IOWA
WATER QUALITY REPORT

IOWA DEPARTMENT OF ENVIRONMENTAL QUALITY
1975

WATER QUALITY REPORT

prepared by the
IOWA DEPARTMENT OF ENVIRONMENTAL QUALITY
Water Quality Management Division
Planning and Analysis Section

April, 1975

as required by
Section 305(b) of FWPCA Amendment of 1972

FOREWARD

The purpose of this report is to identify, by basin, the status of Iowa's water quality, based upon available data. The water quality data has been reviewed for its historical significance, but the main emphasis has been placed upon data since 1970. Not all river basins are discussed, however, those basins with sufficient data have been addressed.

It is planned that this report shall be updated during April, 1976 and every two years thereafter.

iowa department of environmental quality

ERRATA

The following are corrections and additions to the 1975 Iowa Water Quality Report as required by Section 305(b) of FWPCA Amendment of 1972. Further information or clarification can be obtained by contacting this Department.

WATER QUALITY MANAGEMENT DIVISION

Joseph E. Obr, P.E.
Director

PAGE		CORRECTION
xiii	Line 1	Pursuant
I-5	2nd paragraph line 1	approximately
II-3	2nd paragraph line 4	DEQ are
II-14	Suspended Sediment Load column	Reference (USGS, 1969)
II-34	General Physical Description, line 1	northerly
II-36	Line 5	data have
II-41	Table II-41	Reference (McMullen, 1972)
II-65	Line 9	Wapsipinicon
II-65	Line 11	Massillon
II-69	Line 6	load are
II-75	Eutrophication Potential, line 4	runoff are
II-77	Health Hazards and Aesthetic Degradation	no comma after Health
II-78	Line 3	Iowa Counties
II-83	Table II-17, Parameter column 3rd entry	Cd

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PAGE		CORRECTION
II-231	Figure II-107	Station III - Brown's Slough
II-232	Figure II-108	Station III - Brown's Slough
II-233	Figure II-109	Station III - Brown's Slough
II-235	Figure II-111	Station III - Brown's Slough
II-236	Figure II-112	Station III - Brown's Slough
II-237	Figure II-113	Station III - Brown's Slough
II-252	Figure II-118	September
II-256	Line 7	basin have been
II-261	Table II-46, parameter, 15th entry	Methyl Parathion
II-302	Paragraph 3, line 1	affected
II-304	Line 16	creates
II-309	Table II-53, Lake, 8th entry	Mt. Ayr Res.
II-316	Table II-58, line 2	nitrate nitrogen
II-317	Table II-60, line 2	nitrate nitrogen
II-322	Footnote, line 2	Water Resources";
II-323	Last paragraph, line 1	Age
II-326	Last paragraph, line 11	evaporite
VI-2		Change page VI-2 to page VI-3
VI-2	Line 1	or disinfection
VI-3		Change page VI-3 to page VI-2
VII-24	Line 1	areas is
VIII-2	2nd entry	Iowa Conservation

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70-5	Mississippi River Water Quality, Muscatine, Iowa
70-6	Mississippi River Water Quality, Ft. Madison, Iowa
70-7	Mississippi River Water Quality, Davenport, Iowa
70-8	Mississippi River Water Quality, Keokuk, Iowa
70-10	Pesticides in the Environment
70-12	Pesticide Levels in Iowa Birds & Fish Eggs
70-13	Environmental Pollution in Iowa
70-16	Radiation Monitoring of Iowa Surface Waters
70-17	Mississippi River Water Quality, Burlington, Iowa
70-27	Chemical & Bacteriological Survey of Water Quality in the Iowa River
70-29	Water Quality Survey of Winnebago River
70-30	Shricker Slough Fish Taint Incident, Clinton, Iowa
70-33	Pesticide Content of Edible Portion of Iowa Fish
70-34	Mississippi River Water Quality Survey (362-582)
70-35	Water Quality Survey of Shell Rock River
70-41	Mississippi River Water Quality, Burlington, Iowa
71-4	Pesticides in Iowa Fish
71-7	Water Quality of the Cedar River, Cedar Rapids, Iowa
71-10	Pesticide Levels in Fish and Silt in Iowa Streams
71-13	Water Quality Survey Des Moines River, Des Moines, Iowa
71-16	Water Pollution Problems in Central Iowa Streams, R L Morris
71-21	Limnology of Iowa Reach of the Mississippi River, J Gakstatter and R L Morris
71-22	Cedar River Water Quality Survey Cedar Falls - Waterloo
71-27	Mercury Concentration in Surface Waters and Fish in Iowa
71-41	North Raccoon River (Winter Quality) Storm Lake-Van Meter
71-53	Pesticides and Mercury in Migratory Ducks
72-6	Pesticide Residues in Iowa Fish Eggs
72-9	Iowa River Water Quality Survey
72-16	Mercury Concentration in Fish from Iowa River
72-26	Effect of Elkader Waste Discharges on the Turkey River
72-38	West Fork Des Moines River Survey (Estherville)
72-39	West Nishnabotna River Survey
72-40	Big Sioux River Survey
72-49	Winter Water Quality North Raccoon (Storm Lake-Van Meter)
72-53	Fish Kill on North Raccoon (Storm Lake)

Year - Report #	
73-19	Shell Rock River Water Quality
73-25	Limnology Status Report
73-28	Pesticides and Polychlorinated Biphenyls in Fish
73-35	Big Sioux River Quality (Iowa Reach)
74-4	Maquoketa River Survey
74-11	Upper Cedar River Water Quality
74-19	Des Moines River (Ft. Dodge-Des Moines)
74-21	Iowa Internal Stream Quality Survey
74-30	Buffalo Bill Watershed Project (Preliminary)
74-31	Maquoketa River Survey
74-32	Impact of Lead Discharge on the Maquoketa River
74-35	Des Moines River Limnology
75-1	Des Moines River Survey (Winter Quality)
75-6	Mississippi River Water Quality (Dubuque)
75-10	Buffalo Bill Agricultural Runoff Study (Final Report)
75-20	Maple River Water Quality
75-21	North Raccoon River Water Quality
75-23	Wapsipinicon River Water Quality
75-24	Maquoketa River Water Quality
75-25	Nodaway River Water Quality
75-26	Nishnabotna River Water Quality
75-30	Boyer River (Winter Water Quality)
75-31	Upper Iowa River Survey

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SECTION I

INTRODUCTION

Pursant to Section 305 (b) of the 1972 Federal Water Pollution Control Act Amendments (Public Law 92-500) this report addresses the present quality of the waters of the State of Iowa. The primary objective of the report is to establish a base line water quality or frame of reference, and compare that with projected improvements in quality that are anticipated by the implementation of the National Pollutant Discharge Elimination System (NPDES) program. The real objective, simply, is to determine what our dollars are buying. If, in fact, it is improved quality, we should be able to measure that improvement and gain satisfaction that continued degradation had been curbed, and noteworthy improvements have been achieved. Increased beneficial uses, in addition, ought to be realized.

While the major emphasis of PL 92-500 is directed towards surface water improvement via control of point source discharges this report also considers the impact of nonpoint sources, which for an agricultural state like Iowa, is significant. Our historical data for nonpoint pollution is limited and cannot be supported to the extent of our point source studies. A concerted effort has been made in the presentation of this report to make the reader aware that nonpoint pollution is a significant problem to this State, although principal control efforts have been aimed at point sources.

The majority of the point source data used within this report represents the time frame from 1968 through 1974; approximately 100,000 pieces of data taken from 1,500 sampling stations between 1938 and 1974 have been used.

This report was prepared by staff of the Water Quality Management Division of the Iowa Department of Environmental Quality, with the exception of Section III which was prepared by the Iowa Conservation Commission.

SECTION I

SUMMARY

WATER QUALITY

The major organizational breakdown used in this report -- harmful substances, physical modification, eutrophication potential, salinity/acidity/alkalinity, oxygen depletion, health hazards and aesthetic degradation -- was used to identify baseline water quality from 1970 to 1974, to measure trends where possible, and to determine the effects of seasonal and hydrologic variations. Two major categories of harmful substances -- metals and pesticides -- are discussed, but there are not enough data to measure trends.

For the 305(b) study eighteen waterways were examined. Three rivers were subdivided for easier discussion. They were: the Des Moines River, the Iowa River, and the Cedar River.

Trends

The data examined show a varied picture for the rivers studied. Inadequate historical data made trend analysis impossible on many rivers. Based on available data dissolved oxygen, biochemical oxygen demand, ammonia nitrogen and organic nitrogen showed improvement in over half of the streams. Those parameters with historical data which showed no improvement were nitrate, turbidity, and chlorides. The improved picture regarding oxygen depletion and ammonia nitrogen seems to indicate that increased control of point sources is improving stream quality.

The lack of improvement in turbidity and nitrate indicates the need for more effort concerning nonpoint source pollution.

Seasonal and Hydrologic Variations

The concentrations of most water quality parameters are strongly effected by seasonal and hydrologic variations. Temperature changes effect chemical and biological reaction rates. Stream flow variations effect dilution rates, erosion and bottom scour, and correlation with surface runoff.

Physical Modification

Total fixed solids concentrations were highest during the spring and late winter. Over 50% of the rivers studied had highest solids concentrations in the spring, and only two rivers had maximum solids levels in the summer or autumn. Turbidity concentrations for ten of the twelve streams studied were highest during the spring.

Eutrophication Potential

Lack of complete seasonal data prevented seasonal comparisons on nitrates or phosphates. Organic nitrogen did not show any particular seasonal trend with maximum levels scattered fairly evenly among the seasons. Analysis of data collected on the Des Moines River, Floyd River, and Little Sioux River showed high correlation between both nitrate and phosphate and stream flow. Correlations were not significant on data for the Iowa River near Coralville, nor at Palo on the Cedar River.

Oxygen Depletion

Low dissolved oxygen concentrations primarily occurred during winter and early spring. Over 50% of the streams studied had lowest average dissolved oxygen in the winter, with all but one stream having low dissolved oxygen in either winter or spring. This indicated the critical impact of reaeration on the stream. Winter conditions in Iowa produce ice-cover, limiting the ability of the stream to resupply the water with oxygen from the atmosphere.

Ammonia nitrogen concentrations were also highest during the winter. In only one stream were ammonia values highest during another season and in that case it was spring. Again the lack of reaeration under ice cover creates conditions which allow only slow conversion of ammonia to nitrate.

Health Hazards and Aesthetic Degradation

Insufficient data were available for hydrologic correlations or seasonal analysis of coliform data. Indications are that high coliform levels are associated with runoff and high stream flows. No statistical studies have been conducted to verify this.

Metals and Pesticides

While metals and pesticides are potentially harmful in water, laboratory methods have not been developed that are sensitive enough to detect exact quantities present within the sample. There were insufficient data for trend or seasonal analysis. There are enough data, however, to give a general indication of the number of rivers where metals and pesticides have been found in concentrations exceeding reference levels.

Metals

Five metals were found to exceed aquatic life classifications of the Iowa Water Quality Standards. These metals were zinc, lead, copper, chromium, and barium. Lead and copper were the only frequent violators with concentrations above Iowa standards in over 40% of the rivers surveyed. Zinc and barium exceeded standards in two basins, and chromium was exceeded only in the Cedar River. Metals data are shown in Appendix A.

Pesticides

The State of Iowa has no stream standards specifically addressing pesticide concentrations. For determination of reference levels the water quality criteria established by the National Academy of Science (1972) were used. These criteria have established maximum recommended concentrations for many of the pesticides. Using their criteria for comparison, recommended levels were exceeded in over 75% of all stream samples in Iowa for DDT (10 of 14 streams), dieldrin (16 of 18), lindane (6 of 8), heptachlor (1 of 1), and heptachlor epoxide (3 of 4). In addition DDE exceeded maximum criteria in 10 of 18 streams, and aldrin in 4 of 9 streams. Many other pesticides and herbicides were also found, but were in quantities below recommended criteria. Some pesticides that were observed have no recommended standard. Pesticide data is shown in Appendix B.

POLLUTANT REDUCTIONS AND COSTS

Municipal Waste Treatment Facilities

There are over 600 incorporated communities in Iowa with wastewater treatment facilities. Seventy percent of the population of incorporated communities are served by trickling filter wastewater treatment facilities. Three hundred and twenty-three communities (4% of the population of incorporated communities) have no municipal waste treatment facilities, leaving 96% of the incorporated population to be served by some form of municipal wastewater treatment. As reflected in current draft NPDES permits the present level of biochemical oxygen demand (BOD_5) being discharged to Iowa waters is over 100 tons/day. This level must be reduced to approximately 32 tons/day which reflects a 68% removal resulting from implementation of the National Pollutant Discharge Elimination System program. The projected costs for such an achievement have been estimated at 989.58 million dollars, based upon the 1974 Needs Survey conducted in late summer, 1974, and based upon 1973 dollars.

Industrial Waste Treatment Facilities

There are approximatley 600 industrial point source dischargers in Iowa. It is projected that most, if not all, major industries will comply with the 1977 deadline for best practicable treatment. Based upon current draft NPDES permits the present level of biochemical oxygen demand (BOD_5) being discharged into Iowa waters by major industrial dischargers is approximately 61 tons/day. The present level of ammonia being discharged by Iowa's major industries is approximately 10 tons/day. Reductions of approximately 54 tons/day of BOD_5 and 8.5 tons of ammonia are called for within the NPDES permits for industrial dischargers. This reflects an 89% reduction in BOD_5 and a 84% reduction in ammonia. Iowa industries have projected spending 50 million dollars between January 1975, and July 1977, in order to comply with 1977 Federal requirements.

Agricultural Waste Treatment Facilities

There are over 1000 registered feedlot operations in Iowa. There have been 799 construction permits issued for feedlot wastewater control in the last five years. It is projected that all feedlot operations of greater than 1000 animal units will be in compliance by July 1, 1977. Since EPA has not yet promulgated performance standards for under 1000 animal unit operations, and has not defined significant pollution sources, it is presently impossible to make accurate estimates or project compliance dates for under 1000 animal unit operations. It is estimated that Iowa regulations currently require over 4000 open and confined feeding operations to register with the DEQ.

Nonpoint Sources of Pollution

The major sources of nonpoint pollution in Iowa occur in runoff from land areas, including croplands, pastures, ranges, and woodlands. There is relatively little data indicating representative pollutant contribution based upon various land uses. The Soil Conservation Service has reported that soil erosion in Iowa in 1974, was its worst in the last 25 years. The Soil Conservation Service, in their 1970 Needs Inventory estimated a cost of approximately 1 and 2/3 billion dollars for more than 13 million acres which need erosion controls. These costs average $128 per controlled acre.

CONCLUSIONS

Beneficial water uses are not seriously restricted because of gross pollution at the present time. Aquatic productivity, recreational uses, treatment costs and aesthetic values are effected by pollution in several areas. The effect is more pronounced and more widespread during dry years when stream flows are near their minimums.

Compliance with the NPDES permits currently being issued to point source dischargers should significantly improve Iowa's water quality, and make violations of water quality standards a very rare occurrence. The factors that will then be limiting on most streams are likely to be turbidity, nutrients and toxic substances. These factors could be significantly improved through implementation of a nonpoint source control program.

It must be understood that while significant improvements in the quality of Iowa's waters can, and almost certainly will, be attained within the next decade, Iowa will never have sparkling clear streams, free of all harmful substances. Such a condition has never occurred within recorded history. Geology, hydrology and meteorology will always be the ultimate limiting factors influencing Iowa's water quality, independent of man's impact. These natural limitations have not prevented Iowa from being "a place to grow"; man's activities should not either.

SECTION II IOWA WATER QUALITY

STUDY METHOD

This part of the report focuses on the State's largest rivers. The report's objective is to identify current quality of these waters, to describe pollution where it exists, and to assess the progress being made in the removal of pollutants from the waters of the State.

WATERWAYS EXAMINED

A total of 20 rivers, both interstate and intrastate, and 8 lakes were examined for this study. The 20 rivers studied collectively represent approximately 3,500 miles of the estimated 50,000 miles of rivers and streams in the State. Those examined are important because:

- They receive water that drains from about 87 percent of the State's 56,239 square miles (Fig. II-1).
- Approximately 2,000,000 people inhabit their drainage areas, including 1,065,000 people in the 24 largest cities along the studied streams.
- 23 communities use the waterways as their source of drinking water.
- The waterways represent a wide variety of flow and water quality conditions. Conditions can vary tremendously depending on flow; a river on a day of maximum flow often carries over 1,000 times as much water as on a day of minimum flow.

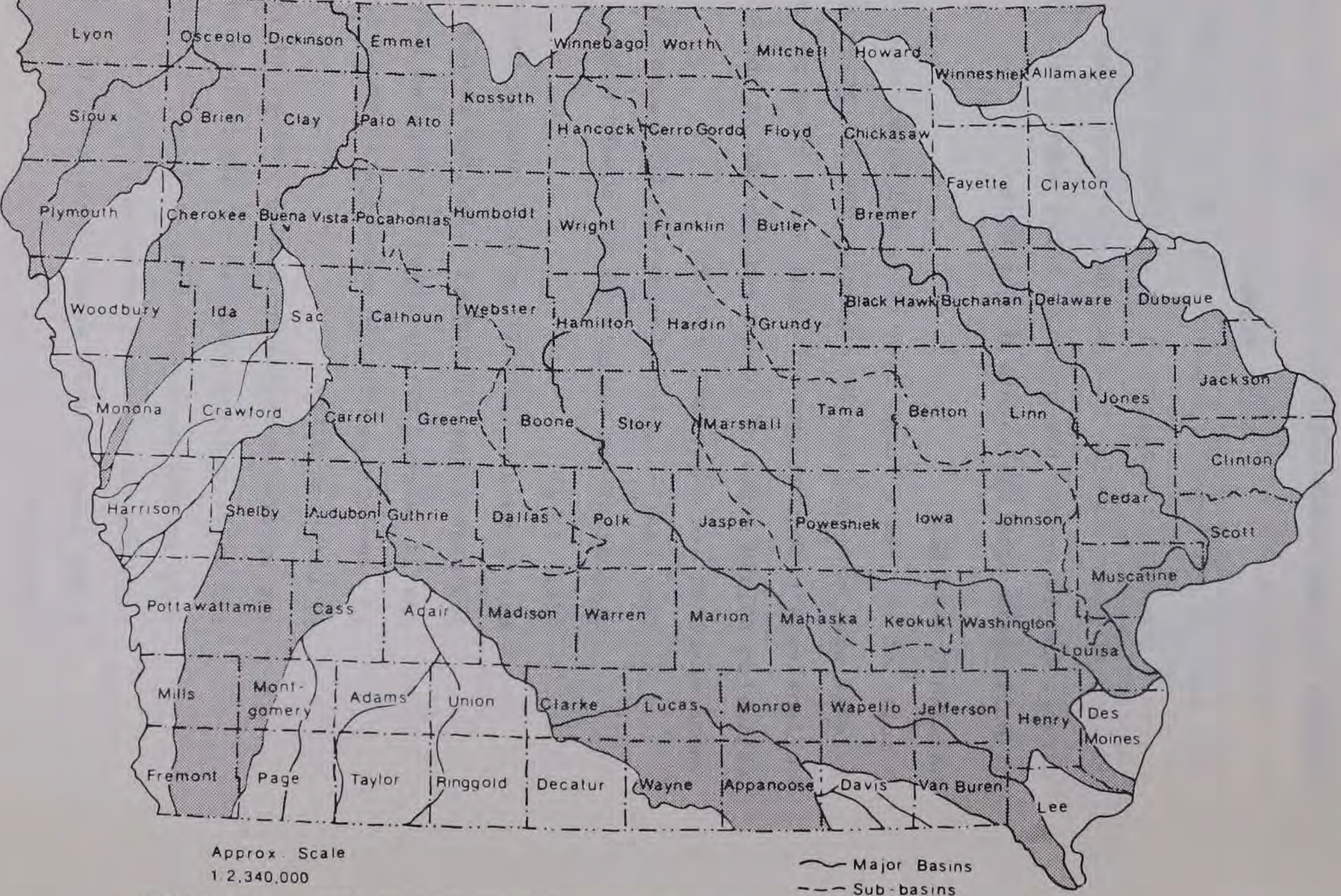


FIGURE II-1 AREA DRAINED BY WATERWAYS STUDIED.

Data used prior to 1967 come largely from the Department of Environmental Quality and predecessor agencies. The data should be examined critically regarding several sample biases. Due to the nature of the work conducted by the DEQ most samples were collected to demonstrate the most adverse stream conditions. Samples have been customarily taken immediately downstream of sewage treatment plants or raw waste discharges. In addition, samples were collected during extreme weather and flow conditions such as low flow periods during the summer, and ice cover in the winter. Statistical analysis of all samples through 1973 currently in STORET indicated that approximately 15% of all the data, both historical and current, were collected between April 1 and June 30 of each sample year. This period normally is a time of spring runoff which contributes increased flows to the stream.

While the bias of the data must be clearly recognized throughout this report, certain comparisons can be made. The assumption was made for this report that all data collected by the DEQ is uniformly biased toward the worst possible water quality conditions, consequently, if the water quality is shown to be good in the DEQ samples for a particular river then it can be assumed that water quality violations throughout the year are infrequent.

An additional word of caution regarding the data in this report is appropriate since many locations in the State have limited data for particular parameters. Where possible the sample size is shown to bring the reliability of the results into focus. Many of the illustrations in this report refer to average conditions within a stream. These are presented to give a base figure for further comparisons. It is unrealistic to establish an "average" water quality for a river system as large and diverse as the Des Moines River with a watershed covering 14,540 square miles.

DATA SOURCES AND ANALYSIS

A large percentage of the total data available for this study was obtained from the Environmental Protection Agency's storage and retrieval (STORET) computerized data base. During the last twelve months the State of Iowa has entered nearly 100,000 water quality values into STORET from nearly 1,500 water quality stations throughout the State. The oldest data come from 1938 studies by the Environmental Engineering Service of the State Health Department, the Department of Environmental Quality's (DEQ) predecessor agency. Data from 1969 to 1974 comprise over 50% of the total data.

Historical data for the purposes of this study were broken down by decade to provide convenient comparisons. Data in the 1940's, 1950's and 1960's were often intensively collected for several years and then research was moved to another basin, therefore, data are seldom available throughout the full 10 years of the decade.

In order to establish minimum criteria for the examination of historical data certain guidelines were followed. No decade was examined for historical comparison unless three consecutive years of data were available with at least three samples during each of those years at four or more stations.

Historical data for the 1960's for the Skunk River were from research conducted by Iowa State University. For comparison with the 1970's data this information is probably adequate because the data for both periods cover the same area of the Skunk River Basin. These data are also biased toward the worst conditions, since much of it was collected at low flow conditions, within twenty miles of the Ames, Iowa sewage treatment plant discharge. Ames, Iowa is the largest municipality along the Skunk River, and is located relatively near the river's headwaters, therefore, little dilution is available for the treated waste from Ames.

Current water quality data, 1970-1974, were obtained from a variety of sources. The Department of Environmental Quality has contracted with the State Hygienic Laboratory, a division of the University of Iowa, to sample streams and analyze data. Thirty-six permanent sampling stations have been established on major streams throughout the State to collect background water quality information. These stations are not significantly effected by point source discharges such as cities and industries. Samples have been collected quarterly for the last three years without regard to critical flow or temperature conditions. These data represent the most unbiased stream information the DEQ routinely receives. In addition to the thirty-six permanent stations, the State Hygienic Laboratory conducts special stream surveys for the DEQ to investigate stream conditions for possible water pollution. These samples are biased in that they represent the worst conditions with regard to both sample location and collection time.

A large amount of information concerning stream and lake water quality is available from Iowa State University at Ames. The information includes: data on the Des Moines River, from Boone to Red Rock Reservoir, near Tracy, from 1967 to the present; data on the Skunk River on the reach from Story City to Colfax; data on the Iowa Great Lakes (Spirit Lake, Gar Lake, East and West Okoboji Lakes); data on the Raccoon River at Van Meter, and various other smaller studies on Iowa lakes and streams. These data provide the most comprehensive information available on water quality in Iowa lakes, the Des Moines River and the Skunk River.

The University of Iowa has also conducted numerous important water quality studies. Continuous twice monthly sampling of Coralville Reservoir and the Iowa River, above and below the reservoir, have been conducted since 1964. A similar sampling program was initiated in 1971 above Cedar Rapids on the Cedar River. Studies on Lake MacBride and the Upper Iowa River have also been conducted. The studies for the Upper Iowa River, the Iowa River near Iowa City, and the Cedar River near Cedar Rapids are among the most comprehensive on the respective rivers.

Data have been compiled by the Environmental Protection Agency on the Missouri River and the Mississippi River. These data were the sole sources used for these rivers in this report. In addition water quality data for 1974 in a number of Iowa lakes was available through the EPA Lake Eutrophication Study. With the exception of the data mentioned above from Iowa State University on the Iowa Great Lakes region, and data on the major reservoirs, the EPA data were used for the lake water quality data in this report.

The Iowa Conservation Commission has been particularly active in water quality analysis on the Chariton River and the Rathbun Reservoir in south-central Iowa. The data on the Chariton River is the most comprehensive water quality data available for the southern part of the State.

The United States Geological Survey (USGS) has collected all of the flow data for the State of Iowa and currently monitors 127 permanent flow gauge stations within the State. While water quality data collection is not their primary function certain areas in the State have significant amounts of water quality data available through the USGS and this data was used in several instances.

The analyses of Iowa's major streams and lakes is a first step toward understanding the quality of the State's waters. While this type of analysis provides a good overview of water quality, it does not attempt to portray local water quality conditions. The lack of sufficient data in all but a few areas of the State make any attempt at assessing local conditions impossible. More data is certainly necessary for a more detailed analysis. Only studies such as those that the universities have undertaken, covering a small area with frequent sampling over an extended period, can provide that information. In short, this report focuses on a broad overview of the State's water quality.

IOWA'S WATER QUALITY TRENDS

The data examined show a mixed picture for the rivers studied. Inadequate historical data made trend analysis impossible on many rivers. Dissolved oxygen, chemical oxygen demand, ammonia nitrogen and organic nitrogen showed improvement in over half of the streams with data available for analysis. Those parameters with historical data which showed no improvement were nitrate, turbidity, and chlorides. The improved picture regarding oxygen depletion and ammonia nitrogen seems to indicate that increased control of point sources is improving stream quality. The lack of improvement in turbidity and nitrate indicates the continued need for more effort concerning nonpoint source pollution.

TABLE II-1

MAJOR STREAMS
WATER QUALITY TRENDS 1950-1974

PARAMETER	STREAMS ANALYZED	STREAMS IMPROVED
Dissolved Oxygen	10	6
Biochemical Oxygen Demand	10	5
Chemical Oxygen Demand	1	1
Organic Nitrogen	6	5
Ammonia Nitrogen	7	5
Nitrate Nitrogen	6	0
Turbidity	3	0
Total Solids	2	1
Dissolved Solids	3	2
Chloride	2	0
Alkalinity	1	1
Total Coliform	2	2

Seasonal and Hydrologic Variations

The concentrations of most water quality parameters are strongly effected by seasonal and hydrologic variations. Temperature changes effect chemical and biological reaction rates. Stream flow variations effect dilution rates, erosion and bottom scour, and correlation with stream flow. Tables II-2 through II-7 depict seasonal variations in collected data.

TABLE II-2

SEASONAL MEAN BIOCHEMICAL OXYGEN DEMAND (mg/l)

RIVER	PERIOD OF RECORD	WINTER	SPRING	SUMMER	AUTUMN
Big Sioux	1971-1974	5.4	ND	11.5	ND
Floyd	1949-1974	11.1	6.0	8.9	9.6
Little Sioux	1950-1974	5.2	ND	14.0	7.8
Nishnabotna	1950-1974	6.0	4.0	8.2	7.6
Des Moines	1939-1974	14.0	8.3	9.9	11.4
Des Moines,E Fork	1940-1974	4.2	4.3	6.9	5.2
Des Moines,W Fork	1940-1974	10.7	3.8	8.5	11.8
Skunk	1970-1974	4.0	28.7	4.3	4.5
Iowa	1950-1974	9.6	9.4	7.7	9.2
Cedar	1949-1974	7.9	8.6	9.7	11.5
Shell Rock	1940-1974	5.2	10.7	9.7	4.6
Wapsipinicon	1940-1974	2.7	3.4	6.9	6.2
Maquoketa	1938-1974	10.4	13.5	2.1	5.2

TABLE II-3

SEASONAL MEAN DISSOLVED OXYGEN (mg/l)

RIVER	PERIOD OF RECORD	WINTER	SPRING	SUMMER	AUTUMN
Big Sioux	1971-1974	2.3	ND	12.8	13.6
Floyd	1949-1974	5.5	11.8	10.2	9.7
Little Sioux	1950-1974	5.3	ND	6.8	6.6
Nishnabotna	1950-1974	4.0	7.4	8.7	9.7
Des Moines	1939-1974	8.8	7.6	7.7	10.5
Des Moines,E Fork	1940-1974	5.4	9.2	8.6	9.2
Des Moines,W Fork	1940-1974	7.5	8.1	10.8	9.8
Skunk	1970-1974	12.0	5.7	6.4	10.2
Iowa	1950-1974	8.1	8.3	8.0	10.8
Cedar	1949-1974	8.6	8.4	8.6	10.7
Shell Rock	1940-1974	7.9	14.1	10.8	13.3
Wapsipinicon	1970-1974	9.4	8.0	9.0	12.5
Maquoketa	1938-1974	11.0	4.3	7.9	9.1

TABLE II-8

SUSPENDED SEDIMENTS ON SELECTED RIVERS
1969 - 1970

RIVER	DRAINAGE AREA (sq. mi.)	SUSPENDED SEDIMENT LOAD (tons/year)	SEDIMENT PER SQ. MILE (tons)
Wapsipinicon River at Independence	1,048	28,159	26.9
Des Moines River at Saylorville	5,841	723,238	123.8
Whitebreast Creek near Dallas	342	241,123	705.0
Floyd River at James	882	253,478	287.4
East Nishnabotna River at Red Oak	432	1,576,799	3,650.0
Thompson River at Davis City	701	523,462	746.7
Chariton River near Chariton	182	56,209	308.8

TABLE II-9

DISSOLVED OXYGEN VIOLATIONS

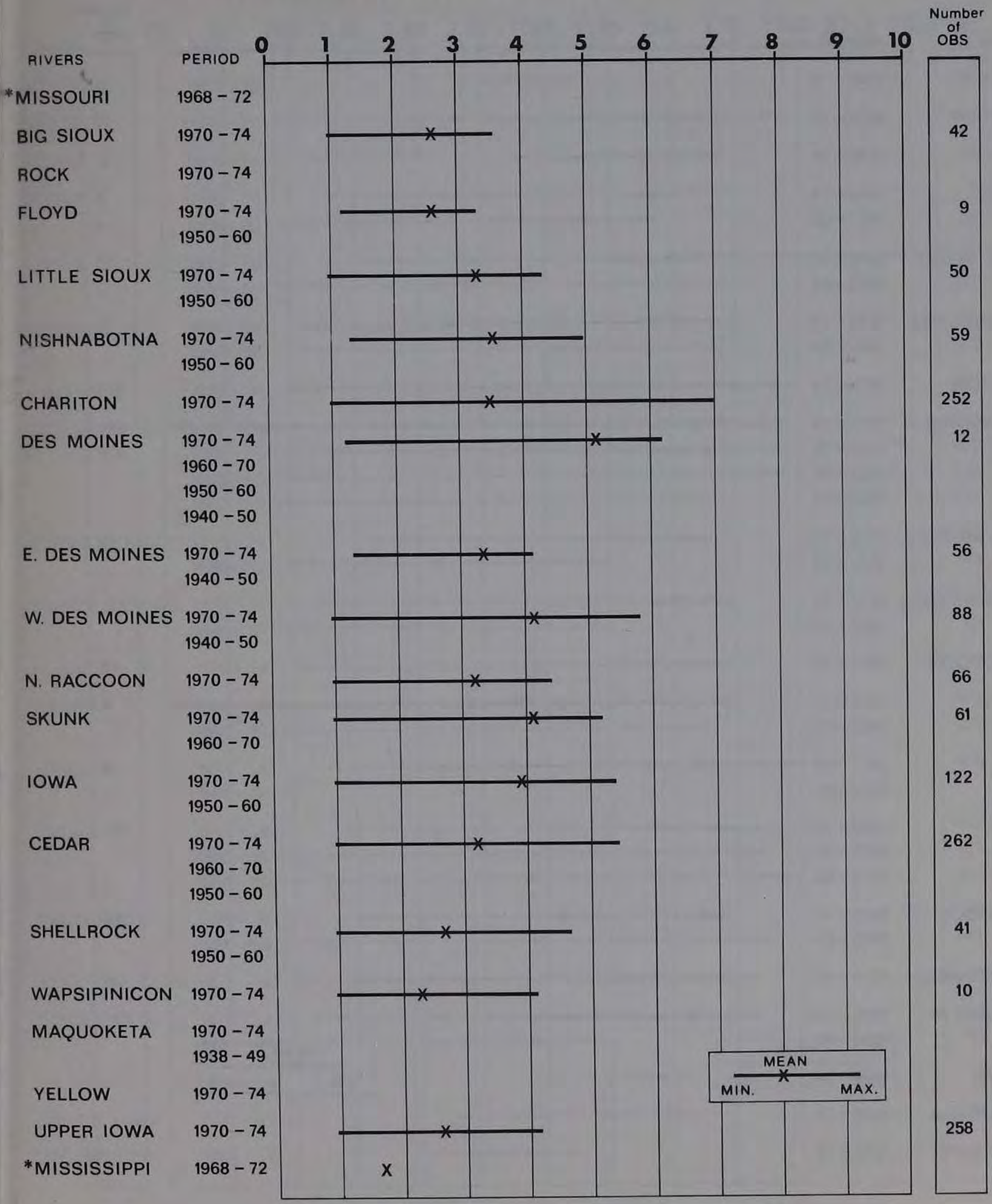
RIVER	YEARS	PERCENT	VIOLATIONS/OBS.
Big Sioux	1970-1974	42	51/121
Rock	1970-1974	62	15/24
Floyd	1970-1974	18	2/11
Floyd	1950-1960	21	64/292
Little Sioux	1970-1974	1	1/58
Little Sioux	1950-1960	21	29/136
Nishnabotna	1970-1974	8	8/99
Nishnabotna	1950-1960	5	13/233
Chariton	1970-1974	13	31/227
Des Moines	1970-1974	1	3/1002
Des Moines	1960-1970	1	11/808
Des Moines	1950-1960	12	41/340
Des Moines	1940-1950	17	112/647
North Raccoon	1970-1974	8	13/150
East Fork Des Moines	1970-1974	2	2/91
East Fork Des Moines	1940-1950	36	16/44
West Fork Des Moines	1970-1974	12	20/160
West Fork Des Moines	1940-1950	32	14/43
Skunk	1970-1974	1	3/451
Skunk	1960-1970	22	57/251
Iowa	1970-1974	1	5/306
Iowa	1950-1960	6	13/214
Cedar	1970-1974	1	1/493
Cedar	1960-1970	2	11/427
Cedar	1950-1960	3	18/591
Shellrock	1970-1974	1	1/85
Shellrock	1950-1960	11	17/142
Wapsipinicon	1970-1974	2	1/37
Maquoketa	1970-1974	0	0/535
Maquoketa	1938-1949	1	1/65
Yellow	1970-1974	0	0/4
Upper Iowa	1970-1974	0	0/259

TABLE II-10

AMMONIA NITROGEN VIOLATIONS

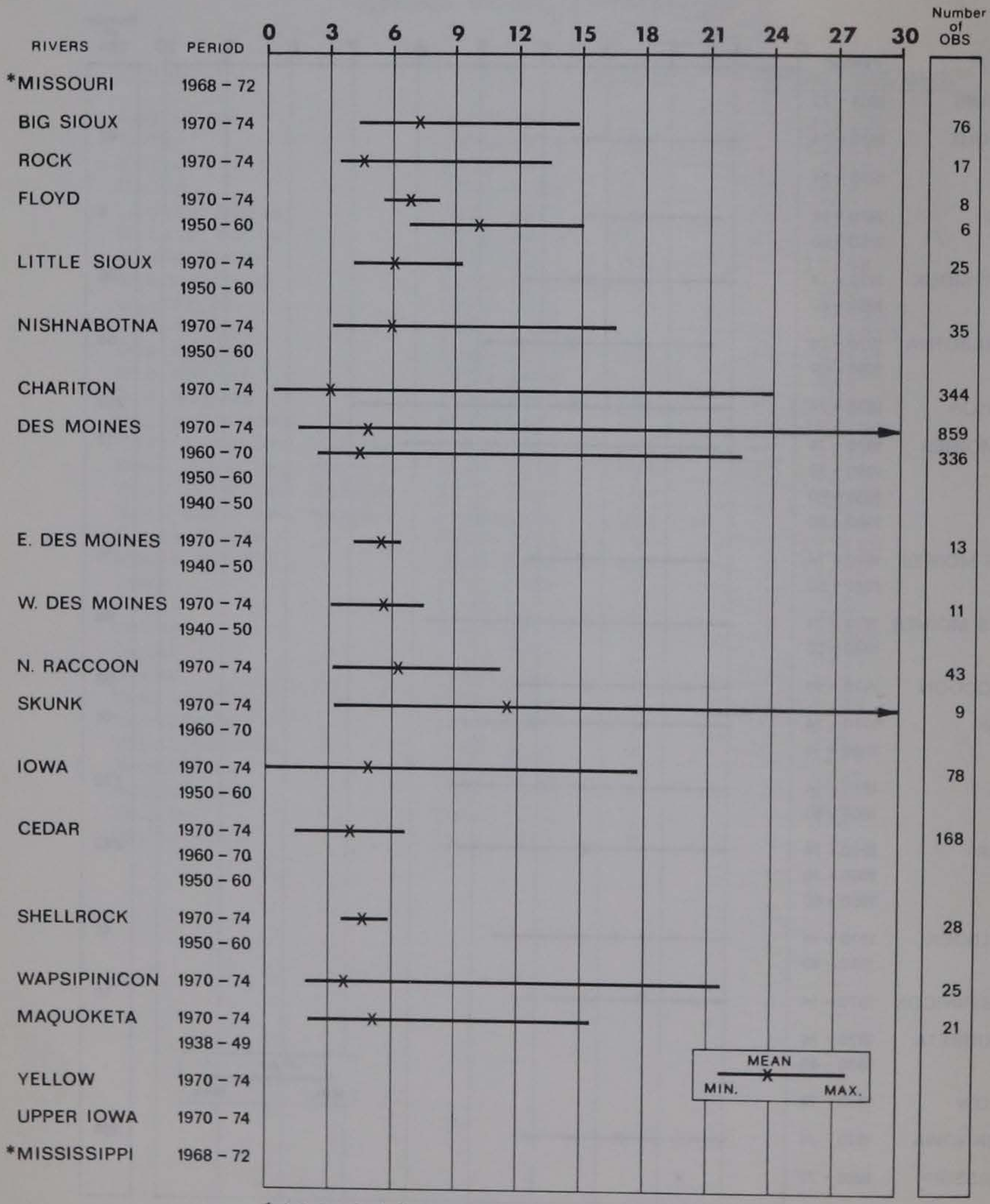
RIVER	YEARS	PERCENT	VIOLATIONS/OBS.
Big Sioux	1970-1974	74	91/122
Rock	1970-1974	50	12/24
Floyd	1970-1974	29	5/17
Floyd	1950-1960	83	5/6
Little Sioux	1970-1974	0	0/69
Little Sioux	1950-1960	100	6/6
Nishnabotna	1970-1974	32	19/58
Nishnabotna	1950-1960	0	0/0
Chariton	1970-1974	1	3/459
Des Moines	1970-1974	1	11/1013
Des Moines	1960-1970	1	5/521
Des Moines	1950-1970	0	0/6
Des Moines	1940-1950	19	118/593
North Raccoon	1970-1974	17	26/150
East Fork Des Moines	1970-1974	1	1/77
East Fork Des Moines	1940-1950	8	2/24
West Fork Des Moines	1970-1974	3	4/106
West Fork Des Moines	1940-1950	25	9/35
Skunk River	1970-1974	3	17/489
Skunk River	1950-1960	33	19/56
Iowa	1970-1974	1	5/297
Iowa	1950-1960	0	0/0
Cedar	1970-1974	1	1/398
Cedar	1960-1970	0	0/37
Cedar	1950-1960	0	0/0
Shellrock	1970-1974	9	7/73
Shellrock	1950-1960	75	6/8
Wapsipinicon	1970-1974	2	1/38
Maquoketa	1970-1974	9	6/65
Maquoketa	1938-1949	0	0/0
Yellow	1970-1974	0	0/4
Upper Iowa	1970-1974	0	0/259

FIGURE II-2 MEAN FECAL COLIFORM CONCENTRATIONS log mean (per 100 ml)



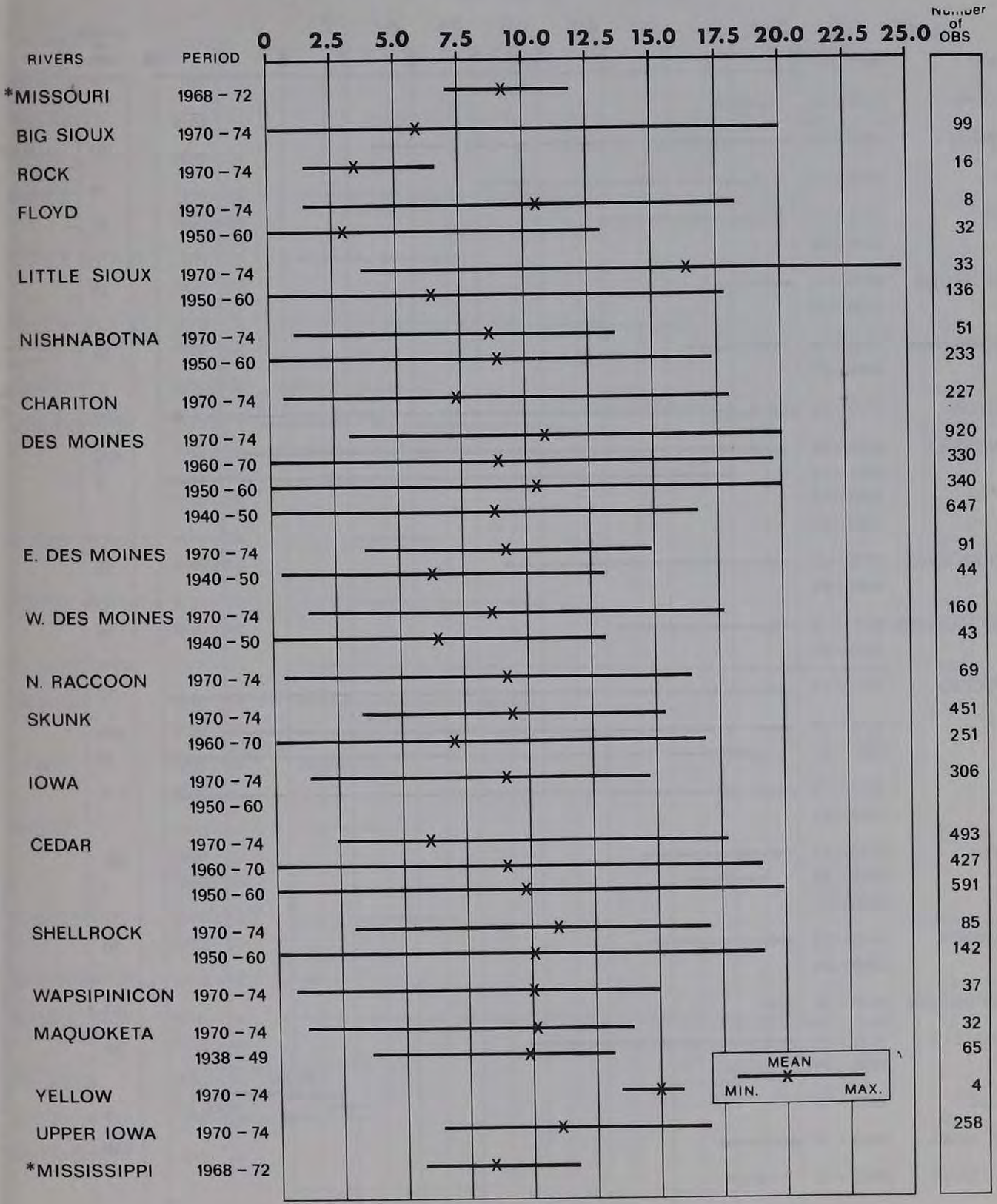
* ± 2 standard deviation

FIGURE II-3 MEAN TOTAL SOLIDS CONCENTRATIONS (mg/l) X 100



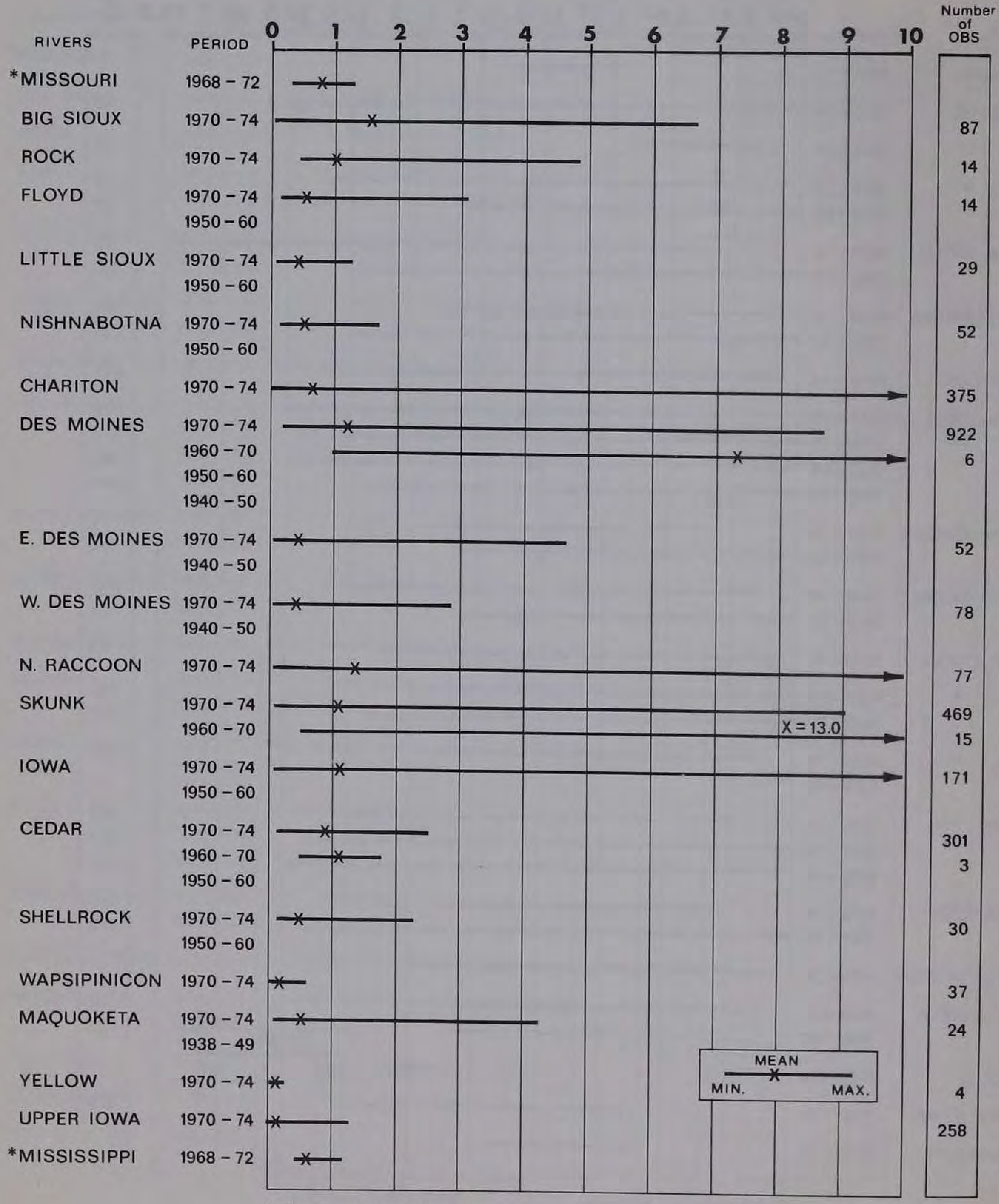
* ± 2 standard deviation

FIGURE II-4 MEAN DISSOLVED OXYGEN CONCENTRATIONS (mg/l)



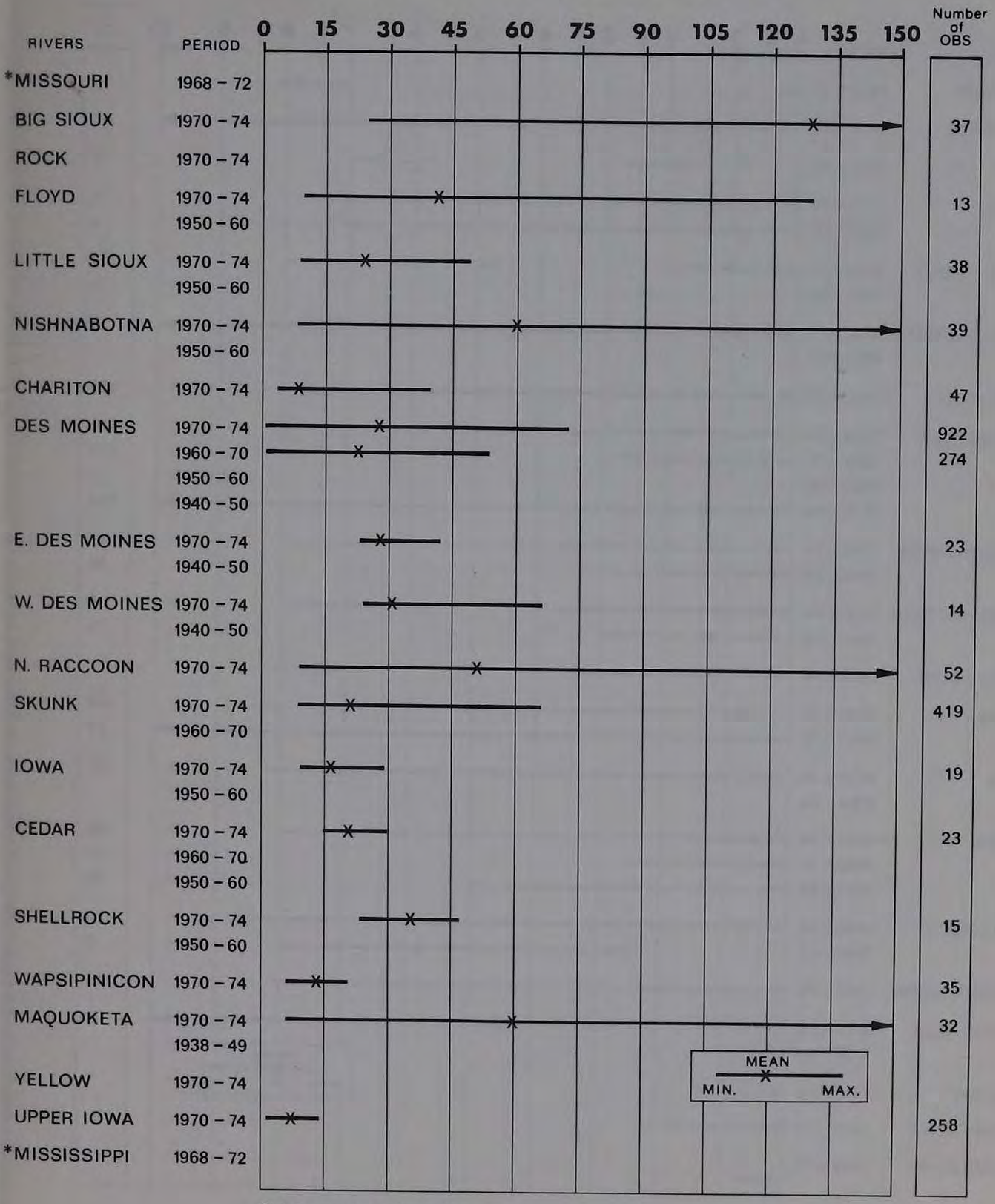
* ± 2 standard deviation

FIGURE II-5 MEAN TOTAL PHOSPHATE CONCENTRATIONS – PO_4-P (mg/l)



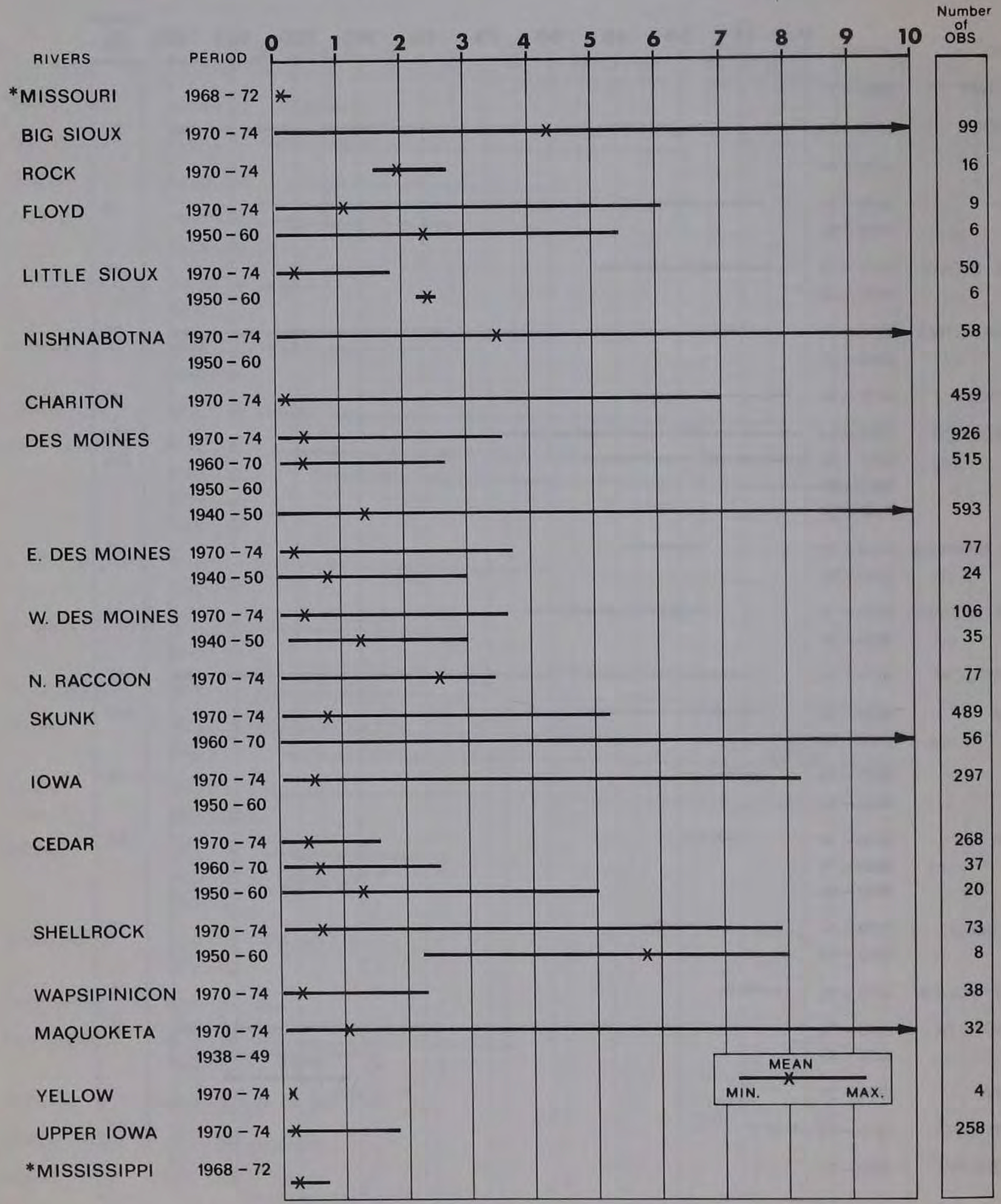
* ± 2 standard deviation

FIGURE II-6 MEAN CHLORIDE CONCENTRATIONS (mg/l)



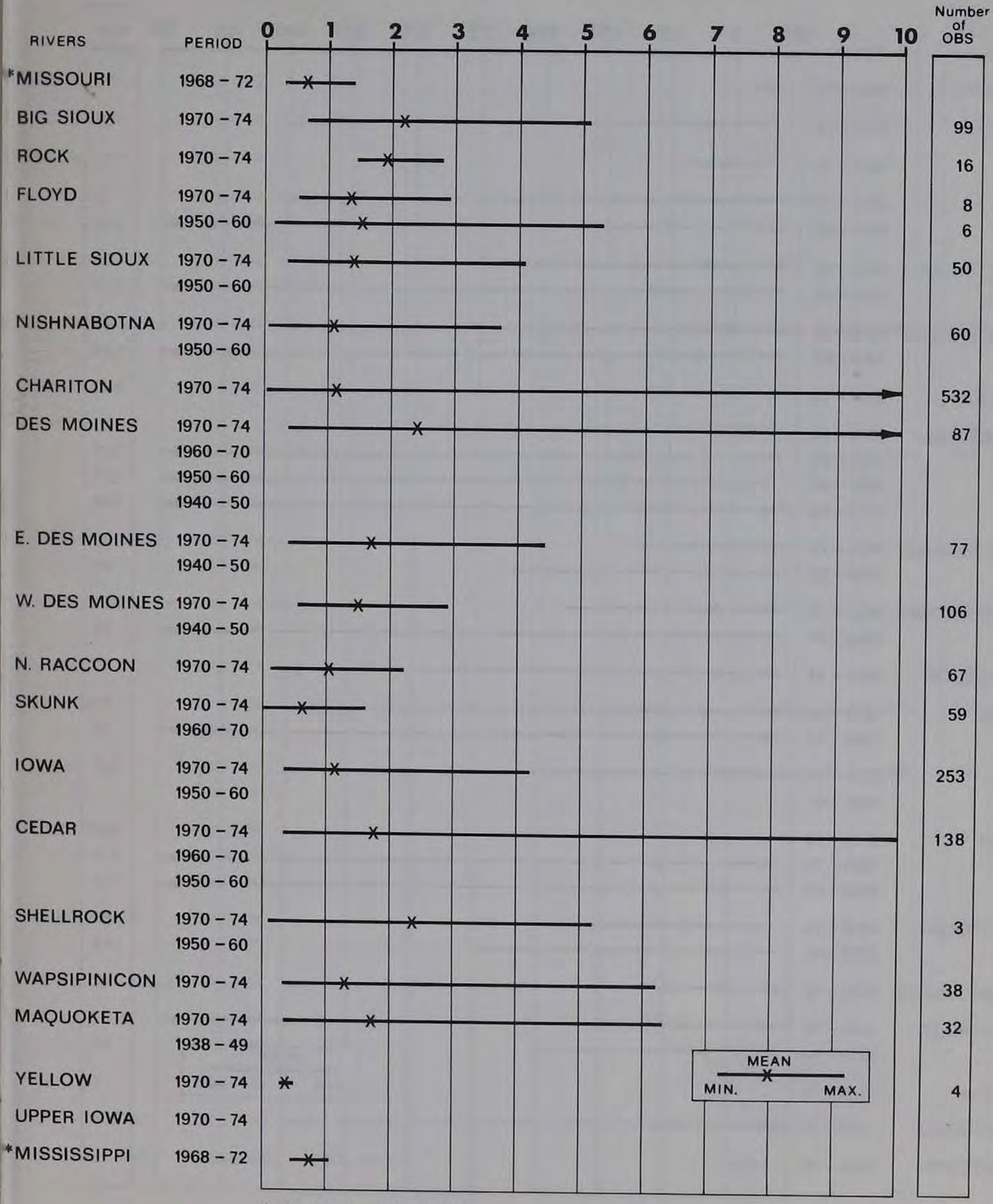
* ± 2 standard deviation

FIGURE II-7 MEAN AMMONIA NITROGEN CONCENTRATIONS – NH_3-N (mg/l)



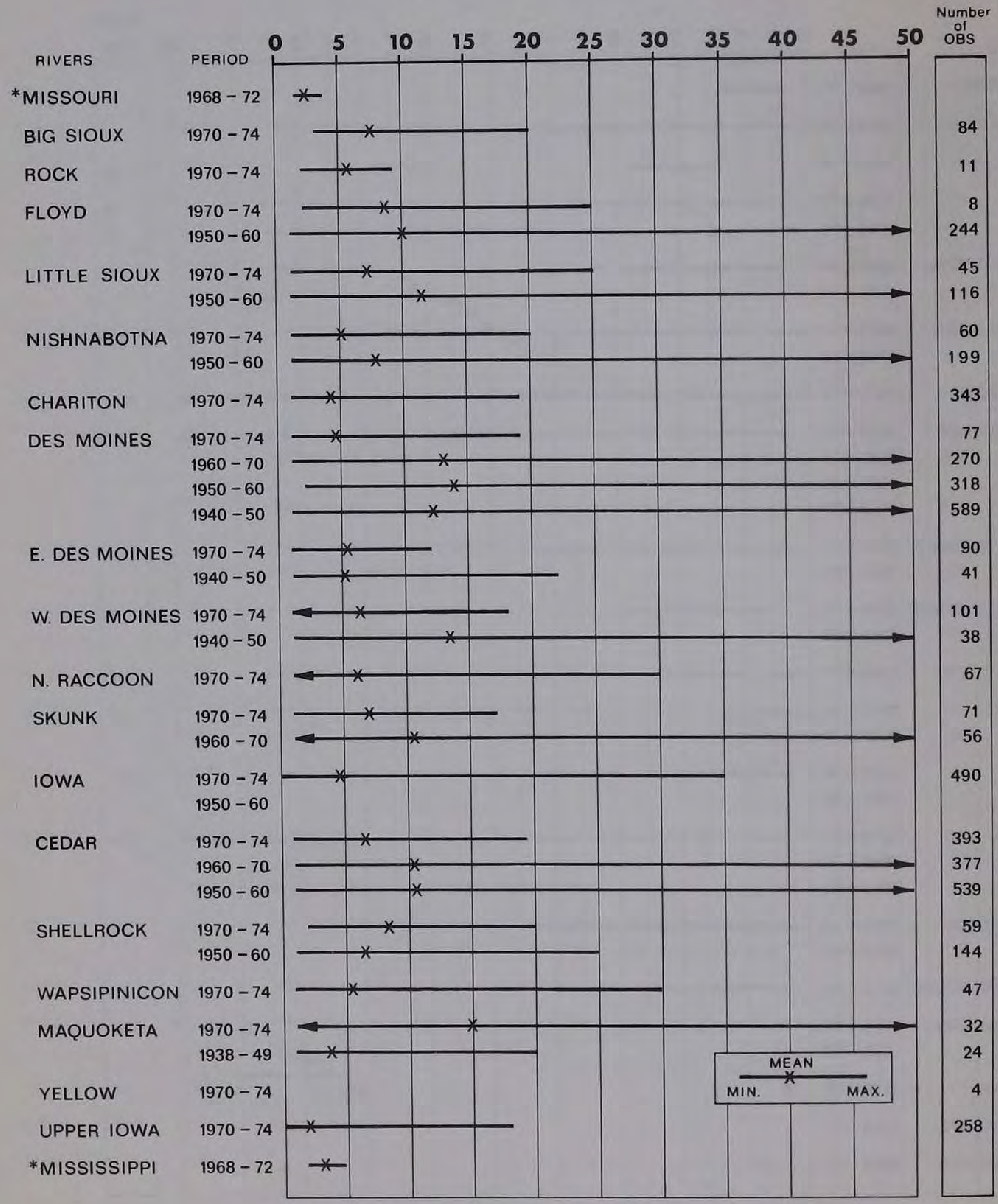
* ± 2 standard deviation

FIGURE II-8 MEAN ORGANIC NITROGEN CONCENTRATIONS (mg/l)



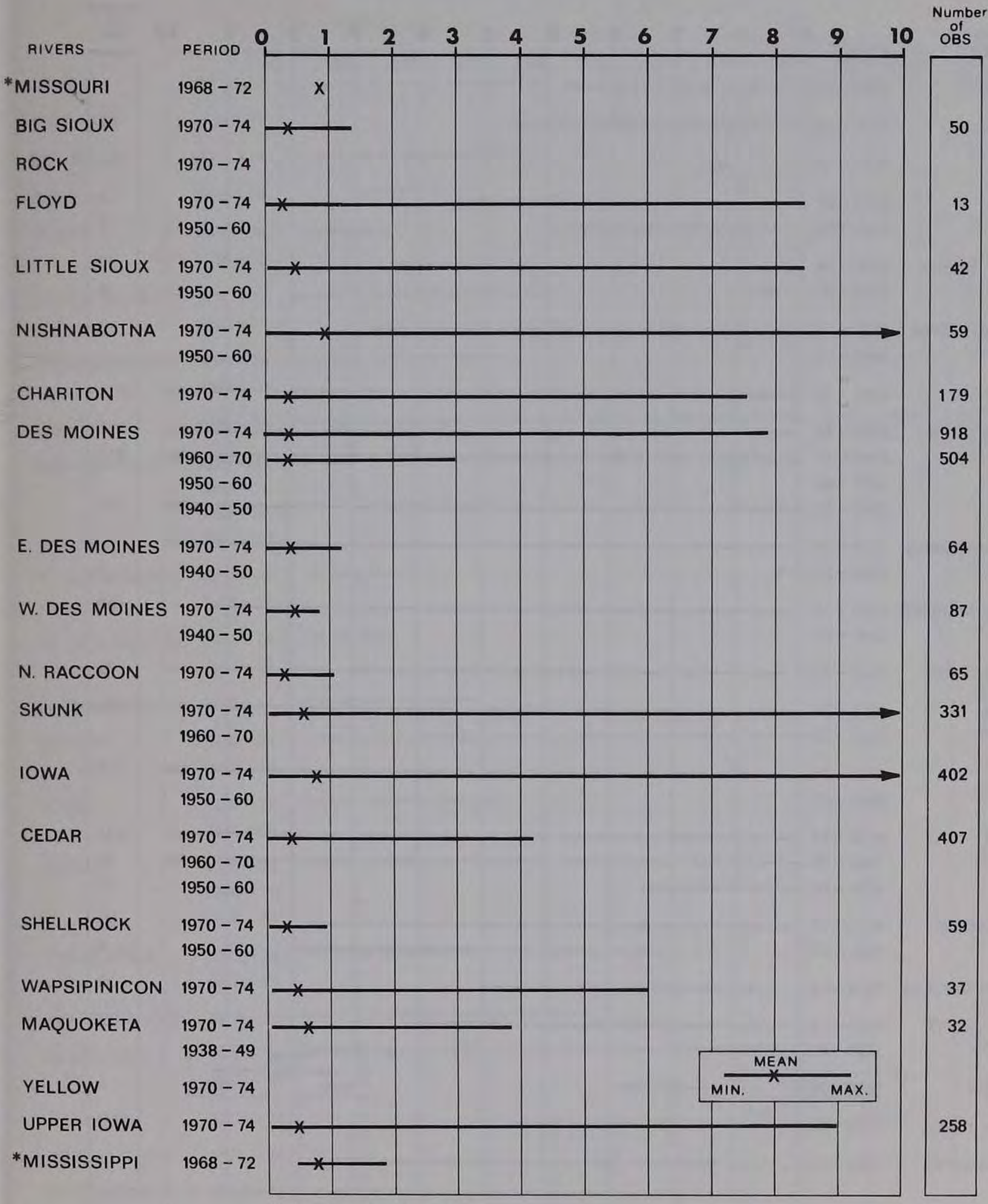
* ± 2 standard deviation

FIGURE II-9 MEAN BIOCHEMICAL OXYGEN DEMAND CONCENTRATIONS (mg/l)



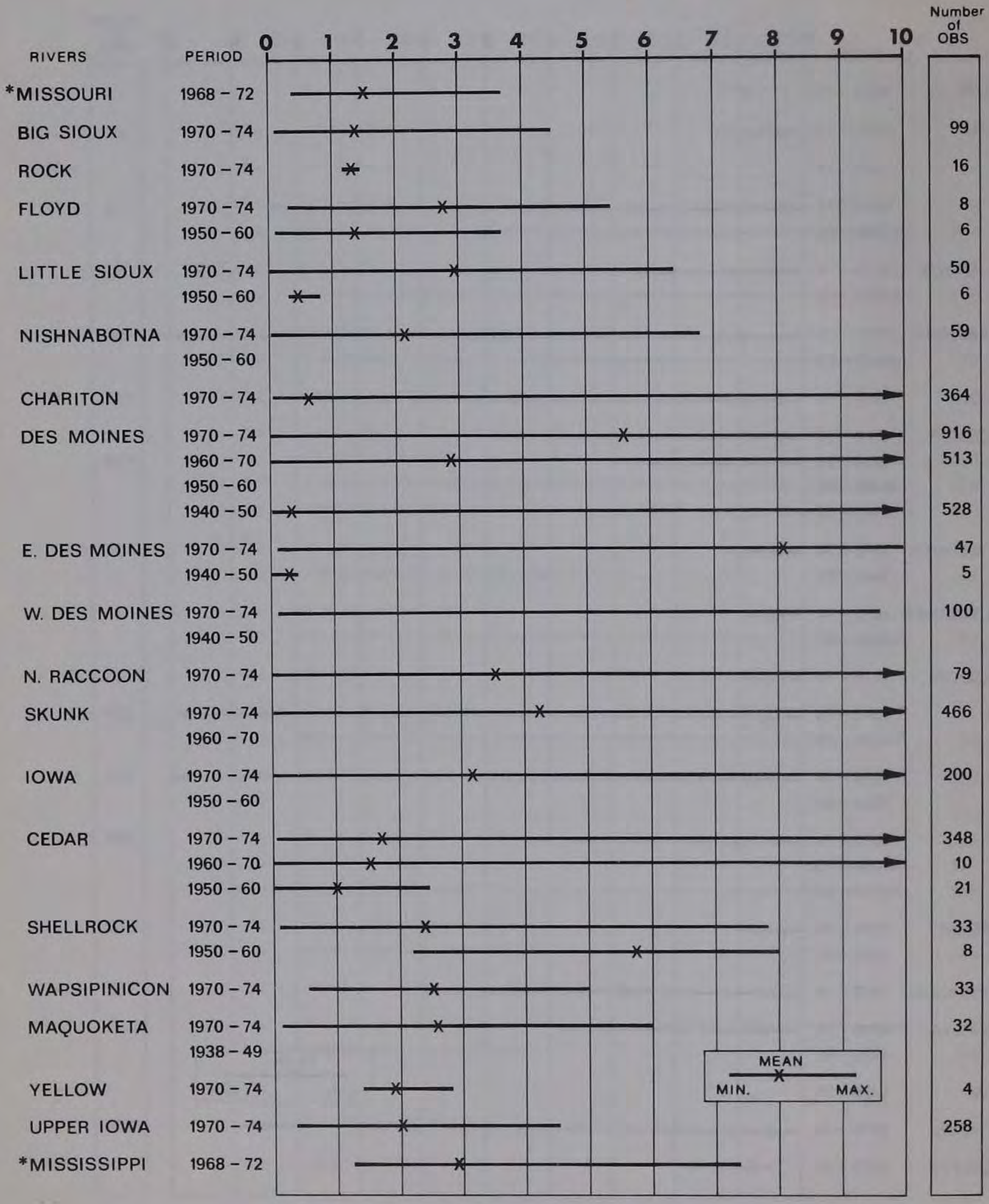
* ± 2 standard deviation

FIGURE II-10 MEAN TURBIDITY CONCENTRATIONS (JTU) X 100



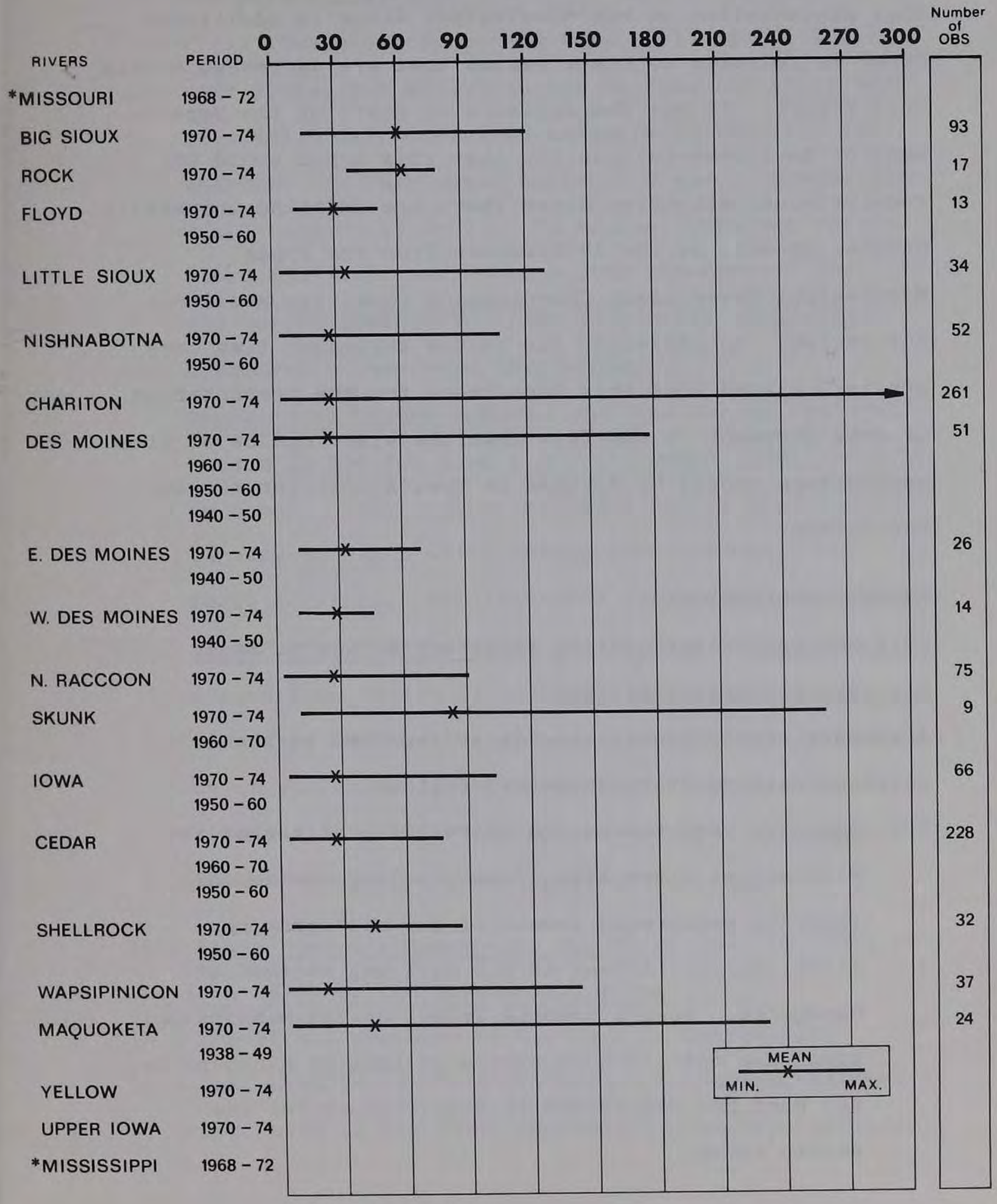
* ± 2 standard deviation

FIGURE II-11 MEAN NITRATE NITROGEN CONCENTRATIONS – NO_3-N (mg/l)



* ± 2 standard deviation

FIGURE II-12 MEAN CHEMICAL OXYGEN DEMAND CONCENTRATIONS (mg/l)



* ± 2 standard deviation

MISSISSIPPI RIVER

INTRODUCTION

This presentation on the Mississippi River is admittedly brief in relation to other basins that are addressed within this report. It was the decision of staff of the Department of Environmental Quality that this topic would not receive equal attention since there are existing university studies as well as the 1970 report from the Upper Mississippi River Basin Coordinating Committee available for review. In addition, due to the stringent time constraints placed upon this Department for the presentation of this document it was felt that the wiser choice of time expenditure should be devoted to Iowa's interior streams and rivers.

RECENT PUBLICATIONS

1974 National Water Quality Inventory-Office Of Water Planning And Standards, EPA

A summary of the general trends as reported in the 1974 National Water Quality Inventory follows:

Ammonia: For the period 1968-1972 profiles of the Mississippi River along Iowa's border for ammonia indicate background levels of 0.1 milligram per liter (mg/l). A peak of 0.5 mg/l was reached at Davenport. Iowa's ammonia impact on the Mississippi River was one-fifth as severe as that of Minneapolis, St. Paul but was second in significance for the entire river.

Dissolved Oxygen: For the months January-March during the period 1963-1972 dissolved oxygen concentrations along Iowa's border ranged from 10-14 mg/l. For the same years, but during summer months, the range was from 6-7.5 mg/l dissolved oxygen,with the 1969 FWPCA standard for warm water biota at 5 mg/l. During the winter period 1968-1972 the highest observed values along the river were observed at Davenport. For the period 1968-1972 a range of 70-85% saturation dissolved oxygen were determined.

Biochemical Oxygen Demand: For the period 1963-1972 ranges in BOD for Iowa's border ranged from 1.5 mg/l to 6 mg/l. The highest recorded values were during January to March which ranged from 3-6 mg/l.

Fecal Coliform: For 1968-1972 fecal coliform data the trends for Iowa's portion of the Mississippi River ranged from 50/100 ml to 1000/100 ml. As far as secondary treatment standards are concerned Iowa would be in violation downstream from Davenport. The 1968 standard of 2000/100 ml for public water supplies was not exceeded along Iowa's borders.

1970 State Hygienic Laboratory Report On The Limnology Of The Iowa Reach Of The Mississippi River

This report was prepared by Dr. Jack H. Gakstatter, Principal Limnologist, and Dr. Robert L. Morris, Associate Director, both of the State Hygienic Laboratory, University of Iowa. Their study included analysis of the effects of the wastewater from the six largest municipal dischargers bordering the Mississippi River. All of these cities had primary waste treatment available, and all, except Burlington, had significant industrial contributors. A study of these six major contributors of waste was considered to give a representative look at the pollutant impact being offered by the State of Iowa. The river's large flow masks, by dilution, the effects of smaller municipalities, and nonpoint pollution from runoff is difficult to pin-point for assignment of responsibility and accountability.

This report concluded that the Iowa reach of the Mississippi River (about 300 river miles) contained water of excellent quality. The Mississippi River was found to have low nutrient and dissolved solids levels when compared with interior Iowa streams. The typical chemistry of one sample taken in early fall under relatively low flow conditions near Burlington is indicated on Table II-11.

TABLE II-11

TYPICAL WATER CHEMISTRY OF THE IOWA REACH OF THE MISSISSIPPI RIVER[1]

(values in mg/l unless otherwise stated)

Alkalinity:	
Phenolphthalein	2
Total	160
Bicarbonate	190
Biochemical Oxygen Demand (BOD)	4
Calcium	51.2
Carbonate	2.4
Chemical Oxygen Demand (COD)	33.5
Chloride	12
Fluoride	0.2
Hardness as $CaCo_3$	200
Magnesium	17.5
Manganese	0.05
Nitrogen as N:	
Organic	1.1
Ammonia	0.07
Nitrate	0.2
pH	8.2 units
Phosphate as PO_4	
Soluble	0.2
Total	0.5
Potassium	2.6
Silica as SiO_2	1.0
Solids:	
Total	230
Dissolved	178
Suspended	52
Specific Conductance	420 micromhos
Sulphates	52

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[1] 1970 State Hygienic Laboratory Report #71-21

UPPER IOWA RIVER

Water quality of the Upper Iowa River is considered by many as the best in the State. Dissolved oxygen levels are high throughout the river and pollution parameters have not been found in violation of Iowa Water Quality Standards. Eutrophication is not a significant problem in the Upper Iowa River.

The key pollutants highlight conditions in the Upper Iowa:

<u>Harmful Substances</u>: Metals concentrations with the exception of lead have consistently been below Iowa standards and national criteria. Limited sampling precludes conclusions concerning lead concentrations in the Upper Iowa River. Limited pesticide analysis has shown no apparent problems.

<u>Physical Modifications</u>: Suspended sediments and other materials result in high turbidity, particularly in the lower portion of the river during heavy runoff periods. The turbidity comes from natural erosion and agricultural practices.

<u>Eutrophication Potential</u>: Phosphate seems to be the limiting nutrient for algal activity. Dissolved oxygen concentrations fluctuate with photosynthetic activity, but reaeration maintains oxygen levels well above critical levels.

<u>Salinity, Acidity, and Alkalinity</u>: The chloride concentrations increase and the alkalinity and total hardness

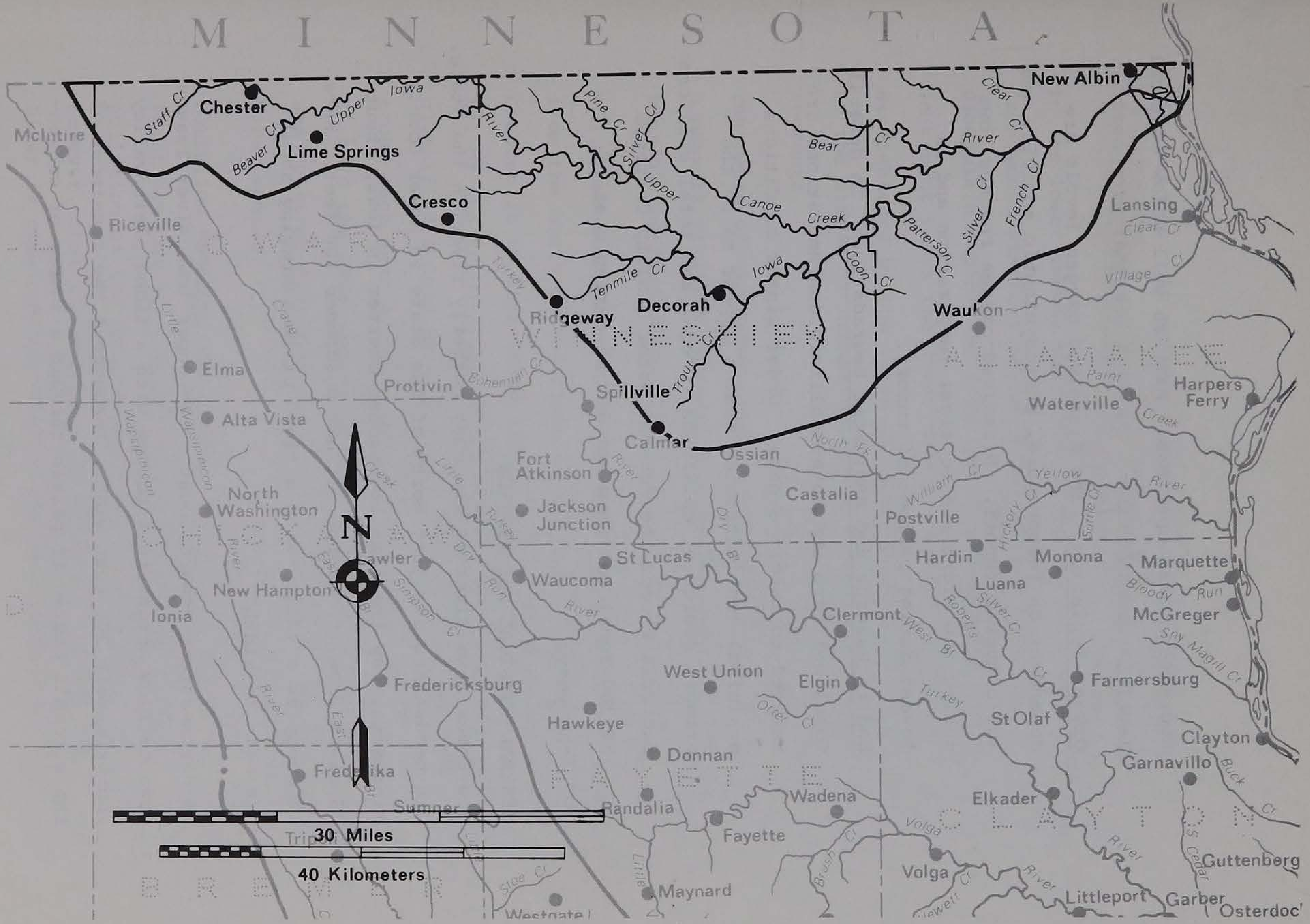


FIGURE II-13 UPPER IOWA RIVER BASIN

decrease moving upstream. All are well below critical levels.

Oxygen Depletion: The dissolved oxygen levels are dependent on temperature, photosynthetic activity and agricultural runoff. Dissolved oxygen reaches lows during the night due to algal respiration and is lowest during periods of runoff.

Health Hazards and Aesthetic Degradation: In general fecal coliform and total coliform concentrations are related to runoff events. Under winter conditions municipal and industrial wastes appear to be the primary source of coliforms. Fecal and total coliform bacteria exceed the Federal Water Quality Criteria of 200 fecal coliform per 100 ml during most of the year.

GENERAL PHYSICAL DESCRIPTION

The Upper Iowa River is the most notherly river in the State. Its headwaters are just north of the State in Mower County, Minnesota. By the time it reaches Chester in Iowa, about 25 miles from its source, it has descended 100 feet. Here it occupies a valley with a flood plain averaging about 1/4 mile in width.

In northeastern Howard County, the Upper Iowa River leaves Iowa to flow across rock bottom with a flood plain valley approximately 300 feet wide. Throughout the remainder of the stream's course it passes through a number of canyon-like reaches. In western Allamakee County the stream is often more than 450 feet below the general topography.

In the lower twenty miles the slope of the river decreases from about six feet per mile to two feet per mile. The floodplain expands to from one-half to one mile in width. In recent years the lower section of the river has been straightened by the Corps of Engineers and the character of the stream is dramatically different from the upstream segments.

The mouth of the river enters the Mississippi River in a network of lakes, sloughs and bayous along the western bank of the Mississippi.

The Upper Iowa River is classified Class A and B Warm Water from the mouth of the river to Decorah. From Decorah to Chester it is classified Class A and B Cold Water. Nearly all of the tributaries to the Upper Iowa River are also classified B Cold Water. These streams are stocked with trout each year by the Iowa Conservation Commission. In 1970 the Iowa General Assembly established the Iowa Scenic River System of which the Upper Iowa became the first member.

POLLUTION PROBLEMS AND SOURCES

Point sources and nonpoint sources both contribute to the pollution of the Upper Iowa River. It should be noted, however, that the magnitude of pollution on the Upper Iowa River is considerably smaller than any other major river in the State.

Nonpoint sources account for the major pollution, including elevated BOD, fecal coliform, nitrates and turbidity during storm runoff. Data available show direct correlation between these parameters and flow. Dissolved oxygen data has an inverse relationship with flow, as seen from the lower dissolved oxygen values at higher flows.

Point sources also contribute significantly to the total and fecal coliform concentrations. The impact of these parameters below waste treatment plants is noticed only during relatively low flow conditions. Runoff obscures point source fecal coliform during rainfall periods. The lack of correlation between flow and phosphate suggests that this nutrient is also largely contributed by point sources, however, the low levels found in the Upper Iowa River make this difficult to verify. The two largest point sources in the Upper Iowa River basin are the cities of Decorah and Cresco. Decorah lies along the river near the center of the basin. Cresco lies off the river at the divide of the Turkey and Upper Iowa basins. The wastes from Cresco are diluted significantly prior to entering the Upper Iowa River itself. There are several smaller communities and creameries which also discharge into the Upper Iowa. The only discharge which produced noticeable effects was Decorah. Fecal coliform, particularly in the winter, could be traced several miles downstream from the city. Samples collected by McMullen (1972) from the various point sources indicated that Decorah contributed nearly 50% of the orthophosphate, ammonia, BOD, nitrate, and chloride from all point sources along the river.

DATA AND METHODS

All data, except metals and pesticides, used in this study were collected during the one year period of 1971. The data were collected and analyzed by the University of Iowa in Iowa City. Methods of analysis were in strict accordance with Standard Methods.

WATER QUALITY CONDITIONS

Harmful Substances

Limited metals have been analyzed on the Upper Iowa River. Only lead has been found in excess of Iowa water quality limitations. Heavy metals may result from land runoff or from industrial discharges to the river. The only metal industry on the Upper Iowa River is in Decorah.

Pesticide data show the infrequent presence of DDT and dieldrin (Table II-12). Concentrations of the pollutants are near the maximum levels recommended by the National Academy of Science, however, they were found only near the limits of detection and usually were not detected.

In general the Upper Iowa River is free of harmful or objectionable substances. Those pollutants found are well below levels routinely found elsewhere in the State.

Physical Modification

Perhaps the most serious pollution problem on the Upper Iowa River is the high turbidity associated with heavy runoff from the agricultural lands. While turbidity rapidly decreases after runoff it contributes to the nutrient and organic loading and detracts from the clear waters present during normal flows.

Chloride concentrations rose significantly from the mouth to the headwaters. This was attributed to the marsh conditions near the headwaters and a general dilution going downstream. (McMullen, 1972).

Eutrophication Potential

As discussed previously phosphates appear to be the limiting nutrient to algal growth. In addition, all of the nitrogen compound concentrations were directly related to flow indicating agricultural origin. Algal studies conducted by McMullen (1972) indicate diatoms are the predominant form. The diatoms are found in high concentrations, but are still considerably below concentrations found in other Iowa streams during the same period of time (McMullen, 1972).

TABLE II-12

PESTICIDES IN THE UPPER IOWA RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	9	0	-	-
DDT	12	1	7	7
Dieldrin	12	2	6	6

TABLE II-13

HEAVY METALS IN THE UPPER IOWA RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	9	0		
Ba	13	10	230	900
Cd	13	0		
Cr	15	0		
Cu	13	0		
Pb	13	2	220	420
Mn	9	4	23	50
Hg	5	0		
Ni	11	0		
Ag	7	0		
Zn	13	7	113	210

Salinity, Acidity, and Alkalinity

Water quality along the river is good, with pH generally between 7.0 and 8.2. Chlorides range from 4 to 11 mg/l. Alkalinity levels range from 80 to 260 mg/l.

Oxygen Depletion

Dissolved oxygen levels were near or above saturation throughout the sampling periods. Dissolved oxygen shows supersaturation during algal blooms following nutrient inputs from runoff,and decreases to equilibrium with stream reaeration during the night. The minimum dissolved oxygen found by McMullen (1972) was 6.3 mg/l.

Health Hazards and Aesthetic Degradation

Total and fecal coliform concentrations are generally above Federal recreational criteria established for contact recreational waters. Violations of Iowa Water Quality Standards for recreational water were exceeded for only short stretches below Decorah.

Tributaries

Because of the classification of many of the tributaries of the Upper Iowa River as B Cold Water streams, a separate section was devoted to them. There is little data on tributaries of any of Iowa's main rivers. What data are available on the Upper Iowa come from studies conducted by the University of Iowa.

TABLE II-14

UPPER IOWA RIVER TRIBUTARY WATER QUALITY

STREAM	ORTHOPHOSPHATE (mg/l)	NITRATE NO_3-N (mg/l)	CHLORIDE Cl (mg/l)
French Creek	0.0	1.37	1.70
Silver Creek (Allamakee Co.)	0.1	0.95	2.0
Patterson Creek	0.0	0.90	3.87
Trout Creek (Sec 9, T98N, R7W)	0.8	1.95	4.70
Trout Creek (Sec 23, T98N, R8W)	0.8	1.73	4.00
Dry Creek	0.4	3.03	5.83
Ten Mile Creek	0.4	1.13	6.33
Silver Creek (Winneshiek Co.)	4.87	3.67	25.16
Beaver Creek (So. of Upper Iowa)	0.8	1.80	9.17
Staff Creek	0.0	1.47	10.30
Little Iowa River	0.0	1.73	10.83
Beaver Creek (Minnesota)	0.0	1.73	8.50
Bigalk Creek	0.2	2.90	5.33
Coldwater Creek	0.3	2.97	6.5
Pine Creek	0.3	0.93	6.17
Silver Creek (Winneshiek Co.)	0.3	1.30	6.33
Canoe Creek	0.4	1.40	3.0
Bear Creek	0.1	1.98	3.2
Clear Creek	0.2	1.07	4.33

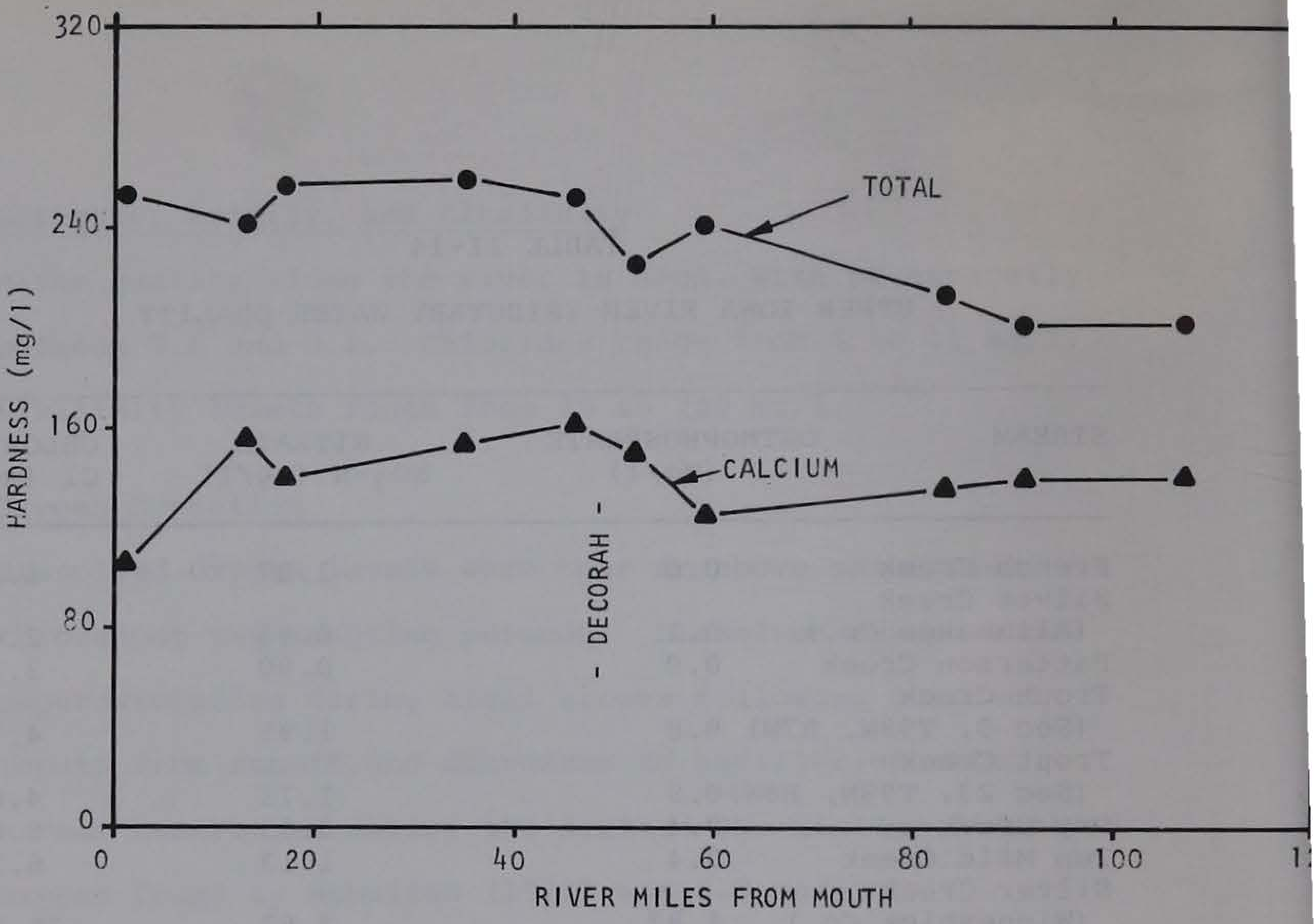


FIGURE 11-14 UPPER IOWA RIVER[1] 1970-1974 MEAN HARDNESS
[1](McMULLEN, 1972)

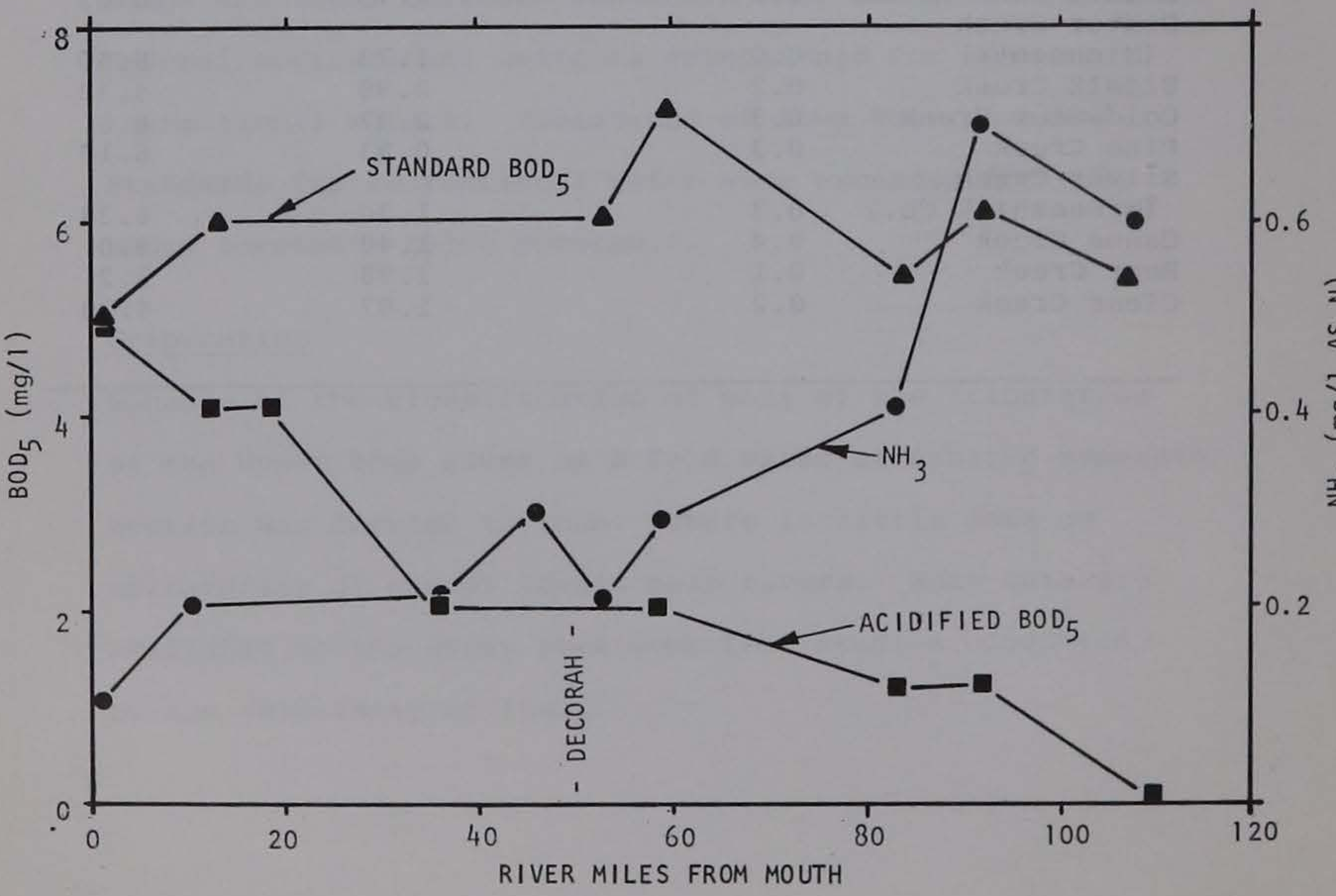


FIGURE 11-15 UPPER IOWA RIVER[1] 1970-1974 AMMONIA AND BOD$_5$ CONCENTRATION [1](McMULLEN, 1972)

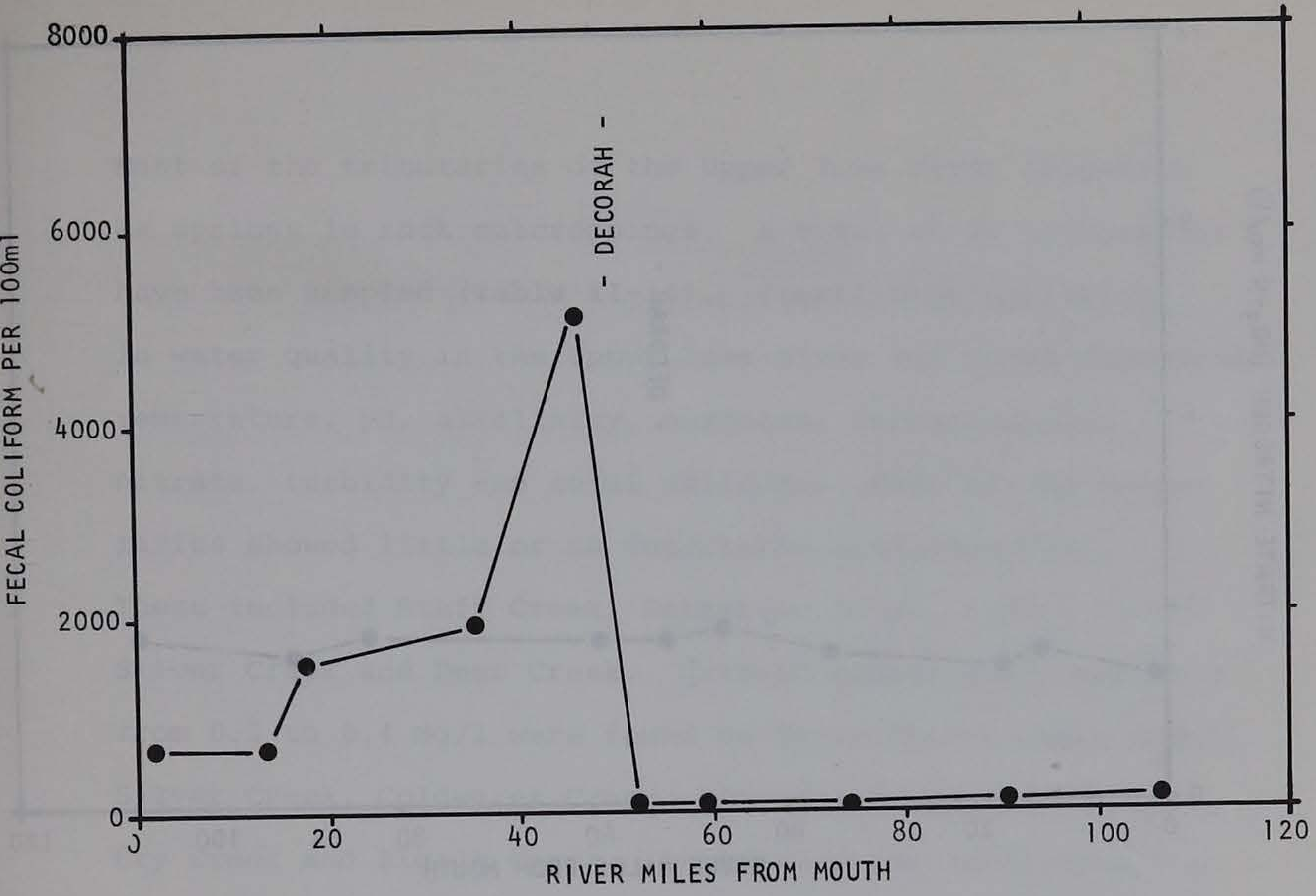


FIGURE 11-16 MEAN FECAL COLIFORM CONCENTRATIONS IN THE UPPER IOWA RIVER 1970-1974 [1] (McMULLEN, 1972)

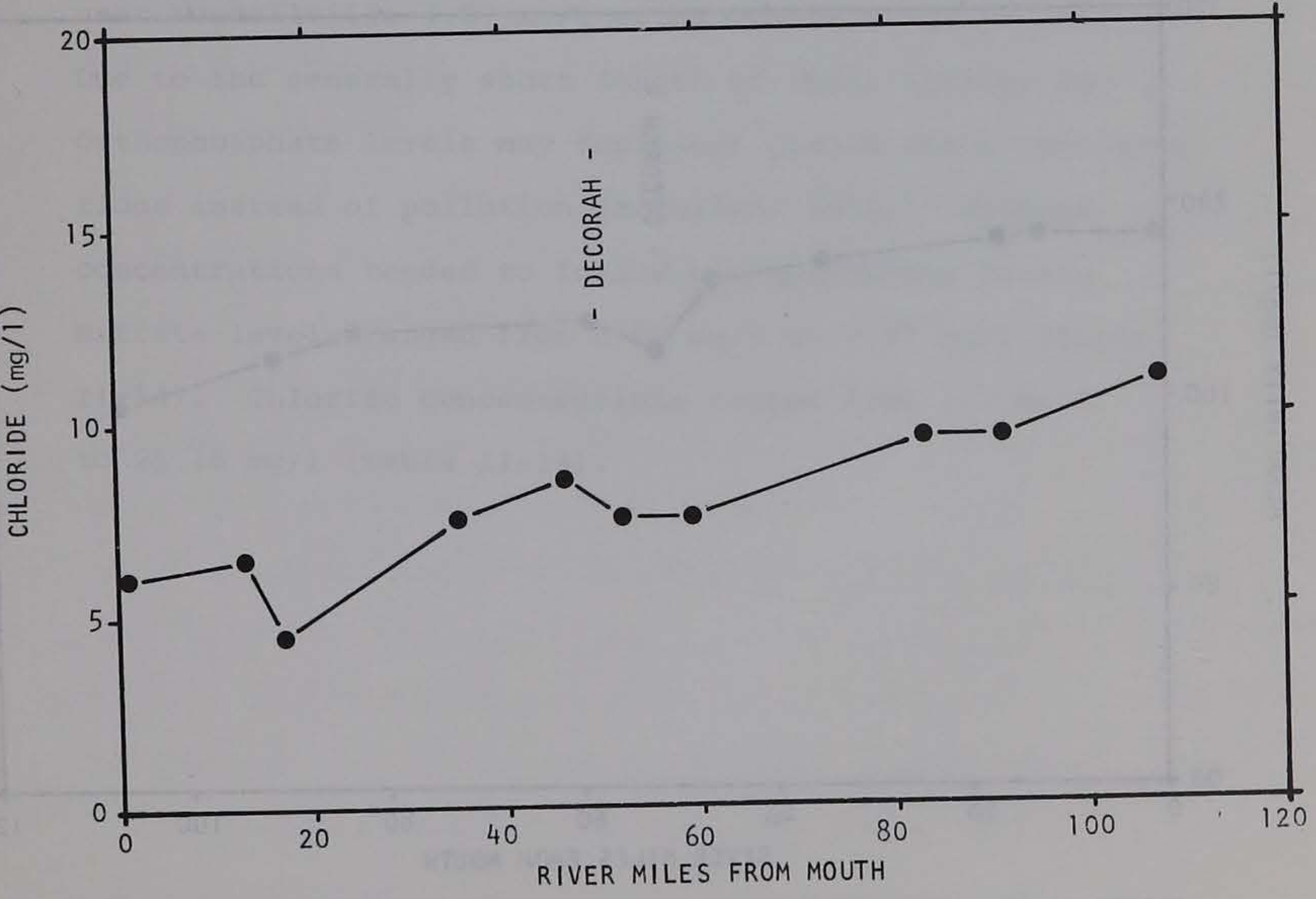


FIGURE 11-17 MEAN CHLORIDE CONCENTRATIONS IN THE UPPER IOWA RIVER 1970-1974 [1] (McMULLEN, 1972)

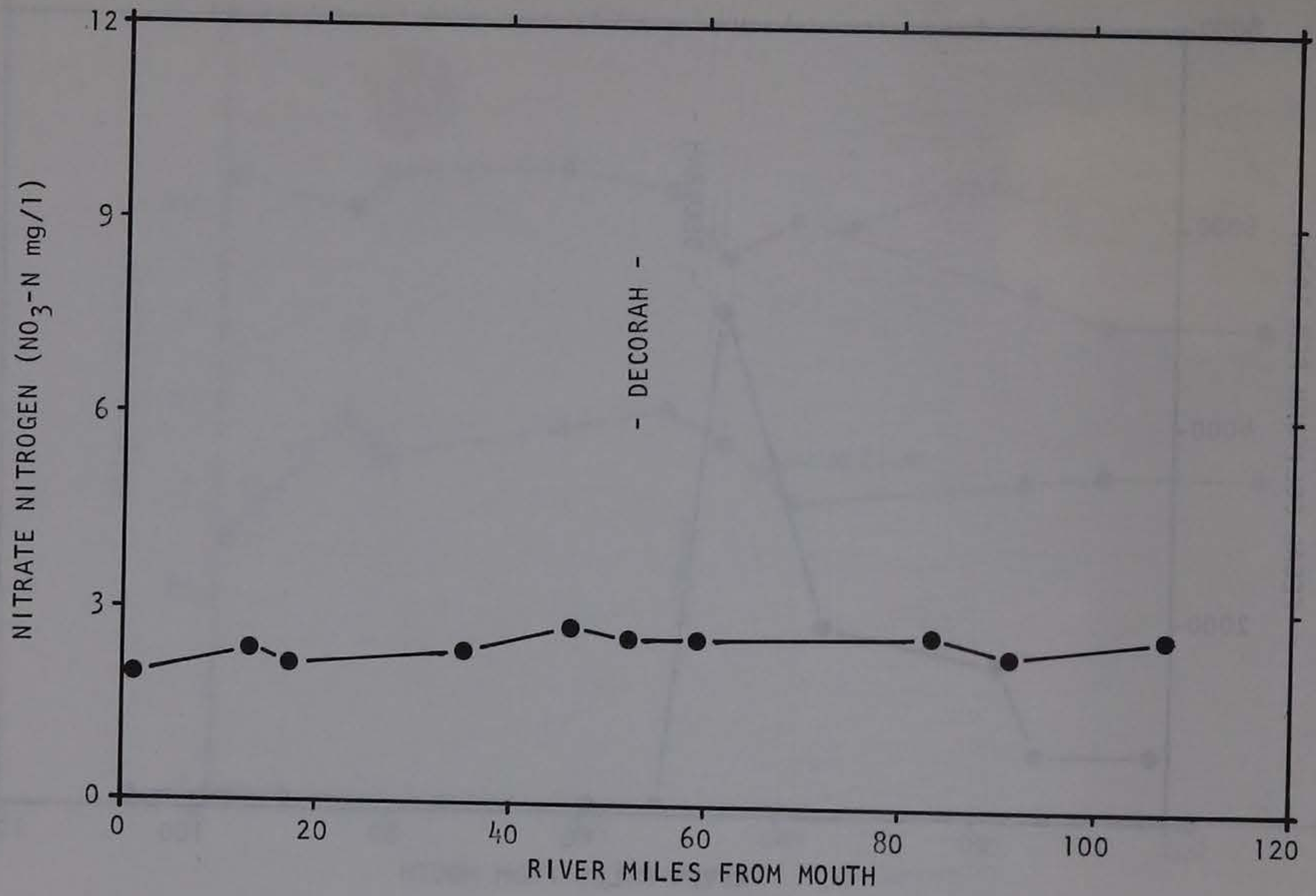


FIGURE 11-18 MEAN NITRATE NITROGEN CONCENTRATIONS IN THE UPPER IOWA RIVER 1970-1974 [1] (McMULLEN, 1972)

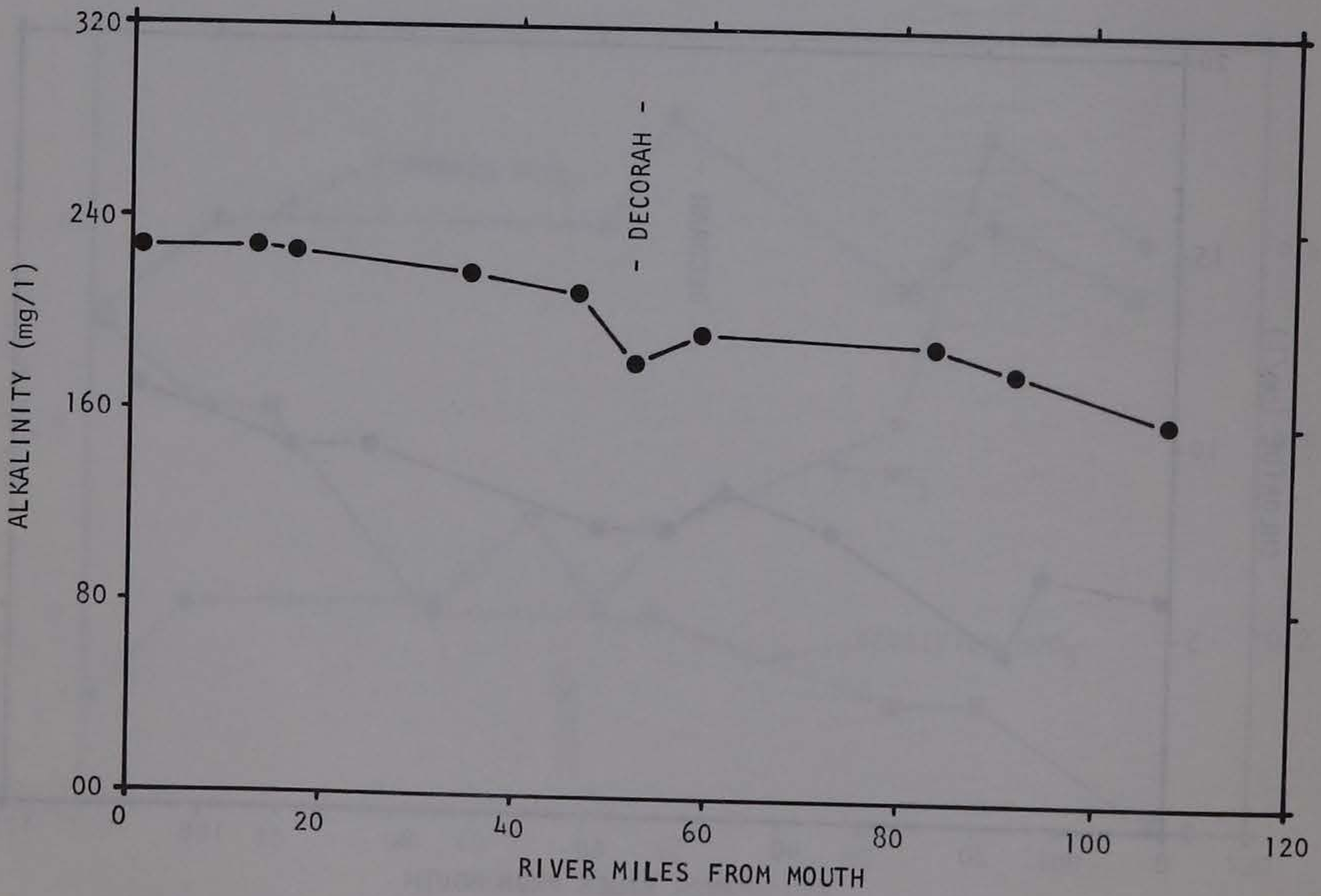


FIGURE 11-19 MEAN ALKALINITY CONCENTRATIONS IN THE UPPER IOWA RIVER 1970-1974 [1] (McMULLEN, 1972)

Most of the tributaries of the Upper Iowa River originate as springs in rock outcroppings. A total of 20 tributaries have been sampled (Table II-14). Significant variation in water quality in the Upper Iowa River was noted regarding temperature, pH, alkalinity, hardness, orthophosphate, nitrate, turbidity and total coliform. Many of the tributaries showed little or no detectable orthophosphate. These included Staff Creek, Patterson Creek, French Creek, Silver Creek and Deer Creek. Orthophosphate concentrations from 0.2 to 0.4 mg/l were found on Clear Creek, Canoe Creek, Silver Creek, Coldwater Creek, Pine Creek, Ten Mile Creek, Dry Creek and Bigalk Creek. Orthophosphate concentrations of 0.8 mg/l were found in Trout Creek (Sec. 9, T98N, R7W) and Trout Creek (Sec. 23, T98N, R8W). In Silver Creek near Kendallville 4.87 mg/l orthophosphate was present. Due to the generally short length of these streams the orthophosphate levels may represent ground water concentrations instead of pollution (McMullen, 1972). Nitrate concentrations tended to follow orthophosphate levels. Nitrate levels ranged from 0.90 mg/l to 3.67 mg/l (Table II-14). Chloride concentrations ranged from 1.7 mg/l to 25.16 mg/l (Table II-14).

MAQUOKETA RIVER

In spite of several significant point sources, water quality on the Maquoketa River is quite good. Water in many areas flows over sand and rock bottoms which are visible from the water's surface. Nutrients in some areas appear limiting, and adequate dissolved oxygen is available. Water quality below the cities of Manchester and Maquoketa is adversely effected but, except under ice cover or low flow, appears to quickly recover.

The following parameters highlight water quality on the Maquoketa:

Harmful Substances: No pesticide data are available on the Maquoketa River. Data from other basins suggest nonpoint sources do contribute pesticides to the river during runoff. Heavy metals have not been found to violate Iowa standards.

Physical Modification: Turbidity is higher on the North Fork than on the South Fork. While nonpoint sources may cause turbidity problems during runoff they appear less serious than in most areas of the State based on the limited data available. No temperature problems have been noted.

Salinity, Acidity, and Alkalinity: Salinity and chloride effects below Manchester present a serious problem. Total dissolved solids and chlorides at this point are among the highest in the State and

FIGURE II-20 MAQUOKETA RIVER BASIN

are considerably elevated above background levels. No problems with salinity or acidity have been noted elsewhere.

Eutrophication Potential: Nutrient concentrations on the South Fork below the main point sources may cause algal blooms. Above point sources phosphate may be limiting at times. Concentrations on the North Fork are more dependent upon nonpoint sources and reach maximums during runoff. During lower stream flows phosphates may be limiting on this branch as well.

Oxygen Depletion: While no violations of dissolved oxygen criteria have occurred in samples collected since 1970, oxygen concentrations decrease below Manchester and Maquoketa. Elevated ammonia concentrations below point sources are potentially toxic to fish depending on pH, duration, magnitude, and temperature.

Health Hazards and Aesthetic Degradation: Point sources cause high fecal coliform concentrations downstream of their discharge. This is a greater potential problem below Manchester, which is above the Lake Delhi impoundment. Elsewhere concentrations are generally near the 200/100ml suggested levels of the Environmental Protection Agency (EPA). Nonpoint sources also contribute fecal coliform during runoff.

GENERAL PHYSICAL DESCRIPTION

The Maquoketa River rises in the southeastern corner of Fayette County at an elevation of about 1,160 feet. It flows in a southeasterly direction to the vicinity of Maquoketa, then easterly and northeasterly to join the Mississippi River near Green Island at an elevation of 584 feet. The river's length is 134 miles and its drainage area is 1,879 square miles. The principal tributary of the Maquoketa River is the North Fork, a stream draining 587 square miles and joining the main river 30 miles above its mouth. The North Fork falls about 536 feet in a distance of 72 miles.

The Maquoketa River rises in the slightly dissected Iowan drift plain of Fayette County and flows in a shallow valley only 15 to 30 feet below the summits of the plain. This characteristic persists across the northeast corner of Buchanan County, but shortly after entering northwestern Delaware County the stream swings in a gigantic loop through Backbone State Park, among rugged bluffs of Niagaran dolomite, some over 140 feet high. Richmond Springs, the largest in Iowa, are developed here to nourish a large trout and bass hatchery maintained by the State. About three miles below Richmond Springs the Maquoketa River leaves this gorge and flows through a subdued Iowan drift topography less than 100 feet below the plain. A few miles below Manchester the stream leaves the Iowan drift and enters a canyon which persists throughout much of the remaining length of the stream. Ledges of limestone cross the river in many places and it is bordered by rocky cliffs and well defined terraces. Near Maquoketa the river occupies one of the most scenic sections of its valley, typical of which is Maquoketa Caves State Park, seven miles northwest of Maquoketa, in which are located large limestone caves and Iowa's one natural bridge. In southeastern Jackson County, the river enters the old "Goose Lake Channel", a preglacial channel of the Mississippi River, and follows it northeastward for about eleven river miles to the mouth.

POLLUTION PROBLEMS AND SOURCES

The municipalities of Maquoketa and Manchester are the biggest point sources on the Maquoketa River. Increases in nutrients, fecal coliform, total dissolved solids, turbidity, chlorides, BOD, and COD result from point source discharges to the river. While the river appears to rapidly recover during high stream flow, insufficient studies at low flow are available to determine the overall effect. Nonpoint sources are a somewhat smaller problem than on many rivers in the State.

WATER QUALITY CONDITIONS

Harmful Substances

Considerable concern has been expressed concerning lead pollution in the Maquoketa River below Manchester. The recent addition of a battery manufacturer with heavy metal wastes to the community has caused a considerable amount of study on heavy metals in the river in the last two years. Background data collected to date, prior to discharge of any heavy metal waste, indicate no problem with heavy metals. Concentrations of most heavy metals including lead, have been at or near the limits of detection. The maximum concentration of lead found to date is 70 µg/l, which is less than Iowa's Water Quality Standard of 100 µg/l. Other metals below Iowa's limitations that have been detected include barium, chromium, copper, manganese and zinc. The highest heavy metal concentrations found to date are for barium and zinc, 0.7 mg/l and 0.71 mg/l respectively (Table II-15).

TABLE II-15

HEAVY METALS IN THE MAQUOKETA RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	11	0		
Ba	29	18	183	700
Cd	29	0		
Cr	33	1	20	20
Cu	29	3	23	30
Pb	32	2	50	70
Mn	9	5	38	50
Hg	19	0		
Ni	25	0		
Ag	23	0		
Zn	29	22	183	710

Physical Modification

Turbidity in the Maquoketa River is the main type of physical modification. The turbidity is primarily a result of nonpoint source runoff. While a problem on both forks, turbidity appears somewhat more severe on the North Fork. Maximum turbidity found to date is slightly below 400 JTU. No studies have been directed specifically at determining the magnitude of nonpoint source problems on the Maquoketa and samples have not been collected during critical high flow runoff periods.

Salinity, Acidity, and Alkalinity

Salinity problems below Manchester are potentially among the most significant in the State. Hide curing operations at Manchester create large volumes of saline waste which is discharged to the municipal treatment plant and hence to the river. Conventional treatment processes are not designed to remove chlorides and other dissolved solids which cause the salinity. The dissolved solids run through the treatment plant and are discharged directly to the river. Total dissolved solids levels above Manchester have been found to be from 150-300 mg/l. Total dissolved solids in the Manchester effluent sometimes exceed 5,000 mg/l. At high stream flows rapid dilution makes the increase to the river undetectable. At low stream flows, however, dilution may be only about five times the volume of waste.

Alkalinity on the South Fork averages about 175 mg/l and that on the North Fork, somewhat higher, near 275 mg/l.

Eutrophication Potential

Where water quality is not influenced by point sources nutrients show similar patterns in both the North Fork and South Fork. Nitrates are abundant, usually 2.5 - 4.0 mg/l. Phosphate concentrations are quite low, usually near 0.1 mg/l or less total phosphate. Nutrient levels increase with flow indicating their probable nonpoint source origin.

Nitrate levels below Manchester and Maquoketa, remain adequate for algal growth, and phosphate concentrations increase. Maximum phosphate concentrations are found near the discharge, but are still elevated for several miles downstream. Below Maquoketa, Iowa the North Fork dilutes out much of the impact of the discharge, but below Manchester there is little dilution above the Lake Delhi impoundment. This nutrient addition along with contamination from individual dwellings around the lake and nonpoint source runoff, have caused serious algal blooms in the past within the reservoir.

In spite of some localized problems, nutrient levels in the Maquoketa River are lower than most Iowa rivers. This is due partly to the smaller drainage area, and the smaller number of point sources.

Oxygen Depletion

No dissolved oxygen violations have been found in the samples analyzed since 1970. While several point sources add substantial loading to the river, little effect has been seen. The Maquoketa River has been able to assimilate the oxygen demand quickly and has had adequate reaeration. Flows in recent years, however, have been well above minimum flow levels which would be critical for dissolved oxygen. Numerous riffle areas, kept ice free by turbulence, have provided reaeration necessary for maintenance of adequate dissolved oxygen.

Ammonia nitrogen concentrations may better reflect the problems resulting from point sources. Nine percent of all ammonia nitrogen samples violated the Iowa Water Quality Standard of 2.0 mg/l. Ammonia is toxic to fish near this level. Ammonia also creates an additional oxygen demand in its conversion to nitrate. Improved treatment efficiency and advanced treatment at several of the most important point sources should assure adequate oxygen and lower ammonia concentration on the Maquoketa River.

Health Hazards and Aesthetic Degradation

Fecal coliform levels from point sources and nonpoint sources keep concentrations above 200/100 ml much of the time. Fecal coliform concentrations are high throughout the river during runoff. Concentrations, at other times, are relatively low except below point source discharges. In spite of high concentrations immediately below Manchester, concentrations are at normal background levels before entering the Delhi impoundment. Contact recreation in this area makes fecal coliform concentrations a concern. Limited sampling at Delhi indicates that concentrations may exceed 200/100 ml at times.

MAQUOKETA RIVER TRIBUTARIES

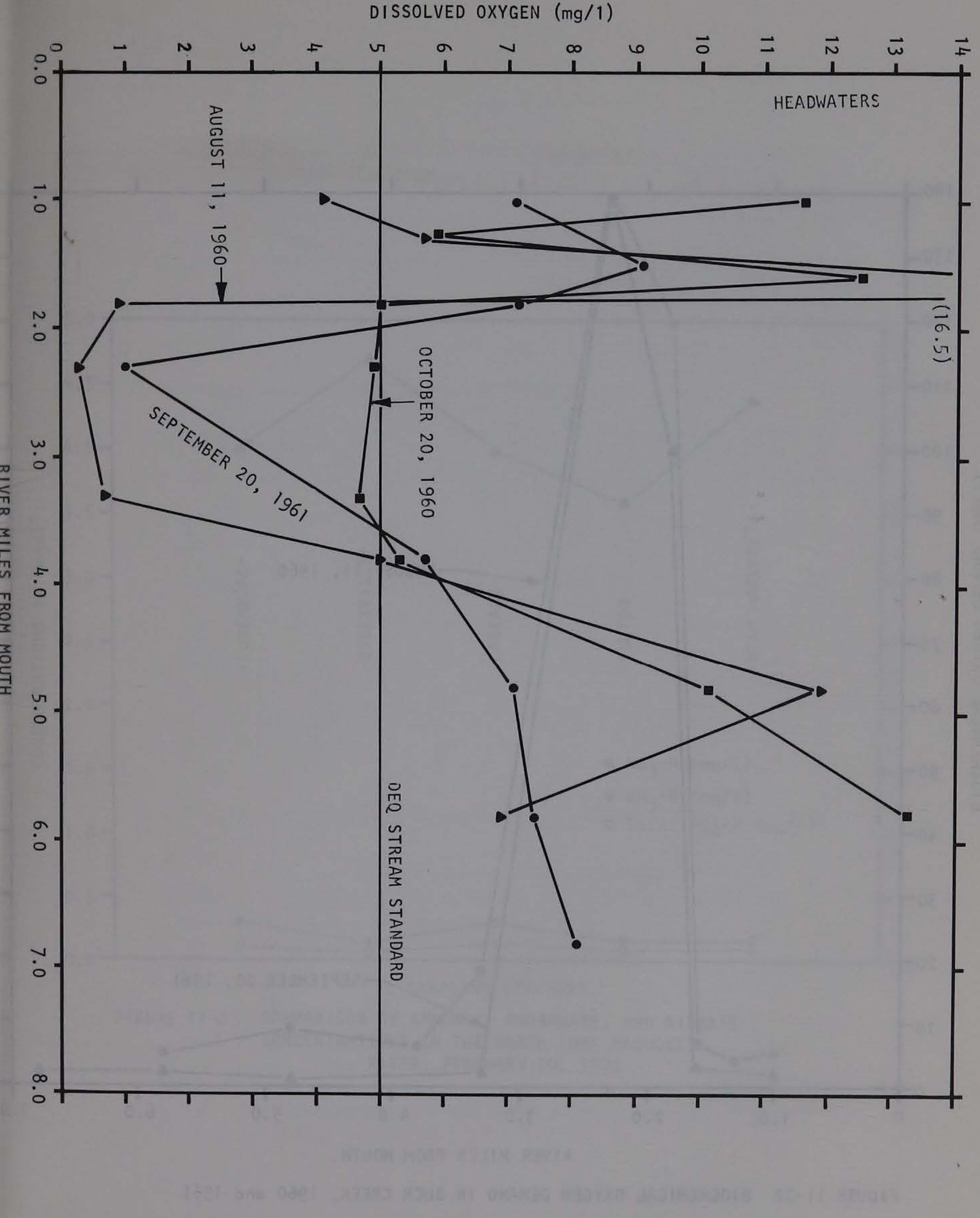
Over fifty tributaries and branches of tributaries to the North and South Fork Maquoketa River are classified by the Iowa Department of Environmental Quality; three are cold water fisheries, the rest are warm water fisheries. Sampling data since 1970 is not available on any of them. Surveys were conducted on two of them in the late 1950's and early 1960's concerning pollution problems.

Pollution studies on Farmer's Creek, tributary to the North Fork Maquoketa River, were conducted in 1957, 1958, and 1959. Pollution caused by creamery and sawmill discharges near La Motte, Iowa seriously degraded the stream at the time. Sludge deposits, sawdust, odor, and color problems are documented. Solids, fungus and odor appeared to be predominant in the stream. While no recent problems have been documented there are no data available to indicate the current water quality of this stream.

Pollution studies on Buck Creek, tributary to the South Fork Maquoketa River, were conducted in 1960 and 1961. Pollution was caused by the discharge of creamery wastes near Ryan.

Again sludge deposits, fungus growth, coliform bacteria and odor were problems. Data indicated, however, that the stream recovered prior to discharge into the Maquoketa River (Figures II-21 & 22). The creamery and the town of Ryan are currently served by a roughing trickling filter and lagoon. Current discharges, while below early 1960's levels, are still inadequate to protect the stream and continued pollution probably exists. No current water quality data is available for comparison.

No data has been collected by the DEQ, the State Hygienic Laboratory, or any university, as far as is known on the other tributaries of the Maquoketa River.


DISSOLVED OXYGEN (mg/1)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
RIVER MILES FROM MOUTH
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
HEADWATERS
AUGUST 11, 1960
(16.5)
OCTOBER 20, 1960
SEPTEMBER 20, 1961
DEQ STREAM STANDARD

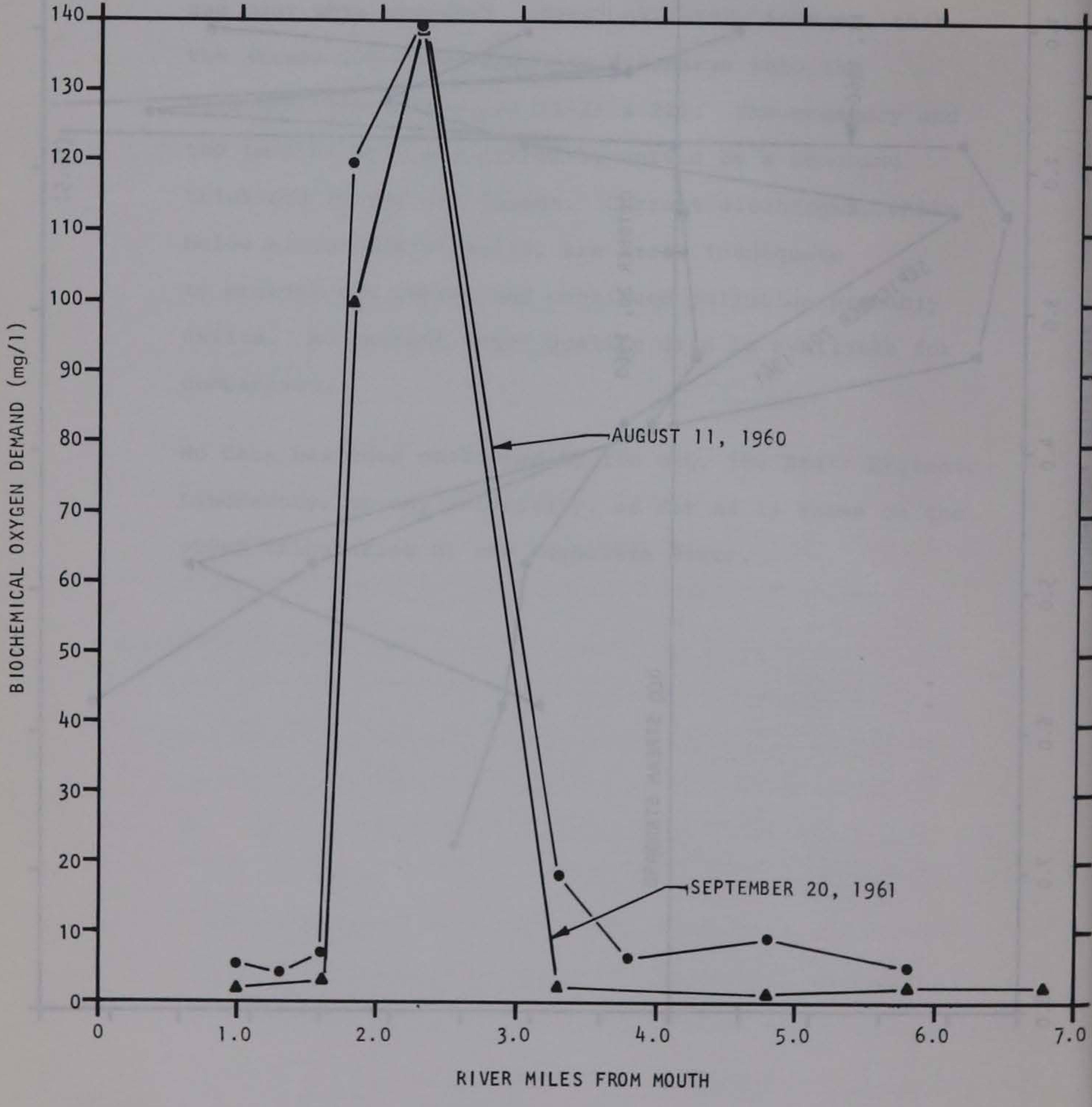


FIGURE 11-22 BIOCHEMICAL OXYGEN DEMAND IN BUCK CREEK, 1960 and 1961

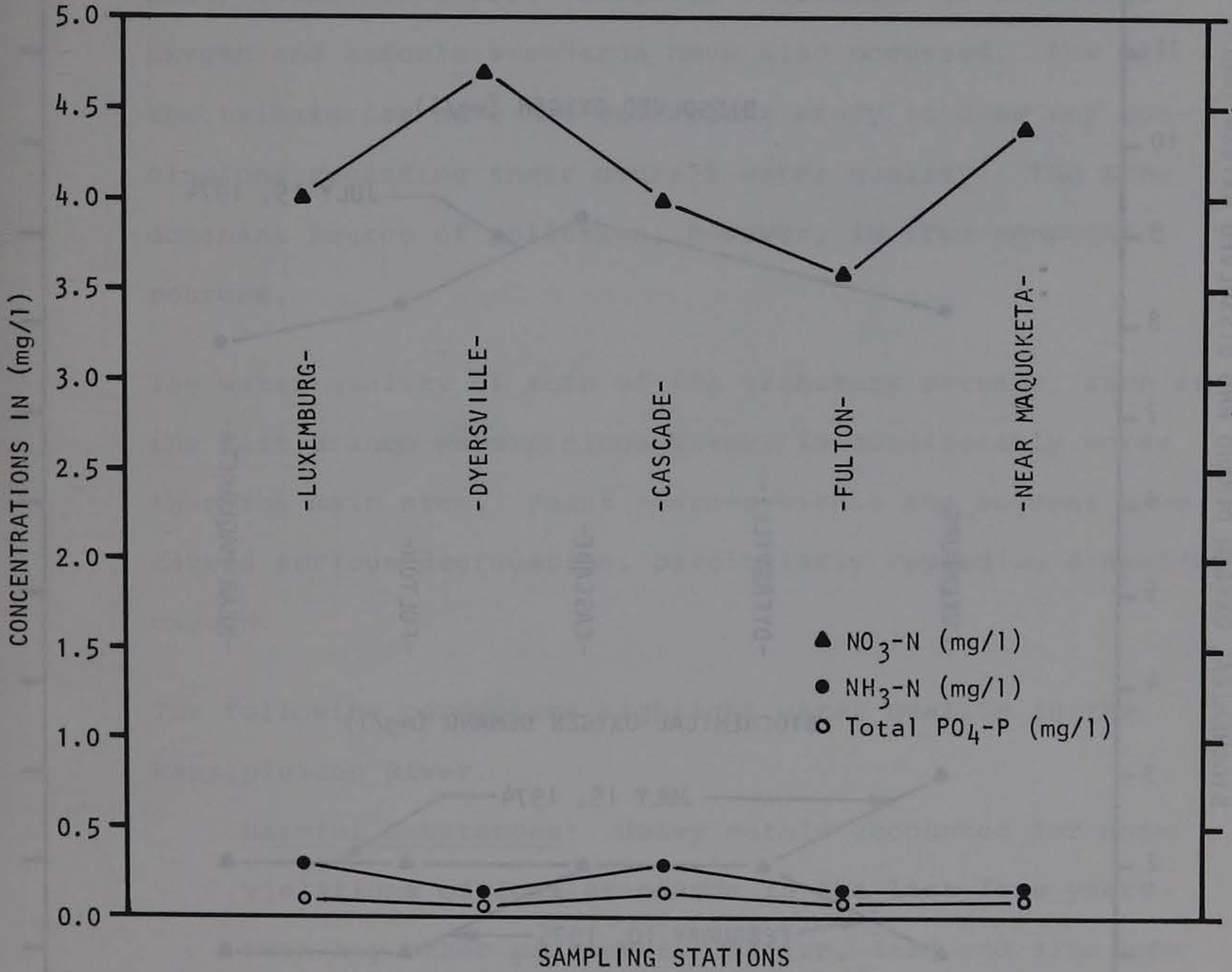


FIGURE II-23 COMPARISON OF AMMONIA, PHOSPHATE, AND NITRATE CONCENTRATIONS IN THE NORTH FORK MAQUOKETA RIVER, FEBRUARY 10, 1975

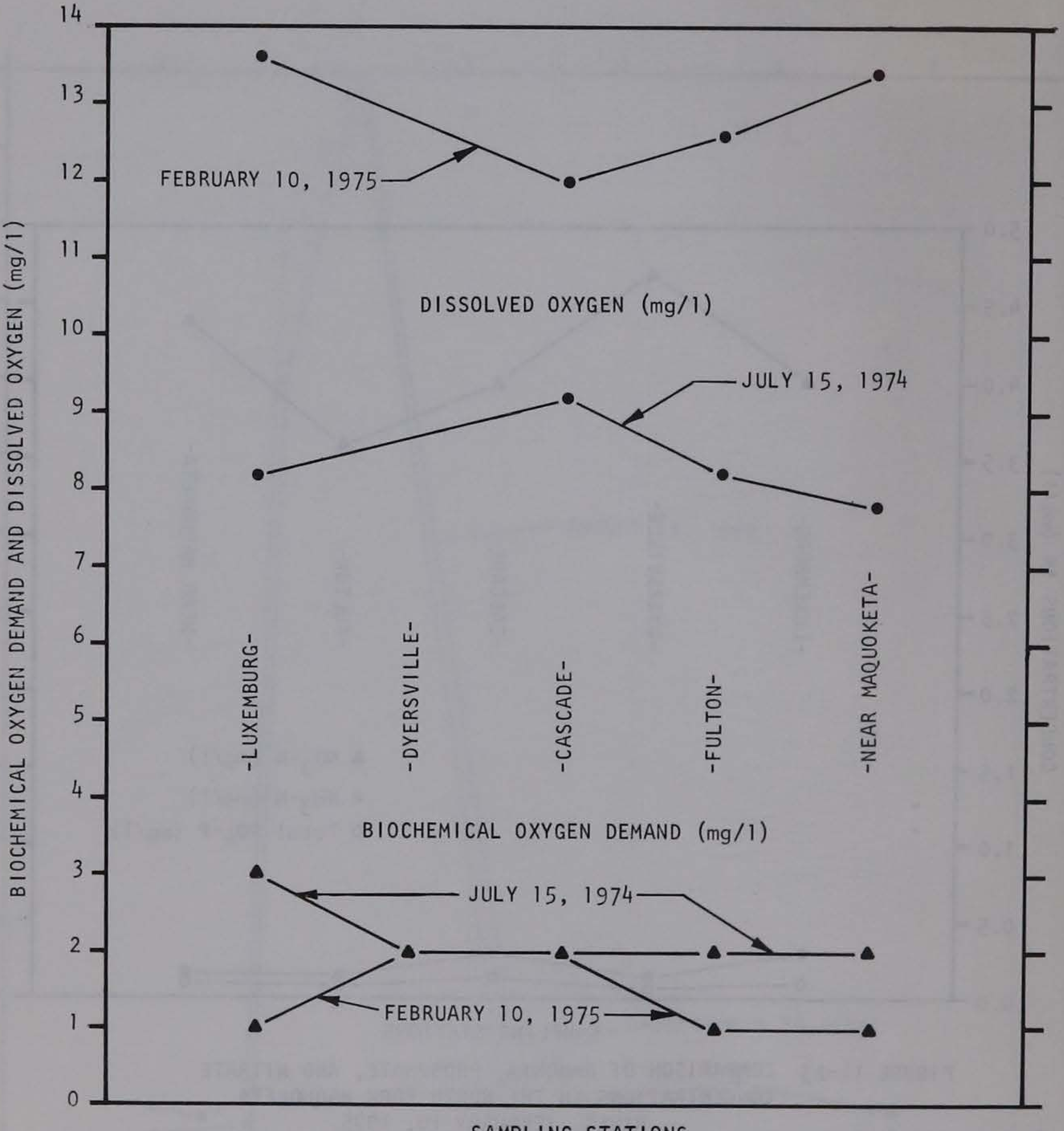


FIGURE 11-24 DISSOLVED OXYGEN AND BOD CONCENTRATIONS IN THE NORTH FORK MAQUOKETA RIVER, JULY 15, 1974 AND FEBRUARY 10, 1975

WAPSIPINICON RIVER

Water quality in the Wapsipinicon River is generally good. Very few violations of Iowa Water Quality Standards have occurred. The most common have been violations of the heavy metal standards. Isolated violations of dissolved oxygen and ammonia standards have also occurred. Few of the tributaries have had sufficient study to draw any conclusions regarding their overall water quality. The predominant source of pollution, however, is from nonpoint sources.

The water quality of some of the tributary streams, such as the East Branch Wapsipinicon River, is considerably worse than the main stem. Point sources within the segment have caused serious degradation, particularly regarding dissolved oxygen.

The following parameters highlight water quality in the Wapsipinicon River.

> <u>Harmful Substances</u>: Heavy metals accounted for more violations of Iowa standards in the last five years than any other parameter. Barium, lead and zinc have all violated standards. A lack of industrial point sources leads to the assumption that unusual nonpoint sources or unknown point sources are causing these high levels.

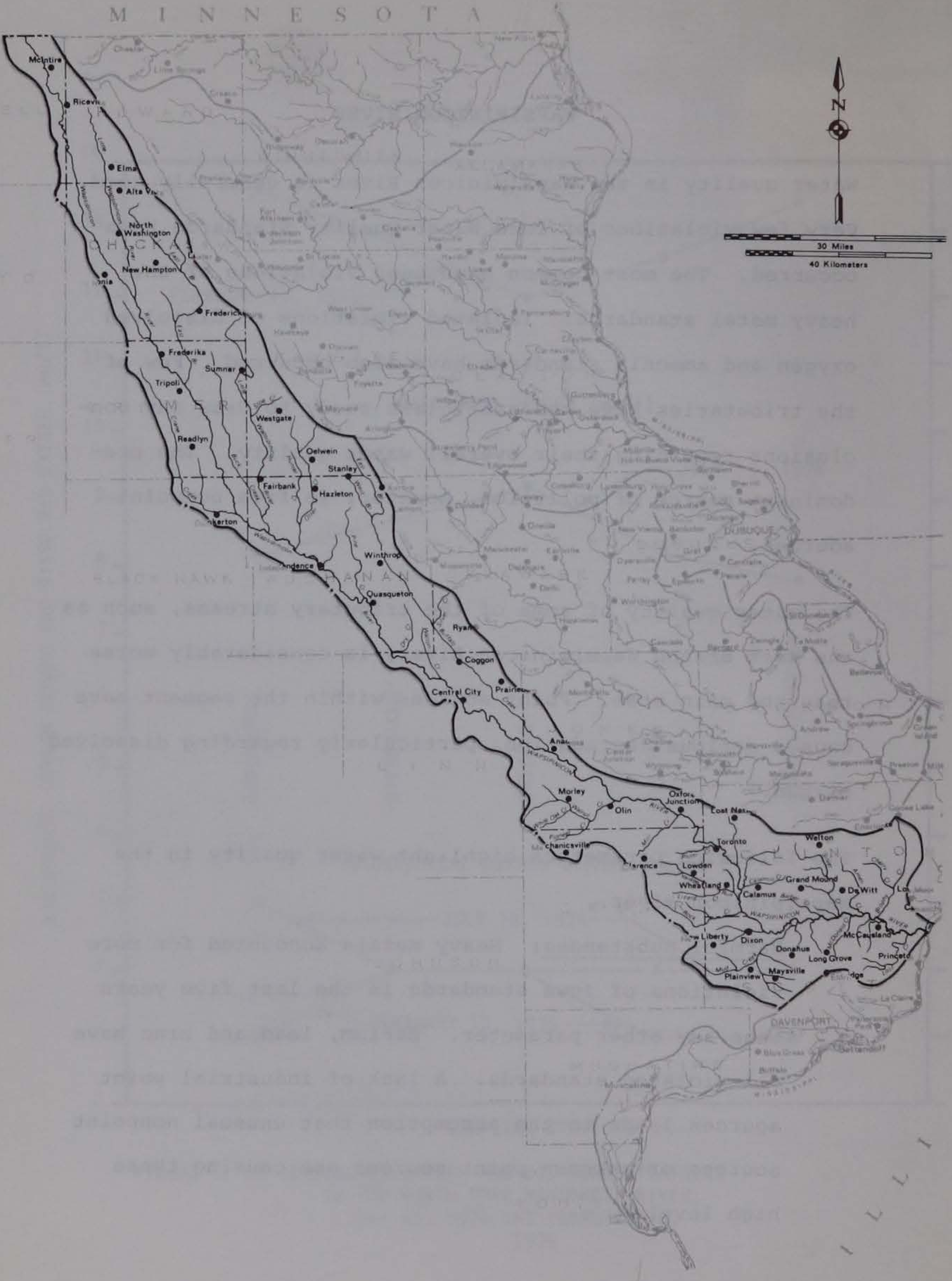


FIGURE II-25 WAPSIPINICON RIVER BASIN

Physical Modification: Turbidity resulting from non-point source runoff is the main problem regarding physical modification. While the magnitude is less than western Iowa streams, turbidity has been found as high as 990 JTUs.

Salinity, Acidity, and Alkalinity: Total dissolved solids violations have not occurred in the Wapsipinicon River. Acidity is within normal ranges.

Eutrophication Potential: Nitrate is present in large amounts. Minimums seem to occur during low flow periods. Phosphates are found in much smaller amounts. Highest phosphate concentrations occur during runoff periods and correspond to high turbidity.

Oxygen Depletion: The biggest problems concerning dissolved oxygen deficiencies have occurred on some of the tributary streams, notably the East Branch Wapsipinicon River and the Spring Branch. Point sources discharging high BOD loadings are the main problems.

Health Hazards and Aesthetic Degradation: Fecal coliform concentrations have generally been below 200/100 ml. Concentrations increase dramatically during runoff periods. Smaller increases can also be seen below municipal dischargers.

GENERAL PHYSICAL DESCRIPTION

The Wapsipinicon River, southern-most of the streams of northeast Iowa, is the largest and longest of the group. It rises in southeastern Mower County, Minnesota, not far from the head of the Upper Iowa River, at an elevation of 1,250 feet, and flows southeastward for a distance of 225 miles, to join the Mississippi at an elevation of 565 feet, 12 miles below Clinton. The watershed comprises 2,540 square miles, of which all but ten are in Iowa. The basin is very narrow, averaging only ten miles in width, with a maximum width of twenty miles in Clinton and Scott counties. There is only one major tributary, Buffalo Creek, which drains 232 square miles and joins the main stream at Anamosa.

Only in a few places is the topography of this basin as rugged as parts of the other stream basins of this area. Throughout most of its length the Wapsipinicon River flows through young glacial plains which have undergone only slight to moderate modification by geologic erosion. In Jones and Linn counties it flows through areas of Kansan topography, only to reenter the younger Iowan and Illinoian drift in its lower reaches.

In its upper basin the Wapsipinicon is a typical drift-prairie stream flowing through broad sags not very much depressed below adjacent plains. Downstream the valley becomes deeper but in only a few places does it take on the rugged aspect so characteristic of the other northeastern Iowa streams. In some areas the valley is as much as two to three miles wide, but narrows to less than one-half mile where resistant bedrock is crossed. Notable exceptions to the drift-prairie nature of the valley are found near Fredericka where the valley narrows and bedrock outcrops occur along the valley wall; at Independence where the stream is confined between rocky bluffs 40 to 100 feet high; near Quasqueton in the rock-bound gorge 100 to 130 feet deep; near Troy Mills in Linn County where it follows a canyon 200-300 feet deep through rocky ridges of Wapsipinicon limestone; at Anamosa where the valley is flanked by bold cliffs of Niagaran dolomite in Wapisipinicon State Park; and through restricted reaches between Olin and Hale, at Massilon, and near Big Rock. These canyon-like reaches are interspersed with longer reaches where the flood plain is wide and the valley is flanked by low, rolling hills. Below Buena Vista the Wapsipinicon meanders through a valley three to four miles wide to the mouth.

POLLUTION PROBLEMS AND SOURCES

The major pollution problems on the Wapsipinicon River are associated with nonpoint sources. Elevated levels of metals, pesticides, bacteria, nutrients, organic material, and solids appear to be connected with runoff conditions. No known point sources could account for the levels of these parameters at high flows, therefore, they have been assumed to be connected with nonpoint sources.

Point sources are significant problems on the tributary streams including East Branch Wapsipinicon, Spring Branch, Otter Creek and Walnut Creek. Dissolved oxygen concentrations and ammonia concentrations are the biggest concern in these areas.

WATER QUALITY PROBLEMS

Harmful Substances

While no pesticide studies have been done directly on the Wapsipinicon, the State Hygienic Laboratory has carried out extensive sampling for pesticides on Jones Creek, a tributary basin in Scott County. Extremely high pesticide levels found in this tributary indicate that nonpoint sources are contributing large amounts of pesticides to the river. No measurements were made on the river itself to provide comparisons with other basins, so it is difficult to determine if pesticides are more prevalent in the Wapsipinicon River or elsewhere. Data from other basins suggest that the problem of pesticides in runoff is statewide and not restricted to any one area.

Heavy metals in the Wapsipinicon River show elevated levels on a number of occasions. Most of the metals data are derived from the quarterly samples collected by the State Hygienic Laboratory near De Witt. Three metals: barium, lead and zinc, have been found at levels in violation of Iowa Water Quality Standards. Barium has been found at detectable levels in most samples collected. In samples with detectable levels the concentration has averaged

0.24 mg/l with a maximum concentration of 1.1 mg/l. Lead has been found in only about 15% of the samples, but it has been in violation of standards each time it was found. Concentrations have averaged 0.5 mg/l when found and the maximum has been 1.3 mg/l. Zinc has also been found in almost all samples. A maximum zinc concentration of 2.2 mg/l has been found. Other metals which have been found in concentrations below standard limitations include copper and manganese.

TABLE II-16

HEAVY METALS IN THE WAPSIPINICON RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	11	0		
Ba	18	14	243	1100
Cd	18	0		
Cr	18	0		
Cu	18	2	10	10
Pb	18	3	500	1300
Mn	18	9	39	50
Hg	1	0		
Ni	18	0		
Ag	12	0		
Zn	18	14	163	2200

Physical Modification

Limited data is available on physical modification in the Wapsipinicon River. Surveys conducted to date have shown wide fluctuations in turbidity. This would be expected due to the nature of the source and the occurance of rainfall and runoff. Maximum concentrations of 990 JTU's have been observed in the upper portion of the river (Figure II-26).

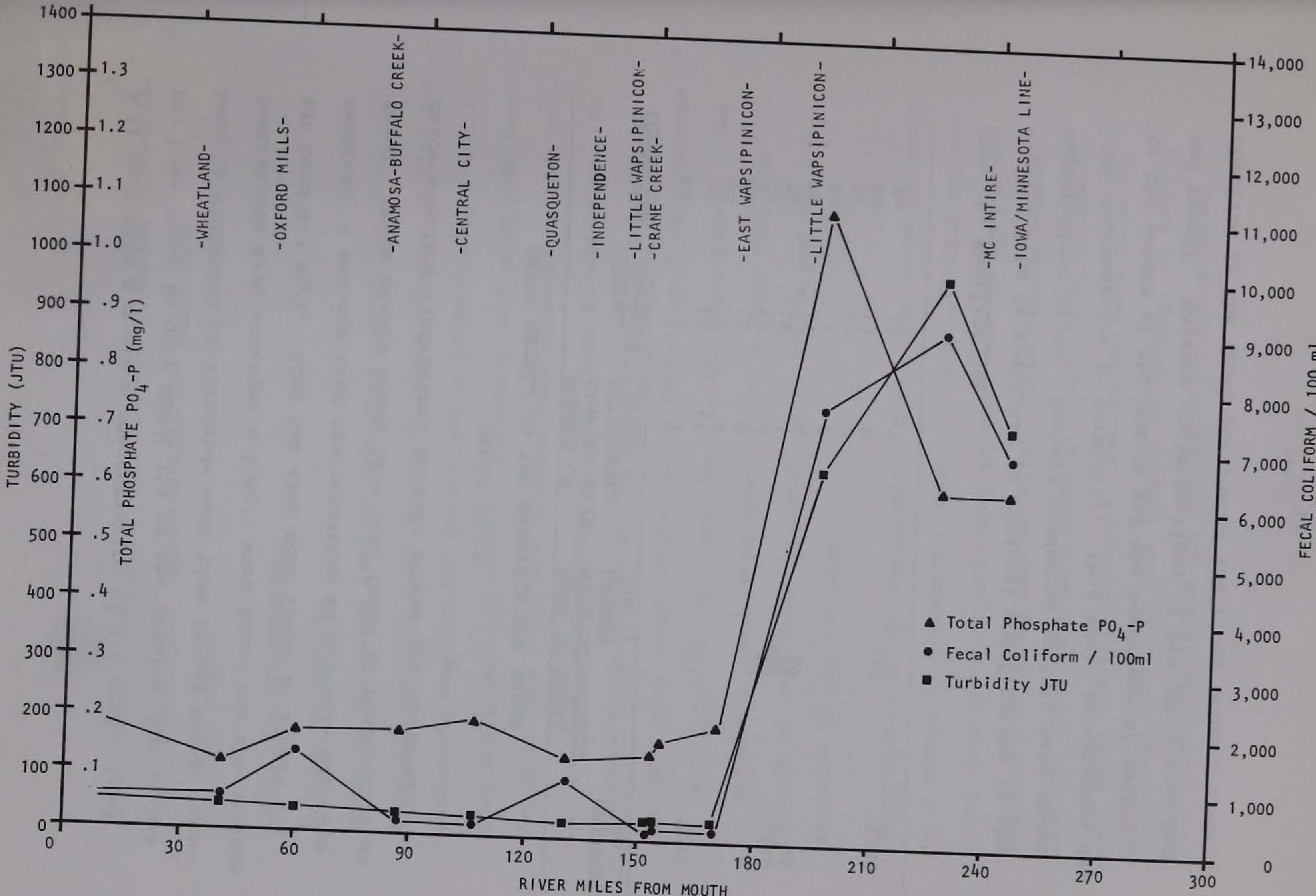


FIGURE 11-26 COMPARISON OF TURBIDITY, FECAL COLIFORM, AND TOTAL PHOSPHATE PROFILES IN THE WAPSIPINICON RIVER, JUNE 5, 1974

The pattern of turbidity change going downstream is probably a result of runoff conditions at the time of sampling rather than a reflection of the magnitude of runoff problems within the basin. Studies by the State Hygienic Laboratory and the USGS demonstrate that turbidity and sediment load is common in the lower part of the river also. It is interesting that even within the small drainage area of the upper portion of the Wapsipinicon River that these high turbidity values are found. In addition, Figure II-26 demonstrates the dilution impact the East Branch Wapsipinicon River has on the main stem near Tripoli.

Salinity, Acidity and Alkalinity

Alkalinity concentrations found to date range from near 50 mg/l to 185 mg/l. Lowest concentrations have been associated with highest turbidity. This is probably the result of complexation of carbonate and bicarbonate with the clay soil particles in the stream and the buffering effect the soil particles exert. Alkalinity of about 150 mg/l has been average.

Eutrophication Potential

Nitrate concentrations are high throughout the year. Lowest concentrations were found in August 1974 during the period of sampling at lowest flow. This indicates that high nitrate concentrations correlate with high stream flows thus pointing to runoff as a major contributor.

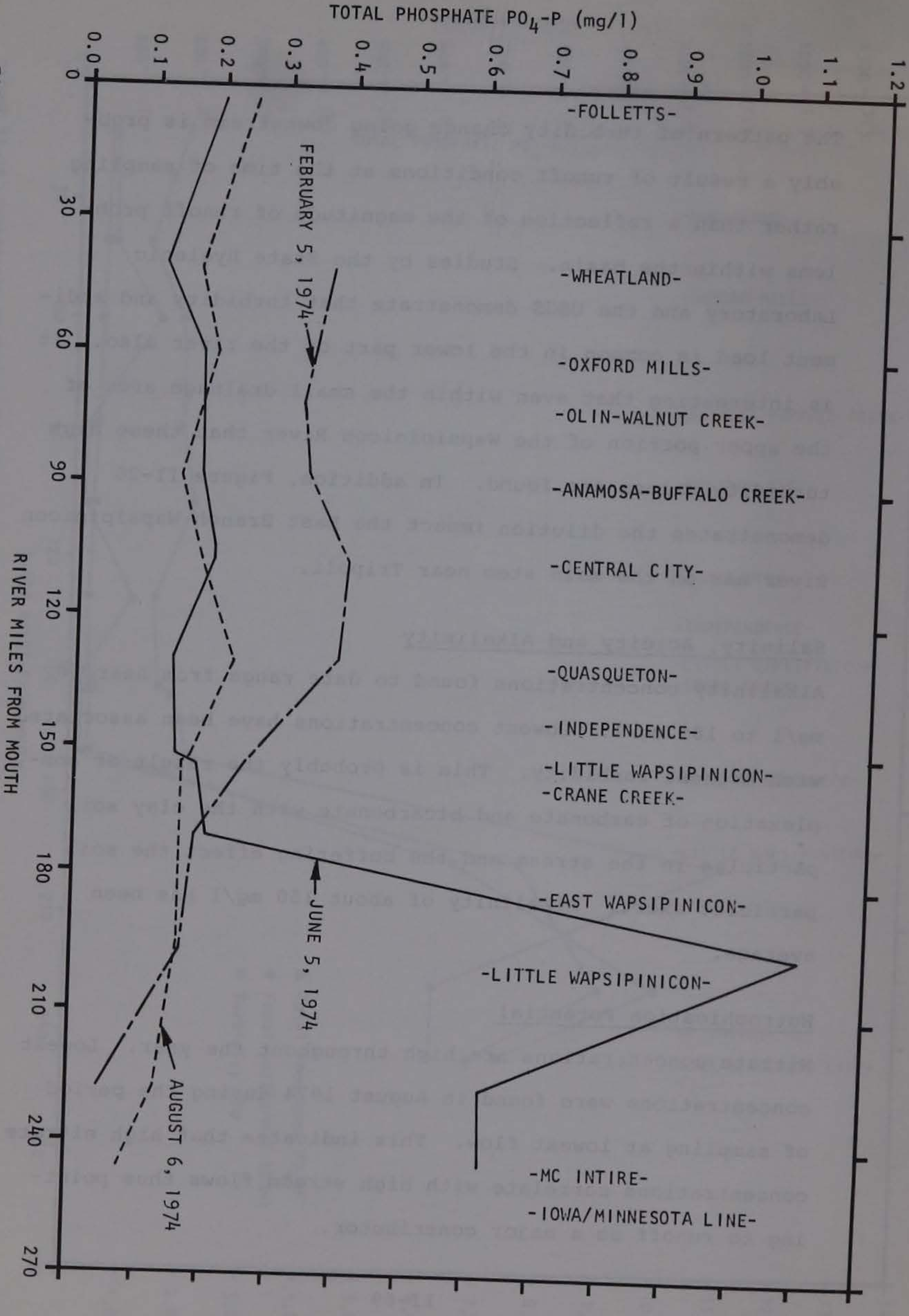


FIGURE 11-27

TOTAL PHOSPHATE CONCENTRATIONS IN THE WAPSIPINICON RIVER, 1974

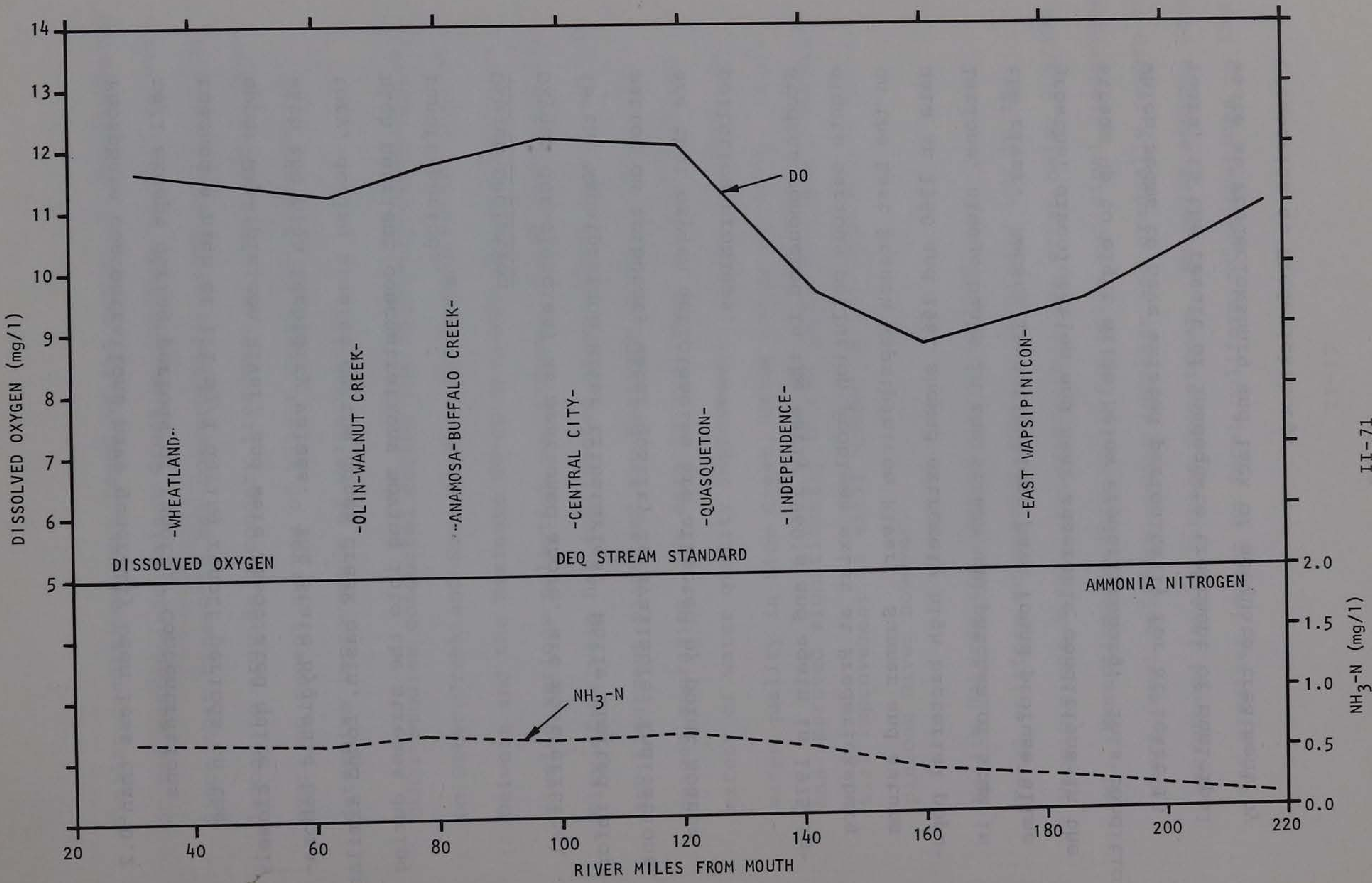


FIGURE 11-28 DISSOLVED OXYGEN AND AMMONIA NITROGEN CONCENTRATIONS IN THE WAPSIPINICON RIVER, FEBRUARY 5, 1974

Phosphate concentrations have generally been less than 0.2 mg/l except during periods of runoff. Concentrations reached a high of 1.1 mg/l during runoff periods on the upper Wapsipinicon River, and were associated quite closely with the high turbidity values. The State Hygienic Laboratory, during studies on the Jones Creek basin, found similar high nutrient concentrations moving into the streams during runoff periods.

Oxygen Depletion

Oxygen deficiencies, as mentioned above, are most critical in the Wapsipinicon River tributaries. While limited information on tributary water quality is available, indications are that oxygen deficiencies are affected by point source pollution problems.

Studies conducted in the early 1960's and again in 1975 indicate serious pollution problems exist at Fredericksburg on the East Branch Wapsipinicon River. Summer and autumn data in 1960 and 1961 showed extremely high bacterial populations, sludge banks in the stream and patches of scum in the river. Recent investigations have found profuse slime growths, discoloration and near anaerobic conditions in the stream up to eight miles below Fredericksburg. This condition, which seems to have existed periodically for at least 15 years, is the result of inadequate treatment of municipal waste at Fredericksburg and lack of adequate treatment by creameries at Fredericksburg.

Similar conditions were found as the result of the discharge of raw wastes into Walnut Creek by the Town of Olin in 1964. Since that time Olin has constructed a waste stabilization lagoon to provide secondary treatment of their waste, however, no recent survey of Walnut Creek has been made to determine improvement of water quality.

Other studies conducted during the 1960's included studies on Otter Creek and Stoe Creek. Discharges by the City of Oelwein and the Westgate Co-op Creamery respectively were causing serious pollution conditions. Since that time the City of Oelwein has constructed an activated sludge secondary treatment plant and the Westgate Co-op Creamery has ceased operation. No data is available to determine the extent of water quality improvement. It is expected that water quality in Stoe Creek, Otter Creek and Walnut Creek has improved significantly in the last ten years. Substantial improvement is still needed on the East Branch Wapsipinicon River however.

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations are generally low in the Wapsipinicon River. Concentrations are often below 200/100 ml. Exceptions to this are areas below municipal discharges where fecal coliform counts increase and gradually return to background levels further downstream. Nonpoint sources cause the greatest impact on fecal coliform concentrations in the

Wapsipinicon River. Fecal coliform levels during runoff have exceeded 1,000/100 ml. Concentrations closely follow the patterns of turbidity and nutrients during runoff (Figure II-26).

WAPSIPINICON RIVER TRIBUTARIES

Twenty-five tributaries or branches of tributaries to the Wapsipinicon River are classified by the Iowa Department of Environmental Quality. One is classified for protection for cold water fishery and the others for warm water aquatic life. Water quality data are available on six of these streams. Data collected since 1970 are available on only two of those six streams. No water quality data are available on the others.

IOWA RIVER

The most significant pollution problems on the Iowa River are low dissolved oxygen and high turbidity, primarily the result of high organic loadings from nearby municipal and industrial sources. Dissolved oxygen levels have often been found in violation of Iowa stream standards. Turbidity problems are even more unique in that the Iowa River has the worst turbidity of any eastern Iowa river.

The key pollutants highlight conditions in the Iowa River:

Harmful Substances: Heavy metals samples collected to date have not violated Iowa stream standards. Pesticides from agricultural runoff are found frequently. DDE, DDT, and dieldrin have exceeded recommended maximum concentrations.

Physical Modification: Turbidity and suspended solids levels are high during runoff periods. Temperature is a potential problem in cooling water discharges and reservoirs on the Iowa River.

Eutrophication Potential: High phosphate and nitrate concentrations are common. Contributions are primarily from point sources in the segment above Marshalltown. Contributions from nonpoint source runoff is significant throughout the river.

Salinity, Acidity, and Alkalinity: Total dissolved

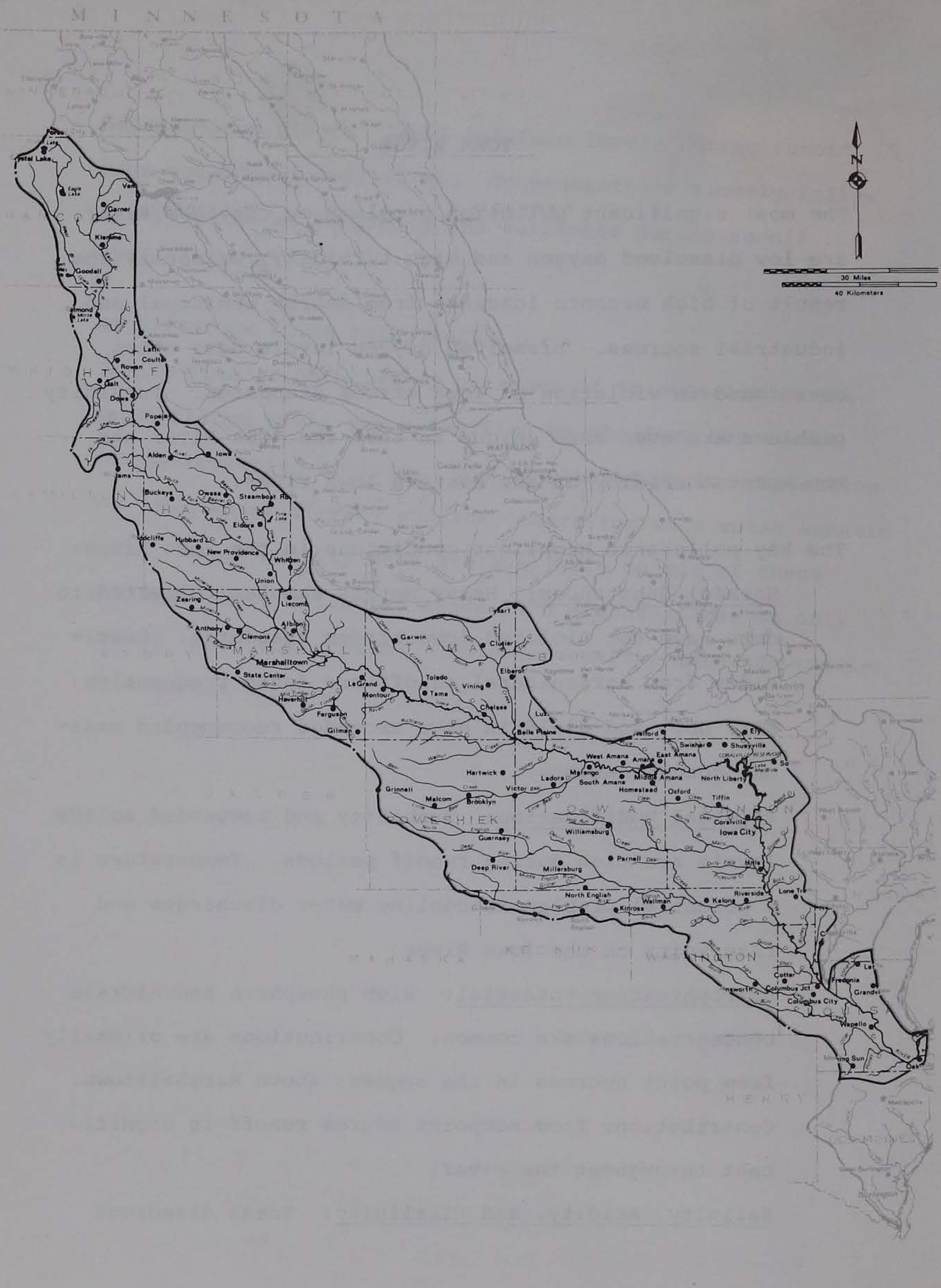


FIGURE II-29 IOWA RIVER BASIN

solids concentrations are normally within Iowa standards, but violations have been found. Alkalinity averages about 250 mg/l and pH ranges from 7-9 units.

Oxygen Depletion: Low dissolved oxygen concentrations have been found throughout the river from the East Branch Iowa River to below Iowa City. Dissolved oxygen lows normally result from the influence of point sources, but other factors may be important near the headwaters.

Health, Hazards and Aesthetic Degradation: Total and fecal coliform fluctuate greatly in the river. Concentrations are highest below point sources and during heavy runoff periods.

GENERAL PHYSICAL DESCRIPTION

From the outlet of Crystal Lake in Hancock County to its junction with the East Branch in Wright County, the West Branch of the Iowa River is a ditch-type channel which has been improved in most reaches to furnish an outlet for lateral drains. Below the confluence, as far as the Hardin County line, the stream is slow moving and shallow, but at Alden the river enters a rock gorge which extends for about forty miles to below Eldora. From Alden to Iowa Falls, about six miles, the gorge is cut through solid limestone and is narrow and deep. Below Iowa Falls the valley widens somewhat, and an outcropping of sandstone replaces the limestone about twelve miles above Eldora. The outcroppings disappear near the Marshall County line, and the river winds through a rather broad valley about one to one and a half miles wide. Below Marshalltown gorge-like conditions again occur near LeGrand in Marshall County, but the valley flood plain is generally broad through Tama and Iowa counties. The river enters the Coralville Reservoir through Johnson County.

Below Iowa City the valley is about two miles wide as it enters the Lacustrian plain of old Lake Calvin, and the flood plain remains broad to the mouth of the stream. At the Cedar River junction the channel width approximately doubles, and many islands, sloughs, and old oxbow lakes occur along the lower reaches of the river.

WATER QUALITY CONDITIONS

Harmful Substances

Heavy metals found in the Iowa River have included barium, lead and zinc. Pesticides found in the Iowa River include DDE, DDT, dieldrin and atrazine. Only dieldrin and atrazine have been found in more than 50 percent of the samples. DDE, DDT, and dieldrin have been found in concentrations which exceed recommended maximum levels established by the National Academy of Science. Studies conducted at Coralville Reservoir indicate that these pesticides, coming from agricultural runoff, are concentrated in algae and fish in the reservoir. Concentrations many times higher than in the river have been found in algae and fish at Coralville.

Physical Modification

Turbidity and suspended solids cause several problems in the Iowa River. They are unusually high for this part of the State. Suspended sediment concentrations found in the Iowa River have ranged from 9 to 4700 mg/l in recent years. The annual computed sediment load to Coralville was 1.34 million tons in 1966. This value represents over 475 tons of sediment per square mile of drainage area. Sediment loadings for other rivers in the State, with a few exceptions, are considerably below this figure (Table II-8). For comparison, sediment loads for the Des Moines River at Saylorville have averaged 1.25 million tons per year. The drainage area at this point on the Des Moines River is 5841 square miles. The drainage area on the Iowa River above Coralville is 2794 square miles. This shows that the Iowa River, draining only half the area that the Des Moines River at Saylorville does, carries as much and often more sediment. Only in western Iowa rivers that have been channelized and straightened do sediment loads exceed those of the Iowa River. Effects of this high sediment load include: 1) loss of reservoir storage because of sediment deposition; 2) destruction of fish and wildlife habitats; 3) loss of water oriented recreation because of stream turbidity; and 4) increased cost of water treatment for municipal and industrial supplies.

Temperature effects from possible stratification of Coralville Reservoir and from cooling water discharges may create problems. The wide fluctuations in water level at Coralville have not allowed stratification to develop to the point that it does in some reservoirs. For this reason the temperature changes from discharges have been less severe. The impact of cooling water discharge on temperature in the Iowa River is not known.

Eutrophication Potential

Nitrates and phosphates are both abundant in the Iowa River. Phosphate data for the 1970's indicates a general decrease in total phosphate from the Iowa Falls area to the mouth. Higher concentrations are also found below other point sources, particularly Marshalltown. Point sources appear to add significant concentrations of phosphates all along the river. At high flows additional nutrients are washed from the predominantly agricultural basin and provide adequate nutrients throughout the river. Concentrations of nutrients in Coralville Reservoir appear to be predominantly from nonpoint sources (McDonald, 1972). Large algal populations including significant blue-green algal blooms have occurred in Coralville Reservoir due to the abundance of nutrients. The reservoir has the effect of lowering nutrient levels below the dam (Figure II-30).

Salinity, Acidity, and Alkalinity

Total dissolved solids concentrations in the Iowa River have averaged 271 mg/l in samples collected since 1970. Maximum concentrations have exceeded Iowa stream standards, and have reached 782 mg/l.

Alkalinity has ranged from 81 mg/l to 364 mg/l, with an average of 212 mg/l. Hardness has ranged from 92 mg/l to 428 mg/l and averaged 252 mg/l.

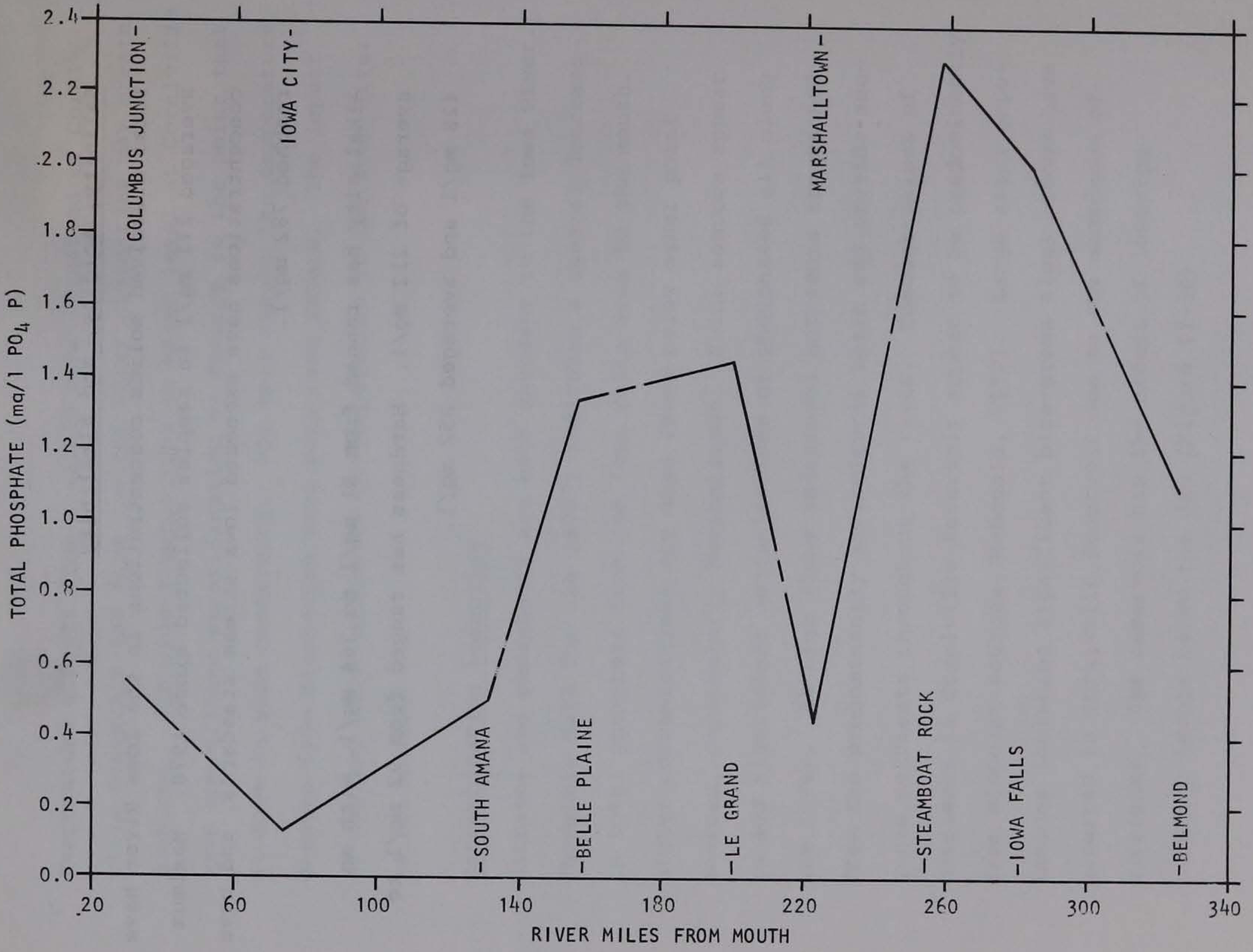


FIGURE 11-30 MEAN TOTAL PHOSPHATE CONCENTRATIONS IN THE IOWA RIVER

TABLE II-17

HEAVY METALS IN THE IOWA RIVER BELOW CORALVILLE

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	18	0		
Ba	19	19	174	400
CD	21	0		
Cr	23	0		
Cu	21	4	50	130
Pb	21	3	40	60
Mn	23	22	139	1600
Hg	9	0		
Ni	18	0		
Ag	14	0		
Zn	21	14	101	300
Se	1	1	1	1

TABLE II-18

HEAVY METALS IN THE IOWA RIVER ABOVE MARSHALLTOWN

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	4	0		
Ba	6	6	180	300
Cd	6	0		
Cr	10	0		
Cu	6	0		
Pb	6	0		
Mn	5	5	328	580
Hg	5	0		
Ni	2	0		
Ag	0	0		
Zn	6	3	110	160

TABLE II-19

HEAVY METALS IN THE IOWA RIVER - MARSHALLTOWN TO CORALVILLE

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	5	0		
Ba	15	13	252	900
Cd	17	0		
Cr	17	0		
Cu	17	0		
Pb	17	3	30	50
Mn	7	6	90	380
Hg	3	0		
Ni	17	0		
Ag	5	0		
Zn	17	11	53	90
Se	1	1	1	1

TABLE II-20

PESTICIDES IN THE IOWA RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
Aldrin	1			
DDE	21	3	119	350
DDT	16	1	12	12
Dieldrin	22	19	10	16
Atrazine	2	2	1600	3000

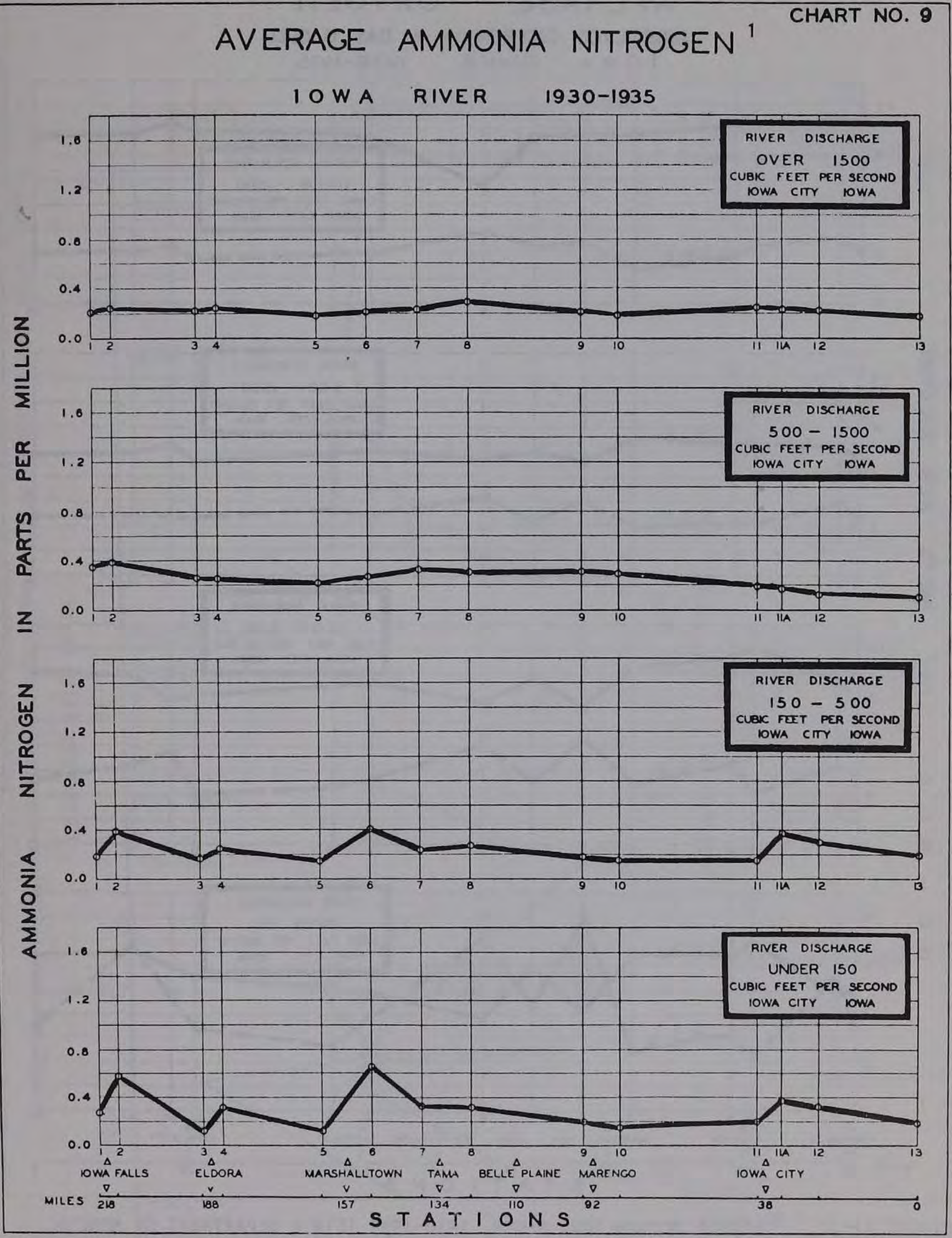


CHART NO. 9

AVERAGE AMMONIA NITROGEN [1]

IOWA RIVER 1930-1935

FIGURE II-31 [1]AVERAGE AMMONIA NITROGEN-IOWA RIVER, 1930-1935 (STATE DEPARTMENT OF HEALTH, JUNE 1935)

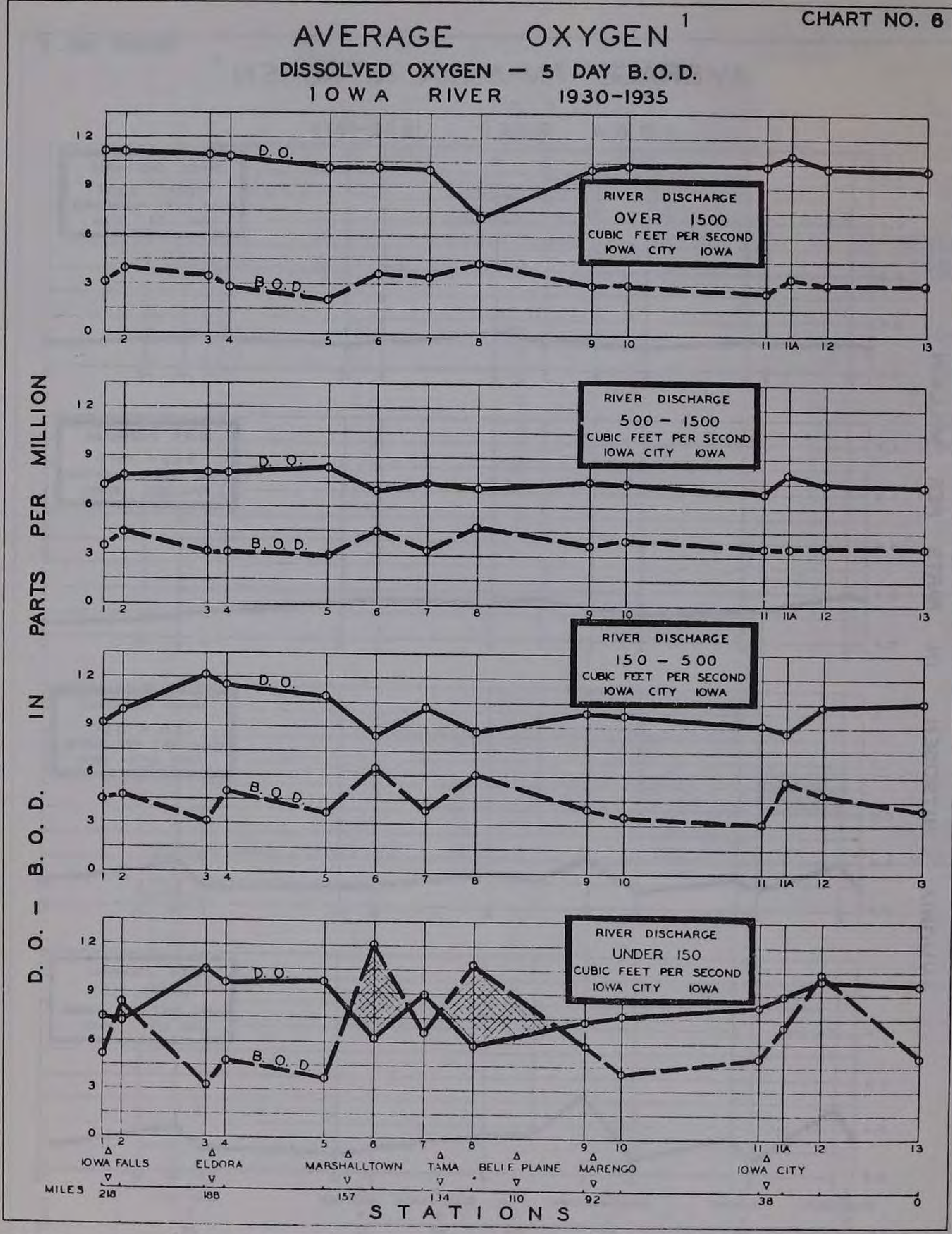


FIGURE II-32 [1]AVERAGE OXYGEN-IOWA RIVER, 1930-1935 (STATE DEPARTMENT OF HEALTH, JUNE 1935)

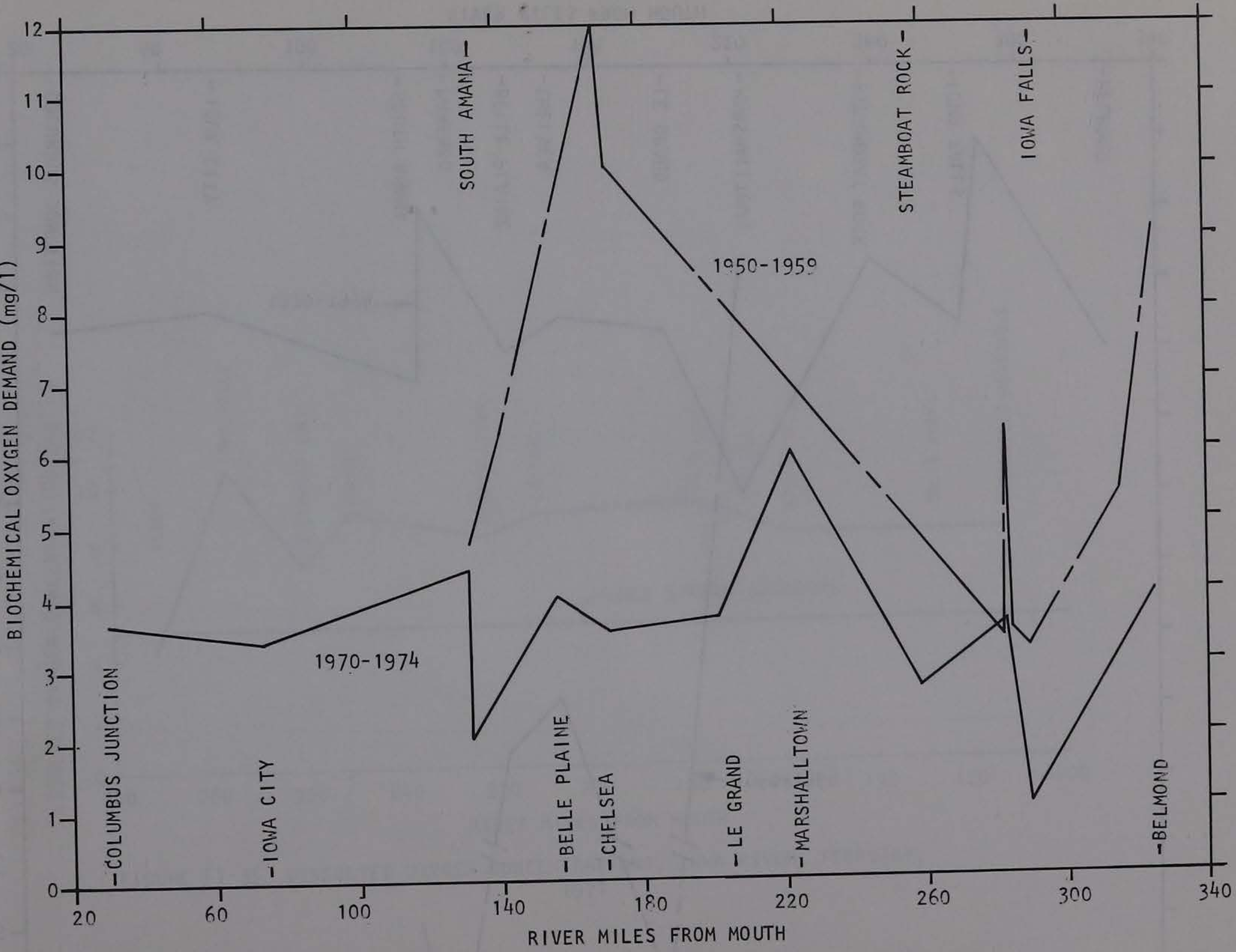


FIGURE 11-33 COMPARISON OF MEAN BIOCHEMICAL OXYGEN DEMAND CONCENTRATIONS FOR THE IOWA RIVER, 1950's-vs-1970's

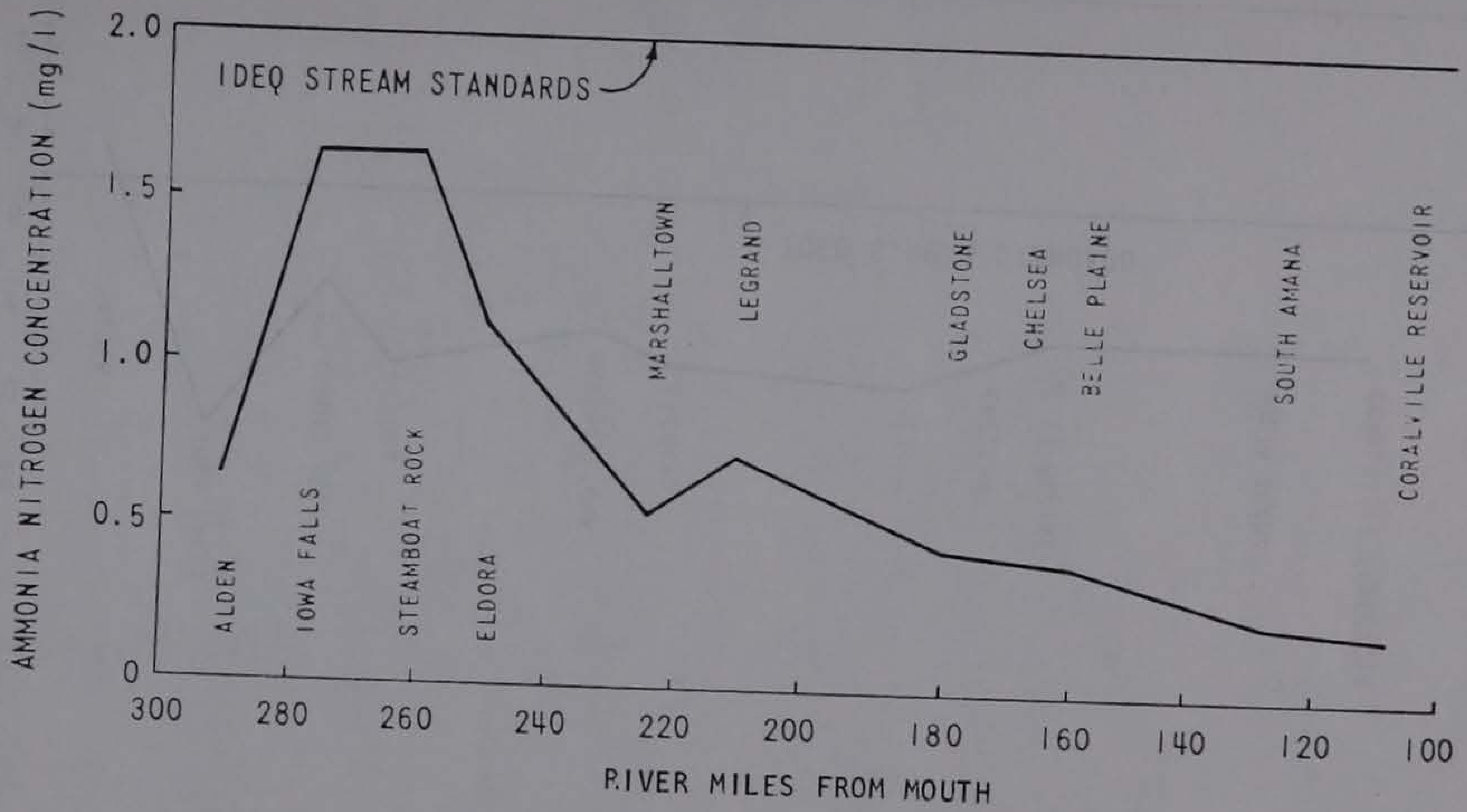


FIGURE 11-36 AMMONIA NITROGEN CONCENTRATIONS, IOWA RIVER, FEBRUARY, 1971

Health Hazards and Aesthetic Degradation:

Total and fecal coliform concentrations vary widely in the Iowa River. Concentrations from point sources cause higher levels below most municipalities. Nonpoint sources cause large increases in fecal and total coliform concentrations during runoff periods. Coralville Reservoir has a tendency to decrease coliform counts below the reservoir and improve general water quality. Highest concentrations have been found below Marshalltown, Iowa Falls, and Belle Plaine (Figure II-37).

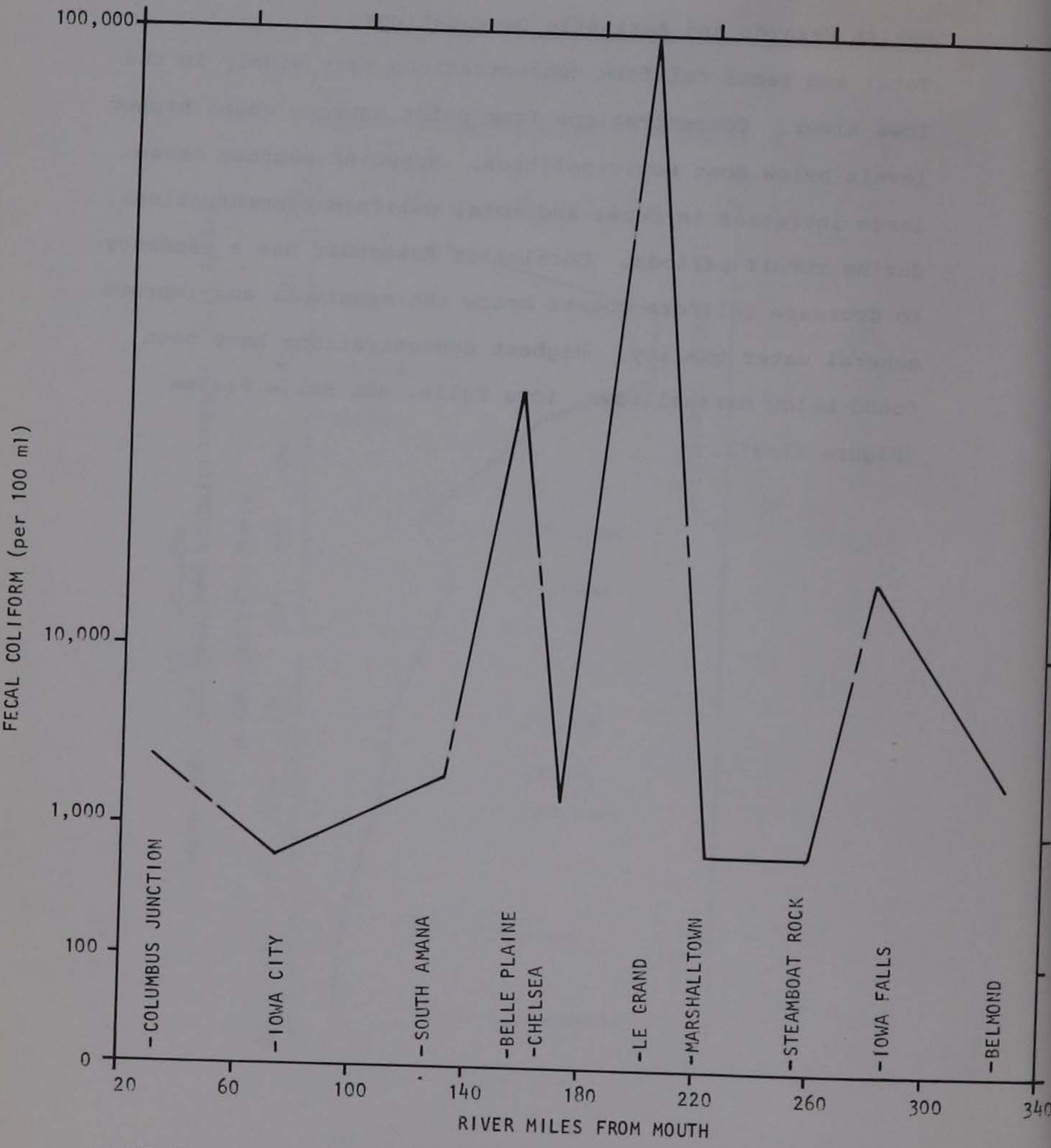


FIGURE 11-37 MEAN FECAL COLIFORM CONCENTRATIONS IN THE IOWA RIVER

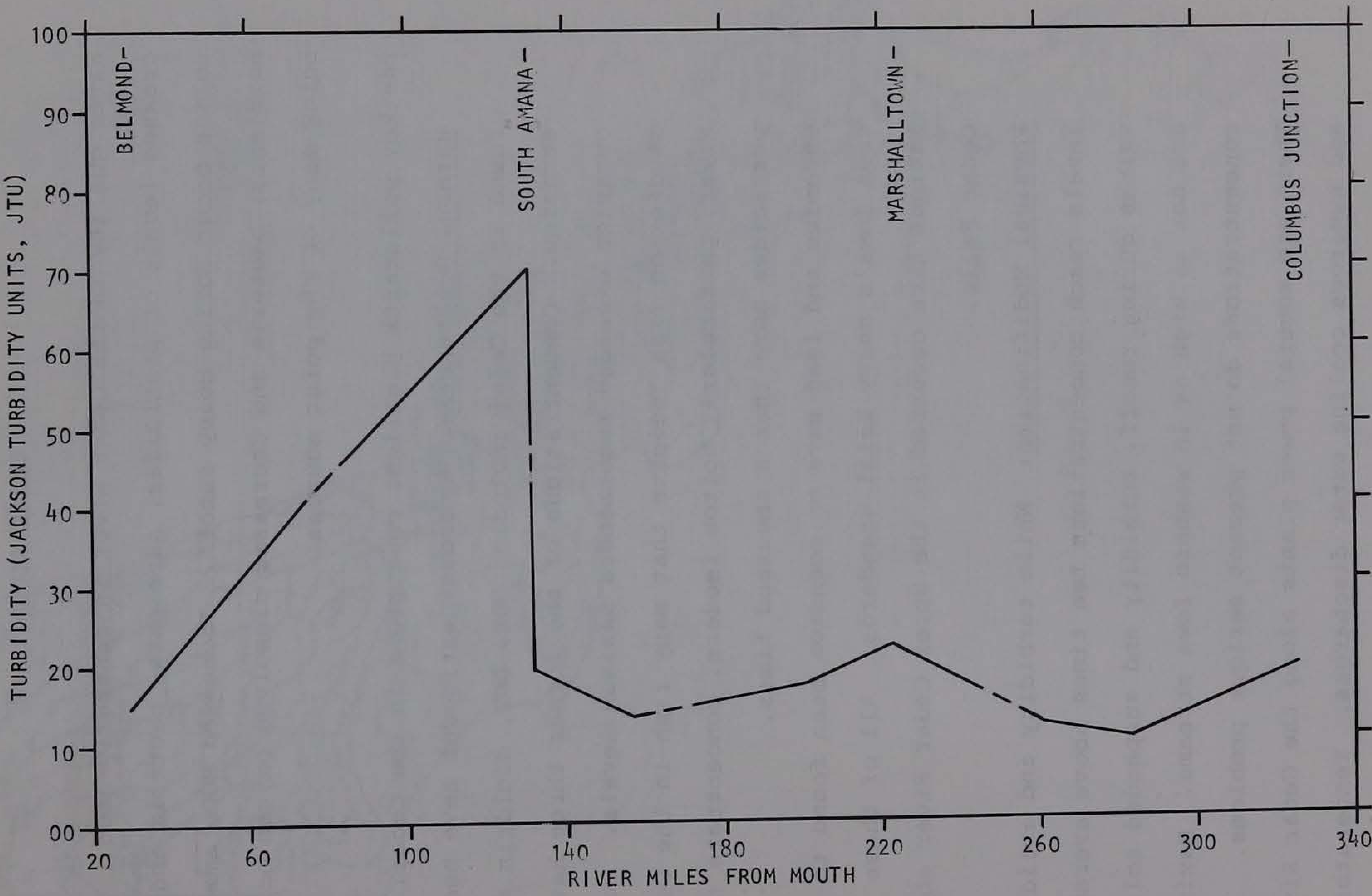


FIGURE 11-38 MEAN TURBIDITY CONCENTRATIONS IN THE IOWA RIVER, 1970-1974

CEDAR RIVER

Water quality in the Cedar River is generally good. Increased levels of pesticides, nutrients, bacteria and solids occur during heavy runoff. Increased BOD, ammonia, nutrients, bacteria and decreased dissolved oxygen occur below many of the point sources.

The key pollutants highlight conditions in the Cedar:

Harmful Substances: Numerous pesticides have been found in the Cedar including DDE, DDT, dieldrin and atrazine. Concentrations of the former three have on occasion exceeded recommended maximum levels. Pesticide studies on fish indicate that many fish in the Cedar River, particularly bottom feeders, concentrate these pesticides more than a thousand times.

Chromium and lead have on occasion been found to exceed Iowa's heavy metal standards. All of these violations have occurred in the Upper Cedar River above Cedar Falls.

Physical Modification: While turbidity and solids levels reach concentrations ten times above average values during runoff, turbidity and suspended solids are not as high as in western Iowa streams. Maximum concentrations do not present serious problems.

There are several power plants along the Cedar River and numerous cooling water discharges. Temperature studies up to now have been inadequate to determine

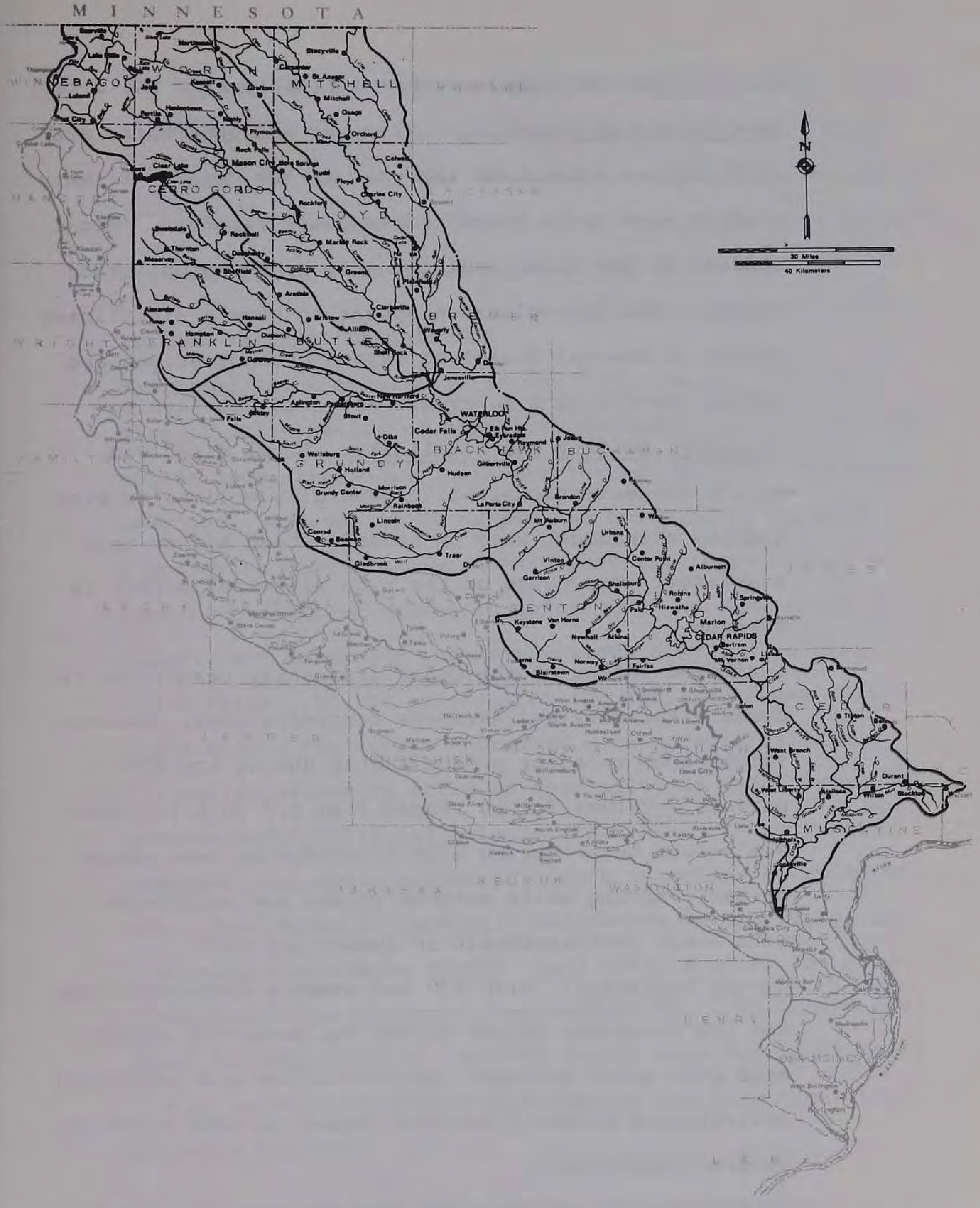


FIGURE II-39 CEDAR RIVER BASIN

the magnitude of temperature modifications in the river.

Eutrophication Potential: Nitrates and phosphates are in abundance throughout the year in the Cedar. Primary sources seem to be runoff after heavy rainfall. Algal studies on the Cedar indicate very high phytoplankton counts. The phytoplankton appear to have a significant effect on diurnal dissolved oxygen concentrations and during die-off tend to create elevated BOD levels.

Salinity, Acidity and Alkalinity: Total dissolved solids concentrations, while generally well below water quality standards, have on occasion been higher than standards. The cause of the high dissolved solids is unknown.

Increased inflow on the Cedar frequently results in reduced alkalinity and hardness concentrations. Maximum values seem to occur predominantly during low flow periods. Values for pH ranged from 7.7 to 9.5. Minimum values occur during high flows during late winter or early spring while maximum values are associated with algal photosynthesis in summer and fall.

Oxygen Depletion: High BOD and ammonia concentrations and low dissolved oxygen values are generally associated with point sources. Municipalities and industrial contributors create a definite impact on this river at several locations.

Health Hazards and Aesthetic Degradation: Total and fecal coliform concentrations have reached highest levels below municipal outfalls. These outfalls often influence water quality many miles downstream particularly in the winter. With the exception of areas within a few miles below point sources, runoff has the greatest impact on coliform concentrations.

GENERAL PHYSICAL DESCRIPTION

The Cedar River originates in the flat, poorly drained, glacial drift region of southern Minnesota, but as the river enters Iowa, the slope increases through Mitchell and Floyd Counties. The valley is narrow and bordered by rounded bluffs with numerous limestone exposures. From Nashua to Waverly the valley widens to about three to four miles in places, but generally the narrow width prevails to near Cedar Falls. At the junction of the Shellrock/West Fork Cedar Rivers the stream increases considerably in size. The valley widens to three to four miles at Cedar Falls. Between Cedar Falls and Waterloo the valley is somewhat narrower, but again widens to one to two miles below Waterloo. This width is generally maintained except for gorge-like conditions below Vinton, near Cedar Rapids, and from Cedar Bluffs to Rochester. At Moscow the river enters and winds through the flat, ancient bed of Lake Calvin which is six to seven miles wide before joining the Iowa River near Columbus Junction.

The drainage area of the Cedar River at Conesville is 7,785 square miles. The main tributaries include the West Fork

Cedar River, Shellrock River, Winnebago River and Little Cedar River. Major tributaries to these streams include Beaver Creek (mouth in Black Hawk County), Beaverdam Creek, Black Hawk Creek and Wolf Creek. Major municipalities include Cedar Rapids, Waterloo and Cedar Falls.

DATA AND METHOD

Data collected on the entire Cedar River come primarily from the State Hygienic Laboratory and the DEQ. Data collected since 1971 by the University of Iowa, near Palo, above Cedar Rapids, were used for determination of seasonal and hydrological changes. These data have been collected twice monthly at four stations between Vinton and Cedar Rapids from 1971 to the present (1975), and are one of the most comprehensive river studies in the State in spite of its limited geographical scope.

In order to better evaluate water quality in the Cedar River, the river was divided into three sections: the upper, middle, and lower Cedar River. The upper Cedar River was defined as that portion of the Cedar above the confluence with the Shellrock/West Fork Cedar Rivers. The middle Cedar is that portion from the upper Cedar to Cedar Rapids. The lower Cedar River is that portion below Cedar Rapids.

WATER QUALITY CONDITIONS

Harmful Substances

Limited data have been collected on pesticides in the Cedar River. Those studies done have found DDE, DDT, dieldrin, and atrazine. Concentrations of DDE, DDT and dieldrin have all been found in excess of recommended maximum concentrations established by the National Academy of Science. The concentration of pesticides found in fish is significant. Studies conducted on fish in the middle Cedar have found concentrations over 1,000 times as great as independently collected water samples. DDE, DDT and dieldrin concentrations have averaged 85 ng/l, 10 ng/l, and 13 ng/l respectively in those samples with detectable concentrations. Concentrations of heptachlor, aldrin, heptachlor epoxide, DDE, DDT, lindane, and dieldrin have been found in fish in the middle Cedar. Total pesticide residues varied from 81 to 160 ppb in fish, compared to less than 100 parts per trillion in the water. Violations of Iowa stream standards for heavy metals have occurred only in the upper Cedar River. On the basis of sampling on the upper Cedar River in the last four years chromium violations have occurred 6.5 percent of the time, and lead violations 10 percent of the time. Heavy metals including arsenic have generally been found more frequently in the upper Cedar than in the rest of the Cedar River combined. At least one point source in this segment is a known heavy metal contributor to the stream. The City of Charles City, with the industrial impact of Salsbury Laboratories, is the only known heavy metals discharger on this stream segment. The industrial waste impact will be reduced as a result of inplementation of their discharge permit.

TABLE II-21

PESTICIDES IN THE CEDAR RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	20	6	85	480
DDT	19	3	10	12
Dieldrin	19	9	13	42
Atrazine	1	1	6350	6350

TABLE II-22

HEAVY METALS IN THE CEDAR RIVER BELOW WATERLOO

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	8	0		
Ba	15	12	167	600
Cd	15	0		
Cr	36	0		
Cu	35	7	87	140
Pb	31	2	55	90
Mn	32	6	37	50
Hg	16	0		
Ni	15	0		
Ag	7	0		
Zn	35	29	42	160

TABLE II-23

HEAVY METALS IN THE CEDAR RIVER BELOW CEDAR RAPIDS

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	6	0		
Ba	8	7	200	400
Cd	49	0		
Cr	55	0		
Cu	48	1	10	10
Pb	8	1	70	70
Mn	4	3	86	160
Hg	6	0		
Ni	41	0		
Ag	0	0		
Zn	48	27	103	210
Se	1	1	1	1

TABLE II-24

HEAVY METALS IN THE CEDAR RIVER ABOVE WATERLOO

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	25	2	45	70
Ba	24	23	552	1000
Cd	36	0		
Cr	37	2	7200	12000
Cu	36	3	13	20
Pb	36	3	320	660
Mn	20	13	48	160
Hg	8	2	3.6	4.0
Ni	34	1	20	20
Ag	12	0		
Zn	36	23	458	5800
Se	1	1	1	1

PHYSICAL MODIFICATION

Nonpoint source runoff causes increases in turbidity. Maximum turbidity found since 1970 in the Cedar River is about 430 JTU which occurred during a period of very high flow and an unusually wet year. For comparison, only the Shellrock (a tributary to the Cedar), the Maquoketa, the North Raccoon, the East Fork and West Fork Des Moines had lower maximum turbidities.

Temperature studies, related to cooling water discharges, have not been complete enough to identify specific problems regarding physical modification. The number of cooling water discharges and the volume of cooling water used suggest that further studies are needed to determine the magnitude of this problem on the Cedar River.

Eutrophication Potential

Nitrate and phosphate are both found in abundance in the Cedar River. Nonpoint sources seem to be associated with this problem, but no definite correlations have been found using available data. It is probable that, at least in the middle and lower Cedar, point sources also contribute significant amounts of nutrients.

Due to the adequate supply of nutrients, the Cedar River frequently supports large plankton populations with totals in excess of 100,000 organisms per ml. These large populations usually occur in the spring and summer, with

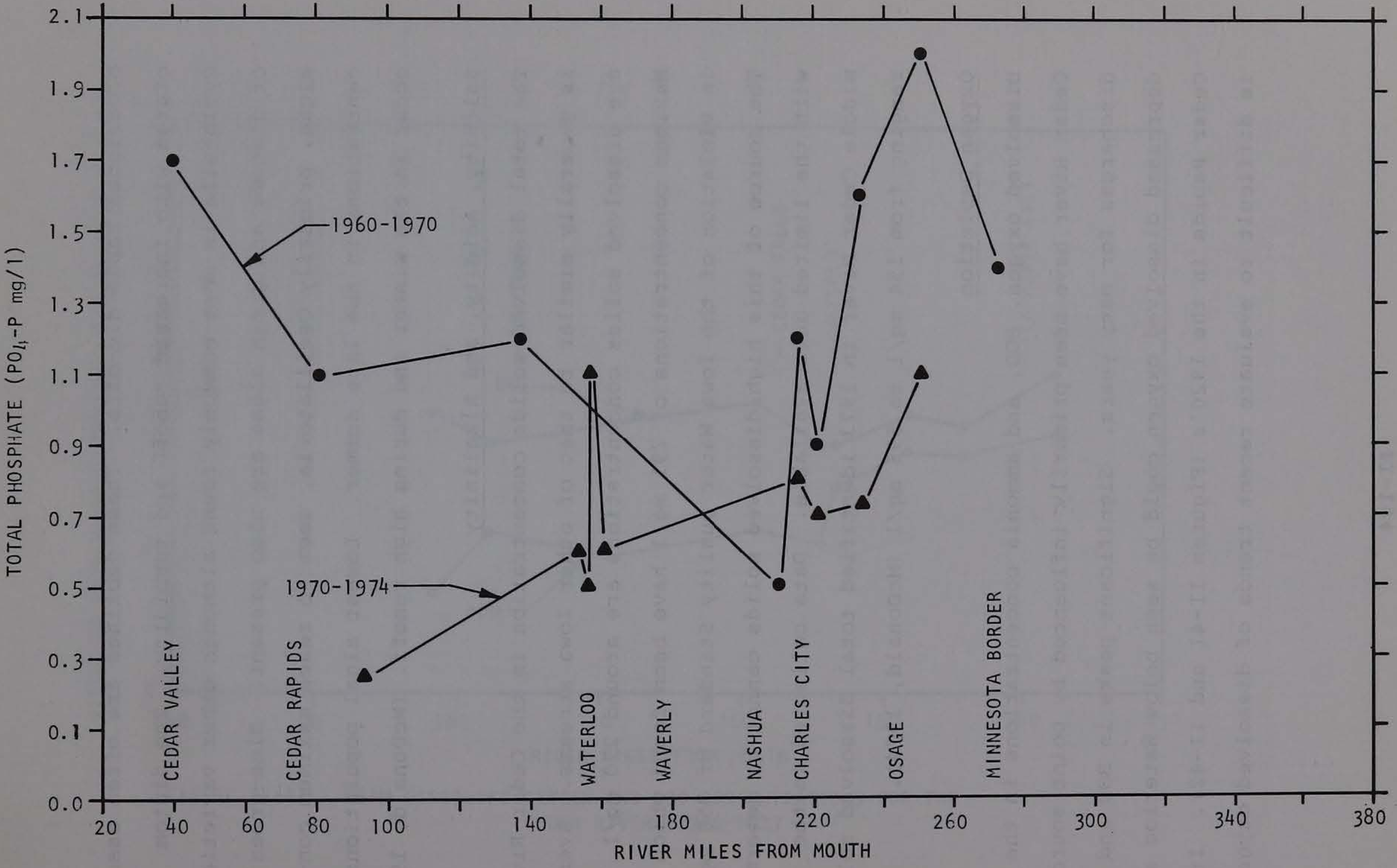


FIGURE 11-40 COMPARISON OF MEAN TOTAL PHOSPHATE CONCENTRATIONS IN THE CEDAR RIVER, 1960's-vs-1970's

occasional rapid die-offs. These declines are often associated with increased runoff and turbidity. The diatom Cyclotella is most commonly found although other varieties of diatoms and green algae are also present. Blue-green algae, primarily Oscillatoria, seem to reach maximum concentrations in the late summer. Lowest algal populations occur in the winter and during high runoff. (McDonald, 1972).

Salinity, Acidity, and Alkalinity

The total dissolved solids concentration in the Cedar River is generally similar to that of other Iowa streams. Average dissolved solids concentrations are around 270 mg/l. Maximum concentrations of 791 mg/l have been found which are in violation of the Iowa Water Quality Standard of 750 mg/l. The source of this high dissolved solids cannot be determined with the limited data available. Data collected in the middle Cedar River in 1973 identified total dissolved solids ranging from 154 mg/l to 595 mg/l (McDonald, 1974).

Oxygen Depletion

Dissolved oxygen, BOD, and ammonia concentrations in the Cedar River have been primarily influenced by point source discharges for many years. Significant peaks in BOD and depressed dissolved oxygen could be seen below Waterloo and Cedar Rapids in the 1920's (Figures II-41 and II-42). It is difficult to evaluate recent trends of dissolved oxygen,

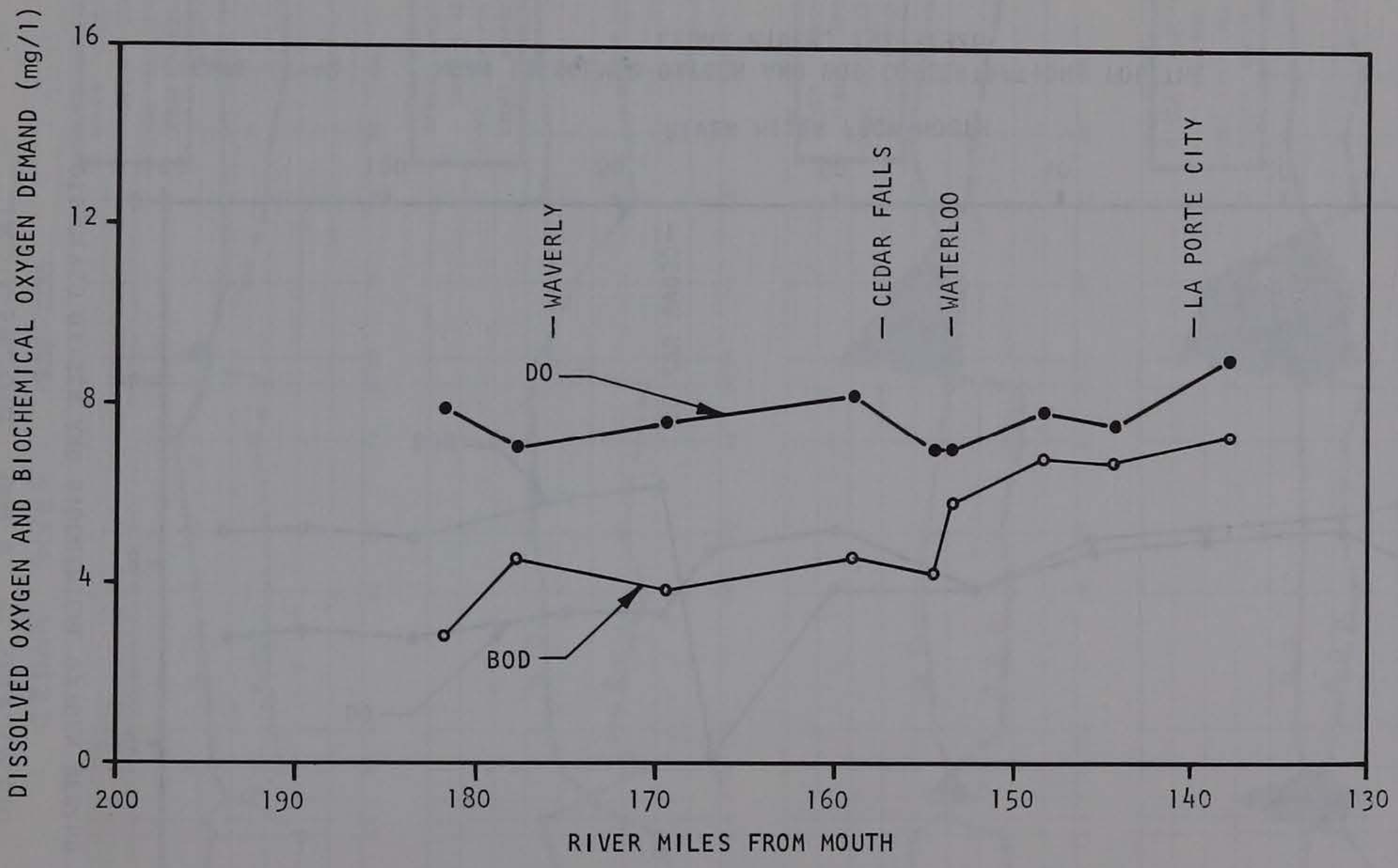


FIGURE 11-41 MEAN DISSOLVED OXYGEN AND BOD CONCENTRATIONS FOR THE CEDAR RIVER, 1926-1927

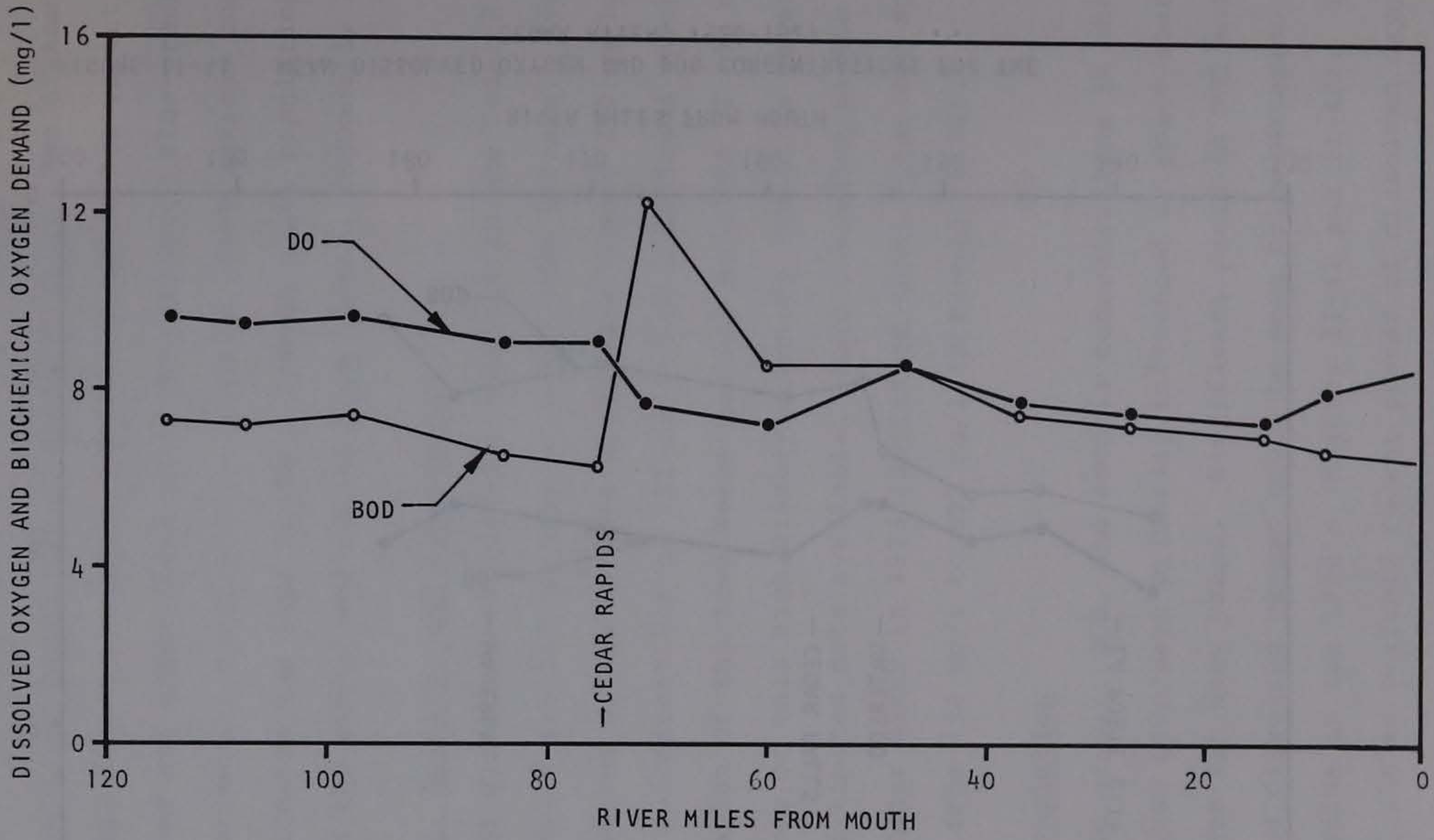


FIGURE 11-42 MEAN DISSOLVED OXYGEN AND BOD CONCENTRATIONS FOR THE CEDAR RIVER, 1927-1928

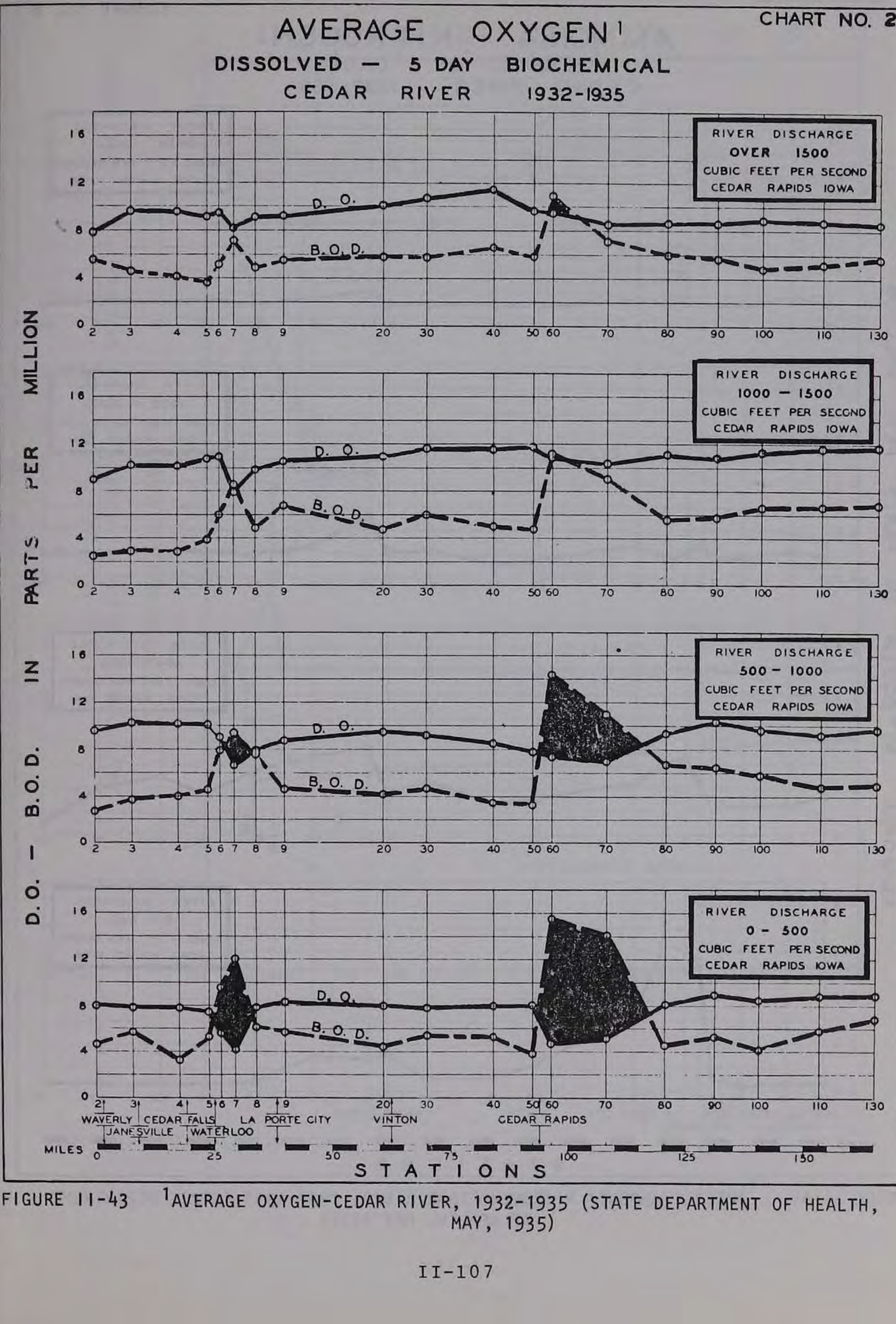


FIGURE II-43 ¹AVERAGE OXYGEN-CEDAR RIVER, 1932-1935 (STATE DEPARTMENT OF HEALTH, MAY, 1935)

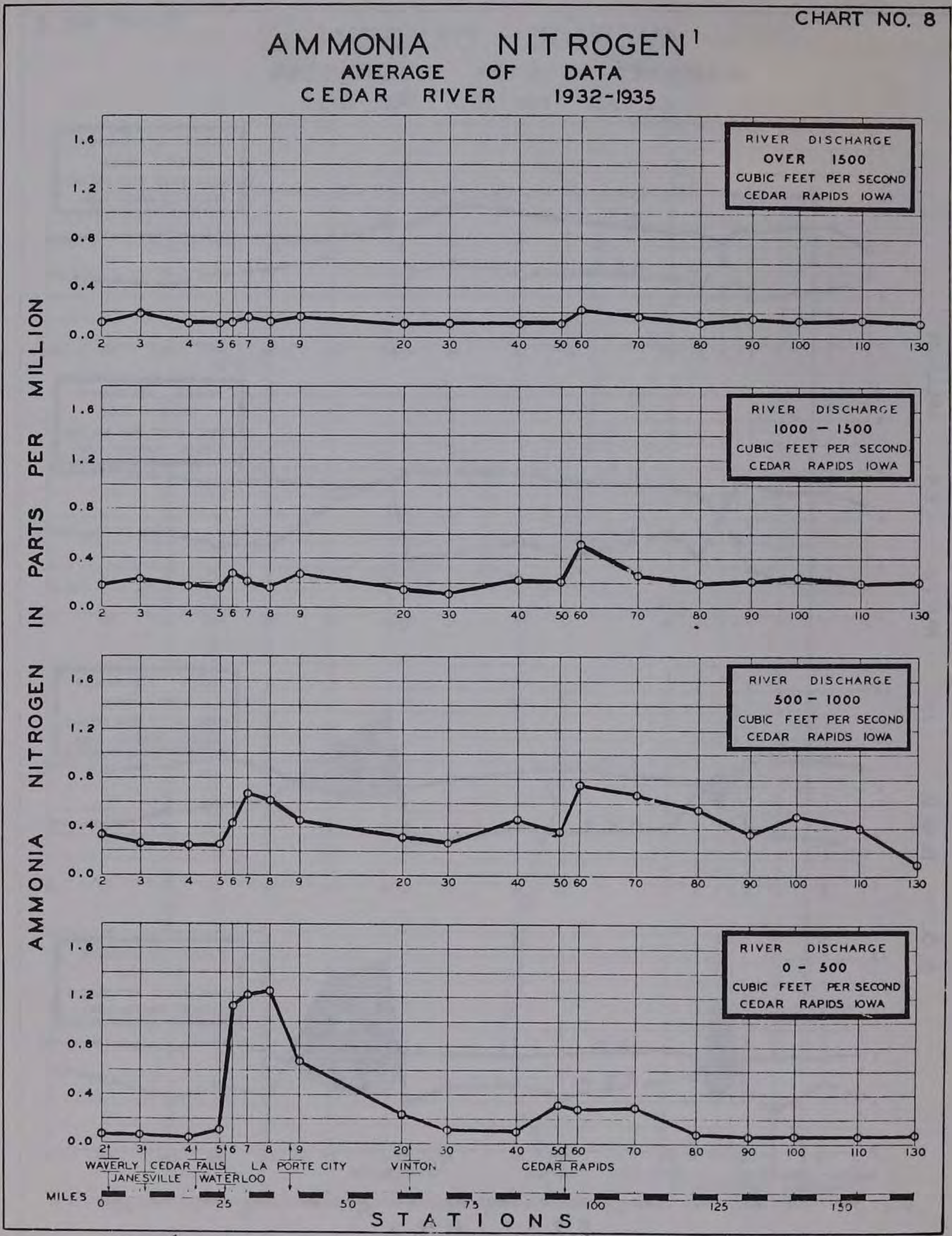


FIGURE II-44 [1]AVERAGE AMMONIA NITROGEN-CEDAR RIVER, 1932-1935 (STATE DEPARTMENT OF HEALTH, MAY 1935)

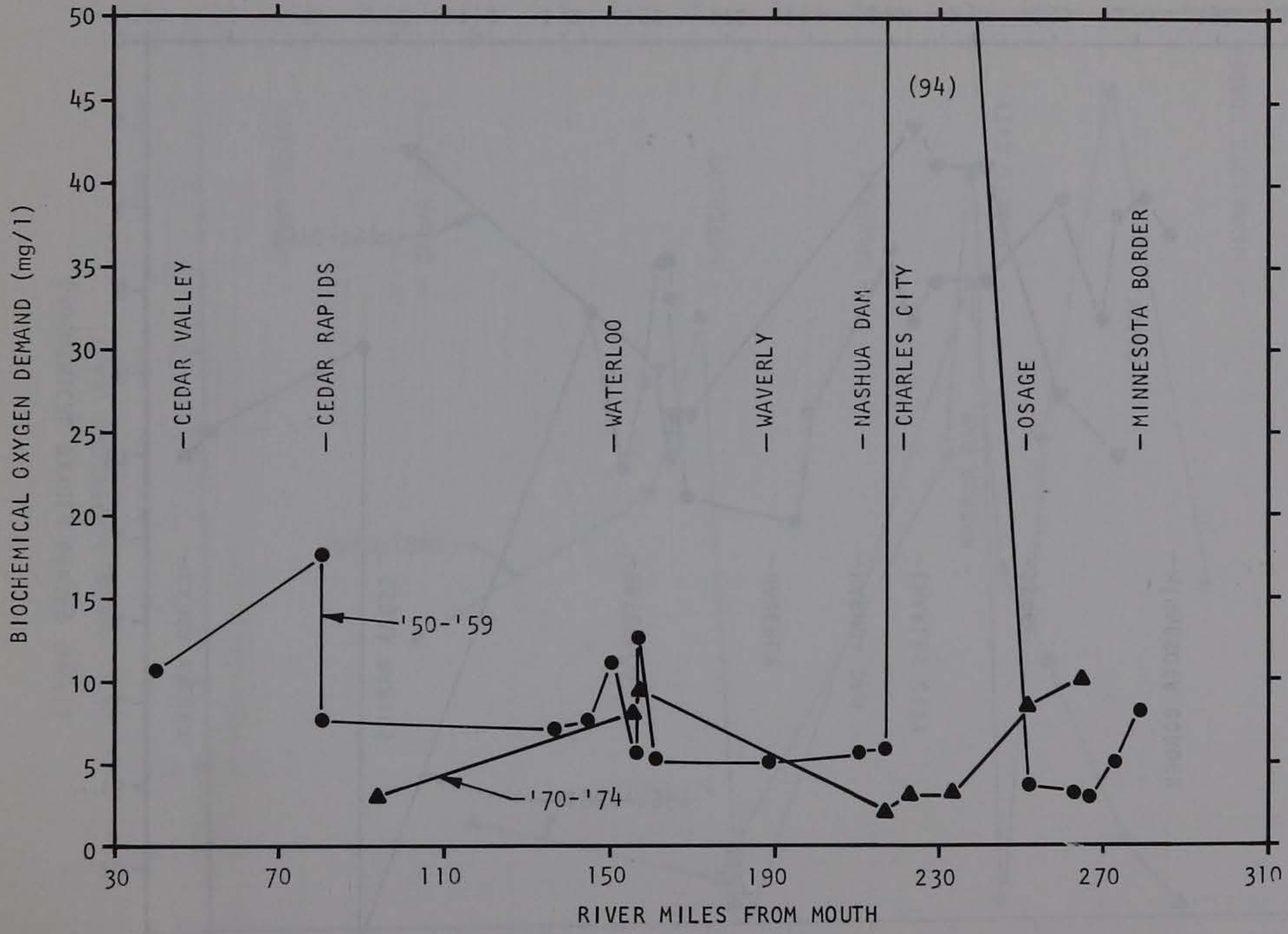


FIGURE 11-45 COMPARISON OF MEAN BIOCHEMICAL OXYGEN DEMAND IN THE CEDAR RIVER, 1950's vs 1970's

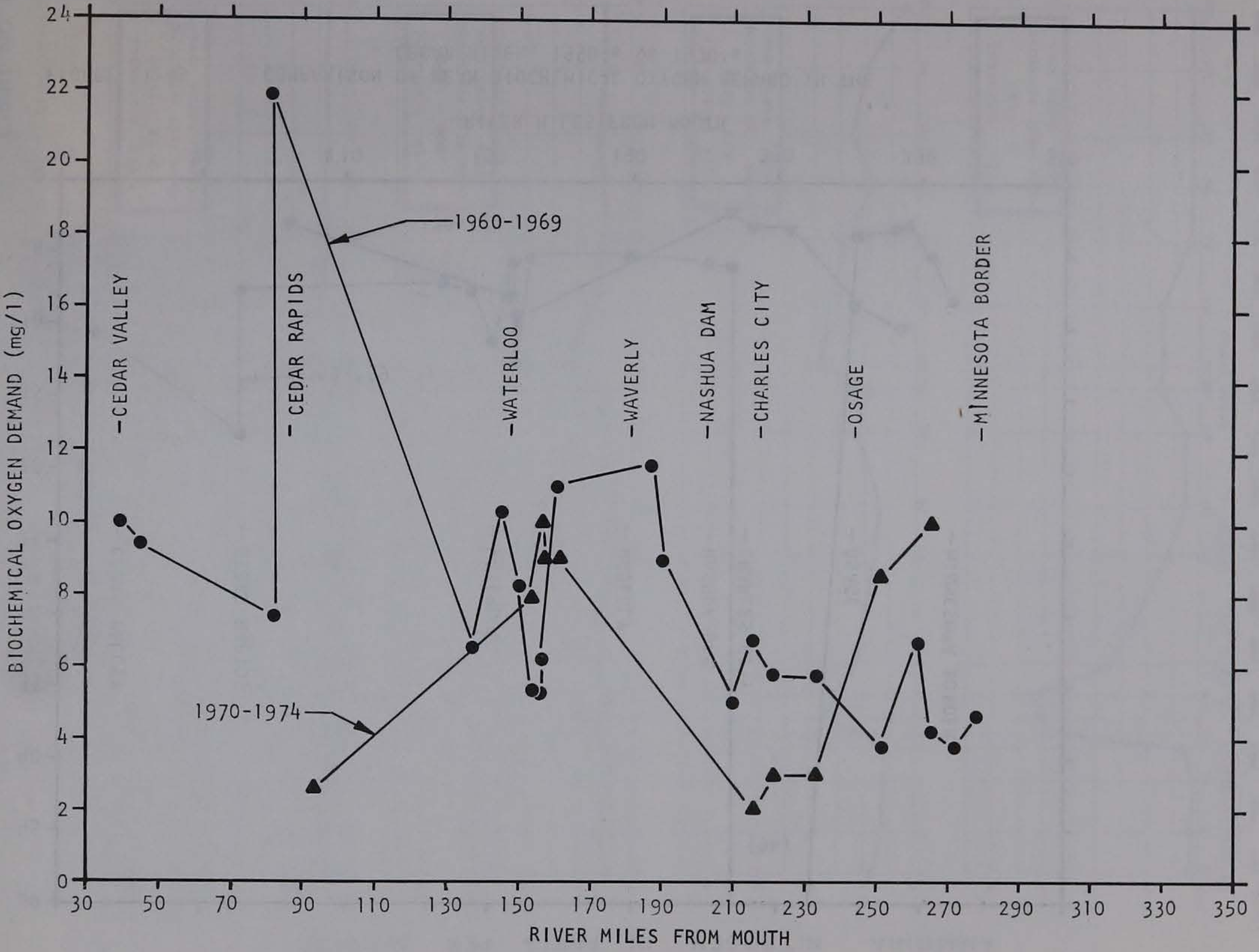


FIGURE 11-46 COMPARISON OF MEAN BIOCHEMICAL OXYGEN DEMAND IN THE CEDAR RIVER, 1960's vs 1970's

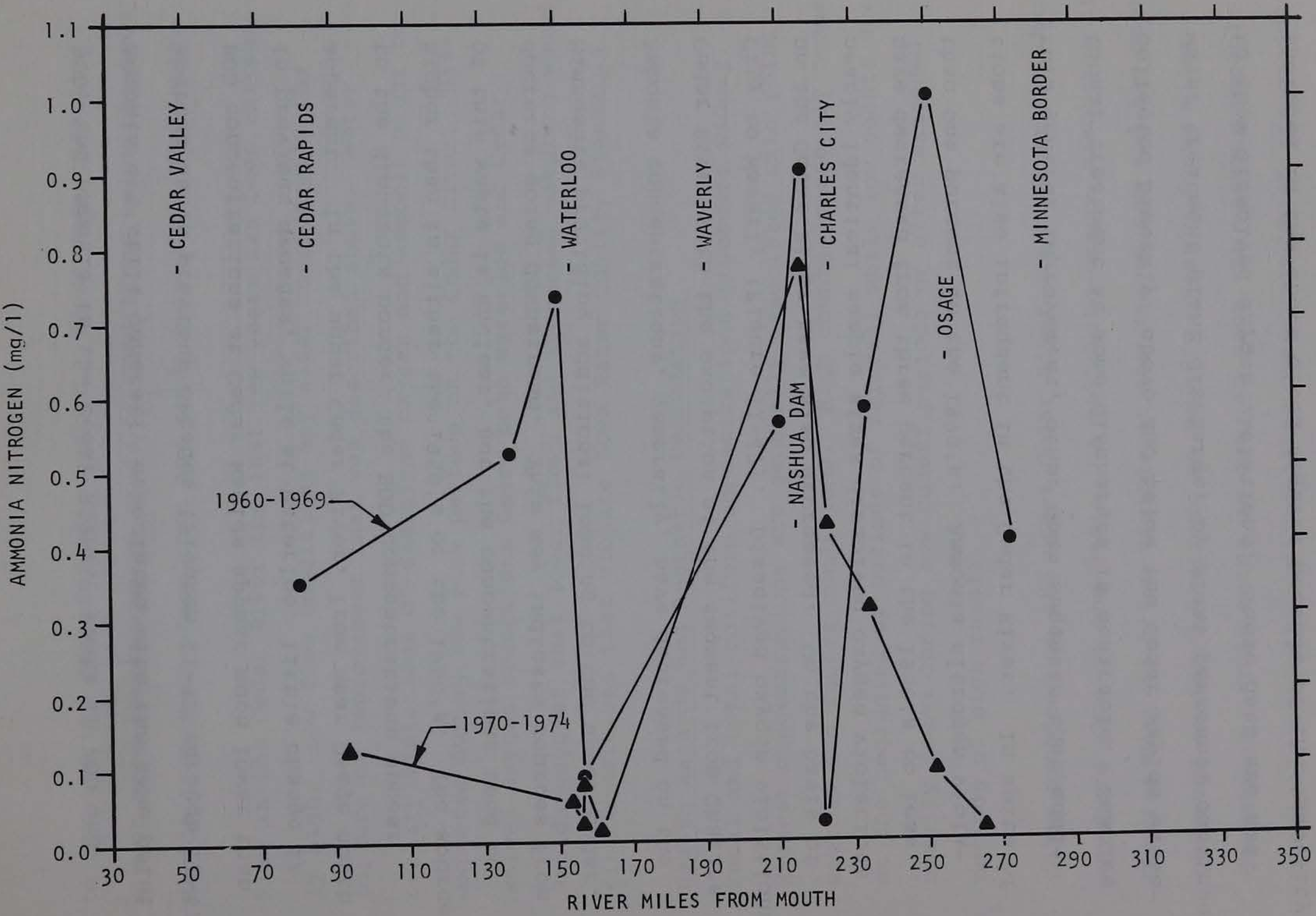


FIGURE 11-47 COMPARISON OF MEAN AMMONIA NITROGEN CONCENTRATIONS IN THE CEDAR RIVER, 1960's vs 1970's

BOD, and ammonia in the Cedar River. Peaks in BOD and ammonia are still generally associated with the same point sources as in previous decades (Figures II-43 through II-47). BOD concentrations at Cedar Rapids appear much lower than in previous decades, while at Waterloo, little change is apparent. In the upper Cedar River, from near Osage north to the Minnesota border, the BOD concentrations appear higher than in either the 1950's or the 1960's. The source of this waste is unclear, but the concentrations tend to decrease going downstream. This may indicate sources from Minnesota providing additional loading to the upper Cedar.

Ammonia concentrations, generally, have decreased on the Cedar River with the exception of the segment from Charles City to Waverly (Figure II-47). Dissolved oxygen violations on the Cedar River have also decreased. On the basis of nearly identical sample sizes dissolved oxygen violations have decreased from three percent in the 1950's to less than one percent in the 1970's. Ammonia nitrogen violations are also infrequent in the Cedar River. In spite of this general improvement, other data suggests that additional treatment at some discharges is desirable. Samples collected biweekly, above and below the Cedar Rapids wastewater treatment plant discharge, by plant personnel continue to show dissolved oxygen violations. These data are not included in the above cited figures because of the inability to compile the data for this report. These data constitute a much more comprehensive study of conditions below the Cedar Rapids treatment plant than any study heretofore available.

Flow in the Cedar River the last few years has been extremely high. Low flow conditions may alter considerably the picture of improvement that was described above. Water quality violations of dissolved oxygen and ammonia might be expected during low flow periods on the Cedar River. Dissolved oxygen reductions below both Waterloo and Cedar Rapids suggest that lower flows and increased sampling would find conditions that violate Iowa Water Quality Standards.

Health Hazards and Aesthetic Degradation

Fecal and total coliform concentrations fluctuate widely. Highest concentrations are generally associated with point sources and runoff conditions. High counts frequently occur at the beginning of periods of rainfall while low counts are usually found during low runoff periods or after extended periods of high runoff.

Color problems on the upper Cedar River are more severe than anywhere else in the State. A yellowish-orange discharge at Charles City is often visible at the Nashua dam and has been observed as far downstream as Waverly, nearly forty miles downstream. This color is due, in part, to various organic chemicals including nitroaniline compounds which are produced by Salsbury Laboratories at Charles City. Color limitations set in the Charles City discharge permit to take effect upon completion of adequate treatment facilities should eliminate this problem from the river.

It is difficult to discuss water quality in the Cedar River without mentioning the taste and odor problems near Cedar Rapids in the early 1960's. This problem was eventually traced to actinomycetes bacteria. The cause of the terrific increases in the population of these bacteria or the sudden decrease and elimination of the problem is not well known, although numerous studies and publications have discussed this episode in detail. It is still unclear if or when another such occurrence might develop. In any case, it is unlikely that a point source caused the problem, and there have been no recent occurrences.

SHELLROCK RIVER

The most notable pollution problems on the Shellrock River are dissolved oxygen and ammonia nitrogen concentrations which often violate Iowa Water Quality Standards and endanger aquatic life. The source of the majority of the pollution is from outside of the State, at Albert Lea, Minnesota. Profiles of the river generally show decreasing ammonia, phosphate, fecal coliform, and biochemical oxygen demand from the Minnesota border to the mouth. Increasing dissolved oxygen can be observed over the same profile.

The key pollutants highlight conditions in the Shellrock:

Harmful Substances: No pesticide samples have been collected to determine the impact on the Shellrock River. The only heavy metal which has exceeded Iowa Water Quality Standards has been lead. This has occurred only rarely.

Physical Modification: No particular problems concerning physical modification have been noted. Turbidity levels are considerably lower than western Iowa, and similar to those in many eastern Iowa streams.

Salinity, Acidity, and Alkalinity: Salinity has consistently been found within Iowa limitations. Alkalinity is similar to other Iowa streams and has averaged about 240 mg/l. Acidity has not been a problem.

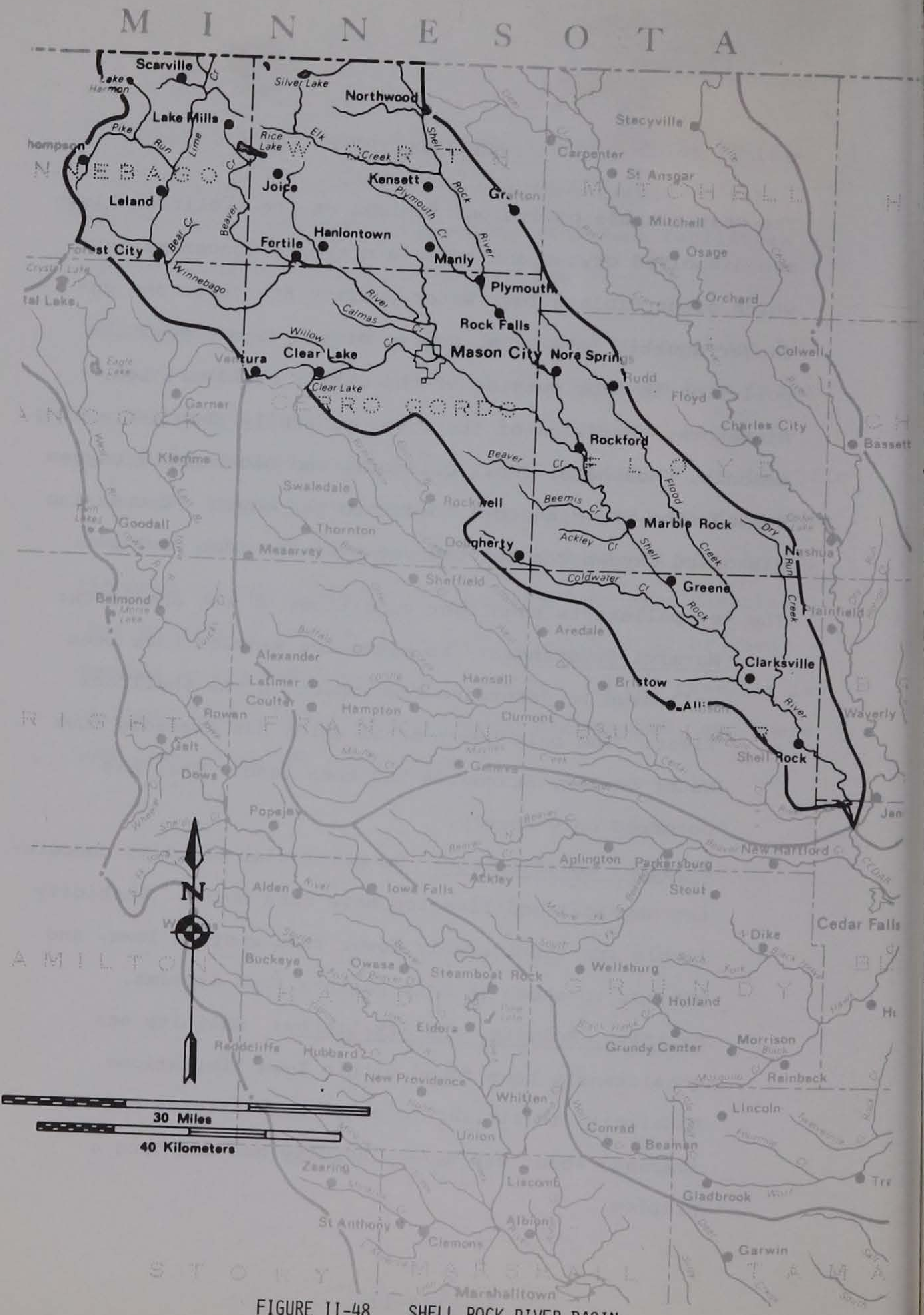


FIGURE II-48 SHELL ROCK RIVER BASIN

Eutrophication Potential: High nitrogen and phosphate concentrations are common in the Shellrock. Concentrations are often highest near the Minnesota border and decrease toward the mouth. Point sources account for larger portions of nitrate and phosphate than on many Iowa rivers.

Oxygen Depletion: Severe oxygen depletion and very high ammonia concentrations have often been found in the upper Shellrock River. Conditions tend to improve going downstream from the Minnesota border, but Iowa point sources aggravate the problem and prevent quick recovery.

Health Hazards and Aesthetic Degradation: Fecal coliform concentrations below point sources reach quite high levels. Anaerobic conditions under ice cover in the upper Shellrock cause odor and an unpleasant physical appearance to the river below the Minnesota border.

GENERAL PHYSICAL DESCRIPTION

The Shellrock River originates at Albert Lea Lake in Minnesota, and after it crosses the Iowa border near Northwood it receives wastes from the towns of Northwood, Manley, Nora Springs, Greene, Clarksville, and Shellrock before it joins the West Fork Cedar River near Janesville. The main tributary of the Shellrock River is the Winnebago River joining the Shellrock near Rockford, Iowa.

WATER QUALITY CONDITIONS

Harmful Substances

Pesticide studies have not been conducted on the Shellrock River. Heavy metal samples collected to date indicate barium, copper, lead, manganese and zinc. Only lead concentrations have exceeded Iowa standards. The maximum lead concentration found was 0.74 mg/l.

TABLE II-25

HEAVY METALS IN THE SHELLROCK RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	10	0		
Ba	16	12	158	400
Cd	0			
Cr	18	0		
Cu	16	1	50	50
Pb	16	2	580	740
Mn	13	7	73	170
Hg	2	0		
Ni	14	0		
Ag	7	0		
Zn	16	8	125	330

Physical Modification

Average turbidity in the Shellrock has been 24 JTU. The maximum concentration found in samples collected since 1970 is 68 JTU. The magnitude of turbidity and suspended solids problems is considerably less than many Iowa streams. This is partly due to the fact that the river originates from Albert Lea Lake, that the drainage area is somewhat smaller, and the lack of straightening and channelization have kept erosion of the river banks down.

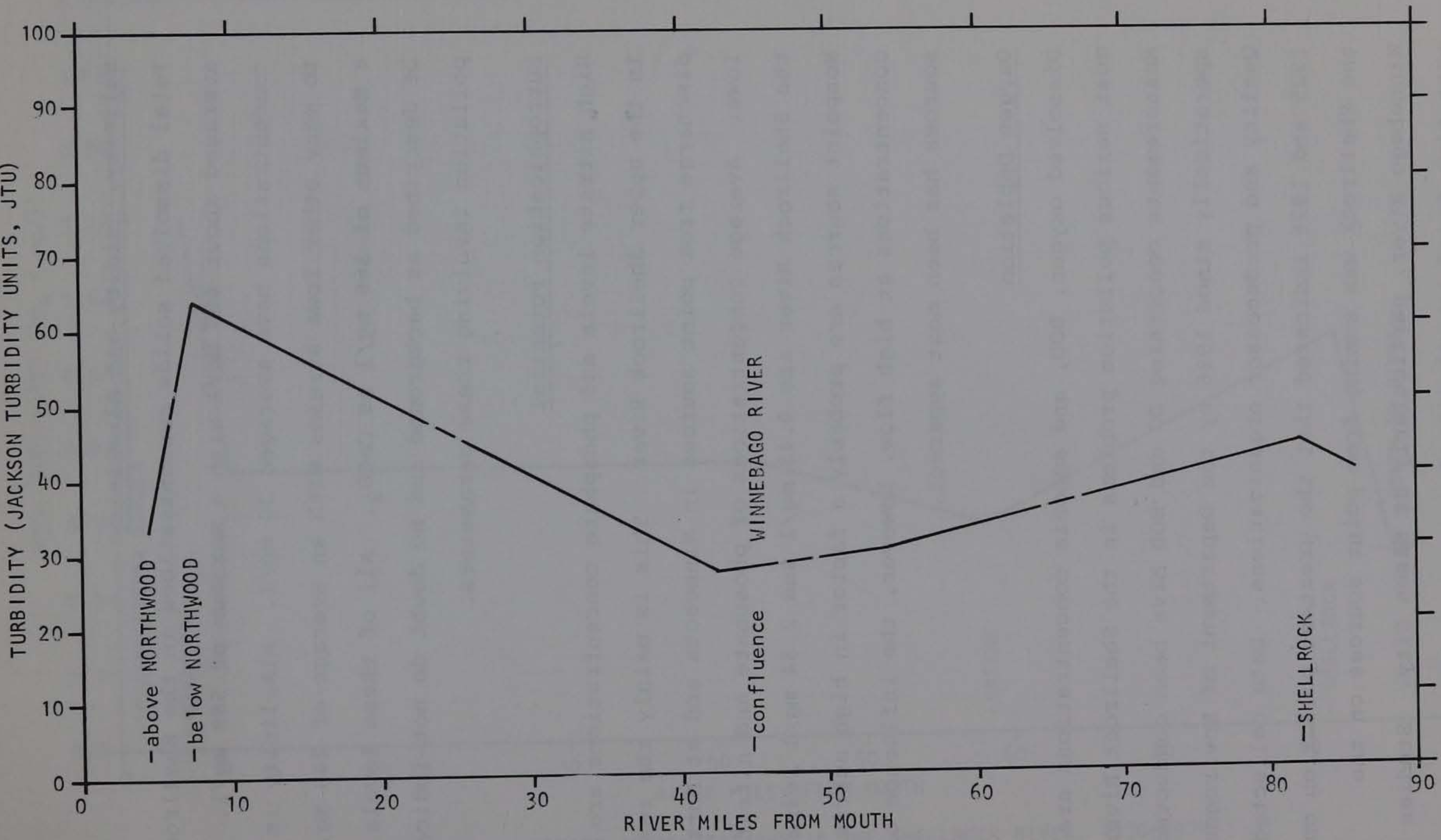


FIGURE 11-49 MEAN TURBIDITY IN THE SHELLROCK RIVER, 1970-1974

Salinity, Acidity and Alkalinity

Total dissolved solids concentrations in the Shellrock have averaged about 400 mg/l with a maximum of 589 mg/l. Chloride concentrations have averaged 30 mg/l. Alkalinity is similar to many other Iowa streams with an average of 243 mg/l and a maximum of 366 mg/l as $CaCO_3$. All of these levels could be described as background and no doubt do not indicate pollution involving these parameters.

Eutrophication Potential

High nitrate levels and phosphate concentrations are common in the upper Shellrock River. This is mainly the result of discharge from point sources in Minnesota and at Northwood, Iowa. Average concentrations of phosphate and nitrate in the Shellrock River are 0.43 mg/l and 2.34 mg/l respectively. Nonpoint sources are probably a factor in high nutrient concentrations at high flow, however, the influence of point sources has been most apparent.

Oxygen Depletion

Dissolved oxygen, BOD, and ammonia concentrations are the most serious pollution problems in the Shellrock River. Measurements concerning DO and BOD have been conducted sporatically since 1926 by the Department of Environmental Quality and predecessor organizations. Data collected in 1925 and 1926 indicated that the greatest pollution on the Shellrock was coming from point sources on the Winnebago River, particularly at Mason City. Studies at that time found low dissolved oxygen and odors downstream

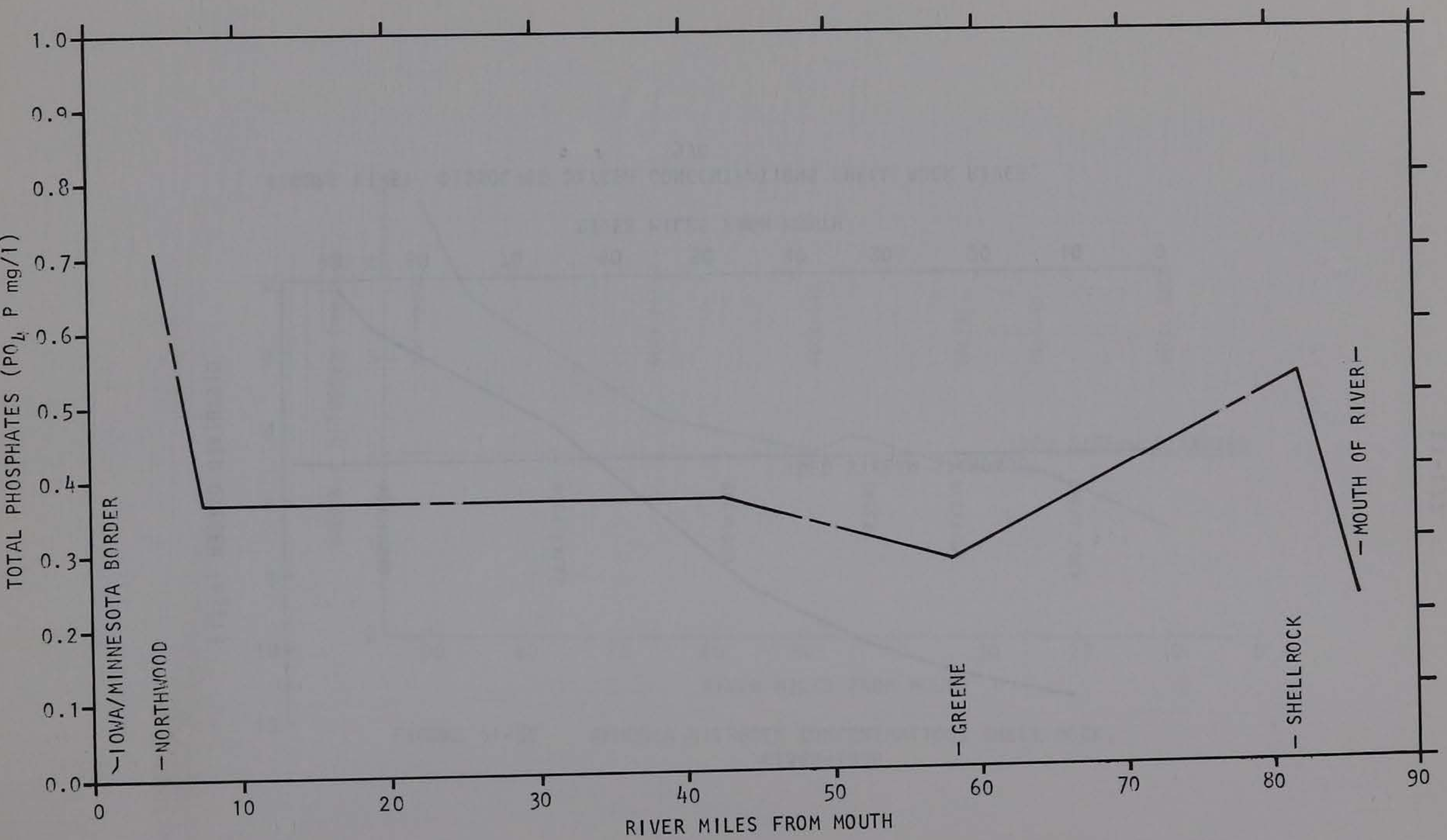


FIGURE 11-50 MEAN TOTAL PHOSPHATE CONCENTRATIONS IN THE SHELLROCK RIVER, 1970-1974

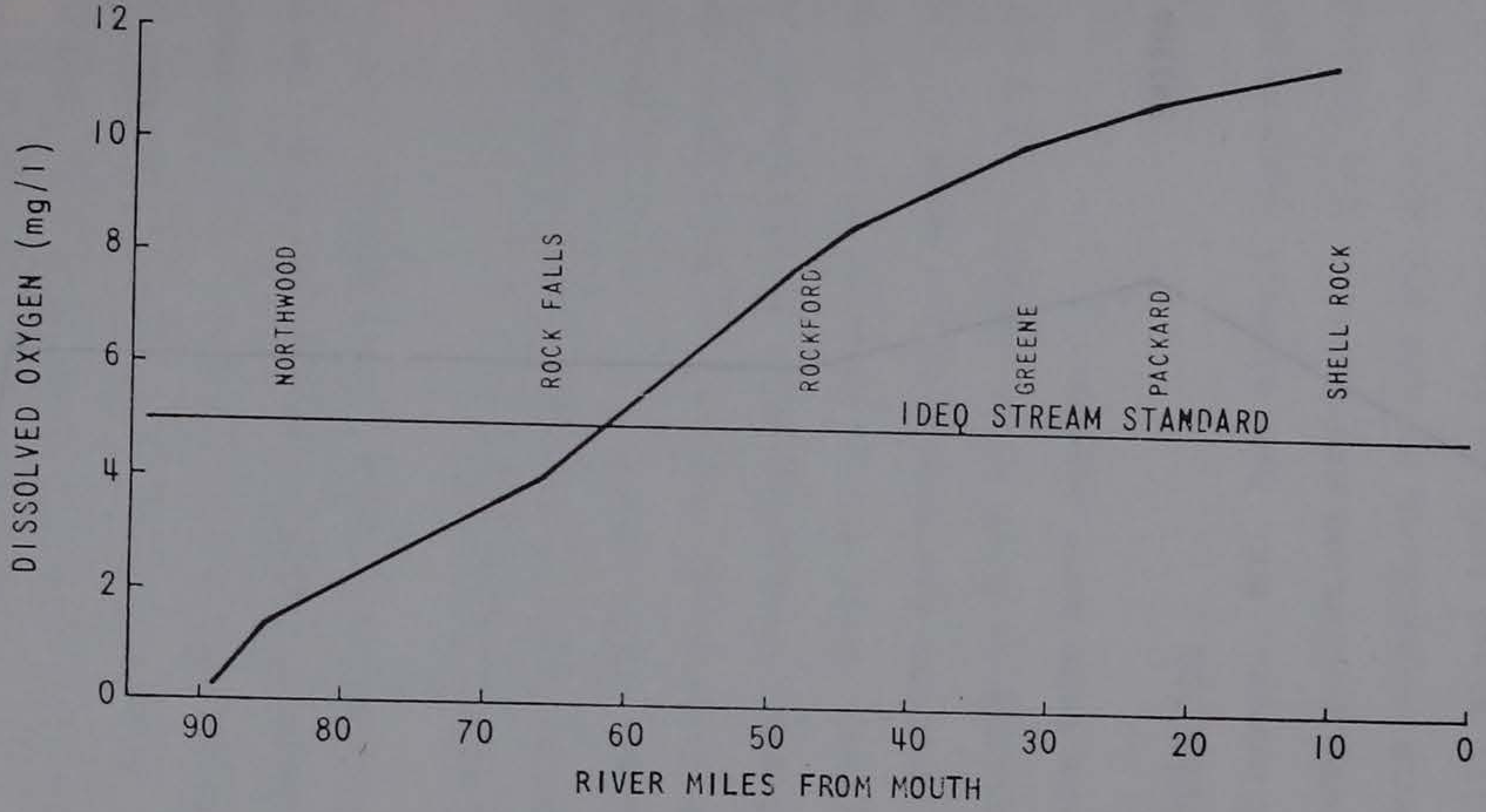


FIGURE 11-51 DISSOLVED OXYGEN CONCENTRATIONS SHELL ROCK RIVER, 1970

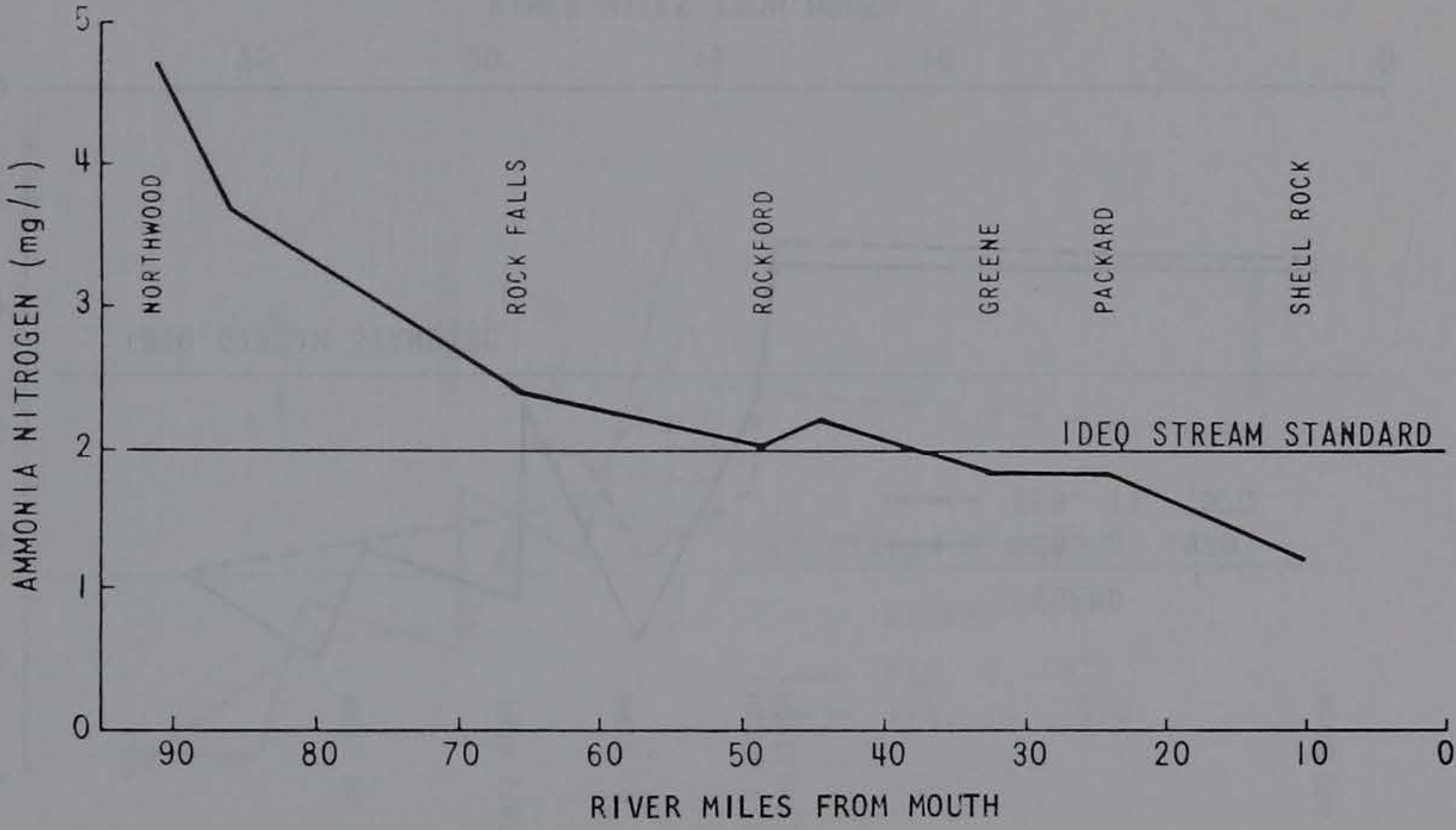


FIGURE 11-52 AMMONIA NITROGEN CONCENTRATIONS SHELL ROCK, RIVER-1970

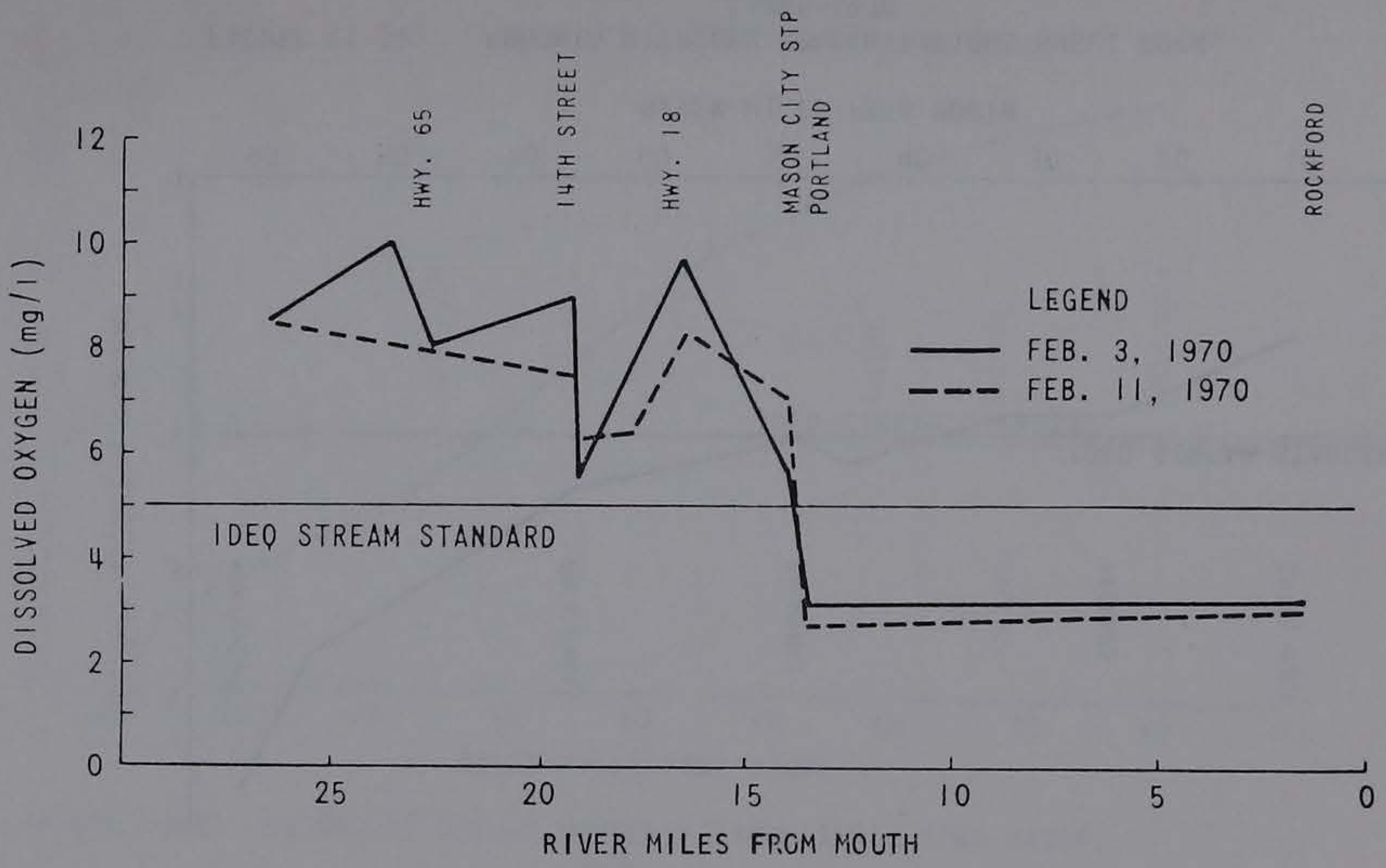


FIGURE II-53 DISSOLVED OXYGEN CONCENTRATIONS, WINNEBAGO RIVER-1970

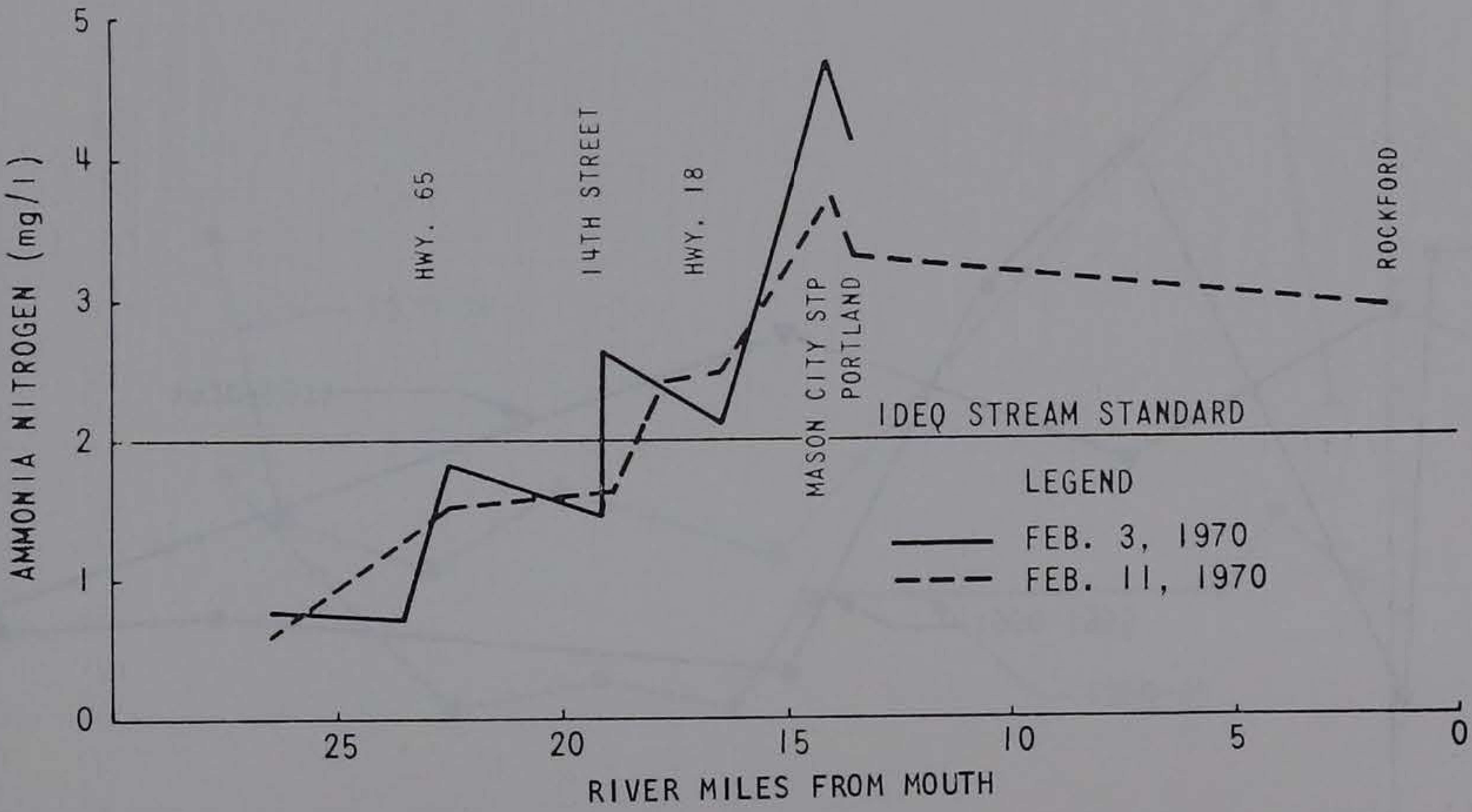


FIGURE II-54 AMMONIA NITROGEN CONCENTRATIONS, WINNEBAGO RIVER-1970

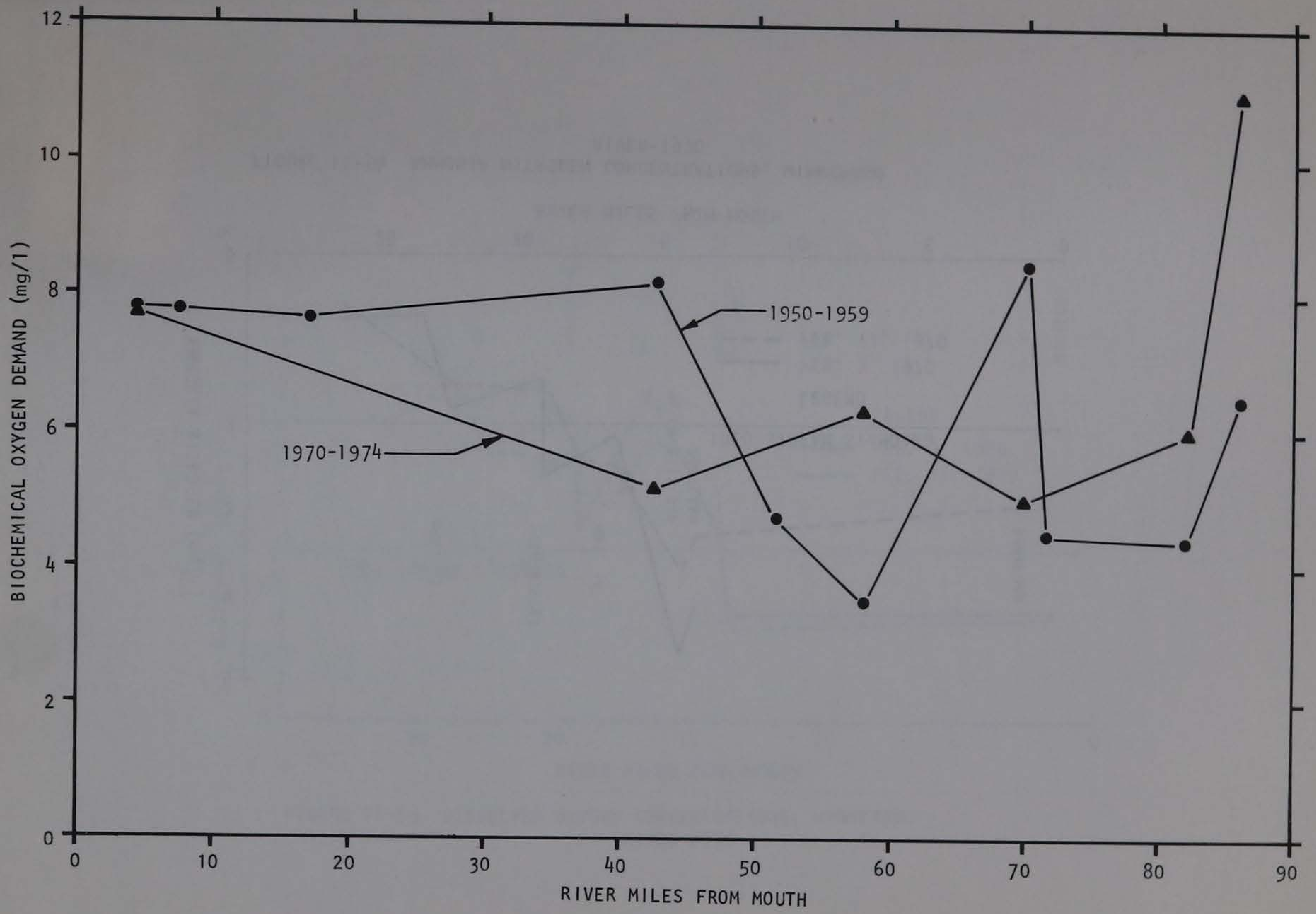


FIGURE 11-55 COMPARISON OF MEAN BIOCHEMICAL OXYGEN DEMAND IN THE SHELLROCK RIVER, 1950's vs 1970's

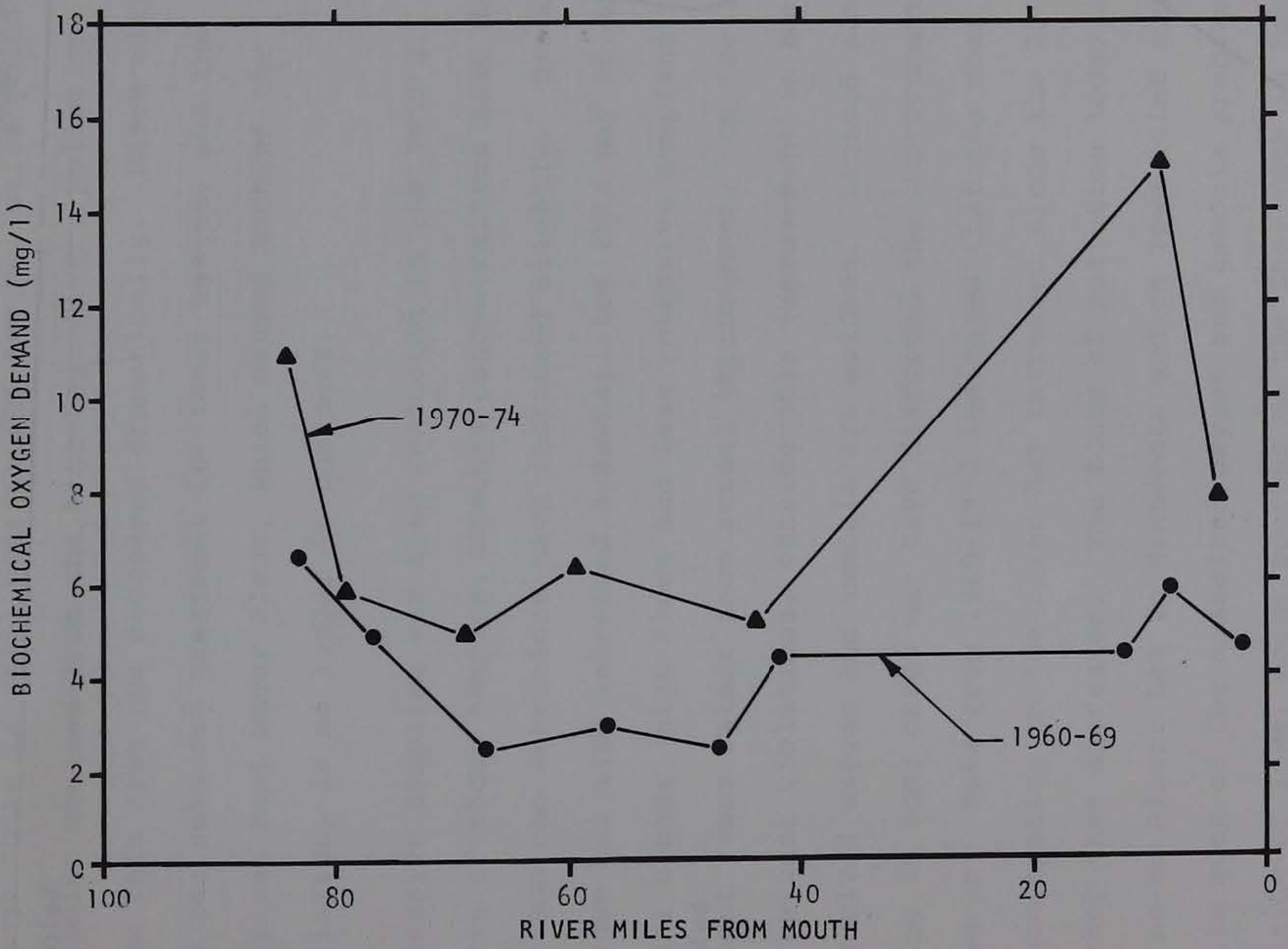


FIGURE 11-56 COMPARISON OF MEAN BIOCHEMICAL OXYGEN DEMAND IN THE SHELLROCK RIVER, 1960's vs 1970's

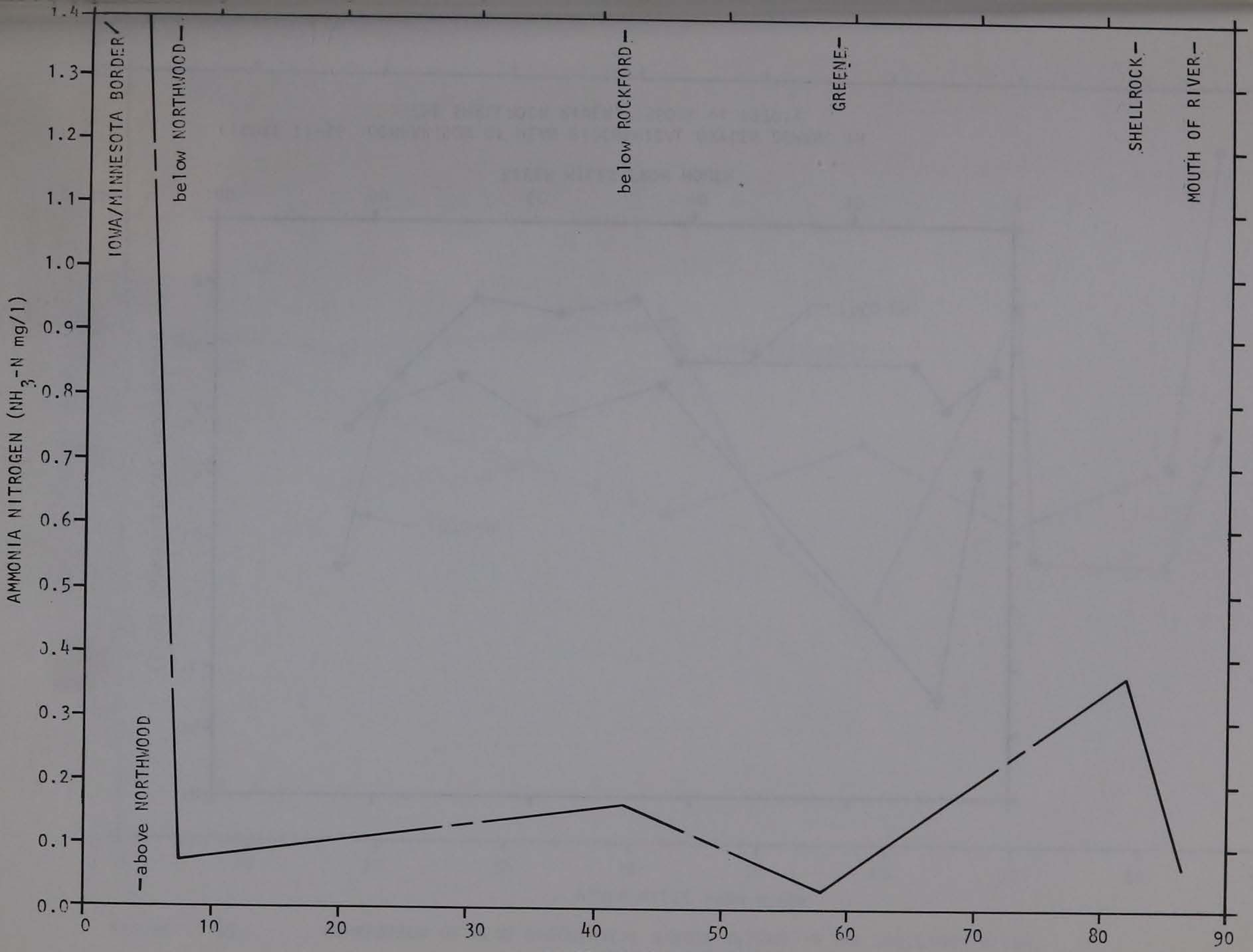


FIGURE 11-57 MEAN AMMONIA NITROGEN CONCENTRATIONS IN THE SHELLROCK RIVER, 1970-1974

from the Winnebago River at Marble Rock and Greene. Though there is still concern for the pollution potential of point sources from the Winnebago River, pollution from this area has decreased dramatically. Mason City now has advanced treatment for their wastes, and the American Beet Sugar Plant, which caused much of the pollution, is no longer in business.

Extensive sampling was also conducted in the 1950's. On the basis of those samples, ammonia concentrations have decreased, but BOD concentrations have increased slightly. Dissolved oxygen has also increased somewhat, but this may be due to algal blooms, high flows and less intensive sampling in recent years rather than actual improvement. On the basis of percent violations, considerable improvement in both dissolved oxygen and ammonia are evident. Limited sampling in some cases may have distorted the improvement however. Data from 1960-1970 indicates that the mean BOD concentration in the river has increased since the 1960's rather than decreased. The focus of pollution today appears to be on Albert Lea in Minnesota and on Iowa point sources. While much of the dissolved oxygen and ammonia problem is outside of Iowa, point sources on the Shellrock in Iowa also need increased waste treatment to eliminate pollution on the river. The Shellrock has the potential for being one of the best recreational rivers in the State, if pollution can be eliminated.

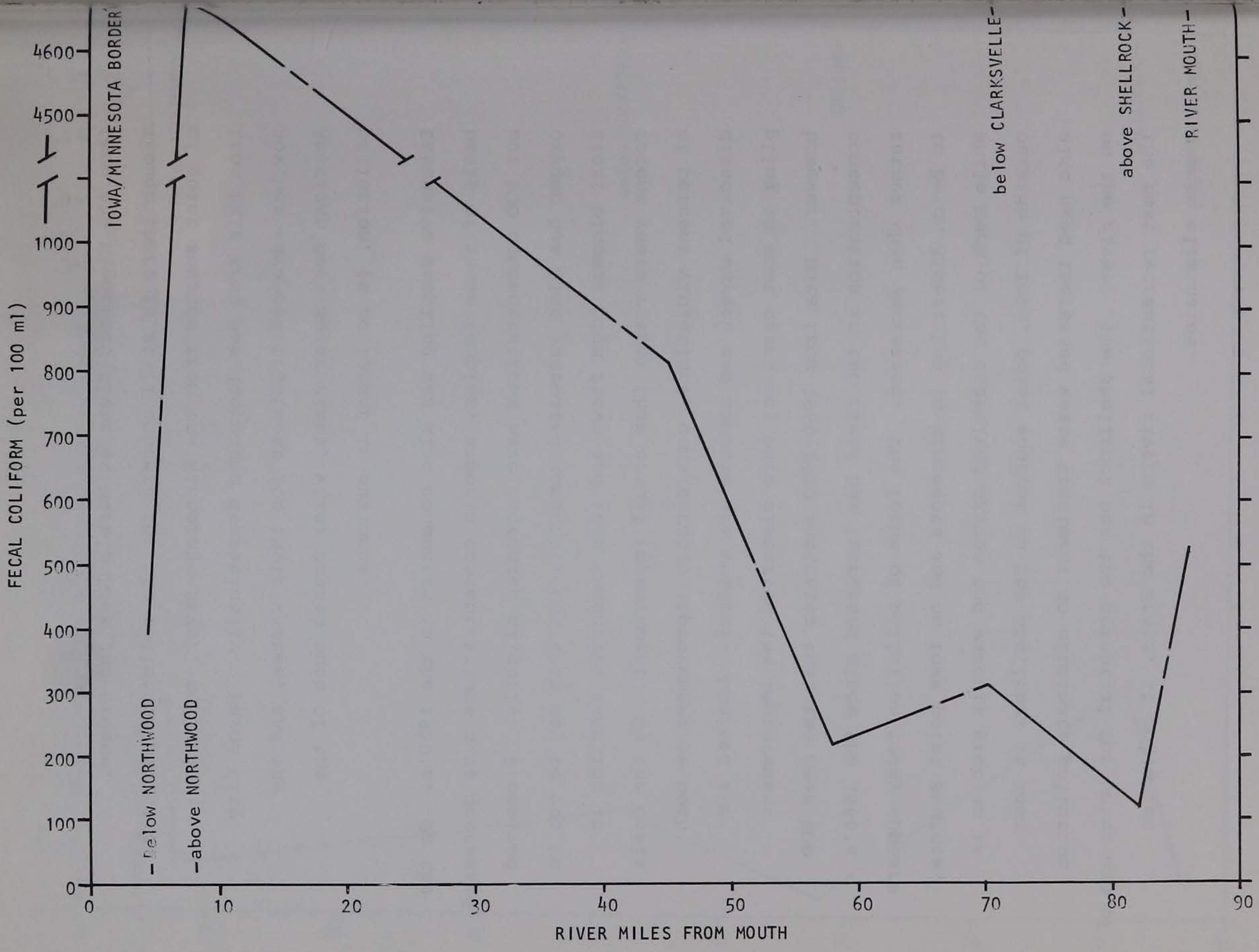


FIGURE 11-58 MEAN FECAL COLIFORM CONCENTRATIONS FOR THE SHELLROCK RIVER, 1970-1974

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations in the Shellrock have been found to be highest below point sources, particularly below Northwood. Point sources seem to have a large impact on the fecal coliform concentrations in the stream (Figure II-58).

Aesthetic degradation particularly concerning odor is also a major problem. As mentioned above, serious odor problems occurred below the Winnebago River at Marble Rock and Greene in the late 1920's. Today the main odor problem is in the Northwood area near where the Shellrock enters the State. Numerous complaints concerning aesthetic degradation have been received by the Department of Environmental Quality over the past several years. Interstate cooperation between Minnesota and Iowa is underway to eliminate the pollution problems in this part of the river. Upon completion of adequate treatment at point sources on the upper Shellrock, considerable improvement should be noted.

SKUNK RIVER

Water quality problems in the Skunk River are primarily related to low dissolved oxygen and high ammonia nitrogen concentrations. While water quality is good during most periods, low flows and ice cover often exhibit critical concentrations of dissolved oxygen and ammonia. High nutrient concentrations and turbidity are generally associated with runoff.

The key pollutants highlight conditions in the Skunk:

<u>Harmful Substances</u>: Pesticide levels for DDE and dieldrin are above recommended maximum levels. The extensive use in agriculture has caused the high levels. Heavy metal concentrations are generally within Iowa standards, although both lead and copper have exceeded Iowa standards.

<u>Physical Modification</u>: Discharges from power plants may pose a significant problem during low flow conditions on the river, however, insufficient data are presently available to adequately evaluate thermal pollution.

<u>Eutrophication Potential</u>: Phosphate and nitrate concentrations vary considerably throughout the basin. Adequate nutrients for algal blooms are normally available. While these nutrients may be limiting under certain conditions, it appears that algal growth may be limited by physical factors.

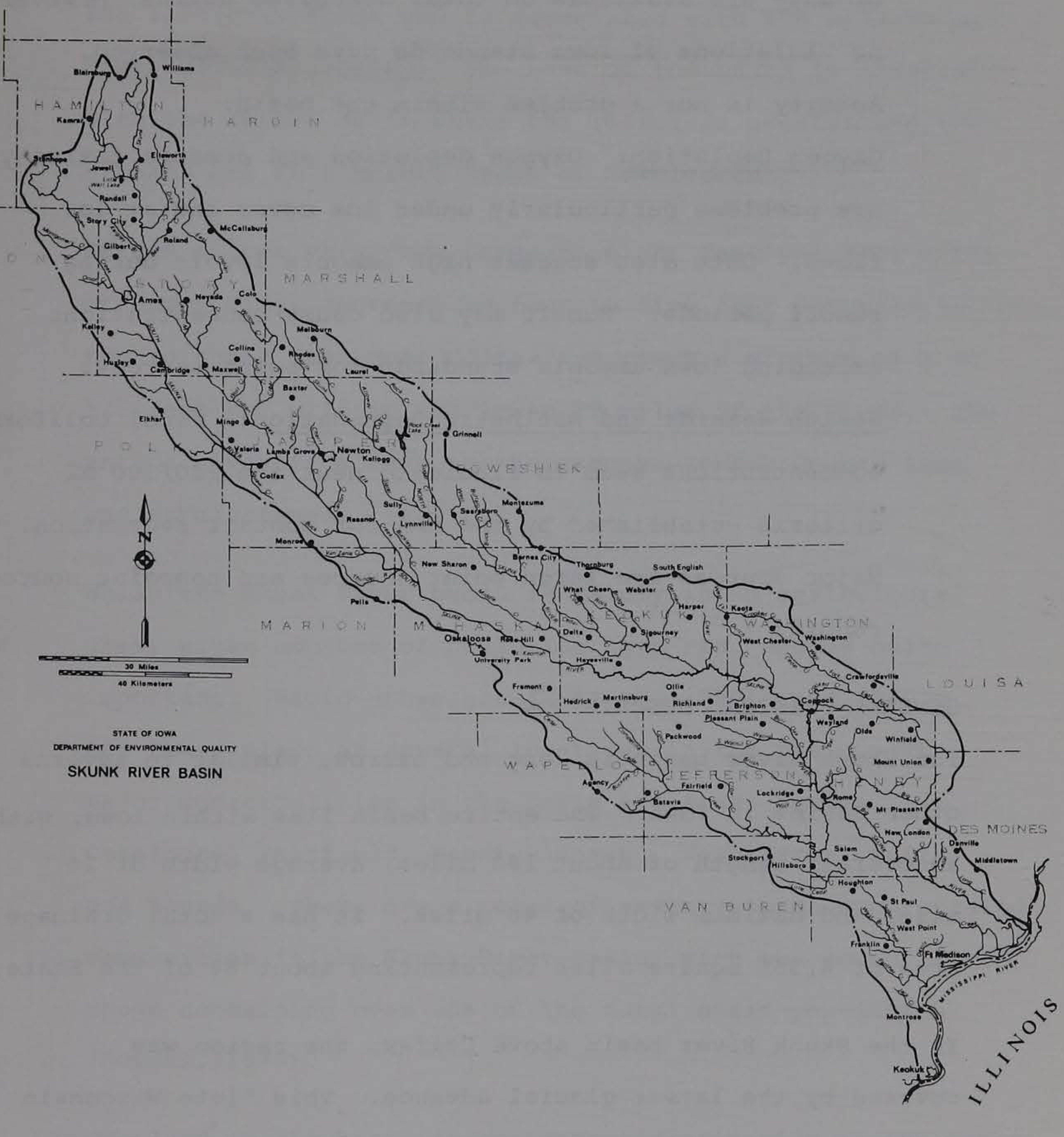


FIGURE II-59 SKUNK RIVER BASIN

Salinity, Acidity, and Alkalinity: Only a small amount of data are available on total dissolved solids, however, no violations of Iowa standards have been observed. Acidity is not a problem within the basin.

Oxygen Depletion: Oxygen depletion and ammonia toxicity are problems particularly under ice cover and at low flows. Data also suggest high ammonia levels during runoff periods. Runoff may also cause concentrations exceeding Iowa ammonia standards for point sources.

Health Hazards and Aesthetic Degradation: Fecal coliform concentrations seem to fluctuate near the 200/100 ml criteria established by the EPA for contact recreation. Major sources are large point sources and nonpoint source runoff.

GENERAL PHYSICAL DESCRIPTION

The Skunk River basin is long and narrow, similar to several other basins in Iowa. The entire basin lies within Iowa, with an overall length of about 180 miles, average width of 24 miles and maximum width of 40 miles. It has a total drainage area of 4,355 square miles representing about 8% of the State.

In the Skunk River basin above Colfax, the region was covered by the latest glacial advance. This "late Wisconsin drift" is an area described as "youthful topography" with nearly level land interspersed with sections of terminal or recessional moraines. Extensive straightening and rechanneling has been done in this area. A small section of the lower basin was covered by glacial drift of the Illinoian stage and is associated with the Mississippi River alluvial valley. The rest of the basin is associated with the Kansan drift where the relief is greater and the streams are in a mature stage of development.

Stream slopes vary from seven to eight feet per mile north of Story City, decrease to four to five feet per mile at Ames, two to three feet near Colfax and reach a minimum of 1 to 1.5 feet per mile in the lower 60 miles of the river. The entire river from Ames to the Mahaska-Keokuk County line was straightened.

While the Skunk River basin is mainly in an agricultural area, urban sources of pollution have also become quite important. Rapid urban growth in the 1950's and 1960's has taken place at several locations in the basin. The major municipalities in the basin are Ames, Newton, Oskaloosa, Fairfield, Mount Pleasant, Washington, Pella and Nevada. There are a total of seventy-three incorporated communities in the Skunk River basin, with the seven listed above containing over 65% of the total basin population (Dougal, 1970).

Cropland in the basin is concentrated primarily in the upper portion. Cropland in Story County accounts for 80% of the county's land. This decreases to 60% in Mahaska County and 54% in Henry County.

POLLUTION PROBLEMS AND SOURCES

Waste from the municipal discharges on the Skunk River, particularly Ames, may at times affect water quality on the entire length of the river. During ice cover and low flow conditions ammonia nitrogen and dissolved oxygen concentrations are significantly influenced by these discharges. Even during non-critical summer periods localized impacts on water quality including bacterial counts, high nutrient levels, and lower dissolved oxygen can occur. Some of the larger municipalities do not discharge directly into the Skunk River, but rather several miles up a tributary stream. The impact of larger municipalities is often sufficient to influence water quality even on the main stem of the river. Only limited data is available to determine how significant these discharges may be. Additional information should aid in determining the magnitude of the impact of tributary point sources on Skunk River water quality.

Nonpoint sources may also be an important source of ammonia nitrogen, and appear to have caused at least some water quality violations. COD, nitrates, and turbidity have all been related to the magnitude of flow in the Skunk River. Nonpoint runoff also contributes pesticides to the river in concentrations higher than those recommended as maximum. Although all counties within the basin are organized into soil conservation districts, only limited soil erosion control has been attempted (Dougal, 1970).

DATA AND METHODS

Most of the data used in the Skunk River water quality study was obtained from Iowa State University. Studies have been conducted on the South Skunk River in the Ames area since the mid 1960's. Surveys of the entire river have only recently been undertaken with one study by the State Hygienic Laboratory in the fall of 1974 and another study by the DEQ in February 1975. A permanent sampling location near Mount Pleasant has been sampling quarterly for the past several years. This limited data on the entire stream presents an undoubtedly distorted picture. The data from Iowa State University, while geographically limited, provides good information on the effect of the Ames treatment plant discharge on the river.

WATER QUALITY CONDITIONS

Harmful Substances

Dieldrin and atrazine have been found in all samples analyzed for these parameters. DDE has been found in over half of the samples also. Both DDE and dieldrin concentrations have generally exceeded the maximum recommended concentrations established by the National Academy of Science. DDE concentrations in those samples where it was detected have averaged 0.22 ug/l with a maximum concentration of 1.82 ug/l. Dieldrin concentrations have averaged 14 ng/l with a maximum of 76 ng/l. Concentrations similar, and in some cases even higher than these, have been found in Indian Creek, a major Skunk River tributary. DDE, dieldrin and atrazine have been found in all samples in Indian Creek. All of the results are on samples collected in or near Story County. As mentioned earlier, Story County has a larger percent of land in cultivation than many of the counties further downstream. The pesticide concentrations found here may be diluted considerably downstream. There is no information on pesticide levels in the lower Skunk River.

Heavy metals including barium, chromium, copper, lead, manganese, mercury, zinc and selenium have been found in the Skunk River. Only lead and copper have been found in concentrations exceeding Iowa Water Quality Standards. There are no known heavy metal dischargers on the Skunk River. Violations of the Iowa lead standard have been found occasionally on other streams. With the lack of a definite point source it has been assumed that nonpoint source runoff accounts for its presence. Further study of the presence of the lead appears necessary.

TABLE II-26

HEAVY METALS IN THE SKUNK RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	12	0		
Ba	8	8	387	900
Cd	11	0		
Cr	13	1	20	20
Cu	11	3	23	50
Pb	11	4	100	150
Mn	11	5	18	40
Hg	5	1	2.2	2.2
Ni	9	0		
Ag	9	0		
Zn	11	9	110	290

TABLE II-27

HEAVY METALS IN THE SOUTH SKUNK RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	2	0		
Ba	4	4	125	200
Ce	4	0		
Cr	6	0		
Cu	4	0		
Pb	4	2	10	10
Mn	0	0		
Hg	2	0		
Ni	2	0		
Ag	0	0		
Zn	4	4	30	50
Se	1	1	3	3

TABLE II-28

PESTICIDES IN THE SKUNK RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	26	18	219	1820
DDT	8			
Dieldrin	28	28	14	76
Atrazine	18	18	797	3900

TABLE II-29

PESTICIDES IN THE INDIAN CREEK / SKUNK RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	15	15	408	3920
Dieldrin	15	15	15	71
Atrazine	15	15	3652	42

Physical Modification

Turbidity is the most significant problem involving physical modification on the Skunk River. Sediment loading is the largest mass contribution of pollutants from agricultural sources. Various estimates have been made regarding the sediment yield from agricultural land to the Skunk River. Estimates range from 0.6 tons per acre to two tons per acre near Ames. This lies between the extremes for sediment runoff for Iowa streams of about 0.95 tons per acre on the East Fork Hardin Creek to 17 tons per acre per year in the Soldier River near Pisgah. Field observations after flood periods have shown that stream clarity returns in seven to ten days. Visibility will return to a depth of one to two feet (Dougal, 1970).

Eutrophication Potential

Nitrogen and phosphate concentrations are highest in the upper Skunk and tend to decrease in concentration toward the mouth. Nutrients are generally in abundance with phosphate concentrations averaging 1.08 mg/l PO_4-P and reaching peaks of 9.1 mg/l PO_4-P. Nitrate concentrations have averaged 4.23 mg/l NO_3-N with a maximum concentration of 35 mg/l. Nitrate and nitrite have been found to be directly related to flow on the upper South Skunk River.

Nitrate concentrations decrease dramatically going downstream (Figure II-60). This has been found in samples collected in both September and February. Nitrate is completely soluble

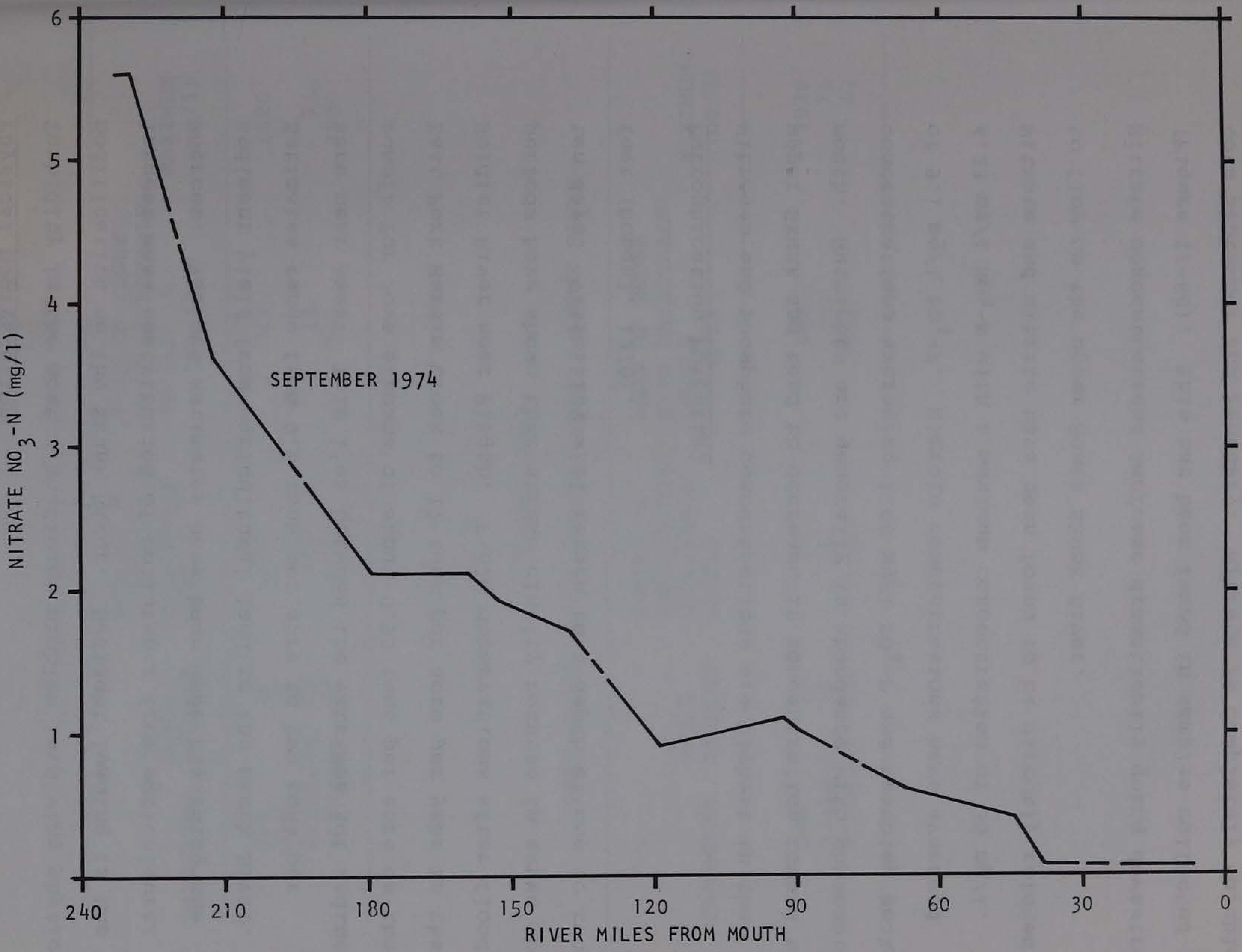


FIGURE II-60 NITRATE NITROGEN CONCENTRATIONS IN THE SKUNK RIVER, SEPTEMBER 1974 in the soil solution, and is the form of nitrogen most subject to leaching. Nitrate is moved into the soil during rainfall and is carried by groundwater and farm tile to the stream. Runoff waters in humid areas have been found to contain relatively little nitrate, but farm tiles have been found to contain large quantities of nitrate. The upper Skunk River in and above Story County flows through highly tiled agricultural lands. As mentioned earlier 80% of Story County is in cultivation. Going downstream a smaller proportion of the land is in cultivation and farm tiles are not as necessary due to the changing topography of the basin. This would account for the higher nitrate concentrations in the upper reaches and the general decrease toward the mouth. Less input and more dilution tend to decrease the nitrate concentration as it travels downstream. A significant correlation between phosphate and flow can not be made on the basis of available data. Point sources, particularly Ames, significantly increase the phosphate concentrations in the river (Figure II-61).

Salinity, Acidity, and Alkalinity:

The chloride content of the Skunk River has averaged about 20 mg/l. The chloride content of natural waters increases with its mineral content. Chlorides gain access to rivers from groundwaters, which carry chlorides from topsoil and aquifers and from sewage effluents. The chloride concentration was higher at all stations during low

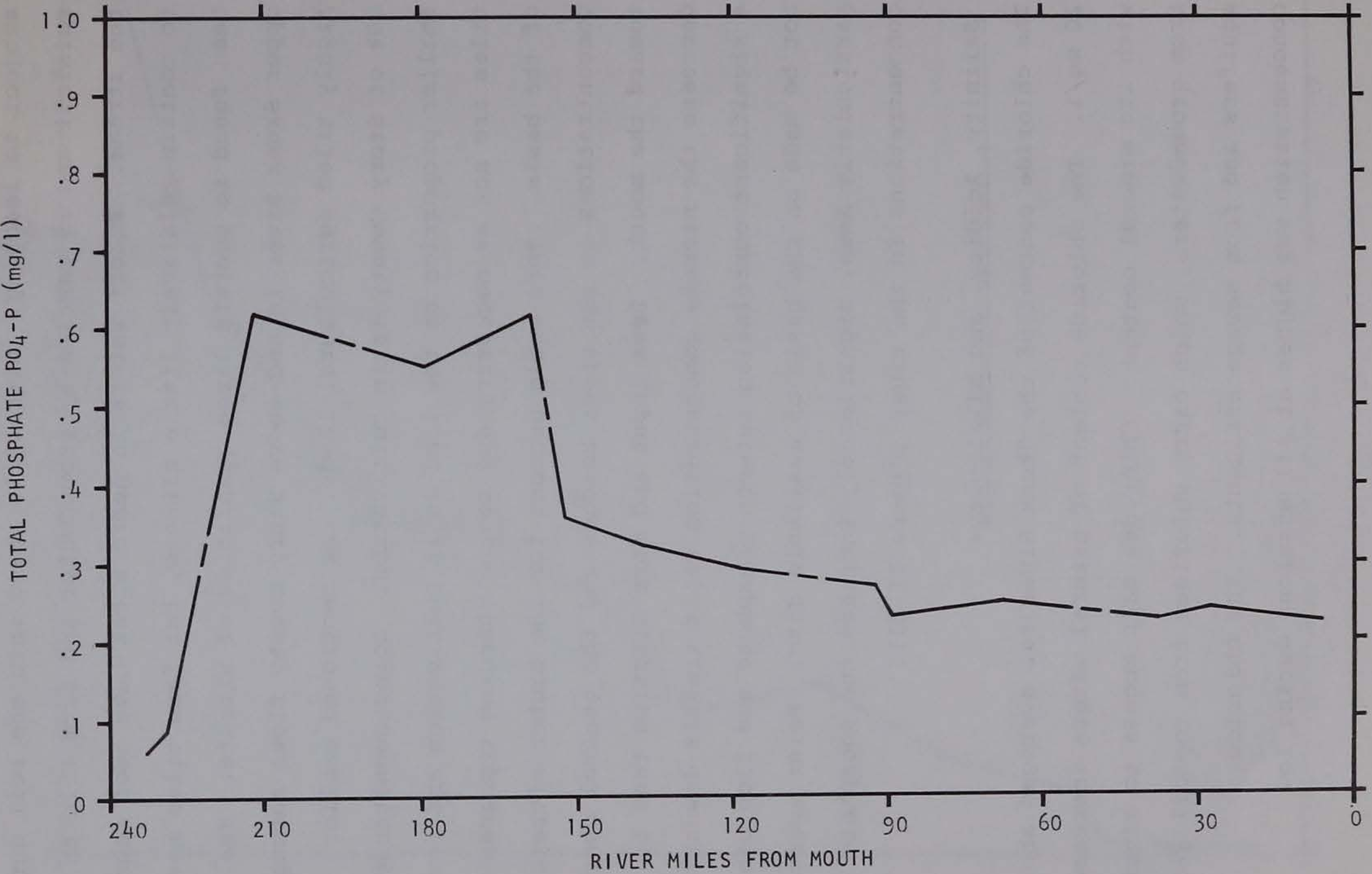


FIGURE 11-61 TOTAL PHOSPHATE CONCENTRATIONS IN THE SKUNK RIVER, SEPTEMBER 1974

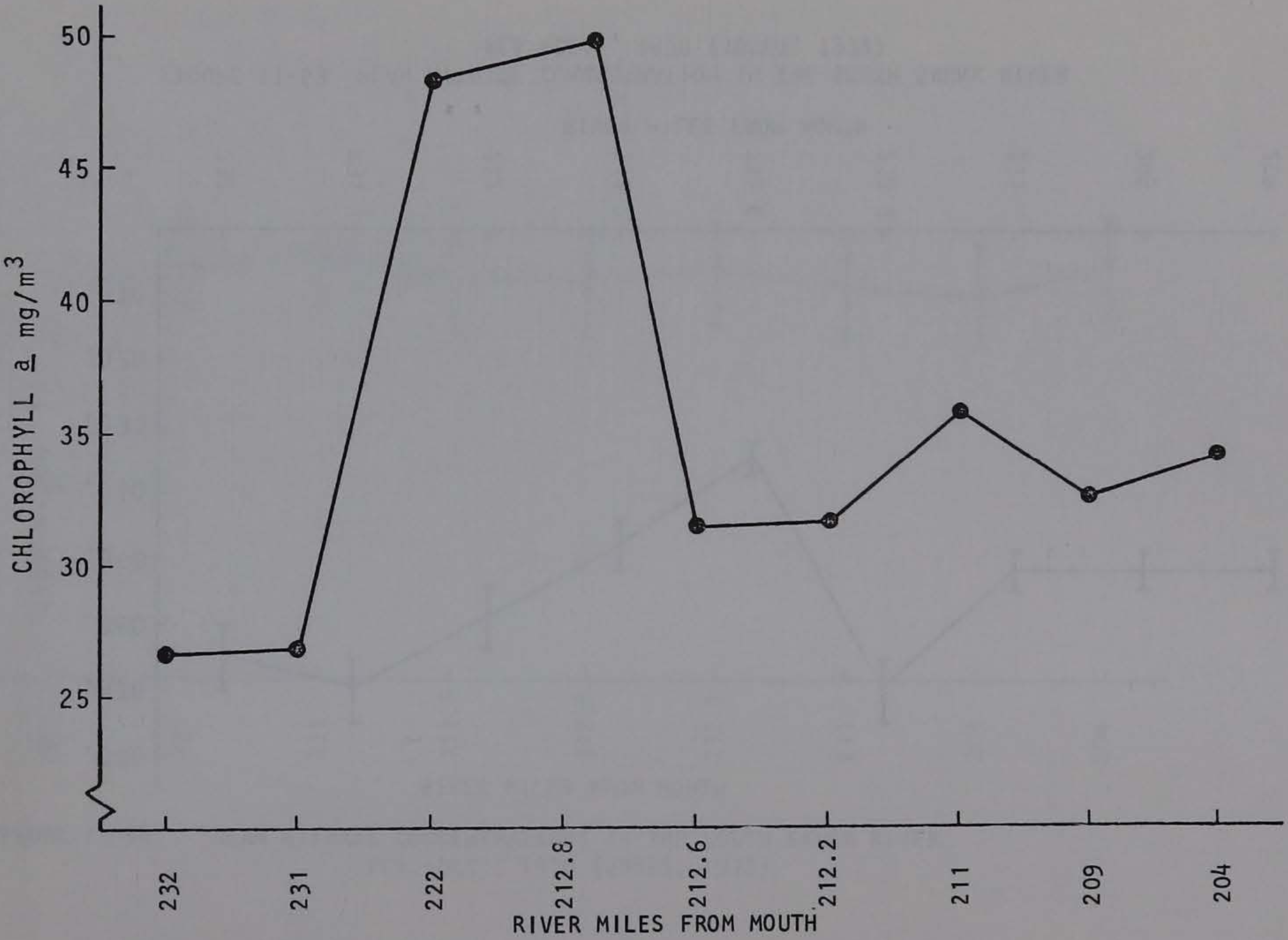


FIGURE 11-62 MEAN CHLOROPHYLL a CONCENTRATIONS IN THE SOUTH SKUNK RIVER FEB.-DEC., (JONES, 1972)

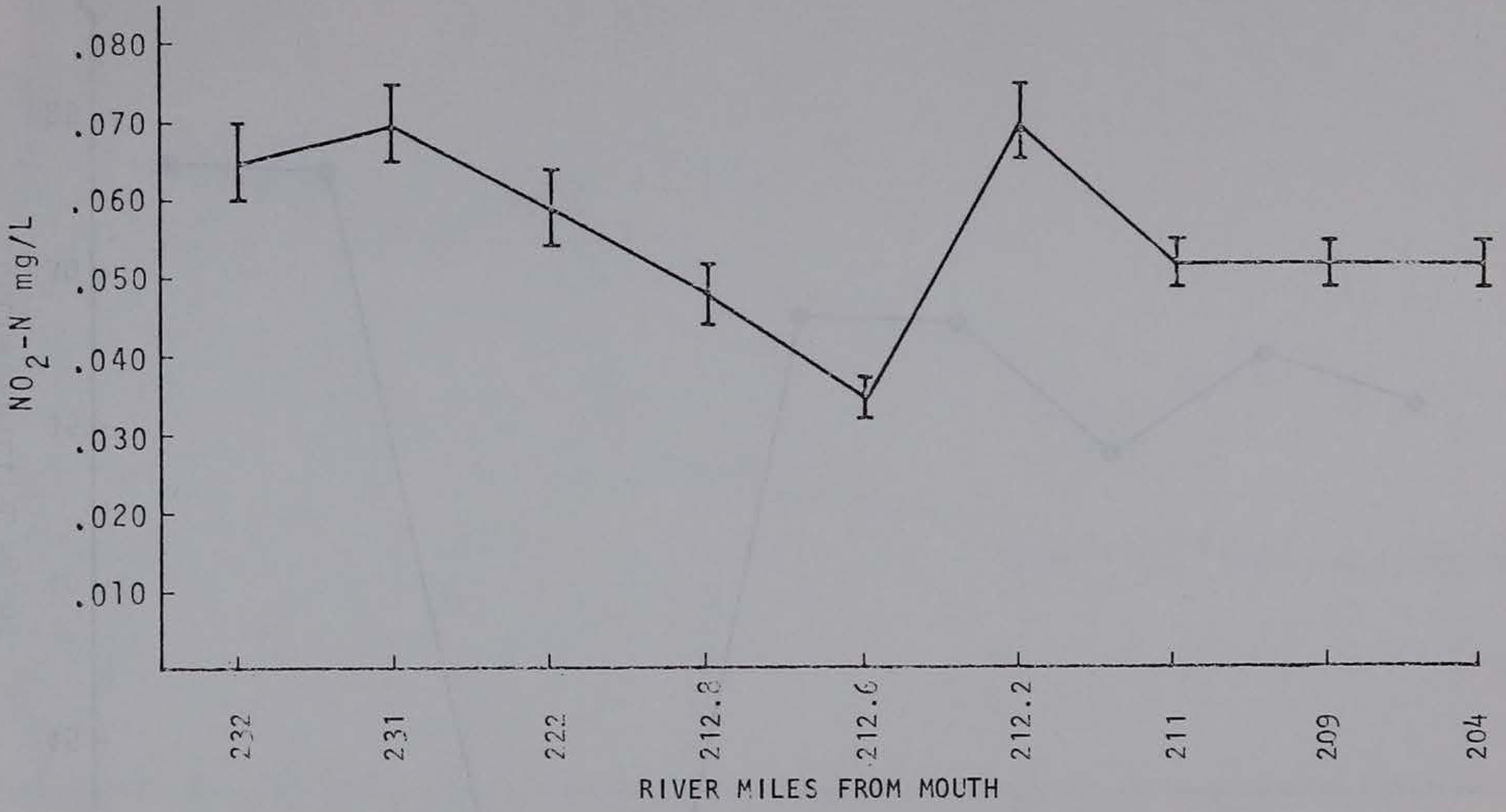


FIGURE 11-63 MEAN NITRITE CONCENTRATION IN THE SOUTH SKUNK RIVER FEB.-DEC., 1970 (JONES, 1972)

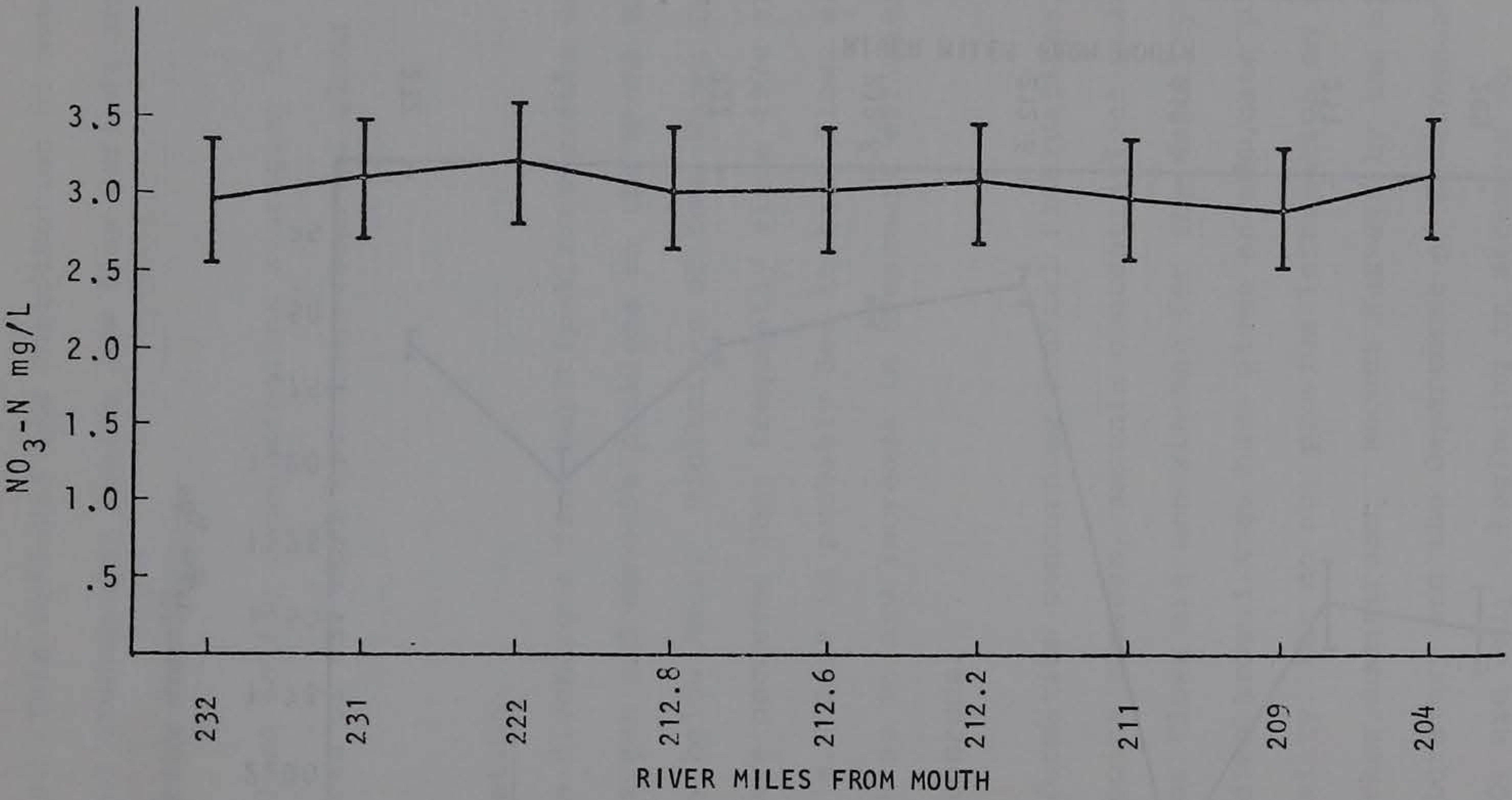


FIGURE 11-64 MEAN NITRATE CONCENTRATIONS IN THE SOUTH SKUNK RIVER FEB.-DEC., 1970 (JONES, 1972)

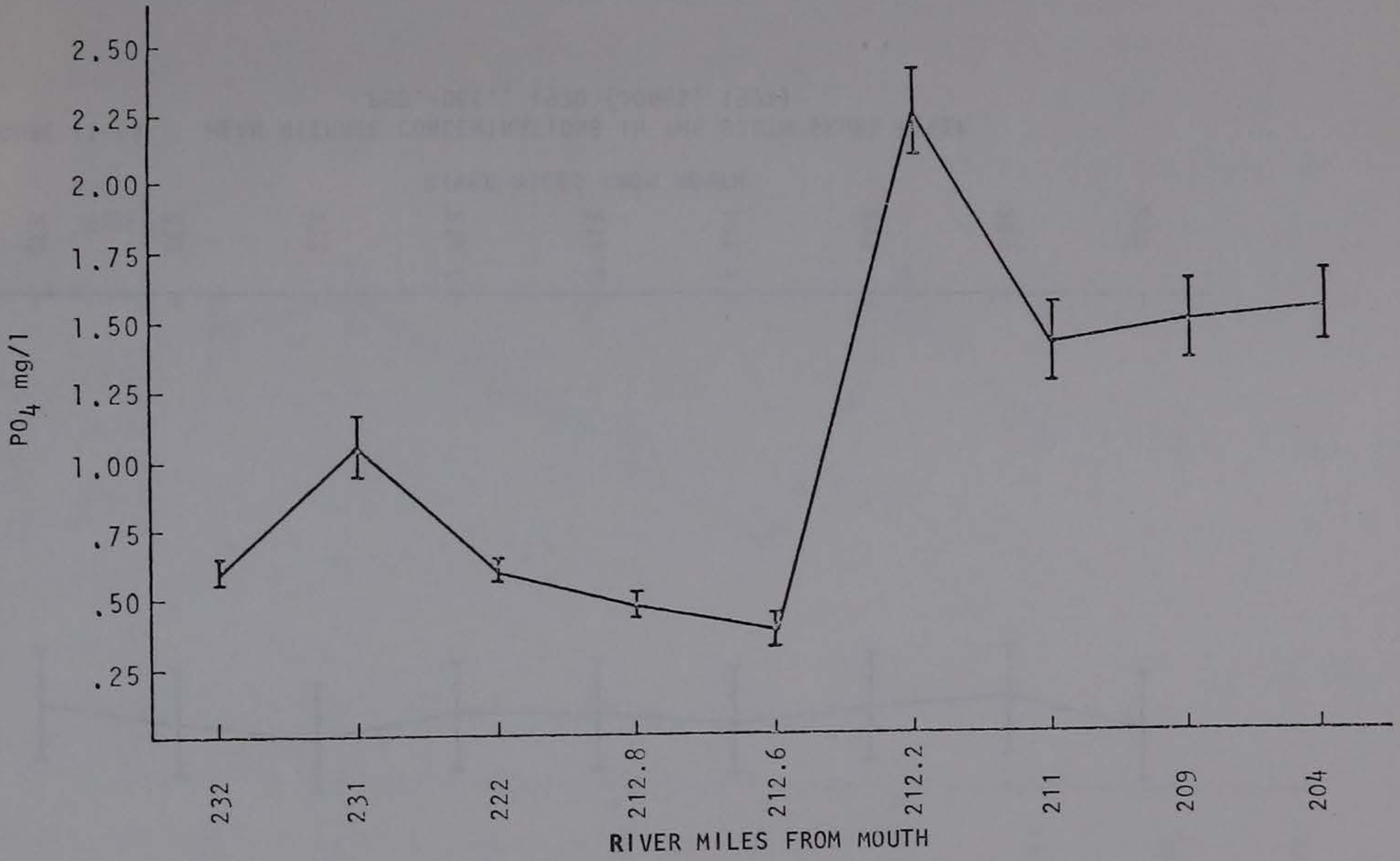


FIGURE II-65 MEAN TOTAL PHOSPHATE CONCENTRATIONS IN THE SOUTH SKUNK RIVER FEB. - DEC., 1970 flow periods. This reflects the contribution of sewage effluents and groundwater during low flow periods and dilution during runoff.

Total dissolved solids concentrations averaging 329 mg/l with a maximum of 437 mg/l have been observed along the Skunk River.

Oxygen Depletion:

Point source discharges from municipalities create serious dissolved oxygen and ammonia problems on the Skunk River, particularly below Ames. Violations of Iowa Water Quality Standards have occurred less frequently since 1970 than in the 1960's. This is probably due to high flows since 1970 as much as to any increase in treatment efficiency from point sources.

Adequate information concerning diurnal fluctuations, oxygen sags below point sources, ammonia concentrations under ice cover and low flows are nonexistent for the majority of the basin. Studies around Ames have given an adequate picture of water quality, but do not provide information on the effects further downstream. Recent surveys by the State Hygienic Laboratory and the Department of Environmental Quality (DEQ) are only a beginning in attempts to understand reaeration, nitrification and algal activity under ice or low flow conditions.

Mathematical modeling has suggested that ammonia concentrations under complete ice cover may violate Iowa Water Quality Standards over the entire stream during low flows. Additionally dissolved oxygen violations are likely to occur. Recent surveys under ice cover at average flow conditions have not found dissolved oxygen or ammonia violations. Instead, high algal activity with supersaturated oxygen has been found and daily dissolved oxygen fluctuations still are far above critical levels. Ammonia concentrations, while somewhat elevated, have not been found in violation of Iowa standards.

The reasons for this descrepancy between model and field data are difficult to explain. It is unlikely, in any case, that a survey at one period represents conditions at all times. Lower flows could have significantly changed the results by increasing ammonia concentrations. Conditions less favorable for algal growth could have caused significantly different dissolved oxygen concentrations. Studies conducted by Iowa State University have documented the water quality violations and stream degradation below Ames, yet samples in February, 1975, found no violations. A long term effort of sample collection and analysis on the entire Skunk River is needed to determine the magnitude of problems from point sources other than Ames.

While most studies concerning ammonia and dissolved oxygen have been aimed at point source pollution, nonpoint sources

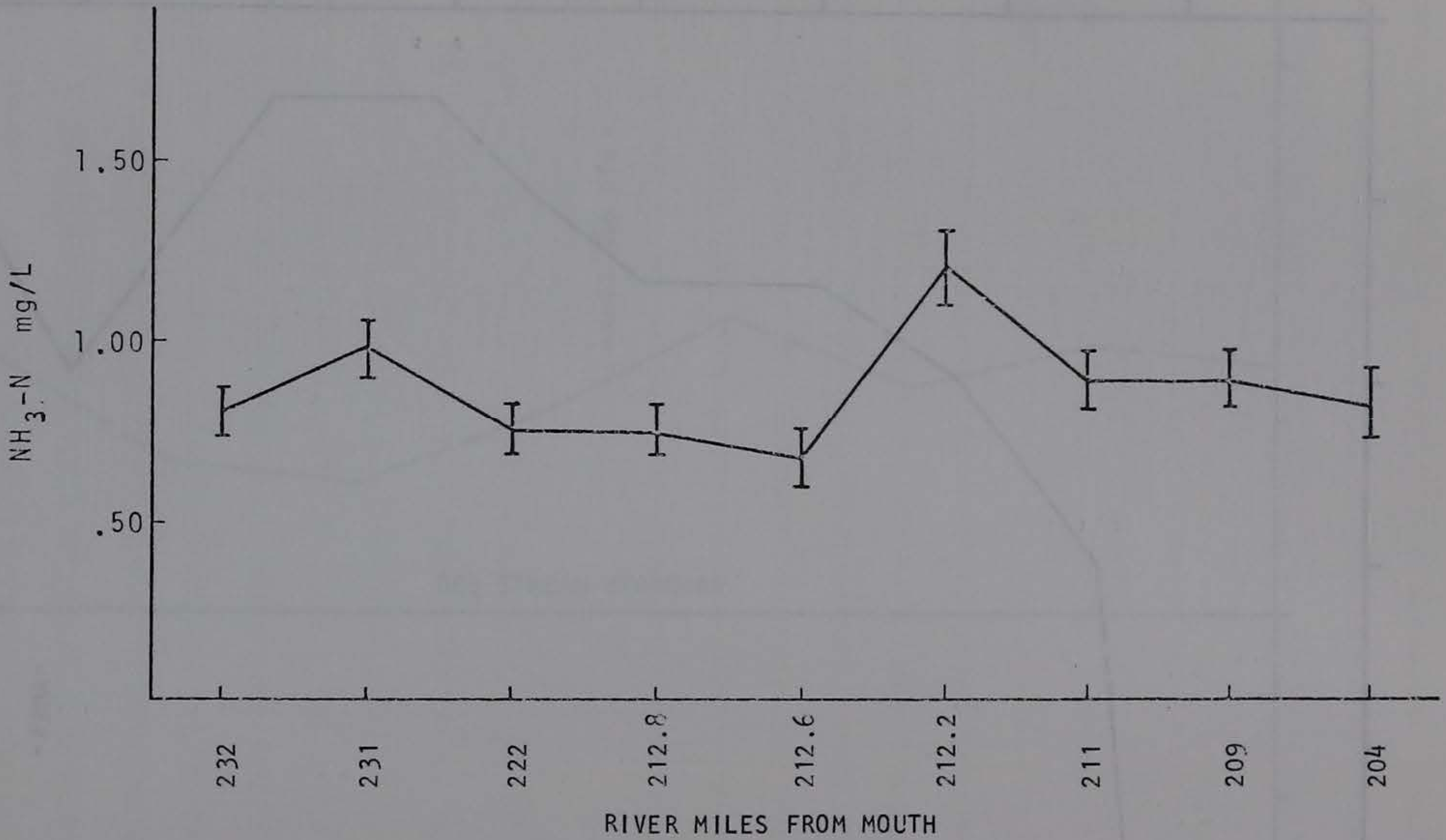


FIGURE 11-66 MEAN AMMONIA CONCENTRATIONS IN THE SOUTH SKUNK RIVER FEB.-DEC., 1970 (JONES, 1972)

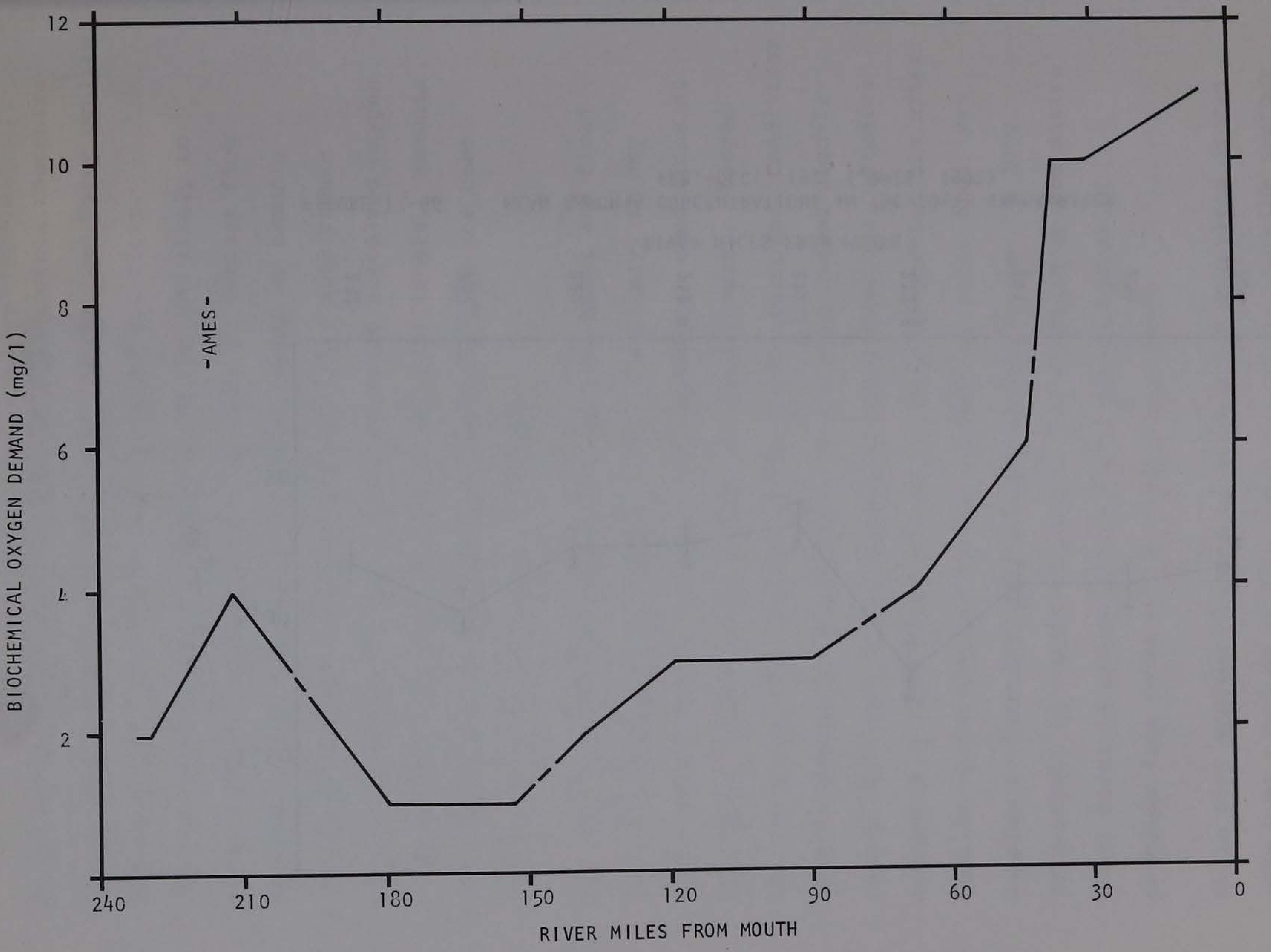


FIGURE 11-67 BIOCHEMICAL OXYGEN DEMAND CONCENTRATIONS IN THE SKUNK RIVER, SEPTEMBER 1974

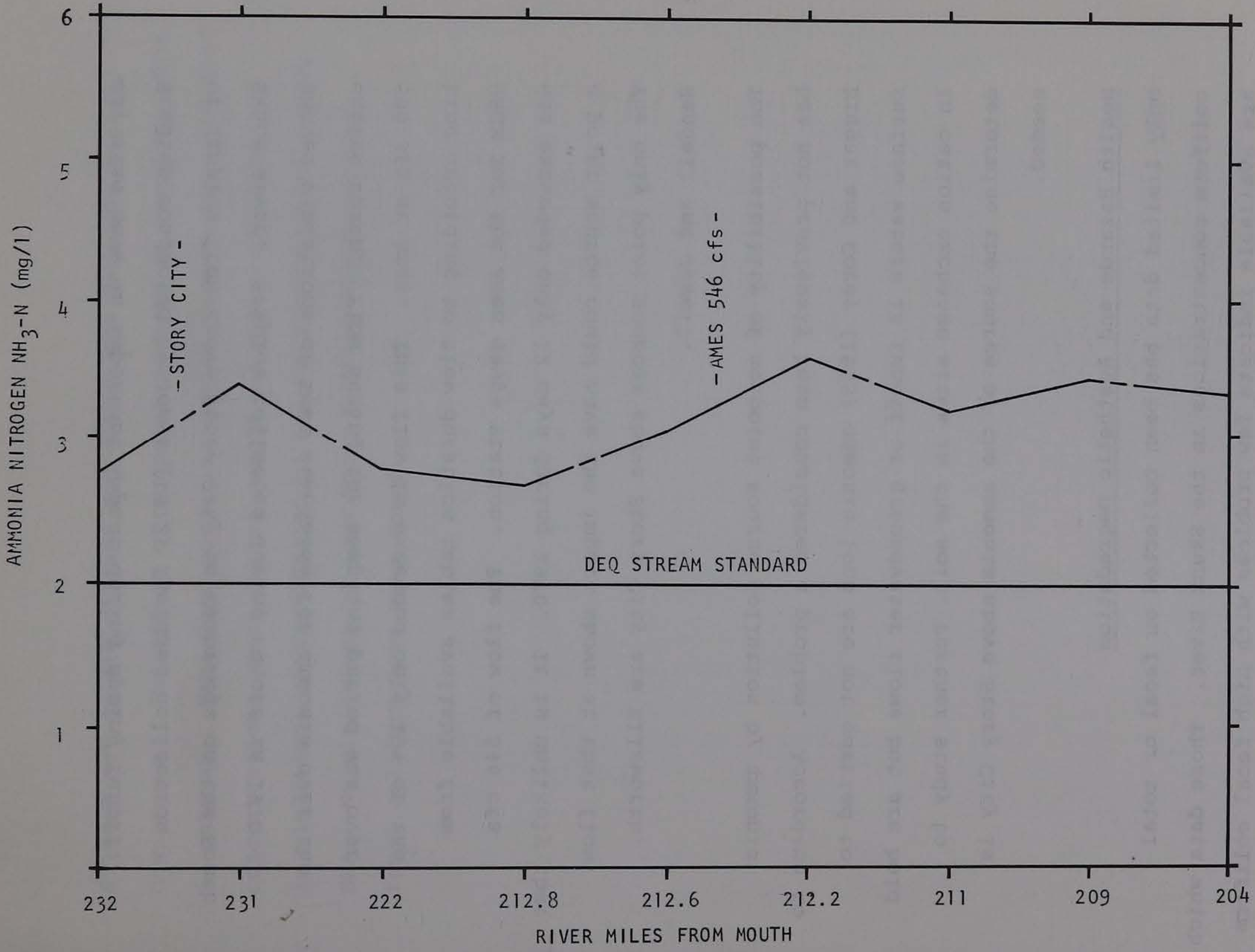


FIGURE II-68 AMMONIA NITROGEN CONCENTRATIONS IN THE SOUTH SKUNK RIVER, MARCH 4, 1978. FLOW OF 546 cfs AT AMES may also have an important impact during spring runoff. Studies conducted by Jones (1972) included collection of samples from above Story City to Cambridge on the South Skunk River. Samples collected during runoff in 1970 showed violations of Iowa standards for ammonia over the entire reach. Flow during the sampling period was over 500 cfs at Ames. This flow is exceeded only 10% of the time according to flow duration tables available from USGS for the Ames gauge station. The flow of 546 cfs was exceeded only 12 days during 1970. It is unlikely that a point source could have the impact shown at that flow. The only point sources above Story City are Ellsworth, Randall and Jewell.

The possibility of nonpoint source pollution by ammonia has not previously been considered a problem. According to Biggar and Corey (1969) ammonia ions are not carried to surface waters in runoff or groundwater flows but are held in cation exchange sites in the soil. Further study to determine the source of the ammonia above Story City is needed.

Health Hazards and Aesthetic Degradation

Only limited data has been collected on fecal or total coliform concentrations in the Skunk River. Those data which are available indicate few problems with high fecal coliform concentrations in the Skunk except below major municipal discharges (Figure II-69). These bacteria are quickly diluted out or die off and concentrations decrease rapidly downstream. The effect of nonpoint sources on fecal coliform is unknown. Data from bordering basins suggest that elevated concentrations occur during runoff periods, resulting in violations of the 200/100 ml criteria established by the EPA. No violations of Iowa Water Quality Standards for fecal coliform have been found.

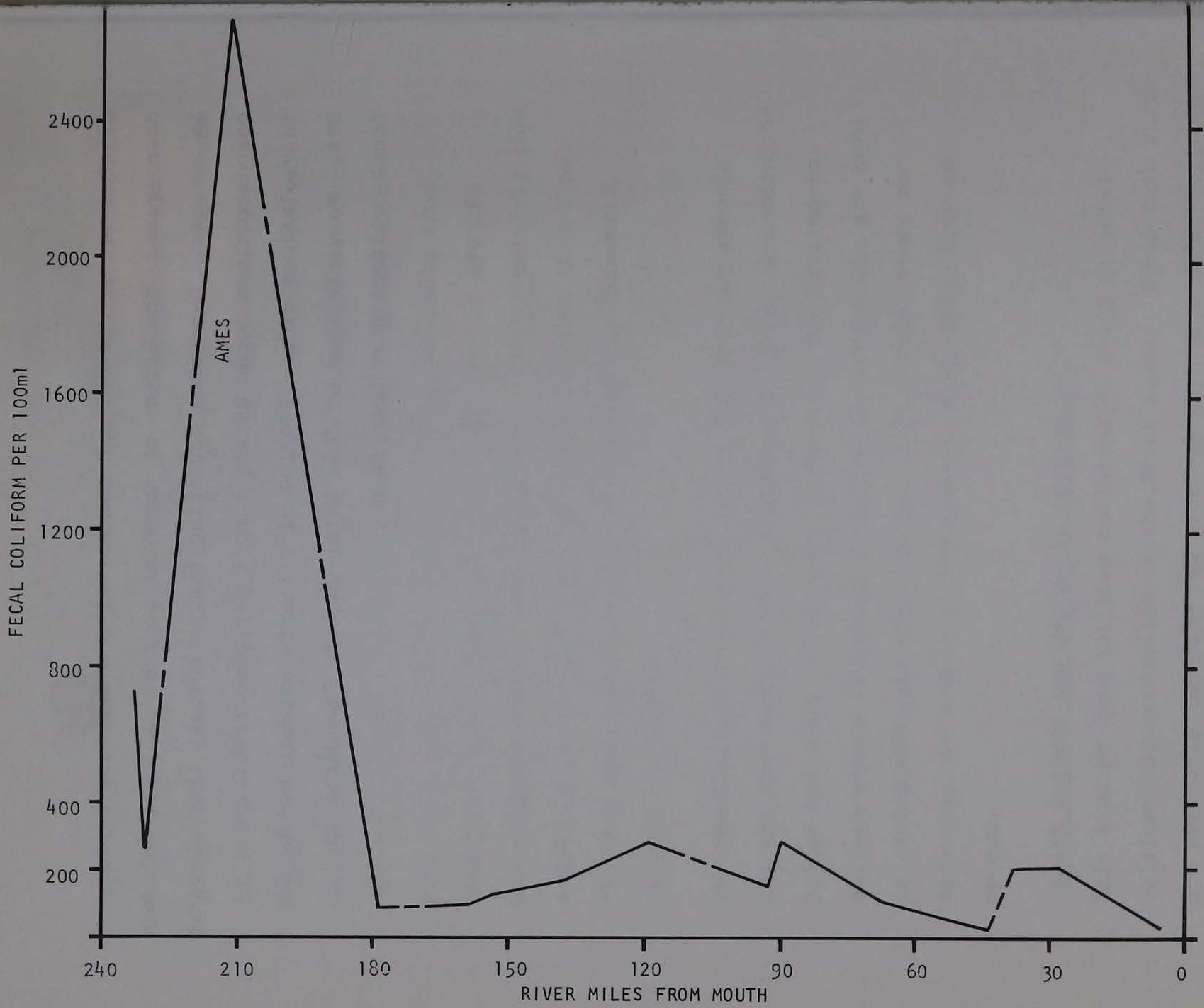


FIGURE 11-69 FECAL COLIFORM CONCENTRATIONS IN THE SKUNK RIVER, SEPTEMBER 1974

TABLE II-30

SKUNK RIVER TRIBUTARIES 1974-1975

TRIBUTARY TO SOUTH SKUNK	BOD (mg/l)	FECAL COLIFORM (#/100ml)	TOTAL PHOSPHATE (mg/l)	AMMONIA (mg/l)	NITRATE (mg/l)	TURBIDITY (JTU)	DISSOLVED SOLIDS (mg/l)	CHLORIDE (mg/l)
Indian Creek	2	30	0.07	0.29	3.5	5	382	17
Cherry Creek	4.5	12,000	1.4	1.22	2.4	12	358	22
Sewer Creek	8.8	35,000	5.2	2.7	3.5	22	606	70
Spring Creek	8	1,000	2.6	2.9	2.0	15	606	42
Big Cedar Creek	6	150	0.19	0.01	0.1	22	275	20
Big Creek	10	620	1.2	0.16	1.6	22	589	74
Squaw Creek	5	-	-	0.34	4.4	-	-	-

TRIBUTARY TO NORTH SKUNK	BOD (mg/l)	FECAL COLIFORM (#/100ml)	TOTAL PHOSPHATE (mg/l)	AMMONIA (mg/l)	NITRATE (mg/l)	TURBIDITY (JTU)	DISSOLVED SOLIDS (mg/l)	CHLORIDE (mg/l)
Rock Creek (Jasper Co.)	3.3	-	-	0.27	1.3	-	-	-
Moon Creek	4	-	-	0.33	1.0	-	-	-
Sugar Creek	3.3	-	-	0.42	3.7	-	-	-
Middle Creek	4.3	-	-	0.61	3.8	-	-	-
Rock Creek (Keokuk Co.)	3.7	-	-	0.71	2.9	-	-	-

DES MOINES RIVER

The most significant types of pollution appear to be physical degradation (related to erosion) and bacteria (below major municipalities). Dissolved oxygen and ammonia violate Iowa stream standards at times.

The key pollutants highlight conditions in the Des Moines:

<u>Harmful Substances</u>: Pesticides, particularly DDE and dieldrin, are common in the Des Moines River. Concentrations routinely exceed maximum recommended levels. While most heavy metals have been found in the Des Moines River, only cadmium, zinc and lead have violated Iowa Water Quality Standards.

<u>Physical Modification</u>: Turbidity and suspended solids are the major problems in terms of physical modification. Turbidity is particularly severe during runoff periods. Thermal pollution from power plants is a potential problem in the lower Des Moines River.

<u>Eutrophication Potential</u>: No nuisance algal growths have been reported, even though phosphates and nitrogen are present in high concentrations. Concentrations are directly related to runoff conditions, at least in the upper Des Moines River.

<u>Salinity, Acidity, and Alkalinity</u>: Dissolved solids concentrations have ranged from 242 mg/l to 618 mg/l. Acidity is not a problem in the river.

<u>Oxygen Depletion</u>: While dissolved oxygen concentrations have generally increased and violations of standards

FIGURE II-70 UPPER DES MOINES RIVER BASIN

FIGURE II-71 LOWER DES MOINES RIVER BASIN decreased, problems continue to exist below major municipal dischargers, particularly during low flow periods. Problems are mainly restricted to segments downstream from Fort Dodge, Des Moines, and Ottumwa.

Health Hazards and Aesthetic Degradation: Fecal coliform levels exceed the EPA guidelines throughout the river. Major point sources provide chlorination during the recreational season. The main sources are agricultural runoff.

GENERAL PHYSICAL DESCRIPTION

The Des Moines River with its tributaries is the largest river in the State of Iowa, and the most westerly of the major rivers within the State which are directly tributary to the Mississippi River. Watersheds bordering the basin on the west drain into the Missouri River.

The river rises in Murray and Pipestone Counties, Minnesota at an altitude of about 1900 feet. It flows generally southeasterly for about 535 miles and joins the Mississippi River just south of Keokuk, Iowa. The total area drained is 14,540 square miles, of which 1525 are in Minnesota, 12,925 in Iowa and 90 in Missouri. The area drained in Iowa comprises 23% of the total area of the State.

The major tributaries of the Des Moines River include the Raccoon River, Boone River, Lizard Creek, North River, Middle River, South River, and Whitebreast Creek. Major point sources include municipalities of Fort Dodge, Boone, Des Moines, and Ottumwa.

This section will only discuss the main stem Des Moines River, excluding the East and West Forks which join near Humboldt. The upper Des Moines for this discussion is defined to be from the confluence of the East and West Fork Des Moines rivers to the City of Des Moines. The lower Des Moines is from the City of Des Moines to the mouth.

The 1911 - 1966 mean flow for the Des Moines at Keosauqua was 6191 cfs, with a maximum daily discharge of 146,000 cfs. The 7-day 10 year low flow ranges from 126 cfs at Keosauqua to 27 cfs at Fort Dodge.

Two large reservoirs have been constructed by the U.S. Corps of Engineers on the river. Red Rock Reservoir is located downstream from the City of Des Moines. Saylorville Reservoir is currently under construction upstream from the City of Des Moines. These reservoirs, designed primarily for flood control, are expected to have increased recreational use in the coming years. Swimming, fishing, boating and water skiing are the main water recreational activities projected.

DATA AND METHODS

Data collected between Boone and Tracy by Iowa State University provide perhaps the best data available in the State. Data have been collected on the Des Moines River above Des Moines since 1967 and below Des Moines since 1971. Data at other river stations are much less frequent but generally support the Iowa State University studies. For analysis purposes the river was divided into two segments:

The upper Des Moines River is the first segment and has its beginning at the confluence of the East and West Fork Des Moines near Humboldt and includes the river to Des Moines. This segment has a drainage area of 6245 square miles.

The lower Des Moines River from Des Moines to the mouth near Keokuk has a drainage area of an additional 8222 square miles including the largest tributary, the Raccoon River.

WATER QUALITY CONDITIONS

Harmful Substances

The majority of pesticide data collected on the Des Moines River has been collected in the upper segment. Dieldrin has been found in all samples collected. The average concentration of 11 ng/l (parts per trillion) is above the National Academy of Science recommended maximum concentration of 5 ng/l. The maximum concentration found was 50 ng/l. DDE was also found in nearly all samples. The average concentration of DDE was 123 ng/l which is considerably above the recommended maximum of 6 ng/l. The maximum concentration of DDE found was 363 ng/l. Herbicides found include 2,4-D (50 ng/l) and atrazine (739 ng/l average, 2500 ng/l maximum).

Heavy metals found in the upper Des Moines River include barium, lead, manganese, zinc and selenium. No metals in the upper Des Moines were found in violation of Iowa Water Quality Standards. Lead, zinc, and cadmium have exceeded

Iowa standards on the lower Des Moines. Only lead appears to have frequently violated stream standards. The sources of these heavy metals are unknown. Increased surveillance of heavy metals from point sources is recommended to aid in determining the sources.

TABLE II-31

HEAVY METALS IN THE DES MOINES RIVER

(FORT DODGE - DES MOINES)

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	2	0		
Ba	4	2	150	200
Cd	4	0		
Cr	6	0		
Cu	4	0		
Pb	4	2	75	80
Mn	2	1	70	70
Hg	2	0		
Ni	2	0		
Ag	0	0		
Zn	4	4	71	160
Se	1	1	2	2

TABLE II-32

HEAVY METALS IN THE DES MOINES RIVER

(DES MOINES TO KEOKUK)

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	35	0		
Ba	67	50	262	900
Cd	76	1	30	30
Cr	81	4	22	40
Cu	76	19	35	100
Pb	76	26	208	3200
Mn	9	3	136	200
Hg	17	3	1.3	2
Ni	70	3	80	200
Ag	30	0		
Zn	76	61	125	1300
Se	2	2	2.5	4

TABLE II-33

PESTICIDES IN THE DES MOINES RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Aldrin	4			
Chlordane	4			
DDD	4			
DDE	35	32	123	373
DDT	4			
Dieldrin	96	96	11	50
Endrin	4			
Heptachlor Epoxide	4			
Lindane	4			
2, 4-D	4	2	50	50
2, 4, 5-T	4			
Silvex	4			
PCB	3			
Atrazine	35	24	739	2500
Heptachlor	4			

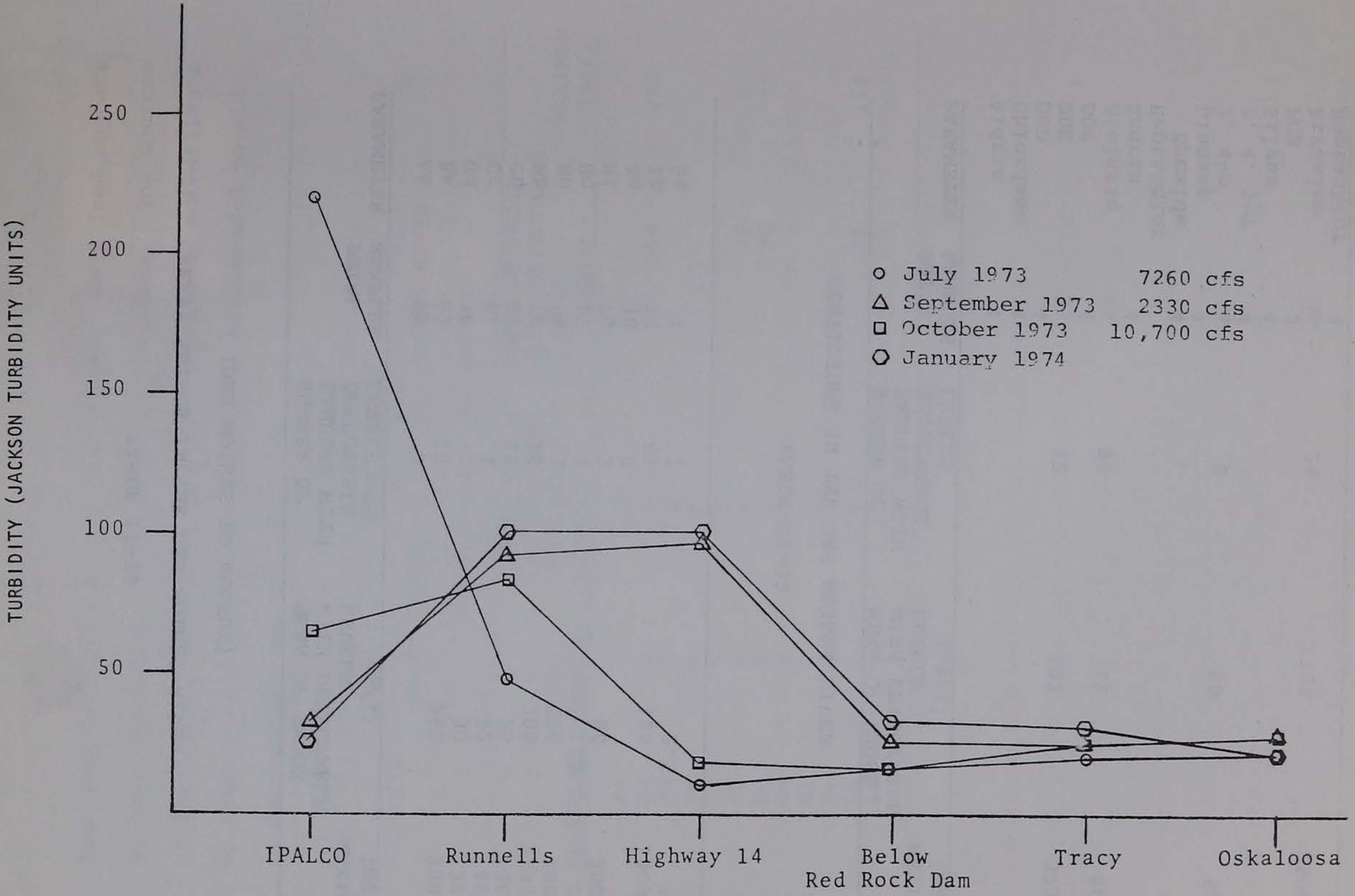


FIGURE 11-72 TURBIDITY PROFILES FOR THE LOWER DES MOINES RIVER

Physical Modification

The major physical modification in the upper Des Moines River is turbidity. Wide fluctuations in turbidity occur depending on runoff conditions. Average turbidity is less than 50 JTU's, but a maximum of 800 JTU's has been recorded. These levels are still below concentrations found in some Iowa streams, but may cause an impact on aquatic life. Saylorville Reservoir is currently under construction just north of the City of Des Moines. This will be the final receptacle for a large portion of the suspended solids carried downstream by the river. The reservoir will have the effect of improving the physical quality of the water moving on downstream toward Red Rock Reservoir and the mouth. Turbidity is also a major concern below Des Moines.

Temperature violations have been found below the power plant at Des Moines (Figure II-73), and are a potential problem at low flows at other locations on the river. Upon completion of Saylorville Reservoir, flow regulation will decrease the chance of extreme low flow conditions. This might result in fewer temperature problems downstream from the reservoir due to greater dilution.

Eutrophication Potential

Statistical analysis of data collected near the future site of the Salyorville Reservoir gives a significant correlation (95% confidence interval) between flow, total nitrogen and

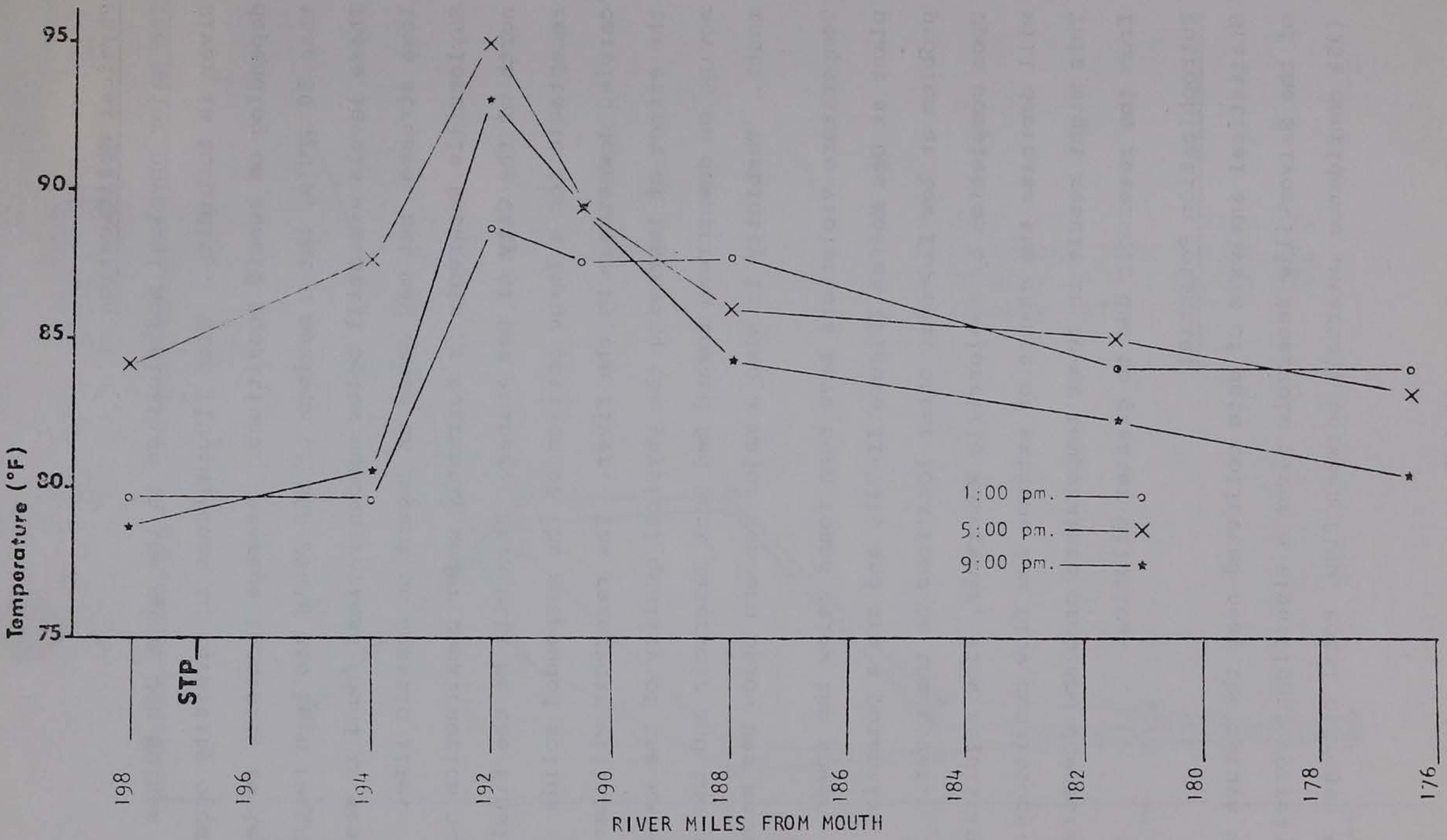


FIGURE 11-73 SEPTEMBER 4, 1970 TEMPERATURE PROFILES FOR THE LOWER DES MOINES RIVER (365 cfs)

total phosphate concentrations. This indicates that nonpoint sources are responsible for the nutrient levels in the upper Des Moines River. Phosphate concentrations in the river average slightly over 1 mg/l and reach maximums near 9 mg/l. Nitrate concentrations are among the highest of any river in the State averaging over 5.5 mg/l and sometimes exceeding 10 mg/l. While nutrient concentrations are quite high there are no reported nuisance algal conditions. In spite of adequate nutrients algae are limited by other factors. These limiting factors may be other trace nutrients such as vitamins or they may be limited by such physical factors as light penetration or temperature.

Total dissolved solids concentrations in the Des Moines River have ranged from 242 mg/l to 618 mg/l. The mean concentration was 435 mg/l. Alkalinity has ranged from 70 mg/l to 338 mg/l with an average of 228 mg/l. All are within the range of normal water quality for Iowa streams.

Oxygen Depletion

Dissolved oxygen and ammonia concentrations have generally been satisfactory in recent years. Considerable improvement in BOD and ammonia concentrations has taken place, particularly in the lower Des Moines River (Figures II-76 - II-78). A certain amount of this improvement is undoubtedly the result of high flows causing dilution. The most notable improvement can be shown at Ottumwa where high BOD and ammonia concentrations had been common for over thirty years until the John Morrell Packing Plant closed down.

Low dissolved oxygen levels are still a problem during low flow conditions. This is particularly true in the lower Des Moines below the City of Des Moines. Only one dissolved oxygen violation has been found in the upper Des Moines River. Fort Dodge is the main point source on the upper Des Moines. Surveys conducted in the lower Des Moines in 1970 showed dissolved oxygen violations below Des Moines, Iowa. This was the lowest flow period during the last several years. Even during recent high flow periods the oxygen sag can be seen below Des Moines. While there have been few recent dissolved oxygen violations, the potential exists, during low flows, for numerous violations of Iowa standards for dissolved oxygen.

Ammonia violations have occurred with equal frequency in both the upper and lower Des Moines since 1970. They have been more widespread than dissolved oxygen violations. In general ammonia concentrations have decreased in the Des Moines River during recent years. Again, dilution is a factor. The closing of the John Morrell plant at Ottumwa has also improved water quality. Des Moines continues to cause some ammonia violations in the lower Des Moines. The widely scattered nature of ammonia violations on the upper Des Moines suggests that nonpoint runoff is responsible

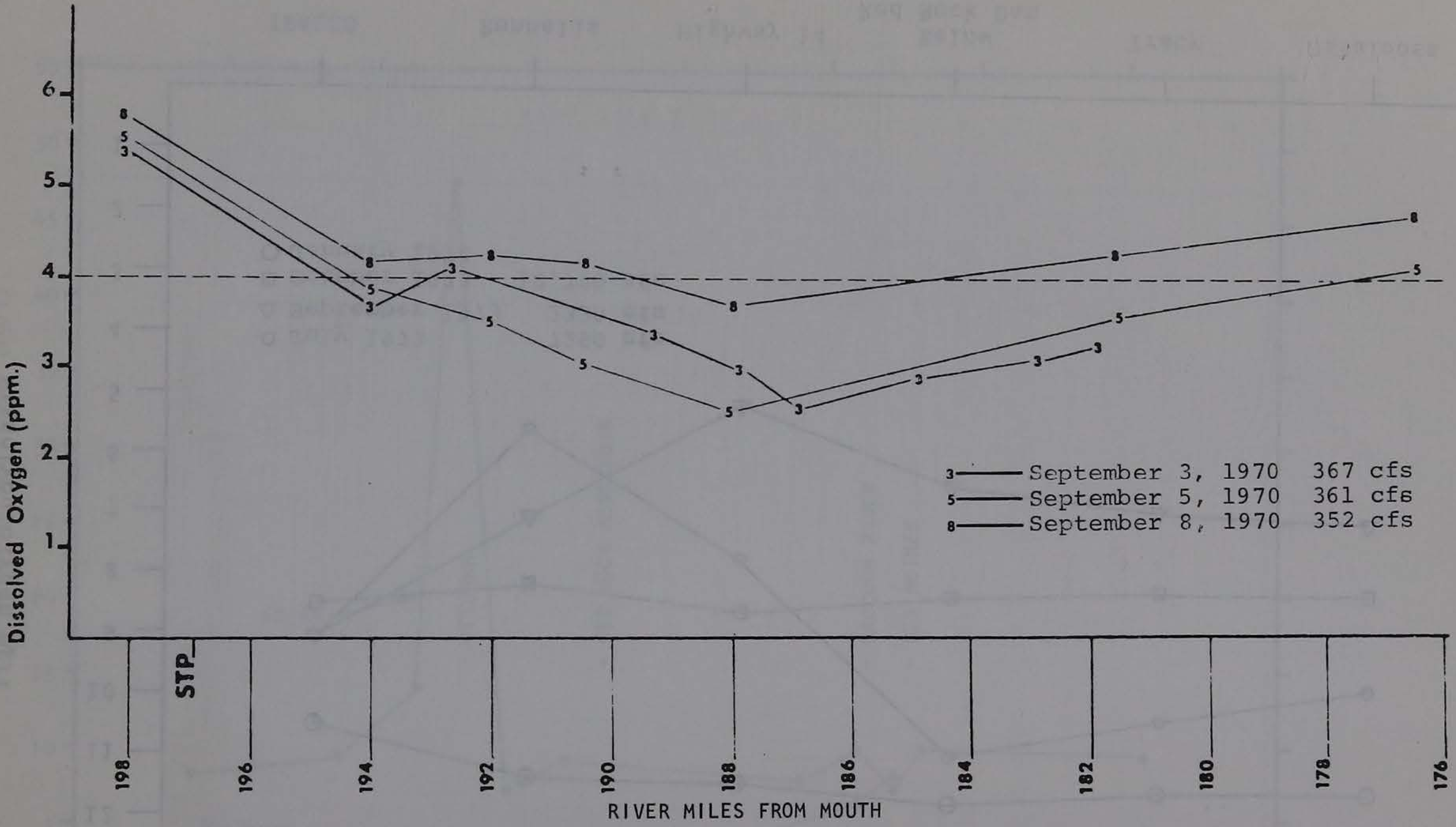


FIGURE II-74 DISSOLVED OXYGEN PROFILES FOR THE LOWER DES MOINES RIVER

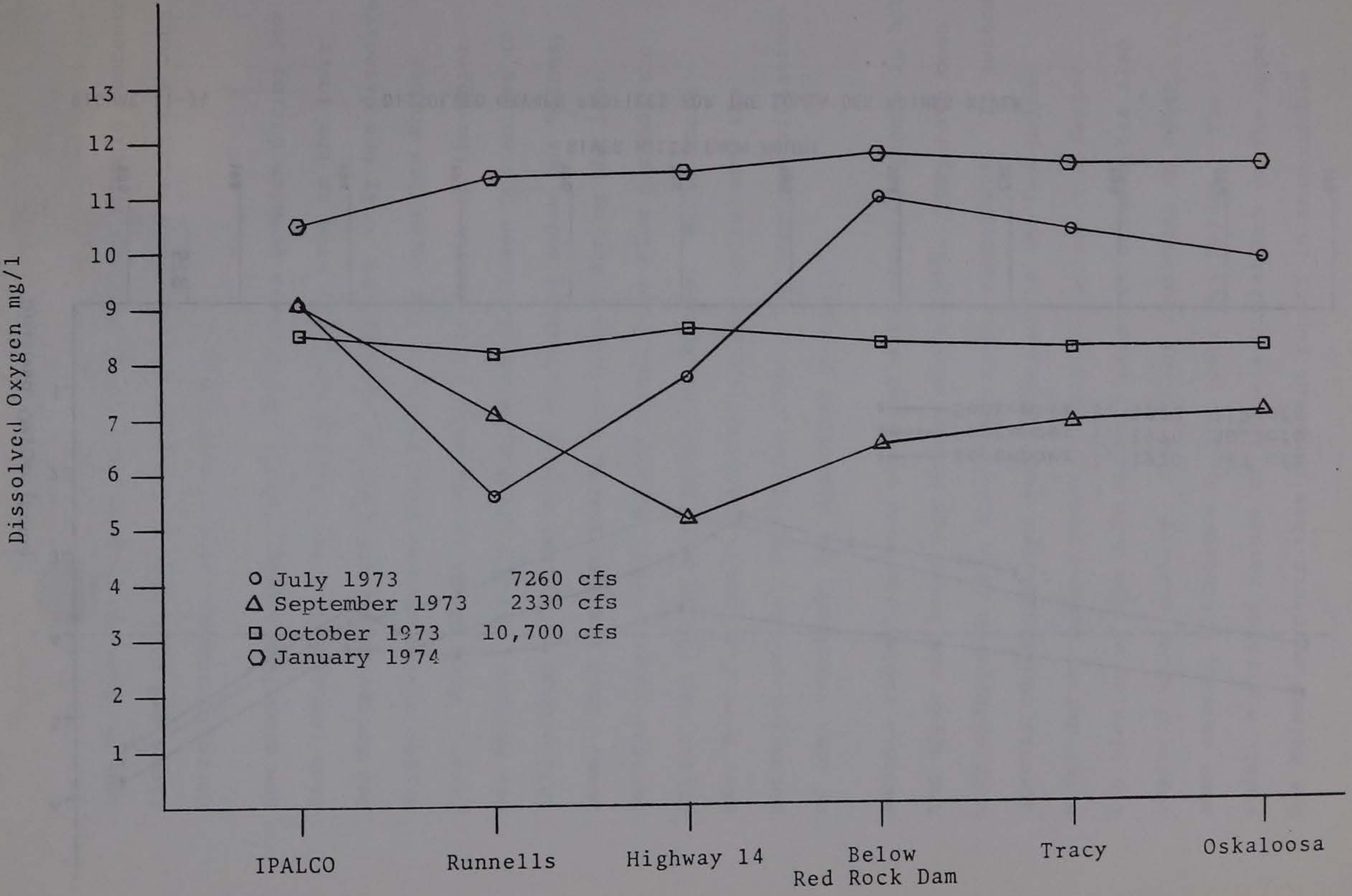


FIGURE 11-75 DISSOLVED OXYGEN PROFILES FOR THE LOWER DES MOINES RIVER

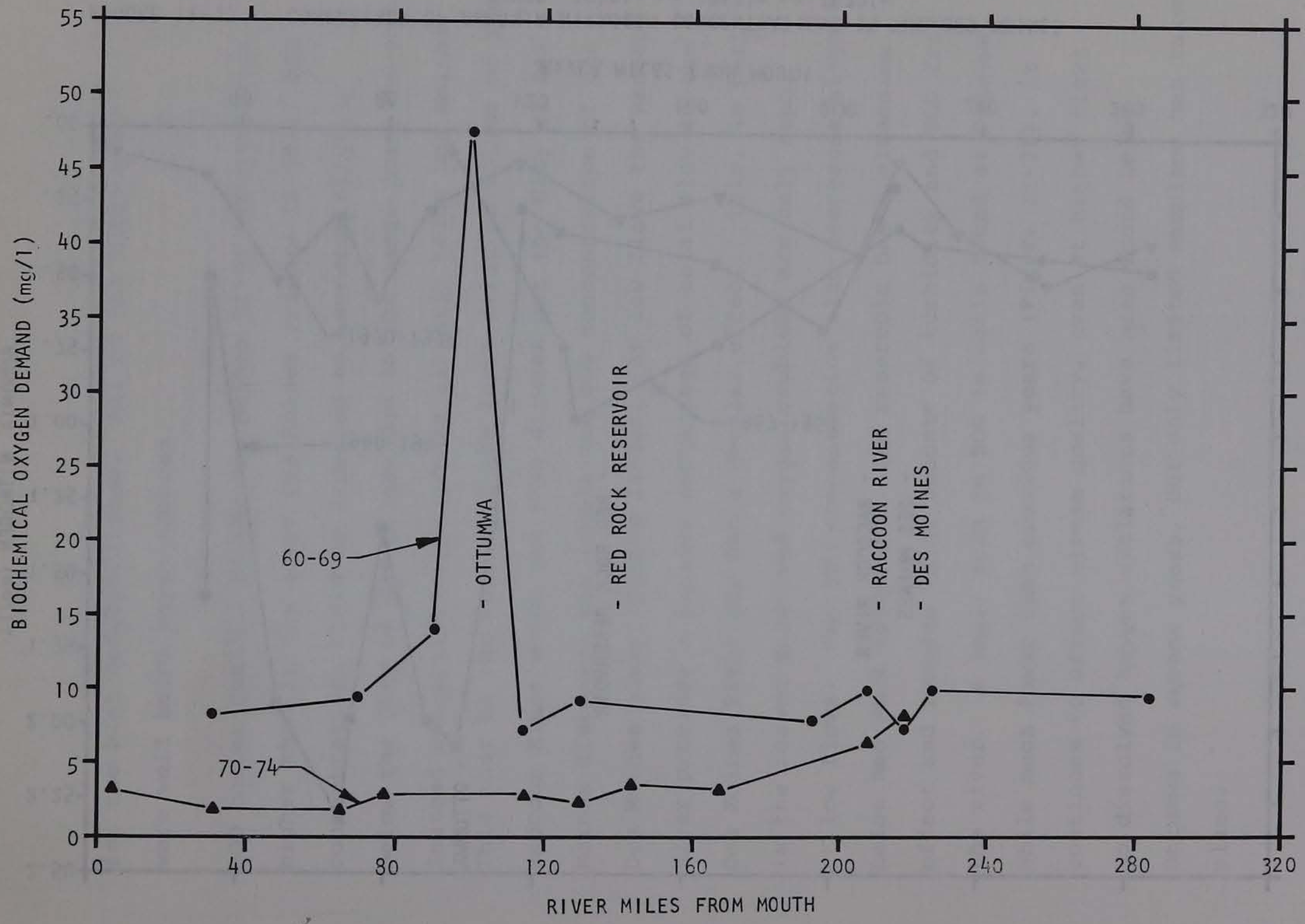


FIGURE 11-76 COMPARISON OF BIOCHEMICAL OXYGEN DEMAND IN THE DES MOINES RIVER, 1960's vs 1970's

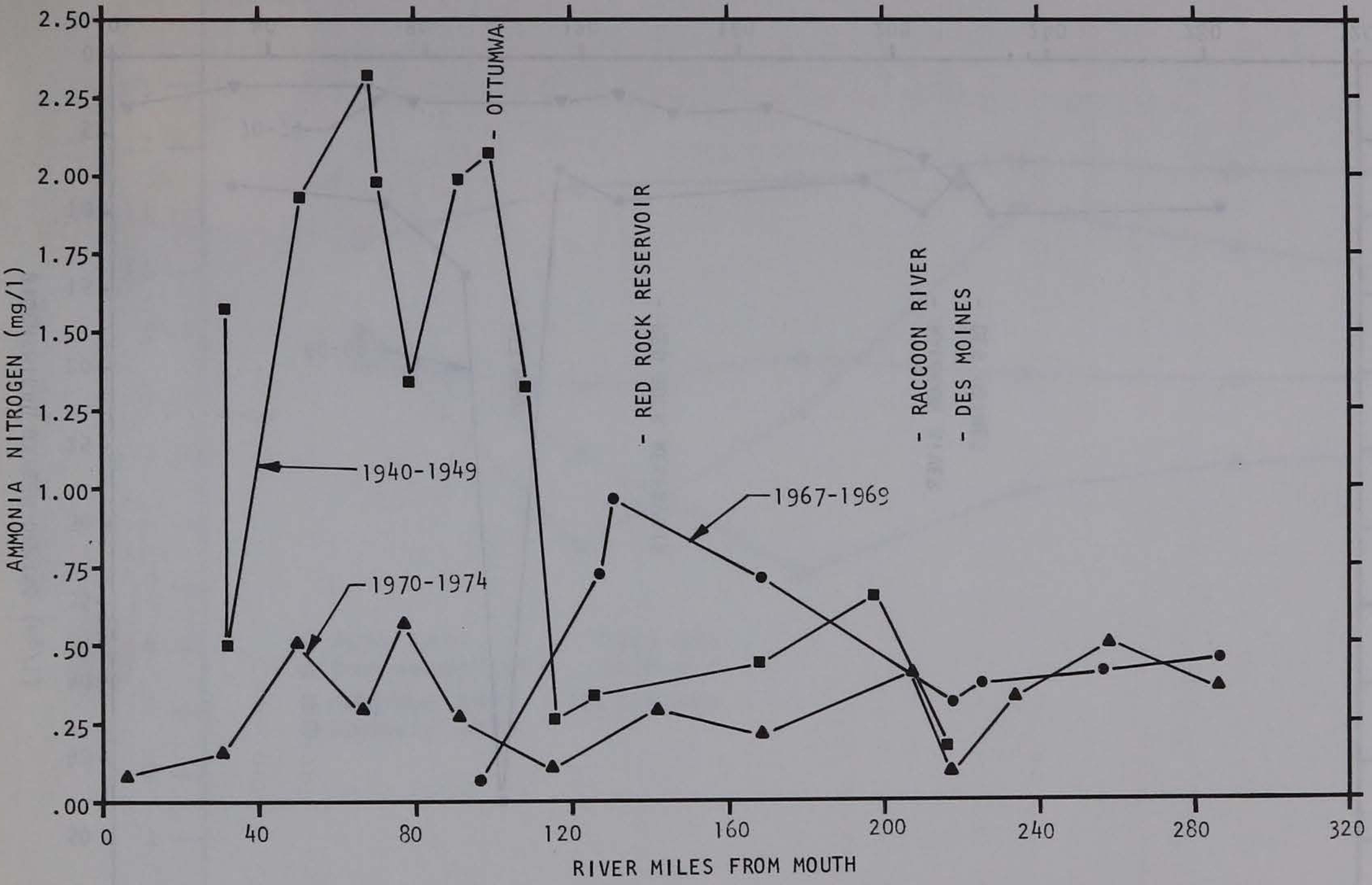


FIGURE 11-77 COMPARISON OF AMMONIA NITROGEN CONCENTRATIONS IN THE DES MOINES RIVER, 1940's vs 1960's vs 1970's.

for the high concentrations. All of the violations were well below point sources.

BOD concentrations in the Des Moines River are generally higher than in the lower Des Moines (Figure II-78). BOD concentrations would be expected to increase slightly below the City of Des Moines due to the large point source. Instead concentrations decrease slightly below Des Moines. This must be the result of the large dilution volume of the Raccoon River which not only dilutes out the City of Des Moines discharge but lowers the BOD concentration of the Des Moines River (Figure II-78). At low flows the Raccoon River provides a smaller percentage of total flow to the Des Moines River and has a smaller effect. This, in part, is the reason dissolved oxygen problems are only seen at low flows. The BOD concentration also decreases slightly below Red Rock reservoir. The reservoir has a cleansing effect and removes large amounts of turbidity and BOD from the river. A small peak in BOD is again found at Ottumwa. While much lower than previous years (Figure II-78), it continues to effect stream quality, even at higher flows. No dissolved oxygen violations have been found below Ottumwa in recent years, but only limited sampling has taken place.

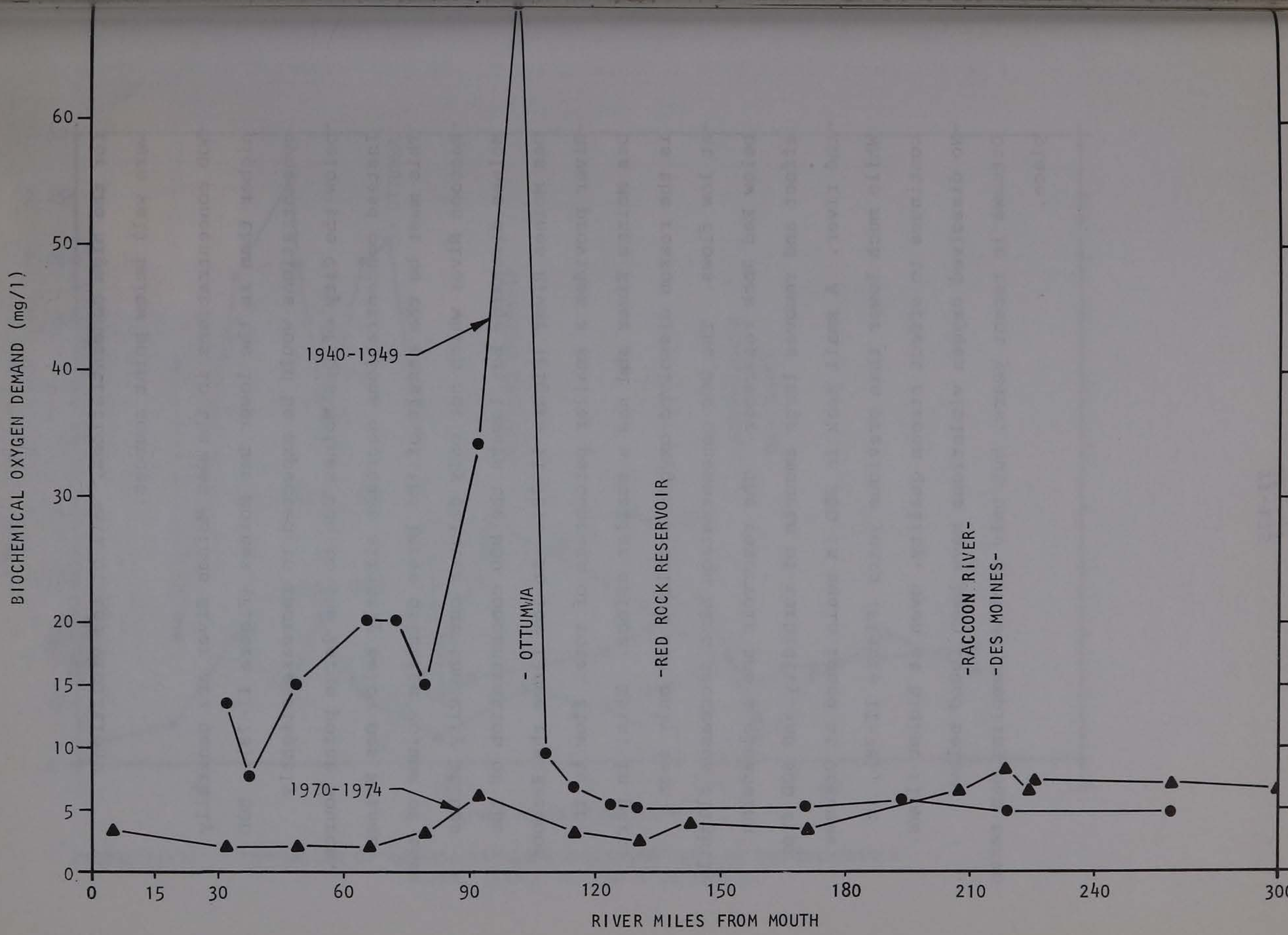
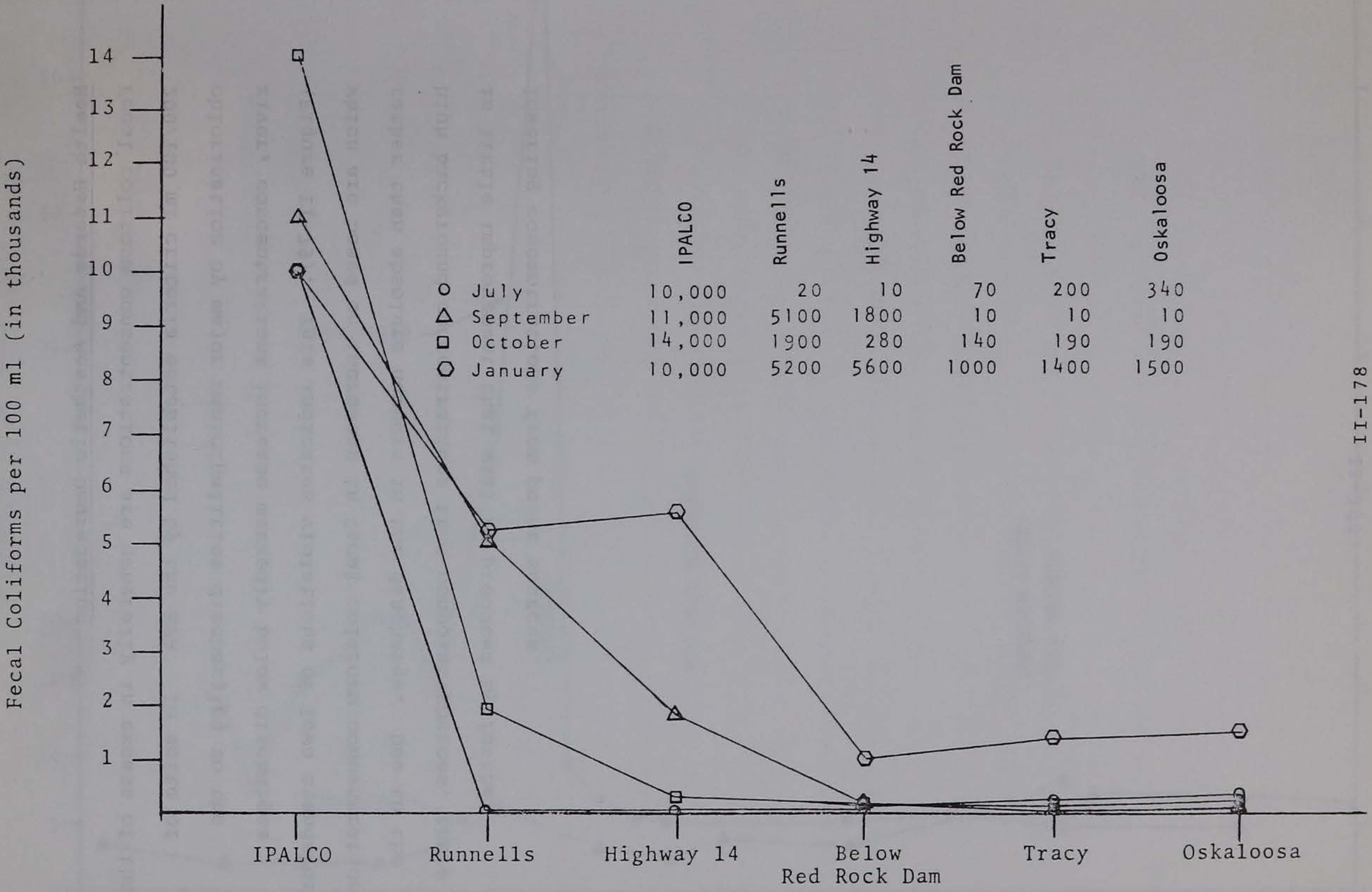


FIGURE 11-78 COMPARISON OF MEAN BIOCHEMICAL OXYGEN DEMAND CONCENTRATIONS FOR THE DES MOINES RIVER, 1940's vs 1970's

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations are generally in excess of the 200/100 ml criteria established by the EPA. In spite of chlorination by major municipalities discharging to the river, concentrations increase markedly below discharges (Figure II-79). This indicates violations of Iowa standards, which are based on increases in fecal coliform concentrations rather than absolute numbers in the discharge. Due to the high background concentrations from nonpoint sources, there is little improvement that will be produced by further lowering concentrations from point sources.



	IPALCO	Runnells	Highway 14	Below Red Rock Dam	Tracy	Oskaloosa
○ July	10,000	20	10	70	200	340
△ September	11,000	5100	1800	10	10	10
□ October	14,000	1900	280	140	190	190
⬡ January	10,000	5200	5600	1000	1400	1500

FIGURE 11-79 FECAL COLIFORM PROFILES FOR THE LOWER DES MOINES RIVER

EAST FORK DES MOINES RIVER

Water quality in the East Fork Des Moines River is generally better than in the West Fork Des Moines River. With few exceptions, dissolved oxygen and ammonia have not violated Iowa Water Quality Standards. The East Fork Des Moines River has fewer and smaller point source discharges than the West Fork. The only point source to show appreciable impact on the stream is Algona, the largest city on the East Fork.

The key pollutants highlight conditions in the East Fork Des Moines River:

<u>Harmful Substances</u>: No pesticide studies have been conducted on the East Fork Des Moines River to determine the effects of runoff on the water quality.

<u>Physical Modification</u>: Turbidity, total solids and temperature are all similar to conditions in the West Fork. No problems connected with adverse physical modifications have been noted.

<u>Eutrophication Potential</u>: Nitrogen and phosphorus concentrations are generally high. The nutrient concentrations tend to increase toward the mouth, indicating the influence of nonpoint sources. A slight increase is sometimes noted below Algona.

<u>Oxygen Depletion</u>: Oxygen is generally at or near saturation. Few violations have been noted and point sources have not shown a severe impact. Oxygen depletion

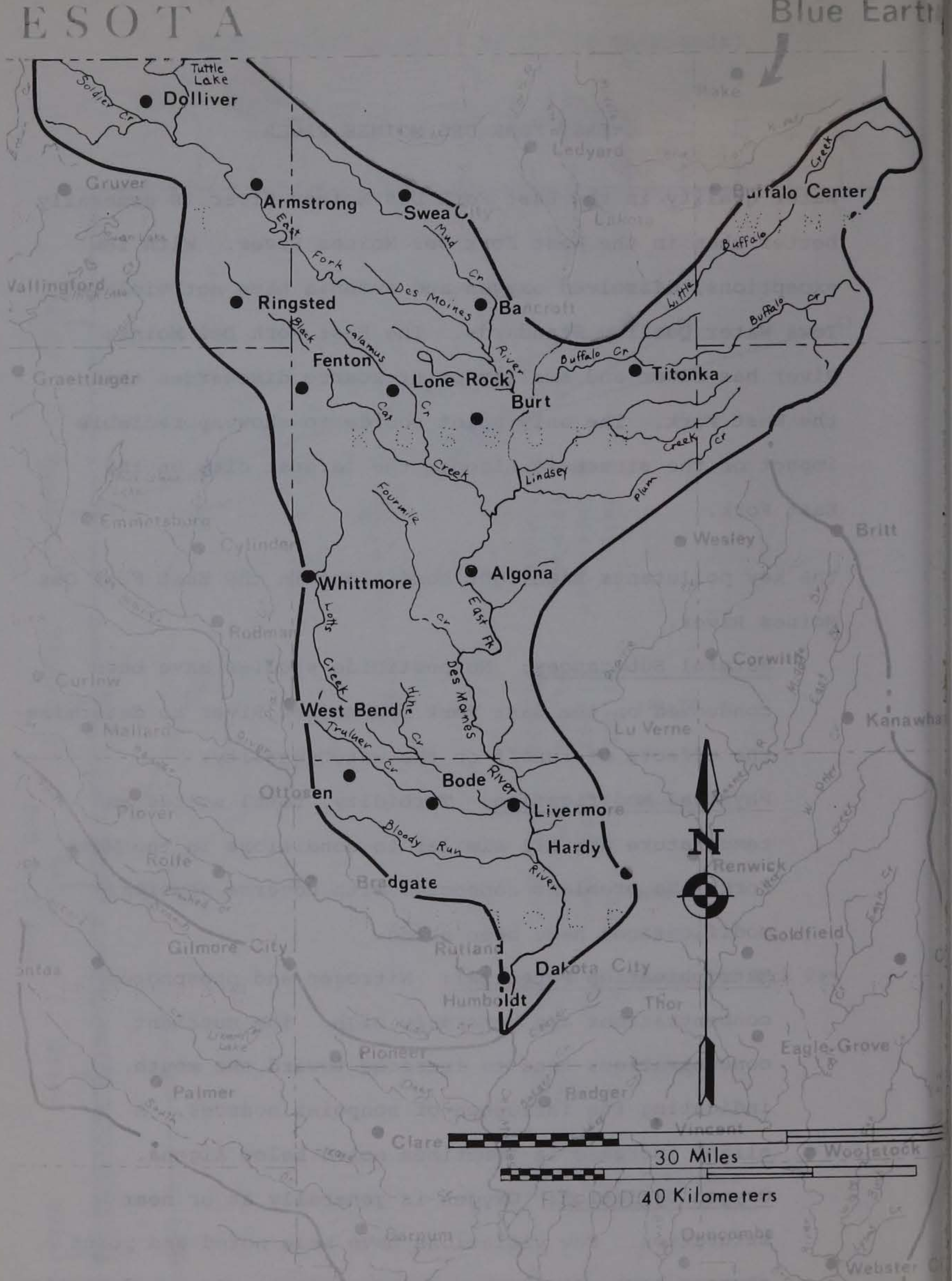


FIGURE II-80 EAST DES MOINES RIVER BASIN may become a problem at extremely low flows due to point sources.

Health Hazards and Aesthetic Degradation: Fecal coliform concentrations are lower than on the West Fork. Concentrations are generally near 200/100 ml with some increase found below point sources. Runoff results in high fecal coliform concentrations throughout the river.

GENERAL PHYSICAL DESCRIPTION

The East Fork Des Moines River originates in southern Minnesota. Prior to entering Iowa it passes through Lake Pierce and Lake Okamanpeedan in Minnesota. Upon entering Iowa the river flows southeasterly joining the West Fork Des Moines River below Dakota City to form the main stem Des Moines River.

The East Fork Des Moines River has a drainage area of 1110 square miles. The largest tributaries are Union Slough joining the river near Burt and Lotts Creek joining the river near Livermore. Lotts Creek and the East Fork Des Moines River are classified for aquatic life propagation. The main point sources are Algona and Dakota City. The main point source on Lotts Creek is the town of Whittemore.

WATER QUALITY CONDITIONS

Harmful Substances

Heavy metals found in the East Fork Des Moines River include barium, copper, lead, manganese and zinc. The highest lead concentration has been only 0.07 mg/l which is below the 0.10 mg/l standard. Since there are no known point sources that contributes metals on the East Fork Des Moines River it is assumed that the metal concentrations found are the result of nonpoint sources.

TABLE II-34

HEAVY METALS IN THE EAST FORK DES MOINES RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	11	0		
Ba	10	8	125	200
Cd	13	0		
Cr	13	0		
Cu	13	1	10	10
Pb	13	2	65	70
Mn	8	5	308	570
Hg	0	0		
Ni	12	0		
Ag	7	0		
Zn	13	11	67	

Physical Modification

Turbidity, solids and temperature levels in the East Fork Des Moines River are similar to those found in the West Fork. There is no information to suggest that there is significant physical modification.

Eutrophication Potential

High concentrations of nitrogen and phosphorus have been found in the East Fork Des Moines River. Nitrate concentrations are much higher than on the West Fork and are among the highest in the State. Phosphate concentrations are also slightly higher on the East Fork than on the West Fork. The increases can be attributed to nonpoint sources since point sources are smaller and less numerous on this river than on the West Fork Des Moines. In addition nitrate and phosphate concentrations generally increase slightly going downstream.

Oxygen Depletion

Dissolved oxygen concentrations have been adequate during most sampling periods. In January 1970 samples collected at three locations all showed dissolved oxygen (DO) concentrations below 5.0 mg/l. It is difficult to determine what the cause of this low dissolved oxygen was since the DO at Armstrong near the Minnesota border was already 3 mg/l. The DO then seemed to recover slightly by Algona and was lowered slightly again below Algona (Figure II-81). On other occasions dissolved oxygen conditions have been very good. Only two dissolved oxygen violations, those noted above, and one ammonia violation have been found on the East Fork Des Moines River.

The oxygen and ammonia concentrations are much better than in previous periods. Data sufficient for comparison is available only for the 1940's. During that 10 year period dissolved oxygen violations occurred in over 35% of the samples collected. Ammonia violations occurred in 8% of the samples. These figures are significantly higher than data for the past four years. Considerable improvement has occurred in the water quality of the East Fork Des Moines River since the 1940's.

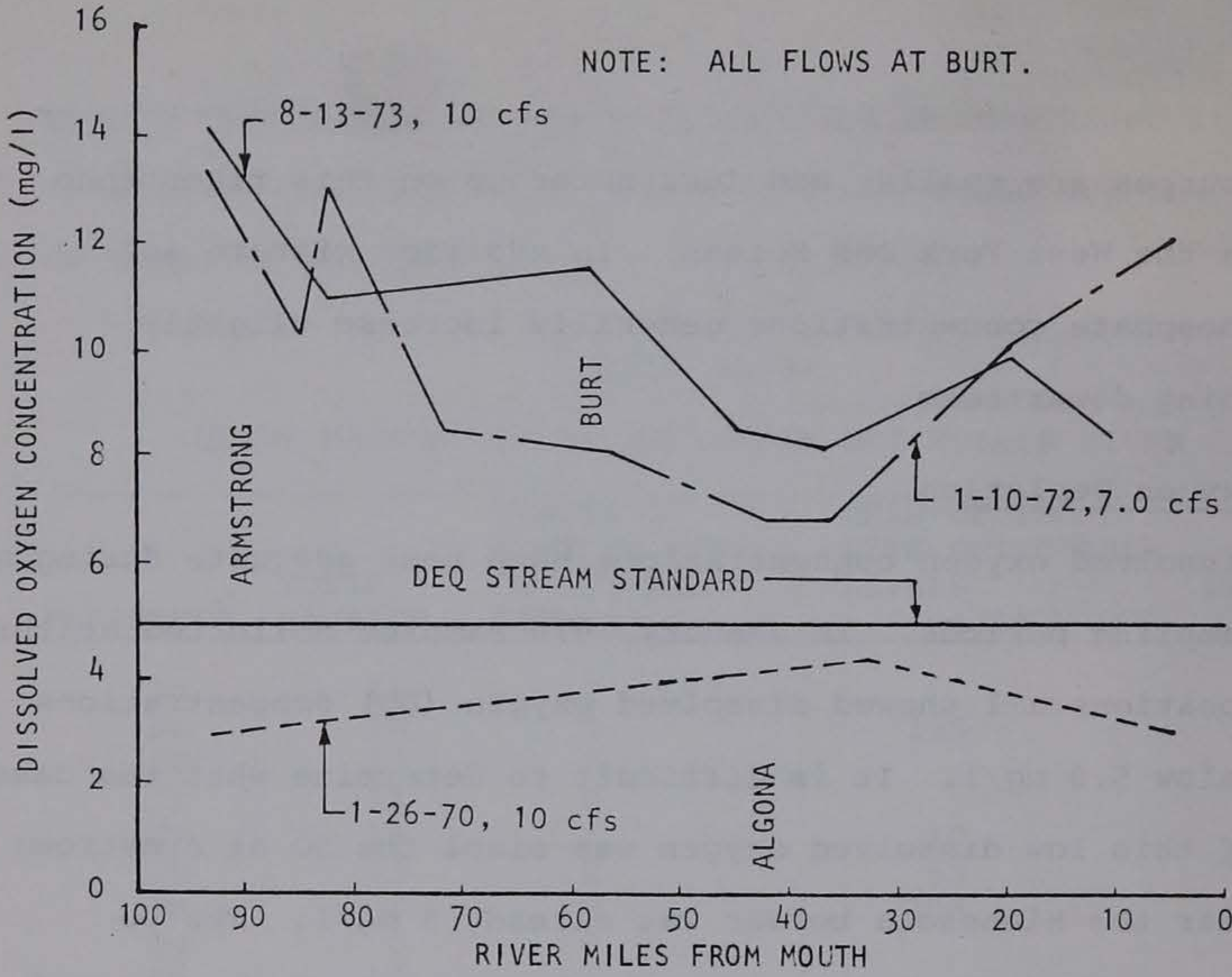


FIGURE 11-81 EAST FORK DES MOINES RIVER,
DISSOLVED OXYGEN CONCENTRATION

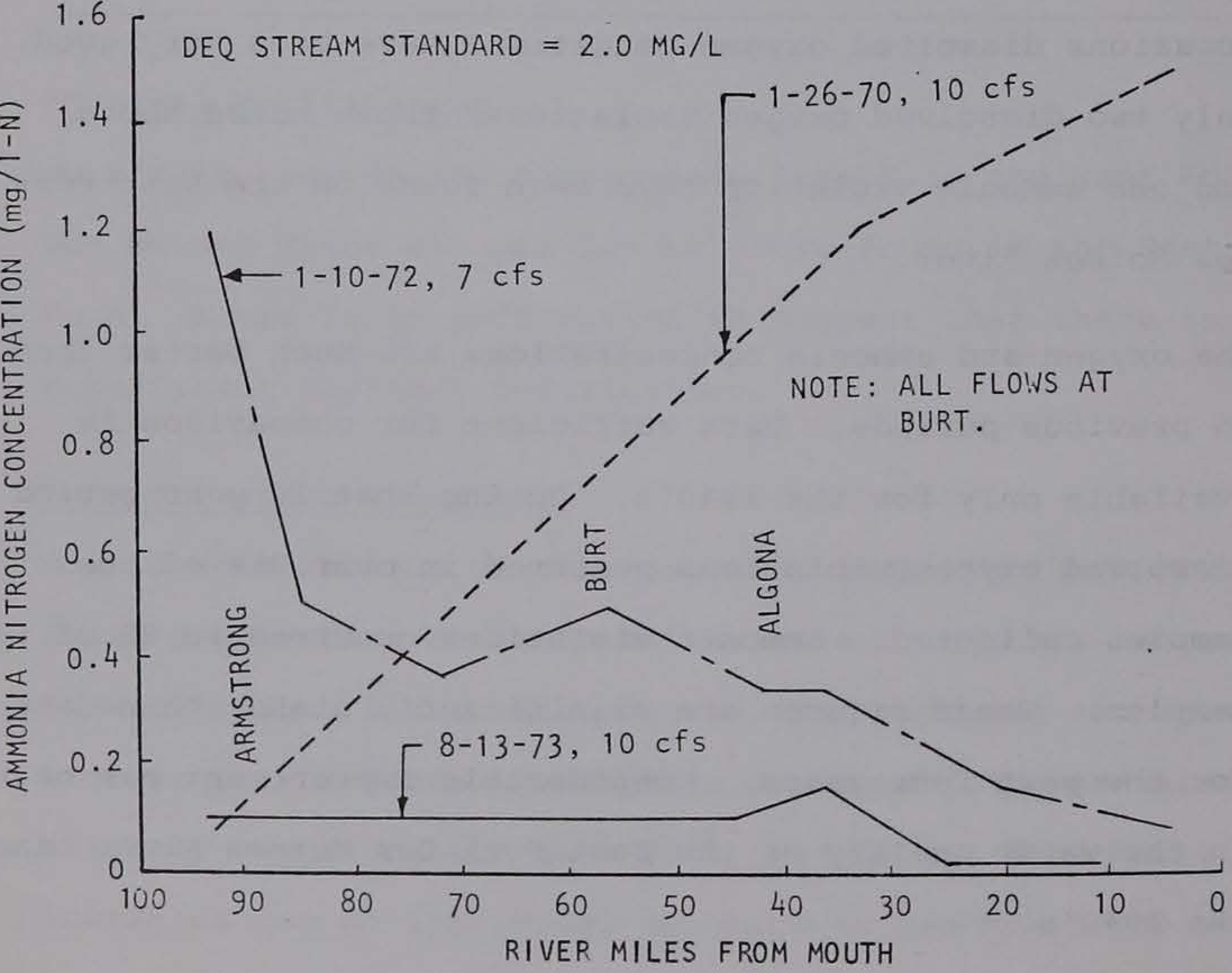


FIGURE 11-82 EAST FORK DES MOINES RIVER,
AMMONIA NITROGEN CONCENTRATION

Health Hazards and Aesthetic Degradation

Fecal coliform levels are low compared to the West Fork. This is due in part to the number of point sources, as well as the relatively small size of the municipalities. Fecal coliform concentrations do increase during runoff periods.

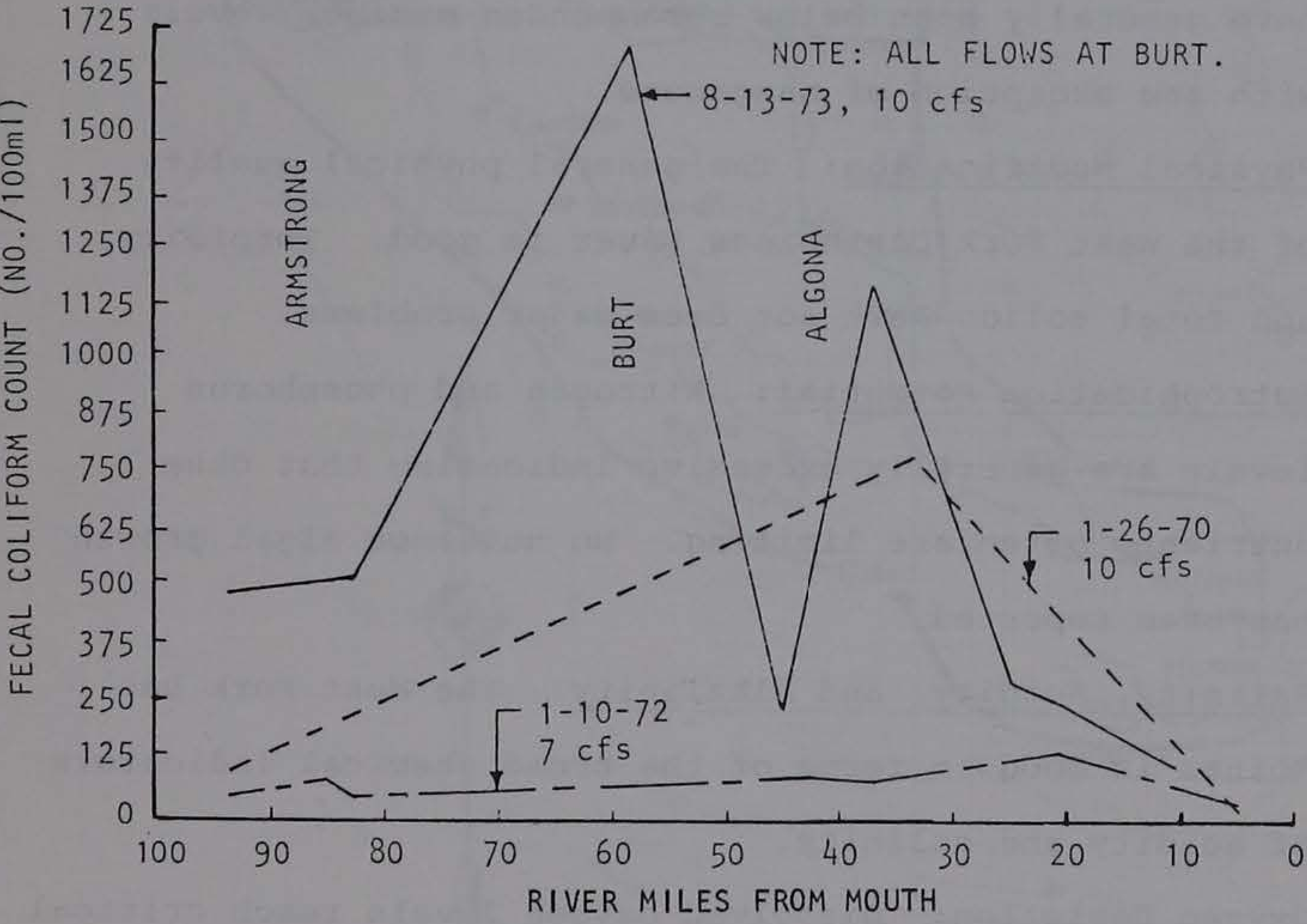


FIGURE 11-83 EAST FORK DES MOINES RIVER, FECAL COLIFORM COUNT

WEST FORK DES MOINES RIVER

Water quality in the West Fork Des Moines River is generally good. Exceptions to this occur during winter and low flow conditions when point sources cause a greater impact on the stream. Water quality is generally poorer below the communities of Estherville, Emmetsburg and Humboldt.

The key pollutants highlight conditions in the West Fork Des Moines:

Harmful Substances: No pesticide studies have been conducted on the river. Heavy metal concentrations have generally been below recommended maximum levels with the exception of manganese.

Physical Modification: The general physical quality of the West Fork Des Moines River is good. Turbidity and total solids have not been major problems.

Eutrophication Potential: Nitrogen and phosphorus levels are generally excessive indicating that other nutrients often are limiting. No nuisance algal growth has been reported.

Salinity, Acidity, and Alkalinity: The West Fork Des Moines is good in terms of the broad chemical indicators of acidity and salinity.

Oxygen Depletion: Dissolved oxygen levels reach critical levels during several periods. Low oxygen concentrations are generally experienced below the larger municipalities along the river, particularly Estherville.

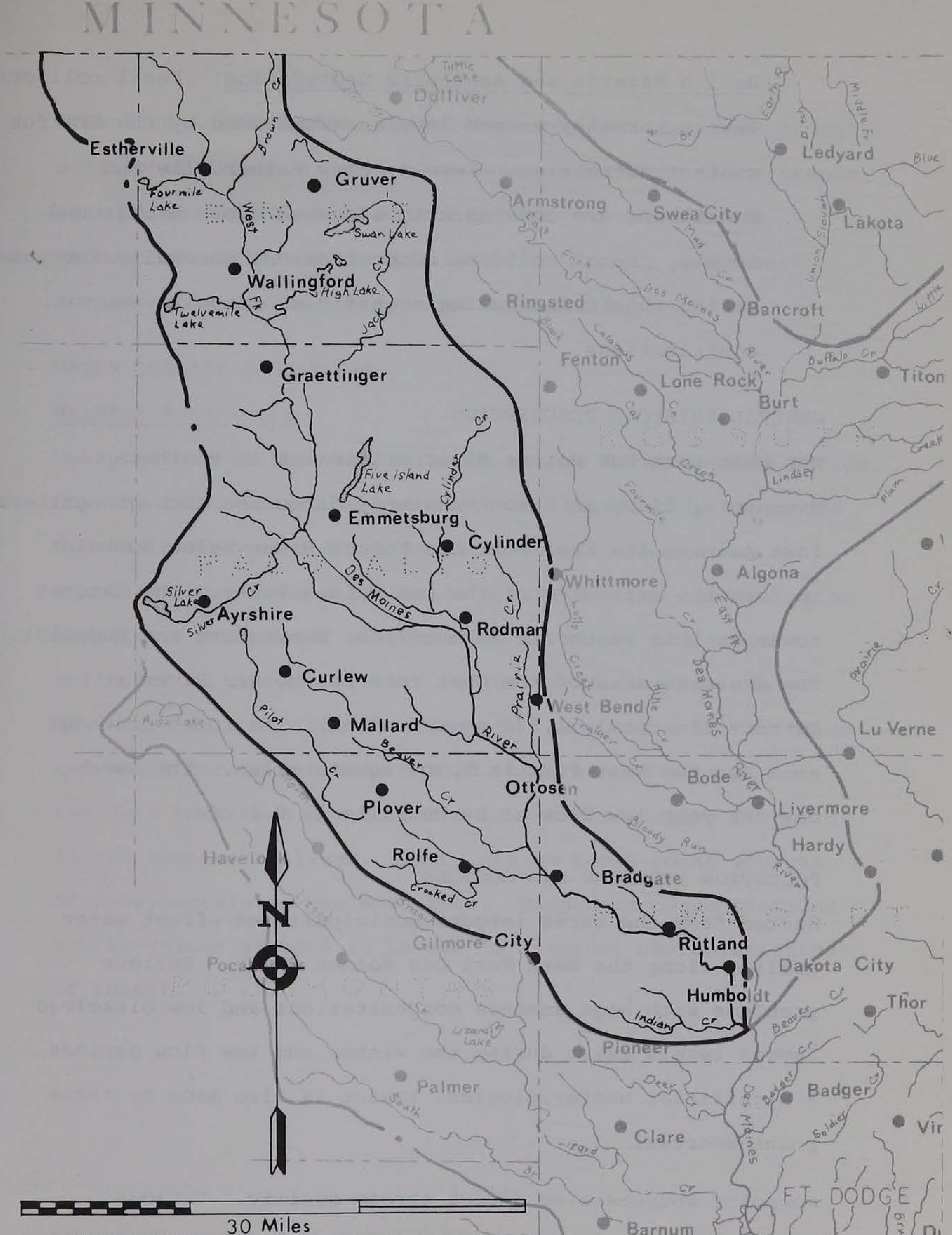


FIGURE II-84 WEST DES MOINES RIVER BASIN

Health Hazards and Aesthetic Degradation: Fecal coliform levels normally exceed levels recommended by the EPA for contact recreation. Levels below Estherville and Emmetsburg are considerably elevated above background levels. Fecal coliform concentrations generally increase during runoff indicating significant nonpoint source contributions.

GENERAL PHYSICAL DESCRIPTION

The West Fork Des Moines River originates in southern Minnesota, flows in a southeasterly direction through northern Iowa joining the East Fork Des Moines River below Humboldt to form the main stem of the Des Moines River. The largest towns on this reach are Estherville, Emmetsburg and Humboldt. The drainage area of the West Fork Des Moines River at Estherville totals 1,372 square miles. The total drainage area for the West Fork is 2,308 square miles. The seven day ten year low flow at Estherville is 0.1 cfs.

POLLUTION PROBLEMS AND SOURCES

Wastes from the three largest municipalities effect water quality along the West Fork Des Moines River. Serious problems with high ammonia concentrations and low dissolved oxygen levels exist during the winter and low flow periods. A significant bacteriological impact is also made by these point sources.

Nonpoint sources also affect stream quality. Various researchers have shown that during periods of storm runoff increases in the concentrations of phosphorus, nitrogen, dissolved solids and fecal coliform counts occur even though additional dilution water is present. Although these trends seem to be indicated by existing data, no correlation between rainfall and changes in water quality parameters are possible due to the limited data available.

WATER QUALITY CONDITIONS

Harmful Substances

Heavy metals in the West Fork Des Moines River include barium, copper, lead, manganese and zinc. Of these, only manganese exceeds recommended drinking water levels. Manganese standards have been established by the EPA for surface water supplies. This level was exceeded in 85% of the samples collected in the West Fork. No municipalities use the West Fork as a surface water supply. Manganese is not toxic and would not be a health hazard. Lead concentrations in the West Fork have not exceeded Iowa Water Quality Standards in the samples analyzed. There are no known point sources of heavy metals on the West Fork. Manganese concentrations are therefore assumed to be due to chemical characteristics of runoff.

TABLE II-35

HEAVY METALS IN THE WEST FORK DES MOINES RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	11	0		
Ba	11	9	144	200
Cd	12	0		
Cr	14	0		
Cu	12	2	10	10
Pb	12	4	65	130
Mn	7	6	283	510
Hg	2	0		
Ni	10	0		
Ag	6	0		
Zn	12	10	57	210

Physical Modification

Turbidity and solids levels increase during storm runoff periods. Concentrations are typical of most Iowa streams during runoff and not critical. In general the physical condition of the West Fork is good.

Eutrophication Potential

Nutrients are abundant in the West Fork Des Moines River allowing large algal populations. Nutrient peaks occur below Estherville for total phosphates and ammonia (Figure II-85, Figure II-87, and Figure II-88). The nitrate concentration below Estherville is low as most of the nitrogen at this point is in the ammonia or organic form. Downstream the ammonia concentration decreases and levels off while the nitrate concentration increases dramatically.

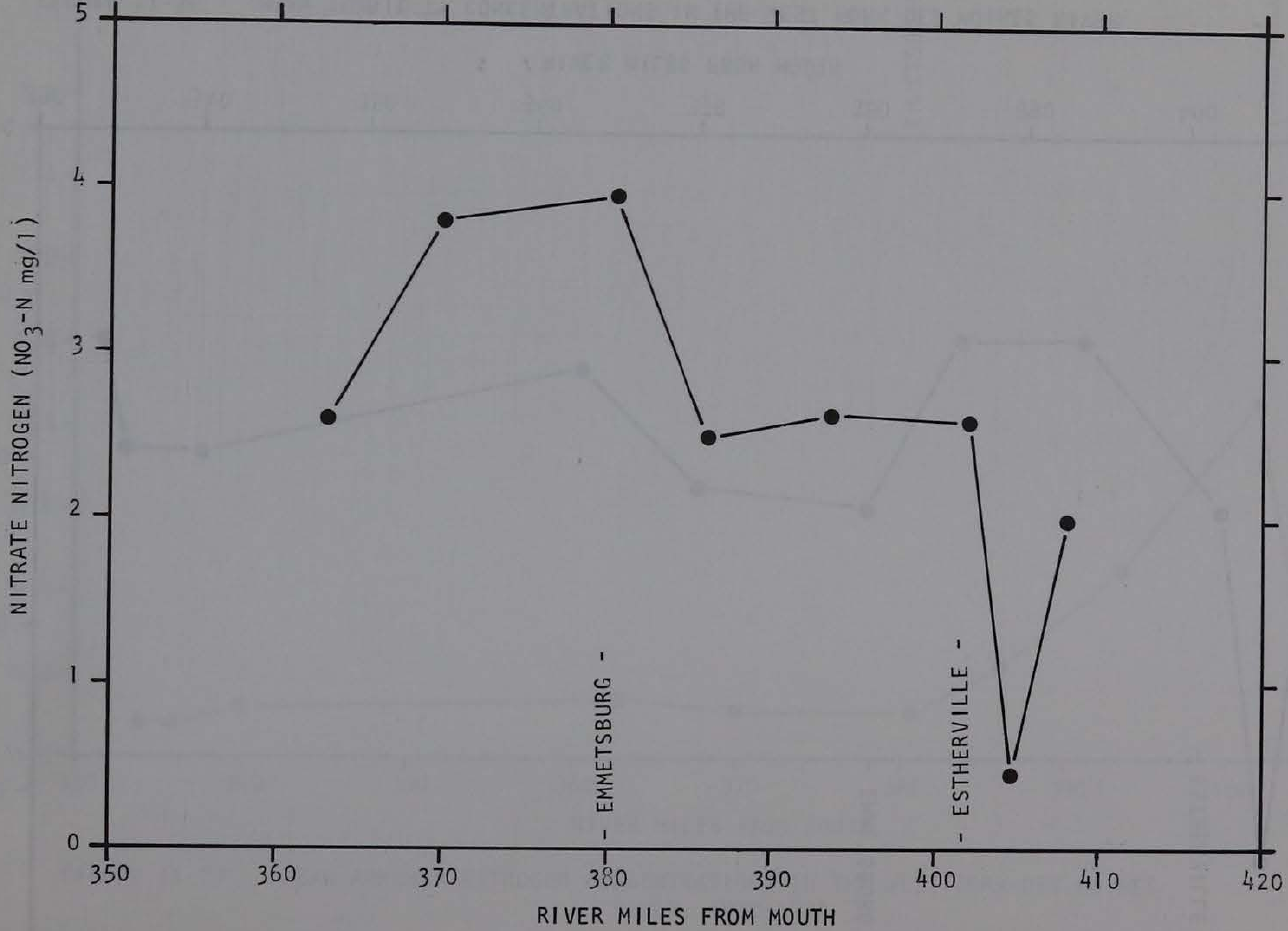


FIGURE 11-85 MEAN NITRATE NITROGEN CONCENTRATIONS IN THE WEST FORK DES MOINES RIVER, 1970-1974

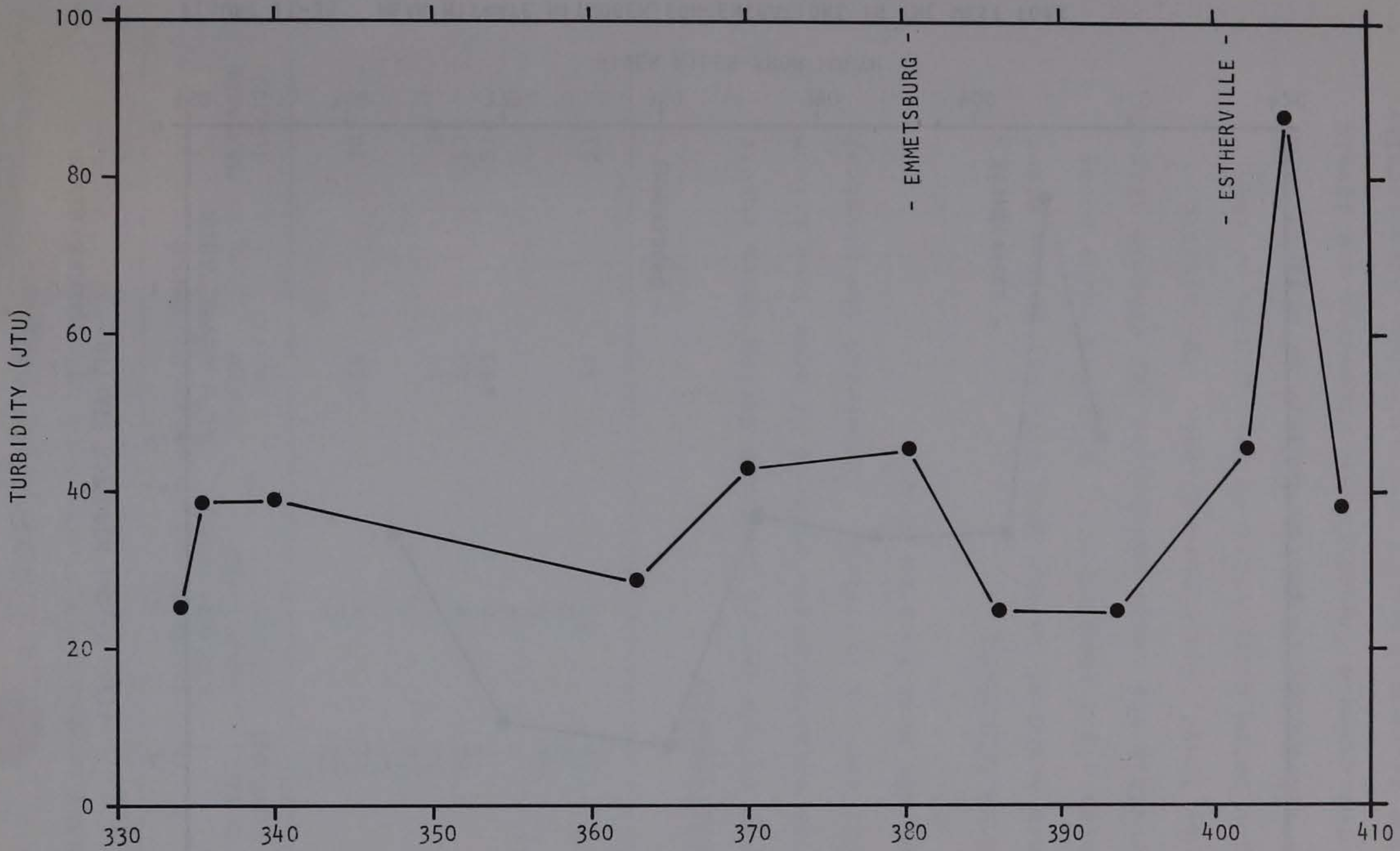


FIGURE 11-86 MEAN TURBIDITY CONCENTRATIONS IN THE WEST FORK DES MOINES RIVER, 1970-1974

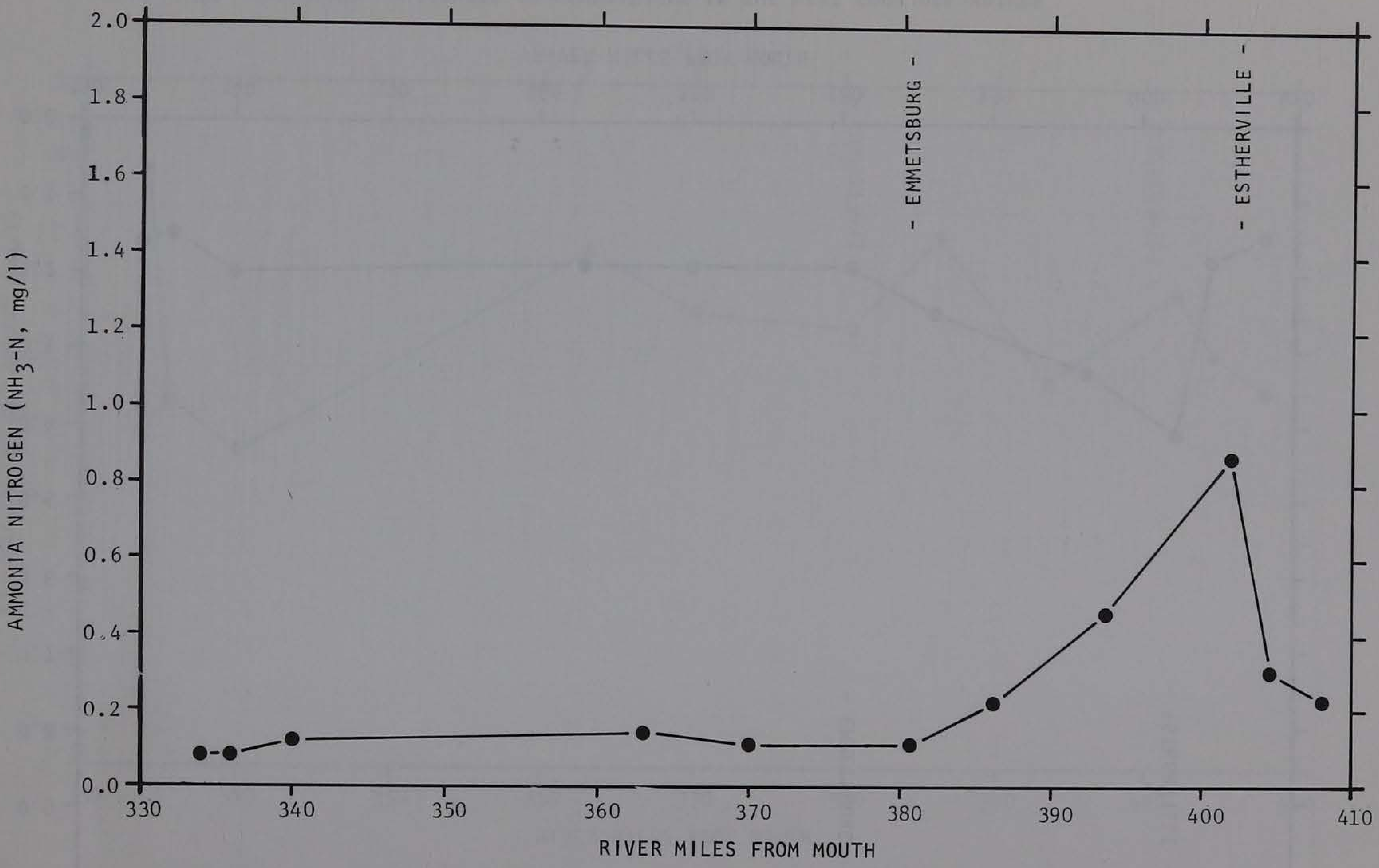


FIGURE II-87 MEAN AMMONIA NITROGEN CONCENTRATIONS IN THE WEST FORK DES MOINES RIVER, 1970-1974

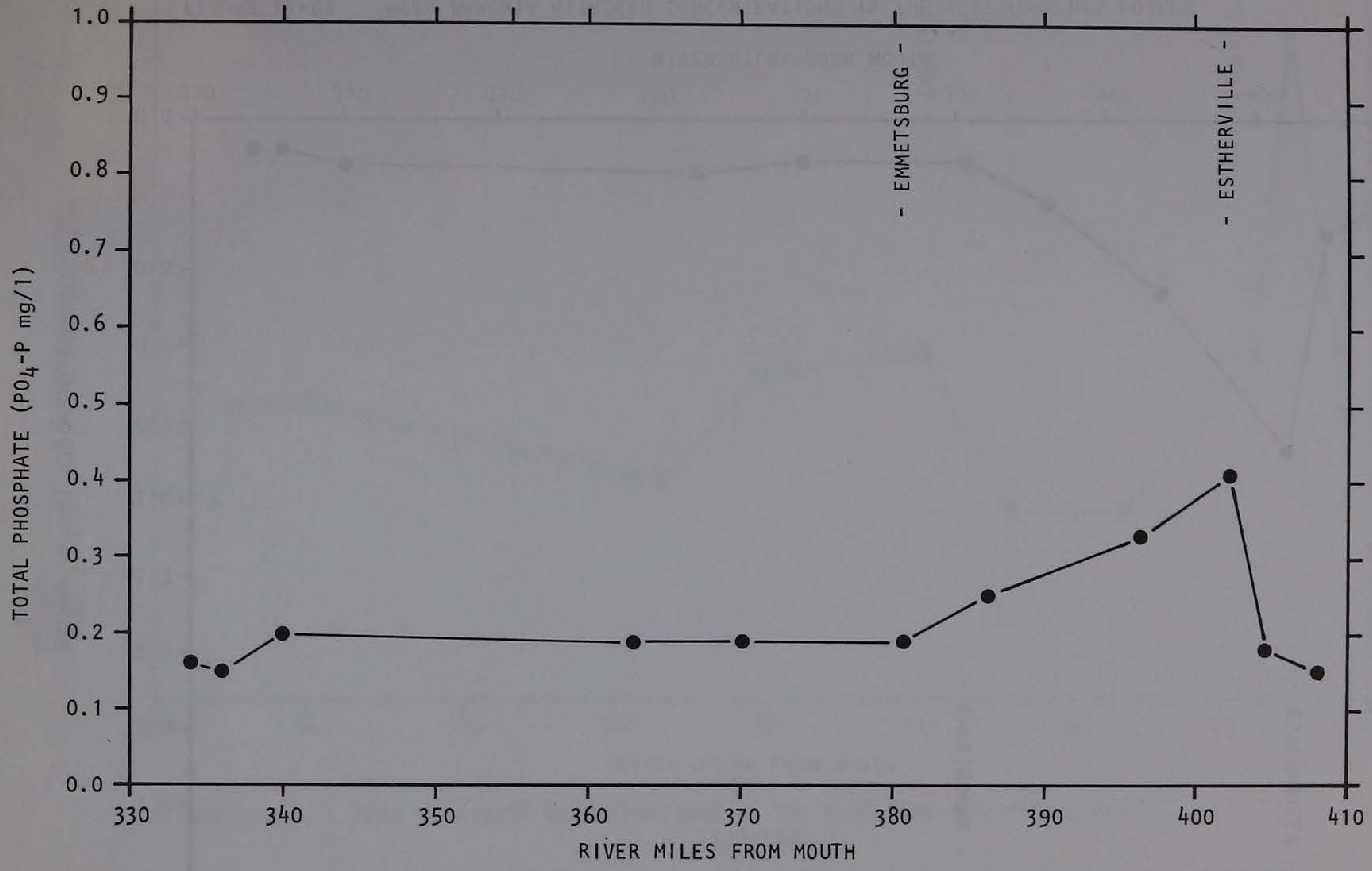


FIGURE 11-88 MEAN TOTAL PHOSPHATE CONCENTRATIONS IN THE WEST FORK DES MOINES RIVER, 1970-1974

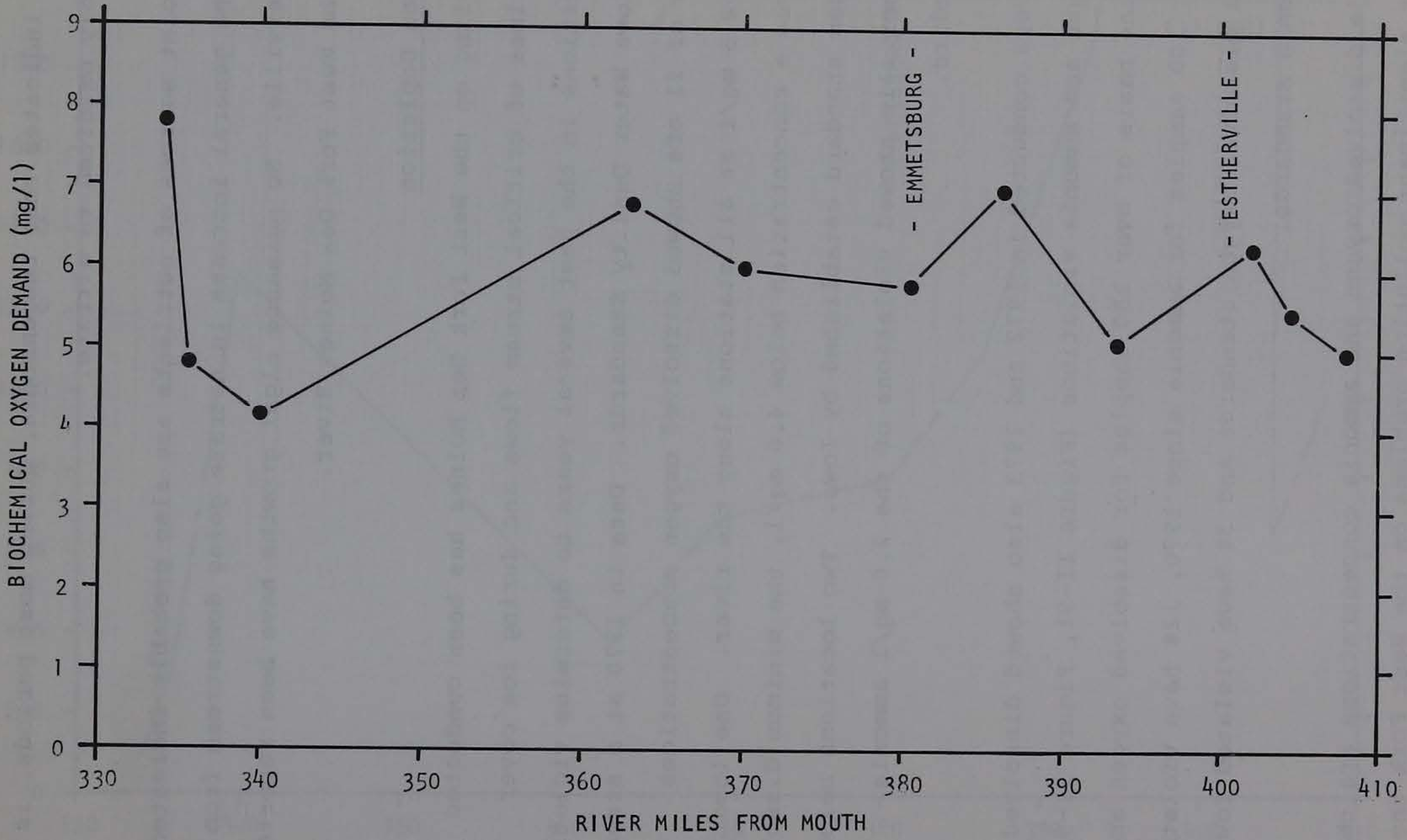


FIGURE 11-89 MEAN BIOCHEMICAL OXYGEN DEMAND IN THE WEST FORK DES MOINES RIVER, 1970-1974

This indicates that the ammonia, during most periods, is rapidly oxidized to nitrate.

Nonpoint sources of nutrients are also probably indicated by the general increase in nitrate going downstream from Estherville. No nuisance algal growths have been reported on the West Fork Des Moines River.

Oxygen Depletion

Sampling on the West Fork Des Moines has been conducted at times of critical stream flows and during ice cover conditions in the past several years to determine violations of Iowa Water Quality Standards. Data in 1970 at a stream flow of 21 cfs showed dissolved oxygen concentrations below 5 mg/l at all stations along the river. One location showed a concentration below 4.0 mg/l, the minimum dissolved oxygen standard established by Iowa. Two locations below Estherville showed violations of the 2.0 mg/l ammonia standard.

Surveys conducted in 1972 and 1973 also showed dissolved oxygen and ammonia violations (Figure II-91, Figure II-92). On the basis of over 150 samples for dissolved oxygen and over 100 samples for ammonia since 1970, 12% have violated Iowa dissolved oxygen standards and 3% have violated Iowa ammonia standards.

While dissolved oxygen and ammonia concentrations are the most significant pollution problems on the West Fork there

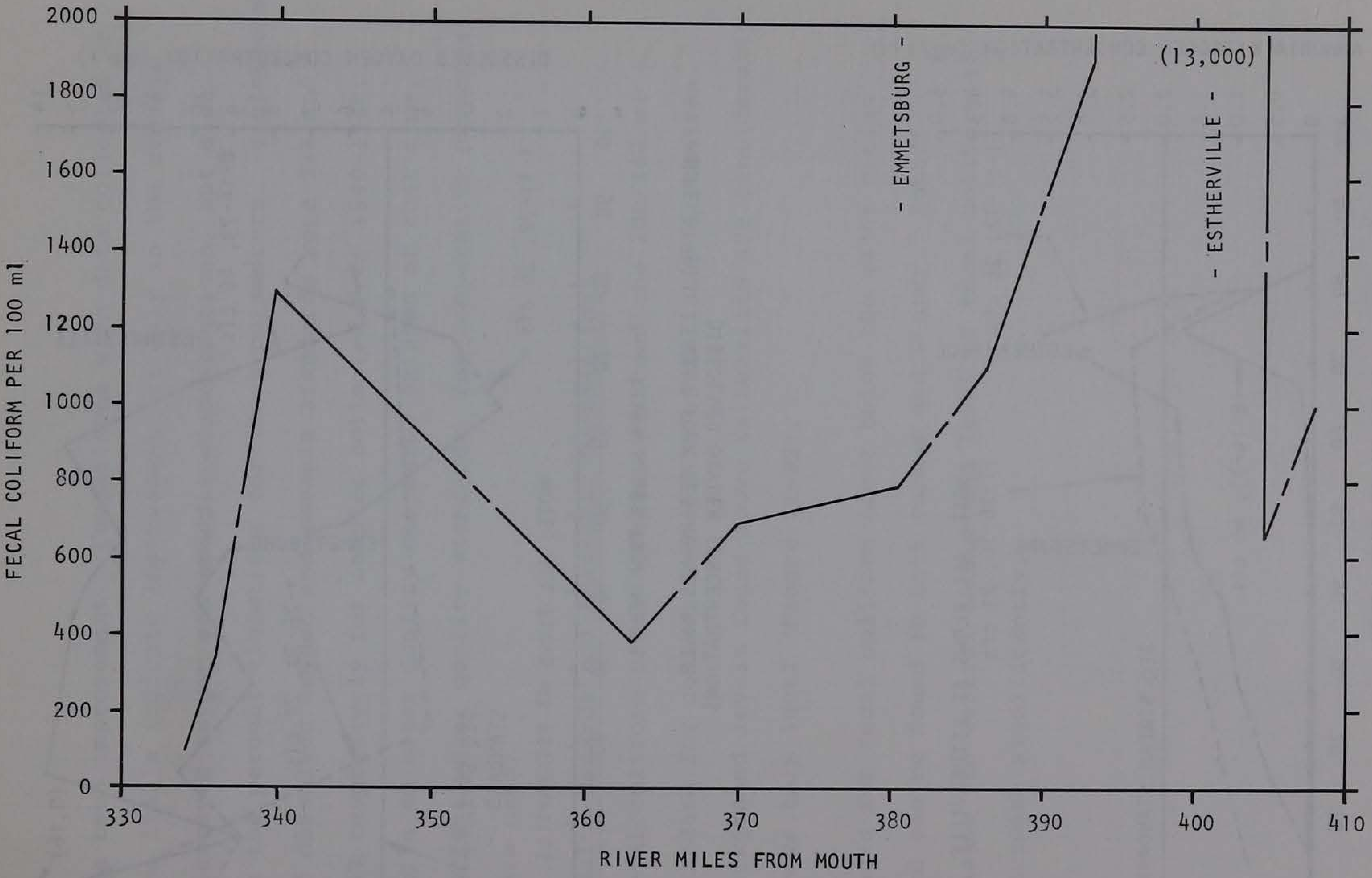


FIGURE 11-90 MEAN FECAL COLIFORM CONCENTRATIONS IN THE WEST FORK DES MOINES RIVER, 1970-1974

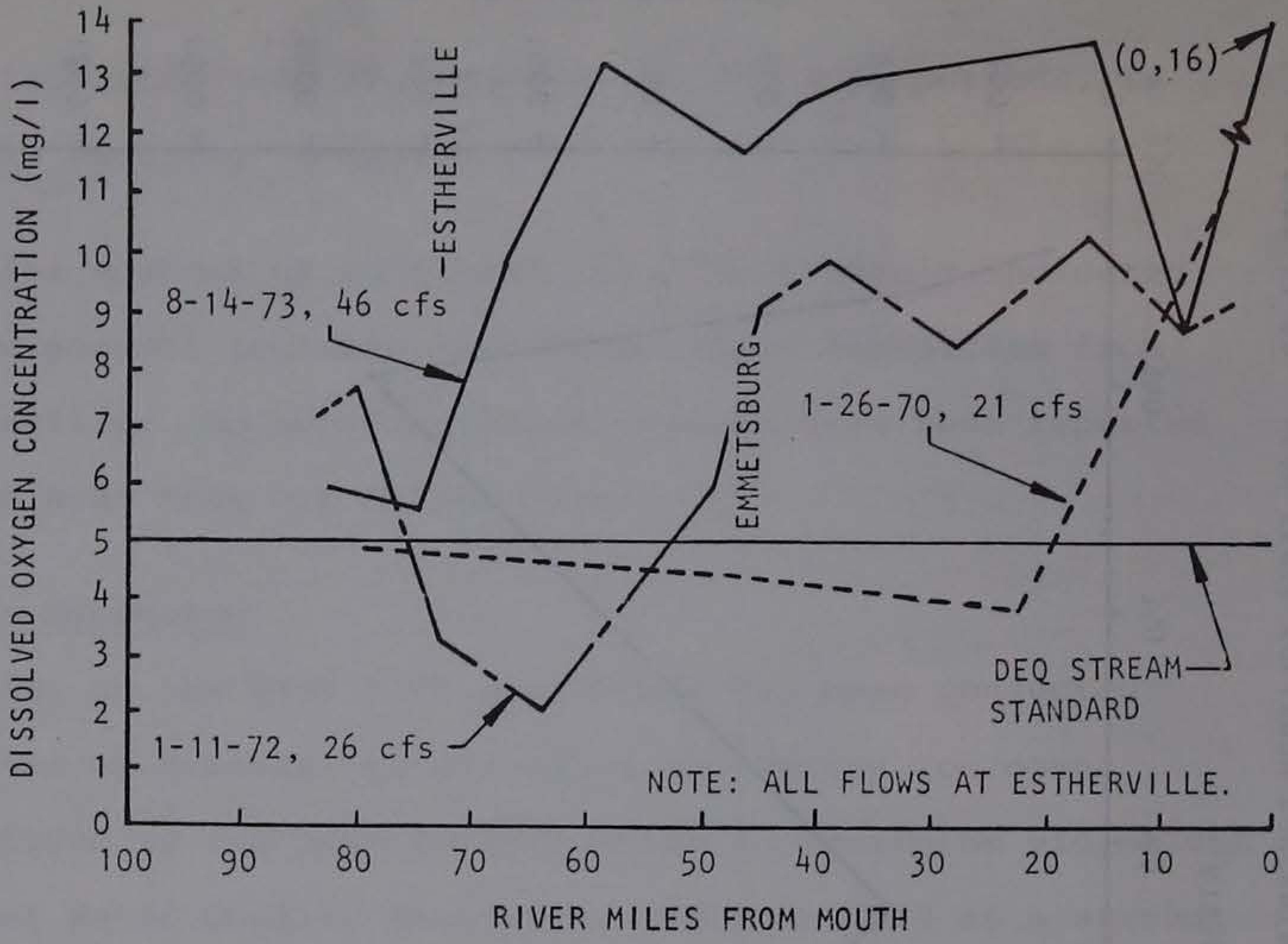


FIGURE 11-91 WEST FORK DES MOINES RIVER, DISSOLVED OXYGEN CONCENTRATIONS

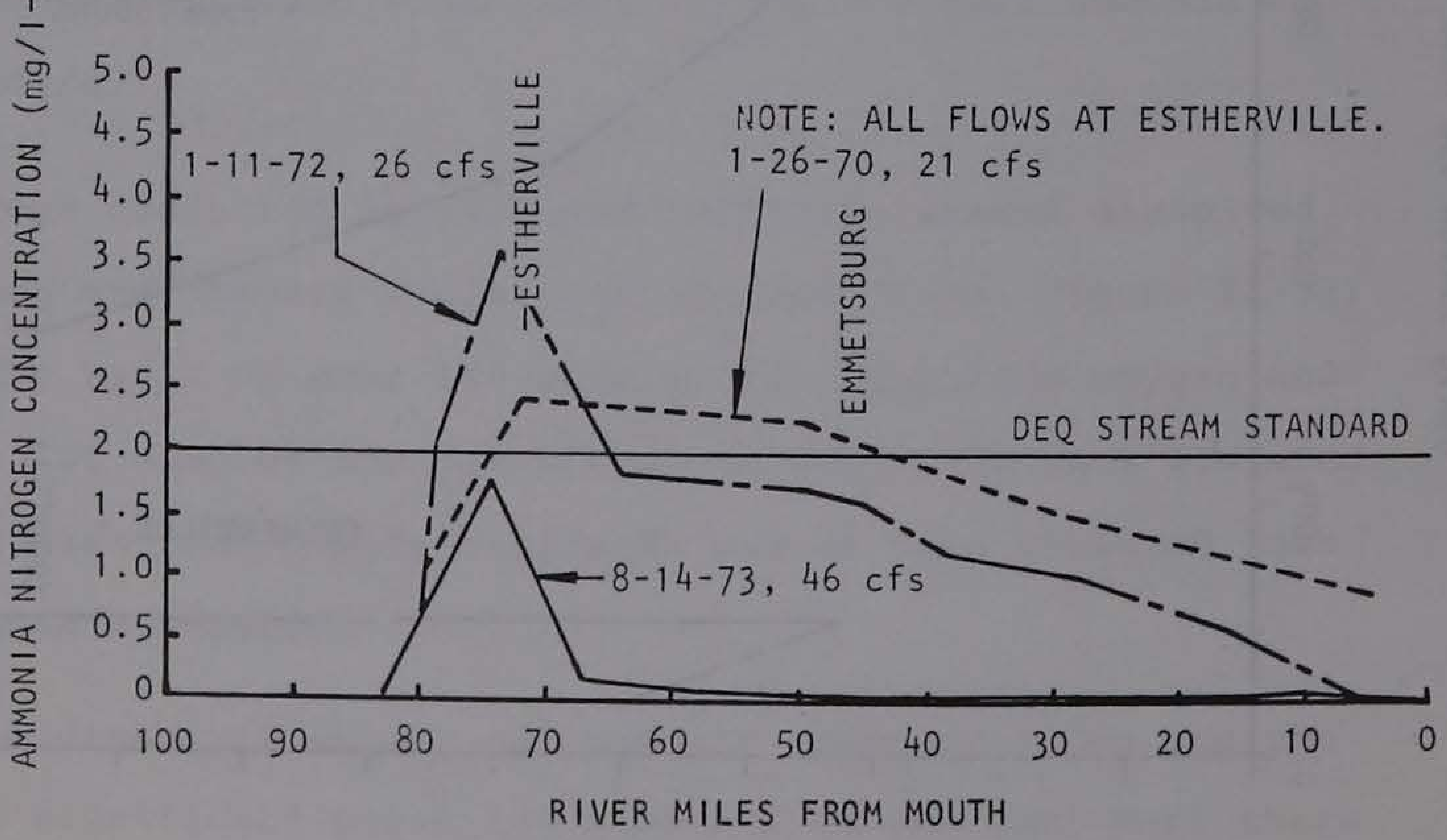


FIGURE 11-92 WEST FORK DES MOINES RIVER, AMMONIA NITROGEN CONCENTRATIONS

has been improvement. Comparisons with data collected in the 1940's indicate improvement not only in the average dissolved oxygen and ammonia concentrations, but also in the percent violations for these parameters. Violations of dissolved oxygen and ammonia standards were 32% and 25% respectively for samples collected from 1940-1949. While no water quality standards existed at that time, current water quality standards, for comparative purposes, were used.

Health Hazards and Aesthetic Degradation:
Fecal coliform counts generally exceed the 200/100 ml standard for contact recreation established by the EPA. Background levels found above Estherville are considerably above this level (Figure II-93).

Peaks for fecal coliform occur below the major cities and can be found in both summer and winter. Runoff causes the general background level of fecal coliform to increase significantly.

TABLE II-36

WATER QUALITY IOWA-MINNESOTA BORDER 1967-1973

WATER QUALITY PARAMETER	NUMBER OF DETERMINATIONS	AVERAGE VALUE	HIGH VALUE	LOW VALUE
West Fork Des Moines River[1]				
Dissolved Oxygen (mg/l)	30	9.40	17.00	3.80
5-Day BOD (mg/l)	43	6.00	12.00	1.50
pH (unit)	43	7.80	8.80	7.30
Turbidity (JTU)	43	30.80	100.00	0.04
Conductivity (micromho)	43	762.00	1,200.00	210.00
Total Solids (mg/l)	38	718.00	1,300.00	65.00
Total Non-filterable Solids (mg/l)	43	64.00	390.00	3.00
Ammonia Nitrogen (mg/l-N)	43	0.30	1.30	0.05
Nitrate Nitrogen (mg/l-N)	43	1.20	6.00	0.02
Total Phosphorus (mg/l-P)	43	0.31	1.00	0.10
Fecal Coliforms (No./100 ml)	43	2,030.00	23,000.00	20.00

[1] Eight river miles north of Iowa-Minnesota border.

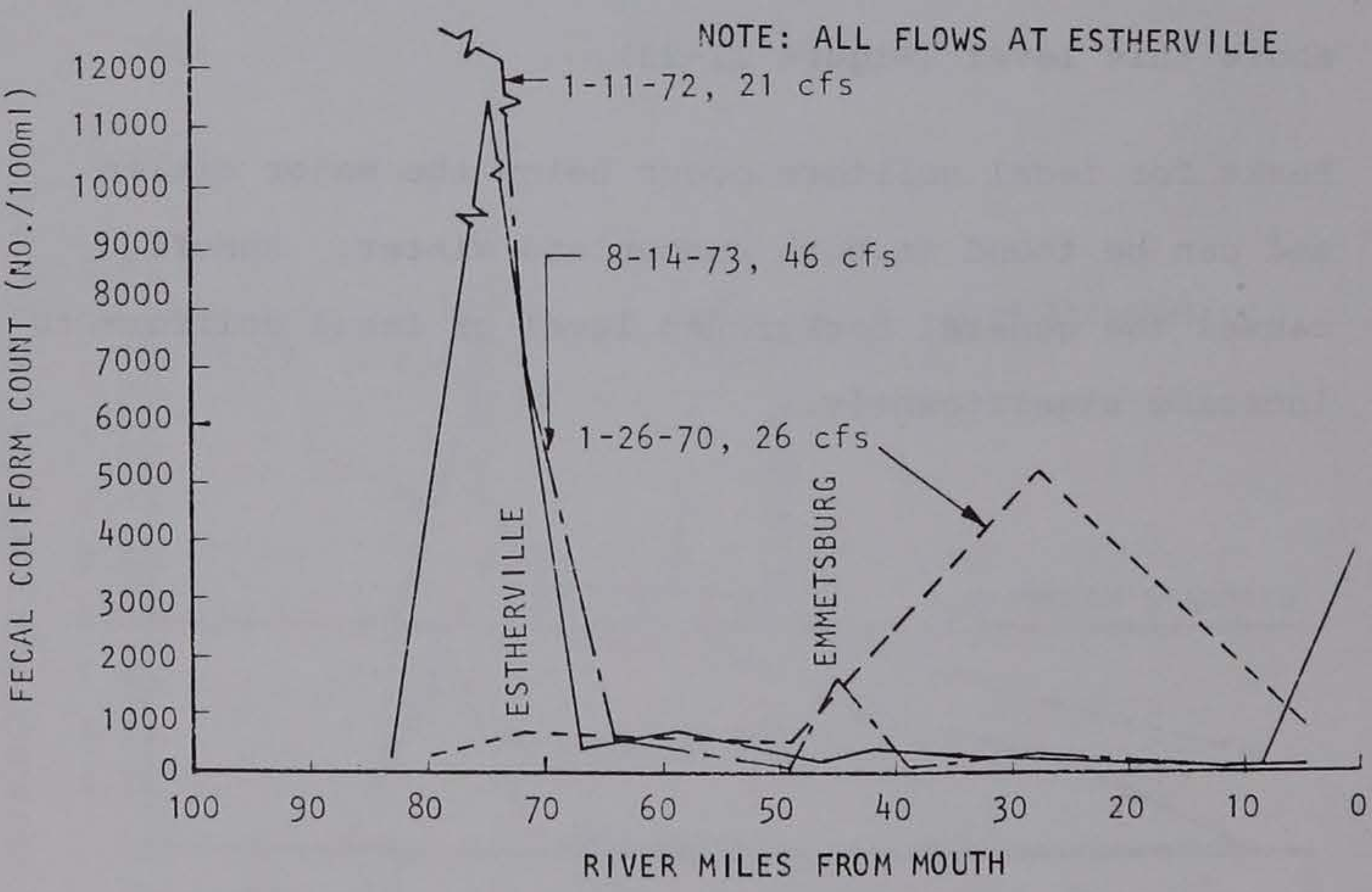


FIGURE II-93 WEST FORK DES MOINES RIVER, FECAL COLIFORM COUNT

NORTH RACCOON RIVER

Water quality in the North Raccoon River is effected by point source discharges with resulting low dissolved oxygen concentrations, high ammonia concentrations, and high fecal coliform concentrations. During winter and low flow conditions numerous violations of Iowa Water Quality Standards occur. Water quality is generally improved during average or above average flow.

The key pollutants highlight conditions in the North Raccoon:

Harmful Substances: No pesticide samples have been collected on the North Raccoon River. Metals found on the North Raccoon include barium, copper, manganese, and zinc. No violations of Iowa standards have been found.

Physical Modification: No problems have been found with turbidity, total solids, or temperature in the North Raccoon River. Limited sampling data are available to provide information for runoff conditions.

Eutrophication Potential: Nutrient concentrations are high. Phosphate concentrations decrease rapidly going downstream. Phosphates may be limiting at times in the lower half of the river.

Salinity, Acidity, and Alkalinity: Chloride concentrations are elevated compared to bordering river basins. Total dissolved solids, however, are normally within acceptable levels. Acidity is not a problem in the North Raccoon.

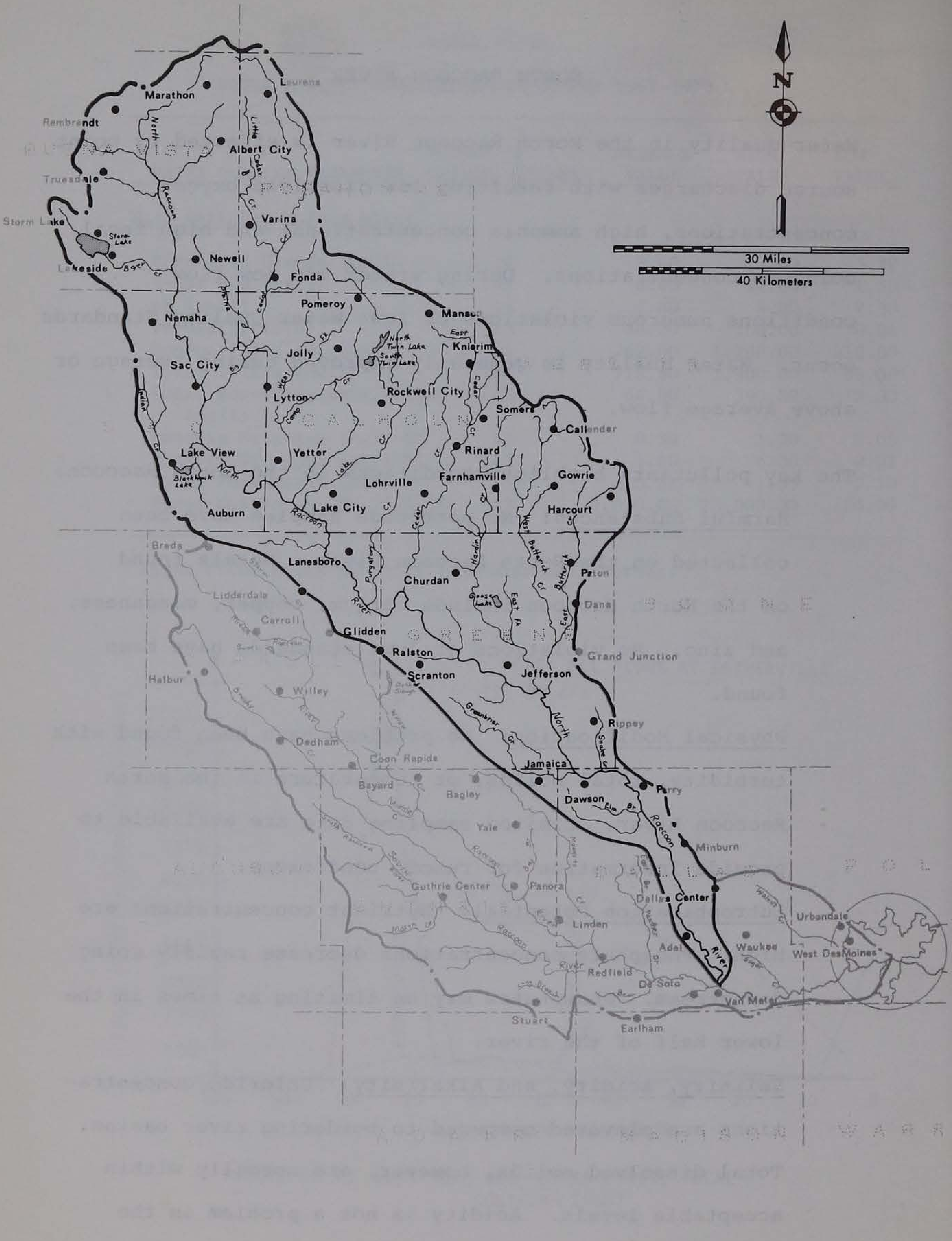


FIGURE II-94 NORTH RACCOON RIVER BASIN

Oxygen Depletion: Dissolved oxygen and ammonia problems are common from Storm Lake to the mouth during many periods, particularly the winter.

Health Hazards and Aesthetic Degradation: Bacteriological criteria for recreation established by the EPA have rarely been met on the North Raccoon. A combination of point and nonpoint sources appear responsible.

GENERAL PHYSICAL DESCRIPTION

The North Raccoon River, with a drainage area of approximately 2,200 square miles, originates near Leverett, in northern Buena Vista County and flows southeasterly for approximately 175 miles to its confluence with the South Raccoon River near Van Meter. The combined rivers form the Raccoon River which discharges into the Des Moines River at Des Moines. From its confluence with the Raccoon River to the Buena Vista County line, the North Raccoon River is designated for aquatic life use as a warm water area and is subject to Iowa Water Quality Standards.

Major tributaries to the North Raccoon River generally drain from the north and include Butterick Creek, Hardin Creek, **Cedar Creek,** Camp Creek, and Cedar Creek. These five creeks drain approximately 50% of the North Raccoon River drainage area. Major point sources on the North Raccoon are Storm Lake and Hygrade Food Products, Inc. at Storm Lake; Sac City; Jefferson; Perry and the Oscar Mayer Plant at Perry.

Use of the river for recreation and fishing is extensive particularly near Adel, Iowa. This area is noted especially for its large flathead catfish and also supports some smallmouth bass (State Hygienic Laboratory, 1970). The 7 day 10 year low flow at Jefferson is 12 cfs.

POLLUTION PROBLEMS AND SOURCES

Water quality of the North Raccoon River above the first point source, Storm Lake via Boyer Creek, is good. The City of Storm Lake, Hygrade Foods, Sac City, Jefferson and Perry have a significant impact on stream quality. Normal reaeration at average flow conditions allows recovery below Storm Lake. During low flow or winter periods when reaeration decreases due to low velocity or ice cover the dissolved oxygen concentrations often violate Iowa standards. Ammonia concentrations also exceed Iowa standards over large areas during the winter. The extent to which nonpoint sources contribute nutrients is difficult to determine due to the overwhelming effect of the point sources. Point sources are the greatest problem on the North Raccoon River regarding dissolved oxygen and ammonia.

WATER QUALITY CONDITIONS

Harmful Substances

No problems associated with harmful substances have been detected in the North Raccoon River. Water samples for pesticides and metals have been taken more extensively at the Des Moines water supply intake on the main stem of the Raccoon River. The North Raccoon River contains two-thirds of the drainage area for the whole basin and is therefore the most significant contributor to water quality on the main stem. Metals on the main stem of the Raccoon River contain approximately the same metals as on the North Raccoon. Lead and mercury have also been detected. While mercury concentrations have all been below Iowa standards, lead has exceeded Iowa standards.

Pesticide data for the main stem Raccoon River have generally been in excess of the National Academy of Science recommended maximum levels for DDE, DDT, and dieldrin. DDE concentrations average 48 ng/l in samples with detectable levels and reached a maximum concentration of 250 ng/l. Average concentrations of DDT and dieldrin in samples with detectable levels were 9 ng/l. Maximum concentrations were 23 and 41 ng/l respectively.

TABLE II-37

HEAVY METALS IN THE NORTH RACCOON RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	8	0		
Ba	9	9	170	200
Cd	9	0		
Cr	21	0		
Cu	9	2	20	20
Pb	9	0		
Mn	4	2	140	140
Hg	8	0		
Ni	1	0		
Ag	0	0		
Zn	9	6	23	30

TABLE II-38

HEAVY METALS IN THE MAIN STEM RACCOON RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	0	0		
Ba	15	13	177	300
Cd	16	0		
Cr	16	0		
Cu	16	2	25	40
Pb	16	4	95	290
Mn	1	0		
Hg	2	1	1	1
Ni	15	2	30	40
Ag	1	0		
Zn	15	12	46	140

TABLE II-39

PESTICIDES IN THE MAIN STEM RACCOON RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	24	10	48	250
DDT	17	9	9	23
Dieldrin	25	16	8.8	41
Atrazine	9	9	639	3300

Physical Modification

Turbidity, total solids and temperature on the North Raccoon River are similar to other streams of the State. Limited data are not sufficient to determine the magnitude of nonpoint runoff regarding turbidity and solids. Turbidity concentrations during sampling periods have averaged approximately 30 JTU with a maximum of 110 JTU. Total solids concentrations have averaged approximately 650 mg/l with a maximum of over 1100 mg/l. No temperature problems have been noted on the North Raccoon River.

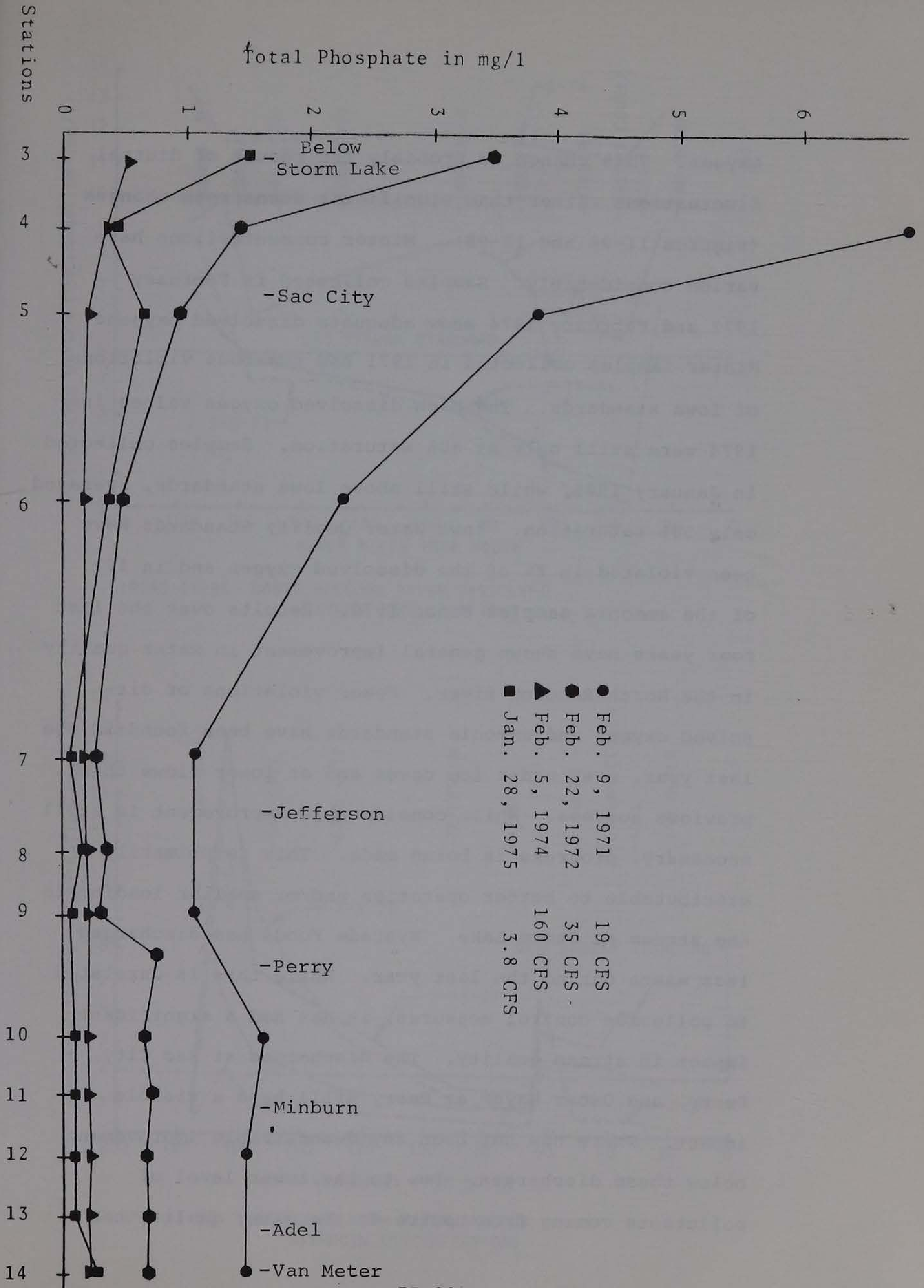
Eutrophication Potential

High nitrogen and phosphorus concentrations have been found in the North Raccoon River. Organic nitrogen has been higher in the summer months (August 1.2 mg/l - 2.3 mg/l) as compared to winter (0.08 mg/l - 0.79 mg/l). Organic nitrogen is related to the amount of aquatic plants present and would be expected to be higher in the summer. Only small variations in organic nitrogen have been found between stations. Summer nitrate values were highest in June, 8.5 mg/l - 11 mg/l, and decreased in July and August, 6.0-7.6 mg/l and 0.1-1.3 mg/l respectively. The downward trend is probably related to increased algal growth during the summer. Increases in organic nitrogen in August samples support this conclusion. Winter nitrate concentrations have fluctuated widely from 7.0-9.5 mg/l in February, 1974 to 1.0-3.2 mg/l in January, 1975. This may be due to the low flows during the 1975 sampling period and the relatively high flows during the February 1974 sampling. Flow on the North Raccoon in January 1975 was 3.8 cfs and in February 1974 was 160 cfs.

Phosphate concentrations in the North Raccoon River show a significant decrease from a peak below Storm Lake during winter sampling. Another small increase can be detected below Perry and the Oscar Mayer discharges (Figure II-95). Phosphate levels during the summer ranged from 0.06 mg/l-0.75 mg/l. Phosphate may be limiting during both summer and winter.

Oxygen Depletion

Summer dissolved oxygen values ranged from 6.5 mg/l (85% saturation) to 15.5 mg/l (140% saturation), with August having the greatest change between stations in dissolved


Stations
Total Phosphate in mg/l
0
1
2
3
4
5
6
3
4
5
6
7
8
9
10
11
12
13
14
-Below Storm Lake
-Sac City
-Jefferson
-Perry
-Minburn
-Adel
-Van Meter
● Feb. 9, 1971 19 CFS
● Feb. 22, 1972 35 CFS
▲ Feb. 5, 1974 160 CFS
■ Jan. 28, 1975 3.8 CFS

oxygen. This change is probably the result of diurnal fluctuations rather than significant downstream changes (Figures II-96 and II-98). Winter concentrations have varied considerably. Samples collected in February 1972 and February 1974 show adequate dissolved oxygen. Winter samples collected in 1971 had numerous violations of Iowa standards. The high dissolved oxygen values in 1974 were still only at 80% saturation. Samples collected in January 1975, while still above Iowa standards, averaged only 50% saturation. Iowa Water Quality Standards have been violated in 8% of the dissolved oxygen and in 17% of the ammonia samples since 1970. Results over the last four years have shown general improvement in water quality in the North Raccoon River. Fewer violations of dissolved oxygen and ammonia standards have been found in the last year, even under ice cover and at lower flows than previous surveys. While considerable improvement is still necessary, progress is being made. This is primarily attributable to better operation and/or smaller loading to the stream at Storm Lake. Hygrade Foods has discharged less waste during the last year. While this is unrelated to pollution control measures, it has had a significant impact in stream quality. The discharges at Sac City, Perry, and Oscar Mayer at Perry still have a visible impact. There has not been any demonstrable improvement below these discharges. Due to the lower level of pollutants coming from upstream, the water quality has

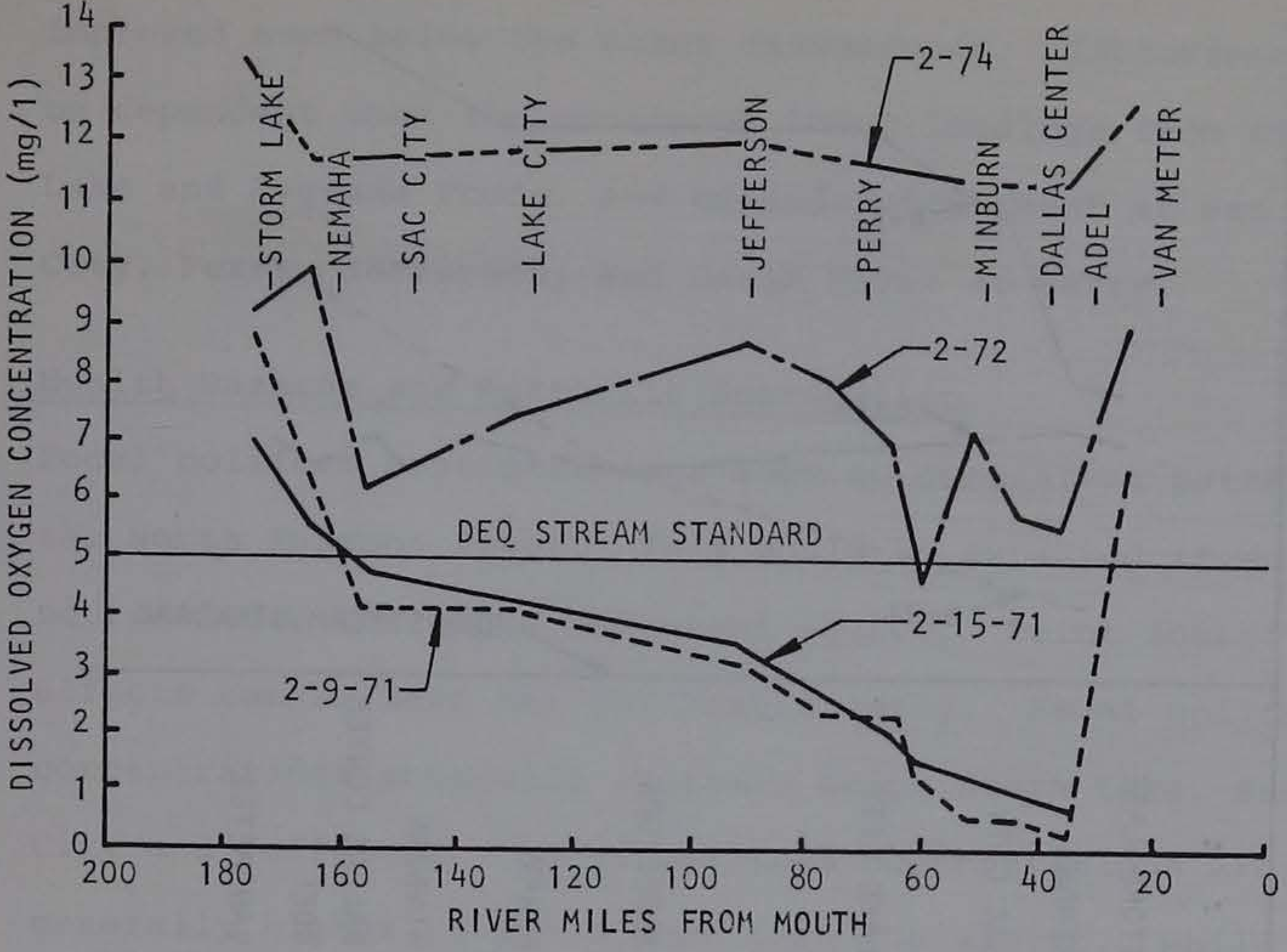


FIGURE II-96 NORTH RACCOON RIVER, DISSOLVED OXYGEN CONCENTRATIONS

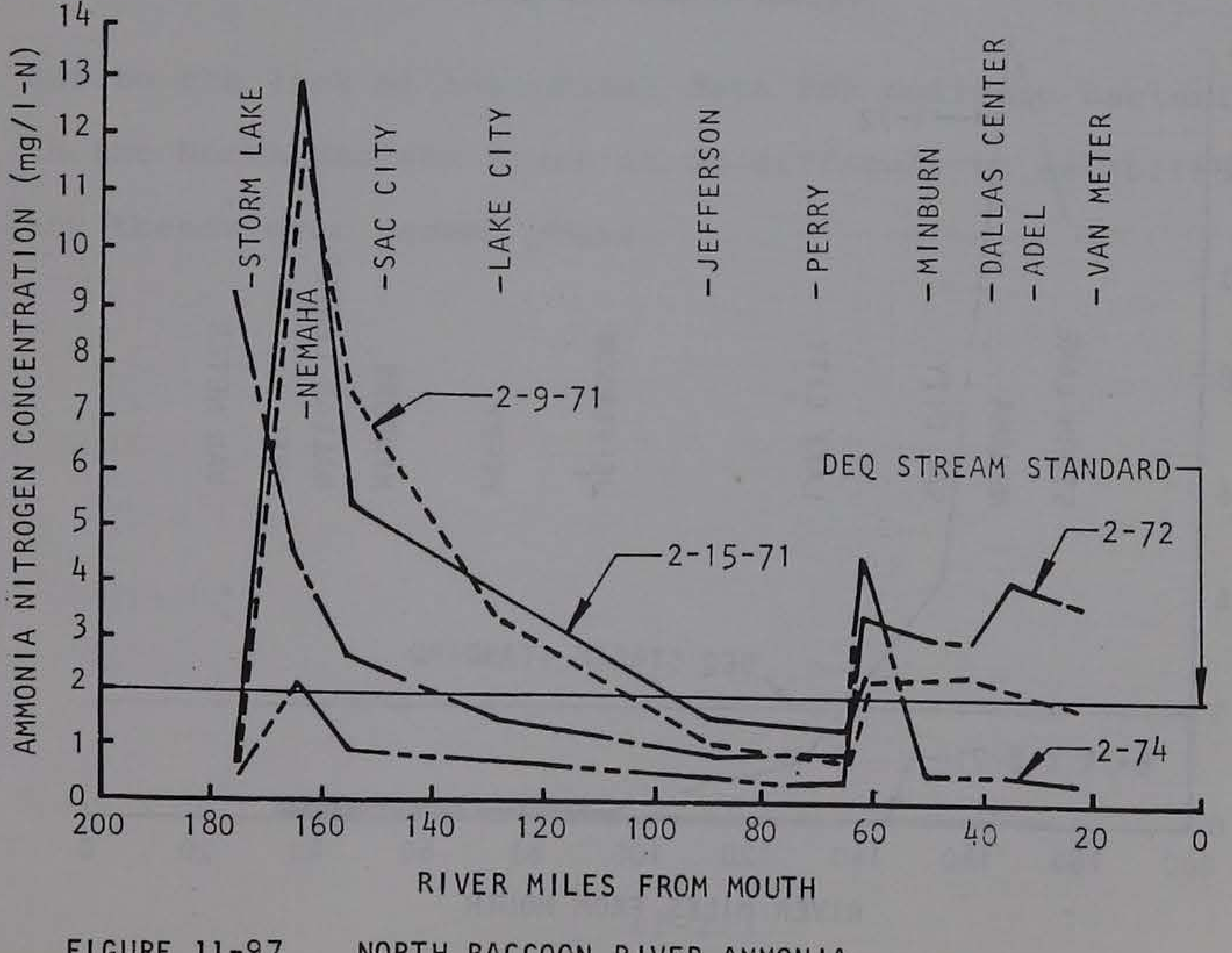


FIGURE II-97 NORTH RACCOON RIVER, AMMONIA NITROGEN CONCENTRATIONS

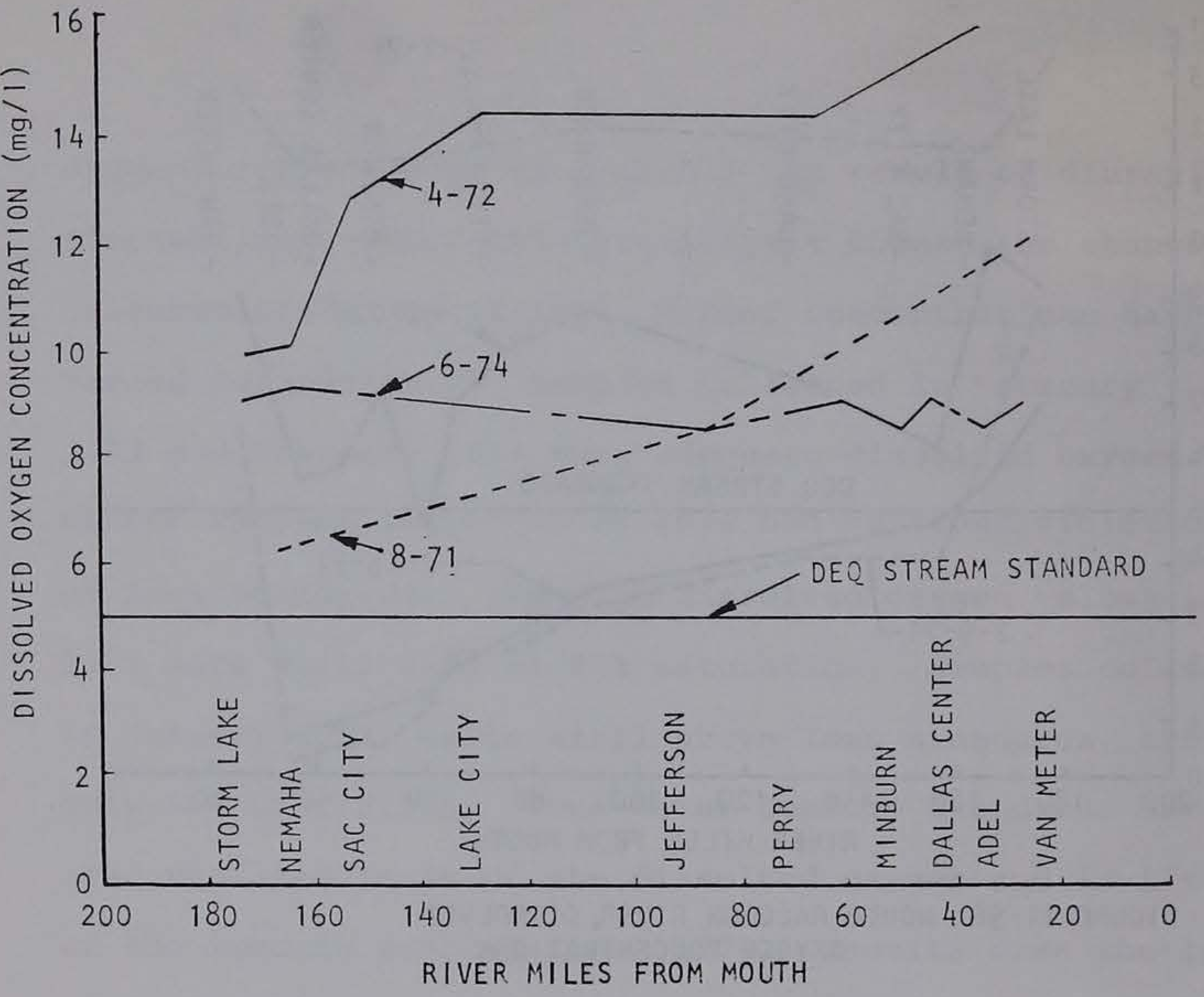


FIGURE 11-98 NORTH RACCOON RIVER, DISSOLVED OXYGEN CONCENTRATIONS

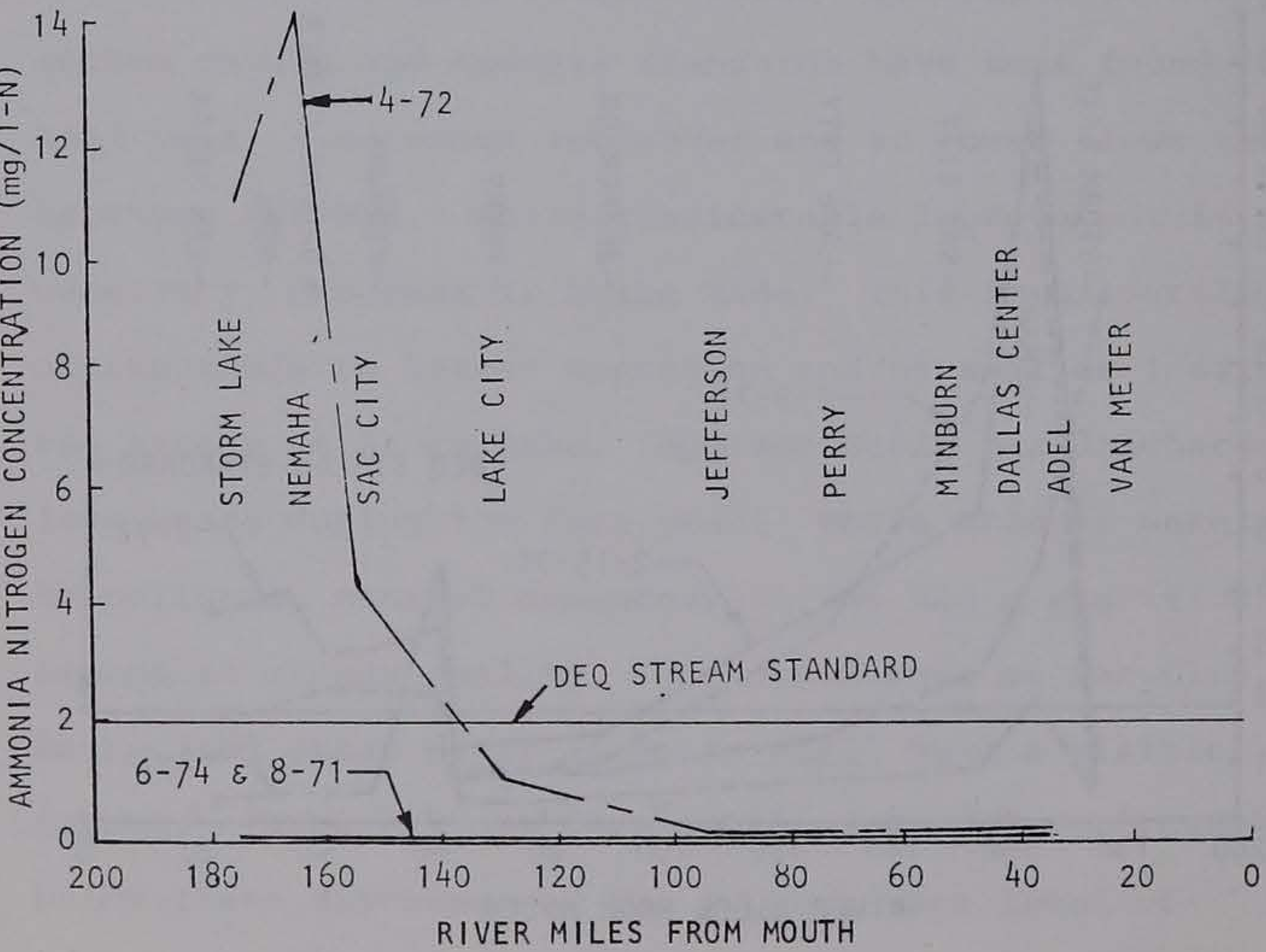


FIGURE 11-99 NORTH RACCOON RIVER, AMMONIA NITROGEN CONCENTRATIONS

improved even below the other dischargers. Improvement will be dependent upon the continued lower loadings from Storm Lake and Hygrade Foods, and expanded treatment at Sac City, Perry, Jefferson, and Oscar Mayer at Perry.

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations show no consistent pattern in the North Raccoon River. This would be expected if nonpoint sources were the major pollutant source. Point source effects can be seen but not consistently. Fecal coliform concentrations generally increase below Storm Lake, Sac City and Jefferson. Fecal coliform concentrations are generally higher in the summer than the winter. While there is little significant fluctuation in concentration, the recreation criteria established by the EPA of 200/100 ml is almost always exceeded.

Due to the lack of historical data for coliform bacteria in the North Raccoon River it is difficult to establish any trends over recent years.

TABLE II-40

BACTERIOLOGICAL DATA - NORTH RACCOON RIVER

SAMPLING STATIONS	Fecal Coliform per 100 ml JUNE '74	JULY '74	AUG '74	FEB '74	JAN '75
Above Storm Lake	660	950	620	50	NS
Boyer Creek	33,000	2,100	4,000	NS	100
Below Storm Lake	1,200	680	560	1,400	160
Nemaha	590	950	690	1,200	10
Below Sac City	2,300	3,700	1,400	450	9,200
Lake City	2,200	NS	14,000	180	70
Above Jefferson	810	550	320	40	10
Below Jefferson	480	4,100	1,400	140	1,200
Above Perry	1,100	520	60	330	180
Below Perry	1,100	490	120	290	440
Adel	680	380	90	160	120
Van Meter	440	240	170	90	950

NS--Not sampled

CHARITON RIVER

Water in the Chariton River is generally of good quality with the exception of the segment directly below the city of Chariton. This segment is characterized by undesirable bacteria, elevated BOD, excessive nutrients, and depressed dissolved oxygen particularly during low flow conditions. Pesticide levels in the Chariton River from nonpoint sources may be of concern if current levels persist.

The key pollutants highlight conditions in the Chariton:

<u>Harmful Substances</u>: Studies are presently underway by Iowa State University concerning the effects of pesticide residuals on aquatic life in the Chariton River and Rathbun Reservoir. Levels found to date generally exceed maximum concentrations recommended by the National Academy of Science for dieldrin and DDE. Atrazene has also been found in high concentrations. Heavy metals are within acceptable limits for drinking water supplies except for manganese. (Table II-41).

<u>Physical Modification</u>: Wide variations in total and suspended solids occur during and after heavy rainfall due to extensive runoff from agricultural lands.

<u>Eutrophication Potential</u>: Nitrogen and phosphorus concentrations are related to flow. Nonpoint source pollution contributes the vast majority of these nutrients to the river.

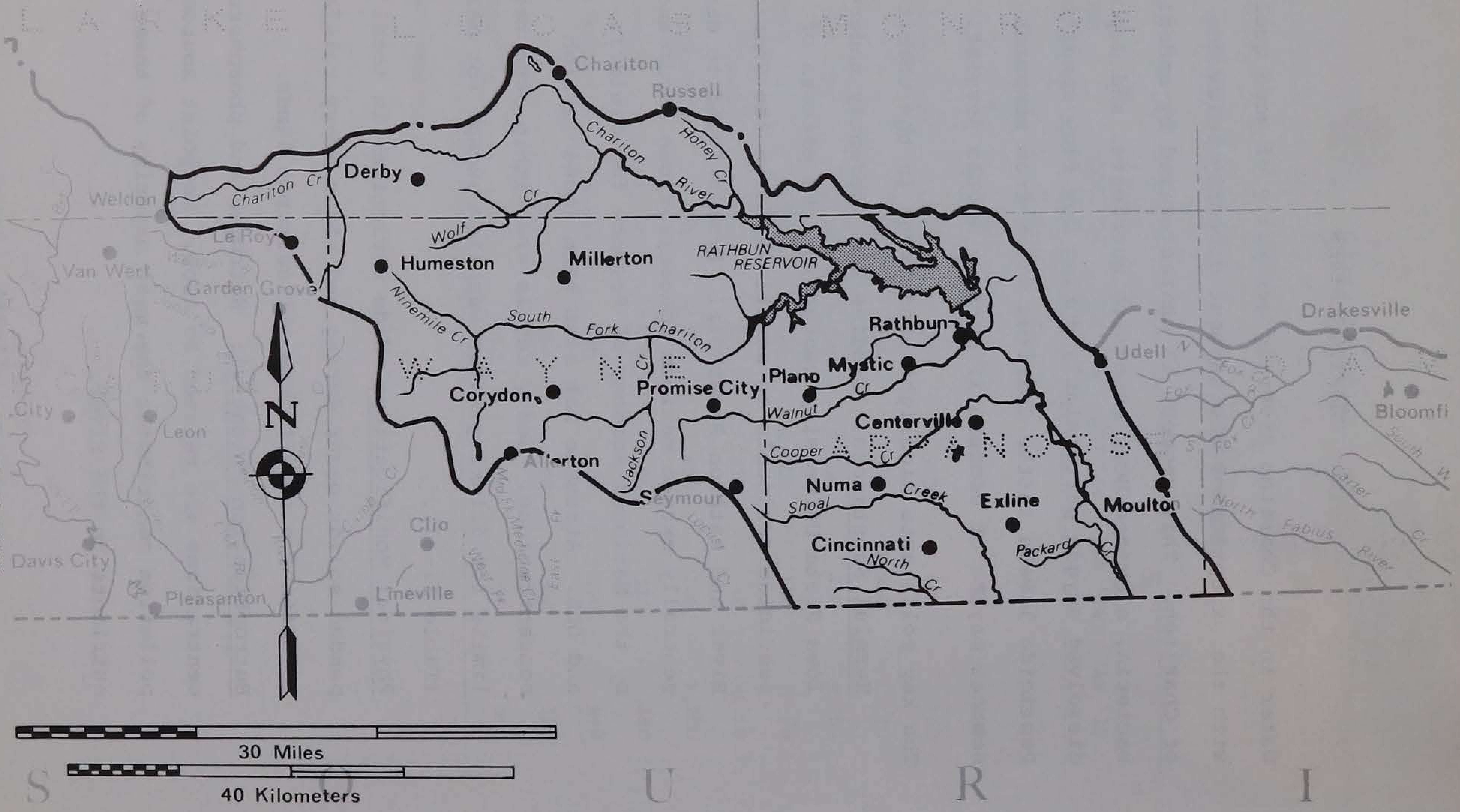


FIGURE II-100 CHARITON RIVER BASIN

Salinity, Acidity and Alkalinity: Salinity and acidity have not been problems in the Chariton River to date. Concentrations of dissolved solids have been within Iowa standards.

Oxygen Depletion: Problems exist below Chariton for several miles. Oxygen depleted waters also occur below Rathbun during stratified conditions when bottom waters are discharged.

Health Hazards and Aesthetic Degradation: The bacteriological criteria for recreation are met along the Chariton River, except below the Chariton municipal waste treatment discharge.

GENERAL PHYSICAL DESCRIPTION

The Chariton River is a major tributary of the lower Missouri River. It has a B Warm Water classification from the Missouri border to Highway 65 near Lucas. Its source is located in the southeastern corner of Clarke County. It then flows in a southeasterly direction through Lucas and Appanoose Counties. The stream leaves Iowa and enters Missouri in the southeastern corner of the latter county. The Chariton River divides into two main branches in the northwestern corner of Appanoose County. The South Fork Chariton River flows through Wayne and Appanoose Counties in an easterly direction.

For the most part stream flow is sluggish, often choked by fallen trees and log drifts. Daily flow records at the

Walnut Creek gauging station in Appanoose County, which has been operational since 1956, revealed a mean discharge of 338 cfs. Maximum flow of 21,800 cfs was recorded on June 24, 1960 prior to completion of Rathbun Reservoir. Low flow of 0.1 cfs was recorded on October 17, 1957 and October 11, 1966.

Prior to extensive rechannelization in the late 1930's the stream followed a tortuous course through a broad alluvial valley in the six county area. Most of the original channel in Wayne and Appanoose Counties has been straightened to promote rapid drainage for agriculture. In Lucas and Clarke Counties much of the original channel remains. In the rechanneled region more than 100 cut-off oxbow overflow ponds presently exist. These ponds depend upon periodic flooding and limited storm run-off to maintain water levels. Without heavy precipitation many bayous are dry in late summer and autumn.

The river channel is characterized by very steep, barren banks varying from five feet high in the upper reaches of the basin to as much as 25 feet high in the lower basin. There are more than seventy small streams tributary to the Chariton and South Chariton Rivers upstream from the damsite. These also have been largely rechanneled for rapid drainage. In the upper basin several small natural marshes are located within the flood plain.

Much of the Chariton River valley is covered with dense stands of mixed soft-hardwood forest. In many places the woodland cover is so dense there is complete forest canopy over the stream. The rechanneled regions have been cleared of forest cover and are presently farmed for small grain crops and pasture.

Rathbun Dam and Reservoir controls 549 square miles of the Chariton River Basin. An additional 366 square miles of the river drainage in Iowa is also located below the damsite.

This section of Iowa is located in the area covered by the Kansan glacial drift which was later covered by loessial deposits of more recent origin. In the eastern part of the basin, erosion has cut deeply into the face of the land and produced rugged terrain characterized by tributary streams of flat gradient in broad alluvial valleys.

Rainfall in the Chariton River valley has varied between relatively wide limits. Records available since 1881 reveal a minimum precipitation of 22 inches which occurred in 1921. Maximum recorded rainfall of 52 inches occurred during 1881. The mean annual precipitation for the entire period was 33.3 inches. Over a period of the last 30 years the long range trend has been downward, although individual years have varied greatly. The rate of decline has ranged from 0.05 to 0.12 inches per year with an average of 0.07 inches.

According to the U.S. Geological Survey's list of Iowa's drainage areas and plat maps of individual counties in the basin, seventy streams are tributary to the Chariton River.

The most important tributary is the South Chariton River which contains 225 square miles or 41% of the river basin. Other tributaries of the Chariton River are Wolf Creek in Lucas and Wayne Counties which drain 93.3 square miles, Goodwater Creek in Lucas County containing 19.8 square miles of drainage, and Honey Creek in Appanoose County with 14.9 square miles in the watershed. Only the lower reaches of Wolf Creek maintain flow at all times.

Major tributaries of the South Chariton River are Jackson Creek with 72.1 square miles of watershed; Jordan Creek with 26.3 square miles of drainage; and Walnut Creek which drains 18.1 square miles. All of these streams are located in Wayne County and are classed as intermittent without flow during periods of low precipitation.

POLLUTION PROBLEMS AND SOURCES

Wastes from the Chariton sewage treatment plant seriously reduce water quality in the river during low flow conditions. The river at Chariton often has flows below one cfs and due to rechannelization, artificial ponding occurs and extends several miles below the city. During low flow conditions, adequate dilution of the waste by this stream segment does not occur and serious pollution is often encountered. These conditions include high nutrients, high ammonia, high BOD, and low dissolved oxygen.

During periods of high flow extensive runoff causes high levels of nutrients, solids and pesticides. Nonpoint sources cause the majority of pollution for these constituents.

Reservoirs and dams produce both beneficial and deleterious effects. They provide flood control, recreation, and allow settling of suspended silt. On the other hand, dissolved oxygen in the lower depths of reservoirs can become low, or nonexistent. Discharges from the lower reach of Rathbun Reservoir during summer months sometimes violates dissolved oxygen criteria for aquatic life.

WATER QUALITY CONDITIONS

Harmful Substances

The soils in the Chariton Basin are rich in manganese, and high levels in the water are associated more with surface runoff than with waste discharges. Manganese, although not toxic, can interfere with drinking water supplies. Concentrations of manganese exceeded reference levels for drinking water supplies in over 75% of samples collected since 1970 (Table II-41). While there are currently few surface water supplies in the Chariton Basin, the Chariton Valley Regional Water District serving Lucas, Monroe, Wayne, and Appanoose Counties are planning on the use of Rathbun Reservoir for a water supply.

Pesticide levels for dieldrin and DDE exceed the recommended maximum concentrations established by the National Academy of Science (1972) (Table II-42).

TABLE II-41

HEAVY METALS IN THE CHARITON RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	19	0		
Ba	21	16	169	300
Cd	25	0		
Cr	27	0		
Cu	25	5	18	18
Pb	25	0		
Mn	25	0	294	940
Hg	8	0		
Ni	17	0		
Ag	13	0		
Zn	25	18	44	100

TABLE II-42

PESTICIDES IN THE CHARITON RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	29	26	198	1121
Dieldrin	29	29	5	22
Atrazine	29	17	3105	9400

Physical Modification

The Chariton River and tributaries are characterized by high turbidity during periods of heavy rains and runoff conditions. The high turbidity has the effect of preventing significant light penetration which prevents algal blooms which might otherwise result from the increased nutrients associated with the runoff events.

The rechannelization and dredging of some portions of the river have had serious effects on water quality and biological parameters. Due to the extreme variations in flow these segments fluctuate between high flow scouring periods and low flow stagnant pooling. The Chariton sewage treatment plant discharges into one of these pool areas and further contributes to this problem.

Eutrophication Potential

Both nitrate and phosphate are consistently found in high concentrations in the Chariton River. The average total phosphate concentration based on samples collected over the last six years is 0.66 mg/l. The average nitrate concentration over the same period was 0.60 mg/l. While the nutrient concentrations are high, nuisance algal blooms have not developed. This is probably due to the turbidity described earlier.

Oxygen Depletion

Dissolved oxygen has generally been sufficient to support a variety of fish life in the river. Exceptions are noted above, near the city of Chariton. Reaeration takes place below Chariton and adequate oxygen has been found throughout the rest of the river. The water quality violations for dissolved oxygen and ammonia reflect violations found almost exclusively in the segment immediately below Chariton.

Health Hazards and Aesthetic Degradation

Fecal and total coliform concentrations reflect the point source nature of these parameters during low stream flows. Coliform concentrations decrease from a peak below Chariton and are within standards for water supplies and recreational use by the time they reach Rathbun Reservoir. During runoff conditions the fecal coliform concentrations are high throughout the river reflecting the nonpoint surce runoff contributions to the river.

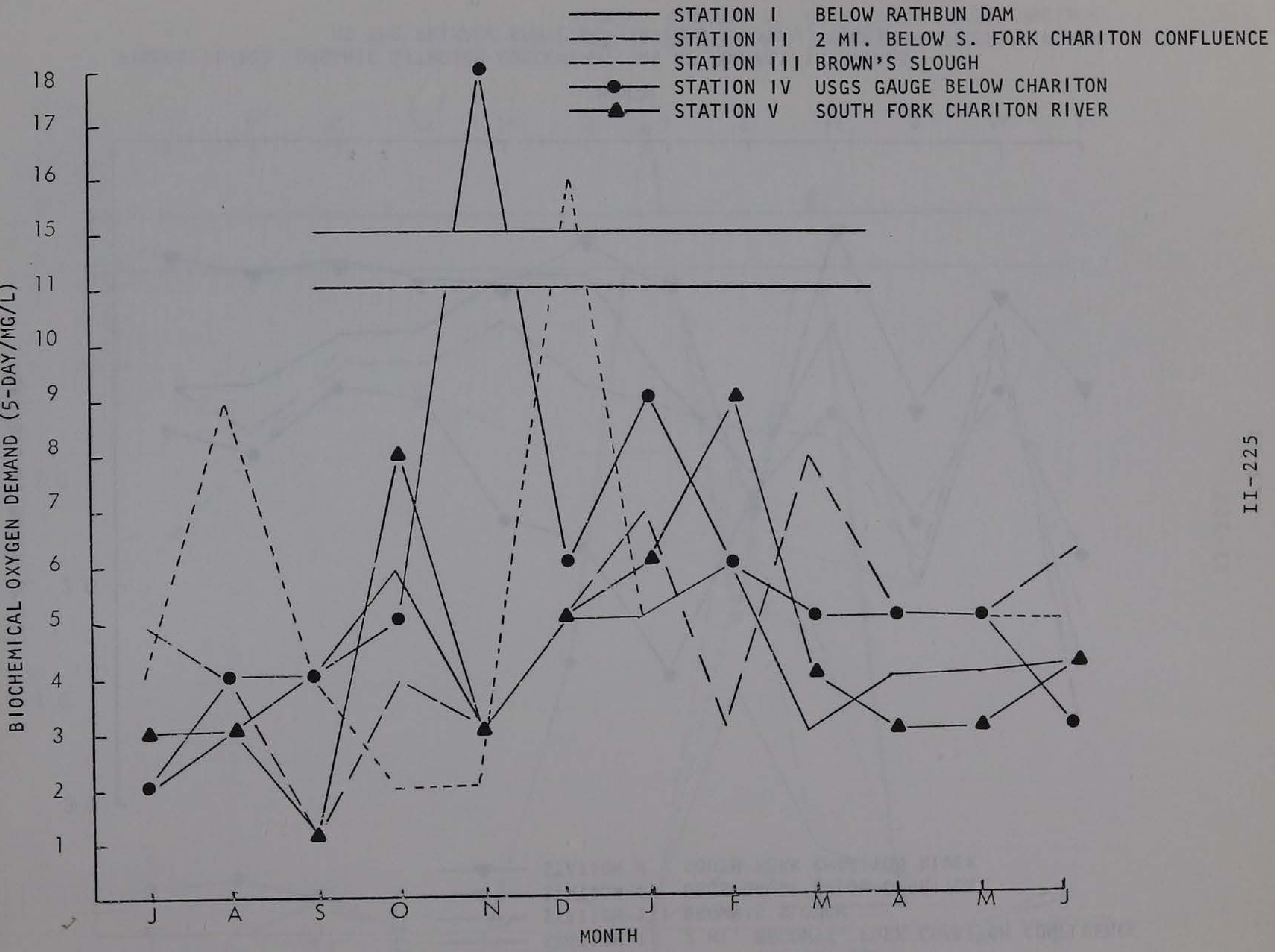


FIGURE 11-101 FIVE-DAY BOD AT THE MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

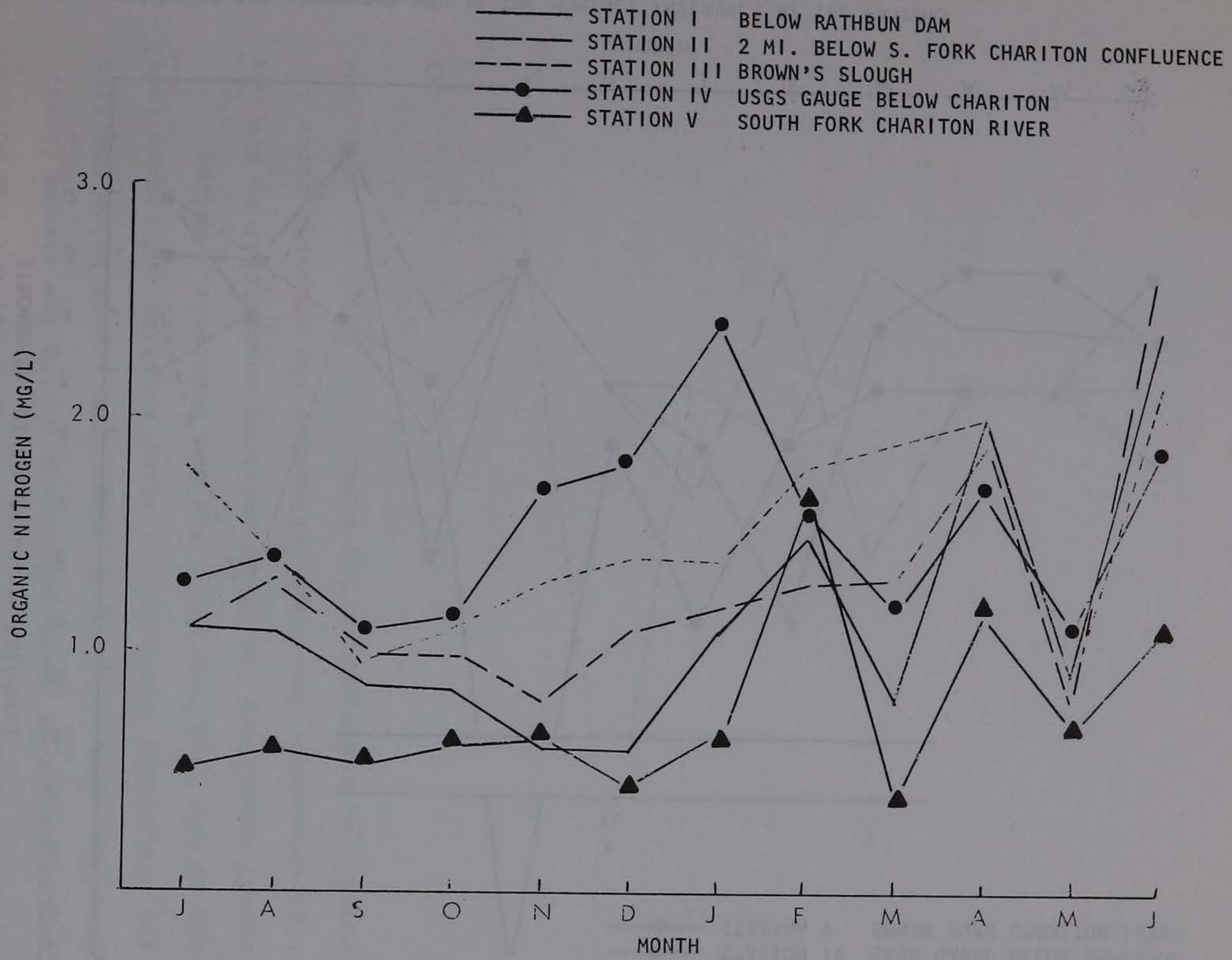
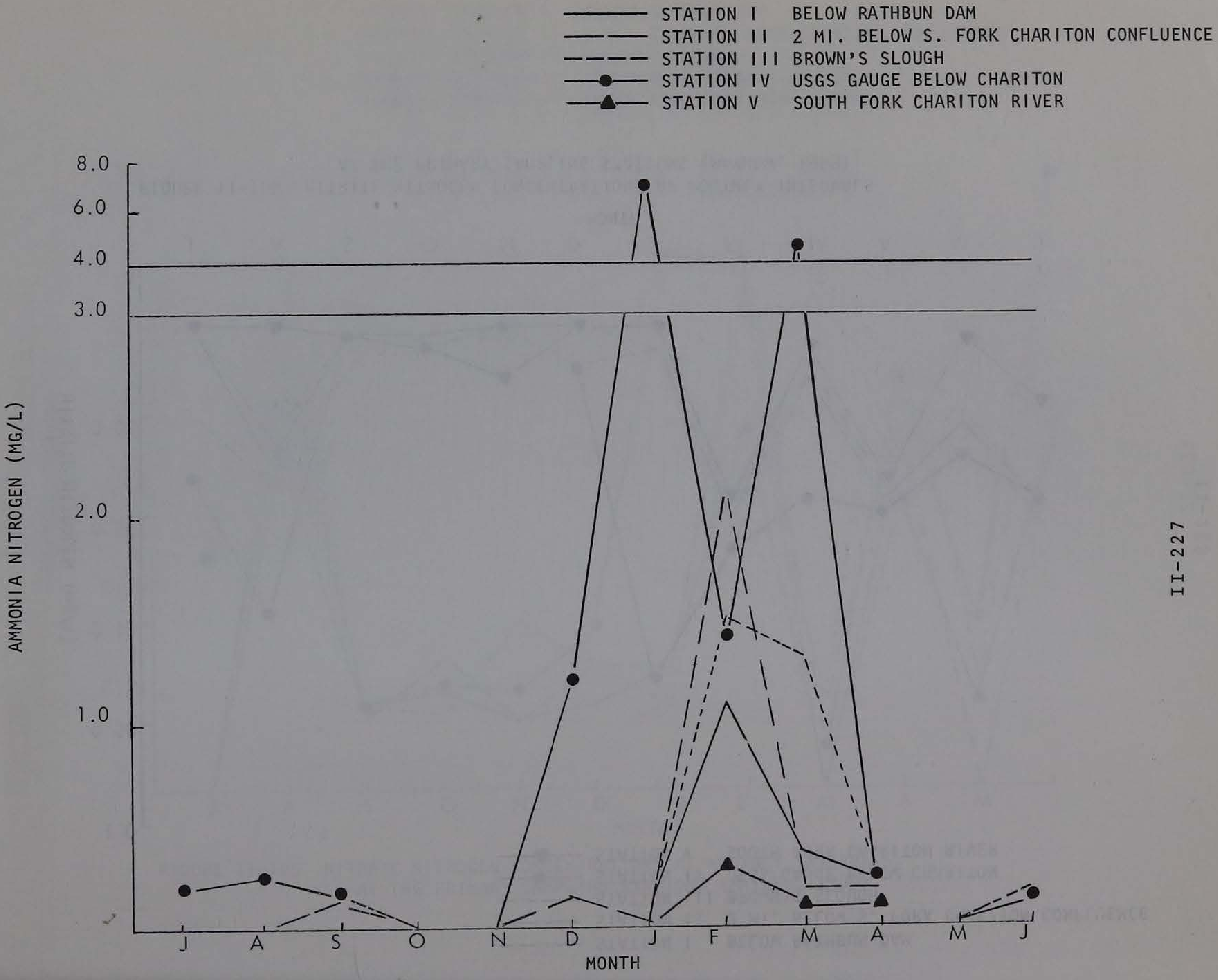


FIGURE 11-102 ORGANIC NITROGEN CONCENTRATIONS AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)



AMMONIA NITROGEN CONCENTRATIONS AT MONTHLY INTERVALS

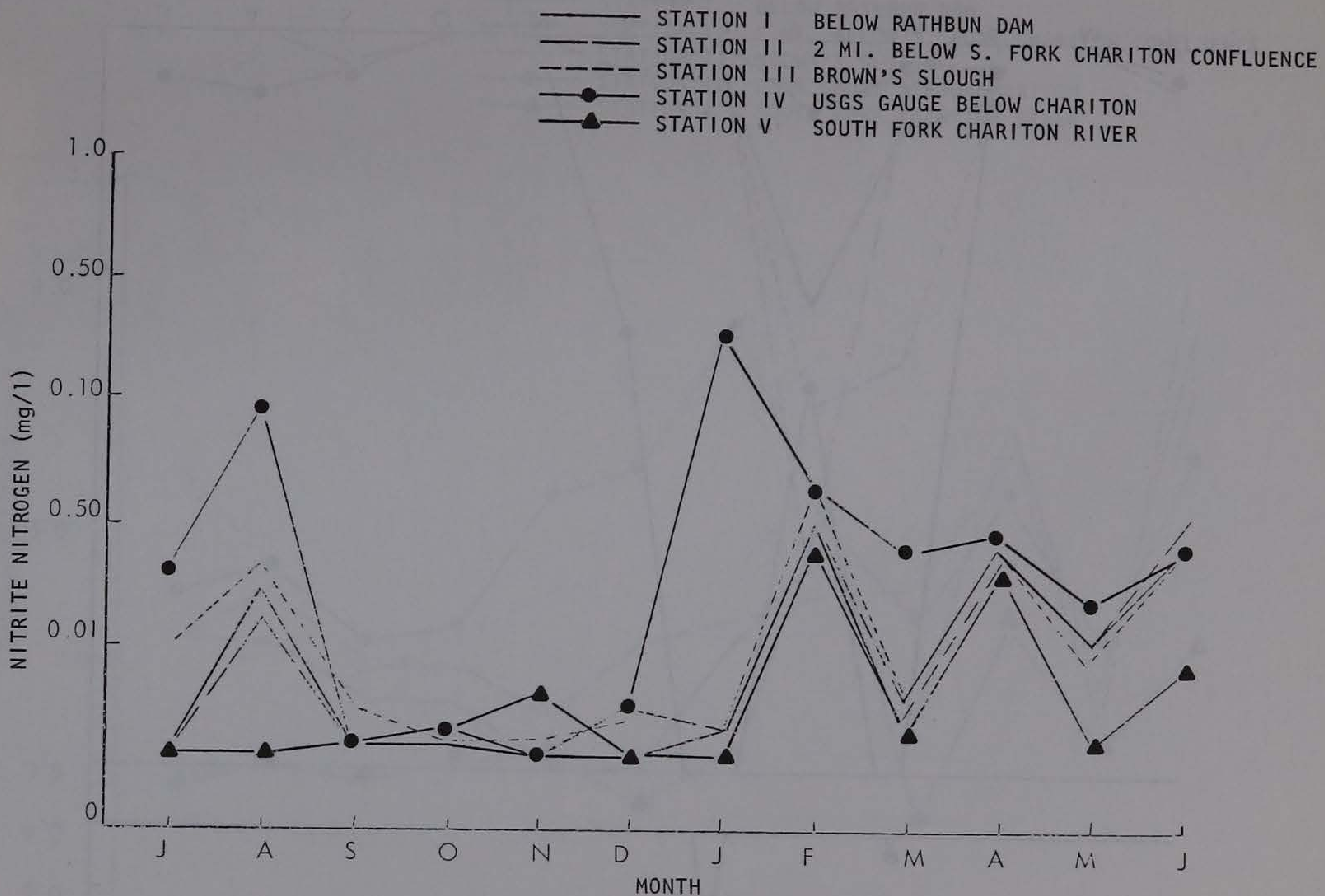


FIGURE 11-104 NITRITE NITROGEN CONCENTRATIONS AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

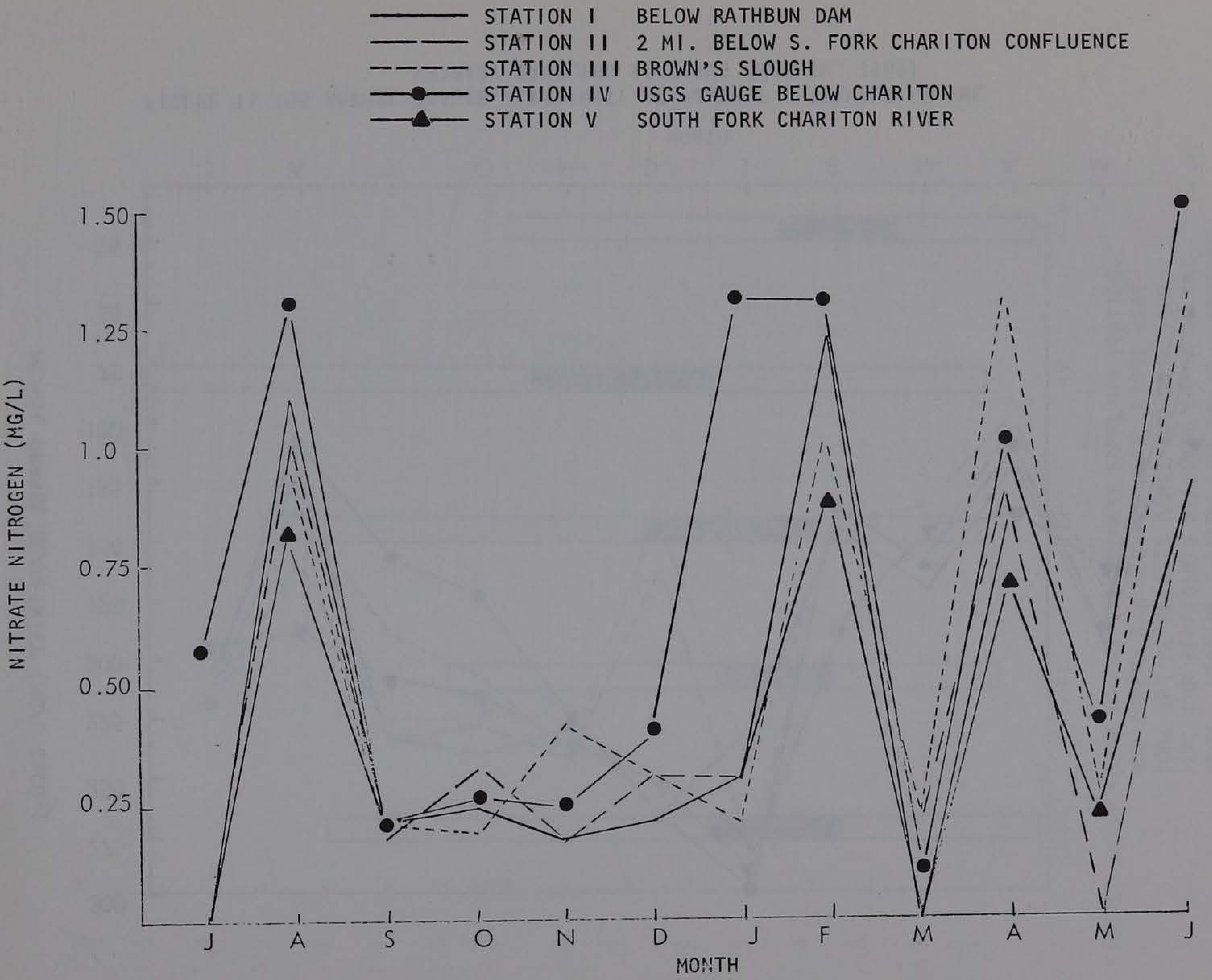


FIGURE II-105 NITRATE NITROGEN CONCENTRATIONS AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

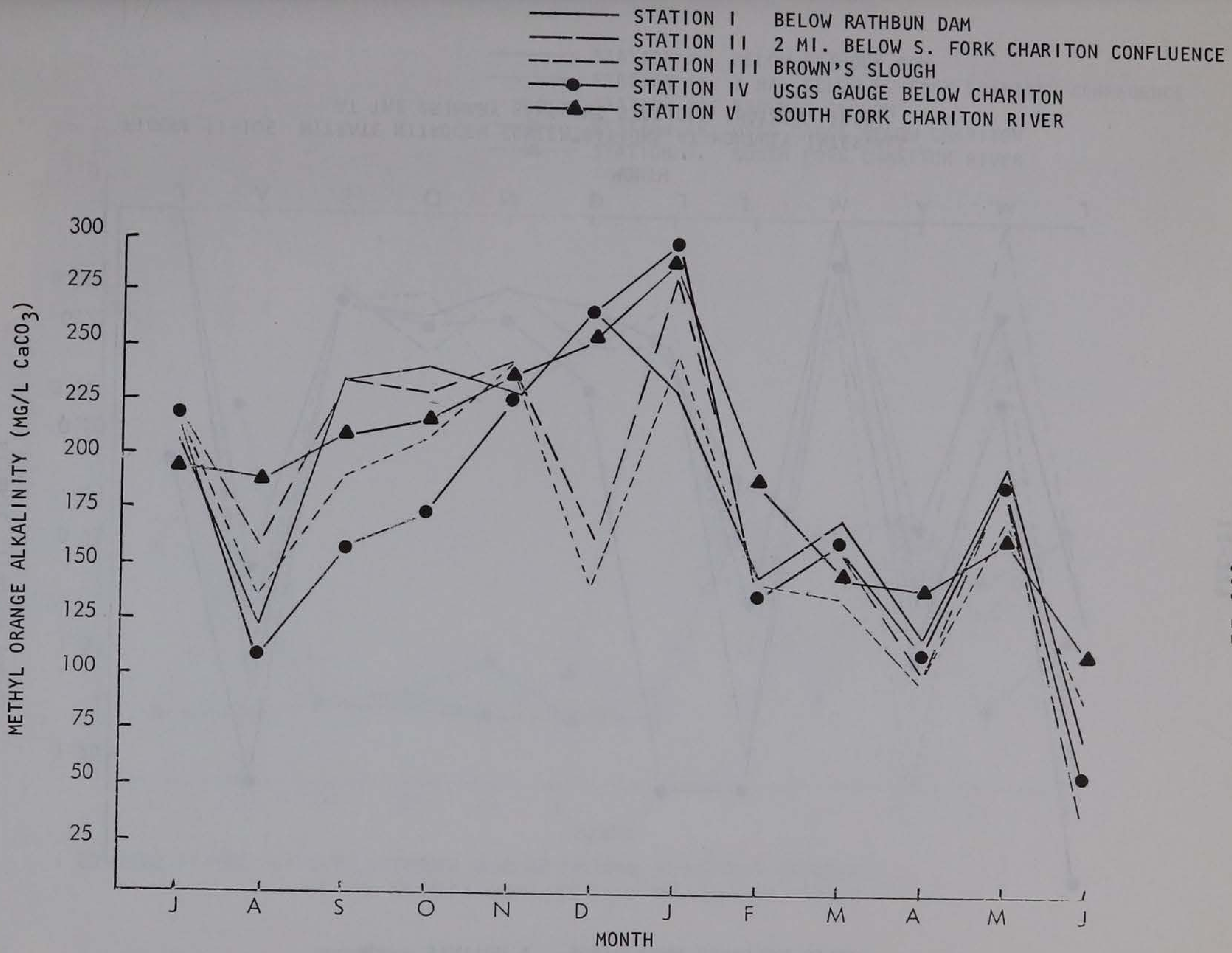


FIGURE 11-106 METHYL ORANGE ALKALINITY AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

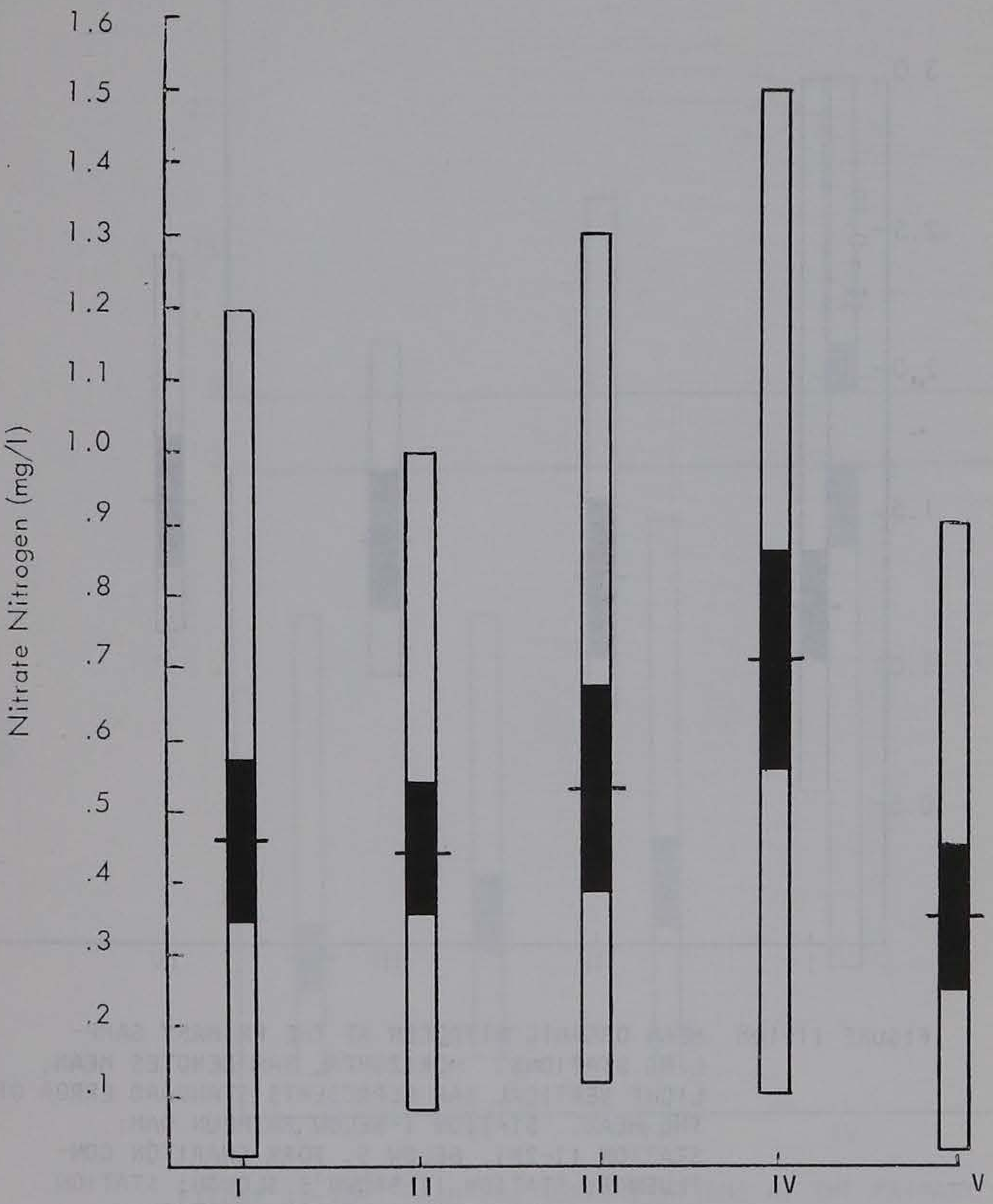


FIGURE II-107 MEAN NO_3 AT THE PRIMARY SAMPLING STATION. HORIZONTAL BAR DENOTES MEAN, LIGHT VERTICAL BAR REPRESENTS RANGE AND DARK VERTICAL BAR REPRESENTS STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II-2MI. BELOW S. FORK CHARITON CONFLUENCE; STATION II-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUTH FORK CHARITON RIVER (MAYHEW, 1969)

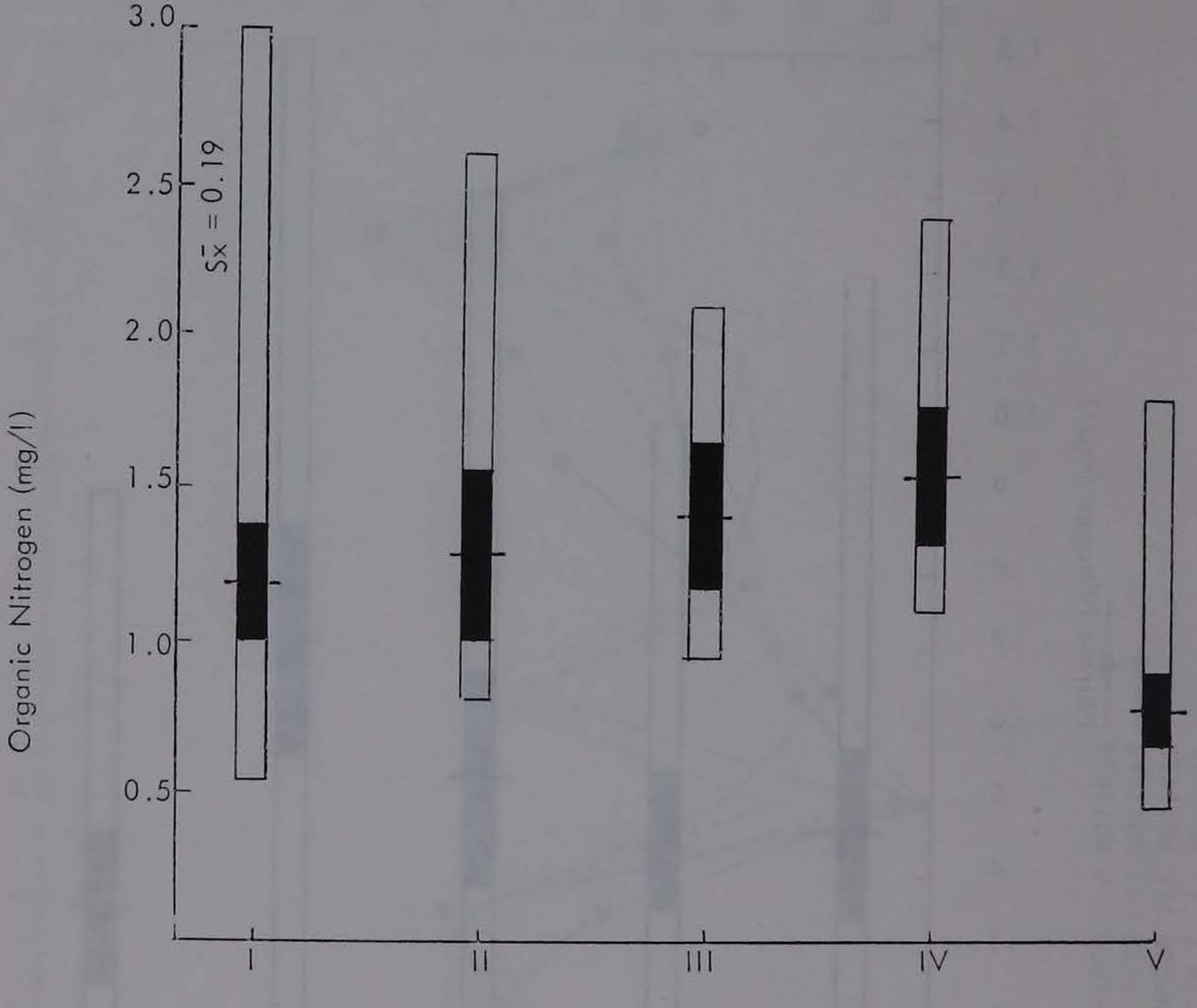


FIGURE II-108 MEAN ORGANIC NITROGEN AT THE PRIMARY SAMPLING STATIONS. HORIZONTAL BAR DENOTES MEAN, LIGHT VERTICAL BAR REPRESENTS STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II-2MI. BELOW S. FORK CHARITON CONFLUENCE; STATION II-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUTH FORK CHARITON RIVER (MAYHEW, 1969)

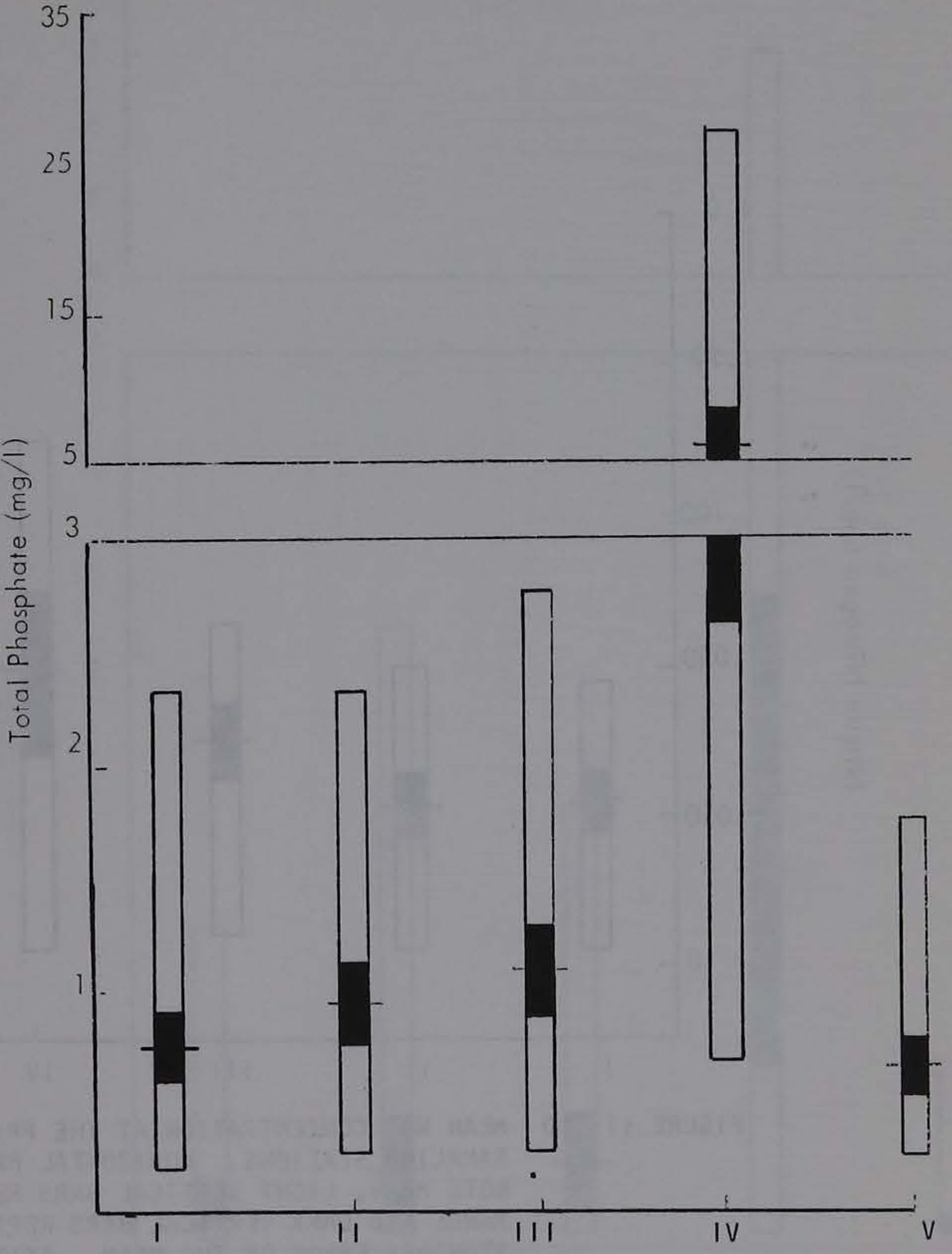


FIGURE II-109 MEAN PO_4 CONCENTRATIONS AT THE PRIMARY SAMPLING STATION. HORIZONTAL BAR DENOTES MEAN, LIGHT VERTICAL BAR REPRESENTS RANGE AND DARK VERTICAL BAR REPRESENTS STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II-2 MI. BELOW S. FORK CHARITON CONFLUENCE; STATION II-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUGH FORK CHARITON RIVER (MAYHEW, 1969)

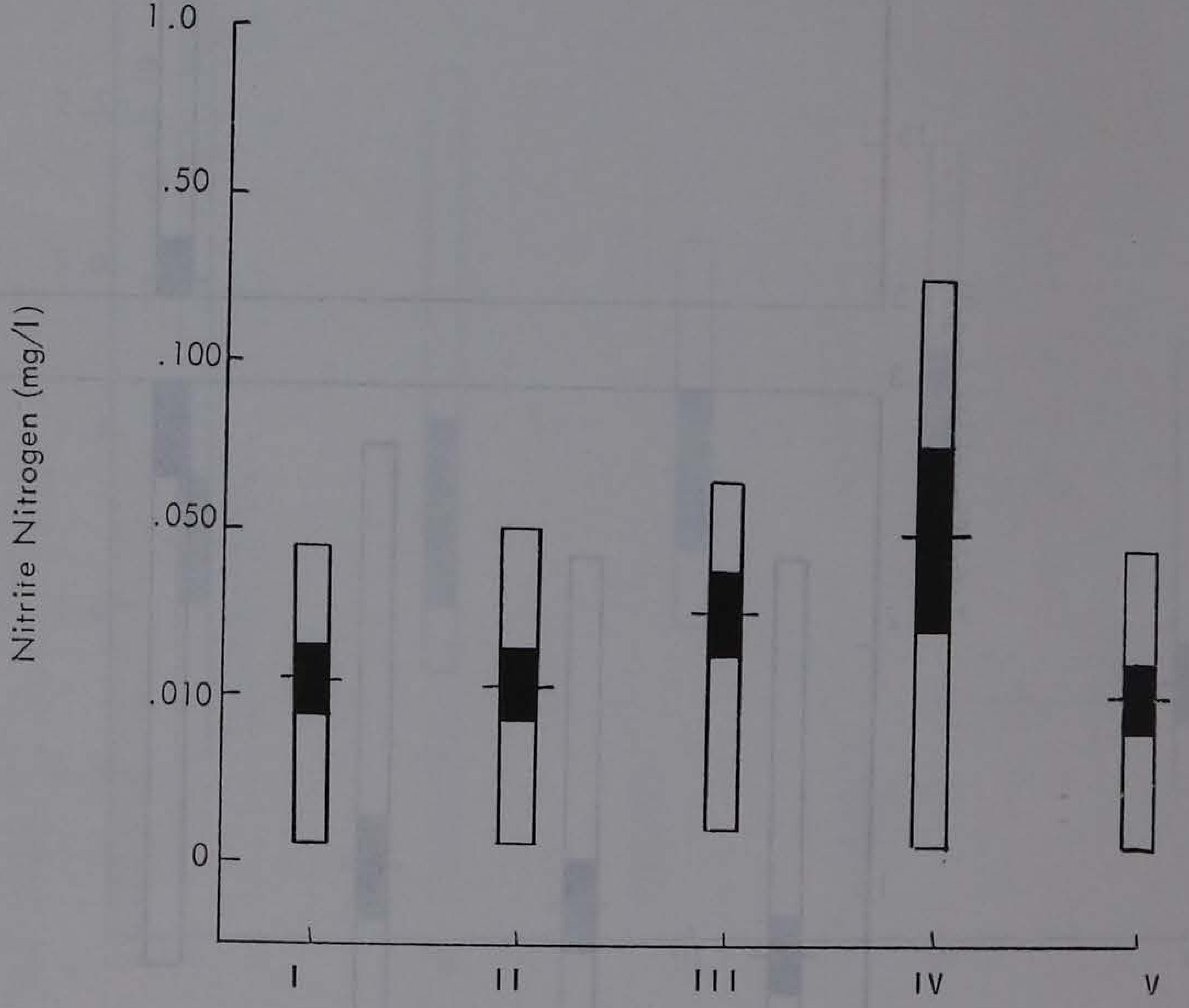


FIGURE II-110 MEAN NO_2 CONCENTRATION AT THE PRIMARY SAMPLING STATIONS. HORIZONTAL BARS DENOTE MEAN, LIGHT VERTICAL BARS REPRESENT RANGE AND DARK VERTICAL BARS REPRESENT STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II-2 MI. BELOW S. FORK CHARITON CONFLUENCE; STATION III-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUGH FORK CHARITON RIVER (MAYHEW, 1969)

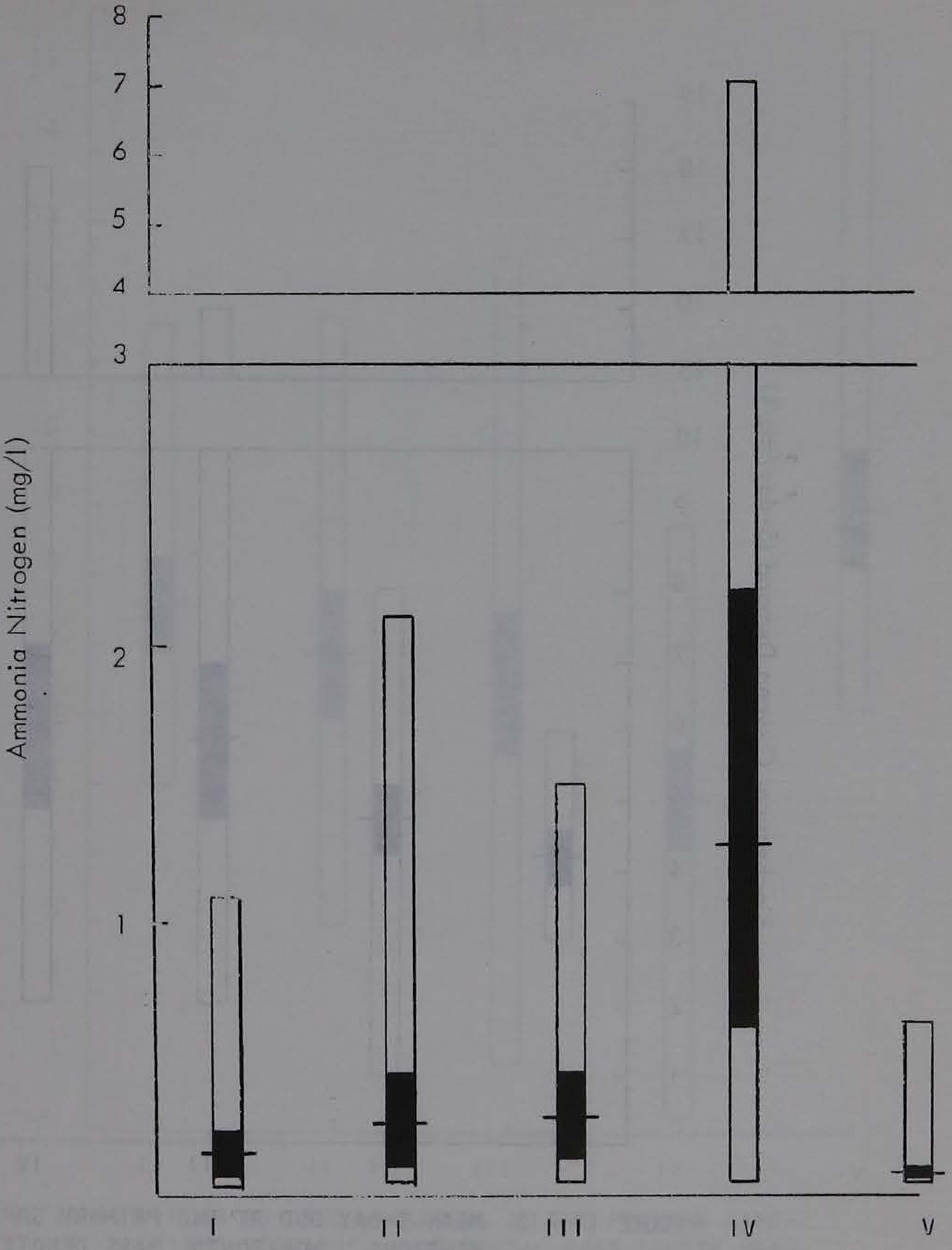


FIGURE II-111 MEAN NH_3 CONCENTRATIONS AT THE PRIMARY SAMPLING STATIONS. HORIZONTAL BARS DENOTE MEAN, LIGHT VERTICAL BARS REPRESENT RANGE AND DARK VERTICAL BARS REPRESENT STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II-2 MI. BELOW S. FORK CHARITON CONFLUENCE; STATION II-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUTH FORK CHARITON RIVER (MAYHEW, 1969)

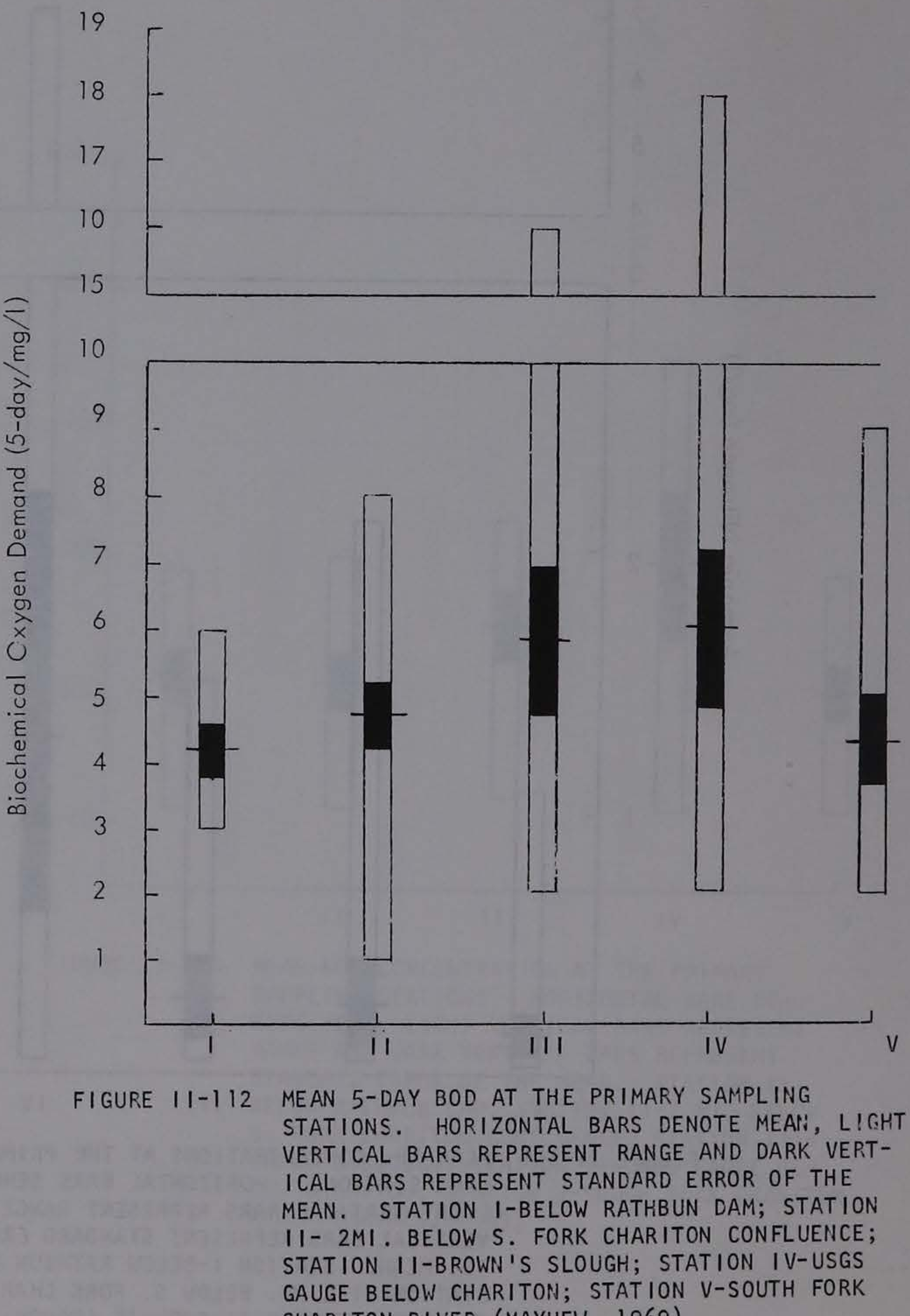


FIGURE II-112 MEAN 5-DAY BOD AT THE PRIMARY SAMPLING STATIONS. HORIZONTAL BARS DENOTE MEAN, LIGHT VERTICAL BARS REPRESENT RANGE AND DARK VERTICAL BARS REPRESENT STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II- 2MI. BELOW S. FORK CHARITON CONFLUENCE; STATION II-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUTH FORK CHARITON RIVER (MAYHEW, 1969)

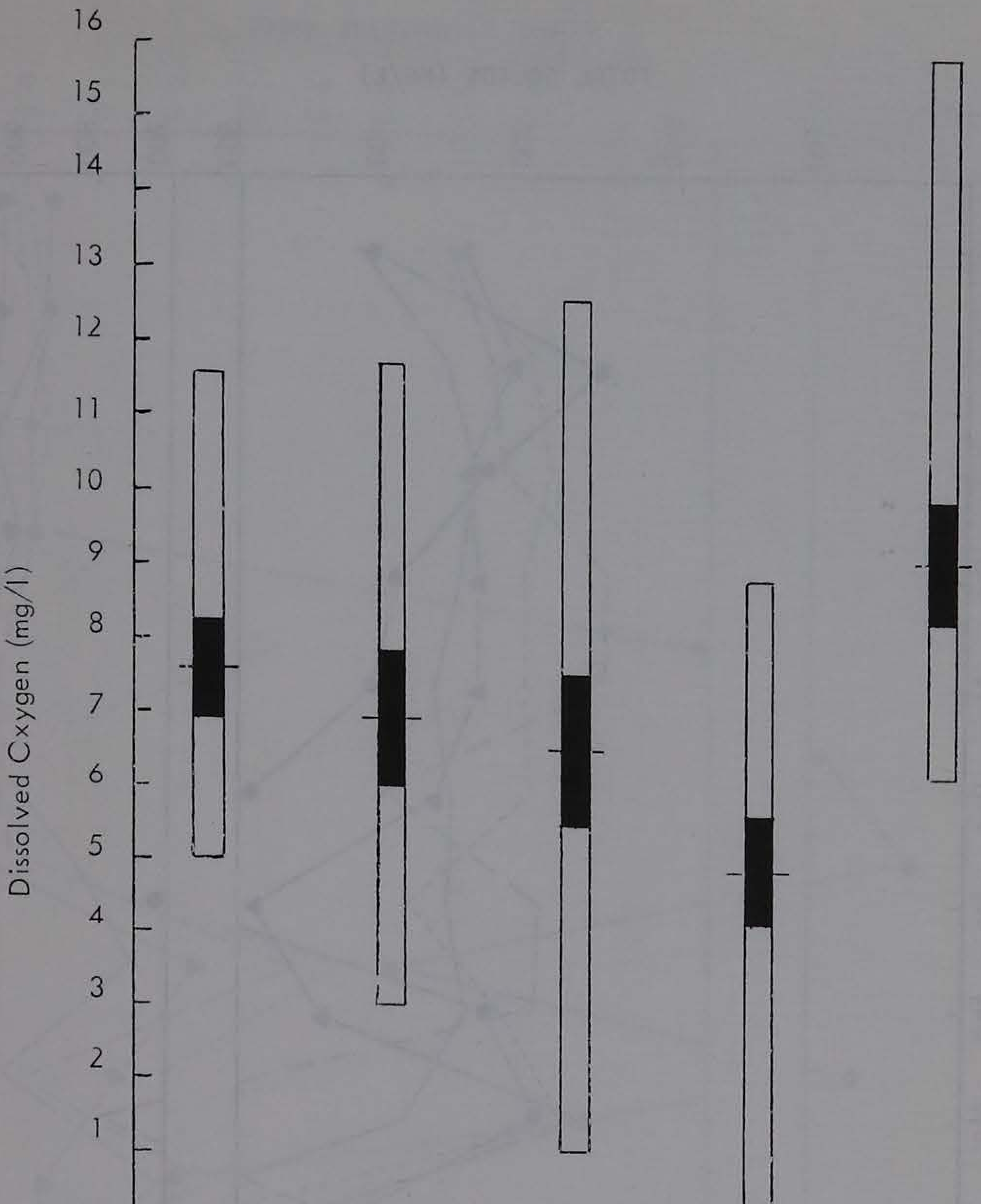


FIGURE II-113 MEAN DO CONCENTRATIONS AT THE PRIMARY SAMPLING STATIONS. HORIZONTAL BARS DENOTE MEAN, LIGHT VERTICAL BARS REPRESENT RANGE AND DARK VERTICAL BARS REPRESENT STANDARD ERROR OF THE MEAN. STATION I-BELOW RATHBUN DAM; STATION II-2 MI. BELOW S. FORK CHARITON CONFLUENCE; STATION II-BROWN'S SLOUGH; STATION IV-USGS GAUGE BELOW CHARITON; STATION V-SOUTH FORK CHARITON RIVER (MAYHEW, 1969)

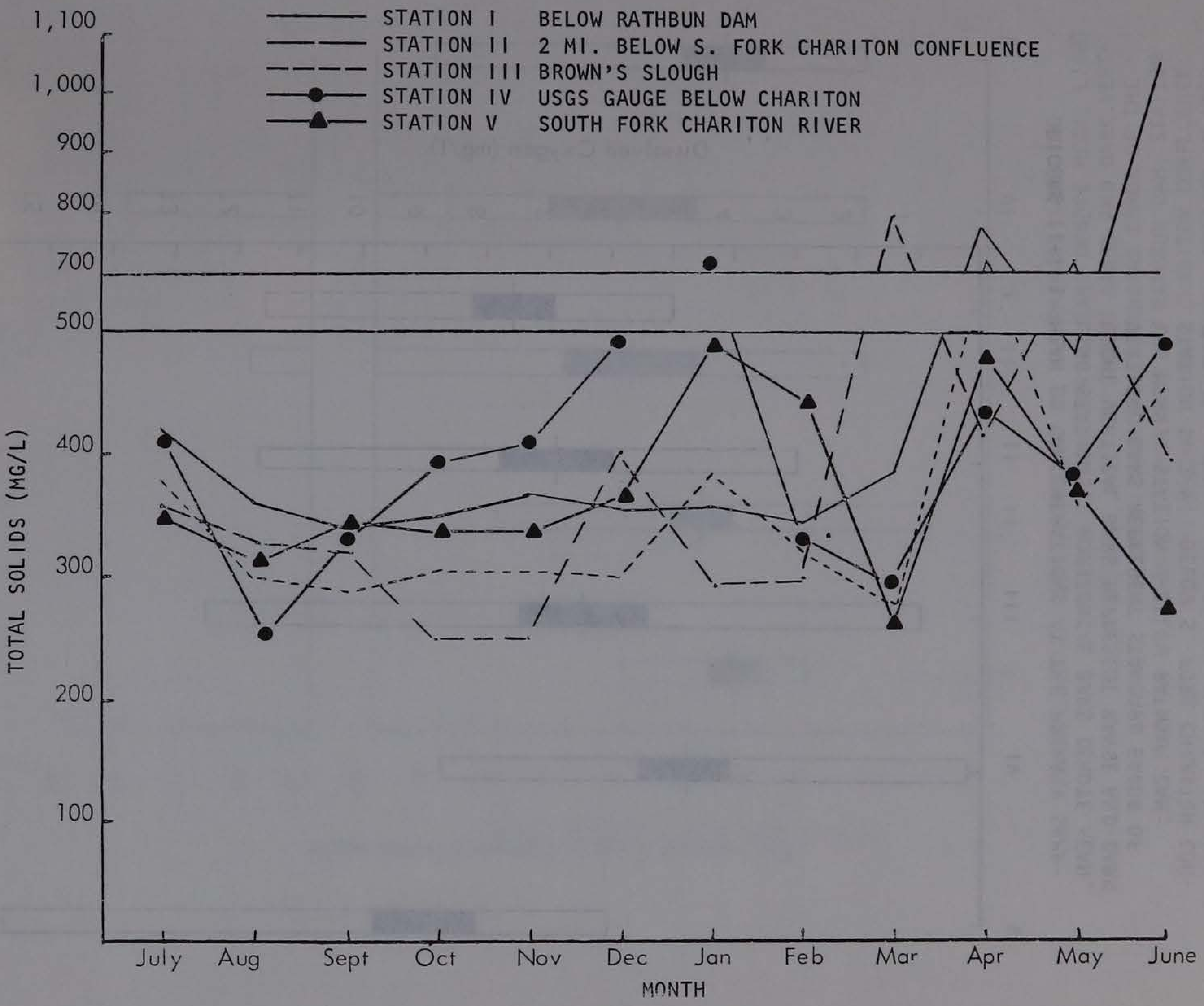


FIGURE 11-114 TOTAL SOLIDS CONCENTRATIONS AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

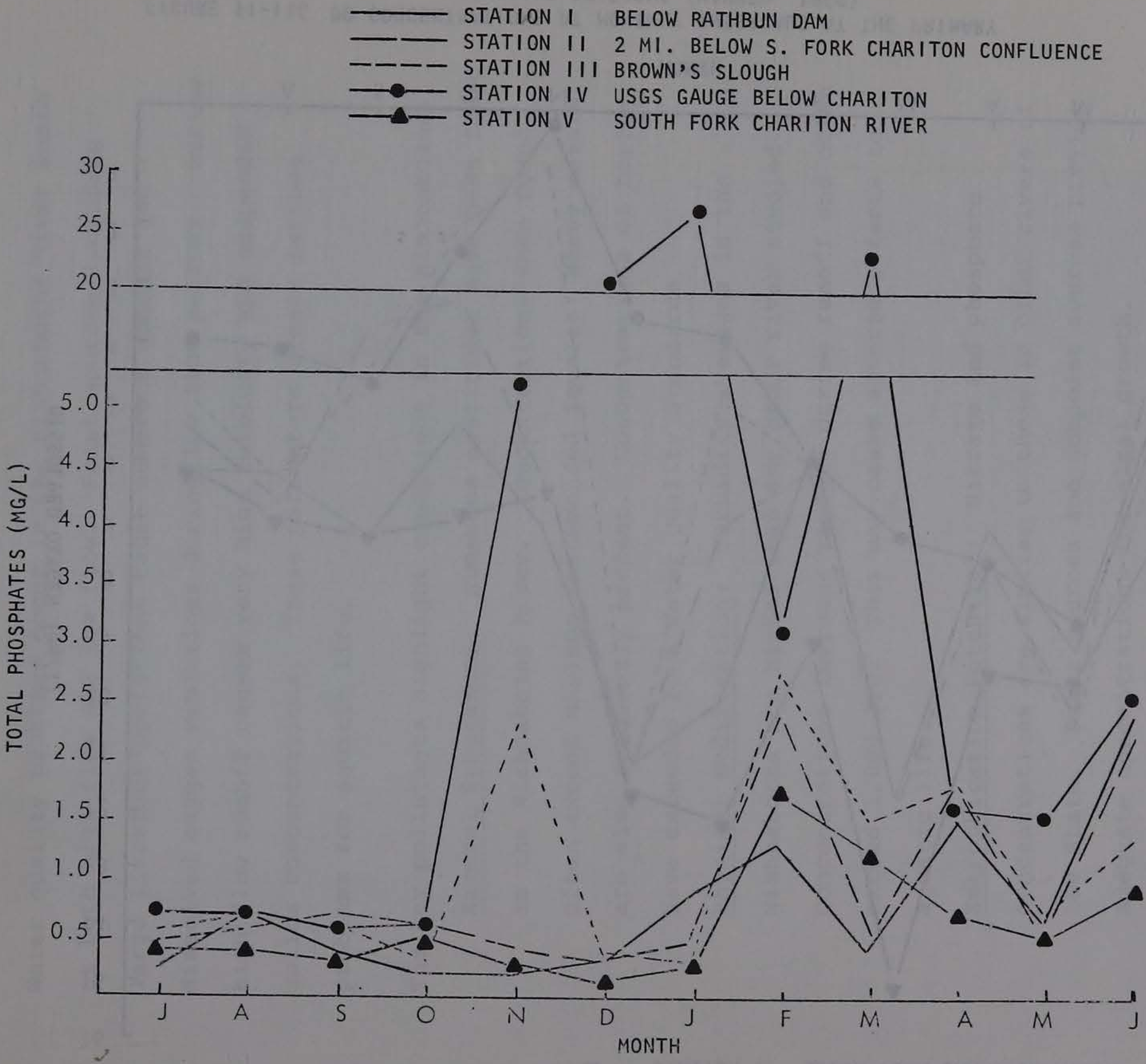


FIGURE II-115 TOTAL PO_4 CONCENTRATIONS AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

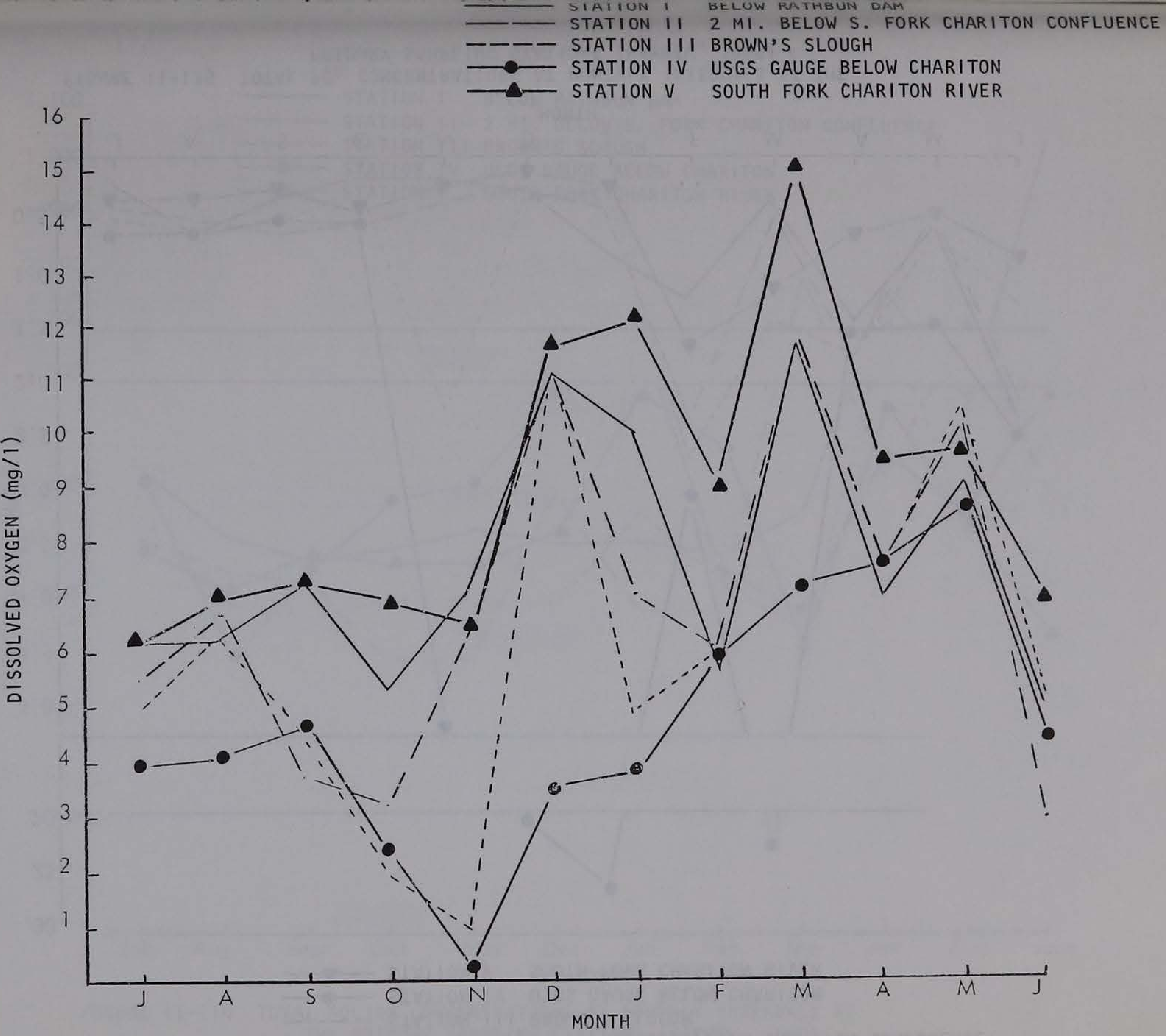


FIGURE 11-116 DO CONCENTRATIONS AT MONTHLY INTERVALS AT THE PRIMARY SAMPLING STATIONS (MAYHEW, 1969)

NISHNABOTNA RIVER

Water quality problems occur in the Nishnabotna River Basin at both high flow and low flow. Point sources including large livestock operations cause numerous ammonia and dissolved oxygen violations during low flow periods. During high flow runoff causes very high turbidity and suspended solids concentrations. These parameters create serious problems for aquatic life.

The key pollutants highlight conditions in the Nishnabotna.

Harmful Substances: Numerous pesticides have been found in the Nishnabotna River. Concentrations when found often exceed maximum recommended levels. Heavy metals are also frequently present. Concentrations of barium have exceeded Iowa Water Quality Standards.

Physical Modification: Turbidity averages in the Nishnabotna are higher than any other river studied. Concentrations increase rapidly during runoff and often exceed 1,000 JTU. This may cause adverse effects to aquatic life.

Eutrophication Potential: Nitrate and phosphate concentrations are similar to those in other rivers of the State. Point sources and nonpoint sources provide adequate concentrations for algal growth.

Salinity, Acidity, and Alkalinity: Acidity is not a problem in the Nishnabotna River Basin. Total dissolved

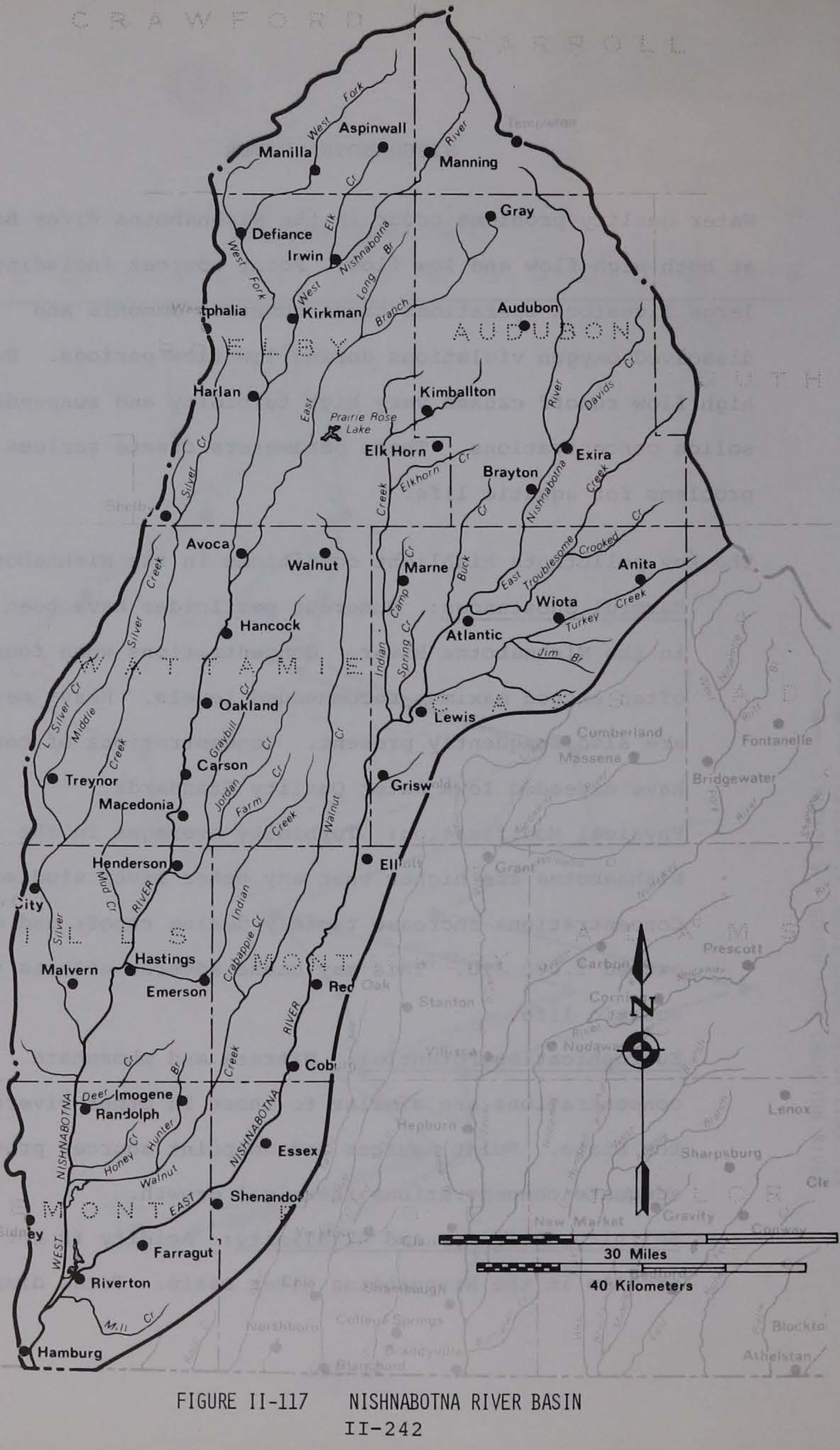


FIGURE II-117 NISHNABOTNA RIVER BASIN

solids concentrations have exceeded Iowa Water Quality Standards at times.

Oxygen Depletion: High oxygen demand and ammonia concentrations from point sources are a problem in the river. During lower flows insufficient dilution may cause oxygen depletion and ammonia toxicity which may cause fish kills.

Health Hazards and Aesthetic Degradation: The bacteriological criteria for recreation are seldom met along the Nishnabotna River. Both point sources and nonpoint sources contribute fecal coliform.

GENERAL PHYSICAL DESCRIPTION

The Nishnabotna River is a left bank tributary of the Missouri River. The river and its tributaries drain lands in Audubon, Crawford, Carroll, Cass, Fremont, Mills, Montgomery, Page, Pottawattomie, and Shelby Counties of Iowa, and Atchison County, Missouri. The wedge-shaped drainage area includes 2,995 square miles.

The headwaters of the Nishnabotna River are in Carroll and Crawford Counties. The basin consists of two principal subbasins drained by the East Nishnabotna and West Nishnabotna Rivers. Both rivers have essentially parallel courses extending southward 100 miles from their sources to their confluence near Riverton, Iowa, where they form the Nishnabotna River. The main stream then flows southerly another twelve miles joining the Missouri River about six miles south of the Iowa-Missouri state line.

The West Branch has six major tributary streams. They are: East Branch, Jordan Creek, Farm Creek, Walnut Creek, Graybill Creek, and Silver Creek. The East Branch has ten major tributary streams: Clarks Branch, Davids Creek, Baughmans Creek, Turkey Creek, Spring Creek, Indian Creek, Elkhorn Creek, Buck Creek, Troublesome Creek and Crooked Creek.

The topography of the drainage area is characterized by wooded stream courses, moderately wide, shallow, flood plains, and uplands with low ridges and gentle slopes. The streambeds, upland farmsteads, and some pastures are heavily wooded with conifers, oak, cottonwood, willow, and elm trees. The soils, which are very productive, have been developed from three general kinds of parent materials: loess, glacial till (Kansan), and alluvial material derived from either of these. The bottomland soils are predominantly alluvial, dark-colored, medium to moderately fine-textured, and relatively poorly drained.

The basic economy of the area is centered in agricultural production. About 90 percent of the farm income is derived from the sale of livestock and livestock products, and 10 percent from the sale of crops. Approximately 75 percent of the land is under cultivation, 15 percent in pasture, and 10 percent in miscellaneous use. The flat bottom lands are very fertile and productive. The lands bordering the major streams and small drainages are wooded, and most of the pastures are sparsely wooded.

The climate is typical of western Iowa. Summers are warm, the humidity varies widely, and there are periods of prolonged high temperatures. Winters are cold and dry. The average annual precipitation is about 31 inches, with most of this occurring between April 1 and September 30.

WATER QUALITY CONDITIONS

Harmful Substances

Barium has been found in violation of Iowa Water Quality Standards in the Nishnabotna River. Maximum barium concentrations of 1.7 mg/l have been found. The average concentration has been 0.47 mg/l. Since there are no known heavy metal dischargers on the Nishnabotna, it is assumed that the barium is characteristic of the basin and is from runoff.

Pesticides found in the Nishnabotna River include DDE, DDT, dieldrin, heptachlor, heptachlor epoxide, and lindane. Herbicides found include 2,4,-D and 2,4,5-T. Concentrations of DDE, DDT, dieldrin, heptachlor, and heptachlor epoxide, when found, average higher than the recommended maximum concentrations established by the National Academy of Science. Only dieldrin and 2,4,5-T have been found consistently in the Nishnabotna River. The wide variety of pesticides found are not particularly surprising considering the predominantly agricultural nature of the basin.

TABLE II-43

PESTICIDES IN THE NISHNABOTNA RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
DDE	5	1	17	17
DDT	5	1	14	14
Dieldrin	13	13	30	30
Heptachlor Epoxide	3	1	20	20
Heptachlor	4	2	310	600

TABLE II-44

HEAVY METALS IN THE NISHNABOTNA RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	18	0		
Ba	15	12	467	1700
Cd	17	0		
Cr	22	2	10	10
Cu	17	6	23	30
Pb	17	4	40	60
Mn	23	20	401	2800
Hg	4	0		
Ni	13	0		
Ag	7	0		
Zn	17	12	53	160

<u>Physical Modification</u> (Iowa Natural Resource Council, 1955)

Between 1881 and 1929 about 75 and 90 percent of the lower 100 miles of the East and West Nishnabotna Rivers, respectively, were straightened. In addition, major portions of Walnut, Silver, and Indian Creeks were straightened.

The channel straightening and levee work in the Nishnabotna River Basin was successful in improving drainage and reducing flooding so that cultivated crops could be produced profitably on the bottomlands. Extensive channel straightening has, however, also changed the natural stream characteristics in the basin, and other serious problems have developed. Artificial degradation of the channels by straightening and the natural scour that followed has lowered the outlets of tributary streams causing them to dig deeply into the loess soil. As a result, the rate of development of gullies in the basin has been seriously increased.

The natural stream channels in the basin meandered extensively and tended to be wide and shallow. After straightening, they became steepsided, flat-bottomed ditches, which are narrow and deeply entrenched in the valleys. In practically every case noted in a study of drainage plans in this area, one mile of straightened channel replaced two and one-half miles of natural channel. This reduction in stream length naturally produced an accompanying increase in stream slope. The velocity of flow in a stream is proportional to the square root of the slope so the 250 percent increase in stream slopes could be expected to increase the velocity of flow 58 percent if all other factors remained the same. Actually the resistance to flow in straightened stream channels is also less than in the natural meandered channels, and velocities of flow may have been increased even more than the change in slope alone would indicate.

The increased velocity of flow in the straightened channels greatly increased the capacity of the flowing water to erode soil from the bottom and sides of the channel and to transport this sediment downstream. This tendency for the straightened channels to increase in size is quite evident in the basin.

The sediment produced in the Nishnabotna River Basin from sheet erosion, gully erosion, and channel erosion is tremendous. During June 1947, over 28.8 million tons of suspended sediment were carried past the gauge at Hamburg (U. S. Corps of Engineers, 1937-1948). If soil in place is assumed to weigh 150 tons an acre inch, this sediment is equivalent to a layer of soil six inches deep from 32,000 acres. One day during the month an estimated 6.5 million tons of sediment passed the gauge at Hamburg. During a comparable flood flow 590,000 tons were carried in one day by the Des Moines River below the mouth of the Raccoon River (U. S. Geological Survey, 1947). Although the average concentration of sediment in the water during the aforementioned day was a little less than five percent by weight, concentrations of over fifteen percent have been measured on the Nishnabotna River. Even this is only a partial measure of the erosion losses in the basin. Vast quantities of sediment are also deposited on the flood plains, along highways, and in drainage ditches upstream from Hamburg. Erosion thereby causes twofold damages, once as a loss from its original removal and again as a damage where it is deposited.

The sediment load which originates in the channels throughout the basin would continue to create tremendous problems even if sheet erosion and flood flows were reduced materially. No economical or generally adaptable measures for the control of channel erosion have yet been developed. It remains as probably the greatest single problem for which a solution must be devised in the Nishnabotna River Basin.

Recent measurements of sediment loading and turbidity indicate that there has been no improvement since the 1940's and 1950's data mentioned above. Suspended sediment measurements at Red Oak on the East Nishnabotna River above much of the straightened channel found 1.5 million tons of sediment discharge for the year 1972. For the same year sediment loading on the Iowa River at Iowa City was approximately 0.5 million tons per year and for the Des Moines River at Saylorville 0.7 million tons per year. Turbidity levels have averaged 100 JTU, among the highest in the State, with maximum levels of 1,700 JTU.

A 1968 report on the fish and wildlife conditions in the Nishnabotna River by the Fish and Wildlife Service states: "The streams in the Nishnabotna River drainage have been channelized in all but a few reaches and provide very little fishing except during occasional periods of high water. Channel alterations have almost completely eliminated game fish habitat. That which remains is marginal, of limited value, and unlikely to improve."

Eutrophication Potential

Phosphate and nitrate concentrations in the Nishnabotna River are high. Concentrations are similar to other rivers in the State in this regard. Total phosphate concentrations have averaged 0.53 mg/l. Nitrate concentrations have averaged 2.14 mg/l. Nutrient sources are both point and nonpoint. Point sources seem to generally provide an elevated background level with peaks below dischargers. High concentrations on the whole river result from runoff conditions and nonpoint sources. While concentrations of nutrients are adequate to stimulate large algal blooms, no nuisance algal conditions have been reported. Light penetration and other physical factors may often limit algal populations instead of nitrates or phosphates.

Salinity, Acidity, and Alkalinity

Total dissolved solids concentrations in the Nishnabotna River have ranged from 207 mg/l to 539 mg/l with an average of 348 mg/l. Total alkalinity averages 236 mg/l, similar to other Iowa streams. The alkalinity has fluctuated from 134 mg/l to 283 mg/l.

Oxygen Depletion

Eight percent of the dissolved oxygen samples and 32 percent of the ammonia samples collected since 1970 on the Nishnabotna River have violated Iowa Water Quality Standards. High ammonia and biochemical oxygen demand concentrations are mainly the result of point sources.

Ammonia and dissolved oxygen concentrations have been adequate on the East Nishnabotna but numerous violations have occurred on the West Nishnabotna (Figures II-120 & II-122). Western Iowa Pork at Harlan and American Beef Packing at Oakland have caused severe pollution of the upper West Nishnabotna. This pollution is diluted at high flows sufficiently to prevent violations of Iowa standards, however during low flows gross pollution over the entire reach has occurred (Figures II-119 & II-120). Maximum ammonia concentrations of 27 mg/l have been found in the river below Oakland.

Both Silver Creek and Walnut Creek, major tributaries entering the West Nishnabotna, have relatively low ammonia-nitrogen concentrations. Their flow relative to that of the West Nishnabotna is insufficient, however, to significantly lower ammonia concentrations in the main stem.

Data from samples collected between 1950-1959 indicate that dissolved oxygen violations have increased in recent years and that water quality has generally worsened since that time. The Nishnabotna is one of the few rivers in the State that indicates poorer water quality currently than in previous decades. This is probably the result of the large increase in the meat packing industry that has occurred and the subsequent discharge of wastes to the West Nishnabotna River. Dramatic improvement in water quality could be achieved if point source pollution is reduced.

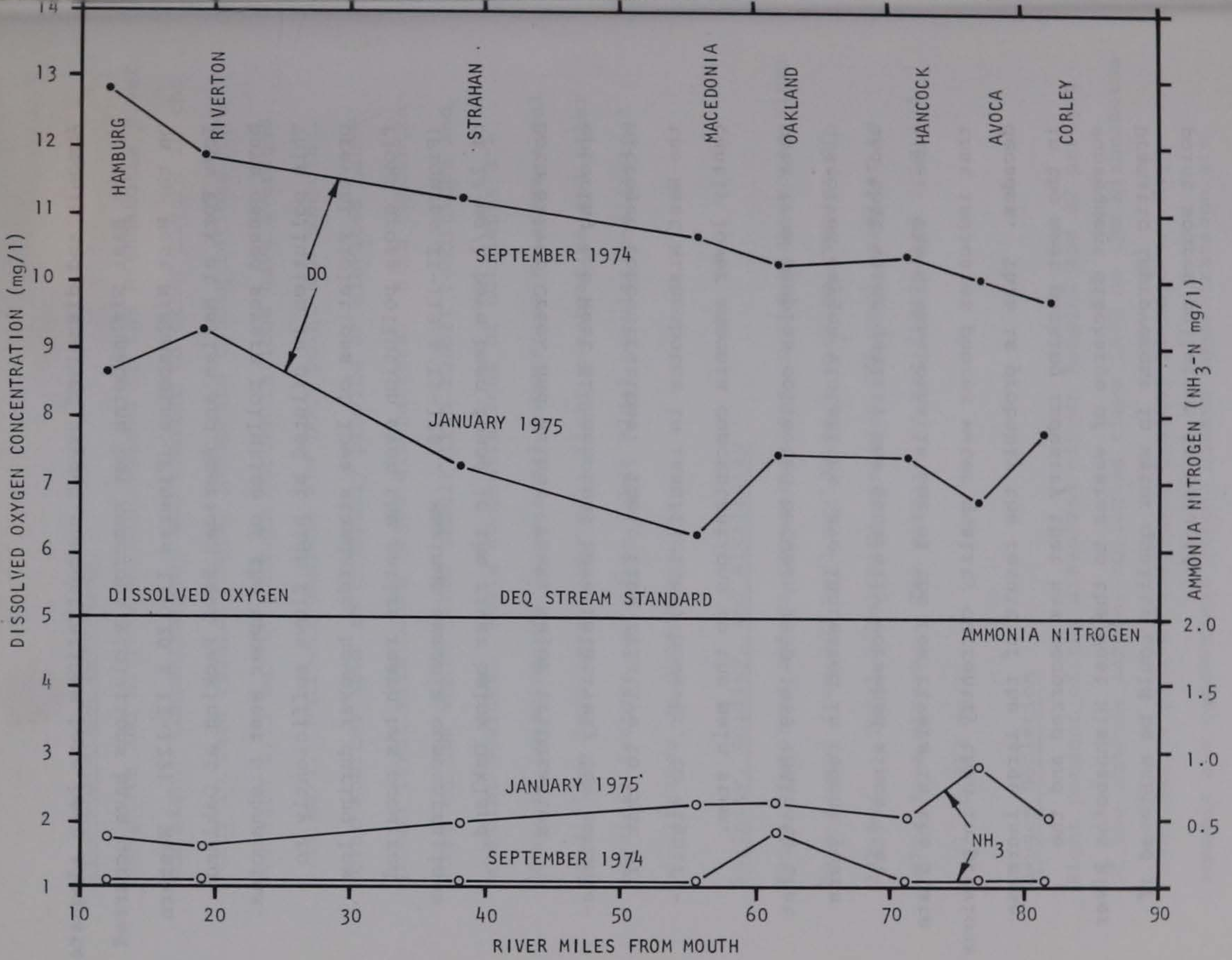


FIGURE 11-118 DISSOLVED OXYGEN AND AMMONIA NITROGEN CONCENTRATIONS IN THE WEST NISHNABOTNA RIVER, SPETEMBER 1974 AND JANUARY 1975

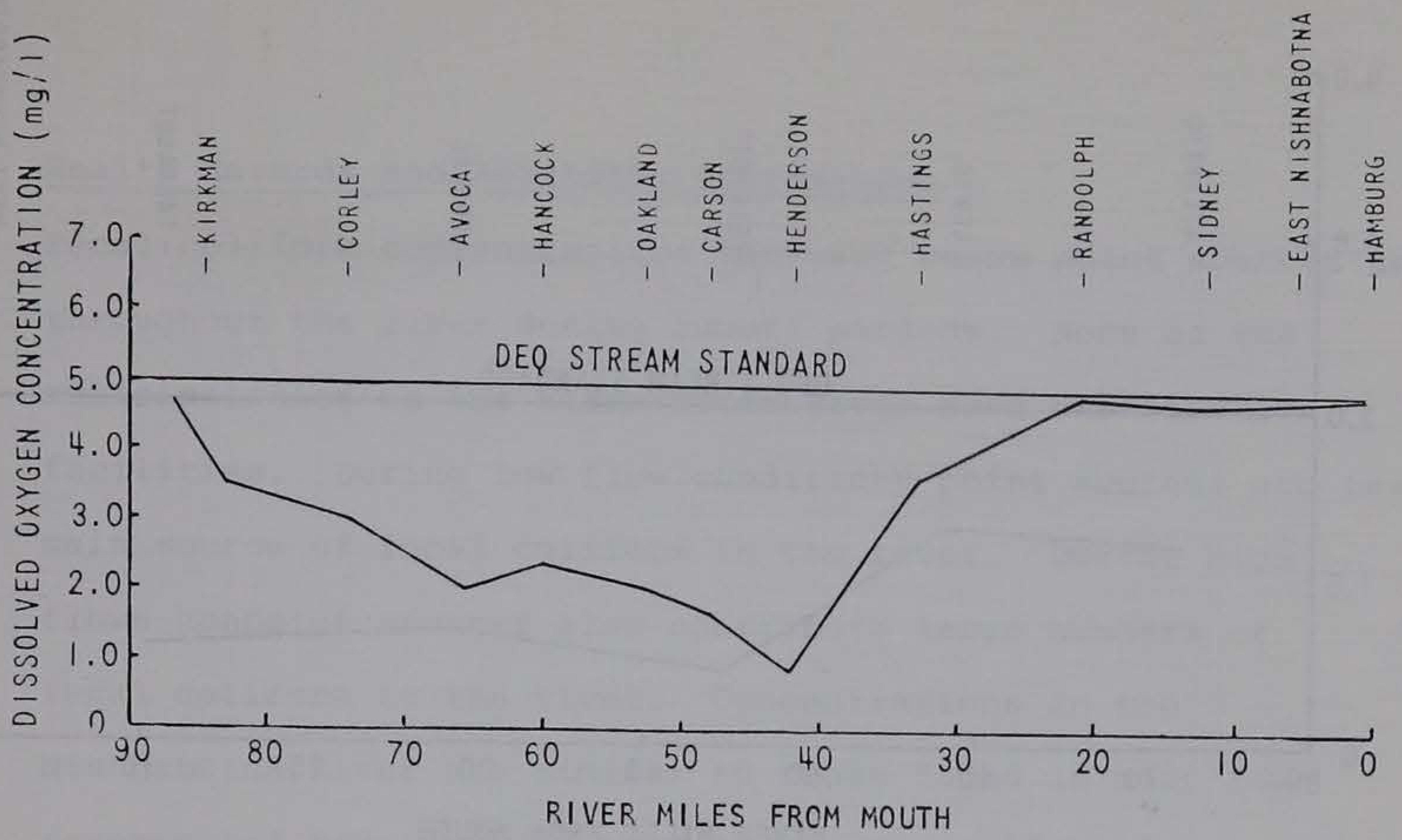


FIGURE II-119 WEST NISHNABOTNA AND NISHNABOTNA, DISSOLVED OXYGEN CONCENTRATIONS

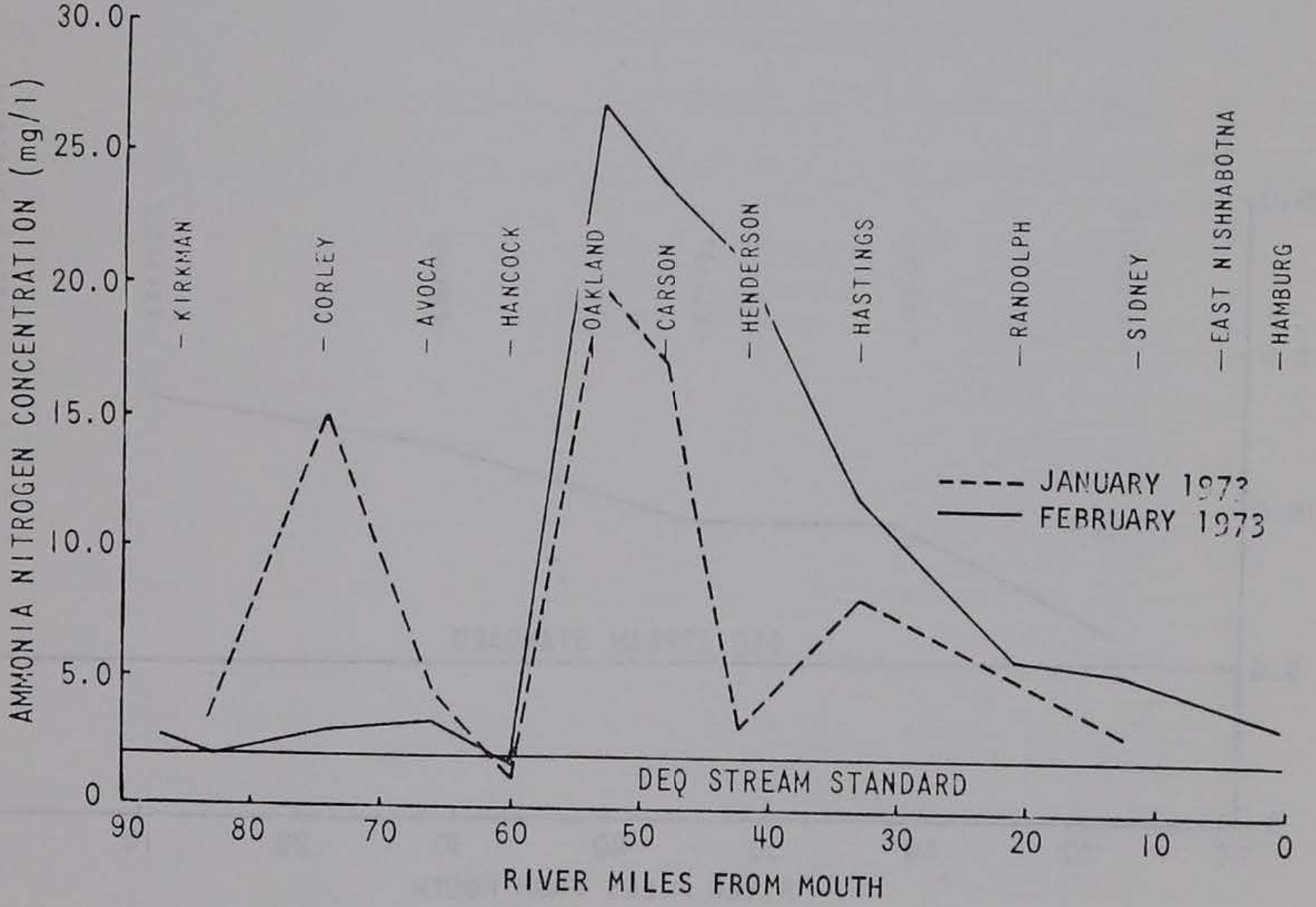


FIGURE II-120 WEST NISHNABOTNA AND NISHNABOTNA, AMMONIA NITROGEN CONCENTRATIONS

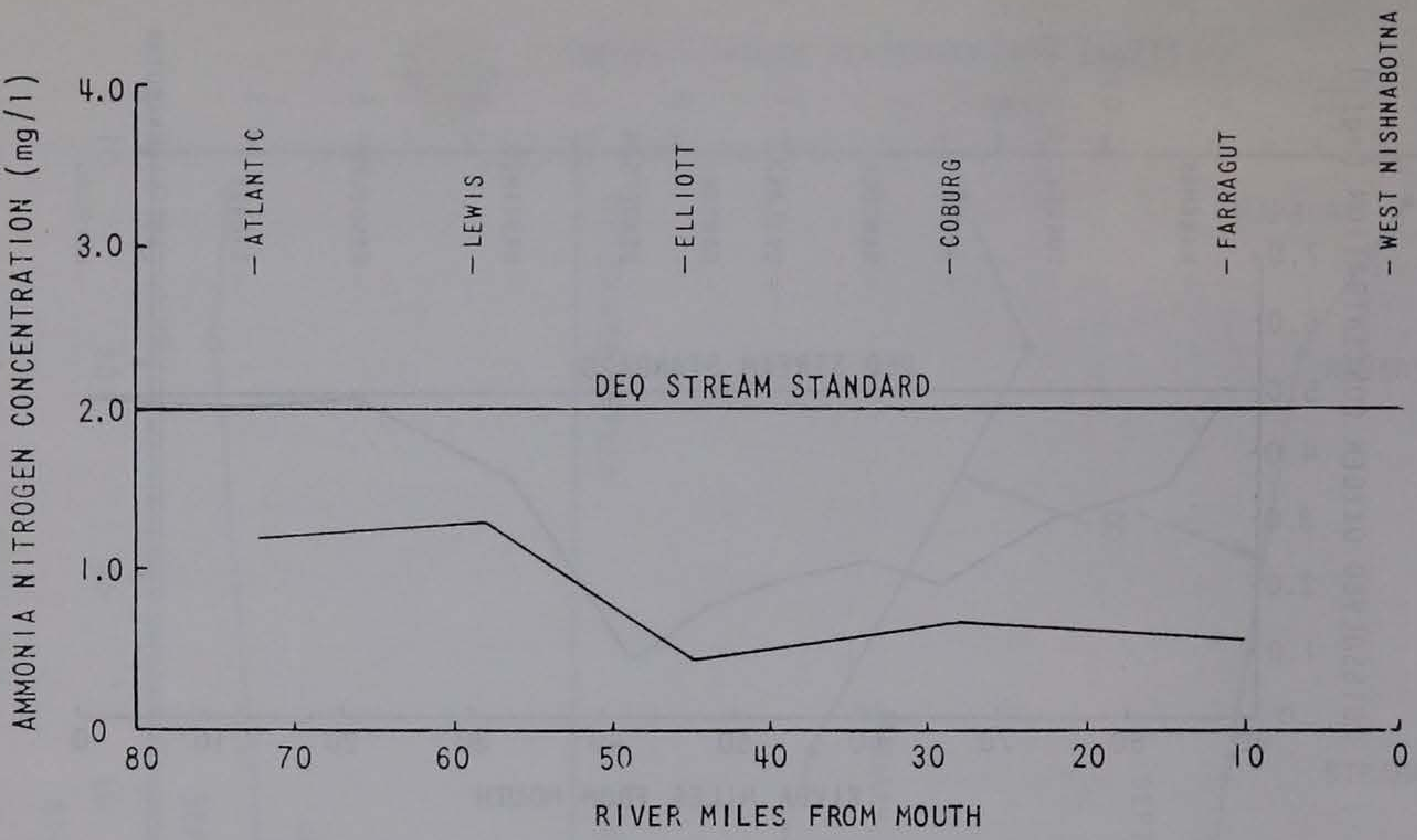


FIGURE 11-121 EAST NISHNABOTNA, DISSOLVED OXYGEN CONCENTRATIONS

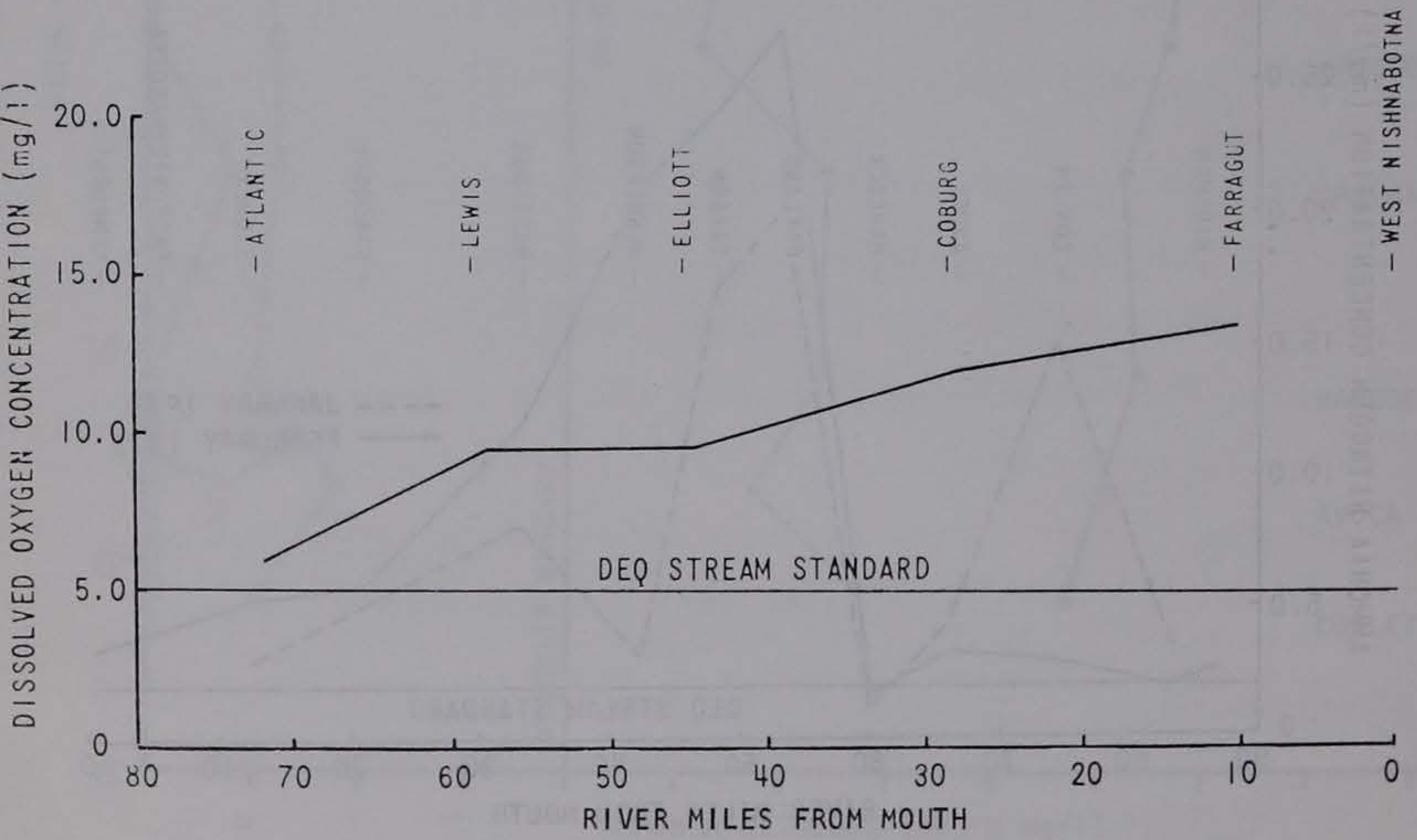


FIGURE 11-122 EAST NISHNABOTNA, AMMONIA NITROGEN CONCENTRATIONS

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations increase below point sources and throughout the river during runoff periods. None of the municipalities on the Nishnabotna River have chlorination facilities. During low flow conditions point sources are the main source of fecal coliform in the river. During high flows nonpoint sources also contribute large numbers of fecal coliform to the river. Concentrations in the Nishnabotna River are similar to those found in most Iowa streams and have not resulted in any reported health hazards.

LITTLE SIOUX RIVER

Little information on water quality in the Little Sioux River is available. Available data indicate various problems with dissolved oxygen, ammonia and total dissolved solids. These problems have mainly been found below point sources. High concentrations of turbidity and ammonia have been found in the lower portion of the river. Turbidity and suspended matter in the lower Little Sioux basin has been described as among the worst in the State (Iowa Natural Resources Council, 1959).

The key pollutants highlight conditions in the Little Sioux:

Harmful Substances: Pesticides including aldrin, DDE, DDT, dieldrin, heptachlor epoxide, lindane, 2,4-D, and 2,4,5-T have been found in the Little Sioux. Concentrations of aldrin, DDT, dieldrin and heptachlor epoxide have exceeded maximum recommended levels. Heavy metals have all been within Iowa standards in samples collected to date.

Physical Modification: Turbidity and suspended sediment are major problems in the Little Sioux River, particularly the lower one-fourth of the basin. Temperature has not been found to be a problem.

Eutrophication Potential: Nitrogen and phosphates show significant correlation with flow near the mouth of the Little Sioux. Algal mats have occasionally been noted in the Little Sioux near the mouth.

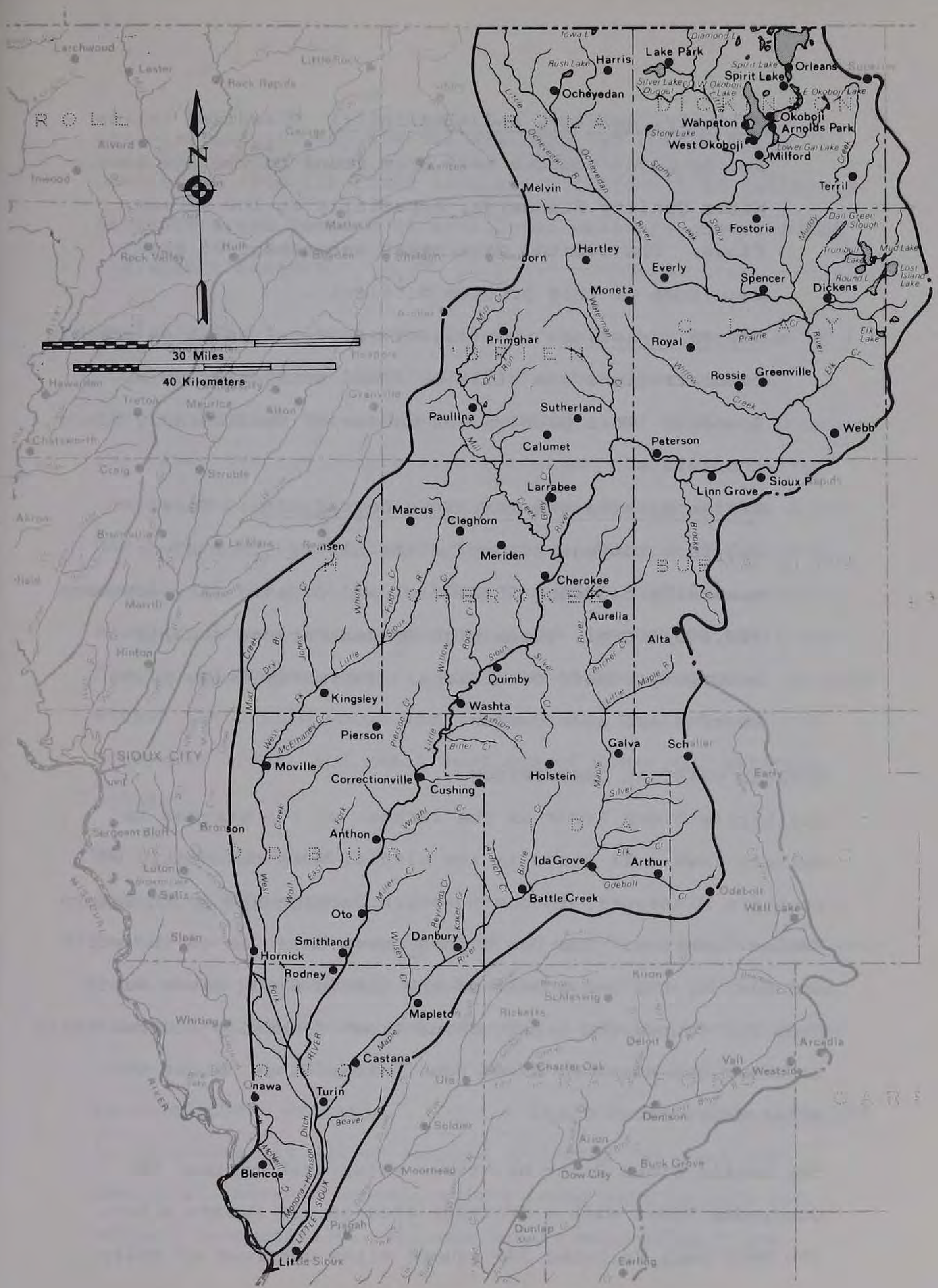


FIGURE II-123 LITTLE SIOUX RIVER BASIN

Salinity, Acidity, and Alkalinity: Dissolved solids due to point sources have been found to violate Iowa Water Quality Standards, expecially at low stream flows. The limited data makes assessment of the magnitude of this problem difficult.

Oxygen Depletion: Low dissolved oxygen and high ammonia concentrations can still be found near major point sources. This problem has decreased considerably since the 1950's.

Health Hazards and Aesthetic Degradation: Fecal coliform concentrations in the Little Sioux River generally exceeded 200/100 ml and occasionally approach 100,000/100 ml. These high concentrations usually accompany runoff conditions. Increases below point sources are also common.

GENERAL PHYSICAL DESCRIPTION

The Little Sioux River is the largest of the streams in Western Iowa. It rises in the glacial moraine country of southern Minnesota, in southwestern Jackson and southeastern Nobles Counties. The Des Moines River Basin is to the north and east of the upper half of the Little Sioux River Basin. From its source the Little Sioux flows generally southwesterly to enter the Missouri River near Little Sioux, about 65 miles below Sioux City.

The Little Sioux River has three major tributaries, the Ocheyedan River with a drainage area of 434 square miles, the West Fork draining 399 square miles upstream of Holly

Springs, and the Maple River draining 742 square miles. Downstream from the bluff line it is difficult to delineate drainage areas because of artificial drainage channels and indistinct divides.

In the glacial plains near its source the Little Sioux is a shallow, unincised stream, while farther downstream in Dickinson, Clay, Buena Vista, Cherokee, and Woodbury Counties the river has cut deeply into the older glacial deposits. Channel straightening is less extensive in the Little Sioux Basin than in the basins to the south, being limited to a section of the main channel and the West Fork from central Woodbury County downstream to a point just below their confluence in Monona County. Other straightened channel reaches within the Little Sioux Basin are on the Maple River, the Ocheyedan River, and small sections of Stony and Waterman Creeks.

WATER QUALITY CONDITIONS

Harmful Substances

Pesticides have often been found in excess of the maximum concentrations recommended by the Natural Academy of Science. Aldrin, DDT, dieldrin, and heptachlor epoxide have exceeded these criteria. Only DDT and dieldrin have consistently exceeded these criteria. DDT and dieldrin have been detected in approximately 40% of samples collected for pesticide analysis. Average concentrations found were 11 ng/l and 20 ng/l respectively. Maximum levels were 20 ng/l and

50 ng/l respectively. The pesticide concentrations result from nonpoint runoff from agricultural land.

Heavy metals in the Little Sioux River include barium, copper, manganese and zinc. None of these metals have violated Iowa Water Quality Standards in the Little Sioux River.

TABLE II-45

HEAVY METALS IN THE LITTLE SIOUX RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	24	0		
Ba	26	18	189	300
Cd	29	0		
Cr	37	0		
Cu	30	5	12	20
Pb	30	0		
Mn	22	18	175	610
Hg	6	0		
Ni	24	0		
Ag	17	0		
Zn	30	21	78	360

TABLE II-46

PESTICIDES IN THE LITTLE SIOUX RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Aldrin	15	1	20	20
Chlordane	13			
DDD	15			
DDE	32	1	3	3
DDT	27	12	11	20
Dieldrin	24	9	20	50
Endrin	15			
Heptachlor Epoxide	15	1	20	20
Lindane	15	1	10	10
2, 4-D	14	8	240	650
2, 4, 5-T	14	6	30	70
Silvex	14			
PCB	4			
Parathion	1			
Methyl	1			
Malathion	1			
Diazinon	1			
Heptachlor	15			

Physical Modification[1]

Erosion and sedimentation contribute to the water quality problems of the Little Sioux River, particularly in the southern part where topography and soils are conducive to rapid erosion under both natural and man-induced conditions. Turbidity levels found in the Little Sioux River have been as high as 850 JTU. The Little Sioux probably has always carried heavier sediment loads than streams to the east because of the nature of the loessial silts of the watershed.

[1] Iowa Natural Resources Council, 1959

In the northern part of the Little Sioux Basin, where the loess is thin or absent and slopes are not as steep, the erosion problem is classified as "moderate" to "slight".

In compliance with the Flood Control Act of 1936, the Little Sioux River Basin was selected along with problem areas in other states as test areas in which to develop flood prevention programs by land treatment and gully control works.

The program being installed includes: (1) The treatment of farmlands in the loess-covered part of the watershed to reduce runoff and erosion at the source, and (2) the building of structures to control major gully erosion which cannot be stopped by individual action. Authority for use of program funds is generally limited to that portion of the Little Sioux Watershed lying south of the Clay and Osceola County Soil Conservation Districts. The program is twofold; (1) proper use of land and the application of terraces, grassed waterways, contouring, and other conservation measures which tend to retard runoff, and (2) the installation of dams and other measures designed to stabilize major gullies as well as to reduce peak flood flows and sediment production from small watersheds.

Eutrophication Potential

Nitrate and phosphate levels in the Little Sioux River are similar to those in other Iowa streams. Total phosphate concentrations have averaged about 0.5 mg/l in samples collected since 1970. Nitrate concentrations have significant correlations with flow. Phosphates and nitrogen tend to increase as flow increases. This would seem to indicate the nonpoint nature of these parameters and the magnitude of fertilizer runoff. Calculations indicate over 95% of the nitrogen and phosphate in the Little Sioux River is the result of nonpoint source runoff. Limited nitrate data available from the 1950's indicate that nutrient levels may be increasing in the stream. This is comparable with data available on the Missouri River bordering Iowa. The amount of data available for comparison makes conclusions very questionable. Algal mats in the river have been observed at times, indicating that large algal populations have developed.

Salinity, Acidity, and Alkalinity

Total dissolved solids concentrations in the Little Sioux River exceeded the Iowa Water Quality Standards. Studies conducted on the Little Sioux River in 1974 indicated that the City of Spencer discharged large quantities of dissolved solids and chlorides to the river, and that during low flow conditions stream violations occurred (Figure II-124). These are the only violations of stream standards that have been noted in the Little Sioux River.

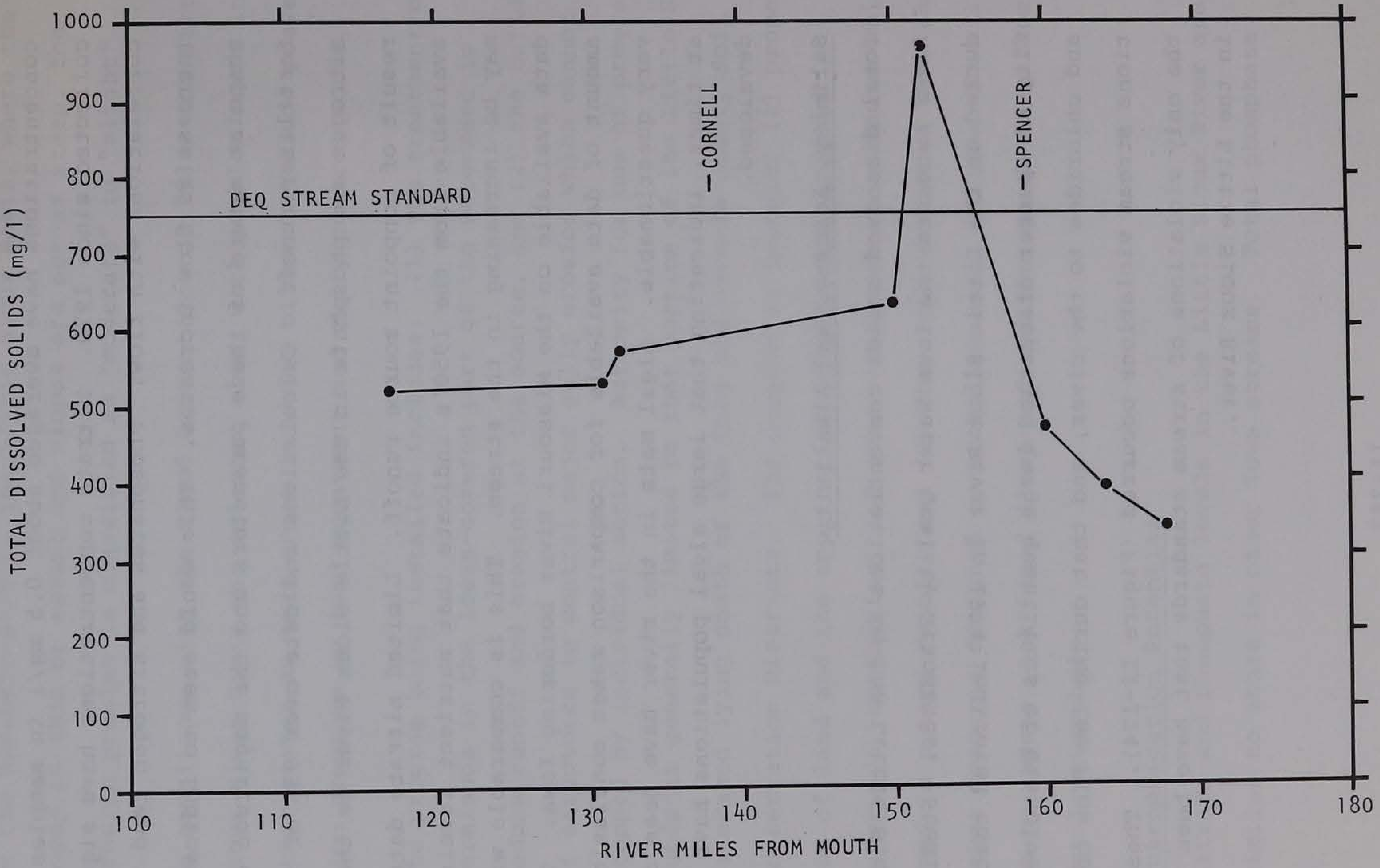


FIGURE 11-124 TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN THE LITTLE SIOUX RIVER, JULY 16, 1974

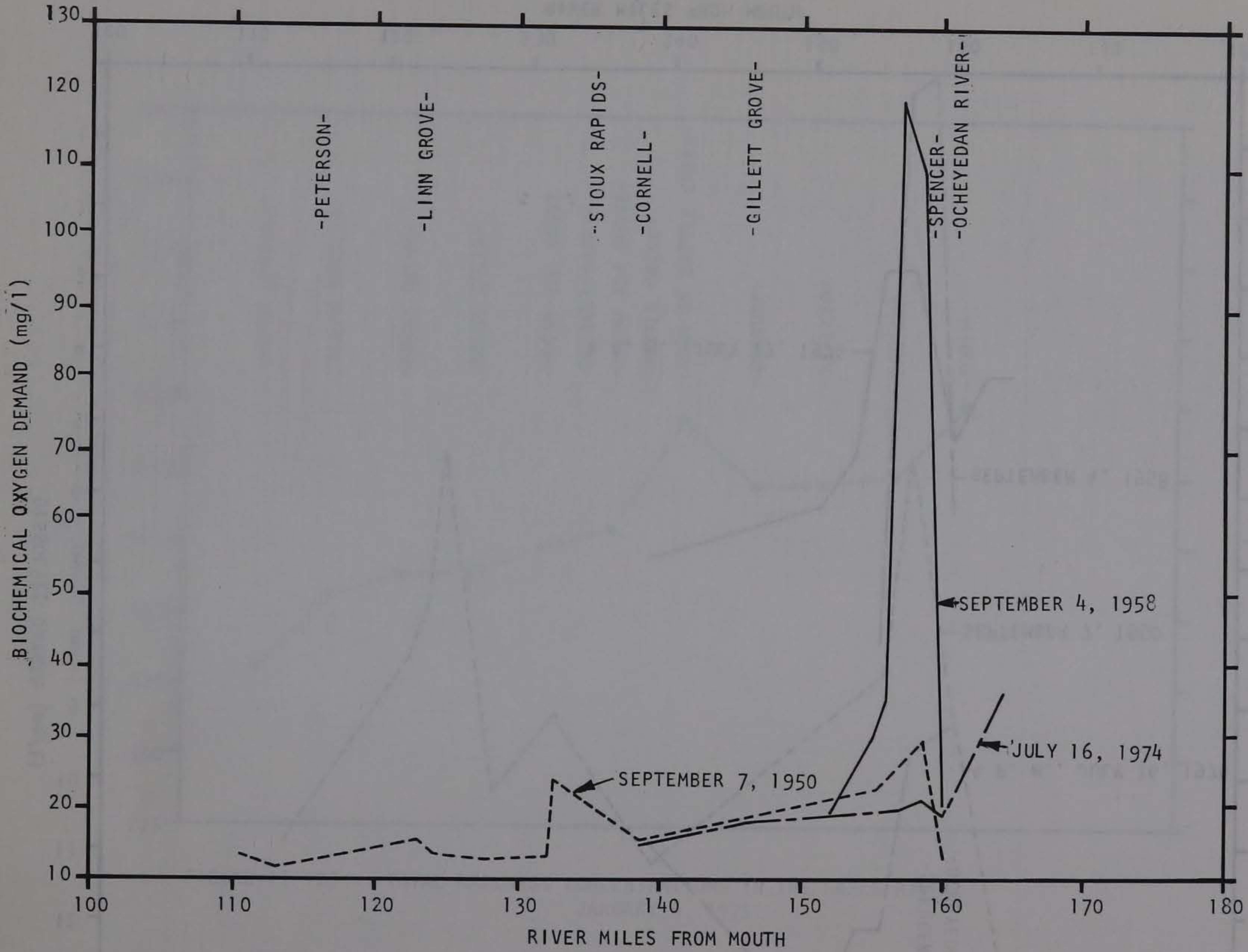


FIGURE 11-125 COMPARISON OF BIOCHEMICAL OXYGEN DEMAND IN THE LITTLE SIOUX RIVER NEAR SPENCER, IOWA, 1950-1974

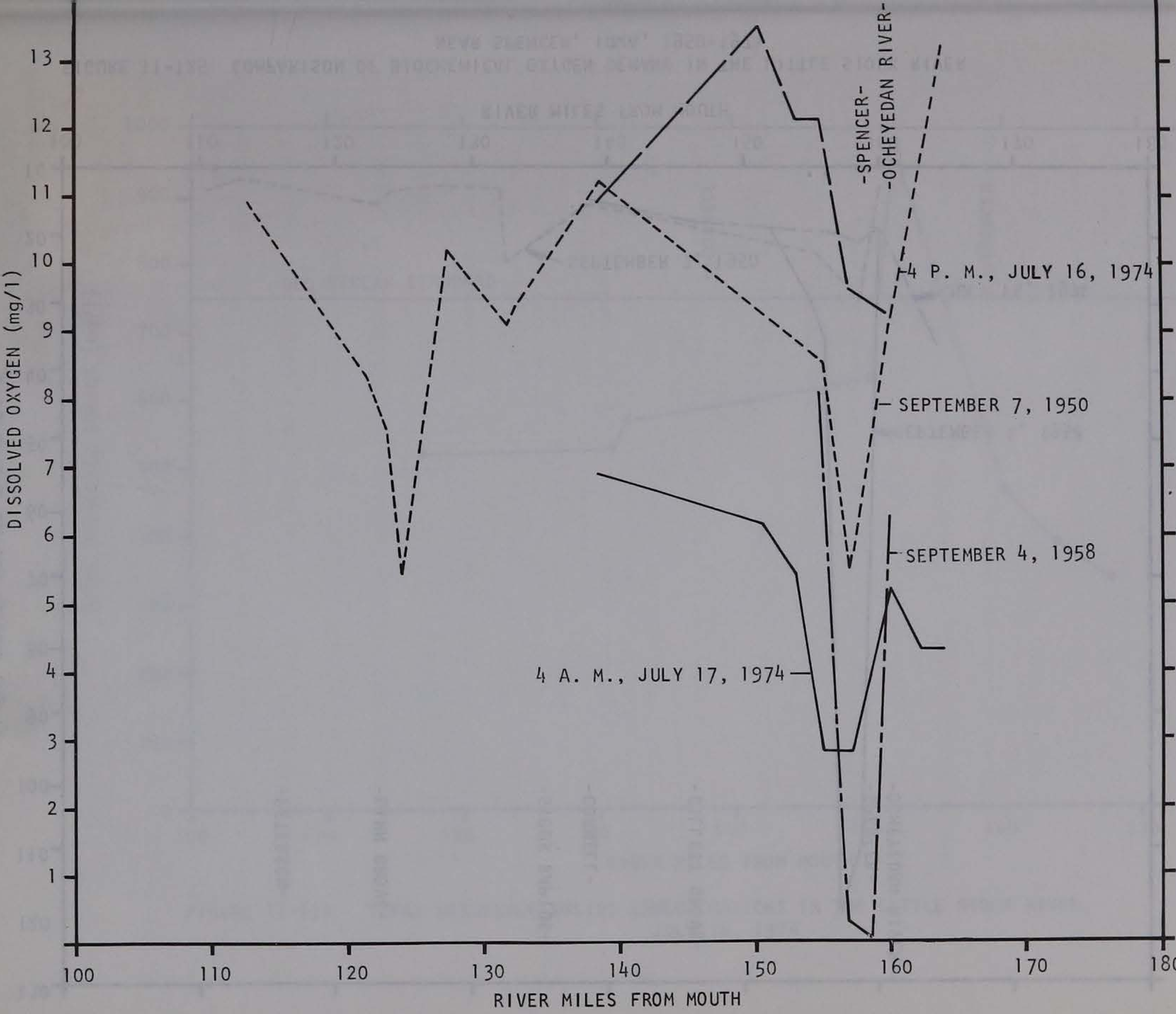


FIGURE 11-126 COMPARISON OF DISSOLVED OXYGEN CONCENTRATIONS IN THE LITTLE SIOUX RIVER NEAR SPENCER, IOWA, 1950-1974

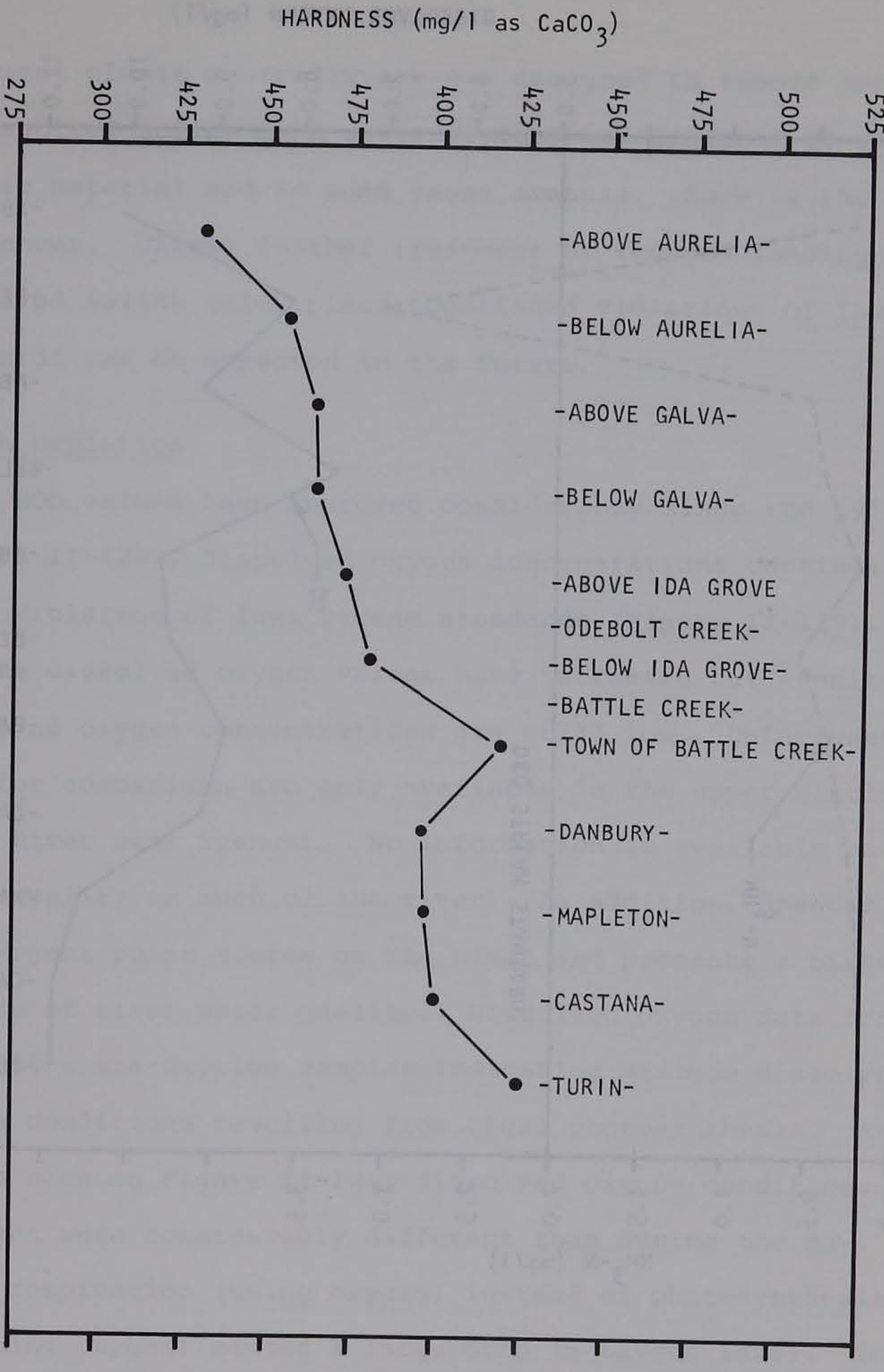


FIGURE II-127 TOTAL HARDNESS CONCENTRATIONS IN THE MAPLE RIVER, JANUARY 6, 1975

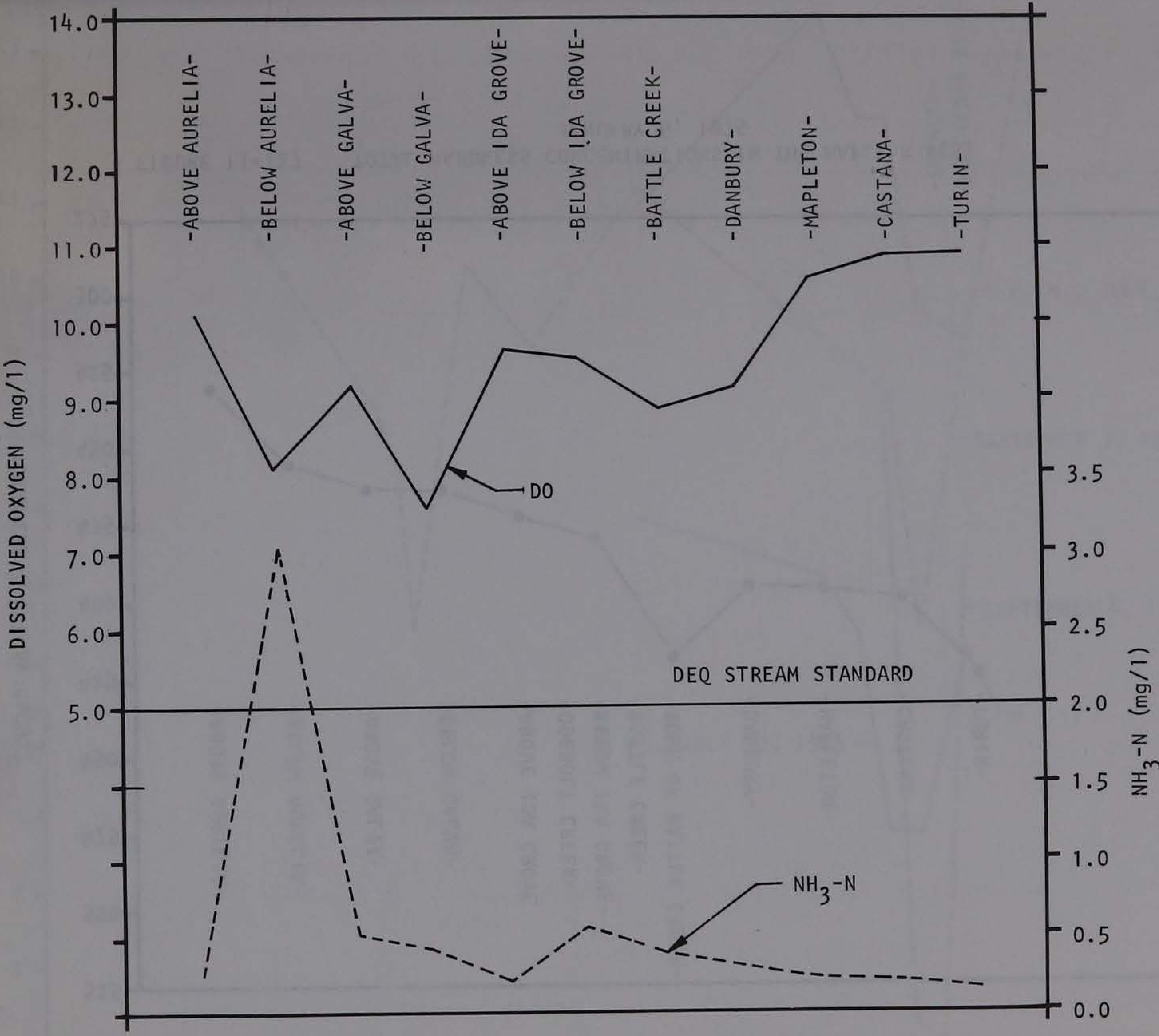


FIGURE 11-128 DISSOLVED OXYGEN AND AMMONIA NITROGEN CONCENTRATIONS IN THE MAPLE RIVER, 1974-1975

Treatment plants generally are not designed to remove salts or dissolved solids from wastes. They are designed to remove organic material and in some cases ammonia. Such is the case of Spencer. Unless further treatment or reduced loading of dissolved solids takes place, continued violations of Iowa standards can be expected in the future.

Oxygen Depletion

While BOD values have improved considerably since the 1950's (Figure II-126), dissolved oxygen concentrations continue to be in violation of Iowa stream standards (Figure II-128). Daytime dissolved oxygen values have increased but evening dissolved oxygen concentrations are still low. Unfortunately, data for comparison are only available in the upper Little Sioux River near Spencer. No information is available on water quality in much of the river. In addition, Spencer is the largest point source on the river and presents a biased picture of river water quality. Dissolved oxygen data from the 1950's are daytime samples indicating maximum dissolved oxygen conditions resulting from algal photosynthesis. As can be seen in Figure II-126, dissolved oxygen conditions at night were considerably different than during the day. Algal respiration (using oxygen) instead of photosynthesis (creating oxygen) caused a large drop in oxygen level. Iowa stream standards require that dissolved oxygen shall be maintained above 4 mg/l at all times and above 5.0 mg/l at least 16-hours per day.

Taking all samples for the periods studied, dissolved oxygen and ammonia nitrogen concentrations have improved considerably since the 1950's (Figure II-126). No ammonia violations have been observed in this type of sampling below point sources since 1970.

Data available from USGS, not presented in Figure II-128, show some ammonia violations in recent years near the mouth of the Little Sioux. Instead of occurring under ice cover, or at low flow, or just below a point source discharge, these violations have occurred at high flows, away from point sources, during late February or early March. Samples collected in early March of both 1972 and 1973 show ammonia concentrations above the Iowa standard of 2.0 mg/l. Both samples were taken at high flows which normally occur less than 10% of the time. This seems to indicate that during spring thaw and with runoff ammonia nitrogen from nonpoint sources is causing elevated concentrations in the stream. This is similar to findings on the Skunk, Floyd, Soldier, and Platte Rivers in Iowa. Since no other ammonia violations have been found from point sources since 1970, this nonpoint runoff may be the most important source of ammonia in the Little Sioux River. Clearly, more study is necessary to establish a water quality baseline in the Little Sioux and further studies on ammonia runoff at spring thaw is necessary.

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations are generally high in the Little Sioux River. Concentrations normally exceed the

200/100 ml criteria. Concentrations have averaged over 2000/100 ml since 1970. Concentrations below point sources are higher than background concentrations and are gradually diluted downstream. During periods of runoff, point source contributions are virtually masked by concentrations from nonpoint source runoff. At these times concentrations near 100,000 fecal coliform per 100 ml are not uncommon.

Tributaries

Little information is available on most tributaries to the Little Sioux River. Only a few isolated samples have been taken on the Ocheyedan River. No sample data is available on the West Fork, and only recently have samples been collected on the Maple River. Based on this recent sampling, it appears that some pollution from point sources is taking place. Ammonia samples have been found which exceed Iowa standards and dissolved oxygen concentrations, while not critical, appear generally below saturation. Water quality data available for the Maple River are summarized in Figure II-129. Hardness and total dissolved solids generally increase going toward the mouth. This is probably due to groundwater and runoff characteristics of the basin. Note the particular jump in hardness and dissolved solids below Battle Creek (Figure II-127). No water quality data is available on this stream.

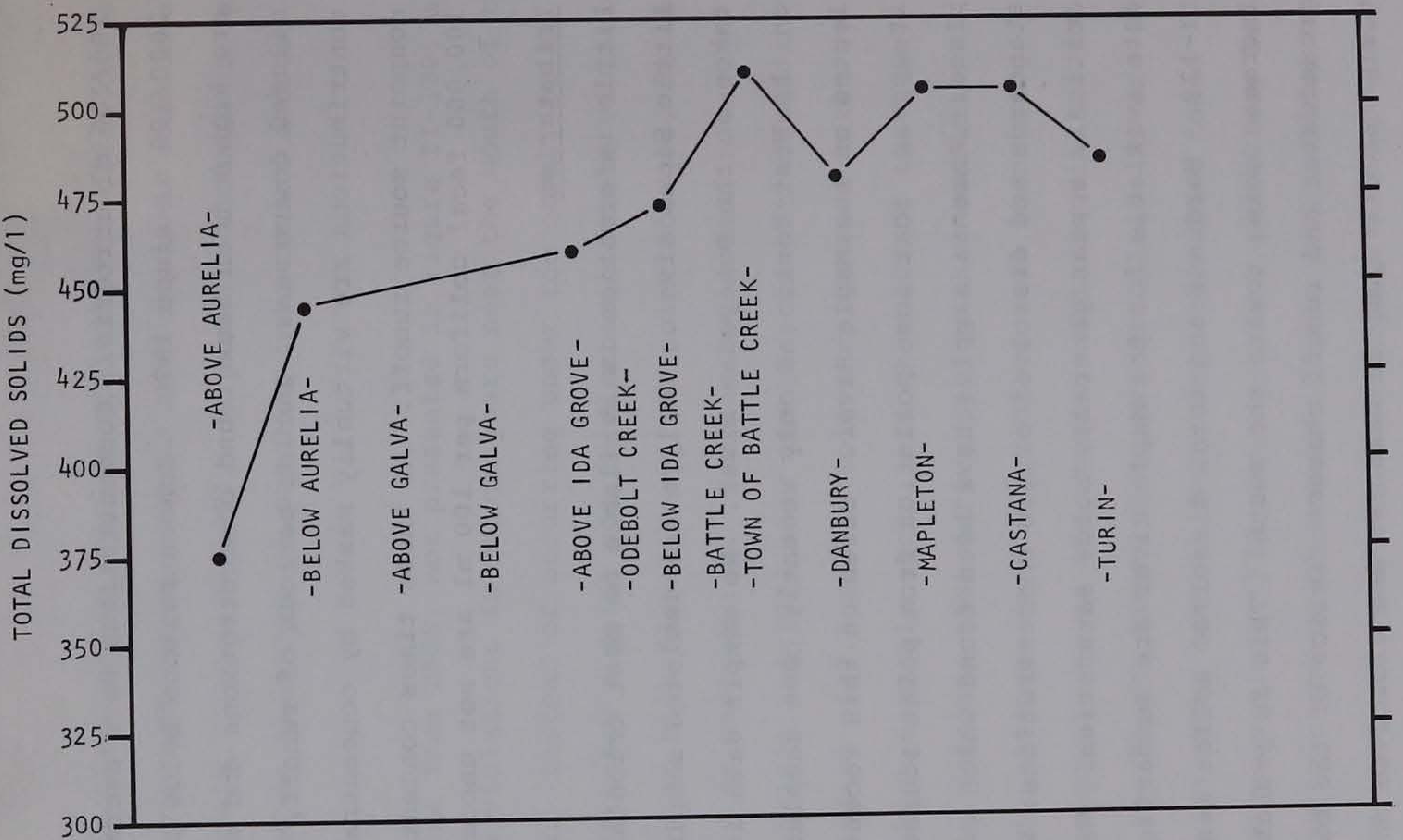


FIGURE 11-129 TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN THE MAPLE RIVER, JANUARY 6, 1975

FLOYD RIVER

Ammonia nitrogen, dissolved oxygen, and BOD concentrations seem to be the most serious pollution problems on the Floyd River. Numerous point sources with inadequate waste treatment have repeatedly been shown as sources of high BOD and ammonia. Because of the high BOD values numerous violations of Iowa dissolved oxygen standards have occurred.

The key pollutants highlight conditions in the Floyd:

Harmful Substances: Pesticides including aldrin, DDT, dieldrin, heptachlor epoxide, lindane, 2,4-D, and 2,4,5-T have been found in the Floyd River. Concentrations of aldrin, DDT, dieldrin, and heptachlor epoxide have exceeded maximum recommended levels. Heavy metals found include barium, manganese and zinc. No metals violations have occurred in samples collected to date.

Physical Modification: Turbidity and suspended sediment are the major problems concerning physical modification. No temperature problems have been noted.

Eutrophication Potential: Nitrates and phosphates are abundant and do not appear to reach levels where they might be limiting. Nitrogen and total phosphates show significant correlation with flow indicating possible nonpoint sources.

Salinity, Acidity, and Alkalinity: Alkalinity in the winter has been found to be near 300 mg/l. Total dissolved solids have not violated stream standards.

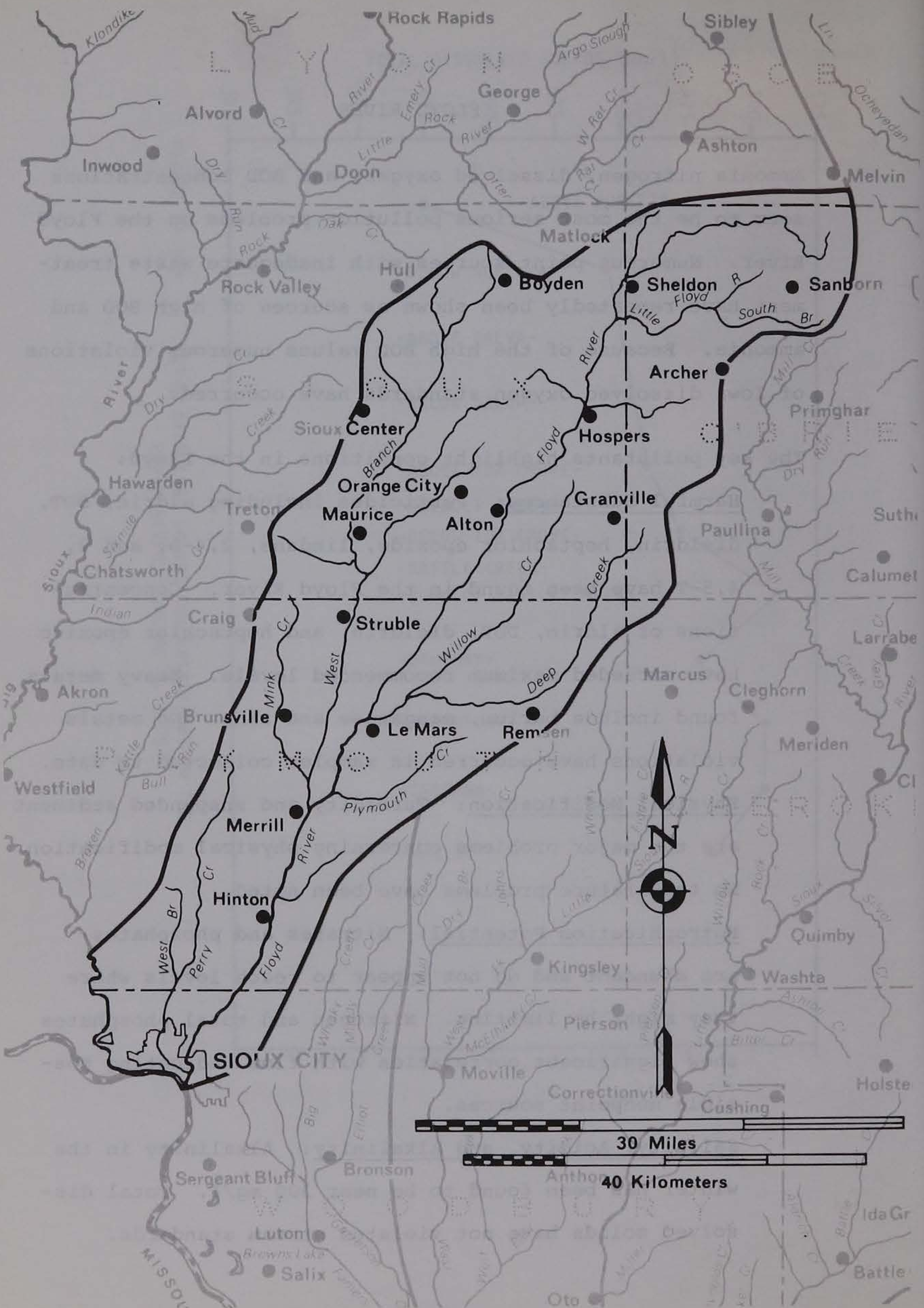


FIGURE II-130 FLOYD RIVER BASIN

Oxygen Depletion: This is probably the most serious problem in the Floyd River. Point source pollution from a number of municipalities cause severe oxygen depletion, particularly during low flows and ice cover. During these same periods, high ammonia nitrogen from the same sources also often violate Iowa stream standards.

Health Hazards and Aesthetic Degradation: A combination of point and nonpoint sources keeps concentrations of fecal coliform high most of the time. Concentrations below point sources are most important during low flows while runoff causes high levels throughout the river during high flows.

GENERAL PHYSICAL DESCRIPTION

The Floyd River is sandwiched in between the Rock River on the west and the Little Sioux on the east. It rises in northern O'Brien County and flows to the southwest to enter the Missouri River at Sioux City. The Floyd River drainage basin is slightly fan shaped and restricted to a rather narrow bottlenecked valley above Sioux City. The total drainage area is 2,416 square miles.

The major tributary to the Floyd River is the West Fork which enters the Floyd near Merrill. The main municipalities discharging to the river are Sheldon, Hospers, Orange City and Le Mars.

WATER QUALITY CONDITIONS

Harmful Substances

Pesticide concentrations found in the Floyd River have sometimes exceeded recommended maximum levels established by the National Academy of Science. While none of the pesticides are consistently found, as in some Iowa streams, dieldrin and 2,4-D have been found in over 50% of the samples collected. Dieldrin, DDT, aldrin, and heptachlor epoxide are the pesticides with concentrations above recommended levels. DDT, heptachlor epoxide, and aldrin have only occasionally been found in the Floyd River.

To date no metals concentrations have been found exceeding Iowa standards, however, only limited data is available to indicate the presence of barium, manganese, and zinc.

TABLE II-47

HEAVY METALS IN THE FLOYD RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
As	4	0		
Ba	4	4	125	200
Cd	5	0		
Cr	5	0		
Cu	5	0		
Pb	5	0		
Mn	6	5	174	390
Hg	0	0		
Ni	5	0		
Ag	3	0		
Zn	5	4	40	70

TABLE II-48

PESTICIDES IN THE FLOYD RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Aldrin	15	1	20	20
Chlordane	13			
DDD	15			
DDE	15			
DDT	15	2	10	10
Dieldrin	15	12	20	50
Endrin	15			
Heptachlor Epoxide	15	2	20	20
Lindane	15	2	10	10
2, 4-D	13	7	340	1100
2, 4, 5-T	13	4	10	20
Silvex	13			
PCB	4			
Parathion	4			
Methyl Parathion	4			
Malathion	4			
Diazinon	4			
Heptachlor	15			

Physical Modification

Turbidity and suspended solids create the biggest problem regarding physical modification. This problem, in regard to stream channelization and straightening, was discussed in the sections on the Little Sioux and Nishnabotna River.

Channelization of the lower portion of the Floyd River has created similar conditions although in smaller magnitude. Turbidity concentrations as high as 850 JTU have been found in the Floyd. Suspended sediment loads on the Floyd River at James have been measured by the U.S. Geological Survey. Suspended sediment loading since 1970 has been about 450,000 tons per year with a maximum of nearly 800,000 tons per year in 1970-1971.

Salinity, Acidity, and Alkalinity

Acidity and alkalinity are not problems in the Floyd River. Alkalinity concentrations have averaged slightly over 300 mg/l in the winter and dropped below 200 mg/l in the summer. Values for pH have ranged between 6.9 and 9.1. Most values are between 7.5 and 8.5 with only occasional samples approaching the extremes.

Chloride concentrations in the Floyd River are higher than most Iowa rivers, but are not found at the extremely high levels as in the Big Sioux or Maquoketa River.

Eutrophication Potential

Nitrate and phosphate concentrations in the Floyd River have averaged 2.74 mg/l and 0.54 mg/l respectively based on limited data. Nitrate samples collected in the 1950's were generally lower than those found in the last few years. Limited sampling makes any conclusions concerning trends very questionable. Concentrations of both total nitrogen and total phosphates show high correlation with flow. This tends to indicate that runoff is the main source of these nutrients. Algal mats have been reported at James on several occasions since 1970.

Oxygen Depletion

Significant improvement in dissolved oxygen and ammonia concentrations have been seen since the 1950's. Considerable improvement is still necessary. Numerous violations of dissolved oxygen and ammonia standards have occurred in the last year. These result from point sources, many of which were mentioned above.

Biochemical oxygen demand (BOD) concentrations for the 1970's have generally decreased below Hospers, Orange City, Alton, and Le Mars, since the 1950's. BOD has increased below Sheldon (Figure II-132). The decreases are due to treatment plants built by these municipalities. Many of these treatment plants are now inadequate to handle the current load and need to be expanded or replaced. Considerable improvement in BOD, dissolved oxygen, and ammonia concentrations can be expected as adequate treatment facilities are constructed in the Floyd River Basin.

Ammonia nitrogen violations may not be due completely to point sources. Samples collected in early March at spring thaw had ammonia concentrations above 2 mg/l. This may be due to point sources but the flow is so high that point source pollution would be expected to be diluted. Similar nonpoint source ammonia has been noted in the Little Sioux, Skunk, Soldier, and Platte Rivers. These other locations tend to substantiate the possibility of nonpoint source ammonia concentrations above 2 mg/l.

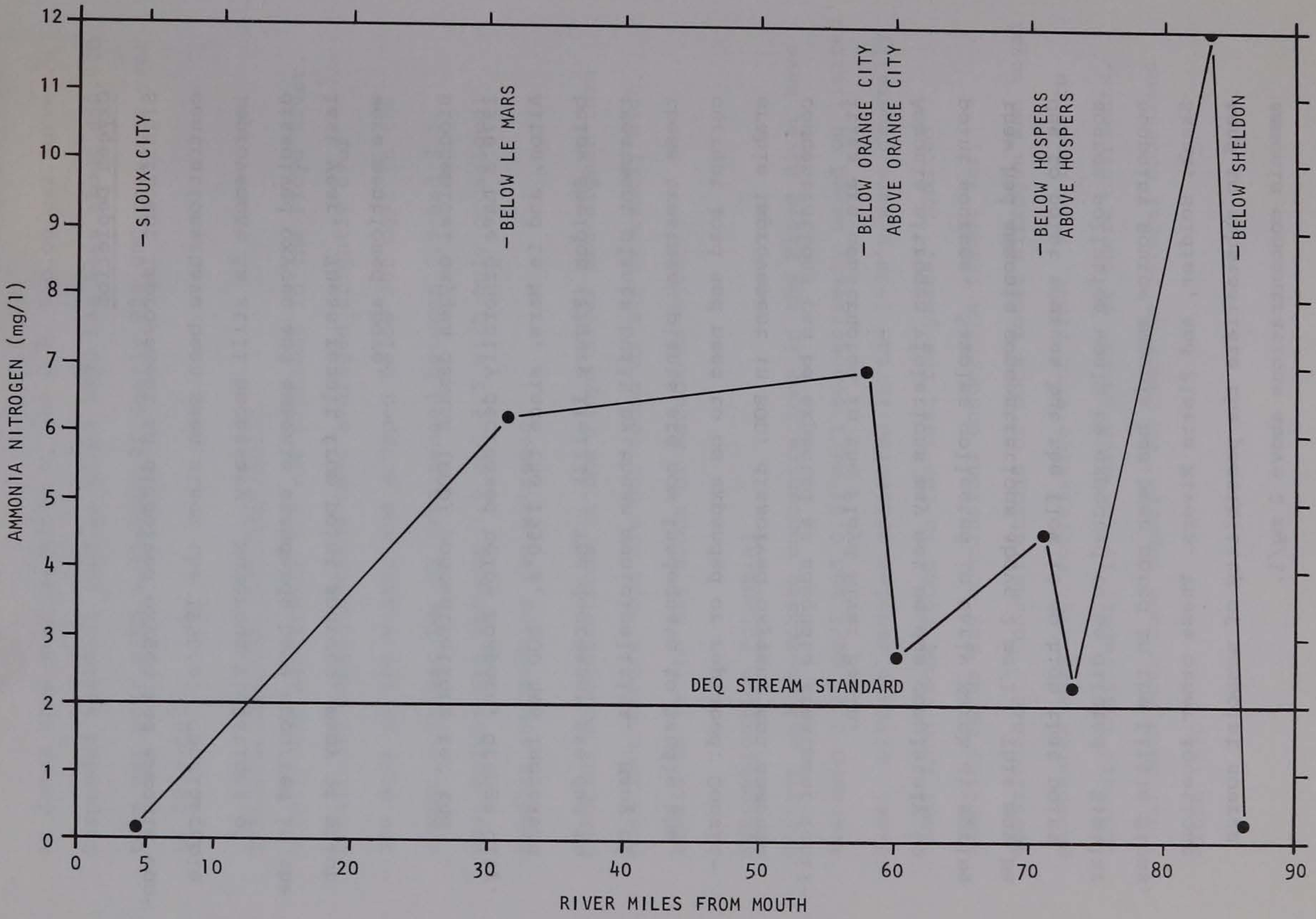


FIGURE 11-131 MEAN AMMONIA NITROGEN CONCENTRATIONS IN THE FLOYD RIVER 1970-1974

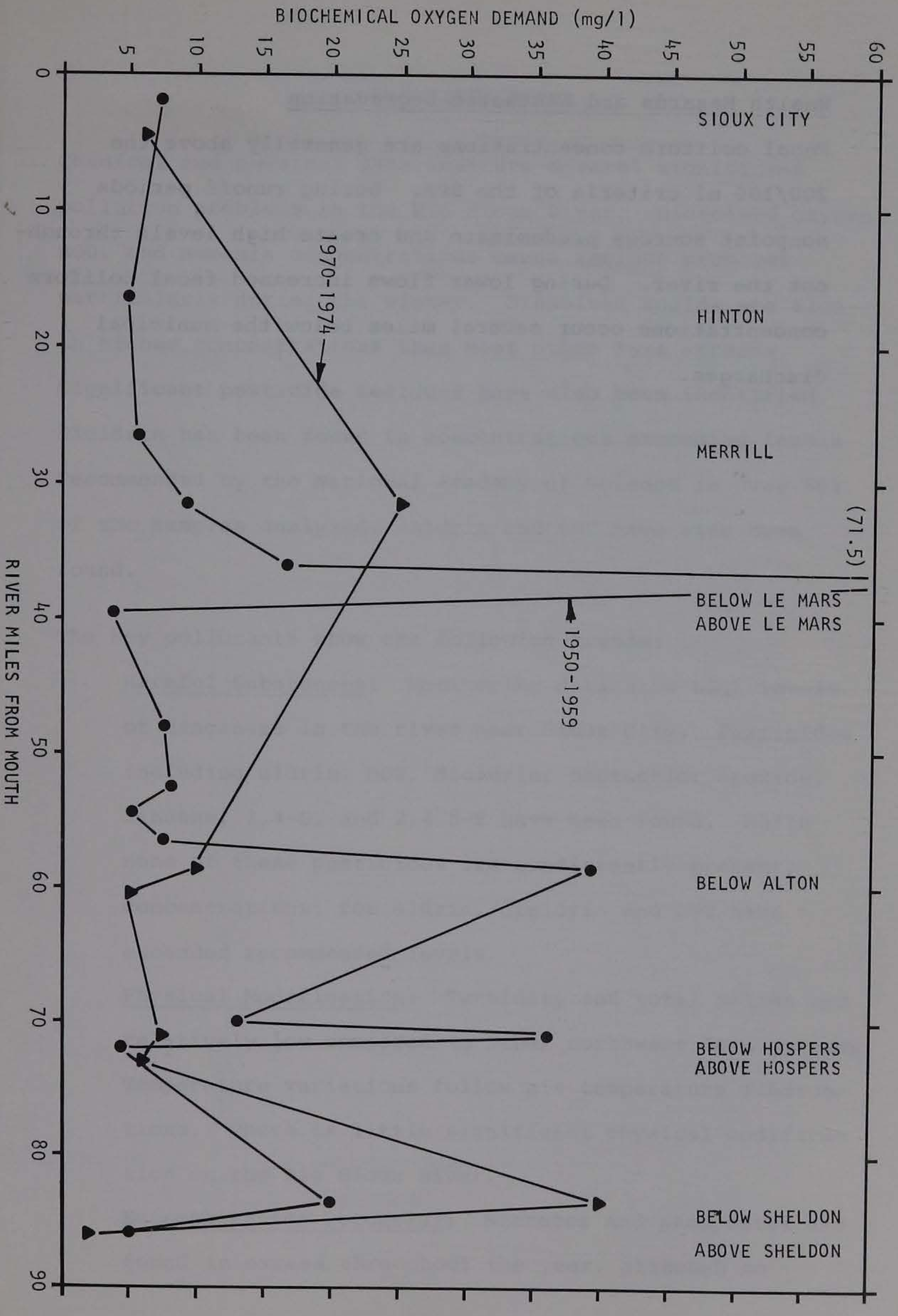


FIGURE II-132 COMPARISON OF MEAN BOD CONCENTRATIONS IN THE FLOYD RIVER; 1950's-vs-1970's

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations are generally above the 200/100 ml criteria of the EPA. During runoff periods nonpoint sources predominate and create high levels throughout the river. During lower flows increased fecal coliform concentrations occur several miles below the municipal discharges.

BIG SIOUX RIVER

Chemical and physical data indicate several significant pollution problems in the Big Sioux River. Dissolved oxygen, BOD, and ammonia concentrations cause serious problems particularly during the winter. Dissolved solids are also in higher concentrations than most other Iowa streams. Significant pesticide residues have also been identified. Dieldrin has been found in concentrations exceeding levels recommended by the National Academy of Science in over 50% of the samples analyzed. Aldrin and DDT have also been found.

The key pollutants show the following trends:

Harmful Substances: Monitoring data show high levels of manganese in the river near Sioux City. Pesticides including aldrin, DDT, dieldrin, heptachlor epoxide, lindane, 2,4-D, and 2,4,5-T have been found. While none of these pesticides are consistently present, concentrations, for aldrin, dieldrin and DDT have exceeded recommended levels.

Physical Modification: Turbidity and total solids are relatively low compared to other northwest Iowa streams. Temperature variations follow air temperature fluctuations. There is little significant physical modification on the Big Sioux River.

Eutrophication Potential: Nitrates and phosphates are found in excess throughout the year, although no

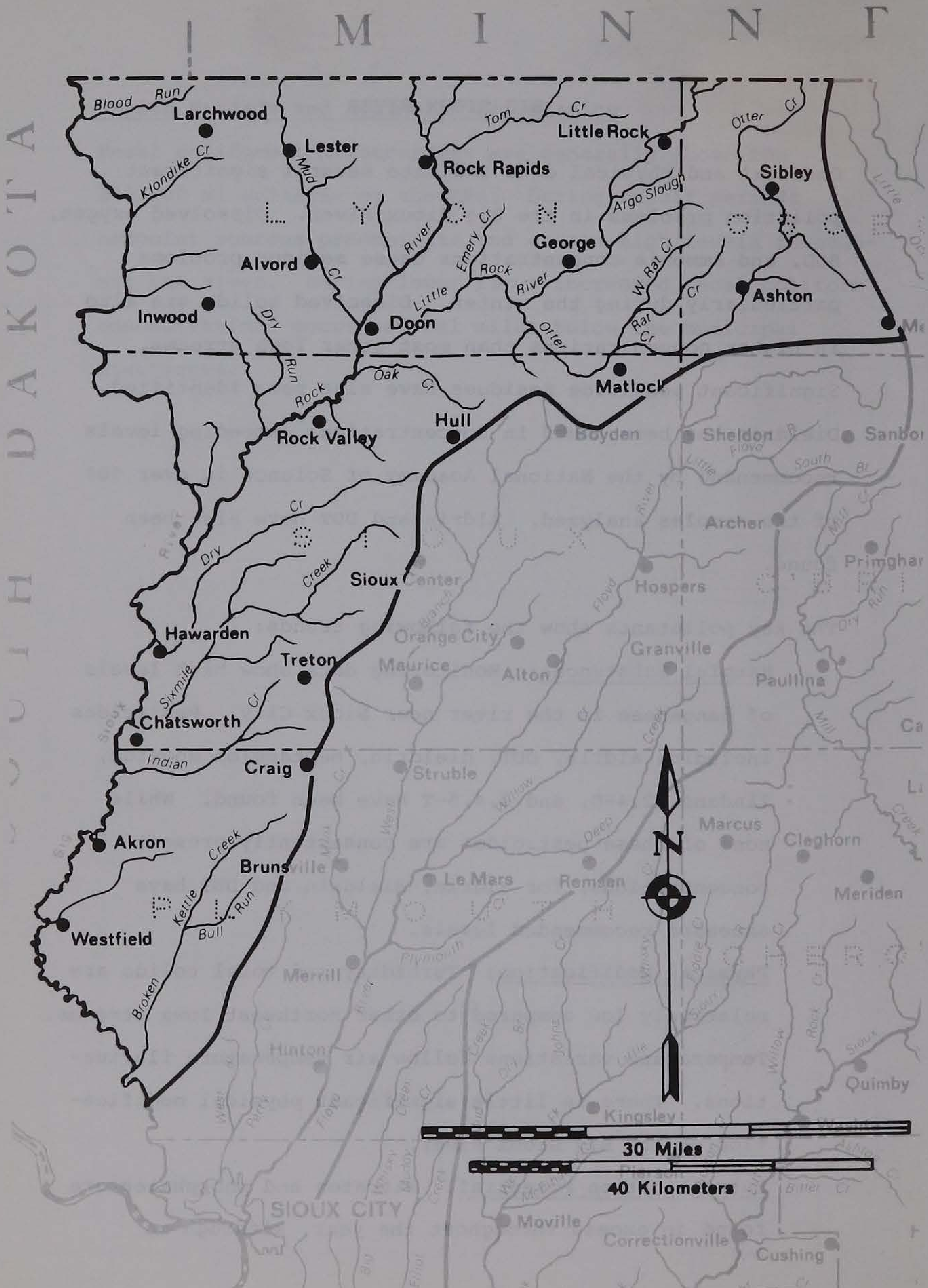


FIGURE II-133 BIG SIOUX RIVER BASIN

nuisance algal growth have been reported. Phosphate concentrations are highest at the Iowa-Minnesota border and decrease toward the mouth.

Salinity, Acidity, and Alkalinity: Iowa Water Quality Standards for dissolved solids were violated in over 40% of the samples analyzed. While the significance of this salinity on aquatic life is unknown at this time, a salinity problem is evident.

Oxygen Depletion: While not widespread during summer and high flow periods, oxygen depletion becomes serious at other times. Over 40% of the samples collected have shown violations of Iowa Water Quality Standards for dissolved oxygen and nearly 75% have shown violation of the ammonia standards.

Health Hazards and Aesthetic Degradation: Total and fecal coliform concentrations are present in fairly low numbers. Coliform concentrations fluctuate with runoff as in other Iowa streams. Concentrations generally decrease downstream toward the mouth.

GENERAL PHYSICAL DESCRIPTION

The Big Sioux River originates in northeast South Dakota, and flows generally south-southeast to the Missouri River at Sioux City, Iowa. Approximately 69% of its drainage area is located in South Dakota with 15% from Iowa and 16% from Minnesota.

The Rock River is the largest tributary draining most of the Minnesota and Iowa portions of the basin. Throughout its lower reach, the Big Sioux meanders through the flood plain forming the border between Iowa and South Dakota.

Due to the size and meandering nature of the stream, there is wide diversity of aquatic habitats. While many of the rivers in northwestern Iowa have been physically altered by channelization or straightening, this has not been done to the Big Sioux. As a result, the Big Sioux has a greater fishery potential than any other stream in the northwest part of the State. The entire Iowa portion of the Big Sioux River is classified as a warm water area for the propagation of aquatic life.

POLLUTION PROBLEMS AND SOURCES

Wastes from the Sioux Falls, South Dakota sewage treatment plant have by far the greatest impact on the Big Sioux River from Sioux Falls to the mouth. Low dissolved oxygen and high ammonia values are sufficient to cause numerous fish kills. Water quality in the Rock River alternately improves or aggravates the conditions in the Big Sioux. Inadequate treatment at several locations on the Rock River in Iowa and Minnesota cause sporadic periods of low dissolved oxygen concentrations and high ammonia nitrogen concentrations similar to those in the Big Sioux River.

WATER QUALITY CONDITIONS

Harmful Substances

Limited data are available on heavy metals, pesticides and herbicides in the Big Sioux River. All metals found in the Big Sioux have been within the limitations of the applicable Iowa Water Quality Standards. While no standards are established by Iowa for manganese, the EPA has established suggested drinking water criteria. On the basis of the EPA criteria of 50 ppb, manganese in the Big Sioux River is in violation in over 40% of the samples analyzed. These concentrations are most likely the result of chemical characteristics of the drainage area rather than the result of point source pollution.

A variety of pesticides have been detected in the Big Sioux River (Table II-50). Concentrations of aldrin, DDT, and dieldrin have exceeded recommended maximum concentrations established by the National Academy of Science (1972). Pesticide concentrations indicate the need for increased control of nonpoint source runoff.

TABLE II-49

HEAVY METALS IN BIG SIOUX RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
As	12	0		
Ba	9	8	137	200
Cd	11	0		
Cr	13	0		
Cu	11	4	12	20
Pb	11	0		
Mn	13	12	423	2400
Hg	2	0		
Ni	9	0		
Ag	6	0		
Zn	11	9	39	60

Physical Modification

Turbidity and suspended solids increase during runoff periods. These increases are smaller than those for many other Iowa streams in the northwest part of the State. Temperature changes generally reflect air temperature conditions. There is no known thermal pollution on the Iowa portion of the Big Sioux River.

Eutrophication Potential

High levels of both nitrogen and phosphorus are characteristic of the Big Sioux River. Neither nutrient appears to be limiting to algal growth. The Sioux Falls, South Dakota sewage treatment plant discharge provides ample nutrients.

TABLE II-50

PESTICIDES IN THE BIG SIOUX RIVER

PARAMETER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Aldrin	15	1	20	20
Chlordane	13			
DDD	15			
DDE	15			
DDT	15	1	20	20
Dieldrin	15	9	20	50
Endrin	15			
Heptachlor Epoxide	15	1	10	10
Lindane	15	1	10	10
2, 4,-D	14	8	290	940
2, 4, 5-T	14	2	10	10
Silvex	14			
PCB	4			
Parathion	4			
Methyl Parathion	4			
Malathion	4			
Diazinon	4			
Atrazine	15			

If nitrification is used as a wastewater treatment process to convert ammonia nitrogen to nitrate no decrease will be noticed on the nutrient levels. In spite of high nutrient levels algal populations seem to be checked by other limiting factors. The most serious effect of the nutrients is the dissolved oxygen levels created at night by algal respiration. The lowered dissolved oxygen caused by the biochemical oxygen demand is further reduced by algal respiration and may cause additional problems for fish in the stream.

Salinity, Acidity, and Alkalinity

Total dissolved solids concentrations in the Big Sioux River are among the highest of any stream in the State. Total dissolved solids have averaged greater than 750 mg/l (the Iowa Water Quality Standards) and have been found as high as 1300 mg/l. Concentrations tend to decrease toward the mouth of the river. This is probably the result of dilution as the solids concentration in tributary streams is considerably lower than the solids concentration in the main stem.

Chloride concentrations are the highest of any Iowa stream, and follow the same pattern as total dissolved solids. The average chloride concentration in the Big Sioux River is over 125 mg/l, with maximums well over 150 mg/l. While total dissolved solids concentrations are not necessarily detrimental to aquatic life, the chloride concentration may have an impact on aquatic life. Additional study on the complex problems in the Big Sioux River is needed to determine the effect of these salts on aquatic life.

Oxygen Depletion

As stated earlier, dissolved oxygen and ammonia concentrations in the Big Sioux are currently the most critical pollution parameters. Oxygen concentrations in the summer during the day are at or above saturation. No oxygen studies have been undertaken to determine the seriousness of the algal respiration at night.

During the winter period of near complete ice cover dissolved oxygen often violates Iowa Water Quality Standards along the entire stream. This is also true of ammonia concentrations in winter due to the lack of reaeration, or oxygenation, that the river normally receives while flowing. No additional oxidation of the BOD or ammonia is available under ice cover when the oxygen in the water has been used.

While the low dissolved oxygen levels may fail to support fish life during the winter, ammonia nitrogen may become toxic to fish at high levels. Studies conducted by the EPA in 1972 on the Big Sioux found that ammonia concentrations over 1.8 mg/l caused fish kills. The concentration at which ammonia may kill fish depends on the pH, or acidity, of the water. The actual concentration may vary somewhat from time to time. Iowa's Water Quality Standard for ammonia is 2.0 mg/l. As mentioned above, under winter conditions it is not uncommon for ammonia concentrations to violate this standard along the river below Sioux Falls, South Dakota. The average ammonia concentration for 99 samples collected on the Big Sioux, mostly during winter conditions, was over 4 mg/l.

Health Hazards and Aesthetic Degradation

Fecal coliform concentrations in the Big Sioux are generally acceptable. Fecal coliform from the Sioux Falls, South

Dakota treatment plant are diluted sufficiently below the Iowa-Minnesota line to be near federal guidelines (200 bacteria per 100/ml). Concentrations on the Rock River are generally higher and tend to increase levels in the Big Sioux below the confluence. No violations of Iowa Water Quality Standards have been noted.

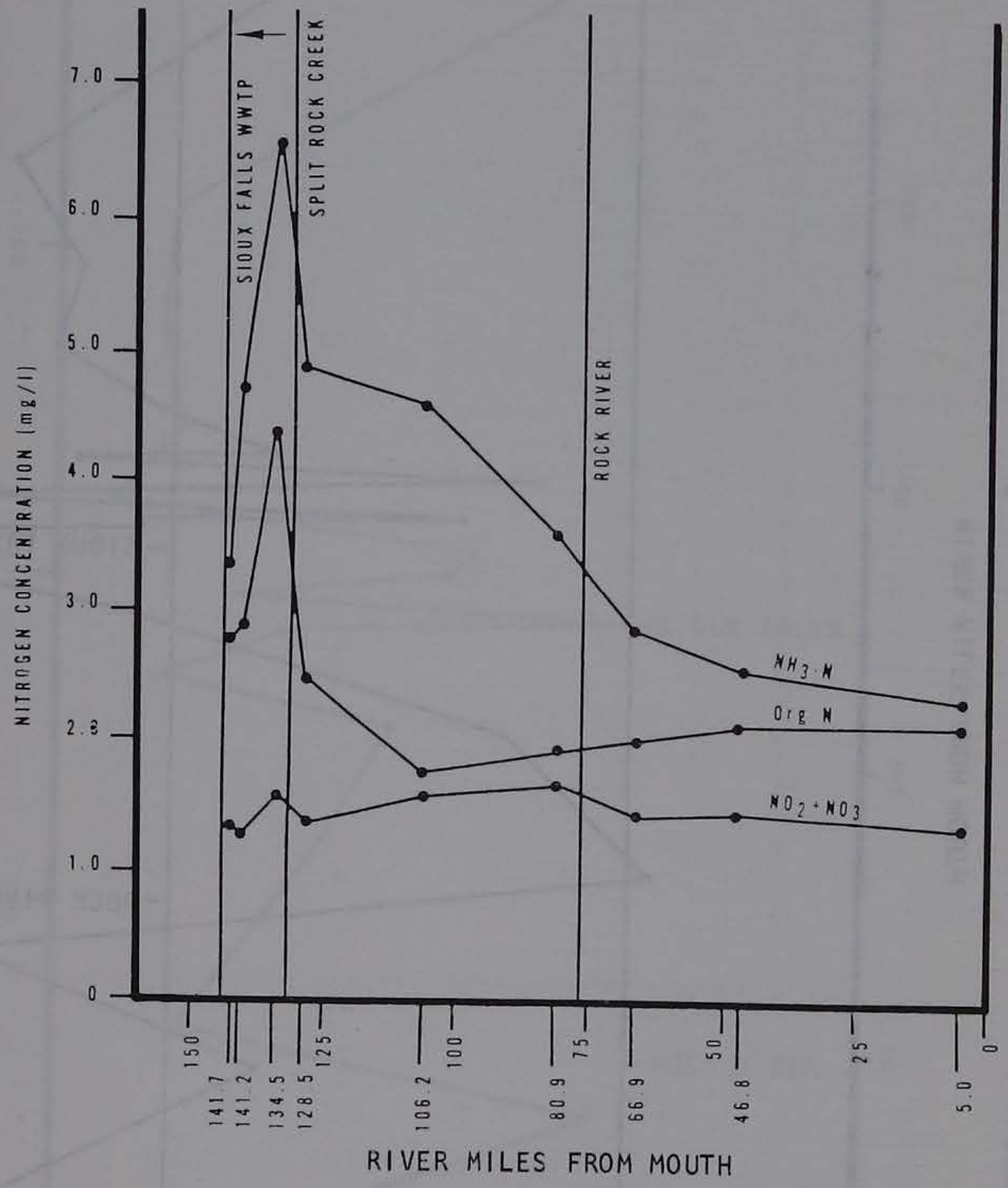


FIGURE 11-134

NITROGEN PROFILE, BIG SIOUX RIVER, ESTELLINE, SOUTH DAKOTA TO SIOUX CITY, IOWA
1-10 FEBRUARY 1973
(ENVIRONMENTAL PROTECTION AGENCY 1973)

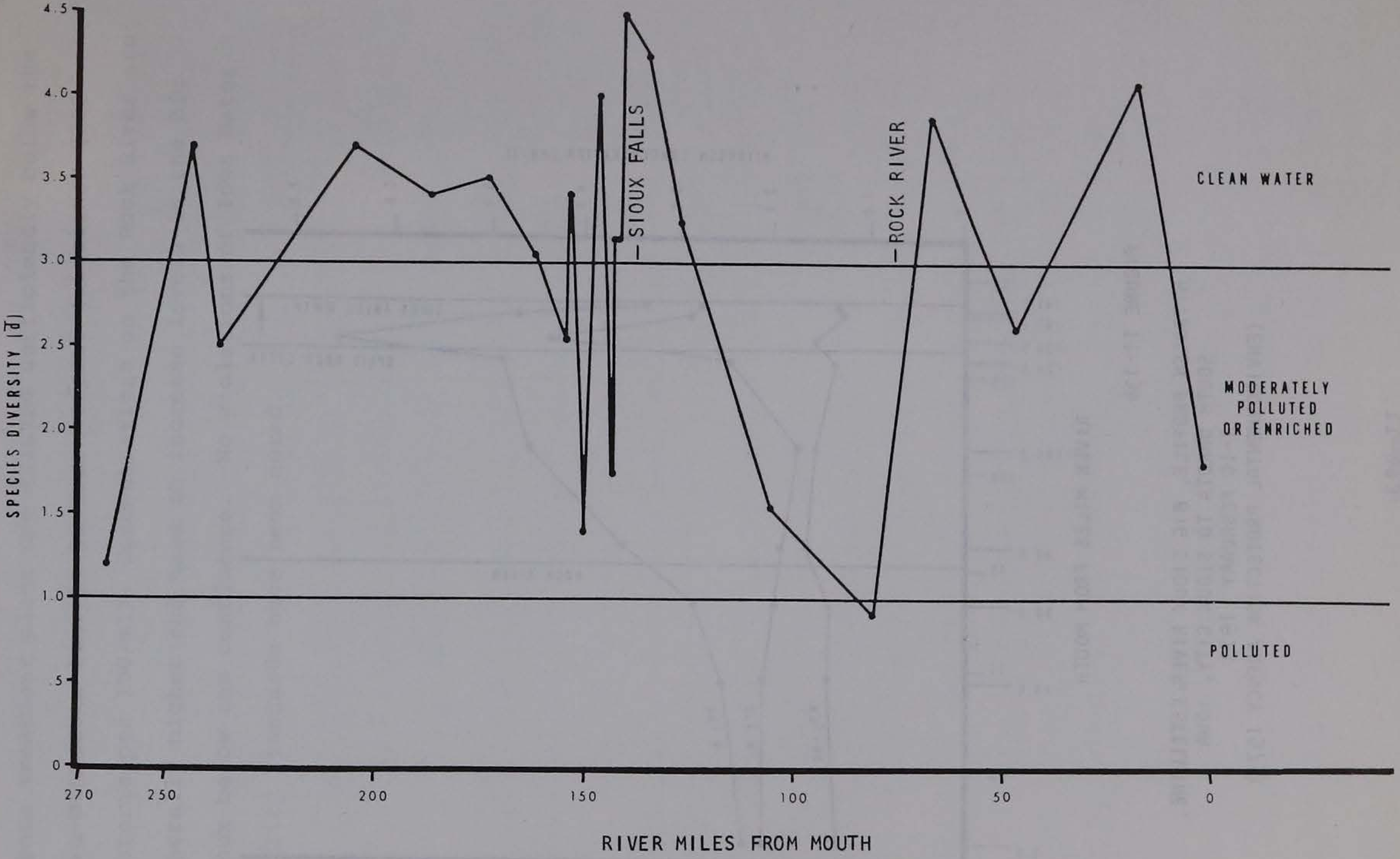


FIGURE 11-135 SPECIES DIVERSITY ($\bar{d}$) OF BENTHIC INVERTEBRATES, BIG SIOUX RIVER, SEPTEMBER-OCTOBER, 1972

(ENVIRONMENTAL PROTECTION AGENCY 1973)

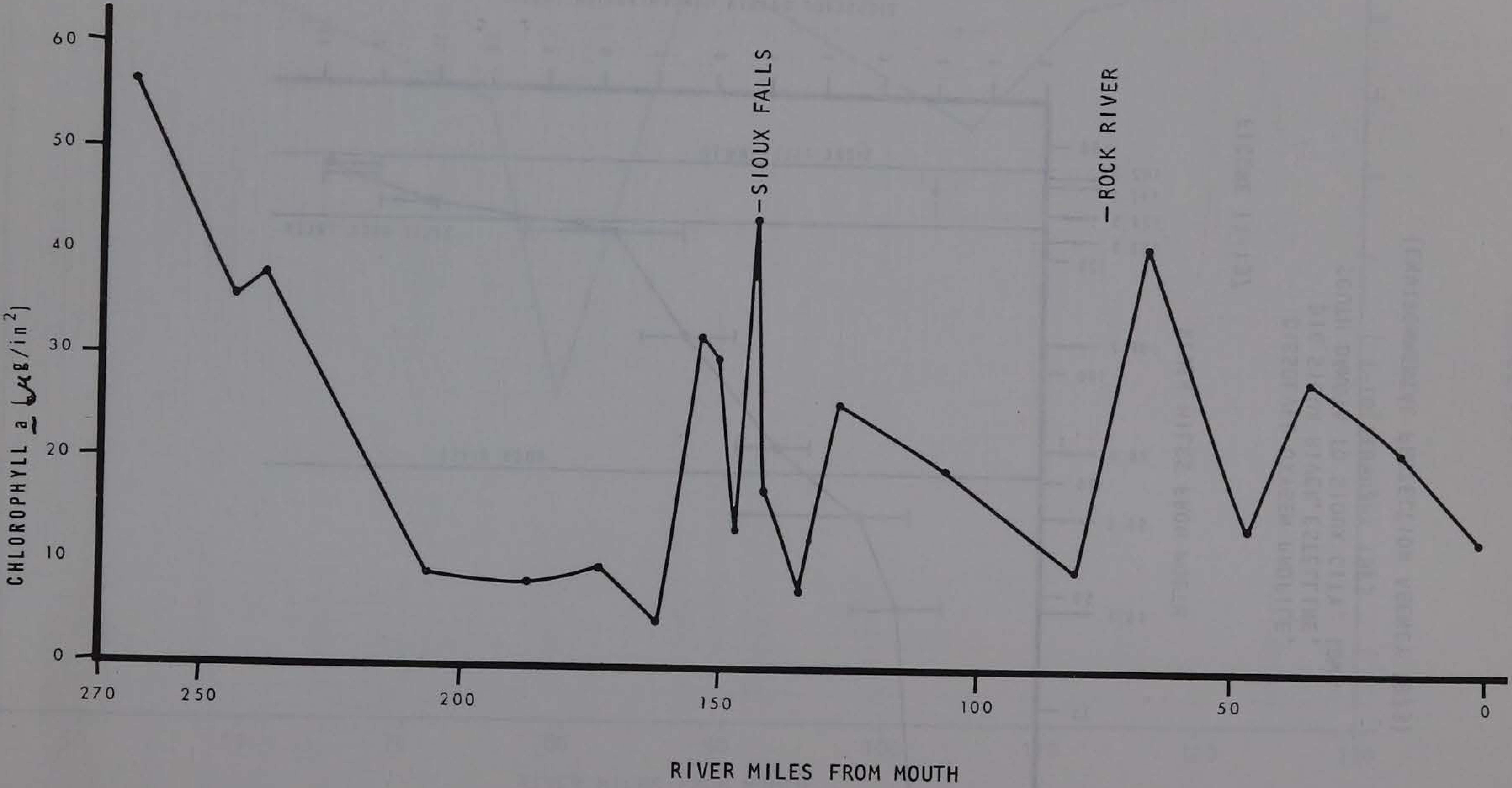


FIGURE 11-136

CHLOROPHYLL a FROM PERIPHYTON, BIG SIOUX RIVER, 10 SEPTEMBER TO 3 OCTOBER 1972

(ENVIRONMENTAL PROTECTION AGENCY 1973)

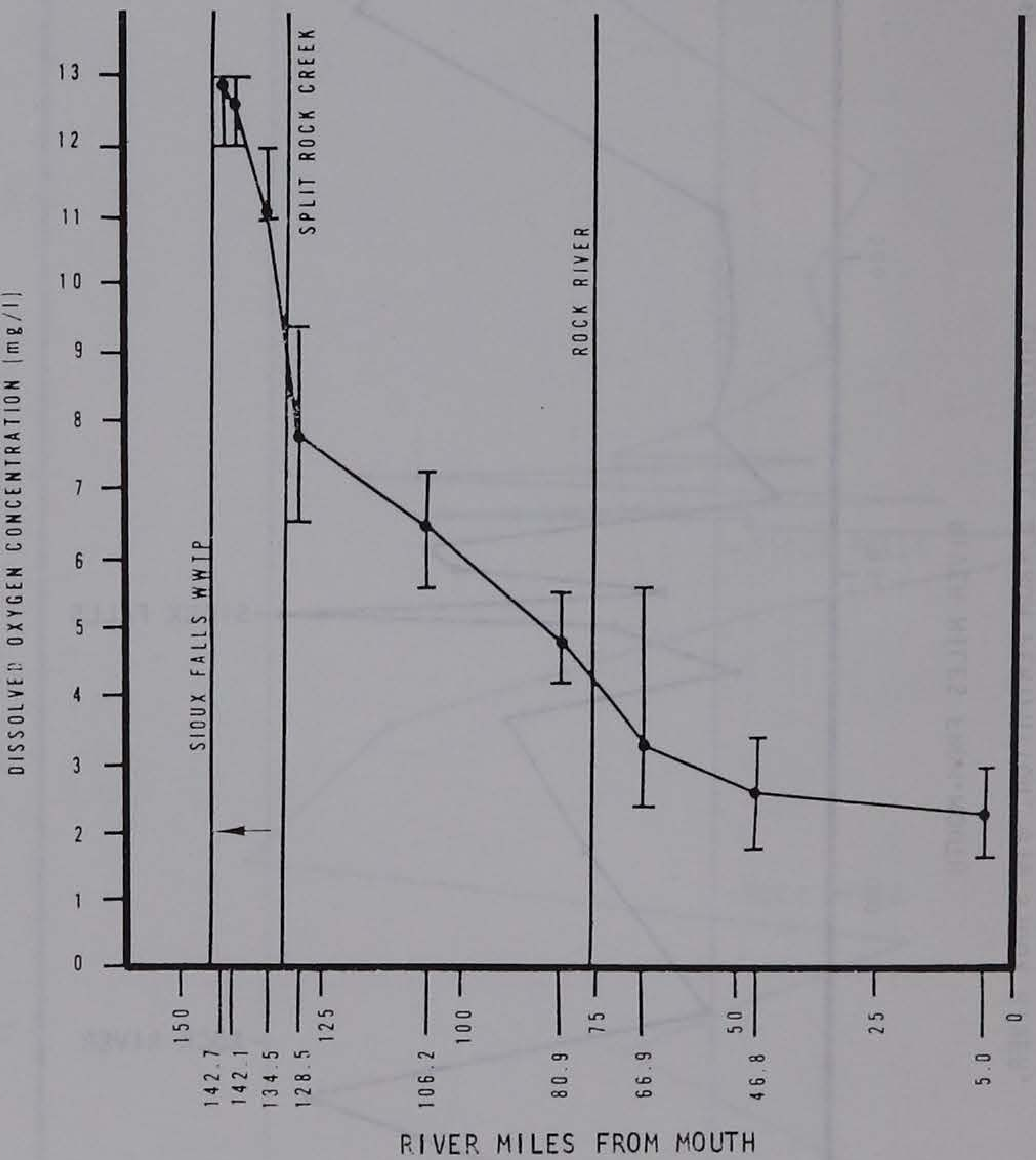


FIGURE 11-137

DISSOLVED OXYGEN PROFILE,
BIG SIOUX RIVER, ESTELLINE,
SOUTH DAKOTA TO SIOUX CITY, IOWA
1-10 FEBRUARY 1973

(ENVIRONMENTAL PROTECTION AGENCY 1973)

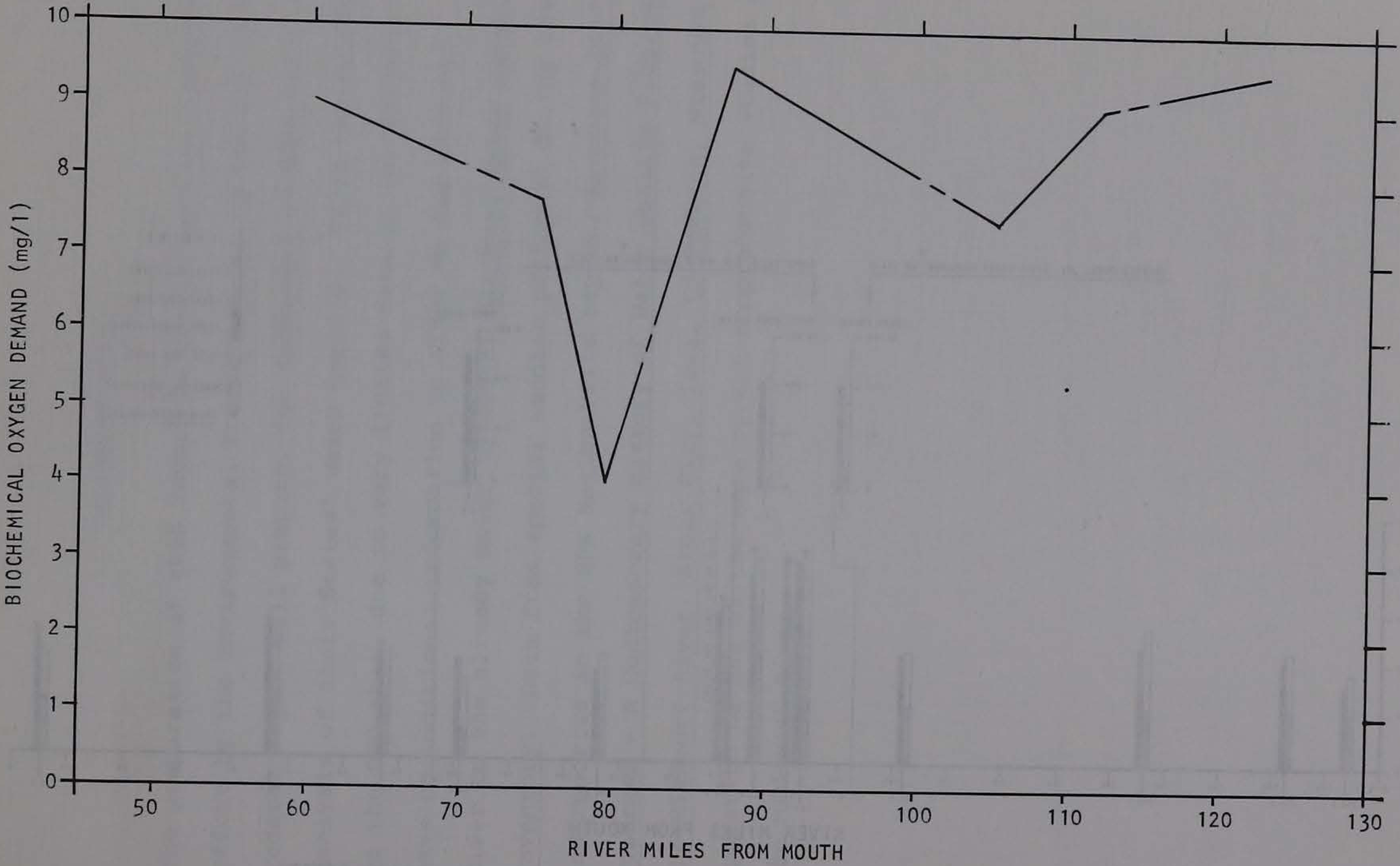


FIGURE 11-138 MEAN BIOCHEMICAL OXYGEN DEMAND CONCENTRATIONS FOR THE BIG SIOUX RIVER, 1970-1974

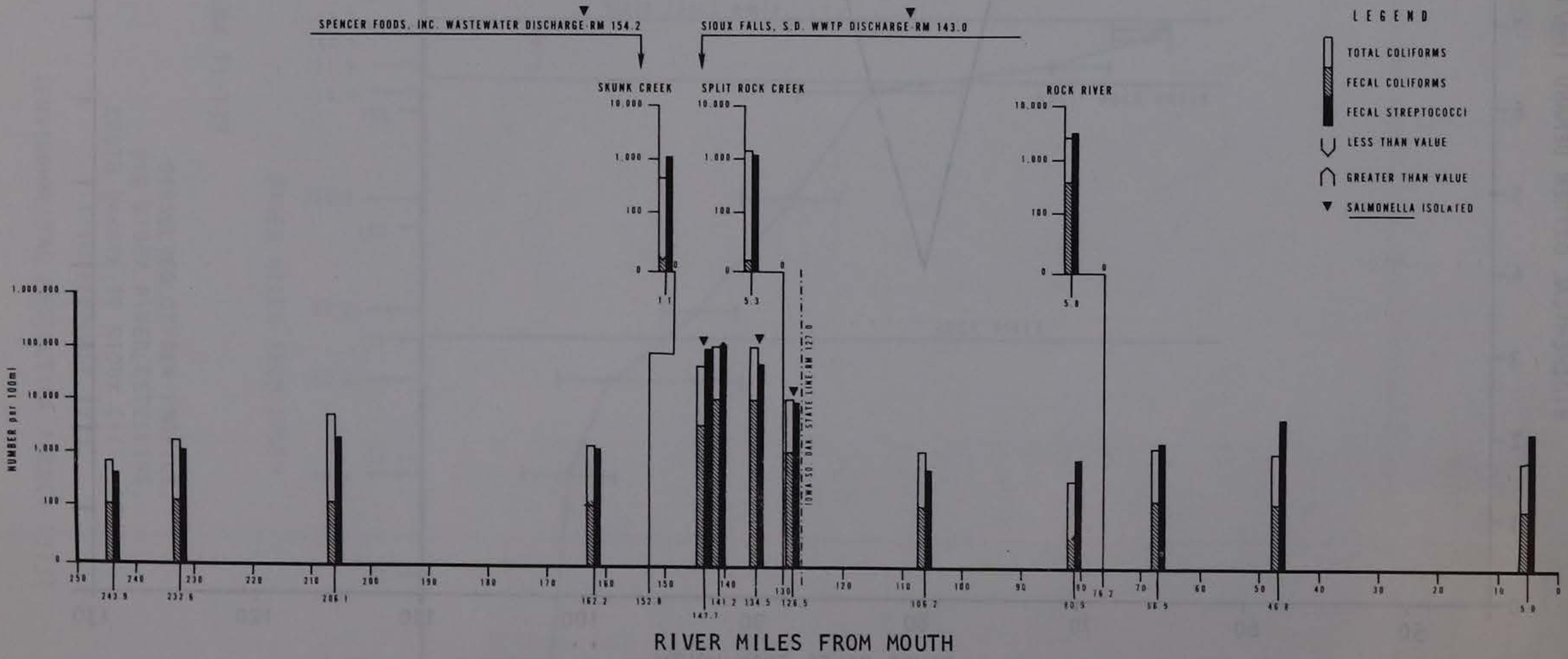


FIGURE 11-139 BACTERIAL DENSITIES (LOGARITHMIC MEAN) BIG SIOUX RIVER, SOUTH DAKOTA, FEBRUARY 1973

(ENVIRONMENTAL PROTECTION AGENCY 1973)

MISSOURI RIVER

The preparation of this report is preliminary to a compositing effort by the Environmental Protection Agency wherein each Federal region will prepare, for submittal to Congress, its analysis of their States' water quality. It is the opinion of the DEQ that, due to very limited data on the subject, we have no additional information to offer on the Missouri River to the already existing 305(a) National Water Quality Inventory. Data from special studies performed during 1968-70 and reported in the EPA Region VII's report, Everyone Can't Live Upstream - A Contemporary History of Water Quality Programs on the Missouri River, Sioux City, Iowa, to Hermann, Missouri appear to be one of the more recent comprehensive studies on the Missouri River.

IOWA LAKES

The State of Iowa has over 275 lakes and reservoirs classified by the Department of Environmental Quality. Of these, 43 are classified for surface water supplies. Only a limited number of these lakes and reservoirs have water quality data available. Of those with data, only a few have received extensive study. Chemical and physical data are presented where available (Tables II-51 through II-64). Those lakes which have been studied rather extensively are discussed in this section. They include the Iowa Great Lakes, Coralville Reservoir, Lake MacBride, Rathbun Reservoir and Blackhawk Lake.

Iowa Great Lakes

The Iowa Great Lakes include Big Spirit Lake, Lake West Okoboji, Lake East Okoboji, Upper Gar Lake, Lower Gar Lake and Lake Minnewashta. They are all located in Dickinson County and comprise the only true lake district in Iowa. Lake West Okoboji is the deepest natural lake in the State (over 120 ft. deep) and Big Spirit is the largest natural lake in the State (5357 acres). Extensive water quality data on these lakes have been collected by Bachmann (1974) (Tables II-55 through II-64). He has found lake West Okoboji to be the least eutrophic of these lakes, and Lower Gar Lake the most eutrophic. He has ranked these lakes in order of decreasing water quality; Lake West Okoboji, Big Spirit Lake, Lake East Okoboji, and Lower Gar Lake.

Algal problems have been reported in all of these lakes. Because of the low algal densities in Lake West Okoboji it probably has the clearest water of any major natural lake in Iowa (Bachmann, 1974).

The most dramatic changes noted in the lakes are the decrease in the number of species of aquatic plant life in East Okoboji, Lake Minnewashta and Gar Lakes, and their replacement by blue-green algae. The number of shellfish species has also dropped in West Okoboji (Bachmann, et al, 1974).

Dissolved oxygen sampling indicates that oxygen deficiencies in the lower depths of West Okoboji have increased 50% since the 1920's (Bachmann, et al, 1974). Most of the recent changes in lake quality can be attributed directly or indirectly to man's activities. During the past fifty years increased row cropping, increased tiling for agricultural drainage, increased confined livestock activity, urban development, canal dredging, shoreline filling, construction of outlet structures, and introduction of sewage have all contributed to the increased eutrophication. Although eutrophic conditions occur in the lakes, there is reason to believe that they have been eutrophic for several thousand years (Bachmann, et al, 1974). Man's activity has merely sped the process along. It is not the objective of environmental control to eliminate eutrophication. The concern instead, is to limit eutrophication to a "natural" rate and eliminate the human influence on lake eutrophication.

Because West Okoboji is the deepest lake, it is likely to be the last lake to be severely altered eutrophically. Efforts to reduce nonpoint pollution will maintain water quality in the Iowa Great Lakes and perhaps reduce the speed of eutrophication in these lakes.

Coralville Reservoir

The Coralville Reservoir is located in Johnson County about three miles north of Iowa City on the Iowa River. At conservation pool level it forms a lake 21.7 miles long with a surface area of 4900 acres and storage of 53,750 acre feet of water. The reservoir was designed primarily for flood control protection of Iowa City and the lower Iowa River valley. It has also achieved some importance as a recreation area close to both the urban areas of Cedar Rapids and Iowa City.

The water quality of Coralville Reservoir is directly effected by water quality in the Iowa River which has been discussed previously. Water quality problems in the Iowa River are mirrored in the reservoir. This has created an eutrophic situation within the reservoir due to the physical characteristics of the impoundment and the nutrients entering the lake, primarily associated with runoff (McDonald, 1972).

Although agricultural activities are the main cause of the induced eutrophication, the runoff also aids in inhibiting algal blooms. The large volumes of silt carried by the river results in high turbidities. Algal populations have been found to generally decrease during this time, although ample nutrients were present and temperatures favorable (McDonald, 1972).

The operation of Coralville Reservoir as a flood control structure also has a significant impact on water quality. The rapid fluctuations in water level have tended to minimize the magnitude of nuisance algal blooms. Large numbers of both green and blue-green algae have been found and blooms of a nuisance nature have occurred. These blooms are generally associated with the maintenance of high water levels for an extended period providing many shallow nearshore areas. This seems to create conditions optimal for large blooms, and has created numerous problems. For the most part, however, water levels have fluctuated so much that nuisance algal blooms have not been that widespread (McDonald, 1972). Little improvement in water quality in the reservoir can be expected before vast improvement of water quality in the Iowa River is achieved.

Lake MacBride

Lake Macbride is located in Johnson County just north of Iowa City. Discharge from Lake MacBride enters the Coralville Reservoir. Lake MacBride is an impoundment originally built in 1926, and enlarged to its present size in the mid 1950's. Prior to enlargement numerous problems associated with agricultural runoff of silt and nutrients occurred.

Numerous algal blooms occurred creating unpleasant conditions at many times. After enlargement of the lake in the 1950's, the magnitude of these problems decreased due to the larger dilution volume available. Silt and nutrient input have continued but have not caused problems similar to pre-enlargement. In recent years development around the lake has increased rapidly. The Cottage Reserve treatment plant was built to handle human waste from the lakeside population and the effluent was pumped under the lake to the Coralville Reservoir area. It was not until several years ago that it was determined that leaks within the effluent pipe were contributing significant organic, bacterial, and nutrient loading to the lake. This contributed to weed and algal problems in the lake. The treatment plant effluent pipe is no longer discharging waste water into the lake, however, continued agricultural runoff still create algal blooms in the upper arms of the lake. Siltation also remains a problem. In addition, thermal stratification during summer months causes oxygen levels below the thermocline to reach zero. This has created additional problems for aquatic life. Work is continuing in efforts to abate agricultural runoff into the Lake MacBride drainage basin. In the interim turbidity, siltation, organic matter, bacteria, and nutrients continue to be problems particularly during runoff.

TABLE II-51

LAKE MACBRIDE WATER QUALITY

PARAMETER	AVERAGE	MAXIMUM	MINIMUM	NUMBER OF OBSERVATIONS
Ammonia Nitrogen (mg/l)	0.51	4.16	.03	22
Kjeldahl Nitrogen (mg/l)	1.25	4.60	.70	22
Nitrate/Nitrite (mg/l)	1.31	3.50	.04	22
Total Phosphate (mg/l)	0.07	.13	.02	22
Orthophosphate (mg/l)	0.01	.015	.006	22
Chlorophyll A	17.06	46.40	4.70	9
Secchi Disc Transparency (inches)	41.55	72.0	14.0	9
Depth of Lake (Feet)	24.66	45.0	12.0	9

Blackhawk Lake

Blackhawk Lake is located near Lake View in Sac County. It is a natural lake of glacial origin. It has a surface area of 957 acres and an average depth of between six and seven feet. Inlet creek is the only tributary to the lake and has a drainage area of about 19 square miles.

Blackhawk Lake can be classified as a eutrophic lake. A number of problems appear to contribute to its' eutrophication. The shallowness of the lake keeps nutrients that would settle out mixed and constantly exposed to aquatic vegetation. Nutrients present in the lake are such that algal blooms can be expected each year. Flow through the lake is minimal and reduces the chance for flushing the nutrient rich water from the lake. Sources of pollution to Blackhawk Lake appear to be runoff from nonpoint sources into Inlet Creek and unknown direct discharges of sewage into the lake. Considerable work in determining and removing point source pollution, and more widespread use of soil conservation practices are necessary to begin any improvement in water quality at Blackhawk Lake.

Rathbun Reservoir

Lake Rathbun Dam is located in South Central Iowa about six miles north of Centerville. Rathbun Lake, located near the headwaters of the Chariton River, controls 549 square miles of drainage area. At conservation pool the reservoir has a length of eleven miles, a surface area of about 11,000 acres, and 180 miles of shoreline.

Water quality problems in Rathbun Lake originate for the most part from a few basic conditions inherent in the Chariton River basin and the morphology of Rathbun Lake. These are (1) high turbidity, (2) high nutrient input, and (3) regular temperature stratification with oxygen depletion in the lower strata. Temperature stratification exists yearly from June through August or September. The high nutrient content is derived from sewage treatment plant effluents entering the Chariton River and agricultural runoff in the upstream drainage basin. These nutrients stimulate heavy seasonal algae and macrophyte growth which creates a large BOD load on the lake in addition to that which emanates naturally from the vegetation adjacent to the lake and river. In conjunction with summer stratification, this BOD brings about oxygen depletion in the lowest depth of the lake and subsequently anaerobic decomposition. Low oxygen throughout the hypolimnion severely restricts populations of fish food organisms as well as fish habitat. In addition, byproducts of any anaerobic decomposition occuring near the lake floor create toxic conditions for fish and other aquatic life downstream. In addition, odors are created that are aesthetically unpleasant in the outlet area. Turbidity further aggravates the water quality situation by limiting the penetration of light which in turn effects oxygen production. Underwater visibility in swimming areas is also reduced.

TABLE II-52

RATHBUN RESERVOIR WATER QUALITY

PARAMETER	AVERAGE	MAXIMUM	MINIMUM	NUMBER OF OBSERVATIONS
Ammonia Nitrogen (mg/l)	0.031	0.10	0.02	44
Kjeldahl Nitrogen (mg/l)	0.68	1.50	0.40	44
Nitrate/Nitrite (mg/l)	1.08	1.34	0.65	44
Total Phosphate (mg/l)	0.05	0.12	0.03	44
Orthophosphate (mg/l)	0.007	0.017	0.005	44
Chlorophyll A (mg/l)	12.02	38.80	0.10	18
Secchi Disc Transparency (Inches)	34.1	36.0	2.0	18
Depth of Pond (Feet)	30.8	45.0	22.0	18

In spite of these problems, Lake Rathbun is the most attractive large reservoir in the State for recreation and has probably the best water quality of the large reservoirs. The algal problems, while present, are not as great as in most Iowa lakes.

TABLE II-53

CHEMICAL COMPOSITION OF IOWA LAKES (BACHMANN, 1965)

LAKE	SPECIFIC CONDUCTANCE (μmhos)	ALKALINITY (mg/l as $CaCO_3$)	TOTAL HARDNESS (mg/l as $CaCO_3$)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	CHLORIDE (mg/l)	SULFATE (mg/l)
Allerton Res.	186	63	76	23	5	2.4	23
Ahquabi Lake	240	105	109	29	9	3.9	13
Backbone Lake	358	153	181	42	19	5.0	33
Beeds Lake	370	164	184	37	22	6.4	29
Big Spirit Lake	491	208	243	36	37	6.1	56
Big Wall Lake	314	156	146	37	13	3.8	5
Blackhawk Lake	430	153	206	37	27	1.9	61
Centerville Res.	334	97	142	41	9	6.6	66
Center Lake	437	241	227	29	38	10.4	5
Clear Lake	306	143	146	23	22	7.8	13
Coralville Res.	380	145	178	42	17	7.6	43
Cornelia Lake	403	190	194	33	27	7.8	19
Crystal Lake	337	153	174	41	18	7.9	20
Dan Green Slough	535	254	283	68	28	2.0	34
Dead Man's Lake	61	26	29	7	3	0.7	2
Delhi Lake	143	67	65	15	7	2.4	4
East Okoboji	452	209	221	34	33	7.7	31
East Osceola Res.	363	97	113	31	9	39.8	19
East Twin Lake	314	128	171	41	17	8.4	38
Elk Cr. Refuge	535	234	286	69	28	10.8	45
Elk Lake	322	112	148	20	24	2.7	45
Five Islands Lake	327	136	151	28	20	14.9	14
Green Valley	243	93	105	29	8	3.6	25
High Lake	582	114	273	36	45	10.8	172
Ingham Lake	653	117	317	51	46	11.0	211
Iowa Lake	430	179	214	42	26	10.2	41
Lake MacBride	246	97	111	27	11	5.4	23
Lake Keomah	213	88	95	23	9	5.2	19

TABLE II-53 (CONTINUED)

LAKE	SPECIFIC CONDUCTANCE (μmhos)	ALKALINITY (mg/l as $CaCO_3$)	TOTAL HARDNESS (mg/l as $CaCO_3$)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	CHLORIDE (mg/l)	SULFATE (mg/l)
Lake of Three Fires	172	71	79	23	5	1.8	12
Lake Wapello	212	66	92	26	7	2.1	37
Little Wall Lake	508	250	256	40	38	3.1	17
Lizzard	365	144	173	21	30	9.3	45
Lost Island	480	224	240	29	41	1.9	36
Maffit Res.	309	135	141	31	16	6.2	25
Minnewashta	494	210	232	39	33	7.1	42
Mr. Ayr Res.	229	100	103	31	6	2.9	15
Mud Lake	602	243	314	58	41	2.5	81
North Twin Lake	458	138	218	34	32	3.5	58
Pickerel Lake	320	153	167	32	21	1.4	25
Pilot Knob Lake	176	53	53	17	3	1.5	5
Prairie Rose Lake	332	150	152	38	14	5.1	12
Pine Lake	266	121	121	20	17	4.8	13
Rice Lake	239	127	135	33	13	5.6	6
Red Haw Lake	234	65	99	27	7	3.4	45
Rock Creek Lake	289	125	140	36	12	4.0	26
Silver Lake	588	114	276	46	39	6.9	26
Silver Lake	448	177	228	44	29	2.2	104
Silver Lake	271	125	130	24	17	7.8	18
Smiths Slough	522	203	257	41	38	2.4	65
Spring Lake	369	110	170	21	29	3.4	62
Storm Lake	541	136	236	47	29	5.3	108
Summit Lake	259	100	115	32	8	4.4	27
Swan Lake	341	144	159	33	19	1.8	28
Thayer Lake	191	81	88	26	6	4.8	13
Trumbull Lake	404	162	192	21	34	3.1	64
Tuttle Lake	513	154	245	50	30	12.6	101
Twin Sisters Lake	257	93	102	21	12	10.1	20
Union Grove Lake	318	133	145	34	15	4.2	24
Viking Lake	221	102	101	27	8	2.8	10

TABLE II-53 (Continued)

LAKE	SPECIFIC CONDUCTANCE (µmhos)	ALKALINITY (mg/l as $CaCO_3$)	TOTAL HARDNESS (mg/l as $CaCO_3$)	CALCIUM (mg/l)	MAGNESIUM (mg/l)	CHLORIDE (mg/l)	SULFATE (mg/l)
Virgin Lake	336	168	171	19	30	1.8	18
West Okoboji	421	199	205	27	34	6.2	29

TABLE II-54

IOWA LAKE WATER QUALITY

LAKE	AMMONIA NITROGEN (mg/1)	TOTAL PHOSPHATE (mg/1)	NITRATE (mg/1)	ORTHO-PHOSPHATE (mg/1)	CHLOROPHYLL A (mg/1)	SECCHI DISC TRANSPARENCY (Inches)
Lake Ahquabi	0.07	0.05	0.08	0.0095	35.71	
Clear Lake	0.09	0.04	0.18	0.01	17.39	34.87
Lake Darling	0.07	0.08	1.39	0.01	13.81	17.5
Lost Island Lake	0.12	0.14	0.07	0.01	36.1	78.83
Lake MacBride	0.51	0.07	1.31	0.01	17.06	41.55
Rathbun Reservoir	0.031	0.05	1.08	0.007	34.8	29
Red Rock Lake	0.067	0.214	5.06	0.105	15.09	26.49
Spirit Lake[2]	0.239	0.041	0.017	0.007	27.5	66.3
West Lake Okoboji[2]	0.110	0.033	0.009	0.027	4.28	124.8
Tuttle Lake	0.091	0.263	0.089	0.055	86.39	9
Rock Creek Lake	0.105	0.067	1.63	0.006		
Little Wall Lake	0.46	0.09	0.05		24.72	15.6[1]
Big Wall Lake	0.71	0.79	0.07		12.35	
Lake Cornelia	0.44	0.12	0.07		29.69	23.4[1]
Beeds Lake	0.36	0.11	1.54		80.29	42.9[1]
Pine Lake	0.38	0.25	0.21		92.53	70.2[1]
Coralville Res.	0.321		1.11			
Blackhawk Lake	0.42	0.207	3.33	0.157	134.4[1]	11.7[1]
East Lake Okoboji[2]	0.468	0.165	0.085		122.2	35.1
Lower Gar Lake[2]	0.644	0.222	0.145		226.8	15.6
Center Lake[1]	0.084				81.2	19.0
Big Creek Res.[1]	0.0345				9.0	93.6
Don Williams Res.[1]	0.024				15.3	58.0
McFarland Res.[1]	0.050				40.2	39.0
Hickory Grove Res.[1]	0.028				12.6	62.4
Spring Lake[1]	0.019				7.4	42.9
Storm Lake[1]	0.066				48.8	15.6
Trumbell Lake[1]	0.104				53.6	15.6

TABLE II-54 (CONTINUED)

LAKE	AMMONIA NITROGEN (mg/l)	TOTAL PHOSPHATE (mg/l)	NITRATE (mg/l)	ORTHO-PHOSPHATE (mg/l)	CHLOROPHYLL A (mg/l)	SECCHI DISC TRANSPARENCY (Inches)
High Lake[1]	0.130				227.3	9.75
Ingham Lake[1]	0.088				63.4	19.0
Five Island Lake[1]	0.073				57.3	21.45
No. Twin Lake[1]	0.053				76.6	19.0

[1] Jones, Personal Communication

[2] Bachmann, et al, 1974

TABLE II-55

Mean Chlorophyll *a* (mg/m^3) values from West Okoboji (Bay Stations), West Okoboji (Deep Hole), East Okoboji (North Stations), East Okoboji (South Stations), Spirit Lake, Upper Gar, Minnewashta, Lower Gar, and Loon Lake (at 4.3 in 1971 and 4.0 in 1972), summarized by seasons between June 1971 and September 1973. N = the number of samples in the mean.[1]

Period	W. Okoboji B. Stations	W. Okoboji Deep Hole	E. Okoboji North	E. Okoboji South
June-Sept. 1971	(41) 5.63	(5) 5.70	(36) 207.21	(23) 132.45
Oct. Nov. 1971	(9) 4.35	(2) 2.96	(6) 99.40	(11) 12.38
Jan.-May 1972	(15) 1.74	(4) 1.79	(11) 12.38	(4) 2.65
June-Sept. 1972	(59) 4.76	(10) 3.42	(43) 142.19	(30) 72.82
Oct.-Nov. 1972	(19) 4.86	(2) 4.62	(9) 97.76	(9) 36.84
Dec.-May 1973	(21) 5.29	(11) 3.94	(16) 8.51	(23) 15.04
June-Sept. 1973	(48) 4.20	(16) 3.43	(22) 51.21	(34) 79.82

TABLE II-55 (Continued)

Period	Spirit Lake	Upper Gar	Minnewashta	Lower Gar	Loon Lake
June-Sept. 1971	(18) 57.89	(13) 135.06	(13) 160.86	(11) 338.54	(3) 177.24
Oct.-Nov. 1971	(4) 128.12	(1) 11.23	(1) 3.76	(2) 4.15	-
Jan.-May 1972	(13) 1.36	(2) 2.66	(2) 0.70	(2) 2.87	(1) 7.04
June-Sept. 1972	(52) 9.79	(13) 93.31	(13) 74.85	(13) 123.41	(5) 227.90
Oct.-Nov. 1972	(10) 5.22	(3) 31.57	(2) 60.64	(1) 79.84	(2) 107.51
Dec.-May 1973	(35) 6.22	(6) 16.72	(5) 22.69	(5) 25.16	(14) 53.07
June-Sept. 1973	(55) 12.12	(9) 56.31	(8) 83.95	(8) 148.70	(2) 148.4

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[1] Bachmann, et al, (1974)

TABLE II-56

Mean and range of Silica Measurements (mg/l SiO_2) made on Lake West Okoboji, Lake East Okoboji, Spirit Lake, Upper Gar Lake, Lake Minnewashta, and Lower Gar Lake between August 1971 and September 1973[1].

Lake	Mean	Range
Lake West Okoboji	6.0	1.5 - 12.9
Lake East Okoboji	16.3	0.0 - 48.0
Spirit Lake	10.6	1.3 - 57.0
Upper Gar Lake	17.4	0.9 - 52.0
Lake Minnewashta	16.1	4.3 - 37.0
Lower Gar Lake	19.2	0.2 - 58.0

[1] Bachmann, et al, (1974)

TABLE II-57

Mean seasonal concentration of total phosphorus, orthophosphate phosphorus, nitrate nitrogen and ammonia nitrogen (mg/l) in Lake West Okoboji between March 1971 and September 1973.[1]

Season	Mean Total Phosphorus (mg/l)	Mean Orthophosphate Phosphorus (mg/l)	Mean Nitrate Nitrogen (mg/l)	Mean Ammonia Nitrogen (mg/l)
June-Sept. 1971, 1972, 1973	0.033	0.010	0.009	0.110
Oct.-Nov. 1971, 1972	0.049	0.028	0.043	0.231
Dec.-May 1971, 1972, 1973	0.032	0.021	0.043	0.178

TABLE II-58

Mean seasonal concentration of total phosphorus, orthophosphate phosphorus, nitrage nitrogen, and ammonia nitrogen (mg/l) in Lake East Okoboji between March 1971 and August 1972.[1]

Season	Mean Total Phosphorus (mg/l)	Mean Orthophosphate Phosphorus (mg/l)	Mean Nitrate Nitrogen (mg/l)	Mean Ammonia Nitrogen (mg/l)
June-Sept. 1971, 1972, 1973	0.165	0.054	0.085	0.468
Oct.-Nov. 1971, 1972	0.212	0.092	0.163	0.683
Dec.-May 1971, 1972, 1973	0.207	0.130	0.431	0.881

[1] Bachmann, et al, (1974)

TABLE II-59

Mean seasonal concentration of total phosphorus, orthophosphate phosphorus, nitrate nitrogen and ammonia nitrogen (mg/l) in Lake West Okoboji between March 1971 and September 1973. [1]

Season	Mean Total Phosphorus (mg/l)	Mean Orthophosphate Phosphorus (mg/l)	Mean Nitrate Nitrogen (mg/l)	Mean Ammonia Nitrogen (mg/l)
June-Sept. 1971, 1972, 1973	0.033	0.010	0.009	0.110
Oct.-Nov. 1971, 1972	0.049	0.028	0.043	0.231
Dec.-May 1971, 1972, 1973	0.032	0.021	0.043	0.178

TABLE II-60

Mean seasonal concentration of total phosphorus, orthophosphate phosphorus, nitrage nitrogen, and ammonia nitrogen (mg/l) in Lake East Okoboji between March 1971 and August 1972. [1]

Season	Mean Total Phosphorus (mg/l)	Mean Orthophosphate Phosphorus (mg/l)	Mean Nitrate Nitrogen (mg/l)	Mean Ammonia Nitrogen (mg/l)
June-Sept. 1971, 1972, 1973	0.165	0.054	0.085	0.468
Oct.-Nov. 1971, 1972	0.212	0.092	0.163	0.683
Dec.-May 1971, 1972, 1973	0.207	0.130	0.431	0.881

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[1] Bachmann, et al, (1974)

TABLE II-61

Mean and standard error of the mean values for total hardness, calcium hardness, alkalinity and chloride measurements made on the Iowa Great Lakes between August 17, 1971 and July 20, 1973.[1]

Lake	N	Total Hardness mg/l CaCO$_3$	N	Calcium Hardness mg/l CaCO$_3$	N	Alkalinity mg/l CaCO$_3$	N	Chloride mg/l
West Okoboji	62	212.0 ± 2.2	45	75.6 ± 1.3	45	203.6 ± 0.8	62	7.8 ± 0.1
East Okoboji	52	228.9 ± 6.3	37	110.1 ± 4.5	52	210.0 ± 4.9	47	10.6 ± 0.2
Spirit Lake	45	225.7 ± 2.6	45	87.1 ± 1.9	45	180.6 ± 3.0	44	9.1 ± 0.1
Upper Gar	6	221.9 ± 22.7	4	107.7 ± 20.3	6	202.7 ± 14.3	6	10.4 ± 0.4
Minnewashta	7	221.4 ± 16.0	5	117.4 ± 16.1	7	200.3 ± 9.8	7	10.4 ± 0.3
Lower Gar	6	229.4 ± 35.4	4	124.5 ± 24.1	6	210.6 ± 25.6	6	10.4 ± 0.4

[1] Bachmann, et al, (1974)

TABLE II-62

Mean values of total hardness, calcium hardness, alkalinity and chloride measurements made on West Okoboji, East Okoboji, Spirit Lake, and Lake Minnewashta collected in past work.[1]

Lake and Collector	Total Hardness mg/l $CaCO_3$	Calcium Hardness mg/l $CaCO_3$	Alkalinity mg/l $CaCO_3$	Chloride mg/l
East Okoboji Volker (1962)	210.7	84.5	198.7	10.4
West Okoboji Stoermer (1963)	220.6	83.2	216.5	12.1
West Okoboji Bachmann (1965)	205.0	-	199.0	6.2
East Okoboji Bachmann (1965)	221.0	-	209.0	7.1
Spirit Bachmann (1965)	243.0	-	208.0	6.1
Minnewashta Bachmann (1965)	232.0	-	210.0	7.1
Miller Bay West Okoboji Cooke (1966a)	210.0	65.0	200.0	-
West Okoboji Hostetter & Stoermer (1968)	206.5	-	195.5	-
Spirit March 1970 to 1971 Krohn	256.7	89.6	188.6	10.9
West Okoboji Lang (1970)	-	-	228.9	-
West Okoboji Gale et al (1972)	232.0	-	212.0	-
East Okoboji Gale et al (1972)	248.0	-	218.0	-

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[1] Bachmann, et al, (1974)

TABLE II-63

Mean chemical oxygen demand values (mg/l O_2) from Lake West Okoboji (Bay Stations), Lake West Okoboji (Deep Hole), Lake East Okoboji (North Stations, 55 and 55.1), Lake East Okoboji (South Stations, 56 to 57), Spirit Lake, Upper Gar Lake, Lake Minnewashta, and Lower Gar Lake summarized by seasons between June 1971 and September 1973. N = the number of samples in the mean.[1]

COD	Lake West Okoboji Bay Stations N	Lake West Okoboji Deep Hole N	Lake East Okoboji N Stations N	Lake East Okoboji S Stations N	Spirit Lake N	Upper Gar Lake N	Lake Minnewashta N	Lower Gar Lake N
Aug.-Sept. 1971	(50)20.9	(27)20.6	(15)62.0	(23)42.9	(15)24.5	(6)60.6	(6)48.5	(6)71.6
Oct.-Nov 1971	(20)21.2	(16)22.2	(8)46.3	(12)44.4	(13)31.9	(4)54.0	(4)42.8	(4)43.4
Jan.-May 1972	(44)20.8	(50)19.8	(17)34.7	(28)29.2	(31)25.4	(7)27.9	(10)26.7	(9)27.7
June-Sept. 1972	(54)20.9	(37)20.2	(24)59.9	(33)43.3	(70)24.0	(10)50.3	(10)38.9	
Oct.-Nov. 1972	(22)21.9	(16)20.7	(8)62.9	(16)34.6	(20)25.4	(6)41.1	(4)38.5	(4)48.8
Dec.-May 1973	-	(51)19.4	(8)37.8	(22)32.5	(36)27.5	(4)31.0	(3)28.1	(3)29.6
June-Sept. 1973	-	(56)20.2	(14)36.0	(25)34.8	(30)26.2	(5)35.5	(5)36.4	(5)45.3

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[1] Bachmann, et al, (1974)

TABLE II-64

Morphometric characteristics of each major lake in the Iowa Great Lakes Watershed.[1]

	West Okoboji	East Okoboji	Spirit Lake	Lower Gar	Minnewashta	Upper Gar	Little Spirit	Hottes Lake	Marble Lake	Loon Lake
Lake Area (ha)	1540	764	2168	98.1	47.3	14.1	292	126	71	291
Lake Volume ($1x10^6m^3$)	184.0	21.24	111.92	1.06	1.20	0.15	7.12	1.89	1.06	4.49
Mean Depth (M)	11.9	2.78	5.16	1.08	2.56	1.06	2.43	1.5	1.5	1.54

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[1] Bachmann, et al, (1974)

GROUNDWATER QUALITY[1]

Dissolved Solids

The better quality waters in Iowa are those containing less than 500 mg/l (milligrams per liter) of dissolved solids. These waters are almost always of the calcium bicarbonate or calcium magnesium bicarbonate type. Waters containing from 500 to 1,000 mg/l of dissolved solids are considered to be of fair quality. In some areas, ground water with concentrations of up to 1,500 mg/l is used extensively, and is considered to be acceptable. These waters usually grade from calcium magnesium to the sodium type and from bicarbonate to sulfate or sulfate chloride type in areas where the dissolved solids content increases.

Unconsolidated alluvial aquifers are present along most major stream courses in Iowa. These sands and gravels offer a source of good-to-fair quality water in many areas where the underlying bedrock aquifers contain highly mineralized water. The quality of the water from the alluvial aquifers is quite variable. It is difficult to delineate areas where dissolved solids fall within a particular range. Often there will be as much of a variation within one well field as there is from several locations along any particular valley. The quality depends a great deal on the thickness of the aquifer, the depths of the wells, the underlying

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[1] Portions of these sections were taken from Coble, R.W. 1970. "The Chemical Quality of Iowa's Water Resources; Water Resources of Iowa, University Printing Service, Iowa City, Iowa.

aquifer or aquiclude, and whether the water is coming from storage, induced infiltration, or from local precipitation. The climatic conditions often have much to do with the quality. Generally, water containing less than 500 mg/l of dissolved solids can be found in the alluvial aquifers (Figure II-140). The water at one well field may range from 300 to 700 or 400 to 800 mg/l, but in the areas shown on the map as having less than 500 mg/l of dissolved solids a lower value can be obtained even though some water with higher values is present. The only areas having dissolved solids generally greater than 1,000 mg/l are in the northwest along the Little Sioux and the Little Rock Rivers. All alluvial waters in Iowa are of the calcium bicarbonate or calcium magnesium bicarbonate type except in the reaches where the dissolved solids concentrations are more than 1,000 mg/l. These waters are of the calcium sulfate type.

The major bedrock aquifers in Iowa are the Dakota Sandstone, Mississippi limestones and dolomites, Silurian-Devonian limestones and dolomites, and the Jordon Sandstone and associated dolomites.

The Dakota Sandstone of Cretaceous age is the major bedrock aquifer in western and northwestern Iowa. It covers more than twenty percent of the State, but its dissolved solids concentration is below 500 mg/l in less than five percent of

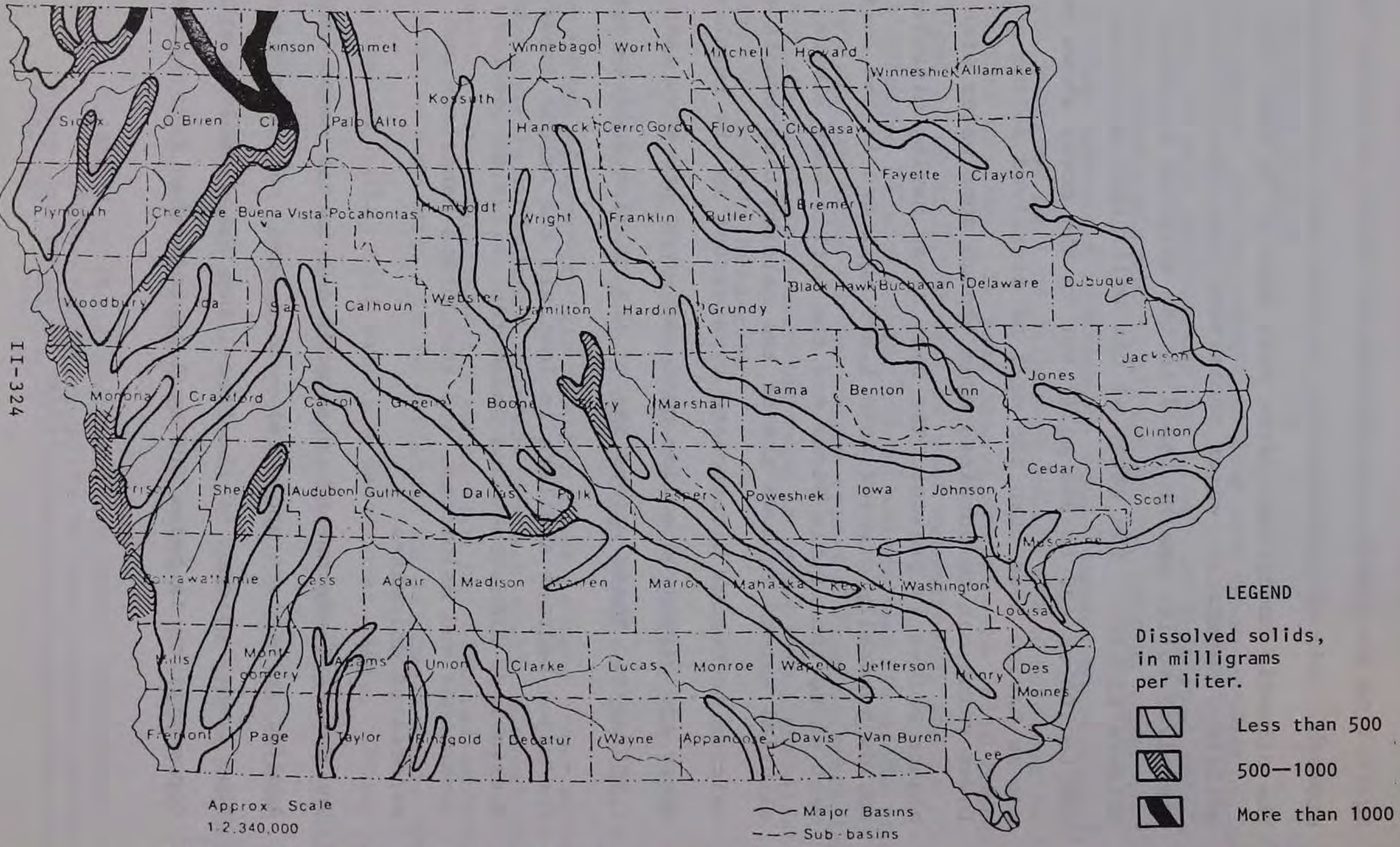

FIGURE 11-140 DISSOLVED SOLIDS CONCENTRATIONS OF THE WATER FROM THE ALLUVIAL AQUIFERS

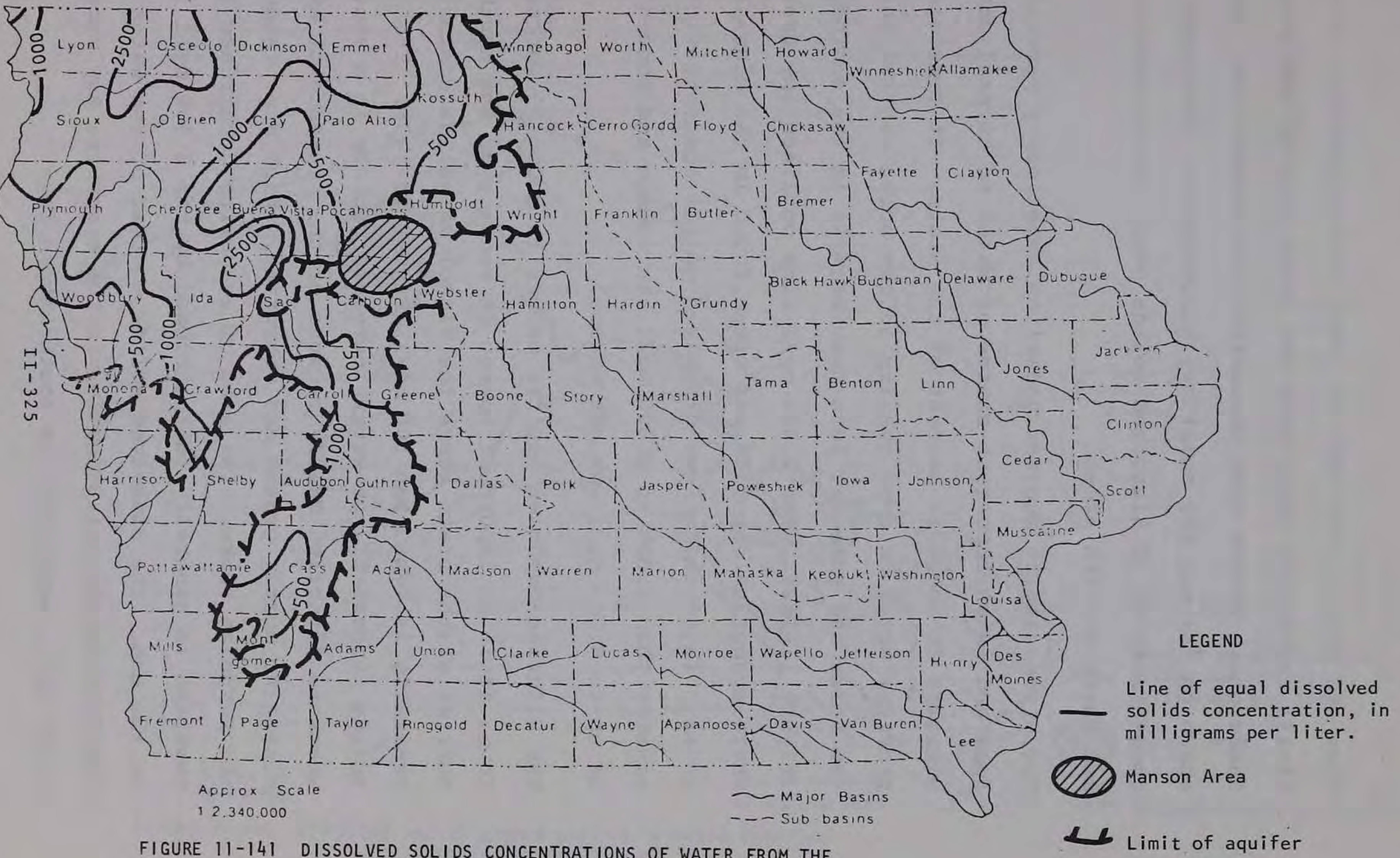

FIGURE 11-141 DISSOLVED SOLIDS CONCENTRATIONS OF WATER FROM THE DAKOTA AQUIFER

Iowa and below 1,000 mg/l in about twelve percent. Figure II-141 represents water from the upper part of the Dakota Sandstone. Waters with concentrations greater than those shown on the map are sometimes encountered. The highest concentrations of dissolved solids occur in the west-central and north-western areas.

The Mississippian aquifer underlies about sixty percent of Iowa and is an important source of water to several communities in about 10 percent of the State. It consistently provides water of good quality in the north central part of the State and somewhat less consistently in the southeast (Figure II-142). The 2,500 mg/l line outlines the area where evaporite deposits are often found in the Mississippian rocks. In southern Iowa dissolved solids concentrations of greater than 3,000 to 4,000 mg/l are common and concentrations of up to 8,000 mg/l are not unusual.

The Silurian-Devonian aquifer occurs in about 85 percent of Iowa. It is an important source of water over the northeastern quarter of the state where the dissolved solids content generally is less than 500 mg/l (Figure II-143). The dissolved solids content of the water increases rapidly in a southwestward direction mainly because of the presence of evaporite minerals, mostly gypsum and anhydrite, which are present in the Devonian rocks. The area of evaporite occurrence in the Devonian is generally that enclosed by the 2,500 mg/l line on the map. The dissolved solids content of the water from the Silurian-Devonian aquifer in the evaportie may exceed 8,000 mg/l, especially in southeastern Iowa.

FIGURE II-142 DISSOLVED SOLIDS CONCENTRATIONS OF WATER FROM THE MISSISSIPPIAN AQUIFER

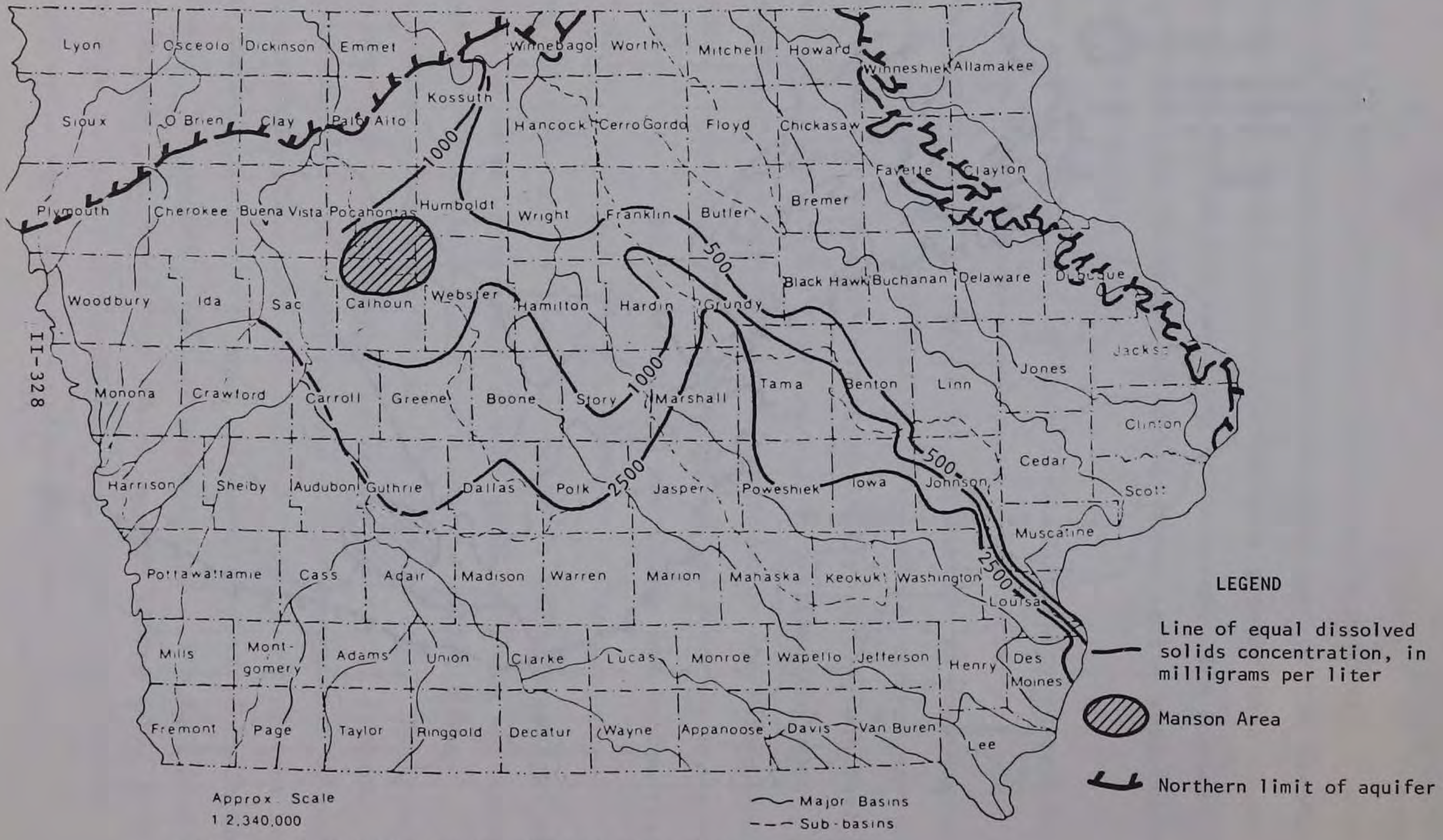

FIGURE 11-143 DISSOLVED SOLIDS CONCENTRATIONS OF WATER FROM THE SILURIAN-DEVONIAN AQUIFER

The most productive bedrock aquifer in Iowa is the Jordan aquifer. It is found in nearly the entire State and is used extensively in the eastern two-thirds of Iowa. The dissolved solids concentration is often less than 300 mg/l in the northeast and increases toward the west and south (Figure II-144).

Water with less than 500 mg/l of dissolved solids is found in the Jordan aquifer over more than twenty percent of the State, less than 1,000 mg/l in more than 35 percent, and less than 1,500 mg/l in over 60 percent of the State.

A comparison of Figures II-142 and II-143 with Figure II-144 will reveal why the Jordan is an important aquifer in Iowa. In a large area, the Jordan contains water with lower concentrations of dissolved solids than is contained in the bedrock aquifers which overlie it. This fortunate situation affords a potable supply to many communities and industries where other sources of water are unsuitable.

A problem does exist in these areas, however, in that a well must pass through the saline water in the upper aquifers in order to reach the potable supply in the Jordan. The saline water must be completely excluded from these wells by placing well casing through the saline water zones and then completely filling the drill hole around the casing with cement. Some Jordan wells were not constructed this way in the past, and many have been abandoned because they produced saline water. Saline water from these aquifers is flowing

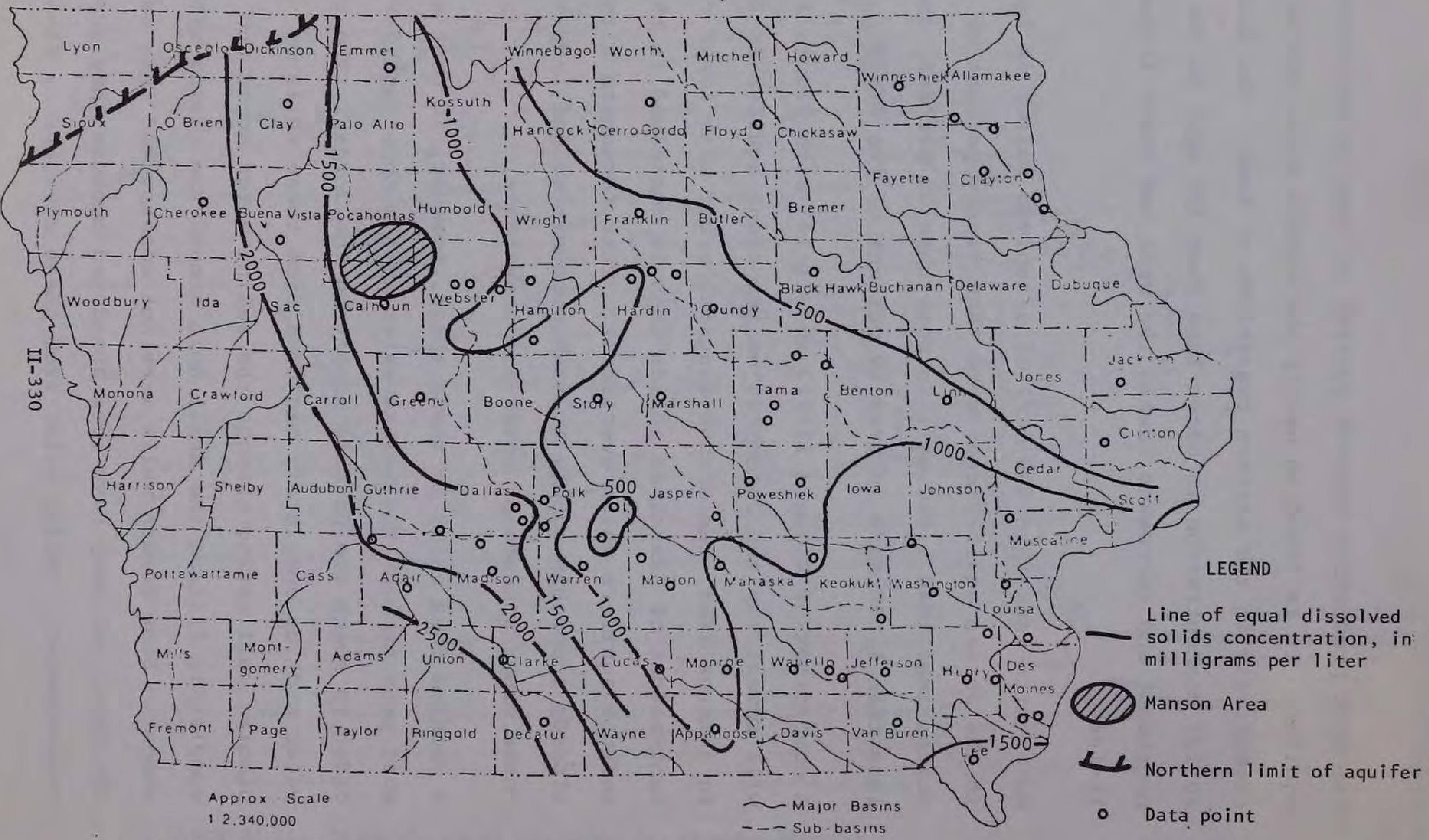

FIGURE 11-144 DISSOLVED SOLIDS CONCENTRATIONS OF WATER FROM THE JORDAN AQUIFER

through these well bores and into other aquifers which contain potable water, thus the potable source is being contaminated. Improper construction is not the only reason this is taking place. The saline water, being very corrosive, can cause the well casing to be eaten away or to disintegrate allowing free passage of the saline water into wells that were once properly constructed.

Figure II-145, a summary of Figures II-142, II-143 and II-144, shows the minimum dissolved solids content available from bedrock aquifers in the state. The better quality water consistently occurs in north-central, northeastern Iowa. The water in all the bedrock aquifers is much more mineralized in the southern, southwestern, and western parts of Iowa.

Hardness

Nearly all of Iowa's natural waters are very hard. Hardness is a nuisance which affects the use of the water for many domestic and industrial purposes, but it can effectively be eliminated by treatment. Hardness in excess of about 100 to 150 mg/l, calculated as an equivalent amount of $CaCO_3$ is noticeable and troublesome for many uses. Hardness ranges from 250 to 500 mg/l for ground waters from the more commonly used aquifers. Some alluvial aquifers will yield water with a hardness of from 150 to 200 mg/l, and water from some bedrock aquifers in areas where they yield highly mineralized water often will have a hardness in excess of 1,000 mg/l.

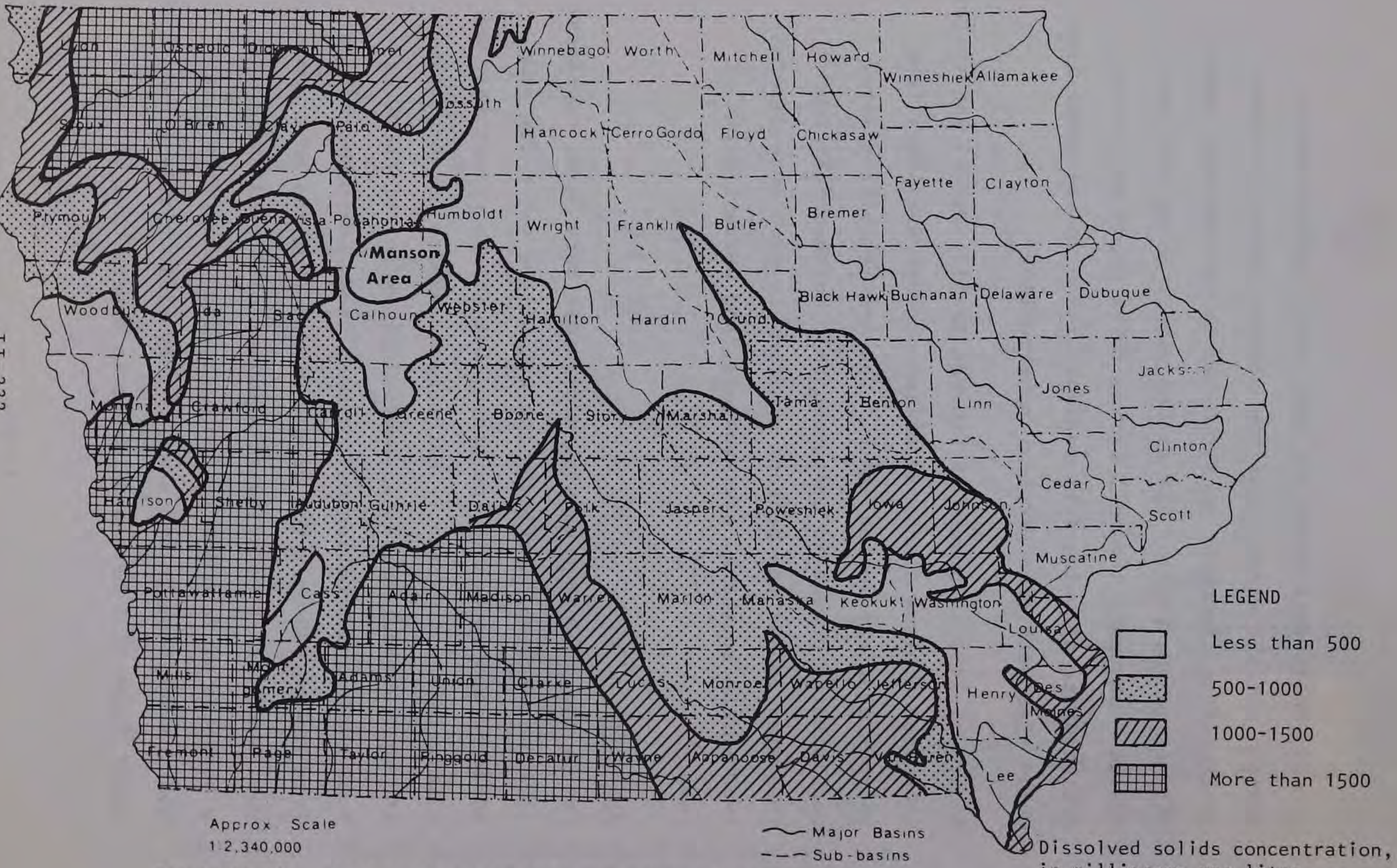

FIGURE 11-145 AREAS WHERE WATER WITH THE MINIMUM DISSOLVED SOLIDS CONTENT IS AVAILABLE FROM BEDROCK AQUIFERS

Nitrates

Nitrates in excess of acceptable concentrations occur at times in many shallow wells. More than 45 mg/l of nitrates are thought tc cause methemoglobinemia in infants. The nitrates are of organic origin and come mainly from barnyard wastes, septic tank effluent and fertilizers.

The occurrence of high nitrate concentrations is related more to improper well construction and location than to a particular region. Problems are encountered in almost all cases in shallow dug or bored wells which have brick, field stone, concrete or clay tile as casing or shoring material. Water in these wells is obtained from glacial drift or sand and gravel. Contaminated water enters these wells by running directly into the well from the ground surface or through porous casing or shoring material after infiltrating only a short distance through the surficial material.

Most wells that are constructed with continuous iron or steel casing, and that are situated so that surface drainage runs away from the well usually are not contaminated with nitrates. Some exceptions do exist, however. Instances of properly constructed wells yielding high nitrate concentrations are common in some alluvial aquifers. Upper layers of sand and gravel may contain unacceptable amounts whereas parts of the aquifer below an intervening clay layer contain negligible amounts of nitrate. Continued applications of fertilizer on flood plain and terrace areas may result in this problem becoming more widespread. Where clay layers do not separate the alluvial aquifers into two or more parts, nitrates may contaminate the only major source of ground water over a large area.

Other exceptions occur in wells which are drilled into limestone or dolomite, where the aquifer lies near the land surface. Joints and crevices, which are common to these rocks, can transmit water from the surface to the waterbearing zone rather rapidly. A few cases of nitrate concentrations approaching excessive levels are known, particularly in eastern Iowa.

Although the extent of nitrate contamination of municipal wells is not nearly comparable to that of private wells, there are a number of public supplies served by wells with nitrate levels approaching, and quite frequently exceeding the recommended standard by a factor of two or three. An incomplete compilation indicates that at least 47 municipal supplies are served by wells which contain nitrate levels exceeding 30 mg/l. Of these, 29 supplies are served by wells exceeding the recommended maximum of 45 mg/l (Figure II-146). A number of these supplies maintain levels below 45 mg/l in the system through dilution or controlled pumping.

As a general rule, high nitrate concentrations are found in water from wells no greater than 50 feet deep, however, the standard is exceeded in wells up to 150 feet in depth.

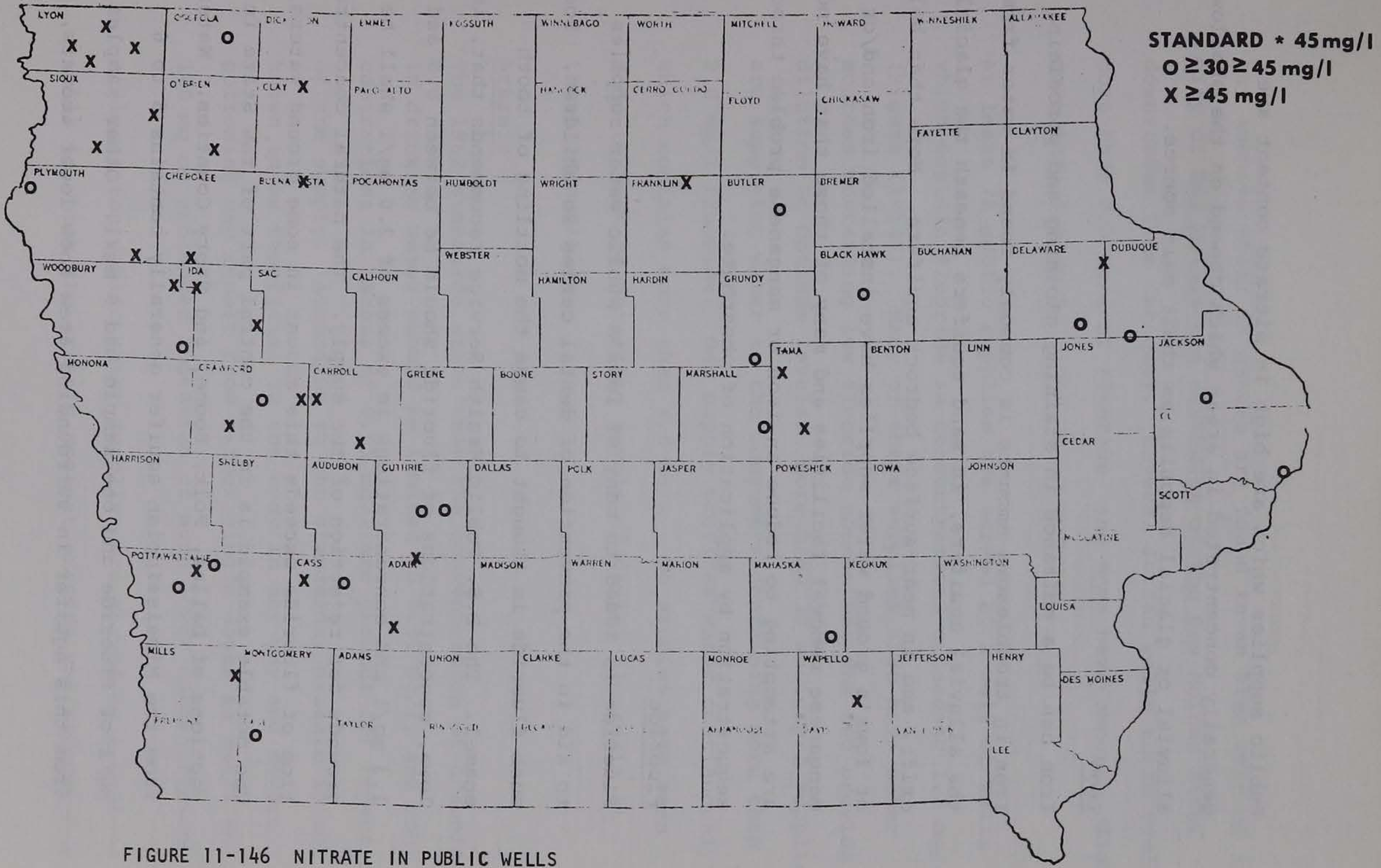

FIGURE 11-146 NITRATE IN PUBLIC WELLS

Public supplies which are high in nitrate content are generally concentrated in areas which depend on the shallow alluvial or glacial deposits as their main source.

Iron

Iron can be a nuisance in staining clothing and porcelain, Iron in troublesome amounts is commonly found in water from the alluvial aquifers, in sand aquifers beneath the glacial drift, and in near-surface bedrock aquifers. More than half of Iowa's ground water supplies have installed iron and/or manganese removal facilities and many of those that have not are attempting to reduce an iron or manganese problem through sequestration by application of phosphate.

Fluoride

Fluoride is added to many of Iowa's public water supplies to aid in the prevention of dental caries in children. Too much fluoride is thought to cause the mottling of tooth enamel. The U.S. Public Health Service recommends that, in Iowa, concentrations of fluoride should be between 0.8 and 1.3 mg/l and concentrations in excess of 2.0 mg/l shall be grounds for rejection of the supply. The natural concentration of fluoride exceeds this amount in some ground waters. One notable example is in the central part of the State in sections of Dallas, Polk, Boone, and Story Counties. Water from the Mississippian aquifer generally contains 5 to 6 mg/l of fluoride and one sample had 9 mg/l. Other samples from this aquifer in surrounding area show lower amounts, but amounts still in excess are found in an area west of the City of Des Moines and southwest of the Des Moines River downstream from the city. Several Jordan wells there yield more than 2.0 mg/l of fluoride, and some have amounts slightly more than 3.0 mg/l.

At least 72 public supplies are served by a well or wells which contain fluoride in concentrations exceeding 1.5 mg/l (Figure II-147). Many of these supplies also have other sources containing low fluoride concentrations and provide dilution to optimum levels. More than 30 municipal supplies are supplying water to the consumers containing more than 2.0 mg/l fluoride. One supply provides water continuously which contains more than 4.0 mg/l. No studies have been made in Iowa to determine levels of dental fluorosis in these communities.

Arsenic

The 1962 standards state that the concentration of arsenic in drinking water should be limited to 0.01 mg/l, and concentrations in excess of 0.05 mg/l are grounds for rejection of the supply. According to the standards, arsenic is not known to be beneficial to the body in any way and severe poisoning may result from either single doses as small as 100 mg or prolonged ingestion of much lower concentrations.

At least ten public water supplies are served by a well or wells in which the arsenic content exceeds the recommended

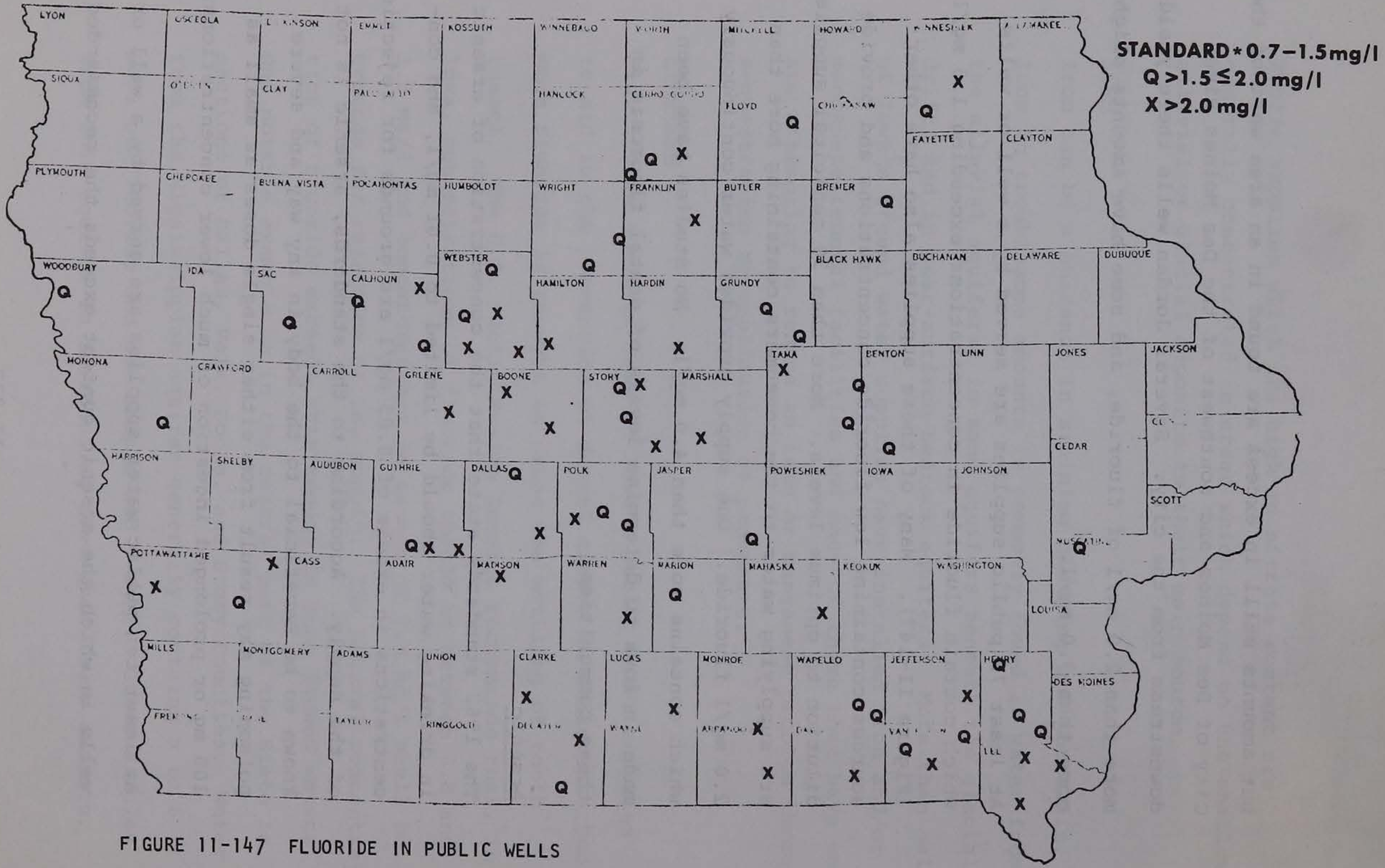

FIGURE II-147 FLUORIDE IN PUBLIC WELLS

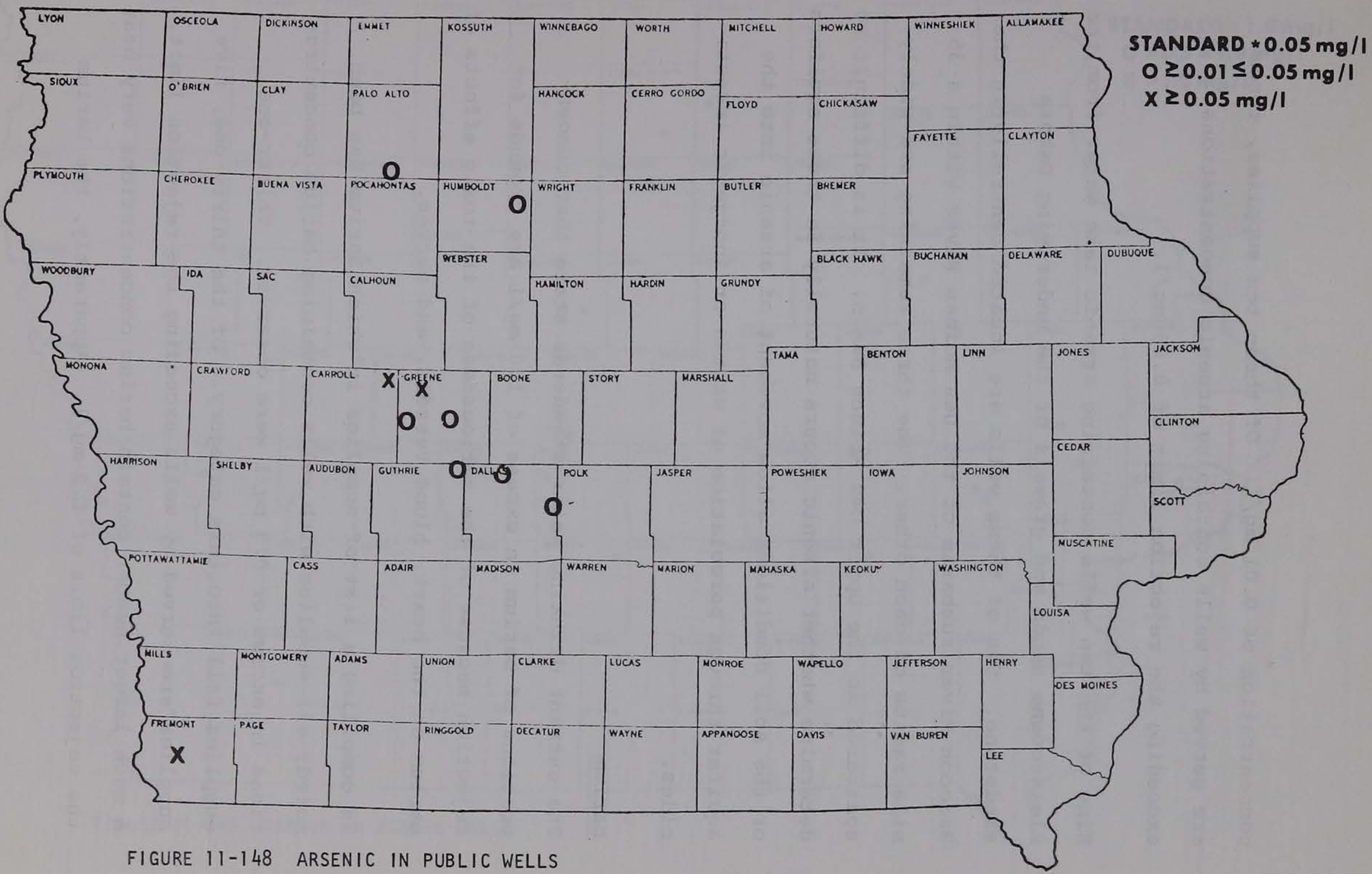

FIGURE 11-148 ARSENIC IN PUBLIC WELLS

concentration of 0.01 mg/l. Of these ten supplies, three are served by wells containing arsenic concentrations exceeding the rejection limit of 0.05 mg/l.

Nine of the ten wells containing arsenic take water from the Pleistocene sands and gravels or the underlying Dakota sandstone. Six of these wells are located centrally in the Raccoon River subbasin of the Des Moines River within a 35 mile radius of each other. The three remaining are widely scattered in the Upper Des Moines Basin. It is difficult to determine whether arsenic occurs naturally in these aquifers or the soil conditions allow movement of arsenic into the aquifer through percolation of wastes or inorganic insecticides.

Barium

The current drinking water standards state that concentrations of barium in excess of 1.0 mg/l are grounds for rejection because of the seriousness of the toxic effects of barium on the heart, blood vessels, and nerves.

In compiling a list of supplies in which barium has been noted, all supplies with wells containing barium concentrations in excess of 0.5 mg/l were observed. Thirty-one supplies fall into this category. Of the thirty-one, five supplies are served by wells exceeding the rejection limit. A much larger number contain barium concentrations very near the rejection limit of 1.0 mg/l. Apparently, the barium

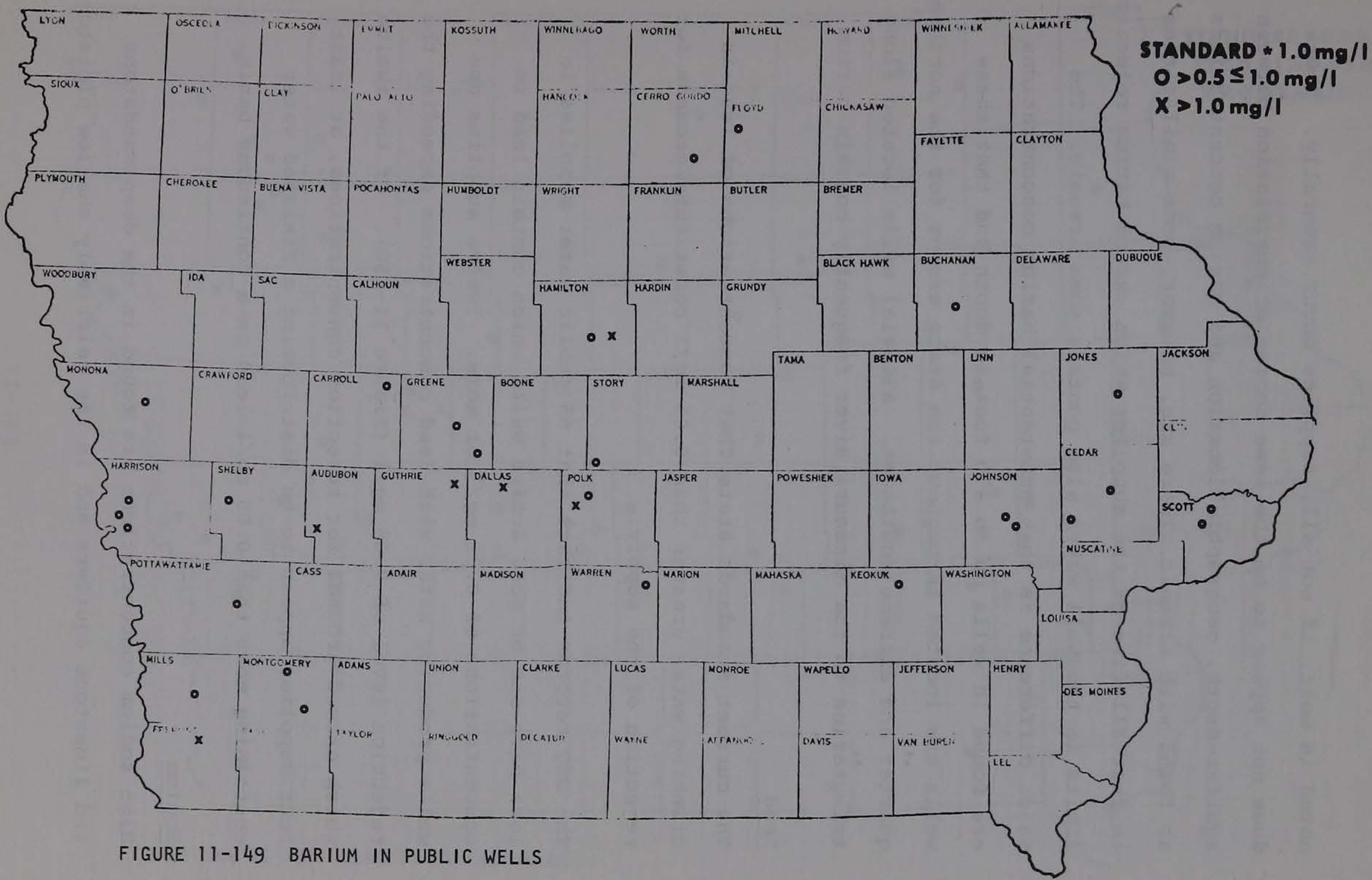

FIGURE 11-149 BARIUM IN PUBLIC WELLS

noted in most, if not all, supplies occur naturally. There does not appear to be the same degree of correlation between aquifer-depth, geographic location and barium concentrations as found with arsenic. There are, however, some similarities in that all five of the supplies which exceed barium rejection limits in the well water also contain some arsenic. The major difference is that substantial barium concentrations are found in wells up to 470 feet in depth and that these wells are located throughout the State except for the northeast quarter and extreme southeast. Alluvial wells located along tributaries to the Missouri River frequently contain barium.

Lead

The current standards state that concentrations of lead in drinking water greater than 0.05 mg/l constitute grounds for rejection of the supply.

The DEQ records indicate that 65 public water supplies in Iowa have one or more active wells which contain lead in concentrations of 0.01 mg/l or more. Twelve supplies use wells producing water with lead concentrations exceeding the rejection level of 0.05 mg/l (Figure II-150). Of the twelve which exceed grounds for rejection concentrations, at least four supplies appear to be distributing a finished water containing more than 0.05 mg/l lead on a continuous basis.

Sodium

High sodium concentrations are found in the deep sandstone and limestone aquifers and in the relatively shallow pleisto-

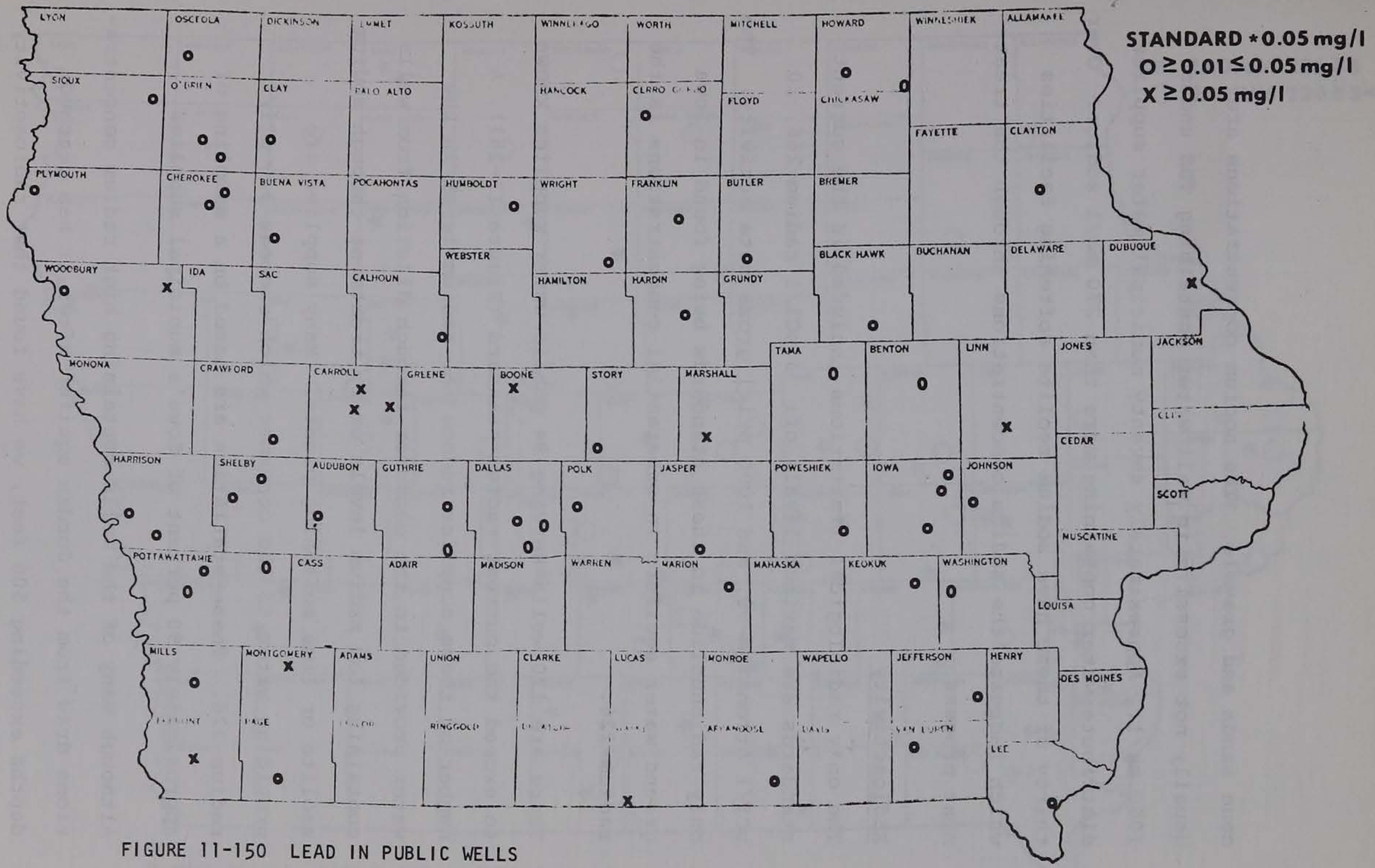

FIGURE 11-150 LEAD IN PUBLIC WELLS

cene sands and gravels. The sodium concentrations are usually not excessive in well water containing TDS under 1000 mg/l. Approximately seventy municipal water supplies distribute water containing more than 270 mg/l sodium. Over thirty of these have sodium zeolite softening facilities which increase the sodium concentrations through the treatment process.

Radioactivity

The only radiological limitations included in the current standards are maximum levels of: 3 pCi/l radium-266, 10 pCi/l strontium-90, and 1000 pCi/l gross beta activity. The only radionuclide in these standards being found in Iowa ground water aquifers in substantial concentrations is the radium-226.

There are 120 wells serving 94 public water supplies known to exceed the current radium standard (Figure II-151). A number of these supplies reduce the radium level in the water provided to the consumer through dilution from wells containing low radium levels or by treatment through sodium zeolite or lime softening plants. Many supplies are providing water to the consumer which exceeds 3.0 pCi/l radium-226. These statistics are based on a sampling of approximately 90 percent of Iowa's municipal supplies.

Although many of the wells containing high radium concentrations draw from the Jordan aquifer after it has reached depths exceeding 500 feet, we have found that radioactivity is not limited to that aquifer.

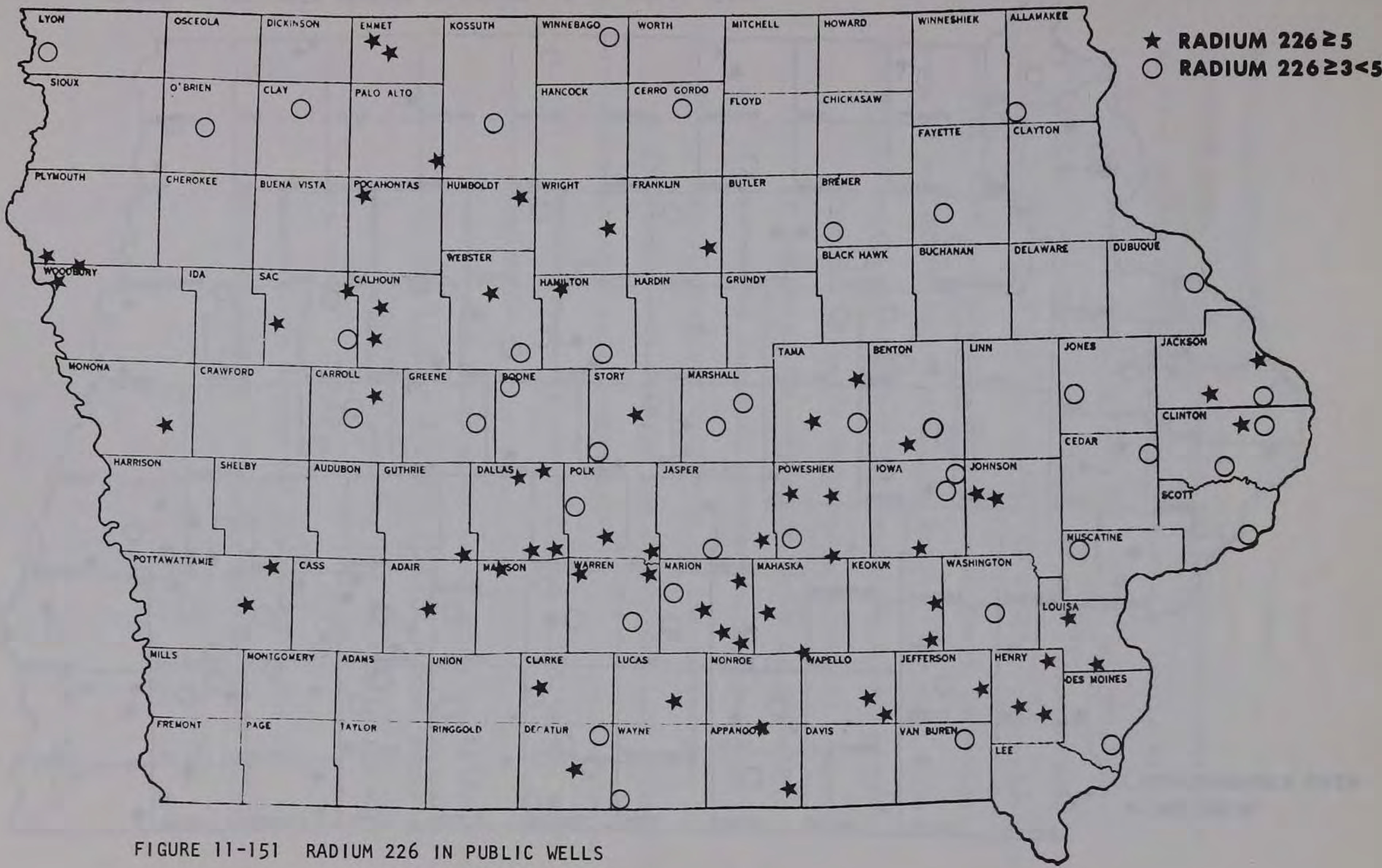

FIGURE 11-151 RADIUM 226 IN PUBLIC WELLS

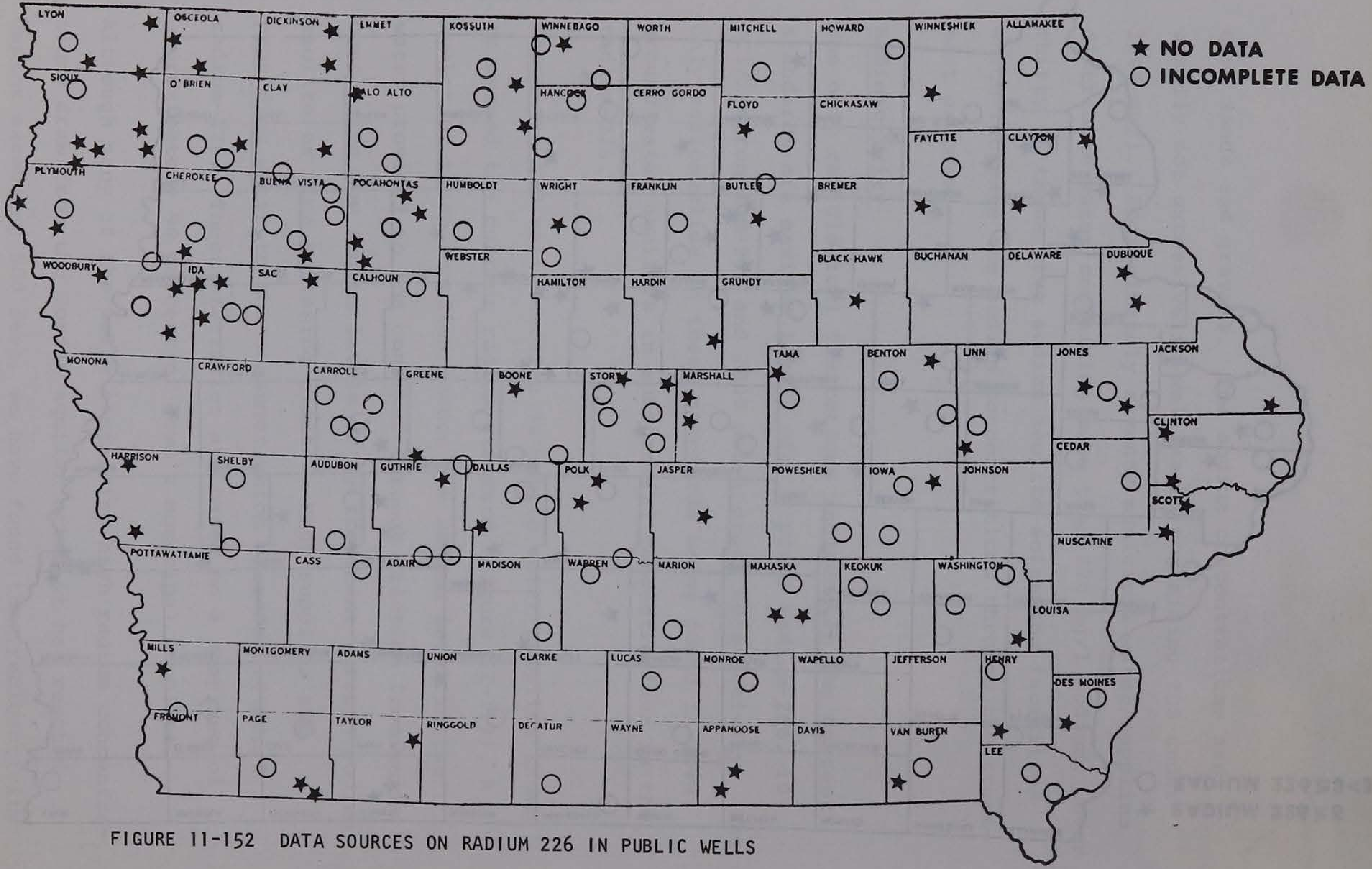

FIGURE 11-152 DATA SOURCES ON RADIUM 226 IN PUBLIC WELLS

Bacterial Contamination

Coliform bacterial contamination of ground water aquifers serving public supplies in Iowa has nearly always been proven to be of a localized nature. Positive coliform analyses of well water can seldom, if ever be, attributed to contamination of an entire aquifer or a major segment of an aquifer, with the possible exception of karst formations, such as northeast Iowa's sinkhole areas. The most common causes of localized coliform contamination of wells are:

a. Location of wells near known potential sources of bacterial contamination, such as private wastewater disposal systems and abandoned or unprotected wells located in the vicinity.

b. Drilling mud used in the rotary drilling procedure.

c. Improper well construction.

d. Inadequate disinfection during drilling and upon completion.

e. Well or pump maintenance with insufficient or complete lack of disinfection of pumps, appurtenances, tools, etc. during and on completion of the work.

f. Contaminants within the system by means of cross connection with other contaminated sources.

DATA NEEDS

Until quite recently it was impossible to determine data needs for water quality sampling. Data available to the DEQ were so scattered and diverse as to make analysis nearly impossible. During the last year, substantial progress has been made in computerized data entry. The DEQ currently has an estimated 85% of its collected data on the federal storage and retrieval system (STORET). Data on the Des Moines River from Iowa State University, and on the Iowa and Cedar Rivers from the University of Iowa have also been entered. Data on the Chariton River from the Conservation Commission, the Upper Iowa River and Lake MacBride from the University of Iowa, and the Iowa Great Lakes from Iowa State University are currently being entered. Over 100,000 pieces of data from over 1,500 stations are currently in STORET for the State of Iowa. This has allowed a much easier assessment of additional data needs than has ever been possible before.

After review of the data mentioned above, a variety of deficiencies in the available data have been noted. These include 1) insufficient recent data on several Iowa river basins; 2) complete lack of data on many classified streams; 3) lack of comprehensive data, collected monthly or more frequently on all but a few areas of the State; 4) inadequate heavy metals and pesticide data on Iowa streams; 5) insufficient data to determine the magnitude of nonpoint source pollution.

Major Iowa streams not discussed directly in the report on Iowa water quality were the Boyer River, Thompson River, Boone River, South Raccoon River, North Skunk River, Winnebago River, and the Turkey River. Data on the Maquoketa River, Little Sioux River, Nishnabotna River, and South Skunk River were so limited that any conclusions drawn were very tentative. Additional data would be needed in order to establish a baseline adequate for future comparison.

In addition to those rivers listed above, many of the classified streams in Iowa have no data available at all. Not a single sample has been taken on over 50% of Iowa's classified streams. The most visible example of this is in northeastern Iowa where nearly 160 tributary streams to the Wapsipinicon, Maquoketa, Turkey and Upper Iowa Rivers are classified. While it is certainly unrealistic to expect extensive data collection on each of these streams, some sample collection would certainly be desirable.

Comprehensive sampling and analysis are probably beyond the capability of a State agency. Data have been collected by the various State universities and USGS which provide a good start in a comprehensive data program. To date the comprehensive data available in the State are on the Iowa, Cedar, Des Moines, and Chariton Rivers. Isolated stations on several other rivers are available from USGS. It would be advantageous to establish a comprehensive sampling station (with at least monthly sampling) on each of the major basins not currently being sampled in this way. This would include the Big Sioux, Floyd, Little Sioux, Boyer, Nishnabotna, Lower Skunk, Raccoon, Wapsipinicon, Maquoketa, Shellrock, Winnebago, Turkey, and Upper Iowa.

Data available on heavy metals and pesticides are very limited. Some data were available on most of the major rivers, but the small number of samples makes conclusions difficult. Increased monitoring, particularly for pesticides, would be required to determine the magnitude of these parameters in Iowa streams. Once an adequate data base is established, less frequent monitoring should be sufficient to determine changes.

Insufficient data is available during spring months, in general, and during high flow periods, in particular, to determine problems under these conditions. So little sampling has taken place at high flows that there is little information on pollution problems under these conditions. As with the ammonia during spring thaw, other unknown problems may be occurring at high flows which have not as yet been observed. Sampling during all seasons and various flows would put Iowa's pollution problem in better perspective. Only by sampling at representative periods can the magnitude of both point and nonpoint source pollution be adequately assessed.

In recent years the suggestion that more water quality data were needed could be easily refuted. The lack of any systematic compilation or method for analysis made such suggestions unrealistic. Reliability of the computer system has improved to the point where data retrievals can be made more quickly than in the past. The DEQ has reached the point where data needs can be more realistically assessed.

The inadequacies cited above reflect areas that need improvement. It is hoped that these data needs will be addressed as time, manpower, and money permit to provide a complete picture of Iowa water quality.

TABLE II-65

DATA NEEDS - IOWA RIVERS

WITH NO RECENT DATA	WITH LITTLE RECENT DATA	WITH INADEQUATE RECENT DATA	NEED COMPREHENSIVE SURVEYS
Soldier	Rock	Little Sioux	Little Sioux
Platte	Boyer	Maquoketa	Maquoketa
Thompson	Middle	Upper Iowa	Skunk
Winnebago	South Raccoon	Skunk	Turkey
Turkey	West Fork Cedar	Nishnabotna	Cedar
English	Yellow	Floyd	Iowa
Boone			Boone
			Thompson
			Winnebago

SECTION III

IOWA'S FISHERIES & RECREATIONAL USES OF ITS WATER RESOURCES

At the time of publication, this Section had not been received from the Iowa Conservation Commission for inclusion with the remainder of the report.

SECTION IV

POINT SOURCE INVENTORY

Iowa point sources can be grouped into three major categories: industrial, municipal, and agricultural. Municipal point sources include all incorporated communities with wastewater collection systems and treatment facilities. Industrial point sources include all industries with direct wastewater discharges into receiving streams, semi-public treatment facilities such as rest areas, parks, schools and water treatment plant discharges to receiving streams. Agricultural point sources are feedlot operations which meet Iowa feedlot regulation requirements (Sec. 1.3(455B), Code of Iowa) and operations designated as significant pollution sources.

The Iowa Operation Permit System is the State's enforcement tool for point source pollution control. All point source dischargers are required to have an Iowa Operation Permit. In addition, Iowa Department Rules call for the issuance of an operation permit to the owner of any waste water disposal facility. Table IV-1 summarizes the status of Iowa Operation Permits as of January 1, 1975.

TABLE IV-1

STATUS OF IOWA OPERATION PERMITS AS OF JANUARY 1, 1975
(includes no-discharge system permits)

	NUMBER OF PERMIT APPLICATIONS	NUMBER OF PERMITS DRAFTED	NUMBER OF PERMITS ISSUED
Industrial	737	258	75
Municipal	652	595	21
Agricultural	922	799	799

Municipal Waste Treatment Facilities

There are approximately 600 incorporated communities in Iowa with wastewater treatment facilities. Table IV-2 summarizes wastewater treatment types, numbers of communities served, and populations served for each river basin. Nearly 70% of the population of incorporated communities are served by trickling filter wastewater facilities. Three hundred and twenty-three communities, which comprise less than four percent of the population of incorporated communities, have no waste water treatment facilities.

There has been considerable progress in construction of wastewater treatment facilities in Iowa in the last twenty years. In the 1950's 74% of the population of communities in Iowa were served by wastewater treatment facilities. Currently, 96% of the population of incorporated communities are served (Table IV-3). The most significant increases were in river basins in western and northeastern areas of the State.

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Mississippi River and minor tributaries Number of Municipalities	Population	Upper Iowa River Basin Number of Municipalities	Population	Yellow River Basin Number of Municipalities	Population
Imhoff, Septic Tank, or Solids removal	8	68,189				
Waste Stabilization Lagoon	8	4,281			1	225
Trickling Filter	5	187,205	2	7,955	3	3,788
Activated Sludge	3	5,097	1	3,927		
Total		264,772		11,882		4,013
Municipalities W/O Treatment Facilities	14	2,416	1	185		

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

	Turkey River Basin		Maquoketa River Basin		Wapsipinicon River Basin	
Treatment Type	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank, or Solids removal	1	613	1	5,677		
Waste Stabilization Lagoon	6	4,234	9	7,415	17	9,935
Trickling Filter	8	8,591	7	13,531	12	21,640
Activated Sludge	1	503	2	477	5	10,410
Total		13,941		27,100		41,985
Municipalities W/O Treatment Facilities		2,862	15	2,747	13	2,110

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Iowa River Basin		Cedar River Basin (except Winnebago and Shell Rock)		Shell Rock River Basin	
	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank, or Solids removal	1	563	8	13,721	1	1,360
Waste Stabilization Lagoon	24	20,073	30	20,748	3	2,274
Trickling Filter	18	76,711	34	308,466	3	4,472
Activated Sludge	9	43,216	4	38,520		
Total		140,563		381,455		8,106
Municipalities W/O Treatment Facilities	29	5,835	28	7,263	4	1,209

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Winnebago River Basin		Skunk River Basin		Des Moines River Basin (except East & West Forks & Raccoon)	
	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank, or Solids removal						
Waste Stabilization Lagoon	2	1,223	26	15,734	42	33,919
Trickling Filter	2	4,965	26	122,200	28	349,572
Activated Sludge	1	31,951			2	6,710
Total		38,139		137,934		389,201
Municipalities W/O Treatment Facilities	4	1,257	27	6,619	41	12,355

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

	Raccoon River Basin		East Fork Des Moines River Basin		West Fork Des Moines River Basin	
Treatment Type	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank, or Solids removal	3	1,678	1	1,103		
Waste Stabilization Lagoon	18	11,749	6	3,834	3	2,058
Trickling Filter	23	53,281	4	8,035	4	17,743
Activated Sludge						
Total		66,698		12,972		19,801
Municipalities W/O Treatment Facilities	20	5,172	5	830	9	1,429

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Fox River Basin		Chariton River Basin		Weldon River Basin	
	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank or Solids removal			1	931		
Waste Stabilization Lagoon	3	1,588	3	3,009		
Trickling Filter	1	2,718	2	11,540	1	2,142
Activated Sludge						
Total		4,306		15,480		2,142
Municipalities W/O Treatment Facilities	4	576	9	2,268	4	727

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Thompson River Basin		Platte River Basin		102 River Basin	
	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank, or Solids removal						
Waste Stabilization Lagoon	1	823			3	2,002
Trickling Filter	1	2,212	2	9,996	1	1,733
Activated Sludge						
Total		3,035		9,996		3,735
Municipalities W/O Treatment Facilities	9	2,304	12	1,779	2	197

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Nodaway River Basin Number of Municipalities	Nodaway River Basin Population	Tarkio River Basin Number of Municipalities	Tarkio River Basin Population	Nishnabotna River Basin Number of Municipalities	Nishnabotna River Basin Population
Imhoff, Septic Tank, or Solids Removal						
Waste Stabilization Lagoon	3	1,064	1	574	22	16,274
Trickling Filter	5	9,735			10	32,578
Activated Sludge						
Total		10,799		574		48,852
Municipalities W/O Treatment Facilities	7	1,083	5	948	14	2,813

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

Treatment Type	Floyd River Basin Number of Municipalities	Floyd River Basin Population	Big Sioux River Basin (except Rock River) Number of Municipalities	Big Sioux River Basin (except Rock River) Population	Rock River Basin Number of Municipalities	Rock River Basin Population
Imhoff, Septic Tank, or Solids removal	1	226				
Waste Stabilization Lagoon	8	4,179	2	759	5	2,556
Trickling Filter	7	24,071			5	9,640
Activated Sludge			2	4,113		
Total		28,476		4,872		12,196
Municipalities W/O Treatment Facilities	2	232	1	90	1	89

TABLE IV-2

MUNICIPAL WASTE TREATMENT BY RIVER BASIN

	Missouri River and minor tributaries		Boyer River Basin		Little Sioux River Basin	
Treatment Type	Number of Municipalities	Population	Number of Municipalities	Population	Number of Municipalities	Population
Imhoff, Septic Tank, or Solids Removal	3	88,120				
Waste Stabilization Lagoon	9	4,480	9	9,548	27	15,615
Trickling Filter	5	69,690	2	6,488	22	36,412
Activated Sludge	2	1,530	1	1,526	2	8,919
Total	10	163,820		17,562		60,946
Municipalities W/O Treatment Facilities		2,663	5	1,157	12	1,916

SUMMARY

Treatment Type	Municipalities	Population
Imhoff, Septic Tank, or Solids Removal	29	182,181
Waste Stabilization Lagoon	291	200,173
Trickling Filter	243	1,407,110
Activated Sludge	35	156,899
Total		1,946,363
Municipalities W/O Treatment Facilities	323	71,131

TABLE IV-3

POPULATION SERVED BY WASTEWATER TREATMENT PLANTS IN THE 1950's AND THE 1970's BY RIVER BASIN
(based on 1950 and 1970 population census)

	1950's		1970's	
River Basin	Population of Incorporated Communities	Percent Population of Incorporated Communities With Treatment Facilities	Population of Incorporated Communities	Percent Population of Incorporated Communities With Treatment Facilities
Des Moines River Basin	451,972	84	508,458	96
Iowa-Cedar River Basins	393,413	90	483,827	97
Skunk River Basin	109,665	87	144,553	96
Floyd-Big Sioux River Basins	35,502	62	45,955	99
Nishnabotna River Basin	52,833	43	51,665	95
Western River Basins	218,701	26	248,064	98
Southern River Basins	55,378	84	59,949	92
Northeastern River Basins (except Mississippi R.)	92,413	68	106,825	93
Total	1,409,887	74	1,649,296	96

Table IV-4 summarizes construction of wastewater facilities from 1967 through 1974. During this period, construction permits were issued by the DEQ for 1,969 sewer extension projects and 723 treatment facility projects (both new facilities and modifications of existing facilities). Between 1967 and 1973, over 212 million dollars in Federal grants were spent in Iowa for municipal wastewater treatment facilities.

The Environmental Protection Agency requires, by July 1977, that publicly owned treatment works achieve, at a minimum, BOD_5 effluent concentrations of 30 mg/l and at least 85 percent BOD_5 removal. Approximately 245 Iowa communities will have to increase waste treatment in order to meet this requirement. Table IV-5 summarizes current BOD_5 loadings and pounds of reduction necessary by July 1, 1977 for each river basin. There are currently 206,173 pounds/day BOD_5 discharged from municipalities to receiving streams in Iowa. Sixty-six percent (136,561 lbs/day) of these current loadings must be removed to meet the EPA's secondary treatment requirement.

TABLE VI-4

SUMMARY OF CONSTRUCTION PERMITS AND FUNDING FOR MUNICIPAL WASTEWATER TREATMENT FACILITIES IN IOWA FROM 1967 TO 1974

	CONSTRUCTION PERMITS ISSUED			Project Costs Eligible For State & Federal Money[a]	Federal Grants[a]	State Grants[a]	Initial Federal Appropriations[a]
	Sanitary Sewer Extensions		Number of Wastewater Treatment Facilities				
Year	Number	Feet					
1967	214	1,233,374	117	6,306,657	1,985,704	-	2,384,700
1968	270	1,322,859	106	12,506,804	4,058,297	-	3,196,000
1969	220	718,384	82	7,548,888	3,216,322	-	3,327,300
1970	184	737,421	108	41,201,638	17,451,973	9,997,925[b]	12,203,800
1971	220	961,273	76	23,831,238	12,716,909	5,897,946	12,221,800
1972	257	879,246	92	55,221,190	25,377,548	49,708[c]	27,588,850
1973	274	984,486	66	65,695,864	47,454,153	0[c]	23,114,000
1974	330	932,653	76	4,197,600[c]	3,398,610[c]	0[c]	34,671,000
Total	1,969	7,769,696	723	216,509,879[c]	115,659,516[c]	15,945,579[c]	118,707,450

a - Data cited covers fiscal year
b - Total from 1966 thru 1970
c - To March 1, 1975, subject to change

TABLE IV-5

CURRENT MUNICIPAL BOD_5 LOADINGS AND POUNDS OF REDUCTION NECESSARY TO MEET EPA REQUIREMENTS

RIVER BASIN	NUMBER CURRENT POUNDS BOD_5 LOADING FROM MUNICIPALITIES	NUMBER POUNDS BOD_5 REDUCTION NECESSARY BY JULY, 1977
Mississippi and minor tributaries	94,079	66,798
Upper Iowa	466	194
Yellow River	135	31
Turkey River	700	180
Maquoketa	1,172	427
Wapsipinicon	1,676	412
Iowa River	3,821	967
Cedar River (except Winnebago and Shell Rock)	34,441	23,215
Winnebago	231	59
Shell Rock	120	3
Skunk	3,393	762
Des Moines (except East and West Forks and Raccoon)	8,202	1,083
Raccoon	2,502	1,078
East Fork Des Moines	451	242
West Fork Des Moines	575	30
Chariton	1,059	125

TABLE IV-5 (continued)

RIVER BASIN	NUMBER CURRENT POUNDS BOD_5 LOADING FROM MUNICIPALITIES	NUMBER POUNDS BOD_5 REDUCTION NECESSARY BY JULY, 1977
Weldon	73	27
Thompson	266	77
Platte	343	0
102 River	143	0
Nodaway	399	103
Tarkio	87	34
Nishnabotna	1,150	263
Missouri (and minor tributaries)	46,649	38,162
Boyer	375	133
Little Sioux	2,324	1,493
Floyd	944	524
Big Sioux (except Rock)	94	10
Rock	303	129
Total	206,173	136,561

INDUSTRIAL/COMMERCIAL SOURCES

There are over 422 industrial point source discharges in Iowa, not including semi-public parks, schools, etc., or water treatment plant discharges. Table IV-6 summarizes industrial discharges by river basin. The inventory, however, is only partially complete. Those river basins noted with an asterisk represent incomplete inventories. In these cases, the number of food processing and manufacturing discharges are probably inflated, since some of these may only discharge cooling water to the receiving stream.

To meet the DEQ ammonia (NH_3) and BOD effluent requirements, many industries must significantly reduce the loadings to the receiving streams. Table IV-7 summarizes the pounds of ammonia and BOD_5 per day discharged from industrial sources. To meet the DEQ requirements, 89% of current BOD_5 loadings must be reduced, and 84% of current NH_3 loadings must be reduced.

TABLE IV-6

SUMMARY OF INDUSTRIAL POINT SOURCE DISCHARGES BY RIVER BASIN (INCOMPLETE INVENTORIES ARE NOTED WITH AN ASTERISK)

RIVER BASIN	NUMBER OF DISCHARGES
Mississippi River (and minor tributaries)*	
Cooling Water	13
Quarries and Mines	5
Food Processing	15
Manufacturing	25
Railroads	5
Other	5
Total	68
Upper Iowa River*	
Quarries and Mines	1
Food Processing	1
Manufacturing	1
Total	3
Turkey River*	
Quarries and Mines	1
Food Processing	6
Manufacturing	2
Total	9
Maquoketa River*	
Cooling Water	1
Quarries and Mines	6
Food Processing	1
Total	8
Wapsipinicon River*	
Cooling Water	1
Quarries and Mines	6
Food Processing	4
Manufacturing	2
Railroads	1
Total	14

TABLE IV-6 (continued)

RIVER BASIN	NUMBER OF DISCHARGES
Iowa River*	
Cooling Water	3
Quarries and Mines	11
Food Processing	8
Manufacturing	7
Railroads	1
Other	2
Total	32
Cedar River (except Winnebago and Shell Rock)*	
Cooling Water	19
Quarries and Mines	35
Food Processing	9
Manufacturing	16
Railroads	3
Other	2
Total	84
Shell Rock*	
Quarries and Mines	3
Food Processing	2
Total	5
Winnebago	
Cooling Water	2
Quarries and Mines	14
Manufacturing	4
Railroads	1
Total	21
Skunk River	
Cooling Water	9
Quarries and Mines	15
Food Processing	1
Natural Gas	1
Other	2
Total	28

TABLE IV-6 (continued)

RIVER BASIN	NUMBER OF DISCHARGES
Des Moines River (except East and West Forks and Raccoon)	
Cooling Water	16
Quarries and Mines	28
Food Processing	6
Manufacturing	6
Natural Gas	2
Railroads	2
Other	6
Total	66
Raccoon River	
Cooling Water	6
Quarries and Mines	3
Food Processing	2
Manufacturing	3
Natural Gas	1
Other	3
Total	18
East Fork Des Moines River	
Cooling Water	1
Quarries and Mines	1
Other	2
Total	4
West Fork Des Moines River	
Cooling Water	1
Quarries and Mines	4
Food Processing	1
Total	6
Thompson River	
Quarries and Mines	2
Manufacturing	1
Total	3

TABLE IV-6 (continued)

RIVER BASIN	NUMBER OF DISCHARGES
Platte River*	
Food Processing	1
Total	1
Nodaway River*	
Quarries and Mines	3
Total	3
Nishnabotna River	
Cooling Water	1
Quarries and Mines	3
Food Processing	3
Manufacturing	1
Total	8
Missouri River (and minor tributaries)*	
Cooling Water	2
Quarries and Mines	1
Food Processing	7
Manufacturing	7
Natural Gas	1
Railroads	2
Other	20
Boyer River*	
Quarries and Mines	2
Food Processing	3
Manufacturing	1
Total	6
Little Sioux River	
Cooling Water	3
Quarries and Mines	1
Food Processing	4
Total	8

TABLE IV-6 (continued)

RIVER BASIN	NUMBER OF DISCHARGES
Floyd River	
Quarries and Mines	1
Food Processing	2
Other	1
Total	4
Big Sioux River (except Rock)*	
Cooling Water	1
Other	1
Total	2
Rock River	
Cooling Water	1
Quarries and Mines	1
Total	2
Total*	
Cooling Water	80
Quarries and Mines	146
Food Processing	76
Manufacturing	76
Natural Gas	5
Railroads	15
Other	24
Total	422

TABLE IV-7

CURRENT INDUSTRIAL BOD$_5$ AND AMMONIA LOADINGS IN POUNDS PER DAY AND REDUCTIONS NECESSARY TO MEET DEQ REQUIREMENTS.

RIVER BASIN	POUNDS CURRENT BOD$_5$ PER DAY	POUNDS REDUCTION PER DAY	POUNDS CURRENT NH$_3$ PER DAY	POUNDS REDUCTION PER DAY
Mississippi River (and minor tributaries)	99,624	90,473	12,313	10,268
Upper Iowa River	20	0	0	0
Yellow River	6,136	6,063	0	0
Turkey River	0	0	20	0
Maquoketa River	57	55	0	0
Wapsipinicon River	6,000	5,988	30	25
Iowa River	2,146	752	359	302
Cedar River	2,409	1,858	53	18
Skunk River	27	10	3	0
Des Moines River	1,702	1,426	988	678
Raccoon River	563	281	525	450
Platte	50	0	5	0
Nishnabotna River	474	0	350	0
Missouri River (and minor tributaries)	665	160	2,688	2,346
Boyer River	1,259	1,188	2,742	2,691
Total	121,132	108,254	20,076	16,778

AGRICULTURAL SOURCES

There are over 1,000 registered feedlot operations in Iowa. There have been 799 construction permits approved by the DEQ for construction of feedlot wastewater control structures. The table below summarizes progress made toward control of feedlot point sources in Iowa. Most of the construction permits are for no-discharge systems.

TABLE IV-8

FEEDLOT CONSTRUCTION PERMITS ISSUED

Year	Permits
1970	26
1971	157
1972	212
1973	138
1974	266
TOTAL	799

A list of feedlot facilities over 1,000 animal units and/or facilities which are classified as significant point sources is included in Appendix D. All facilities on this list have been issued NPDES permits as of January 1, 1975.

SECTION V

GOALS AND OBJECTIVES

The Federal Water Pollution Control Act Amendments of 1972 established numerous goals with finite deadlines aimed at improving the quality of the Nation's waters. Included in these goals were requirements that all publicly owned treatment works provide secondary treatment or better, if necessary to meet Iowa Water Quality Standards by July 1, 1977. All industrial dischargers are to provide "best practicable treatment" by that date. All surface waters are to be "swimmable and fishable" by 1983. The principal mechanisms for attaining these goals are through the issuance of permits for all dischargers of waste into the waters of the Nation.

Implementation of this program has not been as rapid as desirable, and it is now evident that all the goals of the Act will not be met within the time specified. The reasons for delays are numerous and complex. Principal reasons include: difficulty in establishing effluent criteria stringent enough to provide adequate protection, but liberal enough to be attainable; a lack of adequate staff resources in the federal and state agencies responsible for enforcing the Act; inadequate financial resources to build all the needed facilities; and the usual obstacles in planning, designing and building complex systems.

Despite the problems inherent in the administration of a complex act significant progress is being made. Table V-1 shows a breakdown of known point source dischargers within the State and a conservative estimate of their progress towards compliance with the Act. A simple glance at the figures would appear to suggest that little progress is being made, but this is far from the truth and a brief discussion is given for each category of major dischargers.

Publically Owned Treatment Works

Over 90% of the State's population, living in incorporated communities and sanitary districts, are currently served by sanitary sewer systems and some form of secondary treatment. It is estimated that 85% to 95% of the present treatment works are not presently capable of meeting the 1977 requirements. Consequently, these systems are being issued permits that include a time schedule for upgrading the quality of their effluent. The work required to meet the 1977 requirements ranges from replacement of an existing obsolete facility with a completely new plant, to minor expansions or modifications of an existing facility.

As a result of priorities established by the State for federal grant assistance many of the major dischargers will be in compliance by 1977. The majority of the major dischargers will be in the active construction phase by that date, and many of the minor dischargers will be in the planning or design stages.

TABLE V-I

PROJECTED COMPLIANCE WITH 1977 STANDARDS FOR KNOWN POINT SOURCES

	NUMBER OF KNOWN SOURCES	NUMBER ESTIMATED NEEDING UPGRADING	NUMBER ESTIMATED TO BE IN COMPLIANCE BY JULY 1, 1977
Publically Owned Treatment Works (by Population)			
1,000	368	350	50*
1,000 to 10,000	215	200	75*
10,000 to 50,000	16	13	9*
50,000	7	7	3*
Industrial/Commercial Sources			
Major Industry	34	30	34
Minor Industry	400	75	400
Public or Private Water Supply Systems	100	(see discussion)	-
Domestic & Commercial	250	250	40
Agricultural Point Sources			
>1,000 animal units	104	57	104
<1,000 animal units	Unknown	(see discussion)	-
open & confined Feeding operations Subject to DEQ Rules	4,000	NA	NA

* Most all publically owned treatment works will be in some phase of their construction program, however, this figure indicates only those which are anticipated to be totally complete and in service.

The concentration of funds and enforcement effort toward the most significant publicly owned discharge systems is expected to result in significant progress in reduction of the amount of pollutants discharged to the waters of the State by July 1, 1977 or shortly thereafter.

Industrial and Commercial Sources

Iowa appears to enjoy an enviable position in terms of its industrial development. Geographically, industry is scattered throughout the State roughly in proportion to the population. Most municipalities can boast of at least one or two local industries.

As can be seen on Table V-1, it is projected that nearly all industrial facilities will meet the July 1, 1977 deadline, with most being completed much earlier. As noted in the table, the majority of the industrial discharges are classified as minor. These discharges are relatively insignificant in terms of adverse impact on the receiving stream. In addition, these and other industries have been on compliance schedules for some time and are scheduled for completion in 1975 and 1976.

Those facilities identified as "Public or Private Water Supply Systems" are also classified as insignificant dischargers having little, if any, impact on the receiving streams. Most of these facilities do not provide any form of treatment for their discharge, however, inasmuch as the EPA has not yet promulgated an effluent standard, it is impossible to project compliance dates.

Agricultural Point Sources

Iowa always has been and continues to be proud of its agricultural heritage. The State is basically agriculturally oriented. Although significant water pollution problems in Iowa can be attributed to agricultural sources (both point and nonpoint sources), relatively little legislation and program activity at the state and national levels have been directed at this problem.

Iowa was one of the leaders in developing an abatement and correction program for controlling agricultural wastes. This program concentrates on controlling point source pollution from open and confined livestock and poultry feeding operations.

As noted in Table V-1, a number of livestock feeding operations greater than 1,000 animal units will require upgrading to meet the EPA standards. It is projected that all of these facilities will be in compliance by the July 1, 1977 date. No projections have been made for facilities less than 1,000 animal units. Since the EPA has not yet promulgated performance standards for under 1,000 animal unit operations, and has not defined significant pollution sources, it is presently impossible to make accurate estimates or project compliance dates.

It is estimated that Iowa regulations currently require over 4,000 open and confined feeding operations to register with the Department of Environmental Quality.

Action is currently being taken by the DEQ against livestock feeding operations under 1,000 animal unit capacity where significant pollution problems exist. No action is contemplated against livestock operations under 1,000 animal units whose waste discharges have relatively minor impact on a receiving stream until the EPA has promulgated appropriate performance standards. Confined feeding operations constitute "no discharge" systems and are not subject to the Federal regulations, although State regulations may apply.

Conclusion

Congress is to be commended for passage of an Act providing for the significant improvement of our Nations waterways. The Act would have been better if more reasonable time constraints had been provided with appropriate manpower capabilities at regulatory agency levels for implementation, coupled with the availability of adequate financial resources to implement the high ideals of the Act.

SECTION VI

BENEFITS, COSTS, AND ENVIRONMENTAL IMPACT OF ACHIEVING THE GOALS OF THE ACT

Public Law 92-500 has the national goal of significant pollutant reductions to the Nation's surface waters, protection and propagation of aquatic life, and additional beneficial uses of the Nation's water resources. Aspirations as high as these are extremely costly, but coincidental with that cost are numerous benefits that have been determined worthwhile to the extent of justifying those high costs. Probably of greatest significance in the benefit analysis is the fact that the benefits should endure for future generations to enjoy.

Benefits to be realized as a result of implementing PL 92-500 will be varied and far reaching. Some of the benefits will be aesthetic, while many will have economic impacts.

Implementation of the National Pollutant Discharge Elimination System permits will result in substantial reduction in pollutants introduced from point sources into State waters. This reduction in pollutants is a reduction in demand upon the aquatic environment. Removal of the pollutant load will result in a greater availability of dissolved oxygen for the support of aquatic life and the natural purification of the waters. Oxygen that has previously been required for the oxidation of organic material in raw or poorly treated wastewaters will be available to support plant and fish of disinfection. It can be anticipated that recreation in the form of improved fishing and increased swimming are almost a certainty. To quantify these benefits in terms of dollars or satisfaction, however, would be entirely subjective at this point.

The reduction in pollutants to the State's waters can have a distinct economic impact. For municipalities that use surface water for the water supply source improvement resulting from adequate upstream waste treatment will pass on a savings in the operation of water treatment plants. Chemical costs should be reduced, in that less coagulants, flocculants, and chlorine would be required. In addition reduced power costs should be realized.

A potential beneficial use of higher quality effluents from municipal wastewater treatment facilities is reuse of that treated water by industry. Options may be open for industries within close proximity to municipal wastewater treatment plants to use the effluent as an alternative to groundwater or surface water. This option will be more likely from wastewater plants employing tertiary treatment, or those where the industry is faced with pretreating raw water source prior to use.

The principle of water reuse need not totally replace another supply system, but could more reasonably supplement the industry's water needs. There are numerous possibilities for water reuse that are worthy of consideration and represent efficient utilization of natural resources.

life. In many instances the visual appearance of the waters will improve, since the bypassing of raw sewage will be dramatically reduced. In addition greyish-black sludge blankets should be eliminated by provision of adequate secondary or better waste treatment. Floating scum, foreign matter, and algal mats should also be reduced. There should be less toxic affect on the aquatic wildlife because of pH, temperature, and heavy metal controls called for in each NPDES permit. It can be seen that many single parameters of pollutants from point source discharges should improve. In addition, it is probable that there has been a collective damage caused by more than one of these parameters acting together. On the other hand, it is likewise possible that in some cases there has been a buffering effect or balance of opposing pollutants. From an aesthetic point of view hopes are quite high.

Optimistically one might predict crystal clear waters, with abundant game fish to entice all outdoorsmen to Iowa as the Mecca of outdoor recreation. More realistically this is not immediately likely until nonpoint source pollution is effectively dealt with. Nonpoint pollution contributes significantly to the turbidity problem of flowing waters, but it probably protects the waters, to some extent, from algal mats because light penetration is reduced by the solids present in the water.

Fecal coliform bacteria are significantly reduced to safe levels at municipal treatment plants with long term storage

COST ESTIMATES

The projected costs for implementing Public Law 92-500 shall be addressed in two parts. One part, the municipal estimate, is based on the 1974 Needs Survey conducted during the late summer of 1974. The second part, the industrial sector, is based on cost estimates provided by the principal industrial dischargers having BOD or ammonia reductions in operation permits.

MUNICIPAL COST ESTIMATES

In an attempt to obtain the most accurate cost estimates for the 1974 survey of municipal wastewater needs, the State of Iowa retained the consulting engineer of record for municipalities, SMSA's (Standard Metropolitan Statistical Areas), and cities with populations greater than 10,000. It was assumed that each city's consulting engineer was best suited to respond in a timely manner in summarizing the city's needs within the prescribed survey format.

Effluent requirements were established by the State, and consultants were directed to estimate costs to satisfy those requirements. The consulting engineers were also asked to estimate costs for storm water needs for their client cities, which the State composited and used for statewide projections. The Iowa Department of Environmental Quality sampled 20% of those cities outside of SMSA's with populations less than 10,000, and projected total needs based upon that sample.

Needs for the 20% sample were based file data, permit requirements, selected interviews with municipal officials, and data obtained from the 1973 Needs Survey. Costs were estimated using EPA procedural guidance curves and estimating techniques. When available, cost estimates were taken from preliminary engineering reports and facility plans. When costs were unavailable, cost curves based on past comparable construction contracts were used.

The 1974 survey resulted in needs almost twice the 1973 figures for the categories I through V (Table VI-1) (secondary treatment needs, treatment needs more stringent than secondary treatment, infiltration correction needs, major sewer rehabilitation needs, new interceptor and collector sewer needs, and correction of overflow needs). The increases were a result of the following:

1. Adoption of revised water quality standards and designation of new water quality limited segments.
2. Category III and V were disallowed in the 1973 survey but included within the 1974 survey.
3. The 1973 survey made extensive use of the EPA cost curves, in the absence of consulting engineers' estimates, or State or municipal estimates based on past comparable construction.

Categories I through IV represent current needs for meeting effluent requirements regarded as best practicable technology currently available, or for meeting State Water Quality Standards. No artificial standards were established for the Needs Survey. The needs reported are substantiated within grants, NPDES permits, and other phases of Iowa's regulatory program. The reported needs may not meet the long range goals of the Act, but that becomes a matter of conjecture because the goals are so ill-defined. It is the State's opinion that the Needs Survey should be evaluated in terms of current water quality standards and treatment technology. Allocation of grant funds based on inflated needs in order to meet poorly defined goals would certainly result in economic inefficiency. In attempting to be competitive for Federal grants, gross overestimation would undoubtedly occur.

For stormwater treatment needs the cost estimate was based on a composite of estimates made by ten consulting engineers retained by the State to survey forty cities and towns. In the absence of detailed studies and firm guidelines for degree of treatment/control, which would be necessary for accurate estimates, the engineers were directed to make rough estimates of need for the Category VI (storm water needs) sample. These estimates varied from facilities for towns of less than 1,000 population and sewered area of 58 acres to facilities for cities of greater than 25,000 population and 54,000 sewered acres, designs for 3 inch/24 hour storms to 2 hr/25 year storms, and treatment consisting of two hour detention settling and chlorination to complete event storage. In general, costs for storm sewers not presently in existence were included.

In compositing the costs for the Category VI sample, the cost data were plotted against city area on log paper. It was intended that different curves be drawn for each of four or five different city population groupings. The data for the whole spectrum of city populations, however, fit fairly well on two different linear curves, one each for populations of greater and less than 5,000.

It was also found that there was good correlation between city population and area. Plotted on log log paper, population versus area fit fairly well on a linear curve. Assuming that the Category VI sample was representative of the rest of the State, the two curves (cost versus area and area versus population) were used to determine constants, which were then applied to project statewide cost, given population of each city and town. The statewide Category VI cost so determined was $2,885,489,000.

The construction cost applied as above to cities and towns on water quality limited segments was found to be $1,323,613,000.

INDUSTRIAL COST ESTIMATE

For the purpose of this report an abbreviated survey was conducted of the major Iowa industries that contribute BOD (biochemical oxygen demand) or NH_3 (ammonia) loads to Iowa waters. The industries were identified by reviewing the draft NPDES permits for each industry and noting those industries that had implementation schedules to reduce present pollutant loadings to the waters of the State. The rationale for selection of BOD and NH_3 as the parameter for observation was that these parameters would have the most direct effect upon the quality of the water environment. In addition it was felt that these parameters are the most common pollutants that are encountered throughout this State. The dollar value reached for the State can only be judged as a rough estimate indicating an order of magnitude of the projected costs. Each surveyed industry was asked how much it anticipated spending between January 1, 1975, and July 1, 1977, for water pollution abatement in order to comply with it's permit conditions. For the most part, these estimates reflect capital expenditures as opposed to operation, maintenance, overhead or salaries.

The total estimate resulting from the industrial survey was 50 million dollars. These figures are based solely upon the information provided by the surveyed industries that have implementation schedules within their operation permits calling for reduction in biochemical oxygen demand and ammonia by July 1, 1977. As a result of this permit program, current daily discharges of 61 tons BOD and 10.2 tons of NH_3 should be reduced to 6.5 tons of BOD and 1.75 tons of NH_3 by July 1, 1977. This reflects an 83% reduction in ammonia and an 89% reduction in BOD over the next two years. The most significant reductions in pollutant loads are projected for tributaries of the Mississippi River and, more specifically, the Northeast Iowa Conservancy District which includes about 75% of Iowa's eastern border.

TABLE V1-1

STATE OF IOWA
FINAL REPORT
1974 SURVEY OF NEEDS FOR
MUNICIPAL WASTEWATER TREATMENT FACILITIES

A. SUMMARY OF STATE TOTAL NEEDS (In Thousands of Dollars) BASIS: June, 1973 Dollars

	Unchanged	Changed	New	Total Reported on Forms	Sample Add On	State Needs I-V	State Needs I-VI
CATEGORY I (Secondary Treatment)	5,548K	64,563K	4,000K	74,111K	83,252K	157,363K	
CATEGORY II (More Stringent Than Secondary Treatment)	704K	168,513K	-	169,217K	46,528K	215,745K	
CATEGORY III-A (Infiltration Correction)	94K	107,279K	1K	107,374K	18,984K	126,358K	
CATEGORY III-B (Major Sewer Rehabilitation)	-	8,816K	-	8,816K	1,052K	9,868K	
CATEGORY IV-A (New Collector Sewer)	1,426K	42,420K	-	43,846K	79,068K	112,914K	
CATEGORY IV-B (New Interceptors)	5,755K	165,409K	-	171,164K	60,332K	231,496K	
CATEGORY V (Overflow Correction)	-	124,304K	-	124,304K	1,536K	125,840K	
CATEGORY VI (Stormwater Treatment)	-	-	-	-	-	-	2,885,489K

TABLE VI-1 (Continued)

STATE OF IOWA
FINAL REPORT
1974 SURVEY OF NEEDS FOR
MUNICIPAL WASTEWATER TREATMENT FACILITIES

TOTAL DOLLARS	13,527K	681,304K	4,001K	698,832K	290,752K	989,584K	3,875,073K
NUMBER OF FORMS	45	281	1	327	-	-	-

B. EXTRAPOLATION OF SAMPLE (In Thousands of Dollars) BASIS: June 1973 Dollars

	Total Dollar: Sample	Sample Percentage	Total Needs (Total Dollars x $\frac{100}{20}$)	Sample "ADD-ON" (B3-B1)
CATEGORY I (Secondary Treatment)	20,813K	20	104,065K	83,252K
CATEGORY II (More Stringent Than Secondary Treatment)	11,632K	20	58,160K	46,528K
CATEGORY III-A (Infiltration Correction)	4,746K	20	23,730K	18,984K
CATEGORY III-B (Major Sewer Rehabilitation)	263K	20	1,315K	1,052K
CATEGORY IV-A (New Collector Sewer)	19,767K	20	98,835K	79,068K
CATEGORY IV-B (New Interceptors)	15,083K	20	75,415K	60,332K
CATEGORY V (Overflow Correction)	384K	20	1,920K	1,536K
CATEGORY VI (Stormwater Treatment)	-	-	-	-
TOTAL DOLLARS	72,688K		363,440K	290,752K

TABLE VI-1 (Continued)

STATE OF IOWA
FINAL REPORT
1974 SURVEY OF NEEDS FOR
MUNICIPAL WASTEWATER TREATMENT FACILITIES

C. FINAL REPORT

NOTE: Values in Column (A) Should Include Values in Column (B)	TOTAL SURVEY (A)	WITHIN THE REQUIRED SAMPLE GROUP (B)
1. Number of Authorities Reported	303	156
2. Number of Facilities Reported	327	161
3. Population, State-Wide, 1972-73	1,355,216	
4. Population Projection, State-Wide, 1990	2,737,704	
5. Population, Place 10,000 Outside SMSA (1990)	1,072,105	214,421

QUALIFICATION OF COST ESTIMATES

The projected costs to achieve the objectives of Public Law 92-500 can only provide a general indication of anticipated costs. The estimates for municipal needs are based upon the 1974 Needs Survey, conducted under the direction of the Iowa Department of Environmental Quality. Many of the conscientious judgments made during the summer of 1974 are now erroneous due to the recent determinations of waste load allocations for significant wastewater dischargers. These allocations are more stringent than federally imposed effluent restrictions and in some instances call for very expensive tertiary treatment. Where a decision for plant upgrade might have been reported on the 1974 Needs Survey as being cost effective when considering secondary treatment requirements, total replacement is now cost effective when compared to a more stringent criteria. One can conclude that a true evaluation of municipal "needs" must include the present regulatory requirements as well as an adjustment of these figures for dollars at the time of implementation. In addition, it can be anticipated that as Section 303(e) planning progresses, additional waste load allocations may become necessary in order to meet or maintain water quality standards.

SECTION VII

NONPOINT SOURCE POLLUTION

Of the 35.84 million acres of land in Iowa, about 2.72 million acres are damaged by flood water and sediment, and 5.80 million acres are damaged by erosion (Table VII-1). These damages are not the only losses incurred. The same runoff that causes erosion, flooding, and sediment damage carries nutrients, agricultural chemical residues, animal wastes and other pollutants to the lakes and rivers of the State. Feedlots, cropland, forests, pastures, and urban areas are called nonpoint sources of pollution. Nonpoint sources of pollution are not easily isolated or controlled because there is generally no single identifiable point of discharge into a receiving body of water.

Cropland Runoff Studies

The major nonpoint pollution in Iowa occurs in runoff from land areas, including cropland, pastures, ranges, and woodlands. There is relatively little data indicating representative pollutant losses for the various land uses in Iowa, however, several studies have been conducted on isolated areas throughout the State.

A study of the Iowa Great Lakes area in Dickinson County (Borokfa, 1974) indicated nutrient runoff concentrations for various land use practices as well as runoff from feedlot areas. Ammonia concentrations from feedlot runoff was

TABLE VII-1

LAND AREAS IN IOWA WITH RUNOFF DAMAGE

RIVER BASIN	ACRES WITH FLOODWATER AND SEDIMENT DAMAGE	ACRES WITH EROSION DAMAGE	ACRES WITH CONTROLLED DRAINAGE	ACRES WITH IRRIGATION
Rock	28,073	18,440	7,330	0
Floyd	33,140	36,051	5,674	0
Maple	34,425	154,470	14,310	0
Little Sioux	147,909	461,639	139,042	500
Nishnabotna	244,095	626,073	59,659	0
Nodaway	97,739	295,272	20,640	0
Chariton	46,831	220,480	8,685	0
West Fork Des Moines	43,170	12,194	178,080	0
East Fork Des Moines	30,372	28,806	228,011	0
Boone	8,010	618	252,026	50
Raccoon	99,773	230,098	406,296	1,100
Des Moines	307,611	851,173	337,670	700
Skunk	251,434	548,146	388,639	0
Iowa	235,072	80,268	365,780	1,000
Cedar	206,792	158,339	464,337	245
West Fork Cedar	50,030	3,502	255,095	3,300
Shell Rock	44,573	15,564	291,218	775
Maquoketa	43,122	82,958	53,755	0
Wapsipinicon	98,936	210,713	387,329	1,400
Upper Iowa	30,602	30,355	21,265	0
Iowa Total	2,719,727	5,801,031	4,345,369	10,920

considerably higher than runoff from cropland (Figure VII-1). Nitrate concentrations from feedlot runoff were also high, as were tile drainage (Figure VII-2). Particulate phosphorus concentrations (Figure VII-3) were considerably higher for cropland and feedlot uses than for tile drainage. The total phosphorus concentrations from feedlot runoff (Figure VII-4) were also higher than the concentrations from the other sources. Since no flow records were available, no calculations of the annual nutrient loss for the given land use can be made.

Studies conducted by Iowa State University at the Western Iowa Experimental Farm (1973, 1974) measured nutrient runoff from small plots of cropland. Results of this study (Table VII-2) represent concentrations and losses for the growing season May through September, with losses calculated from an average 2.5 inches of runoff and 15 tons/acre sediment production for this period. It should be noted that these values represent nutrient runoff from the study area, and not necessarily the amount of nutrient runoff reaching a stream.

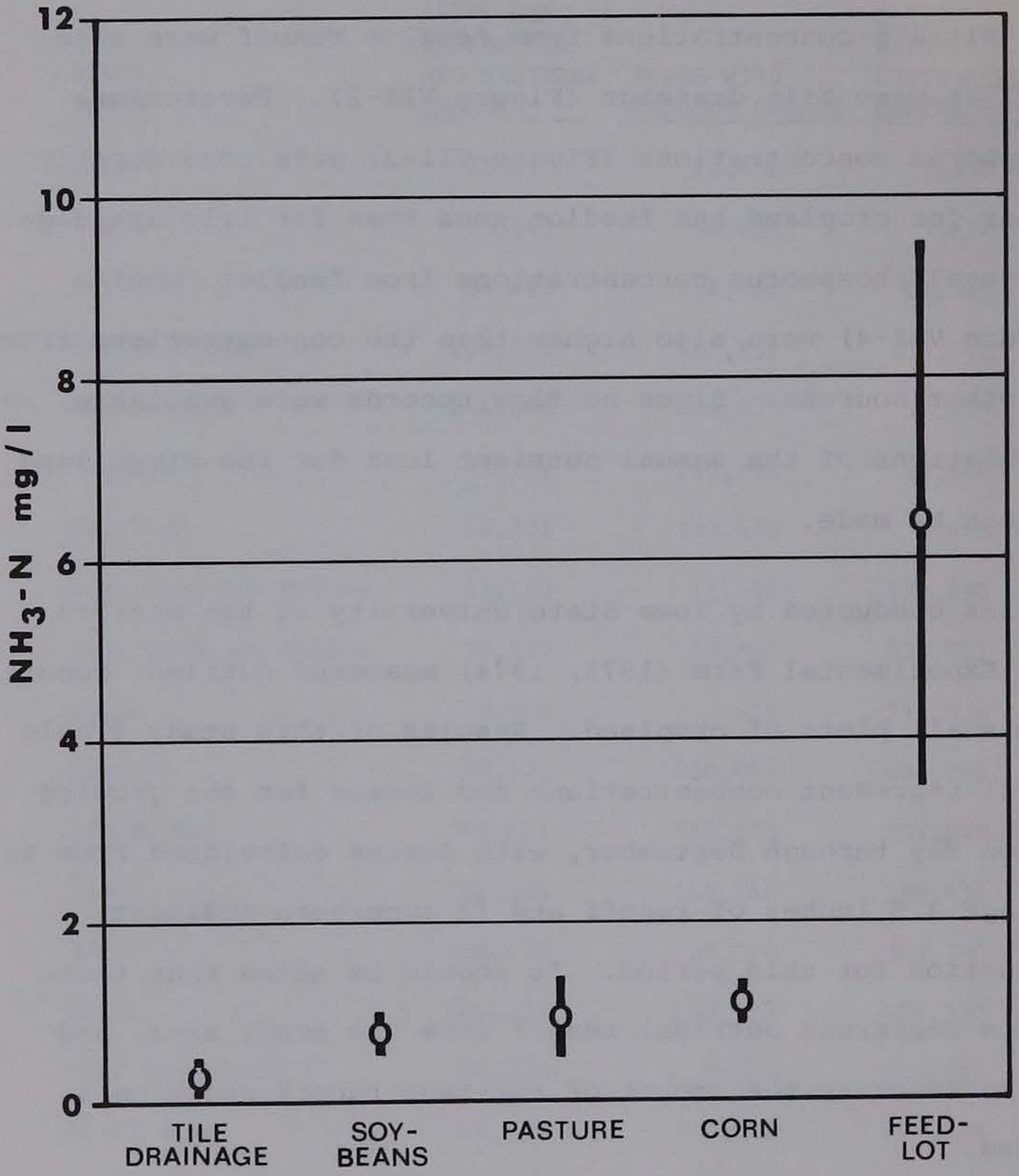

FIGURE VII-1 MEAN AND STANDARD ERROR OF THE MEAN OF AMMONIA NITROGEN CONCENTRATIONS (MG/L) IN FIVE TYPES OF RUNOFF FROM MARCH 1 TO MAY 20, 1974 IN DICKINSON COUNTY (BOROFKA, 1974)

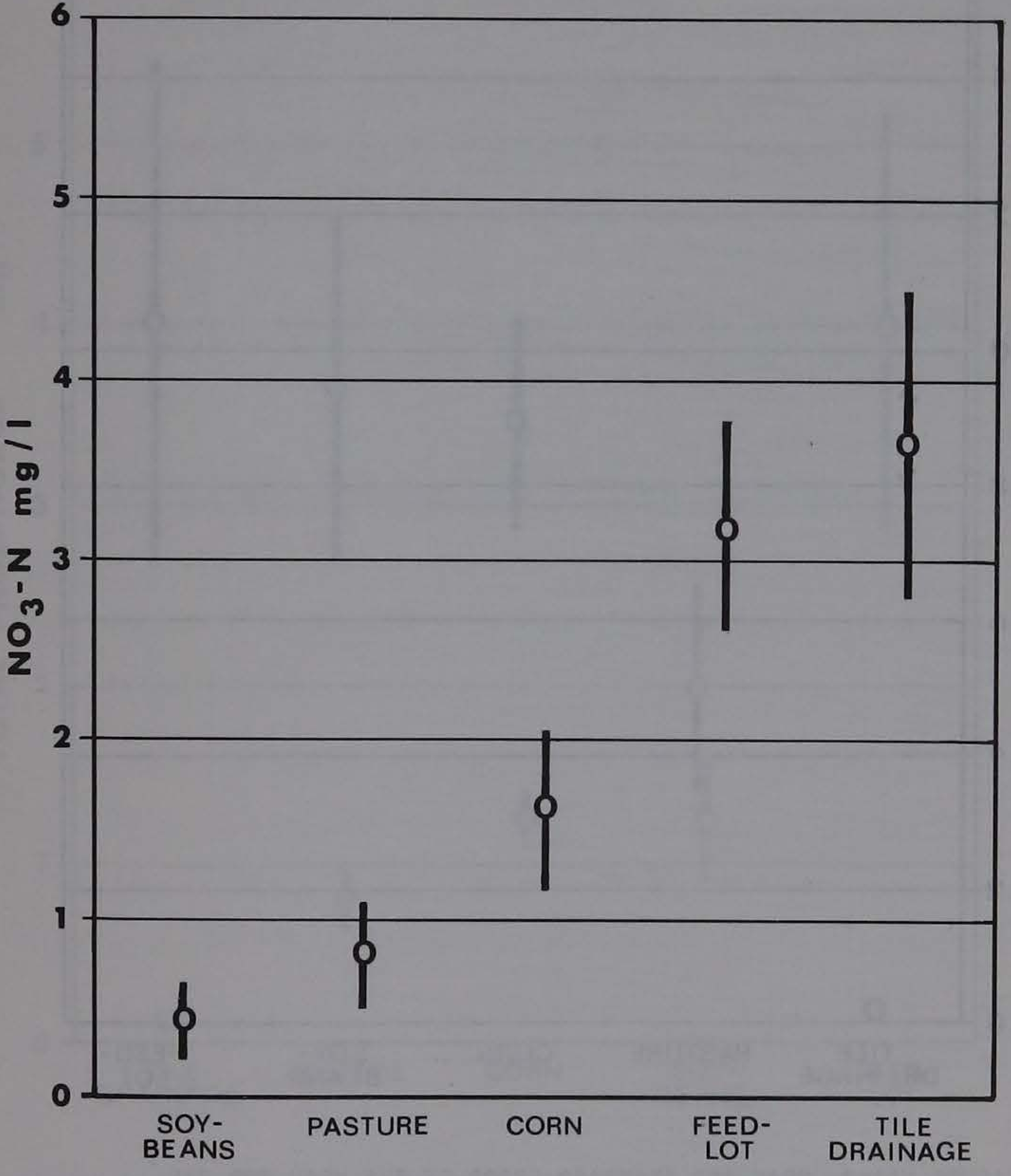

FIGURE VII-2 MEAN AND STANDARD ERROR OF THE MEAN FOR NITRATE NITROGEN CONCENTRATIONS (MG/L) IN FIVE TYPES OF RUNOFF FROM MARCH 1 TO MAY 20, 1974 IN DICKINSON COUNTY (BOROFKA, 1974)

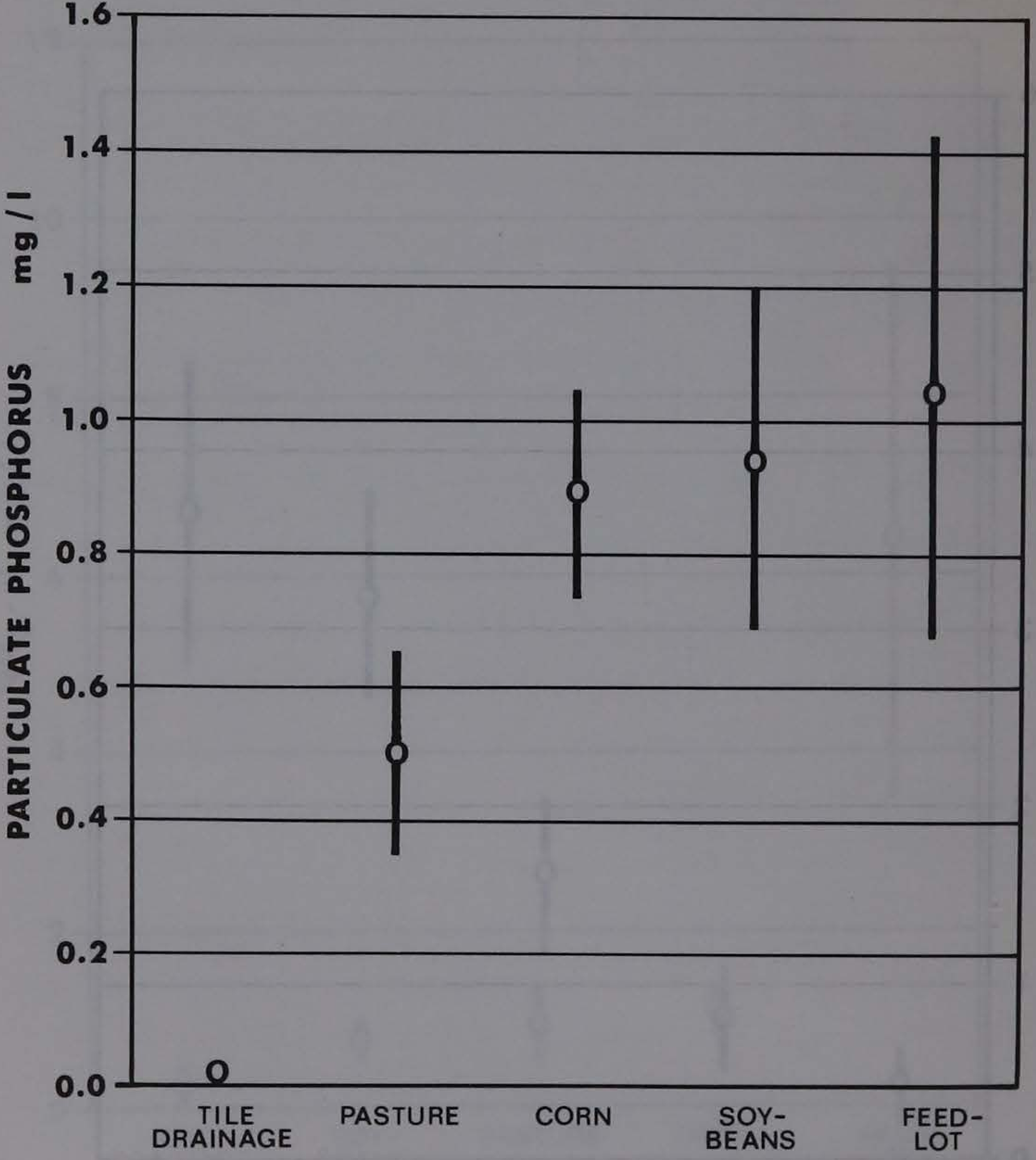

FIGURE VII-3 MEAN AND STANDARD ERROR OF THE MEAN FOR PARTICULATE PHOSPHORUS CONCENTRATIONS (MG/L) IN FIVE TYPES OF RUNOFF FROM MARCH 1 TO MAY 20, 1974 IN DICKINSON COUNTY (BOROFKA, 1972)

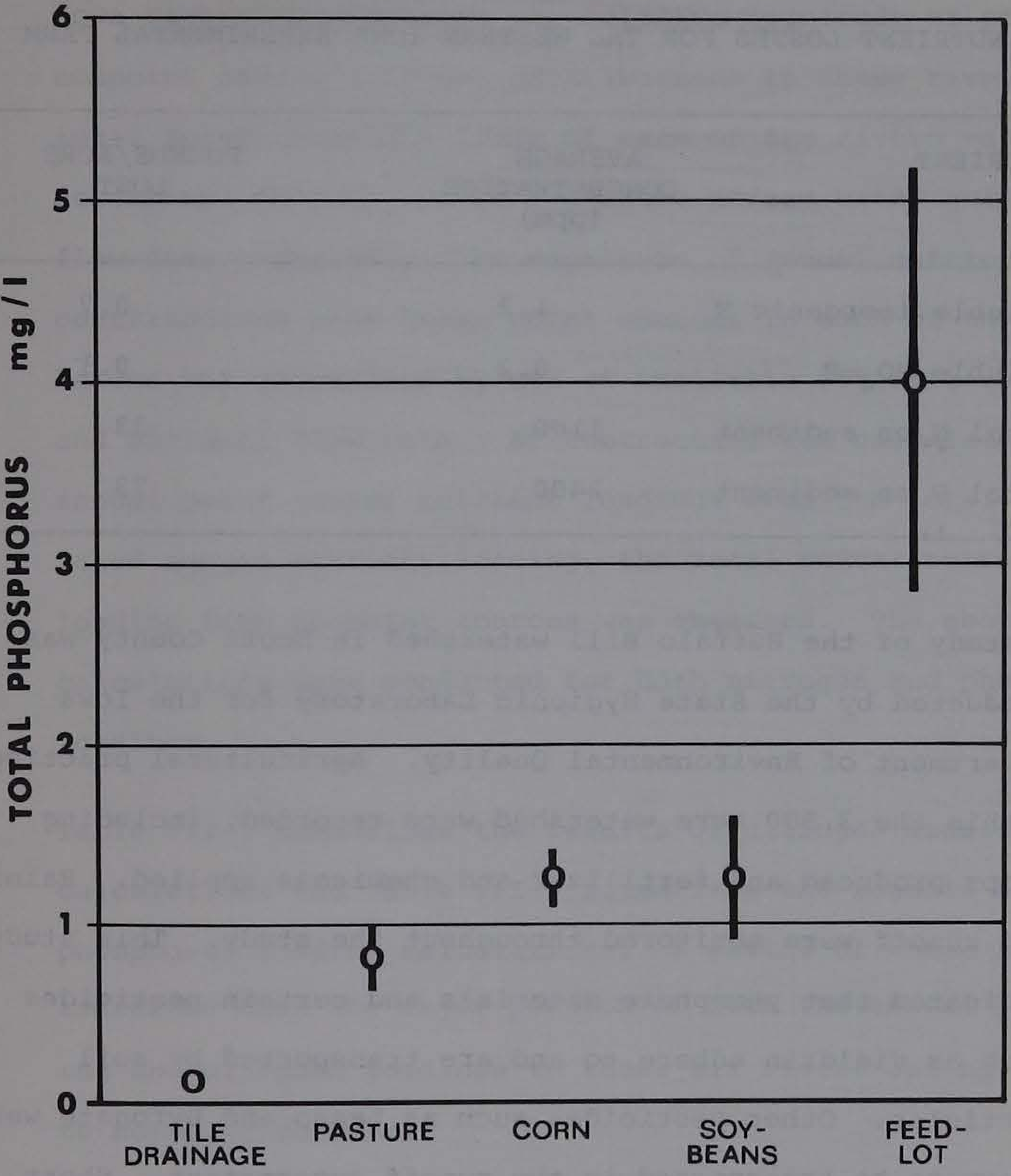

FIGURE VII-4 MEAN AND STANDARD ERROR OF THE MEAN FOR TOTAL PHOSPHORUS CONCENTRATIONS (MG/L) IN FIVE TYPES OF RUNOFF FROM MARCH 1 TO MAY 20, 1974 IN DICKINSON COUNTY (BOROFKA, 1974)

TABLE VII-2

NUTRIENT LOSSES FOR THE WESTERN IOWA EXPERIMENTAL FARM

NUTRIENT	AVERAGE CONCENTRATION (ppm)	POUNDS/ACRE LOST
Soluble inorganic N	1.2	0.7
Soluble PO_4-P	0.2	0.1
Total N on sediment	1100	33
Total P on sediment	2400	73

A study of the Buffalo Bill watershed in Scott County was conducted by the State Hygienic Laboratory for the Iowa Department of Environmental Quality. Agricultural practices within the 3,500 acre watershed were recorded, including crops produced and fertilizer and chemicals applied. Rainfall and runoff were monitored throughout the study. This study indicated that phosphate materials and certain pesticides such as dieldrin adhere to and are transported by soil particles. Other pesticides such as Lasso and Dyfonate were shown to be transported in the runoff supernatant. Short, half-lived pesticides were found in high concentrations in the runoff shortly after application. Concentrations of the siltation related chemicals were greatest during periods when cropland areas had little plant cover and the soil was loosely compacted.

A recent study conducted by the Iowa Department of Environmental Quality analyzed the annual nutrient loadings to six Iowa rivers to determine the relative magnitude of point and nonpoint source nutrient contributions to these rivers. The total annual nutrient loads of each of the rivers was first determined through use of available stream water quality and flow data. Secondly, the magnitude of annual nutrient contributions from known point sources in each of the river basins was determined by use of available effluent quality and effluent flow data. By subtracting the calculated annual point source nutrient loadings from the total calculated annual nutrient loading, the total annual nutrient loading from nonpoint sources was obtained. The above calculations were conducted for both nitrogen and phosphorus loadings.

Table VII-5 summarizes the results of nitrogen loading calculations and Table VII-6 summarizes the results of the phosphorus loading calculations. A review of these summaries indicates that the major portion of both the annual phosphorus and nitrogen loadings to these six rivers can be attributed to nonpoint sources.

For comparative purposes, calculations of anticipated total annual nitrogen and phosphorus loadings were also conducted for each of these six river basins using literature values for nutrient losses from various land uses. The results of these calculations are summarized in page VII-15 to page

TABLE VII-3

NITROGEN · FLOW REGRESSION ANALYSIS FOR THE INDICATED RIVER BASINS BASED ON WATER QUALITY AND FLOW DATA

RIVER	ESTIMATED LBS/YR STREAM SAMPLES	NO. OF OBS.	MEAN CONC. (mg/l)	STANDARD DEVIATION	MEAN FLOW (cfs)	STANDARD DEVIATION	$r_{flow \cdot N}$	t-VALUE	P LEVEL OF SIGNIFICANCE
Floyd	1,507,984	44	4.13	3.06	191	264	.403	2.85	.007
Little Sioux	9,609,556	42	4.25	2.59	1,294	1,307	.458	3.25	.003
Chariton	1,585,427	18	2.02	1.00	2.5	683	.480	2.19	.050
Des Moines	41,334,897	125	6.22	3.84	3,249	3,312	.571	7.69	<.001
Iowa	2,075,830	268	0.68	0.75	1,593	1,988	.045	0.73	.450*
Cedar	6,804,881	59	1.02	.847	4,239	3,140	.369	2.99	.004

* Non-significant relationships

TABLE VII-4

PHOSPHORUS · FLOW REGRESSION ANALYSIS FOR THE INDICATED RIVER BASINS BASED ON WATER QUALITY AND FLOW DATA

RIVER	ESTIMATED LBS/YR STREAM SAMPLES	NO. OF OBS.	MEAN CONC. (mg/l)	STANDARD DEVIATION	MEAN FLOW (cfs)	STANDARD DEVIATION	$r_{flow \cdot PO_4}$	t-VALUE	P LEVEL OF SIGNIFICANCE
Floyd	720,207	44	.88	1.17	192	265	.909	14.09	$<.001$
Little Sioux	1,851,632	42	.77	.82	1,287	1,311	.344	2.32	.025
Chariton	579,916	18	0.94	.729	215	682	.497	2.29	.040
Des Moines	5,621,007	111	1.03	.867	3,799	4,201	.264	2.81	.006
Iowa**	1,723,975**	262	0.57**	.402	1,614	2,004	.061	0.98	.300*
Cedar	5,099,507	61	0.90	.432	4,952	4,789	.045	0.35	$>.500$*

* Non-significant relationships
** Orthophosphorus

TABLE VII-5

ANNUAL NITROGEN LOAD FOR THE INDICATED RIVER BASINS BASED ON WATER QUALITY AND FLOW DATA

RIVER	ESTIMATED LBS/YR BASED ON STREAM SAMPLES	ESTIMATED LBS/YR POINT SOURCES	ESTIMATED LBS/YR NONPOINT SOURCES	DRAINAGE AREA IN ACRES	ANNUAL RUNOFF LBS/ACRE	NONPOINT PERCENT OF TOTAL
Floyd	1,705,984	65,171	1,640,813	564,480	2.91	96.2
Little Sioux	9,609,556	87,308	9,522,248	2,256,640	4.22	99.1
Chariton	1,585,427	24,795	1,560,632	342,400	4.56	98.4
Des Moines	41,334,897	695,235	40,639,662	3,738,240	10.87	98.3
Iowa	2,075,830	91,287	1,984,543	1,993,600	.99	95.6
Cedar	6,804,881	1,552,334	5,252,547	4,166,400	1.26	77.2

TABLE VII-6

ANNUAL PHOSPHORUS LOAD FOR THE INDICATED RIVER BASINS BASED ON WATER QUALITY AND FLOW DATA

RIVER	ESTIMATED LBS/YR BASED ON STREAM SAMPLES	ESTIMATED LBS/YR POINT SOURCES	ESTIMATED LBS/YR NONPOINT SOURCES	DRAINAGE AREA IN ACRES	ANNUAL RUNOFF LBS/ACRE	NONPOINT PERCENT OF TOTAL
Floyd	720,207	29,807	690,400	564,480	1.22	95.9
Little Sioux	1,851,632	129,088	1,722,544	2,256,640	.76	93.0
Chariton	879,916	48,203	831,713	342,400	2.43	94.5
Des Moines	5,621,007	586,015	5,034,992	3,738,240	1.35	89.6
Iowa	1,723,975 **	103,445	1,620,530	1,993,600	.81	94.0
Cedar	5,099,507	1,526,775	3,572,732	4,166,400	.86	70.1

** Orthophosphorus

VII-17. Comparison of these results with the results given in Tables VII-5 and VII-6 indicates that the calculated nonpoint nutrient loading fell within the lower end of the range of values found in the literature.

Status of the Soil and Water Conservation Practice Needs

The magnitude of soil erosion related problems becomes evident with a statewide survey of conservation practices.

The Soil Conservation Service (Wilson Moon, 1974) recently indicated that only 60,000 miles of a needed 368,000 miles of terraces have been built. About 200,000 acres of a needed 349,000 acres of grassed waterways have been built. Only 36,000 of 92,000 needed ponds have been built. Drainage work on 255,000 miles of a needed 360,000 miles of drainage needs is finished. Though the drainage work appears to be two-thirds complete, many old systems are deteriorating and need to be rebuilt. Only 18,000 of a needed 47,000 grade stabilization structures have been built to control gullies. There is considerable potential for increased use of conservation tillage, since conservation tillage is currently being practiced on only about one-fourth of Iowa's cropland.

The Soil Conservation Service has reported that soil erosion in Iowa in 1974 was the worst it had been in twenty-five years, with 4.5 million acres having soil losses of more

FLOYD RIVER DATA SUMMARY

Gauge Station @ James:

Drainage Area Above Gauge	
Floyd River (88.65%)	564,480 Acres

Anticipated Nutrient Loadings Using Literature Values

BASIN	NITROGEN (lbs.) LOW	NITROGEN (lbs.) HIGH	PHOSPHORUS (lbs.) LOW	PHOSPHORUS (lbs.) HIGH
Floyd (88.65%)	461,475	4,533,791	115,222	7,389,376

LITTLE SIOUX RIVER SUMMARY

Gauge Station @ Turin:

Drainage Area Above Gauge	
Out-of-State	376,488 Acres
Maple River	504,320 Acres
Little Sioux River (68.66%)	1,375,832 Acres

Anticipated Nutrient Loadings Using Literature Values

SUB BASIN	NITROGEN (lbs.) LOW	NITROGEN (lbs.) HIGH	PHOSPHORUS (lbs.) LOW	PHOSPHORUS (lbs.) HIGH
Maple	406,532	3,788,052	97,732	6,123,417
Little Sioux (68.66%)	1,106,945	10,731,926	273,395	17,491,349
In-State-Total	1,513,477	14,519,978	371,127	23,614,766
Total	1,816,172	17,423,973	445,352	28,337,719

CHARITON RIVER DATA SUMMARY

Gauge Station @ Rathbun:

Drainage Area Above Gauge	
Chariton River (60.57%)	342,400 Acres

Anticipated Nutrient Loadings Using Literature Values

	NITROGEN (lbs.)		PHOSPHORUS (lbs.)	
BASIN	LOW	HIGH	LOW	HIGH
Chariton (60.57%)	300,107	1,627,366	54,478	2,364,948

DES MOINES RIVER DATA SUMMARY

Gauge Station @ Saylorville:

Drainage Area Above Gauge	
Out-of-State	1,034,521 Acres
West Fork Des Moines	586,532 Acres
East Fork Des Moines	727,540 Acres
Boone	576,812 Acres
Upper Des Moines (75.96%)	812,535 Acres
	3,738,240 Acres

Anticipated Nutrient Loadings Using Literature Values

	NITROGEN (lbs.)		PHOSPHORUS (lbs.)	
SUB BASIN	LOW	HIGH	LOW	HIGH
West Fork Des Moines	473,745	5,137,143	133,829	8,486,096
East Fork Des Moines	589,926	6,407,099	153,656	10,605,408
Boone	429,559	4,968,862	119,327	8,370,801
Upper Des Moines(75.86%)	677,971	6,718,651	166,128	11,063,554
In-State-Total	2,171,201	23,221,755	671,940	38,525,859
Total	3,001,903	32,106,398	776,938	53,265,852

IOWA RIVER DATA SUMMARY

Gauge Station @ Marengo:

Drainage Area Above Gauge	
Iowa (68.99%)	1,993,600 Acres

Anticipated Nutrient Loadings Using Literature Values

	NITROGEN (lbs.)		PHOSPHORUS (lbs.)	
BASIN	LOW	HIGH	LOW	HIGH
Iowa (68.99%)	1,550,044	14,021,513	346,780	22,453,811

CEDAR RIVER DATA SUMMARY

Gauge Station @ Palo:

Drainage Area Above Gauge	
Out-of-State	681,821 Acres
Red Cedar	604,800 Acres
Shell Rock	935,600 Acres
West Fork Cedar	682,971 Acres
Cedar (60.08%)	1,261,208 Acres
	4,166,400 Acres

Anticipated Nutrient Loadings Using Literature Values

	NITROGEN (lbs.)		PHOSPHORUS (lbs.)	
SUB BASIN	LOW	HIGH	LOW	HIGH
Red Cedar	480,422	4,572,342	112,124	7,359,476
Shell Rock	748,979	7,433,874	182,223	12,092,376
West Fork Cedar	553,227	5,440,632	135,212	8,848,959
Cedar (60.08%)	1,018,394	9,130,641	227,044	14,617,117
In-State-Total	2,801,022	26,577,489	656,603	42,917,928
Total	3,349,182	31,778,703	785,100	51,316,966

than ten tons per acre. Soil losses of 40 to 50 tons per acre were not uncommon, and soil losses in some areas reached 200 tons per acre.

Since 1960, about 4.5 million acres, or an average of 300,000 acres each year, have been reported by the Soil Conservation Service as being protected against erosion. During that same period corn and soybean acreages have increased from 15 million acres to over 20 million acres. Thus, little overall progress has been made in the control of soil erosion.

The cost of reducing erosion losses is quite high. Table VII-7 shows the cost of control measures for various land uses. The conservation needs are based on the 1970 Iowa Conservation Needs Inventory. The cost of treatment measures are based on June 1973 Soil Conservation Service cost estimates. Conservation treatment measures are designed to reduce soil losses to acceptable levels established by Soil Conservation Districts, usually in the range of from three to five tons per acre per year.

Iowa Soil Conservation Program

Iowa has enacted legislation which is significant toward the control of soil erosion and sediment. The Iowa Conservancy District Act became effective on July 1, 1971. This act provides that soil erosion, when exceeding the soil loss limits established by soil conservation districts, can be abated as a nuisance. This Act applies to all land areas,

TABLE VII-7

EROSION CONTROL COSTS FOR THE STATE OF IOWA

CONTROL COSTS

LAND USE	TOTAL COST	TOTAL ACRES	COST/ACRE
Cropland			
Stripcropping and Terracing	$824,677,000	7,932,499	$ 103.96
Grade Stabilization	$638,440,000	1,873,037	$ 340.86
Pasture			
Diversions	$ 7,003,000	610,660	$ 11.47
Land Conversions	$ 29,647,000	16,682	$1,777.18
Critical Area Planting	$ 8,002,000	715,003	$ 11.19
Grassland Management	$ 9,296,000	229,332	$ 40.54
Woodland			
Woodland Management	$160,080,000	2,055,435	$ 77.88
Total	$1,677,145,000	13,432,648	

both rural and urban, and covers erosion from both wind and water. The Act required that soil conservation district commissioners adopt soil loss limits for all lands located within the soil conservation district, and gives the district commissioners responsibility for carrying out the provisions of the Act.

This Act provides for the filing of complaints by concerned persons against the owner of land on which erosion is allegedly occurring. Once a complaint is filed with the soil conservation district, the commissioners have an administrative procedure for effecting the correction of the condition of erosion.

The Conservancy District Act also established six conservancy districts in Iowa, with each district covering a major river basin area of the State. The governing board of each conservancy district is the State Soil Conservation Committee. This law requires the Department of Soil Conservation to prepare and implement a comprehensive plan for each of the districts. An intermediate plan for one basin has been completed and work on plans for the other basins is underway.

Iowa has also established a State cost-share program to support the soil conservation program being conducted within the State. A two million dollar appropriation was provided for cost-sharing for each year of the 1973-75 biennium for soil conservation cost-share purposes.

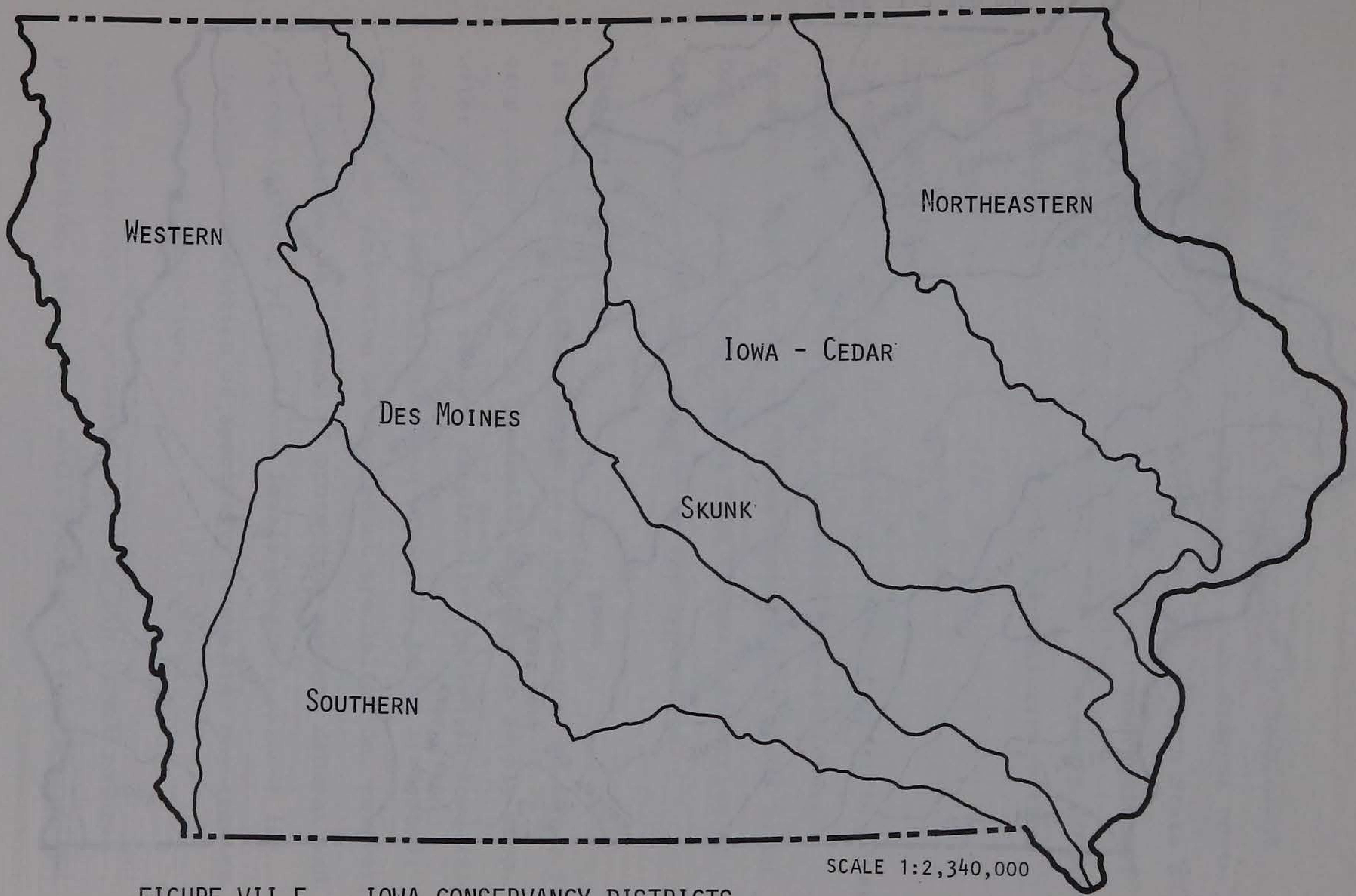

FIGURE VII-5 IOWA CONSERVANCY DISTRICTS

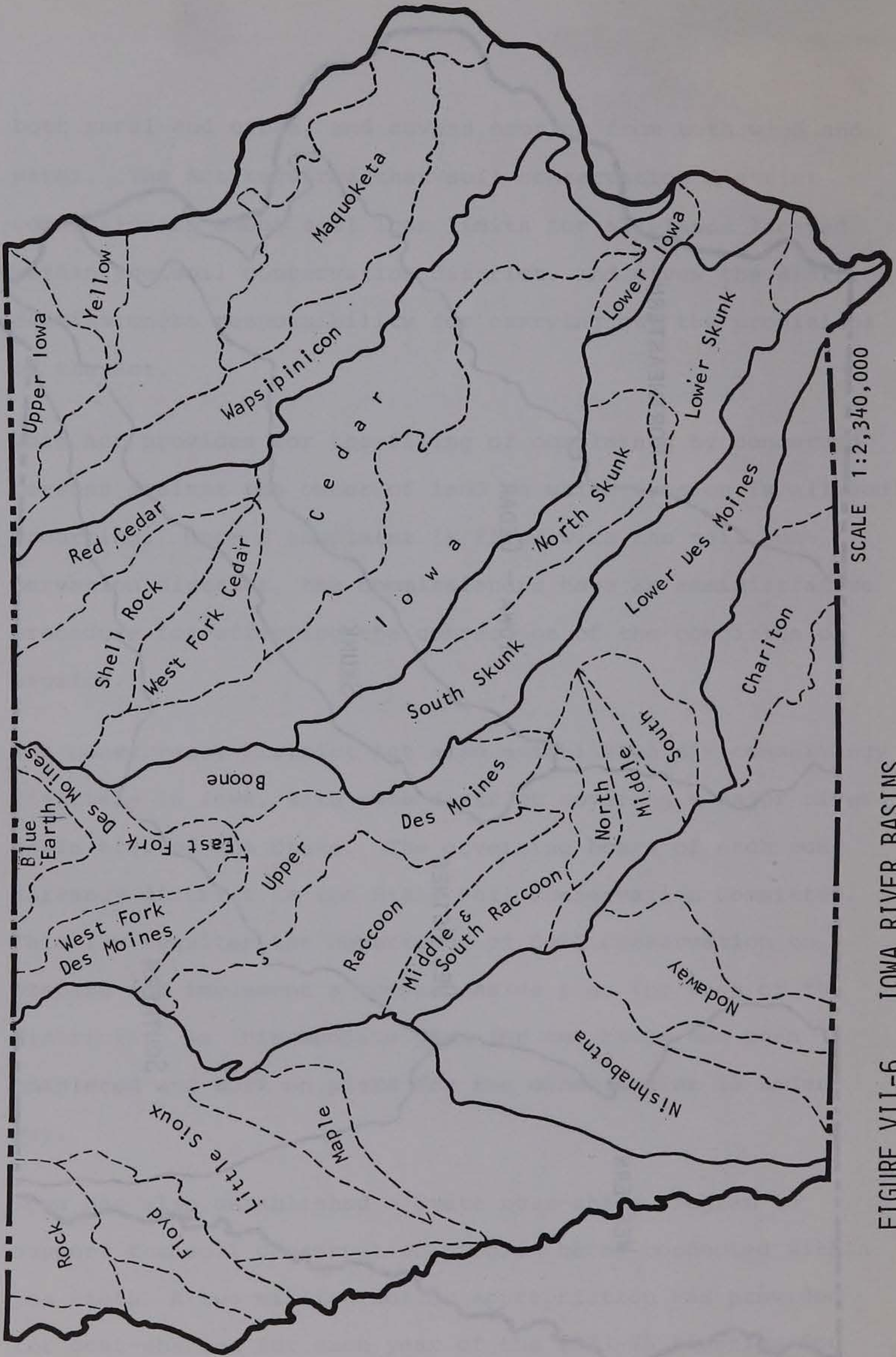

FIGURE VII-6 IOWA RIVER BASINS

The State cost-share funds have been used to supplement federal conservation cost-share funds, when federal cost-share funds have been available. The use of both State and Federal funds has resulted in substantial construction of soil conservation practices within Iowa. The above programs are significant in control of nonpoint pollution within Iowa.

Iowa Inventories

In order to determine the characteristics of specific river basins throughout the State, statewide inventories were conducted based on the 1970 Iowa Conservation Needs Inventory and the 1971 Iowa Annual Farm Census. Summaries of these inventories can be found in the Appendices.

Cropland Irrigation

In Iowa, precipitation serves as a major source of water for crop production, and is generally adequate to supply crop water needs. As a result, cropland irrigation in Iowa is minor, with about 11,000 acres presently being irrigated. The use of irrigation to supplement precipitation, however, is increasing as a means of protecting against drought and increasing crop yields above levels possible without irrigation. Production of speciality crops also may require the use of irrigation.

Since irrigation is primarily used to supplement natural precipitation, and only a small portion of Iowa's cropland areas are being irrigated, no significant problems have been created because of cropland irrigation in Iowa. Unless current irrigation practices change significantly the characteristics of runoff which may occur from irrigated land in Iowa would be expected to be similar to those from non-irrigated land.

Runoff From Waste Disposal Land Areas

Limited use is presently being made of land disposal as a means of ultimate disposal for municipal and industrial wastes in Iowa. One Iowa meat packing plant is presently irrigating its waste on cropland, as are several minor food processing industries. In addition, a number of Iowa communities dispose of waste sludge solids by land application. Several Iowa communities and industries are currently exploring the feasability of disposing of all liquid wastes by land disposal.

Surface runoff from land areas used for disposal of municipal and industrial waste can be high in organic and chemical pollutants. In addition, unless disposal is limited to land areas having suitable soil and groundwater conditions, percolation of applied wastewater through soil can lead to excessive leaching of pollutants into tile drainage or groundwater supplies.

Interest in utilizing land disposal for municipal and industrial wastes is increasing in Iowa, and expanded use of land disposal is expected. To avoid the development of substantial surface or groundwater pollution problems from these disposal systems proper design and operation of the disposal systems will be essential.

Iowa has a substantial livestock industry, with over 100,000 Iowa farms having livestock enterprises. Although a number of these are pasture type livestock operations, a substantial number of confinement or semi-confinement operations exist. In these operations the wastes produced are collected and stored on the feedlot surfaces or in waste storage facilities, and periodically removed and disposed of by land application.

Excessive or improper application of livestock waste to cropland areas can result in elevated levels of organic and nutrient constituents in surface runoff from these waste disposal land areas. Excessive application rates of animal wastes on cropland can result in excessive leaching of nitrates into tile drainage or groundwater supplies. Since most Iowa livestock operations are operated as part of an overall grain and livestock farm, sufficient land areas generally exist for waste disposal. Exceptions occur in cases where large livestock facilities are being operated on small land areas.

In an effort to minimize pollution problems which may occur as a result of land application of animal wastes, the Iowa Water Quality Commission has adopted policies governing the land disposal of livestock wastes. These disposal policies establish maximum application rates based on nutrient content of the waste material, and include restrictions on disposal practices used based on soil conditions, topography, and location of disposal areas with respect to a watercourse.

Feedlot Runoff

A large portion of the complaints and reports of fish kills received by the Water Quality Management Division of the Iowa Department of Environmental Quality stem from feedlot related sources. Iowans marketed over 17.65 million swine and over 3.63 million cattle in 1971.

An inventory of livestock in Iowa was compiled to indicate the animal concentration by conservancy district (See Appendix F). The inventory was based on the 1971 Iowa Annual Farm Census. Statewide increases of approximately 130,000 hogs, 100,000 cattle, 12,000 sheep, and 1,050,000 turkeys were experienced in 1972 while the number of chickens in the State declined.

Feedlot runoff in an Iowa Great Lakes study (Borofka, 1974) averaged 4.02 mg/l total phosphorus. Average values as high as 5.55 mg/l, 4.33 mg/l and 12.67 mg/l for PO_4, NH_3, and NO_3 respectively were found for certain streams containing high concentrations of feedlot runoff. These values indicate that high nutrient levels can occur in streams receiving feedlot drainage.

A study conducted by the Iowa State Hygienic Laboratory also investigated the effect of cattle feedlot runoff on stream water quality. The water quality of the Boyer River in Sac County was measured during runoff and non-runoff conditions. Results of this survey can be seen in Table VII-8. As would be expected, nutrient, BOD, COD and turbidity concentrations were significantly increased when feedlot runoff reached the river.

TABLE VII-8

EFFECTS OF FEEDLOT RUNOFF ON THE BOYER RIVER

	CONDITION	
ANALYSIS	NON-RUNOFF	RUNOFF
Fecal Coliforms (MPN/100ml)	340	21,500
Nitrogen		
Organic (mg/l)	0.43	8.1
Ammonia (mg/l)	0.04	3.5
Nitrate (mg/l)	12	216
Phosphate as P		
Filterable (mg/l)	0.05	0.83
Total (mg/l)	0.06	1.4
BOD (mg/l)	1	40
COD (mg/l)	15	151
Turbidity (JTU)	40	400

Similar results were obtained during a portion of the study conducted in Hardin County where samples were taken below a single feedlot. Under moderate runoff conditions, this stream was able to recover considerably in approximately 1 and 1/2 miles.

With the livestock numbers in Iowa increasing the need for controlling runoff from feedlot areas is increasing. Runoff control costs will vary greatly with the size of the operation and the type of controls used. Runoff control facilities must meet the requirements of the rules and regulations of the Environmental Protection Agency and the Iowa Department of Environmental Quality.

Urban Nonpoint Runoff

In urban areas, surface runoff and combined sewer overflows can result in the discharge of significant levels of pollutants to a watercourse. Iowa has 2,550 square miles of land located within its cities and towns. Many of these areas are served by storm sewers, and combined sewers are found in some of the older urban areas.

At present Iowa is not actively requiring the control of urban runoff, except in the area of controlling combined sewer overflows. Where combined sewers exist the DEQ is requiring that a study be conducted to determine the best means for controlling the combined sewer overflows, including looking at sewer separation and/or treatment of the combined flows.

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APPENDIX A

Heavy Metals

ZINC IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/1)	MAXIMUM (µg/1)
Wapsipinicon	18	14	163	220
Floyd	5	4	40	70
Big Sioux	11	9	39	60
Rock	12	11	73	440
Chariton	25	18	44	100
Nodaway	12	11	41	90
Boyer	11	10	47	100
Turkey	10	7	97	210
Yellow	2	1	120	120
Upper Iowa	13	7	113	210
Mid Cedar	35	29	42	160
Lower Cedar	48	27	103	210
Upper Cedar	36	23	458	5800
Shellrock	16	8	125	330
Lower Iowa	21	14	101	300
Mid Iowa	17	11	53	90
Iowa above Marshalltown	6	3	110	160
Skunk	11	9	110	290
South Skunk	4	4	30	50
Upper Des Moines	4	4	71	160
Lower Des Moines	76	61	125	1300
East Fork Des Moines	13	11	76	360
West Fork Des Moines	12	10	57	210
North Raccoon	9	6	23	30
Raccoon	15	12	46	140
Nishnabotna	17	12	53	160
Maquoketa	29	22	183	710
Little Sioux	30	21	78	360

NICKEL IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/1)	MAXIMUM (μg/1)
Wapsipinicon	18	0		
Floyd	5	0		
Big Sioux	9	0		
Rock	9	0		
Chariton	17	0		
Nodaway	8	0		
Boyer	9	0		
Turkey	8	0		
Yellow	0	0		
Upper Iowa	11	0		
Mid Cedar	15	0		
Lower Cedar	41	0		
Upper Cedar	34	1	20	20
Shellrock	14	0		
Lower Iowa	18	0		
Mid Iowa	17	0		
Iowa above Marshalltown	2	0		
Skunk	9	0		
South Skunk	2	0		
Upper Des Moines	2	0		
Lower Des Moines	70	3	80	200
East Fork Des Moines	12	0		
West Fork Des Moines	10	0		
North Raccoon	1	0		
Raccoon	15	2	30	40
Nishnabotna	13	0		
Maquoketa	25	0		
Little Sioux	24	0		

MERCURY IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/1)	MAXIMUM (μg/1)
Wapsipinicon	1	0		
Floyd	0	0		
Big Sioux	2	0		
Rock	2	0		
Chariton	8	0		
Nodaway	4	0		
Boyer	2	0		
Turkey	5	1		
Yellow	5	0		
Upper Iowa	5	0		
Mid Cedar	16	0		
Lower Cedar	6	0		
Upper Cedar	8	2	3.6	4.0
Shellrock	2	0		
Lower Iowa	9	0		
Mid Iowa	3	0		
Iowa above Marshalltown	5	0		
Skunk	5	1	2.2	2.2
South Skunk	2	0		
Upper Des Moines	2	0		
Lower Des Moines	17	3	1.3	2
East Fork Des Moines	0	0		
West Fork Des Moines	2	0		
North Raccoon	8	0		
Raccoon	2	1	1	1
Nishnabotna	4	0		
Maquoketa	19	0		
Little Sioux	6	0		

MANGANESE IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/1)	MAXIMUM (μg/1)
Wapsipinicon	18	9	39	50
Floyd	6	5	174	390
Big Sioux	13	12	423	2400
Rock	12	11	113	480
Chariton	25	20	294	940
Nodaway	10	6	73	220
Boyer	20	12	42	160
Turkey	9	2	35	60
Yellow	1	0		
Upper Iowa	9	4	23	50
Mid Cedar	32	6	37	50
Lower Cedar	4	3	86	160
Upper Cedar	20	13	48	160
Shellrock	13	7	73	170
Lower Iowa	23	22	139	1600
Mid Iowa	7	6	90	380
Iowa above Marshalltown	5	5	328	580
Skunk	11	5	18	40
South Skunk	9	0		
Upper Des Moines	2	1	70	70
Lower Des Moines	9	3	136	200
East Fork Des Moines	8	5	308	570
West Fork Des Moines	7	6	283	510
North Raccoon	4	2	140	140
Raccoon	1	0		
Nishnabotna	23	20	401	2800
Maquoketa	9	5	38	50
Little Sioux	22	18	175	610

LEAD IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/1)	MAXIMUM (µg/1)
Wapsipinicon	18	3	500	1300
Floyd	5	0		
Big Sioux	11	0		
Rock	12	0		
Chariton	25	0		
Nodaway	12	2	85	130
Boyer	11	1	60	60
Turkey	10	1	80	80
Yellow	2	0		
Upper Iowa	13	2	220	420
Mid Cedar	31	2	55	90
Lower Cedar	8	1	70	70
Upper Cedar	36	3	320	660
Shellrock	16	2	380	740
Lower Iowa	21	3	40	60
Mid Iowa	17	3	30	50
Iowa above Marshalltown	6	0		
Skunk	11	4	100	120
South Skunk	4	2	10	10
Upper Des Moines	4	2	75	80
Lower Des Moines	76	26	208	3200
East Fork Des Moines	13	2	65	70
West Fork Des Moines	12	4	65	130
North Raccoon	9	0		
Raccoon	16	4	95	290
Nishnabotna	17	4	40	60
Maquoketa	32	2	50	70
Little Sioux	30	9		

COPPER IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
Wapsipinicon	18	2	10	10
Floyd	5	0		
Big Sioux	11	4	12	20
Rock	12	1	10	10
Chariton	25	5	18	30
Nodaway	12	4	15	20
Boyer	11	4	10	10
Turkey	10	0		
Yellow	2	0		
Upper Iowa	13	0		
Mid Cedar	35	7	87	140
Lower Cedar	48	1	10	10
Upper Cedar	36	3	13	20
Shellrock	16	1	50	50
Lower Iowa	21	4	50	130
Mid Iowa	17	0		
Iowa above Marshalltown	6	9		
Skunk	11	3	23	50
South Skunk	4	0		
Upper Des Moines	4	0		
Lower Des Moines	76	19	35	100
East Fork Des Moines	13	1	10	10
West Fork Des Moines	12	2	10	10
North Raccoon	9	2	20	20
Raccoon	16	2	25	40
Nishnabotna	17	6	23	30
Maquoketa	29	3	23	30
Little Sioux	30	5	12	20

CHROMIUM IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/1)	MAXIMUM (µg/1)
Wapsipinicon	18	0		
Floyd	5	0		
Big Sioux	13	0		
Rock	14	0		
Chariton	27	0		
Nodaway	16	1	10	10
Boyer	13	1	20	20
Turkey	12	0		
Yellow	4	0		
Upper Iowa	15	0		
Mid Cedar	36	0		
Lower Cedar	55	0		
Upper Cedar	37	2	7200	12000
Shellrock	18	0		
Lower Iowa	23	0		
Mid Iowa	17	0		
Iowa above Marshalltown	10	0		
Skunk	13	1	20	20
South Skunk	6	0		
Upper Des Moines	6	0		
Lower Des Moines	81	4	22	40
East Fork Des Moines	13	-		
West Fork Des Moines	14	0		
North Raccoon	21	0		
Raccoon	16	0		
Nishnabotna	22	2	10	10
Maquoketa	33	1	20	20
Little Sioux	37	0		

CADMIUM IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (μg/l)	MAXIMUM (μg/l)
Wapsipinicon	18	0		
Floyd	5	0		
Big Sioux	11	0		
Rock	12	0		
Chariton	25	0		
Nodaway	12	0		
Boyer	11	0		
Turkey	10	0		
Yellow	2	0		
Upper Iowa	13	0		
Mid Cedar	15	0		
Lower Cedar	49	0		
Upper Cedar	36	0		
Shellrock	16	0		
Lower Iowa	21	0		
Mid Iowa	17	0		
Iowa above Marshalltown	6	0		
Skunk	11	0		
South Skunk	4	0		
Upper Des Moines	4	0		
Lower Des Moines	76	1	30	30
East Fork Des Moines	13	0		
West Fork Des Moines	12	0		
North Raccoon	9	0		
Raccoon	16	0		
Nishnabotna	17	0		
Maquoketa	29	0		
Little Sioux	29	0		

BARIUM IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/1)	MAXIMUM (µg/1)
Wapsipinicon	18	14	243	1100
Floyd	4	4	125	200
Big Sioux	9	8	137	200
Rock	10	8	137	200
Chariton	21	16	169	300
Nodaway	10	8	375	1000
Boyer	9	8	288	500
Turkey	10	8	212	400
Yellow	2	1	200	200
Upper Iowa	13	9	230	900
Mid Cedar	15	12	167	600
Lower Cedar	8	7	200	400
Upper Cedar	34	23	552	1000
Shellrock	16	12	158	400
Lower Iowa	19	19	174	400
Mid Iowa	15	13	262	900
Iowa above Marshalltown	6	6	180	300
Skunk	8	8	387	900
South Skunk	4	4	125	200
Upper Des Moines	4	2	150	200
Lower Des Moines	67	50	262	900
East Fork Des Moines	10	8	125	200
West Fork Des Moines	11	9	144	200
North Raccoon	9	9	170	200
Raccoon	15	13	177	300
Nishnabotna	15	12	467	1700
Maquoketa	29	18	183	700
Little Sioux	26	18	189	300

ARSENIC IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (µg/l)	MAXIMUM (µg/l)
Wapsipinicon	11	0		
Floyd	4	0		
Big Sioux	12	0		
Rock	11	0		
Chariton	19	0		
Nodaway	12	0		
Boyer	12	0		
Turkey	4	0		
Yellow	2	0		
Upper Iowa	9	0		
Mid Cedar	8	0		
Lower Cedar	6	0		
Upper Cedar	25	2	45	70
Shellrock	10			
Lower Iowa	19	0		
Mid Iowa	5	0		
Iowa above Marshalltown	4	0		
Skunk	12	0		
South Skunk	2	0		
Upper Des Moines	2	0		
Lower Des Moines	35	0		
East Fork Des Moines	11	0		
West Fork Des Moines	11	0		
North Raccoon	8	0		
Raccoon	0	0		
Nishnabotna	18	0		
Maquoketa	11	0		
Little Sioux	24	0		

APPENDIX B

Pesticides

2, 4-D IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/1)	MAXIMUM (ng/1)
Little Sioux River	14	8	240	650
Nishnabotna River	3	2	220	360
Des Moines River	4	2	50	50
Big Sioux River	14	8	290	940
Floyd River	13	7	340	1100
Mississippi River	10	4	50	100
Soldier River	12	7	420	1300
Elk Creek/ Grand River	3			

2, 4, 5-T IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/1)	MAXIMUM (ng/1)
Little Sioux River	14	6	30	70
Nishnabotna River	3	3	30	70
Big Sioux River	12	2	10	10
Floyd River	13	4	10	20
Mississippi River	10	2	20	20
Soldier River	12	3	640	600

ALDRIN IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Little Sioux River	15	1	20	20
Nishnabotna River	3			
Des Moines River	4			
Big Sioux River	15	1	20	20
Floyd River	15	1	20	20
Iowa River	1			
Mississippi River	8			
Soldier River	11	1		
Elk Creek/ Grand River	4		20	20

CHLORDANE IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Cedar River	13			
Des Moines River	4			
Big Sioux River	13			
Floyd River	13			
Mississippi River	9			
Soldier River	11			
Elk Creek/ Grand River	3			

PCB IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Mississippi River	8	4	30	400

HEPTACHLOR IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Nishnabotna River	4	2	310	600

HEPTACHLOR EPOXIDE IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Little Sioux River	15	1	20	20
Nishnabotna River	3	1	20	20
Big Sioux River	15	1	10	10
Floyd River	15	2	20	20

LINDANE IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/1)	MAXIMUM (ng/1)
Little Sioux River	15	1	10	10
Nishnabotna River	3	2	20	30
Des Moines River	4			
Big Sioux River	15	1	10	10
Floyd River	15	2	10	10
Mississippi River	10	1	10	10
Soldier River	11	1	10	10

DDD IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/1)	MAXIMUM (ng/1)
Little Sioux River	15			
Nishnabotna River	3			
Des Moines River	4			
Big Sioux River	15			
Floyd River	15			
Mississippi River	9			
Soldier River	11			
Elk Creek/ Grand River	4			

DDT IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/1)	MAXIMUM (ng/1)
Cedar River	19	3	10	12
Little Sioux River	27	12	11	20
Missouri River	16	3	10	23
Nishnabotna River	5	1	14	14
South Skunk River	8			
Upper Iowa River	12	1	7	7
Des Moines River	4			
Big Sioux River	15	1	20	20
Floyd River	15	2	10	10
Raccoon River	17	9	9	23
Iowa River	16	1	12	12
Mississippi River	53	4	5	6
Soldier River	11	1	20	20
Elk Creek/ Grand River	4	1	10	10

DDE IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/l)	MAXIMUM (ng/l)
Cedar River	20	6	85	480
Little Sioux River	32	1	3	3
Missouri River	20	2	7	8
Nishnabotna River	5	1	17	17
South Skunk River	26	18	219	1820
Upper Iowa River	9			
Des Moines River	35	32	123	373
Big Sioux River	15			
Floyd River	15			
Raccoon River	24	10	48	250
Iowa River	21	3	119	350
Mississippi River	49	9	3	10
Chariton River	29	26	198	1121
Soldier River	11			
Elk Creek/ Grand River	4			
Indian Creek/ Skunk River	15	15	408	3920
Rathbun Reservoir	29	26	198	1121
Red Rock Reservoir	27	25	135	373
Gremore Lake	1	1	4	4

DIELDRIN IN IOWA RIVERS

RIVER	TOTAL SAMPLES	NUMBER OF SAMPLES WITH DETECTABLE LEVELS	MEAN OF THOSE WITH DETECTABLE LEVELS (ng/1)	MAXIMUM (ng/1)
Cedar River	19	9	13	42
Little Sioux River	24	9	20	50
Missouri River	20	2	8	14
Nishnabotna River	13	13	32	20
South Skunk River	28	28	14	76
Upper Iowa River	12	2	6	6
Des Moines River	96	96	11	50
Big Sioux River	15	9	10	50
Floyd River	15	12	20	50
Raccoon River	25	16	9	41
Iowa River	22	19	16	10
Mississippi River	50	11	8	10
Chariton River	29	29	5	22
Soldier River	11	8	18	50
Elk Creek/ Grand River	4			
Indian Creek/ Skunk River	15	15	15	71
Rathbun Reservoir	29	29	5	22
Red Rock Reservoir	27	27	12	36
Gremore Lake	1			

APPENDIX C

Fish Kills

SUMMARY OF FISH KILLS REPORTED TO EPA BY SOURCE OF POLLUTION, 1960-1973

SOURCE OF POLLUTION	TOTAL REPORTS	REPORTS SPECIFYING REPORTED FISH KILL		AVERAGE KILL*	ESTIMATED FISH KILLED**		
		NO. OF REPORTS	NO. OF FISH		TOTAL	GAME	NONGAME
Agricultural Operations	19	13	36,800	2,830	53,780	5,378	48,402
Industrial Operations	32	25	7,110,175	6,998	7,159,161	178,979	6,980,182
Municipal Operations	29	21	1,385,150	9,744	1,463,102	87,786	1,375,316
Transportation Operations	6	6	155,600	25,933	155,600	26,607	128,993
Other Operations	13	9	100,325	11,147	144,913	96,656	48,257
Unknown	20	15	43,550	2,903	58,065	19,161	38,904
Total	119	89	8,831,600	6,767	9,034,621	414,567	8,620,054

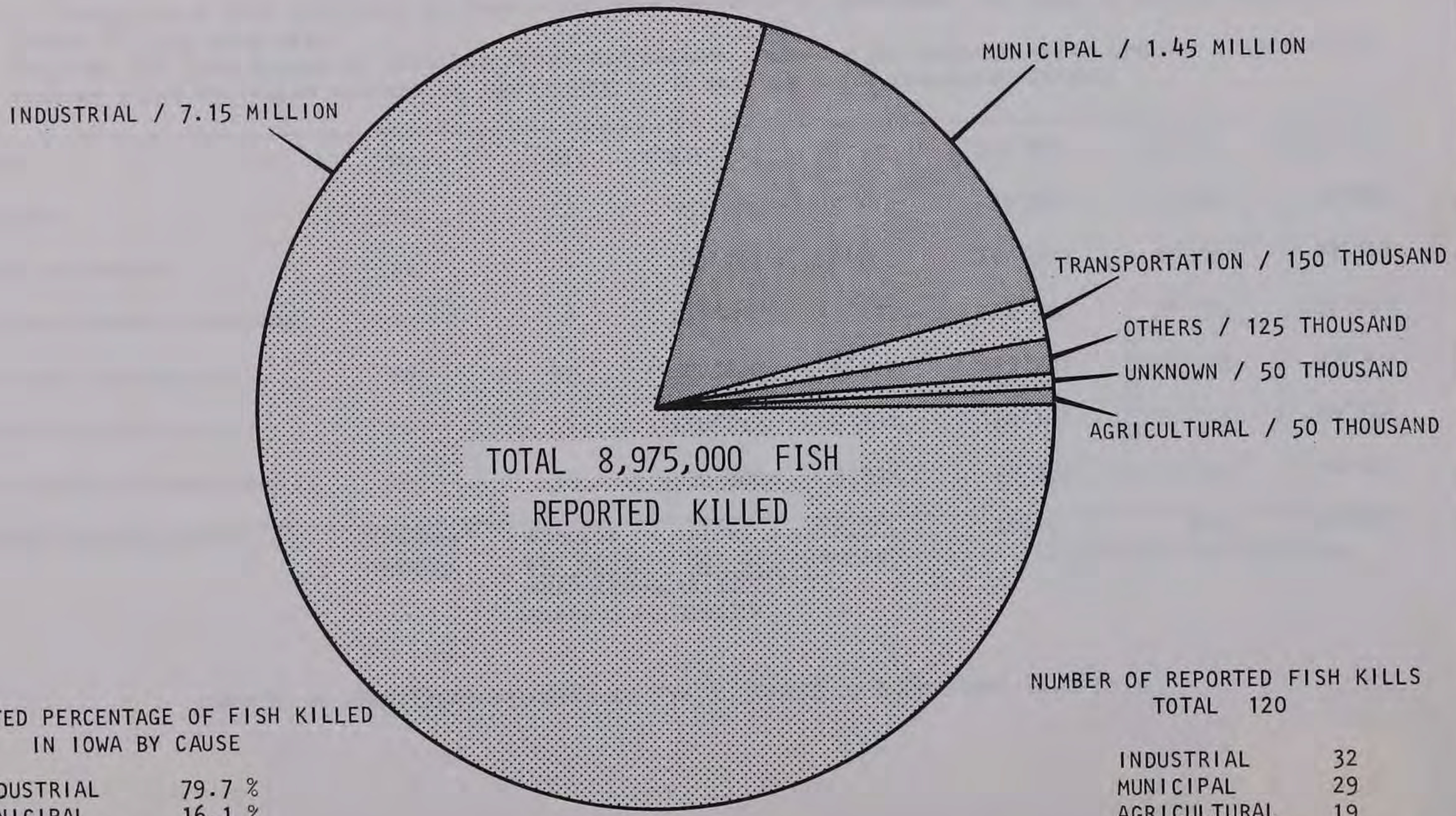
* Derived after excluding reports of 100,000 kills or more as being unrepresentative.

** Includes all fish killed as reported plus an allowance computed for reports which did not indicate the number of fish that died.

Note: Insufficient data available to make a reliable estimate of the number of fish of commercial value that died.

ESTIMATED NUMBER OF FISH KILLED IN IOWA BY CAUSE

1960-1974

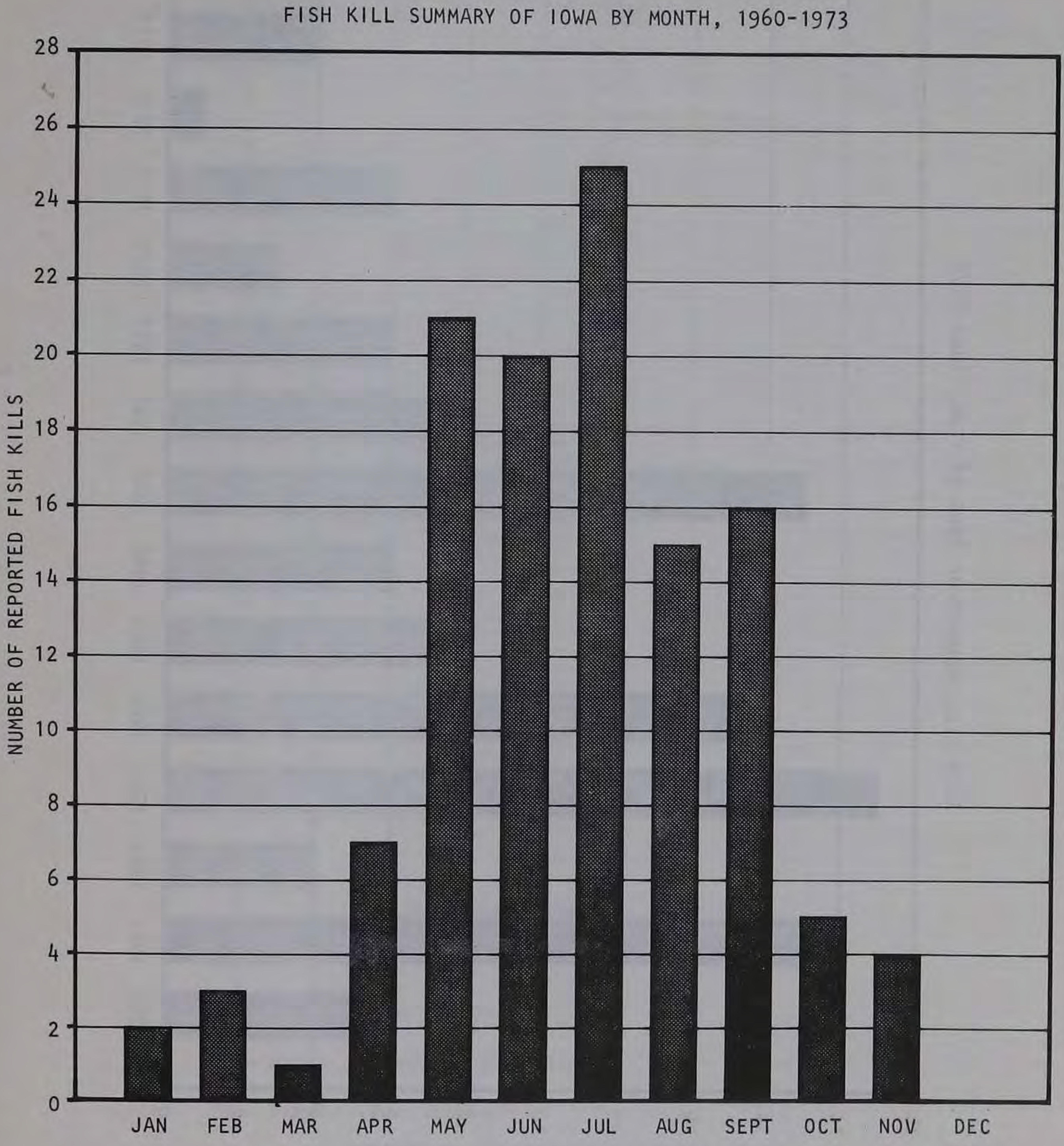


ESTIMATED PERCENTAGE OF FISH KILLED
IN IOWA BY CAUSE

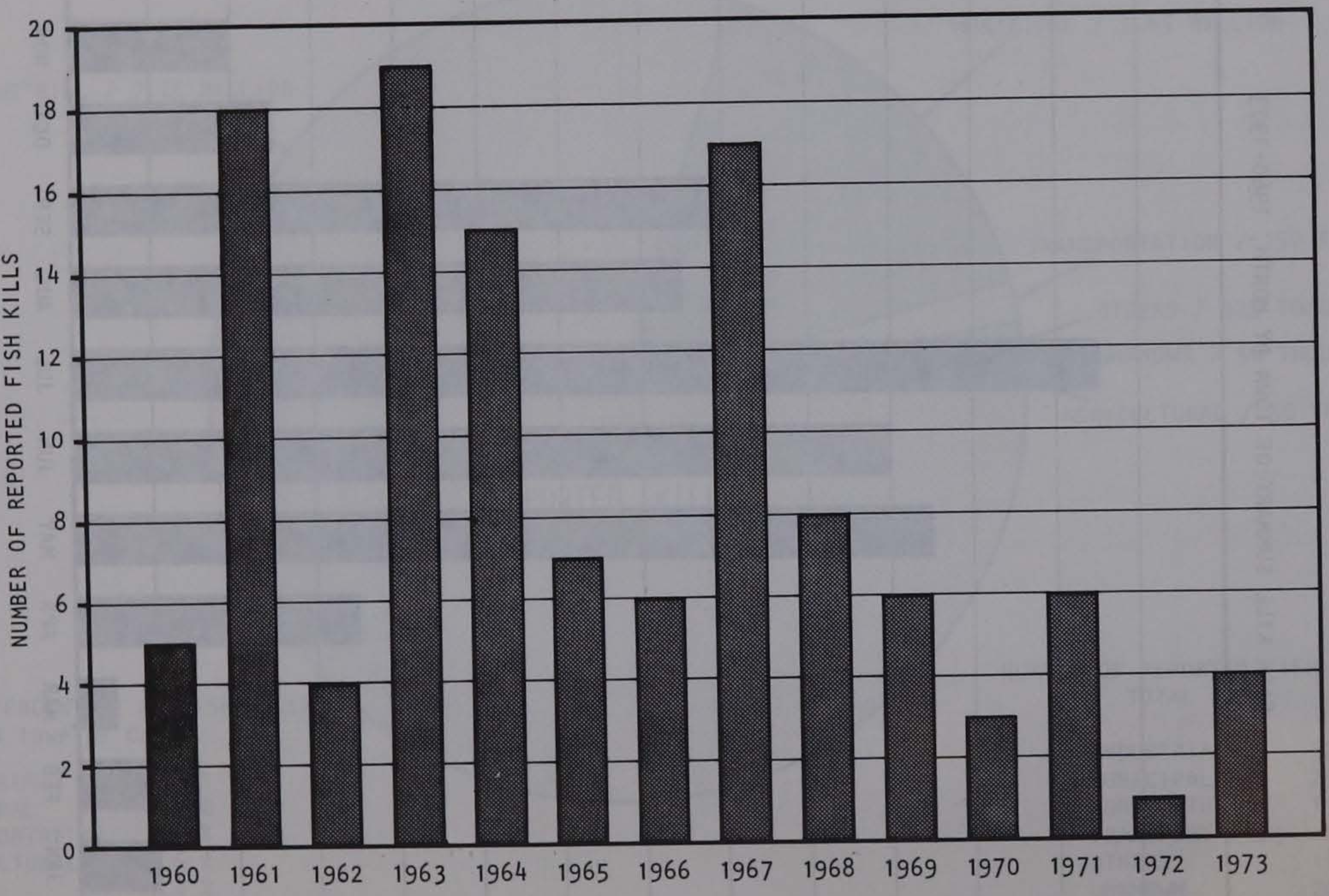
INDUSTRIAL	79.7 %
MUNICIPAL	16.1 %
TRANSPORTATION	1.7 %
AGRICULTURAL	.6 %
OTHERS	1.4 %
UNKNOWN	.6 %

NUMBER OF REPORTED FISH KILLS
TOTAL 120

INDUSTRIAL	32
MUNICIPAL	29
AGRICULTURAL	19
TRANSPORTATION	6
OTHERS	14
UNKNOWN	20


FISH KILL SUMMARY OF IOWA BY MONTH, 1960-1973
NUMBER OF REPORTED FISH KILLS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC

FISH KILL SUMMARY OF IOWA BY YEAR, 1960-1973



APPENDIX D

Major Dischargers

TABLE OF CONTENTS

MAJOR MUNICIPAL DISCHARGERS
APRIL 1975

Basin	Discharger
Mississippi River and minor tributaries	Bellevue
	Burlington
	Camanche
	Clinton
	Davenport Main Plant
	Davenport Ridgeview Plant
	Dubuque
	Fort Madison Main Plant
	Fort Madison Westerly Plant
	Guttenberg
	Keokuk Main Plant
	LeClaire
	Muscatine
	Waukon
	West Burlington
Upper Iowa River	Cresco
	Decorah
Yellow River	Postville Industrial Lagoon
Turkey River	Fayette
	West Union South Plant
Maquoketa River	Dyersville
	Hopkinton
	Manchester
	Maquoketa
	Monticello
	Ryan
Wapsipinicon	Anamosa
	DeWitt
	Fredericksburg
	Independence
	New Hampton
	Oelwein
	Sumner
Cedar River	Cedar Falls
	Cedar Rapids Main Plant
	Cedar Rapids Indian Creek
	Charles City
	Clear Lake Sanitary District
	Evansdale
	Forest City Main Plant
	Grundy Center

Basin	Discharger
Cedar River (cont.)	Hampton
	Hudson
	Jesup
	Lake Mills
	Mason City
	Mount Vernon
	Osage
	Reinbeck
	Tipton
	Vinton
	Waterloo
	Waverly
	West Liberty
Iowa River	Belle Plaine
	Belmond
	Coralville
	Eldora
	Iowa City
	Iowa Falls
	Marshalltown
	State Center
	Tama
Skunk River	Ames
	Ellsworth
	Fairfield
	Grinnell
	Mt. Pleasant
	Nevada
	New London
	Newton Northwest Plant
	Newton South Plant
	Newton Southwest Plant
	Oskaloosa Northeast Plant
	Pella Northeast Plant
	Pella East Plant
	Story City
	Washington
Des Moines River	Adel
	Albia North Plant
	Algona
	Altoona
	Ankeny East Plant
	Ankeny West Plant
	Boone
	Carroll
	Clarion

Basin	Discharger
Des Moines River (cont.)	Des Moines Main Plant
	Des Moines Highland Hills Plant
	Eagle Grove
	Emmetsburg
	Estherville
	Fort Dodge
	Grimes
	Guthrie Center
	Humboldt
	Indianola North Plant
	Indianola South Plant
	Jefferson
	Knoxville
	Lake City West Plant
	Lake City North Plant
	Lake View
	Madrid
	Osceola Lagoon
	Oskaloosa Southwest Plant
	Ottumwa
	Perry
	Pleasant Hill
	Pocahontas
	Rockwell City
	Sac City
	Storm Lake Main Plant
	Storm Lake Industrial Lagoon
	Webster City
	Winterset
Fox River	Bloomfield
Chariton River	Centerville East Plant
	Centerville West Plant
	Chariton
West Fork Big Creek	Lamoni
Platte River	Creston
Middle 102 River	Lenox
Nodaway River	Nodaway
	Clarinda
Nishnabotna River	Atlantic
	Audubon
	Harlan
	Red Oak
	Shenandoah

Basin	Discharger
Missouri River and Minor Tributaries	Council Bluffs Glenwood Onawa Sioux City
Boyer River	Denison Missouri Valley
Little Sioux River	Cherokee Main Plant Cherokee Industrial Lagoon Ida Grove Iowa Great Lakes Sanitary District Remsen Spencer
Floyd River	Hospers LeMars Orange City Sheldon Sioux Center
Big Sioux River	Hawarden Rock Rapids Rock Valley Sibley

* A "major municipal discharger" is defined as any publically owned point source which has the potential to cause a violation of Iowa Water Quality Standards or which may cause a deleterious or detrimental impact on the receiving watercourse so as to impair legitimate water uses.

MAJOR INDUSTRIAL DISCHARGERS*
MARCH 1973

Basin	Discharger	
Mississippi River and Minor Tributaries	Armour Dial, Inc.	Fort Madison
	Chemplex Company	Clinton
	Chevron Company	Fort Madison
	Clinton Corn Processors	Clinton
	Collis Company	Clinton
	Consolidated Packaging Corp.	Fort Madison
	E.I. du Pont de Nemours and Company	Clinton
	First Miss Corp.	Fort Madison
	Grain Processing Company	Muscatine
	Hawkeye Chemical Company	Clinton
	Hubinger Company	Keokuk
	John Deere and Company	Dubuque
	Monsanto Company	Muscatine
Turkey River	Mississippi Valley Milk Producers	Luana
	Polaris Plating	Elkader
Wapsipinicon	Assoc. Milk Producers Inc.	Arlington
	Meinerz Creamery	Fredericksburg
Cedar River	John Deere and Company	Waterloo
Iowa River	Central Soya Company	Belmond
	Farmland Foods, Inc.	Iowa Falls
	Packaging Corp. of America	Tama
	Rath Packing	Columbus Junction
	Tama Meat Packing Corp.	Tama
Skunk River	Smith-Jones, Inc.	Kellogg
Des Moines River	Farmland Industries, Inc.	Fort Dodge
	Iowa Beef Processors	Fort Dodge
	Oscar Mayer	Perry
Nishnabotna River	American Beef Packers	Oakland

* A "major industrial discharger" is defined as any privately owned point source which has the potential to cause a violation of Iowa Water Quality Standards or which may cause a deleterious or detrimental impact on the receiving watercourse so as to impair legitimate water uses.

MAJOR INDUSTRIAL DISCHARGERS (Continued)

Basin	Discharger	
Nishnabotna River	Western Iowa Pork	Harlan
Missouri River and Minor Tributaries	Flavorland Industries (Hide Processing Division)	Sioux City
	Swift Fresh Meats	Glenwood
	Terra Chemicals International	Sioux City
Boyer River	Farmland Foods, Inc.	Denison
	Iowa Beef Processors	Denison

FEEDLOT FACILITIES OVER 1,000 ANIMAL UNITS AND/OR SIGNIFICANT POINT SOURCES

January 1, 1975

Basin	Discharger	
Wapsipinicon River	York Feedlot Corporation	Ryan
Cedar River	Plager, Robert S. & Sons, Inc.	Grundy Center
	Roger Rust	Sheffield
	James E. Miller	Grundy Center
Iowa River	Marvin Reed	Iowa Falls
	Meade Cattle Company, Inc.	Oxford
	Eller Feedlots, Inc.	Hubbard
Des Moines River	Simons Brothers	Carroll
	Marywood Farms, Inc.	Indianola
	Greig & Company, Inc.	Estherville
Weldon River	Yoder, Alva	Leon
Grand River	Armour & Company	Mount Ayr
Nishnabotna River	Keith Bruce	Hastings
	Midwestern Pork Co. Farm	Oakland
	Oakland Feeding Corporation	Oakland
	Lazy K. Inc.	Defiance
	Kay Farms, Inc.	Atlantic
	Goetzman, Paul G.	Atlantic
	Hunt Brothers Farms	Atlantic
Missouri River	Hanson Cattle Co., Inc.	Little Sioux
	Hanson Cattle Co., Inc.	Little Sioux
Boyer River	Shinrone, Inc.	Odebolt
Little Sioux	Group 21, Inc.	Sutherland
Floyd	Getting, Leroy	Sanborn

APPENDIX E

Iowa River Basin Inventory - Acreage/County

(Based on Soil Conservation Service County Maps)

RIVER BASINS

CHARITON RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Appanoose	334,573	80.1	268,013
Clarke	261,330	5.9	15,360
Davis	325,760	0.4	1,280
Decatur	339,200	1.5	5,120
Lucas	264,380	34.1	90,240
Monroe	262,278	2.2	5,760
Wayne	317,084	56.6	179,484
		Total	565,257

NODAWAY RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Adair	364,160	46.0	167,680
Adams	272,642	74.2	202,242
Cass	357,700	41.0	146,560
Guthrie	366,241	1.8	6,400
Montgomery	271,360	27.4	74,240
Page	342,400	33.5	114,560
Taylor	337,920	10.8	36,480
Union	272,641	4.0	10,880
		Total	759,042

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (continued)

NISHNABOTNA RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Adair	364,160	1.6	5,760
Audubon	280,558	95.9	269,038
Carroll	365,145	15.4	56,320
Cass	357,700	58.5	209,220
Crawford	447,260	16.2	72,320
Fremont	334,720	72.2	243,840
Guthrie	366,241	4.5	16,640
Mills	276,047	62.1	171,520
Montgomery	271,360	47.6	129,280
Page	342,400	16.8	57,600
Pottawattamie	616,960	56.3	347,520
Shelby	371,073	72.9	270,593
		Total	1,849,651

ROCK RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Lyon	365,522	75.9	277,202
Osceola	253,536	44.9	113,920
Sioux	480,999	17.3	83,200
		Total	474,322

FLOYD RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
O'Brien	359,119	29.8	106,880
Plymouth	541,012	46.5	251,732
Sioux	480,999	50.9	244,839
Woodbury	557,440	6.0	33,280
		Total	636,731

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (Continued)

MAPLE RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Buena Vista	366,720	14.1	51,840
Cherokee	366,720	19.0	69,760
Ida	275,840	65.4	180,480
Monona	446,080	22.1	98,560
Sac	359,265	15.1	54,400
Woodbury	557,440	8.8	49,280
		Total	504,240

LITTLE SIOUX RIVER BASIN (Without Maple)

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Buena Vista	366,720	19.0	69,760
Cherokee	366,720	80.4	295,040
Clay	365,440	95.4	348,800
Dickinson	240,937	92.6	223,017
Emmet	246,992	4.1	10,240
Harrison	444,800	4.3	19,200
Ida	275,840	17.6	48,640
Monona	446,080	30.4	135,680
O'Brien	359,119	70.2	252,239
Osceola	253,536	55.1	139,616
Palo Alto	359,040	7.0	24,960
Plymouth	541,012	23.5	127,360
Woodbury	557,440	55.5	309,120
		Total	2,003,672

RIVER BASINS (Continued)

WEST FORK DES MOINES

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Dickinson	240,937	7.4	17,920
Emmet	246,992	54.7	134,992
Humboldt	268,020	21.5	57,600
Kossuth	626,560	0.3	1,920
Palo Alto	359,040	83.9	301,440
Pocahontas	361,492	20.2	72,960
		Total	586,832

EAST FORK DES MOINES

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Emmet	246,992	39.1	96,640
Hancock	356,969	8.2	29,440
Humboldt	268,020	40.3	108,020
Kossuth	626,560	64.6	404,480
Palo Alto	359,040	2.9	10,240
Winnebago	250,080	31.5	78,720
		Total	727,540

BLUE EARTH

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Emmet	246,992	2.1	5,120
Kossuth	626,560	23.7	148,840
Winnebago	250,080	18.2	45,440
		Total	199,040

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (Continued)

BOONE RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Hamilton	359,025	30.8	110,720
Hancock	356,969	28.9	103,040
Humboldt	268,020	21.7	58,240
Kossuth	626,560	11.4	71,680
Webster	459,520	1.9	8,960
Wright	358,572	62.5	224,172
		Total	576,812

UPPER DES MOINES RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Boone	366,560	78.2	286,560
Calhoun	366,080	1.9	7,040
Dallas	382,083	26.3	100,483
Greene	356,383	7.2	25,600
Hamilton	359,025	2.7	9,600
Humboldt	268,020	16.5	44,160
Pocahontas	361,492	44.9	162,452
Polk	380,160	27.3	103,680
Story	363,400	1.6	5,760
Webster	459,520	70.9	325,760
		Total	1,071,095

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RACCOON RIVER BASIN (Without Middle & South)

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Buena Vista	366,720	62.8	230,400
Calhoun	366,080	98.1	359,040
Carroll	365,145	15.9	58,240
Clay	365,440	0.9	3,200
Dallas	382,083	42.9	163,840
Greene	356,383	80.0	285,343
Guthrie	366,241	1.9	7,040
Palo Alto	359,040	6.2	22,400
Pocahontas	361,492	34.9	126,080
Polk	380,160	12.6	48,000
Sac	359,265	47.8	171,745
Webster	459,520	26.8	122,880
		Total	1,598.208

MIDDLE & SOUTH RACCOON RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Audubon	280,558	4.1	11,520
Carroll	365,145	61.5	224,345
Dallas	382,083	28.1	107,520
Greene	356,383	12.8	45,440
Guthrie	366,241	88.1	322,727
		Total	711,552

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (Continued)

NORTH RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Adair	364,160	10.5	38,400
Dallas	382,083	2.7	10,240
Madison	361,600	42.7	154,240
Warren	348,376	15.1	52,480
		Total	255,360

MIDDLE RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Adair	364,160	22.5	81,920
Guthrie	366,241	3.7	13,440
Madison	361,600	45.7	165,120
Union	272,641	0.9	2,560
Warren	348,376	22.6	78,720
		Total	341,760

SOUTH RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Clarke	261,330	30.1	78,720
Madison	361,600	4.2	15,360
Marion	354,570	1.6	5,760
Union	272,641	0.9	2,560
Warren	348,376	44.1	153,816
		Total	256,216

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (Continued)

LOWER DES MOINES RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Appanoose	334,573	11.5	38,400
Clarke	261,330	38.1	99,410
Davis	325,760	37.9	123,520
Jasper	471,040	10.3	48,640
Jefferson	262,504	8.0	21,120
Lee	296,509	39.3	116,480
Lucas	264,380	65.9	174,140
Mahaska	366,080	31.8	116,480
Marion	354,570	88.1	312,330
Monroe	262,278	97.8	256,518
Polk	380,160	42.1	160,000
Van Buren	295,516	70.8	209,116
Wapello	258,131	62.8	162,131
Warren	348,376	18.2	63,360
			1,901,645

NORTH SKUNK RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Jasper	471,040	32.9	154,880
Keokuk	370,560	43.7	161,920
Mahaska	366,080	29.2	106,880
Marshall	351,408	14.2	49,920
Poweshiek	376,960	23.6	88,960
		Total	562,560

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (Continued)

SOUTH SKUNK RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Boone	366,560	21.8	80,000
Hamilton	359,025	51.9	186,225
Hardin	367,360	1.9	7,040
Jasper	471,040	55.6	261,760
Keokuk	370,560	20.2	74,880
Mahaska	366,080	31.5	115,200
Marion	354,570	10.3	36,480
Marshall	351,408	4.0	14,080
Polk	380,160	18.0	68,480
Story	363,400	85.2	309,640
Webster	459,520	0.4	1,920
		Total	1,155,705

LOWER SKUNK RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Des Moines	261,760	21.0	55,040
Henry	260,869	98.5	257,029
Jefferson	262,504	92.0	241,384
Keokuk	370,560	19.5	72,320
Lee	296,509	16.2	48,000
Louisa	233,595	6.6	15,360
Van Buren	295,516	12.3	36,480
Wapello	258,131	37.2	96,000
Washington	342,138	46.9	160,378
		Total	981,991

RIVER BASINS (Continued)

RED CEDAR RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Black Hawk	362,880	1.9	7,040
Bremer	268,024	39.6	106,240
Butler	357,851	0.7	2,560
Chickasaw	323,200	16.2	52,480
Floyd	321,920	40.8	131,200
Mitchell	298,880	85.5	255,360
Worth	258,640	19.3	49,920
		Total	604,800

SHELL ROCK RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Bremer	268,024	6.7	17,920
Butler	357,851	34.5	123,520
Cerro Gordo	368,640	61.3	225,920
Floyd	321,920	58.2	187,520
Hancock	356,969	11.5	40,960
Mitchell	298,880	1.7	5,120
Winnebago	250,080	50.3	125,920
Worth	258,640	80.7	208,720
		Total	935,600

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

WEST FORK CEDAR RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Black Hawk	362,880	0.9	3,200
Butler	357,851	64.8	231,771
Cerro Gordo	368,640	38.7	142,720
Floyd	321,920	0.4	1,280
Franklin	375,040	81.1	304,000
			682,971

CEDAR RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Benton	459,520	84.7	389,213
Black Hawk	362,880	85.4	309,760
Buchanan	354,990	24.5	87,040
Cedar	374,402	74.9	280,322
Grundy	311,768	91.2	284,248
Hardin	367,360	7.1	26,240
Johnson	395,840	14.6	57,600
Jones	350,011	0.5	1,920
Linn	456,320	72.7	331,520
Louisa	233,595	1.4	3,200
Marshall	351,408	2.5	8,960
Muscatine	253,668	62.4	158,305
Scott	270,774	6.4	17,280
Tama	442,605	32.4	143,360
			2,098,968

IOWA RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Benton	459,520	15.3	188,800
Franklin	375,040	18.9	71,040
Grundy	311,768	8.8	27,520
Hamilton	359,025	14.6	52,480
Hancock	356,969	51.4	183,529
Hardin	367,360	91.0	334,080
Iowa	373,760	100.0	373,760
Jasper	471,040	1.2	5,760
Johnson	395,840	85.4	338,240
Keokuk	370,560	16.6	61,440
Linn	456,320	8.1	37,120
Louisa	233,595	11.2	26,240
Mahaska	366,080	0.3	1,280
Marshall	351,408	79.3	278,448
Muscatine	253,668	3.3	8,320
Poweshiek	376,960	76.4	288,000
Story	363,400	13.2	48,000
Tama	442,605	76.6	299,245
Washington	342,138	38.5	131,840
Wright	358,572	37.5	134,400
		Total	2,889,542

LOWER IOWA RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Des Moines	261,760	5.4	14,080
Louisa	233,595	62.7	146,555
Washington	342,138	14.6	49,920
		Total	210,555

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

RIVER BASINS (Continued)

WAPSIPINICON RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Black Hawk	362,880	11.8	42,880
Bremer	268,024	53.7	143,864
Buchanan	354,990	75.5	267,950
Cedar	374,402	25.1	94,080
Chickasaw	323,200	60.2	194,560
Clinton	444,800	58.8	261,760
Delaware	349,401	9.9	34,560
Fayette	448,759	23.7	106,240
Floyd	321,920	0.6	1,920
Howard	296,944	18.1	53,760
Jones	350,011	40.6	142,080
Linn	456,320	18.0	81,920
Mitchell	298,880	12.4	37,120
Scott	270,774	54.6	147,894
		Total	1,610,588

MAQUOKETA RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Buchanan	354,990	10.1	35,840
Clayton	497,920	2.6	12,800
Clinton	444,800	22.2	98,560
Delaware	349,401	81.1	283,481
Dubuque	389,120	51.5	200,320
Fayette	448,759	9.0	40,320
Jackson	378,692	65.4	247,492
Jones	350,011	58.9	206,011
Linn	456,320	1.2	5,760
			1,130,584

YELLOW RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Allamakee	408,960	28.2	115,200
Clayton	497,920	3.0	14,720
Winneshiek	440,320	-.4	28,160
		Total	158,080

UPPER IOWA RIVER BASIN

COUNTY	TOTAL ACRES IN COUNTY	PERCENT OF COUNTY IN NAMED BASIN	ACRES IN NAMED BASIN
Allamakee	408,960	33.2	135,680
Howard	296,944	32.3	96,000
Mitchell	298,880	0.4	1,280
Winneshiek	440,320	64.0	281,600
		Total	514,560

SEE PAGE E-1 FOR FURTHER IDENTIFICATION

APPENDIX F

Iowa Livestock Inventory by Conservancy Districts (1971 Iowa Annual Farm Census. Bulletin No. 92-AG, U.S. Department of Agriculture, Des Moines, Iowa).

WESTERN CONSERVANCY DISTRICT

RIVER BASIN	HOGS	CATTLE	SHEEP	POULTRY
Rock	273,645	135,320	16,524	216,474
Floyd	459,891	195,288	4,158	249,200
Maple	271,921	104,160	6,520	201,296
Little Sioux	936,569	335,717	32,381	884,593
Sub-Total	1,942,026	770,485	59,583	1,551,563
Other	1,148,761	940,637	18,288	653,228
Total	3,090,787	1,711,122	77,871	2,204,791

SEE PAGE F-1 FOR FURTHER IDENTIFICATION

APPENDIX G

TABLE OF CONTENTS

COUNTY	CROPLAND ACRES ROW	CROPLAND ACRES TOTAL	ACRES PASTURE	ACRES RANGE	ACRES FOREST	ACRES FEDERAL	ACRES URBAN	ACRES SMALL WATER	ACRES OTHER
Adair	122,126	265,545	63,692	0	12,000	1,000	11,278	876	9,769
Adams	104,506	187,617	53,993	0	16,000	0	7,744	40	7,248
Allamakee	62,616	196,425	53,016	0	132,000	11,196	10,753	0	5,570
Appanoose	71,897	167,717	74,910	0	42,851	25,612	10,881	792	11,810
Audubon	117,508	232,953	36,199	0	4,000	0	6,059	295	7,215
Benton	213,904	362,526	40,422	0	20,000	0	17,251	1,070	18,251
Black Hawk	169,928	277,884	17,000	0	17,000	0	15,155	946	15,626
Boone	210,708	283,017	30,112	0	30,000	0	35,370	0	7,330
Bremer	127,011	217,432	25,483	0	18,171	0	10,095	0	9,819
Buchanan	184,688	290,763	32,194	0	17,000	0	13,472	945	9,146
Buena Vista	219,933	311,617	24,771	0	5,015	0	15,998	0	9,319
Butler	187,396	294,098	40,567	0	15,000	0	13,850	0	8,965
Calhoun	268,377	354,299	12,616	0	2,000	0	10,340	0	6,825
Carroll	204,291	310,513	26,429	0	5,000	0	13,540	653	11,225
Cass	154,012	275,135	51,563	0	9,000	0	15,186	1,000	5,816
Cedar	161,879	290,016	37,030	0	23,000	0	14,006	0	10,350
Cerro Gordo	194,810	306,245	26,824	0	3,507	0	22,160	0	9,904
Cherokee	188,364	273,717	57,222	0	11,000	0	13,548	310	10,923
Chickasaw	132,251	251,360	33,063	0	16,000	0	11,792	1,111	9,874
Clarke	57,947	140,335	77,361	0	39,000	0	11,747	32	6,085
Clay	233,543	305,675	23,579	0	8,000	0	13,795	0	14,391
Clayton	101,000	293,140	51,394	0	120,000	7,734	15,561	1,099	8,992
Clinton	187,046	331,345	39,895	0	30,000	6,178	27,978	602	8,802
Crawford	177,000	362,881	56,362	0	14,000	0	16,487	874	7,643
Dallas	210,257	283,024	37,825	0	36,000	1,034	13,824	1,490	8,886
Davis	73,672	152,090	104,214	0	51,000	0	10,661	306	7,489
Decatur	84,783	164,065	103,325	0	56,734	0	10,200	14	4,862
Delaware	140,534	284,000	34,219	0	27,000	5	12,432	236	8,828
Des Moines	99,478	165,512	20,419	0	40,000	14,238	15,716	48	5,827
Dickinson	131,533	192,179	25,118	0	4,047	0	10,128	0	9,465
Dubuque	95,071	256,203	37,424	0	56,000	2,649	23,672	0	13,172
Emmet	152,503	214,745	18,624	0	4,000	0	9,685	0	5,746
Fayette	175,060	351,379	46,974	0	38,000	0	18,744	553	10,270

SEE PAGE G-1 FOR FURTHER IDENTIFICATION

COUNTY	CROPLAND ACRES		ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
	ROW	TOTAL	PASTURE	RANGE	FOREST	FEDERAL	URBAN	SMALL WATER	OTHER
Floyd	187,964	268,364	25,198	0	9,000	0	12,328	0	7,030
Franklin	225,000	322,340	23,330	0	4,000	0	16,059	1,370	9,311
Fremont	168,033	251,683	30,613	0	31,000	0	10,064	940	9,777
Greene	247,606	314,963	15,000	0	12,000	0	13,869	940	7,388
Grundy	208,851	277,174	23,729	0	1,432	0	10,719	18	7,568
Guthrie	151,681	252,908	66,470	0	38,000	0	9,570	403	14,089
Hamilton	242,765	319,599	18,324	0	9,000	0	13,774	96	8,487
Hancock	230,408	325,317	15,818	0	2,914	0	12,218	0	8,533
Hardin	204,994	304,619	19,936	0	14,000	0	19,995	0	8,810
Harrison	207,419	329,912	38,064	0	44,000	3,048	16,579	1,898	11,299
Henry	132,615	195,242	32,147	0	36,000	0	10,687	24	7,500
Howard	124,607	238,924	32,604	0	10,867	0	9,924	0	9,121
Humboldt	196,894	246,229	3,693	0	6,000	0	11,278	900	10,300
Ida	142,636	228,298	29,690	0	1,205	0	9,261	364	7,022
Iowa	149,900	295,416	22,787	0	30,000	0	17,734	28	7,795
Jackson	95,780	232,776	63,943	0	82,000	11,531	11,136	0	10,774
Jasper	211,681	345,061	71,920	0	31,000	0	12,232	670	10,157
Jefferson	107,510	174,949	47,303	205	37,000	0	13,416	23	6,144
Johnson	125,455	255,793	12,503	0	41,000	27,434	45,840	35	13,235
Jones	158,070	262,630	47,335	210	42,000	0	12,058	71	10,096
Keokuk	157,216	262,378	52,366	0	32,000	0	15,951	0	7,865
Kossuth	407,270	552,219	22,011	0	8,000	2,077	21,281	149	20,823
Lee	114,125	184,765	40,990	0	81,000	0	16,722	104	10,499
Linn	184,958	317,111	19,120	0	46,000	0	57,930	0	16,159
Louisa	113,746	167,816	25,957	0	41,000	8,679	8,853	0	5,615
Lucas	66,148	122,736	69,763	0	51,000	4,603	11,819	651	17,188
Lyon	202,418	304,955	44,721	0	4,000	0	11,491	425	10,728
Madison	112,944	209,852	72,224	0	50,000	0	22,625	586	6,313
Mahaska	143,589	237,841	73,215	0	31,000	0	12,957	107	10,960
Marion	124,211	204,892	50,431	0	45,100	24,688	13,694	1,111	14,654
Marshall	196,168	290,320	33,370	0	14,000	0	15,242	638	13,790
Mills	128,289	210,939	13,242	0	25,000	0	9,647	977	16,242
Mitchell	148,416	253,736	15,305	0	10,000	0	9,497	1,515	8,827

SEE PAGE G-1 FOR FURTHER IDENTIFICATION

	CROPLAND ACRES		ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
COUNTY	ROW	TOTAL	PASTURE	RANGE	FOREST	FEDERAL	URBAN	SMALL WATER	OTHER
Monona	223,545	311,129	47,508	15,278	48,000	0	14,055	483	9,627
Monroe	57,248	119,830	69,891	0	71,000	94	8,677	210	8,698
Montgomery	141,663	200,810	38,392	0	10,000	0	11,000	798	9,100
Muscatine	135,099	199,807	25,883	0	30,000	1,280	13,312	384	10,294
O'Brien	234,477	311,630	26,814	0	4,000	0	14,093	0	11,463
Osceola	161,454	217,506	17,250	0	2,000	0	8,630	0	8,904
Page	160,259	257,763	45,386	448	12,000	0	11,637	3,527	11,639
Palo Alto	231,600	313,967	10,474	0	6,000	0	10,963	0	17,636
Plymouth	266,353	431,448	75,269	0	12,000	0	16,997	1,050	15,556
Pocahontas	251,709	329,560	16,819	0	1,000	0	14,359	0	9,462
Polk	172,890	234,271	36,124	0	21,000	0	62,652	65	26,048
Pottawattamie	274,650	488,009	46,802	4,948	26,958	1,343	36,493	1,270	11,137
Poweshiek	158,337	283,130	47,849	0	17,000	0	16,740	0	12,241
Ringgold	83,737	208,992	81,108	619	26,000	0	13,585	1,690	7,809
Sac	209,621	307,380	25,396	0	6,000	0	17,590	0	13,554
Scott	142,179	211,203	11,764	0	15,000	2,893	38,108	90	10,862
Shelby	182,194	305,907	34,696	0	5,750	0	14,884	2,150	12,293
Sioux	303,352	417,882	33,615	5,961	3,000	0	17,902	810	11,070
Story	214,695	292,284	21,530	0	13,000	403	24,546	60	11,577
Tama	205,413	374,072	38,110	0	30,000	0	12,252	40	6,326
Taylor	117,371	216,220	86,094	398	21,000	0	9,047	374	4,787
Union	75,289	170,635	63,431	0	22,000	0	11,434	90	5,051
Van Buren	81,129	152,769	78,987	0	64,000	572	10,436	30	4,886
Wapello	101,082	152,241	45,896	0	49,000	0	18,491	2,088	11,964
Warren	124,775	209,981	59,858	0	44,000	1,106	12,876	1,980	36,079
Washington	165,340	274,000	26,254	0	37,000	0	16,700	923	8,643
Wayne	100,711	198,731	89,280	0	25,034	0	16,059	492	10,884
Webster	304,853	382,103	18,703	0	26,000	0	23,168	40	9,506
Winnebago	155,467	224,918	10,184	0	3,000	0	8,631	0	10,141
Winneshiek	108,669	291,928	71,953	0	56,000	0	10,366	0	10,073
Woodbury	250,796	432,746	59,842	0	25,000	0	27,217	198	12,437
Worth	136,677	216,080	12,280	0	5,000	0	9,954	375	12,511
Wright	259,401	332,180	8,228	0	6,000	0	15,630	329	6,913
State Total:	16,427,066	26,458,321	3,968,631	28,280	2,585,585	159,397	1,564,033	45,941	1,028,715

SEE PAGE G-1 FOR FURTHER IDENTIFICATION

IOWA LAND USE SUMMARY

	CROPLAND ACRES		ACRES	ACRES	ACRES	ACRES	ACRES	ACRES	ACRES
CONS. DISTRICT	ROW	TOTAL	PASTURE	RANGE	FOREST	FEDERAL	URBAN	SMALL WATER	OTHER
Western	3,533,852	4,860,832	595,744	23,401	200,964	3,635	231,906	8,030	169,991
Southern	1,684,722	3,593,842	1,974,633	4,251	364,627	25,761	196,796	13,951	141,598
Des Moines	4,323,353	6,109,071	893,573	16	608,158	33,174	380,748	10,841	279,741
Skunk	1,345,126	2,067,484	365,064	189	286,010	6,519	208,219	2,252	80,762
Iowa-Cedar	3,756,193	5,999,247	546,638	1	407,727	46,499	376,592	6,966	219,607
Northeast	2,191,113	3,810,883	659,373	209	681,071	44,011	238,951	4,821	140,457
Total	16,834,359	26,441,359	5,035,025	28,067	2,548,557	159,599	1,633,212	46,861	1,032,156

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