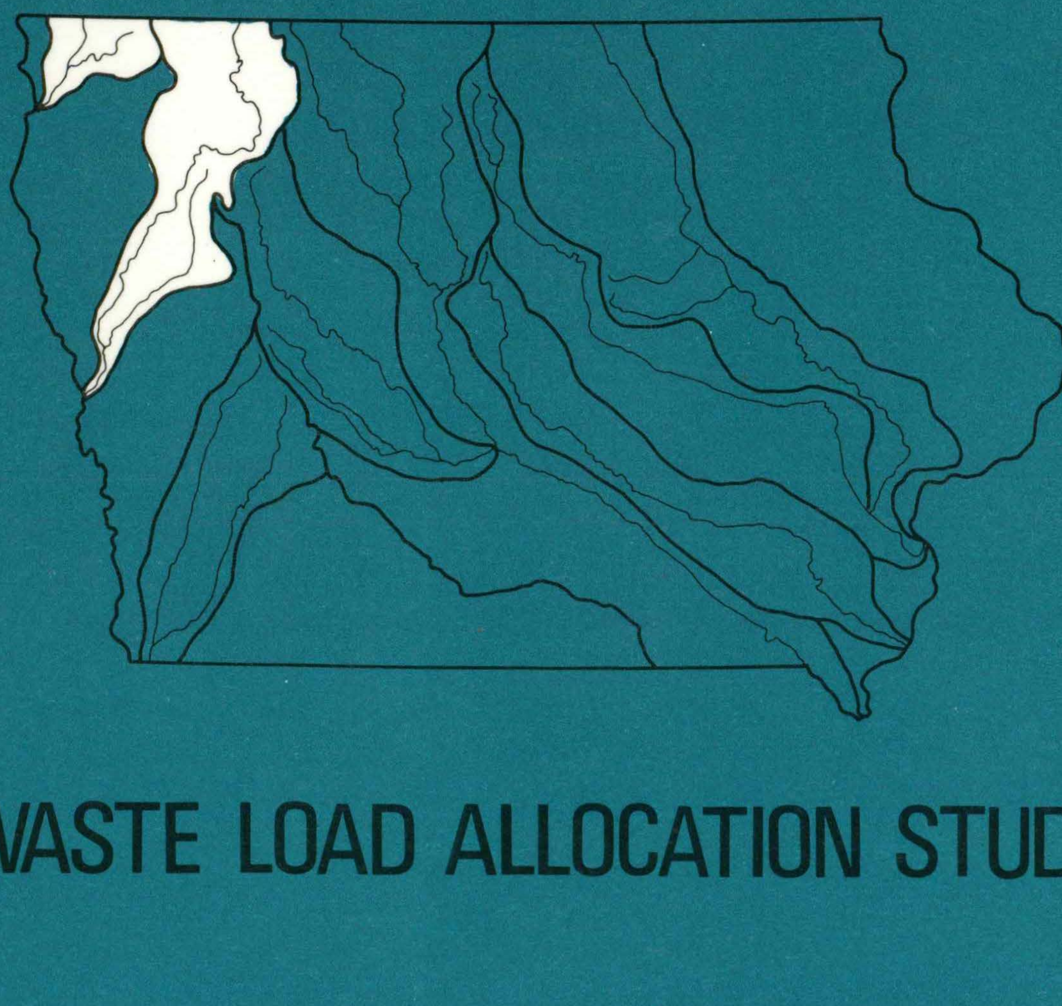
iowa department of environmental quality
Water Quality Management Division

MISSOURI RIVER TRIBUTARIES



WASTE LOAD ALLOCATION STUDY

STANLEY CONSULTANTS
INTERNATIONAL CONSULTANTS IN ENGINEERING, ARCHITECTURE, PLANNING, AND MANAGEMENT

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January 7, 1975

Iowa Department of Environmental
Quality
3920 Delaware Avenue
P. O. Box 3326
Des Moines, Iowa 50316

Gentlemen:

We are pleased to submit our report entitled "Missouri River Tributaries - Waste Load Allocation Study." This report has been prepared in accordance with our contract dated November 12, 1973, and Amendment No. 1 dated April 8, 1974, with the Iowa Department of Environmental Quality for a series of waste load allocation studies.

Respectfully submitted,

STANLEY CONSULTANTS, INC.

R. J. Gear

Ronald J. Gear
Vice President

MISSOURI RIVER TRIBUTARIES

WASTE LOAD ALLOCATION STUDY

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SYNOPSIS

The study area is comprised of those portions of the Rock River Basin and the Little Sioux River Basin within the state of Iowa, encompassing an area of approximately 4,015 square miles in the northwestern section of Iowa. The topography of the Rock River Basin is a gently rolling or undulating plain; while the Little Sioux River Basin ranges from nearly flat to gently undulating glacial draft areas in the north to more rolling loess covered areas in the southern portion. Stream flows per square mile are significantly less than those of the state of Iowa as a whole, especially for the 7-day, 1-in-10 year low flow.

Most of the main streams in the basin have a Class B (warm water fisheries) water quality criteria classification. A lack of comprehensive water quality data for the Rock River Basin does not allow identification of existing water quality under low flow conditions. Available data for the Little Sioux River shows lowered water quality. This decrease in water quality is directly related to the impact of treated wastewater discharges upon the stream. Additional water quality data are necessary from both basins for identification of stream quality and to check the effectiveness of waste load allocations.

Within the basin, 68 communities are incorporated. There are 47 wastewater treatment facilities with 6 communities forming the Iowa Great Lakes Sanitary District. Also, there are 16 industrial and 2 semipublic wastewater dischargers. Eighteen municipalities maintain wastewater treatment facilities which will not be required to adopt a controlled discharge mode of operation under the National Pollutant Discharge Elimination System (NPDES).

To determine allowable waste load allocations for these 18 dischargers, a computer model based upon a modified Streeter-Phelps equation was utilized. Input data to the model included such physical characteristics as length of reach, water temperature, channel slope, river width, roughness coefficient, deoxygenation rate constants, wastewater discharge characteristics, and flow and characteristics of groundwater and tributaries.

The model approximates the impact of discharges on stream quality for the specified winter and summer low flow conditions. Wherever stream quality criteria were not met by secondary treatment, reductions were made in the allowable wastewater discharges until satisfactory conditions prevailed.

Under summer low flow conditions, Iowa Great Lakes Sanitary District (IGLSD) and the communities of Alta, Aurelia, Cherokee, Galva, Hartley, Rock Rapids, and Spencer must provide better than secondary treatment to meet stream quality criteria. However, under winter low flow conditions, better than secondary treatment is required by the communities of Alta, Aurelia, Cherokee, Galva, Hartley, Hull, Ida Grove, Iowa Great Lakes Sanitary District (IGLSD), Little Rock, Odebolt, Rock Rapids, Rock Valley, Sibley, and Spencer to meet stream quality criteria.

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branches of the main rivers, approximate stream lengths, and drainage areas are tabulated below.

Stream	Stream Length (miles)	Drainage Area* (1,000 acres)	(square miles)
Rock River	52	777	1,214
Little Rock River	35	169	264
Otter Creek	45	134	210
Little Sioux River	205	1,798	2,808
Maple River	85	413	644.9
Odebolt Creek	18	39	61.4
Little Maple River	15	23	35.7
Bacon Creek	10	22	33.6
Pierson Creek	15	35	55.4
Mill Creek	55	188	294
Waterman Creek	35	90	140
Ocheyedan River	45	278	434

* Includes both Iowa and Minnesota.

Average annual precipitation is approximately 25.7 inches for the Rock River Basin; of this total, 19.7 inches fall during the April through September growing season. For the Little Sioux River Basin, average annual precipitation is approximately 27.8 inches with 20.8 inches of this total occurring during the April through September growing season.

Political Subdivisions

Within the study area are 68 incorporated communities with a total population of 65,257 according to the "1970 Census of Population." The Rock River Basin contains 11 communities with a population of 12,285 and the Little Sioux River Basin contains 57 communities with a population of 52,972. Populations are summarized for each county and city in Table 1.

Of the 11 communities in the Rock River Basin, 5 communities have populations greater than 1,000, comprising about 84 percent of the total population. There are no municipalities having a population greater than 5,000.

TABLE 1

EXISTING AND PROJECTED POPULATIONS
FOR WASTE LOAD ALLOCATIONS

	1970	1990
BUENA VISTA COUNTY	20,693	24,423
Alta	1,717	1,816
Hanover	--	--
Linn Grove	240	254
Sioux Rapids	813	860
CHEROKEE COUNTY	17,269	19,016
Aurelia	1,065	1,179
Cherokee	7,272	7,952
Cleghorn	274	303
Diamond Center	--	--
Fielding	--	--
Larrabee	167	185
Mary Hill	--	--
Meriden	167	185
Quimby	395	437
Washta	319	353
CLAY COUNTY	18,464	22,464
Dickens	240	240
Everly	699	699
Fostoria	219	219
Greenville	117	117
Peterson	469	469
Rossie	91	91
Royal	469	469
Spencer	10,278	14,302
Webb	234	234
DICKINSON COUNTY	12,565	15,314
Arnolds Park	970	1,127
Lake Park	918	1,066
Milford	1,668	1,937
Okoboji	361	419
Orleans	396	460
Spirit Lake	3,014	4,222
Superior	139	161
Terrill	397	461
West Okoboji	210	244
HARRISON COUNTY	16,240	17,782
Little Sioux	239	255
River Sioux	--	--
IDA COUNTY	9,283	9,907
Arthur	273	291
Battle Creek	837	893
Galva	319	340
Holstein	11,445	1,542
Ida Grove	2,261	2,412

	1970	1990
LYON COUNTY	13,340	14,516
Alvord	204	220
Doon	437	471
Edna	--	--
George	1,194	1,287
Lester	238	256
Little Rock	531	572
Rock Rapids	2,632	2,969
MONONA COUNTY	12,069	12,121
Castana	211	211
Grant Center	--	--
Mapleton	1,647	1,647
Rodney	66	66
Ticonic	--	--
Turin	115	115
O'BRIEN COUNTY	17,522	19,343
Calumet	219	227
Hartley	1,694	1,758
Moneta	41	43
Paullina	1,257	1,305
Primghar	995	1,033
Sutherland	875	908
OSCEOLA COUNTY	8,555	8,383
Ashton	483	483
Cloverdale	--	--
Harris	195	195
Melvin	325	325
Ocheyedan	545	545
Sibley	2,749	3,155
PALO ALTO COUNTY	13,289	14,081
Ruthven	708	708
SAC COUNTY	15,573	16,802
Odebolt	1,373	1,394
Schaller	835	880
SIOUX COUNTY	27,996	37,088
Hull	1,523	1,696
Matlock	89	99
Perkins	--	--
Rock Valley	2,205	2,448
WOODBURY COUNTY	103,052	118,088
Anthon	711	772
Correctionville	870	944
Cushing	204	221
Danbury	527	572
Oto	203	220
Pierson	421	457
Smithland	293	318

For the Little Sioux River Basin, 12 communities have populations greater than 1,000, comprising about 65 percent of the total population. Municipalities having a population greater than 5,000 number two, accounting for 33 percent of the population.

Table 1 summarizes the populations and projected populations for each county and city. Population projects for 1990 have been made by the Iowa State Department of Health (Provisional Projections of the Population of Iowa Counties and Cities: 1975 to 1990, by James R. Taylor, June, 1972). These projections were utilized in determinging future waste loads.

Physiography

Rock River Basin - The topography of the study area is a gently rolling or undulating plain on the upland areas. Slopes and hill crests are smooth and round. Stream valley bottoms are about 200 feet below the general upland level. Slopes to major stream valleys are relatively steep.

The dendritic drainage pattern of the basin provides good surface water removal from all portions except the extreme northeast area. In the northeast, glaciers have left relatively flat land with numerous depressions interspread among morainic hills and ridges. In this area, where the dendritic pattern is not mature enough to provide adequate natural drainage, surface drains and drain tile are needed. The drainage system of the basin exhibits a more mature pattern as tributaries flow in a southwesterly direction to outlet in the Big Sioux River. Artificial drainage is also needed on some bottomlands and level terraces.

Upland soils in the study area have been formed primarily from loess which was deposited over Nebraskan and Kansan till. The loess mantle is thicker at the southern end of the basin. Loess thickness averages 75 inches. It covers summits and generally covers slopes. Marshall is the predominant soil series on uplands in the study area. When the glacial till is covered by more than 30 inches of loess, permeability is moderate. In the northeast portion of the study area where less than 30 inches of loess covers the till, internal drainage is poor. Pockets of much soils, which also have poor drainage, occur in depressions formed in the upland areas.

Terrace soils consist of outwash sands and gravels covered by loess. Most of these soils are well drained. Waukesha soil series is characteristic of soils found on terrace positions.

Bottomland soils have been formed from alluvial deposits. These soils generally have slow permeability, a high water table, and are subject to flooding. Flood plains are generally well developed on smaller creeks. The Wabash soil series is found on bottomlands.

Contamination of the surficial aquifer in areas where glacial till is blanketed by loess is generally not a problem. However, in the extreme northeastern portion of the study area, where loess is thin, the groundwater table can be close to the surface during certain times of the year. This produces a potential local pollution problem. Unsealed sewage lagoons or septic tank filter fields should not be constructed in these areas without careful site evaluation. If artificial subsurface drainage is provided by tile fields, wastewater applied on the surface can infiltrate tile and be carried to outlet channels. Care should also be taken when applying wastewater to uplands with good surface drainage. If surface runoff is high, pollutants can be carried to streams.

Alluvial aquifers in river bottoms and on terraces produce large quantities of water. These aquifers are recharged by local precipitation. Water quality varies even in local areas, but is generally fair to good. Potential contamination of groundwater in alluvial aquifers is great. The sand and gravel underlying some terrace soils have high permeability. Polluted surface runoff flowing over these areas can infiltrate the soil rapidly. Since these aquifers are located adjacent to streams, contaminated groundwater can transmit polution to streams. Bottomlands have sever limitations for wastewater disposal because they have slow permeability, a high groundwater table, and are subject to flooding.

Because of the variability of soils, all sites for wastewater disposal should be carefully evaluated on an individual basis.

Little Sioux River Basin - The topography of the study area ranges from the nearly flat to gently undulating glacial drift areas in the north to the more rolling loess covered areas in the southern part. In the south portion of the basin, slopes are smooth and even. Hill tops are rounded. Steep slopes border the major river valleys. The shallow river valleys of the northern part of the basin become well developed valleys which are 90 to 170 feet below the upland elevations in the southern portion. Missouri River bottomlands extend into the southwestern edge of the basin. The eastern boundary of the basin at the south end is part of the divide which separates drainage to the Missouri River on the west and the Mississippi River on the east.

The immature dendritic drainage pattern in the north part of the study area becomes well defined and more extensive as it approaches the Missouri River. This drainage pattern causes natural surface drainage to be generally poor in the northern one-third of the study area and good in the southern two-thirds of the study area. Drain tile and drainage ditches are needed to facilitate drainage on both the uplands in the north and the bottomlands throughout the study area.

Upland soils in the study area have been formed from glacial drift and loess. Drift soils occupy approximately the northern one-third of the study area. Loess soils occupy the remainder. Loess is thickest on the western side and thinnest on the eastern part. Most soils have moderate permeability. Clarion soils are formed from glacial till. Marshall soils represent upland loess soils.

Terrace soils consist of medium-textured outwash over sand and gravel. Permeability is high.

Bottomland soils are formed from alluvial materials. These soils have slow permeability, a high water table, and are subject to flooding. Wabash soils are representative of soils found on bottomlands.

The surficial aquifer that overlies the bedrock aquifer is formed by alluvium and glacial drift. Although surficial aquifers of glacial drift do not generally produce large enough quantities of water for public or industrial use, they do produce water in sufficient quantities for farmsteads and rural residences.

Contamination of groundwater in the glacial drift aquifers is generally not a great problem. However, the Dakota Sandstone which underlies the Western Iowa Groundwater District is recharged by overlying sands and gravels. Small pockets of sand and gravel occur in the glacial drift material. Any pollutants infiltrating these pockets could contaminate the groundwater in this sandstone aquifer. Although permeability is generally moderate, some upland soils have slow permeability and a water table which is high at certain times during the year. These problems create a potential hazard for wastewater disposal. Septic tank filter fields can fail. Surface runoff can carry septic tank effluent, barnyard water, fertilizer, and pesticides downstream through surface drains.

Alluvial aquifers in river bottoms, especially those along major river valleys and on terraces, produce large quantities of water. These aquifers are recharged locally. Water quality is variable even in local areas, but generally fair to good.

Potential contamination of groundwater in alluvial aquifers is great. Some terrace soils have high permeability. Pollutants can easily infiltrate this aquifer. Since these aquifers are adjacent to streams, contaminated groundwater can transmit any pollution to the streams. These areas have severe limitations for wastewater disposal because terrace areas have high permeability, and bottomlands have slow permeability, a high groundwater table, and are subject to flooding.

Because of the variable soil conditions, all sites for wastewater disposal should be evaluated on an individual basis.

Streams

Water contains oxygen required by microorganisms for degradation of organic material. The quantity of oxygen available for waste assimilation is a direct function of the flow volume. In addition, physical characteristics of the channel establish velocity and turbulence, and determine the reoxygenation capability of a stream. Therefore, physical conditions in a stream influence the available oxygen supply, and the biological degradation of organic matter and ammonia which occurs naturally.

Water quality criteria of the state of Iowa must be met at all times when the flow of the stream equals or exceeds the statistical seven-day, one-in-ten year (7-day, 1-in-10 year) low flow. Based upon this flow information and the physical characteristics of the stream, the assimilative capacity may be analyzed and allowable discharges determined.

Low Flow Characteristics - The United States Geological Survey (USGS) maintains an extensive nationwide network of stream gaging stations. Stream flow and certain water quality parameters are monitored continuously at some stations and periodically at others. By extrapolation of data from this established network and review of partial-record stations, additional flow information may be determined for streams where continuous-record gaging stations are not provided.

Low flows in both basins are significantly less than the state average when results are reduced to the common basis of discharge per square mile. Low flows in the Rock River Basin are mostly an order of magnitude less than those in the Little Sioux River Basin. Low flow characteristics for the Rock River Basin have been taken to be represented by the continuous-record gaging station near Rock Valley. The continuous-record gaging station near Kennebec (discontinued in 1969) has been taken as representing total basin flow in the Little Sioux River Basin. The drainage area of the West Fork Little Sioux River has not been considered as part of the Little Sioux River Basin as it is now a tributary to the Monona-Harrison Ditch which is physically separated from the Little Sioux River. The following tabulation compares the average flow of 84 continuous-record gaging stations within the state of Iowa with the above-mentioned gaging stations for the Rock River and Little Sioux River Basins and additional gaging stations on water quality classified tributaries to the main streams.

The following tabulation refers to daily average discharges recorded at each gaging station regardless of chronological sequence. For the Rock River gage, the period of record is 26 years, beginning in 1948; for the Little Sioux River gage, 30 years beginning in 1939; for the Maple River gage, 33 years beginning in 1941; and for the Odebolt Creek gage, 17 years beginning in 1957.

	Percentage of Time Flow Equaled or Exceeded[1]				
	50	90	95	98	99
State of Iowa Average (cfs/sq mi)	0.150	0.033	0.024	0.018	0.015
Rock River Basin Near Rock Valley (cfs/sq mi)	0.043	0.006	0.002	0.001	0.0004
Little Sioux River Basin Near Kennebec (cfs/sq mi)	0.115	0.022	0.014	0.009	0.008
Maple River at Mapleton (cfs/sq mi)	0.135	0.031	0.021	0.010	0.007
Odebolt Creek Near Arthur (cfs/sq mi)	0.148	0.038	0.023	0.008	0.006

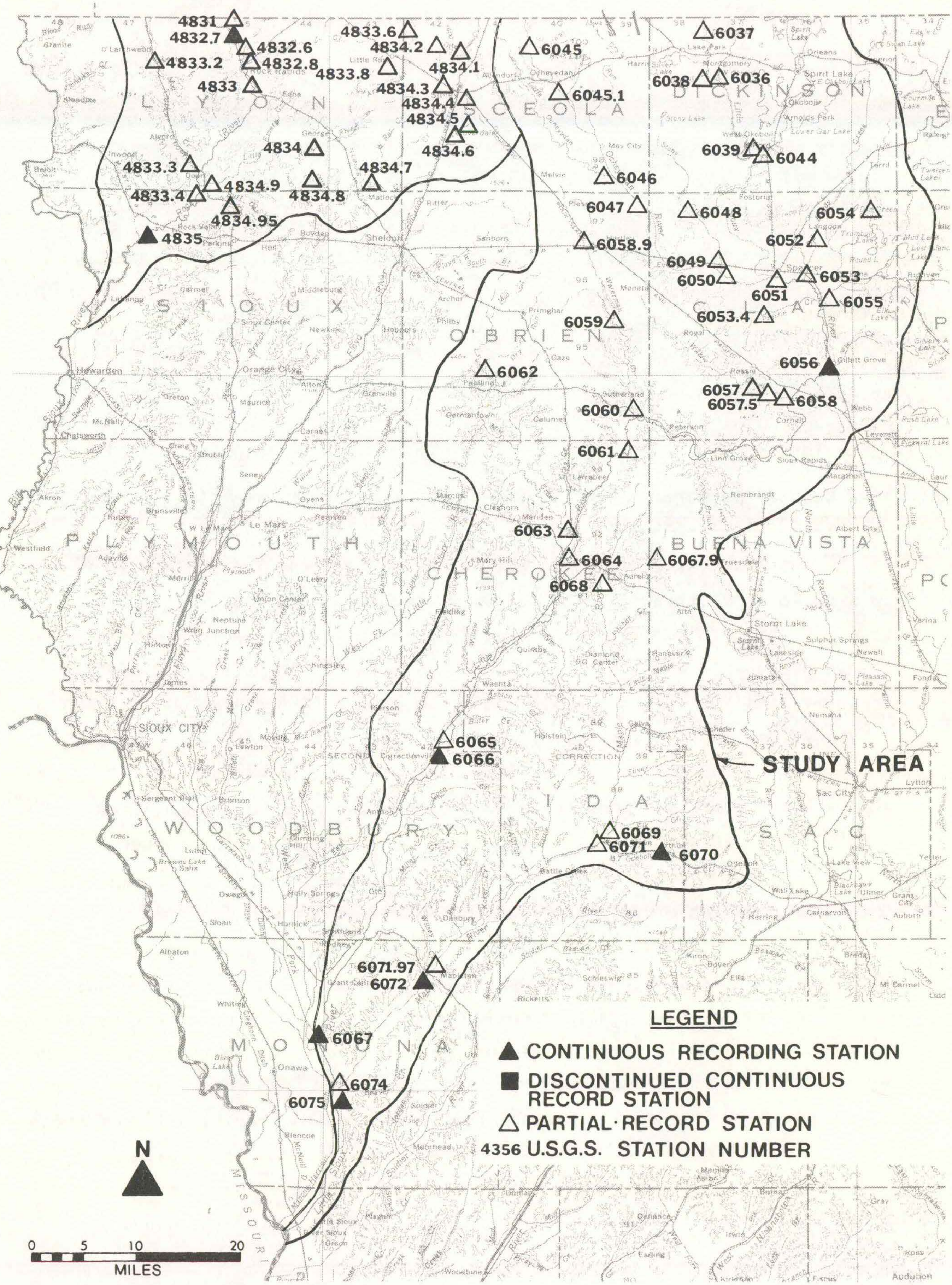
[1] Iowa Natural Resources Council, Low-Flow Characteristics of Iowa Streams Through 1966, Bulletin No. 10, 1970.

As with the daily flow data presented, the average 7-day, 1-in-10 year low flow for the streams is considerably lower than that for the entire state. On an areal basis, the 7-day, 1-in-10 year low flow for the state of Iowa averages 0.020 cfs/sq mi. The Rock River Basin averages 0.0001 cfs/sq mi, the Little Sioux River Basin averages 0.0084 cfs/sq mi, and its tributary, the Maple River Basin, averages 0.009 cfs/sq mi.

Specific USGS gaging station locations are identified on Figure 1. Both partial-record and continuous-record stations have been identified on this presentation. Table 2 identifies the specific station number, tributary drainage areas above the station, and the 7-day, 1-in-10 year low flow (where available) for each station.

As indicated in Table 2, insufficient data are available for identification of low flow at each gaging station. In order to conduct the waste load allocation analysis, determination of 7-day, 1-in-10 year low flow was conducted for specific gaging stations. These values were obtained utilizing the same procedures conducted by the USGS, but based upon less than 10 years of recorded data in some instances. For these reasons, verification of these values, as additional flow information becomes available, is required.

The frequency of extreme low flows is cyclic within the study area. Due to the climatological and geological characteristics of the study area,



U.S.G.S. GAGING STATIONS

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FIG. 1

TABLE 2

USGS GAGING STATION INFORMATION

Station No.	Stream[1]	Location	Drainage Area (sq mi)	7 Day, 1-in-10 Year Low Flow (cfs)	(mgd)
4831	Rock River	Near Rock Rapids	558	---	---
4832.6	Kanaranzi Creek	Near Rock Rapids	203	<0.1	<0.06
4832.7	Rock River	Rock Rapids	788	1.14[2]	0.74
4832.8	Tom Creek	Rock Rapids	61.9	0	0
4833	Rock River	Below Rock Rapids	859	---	---
4833.2	Mud Creek	Lester	63.7	---	---
4833.3	Mud Creek	Near Doon	138	<0.1	<0.06
4833.4	Rock River	Near Doon	1,050	---	---
4833.6	Little Rock River	Near Little Rock	92	0	0
4833.8	Little Rock River	Little Rock	134	<0.1	<0.06
4834	Little Rock River	Near George	199	---	---
4834.1	Otter Creek	North of Sibley	11.9	---	---
4834.2	Schuttle Creek	Near Sibley	1.43	---	---
4834.3	Otter Creek	Sibley	29.9	---	---
4834.4	Dawson Creek	Near Sibley	4.35	---	---
4834.5	Wagner Creek	Near Ashton	7.09	---	---
4834.6	Otter Creek	Near Ashton	88	<0.1	<0.06
4834.7	Otter Creek	Near Matlock	129	<0.1	<0.06
4834.8	Otter Creek	Near George	208	---	---
4834.9	Little Rock River	Near Doon	474	---	---
4834.95	Burr Oak Creek	Near Perkins	30.9	---	---
483.5	Rock River	Near Rock Valley	1,600	1.0[2]	0.65
6036	Little Sioux River	Near Montgomery	118	---	---
6037	West Fork Little Sioux River	Near Lake Park	116	0	0
6038	West Fork Little Sioux River	Near Montgomery	173	---	---
6039	Little Sioux River	Near Milford	333	---	---
6044	Okoboji Lake Outlet	Near Milford	151	---	---
6045	Ocheyedan River	Near Bigelow, Minn.	68.7	---	---
6045.1	Ocheyedan River	Near Ocheyedan	73.5	---	---
6046	Little Ocheyedan River	Near May City	54.2	---	---
6047	Ocheyedan River	Near May City	226	---	---
6048	Stoney Creek	Near Fostoria	65.4	---	---
6049	Stoney Creek	Near Everly	81.6	---	---

TABLE 2 (Cont.)

USGS GAGING STATION INFORMATION

Station No.	Stream[1]	Location	Drainage Area (sq mi)	7 Day, 1-in-10 Year Low Flow (cfs)	(mgd)
6050	Ocheyedan River	Near Spencer	426	---	---
6051	Little Sioux River	Spencer	990	---	---
6052	Big Muddy Creek	Near Langdon	59.7	---	---
6053	Muddy Creek	Near Spencer	102	---	---
6053.4	Prairie Creek	Near Spencer	22.3	---	---
6054	Pickerel Run	Near Spencer	75.7	0	0
6055	Lost Island Outlet	Near Dickens	151	---	---
6056	Little Sioux River	Gillett Grove	1,334	6.42[2]	4.15
6057	Willow Creek	Near Rossi	62.6	0	0
6057.5	Willow Creek	Near Cornell	78.6	---	---
6058	Willow Creek	Near Greenville	90.3	---	---
6058.9	Waterman Creek	Hartley	28.7	---	---
6059	Waterman Creek	Near Hartley	58.4	---	---
6060	Waterman Creek	Near Sutherland	139	<0.1	<0.06
6061	Little Sioux River	Near Sutherland	1,803	---	---
6062	Mill Creek	Near Paullina	61.6	---	---
6063	Mill Creek	Near Cherokee	292	---	---
6064	Little Sioux River	Cherokee	2,173	---	---
6065	Pierson Creek	Near Correctionville	55.1	<0.1	<0.06
6066	Little Sioux River	Correctionville	2,500	10.0	6.5
6067	Little Sioux River	Near Kennebec	2,738	23.0	14.9
6067.9	Maple Creek	Near Alta	15.5	---	---
6968	Maple River	Near Aurelia	85.2	---	---
6069	Maple River	Near Ida Grove	364	---	---
6070	Odebolt Creek	Near Arthur	39.3	---	---
6071	Odebolt Creek	Ida Grove	61.1	---	---
6071.97	Wilsey Creek	Mapleton	18.4	---	---
6072	Maple River	Mapleton	669	5.8	3.7
6074	Maple River	Near Turin	741	---	---
6075	Little Sioux River	Near Turin	3,526	---	---

[1] Iowa Natural Resources Council, Low-Flow Characteristics of Iowa Streams Through 1966, Bulletin No. 10, 1970.

[2] Flow values are those computed for use in this study.

low flows can occur either during August and September or during January and February of any given year. In addition, long-term climatological cycles have an influence on stream flow. Based upon this information, analyses of critical conditions for defining waste load allocations must be conducted for both warm and cold water temperatures.

Stream Hydrodynamics - The term hydrodynamics refers to the characteristics of motion associated with a body of water. As is disucssed in further detail in PART V - WASTE LOAD ALLOCATION METHODOLOGY, stream velocity and slope are of major interest. The relationship between these two characteristics allows definition of reaeration rate constants within particular reaches of streams based upon cross section and slope information. The two physical characteristics which are required to define the reaeration rate constants are the slope of the water surface and time of travel for each reach.

Information on the actual slope of the water surface is not available for these river basins. Surface water slope varies with the amount of flow in the stream and at 7-day, 1-in-10 low flows, the assumption is made that the slope of the water surface is essentially the same as the slope of the stream bottom. Stream bed slopes have been obtained from the information on USGS topographic maps. Channel slopes in the Rock River Basin for the modeled sections of the streams range from approximately 2.3 ft/mi to 13.1 ft/mi with an average slope of about 4.4 ft/mi. The average channel slope for the Little Sioux River Basin is approximately 2.8 ft/mi, with a range of approximately 0.3 ft/mi to 25.0 ft/mi.

Determination of time of travel is dependent only upon distance traveled and stream velocity. Distance is measured from USGS topographic maps. Determination of stream velocity is described in detail in PART V. The two physical characteristics required to calculate stream velocity are the width of stream and value of the Manning coefficient ("n"). Values of both the width and "n" are dependent upon the stream flow, and so these values must be determined at the 7-day, 1-in-10 year low flow. Values for these two characteristics can be obtained at USGS gaging stations, but data available at the stations do not usually include measurements at the 7-day, 1-in-10 year low flows. Available data must be extrapolated to obtain an approximate value for these characteristics under low flow conditions. Since there are few USGS gaging stations at which these characteristics may be obtained, the values of "n" and stream width for other reaches of the stream must be estimated from the approximations available at the gaging stations and from field observations. Field observations of stream widths at low flows (not 7-day, 1-in-10 year low flows) also aid in estimating stream widths under the low flow condition. The approximate "n" values at the gaging stations, visual examination of the stream, and use of the method for estimating "n" presented in Open Channel Hydraulics (by V. T. Chow) are all aids in estimating "n" values for stream reaches which do not have a USGS gaging station.

Approximate values of the Manning coefficient and stream widths at 7-day, 1-in-10 year low flows are given in Table 3.

TABLE 3

ESTIMATED PHYSICAL CHARACTERISTICS AT USGS GAGING STATIONS

Station No.	Stream Width (ft)	"n"
6-4832.7 (Rock River)	2	0.033
6-4835 (Rock River)	6	0.046
6-6075 (Little Sioux River)	135	0.025
6-6066 (Little Sioux River)	36	0.038
6-6056 (Little Sioux River)	12	0.023
6-6072 (Maple River)	10	0.032

PART III

WATER QUALITY

General

The main objective of determining allowable waste loads is protection and enhancement of water resources to ensure acceptable conditions for designated uses. Identification of realistic waste load allocations requires knowledge of the existing water quality resulting from the interaction of man with nature throughout the study area.

Iowa Water Quality Standards establish a baseline for evaluating adequate stream quality under existing and projected discharge conditions. The National Water Quality Criteria, as proposed by the Federal Environmental Protection Agency (EPA), provide an additional measure of the adequacy of existing water quality.

Existing water quality for the Little Sioux River and the Rock River has been identified from available data obtained from the State Hygienic Laboratory. The data indicate some areas of degraded water quality and provide limited information on overall water quality within the basins. Review of existing data shows major deficiencies in the extent of water quality monitoring in the study area.

Water Quality Criteria

Water quality criteria define the constituent levels which will protect the utility of the water resource for multiple uses. Concentrations of water quality parameters in a "pristine" state are impossible to locate or estimate because of the activities of man within the basin. Existing criteria are the standard against which water quality parameters are compared to determine the quality of a stream. Differences between existing quality and criteria establish a basis for defining waste load allocations.

Iowa Department of Environmental Quality Regulations - Regulations promulgated by the Iowa Water Quality Commission specify water quality for all surface waters within Iowa. Powers and authorities of IDEQ are defined in the Code of Iowa, 1973, Sections 455B.32(2) and 455B.35. Specific regulations are given in the "Iowa Departmental Regulations - Department of Enviornmental Quality" (IDR-DEQ).

The most important regulations applicable to the study area are identified in Chapter 16, Sections 1 and 2, "Water Quality Standards" of the IDR-DEQ. This document specifies the stream quality requirements for the following use classifications:

Class A - Body Contact Recreation

Class B - Wildlife, Non-body Contact Recreation and Aquatic Life

Class C - Potable Water Supply

In accordance with use classifications, certain streams within the basin must satisfy the water quality standards for Class B (warm water). Figure 2 indicates which streams within the study area must satisfy the Class B requirements. Other streams have not been classified and must satisfy General Water Quality Criteria. Tables 4 and 5 summarize the applicable water quality standards.

Class B uses apply to waters which will support both cold and warm water fisheries, and different sets of criteria are enumerated for each use. All Class B streams within the basin study area must satisfy criteria for warm water fisheries. Therefore, Table 4 contains stream standards applicable for warm water fisheries. Table 5 identifies the concentration of chemical constituents allowable in Class B streams.

Federal EPA Regulations - In conformance with 1972 Federal Water Pollution Control Act Amendments [Section 304(a)(1) and (2), Public Law 92-500], EPA has published "Proposed Criteria for Water Quality." Under existing legislation, major programs which will be affected by the criteria are:

Water Quality Standards

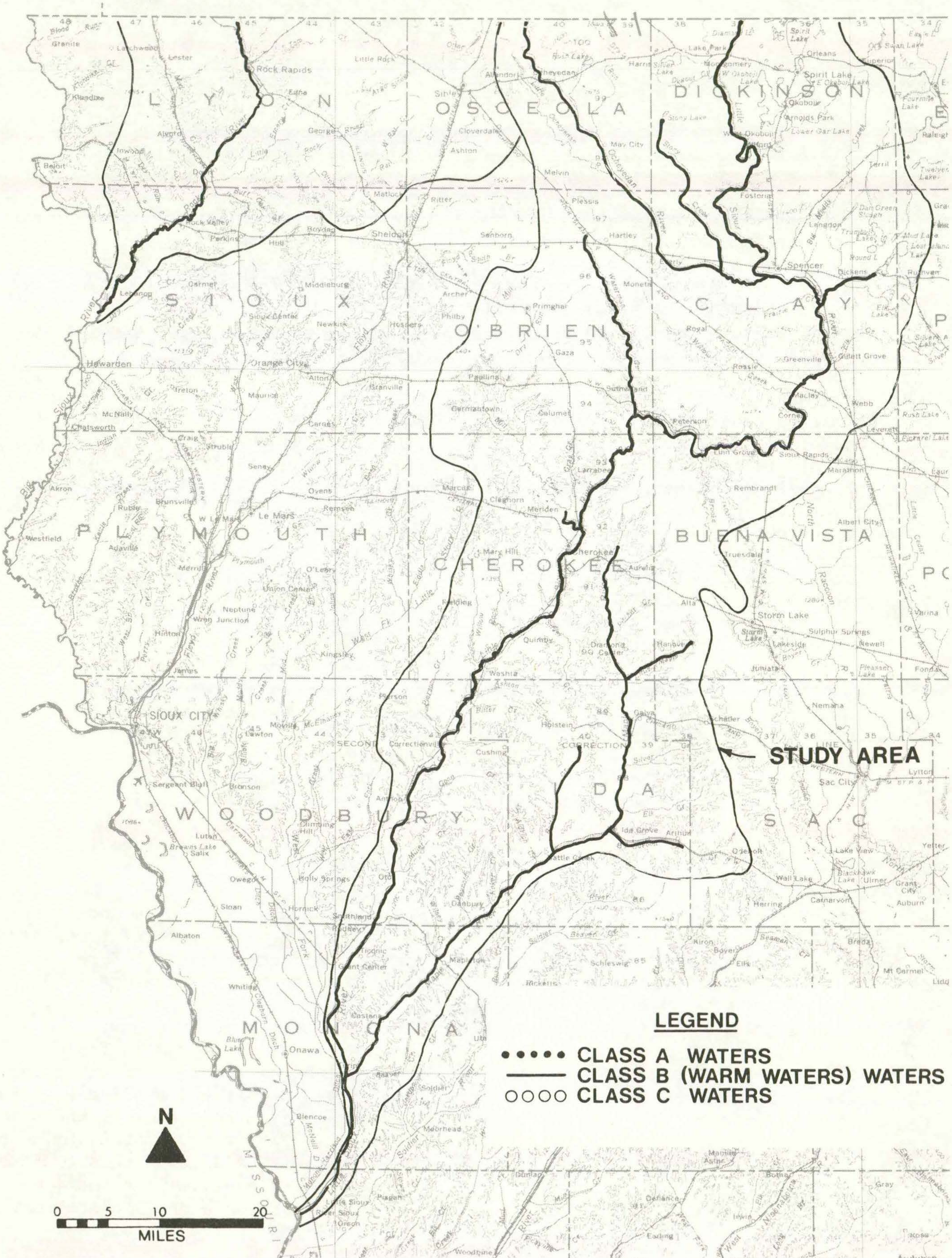
Toxic and Pretreatment Standards

Water Quality Inventory (monitoring)

Toxic and Pretreatment Effluent Standards

National Pollutant Discharge Elimination System

Ocean Discharge Criteria



SURFACE WATER CLASSIFICATION

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FIG. 2

TABLE 4

WATER QUALITY STANDARDS
ROCK AND LITTLE SIOUX RIVER BASINS

General Criteria	Class B
Such waters shall be free from substances attributable to municipal, industrial or other discharges, or agricultural practices that will settle to form objectionable sludge deposits.	Dissolved Oxygen: At least 5.0 mg/l during at least 16 hours of any 24-hour period. At all times equal to or greater than 4.0 mg/l.
Such waters shall be free from floating debris, oil, grease, scum, and other floating materials attributable to municipal, industrial or other discharges, or agricultural practices in amounts sufficient to be unsightly or deleterious.	pH: Not less than 6.5, nor greater than 9.0. Maximum change permitted as a result of a waste discharge shall not exceed 0.5 pH units.
Such waters shall be free from materials attributable to municipal, industrial or other discharges, or agricultural practices producing color, odor, or other conditions in such degree as to create a nuisance.	Turbidity: Shall not be increased by more than 25 Jackson turbidity units by any point source discharge. Fecal Coliforms: Shall not exceed 2,000 per 100 ml, except when waters are materially affected by surface runoff.
Such waters shall be free from substances attributable to municipal, industrial or other discharges, or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life.	Temperature: Maximum increase of 5° F. The rate of temperature change shall not exceed 2° F per hour. Maximum allowable stream temperature is 90° F.
The turbidity of the receiving water shall not be increased by more than 25 Jackson turbidity units by any point source discharge.	Maximum increase for lakes and reservoirs is 3° F. The rate of temperature change shall not exceed 2° F per hour. Maximum allowable temperature is 90° F.
	Chemical Constituents: The concentrations given in Table 5 shall not be exceeded at any time the flow equals or exceeds the 7-day, 1-in-10 year low flow unless it is known that the material is from uncontrollable non-point sources. All substances toxic or detrimental to aquatic life shall be limited to non-toxic or non-detrimental concentrations in the surface water.

TABLE 5

WATER QUALITY STANDARDS
CHEMICAL CONSTITUENTS - CLASS B

Chemical Constituent	Allowable Concentration** (mg/l)
Ammonia Nitrogen-N	2.0
Phenols (other than natural sources)	0.001
Total Dissolved Solids	750
Arsenic	1.00
*Barium	1.00
*Cadmium	0.05
*Chromium (hexavalent)	0.05
*Chromium (trivalent)	1.00
*Copper	0.02
Cyanide	0.025
*Lead	0.10
*Mercury	0.005
*Selenium	1.00
*Zinc	1.0

*The sum of the entire heavy metal group shall not exceed 1.5 mg/l.

**Not to be exceeded when flow is equal to or greater than the 7-day, 1-in-10 year low flow unless from uncontrollable non-point sources.

The major objectives of the EPA water quality criteria are to provide protection of all waters and improve natural water quality. The means by which this will be accomplished is best described by the following:

> "EPA Water Quality Criteria will be incorporated into revised State water quality standards under the direction of EPA Regions by means of policy guidelines developed by the EPA Office of Water Planning and Standards. Those guidelines have provisions for waters to be exempted from specific criteria on a case-by-case basis for specified periods when naturally occurring conditions exceed limits of the EPA criteria or other extenuating conditions prevail to warrant such exemptions."[1]

[1] "Proposed Criteria for Water Quality," Volume 1, U. S. Environmental Protection Agency, Washington, D.C., October, 1973, p. 17.

These criteria are to provide the protection necessary to sustain recreational uses in/on the water, and for the preservation and propagation of desirable aquatic biota. This level of protection ensures the suitability of all waters for other uses. Based upon the latest scientific information, these criteria define the water quality necessary to satisfy 1983 interim goals [Section 101(a)(2), Public Law 92-500].

The "Proposed Criteria for Water Quality" are not used in evaluating water quality for this study. However, a comparison between proposed EPA criteria and IDEQ water quality standards for Class B streams (warm water fisheries) is presented in Table 6 for reference.

Water Quality Criteria Summary - Examination of Table 6 indicates both differences and similarities between proposed EPA criteria and Iowa water quality standards. Many parameters not limited by Iowa criteria are to be regulated by EPA. Since proposed EPA criteria must be incorporated into Iowa criteria through resolution of differences with the state of Iowa, evaluation of existing stream quality using EPA criteria would not provide meaningful results. Thus, for purposes of this study, IDEQ standards will be utilized.

Iowa standards are either more stringent or comparable to proposed EPA criteria for all parameters except trivalent chromium, lead, mercury, and dissolved oxygen (DO). Differences may exist between the two agencies for other toxic materials; however, since EPA values are based upon bioassay determinations of toxic concentrations, a direct comparison is not possible.

Initial review of ammonia levels suggest EPA criteria are much more stringent than Iowa standards. However, EPA criteria refer to the concentration of un-ionized ammonia while Iowa standards specify total ammonia concentration. The differences between the Iowa 2.0 mg/l total ammonia standard and EPA criteria depend on stream pH as evidenced below:

pH	(NH_4^+) (mg/l-N)	(NH_3) (mg/l-N)	Total Ammonia (mg/l-N)
6	39.98	0.02	40.00
7	3.62	0.02	3.64
8	0.36	0.02	0.38

Note: Values based upon the dissociation constant at 25° C.

TABLE 6

COMPARISON OF WATER QUALITY CRITERIA

Water Quality Parameter	IDEQ Class B Water Quality Standards	EPA Proposed Criteria for Water Quality
pH	6.5 - 9.0	6.0 - 9.0
Alkalinity	--	30 - 130 mg/l
Acidity	--	Addition of acids unacceptable
Ammonia	2.0 mg/l-N (ammonia plus ammonium ion)	0.02 mg/l-N maximum (ammonia only) or 0.05 of the 96-hour LC_{50} [1]
Cadmium	0.05 mg/l	0.03 mg/l - hard water[2] 0.004 mg/l - soft water
Chlorine (free)	--	0.003 mg/l - chronic exposure 0.05 mg/l - 30 minute exposure
Chromium (hexavalent)	0.05 mg/l	0.03 mg/l
Chromium (trivalent)	1.0 mg/l	0.03 mg/l
Copper	0.02 mg/l	0.10 of the 96-hour LC_{50} [1]
Cyanide	0.025 mg/l	0.05 of the 96-hour LC_{50} [1]
Lead	0.10 mg/l	0.03 mg/l
Mercury	5.0 ug/l	0.2 ug/l - single occurrance 0.5 ug/l - average concentration
Nickel	--	0.02 of the 96-hour LC_{50} [1]
Phosphorus	--	25 ug/l-P lakes and reservoirs[3] 100 ug/l-P - streams[3]
Zinc	1.0 mg/l	0.003 of the 96-hour LC_{50} [1]

Water Quality Parameter	IDEQ Class B Water Quality Standards	EPA Proposed Criteria for Water Quality
Fecal Coliforms	200 per 100 ml - Class A waters 2,000 per 100 ml - Class B waters	2,000 per 100 ml average - non-recreational waters 200 per 100 ml average - recreational waters.
Dissolved Solids	750 mg/l	Bio-assay to be used to determine limits of tolerance of aquatic ecosystem.
Temperature	4	5
Pesticides	--	0.01 of the 96-hour LC_{50} [1] for those pesticides not listed in Reference 7
Turbidity	Less than 25 Jackson Turbidity Unit increase from any point source.	Compensation point may not be changed by more than 10 percent.
Radioactivity	--	8
Dissolved Oxygen	5.0 mg/l for at least 16 hours of any 24-hour period. Never less than 4.0 mg/l at any time.	6.8 mg/l at 1.5° C 6.8 mg/l at 7.7° C 6.5 mg/l at 16.0° C 6.2 mg/l at 21.0° C 5.8 mg/l at 27.5° C 5.8 mg/l at 36.0° C Never less than 4.0 mg/l for a 24-hour or less period when water temperatures exceed 31.0° C.
Sulfides	--	0.002 mg/l
Detergents (as LAS)	--	0.2 mg/l - maximum or 0.05 of the 96-hour LC_{50} [1]
Oils	--	No visible oil 0.05 of the 96-hour LC_{50} [1]
Phthalate Esters	--	0.3 ug/l
Polychlorinated Biphenyls	--	0.002 ug/l
Tainting Substances	--	6

1 LC_{50} identifies the concentration at which 50 percent of the test organisms die within the stated time period.
2 Hard water is defined as having a total hardness of 100 mg/l as $CaCO_3$ or more.
3 Concentrations required to prevent nuisance aquatic plant growths where phosphorus is the limiting constituent.
4 Refer to Table 4.
5 Refer to "Proposed Criteria for Water Quality," EPA, p. 144-170.
6 Refer to "Proposed Criteria for Water Quality," EPA, p. 141-143.
7 Refer to "Proposed Criteria for Water Quality," EPA, p. 125.
8 "Water Quality and Treatment," American Waterworks Association, Inc., 1971, p. 27-32.

Existing Water Quality

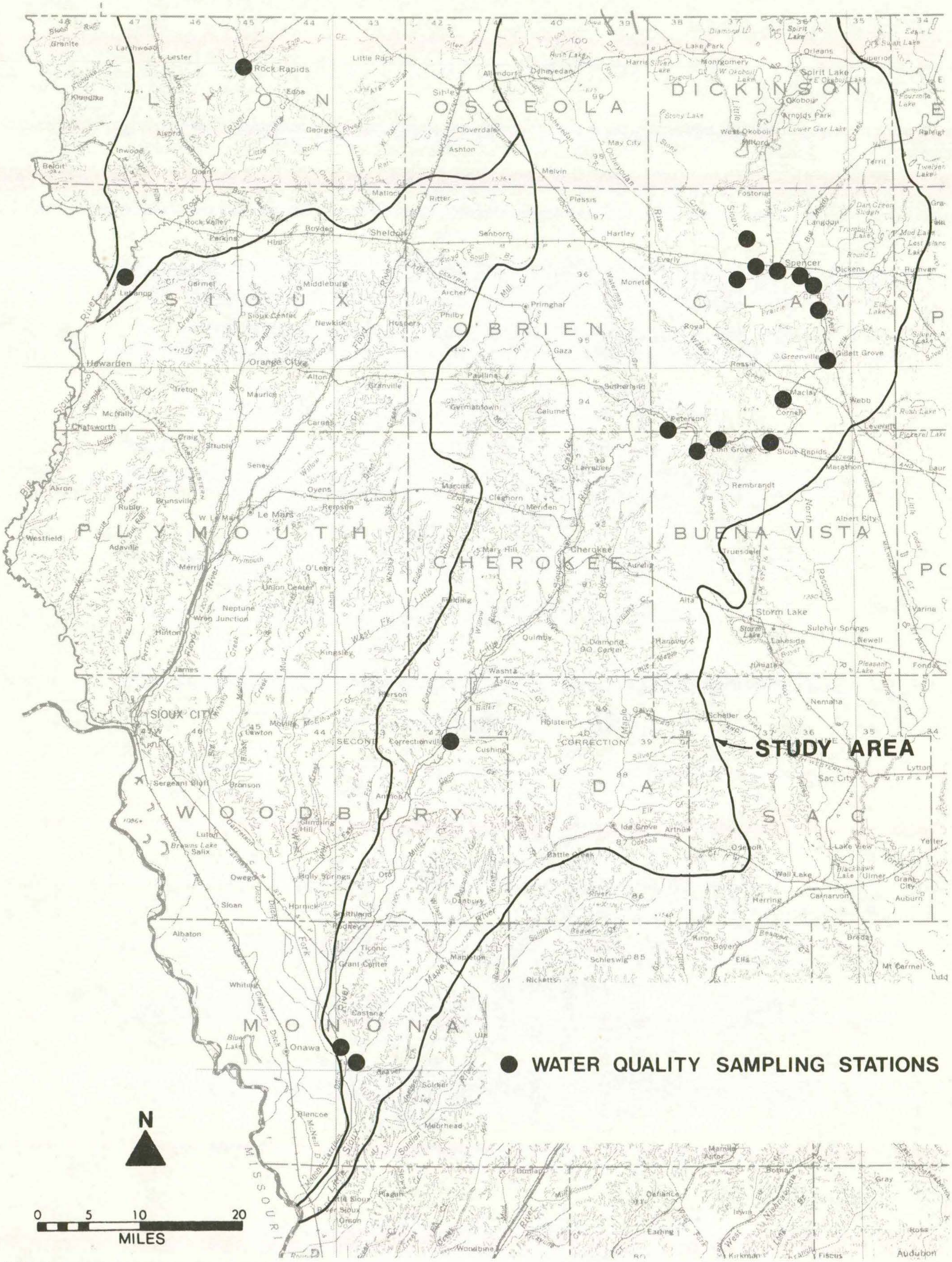
Data Sources - The study area is comprised of the drainage basins of the Rock River and Little Sioux River within the state of Iowa. The evaluation of water quality data herein is based upon data collected by the State Hygienic Laboratory. Some data are available from other Federal, State, and local agencies; but these data are scattered, both in time and over the basin, and are not useful in evaluating water quality. No additional sampling, gaging, or quality analyses were initiated specifically for this program.

The locations of all sampling stations collecting data utilized for this report are shown on Figure 3. All of the water quality data used in this evaluation have been obtained since 1971.

Rock River - The study portion of this stream begins with the Rock River as it crosses the Iowa-Minnesota border and ends at the confluence with the Big Sioux River. Major tributaries to the Rock River within the study area are the Little Rock River and Otter Creek. No water quality data are available for the tributaries.

The only available data on the Rock River are from Report No. 74-21, "Iowa Internal Stream Quality Survey" containing data collected from August through December, 1973, and from the quarterly stream monitoring survey which began in August, 1972. Both data sources identify water quality at only one given location. No water quality data are available to show conditions along the stream for a given point in time.

Data from Report No. 74-21 consists of four samples taken near Rock Rapids, covering four months time. None of the parameters measured except fecal coliform counts is in violation of stream quality criteria. Although the fecal coliform counts do exceed the stream quality criteria of 2,000 per 100 ml, the high value of the sample in violation could be due to surface runoff. Water quality data for this sampling station are summarized in Table 7. Other than the fecal coliform counts, there are no indications of stream pollution except for slightly elevated ammonia nitrogen concentrations. This water quality survey was conducted during a time of relatively high flow, as is demonstrated by comparing the stream flows at the USGS gaging station near Rock Rapids against its 7-day, 1-in-10 year low flow of 1.14 cfs.



WATER QUALITY SAMPLING STATIONS

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FIG. 3

TABLE 7

1973 WATER QUALITY DATA
ROCK RIVER - NEAR ROCK RAPIDS

Parameter	Date of Sampling Aug. 7, 1973	Sept. 4, 1973	Oct. 1, 1973	Oct. 29, 1973
Temperature (° C)	23.5	24.0	16.0	9.0
Dissolved Oxygen (mg/l)	11.6	17.1	11.0	13.6
Fecal Coliform (MPN/100 ml)	1,000	660	3,300	100
Total Kjeldahl Nitrogen (mg/l)	1.2	0.68	0.9	0.72
Ammonia Nitrogen (mg/l)	0.22	0.66	0.46	0.14
Nitrate Nitrogen (mg/l)	0.3	<0.1	0.4	0.8
Total Suspended Solids (mg/l)	---	128	---	13
Phosphate (filtrable) (mg/l)	---	<0.01	---	0.20
BOD_5 (mg/l)	15	5	4	6
Total Chromium (mg/l)	<0.01	<0.01	<0.01	---
Hexavalent Chromium (mg/l)	<0.01	<0.01	<0.01	---
Flow (cfs)	20	8.9	---	---

Water quality data from the quarterly stream monitoring survey are presented in Table 8. This sampling station is located just above the confluence of the Rock River with the Big Sioux River. None of the parameters measured violates stream quality criteria, and there is no indication of stream pollution. Again, stream flows during most sampling times are far in excess of the 7-day, 1-in-10 year low flow. Flows for the USGS gaging station near Rock Valley are given in Table 8 and are much greater than the 7-day, 1-in-10 year low stream flow of 1.0 cfs.

Little Sioux River - The study portion of this stream begins at the Iowa-Minneosta border and ends at the confluence with the Missouri River. The Maple River, a major tributary to the Little Sioux River, is modeled for waste load allocation purposes. The only available data on the Maple River are contained in Report No. 74-21, "Iowa Internal Stream Quality Study" consisting of four samples taken between August and December, 1973. The only violation of stream quality criteria is a single fecal coliform count. All other data meet stream quality standards and there is little indication of stream pollution. Data from this sampling station are summarized in Table 9 along with stream flow data from the USGS gaging station at Mapleton. At the gage, stream flows over the sampling period are far in excess of the 7-day, 1-in-10 year low flow of 5.8 cfs.

Definitive data for the Little Sioux River come from Report No. 74-21, "Iowa Internal Stream Quality Survey" containing data taken from August through December, 1973; and the quarterly stream monitoring survey which has sampling stations near Spencer and Onawa; and two unpublished stream surveys near Spencer done during January, 1971, and July, 1974. These data sources also contain a limited amount of water quality information on the Ocheyedan River, which has also been modeled for waste load allocations. The Ocheyedan River water quality data will be presented along with that for the Little Sioux River.

The two unpublished reports taken near Spencer are the only sources which allow water quality profiles to be constructed for a portion of the stream. A dissolved oxygen profile for the January, 1971, survey is shown on Figure 4. The stream quality criteria for dissolved oxygen is not met near the end of the sampling reach. Due to cold water temperatures, the maximum DO sag is a considerable distance downstream from the Spencer

TABLE 8

WATER QUALITY DATA
ROCK RIVER - NEAR SIOUX CENTER

Parameter	Aug. 21, 1972	Nov. 2, 1972	Jan. 16, 1973	June 11, 1973	Aug. 7, 1973	Oct. 29, 1973
	Date of Sampling					
Temperature (° C)	26.0	7.5	0.0	27.0	25.0	8.0
Dissolved Oxygen (mg/l)	13.9	11.0	6.7	10.1	13.1	13.3
Fecal Coliforms (MPN/100 ml)	30	450	50	<100	1,200	80
Conductance (micromhos)	---	---	550	700	630	790
pH (SU)	---	---	7.5	7.8	7.7	8.4
Organic Nitrogen (mg/l)	2.0	1.5	1.5	2.4	2.7	1.4
Ammonia Nitrogen (mg/l)	<0.01	0.15	0.97	0.01	0.01	<0.01
Nitrate Nitrogen (mg/l)	0.2	4.5	1.6	0.7	<0.1	1.6
Total Solids (mg/l)	523	710	368	630	554	570
Total Volatile Solids (mg/l)	146	168	127	215	252	198
Total Suspended Solids (mg/l)	115	152	43	158	112	27
Volatile Suspended Solids (mg/l)	34	6	7	42	66	0
Phosphate (filtrable) (mg/l)	0.01	0.22	0.55	0.02	0.02	0.11
Total Phosphate (mg/l)	0.09	0.33	0.56	0.11	0.14	0.14
BOD_5 (mg/l)	15	4	8	12	16	8
COD (mg/l)	41.3	32	41	59	64	18
Flow (cfs)	125	240	70	189	77	---

TABLE 9

1973 WATER QUALITY DATA
MAPLE RIVER - NEAR TURIN

Parameter	Date of Sampling Aug. 7, 1973	Sept. 4, 1973	Oct. 1, 1973	Oct. 30, 1973
Temperature (° C)	28.0	21.0	16.5	7.5
Dissolved Oxygen (mg/l)	9.3	10.3	8.3	11.7
Fecal Coliform (MPN/100 ml)	180	600	33,000	900
Total Kjeldahl Nitrogen (mg/l)	1.3	0.34	1.4	0.34
Ammonia Nitrogen (mg/l)	0.18	0.06	0.50	0.16
Nitrate Nitrogen (mg/l)	5.8	3.5	5.2	6.6
Total Suspended Solids (mg/l)	---	85	---	95
Phosphate (filtrable) (mg/l)	---	0.11	---	0.17
BOD_5 (mg/l)	2	3	12	1
Total Chromium (mg/l)	<0.01	<0.01	<0.01	---
Hexavalent Chromium (mg/l)	<0.01	<0.01	<0.01	---
Flow (cfs)	200	124	---	---

FIGURE 4
LITTLE SIOUX RIVER
JANUARY 18-19, 1971
DISSOLVED OXYGEN CONCENTRATIONS

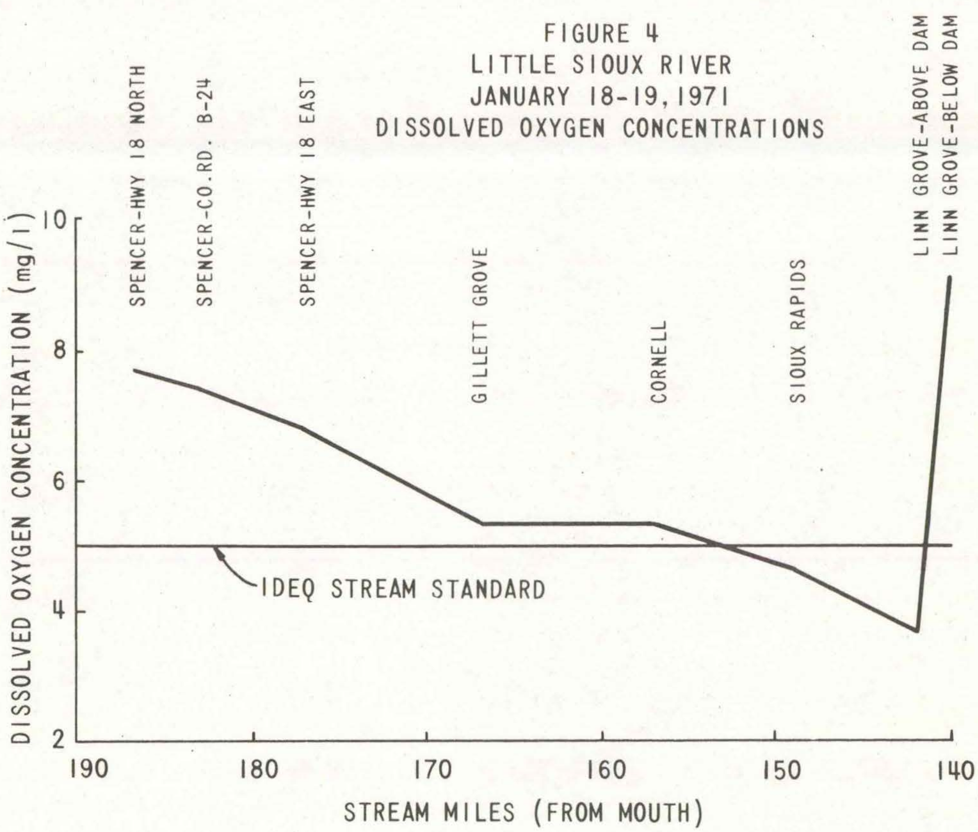
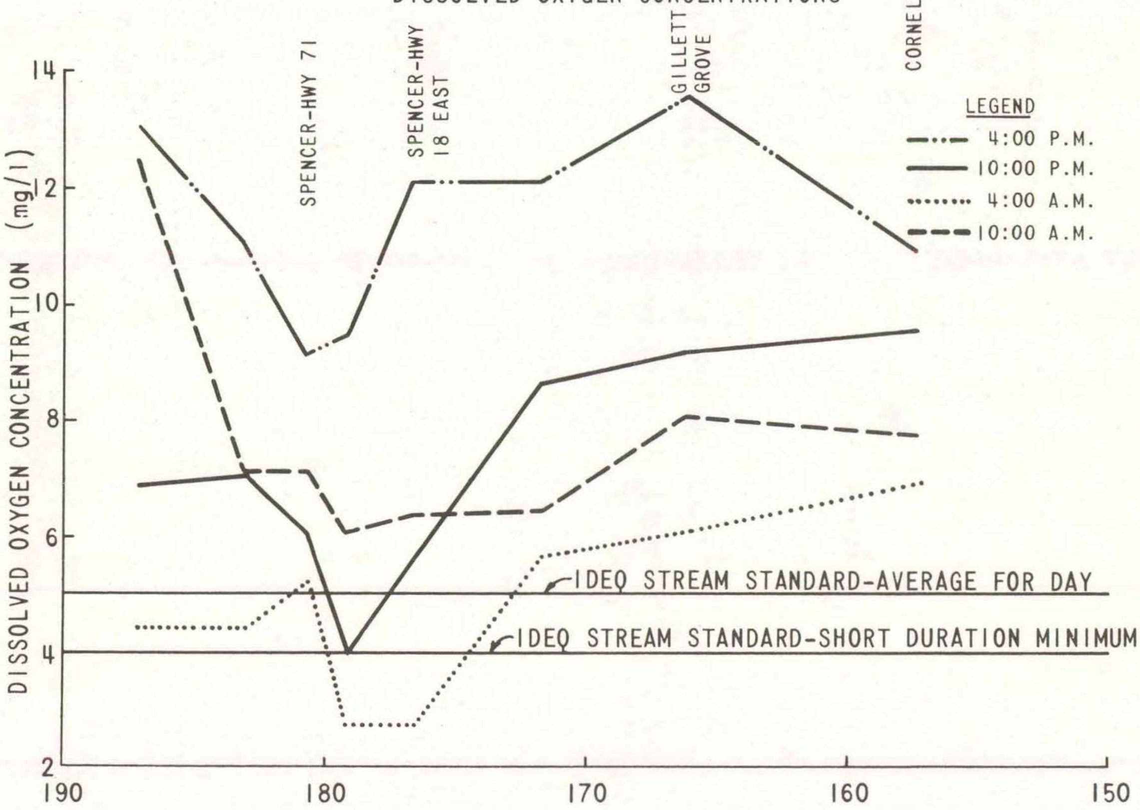


FIGURE 5
LITTLE SIOUX RIVER
JULY 16-17, 1974
DISSOLVED OXYGEN CONCENTRATIONS



STP. Aeration of the stream over the dam at Linn Grove restores high DO levels. A set of dissolved oxygen profiles may be drawn for data taken during the July, 1974, survey. Dissolved oxygen concentrations were taken at two-hour intervals at each sampling station from 2:00 p.m. to 10:00 a.m. of the following day. The highest dissolved oxygen concentrations were recorded at 4:00 p.m., while the lowest were taken at 4:00 a.m. Dissolved oxygen profiles for these two times and for 10:00 a.m. and 10:00 p.m. are shown on Figure 5. All of the DO concentration data are given in Table 10, including that taken at the sampling station on the Ocheyedan River. Ammonia nitrogen concentration profiles for both surveys are shown on Figure 6. No violations of the 2.0 mg/l stream quality criteria occur, but the impact of the wastewater discharge from the Spencer STP is evident. Water quaility data from the January, 1971, survey are summarized in Table 11, while data from the July, 1974, survey are contained in Table 12. Other than dissolved oxygen and total dissolved solids concentrations, the only criteria violated is that for fecal coliforms. For both surveys the likely cause of high fecal coliform counts is the wastewater discharges. Stream flows for both surveys were well above 7-day, 1-in-10 year low flows. Flow during the survey of January, 1971, was 106 cfs and in July, 1974, was 55 cfs. The 7-day, 1-in-10 year low flow at the USGS gaging station near Gillett Grove is 6.42 cfs.

Water quality data taken during the quarterly stream monitoring survey do not show any violations of stream quality criteria. Data taken at the sampling station near Onawa are summarized in Table 13. The sampling station near Spencer is upstream of the wastewater treatment plant discharge and data from this station are given in Table 14. Due to their locations, these sampling stations should not and are not indicating any heavy stream pollution.

Data taken for Report No. 74-21 were collected at three sampling stations near Sioux Rapids, Peterson, and Correctionville. Other than two violations of fecal coliform criteria, which may be due to surface runoff, none of the samples shows any violations of stream quality criteria. Data and stream flow for the sampling station near Sioux Rapids are summarized in Table 15, for the sampling station near Peterson in Table 16, and for the sampling station near Correctionville in Table 17.

TABLE 10

DIURNAL DISSOLVED OXYGEN STUDY
LITTLE SIOUX RIVER - NEAR SPENCER
JULY 16 & 17, 1974

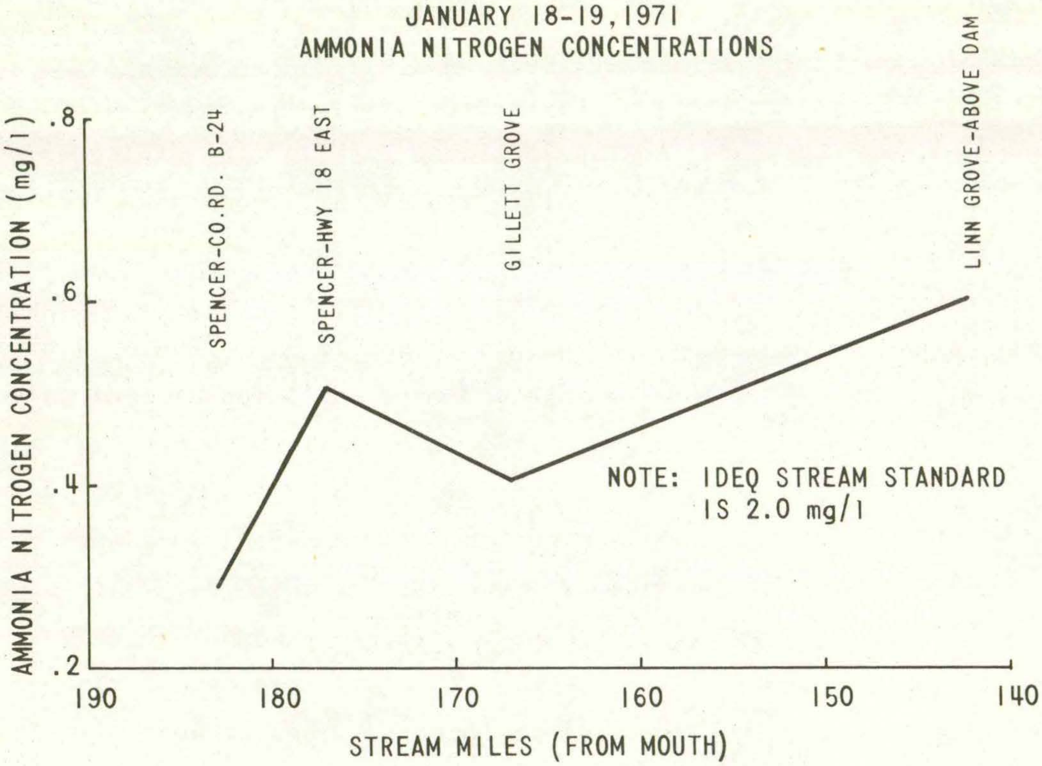
	STATIONS								
	1	2	3	4	5	6	7	8	9
Time	County Road Bridge Near Spencer	County Road Bridge Near Spencer	Highway 71 Bridge In Spencer	4-County Road Bridge Near Spencer	Highway 18 Bridge East of Spencer	County Road B-40 Bridge S.E. of Spencer (Gillett Grove)	County Road B-53 Bridge Near Gillett Grove	Highway 374 Bridge Near Cornell	County Road M-38 Bridge Near Spencer
2:00 p.m.	*	10.4	8.8	8.1	10.6	9.2	12.0	9.5	**
4:00 p.m.	13.2	11.0	9.1	9.6	12.1	12.1	13.5	10.9	**
6:00 p.m.	12.5	10.2	8.1	8.3	11.6	12.9	13.1	12.2	**
10:00 p.m.	6.9	7.1	6.0	3.9	5.8	8.6	9.2	9.5	6.7
12:00 midnight	5.7	5.8	5.7	3.6	3.2	7.1	7.5	7.6	6.7
4:00 a.m.	4.3	4.3	5.2	2.8	2.8	5.4	6.1	6.9	6.8
6:00 a.m.	4.5	4.0	5.2	2.9	2.8	4.6	5.7	6.2	6.8
10:00 a.m.	12.5	7.1	7.1	6.1	6.3	6.5	8.1	7.7	8.8

Note: Station 9 is on the Ocheyedan River

*Bottle broken
**Sample not collected

FIGURE 6

LITTLE SIOUX RIVER
JANUARY 18-19, 1971
AMMONIA NITROGEN CONCENTRATIONS



LITTLE SIOUX RIVER
JULY 16-17, 1974
AMMONIA NITROGEN CONCENTRATIONS

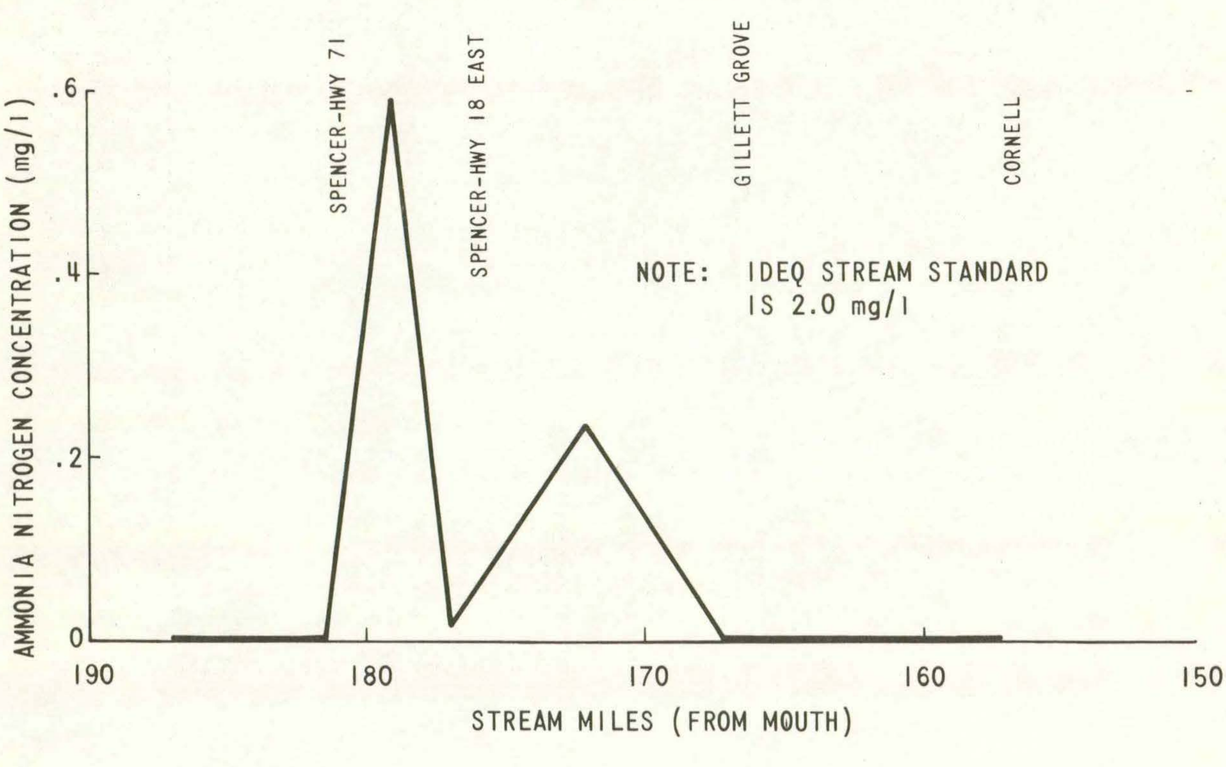


TABLE 11

WATER QUALITY DATA
LITTLE SIOUX RIVER
JANUARY 18-19, 1971

Parameter	SAMPLING STATION							
	Highway 18 Bridge North of Spencer	County Road B-24 Bridge West of Spencer	Highway 18 Bridge East of Spencer	County Road B-53 Bridge Near Gillett Grove	Highway 374 Bridge Near Cornell	Highway 71 Bridge North of Sioux Rapids	1/4 Mile Above Dam Near Linn Grove	County Road Bridge Below Dam Near Linn Grove
Temperature (° C)	0	0	0	0	0	0	0	0
Dissolved Oxygen (mg/l)	7.8	7.5	6.9	5.4	5.4	4.6	3.7	9.1
Fecal Coliform (MPN/100 ml)	---	600	29,000	10,000	---	---	190	---
pH (SU)	---	7.65	7.3	7.4	---	---	7.35	---
Organic Nitrogen (mg/l)	---	1.1	0.99	0.88	---	---	0.93	---
Ammonia Nitrogen (mg/l)	---	0.28	0.51	0.41	---	---	0.61	---
Nitrate Nitrogen (mg/l)	---	4.4	4.4	4.2	---	---	4.0	---
Phosphate (filtrable) (mg/l)	---	0.09	1.1	0.7	---	---	0.9	---
Total Phosphate (mg/l)	---	1.0	1.3	0.9	---	---	1.0	---
BOD_5 (mg/l)	---	2.0	2.0	1.0	---	---	2.0	---
COD (mg/l)	---	28.2	28.2	20.2	---	---	20.2	---

TABLE 12

WATER QUALITY DATA
LITTLE SIOUX RIVER
JULY 16, 1974

Parameter	Location By Station Number							
	1	2	3	4	5	6	7	8
Temperature (° C)	28.5	29	28	28	28	27	28.5	28
Fecal Coliform (MPN/100 ml)	20	150	24,000	3,300	2,500	1,600	200	9,500
Conductance (Micromhos)	500	550	680	1,590	960	820	770	770
pH (SU)	9.0	8.3	8.3	8.2	7.8	8.0	8.3	8.2
Organic Nitrogen (mg/l)	3.5	2.9	2.9	2.4	2.2	2.1	2.0	1.5
Ammonia Nitrogen (mg/l)	<0.01	<0.01	<0.01	0.59	<0.01	0.24	<0.01	<0.01
Nitrate Nitrogen (mg/l)	<0.1	<0.1	0.8	1.4	1.0	1.5	1.3	2.4
Total Solids (mg/l)	530	586	577	1,090	735	668	646	618
Total Volatile Solids (mg/l)	202	299	202	257	228	210	203	211
Total Suspended Solids (mg/l)	186	197	107	117	105	102	116	95
Volatile Suspended Solids (mg/l)	62	58	17	49	16	24	19	18
Phosphate (filtrable) (mg/l)	0.02	0.03	0.14	0.46	0.18	0.30	0.17	0.13
Total Phosphate (mg/l)	0.57	0.46	0.40	0.85	0.41	0.38	0.29	0.27
BOD_5 (mg/l)	25	17	9	11	10	8	9	5
COD (mg/l)	91	77	49	73	55	45	45	36

TABLE 13

WATER QUALITY DATA
LITTLE SIOUX RIVER - NEAR ONAWA

Parameter	Date of Sampling								
	Aug. 22, 1972	Nov. 8 1972	Feb. 14, 1973	June 12, 1973	Aug. 7, 1973	Oct. 30, 1973	Feb. 13, 1974	May 8, 1974	Aug. 28, 1974
Temperature (° C)	19	6.5	0	20	27	8	0	13	20
Dissolved Oxygen (mg/l)	8.1	11.4	12.5	7.5	19.1	13.2	9.2	9.9	6.8
Fecal Coliform (MPN/100 ml)	200	800	40	570	<100	310	180	60	530
Conductance (Micromhos)	---	---	780	740	540	780	860	740	640
pH (SU)	---	---	8.0	8.0	8.3	8.35	7.7	8.2	8.2
Organic Nitrogen (mg/l)	1.4	0.72	0.56	1.3	2.9	1.3	0.64	1.7	1.7
Ammonia Nitrogen (mg/l)	0.08	0.24	0.81	0.11	<0.01	<0.01	0.45	0.05	0.07
Nitrate Nitrogen (mg/l)	1.4	3.0	3.1	4.8	<0.1	4.4	5.2	4.0	2.7
Total Solids (mg/l)	530	624	492	816	674	634	605	649	680
Total Volatile Solids (mg/l)	101	122	101	92	214	149	142	186	214
Total Suspended Solids (mg/l)	129	96	2	360	288	96	15	139	234
Volatile Suspended Solids (mg/l)	1	5	1	16	72	0	15	132	162
Phosphate (filtrable) (mg/l)	0.01	0.14	0.13	0.10	0.01	0.09	0.26	0.02	<0.01
Total Phosphate (mg/l)	0.14	0.26	0.20	0.39	0.19	0.20	0.29	0.33	0.42
BOD_5 (mg/l)	6	2	2	4	15	5	3	7	4
COD (mg/l)	24.8	15	16	33	62	12	131	34	39
Arsenic (mg/l)	---	---	---	---	---	---	<0.01	<0.01	---
Barium (mg/l)	---	---	---	---	---	---	0.1	0.1	---
Cadmium (mg/l)	---	---	---	---	---	---	<0.01	<0.01	---
Chromium (mg/l)	---	---	---	---	---	---	<0.01	<0.01	---
Copper (mg/l)	---	---	---	---	---	---	<0.01	<0.01	---
Lead (mg/l)	---	---	---	---	---	---	<0.01	<0.01	---
Zinc (mg/l)	---	---	---	---	---	---	0.01	0.02	---
Nickel (mg/l)	---	---	---	---	---	---	<0.1	<0.1	---
Silver (mg/l)	---	---	---	---	---	---	<0.01	<0.01	---

TABLE 14

WATER QUALITY DATA
LITTLE SIOUX RIVER - NEAR SPENCER

Parameter	Aug. 21, 1972	Nov. 7, 1972	Feb. 13, 1973	June 11, 1973	Aug. 6, 1973	Oct. 29, 1973	Feb. 11, 1974	May 7, 1974	Aug. 27, 1974
	Date of Sampling								
Temperature (° C)	28	6.5	0	25	27	9.5	1.5	11	24
Dissolved Oxygen (mg/l)	15.7	10.4	5.9	8.2	13.4	24.8	13.4	9.9	12.1
Fecal Coliform (MPN/100 ml)	100	300	600	300	200	30	20	100	460
Conductance (micromhos)	540	880	740	810	510	610	880	770	510
pH (SU)	7.7	8.0	8.05	7.9	8.4	8.35	7.8	8.4	8.8
Organic Nitrogen (mg/l)	4.1	1.7	1.1	1.4	2.7	2.6	0.77	1.7	3.1
Ammonia Nitrogen (mg/l)	0.15	0.15	0.87	0.04	0.01	<0.01	0.48	0.04	<0.01
Nitrate Nitrogen (mg/l)	0.4	6.2	2.2	4.6	<0.1	0.1	4.0	3.2	<0.1
Total Solids (mg/l)	585	937	489	900	488	519	593	579	603
Total Volatile Solids (mg/l)	185	180	85	306	194	196	154	174	191
Total Suspended Solids (mg/l)	193	284	13	344	76	106	0	51	153
Volatile Suspended Solids (mg/l)	31	5	3	96	24	35	0	11	7
Phosphate (filtrable) (mg/l)	0.03	0.16	0.32	0.14	0.06	0.06	0.43	0.09	0.23
Total Phosphate (mg/l)	0.45	0.35	0.36	0.39	0.25	0.22	0.43	0.28	0.30
BOD_5 (mg/l)	18	3	3	4	18	15	3	4	14
COD (mg/l)	99.1	42	33	68	56	53	6	29	71
Arsenic (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	---
Barium (mg/l)	0.2	<0.01	0.1	0.2	0.2	0.1	<0.1	<0.1	---
Cadmium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	---
Chromium (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	---
Copper (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	---
Lead (mg/l)	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	---
Zinc (mg/l)	0.07	0.02	0.07	0.19	0.34	0.08	<0.01	0.06	---
Nickel (mg/l)	<0.01	<0.01	<0.01	<0.1	<0.1	<0.01	<0.1	<0.1	---
Silver (mg/l)	---	---	---	<0.01	<0.01	<0.01	<0.01	<0.01	---

TABLE 15

1973 WATER QUALITY DATA
LITTLE SIOUX RIVER - NEAR SIOUX RAPIDS

Parameter	Date of Sampling			
	Aug. 6, 1973	Sept. 4, 1973	Oct. 1, 1973	Oct. 29, 1973
Temperature (° C)	25	24	16	7.5
Dissolved Oxygen (mg/l)	16.4	14.8	7.8	14.6
Fecal Coliform (MPN/100 ml)	<10	170	12,000	130
Total Kjeldahl Nitrogen (mg/l)	0.44	0.70	3.7	0.58
Ammonia Nitrogen (mg/l)	0.16	0.14	1.8	0.18
Nitrate Nitrogen (mg/l)	<0.1	2.6	6.4	4.8
Total Suspended Solids (mg/l)	---	68	---	46
Phosphate (filtrable) (mg/l)	---	0.06	---	0.06
BOD_5 (mg/l)	12	8	5	6
Total Chromium (mg/l)	<0.01	<0.01	<0.01	---
Hexavalent Chromium (mg/l)	<0.01	<0.01	<0.01	---

TABLE 16

1973 WATER QUALITY DATA
LITTLE SIOUX RIVER - NEAR PETERSON

Parameter	Date of Sampling: Aug. 6, 1973	Sept. 4, 1973	Oct. 1, 1973	Oct. 29, 1973
Temperature (° C)	25	23	16.5	9
Dissolved Oxygen (mg/l)	15.2	9.8	8.4	15.8
Fecal Coliform (MPN/100 ml)	840	920	2,400	220
Total Kjeldahl Nitrogen (mg/l)	0.87	0.72	3.6	0.58
Ammonia Nitrogen (mg/l)	0.20	0.16	1.5	0.14
Nitrate Nitrogen (mg/l)	<0.1	1.4	5.6	4.4
Total Supended Solids (mg/l)	---	73	---	69
Phosphate (filtrable) (mg/l)	---	0.09	---	0.02
BOD_5 (mg/l)	8	4	4	6
Total Chromium (mg/l)	<0.01	<0.01	<0.01	---
Hexavalent Chromium (mg/l)	<0.01	<0.01	<0.01	---

TABLE 17

1973 WATER QUALITY DATA
LITTLE SIOUX RIVER - NEAR CORRECTIONVILLE

Parameter	Date of Sampling: Aug. 7, 1973	Sept. 4, 1973	Oct. 1, 1973	Oct. 30, 1973
Temperature (° C)	26	23	16	7.5
Dissolved Oxygen (mg/l)	16.1	13.8	8.3	12.8
Fecal Coliform (MPN/100 ml)	390	620	6,900	400
Total Kjeldahl Nitrogen (mg/l)	0.65	0.46	1.4	0.58
Ammonia Nitrogen (mg/l)	0.16	0.06	0.70	0.14
Nitrate Nitrogen (mg/l)	0.1	1.9	5.5	0.4
Total Suspended Solids (mg/l)	---	163	---	92
Phosphate (filtrable) (mg/l)	---	<0.01	---	0.04
BOD_5 (mg/l)	11	7	5	7
Total Chromium (mg/l)	<0.01	<0.01	<0.01	---
Hexavalent Chromium (mg/l)	<0.01	<0.01	<0.01	---

Summary

Available water quality data for the Rock River Basin do not permit identification of stream quality under low flow conditions. The available data for the Little Sioux River shows lowered stream quality due to wastewater discharges. At stream flows approaching the 7-day, 1-in-10 year low flows, the extent of stream pollution would be much greater. Additional stream quality data are needed in the Rock River Basin under low flow conditions to better assess the impact of wastewater discharges. Additional water quality data for the Little Sioux River will be necessary to assess the effectiveness of the waste load allocations in maintaining stream quality standards.

PART IV

POINT SOURCE WASTEWATER DISCHARGES

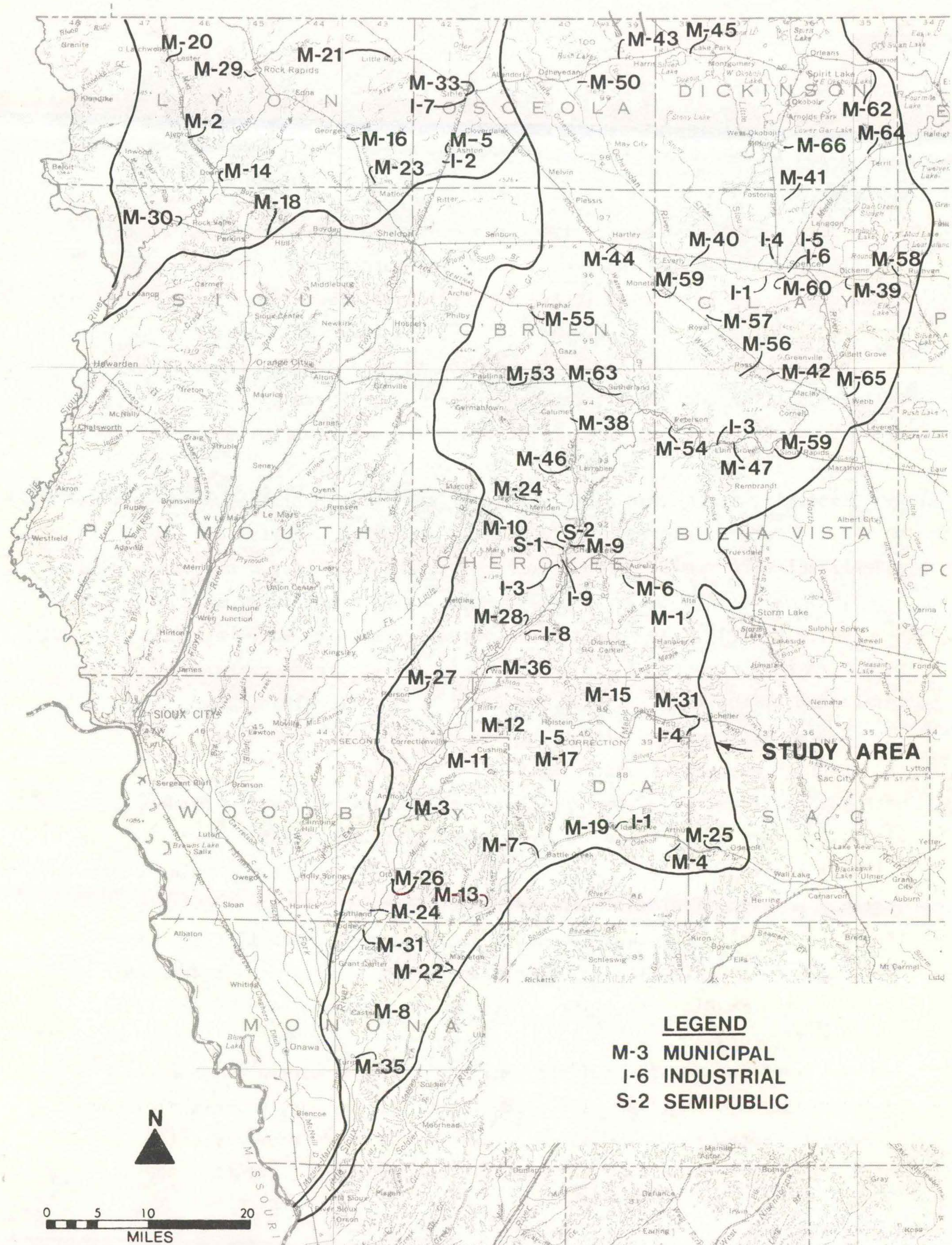
General

Point source wastewater discharges consist of effluents from municipal, industrial, and semipublic wastewater treatment facilities. Wastewater discharges identified in the IDEQ files as discharging to the surface waters of the Rock River and Little Sioux River Basins have been inventoried and are compiled in the following tables. The tabulations include location and identification of dischargers, quantity and quality of wastewater discharged, and operational data and descriptions of treatment facilities.

Table 18, at the end of this PART, lists individual wastewater discharges, location, and river mile. An identification system has been established with municipal wastewater discharge reference numbers preceded by "M," industrial discharges by "I," and semipublic discharges by "S." River mile locations are identified for each discharge with reference to mile zero at the mouth of the major stream. Dischargers on tributaries are referenced by the river mile at the confluence of the tributary.

Table 19, which appears at the end of this PART, identifies characteristics of each point source wastewater discharge in order, beginning with the upstream end of the Rock River at the Iowa-Minnesota border. Dischargers are then listed in order proceeding downstream, picking up the tributaries, to the Big Sioux River. For each tributary, the point source furthest upstream is identified and the tabulation continues downstream to the main channel. The same procedure is followed for the Little Sioux River beginning at the Iowa-Minnesota border and continuing to the confluence with the Missouri River. The location of each point source is shown on Figure 7.

Available wastewater quantity and quality information is tabulated in Table 19. Average flow rate, BOD_5, suspended solids, ammonia nitrogen, phosphorus, total dissolved solids, temperature, and other miscellaneous constituents are reported. Where sufficient data are available, BOD_5,



POINT SOURCE WASTEWATER DISCHARGES

STANLEY CONSULTANTS

FIG. 7

ammonia nitrogen, and temperature values have been indicated for both summer and winter conditions. Discharge quantities are tabulated in both milligrams per liter (mg/l) and pounds per day (lb/day) unless otherwise stated.

Municipal

Sewage flow and quality data for 47 municipalities were extracted from IDEQ recoreds and files. Average sewage flow values contained in reports submitted by treatment plant operators have been extracted by IDEQ and published in "Wastewater Treatment Plant Flow Data - 1970, 1971, and 1972." Flow values shown in Table 19 are the averages obtained for the last full year of record; in most instances 1972.

Most quality data were collected from "Effluent Quality Analysis Program" (EQAP) by IDEQ. These data were supplemented by a review of treatment facility reports supplyed by the operators. Data reported through EQAP are results of tests conducted by the Iowa State Hygienic Laboratory on wastewater samples supplied by the individual discharges. In most instances, the number of BOD_5, ammonia nitrogen, and total phosphorus values reported each year was minimal. Because of large seasonal variations in BOD_5, ammonia nitrogen, and temperature removal, both summer and winter values have been tabulated, where available.

BOD_5 analysis results from the Iowa State Hygienic Laboratory (report in EQAP) are reported between 25 mg/l and 150 mg/l. For some communities, a large percentage of the values reported are 25 or "25-" mg/l. Values designed "25-" are less than 25 mg/l, thus lower summer BOD_5 average values would result. The adequacy of this reporting procedure should be reviewed since some dischargers are, or soon will be, required to provide BOD_5 removals to less than 25 mg/l. In some instances, due to the scarcity and scatter of data, engineering judgment was applied to arrived at representative values rather than taking averages of the available data.

TABLE 19

POINT SOURCE WASTEWATER DISCHARGE QUANTITIES

Ref. No.	Average Flow (mgd)	BOD$_5$ Summer (mg/l)	BOD$_5$ Summer (lb/day)	BOD$_5$ Winter (mg/l)	BOD$_5$ Winter (lb/day)	Suspended Solids (mg/l)	Suspended Solids (lb/day)	Ammonia Nitrogen (N) Summer (mg/l)	Ammonia Nitrogen (N) Summer (lb/day)	Ammonia Nitrogen (N) Winter (mg/l)	Ammonia Nitrogen (N) Winter (lb/day)	Phosphorus (Total P) (mg/l)	Phosphorus (Total P) (lb/day)	Total Dissolved Solids (mg/l)	Total Dissolved Solids (lb/day)	Temperature Summer (F)	Temperature Winter (F)	Other (mg/l unless noted otherwise)
Rock River																		
M-29	0.201	25	41	28	46			8	13	29	48	26	43					pH = 7.5 SU Fluoride max concentrate = 1.3
M-20	0.028	35	8	40	9			1	0.2	32	7							
Mud Creek																		
M-2	0.016																	
M-21		67		67				35		45		35						
Little Rock River																		
M-16	0.076	26	16	25	16			4	3	1	1	7	4					
Otter Creek																		
M-33	0.371	70	217	25	77			15	46	21	65	29	90			65	11	pH = 8.4 SU
I-7																		
M-5	0.030	80	20	100	25			8	2			7	2					
I-2	1.5													602	7,531	80		Alk = 253 pH = 8.5 SU
Little Rock River																		
M-14	0.044	30	11	40	15			5	2	13	5	21	8					
Burr Oak Creek																		
M-18	0.091	25	19	74	56			9	7	18	14	33	25					pH = 7.4 SU
Rock River																		
M-30	0.118	35	34	55	54			14	14	15	15	16	16					pH = 5.3 SU
Little Sioux River																		
Silver Lake																		
M-45	0.045	69	26	44	17			3	1.1	1	0.4	7	3					
Spirit Lake																		
M-52*																		
I-10*																		
East Okoboji Lake																		
M-61*																		
West Okoboji Lake																		
M-51*																		
M-37*																		
M-66*																		
Okoboji Lake Outlet																		
M-70	1.690																	
M-48*																		
Ocheyedan River																		
Rush Lake Outlet																		
M-50	0.039	31	10	41	13			2	0.7	22	7	16	5					
Dry Run																		
M-43		35		50				7		2		5						
Sewer Creek																		
M-44	0.266	25	55	40	89			4	9	10	22	11	24					

* To M-70 (Iowa Great Lakes Sanitary District)

TABLE 19 (Cont.)

POINT SOURCE WASTEWATER DISCHARGE QUANTITIES

Ref. No.	Average Flow (mgd)	BOD$_5$ Summer (mg/l)	BOD$_5$ Summer (lb/day)	BOD$_5$ Winter (mg/l)	BOD$_5$ Winter (lb/day)	Suspended Solids (mg/l)	Suspended Solids (lb/day)	Ammonia Nitrogen (N) Summer (mg/l)	Ammonia Nitrogen (N) Summer (lb/day)	Ammonia Nitrogen (N) Winter (mg/l)	Ammonia Nitrogen (N) Winter (lb/day)	Phosphorus (Total P) (mg/l)	Phosphorus (Total P) (lb/day)	Total Dissolved Solids (mg/l)	Total Dissolved Solids (lb/day)	Temperature Summer (F)	Temperature Winter (F)	Other (mg/l unless noted otherwise)
Little Sioux River (cont.)																		
Ocheyedan River																		
M-40	0.065	25	14	35	19			4	2	2	1	6	3					
Spring Creek																		
M-57	0.062	42	24	25	14													
Ocheyedan River																		
I-9	0.034	<1						<0.2								85	76	Cr = 9,960 Cu = <20 SO_4 = 644 SO_3 = <0.5
Little Sioux River																		
M-60	1.990	38	631	78	1,295			18	299	19	315	26	432					
I-14	0.0017																	
I-13																		
Lost Island Outlet																		
Drainage Ditch #61																		
M-64	0.032	40	11	42	11			2	0.5			9	2					
Drainage Ditch #60																		
M-58	0.060	30	15	60	30			1	0.5			4	2.0					
Little Sioux River																		
M-59	0.030	60	15	85	21			27	7	30	8	29	7					
M-47		25		40				1		15		4						
I-11	0.019	126	20															
M-54		110		130				20		25		17						
Waterman Creek																		
M-63																		
Mill Creek																		
Dry Run																		
M-55	0.082	27	18	30	20			2	1.4			7	5					
Mill Creek																		
M-53	0.129	25	27	25	27			5	5			8	9					
Gray Creek																		
M-46	0.006	32	1.6	45	2.3													pH = 6.0 to 9.0 SU
Hill Creek																		
M-24	0.015							8	0.1			8	0.1					
Little Sioux River																		
M-9	0.559	25	117	30	140			8	37	20	93	25	117					
I-3	1.5													416	5,204			Alk = 278 pH = 8.35 SU Turb = 40 JU
M-69	1.011	30	253	25	211			16	135	85	717							

TABLE 19 (Cont.)

POINT SOURCE WASTEWATER DISCHARGE QUANTITIES

Ref. No.	Average Flow (mgd)	BOD5 Summer (mg/l)	BOD5 Summer (lb/day)	BOD5 Winter (mg/l)	BOD5 Winter (lb/day)	Suspended Solids (mg/l)	Suspended Solids (lb/day)	Ammonia Nitrogen (N) Summer (mg/l)	Ammonia Nitrogen (N) Summer (lb/day)	Ammonia Nitrogen (N) Winter (mg/l)	Ammonia Nitrogen (N) Winter (lb/day)	Phosphorus (Total P) (mg/l)	Phosphorus (Total P) (lb/day)	Total Dissolved Solids (mg/l)	Total Dissolved Solids (lb/day)	Temperature Summer (°F)	Temperature Winter (°F)	Other (mg/l unless noted otherwise)
Little Sioux River																		
S-1	0.150							36	45									
M-28	0.024	130	26	150	30			34	7	40	8	55	11					
Willow Creek																		
M-10	0.006	35	2	43	2			27	1	9	0.5	22	1			46	40	pH = 8.4 SU
Little Sioux River																		
M-36	0.017	25	4	25	4			6	1	18	3	20	3					pH = 8.8 SU D.O. = 4
Pierson Creek																		
M-27	0.066	25	14	85	47			14	8	26	14	17	9					
Bacon Creek																		
M-12	0.036	55	17	55	17			24	7	26	8	24	7					
M-11	0.150	37	46	39	49			11	14	18	23	16	20					
Little Sioux River																		
M-3	0.081	30	2	60	41			26	18			27	18					pH = 3 SU
Maple River																		
Dry Creek Bed																		
M-6	0.075	36	23	36	23			14	9	10	6	26	16					D.O. = 5
Little Maple River																		
M-1	0.140	26	30	40	47			14	16			35	41					
Halfway Creek																		
M-32	0.063	35	18	35	18			1	1			4	2					D.O. = 6 Fecal coliform = 6 MPN/100 ml.
M-15	0.019	34	5	80	13			6	1	13	2	27	4	2,842	450			
Odebolt Creek																		
M-25	0.141	25	29	36	42			2	2	25	29	25	29					pH = 6.7 SU
I-6														4,678				pH = 6.6 SU
Unnamed Creek																		
M-4	0.038	27	8	30	9			4	1	18	5	9	3					pH = 8.00 SU (1969) D.O. = 7.0 (1969)
Maple River																		
M-19	0.205	28	48	58	100			9	15	10	17	38	65					
I-1				25														
Battle Creek																		
M-17	0.150	35	44	43	50			4	5	3	5	5	6					SO_4 = 40 Na^+ = 140 Flouride = 0.85
Maple River																		
M-7	0.070	25	15	54	32													
M-13	0.060	27	14	28	14					1	0.5	3	1.5					
M-22	0.123	25	26	25	26			6	6	1	1	38	39					

TABLE 20

WASTEWATER TREATMENT FACILITIES

Discharge (Ref. No.)	Existing Design Average Day Capacity (mgd)	Present Average Day Flow (mgd)	BOD5 Influent Conc. (mg/1)	BOD5 Effluent Conc. (mg/1)	Suspended Solids Influent Conc. (mg/1)	Suspended Solids Effluent Conc. (mg/1)	Type of Treatment: Primary	Type of Treatment: Secondary	Type of Treatment: Solids Treatment	Comments
Rock River										
Rock Rapids (M-29)	0.379	0.201		26			Sr Sc Cm	Ftr Cm	Dfh Bo Xl	
Mud Creek										
Lester (M-20)	0.030	0.028		37			Lo	Lo		
Alvord (M-2)	0.023	0.016		60			Lo			One cell waste stabilization lagoon, 2.1 acres.
Little Rock River										
Little Rock (M-21)				67			Ci	Ftnc	Bo Xl	Circular covered Imhoff tank, dosing tanking with one siphen, covered trickling system.
George (M-16)	0.110	0.076		26			Lo	Lo		Two-cell lagoon, 9.86 acres total.
Otter Creek										
Sibley (M-33)	0.510	0.371		49		73	Sch Gm Cm	Fo Cm Ftnc Cm	Dfh Bo Xl	Permit data - 0.49 to 1.1 mgd. Industrial wastes from creamery, eggs and poultry, bag company.
Sibley Municipal Utilities (I-7)										Evaporation - bleedoff water.
Ashton (M-5)	0.045	0.030		85			Lo	Lo		Two-cell lagoon 3.04 acres and 2.93 acres in series or parallel.
Hallett Construction Co., Ashton (I-2)		1.5			240					Surface water supply. Summer operation only.
Matlock (M-23)										No existing municipal facility.
Little Rock River										
Doon (M-14)	0.044	0.044		35			Lo	Lo		Two-cell waste stabilization lagoon, 7.0 acres total.
Burr Oak Creek										
Hull (M-18)	0.130	0.091		62			Sh Cm	Ftr Cm	Dfh Bo Xl	
Rock River										
Rock Valley (M-30)	0.260	0.118		40			Sch Cm	Ftr Cm	Dfh Bo	Trickling filter originated April 1, 1970.
Little Sioux River										
Silver Lake										
Lake Park (M-45)	0.083	0.045		59			Lo	Lo		Two-cell lagoon, total surface area 8.45 acres. Seepage is a problem and sealing may be required (per IDEQ, 1971).

TABLE 20 (Cont.)

WASTEWATER TREATMENT FACILITIES

Discharge (Ref. No.)	Existing Design Average Day Capacity (mgd)	Present Average Day Flow (mgd)	BOD_5 Influent Conc. (mg/1)	BOD_5 Effluent Conc. (mg/1)	Suspended Solids Influent Conc. (mg/1)	Suspended Solids Effluent Conc. (mg/1)	Type of Treatment: Primary	Type of Treatment: Secondary	Type of Treatment: Solids Treatment	Comments
Little Sioux River										
Spirit Lake										
Orleans (M-52)							To Iowa Great Lakes Sanitary District			
Iowa Electric Light & Power (I-10)										NPDES File 0.007 mgd boiler blowdown and softener recharge to municipal system.
East Okoboji Lake										
Spirit Lake (M-61)							To Iowa Great Lakes Sanitary District			
West Okoboji Lake										
Okoboji (M-51)							To Iowa Great Lakes Sanitary District			
Arnolds Park (M-37)							To Iowa Great Lakes Sanitary District			
West Okoboji (M-66)							To Iowa Great Lakes Sanitary District			
Okoboji Lake Outlet										
Iowa Great Lakes Sanitary District (M-70)	1.500	1.690					Sc Gm Cm	Ftrc Cm	Dchts Bo Ls	
Milford (M-48)							To Iowa Great Lakes Sanitary District			
Ocheyedan River										
Rush Lake Outlet										
Ocheyedan (M-50)	0.036	0.039		36			Lo	Lo		Two-cell lagoon, surface area 5.96 acres.
Dry Run										
Harris (M-43)				33			Lo	Lo		One-cell lagoon, surface area 2.5 acres. Constructed in 1971.
Sewer Creek										
Hartley (M-44)	0.194	0.266		33			Sch Km Cm	Fth Cp	Dfh Bo Xl	Constructed in 1948.
Ocheyedan River										
Everly (M-40)		0.065		30			Lo	Lo		Two-cell lagoon, surface area 9 acres. Constructed in 1968.
Spring Creek										
Royal (M-57)	0.125	0.068		37			Lo	Lo		Some infiltration/inflow from septic tanks.
Ocheyedan River										
Cornbelt Power Co-op (I-9)		0.034								Water supply from wells 0.372 mgd.
Little Sioux River										
Spencer (M-60)	1.74	2.2		90			Gmw (KaCm)	Fo Cm Ftr Cm	Dfht Ho Bo Xl	New plant in final design.

TABLE 20 (Cont.)

WASTEWATER TREATMENT FACILITIES

Discharge (Ref. No.)	Existing Design Average Day Capacity (mgd)	Present Average Day Flow (mgd)	BOD_5 Influent Conc. (mg/l)	BOD_5 Effluent Conc. (mg/l)	Suspended Solids Influent Conc. (mg/l)	Suspended Solids Effluent Conc. (mg/l)	Type of Treatment: Primary	Type of Treatment: Secondary	Type of Treatment: Solids Treatment	Comments
Little Sioux River (cont.)										
Spencer Rendering Plant (I-14)		0.0017								Corps permit June 30, 1971. Latest information (7-11-74) shows a sump overflow discharge. No information available on this.
Spencer Municipal Power Plant (I-13)										No NPDES information available.
Big Muddy Creek										
Superior (M-62)										No existing municipal treatment facility.
Little Muddy Creek										
Fostoria (M-41)										Site approval 1972. Two-cell lagoon, surface area 4.0 acres.
Lost Island Outlet										
Drainage Ditch #61 C										
Terrill (M-64)	0.052	0.032		37			Lo	Lo		
Lost Island Outlet										
Dickens (M-39)										No existing municipal treatment facility.
Drainage Ditch #60										
Ruthven (M-58)	0.121	0.053		16			Lo	Lo		Severe infiltration/inflow problems. Total lagoon area 10 acres.
Montgomery Creek										
Webb (M-65)										No existing municipal treatment facility.
Willow Creek										
Moneta (M-49)										No existing municipal treatment facility.
Rossi (M-56)										No existing municipal treatment facility.
Greenville (M-42)										No existing municipal treatment facility.
Little Sioux River										
Sioux Rapids (M-59)	0.064	0.030		75			Sh Ci	Ftr Cp	Bo	
Linn Grove (M-47)				35						Single cell lagoon made by damming irregular high water channel of Little Sioux River. Flushed during every high water period. Combined sewer system. Plant should be upgraded and protected from high water (per IDEQ 1-22-74). Surface area about 5 acres.
Linn Grove Rendering (I-11)		0.019		126						Water supply - well (0.0187 mgd).
Peterson (M-54)	0.050			135			Lo	Lo Lp		Three-cell lagoon, total surface area 5.26 acres. Built in 1974.

TABLE 20 (Cont.)

WASTEWATER TREATMENT FACILITIES

Discharge (Ref. No.)	Existing Design Average Day Capacity (mgd)	Present Average Day Flow (mgd)	BOD_5 Influent Conc. (mg/1)	BOD_5 Effluent Conc. (mg/1)	Suspended Solids Influent Conc. (mg/1)	Suspended Solids Effluent Conc. (mg/1)	Type of Treatment Primary	Type of Treatment Secondary	Type of Treatment Solids Treatment	Comments
Little Sioux River (cont.)										
Waterman Creek										
Sutherland (M-63)				29			Lo	Lo		
Mill Creek										
Dry Run										
Primghar (M-55)	0.135	0.080		27			Lo	Lo		Two-cell lagoon, total surface area 13.0 acres.
Mill Creek										
Paullina (M-53)	0.183	0.129		25			Lo	Lo		Two-cell lagoon, total surface area 15.0 acres.
Willow Creek										
Mugge Creek										
Calumet (M-38)										Septic tank discharges causing pollution. (IDEQ, April, 1972.)
Gray Creek										
Larrabee (M-46)	0.017	0.006		36			Lo	Lo		One-cell lagoon, surface area 1.5 acres. Constructed in 1970.
Hill Creek										
Meriden (M-24)	0.024	0.015		40		70	Lo	Lo		
Little Sioux River										
Cherokee (M-9)	0.600	0.559		28	20	10	Sc Cm	Aa Cm Edg	Vv	In process of building new plant; data from old trickling filter plant.
Hallet Construction Co., Cherokee (I-3)		1.5			56					Surface water supply. Summer operation only.
Cherokee Industrial Site (Wilson Packing Plant) (M-69)	1.300	1.011		26			Ln La	Lo Lo		
Railroad Creek										
Meadow Brook Mobile Home Court (S-2)							Lo			
Little Sioux River										
Cherokee Mental Health Institute (S-1)	0.200	0.150						Ftr		General conditions very poor with exception of trickling filter; soon to be sending their raw sewage to city of Cherokee for treatment.

TABLE 20 (Cont.)

WASTEWATER TREATMENT FACILITIES

Discharge (Ref. No.)	Existing Design Average Day Capacity (mgd)	Present Average Day Flow (mgd)	BOD_5 Influent Conc. (mg/l)	BOD_5 Effluent Conc. (mg/l)	Suspended Solids Influent Conc. (mg/l)	Suspended Solids Effluent Conc. (mg/l)	Type of Treatment: Primary	Type of Treatment: Secondary	Type of Treatment: Solids Treatment	Comments
Little Sioux River (cont.)										
Quimby (M-28)	0.025	0.024		135			Lo	Lo		Presently operating an obsolete Imhoff tank followed by trickling filter with no secondary clarification. A new two-cell-in-series lagoon system has been constructed but requires installation of a pump station and a river crossing to be operable.
Simonsen Mill and Rendering Plant Inc. (I-8)										Evaporation lagoon, 100 percent retention (1973).
Willow Creek										
Cleghorn (M-10)	0.021	0.006		40			Lo	Lo		One-cell lagoon; 1.5 acres.
Little Sioux River										
Washta (M-36)	0.031	0.017		25			Lo	Lo		Single-cell lagoon; 2.04 acres.
Pierson Creek										
Pierson (M-27)	0.050	0.066		49			Ci	Fs	Bo	Imhoff tank and filter bed. 1928. Applied for grant to construct two-cell lagoon with 5.0 total acres.
Bacon Creek										
Cushing (M-12)	0.030	0.036		55			Cs	Fs	Bo	Community spetic tank, dosing tank, filter bed with distributing lines.
Correctionville (M-11)	0.169	0.150		39			Cp Do	Fctr Cm	Bo Xl	Trickling filter, 1971: Imhoff tank type units.
Little Sioux River										
Anthon (M-3)	0.100	0.081	53	60	3		Sh Cp Do	Ftrc Cm	Xl	
Oto (M-26)										No plant. Treatment consists of septic tanks, cesspools and privies. A serious health problem has arisen and Oto has submitted for FHA funds for sewage system.
Smokey Hollow Creek										
Smithland (M-34)							Lo	Lo		In the process of building a wastewater collection and treatment system.
Little Sioux River										
Rodney (M-31)										No existing municipal treatment facility.
Maple River										
Dry Creek Bed										
Aurelia (M-6)	0.127	0.075		36			Sch Ci	Ftrc Cp	Bo Xl	Two compartment sludge drying bed has been abandoned. Digested sludge distributed on farmland.

TABLE 20 (Cont.)

WASTEWATER TREATMENT FACILITIES

Discharge (Ref. No.)	Existing Design Average Day Capacity (mgd)	Present Average Day Flow (mgd)	BOD5 Influent Conc. (mg/l)	BOD5 Effluent Conc. (mg/l)	Suspended Solids Influent Conc. (mg/l)	Suspended Solids Effluent Conc. (mg/l)	Type of Treatment Primary	Type of Treatment Secondary	Type of Treatment Solids Treatment	Comments
Little Sioux River (cont.)										
Maple River (cont.)										
Little Maple River										
Alta (M-1)	0.155	0.140		35			Sh Cm	Ftr Cm	Dfh Bo	
Halfway Creek										
Schaller (M-32)	0.133	0.063		35		6	Lo	Lo		Two-cell lagoon; 4.8 acres and 4.7 acres; constructed in 1968.
Pork Processors Inc. (I-4)										Plans presented to the IDEQ in January, 1974. The processing industrial plant has not been built nor received its permit as yet to build some type of wastewater treatment plant.
Galva (M-15)	0.045	0.019		48			Sch Ci	Ftcr Cm Ecg	Bo	Trickling filter; new plant 1974.
Odebolt Creek										
Odebolt (M-25)	0.187	0.141		28		142	Sh Cm	Ftr Cp	Dop Bo	Built in 1956.
Selected Casing (Odebolt) (I-6)						668				Has solids retention tank. Mucasa recovered from tank, spread on fields or sold to rendering. Plant has increased its capacity and is still overloading community sewage plant.
Unnamed Creek										
Arthur (M-4)	0.036	0.038		30			Lo	Lo		Two-cell waste stabilization pond; 1.63 acres and 1.57 acres.
Odebolt Creek										
Ida Grove (M-19)	0.240	0.205		39			Sh Cm	Ftr Cm	Dchm Bo	Old plant. New activated sludge plant proposed in 1972 and is still being constructed.
Deluxe Motel (Ida Grove) (I-1)				25						Permit issued for septic tank and subsurface sand filter January 13, 1965.
Battle Creek										
Holstein (M-17)	0.130	0.150		38			Lo	Lo		Two-cell waste stabilization lagoon; 6.3 acres east cell and and 6.9 acres west cell.
Robert Bagenstos Slaughter House (I-5)										550-gallon septic tank.
Maple River										
Battle Creek (M-7)	0.085	0.070		42			Lo	Lo		Two-cell waste stabilization lagoon, 1970.
Danbury (M-13)	0.102	0.060		28			Lo	Lo		Two-cell lagoon, total surface area 5.1 acres.
Mapleton (M-22)	0.300	0.123		25			Sch Ac	Ac Lp	Ad	New plant in 1970.
Castana (M-8)										No existing municipal treatment facility.
Turin (M-35)										No plant. In the process of building waste stabilization lagoon. Previous method of individual septic tanks will continue until completion.

ABBREVIATIONS

WASTEWATER TREATMENT FACILITIES

A ----Aeration (in tanks or basins)
Aa----Activated sludge, diffused air aeration
Ac----Contact stabilization
Ad----Aerobic digestion
Ae----Extended aeration
Af----Air flotation
Am----Activated sludge, mechanical aeration
Ao----Oxidation ditch
Ap----Aeration, plain, without sludge return

B ----Sludge beds
Bo----Open
Bc----Glass covered

C ----Settling tanks
Ci----Two-story (Imhoff)
Cm----Mechanically equipped
Cp----Plain, hopper bottom, or intermittently drained for cleaning
Cs----Septic tank
Ct----Multiple tray, mechanically equipped
CmDm--Two-story "Clarigester"
CpDo--Two-story "Spiragester"

D ----Digesters, separate sludge
Dc----With cover (fixed if not otherwise specified)
D(cg)-Gasometer in fixed cover
De----Gas used in engines (heat usually recovered)
Df----With floating cover
Dg----With gasometer cover
Dh----Gas used in heating
Dm----Mixing
Do----Open top
Dp----Unheated
Dr----Heated
Ds----Gas storage in separate holder
Dt----Stage digestion

E ----Chlorination
Ec----With contact tank
Eg----By chlorine gas
Eh----By hypochlorite

F ----Filters
Fc----Covered filter
Fo----Roughing filter
Fr----Rapid sand or other sand straining
Fs----Intermittent sand
Ft----Trickling (no further details)
Fth---High capacity
Ft2H--High capacity, two-stage
Ftn---Fixed nozzle, standard capacity
Ftr---Rotary distributor, standard capacity
Ftt---Traveling distributor, standard capacity

G ----Grit chambers
Ga----Aerated grit removal
Gh----Without continuous removal mechanism
Gm----With continuous removal mechanism
Gp----Grit pocket at screen chamber
Gw----Separate grit washing device

H ----Sludge storage tanks (not second-stage digestion units)
Ha----Aerated
Hc----Covered
Hm----With stirring or concentrating mechanism
Ho----Open

I ----Sewage application to land
If----Ridge and furrow irrigation
Is----Subsurface application
Iu----Land underdrained
Iy----Spray irrigation

ABBREVIATIONS

WASTEWATER TREATMENT FACILITIES

K ----Chemical treatment-flocculation. Chemical treatment-type units or equipment not necessarily complete or operated as chemical treatment.
Ka----Flocculation tank, air agitation
Kc----Chemicals used
Km----Flocculation tank, mechanical agitation
Kx----No chemicals used

L ----Lagoons
La----Aerated lagoon
Le----Evaporation lagoon
Ln----Anaerobic lagoon
Lo----Waste stabilization lagoon
Lp----Polishing lagoon
Ls----Sludge lagoon - not for treatment of sewage

O ----Grease removal or skimming tanks - not incidental to settling tanks
Oa----Aerated tank (diffused air)
Om----Mechanically equipped tank
Ov----Vacuum type

S ----Screens
Sc----Comminutor (screenings ground in sewage stream)
Sf----Fine screen (less than 1/8" opening)
Sg----Screenings ground in separate grinder and returned to sewage flow
Sh----Bar rack, hand cleaned 1/2" to 2" openings
Si----Intermediate screen 1/8" to 1/2" openings
Sm----Bar rack mechanically cleaned 1/2" to 2" openings
Sr----Coarse rack (openings over 2")
St----Garbage ground at plant and returned to sewage flow

T ----Sludge thickener
Tc----Covered
Tm----Stirring mechanism
Tp----Open top

V ----Mechanical sludge dewatering
Vc----Sludge centrifuge
Vp----Pressure filter
Vv----Rotary vacuum filter
Vo----Other

X ----Sludge drying or incineration
Xd----Used for fertilizer
Xf----Sludge burned for fuel
Xl----Disposal to land
Xn----Incinerated
Xp----Used for fill

Z ----Sludge conditioning
Za----Chemicals used, alum
Zc----Chemical used (unidentified)
Zi----Chemicals used, iron salts
Zl----Chemicals used, lime
Zp----Polyelectrolytes used
Zx----No chemicals used
Zy----Elutriation

PART V

WASTE LOAD ALLOCATION METHODOLOGY

The most important consideration in determining the capacity of a stream to assimilate wastewater discharges is the ability to maintain an acceptable dissolved oxygen (DO) concentration. Microbial oxidation of organics and certain inorganics present in wastewater creates an oxygen demand. Oxygen is supplied to a stream principally by reaeration from the atmosphere. If the rate of deoxygenation exceeds the rate of reoxygenation, DO concentrations may decrease below minimum allowable standards.

To assess the variations in DO and ammonia nitrogen concentrations in the Little Sioux River and Rock River Basins, a computer-based mathematical model was utilized. Model input data was developed from available information. In most cases, data were lacking and more extensive data would improve the validity of the model. However, it is felt that the developed methodology is an equitable method for establishing waste load allocations.

It is recommended that the computer-based mathematical modeling techniques should be dated and improved as more information is obtained for the streams to more accurately predict water quality.

Theory and Methodology

General - Dissolved oxygen concentrations in streams are controlled by atmospheric reaeration, biochemical oxygen demands (carbonaceous and nitrogenous), algal photosynthesis and respiration, benthal demands, temperature, and the physical characteristics of the stream. Many of these factors are difficult, if not impossible, to accurately define.

Photosynthesis can produce large quantities of oxygen during the day if algae are present in the stream. Conversely, at night algal respiration creates an oxygen demand. Research efforts have attempted to fit harmonic functions to this phenomenon, but with limited success. Therefore, allowance for diurnal fluctuations in oxygen levels is not included in the computer model.

Benthal demands result from anaerobic decomposition of settled organic material at the bottom of the stream. These reactions release carbonaceous and nitrogenous organic materials which create biochemical oxygen demands.

The inclusion of benthal demands in the model requires extensive field surveys to determine the areal extent of sludge deposits within a stream and coefficients that describe the release into the water. Since the impact is minor in most instances and no data are available describing sludge deposition areas, no benthal oxygen demands are included in the model formulation.

Model Equation - A complete mathematical model to describe DO concentrations within the stream would include all significant factors. Natural systems cannot presently be expressed mathematically with absolute certainty, but reasonably accurate predictions can be made through realistic assumptions of the reaeration phenomenon and deoxygenation caused by carbonaceous and nitrogenous biochemcial oxygen demands.

The nitrogenous biochemical oxygen demand is due to the oxidation of ammonia to nitrates by certain species of bacteria. This oxidation process is called nitrification. Nitrification is a two-step process whereby a specific bacterial species oxidizes ammonia to nitrite and a different bacterium oxidizes the nitrite to nitrate. Approximately 4.5 mg/l of oxygen are required to oxidize 1 mg/l of ammonia (expressed as nitrogen) to nitrate, although this value may vary between 3.8 and 4.5 mg/l. Since secondary wastewater effluents quite commonly contain ammonia nitrogen levels of 10 mg/l, the equivalent nitrogenous biochemical oxygen demand (should all the ammonia be converted to nitrates) is approximately 45 mg/l. This is equivalent to the carbonaceous biochemical oxygen demand of most secondary wastewater effluents.

For the modeling program, a modified version of the Streeter-Phelps equation for DO deficit within the stream was utilized. This approach recognizes both carbonaceous and nitrogenous biochemical oxygen demands, and atmospheric reaeration. Effects of photosynthesis and benthal demands are not considered. The rate of deoxygenation is as follows:

$$\frac{dD}{dt} = K_1L + K_nN - K_2D$$

Integrated this equation becomes the modified Streeter-Phelps equation as follows:

$$D(t) = \frac{K_1 L_o}{K_2 - K_1}\left(e^{-K_1 t} - e^{-K_2 t}\right) + \frac{K_n N_o}{K_2 - K_n}\left(e^{-K_n t} - e^{-K_2 t}\right) + D_o e^{-K_2 t}$$

Where:

$D(t)$ = DO deficit at time t.

D_o = Initial DO deficit.

L_o = Initial ultimate carbonaceous BOD.

N_o = Initial nitrogenous BOD.

K_1 = Carbonaceous deoxygenation rate constant.

K_n = Nitrogenous deoxygenation rate constant.

K_2 = Reaeration rate constant.

In this equation, the rates of oxygen utilization due to both carbonaceous and nitrogenous biochemical oxygen demands are expressed as first order reactions.

Ultimate BOD and ammonia nitrogen concentrations are calculated as follows:

$$L(t) = L_o e^{-K_1 t}$$

$$N(t) = N_o e^{-K_n t}$$

Where:

$L(t)$ = Ultimate carbonaceous BOD at time t.

$N(t)$ = Nitrogenous BOD at time t.

and nitrogenous oxygen demand (N) equals 4.5 times the ammonia nitrogen concentration.

Since nitrification is a two-step process, many researchers have proposed that it is a second order reaction, although no practical DO prediction equation has been developed in this form. Since nitrogenous biochemical oxygen demands are too great to ignore, most developed models assume that it is a first order reaction. The present investigation has also utilized this assumption.

Nitrifying bacteria are generally present in relatively small numbers in untreated wastewaters. The growth rate at 20° C (68° F) is such that the organisms do not exert an appreciable oxygen demand until about 8 to

10 days have elapsed. This lag period may be reduced or practically eliminated in a stream receiving large amounts of secondary effluent containing seed organisms. In biological treatment systems, substantial nitrification can take place with a resultant buildup of nitrifying organisms. These nitrifying bacteria can immediately begin to oxidize the ammonia nitrogen present and exert a significant oxygen demand in a stream.

In addition to dispersed bacteria, there can be considerable nitrification by nitrifying organisms that are attached to sediments, rocks, weeds, etc., along the stream bottom. These organisms oxidize the ammonia nitrogen in the stream as it passes by them. Such attached growths can build up below treatment plant discharges where the stream is enriched with ammonia nitrogen.

It is known that the nitrification biological process is generally more sensitive to environmental conditions than carbonaceous decomposition. The optimal temperature range for growth and reproduction of nitrifying bacteria is 26° to 30° C (79° to 86° F). It is generally concluded that the nitrogenous BOD will assume greatest importance in small streams which receive relatively large volumes of secondary wastewater effluents, and during the low flow, warm weather periods of the year (August and September). These conditions were utilized for the low flow determination of allowable effluent characteristics during summer periods. During winter low flow periods (January and February), nitrification will probably have limited influence upon the oxygen demand due to the intolerance of the nitrifying bacteria to low temperatures; thus, for winter conditions, it was assumed nitrification did not occur.

To assume that nitrification, during summer conditions, proceeds immediately following a wastewater discharge, and simultaneously with carbonaceous oxidation, is to generally assume the worst possible conditions in regards to downstream dissolved oxygen concentrations. Therefore, waste load allocations identified in this manner will generally be on the conservative side.

In addition, to assume no nitrification occurs during winter flow conditions is to treat ammonia nitrogen as a conservative (nondegrading) pollutant.

In many streams during winter conditions, the water quality criteria of 2 mg/l of ammonia nitrogen becomes the determining factor in waste load allocations. During summer conditions, the critical water quality factor is generally dissolved oxygen.

Rate Constant Determination - The carbonaceous deoxygenation rate constant (K_1) for most streams will vary from 0.1 to 0.5 per day. Early work by Streeter and Phelps determined an average value for the Ohio River of 0.23/day (0.1/day, base 10). This value has been accepted and commonly used for years with reasonable results.

Deoxygenation rates higher than 0.23/day have been reported for various streams in the United States. No measurements of deoxygenation rates for the streams under investigation are available. For this study a carbonaceous deoxygenation rate of 0.2/day (base e) was used. Field measurements of typical deoxygenation rates for streams in Iowa are needed to verify this value and would greatly improve the predictability of the modeling.

Information on nitrogenous deoxygenation rates is extremely limited. Available information indicates that nitrification rates (when active nitrification does occur) are somewhat greater than carbonaceous oxidation rates. Therefore a nitrogenous deoxygenation rate (K_n) of 0.3/day (base e) was selected for the study. Again, field measurements of typical nitrogenous deoxygenation rates in Iowa streams would greatly enhance the accuracy of the modeling effort.

Many predictive formulations have been used for stream reaeration. For this study, reaeration rate constants were predicted by a method developed by Tsivoglou ("Characterization of Stream Reaeration Capacity," Tsivoglou and Wallace, EPA-R3-72-012, October, 1972). Tsivoglou's method is based on the premise that the reaeration capacity of nontidal fresh water streams is directly related to the energy expended by the flowing water, which in turn is directly related to the change in water surface elevation.

The change in water surface elevation divided by the time of flow is the average rate of energy expenditure. This relationship is expressed by:

$$K_2 = 0.048 \left(\frac{h}{t}\right) \text{ @ } 20° \text{ C}$$

Where:

K_2 = Reaeration rate constant (base e) per day.

h = Water surface elevation change in feet.

t = Time of flow in days.

Tsivoglou's method was derived from actual measurement of stream reaeration rates by a new field tracer procedure in which a radioactive form of the noble gas krypton serves as a tracer for oxygen.

The reaeration rate predictive model has been verified for streams ranging in flow from 5 to 3,000 cfs. It can also be used to quite accurately predict reaeration effects of dams and waterfalls.

In development of Tsivoglou's procedure, other reaeration rate predictive formulas were compared with results obtained from the field tracer technique, but none appeared to predict stream reaeration rates as accurately as the Tsivoglou model.

Under winter ice conditions, the reaeration rate constant is reduced in direct proportion to the percentage of ice cover up to 95 percent. For instance, if it is estimated that there is 90 percent ice cover, then the reaeration rate constant is reduced by 90 percent. With 100 percent ice cover, the reaeration rate is reduced only by 95 percent, for it is estimated that there will always be a small amount of reaeration taking place.

Temperature corrections for the carbonaceous and nitrogenous deoxygenation rate constants and also the reaeration rate constants are subroutines within the computer model. The following formulations define the specific temperature corrections utilized in the program:

$$K_{1(T)} = K_{1(20)} \times 1.047^{T-20}$$

$$K_{2(T)} = K_{2(20)} \times 1.0241^{T-20}$$

$$K_{n(T)} = K_{n(20)} \times (0.058T - 0.16) \qquad T > 3° \text{ C}$$

Where T = water temperature, ° C.

Temperature corrections for K_1 and K_2 are generally accepted formulations. Information on the effects of temperature on K_n is lacking. The formula given was derived from information on temperature effects on nitrification rates in biological treatment systems. The formula predicts nitrification rates of zero at approximately 3° C (37° F). The rate constant is set to zero at all temperatures below 3° C (37° F).

The principal factor affecting the solubility of oxygen is the water temperature. Dissolved oxygen saturation values at various temperatures are calculated as follows:

$$C_s = 24.89 - 0.426t + 0.00373t^2 - 0.0000133t^3$$

Where:

t = Water temperature, ° F.

C_s = Saturation value for oxygen at temperature, t (° F), at standard pressure.

Stream Velocity Calculations - Stream velocities are important in determining reaeration rates and the downstream dispersion of pollutants. The computer model utilized calculates velocity based on a variation of the Manning formula for open channel flow. The Manning formula for open channel flow is:

$$v = \frac{1.5R^{2/3}S^{1/2}}{n}$$

Where:

v = Velocity, fps.

R = Hydraulic radius, ft = wetted perimeter/cross sectional area which approximately equals the mean depth for rivers.

S = Channel slope, ft/ft.

n = Roughness coefficient.

By multiplying both sides of the equation by the cross sectional area, which is equal to the mean depth times the water surface width, and solving for the mean depth, the following relationship is obtained:

$$d = \left(\frac{Qn}{1.5WS^{1/2}}\right)^{3/5}$$

Where:

- d = Mean river depth, ft.
- Q = Discharge, cfs.
- W = Water surface width, ft.
- S = Slope, ft/ft.
- n = Roughness coefficient.

Once mean depths were calculated, velocities were determined from the relationship:

$$v = Q/A = Q/W \cdot d$$

River slopes were obtained from existing profiles when available, but usually were taken from USGS topographic maps. Slopes obtained from USGS maps are rather generalized, and more accurate river profiles would greatly improve the accuracy of velocity determinations.

River widths and roughness coefficients were estimated from information obtained from field observations, and flow and cross section data at each USGS gaging station.

<u>Computer Input and Output Data</u> - In order to calculate water quality at various points in the river, the river length to be modeled was divided into reaches. River characteristics such as mean velocities and depths, river widths, deoxygenation and reaeration rate constants, and water temperature were considered constant for each reach. The location of the reaches was set by one or more of the following:

1. A tributary.
2. A wastewater discharge.
3. A change in river characteristics such as river width or slope.
4. A dam.

In order to calculate water quality characteristics at various points within each reach, the reaches were divided into segments called sections.

Mixing and dispersion assumptions inherent in the model are:

1. Complete and instantaneous mixing of wastewater and tributary flows with the main river flow.
2. Uniform lateral and logitudinal dispersion (plug flow) of the stream constituents as they move downstream.

Flows that could not be allocated to tributary inflows or wastewater discharges were distributed uniformly along the main river stem and are called groundwater contributions.

Actual data input into the computer program are as follows:

1. Initial river conditions such as flow and concentrations of ultimate carbonaceous BOD, ammonia nitrogen, and DO.
2. Uniform groundwater contributions for each reach and concentrations of ultimate carbonaceous BOD, ammonia nitrogen, and DO.
3. The number of reaches and the following for each reach:
   a. Length.
   b. Number of sections.
   c. Water temperature.
   d. Channel slope.
   e. River width.
   f. Deoxygenation rate constants.
   g. Roughness coefficient.
4. Wastewater or tributary inflows consisting of inflow rates, ultimate carbonaceous BOD, ammonia nitrogen, and DO concentrations.

After calculations, computer output data consists of the following for each reach:

1. Mean river velocities.
2. Mean river depths.
3. Reaeration rate constants.
4. Temperature corrected reaeration and deoxygenation rate constants.
5. Saturation DO concentrations for the given temperature.

and the following at the beginning of every section within a reach:

1. Summation of the river miles evaluated.
2. Cumulative discharge.
3. Cumulative travel time in days.
4. Ammonia nitrogen concentrations.
5. Ultimate carbonaceous BOD concentrations.
6. DO concentrations.
7. DO deficits.

PART VI

WASTE LOAD ALLOCATIONS

Utilizing the previously defined computer methodology, waste load allocations required for dischargers to meet state water quality standards within the study area were determined. Within the Rock River Basin, the Rock River is the only classified stream. However, modeling was conducted for the Little Rock River and Otter Creek because of the impact these streams have upon the water quality of the Rock River. The entire Little Sioux River within the state of Iowa is water quality classified as are all, or portions of, the following tributaries: the Maple River, Mill Creek, Waterman Creek, Lost Island Outlet, the Ocheyedan River, Battle Creek, Odebolt Creek, and the Little Maple River. Of these classified tributaries, only the Maple River, Little Maple River, Ocheyeday River, and Odebolt Creek required modeling for purposes of waste load allocations. The evaluation procedure considered the situation with 1990 wastewater discharges under both summer and winter low flow conditions. The following sections describe specific results for these evaluations and a tabulation of the waste load allocation for each discharger is presented for both summer and winter conditions.

Evaluation Assumptions

In order to define waste load allocations for dischargers within the study area, specific assumptions are required. Identification of the major items required to evaluate and determine waste load allocations are identified in the following list.

1. The major objective of the present investigation is to satisfy Iowa Water Quality Standards with future effluent discharges. Determination of allowable effluent concentrations was based upon varying the effluent quality from point source discharges until the model maintained dissolved oxygen concentrations above 5.0 mg/l and ammonia nitrogen concentrations below 2.0 mg/l in all water quality classified sections of the stream. Because NPDES permits are requiring discharges with stabilization ponds

to utilize controlled discharge of the effluent, no discharge from stabilization pond treatment facilities to the stream was assumed for the low flow conditions.

2. Definition of 7-day, 1-in-10 year low flow was required for each stream modeled. For all major streams within the Rock River Basin and portions of the Little Sioux River above Cherokee, the total present average daily wastewater discharges from all entities within their respective basins exceeds the measured low flow. For all other streams, the low flow was larger than the total wastewater discharges to the stream. Where the low flow is exceeded by wastewater discharges, two possible explanations are:
   a. During extreme dry periods (7-day, 1-in-10 year low flow), evaporation and exfiltration exceed any infiltration taking place with the result being a net loss of natural flow from the river. Some flow is maintained as a result of wastewater discharges from communities and industries.
   b. The 7-day, 1-in-10 year low flow is a statistical number based upon the flow in the river for the number of years of record at the various gaging stations. Most present point source discharge quantities are higher than they were in past years, and this accounts (at least in part) for the higher flows based upon present discharges.

Sufficient information is not available in the Rock River Basin or the upper portion of the Little Sioux River Basin to establish the exact water balance during low flow condtions and, in reality, some combination of these two factors probably causes the point source discharges to exceed the 7-day, 1-in-10 year low flow.

In order to obtain river flows for use in the stream model which approximate the 1990, 7-day, 1-in-10 year low flow, the following assumptions were made regarding the groundwater inflow and groundwater recharge:

a. For the Rock River, the present flow from point source discharges and tributaries upstream of USGS Gaging Station 6-4835 near Rock Valley is greater than the calculated 7-day, 1-in-10 year low flow. Uniform exfiltration from the Rock River is assumed to take place from the furthest upstream discharger to the gage to meet the 7-day, 1-in-10 year low flow. Between the present time and 1990, the flow from upstream point source dischargers is expected to increase slightly. For purposes of the computer model, the percent of groundwater recharge due to the incremental increase in flow from point dischargers was assumed to equal the percent of groundwater recharge under existing conditions. This results in an increase in the 7-day, 1-in-10 year low flow at the gage near Rock Valley from 1.0 to 1.06 cfs. The rate of groundwater recharge from the furthest upstream discharger to gage 6-4835 has been assumed to apply to the reach of stream from the gage to the confluence with the Big Sioux River.

b. For sections of the Little Sioux River above Cherokee, the 7-day, 1-in-10 year low flow does not equal the sum of present upstream wastewater discharges, or the 7-day, 1-in-10 year low flow of a downstream gage will be less than the upstream gage. Because there are few continuous-record gages on the upper portion of the Little Sioux River, there is a higher degree of uncertainly associated with the 7-day, 1-in-10 year low flows at the gages. The same procedure is utilized as in the Rock River Basin above for those sections of the Little Sioux River where there is a net outflow of water to groundwater. For sections of the stream where flow exceeds upstream discharges or the upstream gage 7-day, 1-in-10 year low flow, the groundwater contribution was determined by the method given in "c" below.

c. For portions of the Little Sioux River and all other modeled streams within the study area except the Rock River, the excess stream flow above the sum of present wastewater discharges was assumed to be the result of groundwater inflow to the stream. This amount of groundwater inflow was assumed to remain constant over the planning period. Since most wastewater discharges will increase during this time, the 7-day, 1-in-10 year low flow in 1990 will be greater by the amount of the increase. Groundwater contribution to the stream flow was distributed throughout the drainage area in relationship to the area contributing to the stream along the length of the channel. Values of 4.0 mg/l BOD_5, 0.0 mg/l ammonia nitrogen, and 2.0 mg/l dissolved oxygen concentration were assumed as water quality of the groundwater contribution.

3. Ultimate carbonaceous BOD was assumed to 1.5 times the BOD_5.
4. Since no data are available describing effluent dissolved oxygen concentrations or temperatures, the following values were assumed for each class of wastewater discharge.

Discharger	Summer Condition			Winter Condition		
	Dissolved Oxygen (mg/l)	Temperature (°C)	Temperature (°F)	Dissolved Oxygen (mg/l)	Temperature (°C)	Temperature (°F)
Trickling Filter	3.0	20	68	4.0	9	48
Activated Sludge	3.0	20	68	4.0	9	48
Industrial	Each Discharger Handled Individually					

5. In order to assess the reaeration rate constants under wintertime conditions, the amount of ice cover on the stream was estimated. Then the winter reaeration rate constant for each reach of the stream was determined by multiplying the predicted constant by the percentage of open water in the reach. Ice cover estimates were based upon general climatological conditions for the basin and upon personal observations of persons familiar with the area. Complete ice cover was assumed to be noncoincidental with the 7-day, 1-in-10 year low flow.
6. Deoxygenation rate coefficients were assumed to be 0.2/day for carbonaceous demand and 0.3/day for nitrogenous demand.

7. Best practicable waste treatment technology (BPWTT) effluent limitations described by EPA guidelines were utilized for industrial discharges when available. Otherwise, the actual allowable waste load which could be discharged into the stream was determined and identified as the waste load allocation for that discharger.
8. Tributaries (without wastewater sources) discharging to the streams being modeled were assumed to have saturated dissolved oxygen concentrations, an ultimate BOD of 6.0, and ammonia nitrogen concentrations of 0.0 mg/l in the summer and 0.5 mg/l in the winter.
9. The Little Sioux River, Rock River, Little Rock River, and some small tributaries all rise in Minnesota. A lack of water quality data does not permit identification of stream water quality as it enters the study area. Water quality of the streams entering the study area is assumed to be the same as that of tributaries without wastewater sources, as given above.
10. The impoundment above Linn Grove is shallow, and the model has been carried through the impoundment and over the dam. Through the impoundment reach of the Little Sioux River, the actual water surface slope is estimated. Stream width is also increased through the impoundment area. The dam is assumed to take a reach of stream equal to 0.001 miles with a change in head equal to the height of the dam. This results in a high reaeration rate constant for the stream flow over the dam.

Discussion of Results

The waste load allocations are based on a computer model that utilizes the best available information for the study area. Some of the input data provided are approximations, and model predictability can be considerably improved with more accurate information. Based upon available data, the model computes stream quality for the assigned wastewater discharges. For the initial run, all discharges were assumed to meet either secondary treatment (municipalities) or best practible treatment (BPT) (industries). Where the model indicated violation of IDEQ stream quality criteria, more stringent effluent requirements were imposed until satisfactory levels were achieved. Whenever more than one entity was required to meet more stringent effluent limitations in a particular stream reach to maintain quality, approximately the same requirements were established for all the entities regardless of size or whether they were municipal or industrial dischargers. Other possible combinations of effluent limitations of BOD, ammonia nitrogen, and dissolved oxygen could result in meeting stream quality criteria.

Summer Conditions - The upper limit for wastewater discharges is secondary treatment from municipal discharges and BPT for industrial discharges. IDEQ has set the allowable ammonia nitrogen level for secondary treatment as 10 mg/l in summer.

Rock River Basin - Rock River is the only water quality classified stream within the basin, but due to extremely low 7-day, 1-in-10 year low flow, modeling of the Little Rock River and Otter Creek was also necessary to determine waste load allocations throughout the basin. Waste load allocations for each discharger under summer conditions are given in Table 25.

Dissolved oxygen concentration profiles for both secondary treatment conditions and waste load allocations with 1990 flows for Rock River, Little Rock River, and Otter Creek are shown on Figures 8, 9, and 10, respectively. Secondary treatment for wastewater discharges to the Little Rock River and Otter Creek will meet the stream quality criteria of 5.0 mg/l, but other dischargers require waste load allocations more stringent than secondary treatment.

Summer ammonia nitrogen concentrations are shown on Figures 8, 9, and 10 for Rock River, Little Rock River, and Otter Creek, respectively. Secondary treatment removal levels for ammonia nitrogen are required for dischargers to tributaries of the Rock River. Ammonia nitrogen removal below secondary levels is required at Rock Rapids and Rock Valley to reduce oxygen demand upon the stream.

TABLE 25

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Rock River							
Rock Rapids (M-20)	0.70	0.220	15	28	3	6	3.0
Mud Creek							
Lester (M-20)		0	Controlled Discharge				
Alvord (M-2)		0	Controlled Discharge				
Little Rock River							
Little Rock (M-21)	0.74	0.040	45[3]	15	10[3]	3	3.0
George (M-16)		0	Controlled Discharge				
Otter Creek							
Sibley (M-33)	0.74	0.356	45	134	10[3]	30	3.0
Sibley Municipal Utilities (I-7)	0.74	0.030	No Discharge Limitations Necessary[4]				
Ashton (M-5)		0	Controlled Discharge				
Hallet Constructon Co. - Ashton (I-2)			No Discharge Limitations Necessary[4]				
Matlock (M-23)		-	No Existing Municipal Facility				
Little Rock River							
Doon (M-14)		0	Controlled Discharge				
Burr Oak Creek							
Hull (M-18)	0.69	0.108	27	24	10	9	3.0

TABLE 25 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

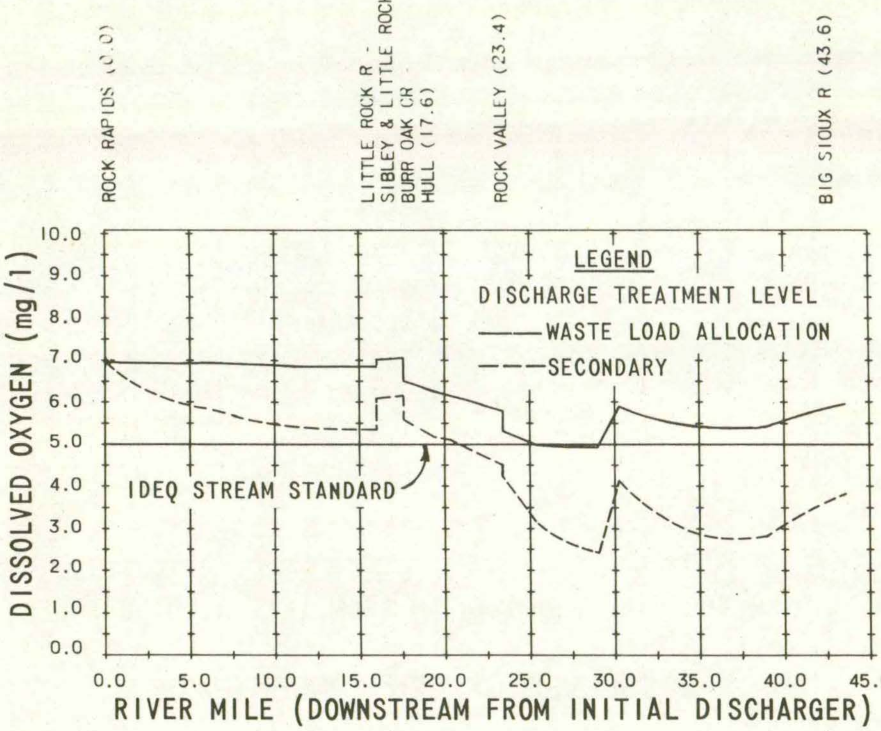
Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	(lb/day)	Ammonia Nitrogen (N) (mg/l)	(lb/day)	Effluent Dissolved Oxygen (mg/l)
Rock River							
Rock Valley (M-30)	0.63	0.130	15	16	4	4	3.0

[1] Seven-day, 1-in-10 year low flow in stream just above point of discharge, if stream is classified; or flow of classified stream at confluence with tributary.

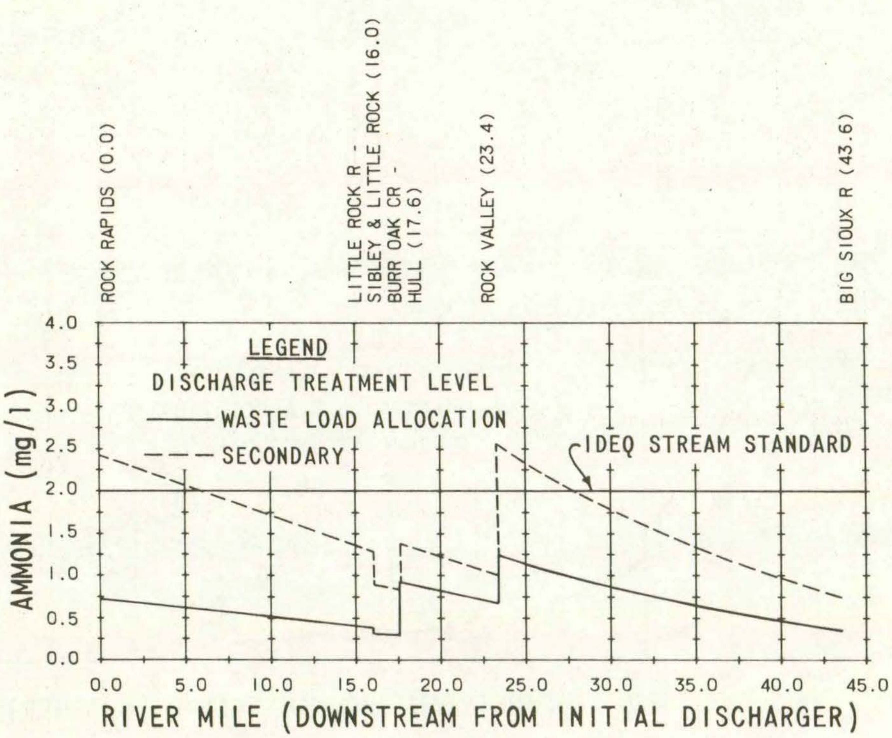
[2] UBOD = 1.5 (BOD_5).

[3] Meets BPWTT guidelines. Higher discharge quantities could satisfy stream criteria.

[4] No waste load allocation is necessary; low quantities of BOD and ammonia nitrogen in effluent.

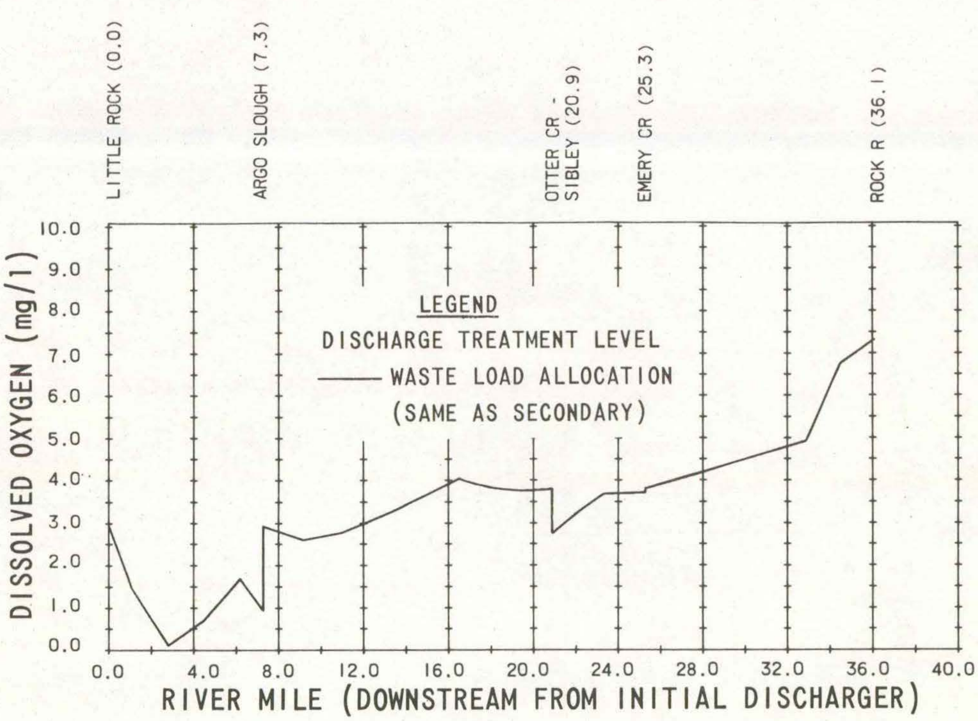


DISSOLVED OXYGEN CONCENTRATIONS



AMMONIA NITROGEN CONCENTRATIONS

FIGURE 8
ROCK RIVER
SUMMER CONDITIONS



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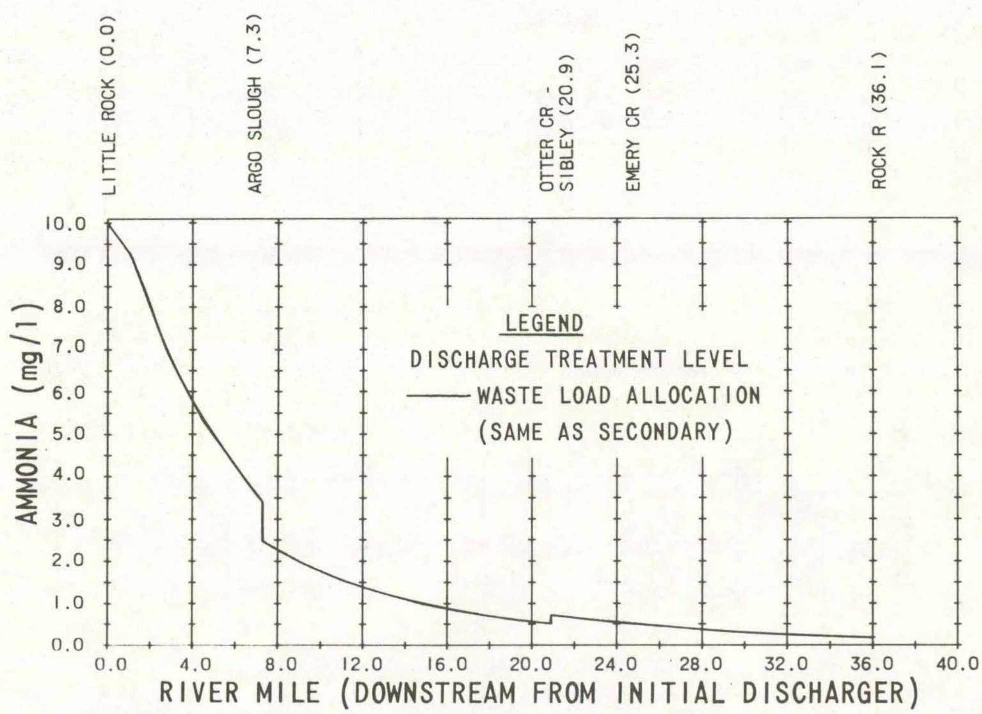
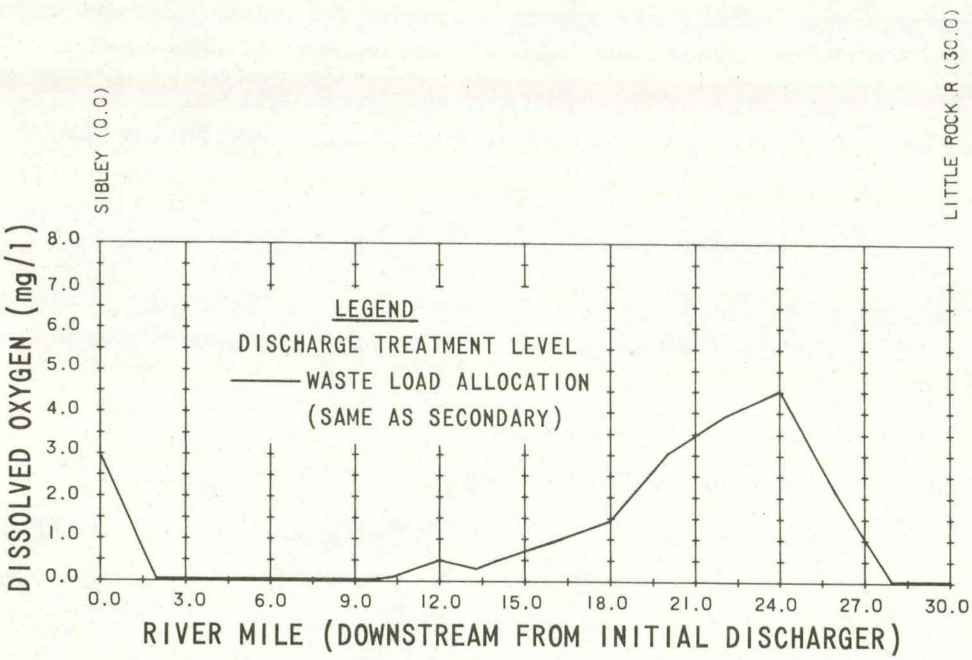


AMMONIA NITROGEN CONCENTRATIONS

FIGURE 9
LITTLE ROCK RIVER
SUMMER CONDITIONS



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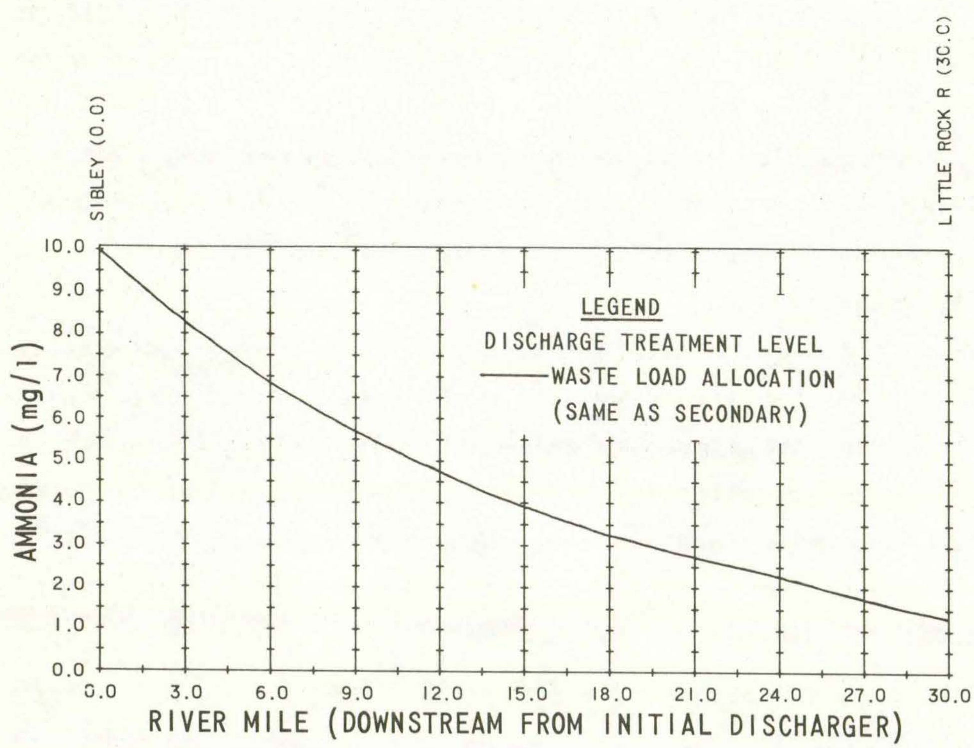


AMMONIA NITROGEN CONCENTRATIONS

FIGURE 10
OTTER CREEK
SUMMER CONDITIONS

To meet water quality criteria under summer low flow conditions, the communities of Hull, Rock Rapids, and Rock Valley must provide a level of wastewater treatment exceeding that of secondary treatment.

Little Sioux River Basin - Within the basin the water quality classified streams which have wastewater discharges are the Little Sioux River, Ocheyedan River, Maple River, Little Maple River, and Odebolt Creek. Waste load allocations were necessary for some dischargers to unclassified streams which have an impact upon the water quality of a classified stream. Waste load allocations for each discharger under summer conditions are given in Table 26.

Dissolved oxygen concentration profiles for both secondary treatment conditions and the waste load allocations for 1990 discharges are shown on Figure 11 for Odebolt Creek and Little Maple River. Figure 12 presents profiles for Maple River and Ocheyedan River, while the Little Sioux River dissolved oxygen profiles are given on Figure 13. The upper reaches of the Little Sioux River and the Maple River require better than secondary treatment level removals of BOD to maintain DO stream quality criteria. In the upper reaches of the little Sioux River, removal of ammonia nitrogen to decrease oxygen demand in the stream and increases in the DO content of wastewater effluents are necessary to maintain the stream standards for DO. Because of the extremely high levels of BOD removal required, further study of the upper reaches of the Little Sioux River is recommended. To meet water quality criteria in the classified portions of the Little Maple River, very stringet waste load allocations for both BOD and ammonia nitrogen removal must be assigned to Alta. Again, further study of the stream is recommended.

In addition to the critical stream reaches above, Odebolt Creek requires better than secondary treatment level removal of ammonia nitrogen to meet the stream quality criteria of 2.0 mg/l. Figure 14 shows the ammonia nitrogen profiles for Little Maple River and Odebolt Creek. Profiles for Maple River and Ocheyedan River are given on Figure 15, and Figure 16 gives ammonia nitrogen concentration profiles for the Little Sioux River.

To meet water quality criteria under summer low flow conditions, the Iowa Great Lakes Sanitary District (IGLSD) and the communities of Alta, Aurelia, Cherokee, Galva, Hartley, Odebolt, and Spencer must provide better

TABLE 26

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River							
Silver Lake							
Lake Park (M-45)		0	Controlled Discharge				
Spirit Lake							
Orleans (M-52)			To Iowa Great Lakes Sanitary District				
Iowa Electric Light & Power (I-10)			No Discharge Limitations Necessary[3]				
East Okoboji Lake							
Spirit Lake (M-61)			To Iowa Great Lakes Sanitary District				
West Okoboji Lake							
Okoboji (M-51)			To Iowa Great Lakes Sanitary District				
Arnolds Park (M-37)			To Iowa Great Lakes Sanitary District				
West Okoboji (M-66)			To Iowa Great Lakes Sanitary District				
Okoboji Lake Outlet							
Iowa Great Lakes Sanitary District (M-70)	0.00	2.146	6	107	2	36	3.0
Milford (M-48)			To Iowa Great Lakes Sanitary District				
Ocheyedan River							
Rush Lake Outlet							
Ocheyedan (M-50)		0	Controlled Discharge				
Dry Run							
Harris (M-43)		0	Controlled Discharge				

TABLE 26 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Ocheyedan River (cont.)							
Sewer Creek							
Hartley (M-44)	0.40	0.181	10	15	10	15	3.0
Ocheyedan River							
Everly (M-4)		0		Controlled Discharge			
Spring Creek							
Royal (M-57)		0		Controlled Discharge			
Ocheyedan River							
Cornbelt Power Co-op. (I-9)			No Discharge Limitations Necessary[3]				
Little Sioux River							
Spencer (M-60)	2.40	2.560	6	128	2	43	4.0
Spencer Rendering Plant (I-14)				To Municipal Treatment Facility			
Spencer Municipal Plant (I-13)				No Discharge Data Available			
Big Muddy Creek							
Superior (M-62)				No Existing Municipal Facility			
Little Muddy Creek							
Fostoria (M-41)		0		Controlled Discharge			

TABLE 26 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Lost Island Outlet							
Drainage Ditch #61							
Terrill (M-64)		0	Controlled Discharge				
Lost Island Outlet							
Dickens (M-39)		-	No Existing Municipal Facility				
Drainage Ditch #60							
Ruthven (M-58)		0	Controlled Discharge				
Montgomery Creek							
Webb (M-65)		-	No Existing Municipal Facility				
Willow Creek							
Moneta (M-49)		-	No Existing Municipal Facility				
Rossi (M-56)		-	No Existing Municipal Facility				
Greenville (M-42)		-	No Existing Municipal Facility				
Little Sioux River							
Sioux Rapids (M-59)	4.75	0.054	45	20	10	5	3.0
Linn Grove (M-47)		0	Controlled Discharge				
Linn Grove Rendering (I-11)	4.60	0.014	45	5	20	2	3.0
Peterson (M-54)		-	Controlled Discharge				
Waterman Creek							
Sutherland (M-63)		0	Controlled Discharge				

TABLE 26 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Mill Creek							
Dry Run							
Primghar (M-55)		0	Controlled Discharge				
Mill Creek							
Paullina (M-53)		0	Controlled Discharge				
Willow Creek							
Mugge Creek							
Calumet (M-38)		-	No Existing Municipal Facility				
Gray Creek							
Larrabee (M-46)		0	Controlled Discharge				
Hill Creek							
Meriden (M-24)		0	Controlled Discharge				
Little Sioux River							
Cherokee (M-9)	5.57	0.756	15	95	5	32	3.0
Hallett Construction Co. - Cherokee (I-3)			No Discharge Limitations Necessary[3]				
Cherokee Industrial Site (Wilson Packing Plant) (M-69)		0	Controlled Discharge				

TABLE 28 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Railroad Creek							
Meadow Brook Mobile Home Court (S-2)		0	Controlled Discharge				
Little Sioux River							
Cherokee Mental Health Institute (S-1)			To Municipal Facility				
Quimby (M-28)		0	Controlled Discharge				
Simonsen Mill & Rendering Plant, Inc. (I-8)		0	Controlled Discharge				
Willow Creek							
Cleghorn (M-10)		0	Controlled Discharge				
Little Sioux River							
Washta (M-36)		0	Controlled Discharge				
Pierson Creek							
Pierson (M-27)	7.27	0.074	45[5]	28	10[5]	6	3.0
Bacon Creek							
Cushing (M-12)	7.61	0.039	45[5]	15	10[5]	3	3.0
Correctionville (M-11)	7.61	0.163	45[5]	61	10[5]	14	3.0

TABLE 26 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River							
Anthon (M-3)	10.14	0.085	45[5]	32	10[5]	7	3.0
Oto (M-26)		-	No Existing Municipal Facility				
Smokey Hollow Creek							
Smithland (M-34)		0	Controlled Discharge				
Little Sioux River							
Rodney (M-31)		-	No Existing Municipal Facility				
Maple River							
Dry Creek Bed							
Aurelia (M-6)	0.00	0.128	7	7	2.5	3	3.0
Little Maple River							
Alta (M-1)	0.00	0.229	4.5	9	1	2	3.0
Halfway Creek							
Schaller (M-32)		0	Controlled Discharge				
Pork Processors, Inc. (I-4)		0	Controlled Discharge				
Galva (M-15)	0.23	0.020	45[4]	8	10[4]	2	3.0
Odebolt Creek							
Odebolt (M-25)	0.24	0.149	45[4]	56	5	6	3.0
Selected Casing (I-6)			To Municipal Facility				
Un-named Creek							
Arthur (M-4)		0	Controlled Discharge				

TABLE 26 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 SUMMER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Maple River (cont.)							
Ida Grove (M-19)	1.16	0.220	45[4]	83	10[4]	18	3.0
Deluxe Motel (I-1)				No Discharge Data Available			
Battle Creek							
Holstein (M-17)		0		Controlled Discharge			
Robert Bagenstos Slaughter House (I-5)				No Discharge Data Available			
Maple River							
Battle Creek (M-7)		0		Controlled Discharge			
Danbury (M-13)		0		Controlled Discharge			
Mapleton (M-22)	3.61	0.116	45[4]	44	10[4]	10	3.0
Castana (M-8)		-		No Existing Municipal Facility			
Turin (M-35)		0		Controlled Discharge			

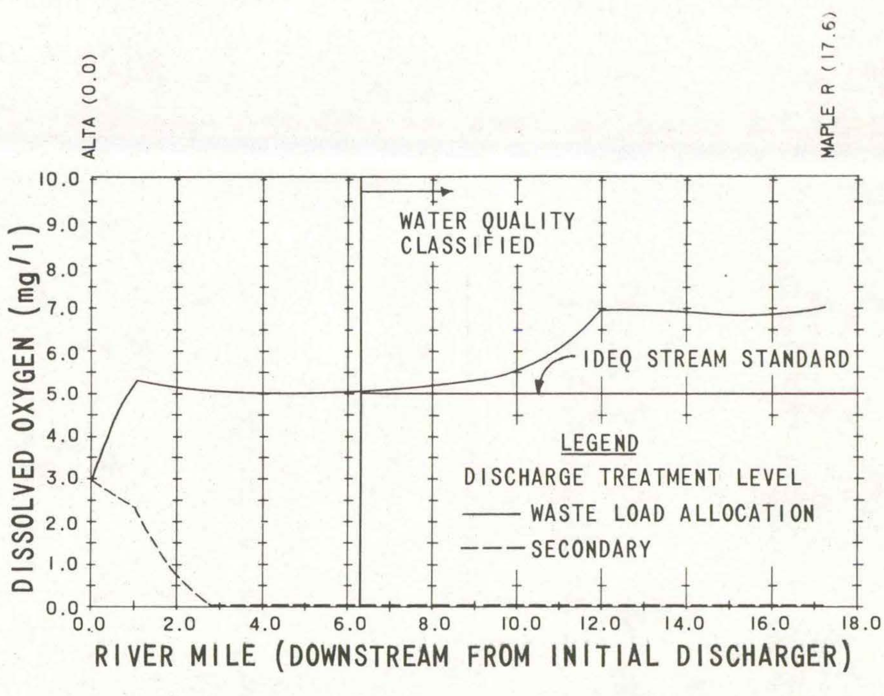
1 Seven-day, 1-in-10 year low flow in stream just above point of discharge, if stream is classified; or flow of classified stream at confluence with tributary.

2 UBOD = 1.5 (BOD_5).

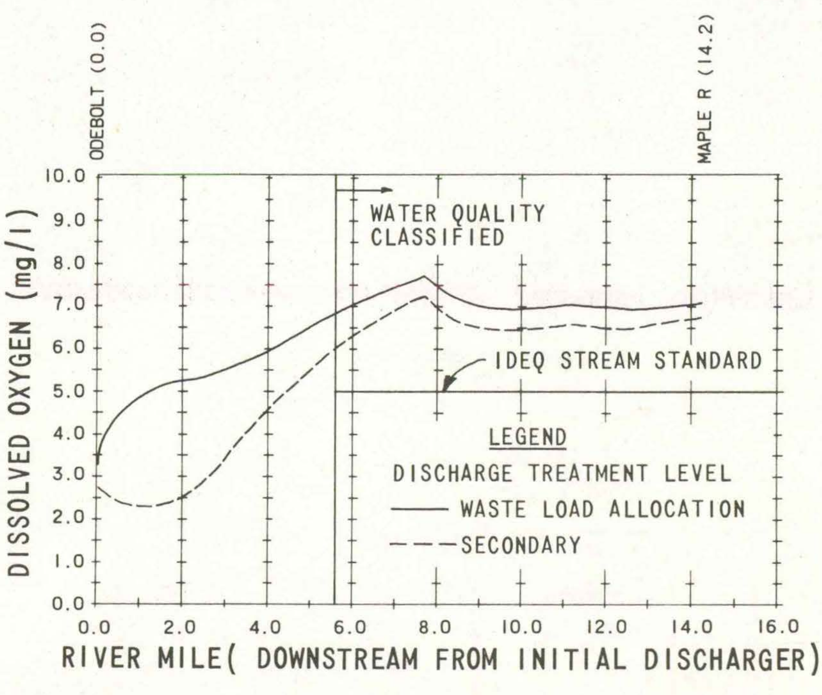
3 No waste load allocation is necessary; low quantities of BOD and ammonia nitrogen in effluent.

4 Meets BPWTT guidelines. Higher discharge quantities could satisfy stream criteria.

5 Meets BPWTT guidelines. Could be higher without affecting stream profiles significantly.

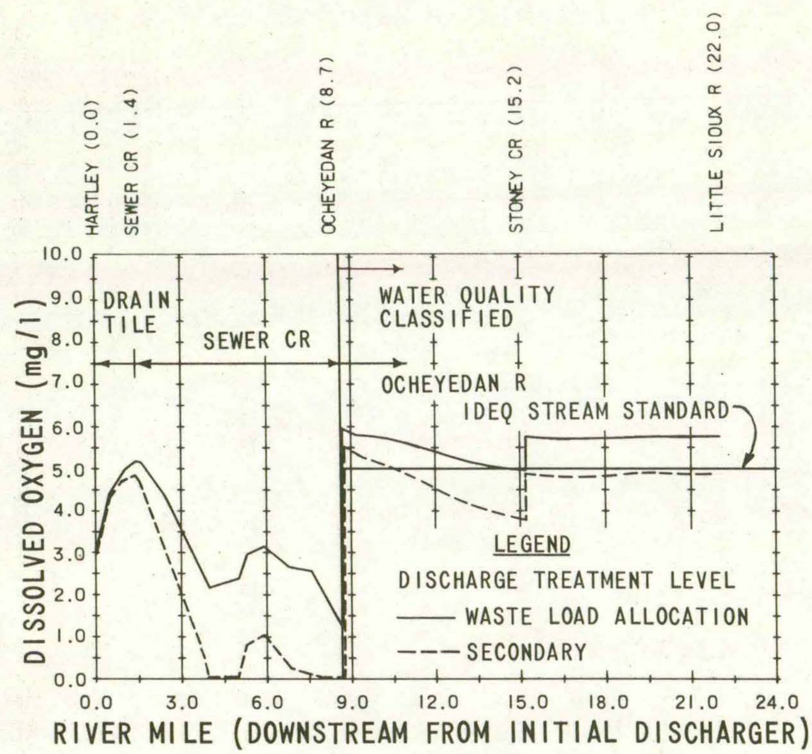


LITTLE MAPLE RIVER

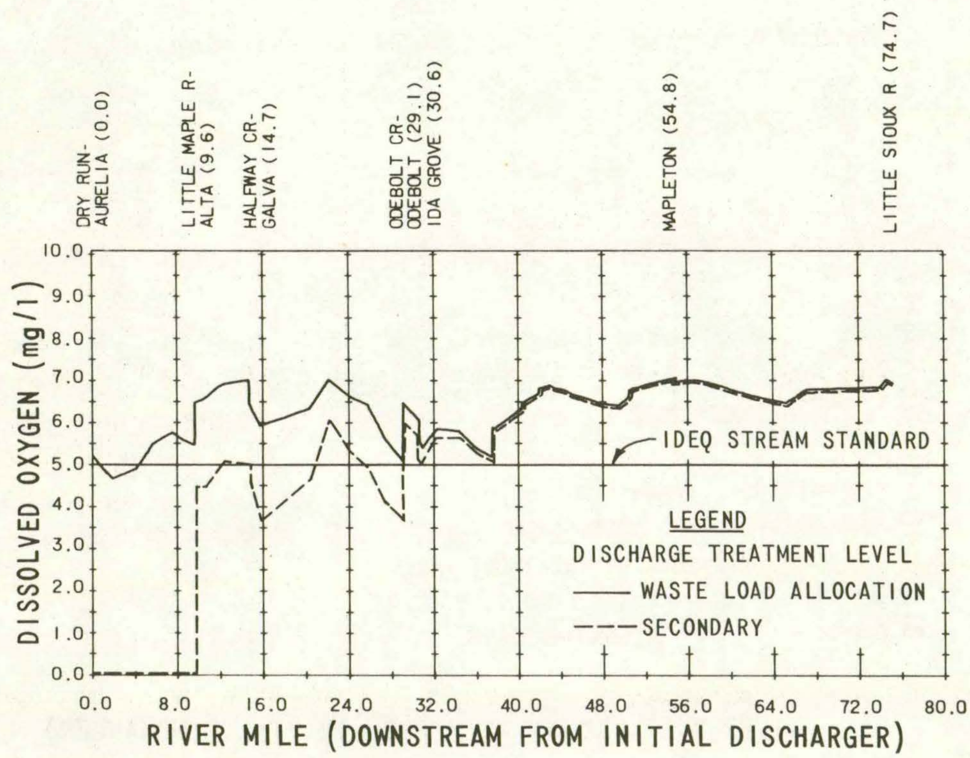


ODEBOLT CREEK

FIGURE 11
DISSOLVED OXYGEN
CONCENTRATIONS
SUMMER CONDITIONS

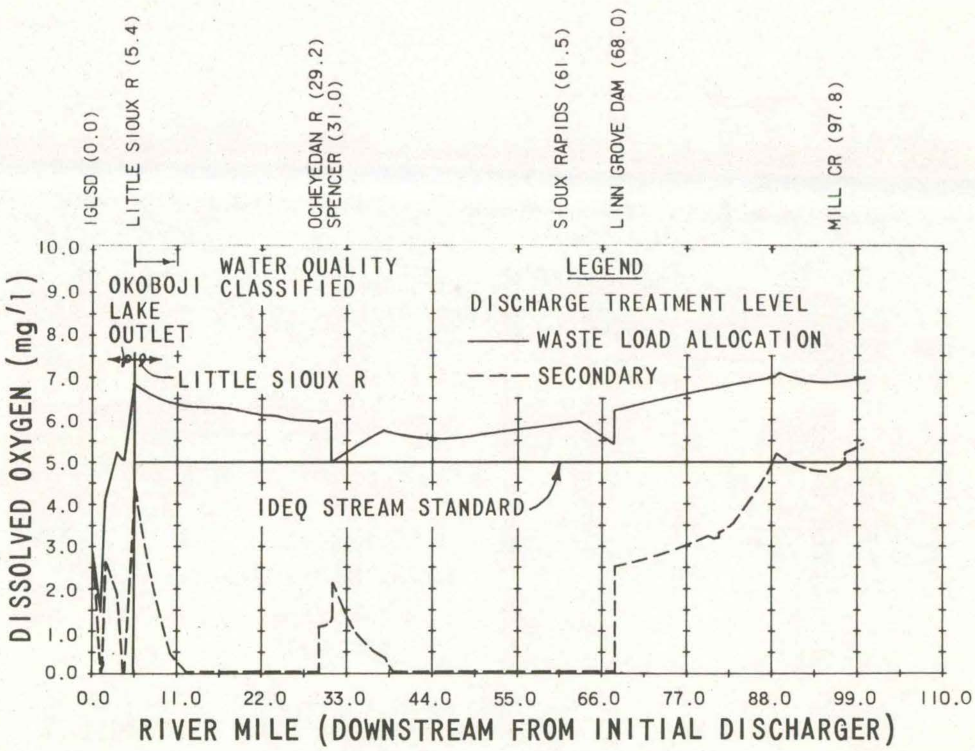


OCHEYEDAN RIVER

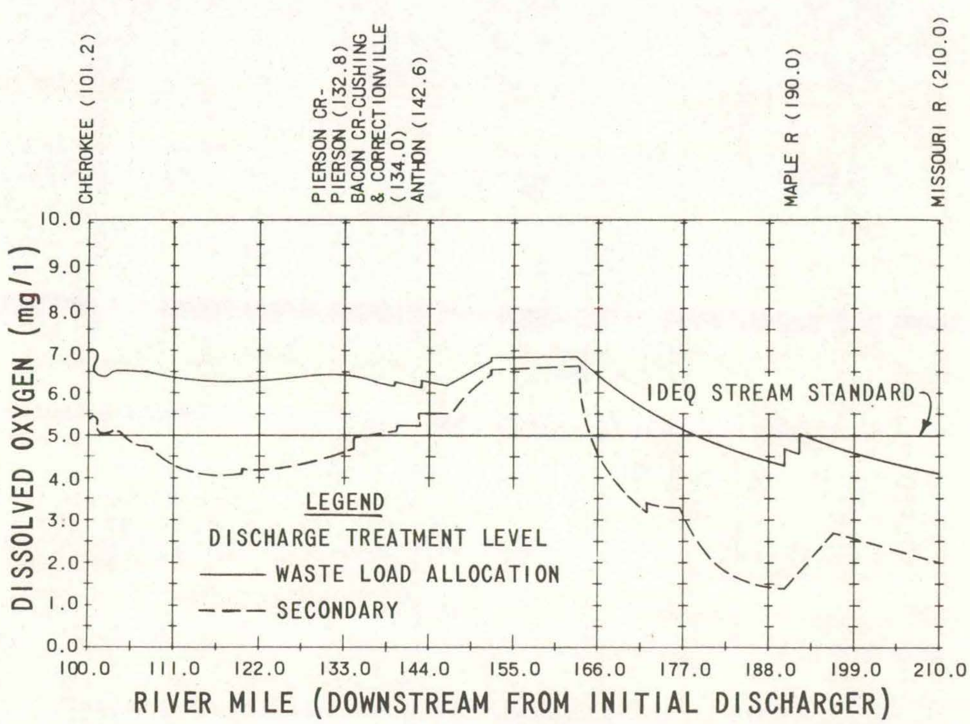


MAPLE RIVER

FIGURE 12
DISSOLVED OXYGEN
CONCENTRATIONS
SUMMER CONDITIONS

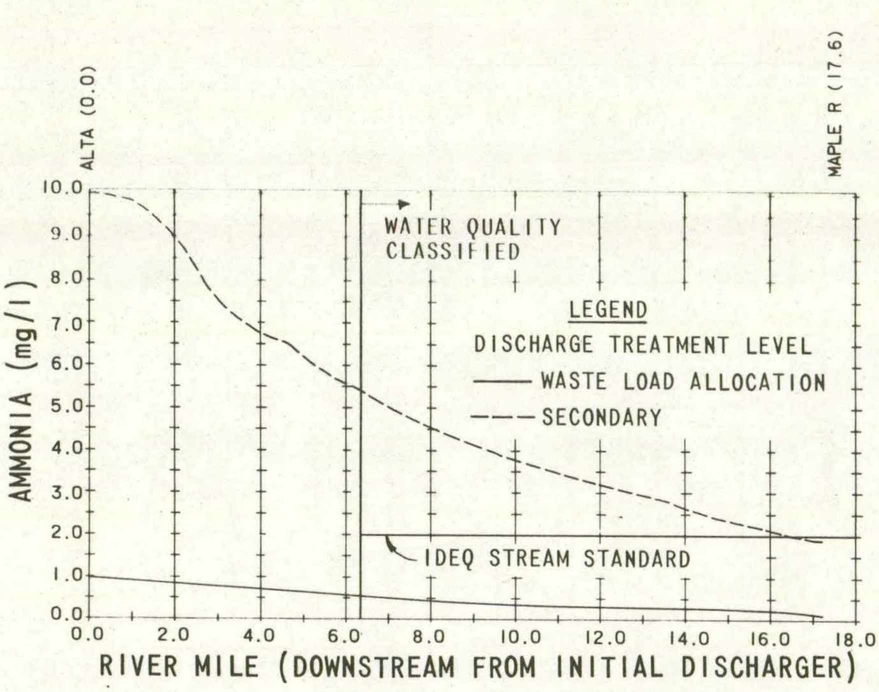


LITTLE SIOUX RIVER

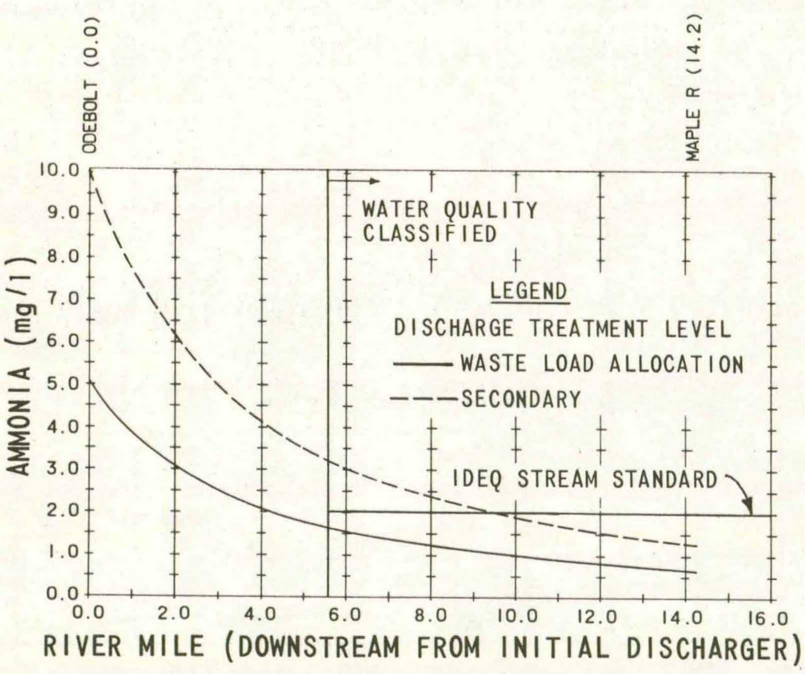


LITTLE SIOUX RIVER

FIGURE 13
DISSOLVED OXYGEN CONCENTRATIONS
LITTLE SIOUX RIVER
SUMMER CONDITIONS

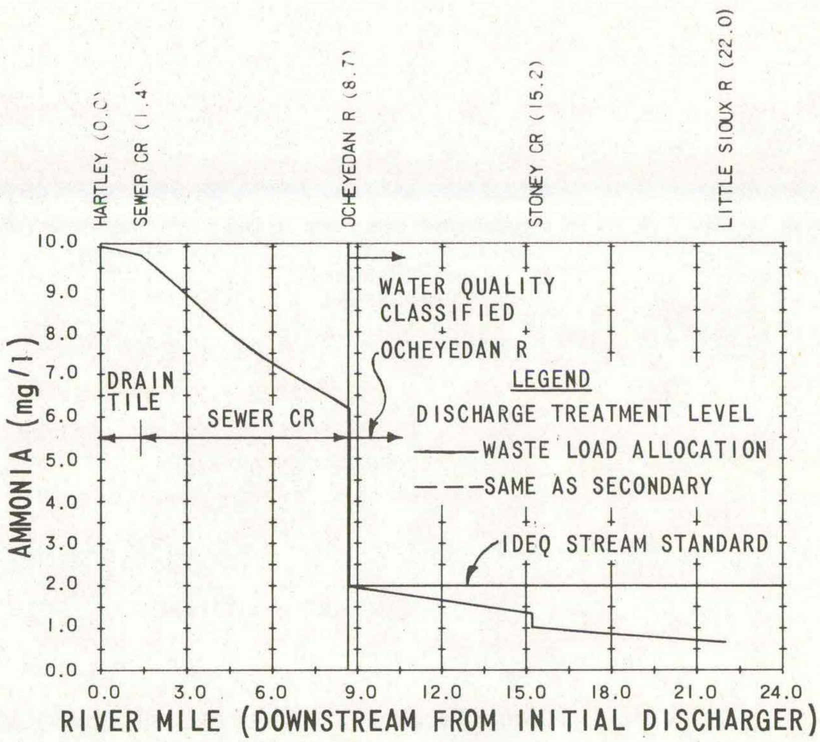


LITTLE MAPLE RIVER

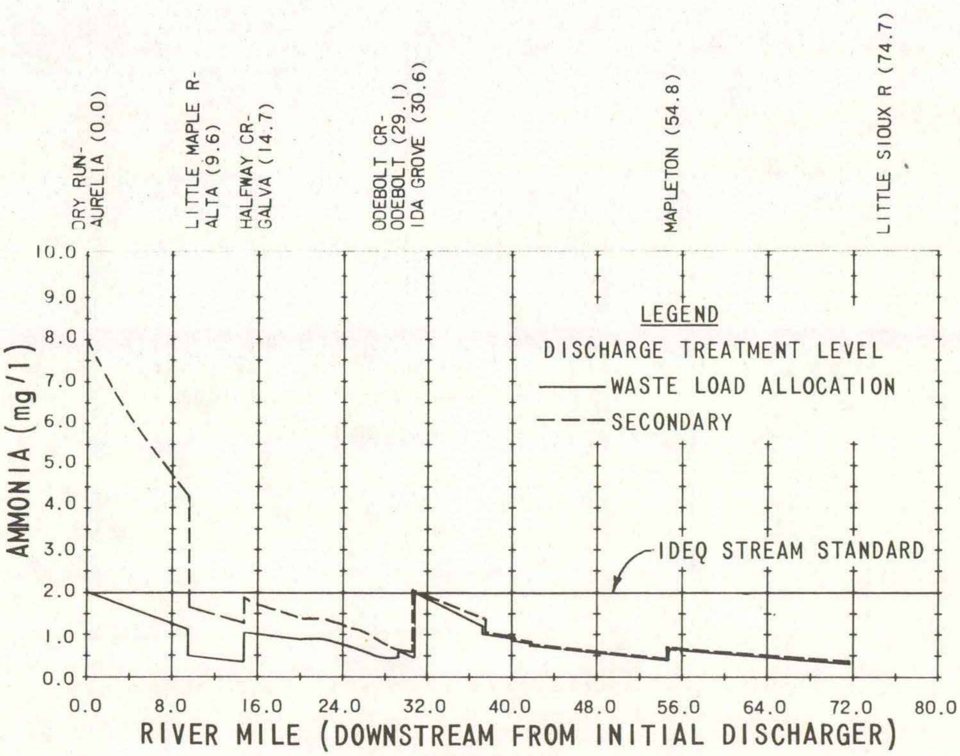


ODEBOLT CREEK

FIGURE 14
AMMONIA NITROGEN
CONCENTRATIONS
SUMMER CONDITIONS

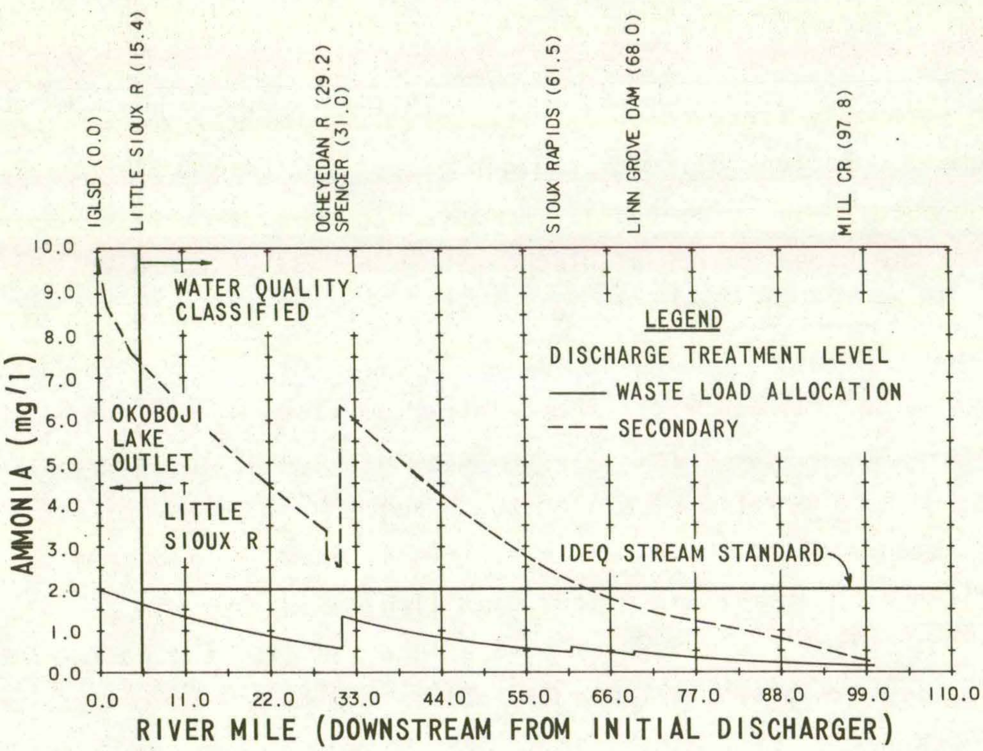


OCHEYEDAN RIVER

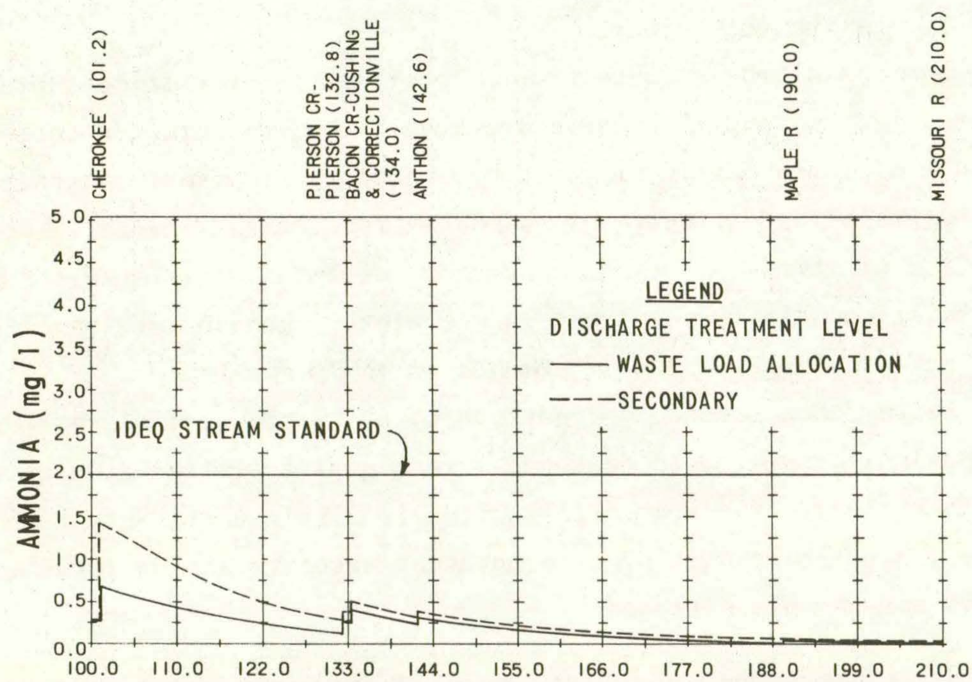


MAPLE RIVER

FIGURE 15
AMMONIA NITROGEN
CONCENTRATIONS
SUMMER CONDITIONS



LITTLE SIOUX RIVER



LITTLE SIOUX RIVER

FIGURE 16
AMMONIA NITROGEN CONCENTRATIONS
LITTLE SIOUX RIVER
SUMMER CONDITIONS

than secondary treatment. All industrial wastewater dishcargers are assumed to be controlled discharges except for Linn Grove Rendering, which needs only to meet BPT. Ammonia nitrogen removal is required of all the above municipal discharges except Galva and Hartley.

Winter Conditions - The allowable ammonia nitrogen concentration for secondary treatment has been set as 15 mg/l for winter conditions by IDEQ. Hydrological data indicate that winter low flows within the study area may be at least an order-of-magnitude less than summer low flows. Exact determination of the ratio of winter to summer low flows is not possible from available data, so the same 7-day, 1-in-10 year low flow has been used in modeling both summer and winter conditions.

Rock River Basin - Waste load allocations for the basin under winter conditions are given in Table 27. Dissolved oxygen concentration profiles for Rock River, Little Rock River, and Otter Creek for both secondary treatment and waste load allocations are shown on Figures 17, 18, and 19, respectively. The small amount of dilution available at low flows and the reduced reaeration rate due to ice cover combine to require better than secondary treatment levels of BOD removal to meet the stream quality criteria of 5.0 mg/l DO for the Rock River.

Ammonia nitrogen concentration profiles for the streams are shown on Figures 17, 18, and 19. There are significant differences between the ammonia nitrogen levels provided by secondary treatment and those necessary in the waste load allocations to meet stream quality criteria because of the lack of stream dilution. Reduction of ammonia nitrogen concentrations in the streams is less evident in the winter than in the summer because of the lack of bio-oxidation of ammonia at low temperatures.

Better than secondary treatment of all wastewater discharges within the basin is required to meet the stream quality criteria which apply to the Rock River. The communities of Hull, Little Rock, Rock Rapids, Rock Valley, and Sibley must provide advanced waste treatment for the removal of BOD and ammonia nitrogen.

TABLE 27

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Rock River							
Rock Rapids (M-20)	0.70	0.220	15	28	2	4	4.0
Mud Creek							
Lester (M-20)		0	Controlled Discharge				
Alvord (M-2)		0	Controlled Discharge				
Little Rock River							
Little Rock (M-21)	0.74	0.040	15	5	4	1	4.0
George (M-16)		0	Controlled Discharge				
Otter Creek							
Sibley (M-33)	0.74	0.356	20	59	3	9	4.0
Sibley Municipal Utilities (I-7)	0.74	0.030	No Discharge Limitations Necessary[3]				
Ashton (M-5)		0	Controlled Discharge				
Hallet Constructon Co. - Ashton (I-2)			No Discharge Limitations Necessary[3]				
Matlock (M-23)		-	No Existing Municipal Facility				
Little Rock River							
Doon (M-14)		0	Controlled Discharge				
Burr Oak Creek							
Hull (M-18)	0.69	0.108	18	16	4	4	4.0

TABLE 27 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

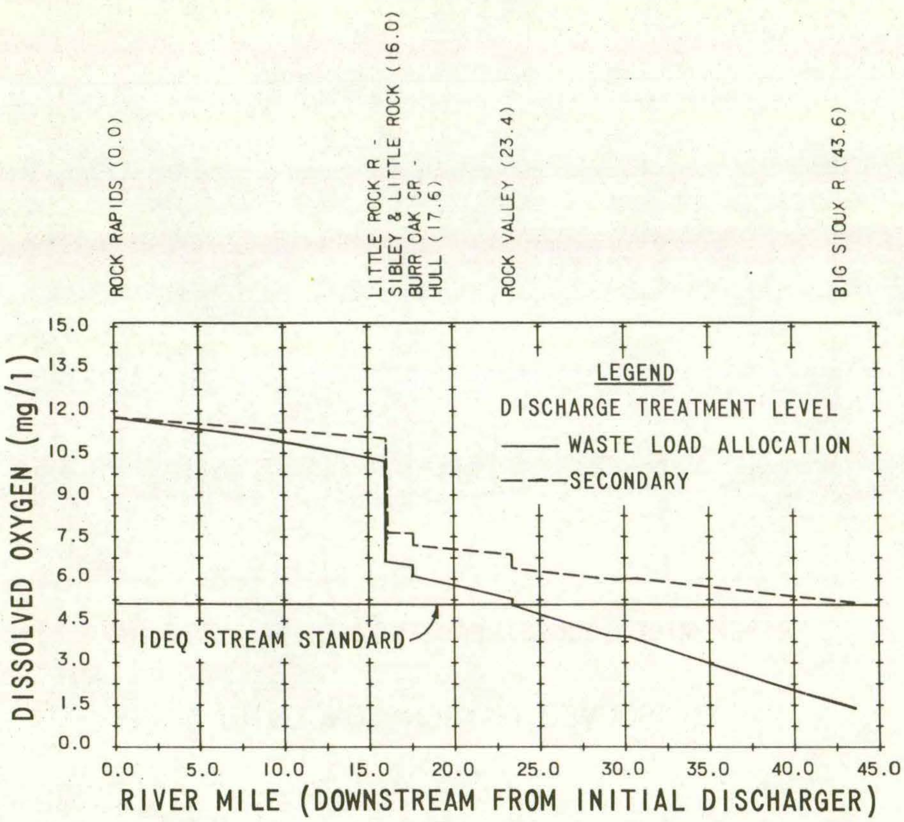
1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Rock River							
Rock Valley (M-30)	0.63	0.130	15	16	4	4	4.0

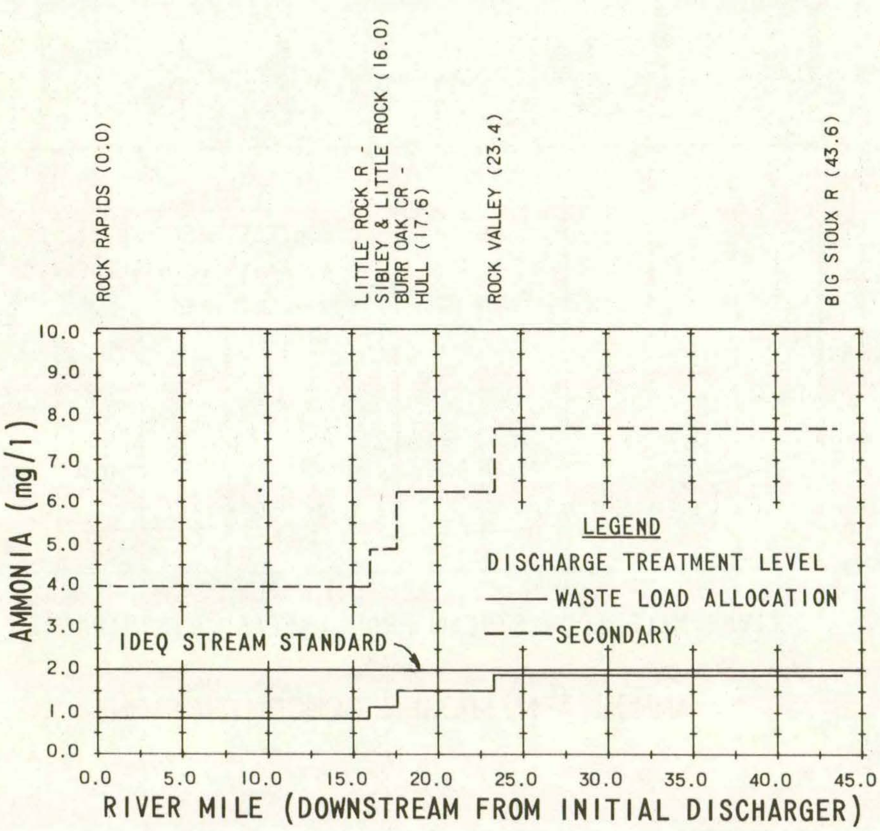
[1] Seven-day, 1-in-10 year low flow in stream just above point of discharge, if stream is classified; or flow of classified stream at confluence with tributary.

[2] UBOD = 1.5 (BOD_5).

[3] No waste load alloctation is necessary; low quantities of BOD and ammonia nitrogen in effluent.

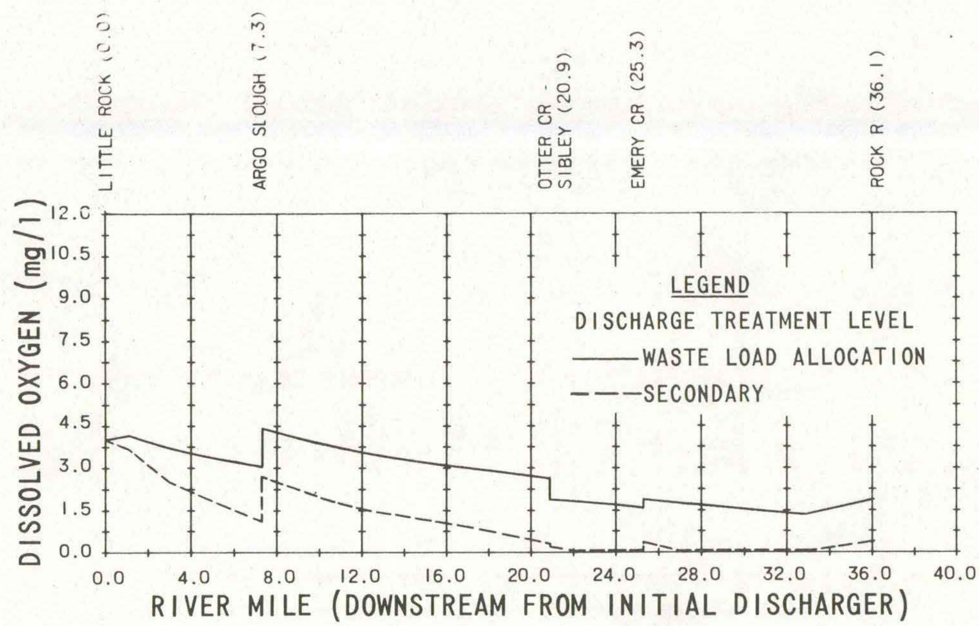


DISSOLVED OXYGEN CONCENTRATIONS

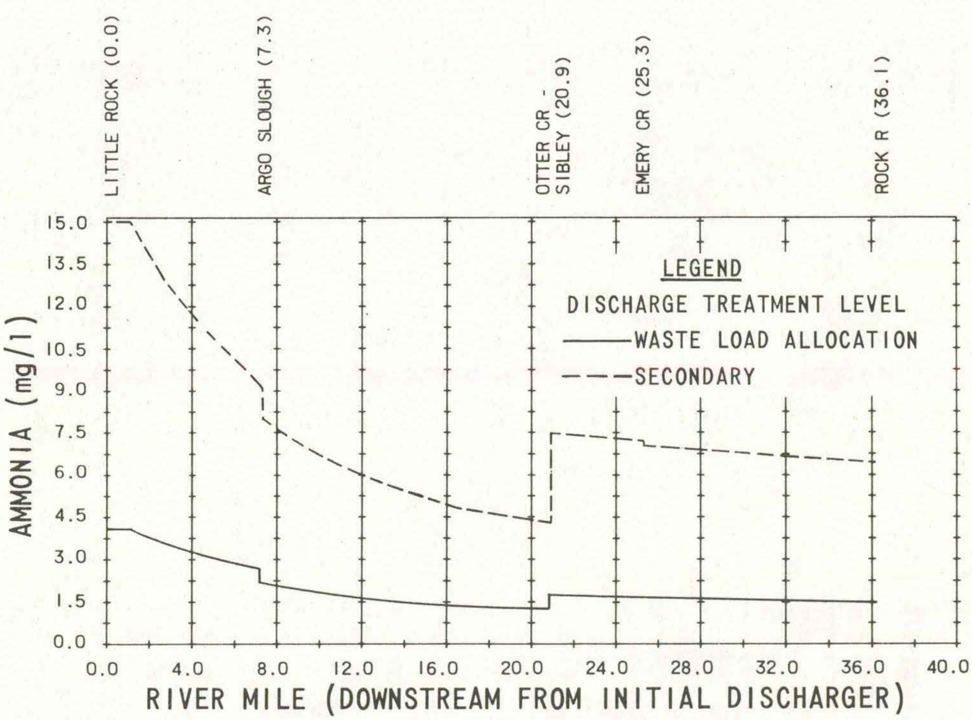


AMMONIA NITROGEN CONCENTRATIONS

FIGURE 17
ROCK RIVER
WINTER CONDITIONS

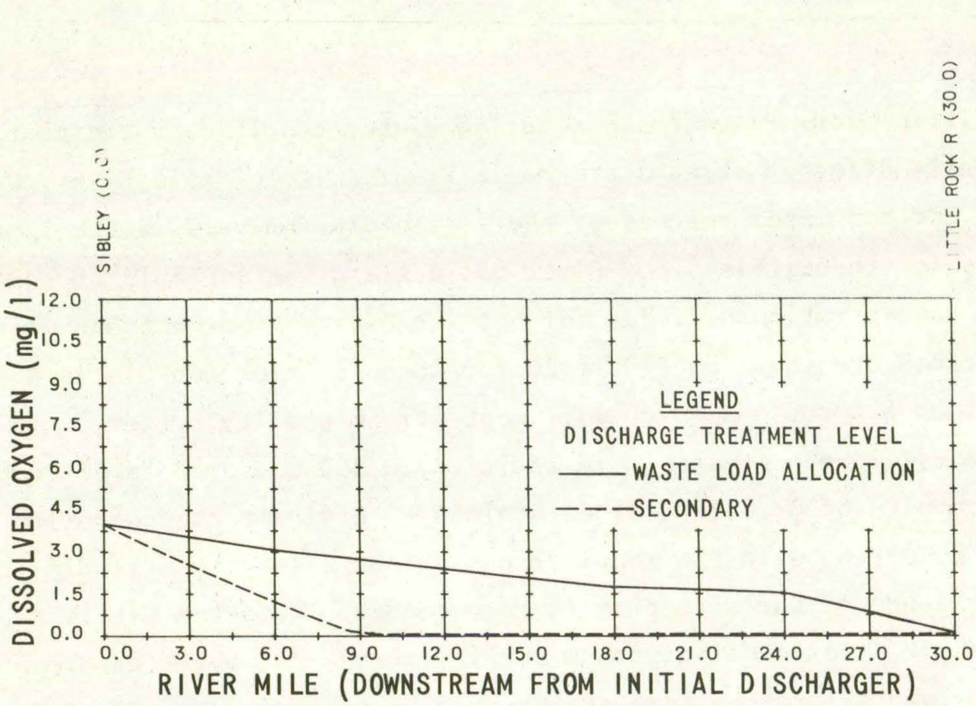


DISSOLVED OXYGEN CONCENTRATIONS

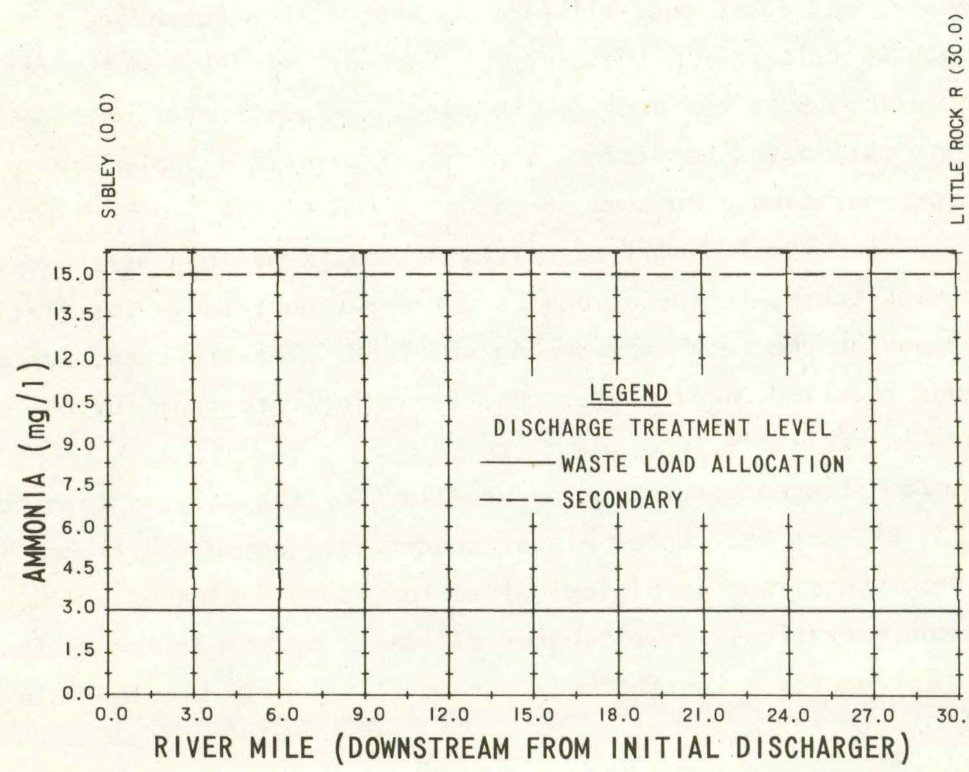


AMMONIA NITROGEN CONCENTRATIONS

FIGURE 18
LITTLE ROCK RIVER
WINTER CONDITIONS



DISSOLVED OXYGEN CONCENTRATIONS



AMMONIA NITROGEN CONCENTRATIONS

FIGURE 19
OTTER CREEK
WINTER CONDITIONS

Little Sioux River Basin - During winter conditions, the most critically affected streams are Maple River, Little Maple River, Odebolt Creek, and the upper reaches of the little Sioux River. Waste load allocations for the Little Sioux River Basin are given in Table 28. Dissolved oxygen concentration profiles for both secondary treatment and waste load allocations are shown on Figure 20 for Odebolt Creek and Little Maple River. Waste load allocations which will meet stream quality criteria are extremely stringent for both streams. In addition to BOD and ammonia nitrogen removal, the community of Odebolt must maintain a DO effluent concentration of 12.0 mg/l. Complying with the required waste load allocations is difficult and further study of the situation is recommended. With the Little Maple River and Odebolt Creek meeting stream quality standards, only Ida Grove requires a waste load allocation more stringent than secondary treatment for the Maple River to meet the DO criteria of 5.0 mg/l. Dissolved oxygen concentration profiles for both the Maple River and the Ocheyedan River are shown on Figure 21. Profiles for the Little Sioux River are shown on Figure 22 for both waste load allocation and secondary treatment conditions. Cherokee, Spencer, and IGLSD must all provide better than secondary treatment to approach DO criteria in the stream. Spencer and IGLSD must meet extremely stringent allocations and provide the specified post-aeration levels given in Talbe 28 to obtain the conditions shown on Figure 22. Sioux Rapids must also provide post-aeration. In some sections of the Little Sioux River, it is not possible to meet the 5.0 mg/l DO criteria because as long as there are oxygen demanding substances in the stream, the reaeration rate is insufficient to supply oxygen at the rate it is being utilized. The stringent waste load allocations required under winter conditions indicate that further study of the stream is desirable.

Ammonia nitrogen concentration profiles for the streams are shown on Figures 23, 24, and 25. Under winter conditions, ammonia nitrogen is not removed from the stream by biological action, so dilution of ammonia nitrogen concentrations in wastewater effluents by streamflow is the only means of meeting the criteria. Low stream dilution in Little Maple River,

TABLE 28

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River							
Silver Lake							
Lake Park (M-45)		0	Controlled Discharge				
Spirit Lake							
Orleans (M-52)			To Iowa Great Lakes Sanitary District				
Iowa Electric Light & Power (I-10)			No Discharge Limitations Necessary[3]				
East Okoboji Lake							
Spirit Lake (M-61)			To Iowa Great Lakes Sanitary District				
West Okoboji Lake							
Okoboji (M-51)			To Iowa Great Lakes Sanitary District				
Arnolds Park (M-37)			To Iowa Great Lakes Sanitary District				
West Okoboji (M-66)			To Iowa Great Lakes Sanitary District				
Okoboji Lake Outlet							
Iowa Great Lakes Sanitary District (M-70)	0.00	2.146	9	161	2	36	6.0
Milford (M-48)			To Iowa Great Lakes Sanitary District				
Ocheyedan River							
Rush Lake Outlet							
Ocheyedan (M-50)		0	Controlled Discharge				
Dry Run							
Harris (M-43)		0	Controlled Discharge				

TABLE 28 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Ocheyedan River (cont.)							
Sewer Creek							
Hartley (M-44)	0.40	0.181	45[4]	45	5	5	4.0
Ocheyedan River							
Everly (M-4)		0	Controlled Discharge				
Spring Creek							
Royal (M-57)		0	Controlled Discharge				
Ocheyedan River							
Cornbelt Power Co-op. (I-9)			No Discharge Limitations Necessary[3]				
Little Sioux River							
Spencer (M-60)	2.40	2.560	6	128	2	43	7.0
Spencer Rendering Plant (I-14)			To Municipal Treatment Facility				
Spencer Municipal Plant (I-13)			No Discharge Data Available				
Big Muddy Creek							
Superior (M-62)			No Existing Municipal Facility				
Little Muddy Creek							
Fostoria (M-41)		0	Controlled Discharge				

TABLE 28 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Lost Island Outlet							
Drainage Ditch #61							
Terrill (M-64)		0	Controlled Discharge				
Lost Island Outlet							
Dickens (M-39)		-	No Existing Municipal Facility				
Drainage Ditch #60							
Ruthven (M-58)		0	Controlled Discharge				
Montgomery Creek							
Webb (M-65)		-	No Existing Municipal Facility				
Willow Creek							
Moneta (M-49)		-	No Existing Municipal Facility				
Rossi (M-56)		-	No Existing Municipal Facility				
Greenville (M-42)		-	No Existing Municipal Facility				
Little Sioux River							
Sioux Rapids (M-59)	4.75	0.054	45	20	15	7	6.0
Linn Grove (M-47)		0	Controlled Discharge				
Linn Grove Rendering (I-11)	4.60	0.014	45	5	20	2	4.0
Peterson (M-54)		-	Controlled Discharge				
Waterman Creek							
Sutherland (M-63)		0	Controlled Discharge				

TABLE 28 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Mill Creek							
Dry Run							
Primghar (M-55)		0	Controlled Discharge				
Mill Creek							
Paullina (M-53)		0	Controlled Discharge				
Willow Creek							
Mugge Creek							
Calumet (M-38)		-	No Existing Municipal Facility				
Gray Creek							
Larrabee (M-46)		0	Controlled Discharge				
Hill Creek							
Meriden (M-24)		0	Controlled Discharge				
Little Sioux River							
Cherokee (M-9)	5.57	0.756	15	95	4	25	5.0
Hallett Construction Co. - Cherokee (I-3)			No Discharge Limitations Necessary[3]				
Cherokee Industrial Site (Wilson Packing Plant) (M-69)		0	Controlled Discharge				

TABLE 28 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Railroad Creek							
Meadow Brook Mobile Home Court (S-2)		0	Controlled Discharge				
Little Sioux River							
Cherokee Mental Health Institute (S-1)			To Municipal Facility				
Quimby (M-28)		0	Controlled Discharge				
Simonsen Mill & Rendering Plant, Inc. (I-8)		0	Controlled Discharge				
Willow Creek							
Cleghorn (M-10)		0	Controlled Discharge				
Little Sioux River							
Washta (M-36)		0	Controlled Discharge				
Pierson Creek							
Pierson (M-27)	7.27	0.074	45[5]	28	15[5]	9	4.0
Bacon Creek							
Cushing (M-12)	7.61	0.039	45[5]	15	15[5]	5	4.0
Correctionville (M-11)	7.61	0.163	45[5]	61	15[5]	20	4.0

TABLE 28 (Cont)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River							
Anthon (M-3)	10.14	0.085	45[5]	32	15[5]	11	4.0
Oto (M-26)		-		No Existing Municipal Facility			
Smokey Hollow Creek							
Smithland (M-34)		0		Controlled Discharge			
Little Sioux River							
Rodney (M-31)		-		No Existing Municipal Facility			
Maple River							
Dry Creek Bed							
Aurelia (M-6)	0.00	0.128	12	13	1.5	2	8.0
Little Maple River							
Alta (M-1)	0.00	0.229	1.5	3	2	4	4.0
Halfway Creek							
Schaller (M-32)		0		Controlled Discharge			
Pork Processors, Inc. (I-4)		0		Controlled Discharge			
Galva (M-15)	0.23	0.020	12	2	7	1	4.0
Odebolt Creek							
Odebolt (M-25)	0.24	0.149	5	6	1	1	12.0
Selected Casing (I-6)				To Municipal Facility			
Un-named Creek							
Arthur (M-4)		0		Controlled Discharge			

TABLE 28 (Cont.)

WASTE LOAD ALLOCATION

7-DAY, 1-IN-10 YEAR LOW FLOW

1990 WINTER CONDITIONS

Discharger (Ref. No.)	Stream Flow[1] (mgd)	1990 Discharge (mgd)	Ultimate BOD[2] (mg/l)	Ultimate BOD[2] (lb/day)	Ammonia Nitrogen (N) (mg/l)	Ammonia Nitrogen (N) (lb/day)	Effluent Dissolved Oxygen (mg/l)
Little Sioux River (cont.)							
Maple River (cont.)							
Ida Grove (M-19)	1.16	0.220	30	55	7	13	4.0
Deluxe Motel (I-1)			No Discharge Data Available				
Battle Creek							
Holstein (M-17)		0	Controlled Discharge				
Robert Bagenstos Slaughter House (I-5)			No Discharge Data Available				
Maple River							
Battle Creek (M-7)		0	Controlled Discharge				
Danbury (M-13)		0	Controlled Discharge				
Mapleton (M-22)	3.61	0.116	45[4]	44	15[4]	15	4.0
Castana (M-8)		-	No Existing Municipal Facility				
Turin (M-35)		0	Controlled Discharge				

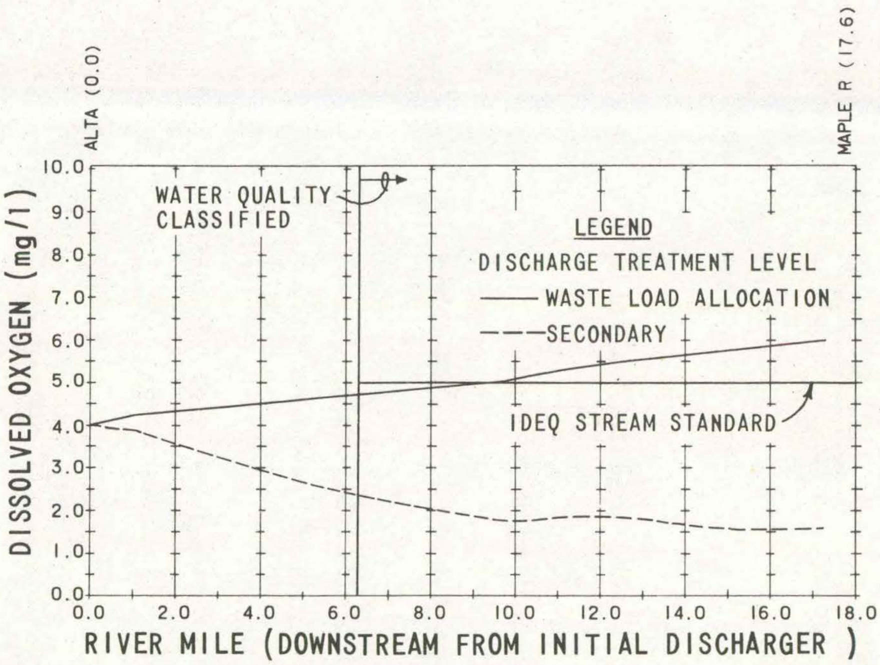
[1] Seven-day, 1-in-10 year low flow in stream just above point of discharge, if stream is classified; or flow of classified stream at confluence with tributary.

[2] UBOD = 1.5 (BOD_5).

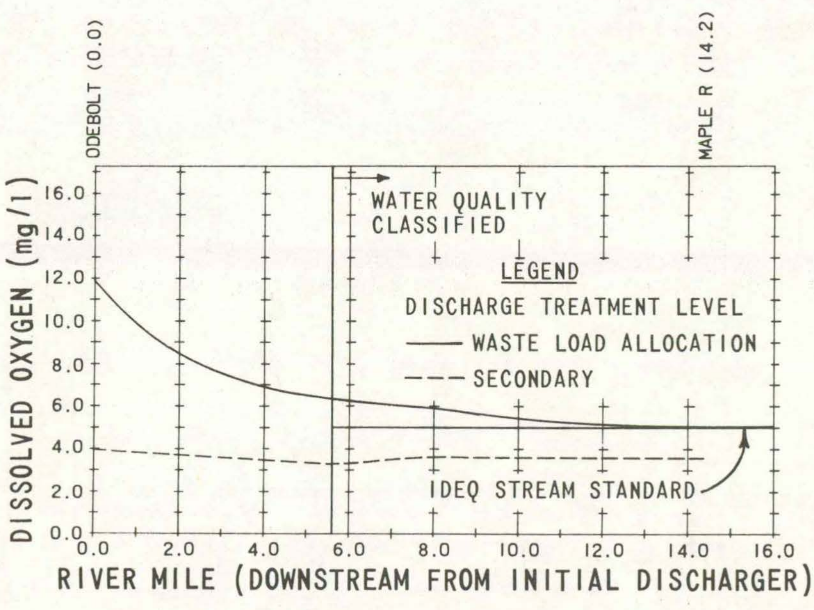
[3] No waste load allocation is necessary; low quantities of BOD and ammonia nitrogen in effluent.

[4] Meets BPWTT guidelines. Higher discharge quantities could satisfy stream criteria.

[5] Meets BPWTT guidelines. Could be higher without affecting stream profiles significantly.

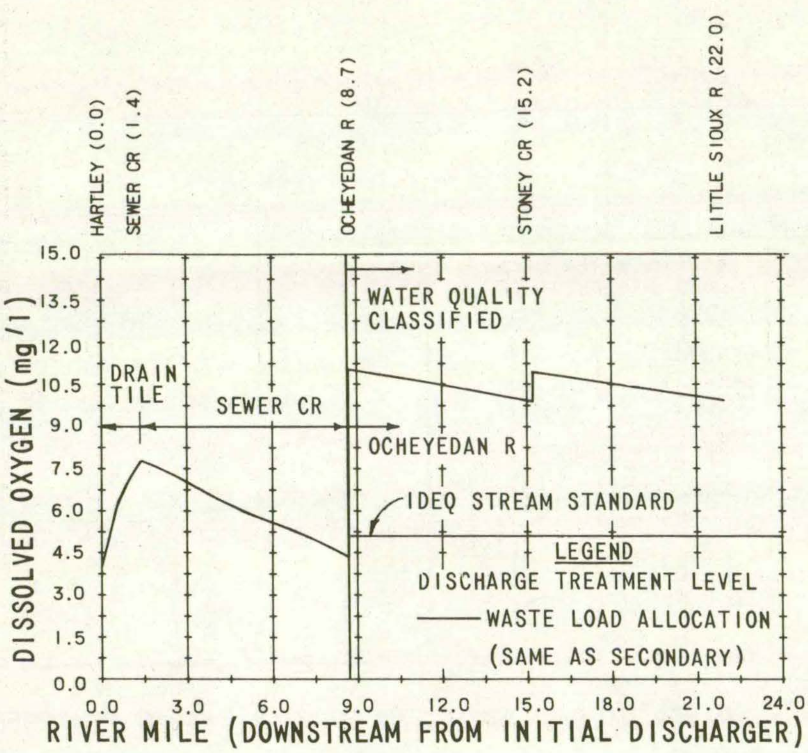


LITTLE MAPLE RIVER

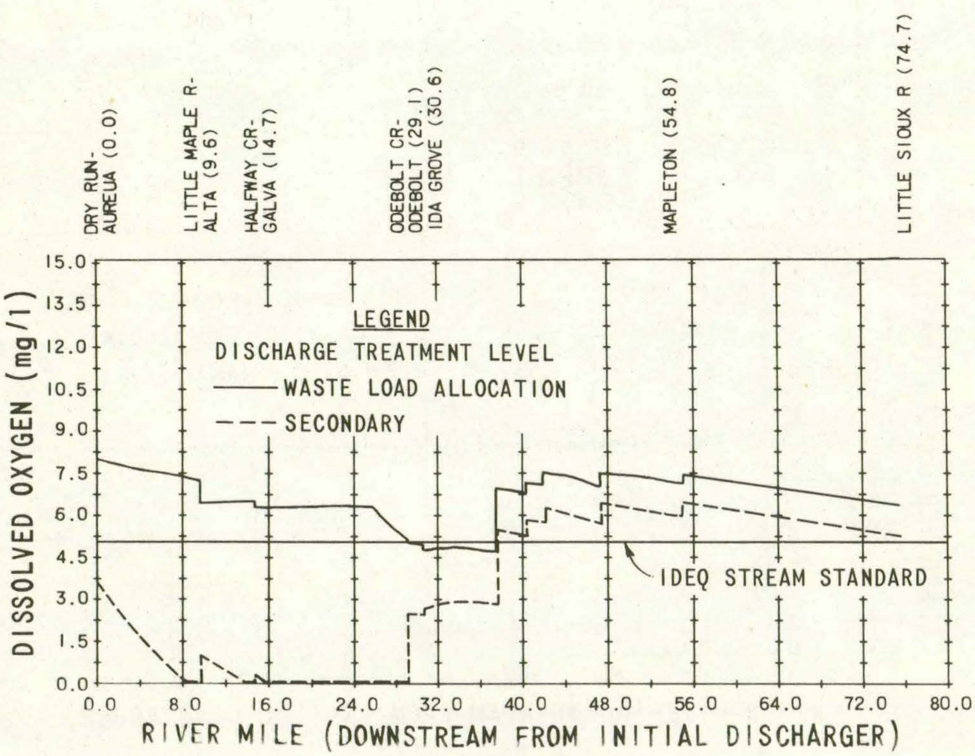


ODEBOLT CREEK

FIGURE 20
DISSOLVED OXYGEN
CONCENTRATIONS
WINTER CONDITIONS

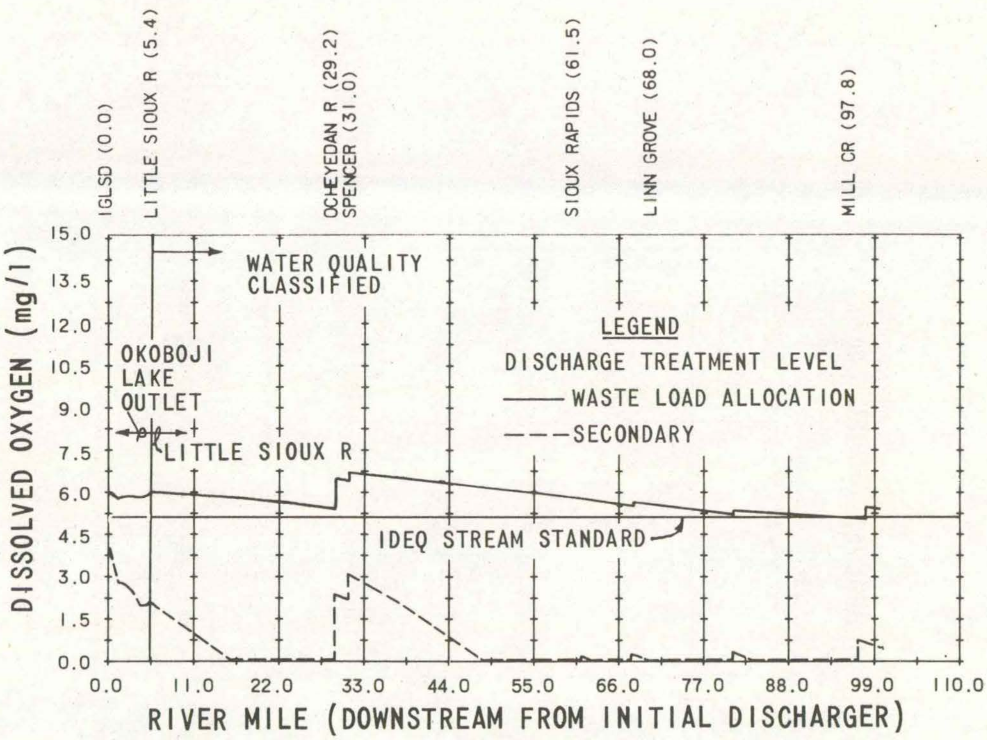


OCHEYEDAN RIVER

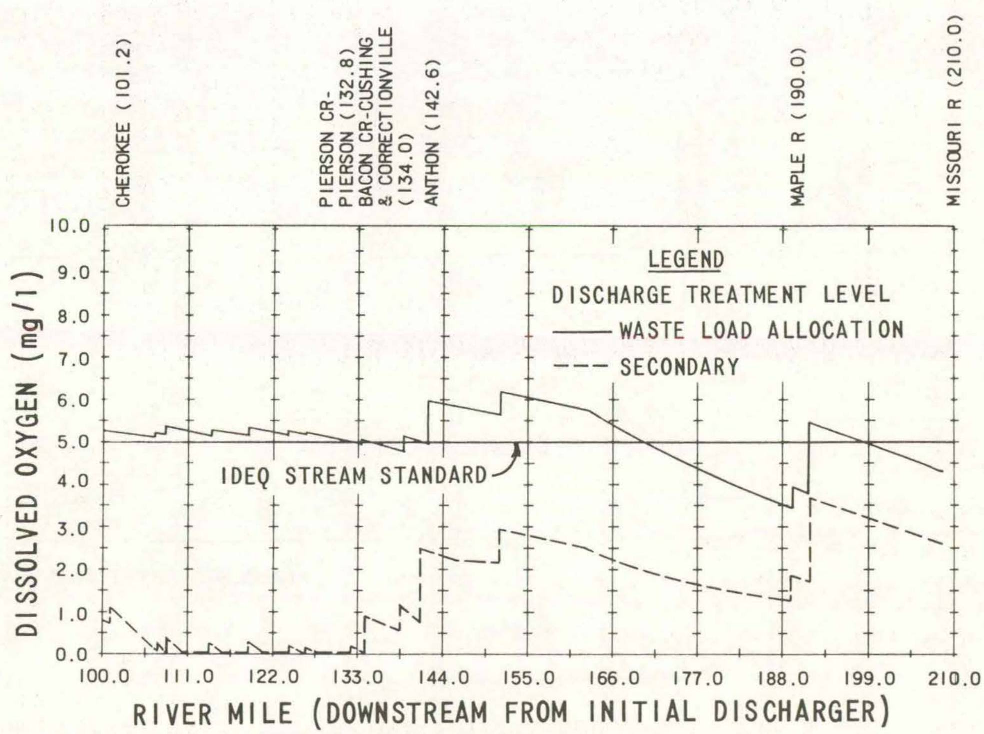


MAPLE RIVER

FIGURE 21
DISSOLVED OXYGEN
CONCENTRATIONS
WINTER CONDITIONS

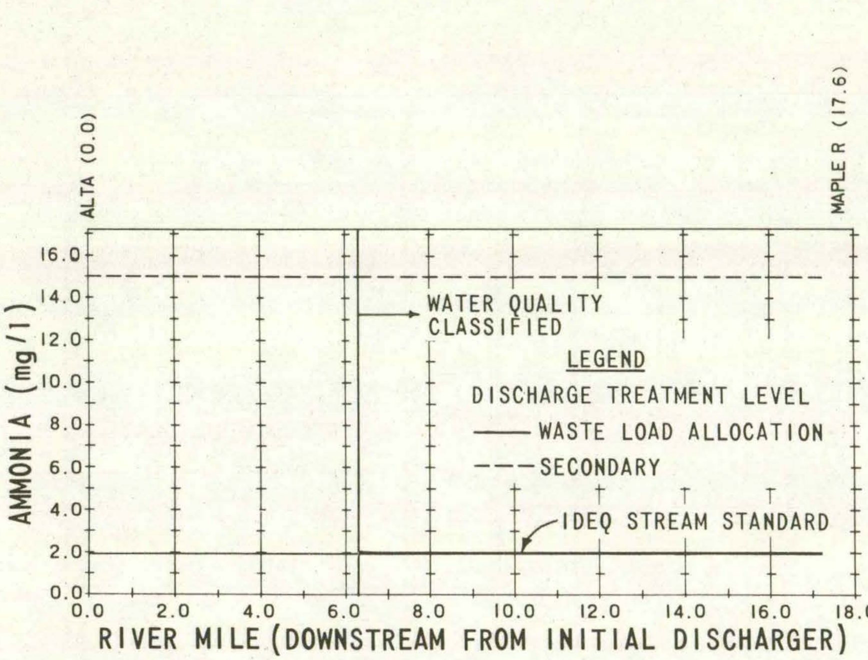


LITTLE SIOUX RIVER

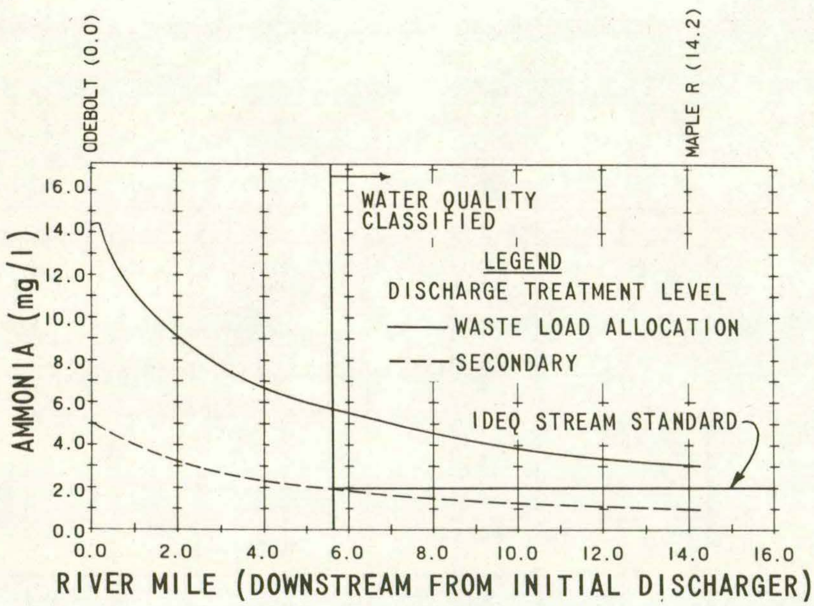


LITTLE SIOUX RIVER

FIGURE 22
DISSOLVED OXYGEN CONCENTRATIONS
LITTLE SIOUX RIVER
WINTER CONDITIONS

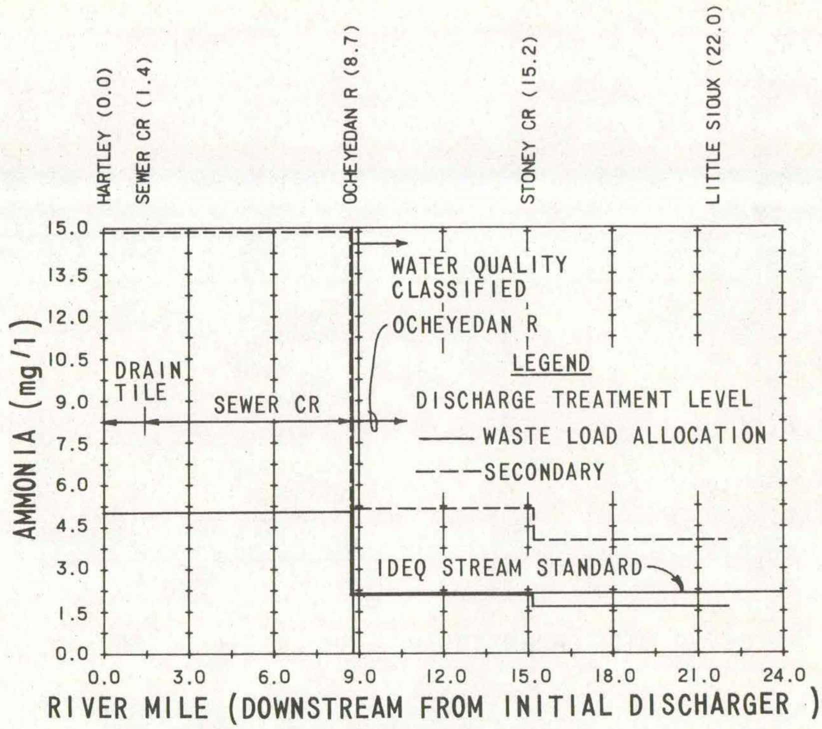


LITTLE MAPLE RIVER

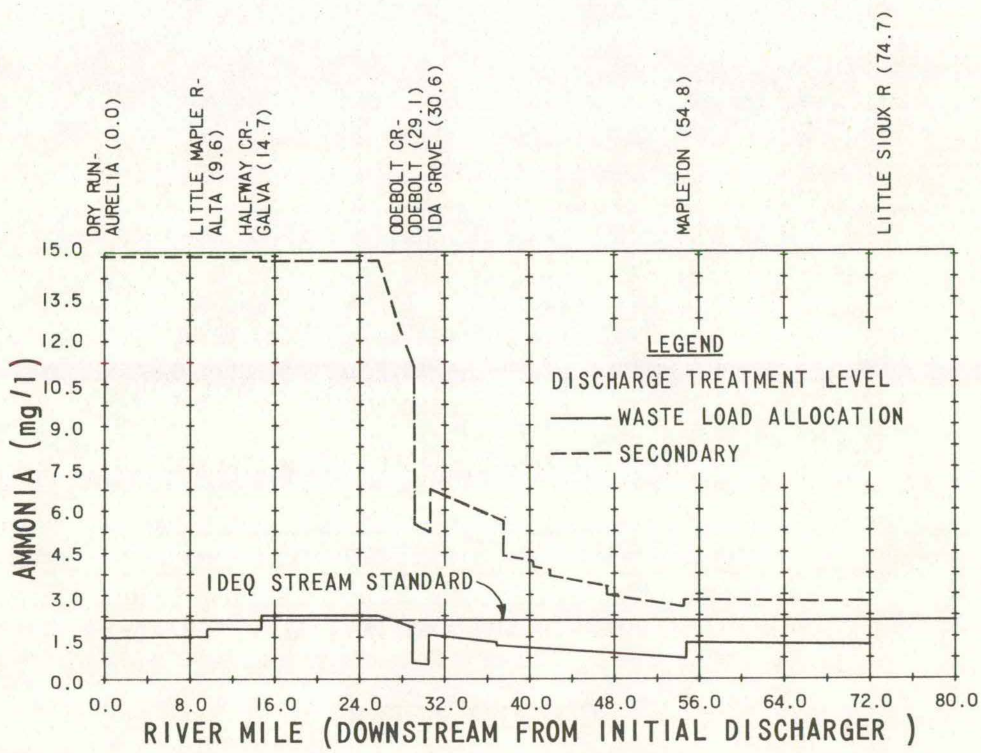


ODEBOLT CREEK

FIGURE 23
AMMONIA NITROGEN
CONCENTRATIONS
WINTER CONDITIONS

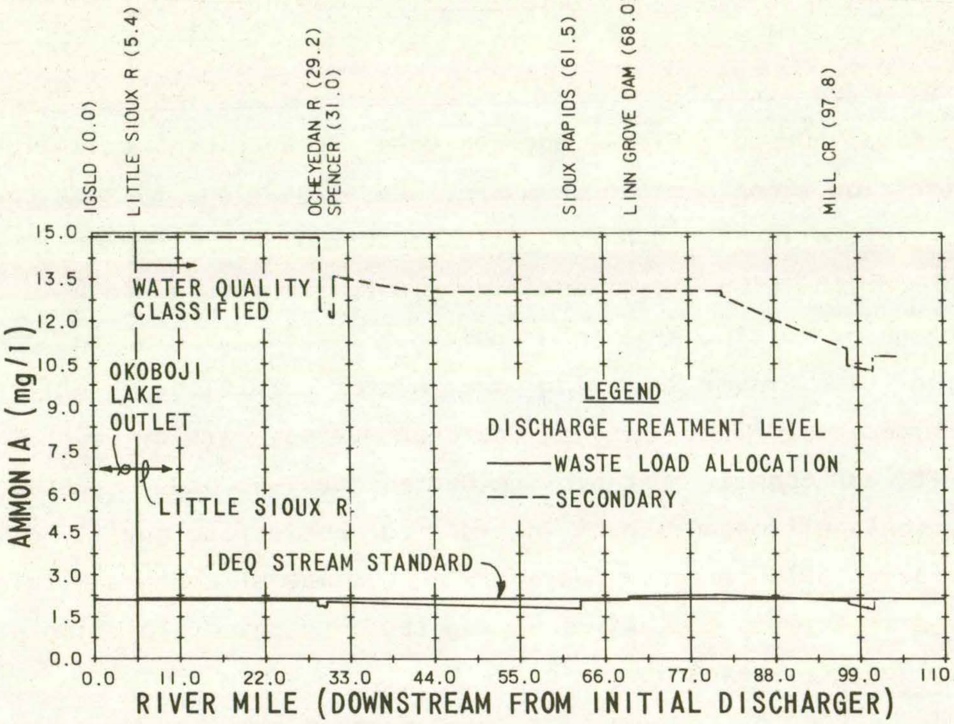


OCHEYEDAN RIVER

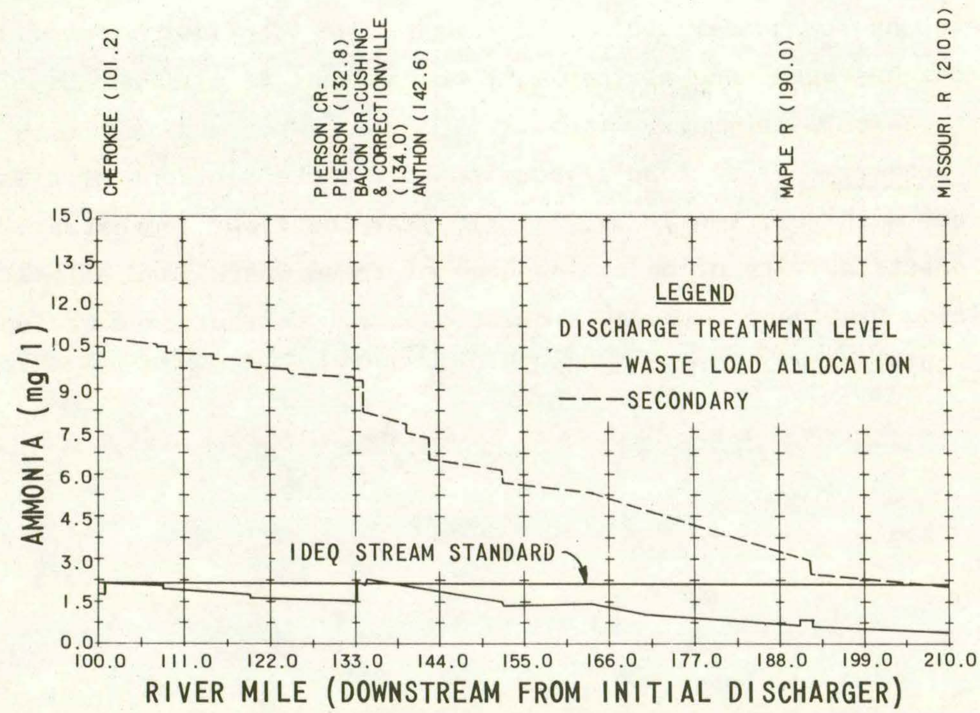


MAPLE RIVER

FIGURE 24
AMMONIA NITROGEN
CONCENTRATIONS
WINTER CONDITIONS



LITTLE SIOUX RIVER



LITTLE SIOUX RIVER

FIGURE 25
AMMONIA NITROGEN CONCENTRATIONS
LITTLE SIOUX RIVER
WINTER CONDITIONS

Maple River, Odebolt Creek, and the upper reaches of Little Sioux River requires low ammonia nitrogen waste load allocations to meet the stream quality criteria of 2.0 mg/l. All industries within the study area, except for the Linn Grove Rendering Plant, are assumed to have controlled dishcarge or to discharge to a municipal system. The waste load allocation for Line Grover Rendering under winter conditions is BPT. Wastewater discharges from Alta, Aurelia, Cherokee, Galva, Hartley, IGLSD, Ida Grove, Odebolt, and Spencer must provide better than secondary treatment levels for ammonia nitrogen removal in order to meet stream quality criteria.

Thermal Discharges - There are no thermal discharges within the study area streams of sufficient magnitude to cause violation of the stream quality standards.

Waste Load Allocations for Non-regulated Substances - Within the study area, the main type of wastewater discharges which could have an impact upon the aquatic environment but are not covered by water quality standards are sludge discharges from potable water treatment plants. The main pollutant constituent of these discharges is suspended solids, which is not covered by Iowa water quality standards. No identification of these discharges has been done as they will be effluent limited and usually restricted to zero discharge.

Summary - Waste load allocations for those sections of classified streams with very low 7-day, 1-in-10 year low flows are extremely stringent. The practicability of obtaining some of these waste load allocations with existing treatment methods is questionable. Further examination of these particular cases is recommended.

Respectfully submitted,

STANLEY CONSULTANTS, INC.

By ______________________
Sharon L. Carter

By ______________________
R. John Tagg

Approved by ______________________
Robert L. Thoem

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Iowa.

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Robert L. Thoem

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