-225	|
9	226-235	
	236-245	
10	246-255	
	256-265	
	266-275	
11	276-285	
	286-295	|
12	296-305	
	306-315	
	316-325	|
13	326-335	
	336-345	
	346-355	|
14	356-365	
	366-375	||
15	376-385	|
	386-395	|
	396-405	
16	406-415	||
	416-425	||
17	426-435	||
	436-445	
	446-455	
18	456-465	
	466-475	
19	476-485	
	486-495	
	496-505	

in.	mm	Tally
20	506-515	
	516-525	
21	526-535	
	536-545	
	546-555	
22	556-565	
	566-575	
23	576-585	
	586-595	
	596-605	
24	606-615	
	616-625	
25	626-635	
	636-645	
	646-655	
26	656-665	
	666-675	
	676-685	
27	686-695	
	696-705	
28	706-715	
	716-725	
	726-735	
29	736-745	
	746-755	
30	756-765	
	766-775	
	776-785	
31	786-795	
	796-805	
32	806-815	
	816-825	
	826-835	
33	836-845	
	846-855	
34	856-865	
	866-875	
	876-885	
35	886-895	
	896-905	
36	906-915	
	916-925	
	926-935	
37	936-945	
	946-955	
38	956-965	
	966-975	
	976-985	
39	986-995	
	996-	

LAKE HENDRICKS

Physical and Lake Impact Data

Lake Hendricks is a 42 acre impoundment located one mile north of Riceville on the west border of Howard County, Iowa. The lake was constructed in the early 1960's on donated land using volunteer labor from Riceville and the surrounding area. It is managed as a multiple-use area by the Howard County Conservation Board who assumed responsibility for the area in the mid 1960's. Most of Lake Hendrick's 1122 acre watershed in 1979 (1) was used for cropland (84.5%) and pasture (10%). A map of Lake Hendricks produced from 1986 data may be found on page 77.

The lake lies to the northeast of the dam and contains two main bays. One smaller inlet to the east receives the major inflow to the lake and is moderately silted. Boat access is via a small ramp on the west bay. Camping and shoreline angling are encouraged along the east and west shorelines. A swimming beach is located in the southwest corner just above the dam. The mean depth of the lake is about nine feet, the deepest point being nineteen feet just above the lake outlet. A comparison of the lake's physical characteristics for 1979 (1) and 1986 are given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lake's physical characteristics. (See Appendix for lake mapping procedure.)

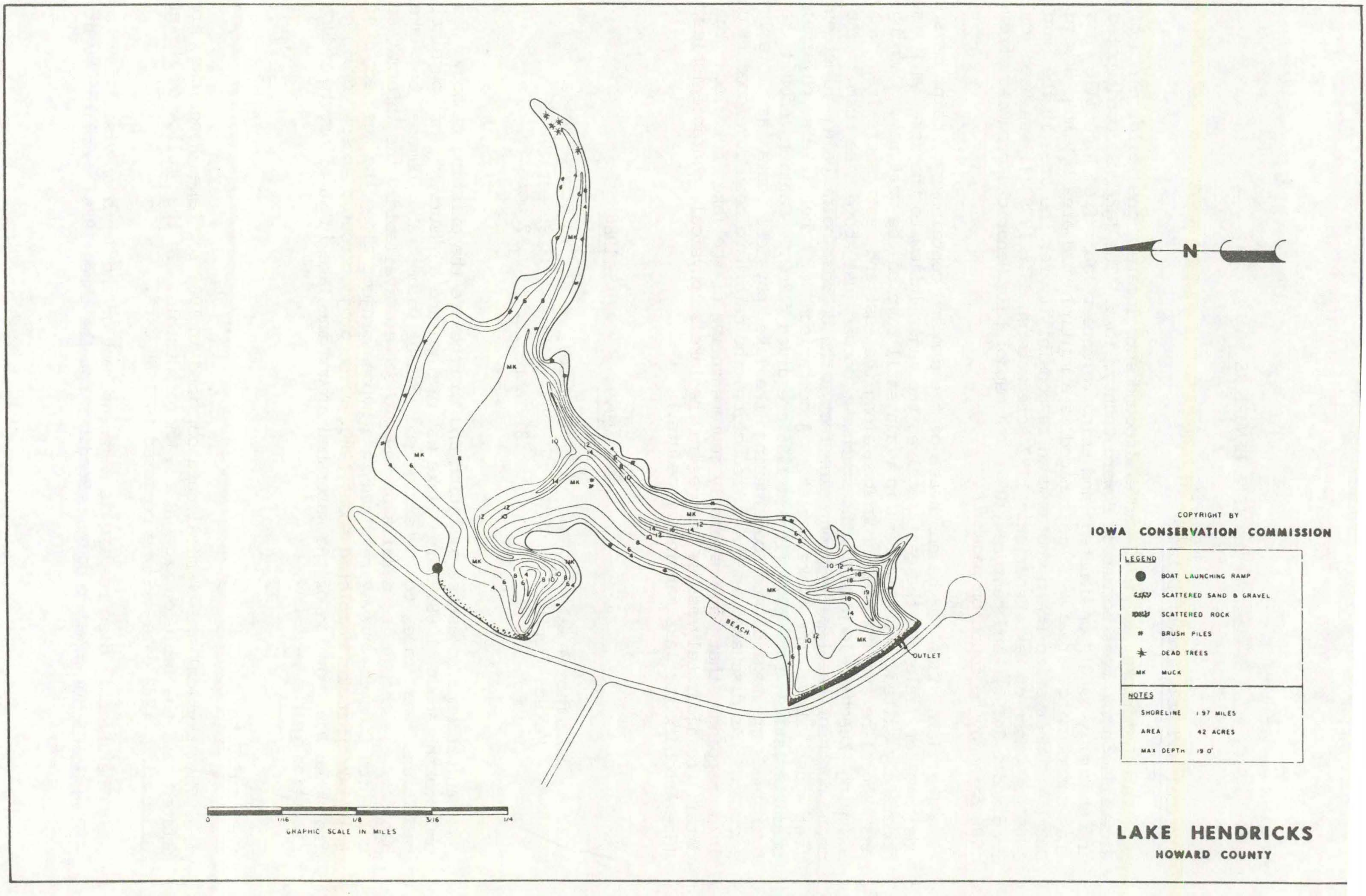
	1979	1986
Surface Area	40 acres	40 acres
Maximum depth	19 feet	19 feet
Volume	312 acre ft.	312 acre ft.

An attempt to assess siltation and to renovate the existing fishery was undertaken about 1968. The lake was drained and a "survey" of physical conditions was made to determine the loss of volume and damage to lake habitat. Although no details of the project are available, the information collected from the survey resulted in a bypass project along the west edge of the lake that was completed about 1980. The project routed excess drainage from the west portion of the watershed around the lake in an effort to reduce siltation in the west bay.

Chemical Data

The physical and chemical data obtained in 1986 for Lake Hendricks are listed in the table on page 78. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events


MK
BEACH
OUTLET
N
0
1/16
1/8
3/16
1/4
GRAPHIC SCALE IN MILES
COPYRIGHT BY
IOWA CONSERVATION COMMISSION
LEGEND
BOAT LAUNCHING RAMP
SCATTERED SAND & GRAVEL
SCATTERED ROCK
BRUSH PILES
DEAD TREES
MK MUCK
NOTES
SHORELINE 1.97 MILES
AREA 42 ACRES
MAX DEPTH 19.0'
LAKE HENDRICKS
HOWARD COUNTY

Lake Hendricks
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/12/86		7/29/86		9/09/86	
*Depth[1]	0	18	0	16	0	17
*Secchi[2]	78		20		36	
*Temperature[3]	20	14	27	19	18.3	18
*Dissolved Oxygen	7.8	0.2	8.6	0.1	9.3	3.6
*pH[4]	9.0	8.4	9.2	7.0	NDA**	NDA**
Conductivity[5]	320	350	220	400	270	280
Ammonia Nitrogen	0.09	0.81	0.10	3.1	0.15	0.19
Nitrate-Nitrite Nitrogen	2.0	1.3	0.1	0.3	0.1	0.1
Suspended Solids	9	17	28	52	15	30
Total Phosphorus	0.18	0.22	0.15	0.69	0.12	0.11
Chlorophyll a (Corrected)[6]	7	6	277	10	35	32
Thermally Stratified	No		No		No	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site
**No Data Available

ranged from 20 to 78 inches with a mean (N = 3) of 45 inches. The 1979 Secchi readings ranged from 20 to 32 inches with an average (N = 2) of 26 inches.

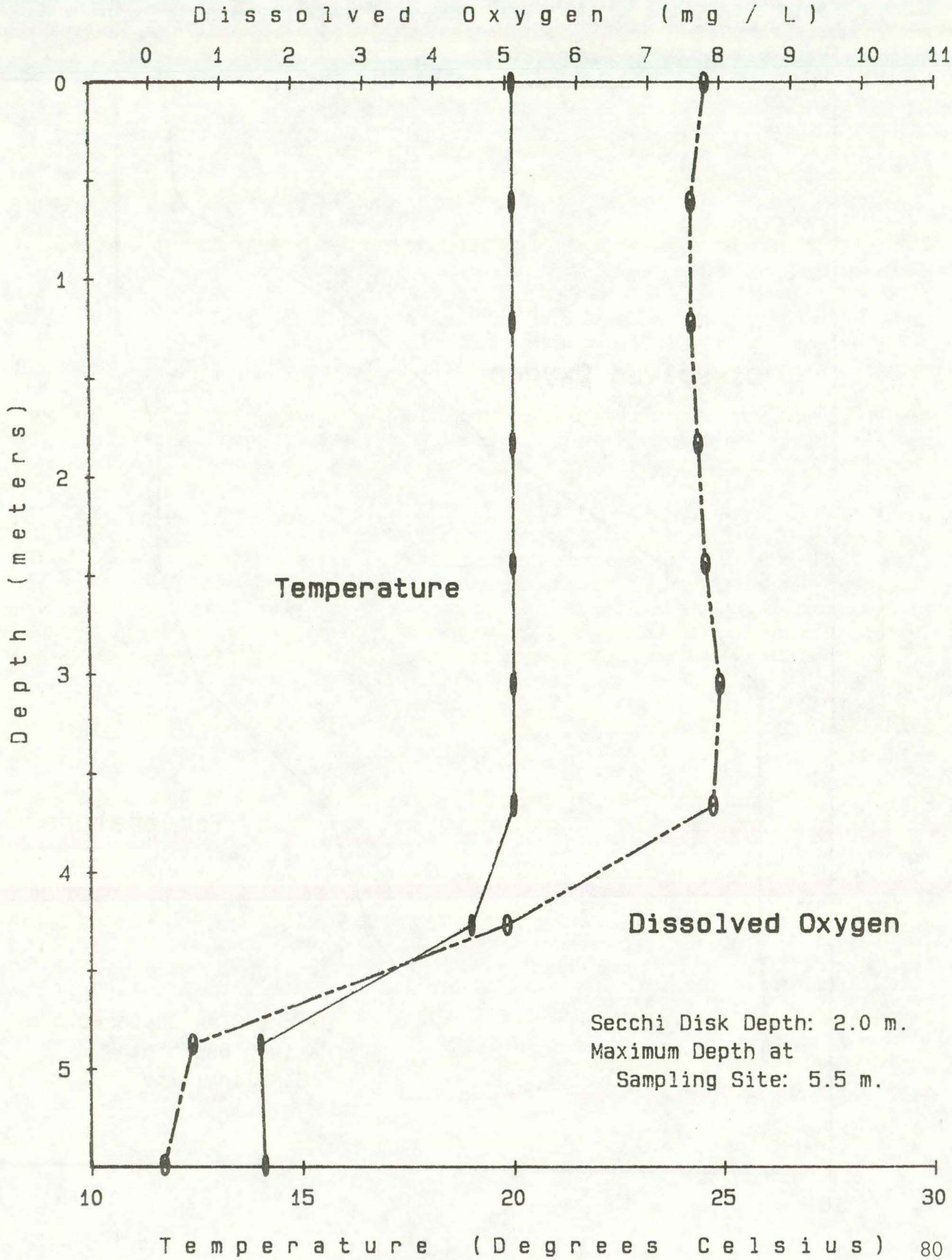
Lake Hendricks water temperature ranged from a low of 14°C in the June bottom sample to a high of 27°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with the 1986 data.

Dissolved oxygen (DO) values ranged from less than 1.0 mg/L in two bottom samples to 9.3 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 80, 81 and 82 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. The June profile reflects early summer conditions where both a temperature and DO gradient had developed in Lake Hendricks. That is, the values for both parameters were constant (DO 7.6 to 8.0 mg/L and temperature 20°C) to a depth of about 12 feet (3.5 meters) then sharply dropped to less than 1 mg/L DO and a temperature of 14°C at 15 feet (5 meters). In July the temperature gradient was not as sharp as in June. However, the DO had declined to 1 mg/L at 8 feet (7.5 meters) with essentially no dissolved oxygen (0.2 mg/L) present below that depth. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification whfere the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heaver bottom layer (hypolimnion). The water temperature and density differentials prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom samples of less than 1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with high organic content in the water and sediment frequently have no dissolved oxygen in the lower water layer.

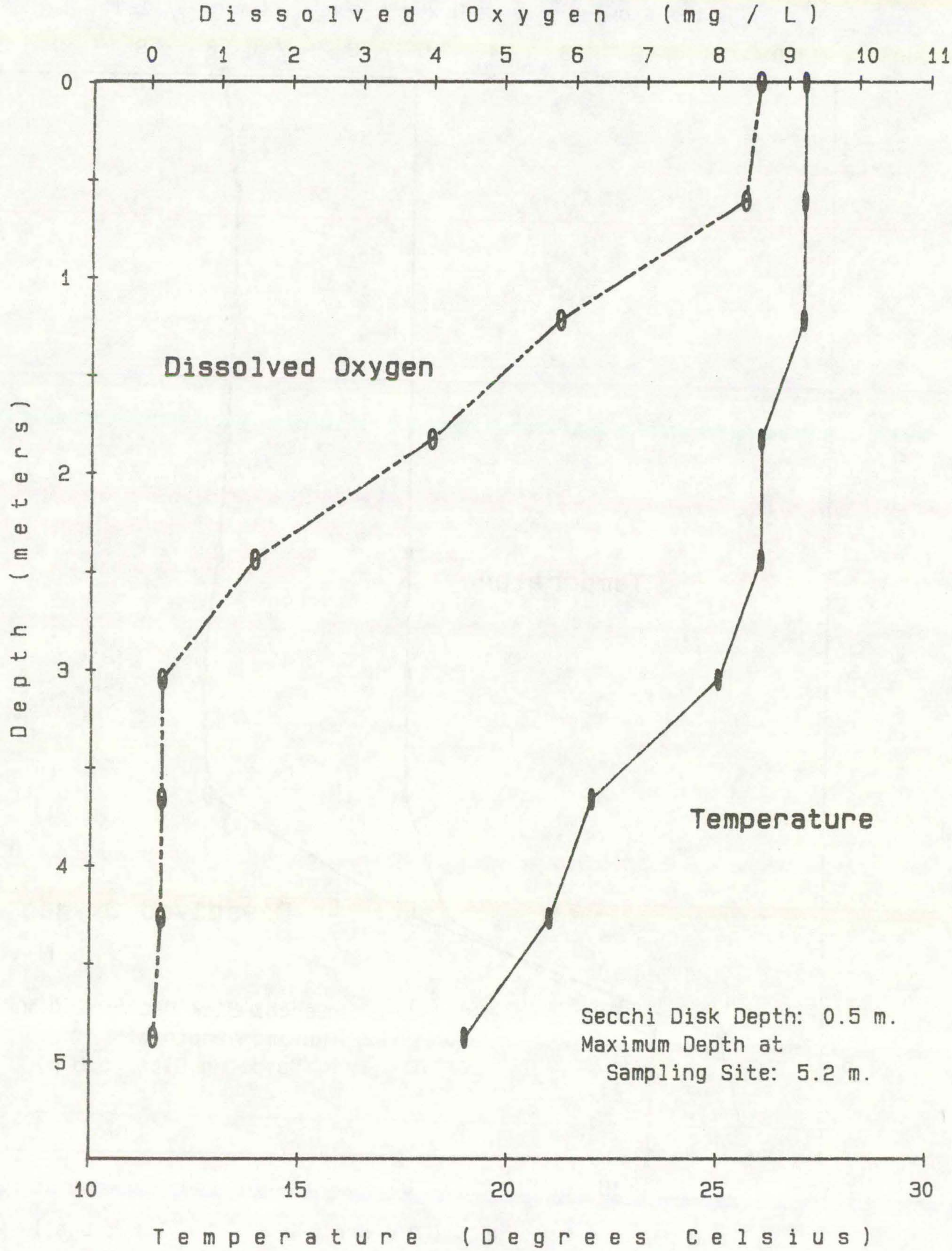
In September (page 82), as a result of the cooling of water in the epilimnion, the water temperature was similar throughout the water column (18°C). When the lake water temperature became the same from top to bottom, mixing of the epilimnion and hypolimnion took place and the DO gradient from top (9.3 mg/L) to bottom (3.6 mg/L) was reduced. As the lake water continues to mix, the DO concentration would be expected to become uniform throughout the water column. This phenomenon is called fall turnover and is typical of many Iowa lakes. Additional information provided by the DNR field staff indicates the "lake aerator" was running and probably initiated the lake mixing sooner than would occur naturally. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

	September 10, 1979		July 29, 1986	
	Surface	13 feet	Surface	16 feet
DO (mg/L)	8.8	1.0	8.6	0.1
Temperature (°C)	23.3	20.0	27.0	19.0

Lake Hendricks
Dissolved Oxygen and Temperature Profile
June 12, 1986



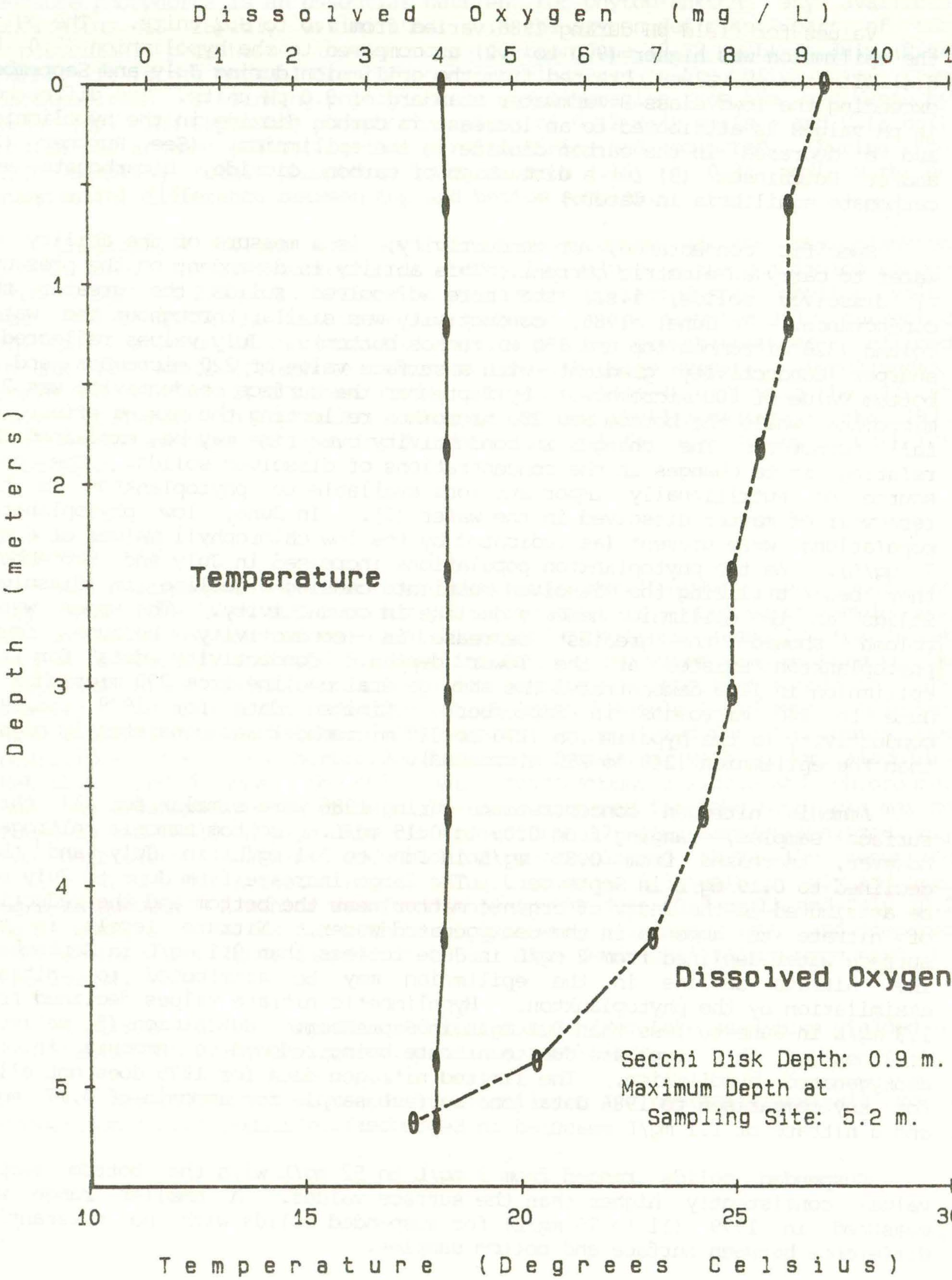
Lake Hendricks
Dissolved Oxygen and Temperature Profile
July 29, 1986



Lake Hendricks

Dissolved Oxygen and Temperature Profile

September 9, 1986



Lake Hendricks
Pesticide Data - 1986
(all values in micrograms per liter or parts per billion)

Date Collected	6/12/86	7/07/86	8/15/86	7/11/86
Sample Matrix	Water	Water	Water	Sediment
Atrazine (AAtrex)	0.56	0.32	0.66	<30
Cyanazine (Bladex)	<0.1	<0.1	<0.1	<30
Methlachlor (Dual)	<0.1	<0.1	<0.1	<30
Alachlor (Lasso)	0.3	0.2	<0.1	<30
Metribuzin (Sencor)	<0.1	<0.1	<0.1	<30
Dicamba (Banvel)	<0.1	<0.1	<0.1	<15
Dieldrin (Dieldrin)	<0.05	<0.05	<0.05	<15
Fonfos (Dyfonate)	<0.1	<0.1	<0.1	<30
Chlordane (Chlordane)	<0.2	<0.2	<0.2	<50

Biological Data

The fisheries renovation conducted in 1968 consisted of removal of the fish population by draining the lake and the application of a fish toxicant to the remaining water areas. Mixed results were obtained because of the difficulty encountered in draining the lake entirely and from the presence of several small springs in the lake bed which furnished fresh water for the target fish species.

Follow-up fisheries surveys in the early 70's confirmed the limited success of the renovation project and the continuing presence of undesirable fish. Major gamefish species included largemouth bass, bluegill, and channel catfish which had been restocked by Iowa Conservation Commission personnel after the renovation. Undesirable fish species reported included crappie, carp, and bullhead which had either been introduced by local residents, washed in from a small impoundment in the watershed, or had survived the renovation effort.

A partial renovation project was then completed in the mid 70's to reduce or eliminate the carp and crappie populations. It was successful as no carp and only remnant numbers of crappie have been reported in later fisheries surveys. No effort was made to reduce bullhead numbers and this species continues to be a serious problem in the lake. Other manipulation of the fish populations has been limited to restocking largemouth bass following a serious winter fish kill and subsequently applying a bass size limit to reduce the harves of the subadults.

Frequent winter fish kills occurred during the late 1970's. The extensive shallow bays, inherent fertility, and annual "blooms" of rooted vegetation combined to cause significant die-offs. In one year, the fish die-off resulted in a complete loss of the largemouth bass population. The addition of white amur for vegetation control and aeration equipment to enhance dissolved oxygen levels have nearly eliminated the winterkill problem. Considerable areas of rooted vegetation continue to occur in the shallow bays however, and are responsible for numerous angler complaints each year.

The following is a summary of the 1986 fisheries survey.

The fish species composition and relative abundance: largemouth bass, moderate; bluegill, abundant; channel catfish, moderate. Species present but of little angling importance are: grass carp, rare; black bullhead, moderate; crappie sp., rare; green sunfish, moderate; sauger, rare.

Length frequency graphs of selected species may be found in the Appendix.

Fish Age and Length

Species	Age	Length (Inches) Range	Mean
Largemouth Bass	0	3.5-5.1	4.2
	1	NA	7.6
	3	7.6-10.2	9.4
	4	12.3-13.3	12.9
	6	19.0-19.3	19.1
	7	NA	19.5
Bluegill	1	4.7-4.8	4.7
	2	4.9-5.7	5.4
	3	5.8-6.0	5.9
	4	6.1-6.5	6.3
Channel Catfish (est.)	2	NA	10.7
	4	14.2-23.0	18.4

General Assessment:

Largemouth Bass - This population is in good condition and has provided local anglers with an excellent fishery for over fifteen years. Numbers of large bass continue to be adequate to support the fishery and reproduction is adequate although one or two year classes may be weak. Continued use of a size limit on the lake to prevent over harvest of the smaller bass should preserve angling quality.

Bluegill - The population is old and is not providing as adequate fishery for the typical "still" fisherman on the lake. Considerable numbers of marginal size bluegills are creeled each year but anglers complain of the mean size. Growth will continue to be slow and result in a small mean size in future years. Few convenient solutions exist to remedy this situation other than renovation of the existing fishery.

Channel Catfish - These fish are doing well in the lake and support an excellent fishery. The fish are stocked every second year as part of the caged catfish program operated in cooperation with the local county conservation board. Growth of catfish in this lake is very good and the large mean size assures few angler complaints.

SUMMARY

Although the data presented in this report are rather limited, it is possible to make several general statements about the data.

> Since 1979, the volume of water in Lake Hendricks has remained about the same. Although soil erosion may not currently be a problem, the possibility of sediment retention basins for the lake inlets or installation of other sediment control measures in the watershed should be evaluated.

Although the 1986 dissolved oxygen and temperature profile was more pronounced as compared to the 1979 profile, no major changes in lake water quality appear to have occurred from 1979 to 1986. Chlorophyll data did indicate an increase in algal populations from 1979 to 1986. Continued monitoring is necessary to determine long-term trends in water quality.

In general, fish growth and population structure have been improving. Continued assessment of the fisheries will allow for maximizing its potential.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00531 994500101000
43 22 00.0 092 33 00.0 5
DEEPEST PART LAKE HENDRICKS-.5MI NE RICEVILLE
19089 IOWA HOWARD
MISSISSIPPI RIVER BASIN 070800
WAPSI R-LAKE HENDRICKS T099NR14WSC19
21IOWA 801004 07080102 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/02		WATER	0				290	14.50		8.90			
79/07/02		WATER	3				290	13.10		8.80			
79/07/02		WATER	6				310	7.40		8.20			
79/07/02 CP(1)- 79/07/02	REP	WATER	0				290	14.50		8.90			
79/07/04		WATER	0								14		
79/07/04		WATER	3								13		
79/07/04		WATER	6								14		
79/07/31		WATER	0	.00		.50	300	10.80		9.40	24		
79/07/31		WATER	3				300	11.00		9.40	25		
79/07/31		WATER	6				300	11.20		9.30	25		
79/07/31 CP(1)- 79/07/31	REP	WATER	0	7.70		.50							
79/07/31 CP(1)- 79/07/31	REP	WATER	3					11.20					
79/09/10		WATER	0	23.30		.80	240	8.80		8.90	13	.170	1.10
79/09/10		WATER	3				260	6.20		8.60	11		
79/09/10		WATER	6				260	6.60		8.75	12		
79/09/10		WATER	13				270	1.00		7.90	16		
79/09/10 CP(1)- 79/09/10	REP	WATER	0	.00		.70						.050	1.80
79/09/10 CP(1)- 79/09/10	REP	WATER	3							8.60			
86/06/12	1115	WATER	0	20.00	78.0		320	7.80	9.00	8.30	9	.090	2.00
86/06/12	1145	WATER	18	14.10			350	.20	8.40	8.40	17	.810	1.30
86/07/29	0800	WATER	0	27.00	20.0		220	8.60	9.20	9.40	28	.100	.10K
86/07/29	0800	WATER	16	19.00			400	.10	7.00	7.00	52	3.100	.30
86/09/09	0810	WATER	0	18.30			270	9.30		8.70	15	.150	.10K
86/09/09	0815	WATER	17	18.00			280	3.60		8.20	30	.190	.10K

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

L00531 994500101000
43 22 00.0 092 33 00.0 5
DEEPEST PART LAKE HENDRICKS-.5MI NE RICEVILLE
19089 IOWA HOWARD
MISSISSIPPI RIVER BASIN 070800
WAPSI R-LAKE HENDRICKS T099NR14WSC19
21IOWA 801004 07080102 HQ
0000 FEET DEPTH

/TYPA/AMBNT/LAKE

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/02		WATER	0	.16			23.90						
79/07/02		WATER	3	.17			26.80						
79/07/02		WATER	6	.18			38.50						
79/07/31		WATER	0	.25			140.00						
79/07/31		WATER	3	.25			115.30						
79/07/31		WATER	6	.26			120.50						
79/07/31 CP(1)- 79/07/31	REP	WATER	3	.26									
79/09/10		WATER	0	.21			74.40						
79/09/10		WATER	3	.16			41.50						
79/09/10		WATER	6	.20			48.60						
79/09/10		WATER	13	.31			28.40						
86/06/12	0000	WATER	0							.560	.200U		.10U
86/06/12	1115	WATER	0		.180	12.00	7.00						
86/06/12	1145	WATER	18		.220	11.00	6.00						
86/07/07	0000	WATER	0							.320	.200U		.10U
86/07/10	0000	WATER	0					15.000U	30.000U			50.00U	
86/07/29	0800	WATER	0		.150	296.00	277.00						
86/07/29	0800	WATER	16		.690	13.00	10.00						
86/08/27	0000	WATER	0							.660	.200U		.10U
86/09/09	0810	WATER	0		.120	39.00	35.00						
86/09/09	0815	WATER	17		.110	42.00	32.00						

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00531 994500101000
43 22 00.0 092 33 00.0 5
DEEPEST PART LAKE HENDRICKS-.5MI NE RICEVILLE
19089 IOWA HOWARD
MISSISSIPPI RIVER BASIN 070800
WAPSI R-LAKE HENDRICKS T099NR14WSC19
21IOWA 801004 07080102 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	39380 DIELDRIN TOTUG/L	39383 DIELDRIN SEDUG/KG DRY WGT	39631 ATRAZINE MUD UG/KG	46317 LASSO WHL SMPL UG/L	77780 BLADEX TOTAL UG/L	81294 DYFONATE TOT UG/L	81407 ALACHLOR SED DRY WGTUG/KG	81408 MTRBUZIN TOT UG/L	81409 MTRBUZIN SED DRY WGTUG/KG	82052 BANVEL TOTAL UG/L
86/06/12	0000	WATER	0	.050U			.30	.100U	.100U		.100U		
86/07/07	0000	WATER	0	.050U			.20	.100U	.100U		.100U		
86/07/10	0000	WATER	0		15.00U	30.00U				30.000U		30.000U	
86/08/27	0000	WATER	0	.050U			.10U	.100U	.100U		.100U		

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

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19089 IOWA HOWARD
MISSISSIPPI RIVER BASIN 070800
WAPSI R-LAKE HENDRICKS T099NR14WSC19
21IOWA 801004 07080102 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	82502 IRON INS OL DRYDP UG/KG	82543 BLADEX DRY WT. MG/KG	82544 DYFONATE DRY WT / MG/K
86/06/12	0000	WATER	0	.1U		
86/07/07	0000	WATER	0	.1U		
86/07/10	0000	WATER	0		.03U	.03U
86/08/27	0000	WATER	0	.1U		

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

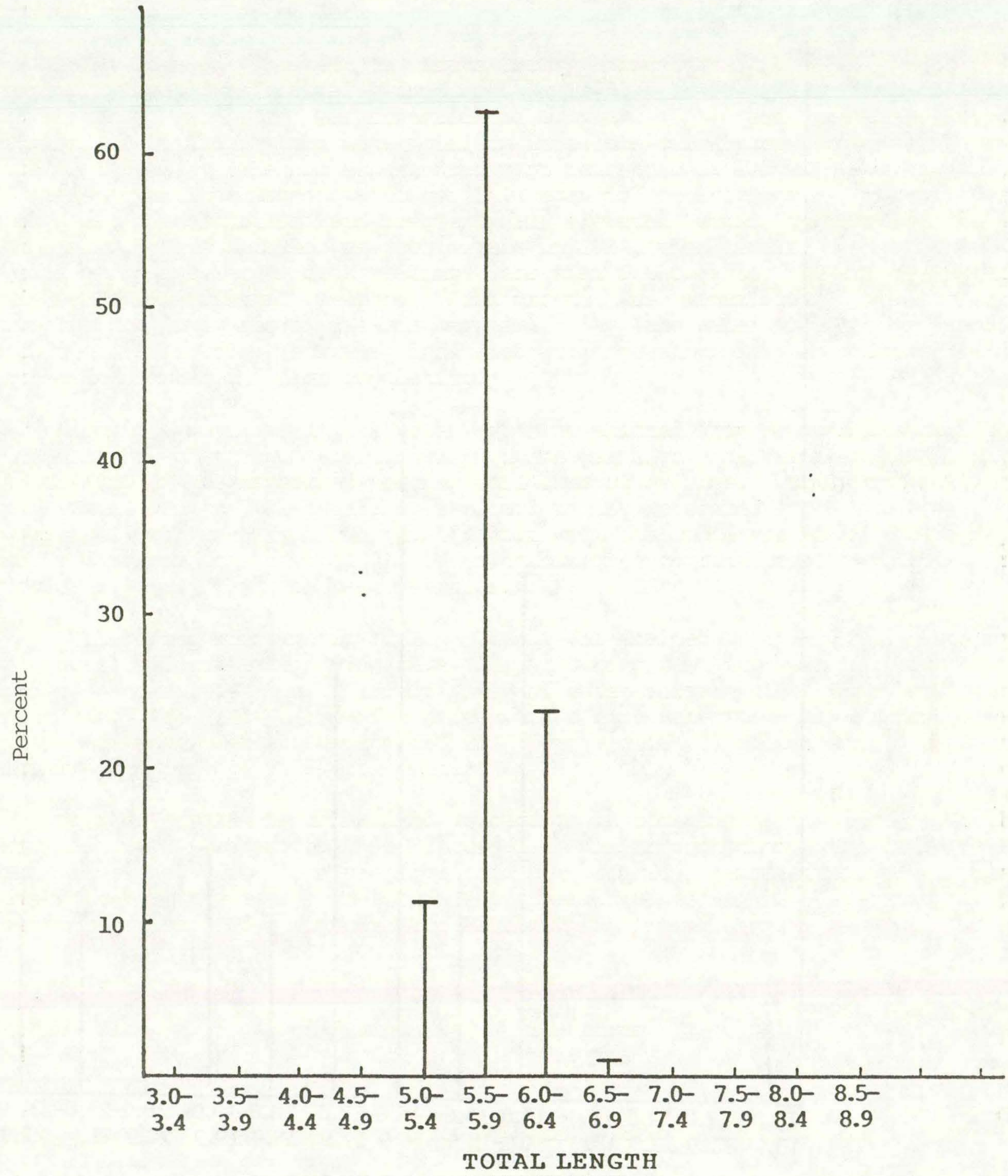
** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

LAKE HENDRICKS

LENGTH FREQUENCY

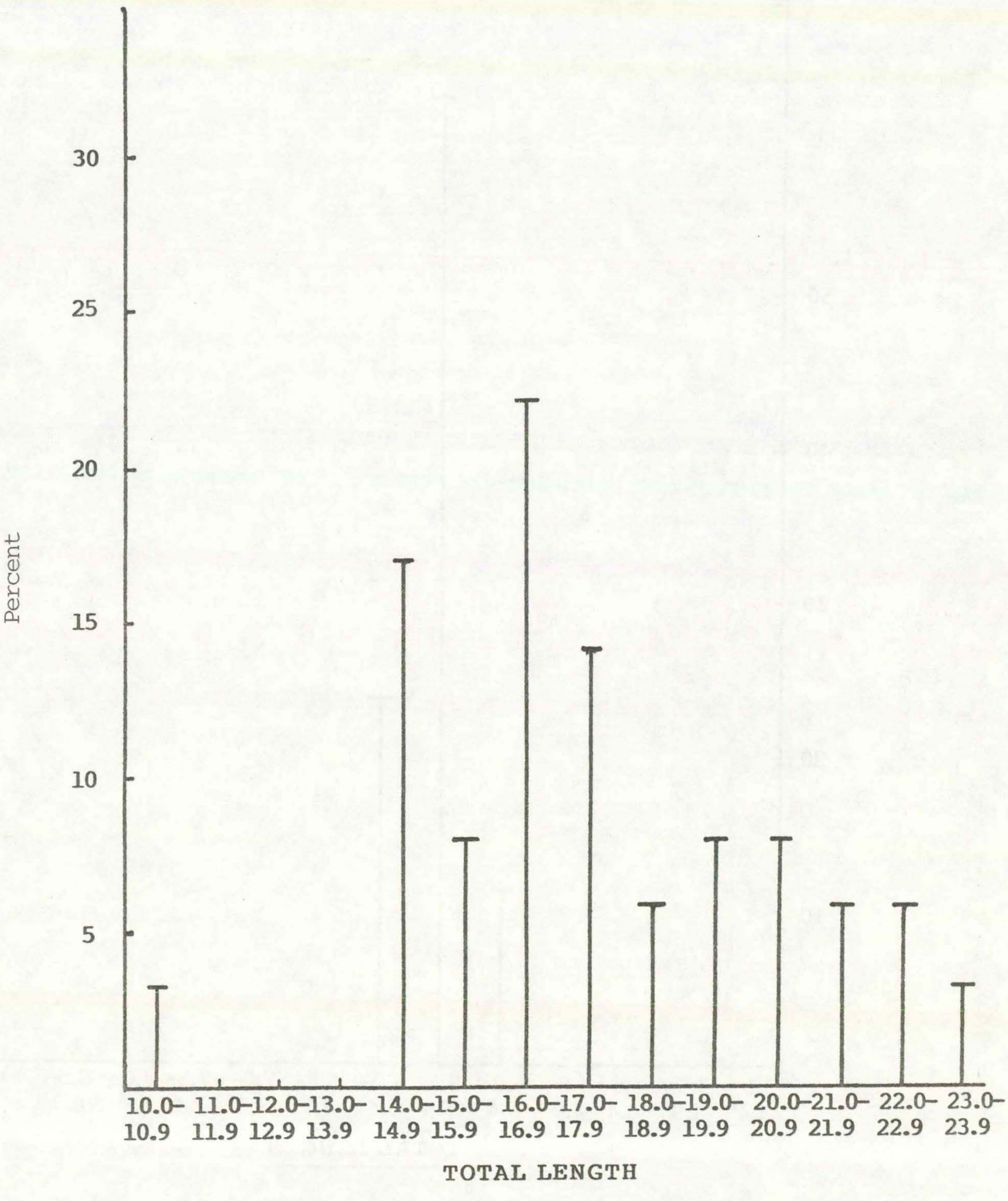
BLUEGILL



LAKE HENDRICKS

LENGTH FREQUENCY

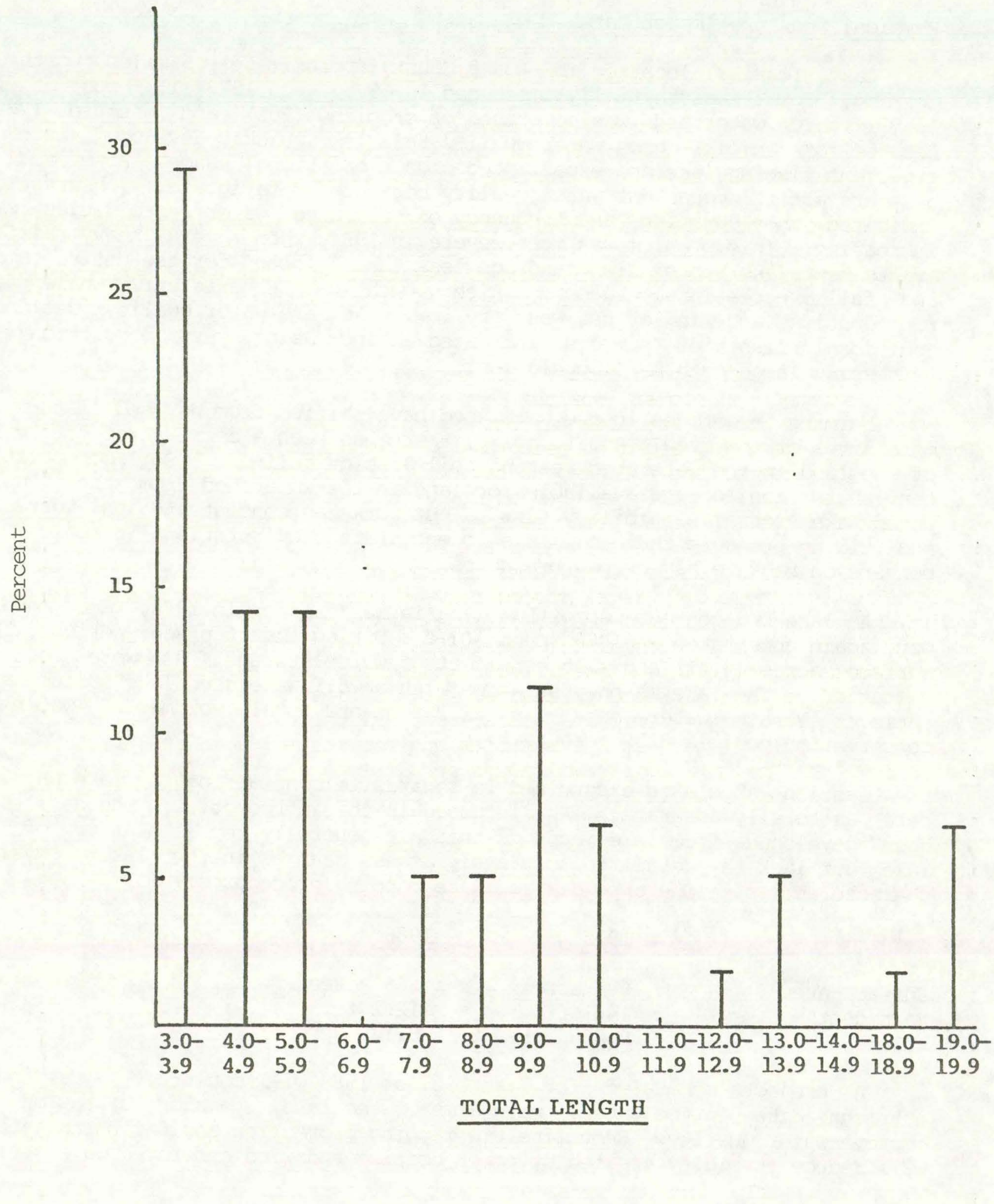
CHANNEL CATFISH



LAKE HENDRICKS

LENGTH FREQUENCY

LARGEMOUTH BASS



LAKE ICARIA

Physical and Lake Impact Data

Lake Icaria, located in Adams County approximately 5 miles north of Corning, Iowa, was initially impounded in 1975. In 1979 (1), most of its 16,791 acre watershed was comprised of cropland (70%) and pasture (22%). Because of initial good water quality this lake quickly developed into an excellent fishing lake and experienced high recreational usage. However, 4 or 5 years after impoundment water quality began to deteriorate. Observations indicated the duration and frequency of elevated water turbidities were increasing. This problem was most severe in 1984, when several heavy rainfall events kept lake Secchi disk readings less than 6 inches for the entire summer and fall recreational season. Fish growth was nonexistent, while fish reproduction and angler use was very low. As lake water quality declined, additional fisheries surveys indicated an increasing carp population and decreasing largemouth bass population.

Farming practices in the watershed have shifted from hay and pasture to more acres of row crop. Additionally, there has been a decrease of 75% to 55% of the land in the watershed meeting soil loss guidelines. Soil conservation cost-share monies are available for land in the watershed from the "Public Owned Lake Program Eligibility List", but work has concentrated on terracing and tiling projects that do little to encourage crop rotational practices or conversion back to hay or pasture acres.

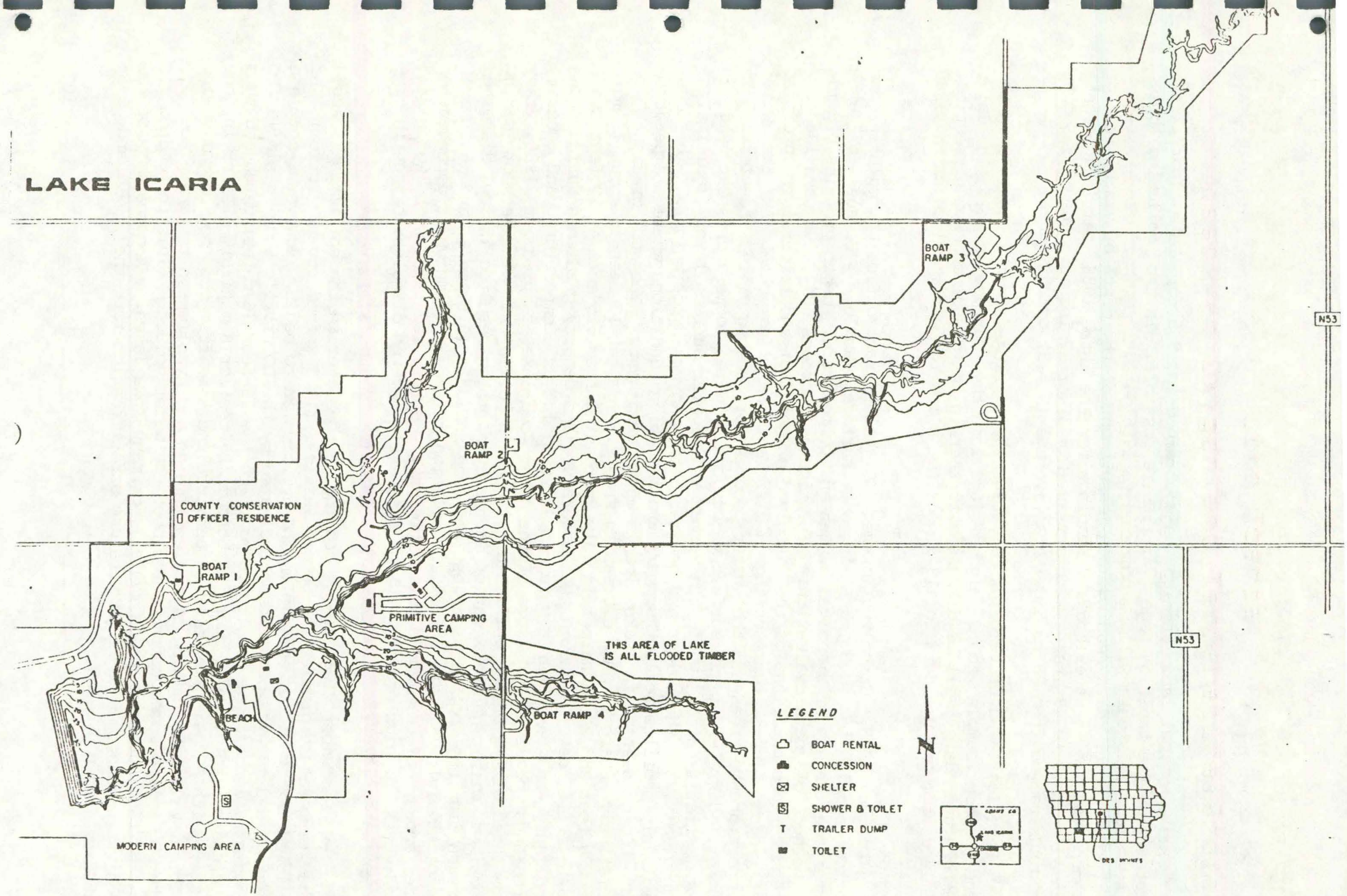
A lake bed contour map of Lake Icaria was drafted in 1976, and mapping was again undertaken in 1986 (page 101). During that ten year period, 30.9 surface acres (4.4%) and 1715 acre feet of water storage (18%) were lost to siltation. The lake is now 666 acres with a 25:1 watershed/lake surface area ratio. Average water depth is 12.2 feet and total volume of water at conservation pool is 8139 acre feet.

Caution should be excercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures).

	1976	1986
Surface Area	697 acres	666 acres
Mean depth	14.1 ft.	12.2 ft.
Volume	9,856 acre ft.	8,139 acre ft.

A project scheduled for late 1987 or 1988 will construct 3 sediment-nutrient dikes in the upper, main arms of the lake, to slow siltation and improve water quality. Shoreline rip rapping protection and 6 fishing jetties will reduce turbidity created by power boating and wind generated wave action.

LAKE ICARIA


BOAT RAMP 3
N53
BOAT RAMP 2
COUNTY CONSERVATION OFFICER RESIDENCE
BOAT RAMP 1
PRIMITIVE CAMPING AREA
THIS AREA OF LAKE IS ALL FLOODED TIMBER
N53
BEACH
BOAT RAMP 4
MODERN CAMPING AREA
LEGEND
BOAT RENTAL
CONCESSION
SHELTER
SHOWER & TOILET
TRAILER DUMP
TOILET

Chemical Data

The physical and chemical data obtained in 1986 for Lake Icaria are listed in the table on page 103. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 19 to 43 inches with a mean (N = 3) of 29 inches. The 1979 Secchi readings ranged from 20 to 51 with an average (N = 3) of 32 inches.

Lake Icaria water temperature during 1986, ranged from a low 15°C in the June bottom sample to a high of 26°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with 1986 data.

During 1986, dissolved oxygen (DO) values ranged from 0.4 mg/L in one bottom sample to 10.5 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 104 , 105 and 106 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. As the water temperature decreases, the water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The June and July profiles reflect summer stratification conditions where temperature and DO gradients in Lake Icaria were prominent. The DO gradient was relatively sharp in June decreasing from 7.5 mg/L at 13 feet to about 1 mg/L at 20 feet and even sharper in July decreasing from 6.5 mg/L at 10 feet to 1 mg/L at 14 feet. Although the temperature and density gradients during June and July in Lake Icaria were not as dramatic as temperature and density gradients observed in some of the other Iowa lakes sampled in 1986, they prevented mixing of the epilimnion with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in low dissolved oxygen in the bottom samples for June and July (0.5 mg/L and 0.4 mg/L respectively). The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with water and sediments of high organic content frequently have no dissolved oxygen in the lower water layer.

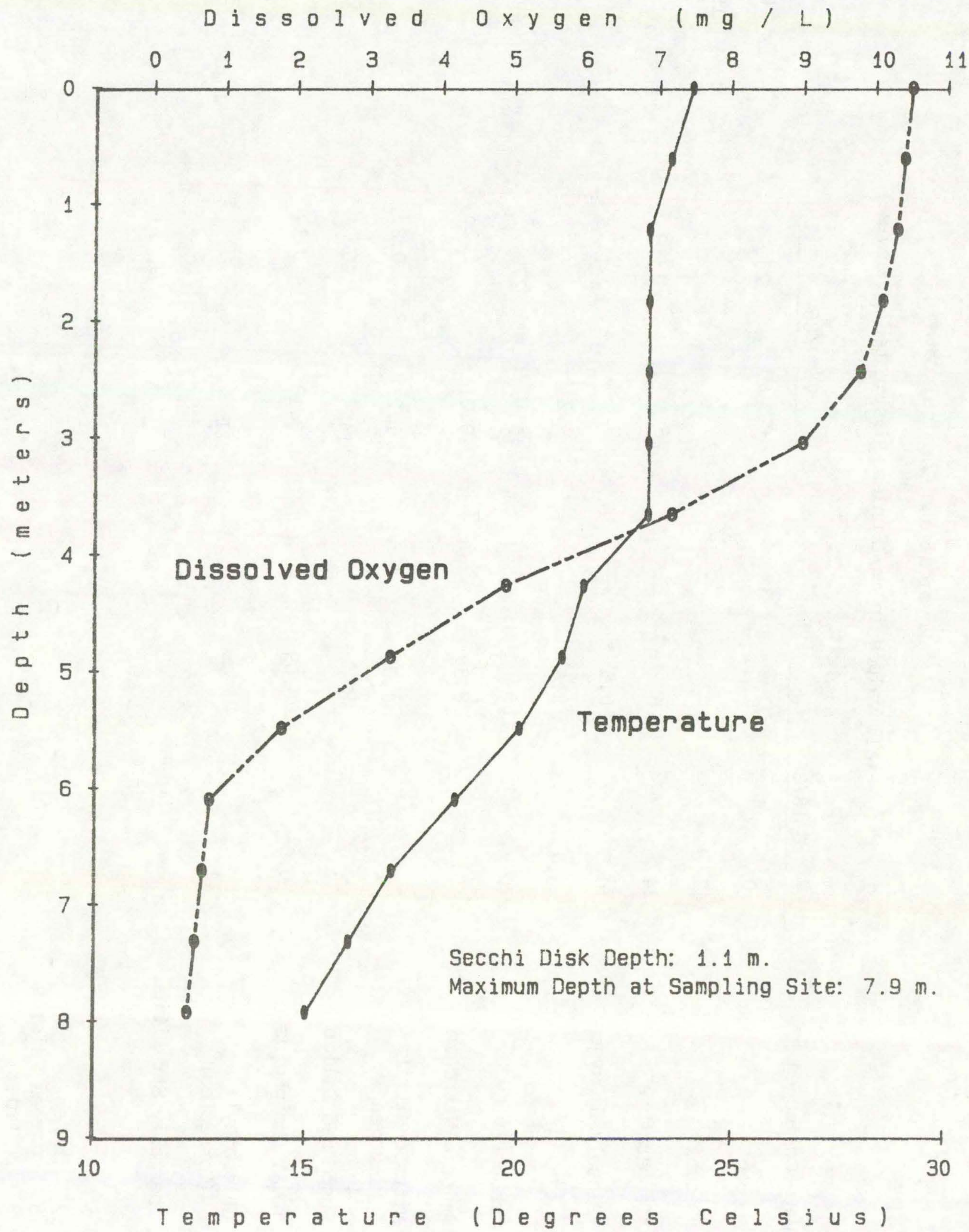
By September (Page 106), cooling of the water in the epilimnion caused the temperature gradient to become vertical (19.5°C from top to bottom) and allowed mixing of the epilimnion and hypolimnion to begin. However, complete mixing had not yet occurred as indicated by the DO profile showing similar DO concentrations (range 7.2 to 7.6 mg/L) to the 20 foot (6 meter) depth and then decreasing to 4.4 mg/L near the bottom (26 feet or 8 meters). Later in the fall, with the lake water temperature the same from top to bottom, wind action will cause mixing of the epilimnion and hypolimnion to take place and the DO will become uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

Lake Icaria
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

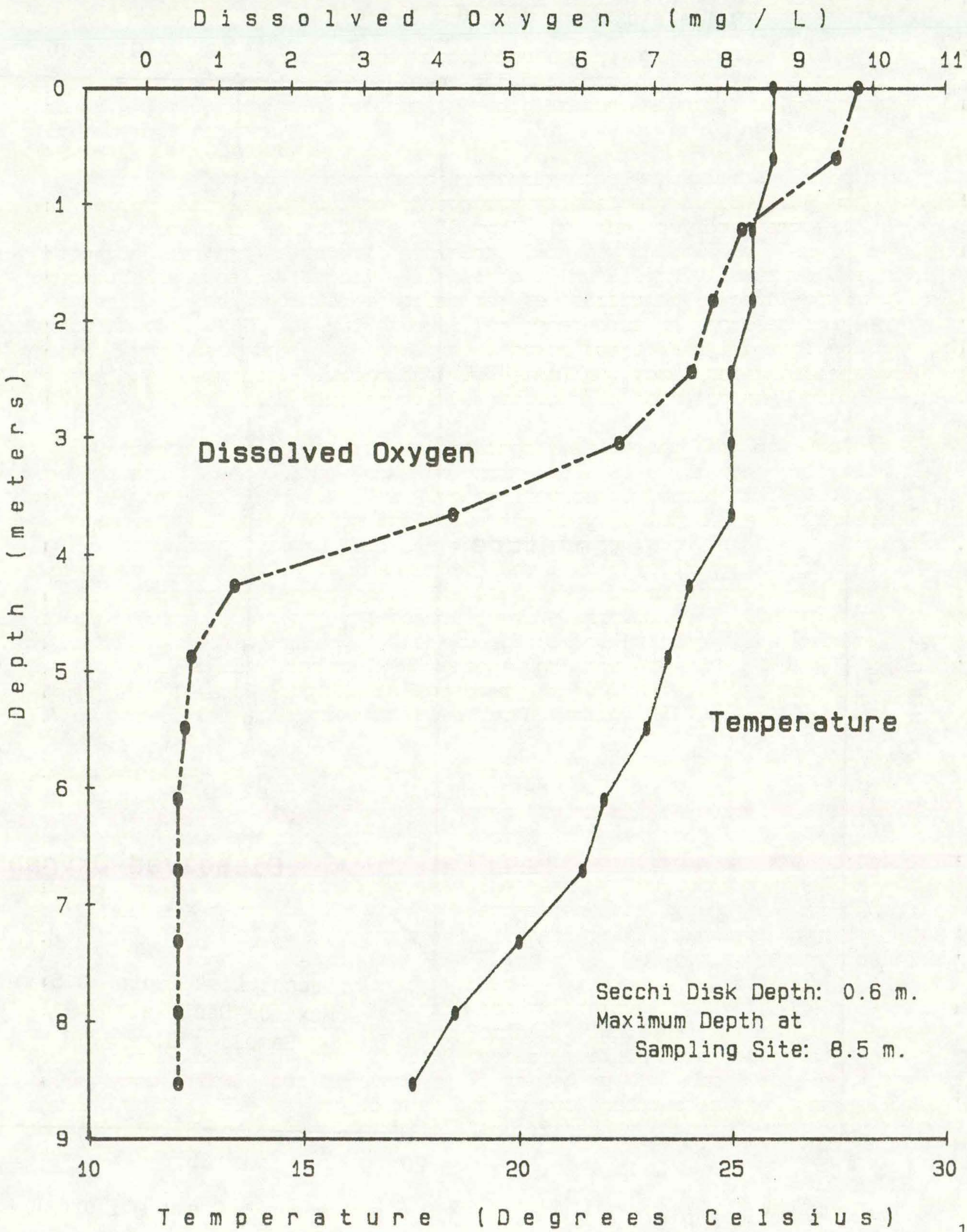
Date Collected	6/18/86		7/22/86		9/11/86	
*Depth[1]	0	26	0	28	0	26
*Secchi[2]	43		25		19	
*Temperature[3]	24	15	26	17.5	19.5	19.5
*Dissolved Oxygen	10.5	0.5	9.8	0.4	7.6	4.4
*pH[4]	8.7	7.6	9.2	7.7	8.0	8.3
Conductivity[5]	270	280	240	270	250	250
Ammonia Nitrogen	0.11	0.39	0.01	1.2	0.02	0.05
Nitrate-Nitrite Nitrogen	1.9	1.7	1.2	0.8	0.3	0.3
Suspended Solids	6	29	14	46	21	22
Total Phosphorus	0.06	0.09	0.13	0.17	0.19	0.19
Chlorophyll a (Corrected)[6]	11	2	21	7	39	35
Thermally Stratified	No		No		No	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

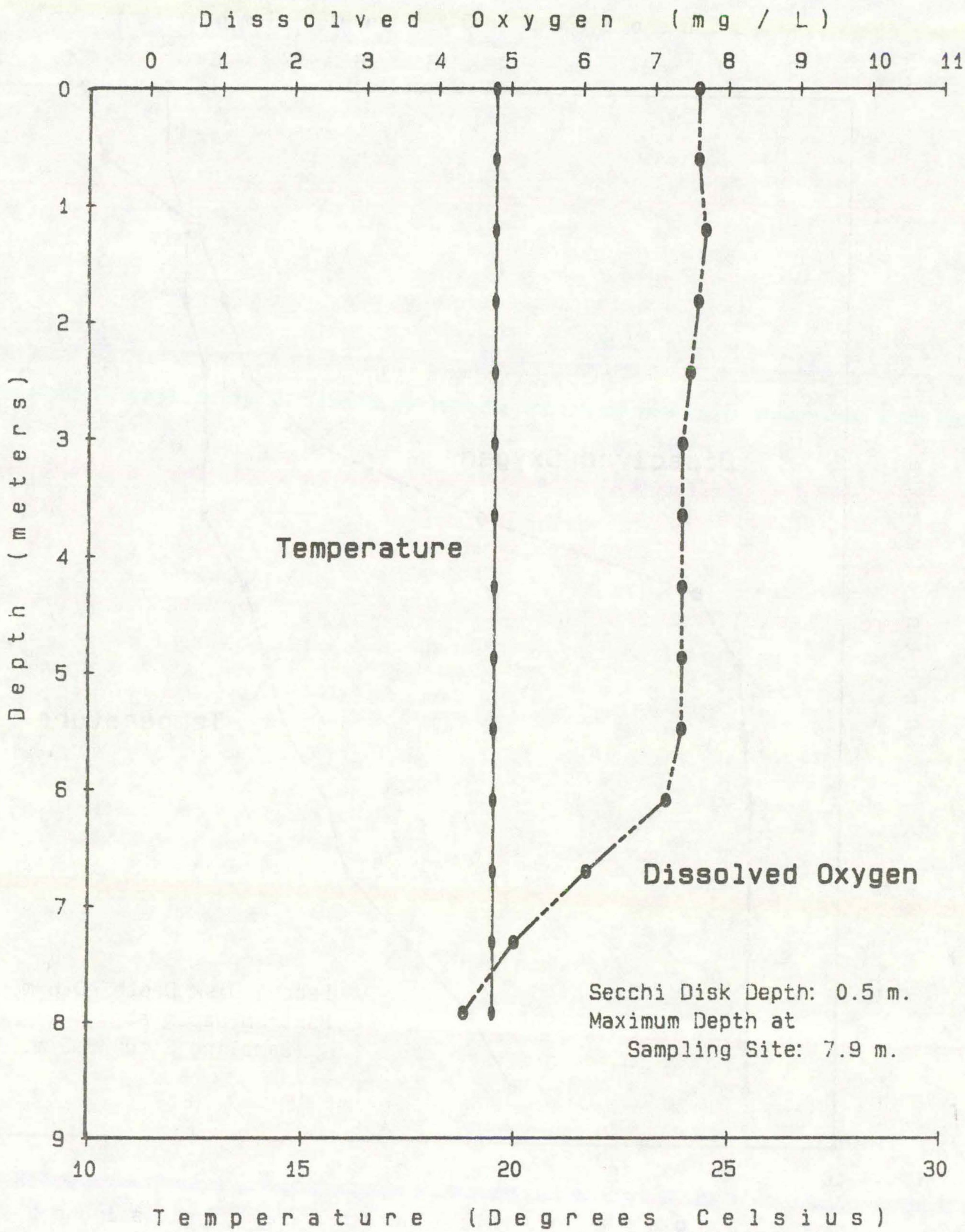
Lake Icaria
Dissolved Oxygen and Temperature Profile
June 18, 1986



Lake Icaria
Dissolved Oxygen and Temperature Profile
July 22, 1986



Lake Icaria
Dissolved Oxygen and Temperature Profile
September 11, 1986



	7 August 1979 Surface	23 feet	18 June 1986 Surface	23 feet
DO (mg/L)	6.9	0.3	10.5	0.5
Temperature (°C)	27.3	21.8	24	15

Compared to 1979, the 1986 DO and temperature in the surface sample reflect much cooler water and greater dissolved oxygen. Depletion of DO in the bottom samples was approximately the same in both 1979 and 1986.

In 1986, values for pH varied from 7.6 to 9.2 units. The pH in the epilimnion was higher (8.0 to 9.2) as compared to the hypolimnion (7.6 to 8.3) with the pH value obtained fromt he epilimnion during July exceeding the Iowa class B warm water standard of 9.0 pH units. The difference in pH values is attributed to a decrease in the carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. During June 1986, conductivity was similar throughout the water column (270 micromhos top and 280 micromhos bottom). July values reflected a conductivity gradient developing with a surface value of 240 micromhos and a bottom value of 270 micromhos. By early September the conductivity was 250 micromhos (top and bottom) as mixing was in progress. The decline in conductivity between June and July is related it to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (3). In June, low populations of phytoplankton were present (as indicated by the low chlorophyll values). As the phytoplankton populations increased in July they began utilizing the dissolved nutrients, causing a decline in dissolved solids hence a decline in conductivity. The upper water column showed the greatest decrease because fewer phytoplankton existed at the lower depths. Conductivity data for the epilimnion in 1979 was 220 micromhos for July, 280 micromhos for August and 220 micromhos for September. Limited 1979 data indicate conductivity in the hypolimnion was consistently higher than the epilimnion.

Ammonia nitrogen concentrations in 1986 were similar for all three surface samples ranging from 0.01 to 0.11 mg/L. The ammonia concentration in the bottom samples, however, increased from 0.39 mg/L in June to 1.2 mg/L in July. This increase may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. In September the ammonia nitrogen levels for both surface and bottom samples were low and similar (0.02 mg/L and 0.05 mg/L, respectively). The similarity of values can be attributed to fall turnover and subsequent uptake by the phytoplankton. Nitrate levels in the surface water declined from 1.9 mg/L in June to 0.3 mg/L in September. The nitrate decline in the epilimnion may be attributed to nitrate assimilation by the phytoplankton. Hypolimnetic nitrate values declined from 1.7 mg/L in June to 0.8 mg/L in July and to 0.3 mg/L in September. Hutchinson (3) believes declines of this type are due to nitrate being reduced to ammonia in the deoxygenated hypolimnion. As noted previously, ammonia levels did increase as nitrate values decreased. Part of the reason for the nitrate decline in September can be attributed to fall turnover and subsequent nitrate utilization by the phytoplankton community. The limited nitrogen data for 1979 does not allow for any comparison to 1986 data (one surface sample for ammonia (0.06 mg/L) and nitrate (0.13 mg/L) measured in September).

Suspended solids (in 1986) ranged from 6 mg/L in the June surface sample to 46 mg/L in the July bottom sample. Higher values were consistently found in the bottom sample and can be attributed to the settling of solids from the upper water layers including contributions from, turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter.

During 1986, total phosphorus concentrations were similar in both surface and bottom samples. Surface phosphorus values ranged from 0.06 mg/L to 0.19 mg/L as compared to 0.09 to 0.19 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is usually rapidly assimilated. The slightly lower values of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. During the 1979 sampling, total phosphorus ranged from 0.04 to 0.15 mg/L with similar values measured in both top and bottom samples.

Chlorophyll values are an indirect measurement of the phytoplankton populations. The 1986 corrected chlorophyll a values in the epilimnion ranged from 11 µg/L to 39 µg/L. The June epilimnion corrected chlorophyll a value was lowest (11 µg/L) while the value for July (21 µg/L) and September (39 µg/L) indicated growth of the phytoplankton population. Hypolimnetic corrected chorophyll a values ranged from 2 µg/L to 35 µg/L with the highest value occurring in September. The similarity in chlorophyll values for the top and bottom samples in September may be attributed to the mixing of the epilimnion and hypolimnion. The mean corrected chlorophyll a values (N = 3) in the epilimnion during 1979 were 34 µg/L for July (N = 2), 27 µg/L for August (N = 3) and 96 µg/L for September (N = 3). The 1979 September value is almost three times the maximum value found during 1986.

Pesticide Data

As described in the 1986 Iowa Lakes Study Work/QA plan (4), Lake Icaria was one of five lakes selected for pesticide analysis. One water sample was to be collected during non-rainfall runoff conditions (usually the first sample collected) and used for baseline data. Two water samples were to be collected after rainfall runoff to demonstrate the impact of runoff on lake quality. In addition, a composite (of at least 3 samples) sediment sample was also obtained from each lake. All samples were analyzed for nine common Iowa pesticides; i.e., the herbicides Atrazine, Cyanazine, Methlachlor, Alachlor, Metribuzin and Dicamba; the chlorinated hydrocarbons dieldrin and chlordane; and the organophosphate Fonfos. The data for Lake Icaria may be found in the table on page 109. Reportable values were measured in all three water samples for Atrazine (range 0.71 to 2.3 ug/L), and Cyanazine (range 1.5 to 2.0 ug/L). The herbicide Mathlachlor was observed in the June (0.72 ug/L) and July (0.78 ug/L) samples while Alachlor and Metribuzin were found only in the July sample (both 0.1 ug/L).

Lake Icaria
Pesticide Data - 1986
(all values in micrograms per liter)

Date Collected	6/18/86	7/09/86	9/11/86	6/27/86
Sample Matrix	Water	Water	Water	Sediment
Atrazine (AAtrex)	2.3	1.8	0.71	<50
Cyanazine (Bladex)	1.7	1.5	2.0	<50
Methlachlor (Dual)	0.72	0.78	<0.1	<200
Alachlor (Lasso)	<0.1	0.1	<0.1	<200
Metribuzin (Sencor)	<0.1	0.1	<0.1	<75
Dicamba (Banvel)	<2	<0.1	<0.1	<2
Dieldrin (Dieldrin)	<0.05	<0.05	<0.1	<15
Fonfos (Dyfonate)	<0.1	<0.1	<0.1	<50
Chlordane (Chlordane)	<0.2	<0.2	<0.5	<100

The number of reportable values and concentrations of pesticides were generally greater in the samples obtained in June and July than in the samples obtained during September. This is not unexpected since the application of herbicides generally occurs in the late spring after the crops are planted. Pesticide analysis of the sediment sample collected from Lake Icaria indicated no reportable pesticide values were present. During 1979 there were no samples collected for pesticide analysis so a comparison with 1986 data is not possible.

Biological Data

Fish were sampled in September 1986, utilizing fyke nets and electrofishing equipment. Summarized results are found below with complete field data information listed in the Appendix.

Major fish species abundance, average length, and range during the fall 1986 survey at Lake Icaria

SPECIES	Number	AVERAGE LENGTH (inches)	RANGE (inches)
Bluegill	89	7.0	1.0-9.0
White Crappie	68	8.4	3.5-11.5
Black Crappie	108	8.9	4.0-12.5
Largemouth Bass	30	10.4	3.5-16.5
Walleye	14	15.1	9.0-25.0
Channel Catfish	22	15.3	9.5-19.0
Carp	58	20.2	8.5-30.5

The poor water quality conditions of 1984 have not been repeated and fish growth, reproduction and body condition have responded positively. An aggressive walleye stocking program is entering its third year at the lake and an expanding walleye population is the result. An excellent white and black crappie population also is present. The largemouth bass population is only fair, despite an annual fall fingerling stocking program at a rate of 20 fish/acre. Bluegill numbers appear to be declining as water quality deteriorates. Excellent channel catfish fishing is maintained by annual stockings. The carp population appears to be increasing and several, strong year classes dominate the population. Tiger muskie are also annually stocked, but difficult to sample.

Summary

Although the data presented in the report are rather limited at best, it is possible to make several general statements.

> Since 1979, the volume in Lake Icaria has declined as a result of siltation. Changes in land management practices in the watershed (i.e. conservation reserve program, terracing, retention structures and minimum tillage practices) and in-lake (shoreline rip rapping and sediment-nutrient dikes) construction could help improve water quality and slow the rate of siltation. Although the 1986 dissolved oxygen and temperature profiles were more

pronounced as compared to 1979, no major changes in lake water quality appeared to have occurred from 1979 to 1986. In fact algal productivity, measured indirectly by chlorophyll, appears to have decreased from 1979 to 1986. Continued monitoring is necessary to determine long term trends in water quality. The Lake Icaria fishery is in good condition and responding positively.

LITERATURE CITED

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2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

4. Wnuk, M. 1986. 1986 Iowa Lakes Study - Work/QA Plan. Iowa Department of Natural Resources, Des Moines, Iowa.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00534 990200201000
41 03 20.0 094 45 00.0 5
DEEPEST PART LAKE ICARIA 4MI N CORNING
19003 IOWA ADAMS
NODAWAY RIVER BASIN 091200
NODAWAY R-LAKE ICARIA T072NR34WSC10
21IOWA 801004 10240001 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/16		WATER	0	26.70		.50	220	8.30		8.80	14		
79/07/16		WATER	6				230	8.00		8.80	14		
79/07/16		WATER	13				230	7.40		8.70	14		
79/07/16		WATER	22				260	.20		7.60	14		
79/07/16													
CP(1)-	REP	WATER	0	.00		.55							
79/07/16													
79/07/16													
CP(1)-	REP	WATER	13					7.40					
79/07/16													
79/08/07		WATER	0	27.30		1.30	280	6.90		8.22	7		
79/08/07		WATER	3				285	6.50		8.28	7		
79/08/07		WATER	6				280	6.50		8.15	7		
79/08/07		WATER	16				300	1.90		7.70	10		
79/08/07		WATER	22				320	.30		7.65	8		
79/08/07													
CP(1)-	REP	WATER	0	.00		1.30							
79/08/07													
79/09/04		WATER	0	25.40		.60	220	10.45		9.00	12	.060	.13
79/09/04		WATER	3				210	10.50		8.50	13		
79/09/04		WATER	6				210	10.70		9.00	12		
79/09/04		WATER	13				220	2.40		8.10	7		
79/09/04		WATER	19				225	1.35		7.90	6		
79/09/04													
CP(1)-	REP	WATER	0	.00		.65	220			9.00		.130	.09
79/09/04													
86/06/18	1050	WATER	0	24.00	43.0		270	10.50	8.70	8.30	6	.110	1.90
86/06/18	1050	WATER	26	15.00			280	.50	7.60	7.30	29	.390	1.70
86/07/22	1000	WATER	0	26.00	25.0		240	9.80	9.20	8.70	14	.010	1.20
86/07/22	1000	WATER	28	17.50			270	.40	7.70	7.50	46	1.200	.80
86/09/11	0950	WATER	0	19.50	19.0		250	7.60	8.00	7.60	21	.020	.30
86/09/11	0953	WATER	26	19.50			250	4.40	8.30	7.70	22	.050	.30

STORET RETRIEVAL DATE 87/07/08 PGM=RET PAGE: 15

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00534 990200201000
41 03 20.0 094 45 00.0 5
DEEPEST PART LAKE ICARIA 4MI N CORNING
19003 IOWA ADAMS
NODAWAY RIVER BASIN 091200
NODAWAY R-LAKE ICARIA T072NR34WSC10
21IOWA 801004 10240001 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/16		WATER	0	.18			34.80						
79/07/16		WATER	6	.19			32.90						
79/07/16		WATER	13	.19			32.90						
79/07/16		WATER	22	.18									
79/07/16 CP(1)- 79/07/16	REP	WATER	6	.21									
79/08/07		WATER	0	.13			26.90						
79/08/07		WATER	3	.15			30.70						
79/08/07		WATER	6	.13			21.70						
79/08/07		WATER	16	.28			11.20						
79/08/07		WATER	22	.46			9.40						
79/08/07 CP(1)- 79/08/07	REP	WATER	0	.14									
79/09/04		WATER	0	.17			95.10						
79/09/04		WATER	3	.18			92.80						
79/09/04		WATER	6	.18			98.80						
79/09/04		WATER	13	.16			39.30						
79/09/04		WATER	19	.18			10.50						
79/09/04 CP(1)- 79/09/04	REP	WATER	13	.16									
86/06/18	0000	WATER	0							2.300	.200U		.72
86/06/18	1050	WATER	0		.060	13.00	11.00						
86/06/18	1050	WATER	26		.090	5.00	2.00						
86/06/27	0000	WATER	0					2.000U	200.000U			100.00U	
86/07/09	0000	WATER	0							1.800	.200U		.78
86/07/22	1000	WATER	0		.130	26.00	21.00						
86/07/22	1000	WATER	28		.170	11.00	7.00						
86/09/11	0000	WATER	0							.710	.500U		.10U
86/09/11	0950	WATER	0		.190	43.00	39.00						
86/09/11	0953	WATER	26		.190	43.00	35.00						

STORET RETRIEVAL DATE 87/07/08 PGM=RET PAGE: 16

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00534 990200201000
41 03 20.0 094 45 00.0 5
DEEPEST PART LAKE ICARIA 4MI N CORNING
19003 IOWA ADAMS
NODAWAY RIVER BASIN 091200
NODAWAY R-LAKE ICARIA T072NR34WSC10
21IOWA 801004 10240001 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	39380 DIELDRIN TOTUG/L	39383 DIELDRIN SEDUG/KG DRY WGT	39631 ATRAZINE MUD UG/KG	46317 LASSO WHL SMPL UG/L	77780 BLADEX TOTAL UG/L	81294 DYFONATE TOT UG/L	81407 ALACHLOR SED DRY WGTUG/KG	81408 MTRBUZIN TOT UG/L	81409 MTRBUZIN SED DRY WGTUG/KG	82052 BANVEL TOTAL UG/L
86/06/18	0000	WATER	0	.050U			.10U	1.700	.100U		.100U		
86/06/27	0000	WATER	0		15.00U	50.00U				200.000U		75.000U	
86/07/09	0000	WATER	0	.050U			.10	1.500	.100U		.100		
86/09/11	0000	WATER	0	.100U			.10U	2.000	.100U		.100U		

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00534 990200201000
41 03 20.0 094 45 00.0 5
DEEPEST PART LAKE ICARIA 4MI N CORNING
19003 IOWA ADAMS
NODAWAY RIVER BASIN 091200
NODAWAY R-LAKE ICARIA T072NR34WSC10
21IOWA 801004 10240001 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	82502 IRON INS OL DRYDP UG/KG	82543 BLADEX DRY WT. MG/KG	82544 DYFONATE DRY WT / MG/K
86/06/18	0000	WATER	0	2U		
86/06/27	0000	WATER	0		.05U	.05U
86/07/09	0000	WATER	0	.1U		
86/09/11	0000	WATER	0	.1U		

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

Lake	1979 Mapping Surface Area (acres)	1979 Mapping Maximum Depth (feet)	1979 Mapping Volume (ac-ft)	1986 Mapping Surface Area (acres)	1986 Mapping Maximum Depth (feet)	1986 Mapping Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

Lake Icaria Storage Capacity - 1978

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
40	1.00	1.00
39	1.38	2.38
38	1.76	4.14
37	2.14	6.28
36	2.52	8.80
35	2.90	11.70
34	4.84	16.54
33	6.78	23.32
32	8.72	32.04
31	10.66	42.70
30	12.60	55.30
29	21.26	76.56
28	29.92	106.48
27	38.58	145.06
26	47.24	192.30
25	55.90	248.20
24	74.70	322.90
23	93.50	416.40
22	112.30	528.70
21	131.10	659.80
20	149.90	809.70
19	196.08	1005.78
18	242.26	1248.04
17	288.44	1536.48
16	334.62	1871.10
15	380.80	2251.90
14	383.74	2635.64
13	386.68	3022.32
12	389.62	3411.94
11	392.56	3804.50
10	395.50	4200.00
9	427.36	4627.36
8	459.22	5086.58
7	491.08	5577.66
6	522.94	6100.60
5	554.80	6655.40
4	583.24	7238.64
3	611.68	7850.32
2	640.12	8490.44
1	668.56	9159.00
Surface	697.00	9856.00

Total Storage 9856.00 acre/feet
Average Depth 14.14 feet

Lake Icaria Storage Capacity - 1986

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
40	0.50	0.50
39	0.84	1.34
38	1.18	2.52
37	1.52	4.04
36	1.86	5.90
35	2.20	8.10
34	3.62	11.72
33	5.04	16.76
32	6.46	23.22
31	7.88	31.10
30	9.30	40.40
29	17.08	57.48
28	24.86	82.34
27	32.64	114.98
26	40.42	155.40
25	48.20	203.60
24	64.02	267.62
23	79.84	347.46
22	95.66	443.12
21	111.48	554.60
20	127.30	681.90
19	146.56	828.46
18	165.82	994.28
17	185.08	1179.36
16	204.34	1383.70
15	223.60	1607.30
14	245.64	1852.94
13	267.68	2120.62
12	289.72	2410.34
11	311.76	2722.10
10	333.80	3055.90
9	363.68	3419.58
8	393.56	3813.14
7	423.44	4236.58
6	453.32	4689.90
5	483.70	5173.60
4	520.18	5693.78
3	556.66	6250.44
2	593.14	6843.58
1	629.62	7473.20
Surface	666.10	8139.30

Total Storage 8139.30 acre/feet
Average Depth 12.22 feet

9/29/86

Lake [illegible] – Day

INVESTIGATOR: M'Clun, Sch[illegible], Still

NET:
TOTAL NET HOURS:
MIN. SHOCKER: 60 MIN.

SEINE:
NO. HAULS:
OTHER:

LENGTH FREQUENCY

Carp in. #	LMB in. #	C. Catfish #	Gr. Sunfish #	Bl. Bullhead #	Walleye #	Black Crappie #	White Crappie #	Blg #	IN.
8.5	3.5	in. 15.5			in. 21			1	.5-1.0
11	4							1	1.0-1.5
12	5 (3)							4	1.5-2.0
15	9							2	2.0-2.5
16.5	9.5 (3)							1	2.5-3.0
17.5 (2)	10 (3)						1	1	3.0-3.5
18	10.5 (4)								3.5-4.0
19 (4)	11		1			1		2	4.0-4.5
19.5 (3)	12							7	4.5-5.0
20 (2)	12.5 (4)							5	5.0-5.5
20.5 (4)	13 (2)							5	5.5-6.0
21 (5)	14.5 (2)					2		3	6.0-6.5
22.5	15							7	6.5-7.0
23 (2)	16.5 (2)							9	7.0-7.5
24.5						3		4	7.5-8.0
25							2	6	8.0-8.5
30.5					1	1	4	2	8.5-9.0
						3	2		9.0-9.5
						3			9.5-10.0
						3	2		10.0-10.5
						2	1		10.5-11.0
				1		1			11.0-11.5
									11.5-12.0
					1	2			12.0-12.5
	YOY LMB & Blg seen								12.5-13.0
	Water muddy in upper end of lake								13.0-13.5
									13.5-14.0
									14.0-14.5

9/30/86 ICAB(?)

NET: Fyke Nets - 4
TOTAL NET HOURS:
MIN. SHOCKER:
SEINE:
NO. HAULS:
OTHER:

INVESTIGATOR: McGhee, Schlottke
H_2O TEMP 70°F

LENGTH FREQUENCY

CARP IN #		C. CATFISH IN #		LMB "	Bl. BULLHEAD IN.	WALLEYE IN.		BLACK CRAPPIE #'s	WHITE CRAPPIE	Blg	
17 (3)		10.5		5	8.5	9					.5-1.0
18 (5)		12.5 (2)			11	9					1.0-1.5
19.5 (2)		13 (2)			12	9					1.5-2.0
20 (3)		13.5 (2)				12.5					2.0-2.5
21 (3)		14				13.5					2.5-3.0
22 (2)		15 (2)				13.5					3.0-3.5
22.5		15.5 (2)				13.5					3.5-4.0
24		16.5 (2)				13.5				2	4.0-4.5
25 (3)		17 (3)				14			2	5	4.5-5.0
28		18 (3)				17				6	5.0-5.5
28.5		19				18.5				5	5.5-6.0
		[illegible]				22.5				1	6.0-6.5
		[illegible]				25		9	5	1	6.5-7.0
		[illegible]						14	8	2	7.0-7.5
		[illegible]						5	11	4	7.5-8.0
		[illegible]						4	7	2	8.0-8.5
		[illegible]						5	10	1	8.5-9.0
		[illegible]						19	1		9.0-9.5
		[illegible]						14	1		9.5-10.0
								13	4		10.0-10.5
								4	9		10.5-11.0
									1		11.0-11.5
											11.5-12.0
											12.0-12.5
											12.5-13.0
											13.0-13.5
											13.5-14.0
											14.0-14.5

4 OTHER FYKE NETS WERE FISHED PROVIDING THE SAME RESULTS

1 NET PRODUCED MOST OF THE CARP

LAKE KEOMAH

Physical and Lake Impact Data

Lake Keomah is located in Mahaska county approximately 5 miles east of Oskaloosa, Iowa. Most of Lake Keomah's 1,855 acre watershed is in cropland (74%), pasture (16%) and forest (7%). A map of Lake Keomah developed from 1986 data may be found on page 125. In addition a comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures).

	1979	1986
Suface Area	84 acres	74 acres
Maximum depth	22 ft.	18 ft.
Volume	846 acre ft.	737 acre ft.

Based on 1986 data for Lake Keomah, it is apparent that the lake has lost a large amount of water volume due to siltation. The west or inlet end of the lake has lost several feet of water due to siltation. The maximum water depth in 1979 was 22 feet while in 1986 the maximum depth is only 18 feet. A silt retention dam in the east arm of the lake has reduced the loss of water volume in that area. Good soil conservation practices should be followed in an effort to slow the rate of siltation as much as possible and thus lengthen the life of the lake. Water clarity at Lake Keomah is generally good; however, during periods of heavy runoff the lake becomes quite turbid. The lake also periodically has dense blooms of blue-green algae.

Chemical Data

The physical and chemical data obtained in 1986 for Lake Keomah are listed in the table on page 126. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data. All Lake Keomah data for both 1979 and 1986 may be found in the Appendix.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 15 to 39 inches with a mean (N = 3) of 23 inches. The 1979 Secchi readings ranged from 20 to 28 with an average (N = 3) of 24 inches.

Lake Keomah water temperature ranged from a low of 16°C in the June bottom sample to a high of 28°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with 1986 data.

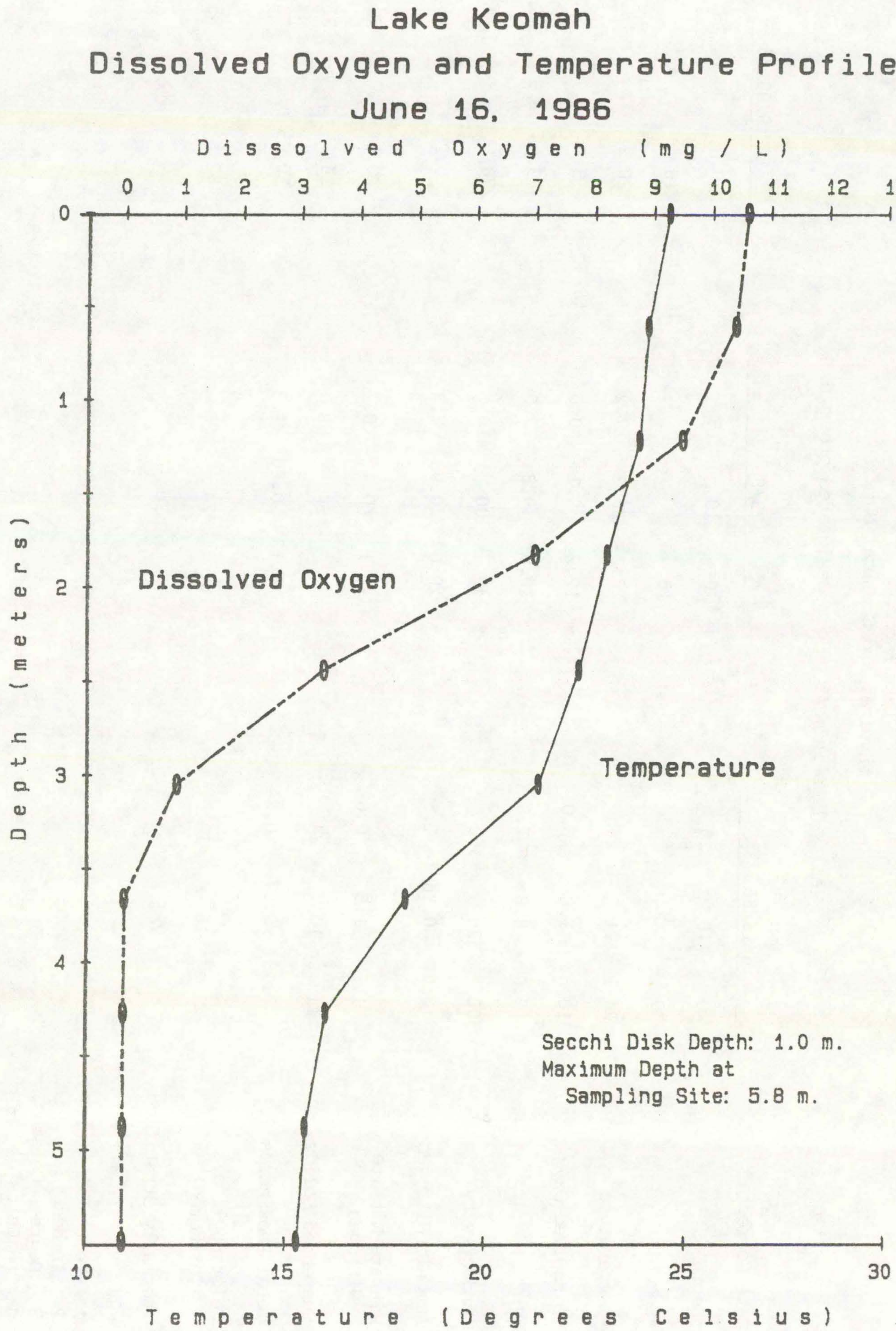
Dissolved oxygen (DO) values ranged from 0.0 mg/L in two bottom samples to 12.2 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 127, 128 and 129 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling date. The June profile reflects summer conditions where


LAKE KEOMAH
Mahaska County
SCALE IN FEET
200
400
Legend
STATE BOUNDARY
CAMPING
CONCESSION
notes
AREA 72
MAX.
4
6
8
10
12
14
16
18

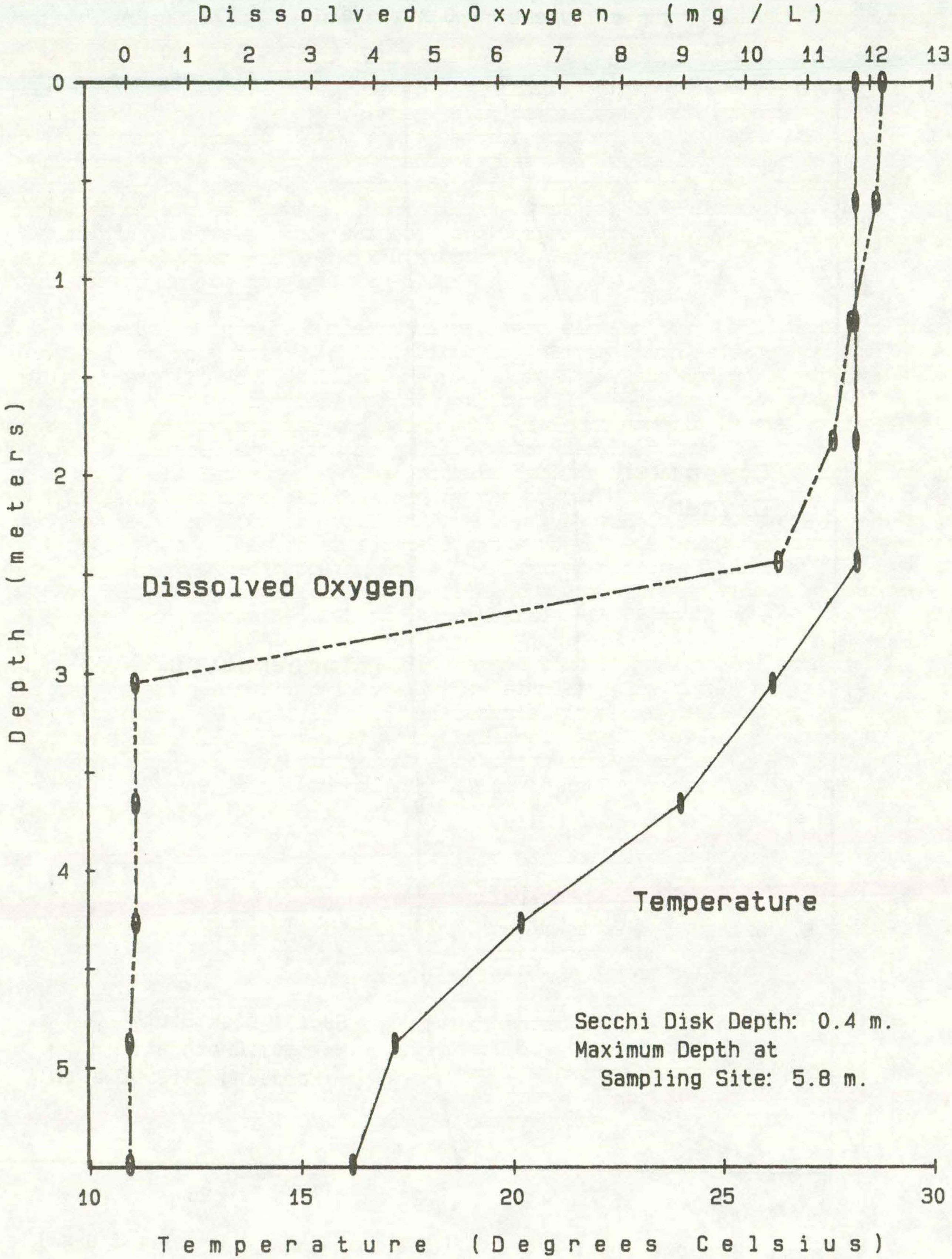
Lake Keomah
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/16/86			7/23/86			9/08/86	
*Depth[1]	0	10	15	0	10	15	0	18
*Secchi[2]	39			15			16	
*Temperature[3]	24	21	16	28.2	26.2	17.2	20.2	18.8
*Dissolved Oxygen	10.6	1.0	0.0	12.2	0.1	0.0	5.0	0.3
*pH[4]	9.0	8.8	7.8	10.0	9.8	7.0	9.0	7.5
Conductivity[5]	300	320	360	240	300	410	270	320
Ammonia Nitrogen	0.07	0.36	1.5	0.07	0.98	7.3	0.26	14
Nitrate-Nitrite Nitrogen	1.5	1.5	0.6	<0.1	<0.1	<0.1	<0.1	<0.1
Suspended Solids	11	10	24	30	54	58	14	21
Total Phosphorus	0.18	0.07	0.24	0.18	0.20	1.3	0.35	2.4
Chlorophyll a (Corrected)[6]	21	16	13	167	24	20	82	85
Thermally Stratified	Yes			Yes			No	

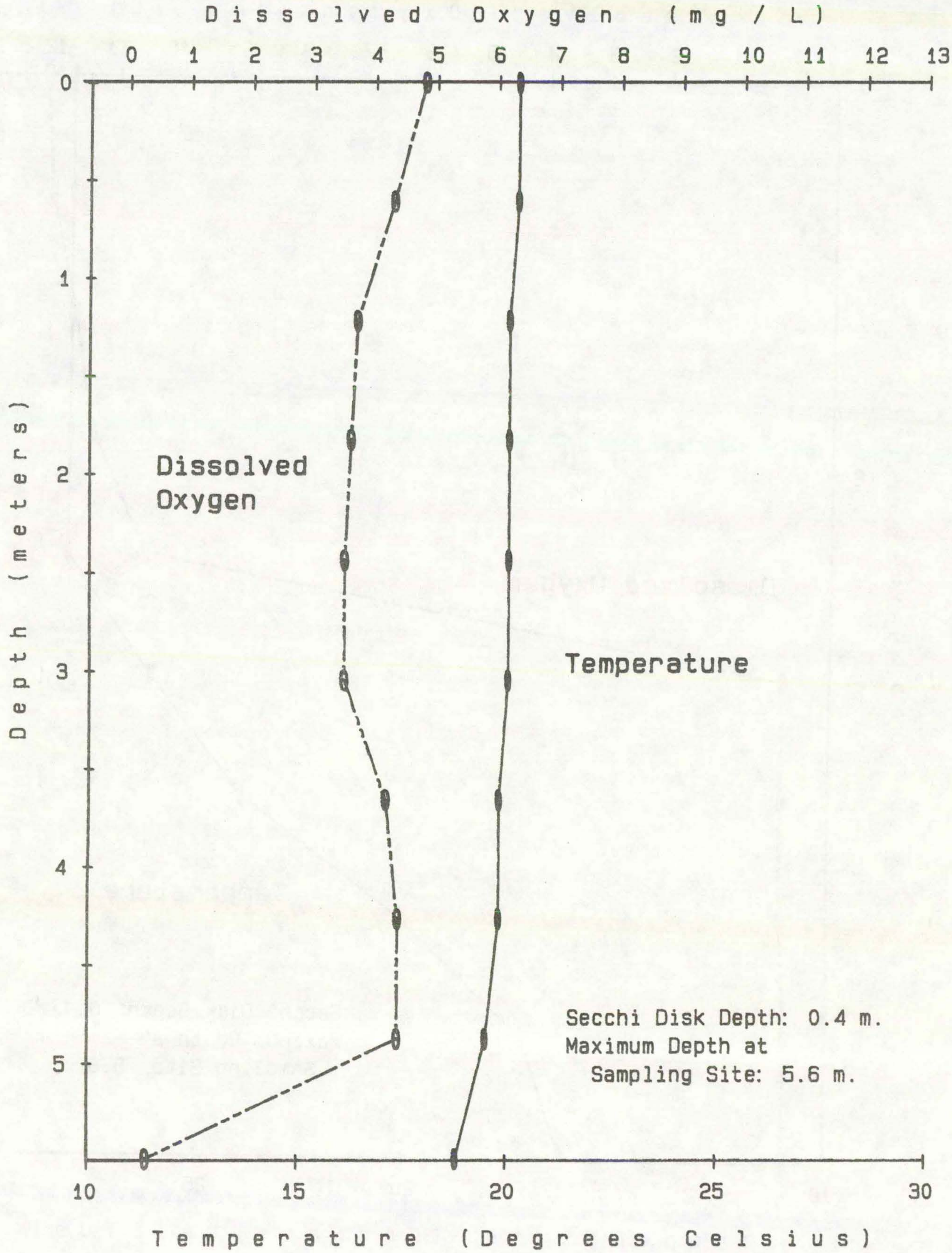
1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site


Lake Keomah
Dissolved Oxygen and Temperature Profile
June 16, 1986
Dissolved Oxygen (mg / L)
0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 1 2 3 4 5
Depth (meters)
Dissolved Oxygen
Temperature
Secchi Disk Depth: 1.0 m.
Maximum Depth at
Sampling Site: 5.8 m.
10 15 20 25 30
Temperature (Degrees Celsius)

Lake Keomah
Dissolved Oxygen and Temperature Profile
July 23, 1986



Lake Keomah
Dissolved Oxygen and Temperature Profile
September 8, 1986



both temperature and DO gradients had developed in Lake Keomah. That is, the value for both parameters declined from top (temperature of 24.5°C and DO of 10.6 mg/L) to bottom (temperature 15°C and DO of 0 mg/L). As water temperature decreases, water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratificiation when the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The temperature differences and density prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom sample of 0.0 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with water and sediment of high organic content frequently have no dissolved oxygen in the lower water layer. The temperature and DO gradients became even sharper in July with a very sharp decrease in the DO concentration (from 10.5 to 0.1 mg/L) between the 8 foot (2.5 M) and 10 foot (3.0 M) depths. The temperature gradient was not as well-defined dropping gradually from 28°C at a depth of 8 feet to 16°C near the bottom. Typically in the fall, as the ambient temperature declines, the lake water temperature becomes the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 129) for Lake Keomah indicated fall turnover was almost complete. The temperature profile had become vertical at approximately 19°C and the DO profile was vertical (4.4 to 4.8 mg/L) to a depth of 16 feet (5 M) where a small gradient (from 4.4 mg/L at 16 feet to 0.3 mg/L at 18 feet) still existed. The presence of this small DO gradient indicates that the mixing of the water layers was nearing completion. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

	September 5, 1979		July 23, 1986	
	Surface	13 feet	Surface	15 feet
DO (mg/L)	10.5	0.2	12.2	0.0
Temperature (°C)	27	23	28	17

Compared to 1979, the 1986 ranges for both DO and temperature were broader. Depletion of DO in the bottom sample was also slightly greater in 1986.

Values for field pH in 1986 varied from 7.0 to 10.0 units. The pH in the epilimnion was higher (9.0 to 10.0) as compared to the hypolimnion (7.0 to 7.8) with the pH values obtained from the epilimnion during July exceeding the Iowa class B warmwater standard of 9.0 pH units. The difference in pH values is attributed to a decrease of carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. In June a conductivity gradient had begun to develop with a surface value of 300 micromhos and a bottom value of 360 micromhos. This gradient became sharper in July (270 micromhos at the surface and 410 micromhos at the bottom) but declined in September (270 and 320 micromhos surface and bottom respectively). The decline in conductivity in the epilimnion from June to July is related to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). In June, low phytoplankton populations were present (as indicated by the low chlorophyll values). As the phytoplankton populations increased in July, they began utilizing the dissolved nutrients, thus causing a decline in dissolved solids and a decline in conductivity. The upper water layer demonstrated the greatest decrease in conductivity because fewer phytoplankton existed at the lower depths. The reduction in the conductivity gradient observed in the September values can be attributed to can be attributed to fall turnover and the mixing of the hypolimnion and epilimnion. Conductivity data for 1979 demonstrated much less variability between the surface and bottom samples (July - 290 and 330 micromhos, August - 230 and 250 micromhos, September - 220 and 240 micromhos, surface and bottom respectively).

Ammonia nitrogen concentrations were similar for all three surface samples, ranging from 0.07 to 0.26 mg/L. Bottom samples, however, reflected an increase from 1.5 mg/L in June to 7.3 mg/L in July and to 14 mg/L in early September. This increase may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate levels in the surface water declined from 1.5 mg/L in June to <0.1 mg/L in September. The nitrate decline in the epilimnion may be attributed to nitrate assimilation by the phytoplankton. Hypolimnetic nitrate values declined from 0.6 mg/L in June to <0.1 mg/L in September. Hutchinson (3) believes declines of this type are due to nitrate being reduced to ammonia in the deoxygenated hypolimnion. The limited nitrogen data for 1979 do not allow for any comparison to the 1986 data (one surface sample measured in September for ammonia - 0.10 mg/L and nitrate - 0.01 mg/L).

Suspended solids during 1986 ranged from 10 mg/L to 58 mg/L with the higher values being found in the bottom samples. The higher solids values can be attributed to the settling of material from the upper water layers and include turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter. During the 1979 study suspended solids ranged from 12 to 33 mg/L, generally increasing with depth.

Total phosphorus concentrations in surface samples ranged from 0.18 to 0.35 mg/L as compared to 0.24 to 2.4 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The lower values of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. In the oxygen-deficient part of the hypolimnion phophorus levels increased from June to September. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. During the 1979 sampling, total phosphorus ranged from 0.06 to 0.19 mg/L with only minor differences between the top and bottom samples (July ranged from 0.06 to 0.07 mg/L, August ranged from 0.09 to 0.19 mg/L and September ranged from 0.09 to 0.10 mg/L).

Chlorophyll values are an indirect measurement of the phytoplankton populations. The 1986 corrected chlorophyll a values in the epilimnion ranged from 21 ug/L in June to 167 ug/L in July. Hypolimnetic values ranged from 13 ug/L to 85 ug/L with the highest value occurring in September. The elevated hypolimnetic September corrected chlorophyll a value can be attributed to fall turnover and the subsequent mixing of the water layers. Corrected chlorophyll a values in the 1979 surface samples were 60 ug/L for July, 139 ug/L for August and 85 ug/L for September. These 1979 values are relatively similar to the values found in 1986.

Biological Data

A fisheries survey was conducted on Lake Keomah on September 30 and October 1, 1986. Six pound nets were used overnight, and an electrofishing unit was utilized for 89 minutes.

Species composition and relative abundance are shown below.

Species	Nets	Shocker	Total No.	Total Percent
Bluegill	43	40	83	9
Black Crappie	17		17	2
Largemouth Bass		106	106	12
Redear		1	1	<1
Black Bullhead	526	4	530	60
Channel Catfish	53	14	67	8
Green Sunfish	8	77	85	10
Total	647	242	889	

Length-frequency graphs of the species may be found in the appendix. The relative weight and back-calculated total lengths of the major species may also be found in the appendix.

Summary

Although the data presented in this report are rather limited, it is possible to make several general statements about the data.

> Since 1979, the volume of water in Lake Keomah has declined as a result of siltation. Although the east arm of the lake has a silt retention dam, the possiblity of additional sediment control structures in the watershed should be evaluated.
>
> Even though the 1986 dissolved oxygen and temperature profiles were more pronounced as compared to the 1979 profiles, no major changes in lake water quality appear to have occurred from 1979 to 1986. Continued monitoring is necessary to determine long-term trends in water quality.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa's Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00538 996200104000
41 17 00.0 092 32 00.0 5
DEEPEST PART LAKE KEOMAH 6 MI E OSKALOOSA
19123 IOWA MAHASKA
SKUNK RIVER BASIN 071100
S SKUNK R-LAKE KEOMAH T075NR15WSC24
21IOWA 801004 07080105001 0033.530 ON
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/06		WATER	0	24.50		.70	290	11.90		9.00	16		
79/07/06		WATER	6				310	9.50		8.80	14		
79/07/06		WATER	13				330	7.60		8.00	26		
79/07/06 CP(1)- 79/07/06		REP WATER	0	.00		.70							
79/07/06 CP(1)- 79/07/06		REP WATER	13				330			8.10			
79/08/22		WATER	0	27.80		.50	230	13.90		9.30	20		
79/08/22		WATER	6				240	3.10		8.00	23		
79/08/22		WATER	13				250	.00		7.60	33		
79/08/22 CP(1)- 79/08/22		REP WATER	0	.00		.50	240			9.40			
79/08/22 CP(1)- 79/08/22		REP WATER	6					3.20					
79/09/05		WATER	0	.00		.60	220	10.50		9.10	15	.100	.07
79/09/05		WATER	3				230	11.00		8.90	15		
79/09/05		WATER	6				230	7.90		8.90	12		
79/09/05		WATER	13				240	.20		7.70	16		
79/09/05 CP(1)- 79/09/05		REP WATER	0	8.10		.60		10.80				.050	.08
86/06/16	1200	WATER	0	24.00	39.0		300	10.60	9.00	8.95	11	.070	1.50
86/06/16	1200	WATER	10	21.00			320	1.00	8.75	8.00	10	.360	1.50
86/06/16	1200	WATER	15	16.00			360	.00	7.75	7.55	24	1.500	.60
86/07/23	0930	WATER	0	28.25	15.0		240	12.20	10.00	9.60	30	.070	.10K
86/07/23	0930	WATER	10	26.25			300	.10	9.75	7.10	54	.980	.10K
86/07/23	0930	WATER	15	17.25			410	.00	7.00	7.00	58	7.300	.10K
86/09/08	1000	WATER	0	20.25			270	5.00	9.00	7.80	14	.260	.10K
86/09/08	1000	WATER	18	18.75			320	.30	7.50	6.80	21	14.000	.10K

STORET RETRIEVAL DATE 87/07/08 PGM=RET PAGE: 19

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00538 996200104000
41 17 00.0 092 32 00.0 5
DEEPEST PART LAKE KEOMAH 6 MI E OSKALOOSA
19123 IOWA MAHASKA
SKUNK RIVER BASIN 071100
S SKUNK R-LAKE KEOMAH T075NR15WSC24
21IOWA 801004 07080105001 0033.530 ON
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/06		WATER	0	.18			59.90						
79/07/06		WATER	6	.19			23.20						
79/07/06		WATER	13	.21			56.10						
79/08/22		WATER	0	.37			139.20						
79/08/22		WATER	6	.28			29.90						
79/08/22		WATER	13	.57			8.20						
79/08/22 CP(1)- 79/08/22	REP	WATER	6	.30									
79/09/05		WATER	0	.27			84.60						
79/09/05		WATER	3	.30			90.60						
79/09/05		WATER	6	.28			58.80						
79/09/05		WATER	13	.28			6.70						
86/06/16	1200	WATER	0		.180	23.00	21.00						
86/06/16	1200	WATER	10		.070	23.00	16.00						
86/06/16	1200	WATER	15		.240	18.00	13.00						
86/07/23	0930	WATER	0		.180	167.00	167.00						
86/07/23	0930	WATER	10		.200	30.00	24.00						
86/07/23	0930	WATER	15		1.300	29.00	20.00						
86/09/08	1000	WATER	0		.350	98.00	82.00						
86/09/08	1000	WATER	18		2.400	91.00	85.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

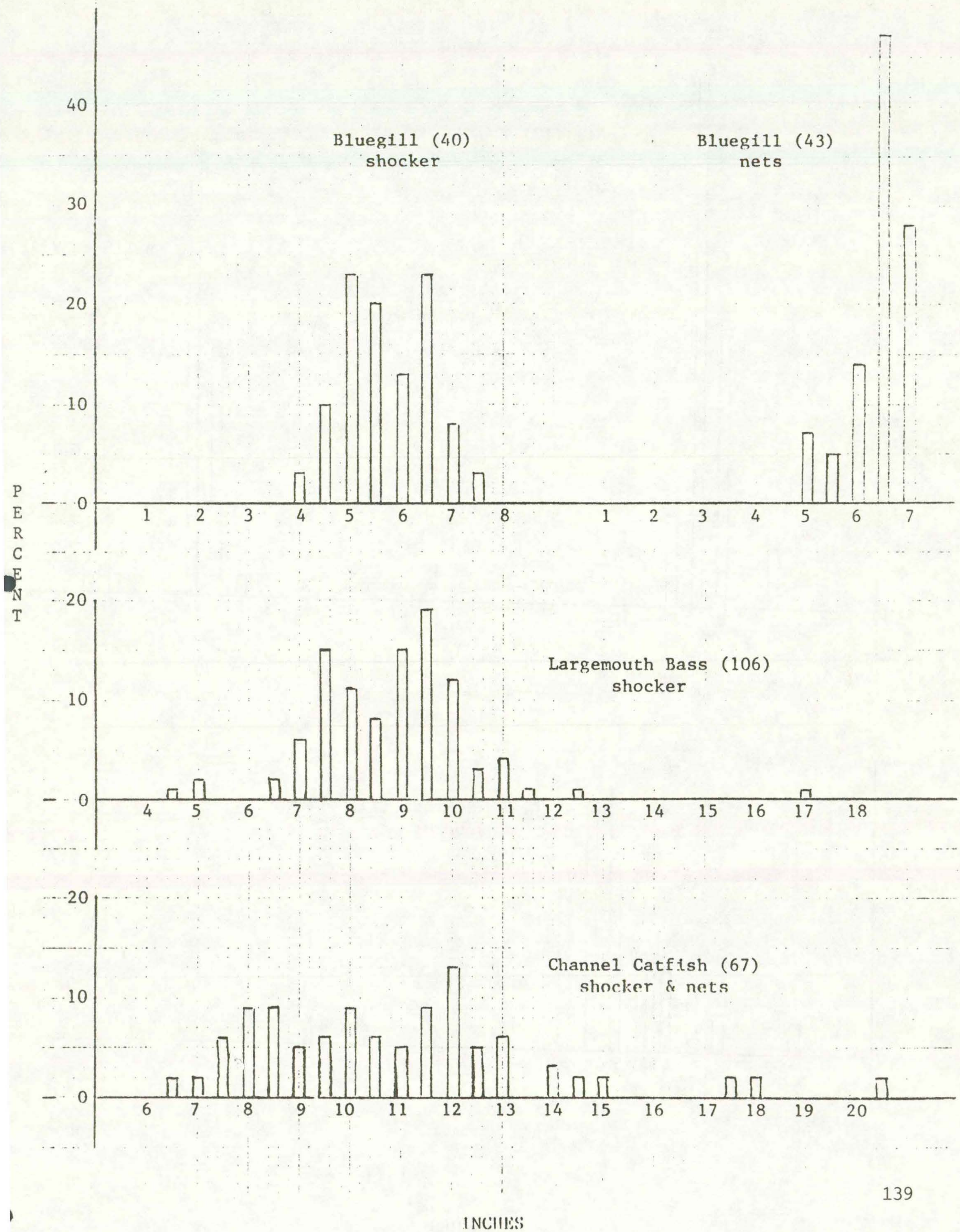
* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

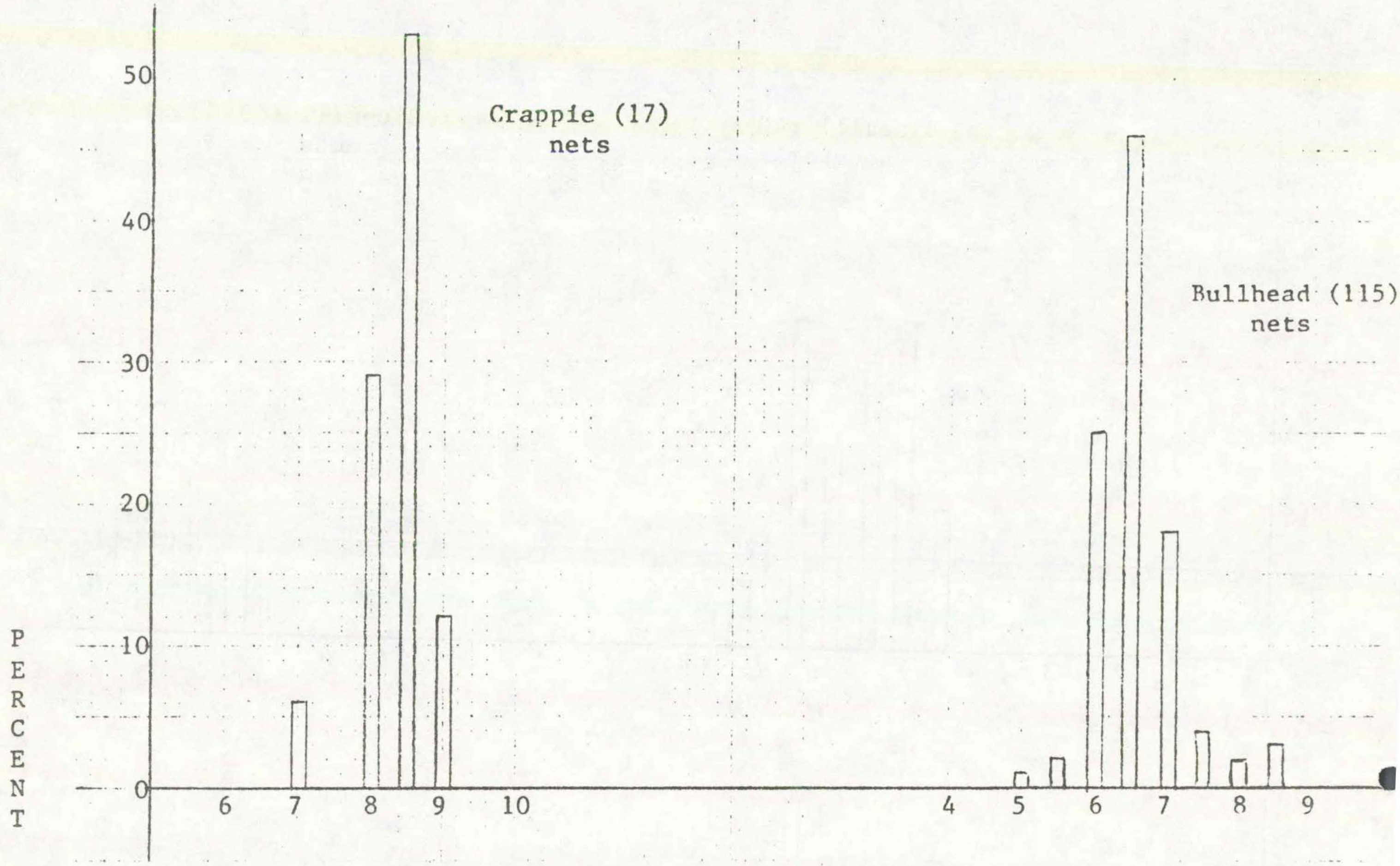
*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

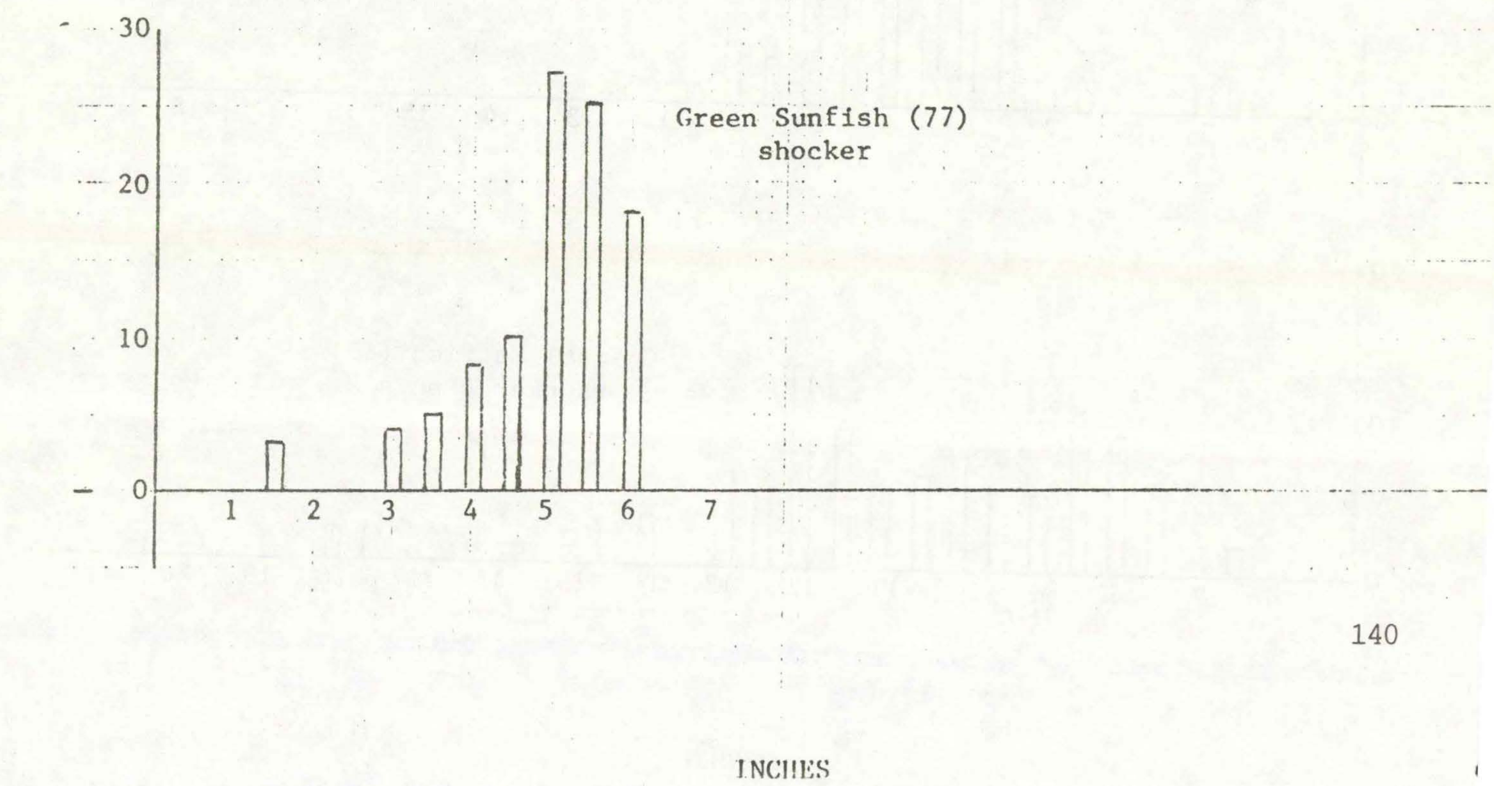
SIZE COMPOSITION, SELECTED SPECIES

KEOMAH LAKE 9/30/86, 10/1/86



KEOMAH LAKE 9/30/86, 10/1/86





LAKE KEOMAH, 1986

BACK-CALCULATED TOTAL LENGTHS (INCHES)

LARGEMOUTH BASS

Age Group	N	Annulus 1	2	3	4
I	4	4.4			
II	23	4.6	6.8		
III	0				
IV	1	5.8	12.2	14.4	15.4
Mean		4.6	7.1	14.4	15.4

BLUEGILL

Age Group	N	Annulus 1	2
I	10	4.1	
II	14	2.7	5.4
Mean		3.3	5.4

BLACK CRAPPIE

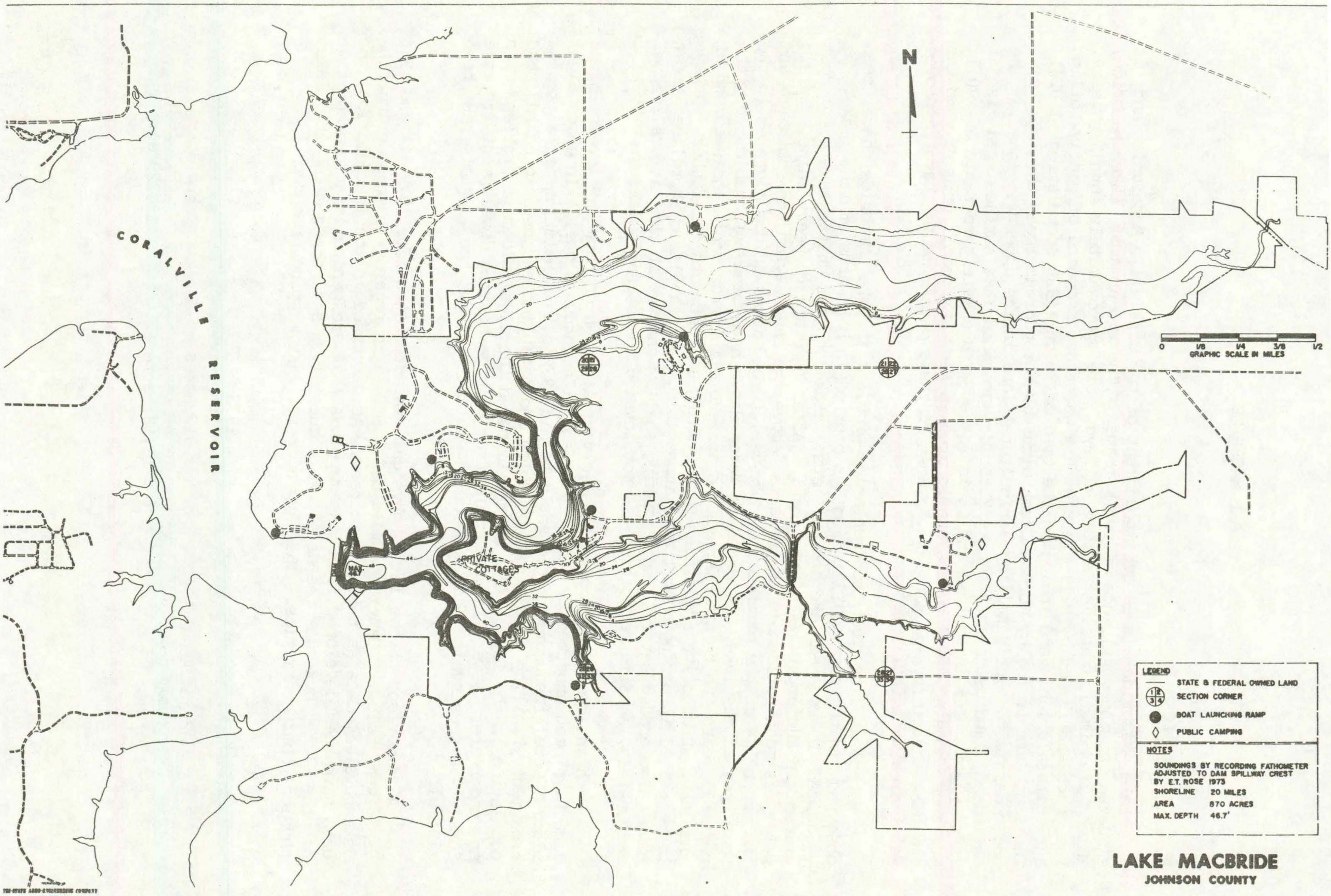
Age Group	N	Annulus 1	2	3
I	3	4.4		
II	12	4.3	7.1	
III	4	4.6	6.1	7.6
Mean		4.4	6.9	7.6

LAKE KEOMAH - RELATIVE WEIGHT OF SELECTED SPECIES - FALL 1986

Species	Length	W_r
Largemouth Bass	<8.0"	.92
Largemouth Bass	8.0 - 11.9"	.97
Largemouth Bass	≥12.0"	1.17
Bluegill	<6.0"	1.08
Bluegill	≥6.0"	1.08
Black Crappie	7.4 - 9.4"	.84
Channel Catfish	<11.0"	.78
Channel Catfish	11.0 - 15.9"	.80
Channel Catfish	≥16.0"	.95

LAKE KEOMAH, AREA-CAPACITY CHART
1986 DATA

Elevation	Surface Area (Acres)	Capacity (Acre Feet)
Spillway Crest	73.5	737
-2'	68.8	594
-4'	61.3	463
-6'	52.6	350
-8'	45.8	252
-10'	38.9	167
-12'	30.3	98
-14'	19.1	49
-16'	13.1	16
-18'	1.6	2


CORALVILLE RESERVOIR
N
PRIVATE COTTAGES
MAX. 46.7
0 1/8 1/4 3/8 1/2
GRAPHIC SCALE IN MILES
LEGEND
STATE & FEDERAL OWNED LAND
SECTION CORNER
BOAT LAUNCHING RAMP
PUBLIC CAMPING
NOTES
SOUNDINGS BY RECORDING FATHOMETER ADJUSTED TO DAM SPILLWAY CREST BY E.T. ROSE 1973
SHORELINE 20 MILES
AREA 870 ACRES
MAX. DEPTH 46.7'
LAKE MACBRIDE
JOHNSON COUNTY

LAKE MACBRIDE

Physical and Lake Impact Data

Lake Macbride is a subimpoundment of the Coralville Reservoir and is situated at the confluence of two streams. The two arms of Lake Macbride, which lie in the parallel stream valleys, are approximately equal in size. The north arm is fed by Mill Creek with a watershed composed of gently rolling agricultural land and including the town of Solon (1980 population 1,024). The south arm is fed by Jordan Creek with rough topography near the lake site and moderate to gently rolling agricultural land in the upper watershed. The estimated land usage in the Lake Macbride watershed/lake surface area is 76% in cropland, 14% in pasture and 6% in forest with a watershed ratio of 20:1. Numerous housing developments are located in the watershed, primarily in the immediate vicinity of the lake. Most of these developments have approved waste treatment facilities.

Water quality and sedimentation problems in Lake Macbride have been observed in the past. Siltation has ocurred in both arms of the lake, as evidenced by updated lake contour maps. Lake contour shifts have been most evident in the upper 1/4 of each arm. After moderate to heavy rains, turbid water is most noticeable in the areas above the causeway on the south arm and the upper 1/4 of the north arm. However, turbid water seldom migrates to the main body of the lake. Changes in water depth have been noticeable over the past 15 years due to silt deposition and shoreline erosion in the head end of the lake. Productive areas for sport fishing and net sets for fishery surveys have silted in making boat travel impossible. Unstabilized shoreline areas have also eroded several feet, making shallow shelves in the littoral zone. Fortunately, aquatic vegetation has not invaded these shallow areas.

With an absence of rooted aquatic vegetation, high nutrient levels in the lake have been absorbed by unicellular and filamentous algae. Intense algal blooms were frequent in the early to mid 1970's. Completion of a sewage treatment facility in the town of Solon and establishment of a gizzard shad population in the late 1970's have eliminated the algal blooms. Problems with an underwater sewer line, running from a large housing development to the Coralville Reservoir, have occurred in the past but the impact has been minimal.

A comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See Appendix for lake mapping procedure.)

	1973	1986
Surface Area	812 acres	825 acres
Maximum depth	47 feet	46.7 feet
Volume	13,131 acre ft.	13,229 acre ft.

Chemical Data

The physical and chemical data obtained in 1986 for Lake Macbride are listed in the table on page 146. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 36 to 85 inches with a mean (N = 3) of 62 inches. The 1979 Secchi readings ranged from 20 to 32 inches with an average (N = 3) of 28 inches.

Lake Macbride water temperature ranged from a low of 9.7°C in the June bottom sample to a high of 28°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with the 1986 data.

Dissolved oxygen (DO) values ranged from less than 1.0 mg/L in several bottom samples to 10.2 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 147, 148 and 149 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. The June profile reflects early summer conditions where both temperature and DO gradients had developed in Lake Macbride. The DO gradient was very defined, decreasing from 7.0 mg/L at a depth of 5 feet (1.5 meters) to <1 mg/L at 18 feet (5.5 meters). The June temperature gradient was more gradual, dropping from 24°C at the surface to 9°C near the bottom. In July, both the DO and temperature profiles were more defined than in June. The DO gradient was very sharp, decreasing from 7.2 mg/L at 10 feet to less than 1 mg/L at 12 feet. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The water temperature and density differentials from the surface to bottom prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom samples of less than 1 mg/L. The amount of DO depletion in the hypolimnion is dependent upon the amount of oxidizable matter present. Stratified lakes with water and sediment of high organic content frequently have no dissolved oxygen in the lower water layer. For all practical purposes there was no dissolved oxygen in Lake Macbride below 14 feet in June and below 12 feet in July. Therefore, during June and July only about 30% of the water column at that location was suitable for fish life.

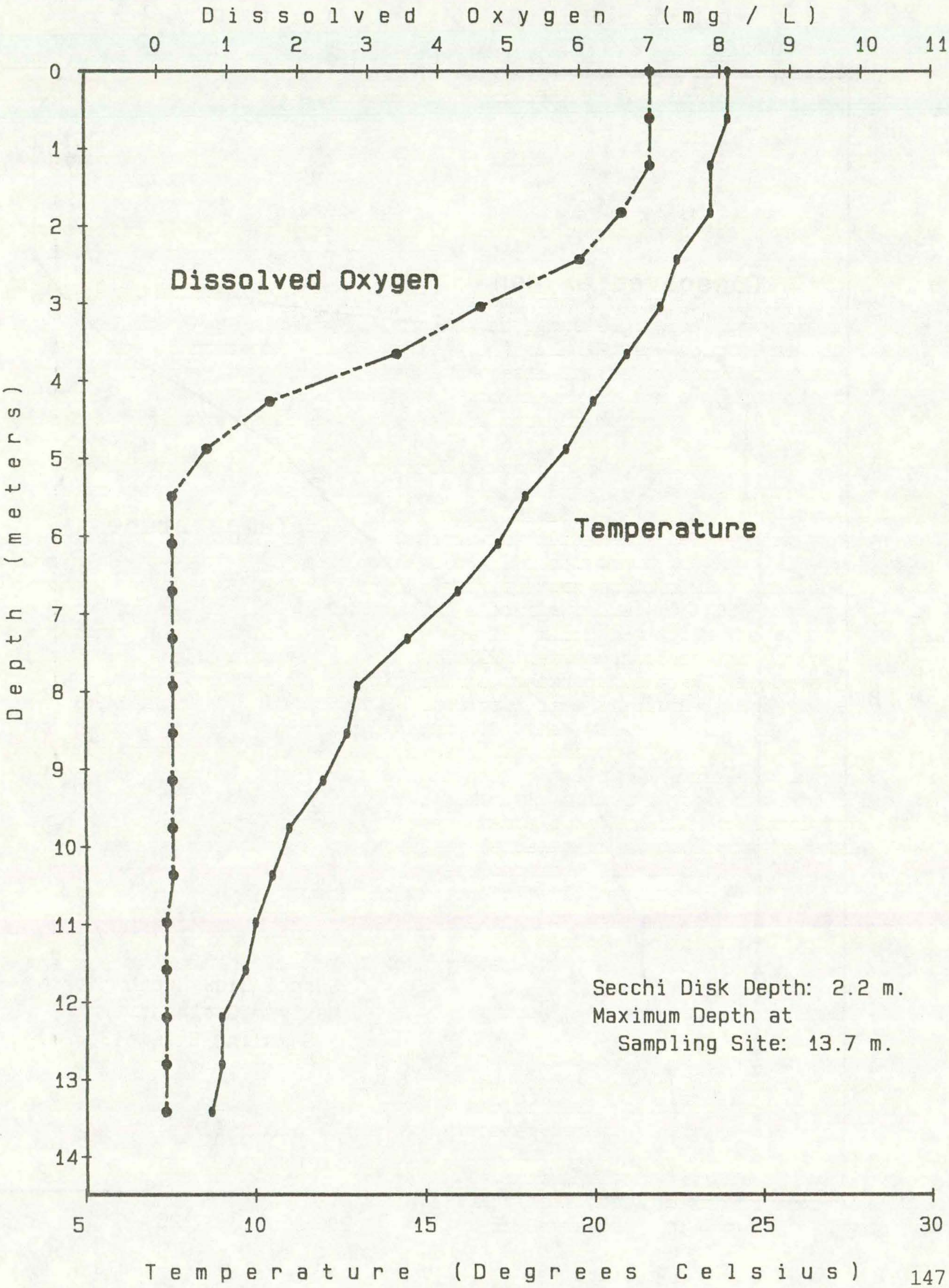
In September (page 149), cooling of water in the epilimnion reduced the water temperature and DO gradients. The temperature differential from top to to bottom was only 9°C (20°C to 11°C bottom) and dissolved oxygen, sufficient to sustain aquatic life (5.4 mg/L), extended to a depth of 20 feet. Later in the fall, as the lake water temperature and density become the same from top to bottom, mixing of the epilimnion and hypolimnion will take place and the DO concentration would be expected to become uniform throughout the water column. This phenomenon is called fall turnover and is typical of many Iowa lakes. A

Lake Macbride
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

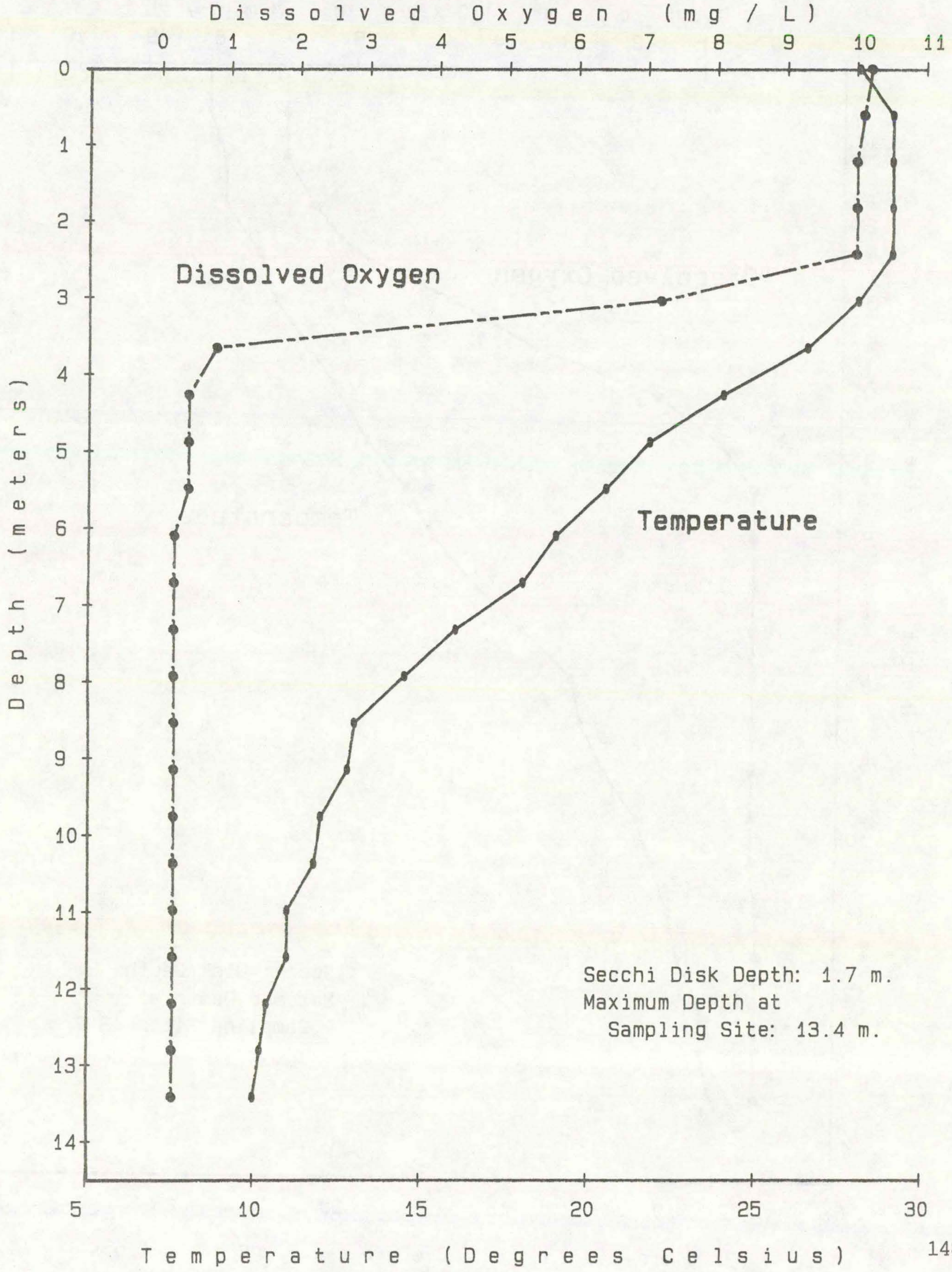
Date Collected	6/18/86			7/30/86			9/09/86		
*Depth[1]	0	11	38	0	11	40	0	24	42
*Secchi[2]	85			66			36		
*Temperature[3]	24	21.5	9.7	28	27	10.4	20	17	11
*Dissolved Oxygen	7.0	4.0	0.1	10.2	5.4	0.2	6.6	0.4	0.4
*pH[4]	8.5	8.5	7.7	9.0	9.0	7.7	9.0	8.3	7.5
Conductivity[5]	350	350	410	260	290	420	290	300	420
Ammonia Nitrogen	0.16	0.15	0.27	0.04	0.10	3.0	0.15	0.46	4.7
Nitrate-Nitrite Nitrogen	4.2	4.2	0.5	3.8	4.0	0.2	2.1	1.9	1.9
Suspended Solids	9	10	43	11	10	160	10	9	200
Total Phosphorus	0.07	0.12	0.18	0.04	0.04	0.13	0.10	0.10	1.2
Chlorophyll a (Corrected)[6]	3	3	3	15	10	19	23	17	64
Thermally Stratified		Yes			Yes			Yes	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

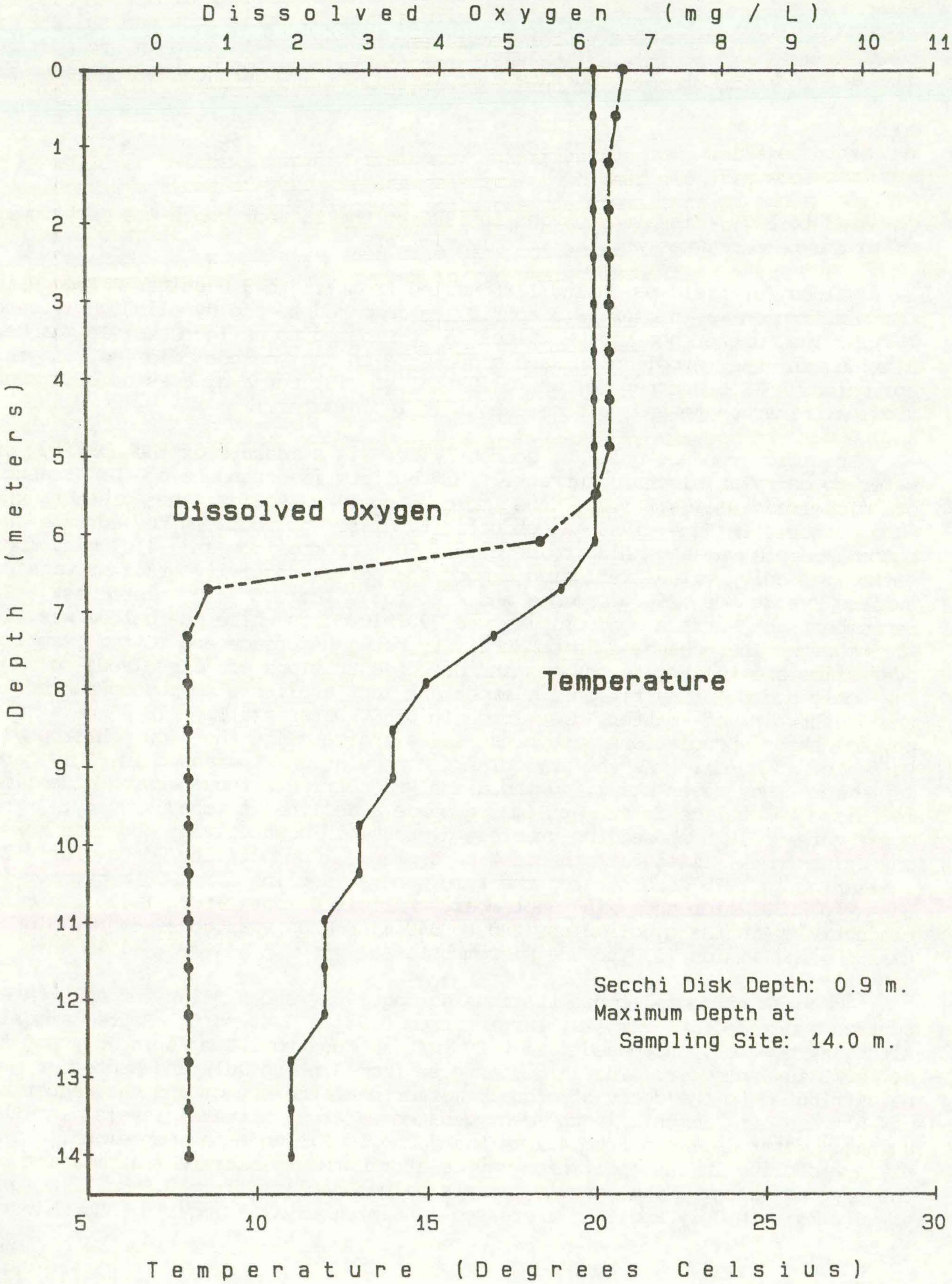
Lake MacBride
Dissolved Oxygen and Temperature Profile
June 18, 1986



Lake MacBride
Dissolved Oxygen and Temperature Profile
July 30, 1986



Lake MacBride
Dissolved Oxygen and Temperature Profile
September 9, 1986



comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

	August 29, 1979		July 30, 1986	
	Surface	16 feet	Surface	16 feet
DO (mg/L)	12.6	5.3	10.2	0.4
Temperature (°C)	25.6	22.8	28	21.8

Compared to 1979, dissolved oxygen in 1986 at the 16 foot depth was much lower while the temperatures were relatively similar.

Values for field pH during 1986 varied from 7.5 to 9.0 units. The pH in the epilimnion was higher (8.3 to 9.0) as compared to the hypolimnion (7.5 to 7.7). The difference in pH values is attributed to an increase in carbon dioxide in the hypolimnion and a decrease in the carbon dioxide in the epilmnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. In June, 1986, a conductivity difference between the surface and bottom sample was beginning to develop (350 micromhos top and 410 micromhos bottom). July values reflected a much sharper conductivity gradient with a surface value of 260 micromhos and a bottom value of 420 micromhos. In September, the surface conductivity was 290 micromhos while the bottom was 420 micromhos. The changes in conductivity between surface and bottom samples over time are related to changes in the concentrations of dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). In June, low phytoplankton populations were present (as indicated by the low chlorophyll value of 3 µg/L). As the phytoplankton populations increased in July and September they began utilizing the dissolved nutrients thus causing a decline in dissolved solids in the epilimnion hence a decline in conductivity. The upper water column showed the greatest decrease in conductivity because fewer phytoplankton existed at the lower depths. Conductivity data for the epilimnion in 1979 demonstrated the same general decline from 300 micromhos in June to 230 micromhos in September. Limited data for 1979 indicate conductivity in the hypolimnion (240 to 340 micromhos) was consistently higher than the epilimnion (230 to 300 micromhos).

Ammonia nitrogen concentrations during 1986 were similar for all three surface and mid-depth samples, ranging from 0.04 to 0.46 mg/L. Bottom ammonia nitrogen, however, increased from 0.27 mg/L in June to 3.0 mg/L in July and to 4.7 mg/L in September. The large increase from June to July and September may be attributed to the decay of orgnaic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate levels in the surface water declined from 4.2 mg/L in June to 2.1 mg/L in September. The nitrate decline in the epilimnion may be attributed to nitrate assimilation by the phytoplankton. Hypolimnetic nitrate values declined from 0.5 mg/L in June to 0.2 mg/L in July and then increased in September (1.9 mg/L). Hutchinson

(3) believes that nitrate declines as observed in July are due to nitrate being reduced to ammonia in the deoxygenated hypolimnion. The limited nitrogen data for 1979 does not allow for any comparison to 1986 data (one surface sample for ammonia of 0.20 mg/L and a nitrate of 0.21 mg/L measured in September).

During 1986, suspended solids ranged from 9 mg/L to 200 mg/L with the bottom sample values consistently higher than the surface values. A smaller range was measured in 1979 (9 to 36 mg/L) for suspended solids with no substantial difference between surface and bottom samples.

Total phosphorus concentrations in the 1986 surface samples ranged from 0.04 mg/L to 0.12 mg/L as compared to 0.13 and 1.2 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. In the oxygen deficient part of the hypolimnion, phosphorus levels remained about the same from June (0.18 mg/L) to July (0.13 mg/L) and increased in September (1.2 mg/L). It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. During the 1979 sampling, total phosphorus ranged from 0.04 to 0.22 mg/L with no major difference between top and bottom samples.

Chlorophyll values are an indirect measurement of the phytoplankton populations. The 1986 corrected chlorophyll a values in the epilimnion ranged from 3 µg/L to 23 µg/L. The June epilimnion corrected chlorophyll a value was lowest while the September value was greatest. The higher corrected chlorophyll value in September indicates greater algal growth at that time. Hypolimnetic corrected chlorophyll values ranged from 3 µg/L to 64 µg/L with the highest value occurring in September. Corrected chlorophyll a values in the 1979 epilimnion averaged 40 µg/L for 2 July, 27 µg/L for 31 July and 38 µg/L for September.

Biological Data

Lake Macbride hosts a wide variety of fish species. Major sport fishes include largemouth bass, spotted bass, white bass, walleye, white crappie, black crappie, bluegill, channel catfish, flathead catfish, and bullhead. Other species of lesser importance include carp, buffalo, carpsucker and yellow perch.

Fisheries surveys were conducted in Lake Macbride during the first week of August, 1986. An electrofishing survey was also conducted in early October to capture sufficient numbers of crappie for a population assessment. Data analysis sheets are included, listing statistical parameters and length frequency distributions of individual populations. A listing of the species samples and a biological assessment follows.

Largemouth Bass - Population indexes are within normal limits for a healthy population. Broad based year class strengths are indicated by length frequency graphing. Strong year classes of juvenile bass are evident with a mean length of approximately 8 inches in the sample. Age and growth data corresponds with average growth rates in Iowa waters. Compared with age and growth data from a 1982 study in Lake Macbride, largemouth bass exhibited improved growth rates in 1986.

Spotted Bass - The condition of the spotted bass population is similar to the largemouth bass population, which is within accepted standards. Catch per effort and the size range of both species of bass sampled were similar. Mean length of spotted bass sampled was larger and is reflected in the length frequency graph. Age and growth determination is similar to Missouri and Illinois stream populations and is equivalent to findings of a 1982 bass population study in Lake Macbride.

Walleye - The length frequency distribution of walleye captured illustrates a range of year classes present. Two year old fish were dominate although the time of sampling could influence the prevalence of adult walleye in the sample. Age and growth data are above average for Iowa waters. Improvements in growth were seen from data collected in 1980 but the sample size was smaller in 1986 and limited to two year classes.

Crappie - Data collected illustrates a productive crappie population. Length frequency distribution illustrates multiple year classes, and the mean length of crappie sampled was nearly nine inches. The proportional stock density (PSD) of the sample was high with a value of 84% but juvenile fish were not in shoreline areas as expected, due to cool weather. Age and growth data are above average for this region and growth increments for older fish were exceptional.

Bluegill - As with all species sampled in Lake Macbride, the bluegill population data is within accepted standards for a healthy population. Mean length of bluegill sampled was very near the minimum acceptable size for anglers and WR (fish condition) values were above average. Age and growth data were also average for populations in Midwest waters.

Channel Catfish - Channel catfish numbers were not sufficient in the sample to get an index of their condition. Sampling of Lake Macbride by Hill in 1982 indicated a strong population of channel catfish with a biomass of 87 pounds/acre and 81% acceptability to the angler.

Species Composition of Sample

Species	Number	Percent
Largemouth Bass	71	21
Spotted Bass	66	20
Walleye	47	14
Black Crappie	50	15
Bluegill	100	30
TOTAL	334	100

SUMMARY

Although the data presented in the report are rather limited, it is possible to make several general statements.

> Since 1979, the volume in Lake Macbride has declined as a result of siltation which has been most notable in the two upper arms. The best possible land use practices should be applied to the watershed in an effort to slow the rate of siltation. Compared to 1979, water clarity in the main lake has improved while dissolved oxygen depletion in the hypolimnion has increased. No other major changes in lake water quality appear to have occurred from 1979 to 1986. Continued monitoring is necessary to determine long term trends in water quality.
>
> In general, fish growth and population structure are within normal limits. Continued assessment of the fisheries will allow for maximizing its potential.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00542 995200301000
41 48 00.0 091 34 00.0 5
DEEPEST PART LAKE MACBRIDE- 4MI W SOLON
19103 IOWA JOHNSON
IOWA RIVER BASIN 071000
IOWA R-LAKE MACBRIDE T081NR06WSC29
21IOWA 801004 07080208 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/06/26		WATER	0	24.10		.80	300	12.30		8.60			
79/06/26		WATER	6				310	12.10		8.70			
79/06/26		WATER	13				340	9.20		8.40			
79/06/26 CP(1)- 79/06/26	REP	WATER	0	.00		.80	300			8.50			
79/06/26 CP(1)- 79/06/26	REP	WATER	6				300			8.50			
79/06/26 CP(1)- 79/06/26	REP	WATER	13				320			8.60			
79/06/27		WATER	0								11		
79/06/27		WATER	6								11		
79/06/27		WATER	13								11		
79/07/30		WATER	0	26.40		.80	250	7.80		8.40	9		
79/07/30		WATER	3				220	7.30		8.50	10		
79/07/30		WATER	9				250	7.00		8.50	33		
79/07/30 CP(1)- 79/07/30	REP	WATER	0	.00		.80	250	7.60		8.40			
79/08/29		WATER	0	.00		.50	230	12.60		9.00	14	.200	.21
79/08/29		WATER	3				230	12.00		9.60	15		
79/08/29		WATER	9				230	11.60		9.10	15		
79/08/29		WATER	16				240	5.30		8.50	36		
79/08/29 CP(1)- 79/08/29	REP	WATER	0	7.80		.50						.210	.17
79/08/29 CP(1)- 79/08/29	REP	WATER	16				240			8.50			
86/06/18	0930	WATER	0	24.00	85.0		350	7.00	8.50	8.20	9	.160	4.20
86/06/18	1000	WATER	11	21.50			350	4.00	8.50	8.10	10	.150	4.20
86/06/18	1015	WATER	38	9.70			410	.10	7.70	8.10	43	.270	.50
86/07/30	0800	WATER	0	28.00	66.0		260	10.20	9.00	8.40	11	.040	3.80
86/07/30	0845	WATER	11	27.00			290	5.40	9.00	8.00	10	.100	4.00
86/07/30	0900	WATER	40	10.40			420	.20	7.70	7.10	160	3.000	.20
86/09/09	1020	WATER	0	20.00	36.0		290	6.60	9.00	8.20	10	.150	2.10
86/09/09	1030	WATER	24	17.00			300	.40	8.30	8.00	9	.460	1.90
86/09/09	1035	WATER	42	11.00			420	.40	7.50	7.10	200	4.700	1.90

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00542 995200301000
41 48 00.0 091 34 00.0 5
DEEPEST PART LAKE MACBRIDE- 4MI W SOLON
19103 IOWA JOHNSON
IOWA RIVER BASIN 071000
IOWA R-LAKE MACBRIDE T081NR06WSC29
21IOWA 801004 07080208 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/06/26		WATER	0	.11									
79/06/26		WATER	6	.16									
79/06/26		WATER	13	.14									
79/06/27		WATER	0				37.40						
79/06/27		WATER	6				43.40						
79/06/27		WATER	13				19.50						
79/07/30		WATER	0	.22			28.40						
79/07/30		WATER	3	.23			26.90						
79/07/30		WATER	9	.23			22.80						
79/08/29		WATER	0	.15			40.40						
79/08/29		WATER	3	.18			35.20						
79/08/29		WATER	9	.18			40.40						
79/08/29		WATER	16	.69			24.70						
86/06/18	0930	WATER	0		.070	5.00	3.00						
86/06/18	1000	WATER	11		.120	6.00	3.00						
86/06/18	1015	WATER	38		.180	11.00	3.00						
86/07/30	0800	WATER	0		.040	21.00	15.00						
86/07/30	0845	WATER	11		.040	21.00	10.00						
86/07/30	0900	WATER	40		.130	98.00	19.00						
86/09/09	1020	WATER	0		.100	26.00	23.00						
86/09/09	1030	WATER	24		.100	25.00	17.00						
86/09/09	1035	WATER	42		1.200	173.00	64.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

LAKE MACBRIDE
8/6/86

SPECIES: BLUEGILL

EFFORT: 2 HOURS SHOCKING

NUMBER OF FISH IN SAMPLE: 100

FISH SHOCKED PER HOUR: 50

RANGE OF BLUEGILL SAMPLED: 100 MM TO 200 MM

MEAN LENGTH OF FISH SAMPLED (MM): 147

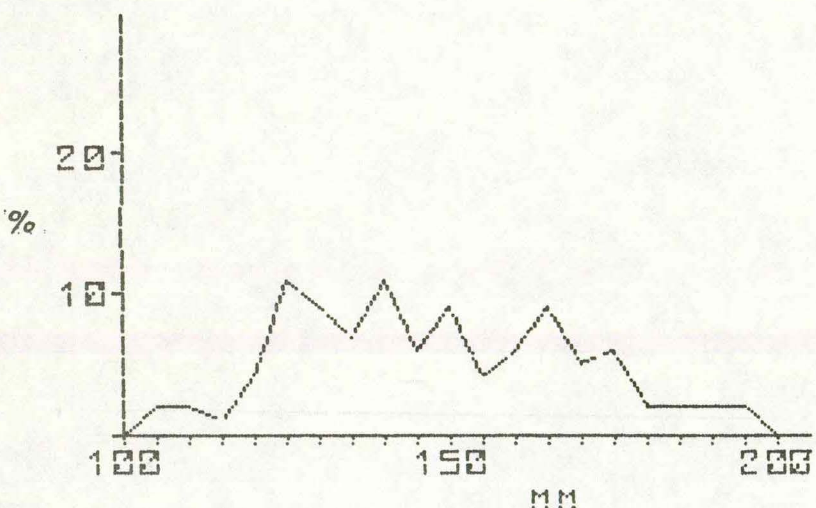
MEAN WEIGHT OF FISH SAMPLED: 67.5 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-4.33263713 + 2.84145654 LOG L

WR OF SAMPLE: 103

PSD OF SAMPLE: 47 %

LENGTH FREQUENCY DISTRIBUTION OF BLUEGILL, EXPRESSED IN PERCENT OF TOTAL SAMPL



LAKE MACBRIDE
8/6/86

SPECIES: LARGEMOUTH BASS

EFFORT: 2 HOURS SHOCKING

NUMBER OF FISH IN SAMPLE: 71

FISH SHOCKED PER HOUR: 35.5

RANGE OF LARGEMOUTH BASS SAMPLED: 50 MM TO 470 MM

MEAN LENGTH OF FISH SAMPLED (MM): 193

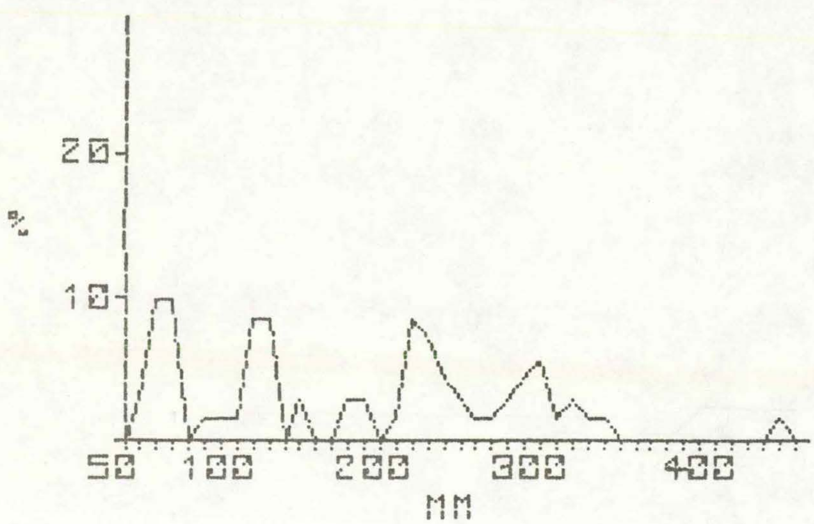
MEAN WEIGHT OF FISH SAMPLED: 92.7 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-5.40327658 + 3.22539874 LOG L

WR OF SAMPLE: 99

PSD OF SAMPLE: 36 %

LENGTH FREQUENCY DISTRIBUTION OF LARGEMOUTH BASS, EXPRESSED IN PERCENT OF TOTAL SAMPLE.



LAKE MACBRIDE
8/6/86

ECIES: SPOTTED BASS

EFFORT: 2 HOURS SHOCKING

UMBER OF FISH IN SAMPLE: 66

ISH SHOCKED PER HOUR: 33

RANGE OF SPOTTED BASS SAMPLED: 50 MM TO 380 MM

EAN LENGTH OF FISH SAMPLED (MM):   243

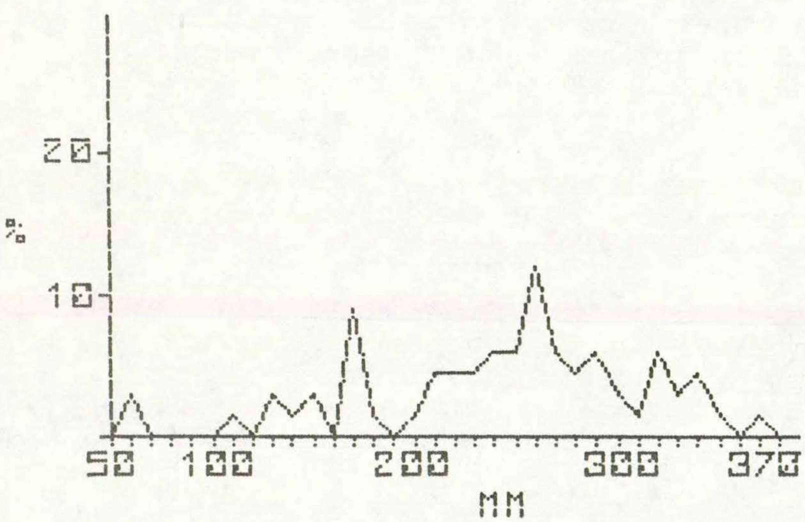
MEAN WEIGHT OF FISH SAMPLED: 199.1 GRAMS

EIGHT/LENGTH FORMULA IS: LOG W =-5.57895641 + 3.30303642 LOG L

R OF SAMPLE: 100

PSD OF SAMPLE: 40 %

LENGTH FREQUENCY DISTRIBUTION OF SPOTTED BASS, EXPRESSED IN PERCENT OF TOTAL SAM
LE.



LAKE MACBRIDE
8/6/86

SPECIES: WALLEYE

EFFORT: 2 HOURS SHOCKING

NUMBER OF FISH IN SAMPLE: 47

FISH SHOCKED PER HOUR: 23.5

RANGE OF WALLEYE SAMPLED: 190 MM TO 430 MM

MEAN LENGTH OF FISH SAMPLED (MM): 294

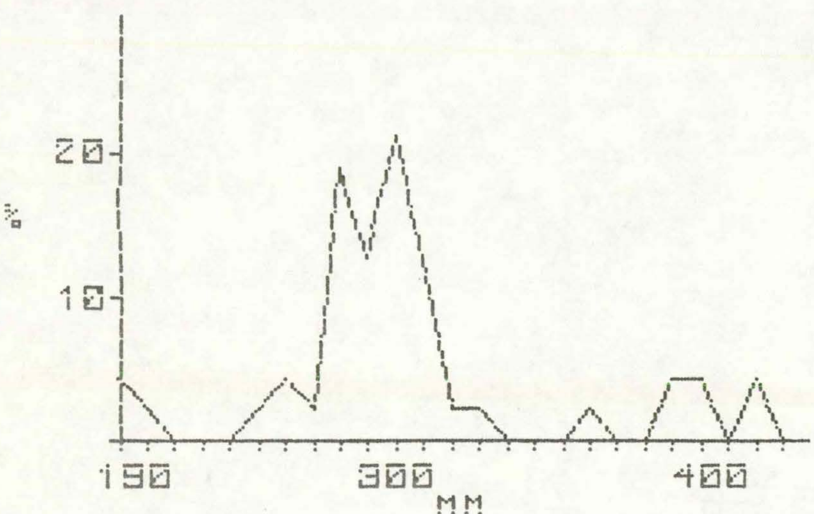
MEAN WEIGHT OF FISH SAMPLED: 256.0 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-2.86510238 + 2.13690946 LOG L

WR OF SAMPLE: [illegible]

PSD OF SAMPLE: 14 %

LENGTH FREQUENCY DISTRIBUTION OF WALLEYE, EXPRESSED IN PERCENT OF TOTAL SAMPLE



LAKE MACBRIDE
10/9/86

PECIES: BLACK CRAPPIE

FFORT: 1 HOURS SHOCKING

UMBER OF FISH IN SAMPLE: 50

ISH SHOCKED PER HOUR: 50

ANGE OF BLACK CRAPPIE SAMPLED: 135 MM TO 265 MM

IEAN LENGTH OF FISH SAMPLED (MM): 218

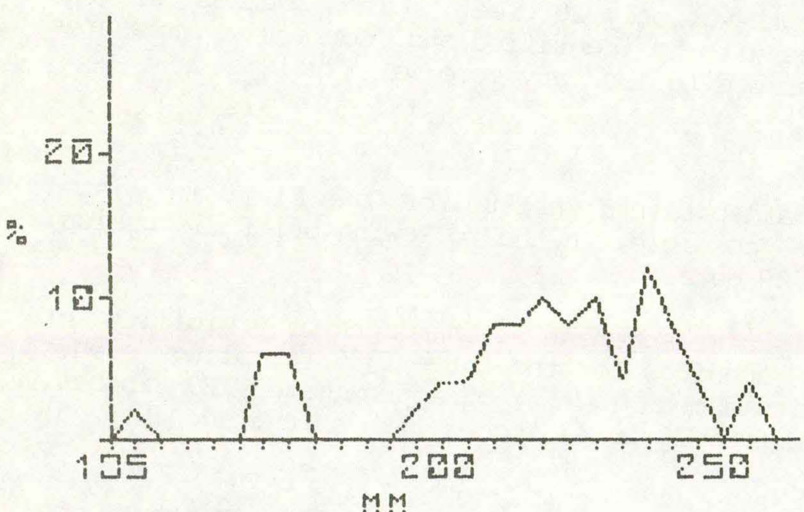
IEAN WEIGHT OF FISH SAMPLED: 163.4 GRAMS

IEIGHT/LENGTH FORMULA IS: LOG W =-5.82472428 + 3.4367025 LOG L

IR OF SAMPLE: 97

'SD OF SAMPLE: 84 %

.ENGTH FREQUENCY DISTRIBUTION OF BLACK CRAPPIE, EXPRESSED IN PERCENT OF TOTAL S
IPLE.



LAKE MIAMI

Physical and Lake Impact Data

Lake Miami is located in Monroe County approximately 3.5 miles southeast of Lovilla, Iowa. Lake Miami's 3,735 acre watershed is in cropland (28%), pasture (34%), forest (9%) and other land uses (19%). The water quality of Lake Miami varies considerably, depending on duration and/or intensity of precipitation. During "wet" years the lake remains turbid much of the time, but during "drier" years there is a noticeable decrease in lake turbidity. Three silt retention dams constructed in 1978 have helped to alleviate siltation into the lake; however, a significant amount of siltation appears to be continuing below the silt dams and about one-half of the watershed remains uncontrolled.

A map of Lake Miami developed from 1986 data may be found on page 166. In addition a comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures).

	1979*	1986
Surface Area	140 acres	122 acres
Maximum depth	24 ft.	20 ft.
Volume	1,336 acre ft.	1,158 acre ft.

Based on 1986 data for Lake Miami, it is apparent that the lake has lost water volume due to siltation. The maximum water depth in 1979 was 24 feet while in 1986 the maximum depth was only 20 feet. The sources of the additional siltation problem need to be identified and corrective measures implemented as the lake cannot afford to lose any more water volume.

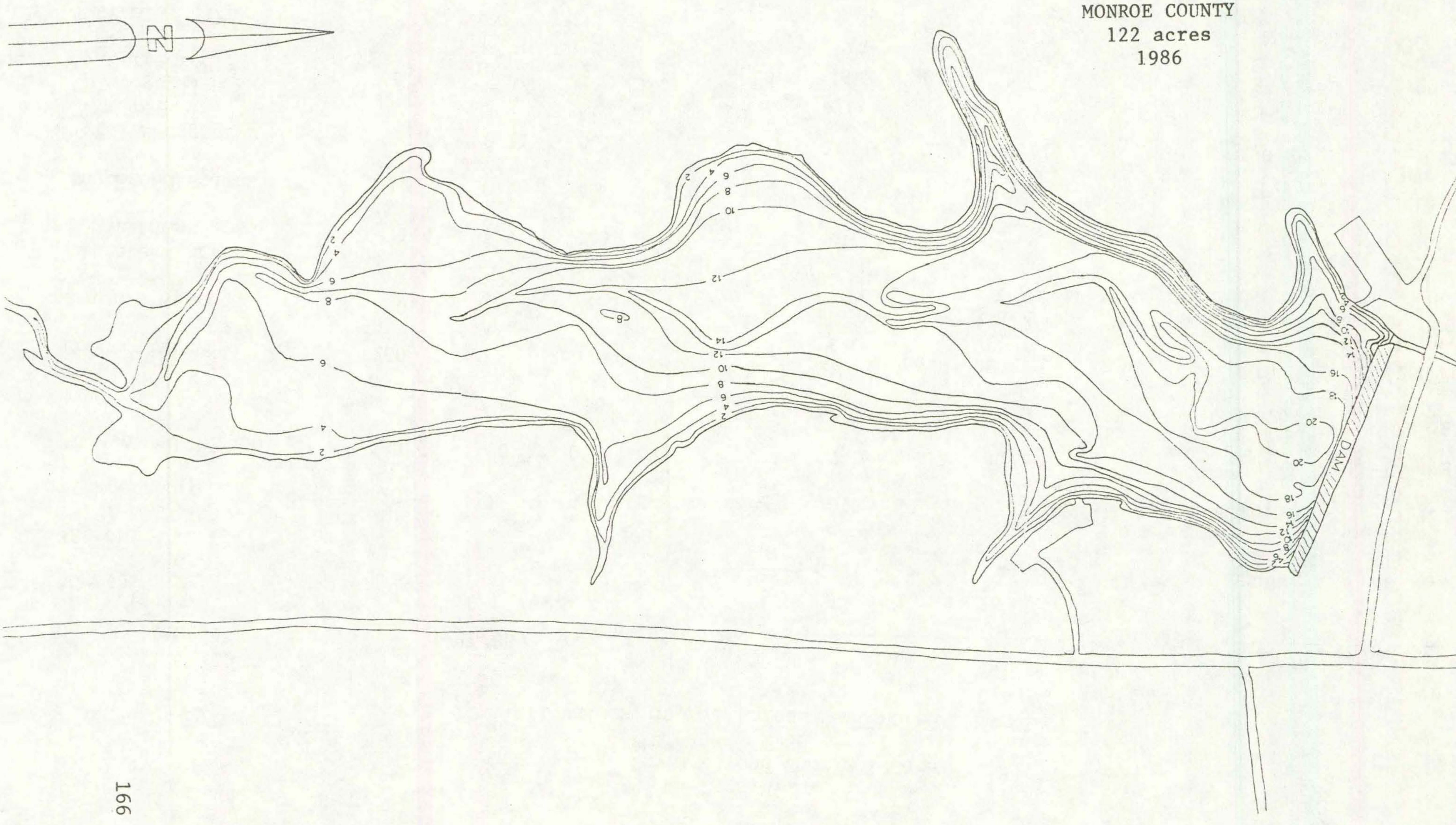
Chemical Data

The physical and chemical data obtained in 1986 for Lake Miami are listed in the table on page 167. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 22 to 37 inches with a mean (N = 3) of approximately 29 inches. The 1979 Secchi readings ranged from 28 to 47 inches with an average (N = 3) of 35 inches.

Lake Miami water temperature ranged from a low of 15.5°C in the June bottom sample to a high of 28.8°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Although limited data for 1979 does not allow for comparison with 1986 data the 1979 surface water temperature ranged from approximately 20°C to 27°C during the sampling period.

LAKE MIAMI
MONROE COUNTY
122 acres
1986



Lake Miami
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/16/86			7/23/86			9/08/86	
*Depth[1]	0	8	15	0	13	16	0	18
*Secchi[2]	22			37			28	
*Temperature[3]	25	21	15.5	28.8	21	17.2	20.5	19.8
*Dissolved Oxygen	8.6	1.0	0.0	9.8	0.2	0.2	7.4	4.2
*pH[4]	9.0	7.5	7.0	9.5	9.0	8.0	9.0	8.5
Conductivity[5]	260	260	250	260	260	290	260	260
Ammonia Nitrogen	0.07	0.14	0.24	0.08	1.6	1.4	0.03	0.07
Nitrate-Nitrite Nitrogen	1.4	1.6	1.5	<0.1	<0.1	<0.1	<0.1	<0.1
Suspended Solids	12	20	34	10	10	18	12	12
Total Phosphorus	0.09	0.11	0.14	0.14	0.26	0.24	0.25	0.25
Chlorophyll a (Corrected)[6]	17	10	2	46	22	8	35	29
Thermally Stratified	Yes			Yes			No	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

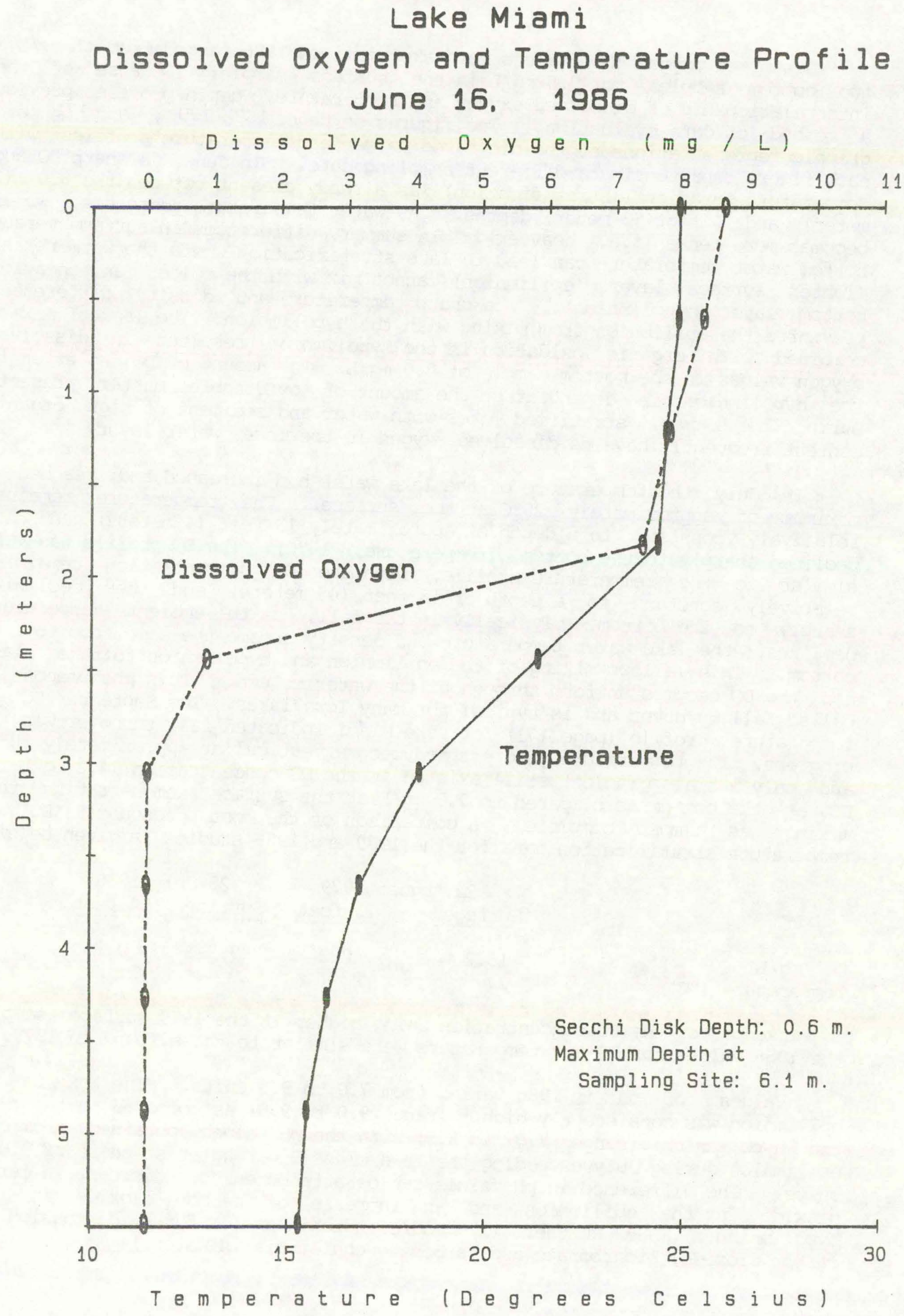
Dissolved oxygen (DO) values for Lake Miami in 1986 ranged from <1 mg/L in two bottom samples to 9.8 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 169, 170, and 171 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling date. In June, a sharp DO and temperature gradient (stratification) was already present between the 6.0 (2 meter) and 10 foot (3 meter) depths. As water temperature decreases, water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperature can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The sharp temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom sample of 0.0 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. During the summer, stratified lakes with water and sediment of high organic content frequently have no dissolved oxygen in the lower water layer.

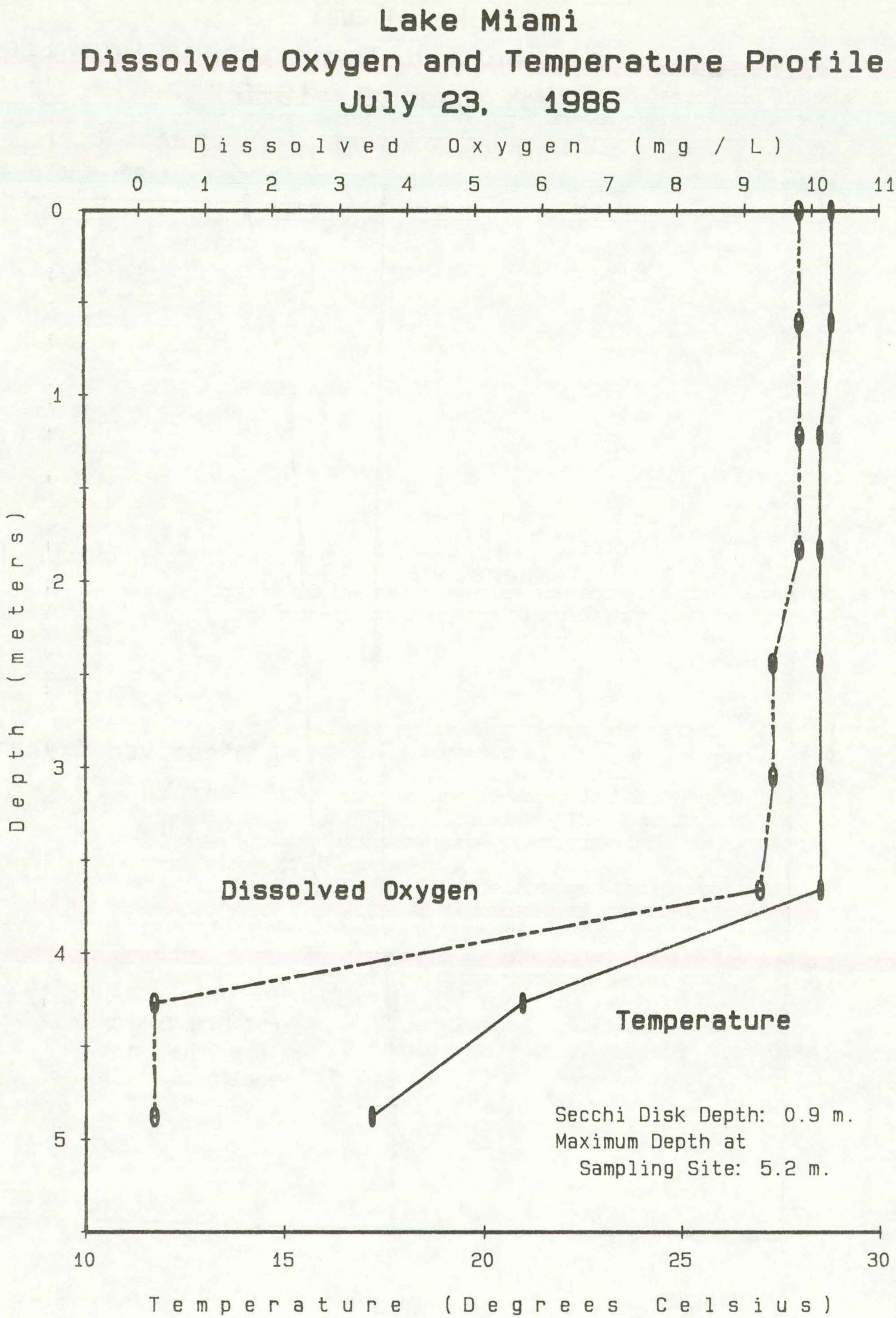
In July the temperature of the lake water had increased and reached a maximum of approximately 29°C at the surface. The temperature remained relatively constant to a depth of approximately 13 feet (4 meters) and then declined sharply to the bottom (temperature, 17°C). The DO profile was very similar to the temperature profile, with the DO concentration remaining relatively constant to a depth of 13 feet (4 meters) and then declining sharply to the bottom. Typically in the fall, as the ambient temperature declines, the lake water temperature and density become the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 171) for Lake Miami indicated fall turnover was in progress. The temperature gradient had become vertical at approximately 20°C, and only a small gradient still existed in the DO concentration (4.2 mg/L of DO at the bottom as compared to 7.7 mg/L at the surface) demonstrating that mixing was almost complete. A comparison of the most pronounced DO and temperature stratification data for the 1979 and 1986 studies is given below.

	22 August 1979		23 July 1986	
	Surface	13 feet	Surface	14 feet
DO (mg/L)	13.2	0.2	9.8	0.2
Temperature (°C)	27	23	29	21

Except for the DO concentration being higher in the 1979 surface sample, the 1986 values for DO and temperature were similar to those found in 1979.

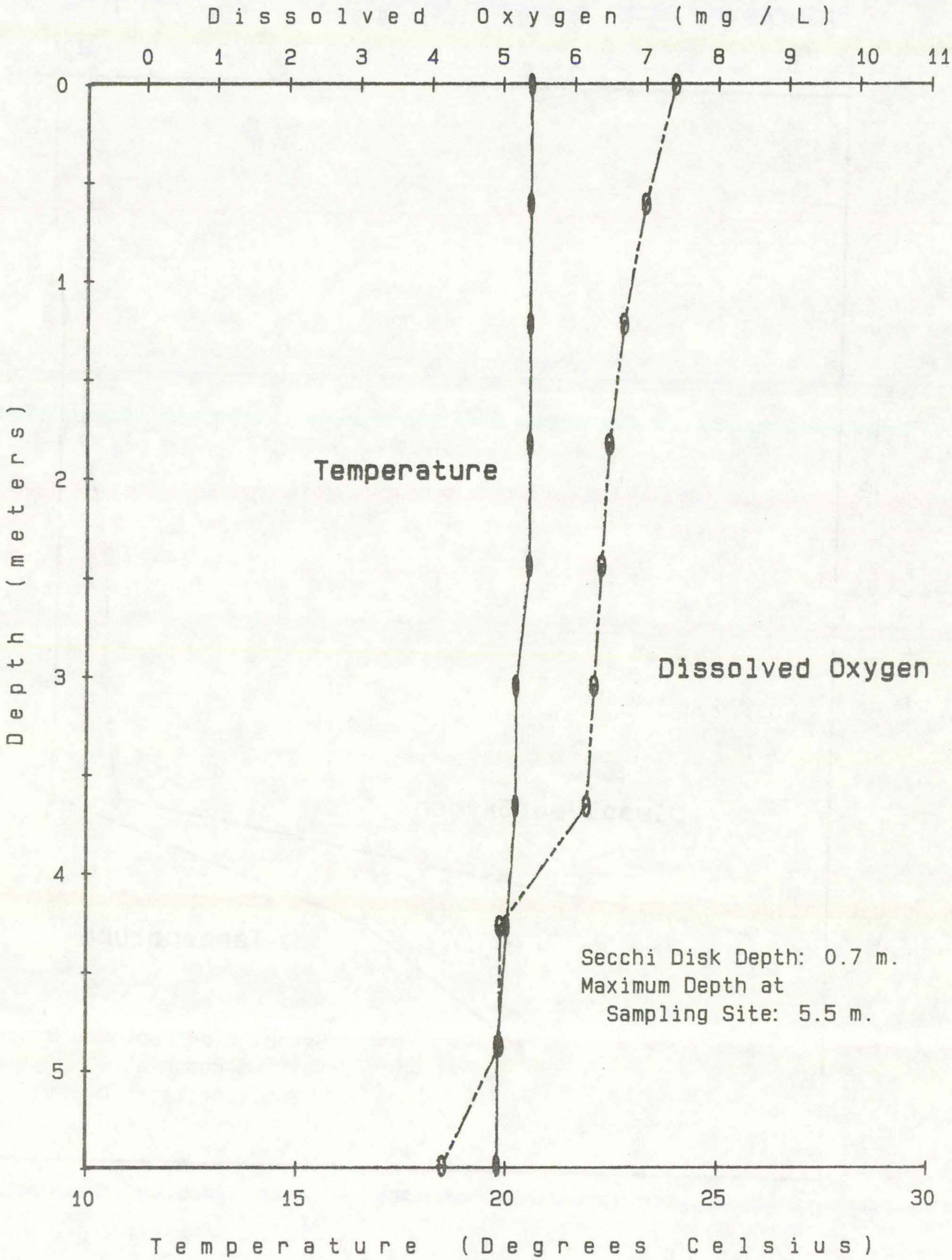
Values for pH in 1986 varied from 7.0 to 9.5 units. The pH in the epilimnion was consistently higher (range 9.0 to 9.5) as compared to the pH of the hypolimnion (range 7.0 to 8.5) with the pH values obtained from the epilimnion during July exceeding the Iowa class B warmwater standard of 9.0 pH units. The difference in pH values can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)


Lake Miami
Dissolved Oxygen and Temperature Profile
June 16, 1986
Dissolved Oxygen (mg / L)
0
1
2
3
4
5
6
7
8
9
10
11
Depth (meters)
0
1
2
3
4
5
Dissolved Oxygen
Temperature
Secchi Disk Depth: 0.6 m.
Maximum Depth at
Sampling Site: 6.1 m.
10
15
20
25
30
Temperature (Degrees Celsius)



Lake Miami
Dissolved Oxygen and Temperature Profile
July 23, 1986
Dissolved Oxygen (mg / L)
0 1 2 3 4 5 6 7 8 9 10 11
Depth (meters)
0 1 2 3 4 5
Dissolved Oxygen
Temperature
Secchi Disk Depth: 0.9 m.
Maximum Depth at
Sampling Site: 5.2 m.
10 15 20 25 30
Temperature (Degrees Celsius)

Lake Miami
Dissolved Oxygen and Temperature Profile
September 8, 1986



Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. Values for specific conductance in 1986 were very similar (ranging from 250 to 290 umhos) throughout the water column for all sampling periods. Conductivity data from the 1979 study (1) also reflected this uniformity between sampling periods and within the water column.

During 1986, except for two elevated values found in the hypolimnion in July (1.6 and 1.4 mg/L), the ammonia nitrogen concentration remained at relatively low levels (0.03 to 0.24 mg/L) throughout the three sampling periods. The increase in ammonia with depth and the elevated hypolimnetic values observed in July may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate nitrogen levels in the water were highest in June (1.4 to 1.6 mg/L) and declined to <0.1 mg/L in both July and September. The decline in the nitrate concentration in the epilimnion can be attributed to assimilation by the phytoplankton and other plant life. The limited nitrogen data for 1979 does not allow for any comparison to the 1986 data (one surface sample for nitrate of 0.06 mg/L and ammonia of 0.80 mg/L).

Suspended solids in 1986 ranged from 10 mg/L to 34 mg/L with the higher values being found in the bottom samples. The higher bottom solids values can be attributed to the settling of material from the upper water layers and include turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter. During the 1979 study suspended solids ranged from 5 to 19 mg/L with no discernable pattern.

Total phosphorus concentrations in surface samples in 1986 ranged from 0.09 mg/L to 0.25 mg/L as compared to 0.14 to 0.26 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The slightly lower value of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part of the hypolimnion, phosphorus levels were slightly higher for each sampling period than those of the epilimnion. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation of phosphorus from the sediment by reduction. The same general trends were found during the 1979 sampling of Lake Miami. Total phosphorus in 1979 ranged from 0.04 to 0.23 mg/L with no discernable pattern.

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986 the corrected chlorophyll _a_ values ranged from 2 µg/L to 46 µg/L. The corrected chlorophyll _a_ value was lowest in June and higher in both July (46 µg/L) and September (35 µg/L). Chlorophyll _a_ values in the 1979 study averaged 21 µg/L for July, 49 µg/L for August and 42 µg/L for September. Chlorophyll data for both 1979 and 1986 indicated average phytoplankton populations.

Biological Data

A fisheries survey was conducted on Lake Miami on September 22 and 23, 1986. Six pound nets were used overnight and an electrofishing unit was utilized for 83 minutes. Species composition and relative abundance are shown below.

Species	Nets	Shocker	Total No.	Total Percent
Bluegill	81	107	188	35
White Crappie	40	16	56	11
Black Crappie	11	1	12	2
Largemouth Bass	1	59	60	11
Redear	47	24	71	13
Black Bullhead	6	1	7	1
Channel Catfish	121	3	124	23
Walleye	1		1	<1
Carp	1		1	<1
Northern Pike	1		1	<1
Green Sunfish		9	9	2
Golden Shiner		3	3	<1
Total	310	223	533	

Length-frequency graphs of the major species are shown in the appendix. The relative weight and back-calculated total lengths may also be found in the appendix.

Summary

Although the data presented in this report are rather limited it is possible to make several general statements

> Since 1979, the volume of water in Lake Miami has declined as a result of siltation. The possibility of additional soil conservation practices for the near vicinity should be evaluted.
>
> Although the 1986 dissolved oxygen and temperature profiles were not quite as pronounced as compared to the 1979 data there have been no major changes in lake water quality from 1979 to 1986. Continued monitoring is necessary to determine long term trends in water quality.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00546 996800101000
41 07 00.0 092 51 00.0 5
DEEPEST PART LAKE MIAMI- 5MI SE LOVILLA
19135 IOWA MONROE
DES MOINES RIVER BASIN 071100
DM R-LAKE MIAMI T073NR17WSC20
21IOWA 801004 07100009 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/19		WATER	0	26.00		1.20	275	7.30		8.40	7		
79/07/19		WATER	3				255	7.20		8.40	7		
79/07/19		WATER	6				260	7.10		8.40	7		
79/07/19		WATER	16				310	.00		7.60	5		
79/07/19 CP(1)- 79/07/19		REP WATER	0	.00		1.10							
79/08/22		WATER	0	27.30		.80	250	13.20		9.20	19		
79/08/22		WATER	6				260	1.30		7.80	5		
79/08/22		WATER	13				280	.20		7.60	4		
79/08/22 CP(1)- 79/08/22		REP WATER	0	.00		.50							
79/09/26		WATER	0	20.40		.70	270	10.80		9.00	12	.080	.06
79/09/26		WATER	6				270	10.30		8.90	12		
79/09/26		WATER	13				270	8.80		8.70	12		
79/09/26 CP(1)- 79/09/26		REP WATER	0	.00		.70		10.60				.070	.08
79/09/26 CP(1)- 79/09/26		REP WATER	13				270			8.70			
86/06/16	0921	WATER	8	21.00			260	1.00	7.50	7.40	20	.140	1.60
86/06/16	0930	WATER	0	25.00	22.0		260	8.60	9.00	8.20	12	.070	1.40
86/06/16	0930	WATER	15	15.50			250	.00	7.00	7.40	34	.240	1.50
86/07/23	1145	WATER	0	28.75	37.0		260	9.80	9.50	8.90	10	.080	.10K
86/07/23	1200	WATER	13	21.00			260	.20	9.00	8.10	10	1.600	.10K
86/07/23	1200	WATER	16	17.25			290	.20	8.00	7.70	18	1.400	.10K
86/09/08	1200	WATER	0	20.50			260	7.40	9.00	7.70	12	.030	.10K
86/09/08	1200	WATER	18	19.75			260	4.20	8.50	7.60	12	.070	.10K

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00546 996800101000
41 07 00.0 092 51 00.0 5
DEEPEST PART LAKE MIAMI- 5MI SE LOVILLA
19135 IOWA MONROE
DES MOINES RIVER BASIN 071100
DM R-LAKE MIAMI T073NR17WSC20
21IOWA 801004 07100009 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/19		WATER	0	.14			26.90						
79/07/19		WATER	3	.13			26.60						
79/07/19		WATER	6	.15			23.60						
79/07/19		WATER	16	.72			4.50						
79/08/22		WATER	0	.26			113.80						
79/08/22		WATER	6	.28			24.70						
79/08/22		WATER	13	.18			7.10						
79/09/26		WATER	0	.15			41.90						
79/09/26		WATER	6	.18			40.40						
79/09/26		WATER	13	.14			42.30						
79/09/26 CP(1)- 79/09/26	REP	WATER	0	.15									
86/06/16	0921	WATER	8		.110	12.00	10.00						
86/06/16	0930	WATER	0		.090	21.00	17.00						
86/06/16	0930	WATER	15		.140	5.00	2.00						
86/07/23	1145	WATER	0		.140	49.00	46.00						
86/07/23	1200	WATER	13		.260	24.00	22.00						
86/07/23	1200	WATER	16		.240	13.00	8.00						
86/09/08	1200	WATER	0		.250	43.00	35.00						
86/09/08	1200	WATER	18		.250	36.00	29.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

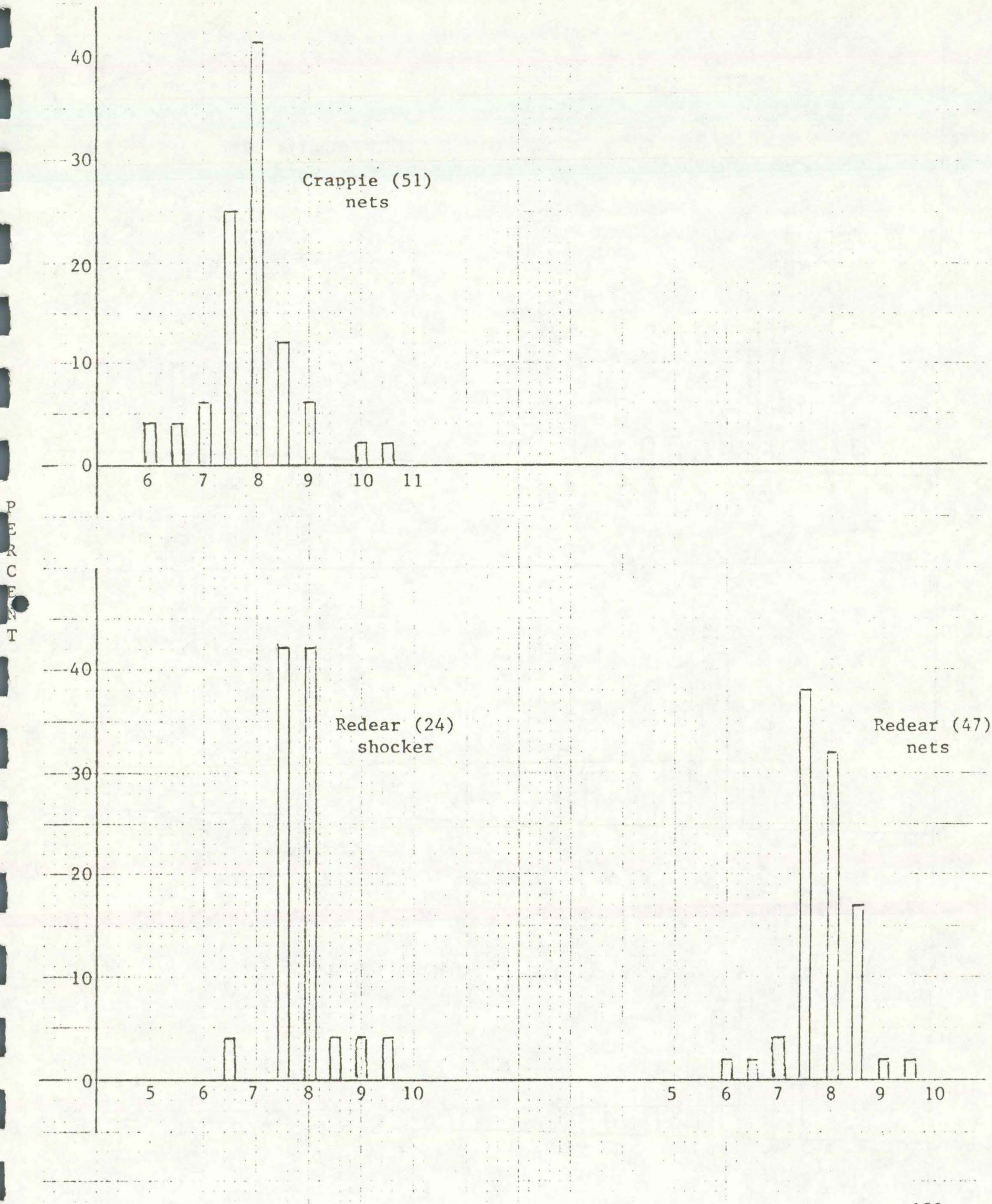
* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

SIZE COMPOSITION, SELECTED SPECIES

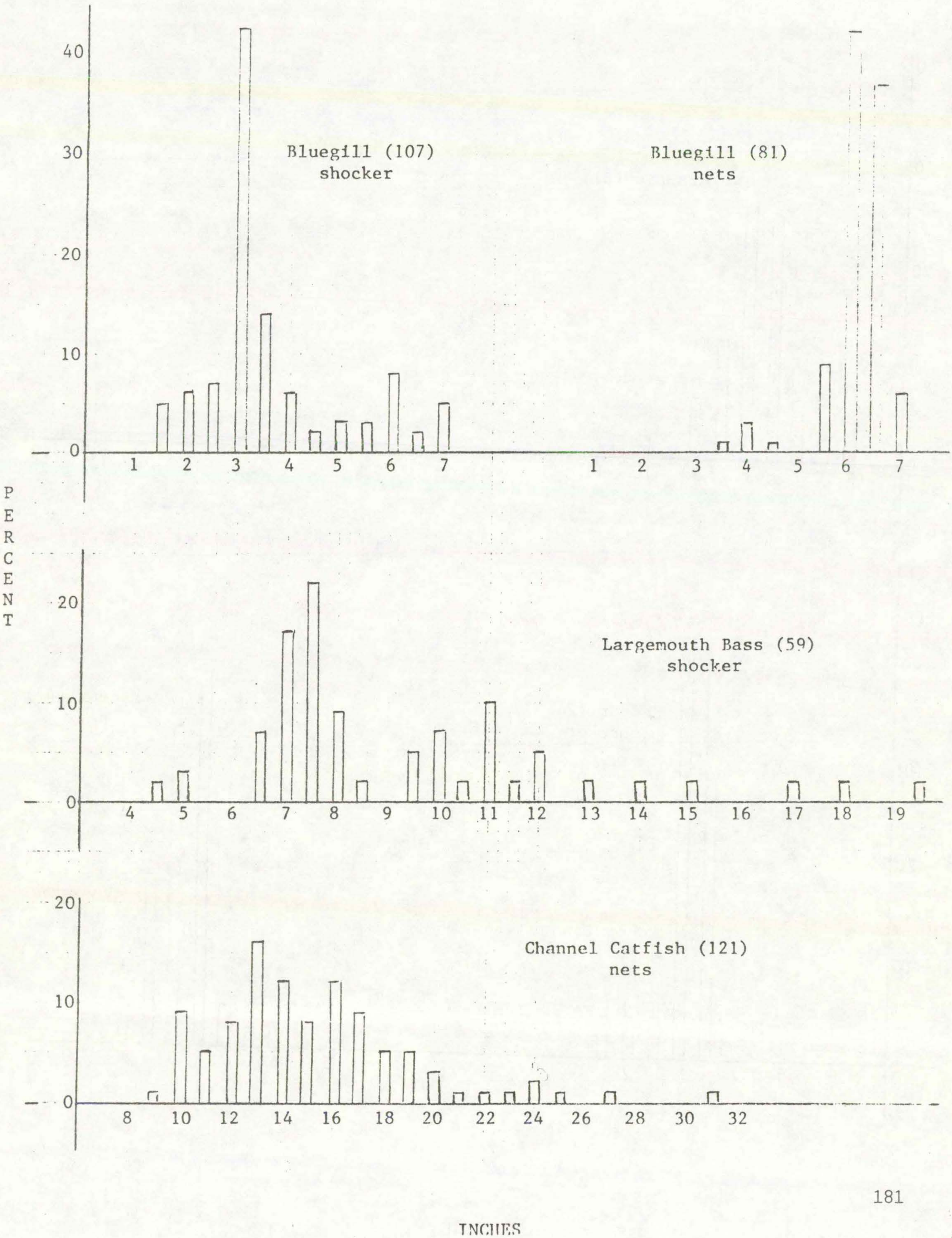
MIAMI LAKE 9/22/86, 9/23/86



INCHES

SIZE COMPOSITION,

MIAMI LAKE 9/22/86, 9/23/86



LAKE MIAMI, 1986

BACK-CALCULATED TOTAL LENGTHS (INCHES)

LARGEMOUTH BASS

Age Group	N	Annulus 1	2	3
I	9	3.8		
II	2	4.1	7.9	
III	7	4.9	7.8	10.1
Mean		4.3	7.8	10.1

BLUEGILL

Age Group	N	Annulus 1	2	3
I	9	1.8		
II	6	2.5	4.7	
III	1	3.6	4.5	6.1
Mean		2.2	4.7	6.1

WHITE CRAPPIE

Age Group	N	Annulus 1	2	3
I	5	3.0		
II	4	3.0	5.0	
III	8	3.3	5.8	7.5
Mean		3.1	5.5	7.5

LAKE MIAMI - RELATIVE WEIGHT OF SELECTED SPECIES - FALL 1986

Species	Length	W_r
Largemouth Bass	<8.0"	.98
Largemouth Bass	8.0 - 12.0"	.91
Largemouth Bass	12.0 - 15.0"	.93
Largemouth Bass	≥15.0"	1.03
Bluegill	3.0 - 6.0"	.99
Bluegill	≥6.0"	.93
White Crappie	5.0 - 7.9"	.82
White Crappie	≥8.0"	.81
Black Crappie	5.0 - 7.9"	.85
Black Crappie	≥8.0"	.88
Channel Catfish	<11.0"	.81
Channel Catfish	11.0 - 15.9"	.77
Channel Catfish	≥16.0"	.81

MIAMI LAKE AREA-CAPACITY CHART 1986 DATA

Elevation	Surface Area (Acres)	Capactiy (Acre Feet)
Spillway Crest	122.2	1158.0
-2'	113.0	923.0
-4'	102.0	708.0
-6'	83.2	522.0
-8'	65.0	375.2
-10'	54.2	256.2
-12'	42.9	159.3
-14'	29.3	87.5
-16'	19.1	39.5
-18'	8.9	12.1
-20'	2.0	2.0

LAKE WAPELLO

Physical and Lake Impact Data

Lake Wapello is located in Davis County approximately 8 miles northwest of Bloomfield, Iowa. The majority of Lake Wapello's 4,950 acre watershed is in cropland (34.9%), pasture (35.8%), and forestry (27.3%).

Water quality of Lake Wapello varies with precipitation events in the watershed. Water clarity tends to be good except for periods of turbidity resulting from heavy rains. Sedimentation associated with the silt turbidity has resulted in a loss of approximately 20% of the lake volume over the past 50 years. This turbidity and siltation present both a short and long term negative effect on fish production.

A map of Lake Wapello developed from 1986 data may be found on page 185. In addition a comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See Appendix for lake mapping procedure.)

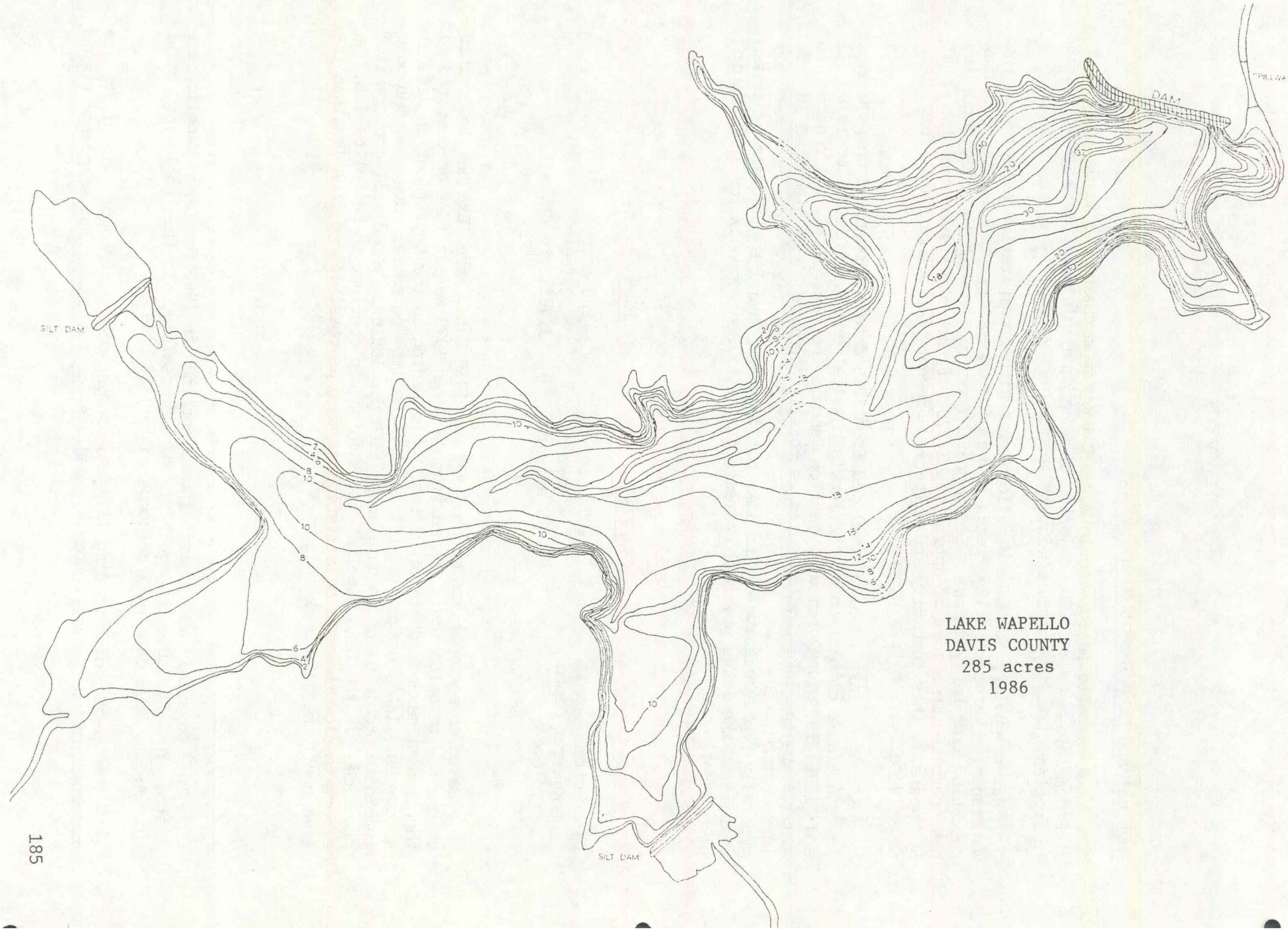
	1973	1986
Surface Area	289 acres	285 acres
Maximum depth	34 feet	32 feet
Volume	3,717 acre ft.	3,481 acre ft.

Based on a comparison of the 1979 and 1986 data, the lake has lost water volume due to siltation. The maximum depth in 1979 was 34 feet as compared to the present maximum dpeth of 32 feet. According to the Department of Natural Resources, lake usage in 1979 was below its potential due to periodic turbidity problems and an unbalanced fish population. Good soil conservation practices in the Lake Wapello watershed should continue to be followed in an effort to slow the rate of siltation as much as possible and thus lengthen the time until the lake's extinction.

Chemical Data

The physical and chemical data obtained in 1986 for Lake Wapello are listed in the Table on page 186. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events



LAKE WAPELLO
DAVIS COUNTY
285 acres
1986

Lake Wapello
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/17/86			7/24/86			9/09/86	
*Depth[1]	0	8	24	0	16	30	0	36
*Secchi[2]	37			29			22	
*Temperature[3]	25	23	16	28.2	21.8	15.5	21	20.5
*Dissolved Oxygen	8.8	3.0	0.0	6.6	0.1	0.0	6.3	2.8
*pH[4]	9.0	8.5	7.5	9.0	7.3	7.0	8.5	7.5
Conductivity[5]	240	240	230	230	210	250	230	230
Ammonia Nitrogen	0.09	0.05	0.48	0.08	0.35	1.3	0.04	0.21
Nitrate-Nitrite Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Suspended Solids	5	11	50	10	52	66	17	110
Total Phosphorus	0.08	0.11	0.17	0.01	0.06	0.30	0.09	0.16
Chlorophyll a (Corrected)[6]	6	9	3	14	<1	4	19	11
Thermally Stratified		Yes			Yes		No	

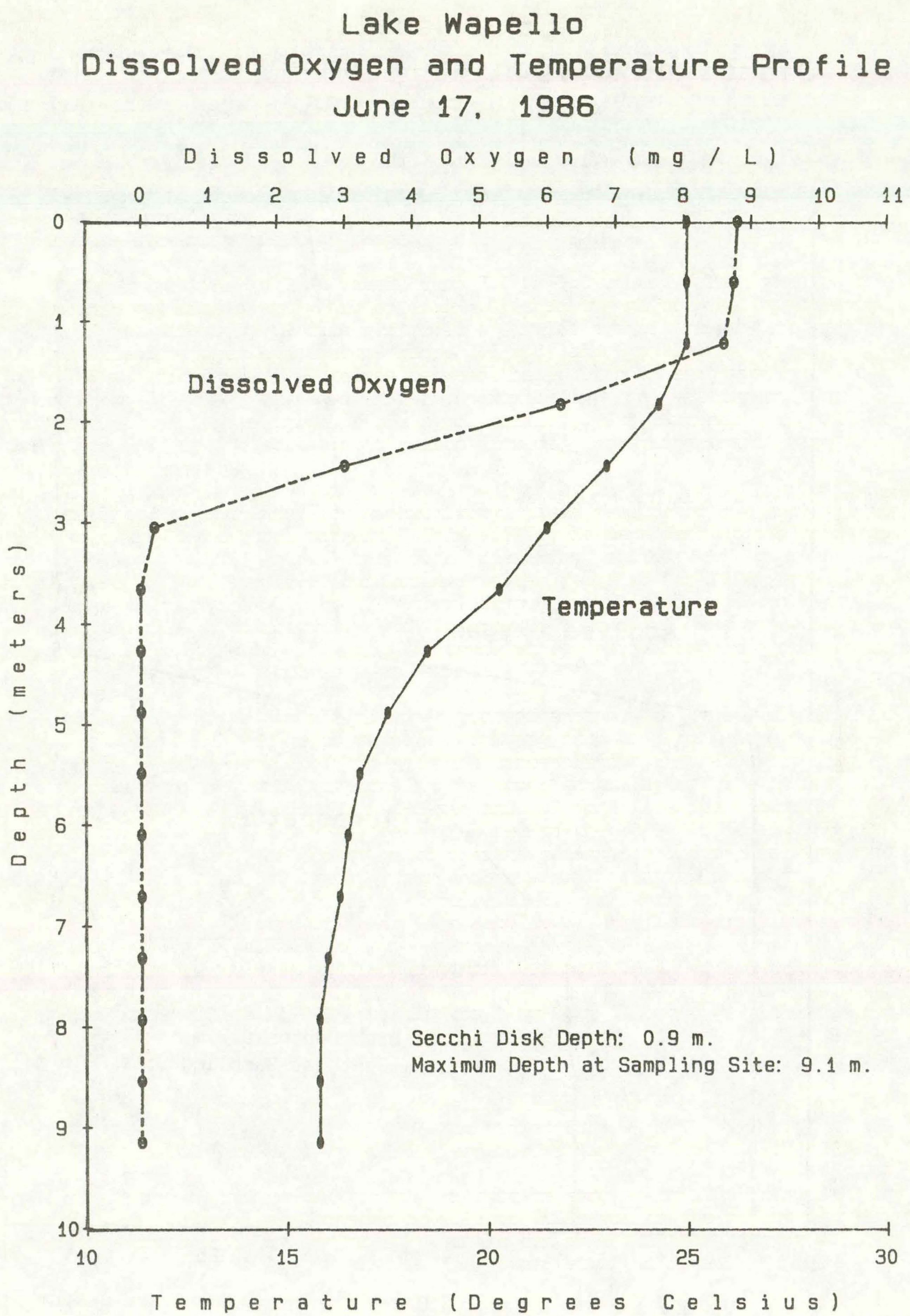
1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

ranged from 22 to 37 inches with a mean (N = 3) of approximately 29 inches. The 1979 Secchi readings ranged from 32 to 51 inches with an average (N = 3) of 42 inches.

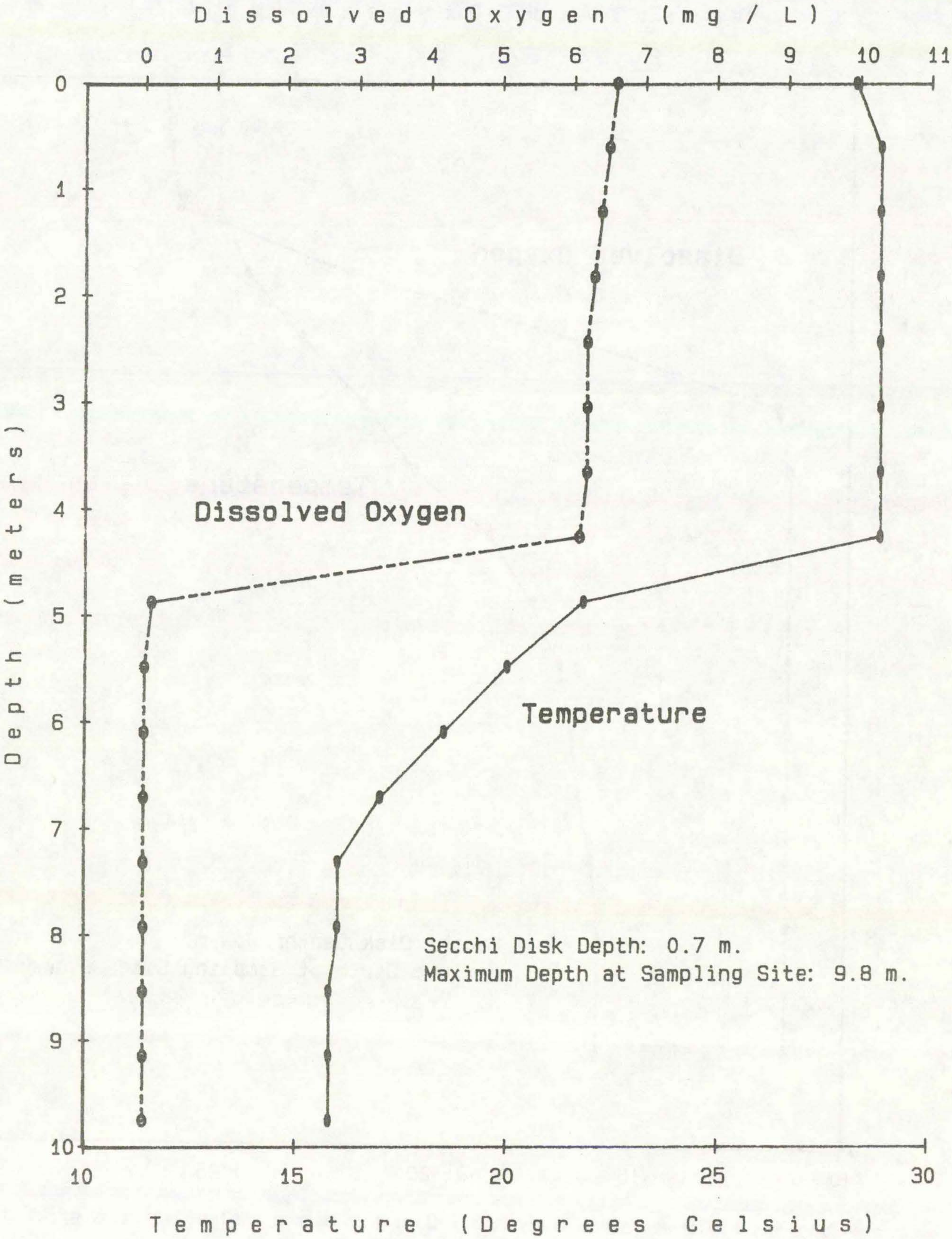
Lake Wapello water temperature in 1986 ranged from a low of 15.5°C in the July bottom sample to a high of 28.2°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Although limited temperature data for 1979 does not allow for comparison with 1986 data, the 1979 surface water temperature ranged from approximately 21.3°C to 28°C during the sampling period.

Dissolved oxygen (DO) values ranged from 0.0 mg/L in two bottom samples to 8.8 mg/L in the June surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 188, 189 , and 190 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling date. The June profile indicates that Lake Wapello already had developed a sharp DO and temperature gradient (stratification) that began at a depth of 6 feet (2 meters). By a depth of 10 feet (3 meters), the DO had declined to 0.0 mg/L and remained at that concentration to the bottom (30 feet). June lake water temperature decreased from a surface temperature of 25°C to a bottom temperature of 16°C.

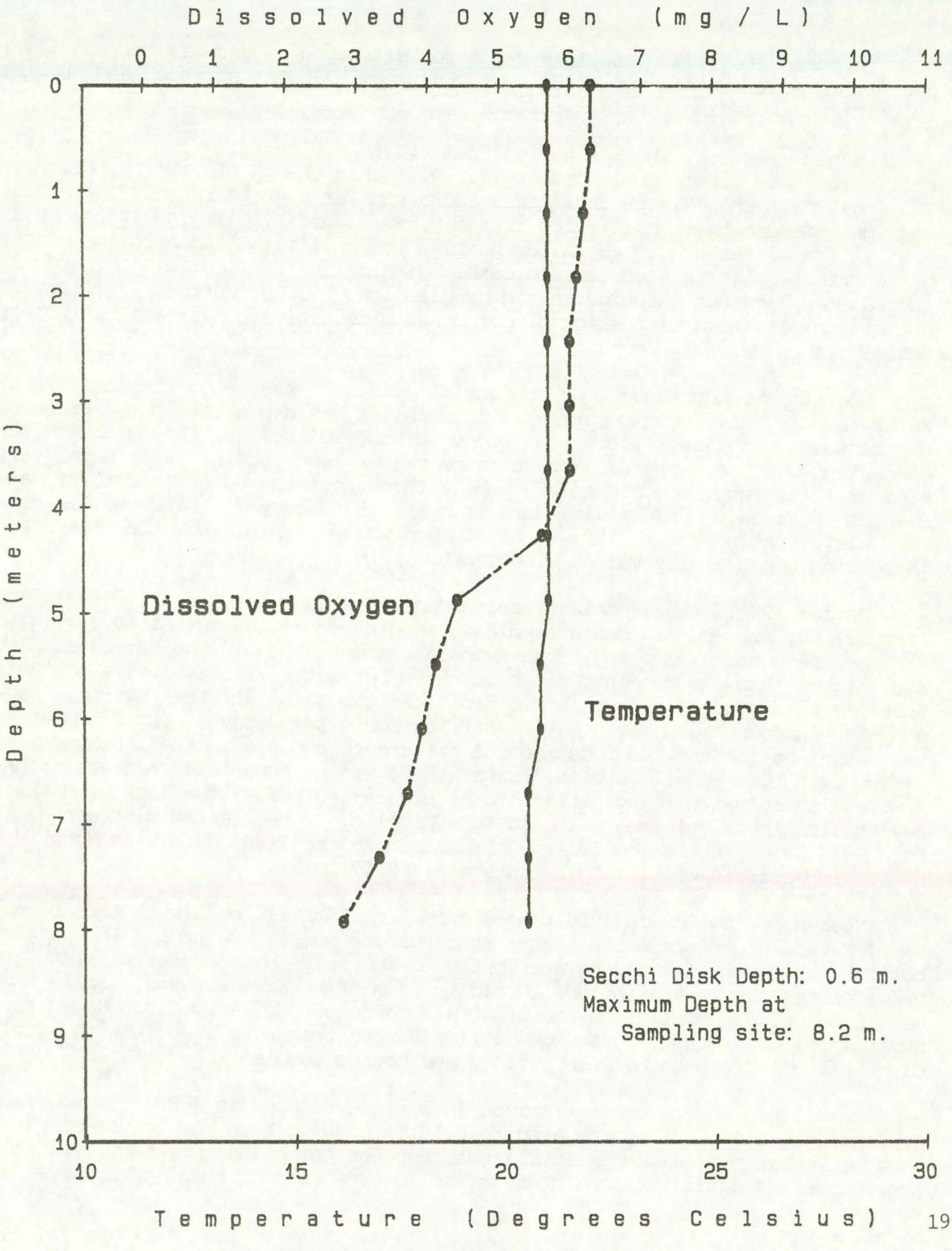
The temperature and DO profiles for July were ever more pronounced than in June. Both water temperature and DO were constant to a depth of 14 feet (4.5 meters). In the span of two feet the temperature dropped 7°C and DO was reduced from 6.1 mg/L to 0.0 mg/L. Temperature continued to drop with depth stabilizing at 16°C while DO remained at 0.0 mg/L. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The sharp temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values of 0.0 mg/L in the bottom samples. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with water and sediment having high organic content frequently have no dissolved oxygen in the lower water layer. Typically in the fall, as the ambient temperature declines, the lake water temperature and density become the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place, and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 190) for Lake Wapello indicated fall turnover was in progress. The temperature gradient had become vertical at approximately 20°C while a small gradient still existed in the DO concentration (6.3 mg/L of DO at the surface as compared to 2.8 mg/L at the bottom) demonstrating that complete mixing had not yet occurred. A comparison of the most pronounced DO and temperature stratification data for the 1979 and 1986 studies is given below.


Lake Wapello
Dissolved Oxygen and Temperature Profile
June 17, 1986
Dissolved Oxygen (mg / L)
0 1 2 3 4 5 6 7 8 9 10 11
Dissolved Oxygen
Temperature
Depth (meters)
0 1 2 3 4 5 6 7 8 9 10
Secchi Disk Depth: 0.9 m.
Maximum Depth at Sampling Site: 9.1 m.
10 15 20 25 30
Temperature (Degrees Celsius)

Lake Wapello
Dissolved Oxygen and Temperature Profile
July 24, 1986



Lake Wapello
Dissolved Oxygen and Temperature Profile
September 9, 1986



	22 August 1979		24 July 1986	
	Surface	23 feet	Surface	24 feet
DO (mg/L)	7.8	0.0	6.6	0.0
Temperature (°C)	25.1	18.9	28.7	16

Compared to 1979, the 1986 range for dissolved oxygen was very similar. The temperature range in 1986 was wider with both surface and bottom temperature exceeding the 1979 range.

Values for pH in 1986 varied from 7.0 to 9.0 units. The pH in the epilimnion was consistently higher (8.5-9.0) than the pH of the hypolimnion (7.0 to 7.5). The 1979 pH data reflected a similar overall range (7.3 to 9.3) and pH trend between epilimnion (range 8.5-9.3) and hypolimnion (range 7.3-7.8). The difference in pH values between the epilimnion and hypolimnion can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. The specific conductance values reported for 1986 were very similar (ranging from 210 to 250 umhos) throughout the water column for all sampling periods. Conductivity data from the 1979 study (1) was somewhat more variable, ranging from 190 to 285 umhos while exhibiting the trend of increasing conductivity values with depth.

During 1986, the ammonia nitrogen concentrations were relatively similar for all surface and mid depth samples, ranging from 0.04 mg/L to 0.35 mg/L. For each respective sampling, the ammonia concentration in the bottom samples were higher than the concentrations in the upper water layer; i.e., for July 0.08 mg/L surface, 0.35 mg/L mid-depth and 1.3 mg/L at the bottom. The ammonia increase with depth may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. In Lake Wapello's case, since there was no reportable nitrate in any sample, there was not any nitrate to be reduced. In fact the lack of nitrate may be limiting algal production in Lake Wapello. The limited nitrogen data for 1979 does not allow for any comparison to the 1986 data (one surface sample for nitrate of 0.11 mg/L and ammonia 0.07 mg/L).

Suspended solids in 1986 ranged from 5 mg/L to 110 mg/L with the bottom sample values consistently higher than surface sample values. The higher bottom solids values can be attributed to the settling of material from the upper water layers and include turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter. During the 1979 study, suspended solids ranged from 6 to 16 mg/L with little discernible difference between surface and bottom samples.

Total phosphorus concentrations in surface samples in 1986 ranged from 0.01 mg/L to 0.09 mg/L as compared to 0.16 to 0.30 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The lower values of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part of the hypolimnion phosphorus levels were consistently higher than those of the epilimnion. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation of phosphorus from sediment by reduction. The same general trends were found during the 1979 sampling of Lake Wapello. Total phosphorus in 1979 ranged from 0.03 to 0.23 mg/L with higher concentrations being found near the bottom during the July and August sampling.

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986 the corrected chlorophyll a values range from <1 µg/L to 19 µg/L. The average corrected chlorophyll a value was lowest in June and July (6 µg/L) and increased in September (15 µg/L). Compared to 1979 data (1) (mean chlorophyll a value of 49.5 µg/L, N=8), chlorophyll a data in 1986 was much lower indicating relatively lower phytoplankton populations.

Biological Data

The species composition of fish in Lake Wapello is listed in the following table. Additional fishery information may be found in the appendix.

LAKE WAPELLO FISH POPULATION SAMPLE (9/17/86, 9/18/86)

Species Composition - Collected with 6 pound nets (overnight) and elctro-fishing (59 minutes) plus 25 minutes for bass only.

Species	Nets	Shocker	Total No.	Total Percent
Bluegill	35	27	62	13
Black Crappie	40		40	9
White Crappie	163	14	177	38
Largemouth Bass		63	63	14
Black Bullhead	1	2	3	<1
Yellow Bullhead	13		13	3
Redear	17	1	18	4
Warmouth	5		5	1
Green Sunfish	10	5	15	3
Yellow Perch	1	5	6	1
Carp		1	1	<1
Shad		63	63	14
Golden Shiner		1	1	<1
Total	285	182	467	

SUMMARY

Although the data presented in the report are rather limited , it is possible to make several general statements.

Since 1979, the volume in Lake Wapello has declined as a result of siltation. The best possible land use practices should be applied to the area in an effort to slow the rate of siltation.

The 1986 dissolved oxygen and temperature profiles were very similar to 1979. Although the algal populations have declined since 1979 the lake water chemistry does not appear to have improved. No other major changes in lake water quality appear to have occurred from 1979 to 1986. Continued monitoring is necessary to determine long term trends in water quality.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

STORET RETRIEVAL DATE 87/07/08 PGM=RET PAGE: 37

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00340 992600101000
40 49 05.0 092 30 25.0 3
T070NR15WSC34SITE #1
19051 IOWA DAVIS
DES MOINES 071100
WAPELLO LAKE
21IOWA 771221 07100009 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/18		WATER	0	28.00		1.10	200	8.40		9.29	9		
79/07/18		WATER	3				200	7.50		9.29	16		
79/07/18		WATER	6				148	6.60		9.14	10		
79/07/18		WATER	13				249	.70		7.59	5		
79/07/18		WATER	19				270	.00		7.40	7		
79/07/18		WATER	26				285	.00		7.30	6		
79/07/18 CP(1)- 79/07/18	REP	WATER	0	.00		1.10		10.00					
79/07/18 CP(1)- 79/07/18	REP	WATER	19				270			7.40			
79/08/22		WATER	0	25.10		1.30	191	7.80		8.50	7		
79/08/22		WATER	6				190	7.60		8.50	9		
79/08/22		WATER	13				200	.60		7.70	5		
79/08/22		WATER	16				200	1.40		7.70	6		
79/08/22		WATER	19				210	1.90		7.50	10		
79/08/22		WATER	22				220	.00		7.50	10		
79/08/22 CP(1)- 79/08/22	REP	WATER	0	.00		1.20							
79/09/26		WATER	0	21.30		.80	199	10.90		9.10	14	.070	.11
79/09/26		WATER	6				199	10.90		9.10	15		
79/09/26		WATER	13				200	7.60		8.50	10		
79/09/26		WATER	26				200	.80		7.80	6		
79/09/26 CP(1)- 79/09/26	REP	WATER	0	.00		.70						.040	.16
86/06/17	0830	WATER	0	25.00	37.0		240	8.80	9.00	8.40	5	.090	.10K
86/06/17	0900	WATER	8	23.00			240	3.00	8.50	7.80	11	.050	.10K
86/06/17	0900	WATER	24	16.00			230	.00	7.50	7.60	50	.480	.10K
86/07/24	1200	WATER	0	28.25	29.0		230	6.60	9.00	7.60	10	.080	.10K
86/07/24	1200	WATER	16	21.75			210	.10K	7.30	7.10	52	.350	.10K
86/07/24	1200	WATER	30	15.50			250	.00	7.00	7.00	66	1.300	.10K
86/09/09	1100	WATER	0	21.00			230	6.30	8.50	7.50	17	.040	.10K
86/09/09	1100	WATER	26	20.50			230	2.80	7.50	7.30	110	.210	.10K

STORET RETRIEVAL DATE 87/07/08 PGM=RET PAGE: 38

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00340 992600101000
40 49 05.0 092 30 25.0 3
T070NR15WSC34SITE #1
19051 IOWA DAVIS
DES MOINES 071100
WAPELLO LAKE
21IOWA 771221 07100009 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/18		WATER	0	.11									
79/07/18		WATER	3	.15									
79/07/18		WATER	6	.14									
79/07/18		WATER	13	.11									
79/07/18		WATER	19	.14									
79/07/18		WATER	26	.16									
79/07/18 CP(1)- 79/07/18	REP	WATER	26	.17									
79/08/22		WATER	0	.11									
79/08/22		WATER	6	.13									
79/08/22		WATER	13	.12									
79/08/22		WATER	16	.13									
79/08/22		WATER	19	.27									
79/08/22		WATER	22	.70									
79/09/26		WATER	0	.20									
79/09/26		WATER	6	.20									
79/09/26		WATER	13	.17									
79/09/26		WATER	26	.31									
86/06/17	0830	WATER	0		.080	9.00	6.00						
86/06/17	0900	WATER	8		.110	12.00	9.00						
86/06/17	0900	WATER	24		.170	8.00	3.00						
86/07/24	1200	WATER	0		.010	14.00	14.00						
86/07/24	1200	WATER	16		.060	12.00	1.00K						
86/07/24	1200	WATER	30		.300	9.00	4.00						
86/09/09	1100	WATER	0		.090	26.00	19.00						
86/09/09	1100	WATER	26		.160	22.00	11.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

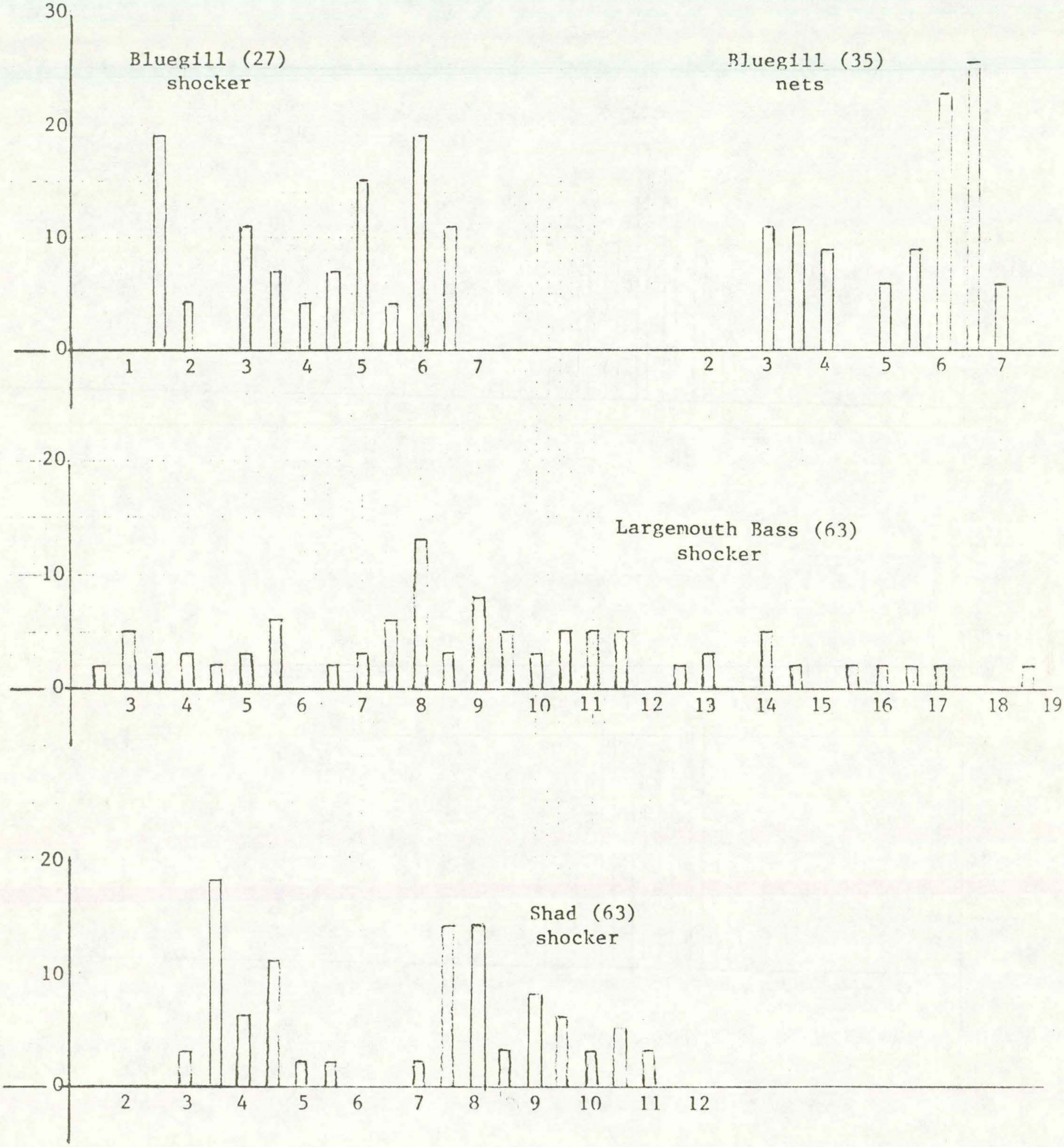
	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

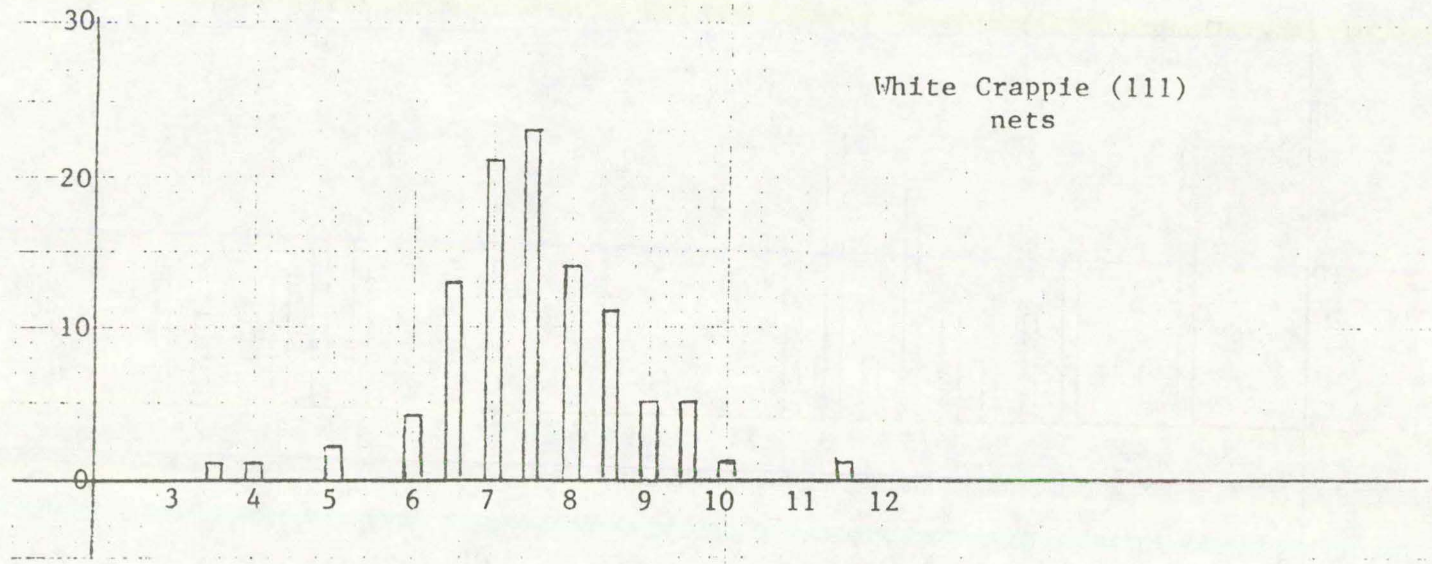
** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

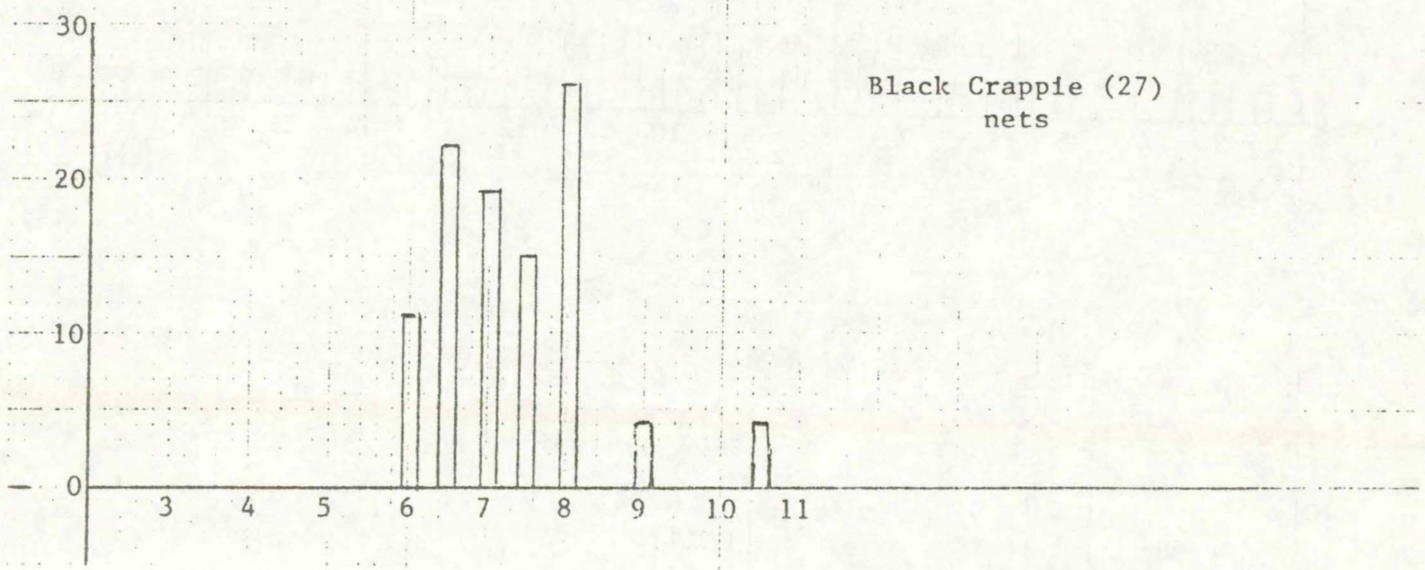
LAKE WAPELLO 9/17/86, 9/18/86



INCHES



PERCENT



INCHES

LAKE WAPELLO, 1986

BACK-CALCULATED TOTAL LENGTHS (INCHES)

LARGEMOUTH BASS

Age Group	N	Annulus 1	2	3	4	5
I	7	4.0				
II	7	4.7	7.8			
III	0					
IV	0					
V	1	4.7	9.1	11.8	13.2	14.2
Mean		4.3	7.9	11.8	13.2	14.2

BLUEGILL

Age Group	N	Annulus 1	2	3
I	12	2.5		
II	4	2.6	4.2	
III	6	1.9	3.7	5.2
Mean		2.3	3.9	5.2

WHITE CRAPPIE

Age Group	N	Annulus 1	2	3	4
I	0				
II	5	2.9	5.1		
III	13	2.8	5.1	6.8	
IV	1	3.6	6.1	7.9	8.5
Mean		2.9	5.2	6.9	8.5

LAKE WAPELLO - RELATIVE WEIGHT OF SELECTED SPECIES - FALL 1986

Species	Length	W_r
Largemouth Bass	<8.0"	1.00
Largemouth Bass	8.0 - 11.9"	.92
Largemouth Bass	12.0 - 14.9"	.95
Largemouth Bass	≥15.0"	1.00
Bluegill	3.0 - 5.9"	1.07
Bluegill	≥6.0"	.88
White Crappie	5.0 - 7.9"	.78
White Crappie	≥8.0"	.80
Black Crappie	5.0 - 7.9"	.80
Black Crappie	≥8.0"	.80

LAKE WAPELLO, AREA-CAPACITY CHART
1986 DATA

Elevation	Surface Area (Acres)	Capacity (Acre Feet)
Spillway Crest	285.0	3481.0
-2'	261.0	2935.0
-4'	237.0	2437.0
-6'	210.0	1990.0
-8'	179.0	1601.0
-10'	155.0	1267.0
-12'	138.0	974.0
-14'	120.0	716.0
-16'	93.0	504.0
-18'	74.0	336.0
-20'	52.0	210.0
-22	38.0	120.0
-24	23.0	59.4
-26	11.0	25.4
-28	4.3	10.1
-30	2.2	3.6
-32	0.7	0.7

NINE EAGLES LAKE

Physical and Lake Impact Data

Nine Eagles is a 55 acre, man-made lake, located in Decatur County, in extreme southern Iowa. Constructed in Nine Eagles State Park in 1951, the lake has a maximum depth of 32 feet and a mean depth of 15.5 feet.

The majority of Nine Eagles Lake's 1192 acre watershed is in cropland (34%), pasture (36%) and forest (28%). It has a watershed to lake area ratio of 22:1. Severe summer stratification has historically occurred beginning at depths of 10-12 feet from June thru mid-September. A lake bed contour map was constructed in 1973 and again in 1986.

A comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures).

	1979*	1986
Surface Area	67 acres	55 acres
Maximum depth	34 ft.	32 ft.
Volume	888 acre ft.	850 acre ft.

*Based on measurement from a 1977 map (1)

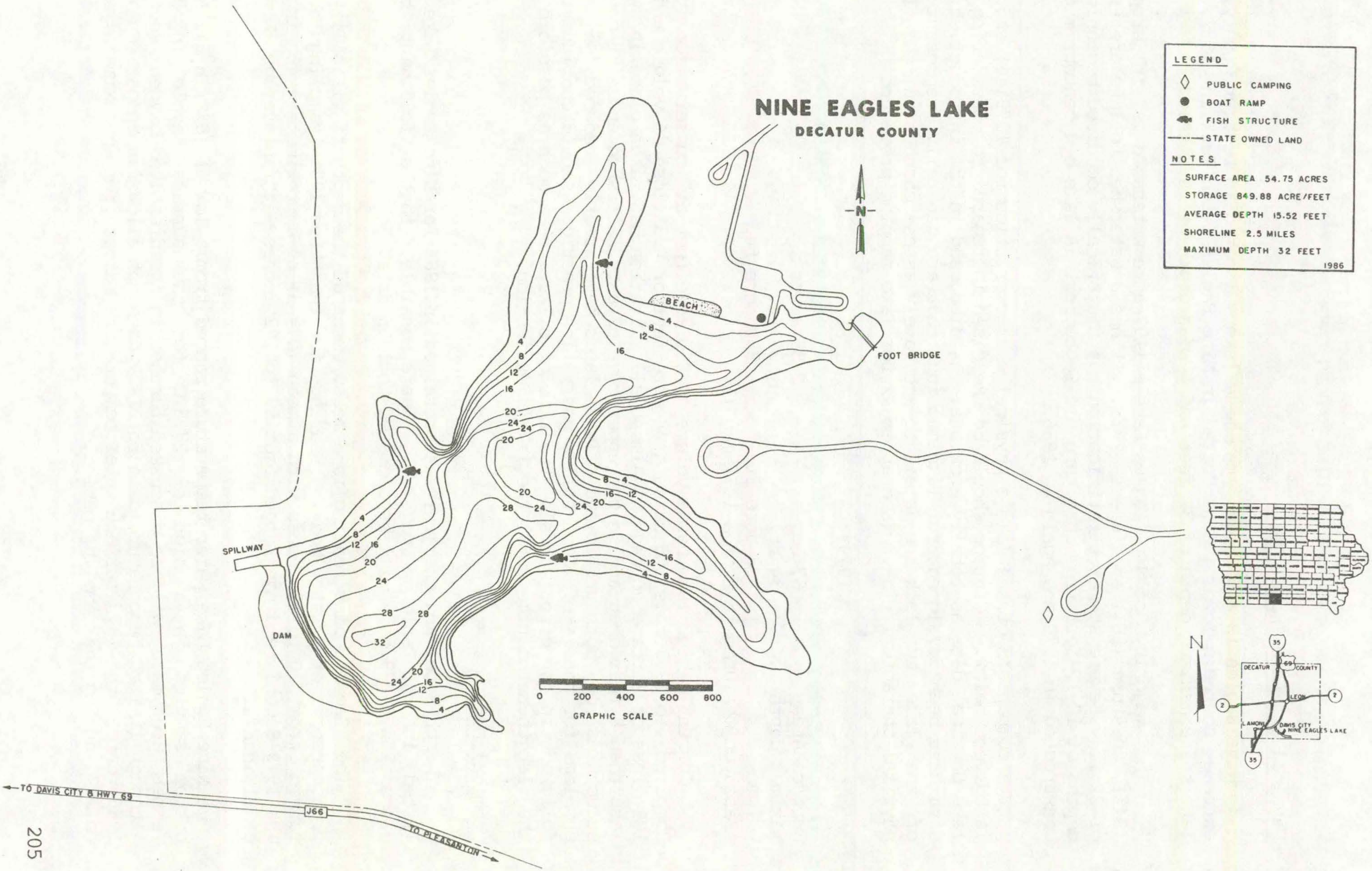
Currently the lake has a volume of 850 acre feet at conservation pool. Compared to 1973 this indicates a 38 acre feet or 4.3% loss of volume and an 18% loss of surface acreage. Almost all siltation has taken place in water less than 8 feet deep and in the upper cove areas. Watershed and silt control structures on both public and private lands have greatly reduced siltation problems for the lake. Good soil conservation practices should continue to be followed in an effort to slow the rate of siltation as much as possible and thus lengthen the time until the lake's extinction.

Chemical Data

The physical and chemical data obtained in 1986 for Nine Eagles Lake are listed in the Table on page 206. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 30 to 68 inches with a mean (N = 3) of approximately 45 inches. The 1979 Secchi readings ranged from 59 to 102 inches with an average (N = 3) of 81 inches.

Nine Eagles Lake water temperature ranged from a low of 10°C in all three bottom samples to a high of 27.5°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Although limited temperature data for 1979 does not allow for comparison with 1986 data, the 1979 surface water temperature ranged from approximately 20°C to 29°C during the sampling period.


NINE EAGLES LAKE
DECATUR COUNTY
LEGEND
PUBLIC CAMPING
BOAT RAMP
FISH STRUCTURE
STATE OWNED LAND
NOTES
SURFACE AREA 54.75 ACRES
STORAGE 849.88 ACRE/FEET
AVERAGE DEPTH 15.52 FEET
SHORELINE 2.5 MILES
MAXIMUM DEPTH 32 FEET
1986
N
BEACH
FOOT BRIDGE
SPILLWAY
DAM
0 200 400 600 800
GRAPHIC SCALE
TO DAVIS CITY & HWY 69
J66
TO PLEASANTON
DECATUR COUNTY
LEON
LAMONI
DAVIS CITY
NINE EAGLES LAKE
35
69
2

Nine Eagles Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/25/86			7/22/86			9/03/86		
*Depth[1]	0	14	30	0	10	30	0	16	30
*Secchi[2]	68			36			30		
*Temperature[3]	25.5	14	10	27.5	23.5	10	22.5	16	10
*Dissolved Oxygen	8.2	0.8	0.6	9.9	1.3	0.4	10.8	0.6	0.4
*pH[4]	8.7	8.0	7.7	8.7	8.9	7.4	8.7	8.6	7.2
Conductivity[5]	220	220	270	209	220	260	200	190	250
Ammonia Nitrogen	0.09	0.02	1.1	0.18	0.10	1.0	0.17	0.13	0.39
Nitrate-Nitrite Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Suspended Solids	8	13	21	24	14	40	16	14	32
Total Phosphorus	0.06	0.07	0.11	0.04	0.02	0.07	0.05	0.08	0.20
Chlorophyll a (Corrected)[6]	8	9	6	61	18	8	32	9	11
Thermally Stratified		Yes			Yes			Yes	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

Dissolved oxygen (DO) values ranged from <1 mg/L in several bottom samples to 10.8 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 208, 209, and 210 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. In June, a sharp DO and temperature gradient (stratification) was already present between the 6.0 (2 meter) and 10 foot (3 meter) depths. As water temperature decreases, water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier lower layers (hypolimnion). The sharp temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom sample of <1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with sediment and water of high organic content frequently have no dissolved oxygen in the lower water layer.

The July and September DO and temperature profiles were almost identical to the June profile; i.e., DO and temperature decline rapidly between 6 and 10 feet. Typically in the fall, as the ambient temperature declines, the lake water temperature and density become the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform througout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 210) for Nine Eagles Lake indicated fall turnover had not yet occurred. A comparison of the most pronounced DO and temperature stratification data for the 1979 and 1986 studies is given below.

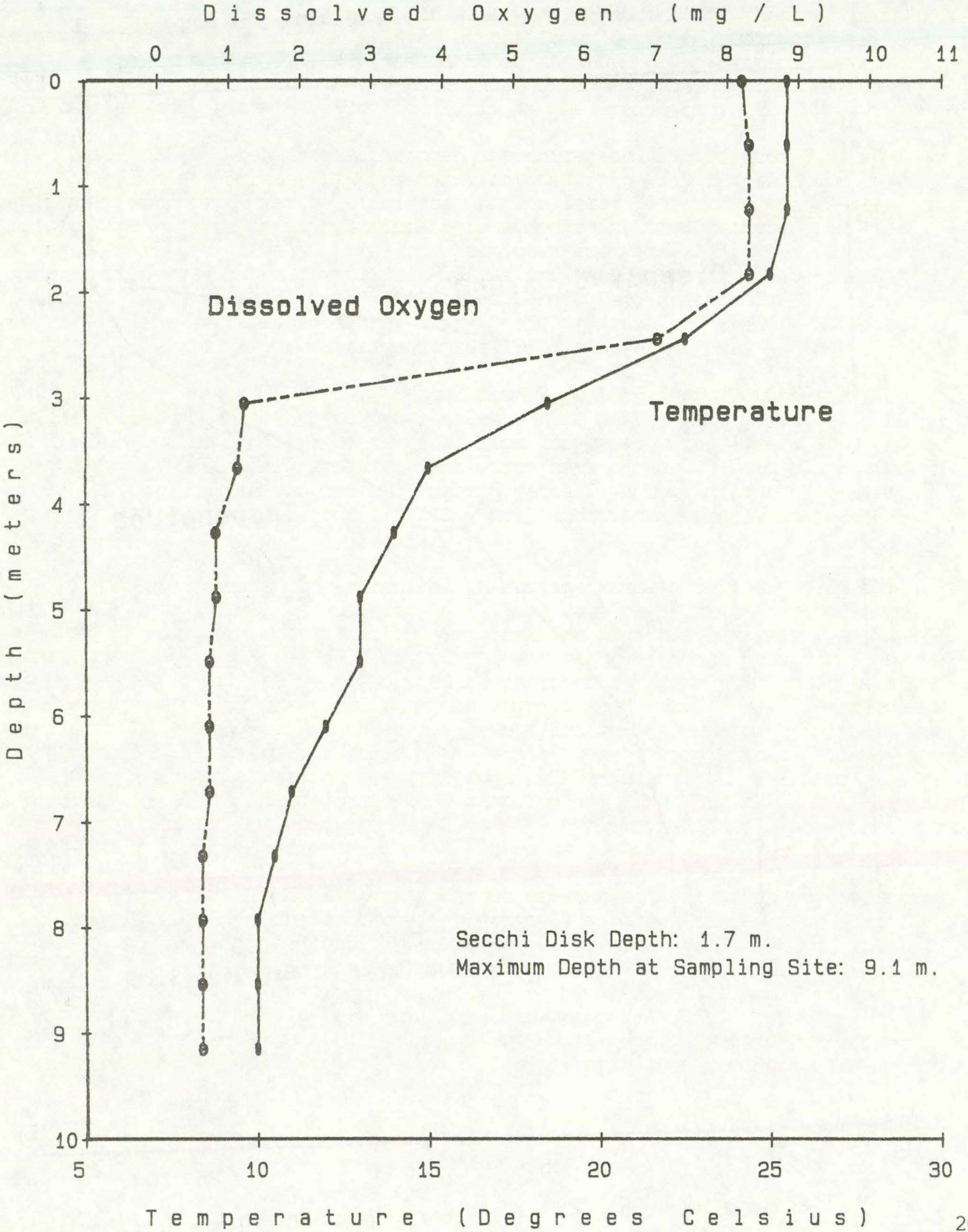
	21 August 1979		22 July 1986	
	Surface	23 feet	Surface	23 feet
DO (mg/L)	9.3	1.2	9.8	0.6
Temperature (°C)	27.2	11.3	27.5	11.0

Compared to 1979, the 1986 dissolved oxygen and temperature values were very similar.

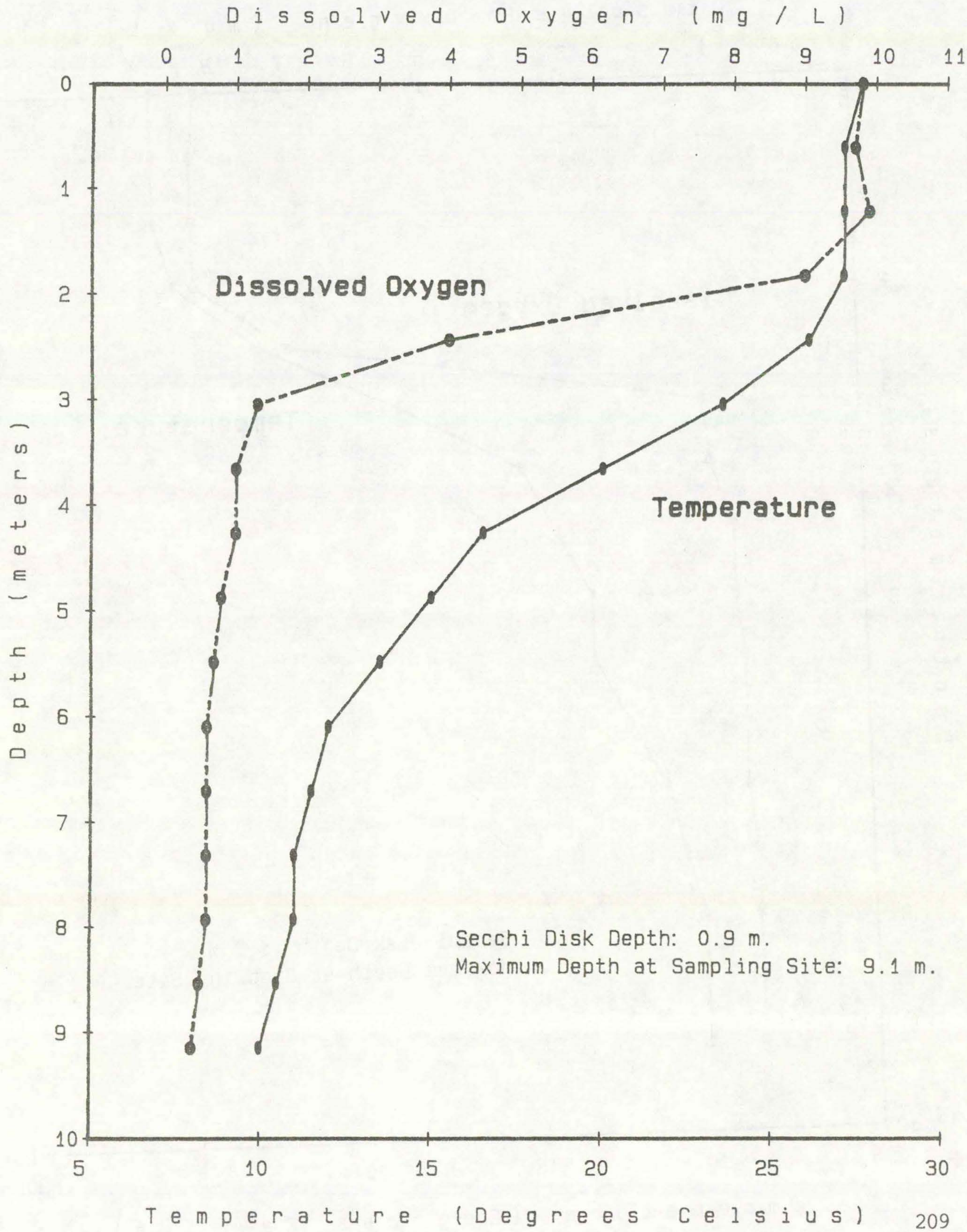
Values for pH in 1986 varied from 7.2 to 8.9 units. The pH in the epilimnion was higher (8.7) as compared to the pH of the hypolimnion (7.2 to 7.7). The difference in pH values can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. Values for specific conductance in 1986 were not much different (ranging from 190 to 270 micromhoss) throughout the water column for all sampling periods. Conductivity in the bottom sample was always the highest. The decline in the conductivity in the epilimnion is related to dissolved

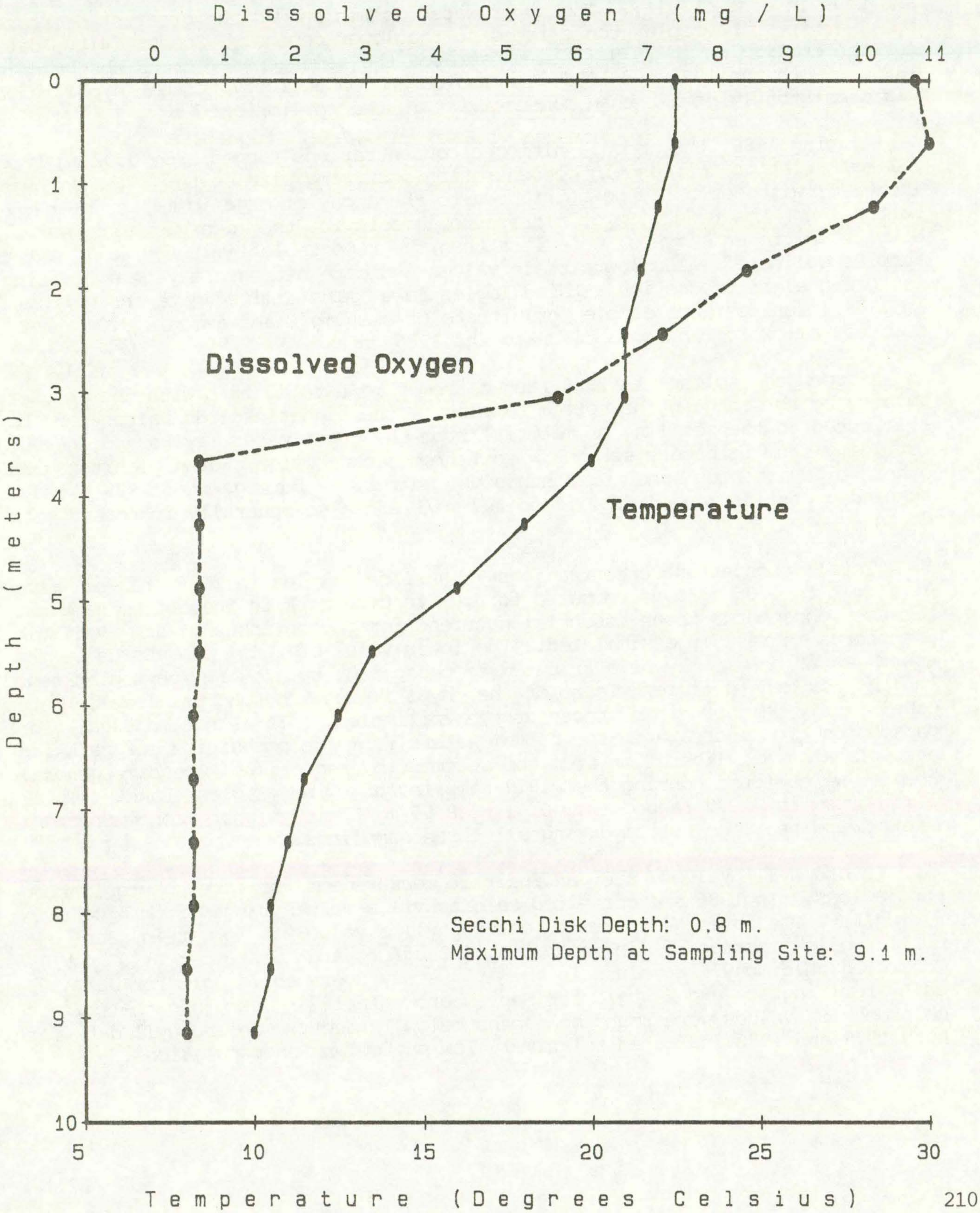
Nine Eagles Lake
Dissolved Oxygen and Temperature Profile
June 25, 1986



Nine Eagles Lake
Dissolved Oxygen and Temperature Profile
July 22, 1986



Nine Eagles Lake
Dissolved Oxygen and Temperature Profile
September 3, 1986



solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). In June, as indicated by the low chlorophyll values, low phytoplankton were present. As the phytoplankton populations increased in July and September, they began utilizing the dissolved nutrients and causing a decline in dissolved solids and thus in conductivity. The upper water column showed the greatest decrease because fewer phytoplankton existed at the lower depths. Conductivity data for the epilimnion in 1979 (1) demonstrated the same general trend observed in 1986. Both the 1979 and 1986 data indicated conductivity in the hypolimnion was consistently higher than conductivity in the epilimnion.

During 1986, the ammonia nitrogen concentrations ranged from 0.02 mg/L to 1.1 mg/L with an increase in concentration occurring with depth. The ammonia increase with depth may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate nitrogen levels were less than the reportable limit for all water samples collected. The low nitrate values indicate nitrogen may be a limiting factor in algal production at Nine Eagles Lake. The limited data for nitrogen in 1979, (one surface sample for nitrate of 0.16 mg/L and ammonia 0.04 mg/L) does not allow for any comaprison to the 1986 data.

Suspended solids in 1986 ranged from 8 mg/L to 40 mg/L with the higher values being found in the bottom samples. The higher solids values can be attributed to the settling of material from the upper water layers and include turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter. During the 1979 study, suspended solids ranged from 17 to 107 mg/L and also generally increased with depth.

Total phosphorus concentrations in surface samples in 1986 ranged from 0.04 mg/L to 0.06 mg/L as compared to 0.07 to 0.20 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phsophorus is rapidly assimilated. The lower value of total phosphorus in the upper water column may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part of the hypolimnion phosphorus levels were consistently higher than those of the epilimnion. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. The same general trends were found during the 1979 sampling of Nine Eagles Lake. Total phosphorus in 1979 ranged from 0.01 to 0.09 mg/L with higher concentrations being found near the bottom during all three samplings.

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986 the corrected chlorophyll <u>a</u> values ranged from 6 µg/L to 61 µg/L. The average corrected chlorophyll <u>a</u> value was lowest in June (8 µg/L) while increasing in both July (29 µg/L) and September (17 µg/L). Corrected chlorophyll <u>a</u> values in the 1979 study averaged 14 µg/L for July, 35 µg/L for August and 24 µg/L for September. In 1979 most of the higher chlorophyll values were found at depths below 12 feet. Chlorophyll data for both 1979 and 1986 indicated relatively low phytoplankton populations.

Biological Data

An intensive research project has been underway for several years at Nine Eagles Lake. The study objective is to determine the impact of thermal and chemical destratification (through aeration) during summer months on the growth rate, size structure, biomass and harvest of largemouth bass, bluegill, redear sunfish, crappie and channel catfish. This study has shown that rotating the years when the lake will be destratified and years when the axial flow units will be shut off, creates strong year classes of fish, improves fish growth and increases fish harvest.

Analysis of the fish population has centered around cove rotenone work in 1983 and fish population estimates in 1984-1986. Utilizing mark and recapture methods, Hill (4) estimated the standing stock of bluegill, redear sunfish, crappie, largemouth bass and channel catfish in Nine Eagles Lake as 245, 210, 159, 89, and 80 lbs/acre, respectively. Cove rotenone samples from 1984 estimated 128 lbs/acre of bluegill, 272 lbs/acre of redear sunfish, 122 lbs/acre of crappie, 29 lbs/acre of largemouth bass, and 102 lbs/acre of more valid than estimates based on cove rotenone samples. Estimated population biomass and numbers of fish for Nine Eagles Lake in 1986 are found in the following table.

Major species, biomass and population estimates with confidence intervals, for Nine Eagles Lake, 1986.

Species	Pounds/Acre	Total Number
Bluegill	138 ± 33	83,300 ± 19,100
Redear Sunfish	48 ± 10	7,800 ± 2,100
Black Crappie	24 ± 6	5,700 ± 1,720
Largemouth Bass	38 ± 4	4,860 ± 694
Channel Catfish	14 ± 1	1,006 ± 165

Total biomass estimates for 1985 were quite similar. The current black crappie population is dominated by two size groups, 6 to 7 inches long (1985 year class) and 8 to 9 inches long. The redear sunfish population has almost 50% of its population greater than 8 inches in length. Strong numbers of bluegill less than 7 inches in length dominate the population because of 1985 production and angler harvest of larger fish. Bass body condition has improved and bass numbers greater than 12 inches in length have more than doubled. Despite yearly fall stocking of 35 seven inch channel catfish per acre, a significant population has failed to develop. Tiger muskie and white crappie are also caught by anglers and are present at low levels. Grass carp have been stocked periodically for several years and provide good aquatic vegetation control.

Artificial destratification with aerators has improved the fishery at Nine Eagles Lake. Though angling pressure has increased 50% from 1985 to 1986, angling success also increased 60% (to 2.6 fish/hr). Angler use at this lake is only limited by difficult shoreline access and the lakes isolated location in a low population density area.

Summary

Although the data presented in the report are rather limited, it is possible to make several general statements.

> Since 1979, the volume in Nine Eagles Lake has declined as a result of siltation. The best possible land use practices should be applied to the area in an effort to slow the rate of siltation. The 1986 dissolved oxygen and temperature profiles were very similar to 1979 and no major changes in lake water quality appeared to have occurred from 1979 to 1986. Continued monitoring is necessary to determine long term trends in water quality. Studies conducted on Nine Eagles Lake have demonstrated that artificial destratification has improved the fishery considerably.

LITERATURE CITED

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2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

4. Hill, K.R. 1984. Classification of Iowa lakes and their fish standing stock. Iowa Cons. Comm. Fed. Aid Proj. F-90-R. Completion Report. 40pp.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00429 992700101000
40 35 45.0 093 46 20.0 3
SITE NO 1
19053 IOWA DECATUR
THOMPSON RIVER 091300
NINE EAGLE LAKE T067NR25WSC18
21IOWA 771123 10280102 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
76/07/15		WATER					145						
79/07/18		WATER	0	26.80		2.60	165	7.60		8.70	3		
79/07/18		WATER	6				160	8.40		8.75	4		
79/07/18		WATER	13				190	3.10		7.79	21		
79/07/18		WATER	19				220	.30		7.30	10		
79/07/18		WATER	22				230	.00		7.30	11		
79/07/18 CP(1)- 79/07/18	REP	WATER	0	.00		2.50		8.40					
79/07/18 CP(1)- 79/07/18	REP	WATER	19				220			7.40			
79/08/21		WATER	0	27.20		1.50	133	9.30		9.19	4		
79/08/21		WATER	6				133	9.50		9.10	6		
79/08/21		WATER	13				146	3.20		7.99	4		
79/08/21		WATER	16				160	2.80		7.80	6		
79/08/21		WATER	22				200	1.20		7.44	9		
79/08/21 CP(1)- 79/08/21	REP	WATER	0	.00		1.50		9.20					
79/09/26		WATER	0	20.30		2.10	156	8.30		8.50	4	.040	.16
79/09/26		WATER	6				156	8.10		8.50	4		
79/09/26		WATER	13				159	5.60		8.10	4		
79/09/26		WATER	22				230	.00		7.50	9		
79/09/26 CP(1)- 79/09/26	REP	WATER	0	.00		2.10						.060	.08
86/06/25	0915	WATER	0	25.50	68.0		220	8.20	8.70	8.00	8	.090	.10K
86/06/25	0915	WATER	14	14.00			220	.80	8.00	7.50	13	.020	.10K
86/06/25	0915	WATER	28	10.00			270	.60	7.70	7.50	21	1.100	.10K
86/07/22	0930	WATER	0	27.50	36.0		209	9.80	8.70	8.90	24	.180	.10K
86/07/22	0930	WATER	10	23.50			220	1.30	8.90	8.20	14	.100	.10K
86/07/22	0930	WATER	30	10.00			260	.40	7.40	7.50	40	1.000	.10K
86/09/03	0915	WATER	30	10.00			250	.40	7.20	7.20	32	.390	.10K
86/09/03	0938	WATER	16	16.00			190	.60	8.60	8.10	14	.130	.10K
86/09/03	0943	WATER	0	22.50			200	10.80	8.70	8.90	16	.170	.10K

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00429 992700101000
40 35 45.0 093 46 20.0 3
SITE NO 1
19053 IOWA DECATUR
THOMPSON RIVER 091300
NINE EAGLE LAKE T067NR25WSC18
21IOWA 771123 10280102 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
76/07/15		WATER				1.83							
76/07/28		WATER				2.16							
76/08/11		WATER				3.47							
76/08/18		WATER				2.50							
79/07/18		WATER	0	.05			5.80						
79/07/18		WATER	6	.07			6.40						
79/07/18		WATER	13	.14			21.80						
79/07/18		WATER	19	.13			19.50						
79/07/18		WATER	22	.19			19.10						
79/07/18 CP(1)- 79/07/18	REP	WATER	13	.13									
79/08/21		WATER	0	.03			19.80						
79/08/21		WATER	6	.07			26.60						
79/08/21		WATER	13	.05			6.00						
79/08/21		WATER	16	.12			66.60						
79/08/21		WATER	22	.15			64.70						
79/08/21		WATER	29				22.10						
79/09/26		WATER	0	.05			13.90						
79/09/26		WATER	6	.06			16.50						
79/09/26		WATER	13	.11			16.80						
79/09/26		WATER	22	.28			47.90						
86/06/25	0915	WATER	0		.060	8.00	8.00						
86/06/25	0915	WATER	14		.070	13.00	9.00						
86/06/25	0915	WATER	28		.110	7.00	6.00						
86/07/22	0930	WATER	0		.040	65.00	61.00						
86/07/22	0930	WATER	10		.020	24.00	18.00						
86/07/22	0930	WATER	30		.070	16.00	8.00						
86/09/03	0915	WATER	30		.200	24.00	11.00						
86/09/03	0938	WATER	16		.080	13.00	9.00						
86/09/03	0943	WATER	0		.050	44.00	32.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

Nine Eagles Storage Capacity - 1973

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
32	0.32	0.32
31	1.07	1.39
30	1.82	3.20
29	2.56	5.77
28	3.31	9.08
27	5.20	14.28
26	7.10	21.37
25	8.99	30.36
24	10.88	41.24
23	12.21	53.45
22	13.54	66.99
21	14.87	81.86
20	16.20	98.06
19	18.75	116.81
18	21.29	138.10
17	23.84	161.93
16	26.38	188.31
15	28.14	216.45
14	29.90	246.35
13	31.66	278.01
12	33.42	311.43
11	35.40	346.83
10	37.38	384.20
9	39.35	423.56
8	41.33	464.89
7	43.66	508.55
6	45.99	554.54
5	48.32	602.86
4	50.65	653.51
3	54.04	707.54
2	57.42	764.96
1	60.81	825.77
Surface	64.19	889.96

Total Storage	889.88 acre/feet
Average Depth	13.86 feet

Nine Eagles Storage Capacity - 1986

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
32	0.32	0.32
31	1.06	1.38
30	1.80	3.17
29	2.53	5.71
28	3.27	8.98
27	5.11	14.09
26	6.96	21.04
25	8.80	29.84
24	10.64	40.48
23	11.91	52.39
22	13.18	65.57
21	14.45	80.02
20	15.72	95.74
19	17.88	113.62
18	20.05	133.67
17	22.21	155.88
16	24.37	180.25
15	26.62	206.86
14	28.87	235.73
13	31.11	266.84
12	33.36	300.20
11	35.29	335.49
10	37.23	372.72
9	39.16	411.88
8	41.09	452.97
7	43.22	496.18
6	45.35	541.53
5	47.47	589.00
4	49.60	638.60
3	50.89	689.49
2	52.18	741.66
1	53.46	795.13
Surface	54.75	849.88

Total Storage 849.88 acre/feet
Average Depth 15.52 feet

Population estimates, 75% confidence intervals a
biomass estimates of black crappie in Nine Eagles Lake, 1986

	Length Group (in)						
	4-5	5-6	6-7	7-8	8-9	9-10	10+
$\bar{X}$ weight (lbs)	.06	.16	.18	.24	.30	.38	.80
Population Estimate	100 ± 50	200 ± 70	2800 ± 700	900 ± 400	1200 ± 300	300 ± 100	200 ± 100
Biomass Estimate (lbs/ac)	< 1	< 1	9 ± 1	4 ± 2	6 ± 2	2	3 ± 1

Total black crappie biomass 1985 = 24 ± 8 lbs/ac
1986 = 24 ± 6 lbs/ac

Population estimates, 75% confidence intervals, biomass estimates of redear sunfish in Nine Eagles Lake, 1

	Length Group (in)					
	3-5	5-6	6-7	7-8	8-9	9-10
$\bar{X}$ weight (lbs)	.07	.14	.24	.37	.54	.65
Population Estimate	800 ± 300	1000 ± 300	2000 ± 600	700 ± 200	2300 ± 400	1000 ± 300
Biomass Estimate (lbs/ac)	1	3 ± 1	8 ± 2	4 ± 1	21 ± 3	11 ± 3

Total redear sunfish biomass 1985 = 46 ± 7 lbs/ac
1986 = 48 ± 10 lbs/ac

Population estimates, 95 % confidence intervals a[nd] biomass estimates of largemouth bass in Nine Eagles Lake, 198[6]

	Length Group (in)						
	3-6	6-8	8-10	10-12	12-14	14-16	16-18
$\bar{X}$ weight (lbs)	.04	.16	.50	.75	1.01	1.70	2.45
Population Estimate	1500 ± 300	900 ± 130	480 ± 50	830 ± 80	1000 ± 100	130 ± 30	20 ± 4
Biomass Estimate (lbs/ac)	1	2	4	10 ± 1	17 ± 2	4 ± 1	<1

Total bass biomass 1985 = 34 ± 2 lbs/ac
1986 = 38 ± 4 lbs/ac

Population estimates, 95% confidence intervals and biomass estimates of bluegill in Nine Eagles Lake, 198[illegible]

	Length Group (in)					
	3-4	4-5	5-6	6-7	7-8	8-9
$\bar{X}$ weight (lbs)	.03	.07	.16	.22	.29	.34
Population Estimate	33,000 ± 10,000	22,000 ± 2500	13,000 ± 2800	12,000 ± 3000	2000 ± 500	1300 ± 500
Biomass Estimate (lbs/ac)	16 ± 5	25 ± 3	35 ± 8	44 ± 11	10 ± 3	8 ± 3

Total bluegill biomass 1985 = 143 ± 34 lbs/ac
1986 = 138 ± 33 lbs/ac

Population estimates, 95% confidence intervals a[illegible] biomass estimates of channel catfish in Nine Eagles Lake, 198[illegible]

	Age		Group			
	II	III	IV	V	VI	VII+
$\bar{X}$ weight (lbs)	.30	.88	2.4	3.8	4.8	5.2
Population Estimate ±	650 ± 100	100 ± 20	90 ± 15	40 ± 15	33 ± 10	13 ± 5
Biomass Estimate (lbs/ac)	3 ± 1	1	3	3	3	1

Total catfish biomass 1985 = 19 ± 3
1986 14 ±

PIERCE CREEK LAKE

Physical and Lake Impact Data

Pierce Creek Lake is located in Page County approximately 3 miles northeast of Shenandoah, Iowa. Most of Pierce Creek's 2,789 acre watershed is in cropland (88%) and pasture (9%). The Iowa Conservation Commission entered a management agreement with the Page County Conservation Board in 1978 to manage the fisheries resource at Pierce Creek Lake. A lake bed contour map was constructed at that time to aid fisheries management efforts and assist fishermen utilizing the area. Mapping was again undertaken in 1986 to determine changes due to siltation. A map of Pierce Creek Lake developed from 1986 data may be found on page 227. In addition a comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake's physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical chracteristics. (See appendix for lake mapping procedures).

	1978	1986
Surface Area	35 acres	33 acres
Maximum depth	20 ft.	16 ft.
Volume	269 acre ft.	205 acre ft.

Based on a comparison of the 1986 and 1978 data, the lake has lost approximately 5% of its surface acreage and 24% of its volume due to siltation. (Complete water storage capacity data may be found in the appendix.) This loss of water volume is directly related to the relatively large watershed (85:1 watershed/lake surface area ratio). Approximately 88% of the watershed is used for row crops and acceptable soil conservation management practices are used on only 60% of row crop acres. Additional soil conservation measures should be implemented as soon as possible as the lake can not afford to lose any additional water volume.

Chemical Data

The physical and chemical data obtained in 1986 for Pierce Creek Lake are listed in the table on page 228 . Where possible in the following brief discussion, 1979 data will be compared to 1986 data. All Pierce Creek Lake data for both 1979 and 1986 may be found in the appendix.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 3 to 16 inches with a mean (N = 3) of 11 inches. The 1979 Secchi readings ranged from 9 to 18 inches with an average (N = 3) of 14 inches.

Pierce Creek Lake water temperature in 1986 ranged from a low of 19°C in September top and bottom samples to a high of 26°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with 1986 data.

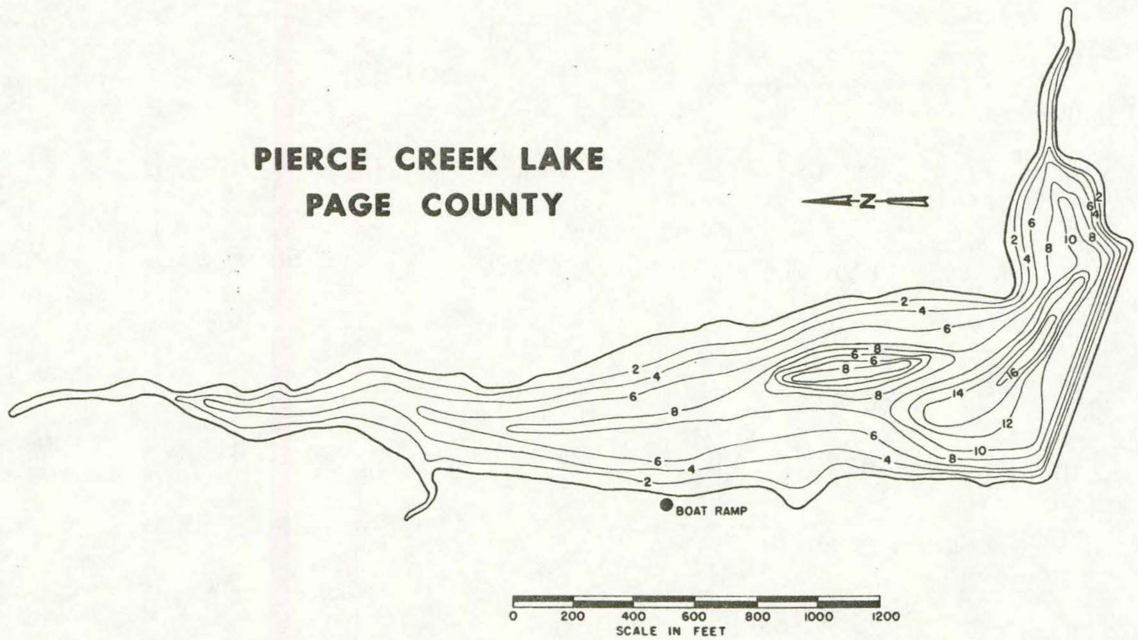
PIERCE CREEK LAKE
PAGE COUNTY

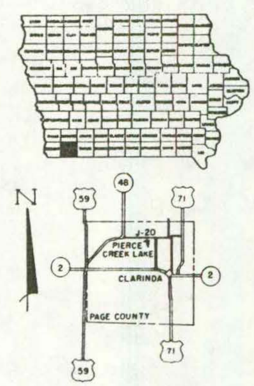
LEGEND

● BOAT RAMP

NOTES

SHORELINE 1.9 MILES
SURFACE AREA 32.87 ACRES
STORAGE 204.6 ACRE/FEET
AVE. DEPTH 6.2 FEET





Pierce Creek Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/18/86		7/22/86		9/11/86	
*Depth[1]	0	12	0	12	0	12
*Secchi[2]	16		3		15	
*Temperature[3]	25	20	26	20	19	19
*Dissolved Oxygen	10.3	0.5	5.8	0.7	8.5	7.2
*pH[4]	8.5	8.0	8.0	7.0	8.6	7.6
Conductivity[5]	370	370	260	180	300	300
Ammonia Nitrogen	0.05	0.46	0.11	1.8	0.05	0.13
Nitrate-Nitrite Nitrogen	0.3	0.3	1.9	0.1	0.1	0.1
Suspended Solids	26	20	100	8600	32	45
Total Phosphorus	0.12	0.12	0.30	3.5	0.24	0.22
Chlorophyll a (Corrected)[6]	63	16	6	1	46	23
Thermally Stratified	Yes		Yes		No	

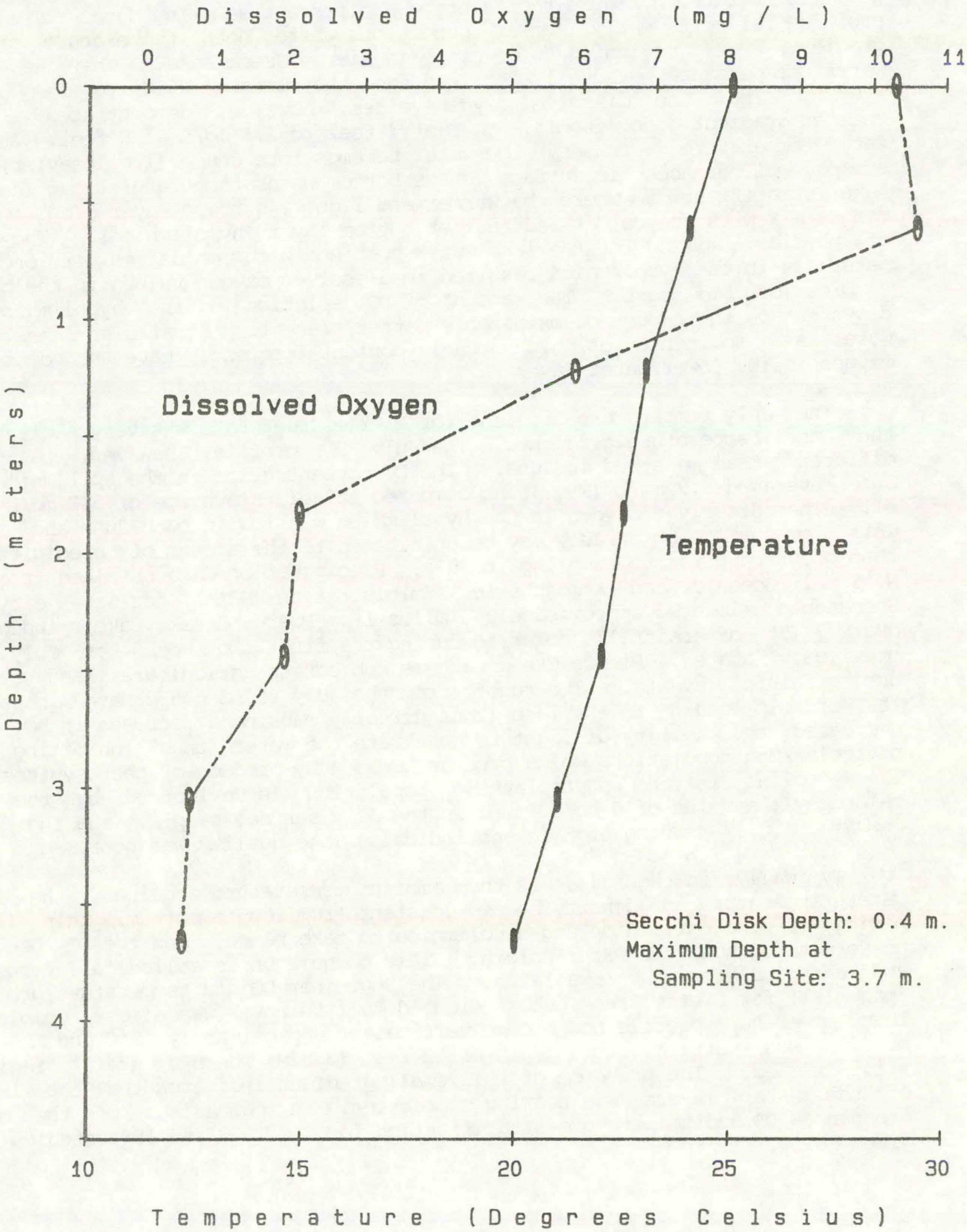
1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

Dissolved oxygen (DO) values in Pierce Creek Lake for 1986 ranged from 0.5 mg/L in the June bottom sample to 10.3 mg/L in the June surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 231, 232 and 233 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling date. The June profile reflects early summer conditions where both temperature and DO gradients were beginning to develope in Pierce Creek Lake. That is, the water temperature gradually declined from the surface (25°C) to the bottom (20°C). The June dissolved oxygen values, however, demonstrated a much sharper gradient going from 5.9 mg/L at 4 feet to 2.1 mg/L at 6 feet. As the water temperature decreases, the water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The lack of physical mixing of the lake water combined with oxidation of orgainci materials in the hypolimnion resulted in dissolved oxygen values in the bottom samples of 0.5 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with water and sediments of high organic content frequently have no dissolved oxygen in the lower water layer.

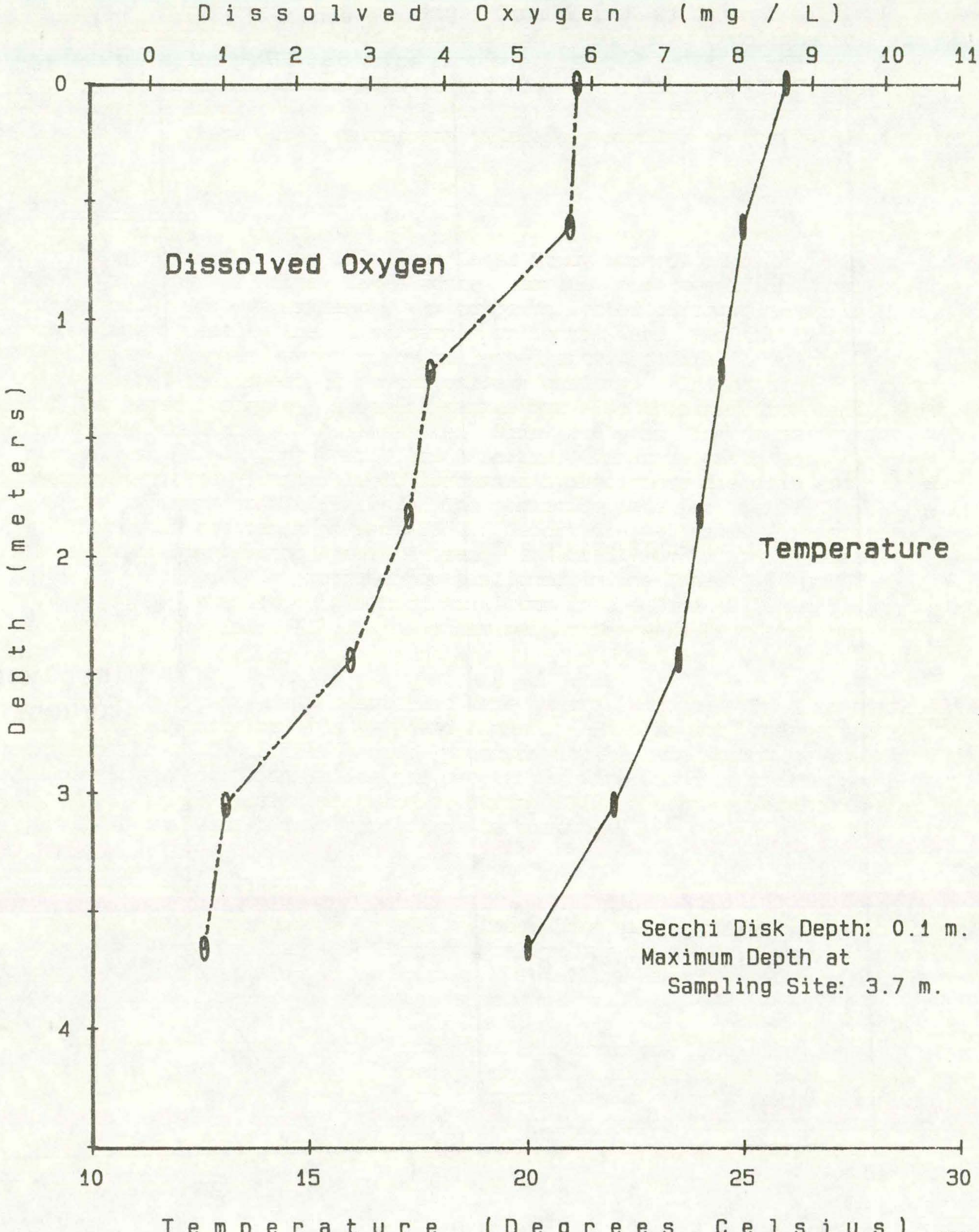
The July temperature gradient for Pierce Creek Lake was very simliar to the June temperature gradient. The July DO profile, however, was much different than measured in June. The DO concentration in the epilimnion in June averaged 8.9 mg/L (N = 3) as compared to July's average of 5.2 mg/L (N = 3). The dissolved oxygen in the hypolimnion was low in both June and July. This low surface DO in July may be attributed to the amount of precipitation that occurred prior to sampling in July. Precipitation data obtained from the National Oceanic and Atmospheric Administration (NOAA) for the city of Shenandoah (located approximately 3 miles from Pierce Creek Lake) indicated over 7.75" of rainfall occurred during the first two weeks of July. As previously stated, Pierce Creek Lake is subject to agricultural land runoff during rainfall events. The runoff from the July rains could have increased the organic loading to the lake (thus directly causing a decrease in DO) and decreased the ability of light to penetrate the water (thus inhibiting the phytoplankton populations which produce DO as a by-product of photosynthesis). The decline in the phytoplankton population is evidenced by the low chlorophyll a value of 6 µg/L found in the July surface sample, and the very low Secchi disk reading of 3 inches indicates lake quality was poor.

Typically in the fall, as them ambient temperature declines, the lake water temperature and density become constant from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place, and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 233) for Pierce Creek Lake indicated fall turnover was almost complete. The temperature profile had become vertical at approximately 19°C and the DO profile was vertical to a depth of 12 feet (3.5 M) where a small gradient still existed. The presence of this small gradient indicates that the mixing of the water layers was nearing completion. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

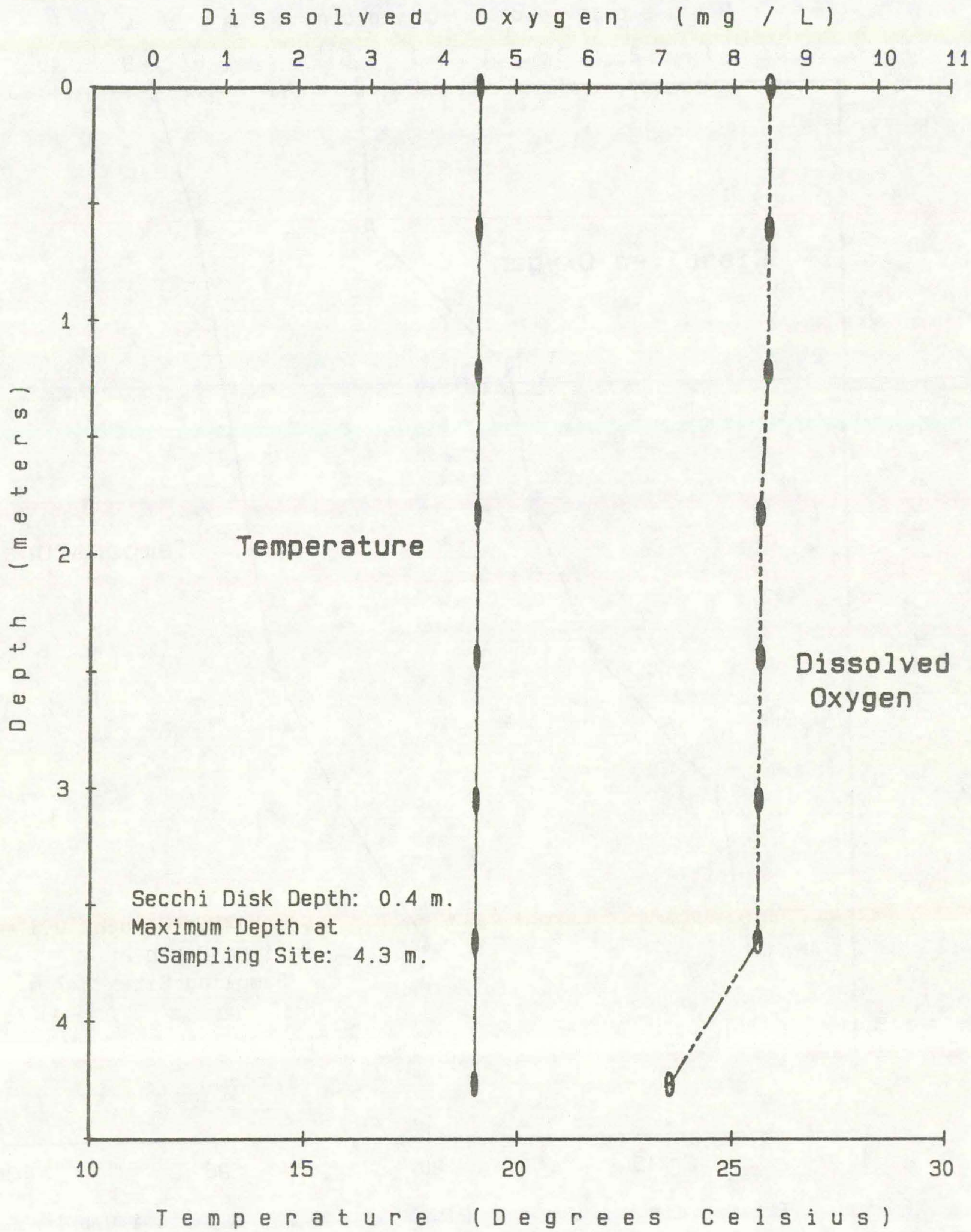
Pierce Creek Lake
Dissolved Oxygen and Temperature Profile
June 18, 1986



Pierce Creek Lake
Dissolved Oxygen and Temperature Profile
July 22, 1986



Pierce Creek Lake
Dissolved Oxygen and Temperature Profile
September 11, 1986



	August 7, 1979 Surface	10 feet	June 18, 1986 Surface	12 feet
DO (mg/L)	10.1	0.5	10.3	0.5
Temperature (°C)	29	23	25	20

Compared to 1979, the 1986 ranges for both DO and temperature were similar.

Values for field pH in 1986 varied from 7.0 to 8.6 units. The pH in the epilimnion was higher (8.0 to 8.6) as compared to the hypolimnion (7.0 to 8.0). The difference in pH values is attributed to a decrease of carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. Values for specific conductance were uniform throughout the water column in both June (370 umho, surface and bottom) and September (300 umho, surface and bottom). During the July sampling, conductivity was lower and there was a difference in conductivity between the surface and bottom samples (260 umho and 180 umho, surface and bottom respectively). Both the lower values and the difference in conductivity may be attributed to the dilutional effects of the heavy of precipitation that occurred during the first two weeks of July.

Ammonia nitrogen concentrations were similar for all three surface samples, ranging from 0.05 to 0.11 mg/L. Bottom samples, ranged from 0.13 to 1.8 mg/L with no discernable pattern. Except for the elevated nitrate value (1.9 mg/L) found in the July surface sample, nitrate remained at relatively low levels (0.1 - 0.3 mg/L) throughout all 3 sampling periods. The elevated July value may also be attributed to the above normal precipitation during the first two weeks of July. The limited nitrogen data for 1979 does not allow for any comparison to 1986 data (one surface sample for ammonia of 0.26 mg/L and nitrate of 0.52 mg/L measured in September). Suspended solids during 1986 ranged from 20 mg/L to 8,600 mg/L with generally higher values being found in the bottom samples. The higher solids values in the bottom samples can be attributed to the settling of material from the upper water layers and include turbidity from tributary streams, soil from bank erosion, dead plankton and other allochthonous and autochthonous matter. The very high level of solids found in the bottom sample obtained in July (8,600 mg/L) illustrates the severity of non-point source runoff on Pierce Creek Lake water quality. During the 1979 study suspended solids ranged from 21 to 107 mg/L and also generally increased with depth.

Total phosphorus concentrations in surface samples ranged from 0.12 to 0.30 mg/L as compared to 0.12 to 3.5 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction. The elevated value of phosphorus in the July sample (3.5 mg/L) may also be attributed to the elevated suspended solids in this sample as total phosphorus is frequently associated with soil particles. During the 1979 sampling, total phosphorus ranged from 0.08 to

0.47 mg/L with the surface samples generally having lower values.

Chlorophyll values are an indirect measurement of the phytoplankton populations. The corrected chlorophyll a values in the epilimnion ranged from 6 µg/L to 63 µg/L in 1986. As previously mentioned, the July epilimnion corrected chlorophyll a value was lowest (6 mg/L) while June (63 µg/L) was the highest. Hypolimnetic values ranged from <1 µg/L to 23 µg/L with the highest value occurring in September. The slightly elevated hypolimnetic September corrected chlorophyll a value can be attributed to fall turnover and the subsequent mixing of the lake water. Corrected chlorophyll a values in the 1979 surface samples were 80 µg/L for July, 54 µg/L for August and 20 µg/L for September. These 1979 values are relatively similar to the values found in 1986.

Pesticide Data

As described in the 1986 Iowa Lakes Study Work/QA plan (4), Pierce Creek Lake was one of five lakes where samples for pesticide analysis were collected. One water sample was to be collected during non-rainfall runoff conditions (usually the first sample collected) and used for baseline data. Two water samples were to be collected after rainfall runoff events to demonstrate the impact of runoff on lake quality. In addition, a composite (of at least 3 samples) sediment sample was also obtained from each lake for pesticide analysis. All samples were analyzed for nine common Iowa pesticides; i.e., the herbicides Atrazine, Cyanazine, Methlachlor, Alachlor, Metribuizen, and Dicamba; the chlorinated hydrocarbons dieldrin and chlordane; and the organophosphate Fonfos. The pesticide data for Pierce Creek Lake may be found in the table on page 236. Reportable values were measured in all three water samples for Atrazine (range 1.4 to 3.9 µg/L) and Cyanazine (range 0.78 to 2.7 µg/L). Methlachlor was found in the June (0.86 µg/L) and July (0.39 µg/L) samples. Alachlor was found in the June (0.20 µg/L) and July (0.41 µg/L) sample. All of the other pesticides were less than the reporting limit.

The levels of these herbicides were generally highest in June and less in the samples obtained in July and August. This is not unexpected as the application of herbicides generally occurs in the late spring as the crops are planted. No reportable values for pesticides were found in the sediment sample obtained from Pierce Creek Lake. During 1979 no samples were collected for pesticide analysis and no comparison is possible.

Biological Data

The fish population in Pierce Creek Lake has suffered from the poor water quality conditions. Panfish quality has decreased, carp numbers have increased and bass fishing is poor. The decline has occurred since 1983 when an acceptable fishery was still present.

Fisheries survey work conducted in September 1986 indicated a fish population dominated by 7 to 8 inch thin crappie, a substantial carp population, and a bass population characterized by poor reproduction and the majority of fish under 13 inches in length. Major fish species abundance, average length, and range during the fall 1986 survey at Pierce Creek Lake are given in the table below.

Pierce Creek Lake
Pesticide Date
1986
(all values in micrograms per liter or parts per billion)

Date Collected	6/16/86	7/01/86	8/14/86	7/10/86
Sample Matrix	Water	Water	Water	Sediment
Atrazine (AAtrex)	3.9	1.9	1.4	<50
Cyanazine (Bladex)	2.7	1.9	0.78	<50
Methlachlor (Dual)	0.86	0.39	<0.1	<50
Alachlor (Lasso)	0.20	0.1	0.12	<200
Metribuzin (Sencor)	<0.1	0.41	<0.1	<75
Dicamba (Banvel)	<0.1	<0.1	<0.1	<2
Dieldrin (Dieldrin)	<0.05	<0.05	<0.1	<15
Fonfos (Dyfonate)	<0.1	<0.1	<0.1	<50
Chlordane (Chlordane)	<0.2	<0.2	<0.5	<100

Species	#	Average Length (inches)	Range (inches)
Bluegill	96	6.2	4.0-8.5
White Crappie	214	7.2	4.0-9.0
Black Crappie	123	8.0	6.0-9.5
Largemouth Bass	22	11.5	7.5-20.0
Channel Catfish	17	16.9	13.0-20.5
Carp	22	30.0	23.5-34.0

A fair channel catfish fishery is maintained by an annual stocking of seven inch fingerlings by the Iowa Department of Natural Resources. However, continued agricultural practices, and the high siltation rates will result in further deterioration of the fishery.

Summary

Although the data presented in this report are rather limited it is possible to make several general statements

> Since 1979, the volume of water Pierce Creek Lakes has declined approximately 24% as a result of siltation. Additional siltation control measures should be undertaken as soon as possible as the lake cannot afford to lose more water volume.
>
> The 1986 dissolved oxygen and temperature profiles were similar to those obtained in 1979, and no other major changes in lake water quality appear to have occurred from 1979 to 1986. The fish population has suffered from the elevated silt levels and fishing is generally poor. Continued monitoring is necessary to determine long-term trends in water quality.

LITERATURE CITED

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2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

4. Wnuk, M. 1986. 1986 Iowa Lakes Study - Work/QA Plan. Iowa Department of Natural Resources, Des Moines, Iowa.

APPENDIX

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00554 997300101000
40 50 00.0 095 21 00.0 5
DEEPEST PART PIERCE CR LAKE-W OF ESSEX
19145 IOWA PAGE
NISHNABOTNA RIVER BASIN 091200
NISH R-PIERCE CR LAKE T070NR39WSC29
21IOWA 801004 10240003003 0020.160 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/16		WATER	0	26.40		.45	300	10.00		8.40	23		
79/07/16		WATER	3				300	5.90		7.90	21		
79/07/16		WATER	6				290	1.40		7.50	51		
79/07/16		WATER	9				290	1.00		7.50	58		
79/07/16 CP(1)- 79/07/16	REP	WATER	0	.00		.45							
79/08/07		WATER	0	29.40		.40	315	10.10		8.56	17		
79/08/07		WATER	3				315	9.80		8.59	25		
79/08/07		WATER	9				300	.50		7.65	26		
79/08/07 CP(1)- 79/08/07	REP	WATER	0	.00		.40		9.90					
79/08/07 CP(1)- 79/08/07	REP	WATER	9				300			7.60			
79/09/04		WATER	0	25.70		.22	180	5.40		7.50	28	.260	.52
79/09/04		WATER	3				210	5.80		7.70	35		
79/09/04		WATER	13				150	.20		7.40	107		
79/09/04 CP(1)- 79/09/04	REP	WATER	0	.00		.25		5.50				.320	.47
86/06/18	1400	WATER	0	25.00	16.0		370	10.30	8.50	8.50	26	.050	.30
86/06/18	1400	WATER	12	20.00			370	.50	8.00	7.80	20	.460	.30
86/07/22	1300	WATER	0	26.00	3.0		260	5.80	8.00	7.70	100	.110	1.90
86/07/22	1300	WATER	12	20.00			180	.70	7.00	7.10	8600	1.800	.10
86/09/11	1227	WATER	0	19.00	15.0		300	8.50	8.60	7.70	32	.050	.10
86/09/11	1228	WATER	12	19.00			300	7.20	7.60	7.70	45	.130	.10

STORET RETRIEVAL DATE 87/07/08 PGM=RET PAGE: 27

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00554 997300101000
40 50 00.0 095 21 00.0 5
DEEPEST PART PIERCE CR LAKE-W OF ESSEX
19145 IOWA PAGE
NISHNABOTNA RIVER BASIN 091200
NISH R-PIERCE CR LAKE T070NR39WSC29
21IOWA 801004 10240003003 0020.160 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/16		WATER	0	.26			80.10						
79/07/16		WATER	3	.28			27.30						
79/07/16		WATER	6	.42			26.60						
79/07/16		WATER	9	.43			9.10						
79/07/16		WATER	22				43.40						
79/08/07		WATER	0	.25			53.90						
79/08/07		WATER	3	.27			59.90						
79/08/07		WATER	9	.40			56.90						
79/09/04		WATER	0	.61			20.20						
79/09/04		WATER	3	.61			26.20						
79/09/04		WATER	13	1.45			6.00						
86/06/18	0000	WATER	0							3.900	.200U		.86
86/06/18	1400	WATER	0		.120	69.00	63.00						
86/06/18	1400	WATER	12		.120	27.00	16.00						
86/06/26	0000	WATER	0					2.000U	200.000U			100.00U	
86/07/09	0000	WATER	0							1.900	.200U		.39
86/07/22	1300	WATER	0		.300	7.00	6.00						
86/07/22	1300	WATER	12		3.500	76.00	1.00K						
86/09/11	0000	WATER	0							1.400	.500U		.10U
86/09/11	1227	WATER	0		.240	49.00	46.00						
86/09/11	1228	WATER	12		.220	29.00	23.00						

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00554 997300101000
40 50 00.0 095 21 00.0 5
DEEPEST PART PIERCE CR LAKE-W OF ESSEX
19145 IOWA PAGE
NISHNABOTNA RIVER BASIN 091200
NISH R-PIERCE CR LAKE T070NR39WSC29
21IOWA 801004 10240003003 0020.160 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	39380 DIELDRIN TOTUG/L	39383 DIELDRIN SEDUG/KG DRY WGT	39631 ATRAZINE MUD UG/KG	46317 LASSO WHL SMPL UG/L	77780 BLADEX TOTAL UG/L	81294 DYFONATE TOT UG/L	81407 ALACHLOR SED DRY WGTUG/KG	81408 MTRBUZIN TOT UG/L	81409 MTRBUZIN SED DRY WGTUG/KG	82052 BANVEL TOTAL UG/L
86/06/18	0000	WATER	0	.050U			.20	2.700	.100U		.100U		
86/06/26	0000	WATER	0		15.00U	50.00U				200.000U		75.000U	
86/07/09	0000	WATER	0	.050U			.10U	1.900	.100U		.410		
86/09/11	0000	WATER	0	.100U			.12	.780	.100U		.100U		.1U

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00554 997300101000
40 50 00.0 095 21 00.0 5
DEEPEST PART PIERCE CR LAKE-W OF ESSEX
19145 IOWA PAGE
NISHNABOTNA RIVER BASIN 091200
NISH R-PIERCE CR LAKE T070NR39WSC29
21IOWA 801004 10240003003 0020.160 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	82502 IRON INS OL DRYDP UG/KG	82543 BLADEX DRY WT. MG/KG	82544 DYFONATE DRY WT / MG/K
86/06/18	0000	WATER	0	.1U		
86/06/26	0000	WATER	0		.05U	.05U
86/07/09	0000	WATER	0	.1U		

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

Pierce Creek Storage Capacity - 1978

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
28	0.01	0.01
27	0.02	0.03
26	0.02	0.05
25	0.04	0.08
24	0.05	0.13
23	0.08	0.21
22	0.11	0.32
21	0.13	0.45
20	0.15	0.60
19	0.43	1.03
18	0.71	1.74
17	1.05	2.79
16	1.38	4.17
15	2.14	6.31
14	2.90	9.21
13	4.40	13.61
12	5.90	19.51
11	8.12	27.63
10	10.34	37.97
9	12.39	50.36
8	14.44	64.80
7	16.88	81.67
6	19.31	100.98
5	21.63	122.61
4	23.95	146.56
3	26.45	173.01
2	28.95	201.96
1	31.93	233.89
Surface	34.90	268.79

Total Storage 268.79 acre/feet
Average Depth 7.70 feet

Pierce Creek Storage Capacity - 1986

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
16	0.19	0.19
15	0.63	0.82
14	1.07	1.89
13	1.57	3.46
12	2.07	5.53
11	2.92	8.445
10	3.76	12.205
9	6.01	18.21
8	8.25	26.46
7	11.67	38.13
6	15.09	53.22
5	18.08	71.3
4	21.07	92.37
3	23.64	116.005
2	26.20	142.205
1	29.54	171.74
Surface	32.87	204.61

Total Storage	204.61 acre/feet
Average Depth	6.22 feet

IOWA CONSERVATION COMMISSION

Larry J. Wilson — Director
Wallace State Office Building, Des Moines, Iowa 5
515/281-5145

An EQUAL OPPORTUNITY Agency

SW Regional Office
Cold Springs State Park
Lewis, IA 51544
December 5, 1983

Jerry Abma, Executive Officer
Page County Conservation Board
Safety Center
Clarinda, IA 51632

Dear Jerry:

The fisheries research personnel of Iowa Conservation Commission cove rotenoned one sma cove totaling 1.21 acres in Pierce Creek Lake to estimate the fish standing stock on September 5, 1983. The results are listed below:

Species			Biomass lbs/ac
Bluegill	0-3	inches	15
	3-6	"	112
	6-8	"	130
			257
Channel Catfish	6-8	inches	3
	8-10	"	2
	10-12	"	11
	12-14	"	14
	14-16	"	25
	16-18	"	23
	18-20	"	20
			108
Green Sunfish	3-6	inches	3

Species			Biomass lbs/ac
Largemouth bass	3-6	inches	13
	6-8	"	11
	8-10	"	15
	10-12	"	13
	12-14	"	12
			64
White Crappie	0-3	inches	4
	3-6	"	16
	6-8	"	96
	8-10	"	6
			125
Black Crappie	3-6	inches	< 1
Black Bullhead	3-6	inches	< 1

Total fish biomass: 558 lbs/ac
Biomass acceptable to anglers: 243 lbs/ac

Thank you for your interest and cooperation. Please pass this information on to your board members and subordinates.

Sincerely,

Kay R. Hill

Kay R. Hill
Fisheries Research Biologist

KH/ej
cc: Joe Schwartz
Mike McGhee
Don Priebe
File

DATE: Pierce Creek
WATER:
CATALOG NO.:

INVESTIGATOR: Sobotka, Still

TOTAL NET HOURS:
MIN. SHOCKER: 60 Min.

NO. HAULS:
OTHER:

LENGTH FREQUENCY

SPECIES / IN.	.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0
Blg.								2	12	12	2	8	10
White Crappie													
Green Sunfish								2	4				
Channel Catfish	in #	14.5 (2)	16	16.5	18.5 (2)								
LMB	in #	20 inches	19 inches										
Carp	in #	25 (2)	30 (2)	30.5	31 (2)	31.5	32 (3)	33 (2)	34 (2)				

SPECIES / IN.	7.0-7.5	7.5-8.0	8.0-8.5	8.5-9.0	9.0-9.5	9.5-10.0	10.0-10.5	10.5-11.0	11.0-11.5	11.5-12.0	12.0-12.5	12.5-13.0	13.0-13.5	13.5-14.0	14.0-14.5
Blg.	4	2													
White Crappie	4	2													
Green Sunfish															
Channel Catfish															
LMB		4	2					4	2		2		4		
Carp															

DATE: 9/20/86
WATER: Pierce Creek
CATALOG NO.:

INVESTIGATOR: M'Ghee, Sobotka, Still

NET: 4 Fyke
TOTAL NET HOURS: 96
MIN. SHOCKER:

SEINE:
NO. HAULS:
OTHER:

LENGTH FREQUENCY

SPECIES IN.	.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5	7.5-8.0	8.0-8.5	8.5-9.0	9.0-9.5	9.5-10.0	10.0-10.5	10.5-11.0	11.0-11.5	11.5-12.0	12.0-12.5	12.5-13.0	13.0-13.5	13.5-14.0
Blg.									2	4	7	9	8	5	3	6											
White Crappie											4	24	27	88	40	19	5										
Black Crappie												4	13	11	12	59	21	3									
Green Sunfish										3	2																
LMB																						1	1				
Black Bullhead																						1	1				
Channel Catfish IN. #		13-(2)	15.(2)	17.5(2)	19(3)	20	20.5																				
CARP IN #		23.5(2)	25	30	31(2)																						

RED HAW LAKE

Physical and Lake Impact Data

Red Haw Lake is located in Lucas County approximately 1 mile southeast of Chariton, Iowa. Most of the lake's watershed (1) is in cropland (56%), pasture (33%) and forest (7%). A map of Red Haw Lake produced from 1986 data may be found on page 252.

A comparison of the lake's physical characteristics for 1979 and 1986 are given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures).

	1973	1986
Surface Area	64 acres	71 acres
Maximum Depth	40 feet	38 feet
Volume	948 acre feet	908 acre feet

The volume of Red Haw Lake decreased from 948 acre feet in 1973 to 908 acre feet in 1986, a decrease of about 4% during the 13 year period.

Nonpoint source eutrophication was similar to that recorded in the 1979 survey. Two small silt dams, prior to 1980, were constructed to alleviate further siltation. Good soil conservation should be followed in an effort to slow the rate of siltation and thus lengthen the lake's lifespan.

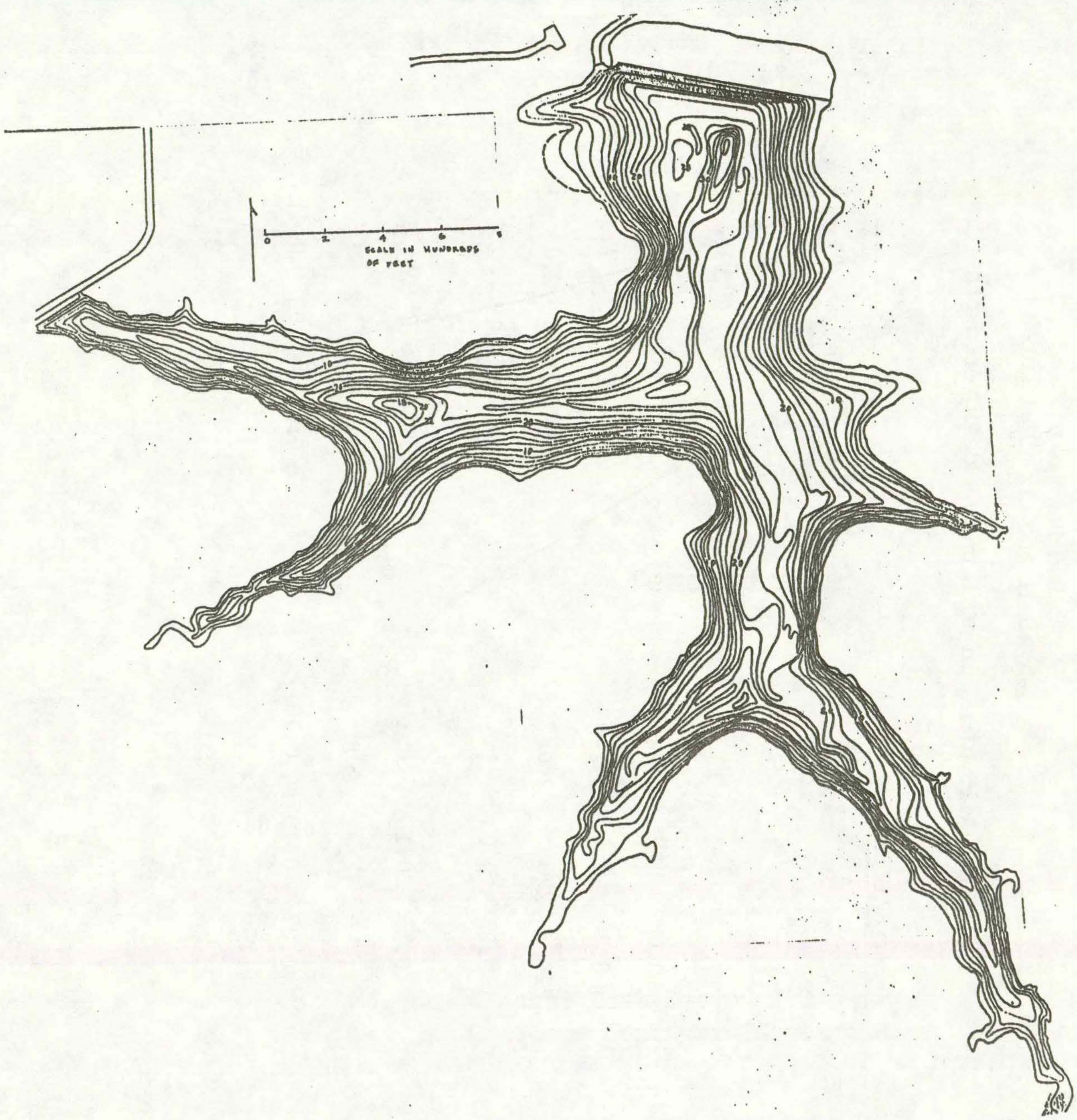
Chemical Data

The physical and chemical data obtained in 1986 for Red Haw Lake are listed in the table on page 253. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 31 to 39 inches with a mean (N = 3) of 36 inches. The 1979 Secchi readings ranged from 28 to 47 inches with an average (N = 3) of 36 inches.

Red Haw Lake water temperature ranged from a low of 13°C in the June bottom sample to a high of 28°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Limited temperature data for 1979 does not allow for a comparison with the 1986 data.

Dissolved oxygen (DO) values ranged from 0.0 mg/L in two bottom samples to 10.0 mg/L in one surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 254, 255 and 256 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling date. The June profile reflects early summer conditions where relatively sharp temperature and DO gradients had developed in Red Haw Lake. That is, the values for both parameters were constant (DO 10 mg/L and temperature 27°C) to a depth of about 6 feet (2 meters) then sharply dropped



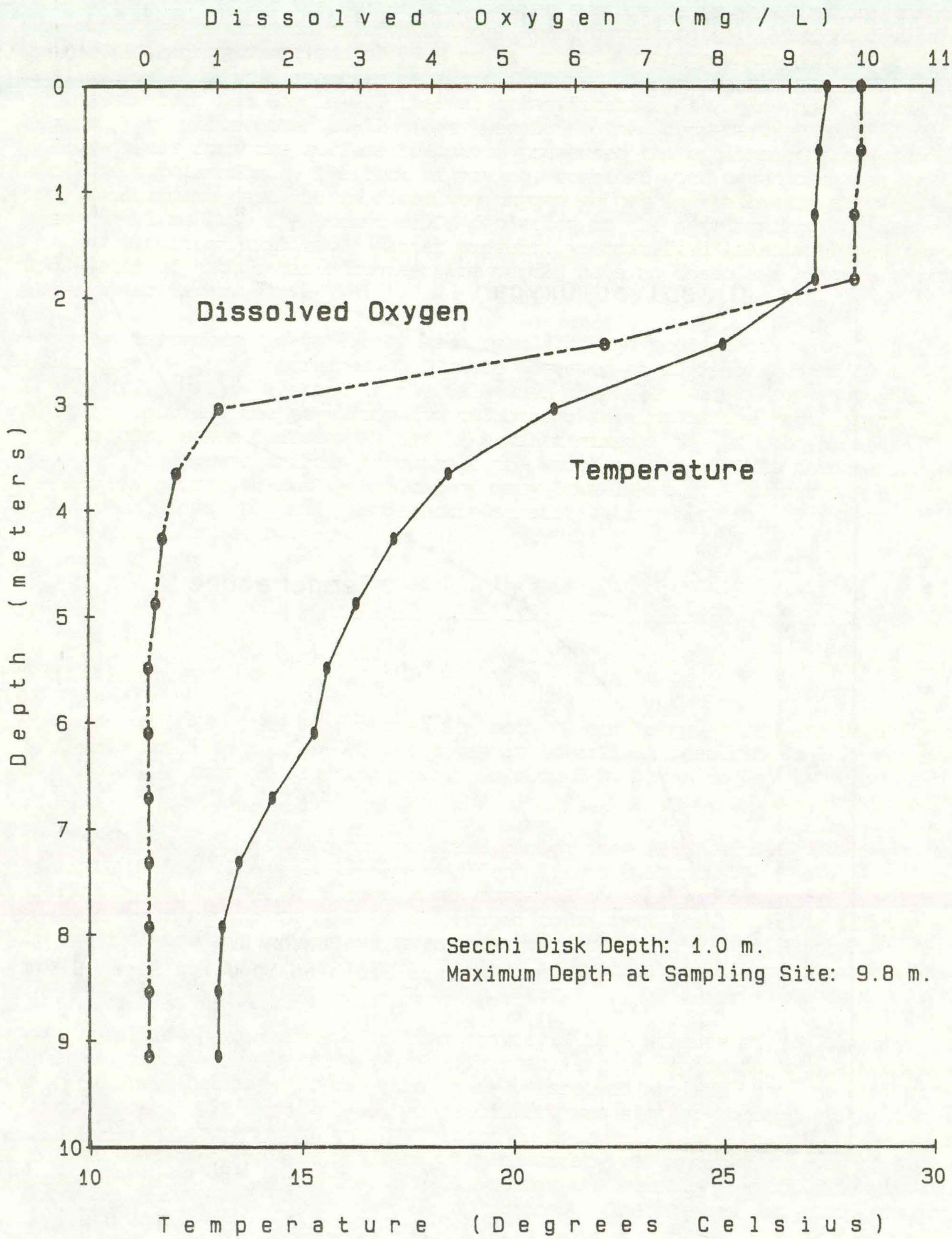
Hydrographic map of Red Haw Lake, mapped in September, 1986.

Red Haw Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

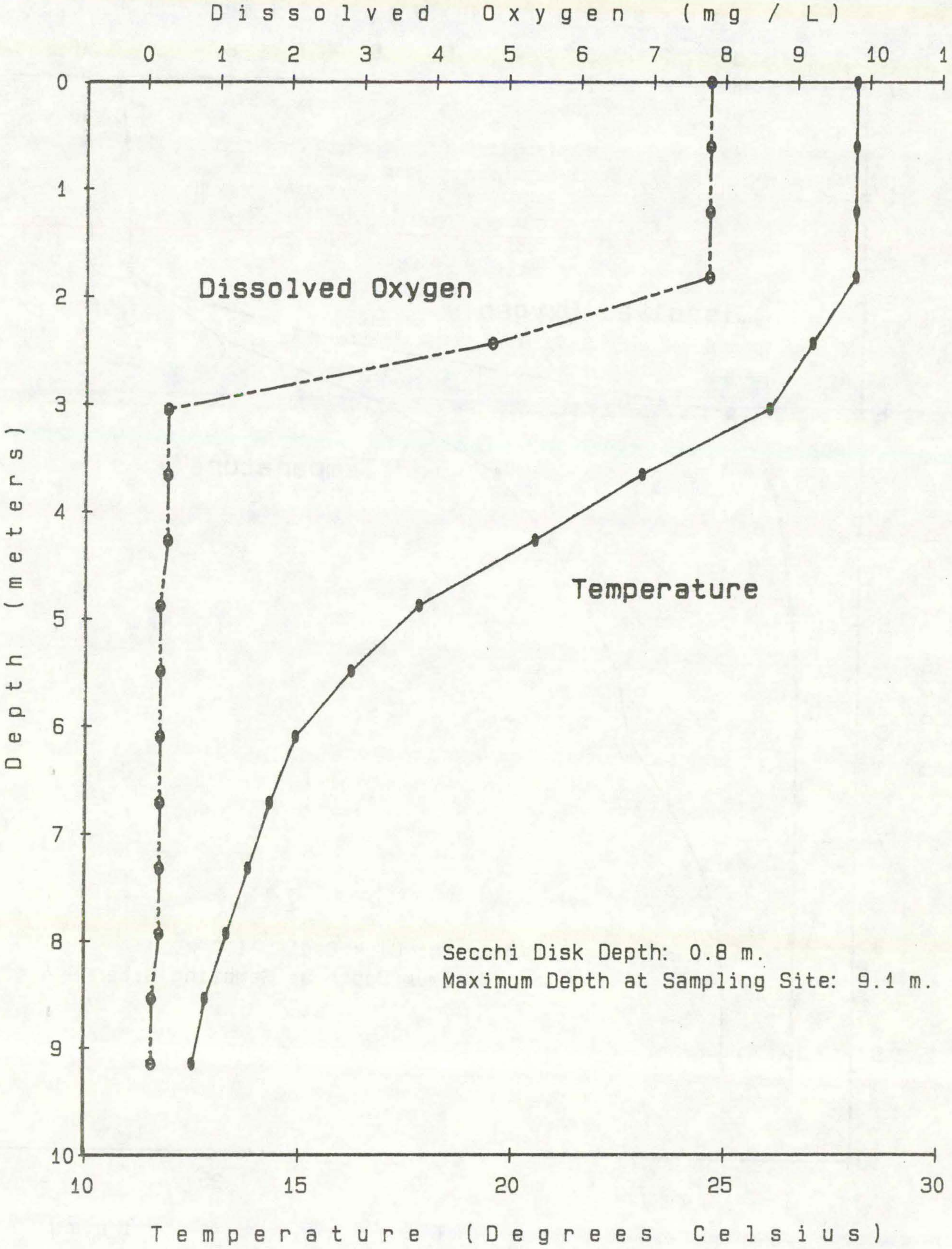
Date Collected	6/18/86			7/21/86			9/02/86		
*Depth[1]	0	9	28	0	10	30	0	19	30
*Secchi[2]	39			31			39		
*Temperature[3]	27.5	24	13	28	26	13	23	16	13
*Dissolved Oxygen	10.0	6.0	0.0	7.8	0.3	0.1	9.4	0.0	0.0
*pH[4]	8.9	8.4	7.6	8.6	8.0	7.2	8.6	7.2	7.1
Conductivity[5]	220	220	240	200	210	270	190	260	310
Ammonia Nitrogen	0.03	0.03	1.1	0.06	0.19	2.1	0.10	2.9	6.1
Nitrate-Nitrite Nitrogen	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
Suspended Solids	11	14	17	30	48	32	8	8	16
Total Phosphorus	0.07	0.10	0.20	0.06	0.05	0.41	0.10	0.55	0.94
Chlorophyll a (Corrected)[6]	21	24	13	44	54	8	14	6	7
Thermally Stratified		Yes			Yes			Yes	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

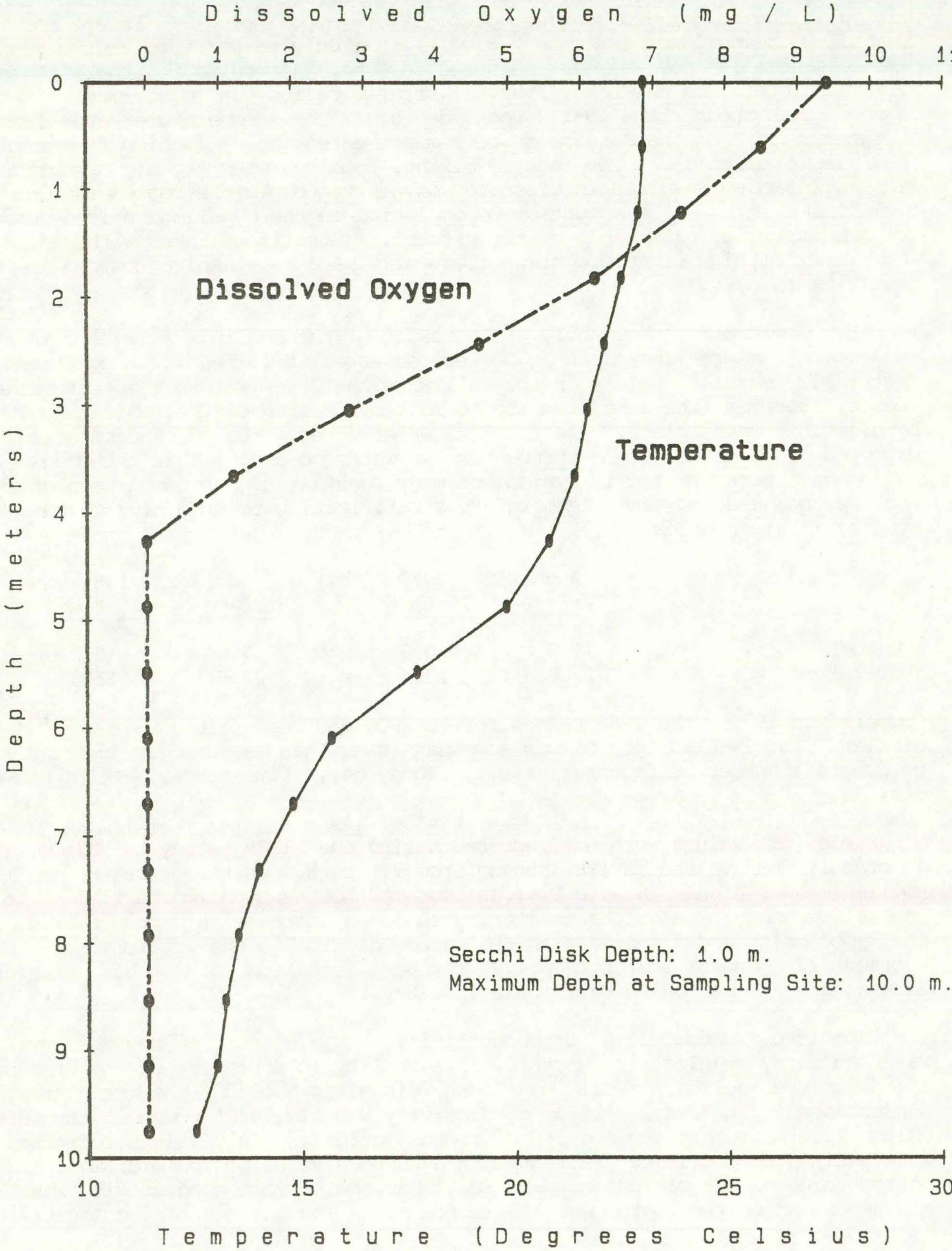
Red Haw Lake
Dissolved Oxygen and Temperature Profile
June 18, 1986



Red Haw Lake
Dissolved Oxygen and Temperature Profile
July 21, 1986



Red Haw Lake
Dissolved Oxygen and Temperature Profile
September 2, 1986



to less than 1 mg/L DO and a temperature of 21°C at a depth of 10 feet (3 meters) and continued to decline to the bottom. As the water temperature decreases, the water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratificiation where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). Except for the initial DO being lower (surface 7.8 mg/L), the July temperature and DO profile was essentially the same as measured in June. According to the fisheries biologist for Red Haw Lake, thermal stratification in midsummer normally begins at about the 10-12 foot depth. The temperature and density differentials from the surface to bottom prevented the epilimnion from mixing with the hypolimnion. The lack of mixing, combined with organic oxidation in the hypolimnion resulted in dissolved oxygen values in the bottom samples of less than 1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with sediments and water of high organic content frequently have no dissolved oxygen in the lower water layer.

By September (page 256), as a result of the cooling of water in the epilimnion, minor increases in DO were observed at 10 feet (2.8 mg/L) and 12 feet (1.2 mg/L). Later in the fall when the lake water temperature and density becomes the same from top to bottom, mixing of the epilimnion and hypolimnion takes place. As the lake water mixes, the DO concentration is expected to become uniform throughout the water column. This phenomenon is called fall turnover and is typical of many Iowa lakes. A comparison of the most pronounced DO and temperature stratification for the 1979 and 1986 studies is given below.

	August 21, 1979		July 21, 1986	
	Surface	26 feet	Surface	26 feet
DO (mg/L)	11.0	0.0	7.8	0.2
Temperature (°C)	27.0	13.4	28.0	13.3

Compared to 1979, the 1986 ranges for both DO and temperature were relatively similar. The 1986 surface DO was somewhat lower than measured in 1979 but may be due to a number of factors; i.e., cloudy day, time of day, method used, etc.

Field pH values were not reported during the 1986 study. Values for laboratory pH values in 1986 ranged from 7.1 to 8.9 units. The pH in the epilimnion was higher (8.6 to 8.9) as compared to the hypolimnion (7.1 - 7.6). The difference in pH values is attributed to an increase in carbon dioxide in the hypolimnion and a decrease in the carbon dioxide in the epilimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids, i.e., the more dissolved solids the greater the conductance. In June, 1986, conductivity was similar throughout the water column (220 micromhos top and 240 micromhos bottom). July values reflected a well defined conductivity gradient with a surface value of 200 micromhos and a bottom value of 270 micromhos. By September the surface conductivity was 190 micromhos while the bottom was 310 micromhos. The changes in conductivity over time may be related to changes in the concentrations of dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2,3). In June, low phytoplankton populations were present. As the phytoplankton populations increased in July they began utilizing the dissolved nutrients causing a decline of dissolved solids in the epilimnion hence a decline in conductivity. The upper water column showed the greatest decrease in conductivity because fewer phytoplankton existed at the lower depths. Conductivity data for the epilimnion in 1979 demonstrated an increase from July (160 micromhos) to September (200 micromhos). Limited data for 1979 indicate conductivity in the hypolimnion (240 to 270 micromhos) was consistently higher than the epilimnion (160 to 200 micromhos).

Ammonia nitrogen concentrations during 1986 were similar for all three surface samples, ranging from 0.03 to 0.10 mg/L. The bottom ammonia nitrogen concentrations, however, increased from 1.1 mg/L in June to 2.1 mg/L in July and reached a maximum of 6.1 mg/L in September. The increase from June to September may be attributed to the decay of organic matter in the deoxygenated water near the bottom. Nitrate values were less than the reporting limit (<0.1 mg/L) in all samples collected but one (0.2 mg/L). The low nitrate levels in Red Haw Lake may partially be attributed to assimilation by the phytoplankton. In fact, the lack of nitrate may be limiting algal production. The limited nitrogen data for 1979 do not allow for any comparison to 1986 data (one surface sample for ammonia of 0.20 mg/L and a nitrate of 0.1 mg/L measured in September).

Suspended solids ranged from 8 mg/L to 48 mg/L with the bottom sample values higher than the surface values in June and September. A smaller range was measured in 1979 (0.9 to 15 mg/L) for suspended solids with no substantial difference between surface and bottom samples.

Total phosphorus concentrations in the 1986 surface samples ranged from 0.06 mg/L to 0.10 mg/L as compared to 0.20 to 0.94 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phsophorus is rapidly assimilated. In the oxygen deficient part of the hypolimnion, phosphorus levels increased from 0.20 mg/L in June to 0.41 mg/L in July to 0.94 mg/L in September. It is not unusual for phosphorus to increase in the bottom waters from decomposition (of plankton and miscellaneous matter) and liberation from the sediment by reduction. During the 1979 sampling, total phosphorus ranged from 0.08 to 2.14 mg/L with a mean for all three bottom samples of 1.8 mg/L.

Chlorophyll values are an indirect measurement of the phytoplankton populations. The 1986 corrected chlorophyll a value was lowest while the July value was greatest. Hypolimnetic chlorophyll values ranged from 7 µg/L to 13 µg/L with the highest value occurring in June. Corrected chlorophyll a values in the 1979 epilimnion average 62 µg/L for 2 July, 36 µg/L for July and 51 µg/L for September.

Biological Data

Fish populations at Red Haw Lake were sampled on September 3-4, 1986 with 2 ft. x 4 ft. fyke nets and electrofishing gear. Thirteen fyke nets were set for two days yielding an overall effort of 26 net days. Of the 13 nets, five were set at sites used in previous investigations. Electrofishing occurred at night with two, 12-minute runs, accounting for 24 electrofishing minutes.

In all, 536 fish were sampled of which 425 were taken in fyke net sets, while 111 were captured by electrofishing. In fyke net catches bluegill, crappie and green sunfish were nearly equal in abundance at approximately 20% (Table 1). Yellow bullhead comprised about 11% of the catch, while redear sunfish, yellow perch and warmouth each contributed 7-8% of the sample. Largemouth bass was represented by four fish comprising 1% of the catch.

Table 1. Species, catch, species composition and catch per unit effort (CPUE) in fyke nets at Red Haw Lake, 1986.

Species	Number	Percent Composition	CPUE (net day)
Bluegill	95	22.4	3.7
Crappie	94	22.1	3.6
Green Sunfish	86	20.2	3.3
Largemouth Bass	4	0.9	0.2
Redear Sunfish	37	8.7	1.4
Warmouth	30	7.1	1.2
Yellow Bullhead	48	11.3	1.8
Yellow Perch	31	7.3	1.2
Total	425	100.0	16.4

Composition in the electrofishing sample was considerably different; largemouth bass dominated with 56 individuals, making up 50% of the total (Table 2). Bluegill accounted for 28 fish (25%), followed by green sunfish at 22% and crappie at 2%. Redear sunfish was represented by a single fish.

Table 2. Species, catch, species composition and catch per unit effort (CPUE) in the electrofishing sample at Red Haw Lake, 1986.

Species	Number	Percent Composition	CPUE
Largemouth Bass	56	50.1	140
Bluegill	28	25.2	70
Green Sunfish	24	21.6	60
Crappie	2	1.8	5
Redear Sunfish	1	0.9	2
Total	111	99.6	277

Relative abundance, as measured by number of fish per fyke net day (CPUE), ranged from 3.7 CPUE for bluegill to 0.2 CPUE for largemouth bass (Table 1). Overall, 16.4 CPUE was attained for fyke nets. Relative abundance for electrofishing was measured as fish per hour. Largemouth bass represented the greatest CPUE at 140 followed by bluegill at 70 CPUE (Table 2). Redear sunfish CPUE was lowest at 2. Total sample CPUE was 277.

Length-frequency distributions for major fish species were constructed by combining fyke net and electrofishing samples. Bluegill length ranged from 6 cm (2.4 in) to 21 cm (8.3 in) with a mode at 10 cm (3.9 in) (Figure 1). Proportional stock density (PSD) was 46%. Largemouth bass length-frequency showed several modes which corresponded to age groups. The first mode was at 13 cm (5 in) for 0-age fish, while the second and third modes were at 21 cm (8.3 in) and 29 cm (11.4 in) representing age groups one and two, respectively. Largemouth bass PSD was 25%. Crappie ranged in length from 9 cm (3.5 in) to 26 cm (10.2 in) with a mode at 18 cm (7.1 in). PSD for crappie was 29%.

Body condition of bluegill, crappie, largemouth bass and channel catfish was determined at Red Haw Lake and expressed as a function of relative weight (W_r). Channel catfish were not taken in the September sample; however, catfish were collected earlier for another investigation. Table 3 is a summary of weight-length relationships and body condition for the four major sportfish species at the lake. Weight, W, is in grams and length, L, is in millimeters.

Table 3. Weight-length relationships for major fish species at Red Haw Lake, 1986.

	N	Weight-Length Relationship	Average W_r	Standard Error of W_r
Bluegill	88	LogW = -5.1031 + 3.1853 LogL	98	1.1
Largemouth Bass	27	LogW = -4.7032 + 2.9161 LogL	98	4.2
White Crappie	4	LogW = -6.4335 + 3.6688 LogL	88	8.0
Black Crappie	31	LogW = -4.9944 + 3.0778 LogL	95	1.2
Channel Catfish	27	LogW = -5.5067 + 3.1699 LogL	93	2.1

Growth rate and age structure of crappie, largemouth bass, and bluegill were determined by standard age-growth methods using annular marks on scale samples taken during the survey period.

Crappie showed most rapid growth during the first year of life when average length by the end of the growing season was 3.2 inches (Figure 2). Thereafter, growth rate decreased. For example, the average growth increment during the second year of life was 1.53 inches. Average lengths at ages 3-6 were 6.4, 7.9, 9.2 and 10.6 inches, respectively. Growth rate in 1986 compared to collections in 1974-78 were similar in that average calculated lengths after six years were nearly identical. The primary difference between the samples was fish in 1974-78 exhibited a slower growth during the first year of life and an accelerated growth during the second year of life.

Crappie in 1986 were dominated by age 4 fish comprising 32% of the sample. Age 2 fish represented 29%, while ages 3, 5 and 6 comprised 21%, 14% and 4% respectively of the population.

Growth of largemouth bass was similar to past years except increments at each year of life were slightly greater in recent years. After six years of growth, average bass length was 16.5 inches for the 1986 collection (Figure 3). Growth from this year's collection showed most rapid growth was during the first year when 4.3 inches was attained. Average lengths for ages 2-5 were 8.1, 10.4, 12.5 and 15.1 inches, respectively.

Age structure was dominated by age 2 fish at 52% followed by age 1 bass at 24%. Ages 3 and 4 each contributed 9.5%, while age 6 fish contributed 5% to the sample.

Bluegill from the 1986 sample showed most rapid growth in the third year of life when an increment of 2.1 inches was attained (Figure 4). Average growth increments for the first and second years were 2.0 and 1.9 inches, respectively. Thus, at the end of three years of growth average bluegill length was 6.0 inches. Average lengths at ages 4 and 5 were 7.3 and 7.8 inches, respectively. Calculations from the 1986 sample showed growth had increased considerably since the collection in 1970-76. Accumulated length to age 4 showed mean length in 1986 was about 18% greater than in previous years.

Bluegill in the 1986 sample consisted primarily of age 2 fish making up 57% of all ages. Ages 3 and 4 represented 14% and 15% of the sample, while ages 1 and 5 contributed 7% and 6%, respectively.

In addition to sampling with fyke nets and electrofishing, mark-recapture population estimates were conducted at the lake concurrently with a creel census. The combined estimate for bluegill was 47,846, or 683 per acre. Small bluegill (3-5.1 in) were most numerous at 21,451 (Table 4), while intermediate bluegill (5.2-7.1 in) and larger bluegill (≥ 7.2 in) comprised 13,100 and 13,295 of the population, respectively. Largemouth bass ≥ 10 inches had an estimate of 785, while channel catfish ≥ 10.3 inches were estimated at 479.

Table 4. Population estimates of bluegill, largemouth bass and channel catfish at Red Haw Lake, 1986.

	Estimate	95% Confidence Limits
Bluegill		
3-5.1 inches	21,451	16,919-29,299
5.2-7.1 inches	13,100	10,466-17,505
≥ 7.2 inches	13,295	10,955-16,907
Largemouth Bass		
≥ 10 inches	785	416-6,882
Channel Catfish		
≥ 10.3 inches	479	317-987

Creel census estimates showed a total sportfish catch of 14,130 (Table 5). Bluegill were, by far, the most prevalent contributing 9,738 to the catch. Green sunfish and warmouth yielded 1,777, while crappie contributed 425 fish to the catch. Largemouth bass catch was estimated at 1,336 of which 812 were kept and 524 released. Harvest of channel catfish was 612. The remaining species including redear sunfish, bullhead, grass carp and yellow perch provided 222 fish to the catch. Total fishing effort was estimated at 153 hours per acre with a success rate of 1.36 fish per hour.

Summary

Although the data presented in the report are rather limited, it is possible to make several general statements.

> Since 1979, the volume of water in Red Haw Lake has declined as a result of siltation. The best possible land use practices should be applied to the area in an effort to slow the rate of siltation. The 1986 dissolved oxygen and temperature profiles were very similar to 1979 and no major changes in lake water quality appeared to have occurred from 1979 to 1986. Continued monitoring is necessary to determine long-term trends in water quality.
>
> The primary biological change at Red Haw Lake has been introduction of grass carp in 1973, with complete elimination of aquatic vegetation by 1976. Grass carp biomass at the lake was estimated at over 100 lb/acre in 1976. However, based upon routine fish sampling at the lake, combined with sportfish surveys, there has been no degradation in catch rate, abundance or size structure of any fish species at Red Haw Lake. Growth rate of largemouth bass and bluegill has increased since grass carp introduction, while crappie growth remains the same.

Table 5. Summary of creel census statistics at Red Haw Lake, 1971-1986.

Species	1971	1974	1975	1976	1979	1986
Bluegill	15,515	14,899	20,303	10,991	14,739	9,738
Crappie	1,260	3,012	2,524	1,359	11,322	425
Largemouth Bass	1,260	1,521	2,245	865	2,489	812
Largemouth Bass Released	---	---	---	---	---	524
Green Sunfish	19	75	539	143	137	959
Warmouth	169	71	169	302	61	818
Redear	0	0	0	0	71	40
Channel Catfish	0	36	645	304	315	612
Channel Catfish Released	---	---	---	---	---	20
Bullhead	226	349	336	517	438	66
Grass Carp	---	0	0	0	0	32
Perch	339	682	414	157	722	84
Total	18,788	20,645	27,175	14,638	30,294	14,130
Effort (hrs/ac)	276	175	211	223	225	153
Success (catch/hr)	1.00	1.73	1.89	.97	1.98	1.36
Dates Conducted	5/1-9/17	4/18-9/29	4/15-9/28	4/15-9/29	4/15-9/23	4/1-9/3
Hours Censused	12	12	12	12	12	dawn-dusk (12-16)

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APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00212 995900201000
41 00 05.0 093 16 25.0 3
RED HAW LAKE
19117 IOWA LUCAS
CHARITON RIVER BASIN 071100
RED HAW LAKE T072NR21WSC28
21IOWA 771123 07100008 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
65/01/15		WATER						12.80		7.80	5	.160	
65/02/15		WATER						11.20		7.50	4	.150	
65/03/15		WATER						10.60		8.20	17	.010	
65/04/15		WATER						8.60		7.90	1	.070	
65/05/15		WATER						9.40		8.30	4	.010	
65/06/15		WATER						7.10		8.40	6	.010	
65/07/15		WATER						9.50		8.30	2	.010	
65/08/15		WATER						7.30		7.40	11	.010	
65/09/15		WATER						8.50		7.80	15	.010	
65/10/15		WATER						10.00		7.80	4	.060	
65/11/15		WATER						13.40		7.70	3	.120	
65/12/15		WATER						11.70		7.50	0	.230	
79/07/19		WATER	0	27.00		.70	160	12.50		9.20	14		
79/07/19		WATER	6				160	10.40		9.10	15		
79/07/19		WATER	9				197	2.40		8.10	11		
79/07/19		WATER	16				250	.00		7.60	5		
79/07/19		WATER	22				250	.00		7.50	6		
79/07/19		WATER	29				260	.00		7.30	8		
79/07/19 CP(1)- 79/07/19	REP	WATER	6					9.80					
79/08/21		WATER	0	27.00		1.20	185	11.00		9.24	9		
79/08/21		WATER	6				190	6.20		8.32	11		
79/08/21		WATER	13				195	1.10		7.80	4		
79/08/21		WATER	19				220	.00		7.58	.9		
79/08/21		WATER	26				240	.00		7.30	5		
79/08/21 CP(1)- 79/08/21	REP	WATER	0	.00		1.20	185			9.21			
79/09/27		WATER	0	19.70		.80	200	7.80		8.70	11	.200	.10
79/09/27		WATER	6				200	7.50		8.70	11		
79/09/27		WATER	13				200	6.30		8.50	9		
79/09/27		WATER	19				210	1.30		7.90	4		
79/09/27		WATER	26				270	.00		7.50	12		
79/09/27 CP(1)- 79/09/27	REP	WATER	0	.00		.70						.160	.07
86/06/18	1900	WATER	0	27.50	39.0		220	10.00		8.90	11	.030	.10K
86/06/18	1900	WATER	9	24.00			220	6.00		8.40	14	.030	.10K
86/06/18	1900	WATER	28	13.00			240	.00		7.60	17	1.100	.10K
86/07/21	1115	WATER	0	28.00	31.0		200	7.80		8.60	30	.060	.10K
86/07/21	1120	WATER	10	26.00			210	.30		8.00	48	.190	.20

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00212 995900201000
41 00 05.0 093 16 25.0 3
RED HAW LAKE
19117 IOWA LUCAS
CHARITON RIVER BASIN 071100
RED HAW LAKE T072NR21WSC28
21IOWA 771123 07100008 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
86/07/21	1130	WATER	30	12.50			270	.10		7.20	32	2.100	.10K
86/09/02	0900	WATER	0	23.00			190	9.40		8.60	8	.100	.10K
86/09/02	0900	WATER	19	16.00			260	.00		7.20	8	2.900	.10K
86/09/02	0900	WATER	30	13.00			310	.00		7.10	16	6.100	.10K

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00212 995900201000
41 00 05.0 093 16 25.0 3
RED HAW LAKE
19117 IOWA LUCAS
CHARITON RIVER BASIN 071100
RED HAW LAKE T072NR21WSC28
21IOWA 771123 07100008 HQ
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
65/01/15		WATER		.10									
65/02/15		WATER		.10									
65/03/15		WATER		.10									
65/04/15		WATER		.10									
65/05/15		WATER		.10									
65/06/15		WATER		.10									
65/07/15		WATER		.10									
65/08/15		WATER		.10									
65/09/15		WATER		.10									
65/10/15		WATER		.10									
65/11/15		WATER		.10									
65/12/15		WATER		.20									
79/07/19		WATER	0	.12			69.20						
79/07/19		WATER	6	.12			80.00						
79/07/19		WATER	9	.12			37.00						
79/07/19		WATER	16	.38			4.50						
79/07/19		WATER	22	.85			4.90						
79/07/19		WATER	29	1.49			9.00						
79/08/21		WATER	0	.10			30.30						
79/08/21		WATER	6				53.10						
79/08/21		WATER	13	.08			25.80						
79/08/21		WATER	19	.44			2.80						
79/08/21		WATER	26	1.81			4.90						
79/08/21													
CP(1)-	REP	WATER	0	.10									
79/08/21													
79/09/27		WATER	0	.13			59.50						
79/09/27		WATER	6	.13			59.70						
79/09/27		WATER	13	.11			34.20						
79/09/27		WATER	19	.10			11.50						
79/09/27		WATER	26	2.14									
86/06/18	1900	WATER	0		.070	22.00	21.00						
86/06/18	1900	WATER	9		.100	24.00	24.00						
86/06/18	1900	WATER	28		.200	15.00	13.00						
86/07/21	1115	WATER	0		.060	46.00	44.00						
86/07/21	1120	WATER	10		.050	58.00	54.00						
86/07/21	1130	WATER	30		.410	10.00	8.00						
86/09/02	0900	WATER	0		.100	24.00	14.00						
86/09/02	0900	WATER	19		.550	11.00	6.00						
86/09/02	0900	WATER	30		.940	12.00	7.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

HISTORICAL INFORMATION

Numerous studies have been conducted at Red Haw Lake, primarily dealing with fish populations, although some have focused on lake morphometry and primary productivity. Following is a list of historical references which apply directly to biological, chemical and physical characteristics of Red Haw Lake.

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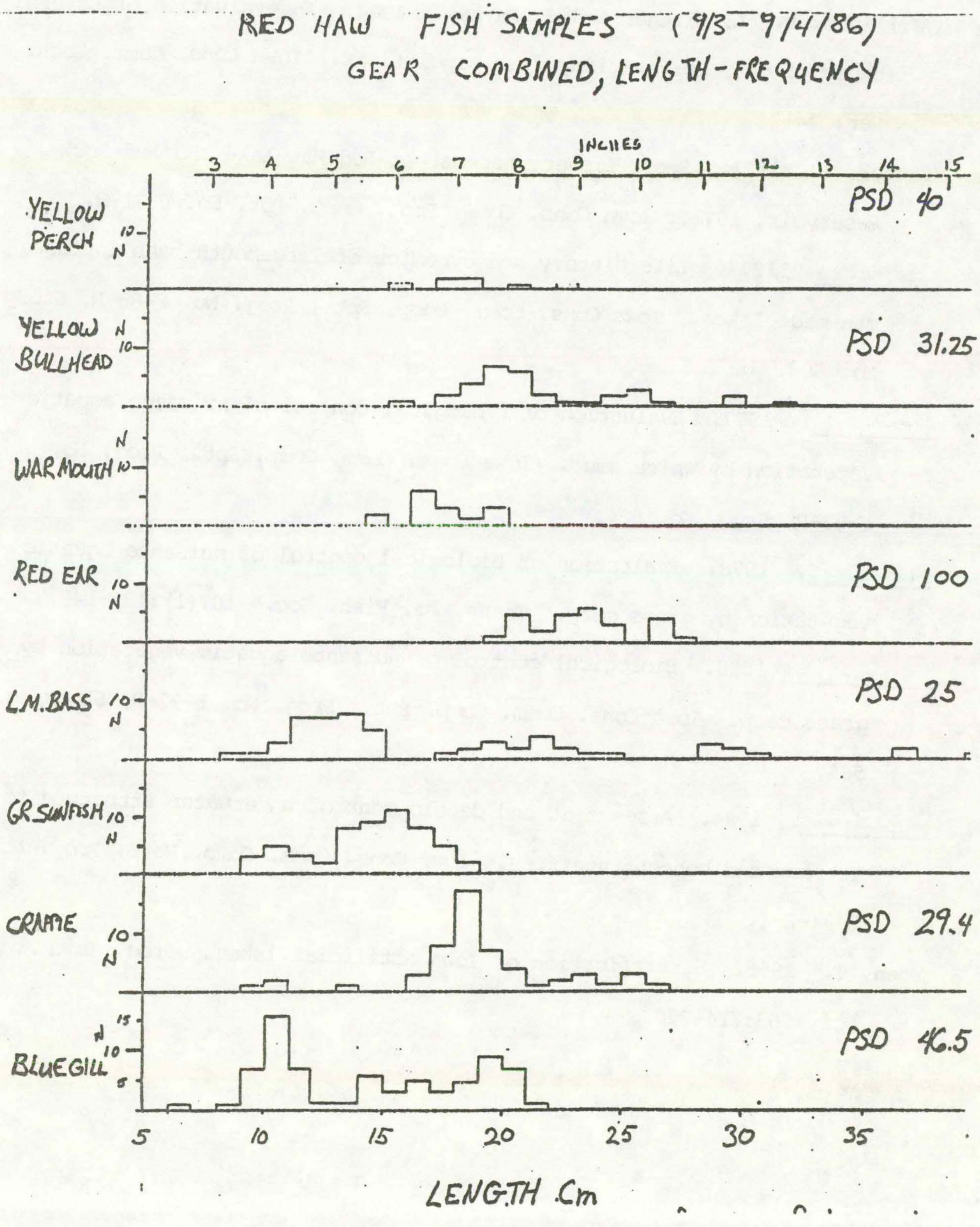


Figure 1. Length-frequency distribution of major fish species at Red Haw Lake, 1986.

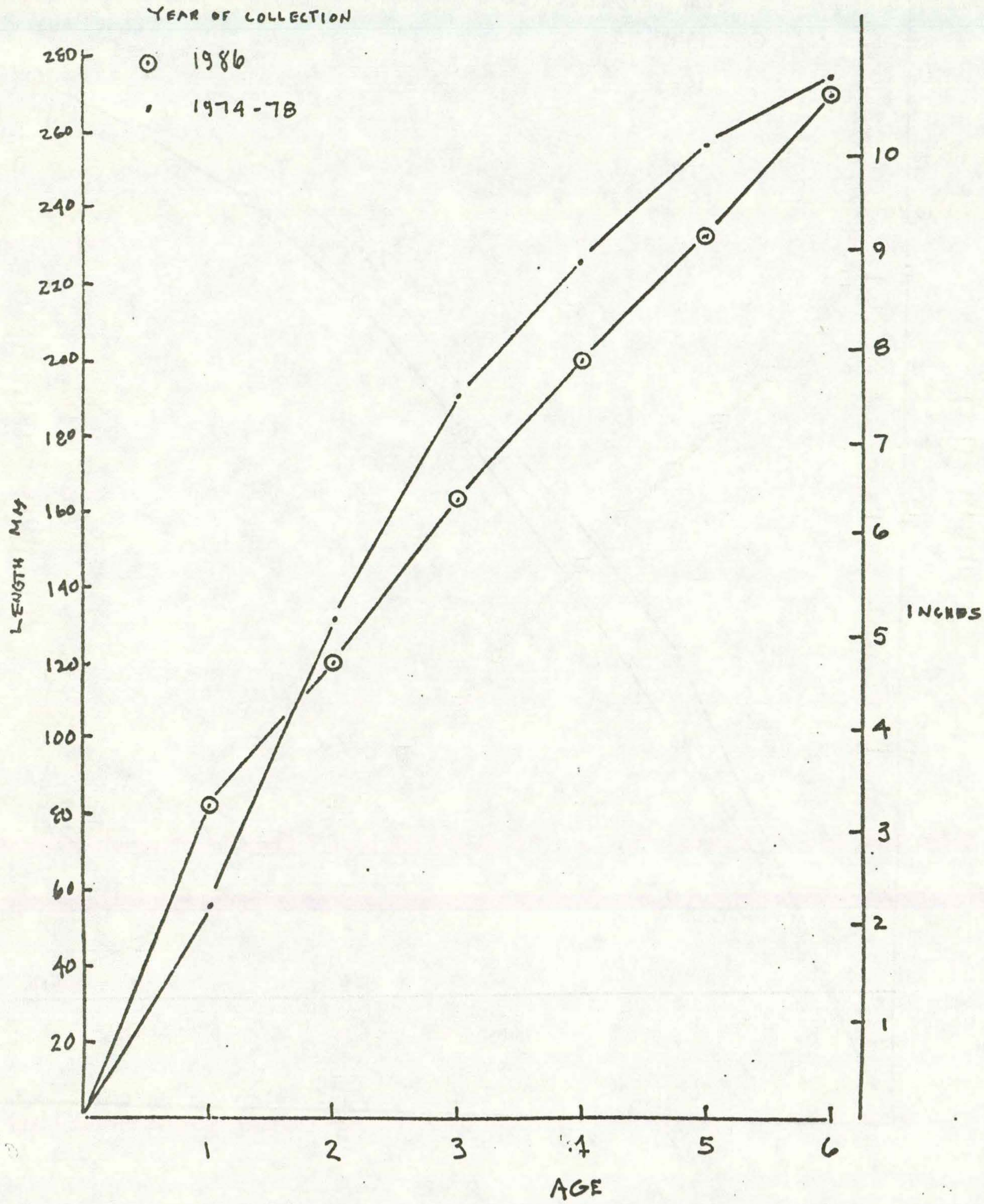


Figure 2. Average backcalculated lengths of crappie at Red Haw Lake from collections in 1986 and 1974-78.

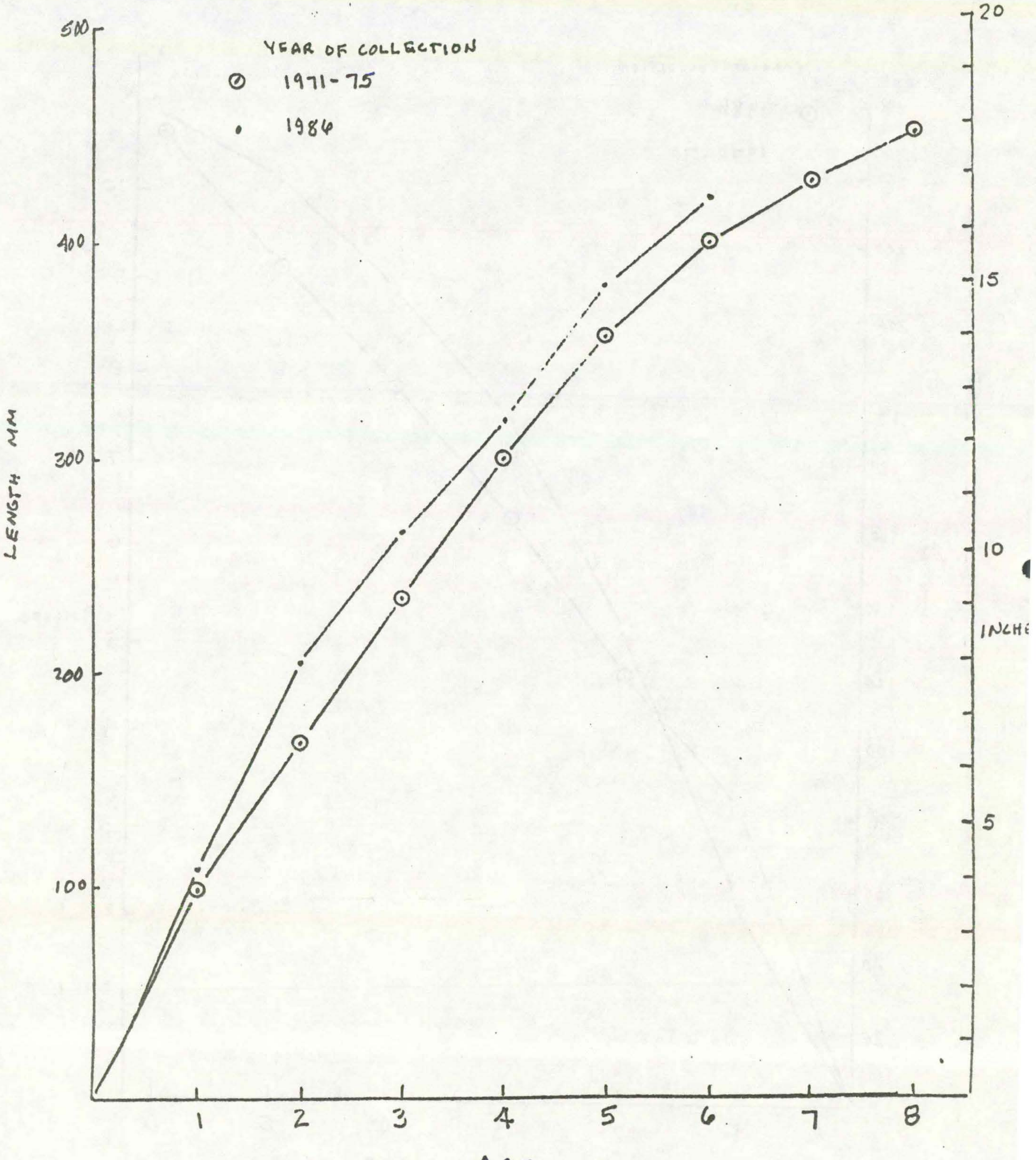


Figure 3. Average backcalculated lengths of largemouth bass at Red Haw Lake from collections in 1986 and 1971-75.

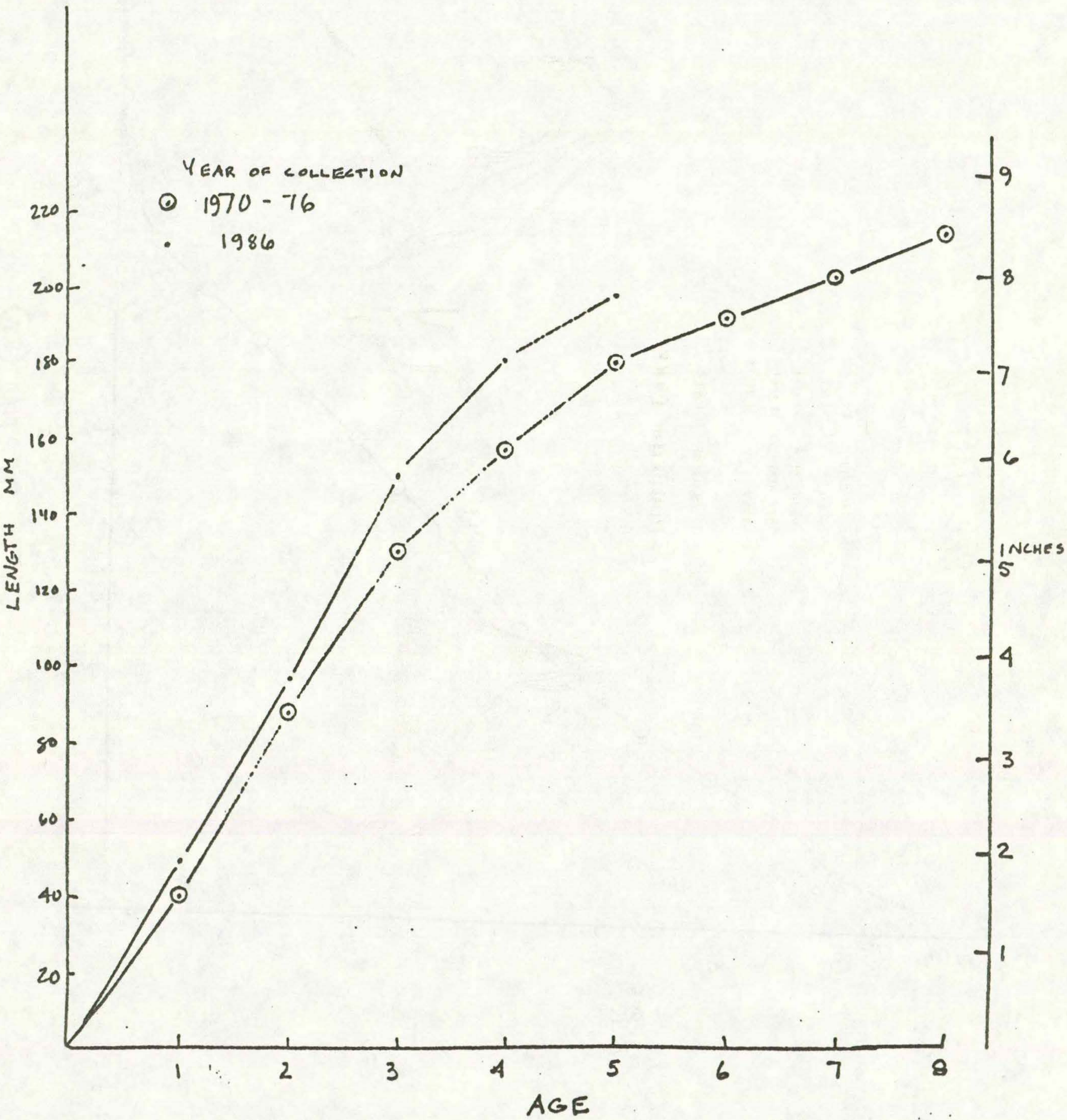


Figure 4. Average backcalculated lengths of bluegill at Red Haw Lake from collections in 1986 and 1970-76.

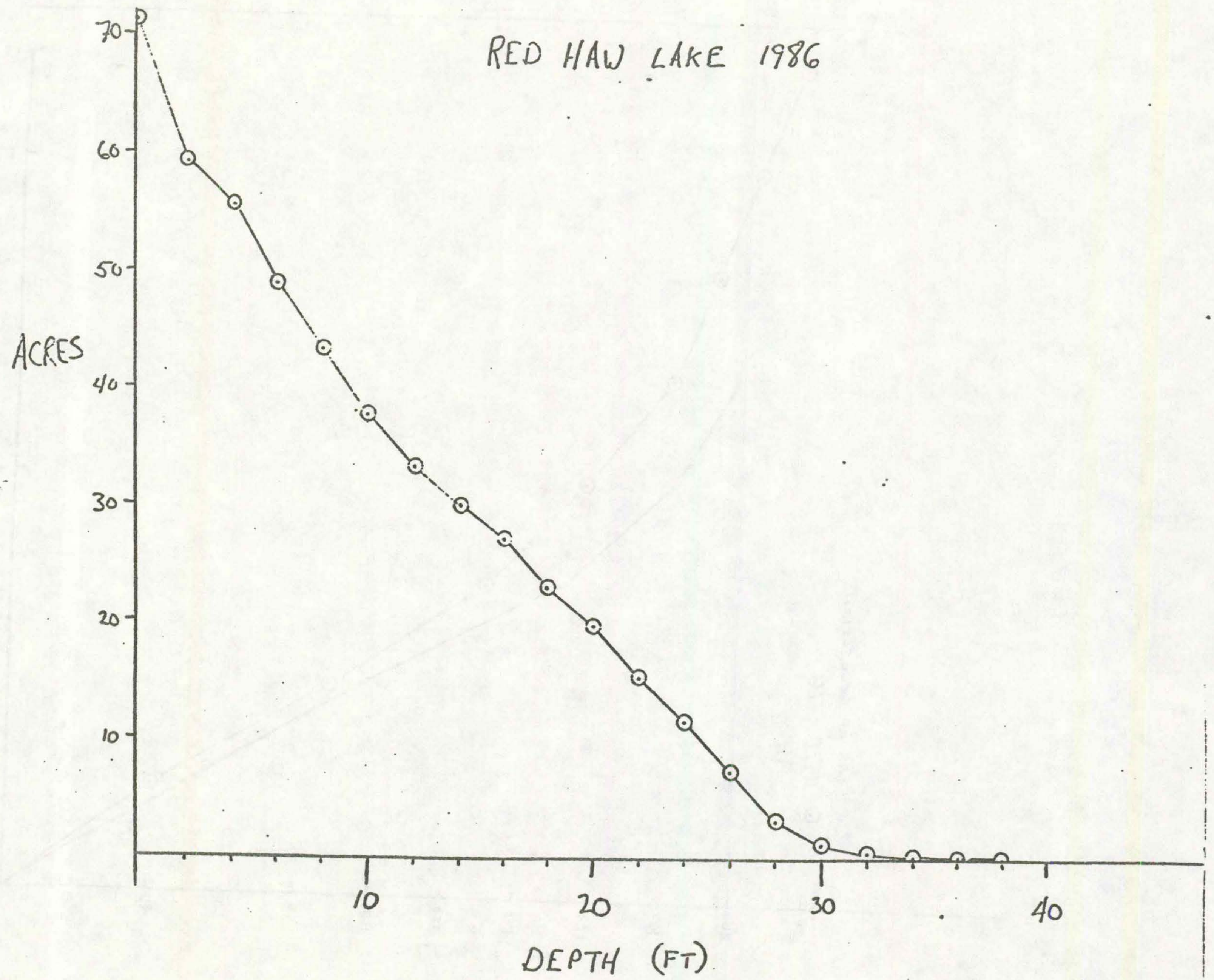


Figure 6. Area hypsographic curve of Red Haw Lake, 1986.

RODGERS PARK LAKE

Physical and Lake Impact Data

Rodgers Park Lake is located in Benton County approximately 3.5 miles northwest of Vinton, Iowa. The majority of Rodgers Park Lake's 1,924 acre watershed is in cropland (89%) and pastue (7%). A high watershed area/lake surface area ratio of 86:1, combined with a high row crop land usage (89%), has resulted in large inflows of silt into Rodgers Park Lake after heavy rains. The impacts of siltation have been noticeable since the lakes initial filling, ten years ago. Due to the lakes long and narrow configuration, the worst silt damage occurs in the upper 1/3 of the lake, where the lake has lost several feet of water. Since most of the silt settles out in the upper 1/3 of the lake, turbidity has generally not been a problem; however, the nutrients brought in by the non-point source runoff have periodically triggered excessive growth of aquatic vegetation and algal blooms.

A map of Rodgers Park Lake developed from 1986 data may be found on page 279. In addition a comparison of the lake's physical characteristics for 1979 (1) and 1986 is given below. Caution should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See Appendix for lake mapping procedure.)

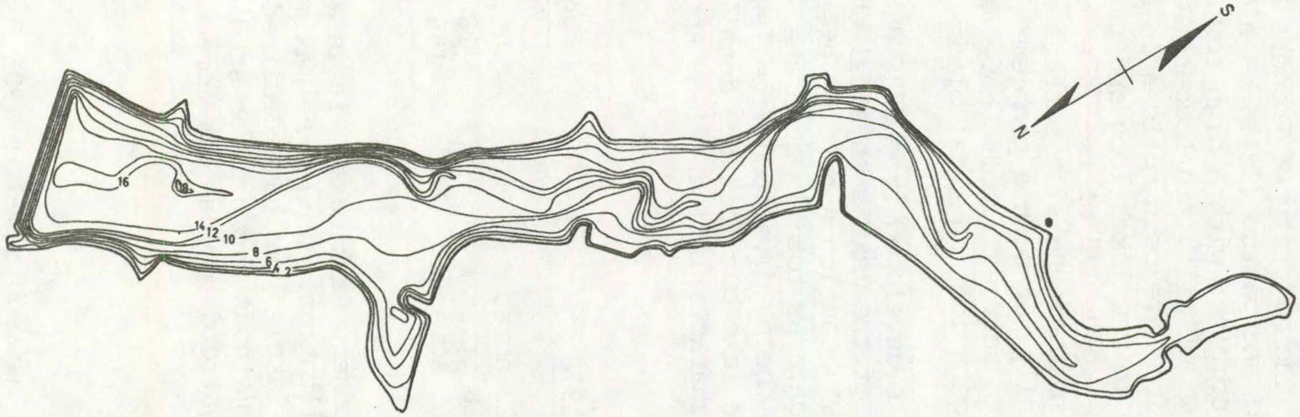
	1978	1986
Surface Area	22 acres	21.1 acres
Maximum Depth	18 ft.	18 ft.
Volume	161 acre ft.	155.7 acre ft.

Based on 1986 data for Rodgers Park Lake, it is apparent that the lake has lost water volume due to siltation. While the maximum water depth has not changed the surface area and lake volume have declined. The feasibility of additional siltation control methods needs to be studied and if possible, implemented as the lake cannot afford to lose any more water volume.

Chemical Data

The physical and chemical data obtained in 1986 for Rogers Park Lake are listed in the table on page 280. Where possible, in the following brief discussion, 1979 data will be compared to 1986 data.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 40 to 84 inches with a mean (N = 3) of approximately 63 inches. The three Secchi reading measurements made in 1979 were all 20 inches.



RODGERS LAKE

BENTON COUNTY

AREA	21 ACRES
MAX DEPTH	18 FEET
MEAN DEPTH	7.5 FEET
SCALE	1" = 150'
BOAT RAMP	●

TITLE ______ DRAWN BY R. GENT DATE 6-86
PROJECT ______ COUNTY ______ PROJ. NO. ______

SHEET ___ OF ___

Rodgers Park Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

Date Collected	6/18/86		7/30/86			9/09/86	
*Depth[1]	0	12	0	10	13	0	11
*Secchi[2]	84		66			40	
*Temperature[3]	24	16	27.2	23.5	21.3	20	19
*Dissolved Oxygen	12.0	6.2	10.0	4.3	0.4	9.0	5.6
*pH[4]	8.7	7.7	8.8	7.8	7.5	8.5	8.3
Conductivity[4]	480	550	480	580	580	460	470
Ammonia Nitrogen	0.08	0.08	<0.01	0.34	0.48	0.05	0.08
Nitrate-Nitrite Nitrogen	12	12	9.2	16	9.3	3.6	3.6
Suspended Solids	16	11	14	17	9	16	15
Total Phosphorus	0.04	0.06	0.04	0.06	0.03	0.15	0.13
Chlorophyll a (Corrected)[6]	8	19	22	18	13	48	<1
Thermally Stratified	Yes		Yes			No	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

Rodgers Park Lake water temperature ranged from a low of 16°C in the June bottom sample to a high of 27.2°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section. Although limited data for 1979 does not allow for comparison with 1986 data the 1979 surface water temperature ranged from approximately 24°C to 27°C during the sampling period.

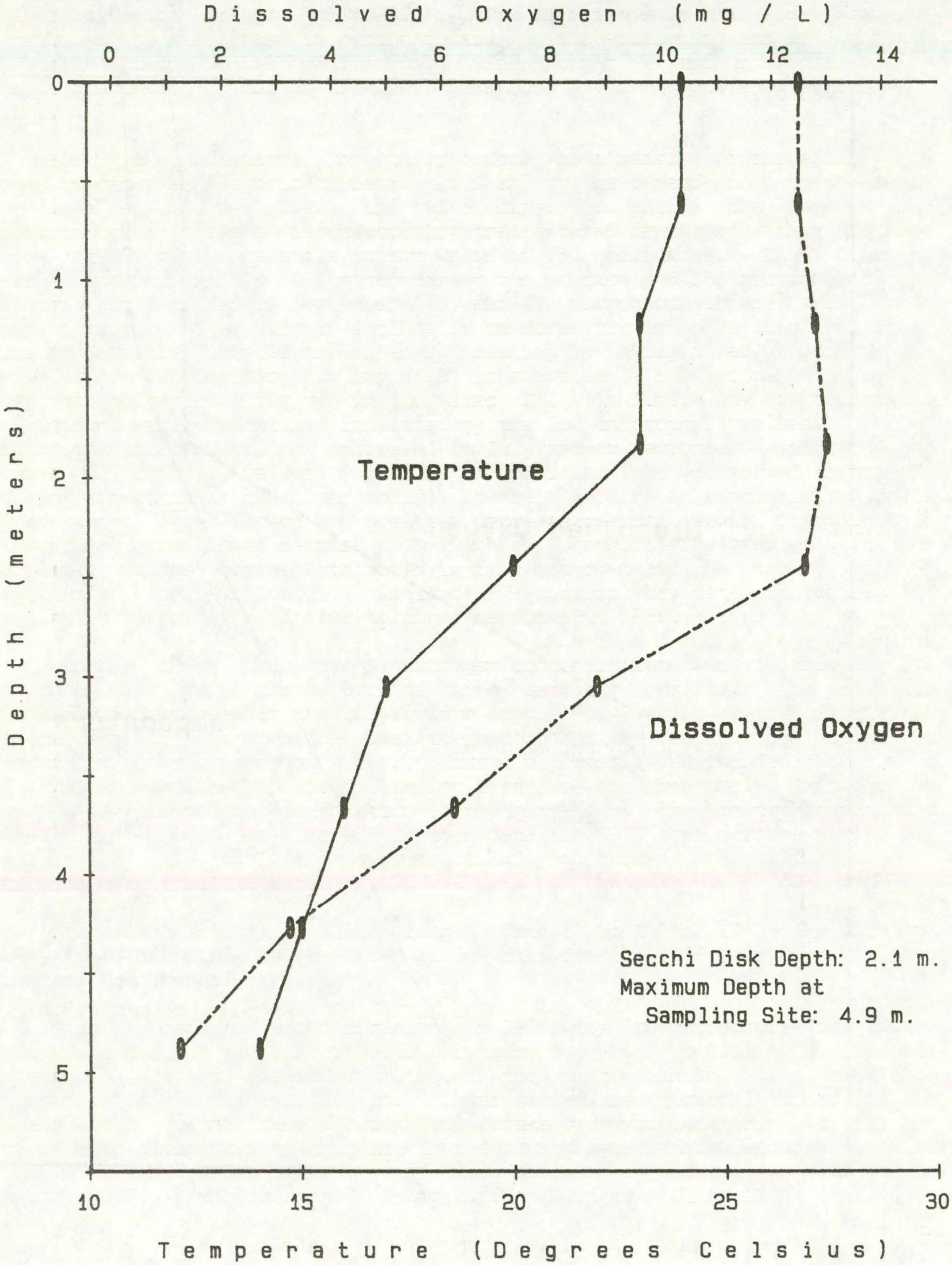
Dissolved oxygen (DO) values ranged from 0.4 mg/L in the July bottom sample to 12.0 mg/L in the June and July surface samples. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 282 , 283 , and 284 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling date. In June, a DO and temperature gradient (stratification) was already present between the 8.0 (2.5 meter) and 10 foot (3 meter) depths. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The temperature and density differences prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with oxidation of organic material in the hypolimnion resulted in a dissolved oxygen value of 1.2 mg/L at a depth of 16 feet. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with high organic content frequently have no dissolved oxygen in the lower water layer.

In July the temperature of the lake had increased and reached a maximum of approximately 27°C at the surface. The temperature remained constant (27°C) to a depth of approximately 8 feet (2.5 meters) and then declined to 19.5°C at the bottom. The DO gradient became even sharper in July falling from 8.2 mg/L at 8 feet (2.5 meters) to 0.4 mg/L at 12 feet (3.6 meters). Typically in the fall, as the ambient temperature declines, the lake water temperature and density become the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profile (page 284) for Rodgers Park Lake indicated fall turnover was in progress. The temperature gradient had become nearly vertical at approximately 20°C, and only a small gradient still existed in the DO concentration (9.0 mg/L of DO at the surface as compared to 6.2 mg/L at the bottom) demonstrating that mixing was in progress. A comparison of the most pronounced DO and temperature stratification data for the 1979 and 1986 studies is given below. Since the August 1979 data is reported only to a depth of 6.5 feet, that depth was used for comparing to the 1986 data.

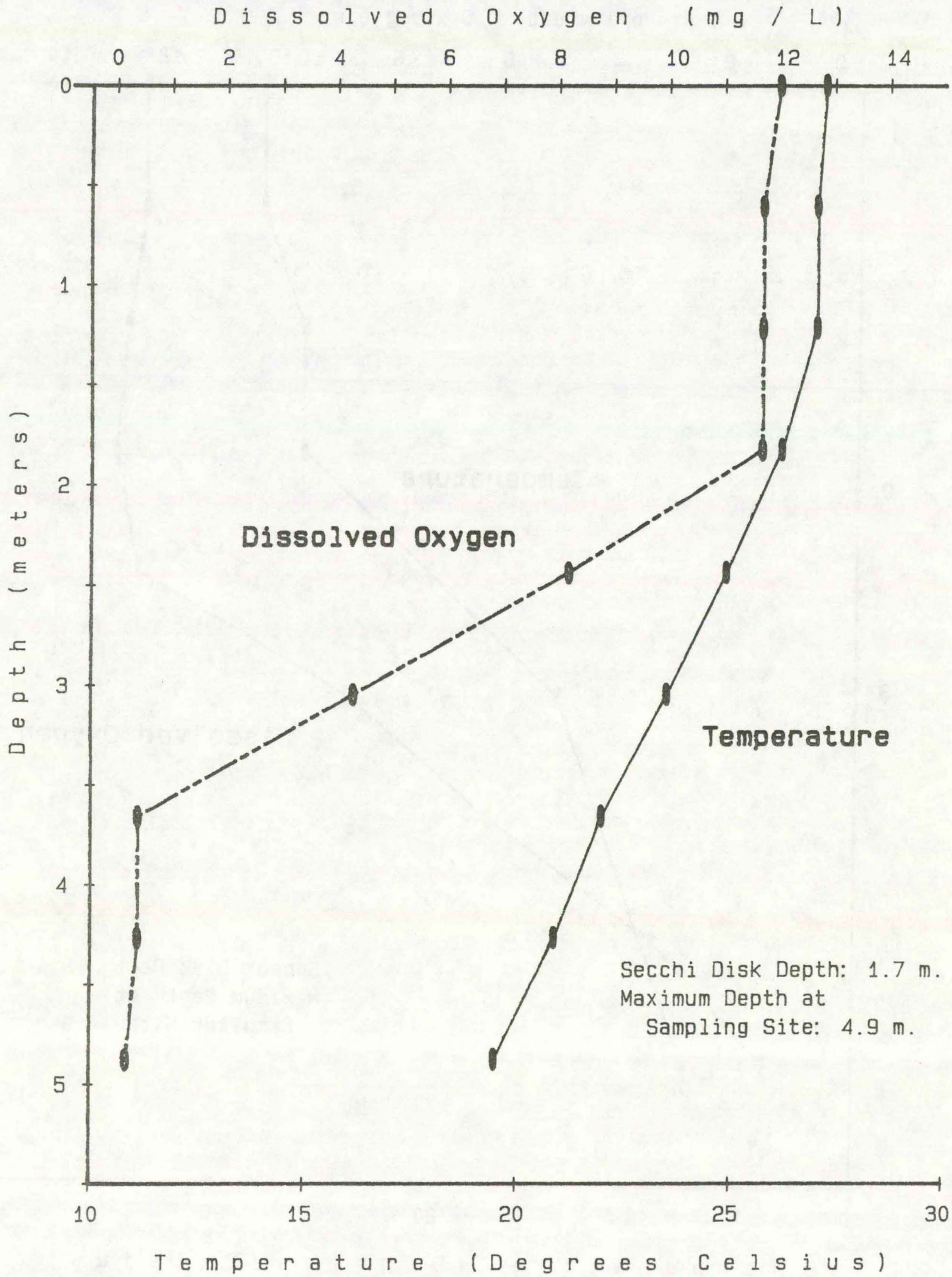
	8 August 1979		July 1986	
	Surface	6.5 feet	Surface	6 feet
DO (mg/L)	14.6	11.1	12.0	11.7
Temperature (°C)	27	24	27	26

The values listed in the above table are therefore only reflective of conditions in the epilimnion and not the entire water column. With the

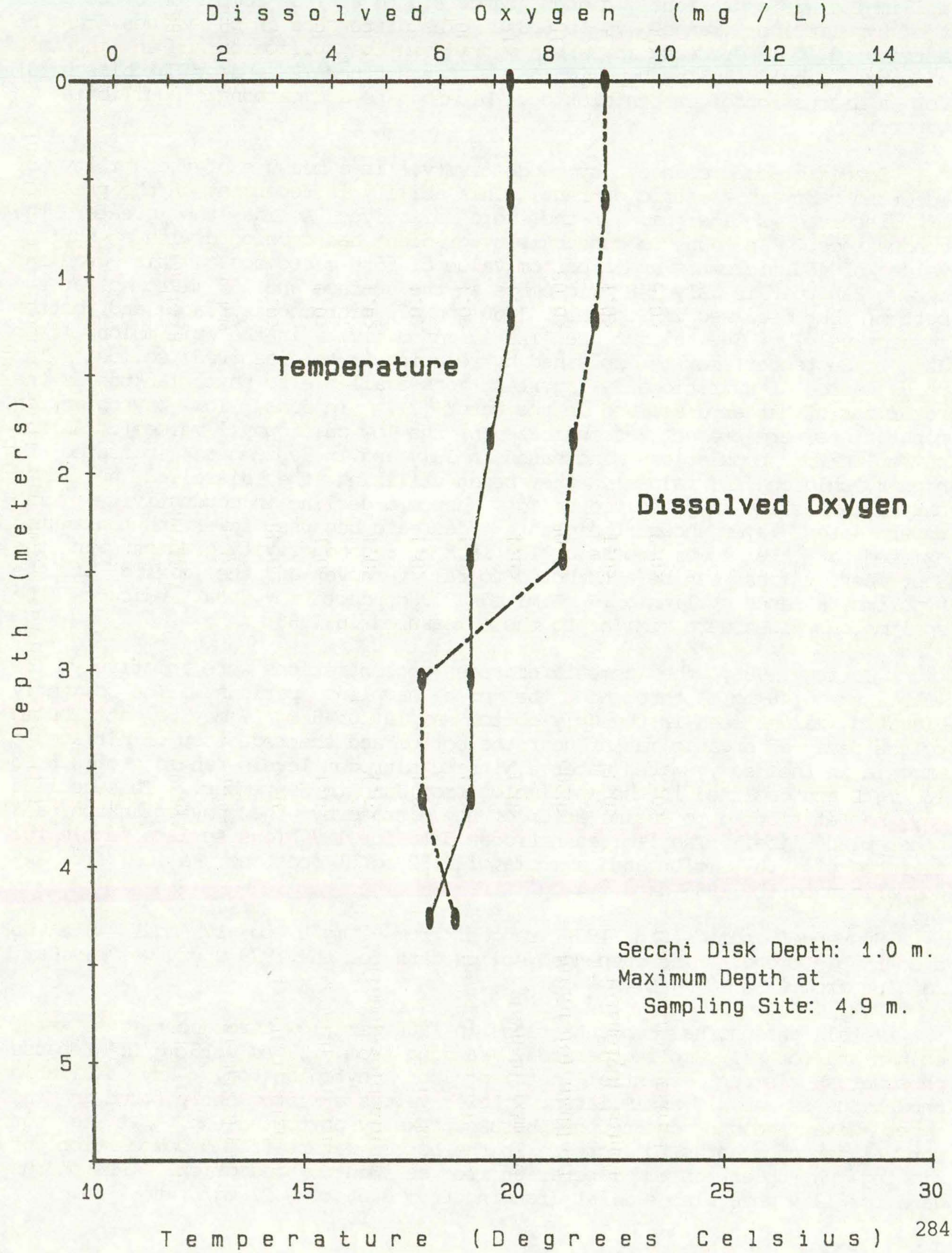
Rodgers Park Lake
Dissolved Oxygen and Temperature Profile
June 18, 1986



Rodgers Park Lake
Dissolved Oxygen and Temperature Profile
July 30, 1986



Rodgers Park Lake
Dissolved Oxygen and Temperature Profile
September 9, 1986



limited data available no valid comparison can really be made between the 1979 and 1986 data.

Values for pH in 1986 varied from 7.5 to 8.8 units. The pH in the epilimnion was consistently higher (range 8.5 to 8.8) as compared to the pH of the hypolimnion (range 7.5 to 8.3). The difference in pH values can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. In June a conductivity gradient had developed with a surface value of 480 micromhos and a bottom value of 550 micromhos. This gradient became sharper in July (480 micromhos at the surface and 580 micromhos at the bottom) but decilned in September (460 and 470 micromhos surface and bottom respectively). The slight decline in conductivity in the epilimnion (from June to September) may be explained by relating it to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). In June, low phytoplankton populations were present (as indicated by the low chlorophyll values). As the phytoplankton populations increased in July and in September (indicated by higher chlorophyll values), they began utilizing the dissolved nutrients causing a decline in dissolved solids, hence a decline in conductivity. The upper water layer showed the greatest decrease because fewer phytoplankton existed at the lower depths. The lack of a conductivity gradient in the September values can be attributed to fall turnover and the mixing of the hypolimnion and epilimnion. Limited 1979 conductivity data indicates the epilimnion values were similar to those measured in 1986.

During 1986, the ammonia nitrogen concentrations were relatively low (0.05 to 0.48 mg/L) throughout the three sampling periods. The slightly elevated values seen in the July bottom sample (0.48 mg/L) may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate nitrogen levels ranged from 3.6 to 16 mg/L and declined in the epilimnion from June to September. This decline may be attributed to assimilation of the nitrate by the phytoplankton and other plant life. The limited nitrogen data for 1979 (one surface sample for nitrate of 0.07 mg/L and ammonia of 0.50 mg/L) does not allow for any comparison to the 1986 data.

Suspended solids in 1986 ranged from 9 mg/L to 17 mg/L with no discernable trend. The suspended solids data for the 1979 study was similar, ranging from 6 to 28 mg/L.

Total phosphorus concentrations in 1986 were low throughout the water column and for all sampling periods, ranging from 0.03 to 0.15 mg/L. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. Lower values are frequently found in the upper water column due to phosphorus uptake by phytoplankton. It is not unusual for phosphorus to increase in the bottom waters from decomposition of sinking phytoplankton and liberation from sediment by reduction. Phosphorus data for 1979 were also similar (ranging from 0.06 to 0.21 mg/L) to 1986.

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986 the corrected chlorophyll a values ranged from <1 µg/L to 48 µg/L. Surface corrected chlorophyll a values increased from June to September (from 8 to 48 µg/L). In 1979 the surface corrected chlorophyll a concentrations were higher than in 1986 increasing from 94 µg/L in July to 162 µg/L in August to 198 µg/L in September.

Pesticide Data

As described in the 1986 Iowa Lakes Study Work/QA plan (4), Rodgers Park Lake was one of five lakes in which samples for pesticide analysis were collected. One water sample was to be collected during non-rainfall runoff conditions (usually the first sample collected) and used for baseline data. Two water samples were to be collected after rainfall runoff to demonstrate the impact of runoff on lake quality. In addition, a composite (of at least 3 samples) sediment sample was also obtained from each lake. All samples were analyzed for nine common Iowa pesticides; i.e., the herbicides Atrazine, Cyanazine, Methlachlor, Alachlor, Metribuzin and Dicamba; the chlorinated hydrocarbons dieldrin and chlordane; and the organophosphate Fonfos. The pesticide data for Rodgers Park Lake may be found in the table on page 287. Atrazine was the only pesticide found in the water samples and was present in all three samples collected. Values for atrazine ranged from 0.22 to 0.53 ug/L. All of the other pesticides analyzed for wer less than the reporting limits. The concentration of Atrazine was highest in June and lower in the samples obtained in July and August. This is not unexpected and can be explained when several factors are considered. Applications of herbicides generally occur during spring planting. No reportable values for pesticides were found in the sediment sample obtained from Rodgers Park Lake. During 1979 no samples were collected for pesticide analysis and no comparison is possible.

Biological Data

Fish species present in Rodgers Lake include largemouth bass, black crappie, bluegill, channel catfish, redear sunfish, and white amur. Fish population surveys for the Clean Lakes Study were conducted in the third week of August, 1986. Dense strands of rooted aquatic vegetation covered most shallow water areas during the summer but had declined to tolerable levels by mid-August. Data analysis sheets are included, listing statistical parameters and length frequency distributions of individual fish populations. A listing of the species sampled and a biological assessment follows.

Laregmouth Bass - Length-frequency distribution of bass sampled illustrates a large proportion of sub-adult fish, although a wide range of year classes were sampled. Mean length of bass sampled was eight inches and the proportional stock density (PSD) was 14%. Growth of bass is poor, especially in the first two years of life. Competition with other juvenile fish may be retarding growth. Excess aquatic vegetation should be controlled and additional white amur have been stocked.

Rodgers Park Lake
Pesticide Data - 1986
(all values in micrograms per liter or parts per billion)

Date Collected	6/16/86	7/01/86	8/14/86	7/10/86
Sample Matrix	Water	Water	Water	Sediment
Atrazine (AAtrex)	0.53	0.48	0.22	<30
Cyanazine (Bladex)	<0.1	<0.1	<0.1	<30
Methlachlor (Dual)	<0.1	<0.1	<0.1	<30
Alachlor (Lasso)	<0.1	<0.1	<0.1	<30
Metribuzin (Sencor)	<0.1	<0.1	<0.1	<30
Dicamba (Banvel)	<0.1	<0.1	<0.1	<15
Dieldrin (Dieldrin)	<0.05	<0.05	<0.05	<15
Fonfos (Dyfonate)	<0.1	<0.1	<0.1	<30
Chlordane (Chlordane)	<0.2	<0.2	<0.5	<50

Black Crappie - Length frequency distribution of crappie also illustrates an abundance of small fish with three year classes represented. PSD values are average but mean length of fish sampled is only seven inches. Growth increments from age and growth data are near normal. However, WR values are low, indicating poor body condition. In overview, the crappie population appears to be evolving to an abundance of small fish with sub-standard body condition.

Channel Catfish - All indexes of the channel catfish population are at acceptable levels. Catfish are stocked biennially in the cage catfish program, and multiple year classes are evident in the length-frequency distribution. Mean length was 14 inches and body condition was good. No age and growth determination was made on this species.

Bluegill - Length-frequency distribution of bluegill exhibits a grouping of the population between 4 and 6.5 inches, with a mean length of 5.5 inches. Few small bluegill were in the sample, primarily due to the remaining stands of dense aquatic vegetation that made it difficult to pick up small fish. PSD is on the low end of acceptable levels and WR values are below average. Age and growth data indicated growth was average for Iowa waters.

Redear Sunfish - The redear sunfish sampled exhibit an excellent quality sunfish population. Mean length of the sample was eight inches and all redear sampled were acceptable to the angler. The excellent growth of the redear sunfish is a result of their limited numbers and dissimilar food source, compared to other fish species in the lake.

Species Composition of Sample

Species	Number	Percent
Largemouth Bass	50	13
Black Crappie	19	5
Channel Catfish	40	10
Bluegill	267	67
Redear Sunfish	21	5
TOTAL	396	100

SUMMARY

Although the data presented in this report are rather limited , it is possible to make several general statements.

> Since 1979, the volume of water in Rodgers Park Lake has declined as a result of siltation. Additional siltation control measures should be undertaken as soon as possible as the lake cannot afford to lose any more water volume.

The 1986 dissolved oxygen and temperature profiles showed that thermal stratification was present in June and July. No other major changes in lake water quality appear to have occurred from 1979 to 1986.

The fish population survey showed that the populations of channel catfish, bluegill and redear sunfish were acceptable, but the populations of largemouth bass and black crappie were not in good condition. Continued monitoring of Rodgers Park Lake is necessary to determine long term trends in water quality and the fish population.

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2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

4. Wunk, M. 1986. 1986 Iowa Lakes Study - Work/QA Plan. Iowa Department of Natural Resources, Des Moines, Iowa.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00557 090700201000
42 11 50.0 092 04 45.0 4
RODGERS PARK LAKE, APPROX 3.5 MI NW OF VINTON
19011 IOWA BENTON
UPPER MISSISSIPPI BASIN 071000
IOWA-CEDAR RIVER SUBBASIN T085NR11WSC01
21IOWA 801004 07080205010 0002.900 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
79/07/03		WATER	0	26.80		.50	290	14.70		9.20			
79/07/03		WATER	6				300	12.10		9.00			
79/07/03		WATER	13				450	.10		8.40			
79/07/03 CP(1)- 79/07/03	REP	WATER	13				460			8.50			
79/07/04		WATER	0								17		
79/07/04		WATER	6								12		
79/07/04		WATER	13								6		
79/08/01		WATER	0	.00		.50	360	14.60		9.00	28		
79/08/01		WATER	3				360	15.70		9.10	27		
79/08/01		WATER	6				370	11.10		8.80	18		
79/08/01 CP(1)- 79/08/01	REP	WATER	0	8.00		.50							
79/09/11		WATER	0	23.80		.50	310	4.50		8.40	25	.050	.07
79/09/11		WATER	3				310	9.70		8.40	22		
79/09/11		WATER	6				310	5.50		8.30	11		
79/09/11 CP(1)- 79/09/11	REP	WATER	0	.00								.050	.08
79/09/11 COMP 79/09/11		WATER	3				310			8.40			
86/06/18	1300	WATER	0	24.00	84.0		480	12.00	8.70	8.60	10	.080	12.00
86/06/18	1330	WATER	12	16.00			550	6.20	7.70	8.00	11	.080	12.00
86/07/30	1100	WATER	0	27.20	66.0		480	12.00	8.80	8.30	14	.010K	9.20
86/07/30	1100	WATER	10	23.50			580	4.30	7.80	7.60	17	.340	16.00
86/07/30	1100	WATER	13	21.30			580	.40	7.50	7.50	9	.480	9.30
86/09/09	1400	WATER	0	20.00	40.0		460	9.00	8.50	8.00	16	.050	3.60
86/09/09	1412	WATER	11	19.00			470	5.60	8.30	7.70	15	.080	3.60

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00557 090700201000
42 11 50.0 092 04 45.0 4
RODGERS PARK LAKE, APPROX 3.5 MI NW OF VINTON
19011 IOWA BENTON
UPPER MISSISSIPPI BASIN 071000
IOWA-CEDAR RIVER SUBBASIN T085NR11WSC01
21IOWA 801004 07080205010 0002.900 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
79/07/03		WATER	0	.47			93.60						
79/07/03		WATER	6	.43			71.10						
79/07/03		WATER	13	.20			9.70						
79/08/01		WATER	0	.36			161.70						
79/08/01		WATER	3	.45			203.60						
79/08/01		WATER	6	.34			151.20						
79/08/01													
CP(1)-	REP	WATER	3	.45									
79/08/01													
79/09/11		WATER	0				198.30						
79/09/11		WATER	3	.63			157.20						
79/09/11		WATER	6	.55			43.40						
86/06/18	0000	WATER	0							.530	.200U		.10U
86/06/18	1300	WATER	0		.040	8.00	8.00						
86/06/18	1330	WATER	12		.060	24.00	19.00						
86/07/01	0000	WATER	0							.480	.200U		.10U
86/07/10	0000	WATER	0					15.000U	30.000U			50.00U	
86/07/30	1100	WATER	0		.040	24.00	22.00						
86/07/30	1100	WATER	10		.060	21.00	18.00						
86/07/30	1100	WATER	13		.030	18.00	13.00						
86/08/14	0000	WATER	0							.220	.500U		.10U
86/09/09	1400	WATER	0		.150	48.00	48.00						
86/09/09	1412	WATER	11		.130	9.00	1.00K						

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00557 090700201000
42 11 50.0 092 04 45.0 4
RODGERS PARK LAKE, APPROX 3.5 MI NW OF VINTON
19011 IOWA BENTON
UPPER MISSISSIPPI BASIN 071000
IOWA-CEDAR RIVER SUBBASIN T085NR11WSC01
21IOWA 801004 07080205010 0002.900 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	39380 DIELDRIN TOTUG/L	39383 DIELDRIN SEDUG/KG DRY WGT	39631 ATRAZINE MUD UG/KG	46317 LASSO WHL SMPL UG/L	77780 BLADEX TOTAL UG/L	81294 DYFONATE TOT UG/L	81407 ALACHLOR SED DRY WGTUG/KG	81408 MTRBUZIN TOT UG/L	81409 MTRBUZIN SED DRY WGTUG/KG	82052 BANVEL TOTAL UG/L
86/06/18	0000	WATER	0	.050U			.10U	.100U	.100U		.100U		
86/07/01	0000	WATER	0	.050U			.10U	.100U	.100U		.100U		
86/07/10	0000	WATER	0		15.00U	30.00U				30.000U		30.000U	
86/08/14	0000	WATER	0	.050U			.10U	.100U	.100U		.100U		

L00557 090700201000
42 11 50.0 092 04 45.0 4
RODGERS PARK LAKE, APPROX 3.5 MI NW OF VINTON
19011 IOWA BENTON
UPPER MISSISSIPPI BASIN 071000
IOWA-CEDAR RIVER SUBBASIN T085NR11WSC01
21IOWA 801004 07080205010 0002.900 OFF
0000 FEET DEPTH

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	82502 IRON INS OL DRYDP UG/KG	82543 BLADEX DRY WT. MG/KG	82544 DYFONATE DRY WT / MG/K
86/06/18	0000	WATER	0	.1U		
86/07/01	0000	WATER	0	.1		
86/07/10	0000	WATER	0		.03U	.03U
86/08/14	0000	WATER	0	.1U		

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
Lake	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)	Surface Area (acres)	Maximum Depth (feet)	Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

RODGERS LAKE
8/18/86

SPECIES: LARGEMOUTH BASS

EFFORT: .75 HOURS SHOCKING

NUMBER OF FISH IN SAMPLE: 50

FISH SHOCKED PER HOUR: 66.6666667

RANGE OF LARGEMOUTH BASS SAMPLED: 60 MM TO 450 MM

MEAN LENGTH OF FISH SAMPLED (MM): 197

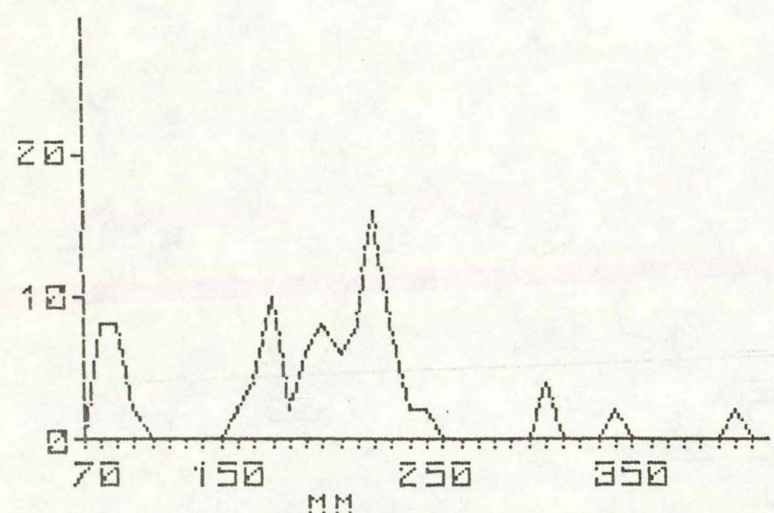
MEAN WEIGHT OF FISH SAMPLED: 94.9 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-4.98250674 + 3.03337329 LOG L

WR OF SAMPLE: ~~369~~

PSD OF SAMPLE: 14 %

LENGTH FREQUENCY DISTRIBUTION OF LARGEMOUTH BASS, EXPRESSED IN PERCENT OF TOTAL SAMPLE.



RODGERS LAKE
8/19/86

SPECIES: BLACK CRAPPIE

EFFORT: 4 NET DAYS

NUMBER OF FISH IN SAMPLE: 19

FISH PER NET DAY: 4.75

RANGE OF BLACK CRAPPIE SAMPLED: 140 MM TO 260 MM

MEAN LENGTH OF FISH SAMPLED (MM): 176

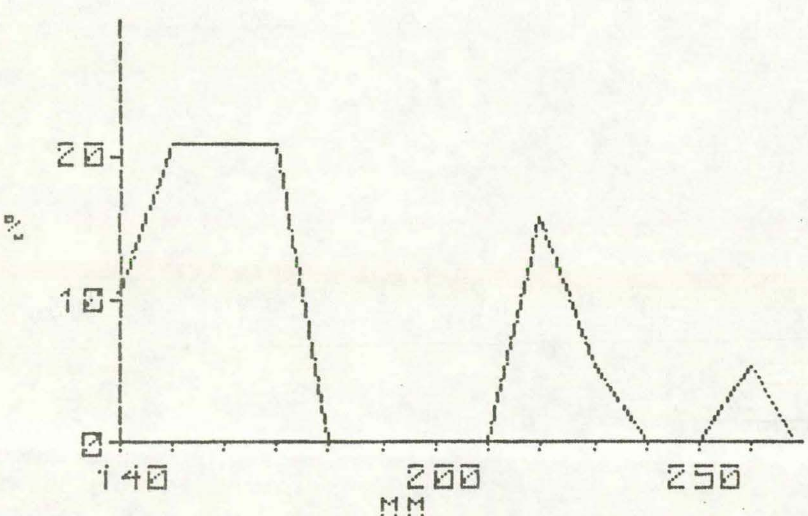
MEAN WEIGHT OF FISH SAMPLED: 70.0 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-4.97912998 + 3.0380583 LOG L

WR OF SAMPLE: 78

PSD OF SAMPLE: 26 %

LENGTH FREQUENCY DISTRIBUTION OF BLACK CRAPPIE, EXPRESSED IN PERCENT OF TOTAL
MPLE.



RODGERS LAKE
8/19/86

;PECIES: CHANNEL CATFISH

:FFORT: 4 NET DAYS

JUMBER OF FISH IN SAMPLE: 40

:ISH PER NET DAY: 10

RANGE OF CHANNEL CATFISH SAMPLED: 160 MM TO 700 MM

1EAN LENGTH OF FISH SAMPLED (MM): 348

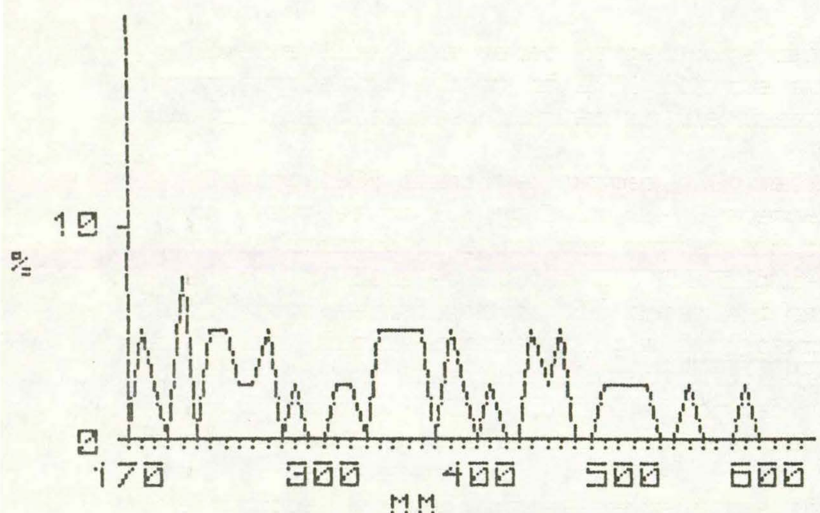
1EAN WEIGHT OF FISH SAMPLED: 360.3 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-5.77042518 + 3.27716644 LOG L

WR OF SAMPLE: 93

PSD OF SAMPLE: 46 %

LENGTH FREQUENCY DISTRIBUTION OF CHANNEL CATFISH, EXPRESSED IN PERCENT OF TOTAL SAMPLE.



RODGERS LAKE
8/19/86

SPECIES: BLUEGILL

EFFORT: 4 NET DAYS

NUMBER OF FISH IN SAMPLE: 267

FISH PER NET DAY: 66.75

RANGE OF BLUEGILL SAMPLED: 70 MM TO 190 MM

MEAN LENGTH OF FISH SAMPLED (MM): 137

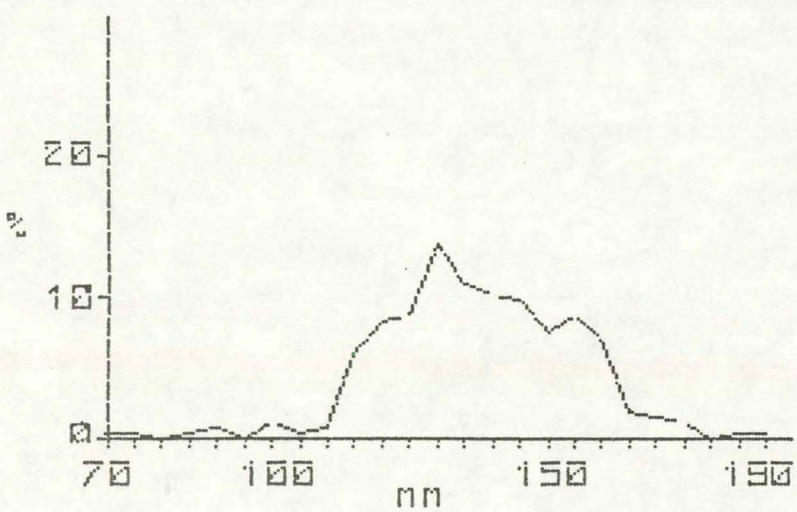
MEAN WEIGHT OF FISH SAMPLED: 46.8 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-5.36699837 + 3.29182788 LOG L

WR OF SAMPLE: 90

PSD OF SAMPLE: 29 %

LENGTH FREQUENCY DISTRIBUTION OF BLUEGILL, EXPRESSED IN PERCENT OF TOTAL SAMP



RODGERS LAKE
8/19/86

SPECIES: REDEAR SUNFISH

EFFORT: 4 NET DAYS

NUMBER OF FISH IN SAMPLE: 21

FISH PER NET DAY: 5.25

RANGE OF REDEAR SUNFISH SAMPLED: 180 MM TO 280 MM

MEAN LENGTH OF FISH SAMPLED (MM): 202

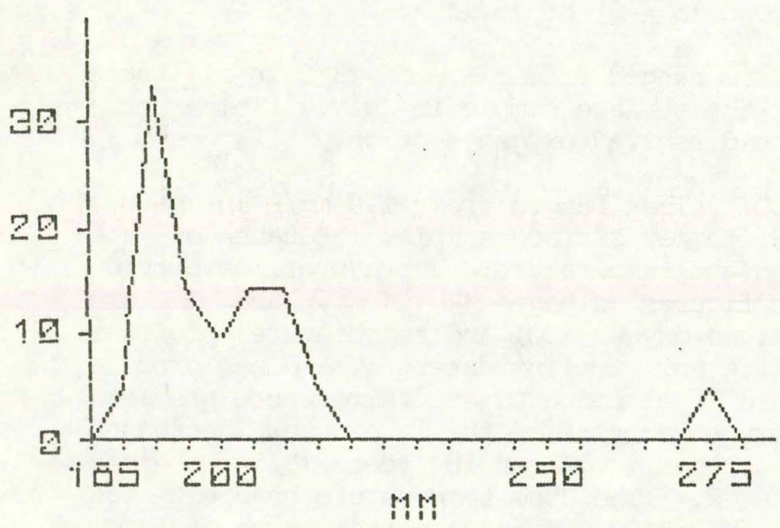
MEAN WEIGHT OF FISH SAMPLED: 217.7 GRAMS

WEIGHT/LENGTH FORMULA IS: LOG W =-4.41283071 + 2.92917687 LOG L

WR OF SAMPLE: ~~%25254~~

PSD OF SAMPLE: 100 %

LENGTH FREQUENCY DISTRIBUTION OF REDEAR SUNFISH, EXPRESSED IN PERCENT OF TOTAL SAMPLE.



TWELVE MILE LAKE

Physical and Lake Impact Data

Twelve Mile Lake is a 639 acre lake located near Creston in southwest Iowa. The lake was initially impounded in the fall of 1984 when the Department of Natural Resources and the City of Creston's Water Board entered into an agreement to manage the fish and wildlife resources of the lake and surrounding land. The lake has a watershed/lake surface area ratio of 23:1, with over 90% of the land in the watershed at or below soil loss standards. Flooded standing timber has diminshed wind created wave action on the lake, and all boats must be operated at no wake speeds. The lake at conservation pool has 10,034 acre/feet of storage, with an average depth of 15.75 feet and a maximum depth of 44 feet (see map on page 304). Care should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See Appendix for lake mapping procedure.)

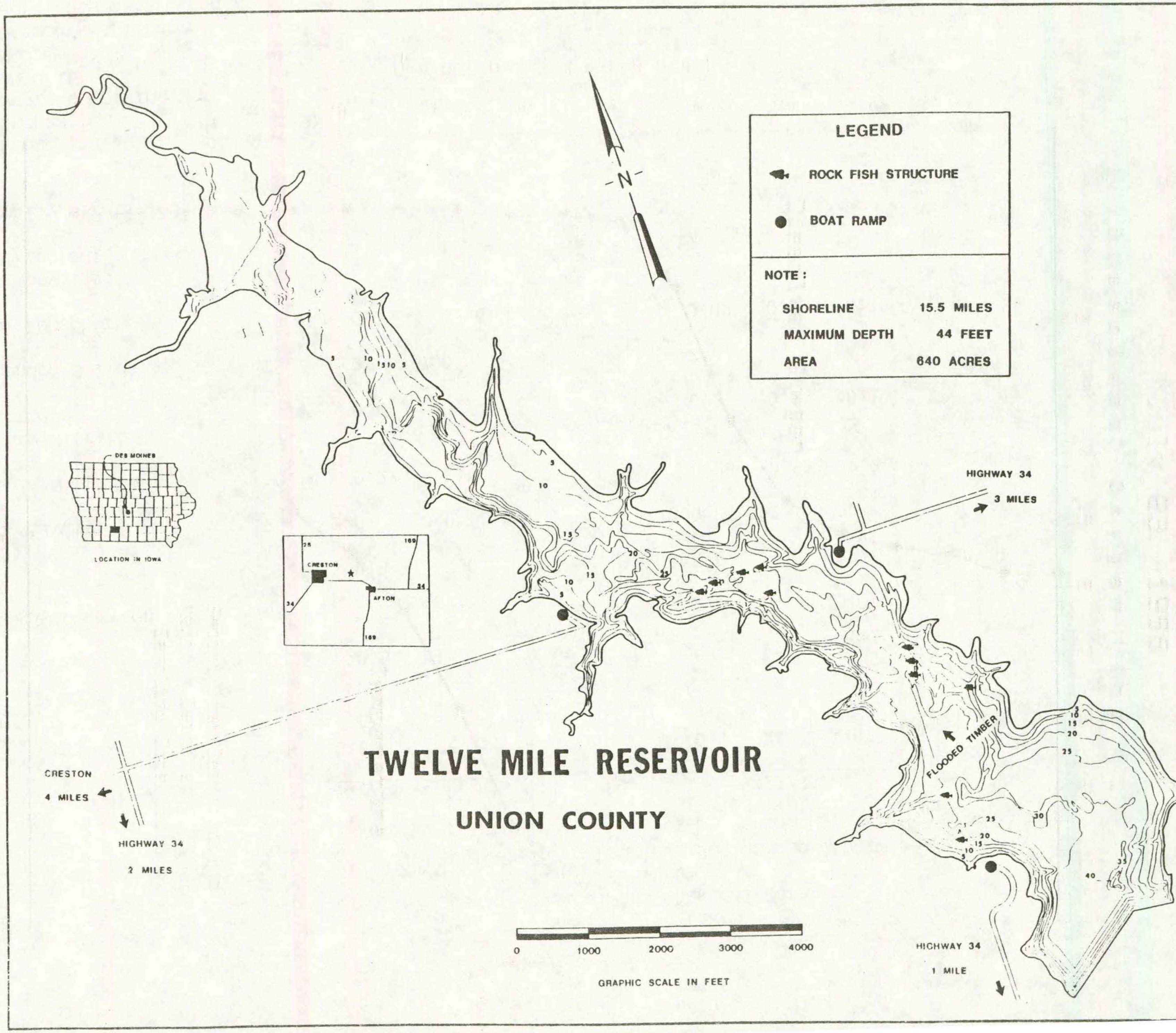
Chemical Data

Prior to the 1986 study, there had been no assessments of Twelve Mile Lake water quality. The physical and chemical data obtained in 1986 for Twelve Mile Lake are listed in the table on page 305 and also in the appendix.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 72 to 80 inches with a mean (N = 3) of 76 inches.

Twelve Mile Lake water temperature ranged from a low of 13°C in all three bottom samples to a high of 25°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section.

During 1986 dissolved oxygen (DO) values ranged from 1.0 mg/L in several bottom samples to 8.8 mg/L in the September surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 306, 307, and 308 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. The June profile indicates Twelve Mile Lake already had developed a DO and temperature gradient (stratification). The dissolved oxygen content of the lake water decreased from 8.5 mg/L at the surface to less than 1 mg/L at 18 feet (5.5 meters). Below 18 feet essentially no DO existed. The June temperature gradient was more gradual with a surface temperature of 22.5°C and a bottom value of 13°C. As the water temperature decreases, the water becomes more dense (i.e., heavier). In summer differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The profile for the July sampling period was very similar to the June profile except that the DO and temperature gradients were even

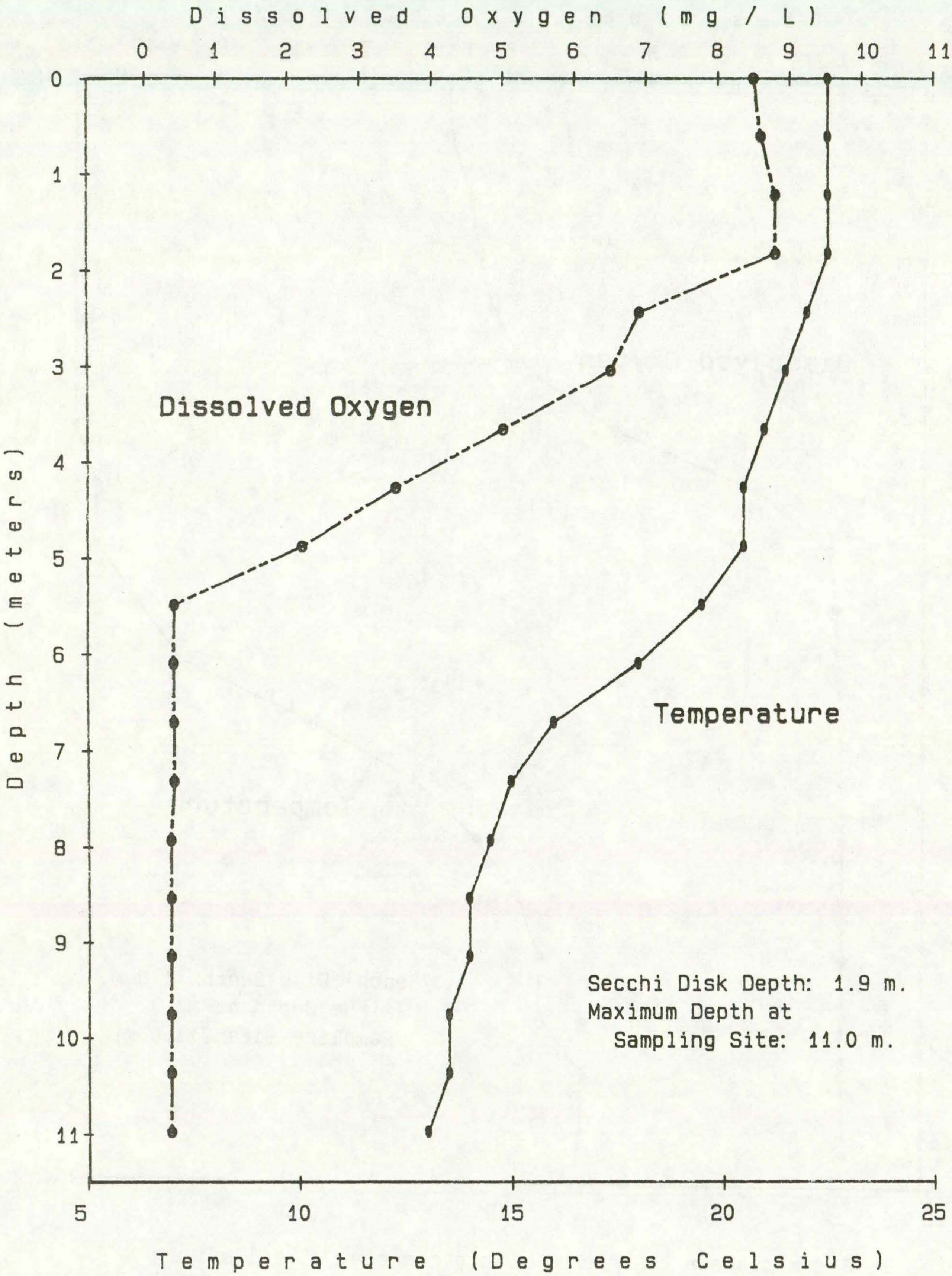

TWELVE MILE RESERVOIR
UNION COUNTY
LEGEND
ROCK FISH STRUCTURE
BOAT RAMP
NOTE:
SHORELINE 15.5 MILES
MAXIMUM DEPTH 44 FEET
AREA 640 ACRES
N
DES MOINES
LOCATION IN IOWA
CRESTON
AFTON
HIGHWAY 34
3 MILES
CRESTON
4 MILES
HIGHWAY 34
2 MILES
HIGHWAY 34
1 MILE
FLOODED TIMBER
0 1000 2000 3000 4000
GRAPHIC SCALE IN FEET

Twelve Mile Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

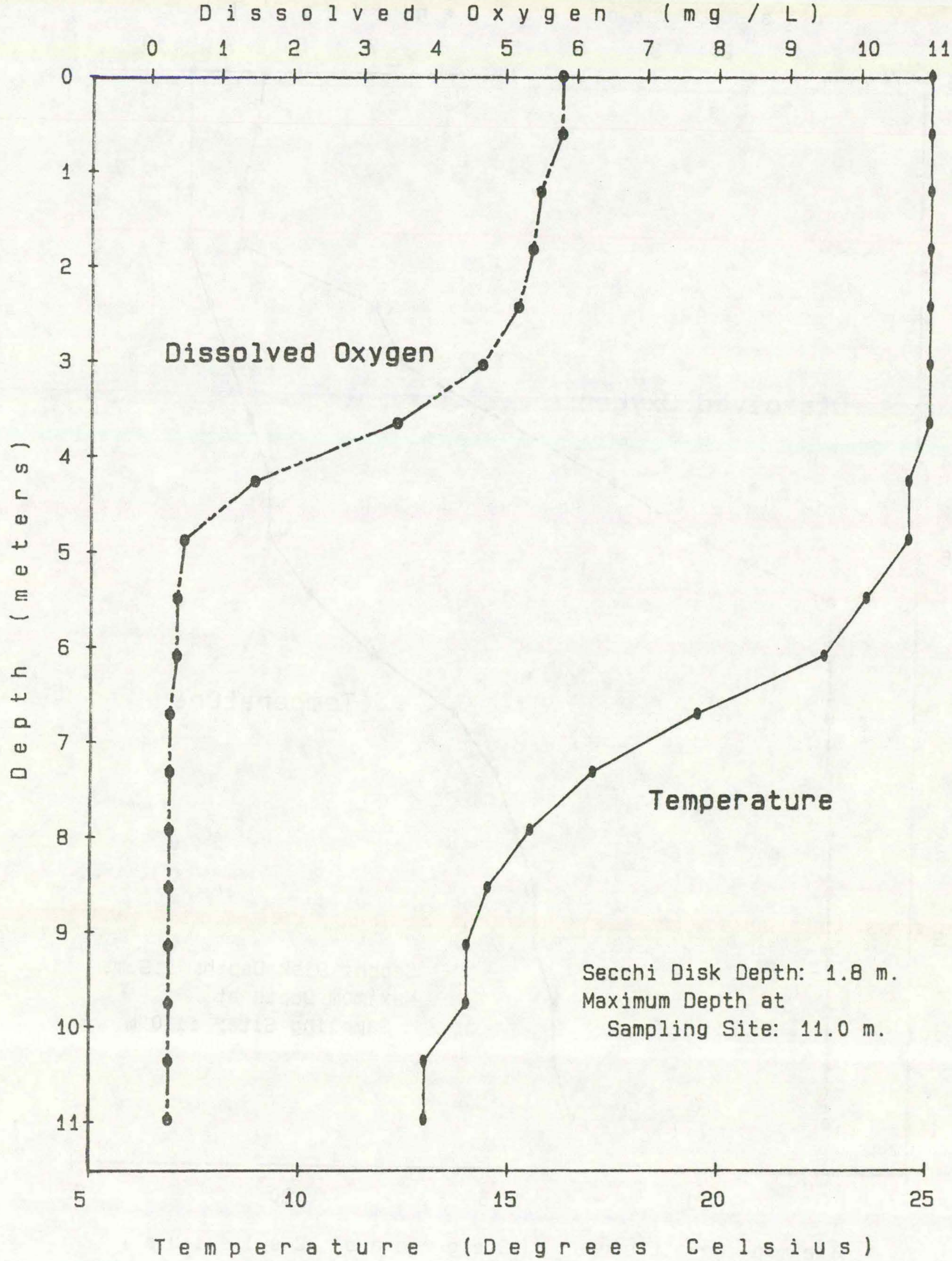
Date Collected	6/18/86			7/22/86			9/03/86		
*Depth[1]	0	16	36	0	24	36	0	18	32
*Secchi[2]	75			72			80		
*Temperature[3]	22.5	20.5	13	25	17	13	20.5	19.5	13.5
*Dissolved Oxygen	8.5	2.2	0.4	5.8	0.3	0.3	8.8	8.2	0.6
*pH[4]	9.6	8.3	7.0	8.6	7.8	8.0	8.7	8.5	8.6
Conductivity[5]	320	320	340	300	320	320	280	280	280
Ammonia Nitrogen	0.18	0.27	1.6	0.28	0.58	2.3	0.08	0.37	0.07
Nitrate-Nitrite Nitrogen	0.4	0.4	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1
Suspended Solids	15	2	700	2	4	64	8	11	12
Total Phosphorus	0.05	0.06	0.56	0.02	0.02	0.30	0.26	0.06	0.07
Chlorophyll a (Corrected)[6]	9	3	<1	17	<1	<1	16	3	21
Thermally Stratified		Yes			Yes			Yes	

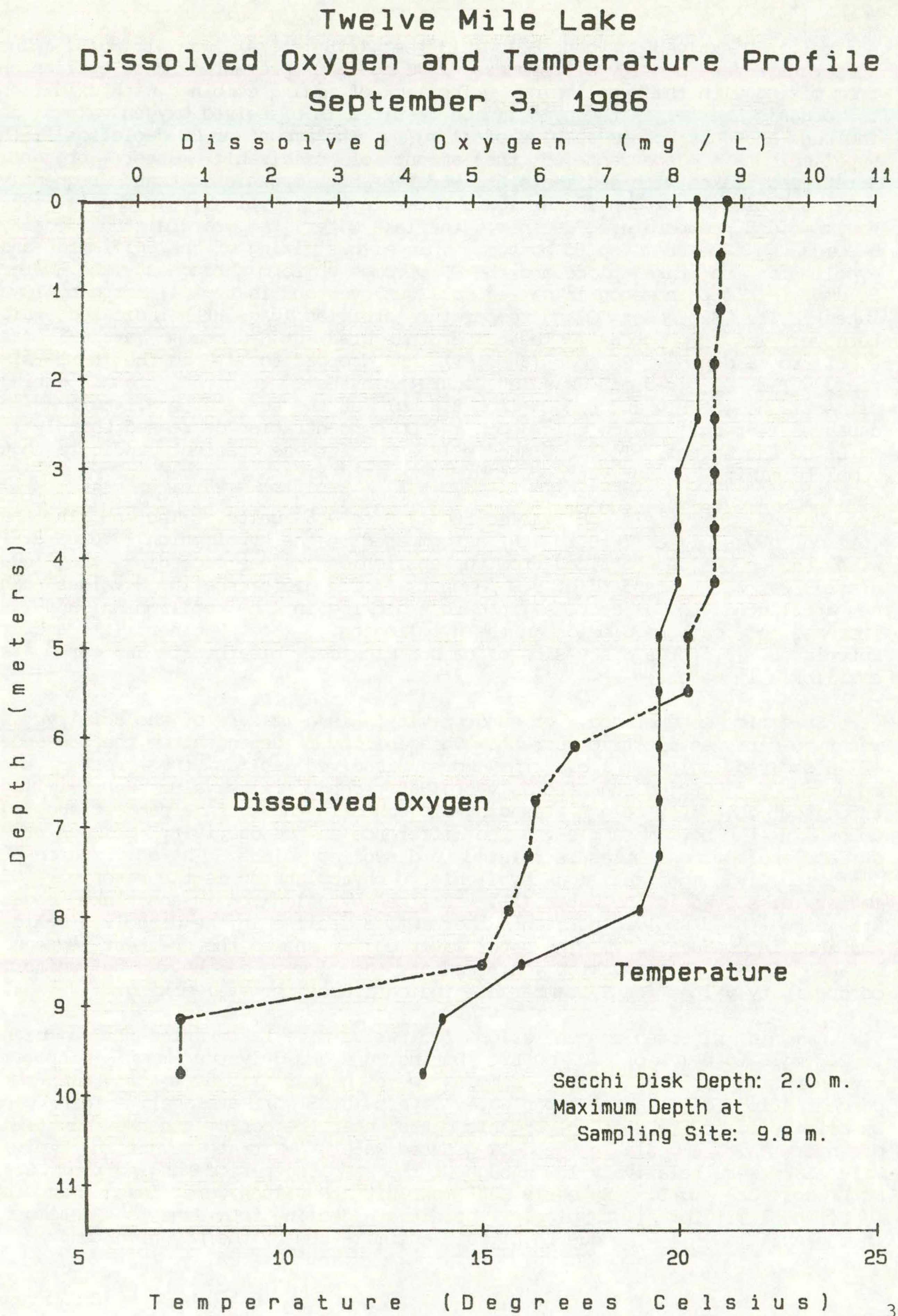
1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

Twelve Mile Lake
Dissolved Oxygen and Temperature Profile
June 18, 1986



Twelve Mile Lake
Dissolved Oxygen and Temperature Profile
July 23, 1986




Twelve Mile Lake
Dissolved Oxygen and Temperature Profile
September 3, 1986
Dissolved Oxygen (mg / L)
0
1
2
3
4
5
6
7
8
9
10
11
Depth (meters)
Dissolved Oxygen
Temperature
Secchi Disk Depth: 2.0 m.
Maximum Depth at
Sampling Site: 9.8 m.
5
10
15
20
25
Temperature (Degrees Celsius)

sharper. Dissolved oxygen below 15 feet (4.5 meters) was <1 mg/L. The temperature and density differences (25°C to 15°C) prevented the epilimnion from mixing with the hypolimnion. The lack of mixing combined with oxidation of organic matter in the hypolimnion resulted in dissolved oxygen values in the June and July bottom samples of <1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with sediments and water of high organic content frequently have no dissolved oxygen in the lower water layer. Typically in the fall, as the ambient temperature decines, the lake water temperature and density becomes the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profiles (page 309) indicated fall turnover was in progress. The temperature gradient had become vertical (at 20°C) to a depth of 26 feet (8 meter) then dropped to 14°C in the next six feet. The DO gradient was less sharp than the DO gradients found during either June or July and ranged from 8.8 mg/L at the surface to 5.1 mg/L at a depth of 28 feet. Below this depth the DO concentration decreased sharply (<1 mg/L) to the bottom. The continued existence of these gradients indicate that complete mixing had not yet occurred.

Values for field pH varied from 7.0 to 9.6 units. The pH in the epilimnion was higher (8.6 to 9.6) as compared to the hypolimnion (7.0 to 8.6) with the pH values obtained from the epilimnion in June exceeding the Iowa class B warmwater standard of 9.0 pH units. The difference in pH values can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. During June and July of 1986, conductivity values were similar throughout the water column averaging 310 umhos in the surface samples and 330 umhos in the bottom samples. The difference in conductivity between the surface and bottom samples is related to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). As the phytoplankton in the lake began utilizing the dissolved nutrients there was a decline in the dissolved solids and thus in conductivity. The upper water column showed the greatest decrease because fewer phytoplankton existed at the lower depths. The uniform conductivity values for September are indicative of the fall mixing.

Ammonia nitrogen concentrations for Twelve Mile Lake varied from a high of 2.3 mg/L to a low of 0.07 mg/L. During June and July the ammonia nitrogen concentration in the bottom samples were higher (1.95 mg/L) than the concentration found in the upper water layers (0.23 mg/L average). This can be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate levels in Twelve Mile Lake were relatively low thoughout the sampling period ranging from 0.4 mg/L to < 0.1 mg/L. By early September nitrate values were less than the reproting limit for all samples. The nitrate decline from June to September in the epilimnion may be due to nitrate assimilation by the phyoplankton.

Suspended solids ranged from 2 mg/L to 700 mg/L with the higher values being found in the bottom samples. The 700 mg/L value for the June bottom sample does not appear realistic. This sample may have been contaminated with bottom mud. The higher solids values in the bottom samples may be attributed to the settling of material from the upper water layers and include turbidity from tributaries, soil bank erosion, dead plankton and other allochthonous and autochthonous matter.

During 1986, total phsophorus concentrations in surface samples ranged from 0.02 to 0.26 mg/L as compared to 0.07 to 0.56 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The lower value of total phosphorus in the epilimnion may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part fo the hypolimnion, phosphorus levels were highest in June (0.56 mg/L), declined to 0.30 mg/L in July and to 0.07 mg/L in September. It is not unusual for phsophorus to be higher in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction (3).

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986, the chlorophyll a values in the epilimnion ranged from 9 ug/L to 17 ug/L. The June epilimnion mean chlorophyll a value was lowest (4 ug/L) while July and September had similar values (17 ug/L and 16 ug/L, respectively). Hypolimnetic values for chlorophyll a ranged from <1 ug/L to 21 ug/L with the highest value occurring in September.

Biological Data

Initial fish stockings were completed in 1986, and yearly maintenance stockings of walleye, tiger muskie and channel catfish are to be conducted.

Two fish sampling periods, May 6 and September 9, 1986 were necessary to provide some basic information concerning the fish population. Major fish species sampled, average length and ranges are given in the tables below, and complete field data information is listed in the Appendix.

Major fish species abundance, averge length, and range during the May 6, 1986 survey at Twelve Mile Reservoir.

Species	Number	Average Length (Inches)	Range (Inches)
Bluegill	138	7.3	5.0-8.5
White Crappie	38	9.6	8.5-10.5
Black Crappie	17	8.6	8.0-9.5
Black Bullhead	331	8.3	6.0-9.5

Major fish species abundance, average length, and range during September 9, 1986 survey at Twelve Mile Reservoir.

Species	Number	Average Length (Inches)	Range (Inches)
Bluegill	13	8.0	5.0-9.0
Black Bullhead	190	8.7	7.5-10.0
Largemouth Bass	168	8.8	3.0-17.0
Walleye	56	7.6	7.0-8.5

The fishery at Twelve Mile Reservoir is still in the developmental stages. A large population of bullheads developed following impoundment. With the good water quality and high density bass population, future, significant bullhead year classes are doubtful. The larger size bass population is difficult to sample because of the water clarity, but bass less than twelve inches are sometimes sampled at rates exceeding 100 fish/hour. Walleye growth should improve as the forage expands, and as the large initial year class of walleye declines. The crappie and bluegill populations are still developing and fishing opportunities should improve. Previous sampling efforts have indicated good numbers of 12 to 15 inch channel catfish (initially stocked with 96,000 two inch channel catfish), but they were not sampled in our 1986 efforts. Yearly maintenance stockings of channel catfish, tiger muskie and walleye will be necessary to maintain excellent fishing.

This lake has the potential to be one of the better fishing lakes in the state.

SUMMARY

This report constitutes the first assessment of water quality of Twelve Mile Lake since its impoudment in the fall of 1984. Although the data are somewhat limited, it is possible to make several general statements about the lake.

Throughout the summer, the water transparency of Twelve Mile Lake remained good (average Secchi disk readings of 76 inches). During June and July, sharp DO gradients limited the fish populations to depths of approximately 10 to 12 feet. The phytoplankton population remained low throughout the summer (indicated by low chlorophyll values), and all other analytes appeared to be in "expected" ranges.

The fish populations at Twelve Mile Lake are still in the developmental stages. Fish species found in the lake include black bullehad, bluegill, white crappie, black crappie, largemouth bass and walleye. Staff from the Department of Natural Resources feel that this lake has the potential to be one of the better fishing lakes in Iowa.

Good soil conservation practices should be followed in the watershed to keep the rate of siltation as low as possible, thus lengthening the lake's life. Continued monitoring is necessary to determine long-term trends in water quality and the lake fisheries.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa'a Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00630 998800401000
41 03 22.0 094 15 00.0 5
TWELVEMILE LAKE, 4 MI E OF CRESTON, DEEPEST PART
19175 IOWA UNION
SOUTHERN IOWA RIVER BAS 091300
THOMPSON RIVER SUBBASIN
21IOWA 860628 10280102047 0019.150 ON
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
86/06/18	0920	WATER	16	20.50			320	2.20	8.30	8.10	2	.270	.40
86/06/18	0925	WATER	36	13.00			340	.36	7.00	7.50	700	1.600	.10K
86/06/18	0930	WATER	0	22.50	75.0		320	8.50	9.60	8.30	15	.180	.40
86/07/22	0900	WATER	0	25.00	72.0		300	5.80	8.60	8.10	2	.280	.20
86/07/22	0900	WATER	24	17.00			320	.30	7.80	7.50	4	.580	.20
86/07/22	0900	WATER	36	13.00			320	.30	8.00	7.70	64	2.300	.10K
86/09/03	1307	WATER	18	19.50			280	8.20	8.50	8.10	11	.370	.10K
86/09/03	1310	WATER	0	20.50			280	8.80	8.70	8.20	8	.080	.10K
86/09/03	1310	WATER	32	13.50			280	.60	8.60	8.30	12	.070	.10K

L00630 998800401000
41 03 22.0 094 15 00.0 5
TWELVEMILE LAKE, 4 MI E OF CRESTON, DEEPEST PART
19175 IOWA UNION
SOUTHERN IOWA RIVER BAS 091300
THOMPSON RIVER SUBBASIN
21IOWA 860628 10280102047 0019.150 ON
0000 FEET DEPTH

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
86/06/18	0920	WATER	16		.060	6.00	3.00						
86/06/18	0925	WATER	36		.560	17.00	1.00K						
86/06/18	0930	WATER	0		.050	11.00	9.00						
86/07/22	0900	WATER	0		.020	20.00	17.00						
86/07/22	0900	WATER	24		.020	8.00	1.00K						
86/07/22	0900	WATER	36		.300	14.00	1.00K						
86/09/03	1307	WATER	18		.060	3.00	3.00						
86/09/03	1310	WATER	0		.260	24.00	16.00						
86/09/03	1310	WATER	32		.070	28.00	21.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

These procedures have been used to develop topographic maps for Iowa lakes for a number of years. Experience has shown the resulting maps are of considerable value in describing general lake features to fishermen, boaters, and other lake users.

However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

This lack of mapping accuracy is not a particular concern if the maps are only being used to delineate general physical lake features. However, these inaccuracies are of major concern if the maps are being used to determine if relatively small changes in lake features are occurring, since the mapping errors may obscure the actual changes occurring. For example, although comparison of the 1979 and 1986 maps should have shown how each lake's surface area had decreased due to sedimentation occurring over this period, for a least 4 lakes the maps were not sufficiently accurate to show any such impacts. These results indicate that if lake topographic maps are to be used for determining small changes in a lake's physical features, a more accurate mapping procedure must be used.

Comparison of 1979 and 1986 Lake Topographic Maps*

Lake	1979 Mapping Surface Area (acres)	1979 Mapping Maximum Depth (feet)	1979 Mapping Volume (ac-ft)	1986 Mapping Surface Area (acres)	1986 Mapping Maximum Depth (feet)	1986 Mapping Volume (ac-ft)
Badger	45	24	380	38	18	249
Bob White	89	14	444	90	13	456
Geode	181	52	4515	190	42	4542
Hendricks	40	19	312	40	19	312
Icaria	697	14.1	9856	666	12.2	8139
Keomah	84	22	846	74	18	737
Macbride	812	47	13131	825	46.7	13229
Miami	140	24	1336	122	20	1158
Wapello	289	34	3717	285	32	3481
Nine Eagles	67	34	888	55	32	850
Pierce Creek	35**	20***	269	33	16	205
Red Haw	64	40	948	71	38	908
Rodgers Park	22	18	161	21.1	18	155.7

* - Volga, Yellow Smoke, and Twelve Mile Lakes were first mapped in 1986, and thus are not listed in this table.

** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

Twelve Mile Reservoir Storage Capacity - 1986

Depth (feet)	Surface Area (acres)	Accumulative Storage (acre/feet)
40	0.40	0.40
39	0.68	1.08
38	0.96	2.04
37	1.24	3.28
36	1.52	4.80
35	1.80	6.60
34	10.88	17.48
33	19.96	37.44
32	29.04	66.48
31	38.12	104.60
30	47.20	151.80
29	65.32	217.12
28	83.44	300.56
27	101.56	402.12
26	119.68	521.80
25	137.80	659.60
24	154.86	814.46
23	171.92	986.38
22	188.98	1175.36
21	206.04	1381.40
20	223.10	1604.50
19	239.64	1844.14
18	256.18	2100.32
17	272.72	2373.04
16	289.26	2662.30
15	305.80	2968.10
14	325.12	3293.22
13	344.44	3637.66
12	363.76	4001.42
11	383.08	4384.50
10	402.40	4786.90
9	423.18	5210.08
8	443.96	5654.04
7	464.74	6118.78
6	485.52	6604.30
5	506.30	7110.60
4	532.40	7643.00
3	558.50	8201.50
2	584.60	8786.10
1	610.70	9396.80
Surface	636.80	10033.60

Total Storage	10033.60 Acre/ft
Average Depth	15.76 Feet

DATE: 5/6/'86
WATER: 12 Mile Lake
CATALOG NO.:

INVESTIGATOR: McGhee, Sobotka, Still

NET: 4 Fyke
TOTAL NET HOURS: 96
MIN. SHOCKER:

SEINE:
NO. HAULS:
OTHER:

LENGTH FREQUENCY

SPECIES IN.	.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5	7.5-8.0	8.0-8.5	8.5-9.0	9.0-9.5	9.5-10.0	10.0-10.5	10.5-11.0	11.0-11.5	11.5-12.0	12.0-12.5	12.5-13.0	13.0-13.5	13.5-14.0
Blg.										8	4	13	8	35	44	26											
White Crappie																	4	8	9	7							
Black Crappie																8	5	4									
Black Bullhead												4		52	85	68	85	57									
Walleye															2	4											
Channel Catfish																			1	2	3						

9/8/86
12-Mile

INVESTIGATOR: McGhee, Sobotka, Still

NET: ______ TOTAL NET HOURS: ______ MIN. SHOCKER: 60 min. (day) 69°F - H_2O

SEINE: ______ NO. HAULS: ______ OTHER: ______

LENGTH FREQUENCY

IN.	.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Blg.														
Green Sunfish										2		7	2	1
Bls/GS HYB												2	2	2
Walleye														27
LMB						3							5	16

IN.	7.5-8.0	8.0-8.5	8.5-9.0	9.0-9.5	9.5-10.0	10.0-10.5	10.5-11.0	11.0-11.5	11.5-12.0	12.0-12.5	12.5-13.0	13.0-13.5	13.5-14.0	14.0-14.5
Blg.	3	2	4											
Green Sunfish														
Bls/GS HYB														
Walleye	19	10												
LMB	21	32	35	27	2	16		3		3		2		1

Numerous YofY Blg
1/2-1.5 inches long

9/9/86
12-Mile

INVESTIGATOR: McGuire, Still

NET: 4 FRE
TOTAL NET HOURS: 96
MIN. SHOCKER:

SEINE:
NO. HAULS:
OTHER:

LENGTH FREQUENCY

IN.	LMB (lb. #)	Channel Catfish (Wt. #)	Black Bullhead	Green Sunfish	Black Crappie	White Crappie	Blg
.5-1.0	17 (1)	15 (2)					
1.0-1.5		14.5 (1)					
1.5-2.0							
2.0-2.5							
2.5-3.0							
3.0-3.5							
3.5-4.0							
4.0-4.5							
4.5-5.0							
5.0-5.5				1			1
5.5-6.0							
6.0-6.5				1			
6.5-7.0	2			1			
7.0-7.5							
7.5-8.0			8				2
8.0-8.5	1		72				1
8.5-9.0	1		64		1		1
9.0-9.5			42			1	
9.5-10.0			4				
10.0-10.5	1					2	
10.5-11.0							
11.0-11.5							
11.5-12.0							
12.0-12.5							
12.5-13.0							
13.0-13.5							
13.5-14.0							
14.0-14.5							

- 3 Other Nets With Similar Results

VOLGA LAKE

Physical and Lake Impact Data

Volga Lake is a 119 acre impoundment located in north-central Fayette County, Iowa. The lake was completed in 1979 by the Iowa Conservation Commission (now part of the Iowa Department of Natural Resources) on a mandate from the Iowa General Assembly. The lake is located in a multiple-use recreation area managed by the Iowa Department of Natural Resources.

The lake lies northwest from the dam site and contains two large bays (map on page 324). The lake bed was cleared of vegetation and a clay "seal" added to assure impermeability. The depth of the seal varies from 1.5 feet along the shoreline to 4 feet at the dam base. Due to this sealing process, no natural structures or contours occur on the lake bottom. Artificial devices have been added at three sites to provide additional fish habitat. Shoreline and boat angling are encouraged on the lake but swimming is prohibited and camping in the near vacinity of Volga Lake is not allowed. Volga Lake contains 1,266 acre-feet of water with the mean depth of the lake estimated to be seven feet and the deepest pointis about 22.5 feet in from of the outlet structure. Care should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures). DNR fisheries staff have estimated that slight to moderate siltation has occurred in the uppermost portion of Volga Lake's two large bays.

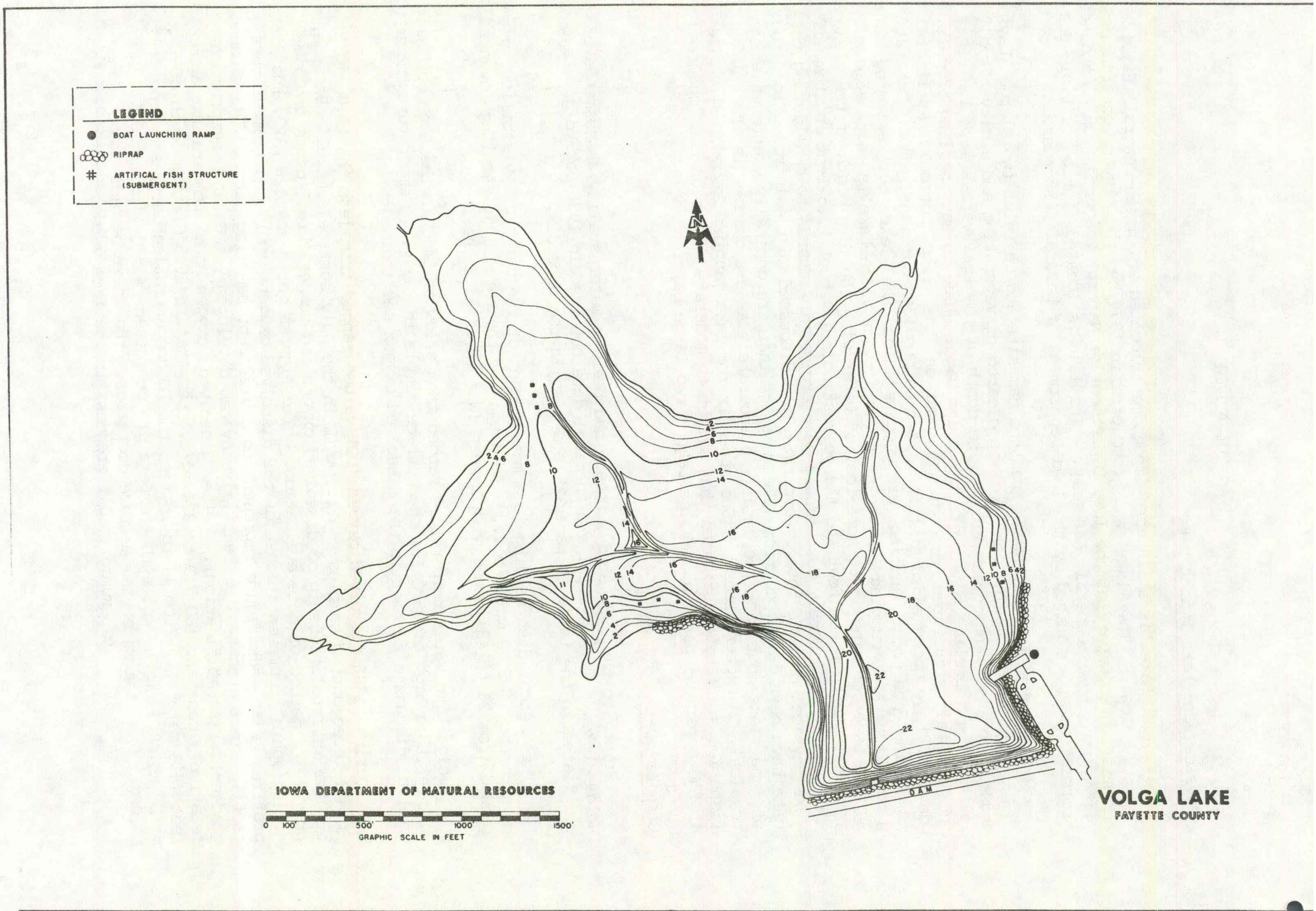
Chemical Data

Prior to the 1986 study, there had been no water quality assessments of Volga Lake. The physical and chemical data obtained in 1986 for Volga Lake are listed in the table on page 325 and also in the appendix.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 26 to 43 inches with a mean (N = 3) of 33 inches.

Volga Lake water temperature ranged from a low of 14°C in the June bottom sample to a high of 29°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section.

During 1986 dissolved oxygen (DO) values ranged from less than 1.0 mg/L in all three bottom samples to 11.2 mg/L in the July surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 326 ,327, and 328 are graphic representations of the dissolved oxygen (DO) and temperature profiles with each figure representing a different sampling date. The June profile indicates Volga Lake already had developed DO and temperature gradients (stratification). The dissolved oxygen and temperature were relatively constant (DO 7.9 to 8.4 mg/L, temperature 20.5°C) to a depth of 14 feet (4.3 meters). From 14 to 16 feet the DO concentration decreased from 7.9 mg/L to 0.5 mg/L while the temperature decreased 4.5°C (from 20.5°C to 16.0°C). As the water temperature decreases, the water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water

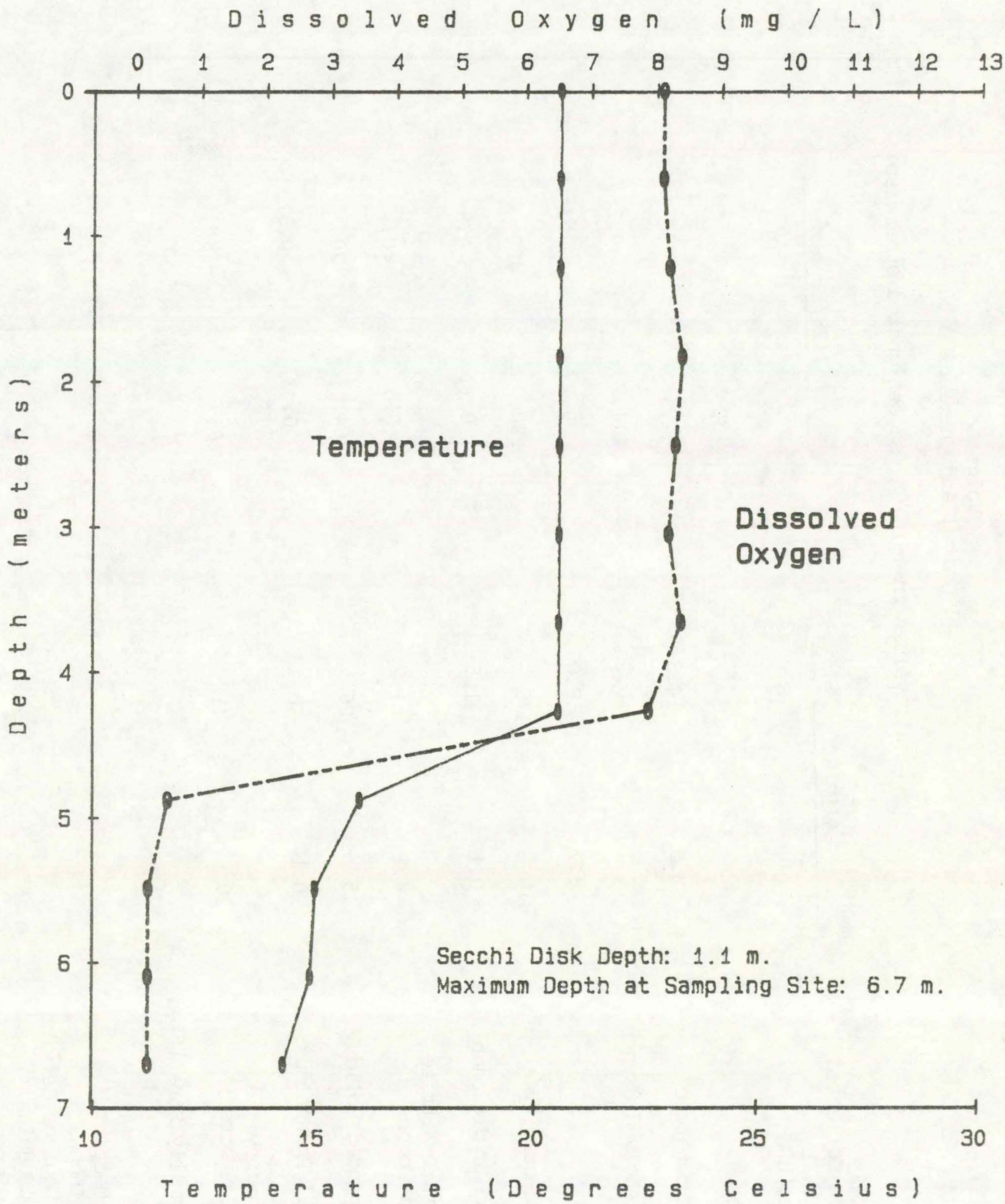

LEGEND
BOAT LAUNCHING RAMP
RIPRAP
ARTIFICAL FISH STRUCTURE (SUBMERGENT)
N
DAM
IOWA DEPARTMENT OF NATURAL RESOURCES
0 100' 500' 1000' 1500'
GRAPHIC SCALE IN FEET
VOLGA LAKE
FAYETTE COUNTY

Volga Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

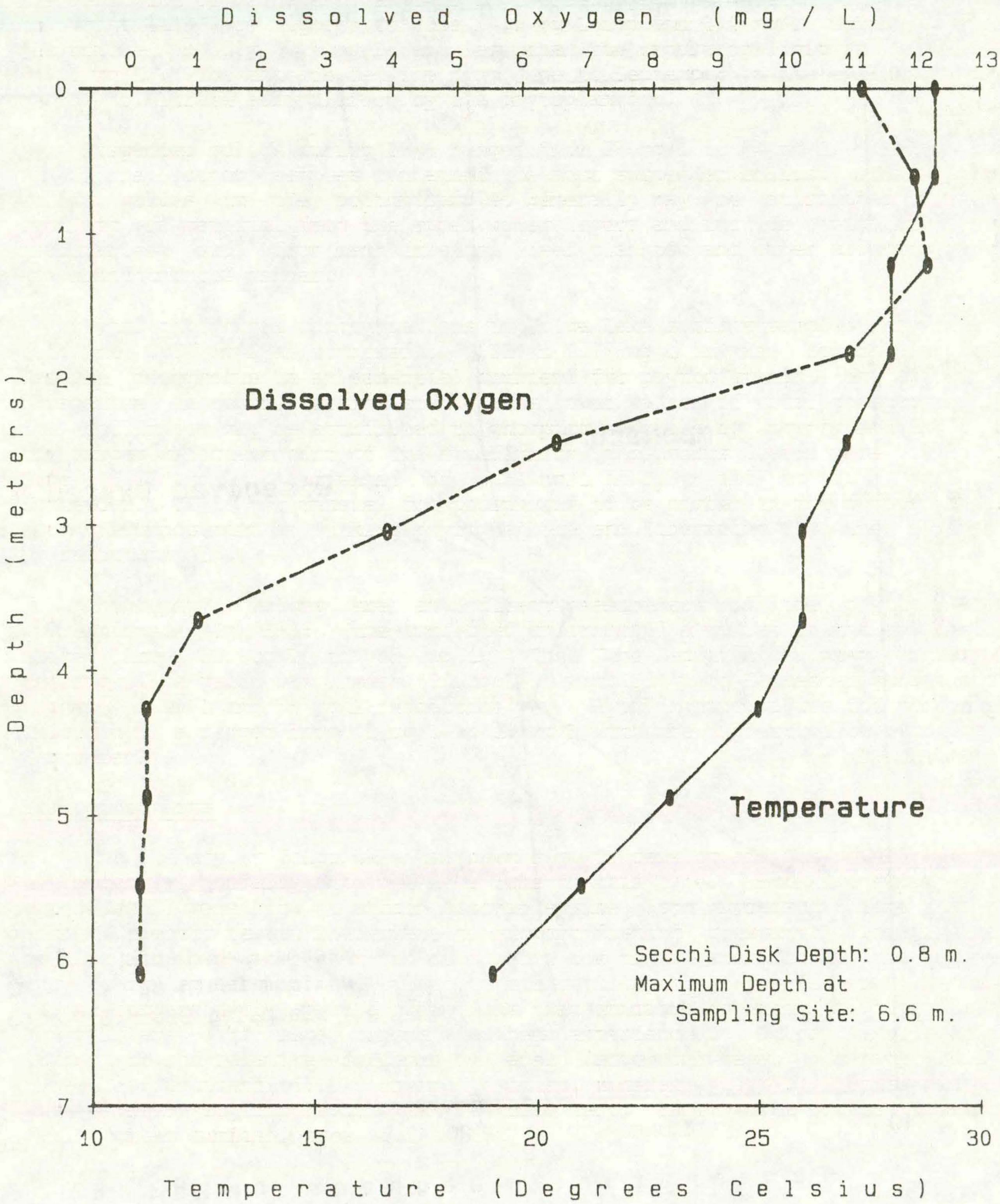
Date Collected	6/12/86		7/29/86		9/09/86	
*Depth[1]	0	19	0	19	0	19
*Secchi[2]	43		30		26	
*Temperature[3]	20.5	14.3	29	20	18.9	17.5
*Dissolved Oxygen	8.1	0.2	11.2	0.1	7.4	0.3
*pH[4]	8.7	8.0	9.2	7.3	NDA**	NDA**
Conductivity[5]	410	470	290	480	320	390
Ammonia Nitrogen	0.15	1.5	0.11	4.9	0.23	8.1
Nitrate-Nitrite Nitrogen	4.1	1.2	0.5	<0.1	<0.1	<0.1
Suspended Solids	15	26	64	20	20	37
Total Phosphorus	0.17	0.22	0.33	0.31	0.10	0.77
Chlorophyll a (Corrected)[6]	20	<1	65	8	56	18
Thermally Stratified	Yes		No		No	

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site
**No Data Available

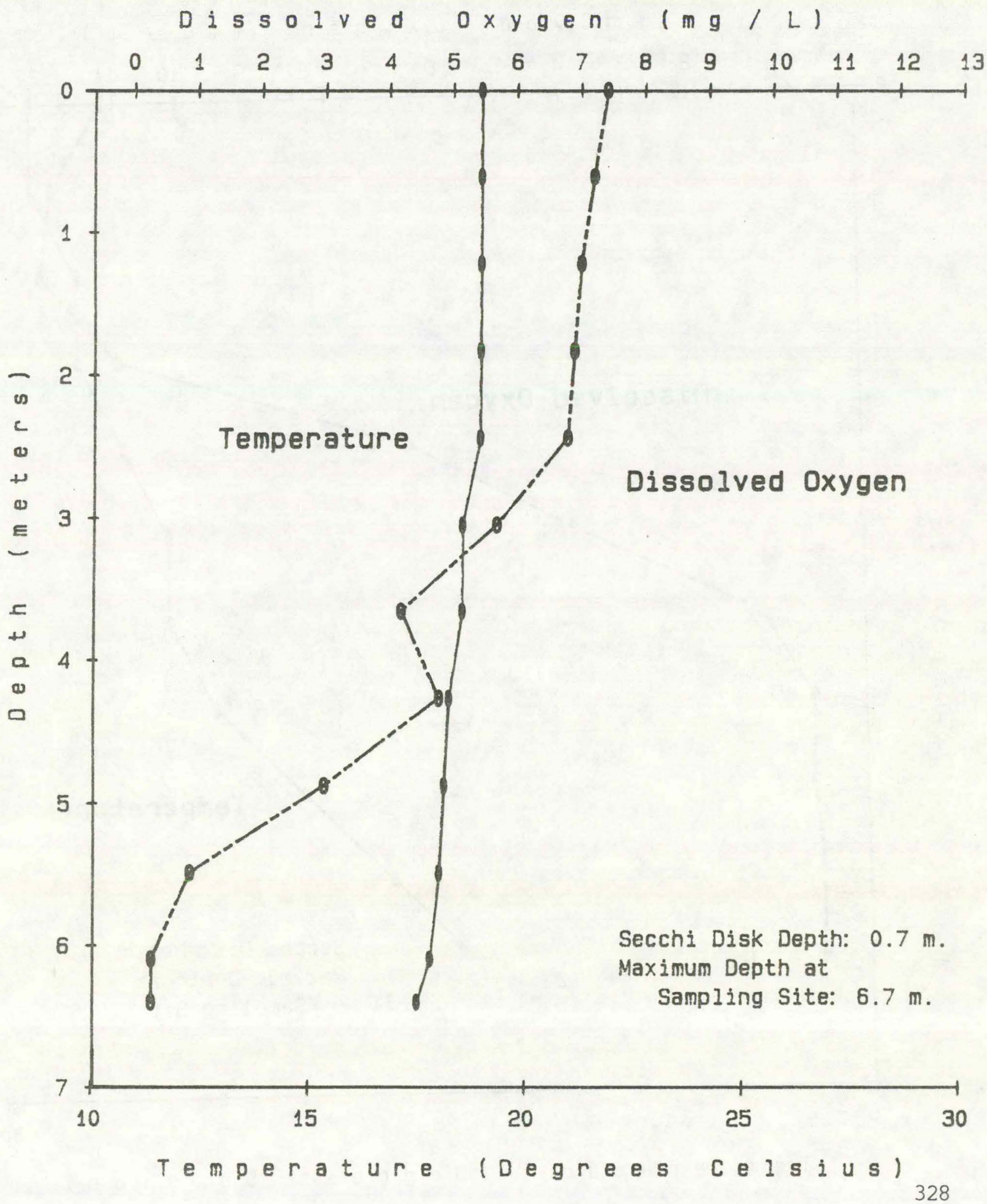
Volga Lake
Dissolved Oxygen and Temperature Profile
June 12, 1986



Volga Lake
Dissolved Oxygen and Temperature Profile
July 29, 1986



Volga Lake
Dissolved Oxygen and Temperature Profile
September 9, 1986



temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The temperature and density differences (20.5°C to 16°C) prevented the epilimnion from mixing with the hypolimnion. The lack of mixing, combined with organic oxidation in the hypolimnion resulted in dissolved oxygen value in the June bottom sample of <1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with sediments and water of high organic content frequently have no dissolved oxygen in the lower water layer. The July temperature and DO profiles were not the same as June's. The temperature of the entire water column had increased, ranging from 29°C at the surface to 19°C at the bottom. The temperature change was more gradual and did not exhibit the sharp drop within a short distance. The DO profile was also more gradual than in June, and the depth at which a very low DO occurred moved up from 16 feet to 12 feet. As a result, less volume of lake water was available for aquatic life. Typically in the fall, as the ambient temperature declines, the lake water temperature becomes the same from top to bottom. This allows mixing of the epilimnion and hypolimnion and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profiles (page 328) indicated fall turnover was in progress. The temperature gradient had become almost vertical ranging from 18.9°C at the surface to 17.5°C at 21 feet. The DO profile continued to demonstrate a gradient top to bottom, but the zone of oxygen depletion had dropped to 18 feet. The continued existence of a gradient indicates complete mixing had not yet occurred.

Values for field pH varied from 7.3 to 9.2 units (for June and July, no data were available for September). The pH in the epilimnion was higher (range 8.7 to 9.2) as compared to the hypolimnion (range 7.3 to 8.0) with the pH values obtained from the epilimnion in July exceeding the Iowa class B warmwater standard of 9.0 pH units. The difference in pH values can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids, i.e., the more dissolved solids present the greater the conductance. During June 1986, conductivity values were similar throughout the water column ranging from 410 micromhos in the surface samples to 470 micromhos in the bottom samples. In July a substantial difference was observed between surface (290 micromhos) and bottom (480 micromhos) samples. The difference in conductivity between the samples related it to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). As the phytoplankton in the lake began utilizing the dissolved nutrients, there was a decline in the dissolved solids and thus in conductivity. The upper water column showed the greatest decrease because fewer phytoplankton existed at the lower depths. The similar conductivity values for September (320 and 390 micromhos) are indicative that fall mixing was beginning.

Ammonia nitrogen concentrations for Volga Lake varied from a high of 8.1 mg/L to a low of 0.11 mg/L. Ammonia values for all three surface samples were similar, ranging from 0.11 mg/L to 0.23 mg/L. Bottom ammonia nitrogen concentrations, however, increased from 1.5 mg/L in June to 4.9 mg/L in July reaching a maximum of 8.1 mg/L in September. The increase from June to September may be attributed to the decay of organic matter near the bottom and the reduction of nitrate to ammonia in the deoxygenated water. Nitrate levels in Volga Lake were highest in June (4.1 mg/L top and 1.2 mg/L bottom), just measurable in July (0.5 mg/L) and less than the reporting limit in September (<0.1 mg/L). The nitrate decline from June to September in the epilimnion may be due to nitrate assimilation by the phytoplankton.

Suspended solids during 1986 ranged from 20 mg/L to 64 mg/L. Except for July, the bottom samples contained the most suspended solids. The higher solids values in the bottom samples generally may be attributed to the settling of material from the upper water layers and include turbidity from tributaries, soil from bank erosion, dead plankton and other allochtohonous and autochthonous matter.

Total phosphorus concentrations in Volga Lake surface samples ranged from 0.10 to 0.33 mg/L as compared to 0.22 to 0.77 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The lower values of total phosphorus in the epilimnion may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part of the hypolimnion, phosphorus levels were lowest in June (0.22 mg/L), increased to 0.31 mg/L in July and to 0.77 mg/L in September. It is not unusual for phosphorus to be higher in the bottom waters from decomposition of sinking phytoplankton and liberation from the sediment by reduction (3).

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986, the corrected chlorophyll a values in the epilimnion ranged from 20 ug/L to 65 ug/L. The June epilimnion mean corrected chlorophyll a value was lowest (20 ug/L), with July and September values much higher (65 ug/L and 56 ug/L respectively). Hypolimnetic values for corrected chlorophyll a ranged from <1 ug/L to 18 ug/L with the highest value occuring in September.

Biological Data

The fishery in Volga Lake has been slow to develop and has never realized the potential normally attained in a lake of this type. Both largemouth bass and bluegill were slow to attain catchable size, and numbers of large fish of either species remain inadequate to support fishing pressure. Insufficient benthic and open-water plankton production due to the sterility of the applied clay bottom appears to have caused this slow response of the fishery. Because of the comparatively sterile conditions that continue to exist in Volga Lake, no problems with algae blooms have been experienced. Volga Lake species comparison and relative abundance (%) are: largemouth bass, moderate (13.3); bluegill, abundant (65.8); channel catfish, moderate (10.4). Species present but of little angling importance are grass carp, rare; white sucker, moderate (9.3); green sunfish, rare (1.3).

Age and Rate of Growth:

Species	Age	Length (Inches) Range	Mean
Largemouth Bass	0	4.0 - 6.0	5.1
	I	8.3 - 10.2	9.2
	II	10.6 - 12.5	11.6
	III	12.3 - 14.0	13.0
	IV	12.7 - 15.5	13.7
Bluegill	I	3.0 - 4.0	3.4
	II	4.4 - 5.7	4.8
	III	4.5 - 6.6	5.7
	IV	NA	6.4
Channel Catfish	II	11.2 - 13.5	12.4
	IV+	15.0 - 21.9	18.4

General Fishery Assessment:

Largemouth Bass - The population has been slow to develop and remains below average for similar Iowa lakes. Past studies have shown a relatively sterile lake environment probably attributable to the clearing and sealing process used when the lake was constructed. Angling pressure and vulnerability of the bass further add to the problem of slow growth. Although numbers and age structure are adequate below the thirteen-inch size group, the population deteriorates rapidly above this size, and few bass are seen larger than fifteen inches.

Bluegill - The bluegill supported the initial fishery as is common in most new Iowa lakes. However, a mature population of older, larger bluegills has failed to develop. Mean size of the largest adult fish has remained between six and seven inches since shortly after the lake was impounded. Few fish are noted larger than seven inches. Overall, numbers remain adequate to support a fishery for the bluegill, but the quality of the individual fish is lacking.

Channel Catfish - The channel catfish population is providing the best fishing in the lake. The fish are stocked annually at about seven inches total length and grow very well with many nearly doubling in size the first year after their introduction. The catfish supports an important fishery at Volga Lake and many compliments are noted each year.

Summary

Although the data presented in the report are rather limited, it is possible to make several general statements.

> Since the lake was constructed in 1979, slight to moderate siltation appears to have occurred in the uppermost portions of both bays of Volga Lake. The best possible land use practice should be applied to the area in an effort to slow the rate of siltation. The temperature and DO profiles for Volga Lake were similar to those found in many "typical" shallow Iowa Lakes. The fishery in Volga Lake has been slow to develop and has not realized the potential normally attained in a lake of this type. Continued monitoring is necessary to determine long term trends in water quality.

LITERATURE CITED

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2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00640 993300101000
42 53 51.0 091 46 32.8 5
VOLGA LAKE, 4 MI SSE WEST UNION, DEEPEST PART
19065 IOWA FAYETTE
NORTHEAST IOWA RIVER BAS 070800
VOLGA RIVER SUBBASIN T093NR08WSC03
21IOWA 860628 07060004
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
86/06/12	0815	WATER	0	20.50			410	8.10	8.70	8.30	15	.150	4.10
86/06/12	0815	WATER	19	14.30			470	.20	8.00	8.20	26	1.500	1.20
86/07/29	1045	WATER	0	29.00	30.0		290	11.20	9.20	9.20	64	.110	.50
86/07/29	1045	WATER	19	20.00			480	.10	7.30	7.50	20	4.900	.10K
86/09/09	1100	WATER	0	18.90			320	7.40		8.50	20	.230	.10K
86/09/09	1100	WATER	19	17.50			390	.30		6.80	37	8.100	.10K

STORET RETRIEVAL DATE 87/07/08 PGM=RET

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00640 993300101000
42 53 51.0 091 46 32.8 5
VOLGA LAKE, 4 MI SSE WEST UNION, DEEPEST PART
19065 IOWA FAYETTE
NORTHEAST IOWA RIVER BAS 070800
VOLGA RIVER SUBBASIN T093NR08WSC03
21IOWA 860628 07060004
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
86/06/12	0815	WATER	0		.170	24.00	20.00						
86/06/12	0815	WATER	19		.220	7.00	1.00K						
86/07/29	1045	WATER	0		.330	70.00	65.00						
86/07/29	1045	WATER	19		.310	13.00	8.00						
86/09/09	1100	WATER	0		.100	68.00	56.00						
86/09/09	1100	WATER	19		.770	21.00	18.00						

APPENDIX

Development of Lake Topographic Maps

In conjunction with the water quality monitoring studies conducted on the 16 lakes, a new lake topographic map was developed for each lake by staff of the Fish and Wildlife Division of the DNR. The procedure followed in developing these maps were:

a. Prominent shoreline landmarks were selected for the purpose of running transects the width of each lake. A boat was motored at a constant speed along each transect as a graph recorder measured the water depth along the transect. This was done for the entire lake.

b. Existing lake topographic maps were compared to 1984 or 1985 aerial photos to determine whether the lake shoreline configuration had changed appreciably. If no significant change in shoreline configuration was found, the existing topographic map was used to delineate the lake's shoreline. However, if appreciable changes were evident, the aerial photo was drawn to scale and transferred to the topographic map. This new lake shoreline map was then used to develop the lake topographic map.

c. The length of each transect was measured on the graph paper and lake map, and a proportional ratio of their lengths was determined. This ratio was then used to transfer the depth measurements from the transect graphs to the topographic map. In transferring the depth information, measurements were corrected to lake spillway crest elevation (if needed) and the location of two foot depth intervals were noted on the maps. When all depths had been mapped, contour lines were drawn by connecting the corresponding transect depth points.

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However, comparison of the 1986 maps with maps developed under the 1979 Clean Lakes Classification Study indicates the maps are not highly accurate. The attached table lists the lake areas, depths, and volumes determined by both the 1979 and 1987 mapping efforts. Review of this table shows that, out of the 12 lakes listed, the surface area of 4 lakes and the water volume of 3 lakes was reported as being greater in 1986 than in 1979. Since none of these lakes was dredged or otherwise enlarged since 1979, the reported increases in surface area and water volume reflect a lack of accuracy in the 1979 and/or 1986 maps. A number of factors may influence the accuracy of a developed map, including the degree to which the boat taking depth readings deviates from the transect line or fails to maintain a constant speed, the level of precision of the depth recording equipment, and the accuracy achieved in developing the lake surface area map or transferring depth measurements to it.

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Comparison of 1979 and 1986 Lake Topographic Maps*

	1979 Mapping			1986 Mapping		
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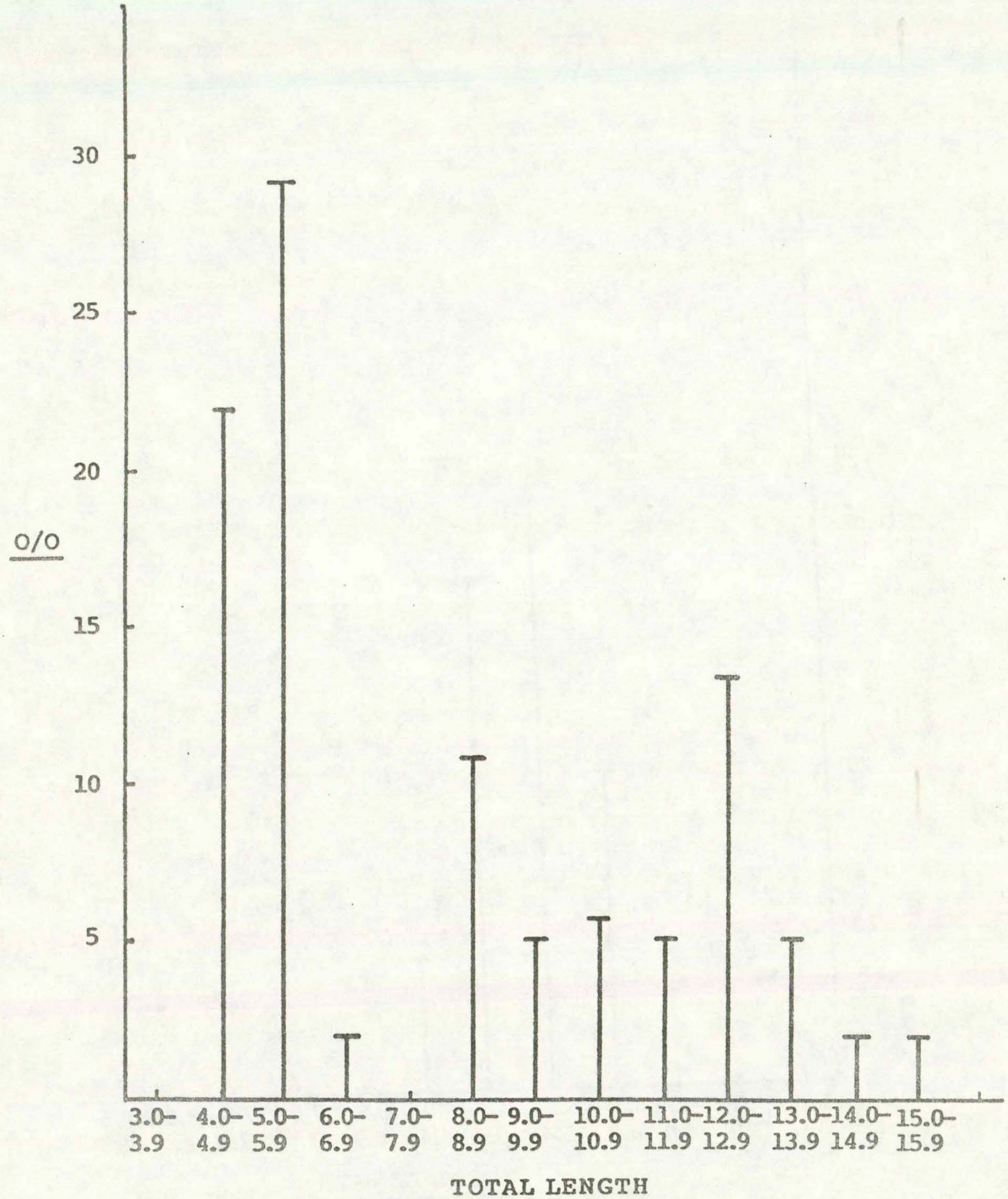
** - 1979 Clean Lakes report listed a depth of 34 feet.

*** - Depth of 28 feet listed in Clean Lakes report - map indicates that if this depth existed, it was only found in a very small area of the lake - last contour shown is at 20 feet.

VOLGA LAKE

LENGTH FREQUENCY

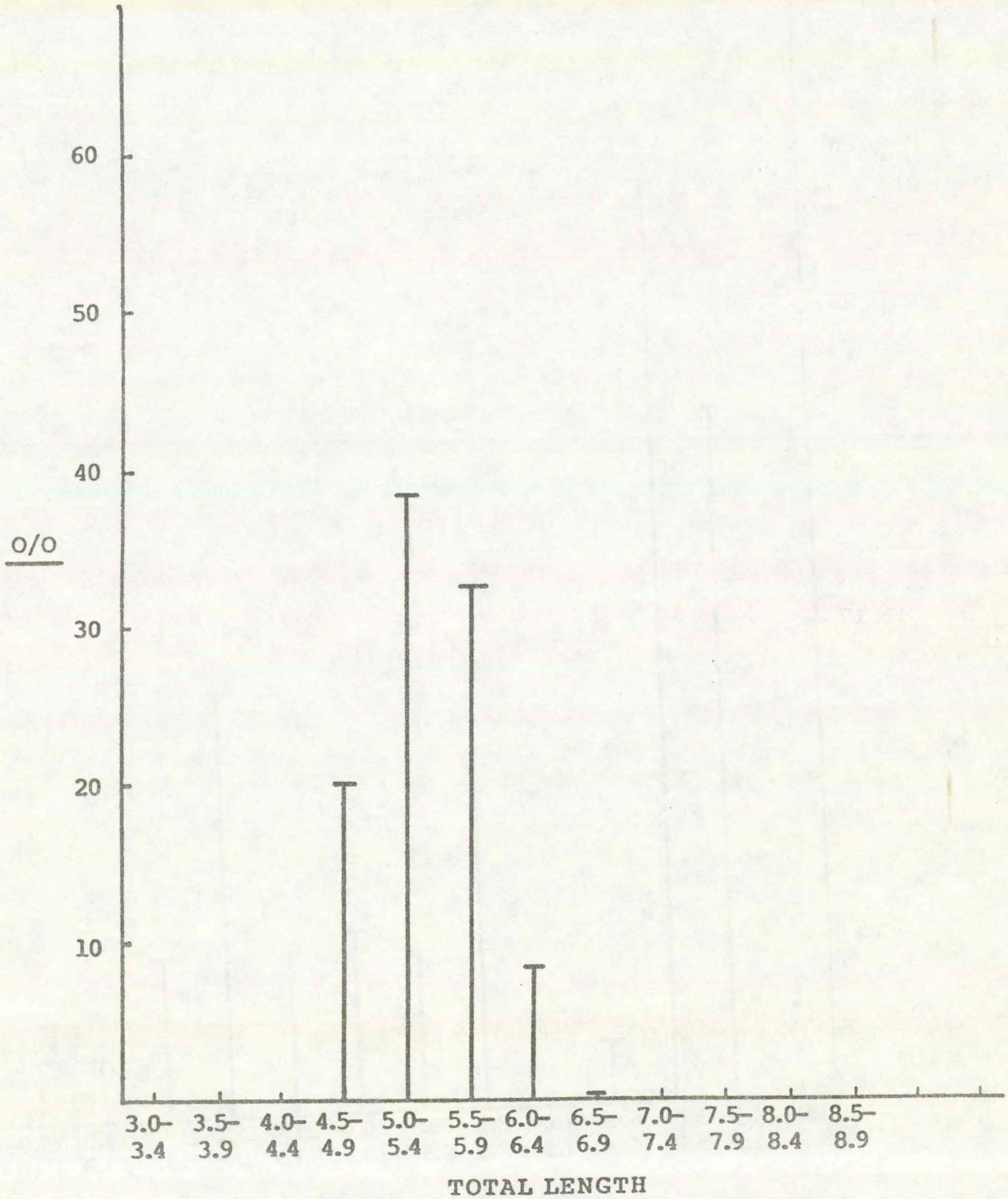
LARGEMOUTH BASS



VOLGA LAKE

LENGTH FREQUENCY

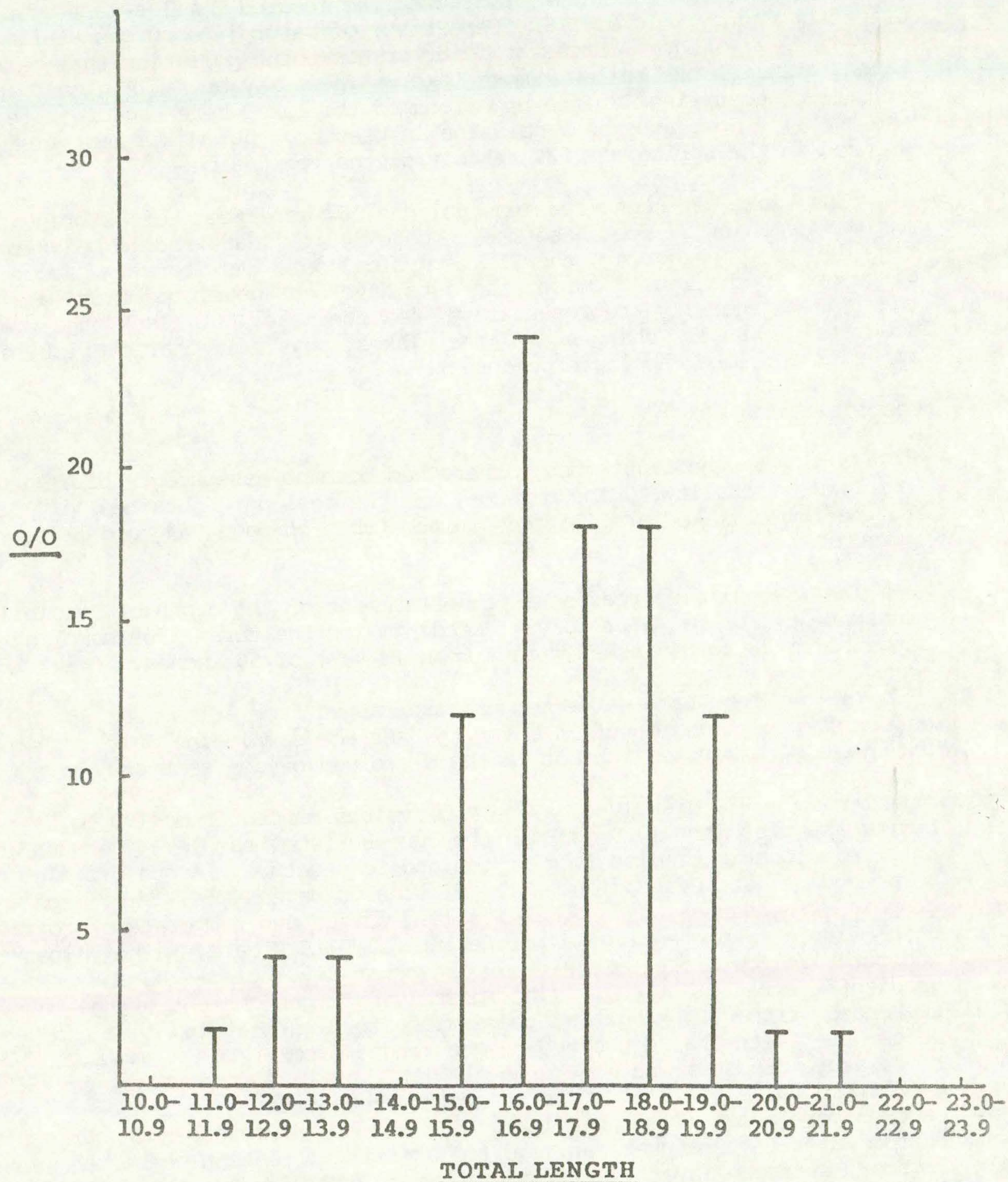
BLUEGILL



VOLGA LAKE

LENGTH FREQUENCY

CHANNEL CATFISH



YELLOW SMOKE LAKE

Physical and Lake Impact Data

Yellow Smoke Lake is a 38.5 acre lake located 2 miles east of Denison in Crawford County, Iowa. The Department of Natural Resources staff are not aware of any major sources of point or non-point pollution that affect the water quality of Yellow Smoke Lake. There may be a minimal amount of siltation occurring in the upper end of the lake where the creek feeds into the lake. Some aquatic vegatation is present, but white amur fish will be stocked in the spring of 1987 to control the vegetation.

The lake at conservation pool has 167 acre/feet of storage, with a maximum depth of 27 feet (see map on page 343). Care should be exercised in regards to considering the lake physical data as totally accurate. As discussed in the introduction, the data have been developed from lake mappings that are generally representative of the lake but lack the detail to accurately assess changes in the lakes physical characteristics. (See appendix for lake mapping procedures).

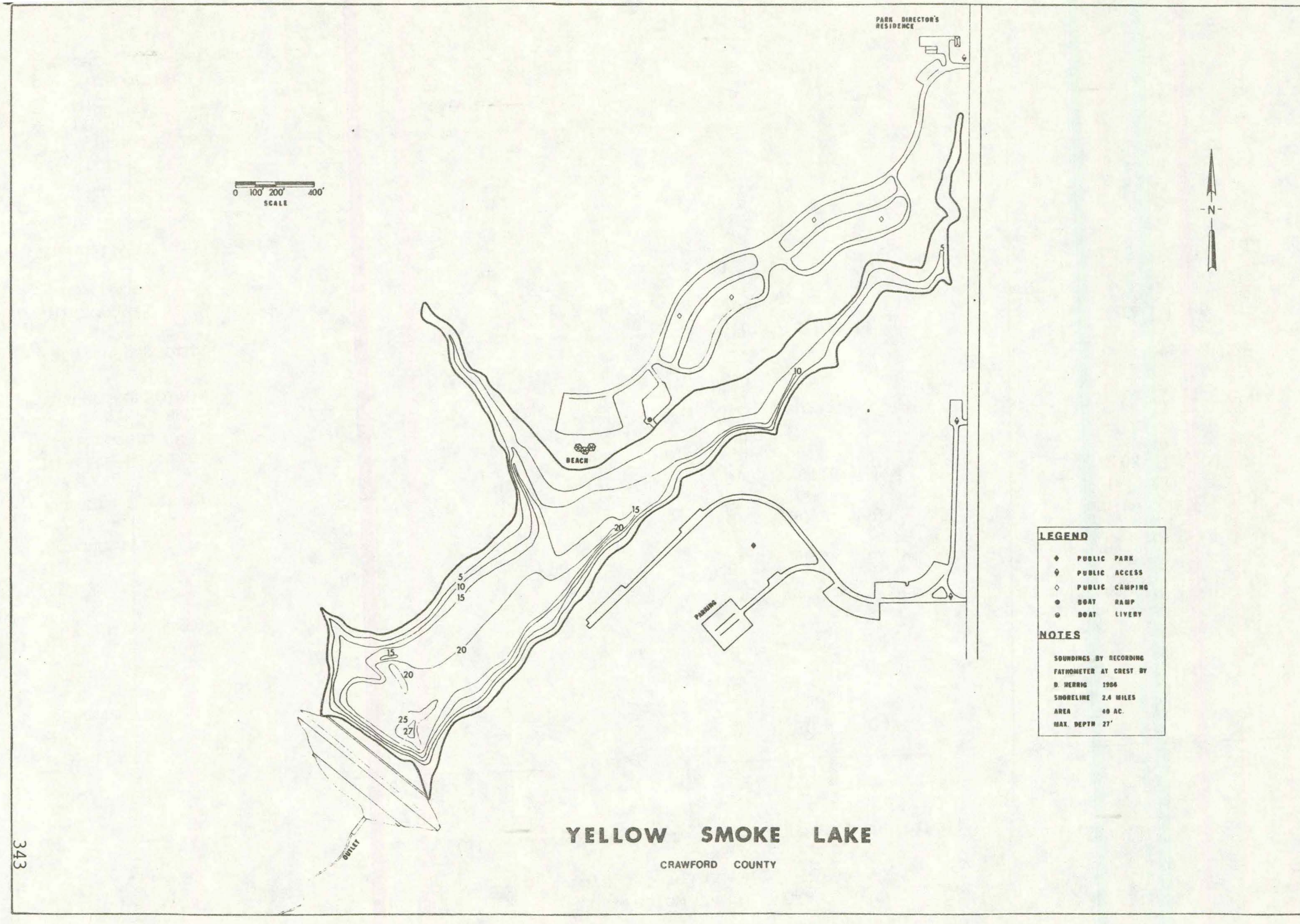
Chemical Data

Prior to the 1986 study, there had been no assessment of Yellow Smoke Lake water quality. The physical and chemical data obtained in 1986 for Yellow Smoke Lake are listed in the table on page 344 and also in the appendix.

The Secchi disc reading is a measurement of the depth of visibility or transparency of a water body. Readings for the three 1986 sampling events ranged from 38 to 84 inches with a mean (N = 3) of 56 inches.

Yellow Smoke Lake water temperature ranged from a low of 15.5 in the June bottom sample to a high of 28°C for the surface sample in July. Temperature data will be discussed further in the dissolved oxygen section.

During 1986 dissolved oxygen (DO) values ranged from <1.0 mg/L in several bottom samples to 10.0 mg/L in the June surface sample. Because of the interrelationship of dissolved oxygen and temperature, depth profiles provide a method of data evaluation. The figures on pages 345 , 346 , and 347 are graphic representations of the dissolved oxygen and temperature profiles with each figure representing a different sampling data. The June profile indicates Yellow Smoke Lake already had began developing a DO and temperature gradient (stratification). The dissolved oxygen content of the lake water decreased from 10.0 mg/L at the surface to 2 mg/L at 16 feet (5 meters). Below 16 feet the dissolved oxygen ranged from 1 to 2 mg/L. The June temperature gradient was more gradual with a surface temperature of 25.5°C and a bottom value of 15.5°C. As the water temperature decreases, the water becomes more dense (i.e. heavier). In summer, differences in surface versus bottom water temperatures can lead to lake stratification where the warmer and lighter surface layer (epilimnion) cannot mix with the colder and heavier bottom layer (hypolimnion). The profile for the July sampling period was very similar to the June profile except that the DO and temperature gradients were even sharper. Dissolved oxygen below 14 feet (4.3 meters) was <1 mg/L. The temperature and density differences experienced in June (25°C to 15.5°C) and July (28°C to 15.5°C) prevented the epilimnion from mixing with the

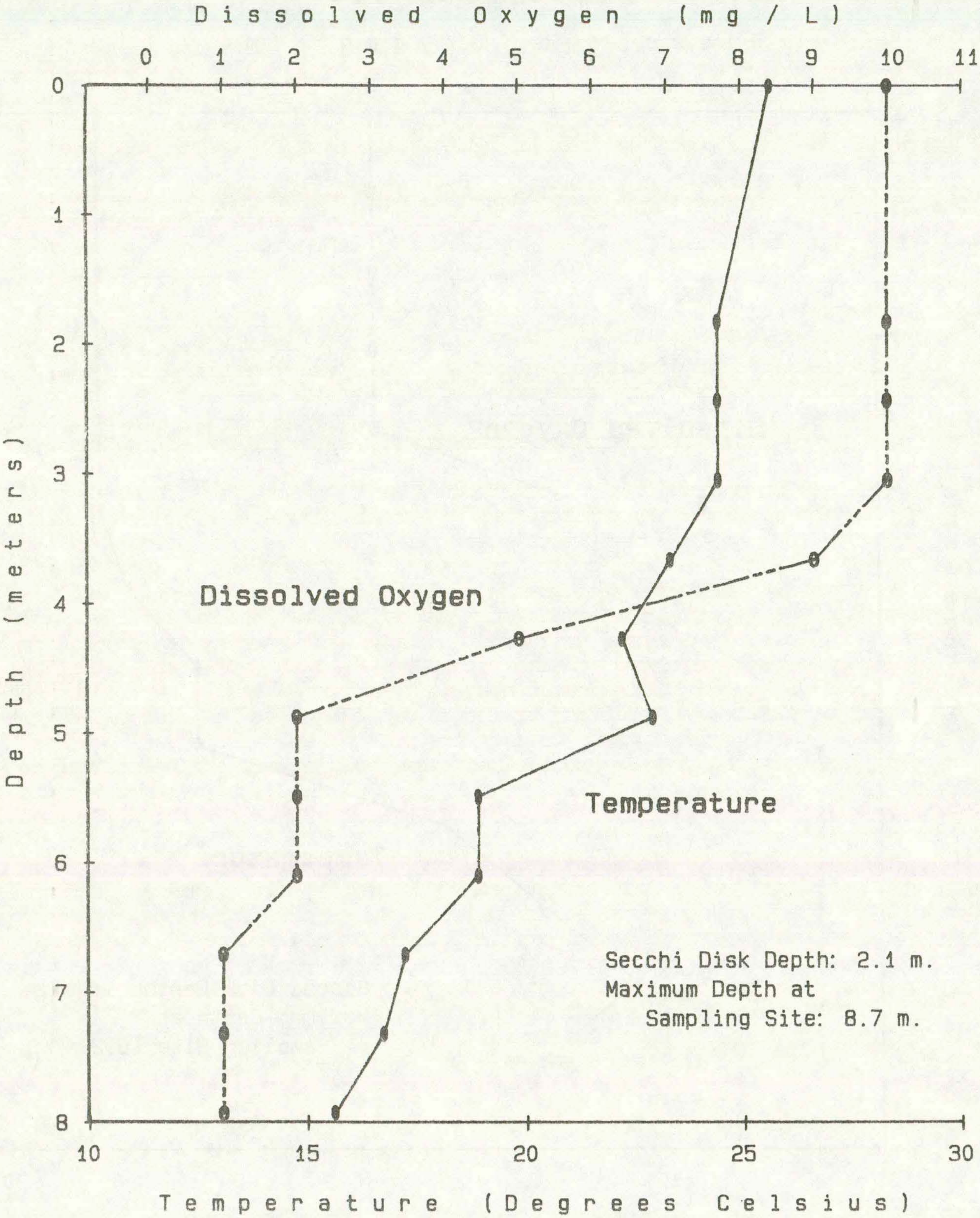

YELLOW SMOKE LAKE
CRAWFORD COUNTY
PARK DIRECTOR'S RESIDENCE
0 100' 200' 400'
SCALE
N
BEACH
PARKING
OUTLET
5
10
15
20
25
27
LEGEND
PUBLIC PARK
PUBLIC ACCESS
PUBLIC CAMPING
BOAT RAMP
BOAT LIVERY
NOTES
SOUNDINGS BY RECORDING
FATHOMETER AT CREST BY
D. HERRIG 1986
SHORELINE 2.4 MILES
AREA 40 AC.
MAX. DEPTH 27'

Yellow Smoke Lake
Physical and Chemical Data
1986
(All values in mg/L unless designated otherwise)

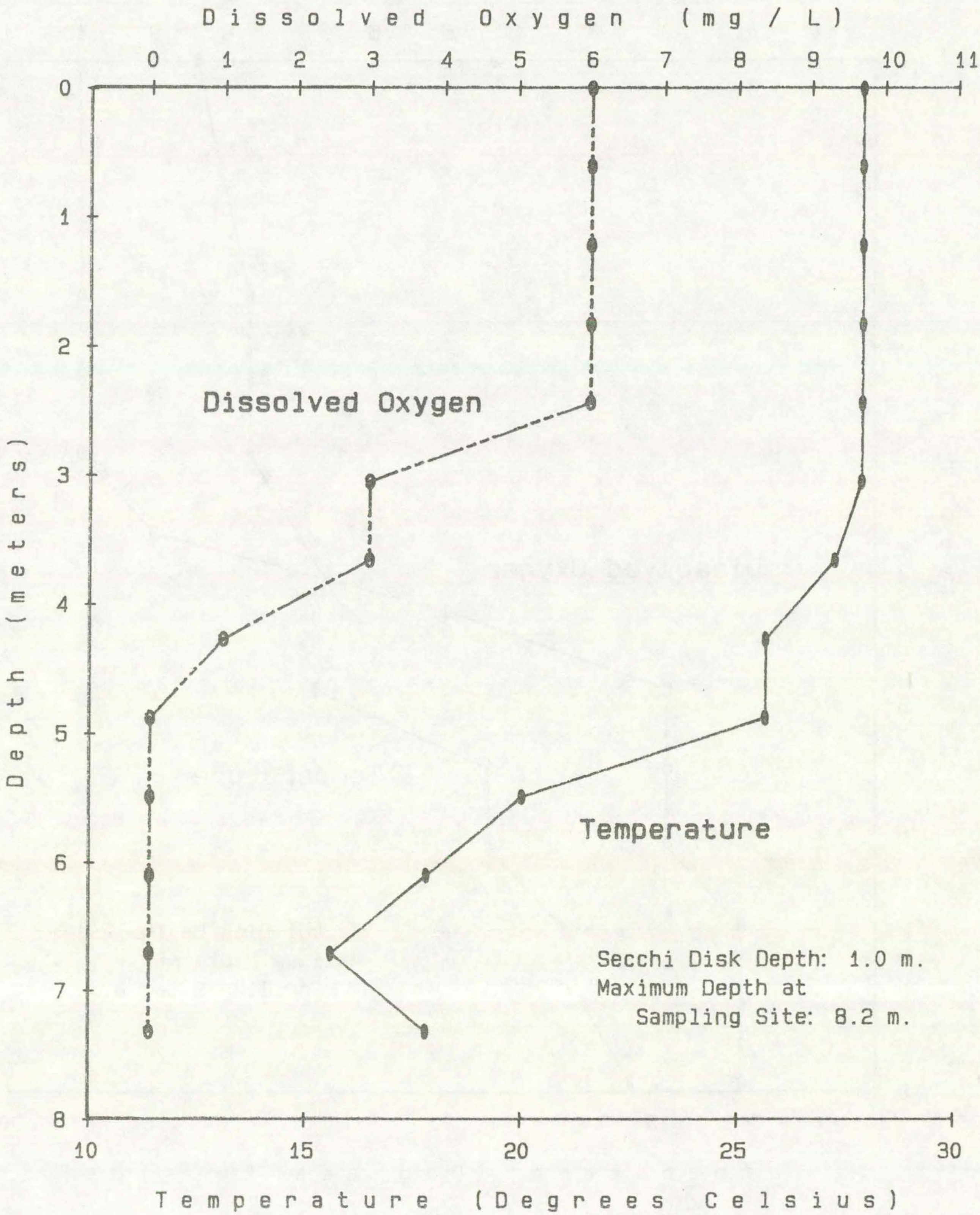
Date Collected	6/17/86		7/24/86			9/03/86		
*Depth[1]	0	12	0	10	24	0	14	24
*Secchi[2]	84		38			46		
*Temperature[3]	25.5	15.5	28	28	18	24	23	18
*Dissolved Oxygen	10.0	1.0	6.0	3.0	0.0	9.0	5.0	0.0
*pH[4]	8.4	7.2	7.9	7.7	7.2	8.1	7.7	6.8
Conductivity[4]	380	420	380	380	450	340	480	450
Ammonia Nitrogen	0.24	0.36	0.05	0.10	1.4	0.04	0.13	2.9
Nitrate-Nitrite Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.2
Suspended Solids	9	23	8	10	10	8	4	29
Total Phosphorus	0.02	0.23	0.01	0.01	0.06	0.07	0.05	0.21
Chlorophyll a (Corrected)[6]	4	44	23	24	42	33	9	10
Thermally Stratified	Yes		Yes			Yes		

1 Feet
2 Inches
3 Degrees Celsius
4 pH Units
5 Micromhos
6 Micrograms/liter
*Measurements determined on site

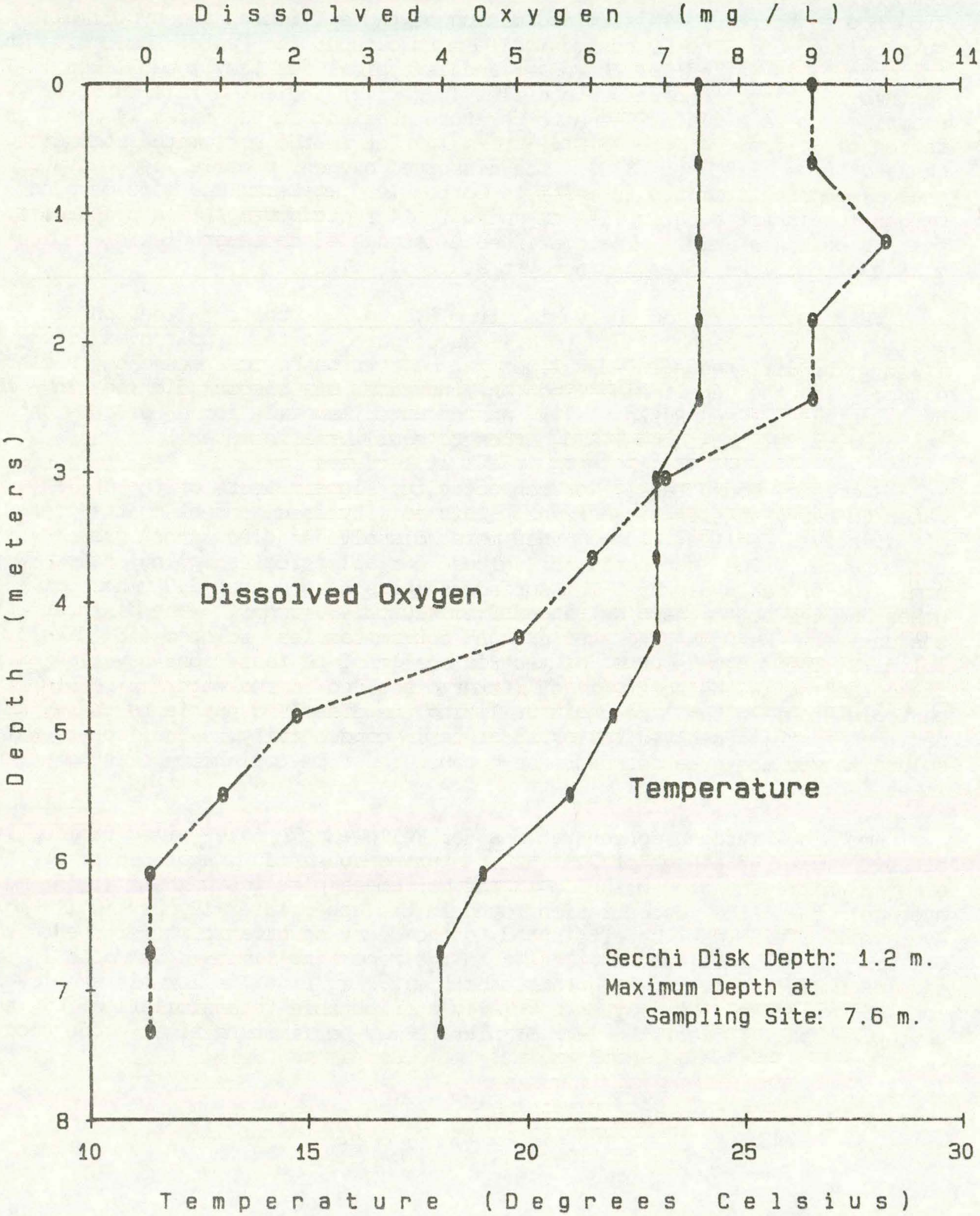
Yellow Smoke Lake
Dissolved Oxygen and Temperature Profile
June 17, 1986



Yellow Smoke Lake
Dissolved Oxygen and Temperature Profile
July 24, 1986



Yellow Smoke Lake
Dissolved Oxygen and Temperature Profile
September 3, 1986



hypolimnion. The lack of mixing combined with oxidation of organic materials in the hypolimnion resulted in dissolved oxygen values in the June and July bottom samples of < 1 mg/L. The amount of DO depletion in the hypolimnion is dependent on the amount of oxidizable matter present. Stratified lakes with high sediments and water of organic content frequently have no dissolved oxygen in the lower water layer. Typically in the fall, as the ambient temperature declines, the lake water temperature and density become the same from top to bottom. This allows mixing of the epilimnion and hypolimnion to take place and the DO becomes uniform throughout the water column. This phenomenon is called fall turnover and is typical for many Iowa lakes. The September DO and temperature profiles (page 347) indicated fall turnover was starting to take place. The temperature gradient in the first 14 feet only varied 1°C (from 24°C to 23°C). From 16 feet to the bottom the temperature changed from 22°C to 18°C. The dissolved oxygen profile demonstrated a gradual decline from top (9 mg/L) to bottom (0.0 mg/L). The zone of adequate oxygen levels for aquatic life extended to 14 feet (5.0 mg/L) as compared to 8 feet (6 mg/L) in July. The continued existence of these gradients indicated mixing of the lake water had not yet started.

Values for field pH varied from 6.8 to 8.4 units. The pH in the epilimnion was higher (7.9 to 8.4) as compared to the hypolimnion (6.8 to 7.2). The difference in pH vallues can be attributed to a decrease in carbon dioxide in the epilimnion and an increase of carbon dioxide in the hypolimnion. (See Ruttner (2) and/or Hutchinson (3) for a discussion of carbon dioxide, bicarbonate and carbonate equilibria in water.)

Specific conductance, or conductivity, is a measure of the ability of water to carry an electric current. This ability is dependent on the presence of dissolved solids; i.e., the more dissolved solids the greater the conductance. The conductivity values for all three sampling dates were similar for each depth. The surface samples ranged from 340 umhos to 380 umhos and the bottom samples ranged from 420 to 450 umhos. The difference in conductivity between the surface and bottom samples related to dissolved solids. The only source of nutritionally important ions available to phytoplankton is the reservoir of matter dissolved in the water (2). As the phytoplankton in the lake began utilizing the dissolved nutrients there was a decline in the dissolved solids and thus in conductivity. The upper water column showed the greatest decrease because fewer phytoplankton existed at the lower depths.

Ammonia nitrogen concentrations for Yellow Smoke Lake varied from a low of 0.4 mg/L to a high of 2.9 mg/L. During June, July and September the ammonia nitrogen concentration in the bottom samples was higher (1.55 mg/L average) than the concentration found in the upper water layers (0.11 mg/L average). This can be attributed to the decay of organic matter near the bottom. Nitrate values were less than the reporting limit (<0.1 mg/L) in all samples collected but one (September bottom 2.2 mg/L). The low nitrate levels in Yellow Smoke Lake may be partially attributable to assimilation by the phytoplankton. In fact the lack of nitrate may be limiting algal production.

Suspended solids ranged from 4 mg/L to 29 mg/L with the bottom sample values higher than the surface samples for all three sampling dates. The higher solids values in the bottom samples generally may be attributed to the settling of material from the upper water layers and include turbidity from tributaries, soil bank erosion, dead plankton and other allochthonous and autochthonous matter.

During 1986, total phosphorus concentrations in surface samples ranged from 0.01 to 0.07 mg/L as compared to 0.06 to 0.23 mg/L in the bottom samples. Because phosphorus is an essential nutrient for phytoplankton, any available phosphorus is rapidly assimilated. The lower value of total phosphorus in the epilimnion may be attributed to phosphorus uptake by phytoplankton. In the oxygen deficient part of the hypolimnion, phosphorus levels were highest in June (0.23 mg/L), declined to 0.06 mg/L in July and then increased to 0.21 mg/L in September. It is not unusual for phosphorus to be higher in the bottom waters from decomposition of sinking phytoplankton and liberation of phosphorus from the sediment by reduction (3).

Chlorophyll values are an indirect measurement of the phytoplankton populations. In 1986, the corrected chlorophyll a values in the epilimnion ranged from 4 ug/L to 33 ug/L. The June epilimnion corrected chlorophyll a value was lowest (4 ug/L) while July and September average values were 24 ug/L and 21 ug/L respectively. Hypolimnetic values for corrected chlorophyll a ranged from 10 ug/L to 44 ug/L with the highest values occurring in June and July.

Biological Data

Yellow Smoke Lake fisheries population was sampled on September 15-17, 1986. Five fyke nets were used for a total of 240 net hours and a 220V A.C. boat-mounted electrofishing unit was utilized for 30 minutes.

Species composition, relative abundance, and average lengths and weights are shown in Table 1. Thousands of young of the year (YOY) bluegill, less than one inch long, were observed but were not counted. No channel catfish were sampled, but anglers report catching catfish up to 15 inches in length.

Table 1. Species composition, relative abundance, average lengths and weights in Yellow Smoke Lake (1986).

Species	Number Sampled	Average Length (in.)	Average Weight (lb.)	Percent of Catch
Bullhead	108	10.2"	.63	27
W. Crappie	37	8.2"	.27	9
B. Crappie	35	8.0"	.27	9
Largemouth Bass	81	7.4" Range (4.0-13.6)	.43	20
Bluegill	*Thousands (sample measured 140)	5.0" Range (.6-7.2	.16	35
Total	401			

Length-frequency graphs of the four major species (black and white crappie were combined) are included in the appendix.

Yellow Smoke Lake was impounded in 1980. Prior to hatchery fish being stocked in the new lake, crappie were introduced by the public. This unauthorized stocking resulted in a slow growing fish population consisting primarily of stunted crappie and bullheads and slow growing bass. The lake was drawn down and chemically renovated in 1984. Catfish and bluegill were restocked in the fall of 1984 and bass were added in 1985 and 1986. Crappie appeared again in 1985.

All of the fish in Yellow Smoke Lake are in excellent condition and the lake appears to be well balanced. Natural reproduction of bluegill, crappie and bass was noted. No young-of-the-year bullheads were sampled. Angler harvest and predation by the bass will probably result in the ultimate elimination of the bullheads. Channel catfish will be stocked annually. The current fourteen inch length limit on largemouth bass will be raised to 15 inches in January of 1987.

Summary

Although the data presented in the report are rather limited, it is possible to make several general statements.

Even though Yellow Smoke Lake is a relatively new lake and does not appear to have a siltation problem, the best possible land use practices should be applied to the watershed. The 1986 dissolved oxygen and temperature profiles were typical of Iowa shallow lakes. Water clarity and overall water quality of Yellow Smoke Lake was good. Continued monitoring is necessary to determine long term trends in water quality. The fishery of Yellow Smoke Lake was well balanced and is excellent condition.

LITERATURE CITED

1. Bachmann, R.W., M.R. Johnson, M.V. Moore and T.A. Noonan. 1980. Clean Lakes Classification Study of Iowa's Lakes for Restoration - Final Report. Department of Animal Ecology. Iowa State University, Ames, Iowa.

2. Ruttner, F. 1953. Fundamentals of Limnology. University of Toronto Press, Canada.

3. Hutchinson, G.E. 1957. A Treatise on Limnology, Vol. 1. John Wiley and Sons, Inc. New York, New York.

APPENDIX

L00635 992400301000
WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:
42 01 43.4 095 18 56.9 5
YELLOW SMOKE LAKE, 1 MI E DENISON, DEEPEST PART
19047 IOWA CRAWFORD
WESTERN IOWA RIVER BASIN 091200
/TYPA/AMBNT/LAKE
BOYER RIVER SUBBASIN T083NR38WSC06
21IOWA 860628 10230007010 0003.180 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00010 WATER TEMP CENT	00077 TRANSP SECCHI INCHES	00078 TRANSP SECCHI METERS	00095 CNDUCTVY AT 25C MICROMHO	00300 DO MG/L	00400 PH SU	00403 LAB PH SU	00530 RESIDUE TOT NFLT MG/L	00610 NH3+NH4- N TOTAL MG/L	00630 NO2&NO3 N-TOTAL MG/L
86/06/17	1535	WATER	26	15.50			420	1.00	7.20	7.70	23	.360	.10K
86/06/17	1700	WATER	0	25.50	84.0		380	10.00	8.40	8.60	9	.240	.10K
86/07/24	1040	WATER	24	18.00			450	.00	7.20	7.40	10	1.400	.10K
86/07/24	1235	WATER	0	28.00	38.0		380	6.00	7.90	8.20	8	.050	.10K
86/07/24	1250	WATER	10	28.00			380	3.00	7.70	8.00	10	.100	.10K
86/09/03	1230	WATER	24	18.00			450	.00	6.80	7.50	29	2.900	2.20
86/09/03	1300	WATER	14	23.00			380	5.00	7.70	7.70	4	.130	.10K
86/09/03	1400	WATER	0	24.00			340	9.00	8.10	8.00	8	.040	.10K

WATER QUALITY DATA AT THE FOLLOWING STATION
OF THE 1986 IOWA LAKES SURVEY:

/TYPA/AMBNT/LAKE

L00635 992400301000
42 01 43.4 095 18 56.9 5
YELLOW SMOKE LAKE, 1 MI E DENISON, DEEPEST PART
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WESTERN IOWA RIVER BASIN 091200
BOYER RIVER SUBBASIN T083NR38WSC06
21IOWA 860628 10230007010 0003.180 OFF
0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	MEDIUM	SMK OR DEPTH (FT)	00650 T PO4 PO4 MG/L	00665 PHOS-TOT MG/L P	32210 CHLRPHYL A UG/L	32211 CHLRPHYL A UG/L CORRECTD	38444 DICAMBA (BANVEL) SEDUG/KG	38923 METOCLR (DUAL) SEDUG/KG	39033 ATRZ WHL SMPL UG/L	39350 CHLRDANE TECH&MET TOT UG/L	39351 CDANEDRY TECH&MET MUDUG/KG	39356 METOCLR (DUAL) UG/L
86/06/17	1535	WATER	26		.230	67.00	44.00						
86/06/17	1700	WATER	0		.020	6.00	4.00						
86/07/24	1040	WATER	24		.060	73.00	42.00						
86/07/24	1235	WATER	0		.010	27.00	23.00						
86/07/24	1250	WATER	10		.010	33.00	24.00						
86/09/03	1230	WATER	24		.210	21.00	10.00						
86/09/03	1300	WATER	14		.050	15.00	9.00						
86/09/03	1400	WATER	0		.070	39.00	33.00						

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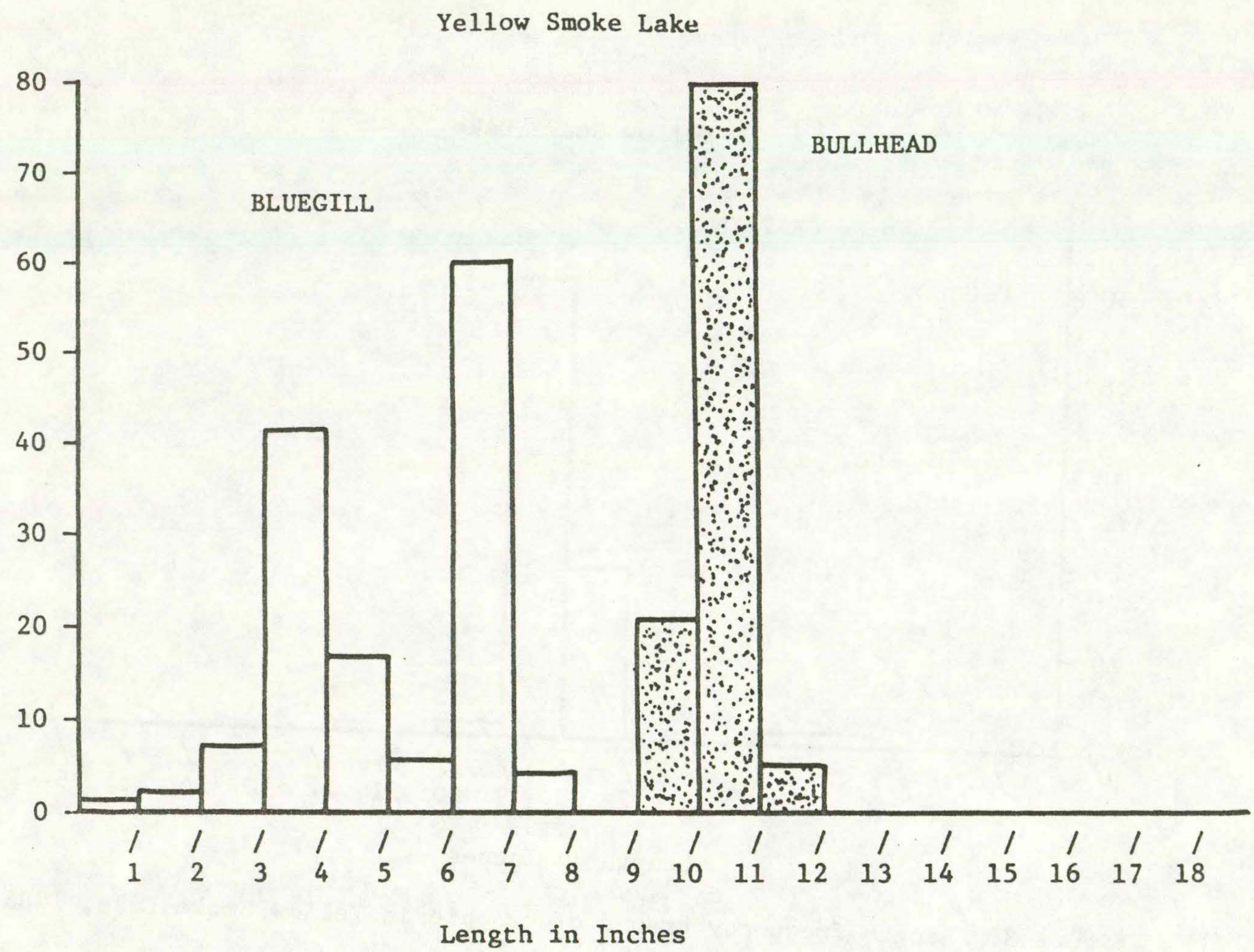

Figure 1. Length frequency graphs of bluegill and bullhead in Yellow Smoke Lake, 1986.

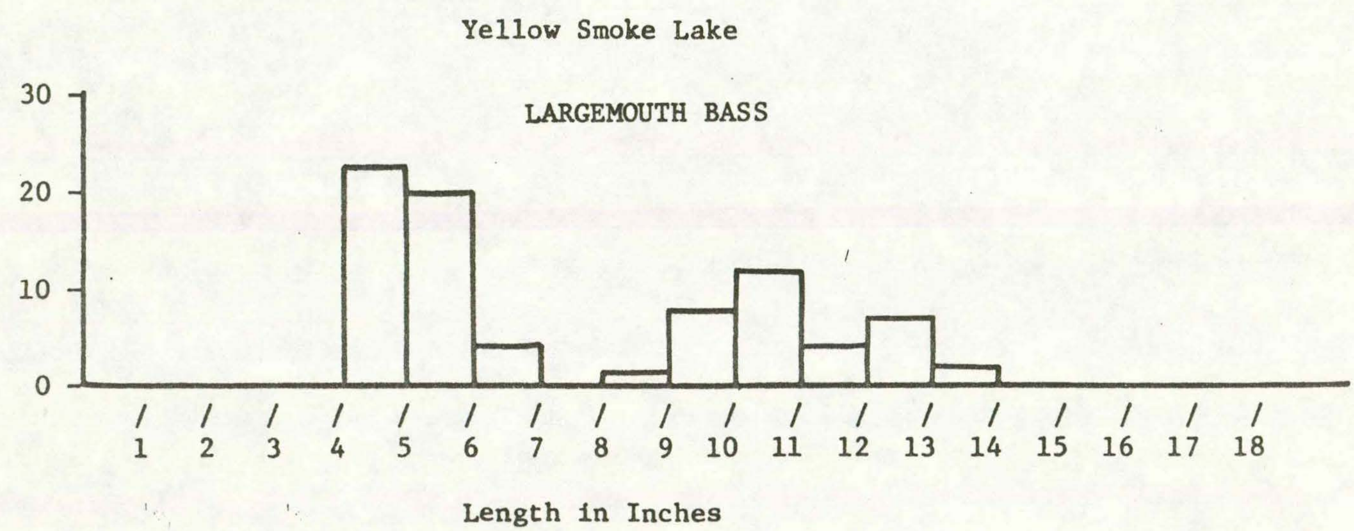

Figure 2. Length frequency graphs of largemouth bass in Yellow Smoke Lake, 1986.

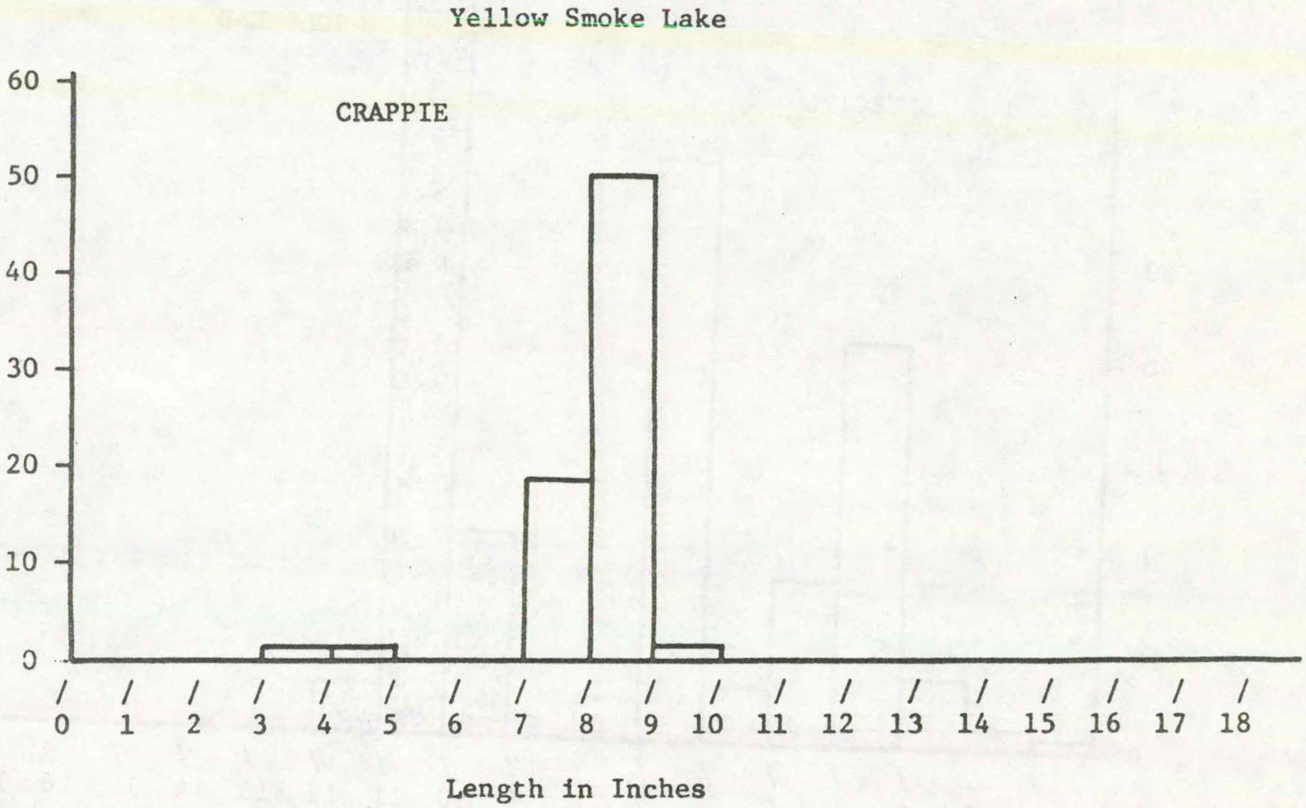

Figure 3. Length frequency graphs of crappie in Yellow Smoke Lake, 1986.

DISCUSSION AND RECOMMENDATIONS

The initial intent of the 1986 Iowa Lakes Study (ILS) was to collect data in a similar fashion as was done in the 1979 study. The comparative studies would have then provided for data comparison and trend development. For a variety of reasons; i.e., limited resources, study design and analytical methodology, it was determined the 1979 study could not and would not be duplicated. Therefore a study plan was developed to provide as much information as possible with the available resources. In reality, three sampling dates throughout a 4 month period provides only limited water quality information. If a good understanding of lake function and trend development is desired, more sampling is required. While the 1986 monitoring efforts provided useful information, additional refinements should be make in the monitoring program (such as including an analysis of lake watershed conditions in the program and utilizing a mapping procedure which results in greater mapping accuracy). A standardized documented procedure should be developed for future lake water quality assessments that provides for adequate sampling and trend development.

In general, the lakes studies in 1986 were shallow (less than 40 feet in depth), eutrophic (nutrient rich) and exhibited varying degrees of oxygen depletion during the sampling period. Because each lake is unique and because of data inconsistencies there was never any intent to make comparison between the different lakes in this report.

No apparent relationships were observed between the fish populations found in these lakes and monitored lake water quality. This finding does not mean that no relationship exists, but instead may simply indicate that fishing pressure and fish management activities are having a greater impact on Iowa's lake fisheries.

Comparison of the 1986 and 1979 lake topographic maps indicates the mapping procedures are not adequate to ensure that the resulting maps will be highly accurate. While the level of accuracy achieved in the maps is sufficient to generally describe the major physical features of the lake, it is not adequate to enable relatively small changes in lake features to be accurately determined (for example, short term changes in lake area or volume due to sediment deposition cannot be accurately determined).

Although some information on the soils, land use, and erosion potential of each lake watershed was obtained during the 1979 Clean Lakes study, no similar data was collected as part of this study. However, it is recommended that such data collection be conducted as part of any future lake monitoring studies, since information on a lake's watershed can help in understanding the water quality conditions found within a lake.

Water and sediment samples for pesticide analysis were collected from five of the 16 lakes. At least one pesticide (Atrazine) was reported in every water sample (15) collected throughout the summer. Values for the four most common pesticides found ranged from 15 to 0.22 ppb for Atrazine, 5.7 to <0.1 ppb for Cyanazine, 5.6 to <0.1 for Methlochlor and 1.5 to <0.1 for Alachlor. Multiple pesticides were found in the water samples from three lakes (Lake Geode, Lake Hendricks and Pierce Creek Lake). Although water in the five lakes contains pesticides, analysis of the lake sediments yielded no pesticide levels aabove the analytical reporting limit.

GLOSSARY

Acre Feet - The amount of water that covers one acre to a depth of one foot; equal to 43,560 cubic feet, 325,850 gallons.

Allochthonous - Substances such as various grades of humus, silt, organic detritus, collodial matter, plants and animals all being produced outside the lake and brought into the lake.

Annulus - A series of closely-spaced ridges on a fish scale that indicates a period of slow growth in the life of a fish. The number of annuli on a fish scale indicates the age of the fish.

Autochthonous - Similar substances as in allochthonous but being "produced within the lake".

Backcalculated Length - The use of annuli (i.e., year marks) on hard parts of fish (for example, scales) to estimate the size of the individual fish at earlier ages. This process assumes a proportional relationship between how much the fish increases in length and how much the hard structure increases in size.

Balanced Populations - A fish population that can sustain a harvest of good-sized fish in proportion to the productivity of the water.

Composite Sample - A sample made up of samples taken from a distinctly different location, time, amount, etc., and combined to form 1 sample.

Creel Census - The collection of information (for example, fishing effort or fish harvest) on a recreational fishery using direct, on-site interviews with fishermen.

Electroshocking (Electrofishing) - Applying alternating or direct electrical current to water that has a resistance different than the fish to demobilize them temporarily.

Epilimnion - In a lake, the warm circulating water overlying the thermocline.

Eutrophic - Rich in nutrients.

Fyke Net - (As used in this report) Consists of netting stretched over approximately five hoops to form a cylinder, with a leader of webbing attached to the mouth to guide fish into the enclosure. Fish are captured when they attempt to get around the leader of the net and they swim into the hoop net.

Gill Net - A vertical wall of netting normally set out in a straight line. Capture of fish occurs when fish attempt to swim through the net and they become entangled in the netting.

Hypolimnion - Water in a lake below the thermocline usually colder and non-circulating as compared to the epilimnion.

Phytoplankton - Minute aquatic plants, usually algae.

Pound Net - Same as fyke net.

Primary Productivity - The rate at which radient energy is stored by phytosynthetic and chemosynthetic activity of producer organisms (green plants) in the form of organic substances which can be used as food.

Proportional Stock Density (PSD) - The proportion of a fish of a quality size (i.e., a size generally preferred by fishermen) in a stock (population) of fish. This index is calculated by the following equation:

$$PSD = \frac{\text{number} \geq \text{minimum quality length}}{\text{number} \geq \text{minimum stock length}} \times 100$$

Quality lengths and stock lengths have been defined for most game fish species. For example, the quality length for largemough bass is 12 inches; the stock length is 8 inches. If 100 largemough bass greater than 8 inches in length were sampled, and 50 of these fish were greater than 12 inches in length, the PSD for that population would be 50.

Relative Weight (Wr) - An index of well-being that compares the observed weight of a fish (W) to a standard weight (Ws) of a fish of the same species of the same length. The standard weight estimates the weight of a fish species of a given length that has been reared under optimal conditions. Relative weight is calculated by the equation:

$$Wr = \frac{W}{Ws} \times 100$$

Low Wr values indicate problems in food and feeding relationships. A Wr value of 100 may indicate ecological and physiological optimality for a fish population.

Shore Development - Refers to ratio of the actual length of the shoreline of a lake to the length of the circumference of a circle the area of which is equal to that of the lake.

Thermal Stratification - Significant water temperature and density differences that frequently occurs in lakes during summer.

Thermocline in Lakes - The zone of rapid drop in temperature - it separates the upper, warmer less dense water (epilimnion) from lower, colder, more dense water (hypolimnion).

Volume Development - The ratio of the total volume of a lake to the volume of a cone whose area of base equals the surface area of the lake with highest = maximum depth of lake.

Weight/Length Relationship - This relationship is described by the following equation:

$$W = a L^b$$

where "W" is weight, "L" is length, and "a" and "b" are parameters. These parameters are estimated by taking the logarithms (base 10) of both sides of the above equation:

$$\log W = \log a + b \ (\log L)$$

Parameter "a" is the intercept, and parameter "b" is the slope of the line described by this equation. The weight/length relationship is the basis for calculating indices of fish well-being (for example, relative weight (Wr)).