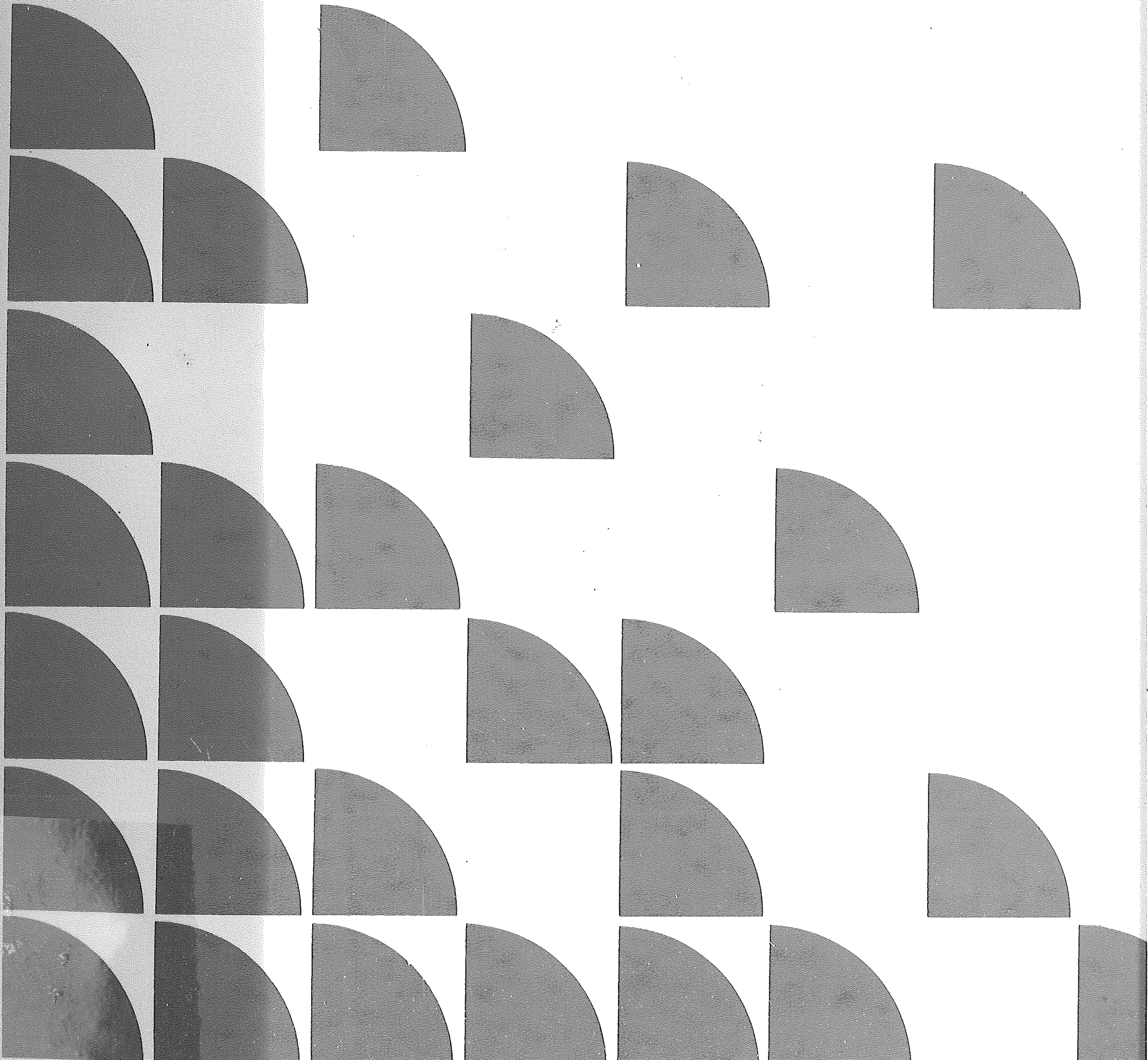
Baseline Environmental Inventory
Twin Cities Metropolitan Area

Metropolitan Waste Control Commission
201 Facility Study
Working For Water Quality



Baseline Environmental Inventory
Twin Cities Metropolitan Area

Metropolitan Waste Control Commission
201 Facility Study
Working For Water Quality

December 1977

E. A. Hickok and Associates

InterDesign, Inc.
David Braslau and Associates
Robert C. Einsweiler, Inc.
Dr. Dwain Warner, University of Minnesota

This inventory was funded, in part, through a grant from the United States Environmental Protection Agency under the construction grant programs, Section 201, of Public Law 92-500.

PREFACE

The Metropolitan Waste Control Commission is charged with the responsibility for developing an area-wide wastewater facilities plan for the seven-county metropolitan area under Section 201 of Public Law 92-500. An important element of this Facilities Plan is the baseline inventory of the area's environmental resources. The environmental inventory will serve as a reference point for numerous aspects of future investigations as well as the Facilities Plan. The environmental features included in the environmental inventory are those associated with and affected by wastewater treatment projects.

The overall objective of the environmental inventory is to describe existing conditions in the metropolitan area without the proposed project. The inventory is intended to describe existing natural features, resources and conditions, and to provide a baseline for further evaluation of the environmental impacts of various selected alternatives. The inventory provides an integrated comprehensive data base for use by the MWCC staff and their consultants. The data base will be useful to MWCC facilities planning staff as they work on the major segments of the Plan. Existing information is used throughout the inventory, which thus dates the study. The information included in the inventory is current as of date of completion.

The format of the inventory has been designed so that new information or additional information can be added to the report as it becomes available. Much of the information in the report is general in nature due to the volume of detailed information that is available. The references are particularly useful to locate more detailed information. The references have been described so that the user can determine in an efficient manner whether the reference is of interest to the user for his particular concern. Graphical representation of data is an objective of the inventory. Much of the existing information is presented in graphic form. Sources for the illustrations are shown on the graphics and more detailed information is available from the referenced sources.

For a site specific environmental assessment more detailed information is required. The inventory outlines for the investigator sources of detailed information for specific sites.

The firm of E.A. Hickok and Associates was the prime consultant for the development of this inventory. The firm of InterDesign Inc. was responsible for tasks involving land use, land quality, plant association, and aesthetic, educational, scarce or unique, cultural and historic features. The firm of David Braslau and Associates was responsible for the air and energy portions of the project. Dr. Dwain Warner, Professor of Zoology, University of Minnesota, prepared the animal population inventory and Robert C. Einsweiler, Inc. assisted in the environmental constraints aspects of the inventory.

This inventory was funded, in part, through a grant from the United States Environmental Protection Agency under the construction grant programs, Section 201, of Public Law 92-500.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

SECTION 10 ENERGY

SECTION 11 WATER RESOURCES

SECTION 12 AIR QUALITY

SECTION 13 LAND/WATER INTERFACE

TABLE OF CONTENTS

SECTION 14

LAND USE

SECTION 15

AGRICULTURE

SECTION 16

ENDANGERED AND THREATENED PLANT AND ANIMAL SPECIES

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF PLATES

PLATE NUMBER TITLE

LIST OF APPENDICES

LIST OF APPENDICES

SECTION 1 CLIMATE

GENERAL

Information on climate may affect the design and operation of areawide treatment facilities. There is variation in parameters such as temperature and precipitation within the metropolitan area.

TEMPERATURE

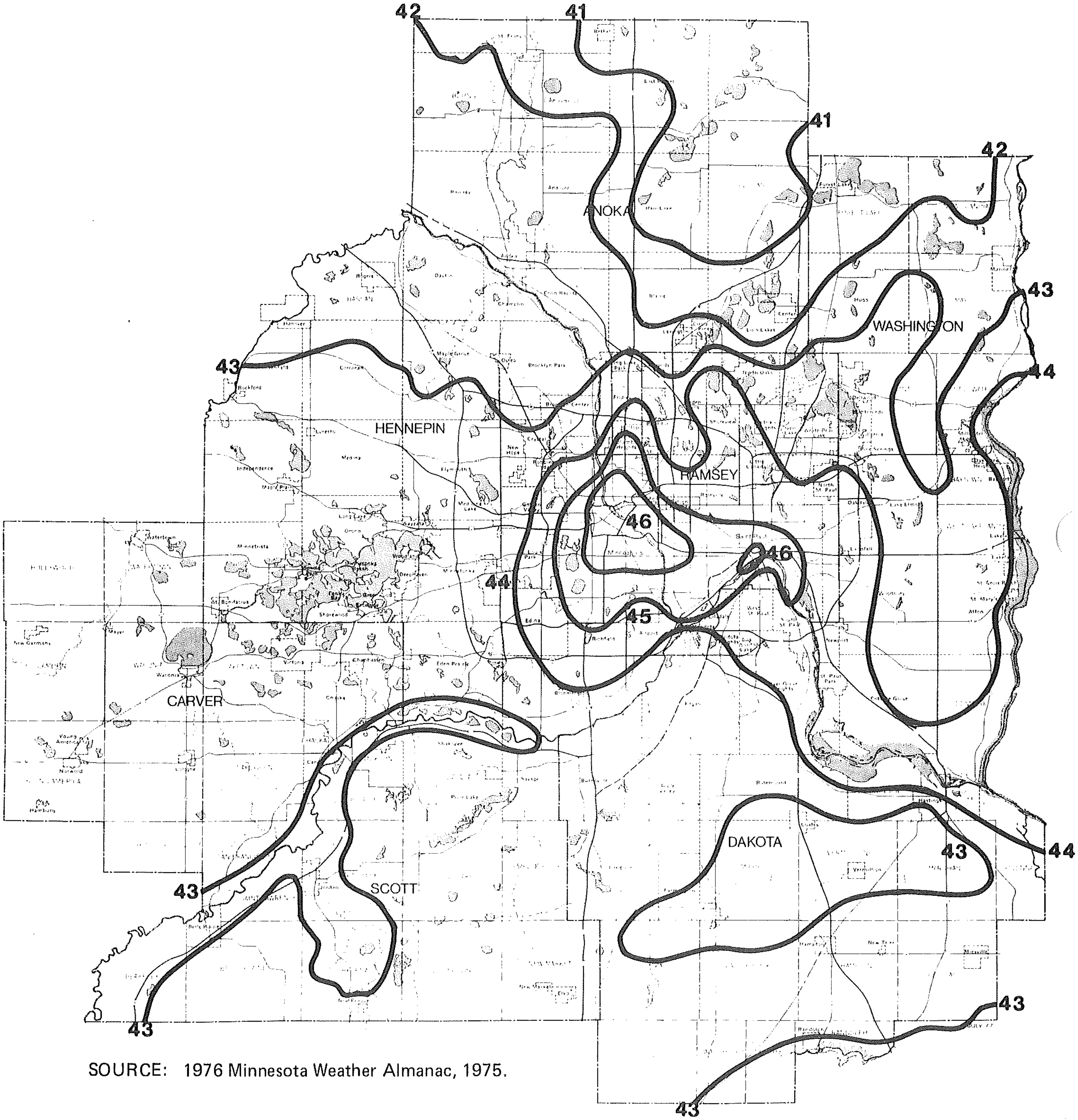
The mean annual temperature over the metropolitan area ranges from 41° Farenheit (F) to 46° F.

Figure 1–1, illustrating mean annual temperatures shows:

1. Temperature values decrease from south to north
2. Enhanced temperature values cover the most built-up areas; maximum values occur over downtown Minneapolis and downtown St. Paul. The Minneapolis maximum is greater.
3. Coldest temperatures are found in northeast Anoka County, in Ham Lake, Bethel, Columbus, and Linwood Townships, and in the Carlos Avery marshland and its environs.
4. Cold areas are illustrated in the Minnesota River Valley from Eden Prairie to points upstream, the Vermillion and Cannon River Valleys and the Sand Creek Valley.
5. Warmer temperatures are found in the St. Croix Valley and Mississippi Valley. This warm is best illustrated below St. Anthony Falls on the Mississippi River.

The total temperature variation in average metropolitan area is 5.4° F. This indicates that topography, among other factors, creates a 3:1 temperature variation.

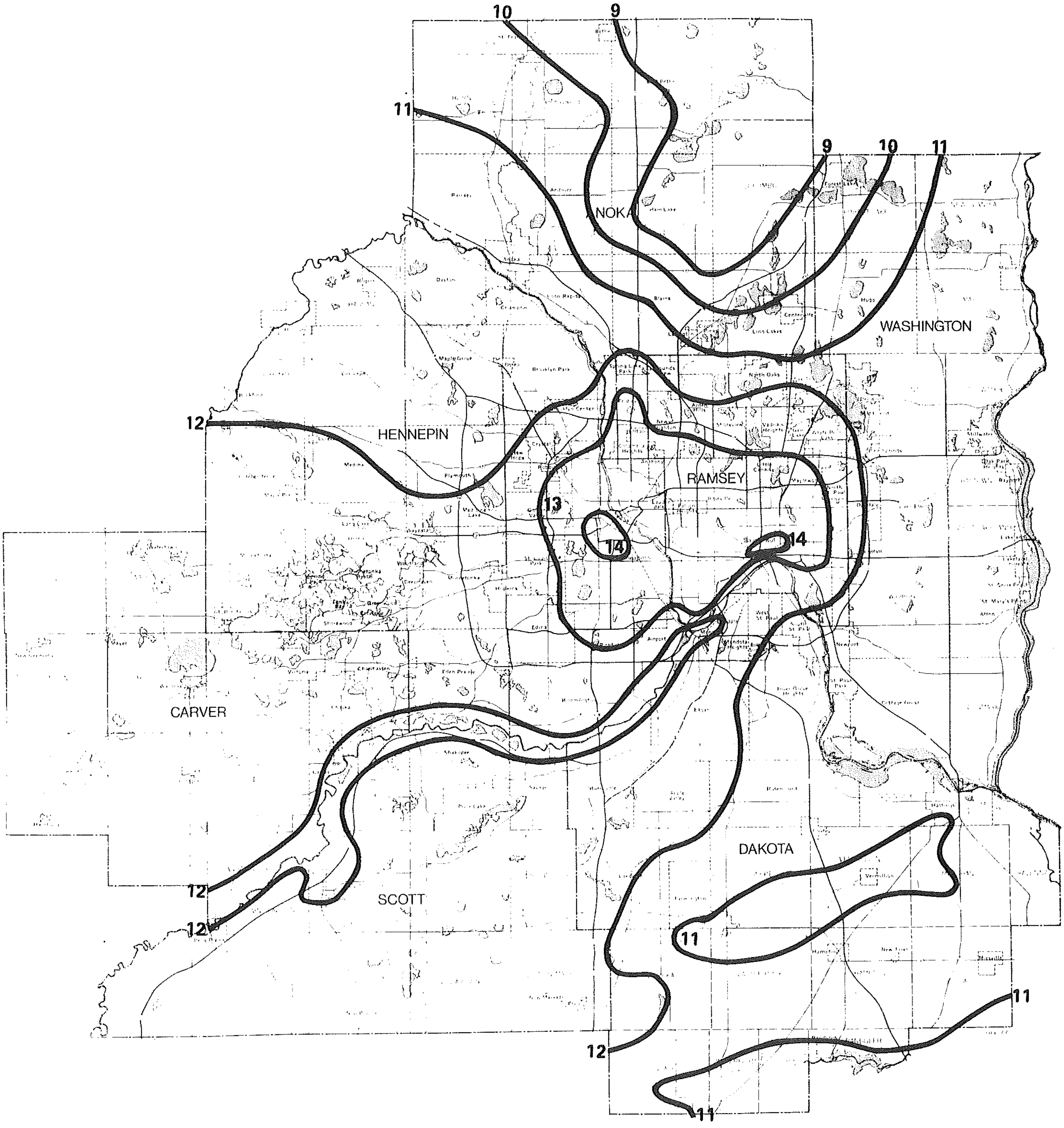
FIGURE 1—1 MEAN ANNUAL TEMPERATURES, °F



SOURCE: 1976 Minnesota Weather Almanac, 1975.

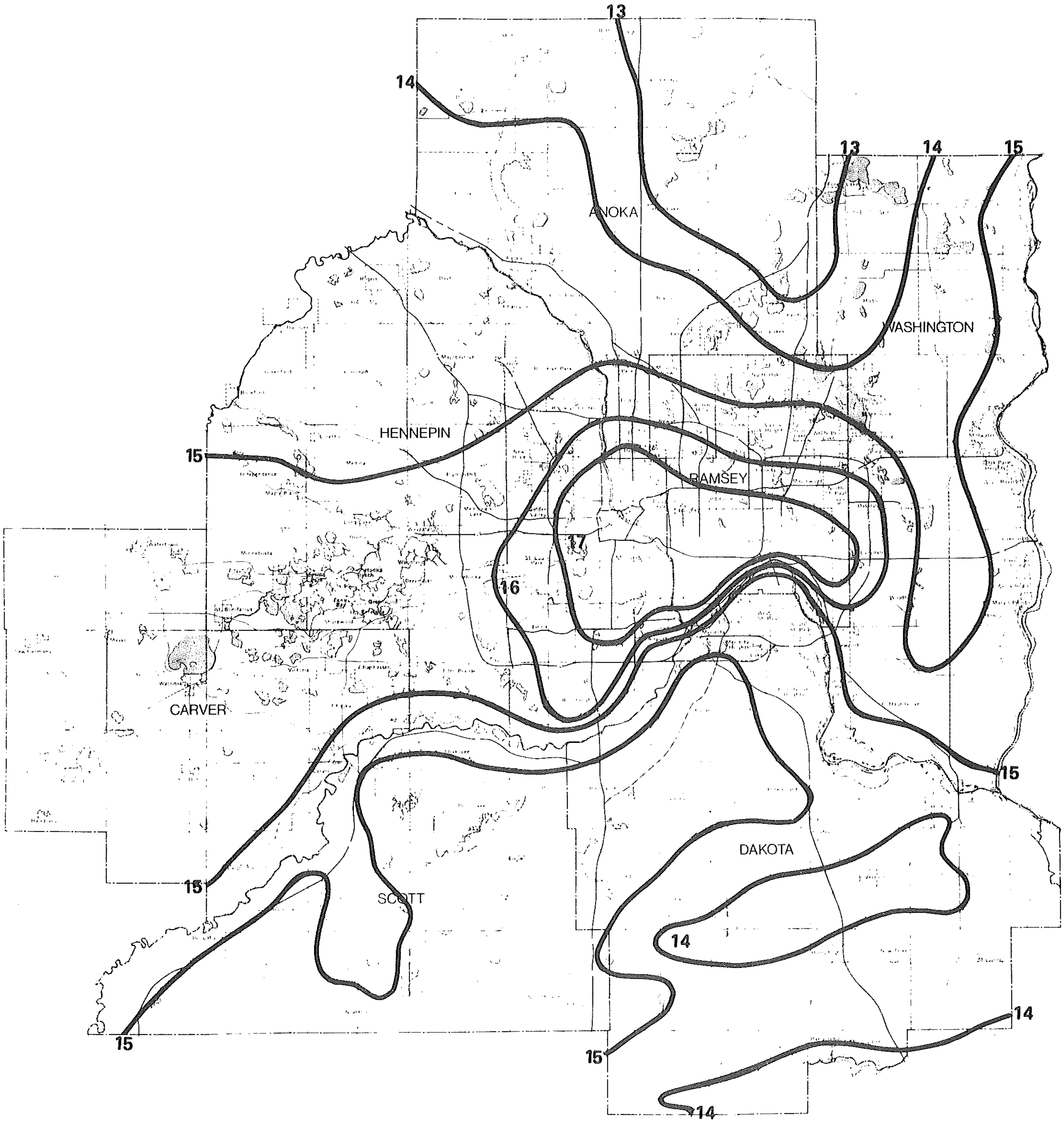
Figure 1—2 to 1—13 indicate mean monthly temperatures over the metropolitan area. The mean monthly temperature differs slightly from curves of the mean daily temperature. The mean daily temperature curve, as averaged on the 100-year period 1870-1969, shows warm maxima on July 12, July 26 (the warmest day of the year), October 2, October 15, December 22, January 9 and March 12.

FIGURE 1–2 AVERAGE JANUARY TEMPERATURES, °F



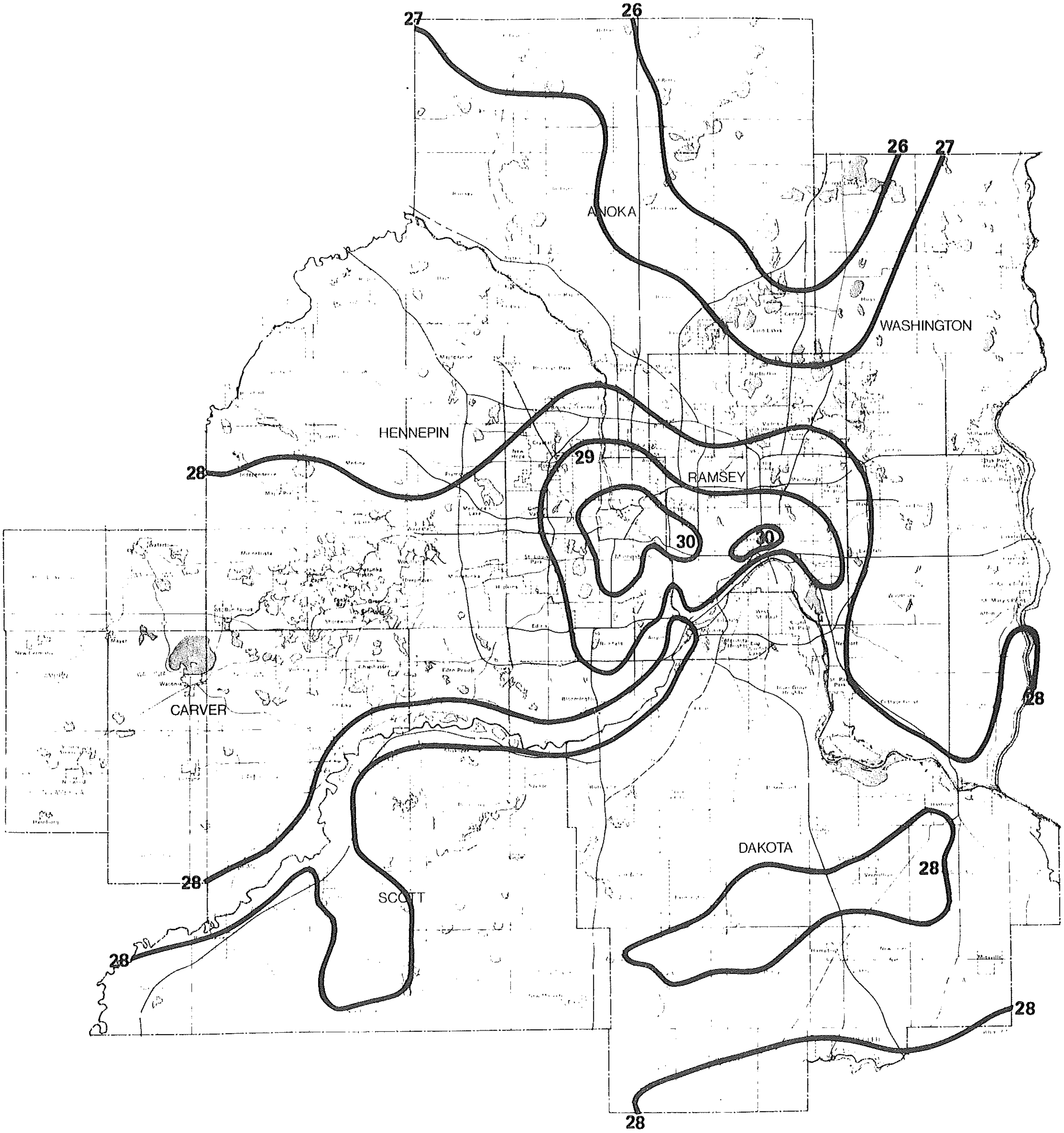
SOURCE: 1976 Minnesota Weather Almanac, 1975.

FIGURE 1–3 AVERAGE FEBRUARY TEMPERATURES, °F



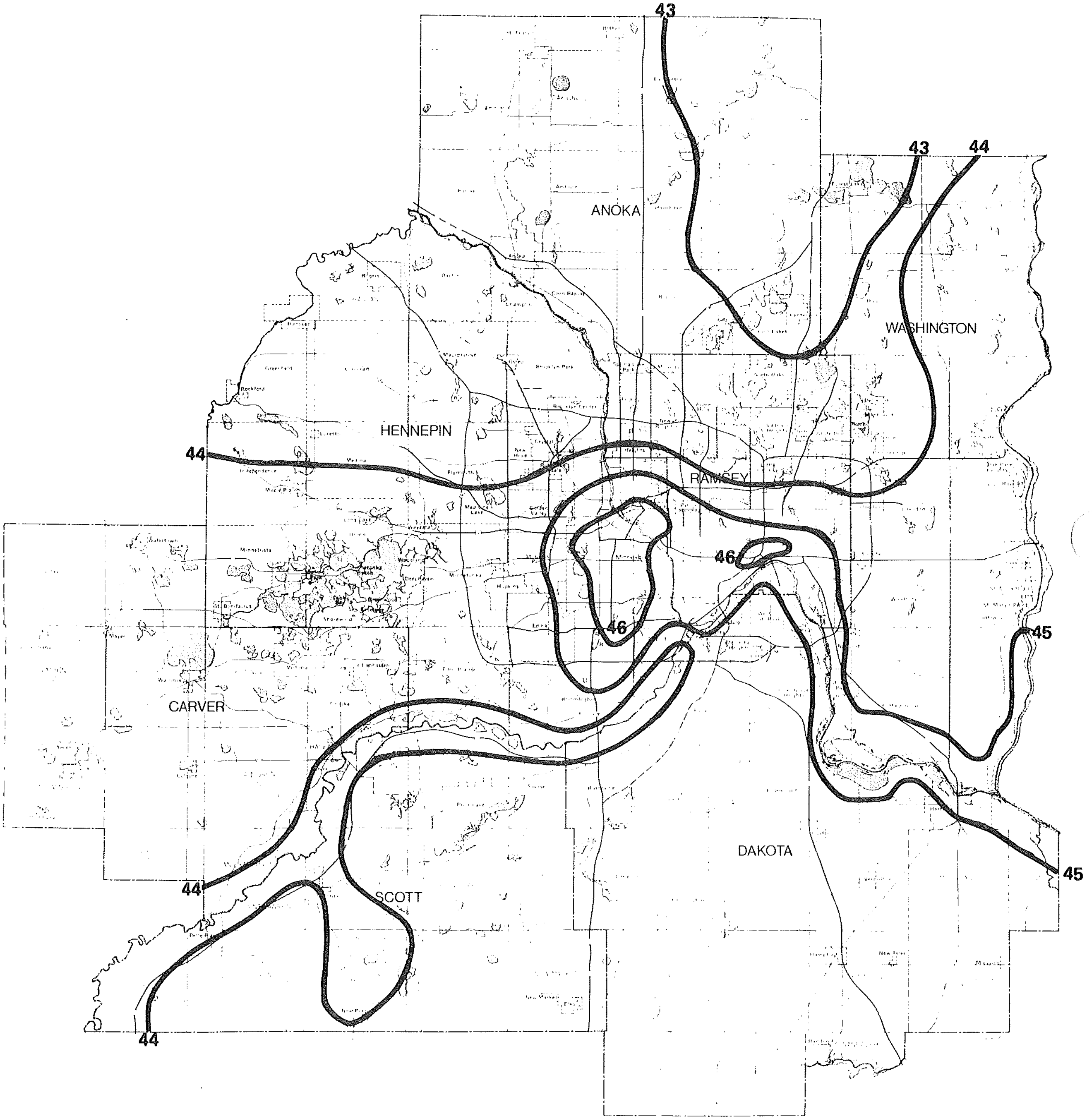
SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–4 AVERAGE MARCH TEMPERATURES, °F



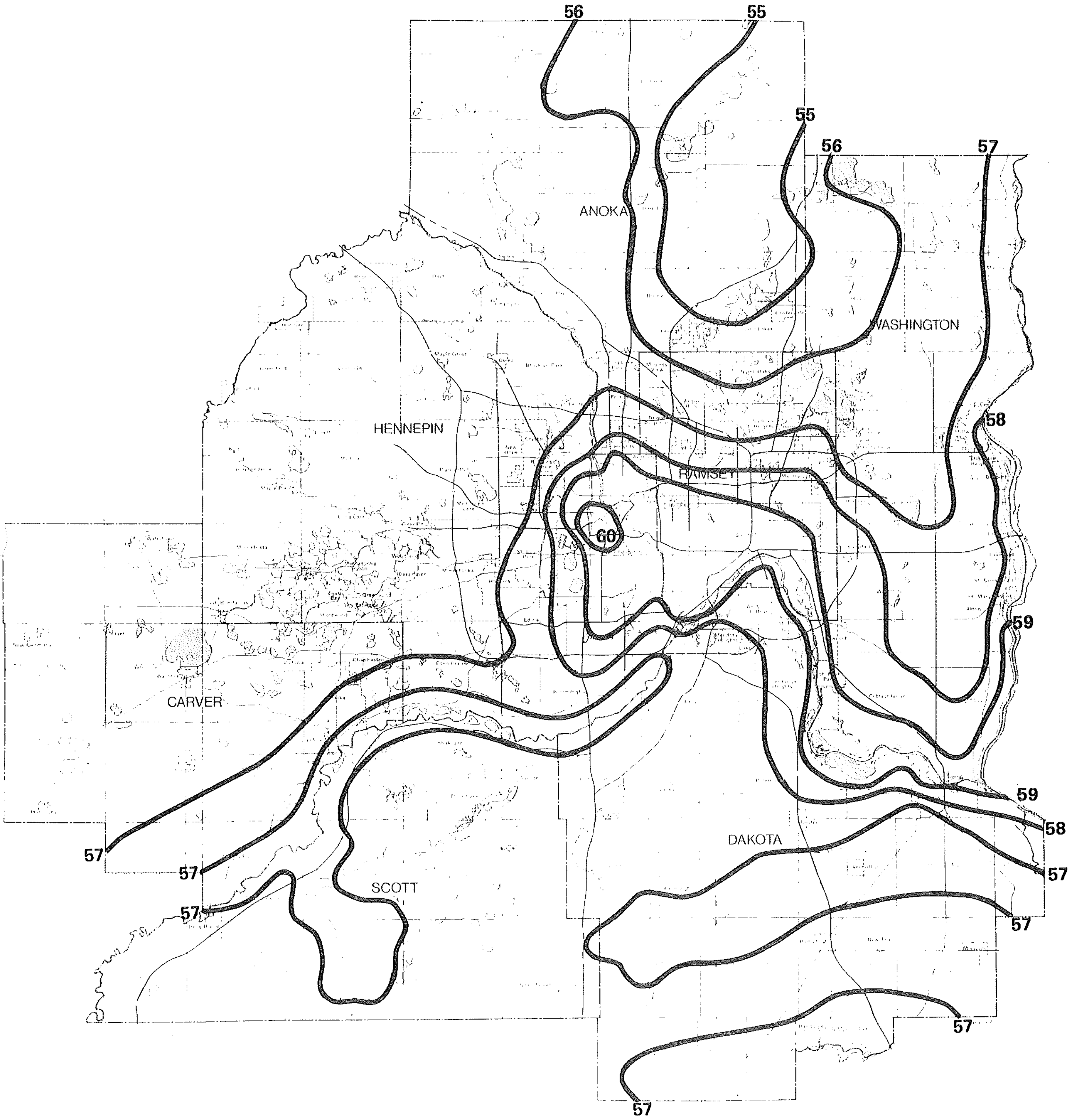
SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–5 AVERAGE APRIL TEMPERATURES, °F



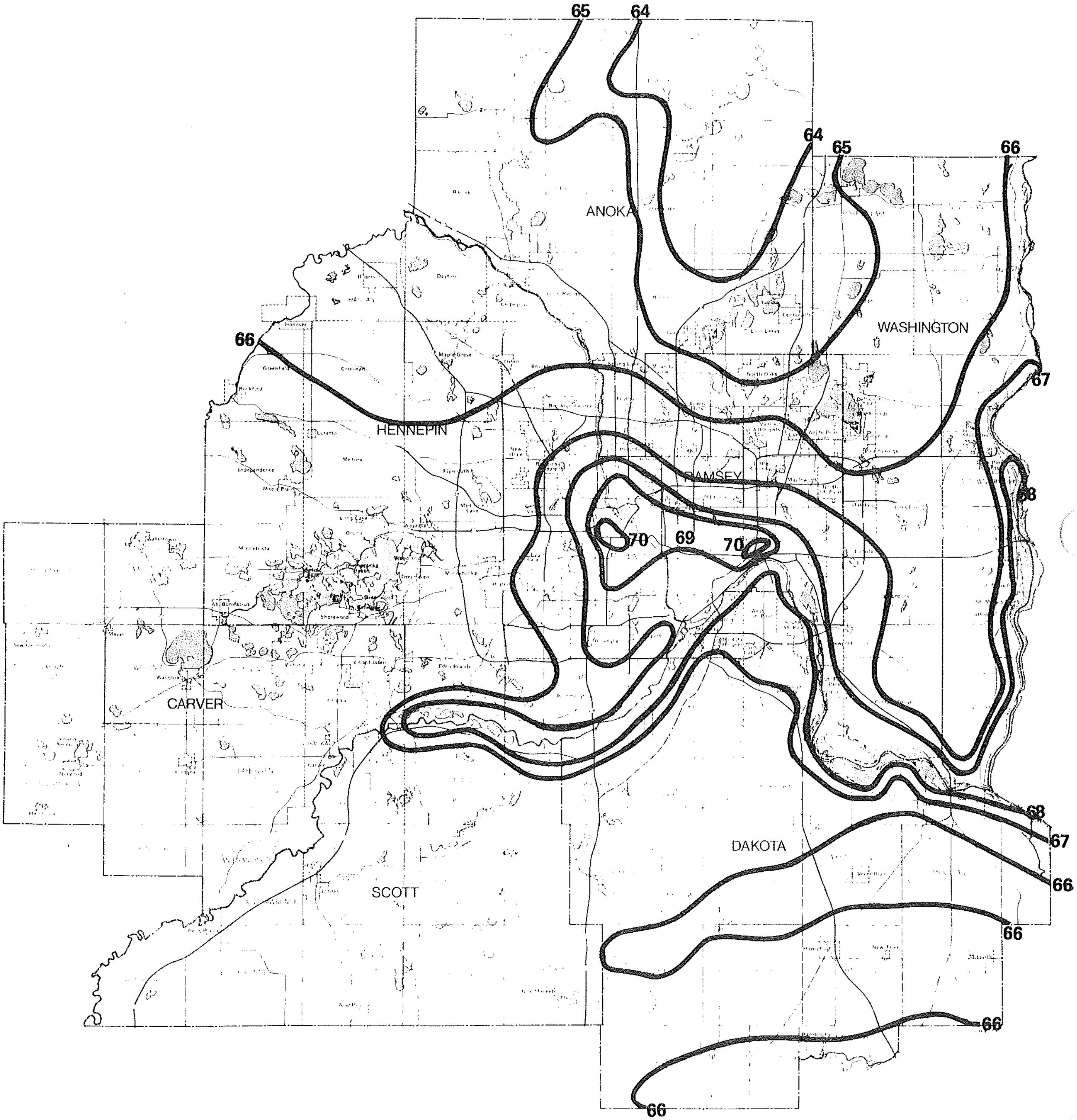
SOURCE: 1976 Minnesota Weather Almanac, 1975.

FIGURE 1–6 AVERAGE MAY TEMPERATURES °F



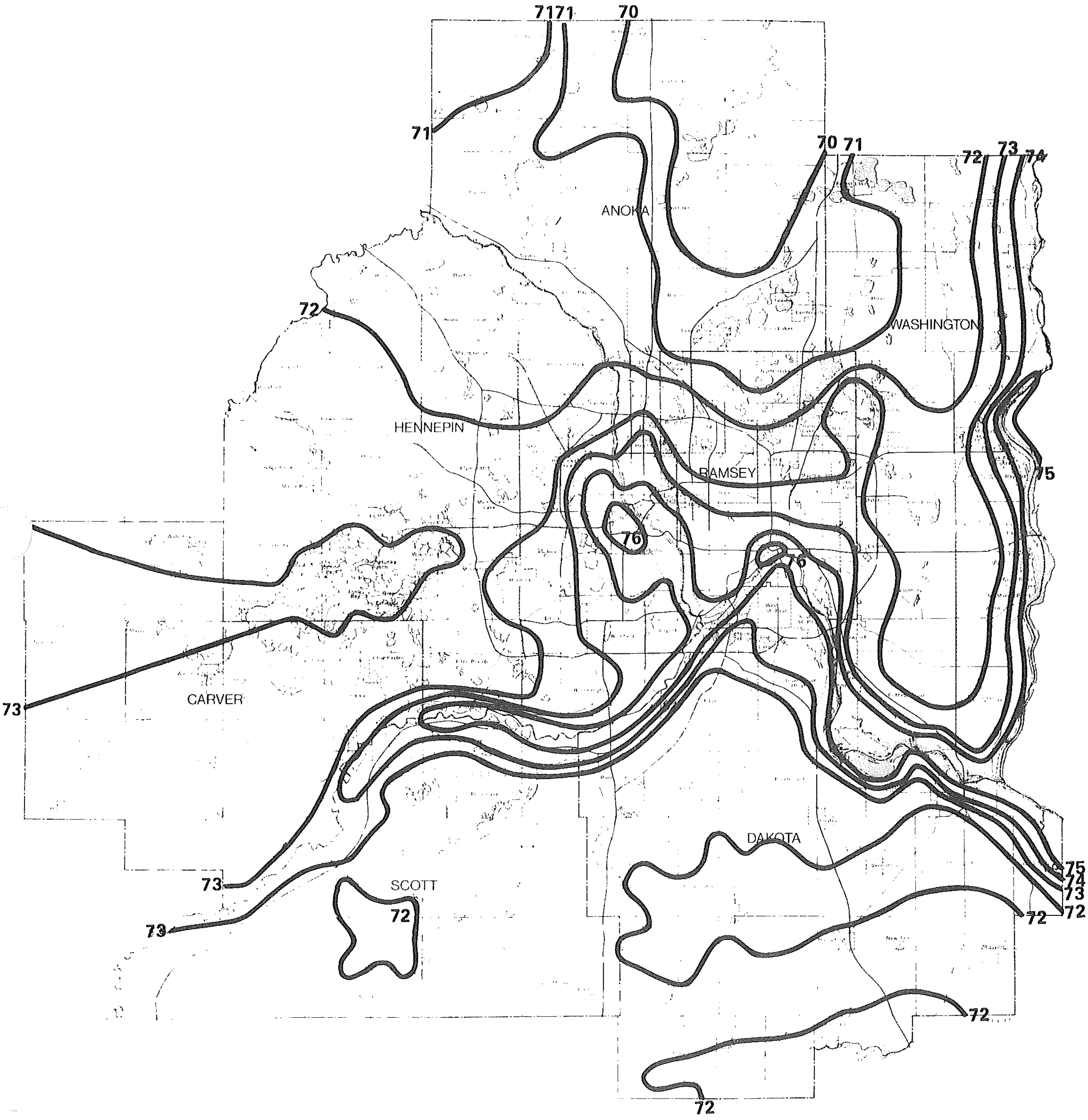
SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–7 AVERAGE JUNE TEMPERATURES, °F



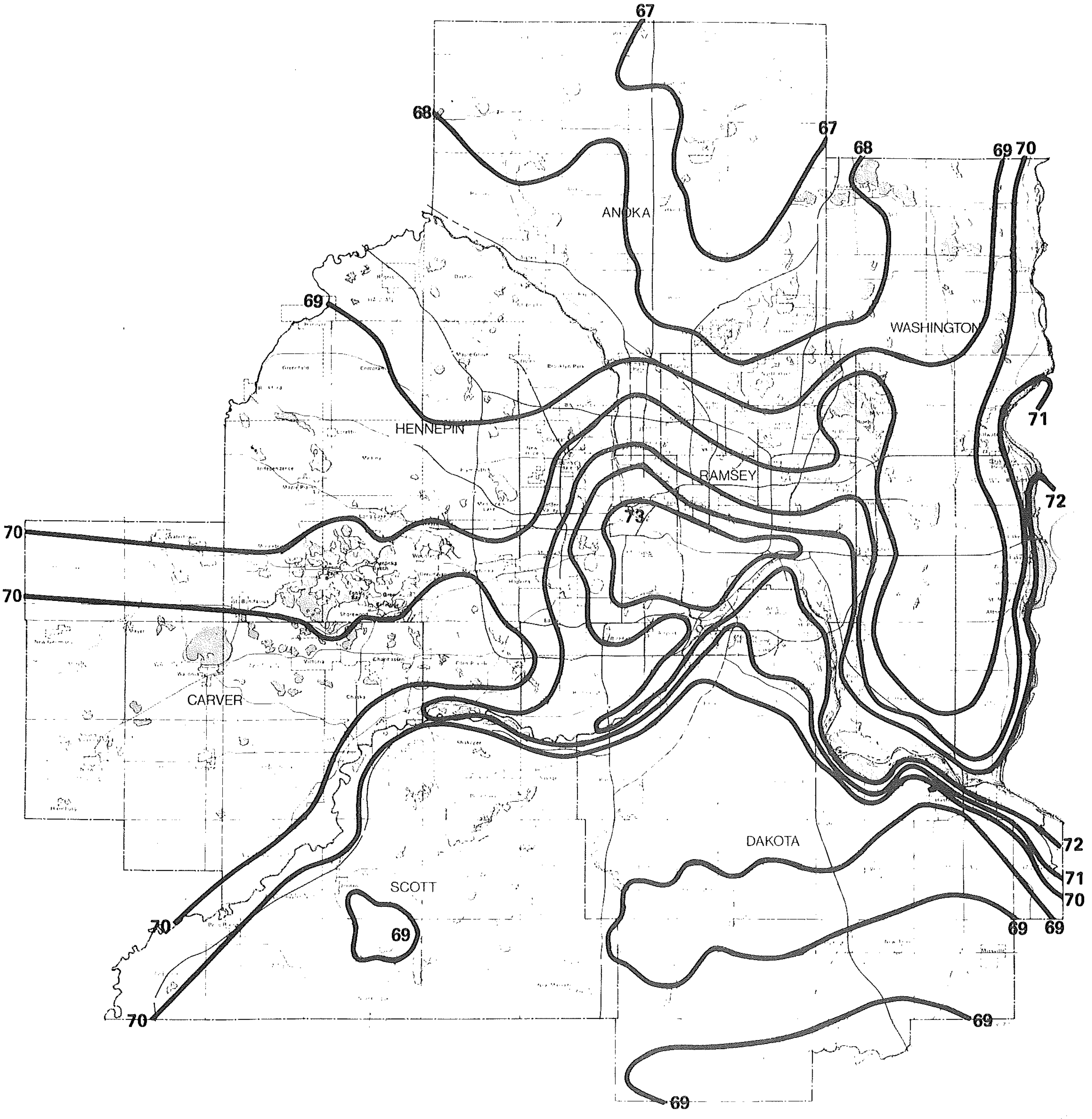
SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–8 AVERAGE JULY TEMPERATURES, °F



SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–9 AVERAGE AUGUST TEMPERATURES, °F

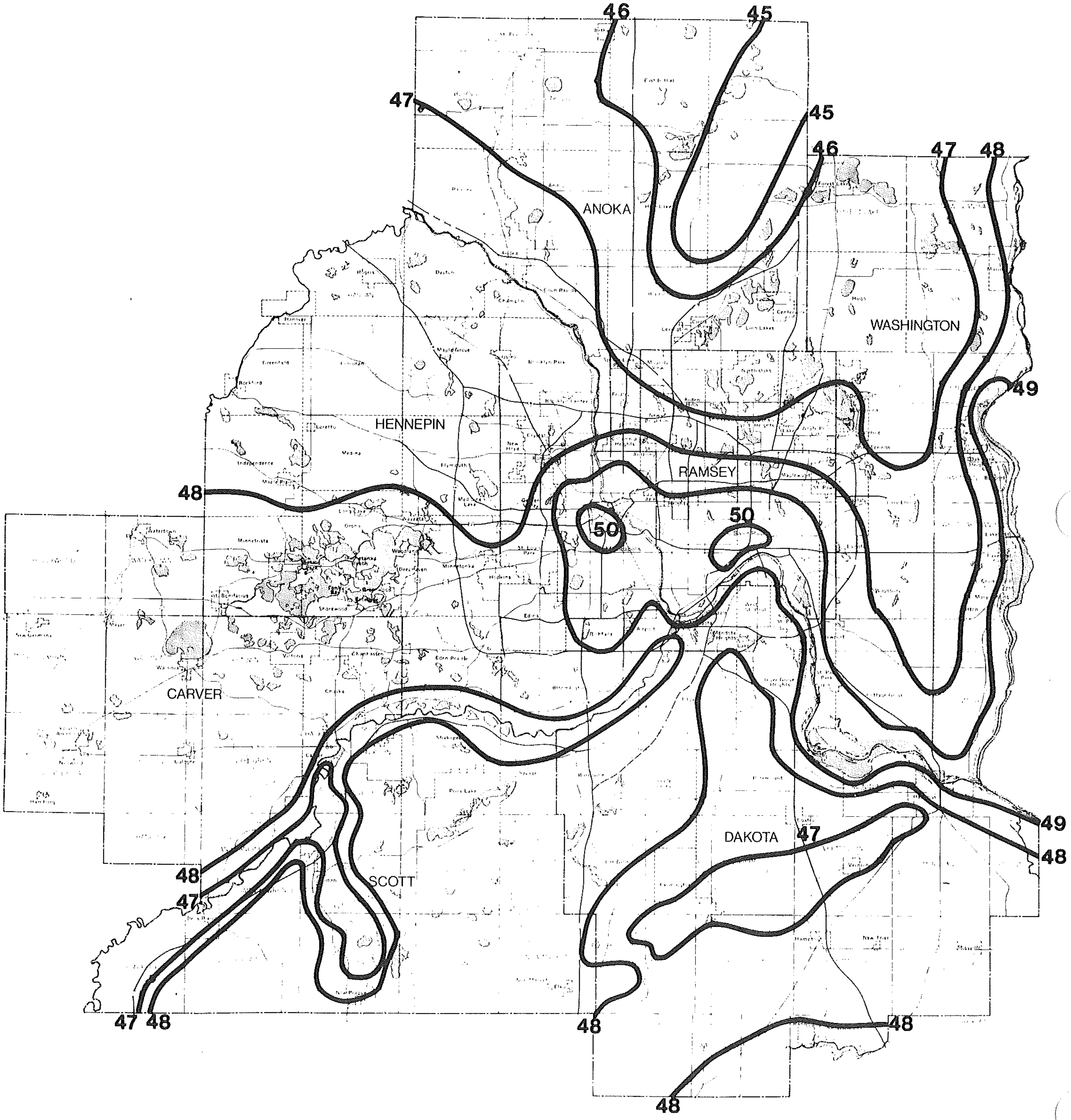


SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–10 AVERAGE SEPTEMBER TEMPERATURES, °F

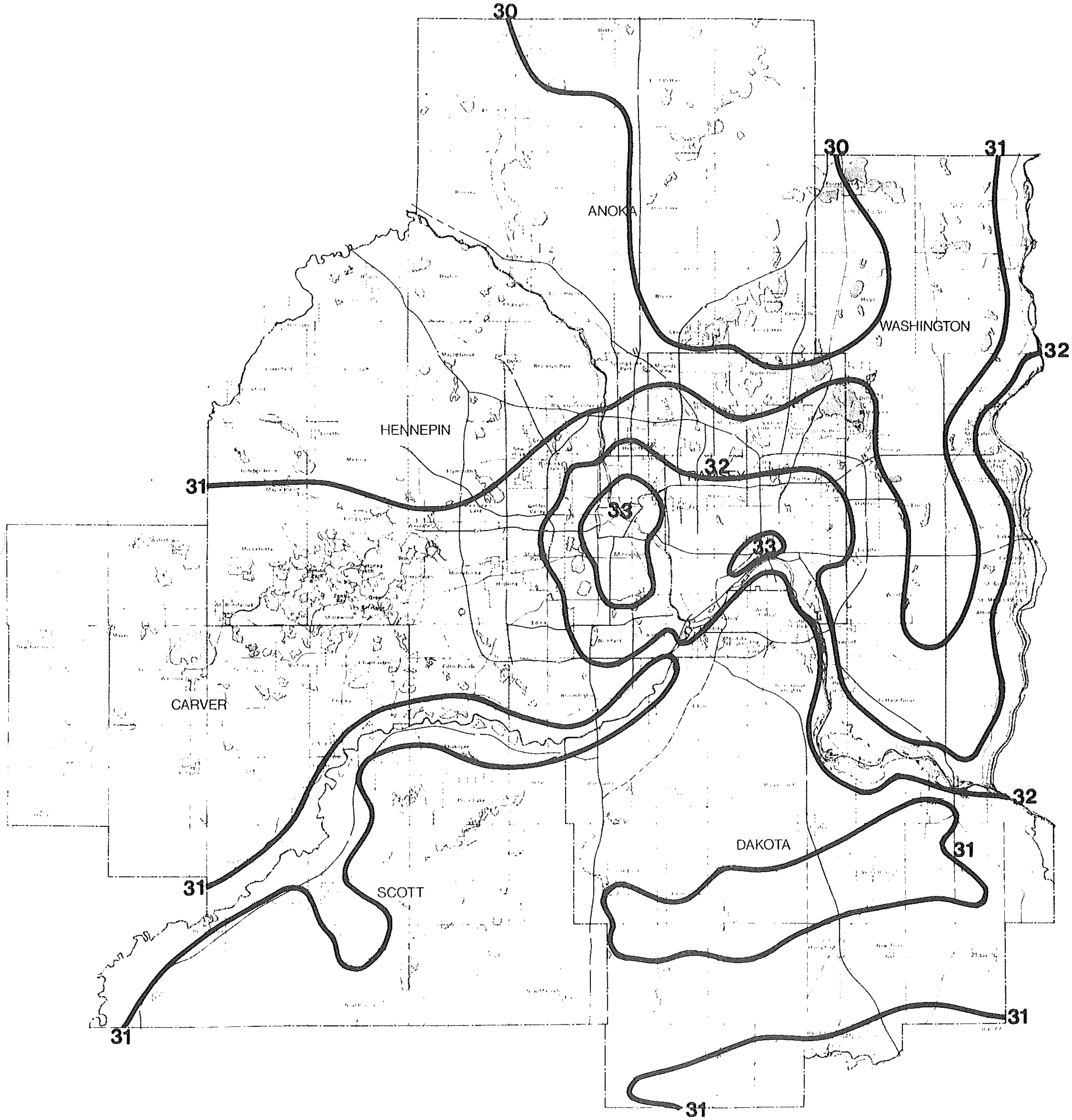
SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–11 AVERAGE OCTOBER TEMPERATURES, °F



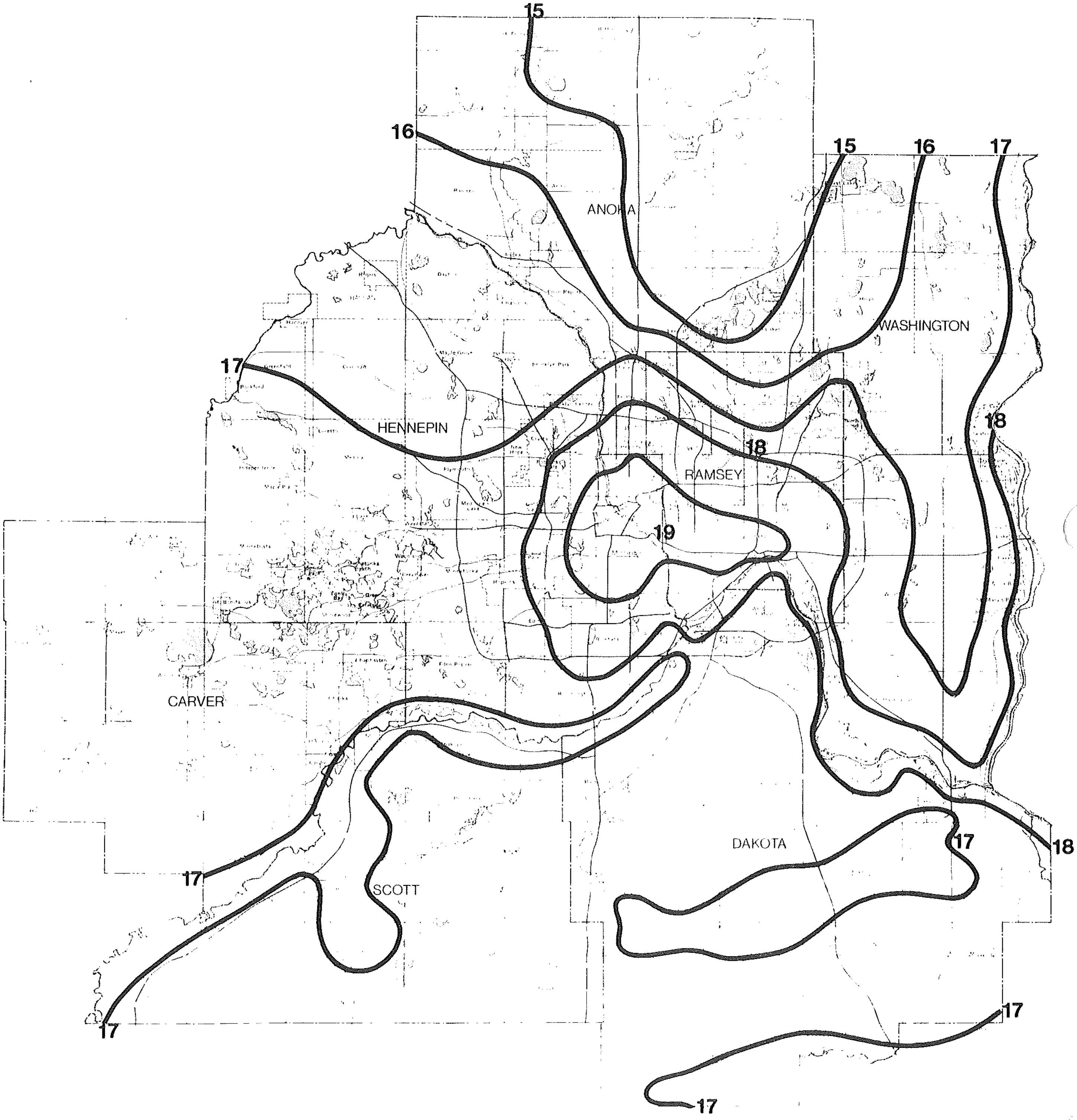
SOURCE: 1976 Minnesota Weather Almanac, 1975

FIGURE 1–12 AVERAGE NOVEMBER TEMPERATURES, °F



SOURCE: 1976 Minnesota Weather Almanac 1975

FIGURE 1–13 AVERAGE DECEMBER TEMPERATURES, °F



SOURCE: 1976 Minnesota Weather Almanac, 1975

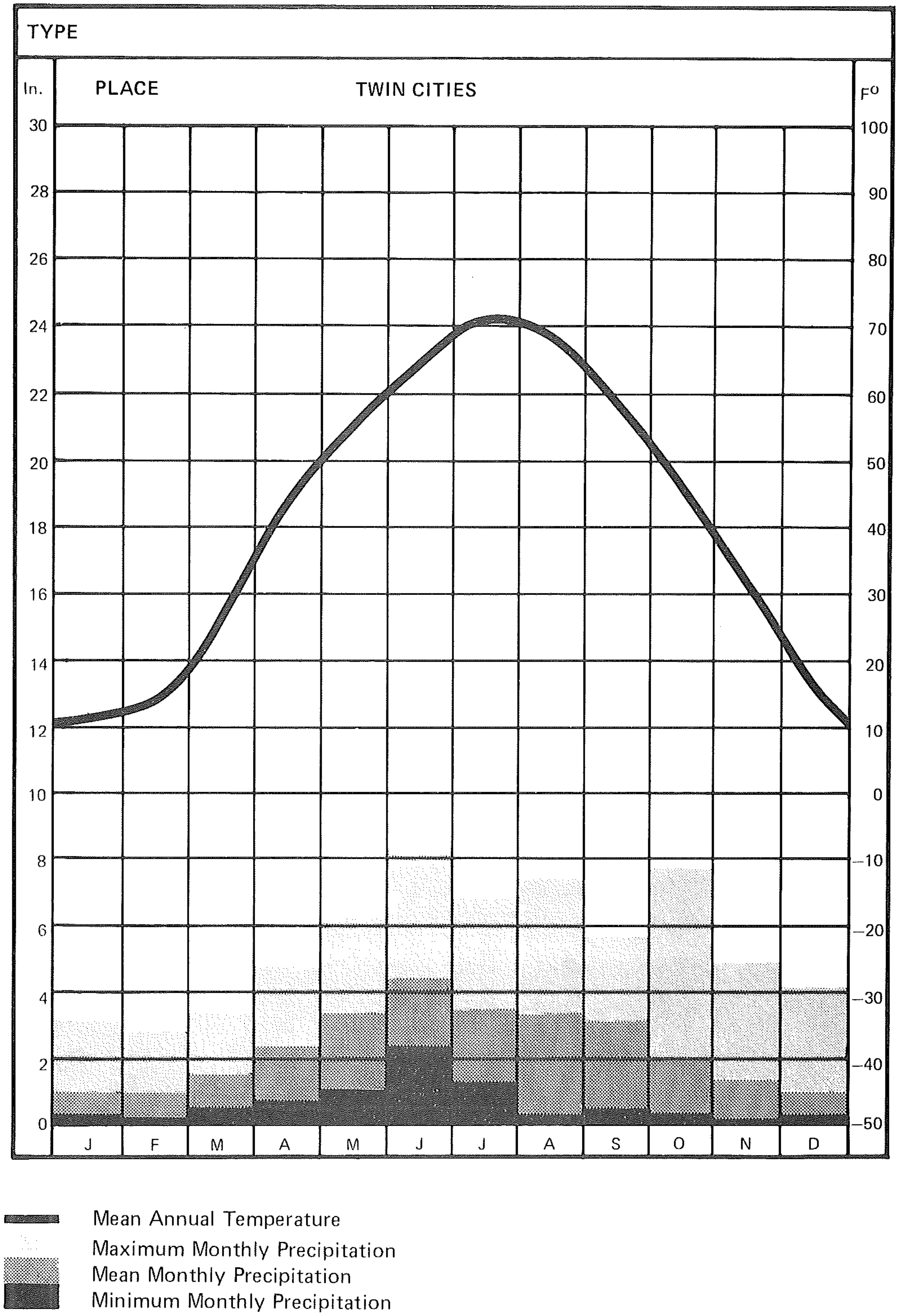
Figures 1–14 through 1–26 present curves of the mean monthly temperatures taken at thirteen stations in the metropolitan area. These stations are identified on Figure 1–27. These values are averages adjusted to the values that would have been observed over the period 1819-1974 (8). Because of this 155-year averaging period, these values reflect the mean temperature for the area more truly than do the present 30-year normals.

The temperature maps do not indicate highly localized regions of warmth and cold. In small hill-and-vale areas, temperatures are localized and varied.

A hill may average approximately ½° to 1° warmer over the year than the uplands, while a valley might average 1°F (sometimes 2°F, in extreme cases) cooler over the year than immediately adjacent uplands.

FIGURE 1–14

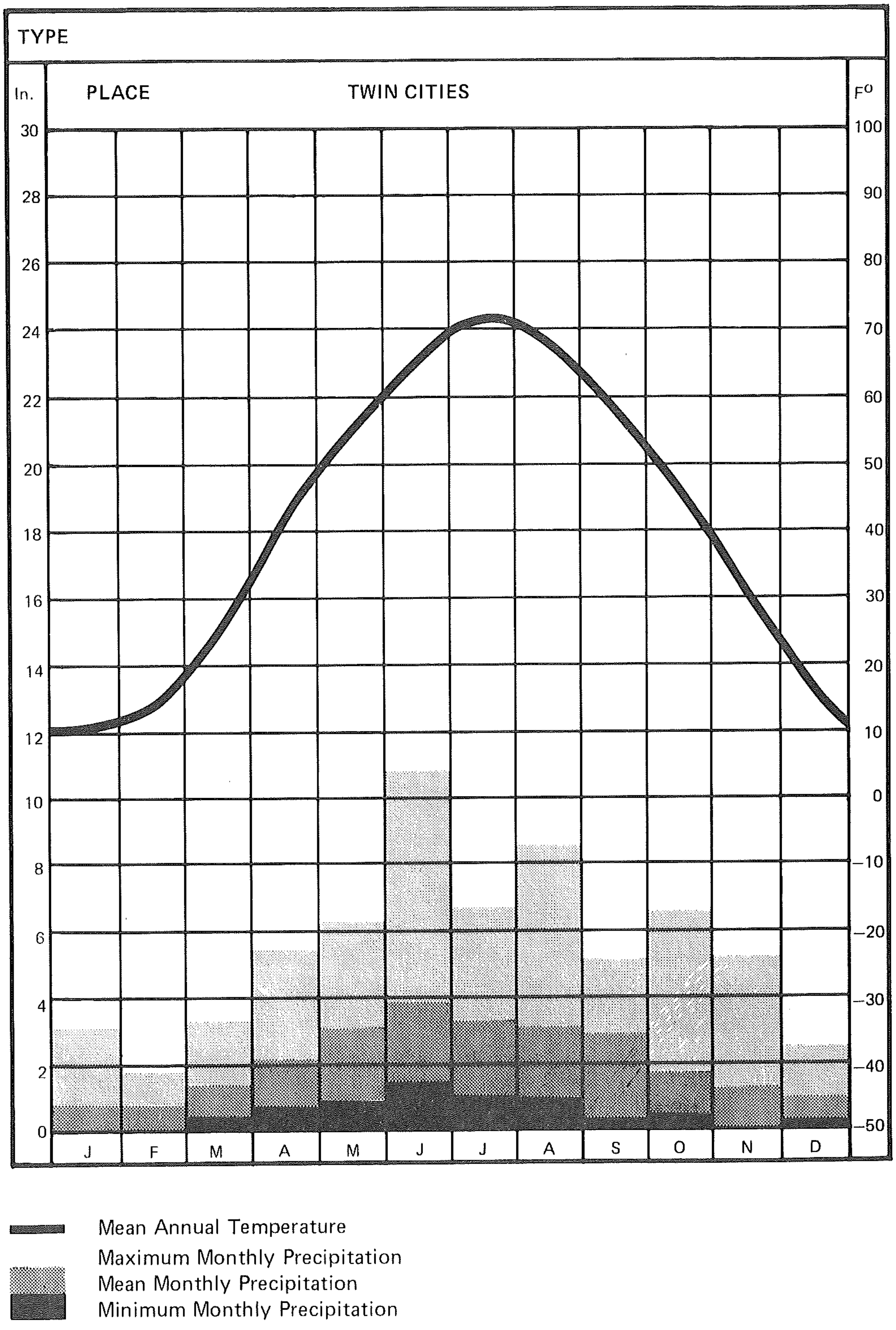
MEAN ANNUAL TEMPERATURE AND PRECIPITATION—
CEDAR STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–15

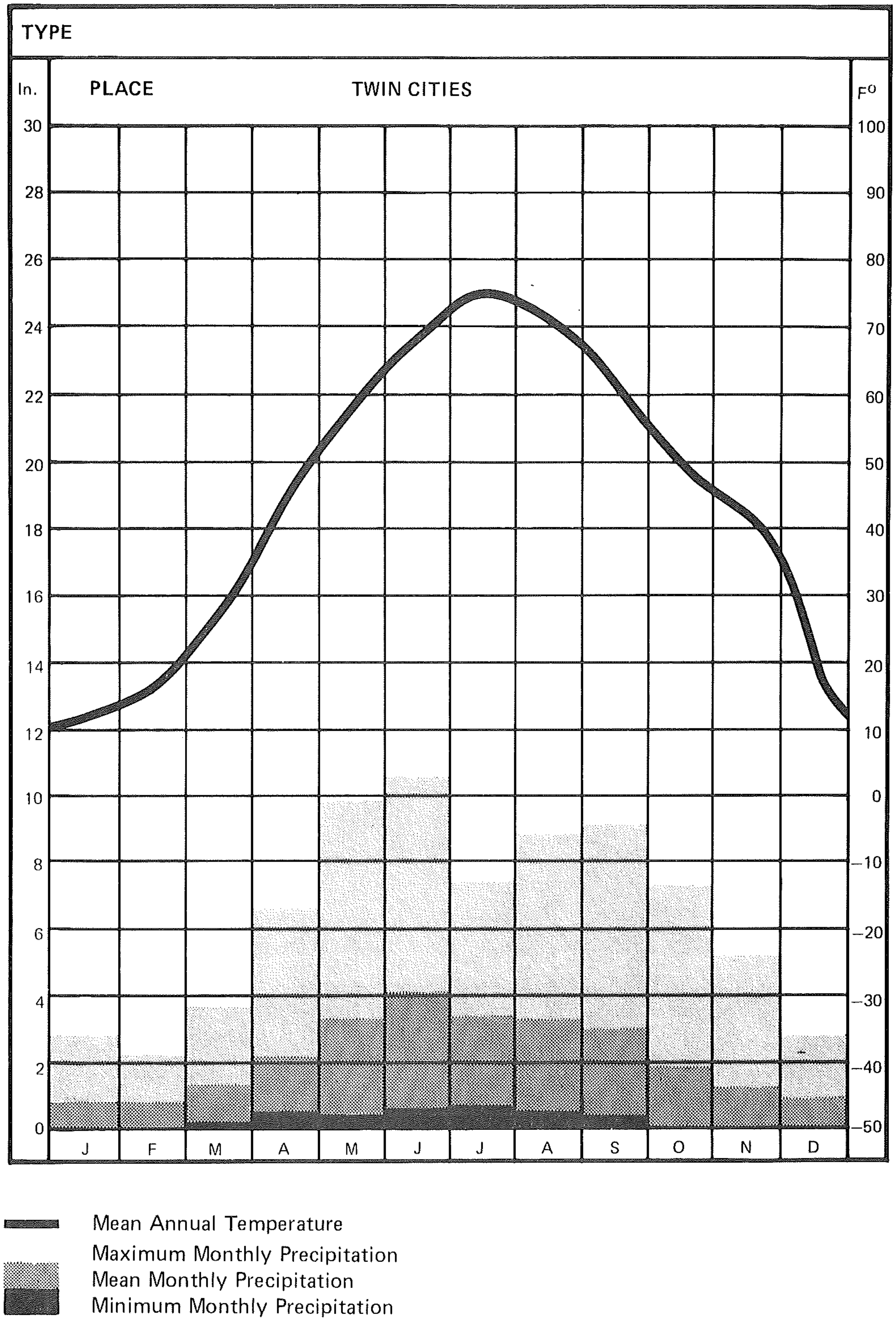
MEAN ANNUAL TEMPERATURE AND PRECIPITATION– FOREST LAKE STATION



SOURCE: Local Climatological Data, 1963-1974

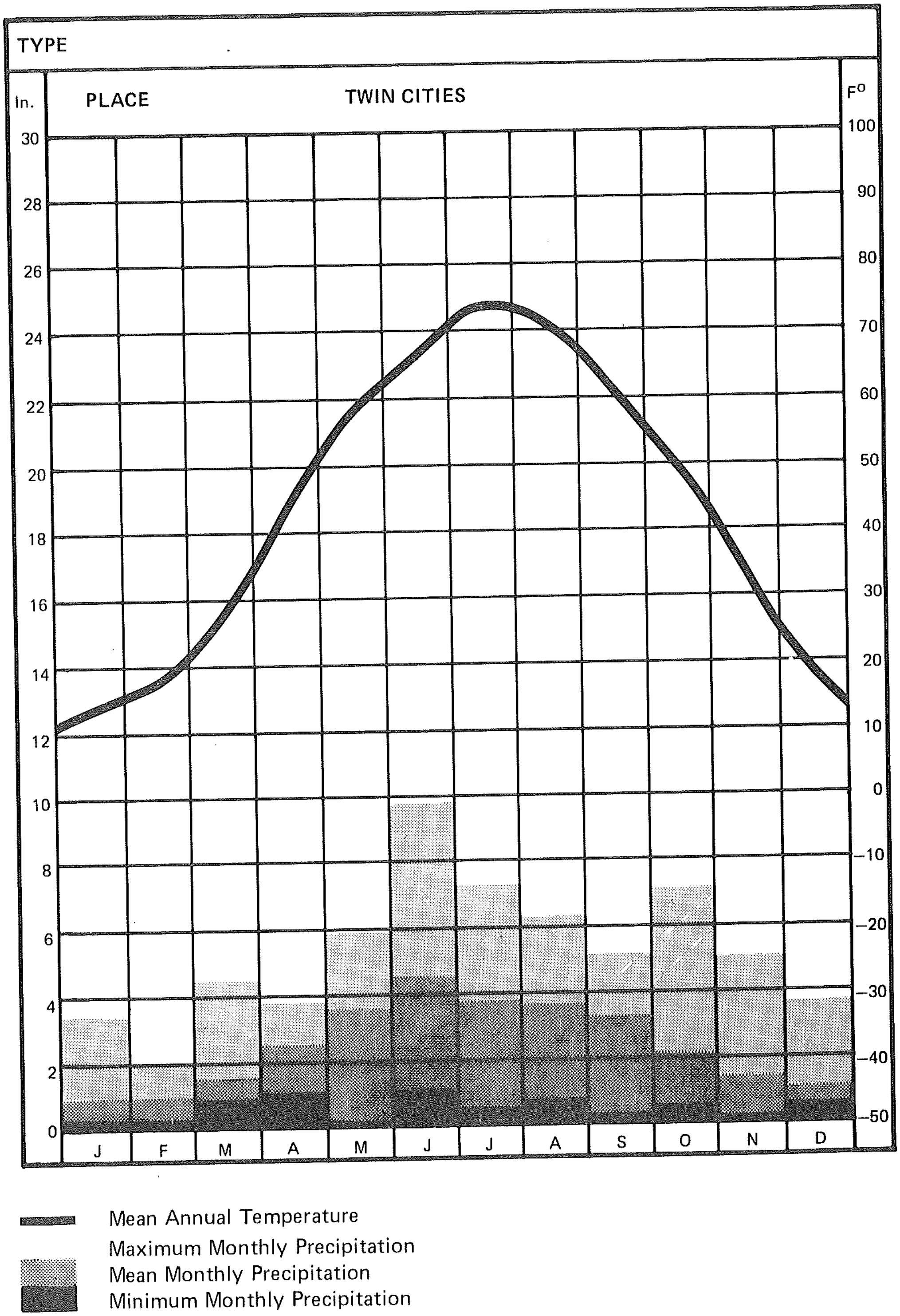
FIGURE 1–16

MEAN ANNUAL TEMPERATURE AND PRECIPITATION– STILLWATER STATION



SOURCE: Local Climatological Data, 1963-1974

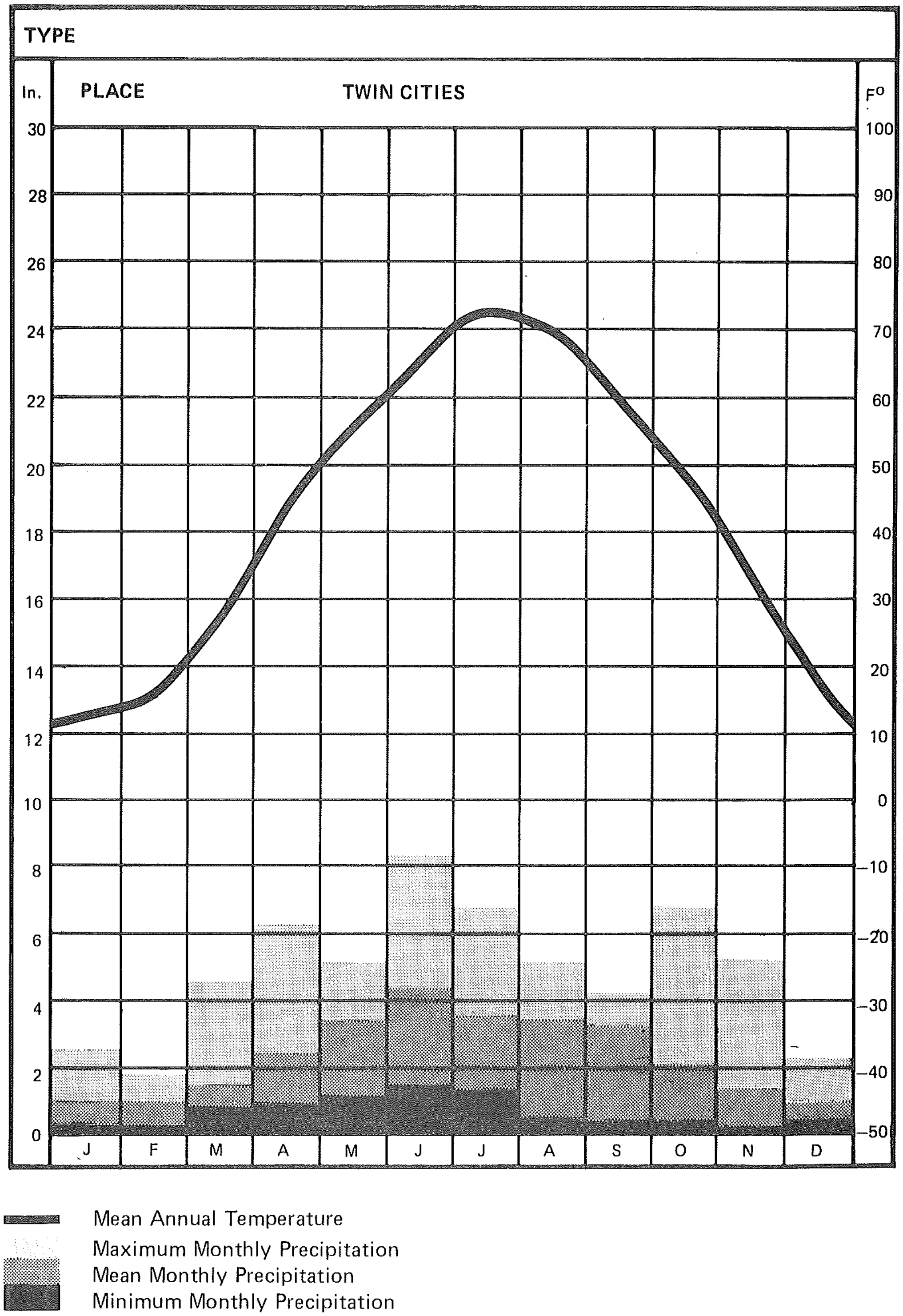
FIGURE 1–17 MEAN ANNUAL TEMPERATURE AND PRECIPITATION–
ROSEVILLE STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–18

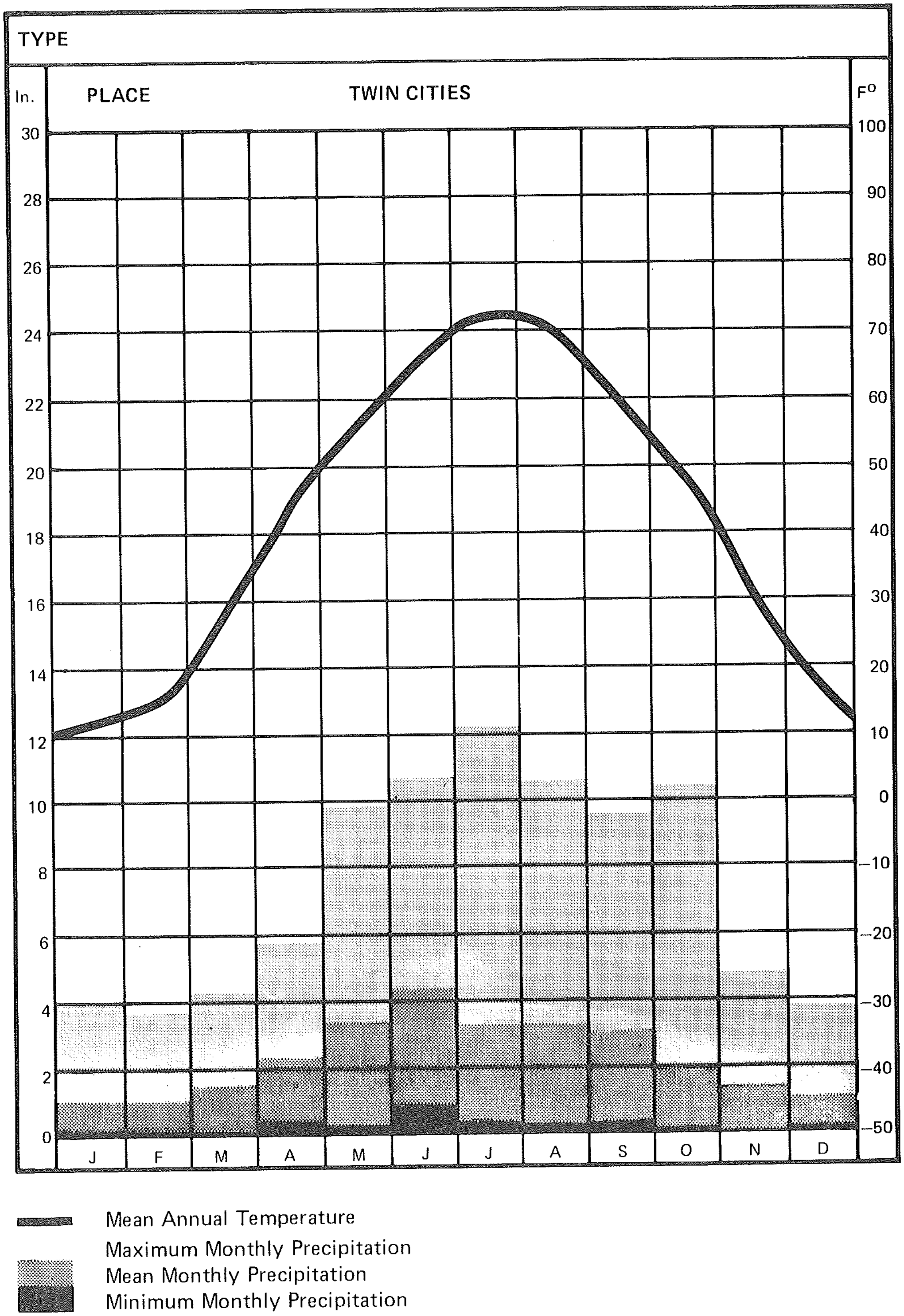
MEAN ANNUAL TEMPERATURE AND PRECIPITATION— NEW HOPE STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1—19

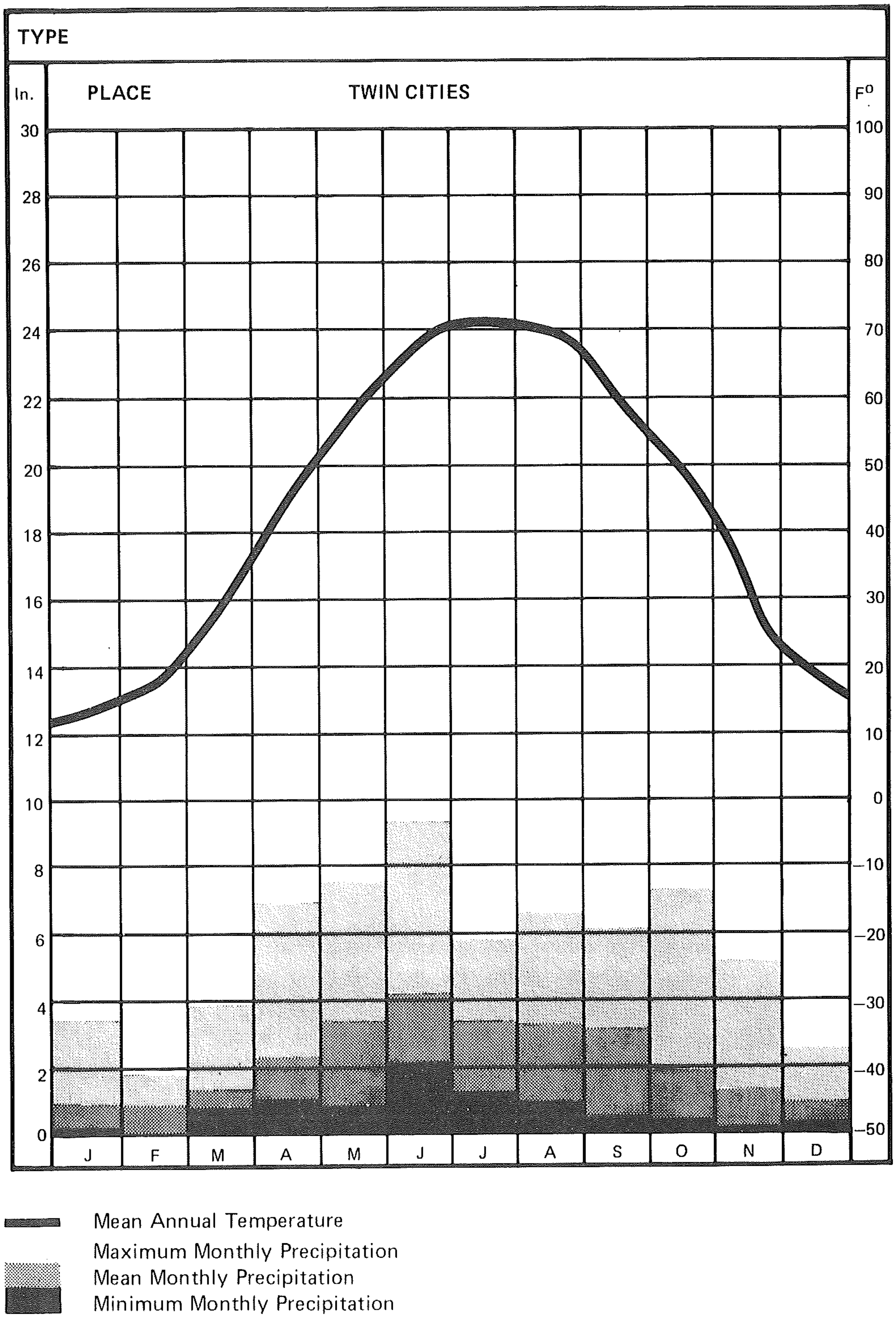
MEAN ANNUAL TEMPERATURE AND PRECIPITATION— MAPLE PLAIN STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–20

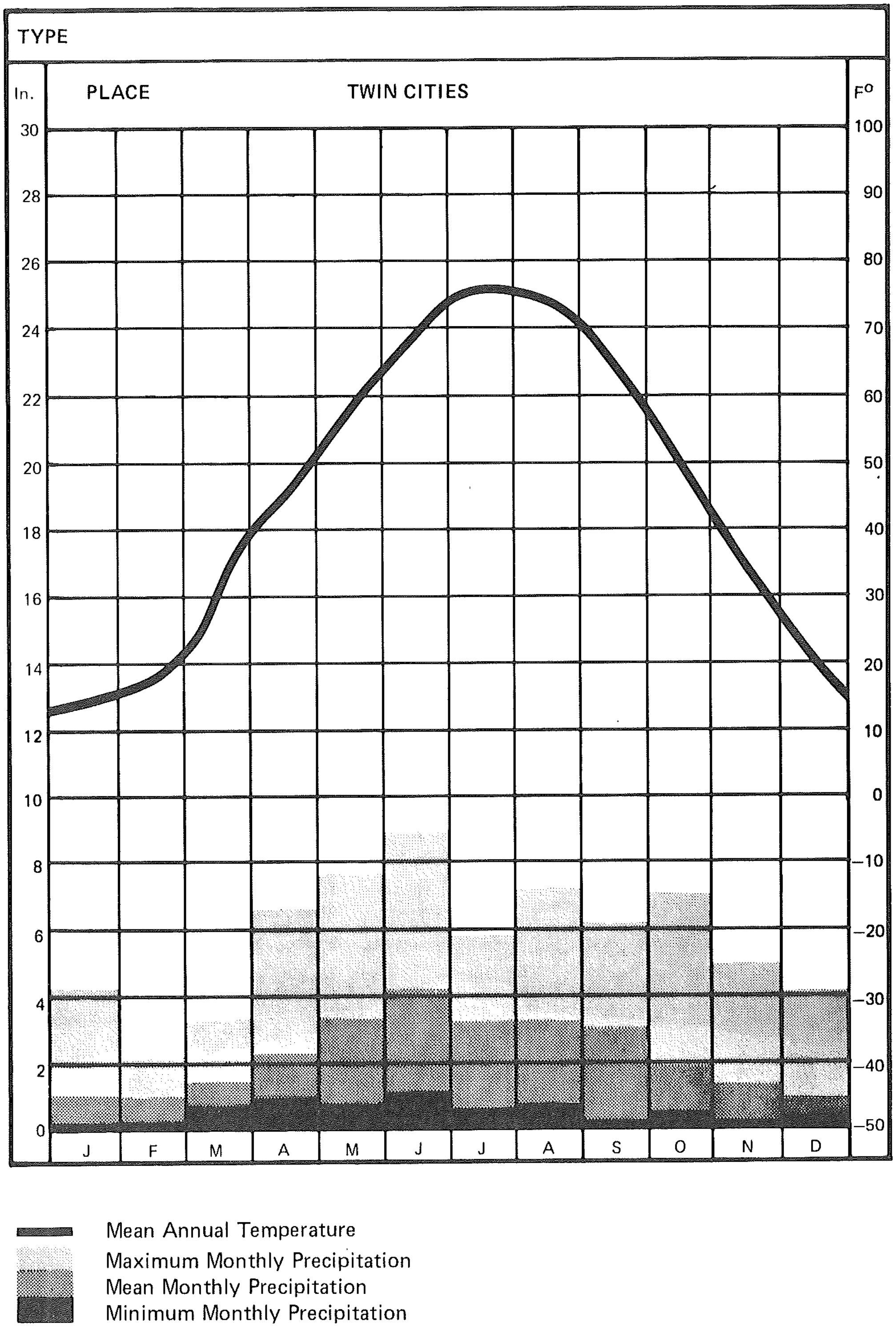
MEAN ANNUAL TEMPERATURE AND PRECIPITATION– ST. PAUL STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–21

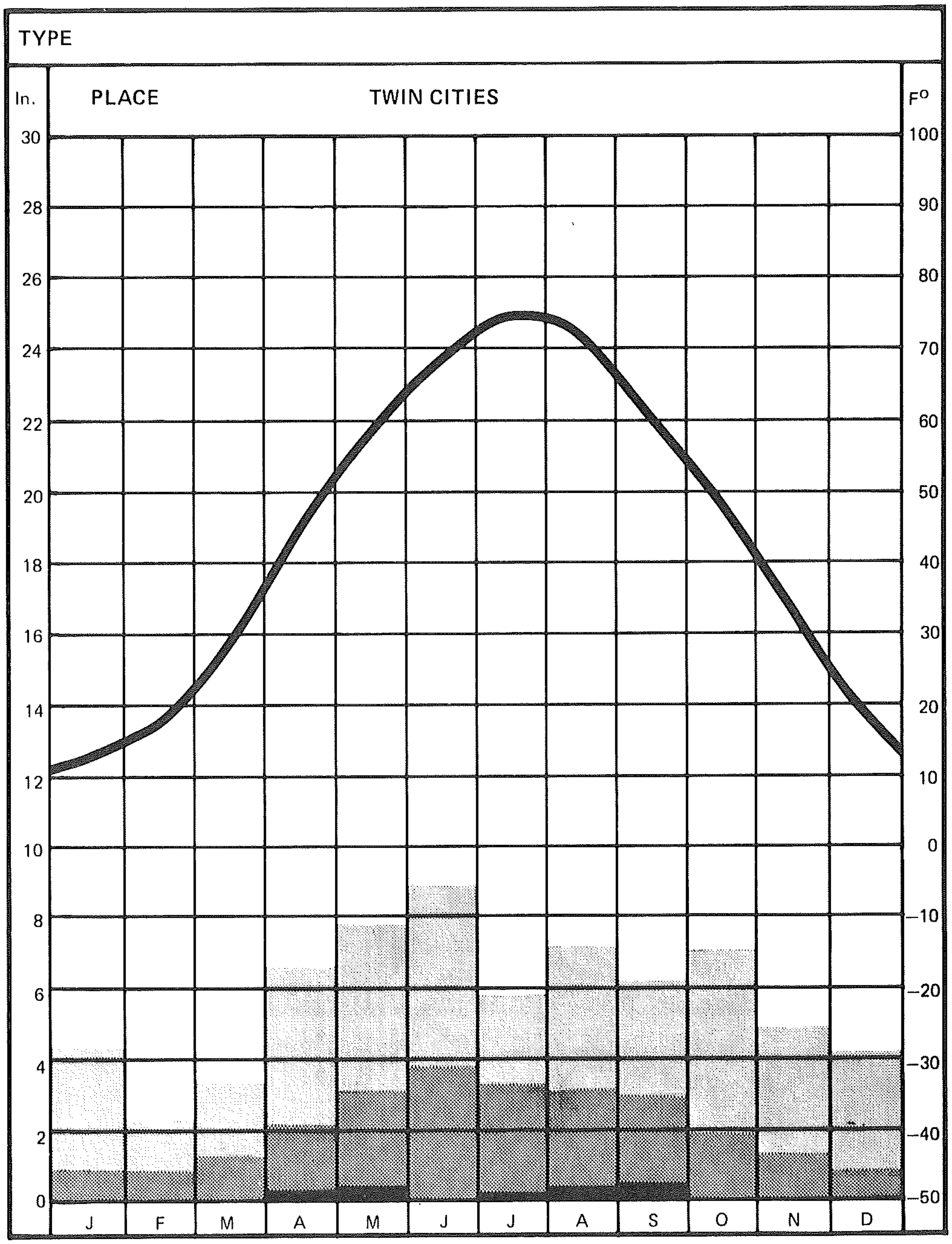
MEAN ANNUAL TEMPERATURE AND PRECIPITATION– FALLS OF ST. ANTHONY STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–22

MEAN ANNUAL TEMPERATURE AND PRECIPITATION– NWS STATION



▬ Mean Annual Temperature

▨ Maximum Monthly Precipitation

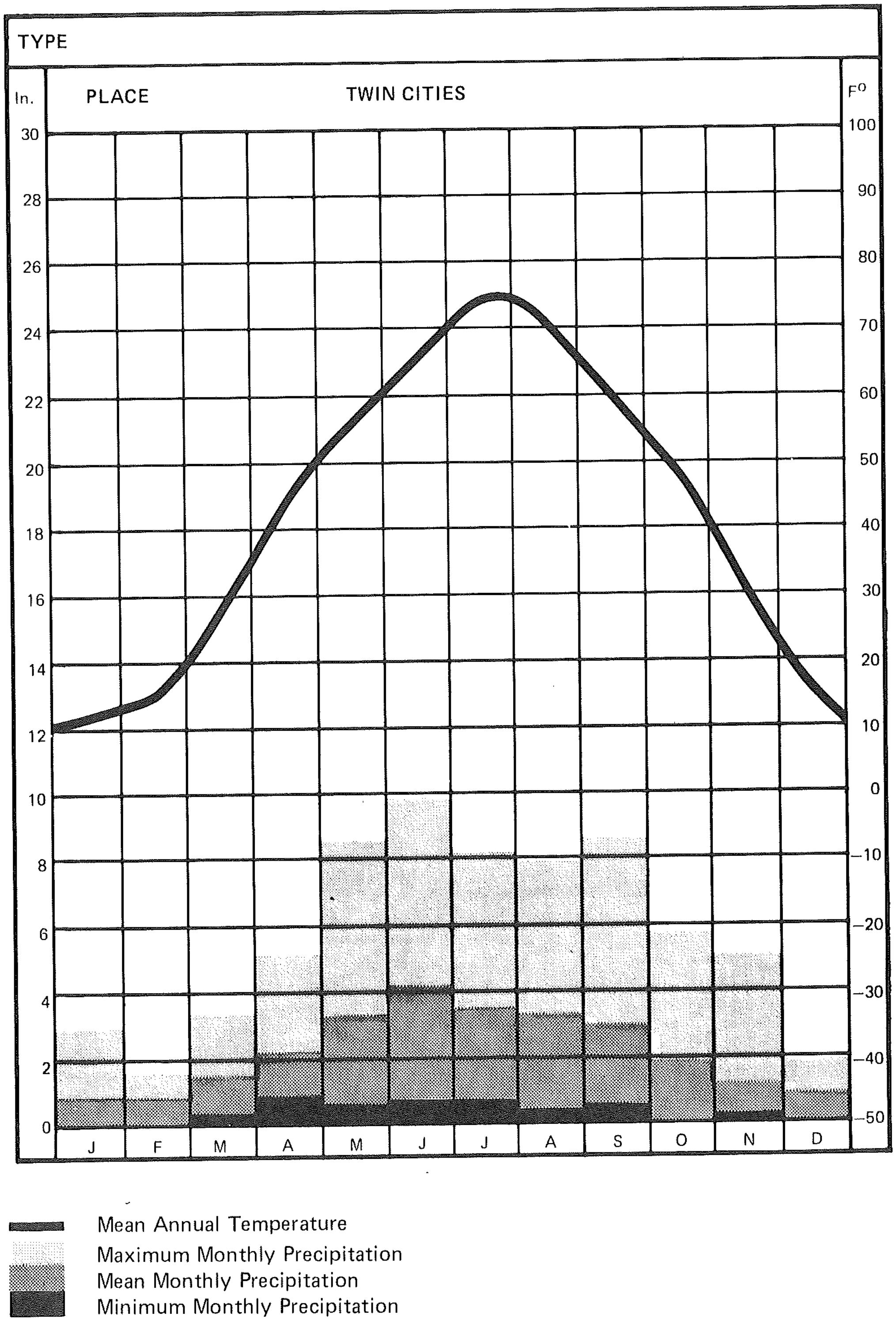
▨ Mean Monthly Precipitation

■ Minimum Monthly Precipitation

SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–23

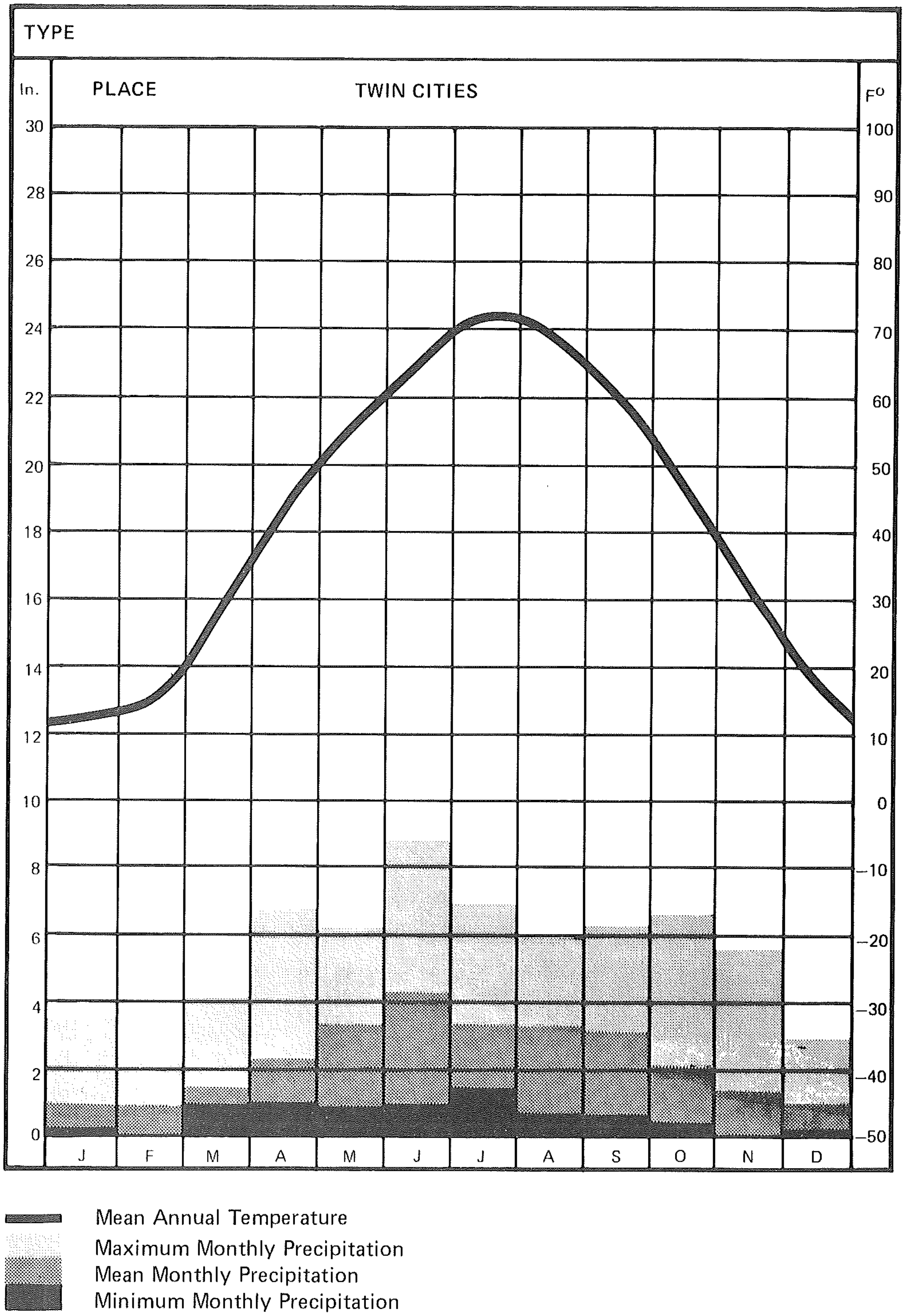
MEAN ANNUAL TEMPERATURE AND PRECIPITATION–CHASKA STATION



SOURCE: Local Climatological Data, 1963-1974

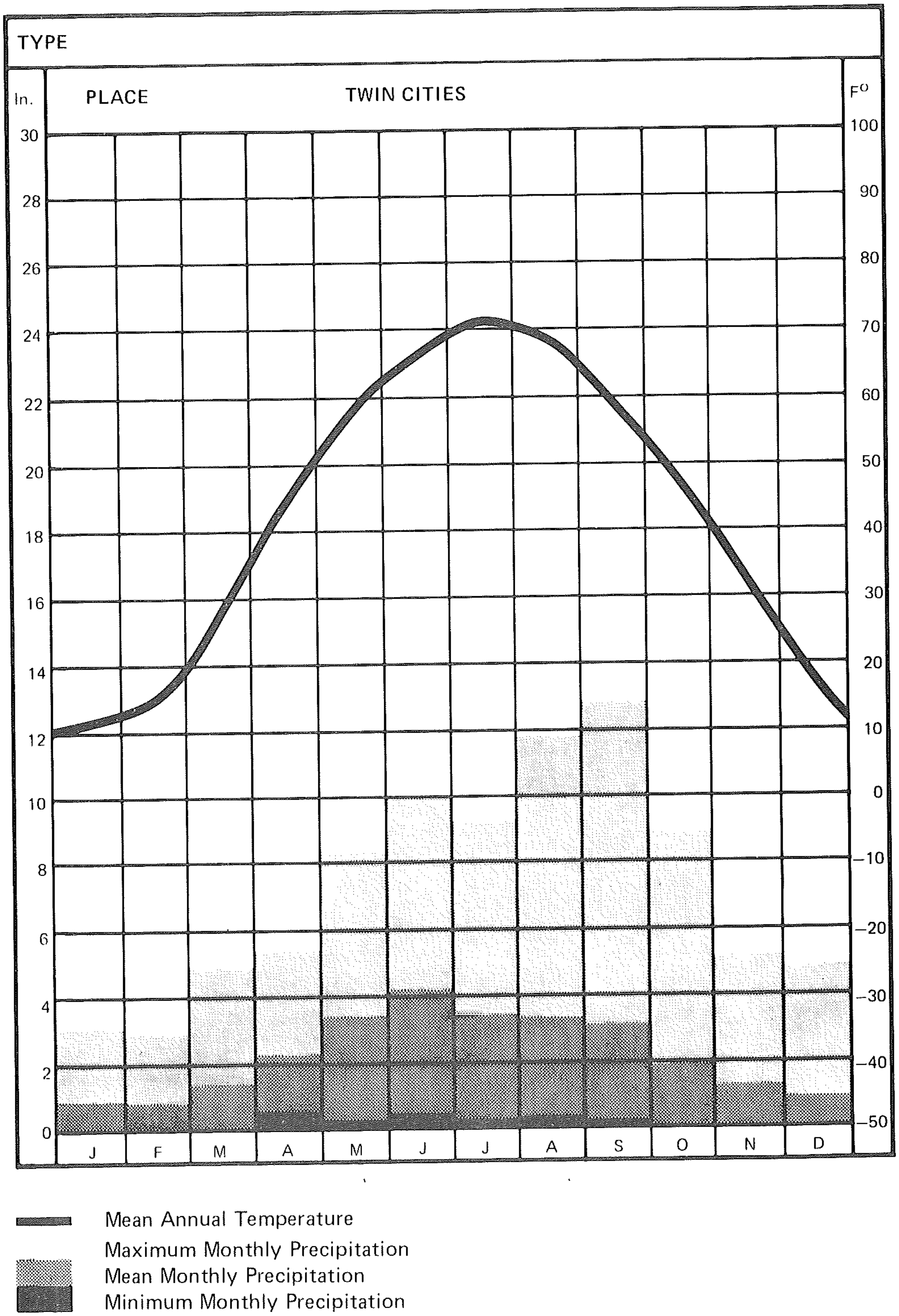
FIGURE 1–24

MEAN ANNUAL TEMPERATURE AND PRECIPITATION—
ROSEMOUNT STATION



SOURCE: Local Climatological Data, 1963-1974

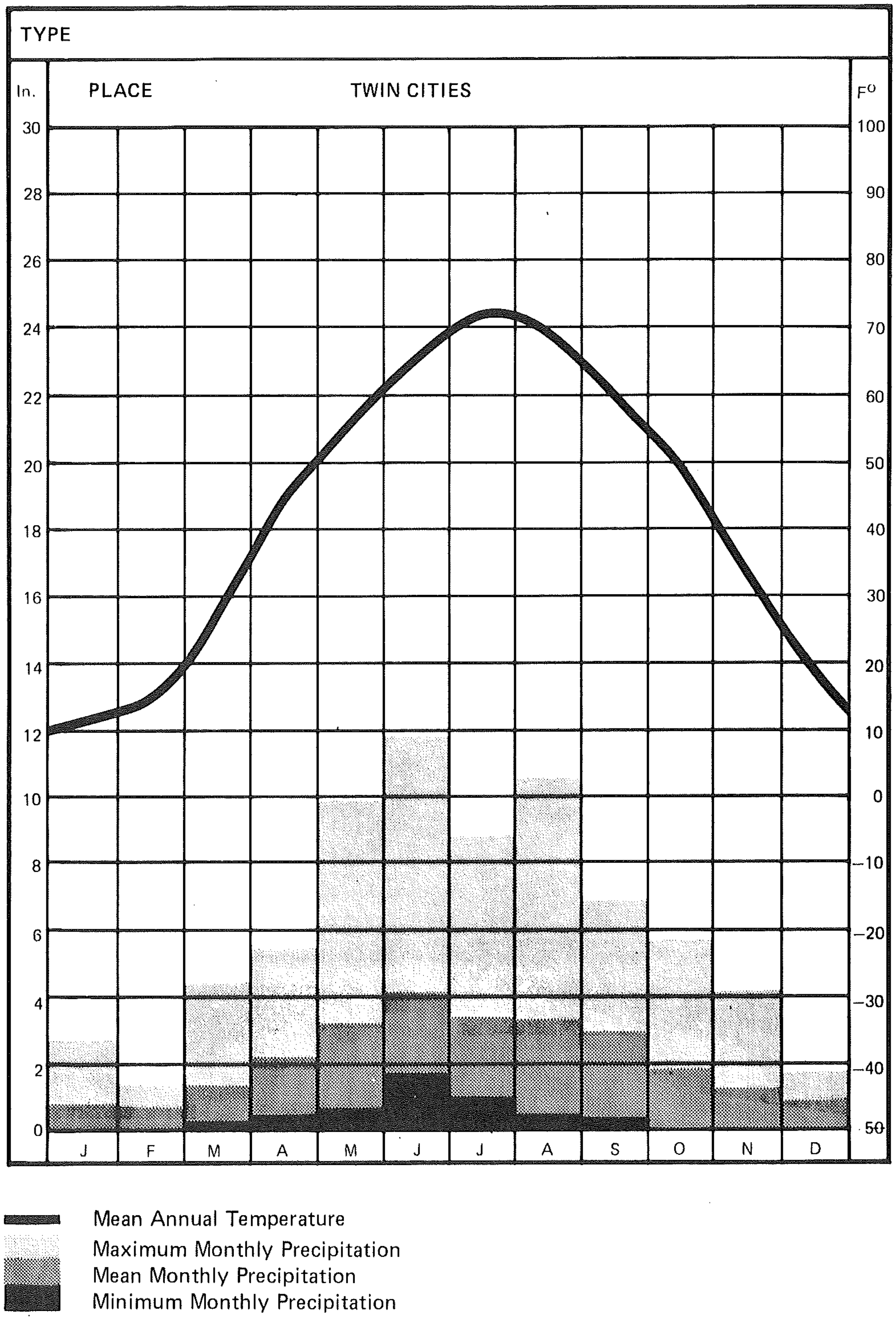
FIGURE 1–25 MEAN ANNUAL TEMPERATURE AND PRECIPITATION– FARMINGTON STATION



SOURCE: Local Climatological Data, 1963-1974

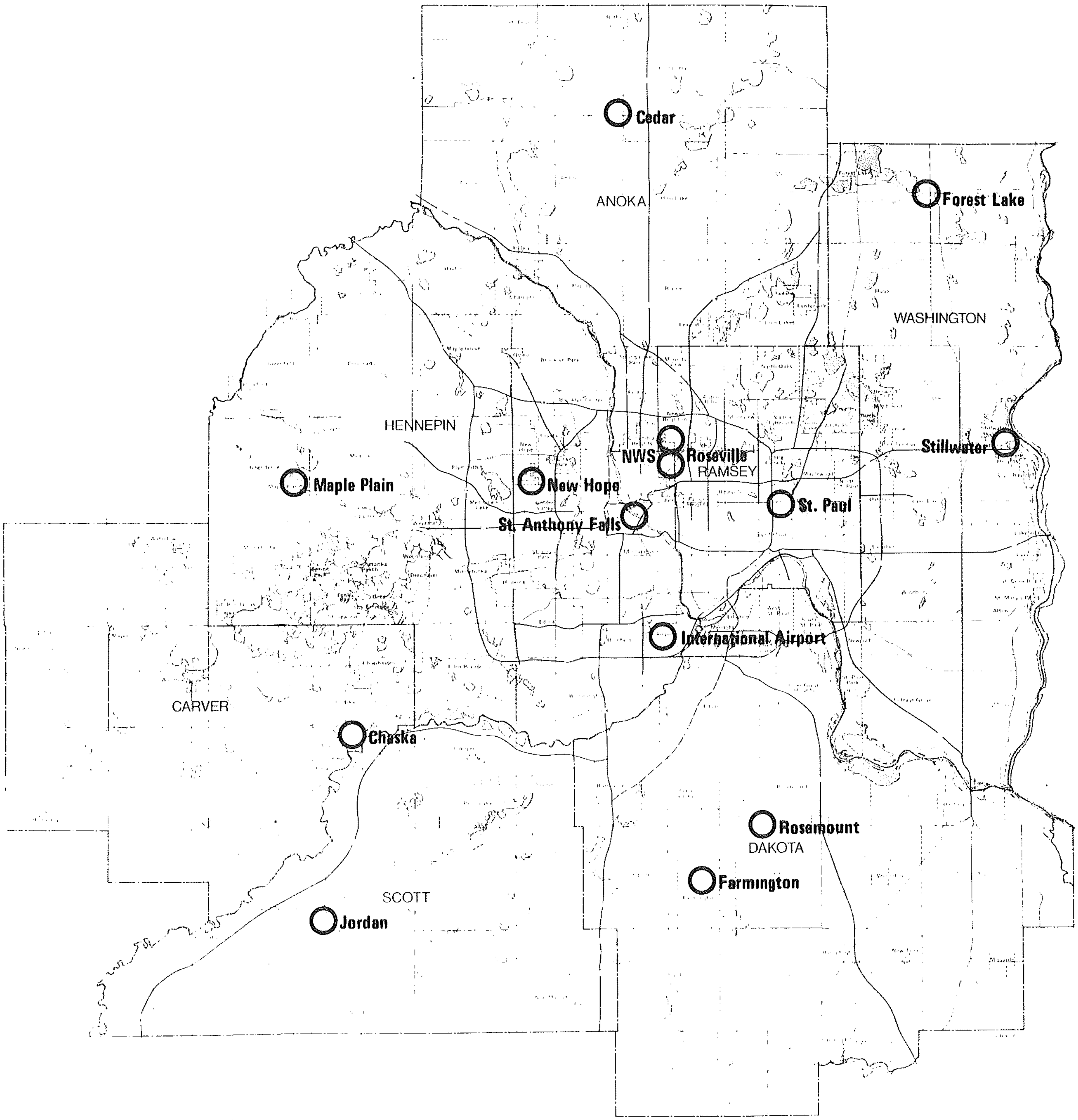
FIGURE 1–26

MEAN ANNUAL TEMPERATURE AND PRECIPITATION–
JORDAN STATION



SOURCE: Local Climatological Data, 1963-1974

FIGURE 1–27 WEATHER OBSERVATION STATIONS



SOURCE: Local Climatological Data

INSOLATION

Insolation, the amount of energy received from the sun, is commonly expressed in langleys per day. A langley is defined as one gram-calorie per square centimeter. In comparison with the rest of the United States, the metropolitan area receives about 75% as much radiation as the sunniest area (the Mojave Desert) in July, and about 45% as much radiation as the sunniest area (the upper Rio Grande Valley) in November and December. Insolation is about five times greater in July as in November and December. Locally, July is the sunniest month, November and December are the cloudiest months.

Average daily values of solar radiation in langleys per day has been recorded at St. Cloud from 1954 to 1970 (2). The data corresponds to that expected in the metropolitan area since cloudiness does not vary significantly over 100 miles. The week with the greatest insolation was July 19 to July 25; the week with the least was December 20 to 26.

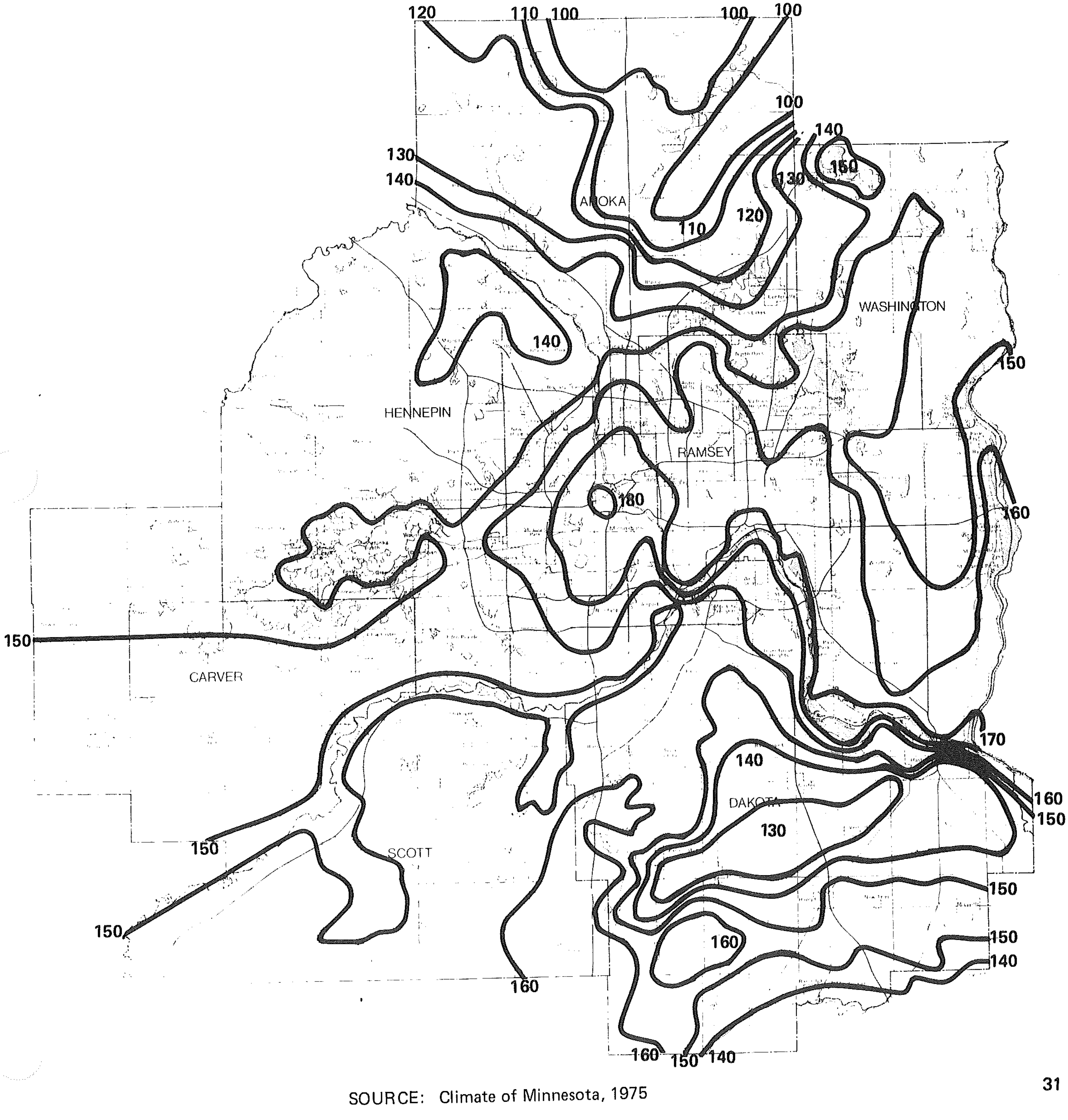
GROWING SEASON AND FROST-FREE DAYS

The length of the growing season in the metropolitan area (as defined by dates between a 32° F ambient air temperature at 4.5 feet above the ground) varies between about 100 days in the vicinity of Carlos Avery marshland to 180 days in downtown Minneapolis. The reason for the great difference in growing season is that the first and last 32° temperature occurrence usually comes when wide variations in areal temperature distribution exist—on clear, still nights.

Figure 1—28 presents the growing season in days between first and last freeze.

FIGURE 1–28

GROWING SEASON, NUMBER OF DAYS BETWEEN 32° MINIMUM TEMPERATURES



SOURCE: Climate of Minnesota, 1975

TABLE 1–1

AVERAGE ANNUAL PRECIPITATION IN INCHES, ADJUSTED TO 1836–1977 PERIOD (5)

STATION	RATIO TO NWS		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Cedar	1.110	1961	.92	.89	1.52	2.29	3.52	4.30	3.61	3.52	3.23	2.00	1.45	1.00	28.25
Forest Lake	.996	1961	.83	.80	1.36	2.05	3.16	3.85	3.24	3.16	2.90	1.79	1.30	.90	25.34
Stillwater	1.047	*	.87	.84	1.43	2.16	3.32	4.05	3.40	3.32	3.05	1.88	1.37	.94	26.63
Roseville	1.170	1967	.97	.94	1.60	2.41	3.71	4.52	3.80	3.71	3.40	2.10	1.53	1.05	29.74
New Hope	1.130	1967	.94	.90	1.55	2.33	3.58	4.37	3.67	3.58	3.28	2.03	1.48	1.02	28.75
Maple Plain	1.090	**	.90	.87	1.49	2.25	3.46	4.22	3.54	3.46	3.17	1.96	1.43	.98	27.73
St. Paul	1.084	1961	.90	.87	1.49	2.23	3.44	4.20	3.52	3.44	3.15	1.95	1.61	.98	27.78
Falls of St. Anthony	1.075	1960	.89	.86	1.47	2.21	3.41	4.16	3.49	3.41	3.13	1.94	1.41	.97	27.35
NWS	1.000	1836	.83	.80	1.37	2.06	3.17	3.87	3.25	3.17	2.91	1.80	1.31	.90	25.44
Chaska	1.052	1931	.87	.84	1.44	2.17	3.33	4.07	3.42	3.33	3.06	1.89	1.38	.95	26.75
Rosemount	1.127	1961	.94	.90	1.54	2.32	3.57	4.36	3.66	3.57	3.28	2.03	1.48	1.01	28.66
Farmington	1.081	1885	.90	.86	1.48	2.23	3.43	4.18	3.51	3.43	3.15	1.94	1.42	.97	27.50
Jordan	1.046	1951	.87	.84	1.43	2.15	3.32	4.05	3.40	3.32	3.04	1.88	1.37	.94	26.61

*Stillwater 1905–1919, 1944–1977

**Maple Plain 1887–1907, 1915–1977

LEAST PRECIPITATION, IN INCHES

STATION	RATIO TO NWS		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Cedar	1.110	1961	.31	.10	.51	.73	1.18	2.38	1.32	.31	.49	.32	.13	.19	14.12
Forest Lake	.996	1961	.04	.02	.37	.64	.77	1.48	1.01	.86	.35	.47	.07	.25	16.08
Stillwater	1.047	*	.04	T	.22	.53	.44	67	.88	.54	.37	.04	T	0	10.55
Roseville	1.170	1967	.26	.26	.85	1.11	.09	1.11	.53	.75	.31	.49	.17	.45	16.30
New Hope	1.130	1967	.19	.11	.70	.82	1.18	1.56	1.26	.45	.39	.38	.15	.35	14.50
Maple Plain	1.090	**	.05	.07	.08	.39	.13	.70	.30	.23	.28	.02	T	.04	16.85
St. Paul	1.084	1961	.15	.01	.74	1.07	.84	2.08	1.24	.92	.51	.42	.13	.23	17.36
Falls of St. Anthony	1.075	1960	.15	.18	.17	.98	.72	.72	1.16	.65	.70	.25	.41	.12	15.00
NWS	1.000	1836	0	T	.02	.18	.21	.02	.11	.20	.27	0	.02	T	11.59
Chaska	1.052	1931	.02	T	.23	.70	.45	.59	.58	.29	.37	T	.08	T	16.44
Rosemount	1.127	1961	.13	.02	.80	.99	.81	.93	1.45	.64	.58	.35	.07	.15	18.60
Farmington	1.081	1885	T	T	.04	.55	.22	.43	.22	.25	.10	T	T	0	12.35
Jordan	1.046	1951	.04	.04	.31	.62	.70	1.79	1.03	.40	.33	0	T	.01	19.64

*Stillwater 1905–1919, 1944–1977

**Maple Plain 1887–1907, 1915–1977

MOST PRECIPITATION, IN INCHES

STATION	RATIO TO NWS		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Cedar	1.110	1961	3.15	2.82	3.45	4.72	6.25	8.13	6.83	7.35	5.81	7.72	4.81	4.06	38.65
Forest Lake	.996	1961	3.09	1.79	3.42	5.66	6.35	10.86	6.66	8.67	5.14	6.51	5.13	2.40	44.44
Stillwater	1.047	*	2.72	2.16	3.73	6.56	9.82	10.47	7.47	8.82	9.04	7.31	5.19	2.74	45.15
Roseville	1.170	1967	3.60	2.00	4.39	3.82	5.93	9.82	7.31	6.22	5.11	7.28	5.07	3.73	45.31
New Hope	1.130	1967	3.46	1.89	4.65	6.24	5.34	8.36	6.78	5.21	4.10	6.85	5.23	2.17	40.74
Maple Plain	1.090	**	3.94	3.72	4.22	5.86	9.91	10.72	12.12	10.52	9.71	10.39	4.78	3.89	44.81
St. Paul	1.084	1961	3.46	1.86	3.94	6.92	7.64	9.22	5.93	6.62	6.06	7.24	5.18	2.48	41.51
Falls of St. Anthony	1.075	1960	4.26	2.21	3.49	6.67	7.70	8.80	5.82	7.17	6.09	7.04	4.72	4.05	46.63
NWS	1.000	1836	4.34	3.25	4.75	5.40	10.33	11.67	11.87	9.16	10.61	6.42	5.75	3.16	40.15
Chaska	1.052	1931	2.85	1.69	3.17	5.06	8.55	9.95	8.06	7.94	8.66	5.78	5.20	1.98	39.94
Rosemount	1.127	1961	3.77	2.11	4.06	6.74	6.24	8.63	6.91	5.68	6.18	6.54	5.74	2.95	43.29
Farmington	1.081	1885	3.06	2.82	4.83	5.49	9.28	10.00	9.21	11.76	12.68	8.75	5.18	4.73	41.48
Jordan	1.046	1951	2.54	1.63	4.38	4.17	9.88	11.87	8.86	10.53	6.80	5.79	4.19	1.75	41.80

*Stillwater 1905–1919, 1944–1977

**Maple Plain 1887–1907, 1915–1977

PRECIPITATION

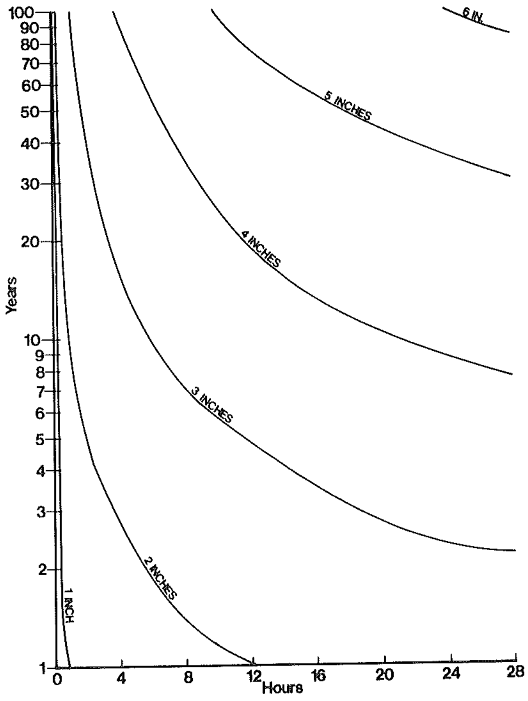
Table 1—1 corresponds to the average monthly and annual precipitation from 1936 to 1977 as presented in Figures 1—14 through 1—27. Stations with longer periods of record tend to have greater extremes. Roseville is the wettest station with 29.74 inches of precipitation and International Airport is the driest with 25.44 inches of precipitation.

Monthly and seasonal maps and an annual map showing rainfall variation over the metropolitan area have been compiled from thirteen stations (6). They were averaged from records during the wet years of 1959 to 1977, when almost an inch of precipitation greater than the long-term average fell. The annual map shows "wet" maxima from central Hennepin to central Anoka County, and from east-central Dakota County to west-central Washington County. "Dry" centers occur from northern Scott County to south-east Hennepin County, over eastern Dakota County and over northern Washington County.

Recurrence of rainfall is also important. Figure 1-29 indicates return frequencies for the general metropolitan area (7). For rains of less than three or four inches, it is possible that the wet zones have a greater return frequency of heavy rains than do the dry areas. This may not be true for rains heavier than three or four inches. Very heavy rains are usually due to a series of large thunderstorms passing in layers along a stationary front. This is a different phenomenon than severe, tornado-bearing thunderstorms which move alone, generally perpendicular to a frontal line. The case of thunderstorms moving along a stationary front is a large-scale generated phenomenon. A stationary front -- tornado-bearing thunderstorm on the other hand, is an intermediate-scale generated phenomenon which may only include several counties.

FIGURE 1—29

RAINFALL RECURRANCE FREQUENCY

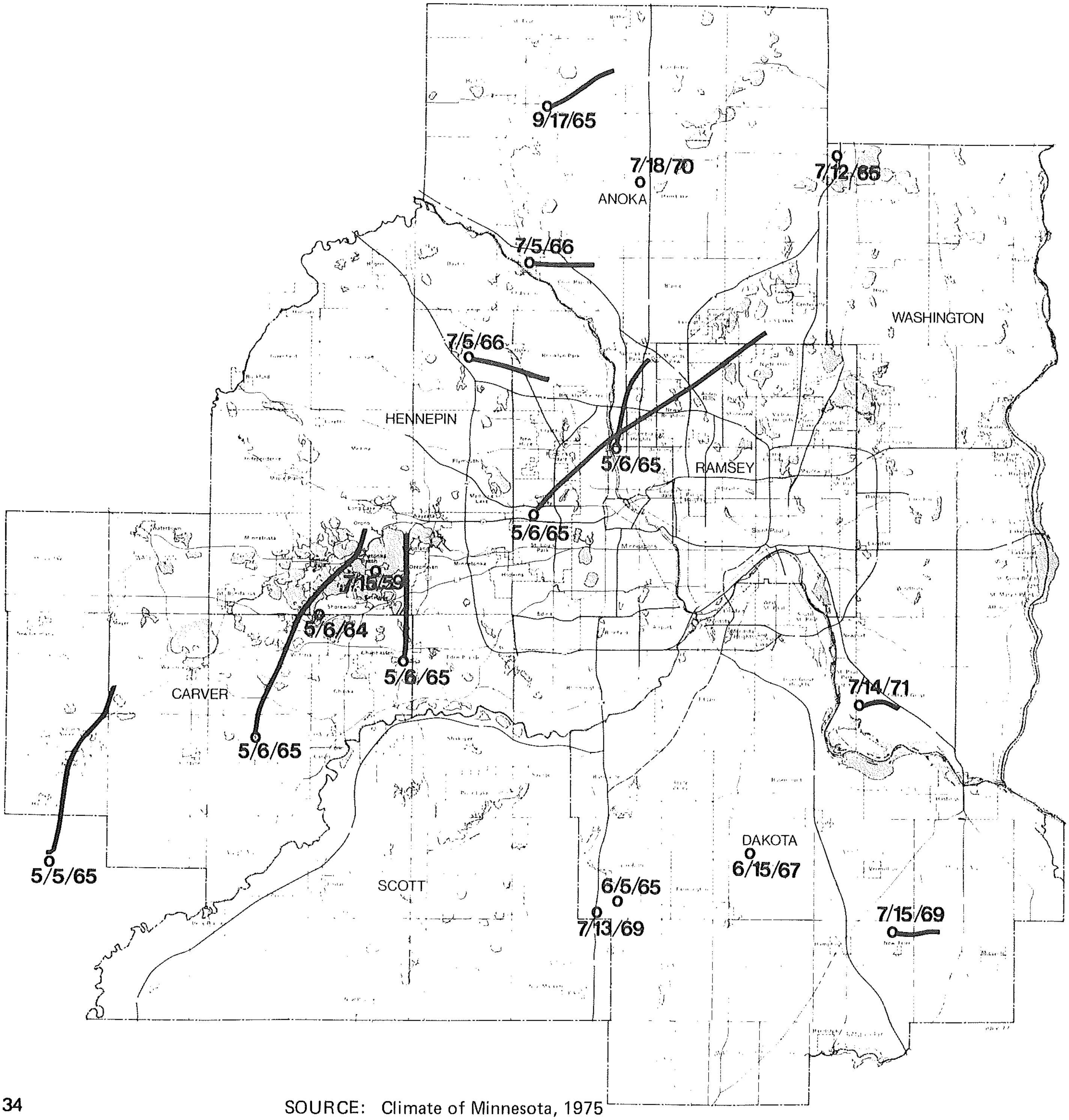


SOURCE: Rainfall Return Frequency Atlas of the United States for Durations of 30 Minutes to 24 Hours and Return Periods 1 to 100 Years, 1961.

FIGURE 1–30

POINT OF TORNADO TOUCHDOWN AND GROUNDPATH OF ALL TORNADOES IN THE METROPOLITAN AREA, 1959–1972

Figure 1-30 (5), indicates tornado touchdowns which reflect the most intense thunderstorms that crossed the metropolitan area from 1959 to 1972. The path follows the "wet belt" from southwest Sibley County to Anoka County.



SOURCE: Climate of Minnesota, 1975

Precipitation has been measured in the metropolitan area continuously since 1836. Table 1-2 lists precipitation figures for the metropolitan area. The top line in the table gives the true adjusted average from 1836 to 1977 for the airport. Some adjustment was needed because observations were several miles away from the International Airport-Fort Snelling area from 1858 to 1866 and 1892 to 1937 (5).For comparison, the current 30-year normal figures, (1941 - 1970) are listed in the second line. The 30-year normal shows an annual rainfall of 25.94 inches, which is one-half inch greater than the long term average. The 30-year normal precipitation has varied from 28.87 inches in the 30 years ending 1920 to 24.72 inches in the 30 years ending in 1950. Adjusted to the Airport, these values would be 26.85 inches for the 30 years ending in 1920 and 23.86 inches for the 30 years ending in 1950. These figures are currently used for predictions. The median precipitation for 1836 to 1977 is also shown in Table 1-2. The median is significantly less than the average, as most months are "below normal" in precipitation. This is because the wetter months tend to contribute a disproportionate share of precipitation to the grand total.

TABLE 1–2

AVERAGE MONTHLY AND ANNUAL PRECIPITATION, 1836–1977 (ADJUSTED) (6)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Airport Adjusted Average, 1836-1977	.83	.80	1.37	2.06	3.17	3.87	3.25	3.17	2.91	1.80	1.31	.90	25.44
Current Normal (1941-1970) (30 year average)	.73	.84	1.68	2.04	3.37	3.94	3.69	3.05	2.73	1.78	1.20	.89	25.94
Greatest 30–Year Average	1.09	1.02	1.69	2.49	3.89	4.56	4.08	4.06	3.62	2.45	1.61	1.22	28.87
Least 30–Year Average	.62	.61	1.19	1.80	3.03	3.67	2.59	2.74	2.43	1.37	1.04	.77	24.72
Median Observed Precipitation, 1936-1977	.71	.64	1.28	2.04	3.05	3.73	3.01	3.05	2.58	1.60	1.04	.72	
Percent of Annual Precipitation Occurring This Month	3.3	3.3	6.5	8.2	11.9	15.2	13.8	12.1	9.8	7.3	4.9	3.7	

DAYS WITH PRECIPITATION

The chance of rain falling between 6:00 p.m. and 6:00 a.m. is much greater than the chance of rain falling between 6:00 a.m. and 6:00 p.m. For this reason, the definition of "rainy day", or days with precipitation, is highly dependent on observation time. Morning observations cannot be compared with those made in the evening or at midnight.

At International Airport, the National Weather Service recorded an average of 110 days per year with rain in excess of 0.01 in the 38-year period ending in 1976. The number of days per month with precipitation is shown in Table 1-3:

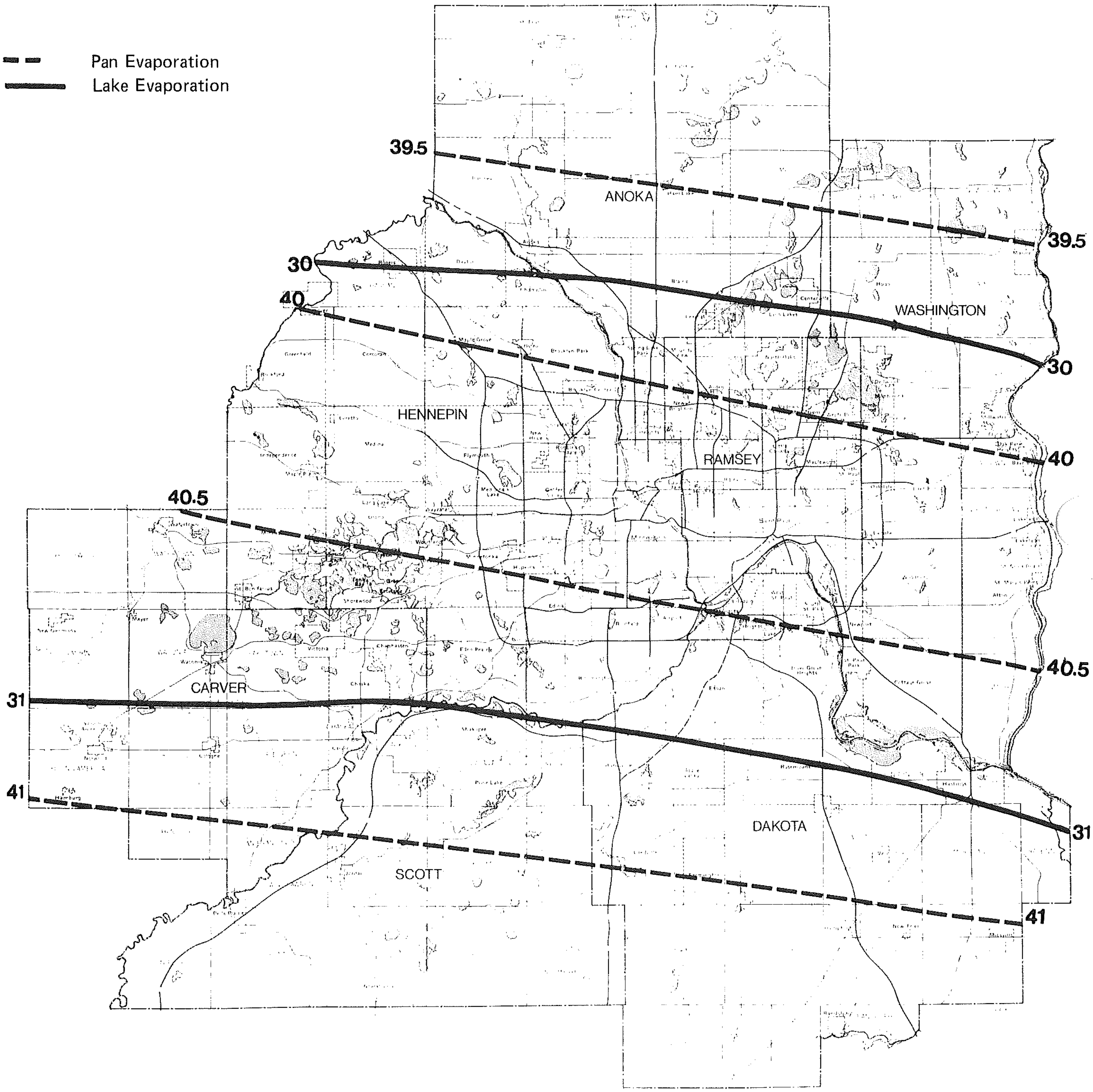
TABLE 1–3

NUMBER OF DAYS PER MONTH WITH PRECIPITATION

JANUARY	9	JULY	10
FEBRUARY	7	AUGUST	9
MARCH	10	SEPTEMBER	8
APRIL	10	OCTOBER	8
MAY	12	NOVEMBER	8
JUNE	12	DECEMBER	9

An average of 18 more days of measureable rain in the period between 1964 - 1968 were reported at Oakdale than at the Airport for the 24-hour period ending at 7:00 a.m.; 10 more days at Woodbury; 4 days less at Maple Plain; and 5 days less at Wayzata. These four stations, all located within "wet" areas, also report an average of an additional 23 days of 0.10 inch of rain than at the airport in the same period. This provides an average of seven days more of one inch greater precipitation.

FIGURE 1–31 ANNUAL LAKE AND PAN EVAPORATION, INCHES



SOURCE: Evaporation Maps for the United States

The number of rains of two inches or more was slightly greater at the airport, although only five cases were involved. Since International Airport is the driest place in the metropolitan area, the number of rainy days ranges from 110 to 135 days a year over the metropolitan area.

EVAPORATION

Figure 1-31 shows annual lake and pan evaporation for the metropolitan area (3). Evaporation is a function of sunshine intensity, temperature, humidity, and wind. Pan evaporation is useful when comparing two D.O. cations. Lake evaporation is useful when comparing particular bodies of water. Usually, the difference between the two figures is .7 inches. Few observation statistics exist. Lake evaporation will vary, depending on modification of the above factors by surrounding topography and lake size.

WIND

Wind values vary a great deal according to location and show different characteristics of climate according to units used. Wind has been observed by instrumentation in various places, in various units, and at various heights in the metropolitan area since 1870. The instrumentation and units currently in use by the National Weather Service have been continuous since 1963.

Figure 1-32 presents the wind speed variation over the metropolitan area. Values reflect the average percent difference between locations on Figure 1-32 and the average values observed by the National Weather Service at the International Airport for each of the four cardinal directions as caused by topography. The map is prepared for locations 21 feet above any local surface. Structure tops, excluding tall buildings, are also considered to be a surface.

The annual wind rose indicates, reading clockwise, a preponderance of winds from 300 to 10 degrees, and from 120 degrees to 180 degrees. Winds between 30 and 100 degrees are relatively rare. Winds between 190 and 280 degrees are less common than the first categories. Light winds between 190 and 280 degrees are much more common than light winds from the 300 to 10 degree category. For more information on how to interpret wind roses, see Appendix A.

Figure 1-33 shows that lowest wind speeds are found in valley areas, especially those valleys situated at right angles to northwesterly and southeasterly winds. Highest values are found at hill tops. To construct an approximate wind rose for any point on the chart, compare the wind or any of the roses with the percent reduction and orientation of the wind on Figure 1-33. In a valley area, the wind parallel to the value will be reduced little. Winds perpendicular to the valley will be severely reduced.

Figures 1-33 to 1-45 present monthly and annual wind roses for the International Airport for the period 1964 to 1973. The winds are presented in units of tens of degrees and knots.

FIGURE 1–32 WIND–PERCENT OF VELOCITY AS COMPARED TO AIRPORT

SOURCE: Local Climatological Data

FIGURE 1–33

AVERAGE ANNUAL WIND ROSE, 1964–1973
(In Tenths of Degrees and Knots)

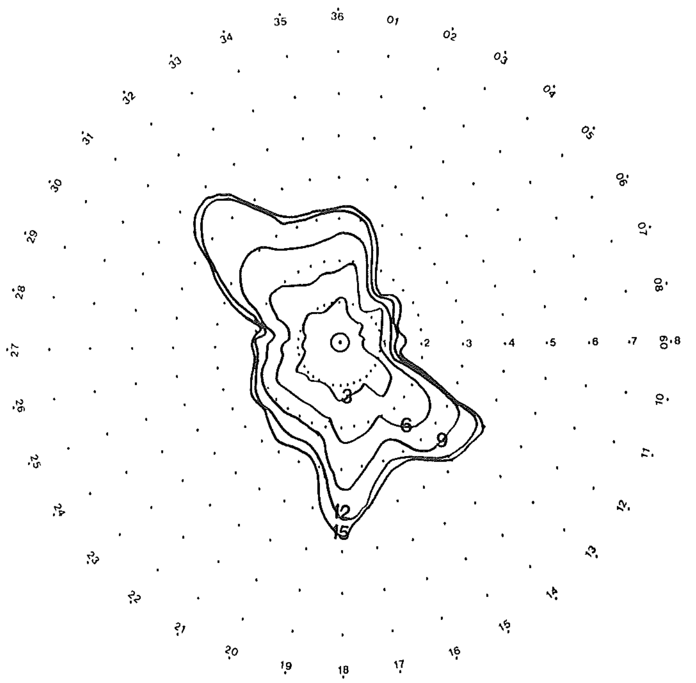
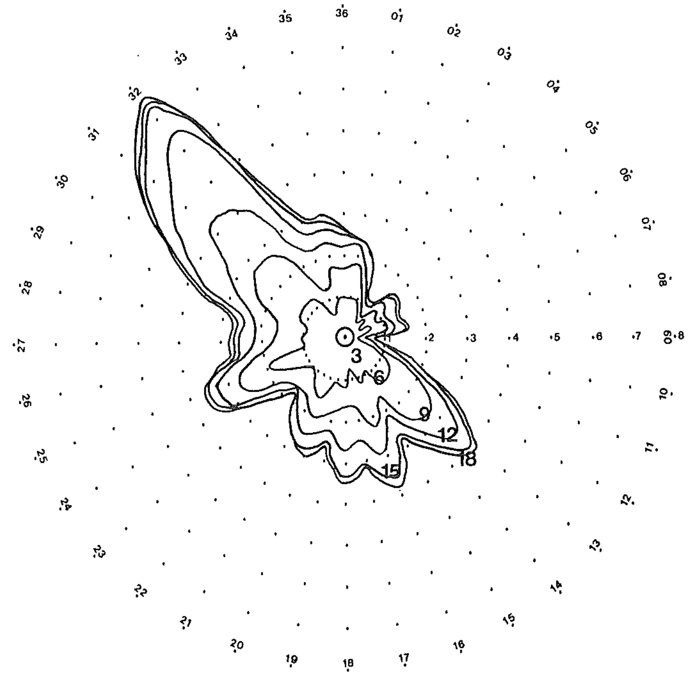


FIGURE 1–34

WIND ROSE–JANUARY
(In Tenths of Degrees and Knots)



SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

FIGURE 1–35

WIND ROSE–FEBRUARY
(In Tenths of Degrees and Knots)

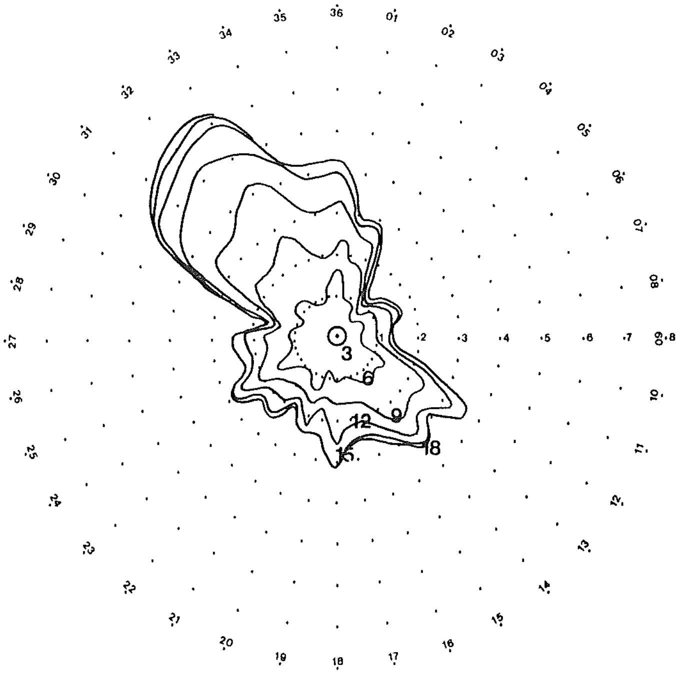


FIGURE 1–36

WIND ROSE–MARCH
(In Tenths of Degrees and Knots)

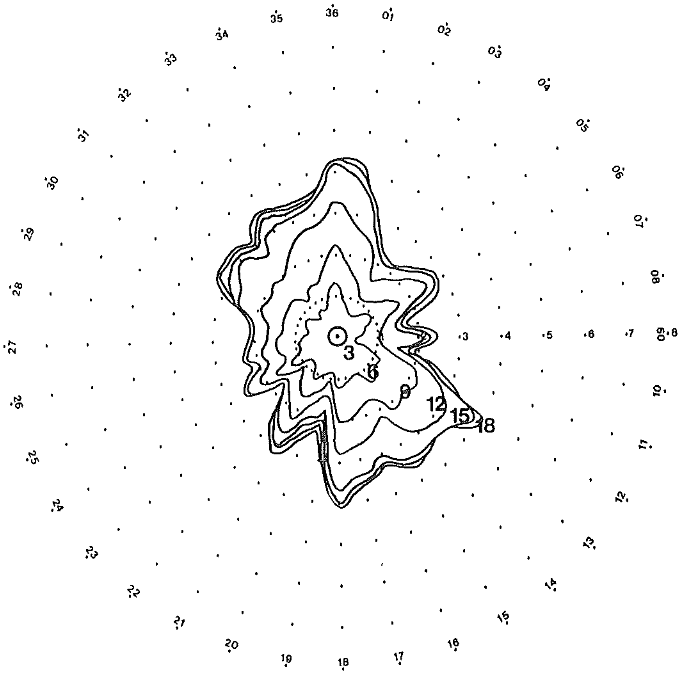
SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

FIGURE 1–37

WIND ROSE—APRIL
(In Tenths of Degrees and Knots)

FIGURE 1–38

WIND ROSE—MAY
(In Tenths of Degrees and Knots)



SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

FIGURE 1–39

WIND ROSE–JUNE
(In Tenths of Degrees and Knots)

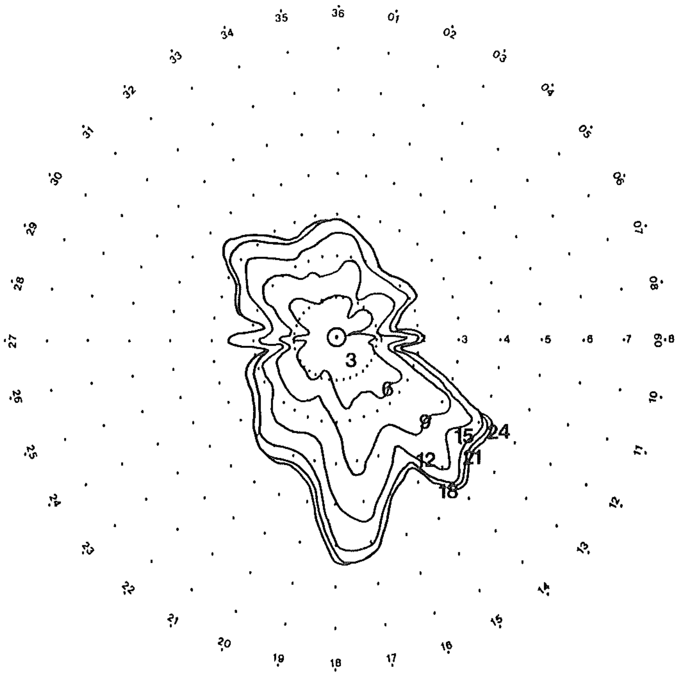


FIGURE 1–40

WIND ROSE–JULY
(In Tenths of Degrees and Knots)

SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

FIGURE 1–41

WIND ROSE—AUGUST
(In Tenths of Degrees and Knots)

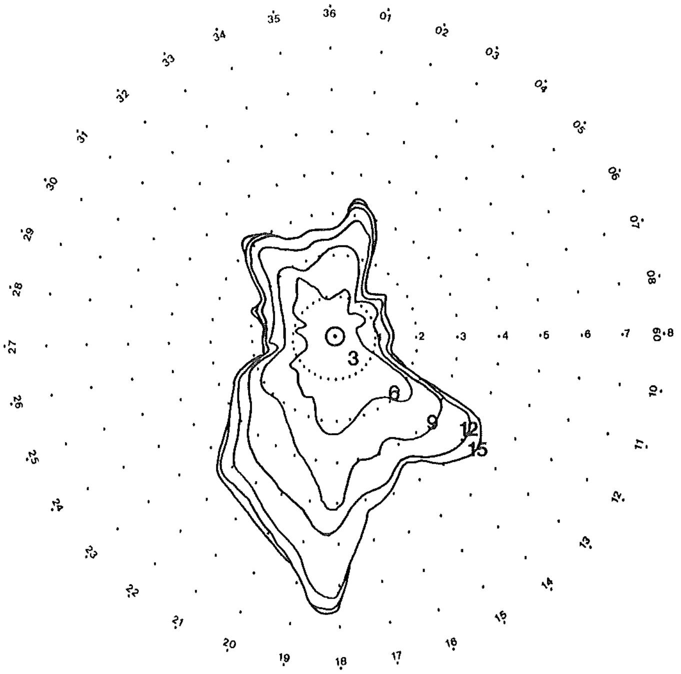
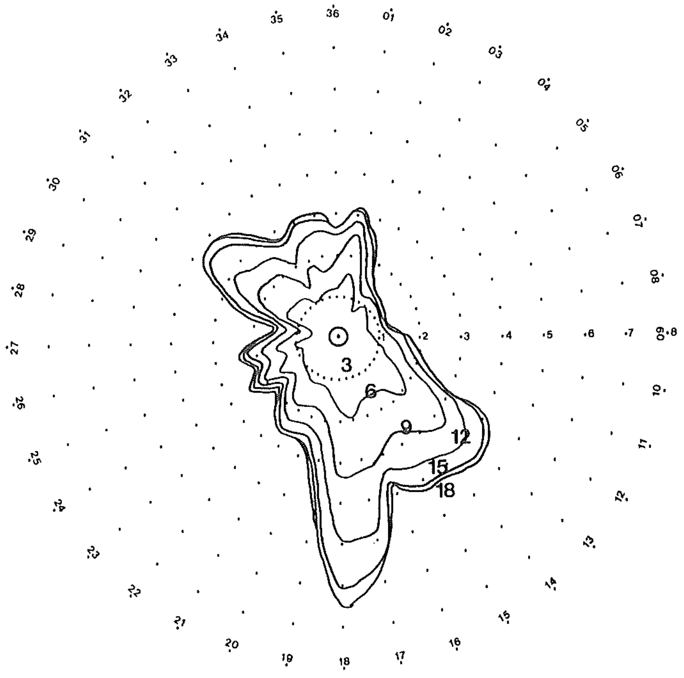


FIGURE 1–42

WIND ROSE—SEPTEMBER
(In Tenths of Degrees and Knots)



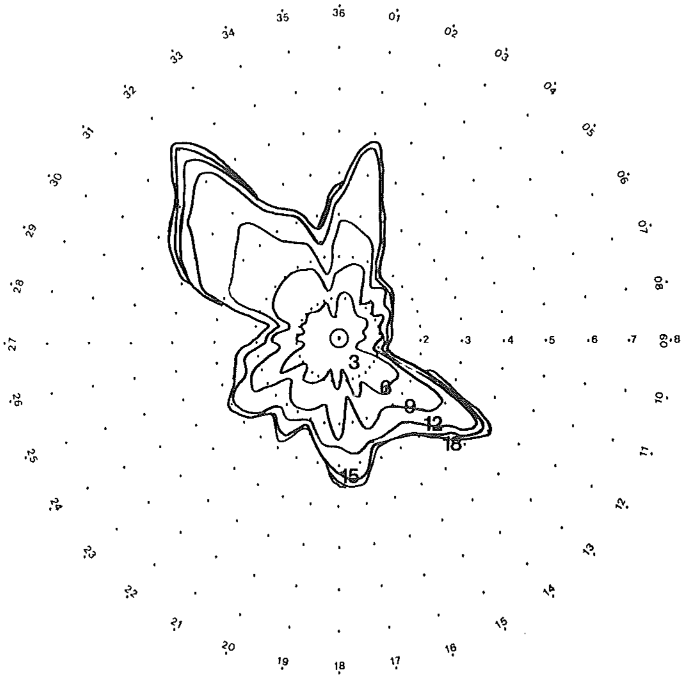
SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

FIGURE 1–43

WIND ROSE–OCTOBER
(In Tenths of Degrees and Knots)

FIGURE 1–44

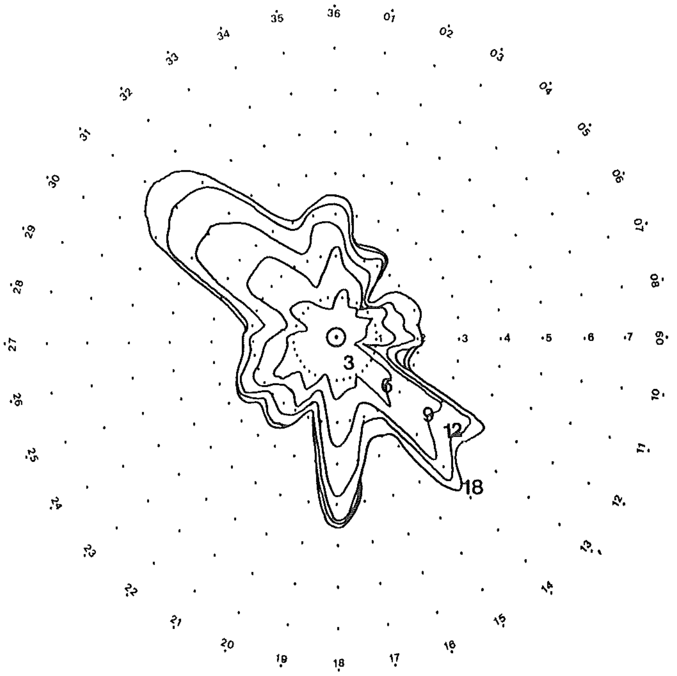
WIND ROSE–NOVEMBER
(In Tenths of Degrees and Knots)



SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

FIGURE 1–45

WIND ROSE–DECEMBER
(In Tenths of Degrees and Knots)



SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota 1963-1974

MONTHLY WIND ROSES

Comparison of the monthly wind roses indicates definite regional changes. The period from May 11-20 receives strong winds from the west, while the last 10 days are loaded with winds from the east. In June, especially during the first 20 days, most winds blow from the southeast. The last ten days of June and the month of July receive hot southwesterly winds. Strong winds out of the south-southwest are well developed by late July and last through late August.

August is marked by strong southwest winds. During late August and early September, northerly winds become relatively rare and southeasterly winds in excess of 12 knots appear once again. Southeasterlies take over from southwesterlies during the first 20 days of September. The wind shifts radically during late September. During this time, there is a sharp drop in rainfall, a sudden peak in the barometric pressure, a sharp increase in sunshine, and a strong drop in temperature.

In October, southwesterlies become more common than in September. During late October, there is a shift to more northerly winds, cloudiness, and a sharp temperature decrease. This is the beginning of the northwesterly wind turn-around that prevails in November. There is a dearth of winds from the northeast to north-northeast from October through December 20th. After December 21st, these winds become common through the end of the month.

January winds come from the northwest. In the last 10 days of January, the time of the temperature minimum, the wind blows from 310 to 320 degrees, combined, over 15 percent of the time. February and March exhibit little change, except for greater wind velocity in March. Early April brings brisk winds and an increase in northeasterlies, while mid-April brings a sharp break and a switch to prevalent southeasterlies. This is the beginning of the wet season, and the sudden end of wintery weather. In May, the wind blows from all directions.

REFERENCES

1. Annual Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota, 1964-1973. Bruce Watson, Report to the Minnesota Pollution Control Agency, 1974. (Available: NWSFO - U of M Libraries)

2. Precipitation Patterns in the Minneapolis-St. Paul Metropolitan Area and Surrounding Counties, Earl Kuehnast, Donald Baker, and John Eng, Technical Bulletin 301-1975, Agricultural Experiment Station, University of Minnesota, 1975. (Available: NWSFO - U of M Libraries)

3. Frequency and Duration of Fog Likely at the Proposed Ham Lake and Farmington Airport Sites, Bruce Watson, Report to Northwest Orient Airlines, July 14, 1970. (Available: NWSFO)

4. Evaporation Maps for the United States, United States Department of Commerce Weather Bureau, Technical Publication. (Available: NWSFO—U of M Libraries)

5. Local Climatological Data, Minneapolis-St. Paul International Airport, 1964-1973, NOAA Environmental Data Service, Asheville, North Carolina, 1976. (Available: NWSFO - U of M Libraries)

6. Minnesota Weather Almanac 1976, Bruce Watson, Bolger Press, Minneapolis, Minnesota, 1975. (Available: NWSFO - U of M Libraries)

7. Rainfall Return Frequency - Atlas of the United States for Durations of 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, United States Department of Commerce Weather Bureau, Technical Publication No. 40, Washington, D.C. May 1961. (Available: NWSFO—U of M Libraries)

8. Solar Radiation Reception, Probabilities, and Areal Distribution in the North-Central Region, Donald G. Baker and John C. Klink, North Central Regional Research Publication 225, Technical Bulletin 300 - 1975, Agricultural Experiment Station, University of Minnesota.

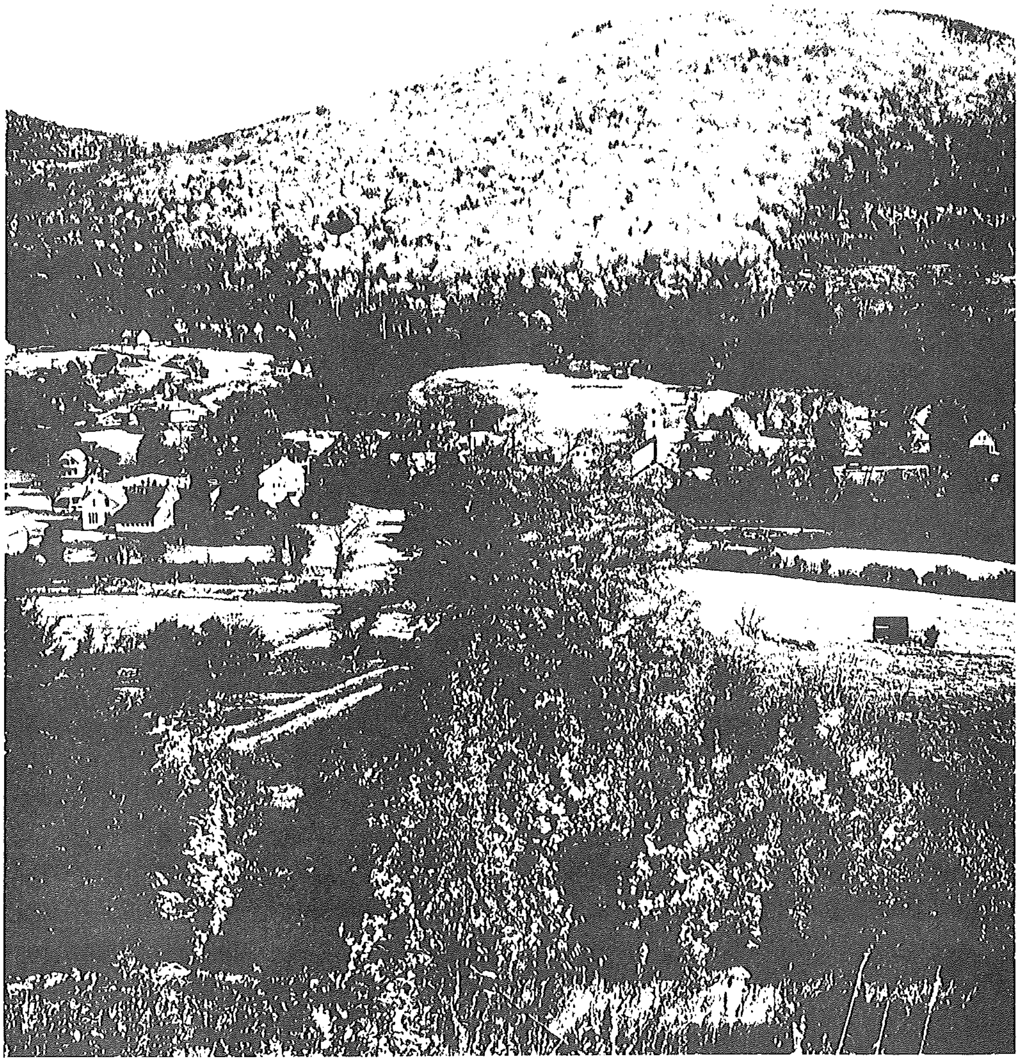
9. Temperature and Wind Variations in Shoreview, Minnesota, Bruce Watson, Report for Metropolitan Mosquito Control, 1974. (Available: MMC)

MMC - Metropolitan Mosquito Control, St. Paul
NWSFO - National Weather Service Forecast Office, Minneapolis
U of M Libraries - University of Minnesota, Minneapolis.
Wilson Library is a Federal Depository, and has most government publications on file.

CONTACTS

Dr. Donald Baker	Soil Science Department St. Paul Campus, University of Minnesota Solar radiation and soil temperature - St. Paul Campus Analysis of weather related to agricultural production Analysis of soil moisture and evaporation on state-wide level

John Graff John Butler	National Weather Service Forecast Office Current weather Library of local weather studies File of Minneapolis weather observations
Earl Kuehnast	State Climatologist, Department of Natural Resources Raw weather data for state, nearly all observations on file State precipitation since 1970 Library of climatic books and publications
Bruce Watson	Consulting Meteorologist File of meteorological literature Analysis of weather variables from beginning of observations to present on daily, monthly and yearly basis Analysis of major state storm since 1969 Analysis of regional weather variables for Minnesota, Wisconsin and Iowa Microclimate studies of Minnesota Weather radar data



TOPOGRAPHY

The topographical relief of the metropolitan area ranges from flat areas associated with outwash plains to steep hills characteristic of the Eastern St. Croix moraine to dramatic cliffs along the Mississippi River gorge. While this extreme range of topography provides many natural opportunities, it may impose a variety of problems related to future development.

The most severe limitations usually occur in floodplains; wet, poorly drained areas, including marshes and peatlands; and rolling to hilly areas in moraine regions. Sand plains are generally least problematic for urban development because they are well-drained and nearly level, and the coarse material provides high bearing strength to support foundations. Regional geomorphic features are located on Plate 1.

The topography of the metropolitan area has undergone very few changes since the retreat of the last glacial ice sheet 13,000 years ago. Alterations since then have been limited to rivers and streams which continually erode, transport and deposit portions of the landscape from one point to another. In general, the great expanses of flat landscapes (0-6 percent slope) were formed through the deposition of outwash sand and gravel on the Mississippi Valley outwash plain, the Minnesota Valley outwash plain, the Cannon Valley outwash plain, and the Anoka sand plains. The origin of hilly land in the metropolitan area is the result of glacial deposition in two broad physiographic moraine areas: the Owatonna and the Eastern St. Croix moraine. The latter is one of the sharpest moraines in Minnesota as evidenced by the relatively steep hills and relief up to 200 feet. A detailed discussion of geological land formation may be found in Exhibit C and D.

Elevations throughout the metropolitan area are illustrated on Plate 2. Western, southern and eastern portions of the metropolitan area show the highest elevations while areas of the St. Croix, the Mississippi and the Minnesota River Valley show the lowest elevations in the metropolitan area. Local high points are also indicated on Plate 2. Specific elevations of these points can be found on U.S. Geological Survey quadrangle maps. Localized low points have not been mapped, but are assumed to lie in the wetlands, lakes, ponds and drainageways of the metropolitan area. The major ridges lie at or above 1,000 feet mean sea level.

Areas of slope are mapped on Plate 3. Flat areas of 0-6 percent occur throughout the metropolitan area but are characteristic of the Anoka sand plain, the Minnesota and Mississippi River Outwash Valley and a large portion of central and eastern Dakota County. Moderate slopes of 6-12 percent again occur throughout much of the metropolitan area. Slopes of 12-18 percent frequently occur in the western, south central, southeastern and eastern portions of the metropolitan area. Slopes of greater than 18 percent occur in the eastern and northeastern regions of the metropolitan area as well as in Carver county, along the Minnesota River Valley. Land areas not included in the above three categories are assumed to fall into the 6-12 percent slope categories.

For natural drainage of the area, see Plate 5. To identify man-made drainage divides, sanitary sewers, water mains, and storm sewers, a map was prepared in 1973, by the Metropolitan Council. It is available in their library.

REFERENCES

1. Interpretations of Soil Landscapes and Geomorphic Regions—Twin Cities Metropolitan Sheet, Extension Bulletin 320, 1976, University of Minnesota. (Very helpful updated map)(Available: Agricultural Extension Service)

2. Topography of the Twin Cities Metropolitan Area, Topographical Map, 1:125,000 scale, Metropolitan Waste Control Commission, 1975. (Available: MWCC)

3. Urbanization and Land Features Map, 1:250,000 scale, 1973, Metropolitan Council. (Available: MC)

MC - Metropolitan Council

MWCC - Metropolitan Waste Control Commission

GLACIAL GEOLOGY

At several times during the glacial period, ice sheets crossed the metropolitan area from several directions. With the retreat of each ice sheet an assortment of sand, gravel, clay and boulders was left in irregular, unstratified moraines of various thickness. These are at least moderately hummocky. The most recent ice sheet which covered almost all of the metropolitan area, the Grantsburg sublobe of the Des Moines lobe, naturally had a disproportionate effect on the existing topography and soil. The sublobe apparently followed the Minnesota River Valley (3). As the surface was exposed during interglacial periods, high quantities of water washed out the moraines and added sand and clay, forming stratified outwash. The resulting outwash plains are nearly horizontal. Some, such as the Anoka sand plain, are five to ten miles across.

The soil type and the engineering character of the glacial material at any locality, depend largely on the nature of the original material, the amount of rewashing, and the drainage. Soils and other near-surface material have been further changed to some degree by past glacial events.

The outwash is stratified, so there is a degree of horizontal continuity but the nature of layers can be diverse. In moraines there may be abrupt changes both horizontally and vertically. The various glacial deposits vary greatly in extent and regularity. Mapping is necessarily generalized to a degree. The locations of the principal glacial units are shown on Plate 1 - Geomorphic Regions. Characteristic topography, soil and some engineering properties are presented in Appendix C and D.

GENERAL GEOLOGY

The geologic units in the metropolitan area are shown in Table 3-1. The upper part of this column is divided to show that pre-glacial rivers cut deep valleys in the sedimentary bedrock. These valleys were filled with glacial drift consisting of sand, gravel, clay and occasional boulders. Coherent limestone beds protrude beyond the less resistant shales and sandstones as they generally do on cliff faces. In the metropolitan area these pre-glacial valleys are as deep as 450 feet below nearby high points on the bedrock surface. The glacial valley fill is generally mixed but the proportions of sand, clay, gravel, and boulders vary, gradually or abruptly, both horizontally and vertically. Glacial debris not only fills the pre-glacial valleys but covers all but a few small areas of the bedrock surface. (See Plate 1 - Geomorphic Features.)

Drilling and testing are the primary sources of subsurface geologic data. Soil and geological data which is continuously updated is on file with the Minnesota Geological Survey. The Survey is the best single source of such data. In many cases it can supply information for preliminary planning.

TABLE 3—1

Geologic units and their water-bearing characteristics (modified from Stone, 1965).

System	Geologic Unit		Approx. Range In Thickness (in feet)	Description	Water-Bearing Characteristics
Quaternary	Undifferentiated glacial drift		0-400+	Glacial till, outwash sand and gravel, valley-train sand and gravel, lake deposits, and alluvium of several ages and several provenances; vertical and horizontal distribution of units is complex. Unconformity	Distribution of aquifers and relatively impermeable confining beds is poorly known, especially in subsurface. Where saturated, stratified well-sorted deposits of sand and gravel (alluvium, valley train, outwash, some lake and ice-contact deposits) yield moderate to large supplies of water to wells. Records of 24 large diameter wells completed in sand and gravel show yields ranging from 240 to 2,000 gpm (gallons per minute) with from 2 to 69 feet of drawdown. Des Moines Lobe till is non-water bearing; Superior Lobe till is sandy and may yield small supplies suitable for domestic or farm use.
Ordovician	Decorah Shale		0-95	Shale, bluish-green to bluish-gray; blocky; thin, discontinuous beds of fossiliferous limestone throughout formation.	Only about 25 square miles in extent in area of study. Confining bed.
	Platteville Limestone		0-35	Dolomitic limestone and dolomite, dark-gray, hard, thin-bedded to medium-bedded; some shale partings; can be divided into five members.	Only about 200 square miles in extent in area of study. Where saturated, fractures and solution cavities in rock generally yield small supplies to wells. Records of 23 wells show an average yield of 23 gpm. Water is generally under artesian pressure where overlain by Decorah Shale. Not considered to be an important source of water in area of study.
	Glenwood Shale		0-18	Shale, bluish-gray to bluish-green; generally soft but becomes dolomitic and harder to the east.	Confining bed; locally, some springs issue from the Glenwood-Platteville contact in the river bluffs.
	St. Peter Sandstone		0-150+	Sandstone, white, fine- to medium-grained, well-sorted, quartzose; locally iron-stained and well cemented; rounding and frosting of grains is common; 5-50 feet of siltstone and shale near bottom of formation.	About 650 square miles in extent in Minnesota part of study area; not fully saturated throughout area. Most wells completed in the sandstone are of small diameter and used for domestic supply. They yield 9 to 100 gpm with 1 to 21 feet of drawdown. Two wells known to be used for public supply have been pumped at 600 and 1,250 gpm. Water occurs under both confined and unconfined conditions. Confining bed near bottom of formation seems extensive and hydraulically separates sandstone from underlying Prairie du Chien-Jordan aquifer. Not considered to be an important source for public supplies in area of study, but is suitable source for domestic supplies.
	Prairie du Chien Group	Shakopee Dolomite	0-250+	Dolomite, light-brown to buff, thinly to thickly bedded, cherty; shale partings; commonly sandy and colitic.	About 2,000 square miles in extent in Minnesota part of study area. Together, the Prairie du Chien dolomite and Jordan Sandstone constitute the major aquifer unit in the area. The two are hydraulically connected throughout most of the area, but locally some small head differences may exist owing to intervening low-permeable confining beds of limited extent. Prairie du Chien: Permeability is due to fractures, joints and solution cavities in the rock. Yields small to large supplies of water to wells. Pumping rates of up to 1,800 gpm have been obtained. Prairie du Chien-Jordan aquifer: Supplies about 75 percent of ground water pumped in the metropolitan area. Yields of 115 wells (3-24 inch diameter casings), open to both rocks, ranged from 85 to 2,765 gpm with 3 to 133 feet of drawdown. Higher obtainable yields seem to reflect closeness to the Mississippi and Minnesota Rivers or to places where the aquifer is overlain directly by glacial deposits particularly where drift-filled valleys penetrate. Jordan: Permeability is mostly intergranular but may be due to joint partings in cemented parts. Main source of water for public supply in metropolitan area. Almost all wells completed in the sandstone are of large diameter. Recorded yields are from 36 to over 2,400 gpm with 2 to 155 feet of drawdown.
		New Richmond Sandstone		Sandstone and sandy dolomite, buff; often missing.	
		Oneota Dolomite		Dolomite, light-brownish-gray to buff; thinly to thickly bedded, vuggy.	
Cambrian	Jordan Sandstone		0-100+	Sandstone, white to yellowish, fine- to coarse-grained, massive to bedded, cross-bedded in places, quartzose; commonly iron-stained; loosely to well cemented.	
	St. Lawrence Formation		0-65	Dolomitic siltstone and fine-grained dolomitic sandstone; glauconitic, in part.	Confining bed. No wells are known to obtain water from this formation.
	Franconia Sandstone		0-200+	Sandstone, very fine grained; moderately to highly glauconitic; worm-bored in places. Interbedded very fine grained sandstone and shale; mica flakes common. Glauconitic fine-grained sandstone and orange to buff silty fine-grained sandstone (often worm-bored).	Small amounts of water may be obtainable from the medium- to coarse-grained members of the formation, very little water from the fine-grained members. Not considered to be an important water source in the area of study. Records of wells completed only in the Franconia Formation are lacking.
	Ironton Sandstone		0-80+	Sandstone, white, medium- to fine-grained, poorly sorted and silty.	About 3,000 square miles in extent in area of study. An important aquifer beyond the limits of the Prairie du Chien-Jordan aquifer. Yields of wells range from 40 to 400 gpm with 4 to 110 feet of drawdown.
	Galesville Sandstone			Sandstone, yellow to white, medium- to coarse-grained, poorly cemented.	
	Eau Claire Sandstone		0-150	Sandstone, siltstone, and shale, gray to reddish-brown, fossiliferous.	Confining bed. Sandstone beds may yield small quantities of water to wells for domestic use. Shale of very low permeability and apparent large areal extent constitutes the main confining bed for water in the underlying aquifer.
	Mt. Simon Sandstone		As much as 200	Sandstone, gray to pink, medium- to coarse-grained. Some pebble zones and thin, shalely beds. Unconformity	Secondary major aquifer in the area of study. Supplies about 15 percent of ground water pumped in the metropolitan area. Recorded yields of 27 municipal and industrial wells ranged from 125 to 2,000 gpm with 20 to 209 feet of drawdown. Major source of artesian water in northern half of study area.
Precambrian	Hinckley Sandstone		As much as 200	Sandstone, buff to red, medium- to coarse-grained, well sorted and cemented. Unconformity	
	Red clastics		As much as 4,000	Silty feldspathic sandstone and lithic sandstone, fine-grained; probably included red shale. Unconformity	Aquifer of local interest in Chisago County, T. 35 M., R. 21 W. Wells have yields from 15 to 120 gpm with 41 to 150 feet of drawdown. Data are lacking in metropolitan and other parts of area.
	Volcanic rocks		As much as 20,000	Mostly mafic lava flows, but includes thin interlayers of tuff and breccia.	Rock is at and near the surface at Taylors Falls and north of boundary of study area. Weathered or fractured zones provide small quantities of water for domestic needs. Deeply buried in metropolitan area and no data available.

SOURCE: Water Resources Outlook, 1973.

BEDROCK GEOLOGY

Bedrock of the metropolitan area is divided into and described by units, each having a degree of uniformity in appearance, composition and properties. These units are indicated in Table 3-1. The column shows the approximate maximum thickness exposed or found in drill holes. In many parts of the area the more recent beds down to the St. Lawrence, have been partly or altogether removed by erosion.

There are several important general structural features of bedrock geology. The bedrock surface is composed of a complex network of comparatively steep sided valleys. Between these valleys the bedrock surface tends to be much more uniform in elevation. Areas of bedrock have been mapped at various times as if all soil and glacial material were removed (5). See Figure 3-1 for locations of cross-sectional areas. Figures 3-2 and 3-3 show the Cross-Sectional Units (4). The beds of shale, limestone, and sandstone are nearly horizontal but from all sides they dip very gently toward a central area (6).

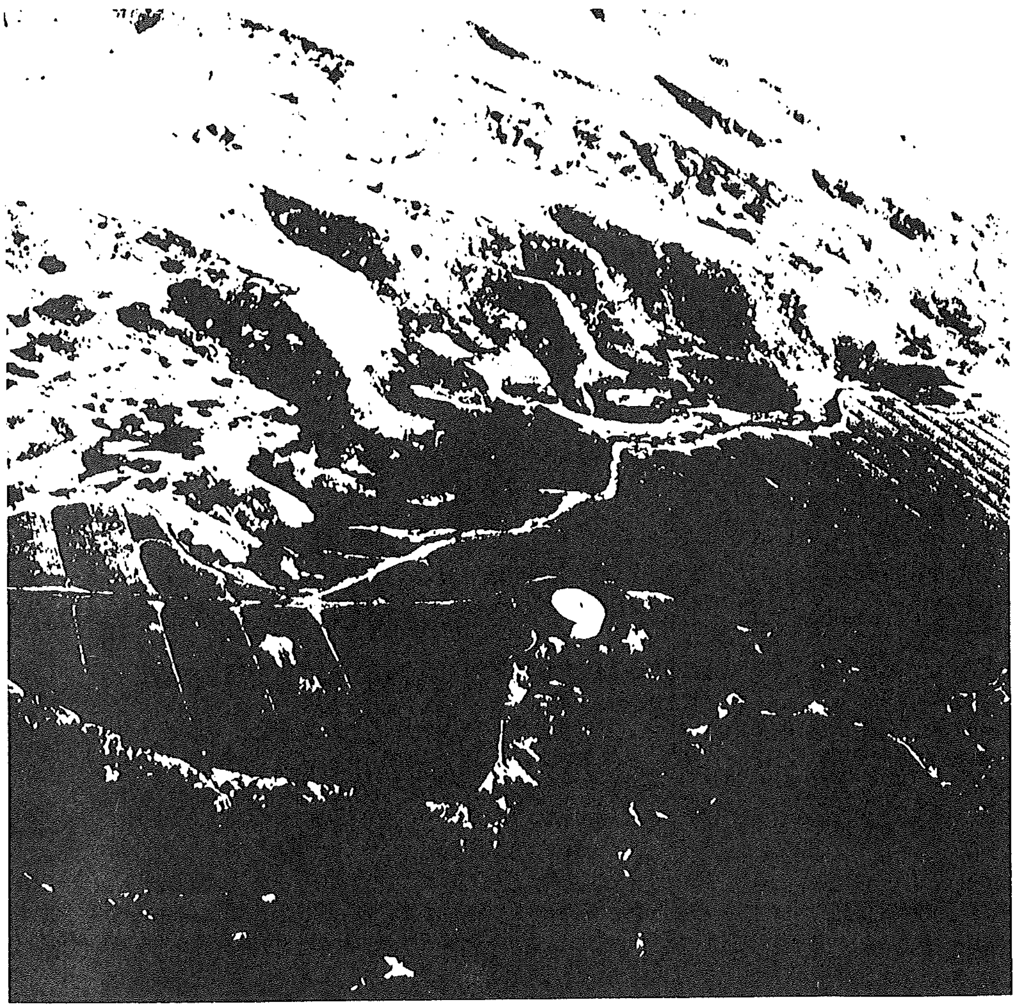
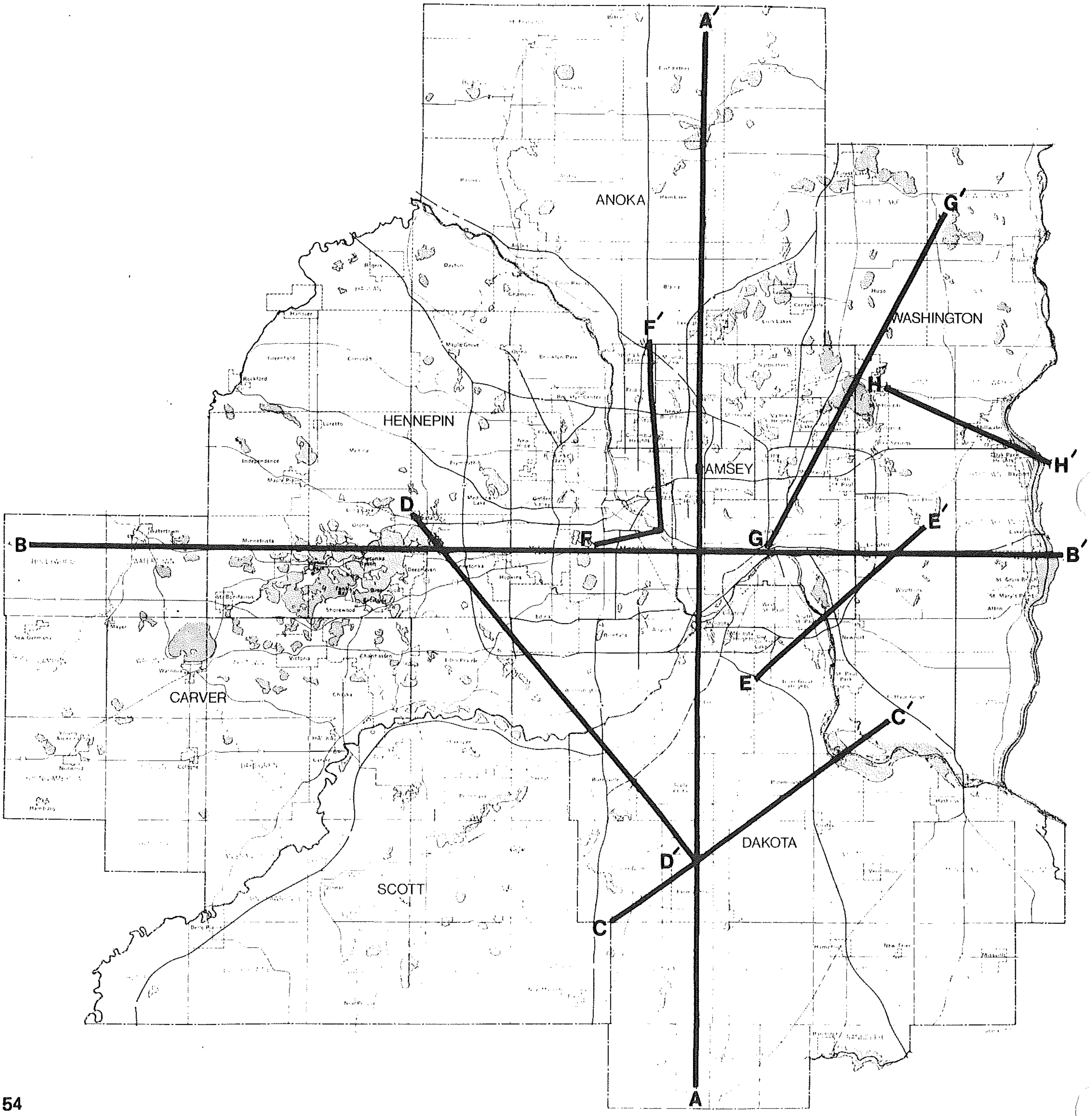


FIGURE 3–1 GEOLOGICAL CROSS SECTION LOCATIONS



SOURCE: Water Resources Outlook, 1973

FIGURE 3–2 GENERALIZED CROSS SECTIONS A–A^1 OF THE METROPOLITAN AREA ARTESIAN BASIN

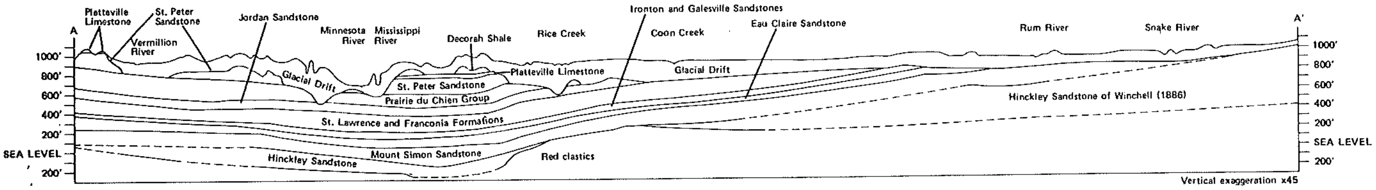
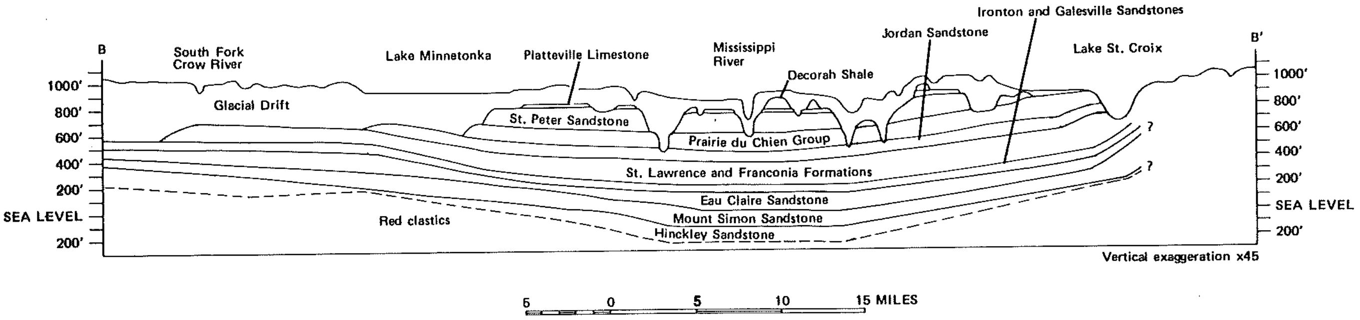


FIGURE 3–3 GENERALIZED CROSS SECTIONS B–B^1 OF THE METROPOLITAN AREA ARTESIAN BASIN



SOURCE: Water Resources Outlook, 1973

Cross-sections of the metropolitan area shown in Figures 3-4 through 3-9 reveal little faulting. Available data comes from well-drilling records. The St. Paul sheet (5) shows a fault at Belle Plaine near the southwestmost corner of the metropolitan area, which brings a red feldspathic sandstone, presumably the Red Clastic and associated overlying beds, to the Prairie du Chien limestone.

Faults show in the Vermillion anticline west of Hastings (7) are also taken from well records. The relation, of this faulting to that in the southeast corner of Washington County and the St. Paul sheet is unclear. Some faults displace the ancient basement and also the Paleozoic sedimentary beds while others do not. (6) See Figures 3-10 through 3-12 for cross sections of the Twin Cities Basin. Apparently there has been no perceptible movement on some of those ancient faults. Two faults lie in the northeast corner of the Stillwater Sheet (4). Displacement is seen in St. Croix River bluffs. In this area, Platteville Limestone, Decorah Shale and St. Peter Sandstone have built up against the Prairie du Chien Limestone and the St. Peter Sandstone and against the St. Lawrence Dolomite Siltstone.

FIGURE 3–4 GENERALIZED HYDROGEOLOGIC CROSS SECTIONS OF THE METROPOLITAN AREA A–A1

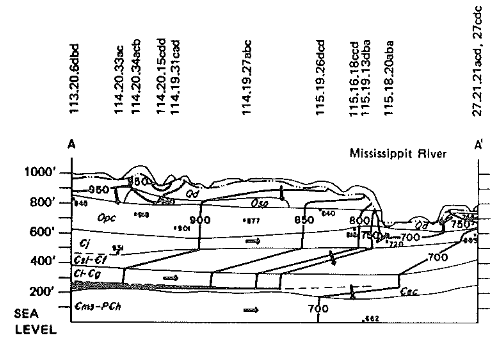


FIGURE 3–5 GENERALIZED HYDROGEOLOGIC CROSS SECTIONS OF THE METROPOLITAN AREA B–B1

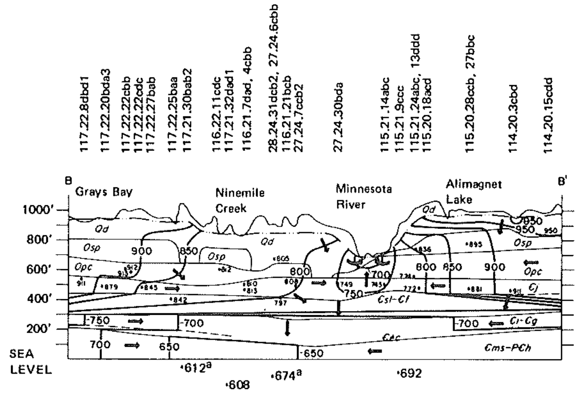


FIGURE 3–6 GENERALIZED HYDROGEOLOGIC CROSS SECTIONS OF THE METROPOLITAN AREA C–C1

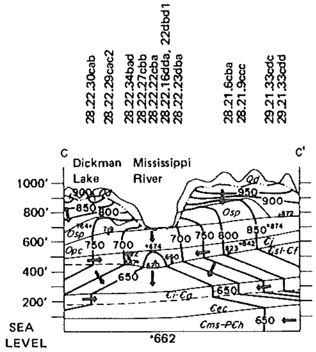


FIGURE 3–7

GENERALIZED HYDROGEOLOGIC CROSS SECTIONS OF THE METROPOLITAN AREA D–D1

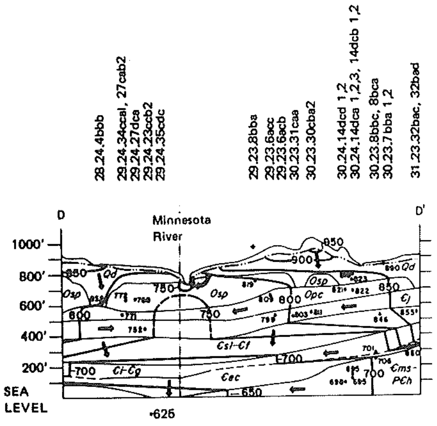


FIGURE 3–8

GENERALIZED HYDROGEOLOGIC CROSS SECTIONS OF THE METROPOLITAN AREA E–E1

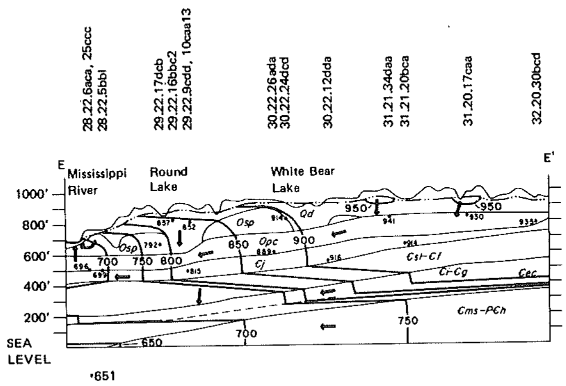
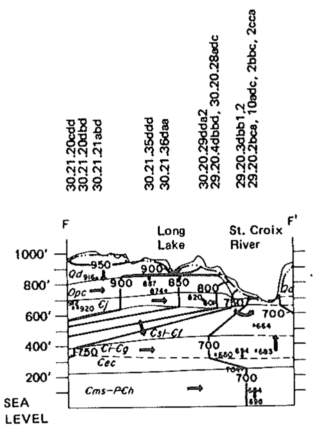


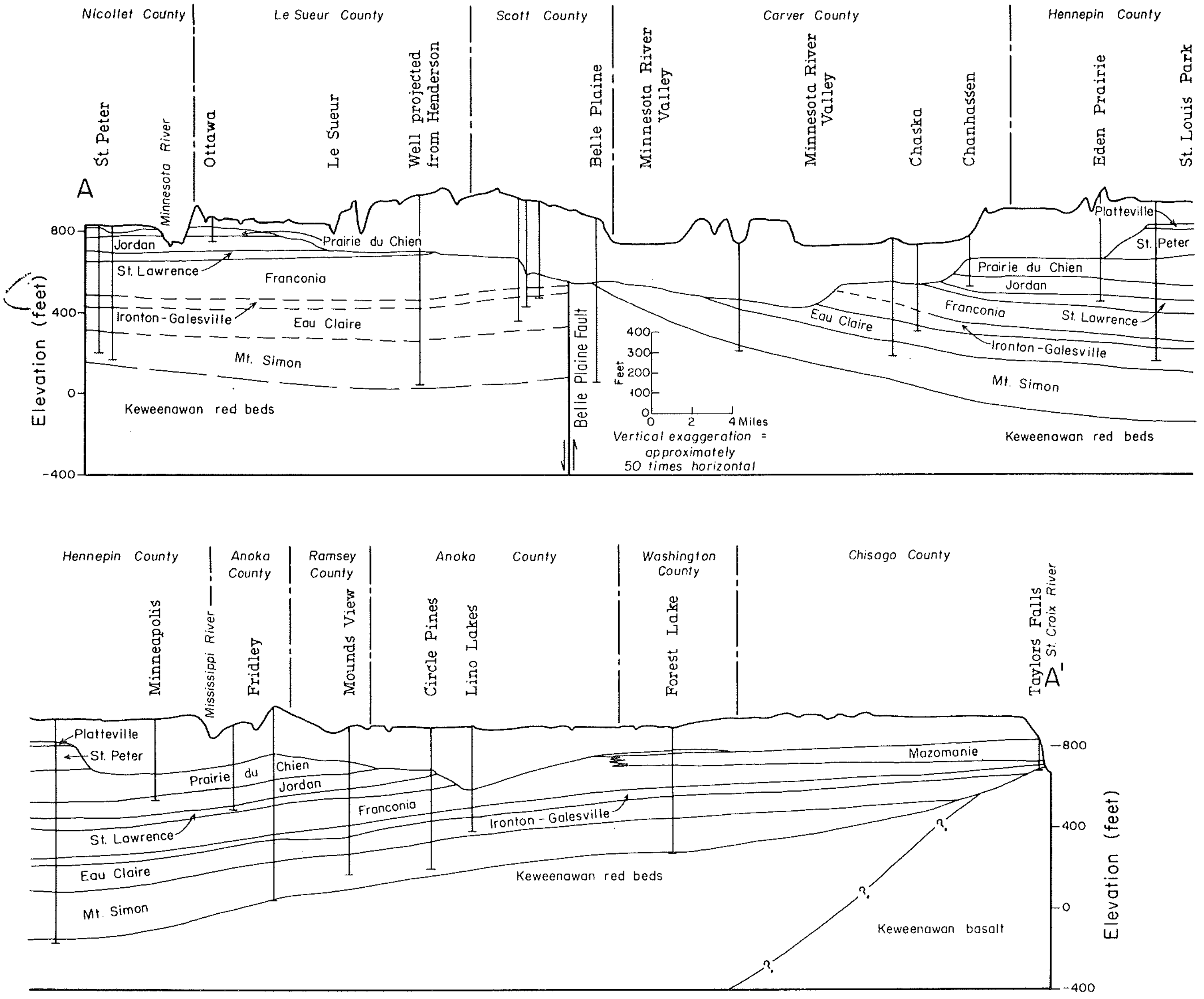
FIGURE 3–9

GENERALIZED HYDROGEOLOGIC CROSS SECTIONS OF THE METROPOLITAN AREA F–F1



SOURCE: Water Outlook Handbook, 1973

FIGURE 3–10 SECTION OF THE TWIN CITIES BASIN, A–A[1]



SOURCE: Geology of Minnesota

FIGURE 3–11 SECTION OF THE TWIN CITY BASIN, B–B^{1}

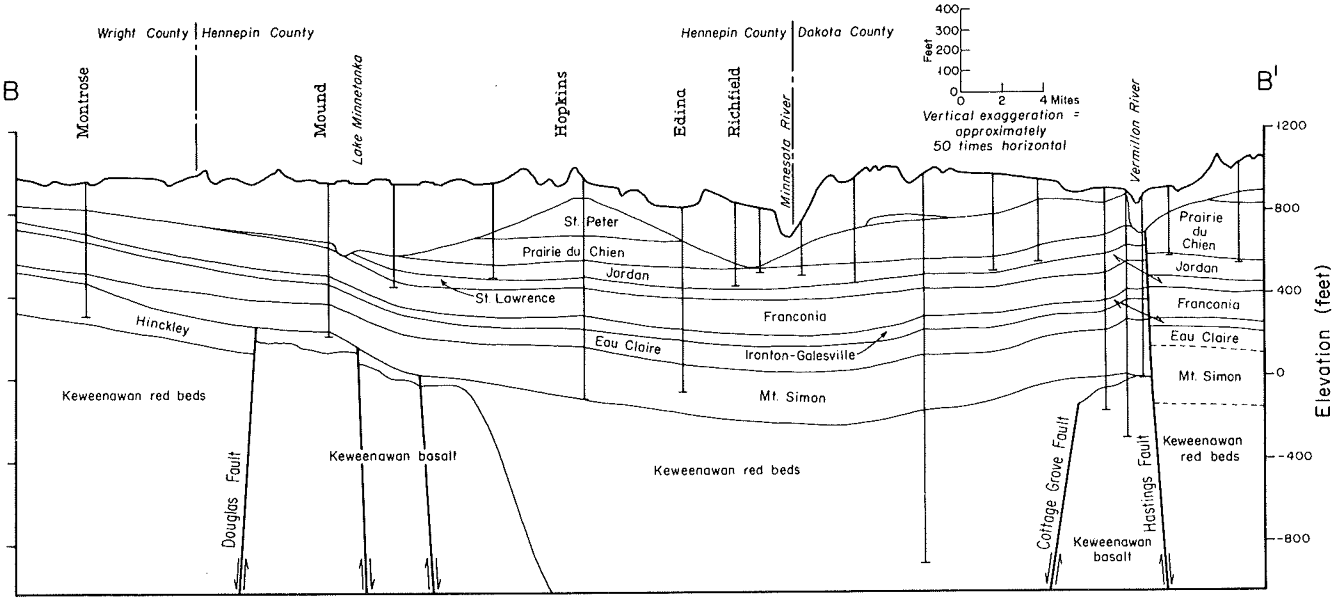
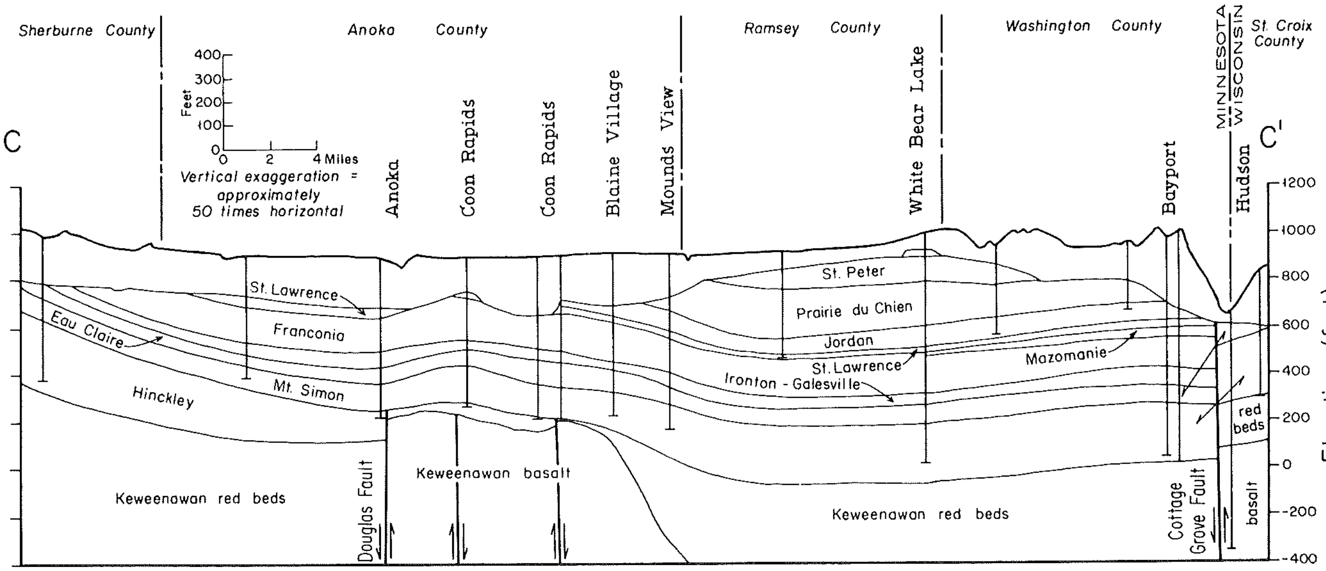


FIGURE 3–12 SECTION OF THE TWIN CITY BASIN, C–C^{1}



DECORAH SHALE

This is the most recent bedrock formation. Decorah Shale is exposed along banks of the Mississippi west of central St. Paul. It is also found under glacial cover in six or eight limited areas near the center of the basin, notably in a bend of the Mississippi River near the Macalester-St. Thomas-St. Catherine-Highland Park Area of St. Paul. The Decorah shale contains lenses and thin beds of limestone (9).

SOURCE: Geology of Minnesota, 1972

PLATTEVILLE LIMESTONE

This dolomitic limestone appears in bluffs of the Mississippi River continuously from St. Anthony Falls to the Robert Street bridge in St. Paul, for a short distance at the lowest reach of the Minnesota River, in old quarries in northeast Minneapolis and in central Washington County between Lake Elmo and Cottage Grove (1). The Platteville constitutes the bedrock surface under glacial cover beneath approximately half of Minneapolis and St. Paul. It has, however, been removed by erosion toward the edges of the basin (4).

The Glenwood beds between the bottom of the Platteville and the top of the St. Peter are a shaley transition between the sandstone and limestone. They are hardly noticeable in some places and up to five feet thick in others.

Platteville quarries in northeast Minneapolis are no longer worked but stone is being taken from a hilltop quarry east of Lake Elmo. Platteville Limestone varies from thin beds to areas that are about two feet thick. See Figures 3-4 through 3-9.

ST. PETER SANDSTONE

St. Peter Sandstone is conspicuous in the white to pale yellow bluffs along the lower Mississippi and Minnesota Rivers. It is easily eroded by air and water in Minneapolis. In central and southern Dakota County it occasionally stands in pinnacles. The buried bedrock outcrop of St. Peter Sandstone is extensive, and generally farther from the center of the basin than the Platteville. It approaches the edges of the metropolitan area only on the east and south. The St. Peter Sandstone is a minor aquifer generally suitable only for domestic supply. The lower part is consistently silty. This separates the St. Peter hydraulically from the more important aquifer below it. See Table 3-1 for geologic units and their waterbearing characteristics.

The St. Peter is a high purity silica sand which was formerly mined beneath the Ford Plant and used for making automobile glass. Many tunnels have been driven in the St. Peter for sewer, water and steam lines and for power cables. Over a period of time this sand tends to fall away from the walls and roofs of these tunnels, especially where the exposed sand has dried. Over the past 20 years, attempts have been made to stabilize sand surfaces by impregnation but most tunnels have been supported by timber, steel or concrete.

Fractures in the St. Peter have been widened in places, presumably by erosion of rapidly moving water. Some sizeable caves extend into the sandstone walls of the Mississippi gorge below St. Anthony Falls (11). See Plate 4 for generalized cave locations.

SHAKOPEE-ONEOTA DOLOMITE (PRAIRIE DU CHIEN FORMATION)

This thick formation stands in the conspicuous cliffs along the Mississippi River above Hastings, especially on the east side. It is prominent along the south and west sides of the river at Nininger, Pine Bend and toward South St. Paul. Outcrops extend up the St. Croix as far as Stillwater. The Shakopee which constitutes approximately the upper third of the formation, extends below younger rock over the area except where eroded. This eroded area covers most of Anoka, northwestern Hennepin, Carver and western Scott counties. The New Richmond sandstone and sandy dolomite just below the Shakopee is recognized by some geologists as a separate unit between the Shakopee and the lower Oneota dolomite. It is not especially noticeable, and except for the sandy-dolomite mixture, the entire formation can be considered as a unit.

The Shakopee Oneota is the most important source of crushed limestone in the area. It is quarried on Grey Cloud Island upriver from Hastings, on the Minnesota River west and south of Shakopee and near the junction of Highways 35 and 13. There is also a smaller quarry southwest of Stillwater. See Plate 4 - Significant Geologic Features for quarry locations.

The Shakopee Oneota carries water in fractures, some of which have been opened by solution. It is hydraulically connected to the underlying Jordan sandstone. This combined aquifer is one of the principal sources of water in bedrock.

JORDAN SANDSTONE

The Jordan sandstone is near the surface and can be seen at points along the Minnesota River near Jordan. It is conspicuous in the lower part of the bluff on the east side of the Mississippi above Hastings and along the river bank at Nininger. Outcrops extend up the St. Croix River to Stillwater. It is near the surface at the crest of the Afton anticline southwest of Afton. Between these exposures, the buried outcrop of Jordan sandstone surrounds the metropolitan area.

The deeper pre-glacial valleys in the center of the basin cut into the Jordan in places (9). The Jordan is hardly coherent and resembles the St. Peter, which is composed of a high purity silica sand of rounded grains. Jordan sandstone is used in making some grades of glass, as blast sand and for stimulating the production of soil (hydrofrac sand). None is produced in the metropolitan area but the sand is worked near the river in Le Sueur County. The Prairie du Chien aquifer (Shakopee-Oneota-Jordan) is the principal source of groundwater in the area supplying about 75 percent of the water pumped. For areas of groundwater recharge, see Figure 3-13.

ST. LAWRENCE FORMATION

This grey-green dolomite siltstone outcrops only along the St. Croix River near Afton and northward toward Stillwater. It is found in wells beneath glacial till around the northwest and west edges of the area. The permeability of the St. Lawrence is low; it separates the Jordan from lower aquifers, as shown on Table 3-1.

FRANCONIA FORMATION

This medium grained sandstone outcrops along the St. Croix River north of the area but is not exposed. The formation extends beneath younger rock throughout the area. Small amounts of water may be obtainable from upper and lower sandstones which are separated by a shaley sandstone. The lower Franconia aquifer is commonly called the Ironton Galesville sandstone, as shown on Table 3-1.

DRESBACH FORMATION

This comparatively thick formation extends beneath younger rocks throughout the area. The upper Eau Claire member is composed of alternating layers of sandstone, siltstone and shale. Its permeability is low. The lower Mt. Simon member is a thick sandstone. It and the still lower Hinckley sandstone are a secondary major aquifer from which about 15 percent of the area's groundwater is pumped, as shown on Table 3-1.

HINCKLEY SANDSTONE

This bed is found in all sufficiently deep wells but its thickness is highly variable.

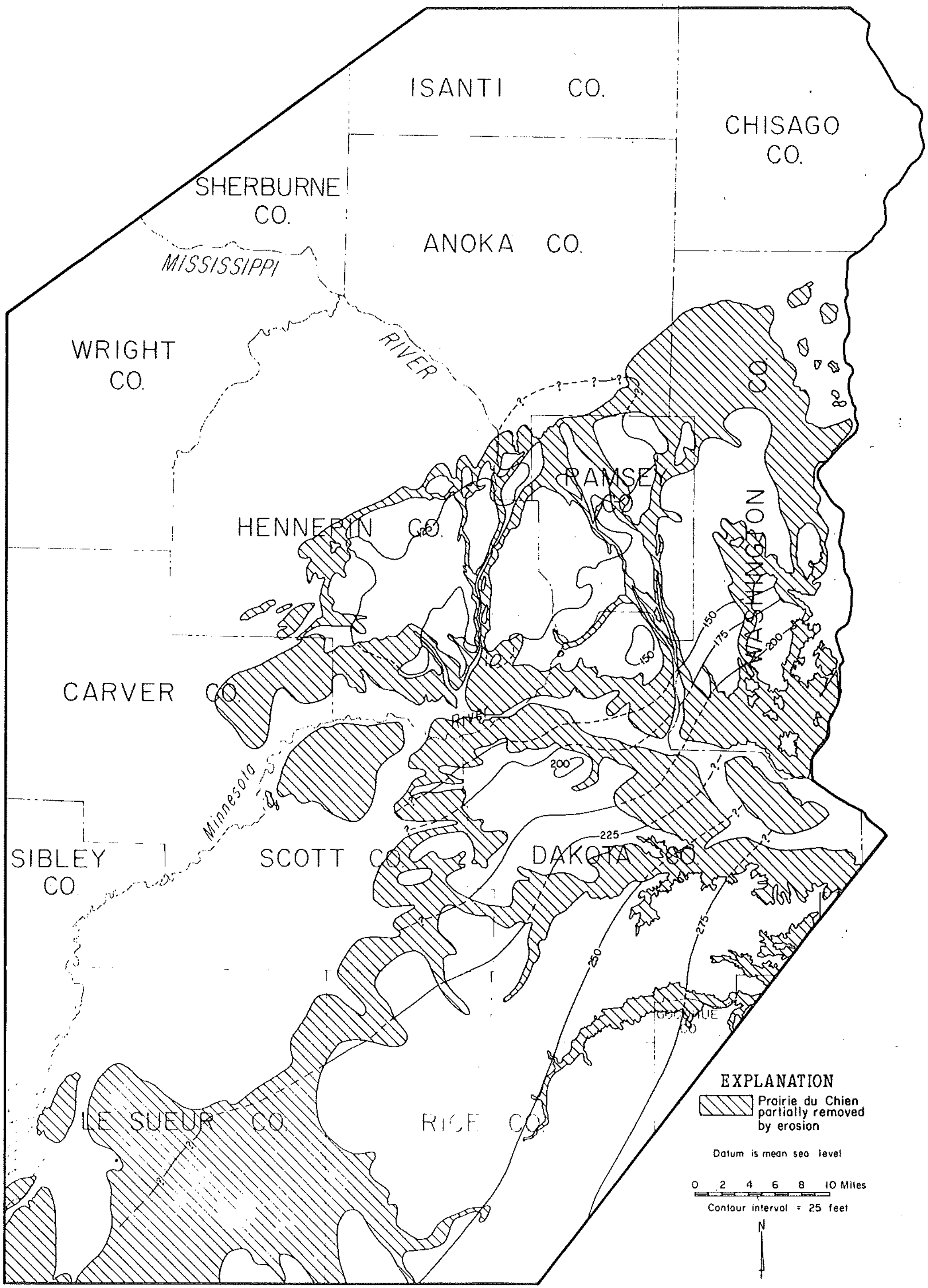
KEWEENAW RED BEDS (RED CLASTICS)

This succession of predominantly chocolate-red shales and fine grained sandstone probably occur under all parts of the area. Except where the older basalt has been elevated by ancient faults, these red beds are thought to be up to 4000 feet thick as shown on Table 3-1. Outside of the Twin Cities Basin, they tend to be silty to sandy; within the basin, shale predominates. Both rock types are strong and believed to be too dense and compact to yield much water (1).

KEWEENAW BASALT

This is a series of ancient lava flows considerably altered but very strong. With a specific gravity of about 3, it is more dense than most rock. It outcrops on the St. Croix River at and above Osceola near the northeastern corner of the metropolitan area. To the south and west of these outcrops, the basalt is covered by younger rock. On the basis of one deep test hole near Stillwater and geophysical gravity and magnetic studies, the basalt surface is expected to be 3000 to 5000 feet beneath the

FIGURE 3–13 GROUNDWATER RECHARGE AREAS OF THE PRAIRIE DU CHIEN AQUIFER



SOURCE: Geology of Minnesota, 1972

surface of much of the area. However, numerous deep test holes have found basalt at depths of from about 700 feet at Coon Rapids to 1025 feet at Hudson, Wisconsin

(8). From this deep drilling and the geophysical data, boundaries of two elevated basalt limbs are projected around the Twin Cities like an inverted, rather irregular wishbone or horseshoe.

Most deep testholes which reached the basalt penetrate it from several feet to several hundred. A testhole about two miles southwest of Osseo was drilled in 1975 into basalt from a depth of 746 feet to 3986 feet, (unpublished data supported by data at the U.S. Bureau of Mines, Twin City Corps Library). Throughout this more than 3200 feet, the rock is said to be dense. Permeability, as judged by appearance and behavior of drill fluid, is exceedingly low and the rock is minimally fractured. A few layers of chocolate conglomerate were found but most of the core is olive green to grey, altered, hard, strong basalt. From the geophysical studies the basalt near the center of the basin is theorized to be as thick as 20,000 feet. Still older intrusive (much presumably granitic) rock is believed to be beneath the basalt. These intrusives and related rock outcrops are quarried in the Minnesota River Valley above Mankato, and in Stearns and Sherburn counties in central Minnesota.

WATER AND GEOLOGIC FEATURES

The river and streambeds of the metropolitan area vary considerably and include bedrock, rubble, gravel, sand, silt, clay, muck, and organic deposits. No single study has inventoried or mapped the soils of these waterways. County soil surveys are one source. The Department of Natural Resources includes general streambank information for selected rivers in their fish surveys, but this information concerns land use. Precise data should be gathered from on-site inspection.

STREAMBED COMPOSITION

Some of the streambeds change seasonally after receiving spring runoff. Streambeds may also change after an intense storm which causes sedimentation through runoff. Detailed descriptions of streambed composition are shown in Exhibit B.

Knowledge of streambed composition is important to preliminary planning. A bedrock bottom requires different design considerations than a mucky bottom. The bottom of streams and rivers is also important to determine the existence and nature of biological communities. Certain bottoms, for example, need to be protected, since they provide spawning areas for fish.

Rivers and streams are grouped under each of the three major rivers. Exact information about a specific point may best be gathered by on-site inspection.

Through the use of soil surveys, topographical maps, surficial geologic maps and land use maps, an approximation of the composition of stream bottoms can be noted for a specific point. Field inspection would be necessary to validate this information.

ICE RAMPARTS

Ice ramparts are formed by the action of ice on the shore zone of a lake. When the ice covering a lake expands, material will be pushed towards the shore. If the shore material is composed of loose sand or pebbles and if the slope of the shore is not exceptionally steep, the ice will push the shore material into a ridge of debris lying more or less parallel to the shore line. The size of an ice rampart depends on significant temperature fluctuations which will produce a new push of ice while the lake remains at the same level. These features could affect construction activities. Ice ramparts exist throughout the metropolitan area; on-site inspection is the best method to use for their location.

SPRINGS

Personnel from the DNR and the watershed districts supplied locations of springs. Very few springs were listed, although many springs do occur throughout the metropolitan area especially in the three major river valleys. Plate 4 shows the location of selected springs. Sources of maps or lists of springs in the metropolitan area were not located. No information was available on the mean discharge and the seasonal fluctuations of springs.

GORGES

The major gorge through which the Mississippi River flows from St. Anthony Falls to the mouth of the Minnesota River is shown on Plate 4. Minor gorges may be located on topographical maps where very steep relief is shown. Sources of maps or lists of gorges were not located.

SAND DUNES

Sand dunes were formed shortly after the last glaciation by wind action upon glacial sand deposits. They were stabilized through the succession of primary and secondary vegetative communities which held the sand in place. The introduction of plant life most likely was preceded by a reduction of wind forces. Sand dunes reportedly occurred in three geographic regions of the metropolitan area: Bloomington, east of Shakopee, and on the Anoka County sand plain. Presently, they are only found on the Anoka County sand plain. There, crescent-shaped dunes run along northwest to southeast axis lines, reflecting prevailing southwesterly winds. The original vegetation of these dunes consisted of prairie on the southwest facing slopes and an oak forest on the northeast facing slopes. Four sand dune locations within the Anoka County sand plain exist. They may be found at the Bunker Prairie Park Reserve, at the west end of Moore Lake at Fridley HIgh School, at Laddie Lake and at the County State Aid Highway 10, and north of the railroad tracks in Andover, as shown on Plate 4.

Dunes may be identified by using the Anoka County soil survey and by locating a combination of Anoka or Zimmerman soils upon sloping land with an oak vegetative cover aligned in a crescent form. On-site inspection is necessary to confirm the actual formation. To locate dune fields on aerial photographs, note the characteristic dune oak forests on northeast facing slopes. Other dune formations may exist.

ERODIBILITY OF SEDIMENTS

The softness of the St. Peter sandstone plus its ability to stand without support has resulted in its use in the metropolitan area for sewer, telephone, power and heat tunnels, as well as caves excavated for various purposes. The upper portion of the sandstone near the Mississippi River bluffs may be easily shovelled out. Near the lower end of the Mississippi River by Lock and Dam Number 2, for example, lies a much harder bed.

The St. Peter sandstone is most favorable for tunnelling where the Platteville limestone still exists above it as a protective cover. Where the limestone has been removed by erosion, the sandstone yields easily to destructive forces and may be disturbed far below the surface. Where attacked by running water, sandstone will erode rapidly, even under the cover of limestone, and result in a cave such as Carver's. The most extensive caves are found near present or preglacial gorges.

Sinkholes are formed when limestone is eroded by the action of running water. The process is similar to the one which forms tunnels.

CAVES

The metropolitan area is characterized by an underground environment of caves, tunnels, mines, cellars, shelters, pipes and sewers. Most caves with entrances are found within the vicinity of the major drainageways of the Minnesota, Mississippi and St. Croix Rivers and their immediate tributaries. They occur in sedimentary rock formations comprised of limestone, dolomite and sandstone.

A majority of the natural caves do not presently have entrances, but occasionally well drilling, quarrying, tunnelling and excavation will expose passageways previously unknown. These hidden caves pose potential hazards to construction, potable water supplies, damming and waste handling. The subsidence of soil and rock into developing voids and collapsing cavern roofs has been accelerating by man's activities. Contamination of drinking water by physical, chemical, geological and radiological agents occurs in cave areas where land use is unrestrained and surface and groundwaters are unprotected. Planning strategies should be developed to incorporate reasonable control measures and to restrict certain uses.

Of the approximately 125 caves reported in the metropolitan area, most are natural or man-made sandstone caves. (1) Plate 4 shows approximate location of these caves. A majority of the natural sandstone caves originated in post-glacial times during the waning of the last continental glaciers.

Early American Indian cultures utilized natural caves as shelters, ceremonial chambers and tombs. Caves along the Mississippi and St. Croix Rivers have recorded the presence of prehistoric traditions in petroglyphs, fire pits, refuse and artifacts. Wakon-teebe or Dwelling of the Great Spirit below Dayton's Bluff in Saint Paul was one such site, and the English explorer Jonathan Carver visited the cave in 1766 and described it in a narrative of his travels. Lee Mill Cave overlooking Spring Lake, and Leslie Cave on the bluffs of the St. Croix River have also witnessed the habitation of paleoindians and their successors. Numerous other sites exist or await discovery, but the protection and preservation of such sites must be secured otherwise their value to the Indian heritage and its archeological perspective will be lost.

The advantages of excavating sandstone tunnels, mines and cellars beneath the limestone caprock were realized by the pioneers, and many natural sandstone caves were enlarged and extended for the aging of beer and cheese, the curing of meat, the cold storage of food, the mining of sand for glass and abrasives, the rerouting of water for mills, and the shelter of people and livestock. Later applications required extensive tunneling for utility lines, stormwater runoff, ventilation and surface water diversion. A maze of accessible and abandoned man-made tunnels exists beneath the cities of Saint Paul and Minneapolis.

REFERENCES

1. Inferred Precambrian Paleogeologic Map of East Central Minnesota; Geophysical Investigations Map G P 563, U.S. Geological survey, 1967. With this map is a 6-page discussion of the data the authors use to map the elevated but still deeply buried surface of the strong, dense basalt. This surface is about 4 to 10 miles wide. The authors' concept of the structure is shown by an east-west cross section. (Available: MGS)

2. Barr Engineering Company, Minneapolis, Minnesota.

3. Bassett Creek Watershed District, Barr Engineering.

4. Bedrock Geologic Map Mpls-St. Paul and Vicinity, 1:24000 Scale, Minnesota Geological Survey, 1965.

5. Coon Creek Watershed District, Israilson Engineering.

6. Environmental Geology of the Twin City Metro Area, Hogberg, P.K., Minnesota Geologic Survey Educational Series 5, 1971. A non-technical discussion of geology, hydrology, supplies of sand and gravel, sand dunes and environmental planning. (Available: MGS)

7. Level B Study, United States Fish and Wildlife, 1976. Lists trout streams and fishable rivers. (Available: DNR)

8. Fish Inventory for Kenaley's Creek, Minnesota Department of Natural Resources, Minnesota Division of Game and Fish, Section of Fisheries, 1967. Old but specific reference on bed bottom by river mile. (Available: DNR)

9. Geology of the . . . Metro Area, Schwartz, George M., Minnesota Geological Survey Bulletin 27, 1936; discusses geology and relations of geography, vegetation, water supply and engineering. Half the book shows well logs and the occasional outcrops of bedrock. These are located on a map of the bedrock surface and 12 cross sections. Although much data has been added, this rationally organized, comprehensive treatise is a good place to start. (Available: libraries)

10. Guide to Caves in Minnesota, Hogberg, R. K. and T. N. Bayer, Origin of sandstone and limestone caves is discussed readably. Maps and sections of several in the metro area are shown. (Available: MGS)

11. Minnesota River Pool, Final Report, Environmental Impact Assessment, North Star Research Institute for the Corps of Engineers. Illustration of streambed composition. (Available: MC)

12. Nine Mile Creek Watershed District, Barr Engineering.

13. Personal Communication with Dick Swanson, Anoka County Extension Agent, October, 1977.

14. St. Paul Sheet Map. Sloan, R. E. and G. S. Austin. Scale 1:250,000, Minnesota Geological Survey, 1966.

15. Sand and Gravel Operations and Costs, Marshall, L. G., Minneapolis-St. Paul area, U. S. Bureau of Mines Information Circular 8157, 66 pages, 1963. This report discusses use and quality of these low cost materials currently consumed at the rate of about 15 million tons annually. The descriptions of some of the nine plants are now out of date. (Available: MGS)

16. Soil Landscapes . . . Twin City Metro Area, University of Minnesota Agricultural Experiment Station, University of Minnesota Miscellaneous Report 130 - 1975. Shows areas covered by various materials of glacial origin and derived from such and classified them showing some engineering qualities. (Available: University Agricultural Extension Service)

17. Soil Survey for Hennepin County, Minnesota, United States Department of Agriculture, April 1974. Used with topographic map and surficial geology-indicates beds. (Available: Hennepin County Soil Conservation Service)

18. Soil Survey of Scott County, Minnesota, United States Department of Agriculture, 1959; useful to locate where dunes may have existed. (Available: Scott County Soil Conservation Office)

19. Status of Urban Geology in the Minneapolis-St. Paul Area, Stone, John E., University of Minnesota, 13 pp., 1965. This is a concise review of what was then known and its basic use in urban planning. Topography of the Twin City bedrock surface, areas of alluvium and glacial deposits and the geologic column are well illustrated. (Available: libraries)

20. Stream Survey Evaluation Report, Eagle Creek-Minnesota Branch, Scott County, Minnesota Department of Natural Resources, Division of Game and Fish, Section of Fisheries, September 1967. General but helpful reference on streambed composition. (Available: DNR)

21. Stream Survey Evaluation Report, Vermillion River, Minnesota Department of Natural Resources.

22. Sundance Creek Watershed District, Barr Engineering.

23. Surficial Geology of the New Brighton Quadrangle, Stone, John E., University of Minnesota, Bulletin GM-2, 39 pp., 1966. Seven units of sand, till, outwash and lake deposit and eight units of late glacial and post-glacial material are described briefly. Their occurrence is shown on a 1:24000 map. Another plate shows bedrock topography and geology. Some engineering properties are tabulated. (Available: University Agriculture Extension Service)

24. Personal Communication with Don Berg, Carver County Soil Conservationist, October, 1977.

25. Personal Communication with George Pascal, Scott County Soil Conservationist, October, 1977.

26. Personal Communication with Pat Kennedy, Soil Conservationist for Hennepin County.

27. Personal Communication with Roger Johnson, Soil Scientist for Washington County, October, 1977.

28. Personal Communication with Ronald Spong, St. Paul, Minnesota, October, 1977.

29. Personal Communication with Steven Lundley, Dakota County Soil Scientist.

30. Personal Communication with Tom Waters, University of Minnesota Fish and Wildlife Department, October, 1977.

31. Personal Communication with Walter Breckenridge, Professor Emeritus, University of Minnesota.

32. Pool 1, Final Report, Environmental Impact Assessment of the Northern Section of the Upper Mississippi River, North Star Research Institute for the Corps of Engineers. Illustrations of streambed composition. (Available: MC)

33. Pool 2, Final Report, Environmental Impact Assessment, North Star Research Institute for the Corps of Engineers, Illustration of streambed composition. (Available: MC)

34. "Quarternary History of Minnesota," published in Geology of Minnesota: A Centennial Volume, H. D. Wright, P. K. Sims, G. B. Morey, Minnesota Geological Survey, 1972. Details sand dune formation, early studies of glacial geology, latest glacial stage, and post-glacial changes. (Available: MGS)

35. Ramsey-Washington-Metro Watershed District, Barr Engineering.

36. Rice Creek Watershed District, E. A. Hickok and Associates, Engineers.

37. Riley-Purgatory Watershed District, Barr Engineering.

38. St. Croix River Pool-Final Report, Environmental Impact Assessment, North Star Research Institute for the Corps of Engineers; Illustration of streambed composition. (Available: MC)

39. Upper and Lower St. Anthony Falls Pool-Final Report, Environmental Impact Assessment, North Star Research Institute for the Corps of Engineers; Illustration of streambed composition. (Available: MC)

40. Valley Branch Watershed District, Barr Engineering.

41. Water Resources Outlook for the Minneapolis-St. Paul Metro Area, Norwitch, R. F., T. F. Ross and Alex Brietkrietz, Metro Council, 1973. This recent, authoritative work treats geology, surface and groundwater, use and quality. It contains many maps most notably a series showing elevations of artesian pressure surfaces in the bedrock aquifers. (Available: MC)

DNR - Department of Natural Resources
MC - Metropolitan Council
MGS - Minnesota Geological Survey

SOILS

Soil is considered to be a mixture of mineral and organic material that is capable of supporting plant life. The metropolitan area has approximately 1,899,000 acres (768,500 hectares) of soil resources. Soils vary from pure organic soils to pure mineral soils such as sand and gravel. (See Exhibit C and Exhibit D).

There are five main factors involved in the soil formation process: parent material, topography, vegetation, climate, and time.

PARENT MATERIAL

Essentially all of the available parent material in the metropolitan area is a result of glaciation. Deposits from four major ice sheets exist in the area. However, only the two latest glacial advances and retreats are of importance to the soil formation process, since debris from these ice sheets have almost completely covered all earlier glacial deposits.

The earlier of the last two ice sheets, the Superior lobe, originated in the Lake Superior region. Ice that accumulated in the Lake Superior basin transported red sandstone and an admixture of igneous rocks from the northeastern portion of the state (1). The ice advance halted just south of the Minnesota River in Scott and Dakota counties and along the western edge of Hennepin County. The Superior lobe drift is reddish in hue and is non-calcareous.

Ice that advanced from the northwest Des Moines lobe carried materials entrained from limestone and dolomite of Manitoba and northwest Minnesota, producing buff colored calcareous drift (2).

The glacial process has resulted in basically five sources of parent material: glacial till, glaciolacustrine deposits (sediment deposited in lakes marginal to a glacier by glacial melt-water streams), glacial outwash, loess and recent alluvium. This difference in glacial activity has resulted in numerous soil landscapes and geomorphic regions in the metropolitan area as shown on the map entitled, "Soil Landscape and Geomorphic Regions - Twin Cities Metropolitan Area Sheet" which is included in Exhibit D. A chart entitled, "Interpretation of Twin Cities Seven County Metropolitan Area" found in Exhibit C evaluates each soil landscape unit.

This map also divides the metropolitan area into five physiographic units: the outwash valley, the Owatonna moraine, the Rochester till plain, Eastern St. Croix moraine and the Anoka sand plain. Further subdivisions include 12 geomorphic regions: Mississippi Valley outwash, Cannon Valley outwash, Minnesota Valley outwash, Lonsdale-Lerdal till region, Waconia-Waseca moraine, Prior Lake moraine, Emmons-Faribault moraine, Hayward-Owatonna moraine, Kenyon-Taopi plain, the Harmony-Plainview uplands, the Twin Cities formation and the Anoka sand plain. These 12 geomorphic regions are further broken down into various soil associations which combine soil with similar characteristics into an association. In each association, data are presented on landscape position (slope), rooting zone, substratum, available soil moisture, drainage class, pH, phosphorus, potassium and significant soil series.

The outwash valley physiographic region is comprised of three very similar geomorphic units. They are composed of outwash resulting in loamy sand and loam with sand and gravel substratum. These geomorphic units are the Mississippi Valley outwash, the Cannon Valley outwash, and the Minnesota Valley outwash. Approximately 27.2 percent of the metropolitan area is occupied by these regions. They are all formed by nearly level terraces and flood plains along the major rivers and their tributaries. Water tables are usually deep, especially on the higher terraces. However, they commonly are shallow in low terraces and flood plains. Actual free water levels vary from one to two feet to several hundred feet in the Rosemount area. These soils have a tendency to be droughty with relatively low available water holding capacity. Typical soil series in these geomorphic regions are: Hubbard, Sparta, Estherville, Dickman, Waukegan, and Dakota. These soils are generally acidic, 5.1 - 6.5 pH, and have a cation exchange capacity of 10 - 15 milliequivalent (meq)/100 grams in the A and B horizon. However, because of the granular substratum of the cation exchange capacity (CEC) values for the C horizon parent material falls off sharply to the order of 5 meq/100 grams of soil. Much of the soils in these three geomorphic regions are recent alluvium and have a very limited soil profile development.

The second physiographic unit, the Owatonna moraine area contains five geomorphic regions located in Hennepin, Carver, Scott and Dakota Counties. The Owatonna is a series of moraines that formed on the eastern edge of the Des Moines lobe. The five geomorphic regions are: Lonsdale - Lerdal till region, Waconia - Waseca moraine, Prior Lake moraine, Emmons - Faribault moraine, Hayward - Owatonna moraine.

The Owatonna moraine and its five geomorphic regions compose approximately 34.4 percent of the land area. Generally they consist of loam to clay loam which indicates its origin from end moraine or dead ice moraine. Typical soil series in these geomorphic regions named are: Hayden, Clarion, Nicollet, Lester and Le Sueur. The majority of these soils are well drained with heavy texture loam and clay loam substratum. Agricultural production is high. Slope is generally a limiting factor. These soils have excellent water holding capacity. They are generally near neutral in soil reaction and have high CEC values in the order of 15 - 10 meq/100 grams of soil. The high CEC of the substratum is an important feature of this soil. These soils are young but somewhat more developed than the weather resistant outwash soils.

The third physiographic area in the metropolitan area is the Rochester till plain. This till plain consists of the Kenyon Taopi plain and the Harmony Plainview uplands. These two geomorphic units are considerably older than others in the area. While there is a well established drainage network, there is an absence of marshes. The entire area has been covered by wind blown deposits (loess) from the Mississippi outwash. These two geomorphic regions occupy approximately 5.3 percent of the metropolitan area. The soils are silt loam both in the root zone and the substratum and are generally well drained. Representative soil series are: Ostrander, Racine, Kenyon, Port Bryon, Temula, and Tallula. They have moderate to excellent available water holding capacity. These soils are also high in natural fertility. The soil reaction is slightly acidic with high CEC in the range similar to Owatonna moraine at 15 - 20 meq/100 grams.

The fourth physiographic unit in the metropolitan area is the Eastern St. Croix moraine. This unit consists of a belt of relatively steep hills and relief located in the Lake Minnetonka area of Hennepin County, northern Dakota, and northeastward through Ramsey and Washington Counties. The St. Croix moraine of Superior lobe origin, is often mixed with high lime material of the Grantsburg sub-lobe. This physiographic unit has one geomorphic unit, the Twin Cities formation. The soils in this region are predominantly sandy loams to loamy, with similar substratum. Almost 20 percent of this area is loamy soil with a granular substratum. Representative soil series of the Twin Cities formation are: Kingsley, Hayden and Nessel-Freeon. The Twin Cities formation occupies approximately 18.7 percent of the metropolitan area. The soil varies from moderate to excellent water holding capacity and are well to excessively well drained. These soils are extremely variable and slightly acidic with CEC values generally ranging in the 15 - 20 meq/100 grams of soil range. Soil with granular substratum probably have CEC values less than 10 meq/100 grams of soil.

The fifth physiographic and geomorphic unit is the Anoka sand plain, an outwash plain formed from the meltwater of the retreating Grantsburg sub-lobe. This area occupies approximately 13.9 percent of the metropolitan area. Approximately 22 percent of the Anoka sand plain consists of organic soils with a sand substratum. These soils have excellent available holding capacity and are poorly drained. They are near neutral in soil reaction with low natural fertility. The cation exchange capacity of these soils may be extremely variable depending upon the percent of mineral soil present and the degree of composition of the organic matter. These soils are economically important to Anoka County for small truck farming as shown in Tables 4-1 and 4-2.

TABLE 4–1

TRUCK FARM YIELDS
ANOKA COUNTY (3)

	Total Per Acre	Gross Value
Vegetables	2,750	$3,365,000
Sod	7,000	5,000,000
	9,750	$8,365,000

TABLE 4–2

CROP YEAR 1972
ANOKA COUNTY (3)

	Acres	Crops Per Year	Gross Value	Gross Value Per Acre
Radishes	1,000	3	$1,500,000	$1,500
Carrots	800	1	640,000	800
Parsnips	300	1	750,000	2,500
Potatoes	350	1	175,000	500
Turnips	100	1	200,000	2,000
Others	200	1	100,000	500

INFORMATION SOURCES

County soil surveys are the most comprehensive and detailed soil information available for planning, agricultural and engineering use. Each soil survey has a general soil map illustrating the soil association within a county. A soil association is a landscape that has a distinctive proportional pattern of soils. Such a map is a useful general guide in managing a watershed, a wooded tract or a wildlife area, or in planning engineering works, recreational facilities and community development. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structures because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage and other characteristics that affect this management.

Each soil association is made up of a number of soil series. Soils which are alike in all their characteristics except texture of the topsoil are grouped together in a series. Detailed information is available on such factors as texture, depth, permeability, available moisture capacity, pH reaction, shrink-swell potential, corrosivity and various uses.

A soils survey interpretation sheet is prepared for each soil series giving each more detail on that particular series. This information is available at both the State and

County Soil Conservation Service offices.

A map entitled, "Soil Suitability for Cropland" found in Exhibit D classifies metropolitan soils into the following five categories: Prime, Good, Marginal, Unsuitable, and Urban and Recreational Land Use.

This map does not indicate whether or not the land is actually utilized for agricultural purpose, but is based solely on soil types. At a more detailed level, these areas often are very undesirable for agricultural land and will never be used for that purpose. Staff from local planning agencies and the Soil Conservation Service will be able to provide local data.

The current statewide system for the classification of agricultural land published by the Soil Conservation Service has five classes: Prime farmland, Good farmland, Marginal farmland, Sub-marginal farmland, and Unique farmland (3).

The 1976 criteria by the Soil Conservation Service is a vast improvement over earlier work because it incorporates a classification "unique farmland" that recognized the value of specific soil situations that with proper management were extremely productive. Examples of these unique farmlands would be Mississippi Valley outwash soils in Osseo within Hennepin County (soil series Hubbard, Sparta, Estherville and Dickman) or the organic soil of Anoka and Washington Counties. These soils, because of either poor drainage or excessive drainage, have been classified as unsuitable for agricultural use in the past. However, irrigation of the Hubbard, Sparta, Estherville and Osseo soils, Mississippi Valley outwash or drainage of the organic soil combined with good scientific farming practices produce exceptionally productive soils.

EROSION

Erosion can decrease agriculture potential dramatically. Due to level topography and sandy soils, the outwash valley region and the Anoka Sandplain have slight hazards of sheet erosion. The loamy soils of the Owatonna Moraine are more susceptible to erosion due to increasing slope. The Prior Lake Moraine has severe hazards of sheet erosion because of the rolling landscape. Even though the hazard of erosion is severe, the sediment yield to drainageways and lakes can be small because that geomorphic region has many natural sediment traps. These are poorly drained depressions without an outlet.

Wind erosion can be easily handled by keeping the disturbed area small and revegetating as soon as possible. The majority of erosion occurs from runoff of storm water, flowing too fast down steep slopes. Careful planning by exposing raw areas for only a short time and installing temporary water storage facilities can significantly reduce erosion, runoff and sedimentation from these areas.

SEDIMENTATION

Sediment particles are major transporters for pesticides and unwanted nutrients that may create fish kills and algae blooms in lakes and streams. (See Section 11 - Water Resources - Present Quality). Sediment destroys fish-spawning beds in lakes and rivers and reduces light penetration in lakes, inhibiting water plant growth which breaks the food chain required to sustain gamefish populations. Coarse sediment can fill road ditches, block road culverts and bridges, fill storm sewers, cause shoaling of navigation channels, and can cover parklands with sand.

The sediment delivery system is related to channel density, topography and entrapment areas. High sediment yields can be expected from areas having abundant channels and gullies, steep hilly topography, and an absence of lakes and swamps. Low sediment yields can be expected from areas having few channels, flat topography, and an abundance of swamps and lakes, such as the flat Anoka sandplain.

The types of sediments carried depend on the erodible materials. For example, streams flowing from the Anoka glacial outwash sand area - such as Coon Creek - carry only coarse sand sediment and are generally clear. Streams flowing from silty or clayey glacial till areas such as the Minnesota River Basin - contain fine sediment and are generally murky.

ESTABLISHMENT OF VEGETATION

Most of the soil landscape units are suitable for growing a variety of trees and shrubs. See Figure 30, in Appendix D. The loamy soils associated with moraines are rated good because of high available water-holding capacity and natural fertility. Units rated as fair suitability include those with sandy texture or are alluvial soils with a high water table. Several trees are adapted to these conditions: pines on dry areas, and willow and tamarack on wet sites. (See Section 7 - Plant Associations for further habitat associations).

REFERENCES

1. Geology of Minnesota - A Centennial Volume. Minnesota Geological Survey. P. K. Sims and G. B. Morey, 1972. Descriptions of geologic regions and events occurring in each era. (Available: ECOL Library).

2. Land Inventory and Monitoring Memorandum MN 1 - United States Department of Agriculture Soil Conservation Service, 316 N. Kobut Street, St. Paul, Minnesota. Explains agricultural land classification. (Available: MWCC)

3. Memorandum from John Mendler, Anoka County Soil Conservation Service, 1977. Trends in Anoka County agriculture.

4. Soil Survey - Carver County, Minnesota. United States Department of Agriculture Soil Conservation Services. November, 1968. New updated version. (Available: SCS Office)

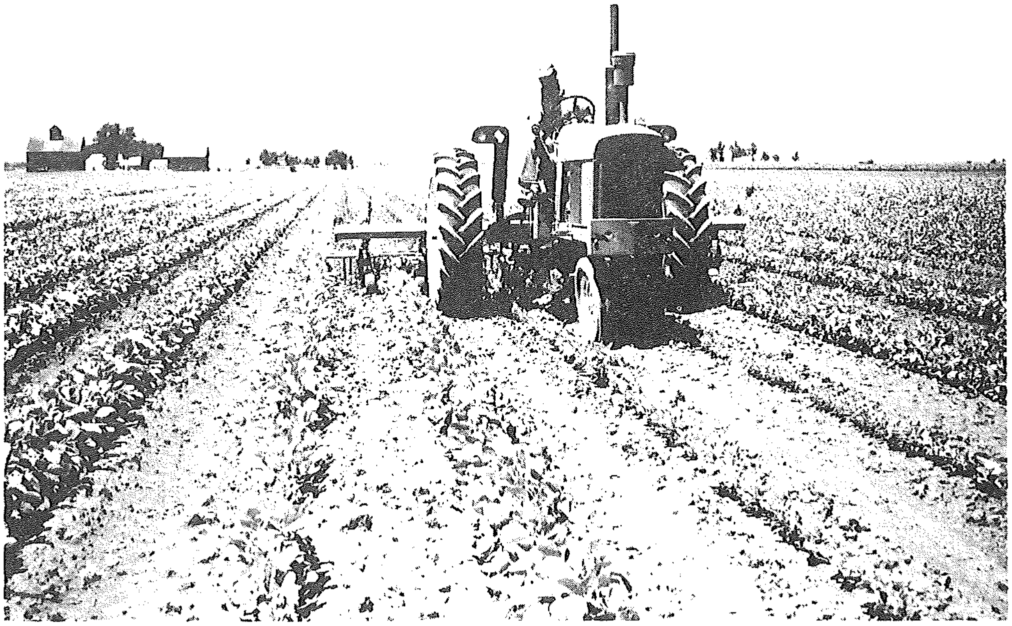
5. Soil Survey - Hennepin County, Minnesota. United States Department of Agriculture - Soil Conservation Services. April, 1974. New updated version. (Available: SCS Office)

6. Soil Survey - Ramsey County, Interim Report, 1977. (Available: SCS Office)

7. Soil Survey - Scott County, Minnesota. United States Department of Agriculture Soil Conservation Services. October, 1959. New updated version. (Available: SCS Office)

8. Soil Survey - Washington County will be presented during 1978. Soil Survey for Anoka County will be published in late 1977. For most current information, see open files at each of these county's Soil Conservation Service Office.

ECOL Library - Ecological Conservation Library, Minneapolis
MWCC - Metropolitan Waste Control Commission, St. Paul
SCS - Soil Conservation Service (by county)



SECTION 5 HYDROLOGY

The extensive water resources of the metropolitan area give it a unique character. A knowledge of their flow regime and characteristics is necessary in the best interest of development and preservation of these resources.

Section 11, Water Resources - Present Use and Quality, indicates the classification and location of the major lakes in the metropolitan area. The inflows and outflows of the major surface waters are shown on Plate 5. Lake level information and regulation are the responsibility of the Minnesota Department of Natural Resources (DNR).

RIVERS

River stretches are ever changing systems whose use and quality vary depending upon location. In the metropolitan area, the Mississippi River stretches 80 river miles, the Minnesota River traverses 62 river miles, and the St. Croix River traverses 40 river miles. Major tributaries to those streams include the Rum River entering the Mississippi at Anoka, the Crow River entering the Mississippi along the northwest corner of the metropolitan area, and the Vermillion River which enters the Mississippi just below the metropolitan area. Drainage patterns of the metropolitan area's 148 subwatersheds are presented on Plate 6.

The Minnesota River flows northeastward and joins the Mississippi River at the southwest border of St. Paul. It contains heavy loads of suspended solids (silt). (See Section 11, Water Resources - Present Quality, for exact depth.) Bottom sediments are composed of fertile silt mixed with sand. However, exposed rock which creates rapids and faster-flowing waters, occurs in the Carver Rapids area in Carver and Scott Counties. The average gradient of the river is 0.3 foot per mile, dropping from an altitude of about 700 feet, where it enters the area, to 687 feet at its confluence with the Mississippi River. (See Section 2, Topography for information on elevations). The upland part of its basin is dotted with numerous lakes, which occupy depressions left after the retreat of the Des Moines Lobe glaciation. (See Section 3, Geology and Geomorphology). The valley floodplain is poorly drained and contains many floodplain lakes and swamps, especially in its lowermost reach.

The St. Croix River flows southward and joins the Mississippi River near Prescott, Wisconsin. With its sandy bottom and adjacent steeply, wooded hillsides, this river has experienced the least man-made change of the three main rivers. Its average gradient is 1.3 feet per mile in the northeast part of the area, entering the metropolitan area at an altitude of about 800 feet and dropping to an altitude of 755 feet outside the metropolitan area at Taylors Falls. Below Taylors Falls, the gradient is 1.3 feet per mile to about 1 mile north of where the Polk County line (Wisconsin) meets the river. From the Polk County line the gradient is only 0.5 foot per mile, for the next 11 miles to the inlet of Lake St. Croix. There the channel broadens and the water surface altitude remains at about 675 feet in the 24 miles to the Mississippi River at Prescott. Between Taylors Falls and Lake St. Croix, the stream channel is highly braided, giving rise to many floodplain ponds and lakes. The upland part of the basin, especially north of the Washington County line, contains many lakes and swamps and is poorly drained, largely because of the flatness of the terrain.

The Mississippi River flows southeastward, diagonally across the central part of the area, entering at an altitude of about 910 feet and leaving at an altitude of 675 feet under controlled conditions. The natural gradient of the stream is altered by five dams. The river flows in a narrow gorge between Upper St. Anthony Falls Lock and Dam to its confluence with the Minnesota River where it flows in a broad valley.

Transport of sediments is facilitated as the granular size of sediment loads decrease and the volume of water increases. As more sediment is deposited, the river bed slopes less. This flattening of the bed reduces both the speed of flow and the carrying capacity of the river. A river deposits sedimentary materials at the bottom, sides and end of its bed. (See Exhibit B Stream Bed Characteristics). Deposition in the bed is usually only temporary or local. Either banks are raised in this way, or bars are formed in the river until later when the opportunity occurs for it to move again. Sediment can also be deposited during floods.

FLOODS

Floods are a natural and inevitable part of life along rivers. They are considered serious when damage occurs to man's objects or when his activities are interrupted. The problem of flooding is partially the result of man's use of the floodplain. As the population increases and more of the flood plain is occupied and used, it is inevitable that damage from flooding will occur unless floodplain development is regulated.

Flooding potentials can be estimated from the maximum, minimum and mean average discharge flows for selected U.S.G.S. gaging sites, as indexed in Table 5-1. The locations of these stations may be found in Figure 5-1. Flood crests recorded in the last thirty years on the Mississippi River at St. Paul occurred in April 1952 and April 1965.

TABLE 5–1 USGS GAGING STATIONS (41)

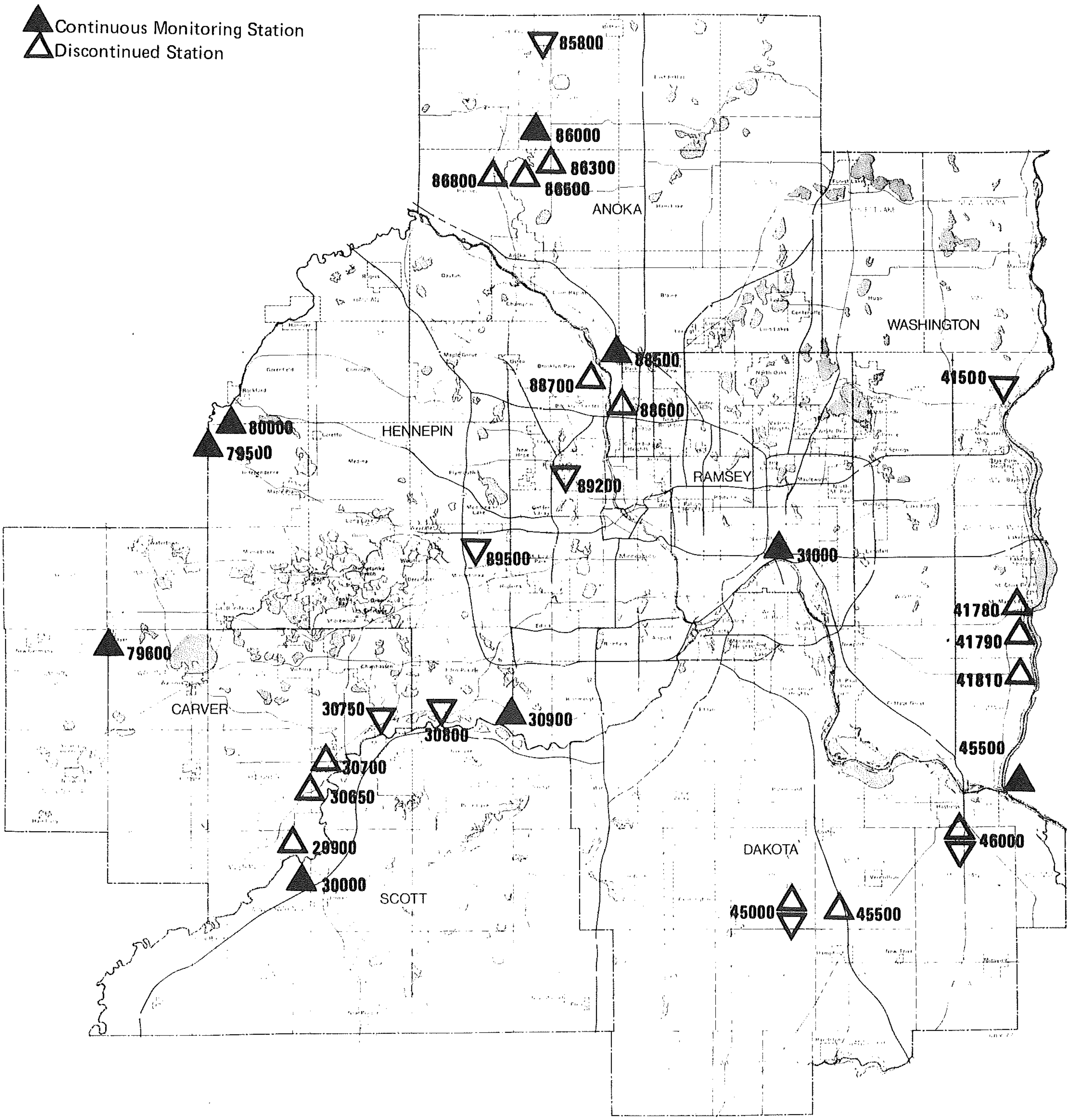
Identification Number	Stream	Location	Discharge
30000	Minnesota	Jordan	Maximum: 117,000 cfs Minimum: 79 cfs Mean: 3355 cfs Years of Record: 42
30900	Minnesota	Nine Mile Creek	Maximum: 535 cfs Minimum: .6 cfs Mean: 18 cfs Years of Record: 34
79000	Crow-South Fork	Young America	Maximum: 16,100 cfs Minimum: 0 cfs Mean: 254 cfs Years of Record: 42
80000	Crow		Maximum: 22,400 cfs Minimum: 1.8 cfs Mean: 629 cfs Years of Record: 51
86000	Rum	Near St. Francis	Maximum: 10,100 cfs Minimum: 29 cfs Mean: 597 cfs Years of Record: 44
88500	Mississippi	Near Anoka	Maximum: 41,500 cfs Minimum: 586 cfs Mean: 7156 cfs Years of Record: 38

31000	Mississippi	St. Paul	Maximum: 171,000 cfs Minimum: 632 cfs Mean: 10,530 cfs Years of Record: 78
44,500	Mississippi	Near Prescott, WI	Maximum: 228,000 cfs Minimum: 880 cfs Mean: 16,200 cfs Years of Record: 48

DISCONTINUED USGS GAGING STATIONS

Identification	Stream	Location
30650	Minnesota	Near San Francisco
29900	Minnesota	Near Jordan
30700	Minnesota	Near Chaska
30750	Minnesota	Near Shakopee
30800	Minnesota	Near Shakopee
45000	Vermillion	Near Empire
45500	Vermillion	Near Vermillion
46000	Vermillion	Near Hastings
41810	St. Croix	Near Denmark
41790	St. Croix	Near Afton
41780	St. Croix	Valley Branch Stream
41500	St. Croix	Stillwater
85800	Rum	Near St. Francis
86300	Rum	Near St. Francis
86500	Rum	Near St. Francis
86800	Rum	Near Ramsey
87900	Mississippi	Near Champlin
83500	Mississippi	Near Anoka
88490	Mississippi	Near Anoka
88700	Mississippi	Near Brooklyn Park
88600	Mississippi	Near Fridley
89200	Mississippi	Near Robbinsdale
89500	near Mississippi	Near Minnetonka

FIGURE 5-1 USGS GAGING STATIONS



Source: Water Resources Outlook, 1973

The Mississippi River basin is the largest in the state. Flows in the river are affected to some extent by releases from the six Federal reservoirs constructed in the headwaters region at Winnibigoshish, Leech, Pokegama, Pine, Sandy and Gull Lakes. Flood frequency data along the river at Anoka and at St. Paul is included in Tables 5-2 and 5-3.

TABLE 5–2

FLOOD FREQUENCY DATA ON THE MISSISSIPPI RIVER NEAR ANOKA, MINNESOTA Gage 5-2885

Recurrence Interval	Peak Discharge CFS	Gage Height Feet	Elevation Feet 1912 Adjustment	Elevation 1929 Adjustment
10-year	57,400	14.35	819.37	818.88
25-year	73,200	16.92	821.94	821.45
50-year	85,200	18.76	823.78	823.29
100-year	98,000	20.48	825.50	825.01
500-year	129,000	24.34	829.36	828.87

SOURCE: U.S. Army Corps of Engineers
(Personal communication)

TABLE 5–3

FLOOD FREQUENCY DATA ON THE MISSISSIPPI RIVER AT ST. PAUL, MINNESOTA Gage 5-3500

Recurrence Interval	Discharge CFS	Elevation Feet 1912 Adjustment
10-year	79,500	700.00
25-year	108,000	703.80
50-year	133,000	706.40
100-year	160,000	709.03
500-year	232,000	715.84

SOURCE: U.S. Army Corps of Engineers
(Personal communication)

Other segments which are subject to frequent flooding include tributaries to the Mississippi, the Crow, the Rum, the Vermillion, the Lower St. Croix and the entire length of the Minnesota River. See Table 5-4 and 5-5 for flood frequency data on the Minnesota River near Jordan and on the Crow River at Rockford.

TABLE 5–4

FLOOD FREQUENCY DATA ON THE MINNESOTA RIVER NEAR JORDAN, MINNESOTA Gage 5-3300

Recurrence Interval	Discharge CFS	Gage Height Feet	Elevation Datum of 1929
10-year	48,400	28.3	718.3
25-year	71,200	31.2	721.2
50-year	91,400	33.4	723.4
100-year	115,000	35.8	725.8
500-year	182,000	42.1	732.1

SOURCE: U.S. Army Corps of Engineers
(Personal communication)

TABLE 5–5

FLOOD FREQUENCY DATA ON THE CROW RIVER AT ROCKFORD, MINNESOTA Gage 5-2800

Recurrence Interval	Discharge CFS	Gage Height Feet	Elevation Datum of 1929
10-year	10,500	13.7	913.9*
50-year	21,800	19.1	
100-year	28,000	20.8	
500-year	46,000	25.9	

* The log-Pearson curve, with assigned skew of –0.2 has been adjusted on the basis of the coordinated Q100. Frequency data are as above.

SOURCE: U.S. Army Corps of Engineers
(Personal communication)

Floods occur primarily in the spring due to combinations of snow melt, precipitation, frozen ground and ice conditions. In the summer and fall they are caused by widespread rains of long duration. An intense local storm could be absorbed by the large channels of the Mississippi and Minnesota Rivers.

Flood damage is caused by inundation, siltation, water pollution or the destructive force of moving water. It includes direct or indirect damage to both urban and agricultural property. For a summary of flood damages along the major rivers in 1975, see Table 5-6. A summary of potential 100-year flood damages along tributary streams is shown in Table 5-7. Floods cause reduction in property value, curtailment of agricultural and industrial production, and deterioration of recreational lands and facilities. Recreation and open space is increasingly occurring on floodplains, since these areas are subject to temporary, seasonal inundation.

TABLE 5–6

SUMMARY OF FLOOD DAMAGES, MAJOR RIVERS (JULY 1974 PRICES, IN $1000'S) (43)

River	1965
Mississippi	20,053
Minnesota	11,120
St. Croix	9,202

TABLE 5–7

SUMMARY OF POTENTIAL 100 YEAR FLOOD DAMAGES, TRIBUTARY STREAMS (July 1975 dollars) (43)

Stream	Flood Damages
Minnehaha Creek	$ 978,900*
Bassett Creek	980,000
Nine-Mile Creek	663,500
Purgatory Creek	149,200
Rice Creek	299,100
Rum River	170,700
Crow River	1,191,000 (Estimated)
	$4,432,400

* Excluding Minneapolis; no data available.

FLOODPLAINS

A floodplain is defined by the DNR as the area adjacent to a watercourse which may be covered by regional or 100-year floods. The incapacity of a stream channel to handle its flow is often seriously aggravated by developments restricting the stream channel and encroaching onto the floodplain. Urbanized areas, with their large proportion of impervious surfaces, intensify runoff. Where development is extensive on two or more of the tributaries, and the concentrated flow from these tributaries arrives at about the same time, flood conditions will be aggravated. Waste disposal sites in the floodplain could lead to contamination of river water, as could on-site absorption systems. The extension of public utilities into the floodplain could encourage unwanted development. Alterations of the floodplain could reduce its water carrying capacity, increasing the probability of flooding and flood damage. For locations of floodplains within the study area, see Plate 7.

Flood insurance studies are under way or have been completed in many communities. The status of present studies is shown on Table 5-8. Flooding of lakes can be deleterious due to lake level rise which may decrease recreation potential, or through addition of phosphorus from storm sewer runoff. For locations of areas of significant increase in stormwater runoff and phosphorus generation, see Plate 8. Present and projected runoff coefficients for 1970 and 2000 based on land use patterns for each of the 148 subwatershed areas have been calculated (34).

In less developed areas, high groundwater levels may contribute to flooding. Lake flooding problems include flooded residential lots, deposition of silt and debris, flooded roads and recreational accesses, flooded septic systems and shoreline erosion.

The floodplain of the Mississippi is often large, and as the silt load increases, photosynthesis is restricted to the shoaling areas of meanders, to floating debris and to oxbows and sloughs, where sunlight can penetrate. In oxbows and sloughs, the current is greatly reduced, suspended solids settle out, and cleaner water permits algae growth. Here are often the greatest concentrations of fish, algae and invertebrates. During high flow, these sloughs and oxbows are often connected with the river. As a result, many aquatic organisms are added to the river.

TABLE 5–8 STATUS OF FLOOD INSURANCE STUDIES IN THE METROPOLITAN AREA (15)

* T—Flood Plain Technical Studies
I —Flood Plain Insurance Studies

** U—Underway
C—Completed
Numbers refer to years

*** 1—Flood plain zoning ordinance providing for a flood plain district
2—Flood plain zoning ordinance providing for designation of floodway and flood fringe districts
3—Subdivision controls containing flood plain provisions
4—Combination zoning and subdivision controls intended to meet minimum HUD land use criteria
5—Amendment of existing zoning ordinance to provide for flood plain provisions designed to meet minimum HUD criteria
6—Amendment of existing subdivision controls to provide for flood plain provisions designed to meet minimum HUD criteria

Community	Streams	Type of* Study	Type** of Study	Type of*** Control
ANOKA COUNTY				
Andover	Mississippi River	T	U	
	Rum River	T	U	
Anoka	Mississippi River	T	U	
	Rum River	T	U	
		I	U	
		I	C-73	2,3
Anoka County	Rum River	T	U	
		I	U	
Blaine		I	U	
Centerville	Clearwater Creek	T	C-75	
		I	U	
Columbia Heights		I	U	
Circle Pines		I	U	
Coon Rapids	Mississippi River	T	U	
		I	C-77	2
East Bethel		I	U	
Fridley	Rice Creek	T	C-71	
	Mississippi River	T	U	
		I	U	2
Ham Lake		I	U	

Community	Stream	Type of* Study	Type** of Study	Type of*** Control
Hugo	Clearwater Creek	T	C-75	
		I	U	
Lexington		I	U	
Lino Lakes	Clearwater Creek	T	C-75	
Ramsey	Mississippi River	T	U	
	Rum River	T	U	
		I	U	
St. Francis	Rum River	T	U	
CARVER COUNTY				
Carver	Minnesota River	T	C-72	
		I	C-72	2
Carver County		I	U	1
Chanhassen	Riley Creek	T	C-71	
	Minnesota River	T	C-72	
		I	U	
Chaska	Minnesota River	T	C-72	
		I	C-72	
		I	U	4
Norwood				
Waconia		I	U	
Watertown		I	U	
DAKOTA COUNTY				
Burnsville		I	U	
Dakota County	All streams with drainage areas over 2 square miles	T	C-74	
	Vermillion River	T	C-74	
		I	U	
Eagan	Minnesota River	T	C-72	2
Farmington	Vermillion River	T	C-74	
		I	U	2
Hastings	Mississippi River	T	C-71	
	Vermillion River	T	C-71	
		I	U	
Inver Grove Heights	Mississippi River	T	C-73	
		I	U	2
Lakeville		I	U	
Lilydale	Mississippi River	T	C-73	
		I	C-73	2
Mendota	Mississippi River	T	C-73	
Mendota Heights	Mississippi River	T	C-73	
Randolph		I	U	

Community	Stream	Type of* Study	Status** of Study	Type of*** Control
Rosemount	Mississippi River	T	C-73	
		I	U	2
South St. Paul	Mississippi River	T	C-73	
		I	U	2
Vermillion	Vermillion River	T	C-74	
		I	U	
HENNEPIN COUNTY				
Bloomington	Nine Mile Creek	T	C-60	
	Minnesota River	T	C-72	
		I	C-72	
		I	U	4
Brooklyn Center	Mississippi River	T	U	
		I	U	
Brooklyn Park	Mississippi River	T	U	
		I	U	
Champlin	Elm-Rush Creek	T	C-75	
	Mississippi River	T	U	
		I	C-77	2,3
Corcoran	N. Fork-Rush Creek	T	U	
	Elm-Rush Creek	T	C-75	
		I	U	
Crystal	Bassett Creek	T	C-74	
		I	U	
Dayton	Elm-Rush Creek	T	C-75	
	Mississippi River	T	U	
	N.Fork-Rush Creek	T	U	
		I	U	
Eden Prairie	Nine Mile Creek	T	C-72	
	Minnesota River	T	C-72	
	Purgatory Creek	T	C-71	
		I	U	1
Edina	Nine Mile Creek	T	C-72	
	Minnehaha Creek	T	C-71	
		I	U	1
Excelsior		I	U	
Golden Valley	Bassett Creek	T	C-74	
		I	U	1
Greenfield		I	U	
Hassan Township	N.Fork-Rush Creek	T	U	
		I	U	
Hopkins	Nine Mile Creek	T	C-72	
	Minnehaha Creek	T	C-71	
		I	U	1
Independence	Pioneer Creek	T	U	

Community	Stream	Type of* Study	Status** of Study	Type of*** Control
Maple Grove	Elm-Rush Creek	T	C-75	
	N.Fork-Rush Creek	T	U	
		I	U	
Medicine Lake	Bassett Creek	T	C-74	1
Medina	Elm-Rush Creek	T	C-75	
	Pioneer Creek	T	U	
		I	U	
Minneapolis	Mississippi River	T	U	
		I	U	2
Minnetonka	Nine Mile Creek	T	C-72	
	Purgatory Creek	T	C-71	
	Minnehaha Creek	T	C-71	
		I	U	1
Minnetrista	Pioneer Creek	T	U	
Mound		I	U	
New Hope	Bassett Creek	T	C-74	
		I	U	1
Robbinsdale	Bassett Creek	T	C-74	
		I	U	2
Orono		I	U	
Plymouth	Bassett Creek	T	C-74	
		I	U	
St. Louis Park	Minnehaha Creek	T	C-71	
		I	C-76	
		I	U	1,3
Shorewood		I	U	
	Purgatory Creek	T	C-71	
Spring Park		I	U	
Tonka Bay		I	U	
Wayzata		I	U	
Woodland		I	U	
RAMSEY COUNTY				
Arden Hills		I	U	
New Brighton	Rice Creek	T	C-71	
		I	U	
North St. Paul		I	U	
St. Paul	Mississippi River	T	C-73	
		I	C-73	2
Shoreview		I	U	
SCOTT COUNTY				
Jordan		I	U	4
New Prague		I	U	4
Prior Lake		I	U	

Community	Stream	Type of* Study	Status** of Study	Type of*** Control
Savage	Minnesota River	T	C-72	
		I	U	
Scott County		I	U	
Shakopee	Minnesota River	T	C-72	
		I	U	
WASHINGTON COUNTY				
Afton	St. Croix River	T	C-71	
		I	C-72	4
Bayport	St. Croix River	T	C-71	
		I	C-72	4
Cottage Grove	Mississippi River	T	C-73	
		I	C-74	2
Lake Elmo		I	U	
Lake St. Croix Beach	St. Croix River	T	C-71	
		I	C-72	4
Lakeland Shores	St. Croix River	T	C-71	4
Newport	Mississippi River	T	C-73	
		I	U	
St. Mary's Point	St. Croix River	T	C-71	
	Mississippi River	T	C-73	
		I	C-72	4
St. Paul Park	Mississippi River	T	C-73	
		I	U	2
Stillwater				5
Washington County	St. Croix River	T	C-71	

DAMS

The natural flow of the river is often altered by the creation of dams which might not have been necessary or could have been greatly reduced in size if man had planned the use of the watershed so that rain penetrated the soil, rather than producing erratic runoff. Effects of the dams are observed both upstream and downstream, in chemical and physical changes in water quality, in changes in the structure of the river channel, in deposition and erosion rates of sediments, and in the abundance and diversity of aquatic life (25).

The locks and dams that are part of the Upper Mississippi River's nine foot channel system, have increased navigable portions of the Minnesota, St. Croix and the Mississippi, thereby increasing the potential for commercial and recreational boating use. Traffic volumes on the Mississippi are listed in Table 5-9.

TABLE 5–9

EXISTING AND PROJECTED COMMERCE ON THE UPPER MISSISSIPPI RIVER BASIN

LOCK	MILE	WATERBORNE COMMERCE MILLION TONS BY YEAR						
		1964	1980		2000		2020	
			M	H	M	H	M	H
1	847.6	4	7	8	11	14	16	21
2	815.2	8	14	17	22	28	31	43

M—Medium Projection
H—High Projection

SOURCE: U.S. Army Corps of Engineers
(Personal communication)

At St. Anthony Falls, a flow of approximately 350 cubic feet per second (cfs) (the peak daily need) is required to operate the locks to accommodate the expected traffic. Limited power facilities are located at the upper and lower St.Anthony Falls dams and Lock and Dam No. 1 since these structures are higher than other dams.

The Corps of Engineers maintains a nine-foot channel on the Minnesota River, from Shakopee to the mouth, a distance of 14.7 miles. A minimum water surface elevation of 682.7 is maintained upstream to Shakopee by Lock and Dam No. 2 at Hastings. On the St. Croix River, a nine-foot channel was excavated for commercial navigation from the mouth to Stillwater, a distance of 24.5 miles. The level of the St. Croix River navigation channel is controlled by Lock and Dam No. 3 at Red Wing.

WATER USE

The metropolitan area is rich in water resources with over 310 larger lakes, three major rivers (Mississippi, Minnesota and St. Croix), smaller rivers (Crow, Vermillion and Rum) and numerous streams. Sources of water and uses of water by counties in the metropolitan area and categories is shown on Table 5-10.

Rural uses include water for private water supplies and level control. Public supply uses refer to public water works usage. Thermoelectric power use refers to usage by mine processing or public water works. Self supplied industrial uses include road construction, industrial processing, industrial cooling and air-conditioning. Dewatering use refers to drainage for construction projects. Irrigation use includes water for wild rice, golf courses, and landscaping. Miscellaneous use refers to any uses not mentioned above.

TABLE 5–10

SOURCES AND USES OF WATER RESOURCES IN THE METROPOLITAN AREA

SOURCES OF WATER, MILLIONS GALLONS PER YEAR

COUNTY	LAKE		RIVER, STREAM BROOK, CREEK		ARTIFICIAL PIT, POND OR SWAMP		NATURAL SWAMP, POND, SLOUGH		DITCH		WELL	
Anoka	4,066	(4)*	55	(5)	1	(1)		(0)	0	1(1)	545.1	(71)
Carver	6	(3)	13	(1)		(0)		(0)		(0)	812	(25)
Dakota	.02	(2)	82,117	(15)	158	(2)		(0)		(0)	827.6	(171)
Hennepin	57	(4)	1,605,912	(12)	18	(2)	3	(2)	.30	(1)	102,722	(246)
Ramsey	19,373	(3)	85,456	(2)		(0)		(0)		(0)	11,771	(120)
Scott	1	(1)	81	(2)	2307	(3)		(0)		(0)	1,639	(25)
Washington	46	(6)	102,469	(40)	.152	(2)	0	(1)		(0)	6,948	(76)
TOTALS	23,549	(17)	1,876,103	(40)	2636	(10)	3	(4)	0.30	(2)	137,619	(734)

USES OF WATER, MILLIONS GALLONS PER YEAR

Anoka	112	(9)	8,396	(48)	108	(16)		(0)	284	(8)		(0)	108	(16)
Carver	16	(2)	512	(15)	31	(5)		(0)	257	(5)		(0)	31	(5)
Dakota	62	(12)	4,623	(52)	1,082	(68)	82,049	(1)	2,683	(33)	0	(2)	1,082	(68)
Hennepin	561	(34)	41,088	(92)	267	(30)	811,198	(5)	8,484	(99)	.89	(1)	267	(30)
Ramsey	87	(17)	21,171	(25)	150	(9)	85,227	(1)	9,199	(62)		(0)	150	(9)
Scott	16	(7)	537	(6)	21	(8)		(0)	1,206	(7)	2,381	(2)	21	(8)
Washington	.27	(4)	2,428	(34)	3,235	(16)	101,770	(1)	3,125	(15)	152	(2)	3,235	(16)
TOTALS	854.27	(85)	78,755	(272)	4,894	(152)	1,080,244	(8)	25,238	(229)	2,534.89	(5)	4,894	(152)

*( ) indicates number of uses or sources in each category

SOURCE: Compilation from the United States Geological Survey Print-out, August 9, 1977.

GROUNDWATER SUPPLY

The groundwater resources in the metropolitan area are immense. Despite the fact that pumpage is increasing steadily, the groundwater reservoir is essentially full and actually is spilling some of its surplus water into the rivers.

There is no unique "recharge" zone or localized replenishment to the groundwaters of the metropolitan area. The majority of the region around the metropolitan area receives infiltration from rainfall. Consequently, even if infiltration were to cease entirely at localized areas of intense development, it would have no overall effect on the recharge potential of the aquifers.

Analysis of the aquifers of the metropolitan area system shows, that the potential for extracting more groundwater in the metropolitan area is large. The best estimates of water needs in the metropolitan area range from 327 MGD (millions of gallons daily (1), which was the usage in 1970, to 474 MGD usage (1) and 363 MGD usage (43) by the year 2000. In comparison, the metropolitan area in 1970 used 194 MGD of groundwater and 133 MGD of surface water (41).

The mean annual precipitation for the metropolitan area, as recorded at five U.S. Weather Bureau stations, is 3.5 inches. The major portion of this precipitation is in the form of rainfall, of which nearly 20 inches occurs between April and September.

Not all of the 35 inches of precipitation received annually in the metropolitan area is available as replenishment for the regional water resources. Between 85% and 90% of it is lost through evapotranspiration. The remaining approximately 3.5 inches of precipitation is available after evapotranspiration for surface runoff and groundwater recharge (2).

Stream flow varies seasonally with maximum discharge generally occurring during April and May and the minimum discharge during August, September and December. In this study, stream discharge is given in million-gallon-per-day units (MGD) for uniformity. One MGD is equal to 1.55 cubic feet per second (cfs).

The Anoka gaging station on the Mississippi River has been in operation since 1931. Its maximum recorded discharge of 58,815 MGD was gauged on April 17, 1965. The minimum discharge, 378 MGD on September 13, 1934. The Jordan gaging station (listed as Carver prior to 1966), is located on the Minnesota River at Jordan. The flows since 1934 have been recorded. The maximum discharge of 75,619 MGD was measured on April 11, 1965. The minimum discharge of 51 MGD occurred on November 17, 1955. The Minnesota River discharges into the Mississippi River in the area of southwest Minneapolis, but no gaging station is maintained at this point.

The St. Paul gauge is approximately six miles below the confluence of the Minnesota and Mississippi Rivers in St. Paul. Seventy years of record are available from this gauge. Maximum discharge was recorded at 171,000 MGD on April 16, 1965. A minimum discharge of 632 MGD occurred August 26, 1934.

Table 5-11 shows mean annual flows at the three stations for the period from 1953 through 1975. Averages for the period are listed and comparisons made between the combined Anoka-Jordan flow and the flow at St. Paul.

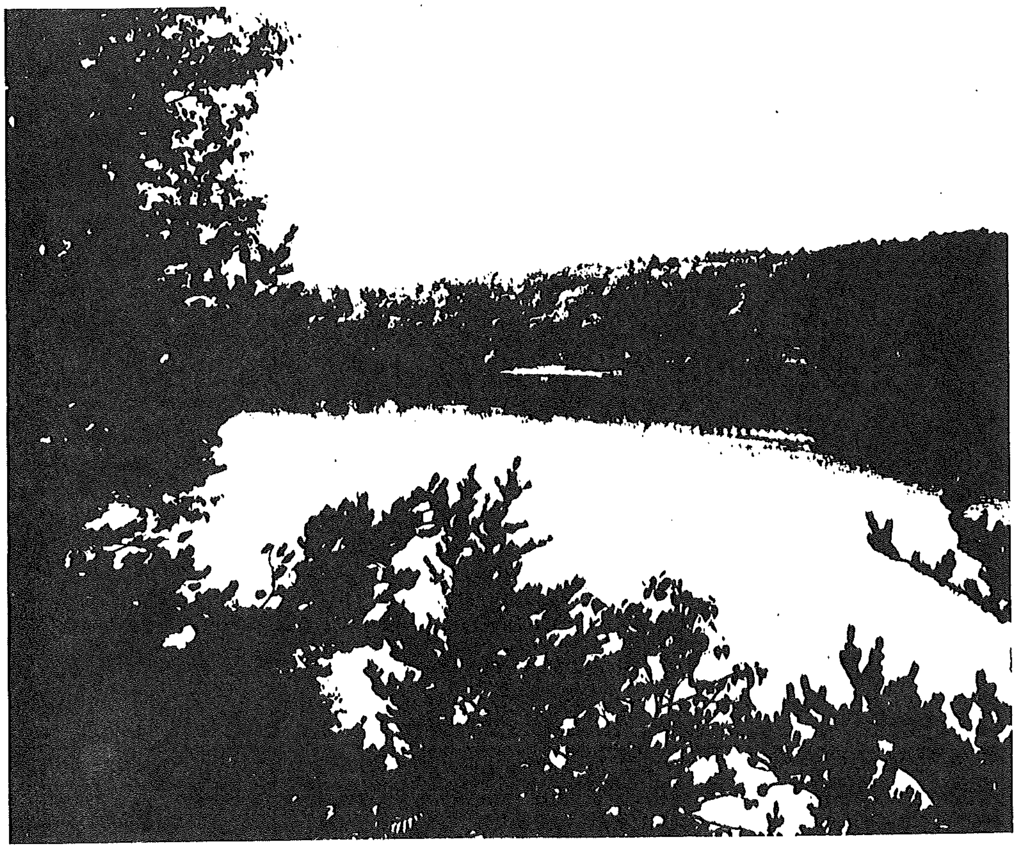


TABLE 5–11

SURFACE WATER DISCHARGE IN THE METROPOLITAN AREA, WATER YEARS 1953 THROUGH 1975 (44)

Water Years	Mississippi River at Anoka	Minnesota River at Jordan	Sum of Discharges at Anoka and Jordan	Mississippi River at St. Paul	Discharge at St. Paul Minus Sum of Discharges at Anoka and Jordan
1953	11,540	5,136	16,676	17,130	454
1954	9,585	2,303	11,888	12,340	452
1955	6,230	1,472	7,702	8,136	434
1956	6,334	1,618	7,952	8,364	412
1957	8,969	3,400	12,369	12,950	581
1958	5,343	2,120	7,463	7,598	135
1959	4,057	697	4,754	4,904	150
1960	5,565	4,078	9,643	9,871	228
1961	3,152	2,260	5,785	5,785	373
1962	7,584	5,861	13,445	14,090	645
1963	6,431	2,866	9,297	9,476	179
1964	5,464	2,103	7,567	7,763	196
1965	11,720	7,182	18,902	20,030	1,128
1966	13,650	3,997	17,647	18,520	873
1967	8,030	3,483	11,513	11,820	307
1968	5,704	2,073	7,777	8,275	498
1969	11,320	9,748	21,068	22,072	1,004
1970	6,579	2,241	8,810	9,077	267
1971	8,141	5,229	13,370	13,910	540
1972	15,340	4,921	20,261	20,950	684
1973	9,225	4,396	13,621	13,720	94
1974	10,790	2,974	13,764	14,270	506
1975	11,290	3,370	14,660	14,980	320
	78,384	34,952	113,331	117,254	3,923
AVE CFS	8,350	3,631	11,981	12,436	455
AVE MGD	5,397	2,347	7,744	8,038	294

The Mississippi River at Anoka, where it enters the metropolitan area, has a 23-year average discharge of 4,900 MGD. The Minnesota River augments the flow of the Mississippi an average of approximately 2,100 MGD, as shown by the discharge measured at Jordan over the past 23 years.

If no other water were to enter the Mississippi system, the 23-year average discharge (1953-1977) at the downstream St. Paul station would be the sum of these two flows - 7,740 MGD. In actuality, the St. Paul station shows an average discharge of 8,040 MGD for the period, which represents an increase of 300 MGD. Part of this increase can be attributed to discharge of groundwater extracted by industries and communities. The remainder is predominantly discharge of groundwater to the Mississippi and Minnesota Rivers through subsurface aquifers.

Industry is the largest user of groundwater resources of the region. Groundwater also serves as a source of water supply for many domestic water users. The available data suggest that groundwater pumpage would have to be nearly doubled to halt the overflow of the aquifers into the rivers. Use of groundwater has been increasing steadily, as shown by records dating back to 1885. Total groundwater pumped in 1959 was estimated to be 136 MGD. The pumpage for 1970 was estimated to be approximately 194 MGD. The Jordan formation supplies an estimated 75 percent of total groundwater pumpage with the Mount Simon-Hinckley supplying 18 percent and the glacial drift Platteville Limestone and St. Peter Sandstone providing 7 percent.

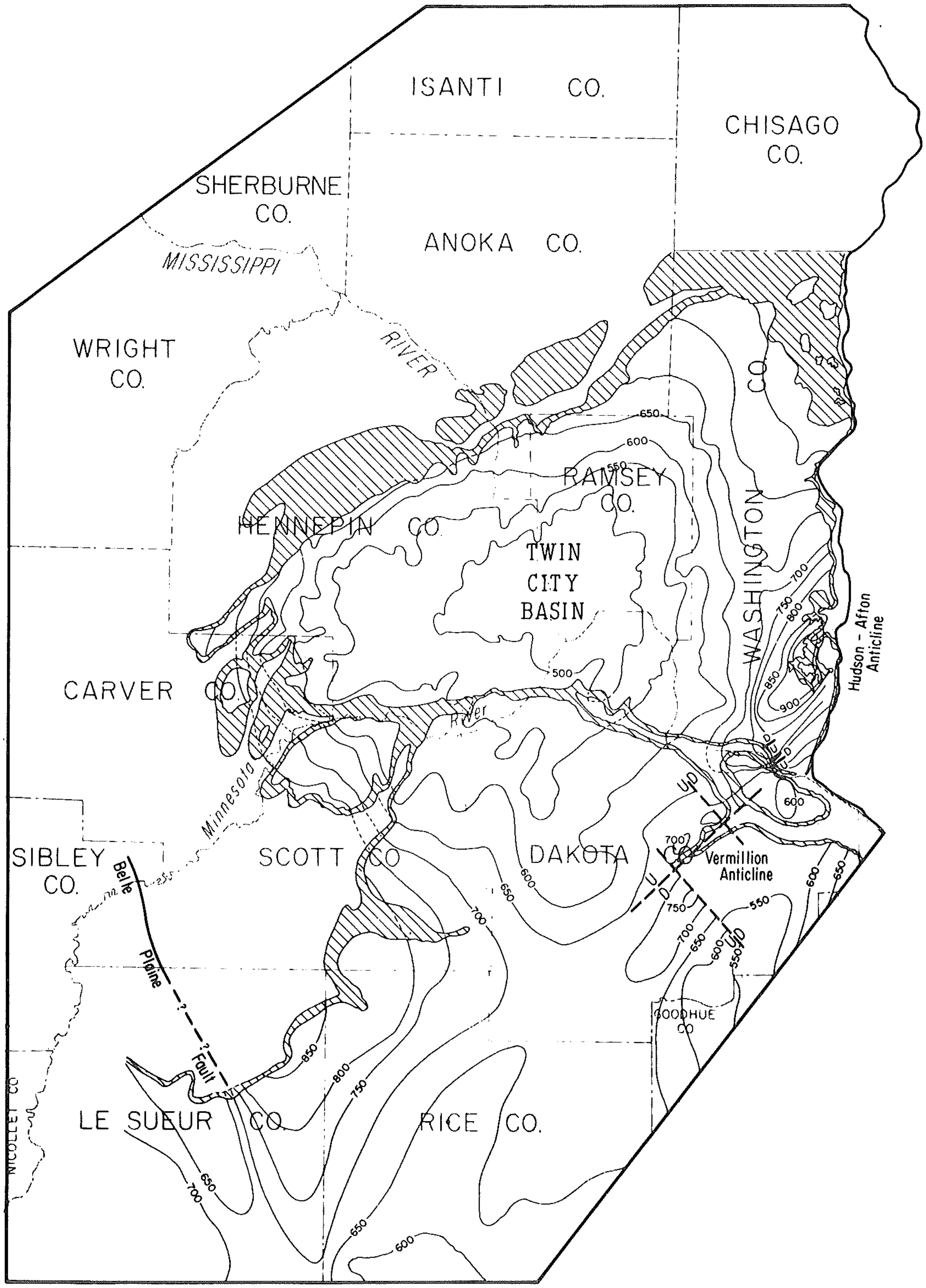
In spite of this withdrawal, the bedrock aquifers in the metropolitan area are still completely saturated with water. In some localities, water levels have been lowered due to pumping, but the cone of depression which exists throughout the Twin Cities is a normal result of well operation, and in no way can be considered serious at this time.

The decline of water levels in the Minneapolis-St. Paul area has given rise to speculation that the groundwater is being mined, or that more water is being pumped than is being recharged to the aquifers. The drawdown, however, does not necessarily indicate an overdraft of groundwater supplies. In the few places where large drawdowns exist, it can be attributed to overlapping of cones of depression from a number of closely spaced wells. Such problems are more a result of lack of planning and knowledge of groundwater hydrology than of an overdraft of the groundwater system.

In actuality, an abundance of water exists. For example, although the Jordan is the most prolific and widely used aquifer in the area, the average drawdown of its piezometric surface is only between 60 - 90 feet. The total drawdown that could be called upon without dewatering the Jordan is over 200 feet. These figures would indicate that the present pumping rate could be multiplied several times without seriously depleting the groundwater resource (1). For locations of recharge areas in the Jordan aquifer, see Figure 5-2.

The second most important aquifer is the Mt. Simon-Hinckley Formation, which is found at greater depths. Recharge to this unit and to the Jordan is largely by direct vertical percolation of water in places where the formations crop out or are overlaid by permeable glacial material. Some recharge is by vertical leakage from overlying aquifers within the center of the artesian basin.

FIGURE 5–2 GROUNDWATER RECHARGE AREAS OF THE JORDAN AQUIFER



Source: Geology of Minnesota, 1972

REFERENCES

1. Classification of Natural Ponds and Lakes in the Glaciated Prairie Region. U.S. Department of the Interior, Fish and Wildlife Service, Resource Publication 92, 1971. Biological information plus ecological classifications. (Available: U of M)

2. Classification Scheme for Public Waters - Shoreland Management. Supplementary Report No. 1. Good background on classification. (Available: MC)

3. Combined Sewer Overflow Study - Project Overview Report, Ganoram, March, 1977. Study that provides basis for this inventory - background data. (Available: MWCC)

4. Configuration of the Water Table and Distribution of Downward Leakage to the Prairie du Chien - Jordan Aquifer in the Minneapolis - St. Paul Metropolitan Area. Minnesota, Open File Report 75-342, U.S. Department of Interior Geological Survey, in cooperation with the Metropolitan Council of the Twin Cities Area. Shows downward leakage and vertical hydraulic conductivity by using computer data. Technical for this report. (Available: USGS)

5. An Economic Analysis of Flood Damage. Reduction Alternatives in the Minnesota River Basin. Alan R. Hopeman, Water Resources Research Center, University of Minnesota Graduate School, May, 1973. Gives current (1969) damage figures and discusses legislation. (Available: U of M)

6. Examination of the Water Resources of the Minneapolis/Hennepin County, State of Minnesota, Limnological Research Center, 1966. Background information, some outdated. (Available: U of M)

7. Final Environmental Impact Statement, Flood Control At Chaska, Minnesota River, July, 1975. Site description and flooding information most valuable. (Available: CE)

8. Flood Hazard Analyses - Vermillion River, USDA with the Dakota County soil and Water Conservation District in cooperation with the Minnesota Department of Natural Resources, December 1974. Very helpful - with maps, by river mile, indicating floodplains. Short, very basic text. (Available: DNR - Waters Division).

9. Flood-Plain Areas of the Lower Minnesota River, USGS in cooperation with the Department of Natural Resources, Water Resources Investigations 15-74, 1973. Large schematic drawings with river mile and flood-plain designations. (Available: USGS, St. Paul)

10. Floods and Flood Damage Alleviations, S. A. Frellsen and J. W. Walters for Water Resources Coordinating Committee, First Draft, Subject to Major Revision, February 1968. Useful information on maximum discharges and flood damages. (Available: SPA)

11. Floods and Flood Damage Reduction in Minnesota. Minnesota Conservation Department, Division of Waters, Soils and Minerals in cooperation with the Minnesota State Planning Agency, October, 1968. Good background - includes legislation and reference agencies . (Available: DNR)

12. Floods in Minnesota - Magnitude and Frequency. Bulletin 12, DNR - Division of Waters, September 1961. Mainly tables indicating peak stages and discharges. (Available: DNR-Division of Waters)

13. Floods of April - May 1969 in Upper Midwestern United States United States Department of the Interior, Geological Survey, Water Resources Division, Open File Report, February 1970. Includes meteorological data, actual occurrence description with aerial photos and text and streamflow data. (Available: USGS, St. Paul.)

14. Geology of the Minneapolis - St. Paul Metropolitan Area. George Schwartz, Bulletin 27, Minnesota Geological Survey, 1936. Small section on geology of lakes, also details locations of springs. (Available: USGS)

15. Minnesota Status of Flood Plain Management, Land Management Section, Division of Waters, Department of Natural Resources, September 1977. Cross-referenced listing of communities with some type of floodplain study and its status. (Available: DNR)

16. Geology and Underground Waters of Southern Minnesota. George Theil, Minnesota Geological Survey, Bulletin 31, 1944. (Chapter on elements of groundwater hydrology most useful. Rest of book discusses in general terms wells, geology and hydrology by county. (Available: USGS)

17. Mississippi River - Floodplain Information and Management (Mile 815.2 to Mile 847.7) Mn/DNR, Division of Waters, Soils and Minerals, 1972. Large aerial photographs with river mile and floodplain designations (DNR - St. Paul)

18. Hydrologic Analysis of Lakes and Open Space in Ramsey County. Barr Engineering Co., April, 1975. Maps useful to determine flowage. (Available: MWCC)

19. Hydrologic Atlas of Minnesota, Bulletin 10, DNR - Division of Waters, 1959. Text and maps describing each watershed unit. (Available: DNR - Division of Waters.)

20. Hydrology for Urban Land Planning - A Guidebook on the Hydrologic Effects of Urban Land Use, Luna Leopold, Geological Survey Circular 554, 1968. Analysis of data as to its impact on urban land use. Very useful. (Available: USGS, St. Paul)

21. Inventory of Minnesota Lakes. Minnesota Department of Conservation, Bulletin No. 25, 1968. Identification of all lakes over 10 acres, their classification, location, and some general information on lakes. (Available: MC)

22. Inventory of Physical Features and Facilities within the Major River Corridors in the Twin Cities Metropolitan Area. Metropolitan Council, September, 1969. Detailed maps - several views - of river sections. (Available: MC)

23. Major River Corridors in the Twin Cities Metropolitan Area. Metropolitan Council, December, 1970. Very helpful - good background on uses, plus descriptions of each river section - present and future. (Available: MC)

24. Metropolitan Lake Inventory. Minnesota Game Department, Division of Game and Fish, Section of Technical Services, Special Publication No. 45, October, 1967. Shortened form of Reference 12 - includes map of metro area with identified lakes. (Available: DNR)

25. Minnesotans and their Mississippi River: A Citizen's Review of Minnesota - Mississippi River Environment. Jean Stanford Replinger, Aesthetic Environment Task Force of the State of Minnesota, 1974. Valuable resource - discusses river as ecosystem plus use data. (Available: MC)

26. Navigation on the Upper Mississippi River, Lock and Dam No. 1. Minneapolis - St. Paul, Minnesota. Pamphlet by U. S. Army Corps of Engineers. Pictures, some text - good for quick reference. (Available: CE)

27. Navigation on the Upper Mississippi River, Lock and Dam No. 2. Hastings, Minnesota pamphlet by U. S. Army Corps of Engineers. Good quick reference source. (Available: CE)

28. Procedural Guide for the Implementation of County Shoreland Ordinances, Shoreland Management, Supplementary Report No. 3, Minnesota Department of Natural Resources, February, 1972. Technical procedures and forms to use. (Available: DNR)

29. Proceedings: Eighth Annual Water Resources Seminar - Groundwater Resources and Development. November 24 and 25, 1975, Bulletin 87, Water Resources Research Center, University of Minnesota Graduate School, May, 1976. Generalized Statewide data and maps. (Available: U of M)

30. St. Anthony Falls Locks and Dams, Mississippi River, Minneapolis pamphlet by U. S. Army Corps of Engineers. Good quick reference source. (Available: CE)

31. St. Croix River Regional Flood Analysis, St. Croix Falls, Wisconsin to mouth, Mn/DNR, Division of Waters, Soils and Minerals, Wisconsin DNR, Division of Environmental Protection, March 1973. Very useful maps of communities along the St. Croix showing floodplains. Short text. Available: DNR - Waters, Soils and Minerals Division)

32. Small - Stream Flood Investigations in Minnesota October 1958 - September 1973 U.S. Department of Interior, Geological Survey in cooperation with Mn/Department of Highways, Open-File Report, 1975. Data from range of years for each location. Includes basin characteristics and other information for each river. USGS - St. Paul.

33. Special Flood Hazard Information, Clearwater Creek, Rice Creek Watershed, Corps of Engineers, 1975. Includes soil data, geology and background information, flood situation, past history and future floods. Flood plain management is discussed in a separate section. Maps included. (CE - St. Paul)

34. Stormwater Impact Investigation for the Metropolitan Council. E. A. Hickok and Associates, 1972. Unpublished study that identifies projected increases of phosphorus and stormwater runoff in the metropolitan area. (Available: MC)

35. Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management, H. O. Phannkuch, Bulletin 81, Water Resources Research Center, University of Minnesota Graduate School, April, 1975. Many mathematical models.; (Available: U of M)

36. Surface Water - Metropolitan Minneapolis - St. Paul Area Map. 1974 State Planning Agency, Center for Urban and Regional Affairs, University of Minnesota and the Geography Department. Shows extent of water as detectable by satellite, extent of water as shown on topography map and extent of water as shown on topography map but not present on satellite images. Useful. (Available: SPA)

37. Techniques for Estimating Magnitude and Frequency of Floods in Minnesota. U. S. Geological Survey, Water Resources Investigations 77-31, 1977. Current flooding data. (Available: USGS)

38. The Upper Mississippi River . . . nine-foot channel. Pamphlet by U. S. Army Corps of Engineers. Readable reference source - mainly pictures. (Available: CE)

39. Water Resources of the Minneapolis - St. Paul Metropolitan Area. Bulletin 11, State Department of Conservation, Division of Waters, August, 1961. Very good background information and general overview of ground and surface water, water use and future water needs. Also describes uses of lakes and minor streams. (Available: DNR)

40. Water Resources of the Minneapolis - St. Paul Area, Minnesota. Geological Survey Circular 274, U. S. Department of Interior, 1953. Details low flow and drainage of many gaging sites. Gives surface and groundwater information, plus details on nearby streams and creeks. (Available: USGS)

41. Water Resources Outlook for the Minneapolis - St. Paul Metropolitan Area. U. S. Geological Survey in cooperation with the Metropolitan Council. Most useful sourcebook with complete text and maps. (Available: USGS)

42. Watershed Management Plan for Bassett Creek. Bassett Creek Flood Control Commission, February, 1972. Useful maps. (Available: Bassett Creek Watershed District.)

43. Level B Report - Minneapolis-St. Paul Water and Land: Future Perspectives and Plans, Upper Mississippi River Basin Commission June 1977 Mainly projections, helpful figures and tables (Available: UMRBC)

44. Water Resources Data for Minnesota, Part 1 - Surface Water Records. Data for most surface waters (rivers) of Minnesota. Annual records available since 1961; previous records found in water supply papers. (Available: USGS)

45. Commercial Navigation on the Upper Mississippi River: An Economic Review of its Development and Public Policy Issues Affecting Minnesota, 1974, Water Resources Research Center, University of Minnesota Graduate School, 1974. General discussions. (Available: U of M)

KEY

CE - Corps of Engineers
DNR - Department of Natural Resources
MC - Metropolitan Council Library
MWCC - Metropolitan Waste Control Commission
SPA - State Planning Agency
U of M - University of Minnesota libraries
UMRBC - Upper Mississippi River Basin Commission
USGS - United States Geological Survey

SECTION 5 HYDROLOGY

CONTACTS:	AGENCY:
Wayne Berg - Floodplains	Corps of Engineers
Chuck Burrows - Supervisor of Fisheries	Minnesota Department of Natural Resources
George Carlson - Flood Frequencies	United States Geological Survey
John Eagen - Hydrographic Unit	Minnesota Department of Natural Resources
Ron Harnack - Regional Hydrologist	Minnesota Department of Natural Resources
Dave Milles - Shoreland Management	Minnesota Department of Natural Resources
Al Pinell - Public Waters Inventory	Minnesota Department of Natural Resources
Mike Robinson - Floodplains	Minnesota Department of Natural Resources
Jim Wright - Flood Plain Management	Minnesota Department of Natural Resources

GENERAL

WETLANDS

Wetlands are transition zones between land and water. Delineation of their boundaries is hindered by seasonal fluctuations and annual fluctuations during dry and wet weather conditions. The U.S. Fish and Wildlife Service defines a wetland as follows:

> "...land where the water table is at, near or above the land surface long enough each year to promote the formation of hydric soils and to support the growth of hydrophytes, as long as other environmental conditions are favorable. Permanently flooded lands lying beyond the deep water boundary of wetlands are referred to as aquatic habitats." (1)

The U.S. Fish and Wildlife Service estimates that 265,000 acres of wetlands exist in the metropolitan area, and comprise 14 percent of the total surface area (1). Small wetland areas are uniformly scattered throughout the western half of Scott, Carver and Hennepin Counties. Anoka County has extensive wetland areas. Dakota and southern Washington Counties have very few wetlands. These wetlands moderate the effect on both the quantity and quality of water which decrease the runoff and groundwater recharge.

IMPORTANCE

Wetlands play a vital role in retention and release of water and stabilization of streamflow and lake levels. During periods of flooding, wetlands act as storage basins by impounding water in open ponds and storing water in their organic soils. In dry periods, this water is released in a controlled manner thus maintaining the receiving water body.

Wetland areas are often cited as being important points of groundwater recharge. However, recharge of aquifers in the metropolitan area is of limited importance due to the impermeable till situated between the wetlands and the bedrock. The majority of wetlands in the metropolitan area are points of discharge rather than of recharge (3). (See Section 5, Hydrology). Along the upper Mississippi River and the Minnesota River, groundwater recharge occurs. The river beds are the major contributors; wetlands are less important. Vast wetland areas located in the Anoka Sandplain are potential sources for recharge of the Ironton and Galesville Sandstone aquifer. However, because these aquifers are generally full, wetland recharge potential is seldom realized.

The role of wetlands in upgrading runoff water quality has been investigated in several recent studies (3, 4). Wetlands act as a soil filter; nutrients adsorbed by the organic soils are then assimilated by the highly productive vegetation. These nutrients are retained as production exceeds decomposition in a wetland. Furthermore, wetlands function as a settling system by removing suspended matter from runoff.

The function of wetlands to dissipate the flow energy of runoff is of considerable importance in the reduction of soil erosion. In hilly and steep landscapes, wetlands located in depressions act as stop gates to reduce the impact of runoff across a gradient.

WETLAND CLASSIFICATION (USFWS)

The United States Fish and Wildlife Service identifies and classifies eight types of wetlands, based on hydrology and vegetation. The interdependency of these two factors is illustrated by the association between the predominant type of vegetation and the amount and regularity of standing water. Within the metropolitan area, Type 2 - Wetland-Inland Fresh Meadows occupies the greatest acreage.

TYPE I WETLAND – SEASONALLY FLOODED BASIN OR FLATS

Type I wetlands can occur in grazed pastures, prairie grasslands, woodlands or on agricultural lands. For this reason, vegetation varies considerably from bare ground to lush grass cover. The soil is covered with water or is waterlogged during seasonal periods, but usually is well drained during much of the growing season. Where water has receded early in the growing season, smartweed, reed, canary grass, foxtail, quack-grass, broom grass, cyperus and weeds (such as marsh elder, ragweed, and pigweed) are likely to occur. Shallow basins that are submerged only temporarily usually have little or no vegetation. Type I wetlands are most visible on agricultural lands where cultivation removes the grass and weed cover.

The presence of this temporary water stimulates high waterfowl production by providing greater area for the establishment of territories by breeding pairs.

TYPE 2 WETLAND – INLAND FRESH MEADOWS

Type 2 wetlands generally are represented by wet, grassy meadows. The soil is usually without standing water during most of the growing season, but is waterlogged within at least a few inches of its surface. Vegetation includes grasses, sedges, rushes, and various broad-leafed plants. The predominant grasses are usually reed canary grass, bluegrasses and prairie cordgrass. Wild hay is often cut from such areas.

Fresh meadows are used by nesting waterfowl (especially blue-winged teal), but their value to waterfowl is mainly as supplemental feeding areas. Other wildlife nesting use includes red-winged blackbirds, pheasants, sparrows and a variety of small animals.

TYPE 3 WETLAND – INLAND SHALLOW FRESH MEADOWS

Type 3 wetlands usually contain the greatest variety of plant species. The soil is usually waterlogged during the growing season. It is often covered with as much as six inches or more water. Vegetation includes grasses, spikerushes, and various other marsh plants such as cattail, arrowhead, pickeralweed and smartweed.

These wetlands are constantly fluctuating between wet and dry. This attracts a variety of plants and micro-organisms highly attractive to nesting wildlife, particularly waterfowl. In combination with deep freshwater marshes (Type 4), they constitute the most productive areas of nest sites for waterfowl, primarily dabbling ducks such as mallard and blue-winged teal. Blackbirds, sparrows, pheasant, muskrat, mink and raccoon are all common inhabitants.

TYPE 4 WETLAND – INLAND DEEP FRESH MARSHES

The soil is often covered with six inches to three feet or more of water during the growing season. Vegetation includes cattail, bulrush, water parsnip, cyperus, sedges, spikerush, duckweed, and pondweed. From a distance, these wetlands appear as scattered cattail clumps in open water. Closer inspection will reveal a great variety of plants and micro-organisms just beneath the water's surface.

Because of the rich abundance of food supplied and the cover afforded by taller emergents such as cattail, these areas constitute the best waterfowl brood-rearing habitat in the metropolitan area. Mallard, blue-winged teal and wood ducks are commonly seen in these areas. In the Minneapolis-St. Paul area at least 33 species of nesting birds are directly associated with these wetlands. Including the surrounding habitat and the water area, nearly 150 species of birds are attracted throughout the year. Thirty species of mammals including mink, muskrat and weasel are known to occur within or adjacent to this habitat type. Thus, Type 4 wetlands are the most diverse and productive plant and animal water-related environment in the metropolitan area.

TYPE 5 WETLAND – INLAND OPEN FRESH WATER

Except for the basin margins, emergent vegetation is nearly lacking in Type 5 wetlands. The water is usually less than ten feet deep and is fringed by a border of cattail, bulrush and burreed. Subemergents, however, can be profuse in the metropolitan area and are usually dominated by pondweed, wild celery, coontail, water milfoil, and muskgrass. Floating vegetation is usually duckweed or waterlilies.

Type 5 wetlands are used extensively as brood areas when, in mid-summer and late summer, the less permanent marshes begin to dry out. The borders of such areas are used for nesting. Where vegetation is plentiful, they are used as feeding and resting areas by ducks, geese and coots, especially during migration periods. In the spring and fall, thousands of diving ducks, including ring-necks and scaup frequent these areas.

TYPE 6 WETLAND – SHRUB SWAMPS

Shrub swamps in the metropolitan area contain a variety of shrubs including alder, willow and dogwood. The soil is usually water-logged during the growing season, and is often covered with as much as six inches of water. Shrub swamps occur mostly along sluggish streams, floodplains and in areas where woodlands are encroaching upon prairie wetlands habitat. In general, the shrub swamp condition is a relatively rapid stage of plant succession from wet to dry. If occasional fires occur during the process, the shrub swamp could become a low, moist meadow, characteristic of Type 2 wetlands. Otherwise, the shrub condition would ultimately revert to a hardwood swamp, characteristic of Type 7 wetlands. In the metropolitan area, the latter is generally the case, as fires are quite restricted. Shrub swamps attract pheasant, deer and a variety of smaller birds. Waterfowl use is limited.

TYPE 7 WETLAND – WOODED SWAMPS

Wooded swamps are dominated primarily by black ash, although in some areas red maple and willow may be abundant. The soil is waterlogged to within a few inches of the surface during the growing season, and is often covered with as much as one foot of water. In the metropolitan area these wetlands occur primarily in the floodplains of the Minnesota and Mississippi Rivers. This habitat is highly attractive to nesting wood ducks.

TYPE 8 WETLAND – BOGS

The metropolitan area lies on the southern edge of a physiographic area containing true acid bogs. As a result, the bogs in the area occur in a variety of forms. Most are being overtaken by a variety of shrubs including bog birch and willow. The water pH is not as acidic as the true "bogs" to the north. Only a few tamarack bogs have been located in the metropolitan area, primarily in northern Anoka County. The remaining bogs generally approach the characteristics of Type 6 (Shrub Swamp) wetlands. The most characteristic plants occurring on a bog are leather-leaf and sphagnum moss.

Bogs have a low wildlife use rating, but are unique due to their history of succession and plant species which are found nowhere else.

HENNEPIN COUNTY SCS WETLAND CLASSIFICATION

Hennepin County Soil Conservation Service adds the location of wetlands to further identify water areas within the seven county area. See Table 6-1 for wetland classifications by location.

TABLE 6–1

WETLAND CLASSIFICATION AND ACREAGE BY COUNTY

	Wetland Type—United States Fish & Wildlife Classification							Total Acreage	Percent of Total County
COUNTY	2	3	4	5	6	7	8		
Anoka	30,000	10,000	10,000	2,500	20,000	4,000	2,500	79,000	27.5
Carver	6,000	4,000	6,000	2,000	4,000	1,000	---	23,000	9.6
Dakota	8,000	5,000	4,000	1,500	4,000	3,500	---	26,000	6.9
Hennepin	10,000	12,000	18,000	10,000	7,000	1,000	---	58,000	14.3
Ramsey	3,000	3,000	4,000	1,200	800	---	---	12,000	11.1
Scott	10,000	8,000	5,000	2,000	8,000	1,000	---	34,000	14.5
Washington	7,000	5,000	5,000	2,000	12,000	1,000	1,000	33,000	12.2
Total Acreage	74,000	47,000	52,000	21,200	55,800	11,500	3,500	265,000	

LAKESIDE

This category includes wetlands that occur on the margin of a lake that are larger than the lake itself. The wetland is clearly subordinate to the lake. Such associations are found for many lakes in the metropolitan area.

STREAMSIDE

This category includes wetlands that occur in association with a stream and occupy part or all of its floodplain or would be connected to its floodplain. Such marshes are found in the floodplain of the Minnesota River and to a lesser extent along the Mississippi. Along the lower St. Croix very few such marshes occur.

HEADWATERS

This category includes wetlands that occur at the origin of major streams. Such wetlands are common in Hennepin County.

UPLANDS

This category includes wetlands that lie above alluvial or outwash plains, or above stream valleys and floodplains. They occur on till with a perched water table. These wetlands are found throughout the metropolitan area.

A further distinguishing characteristic of wetlands is the size of the wetland as it compares to the area of drainage. Within the metropolitan area, the typical ratio in acres of drainage area to wetland basin is 5 to 20. Larger ratios may occur for floodplain wetlands and large area open water wetlands.

PROPOSED CLASSIFICATION SYSTEM

U.S. Fish and Wildlife Service is preparing a new wetlands classification system. This system characterizes vegetation soil types, hydrologic parameters and water chemistry for wetlands. Figures 6-1 through 6-3 show the proposed classification for three ecological systems.

To aid in the transition to the new system, Table 6-3 correlates the old system (5) which relied on Circular 39, to the proposed system.

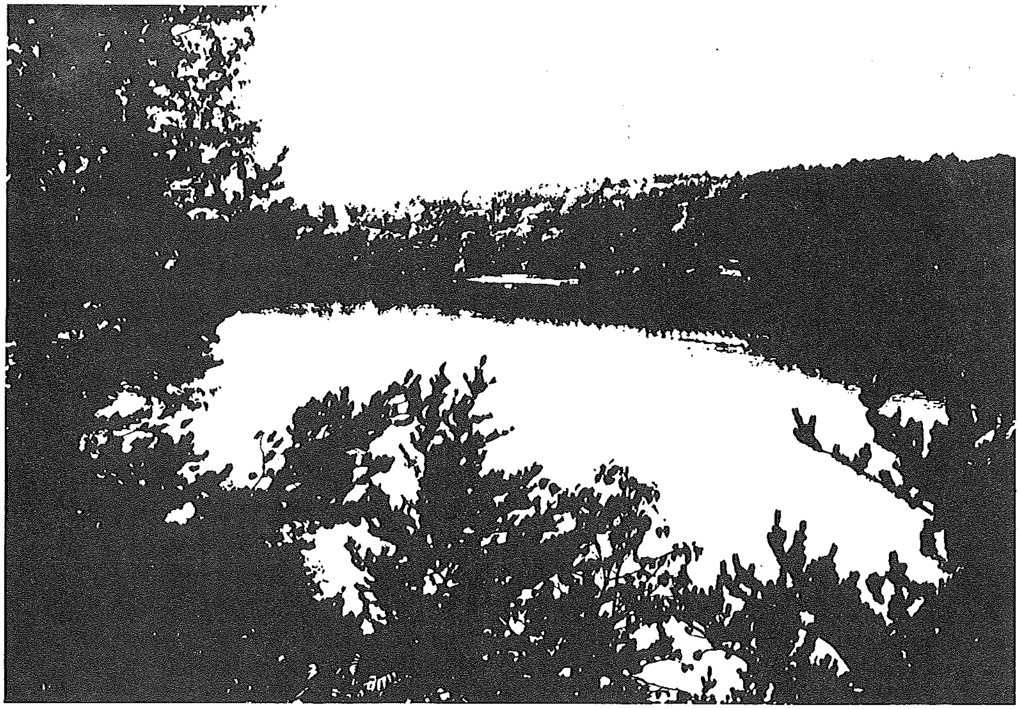
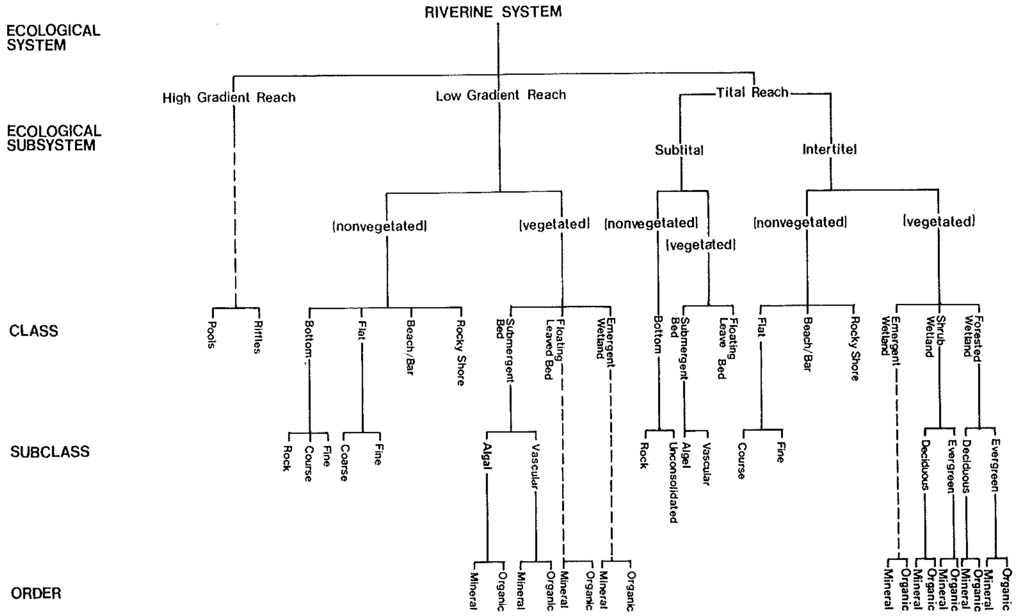


FIGURE 6–1

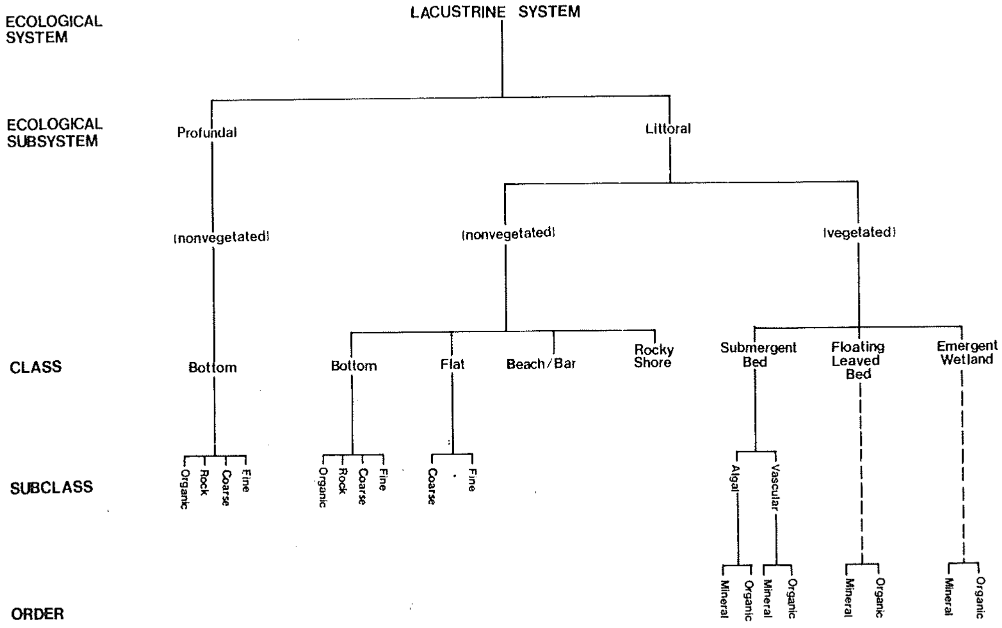
PROPOSED WETLANDS CLASSIFICATION SYSTEM FISH AND WILDLIFE SERVICE



SOURCE: Interim Classification of Wetlands, 1976.

FIGURE 6–2

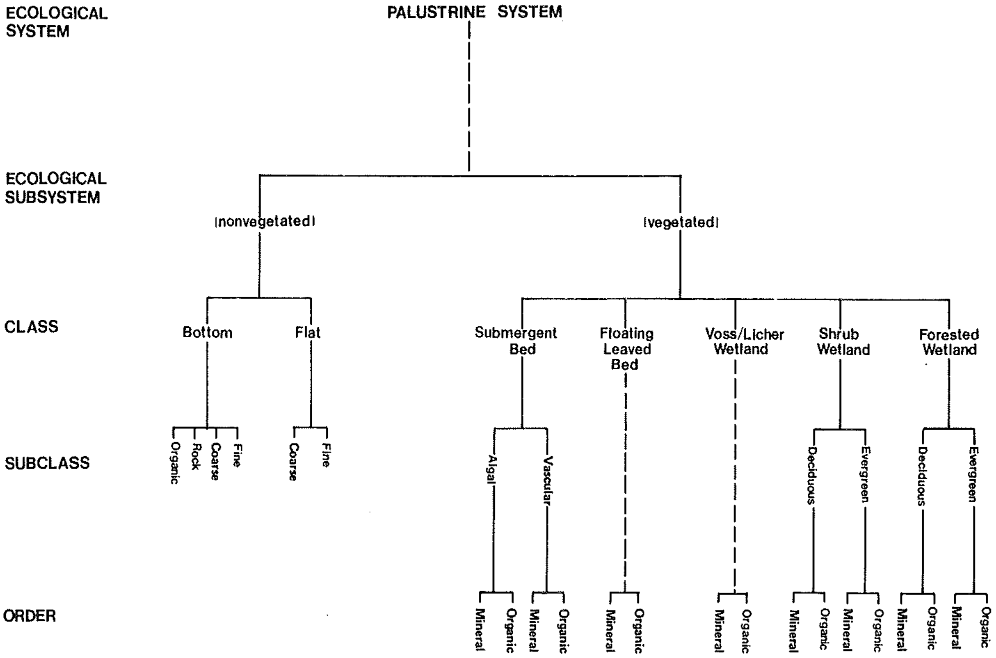
PROPOSED WETLANDS CLASSIFICATION SYSTEM, FISH & WILDLIFE SERVICE



SOURCE: Interim Classification of Wetlands, 1976

FIGURE 6–3

PROPOSED WETLAND CLASSIFICATION SYSTEM, FISH & WILDLIFE SYSTEM

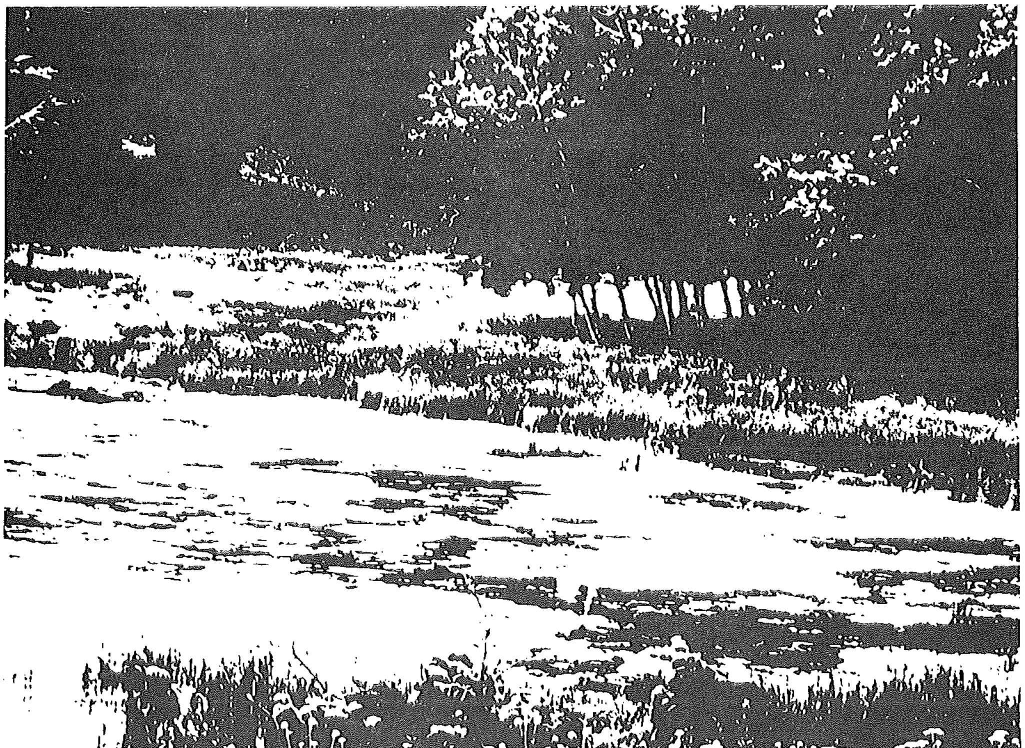


SOURCE: Interim Classification of Wetlands, 1976.

In the new wetlands classification, system refers to the dominant influence factor: hydrologic, geomorphic or chemical. Class and Subclass defines dominant vegetation. Order is the soil type. Water Regime pertains to the regularity of wetness. The Water Chemistry label of freshwater applies to the metropolitan area wetlands; it defines the degree of the water's salinity.

TABLE 6–2 CORRELATION BETWEEN THE EXISTING SYSTEM AND THE PROPOSED SYSTEM (2)

Circular 39	Cowardin et al. (1976)				
	SYSTEM	CLASS/SUBCLASS	ORDER	WATER REGIME	WATER CHEMISTRY
1. Seasonally Flooded Basins or Flats	Palustrine	Emergent Wetland	Mineral	Temporarily flooded Seasonally flooded	Fresh Subsaline
		Deciduous Forested Wetland		Seasonally flooded	Fresh
	Lacustrine	Emergent Wetland		Temporarily flooded Seasonally flooded Intermittently flooded	Fresh Subsaline
	Riverine	Emergent Wetland		Seasonally flooded	
2. Inland Fresh Meadows	Palustrine	Emergent Wetland	Mineral Organic	Saturated Temporarily flooded Seasonally flooded	Fresh Subsaline
3. Inland Shallow Fresh Marshes	Palustrine Lacustrine Riverine	Emergent Wetland	Mineral Organic	Seasonally flooded Semipermanently flooded Permanently flooded ?	Fresh Subsaline
4. Inland Deep Fresh Marshes	Palustrine Lacustrine Riverine	Emergent Wetland	Mineral Organic	Permanently flooded Semipermanently flooded Seasonally flooded	Fresh Subsaline
5. Inland Open Fresh Water	Palustrine Lacustrine Riverine	Submergent Bed Floating-leaved Bed Bottom	Mineral Organic	Permanently flooded Semipermanently flooded	Fresh Subsaline (except for floating-leaved bed) ?
6. Shrub Swamps	Palustrine	Shrub Wetland	Mineral Organic	Seasonally flooded Semipermanently flooded	Fresh
	Riverine-Tidal			Irregularly flooded Regularly flooded	
7. Wooded Swamps	Palustrine	Forested Wetland	Mineral Organic	Seasonally flooded Semipermanently flooded	Fresh
	Riverine-Tidal			Irregularly flooded Regularly flooded	Fresh
8. Bogs	Palustrine	Shrub Wetland Evergreen Forested Wetland Emergent Wetland	Organic Mineral	Saturated Seasonally flooded	Fresh/Acid



WETLAND LOSS

The USFWS attributes the loss of wetland habitat primarily to two actions – draining to increase farm acreage and filling for residential, industrial and commercial use. Safeguards for fish and wildlife resources regarding land use development are limited. Thus, valuable fish and wildlife habitat is being destroyed.

It is estimated that 40 - 50 percent of the original wetlands in the metropolitan area have been destroyed as a result of draining and filling activities, yet a large quantity and high quality of wetland habitat remain. An estimated 265,000 acres of all types of wetlands are located in the area. Many wetlands have been partially drained, thus, are smaller in size and are shallower. These wetlands still have considerable value to fish and wildlife

Seven general areas have been identified where wetlands are faced with current or near future draining and filling actions. These areas are considered of high value to fish and wildlife and have severe degrading conflicts. These areas are: Rice Creek Watershed, Pig's Eye Lake, Lower Minnesota River Floodplain, Western Hennepin County, South-central Carver County, Central Scott County, and Upper Vermillion River Watershed. Figure 6-4 shows the location of these areas which include about one-third of the study area (1).

AGRICULTURAL DRAINAGE

Agricultural drainage of wetlands has been a continuing problem since the 1930's when dry conditions permitted the draining of 30 - 40 percent of the original wetlands. In recent years, a noticeable upsurge in this activity has reoccurred due to improved drainage equipment and techniques and changing economic conditions. Valuable wildlife areas currently facing severe drainage activities include southcentral Carver County, central Scott County, western Hennepin County, Rice Creek Watershed and the Upper Vermillion River Watershed.

Table 6-4 indicates the extent of wetland drainage, primarily as a result of agricultural actions. Although wetlands less than 10 acres in size are experiencing a high loss rate, they are not included in the Table.

TABLE 6–3

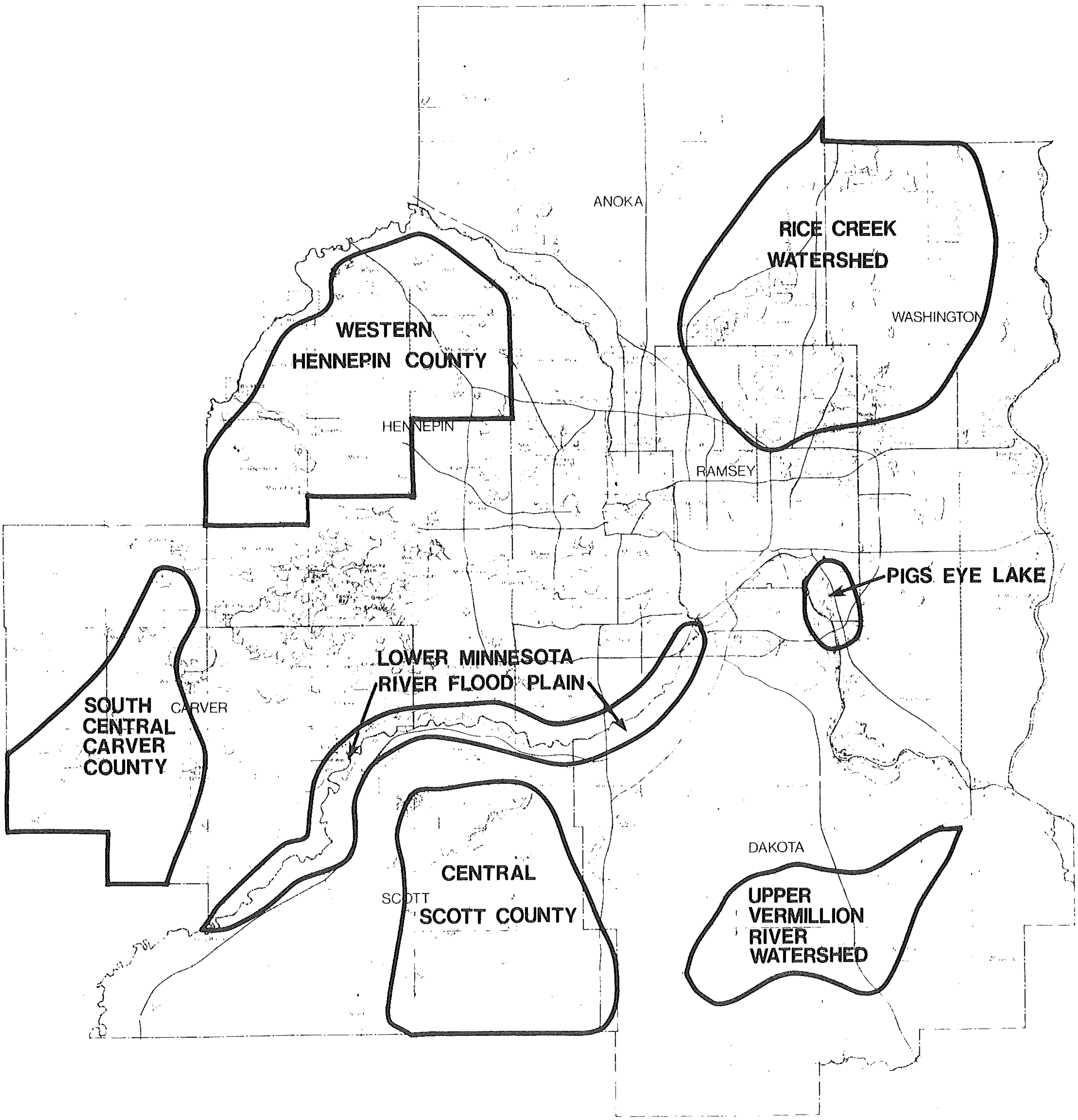
WETLAND DRAINAGE (1)

COUNTY	SOURCE	PERIOD	LOSS
Carver	(2)	1969-1973	27%
Carver	USGS (1975, unpublished)	1967-1975	16.1%
Dakota	SCS (CNI, Revised 1974)	1967-1974	16%
Scott	(2)	1967-1974	16%
Scott	USGS (1975, unpublished)	1967-1975	21.7%

According to the Department of Natural Resources (1973), Dakota and Scott Counties have been the two highest pheasant producing areas in the state, respectively, for the last 4-5 years. It is estimated that 70 percent of the pheasant hunting in the study area is conducted in these areas which contain 45 percent of the available hunting habitat. The high production of pheasants and their corresponding attractiveness to hunters is due to the presence of numerous lowland areas, primarily Type 2 and 3 wetlands. Federal drainage programs through the Soil Conservation Service are proposed for the Upper Vermillion River Watershed which could drain the valuable shallow wetlands present there. Other drainage actions could be and are being accomplished on a smaller scale throughout the peripheral counties, according to the Soil Conservation Service.

FIGURE 6–4

PRIME WETLAND AREAS WITH MODERATE TO SEVERE FUTURE DEGRADATION ANTICIPATED



SOURCE: Fish and Wildlife Level B. Study, 1976

Wetlands in Rice Creek Watershed contain exceptional game habitat as indicated by the Department of Natural Resources. Excellent fishing is found in this area, especially at Lino Lakes. In addition, the water areas are used as a stop over by migratory waterfowl. This key wetland area is only ten miles from downtown Minneapolis, providing convenient access for urban residents. Residential development is spreading into this area with few existing control measures. Other wetlands are being drained by increased agricultural development of "marginal" lands. (1)

FILLING OF WETLANDS

Valuable wildlife areas affected by large scale current or future filling actions include Pig's Eye Lake, Lower Minnesota River Floodplain, Rice Creek Watershed and central Scott County. These actions primarily result from industrial, commercial and residential development.

The Lower Minnesota River Floodplain is becoming increasingly attractive to industrial development which requires the filling of wetlands. This particular area is the last unspoiled floodplain area within the metropolitan area. Its fish and wildlife value lie in the following points:

-- The best waterfowl habitat in the study area exists here.
-- Twenty-four different waterfowl species may be found in this area.
-- A very high productive rate exists for waterfowl: 1.5 - 2.5 ducklings/wetland acre/year.
-- This area lies within 15-20 miles of the metropolitan area. The nearest comparable area is 100 miles away.
-- The area is heavily used by migratory waterfowl in the spring.
-- A heron colony exists here – the only one in the downstream two-thirds area of the Minnesota floodplain.

The development of river navigation industries in the floodplain poses other long-range problems. The DNR-approved Lower Minnesota River Floodplain Management Plan prohibits the deposition of dredged materials into the floodway zone. This protects most wetlands within the floodway zone from being filled with dredged materials. Wetlands outside the floodway zone could be filled, subject to a variety of Federal, State and local permits. The plan does not prohibit the filling of these wetlands for industrial development, if floodwaters are not seriously impeded and adequate protection of the facilities is afforded.

At Pig's Eye Lake, a proposed coal handling/storage facility would conflict with unique wildlife resources. Two heron colonies located near the site could be abandoned as a result of this development. One colony is the largest in the state. The total estimated adult heron population utilizing the two colonies was 1,358 in 1973. The colonies are considered rare in the state, and particularly to the area. Pig's Eye Lake is the closest and largest wetland in the heavily-populated mid-town area, harboring a large number of nesting and migrant waterfowl. Local environmental groups, the Citizens League, Minnesota Pollution Control Agency and U.S. Fish and Wildlife Service have expressed concern about this proposed development. Also, the Metropolitan Council has approved a plan to acquire the site as an open space regional park reserve and zone it as urban open space under the proposed Mississippi River Critical Area Plan. All of these actions may not be adequate, however, as new construction permits for industrial developments are anticipated.

SUMMARY OF WETLAND LOSSES

Table 6-5 summarizes the projected loss of wetland acres through the planning year 2000.

TABLE 6–4 LOSS OF WETLAND HABITAT (1)

	ACRES REMAINING			
	1975	1980	1990	2000
Wetlands*	265,000	238,500	190,800	152,600

*Loss rate=20 percent of remaining wetlands every 10 years.

POTENTIAL DANGER

The wetlands most susceptible to destruction are the shallow Types 2 and 3. These wetlands produce 60-75 percent of the waterfowl in the study area. Up to 30-40 percent of the pheasant habitat could be lost which would include 50-70 percent of the pheasant hunting opportunity.

The primary concern for these wetlands is that no overall planning approach is being taken. Each interest has been pursuing its own development (1).

If the draining and filling of wetlands is allowed to continue, the following additional adverse effects would occur:

- probable loss of hunting use opportunities
- loss of non-consumptive wildlife-oriented recreational and environmental education opportunities
- loss of groundwater recharge areas
- increase in silt in rivers and streams due to increased erosion
- increase in regional flood levels of streams and rivers due to loss of floodwater storage benefits
- loss of heron colonies such as the Pig's Eye Lake colony
- loss of Northern Pike spawning habitat
- loss of valuable open space lands suitable for intended or future public use
- loss of migrant and nesting waterfowl in the study area
- increase in nutrient levels of streams and rivers due to loss of nutrient removal (trap) areas
- loss of valuable game and furbearer habitat and associated consumptive recreational opportunities
- loss of ecological diversity and other valuable aesthetic amenities

RESOURCES

Wetlands of the seven county area are illustrated on Plate 9. This plate updates Metropolitan Council's wetland map and provides the most current information on wetland locations, within designated communities in each county. This information was obtained from county soil conservation offices.

In Anoka County, the communities of East Bethel (excluding the Game Refuge), Coon Rapids, Ramsey and Blaine have updated their inventories. In Hennepin County, the communities of Medina, Hassan (excluding Crow-Hassan Park Reserve), Corcoran and Maple Grove (excluding Elm Creek) have updated their wetland inventories. In Ramsey County, White Bear Township has updated its inventory and included wetland watershed maps.

A detailed inventory of biological, physical, and chemical characteristics for 76 wetlands in the City of Bloomington provides extremely valuable information on these wetlands. Discussion includes water levels both present and historic, peat depths, vegetation types and wildlife. Unique wildlife, vegetation and plankton are identified. This information is valuable for assessing hydrologic impact of changes in wetlands. It also provides baseline data on flora and fauna. This report can be obtained at City of Bloomington Planning Department.

An inventory of wetlands in the western half of the metropolitan area has recently been completed through joint efforts of the Metropolitan Council, Corps of Engineers, Fish and Wildlife Service and Soil Conservation Service. An inventory of the eastern half is in progress and will be completed by June 1978 (1).

REFERENCES

1. Fish and Wildlife Technical Report Minneapolis-St. Paul Area Level B Study. Upper Mississippi River Basin Commission. U.S. Fish and Wildlife Service, December 1971. Past, present and projected wetland type and acreage of the metropolitan area are included in a discussion of conservation of wetland areas as wildlife habitats. Valuable in planning wetland conservation areas. (Available: Upper Mississippi River Basin Commission, Fort Snelling.)

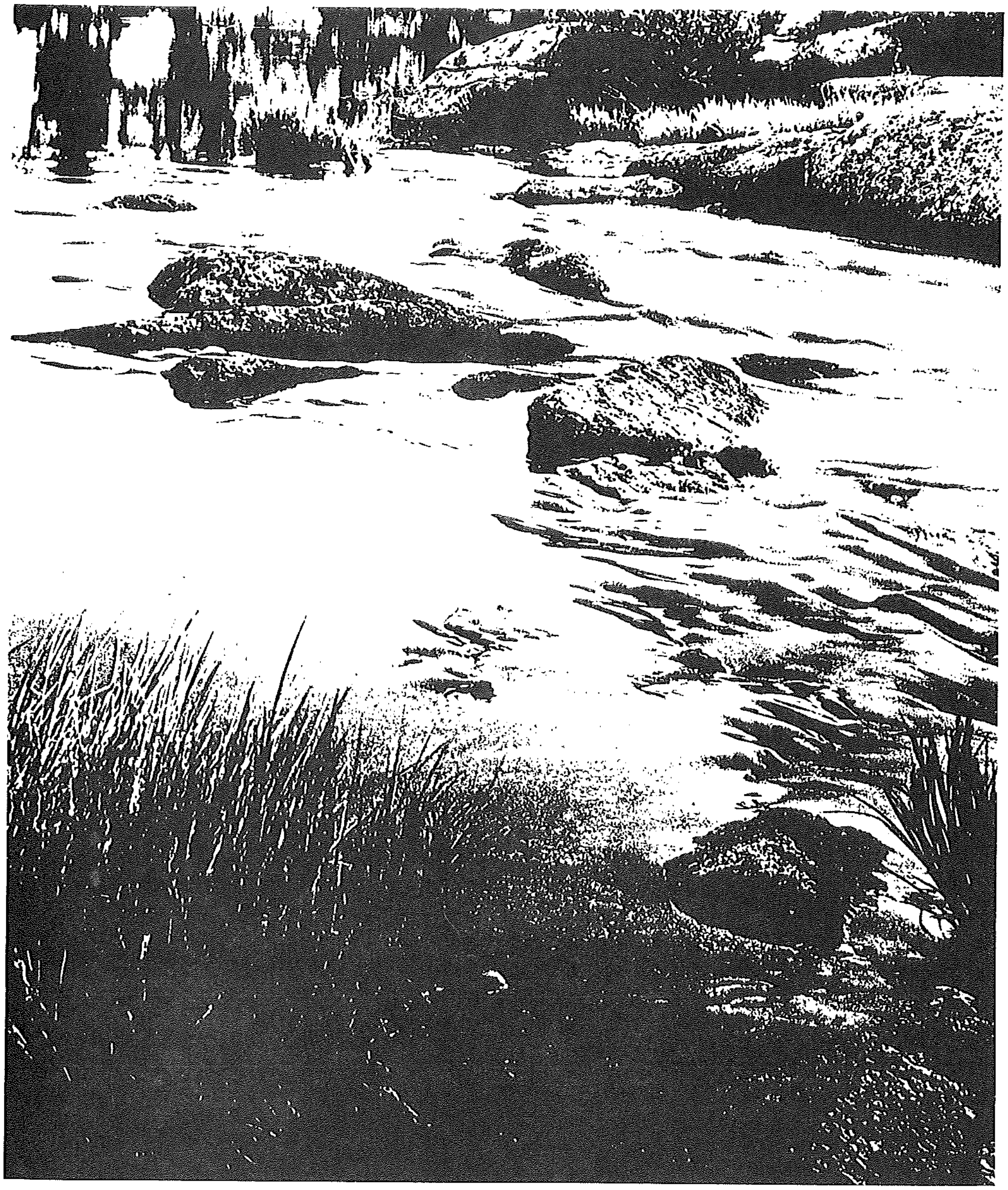
2. Interim Classification on Wetlands and Aquatic Habitats of the United States. U.S. Department of Interior, 1976. Detailed description of characteristics which describe a wetland area. Valuable information for defining wetlands types as prerequisite to assessing suitability of wetland area for proposed projects. Final publication from the United States Fish and Wildlife Service is expected in 1978.

3. Water Resources Outlook for the Minneapolis-St. Paul Metropolitan Area, United States Geological Survey with Metropolitan Council, 1973. Background information. (Available: MC)

4. Urban Runoff Treatment Methods, Volume I Non-Structural Wetlands. E.A. Hickok, M. C. Hannaman, and N. C. Wenck. EPA Grant No. 802535, 1977. Discusses the hydrology of a typical wetland in Hennepin County and the function of wetlands in renovating stormwater runoff. Useful model in assessing impact of changes in wetland watersheds or drainage. (Available: early 1978, EPA).

5. Wetlands of the United States, U.S. Department of the Interior, Fish and Wildlife Service, Circular 39, 1971. Information on the classification of wetlands. (Available: DNR)

DNR - Department of Natural Resources
MC - Metropolitan Council Library
EPA - Environmental Protection Agency



FORMER AND POTENTIAL NATURAL VEGETATION

Three major plant communities once dominated what is now the metropolitan area. The Big Woods (Maple-Basswood forest) covered the western portion of the region (See Plate 10 and Exhibit E). Oak openings and barrens were the dominant vegetation north of the St. Croix. This cover type also extended south of the rivers in a corridor roughly centered on the Scott and Dakota county boundary. Short grass prairies covered most of Dakota County and large prairie areas occurred in eastern Hennepin and southern Washington Counties. Wet prairies, marshes, and sloughs covered a large area of Anoka County beginning in the south-central area and extending in a general north-easterly direction.

Additional communities such as River Bottom Forest (Lowland Hardwoods) occurred along the Minnesota and downstream of its confluence with the Mississippi. Aspen-Oak pockets were concentrated in two general areas: along a general northwestern-southeastern line in Scott and Carver Counties, and in a northwestern-southeastern line in northern Anoka and Washington Counties. Figure 7-1 illustrates the metropolitan portion of Kuchler's "Potential Natural Vegetation of Minnesota and Portions of Adjacent States", Kuchler's map was based largely on Marschner's "Original Vegetation" map. Thus, in the metropolitan area the same dominant associations occur over similar areas (Exhibit F).

Kuchler's objective, however, was to depict climax plant associations that would have occurred through succession of the temporary (seral) types of forest cover. Marschner, on the other hand, was concerned only with recording the type of vegetation as it occurred prior to settlement and was not concerned with succession, disturbances by fire, or other natural processes.

Although these maps do not show the current vegetation patterns, they do reveal the diverstiy of native plant communities. The metropolitan area lies on two vegetation interfaces which not only divide Minnesota into vegetation regions but also form part of the boundary between the prairies of the western states and the forests of the northern United States and Canada.

These boundaries are not to be interpreted as static and even before settlement they were in a constant state of flux. Changes caused by climatic conditions, successional changes initiated by fires, windstorms, plant and insect diseases, and natural eutrophication of wetlands contributed to a dynamic environment. In addition, the very nature of being situated on the prairie-forest edge contributed to the constant change. Forests beginning to invade native prairie lands would be checked by periodic outbreaks of fire and prairies again would dominate.

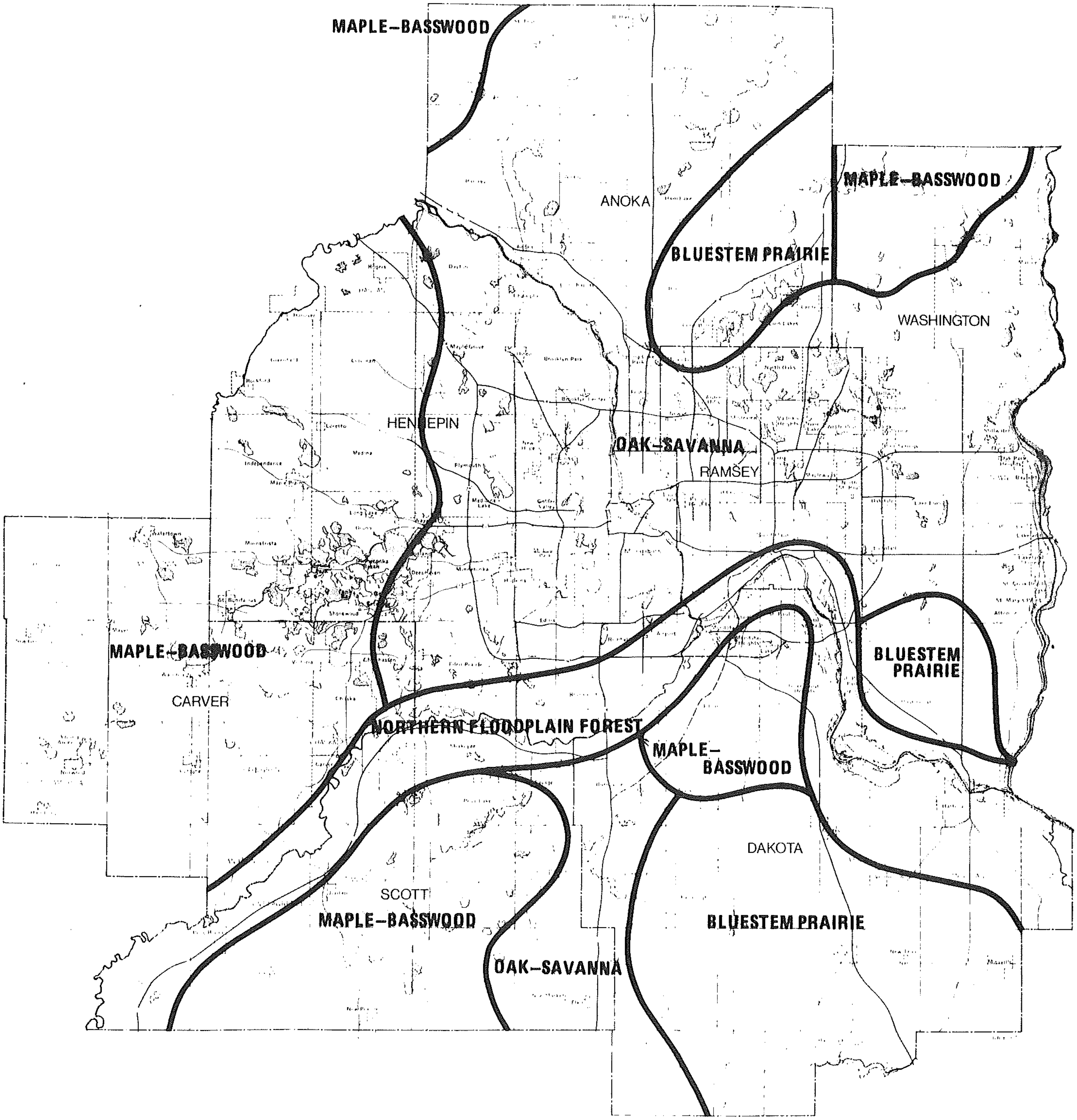
CURRENT CONDITIONS

Plate 11 illustrates current vegetation cover of the metropolitan area with six broad classifications. Two of these, Urban/Developed and Urban Forests, are largely restricted to the central core of the metropolitan area with some outlying areas of development occurring in all seven counties. Very little significant natural vegetation can be found in these areas. However, many indigenous species have been planted in residential areas.

Open and cultivated lands form a general horseshoe shaped zone around the center core with the open end lying in Anoka County. Most of this land is under cultivation. This classification includes pastures, meadows, and vacant lands where remnant prairie communities may still be found, particularly on stoney or sandy excessively drained soils not suited for agriculture.

Plant communities of the present metropolitan area are largely remnants of the vast acreages of the past. Today, natural forest and prairie lands are almost wholly restricted to lands which are not well suited for either agriculture or development, such as wetlands, steep slopes, poor soils and river corridors. Under the State and National Wild, Scenic, and Recreational River acts and the state Critical Areas act (7) forested bluffs and lowlands in the river corridors have been afforded some degree of protection.

FIGURE 7–1 POTENTIAL NATURAL VEGETATION OF THE METROPOLITAN AREA



SOURCE: Adapted from Kuchler's "Potential Natural Vegetation of Minnesota and Portions of Adjacent States", 1964.

Northern Anoka County has many low-lying areas which still support stands of Aspen-Birch, and in the sandy drier areas small stands of Jack Pine.

Wetland areas, swamps and marshes, can be found in all seven counties. However, the most extensive areas occur in northern and eastern Anoka County. These tend to be forested wetlands, swamps, and bogs rather than the herbaceous marshes common to the southern part of the metropolitan area.

Over the last two decades much of the wetland acreage has been lost to agriculture and development, permanently destroying these dynamic, sensitive ecosystems. (See Section 6 - Wetlands). Under metropolitan open space protection policies of recent years, the sensitivity of these areas has been recognized and future protection may be afforded.

Within the six broad vegetation classifications, more defined, readily identifiable plant communities exist. Wallace, McHarg, et. al. (1969) mapped detailed vegetation types at a scale of 1" = 1 mile and 1" = 2 miles. Original prints of these maps are in the Metropolitan Council's map library.

Figure 7-2 illustrates nine different plant communities native to the metropolitan area. The upland forests consist of three distinctly different communities, the oak community, mixed hardwood, and maple-basswood forest. Representative examples of these different communities are shown in Table 7-1.

FIGURE 7–2

ECOSYSTEMS

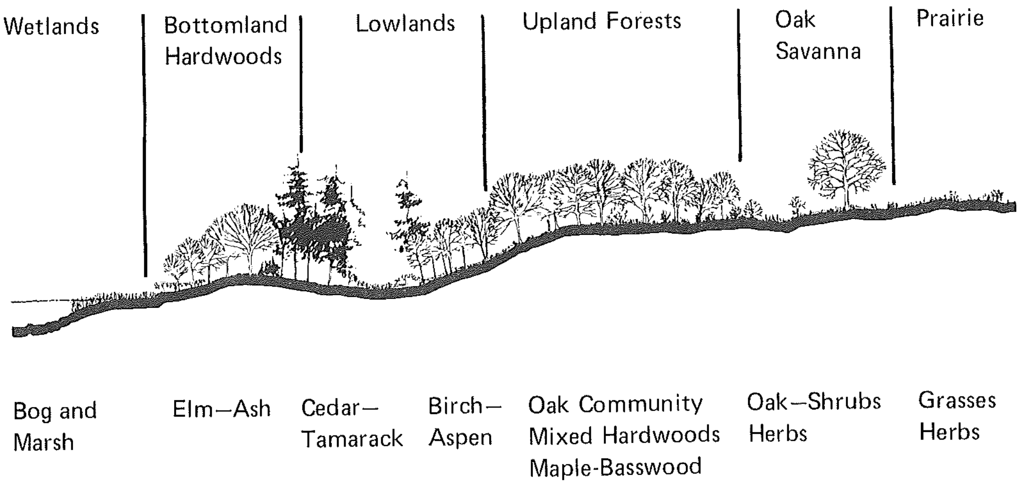


TABLE 7–1

REPRESENTATIVE EXAMPLES OF PLANT COMMUNITIES IN THE METROPOLITAN AREA

PLANT COMMUNITY	EXAMPLE
Bog-Wetlands Marsh-Wetlands	Carlos Avery Wildlife Management Area
Bottomland Hardwoods	Minnesota River Floodplains
Cedar-Tamarack Lowlands	Cedar Creek National History Area
Oak Community	Cedar Creek
Mixed Hardwood	Peck's Woods, Fridley
Maple-Basswood	Baker Park Reserve
Oak Savanna	Allison Savanna
Prairie	Allison Savanna, Bunker Prairie

Figures 7-3—7-10 illustrate major components of typical ecosystems in the metropolitan area. Dominant or common plant and animal species, soil types, and rare and endangered species which may occur are illustrated. Common and scientific names of species are presented in Exhibit G.

FIGURE 7–3

AQUATIC COMMUNITIES – WETLANDS

SUBMERGED PLANTS
- Sago Pondweed
- Clasping Pondweed
- Floating Leaf Pondweed
- Bushy Pondweed
- Wild Celery
- Canada Waterweed
- Coontail

FLOATING PLANTS
- Water Lily
- Duckweed

EMERGENT PLANTS
- Common Cattail
- Giant Burreed
- Hardstem Bulrush
- River Bulrush

TREES
- Black Spruce
- Paper Birch
- Trembling Aspen
- Willow
- Tamarack

SHRUBS
- Alder
- Dogwood
- Willow
- Bog Laurel
- Bog Birch

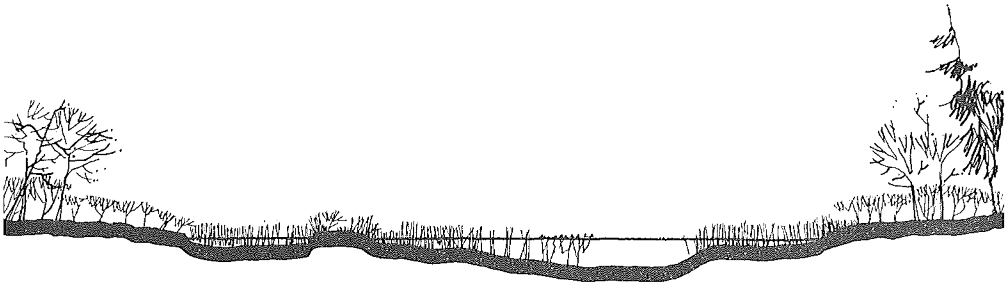
HERBS
- Sedges
- Horsetail
- Cattail
- Sphagnum Moss

MAMMALS
- Muskrat
- Mink

BIRDS
- Ducks
- Redwinged Blackbird
- Marsh Hawk
- Cranes
- Coot
- Common Snipe
- Swamp Sparrow

REPTILES AND AMPHIBIANS
- Turtle
- Newt
- Salamander
- Frog

FISH
- German Carp



RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Bog Adder's Mouth
- Adder's Tongue
- Grass-leaved Arrowhead
- Chickweed
- Sessile-flowered Cress
- Water Bog Rush
- Low Nut Rush
- Slender-leaved Sundew
- Yellow Bartonia
- Cockspur Grass
- Jointed Rush
- Grass-leaved Rush
- Swamp Loosestrife
- Bright Green Naiad
- Rafinesque's Pondweed
- Large Purple Gerardia
- Slender Yellow-eyed Grass

ANIMALS
- Shovelnose Sturgeon
- Blue Sucker
- River Redhorse
- American Brook Lamprey
- American Eel
- Jefferson's Salamander
- Common Newt
- Wood Turtle
- Blanding's Turtle
- False Map Turtle
- Common Loon
- White Pelican
- Double-crested Cormorant
- Great Blue Heron
- Common Egret
- Trumpeter Swan
- Canvasback
- Northern Bald Eagle
- Marsh Hawk
- Yellow Rail
- LeConte's Sparrow
- Henslow's Sparrow

FIGURE 7–4

BOTTOMLAND HARDWOODS COMMUNITY

TREES
- American Elm
- Green Ash
- Aspen
- Basswood
- Black Ash
- Box Elder
- Silver Maple
- Willow
- Cottonwood
- Hop Hornbeam
- Hackberry

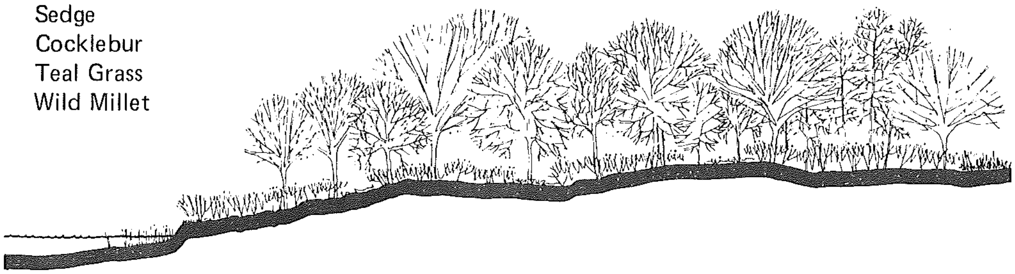
SHRUBS
- Chokecherry
- Alder
- Dogwood
- Hazel
- Gooseberry
- Elderberry
- Riverbank Grape

HERBS
- Cut Grass
- Canadian Nettle
- Sedge
- Cocklebur
- Teal Grass
- Wild Millet

MAMMALS
- Chipmunk
- Cottontail Rabbit
- Raccoon
- Red Fox
- White-tailed Deer

REPTILES & AMPHIBIANS
- Frog
- Garter Snake
- Skink

BIRDS
- Woodduck
- Woodcock
- Red-headed Woodpecker
- Blue Jay
- Yellow Warbler



SOILS

Poorly drained alluvial soils. Representative soil series: Becker and Comfrey.

Poorly drained organic and mineral soils. Representative soil series: Dundas, Isanti, and Peat.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Adder's Tongue
- Bog Adder's Tongue
- Green Dragon
- Golden Coreopsis
- Smartweed Dodder
- Sessile-flowered Cress
- Sedge (Carex Plantaginea)
- Water Bog Rush
- Low Nut Rush
- Slender-leaved Sundew
- Yellow Bartonia

ANIMALS
- Red-backed Salamander
- Jefferson's Salamander
- Common Newt
- Wood Turtle
- False Map Turtle
- Double-crested Cormorant
- Great Blue Heron
- Northern Bald Eagle
- Prothonotary Warbler
- Cooper's Hawk
- Red-shouldered Hawk

FIGURE 7–5

CEDAR-TAMARACK COMMUNITY

TREES

- Tamarack
- White Cedar
- Black Spruce
- White Spruce
- Paper Birch
- Trembling Aspen

SHRUBS

- Alder
- Redosier Dogwood
- Labrador Tea
- Bog Laurel
- Bush Honeysuckle

HERBS

- Goldthread
- Twinflower

MAMMALS

- White-tailed Deer
- Mink
- Raccoon
- Cottontail Rabbit

REPTILES

- Frog
- Salamander
- Newt

BIRDS

- Woodduck
- Woodcock
- Ruffed Grouse
- Crow
- Blue Jay

SOILS

Very poorly drained organic soils. Peats

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS

- Bog Adder's Mouth
- Adder's Tongue
- Low Nut Rush
- Yellow Bartonia

ANIMALS

- Jefferson's Salamander
- Common Newt
- Cooper's Hawk
- Red-shouldered Hawk

FIGURE 7–6

WHITE OAK FOREST COMMUNITY

TREES
- White Oak
- Red Oak
- Pin Oak
- Bur Oak
- Black Cherry

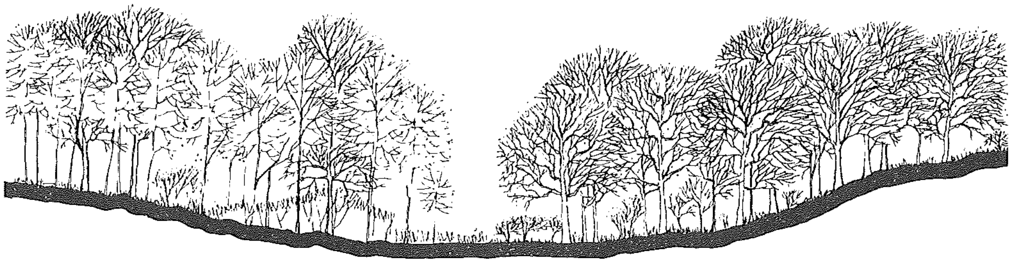
SHRUBS
- Honeysuckle
- Gray Dogwood
- Raspberry
- Prickly Ash
- Sumac

HERBS
- False Solomon's Seal
- Hog Peanut
- Polypody
- Maidenhair Fern

MAMMALS
- Chipmunk
- Gray Squirrel
- Red Fox
- White-tailed Deer

REPTILES & AMPHIBIANS
- Frog
- Garter Snake

BIRDS
- Cardinal
- American Redstart
- Crow
- Scarlet Tanager
- Wood Thrush



SOILS

Well drained loamy soils. Representative soil series: Hayden and Milaca.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Green Dragon
- Sedge (Carex formosa)
- Blackberry (Rubus latifoliolus)
- American Marsh Pennywort

ANIMALS
- Red-backed Salamander
- Jefferson's Salamander
- Common Newt
- Cooper's Hawk

FIGURE 7–7

NORTHERN PIN OAK FOREST COMMUNITY

TREES
- Northern Pin Oak
- White Oak
- Bur Oak
- Ironwood
- Paper Birch

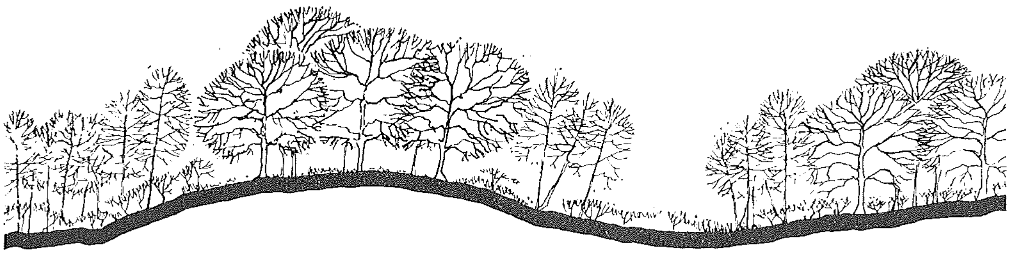
SHRUBS
- Hazelnut
- Honeysuckle
- Raspberry
- Chokecherry
- Prickly Ash
- Sumac

HERBS
- Bracken Fern
- Lily of the Valley
- Strawberry
- Hog Peanut
- New Jersey Tea

MAMMALS
- Gray Squirrel
- Chipmunk
- Cottontail Rabbit
- White-tailed Deer

REPTILES & AMPHIBIANS
- Frog
- Garter Snake

BIRDS
- Blue Jay
- White-breasted Nuthatch
- Black-capped Chickadee
- Crested Flycatcher
- Scarlet Tanager



SOILS

Well drained sandy soils. Representative soil series: Lino, Hubbard sandy loam, and Duelm.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Frostweed
- Sedge (Carex formosa)
- Blackberry (Rubus folioflorus and latifoliolus)
- False Foxglove
- Gerardia
- Narrow-leaved Vervain

ANIMALS
- Bull Snake
- Cooper's Hawk
- Red-shouldered Hawk

FIGURE 7–8

MAPLE-BASSWOOD FOREST COMMUNITY

TREES
- Sugar Maple
- Basswood
- Ironwood
- American Elm
- Slipperly Elm

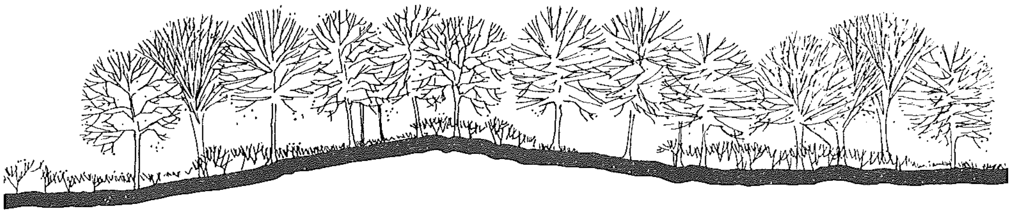
SHRUBS
- Hazelnut
- Chokecherry
- Juneberry
- American Elder

HERBS
- Hepatica
- Violet
- Virginia Creeper
- Climbing Bittersweet
- Sweet Cicely
- Large-flowered Bellwort

MAMMALS
- Vole
- Chipmunk
- Squirrel
- Cottontail Rabbit
- Red Fox

REPTILES & AMPHIBIANS
- Frog
- Garter Snake

BIRDS
- Woodpeckers
- Black-capped Chickadee
- House Wren
- American Redstart
- Least Flycatcher
- Ovenbird
- Rose-breasted Grosbeak



SOILS

Well drained loamy soils. Representative soil series: Nessel, Hayden, and Milaca.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Minnesota Trout Lily
- Green Dragon
- Sedge (Carex formosa and plantaginea)
- American Marsh Pennywort

ANIMALS
- Red-backed Salamander
- Jefferson's Salamander
- Common Newt
- Wood Turtle
- Cooper's Hawk
- Red-shouldered Hawk

FIGURE 7–9

OAK SAVANNA COMMUNITY

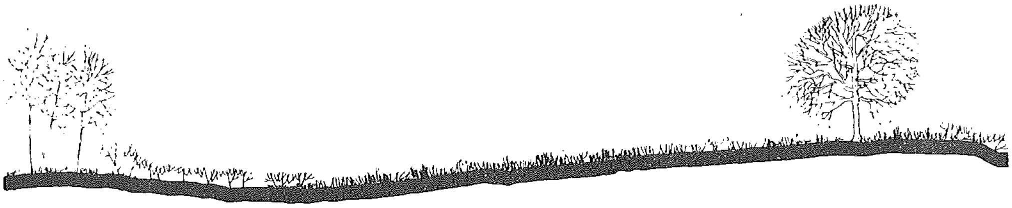
TREES
- Bur Oak
- White Oak
- Northern Pin Oak
- Aspen

SHRUBS
- Hazelnut
- Dogwood
- Wild Rose
- Prickly Ash

HERBS
- Meadow Rue
- Goldenrod
- Burdock
- Yarrow
- Meadowgrass
- Sweet Clover
- Big Bluestem
- Little Bluestem
- Porcupine Grass
- Hoary Puccoon
- New Jersey Tea

MAMMALS
- Cottontail Rabbit
- Gopher
- Red Fox
- Thirteen-lined Ground Squirrel

BIRDS
- Crow
- Western Meadowlark
- Brewer's Blackbird
- Gold Finch
- Indigo Bunting
- Lark Sparrow
- Ring-neck Pheasant



SOILS

Excessively drained sandy soils. Representative soil series: Zimmerman and Hubbard loamy sand.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Prairie Bush Clover
- Prairie Froelichia
- Frostweed
- Sedge (Carex debilis)
- Tall Nut Hatch
- Blackberry (Rubus folioflorus)
- False Foxglove
- Gerardia

ANIMALS
- Bull Snake
- Cooper's Hawk
- Lark Sparrow

FIGURE 7–10

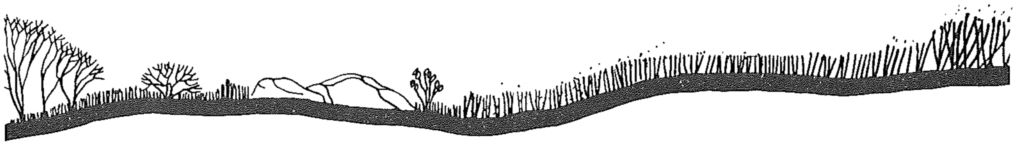
UPLAND PRAIRIE COMMUNITY

DOMINANT TREE SPECIES
None

DOMINANT SHRUBS & HERBS
- Little Bluestem
- June Grass
- Big Bluestem
- Switch Grass
- Grama Grass
- Sedge
- Porcupine Grass
- Sand Grass
- Dogwood
- Bluebell
- Paint Brush
- Thistle
- Draba
- Prairie Smoke
- Sunflower
- Prairie Phlox
- Rose
- Indian Grass
- Wolfberry
- Lead Plant

MAMMALS
- Thirteen-lined Ground Squirrel
- Pocket Gopher
- Badger
- Red Fox
- Spotted Skunk

BIRDS
- Western Meadowlark
- Horned Lark
- Pheasant
- Savanna Sparrow



SOILS

Excessively drained sandy soils. Representative soil series: Dakota, Hubbard, Zimmerman, and Copaston—shifted by wind.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Whitlow Grass
- Prairie Bush Clover
- Prairie Froelichia
- Western Venus Looking Glass
- Frostweed
- Rattle Pod
- Cut-leaved Evening Primrose
- Besseya
- Sullivant's Milkweed
- Yellow Bedstraw
- Gerardia
- Cut-leaved Nightshade
- Narrow-leaved Vervain

ANIMALS
- Bull Snake
- Marsh Hawk
- Grasshopper Sparrow
- Henslow's Sparrow
- LeConte's Sparrow

STEEP SLOPE ASSOCIATIONS

The metropolitan area, though not characterized by great topographic relief, does have bluff and cliff features along the three major river corridors. Diverse plant communities can be found within short distances due to the influence of several factors. Steepness of slope, soil, drainage, and bedrock all contribute to the composition of these plant communities. The most important factor, however, is the orientation of a slope. South and west exposures have warmer temperatures due to the longer hours of sunlight received. These slopes often have micro-climatic conditions which enable vegetation characteristic of the more arid parts of the U.S. to flourish. Prairie communities, drought-tolerant species of deciduous trees and shrubs, and red cedar often are found on the upper slopes. (See Figures 7-11 and 7-12).

North and east facing slopes tend to have cooler, moister climates due to the shaded conditions and retention of snow cover. Plant communities may contain conifer, and deciduous species characteristic of northern boreal forests as well as mixed hardwoods.

Herbaceous plants tend to be shade and moisture tolerant with ferns and mosses quite common.

Detailed reports of species distribution along the major river corridors have been compiled in previous reports. Species abundance was based on field observations along various transect lines on each of the corridors (4).

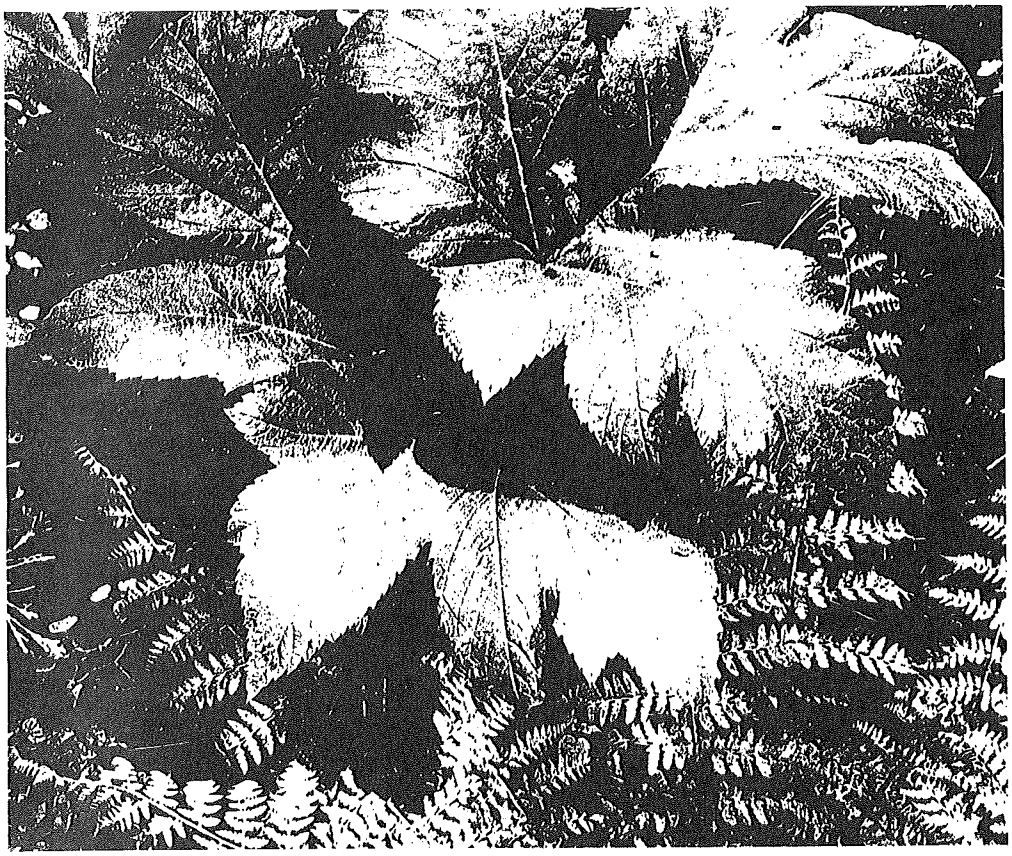


FIGURE 7–11

STEEP SLOPE COMMUNITY–SOUTH AND WEST ASPECT

DOMINANT VEGETATION
- Variable–depending on slope characteristics

LOWER SLOPE
- American Elm
- Basswood
- Bur Oak
- Black Ash
- Green Ash
- Cottonwood
- Willow
- Silver Maple
- Slippery Elm
- Hackberry
- Ironwood
- Shagbark Hickory
- Red Maple
- Box Elder

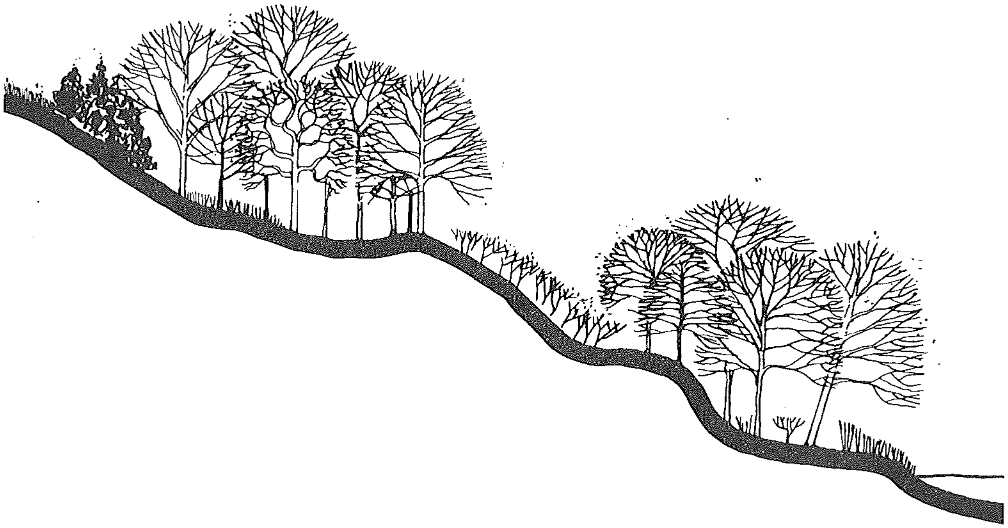
UPPER SLOPE
- Sugar Maple
- Red Oak
- White Oak
- Bur Oak
- Ironwood
- American Elm
- Red Cedar
- American Plum

COMMON WILDLIFE
- Cliff Swallow
- Western Meadowlark
- Savanna Sparrow
- White-breasted Nuthatch
- Red Squirrel

- Badger

SHRUBS
- Hazelnut
- Rose
- Smooth Sumac
- Wolfberry
- Prickly Ash

HERBS
- Big Bluestem
- Little Bluestem
- Grama Grasses
- Porcupine Grass
- Lead Plant
- Ground Plum
- Common Nettle
- Northern Dropseed



SOILS

Variable because of slope and drainage characteristics. Cliff forming rock formations along the St. Croix and Mississippi rivers include the Jordan sandstone, Shakopee and Oneota dolomites and Platteville limestone.

RARE AND ENDANGERED PLANTS AND ANIMALS

PLANTS
- Whitlow Grass
- Prairie Froelichia
- Western Venus Looking Glass
- Frostweed
- Smooth Rock Cress
- Rattle Pod
- Cut-leaved Evening Primrose
- Besseya
- Gerardia

ANIMALS
- Bull Snake
- Northern Bald Eagle
- Peregrine Falcon

FIGURE 7–12

STEEP SLOPE COMMUNITY-NORTH AND EAST ASPECT

DOMINANT VEGETATION

Variable—depending on slope characteristics

LOWER SLOPE

- American Elm
- Aspen
- Basswood
- Bur Oak
- Black Ash
- Green Ash
- Cottonwood
- Willow
- Silver Maple
- Slippery Elm
- Hackberry
- Ironwood
- Shagbark Hickory
- Red Maple
- Box Elder

UPPER SLOPE

- Aspen
- Birch
- Red Oak
- White Oak
- Bur Oak
- American Elm
- Ironwood
- White Pine
- Red Pine
- Balsam Fir

SHRUBS

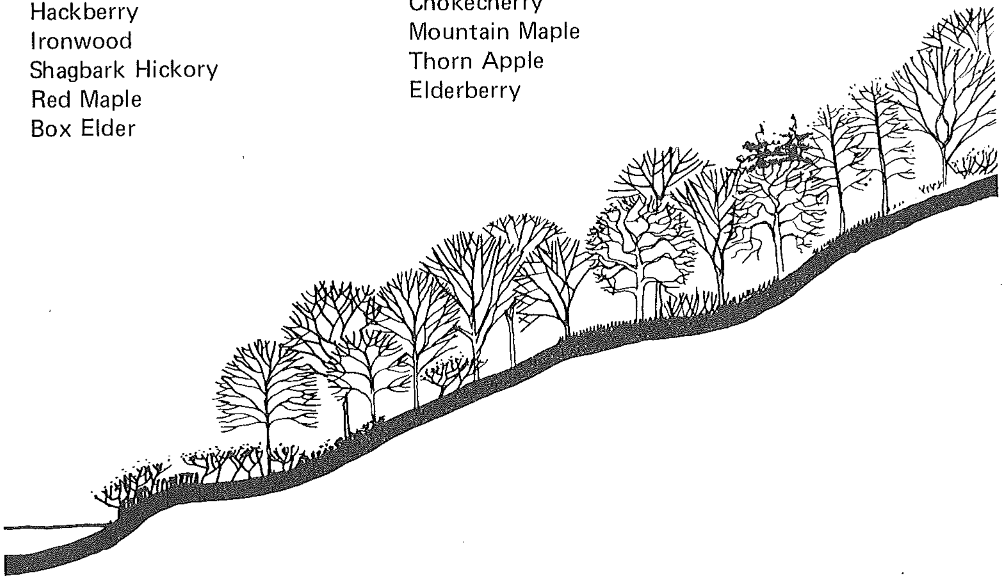
- Hazelnut
- Dogwood
- Chokecherry
- Mountain Maple
- Thorn Apple
- Elderberry

HERBS

- Maidenhair Fern
- Fragile Fern
- Shield Fern
- Polypody
- Common Nettle

COMMON WILDLIFE

- Cliff Swallow
- Western Meadowlark
- Savanna Sparrow
- White-breasted Nuthatch
- Red Squirrel
- Thirteen-lined Ground Squirrel
- Badger



SOILS

Variable because of slope and drainage characteristics. Cliff forming rock formations along the St. Croix and Mississippi rivers include the Jordan sandstone, Shakopee and Oneota dolomites and Platteville limestone.

RARE AND ENDANGERED PLANTS AND SPECIES

PLANTS

- Whitlow grass
- Prairie Froelichia
- Western Venus Looking Glass
- Frostweed
- Smooth Rock Cress
- Rattle Pod
- Cut-leaved Evening Primrose
- Besseya
- Gerardia

ANIMALS

- Bull Snake
- Northern Bald Eagle
- Peregrine Falcon

AREAS OF UNUSUAL VALUE FOR WILDLIFE HABITAT

Over 29,000 acres of wildlife habitat are managed by the DNR in 19 wildlife management areas. This includes 22,000 acres in Carlos Avery Wildlife Management Area, part of which lies in Chisago County, and the 5,300 acre Gores Wildlife Management Area in Dakota County, part of which lies in Goodhue County.

Additional acreage is provided by six state game refuges, one proposed federal wildlife recreation area (Minnesota River valley), and one federal wildlife refuge illustrated on Plate 12 and indexed to Exhibit G.

The state game refuges in the metropolitan area are statutory, not state-owned refuges. Statutory refuges are primarily concerned with prohibiting firearms discharge and are not managed as wildlife habitats. Nevertheless, the natural vegetation within these refuges functions as habitat for many species.

Significant wildlife habitats displayed on Plate 12 include areas that are not under protection or management by public agencies. Major areas not under protection are portions of the Lino Lakes area, rice beds in northern Washington County, and the Cedar Lake area in Scott County; all important waterfowl production areas.

Exhibit G should not be construed as a complete listing of significant habitats, since many parcels of prime importance exist on private lands. (See Section 16 - Endangered and Threatened Plant and Animal Species, Figure 16-1—16-9 for distribution of selected species in the metropolitan area. Additional habitat areas are provided in remaining wetland areas, steep slope communities, and virtually any small parcel in which no development or agriculture exists.

SCENIC TIMBER

Additional acreage of scenic timber is protected in the 2,000,000 acre Richard J. Dorer Memorial Hardwood Forest which extends into southeastern Dakota County. The Department of Natural Resources - Forestry Division owns about 20,000 acres of this land while the rest is owned primarily by private individuals. The forest includes parts of Dodge, Fillmore, Goodhue, Houston, Olmsted, Wabasha, and Winona Counties in addition to the acreage in Dakota County.

Scenic timber areas are based on Department of Natural Resources' Natural and Historic Areas of Minnesota which relies heavily on Project 80. Project 80 data was obtained through a participatory process utilizing the knowledge of local residents. Those areas thought to be of regional or state significance were then field checked and verified. Thus, these areas are based on the aesthetic perspectives of residents, and not a specific set of criteria.

VEGETATION OF SCIENTIFIC AND EDUCATIONAL VALUE

Interpretation of the natural environment is one of the foremost concerns of local as well as state and federal units of government. Forty-one environmental education areas in addition to regional parks, park reserves and state and federal lands are located in the metropolitan area (See Exhibit G). Many of these are open to the public. While some are open only to selected groups or organizations, all include natural areas which are being maintained as environmental learning centers.

Plate 12 illustrates over one hundred recognized areas of vegetation significance within the metropolitan area based on scientific and educational value, wildlife habitat, and scenic timber (See Exhibit G indexed to Plate 12). Over 85,000 acres are included in these sites, with most of these being protected through private ownership or public lands.

Plate 12 also illustrates areas of scientific and educational significance. Section 14 - Sensitive Areas, addresses scientific and natural areas that are based on vegetation, as well as other physical factors.

ECONOMICALLY VALUABLE PLANT SPECIES

Very few species of vegetation in the metropolitan area are considered economically valuable. Black walnut, though not abundant, is highly valued for veneer. Some sugar maple syrup production is carried on locally and a few orchards and vineyards produce crops primarily for the metropolitan market. A few wild rice beds occur in the metropolitan area but commercial harvesting is concentrated north of this region.

Collectively, the value of the vegetation cover of the metropolitan area is immeasurable in terms of watershed control, erosion and sedimentation control. Generally, as development occurs, sedimentation yields increase and water quality deteriorates until such time as the landscape is covered with structures, asphalt, and concrete. Exhibit C, Interpretations of Soil Landscapes and Geomorphic Regions briefly addresses sedimentation hazard in the metropolitan area and illustrates areas subject to slight, moderate, and severe sediment hazard. Row crops are major producers of fine sediments. With present technology, however, soil loss could be cut to a tolerable level of four tons per acre (2,560 tons/square mile) annually. This corresponds to estimated sedimentation yields presented in Table 7-2. These values vary considerably depending on the type of soil, topography, amount and intensity of rainfall, distance to water, in addition to the cover type.

TABLE 7–2

AVERAGE SEDIMENTATION YIELDS FOR DIFFERENT LAND USES

LAND USE	SEDIMENT (Tons/Sq.Mile/Year)
Forest	less than 50
Urban and Suburban	50-100
Farm	1000-5000
Land Stripped for Construction	25,000-50,000

Additional information on runoff and sediment control can be obtained from local Soil Conservation Service offices, the bibliographic references listed in "Woodlands, Plantations, and Shade Trees in the Metropolitan Area" (17), and engineering handbooks such as Seelye's Design-Data Book for Engineers.

Vegetation cover is also economically important in terms of pollution, filtration, glare and temperature reduction, moisture retention, noise abatement, recreation use, marketability of desirable residential areas, and aesthetic value.

REFERENCES

1. American Wildlife & Plants, A Guide to Wildlife Food Habits. Alexander C. Martin, Herbert S. Zim, Arnold L. Nelson. Dover Publications, New York, New York. 1951. 500 pp. Food habits of over 1000 species of American birds, mammals, and fish are presented based on USFW research. Plant and animal relationships are presented by plant species and animal species for easy cross-referencing. (Available: MPL)

2. Dakota County Regional Park System. Dakota County Planning Department. (No date. Post - 1970) 65 pp. The document gives a general overview of population and physical resources on county and site specific scales. A county map depicting vegetation types - 1970 may be of value for county study. Limited value for this study. (Available: MC)

3. Ecological Study on Twin Cities Metropolitan Area. Wallace, McHarg, Roberts & Todd. June, 1969. 105 pp. and Tables and Maps. Original maps are available at Metropolitan Council's Map Library. Contact Person: Bill Schneider. 1 set of maps, not reproducible other than by slides or redrafting. The report can be a valuable data base for studies. Information utilized for plant associations:

35. Existing Forest Cover and Forest Related Industry
36. Natural Forest Regions
37. Ecological Forest Communities
G. Existing Forest Cover (Superceded)
H. Existing Vegetation (Base Map)
HH. Existing Vegetation (Base Map)
38. Wildlife Habitat - Water

(Available: Report - MPL; Maps - MC)

4. Environmental Impact Assessment Study of the Northern Section of the Upper Mississippi River. Minnesota River Pool, St. Croix River Pool, Upper & Lower St. Anthony Falls Pool, Pool 2, and Pool 3. R.F. Colingsworth, et. al., 1973. The six volumes are part of an extensive environmental study of the major river corridors. The volumes are a valuable aid to detailed vegetation studies as well as water quality, river use, and other resource data. (Available: MPL, CE)

5. Fish and Wildlife Technical Report. Minneapolis-St. Paul Area Level B. Study Upper Mississippi River Basin Commission. Prepared by: U.S. Fish and Wildlife Service. December, 1976. The document is a planning study for the Minnesota Valley National Wildlife Recreation Area. It encompasses the seven-county area addressing the status of fish, wildlife and habitat resources. Problems associated with these resources are also presented. (Available: USF & W, Federal Building, Fort Snelling.)

6. A Guide to Minnesota Environmental Education Areas. Mn/DNR, Bureau of I & E. November 1972. 110 pp. The booklet contains a listing, description and ownership of environmental learning centers, nature centers, and refuges by county. Helpful in location of sensitive plant and animal areas. (Available: out-of-print. Copies may be borrowed from DNR, Bureau of Planning, Bureau of Information and Education, or Bureau of Parks and Recreation.)

7. Listing of Variables for the Minnesota State Planning Agency Critical Areas Inventory. Xerox, April, 1977. The list provides a description of location for natural preservation areas, national register historical and archaeological sites and districts, and recreational data. Information is by region and county. This information should be useful for updating sensitive areas, sites of historic, archaeological and educational significance. (Available: SPA; contact: Kitty Miles)

8. Metropolitan Development Guide. Metropolitan Council. 1973-1976. The development guide is an ongoing process of inventory, analysis and policy development for the Metro area. Data maps are at a scale of 1" = 4 miles. Data collection time can be significantly reduced by utilization of pertinent information available from the documents and personnel at Metropolitan Council. Maps utilized in this section:

   Regional Recreation Open Space System Plan, 1977.
   Protection Open Space Plan - (Generalized Locations) 1973 Wetlands

9. "Minnesota Wildlife Lands." Department of Natural Resources. June, 1975. Map. Statewide map @ 1" = 16 miles identifies state wildlife management areas and lists size, location, primary access routes. Updated periodically. (Available: DNR)

10. Natural and Historic Areas of Minnesota. Mn/DNR. Bureau of Planning. September 1971. 72 pp. This is an updated listing and mapping source of Project 80 inventory data. Additional information was added from Minnesota Historical Society and Nature Conservancy data. Information is provided by economic region. This should be a strong base for historical and cultural, and natural inventory data. (Available: Document is out-of-print. Copies may be borrowed from DNR, Bureau of Planning. Contact: John Poate)

11. "Original Vegetation of Minnesota." Francis J. Marschner, 1930. Published by USDA North Central Forest Experiment Station, 1974. This map depicts pre-settlement vegetation of Minnesota at a scale of 1:500,000 based on Marschner's original map. Interpretation and notes are included on reverse side. (Available: NCFES)

12. Our Northern Shrubs. Harriet Keeler. Dover Publications, New York, N.Y. 1969. 537 pp. This volume is a comprehensive listing of native shrub species, range, habitats, and identifying characteristics. Limited value to study except for general information on individual species. (Available: MPL)

13. "Twin Cities Metropolitan Area Land Use, 1974." Based on Earth Resources Technology Satellite Imagery State Planning Agency, CURA, and Geography Department, University of Minnesota. Map. Eight classifications of land use based on 40 acre unit. Scale is approximately 1" = 3 miles. (Available: SPA)

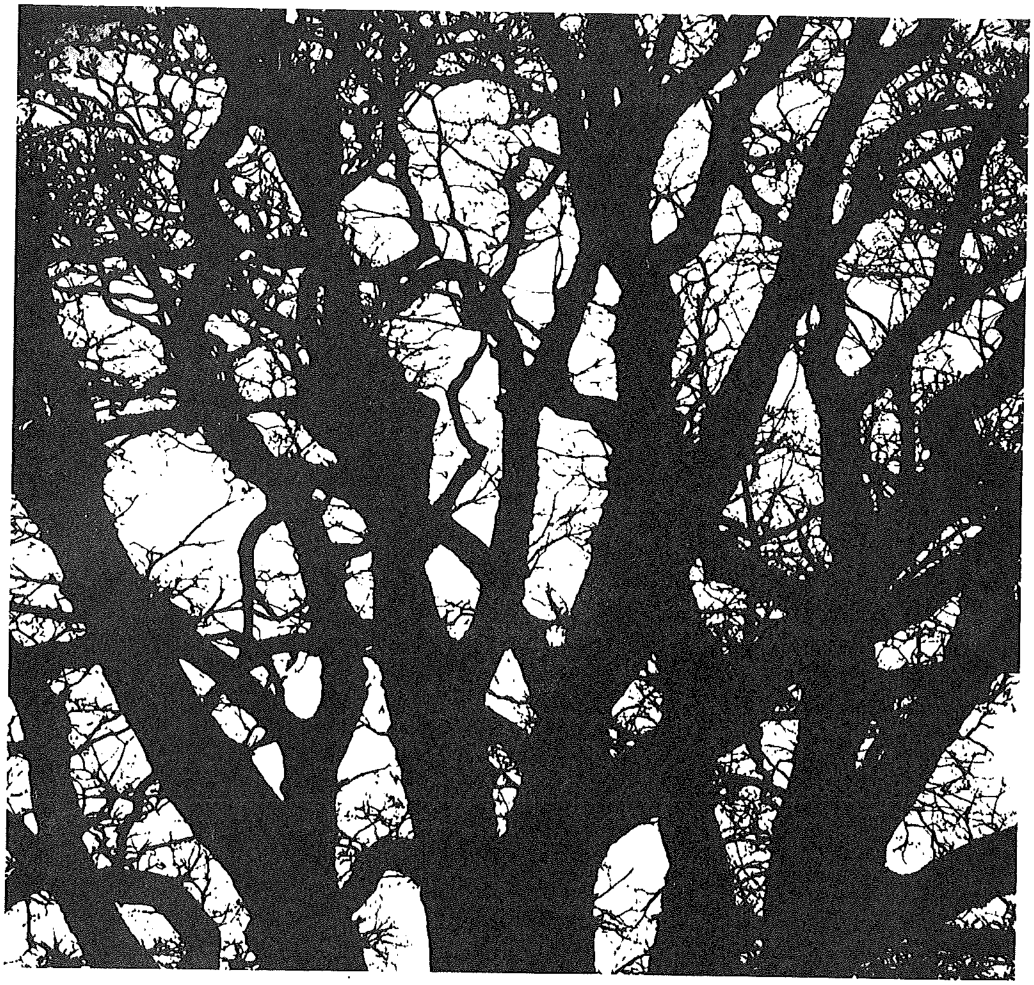
14. The Uncommon Ones. Mn/DNR. October 1975. 32 pp. This booklet provides nformation on rare and endangered plant and animal species. It also includes information on other species which merit special consideration or management. Value to future studies may be limited since much of the habitat information is very general. (Available: DNR - Bureau of Information and Education.)

15. Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June, 1974. 77 pp. This is a very detailed listing of plants, animals (includes reptiles and amphibians) with descriptions of where species are most likely to be found, type of protection and recommendations for management. Valuable asset to the study. (Available: Xerox manuscript - MC)

16. Where We Are Today. Washington County Planning, 1976. 90 pp. This is a comprehensive plan for Washington County. Inventory of agricultural lands, other land uses, population characteristics, and cultural features are presented. Future policies and guidelines are also included. This is the most complete and usable of the county comprehensive plans in the Metro area, to date. Should be of value to MWCC study. (Available: WCPO)

17. Woodlands, Plantations and Shade Trees in the Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June 1974. 77 pp. The document contains information on woodland cover types from pre-settlement times to the present. Relationship to soils and topography is presented. Effects on noise abatement, hydrology and climatic modification are discussed. Should be of value to future studies. Also contains Xerox of Kuchler's potential vegetation map. (Available: Xerox manuscript available at MC)

CE - Corps of Engineers
DNR - Department of Natural Resources
MC - Metropolitan Council Library
MPL - Minneapolis Public Library
NCFES - North Central Forest Experiment Station
USFW - United States Fish and Wildlife Service
WCPO - Washington County Planning Office



In each of the ecosystems in the metropolitan area there exist thousands of species, with numbers of individuals ranging from many to only a few. Species or groups with high population levels are generally viewed for clues to environmental quality. Some rare species will be discussed because they, by their continued existence, indicate the presence of optimum habitat. (See Section 16—Endangered and Threatened Plant and Animal Species, for greater detail.)

HABITATS

Fauna of the metropolitan area will be grouped by habitat associations: 1. water areas, including rivers, streams, lakes, bogs, marshes and other wetlands; 2. prairies, including savannas; and 3. forests, including upland and floodplain types.

These broad categories do not indicate the extreme diversity of habitats present, as shown by two unique but very restricted types:

> White Cedar - Sphagnum Bog, surrounding Cedar Bog Lake (a senescent lake, gradually filling in by the natural encroachment of vegetation), located in northern Anoka County is the southernmost Cedar bog in Minnesota.
>
> Dry, south-facing bluffs along the St. Croix and Mississippi Rivers - restricted habitat of the Six-lined Racer lizard. (See Figures 16-1 through 16-9 in Section 16 - Endangered and Threatened Species.)

Between these extremes are the major habitat types. In each habitat is an assemblage of plants and animals, all interdependent. Table 8-1 lists species grouped according to habitat range. A more detailed list of many vertebrate species occurring in this area is shown in Exhibits I - M. Also identified, in Exhibit H, are the most common groups of invertebrates that are important elements in food chains; most are aquatic.

TABLE 8–1

COMMON ANIMALS IN VARIOUS HABITAT TYPES IN THE METROPOLITAN AREA (52)

HABITAT TYPES	SPECIES
Deep Marshes	Muskrat, mink, ducks, geese, grebes, coot, blackbirds, rails, herons, black terns, snakes, turtles, and frogs.
Shallow Marshes	Ducks, pheasant, muskrat, mink, deer, grebes, coot, frogs, toads, snakes, and other amphibians and reptiles.
Wet Meadows	Deer, red fox, ducks, songbirds, herons, pheasant, snakes, leopard frogs, salamanders, and other reptiles and amphibians.
Mud Flats and Sandy Shores	Deer, small mammals, songbirds, ducks, marsh and shore birds.
Wooded and Shrub Swamps	Beaver, mink, raccoon, woodcock, songbirds, spring peeper, swamp tree frogs, woodduck, herons, deer, small rodents, and shrews.
River Bottom Forests	Raccoon, leopard frogs, upland game birds, white-tailed deer, cottontail rabbits, woodduck, forest songbirds, gray fox, salamanders, snakes and turtles

Upland Hardwoods	Gray fox, red fox, flying squirrel, raccoon, white-tailed deer, salamanders, wood frogs, ruffed grouse, snakes—including Dekay's snake, red-bellied snake.
Dry Oak, Savanna and Dry Uplands	Pheasant, deer, ruffed grouse, striped skunk, woodchuck, red fox, and snakes.
Brush Prairie	Songbirds: Horned lark, bobolink, vesper sparrow, field sparrow, killdeer
Prairie Grassland	Thirteen-lined Ground Squirrel and Franklin Ground Squirrel, upland plover, badger, white-tailed jack rabbit, Savannah sparrow.

ANIMAL POPULATIONS IN WATER

LIFE PROCESSES

Energy in a water system, as on land, comes from sunlight. Only green (chlorophyll-bearing) plants convert chemical elements into compounds essential as food for animals. These primary producers consist of the algae present on the bottom substrate, the obvious rooted or floating flowering plants, and microscopic plants suspended in the water. To survive, these organisms must exist in the correct physical and chemical water balance and have a stable base on which to grow. Primary producers, algae, are food for zooplankton, very small animals suspended in water. (See Exhibit H). Zooplankton are the crucial link between the primary producers and the higher consumers. Consumers of zooplankton are larger organisms such as snails, clams, crustaceans, and aquatic insects. These, in turn, serve as food for fish, amphibians, and turtles. Fish are the largest group of aquatic vertebrates. They are consumed in all stages of their life by other fish, by humans and by other terrestrial vertebrates such as herons, ducks, kingfishers, ospreys, bald eagles, terns, gulls, otters, mink and raccoon. A major aspect of the system is the recycling of dead organisms by bacteria and fungi. A part of the fauna subsists on this organic detritus. Some nutrients are transferred from water to terrestrial habitats when aquatic insect larvae mature and take to the air and land. Thus, the aquatic habitat is the food producer for a major segment of predators and scavengers that are generally terrestrial.

These basic life processes occur in all water environments, yet there are important distinctions between rivers and streams; lakes and bogs; and marshes and other wetlands.

River and stream flow limit some aquatic plant growth, yet it constantly moves detritus and plankton bringing new food to depleted areas and new algal colonizers to scoured sites. This process is the key factor in repopulating moving water when chemical pollutants are eliminated from them.

Floodplain lakes connected to rivers are prime sources of energy for the river biota, since flowering aquatic plants thrive in their backwaters. These plants are primary producers. Plans for use of floodplain land or water for runoff storage, as a drainage area, or other treatment should be considered against the water's use as a river and floodplain lake.

Lakes and bogs are bodies of water with well-defined boundaries and more stable water levels than the running waters of rivers and streams; therefore, they produce a relatively more stable environment for animal populations.

Marshes and other wetlands vary from temporary springtime ponds to near permanent bodies of water. Their aquatic life has adapted to all gradations from wet to totally dry conditions. For example, ducks use temporary ponds in the spring for courtship and pair-formation; other organisms such as fairy shrimp, remain in these ponds and marshes but undergo rapid hatching, maturation and reproduction, finally producing eggs which lie dormant until springtime when there may be water again. For these creatures and perhaps others yet unknown, even the smallest depressions are important biological units that should be considered when planning water removal, ponding and other land and water uses.

ANIMAL POPULATIONS IN METROPOLITAN AREA RIVERS AND STREAMS

Animal populations in rivers and streams reflect the variation of water quality and physical structure within the three major rivers and 35 smaller rivers and streams that transect or border the study area. Seventeen of these support catachable fish as shown in Table 8-2.

TABLE 8–2

METROPOLITAN AREA STREAMS SUPPORTING CATCHABLE FISH POPULATIONS (52)

STREAM OR RIVER	LENGTH–MILES
Mississippi	71
Minnesota	68
Elm Creek	33
Shingle Creek	12
Battle Creek	4
Coon Creek	26
Bassett Creek	15
Valley Branch Creek	11
Rum River	22
Cannon River	15
Crow River	26
Vermillion River	35
Rice Creek	25
St. Croix River	42
Minnehaha Creek	21
Nine-Mile Creek	23
Purgatory Creek	17
TOTAL:	464 Miles of Streams and Rivers

Most fishing occurs on the Mississippi, Minnesota and St. Croix rivers. Among the 96 species of fish present the most important game fish are walleye, northern pike, black crappie, large-mouth bass, yellow perch, catfish, bluegill and other sunfish. Total species composition and populations of fish in these systems are unknown except at a few large river sites and one trout stream. (See Exhibit I for lists of species.)

The St. Croix River contains the most valuable game fish and has the most intense fishing pressure; the Minnesota River is the poorest major river for fishing due to its physical and chemical composition. Many of the other rivers and streams contain high game fish populations but receive little fishing pressure. Trout are stocked at intervals in some of the streams.(See Table 8-3 for a listing of trout streams.)

The water quality deterioration problem in the Mississippi River - Pool 2 is due primarily to sewage discharge from Pig's Eye wastewater treatment plant. Studies conducted by the Minnesota Department of Natural Resources (DNR) indicate a change in fish species between upper Pool 2 and below Pig's Eye. In Upper Pool 2, 50 percent of the population was identified as rough fish, such as carp and redhorse; the other 50 percent were identified as game fish. Below Pig's Eye, 90 percent of the population was identified as rough fish; the other 10 percent were identified as game fish. This discrepancy is due to low disssolved oxygen concentrations which limit the species which are able to carry on their life processes. Aquatic plants have also been reduced below the Pig's Eye plant. Waterfowl and other water birds seldom are seen immediately downstream from the discharge, compared to their frequent use upstream, in Pig's Eye Lake, Spring Lake and below Lock and Dam No. 2.

TABLE 8–3

TROUT WATER IN THE METROPOLITAN AREA (52)

CREEK OR LAKE	LOCATION	SPECIES	DNR'S CURRENT MANAGEMENT STATUS
Brown's Creek	Washington Co.	Rainbow	Stocked
Brown's Creek	Washington Co.	Brown	Stocked
Mill Creek	Washington Co.	Brook	Native
Lawrence Creek	Washington Co.	Brook	Native
Trout Creek	Washington Co.	Brook	Native
Eagle Creek	Scott Co.	Rainbow	Stocked
Eagle Creek	Scott Co.	Brown	Stocked
Kenaley's Creek	Dakota Co.	Rainbow	Stocked
Kenaley's Creek	Dakota Co.	Brown	Stocked
Kenaley's Creek	Dakota Co.	Brook	Native
Purgatory Creek*	Hennepin Co.	Rainbow	Stocked
Purgatory Creek*	Hennepin Co.	Brown	Stocked
Courthouse Lake	Carver Co.	Rainbow	Stocked

*Stocked until 1975.

The largest invertebrates, clams, are sensitive indicators of water quality. They rapidly disappear from turbid and silted water. The larval stages of some species are parasitic on the gills of certain fish species. Loss of these species results in the elimination of clams and a disruption of the food web.

Since all waters in the metropolitan area are sensitive sites for many species of animals, proposed sites for waste disposal should reflect a choice of site based on a broad data base of habitat use by animals and plants.

ANIMAL POPULATIONS IN METROPOLITAN AREA LAKES

The numerous lakes are generally very rich in animal life, showing high diversity of species and populations, and indicating rather high water quality. High fish populations have been recorded. In Lake Minnetonka, a prime fish lake typical of the large deep lakes of the area, 11 species of commonly taken game fish were found. Even some of the urban lakes support fairly well-balanced fish populations (52).

Although fish populations seem adequate for current fishing demands, the continuing loss of spawning grounds for all fish is serious, and should be a prime consideration in development involving any manipulation of waters and water substrate. This should extend to the grassy meadows that are spawning beds for northern pike at spring flood time.

ANIMAL POPULATIONS IN METROPOLITAN AREA MARSHES

Marshes are pulsating habitats, for as seasons change, water levels change, and some species migrate in as others emerge and leave. Marshes are essential to large numbers of species at different times. Waterfowl use the area in the summer for nesting, with peak population in the fall estimated at 300,000 birds. Within the metropolitan area, the migrating ducks and geese concentrate along the rivers, floodplain wetlands and lakes in Carver County Rice Creek Watershed and western Hennepin County. Nearly 14,000 ducks have been known to winter over on the open lakes and rivers in the metropolitan area. See Section 18 - Aesthetic, Educational, Scarce and Unique Features for populations of wintering ducks at locations within the metropolitan area. Plans for marsh use by humans should be made in conjunction with long term marsh studies, many of which are still in their infancy. Since marshes sometimes go dry or sometimes hold water for only a very brief period, they usually contain few or no fish, but support a diverse fauna from invertebrates such as crayfish and snails, to mammals such as blackbrids and deer.

ANIMAL POPULATIONS IN METROPOLITAN AREA PRAIRIES

Although nearly all the original prairie habitat is gone, open, non-forested land is physically similar to a prairie in some seasons. This includes agricultural grasslands which are used as resting spots by migrant birds and by wintering species such as snowy owls, rough-legged hawks, snow buntings, Lapland longspurs and prairie horned larks, all of which are important as predators, insect eaters or seed eaters. Present agricultural practices of fall plowing and clean harvesting leave little food or shelter for winter animal life, but a few prairie animals such as the white-tailed jack rabbit and Brewer's blackbird are still present as breeding species.

Section 7 - Plant Associations - lists prairie inhabiting species and their ecological distributions.

ANIMAL POPULATIONS IN METROPOLITAN AREA FORESTS

The great variety of forest and brushy habitat types support the largest populations of terrestrial animals. In all but the most highly urbanized segments, there exist large numbers of species at various population levels. The following species are indicators of a balanced fauna. These species include grazers and browsers such as meadow voles, rabbits, deer, and Canada geese; insect eaters such as shrews, moles, skunks, and many birds; and vertebrate predators such as foxes, coyotes, mink, weasels, raccoon, hawks and owls. Many of the animal species are rare, partly because they exist at the edge of their range. (See Figures 16-1, 16-2, 16-5 through 16-9.)

At all levels of urban development, man affects the biotic webs of interrelationships. For example, some species such as chimney swifts and barn swallows are dependent on man-made structures for nest sites. These species are aerial feeders who locate food partly in forest habitats. This example illustrates the reliance of one habitat on the existence of another.

HABITAT CONSIDERATIONS FOR ANIMAL SURVIVAL

The most sensitive of all areas are the interfaces between habitat types and ecosystems. These are rarely considered in habitat descriptions, but are absolutely essential to survival of many species.

Barriers and corridors require special consideration since they either permit passage from habitat to habitat or prevent movement. Adequate corridors are few in the metropolitan area. Rivers and streams are best but even they have dams. The Coon Rapids Dam is a barrier to upstream movement of such fish species as sauger, freshwater drum and gizzard shad, among others. Road systems are the most extensive barriers to animal movement.

The most sensitive interfaces between ecosystems is the shoreline area between water types and the adjacent land habitats. These shoreline interfaces are critical to a wide range of organisms as discussed in Section 13, Land-Water Interfaces (See Figures 13-11 and 13-12.) Parts of all of their life cycles are restricted to localized areas within the shoreline interface. For example, turtles, generally aquatic animals, require dry sand or mud shores that remain undisturbed for egg laying. All shorelines are highly sensitive areas, and must be considered carefully when creating plans for river dredging and ponding.

REFERENCES

1. The "Big Woods" of Minnesota: Its Structure and Relation to Climate, Fire and Soils. R. F. Daubenmire. Ecol. Monographs. 1936. Classic detailed ecological study of the past and present hardwood "Big Woods" regions in Minnesota. (Available: U of M Lib.)

2. A Biological Reconnaissance of the Upper Mississippi River, St. Cloud to Fridley. J. W. Enblom. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Ecological Services. Special Publication No. 121. September 1977. A survey of the physical, chemical and biological characteristics of designated river segment with emphasis on fishing, and a section on present and potential uses of the river. Useful tables include lists of tributaries, fish species composition, and length-frequency distribution of fish. (A preliminary report subject to revision). (Available: DNR)

3. Biological Survey of the Crow and North Fork of the Crow River. Minnesota Department of Natural Resources Division of Fish and Wildlife Ecological Section. Special Publication No. 123. July 1977. Comprehensive survey. Includes a listing of streams tributary to the Crow River in Wright and Hennepin Counties. Preliminary draft - subject to revision. (Available: DNR)

4. Birds of the Minneapolis-St. Paul Region, Combined Field Check List and Migration Chart. A. W. Dodge, H. F. Fullerton, W. J. Breckenridge and D. W. Warner. Minnesota Museum of Natural History. University of Minnesota Press. 1966. 28 pp. Bird list, habitat key, map of Metro area and migration charts of all wild species reported in Metro area. (Available: U of M Lib.)

5. Breeding Ecology of the Twin Cities, Minnesota, Metropolitan Canada Geese. R. D. Sayler. M. S. Thesis, University of Minnesota. 1977. Most recent information on an increasingly important metropolitan breeding bird. Includes figures and tables on dates of nest initiation and hatch, nest site types, nesting fate and nest success by flock. (Available: U of M Lib.)

6. Brown's Creek, Washington County. Stream Survey and Management Evaluation Report. Minnesota DNR, Division of Game and Fish Section of Fisheries. 11 pp. 1966. (Mimeo. DNR) Brief physical, chemical, and biological survey for re-evaluation of cold water resources. (Available: DNR)

7. A Catalog of the Flora of Cedar Creek Natural History Area. Anoka and Isanti Counties, Minnesota. J. W. Moore. Bell Museum of Natural History Occas. Papers No. 12. 1973. 28 pp. Lists scientific and common names of 761 taxa of vascular plants occurring in the southern-most bog area of Minnesota. (Available: U of M Lib.)

8. Comprehensive Management Plan, Carlos Avery Wildlife Management Area, Anoka and Chisago Counties (Draft). Minnesota Department of Natural Resources, Division of Fish and Wildlife. March 9, 1977. Comprehensive ten-year management plan - includes present and projected regional perspectives, resource inventories, demand and use analyses, acquisition and development schedules, cost estimates and resource management programs. Numerous tables, species lists, and maps. (Available: DNR)

9. Comments on the Distribution and Natural History of Some Mammals in Minnesota. L. R. Heaney and E. C. Birney. Canadian Field-Naturalist 89 (1): 29-34. 1975. Data on distribution and natural history of 18 species of Minnesota mammals in attempt to up date already existing mammalian data. (Available: U of M Lib.)

10. Distribution of Aquatic Mollusks in Minnesota. C. Dawley. American Midland Naturalist 38: 671-97. 1947. General survey of fresh water mussels and snails in Minnesota in relation to river drainage systems, based on shell collection, Dept. of Ecology, University of Minnesota. (Available: U of M Lib.)

11. The Distribution of Minnesota Minnows and Darters in Relation to Pleistocene Geology. J. C. Underhill. Occasional Papers. No. 7. Minnesota Museum of Natural History. 45 pp. University of Minnesota Press. 1957. Contains geographical description of watersheds in Minnesota; dispersal routes and land barriers to fish migration; annoted list of minnows and darters with distribution maps (maybe somewhat out-dated in Metro Area). (Available: U of M Lib.)

12. Distribution, Relative Abundance, and Species Richness of Small Mammals in Minnesota, With an Analysis of Some Structural Characteristics of Habitats as Factors Influencing Species Richness. O. T. Kalin, Ph. D. Thesis University of Minnesota. 1976. 160 pp. A comprehensive study of small mammals in 14 habitats with 4 major vegetation zones in Minnesota - based on data from 485 sampling sites. Includes species - abundance histograms for major habitats. (Available: U of M Lib.)

13. The Distribution of the Turtles of Minnesota. C. H. Ernst. Journal of Herpetology 7 (1) 42-47. 1973. Lists localities and specimen collection numbers of eight species of turtles occurring in Minnesota. Distribution maps. (Available: U of M Lib.)

14. Distribution and Variation of the Catostomidae of Minnesota. Bell Museum of Natural History, University of Minnesota. Occasional Papers: 10, 1971. 45 pp. Distributions of 15 species of fish of the Family Catostomidae are discussed, keyed, and mapped. (Available: U of M Lib.)

15. Ducks and Land Use in Minnesota. Minnesota Department of Conservation, Division of Game and Fish. Technical Bulletin No. 8. 1964. 140 pp. Report of the findings from four studies on waterfowl and land use. Discusses factors affecting waterfowl production in Minnesota and those which must be considered in the wetland management program. (Available: DNR)

16. Eagle Creek, East Branch. Scott County. Stream Survey and Management Evaluation Report. Minnesota DNR, Division of Game and Fish Section of Fisheries. 7 pp. 1967. (Mimeo. DNR) Brief physical, chemical, and biological survey of cold water resources. (Available: DNR)

17. Eagle Creek, Main Branch. Scott County. Stream Survey and Management Evaluation Report. Minnesota DNR, Division of Game and Fish Section of Fisheries. 11 pp. 1967. (Mimeo. DNR) Brief physical, chemical and biological survey for cold water resources and evaluation of management practices. (Available: DNR)

18. An Ecological Study of the Twin Cities Metropolitan Area. Wallace, McHarg, Roberts and Todd. 1969. Original maps are available at Metropolitan Council's Map Library. Contact person: Bill Schneider. 1 set of maps, not reproducible other than by slides or redrafting. The report should be a valuable data base for study, particularly in those areas which are less subject to change over short periods of time. (Available: MC Lib.)

19. An Environmental Assessment and Plan for Wildlife and Public Use of Three Areas of the Minnehaha Creek Watershed District. Dwain W. Warner. Sept. 1975. (Typescript) 27 pp. Report uses birds as indicators of environmental quality. Includes bird species lists in relation to habitats. (Available: HA)

20. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Minnesota River Pool. North Star Research Institute, Minneapolis, Minnesota, 1973. The document is one volume of an extensive detailed environmental study of the Major River Valleys in the Twin Cities Area. Water quality, river use, aquatic and terrestrial life and other physical resource data is detailed in this report. The book should be a valuable aid to many of the project tasks. (Available: CE)

21. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 1. North Star Research Institute, Minneapolis, Minnesota, 1973. Contains much of the same type of information as others in the series. Emphasis is on area of Mississippi River between Ford Plant or Old Soldier'shome and approximately 6 miles downstream (miles 853.3 to 847.6). Good recent information on river corridor. (Available: CE)

22. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 2. North Star Research Institute, Minneapolis, Minnesota, 1973. Contains much of the same type of information as others in the series. Emphasis is on area of river near Hastings, Minnesota (mile 847.6 to 815.3). Good recent information on river corridor. (Available: CE)

23. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 3. North Star Research Institute, Minneapolis, Minnesota, 1973. Contains much of same type of information as others in the series. Emphasis is on area between Lock and Dam No. 2 and Lock and Dam No. 3 which includes many wing-dams and bank revetments (miles 796.6 through 815.2). Good recent information on river corridor. (Available: CE)

24. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. St. Croix River Pool. North Star Research Institute, Minneapolis, Minnesota, 1973. Contains much of the same type of information as others in the series. Emphasis is on the St. Croix River Valley. The data is up-to-date and provides information for river corridor studies. (Available: CE)

25. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Upper and Lower St. Anthony Falls Pool. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area near St. Anthony Falls. Good recent information on river corridor. (Available: CE)

26. Environmental Monitoring and Ecological Studies Program Annual Report. Allen S. King Generating Plant, Oak Park Heights. Northern States Power Company. 1975. Tenth consecutive report on air and water monitoring and ecological studies of area surrounding Allen S. King Plant. Tables and species lists. (Available: DNR)

27. Environmental Monitoring and Ecological Studies Program. Northern States Power Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota. Volume I. 1976. Results of NSP's seventh consecutive reporting of environmental monitoring studies contained in this detailed 2 volume publication. (Available: DNR)

28. Environmental Monitoring and Ecological Studies Program. Northern States Power Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota. Volume 2. 1976. Results of NSP's seventh consecutive reporting of environmental monitoring. Studies contained in this detailed 2 volume publication. (Available: DNR)

29. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. R. Conant. Hougton Mifflin Co., Boston. 1975. 429 pp. General field guide with colored illustrations and distribution maps. (Available: U of M Lib.)

30. Final Environmental Impact Statement. Flood Control at Minnesota River, Chaska, Minnesota. U. S. Army Corps of Engineers. 1975. (Habitat descriptions and maps.) Proposed plan for flood control - habitat descriptions and maps included. (Available: CE)

31. Final Environmental Impact Statement, Operation and Maintenance 9-foot Navigation Channel Upper Mississippi River, Head of Navigation to Guttenberg, Iowa. Volume I and Volume II, U. S. Army Corps of Engineers, St. Paul District, August 1974. In 2 separately bound volumes: Volume I contains narrative body of impact statement and Volume II contains exhibits such as maps, tables, figures and letters referred to in the narrative. (Available: CE)

32. Final Environmental Impact Statement, Pig's Eye Coal Terminal, Mississippi River at St. Paul, Ramsey County, Minnesota. St. Paul District Corps of Engineers. February, 1974. 272 pp. EIS on the proposed use of Pig's Eye Lake and surrounding area for trans-shipment and storage of low-sulphur coal. (Available: CE)

33. The Fish Fauna of the Mississippi River above St. Anthony Falls as Related to the Effectiveness of this Falls as a Migration Barrier. S. Eddy, J. Moyle and J. Underhill. Minn. Acad. Sci. Pro. 30 (2): 111-115. 1963. History of St. Anthony Falls, theories as to its barrier history, fish migration and listing of fish species occurring above and below falls. (Available: U of M Lib.)

34. Freshwater Wetlands and Sewage Effluent Disposal, Symposium. University of Michigan Wetlands Ecosystem Research Group, Ann Arbor, Michigan. May 1976. A symposium on the feasibility of utilizing freshwater wetland ecosystems to remove certain chemicals from secondarily treated wastewaters before they enter lakes, streams, and groundwaters. (Available: U of M Lib.)

35. Game and Fish Values of the Mississippi River between the Rum River at Anoka and the Chippewa River below Lake Pepin. Department of Conservation, Division of Game and Fish. 1963. Data on comparative fish populations, sport fishing, waterfowl, game management and oil spill mortalities. Includes fish species list. (Available: DNR)

36. Game Lake Survey of Downs Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August, 1976. Several pages of concentrated, all-inclusive information, with location, physical and chemical characteristics, measurements, drainage, shoreline, flora and fauna, utilization and management. Includes maps. (Available: DNR)

37. Game Lake Survey of Eagle Point Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August 1976. (Annotation: See Game Lake Survey of Down's Lake)(Available:DNR)

38. Game Lake Survey of Edith Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. September 1976. (Annotation: See Game Lake Survey of Down's Lake)(Available: DNR)

39. Game Lake Survey of Gun Club Lake, Dakota County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. Several pages of concentrated, all inclusive information, e.g., location, physical and chemical characteristics, measurements, drainage, shoreline, flora and fauna, utilization and management. (Available: DNR)

40. Game Lake Survey of Horseshoe Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August, 1976. (Annotation: See Game Lake Survey of Down's Lake)(Available: DNR)

41. Game Lake Survey of Nine Mile Lake, Hennepin County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. Several pages of concentrated, all-inclusive information, e.g., location, physical and chemical characteristics, measurements, drainage, shoreline, flora and fauna, utilization, management and maps. (Available: DNR)

42. Game Lake Survey of Pig's Eye Lake, Ramsey County, Minnesota. Minnesota Division Minnesota Division of Game and Fish, Section of Research and Planning. August 1972. (Annotation: See Game Lake Survey of Down's Lake)(Available: DNR)

43. Game Lake Survey of Rice Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. September 1974. (Annotation: See Game Lake Survey of Down's Lake)(Available: DNR)

44. Game Lake Survey of Snelling Lake, Hennepin County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. (Annotation: See Game Lake Survey of Down's Lake)(Available: DNR)

45. Game Lake Survey of Sunfish Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August 1976. (Annotation: See Game Lake Survey of Down's Lake)(Available: DNR)

46. Life History of the Leopard Frog, Rana pipiens, in Minnesota. D. J. Merrell. Bell Museum of Natural History. University of Minnesota. Occasional Papers: Number 15. 1977. 23 pp. Data collected on all seasons on more than 25,000 frogs provides information on all phases of life cycle. (Available: U of M Library)

47. The Major River Corridors in the Twin Cities Metropolitan Area. Twin Cities Metropolitan Council, Staff Report. 1970. Limited information on animal use. (Available: MC Library)

48. The Mammals of Minnesota. H. Gunderson and J. Beer. Occasional Papers, Minnesota Museum of Natural History. 1953. 190 pp. Systematic listing and descriptions of Minnesota mammals. Distribution maps for some species may be somewhat out-dated. (Available: U of M Library)

49. The 1968 Metropolitan Breeding Duck Survey. D. Beimborn and D. Warner. The Loon, March 1969. P. 8-9; An attempt to determine the status of ducks breeding in the Twin City Metropolitan Area. Includes map of breeding area boundaries. (Available: U of M Library)

50. Metropolitan Lake Inventory, Special Publication No. 45. S. A. Daley and R. A. Carlson. Minnesota Department of Conservation, Division of Game and Fish Technical Services Section. 1967. Frequently cited reference. A compendium of lake information for the Twin City 7-county Metro area. (Available: DNR)

51. The Minneapolis Chain of Lakes: A Study of Urban Drainage and Its Effects, 1971-1973. Interim Report No. 9, Limnological Research Center, University of Minnesota. 1973. Much biological information (Available: LRC)

52. Minneapolis-St. Paul Area Level B. Study—Upper Mississippi River Basin Commission. Fish and Wildlife Technical Report. Prepared by U.S. Fish and Wildlife Service for the Fish and Wildlife Task Group. December 1976. A detailed description and inventory of fish and wildlife resources in the metropolitan area, including populations, habitats and uses. Identification of problems and recommendations to resolve them are included. Good maps, references, and species lists. (Available: USFWS Library)

53. Minneapolis-St. Paul Water and Land: Future Perspectives and Plans. Upper Mississippi River Basin Commission. (Level B. Study Report and Environmental Impact Statement, 90 day Review Draft, June 1977). The study report outlines program for managing and conserving the water and related land resources of the metropolitan area through the year 2000. Excellent tables and figures and glossary. (Available: USFWS Library)

54. Minnesotans and Their Mississippi River. A Citizen's Review of Minnesota's Mississippi River Environments. J. S. Replinger. Esthetic Environment Task Force of the State of Minnesota. 1974. A basic handbook for assessment of the Mississippi River. Good tables and figures. (Available: DNR)

55. Minnesota Birds—Where, When and How Many. J. C. Green and R. B. Janssen. University of Minnesota Press, Minneapolis. 1975. Excellent recently published references detailing distribution, migration, and estimates of abundance of Minnesota birds. Useful distribution maps. (Available U of M Library)

56. Minnesota River. Carver and Scott Counties. Electrofishing Survey. Minnesota DNR, Division of Game and Fish Section of Fisheries. 3 pp. August 13, 1976. (Mimeo. DNR) Fish species list and results of oxygen sampling. (Available: DNR)

57. Monticello Nuclear Generating Plant, Monticello, Minnesota. Environmental Monitoring and Ecological Studies Program, Annual Report. NSP, 1975. Eighth consecutive report of environmental studies on water, algae, macroinvertegrates and fish in the area of Monticello Nuclear Generating Station. Much quantitative data; maps and species lists. Also contains theses on primary productivity in Mississippi River near Monticello and food habits of young small-mouth bass. (Available: DNR)

58. Monticello Nuclear Generating Plant, Monticello, Minnesota. Environmental Monitoring and Ecological Studies Program, Annual Report. NSP, 1976. Ninth consecutive report of environmental studies on water, algae, macroinvertebrates, and fish in the area of Monticello Nuclear Generating Plant. Much quantitative data; maps and species lists. (Available: DNR)

59. Northern Fishes - with Special Reference to the Upper Mississippi Valley. S. Eddy and J. C. Underhill. University of Minnesota Press, Minneapolis. 3rd Ed. 1974. 414 pp. Contains descriptions by families, line drawings of fish, and map of major drainage basins and stream systems in Minnesota. No distribution maps. (Available: U of M Lib.)

60. Northern States Power Company's Proposed Units 3 and 4 Sherco Steam Electric Station. Environmental Impact Statement (Draft). Minnesota Pollution Control Agency. July, 1977. A recent EIS on proposed expansion of Sherco facility to include additional pair of generating units, cooling water systems, pollution control systems, raw materials handling equipment, and expansion of solid waste disposal area. Good Maps. (Available: DNR; PCA)

61. The Phytoplankton of Minnesota Lakes -- a Preliminary Survey. Alan J. Brook. 1971. Indicates which species inhabit eutrophic and mesotrophic lakes. (Available: LRC)

62. Pig's Eye Lake: Its Status as a Biologically Unique Area. Typescript, 12 pp. 1974. D. W. Warner. Physical and biological qualities of Pig's Eye Lake and its importance to wildlife; relation of Metropolitan Sewage facility to Pig's Eye; recommendations for the Pig's Eye Natural Area. (Available: DWW)

63. Report to the City of Minneapolis Park and Recreation Board on the Condition of Lakes in Minneapolis, 1974. J. Shapiro. Limnological Research Center Interim Report No. 12. 1975. 275 pp. Chemical and physical analysis of 13 Minneapolis Lakes, and sections of the Mississippi River and Bassett's Creek. Algal samples collected and survey of macrophytes. Extensive species lists. (Available: LRC)

64. Reptiles and Amphibians of Minnesota. W. J. Breckenridge. Minnesota Museum of Natural History. University of Minnesota Press. 1958. Includes detailed descriptions, photographs and useful distribution maps (may be outdated in some areas). (Available: U of M Lib.)

65. A Selected Annotated Bibliography of Economic Values of Fish and Wildlife and Their Habitats. J. A. Leitch and D. F. Scott. Agricultural Economics Misc. Report No. 27. Agricultural Exp. Sta., North Dakota State University, Fargo, North Dakota. August, 1977. Useful up-to-date annotated bibliography organized into eight sections using standard bibliographic style. (Available: U of M Lib.)

66. Selected Invertebrate Sites in Metro Area, 1970-1971. Dale Chelberg. Letter, 1977. Brief location descriptions and principal invertebrate fauna of 13 sites in metropolitan area. (Available: DWW)

67. A Special Fisheries Survey of a Portion of the Mississippi River below the Coon Rapids Dam. D. Shodeen. Minnesota Conservation Department. Special Publ. No. 98. 1965. A survey to determine the present fish population and fish habitat to evaluate a proposed removal of river-bed gravel deposits. (Available: DNR)

68. Study of Solid Waste Management and Resource Recovery in the Twin Cities Metropolitan Area, Summary, Conclusions, and Recommendations. Twin Cities Metropolitan Council, St. Paul, Minnesota. 1975. Contains several Tables but no references. (Available: MC Lib.)

69. Thermal Effects of a Nuclear Power Plant on the Mississippi River at Monticello, Minnesota. A. J. Hopwood. Water Resources Research Center, Bulletin 69, University of Minnesota. 1974. Compares biological data from the post-operational (1971-1972) period to baseline data (1968-1971). (Available: DNR; U of M Lib.)

70. Upper Mississippi River Comprehensive Basin Study. UMRCBS Coordinating Committee. 1972. Vol. I, the main report, summarizes the finding of the 17 supporting appendices. Included is geographical, water, navigation, recreation, fish and wildlife resources. (Available: USFWS Lib.)

71. Vermillion River. Dakota County. Stream Survey and Management Evaluation Report. Minnesota DNR, Division of Game and Fish Section of Fisheries. 35 pp. 1956. (Mimeo. DNR) Physical and chemical analyses of Vermillion River, lists of tributaries and fish species. (Available: DNR)

72. Waterfowl in Minnesota. F. B. Lee. Minnesota Department of Conservation, Div. of Game and Fish. Technical Bulletin No. 7. 1964. Descriptions, ranges, food habits, and status as game birds. Includes maps of breeding ranges and band recoveries of some species. (Available: DNR)

ADDITIONAL REFERENCES

73. Algae Variations of Lower Lake Minnetonka, Carver and Hennepin Counties, Minnesota. W. J. Munson. Research paper, Department of Biology, Mankato State College: Problems in Biological Science. 1967. (Available: MSC)

74. Analysis of the composition of fish populations in Minnesota rivers and streams. A.R. Peterson. Minn. DNR Investigational Report No. 335. 1975. (Available: DNR)

75. Annual Production by the Slimy Sculpin Population in a Small Minnesota Trout Stream. C. E. Petrosky and T. F. Waters. Trans. Amer. Fisheries Soc. 104 (2): 237-244. 1975. (Available: U of M Lib.)

76. Annual Report of the Statewide Creek Census on 80 Lakes and 38 Trout Streams in Minnesota. B. W. Hawkinson and H. F. Krosch. Minnesota Dept. of Natural Resources Tech. Services Investigational Report No. 319. 1972. (Available: DNR)

77. Barred Owl Habitat Use as Determined by Radiotelemetry. T. H. Nicholls and D. W. Warner. J. Wildl. Mgmt., 36 (2): 213-224. 1972 (Available: U of M Lib.)

78. A Biological Survey of the Upper Mississippi River System. J. B. Moyle. Fisheries Research Investigational Report No. 10, Minnesota Department of Conservation. 1940. (Available: DNR)

79. A Creek Census of Eighteen Metropolitan Lakes. Minnesota Department of Natural Resources. Unpublished, mimeograph. 1975. (Available: DNR)

80. Differences in the Composition of the Fish Populations in Pool 2 and Other Areas of the Mississippi River as Related to Waste from the Twin Cities Metropolitan Area. J. Skrypek. Minnesota Department of Natural Resources Investigational Report No. 307. 1969. 17 pp. (Available: DNR)

81. Diurnal Periodicity in the Drift of Stream Invertebrates. T. F. Waters. Ecology 43 (2): 316-320. 1962. (Available: U of M Lib.)

82. Dominant Planktonic Rotifers of Major Waterways of the United States. L. S. Williams. Limnol. Oceanogr. II. 1966. (Available: U of M Lib.)

83. 1972 Duck Observation Study. Metropolitan Mosquito Control District. Unpublished, Mimeograph. 1973. (Available: MMCC)

84. Ecological Changes on the Upper Mississippi River Wildlife and Fish Refuge since Inception of the 9-foot Channel. U. S. Dept. of Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Minneapolis. Unpublished mimeograph. 15 pp. 1960. (Available: USFWS Lib.)

85. Ecology of the mudminnow, Umbra limi, in Fish Lake (Anoka County), Minnesota. J. A. Jones. Ph. D. Thesis, Macalester College, St. Paul, Minn. 1973. (Available: Mac C Lib.)

86. Ecosystem studies at Cedar Creek Natural History Area. J. R. Bray and L. C. Pearson. Proc. Minn. Acad. Sci., 25-26: 108-112. 1957-58. (Available: U of M Lib.)

87. Ecosystem studies at Cedar Creek Natural History Area, II. J. D. Ovington and J. R. Bray. Proc. Minn. Acad. Sci., 28: 16-19. 1960. (Available: U of M Lib.)

88. Effect of Light Intensity on the Drift of Stream Invertebrates. C. S. Holt and T. F. Waters. Ecology 48 (2): 225-234. 1967. (Available: U of M Lib.)

89. Effects of Floods on Food Consumption and Production Rates of a Stream Brook Trout Population. J. W. Elwood and T. F. Waters. Trans. Amer. Fisheries Soc. 98 (2): 253-262. 1969. (Available: U of M Lib.)

90. The Effects of Suspended and Deposited Sediments on Estuarine Organisms. Literature summary and research needs. J. AJ Sherk, Jr. Natural Resources Inst., Univ. Md. Contribution No. 443. U.S. Army Corps Engin. Contract No. DACW73-70-C-0013. 1971. (Available: U of M Lib.)

91. Electrofishing survey of the Mississippi River, Monticello to Elk River, Minn. B. Hawkinson. DNR Envir. Sec. 1974. 19 pp. (Available: DNR)

92. An estimate of winter utilization of the Cedar Creek Natural History Area by the White-tailed Deer (Odocaileus virginiaus borealis). L. D. Frenzel. J. Minn. Acad. Sci., 32 (2): 98-100. 1965. (Available: U of M Lib.)

93. Evaluating Effects of Water Resource Developments on Wildlife Habitat. C. Daniel and R. Lamaire. Wild. Soc. Bull. 2 (3): 114-118. (Available: U of M Lib.)

94. Evaluation of Fishes and Bottom Fauna in the Mississippi River Adjacent to the NSP Sherburne County Generating Plant Site, Becker, Minnesota, during October and November, 1971. A. J. Hopwood. St. Cloud State College, St. Cloud, Minnesota. 1972. (Available: DNR)

95. Fish Density Data For 1976 (Unpublished). Northern States Power Company, Becker, Minnesota. 1976. (Available: DNR)

96. Fish Populations of the Mississippi River Near Becker, Minnesota. B. L. Barels. M. A. Thesis, St. Cloud University, St. Cloud, Minnesota. (Available: St. C. S. Lib.)

97. Fish and Wildlife Resources. Fish and Wildlife Service, U. S. Dept. of Interior. In Upper Mississippi River Comprehensive Basin Study. UMRCBS Coordinating Committee, Chicago. Appendix L. 103 pp. 1970. (Available: USFWS Lib.)

98. Floristic and Ecological Studies of Wetlands in Minnesota. R. H. Hofstetter. Ph. D. Thesis, University of Minnesota. 1969. 224 pp. (Available: U of M Lib.)

99. A Guide to Mississippi Flyway Waterfowl Management. Mississippi Flyway Council. 1958. (Available: USFWS Lib.)

100. A History of Fish and Fishing in the Upper Mississippi River. H. B. Carlander. Upper Mississippi River Conservation Committee. 1954. (Available: USFWS Lib.)

101. Interpretation of Invertebrate Drift in Streams. T. F. Waters. Ecology 46 (3): 327-334. 1965. (Available: U of M Lib.)

102. Inventory of Peat Resources in Minnesota, Progress Report. State of Minnesota Department of Natural Resources, Division of Minerals. January 1977. (Available: DNR)

103. Invertebrate Drift in the Mississippi River Over a Five-Day Period Near Becker, Minnesota. D. R. Wefring. M. A. Thesis (Unpublished). St. Cloud State University, St. Cloud, Minnesota. 1976. (Available: St. C. S. Lib.)

104. Lake Minnetonka -- the Lake and its Management for Fish and Wildlife. J. B. Moyle. Minn. Dept. Cons. Inv. Rept. No. 100 52. 1950. (Available: DNR)

105. Lake Minnetonka: Nutrients, Nutrient Abatement, and the Photosynthetic System of the Phytoplankton. R. O. Megard. 1970. (Available: ECOL)

106. Measurement of Habitat Niche of the Least Flycatcher. W. J. Breckenridge. Wilson Club Bull., 68: 47-51. 1956. (Available: U of M Lib.)

107. A Method to Estimate the Production Rate of a Stream Bottom Invertebrate. T. F. Waters. Trans. Amer. Fisheries Soc. 91 (3): 243-250. 1962. (Available: U of M Lib.)

108. Minneapolis-St. Paul Area Level B Study. Upper Mississippi River Basin Commission, Plan of Study (Revised). 1975. (Available: USFWS Lib.)

109. Notes on the Chlorophyll Method of Estimating the Photosynthetic Capacity of Stream Periphyton. T. F. Waters. Limnology and Oceanography 6 (4): 486-488. 1961. (Available: U of M Lib.)

110. Past and Present Forest Communities of St. Croix State Park, Minnesota and Their Use in Determining Ecomanagement Direction. A. W. Fedkenheuer. PhD Thesis. University of Minnesota. 1975. 338 pp. (Available: U of M Lib.)

111. Plant Succession of the Mississippi River Floodplain with Special Reference to the Pioneer Stage. H. George 1924. Unpublished M.S. Thesis, University of Minnesota. (Available: U of M Lib.)

112. Population Estimates of Wintering Ducks in the Metropolitan Twin Cities, Third Week of January 1974. J.A. Cooper. Unpublished, mimeograph. 1974. (Available: Ent, F, W)

113. Preliminary Report on Some Minnesota Lakes and their Productiveness of Fish Food. University of Minnesota Agricultural Experiment Station. Technical Services Section. (Available: U of M Ag Exp Sta)

114. Production Rate, Population Density, and Drift of a Stream Invertebrate. T. F. Waters Ecology 47 (4): 595-604. 1966. (Available: U of M Lib.)

115. Recolonization of Denuded Stream Bottom Areas by Drift. T. F. Water. Trans. Amer. Fisheries Soc. 93 (3): 311-315. 1964. (Available: U of M Lib.)

116. Recovery of Standing Crop and Production Rate of a Brook Trout Population in a Flood-damaged Stream. D. L. Hanson and T. F. Waters. Trans. Amer. Fisheries Soc. 103 (3): 431-439. 1974. (Available: U of M Lib.)

117. Relationship Between the Chemistry of Minnesota Surface Waters and Wildlife Management. Management. J.B. Moyle. J. Wildlife Mgt. 20: 303-321. 1956. (Available: U of M Lib.)

118. Role of Habitat in the Distribution and Abundance of Marsh Birds. M. W. Weller and C. E. Spatcher. Agricultural and Home Economices Experiment Station Iowa State University of Science and Technology, Ames, Iowa. April 1965. (Available: U of M Lib.)

119. Seasonal Food Cycle Dynamics in a Senescent Lake. R. L. Lindeman. Am. Midl. Nat., 26: 636-673. 1941b. (Available: U of M Lib.)

120. Seasonal Variations of Invertebrate Drift in the Mississippi River Below the NSP Sherburne County Generating Plant, Becker, Minnesota. Zimmerman, ______, and A. J. Hopwood. Prepared for Sherburne County Generating Plant Ecological Studies Program. 1975. (Available: DNR)

121. Some Aspects of the Chemistry of Minnesota Surface Waters as Related to Game and Fish Management. J. B. Moyle. Minn. Dept. Cons. Inv. Rept. No. 151. 1954. (Available: U of M Lib.)

122. Some Effects of Heated Water on the Drift of Two Species of Stream Invertebrates. T. A. Wojtalik and T. F. Waters. Trans. Amer. Fisheries Soc. 99 (4): 782-788. 1970. (Available: U of M Lib.)

123. The 1967-68 Sport Fishing Survey of the Upper Mississippi River. K. J. Wright. LaCrosse, Wisconsin: Upper Mississippi River Conservation Committee. 1970. (Available: USFWS Lib.)

124. Standing Crop and Drift of Stream Bottom Organisms. T. F. Waters. Ecology 42 (3): 532-537. 1961. (Available: U of M Lib.)

125. A Study of Some Small Mammal Populations at Cedar Creek Forest, Anoka County, Minn. H. L. Gunderson. Minn. Mus. Nat. Hist. Occas. Paper No. 4. 1950. 49 pp. (Available: U of M Lib.)

126. A Study of Minnesota's Natural Areas. Minnesota Outdoor Recreation Resources Commission, Report Number 2, 1965. (Available: U of M Lib.)

127. A Study of the Pig's Eye Lake Heron Colonies. A. M. Adams, et al. The Loon, Vol. 45, No. 2. 1973. (Available: U of M Lib.)

128. A Study of the Ecological Succession of Stream Communities in the Vicinity of Minneapolis. Harvey E. Adams. Unpublished M.A. Thesis, University of Minnesota. 1937. (Available: U of M Lib.)

129. Survey of Surface Water Drainage Problems in the Twin Cities Metropolitan Area. Twin Cities Metropolitan Council. 1970. (Available: MC Lib.)

130. The Trophic-Dynamic Aspect of Ecology. R. L. Lindeman. Ecology. Vol. 23 (4): 339-417. 1942. (Available: U of M Lib.)

131. The Upper Mississippi: A Wild and Scenic River Study, Environmental Impact Statement. Bureau of Outdoor Recreation, U. S. Dept. of Int., Aug. 1976. (Available: USFWS Lib.)

132. Upper Mississippi River Basin Commission, Upper Mississippi River Comprehensive Basin Study, Appendix L (Fish and Wildlife Resources). 1970. (Available: USFWS Lib.)

133. Waterfowl Status Report 1965. H. A. Hansen and M. R. Hodgins. SSR No. 9, BFS&W U. S. Fish and Wildlife Service. 1965. (Available: USFWS Lib.)

134. White-tailed Deer Movements and Foraging on the Cedar Creek Forest, Minnesota. E. R. Norberg. M.S. Thesis, University of Minnesota. 1957. (Available: U of M Lib.)

135. Taxonomic Keys to the Common Animals of the North Central States, Exclusive of the Parasitic Worms, Insects and Birds, S. Eddy and A. C. Hodson, Revised edition, 1955. Illustrated keys with basic descriptions, life histories and ecological distributions of most invertebrates and vertebrates in Minnesota. (Available: U of M Lib.)

KEY

Limnological Research Center University of Minnesota	LRC
Dr. Dwain W. Warner Bell Museum of Natural History University of Minnesota, Minneapolis	DWW
Environmental Conservation of Minnesota	ECOL
Macalester College Library St. Paul, Minnesota	Mac C Lib
Mankato State College Mankato, Minnesota	MSC
Metropolitan Mosquito Control Commission	MMCC
Environmental Quality Council	EQC

Citizen's League 84 South 6th Street Minneapolis, Minnesota 55402	CL
University of Minnesota Agricultural Extension Service Bulletin Room Coffey Hall St. Paul, Minnesota	U of M Ag Ext
University of Minnesota Agricultural Experiment Station	U of M Ag Exp Sta
Hickok and Associates	HA
University of Minnesota Department of Entomology, Fisheries and Wildlife	Ent, F, W
U. S. Fish and Wildlife Library, Regional Office, Federal Building Fort Snelling, Minneapolis, Mn.	USFWS Lib
University of Minnesota, Library Minneapolis, Minnesota	U of M Lib
St. Cloud State University Library St. Cloud, Minnesota	St. C S Lib
Minnesota Department of Natural Resources	DNR
Pollution Control Agency	PCA
University of Minnesota Department of Botany	U of M Bot
Metropolitan Council Library	MC Lib
St. Paul District Corps of Engineers	CE

CONTACTS

Dr. Dale Chelberg, Curator of Biology	Science Museum of Minnesota, St. Paul
Dr. Donald Gilbertson Professor	Department of Ecology and Behavorial Biology, University of Minnesota, Minneapolis
Dr. Thomas Morley, Professor	Department of Botany, University of Minnesota, St. Paul

SENSITIVE AREAS

Sensitive areas may be regarded as ecosystems which are highly subject to change through natural or man-made causes. Other areas are especially sensitive due to their biologic or geologic uniquesness. Wetlands, floodplains, and steep slopes (greater than 12 percent) are included as sensitive areas due to the multi-faceted habitats afforded by these communities, as well as their fragility in the face of urbanization and intensive agricultural practices.

The wetlands, floodplains, steep slopes, and significant biological and geological areas identified here do not present a complete listing of all sensitive areas. All parklands (Plate 22), Vegetation of Special Significance (Plate 12), Historic and Archaeological Sites (Plate 27) are among other lands sensitive in their response to disruption by man-made and natural events. In addition, prime agricultural lands may be considered sensitive areas in terms of their susceptibility to urbanization. (See Section 15 - Agriculture).

Plate 13 illustrates two major wetland regions in the metropolitan area. The first encompasses the northern portions of Ramsey and Washington counties and nearly all of Anoka County. These are primarily herbaceous marsh wetlands in the southern reaches. Progressing northward, bogs and swamp wetlands predominate. The second major region of wetlands lies in western Hennepin County, extending through most of Carver County and southward through much of Scott County. Wetlands in this area are typically herbaceous prairie marshes. (See Section 6 - Wetlands for a comprehensive overview of wetland areas.)

Floodplains serve as habitat areas for many species of plant and animal life. The lineal corridors of the floodplain also serve as migration routes. While the floodplain forest is a rather stable community which is tolerant of wet and dry conditions, the composition of the ground layer changes greatly from year to year. The change is due "apparently in response to the varying abilities of the different species to recover from the effects of submersion." (9) The most prominent floodplain in the region is the Minnesota River's wide flat lowlands.

Steep slopes are associated with the Minnesota and St. Croix River valleys as well as many of their tributaries. In contrast, the Mississippi has fewer areas where exposed slopes are over 12 percent. Plate 13 denotes areas of steep slopes.

These steep slopes visually define the river corridors. Thus, they become a sensitive aesthetic feature as well as a sensitive ecological community. Visual quality studies indicate that changes or disruptions to these defining edges are more quickly perceived than disruptions anywhere else. (10)

Steep slopes are ecologically sensitive due to the inherent difficulties in establishing a permanent community. They are often droughty due to the high rate of runoff allowing little chance for absorption into the soil. At the same time precious topsoil needed to establish a plant community is carried away. Steep erodible slopes are also located in central Hennepin, eastern Scott, and southeastern Dakota counties.

Shallow or exposed bedrock adds additional stress to the establishment of a community permitting only the toughest inhabitants to take hold and survive. The effects of topography and geology produce unique plant and animal associations that may only be found on these formations.

The most ambiguous of the elements included in sensitive areas are significant natural areas. Different agencies as well as individuals have different perceptions of what constitutes a significant biotic or geologic site. The sites illustrated on Plate 13 and indexed to Exhibit N have been compiled from two data sources, Department of Natural Resources - Bureau of Planning and the State Planning Agency.

State Planning Agency's "Sites of Biological and Geological Significance File" (1977) lists one site at Hastings which has been officially designated as a state Scientific and Natural Area (SNA). Only five such sites have been so designated throughout the state. Over four hundred sites have been proposed by various individuals, organizations, and agencies for SNA designation. Six sites in the metropolitan area have been accepted and placed on the state Scientific and Natural Area Acquisition Program. Four additional sites have been proposed but have not been placed on the acquisition program as yet.

At least one proposed site occurs in each county except Washington. This does not indicate that no significant sites occur in the county, rather it may indicate that more thorough evaluation or inventories have been done in other counties. The State Planning Agency acknowledges that the file is incomplete and welcomes additional information regarding significant sites. DNR's 1971 study, Natural and Historic Areas of Minnesota, while not listing seven of the eleven SPA sites, does include fourteen additional areas. This study was based on Project 80 data. These two studies indicate that at least eighteen sites in the metropolitan area are significant of recognition as scientific and natural areas. The guidelines and criteria used for designation of an SNA are included in Exhibit N.

Two additional classifications utilized in this inventory were Other Sites of Biological and Geological Significance and Unique Features. These include areas identified by state planning and Project 80 as having significant value but they have not been proposed for SNA designation.

Nature Conservancy tracts also have been identified on Plate 13. Six sites in the metropolitan area including the Allison Savannah (proposed SNA) are held by the conservancy at the present time. This organization is currently identifying all potential statewide scientific and natural areas through privately funded field surveys.

REFERENCES

1. Environmental Impact Assessment Study of the Northern Section of the Upper Mississippi River. Minnesota River Pool, St. Croix River Pool, Upper and Lower St. Anthony Falls Pool, Pool 2, and Pool 3. R. F. Colingsworth, et al., 1973. The six valumes are part of an extensive environmental study of the major river corridors. The volumes are a valuable aid to detailed vegetation studies as well as water quality, river use, and other resource data. (Available: MPL)

2. Fish and Wildlife Technical Report. Minneapolis—St. Paul Area Level B. Study Upper Mississippi River Basin Commission. Prepared by: U.S. Fish and Wildlife Service. December, 1976. The document is a planning study for the Minnesota Valley National Wildlife Recreation Area. It encompasses the seven-county area addressing the status of fish, wildlife, and habitat resources. Problems associated with these resources are also presented. (Available: USF&W, Federal Building, Fort Snelling)

3. Listing of Variables for the Minnesota State Planning Agency Critical Areas Inventory. Xerox, April, 1977. The list provides a description of location for natural preservation areas, national register historic and archaeological sites and districts, and recreational data. Information is by region and county. This information should be useful for updating sensitive areas, sites of historic, archaeological and educational significance. (Available: SPA; Contact—Kitty Miles)

4. Metropolitan Development Guide. Metropolitan Council. 1973-1976. The development guide is an on-going process of inventory, analysis and policy development for the Metro area. Data maps are at a scale of 1"=4 miles. Data collection time can be significant significantly reduced by utilization of pertinent information available from the documents and personnel at Metropolitan Council. Maps utilized in this section:

Regional Recreation Open Space System Plan, 1977
Protection Open Space Plan—(Generalized Locations) 1973. Wetlands and Floodplains
Protection Open Space Plan—(Generalized Locations) 1973. Erodible Slopes.

5. Minnesota State Historical Society Listing. 1977. Includes all historic sites (including landmarks and monuments) on the National Register of Historical Sites, sites on the State listing, and sites of statewide historic interest due to the architectural, political, or figurative significance. (Available: MHS, Fort Snelling; Contact: John Hackett, Lize Nagle)

6. Natural and Historic Areas of Minnesota. Mn/DNR. Bureau of Planning. September 1971. 72 pp. This is an updated listing and mapping source of Project 80 inventory data. Additional information was added from Minnesota Historical Society and Nature Conservancy data. Information is provided by economic region. This should be a strong base for historical, cultural and natural inventory data. (Available: SPA Document is out-of-print. Copies may be borrowed from DNR, Bureau of Planning; Contact: John Poate)

7. "Sites of Biological and Geological Significance" State Planning Agency File. August 1977. The file is an on-going inventory of sensitive areas. Data is presented by county and coverage is state-wide. Compilation from nine data sources. (Available: SPA; Contact: Kitty Miles)

8. The Uncommon Ones. Mn/DNR. October 1975. 32 pp. This booklet provides information on rare and endangered plant and animal species. It also includes information on other species which merit special consideration or management. Value to future studies may be limited since much of the habitat information is very general. (Available: DNR—Bureau of Information and Education)

9. Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June, 1975. 77 pp. This is a very detailed listing of plants, animals (includes reptiles and amphibians) with descriptions of where species are most likely to be found, type of protection and recommendations for management. Valuable asset to the study. (Available: Xerox manuscript available at MC)

10. "Visual Vulnerability". R. Burton Litton, Jr. Journal of Forestry. July 1974. pp. 392-297. The article describes landscapes that are particularly sensitive to visual impact. It is an excellent source for background information on aesthetic features vulnerable to disruption. (Available: U of M - Forestry Library).

11. Where We Are Today. Washington County Planning, 1976. 90 pp. This is a comprehensive plan for Washington County Inventory of agricultural lands, other land uses, population characteristics, historic sites, and cultural features are presented. Future policies and guidelines are also included. This is the most complete and usable of the comprehensive plans in the Metro area. Should be of value to MWCC studies. (Available: MC)

MC - Metropolitan Council Library
MHS - Minnesota Historical Society
MPL - Minneapolis Public Library
SPA - State Planning Agency
UM - University of Minnesota
USFW - United States Fish and Wildlife

SECTION 10 ENERGY

GENERAL

An inventory of energy supply and demand in the metropolitan area must necessarily be for a specific time period, since both sources and demand are undergoing constant changes. The latest available detailed inventory for the State of Minnesota, which contains a breakdown of energy sources as well as end uses, has been prepared for the year 1972 by the Minnesota Energy Agency (MEA) (4). The agency is continuously updating and detailing its data files. At the present time, however, while some data on fuel consumption is available on a county-level basis, end use by energy type is not. For this reason, much of the energy inventory presented here will be for the state; since the population of the metropolitan area is approximately one-half that of the state, it may be assumed for general purposes that approximately 50% of the state energy consumption will be accounted for by the metropolitan area.

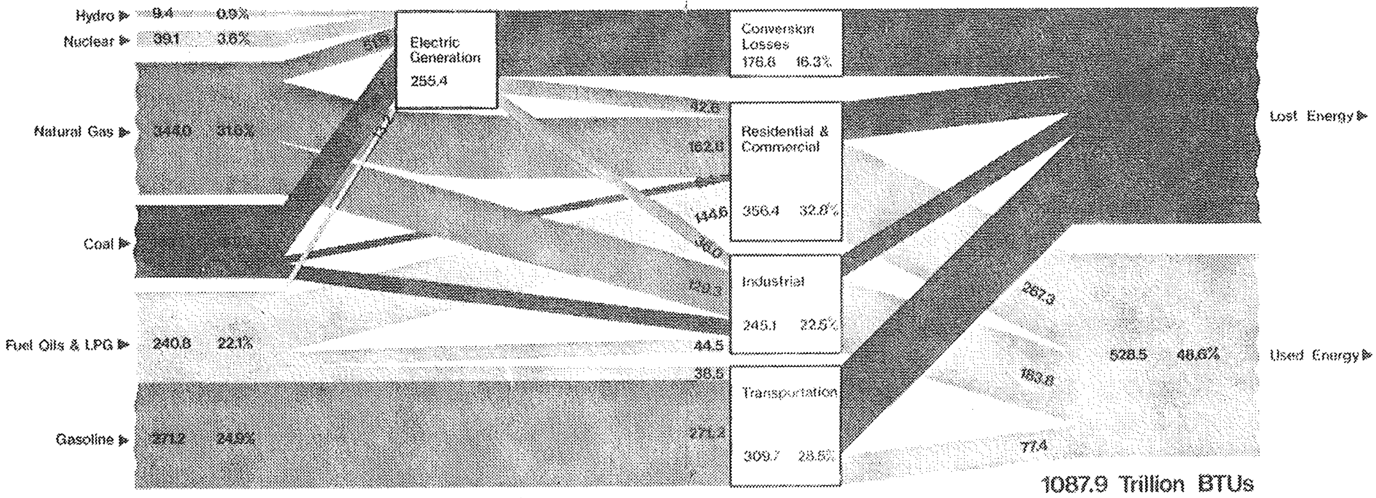
While extension of sewers and additional development may increase gasoline consumption, it would be difficult to discuss availability and use of electricity, natural gas and fuel oil on a subregional basis, until such information has been developed by the MEA. An information system is under study at the Agency (7), which could provide this information.

Figure 10-1, presents the energy flows within the state from sources to end uses, indicating the percentages of each. As noted above, data are presently insufficient to develop such a diagram for the metropolitan area alone. Consumption of selected energy sources by county is presented in Table 10-1.

TABLE 10–1 FUEL CONSUMPTION BY COUNTY (4)

COUNTY	1973 Gasoline (1000 Gal)	1973 Fuel Oil (1000 Gal)	1975 Natural Gas (1000 Mcf)	1975 Electricity (1000 Kwh)
Anoka	49,682	17,127	8,579	1,020,580
Carver	11,582	5,779	1,479	218,473
Hennepin	438,988	341,726	81,625	5,922,371
Ramsey	352,889	120,069	41,671	3,388,560
Washington	26,765	28,562	4,073	636,265
Dakota	38,215	23,809	15,140	1,264,586
Scott	16,150	11,362	3,734	337,129

FIGURE 10–1 MINNESOTA ENERGY/1972



Units shown are trillions of BTUs & percentages of total energy

SOURCE: Minnesota Energy: Supply and Use 1972.

ENERGY SUPPLY

NATURAL GAS

Significant curtailment of natural gas has occurred since the 1972 inventory. Priorities for additional curtailment have been established by Northern Natural Gas, who provides the metropolitan distributors with gas.* A detailed study on the impact of this curtailment program on Minnesota and the availability of alternative fuels has been prepared by the MEA. Examples of curtailment priorities are presented in Table 10-2.

TABLE 10–2

NORTHERN NATURAL GAS CURTAILMENT PROGRAM FOR MINNESOTA

PRIORITY	CURTAILMENT	(Amount provided in 1980 as % of 1974)
11A/11B	0% by 1977	Power plants and major industrial users
9	10.7%	University of Minnesota-St. Paul, St. Regis Paper
7	68.0%	Minnesota Linseed—Fridley
2C	97.4%	Minneapolis Floral, Rosswood Building

Because of this curtailment program, it is unlikely that any new major energy user will be supplied with natural gas. They will have to rely upon alternative fuel sources of either fuel oil or coal.

Natural gas consumption by county within the metropolitan area is shown in Table 10-1.

FUEL OIL

While fuel oil suppliers and storage areas may be identified in this inventory, there are several problems in using the information as presented:

1) Not all grades of fuel oil will be available in the desired amounts from each of the suppliers.

2) The price is not included in the inventory, as it may vary significantly over time.

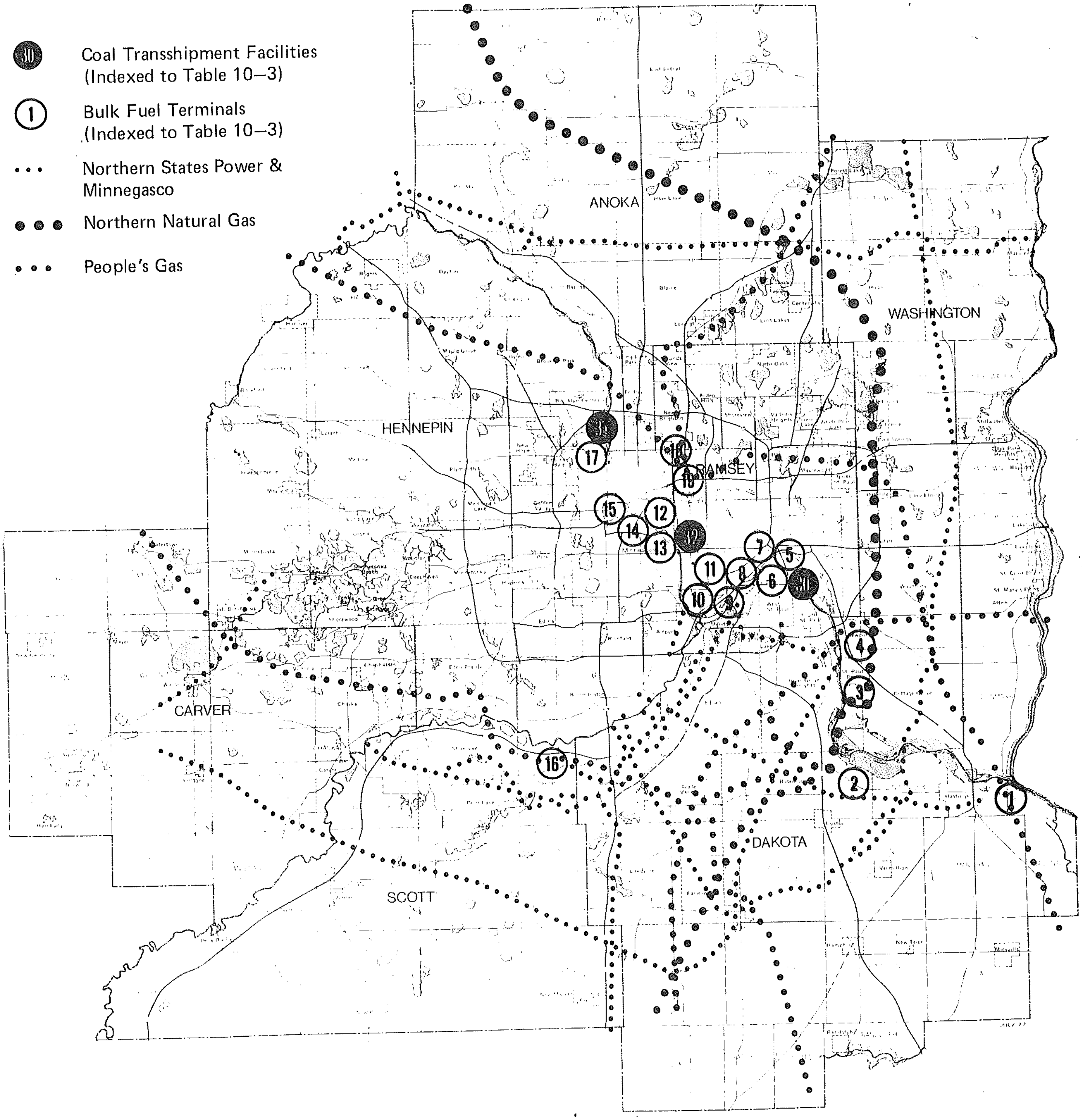
While the above problems may exist, the major fuel oil terminals are shown in Figure 10-2. The names of these suppliers and the capacity of each terminal are presented in Table 10-3. Fuel oil consumption by county is listed in Table 10-1.

---

* The major gas distributors within the metropolitan area are:

North Central Gas - Anoka County
Peoples Gas - Portions of Scott and Dakota County
MSP & Minnegasco - All remaining counties

FIGURE 10–2 LOCATION OF BULK FUEL TERMINALS, COAL TRANSSHIPMENT FACILITIES, AND GAS PIPELINES



SOURCE: Minnesota Energy Agency

TABLE 10–3

MAJOR GASOLINE AND FUEL OIL STORAGE TERMINALS (4)

NO.	TERMINAL	NO.TANKS	MILL. GALS. GASOLINE	MILL. GALS. FUEL OIL
1	Koch (Hastings)	5	––	––
2	Koch (Rosemount)	55	92	65
3	Ashland (St. Paul Park)	12	227	56
4	Erickson (Newport)	12	58	.7
5	Gustafson Oil (St. Paul)	3	––	.3
6	American Mineral Spirits— Union Oil (St. Paul)	13	––	––
7	Union Oil (St. Paul)	23	56	36
8	Clark Oil (St. Paul)	11	30	.1
9	Shell Oil (St. Paul)	12	47	28
10	Mobil Oil (St. Paul)	19	73	32
11	Texaco (St. Paul)	9	72	37
12	Koch (Minneapolis)	6	––	9
13	Union (Minneapolis)	16	––	––
14	Union (Minneapolis)	11	56	36
15	Western-Conoco (Minneapolis)	20	––	––
16	Richards (Savage)	25	––	.2
17	Industrial Fuels	––	––	––
18	WD	––	353	105
19	Amoco	––	159	113
30	Alter Coal Transshipment			
31	Bolander Coal Transshipment			
32	Great Lakes Coal Transshipment			

TRANSPORTATION FUELS

Distillates, kerosine and gasoline accounted for approximately 30% of total fuels consumed within the state in 1972. Because of the problems associated with "moving inventory", i.e., fuels purchased in one region and transmitted to and used in other regions, an inventory of such fuels cannot be included. Problems associated with transportation fuels are being considered in some detail by the Minnesota Department of Transportation (M/DOT) and the MEA, who should be contacted for detailed information.

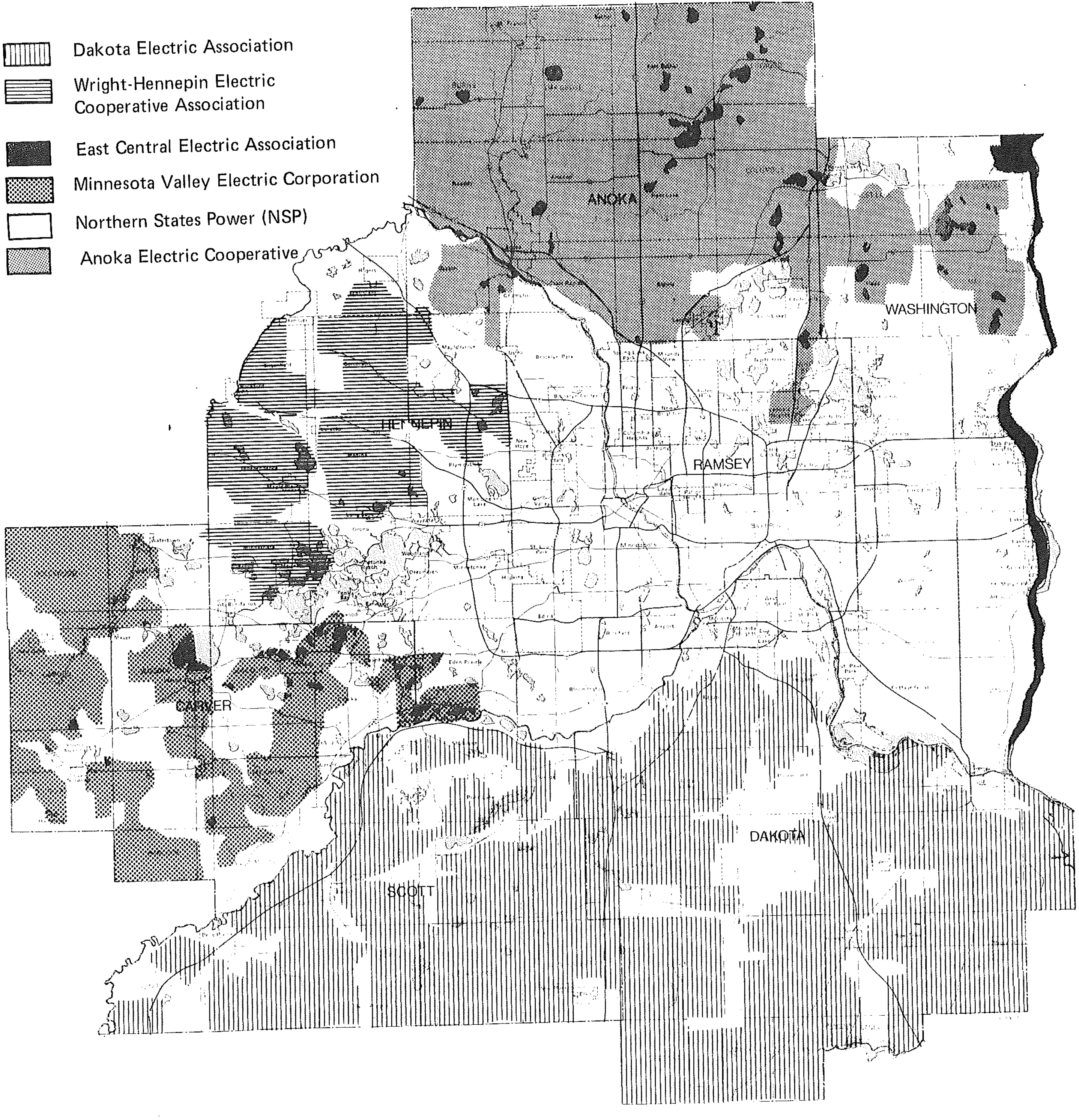
COAL

A comprehensive study of coal use, transportation, and transshipment in Minnesota is presently being performed by the MEA. Results of this effort should be available in 1978. An interim report on coal use and transportation in the metropolitan area prepared for the MEA indicated that rail transportation would be sufficient, at least through 1985, to transport the increased coal required to replace natural gas in Minnesota (1).

Because of the high sulfur content of eastern coal, shipments from the west have increased, with most supplies in the future expected to be from those sources. The coal is shipped by rail directly to large users, primarily power plants, or to transshipment facilities located on the Mississippi River for shipment downriver or to other users within the metropolitan area. (1) The three major coal transshipment facilities and their present capacities are listed in Table 10-4 and are located on Figure 10-2.

At the three major coal facilities alone, there is a capability of 2.9 million tons of western coal. As noted above, the MEA is undertaking a comprehensive study on coal requirements and transportation which should be available in 1978. The data from Table 10-4 can be updated at that time. Since the total fuel requirements for the Metro Wastewater Treatment Plant could be satisfied in 1985 by approximately 100,000 tons of coal per year, the availability of coal as an alternative fuel source does not appear to present any problem.

FIGURE 10–3 ELECTRICAL POWER SERVICE AREAS



SOURCE: Northern States Power Company

TABLE 10–4

AVAILABILITY OF COAL IN THE METROPOLITAN AREA FROM MAJOR TERMINALS (1)

ALTER COAL TRANSSHIPMENT STATION		
Montana Coal	Presently Shipping:	700,000 tons/year
	Capacity:	1,500,000 tons/year
	Additional Capacity:	800,000 tons/year
Illinois Coal	Presently Shipping:	N/A
	Capacity:	1,000,000 tons/year
BOLANDER TRANSSHIPMENT STATION		
Montana Coal	Presently Shipping:	1,000,000 tons/year
	Capacity:	4,000,000 tons/year
	Additional Capacity:	3,000,000 tons/year
Western Coal	Presently Shipping:	150,000 tons/year
	Capacity:	1,500,000 tons/year
	Additional Capacity:	1,350,000 tons/year
GREAT LAKES COAL AND DOCK		
Montana Coal	Presently Shipping:	800,000 tons/year
	Capacity:	1,500,000 tons/year
	Additional Capacity:	700,000 tons/year
Eastern Coal	Presently Shipping:	75,000 tons/year
	Capacity:	not available

ELECTRICAL POWER

Electrical power is not considered a primary energy source since it requires another fuel or source for its production. Figure 10-1 shows the percentage of fuels in Minnesota which are used in electrical generation. A large part of this energy is lost to the atmosphere or to surface waters in the form of waste heat.

While identification of the specific electrical distribution network may not be useful in the evaluation of the siting of wastewater treatment facilities, identification of areas served by different suppliers may be helpful. Figure 10-3 shows the service areas of the various distributors within the metropolitan area. Northern States Power Company (NSP) has given assurances that whatever power needs required by a major new treatment plant within their service area could be met (6).

OTHER ENERGY SOURCES

Other sources include LPgas, hydro and nuclear fuels, and to a much lesser extent potential solar, wind, and biomass sources. Biomass includes residual agricultural products such as corn silage, wood pulp from unusable trees, and use of animal wastes to generate methane, as well as timber production for fuel, and the growing of cattails and other crops for their energy content. In addition to these sources, Minnegasco is investigating the potential of using peat in northern Minnesota by turning it into gas and mixing it with already existing supplies from southern suppliers. This process is being considered by the Minnesota Department of Natural Resources, as well as other agencies in the State, in addition to studies being funded by Minnegasco.

ENERGY DEMAND

The percentage of end use of energy is shown in Figure 10-1. More detailed use by the four economic sectors, and selected public institutions and services (which are included in the commercial category), are presented in Tables 10-5 and 10-6. It can be seen that municipal wastewater treatment facilities account for only .1% of the state energy. Figure 10-4 presents the anticipated growth of energy consumption by sector in the state (5).

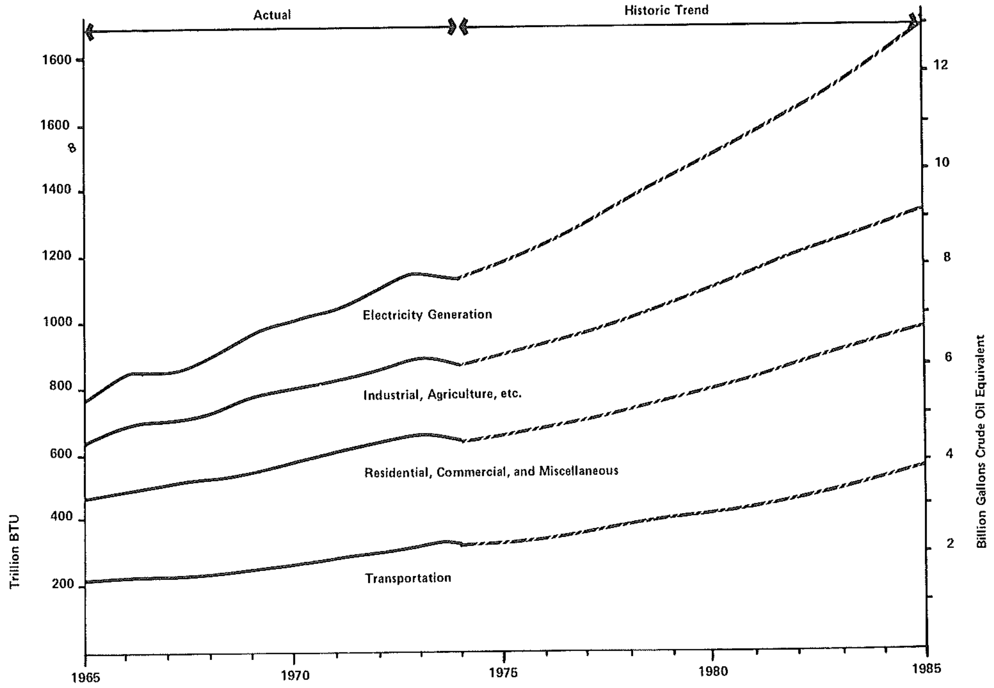
SELECTED REFERENCES AND CONTACTS

Energy sources and uses have become the focus of a large number of studies within the past few years, and numerous publications have been produced. Basic sources for documents are the MEA, the Environmental Collection of the Minneapolis Public Library, and the Libraries of the University of Minnesota. A report prepared for the Metropolitan Sewer Board on potential fuel supply for the Metro Plant may serve as an introduction to the energy considerations which must be included in the siting of plans for expansion of a major wastewater treatment facility (2).

In October 1977 a conference on alternative energy sources for Minnesota was held in Bloomington under the sponsorship of 31 different organizations. The conference included discussions on solar and wind energy, energy storage systems, biomass, conservation systems, and peat. Administration of the conference was handled by the Minnesota Solar Energy Task Force.

FIGURE 10–4

END-USE ENERGY FORECASTS TO 1985



Minnesota's Energy Situation to 1985, 1975

TABLE 10–5 MINNESOTA ENERGY USE BY ECONOMIC SECTOR, 1972 (6)

	TRILLION BTU	AMOUNT	% OF TOTAL RESIDENTIAL/ COMMERCIAL ENERGY USE
A. Residential & Commercial			
1. Distillate Oil	99.7	718.7 Million Gallons	28.0
2. Kerosene	5.2	38.4 Million Gallons	1.5
3. Residual Oil	5.2	34.5 Million Gallons	1.5
4. LPG	34.5	375.2 Million Gallons	9.7
5. Natural Gas	162.8	162.8 Billion Cubic Feet	45.7
6. Coal	6.4	0.3 Million Tons	1.8
7. Purchased Electricity	42.6	12.5 Billion KWH	11.9
TOTAL	356.4		100%

			% OF TOTAL INDUSTRIAL ENERGY USE
B. Industrial			
1. Distillate Oil	6.7	48.1 Million Gallons	2.7
2. Kerosene	0.3	2.3 Million Gallons	0.1
3. Residual Oil	32.9	219.8 Million Gallons	13.4
4. LPG	4.6	50.3 Million Gallons	1.9
5. Natural Gas	129.3	129.3 Billion Cubic Feet	52.8
6. Coal	35.3	1.7 Million Tons	14.4
7. Purchased Electricity	36.0	10.6 Billion KWH	14.7
TOTAL	245.1		100%

	TRILLION BTU	AMOUNT	% OF TOTAL TRANSPORTATION FUEL USE
C. Transportation			
1. Distillate Oil	36.5	263.3 Million Gallons	11.8
2. Kerosene	0	0	0
3. Residual Oil	0.9	5.8 Million Gallons	0.3
4. LPG	1.1	12.0 Million Gallons	0.4
5. Natural Gas	0	0	0
6. Coal	0	0	0
7. Purchased Electricity	0	0	0
8. Motor Gasoline	271.2	2169.4 Million Gallons	87.6
TOTAL	309.7		100%

			% OF TOTAL ELECTRIC GENERATING FUEL USE
D. Electric Generation			
1. Distillate Oil	8.5	61.0 Million Gallons	3.3
2. Kerosene	0	0	0
3. Residual Oil	4.7	31.5 Million Gallons	1.8
4. LPG	0	0	0
5. Natural Gas	51.9	51.9 Billion Cubic Feet	20.3
6. Coal	141.7	6.7 Million Tons	55.5
7. Hydro	9.4	0.9 Billion KWH	3.7
8. Nuclear	39.1	3.6 Billion KWH	15.3
TOTAL	255.4		100%
Total Fuels Less Purchased Electricity	1087.9		

TABLE 10–6

ENERGY USE BY SELECTED INSTITUTIONS AND PUBLIC SERVICES IN MINNESOTA, 1972 (4)

	TRILLION BTU	AMOUNT	% OF STATE ELECTRIC-ITY USE	% OF TOTAL STATE ENERGY
Schools				
Electricity	2.0	580.2 Million KWH	2.5	
Heating Fuels	15.0	107.9 Million Gallons*		
Total Heating & Electricity	17.0			1.6
Heating & Electricity Consuption per student				
Consumption per student	17.9 Million BTU			
Colleges and Universities				
Electricity	1.4	412.4 Million KWH	1.8	
Heating Fuels	7.6	54.8 Million Gallons*		
Total Heating & Electricity	9.0			0.8
Heating & Electricity Consumption per student	70.0 Million BTU			

Hospitals				
Electricity	1.1	315.1 Million KWH	1.4	
Heating Fuels	6.9	49.8 Million Gallons*		
Total Heating & Electricity	8.0			0.7
Heating & Electricity Consumption per Occupied Bed	464.0 Million BTU			
Nursing Homes				
Electricity	0.3	100 Million KWH	0.4	
Heating Fuels	2.5	18.0 Million Gallons*		
Total Heating & Electricity	2.8			0.3
Heating & Electricity Consumption per bed	89.3 Million BTU			
Correctional Institutions				
Electricity	0.05	14.3 Million KWH	0.1	
Heating Fuels	1.20	8.65 Million Gallons*		
Total Heating & Electricity	1.25			0.1
Heating & Electricity Consumption per inmate	583.9 Million BTU			
State-Operated Health Facilities				
Electricity	0.2	47.4 Million KWH	0.2	
Heating Fuels	2.1	14.8 Million Gallons*		
Total Heating & Electricity	2.3			0.2
Heating & Electricity Consumption per bed	212.7 Million BTU			
Municipal Water Treatment				
Electricity	1.1	334 Million KWH	1.4	
Heating Fuels	1.1			
Total Electricity & Heating	2.2			0.2
Average Energy per Person Served	0.8 Million BTU			
Municipal Waste Water Treatment				
Electricity	0.3	88.6 Million KWH	0.4	
Heating Fuels	1.0			
Total Heating & Electricity	1.3			0.1
Average Energy Per Person	0.3 Million BTU			

* Assuming only No. 2 oil is used for heating.

REFERENCES - ALL ARE AVAILABLE FROM THE MINNESOTA ENERGY AGENCY

1. Coal Use and Transportation in the Twin Cities Metropolitan Area; David Braslau Associates, Incorporated, prepared for the Minnesota Energy Agency, June 30, 1976.

   This is an interim report which summarizes available data on coal movement into and through the metropolitan area. The accompanying map of train movements and coal users in the region are of some interest.

2. Fuel Supply - Metropolitan Wastewater Treatment Plant; Toltz, King, Duvall, Anderson and Assoc., Inc., prepared for the Metropolitan Sewer Board, April 1973.

   This report identifies the fuel requirements in 1972 and projections to 1985. Alternatives to natural gas and appropriate facilities for these are also discussed. No information on electric power requirements are contained in this report. That information may be obtained from records of the Metropolitan Waste Control Commission.

3. Impact of Northern Natural Gas Company's Curtailment Plan on Minnesota; Minnesota Energy Agency, July 1976.

   This report describes potential effects of natural gas curtailment and identifies alternative fuels and their price and availability for those industries which will be losing gas supplies.

4. Minnesota Energy: Supply and Use 1972; Minnesota Energy Agency, 1974.

   This document presents a breakdown of energy supply and end use for major fuels and economic sectors. Energy amounts are presented in both physical units and BTU's. A table of conversions for BTU per energy unit is also available.

5. Minnesota's Energy Situation to 1985; Minnesota Energy Agency Research Division, March, 1975.

   This report summarizes statewide energy use by type and end use from 1965 to 1985.

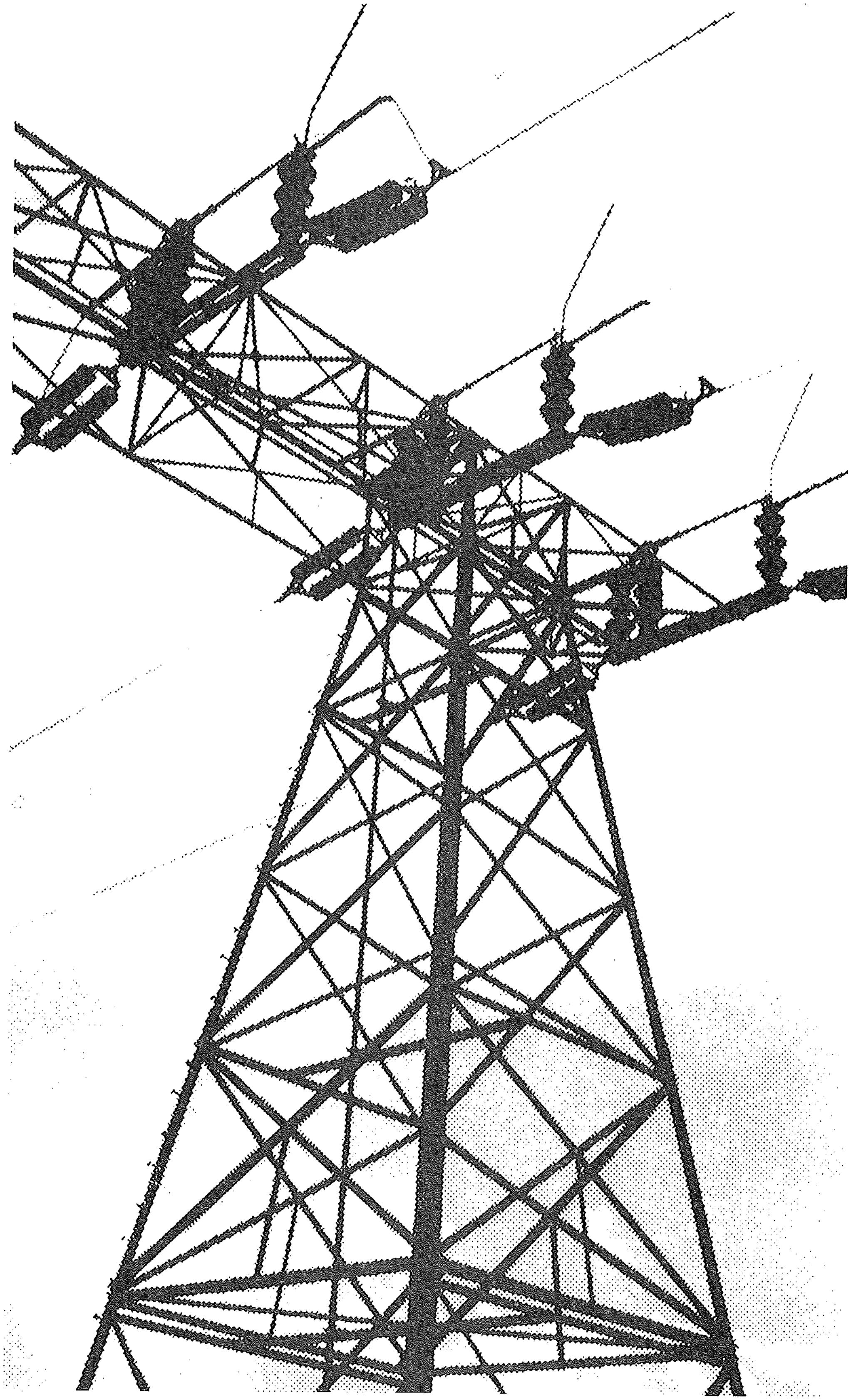
6. Personal communication, William Frederick, Northern States Power Company.

7. Regional Energy Information System for Minnesota: A Preliminary Design; N. L. Chervany and J. D. Naumann, University of Minnesota, prepared for the Minnesota Energy Agency, January 1975.

   This report describes the proposed Regional Energy Information System (REIS) which is intended to maintain a data base on energy flows within the state of Minnesota between suppliers and end users. Additional reports are available at the Minnesota Energy Agency.

CONTACTS IN SELECTED AGENCIES

Minnesota Energy Agency	Larry Kitzman, Research Division
Minnesota Pollution Control Agency	Edward Wiik, Director, Division of Air Quality
Minnesota Solar Energy Task Force	Maxwell L. Oftedal, Chairman



PRESENT USE

Water areas within the metropolitan region provide numerous opportunities for different uses, depending on the quality of the water. The uses of major rivers includes water for domestic supply, industrial processing, commercial navigation, and recreational purposes. Lakes are primarily used for recreation.

LAKES

Lakes larger than 100 acres and important smaller lakes are illustrated on Plate 14. Exhibit P indicates the lake name, size, location, structures on the lake, the Department of Natural Resources (DNR) Public Waters Classification (Natural Environment, Recreation Development, or General Development), and the DNR Wetland Type Classification for selected lakes. The DNR Wetland Type Classification identifies the physical characteristics of each lake as shown on Table 11-1, while the DNR Public Waters Classification, shown on Table 11-2, delineates the type of development permitted along the lakeshore. For lakes lying totally within a city, the DNR Public Waters Classification is only a minimum standard until each city adopts its own ordinance. (2, Hydrology).

TABLE 11–1

WETLAND TYPES

TYPE II – Meadow–Shallow depressions without standing water but waterlogged within at least a few inches of the surface during the growing season. Common vegetation is sedges, reed canary grass, smartweed and burreed.

TYPE III– Shallow Marshes–Marshy depressions which may have variable water depths up to 30 inches or which may be merely waterlogged. Usually covered with heavy-stalked emergents such as cattail, cane and bulrush. The emergents may form a dense cover or there may be scattered open-water areas.

TYPE IV– Deep Marsh–Water depths to six feet. Emergent vegetation, if present, is either confined to a fringe or to scattered plants or clumps of bulrush or cane.

TYPE V– Fish Lake–Open water of sufficient depth to be normally capable of supporting a permanent game fish population.

TYPE VA–Marginal Fish–Game Lake–Water depths 6-15 feet. Includes freeze-out fish lakes but only those with excessive depth for optimum game use.

SOURCE: Department of Natural Resources

TABLE 11–2

PUBLIC WATERS CLASSIFICATION
(Minimum Standards only, for Hennepin and Ramsey Counties)

	Natural Environment (NE)	Recreational Development (RD)	General Development (GD)
Lot Area*	80,000 s.f.	40,000 s.f.	20,000 s.f.
Water Frontage*	200 ft.	150 ft.	100 ft.
Building Setback from shoreline	200 ft.	100 ft.	75 ft.
Soil absorption unit setback from shoreline	150 ft.	75 ft.	50 ft.

*Applies only to newly created lots

SOURCE: Department of Natural Resources, 1972.

Determining the value of a lake for different uses is a difficult task due to the scarcity of data. The recreation value of Lake Minnetonka, for example, was estimated at 165,100 user days for ice fishing and 330,000 user days for annual non-resident boating use (26).

The Minneapolis Park Board surveys the use of city lakes it oversees. A total of 87,290 summer user/hours was recorded in 1974 for angling on seven lakes: Harriet, Nokomis, Cedar, Calhoun, Wirth, Loring and Powderhorn. Beach use was averaged for the years 1972 - 1976 at six lakes. Lake Nokomis showed the highest use with a 226,000 persons, followed by 92,000 persons at Harriet, 91,000 at Calhoun, 62,000 at Cedar, 58,000 at Wirth and 16,000 persons at Hiawatha. Average per day summer use of Minneapolis lakes in 1974 was 638 user/hours for angling, 104 user/hours for canoeing, 178 user/hours for sailing and 6,473 user/hours for beach use (26).

RIVERS CLASSIFICATION

River classification reflects the quality, and thus the use, of the water. See Plate 15 and Tables 11-3, 11-4 and 11-5. These standards are designated and regulated by the Minnesota Pollution Control Agency (MPCA).

TABLE 11–3 WATER QUALITY CLASSIFICATION OF MAJOR RIVER SEGMENTS

	WATER QUALITY STANDARDS	
RIVER SEGMENT	LIMITING STANDARDS	OTHER USES
Mississippi River		
–Source to Rum River at Anoka (Effluent Limiting)	1C, 2B, 3B	2C, 3C, 4A, 4B, 5, 6
–Rum River to St. Anthony Falls (Water Quality Limiting)	1C, 2B, 3B	2C, 3C, 4A, 4B, 5, 6
–St. Anthony Falls to Metropolitan Wastewater Treatment Plant (Water Quality Limited)	2B, 3B	2C, 3C, 4A, 4B, 5, 6
–Metropolitan Wastewater Treatment Plant to Lock and Dam No. 2 (Water Quality Limited)	2C, 3B	3C, 4A, 4B, 5, 6
Minnesota River		
–Inlet to Marsh Lake to Carver Rapids (Effluent Limiting)	2B, 3B	2C, 3C, 4A, 4B, 5, 6
–Carver Rapids to Mouth at Fort Snelling (Water Quality Limiting)	2C, 3B	3C, 4A, 4B, 5, 6
St. Croix River		
–Washington County Line to Mouth at Prescott (Effluent Limiting)	1C, 2B, 3B	2C, 3C, 4A, 4B, 5, 6
Vermillion River		
–Source to Highway 61 Bridge near Hastings (Water Quality Limiting)	2B	3C, 4A, 5, 6

SOURCE: WPC 24, 25

TABLE 11–4

EXPLANATION OF WATER QUALITY CLASSIFICATIONS–1973

USE	CLASS A	CLASS B	CLASS C	CLASS D
1. Domestic Consumption	Drinking quality maintained without any treatment	Drinking quality with approved disinfection	Drinking quality after treatment: coagulation, sedimentation, filtration, storage, chlorination	Drinking quality after treatment for Class C pre, post or intermediate treatment
2. Fisheries & Recreation	Quality permits propogation and maintenance of warm or cold water fish; suitable for all recreation including bathing	Quality permits propogation and maintenance of cool or warm water fish; suitable for all recreation including bathing	Quality permits propogation and maintenance of rough fish species suitable for bathing	
3. Industrial Consumption	Quality suitable for use without chemical treatment except softening	Quality suitable for use after moderate treatment	Quality suitable for use for cooling and materials transport without high degree of treatment	
4. Agriculture and wildlife	Quality sufficient for irrigation	Quality sufficient for use by wildlife and livestock		
5. Navigation & Waste Disposal	Quality suitable for aesthetic enjoyment of scenery and to avoid any interference with navigation or property damage			
6. Other Uses	May be established as determined necessary			

SOURCE: Pollution Control Agency, 1973.

TABLE 11–5

STREAM CLASSIFICATION BY WATER QUALITY STANDARDS*

*All other streams with a drainage area greater than or equal to 2 square miles not listed are classified as General Development.

2B
Cedar Creek
Rum River
Crooked Brook
Seelyer Brook
Ford Brook
Trott Brook
Coon Creek
Sand Creek
Diamond Creek
Elm Creek
Rush Creek
Crow River
Deer Creek
Shingle Creek
Bass Creek
Bassett Creek
Minnehaha Creek
Nine Mile Creek
South Fork—Crow Creek
Purgatory Creek
Riley Creek
Bluff Creek
Chaska Creek
Credit River
Porter Creek
Raven Stream
Sand Creek
Silver Creek
Bevens Creek
Carver Creek
Sarah Creek
Vermillion River
South Branch—Vermillion River
Cannon River
Trout Brook
Battle Creek
Silver Creek
Hardwood Creek
Clearwater Creek

2C
Pioneer Creek
Crane Creek

2C, 3B
Fish Creek
Mississippi (parts)
Minnesota (parts)

1B, 2A, 3B
Valley Branch
Eagle Creek—East Branch

1C, 2B, 3B
Upper Mississippi

2B, 3B
Lower Minnesota
Mississippi (part)

2C, 2A, 3B
Rice Creek

1B, 2B
West Branch—Sunrise River

SOURCE: Pollution Control Agency, 1973

RIVER USES

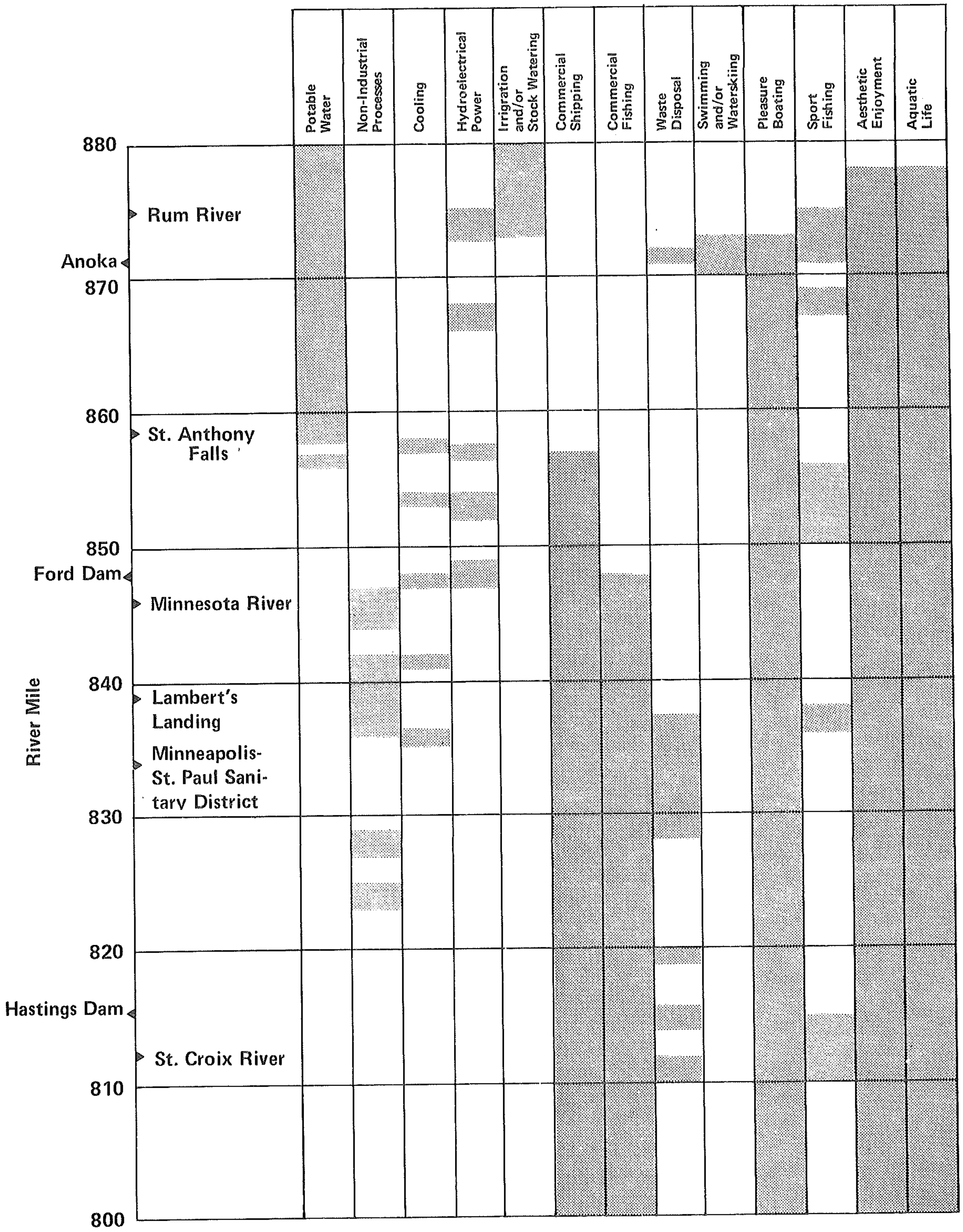
Different uses of a river necessitate different water quality requirements. For industrial processing, the water must have adequate flow rate and good quality. For industrial cooling, an adequate flow rate and good chemical quality is necessary. For navigation, a system of locks and dams regulate water flow. Sewage dilution requires large volumes of water with high oxygen content. Swimming requires high water quality with no pathogens present. For potable water, high quality water without any harmful chemicals, minerals or pathogens is necessary. Chemical parameters have been established for each type of use.

The Minnesota River is used mainly for industrial purposes. Minor purposes include stock watering and irrigation, commercial water transportation as far upstream as Shakopee, sport fishing and pleasure boating. The St. Croix also is used as a commercial waterway as far upstream as Stillwater. Other uses include irrigation, commercial and sport fishing, water skiing and pleasure boating.

Use data is also recorded for smaller rivers. The Vermillion River is used for irrigation and stock watering. Sport fishing has been observed, but the river cannot support body contact sports. The Crow River is used for irrigation and perhaps stock watering. Recreational fishing is possible, but boating areas are confined to the lower stem of the main fork, as the south fork is seasonally dry. Body contact sports are possible near the mouth of the Crow. Picnicking and camping occur along the river bank.

The Mississippi, eighty miles of which lies in the study area, is the most heavily used river in the state, as shown in Figure 11-1. Many uses are limited in certain segments by quality stipulations as shown in Figure 11-2.

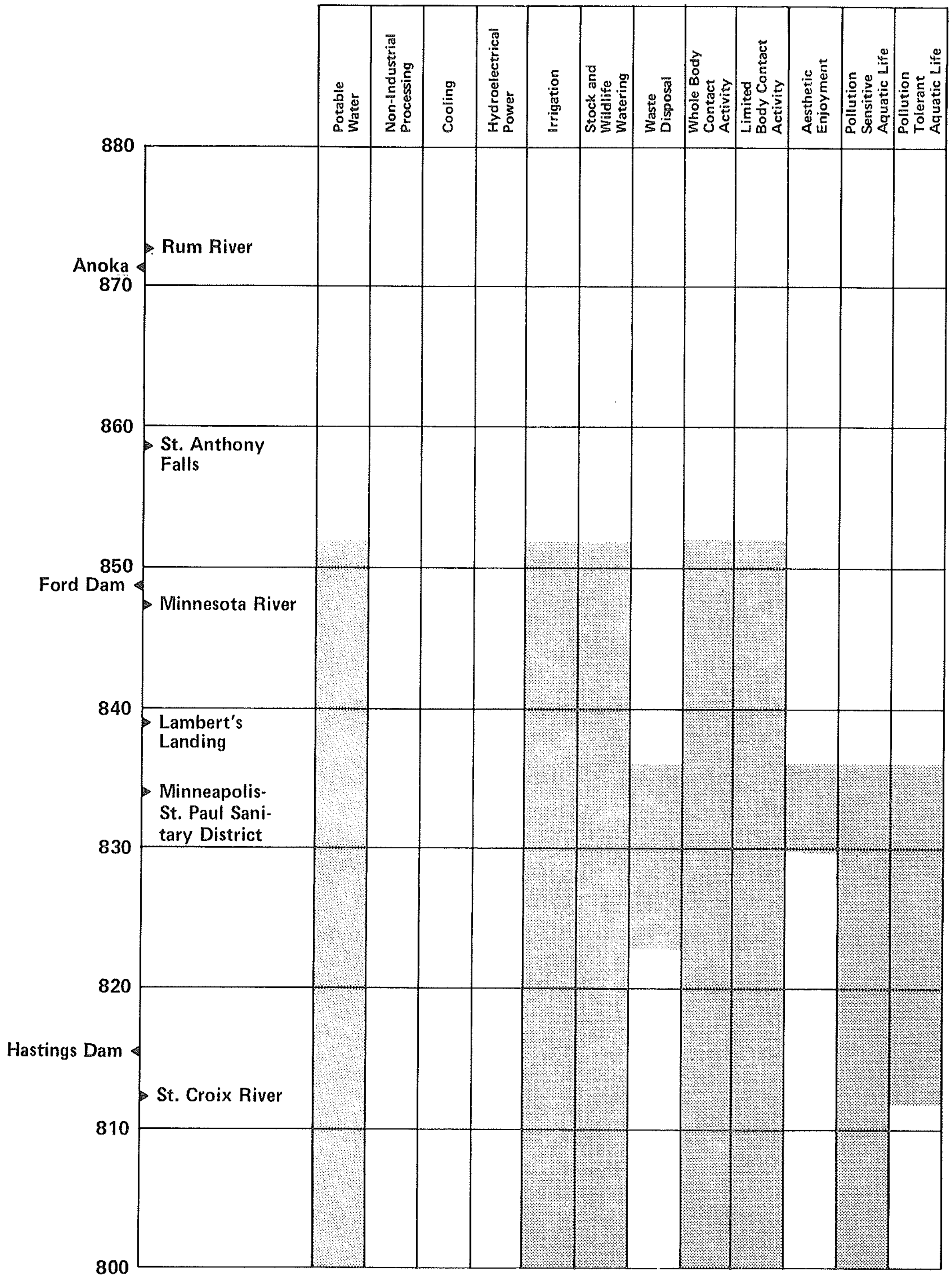
FIGURE 11–1 PRESENT WATER USES ALONG THE MISSISSIPPI RIVER



Source: (1966 FWPCA Chart revised according to 1977 Information Handbook for the Twin Cities Metropolitan Area Mississippi River Corridor Critical Area)

FIGURE 11–2

WATER USES AFFECTED BY WATER QUALITY IN THE MISSISSIPPI RIVER IN THE TWIN CITIES METROPOLITAN AREA



Bars indicate where water is unsuitable for the designated use

Source: (1966 FWPCA Chart)

Water is withdrawn from the Mississippi, Minnesota and St. Croix for use by numerous industries. Most of the uses are non-consumptive; practically all the water is returned near where it is drawn. The only difference is the recirculated water may show a change in turbidity, temperature, or chemical content which may change the oxygen-absorbing capacity of the water and thus the ability to assimilate organic loads. For locations and categories of water appropriation along the Mississippi River, see Table 11-5.

Industrial uses such as cooling, barge washing and gravel washing have seasonal impact, and consequently, require less water.

The Minneapolis Water Department pumps water for a potable water supply from the Mississippi at Fridley. In 1970, the total water pumped into the Minneapolis Water System during maximum use in July was 3,581 million gallons (MG) at an average rate of 116 million gallons per day (MGD). St. Paul withdraws most of its water from the Mississippi at Fridley with supplements from the Rice Creek Watershed. Water from the Centerville Lake chain within the watershed is stored in the Vadnais Lake System. In 1970, total water delivered to the St. Paul system, during maximum use in July, was 2,518 MG at an average rate of 81 MGD. Total water use in 1970 in the metropolitan part of the study area from both surface and ground sources was 327 MGD, 133 MGD surface water and 194 MGD groundwater. Outside the area served by the Minneapolis-St. Paul water systems, groundwater is pumped for domestic, industrial, air conditioning, commercial, irrigation and other uses. Sixty-five MGD are pumped for these uses (94).

Water is used in power generation, although hydropower plants have been gradually replaced by fuel power plants due to economic factors. The two remaining hydropower plants are at St. Anthony, UM 853.36 and at Ford Plant, UM 847.7. Steam-electric generating plants include Highbridge, Riverside and the University of Minnesota on the Mississippi River, Black Dog on the Minnesota, and the Allen S. King on the St. Croix. An overload plant is located at Inver Grove Heights on the Mississippi. North of the study area, Monticello, Elk River and the proposed Sherco facility will appropriate water - not all of which will be returned to the Mississippi. These plants withdraw large quantities of water and produce more waste heat than industrial processing industries.

Through a system of locks and dams constructed by the U. S. Army Corps of Engineers, water usage by barges for commercial shipping on the Upper Mississippi has increased. An upper lock and a lower lock and dam is located at St. Anthony Falls. Lock and Dam No. 1 located UM 847.6, and Lock and Dam No. 2 at UM 815.2, were also constructed by dredging a nine foot channel. See Plate 17 for locations of barge channels. For a summary of commodities, lockages and barges for years 1975-1977, see the computer-printout PM's available from the Corps of Engineers.

USE LIMITATIONS

Usage may be limited by waste discharged into the three major rivers from industries with direct connection to wastewater treatment plants, storm runoff and combined sewer overflows. The 1972 Federal Water Pollution Control Act created a National Pollutant Discharge Elimination System (NPDES) program to insure compliance with national water quality goals. Permits issued by the MPCA define the effluent discharge limits from point source which will not cause a violation of water quality standards (44).

Sewage from communities within the study area is treated to meet designated effluent standards at 20 plants by the Metropolitan Waste Control Commission (MWCC). The largest plant in the seven county region, Metropolitan, at UM 836.3 handles the greatest volume of wastes. Discharge from combined sewer overflows and from storm runoff are intermittent, occurring only as a response to rainfall. Currently, much of the Minneapolis sewer system has switched to separate sewers for sanitary and stormwater runoff, but St. Paul and South St. Paul are still primarily served by a combined system. As a result, at approximately 70 points along the Mississippi, there is intermittent pollution during periods of intense runoff. This water contributes to the formation of sludge near the shores and suspended solids on the riverbed and shorelines.

Water usage is disrupted by flooding. Communities built on the floodplain and subject to flood damage include Anoka, Champlin, Fridley, Minneapolis, Lilydale, St. Paul, South St. Paul, Newport and Inver Grove Heights on the Mississippi; Carver, Chaska, Shakopee and Savage along the Minnesota; Afton and St. Mary's Point on the St. Croix, Rockford along the Crow River; and Hastings along the Vermillion River. Floods often occur in the spring during winter melt off and in the fall after heavy rainstorms, especially at the confluence of major rivers. Floods destroy high-value vegetable crops in the Crow River Basin and corn, oats and hay in the Rum River Basin. Floodwater and sediment may damage urban and non-urban recreational land and facilities. Floods have occurred throughout the state in 1965 and 1969 and regionally in 1966, 1972 and 1974, causing total damage in excess of 200 million dollars (67). For floodplain management status, see Table 5–7 in Section 5–Hydrology.

PRESENT QUALITY

The water quality standards reflect the present use of the rivers (See Tables 11–3 and 11–4). A working draft of revisions of water quality was distributed by the MPCA in August 1977. It proposes a water quality system based on the water's inherent resource value and quality. Four classes are described:

Class A - outstanding national quality system waters
Class B - high resource value waters
Class C - intermediate resource value waters
Class D - limited resource value waters

Water resources classified as Class A, B or C will achieve the national goal of fishable/ swimmable waters. If approved, the new classification will replace the present use classification.

The present water quality standards designate maximum levels of acceptable biological and chemical concentrations of certain parameters including dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, total dissolved solids (TDS), and fecal coliform counts. For example, above St. Anthony Falls, no effluents can be discharged into the river that would cause disease or impair the quality of the water since it is used as a source for drinking water. Below St. Anthony Falls, no wastes containing viable pathogenic organisms can be discharged into the waters without effective disinfection. Downstream, below the Metro Treatment Plant, where effluents are added to the river, present standards encourage propagation of rough fish and non-contact recreational use.

RIVER QUALITY

The locations of the 20 water quality stations maintained by the Metropolitan Waste Control Commission are illustrated on Figure 11–3. Quality sampling of the Mississippi from 1971 to 1976 at four of these stations is shown on Figures 11-4 through 11-29. DO remained above 5 milligrams per liter (mg/1) in all but one sample (Hastings Dam, February, 1971). BOD figures generally improved in 1974, and especially during the high water flow of 1975. BOD rose dramatically in 1976 due to low flows. TDS showed increases in 1975, but lessened considerably in 1976. Turbidity measurements in 1975 and 1976 were much lower than in previous years. Fecal coliform counts indicate a slight downward trend in recent years.

The water quality of the Minnesota River improved during 1970 through 1975. DO concentrations were generally greater than 5 mg/1 indicating good water quality. BOD concentrations ranged from 0 to 10 mg/1 with the average at 4 to 6 mg/1. Turbidity levels decreased substantially after 1974 compared with previous high values. Since 1974, peak values ranged between 50 and 100 Jackson Turbidity Units (JTU) with the mean for 1974 - 1975 less than 50 JTU. Fecal coliform counts were high from 1970 to early 1974, especially during 1973. However, since 1974 fecal coliform counts were less than 200 most probable number per 100 milliliters (MPN/100 ml). See (47) for data.

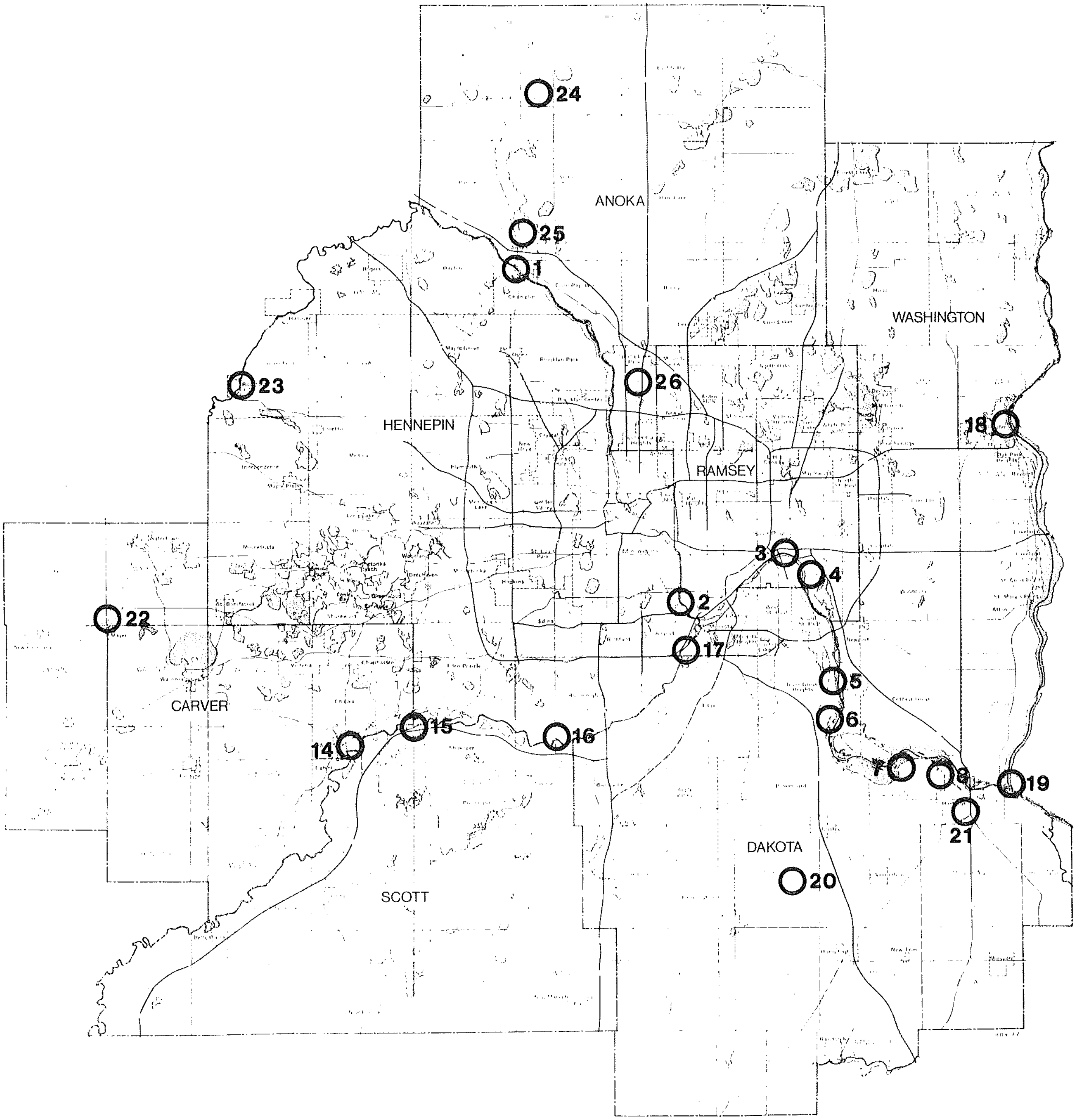
The water quality of the St. Croix River was excellent during the period of record as DO concentrations remained greater than 5 mg/1 at all times. BOD values were consistently low, turbidity was usually much less than 25 JTU and fecal coliform organisms were observed well below 200 MPN/100 ml consistently. See (47) for data.

TABLE 11–5 WATER APPROPRIATION POINTS ON THE MISSISSIPPI RIVER (23)

RIVER MILE	NAME	TYPE OF USE	QUANTITY
Approx. 880 (NB)	Seeber L. Parker	Irrigation	13.3 MG/Yr.
876.65 (NB)	Joseph E. Hipp	Irrigation	13.3 MG/Yr.
873.25 (EB)	Leeds D. Cutter	Irrigation	2.5 MG/Yr.
862.9 (EB)	City of St. Paul	Municipal Water	80 MGD
858.8-895 (EB)	City of Minneapolis	Municipal Water	75 MGD
857-857.5 (EB)	Minneapolis Park Board	Water Supply to City Lakes During May, June and July only	17 MGD
853.85 (EB)	NSP Southeast Steam Plant	Turbine	
853.75 (EB)	NSP Hennepin Island Hydro Plant	Turbine	
853.7 (EB)	B. J. Nelson Mfg.	Cooling	10 MGD
853.5 (EB)	NSP Lower Dam Hydro Plant	Turbine	
847.8 (EB)	Ford Motor Co.	Cooling	0.9 MGD
840.7 (NB)	NSP High Bridge Plant	Cooling	339 MGD
836.7 (EB)	Vy Lactos Northern	Cooling	0.9 MGD

MGD = Million gallons per day
NB = North Bank
EB = East Bank
WB = West Bank

FIGURE 11–3 MWCC WATER QUALITY STATIONS (49)



SOURCE: 1975 Water Quality Report

MISSISSIPPI RIVER

1. UM 871.5 Anoka
2. UM 847.7 Ford Dam
3. UM 839.1 St. Paul—Lambert's Landing (LL)
4. UM 836.8 St. Paul—Industrial Molasses (IM)
5. UM 830.8 Inver Grove
6. UM 826.6 Grey Cloud
7. UM 815.31 Hastings Dam
8. UM 813.9 Hastings Bridge
9-13 Not in Metropolitan Area

MINNESOTA RIVER

14. Mi. 36.0 Jordan
15. Mi. 25.1 Shakopee
16. Mi. 14.3 Savage
17. Mi. 3.5 Fort Snelling

ST. CROIX RIVER

18. SC

18. Sc. 23.3 Stillwater
19. SC

18. Sc. 23.3 Stillwater
19. Sc. 0.3 Prescott

VERMILLION RIVER

20. VR 21 Empire
21. VR 95 Hastings

CROW RIVER

22. CR 35 Mayer
23. CR 22 Rockford

RUM RIVER

24. Rum 12 St. Francis
25. Rum 0.6 Anoka

RICE CREEK

26. RI 1 Fridley

FIGURE 11–4

TEMPERATURE AT ANOKA 1971-1976

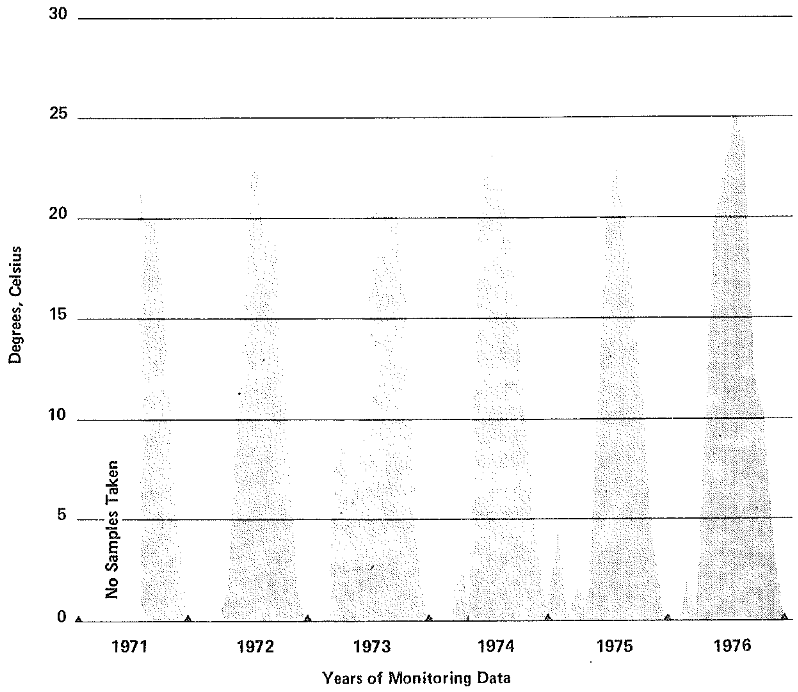


FIGURE 11–5

TEMPERATURE AT FORD DAM 1971-1976

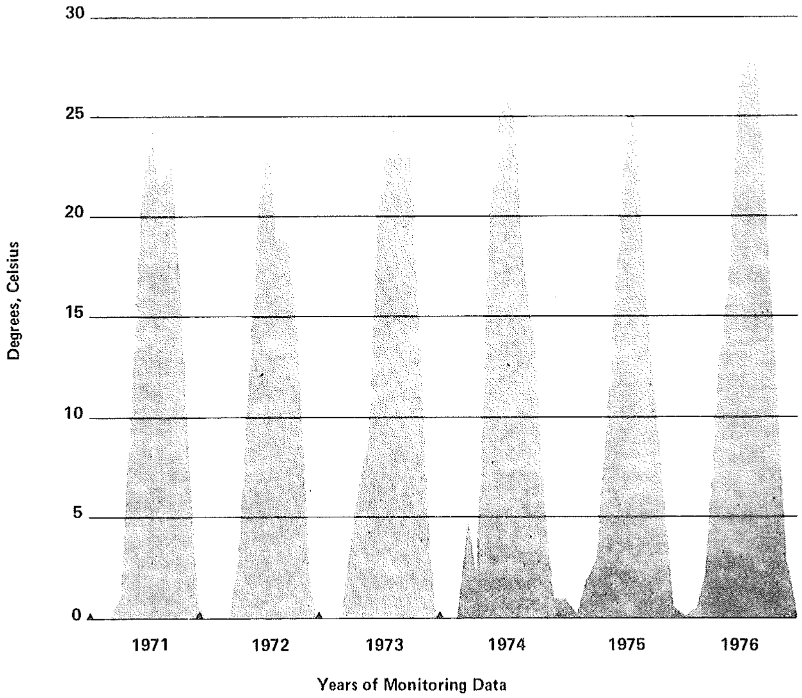


FIGURE 11–6

TEMPERATURE AT ST. PAUL–LAMBERT'S LANDING 1971-1976

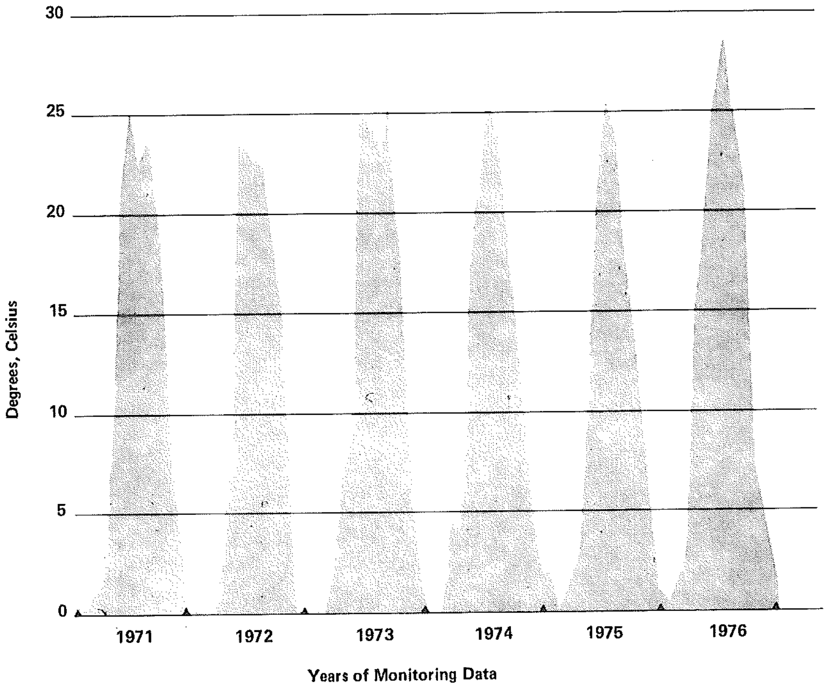


FIGURE 11–7

TEMPERATURE AT HASTINGS DAM 1971-1976

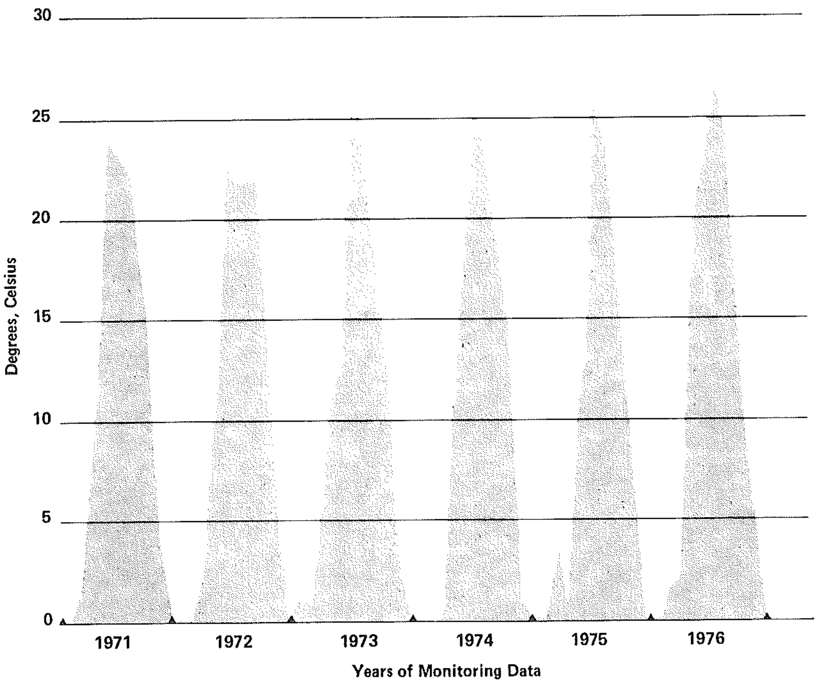


FIGURE 11–8 MISSISSIPPI RIVER D.O.–1975 (HIGH WATER YEAR)

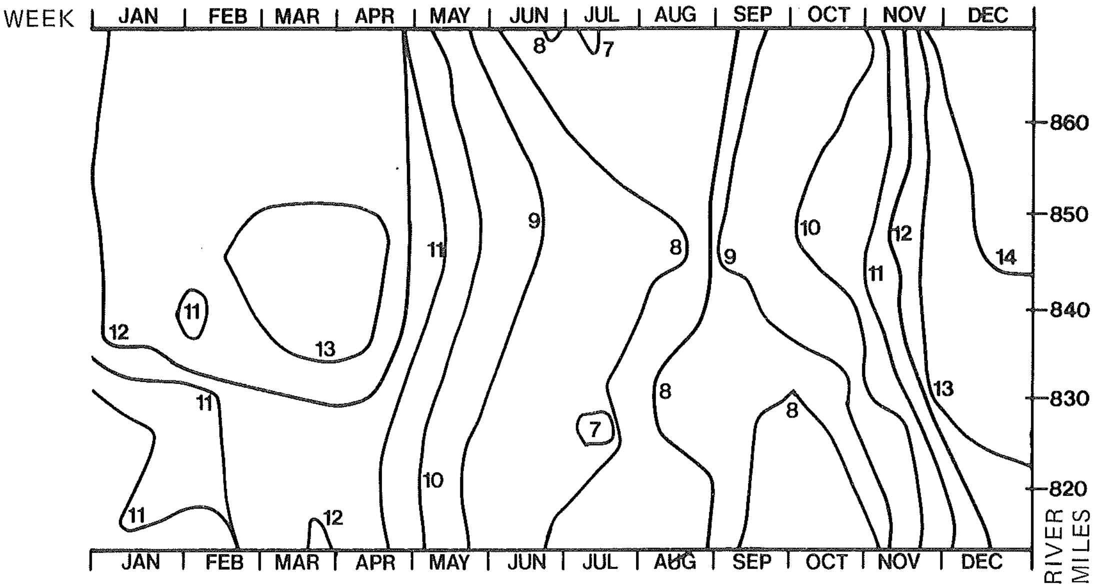


FIGURE 11–9 MISSISSIPPI RIVER D.O.–1976 (LOW WATER YEAR)

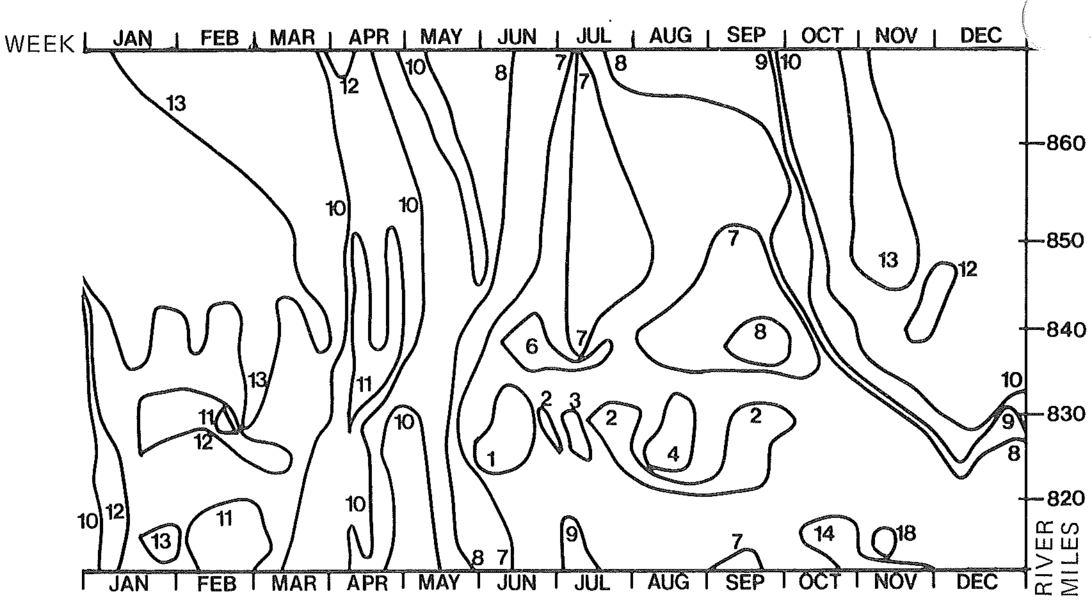


FIGURE 11–10 DISSOLVED OXYGEN CONCENTRATIONS ON THE MISSISSIPPI RIVER

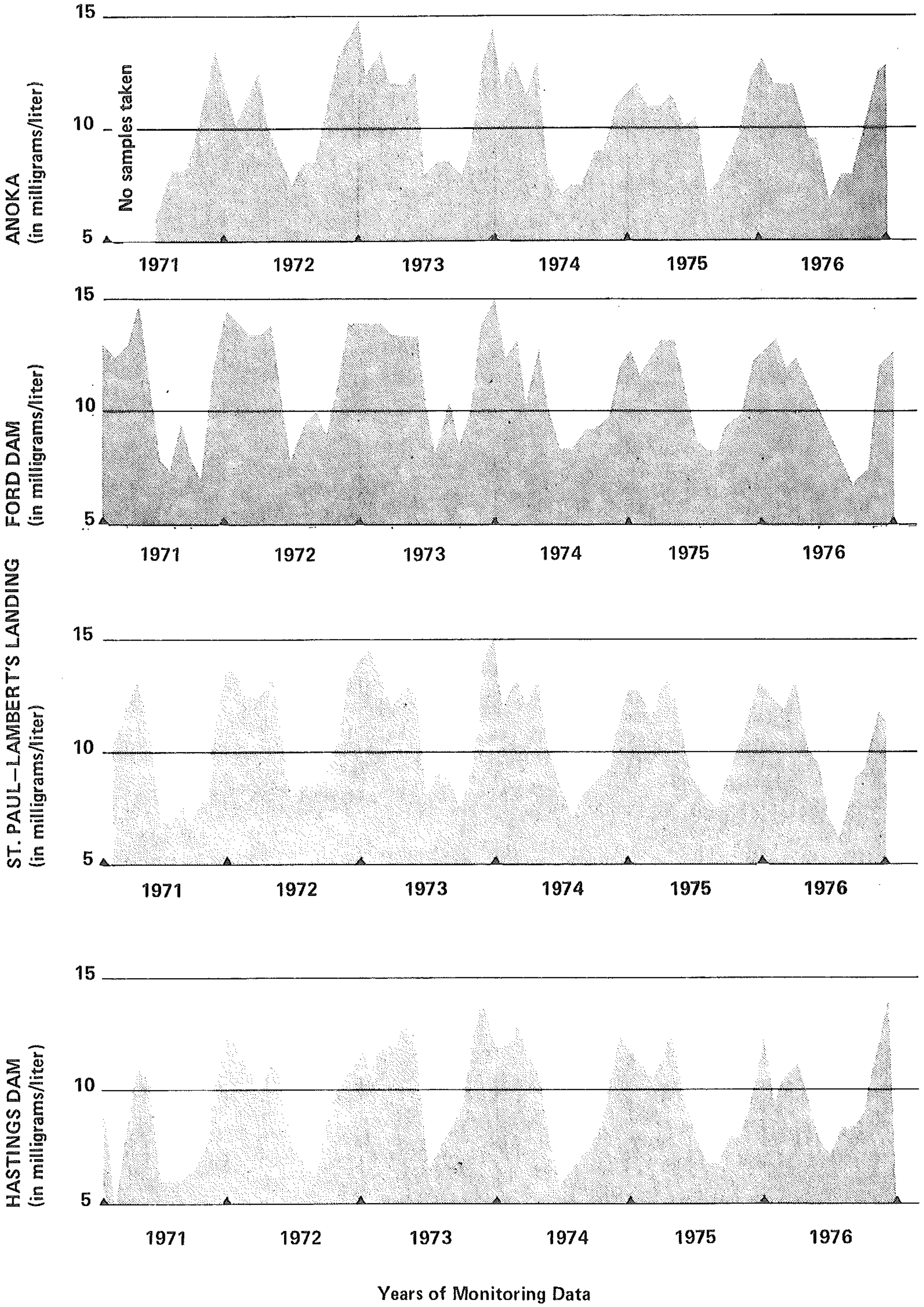


FIGURE 11–11 BIOCHEMICAL OXYGEN DEMAND (BOD) 1971-1976

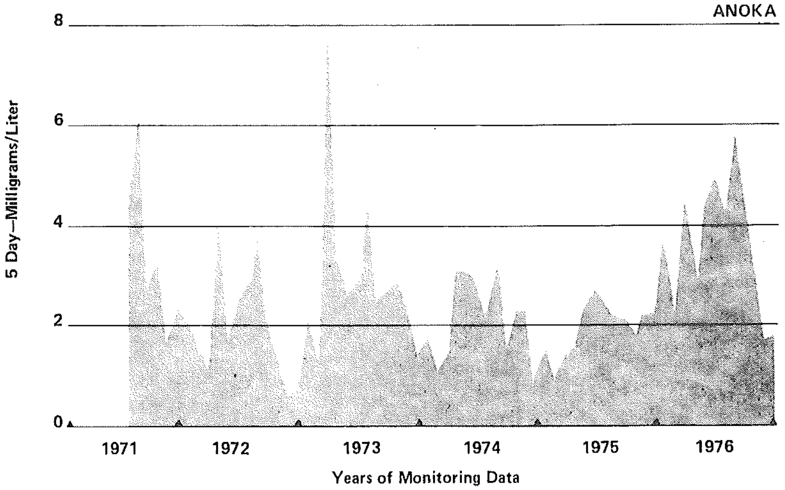


FIGURE 11–12 BIOCHEMICAL OXYGEN DEMAND (BOD) 1971-1976

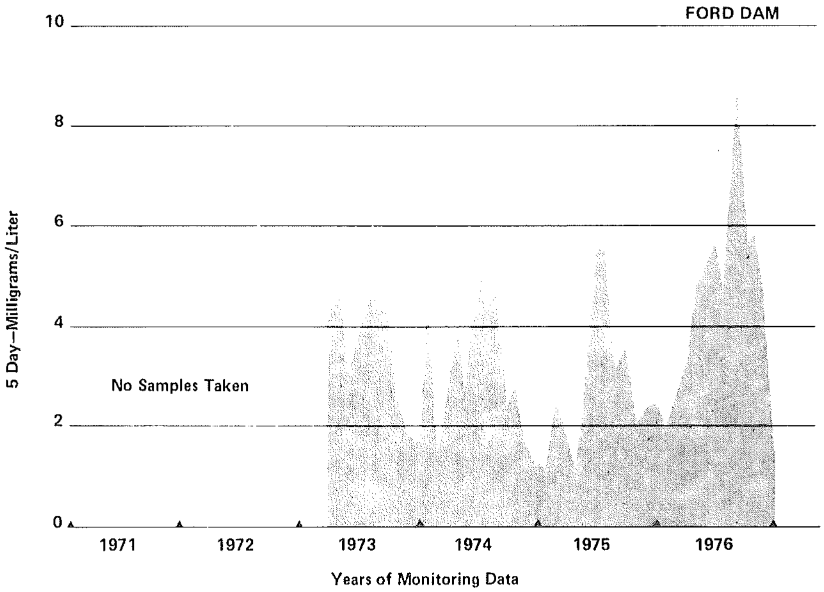


FIGURE 11–13

BIOCHEMICAL OXYGEN DEMAND (BOD) 1971-1976

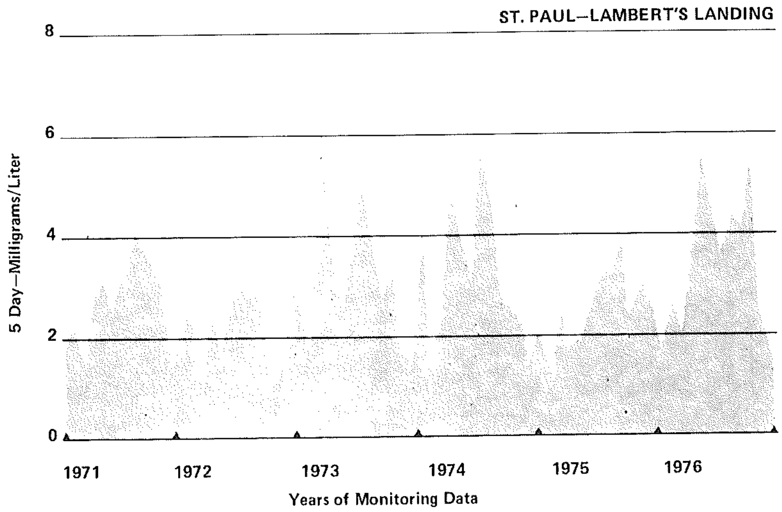


FIGURE 11–14

BIOCHEMICAL OXYGEN DEMAND (BOD) 1971-1976

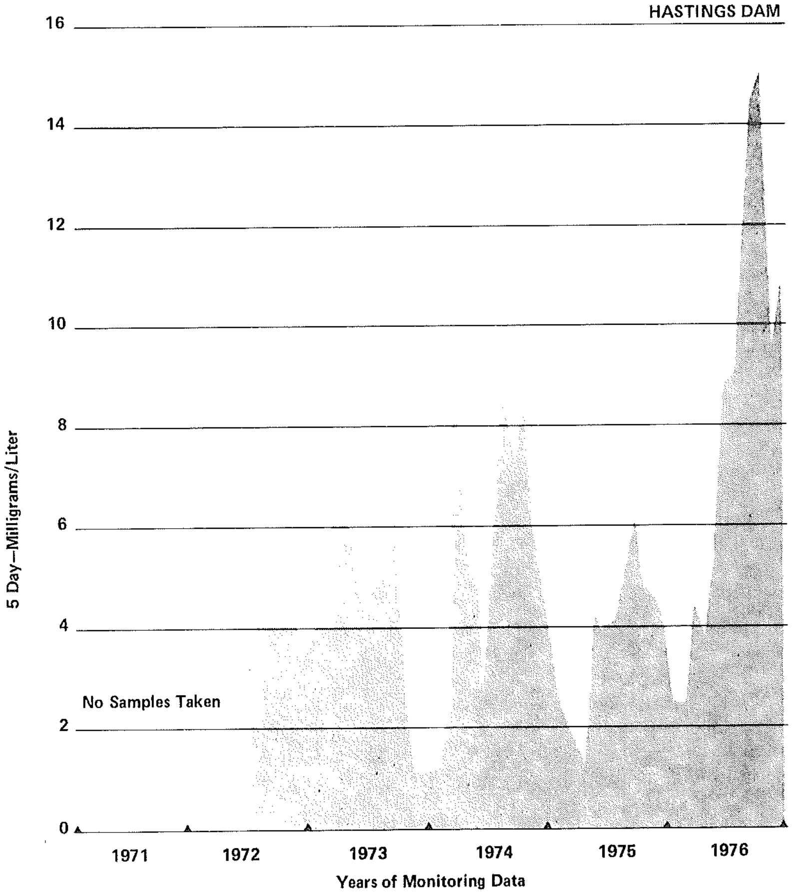


FIGURE 11–15 TOTAL DISSOLVED SOLIDS 1972-1977

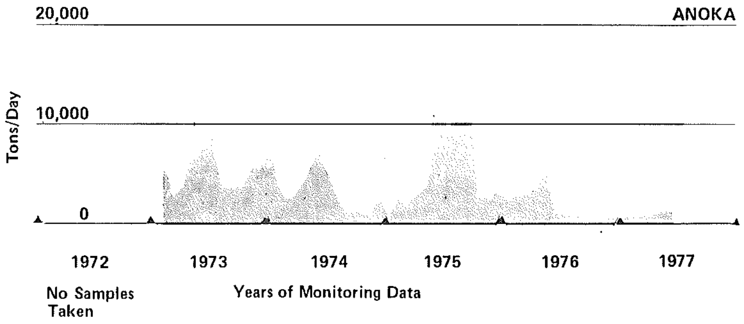


FIGURE 11–16 TOTAL DISSOLVED SOLIDS 1972-1977

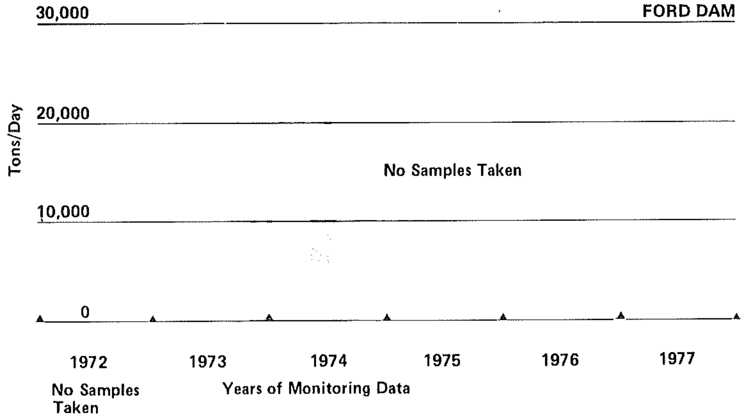


FIGURE 11–17 TOTAL DISSOLVED SOLIDS 1972-1977

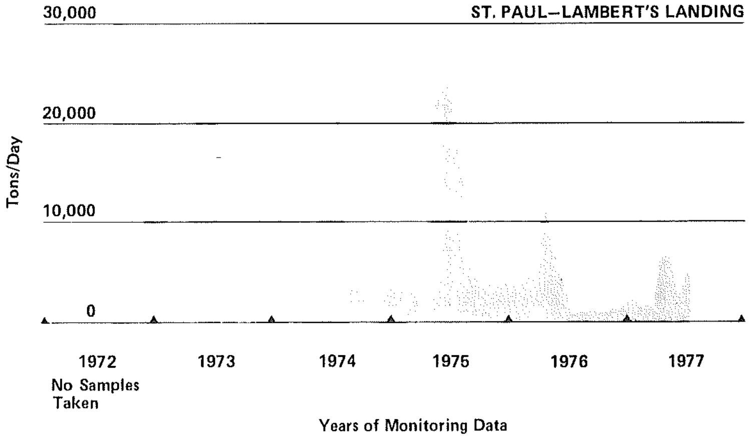


FIGURE 11–18 TOTAL DISSOLVED SOLIDS 1972-1977

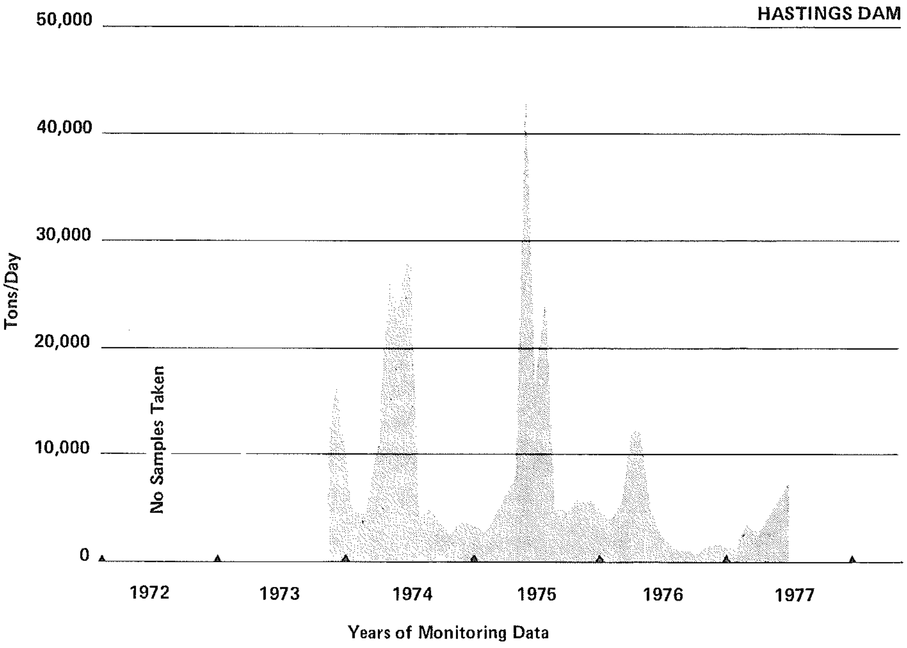


FIGURE 11–19

TURBIDITY 1971-1976

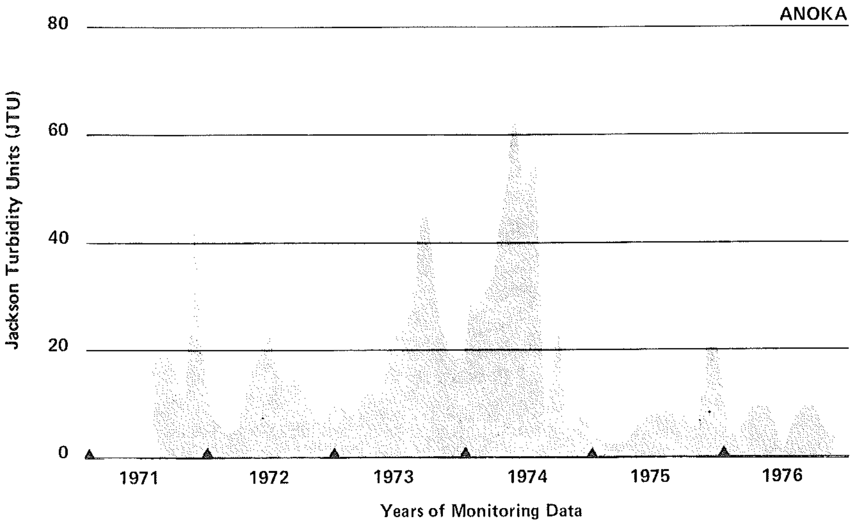


FIGURE 11–20

TURBIDITY 1971-1976

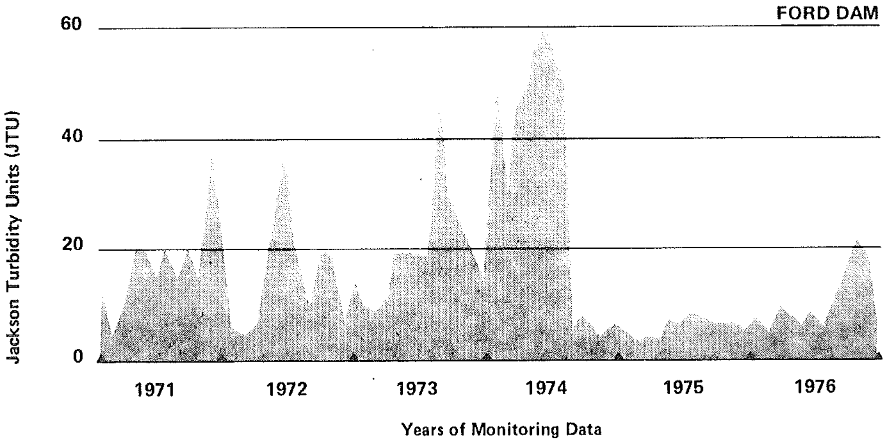


FIGURE 11–21

TURBIDITY 1971-1976

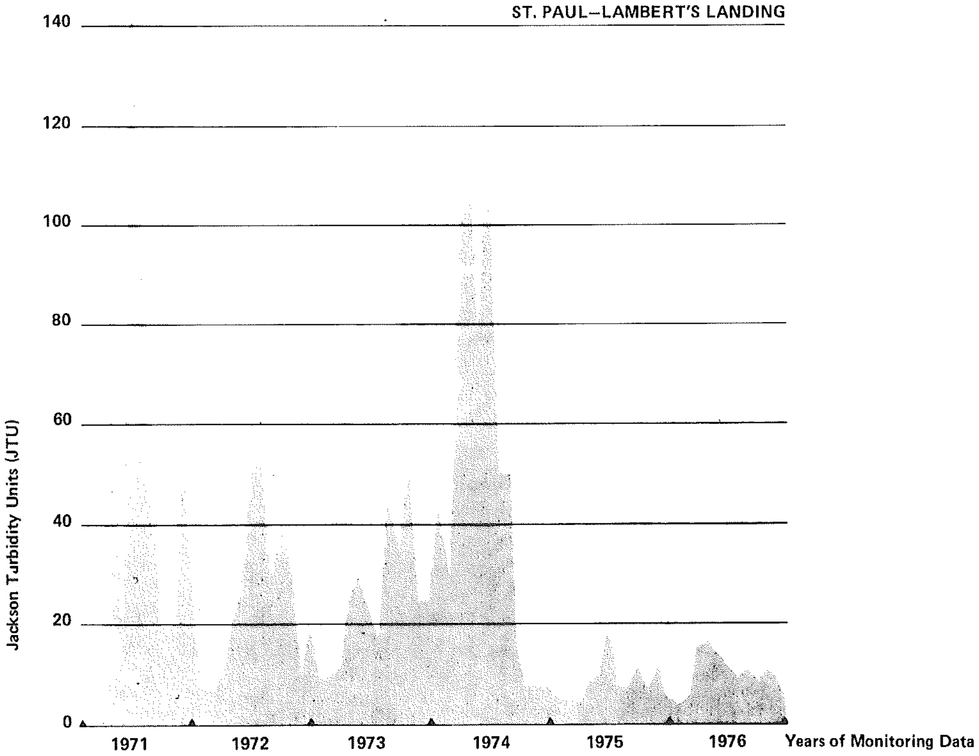


FIGURE 11–22

TURBIDITY 1971-1976

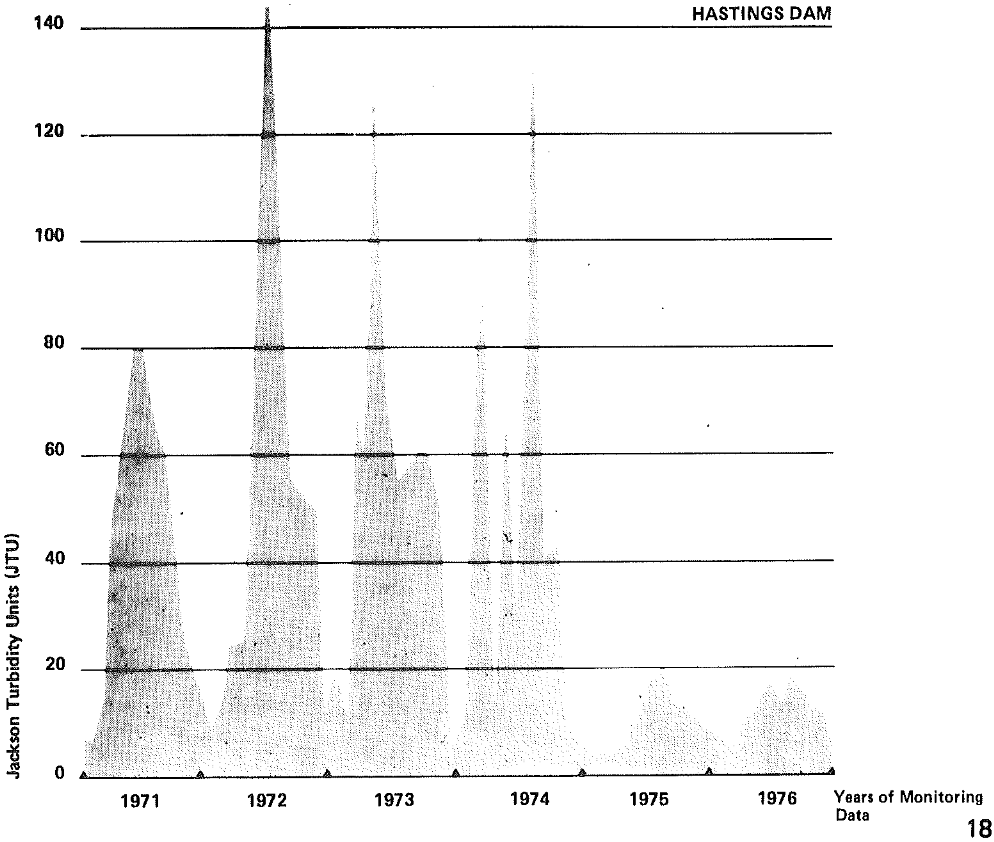


FIGURE 11–23 FECAL COLIFORM AT ANOKA DAM

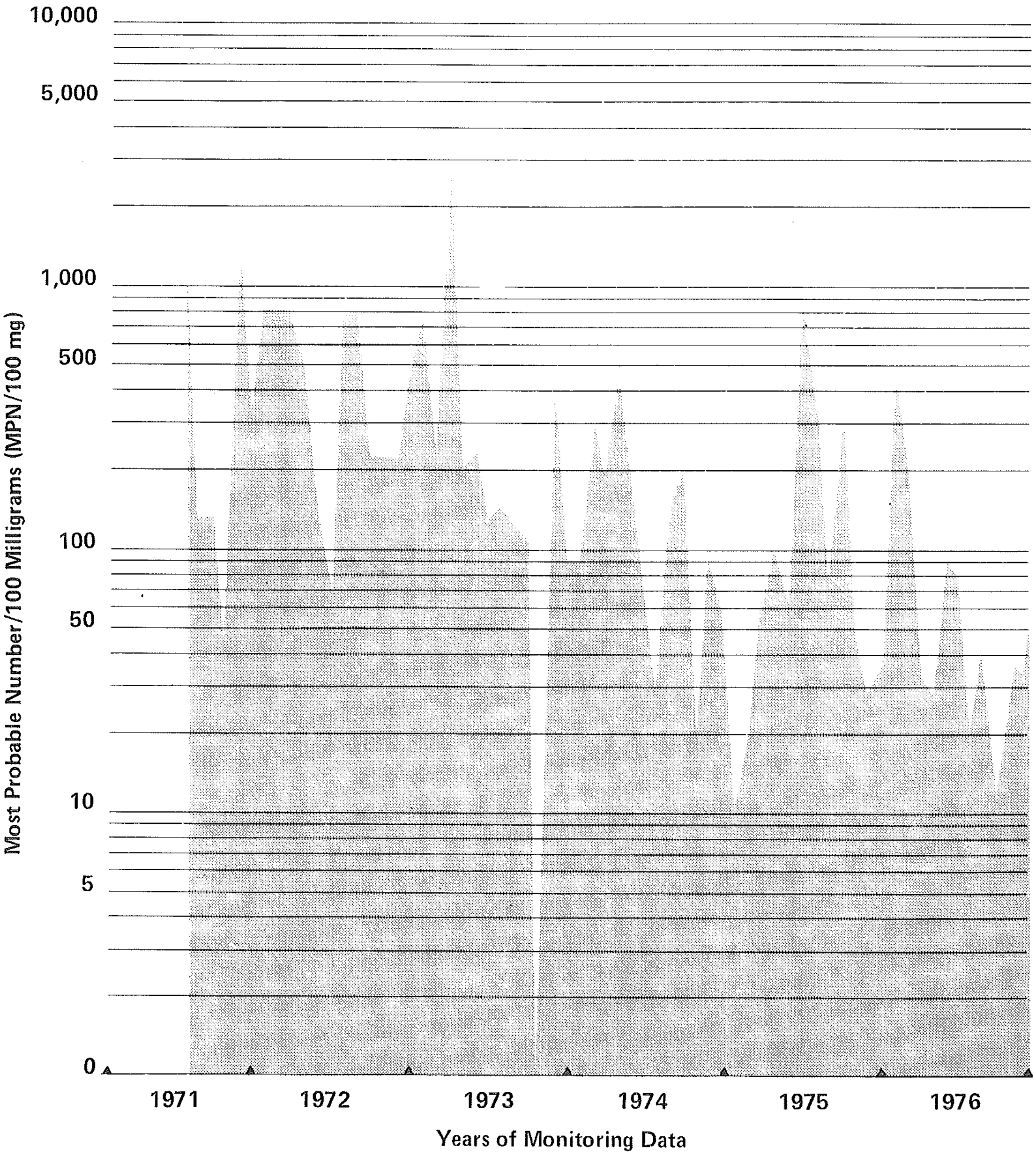


FIGURE 11–24 FECAL COLIFORM AT FORD DAM

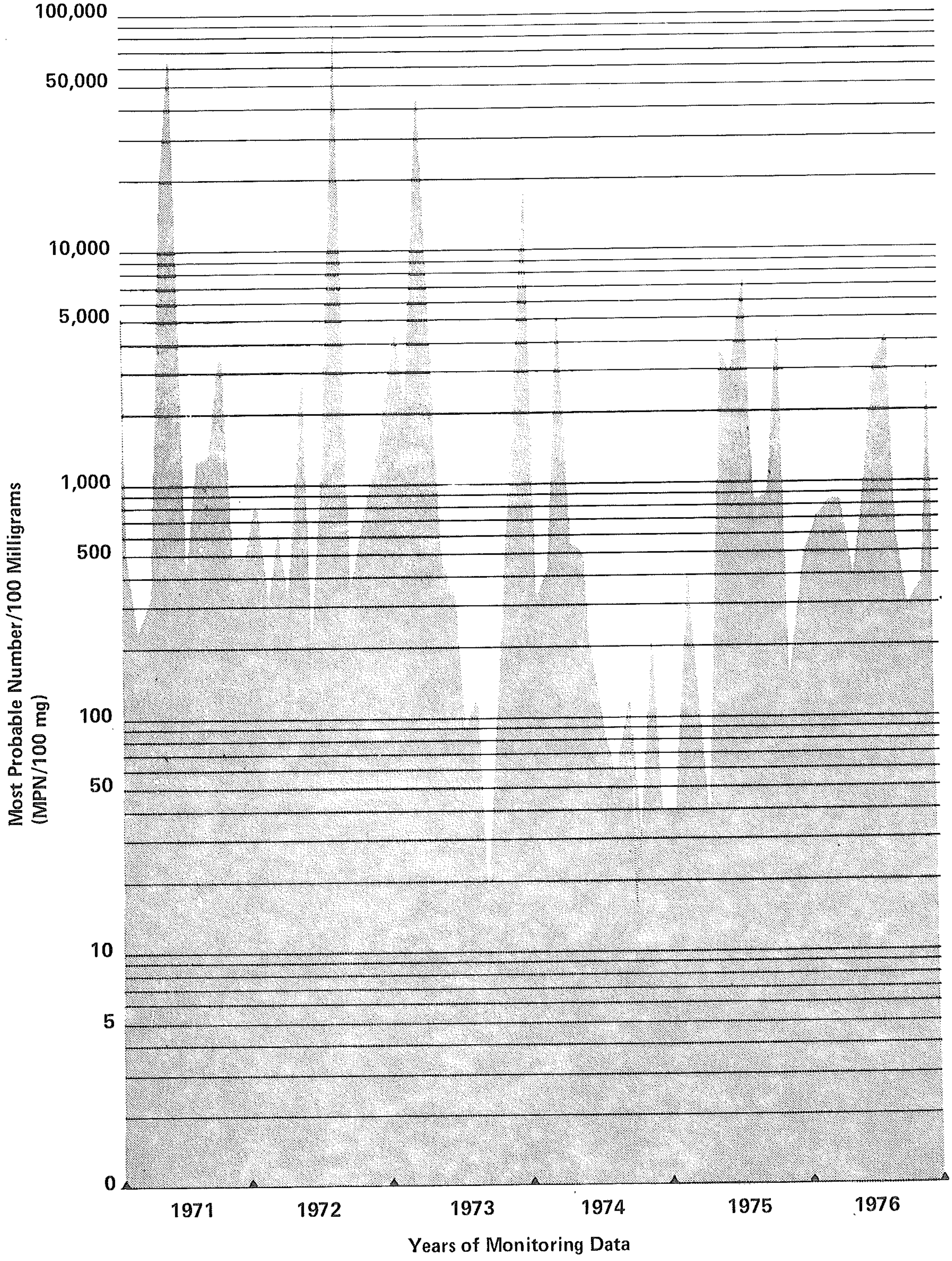


FIGURE 11–25 FECAL COLIFORM AT ST. PAUL–LAMBERT'S LANDING

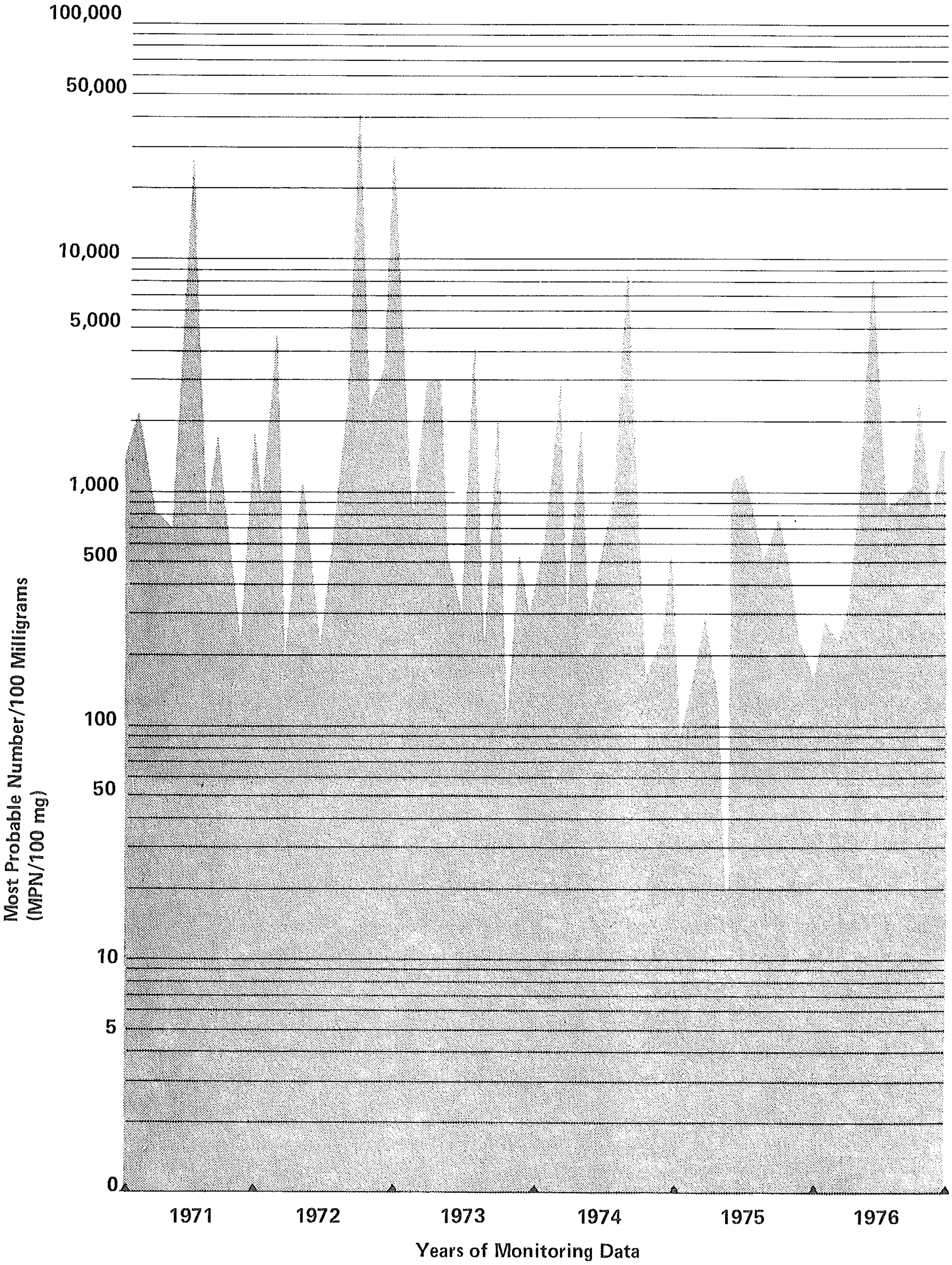
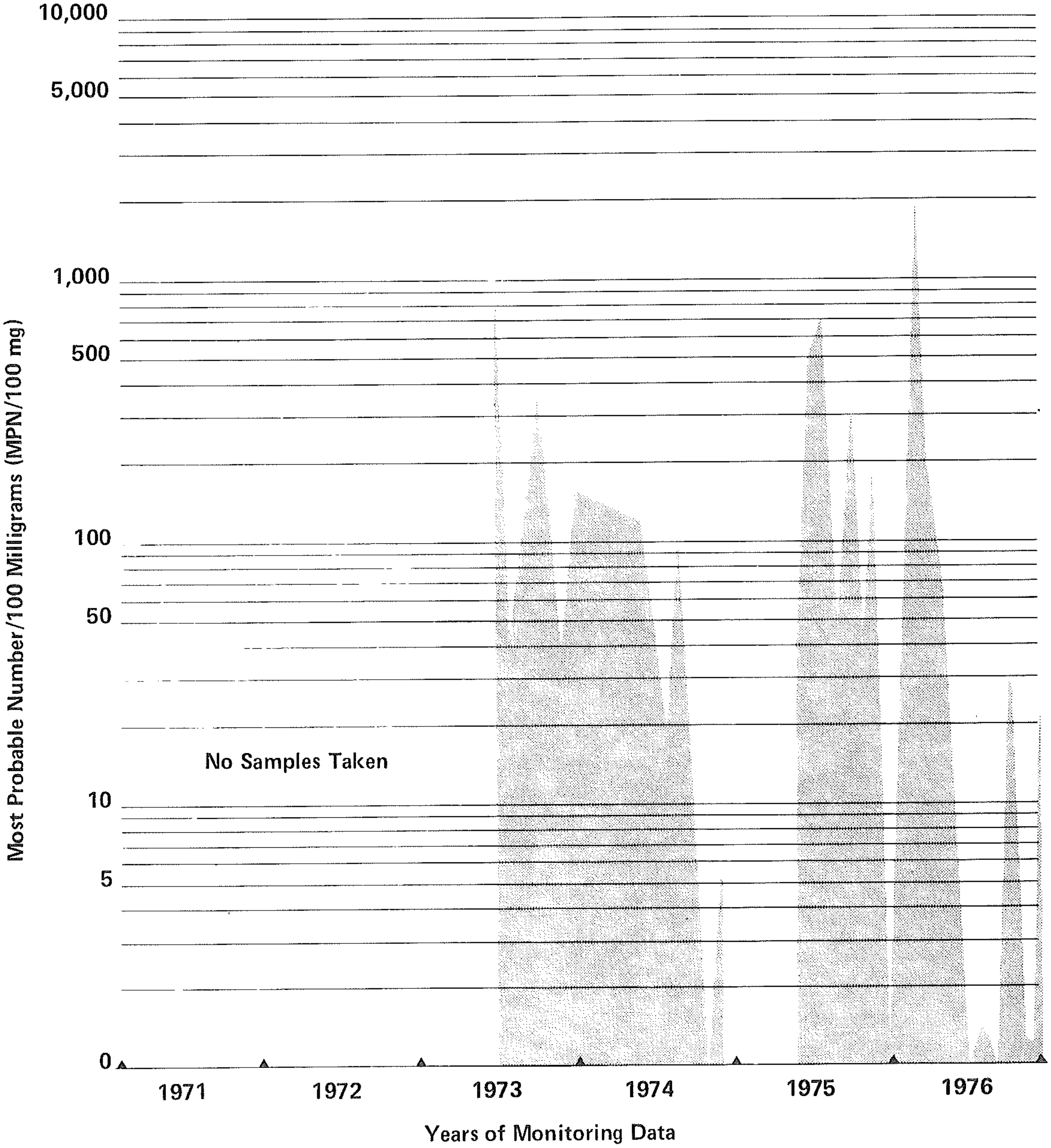


FIGURE 11–26 FECAL COLIFORM AT HASTINGS DAM



QUALITY AT DESIGNATED STATIONS

Data from 1971 to 1976 was compared at four stations on the Mississippi: Anoka, St. Paul - Ford Dam, St. Paul - Lambert's Landing, and Hastings Dam. Measurements of water quality included the parameters of temperature, DO, BOD, TDS, turbidity and fecal coliform counts, as already shown in Figures 11-4 through 11-26. Upstream at river mile UM 871.5, data from the Anoka station reflects headwater quality. Downstream at UM 847.7—Ford Dam, changes in point source inputs are reflected in addition to the DO concentration in the river prior to reaeration at the dam. At UM 839.1—Lambert's Landing, changes in water quality due to metropolitan area non-point source inputs are reflected. At UM 815.3—Hastings Dam, the DO concentration in the river prior to reaeration at the dam and the DO recovery rate through the pool are reflected.

Within the study area, there are 100 municipal dischargers, 142 industrial dischargers and 8 municipal water treatment plants. Table 11-6 lists the major waste dischargers on the Mississippi.

TABLE 11–6 MAJOR WASTE DISCHARGERS (23)

RIVER MILE	NAME OF DISCHARGERS	PRESENTLY DISCHARGED QUANTITY MGD
871.6 (EB)	Anoka WWTP	1.9
857–857.5 (EB)	NSP Riverside Plant	614.0
850.3	Action Construction Co.	0.7
840.45 (EB)	NSP Highbridge	294.4 in August
835.7 (EB)	Vy Lactus Northern Inc.	0.9
833.4–833 (WB)	Stockyard Complex	218.0
	1. Swift Chemical	0.62
	2. South St. Paul Union Stockyard	0.05
	3. South St. Paul Armour Co.	1.8
829.7	Northwestern Refining	1.4
825.0 (EB)	J. L. Shiely Company	0.43
824.4 (WB)	Koch Refining Company	4.3
824.0 (WB)	St. Paul Ammonia Company	0.6
823.3 (WB)	Rosemount WWTP	0.6
818.6 (NB)	Cottage Grove WWTP	10.2
817.2 (NB)	3-M Chemolite Plant	5.3
813.8 (SB)	Hastings WWTP	1.3

MGD = Millions gallons per day
EB = East Bank
NB = North Bank
WB = West Bank
SB = South Bank

An indication of trends for the chemical and biological parameters previously mentioned is useful in projecting long range use. It must be noted, however, that data from 1975, a year of unusually high stream flow, may contrast sharply from data for 1976, a year of unusually low stream flow. With low flow, the river has less capacity to assimilate the discharged pollutional load. Data from the high and low flow years may represent the extreme points on the graph.

Each station from 1971 to 1976 shows DO concentrations consistently at or above the 5 mg/l level established by the MPCA as a standard of good water quality. At least 5 mg/l of DO is necessary to support aquatic life and prevent nuisance conditions from the decomposition of sewage and industrial wastes. For many industrial uses of water, zero DO is desirable as a means of inhibiting corrosion, especially in cooling water or in boiler water. DO concentrations were observed to drop in times of low flow. Figures 11-9 and 11-10 show isopleth contours of DO ranges during the extreme conditions of 1975 and 1976 along the entire reach of the river. In August, 1975, the lowest point of the dissolved oxygen sag (7 mg/1) was recorded at Grey Cloud Station, located in the river reach where the MWTP discharges the majority of its load. Its impact is apparent even during this high flow year. Further downstream, DO levels increased. In 1976, DO plunged as low as 1 mg/1 below the MWTP, comparable to the low figure of 1971. DO contours encompassed smaller areas in 1976 and ranged from highs of 18 parts per milliliter (ppm) to lows of 1 ppm. However, no fish kills nor odor problems were recorded along any of the reaches.

Temperature affects the amount of DO that water can hold, which thus influences the water's suitability for aquatic life. The oxygen demand made upon the water due to the rate of organic bacterial decomposition is also affected in addition to the palatability of water, water treatment processes and the value of water for industrial uses such as cooling. At each station, the temperature fluctuated near 25^{o} C. However, in 1976, each station showed an increase in the temperature peak.

Total dissolved solids data varies but indicates a downward trend. This trend is consistent with the tightening controls on wastewater treatment plants instituted by the 1974 National Pollutant Discharge Elimination System Program. As of January 1, 1975 permits issued by the MPCA were in effect for all wastewater treatment plants. The standards indicate present practical effluent discharge levels, and designate improved standards to be reached by 1979. 1980. In 1976, the MWTP effluent quality deteriorated to the 1972 level, due to increased volume of solids and breakdown of equipment. This was reflected in the high concentrations at Hastings Dam station.

Turbidity concentrations increased at each station located further downstream. High turbidity figures can be aesthetically undesirable for recreational use and palatability of water. Turbidity can interfere with industrial processes such as laundering, bottling beverages, brewing, the production of various textiles, and pulp and paper. It can be lethal to fish life at extremely high concentrations, interfere with biological productivity and may modify the temperature structure of ponds. 1975 levels at each station dropped dramatically below the standard 25 JTU level. BOD predictably rose in 1976 and dropped in 1975. The highest demand was recorded at Hastings Dam, as a result of the discharges upstream.

Fecal coliform counts varied. This data along with other biological data, sanitary surveys and chemical analyses of the water are necessary to gauge the "swimmability" of waters. In the Twin Cities Metropolitan segment of the Mississippi River and along the entire Crow River, swimming is not advisable due to bacterial contamination. In the metropolitan area, the high fecal coliform levels are caused primarily by urban runoff, combined sewer overflows, point sources such as the MWTP and industrial discharges, and tributary runoff, mainly by the Minnesota River. Only at the Anoka station are concentrations low enough to advise swimming. Lakes in the area are generally more suitable for swimming.

Quality and use are upset when harmful water chemicals are discovered. In 1975, polychlorinated biphenols (PCB's) were detected in water at low levels in the Rum River at its confluence with the Mississippi River, and in the Mississippi River at the Lowry Street

Bridge. The mean concentration of PCB's in rough fish fillets taken from the Mississippi River exceeded the Food and Drug Administration (FDA) action level of 5 mg/km, so a consumption advisory of one meal per week of rough fish was issued. This affected private parties with catches of carp and channel catfish on the Mississippi River from St. Anthony Falls to the outlet of Lake Pepin and on the Minnesota River from Mankato to its confluence with the Mississippi. Fish samples taken from the St. Croix River did not exceed the FDA action level. Additional monitoring of fish in the Mississippi River by the PCB task force in 1976 showed no change from the hazardous 1975 level; more sampling is planned in spring 1978. The task force concluded that the PCB pollution problem of the Mississippi River would linger on for many years; there is no one main source of group of input sources (55). A proposed limitation by the FDA in 1977 of 2 ppm of PCB per pound of rough fish taken could prove detrimental to the commercial fishing industry.

WATER QUALITY WITH NUCLEAR PLANTS

At the Monticello Nuclear Plant, which lies 17 miles north of the study area on the Mississippi, wastes have been monitored from 1969 - 1976 by Northern States Power (NSP) to determine downstream effects. The plant appropriates and consumes ground and surface waters, and injects heat to the river. Three miles downstream, in concentrations less than the approved Atomic Energy Commission (AEC) license limitations, small quantities of radioactive material are released into the river. After treatment, the plant releases minute concentrations of chemical wastes to the river (48, 82).

The average mercury values for all fish collected from DNR samples at Monticello during 1970-1973 were respectively .95, .51, .25 and .51 ppm. Since .5 ppm is designated as the FDA action level, the DNR included Monticello in the river stretch from which consumption of fish was recommended to be limited to one meal a week. Preliminary reports indicated only a slight increase in temperature of the water discharged to the stream.

The consumptive use of water occurs in the cooling towers of the plant's water circulation system. These towers are used when the stream flow is insufficient to supply adequate cooling water; the temperature rise of the water is limited. A permit issued by the Water Pollution Control Commission limits the thermal temperature of the discharged water. The cooling towers are not operated in winter, thus enhancing the opportunity for recreational fishing and decreasing the ice jams in the spring.

Ecological change caused by the plant was monitored by NSP during the first six months of 1971 and compared with data from 1968, 1969 and 1970. NSP concluded that the influence of heat had not exceeded the effect of natural environmental changes during the first six months of operation. NSP has continued its annual monitoring studies, including 1976. (82)

NSP has monitored the Allen S. King steam-electric plant on mile 22 of the St. Croix since it began operations in 1968. Although preliminary indications do not reveal any significant pollutional impacts, restraint is urged in premature evaluation of the data (3).

Thermal pollution is detrimental in several ways. First, thermal heat can raise water temperature to such an extent that the water may not be able to be used downstream for cooling purposes. Second, certain aquatic life may be adversely affected. Last and most important the thermal effect may lower the saturation level of DO while at the same time increasing the speed with which BOD is exerted on the stream water. This decreases the ability of the stream to safely handle BOD loads imposed on it.

The Federal Waste Pollution Control Act Amendments of 1972 set a 1985 goal of "zero waste discharge" into public waters. This may alter the future water quality. The Act also establishes an Interim level of water quality by July 1, 1983, that provides for protection of fish, shellfish, wildlife and recreation. The MPCA is charged with implementing these regulations, with the assistance and guidance of the United States Environmental Protection Agency (U.S. EPA).

LAKE QUALITY

Eutrophication is the natural aging process of lakes. Studies of some metropolitan area lakes, however, show that this process is artifically speeded by man to such an extent that the quality of the lake decreases and drastically limits the uses of the water. The EPA, under the National Eutrophication Survey program, has reported on White Bear and Spring Lakes (Ramsey and Washington Counties), Lake St. Croix and Forest Lake (Washington County), Lake Minnetonka and Lake Calhoun (Hennepin County). Of these lakes, only White Bear is not eutrophic.

Some indications of fertility are shown by readings of total nitrogen, total phosphorus, alkalinity and transparency. Established levels of fertility of two chemical parameters have been listed in Tables 11-7 and 11-8.

TABLE 11–7

RANGES OF TOTAL PHOSPHORUS CONCENTRATIONS

0.002	–	0.02	Low fertility. Usually very soft waters with sparse plant growth.
0.021	–	0.05	Moderate fertility. Fairly clear water with good growth of submerged plants, unless the water is brown.
0.051	–	0.1	Good fertility. The normal range in morainic lakes. Growth of submerged plants is often to 12 to 15 feet. Moderate algal blooms.
0.1+			Very fertile, often with objectionable algal blooms, especially if rough fish are present (bullheads and carp).

SOURCE: Agricultural Extension Service Publications, 1975

TABLE 11–8

RANGES OF INORGANIC NITROGEN TO SOLUBLE PHOSPHORUS RATIO

Ratio less than 9:l	–	13:1	Nitrogen limited, eutrophic lake.
Ratio between 9:1	–	13:1	Phosphorus limited, mesotrophic or oligotrophic lakes.
Ratio greater than 13:1			Both nitrogen and phosphorus contributing to algal growth.

SOURCE: Minnesota Pollution Control Agency, 1977.

TABLE 11–9

PHOSPHORUS CONCENTRATIONS (ppm or mg/l)

20	=	Average phosphorus content of septic tank effluent.
.218	=	Mean Total Phosphorus on Spring Lake (Fall, 1972)
.127	=	Mean Total Phosphorus on Lake Calhoun (Fall, 1972)
.065	=	Mean Total Phosphorus on Lake Minnetonka (Fall, 1972)
.031	=	Mean Total Phosphorus on Lake St. Croix (Fall, 1972)
.016	=	Mean Total Phosphorus on Forest Lake (November, 1972)
.013	=	Mean Total Phosphorus on White Bear Lake (Fall, 1972)
.010	=	Level critical for nuisance algal growth.
.005	=	Concentration needed for algal growth.

SOURCE: National Eutrophication Survey, 1975.

TABLE 11–10

TOTAL INORGANIC NITROGEN TO SOLUBLE PHOSPHORUS RATIO (ppm to mg/l)

8:1	Ratio on Forest Lake (June, 1972).
11:4	Mean on Spring Lake (Fall, 1972).
13:4	Mean on White Bear Lake (Fall, 1972).
14:5	Mean on Lake Minnetonka (Fall, 1972).
17:1	Mean on Lake St. Croix (Fall, 1972).
17:1	Ratio on Forest Lake (August and November, 1972).

SOURCE: National Eutrophication Survey, 1975).

Transparency readings are useful in relation to lake depth and as comparisons to each other (83).

Measurements of nutrient concentrations are listed in Tables 11-9 and 11-10.

Probable causes of lakes with water quality problems in the metropolitan area were identified (38). A short summary of the chemical components and problems of each lake follows.

Coon Lake, (Plate 14, identification number 2-42) in Anoka County is presently used for sport fishing, boating, sailing, bathing and skiing, but not for livestock or domestic purposes. The lake is inherently fertile and shallow. Runoff from the farm and cottage developments along the lakeshore contains nutrients which encourage weed growth. In 1971, seven sampling periods averaged a total nitrogen concentration of 2.6 mg/1, and a .12 ppm concentration of total phosphorus. Patches of weeds were reported throughout the lake, especially in the shallow areas. The lake is considered eutrophic although one good sign is the large number of algal species present. In very eutrophic lakes, there is usually one dominant species. Domestic waste and surface drainage were identified as probable causes of the water quality problems.

Cedar Lake (70-91) one of Minneapolis' Chain of Lakes in Hennepin County, is a moderately hard water eutrophic lake. Sampling data from 1973 identified a total nitrogen concentration of 2.41 mg/1, a .18 ppm concentration of total phosphorus, and a 13 ppm concentration of chlorides. At the time of sampling, green water, indicating algae, was observed. Domestic waste is indicated as the probable cause of poor water quality.

Fish Lake (27-118) in Carver County is a low to moderately fertile lake with moderately hard water. It is considered moderately eutrophic, with a history of algal blooms - high concentrations of a few blue-green species. 1973 sampling data indicated concentrations of .36 mg/1 of total nitrogen, .043 ppm of total phosphorus and 24 ppm of chloride. The low chemical figures are due to nutrient uptake by the vegetation which varies depending on the season. The City of Maple Grove recently connected its residential disposal systems to sanitary sewers, consequently surface drainage is considered the probable cause of water quality problem. Erosion from a channel on the west side of the lake and from the banks of Gross Creek is the root of the problem. Currently, the lake is used for fishing and boating.

Lake Sarah (27-191) in Carver County is used for boating, swimming and fishing. In May, 1977, there were reports of a blue-green algal bloom. Sample data from 1974 indicated concentrations of .62 mg/1 of total nitrogen, and .12 ppm of total phosphorus. The most probable cause of water quality problems for Lake Sarah is considered as domestic waste. The MPCA did not observe any physical evidence of sewage pollution, nor any odor.

Bone Lake (82-54) in Washington County is a classic eutrophic lake. Surface drainage is considered the most probable cause of water quality problems. Runoff from agricultural operations is a main source of nutrients. Total phosphorus concentrations ranged from .083 to .135 ppm. In 1974, total nitrogen to phosphorus ratios ranged from 29:1, 10:1 and 1:1 from sites sampled in November, May and August respectively. Bone Lake sampling data indicates that abundant nitrogen and phosphorus were found at different times of the year. During spring and fall, the lake is phosphorus limited, while during the summer it is nitrogen limited.

Forest Lake (82-159) in Washington County was described in the National Eutrophication Survey as one with a history of extensive growths of submerged and emergent vegetation and frequent algal blooms. While there are no known municipal or industrial point sources presently impacting Forest Lake, non-point sources such as phosphorus export from tributaries to the lake are the cause of the problem.

REFERENCES

1. Allen S. King Generating Plant - Design of Circulating Water System to Control River Heating. American Power Conference, Chicago, Illinois, April 25-27, 1967, Pioneer Service and Engineering Company. Technical - mainly text, some diagrams. (Available: ECOL)

2. Allen S. King Generating Plant - Research, Control and Monitoring for Environmental Aspects. American Power Conference, Chicago, Illinois, April 25-27, 1967. General-text only. (Available: ECOL)

3. Northern States Power file. Allen S. King Plant. General and specific information, miscellaneous information - text and pictures. (Available: ECOL)

4. Alternatives for Wastewater Management in the Twin Cities Metropolitan Area. Metropolitan 208 Study Council, September, 1977. Explains the 208 Process and details the sewage treatment plants. (Available: MC)

5. Alternate Program and Projects for Managing Minnesota's Water and Related Land Resources through the Year 2020. Water Resources Coordinating Committee, State Planning Agency, January, 1971. Not too helpful - projections mainly. (Available: SPA)

6. Aquatic and Marsh Vegetation of Minnesota and its Value to Waterfowl. John B. Moyle, and Neil Hotchfiss, Technical Bulletin No. 3, Minnesota Department of Conservation, 1945. Basic and detailed information of useful species. (Available: DNR)

7. Beyond the Faucet - The Story of St. Paul's Water Supply. Board of Water Commissioners, St. Paul, 1972. Brief explanation of water supply with diagrams and pictures. (Available: MC)

8. A Biological Reconnaissance of the Upper Mississippi River - St. Cloud to Fridley. (Preliminary Copy, Department of Natural Resources, Division of Fish and Wildlife, Ecological Services, Special Publication No. 121, September, 1977.) Pertinent information on aquatic vegetation and uses of the river. (Available: DNR)

9. Classification of Natural Ponds and Lakes in the Glaciated Prairie Region. U. S. Department of the Interior, Fish and Wildlife Service, Resource Publication 92, 1971. Biological information plus ecological classifications. (Available: ECOL)

10. Commercial Navigation on the Mississippi River: An Economic Review of its Development and Public Policy Issues Affecting Minnesota. Rodney Christianson, Bulletin 75, Water Resources Research Center, University of Minnesota Graduate School, October, 1974. Good background information. (Available: U of M)

11. Draft Environmental Impact Statement - Northern States Power Company's Proposed Units 3 & 4 - Sherco Steam Electric Station. July, 1977, Minnesota Pollution Control Agency. Good background inventory. (Available: ECOL)

12. Draft Environmental Impact Statement - Operations and Maintenance Nine Foot Navigation Channel. Upper Mississippi River, Head of Navigation to Guttenberg, Iowa, February, 1974. Site analysis and biological data. (Available: CE)

13. Draft Plan for Development - Lake Rebecca Park, Hastings, Minnesota. U. S. Army Corps of Engineers, June, 1977. Background information. (Available: CE)

14. Effects of Condenser Cooling Water Discharge from Projected Allen S. King Generating Plant on Water Temperatures in Lake St. Croix. Ed Silberman and Heinz Stefan. Specific figures. (Available: DNR)

15. Effects of Enrichment on Lake Superior Periphyton. R. R. Nelson, T. O. Odlaug, B. O. Krogstad, O. R. Ruschmeyer, T. A. Olson, Bulletin 59, Water Resources Research Center, University of Minnesota Graduate School, May, 1973. Background information - case study. (Available: ECOL)

16. Environmental Monitoring and Ecological Studies Program for the Allen S. King Generating Plant. Annual Report, 1966, Northern States Power. Much numerical data, presented mainly in graphical form. (Available: ECOL)

17. Environmental Monitoring Program: Temperature Surveys of the St. Croix River, 1969-1970, for the Allen S. King Generating Plant, 1970. Northern States Power. Much data. (Available: ECOL)

18. Final Environmental Impact Statement - Operation and Maintenance, Nine Foot Navigation Channel. Upper Mississippi River, Corps of Engineers, August, 1974. Narrative only - no exhibits - good background information on quality and site analysis. (Available: CE)

19. Fish and Wildlife Technical Report. U. S. Fish and Wildlife Service for Fish and Wildlife Task Group, Minneapolis - St. Paul Area Level B Study, Upper Mississippi River Basin Commission, December, 1976. Information on water and its effects on animals, maps, Federal Refuges. (Available: DNR)

20. Floods and Flood Damage in Reduction in Minnesota. Minnesota Conservation Department, Division of Waters, Soils and Minerals in Cooperation with the Minnesota State Planning Agency, October, 1968. Good background - includes legislation and reference agencies.(Available: DNR)

21. Game Lake Surveys - by individual lake. Department of Natural Resources, Minnesota Division of Game and Fish, 1975. Current hydrology, biology and chemical data for each lake. (Available: DNR)

22. Graphic and Analytical Methods for Assessment of Stream - Water Quality. Mississippi River in the Minneapolis - St. Paul Metropolitan Area, Minnesota, U. S. Geological Survey, Water Resources Investigations 76-94. Explains and illustrates graphic portrayals of data. (Available: USGS)

23. Information Handbook for the Twin Cities Metropolitan Area Mississippi River Corridor Critical Area. State Planning Agency, Environmental Planning Division, Critical Areas Program, January, 1977. Lists reference agencies and legislation - good overview. (Available: SPA)

24. An Introduction to Processes, Problems and Management of Urban Lakes. L. J. Britton, R. C. Averetts, and R. F. Ferreira, U. S. Geological Survey, Geological Survey Circular 601-K, 1977. Good background information. (Available: USGS)

25. An Inventory of Physical Features and Facilities within the Major River Corridors in the Twin Cities Metropolitan Area. Metropolitan Council, September, 1969. Detailed maps - several views - of river sections. (Available: MC)

26. Lake Level Concept Team Report to the Minneapolis Park and Recreation Board. Summer, 1977. Generalized version of how to manage the Minneapolis lakes. (Available: MC)

27. Load Allocation Study for the Minnesota Pollution Control Agency, Minnesota River Segment. E. A. Hickok and Associates, 1974. Identifies point discharges. Computer graphs. Lots of detail on wastewater treatment sites and regulations. (Available: PCA)

28. Low Flow Characteristics of Minnesota Streams. U. S. Geological Survey, Water Resources Investigations 77-48, Open File Report, March, 1977. Computer Printout Data. (Available: MWCC, USGS)

29. Low Flow Survey, Summer, 1976. Metropolitan Waste Control Commission (Twin City Area), Data Report. March, 1977. Biological productivity, enrichment and effluent data at various locations. Raw data, little text. (Available: MWCC)

30. Lake Summary Survey. Minnesota Department of Natural Resources. Listing by county of lakes' physical, chemical and biological aspects. (Available: DNR)

31. Major River Corridors in the Twin Cities Metropolitan Area. Metropolitan Council, December, 1970. Helpful—background on uses, plus descriptions of each river section—present and future. (Available: MC)

32. Main Report - Upper Mississippi River Comprehensive Basin Study. Volume I, 1970. Generalized use data and site analysis. (Available: ECOL)

33. Management of Water Resources for Urban Environmental Enhancement. Environments for Tomorrow, Inc., 1974. Gives case studies of how various cities, including Minneapolis, solve their water conflicts. (Available: MWCC)

34. Metropolitan Development Guide. Water Resources Policy Plan, Dept. HUD, December, 1973. Mainly identifies projected problems. (Available: MC)

35. Metropolitan Development Guide/Policy Plan Water Management, (Sanitary Sewers), Metropolitan Council, February, 1975. Many maps of interceptors, text, discussion of water quality. (Available: MC)

36. The Minneapolis Chain of Lakes - A Study of Urban Drainage and its Effects, 1971-73. Joseph Shapiro, Limnological Research Center, University of Minnesota, Interim Report No. 9. Chemical biological information and lots of discussion. (Available: MC)

37. Minneapolis Lakes. Citizen's Advisory Committee on Lake Water Quality, March, 1975. Recommendations by the Committee on lake restoration. (Available: MC)

38. Minnesota Pollution Control Agency Lake Files. Roseville, Minnesota. Available for most state lakes by name, often indicates physical, chemical and biological information. (Available: MPCA)

39. Minnesota River Pool, Final Report, Environmental Impact Assessment of the Northern Section of the Upper Mississippi River, North Star Research Institute. Readable information on uses and water quality. (Available: ECOL)

40. Minnesota Valley - National Wildlife Refuge. U. S. Fish and Wildlife Service, Bureau of Sports Fisheries. Background information. (Available: ECOL)

41. Minnesota Water and Related Land Resources - First Assessment, Water Resources Coordinating Committee, State Planning Agency, June, 1970. Very general - but maps and charts. Identifies problem areas. (Available: SPA)

42. Minnesota's Lakeshore. Part 1, Resources, Development, Policy Needs, University of Minnesota, 1970 Summary Report of the Minnesota Lakeshore Development Study. Quite general. (Available: U of M)

43. Minnesotans and their Mississippi River: A Citizen's Review of Minnesota - Mississippi River Environment. Jean Stanford Replinger, Aesthetic Environment Task Force of the State of Minnesota, 1974. Valuable resources - discusses river as ecosystem plus use data. (Available: MC)

44. National Pollution Discharge Elimination System: Industrial Municipal Discharge Inventory (1977). Minnesota Pollution Control Agency. Useful raw data —no interpretation. (Available: PCA)

45. Navigation on the Upper Mississippi River, Lock and Dam No. 2. Hastings, Minnesota pamphlet by U.S. Corps of Engineers. Brief reference source. (Available: CE)

46. Navigation on the Upper Mississippi River, Lock and Dam No. 1, Minneapolis - St. Paul, Minnesota, Pamphlet by U. S. Army Corps of Engineers. Pictures, some text - good for quick reference. (Available: CE)

47. 1971 River Analytical Data, 1972 River Analytical Data, Quality Control Report - 1973 Water Quality Data, Quality Control Report - 1974 Water Quality Data, 1975 Water Quality Report, 1976 Grab Sampling Data, Metropolitan Waste Control Commission. Chemical data from MWCC water quality stations - very useful. (Available: MWCC)

48. 1975 and 1976 Annual Report for the Monticello Nuclear Generating Plant. Environmental Monitoring and Ecological Studies Program, Monticello, Minnesota - Northern States Power. Biological data, Water Quality. (Available: ECOL)

49. 1975 Annual Report. Metropolitan Waste Control Commission, Twin Cities Area, 1975. General background information. (Available: MWCC)

50. 1975 National Water Assessment, Technical Memorandum, Activity Two, State/ Regional Future Condition and Final Selected Problems List, Specific Problem Analysis - Phase II, Upper Mississippi and Souris-Red-Rainy Regions, November, 1976, Upper Mississippi River Basin Committee. Lists projected problems. (Available: ECOL)

51. 1976 Annual Report. Metropolitan Waste Control Commission, Twin Cities area, 1976. General background information. (Available: MWCC)

52. Northern States Power Company's Proposed Units 3 and 4 - Sherco Steam Electric Station. Draft Environmental Impact Statement, July, 1977, Minnesota Pollution Control Agency. Good background inventory. (Available: ECOL)

53. Northern States Power 1976 Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota, Environmental Monitoring and Ecological Studies Program. Water quality and biological data, plus some dredging and erosion factors. (Available: ECOL)

54. Operation and Maintenance Nine Foot Navigation Channel - Draft Environmental Impact Statement. Exhibits - February, 1974. Pictures, figures, maps - refers to companion book. (Available: ECOL)

55. PCB's in the Upper Mississippi River Basin. Minnesota-Wisconsin PCB Interagency Task Force, 1976. Current Information - Summary of the Task Force.(Available: MPCA)

56. Phytoplankton of Minnesota Lakes - A Preliminary Survey. A. J. Brook, Bulletin 36, Water Resources Research Center, University of Minnesota Graduate School, June, 1971. Indicates which species inhabit eutrophic and mesotrophic lakes. (Available: MPCA)

57. Phytoplankton, Photosynthesis and Phosphorus in Lake Minnetonka, Minnesota. Robert O. Mehard, Limnological Research Center, 1970. Useful discussions, many graphs of data. (Available: MPCA)

58. Pollution of the Upper Mississippi River and Major Tributaries. U. S. Department of Interior, July, 1966. Outdated, but good background information on water use and quality. Good discussion. (Available: ECOL)

59. Pool 1 - Final Report Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. North Star Research Institute for the Corps of Engineers. Readable water quality and uses information. (Available: ECOL, CE)

60. Pool 2 - Final Report Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. North Star Research Institute for the Corps of Engineers. Water quality uses in detail with diagrams. (Available: ECOL, CE)

61. Pool 3 - Final Report - Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. North Star Research Institute for the Corps of Engineers. Readable water quality and uses information. (Available: ECOL, CE)

62. Potential Metropolitan Pollution Problem Areas: Development and On-Site Sewage Disposal. (Technical Report), Metropolitan Council, 208 Study. General quality information applied to specific cases, many maps. (Available: MWCC)

63. Power Development in Minnesota. Gene Hollenstein, State of Minnesota, Department of Conservation, Division of Water, Bulletin 20, July, 1962. Good background information. (Available: DNR)

64. Proceedings: Eighth Annual Water Resources Seminar - Groundwater Resources and Development. November 24 and 25, 1975, Bulletin 87, Water Resources Research Center, University of Minnesota Graduate School, May, 1976. Generalized Statewide data with maps. (Available: U of M)

65. Proceedings: Minnesota's Water Resources in the Year 2000, A Conference on Planning and Management. Bulletin 92, Water Resources Research Center, University of Minnesota Graduate School, April, 1977. General information on uses, but current figures and data. (Available: U of M)

66. Proceedings of Conference on "Trends in Water Management". Bulletin 80, Water Resources Research Center, University of Minnesota Graduate School, January, 1975. Good background information on various agencies. (Available: U of M)

67. Recommendations for Critical Area Designation of the Mississippi River Corridor. February, 1975. Metropolitan Council and November, 1974. Identifies features of the Mississippi. (Available: MC)

68. Report on Investigation of the Mississippi River from the Mouth of the Rum River to the Mouth of the St. Croix River. July and August, 1960 and August and September, 1961. Old data. (Available: MPCA)

69. Report on Pollution of the Water of the Upper Mississippi River and its Significant Tributaries - Minneapolis - St. Paul Metropolitan Area, Minnesota - Wisconsin. J. M. Rademacher, U. S. Department of Health, Education and Welfare, 1964. Mostly discussions. Outdated—but has uses. (Available: MPCA)

70. Report to the City of Minneapolis Park and Recreation Board on the Condition of Lakes in Minneapolis, 1974. Joseph Shapiro, Limnological Research Center, 1975. Mostly recent biological sampling data, some maps, very little text. (Available: MC)

71. St. Anthony Falls Locks and Dams, Mississippi River, Minneapolis, pamphlet by U.S.. Army Corps of Engineers. Brief with pictures. (Available: CE)

72. St. Croix Pool - Final Report - Environmental Impact Assessment of the Northern Section of the Upper Mississippi River, North Star Research Institute for the Corps of Engineers. Water quality and uses in detail with diagrams. (Available: MC)

73. Sewerage and Water Planning Report. Metropolitan Council and Metcalf and Eddy, 1968. Background information on water uses and quality. (Available: MC)

74. Some Aspects of Hydrology of Ponds and Small Lakes. P. W. Manson, G. M. Schwartz, and E. R. Allred, Agricultural Experiment Station, Technical Bulletin 257, 1968. Good background information. (Available: U of M)

75. State of the Region - Twin Cities Metropolitan Area. Metropolitan Council, February, 1977. Most recent information available. Few pages on water contains some data and graphs, good basic explanations. (Available: MC)

76. Stormwater Impact Investigation for the Metropolitan Council. E. A. Hickok and Associates, 1972. Unpublished Report. (Available: MC)

77. Studies on the Effects of Thermal Additions on Selected Zooplankton Populations, Robert Wilson and R. Peter Neri, Bulletin 84, Water Resources Research Center, University of Minnesota Graduate School, November, 1975. Theoretical studies with "how to do it" information. (Available: U of M)

78. Study of Criteria and Models Establishing Optimum Level of Hydrogeologic Information for Groundwater Basin Management, H. O. Phannkuch, Bulletin 81, Water Resources Research Center, University of Minnesota Graduate School, April, 1975. Many mathematical models. (Available: U of M)

79. Summary and Pollution Abatement Recommendations for the Upper Mississippi River and Major Tributaries. Department of Interior, 1964. Old, but still useful maps and good text. Describes uses of river. (Available: MPCA)

80. A Survey of Attitudes Towards the Mississippi River as a Total Resource in Minnesota. N. J. Baron, E. J. Cecil, P. L. Tideman, Water Resources Research Center, University of Minnesota Graduate School, September, 1972. Some generalized recreational use data - useful for future recreational planning. (Available: U of M)

81. Thermal Effects of a Nuclear Power Plant on the Mississippi River at Monticello, Minnesota. Alfred J. Hopwood, Bulletin 69, Water Resources Research Center, University of Minnesota Graduate School, July, 1974. Compares biological data from post-operational (71-72) period to baseline data (68-71). (Available: ECOL)

82. Transparency of Minnesota Lakes - 1975 and 1976. Interim Reports 16 and 17 of the Limnological Research Center, University of Minnesota. Graphical presentations for many Minnesota lakes. (Available: U of M)

83. Upper Mississippi Comprehensive Basin Study. Volume IV, Department of Interior Federal Water Quality Administration, 1970. (Available: U of M)

84. Twin City Area, Development Program 1977-1981. Metropolitan Waste Control Commission, March, 1976. Mainly projected projects and future trends. (Available: MWCC)

85. Upper Mississippi Comprehensive Basin Study. Department of Interior Federal Water Quality Administration, Great Lakes Region, Volume IV, 1970. Gives general facts on existing resources and legislation in view of future development. Maps included. (Available: ECOL)

86. The Upper Mississippi River ... nine-foot channel. Pamphlet by U. S. Army Corps of Engineers. Readable reference source - mainly pictures. (Available: CE)

87. Water Pollution by Nutrients - Sources, Effects and Controls. Bulletin 13, Water Resources Research Center, University of Minnesota Graduate School, June, 1969. Background information on nutrient sources - general. (Available: U of M)

88. Water Resources Data for Minnesota. U. S. Geological Survey Water Data Report MN-76-1, Water Year 1976. Chemical and biological data at USGS gaging stations along major and minor waterways. (Available: USGS)

89. Water Resources Problems and Research Needs in Minnesota, 1974 - Guidelines for Research Programs. William C. Walton, Bulletin 68, Water Resources Research Center, University of Minnesota Graduate School, June, 1974. Concerned with water development - discusses uses. (Available: U of M)

90. Water Quality in Minneapolis Lakes. Limnological Research Center, Dr. Joseph Shapiro, Associate Director, 1973. Discussions, no numerical data. (Available: MC)

91. Water Quality Monitoring Program on Representative Fish Lakes - 1973. Minnesota Department of Natural Resources, Special Publication No. 106, June, 1973. (Available: DNR)

92. Water Resources of the Minneapolis-St. Paul Metropolitan Area. Bulletin 11, State Department of Conservation, Division of Waters, August, 1961. Very good background information and general overview of ground and surface water, water use and future water needs. Also describes uses and lakes and minor streams. (Available: DNR)

93. Water Resources Outlook for the Minneapolis - St. Paul Metropolitan Area. U. S. Geological Survey in cooperation with the Metropolitan Council. Most useful source book with complete text and maps. (Available: USGS, MC)

94. Water Quality Water Management Plan for the Twin Cities Metropolitan Area. Metropolitan Council, unpublished report. 1975. (Available: MC)

95. Water Supply and Quality Control. Upper Mississippi River Comprehensive Basin Study, Volume IV, Appendix H., 1970. Current information on quality and uses - general and detailed on Minnesota River Basin and Upper Mississippi Main-stem. (Available: ECOL)

96. Water Supply and Water Quality Control Study. Minnesota River Basin Reservoirs, Minnesota, South Dakota, Iowa, U. S. Dept. of the Interior, 1969. Outdated figures, but good background information. (Available: U of M)

97. Water Use, S. A. Freilsen and J. W. Walters, Water Resources Coordination Committee, State Planning Agency, First Draft, Subject to Major Revision, 1968. Outdated information, but text indicates trends and gives background information. (Available: SPA)

CE - Corps of Engineers, St. Paul
DNR - Department of Natural Resources, St. Paul
ECOL - Environmental Conservation Library, Minneapolis
MC - Metropolitan Council, St. Paul
MPCA - Minnesota Pollution Control Agency, St. Paul
MWCC - Metropolitan Waste Control Commission, St. Paul
SPA - State Planning Agency, St. Paul
U of M - University of Minnesota Libraries, Minneapolis and St. Paul
USGS - United States Geological Survey, St. Paul

CONTACTS

Contacts:	Agency:
Cliff Aichinger - Environmental Planner, Critical Areas	State Planning Agency
Craig Affeldt - Head, Lake Studies Unit	Minnesota Pollution Control Agency
Larry Bubacz - Environmental Planner	Metropolitan Council
Bill Lange - Staff Engineer	Metropolitan Waste Control Commission
Roy Peterson - Chairman of Coordination for Level B Program	Upper Mississippi River Basin Commission
Joel Schilling - Biologist, Lake Studies Unit	Minnesota Pollution Control Agency
Wayne Sames - Assistant Wild and Scenic Rivers Coordinator	Minnesota Department of Natural Resources

The State of Minnesota has adopted federal ambient air quality standards except for some minor modifications. These standards are contained in Table 12-1. The primary standard is a limit for a given pollutant above which the public health and welfare may be endangered, while the secondary standard is a limit above which secondary impacts such as vegetative loss or contamination and danger to wildlife may result. These are defined in Section 109 (b) (1) and (2) of the Clean Air Act of 1970 (42 U. S. C. 1857 et seq).

Air quality degradation may be attributed to moving and stationary sources, with different control strategies applied to each. The primary pollutants associated with moving sources (traffic and aircraft) are carbon monoxide and oxidants (generated by a combination of nitrogen oxides, hydrocarbons, and sunlight). Stationary sources account for most of the particulates and sulfur oxides, and also contribute nitrogen oxides, hydrocarbons, and some carbon monoxide. Standards have also been established by the Minnesota Pollution Control Agency (MPCA) (2) for odors although the establishment of emission levels is a more complex process than with the other pollutants. (An example of the determination of odor emissions may be seen in a report submitted to the Metropolitan Sewer Board by Interpoll, Inc., in 1974 (3). The use of air for cooling purposes has not been sufficiently quantified to allow for the establishment of state standards; since most of the waste heat in the state may be attributable to the generation of electrical power, major heat emission sources will be associated with power plants that also have high particulate emissions.

MAJOR POINT SOURCE EMISSIONS IN THE METROPOLITAN AREA

A list of major sources of particulates and hydrocarbons for the year 1977 is contained in Table 12-2, with the location of sources shown in Figure 12-1. These two pollutants were selected as appropriate for inclusion in the inventory because any future wastewater treatment plant may face problems with particulate emissions, while hydrocarbon emissions represent the potential for odor problems.

The area influenced by each of the major sources (i.e., areas for which there is the potential of ambient air quality standards being exceeded) depends upon:

(1) Emission rate

(2) Temperature of effluent and ambient air

(3) Local atmospheric gradients and turbulence spectra (reflected by stability class)

(4) Height of emission above the ground

(5) Local topography

(6) Frequency of occurrence of wind direction in conjunction with atmospheric stability classes over the year

This detailed evaluation has been completed for several power plants by the MPCA, but is beyond the scope for this inventory. The potential for noncompliance in a particular area will have to be analyzed in detail where necessary. Generalized areas of influence assuming standard conditions are shown in Figure 12-2.

TABLE 12–1 MINNESOTA AMBIENT AIR QUALITY STANDARDS (2)

PRIMARY STANDARD	SECONDARY STANDARD	WORDING OF STANDARD	POLLUTANT
75 ug/m^3	60 ug/m^3	Max. annual geometric mean	Particulate Matter
260 ug/m^3	150 ug/m^3	Max. 24-hr. concentration not to be exceeded more than once per year.	
.02 ppm (60 ug/m^3)	.02 ppm (60 ug/m^3)	Max. annual arith. mean	Sulfur Oxides
.10 ppm (260 ug/m^3)	.10 ppm (260 ug/m^3)	Max. 24-hr concentration not to be exceeded more than once per year.	
.25 ppm (655 ug/m^3)	.25 ppm (655 ug/m^3)	Max. 3-hr. concentration not to be exceeded more than once per year.	
9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)	Max. 8-hr. average not to be exceeded more than once once per year.	Carbon Monoxide
30 ppm (35 mg/m^3)	30 ppm (35 mg/m^3)	Max. 1-hr. concentration not to be exceeded more than once per year.	
.07 ppm (130 ug/m^3)	.07 ppm (130 ug/m^3)	Max 1-hr. average not to be exceeded more than once per year.	Photochemical Oxidants
.3 ppm	.3 ppm		
.3 ppm (200 ug/m^3)	.24 ppm (160 ug/m^3)	Max. 3-hr. concentration (6 to 9 a.m.) not to be exceeded more than once per year.	Hydrocarbons (Less Meth.)
.05 ppm (100 ug/m^3)	.05 ppm (100 ug/m^3)	Max. Annual arith. mean	Nitrogen Oxides
.05 ppm (70 ug/m^3)		½ hr. average not to be exceeded over two times per year for primary standard.	Hydrogen sulfide
	.03 ppm (42 ug/m^3)	½ hr. average not to be exceeded over two times in any five consecutive days for secondary standard.	

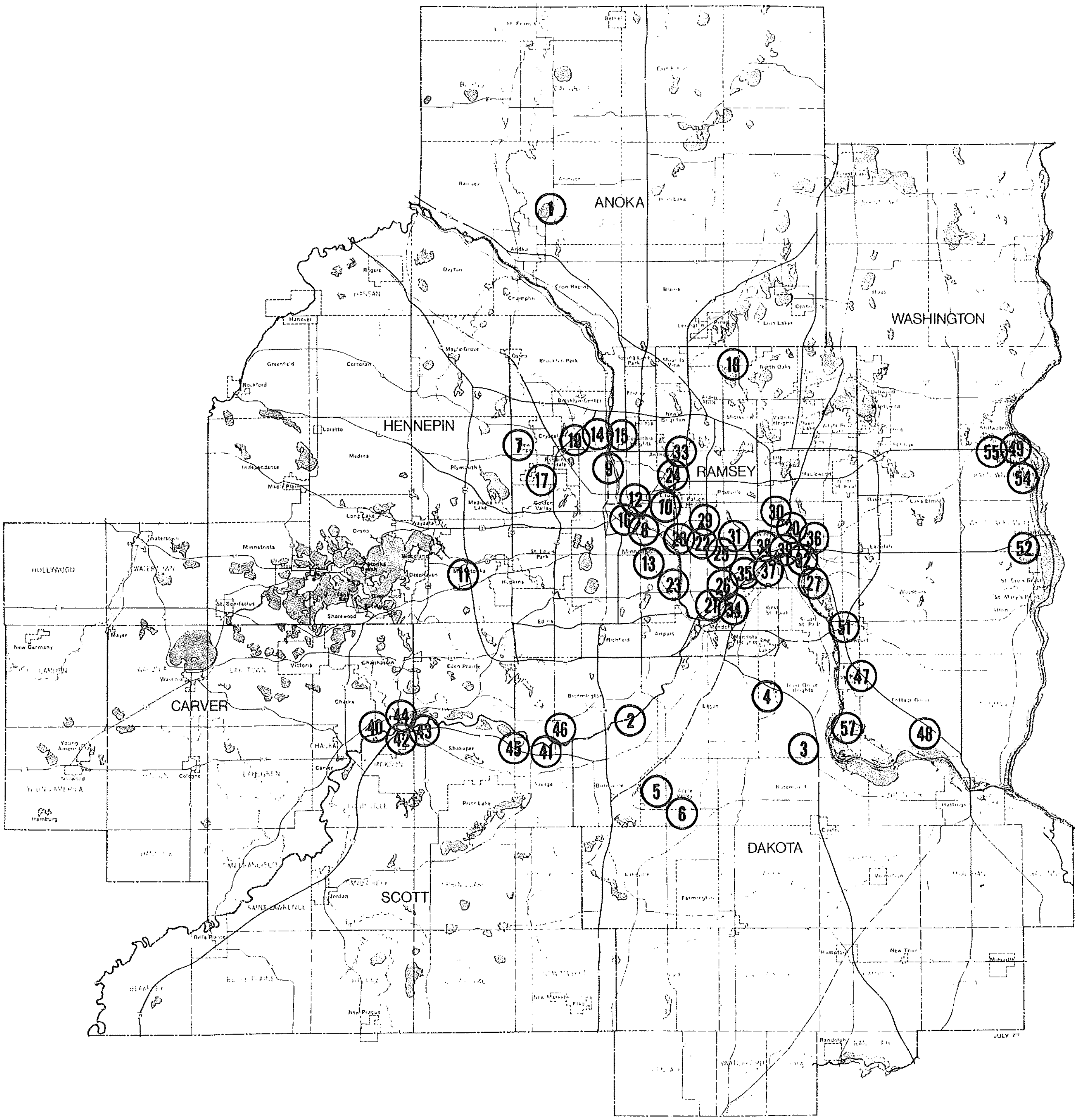
TABLE 12–2 MAJOR POINT SOURCE EMISSIONS INVENTORY 1977

Site		PARTICULATES		HYDROCARBONS	
		Tons/Year	Effective Stack Hgt.	Tons/Year	Effective Stack Hgt.
1	H & S Asphalt	n/a	n/a	–	–
2	NSP–Blackdog	5,866	289′	–	–
3	Koch Refining Co.	234	50′	11,593	60′
4	St. Paul Ammonia	105	45′	–	–
5	Williams Pipe Line Co.	–	–	105	48′
6	Minnesota Valley Surfacing	7,040	n/a	11,826	n/a
7	Agg Sinter, Coke	1,260	30′	–	–
8	Champion Packages Co.	–	–	358	40′
9	NSP-Riverside	503	335′	–	–
10	Fleischmann Malting	252	30′	–	–
11	Tonka Toys	–	–	181	25′
12	University of Minnesota	299	n/a	–	–
13	A D M Nokomis Mill	178	60′	–	–
14	General Electric Service	–	–	175	25′
15	Honeymead Products	157	150′	–	–
16	Commutator Foundry	292	40′	–	–
17	Honeywell Inc.	–	–	119	n/a
18	Onan Div. of Onan Corp.	–	–	112	36′
19	Howe Incorporated	103	25′	–	–
20	3M Company	–	–	42,919	n/a
21	Webb Publishing	–	–	17,273	43′
22	Mobil Oil Corporation	–	–	1,772	n/a
23	Ford Motor Company	–	–	1,008	50′
24	Williams Pipe Line	–	–	1,100	72′
25	American Can Co.	–	–	611	200′
26	Union Oil Co. of California	–	–	1,052	10′
27	Metropolitan Waste Control Commission	2,050	n/a	–	–
28	Hoerner Waldorf Corp.	–	–	463	58′
29	Koppers Co.	180	20′	300	20′
30	Whirlpool Corp.	–	–	266	68′
31	Total-Asphalt	257	36′	–	–
32	Fugta	355	n/a	–	–
33	Standard Oil	–	–	392	24′
34	Shell Oil Company	–	–	604	48′
35	Texaco Inc.	–	–	194	n/a
36	Olympia Brewing Co.	184	n/a	–	–
37	NSP-Highbridge	290	570′	–	–
38	NSP-3rd Street Steam	136	258′	–	–
39	National Can	–	–	132	41′
40	Bryan Rock Products	1,439	20′	–	–
41	Bunge Corporation	1,292	n/a	–	–
42	Rahr Malting Co.	554	n/a	–	–
43	J. L. Shiely Company–Shakopee	500	n/a	–	–
44	Continental Grain Co.	448	20′	–	–
45	Peavey Company	192	n/a	–	–

46	Cargill, Elev. C	147	n/a	–	–
47	Northwestern Refining Co.	–	–	7,720	53′
48	3M Company–Cottage Grove	–	–	2,999	31′
49	NSP-King	659	785′	–	–
51	Erickson Petroleum Corp.	–	–	1,329	48′
52	Tower Asphalt Inc.	465	n/a	–	–
54	Andersen Corp.	–	–	511	25′
55	Minn. State Prison	397	110′	–	–
57	J. L. Shiely–Grey Cloud	325	10′	–	–

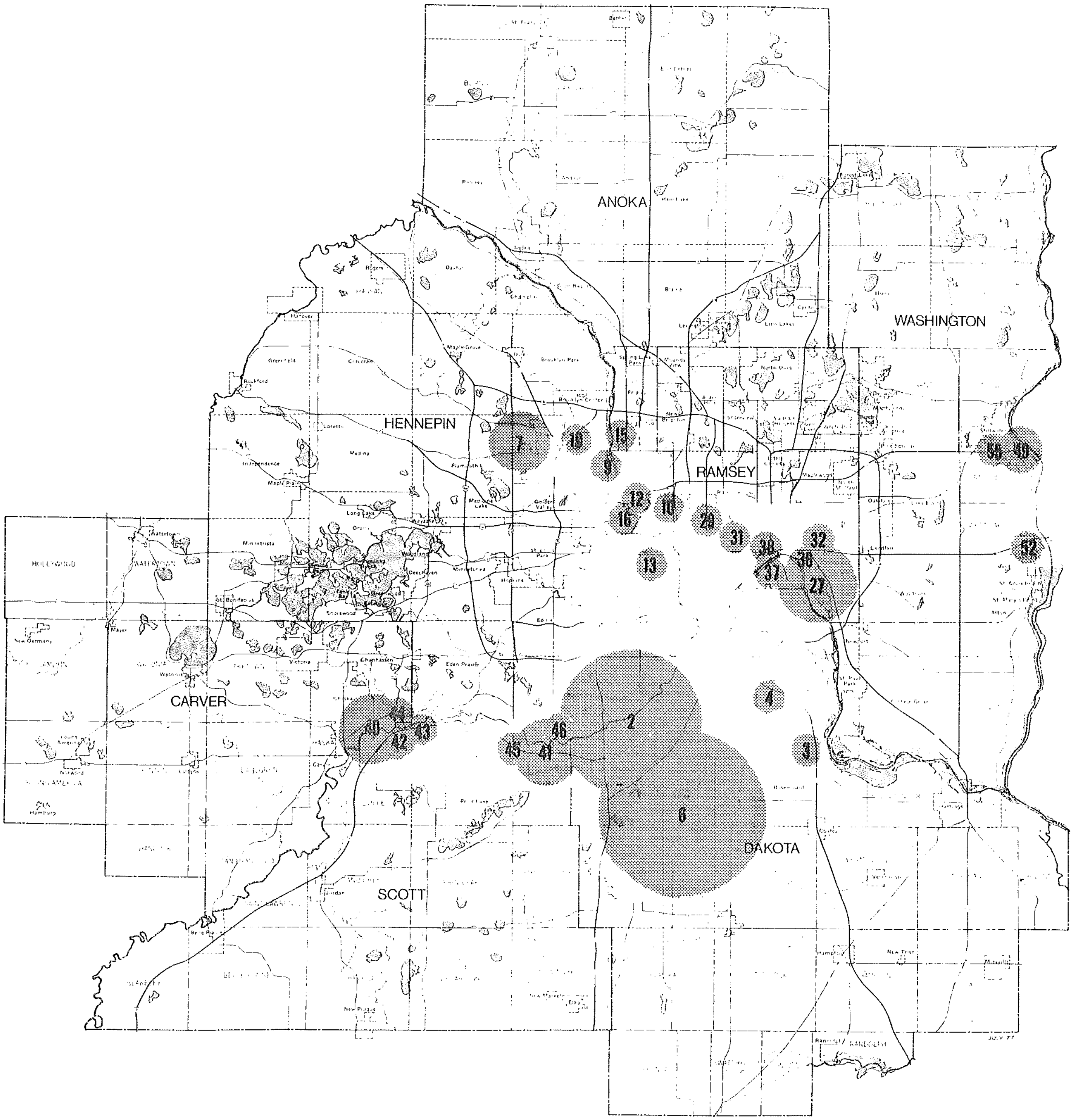
SOURCE: Division of Air Quality, Minnesota Pollution Control Agency

FIGURE 12–1 LOCATION OF MAJOR EMISSION SOURCES



SOURCE: Minnesota Pollution Control Agency

FIGURE 12–2 METROPOLITAN AREAS IMPACTED BY PARTICULATES



SOURCE: David Braslau Associates, Inc.

The Metropolitan Treatment Plant on the Mississippi River in St. Paul contributes 1,799 tons per year of particulate matter, which is the third highest of the 54 major sources identified in Table 12-2. Any modifications or construction of new plants with sewage sludge incineration are covered by APC 28 Standards of Performance for Sewage Sludge Incinerators promulgated by the MPCA, which limits emissions to 1.3 pounds per ton of dry sludge weight and a plume capacity of 20%. New construction is also subject to the provisions of the Clean Air Act Amendments of 1977 (discussed below), which impose tradeoffs on particulate emissions within designated non-attainment areas.

MOBILE EMISSION SOURCES

Emissions associated with automobile traffic are generally proportional to the volume and inversely proportional to the speed of travel. Therefore, the highest emissions are to be anticipated in congested areas of high volumes and low speeds, such as in the Minneapolis and St. Paul Central Business Districts (CBD) and at major intersections and centers in the metropolitan areas. Determination of emissions and associated concentrations is a complex procedure, and requires knowledge not just of the micro-meteorology as with major point sources, but also the variation in time and location of traffic flow parameters. High carbon monoxide concentrations associated with traffic are highly localized and areas exposed to levels over the 8-hour standard extend generally no more than 100 meters from the roadway. Therefore, an inventory presentation of areas impacted by carbon monoxide levels over the standard has not been included here.

MPCA AIR QUALITY MONITORING SITES

The MPCA has established a number of permanent monitoring sites throughout the metropolitan area (which is also Air Quality Control Region No. 131). Air Quality Control Regions are defined as any interstate area or major intrastate area which has been designated by the United States Environmental Protection Agency Administrator under the Clean Air Act of 1970 that are deemed necessary or appropriate for the attainment and maintenance of ambient air quality standards (Clean Air Act, Section 107 (c)). These sites are listed in Table 12-3.

TABLE 12–3

AIR QUALITY MONITORING SITES (13)

MPCA NO.	SAROAD SITE NO.˙	CITY AND ADDRESS OF SITE	AGEN TYPE	PROJ CODE	SITE CLASS	PARAMETER MEASURED, HEIGHT OF INTAKE FROM GROUND (FT)				COMMENTS (Sources listed are within 1 mile of Radius of Site)
						HI-VOL	SO_2	nO_2	CO	
0250	243280006	St. Louis Park (5005 Minnetonka Blvd, City Hall)	F	01	1c	34				
0320	241460005	Hastings (107 W. 5th Street, Fire Station)	F	01	1c	14				
0360	242260027	Minneapolis (3405 University Avenue SE)	F	01	1a		16	16	16	
0370	240360004	Bloomington (Lincoln High School)	F	01	1b	34				
0375	240360009	Bloomington (600 W. 95th Street, Fire Station)	F	01	1b		20			
0420	240940020	Pine Bend (Minn Hwy 55 & US 52)	F	02	3a	14	12	12		refinery, ammonia plant
0431	243320005	St. Paul Park (123 East Broadway Avenue)	F	02	2a		6			refinery
0500	243080001	Richfield (Humboldt & 69th Street)	H	02	2b			10		freeway
0801	243300003	St. Paul (2179 University Avenue, Fire Station)	F	01	1a	40		40		paper recycling plant
0813	243300014	St. Paul (428 Starkey, Fire Station)	F	01	1c	25				
0817	243300018	St. Paul (1303 Red Rock Road)	F	01	2a			14		
0820	243300021	St. Paul (1038 Ross Avenue, Fire Station)	F	01	1a	35		35		chemical products industry
0823	243300024	St. Paul (754 Randolph Avenue, Fire Station)	F	01	1c	35				
0830	243300030	St. Paul (345 Jackson Street)	F	01	1c			12	12	
0833	243300031	St. Paul (10th and Minnesota)	F	01	1c		12		12	
0901	242260022	Minneapolis (3rd Avenue & 4th Street)	F	01	1c	60	12		12	
0905	242260005	Minneapolis (2701 Johnson St. NE, Fire Station)	F	01	1b	20	20			
0907	242260007	Minneapolis (4646 Humboldt Avenue N, Fire St)	F	01	1b	14		14		
0914	242260014	Minneapolis (2000 East Franklin)	F	01	1a			16		
0930	242260032	Minneapolis (11th Street & 4th Avenue)	F	01	1c		10			
0936	242260047	Minneapolis (So. 7th Street & Hennepin)	F	01	1c				12	

Responsible for Station:
F = State
C = County
H = City

AQCR No. 131

Project Code: 01 = Population Oriented
02 = Source Oriented

Site Classification: 1 = Center City
2 = Suburban
3 = Rural

a. industrial
b. residential
c. commercial
d. near urban

SOURCE: Minnesota Air Quality 1971-1976, I. Ritchie, MPCA, February 1977

METROPOLITAN AREA AIR QUALITY OVERVIEW - 1976/1977

CARBON MONOXIDE

Site 0360, located at 3405 University Avenue S. E. in Minneapolis, recorded five periods exceeding the 8-hour CO standard of 8 ppm in 1976. Site 0833 in the St. Paul CBD recorded a total of 17 periods over the standard. Site 901 in the Minneapolis CBD recorded 24 periods over the standard in 1976, while site 936, established first in July 1976, recorded 246 periods over the standard in the latter half of the year. The most critical area at the present time in terms of air quality maintenance for mobile emissions is the Minneapolis CBD.

NITROGEN DIOXIDE

Air quality standards for this pollutant have not been exceeded at any of the permanent monitoring sites.

SULFUR DIOXIDE

Site 420, which is directly related to emissions from the Pine Bend Refinery, showed 2.5% of the observations over the 3-hour standard of .25 ppm and 7.0% over the 24-hour standard of .01 ppm in 1976. Site 431, oriented to the St. Paul Park Refinery, recorded 5.6% of its observations over the 24-hour standard although it did not meet the required data evaluation criteria. All other sites except for the Minneapolis CBD Site 901 (which recorded less than .5% over the 24-hour standard) indicated no violations.

PARTICULATES

Particulate concentrations are a problem in the metropolitan area as well as in other parts of the state. Particulate monitoring sites are shown in Figure 12-3, with sites circled which exceeded the secondary standard of 60 micrograms per cubic meter annual geometric mean in 1976. Most of these sites are concentrated along the Mississippi River and near the Minneapolis and St. Paul CBD's. The actual observations for the sites shown in Figure 12-3 are presented in Table 12-4.

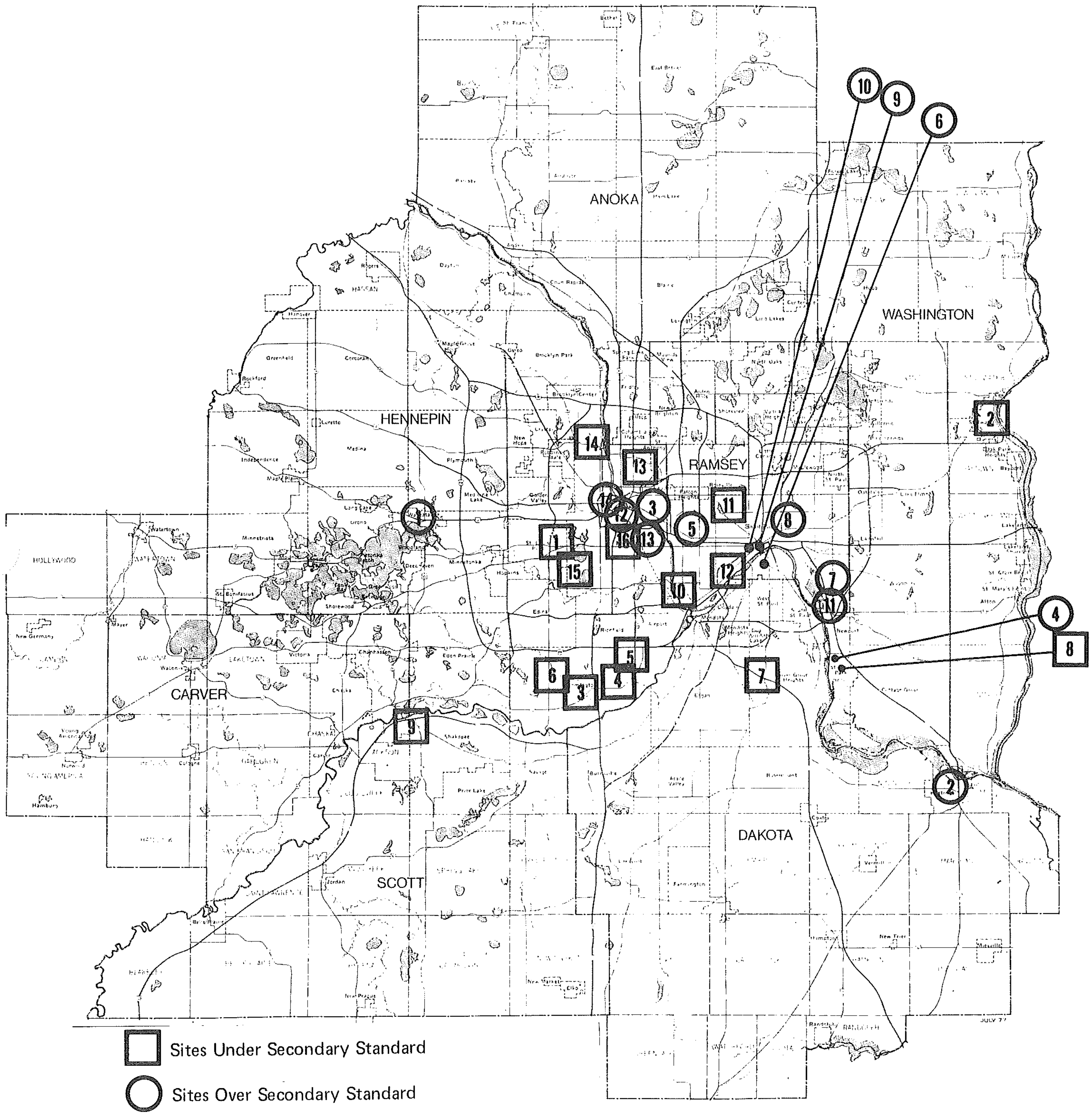
Particulates are of special interest because of the impact of the Metro Wastewater Treatment Plant at Pig's Eye which has the third highest annual particulate emission rate listed (13). Any expansion of the facility or construction of others within the metropolitan area will have to consider the regional particulate emissions, especially if coal is to be used as an alternative fuel in the treatment process (10).

ODORS AND USE OF AIR FOR COOLING

The MPCA does not maintain a detailed inventory of odor emissions in the metropolitan area because of the complexity in their derivation. A study of odor emissions from the Pig's Eye Plant (3) describes the procedures which must be completed for such an inventory. Some relationships exist between odors and hydrocarbon emissions. It may be assumed that large hydrocarbon emissions produce odors; whether or not these are objectionable must be determined on a case-by-case basis.

The use of large masses of air for cooling is generally restricted to major power plants within the metropolitan area. The power plants are identified in Table 12-2. Since no standards have been established for changes in air temperature, these cannot be quantified on a common basis, but must be treated in those situations where problems with condensation and other adverse effects arise.

FIGURE 12–3 PARTICULATE MONITORING STATIONS



SOURCE: Minnesota Pollution Control Agency

TABLE 12–4

OBSERVED PARTICULATE LEVELS (AQMR 131) 1976

MONITORING SITE		CITY	ANNUAL GEOMETRIC MEAN (ug/m^3)	% OF PRIMARY STANDARD (75 ug/m^3)	% OF SECONDARY STANDARD (60 ug/m^3)
(1)	0007	Wayzata	63.9	85	107
1	0250	St. Louis Park	49.2	66	82
(2)	0320	Hastings	60.8	81	101
2	0331	Stillwater	47.0	63	78
(3)	0360	Minneapolis	81.4	109	136
3	0370	Bloomington	45.2	61	75
4	0375	Bloomington	54.3	72	91
5	0376	Bloomington	38.3	51	64
6	0377	Bloomington	32.8	44	55
7	0420	Pine Bend	57.6	77	96
8	0430	St. Paul Park	50.4	67	84
(4)	0432	St. Paul Park	70.7	94	118
9	0440	Shakopee	46.0	61	77
(5)	0801	St. Paul	72.9	97	122
(6)	0813	St. Paul	62.7	84	105
10	0815	St. Paul	42.8	57	72
(7)	0817	St. Paul	83.7	112	140
(8)	0820	St. Paul	65.1	87	109
12	0823	St. Paul	56.6	75	94
(9)	0830	St. Paul	93.4	125	156
(10)	0833	St. Paul	77.6	103	129
(11)	0836	St. Paul	68.7	92	115
(12)	0901	Minneapolis	69.2	92	115
13	0905	Minneapolis	54.4	73	91
14	0907	Minneapolis	54.4	73	91
(13)	0914	Minneapolis	81.9	109	137
15	0920	Minneapolis	61.8	82	103
16	0930	Minneapolis	58.5	78	98
(14)	0935	Minneapolis	73.5	98	123

( ) = Sites over secondary standard
All Other Sites Under Secondary Standard

SOURCE: Minnesota Pollution Control Agency

AIR QUALITY MAINTENANCE/STATE IMPLEMENTATION PLAN

Should the MPCA identify the metropolitan area or subregions within it as non-attainment areas for any given pollutant (as required by the Clean Air Act Amendments of 1977 (5) by December 5, 1977), a revised State Implementation Plan must be approved by July 1, 1979, which provides for attainment of primary standards by December 31, 1982. This requirement is a precondition for construction of major emission sources in non-attainment areas after June 30, 1979 (1). (Non-attainment areas are those air quality control regions or subregions within them, designated by the MPCA, which are not anticipated to meet ambient quality standards.) If, despite "all available measures", a state cannot attain primary standards for carbon monoxide of photochemical oxidants by that date, it must submit a second plan revision by December 31, 1982, which provides for attainment by December 31, 1987.

Also included in the Clean Air Act Amendments is a provision which will allow new stationary sources within non-attainment areas only if emissions from existing sources have been reduced to more than compensate for the new emissions. Additional powers are given to the US EPA for sewage treatment plant construction grants. Therefore, the potential implications of the MPCA actions and the Clean Air Amendments of 1977 must be considered for any expansion of the Metro Plant or construction in non-attainment areas.

NOISE

Noise is generally associated with man's activities, while sounds emanate from natural processes. The quantitative analysis of noise has become important since it was first measured in New York City in 1927 in an attempt to reduce traffic noise in deep city canyons. A general introduction to noise is presented in (16).

The State of Minnesota is unique in the United States in that the MPCA has adopted standards for noise which are based on the concept of "dwell time", or duration above a specified level. The basic descriptors used are:

L_{10} = level exceeded 10% of an hour (or six minutes)

L_{50} = level exceeded 50% of an hour (or thirty minutes)

While the hours during which levels are to be measured are not explicitly stated in the regulation, it is generally assumed that the noisiest hour of a typical day should meet the standards. The basic standards are outlined in Table 12-5 (15).

Since noise levels are referred to a 1-hour period, it is necessary, when developing a baseline map to represent the noise environment, to make certain assumptions with respect to noise generating activities. For the purposes of this noise inventory, it is assumed that transportation sources predominate. The US EPA (12) has identified major noise sources as: motorcycles, buses, wheel and track loaders, wheel and track dozers, truck transport refrigeration units, and truck mounted solid waste compactors. Since the sources vary in localized location, it would be impossible to represent such sources on a map.

Highway, railroad and airport sources are considered and presented in Plate 16. In addition to source noise, the US EPA (6) has identified overall noise levels associated with population densities. This has been used in conjunction with 1977 and Minor Civil Division (MCD) land areas to develop a population density noise map, shown in Figure 12-4.

TABLE 12–5 MPCA NOISE STANDARDS (15)

NPC 2 NOISE STANDARDS

(a) These standards describe the limiting levels of sound established on the basis of present knowledge for the preservation of public health and welfare. These standards are consistent with speech, sleep, annoyance and hearing conservation requirements for receivers within areas grouped according to land activities by the Noise Area Classification (NAC) system herein described. However, these standards do not, by themselves, identify the limiting levels of impulsive noise needed for the preservation of public health and welfare.

(b) Noise Standards

	DAY (0700-2200)		NIGHT (2200-0700)	
NAC	L_{10}	L_{50}	L_{10}	L_{50}
1	60	65	50	55
2	65	70	65	70
3	75	80	75	80

(c) Noise Area. Classification System According to Land Activity at Receiver. Acceptable sound levels for the receiver are a function of the intended activity in that land area. The following noise area classifications are grouped and defined by the SLUCM numerical codes and descriptions.

(d) Noise Area Classification—1 (NAC—1) includes the following land activities:

NAC—1

11	Household units (includes farm houses)
12	Group quarters
13	Residential hotels
14	Mobile home parks or courts
15	Transient lodgings
19	Other residential, NEC*
397	Motion picture production
651	Medical and other health services
674	Correctional institutions
68	Educational services
691	Religious activities
71	Cultural activities and nature exhibitions
721	Entertainment assembly
7491	Camping and picnicking areas (designated)
75	Resorts and group camps
79	Other cultural, entertainment, and recreational activities, NEC

(e) Noise Area Classification—2 (NAC—2) includes the following land activities:

NAC—2

4113	Railroad terminals (passenger)
4115	Railroad terminals (passenger and freight)
4122	Rapid rail transit and street railway passenger terminals
4211	Bus passenger terminals (intercity)
4212	Bus passenger terminals (local)
4213	Bus passenger terminals (intercity and local)
429	Other motor vehicle transportation, NEC

*NEC—Not elsewhere coded.

4312	Airport and flying field terminals (passenger)
4314	Airport and flying field terminals (passenger and freight)
4411	Marine terminals (passenger)
4413	Marine terminals (passenger and freight)
46	Automobile parking
4721	Telegraph message centers
492	Transportation services and arrangements
51	Wholesale trade
52	Retail trade—building materials, hardware, and farm equipment
53	Retail trade—general merchandise
54	Retail trade—food
55	Retail trade—automobile, marine craft, aircraft, and accessories
56	Retail trade—apparel and accessories
57	Retail trade—furniture, home furnishings, and equipment
58	Retail trade—eating and drinking
59	Other retail trade, NEC
61	Finance, insurance and real estate services
62	Personal services
63	Business services
64	Repair services
652	Legal services
659	Other professional services, NEC
66	Contract construction services
67	Governmental services (except 674)
69	Miscellaneous services (except 691)
72	Public assembly (except 721, 7223)
73	Amusements (except 731)
74	Recreational activities (except 7491)
76	Parks

(f) Noise Area Classifications—3 (NAC—3) includes the following land activities:

NAC—3

21	Food and kindred products—manufacturing
22	Textile mill products—manufacturing
23	Apparel and other finished products made from fabrics, leather, and similar materials—manufacturing
24	Lumber and wood products (except furniture)—manufacturing
25	Furniture and fixtures—manufacturing
26	Paper and allied products—manufacturing
27	Printing, publishing and allied industries
28	Chemicals and allied products—manufacturing
29	Petroleum refining and related industries
31	Rubber and miscellaneous plastic products—manufacturing
32	Stone, clay, and glass products—manufacturing
33	Primary metal industries
34	Fabricated metal products—manufacturing
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks—manufacturing
39	Miscellaneous manufacturing, NEC (except 397)
41	Railroad, rapid rail transit, and street railway transportation (except 4113, 4115, 4122)
42	Motor vehicle transportation (except 4211, 4212, 4213, 429)
43	Aircraft transportation (except 4312, 4314)
44	Marine craft transportation (except 4411, 4413)
45	Highway and street right-of-way
47	Communication (except 4721)

48	Utilities
49	Other transportation, communication and utilities, NEC (except 492)
7223	Race tracks
731	Fairgrounds and related activities
81	Agriculture
82	Agricultural and related activities
83	Forestry activities and related services (including commercial forest land, timber production and other related activities)
84	Fishing activities and related services
85	Mining activities and related services
89	Other resource production and extraction, NEC
—	All other activities

(g) Noise Area Classification—4 (NAC—4) includes the following land activities:

NAC—4

91	Undeveloped and unused land area (excluding non-commercial forest development)
92	Non-commercial forest development
93	Water areas
94	Vacant floor area
95	Under construction
99	Other undeveloped land and water areas, NEC

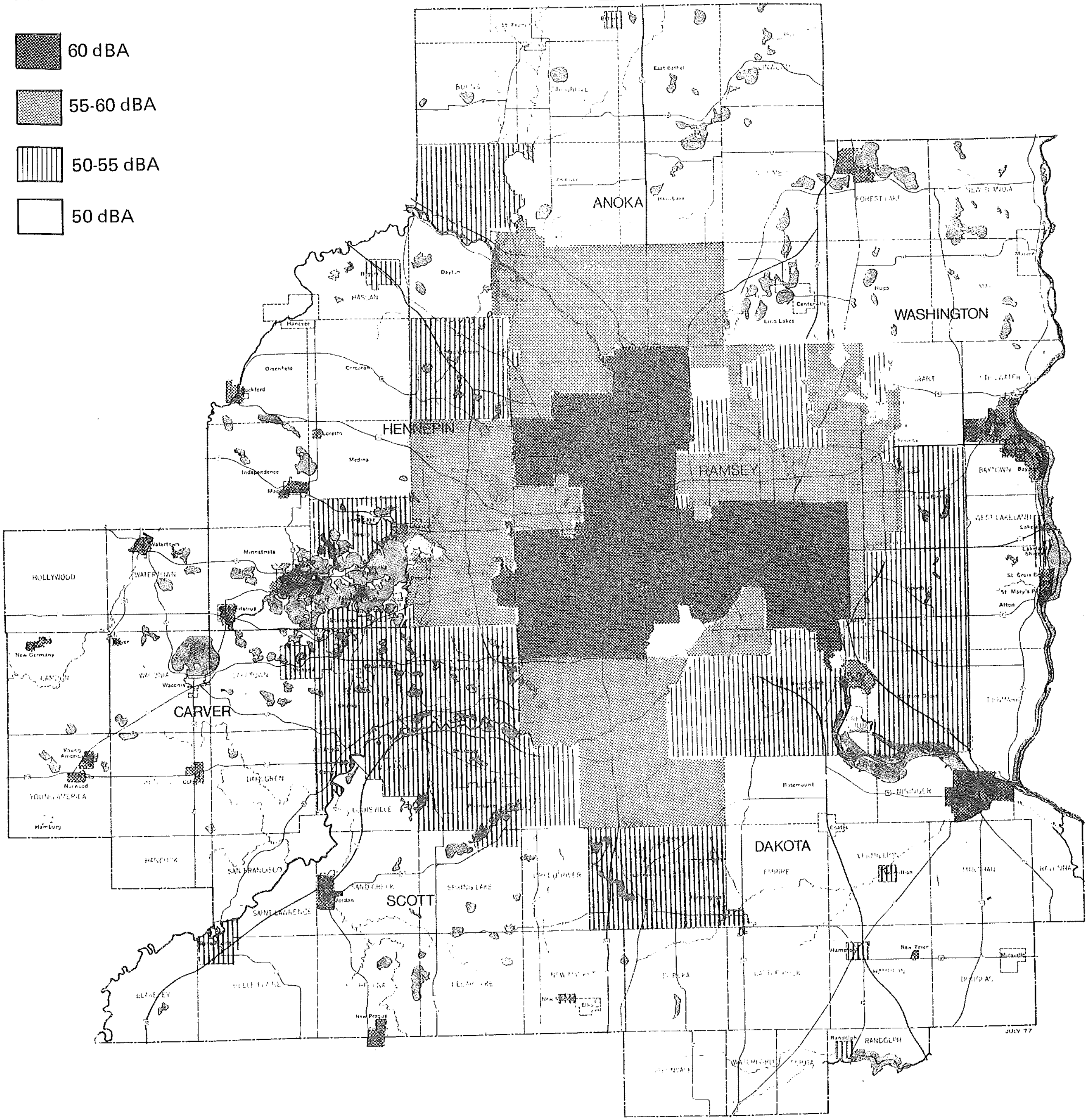
FIGURE 12–4 POPULATION RELATED AMBIENT NOISE LEVELS (10)

▩ 60 dBA

▨ 55-60 dBA

▥ 50-55 dBA

☐ 50 dBA



SOURCE: David Braslau Associates, Inc.

HIGHWAYS AND OTHER ROADWAYS

Highway noise is dependent upon the type and number of vehicles using a roadway, the average speed, roadway surface, distance from the roadway, and intervening barriers (20). Since it would be difficult to develop a detailed map along each roadway, the following generalizations have been made in order to show two impact zones on Plate 16.

a. Roadways are flat and are surrounded by flat terrain

b. Two roadway types have been assumed:

  i. 4 lanes, 40 mph, 10 foot median, interrupted flow

  ii. 6 lanes, 55 mph, 50 foot median, uninterrupted flow

Using these assumptions, two impact zones have been identified:

a. Roadways with L10 = 65 (dBA)[1] at distances greater than 800 but less than 1600 feet from a roadway (this represents the "residential" daytime standard).

b. Roadways with L10 = 65 dBA at distances greater than 1600 feet from the roadway.

RAILROADS

Quantitative predictions of railroad noise required knowledge of train speed, length, and roadway variables. The Department of Housing and Urban Development (HUD) (17) has developed a standard methodology for the treatment of railroad noise to be applied in the evaluation of HUD projects.

Three categories of rail lines are considered here based on data from the Minnesota Department of Transportation:

a. Lines carrying 18 trains/day and 7 trains/night
b. Lines carrying 4 trains/day and 1 train/night
c. Lines carrying 1 train/day and 0 trains/night

Based upon these categories and the HUD criteria, those rail corridors have been identified for which:

a. L10 = 65 dBA is exceeded up to 200 feet from the line
b. L10 = 65 dBA is exceeded from 200 to 500 feet from the line

In addition to noise from moving trains, most complaints in the metropolitan area have come from operations at rail switching yards. Observation of these have revealed levels as high as L10 = 62 dBA at night, which violates the nightime standard of L10 = 55 dBA. Therefore, although noise from switching yards is not as predictable as that from rail lines, these have been identified on the map as potential problem areas for noise. (19)

AIRPORTS

Preliminary noise contours for airports have been derived in two ways. At the Minneapolis-St. Paul International Airport, the L10 = 65 dBA contour was developed by numerous rough measurements by the Noise Control Section of the MPCA, and used for this report. The contour is generally valid for 1976 operations. A comprehensive program is underway as a joint effort of the Metropolitan Council and the Metropolitan Airports Commission to develop contours for the airport through 1990. At General Aviation Airports, contours

---

[1] dBA is a unit of sound level and is the weighted sound pressure level by the use of A-metering characteristic and weighing as specified in ANSI specification for Sound Level Meters. dBA is commonly used as a measure of human response to sound.

have been developed based upon 1976 operations, using a standardized procedure prepared for the Federal Aviation Administration (12, 17). These contours are also being revised by the Metropolitan Council as part of the Aviation Systems Study. The contours increase in size towards 1990.

Information on the current contours for Minneapolis-St. Paul and the General Aviation Airports may be obtained from Chauncey Case of the Twin Cities Metropolitan Council.

POPULATION DENSITY MODEL

The U.S. EPA has funded studies to determine relationships between background noise level and population density, which may be attributable primarily to the amount of traffic associated with a given density (6). While there is a great spread in the data, the relationship of Ldn=10+22 Log (population density) has been proposed. The Ldn (day-night level) is different in concept from the L10/L50 used by Minnesota, and it has been necessary to develop an additional relationship between L10 and Ldn.

Typical urban sites have been examined from the Waco Study (8) where L10 for each hour has been computed in addition to Ldn. Using these data have provided an approximate relationship of L10 (65) = Ldn (63.4). With the most recent population statistics from the Metropolitan Council and land areas for each MCD, population densities have been computed and inserted into the equation above to determine background noise levels, as shown in Figure 12-4.

REFERENCES

1. Air Pollution Primer; National Tuberculosis and Respiratory Disease Association, 1971.

   This introductory booklet describes major pollutants, their effects on man, and major sources. (Availability: American Lung Association)

2. Ambient Air Quality Standards, APC-1; Minnesota Pollution Control Agency, Minnesota State Regulations.

   This document contains standards adopted by the State for major air pollutants. (Availability: Minnesota Department of Administration)

3. Assessment of the Impact of Odorous Emissions from the Metropolitan Wastewater Treatment Plant-St. Paul; Interpoll, Inc., prepared for the Metropolitan Sewer Board, July 1974.

   This document describes the basis for identification of odors and odor emissions, and develops estimates of odor dispersion near the plant. The methodology used here could be applied to other plants with similar emissions. (Availability: MWCC)

4. Bloomington Noise Study; City of Bloomington, 1975.

   This study presents measurements and estimates of noise levels throughout the City of Bloomington, indicating that 43% of the residences are exposed to noise levels over the state standards. (Availability: City of Bloomington)

5. Clean Air Act of 1970, and Clean Air Act Amendments of 1977; U. S. Congress, Conference Committee Report 95-564, August 3, 1977, HR6161, P.L. 95-95.

   These documents contain provisions as established by the U. S. Congress for air quality and emission standards. The Amendments contain provisions for State Implementation Plan revisions, which may be critical in the siting of future wastewater treatment facilities. (Availability: DAQ-MPCA)

6. Community Noise Measurement at One Hundred Sites Throughout the United States; M. A. Simpson, presented at the 89th Meeting of the Acoustical Society of America, Austin, Texas, April, 1975.

   These data have served as a basis for developing the relationship between ambient noise level and population density used in this inventory. There is some question as to its direct applicability to the metropolitan area, but should serve to identify those areas where noise levels are proportionately higher.(Available: U.S. EPA)

7. Control of Odors in the Ambient Air, APC-9; Minnesota Pollution Control Agency, Minnesota State Regulations.

   This document contains definitions of odors and procedures for determination of odor emission and evaluation. (Availability: Minnesota Department of Administration)

8. Environmental Noise Assessment - Waco, Texas Metropolitan Area; U. S. Environmental Protection Agency, April 1974.

   This is one of the earlier and comprehensive noise surveys performed over 24-hour periods in a metropolitan area, and as such provides a basis for the comparison of various noise indicators in different environments and during different times of the day. (Availability: US EPA)

9. Environmental Resource Data and Assessment Guide, St. Paul City Planning, January 1977.

   This summary presents the environmental climate in the City of St. Paul in terms of air, noise, and water quality. (Availability: Planning Department, City of St. Paul)

10. Fuel Supply: Metropolitan Wastewater Treatment Plant; Toltz, King, Duvall, Anderson and Assoc., Inc., prepared for the Metropolitan Sewer Board, April 1973.

    This report identifies fuel requirements in 1972 and through 1985 for the plant, and indicates the amounts of alternative fuels which would be required to replace natural gas consumed in that year. (Availability: MWCC)

11. Handbook for Developing Noise Exposure Contours for General Aviation Airports; D. E. Bishop and A. P. Hays, Bolt, Beranek and Newman, prepared for the Federal Aviation Administration, FAA-AS-75-1, December 1975.

    This document contains methods for developing NEF and Ldn noise contours for general aviation airports without the use of a computer. (Availability: MC, MAC, and NTIS)

12. Identification of Products as Major Sources of Noise; U. S. Environmental Protection Agency, Federal Register, Vol. 40, No. 103, Wednesday May 28, 1975.

    This document discusses the problem of noise in the nation and identifies those sources which are deemed controllable by regulation to reduce overall noise levels and the numbers of persons exposed to potentially hazardous levels. (Availability: U of M Documents Collection)

13. Minnesota Air Quality 1971-1976; Ingrid Ritchie, Minnesota Pollution Control Agency, February 1977.

This document summarizes the major air pollutants in Minnesota and contains monitoring data for these pollutants in air quality regions throughout the state, including the Metropolitan Region (No. 131). Historical trends are shown in both tabular and graphical form. (Availability: DAQ-MPCA)

14. Minnesota State Implementation Plan to Meet Air Quality Standards; 1973. Minnesota Pollution Control Agency.

This document contains an analysis of air quality problems and what must be done to achieve air quality standards. The plan will be revised by 1979. (Availability: DAQ-MPCA)

15. Minnesota State Regulations, MPCA, Noise Pollution Control Section; NPC 1: Definitions, Severability and Variances for Noise Pollution Control Regulations 1974; NPC 2: Noise Standards 1974.

These regulations contain the basic definitions used for noise impact evaluation in Minnesota, the noise criteria and standards used, and categories of land use associated with these standards. (Availability: Department of Administration, State of Minnesota)

16. The Noise Around Us, U. S. Department of Commerce, COM 71-00147, September 1970.

This document is a report of the Panel on Noise Abatement to the Commerce Technical Advisory Board. It includes discussion of noise and noise pollution, methods for noise abatement and control, economics of such methods, and legal aspects of noise control. (Availability: US GPO)

17. Noise Assessment Guidelines, Department of Housing and Urban Development, 1971; and Noise Assessment Guidelines: Technical Background; Bolt, Beranek and Newman, prepared for the Department of Housing and Urban Development.

The first document provides simple guidelijnes for the development of acceptable and nonacceptable noise zones (using HUD standards). The background document contains more detailed material on the variation of noise environments in urban areas and gives the rationale behind the simplified approaches contained in the HUD Guidelines. (Availability: HUD, or U. S. GPO)

18. Noise Exposure Study: Interstate Freeways, Twin Cities Metropolitan Area; Minnesota Department of Highways, 1973.

This document presents results of a comprehensive survey of sites along TCMA freeways, and indicates those areas of greatest impact.

19. Personal communication, Robert Lines, Department of Inspection, City of Minneapolis.

20. Reports by the National Cooperative Highway Research Program of the Highway (now Transportation) Research Board.

NCHRP 78	Highway Noise: Measurement, Simulation, and Mixed Reactions,	1969
NCHRP 117	Highway Noise: A Design Guide for Highway Engineers,	1971
NCHRP 144	Highway Noise: A Field Evaluation of Traffic Noise Reduction Measures,	1973
NCHRP 173	Highway Noise: Generation and Control,	1976
NCHRP 174	Highway Noise: A Design Guide for Prediction and Control,	1976

The above reports describe both manual and computer techniques for traffic noise prediction and are sufficiently complete to treat practical problems associated with roadways and traffic noise as well as sufficient background and foundation for the prediction of highway noise.

(Availability: MnDOT and from the Transportation Research Board, National Research Council, Washington, D. C.)

MWCC = Metropolitan Waste Control Commission
US GPO = United States Government Printing Office
DAQ-MPCA = Division of Air Quality, Minnesota Pollution Control Agency
US EPA = United States Environmental Protection Agency
MnDOT = Minnesota Department of Transportation
HUD = United States Department of Housing and Urban Development
MC = Metropolitan Council
MAC = Metropolitan Airports Commission
NTIS = National Technical Information Service

ADDITIONAL REFERENCES AND CONTACTS

Many references on air quality may be found in the Engineering Library at the University of Minnesota. A simple introductory text to air pollution has been prepared by the National Tuberculosis and Respiratory Disease Association (1). A useful reference is the State of Minnesota Implementation Plan (14), although a revised version will be published in July 1979. Noise studies have been conducted by the Minnesota Department of Highways (Mn/DOT) (18), the City of Bloomington (4), the City of St. Paul, and the MPCA. Noise studies required for highway and airport construction and involving federal funds are available from Mn/DOT and the Metropolitan Airports Commission.

CONTACTS

Agency	Person
City of Bloomington	Lon Loken, Noise Abatement Officer
City of Minneapolis	Robert Lines, Department of Inspection
City of St. Paul	Kenneth Dzugan, Department of Planning
Metropolitan Airports Commission	Jeff Hamiel, Director of Noise Abatement
Metropolitan Council	Chauncey Case, Transportation Planner Ray Thron, Air Resources Planner
Minnesota Department of Transportation	Ms. Terry Hoffman, Director of Environmental Affairs
Minnesota Pollution Control Agency	Al Perez, Noise Control Section Edward Wiik, Director of Division of Air Quality

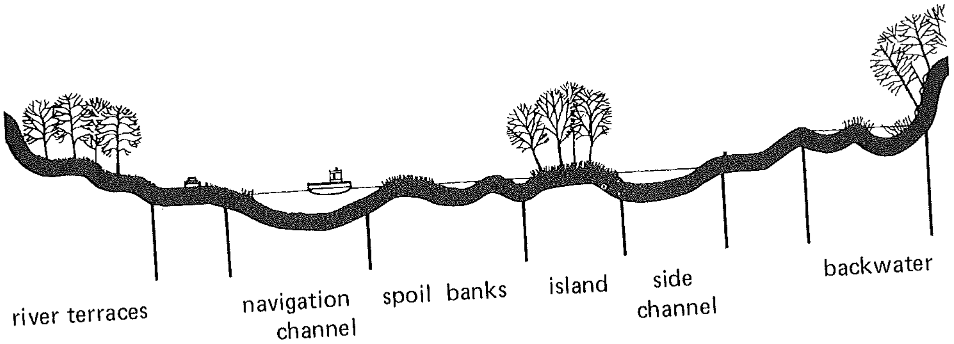
SECTION 13 LAND/WATER INTERFACE

The numerous lakes and rivers in the metropolitan area contribute to a high quality aesthetic environment. The natural beauty of land/water interfaces has long been recognized but not until recent years has there been a concerted effort to protect these areas. Since the late 1960's, state and federal laws have developed guidelines for local governments regarding the protection of their water resources. Some of the most important of these are the Shoreland Management Act, the Floodplain Management Act, the State and National Wild, Scenic and Recreational River Acts, the Critical Areas Act, and locally the Metropolitan Open Space Act. Section 14 - Land Use, summarizes major highlights of these as well as other land use controls.

Three of the major uses of the land/water interface are recreational use, commercial/industrial use, and residential use. Some of the major features and activities that occur on the river interface are illustrated in Figure 13-1.

FIGURE 13–1

TYPICAL ACTIVITIES ON A RIVER INTERFACE (4)



residential
commercial
industrial
institutional
development

FEATURE

riverfront parks
bridge approaches
docks, harbors
harbors
wing dams
bank protection
aquatic plants
dikes and
  floodwalls
railroads

Commercial navigation
- towboats and barges
- sightseeing riverboats

Recreational navigation
- motorboats
- sailboats
- houseboats
- canoes and rafts
- rowboats

Game and fish habitat

ACTIVITY

houseboat
  living
picnicking
fishing
trapping
clamming
hunting
flooding
viewing
  river
  traffic

RECREATION USE

The Department of Natural Resources (DNR) State Comprehensive Outdoor Recreational Plan (SCORP) Inventory (1974) is the most comprehensive data base which addresses recreational attitudes and participation in recreation activities. (11) Major water uses determined by SCORP were based on a 1967 Minnesota demand survey. Although the figures in Table 13-1 are statewide totals, they indicate the importance of high water quality and water oriented recreation to Minnesota's population as a whole.

TABLE 13–1

OUTDOOR RECREATION ACTIVITY PARTICIPATION (11)

ACTIVITY	PERCENT OF STATE POPULATION PARTICIPATING
Swimming	67%
Fishing	50%
Boating	50%
Ice Fishing	20%
Canoeing	12%
Sailing	10%

The DNR is currently working on the 1979 SCORP inventory. Demand surveys will be initiated in many new areas and should give more data on regional aspects as well as state interests.

From 1971 through 1972 attitudes towards the Mississippi River as a total resource in Minnesota were studied by the Water Resources Center of the University of Minnesota (12). Results presented in Table 13-2 on the use of the Mississippi River were obtained from questionnaires distributed to 5000 adults, in depth interviews with 101 adults, and questionnaries to 195 high school students.

When asked to choose a body of water for leisure, 45 percent of the respondents specified a certain lake. The top seven desirable qualities identified by the respondents were beauty and scenery, recreation, fishing, boating and sailing, transportation, wildlife, and historic value. The most undesirable qualities listed were: pollution, oil smells, industrial-heated water, commercial use, barges and dams, and garbage and litter on banks. Totals exceed 100% since respondents often cited a number of qualities that were important rather than one outstanding quality.

TABLE 13–2

ATTITUDE STUDY ON THE DESIRABLE QUALITIES OF THE MISSISSIPPI RIVER (12)

COMBINED		METRO		OUT-STATE	
Beauty, scenery	43%	Beauty, scenery	46%	Boat, sail	44%
Recreation	33%	Recreation	31%	Beauty, scenery	40%
Fishing	32%	Fishing	29%	Fishing	33%
Boat, sail	31%	Boat, sail	25%	Recreation	33%
Transportation	17%	Transportation	17%	Wildlife	21%
Wildlife	17%	Wildlife	17%	Transportation	19%
Historic	14%	Historic	16%	Swimming	6%

UNDESIRABLE QUALITIES OF THE MISSISSIPPI RIVER

COMBINED		METRO		OUT-STATE	
Pollution	44%	Pollution	46%	Pollution	42%
Dirty, oil smell	32%	Dirty, oil smell	35%	Dirty, oil smell	23%
Industrial heated water, commercial use, barges, dams	25%	Industrial heated water, commercial use, barges, dams	26%	Sewage	21%
Garbage, debris, junk on banks	16%	Garbage, debris junk on banks	19%	Industrial heated water, commercial use, barges, dams	19%
				Garbage, debris junk on banks	11%

CHOICE OF BODY OF WATER FOR LEISURE

COMBINED		METRO		OUT-STATE	
Certain lake	45%	Certain lake	46%	Certain lake	41%
Other unspecified river	17%	Other unspecified river	17%	Mississippi	24%
Any other lake	14%	Any other lake	16%	Other unspecified river	18%
Mississippi	13%	Mississippi	9%	Any other lake	6%

Additional studies of the river corridors have been initiated by local, state and federal agencies. Most of these are readily available to interested agencies and the public (see references - Sections 11 and 13).

ACCESS

Over 160 public accesses are provided by different agencies. (See Plate 17). State agencies administer 35 of these sites while the remainder are administered on the county, township, or municipal level. Forty-four sites are located on streams or rivers and the remaining 119 sites provide access to 87 different metropolitan lakes.

Lake Minnetonka, the largest metropolitan lake, has the greatest number of accesses. Other lakes that receive heavy use and have more than one access include Prior and Cedar Lakes (Scott County), Whaletail and Medicine Lakes (Hennepin County), Marion Lake (Dakota County), White Bear Lake (Ramsey and Washington Counties) and Big Marine and Forest Lakes (Washington County).

In addition to public accesses, resorts, marinas and organizations provide access to lakes and rivers. At least 26 marinas are located on the Mississippi, Minnesota, and St. Croix rivers. Numerous private facilities provide access to metropolitan area lakes.

The inventory of public accesses is based on the most current data available from a September, 1977 SCORP printout. At the time of this study, the 1977 Metropolitan Lakes Inventory had just been completed, but accesses had not been coded into the computer listing. Additional sites most likely will appear on the updated inventory.

Recreational and historical developments along the Mississippi are numerous. Harriet Island in St. Paul has been developed into a public park. The State Park at Fort Snelling and the surrounding river bluffs provide a historical glimpse into the state's past. Kelley Farm, north of Anoka, is a designated historic site. Hennepin County is currently developing a park near the Coon Rapids dam. Municipal parks include the North Mississippi Park, a park on the west bank at the mouth of Shingle Creek in Minneapolis, one along East and West River Road, a park from the University south of Fort Snelling and the undeveloped University River flats in Minneapolis, and Crosby Lake Park in St. Paul. Between the City of Minneapolis and the airport lie the virgin prairie of West River Bank and Seven Oaks, and Minnehaha Falls. Lake Rebecca Park is located downstream at Hastings, Minnesota.

Since the Minnesota River has a naturally high turbidity factor, recreational use is limited, although there are several state waysides and the Minnesota Valley Corridor Trail along its shores. (See Plate 22 - Regional Parks and Open Space). There are very few trout streams in the basin. Sites of interest along the Minnesota River near Shakopee include the proposed Minnesota Valley National Wildlife Recreation Area, Purgatory Creek, Riley Creek and Riley Lake natural area, and James W. Wilkie Park Reserve. Near Belle Plaine is the "Lost 80", a natural area containing rare flora (See Project 80, Environmental Education Areas of Minnesota, Natural and Scientific Areas of Minnesota and the Critical Area Inventory).

FIGURE 13–2 LOCATION MAP OF SELECTED RIVER SEGMENTS

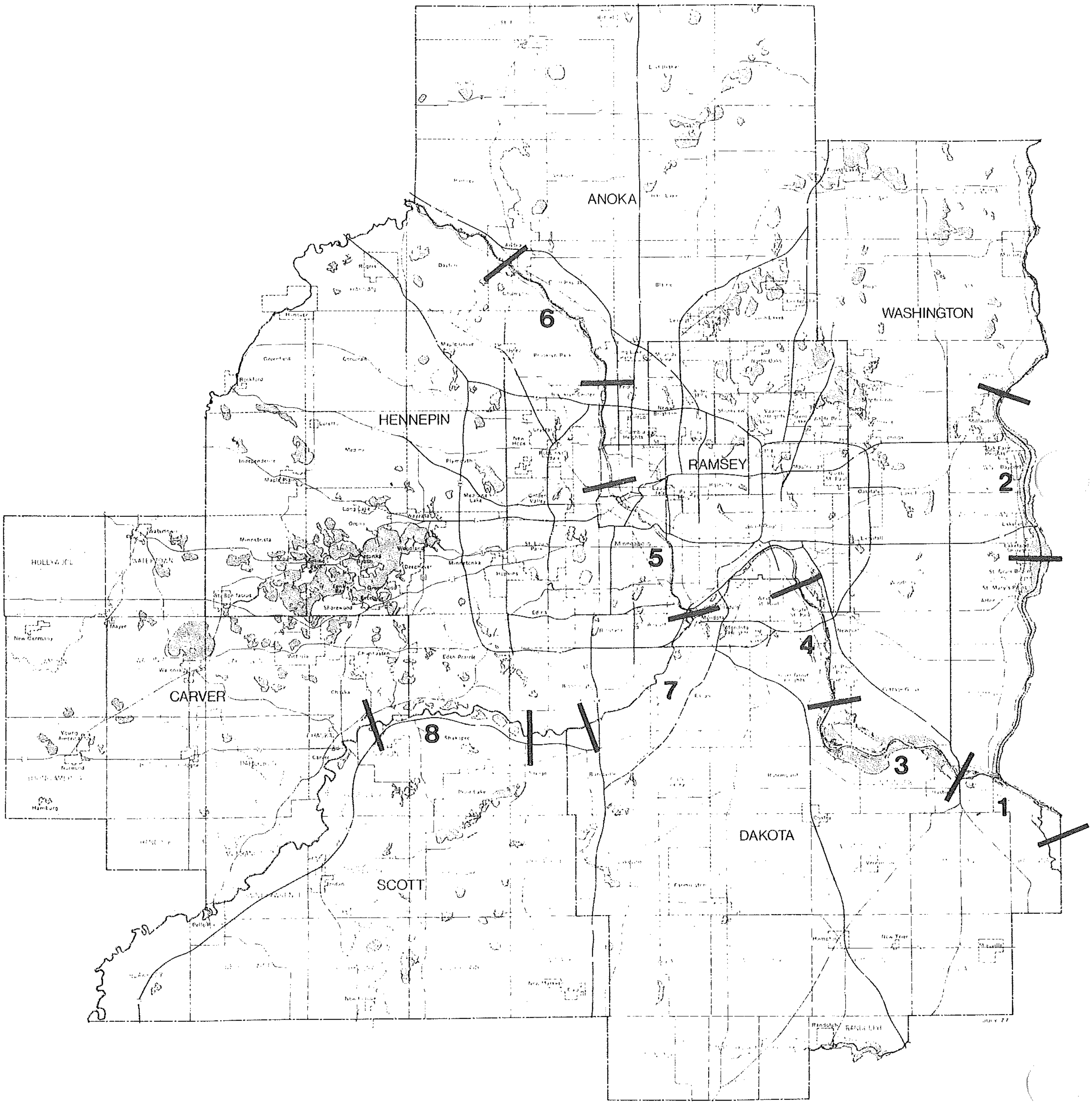


FIGURE 13–3 RIVER SEGMENT 1

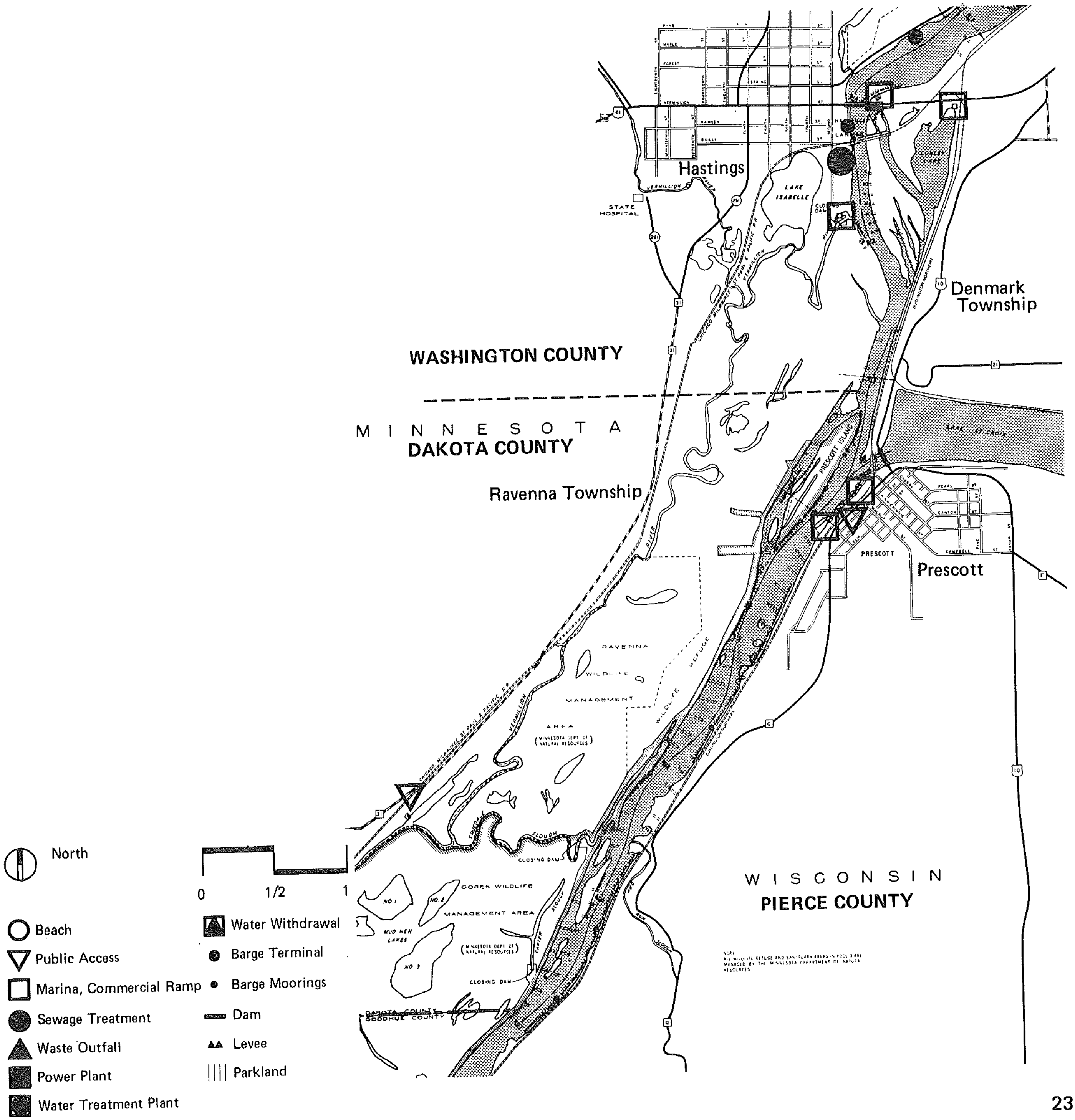


FIGURE 13–4 RIVER SEGMENT 2

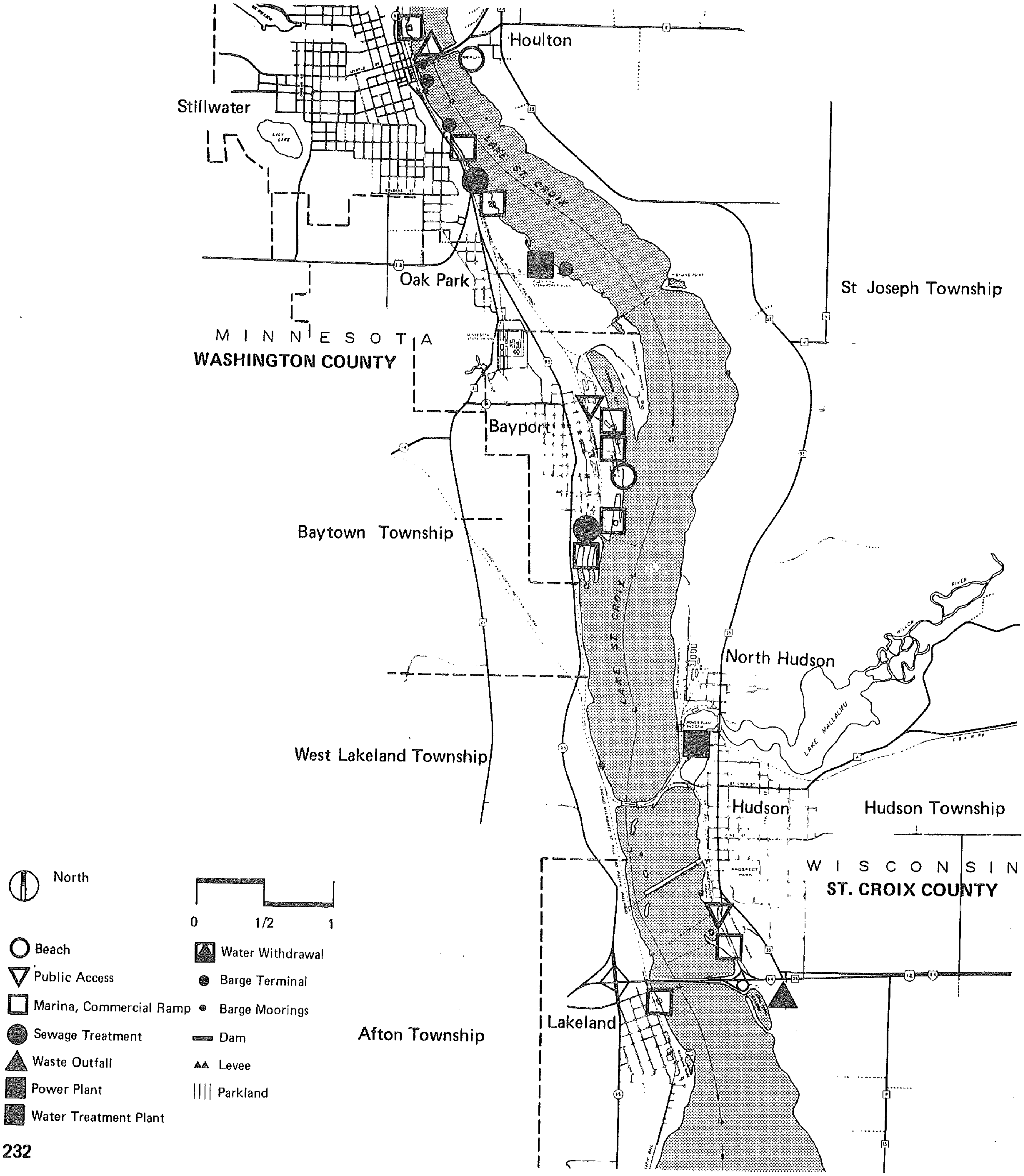


FIGURE 13–5 RIVER SEGMENT 3

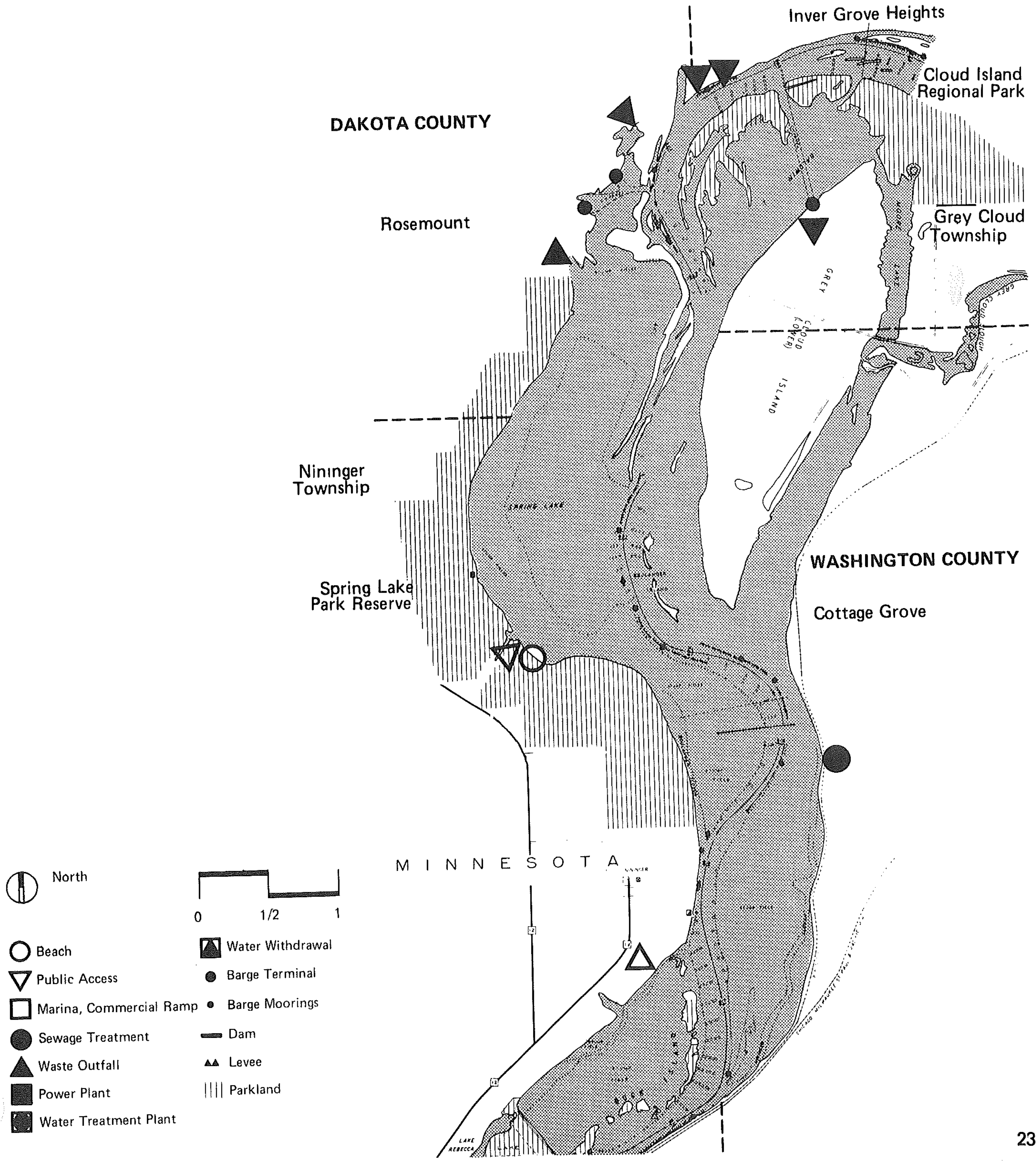


FIGURE 13–6 RIVER SEGMENT 4

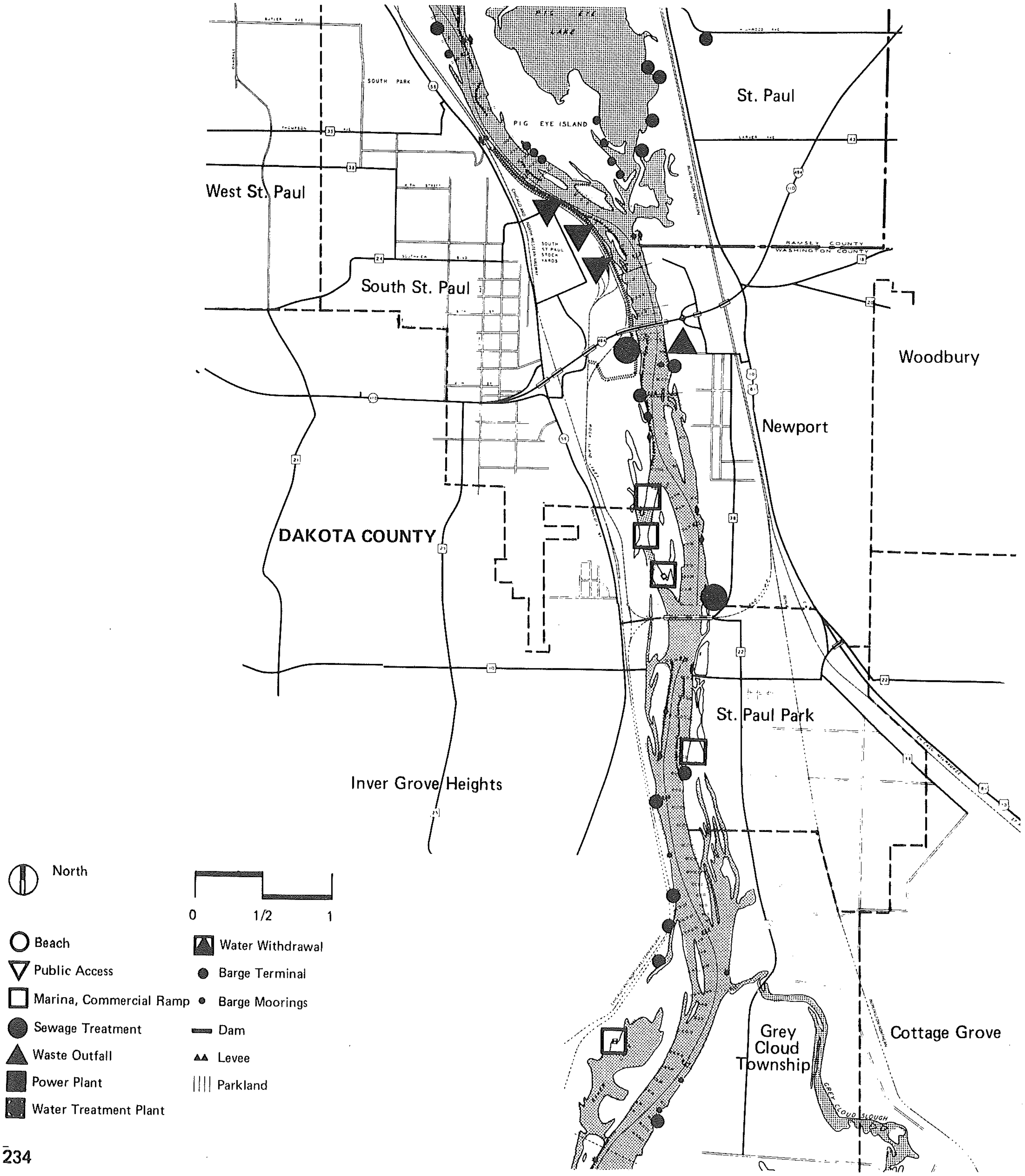


FIGURE 13–7 RIVER SEGMENT 5

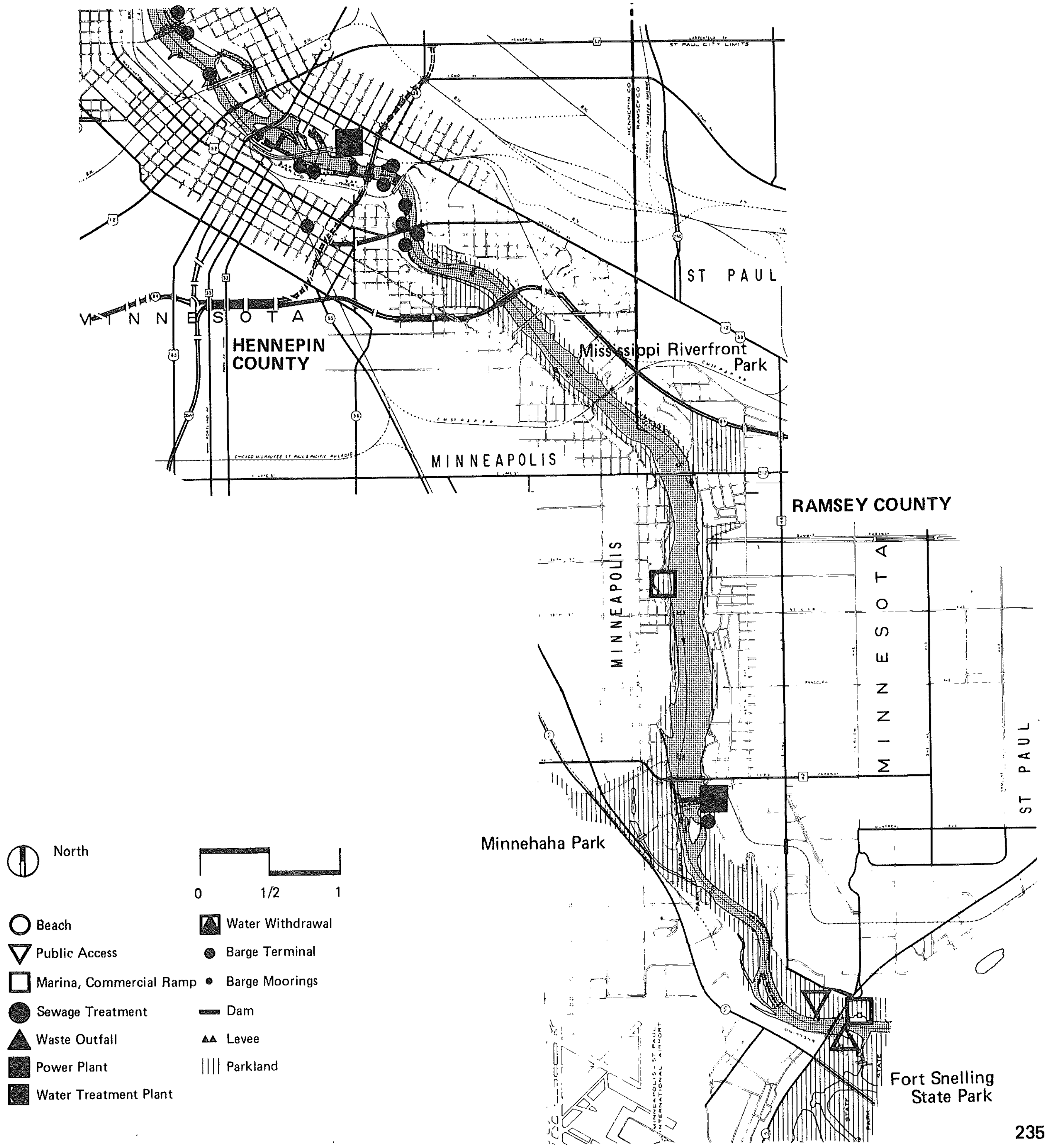


FIGURE 13–8 RIVER SEGMENT 6

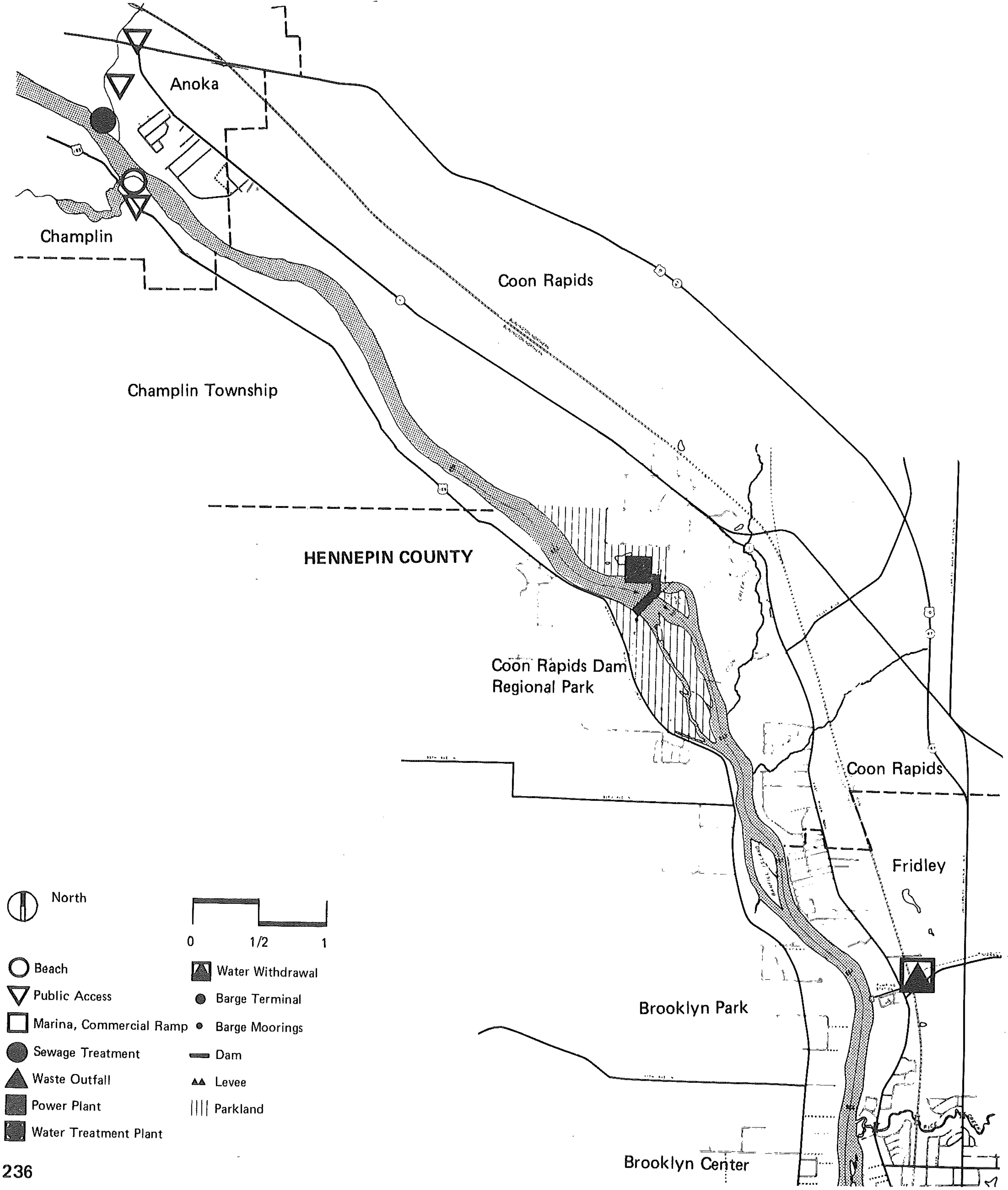


FIGURE 13–9 RIVER SEGMENT 7

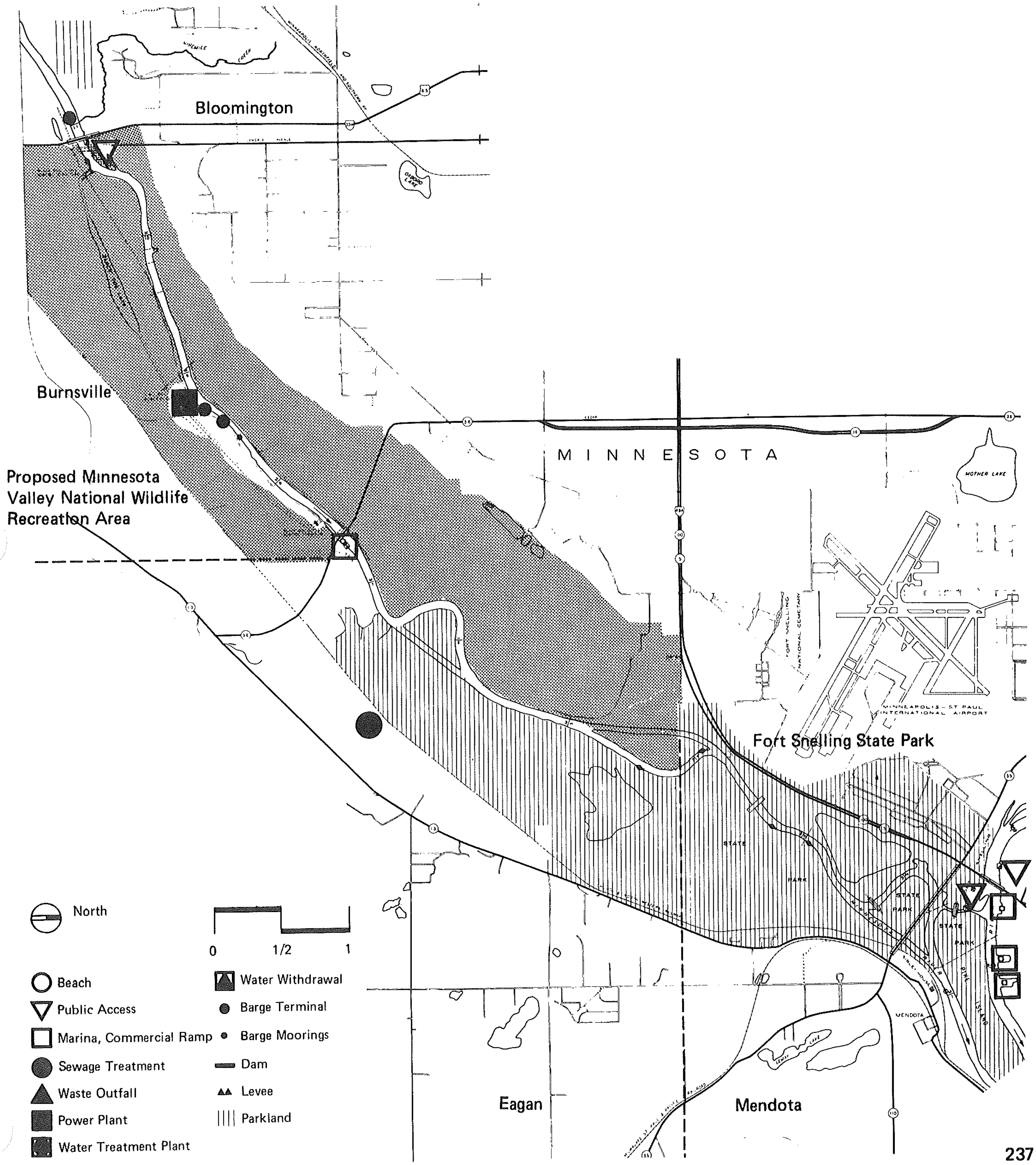
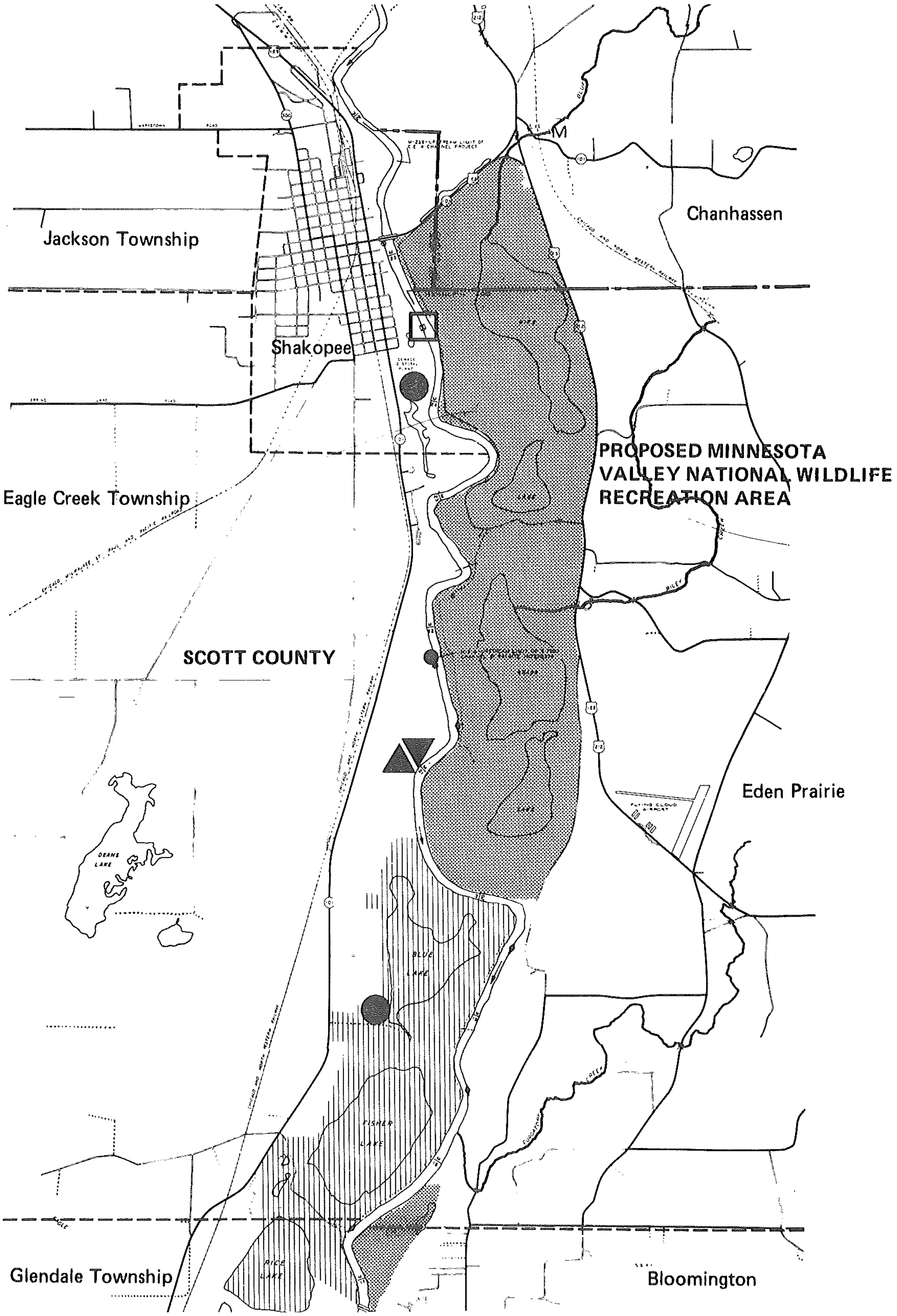


FIGURE 13–10 RIVER SEGMENT 8



GEOMORPHIC AND VEGETATION CHARACTERISTICS OF THE RIVER CORRIDORS

Plate 18 illustrates critical erosion and deposition areas along the major water courses. Slopes over 12 percent were considered by the Metropolitan Council as particularly susceptible to erosion, though lesser slopes, depending on soil characteristics, can also be problem areas. These slopes tend to define the river valleys by forming the bluff lines especially along the St. Croix and Minnesota Rivers.

The three major river corridors are quite different in their geomorphic character. The Mississippi, north of the confluence with the Minnesota, has few slopes over 12 percent which define a corridor. Some slopes do occur around Minnehaha Falls, and St. Paul, and extend downstream to the confluence with the St. Croix.

The St. Croix River has a very well defined corridor with steep slopes rising almost immediately off the river's edge. Aesthetically, these slopes create pleasing vistas both to and from the river. Usually, the steeper slopes are associated with the tributaries, extending inland for eight to ten miles.

The Minnesota River Valley is quite wide compared to the St. Croix. Steep slopes tend to be closer to the river on the northern bank. Slopes on the southern bank are often three to four miles away from the river.

It is difficult to typify the vegetation along the river corridors since the topography, soils, and aspect create different micro-climates capable of supporting diverse plant communities. (See Section 7 - Plant Associations). Figure 13-11, however, illustrates a typical vegetational cross section with an index of plants likely to be associated with the various parts of the corridor.

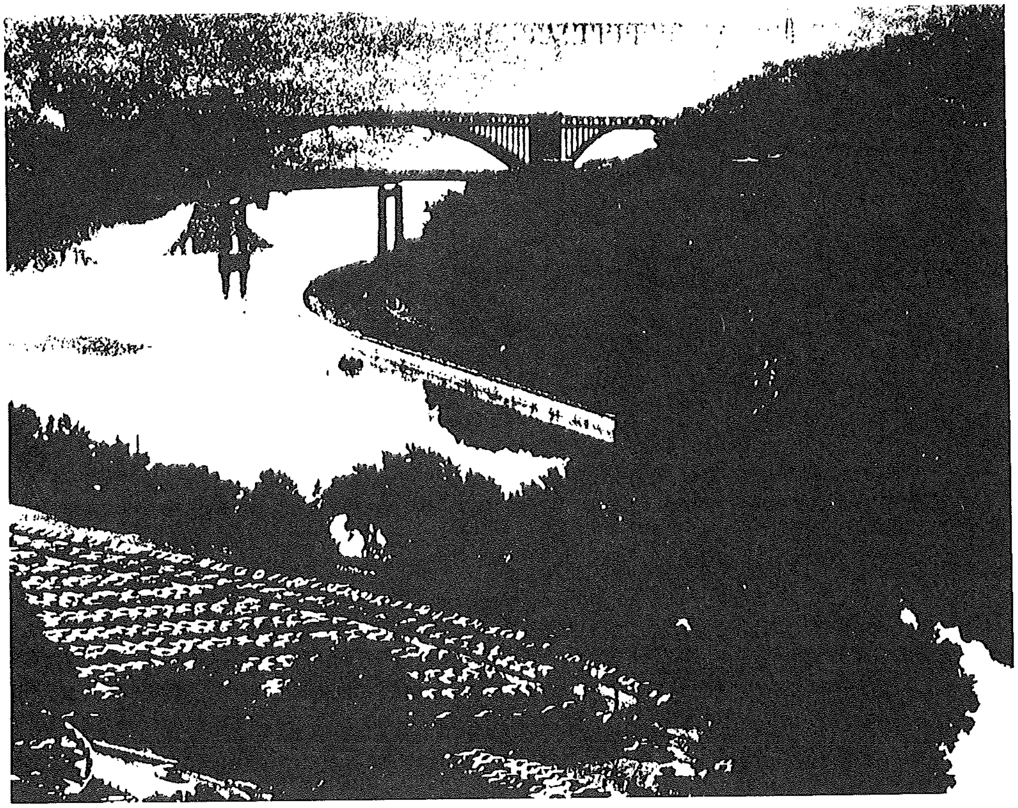
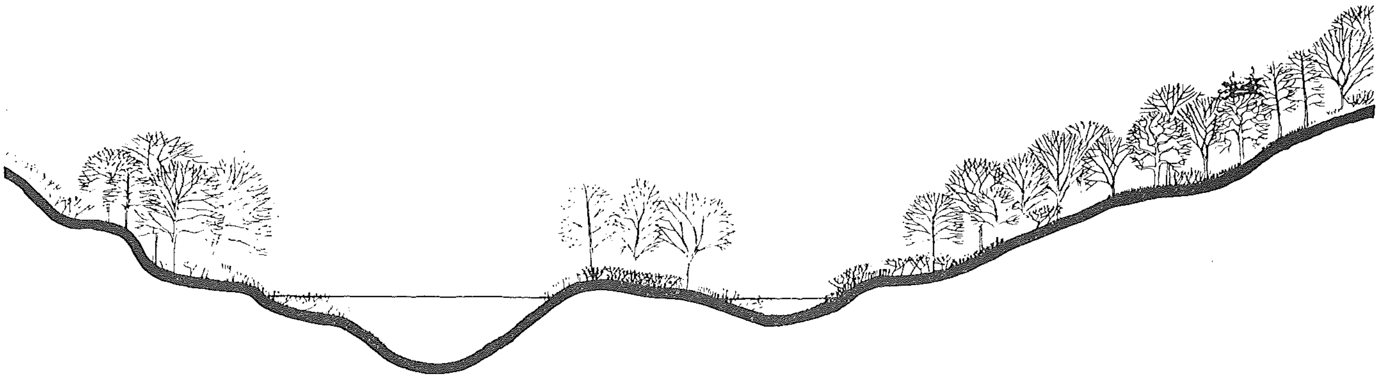


FIGURE 13–11 TYPICAL VEGETATION ZONES ALONG A TRANSVERSE SECTION FROM THE RIVER TO THE BLUFF TOP (4)



Meadow	River Border	River Bottom and Islands	Lower Slope	Upper Slope	Hill Prairie
Bluegrass	Love-grass	Peach-leaved willow	Basswood	Red cedar	Big bluestem
Golden glow	Sand-grass	Hackberry	Bitternut hickory	White oak	Little bluestem
Sedges	Reed-canary-grass	Green ash	Hackberry	White pine	Nodding grama
Milkweed	Rice cutgrass	Cottonwood	Ironwood	Sugar maple	Northern dropseed
Aster	River sedge	Silver maple	Bur oak	Paper birch	Hairy grama
Blue-joint grass	Jewelweed	Slippery elm		Ironwood	Porcupine grass
Field horsetail	Wild cucumber	American elm		Red oak	Leadplant
Joe-pye-weed	Cocklebur	Basswood		Bur oak	Ground plum
Water-horehound	Beggar's ticks	Bur oak		Hazelnut	
	Canada wood-nettle	Common nettle		Sumac	
	Common nettle			Wolfberry	
	White snakeroot			Prickly ash	
	Wild grape				
	Virginia creeper				
	Sandbar willow				
	Peach-leaved willow				
	American elm				
	Green ash				
	Cottonwood				
	Silver maple				

The St. Croix River is heavily used for recreation due to its high water quality and proximity to the metropolitan area. Since 1968, the St. Croix has been protected by the National Wild and Scenic Rivers Act. The river is preserved, managed, and administered by the National Park Service and the Departments of Natural Resources of Minnesota and Wisconsin. Canoeing, boating, and fishing are major river uses. At the St. Croix River Pool, the impoundment lake accommodates all types of motorboat activity including water skiing and houseboating. William O'Brien State Park at Marine-on-the-St. Croix and the State Park at Afton provide areas for camping, hiking, fishing, picnicking and canoeing. State Game Refuges include St. Croix River near Marine-on-the-St. Croix and Stillwater Refuge near Stillwater.

COMMERCIAL/ INDUSTRIAL USE

Barge terminals and railyards within the river corridors are delineated on Plate 20. Terminals with nearby railyards are concentrated along the Mississippi River in Minneapolis and St. Paul, and again downstream near Inver Grove Heights and South St. Paul. Three terminals lie along the St. Croix and are used primarily in coal transport. Seven terminals are located on the Minnesota River with large concentrations in Burnsville and Savage. The major commodity shipped on the Minnesota is grain exports.

Commerical and industrial development along the rivers is primarily agri-business, power production, and larger institutions such as the University of Minnesota which utilize low cost transportation of these bulk commodities. The largest concentration of commercial-industrial development is along the Mississippi River corridor. Railyards and multiple tracks occupy a large amount of riverfront land. Warehouses, storage areas, lumber, gravel and concrete industries and commercial structures occupy much of the Mississippi River edge. As of 1969, 510 industrial operations were located within the river corridors, 435 (85%) are in the Mississippi, 55 (11%) in the Minnesota, and 20 (4%) in the St. Croix River corridor. (9)

RESIDENTIAL USE

Rivers were rapidly developed as power and transportation sources for commercial and industrial use. The result is a major urban core along the Mississippi in both Minneapolis and St. Paul. Residential development is concentrated in the outlying river reaches and around metropolitan area lakes. (See Plate 19—Land Use)

Residential development along the rivers occurs in the communities of Anoka, Champlin, Fridley, Minneapolis, Lilydale, St. Paul, South St. Paul, Newport, Inver Grove Heights, Grey Cloud and Cottage Grove on the Mississippi; Carver, Chaska, Shakopee, Savage, and Bloomington along the Minnesota; Afton, St. Mary's Point, Bayport, and Stillwater on the St. Croix; and Hastings along the Vermillion and Mississippi Rivers.

Nearly all central metropolitan area lakes which did not receive early protection by parklands experienced residential development. Lakes which are not fully developed continue to receive heavy development pressure. Lakes in the outlying metropolitan area receiving residential development pressure include Lake Waconia (Carver County), Forest Lake (Washington County), Bald Eagle and White Bear (Ramsey and Washington Counties), and Prior Lake (Scott County).

SELECTED RIVER SEGMENTS

Metropolitan Council completed an extensive inventory of physical features and facilities of the major river corridors in 1969. (1, 7, 9) While an update of this entire study would be desirable, time and budget constraints of this study didn't allow this approach at a detailed level. However, eight river segments were selected to provide a more updated detailed illustration of uses in the river corridors. Figure 13-2 illustrates the location of each of the river segments. Figures 13-3 through 13-10 correspond to river miles: UM 807-815, Segment 1; St. Croix 15-23, Segment 2; UM 815-826, Segment 3; UM 826-835, Segment 4; UM 846-855, Segment 5; UM 862-872, Segment 6; Minnesota 1-11, Segment 7; Minnesota 17-27, Segment 8.

A concurrent Metropolitan Council study is updating land use information for the seven-county area utilizing 1974-75 air photos. This would provide a future data base for updating land use studies of the river corridors.

The vegetation cover is particularly important on the steeper slopes for controlling erosion and resulting sedimentation of the rivers and water bodies. Exhibit C - Soils discusses effects of different land uses and vegetation coverage on erosion and sedimentation.

DEPOSITION AREAS

Streambed bottoms and floodplains are major deposition areas. Plates 18 and 7 depict floodplains and three types of streambed composition: sand and rubble bottom, sand and organic sludge, and organic sludge.

The upper reaches of all three major rivers and the Rum River have a sand and rubble bottom. Closer to the confluences of the river, the coarser particles of organic sludge begin to settle with the sand. The Mississippi River bottom from St. Paul to Hastings is composed of the finer particles of organic sludge, the last to settle out.

Floodplains are often rich with fertile soils deposited over the years from periodic flooding. The Minnesota River has the most extensive floodplain of the rivers in the metropolitan area. Much of it is utilized for cropland along the southern reaches. Downstream from Shakopee, much of the floodplain immediately adjacent to the river remains wet and is utilized by many species of wildlife for nesting and feeding areas. The steep slopes near the river's edge along the St. Croix define a very narrow floodplain. Alluvial deposits create ever-changing islands and natural levees in addition to changing the river bottom itself.

The impacts of sedimentation and dredging operations for each of the major river pools have been identified by the Corps of Engineers. (2)

SIGNIFICANCE OF LAND/WATER INTERFACE AS HABITAT AREAS

The interface of terrestrial and aquatic environments is extremely sensitive to disruption. Natural changes due to higher or lower water levels can create drastically different habitats within relatively short periods of time. Alterations by man often speed up this process so rapidly that entire communities of plants and animals are endangered.

Figures 13-12 and 13-13 illustrate two examples of the use of the land/water interface by species which have very specialized niches in the ecosystem. Figure 13-12 illustrates the use of undisturbed areas as nesting and feeding sites for some species of birds and reptiles. For example, feeding sites of the kingfisher and three species of herons are directly related to the length of each species' legs. Thus, dredging, riprap, or other alterations can permanently destroy feeding sites of these birds.

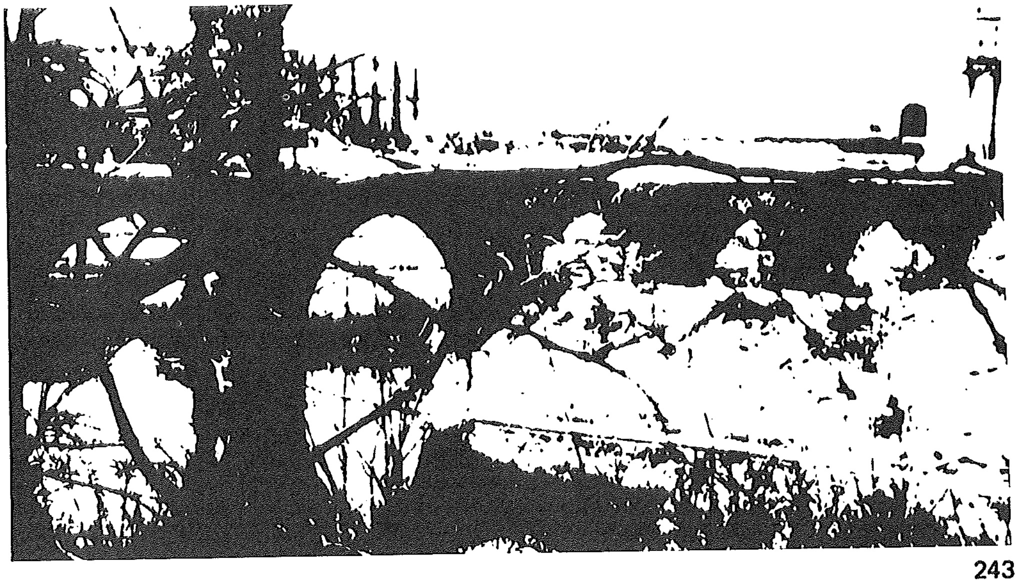


FIGURE 13–12

EXAMPLES OF SPECIES' DEPENDENCE ON UNDISTURBED WATER–LAND INTERFACE

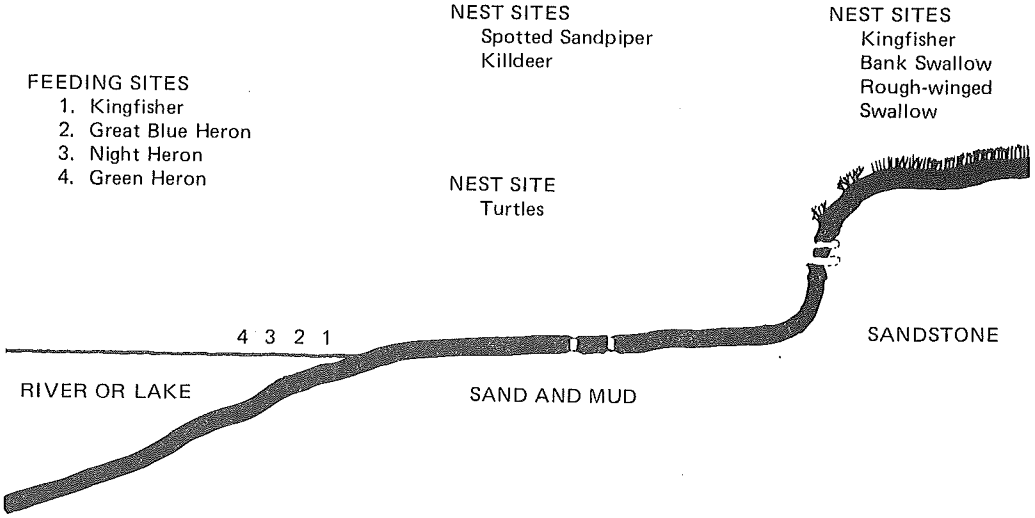
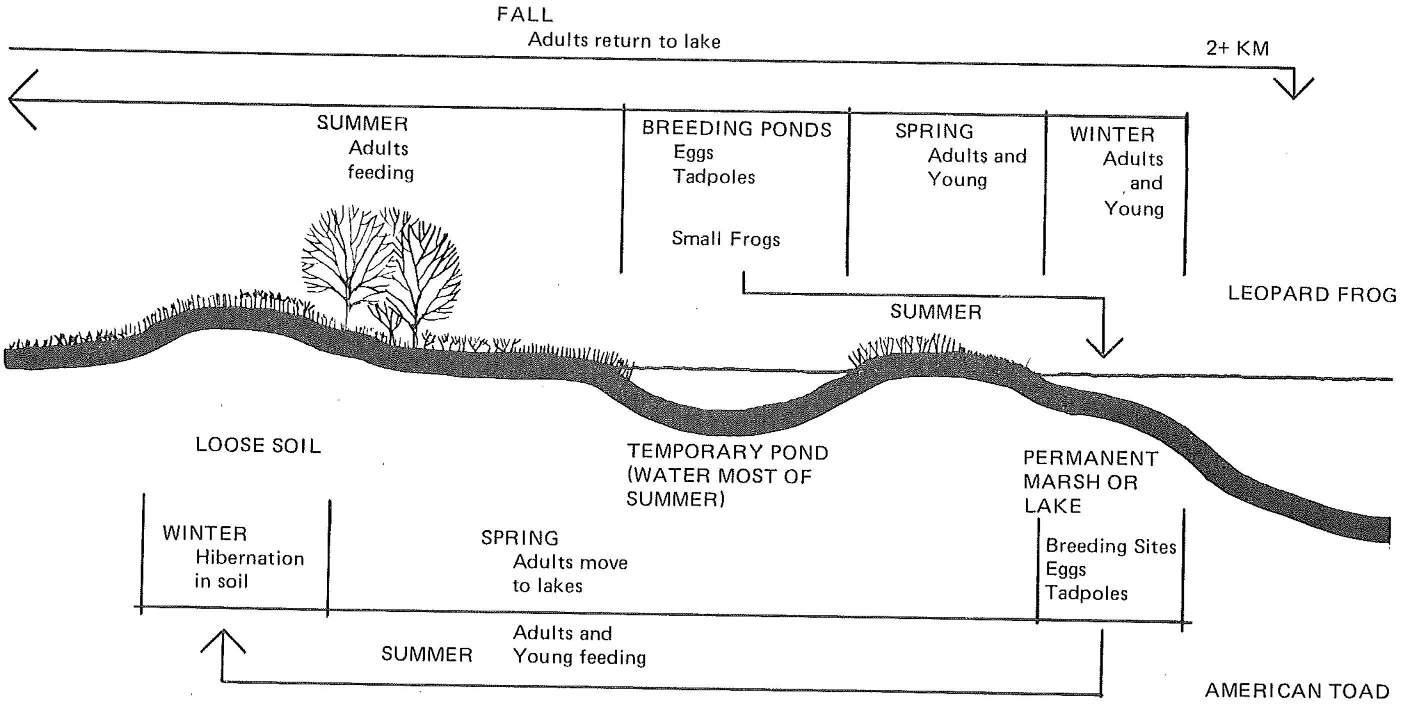


Figure 13-13 illustrates the use of the land/water interface by two amphibians. The once-abundant leopard frog has declined rapidly in recent years. Part of this decline has been accelerated by man's alterations to the interface. Roadways are often developed between the breeding ponds and feeding areas of these species, creating a hazardous barrier.

FIGURE 13–13

EXAMPLES OF INTERFACE USE BY TWO AMPHIBIANS



SOURCE: Dr. Dwain Warner, 1977.

REFERENCES

1. Agencies and Organizations Concerned with the Twin Cities Major River Corridors. Metropolitan Council. 1969. Appendix B. The document contains a listing of agencies, contact individuals, firms, and interest groups involved in river related projects, planning, issues, etc. Major property owners are also listed but would be somewhat outdated. (Available: MC)

2. Draft EIS - Operations and Maintenance Nine Foot Navigational Channel. Upper Mississippi River, Head of Navigation to Guttenberg, Iowa. February 1974. Presents site analysis and biological data on Mississippi, St. Croix, and Minnesota Rivers. (Available: CE, MC)

3. Ecological Study on Twin Cities Metropolitan Area. Wallace, McHarg, Roberts & Todd. June, 1969. 105 pp. & Tables & Maps. (Original maps are available at Metropolitan Council's Map Library. Contact Person: Bill Schneider. 1 set of maps, not reproducible other than by slides or redrafting.) Information utilized for L/W Interface:

*	C	Slope
*	CC	Slope-Generalized
	D	Hydrology
	25	Navigability
	36	Natural Forest Regions
	37	Ecological Forest Communities
	G	Existing Forest Cover (Superceded)
*	H	Existing Vegetation (Base Map)
*	HH	Existing Vegetation (Base Map)
	38	Wildlife Habitat - Water

(Available: Report - MPL; Maps - MC)

4. Environmental Impact Assessment Studies of the Northern Section of the Upper Mississippi River. Minnesota River Pool, St. Croix River Pool, Upper & Lower St. Anthony Falls Pool, Pool 1, Pool 2, and Pool 3. R. F. Colingsworth, et al., 1973. (The six volumes are part of an extensive environmental study of the major river corridors. The volumes are a valuable aid to detailed vegetation studies as well as water quality, river use, and other resource data.) (Available: MPL, CE)

5. Fish and Wildlife Technical Report. Minneapolis - St. Paul Area Level B Study Upper Mississippi River Basin Commission. Prepared by: U. S. Fish and Wildlife Service. December, 1976. (The document is a planning study for the Minnesota Valley National Wildlife Recreation Area. It encompasses the seven-county area addressing the status of fish, wildlife, and habitat resources. Problems associated with these resources are also presented.) (Available: U.S.F.W., Federal Building, Fort Snelling)

6. Information Handbook for the Twin Cities Metropolitan Area Mississippi River Corridor Critical Area. State Planning Agency, January, 1977. (Delineates the "critical area" zone for the Mississippi corridor and presents outline of present status, policies, and regulations.)

7. An Inventory of Physical Features and Facilities Within the Major River Corridors in the TCMA. Metropolitan Council. 1969. Appendix A. (Data on the three major rivers is presented on 21 segment maps at a scale of 1″ = 1 miles. Value of graphic material tends to be limited due to poor readability.

8. Listing of Variables for The Minnesota State Planning Agency Critical Areas Inventory. Xerox, April, 1977. (The list provides a description of location for natural preservation areas, national register historical and archaeological sites and districts, and recreational data. Information is by region and county. This information should be useful for updating sensitive areas, sites of historic, archaeological and educational significance.) (Available: SPA; Contact: Kitty Miles)

9. The Major River Corridors in the Twin Cities Metropolitan Area. Metropolitan Council. Dec. 1970. The document is a comprehensive study of metropolitan river corridors, land use information, development statistics, and river use. (Available: MC, also see references 1 and 7).

10. Metropolitan Development Guide. Metropolitan Council. 1973-1976. (The development guide is an on-going process of inventory, analysis and policy development for the Metro area. Data maps are at a scale of 1″ = 4 miles. Data collection time can be significantly reduced by utilization of pertinent information available from the documents and personnel at Metropolitan Council.) Maps utilized in this section:

    Regional Recreation Open Space System Plan, 1977.
    Protection Open Space Plan - (Generalized Locations) 1973.
        Floodplains, Slopes

11. Minnesota State Comprehensive Outdoor Recreation Plan (SCORP). Department of Natural Resources. 1974. (The document is a comprehensive state-wide inventory of recreational facilities and analysis of those facilities in terms of 1975 and 1980 demand. It is the most current compilation of this data available. The new (1979) SCORP is presently underway.) (Available: DNR, MPL) (Additional information: Inventory - John Poate, Bureau of Planning - DNR. Demand - Bob Knepper, Bureau of Planning - DNR)

12. Minnesotans and their Mississippi River: A Citizen's Review of Minnesota - Mississippi River Environment. Jean Stanford Replinger, Aesthetic Environment Task Force of the State of Minnesota, 1974. (Attitude study of the Mississippi River) (Available: MC)

13. Mississippi/Minneapolis. Minneapolis Planning and Development. 1972. 127 pp. (The document is a past and present survey of the Mississippi River waterfront in Minneapolis planning concepts, frameworks and a suggested action program is included. Some inventory data may be helpful on the subject of land/water interface, historic sites, and land use. Maps are at 1″ = 1 mile.) (Available: MPL)

14. Revised SCORP Inventory, Computer Print-Out. Department of Natural Resources, Bureau of Planning. 9/12/77. (Computerized inventory of public and private access to TCMA lakes. Locations, ownership, administrations, type of ramp, and parking spaces are given for each access unless information is unknown. Listing is somewhat incomplete. Data from summer inventory had not been entered as of 9/12/77) (Available: DNR - Bureau of Planning; Contact: John Poate)

15. Upper Mississippi River Comprehensive Basin Study. Volume II. U. S. Army Engineer Division, North Central. 1970. (The document is a large area study encompassing parts of six states in the Upper Midwest. Hydrology, minerals, fish and wildlife, cultural, and recreational aspects were inventoried for the basin. Value is somewhat limited for localized study due to problems with scale transition.) (Available: CE) Purchase price $4.50.

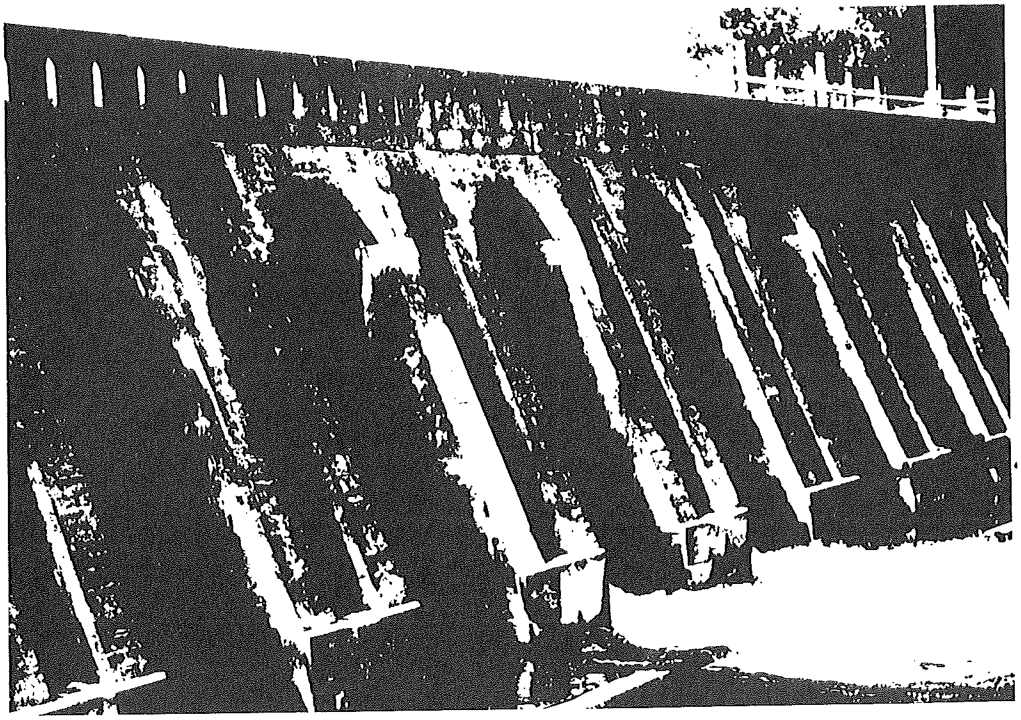
16. River Corridors File. (This file contains numerous documents dealing with regulations, present use, and future proposals dealing primarily with the Mississippi, St. Croix and Minnesota Rivers. Limited value to specific studies.) (Available: MC)

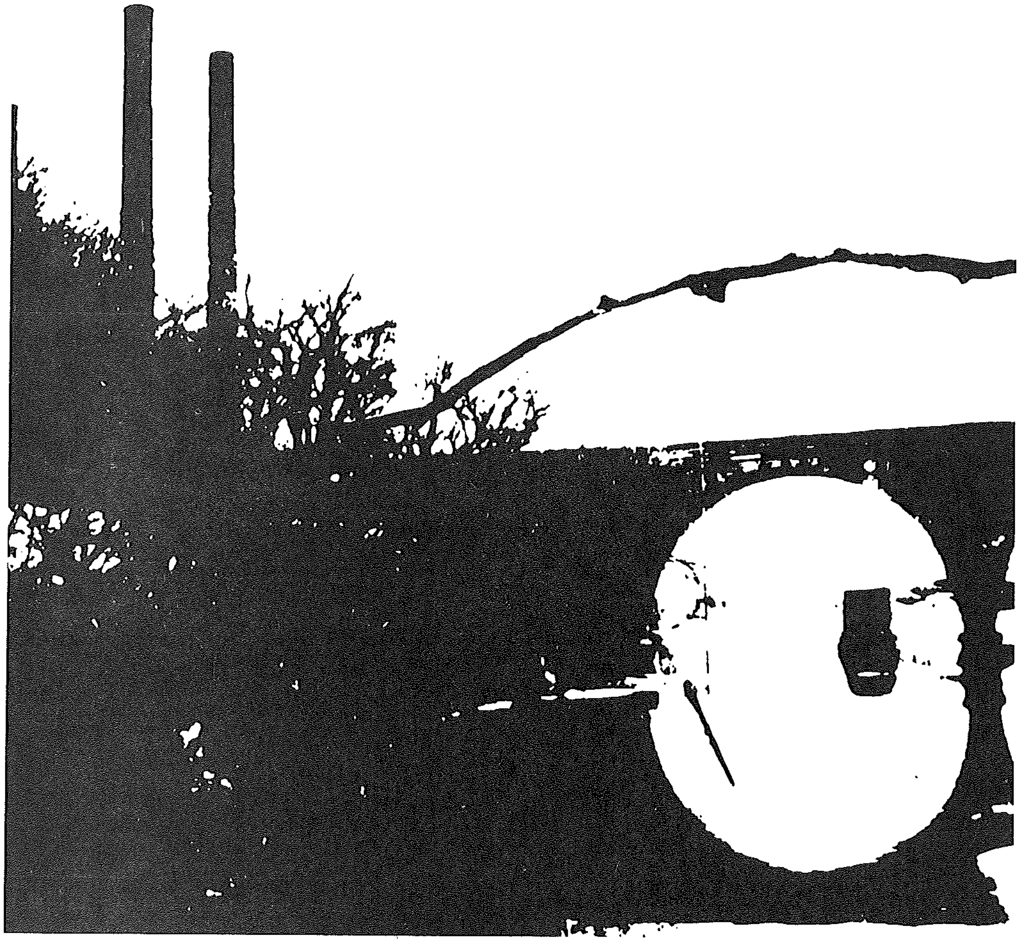
17. Upper Mississippi River Navigation Charts. U. S. Army Corps of Engineers, North Central Division. Chicago, Illinois. 1972. (The document is a complete illustration of the navigation channel of the Mississippi River from Missouri through Minnesota. The St. Croix and Minnesota Rivers in the TCMA are also included. Maps are at a scale of 2" = 1 mile. Dams, roads, communities, docks, barge facilities, recreation sites, historic sites, and wildlife areas are illustrated.) (Available: CE, St. Paul)

18. "Visual Vulnerability", R. Burton Litton, Jr. Journal of Forestry, July 1974 pp. 392-397. (Provides background information on assessing visual impact. Discusses impact of slope, light and shadow, edges, etc. as they relate to visual perception.

Note: Also see Section 11 - Water Resources references for additional studies.

CE - Corps of Engineers
DNR - Department of Natural Resources
MC - Metropolitan Council Library
MPL - Minneapolis Public Library
SPA - State Planning Agency
USFW - United States Fish and Wildlife





LAND USE PATTERNS

Current data on land use for the metropolitan area is scarce. The most recent mapped base at a regional scale is "Twin Cities Metropolitan Area Land Use, 1974." A concurrent Metropolitan Council study is in the process of updating land use information. The data is limited to use at site specific levels since mapping is at a scale of 1" equals 800' utilizing low altitude 1974-75 air photos. This information will be utilized to generate a regional land use map at 1" equals 4 miles (possibly available March 1978) which will be similar to the 1974 map. Boundary resolution of each of the classifications should have a sharper delineation, however. (38)

Metropolitan land use patterns are illustrated on Plate 19. Data for this map was based on Earth Resources Technology Satellite Imagery (ERTS 1974) projected onto a 1:125,000 base map. Cloud cover in the spring prevented the identification of cultivated lands, necessitating either their interpretation for only part of the study area or including them in a broad "open" category. The percent of accuracy of the original data ranged from 79 to 100%, averaging 93%. Table 14-1 illustrates the degree of accuracy for each classification.

TABLE 14–1

ACCURACY OF MAPPING ERTS IMAGERY (34)

CLASS	PERCENT OF ACCURACY
Commercial	100%
Residential	79%
Water	94%
Extractive	100%
Forest	94%
Other (Open)	90%
Average	93%

Boundary location errors are concentrated between residential and the open land classification. Additional distortion was added in the transformation to the common base scale since full map detail could only be preserved to a scale of 1:190,000. These errors are based on photo-technical problems and problems inherent in transferring data from one base to another that is somewhat dissimilar. Nevertheless, the overall value for determination of broad land use patterns is good. (34)

Eight classifications are utilized on Plate 19. The following is a brief description of each of the categories as they appear in the legend of Plate 19.

Central Business District	dominated by very high density commercial-industrial-institutional buildings, characterized by lack of vegetation.
Commercial-Industrial-Institutional	dominated by either buildings of medium density or land-extensive commercial activity with little vegetation, except in newer suburban areas.
Residential 1	dominated by single family dwellings, characterized by a tree canopy.
Residential 2	dominated by moderate to low density single family dwellings, characterized by vegetative cover of grass.

Water	dominated by open water which may contain scattered emergent vegetation.
Extractive	dominated by quarries, gravel pits and/or landfills; active or inactive.
Forest	dominated by forest, brushland with trees, and/or swamp.
Other (Open)	dominated by cropland, grassland (pasture, etc.) and marsh.

DEVELOPED LAND PATTERNS

Some distinct and significant regional patterns are readily apparent. A broad base summary indicates that the metropolitan area is characterized by a central urbanized core which is developing into a somewhat five-armed star shape. Residential development "arms" extend westward around the Lake Minnetonka area, along the Mississippi River corridor towards Anoka, northward around the White Bear-Bald Eagle Lakes area, southeasterly along U.S. 61, and southward across the Minnesota along I-35W. The two largest outlying communities are Stillwater to the east and Hastings to the southeast of the central core.

Strip development by the commercial, industrial and institutional sectors is apparent along the major transportation routes. Additional linear development by these sectors is evident along the central regions of the Mississippi River corridor.

UNDEVELOPED LAND PATTERNS

A horseshoe shaped pattern of open and cultivated land surrounds the urban core. The vast wetland and brush areas of Anoka County form the open end of the horseshoe pattern. Wetland and forested areas are scattered elsewhere over the metropolitan area but are particularly evident in western Hennepin, eastern Scott and northern Dakota and Washington Counties. Extensive forested areas are also located along the St. Croix, lower Minnesota, and lower Mississippi River corridors.

EXISTING LAND USE

Land use statistics are in the process of being updated by Metropolitan Council. Comprehensive data should be available by January 1978. At this point, it is questionable whether significant change will be reflected between 1973 data and the new data base which utilized 1974-1975 air photos.

Table 14-2 illustrates major land use in 1960, 1970, and 1973.

TABLE 14–2

URBAN LAND USES, 1960 – 1973 (21)
(In Acres)
Seven-County Metropolitan Area

	1960	1970	1973	1973 Est. % of Total	Acre and Percent Change 1960 – 1970 Acres	%	1960 – 1973 Acres	%	1970 – 1973 Acres	%
Residential	83,454	116,838	125,000	6.5	33,384	40.0	41,546	49,8	8,162	7.0
Commercial	5,021	8,193	9,500	.5	3,172	63.2	4,479	89.2	1,307	16.0
Industrial	27,644	37,356	44,500	2.3	9,712	35.1	16,856	61.0	7,144	19.1
Public	7,924	11,593	12,500	.7	3,669	46.3	4,576	57.7	907	7.8
Recreation	20,987	26,412	38,200	2.0	5,425	25.8	17,213	82.0	11,788	44.6
Streets and Alleys	67,944	108,845	112,658	5.9	40,901	60.2	44,714	65.8	3,813	3.5
Total Developed	212,974	309,237	342,358	17.8	96,263	45.2	129,384	60.8	33,121	10.7
Water	95,856	95,856	95,856	5.0						
Vacant/ Agri.	1,612,297	1,516,034	1,482,913	77.2	-96,263	-6.0	-129,384	-8.0	-33,121	-2.2
Total	1,921,127	1,921,127	1,921,127	100						

---

[1] Land-use survey data for the Twin Cities Metro Area is very meager; the last land-use inventory was in 1962. The 1960 and 1970 data provided in this report utilized aerial photo interpretation to update the 1962 inventory data. This data does not offer great precision in defining detailed land use, but is fully adequate to depict general land trends. The 1973 data is a rough estimate of individual land-use categories based on various development indicators. The overall land consumption figure for the 1970-to-1973 period was derived from aerial photos.

Over 77% of all metropolitan land is either agricultural or undeveloped. This broad classification includes forests and wetlands which are not in parklands or in public recreation facilities. An additional 5% of the land area is water. Thus, over 82% of the total land area is relatively void of development.

Residential and street and alley development (including highway and freeway right-of-ways) are the two largest uses of land within the urban area. Each accounts for about 6% of the total land area. Recreation and public lands account for almost 3% of metropolitan land use. Commercial and industrial lands combined account for about 3% of land use. In total, almost 18% of metropolitan land is developed either for residential, commercial-industrial, or recreational use.

Table 14-2 also illustrates trends based on land use change from 1960 to 1973. The largest increase in land use during the 1960-1973 period was for transportation. This was due partially to an active freeway acquisition program. Residential use was the second largest consumptive use during this same period.

Recreational use was the greatest consumer of land from 1970-1973. An aggressive acquisition program was responsible for the purchase of large tracts for regional parks and park reserves. Industrial land consumption increased by more than 7,000 acres during 1970-1973 compared to a 10,000 acre increase in the previous decade. This increase is largely attributed to the large tracts characteristic of recent suburban industrial growth.

AGRICULTURAL USE

Agricultural land, while still the largest land use category in the metropolitan area, has been declining. Table 14-3 illustrates a decline in total farm land from 980,000 acres in 1967 to about 819,000 acres in 1974 based on acreages voluntarily reported by farmers and county assessors.

Croplands have shown a slight increase during this period. This is due primarily to the decline in dairy farms and consequent utilization of pastured lands, drainage of wetland areas, and irrigation of previously marginal farm lands.

TABLE 14–3

AGRICULTURAL LAND USE, 1967 – 1975 (21)
Seven-County Metropolitan Area

	1967		1973		1974		1975
Use	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres
Corn	240,400	24.4	245,200	27.6	302,700	37.0	318,900
Rye	4,000	.4	2,200	.2	1,500	.2	2,000
Hay	165,800	16.9	171,600	19.3	143,500	17.5	158,500
Wheat	7,900	.8	10,600	1.2	29,500	3.6	38,500
Barley	1,100	.1	1,500	.2	2,000	.2	3,000
Potatoes	3,500	.4	2,000	.2	2,100	.3	2,500
Soybeans	105,700	10.7	121,000	13.6	109,700	13.4	92,900
Oats	84,400	8.6	73,300	8.3	77,600	9.5	69,800
Total Major Crops	612,800	62.3	627,400	70.6	668,600	81.6	686,100
Other Uses[1]	370,567	37.7	260,999	29.4	150,541	18.4	N/A
Total Land in Farms	983,367	100%	888,379	100%	819,141	100%	N/A
Total Vacant and Agriculture	N/A		1,921,127		N/A		

[1] Primary other uses include pastures, wood lots, low lands and marshes, feed lots, buildings and minor crops. These figures are estimated by removing estimates of crop production from independent estimates of total land in farms. The crop acreages are voluntarily reported by farmers and the land in farms by County Assessors.

It should be noted that figures in Table 14-3 do not coincide with Soil Conservation Service (SCS) figures for 1974 as presented in Table 14-4 and Exhibit C, page 12. SCS data indicates that almost 729,000 acres were in crop land in 1974. This is a difference of over 61,000 acres between the two sources -- more than the total decline presented in Table 14-4 between 1958 and 1974. At this time no verification has been made by either data source.

Acreages depicted in Table 15-1, Section 15—Agriculture, do not coincide with either Table 14-3 or 14-4. Over one million acres of farmland were reported in 1976 farmland census data, a difference of over 200,000 acres between 1974 voluntary data and 1976 census data (21, 32). This illustrates one of the major problems—compatibility of data in current land use analysis. Statistics among different agencies as well as the same agency, more often than not, vary significantly. This makes it difficult to provide an accurate picture of past trends or to predict reliable future trends.

TABLE 14–4

ACRES OF CROPLAND IN METROPOLITAN COUNTIES, 1958 and 1974

	YEAR		
COUNTY	1958	1974	CHANGE
Anoka	73,500	59,200	– 14,300
Carver	120,550	133,950	+ 13,400
Dakota	224,200	208,200	– 16,000
Hennepin	94,700	73,800	– 20,900
Ramsey	10,000	NA	– 10,000
Scott	126,000	123,700	– 2,300
Washington	122,500	130,100	+ 7,600
Total	771,450	728,950	– 42,500

SOURCE: Soil Conservation Service, Minneapolis-St. Paul Regional Area Level B Study. Soil and Water Conservation Needs Inventory. Unpublished data, 1975.

TRANSPORTATION SYSTEM

Plate 20 illustrates principal components of the metropolitan transportation system. Airports, railroads, major arterial highways and the nine foot navigation channels are depicted. Industrial sites over 200 acres are also shown in relation to the transportation system.

NAVIGATIONAL CHANNELS

While navigational routes are not considered a consumptive land use in themselves, they do utilize land and influence adjacent land use. Spoils from dredging operations usurp land and affect sensitive backwaters. A dredge spoils disposal conference, sponsored by the St. Paul District - Corps of Engineers is held annually to coordinate spoil disposal between environmental and conservation agencies. Many institutional, commercial, and industrial users who depend on low cost transportation of commodities are located within close proximity to the channels. Colingsworth, et al (1973) detailed dredge spoil impacts, industrial use, and river transportation (13). Additional information is available from reports (1, 11, 16, 19) and from the Corps office.

RAILROADS

With the exception of spur development to industrial areas, it is unlikely that any new rail lines will be developed in the metropolitan area. Three rail lines, currently proposed for abandonment on the ICC schedule, are shown on Plate 20. The Soo Line Railroad has proposed abandonment of the line from North St. Paul to Carnelian Junction. Chicago, Milwaukee, St. Paul, and Pacific has proposed abandonment of two lines, Cologne to Shakopee and St. Croix Junction to Bayport. No hearings have been scheduled as yet. Four additional lines are anticipated to be proposed for abandonment within the next three years. (37) These are also delineated on Plate 20. Existing lines proposed for abandonment in the future, may be used as lineal recreation facilities such as regional and state corridor trails. These established rail line corridors may also offer potential for study as MWCC interceptor routes.

HIGHWAYS

Historically, strip development has occurred along transportation routes (See Plate 19). Increased commuter routes via limited access highways has increased the potential size of the metropolitan development area. Based on a one hour commuter time, the metropolitan land market extends out of the seven county area. This urban influence is reflected in increased land values particularly along major transportation corridors.

Over 112,000 acres (about 6% of the total metropolitan land area) is currently used for automotive transportation routes. This represents approximately one-third of all developed land in the metropolitan area.

AIRPORTS

Six airports are publically owned and operated by the Metropolitan Airports Commission (MAC). Minneapolis-St. Paul International Airport is the only one that provides scheduled air carrier service. The remaining five, Holman Field (St.Paul), Anoka County (Blaine), Crystal (Crystal), Flying Cloud (Eden Prairie), and Lake Elmo (Lake Elmo) provide facilities for smaller craft.

Five additional private and municipal airports are not operated by MAC but are included in the metropolitan system for planning purposes. The Metropolitan Development Guidelines detail airport policies and objectives as of 1973. Since that time, search areas for additional air facilities have been modified. By the end of December 1977, the revised plan should be available, but may not be officially approved.

If all eight peripheral sites, as shown in the 1973 plan were developed, the total land area utilized by airport facilities would still be less than 1% of metropolitan land area. Although the airports themselves may not be a major consumptive land use, development can be significantly influenced by their locations. Thus, the effect on development patterns must be ascertained in facilities planning.

LAND QUALITY

Land quality addresses three factors: areas of solid and liquid waste disposal, areas of erosion and pollution concern, and land misuse.

SOLID AND LIQUID WASTE DISPOSAL

Over two million tons of throw away material ranging from household rubbish and garbage to commercial and industrial waste is generated by the metropolitan population each year. At the present time, the most economical method of disposal is a sanitary landfill. More land is required for this method than for incineration. However, in a planned method of on-land disposal, the despoilation of the environment can be minimized. The Metropolitan Development Guide defines policy, objectives and the development program for solid and liquid waste disposal.

Plate 21 illustrates the locations of solid and liquid waste disposal. Ten sanitary landfills for the disposal of general residential, commercial, and industrial refuse open to the public are located in the metropolitan area: two in Anoka County, four in Dakota, three in Hennepin, and one in Scott County. Washington, Ramsey, and Carver counties do not have sanitary landfills at the present time.

Ten additional special use landfills are used for the disposal of construction and demolition debris, fly ash, and other clean and inert materials. Two are located in Dakota, Washington, and Anoka counties and one is in Ramsey and Hennepin counties. Only two of these are available for use by the general public.

Special use incinerators are also illustrated on Plate 21. Many are currently used for the disposal of toxic chemical wastes.

Thirty-six wastewater treatment facilities operate in the metropolitan area. Nineteen of these are within the metropolitan sewer system boundaries, while the remainder service free-standing communities outside of planned sewer development for the metropolitan area. (40)

Currently, only four of the nineteen sites have an adequate land buffer around the facility itself. Table 14-5 denotes the approximate acreage of each of the facilities and notes the buffered sites.

TABLE 14–5

METROPOLITAN WASTE TREATMENT FACILITIES (40)

FACILITY APPROXIMATE ACREAGE NOTES

FACILITY	APPROXIMATE ACREAGE	NOTES
Anoka	3	
Apple Valley	14	Will be phased out in two years
Bayport	1	
Blue Lake	142	Buffered—original plant size, 75 acres
Chaska	3	
Cottage Grove	11	
Empire	422	Buffered
Farmington	3	
Hastings	2	
Lakeville	3	
Long Lake	12	
Maple Plain	6	
Medina	19	
Metro	377	Buffered—plant size, 50 acres
Mound	30	Lift Station
Orono	20	
Prior Lake	9	
Rosemount	36	
Savage	13	
Seneca	100	Buffered—original plant size, 53 acres
South St. Paul	86	
Stillwater	3	
Waconia	3	Will be phased out by end of 1977

BUFFERED FACILITIES

The adequate buffering of treatment facilities reduces the potential for conflict with non-compatible land uses, aesthetics, and possible devaluation of adjacent land. Currently, buffering occurs through facilities siting in somewhat isolated areas. The geogrphic and visual separation from other urban development reduces potential conflicts. In addition, sites are buffered through the use of vegetation, fencing and the existing terrain.

EROSION AND POLLUTION PROBLEMS

Storm water runoff is the most serious erosion factor in the metropolitan area. Urbanization results in increased runoff due to the increase in impervious materials such as roofs, driveways, parking lots, and streets. Unless properly controlled, runoff can become a major problem, carrying away soils and increasing sedimentation of water courses and water bodies.

Exhibit C - Interpretations of Soil Landscapes and Geomorphic Regions - Twin Cities Metropolitan Sheet addresses some of the problems with erosion and sedimentation hazards. Figures 54 and 59 in this exhibit depict land areas subject to erosion and sedimentation hazards. Table 14-6 indicates the percent of metropolitan land area subject to varying degrees of sheet erosion. Almost 50% of the land area has a slight degree of hazard. Eleven percent of metropolitan land has severe erosion hazard.

TABLE 14–6

SHEET EROSION POTENTIAL IN THE METROPOLITAN AREA (EX. C)

DEGREE OF HAZARD	ACREAGE	PERCENT OF METRO LAND AREA
Slight	862,500	48%
Moderate	744,400	41%
Severe	198,600	11%
Total	1,805,500	100%

Areas with the most severe problems occur in the Prior Lake moraine, encompassing large areas in eastern Carver and Scott, northern Dakota, and southern Hennepin Counties. Scattered areas occur in Washington and Ramsey Counties. Nearly all of Anoka County has only slight problems due to the sand plain. The outwash plains in Dakota County and along the Mississippi and Minnesota River valleys also have only slight problems.

Wind erosion is a secondary problem in the metropolitan area. The most susceptible areas are fall-plowed cultivated lands and areas under new construction. Both types can be controlled through the use of conservation-minded agriculture practices and revegetation at the first opportunity.

Sedimentation is a major problem heightened by poor agricultural practices and increased urbanization. Sediment destroys spawning beds and reduces light penetration in water areas thereby upsetting entire ecosystems. It can also become a physical barrier blocking road culverts and navigational channels.

Figure 59 in Exhibit C illustrates areas of sediment hazard. Lands having natural areas of entrapment and of relatively flat topography are not subject to high sediment hazard. Over 67% of the metropolitan area have only slight problems, while 18% of the land area has moderate problems, and 15% of the area is considered a severe sedimentation hazard. The latter tends to be associated with steep slopes (See Plate 13) and silty, clayey, or sandy soils on or adjacent to escarpments bordering lakes and water courses.

POLLUTION PROBLEMS

Major contributors to the pollution of land in the metropolitan area are associated with soil and water resources. Septic tank fields, hazardous and chemical waste disposal and sanitary landfills are man-made by-products which have to be planned carefully. Since almost all of the metropolitan area is a recharge zone, (See Section 5 - Hydrology) the most serious concern is the contamination of wells and groundwater supplies.

Pollution of both surface and groundwater resources can be caused by excessively high or low permeability rates, depth to bedrock and seasonally high water tables.

LAND MISUSE

Land has a certain intrinsic suitability for utilization by man. For this purpose, land misuse could be defined as the development of land which is counter to the intrinsic suitability of that site. Development in floodplains, on steep slopes (over 12%), on poor soils, or on prime agricultural lands could all be termed misuse. (See Plates 9 - Wetlands, 13 - Selected Sensitive Areas and Exhibit C.)

The passage of the floodplain and shoreland management acts have helped to alleviate problems with floodplain development and the over-development of shorelands.

One major misuse of land has been the usurping of agricultural lands for development. The increase in urban land over the past two decades has been primarily at the expense of pasture, crop, and forested lands. Pastured lands have decreased by almost 136,000 acres, cropland by over 42,000 acres, and forest lands by over 18,000 acres from 1958 through 1974. (Exhibit C).

Although croplands have decreased by 42,000 acres, it is due to several internal factors. While urbanization has been decreasing cropland acreage, the drainage of wetlands and the cultivation of previously cultivated lands has been increasing cropland acreage. However, the quality of these lands may be substantially lower than the land which was available before urban growth. The net effect is the conversion of over 10,000 acres of agricultural land to urbanization.

Information on the misuse of metropolitan area land is deficient. No known studies are currently underway.

RECREATION AND OPEN SPACE

Existing and proposed regional open space is illustrated on Plate 22. Almost 43,000 acres currently comprise the open space network. This includes sites that have been funded for acquisition in addition to those existing at the present time. It also includes state-owned facilities such as Carlos Avery Wildlife Management Area, state parks, state corridor trails and waysides. About 38,000 acres is encompassed by seventeen regional parks, fourteen park reserves, and one corridor trail.

Nine components comprise the metropolitan open space system. Exhibit T denotes the classification, type of use perceived, preferred site size, location, and attributes. Community parks and playgrounds were not inventoried due to their relatively small acreage, limited use, and the difficulty of reviewing each municipality's open space program (18).

At the present time no historic parks or special use areas have been incorporated into the system.

FEDERAL RECREATION OPEN SPACE

No federal acreage is currently included in the regional system. The proposed Minnesota Valley National Wildlife Recreation Area eventually would encompass over 6,600 acres; 3,350 acres in uplands, 1,800 acres in marsh, and 1,450 acres in meandered water. The primary intent of this facility is to preserve migratory bird habitat and make these resources available for public use. The proposed area encompasses some of the most significant wildlife habitat in the state.

STATE RECREATION OPEN SPACE

Five regional facilities are state owned: Afton, William O'Brien and Fort Snelling state parks and the Luce Line and Minnesota Valley Corridor Trails. When fully developed these five areas will provide about 9,000 acres of recreation open space. In addition, Carlos Avery, Gores, and other wildlife management areas provide specialized recreation opportunities. State canoe trails and public accesses provide opportunity for water oriented recreation.

State forests, scientific and natural areas, and historical areas also contribute to the open space system. At the present time, Richard J. Dorer Memorial Hardwood Forest (Dakota County) and Hastings Scientific and Natural Area (Dakota County) and Cedar Creek Natural History Area (Anoka County) are the only three such facilities in the metropolitan area.

REGIONAL OPEN SPACE

The three major components of the regional open space system are regional parks, park reserves, and trail corridors. Utilization of water resources within or contiguous to these facilities is a primary concern.

Regional parks are generally between two and five hundred acres in size embracing a diversity of natural and man-made resources. The primary emphasis is to develop these sites to accommodate picnicking, swimming, boating, sailing, and camping. Other recreation activities are secondary. Over 13,000 acres are currently in the regional park system. Exhibit U depicts the activities which are provided at existing regional parks and park reserves.

The primary emphasis of regional park reserves is to protect and perpetuate significant natural areas of flora and fauna, land form, and water resources. Ideally, minimum site size would be 1,000 acres with at least 2,000 acres preferred. The geographic location is dependent on the basis of availability and the uniqueness of the natural resources.

Since the preservation or restoration of the natural resources is the foremost concern, development of activities is limited to those which are compatible. Over 24,000 acres currently are included in the park reserve system.

Two regional multiple use trail corridors, the Luce Line and Minnesota Valley, are located in the metropolitan area. These trails link components of the regional system. Support facilities, such as waysides, provide additional open space in conjunction with the trail corridor. About 500 miles of trails are proposed for the metropolitan area.

PROPOSED OPEN SPACE DEVELOPMENT

Twenty-four sites or site expansions are proposed for inclusion in the regional system. Exhibit V lists the proposed sites and their general locations. The acquisition and development of these sites will aid in accommodating the increasing demand caused by a projected deficiency of 20,000 acres of open space by 1990.

ACQUISITION SCHEDULE

The Metropolitan Council, as the coordinating agency, has detailed acquisition guidelines, objectives, and policies in the Metropolitan Development Guide. Exhibit W excerpted from the guide outlines the capital improvements program (CIP) through 1981. It was adopted in January of 1977. The CIP is updated annually and is dependent upon legislative funding. Exhibit X shows the current status of the regional open space plan, although revisions may be expected.

PROTECTION

The random spread of development in the metropolitan area has developed into a major problem. Unplanned urbanization often usurps lands which serve natural functions. The result can be the endangering or impairing of entire ecological systems.

The Metropolitan Development Guide has identified nine components based primarily on the hydrologic system which are especially sensitive and warrant protection. "Protection" is defined as the wise and managed use of these lands, not total prohibition of uses other than open space. These nine components are:

Water bodies and water courses
Wetlands
Groundwater recharge areas
Floodplains
Erodible slopes
Forests and woodlands
Soils having severe limitations for development
Production lands
Areas of unique/endangered plants and animals

The Metropolitan Development Guide has mapped all but three of these components (lands containing unique and endangered plants and animals, production lands, and forests and woodlands). The nine components have been reproduced and revised to reflect more recent data. They appear on Plates 3, 7, 9, 11, 12, 13, 14, 18, 24, Appendix C, Figures 16-1 through 16-10 in Section 16—Unique and Endangered Species and Figure 3-14 in Section 3 - Geology and Geomorphology. Regional policies have been outlined in the Development Guide.

The goal of the policies is to establish a harmonious relationship between the natural environment and man's use of the land. To insure this, a regional approach to planning the wise use of these resources is emphasized since these systems function without regard to local governmental jurisdictions.

COUNTY

Until relatively recently counties tended to look upon their role in land use planning as an administrative arm of the state. Often times planning was reactionary to specific issues rather than a comprehensive guide for the county's future. With the passage of the County Planning Act, counties are much more active in the planning of their overall development. The County Planning Act clarifies the planning and zoning authority of each county to deal with certain problems, as well as to provide uniformity throughout the state. It authorizes increased county control over surface water zoning, wetlands preservations, open space, parks, sewage disposal, and erosion and sedimentation control. Townships are provided aid from the county in their planning under this act. This act has very specific provisions for allowing variances. Variances shall only be permitted when they comply with the comprehensive plans or in hardship cases. Hardship means the property cannot be put to a reasonable use under the official controls of the county. Economic conditions alone do not constitute hardship.

LOCAL/MUNICIPAL

MUNICIPAL PLANNING ACT

The 1965 act charged municipalities with the responsibility of preparing comprehensive plans, adopting zoning ordinances and sub-division regulations, and implementation of these controls.

ADDITIONAL REGULATORY AGENCIES AND POLICIES

There are many agencies of government which affect land use and consequently are responsible for open space protection. A partial listing of state and regional agencies that share responsibility for the use of resources, and policies which have or do affect land use and land quality are:

STATE AND REGIONAL AGENCIES INVOLVED WITH LAND USE

Commission on Minnesota's Future

This agency has the potential for a great deal of influence on land use. It prepares strategy for state growth and development for the governor and the legislature.

Department of Natural Resources (DNR)

Its task is conserving and promoting the wise use and management of the state's natural resources. Has many departments that play an important role in land use policies.

Department of Transportation (MN/DOT)

The Minnesota Department of Transportation provides the basic data and research to plan all transportation systems, prepares plans for construction of roads and bridges, landscaping, etc.; acquires property for transportation systems and supervises construction.

Environmental Quality Council (EQC)

E.Q.C. provides for interdepartmental resolution of significant environmental problems. Because of overlapping responsibilities of the agencies involved, E.Q.C. is composed of the following department heads: PCA, DNR, State Planning, Transportation, Health and Agriculture. It also includes four citizens and a representative from the governor's office. It is charged with certain specific responsibilities: power plant siting, selection of critical areas, and the Environmental Impact Statement program. It also reviews major state environmental issues.

Minnesota Land Exchange Commission

Composed of the Governor, State Auditor, and Attorney General. It approves the exchange of federal and private lands for state-owned lands.

Metropolitan Council (MC)

Set up in 1967 to provide effective regional coordination in existing planning authority and to help meet the need requirements for federally funded programs. It helps review plans from counties and municipalities, gives local planning assistance if requested, coordinates plans of agencies throughout the region.

Metropolitan Waste Control Commission (MWCC)

This agency deals with regional aspects of solid, liquid, and hazardous waste disposal. It is the coordinating and planning agency for all sewer systems within the metropolitan region.

Pollution Control Agency (PCA)

This agency deals with virtually all of the state's pollution problems, directly or indirectly. It administers and enforces laws relating to water pollution, air pollution, solid waste disposal, and pollution-related land use planning, and many other policies.

Soil and Water Conservation Commission

This agency became part of DNR in 1971, but it has its own responsibilities. It promotes the organization of county soil and water conservation districts throughout the state, administers their funds and provides technical assistance.

State Planning Agency (SPA)

The Planning Agency provides advice and assistance to the governor and the legislature on many issues. It engages in functional planning efforts for health, transportation, drug abuse, etc. Coordinates state agency activities, gives technical assistance to local and regional governments. Prepares recommendations for the orderly growth of the state for consideration by the governor and legislature.

There are many agencies of government which affect land use and consequently are responsible for open space protection. A partial listing of state and regional agencies that share responsibility for the use of resources, and policies which have or do affect land use and land quality are:

FEDERAL OPEN SPACE POLICIES

The Fifth and Fourteenth Amendments to the U.S. Constitution provide protection for property owners so that governments cannot take property without just compensation. They also state that any government interference with private land rights must be justified by the general public health, safety, or welfare. This law at times inhibits government initiative in land management and development.

The Northwest Ordinances of 1787 provided Federal Government procedures for survey allocations, sales, record keeping and uniform taxation of land. This was intended to establish a land tenure "constitution" for new states joining the Union. It gave private land owners the right to possess, occupy, hold, buy, sell, use, abuse, waste, consolidate, and subdivide land. When this law was passed, there was a general feeling that all lands except the small amount needed to carry on the function of government should be transferred to private landholders.

The Homestead Act of 1862 offered land free to settlers in 160 acre tracts if they occupied and cultivated it for five years. This policy helped to stimulate development and caused rapid settlement of many areas.

F.H.A. Home Mortgage Insurance provided low cost insured loans for new housing. This helped to stimulate housing construction, extended ownership to more people, encouraged single family housing and rapid growth of many urban areas.

Federal Highway Act of 1956 gives aid to states of up to 90% for purchasing right-of-ways and construction of limited access highways. Its main intent was to establish a national system of limited access highways that would provide faster response to national emergencies. These highways increased distance traveled in small amounts of time and therefore encourage long distance commuting and urban sprawl.

The 1965 Water Quality Act provided legislation for the control of industrial wastes, sediments, sewage, and other pollutants that enter our lakes and streams. Allows federal agencies the right to force industries and citizens to stop pollution or face fines or closure of operation.

The Air Quality Act of 1967 authorized financial aid to air pollution control agencies, intensified research efforts to control air pollution, and authorized establishment of minimum standards of air quality. This act affects land use because industries must meet these standards before locating in urban areas.

Capital Gains Taxes – This act provides tax incentive on capital assests held for more than six months; allows them to be taxed at half of the applicable income tax rate to encourage capital investments; encourages land speculation; drives up the price of land to affect tax savings; and makes urban fringe land unavailable to those unable to enter a speculative market.

National Flood Insurance Act of 1968 makes flood insurance available for losses due to flooding from inland waters. It also requires local governments with flood prone areas to qualify for this program before flood insurance can be obtained. The basic objectives are to promote appropriate land use in areas subject to flooding, guide future construction, and assist in reducing damage from floods.

National Environmental Policy Act (NEPA) required environmental impact statements on all major federal and private actions significantly affecting the environment. Primary intent is to consider any adverse environmental effects and alternatives dealing with new projects.

Wild, Scenic and Recreational Rivers Act – This act declares a national policy to preserve and protect rivers which have outstanding scenic, recreational, natural, historical, or scientific values. This act helps to preserve and protect outstanding natural features with highly restrictive regulations, zoning standards, and criteria regulating land use along designated rivers. Local governments are required to adopt wild and scenic river ordinances in accordance with state standards if a river included in the system is within a local government's boundaries. The St. Croix River is a part of this system and the Mississippi has been proposed for inclusion.

STATE POLICIES

Green Acres Law passed to alleviate the inequitable basis for taxation of agricultural property. Real estate consisting of 10 acres or more is entitled to a tax deferrment if it is actively and exclusively devoted to agriculture. At least 33 1/3% of the total family income has to be derived from farming. There are many other provisions that may also qualify land for deferred assessment. These can be found in the Minnesota Statutes section 273.11 "Agricultural Property Tax".

Minnesota Municipal Commission Act gives MMC authority to regulate annexations, incorporation, and mergers. It is intended to give increase authority to local government to provide services and regulate development.

Shoreland Management Act – in 1969, the Minnesota Legislature passed the shoreland management act, requiring all counties to regulate use and development of shorelands by adopting zoning, sanitary, and land subdivision controls by July 1, 1972. In 1973 the shoreland management act was amended to extend its application to municipalities. By July 1, 1975 all Minnesota municipalities were required to have ordinances in accordance with Department of Natural Resources standards. The required controls may be incorporated into subdivision control ordinances, sanitary codes, or zoning ordinances. The act prohibits incompatible use of lands within 300 feet of rivers and 1000 feet of lakes. Another major provision of the act is that all sewage disposal systems must conform to sanitation code standards acceptable to the Minnesota Department of Health within five years of the date of enactment of the ordinance.

Minnesota Power Plant Siting Act – States have prepared rules, regulations, and procedures for siting of new power plants and new high voltage electric power transmission facilities giving the state the lead role in the location of power plants and transmission lines.

Environmental Policy Act (MEPA) – The State of Minnesota assumes continuing responsibility as a trustee of the environment, including management of growth, development of a coordinated program of land use control, protection of environmentally sensitive areas and natural habitats, reduction of waste, conservation of resources and reclamation of mine lands. It provides for a uniform state environmental policy among Federal Agencies, State Agencies, and local governments.

Minnesota Critical Areas Act – Allows the governor to designate a "critical area" and specify development guidelines and helps to supplement existing zoning authority when faced with development that threatens environmental quality. It also slows down or restricts proposed developments.

The Flood Plain Management Act requires local units of government to develop and implement local flood plain management programs and assists local governmental units in becoming eligible to participate in the National Flood Insurance Program: Helps to reduce flood damage and losses; and severely limits development of floodways and floodplains.

Metropolitan Open Space Act – This bill gives the DNR authority to set up standards, criteria, and model ordinances for the Metropolitan Area to protect wetlands, groundwater recharge areas, erodible slopes, forests, and woodlands, non-buildable soils and bedrock, surface water zoning, stormwater runoff channels, areas of unique or endangered species, prime agricultural lands, gravel mining, and historical significant areas.

Wild, Scenic, and Recreational Rivers Act – This act closely resembles the federal policy with emphasis on rivers of state and local significance rather than only those of national interest.

REFERENCES

1. Agencies and Organizations Concerned with the Twin Cities Major River Corridors. Metropolitan Council. 1969. Appendix B. The document contains a listing of agencies, contact individuals, firms, and interest groups involved in river related projects, planning, issues, etc. Major property owners are also listed but would be somewhat outdated. (Available: MC)

2. Anoka County Parks and Open Space: Comprehensive Plan. Midwest Planning and Research Inc. April, 1969. 20 pp. This plan is an analysis of the existing park system. It further provides a proposed countywide comprehensive park plan and guidelines for implementation. Some data on lakes, wetlands, and open space may be of value to future studies. (Available: MC)

3. Anoka County Resource Inventory and Analysis. University of Minnesota. Resource and Community Development, 1975. 181 pp. This report is a fairly detailed inventory and analysis of physical, social and economic resources of the county. Data is relatively new. Could be of value to MWCC studies. (Available: MC)

4. Anoka County's Park Development Guide. Anoka County Park Department. November 1974. This document describes facilities and makes recommendations for proposed parks. A map illustrates locations of 17 sites. Limited value to MWCC studies. (Available: MC)

5. Carver County Comprehensive Development Plan. Carver County Planning Commission and Midwest Planning and Research Inc. June, 1970. 38 pp. This plan is a summary of planning goals with emphasis placed on land use, parks and open space, community facilities, etc. The document itself is not of great value to our study but some background inventory data is available at Carver County offices. (Available: MC)

6. Carver County Parks and Open Space Plan and Implementation Report. Carver County Park Commission. December 1975. 54 pp. This report gives a complete listing of municipal, county and state owned facilities. Information is also presented on maps. Scale is not known. (Available: MC)

7. Carver County Planning Report No. 1, Survey and Analysis. Carver County Planning Commission. Midwest Planning and Research Inc., Planning Consultant. November 1968. 26 pp. This is a partial summary of the County Comprehensive Plan which was being developed at that time. Analysis of social and physical conditions of 1968. Value is subject to question since emphasis was on dynamic resources (i.e. population, community facilities, etc. and data is now almost ten years old.) (Available: MC)

8. Comprehensive Plan, Dakota County, 1970-2000. Dakota County Planning Advisory Commission. October 1971. 55 pp. This document is a preliminary concept plan with guidelines for future development in the areas of land use, transportation and public facilities. Limited value to MWCC study. (Available: MC)

9. Dakota County In Perspective. Dakota County Planning. 1973. 94 pp. The document is a report on historical settlement, natural history, agriculture, and socio-economic patterns. It contains information which may be of value to some portions of future studies. (Available: MC)

10. Dakota County Regional Park System. Dakota County Planning Department. (No data. Post - 1970) 65 pp. The document gives a general overview of population and physical resources on county and site specific scales. A county map depicting vegetation types - 1970 may be of value to future studies. (Available: MC)

11. Draft EIS - Operations and Maintenance Nine Foot Navigational Channel. Upper Mississippi River, Head of Navigation to Guttenberg, Iowa. February 1974. Presents site analysis and biological data on Mississippi, St. Croix and Minnesota Rivers. (Available: CE, MC)

12. Ecological Study on Twin Cities Metropolitan Area. Wallace, McHarg, Roberts & Todd. June, 1969. 105 pp. & Tables & Maps. Original maps are available at Metropolitan Council's Map Library. Contact Person: Bill Schneider. 1 set of maps, not reproducible other than by slides or redrafting.

13. Environmental Impact Assessment Studies of the Northern Section of the Upper Mississippi River. Minnesota River Pool, St. Croix River Pool, Upper & Lower St. Anthony Falls Pool, Pool 1, Pool 2, and Pool 3. R. F. Colingsworth, et al., 1973. The six volumes are part of an extensive environmental study of the major river corridors. The volumes are a valuable aid to detailed vegetation studies as well as water quality, river corridor use, and other resource data. (Available: MPL, CE)

14. A Guide to Environmental Information Resources in the Twin Cities Area. Nancy Lynn Johnson. 1975. 76 pp. This booklet is an extensive listing of all known agencies in the Metropolitan area that have environmental information and research data available for use. In addition to listing agencies, type of information available, level of technical difficulty, available services, and circulating procedures are included. This should serve as a time saving device for future studies. (Available for purchase at Minneapolis Public Library)

15. Information Handbook for the Twin Cities Metropolitan Area Mississippi River Corridor Critical Area. State Planning Agency. January, 1977. Outlines current status of planning process, gives an overview of the Level B study, lists contact persons for specific task problems. Maps included. (Available: SPA, MC)

16. An Inventory of Physical Features and Facilities Within the Major River Corridors in the TCMA. Metropolitan Council. 1969. Appendix A. (Data on the three major rivers is presented on 21 segment maps at a scale of 1" = 1 mile. Value of graphic material tends to be limited due to poor readability.

17. Listing of Variables for the Minnesota State Planning Agency Critical Areas Inventory. Xerox, April, 1977. The list provides a description of location for natural preservation areas, national register historical and archaeological sites and districts, and recreational data. Information is by region and county. This information should be useful for updating sensitive areas, sites of historic, archaeological and educational significance. (Available: SPA)

18. Local Planning in the Twin Cities Metropolitan Area. A 1975 Inventory and Analysis. Metropolitan Council. October 1976. 41 pp. Documents the status of comprehensive plans by community. Regulatory controls such as zoning ordinances, subdivision regulations, etc. are also documented. The report has been updated to include status as of July, 1976. (Available: MC)

19. The Major River Corridors in the Twin Cities Metropolitan Area. Metropolitan Council. December 1970. The document is a comprehensive study of metropolitan river corridors, land use information, development statistics, and river use. (Available: MC)

20. Metropolitan Development Guide. Metropolitan Council. 1973-1977. The development guide is an ongoing process of inventory, analysis and development policy for the Metro area. Data maps are at a scale of 1" = 4 miles. Data collection time significantly reduced by utilization of pertinent information available from the documents and personnel at Metropolitan Council. Maps utilized in this section, Protection Open Space (Series), Metropolitan Sewer System, Transportation (Series) (Available: MC)

21. Minnesota Agricultural Statistics. Minnesota Crop and Livestock Reporting Service. May, 1977. Contact: Cy Phillipi. Documents farmland characteristics for state by district. Information within the metropolitan area must be compiled from several districts. (Available: MC, MCLRS)

22. Mississippi/Minneapolis. Minneapolis Planning and Development. 1972. 127 pp. The document is a past and present survey of the Mississippi River waterfront in Minneapolis planning concepts, frameworks and a suggested action program is included. Some inventory data may be helpful on the subject of land/water interface and historic sites. (Available: MC)

23. Parks and Recreation Facilities Plan, Dakota County: 1970 - 2000. Dakota County Planning Advisory Commission. November 1970. The plan is an inventory of existing recreational facilities (parks and open space). County and community needs are analyzed in terms of additional facilities. (Available: MC)

24. Perspective on Minnesota Land Use. MLMIS - University of Minnesota. (Now with State Planning). October 1974. The document deals with broad land use patterns, issues, and programs on a state-wide basis. Limited applicability at the metropolitan level. Includes Land Use Map of TCMA, 1974. (Available: SPA)

25. Population Profile of the Twin Cities Metropolitan Area. Metropolitan Council Development Framework Data Report. May 1974. 82 pp. Contains elements of population dynamics, characteristics of metropolitan population, information on housing and income. Possible value to MWCC studies. (Available: MC)

26. Ramsey County Open Space System. St. Paul Department of Parks, Recreation and Public Buildings. February 1971. 25 pp. This report presents general information on physical resources related to parks and open space. Plates of vegetation, slopes, soils, floodplains, and planning concepts are included. (Available: MC)

27. Ramsey County Outdoor Recreation Plan. St. Paul Department of Parks, Recreation and Public Buildings. December 4, 1968. 103 pp. This report has a fairly detailed description of existing parks and open space as well as recommendations for future park acquisition and development. County wide maps are illustrated at a scale of 1" = 4 miles. The document may be of some value since it lists county facilities. Larger scale maps may be available at the County Offices. (Available: MC)

28. Recommendations for Critical Area Designation of the Mississippi River Corridor. Metropolitan Council. February 1975. 84 pp. Outlines regional objectives, standards and guidelines for preparation of local plans relating to the Critical Areas corridor. Describes and delineates districts as well as the corridor itself. (Available: MC)

29. Scott County Comprehensive Area-wide Water and Sewer Plan. Scott County Water and Sewer Planning Agency. Consultants: J. Darling & Associates, Inc. and Tri-State Engineering. June 1975. 51 pp. The report is an assessment of physical constraints and future needs for sanitary sewer and water systems. The major emphasis is on six communities. Several plates including soils, forest cover (not specific) and topography are included. (Available: MC)

30. Scott County Comprehensive Development Plan 1971-1985. Scott County Planning and Zoning Advisory Commission and Midwest Planning and Research Inc. 55 pp. The document is a planning guide with emphasis on planning objectives and policy guidelines rather than inventory data. It may be of limited value to MWCC studies. No maps are included. (Available: MC)

31. Solid Waste Disposal and Resource Recovery System. June, 1976. Metropolitan Council Map. Map illustrates locations of sanitary landfills, transfer stations, recycling stations, special use landfills and incinerators. (Available: MC)

32. State of the Region (TCMA) Metropolitan Council. February 1977. 170 pp. The document is an overview and analysis of socio-economic and natural resource characteristics for the TCMA. It is an excellent background resource but is somewhat limited in detail. (Available: SPA)

33. State Register. pp. 497-668. Vol. 2, No. 11. (Sept. 19, 1977) State of Minnesota. This volume contains proposed rules governing transmission line routes, industrial cost recovery system, and hazardous wastes. Lays groundwork for background information. Limited value. (Available: Office of the State Register or Documents Section, Purchase price is $2.25)

34. Twin Cities Metropolitan Area Land Use, 1974. State Planning Agency, map. Land use is mapped at approximately 1" = 3 miles. Eight classifications are used with a mapping unit of 40 acres. Information is based on Earth Resources Technology Satellite Imagery. (Available: SPA)

35. "Urbanized Land - 1973 - TCMA" Metropolitan Council map. Depicts urban land use including public parks ten acres or larger, scale is 1" = 2 miles. (Available: MC)

36. Where We Are Today. Washington County Planning, 1976. 90 pp. This is a comprehensive plan for Washington County. Inventory of agricultural lands, other land uses, population characteristics, and cultural features are presented. Future policies and guidelines are also included. This is the most complete and usable of the comprehensive plans in the metro area to date. Should be of value to MWCC studies. (Available: WCPO)

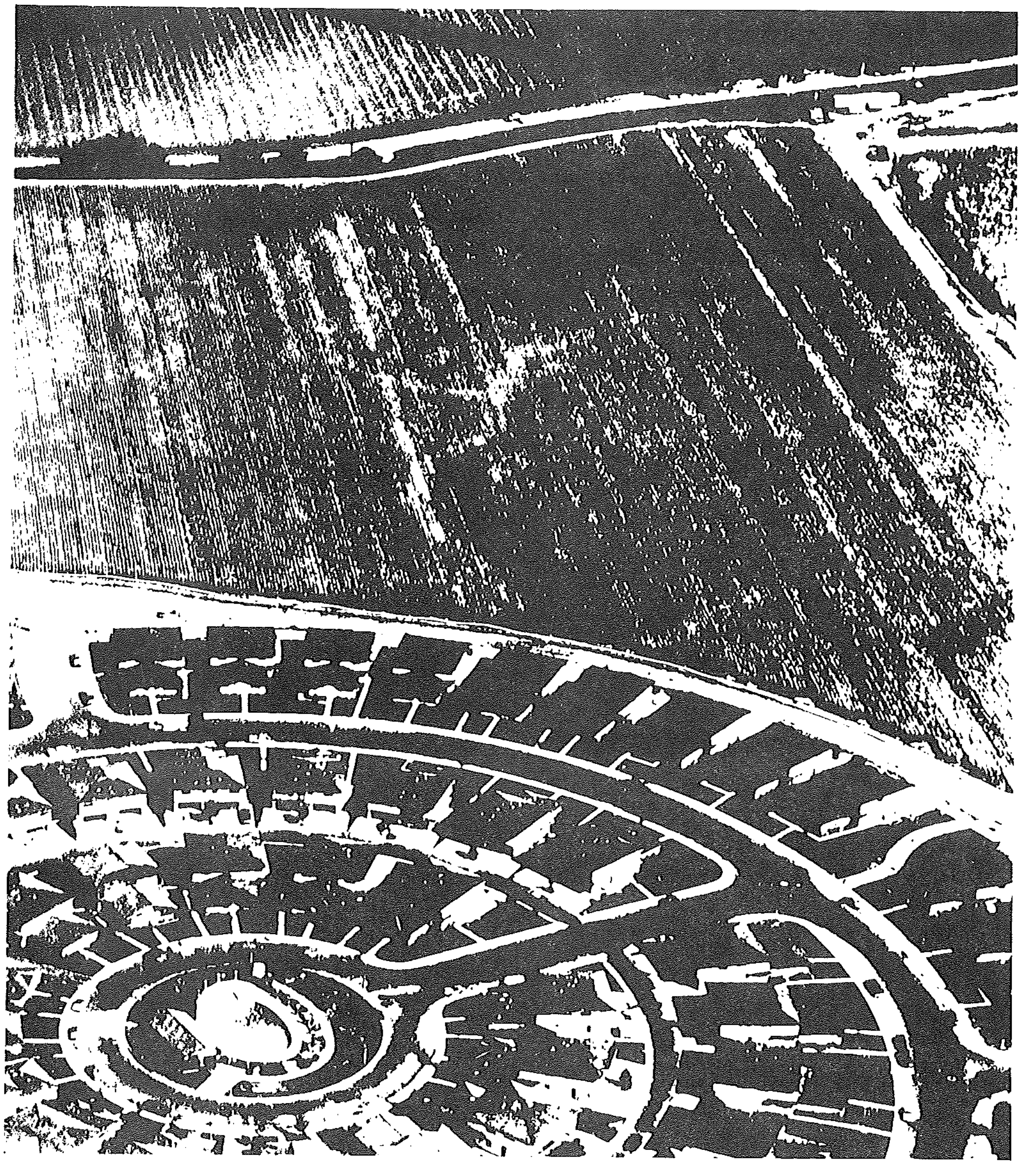
37. "Minnesota Composite of System Diagram Maps for Class I Carriers." MN/DOT map. July, 1977. Shows railroads anticipated for abandonment. (Available: MN/DOT)

38. Personal communications with MC staff.

39. Personal communications with Minnesota Crop and Livestock Reporting Service: Cy Phillipi.

40. Personal communications with MWCC staff.

MC - Metropolitan Council Library
MCLRS - Minnesota Crop and Livestock Reporting Service
MPL - Minneapolis Public Library
SPA - State Planning Agency
WCPA - Washington County Planning Office



FARM CHARACTERISTICS

Agriculture occupies the most acreage of all industries within the metropolitan area. In 1976, the Minnesota Crop and Livestock Reporting Service reported 6650 farms which encompassed 1600 square miles, slightly greater than 50 percent of the metropolitan area. See Plate 23 for locations of farmland (1).Table 15-1 illustrates characteristics of farms for each county.

TABLE 15–1

FARM CHARACTERISTICS IN THE METROPOLITAN AREA–1976 (1)

COUNTY	NO. FARMS	LAND IN FARM ACRES	PERCENT IN FARMS	AVERAGE FARM SIZE ACRES
Anoka	725	104,300	37.9	144
Carver	1390	198,600	86.6	143
Dakota	1225	278,400	75.6	223
Hennepin	1130	130,000	35.8	115
Ramsey	125	4,800	4.9	38
Scott	1185	172,800	75.4	146
Washington	870	136,000	53.1	156
Metro	6650	1,024,900	52.8	138

Carver County has the highest percentage of land farmed with 86.6 percent, and Ramsey County has the least with 4.9 percent. Dakota County has the largest acreage in farmland although it accounts for about 75% of the total land area. The average farm size varies from county to county, which may indicate the predominant type of farming operation. Ramsey County farms averaging 38 acres, are predominantly nurseries and small tract vegetable farms. Such specialized farming yields high value crops using smaller acreages. The largest farms are located in Dakota County, and are primarily dairy and livestock operations. The average farm size in all seven counties is less than the statewide average of 259 acres.

Farm operator characteristics, shown in Table 15-2, indicate that a larger number of farm operators have some other principal occupation in Anoka, Ramsey and Washington Counties. In these cases, farming provides supplemental income or is a hobby operation. Most farm operators live on the farm. Thus, agriculture continues to be an important lifestyle as well as an important industry and land use in the metropolitan area.

AGRICULTURAL SIGNIFICANCE

The agri-business industry in the metropolitan area annually contributes over 100 million dollars in agricultural products. Although profit from the farming industry has been declining in the past two decades, it remains a significant economic activity.

Plate 24 reflects agriculture land values based on county assessors' average market value for agricultural land in 1976. Although these values do not represent selling prices, they do indicate relative agricultural land values among the different townships and municipalities.

Agricultural land escalates in value as development encroaches into the rural areas due to speculation, leap-frog development and resulting social pressure. This is evidenced by the highest land values forming concentric rings around the urban areas as shown in Plate 25.

Figure 15-1 illustrates 1976 land values based on farm land sales. It reflects land values of the metropolitan area in relation to the rest of the state and to the values expressed in Plate 24. The values expressed in Figure 15-1 more accurately reflect the current market price of farmland while Plate 24 illustrates the agricultural value on which taxes are assessed.

TABLE 15–2

FARM OPERATOR CHARACTERISTICS (3)

	ANOKA	CARVER	DAKOTA	HENNEPIN	RAMSEY	SCOTT	WASHINGTON
I. Live on farm	430	890	766	664	42	721	545
a. on another farm	11	20	27	13		26	17
b. in rural area (not on farm)	16	16	22	12		4	15
c. in a city area (town) (or urban area)	29	35	38	51	15	39	33
II. Ownership							
a. full ownership	409	742	587	569	68	645	410
b. part ownership	137	314	316	268	5	267	232
c. tenant	24	90	112	70	7	63	67
III.Operators Principal Occupation							
a. farm	226	881	683	507	26	661	339
b. other	331	261	315	367	42	310	353

TABLE 15–3

1976 DISTRIBUTION AND YIELDS OF METROPOLITAN AREA CROPS (4)

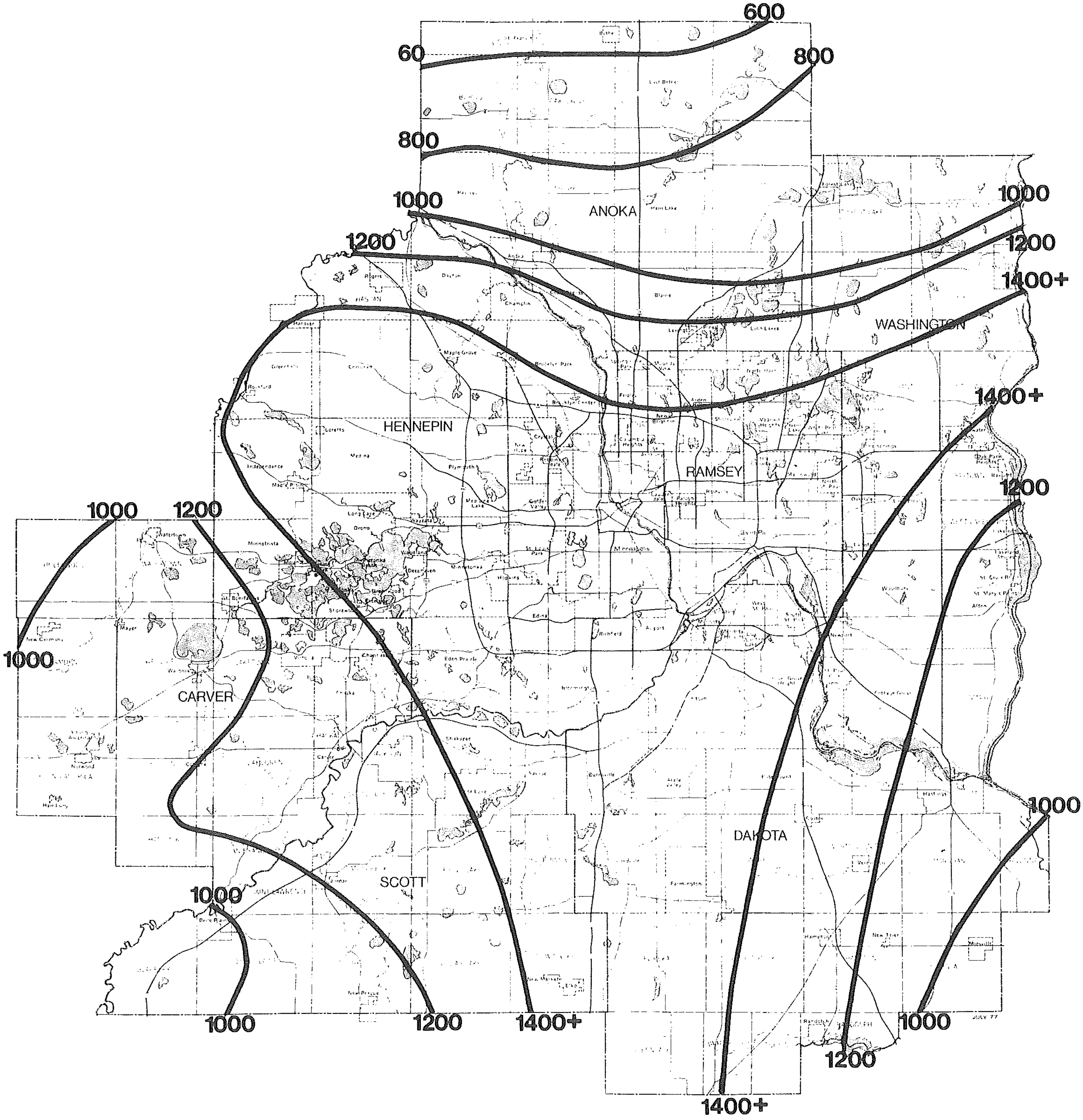
	ALL CORN			SOYBEANS			ALL HAY			OATS		
County	Acres	Percent Metro	Yield Bus/Acre	Acres	Percent Metro	Yield Bus/Acre	Acres	Percent Metro	Yield Bus/Acre	Acres	Percent Metro	Yield Bus/Acre
Anoka	22,500	6.7	33.4	2,800	3.8	10.2	15,100	9.5	1.4	3,200	4.3	26.0
Carver	66,000	19.9	59.2	10,300	13.9	22.5	40,000	25.3	2.8	16,000	21.4	56.4
Dakota	105,000	31.6	48.0	31,000	41.7	16.5	25,500	16.1	2.0	19,300	25.9	41.8
Hennepin	42,000	12.6	51.7	4,800	6.5	18.2	28,000	17.7	2.3	11,400	15.3	46.3
Ramsey	800	0.2	51.2	100	0.1	12.0	1,400	0.9	1.2	400	0.5	49.3
Scott	56,000	16.9	63.6	16,500	22.2	22.4	27,000	17.1	2.8	14,000	18.8	50.6
Washington	39,500	11.9	45.7	8,800	11.8	16.0	21,300	13.4	1.9	10,300	13.8	43.7
METRO	331,800			74,300			158,300			74,600		

AGRICULTURAL ACTIVITY

The four major crops grown in the metropolitan area are corn, soybeans, hay and oats. Distribution of these crops, in each county in 1976 is shown on Table 15-3. The largest percentage of the metropolitan area corn, soybean and oat crops are planted in Dakota County. Hay production is greatest in Carver County. Seventy percent of the orchard crops in the metropolitan area are raised in Washington County.

The greatest yields per acre of all four crops occur in Carver and Scott Counties. Lower yields per acre occurred in Dakota County, although there is more prime cropland area. Cash income received for crops and livestock is shown in Table 15-4. This table reflects the wide range attributed to the predominant crop for each county and productivity of the land. The very high value in Ramsey County, $446 per acre, is due primarily to nurseries which produce a high value crop on limited land area. The low average value in Anoka County, $126 per acre, is due to the poor productivity of soils which are classified as marginal for cropland suitability.

FIGURE 15–1 METROPOLITAN AREA FARMLAND VALUE, 1976
(Dollars per acre)



SOURCE: The Minnesota Rural Real Estate Market, 1976

TABLE 15–4

SOURCES OF CASH INCOME RECEIVED BY FARMERS, 1976 (4)

COUNTY	CROPS*	LIVESTOCK*	CROPS & LIVESTOCK*	VALUE PER ACRE FARMED LAND
Anoka	$ 6,568	$ 6,543	$ 13,111	$ 126
Carver	10,155	30,344	40,499	204
Dakota	27,521	22,830	50,351	181
Hennepin	20,696	11,208	31,904	245
Ramsey	1,796	345	2,141	446
Scott	10,184	20,809	30,993	179
Washington	13,785	12,065	25,850	190
METRO	$90,705	$104,144	$194,849	$ 288

*Thousand Dollars

The location of the metropolitan area within the midwestern dairy belt, is reflected by statistics for dairy farming. Numbers of milk cows, as well as other livestock, are shown in Table 15-5. In Carver County milk and milk products production ranks first among counties in the metropolitan area. Carver, Dakota and Scott Counties raise the greatest number of livestock.

SPECIALTY FARMING

Production of vegetables, orchard fruits, sod and horticulture are highly profitable due to their proximity to the urban area, the major market place. Locations of these farming operations are shown on Plate 25.

Orchards and tree farms are unique farming operations since they require a long time span for crop maturation. No annual clearing of the land is necessary, unlike that for other crops.

Vegetables and sod represent unique crops because under proper management they grow abundantly on peat soils. These soils are not considered prime agricultural land according to soil type classification. See Section 4 - Soils for a more detailed discussion.

There are farming operations in Anoka and Dakota Counties, which use irrigation. A number of vegetable farms, especially those growing for canneries and nurseries, use irrigation. In Dakota County, irrigation of corn is increasing as a reaction to severe drought conditions.

TABLE 5–5 LIVESTOCK ON FARMS, 1976 (4)

COUNTY	MILK COWS	ALL CATTLE AND CALVES	ALL HOGS	ALL STOCK SHEEP & LAMBS
Anoka	1,700	9,300	7,500	1,000
Carver	24,300	52,000	31,400	1,300
Dakota	8,900	42,600	43,000	1,600
Hennepin	7,000	23,900	6,000	200
Ramsey		600	1,100	
Scott	15,200	34,900	20,800	500
Washington	4,500	23,000	7,700	1,600
METRO	61,600	186,300	117,500	6,200

REFERENCES

1. Agricultural Planning Handbook, Identifying Long Term Productive Farmland, Prepared for Metropolitan Council, July 1976. Outlines step by step procedures towards identifying long term agricultural lands and land likely to be lost to development. Useful for small scale communities evaluation. (Available: MC)

2. Agriculture in Twin Cities Metropolitan Area. James Schoettler, 1975. Very comprehensive inventory of agricultural activity past and present. Valuable in accessing the importance of agriculture to this area. Contains figures showing distribution of types of farming operations. (Available: MC)

3. 1974 Census of Agriculture. U. S. Department of Commerce. Vol. I part 23 Minnesota state and county data. Issued April 1977. Overlaps information in Minnesota Agriculture Statistics annual report but includes additional information on characteristics of farm operators. Data is presented in tables for each county - no analysis is included. Census is updated every five years; the lag between data collection and publication makes this information less current. (Available: USDA)

4. Minnesota Agriculture Statistics, 1976 Minnesota Crop and Livestock Reporting Service, U. S. Department of Agriculture. Compilation of Statewide and County data on crops and livestock. Data is presented in tables by county. Helpful in defining distribution of agricultural activity and economic importance. Published annually for previous year data collection. (Available: USDA)

5. The Minnesota Rural Real Estate Market in 1976. Rodney Christianson, Stephan Nelson and Phillip Rays, University of Minnesota Agricultural Department, St. Paul. Discusses current farmland values and trends. (Available: U of Mn - Ag Dept)

6. Prime Agricultural Land in Hennepin County Map to be published by Soil Conservation Office, Hennepin County, suitability of land for farming defined in 40 acre tracts according to soil classification. (Available in approximately 3 months, currently on exhibit at Wayzata SCS office.)

7. Staff report on Agricultural and Commercial Farming in Washington County. October 23, 1975. (Available: Washington County Planning Department)

MC - Metropolitan Council, St. Paul
SCS - Soil Conservation Service
U of Mn - Ag Dept - University of Minnesota, Agriculture Department
USDA - United States Department of Agriculture, University of Minnesota,
St.Paul, Minnesota.

ENDANGERED AND THREATENED PLANT AND ANIMAL SPECIES

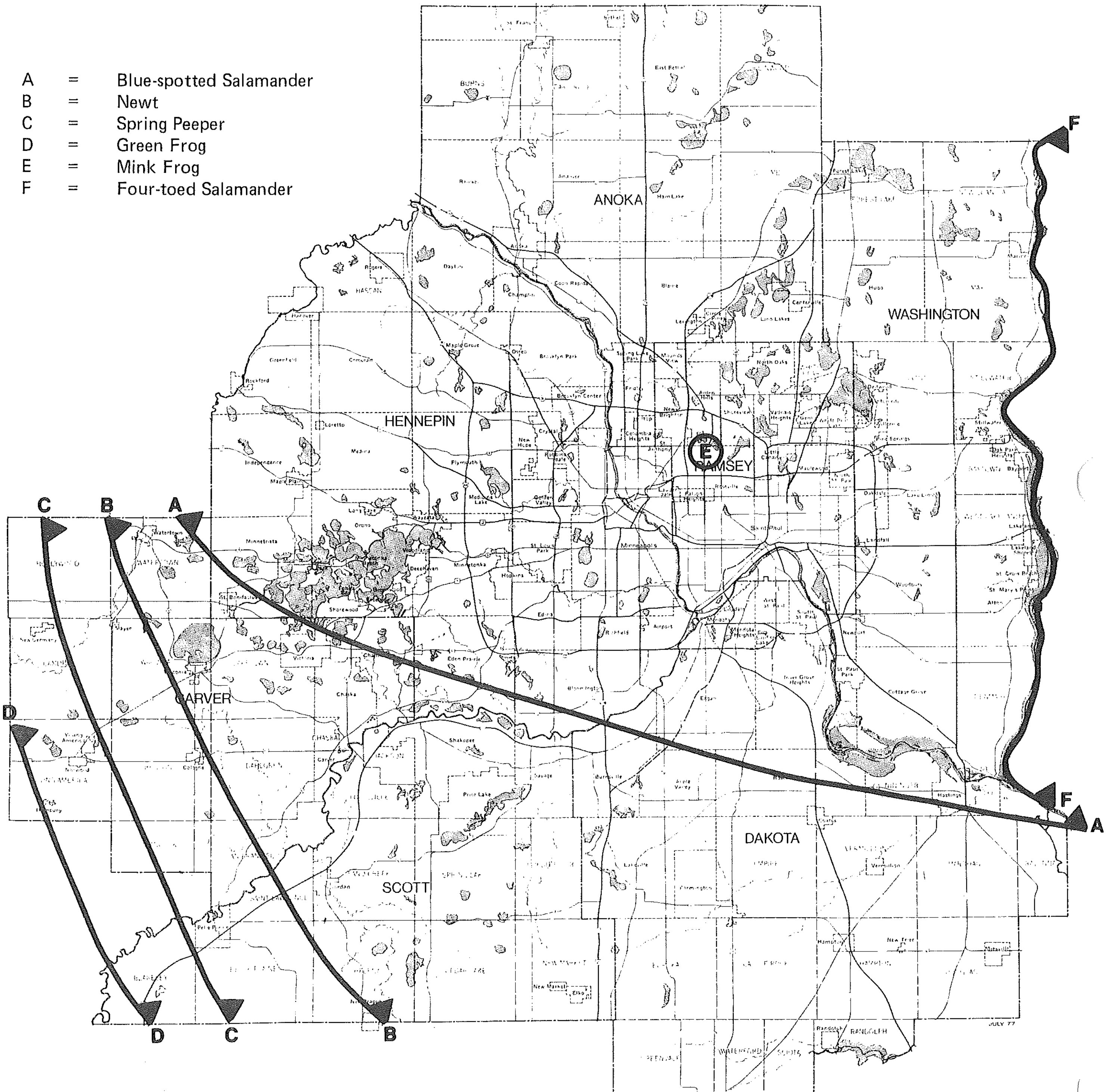
The metropolitan area may be unique among large urban areas in the United States in the number and diversity of endangered, rare, and threatened species that exist here, reflecting the immense diversity of habitat types. Many of the endangered and threatened species exist across the entire spectrum of habitats. Thus, it is extremely difficult to pinpoint exact locations. Figures 16-1 through 16-9 indicate the ranges of rare animal species and Figure 16-10 illustrates recognized locations of rare flora in the metropolitan area.

Disruption by development and agriculture, replacement by introduced species, loss of habitat, and natural migration all contribute to an ever-changing environment. Among the most important habitat areas are the relatively undisturbed river and stream corridors. Many of the corridors provide habitat for rare and endangered plant and animal species, some requiring the cool, moist low-lying areas, other requiring dry bluff habitats. Others use the natural migration routes formed by the lineal corridors.

Many of the regional parks, park reserves, wildlife management areas, and game refuges maintain habitats used by rare and endangered species. Additional areas maintained by private individuals and organizations include Cedar Creek Natural History Area, Allison Savanna, the Lotus Beds, and Kucker Woods. Plate 12, Vegetation of Special Significance, illustrates valuable areas of game habitat, scenic timber, rare flora, and vegetation of educational and scientific value.

FIGURE 16–1 AMPHIBIANS AND REPTILES WITH EDGE OF SPECIES' RANGE IN THE METROPOLITAN AREA.

A = Blue-spotted Salamander
B = Newt
C = Spring Peeper
D = Green Frog
E = Mink Frog
F = Four-toed Salamander

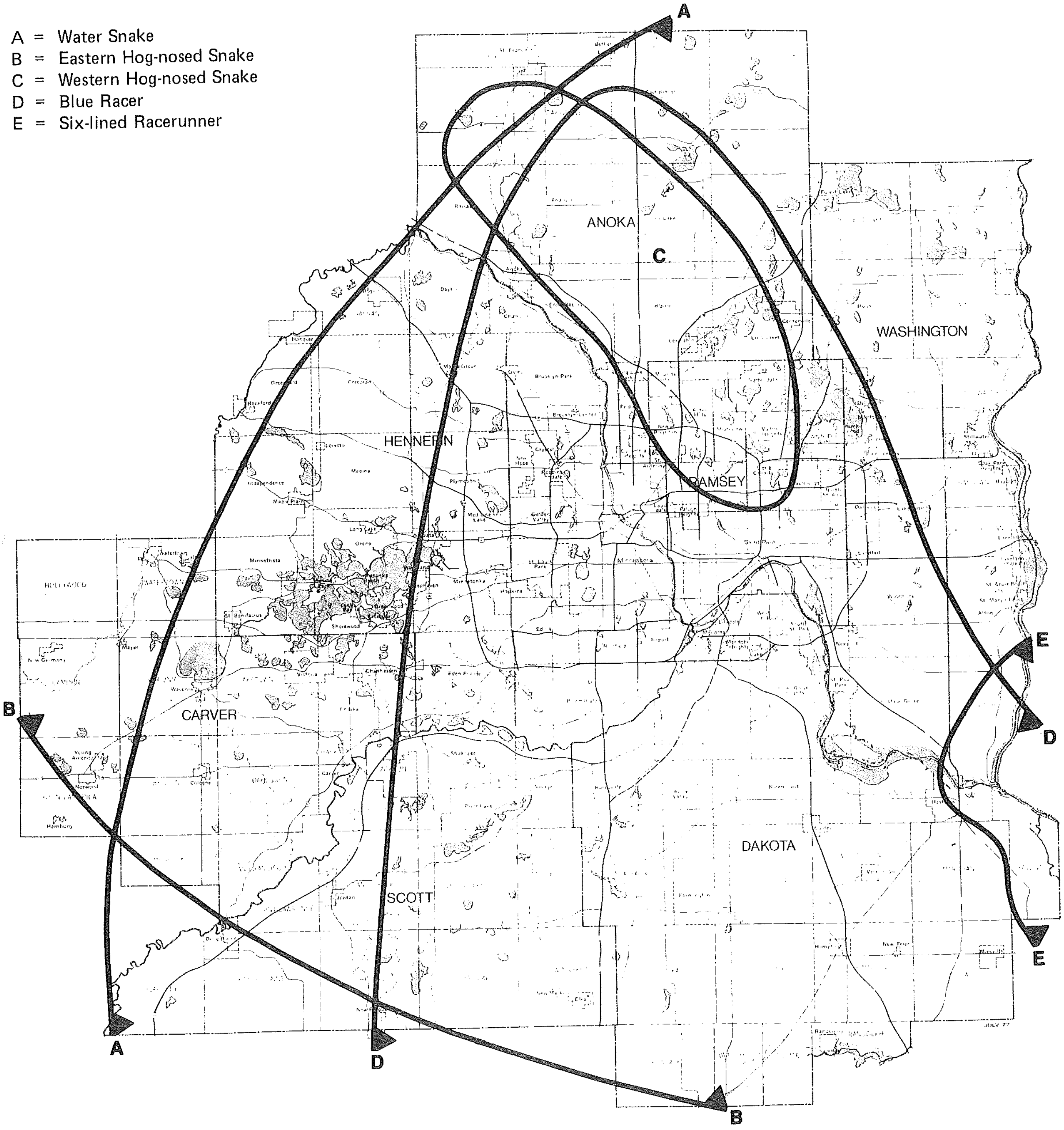


Arrows indicate the appropriate side of the range boundary line for each species.

SOURCE: Breckenridge 1944; Conant 1975

FIGURE 16–2 SNAKES AND LIZARDS WITH EDGE OF SPECIES' RANGE IN THE METROPOLITAN AREA.

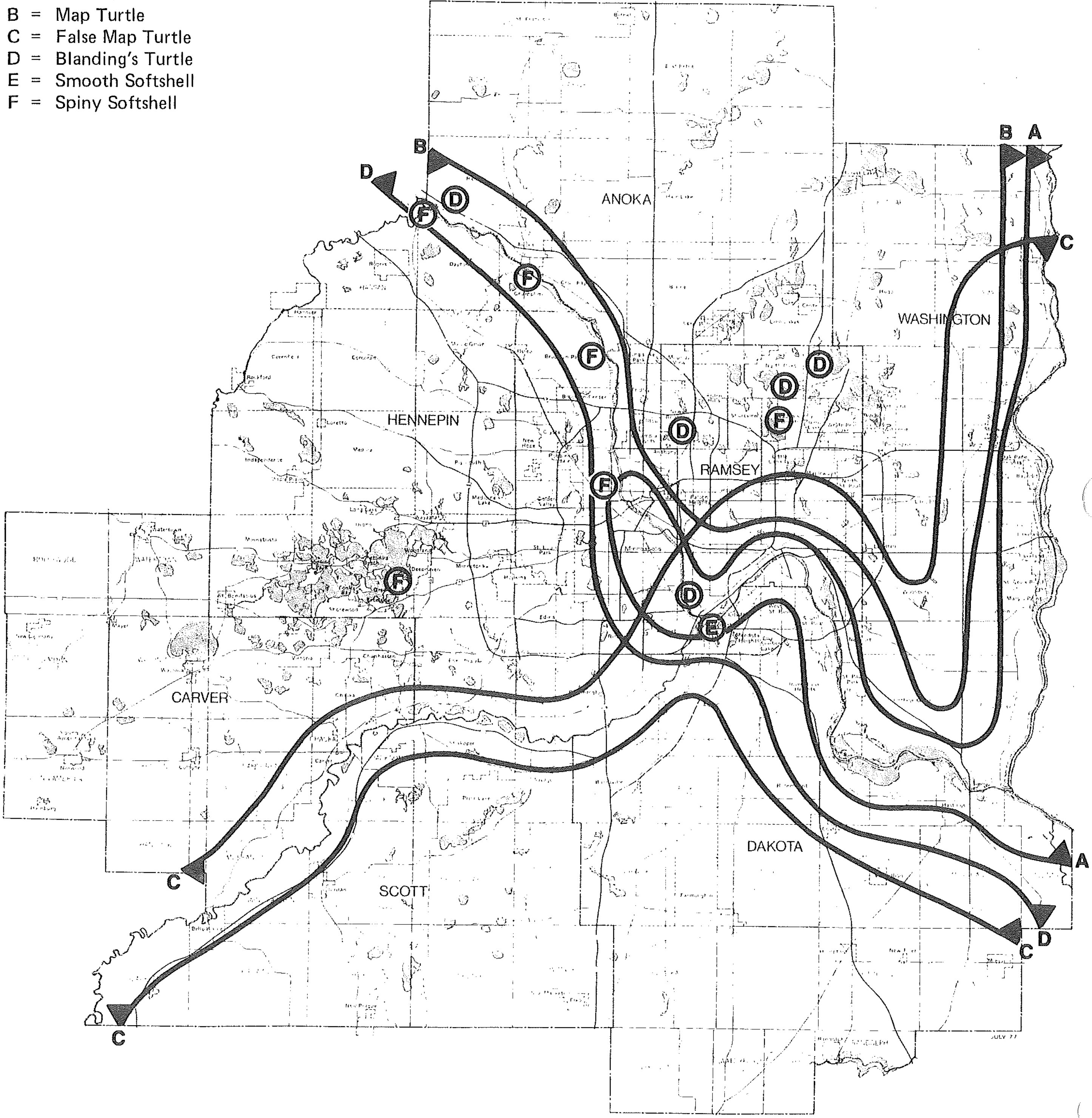
A = Water Snake
B = Eastern Hog-nosed Snake
C = Western Hog-nosed Snake
D = Blue Racer
E = Six-lined Racerunner



SOURCE: Breckenridge 1944; Conant 1975

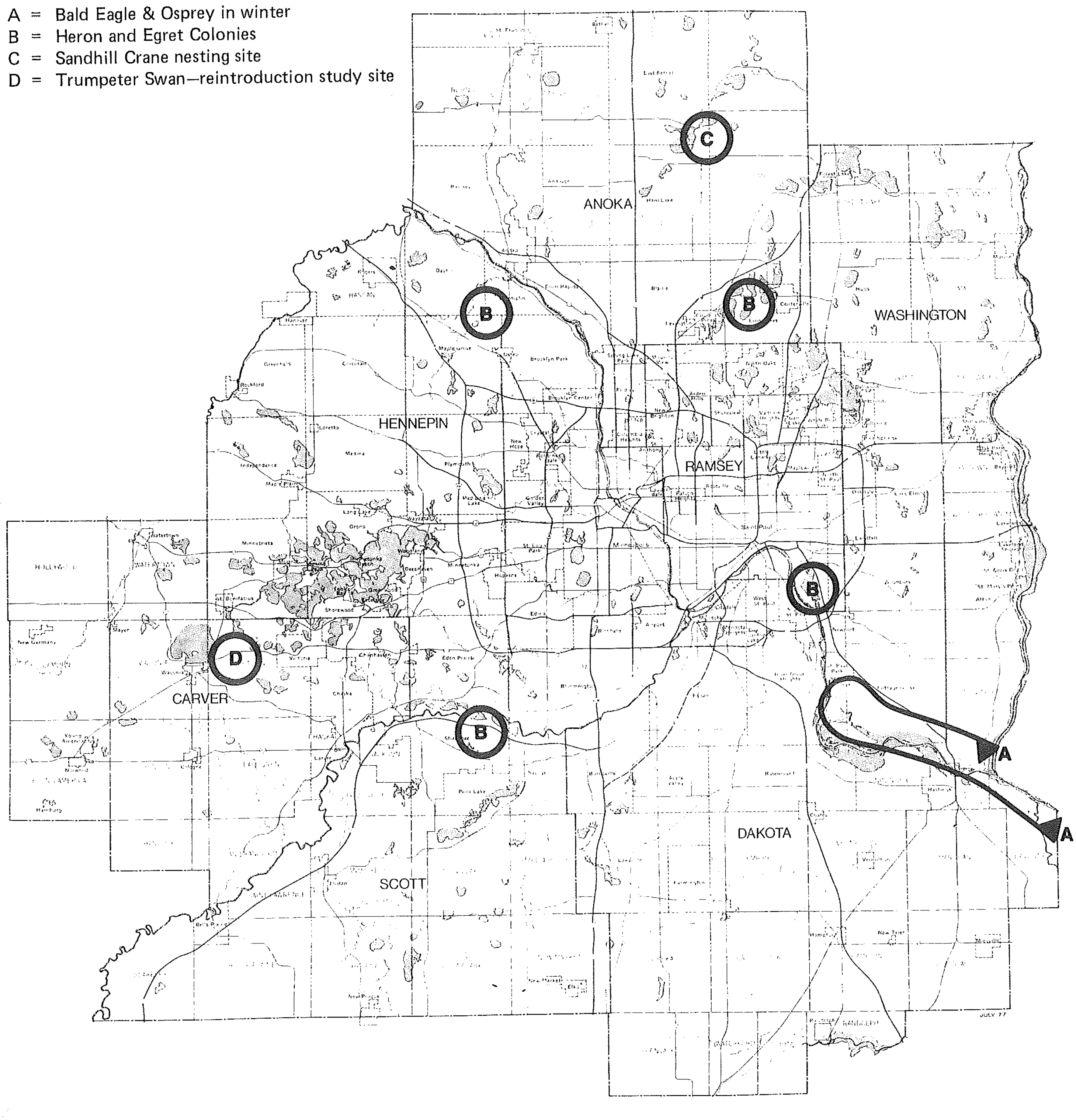
FIGURE 16–3 METROPOLITAN AREA DISTRIBUTION OF RARE AND THREATENED TURTLES

A = Wood Turtle
B = Map Turtle
C = False Map Turtle
D = Blanding's Turtle
E = Smooth Softshell
F = Spiny Softshell



SOURCE: Reptiles and Amphibians of Minnesota, 1958.

FIGURE 16–4 RARE BIRD SPECIES' LOCATIONS

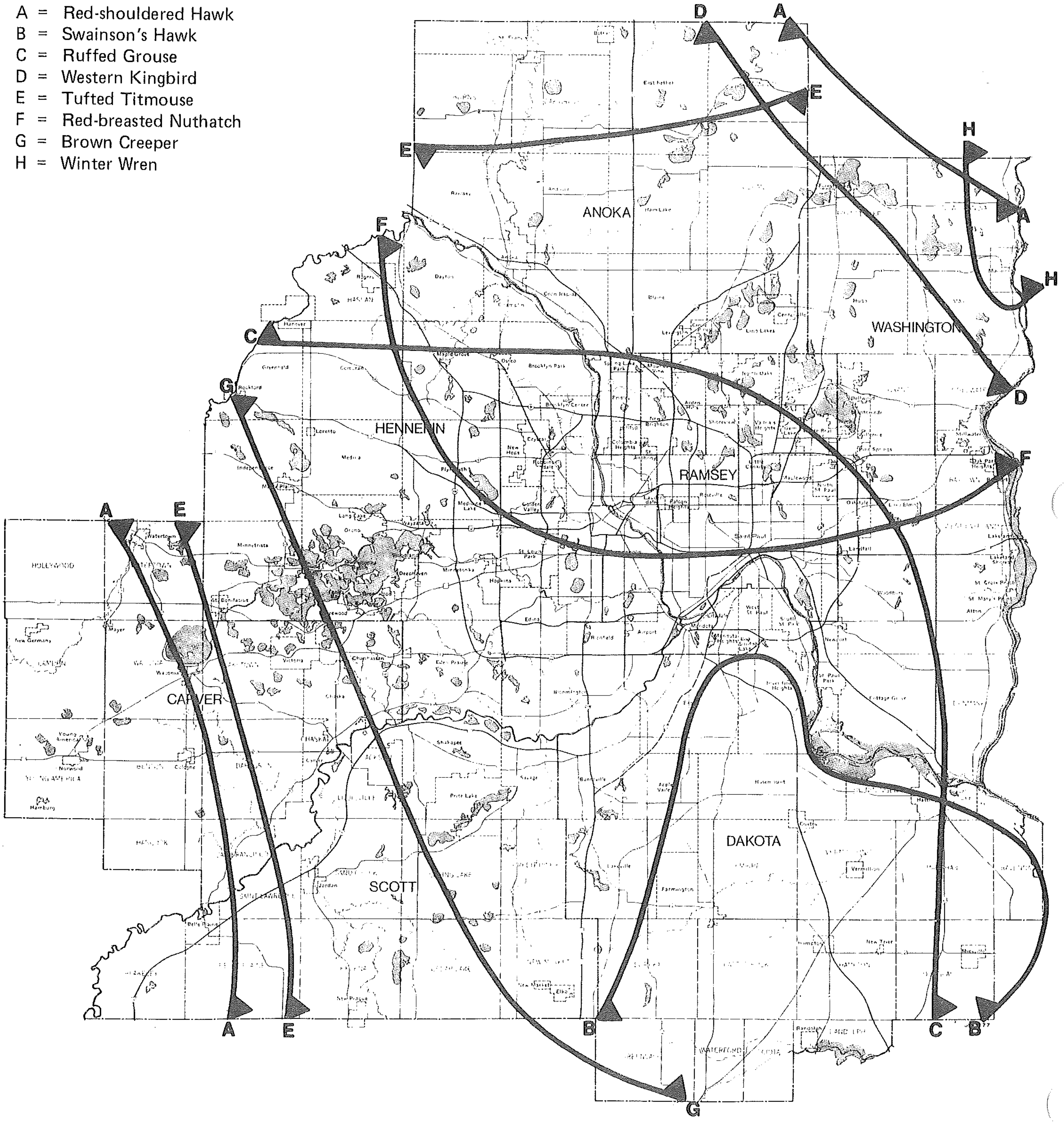


SOURCE: Birds of the Minneapolis-St. Paul Region, 1966

FIGURE 16–5

FOREST-RELATED BIRDS WITH EDGE OF SPECIES' RANGE IN THE METROPOLITAN AREA

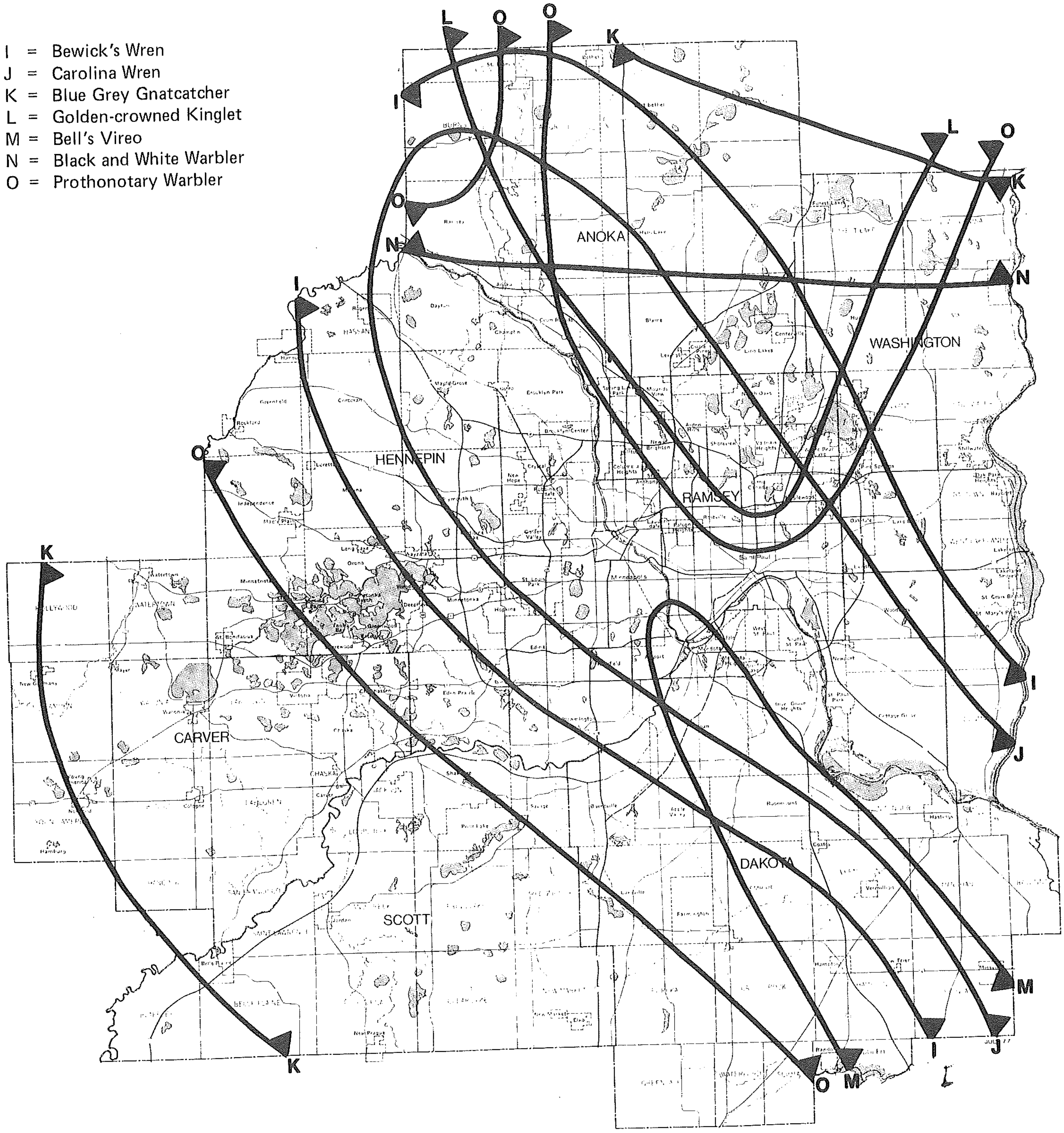
A = Red-shouldered Hawk
B = Swainson's Hawk
C = Ruffed Grouse
D = Western Kingbird
E = Tufted Titmouse
F = Red-breasted Nuthatch
G = Brown Creeper
H = Winter Wren



SOURCE: Birds of the Minneapolis-St. Paul Region, 1966.

FIGURE 16–6

FOREST-RELATED BIRDS WITH EDGE OF SPECIES' RANGE IN THE METROPOLITAN AREA

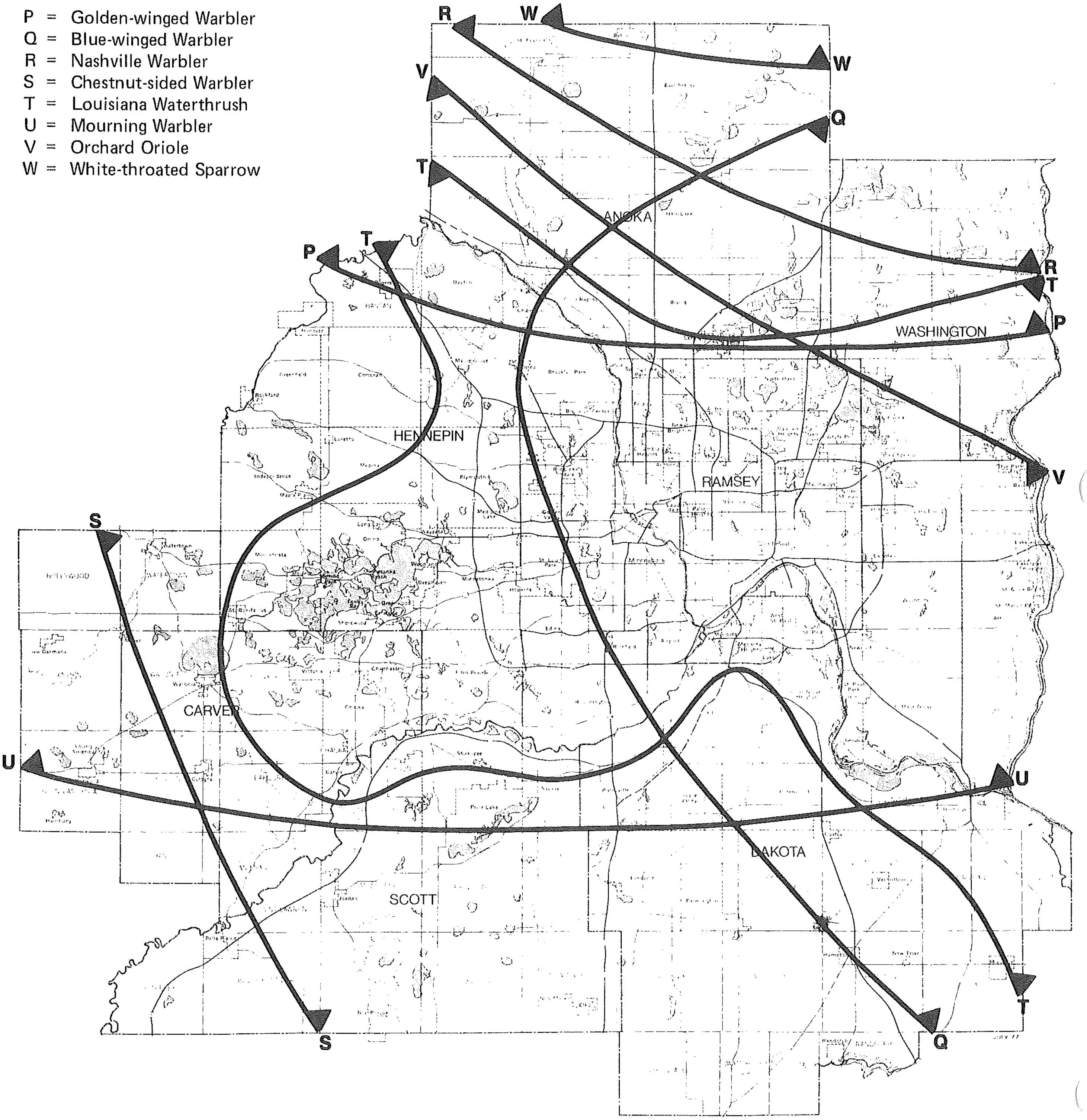


SOURCE: Birds of the Minneapolis-St. Paul Region, 1966.

FIGURE 16–7

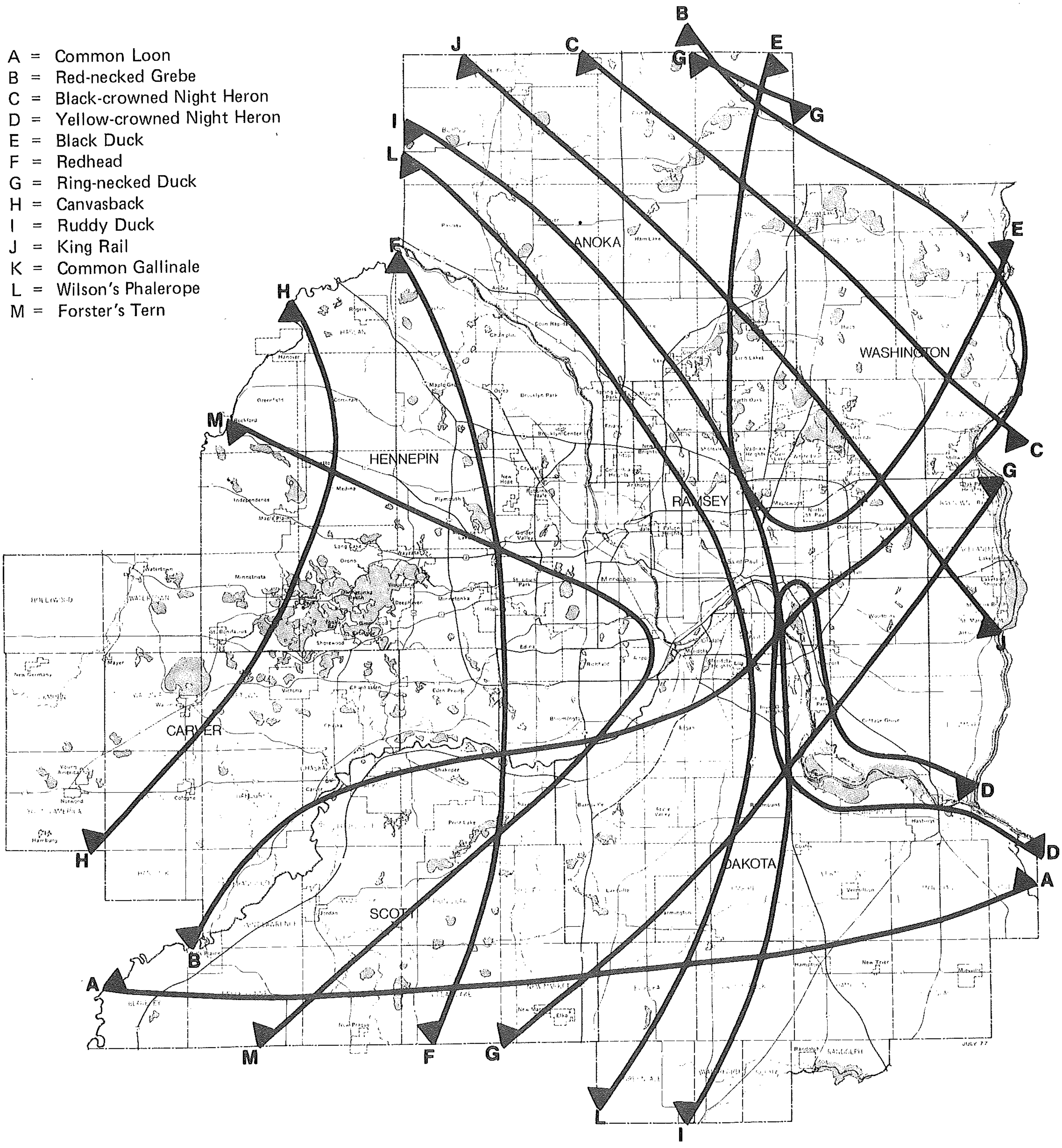
FOREST-RELATED BIRDS WITH EDGE OF SPECIES' RANGE IN THE METROPOLITAN AREA

P = Golden-winged Warbler
Q = Blue-winged Warbler
R = Nashville Warbler
S = Chestnut-sided Warbler
T = Louisiana Waterthrush
U = Mourning Warbler
V = Orchard Oriole
W = White-throated Sparrow



SOURCE: Birds of the Minneapolis-St. Paul Region, 1966.

FIGURE 16–8 WATER-RELATED BIRDS WITH EDGE OF SPECIES' RANGE IN THE METROPOLITAN AREA

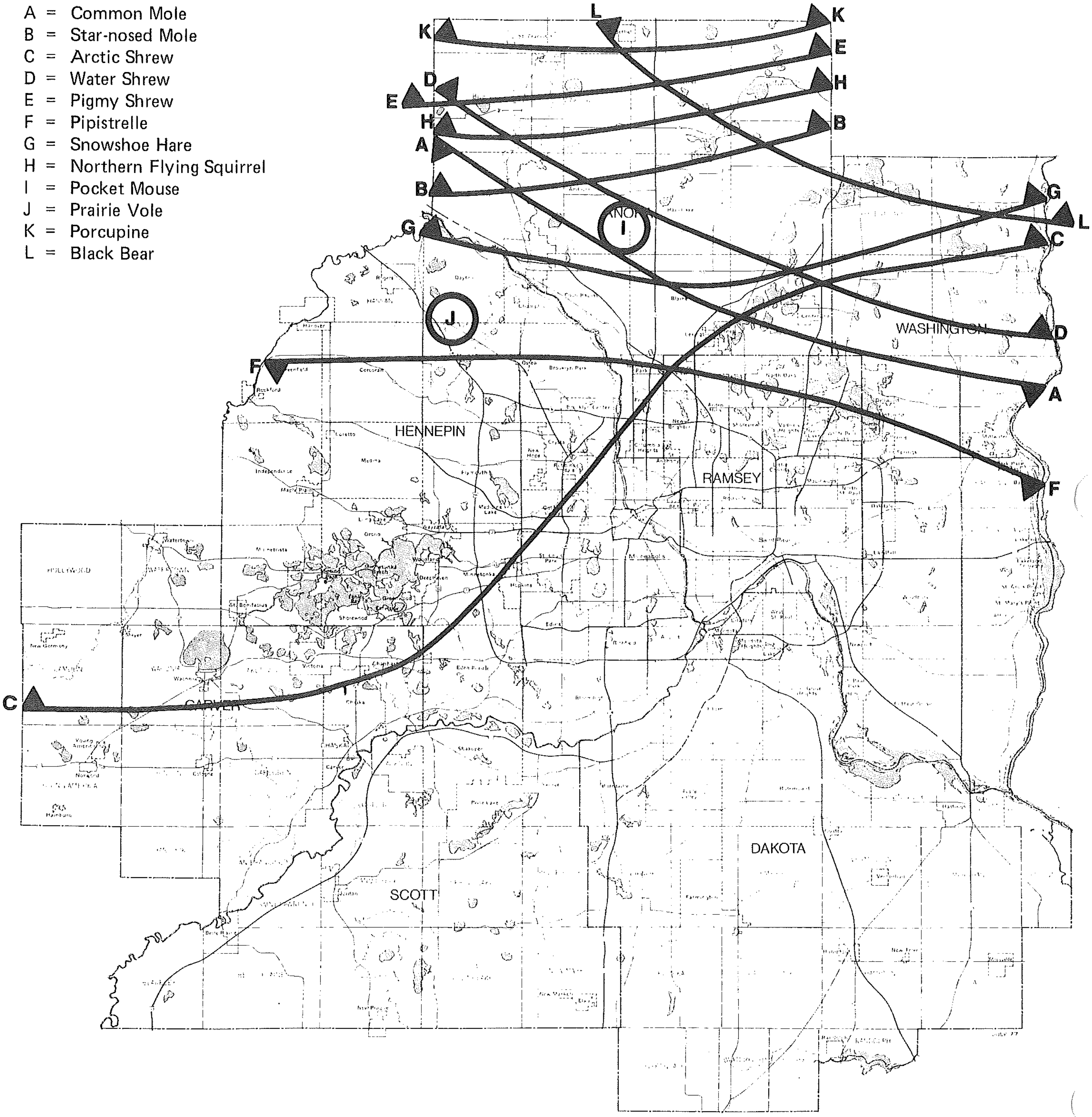


A = Common Loon
B = Red-necked Grebe
C = Black-crowned Night Heron
D = Yellow-crowned Night Heron
E = Black Duck
F = Redhead
G = Ring-necked Duck
H = Canvasback
I = Ruddy Duck
J = King Rail
K = Common Gallinale
L = Wilson's Phalerope
M = Forster's Tern

SOURCE: Birds of the Minneapolis-St. Paul Region, 1966

FIGURE 16–9 RARE AND THREATENED MAMMALS WITH SPECIES' RANGES REACHING THE METROPOLITAN AREA

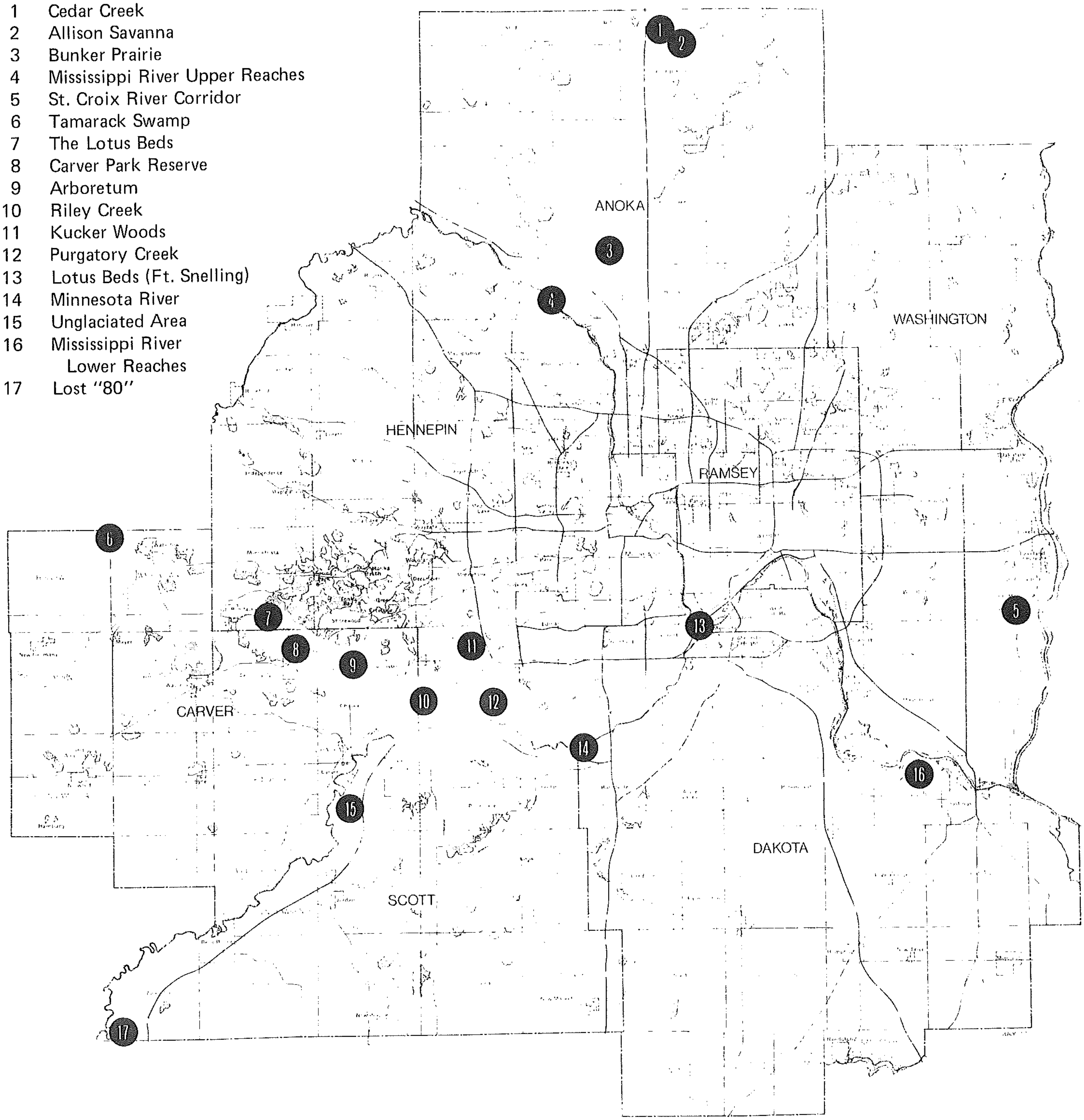
A = Common Mole
B = Star-nosed Mole
C = Arctic Shrew
D = Water Shrew
E = Pigmy Shrew
F = Pipistrelle
G = Snowshoe Hare
H = Northern Flying Squirrel
I = Pocket Mouse
J = Prairie Vole
K = Porcupine
L = Black Bear



SOURCE: Distribution, Relative Abundance, and Species Richness of Small Mammals in Minnesota

FIGURE 16–10 AREAS OF RARE FLORA

1 Cedar Creek
2 Allison Savanna
3 Bunker Prairie
4 Mississippi River Upper Reaches
5 St. Croix River Corridor
6 Tamarack Swamp
7 The Lotus Beds
8 Carver Park Reserve
9 Arboretum
10 Riley Creek
11 Kucker Woods
12 Purgatory Creek
13 Lotus Beds (Ft. Snelling)
14 Minnesota River
15 Unglaciated Area
16 Mississippi River Lower Reaches
17 Lost "80"



SOURCE: Project 80 Identified Sites, Hughes

NATIONALLY ENDANGERED SPECIES - UNITED STATES FISH AND WILDLIFE

The United States Fish and Wildlife lists 19 species of endangered organisms in the Upper Great Lakes Region. Only two, the Artic Peregrine Falcon and the Higgins' Eye Pearly Mussel are believed to occur in the metropolitan area.

Endangered species refers to a species or subspecies that is uncommon or local over its entire natural range and is in imminent danger of extinction and being lost as a genetic entity-especially if its habitat is being or is apt to be changed or destroyed. (42)

There are no plant species officially designated as endangered at this time. Four threatened plant species are known to occur in Minnesota but only two are thought to occur in the metropolitan area.

ANIMALS*

OFFICIAL STATUS (35)

Arctic Peregrine Falcon Falco peregrinus tundrius - Endangered. Occasional migrants are seen in the spring and fall during the peak waterfowl migration. Several recent published reports indicate the presence of this species in the Lower Minnesota River floodplain. None nests in Minnesota. The U. S. Fish and Wildlife Service has proposed the introduction of the American peregrine falcon Falco peregrinus anatum near potentially suitable nesting sites on the upper Mississippi River near Red Wing, Minnesota.

Higgins' Eye Pearly Mussel Lampsilis higginsi - Endangered. The Higgins' eye clam has "endangered" status in Minnesota. Several specimens have been taken recently in Lake St. Croix and the lower Minnesota River. It may also exist in cleaner portions of the Mississippi River such as Pool 1.

SPECIES UNDER OFFICIAL REVIEW

Eastern Sand Darter Ammocrypta pellucida

SPECIES SUGGESTED FOR OFFICIAL REVIEW BY U.S. FISH AND WILDLIFE SERVICE (REGION 3)

Lake Sturgeon Acipenser fulvescens

PLANTS**

Proposed Status Under Official Review	Family	Common Name	Species
Threatened	Fabaceae	Prairie Bush Clover	Lespedeza leptostachya
Threatened	Polemoniaceae	Western Jacob's Ladder	Polemonium occidentale var. lacustre

*Status as of March 1, 1976
**Status as of October 15, 1977

STATEWIDE CLASSIFICATION SYSTEMS

A list of Minnesota animals and plants in need of special consideration with suggestions for management was compiled by the Minnesota Department of Natural Resources in 1974. None of these species has received official state status. However, it should be assumed that many of these species will receive some state protective status with special management considerations in the near future.

Other species of concern are also included on Table 16-1. These species include those on the periphery of their range, hybrids which only rarely occur, some species that are not as rare as were originally thought, and species which have only unconfirmed information.

TABLE 16–1

MINNESOTA ANIMALS AND PLANTS IN NEED OF SPECIAL CONSIDERATION (46)

Endangered Species—Species in danger of extinction in Minnesota within the immediate future. All are protected at present.

1.	American or Arctic Peregrine Falcon	Falco peregrinus
2.	Whooping Crane	Grus americanus
3.	Minnesota Trout Lily	Erythronium propullans

Threatened Species—Species which could become endangered in Minnesota in the foreseeable future but not necessarily throughout their entire natural range.

4.	Pine Marten	Martes americana
5.	Bobwhite Quail	Colinus virginianus
6.	Burrowing Owl	Speotyto cunicularia hypugea
7.	Greater Sandhill Crane	Grus canadensis tabida
8.	Greater Prairie Chicken	Tympanuchus cupida
9.	Blue-tailed Skink	Eumeces fasciatus
10.	Massasauga	Sisturus capensatus
11.	Cricket Frog	Acris crepitans

Species of Changing or Uncertain Status—Species that are uncommon or local in Minnesota but which are not presently endangered or threatened but which could become threatened. Conversely, they could increase under favorable circumstances. Those starred (*) are probably increasing at present (1974).

12.	Fisher (*)	Martes pennanti
13.	Eastern Timber Wolf	Canis lupus lycaon
14.	Canada Lynx	Lynx c. canadensis
15.	Rock Vole	Microtis ochrogaster
16.	Northern Bald Eagle (*)	Heliaetus leucocephalus
17.	Osprey	Pandion haliaetus
18.	Marsh Hawk (*)	Circus cyaneus hudsonius
19.	Cooper's Hawk	Accipter cooperi
20.	Red-shouldered Hawk (*)	Buteo l. lineatus
21.	White Pelican	Pelecanus erythrorhyncus
22.	Double-crested Cormorant	Phalacrocorax a. auritus
23.	Franklin's Gull	Larus pipixcan
24.	Common Tern	Sterna h. hirundo
25.	Western Grebe	Aechmophorus occidentalis
26.	Wood Turtle	Clemmys insculpta
27.	False Map Turtle	Graptemys p. pseudogographica
28.	Blanding's Turtle	Emys blandingii
29.	Lake Sturgeon	Acipenser fulvescens
30.	Paddlefish	Polyodon spathula
31.	Black Redhorse	Moxostoma dequesnei

Species of Special Interest—Species that merit special consideration in Minnesota, and in some places and at some times merit special management, because of unusual or unique values, special public interest, or vulnerability of habitat. They are not presently endangered or threatened or apt to become so in the near future but should be watched.

32.	Bobcat	Lynx rufus
33.	Common Loon	Gavia immer
34.	Great Blue Heron	Ardea h. herodias
35.	Common Egret	Casmerodius albus egretta
36.	Pileated Woodpecker	Dryocopus pileatus
37.	Six-lined Racer	Cnemidophorus sexlineatus
38.	Snapping Turtle	Chelydra serpentina
39.	Redbacked Salamander	Plethodon cinereus
40.	Common Newt	Notophthalmus viridescens
41.	American Brook Lamprey	Lampetra lamottei
42.	Least Darter	Etheostoma microperca
43.	Pugnosed Shiner	Notropis anogenus
44.	Blue Sucker	Cycleptus elongatus
45.	Turk's—cap Lily	Lilium philadelphicum
46.	Showy Ladyslipper	Cypripedium reginae
47.	Ram's—head Ladyslipper	Cypripedium arietinum
48.	Little White Ladyslipper	Cypripedium candidum
49.	Ginseng	Aralia quinquefolium
50.	Eastern Hemlock	Tsuga canadensis
51.	Mamillaria Cactus	Mamillaria vivipara

Species that are rare in Minnesota listed in DNR publication "The Uncommon Ones".

MAMMALS

1. Bison
2. Eastern Cougar
3. Elk
4. Grizzly Bear
5. Pronghorn Antelope
6. Wolverine
7. Woodland Carbou

FISH

1. Blackfin Cisco
2. Blue Catfish
3. Skipjack Herring

BIRDS

1. Swallow-tailed Kite
2. Trumpeter Swan

PLANTS

1. Whitlow Grass
2. Prairie Bush-Clover
3. Boggs Adder's Mouth Orchid

Other Species of Concern listed in DNR publication "The Uncommon Ones".

MAMMALS

1. Pigmy Shrew
2. Woodland Jumping Mouse
3. Red Tree Mouse
4. Richardson's Grounds Squirrel
5. Star Nosed Mole
6. Least Weasel
7. Shoretailed Weasel
8. Little Southern Flying Squirrel
9. Northern Pocket Gopher
10. Pipestral Bat

BIRDS

1. Little Blue Heron
2. Canvasback Duck
3. Cattle Egret
4. Gyrfalcon
5. Yellow Rail
6. Black Rail
7. Marbled Godwit
8. Short-eared Owl
9. Great Gray Owl
10. Acadian Flycatcher
11. Bewick's Wren
12. Carolina Wren
13. Spragues Pipit
14. Loggerhead Shrike
15. Louisiana Water Thrush
16. Blue Grosbeak
17. Baird's Sparrow
18. Willet
19. American Avocet
20. Black-billed Magpie
21. Wilson's Phalarope
22. Chestnut-collared Longspur
23. Cape May Warbler
24. Tennessee Warbler
25. Bay-breasted Warbler
26. Mockingbird
27. Bluebird
28. Orchard Oriole
29. Longbilled Curlew
30. Avocet
31. Eskimo Curlew
32. Blue-gray Gnatcatcher

REPTILES AND AMPHIBIA

1. Great Plains Toad
2. Manitoba Toad

FISH

1. Pallid Shiner
2. Topeka Shiner
3. Gravel Chub
4. Slender Madtom
5. Banded Darter
6. Crystal Darter
7. Warmouth
8. Yellow Bass

PLANTS

1. Chestnut (yellow) Oak
2. Swamp White Oak
3. Kentucky Coffee Tree
4. Sandberg's Birch
5. Betula purpusii (a hybrid birch)
6. Lingonberry
7. Rosinweed

The Minnesota State Wildflower Law, which was passed in 1925 and revised in 1935, prohibits the sale of certain species of wildflowers and the picking or digging of them on public lands or on private lands without the written consent of the property owner. (See Table 16-2 for a list of plants legally protected in Minnesota.)

TABLE 16–2

PLANTS LEGALLY PROTECTED IN MINNESOTA

Trailing Arbustus,	Epigaea repens
Gentian (All Species),	Gentiana
Lily (All Species),	Lilium spp.
Trillium (All Species),	Trillium spp.
Lotus Lily (All Species),	Nelumbo lutea
All species	

SOURCE: Minnesota Law MSA 17.23

According to the Department of Natural Resources 1977 Hunting and Trapping Regulations, there are no open hunting seasons on these protected mammals: elk, caribou, antelope, martens, timber wolves and wolverines. Protected birds include bobwhite, quail, prairie chickens, cranes, Ross' geese, swans, mourning doves, hawks, owls, eagles, herons, bitterns, loons and grebes. All other species are protected, except for those with a designated hunting season or those specified: monk parakeets, English sparrow, starlings, and common pigeons. Although crows are protected by federal law, they may be taken when doing damage or when they are about to do damage.

We have little quantitative data on fish losses from the metropolitan area, but we know they have been considerable. Until the entire spectrum of water quality improves, we can expect no increase in species composition of any of the aquatic animals and plants.

It is therefore, apparent that man's impact on the environment especially on the water, will in some way affect many of these species.

METROPOLITAN AREA SPECIES STATUS

Dr. Thomas Morley, (1972), compiled a list of 256 rare plant species that occur in Minnesota, with at least 36 of them occurring in the metropolitan area. Hughes (1974) recorded 41 rare or uncommon plant species in the metropolitan area. In addition he has identified habitat areas of species. Table 16-3 combines portions of Hughes' and Morley's work indicating in which counties the species have been recorded and their habitat preferences. Those species which have a wide-spread county distribution could occur in other counties not on the list. In some cases, the range of the species can be interpreted from the list. For example, Adder's Tongue found in Washington and St. Louis counties would most likely occur north of the metropolitan area or under micro-climatic conditions similar to the northern regions of the state. This interpretation of distribution may not always be presumed, however, since some of these species are very localized and dependent on specific habitat conditions.

TABLE 16–3

PLANTS RARE IN MINNESOTA BUT MORE OR LESS ABUNDANT IN ADJACENT REGIONS (43)

PLANTS	COUNTIES FOUND IN
Adder's Tongue, Ophioglossum valgatum var. pseudopodum Peaty on grassy swales, shores, damp sand	Washington St. Louis
American Marsh Pennywort, Hydrocotyle americana Meadows and damp woods	Washington Chisago Houston
Auricled Gerardia, Gerardia auriculata Prairies and open woods	Dakota Blue Earth Nicollet
Besseya, Besseya bullii Prairies and bluffs	Dakota, Hennepin, Ramsey, Scott, Washington, Goodhue
Biennial Gaura, Gaura biennis Damp Shores and Meadows	Hennepin Houston
Bright Green Naiad, Najas olivacea Submerged Aquatic	Anoka Ramsey
Chickweed, Stellaria alsine Springs, rills, and wet areas	Ramsey Winona
Cockspur Grass, Echinocloa walteri Marshes, swamps, and shallow water	Washington Wabasha
Blackberry, Rubus folioflorus Dry sand or gravel	Ramsey Washington St. Louis
Blackberry, Rubus latifoliolus Borders of woods	Ramsey Isanti
Blackberry (Rosendahl's Blackberry), Rubus rosendahlii Sandy Soils	Ramsey
Blackberry, Rubus semisetosus Meadows and Swampy thickets	Anoka Ramsey
Cut-leaved Evening Primrose, Oenothera laciniata Sandy open ground	Anoka
False Foxglove, Aureolaria pedicularia Dry hardwoods and clearings	Hennepin Washington Houston
Frostweed, Helianthemum canadeuse Dry sandy soils on bluffs, clearings or open woods	Washington, Fillmore Houston, Winona

PLANTS	COUNTIES FOUND IN
Gattinger's Gerardia, *Gerardia gattingeri* Open woods, slopes, and barrens	Washington, Nicollet Wabasha, Winona
Ginseng, *Panex quinquefolius* Nearly exterminated in Minnesota by herb hunters	Once widespread from Houston to Jackson to Mille Lacs to Washington
Golden Coreopsis, *Coreopsis tinctoria* Low-lying areas	Hennepin Ramsey, Blue Earth
Grass-leaved Arrowhead, *Sagittaria graminea* Wet sand and mud or shallow water	Ramsey, Washington St. Louis
Sedge, *Carex debilis var. rudgei* Open woods, thickets, and meadows	Anoka
Grass-leaved Rush, *Juncus marginatus* Wetlands, peaty soils	Anoka
Green Dragon (Jack-in-the-pulpit), *Arisaema dracontium*	Dakota, Houston, Winona
Jointed Rush, *Juncus articulatus* Wetlands	Ramsey
Large Purple Gerardia, *Gerardia purpurea* Damp, acid soils	Hennepin
Low Nut Rush, *Scleria verticillata* Bogs, shores, wet rocks	Dakota, Hennepin Scott, Blue Earth
Narrow-leaved Vervain, *Verbena simplex* Dry or sandy soil	Scott, Fillmore
Prairie Froelichia, *Froelichia floridana* Sandy soils	Anoka Blue Earth
Rafinesque's Pondweed, *Potamogeton diversifolius* Submerged aquatic	Anoka Ramsey
Rattlepod, *Astragalus ceramicus*	Ramsey
Sedge, *Carex debilis var. rudgei* Open woods, thickets, and meadows	Anoka
Sedge, *Carex formosa* Woods, thickets, and meadows	Ramsey
Sedge, *Carex plantaginea* Moist woods	Hennepin Winona

PLANTS	COUNTIES FOUND IN
Sessile-flowered Cress, Rorippa sessiliflora Muddy or sandy bottoms, river flats, and wet places	Carver Goodhue
Slender-leaved Sundew, Drosera linearis Bogs, wet shores	Hennepin
Slender Yellow-eyed Grass, Xyris torta Damp peaty areas and shores	Anoka Hennepin
Smartweed Dodder, Cruscutu polygonorum Low-lying areas	Hennepin Freeborn
Smooth Rock Cress, Arabis laevigata Woods and slopes, shaded ridges	Hennepin, Clearwater Todd, Houston
Swamp Loosestrife, Decodon verticillatus Swamps and shallow ponds	Anoka, Hennepin Chisago
Sullivant's Milkweed, Asclepias sullivantii Rich low grounds and prairies	Scott, Blue Earth Crow Wing, Martin
Tall Nut Rush, Scleria triglomerata Thin woods and openings	Anoka, Hennepin Ramsey
Water Bog Rush, Cladium mariscoides Swamp, marshes, and sandy shores	Scott, Clearwater Lake, Pine
Western Venus' Looking Glass, Specularia leptocarpa	Ramsey
Yellow Bartonia, Bartonia virginica Wet, acid areas	

The status of metropolitan area animal species is variable. The United States Fish and Wildlife Service has identified the habitat distributions of rare and endangered species, as shown on Table 16-4.

TABLE 16–4

RARE AND THREATENED SPECIES IN THE METROPOLITAN AREA AND HABITAT DISTRIBUTIONS

SPECIES	WATER	SHORE	FOREST	FOREST-PRAIRIE EDGE	PRAIRIE	MIXED
AMPHIBIANS						
Blue-spotted Salamander	X		X			X
Four-toed Salamander	X		X			X
Newt	X		X			X
Spring Peeper	X		X		X	X
Green Frog	X					X
Mink Frog	X		X			X
REPTILES						
Water Snake	X	X				
Eastern Hog-nosed Snake						X
Western Hog-nosed Snake					X	
Blue Racer			X			
Wood Turtle	X	X	X			
Map Turtle	X	X				
False Map Turtle	X	X				
Blanding's Turtle	X	X				
Smooth Softshell Turtle	X	X				
Spiny Softshell Turtle	X	X				
Six-lined Race Runner	(Dry Bluffs)					
BIRDS						
Common Loon	X	X				
Red-necked Grebe	X					
Black-crowned Night Heron	X	X	X			
Yellow-crowned Night Heron	X	X	X			
King Rail	X	X				
Common Gallinule	X	X				
Wilson's Phalarope	X	X				
Forester's Tern	X					
Black Duck	X	X				
Redhead	X					
Ring-necked Duck	X					
Canvasback	X					

SPECIES	WATER	SHORE	FOREST	FOREST-PRAIRIE EDGE	PRAIRIE	MIXED
Ruddy Duck	X					
Red-shouldered Hawk			X	X		
Swainson's Hawk			X	X	X	X
Ruffed Grouse			X	X		X
Western Kingbird				X		
Tufted Titmouse			X			
Red-breasted Nuthatch			X			
Brown Creeper			X			
Winter Wren			X			
Bewick's Wren			X			
Carolina Wren			X			
Blue Gray Gnatcatcher			X			
Golden-crowned Kinglet			X			
Bell's Vireo				X		
Black and White Warbler			X			
Prothonotary Warbler		X				
Golden-winged Warbler				X		
Blue-winged Warbler				X		
Nashville Warbler			X			
Chestnut-sided Warbler				X		
Louisiana Waterthrush		X	X			
Mourning Warbler			X			
Orchard Oriole			X	X		
White-throated Sparrow			X			
MAMMALS						
Common Mole						X
Star-nosed Mole	X	X				X
Arctic Shrew			X	X		X
Water Shrew	X	X				X
Pigmy Shrew			X			
Pipistral			X			
Snowshoe Hare						X
Northern Flying Squirrel			X			
Pocket Mouse					X	
Prairie Vole				X	X	
Porcupine			X			
Black Bear			X			X

Attempts at reintroduction of the Trumpter Swan are occurring to establish a free-flying population in the study area. The first release of paired adults, originally imported from Montana, occurred in 1976. During the warmer months, wing-clipped birds are kept at Carver Park Reserve, Lake Rebecca Park Reserve, Morris T. Baker Park Reserve, Crow-Hassen Park Reserve and Wood Lake Nature Center. Ultimate success of the trumpter swan's introduction strongly depends upon the attitude and actions of the public (35).

The endangered Peregrine Falcon was a breeding bird in Goodhue County and elsewhere along the eastern boundary of Minnesota. Efforts are currently being made by the United States Fish and Wildlife Service, University of Minnesota, and others to re-establish the species there. Since a major part of its population decline has been the result of DDT use, the success or failure of this reintroduction project will probably depend on correction of long-term pollution problems.

Predators and scavengers at the top of the food chain, like the Bald Eagle have also been affected by DDT use. Since this species subsists largely on lower organisms such as dead fish which have accumulated large stores of DDT in their tissues, it is especially vulnerable to pollution materials coming from the metropolitan area. Its hunting territory includes the unfrozen sections of the Mississippi River during the winter.

The heron and egrets are species at the top of the food chain that still occur here as relatively successful breeding species. The four breeding colonies are located on Figure 16-11. Since their food consists of water animals and is obtained from several hundred square kilometers surrounding colony sites, these herons (and others outside the area) utilize aquatic food resources from the entire seven county region.

There is little quantitative data on fish losses from the metropolitan area, but they have been considerable. Until the entire spectrum of water quality improves, no increase in species composition of any of the aquatic animals and plants can be expected.

It is, therefore, apparent that man's impact on the environment, especially on the water, will in some way affect many of these species.

Several tree species found in the metropolitan area merit special consideration though none are endangered or threatened. Four species are considered to be at the northern edge of their range (46):

Black Walnut, Juglans nigra	Rich, moist soils
Kentucky Coffee Tree, Gymnochadus dioicens	Rich soil, mostly river bottoms
Chestnut Oak, Quercus muehlengergii	
Swamp White Oak, Quercus bicolor	

Three species are relics of the past and are common to the cooler moderately wet woods.

Red Pine, Pinus resinosa	Cool, dry or mesic woods
White Pine, Pinus strobus	Cool, mesic woods
Yellow Birch, Betula alleghaniensis	Moist, cool woods

FIGURE 16–11 HERON AND EGRET ROOKERIES AND FEEDING RANGES APRIL–SEPTEMBER

BY LATE JULY 10,000 (EST.) ADULT SIZED HERONS AND EGRETS ARE FEEDING HERE.

SOURCE: Personal Observation, Dwain Warner

REFERENCES

1. A Biological Reconnaissance of the Upper Mississippi River, St. Cloud to Fridley. J. W. Enblom. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Ecological Services. Special Publication No. 121. September 1977. A survey of the physical, chemical, and biological characteristics of designated river segment, with emphasis on fishing, and a section on present and potential uses of the river. Useful tables include lists of tributaries, fish species composition, and length-frequency distribution of fish. (A preliminary report subject to revision). (Available: DNR)

2. Biological Survey of the Crow and North Fork of the Crow River. Minnesota Department of Natural Resources Division of Fish and Wildlife Ecological Section. Special Publication No. 123. July 1977. Comprehensive survey. Includes a listing of streams tributary to the Crow River in Wright and Hennepin Counties. Preliminary draft - subject to revision. (Available: DNR)

3. Birds of the Minneapolis-St. Paul Region, Combined Field Check List and Migration Chart. A. W. Dodge, H. F. Fullerton, W. J. Breckenridge and D. W. Warner. Minnesota Museum of Natural History. University of Minnesota Press. 1966. 28 pp. Bird list, habitat key, map of metro area and migration charts of all bird species reported in metro area. (Available: U of M Lib.)

4. Breeding Ecology of the Twin Cities, Minnesota, Metropolitan Canada Geese. R. D. Sayler. M. S. Thesis, University of Minnesota. 1977. Most recent information on an increasingly important metropolitan breeding bird. Includes figures and tables on dates of nest initiation and hatch, nest site types, nesting fate and nest success by flock. (Available: U of M Lib.)

5. A Catalog of the Flora of Cedar Creek Natural History Area. Anoka and Isanti Counties, Minnesota. J. W. Moore. Bell Museum of Natural History Occas. Papers No. 12. 1973. 28 pp. Lists scientific and common names of 761 taxa of vascular plants occurring in the southern-most bog area of Minnesota. (Available: U of M Lib.)

6. Distribution of Aquatic Mollusks in Minnesota. C. Dawley. American Midland Naturalist 38: 671-97. 1947. General survey of fresh water mussels and snails in Minnesota in relation to river drainage systems, based on shell collection, Dept. of Ecology, University of Minnesota. (Available: U of M Lib.)

7. The Distribution of Minnesota Minnows and Darters in Relation to Pleistocene Geology. J. C. Underhill. Occasional Papers. No. 7. Minnesota Museum of Natural History. 45 pp. University of Minnesota Press. 1957. Contains geographical description of watersheds in Minnesota; dispersal route and land barriers to fish migration; annoted list of minnows and darters with distribution maps (may be somewhat out-dated in metro area). (Available: U of M Lib.)

8. Distribution, Relative Abundance, and Species Richness of Small Mammals in Minnesota, With an Analysis of Some Structural Characteristics of Habitats as Factors Influencing Species Richness. O. T. Kalin. Ph. D. Thesis, University of Minnesota. 1976. 160 pp. A comprehensive study of small mammals in 14 habitats within 4 major vegetation zones in Minnesota - based on data from 485 sampling sites. Includes species - abundance histograms for major habitats. (Available: U of M Lib.)

9. The Distribution of the Turtles of Minnesota. C. H. Ernst. Journal of Herpetology 7 (1): 42-47. 1973. Lists localities and specimen collection numbers of eight species of turtles occurring in Minnesota. Distribution maps. (Available: U of M Lib.)

10. Distribution and Variation of the Catostomidae of Minnesota. Bell Museum of Natural History, University of Minnesota. Occasional Papers: 10, 1971. 45 pp. Distribution of 15 species of fish of the Family Catostomidae are discussed, keyed, and mapped. (Available: U of M Lib.)

11. Ducks and Land Use in Minnesota. Minnesota Department of Conservation, Division of Game and Fish. Technical Bulletin No. 8. 1964. 140 pp. Report of the findings from four studies on waterfowl and land use. Discusses factors affecting waterfowl production in Minnesota and those which must be considered in the wetland management program. (Available: DNR)

12. An Ecological Study of the Twin Cities Metropolitan Area. Wallace, McHarg, Roberts and Todd. 1969. Original maps are available at Metropolitan Council's Map Library. Contact Person: Bill Schneider. 1 set of maps, not reproducible other than by slides or redrafting. The report should be a valuable data base for study, particularly in those areas which are less subject to change over short periods of time. (Available: MC Lib.)

13. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Minnesota River Pool. North Star Research Institute, Minneapolis, Minnesota. 1973. The document is one volume of an extensive detailed environmental study of the Major River Valleys in the Twin Cities Area. Water Quality, river use, aquatic and terrestrial life and other physical resource data is detailed in this report. The book should be a valuable aid to many of the project tasks. (Available: CE)

14. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 1. North Star Research Institute, Minneapolis, Minn. 1973. Contains much of the same type of information as others in the series. Emphasis is on area of river between Ford plant or Old Soldiers home and approximately 6 miles downstream (miles 853.3 to 847.6). Good recent information on River Corridor. (Available: CE)

15. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 2. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area of river near Hastings, Minn. (mile 847.6 to 815.3) Good recent information on river corridor. (Available: CE)

16. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 3. North Star Research Institute, Minneapolis, Minnesota 1973. Contains much of same type of information as others in the series. Emphasis is on area between Lock and Dam No. 2 and Lock and Dam No. 3 which includes many wing-dams and bank revetments (miles 796.6 through 815.2). Good recent information on river corridor. (Available: CE)

17. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. St. Croix River Pool. North Star Research Institute, Minneapolis, Minnesota 1973. Contains much of the same type of information as others in the series. Emphasis is on the St. Croix River Valley. The data is up-to-date and provides information for river corridor studies. (Available: CE)

18. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Upper and Lower St. Anthony Falls Pool. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area near St. Anthony Falls. Good recent information on river corridor. (Available: CE)

19. Environmental Monitoring and Ecological Studies Program Annual Report. Allen S. King Generating Plant, Oak Park Heights. Northern States Power Company. 1975. Tenth consecutive report on air and water monitoring and ecological studies of area surrounding Allen S. King Plant. Tables and species lists. (Available: DNR)

20. Environmental Monitoring and Ecological Studies Program. Northern States Power Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota. Volume I. 1976. Results of NSP's seventh consecutive reporting of environmental monitoring studies contained in this detailed two volume publication. (Available: DNR)

21. Environmental Monitoring and Ecological Studies Program. Northern States Power Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota. Volume II. 1976. Results of NSP's seventh consecutive reporting of environmental monitoring studies contained in this detailed two volume publication. (Available DNR)

22. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. R. Conant. Houghton Mifflin Co., Boston. 1975. 429 pp. General field guide with colored illustration and distribution maps. (Available: U of M Lib.)

23. Final Environmental Impact Statement. Flood Control at Minnesota River, Chaska, Minnesota. U. S. Army Corps of Engineers. 1975. Proposed plan for flood control - habitat descriptions and maps included. (Available: CE)

24. Final Environmental Impact Statement, Operation and Maintenance 9-foot Navigation Channel Upper Mississippi River, Head of Navigation to Guttenberg, Iowa. Volume I and Volume II. U. S. Army Corps of Engineers, St. Paul District, August 1974. In two separately bound volumes: Volume I contains narrative body of impact statement and Volume II contains exhibits such as maps, tables, figures and letters referred to in the narrative. (Available: CE)

25. Final Environmental Impact Statement, Pig's Eye Coal Terminal, Mississippi River at St. Paul. Ramsey County, Minnesota. St. Paul District Corps of Engineers. February 1974. 272 pp. EIS on the proposed use of Pig's Eye Lake and surrounding area for trans-shipment and storage of low-sulphur coal. (Available: CE)

26. The Fish Fauna of the Mississippi River above St. Anthony Falls as Related to the Effectiveness of this Falls as a Migration Barrier. S. Eddy, J. Moyle and J. Underhill. Minn. Acad. Sci. Pro. 30 (2): 111-115. 1963. History of St. Anthony Falls, theories as to its barrier history, fish migration and listing of fish species occurring above and below falls. (Available: U of M Lib.)

27. Freshwater Wetlands and Sewage Effluent Disposal, Symposium. University of Michigan Wetlands Ecosystem Research Group, Ann Arbor, Michigan. May 1976. A symposium on the feasibility of utilizing freshwater wetland ecosystems to remove certain chemicals from secondarily treated wastewaters before they enter lakes, streams, and groundwaters. (Available: U of M Lib.)

28. Game Lake Survey of Gun Club Lake, Dakota County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. Several pages of concentrated, all-inclusive information, e.g., location, physical, and chemical characteristics, measurements, drainage, shoreline, flora and fauna, utilization and management. (Available: DNR)

29. Game Lake Survey of Nine Mile Lake, Hennepin County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. Several pages of concentrated, all-inclusive information, e.g., location, physical, and chemical characteristics, measurements, drainage, shoreline, flora and fauna, utilization, management and maps. (Available: DNR)

30. A Guide to Minnesota Environmental Education Areas. Mn/DNR, Bureau of I & E. Nov. 1972. 110 pp. This booklet contains a listing, description and ownership of environmental learning centers, nature centers, and refuges by county. This should be helpful in location of sensitive plant and animal areas. (Available: DNR)

31. Habitat Evaluation Procedures. U. S. Fish and Wildlife Service, Division of Ecological Services. 1976. A modification of a system developed by the Missouri Department of Conservation and the Soil Conservation Service (Daniel and Lamaire 1974). (Available: USFWS Lib.)

32. A Handbook for Habitat Evaluation Procedures. U. S. Department of the Interior, Fish and Wildlife Service. Resource Publ. No. 132. Washington, D. C. 1977. To be used in conjunction with U. S. Fish and Wildlife Habitat Evaluation Procedures (HEP) 1976 as an aid in developing handbooks for other areas. Habitat unit value calculations provide quantitative measurements to be used in project planning. (Available: USFWS Lib.)

33. Life History of the Leopard Frog, Rana pipiens, in Minnesota. D. J. Merrell. Bell Museum of Natural History, University of Minnesota. Occasional Papers: Number 15. 1977. 23 pp. Data collected in all seasons on more than 25,000 frogs provides information on all phases of life cycle. (Available: U of M Lib.)

34. The Mammals of Minnesota. H. Gunderson and J. Beer. Occasional Papers, Minnesota Museum of Natural History. 1953. 190 pp. Systematic listing and descriptions of Minnesota mammals. Distribution maps for some species may be somewhat out-dated. (Available: U of M Lib.)

35. Minneapolis-St. Paul Area Level B. Study-Upper Mississippi River Basin Commission. Fish and Wildlife Technical Report. Prepared by U. S. Fish and Wildlife Service for the Fish and Wildlife Task Group. December 1976. A detailed description and inventory of fish and wildlife resources in the metropolitan area including populations habitats and uses. Identification of problems and recommendations to resolve them are included. Good maps, references, and species lists. (Available: USFWS Lib.)

36. Minnesota Birds -- Where, When and How Many. J. C. Green and R. B. Janssen. University of Minnesota Press, Minneapolis. 1975. Excellent recently published reference detailing distribution, migration, and estimates of abundance of Minnesota birds. Useful distribution maps. (Available: U of M Lib.)

37. Monticello Nuclear Generating Plant, Monticello, Minnesota. Environmental Monitoring and Ecological Studies Program, Annual Report. NSP. 1976. Ninth consecutive report of environmental studies on water, algae, macroinvertebrates, and fish in the area of Monticello Nuclear Generating Plant. Much quantitative data; maps and species lists. (Available: DNR)

38. Natural and Historic Areas of Minnesota. Mn/DNR. Bureau of Planning. September 1971. 72 pp. An updated listing and mapping source of Project 80 inventory data. Additional information was added from Minnesota Historical Society and Nature Conservancy data. Information is provided by economic region. This should be a strong base for historical, cultural and natural inventory data. (Available: DNR)

39. Northern Fishes—With Special Reference to the Upper Mississippi Valley. S. Eddy and J. C. Underhill. University of Minnesota Press, Minneapolis. 3rd Edition. 1974. 414 pp. Contains descriptions by families, line drawings of fish, and map of major drainage basins and stream systems in Minnesota. No distribution maps. (Available: U of M Lib.)

40. Northern States Power Company's Proposed Units 3 and 4 Sherco Steam Electric Station. Environmental Impact Statement (Draft). Minnesota Pollution Control Agency. July, 1977. A recent EIS on proposed expansion of Sherco facility to include additional pair of generating units, cooling water systems, pollution control systems, raw materials handling equipment, and expansion of solid waste disposal area. Good maps. (Available: DNR, PCA)

41. Polychlorinated Biphenyls (PCBs) in the Upper Mississippi River Basin. Minnesota-Wisconsin PCB Interagency Task Force. 1976. Results and conclusions of extensive water and sediment sampling of upper Mississippi River Basin and tributaries. (Available: USFWS Lib.)

42. Rare and Endangered Plants and Animals in the Twin Cities Metropolitan Area. Metropolitan Council. November 7, 1973. A 90 page (plus Appendix). Third Draft of a detailed study identifying and discussing rare and endangered species of the metropolitan area and the plant communities necessary for their survival.

43. Rare or Endangered Plants of Minnesota with Counties in Which They Have Been Found. T. Moreley. Department of Botany, University of Minnesota. 1972. 4 pp. May be useful as a measure of relative abundance between metropolitan area counties and other counties. Mimeographed and unpublished. (Available: U of M Bot)

44. Reptiles and Amphibians of Minnesota. W. J. Breckenridge. Minnesota Museum of Natural History. University of Minnesota Press. 1958. Includes detailed descriptions, photographs and useful distribution maps (may be outdated in some areas). (Available: U of M Lib.)

45. A Special Fisheries Survey of a Portion of the Mississippi River below the Coon Rapids Dam. D. Shodeen. Minnesota Conservation Department Special Publ. No. 98. 1965. A survey to determine the present fish population and fish habitat to evaluate a proposed removal of river-bed gravel deposits. (Available: DNR)

46. The Uncommon Ones: Animals and Plants Which Merit Special Consideration and Management. J. B. Moyle. Minnesota Department of Natural Resources. 1975. 32 pp. This booklet provides information on rare and endangered plant and animal species. It also includes information on other species which merit special consideration or management. Value to detailed studies somewhat limited since much of the habitat information is very general. (Available: DNR)

47. Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June, 1974. 77 pp. A very detailed listing of plants, animals (includes reptiles and amphibians) with descriptions of where species are most likely to be found, type of protection and recommendations for management. (Available: MC Lib.)

48. Upper Mississippi River Comprehensive Basin Study. UMRCBS Coordinating Committee. 1972. Volume I, the main report, summarizes the finding of the 17 supporting appendices. Included is geographical, water, navigation, recreation, fish and wildlife resources. (Available: USFWS Lib.)

49. Waterfowl in Minnesota. F. B. Lee. Minnesota Department of Conservation, Division of Game and Fish. Technical Bulletin No. 7. 1964. Descriptions, ranges, and food habits; status as game birds. Includes maps of breeding ranges and band recoveries of some species. (Available: DNR)

50. Woodlands, Plantations and Shade Trees in the Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June 1974. 77 pp. The document contains information on woodland cover types from pre-settlement times to the present. Relationship to soils and topography is presented. Effects on noise abatement, hydrology and climatic modification are discussed. Also contains copy of Kuchler's potential veg. map. (Available: MC Lib)

ADDITIONAL REFERENCES

51. Ecological Changes on the Upper Mississippi River Wildlife and Fish Refuge since Inception of the 9-foot Channel. W. Green. U. S. Dept. of Int., Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Minneapolis. Unpublished mimeograph. 15 pp. 1960. (Available: USFWS Lib)

52. The Effects of Synthetic Detergents on the Early Life History of the Bluegill, Lepomis macrochirus (Rafinesque), in the Upper Mississippi River. 1968. Unpublished PhD Thesis University of Minnesota. K. E. F. Hokanson. (Available: U of M Lib.)

53. Endangered and Threatened Wildlife and Plants. Federal Register 41. 1976. (Available: USFWS Lib)

54. Fish and Wildlife Resources. Fish and Wildlife Service, U. S. Dept. of Interior. In Upper Mississippi River Comprehensive Basin Study. UMRCBS Coordinating Committee, Chicago. Appendix L. 103 pp. 1970. (Available: USFWS Lib)

55. Invertebrate Drift in the Mississippi River over a Five-Day Period Near Becker, Minnesota. D. R. Wefring. M. A. Thesis (Unpublished). St. Cloud State University, St. Cloud State University, St. Cloud, Minnesota. 1976. (Available: St C S Lib)

56. Minnesota Animals and Plants in Need of Special Consideration, with Suggestions for Management. Minnesota Department of Natural Resources, Special Publication No. 104. 1974. (Available: DNR)

57. Proposed Modification of Endangered Status in Continuous 48 States. Federal Register 41 (134): 28525-28527. 1976a. (Available: USFWS Lib)

58. Rare and Endangered Fish and Wildlife of the United States. U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. Resource Publ. 34. July 1966. (Available: USFWS Lib)

59. Rare and Endangered Freshwater Mollusks of the Mississippi and St. Lawrence River Systems of North America. D. Stansberg, 1970. In M. Imlay, Our rivers -- deathbeds for endangered species. Minn. Volunteer 35 (201): 31-39. 1972. (Available: DNR)

60. Rare and Endangered Mollusks (Naiads) of the U. S. Bureau of Sport Fisheries and Wildlife, Region 3. S. E. Jorgensen and R. W. Sharp. 1971. (Available: USFWS Lib)

61. Revision of July 27, 1973 of the March 1973 Threatened Wildlife of the U.S. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Office of Endangered Species. Appendix C. 5 pp. 1973b. (Available: USFWS Lib.)

62. Seasonal Variations of Invertebrate Drift in the Mississippi River Below the NSP Sherburne County Generating Plant, Becker, Minnesota. Zimmerman, _______, and A. J. Hopwood. Prepared for Sherburne County Generating Plant Ecological Studies Program. 1975. (Available: DNR)

63. A Study of the Pig's Eye Lake Heron Colonies. A. M. Adams, et al. The Loon, Vol. 45, No. 2. 1973. (Available: U of M Lib)

64. Threatened Wildlife of the U. S. Bureau of Sport Fisheries and Wildlife. Resource Publ. 114. U. S. Dept. of the Interior. Office of Endangered Species and International Activities. 289 pp. 1973a. (Available: USFWS Lib)

65. United States List of Endangered Fauna. U. S. Fish and Wildlife Service, U. S. Dept. of Int. Washington, D. C. 1974. 22 pp. (Available: USFWS Lib)

66. The Upper Mississippi: A Wild and Scenic River Study, Environmental Impact Statement. Bureau of Outdoor Recreation, U. S. Dept. of Int., Aug. 1976. (Available: USFWS Lib)

67. Wildlife Habitat Change and Seasonal Cultivation. D. A. Brown, et al. Minnesota State Planning Agency. 1975. 7 pp. (Available: DNR)

KEY

Limnological Research Center University of Minnesota	LRC
Dr. Dwain W. Warner Bell Museum of Natural History University of Minnesota, Minneapolis	DWW
Environmental Conservation of Minnesota	ECOL
Macalester College Library St. Paul, Minnesota	Mac C Lib
Mankato State College Mankato, Minnesota	MSC
Metropolitan Mosquito Control Commission	MMCC
Environmental Quality Council	EQC
Citizen's League 84 South 6th Street Minneapolis, Minnesota 55402	CL
University of Minnesota Agricultural Extension Service Bulletin Room Coffey Hall St. Paul, Minnesota	U of M Ag Ext
University of Minnesota Agricultural Experiment Station	U of M Ag Exp Sta
Hickok and Associates	HA

University of Minnesota Department of Entomology, Fisheries and Wildlife	Ent, F, W
U. S. Fish and Wildlife Library, Regional Office, Federal Building Fort Snelling, Minneapolis, Mn.	USFWS Lib
University of Minnesota, Library Minneapolis, Minnesota	U of M Lib
St. Cloud State University Library St. Cloud, Minnesota	St. C S Lib
Minnesota Department of Natural Resources	DNR
Pollution Control Agency	PCA
University of Minnesota Department of Botany	U of M Bot
Metropolitan Council Library	MC Lib
St. Paul District Corps of Engineers	CE

CONTACTS

Dr. Dale Chelberg. Curator of Biology	Science Museum of Minnesota, St. Paul
Dr. James Cooper, Assistant Professor	Department of Entomology, Fisheries and Wildlife, University of Minnesota, St. Paul
Mr. Oliver Jarvenpa, Chief	Ecological Services Section, Minnesota Department of Natural Resources, St. Paul
Lloyd Knutson, Area Game Manager for Metropolitan Area	Carlos Avery Wildlife Management Area, Minnesota Department of Natural Resources
Howard Krosch, Coordinator	Monitoring and Control Unit, Ecological Services Section, Minnesota Department of Natural Resources, St. Paul
Ethan Ruben, Biologist	Environmental Resources Branch, Army Corps of Engineers, St. Paul
Dr. Joseph Shapiro, Professor and Associate Director	Limnological Research Center, University of Minnesota
Duane Shodeen, Regional Fisheries Manager for Metropolitan Area	Minnesota Department of Natural Resources, St. Paul
James F. Smith, Natural Resource Ecologist	Ecological Services Section, U. S. Fish and Wildlife Service, St.Paul
Dr. Thomas Waters, Professor	Department of Entomology, Fisheries and Wildlife, University of Minnesota, St. Paul
Dr. Milton Weller, Professor and Head	Department of Entomology, Fisheries and Wildlife, University of Minnesota, St. Paul

Pest animals and plants have varying levels of importance - some determined by individual human biochemistry, some by opinion, others by differing levels of economic, aesthetic and health aspects. See Table 17-1 - Importance and Distribution of Pest Species in the Metropolitan Area.

TABLE 17–1 IMPORTANCE AND DISTRIBUTION OF PEST SPECIES IN THE METROPOLITAN AREA

	PEST	DISTRIBUTION	IMPORTANCE TO WASTE CONTROL PRACTICES
FUNGI	Dutch Elm Disease	Widespread	yes
	Oak Wilt	Widespread	yes
BACTERIA	Botulism	Widespread	yes
PLANTS	Algae "Blooms", toxic, odorous	Widespread	yes
	Flowering plants		
	Allergenic	Widespread	some
	Toxic	Widespread	some
ANIMALS	Fluke		
	Swimmer's Itch	Widespread	yes
	Ticks and Mites		
	(Chiggers)	Widespread	no
	Insects		
	Mosquitos	Widespread	yes
	Elm-bark Beetles	Widespread	yes
	Fish		
	Carp	Widespread	yes
	Birds		
	Pigeon	Widespread	minor
	Starling	Widespread	minor
	English Sparrow	Widespread	minor
	Blackbird Group	Widespread	minor
	Gulls and Waterfowl	Airport	yes
	Mammals		
	Norway Rat	Widespread	yes

SOURCE: Dr. Dwain Warner, 1977.

FUNGI

FUNGUS OF DUTCH ELM DISEASE

The fungus, Ceratocystis ulmi, is the cause of Dutch Elm Disease. Although fungus spores are carried and inoculated into healthy elms by elm-bark beetles (see animal pests), the fungus can spread rapidly from tree to tree through natural root grafts resulting from the practice of closely planting elms near urban environments. For many years, the metropolitan urban and rural environment will change due to elm removal, disposal, and tree replacement. Disposal problems will continue as a major physical and economic problem. The total impact of this loss is immeasurable.

FUNGUS OF OAK WILT

With an estimated nine million oaks in the metropolitan area - twice the number of elms - the threatened loss due to the fungus Ceratocystis fagacearum is major, especially in the suburban areas.

BACTERIA

BOTULISM – CAUSED BY CLOSTRIDIUM BOTULINUS (TYPES)

Although not of current importance as a mortality factor among waterfowl here, an increase in the number and use of ponding areas that are likely to be high in nutrients from runoff, may cause overgrowth of algae, oxygen depletion, and favorable conditions for this anaerobic bacterium.

PLANTS

ALGAE

Algae occur as pests in three forms: (1) mid-to late summer "blooms", unsightly to some people, (2) odor-causing organisms in human water supplies, and (3) producers of highly toxic chemicals.

Algal blooms and an abundance of larger aquatic plants (submerged, emergent and floating) are the result of such parameters as light, temperature, and nutrients in particular. Increased nutrient content of waters in the metropolitan area are the result of runoff from land, both urban and agricultural, and are largely human-produced. While an abundance of these plants may be classed as pests by some people, they are also indicators of a rich ecosystem. Until eutrophication occurs, these aquatic habitats are very productive of waterfowl and other wildlife. This is true for a number of the Metropolitan Waste Control Commission ponding areas in Hennepin County.

Odor-causing algae such as Chara or Marsh grass, and blue-greens are a problem during drought periods when reservoirs are low.

Toxins produced by some blue-green algae species are an occasional problem in the metropolitan area. Pets which drank water in 1973 from Bone Lake (Washington County) were killed. This occurred during the "dog days" of summer when algae growth was promoted. The cause of the problem may be due to favorable growing conditions from the long retention of nutrients in lake basins or due to high nutrient inputs from urban runoff or agricultural non-point sources. This problem may become more severe if no action is taken to reduce the discharge of non-point sources and control urban runoff.

PLANTS PRODUCING ALLERGIC REACTIONS

Ragweed and other species constitute a major seasonal discomfort or even a serious health hazard to some humans. Ragweed is the dominant pioneer species on disturbed soils such as those created by diking, ponding and other activities involved in water and waste control.

Poison ivy and poison oak are also included. These pest plants, occurring nearly everywhere from flood plains to dry sandy soils, are not of major importance except to humans who are especially sensitive to them. Control may be necessary at beach and park sites.

ANIMALS

Swimmer's Itch is caused by the larval stage of the blood-fluke Schistosoma dermatitis. Humans are only accidental subjects for skin penetration. The normal life cycle takes place in aquatic snails and birds, especially ducks. Outbreaks, unpredictable for lack of monitoring, may occur in any of the waters that support snail and vertebrate host populations. Snail hosts are difficult to control by chemicals without affecting fish and other wildlife. This problem is primarily applicable to public swimming beach lakes.

TICKS AND MITES (CHIGGERS)

The few species here as pests during spring and early summer are inhabitants of grassy areas. They are potential disease carriers but at the present time are a minor pest.

INSECTS

Of the 50 species of mosquitos in the metropolitan area, ten account for about 97 percent of the total numbers. One species, Aedes vexans, constitutes 52 percent of all collections.

The 54,000 breeding sites total 200,000 acres in the metropolitan area; 60 percent of the mosquito populations originate in pothole depressions. These depressions, even those dry in summer, serve multiple important biological functions such as habitat for fairy shrimp and courtship for ducks. They are also important stormwater sites for the Metropolitan Waste Control Commission.

Humans and domestic animals are subject to infection of encephalitus viruses (humans and horses) and filarial heartworm (dogs). All of these are serious diseases and effective methods of mosquito control must be constantly advanced and coordinated with the Metropolitan Waste Control Commission program to prevent amplification of mosquito transmitted diseases in the ecosystem. This is especially important since about 50 percent of mosquito-producing sites coincide with residential areas of about three-fourths of the metropolitan population (27).

The elm-bark beetles (Scolytus multistriatus and Hylurgopinus rufipes) are the principal species that transport the Dutch Elm Disease fungus from site to site.

FISH

Carp are major competitors to other fish and survive in poorer quality waters. By plowing the bottom, carp cause siltation of the eggs of other species and destroy cover that could be used by young fish. As carp strain food from the bottom muds, they increase turbidity and destroy vegetation and substrate in nearly all rivers, lakes and large marshes. At the same time, carp are a potential economic resource tht has not been thoroughly explored. In the metropolitan area, there has been very little carp removal. Small carp from Lake Byllesby (Dakota County) have been removed, but they were not used for economic purposes. This year, carp will be removed from Lake Minnetonka and Long Lake (both in Hennepin County) for out-of-state human consumption.

BIRDS

The pigeon, starling, and English sparrow - introduced species living in close association with humans - are not currently at severe pest levels. Effective control methods and bird-proof structures have been responsible for this reduction; yet, the starling, by nesting in tree holes, is severely limiting native species such as flickers, bluebirds, squirrels, and white-footed mice.

Blackbirds (red-winged, yellow-headed, grackle, cowbird and starling) currently are not major pests here as they are elsewhere.

With better marsh management, in the proposed Minnesota River Valley Wildlife Refuge and Recreation Area, other park and recreation area, and the Metropolitan Waste Control Commission ponding areas, population increases of marsh-nesting species are anticipated. Urban summer roosts used by grackles, starlings, cowbirds and purple martins have been a considerable pest problem.

Birds, especially gulls and waterfowl, are an increasing hazard to aircraft. Since mechanical devices are not continuous deterrents to the birds, total elimination of attractants is necessary to reduce the hazard. Although proposed ponding areas are necessary for some Metropolitan Waste Control Commission operations, they should be avoided near all airport approaches and low-level flight corridors. Heron rookery locations at Pig's Eye Island, Blue Lake, Elm Creek and Rice Lake are located near airports, and ranges of feeding areas cross aircraft flight corridors near all airports (See Section 16, Figure 16-11 for the areas which herons inhabit). In early spring, Whistling Swans concentrate on the marshes of the lower Minnesota River and are a potential hazard to aircraft.

MAMMALS

Although no longer at high populations throughout urban or rural communities, Norway rats remain an economic and public health threat. The rat has always been associated with "unsanitary" condition; its population levels reflect the degree of efficiency of food storage and waste disposal by humans. Planned waste disposal methods of all types, from ponding area construction to landfill sites, will continue to be important to control this animal.

REFERENCES

1. A Biological Reconnaissance of the Upper Mississippi River, St. Cloud to Fridley. J. W. Enblom. Minnesota Department of Natural Resources, Division of Fish and Wildlife, Ecological Services. Special Publication No. 121. September 1977. A survey of the physical, chemical, and biological characteristics of designated river segment, with emphases on fishing and a section on present and potential uses of the river. Useful tables include lists of tributaries, fish species composition, and length-frequency distribution of fish. A preliminary report subject to revision. (Available: DNR)

2. Biological Survey of the Crow and North Fork of the Crow River. Minnesota Department of Natural Resources Division of Fish and Wildlife Ecological Section. Special Publication No. 123. July 1977. Comprehensive survey. Includes a listing of streams tributary to the Crow River in Wright and Hennepin Counties. Preliminary draft - subject to revision. (Available: DNR)

3. Bird Hazards to Aircraft. Hans Blokpoel. Clarke, Irwin & Company Limited, Canada. 1976. 236 pp. Detailed review of increasingly serious problem of bird - aircraft collision, including the chapter on planning new airports. Includes many references. (Available: U of M Lib.)

4. Control of Aquatic Nuisance Organisms in Minnesota. Minnesota Outdoor Recreation Resources Commission, Report No. 9, St. Paul. 1964. Discusses biology and control of noxious algae, higher plants, "swimmer's itch" flatworm, and leeches. (Available: U of M Lib.)

5. Dutch Elm Disease Projections in Minnesota. R. Shrum and D. French. Agricultural Experiment Station Misc. Rep. 146. University of Minnesota. 1977. Trend of elm tree deaths expected within the next 15 years with and without the use of sanitation methods. Data for disease prediction formulae collected from Minneapolis, St. Paul, Bloomington and Northfield, Minnesota. Illustrated with figures and a table of elm losses and cost projections. (Available: U of M Ag Ext.)

6. An Ecological Study of the Twin Cities Metropolitan Area. Wallace, McHarg, Roberts and Todd. 1969. Original maps are available at Metropolitan Council's Map Library. Contact Person: Bill Schneider. 1 set of maps, not reproducible other than by slides or redrafting. The report should be a valuable data base for study, particularly in those areas which are less subject to change over short periods of time. (Available: MC Lib.)

7. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Minnesota River Pool. North Star Research Institute, Minneapolis, Minnesota. 1973. The document is one volume of an extensive detailed environmental study of the Major River Valleys in the Twin Cities Area. Water Quality, river use, aquatic and terrestrial life and other physical resource data is detailed in this report. The book should be a valuable aid to many of the project tasks. (Available: CE)

8. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 1. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area of Mississippi River between Ford Plant or Old Soldier's home and approximately 6 miles downstream (miles 853.3 to 847.6). Good recent information on River Corridor. (Available: CE)

9. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 2. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area of river near Hastings, Minnesota (mile 847.6 to 815.3). Good recent information on river corridor. (Available: CE)

10. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Pool 3. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area between Lock and Dam No. 2 and Lock and Dam No. 3 which includes many wing-dams and bank revetments (miles 769.9 through 815.2). Good recent information on river corridor. (Available: CE)

11. Environmental Impact Assessment of the Northern Section of the Upper Mississippi River. Upper and Lower St. Anthony Falls Pool. North Star Research Institute, Minneapolis, Minnesota. 1973. Contains much of the same type of information as others in the series. Emphasis is on area near St. Anthony Falls. Good recent information on river corridor. (Available: CE)

12. Environmental Monitoring and Ecological Studies Program Annual Report. Allen S. King Generating Plant, Oak Park Heights. Northern States Power Company. 1975. Tenth consecutive report on air and water monitoring and ecological studies of area surrounding Allen S. King Plant. Tables and species lists. (Available: DNR)

13. Environmental Monitoring and Ecological Studies Program. Northern States Power Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota. Volume 1. 1976. Results of NSP's seventh consecutive reporting of environmental monitoring studies contained in this detailed 2 volume publication. (Available: DNR)

14. Environmental Monitoring and Ecological Studies Program. Northern States Power Annual Report for the Prairie Island Nuclear Generating Plant near Red Wing, Minnesota. Volume 2. 1976. Results of NSP's seventh consecutive reporting of environmental monitoring studies contained in this detailed 2 volume publication. (Available: DNR)

15. Final Environmental Impact Statement, Operation and Maintenance 9-foot Navigation Channel Upper Mississippi River, Head of Navigation to Guttenberg, Iowa. Volume I and Volume II. U. S. Army Corps of Engineers, St. Paul District, August 1974. In two separately bound volumes: Volume I contains narrative body of impact statement and Volume II contains exhibits such as maps, tables, figures and letters referred to in the narrative. (Available: CE)

16. Final Environmental Impact Statement, Pig's Eye Coal Terminal, Mississippi River at St. Paul. Ramsey County, Minnesota. St. Paul District Corps of Engineers. February 1974. 272 pp. EIS on the proposed use of Pig's Eye Lake and surrounding area for trans-shipment and storage of low-sulphur coal. (Available: CE)

17. The Fish Fauna of the Mississippi River above St. Anthony Falls as Related to the Effectiveness of this Falls as a Migration Barrier. S. Eddy, J. Moyle and J. Underhill. Minnesota Academy Sci. Pro. 30 (2): 111-115. 1963. History of St. Anthony Falls, theories as to its barrier history, fish migration and listing of fish species occurring above and below falls. (Available: U of M Lib.)

18. Game Lake Survey of Downs Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August, 1976. Several pages of concentrated, all-inclusive information, with location, physical and chemical characteristics, measurements, drainage, shoreline flora and fauna, utilization and management. Includes maps. (Available: DNR)

19. Game Lake Survey of Eagle Point Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August 1976. (Annotation: See Game Lake Survey of Downs Lake) (Available: DNR)

20. Game Lake Survey of Edith Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. September 1976. (Annotation: See Game Lake Survey of Downs Lakes) (Available: DNR)

21. Game Lake Survey of Gun Club Lake, Dakota County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. Several pages of concentrated, all-inclusive information, e.g., location, physical and chemical characteristics, measurements, drainage, shoreline, flora and fauna, utilization and management. (Available: DNR)

22. Game Lake Survey of Horseshoe Lake, Washington County, Minnesota. Minnesota Division of Game anf Fish, Section of Research and Planning. August, 1976. (Annotation: See Game Lake Survey of Downs Lake) (Available: DNR)

23. Game Lake Survey of Pig's Eye Lake, Ramsey County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August, 1972. (Annotation: See Game Lake Survey of Downs Lake) (Available: DNR)

24. Game Lake Survey of Rice Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. September, 1974. (Annotation: See Game Lake Survey of Downs Lake) (Available: DNR)

25. Game Lake Survey of Snelling Lake, Hennepin County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. July 1975. (Annotation: See Game Lake Survey and Downs Lake) (Available: DNR)

26. Game Lake Survey of Sunfish Lake, Washington County, Minnesota. Minnesota Division of Game and Fish, Section of Research and Planning. August, 1976. (Annotation: See Game Lake Survey of Downs Lake) (Available: DNR)

27. Metropolitan Mosquito Control District Environmental Impact Statement Options for Control to the Year 2000. (Draft) Minnesota Environmental Quality Council, St. Paul, Minnesota. March 1977. 179 pp. Discusses techniques employed by the M.M.C.D. and projections for future control to minimize mosquito annoyance and control disease vectors. (Available: DNR; PCA; EQC)

28. Minneapolis-St. Paul Area Level B. Study - Upper Mississippi River Basin Commission. Fish and Wildlife Technical Report. Prepared by U. S. Fish and Wildlife Service for the Fish and Wildlife Task Group. December 1976. A detailed description and inventory of fish and wildlife resources in the metropolitan area, including populations, habitats and uses. Identification of problems and recommendations to resolve them are included. Good maps, references, and species lists. (Available: USFWS Lib.)

29. Minnesota Birds -- Where, When and How Many. J. C. Green and R. B. Janssen. University of Minnesota Press, Minneapolis. 1975. Excellent recently published reference detailing distribution, migration, and estimates of abundance of Minnesota birds. Useful distribution maps. (Available: U of M Lib.)

30. Monticello Nuclear Generating Plant, Monticello, Minnesota. Environmental Monitoring and Ecological Studies Program, Annual Report. NSP. 1975. Eighth consecutive report of environmental studies on water, algae, macro-invertebrates and fish in the area of Monticello Nuclear Generating Plant. Much quantitative data; maps and species lists. Also contains thesis on primary productivity in Mississippi River near Monticello and food habits of young small-mouth bass. (Available: DNR)

31. Monticello Nuclear Generating Plant, Monticello, Minnesota. Environmental Monitoring and Ecological Studies Program, Annual Report. NSP. 1976. Ninth consecutive report of environmental studies on water, algae, macro-invertebrates, and fish in the area of Monticello Nuclear Generating Plant. Much quantitative data; maps and species lists. (Available: DNR)

32. Oak wilt disease. D. W. French and W. C. Stienstra. Minn. Agric. Exp. Sta. Ext. Folder 310. 1975. 6 pp. Description, symptons, methods of spread and control of oak wilt. Map of Minnesota showing occurrence by counties. Disease symptoms illustrated in color. (Available: U of M Ag Exp Sta)

33. Northern Fishes - with special reference to the Upper-Mississippi Valley. S. Eddy and J. C. Underhill. University of Minnesota Press, Minneapolis. 3rd Ed. 1974. 414 p. Contains descriptions by families, line drawings of fish, and map of major drainage basins and stream systems in Minnesota. No distribution maps. (Available: U of M Lib.)

34. Northern States Power Company's Proposed Units 3 and 4 Sherco Steam Electric Station. Environmental Impact Statement (Draft). Minnesota Pollution Control Agency. July, 1977. A recent EIS on proposed expansion of Sherco facility to include additional pair of generating units, cooling water systems, pollution control systems, raw materials handling equipment, and expansion of solid waste disposal area. Good maps. (Available: DNR; PCA)

35. Pesky Plants. T. Kommedahl, H. G. Johnson. Agricultural Extension Service Bulletin 287, University of Minnesota. 1972. 58 pp. Information on identification, growth habits and control measures for poisonous, irritating and thorny plants. Excellent line drawings. (Available: U of M Ag. Ext.)

36. Pest Control Strategies for the Future. National Academy of Sciences, Washington, D. C. 1972. A symposium which summarizes the present state of knowledge in pest control, analyzes available information in the light of public concern, examines changes in or alternatives to the use of pesticides, and discusses the use of pesticides in conjunction with other pest control methods. (Available: U of M Lib.)

37. Selective Control is the Only Way to Protect Elms. Citizen's League Report, Shade Tree Disease Committee. March 2, 1977. A proposal for neighborhood-city cooperation in controlling Dutch elm disease in high-priority locations within the Twin Cities Metropolitan Area. (Available: CL)

38. Upper Mississippi River Comprehensive Basin Study. UMRCBS Coordinating Committee. 1972. Vol. 1, the main report, summarizes the finding of the 17 supporting appendices. Included is geographical, water, navigation, recreation, fish and wildlife resources. (Available: USFWS Lib.)

ADDITIONAL REFERENCES

39. Fish Populations of the Mississippi River Near Becker, Minnesota. B. L. Barels, M. A. Thesis, St. Cloud University, St. Cloud, Minnesota. (Available: St. C. S. Lib.)

40. Metropolitan Mosquito Control District, Wetland Inventory Records. 1973. (Available: DNR; MMCC)

41. Fish and Wildlife Resources. Fish and Wildlife Service, U. S. Dept. of Interior. In Upper Mississippi River Comprehensive Basin Study. UMRCBS Coordinating Committee, Chicago. Appendix L. 103 p. 1970. (Available: USFWS Lib.)

KEY

Limnological Research Center University of Minnesota	LRC
Dr. Dwain W. Warner Bell Museum of Natural History University of Minnesota, Minneapolis	DWW
Environmental Conservation of Minnesota	ECOL
Macalester College Library St. Paul, Minnesota	Mac C Lib
Mankato State College Mankato, Minnesota	MSC
Metropolitan Mosquito Control Commission	MMCC
Environmental Quality Council	EQC
Citizen's League 84 South 6th Street Minneapolis, Minnesota 55402	CL
University of Minnesota Agricultural Extension Service Bulletin Room Coffey Hall St. Paul, Minnesota	U of M Ag Ext
University of Minnesota Agricultural Experiment Station	U of M Ag Exp Sta
Hickok and Associates	HA
University of Minnesota Department of Entomology, Fisheries	Ent, F, W
U. S. Fish and Wildlife Library Regional Office, Federal Building Fort Snelling, Minneapolis, Mn	USFWS Lib
University of Minnesota, Library Minneapolis, Minnesota	U of M Lib
St. Cloud State University Library St. Cloud, Minnesota	St. C S Lib
Minnesota Department of Natural Resources	DNR
Pollution Control Agency	PCA
University of Minnesota Department of Botany	U of M Bot
Metropolitan Council Library	MC Lib
St. Paul District Corps of Engineers	CE

SECTION 17 PEST SPECIES

CONTACTS

Dr. Donald Gilbertson, Professor	Department of Ecology and Behavioral Biology, University of Minnesota, Minneapolis
Howard Krosch, Coordinator	Monitoring and Control Unit, Ecological Services Section, Minnesota Department of Natural Resources
Dr. Gloria M. Warner, Plant Pathologist	Department of Plant Pathology, University of Minnesota, St. Paul

The metropolitan area's geographic location, historical development, physiogeographic features, and hydrologic features provide a rich diversity of aesthetic and educational features. Plate 26 and Exhibit Q illustrate sites of biologic and geologic significance, unique land and water features, and major vistas identified by Project 80.

BIOLOGICAL FEATURES

Sites of biological significance have been addressed in Sections 7, Plant Associations; 9, Sensitive Areas; and 16, Endangered and Threatened Plant and Animal Species. Over 130 sites of biological and geological significance exist in the metropolitan area. Most are available for public enjoyment through the efforts of multiple levels of government and private organizations. Some are open only to special interest groups or organizations (2).

Nineteen wildlife management areas (Plate 12), provide opportunities for viewing wildlife. Additional opportunities are afforded by the numerous lakes, wetlands, and rivers. Many rare bird species as well as waterfowl and mammals can be sighted in these aquatic environments.

Thousands of migrating ducks and geese are attracted to the region's marshes and lakes. Indeed, many remain over winter providing year-round enjoyment to local residents. Table 18-1 denotes major winter waterfowl concentrations in the metropolitan area.

Since their reintroduction to Minnesota in 1955, populations of the once threatened giant Canada goose have been expanding. Locations of twelve major Canada goose summer flocks are shown on Figure 18-1. Fall migrations of geese provide the opportunity to view these majestic birds in even greater numbers.

Sanctuaries such as the Roberts' Bird Sanctuary, Wood Lake Nature Center, Grey Cloud Island, and numerous others offer year round viewing opportunities of wildlife.

Sites such as the University of Minnesota arboretum and Cedar Creek Natural History Area, the new Minnesota Zoological Garden, and regional park reserves are becoming increasingly responsive to the environmental education needs of the public. These site areas are illustrated on Plate 12 - Vegetation of Special Significance.

PHYSIOGRAPHIC FEATURES

Unique physiogeographic features (identified in Project 80) in the metropolitan area include eskers, ravines, chasms, caves and sand dunes. A major ravine, located in Cottage Grove, is included in the proposed South Washington County Park Reserve. Other unique features include sand dunes located in Anoka County. At one time dunes reportedly occurred in Bloomington, East of Shakopee, and in Anoka. Now only four sites in Anoka County can be identified. Although once dynamic shifting communities they have since stabilized due to the establishment of plant communities. Over 125 caves and underground caverns are recorded in the metropolitan area. Approximate locations and numbers of caves in the area are illustrated on Plates 4 and 26. Most are concentrated along the Mississippi River with others occurring along the St. Croix and Minnesota River Valleys. Although many of these were natural formations occurring in limestone, dolomite, and sandstone, their utilization by man dates back to prehistoric times. (See Section 19-Archaeological Sites). Early American Indians utilized caves as shelters, ceremonial chambers and tombs. The most famous of these is probably Carver's Cave named after English explorer, Jonathan Carver, who visited the cave in 1766 and 1767. Today, the cave is almost inaccessible, and has been filled with debris and sediment. Only a small remnant of the large cavern remains. A federally funded project is currently involved in the exploration of this cave.

Pioneers utilized many of the caves as natural coolers for cold storage, curing meat, and shelter. Fountain Cave on Shepard Road (not accessible), was a famed tourist attraction for decades, and was the site of the first structure, a shanty saloon, in what is now St. Paul.

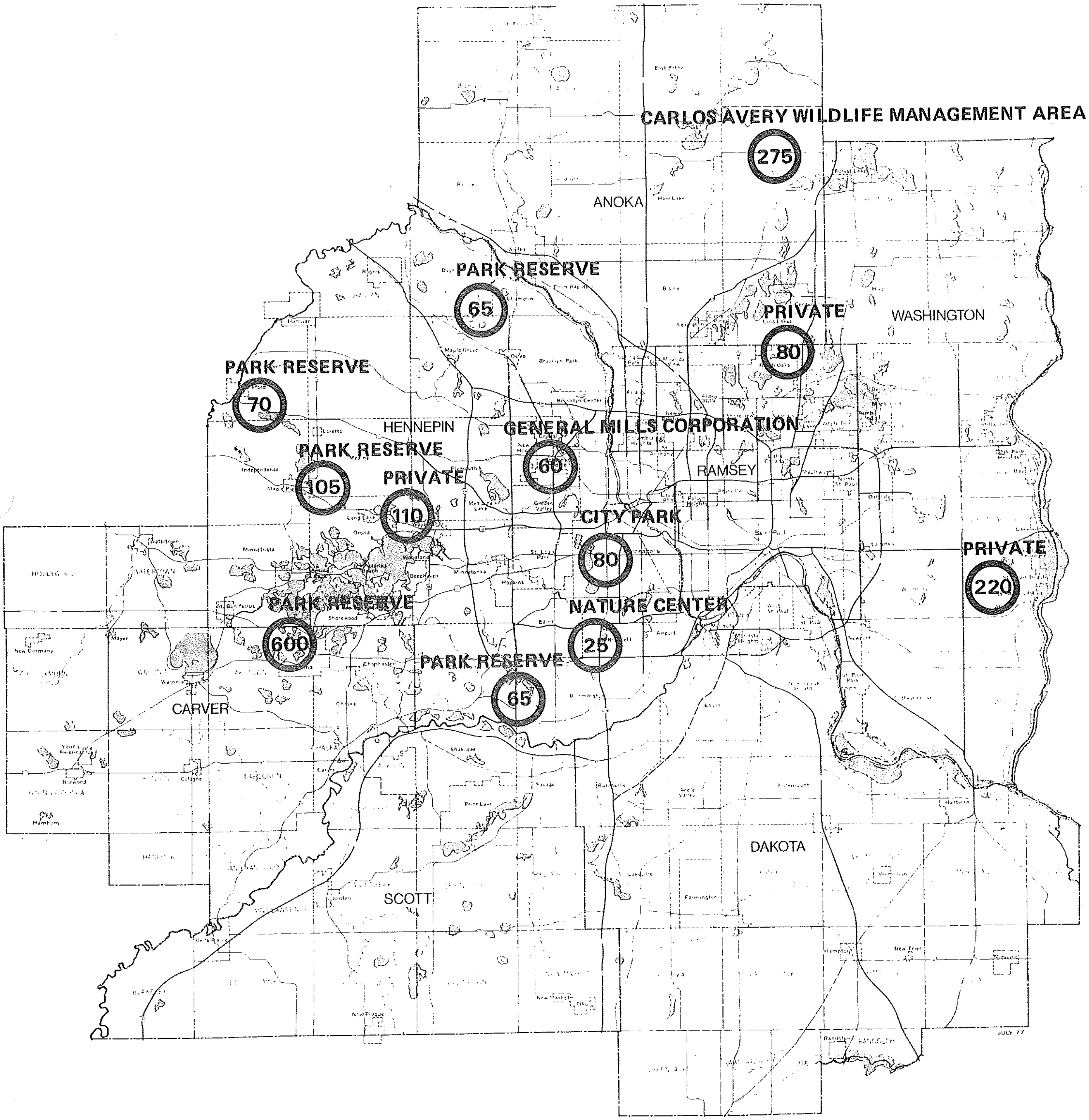
TABLE 18–1

POPULATION ESTIMATES OF WINTERING DUCKS AT SELECTED SITES IN THE METROPOLITAN TWIN CITIES, THIRD WEEK OF JANUARY, 1974*

LOCATION	NUMBER OF DUCKS
Valley Creek, Afton	200
Sucker Creek, Vadnais Heights	300
Rice Creek-Long Lake, Fridley	300
Rice Creek-Lock House, Fridley	100
Rum River-Town Center, Anoka	275
Mississippi River–FMC Plant, Fridley	900-1000
Mississippi River–Edgewater, Minneapolis	350
Mississippi River–Broadway Bridge, Minneapolis	100
Mississippi River–Nicollet Island, Minneapolis	100
Mississippi River–High Bridge, St. Paul	50
Black Dog Lagoon, Burnsville	5,000
Eagle Creek, Savage	25
Mill Pond, Shakopee	850
Hyland Park Reserve, Bloomington	140
Wood Lake Nature Center, Richfield	240
Southdale Shopping Center, Edina	1,300
Lake of the Isles, Minneapolis	15
General Mills, Inc. Headquarters, Golden Valley	175
Colonial Courts–Glenwood Avenue, Golden Valley	600
Elm Creek Park Reserve, Maple Grove	55
Rebecca Park Reserve, Independence	45
Baker Park Reserve, Medina	100
Carver Park Reserve, Laketown	425
Minnetonka Bay–Lake Minnetonka, Wayzata	500
Belford Ponds–Lake Minnetonka, Wayzata	50
Minnetonka Boat Works–Lakes Minnetonka, Mound	350
Surfside Inn–Lake Minnetonka, Mound	800
Tonka Toys–Lake Minnetonka, Mound	400
Eaton Factory, Eden Prairie	10
TOTAL:	13,805

*Compiled by Dr. James A. Cooper, University of Minnesota, St. Paul Level B. Study

FIGURE 18–1 LOCATION AND SIZE OF MAJOR CANADA GOOSE SUMMER FLOCKS



SOURCE: Level B. Study

WATER FEATURES

Unique water features include waterfalls near the Twin Cities: St. Anthony Falls, Bridal Veil Falls, two unnamed sites, and Minnehaha Falls. Other water features include Vermillion Falls, Sand Creek Falls and Carver Rapids. Carver Rapids, upstream from Chaska on the Minnesota River, is the only white water area within the metropolitan area. See Plate 4—Geological Features.

The major river corridors are unique in themselves. Visual quality overall has remained relatively high. The St. Croix (Metropolitan portion) is a National Scenic and Recreation River. The Mississippi north of Anoka is a proposed National Wild, Scenic and Recreation River and is currently a part of the State Scenic and Recreation Rivers Program. South of Anoka to Hastings the river has been designated a State Critical Area. Much of the Minnesota River Valley is protected by public ownership. The Minnesota Valley National Wildlife Recreation Area will encompass about 6,600 acres between Belle Plaine and Shakopee. West of Shakopee the river is a designated State Canoe and Boating River.

Significant vistas identified by Project 80 are also illustrated on Plate 26. The bluffs, particularly those associated with the river corridors, provide scenic views of autumn colors. Additional areas of scenic timber are denoted in Section 7—Plant Associations, Vegetation of Special Significance. The numerous bridges along the rivers provide additional vistas along the river corridors. City lights often enhance these views at night.

REFERENCES

1. Environmental Impact Assessment Study of the Northern Section of the Mississippi River. Minnesota River Pool, St. Croix River Pool, Upper and Lower St. Anthony Falls Pool, Pool 2, and Pool 3. R. F. Colingsworth, et al., 1973. The six volumes are part of an extensive environmental study of the major river corridors. The volumes are a valuable aid to detailed vegetation use, and other resource data. (Available: ECOL Library)

2. A Guide to Minnesota Environmental Education Area. Mn/DNR, Bureau of I & E. November 1972. 110 pp. The booklet contains a listing, description and ownership of environmental learning centers, nature centers, and refuges by county. Helpful in location of sensitive plant and animal areas. (Available: Out-of-print copies may be borrowed from DNR, Bureau of Planning, Bureau of Information and Education of Bureau of Parks and Recreation.)

3. History Along the Highways. Minnesota Historical Society, St. Paul. 1967. The document is an official guide to Minnesota State Markers and monuments dealing with historic events of state-wide interest. A map depicts TCMA sites. (Available: Public Libraries, MHS)

4. Listing of Variables for the Minnesota State Planning Agency Critical Areas Inventory. Xerox, April 1977. The list provides a description of location for natural preservation areas, national register historical and archaeological sites and districts, and recreational data. Information is by region and county. This information should be useful for updating sensitive areas, sites of historic, archaeological and educational significance. (Available: SPA; Contact: Kitty Miles)

5. Minnesota Resource Potentials in State Outdoor Recreation. Department of Natural Resources, State Planning. Project 80 staff report, 1971. The document outlines policies for appropriations, development, criteria, etc. for state-owned lands. An inventory of scenic, historic, and natural sites was developed and weighed against demand projections. (Available: SPA)

6. Natural and Historic Areas of Minnesota. Mn/DNR. Bureau of Planning. September 1971. 72 pp. This is an updated listing and mapping source of Project 80 inventory data. Additional information was added from Minnesota Historical Society and Nature Conservancy data. Information is provided by economic region. This should be a strong base for historical, cultural and natural inventory data. (Available: Document is out-of-print. Copies may be borrowed from DNR, Bureau of Planning. Contact: John Poate.)

7. Sites of Biological and Geological Significance. State Planning Agency File. August 1977. The file is an on-going inventory of sensitive areas. Data is prepsented by county and coverage is state-wide. Compilation from nine data sources. (Available: SPA, Contact: Kitty Miles)

8. The Uncommon Ones. Mn/DNR. October 1975. 32 pp. This booklet provides information on rare and endangered plant and animal species. It also includes information on other species which may merit special consideration or management. Value to future studies may be limited since much of the habitat information is very general. (Available: DNR, Bureau of Information and Education.)

9. Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June, 1974. 77 pp. This is a very detailed listing of plants, animals (includes reptiles and amphibians) with descriptions of where species are most likely to be found, type of protection and recommendations for management. Valuable asset to the study. (Available: Xerox manuscript available at MC)

FEATURES OF ARCHAEOLOGICAL, CULTURAL, AND HISTORIC INTEREST

ARCHAEOLOGICAL SITES

Over 150 archaeological areas have been identified in the metropolitan area. Plate 27 illustrates approximate locations of these areas and is indexed to Exhibit R. Data is based on the most current (1977) files of the Field Historic Sites and Archaeological Division (FHA) of the Minnesota Historical Society. These are confidential files not available to the general public. Section numbers are not included at the request of the Minnesota Historical Society. The archaeology department will help locate specific sites only on a need-to-know basis, since souvenir hunters, artifact collectors, and vandals are presenting increasing problems.

According to the files, twenty of the sites are habitation areas ranging from caves and rock shelters to villages. All but two remaining sites are burial mounds. The exceptions are two "bison kill" areas - apparently major bison harvest areas utilized by Aboriginal Americans.

In a 1975 report, Historic Preservation in Minnesota - The Annual Preservation Program, these burial mounds were described as "Aboriginal Americans". Although the contents of these sites may be questioned, the site locations remain valid for environmental assessments.

There is a pronounced concentration of sites around Lake Minnetonka and along the Minnesota and Mississippi Rivers, and to a lesser extent, along the St. Croix north of Stillwater. This suggests a great probability that archaeological sites would most likely occur near water. The archaeological department is currently involved in a computer research program which would aid in locating possible sites based on such probabilities. Indications at the present time are that sites would most likely be located within 300 feet of a water source.

Archaeological sites have been recorded on the major river corridors which have been or may have been affected by Corps of Engineer projects (4). Brief excerpts of the Lewis and Hill archaeological survey are included and give some insight to the problem of an accurate, all-inclusive inventory. The inventory of archaeological sites is necessarily incomplete because the survey of such sites is not complete.

SITES OF CULTURAL AND ARCHITECTURAL INTEREST

The diversity of ethnic backgrounds and cultural influences have resulted in a large number of structures which are architecturally significant. Plate 27 denotes these sites and they are indexed to Exhibit S. Areas outside of the central cities were considered to be the primary concern to MWCC. Due to the large numbers of sites in Minneapolis (124), St. Paul (18), and Hastings (41) locations were not mapped or listed in Exhibit S. Information regarding these sites can be obtained from the Minnesota Historical Society Listing.

Additional sites of local cultural and historic significance may be obtained from each of the seven counties and municipalities. Washington County, for example, lists 172 sites which are not on the federal or state registers, but have some local significance.

HISTORIC SITES

The National Historic Preservation Act passed in 1966 provides for the indexing of sites which are significant in American history, architecture, archaeology, and modern culture. The register is an official statement of properties which merit preservation.

Eighty sites in the metropolitan area are listed on the National Register. Plate 27 illustrates locations and Exhibit S briefly describes the significance and locations of sites.

One area, the 5,700 acre Cedar Creek Natural History Area, has been designated a National Natural Landmark. It is the only such site in the metropolitan area.

FEATURES OF ARCHAEOLOGICAL, CULTURAL, AND HISTORIC INTEREST

Forty-eight sites are listed by the State. All but three (one in Dakota and two in Carver County) are also on the Federal Register. All Ramsey County sites are included on both the State listing and Federal Register.

Data was obtained from the Minnesota Historical Society's 1977 files. Many additional sources of information are available, providing overviews of specific sites, structures, and historical periods.

REFERENCES

1. Anoka County Resource Inventory and Analysis. University of Minnesota. Resource and Community Development, 1975. 181 pp. This report is a fairly detailed inventory and analysis of physical, social, economic, and historical resources of the county. Data is relatively new. Could be of value to future MWCC studies. (Available: MC)

2. Archaeological & Historical Sites File. Minnesota State Historical Society. State Historic Preservation Office of Archaeological Sites. 1977. The archaeological sites file is a confidential file not intended for public use. Information on specific sites may be gained from contacting Robert Clouse or Ted Lofstrom.

3. Dakota County in Perspective. Dakota County Planning. 1973. 94 pp. The document is a report on historical settlement, natural history, agriculture, and socio-economic patterns. It contains information which may be of value to some portions of MWCC studies. (Available: MC)

4. Environmental Impact Assessment Study of the Northern Section of the Upper Mississippi River. Minnesota River Pool, St. Croix River Pool, Upper & Lower St. Anthony Falls Pool, Pool 2 & Pool 3. R.F. Colingsworth, et al., 1973. The six volumes are part of an extensive environmental study of the major river corridors. The volumes are a valuable aid to detailed vegetation studies as well as water quality, river use, and other resource data. (Available: ECOL Library)

5. A Guide to Minnesota Environmental Education Areas. Mn/DNR, Bureau of I & E. November, 1972. 110 pp. The booklet contains a listing, description and ownership of environmental learning centers, nature centers, and refuges by county. Helpful in location of sensitive plant and animal areas. (Available: Out-of-print copies may be borrowed from DNR, Bureau of Planning, Bureau of Information and Education, Bureau of Parks and Recreation.)

6. Historic Preservation in Minnesota. The Annual Preservation Program. Minnesota Historical Society, Division of Field Services, Historic Sites, and Archaeology. 1974-75. The document is a fairly comprehensive listing of Minnesota historic and archaeologic sites. It also outlines biennial acquisition programs. (Available: Minnesota Historical Society; contact Don Coddington)

7. An Historic Sites Program for Minnesota. M.O.R.R.C. 1965 (?) 94 pp. This document was prepared in coordination with MHS and MHD. It provides information on known historic sites, descriptions of sites, conditions, and ownership, and a 10 year management program for sites. May be of limited value to studies. (Available: MC)

8. History Along the Highways. Minnesota Historical Society, St. Paul. 1967. The document is an official guide to Minnesota State Markers and monuments dealing with historic events of state-wide interest. A map depicts metropolitan area sites. (Available: Public libraries, MHS)

9. Listing of Variables for The Minnesota State Planning Agency Critical Areas Inventory. Xerox, April, 1977. The list provides a description of location for natural preservation areas, national register historical and archaeological sites and districts, and recreational data. Information is by region and county. This information should be useful for updating sensitive areas, sites of historic, archaeological and educational significance. (Available: SPA, Contact Kitty Miles)

10. Minnesota Resource Potentials In State Outdoor Recreation. Department of Natural Resources, State Planning Project 80 staff report 1971. The document outlines policies for appropriations, development, criteria, etc. for state-owned lands. An inventory of scenic, historic, and natural sites was developed and weighed against demand projections. (Available: DNR, SPA)

11. Natural and Historic Areas of Minnesota. Mn/DNR. Bureau of Planning. September 1971. 72 pp. This is an updated listing and mapping source of Project 80 inventory data. Additional information was added from Minnesota Historical Society and Nature Conservancy data. Information is provided by economic region. This should be a strong base for historical, cultural and natural inventory data. (Available: Document is out-of-print. Copies may be borrowed from DNR, Bureau of Planning. Contact: John Poate)

12. "Sites of Biological and Geological Significance." State Planning Agency File. August 1977. The file is an ongoing inventory of sensitive areas. Data is presented by county and coverage is state-wide. Compilation from nine data sources. (Available: State Planning Agency, Contact: Kitty Miles)

13. The Uncommon Ones. Mn/DNR. October 1975. 32 pp. This booklet provides information on rare and endangered plant and animal species. It also includes information on other species which merit special consideration or management. Value to studies may be limited since much of the habitat information is very general. (Available: DNR, Bureau of Information and Education.)

14. Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area. Gordon L. Hughes, February 1974. Revised: Virginia Fuller Holman, March-June, 1974. 77 pp. This is a very detailed listing of plants, animals (includes reptiles and amphibians) with descriptions of where species are most likely to be found, type of protection and recommendations for management. Valuable asset to the study. (Available: Xerox manuscript available at MC)

DNR - Department of Natural Resources
ECOL Library - Environmental Conservation Library, Minneapolis Public Library
MC - Metropolitan Council Library
MHS - Minnesota Historical Society
SPA - State Planning Agency

GENERAL CONSTRAINTS

Man's utilization of land in any manner could be perceived as a disruption of natural systems. Man's very existence necessitates the utilization of land for habitation, food production, transportation, and leisure areas. However, not until recently has there developed an awareness for the wise utilization of man's environment based on the intrinsic suitabilities of natural resources.

It is particularly important to identify the resources, their abundance, limitations, and suitabilities when issues of health, safety, and welfare arise as they do with facilities planning. At this point in the overall process, the constraints posed by individual resources can be only gross generalizations. While limitations of development suitabilities can be discussed for each resource, the application of those limitations really depends on more site specific levels.

For example, the determination of facilities siting can be limited by five major components:

Existing Urban and Developed Areas - Constraints due to safety, economic, and social acceptability.

Water Courses and Water Bodies - By their nature are undevelopable.

Wetland Areas - Constraints similar to lakes and streams although they are more easily modified to sustain certain types of development.

Forested Lands - Constraints to facilities planning by virtue of their aesthetic desirability, social demands for other uses, and additional expense.

Agricultural Production Lands - Constraints by local and regional policies advocating the continued agricultural utilization of these lands. Of the five major constraints, this is perhaps the least restrictive in view of the fact that compromises most often involve the conversion of agricultural lands to other uses.

These five factors comprise all land in the region with the exception of vacant or fallow lands and special use areas. Thus, in at least one respect, all and must be viewed as having inherent desirable suitabilities and corresponding limitations. It is within this framework that additional resource components must be identified and analyzed to determine areas which are the least restrictive for a particular use.

REGIONAL CONCERNS

At this point in the process a number of inventoried resources or features cannot be readily utilized as constraining factors capable of limiting areas for facility development. Rather, they must be perceived as items of significant concern which would apply anywhere in the metropolitan area. Energy supply and air quality are two concerns which must be considered in terms of current and future restrictions which may limit development of certain types of facilities in site specific areas as well as area-wide. General climatic conditions are another concern that do not necessarily eliminate areas for consideration for facilities development. However, localized wind, precipitation, and temperature conditions may make it more advantageous to locate a facility in one area, rather than another. The application of climatic factors as a constraint may be more important on a site specific area. A fourth consideration with an area wide impact is the presence of rare and endangered species. As presented in Section 16 - Rare and Endangered Species, the metropolitan area is the geographic edge of many species' natural range. Although some areas can be specifically defined as supporting rare and endangered plant and animal species, their continued existence often depends on such area-wide aspects as water quality, air quality, feeding ranges, local migrational corridors, natural flyways, and natural evolutionary processes. This is another concern that may be more easily applied as a constraint factor at a site specific level.

A fifth area of regional-wide concern is ground water recharge. Although generalized groundwater recharge locations have been mapped in the Metropolitan Development Guide (MDG), these generalizations do not necessarily reflect the situation at specific sites. The MDG-based recharge areas are those where the Prairie du Chien - Jordan aquifers are covered by a layer of highly permeable glacial materials. In reality, groundwater recharge occurs over a much broader area since many locations not covered by the MDG criteria do in fact contribute to groundwater recharge. The effect of specific facilities development on groundwater resources needs to be addressed on a more detailed level in the metropolitan area both with regard to area coverage and geological and hydrological conditions.

PHYSICAL FACTORS

Certain physical resources can be more easily identified than the previously mentioned, broader concerns. Soils, topographic, hydrologic, and geologic data are more readily available, thus allowing interpretation and the determination of constraining characteristics.

In general analytical review, characteristics such as floodplains, erodible slopes (greater than 12%), and soils with severe limitations for urban development would be areas of concern and probably constraint factors based on environmental, safety, regulatory, and social perspectives. Areas with soil limitations have been identified in the MDG. Limitations are based on topographic, hydrologic, soil, and geologic characteristics such as permeability, shrink-swell potential, slope conditions, depth to bedrock, and depth to the water table. The use of mapped areas of "Soils with Severe Limitations for Urban Development" (Exhibit D) as a constraint should be done cautiously. Many areas so designated are presently developed at densities approaching urbanized areas. At this point in the process, these characteristics are more aptly described as areas of concern rather than constraint areas. As the process progresses to site specific levels, more detailed data will be required for decision making.

AESTHETIC, CULTURAL AND QUALITATIVE FACTORS

Additional areas of concern and probable constraint areas for facilities planning can be identified when factors which contribute to the aesthetic, cultural, and qualitative aspects of the environment are addressed. Park and recreation open space areas would be constraint areas for facilities development both from a regulatory and social acceptability view. Similarly, river corridors are becoming increasingly restrictive to certain types of development. The Mississippi's Critical Areas designation, the St. Croix's National Wild, Scenic, and Recreational River designation, and the proposed extensive federal and state holdings along the Minnesota will prohibit incompatible use along the three major water sources. Wildlife management areas, scientific and natural areas, historic and archaeological sites, and nature centers are among other areas in which it would be difficult to gain approval for development. Thus, they may be considered areas of concern and probable constraint areas.

In recent years many issues and projects have experienced strong organized public opposition. In light of this, it would seem likely that many areas may be eliminated from any type of facilities development. These areas cannot be readily identified until a specific project and a more detailed site scale is addressed.

SUMMARY OF AREA-IDENTIFIABLE CONCERNS

Fourteen topics of concern have been identified and their occurrence relative to political subdivisions have been illustrated in Figures 20-1 through 20-7. At an inventory stage it would be misleading and inaccurate to immediately label all of these constraints as undevelopable areas. They must, therefore, be interpreted as major items of concern due to their relative abundance in a municipality or township. In some cases it is because of their singular presence that they are identified as areas of concern. For example, if one community has numerous forested areas, these may be a general constraint and certainly a major concern. If another community has only few areas, these may be regarded as very special and they, too, become areas of concern. It is difficult to generalize and delete areas of study at this broad scale without specific projects and details to address. The matrices, thus, must be carefully regarded and not interpreted as a "yes" or "no" feasibility summary.

The political subdivisions have been listed as they occur north to south within the county, reading left to right. From a geographical perspective the order indicates that the communities at the top of the list are farthest north and the communities at the bottom of each list are southernmost within each county.

FIGURE 20–1

ANOKA COUNTY ENVIRONMENTAL CONCERNS

ANOKA COUNTY	POTENTIAL CONSTRAINTS													
Political Sub-Division	Existing Developed and Urban Areas	Water Courses	Lakes over 100 Acres	Wetlands	Forested Land	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lakes of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
St. Francis		x		x	x	x	x		x	x	x		x	
Bethel	x		x	x	x	x		x	x				x	
Burns		x	x	x	x	x	x	x	x	x	x	x	x	x
Oak Grove		x	x	x	x	x	x	x	x		x			x
East Bethel		x	x	x	x	x	x		x			x	x	x
Linwood		x	x	x	x	x			x		x	x	x	x
Ramsey	x	x	x	x	x	x	x	x	x	x		x	x	x
Andover (Grow)	x	x	x	x	x	x	x		x	x	x	x	x	
Ham Lake	x	x	x	x	x	x	x		x					x
Columbus		x	x	x	x	x	x		x		x	x	x	x
Anoka	x	x		x	x				x	x				x
Coon Rapids	x	x		x	x	x	x		x	x	x	x	x	x
Blaine		x		x	x	x	x		x			x		x
Lexington	x			x					x		x			
Circle Pines	x	x		x	x				x					
Centerville	x	x	x	x	x	x			x		x		x	x
Lino Lakes		x	x	x	x	x			x		x	x	x	x
Spring Lake Park	x		x	x	x				x					
Fridley	x	x	x	x				x	x	x	x		x	x
Hilltop/Columbia Heights	x	x		x					x	x		x		

FIGURE 20–2

CARVER COUNTY ENVIRONMENTAL CONCERNS

CARVER COUNTY

Politcal Sub-Division	Existing Developed and Urban Areas	Water Courses	Lakes over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitation for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
	POTENTIAL CONSTRAINTS													
Hollywood		x		x		x			x		x			
Watertown	x	x	x	x	x	x	x		x	x	x	x	x	x
Camden	x	x	x	x		x	x		x	x	x		x	
Waconia	x	x	x	x		x	x		x		x	x	x	x
Laketown	x	x	x	x	x	x	x	x	x			x	x	x
Victoria	x		x	x	x	x	x	x	x				x	
Chaska	x	x	x	x	x	x	x	x	x	x	x		x	
Chanhassen	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Young America	x	x	x	x		x			x					
Benton	x	x	x	x		x			x					
Dahlgren		x	x	x		x	x	x	x		x			x
Carver		x		x	x	x		x	x	x	x		x	x
Hancock		x		x		x			x				x	
San Francisco		x	x	x	x	x	x	x	x	x	x	x	x	x

FIGURE 20–3 DAKOTA COUNTY ENVIRONMENTAL CONCERNS

DAKOTA COUNTY	POTENTIAL CONSTRAINTS													
Political Sub-Divisions	Existing Developed and Urban Areas	Water Courses	Lakes Over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
West St. Paul	x					x						x	x	x
Lilydale/Mendota	x	x			x	x		x	x	x	x	x	x	x
South St. Paul	x	x		x				x	x	x	x	x		x
Mendota Heights	x		x	x		x					x		x	x
Sunfish Lake	x		x		x	x								
Eagan	x	x	x	x	x	x		x	x	x	x	x	x	x
Inver Grove Heights	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Burnsville	x	x	x	x	x	x		x	x	x	x	x	x	
Apple Valley	x		x		x	x				x	x	x	x	
Rosemount/Coates	x				x	x		x		x	x		x	
Nininger					x	x		x		x	x	x		
Hastings	x	x			x	x		x	x	x	x	x		x
Lakeville	x	x	x	x	x	x	x	x	x				x	
Farmington	x	x		x		x			x					
Empire		x		x		x	x		x					
Vermillion		x		x		x		x	x	x				
Marshan		x			x	x	x	x	x				x	
Ravenna		x			x	x		x	x	x			x	
Eureka		x	x	x	x	x	x	x	x			x	x	x
Castle Road		x		x	x	x	x	x	x		x	x		x
Hampton		x		x	x	x		x	x		x	x	x	
Douglas		x			x	x		x	x		x		x	
Greenvale		x		x		x	x		x					
Waterford		x				x	x		x	x				x
Sciota		x				x			x	x				x
Randolph		x	x			x		x	x	x				

FIGURE 20–4 HENNEPIN COUNTY ENVIRONMENTAL CONCERNS

POTENTIAL CONSTRAINTS

HENNEPIN COUNTY Political Sub-Divisions	Existing Developed and Urban Areas	Water Courses	Lakes Over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
Rogers	x				x	x			x					
Hassan	x	x	x	x	x	x		x	x	x	x	x	x	
Dayton	x	x	x	x	x	x	x		x	x	x	x	x	x
Champlin	x	x	x	x	x	x			x	x	x	x	x	
Hanover	x	x		x	x	x			x	x	x		x	
Greenfield/Rockford	x	x	x	x	x	x		x						
Corcoran	x	x	x	x	x	x			x					
Maple Grove	x	x	x	x	x		x	x	x		x		x	x
Osseo	x													
Brooklyn Park	x	x		x	x		x	x		x	x	x		x
Brooklyn Center	x	x	x	x					x	x	x		x	
Independence	x	x	x	x	x	x	x	x	x		x		x	x
Maple Plain	x			x		x			x					
Medina	x	x	x	x	x	x		x	x		x		x	
Plymouth	x	x	x	x	x	x		x	x		x			
New Hope	x	x		x					x					
Crystal	x	x							x					
Robbinsdale	x	x	x						x					
Golden Valley	x	x	x					x	x	x	x			
Minnetrista	x	x	x	x	x	x	x	x	x		x	x	x	x
Mound	x		x						x					
St. Bonifacius	x			x					x					
Spring Park/Minnetonka Beach	x		x						x					
Long Lake/Orono	x	x	x	x	x	x	x	x	x		x	x	x	
Wayzata	x		x	x	x				x		x	x	x	x
Woodland/Deephaven	x		x	x					x				x	
Greenwood/Excelsior	x		x	x				x	x					
Tonka Bay/Shorewood	x		x	x					x			x	x	
Minnetonka	x	x	x	x	x			x	x	x		x		
Hopkins	x	x			x				x	x				
St. Louis Park	x	x		x			x		x	x				x

FIGURE 20–4
CONTINUED

HENNEPIN COUNTY ENVIRONMENTAL CONCERNS

POTENTIAL CONSTRAINTS

HENNEPIN COUNTY Political Sub-Divisions	Existing Developed and Urban Areas	Water Courses	Lakes Over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
Minneapolis	x	x	x	x	x	x		x	x	x	x	x	x	x
St. Anthony	x								x					
Edina	x	x	x	x				x	x	x			x	x
Eden Prairie	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bloomington	x	x	x	x	x			x	x	x	x		x	
Richfield	x	x	x	x						x	x		x	
Airport	x							x					x	

FIGURE 20–5 RAMSEY COUNTY ENVIRONMENTAL CONCERNS

POTENTIAL CONSTRAINTS

RAMSEY COUNTY Political Sub-Divisions	Existing Developed and Urban Areas	Water Courses	Lakes Over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
Mounds View	X	X		X						X				
Shoreview	X	X	X	X	X	X	X	X	X	X	X		X	
North Oaks	X	X	X	X	X	X		X	X				X	
White Bear	X		X	X	X	X	X		X		X			
New Brighton	X	X	X		X				X	X	X		X	
Arden Hills	X	X	X	X	X	X		X	X	X	X		X	X
Vadnais Heights	X	X	X	X	X				X		X			
Gem Lake	X		X		X				X					
White Bear Lake	X								X					X
Roseville	X		X	X			X		X				X	
Lauderdale/Falcon Heights	X						X		X					X
Little Canada	X				X	X	X		X					
Maplewood	X	X		X	X	X	X	X	X		X			X
North St. Paul	X								X					
Saint Paul	X			X	X			X	X	X	X	X	X	X

TABLE 20–6

SCOTT COUNTY ENVIRONMENTAL CONCERNS

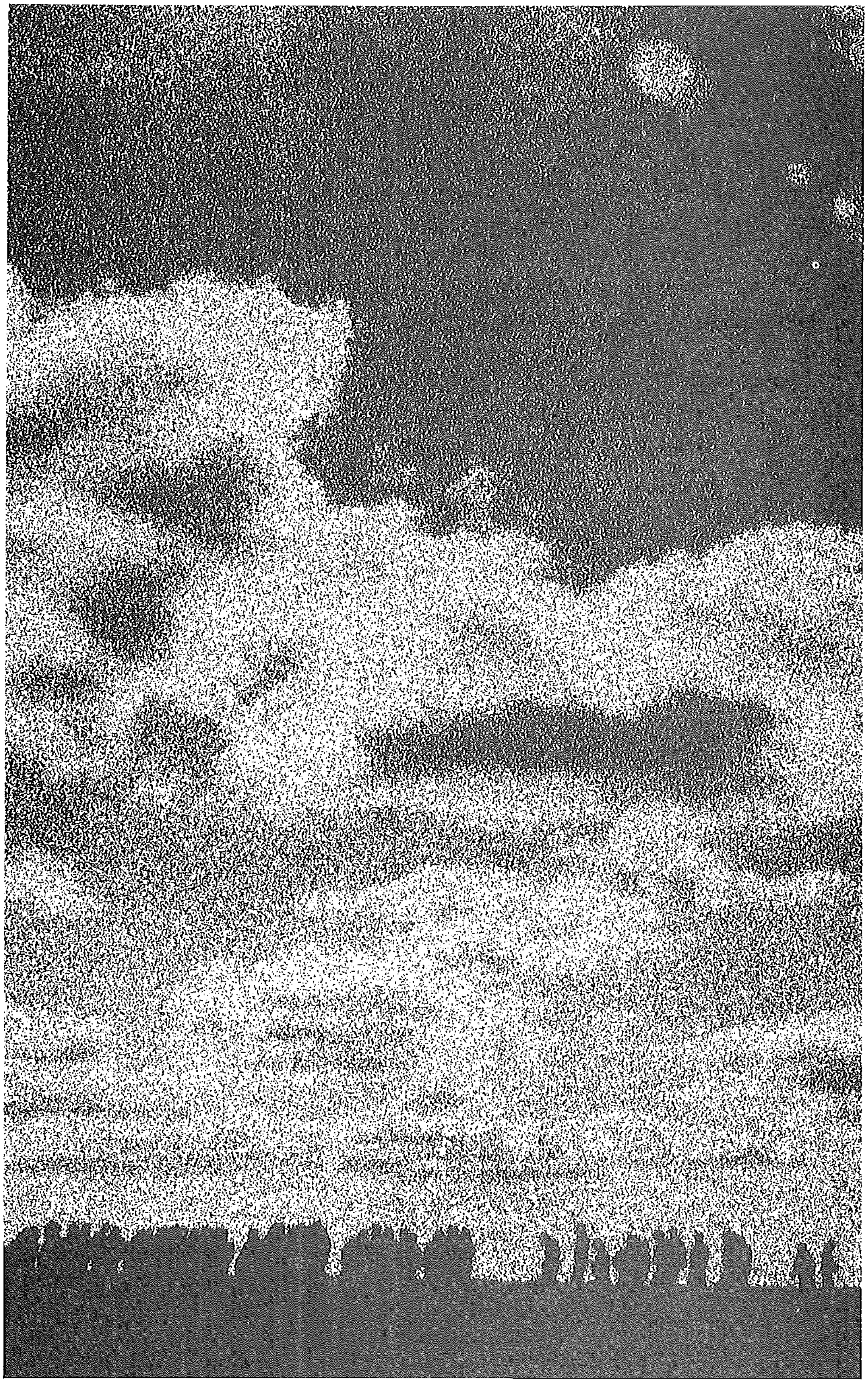
SCOTT COUNTY

POTENTIAL CONSTRAINTS

Political Sub-Divisions	Existing Developed and Urban Areas	Water Courses	Lakes Over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological and Geological Features	Vegetation of Special Significance	Historic and Cultural Features
Jackson	x	x		x		x		x	x	x	x	x	x	x
Shakopee	x	x	x	x	x	x		x	x	x	x	x	x	x
Savage	x	x	x	x	x	x		x	x	x	x	x	x	x
Louisville	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Prior Lake	x		x	x	x	x		x	x					
St. Lawrence		x	x	x	x	x	x	x	x	x	x		x	x
Sand Creek	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Spring Lake	x	x	x	x	x	x	x	x	x		x			
Credit River		x	x	x	x	x		x	x		x		x	x
Blakeley		x	x	x	x	x		x	x	x	x	x	x	
Belle Plaine	x	x		x		x	x	x	x	x	x		x	
Helena	x	x	x	x	x	x		x	x		x			
Cedar Lake		x	x	x	x	x		x	x			x	x	
New Market	x	x		x	x	x	x	x	x					

FIGURE 20–7 WASHINGTON COUNTY ENVIRONMENTAL CONCERNS

WASHINGTON COUNTY	POTENTIAL CONSTRAINTS													
Political Sub-Divisions	Existing Developed and Urban Areas	Water Courses	Lakes Over 100 Acres	Wetlands	Forested Lands	Agricultural Lands	Specialized Farming Operations	Erodible Slopes	Soils with Severe Limitations for Urban Development	Floodplains	Public Lands of Regional Significance	Significant Biological or Geological Features	Vegetation of Special Significance	Historic and Cultural Features
Forest Lake	x	x	x	x	x	x			x			x	x	x
New Scandia		x	x	x	x	x		x	x	x	x	x	x	x
Marine		x			x	x		x	x	x	x		x	x
Hugo		x	x	x	x	x	x	x	x				x	
May		x	x	x	x	x	x	x	x	x	x	x	x	x
Dellwood/Mahtomedi	x		x	x	x	x			x					x
Grant	x		x	x	x	x	x	x	x					
Stillwater	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Oakdale/Landfill	x		x	x	x	x			x					
Lake Elmo	x	x	x		x	x	x	x	x	x	x	x	x	
Baytown	x	x	x	x	x	x	x	x	x	x	x	x	x	x
West Lakeland	x	x	x		x	x	x	x	x	x	x	x	x	x
Woodbury	x		x	x	x	x	x	x	x					
Afton	x	x	x		x	x		x	x	x	x	x	x	x
Newport	x	x			x				x	x				x
St. Paul Park	x	x				x			x	x				
Grey Cloud	x	x			x	x			x	x	x	x	x	x
Cottage Grove	x	x			x	x	x	x	x	x	x	x		x
Denmark		x			x	x	x	x	x	x	x	x		x



HOW TO USE THE WIND ROSES

For the purpose of this report, a total of 13 wind roses were prepared. One is annual, twelve are monthly. A wind rose is a graph of the direction of wind frequency from various directions. Different methods of preparing wind roses exist. The method employed here was selected as being that easiest to visualize.

The plotting sheet used was specially prepared for this report. Data were placed along 36 radials from the origin at intervals representing one percent of the time that the wind blows from the direction represented by each radial. Points were then plotted along each radial corresponding to the observed percent of time that the wind came from the corresponding direction for velocity intervals of 3 knots. The distance from the data point to the origin represents the percent of time that a wind from a certain direction blows at a given speed or less. The distance between the points along the radial is the percent of time that the wind blows from the indicated direction in the speed category defined by the speeds represented by the two points.

Except for speeds of 3 knots, lines were drawn connecting points representing equal speeds at 30knot speed intervals around the 360 degree arc. The data points cannot be seen on the wind roses since the lines were drawn over them. The first solid line from origin represents 6 knots, the second line 9 knots, the third line 12 knots, the fourth line 15 knots, and so on. In most cases, winds over 21 knots are so rare that the lines may seem to merge.

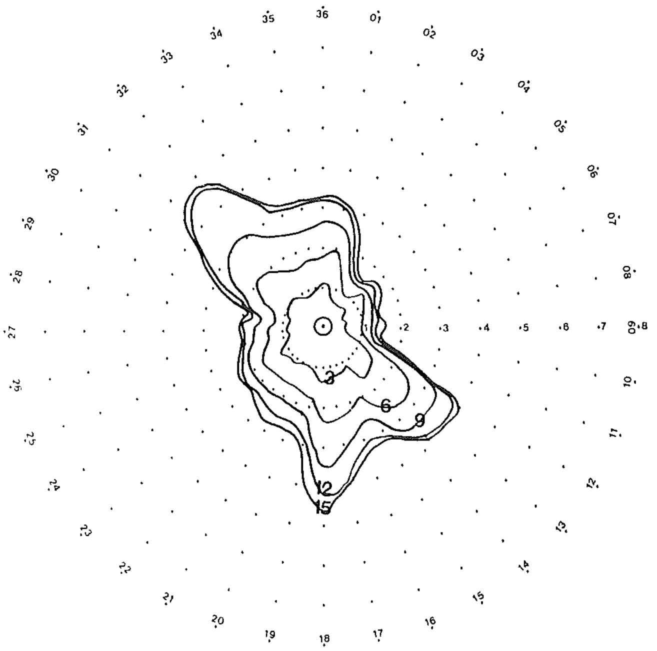
For speeds of 1 to 3 knots, barbs were drawn from the 3 knot point toward the origin. (In some cases, barbs were blended together.) For calms, a circle was drawn proportional to the percent of time the air was calm, after apportioning the percent of time the air was calm equally to all 36 points of the compass.

The resulting diagram is one which the viewer gets a picture of the wind direction and speed frequencies at a glance. The degree of bulge toward certain directions gives a quick idea of the distribution of winds. The diagrams also yield a quick picture of wind regime diffences when one is compared with another. (Note, however, that an area distortion exists, since the scale expands as the distance from origin increases.)

The following example tells how to interpret the wind rose diagram. On the sample wind rose look at the radial labelled "13". This represents the 130 degree azimuth (just a bit to the east of southeast). The center circle represents the calms. The length of the little barb protruding toward 130 degrees describes the frequency of a wind from 130 degrees -- it is about 1/4 of 1% long, telling us that the wind is from 130 degrees (on a scale of 36 compass points) at 1, 2, or 3 knots 1/4 of 1% of the time. Together with the calms, the end of the barb lies about 1/2 of the way to the 1% circle, telling us that about 1/2 of 1% of the time the 130 degree wind is 3 knots or less (assuming that 1/36 of the time, the wind reported as calm is coming from 130 degrees at a speed less than 1 knot which we know is probably not true, but which is not very damaging because the wind is hardly ever less than 1 knot in speed).

The first solid line intersects the 130 degree radial at about 1.6 percent. The value of the first solid line is 6 knots, so that 1.6 percent of the time we have a 130 degree wind of 6 knots or less, subject to the assumption above.

Looking down the radial, we see that the first dashed line (9 knots) intersects at 2.8%, the second solid line (12 knots) at 3.5%, and the lone hash line (15 knots) at about 3.0 percent. The third solid line (18 knots) from origin intersects at about 3.9%. The final dashed line (21 knots) intersects at nearly 4.0%. No winds from 130 degrees in the 10-year period exceeded 21 knots. And, the wind came from 130 degrees a total of 4% of the time.



Suppose one would like to know how often the wind from 130 degrees blew at a speed greater than, say, 6 knots. On a sheet of paper, make a scale patterned after the percent scale and lay it along the radial from 9 knots to the outer dashed line. Try it. If you do, you will see that a 130 degree wind of 6 knots or more occurs 2.4 percent of the time. Use a similar procedure to determine the wind speed interval category for any direction, interpolating as needed.

Notice also that this type of wind rose enables one to interpolate at intermediate directions, providing that one remembers that the percent value is for 36 points of the compass. Values for intermediate points can be converted to 72 points of the compass by dividing the percent value on the scale by 2. Conversely, one may obtain values for 18 points of the compass by adding together percentages along two radials and then multiplying values on the scale by 2. The process can be done for any sector on the rose by the appropriate division or multiplication on the percentage scale.

The accuracy obtainable from the wind roses should be adequate for any purpose, since the difference between any two 10-year data taking periods would vary by more than the loss of resolution in making and using the plots. Notice that plotting the diagrams to 36 points of the compass makes possible the delineation of very small percentage values on the diagrams.

Care should be taken not to "over-interpret" small differences between neighboring radials, especially on the tri-monthly roses. Fraction-of-a-percent differences may not be significant. Plotting to 36 points of the compass on the charts is of value, however, as in the case of the very strong difference in the frequency of 110 degree winds as compared to 120 degree winds. This difference is very likely true over exposed areas of the Twin Cities -- the author recalls concern several years ago as to whether his observations in Roseville were somehow biased with regard to 120 degree versus 110 degree winds. The difference is significant, and this fact might be critical in evaluating impact of certain emission sources on downwind activities and monitoring.

The 10-day wind roses display a "starry" aspect because of the fewer data that comprise them (800 data points per 10-day roses). A star effect also exists to some extent with the monthly roses, but disappear on the annual wind rose, where much data comprises the data base. With a long enough averaging time, the star phenomenon would vanish. The star, it should be emphasized, is due mainly to short data base, not bias. However, northerly bias was not removed from the 10-day roses, since the use of such short-term data would be mainly for comparing winds having a bias in a 10-day period in a given year with the10-year data. Bias was, of course, removed from the monthly and annual roses, since they have a multiplicity of uses.

THE ANNUAL WIND ROSE

The annual wind rose indicates, reading clockwise, a preponderance of winds from 300 to 10 degrees, and from 120 degrees to 180 degrees. Winds between 30 and 100 degrees are relatively rare, and winds between 190 and 280 degrees are less common than the first two categories mentioned. However, light winds between 190 and 280 degrees are much more common than light winds from the 300 to 10 degree category.

THE MONTH

Comparison of the monthly wind roses indicates definite changes in regimes. Possibly the best starting point for a discussion of these starts with May, a month in which the wind blows more equally from all directions than is true of any other month. However, the southeasterly quadrant in that month has an edge on the others.

An interesting feature is observable on the 10-day charts. The period from May 11-20 is very heavily loaded towards winds from the west, while the last 10 days are loaded with winds from the east. At this point, we can only surmise as to whether this is a transient or a permanent feature of May weather. However, there is a lasting shift to winds from the east half of the rose through June 20th, so this feature is probably real.

June is heavily loaded with winds out of the southeast. This is especially true over the first 20 days—which is the time at which air from the Gulf of Mexico invades deep into the heart of North America to bring the wettest time of the year to most of Minnesota and the Dakotas.

The last 10 days of June and the month of July bring in the hot southwesterly winds. Southwesterlies are especially prone to blow between the 21st and the 30th, not uncoincidentally the warmest time of the year.

The wind speeds are very light between the 21st and 30th. Of special interest on the 10-day charts at this time is an utter lack of winds out of the southeast and west-southwest over 12 knots. Strong winds out of the south-southwest are strikingly frequent, however. Though the feature is very well developed from the 21st to the 30th and last through to about August 20th.

August is strongly marked by the southwest winds. Note from the August rose that nearly all strong winds are from the southwest. During the last 10 days of August and into the first 10 days of September, northerly winds become relatively rare and southeasterly winds in excess of 12 knots appear once again. Southeasterlies take over from southwesterlies during the first 20 days of September, a phenomenon which is associated with the intrusion of Gulf of Mexico air back into the area and a secondary rainfall maximum. This is perhaps a "mirror-image" type phenomenon -- a tendency toward similar weather characteristics at those times equidistant from summer peaks and winter minema. It is about 40 days from the July temperature maximum (and rainfall minimum) around the 26th of July and the June and September rainfall peaks.

The wind shifts radically during the last 6 days of September—a feature corroborated by other weather data over the years. At this time, there is a sharp drop in rainfall, a sudden strong peak in barometric pressure, a sharp increase in sunshine, and a strong drop in temperature. Summer is suddenly over.

The roses for the last 10 days of September are right in step with these changes. Northwesterlies become common, and velocities increase.

October does mark a remission to summer in some respects. Southwesterlies become more common than in September, especially in mid-October -- coincident with the well-known historic rise in sunshine and mid-month temperature. The last ten days of the month, however, bring a shift to more northerly winds, lots of cloudiness, and a sharp temperature drop. This is the beginning of the wind turnaround that prevails strongly in November -- lots of northwesterlies.

There is a dearth of winds from the northeast to north-northeast from October through December 20th, but after the 21st they become common through the end of the month, largely at the expense of southwesterlies.

January marks the reign of the northwest wind. In the last 10 days of January, the time of the temperature minimum, the wind blows from 310 and 320 degrees, combined, over 15 percent of the time. Highly predominant winds from the northwestern quadrant persist.

February and March brings little change, except that March brings higher velocities. However, early April brings brisk winds and an increase in northeasterlies, while mid-April brings a sharp break and a switch to very prevalent southeasterlies. This is the beginning of the wet season, and the sudden end of wintry weather, returning us to May, when the wind likes to blow from all directions.

SOURCE: Annual, Monthly and 10-Day Wind Rose for Minneapolis-St. Paul, Minnesota, 1964-1973, 1974.

EXHIBIT B STREAMBED COMPOSITION

Mississippi River Group

RIVER OR STREAM	MOUTH	COUNTY OR COUNTIES	STREAMBED COMPOSITION AND REMARKS	SOURCE OF INFORMATION
Mississippi River		Anoka, Ramsey, Washington, Dakota, Hennepin	Upstream from Minnesota River—Sand and/or rocks and rubble bottom. Minnesota River Mouth—Pig's Eye Sewage Treatment Plant—mixture of sand and organic sludge bottom. Pig's Eye Sewage Treatment Plant—Lock and Dam No. 2 in Hastings—Organic sludge bottom.	East and South Minnesota River Pool; 1976.
Crow River	Mississippi River	Carver, Hennepin	Varies considerably through out, mud, sand rock; surficial geology determines general bottom types.	Pat Kennedy—Soil Conservationist for Hennepin County, Don Berg—Soil Conservationist for Carver County.
Crane Creek	Crow River	Carver		Same as above.
South Fork of Crow River	Crow River	Carver	Varies considerably according to surficial geology. Parts are sand and gravel other portions have a silt and clay bottom.	Same as above.
Sarah Creek	Crow River	Hennepin	Generally: clay bottom	Pat Kennedy—Soil Conservationist for Hennepin County, and Hennepin County Soil Survey.
Elm Creek	Mississippi River		Upper portions of stream—clay and silt bottom. Bottom—4-6 miles of stream is a alluvium mixture of materials.	Same as above.
Rush	Elm Creek		Large portions have been ditched. Bottom—muck or sand where the creek passes through peat areas. Other portions—clay or silt bottom.	Same as above.
Diamond	Elm Creek		Silt, clay bottom. Some portions run through or drain marshland and have a mucky bottom.	Same as above.
Shingle Creek	Mississippi River	Hennepin	Variable	Shingle Creek Watershed District; Barr Engineering
Bassett Creek	Mississippi River	Hennepin	Variable	Bassett Creek Watershed District; Barr Engineering
Minnehaha Creek	Mississippi River	Hennepin	Mixture of sand and gravel underlain by somewhat impervious clays. Portions flow over bedrock near Minnehaha Falls.	Minnehaha Creek Watershed District; E.A. Hickok & Associates
Rum River	Mississippi River	Anoka	Sand and/or rocks and rubble bottom	Environmental Assessments. Minnesota River Pool (11)
Cedar Creek	Rum River	Anoka	Sand, with some mucky areas, not as rocky as Rum River	Dick Swanson—Anoka County Extension Agent
Cracked Brook	Cedar Creek	Anoka	A sand bottom with some muck areas	Dick Swanson—Anoka County Extension Agent
Seelye Brook	Rum River	Anoka	A sand bottom with some muck areas	Same as above.
Trott Brook	Rum River	Anoka	A sand bottom with some muck areas	Same as above.
Ford Brook	Rum River	Anoka	A sand bottom with some muck areas	Dick Swanson—Anoka County Extension Agent
Coon Creek	Mississippi River	Anoka	A sand bottom;Coon Creek was excavated as a county ditch	Coon Creek Watershed District Israilson— Engineer for watershed
Sand Creek	Coon Creek	Anoka	Sand bottom. Sand creek was excavated as a county ditch.	Same as above.
Rice Creek	Mississippi River	Anoka, Ramsey, Washington	Sand and gravel bottom	Rice Creek Watershed District, E.A. Hickok & Associates

RIVER OR STREAM	MOUTH	COUNTY OR COUNTIES	STREAMBED COMPOSITION AND REMARKS	SOURCE OF INFORMATION
Clearwater	Rice Creek	Washington, Anoka	Sand and gravel bottom	Rice Creek Watershed District and E.A. Hickok & Associates
Hardwood	Rice Creek	Washington, Anoka	Sand and gravel bottom	Same as above.
Vermillion River	Mississippi River	Scott, Dakota	Mouth of River to 1/2 the distance to Hastings—70% sand, 30% silt. Dam to Hastings to 1/2 distance to mouth—30% Ledge Rock, 40% Boulder, 20% Rubble, 10% Gravel. Upper Portion—50% Sand, 40% Silt, 10% Rubble.	Minnesota Division of Game and Fish, Research and Planning Section, Stream Survey Report Vermillion River T-49 Dakota Co. November 11, 1958.
Cannon River	Mississippi River	Dakota	The bottom is sand and gravel until it enters Byllesby Lake where sediments overly stratified silt and sand which overlies sand and gravel.	Steven Undley—Soil Scientist Dakota County
Minnesota River Group				
Minnesota River	Mississippi River	Scott, Hennepin, Carver Dakota	Upstream from Chaska—sand, and/or rock rubble bottom. Chaska to Mississippi—Mixture of sand and organic ma and organic sludge	Environmental Assessments, Minnesota River Pool (11)
Sand Creek	Minnesota	Scott	Upstream portions—(In Highlands), gravel overlying glacial till, flowing on a bedrock shelf from a mile upstream of the falls at Jordan to downstream from the falls, Portions in Minnesota River Valley: silt and sand with an alluvial deposit at the mouth.	George Pascal-Scott County Soil Conservationist
Porter Creek	Sand Creek	Scott	Predominately a gravel over glacial till bottom, some portions of bottom mucky where it crosses peat areas.	George Pascal—Scott County Soil Conservationist
Raven Stream	Sand Creek	Scott	Same as above.	Same as above.
Credit River	Minnesota River	Scott	Primarily a drainage ditch with a mud and silt bottom, possibly bedrock bottom near Savage.	Same as above.
Eagle Creek	Minnesota River	Scott	99% shifting sand with the remainder gravel-source at "Boiling Springs"; other springs may be located along the creek	Minnesota Department of Natural Resources, Division of Game and Fish, Section of Fisheries Stream Survey Evaluation Report, Eagle Creek, Minn. Branch Scott County 1967.
Carver Creek	Minnesota River	Carver	Upper Portions—flat bottoms mud and silt segment which descends valley wall a gravel, sand and rock bottom—Portion in Minnesota River Valley of alluvial deposits.	Don Berg, Carver County Soil Conservationist
Silver Creek	Minnesota River	Carver	Upper portions—flat and bottoms mud and silt. segment which descends valley wall—gravel, sand and rock bottom—Portion in Minnesota River Valley—Alluvial deposits	Don Berg-Carver County Soil Conservationist
Beven Creek	Silver Creek	Carver	Same as above.	Same as above
Chaska Creek	Minnesota River	Carver	Same as above	Same as above
Bluff Creek		Carver	Same as above	Same as above
Purgatory Creek	Minnesota River	Hennepin	Bottom varies considerably. Possible spring locations along the stream	Riley-Purgatory Watershed District; Barr Engineering
Riley Creek	Minnesota River	Hennepin	Bottom varies considerably	Same as above
Nine Mile Creek	Minnesota River	Hennepin	Section from 94th Street (Eden Prairie) to the river—steep, bottom is cobble stone and sand. Above 94th street—Bottom is soft organic or mucky	Nine Mile Creek Watershed District; Barr Engineering

EXHIBIT B GEOLOGY AND GEOMORPHOLOGY

St. Croix Group

RIVER OR STREAMS	MOUTH	COUNTY	STREAMBED COMPOSITION AND REMARKS	SOURCE OF INFORMATION
St. Croix	Mississippi River	Washington	Upstream of Stillwater: Sand and/or rocks and rubble bottom. Below Stillwater: mixture of sand and organic sludge	Environmental Assessment, Minnesota River Pool (11)
Mill Creek	St. Croix River	Washington	Trout stream, alternates between pools & riffles pools in general—silt and sand bottom, riffles in general—have a rock and gravel bottom	Fish & Wildlife Technical Report, 1976 (7) and Tom Waters, U of M Wildlife & Fisheries
Lawrence Creek	St. Croix River	Washington	Same as above.	Same as above.
Brown's Creek	St. Croix River	Washington	Trout stream. bottom is sand and glacial till until it enters the St. Croix Valley where bottom becomes bedrock	Roger Johnson—Soil Scientist Washington County, Fish Wildlife Technical Report, 1976 (7)
Trout Brook	St. Croix River	Washington	Trout stream;—upper portion sandy (1 mile) Lower portion in the St. Croix Valley—bedrock	Same as above.
Valley Branch	St. Croix River	Washington	No information available	Valley Branch Watershed District; Barr Engineering
Silver Creek	St. Croix River	Washington	Upper portion sand, lower portion, in the St. Croix Valley, bedrock	Roger Johnson—Soil Scientist Washington Co.
Kenaley's Creek	Blackdog Creek	Dakota	Trout stream, 65% detritus, 7% sand, 3% silt 25% clay	Minn. Division of Game & Fish Section of Fisheries Fish Inventory 1967
Eagle Creek	Blackdog Creek	Dakota	Trout stream; alternates between pools riffles, pools in general silt & sand bottom, riffles in general a rock and gravel bottom	Fish & Wildlife Technical Report, Tom Waters U of M
Battle Creek		Ramsey, Washington	Changes everytime it floods. Bottom of silt, sand clay	Ramsey & Washington Metro Watershed District; Barr Engineering
Fish Creek		Ramsey, Washington	Silt, sand and bedrock	Same as above.

(Miscellaneous Group)

RIVER OR STREAMS	MOUTH	COUNTY	STREAMBED COMPOSITION AND REMARKS	SOURCE OF INFORMATION
Pioneer Creek		Hennepin	Silt and clay bottom. Some portions mucky where stream passes through marsh areas	Pat Kennedy—Soil Conservationist, Hennepin County
Deer Creek		Hennepin	Same as above.	Same as above.

SOURCE: Federal Water Pollution Control Agency, 1966, Metropolitan Watershed Districts, Department of Natural Resources Fish Surveys, Knowledgeable residents.

EXHIBIT E PLANT ASSOCIATIONS

AQUATIC COMMUNITY

SUBMERGED PLANTS
Sago pondweed (*Potamogeton pectinatus*)
Clasping pondweed (*Potamogeton richardsonii*)
Floating leaf pondweed (*Potamoceton natans*)
Bushy pondweed (*Najas flexilis*)
Wild celery (*Vallisneria americana*)
Canada waterweed (*Anacharis canadensis*)
Coontail (*Ceratophyllum demersum*)

FLOATING PLANTS
Water lily (*Nymphae spp.*)
Water lily (*Nuphar spp.*)
Duckweed (*Lemna spp.*)
Duckweed (*Spirodela polyrhiza*)

EMERGENT PLANTS
Common cattail (*Typha latifolia*)
Giant burreed (*Sparganium eurycarpum*)
Reed (*Phragmites maximus*)
Hardstem bulrush (*Scirpus acutus*)
River bulrush (*Scripus fluviatilis*)

BOTTOMLAND HARDWOODS

DOMINANT TREE SPECIES
Box elder (*Acer negundo*)
Silver maple (*Acer saccharinum*)
American elm (*Ulmus americana*)
Willow (*Salix spp.*)
Cottonwood (*Populus deltoides*)
Green ash (*Fraxinus pennsylvanica*)
Basswood (*Tilia americana*)
Black ash (*Fraxinus nigra*)
Hop hornbeam (*Ostrya virginiana*)

DOMINANT SHRUBS AND HERBS
Hazel (*Corylus spp.*)
Chokecherry (*Prunus virginiana*)
Gooseberry (*Ribes spp.*)
Red osier dogwood (*Cornus stolonifera*)
Sweet cicely(*Osmorhiza spp.*)
Canadian nettle (*Laportea canadensis*)
Poison Ivy (*Toxicodendron radicans rhus*)
Frost grape (*Vitis riparia*)
Elderberry (*Sambucus canadensis*)
Nettle (*Urtica dioica*)
Cut grass (*Leersia virginica*)
Sedge (*Carex spp.*)

EXHIBIT E PLANT ASSOCIATIONS

TAMARACK AND WHITE CEDAR SWAMP COMMUNITY

DOMINANT TREE SPECIES
Tamarack (*Larix laricina*)
Black spruce (*Picea mariana*)
White Cedar (*Thuja occidentalis*)
Paper birch (*Betula papyrifera*)

DOMINANT SHRUBS AND HERBS
American hazelnut (*Corylus americana*)
New Jersey tea (*Ceanothus americana*)
Blueberry (*Vaccinium angustifolium*)
Raspberry (*Rubus spp.*)
Hog peanut (*Amphicarpa bracteata*)
Sedge (*Carex pennsylvanica*)
Braken fern (*Pteridium aquilinum*)

SUGAR MAPLE–BASSWOOD COMMUNITY

DOMINANT TREE SPECIES
Sugar maple (*Acer saccharum*)
Basswood (*Tilia americana*)
Slippery elm (*Ulmus rubra*)
American elm (*Ulmus americana*)
Hop hornbeam (*Ostrya virginiana*)

DOMINANT SHRUBS AND HERBS
Virginia creeper (*Parthenocissus vitaceae*)
Climbing bittersweet (*Celastrus scandens*)
Red-berried elder (*Sambucus pubens*)
Sweet cicely (*Osmorhiza claytoni*)
Large-flowered bellwort (*Uvularia grandiflora*)

OAK SAVANNA COMMUNITY

DOMINANT TREE SPECIES
Burr oak (*Quercus macrocarpa*)
White oak (*Quercus alba*)
Northern pin oak (*Quercus ellipsoidalis*)

DOMINANT SHRUBS AND HERBS
Hazelnut (*Corylus americana*)
Rose (*Rosa spp.*)
Big bluestem (*Andropogon gerardi*)
Little bluestem (*Andropogon scoparius*)
Porcupine grass (*Stipa spartea*)
Hoary puccoon (*Lithospermum canescens*)
New Jersey tea (*Ceonothus americana*)
Dogwood (*Cornus spp.*)

EXHIBIT E PLANT ASSOCIATIONS

UPLAND PRAIRIE COMMUNITY

DOMINANT TREE SPECIES
None

DOMINANT SHRUBS AND HERBS
Little bluestem (Andropogan scoparius)
Big bluestem (Andropogan gerardi)
Grama grass (Bouteloua curtipendula)
Grama grass (Bouteloua hirsuta)
June grass (Koeleria cristata)
Indian grass (Sorgastrum nutans)
Porcupine grass (Stipa spartea)
Switch grass (Panicum spp.)
Sand grass (Calamovilfa longifolia)
Sedge (Carex spp.)
Wolfberry (Symphoricarpus occidentalis)
Lead plant (Amorpha canescens)
Dogwood (Cornus spp.)
Bluebell (Campanula rotundifolia)
Paint brush (Castilleja spp.)
Thistle (Circium spp.)
Draba (Draba reptans)
Prairie smoke (Geum Triflorum)
Sunflower (Helianthus laetiflorus)
Prairie phlox (Phlox pilosa)
Rose (Rosa spp.)
Prickley Ash (Zanthoxylum americanum)

STEEP SLOPE COMMUNITY

DOMINANT TREE SPECIES
American elm (Ulmus americana)
Slipperly elm (Ulmus rubra)
Basswood (Tilia americana)
Green ash (Fraxinus pennsylvanica var. subintegerrima)
Box elder (Acer negundo)
Cottonwood (Populus deltoides)
Red cedar (Juniperus virginiana)
Ironwood (Ostrya virginiana)
Butternut (Juglans cinerea)
Oaks (several) Quercus spp.)
Paper birch (Betula papyrifera)
Northern red oak (Quercus borealis)
Pin oak (Quercus palustris)
Bur oak (Quercus macrocarpa)
American elm (Ulmus americana)
Bitternut hickory (Carya cordiformis)
Butternut (Juglans cinerea)
Hackberry (Celtis occidentalis)
Silver maple (Acer saccharinum)
Black ash (Fraxinus nigra)

Willow (Salix spp.)
White pine (Pinus strobus)
Red pine (Pinus resinosa)
Balsam fir (Abres balsamea)

DOMINANT SHRUBS AND HERBS

Red-berried elder (Sambucus pubens)
Missouri gooseberry (Ribes missouriense)
Prickly gooseberry (Ribes cynosbati)
Black raspberry (Rubus occidentalis)
Prickly ash (Xanthoxylum americanum)
Hazel (Corylus americana)
Wolfberry (Symphoricarpos occidentalis)
Redosier dogwood (Cornus stolonifera)
Racemose dogwood (Cornus racemosa)
Willow (Salix longifolia)
Common elder (Sambuccus canadensis)
River-bank grape (Vitis riparia)
Yellow Jewelweed (Impatiens pallida)
Nettle (Urtica procera)
Sweet cicely (Osmorhiza spp.)
Kentucky bluegrass (Poa pratensis)
Smooth sumac (Rhus glabra)

WHITE OAK FOREST COMMUNITY

DOMINANT TREE SPECIES

White oak (Quercus alba)
Red oak (Quercus rubra)
Pin oak (Quercus ellipsoidalis)
Black cherry (Prunus serotina)
Burr oak (Quercus macrocarpa)

DOMINANT SHRUBS AND HERBS

Gray dogwood (Cornus racemosa)
False Solomon's seal (Smilacina racemosa)
Hog peanut (Amphicarpa bracteata)
Raspberry (Rubus spp.)
Polypody (Polypodium spp.)
Maidenhair fern (Adiantum pedatum)
Sedge (Carex pennsylvanicus)

NORTHERN PIN OAK FOREST COMMUNITY

DOMINANT TREE SPECIES

Northern pin oak (Quercus ellipsoidalis)
White oak (Quercus alba)
Burr oak (Quercus macrocarpa)
Red oak (Quercus rubra)
Paper birch (Betula papyrifera)

DOMINANT SHRUBS AND HERBS

American hazelnut (Corylus americana)
New Jersey tea (Ceanothus americana)
Blueberry (Vaccinium angustifolium)
Raspberry (Rubus spp.)
Hog peanut (Amphicarpa bracteata)
Sedge (Carex pennsylvanica)
Bracken fern (Pteridium aquilinum)

EXHIBIT F

MAJOR SPECIES COMPOSITION OF MARSCHNER'S ORIGINAL VEGETATION CLASSIFICATIONS

PRAIRIE

WET PRAIRIES, MARSHES, AND SLOUGHS: Marsh-grasses, Flags, Reeds, Rushes, Wild Rice, with Willow and Alder-brush in places

ASPEN-OAK LAND: Aspen, generally dense, but small in places, with scattered oaks, and few elms, ash and basswood.

OAK OPENINGS AND BARRENS: Scattered trees and groves of oaks (mostly bur) of scrubby form with some brush and thickets and occassionally with pines.

BIG WOODS: Oaks (bur, white, red and black), elm, basswood, ash, maple, hornbeam, aspen, birch, wild cherry, hickory, butternut, black walnut with some white pine.

RIVER-BOTTOM FOREST: Elm ash, cottonwood, boxelder, oaks, basswood, soft maple, willow, aspen, hackberry.

CONIFER BOGS AND SWAMPS: Spruce, tamarack, cedar and balsam.

EXHIBIT G VEGETATION AREAS OF SPECIAL SIGNIFICANCE

(Indexed to Plate 12)

COUNTY: ANOKA

		LOCATION			APPROXIMATE	
NUMBER	FEATURE	SEC.	T	R.	ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Allison Savanna	2	33	23	80	Nature Conservancy tract, oak savanna, prairie
2	Anoka-Ramsey Junior College Natural Area		31		27	School Site
3	Anoka School Site		32	25	81	School Site
4	Bunker Prairie	12, 35, 36	31, 32	24	1800	Park Reserve, game habitat, education area
5	Camp Lockeslea				19	Scout camp
6	Landscape Career Center		32	25	300	School Site
7	Locke Park	15	30	24	104	
8	Martin Lake	33	33	22	130	4–H and Scout Groups, wildlife
WILDLIFE AREAS						
9	Bethel WMA	25, 26	34	24	360	Bethel
10	Carlos Avery WMA	NE Anoka County			22,750	Anoka and Chisago County
11	Cedar Creek Natural History Area		34	23	5,700	(Area is also Anoka-Isanti State Game Refuge) National Natural Landmark
12	Lino Lakes Park Reserve	Lino Lakes				Game habitat. shallow lakes, Blue Heron Rookery. Endangered Natural and Scientific Area
13	Lino Lakes—Additional area				6,450	Acreage includes park reserve and unprotected area.
14	Linwood-Tamarack Lakes	9, 16	33	22	1,190	Aquatic, proposed regional park area
15	Wild Rice Bed	several	33	22, 23	630	Waterfowl area—proposed natural and scientific area.
16	Wild Rice Bed	14, 23	33	23	69	Waterfowl area—"Natural and Scientific Area"
17	Unnamed	6, 7	32	24	1,280	Wooded Shoreline of Cedar Creek, Scenic
18	Unnamed	4, 5	33	25	795 A	Proposed natural and scientific area.

COUNTY: CARVER

		LOCATION			APPROXIMATE	
NUMBER	FEATURE	SEC.	T.	R.	ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Camp Manakiki (Pillsbury Camp)	10	116	25	70	Dense maple forest, burial mounds/private
2	Camp Independence	16	116	23	63	Heavily forested and marsh/Girls Camp
3	Chaska Natural Resource Center	4 or 5	115	23	30	Variety of plant, wooded bluffs/school site
4	Kaster Wildlife Area	12	117	25	40	Private acreage managed for wildlife habitat, education area
5	U of M Landscape Arboretum	17	116	23	560	Scenic timber, rare flora, proposed scientific and natural area
WILDLIFE AREAS						
6	Assumption WMA	7	114	25	67	Wildlife habitat, waterfowl
7	Schneewind WMA	3,33,34	115,116	25	161	Wildlife habitat
8	Gravel Pit 10 WMA	20	116	26	3.2	Wildlife habitat
9	Gravel Pit 11 WMA	17	116	26	2.7	Wildlife habitat
10	Waconia WMA	2,3,34–36	116,117	25	36	Wildlife habitat
ADDITIONAL PROJECT 80 AREAS						
11	Carver Park Reserve (Area)	several	116	24	270	Exceptional marsh, trumpeter swan nesting area
12	Carver Park Reserve (Area)	several	116	24,23	3,840	Big woods, Tamarack swamp, aquatic
13	Tamarack Swamp	6	117	25	40	Scientific and Natural area Unique Tamarack swamp, game habitat

EXHIBIT G VEGETATION AREAS OF SPECIAL SIGNIFICANCE (Indexed to Plate 12)

COUNTY: DAKOTA

			LOCATION			
NUMBER	FEATURE	SEC.	T.	R.	APPROXIMATE ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Camp Butwin	33	27	23	230	Mixed hardwood Forest, Lake/private
2	Camp Lynwood	12	114	21	76	Wooded/ponds/private
3	Friendly Marsh Env. Educational Area	25	28	22	25	Aquatic, marsh area
4	Interstate Environ. Educational Area	17	28	22	35	Nature study, marsh, aquatic, wildlife habitat
5	Macalester College—Katherine Ordway National History	11	27	22	280	Oak and birch, savanna/private
6	Rogers Lake Environ. Educational Area	35	28	23	2.5	Marsh area
7	Thomas Irvine Dodge Natural Area Site	19	28	22	130	Marsh, oak, conifers, prairie/private
WILDLIFE AREAS						
8	Gores Pool WMA	several	114	16	5,310	Wildlife habitat
9	Hastings WMA	2	114	17	158	Wildlife habitat
10	Ravenna WMA					Wildlife habitat
11	Wood Duck WMA	16,21	114	16		Wildlife habitat
12	Bellwood State Game Refuge	22,23,26	114	17	2,240	Wildlife habitat
13	Carleton College State	29,30	112	19	600	Wildlife habitat
14	Wetland	33	113	20	30	Wetlands, game habitat
15	Apple Valley	Apple Valley				Scenic timber
16	Bluff	1	113	19	300	Scenic timber, bluff
17	Fort Snelling State Park	several	28	23	2,105	Educational area, lotus bed
18	Richard J. Dores Memorial Hardwood Forest	S. E. Dakota County			2,000,000	Areas of Scenic timber (Acreage includes parts of Dakota, Dodge, Fillmore, Goodhue, and Houston Counties)
19	Cannon River Scout Reservation		112	18	450	(Goodhue and Dakota Co.s) Lake Byllesby Reservoir

COUNTY: HENNEPIN

			LOCATION			
NUMBER	FEATURE	SEC.	T.	R.	APPROXIMATE ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Boys Club Camp	15	117	24	100	Swamp, wooded area/private
2	Camp Minnetrista	15	117	24	106	Marsh area, wildlife habitat/Scout camp
3	Crow Hassan Park Reserve	several	120	23,24	2500	Maple-basswood scenic timber, aquatic, prairie remnant
4	Elm Creek Park Reserve	several	119,120	21,22	2800	Maple-basswood, scenic timber, Pin Oak, Floodplain, aquatic
5	Eloise Butler Wildflower		29		13	Bird sanctuary, wildflowers, wooded area
6	Hardscrabble Point Woods	26	117	24	23	Big woods
7	Hyland Lake Park Reserve	several	116	21	1000	Pin oak, maple-basswood, aquatic
8	Lake Rebecca Park Reserve	several	118,119	24	1900	Maple-basswood, aquatic, floodplain, scenic timber
9	Lowry Woods	31	118	23	14	Big Woods/Nature Conservancy tract
10	Lyndale Park Rose Gardens	9	28	24	35	Bird sanctuary, waterfowl
11	Margaret Tusler Sanctuary	26	117	24	8	Bog/Nature Conservancy tract
12	Minnehaha Falls Lower Glen	17	28	23	50	Lowlands bog
13	Minnesota Valley Nature Center	5	116	21	52	Upland and floodplain forest, 2 of largest cottonwoods in the state
14	Morris T. Baker Park	several	118	23	1700	Maple-basswood, aquatic, Tamarack
15	Palmer Lake Nature Area	26,27	119	21	58	Marsh, Tamarack, aquatic
16	South Minnehaha Addition	20	28	23	20	Virgin prairie, upland hardwood forest
17	The Lotus Beds	34	117	24	4.5	Rare flora/Nature Conservancy tract
18	W. River Bank & Seven Oaks	31,33	117	23	2mi	Virgin prairie, scenic timber

EXHIBIT G

PLANT ASSOCIATIONS

COUNTY: HENNEPIN

			LOCATION		APPROXIMATE	
NUMBER	FEATURE	SEC.	T.	R.	ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
19	Wood Lake Nature Center	28	116	24	150	Alkaline marsh, waterfowl
20	Ferndale Marsh	1,2	117	23	30	Aquatic/Nature Conservancy tract
WILDLIFE MANAGEMENT AREAS						
21	Schmidt WMA	36	120	22	50	Wildlife habitat
22	Minnetonka State Game Refuge	several	117	24	3,200	Wildlife habitat
ADDITIONAL PROJECT 80 AREAS						
23	Wildlife, Nature Study Area	22	117	24	190	Prairie remnant, scientific and natural area, proposed historic significance
24	Anderson Lakes	18,19	116	22	200	Proposed Natural and scientific area. Proposed park
25	Purgatory Creek	several	Eden Prairie		10mi	Rare flora, proposed scientific and natural area
26	Minnesota River Bottoms and Bluffs	several	Eden Prairie		6–7 mi	Proposed natural and scientific area, historic signigicance
27	Riley Creek & Riley Lake Natural Area	several	Eden Prairie		5 mi	Proposed natural and scientific area, historic significance
28	Kucker Woods	5	Eden Prairie		40	Virgin Maple-basswood-scenic timber, rare flora
29	Nine Mile Creek	Eden Prairie			40	Proposed scientific and natural area
30	Boher Co. Park		118	23	1,700	Scenic timber
31	Lake Sarah Co.Park	33,34	119	24	156	Scenic timber
32	Miss. River Pool—Coon Rapids Dam	several	31	24	225	Henn. and Anoka Co., scenic timber
33	Wawatasso Island Co. Park	36	117	24	35	Scenic timber
34	Goose Island Co. Park	30	117	23	3	Scenic timber

COUNTY: RAMSEY

			LOCATION		APPROXIMATE	
NUMBER	FEATURE	SEC.	T.	R.	ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Battle Creek Regional Park	2,3,4,11	28	22	566	Educational area
2	Lake Josephine	2	29	23	45	Little Lake Josephine marsh
3	Lakewood State Junior College Nature Preserve		30	22	25	Mature hardwood forest/School site
4	St. Paul's Como Zoo	22	29	23	10	Wildlife/waterfowl, educational area
5	Schmidt Park	33	30	23	40	Marsh
6	Round Lake WPA	21	30	23	Round Lake	Waterfowl habitat
7	Hill Farm State Game Refuge	4-9,17,18 6,3	30	22,23	4,800	Wildlife habitat, statuatory refuge Private ownership

COUNTY: SCOTT

			LOCATION		APPROXIMATE	
NUMBER	FEATURE	SEC.	T.	R.	ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Scott County Park	10	114	22	144	Includes Regional Parks and Park Reserves, Municipal and County Parks Education area, woods, uplands
2	Murphy-Hanrahan Park Reserve	several	114	24	1,500	Includes part of Dakota Co., upland open areas, wooded, aquatic, wildlife habitat
3	James W. Wilkie Park Reserve		115	21		Floodplain, aquatic, wildlife habitat

EXHIBIT G PLANT ASSOCIATIONS

COUNTY: SCOTT

		LOCATION			APPROXIMATE	
NUMBER	FEATURE	SEC.	T.	R.	ACREAGE	NOTES
WILDLIFE AREAS						
4	Karnitz WMA	11–14	113	24	184	Wildlife habitat
5	Mahoney's WMA	24,25	113	25	109	Wildlife habitat
6	Michel WMA	27,28,34	113	24	108	Wildlife habitat
7	St. Patrick's WMA	17–20	113	22	81	Wildlife habitat
ADDITIONAL PROJECT 80 AREAS						
8	Three areas correspond	2,11	113	22	240	Aquatic and upland habitat
	to (11-N41-13)	19	113	22	40	Wild rice beds
	Project 80	several	113	22	391	Marsh wildlife
9	"Lost 80"	31	113	25	80	Rare flora, proposed scientific and natural area
10	River Bluffs		114,115	23	5–6mi	Scenic timber, fall color
11	Lawrence, Belle Plaine S.W.	several	114	24		Scenic timber, game habitat
12	Unglaciated Area	28	115	23	40	Rare Flora, endangered
13	Mn. River Floodplain	several	116	22	800	Blue Lake Co. Park, Scenic timber

COUNTY: WASHINGTON

		LOCATION			APPROXIMATE	
NUMBER	FEATURE	SEC.	T.	R.	ACREAGE	NOTES
ENVIRONMENTAL EDUCATION AREAS						
1	Afton State Park	several	27,28	20	675+	Scenic timber
2	Belwin Outdoor Educational Lab.	9,10	28	20	500	Aquatic, conifers/School site
3	Grey Cloud Island	31	27	22	18	Bird sanctuary, conifers/private
4	Lee and Rose Warner NC				300	Upland hardwood forest, wildlife habitat
5	William O'Brien State Park				530	Scenic timber, wildlife habitat
WILDLIFE AREAS						
6	Rutstrum WMA	18	32	19	25	Wildlife habitat
7	Bayport WMA					
8	Jackson WMA					
9	St. Croix River State Game Refuge					Wildlife habitat, statuatory, privately-owned
10	Stillwater State Game Refuge					Wildlife habitat, statuatory, privately-owned
ADDITIONAL PROJECT 80 AREAS						
11	St. Croix River Islands	several	30,31,32	20	500	Wildlife habitat
12	Marshlands	several	31,32	21	1800-2000	Now drained. Wildlife habitat, proposed scientific and natural area

Env–	Environment
NC–	Nature Center
WMA–	Wildlife Management Area
WPA–	Wildlife Production Area

EXHIBIT H

INVERTEBRATES—A SUMMARY LISTING OF MAJOR GROUPS

SPONGES—Porifera

Grow in water as encrusting porous masses to many centimeters in diameter.
Genera common here are:

- *Spongilla*
- *Meyenia*
- *Hetermeyenia*

MOSS ANIMALS—Bryozoa

Colonial; mossy appearing or as lacy patterns of recumbent stalks on gelatinous masses up to many centimeters in diameter; on sticks, stones, pilings.
Genera here are:

- *Paludicella*
- *Fredericella*
- *Plumatella*
- *Pectinatella*
- *Cristatella*

SEGMENTED WORMS (Terrestrial)
Earthworms

They are among the most important invertebrates in the terrestrial ecosystems in their role as detritus consumers, soil movers and as food for all groups of vertebrates. In the latter function the earthworms constitute a prime concentration point for passage of toxic chemicals to higher levels (vertebrates) in the food chains.
Common genera and species are:

- *Lumbricus terrestris* (the introduced nightcrawler)
- *L. rubellus*
- *Helodrilus* (several species)
- *Octolasium*
- *Diplocardia*

(Aquatic)
Leeches

Common to abundant in open water of all types and in mud along banks and shores. Their food includes a wide spectrum, from species that feed on detritus and invertebrates to those that feed on vertebrate blood. Leeches are an important food for many aquatic vertebrates but the magnitude of their role in the food chains is not known.
Common species are:

- *Pisicola punctata*
- *P. milneri*
- *Placobdella montifera*
- *P. pediculata*
- *P. parasitica*
- *P. rugosa*
- *P. hollensis*
- *Theromyzon occidentale*
- *Glossiphonia heteroclita*
- *G. complanata*
- *Helobdella stagnalis*
- *Actinobdella inequiannulata*
- *Erpobdella punctata*
- *Nephelopsis obscura*
- *Macrobdella decora*
- *Haemopis marmoratis*
- *H. lateralis*
- *H. grandis*
- *H. plumbeus*

EXHIBIT H ANIMAL POPULATIONS

LAND SNAILS (with shells)

Representing a major link in food chains as food for vertebrates, the land snail populations have declined drastically in the last 30 years. In highly urbanized areas along the wooded bluffs and floodplains nearly all species are very rare or absent. Their habitat is moist soil and litter of forests and damp meadows.
Common genera and species are:

- *Succinea* (3 spp.)
- *Carychium*
- *Vertigo*
- *Gastrocopta*
- *Pomatiopsis*
- *Cionella*
- *Pupoides*
- *Anguispira alternata*
- *Helicodiscus*
- *Discus*
- *Retinella*
- *Euconulus*
- *Punctum*
- *Striatura*
- *Paravitrea*
- *Zonitoides*
- *Strobilops*
- *Vallonia*
- *Polygyra* (many spp.)

Slugs (snails without shells)

A few species occur here, one a garden pest.

CRUSTACEA—small—Eucrustacea

As a group these are an important part of the plankton in all kinds of waters.
They include:

Fairy shrimp
- *Chirocephalus*
- *Streptocephalus*
- *Eubranchipus*

Conchostraca—represented by
Lynceus brachyurus

These appear in their active stages in the life cycle in very temporary ponds in early spring, sometimes in immense numbers.

Clam shrimp—ostracods—in many kinds of waters.
Genera are:

- *Darwinula*
- *Cypridopsis*
- *Potamocypris*
- *Notodromas*
- *Cyprois*
- *Candona*
- *Cypricercus*
- *Cyprinotus*
- *Ilyocypris*
- *Cyclocypris*
- *Cypria*
- *Physocypria*
- *Limnocythere*
- *Eutocythere*

Water fleas—Cladocera

Cladocerans are inhabitants of many types of waters, those species that are limnetic forming part of the plankton.
Genera are:

- Polyphemus
- Leptodora
- Monospilus
- Holopedium
- Sida
- Latona
- Diaphanosoma
- Chydorus
- Leydigia
- Eurycercus
- Pleuroxus
- Alona
- Acroperus
- Camptocercus
- Kurzia
- Daphnia (4 spp.)
- Scapholeberis
- Simocephalus
- Bosmina
- Ceriodaphnia
- Moina
- Ophryoxus
- Streblocercus
- Acantholeberia
- Illyocryptus
- Macrothrix

Copepods, like the Cladocerans in habitat distribution, are another important plankton group. Some species are parasitic.
Genera are:

- Osphranticum
- Diaptomus (many spp.)
- Mesocyclops
- Cyclops
- Orthocyclops
- Eucyclops
- Ectocyclops
- Paracyclops
- Canthocamptus
- Attheyella
- Attheyella
- Bryocamptus
- Echinocamptus

MALACOSTRACA

Amphipods

Although there are relatively few species of amphipods in this region, they often constitute a major link in the food chains:

Hyalella azteca—abundant in some northern lakes.
Gammarus (several spp.)—in shallow waters of streams and lakes
Crangonyx (several spp.)—in springs, ponds and brooks

Isopods (Sow bugs)

Isopods, represented by both aquatic and terrestrial species, occupy a broad spectrum of damp to aquatic habitats but their level of participation in the biotic web structure is not well known. Some may form an important food source bridge from invertebrate to all small vertebrates.
Genera are:

- Aquatic
  - Lirceus
  - Asellus

Terrestrial

- *Armadillidium*
- *Aniscus*
- *Porcellionides*
- *Cylisticus*
- *Trachelipus*
- *Porcellio*

Crayfish

Crayfish, the largest of our invertebrates, are a major food link between invertebrates and aquatic and shoreline vertebrates, including fish, turtles, birds and mammals. Genera and species in the region are:

- *Procambarus gracilia*
- *P. blandingi*
- *Orconectes rusticus*
- *O. propinquus*
- *O. immunis*
- *Orconectes virilis*
- *O. obscurus*
- *Cambarus bartoni*
- *C. diogenes*
- *C. fodiens*

Arachnids (harvestmen, spiders, mites and ticks)

This large group of important arthropods constitutes relatively unknown but recognized important group in the biota, as both predator and prey. Ticks are considered pest species and they have a potential for disease transmission.

Insects

Insects, as a primary unit in all ecosystems, are so numerous and diverse in form, function and habitat distribution that no overall summary description is possible here. Important groups, especially aquatic forms, are discussed in later sections. Insects are probably basic links in all ecosystem food webs.

Orders—major aquatic groups:

Hemiptera	True bugs
Odonata	Damselflies, dragonflies
Plecoptera	Stoneflies
Ephemeroptera	Mayflies
Diptera	Flies, mosquitos, midges
Lepidoptera	Moths, butterflies
Coleoptera	Beetles
Neuroptera	Dobson flies, fish flies, lace wings
Tricoptera	Caddisflies

SOURCE: Taxonomic Keys to the Common Animals of the North Central States, Exclusive of the Parasitic Worms, Insects and Birds, 1955.

EXHIBIT I

SPECIES OF FISH FOUND IN THE METROPOLITAN MINNEAPOLIS – ST. PAUL AREA

Petromyzontidae – lampreys

Chestnut lamprey	*Ichthyomyzon castaneus*
Silver lamprey	*Ichthyomyzon unicuspis*

Acipenseridae – sturgeons

Shovelnose sturgeon	*Scaphirhynchus platorynchus*
Lake Sturgeon	*Acipenser fulvescens*

Polyodontidae – paddlefishes

Paddlefish	*Polyodon spathula*

Lepisosteidae – gars

Longnose gar	*Lepisosteus osseus*
Shortnose gar	*Lepisosteus platostomus*

Amiidae – bowfins

Bowfin	*Amia calva*

Clupeidae – herrings

Gizzard shad	*Dorosoma cepedianum*

Salmonidae – trouts

Rainbow trout	*Salmo gairdneri*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*

Hiodontidae – mooneyes

Goldeye	*Hiodon alosoides*
Mooneye	*Hiodon tergisus*

Umbridae – mudminnows

Central mudminnow	*Umbra limi*

Esociade – pikes

Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*

Cyprinidae—minnows and carps

Stoneroller	Campostoma anomalun
Northern redbelly dace	Chrosomusuaos
Carp	Cyprinus carpio
Ozark minnow	Dionda nubila
Brassy minnow	Hybognathus hankinsoni
Horneyhead chub	Hybopsis biguttata
Silver Chub	Hybopsis storeriana
Golden shiner	Notemigonus crysoleucas
Pallid shiner	Notropis amnis
Pugnose shiner	Notropis anogenus
Emerald shiner	Notropis atherinoides
River shiner	Notropis blennius
Common shiner	Notropis cornutus
Bigmouth shiner	Notropis dorsalis
Blackchin shiner	Notropis heterodon
Blacknose shiner	Notropis heterolepis
Spottail shiner	Notropis hudsonius
Rosyface shiner	Notropis rubellus
Spotfin shiner	Notropis spilopterus
Mimic shiner	Notropis volucellus
Bluntnose minnow	Pimephales notatus
Flathead minnow	Pimephales promelas
Bullhead minnow	Pimephales vigilax
Blacknose dace	Rhinichthys atratulus
Longnose dace	Rhinichthys cataractae
Creek chub	Semotilus atromaculatus
Pearl dace	Semotilus margarita

Castostomidae—suckers

Plains carpsucker	Carpoides forbesi
Highfin carpsucker	Carpoides velifer
River carpsucker	Carpoides carpio
Quillback	Carpoides cyprinus
White sucker	Catostomus commersoni
Blue sucker	Cycleptus elongatus
Northern hog sucker	Hypentelium nigricans
Smallmouth buffalo	Ictiobus bubalus
Bigmouth buffalo	Ictiobus cyprinellus
Spotted sucker	Minytrema melanops
Northern redhorse	Moxostoma macrolepidotum
Golden redhorse	Moxostoma erythrurum
Silver redhorse	Moxostoma anisurum
River redhorse	Moxostoma carinatum

EXHIBIT L ANIMAL POPULATIONS

Ictaluridae—freshwater catfishes

Black bullhead	*Ictalurus melas*
Yellow bullhead	*Ictalurus natalis*
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Tadpole madton	*Noturus gyrinus*
Stonecat	*Noturus flavus*
Flathead catfish	*Pylodictis olivaris*

Anguillidae—freshwater eels

American eel	*Anguilla rostrata*

Gadidae—codfishes and hakes

Burbot	*Lota lota*

Percopsidae—trout-perches

Troutperch	*Percopsis osmyscomaycus*

Serranidae—sea basses

White bass	*Roccus chrysops*

Centrarchidae—sunfishes

Rock bass	*Ambloplites rupestris*
Green sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*

Percidae—perches

Western sand darter	*Ammocrypta clara*
Mud darter	*Etheostoma asprigene*
Rainbow darter	*Etheostoma caeruleum*
Iowa darter	*Etheostoma exile*
Fantail darter	*Etheostoma flabellare*
Least darter	*Etheostoma microperca*
Johnny darter	*Etheostoma nigrum*
Banded darter	*Etheostoma zonale*
Gill darter	*Percina evides*

Yellow perch	Perca flavescens
Logperch	Percina caprodes
Blackside darter	Percina maculata
Slenderhead darter	Percina phoxocephala
River darter	Percina shumardi
Sauger	Stizostedion canadense
Walleye	Stizostedion vitreum vitreum
Scianidae—drums	
Freshwater drum	Aplodinotus grunniens
Atherinidae—silversides	
Brook silverside	Labidesthes sicculus

---

* Common and scientific names taken from, A List of Common and Scientific Names of Fishes From the United States and Canada, American Fisheries Society, Special Publication No. 2, Reprinted 1966.

SOURCE: Minneapolis—St. Paul Area Level B Study—Upper Mississippi River Basin Commission, 1976.

EXHIBIT J AMPHIBIANS OF THE METROPOLITAN AREA

SALAMANDERS

	Mudpuppy	Necturus maculosus
*	Blue-spotted Salamander	Ambystoma laterale
	Tiger Salamander	Ambystoma tigrinum
*	Newt	Notophthalmus viridescens
*	Four-toed Salamander	Hemidactylium scutatum

FROGS AND TOADS

	American Toad	Bufo americanus
*	Spring Peeper	Hyla crucifer
	Gray Tree Frog	Hyla versicolor
	Gray Tree Frog	Hyla crysoscelis
	Chorus Frog	Pseudacris triseriata
*	Green Frog	Rana clamitans
*	Mink Frog	Rana septentrionalis
	Wood Frog	Rana sylvatica
	Leopard Frog	Rana pipiens

---

* Rare, threatened, edge of range (See Section 16)

SOURCE: Reptiles and Amphibians of Minnesota, 1958.

EXHIBIT K REPTILES OF THE METROPOLITAN AREA

TURTLES

	Snapping Turtle	Chelydra serpentina
*	Wood Turtle	Clemmys insculpta
*	Map Turtle	Graptemys geographica
*	False Map Turtle	Graptemys pseudogeographica
	Painted Turtle	Chrysemys picta
*	Blanding's Turtle	Emyloidea blandingi
*	Smooth Softshell	Trionyx muticus
*	Spiny Softshell	Trionyx spiniferus

LIZARDS

	Six-lined Racerunner	Cnemidophorus sexlineatus
	Prairie Skink	Eumeces septentrionalis

SNAKES

*	Water Snake	Natrix sipedon
	Brown Snake	Storeria dekayi
	Red-bellied Snake	Storeria occipitomaculata
	Eastern Garter Snake	Thamnophis sirtalis
	Plains Garter Snake	Thamnophis radix
*	Eastern Hognose Snake	Heterodon platyrhinus
*	Western Hognose Snake	Heterodon nasicus
*	Blue Racer	Coluber constrictor
	Smooth Green Snake	Opheodrys vernalis
	Fox Snake	Elaphe vulpina
	Bullsnake	Pituophis melanoleucus
	Milk Snake	Lampropeltis triangulum

---

* Rare, threatened, edge of range (See Section 16)

SOURCE: Reptiles and Amphibians of Minnesota, 1958, and
The Distribution of Turtles in Minnesota, 1973.

EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
Common Loon	A1
Red-throated Loon	A1
Red-necked Grebe	A
Horned Grebe	A1-2
Eared Grebe	A1-1
Pied-billed Grebe	A2-3
Western Grebe	A
White Pelican	A1
Double-cr. Cormorant	A1
Great Blue Heron	A2-3
Great Egret	A2-3
Snowy Egret	A2-3
Green Heron	A3, B-5
Little Blue Heron	A2-3
Bl.-cr. Night Heron	A2-3, C-1
Yell.-cr. Night H.	A2-3, C-1
American Bittern	A2-3
Least Bittern	A3
White-faced Ibis	A2, I
Whistling Swan	A1
Trumpeter Swan	A1-2-3
Canada Goose	A1-2
White-fronted Goose	A1-2
Snow-Blue Goose	A1-2
Mallard	A
Black Duck	A
Gadwall	A
European Widgeon	A
Baldpate	A
American Pintail	A
Green-winged Teal	A
Blue-winged Teal	A2-3
Cinnamon Teal	A2-3
Shoveler	A2-3
Wood Duck	
Red head	A
Ring-necked Duck	A
Canvas-back	A
Lesser Scaup Duck	A
Greater Scaup Duck	A
Golden-eye	A1
Barrow's Golden eye	A1
Buffle-head	A1
Old Squaw	A1

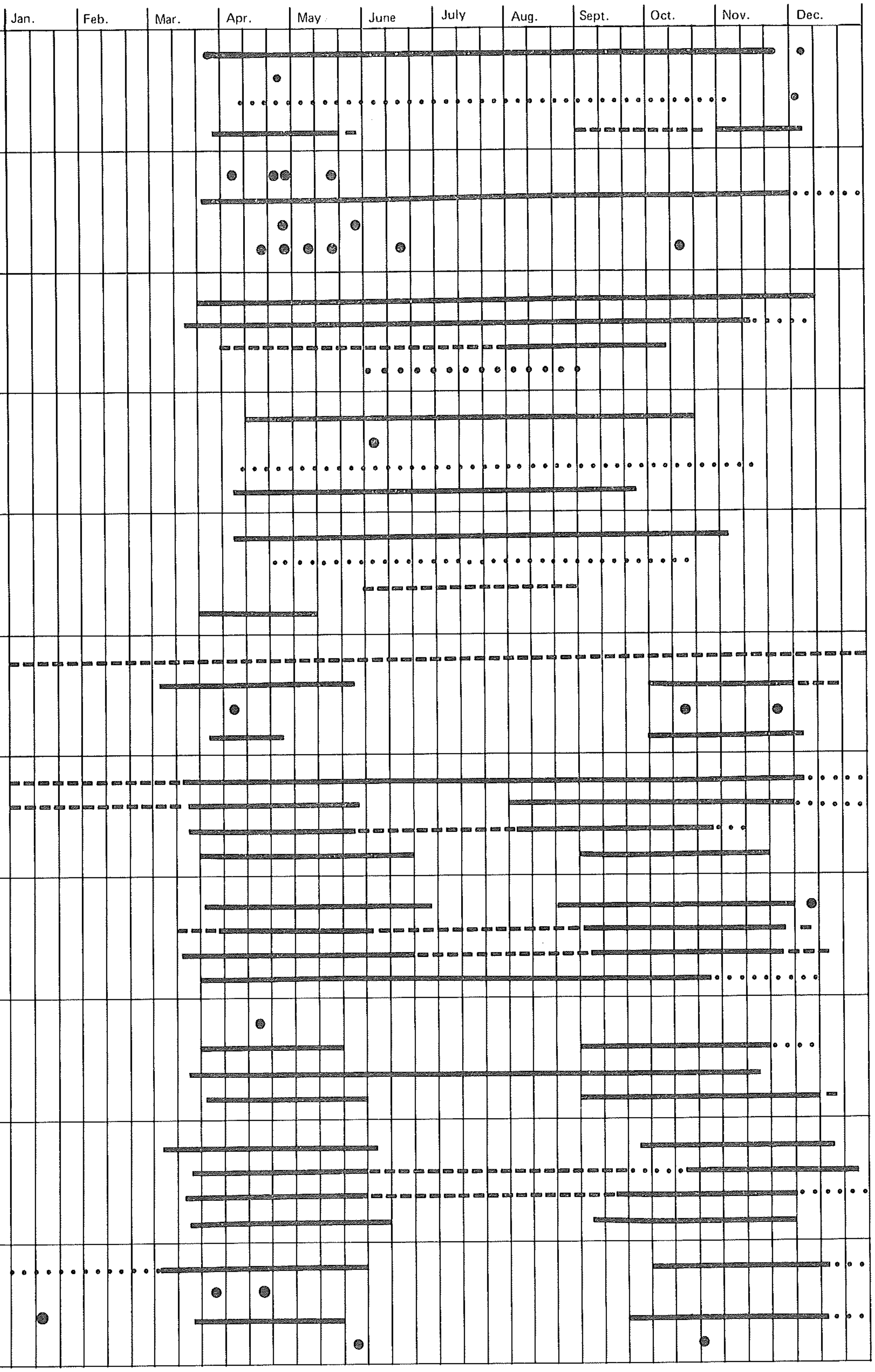


EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
White-winged Scoter	A1
Surf Scoter	A1
American Scoter	A1
Ruddy Duck	A2-3
Hooded Merganser	A
American Merganser	A
Red-breasted Merganser	A
Turkey Vulture	F
Swallow-tailed Kite	F
Goshawk	C
Sharp-shinned Hawk	C
Cooper's Hawk	C
Red-tailed Hawk	F, C
Red-shoulder Hawk	F, C
Broad-winged Hawk	F, C
Rough-legged Hawk	F, D
Ferruginous Rough-leg	F, D
Golden Eagle	F
Bald Eagle	F
Marsh Hawk	F, D
Osprey	F, C
Gyrfalcon	F, D
Duck Hawk	F, G
Pigeon Hawk	F, C
Sparrow Hawk	F, D
Ruffed Grouse	C
Prairie Chicken	D
Sharp-tailed Grouse	B, D
European Partridge	D
Bob-white	B2-3
Ring-necked Pheasant	D
Sandhill Crane	A2-D
King Rail	A2-3
Virginia Rail	A2-3
Sora	A2-3
Yellow Rail	D1-2
Common Gallinule	A2-3
Coot	A
Piping Plover	H
Semipalmated Plover	I, H
Killdeer	A, I, D
Golden Plover	I, D, H
Black-bellied Plover	I, D, H
Ruddy Turnstone	H

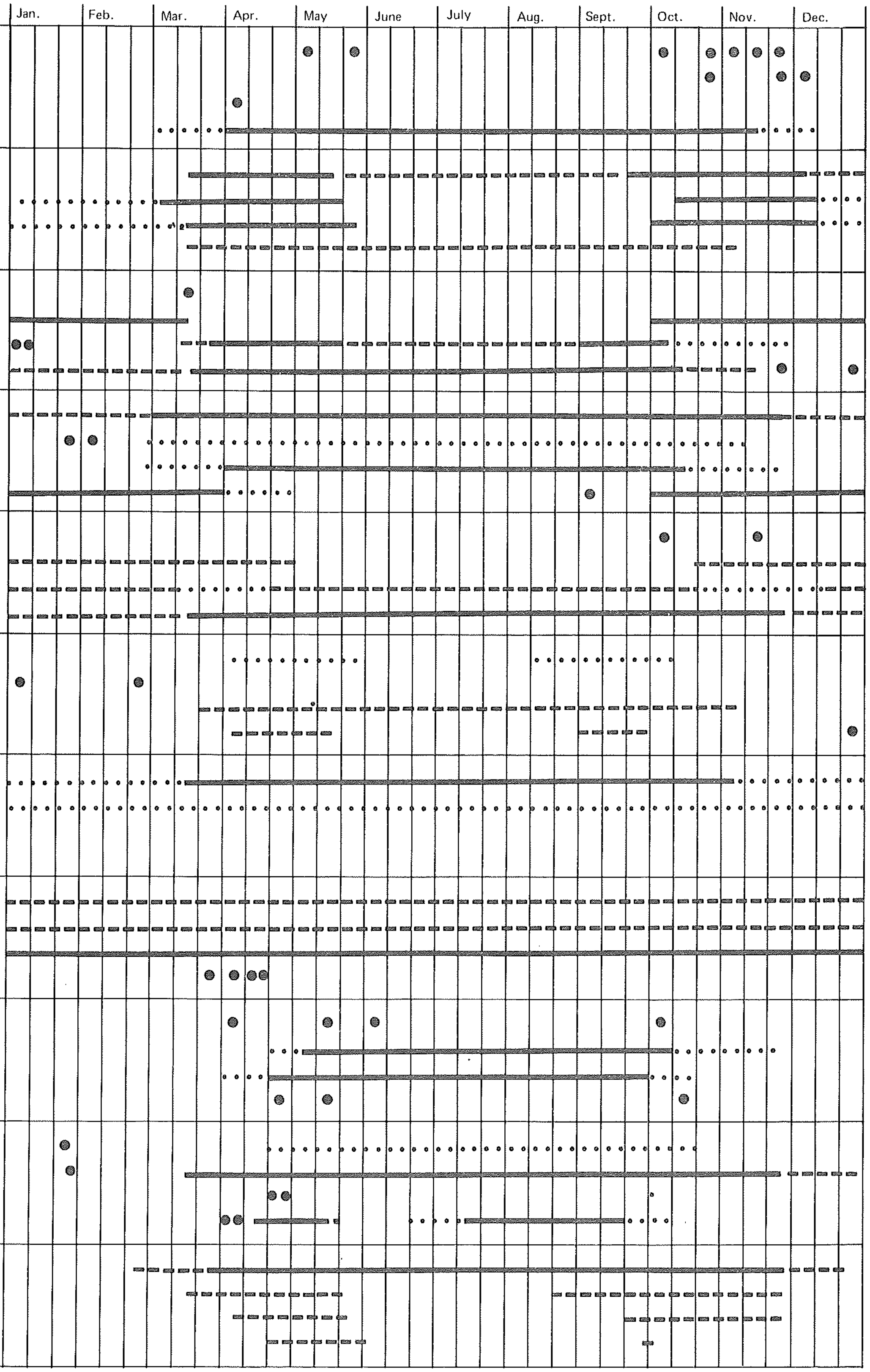


EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
Woodcock	B1
Wilson's Snipe	I, D-1
Upland Plover	D2-3
Spotted Sandpiper	I-H
Solitary Sandpiper	I
Western Willet	H-I
Greater Yellow-legs	H-I
Lesser Yellow-legs	H-I
Knot	H
Pectoral Sandpiper	H-I
White-rumped Sandpiper	H-I
Baird's Sandpiper	H-I
Least Sandpiper	H-I
Red-backed Sandpiper	H-I
Dowitcher, Long-billed	H-I
Dowitcher, Short-billed	
Stilt Sandpiper	H, I
Semipalmated Sandpiper	H, I
Buff-breasted Sandpiper	D, H, I
Marbled Godwit	D, H, I
Hudsonian Godwit	H, I
Sanderling	H
Avocet	H, I
Wilson's Phalarope	D1-A
Northern Phalarope	A, I
Parasitic Jaeger	A, F
Glaucus Gull	A, F
Herring Gull	A, F
Ring-billed Gull	A, F
Franklin's Gull	A, D, F
Bonaparte's Gull	A, F
Forster's Tern	A
Common Tern	A
Least Tern	H, F
Caspian Tern	F, A
Black Tern	A
Mourning Dove	D
Rock Dove	E
Yellow-billed Cuckoo	C
Black-billed Cuckoo	C
Groove-billed Ani	C
Screech Owl	C
Great Horned Owl	C
Snowy Owl	D

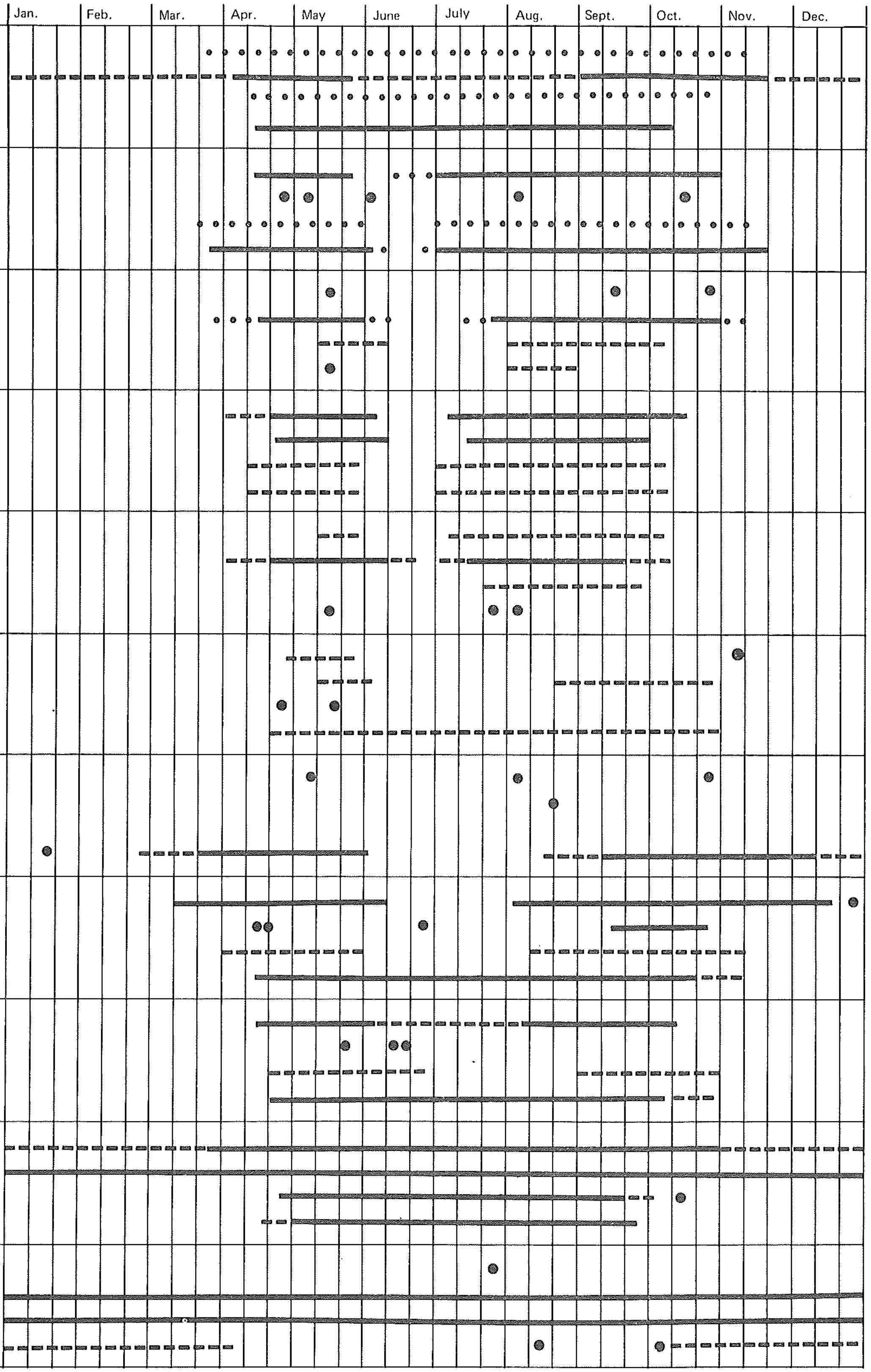


EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
Hawk Owl	C
Barred Owl	C
Great Gray Owl	C
Long-eared Owl	C
Short-eared Owl	D
Saw-Whet Owl	C
Whippoorwill	C
Nighthawk	
Chimney Swift	F
Ruby-th'd Hummingbird	CE
Belted Kingfisher	C-1, G
Flicker	C
Pileated Woodpecker	C
Red-bellied Woodpecker	C
Red-headed Woodpecker	C
Yellow-bellied Sapsucker	C
Hairy Woodpecker	C
Downy Woodpecker	C
Artic 3-toed Woodpecker	C
Northern 3-toed Wood pecker	C
Eastern Kingbird	B-3, C-4,D
Western Kingbird	C-4, D
Scissor-tailed Fly.	C-4, F
Crested Flycatcher	C
Phoebe	C-1, B-3
Starling	E
Bell's Vireo	CB
Yellow-throated Vireo	C
Blue-headed Vireo	C
Red-eyed Vireo	C
Philadelphia Vireo	C
Warbling Vireo	C
Black & White Warbler	C
Prothonotary Warbler	CI
Worm-eating Warbler	B4
Golden-winged Warbler	B3
Blue-winged Warbler	B2-3
Tennessee Warbler	C
Orange-crowned Warbler	C
Nashville Warbler	C
Parula Warbler	C
Yellow Warbler	B2-3, E
Magnolia Warbler	C
Cape May Warbler	C

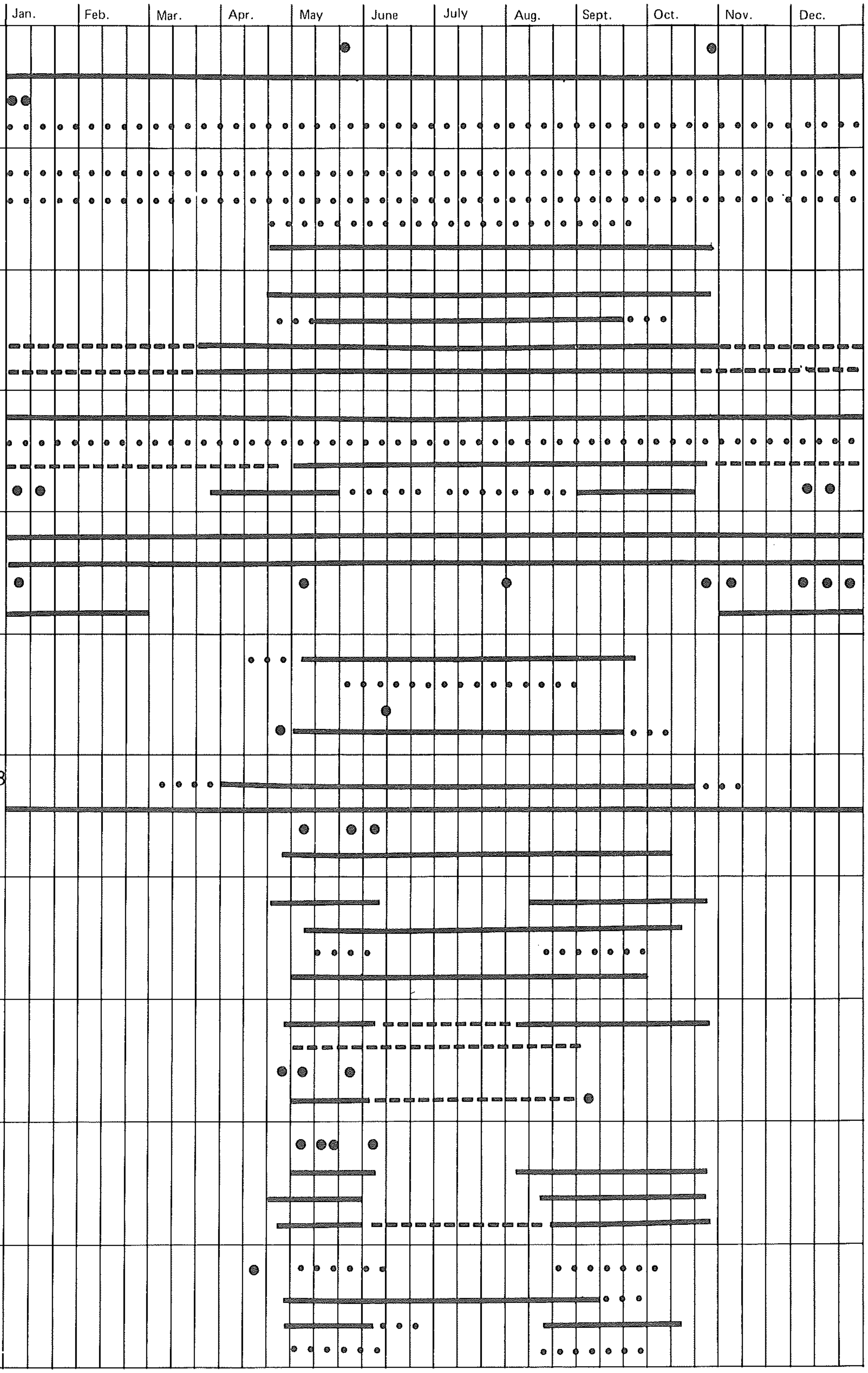


EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
Black-th'd Blue Warbler	C
Myrtle Warbler	C
Audubon's Warbler	C
Black-th'd Green Warbler	C
Cerulean Warbler	C2
Blackburnian Warbler	C
Hooded Warbler	B4
Chestnut-sided Warbler	B3
Bay-breasted Warbler	C
Black-poll Warbler	C
Pine Warbler	C
Prairie Warbler	C
Palm Warbler	CB
Oven-bird	B4
Northern Water-Thrush	B5
Louisiana Water-Thrush	B5
Kentucky Warbler	C
Connecticut Warbler	B4
Mourning Warbler	B4
Yellow-throat	A-3, B1
Yellow-breasted Chat	B2
Wilson's Warbler	B3-4, C
Hooded Warbler	C
Canada Warbler	C
Redstart	C
English Sparrow	E
Bobolink	D1
Eastern Meadowlark	D
Western Meadowlark	D
Yellow-headed Blackbird	A3
Red-winged Blackbird	A3
Orchard Oriole	C3-4
Yellow-bellied Flycatcher	C
Acadian Flycatcher	C
Alder Flycatcher	BC
Least Flycatcher	C
Wood Pewee	C
Olive-sided Flycatcher	C
Horned Lark	D
Tree Swallow	FB
Bank Swallow	FG
Rough-winged Swallow	FG
Barn Swallow	EF
Cliff Swallow	GE

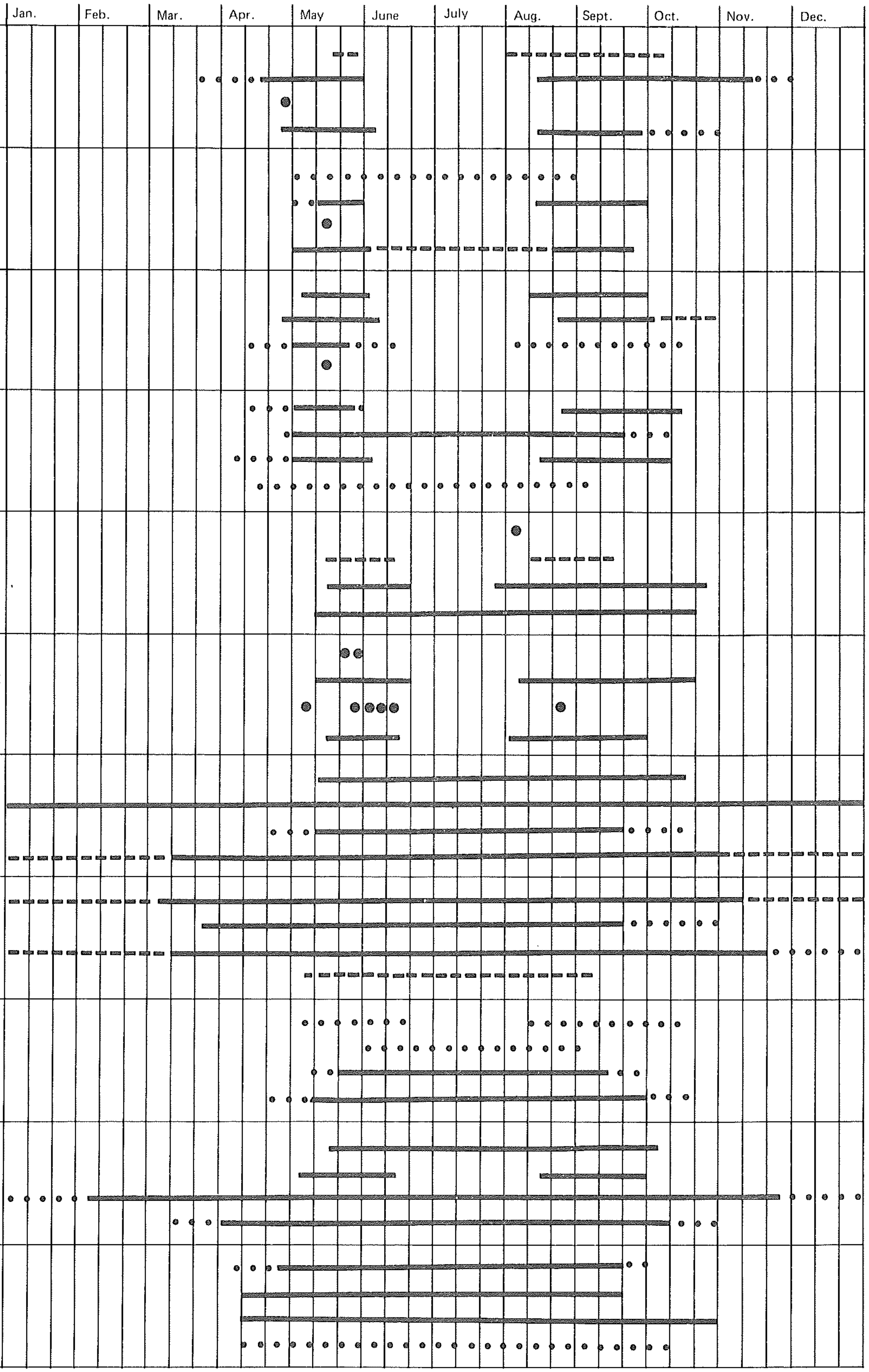


EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
Purple Martin	EF
Gray Jay	C
Blue Jay	C
Magpie	CB
Raven	CF
Crow	CF
Clark's Nutcracker	C
Black-capped Chickadee	C
Boreal Chickadee	C5
Tufted Titmouse	C
White-breasted Nuthatch	C
Red-breasted Nuthatch	C
Brown Creeper	C
House Wren	EC
Winter Wren	B-4, C
Bewick's Wren	C
Carolina Wren	C
Long-billed Marsh Wren	A3
Short-billed Marsh Wren	DI
Mockingbird	C
Cat bird	CE
Brown Thrasher	CE
Robin	CE
Varied Thrush	C
Wood Thrush	C
Hermit Thrush	C
Swainson's Thrush	C
Gray-cheeked Thrush	C
Veery	C
Eastern Bluebird	CE
Mountain Bluebird	C
Townsend's Solitaire	C
Blue-gray Gnatcatcher	C
Golden-crowned Kinglet	C
Ruby-crowned Kinglet	C
American Pipit	
Bohemian Waxwing	C
Cedar Waxwing	C
Northern Shrike	B-3, C-4, D
Migrant Shrike	C-4, D
Northern Oriole	C
Rusty Blackbird	C-1
Brewer's Blackbird	D
Bronzed Grackle	CDE

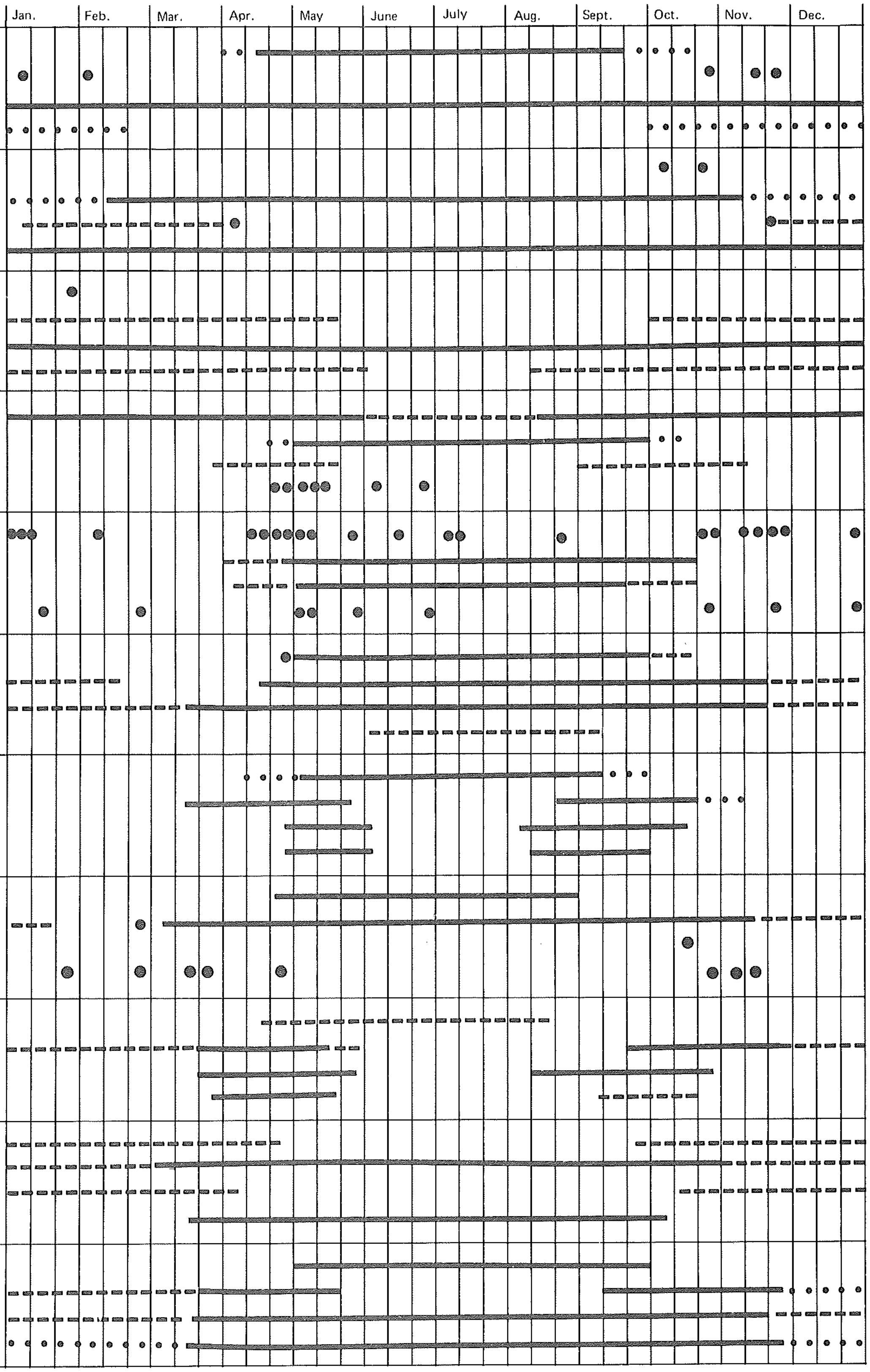
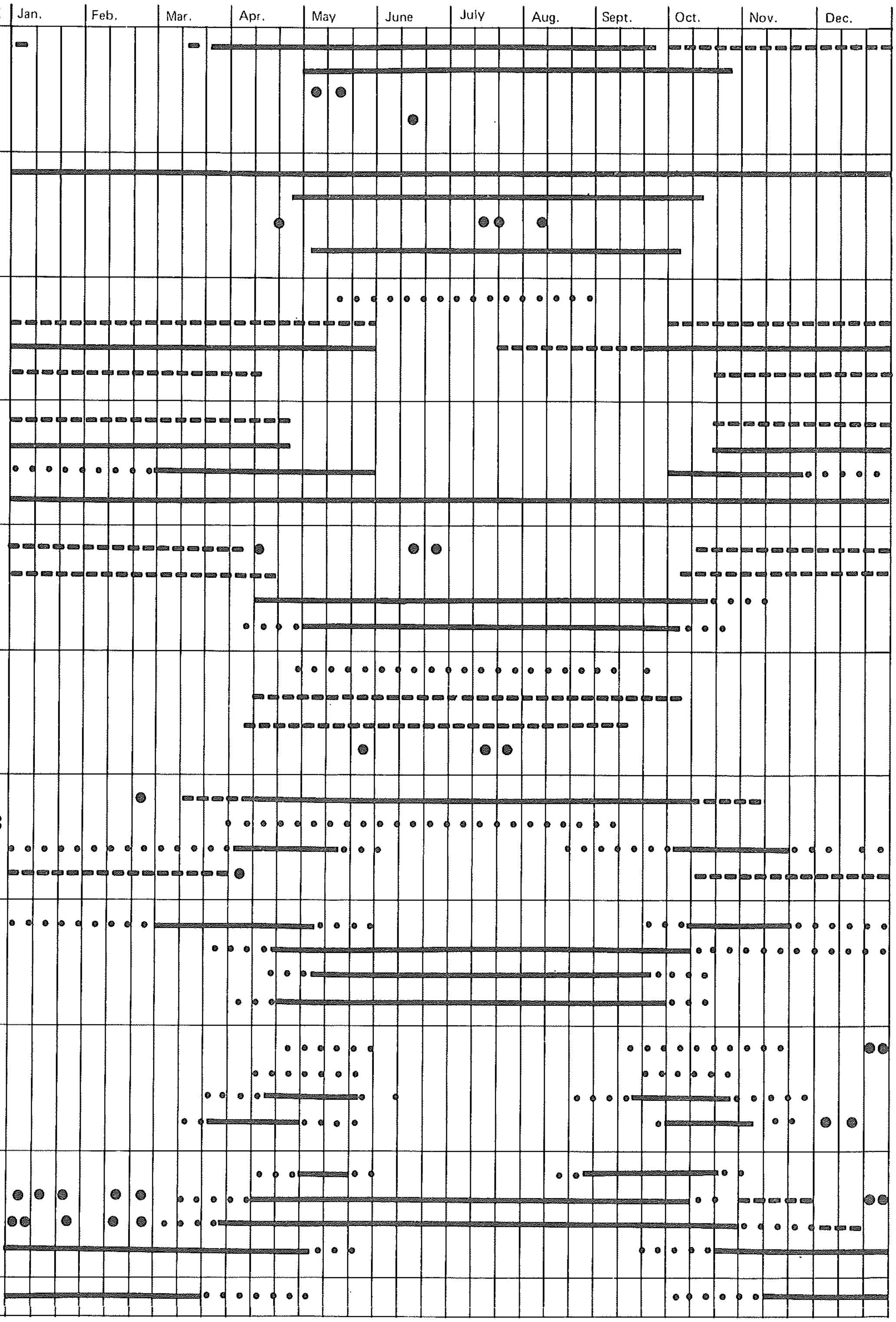


EXHIBIT L BIRDS OF THE MINNEAPOLIS – ST. PAUL REGION

Species	Habitat
Cowbird	BCDE
Scarlet Tanager	C
Western Tanager	C
Summer Tanager	C
Cardinal	C
Rose-breasted Grosbeak	C
Black-headed Grosbeak	C
Indigo Bunting	B-2, 3
Dickcissel	D-2
Evening Grosbeak	C
Purple Finch	C
Pine Grosbeak	C-5
Hoary Redpoll	D, B-2
Redpoll	D, B-2
Pine Siskin	C
Goldfinch	CB
Red Crossbill	C-5
White-winged Crossbill	C-5
Towhee	C
Savannah Sparrow	D-2
Grasshopper Sparrow	D-3
Leconte's Sparrow	A3, D-1
Henslow's Sparrow	A3, D-1
Sharp-tailed Sparrow	A3, D-1
Vesper Sparrow	D-3
Lark Sparrow	C-4, D-3
Dark-eyed Junco	C
Oregon Junco (subsp.)	C
Tree Sparrow	B, C-1
Chipping Sparrow	B, C-5, E
Clay-colored Sparrow	B-2, C-4
Field Sparrow	B-2, C-4
Harris's Sparrow	B-3, C
White-crowned Sparrow	B-3, C
White-throated Sparrow	C
Fox Sparrow	C
Lincoln's Sparrow	B-5, C
Swamp Sparrow	A-3, B-1
Song Sparrow	A-3, B-1, 5
Lapland Longspur	D
Snow Bunting	D



SOURCE: Dodge, Fullerton, Breckenridge and Warner, 1956
revised and updated using: Green and Janssen, 1975

EXHIBIT L

KEY

▬▬▬▬▬ Bird species common to abundant; nesting during summer

– – – – – – Bird species in limited numbers

• • • • • • • Bird species irregular or rare

● Specific record of bird sitings

Habitat to ecological distributions

A. Aquatic
  1. Open lakes and rivers
  2. Marshes
  3. Cattails and marsh borders

B. Shrubs
  1. Wet willow growth
  2. Brushy hillsides
  3. Woods borders
  4. Forest undergrowth
  5. Brushy creek banks

C. Forests
  1. Bottomland
  2. Maple-basswood
  3. Oak-elm upland
  4. Dry oak savanna
  5. Conifer

D. Grassland
  1. Wet sedge meadows
  2. Grassy meadows
  3. Dry uplands

E. Urban

F. Aerial

G. Cliffs and banks

H. Sandy beaches

I. Mud flats

ANIMAL POPULATIONS

EXHIBIT M MAMMALS OF THE METROPOLITAN AREA

Opossum	Dipelphia marsupialis
Cinereous Shrew	Sorex cinereus
Arctic Shrew	Sorex arcticus
Water Shrew	Sorex palustris
Pigmy Shrew	Microsorex hoyi
Short-tailed Shrew	Blarina brevicauda
Common Mole	Scalopus aquaticus
Star-nosed Mole	Condylura cristata
Little Brown Bat	Myotis lucifugus
Keen's Bat	Myotis keenii
Big Brown Bat	Eptesicus fuscus
Pipestrelle	Pipistrellus subflavus
Silver-haired Bat	Lasionycteris noctivagans
Red Bat	Lasiurus borealis
Hoary Bat	Lasiurus cinereus
White-tailed Jack Rabbit	Lepus townsendii
Snowshoe Hare	Lepus americanus
Cottontail Rabbit	Sylvilagus floridanus
Woodchuck	Marmota monax
Striped Ground Squirrel	Spermophilus tridecemlineatus
Franklin's Ground Squirrel	Spermophilus franklinii
Eastern Chipmunk	Tamias striatus
Red Squirrel	Tamiasciurus hudsonicus
Gray Squirrel	Sciurus carolinensis
Fox Squirrel	Sciurus niger
Southern Flying Squirrel	Glaucomys volans
Northern Flying Squirrel	Glaucomys sabrinus
Plains Pocket Gopher	Geomys bursarius
Pocket Mouse	Perognathus flavescens
Beaver	Castor canadensis
Deer Mouse	Peromyscus maniculatus
White-footed Mouse	Peromyscus leucopus
Red-backed Mouse	Clethrionomys gapperi
Meadow Vole	Microtus pennsylvanicus
Prairie Vole	Microtus ochrogaster
Muskrat	Ondatra zibethica
Norway Rat	Rattus norvegicus
House Mouse	Mus musculus
Meadow Jumping Mouse	Zapus hudsonius
Porcupine	Erethizon dorsatum
Black Bear	Ursus americanus
Raccoon	Procyon lotor
Short-tailed Weasel	Mustela erminea
Long-tailed Weasel	Mustela frenata
Least Weasel	Mustela rixosa
Mink	Mustela vison
Otter	Lutra canadensis
Spotted Skunk	Spilogale interrupta
Striped Skunk	Mephistis mephistis

EXHIBIT M MAMMALS OF THE METROPOLITAN AREA

Badger	Taxidea taxus
Red Fox	Vulpes fulva
Gray Fox	Urocyon cinereoargenteus
Coyote	Canus latrans
Bobcat	Lynx rufus
White-tailed Deer	Odocoileus virginianus

Infrequent Occurrence

Lynx	Lynx candensis
Mule Deer	Odocolleus hemionus
Moose	Alces alces

SOURCE: Mammals of Minnesota, 1953 and Comments on the Distribution and Natural History of Some Mammals in Minnesota, 1975.

EXHIBIT N SELECTED SENSITIVE AREAS
(Indexed to Plate 13)

NUMBER	FEATURE	LOCATION SEC.	T.	R.	APPROX. ACREAGE	NOTES
COUNTY: ANOKA						
PROPOSED SCIENTIFIC AND NATURAL AREAS ON ACQUISITION SCHEDULE						
1	Allison Savanna	2	33	23	86	Nature Conservancy tract, Proposed National Natural Landmark Prairie & Oak Savanna—No. 15 on Schedule
2	Boot Lake	17-20	33	22	400	Lake-swamp succession, rare flora, No. 33 on schedule
3	Cedar Creek Natural History Area	several	34	23	5,700	National Natural Landmark, important ecosystem study area, No. 27 on schedule—U of M, owner.
PROPOSED – NOT ON SCHEDULE						
4	Rice Lake Heron Rookery	29	31	22	45	Nesting area—rare species
5	Randeau Duck Pass	34	32	22	10-20	Important waterfowl area
OTHER BIOLOGICAL OR GEOLOGICAL SIGNIFICANT AREAS						
6	Bunker Prairie	1, 2, 35, 36	31, 32	24	1,800	Park Reserve, prairie and oak savanna on sand dunes, geologic and ecological interest
7	(11-N17) Unnamed	4, 5	33	25	795	Project 80 Scientific and Natural Area, proposed Regional Park
8	(11-N20) Unnamed	several	33	22, 23	630	Wild rice bed, and waterfowl area—Project 80 Scientific and Natural Area
9	(22-N21) Unnamed	14, 23	33	23	69	Wild rice bed, and waterfowl area—Project 80 Scientific and Natural Area
COUNTY: CARVER						
PROPOSED SCIENTIFIC AND NATURAL AREA NOT ON SCHEDULE						
None						

EXHIBIT N SENSITIVE AREAS

NUMBER	FEATURE	LOCATION SEC.	T.	R.	APPROX. ACREAGE	NOTES
OTHER BIOLOGICAL AND GEOLOGICAL SIGNIFICANT SITES						
1	(11-N2) Unnamed	6	117	25	40	Unique Tamarack Swamp
2	(11-N3) Unnamed	1-4, 9-12	116	24	270	In Carver Park Reserve, marsh, trumpeter swan
3	U of M Arboretum	17	116	23	560	Scenic timber, rare flora, Project 80 Scientific and Natural Area, vista
UNIQUE FEATURES						
4	Chasm	Exact Location Unknown				From River Basin Study
5	(11-N25) Minnesota River Vista	36	115	24	60	Scenic Timber
6	(11-N5) Carver Rapids	31	114	24	200′	Whitewater, Land formation, vistas
7	Minnesota River	15, 16	114	24	50	Project 80 Scientific and Natural Area, Vista
COUNTY: DAKOTA						
SCIENTIFIC AND NATURAL AREA .						
1	Hastings Scientific and Natural Area	27, 34, 35	115	17	69	Designated 1974, Additional 40 Acres proposed Maple-basswood forest
PROPOSED SCIENTIFIC AND NATURAL AREA ON ACQUISITION SCHEDULE						
2	Castle Rock	½ mile East of Hwy. 3			80-160	Geologic/pre-glacier remnant No. 45 on schedule
3	Ft. Snelling State Park	18	117	23	60	Wet meadows, white and yellow lady-slippers, No. 54 on SNA schedule
PROPOSED SCIENTIFIC AND NATURAL AREAS NOT ON ACQUISITION SCHEDULE						
4	Nichol's Meadow	18	117	23		Peat meadow, rare flora

EXHIBIT N SENSITIVE AREAS

NUMBER	FEATURE	LOCATION SEC.	T.	R.	APPROX. ACREAGE	NOTES
OTHER BIOLOGICAL AND GEOLOGICAL SIGNIFICANT SITES						
5	Black Dog Prairie	26,27	27	24	80	Wet Prairie, part of proposed National Wildlife Refuge
6	Burnsville Oak Savanna	19	115	20	1	Oak Savanna
7	Katherine Ordway Natural History Area	22, 26	27	22	280	Prairie, floodplain forest, Macalester College tract
8	Heron Rookery	Exact location confidential				Great Blue Heron & Giant Egret Colony
9	Snelling Lake	Ft. Snelling State Park				Lotus Beds
OTHER UNUSUAL FEATURES						
10	(11-N37) Chub Lake	21	113	20	30	Scenic Viewpoint
11	(11-N38)	1	113	19	300	Timber covered bluff
12	(11-N39) Apple Valley					One of the highest points in the Twin Cities metropolitan area, vistas

COUNTY: HENNEPIN

PROPOSED SCIENTIFIC AND NATURAL AREA ON ACQUISITION SCHEDULE

None

PROPOSED SCIENTIFIC AND NATURAL AREA NOT ON ACQUISITION SCHEDULE

None

NATURE CONSERVANCY TRACTS OF BIOLOGICAL AND GEOLOGICAL SIGNIFICANCE

NUMBER	FEATURE	LOCATION SEC.	T.	R.	APPROX. ACREAGE	NOTES
1	Ferndale Marsh	1, 2	117	23	30	Carex-Typha marsh, Avian life
2	Hardscrabble Point Woods	26	117	24	23	Big Woods
3	The Lotus Beds	34	117	24	4.5	Lotus lilies
4	Lowry Woods	31	118	23	14	Big woods, wildflowers
5	Margaret Gable Tusler Sanctuary	26	117	24	8	Bog—"Great botannical value" (6)

EXHIBIT N **SENSITIVE AREAS**

NUMBER	FEATURE	LOCATION			APPROX.	NOTES
		SEC.	T.	R.	ACREAGE	
OTHER BIOLOGICAL AND GEOLOGICAL SITES						
6	Coon Rapids Floodplain	2, 11	119	21	200	"Finest Floodplain Forest in the metropolitan area" (6)
7	Diamond Lake Forest	16	120	22	60	Big Woods, proposed National Natural Landmark
8	Heron Rookery	Exact location confidential				Great Blue and Black-crowned Night Herons nesting site
9	Grass Lake	33	116	22		Forster's Tern nesting colony, 1 of 10 in state
10	Minnetonka Woods	Near Sunrise Point			20	Eastside of Lake, Big Woods Proposed National Natural Landmark
11	Kuchner Woods (11-N11)	5	Eden Prairie		40	Virgin stand elm and basswood, rare flora
12	(11-N30) Crow-Hasson Regional Park	several	120	23, 24	2,500	Prairie remnant, 500 A prairie restoration
13	(11-N6)	22	117	24	190	Scenic timber, Project 80 proposed scientific and natural area
14	(11-N7) Anderson Lakes	18, 19	116	22	200	Project 80 NSA, Park Reserve
15	(11-N8) Purgatory Creek	several	Eden Prairie		10 mi.	Project 80 NSA, rare flora
16	(11-N9) Minnesota River Bottom and Bluffs	several	Eden Prairie		6-7 Miles	Project 80 NSA, historic significance
17	(11-N10) Riley Creek and and Riley Lake	several	Eden Prairie		5 mi.	Project 80 NSA, historic significance
18	(11-N12) Old Mill Creek	26	Eden Prairie		2	Rapids, historic significance
19	(11-N13) Nine Mile Creek	several	Eden Prairie			Project 80 NSA
OTHER UNIQUE FEATURES						
20	(11-N14)	Village of Shorewood			½ Mi.	Glacial Esker, significant land formation.
21	(11-N15)	Minnetrista				Esker near Whaletail Lake
22	Chasm	Exact location unknown				River Basin Study
23	Chasm	Exact location unknown				River Basin Study

EXHIBIT N SENSITIVE AREAS

NUMBER	FEATURE	LOCATION SEC.	T.	R.	APPROX. ACREAGE	NOTES
COUNTY: RAMSEY						
None						
PROPOSED SCIENTIFIC AND NATURAL AREA NOT ON SCHEDULE						
1	Langton Lake Area	4	29	23	50	Scientific research area, heron rookery
OTHER BIOLOGICAL AND GEOLOGICAL SIGNIFICANT SITES						
2	Pig's Eye Heron Rookery	14	28	22		Unique biologic entity, ornithological importance
OTHER UNUSUAL FEATURES						
3	Carver's Cave		28	22		
4	Cave		28	22		River Basin Study
COUNTY: SCOTT						
PROPOSED SCIENTIFIC AND NATURAL AREA ON ACQUISITION SCHEDULE						
1	Louisville Prairie	21	115	23	140	Dry Prairie typical of western prairie No. 43
2	Mosquito Glen	15	115	21	200	Forested ravine, marsh no. 42
PROPOSED SCIENTIFIC AND NATURAL AREA NOT ON ACQUISITION SCHEDULE						
3	Eagle Creek	7	27	21	5	Trout stream, wetlands with rare flora
OTHER BIOLOGICAL AND GEOLOGICAL SIGNIFICANT SITES						
4	Great Blue Heron Colony	Exact location confidential				Nesting sites
5	(11-N42)	19	113	22	40	Wild rice beds, uncommon this far south
6	(11-N44) "Lost 80"	31	113	25	80	Rare flora, Project 80 Scientific and Natural area
7	(11-N47) Unglaciated Area	28	115	23	40	Rare flora, rock formations
8	(11-N49) Boiling Springs	18	115	21		Project 80 proposed scientific and natural area

EXHIBIT N SENSITIVE AREAS

NUMBER	FEATURE	LOCATION SEC.	T.	R.	APPROX. ACREAGE	NOTES
OTHER UNIQUE FEATURES						
9	River Bluffs	several	114,115	23	5-6 mi.	Scenic timber, fall color, vista
10	River Bluffs	several	113,114	24	10 mi.	Vistas
11	Caves (11-N48)	16	115	23		Historic significance, land formations
COUNTY: WASHINGTON						
NO PROPOSED SNA AREAS IN WASHINGTON CO.						
OTHER BIOLOGICAL OR GEOLOGICAL SITES						
1	(11-N23)	several	31,32,	21	1800-2000	Not drained, wildlife habitat, Project 80 SNA
UNIQUE FEATURES						
2	(11-N22)	several	30, 31, 32	20	500	St. Croix River Islands, beach, land formations
3	(11-N24)	1,11,12	30	20	200	Beach and vista
4	(11-N50)	23, 26	Village of Lake Elmo		1,500	Metropolitan Area's deepest lake, vista
5	(11-N51)	several	Cottage Grove		1,000	Deep ravine, Proposed Park Reserve, vista
6-9	Vistas					Identified by Project 80

EXHIBIT O

STATE SCIENTIFIC AND NATURAL AREA GUIDELINES

A. PURPOSE OF ESTABLISHMENT

To protect and perpetuate in an undisturbed state, individual features of unique natural significance or areas of land or water which possess inherent natural conditions of exceptional scientific or educational value.

B. RESOURCE AND SITE QUALIFICATIONS

1. Resources which have exceptional scientific and educational values include but are not limited to:

a. Outstanding geological formations or features significantly illustrating geological processes.

b. Significant fossil evidence of the development of life on earth.

c. An ecological community significantly illustrating characteristics of a physiographic province or a biome.

d. A biota of relative stability maintaining itself under prevailing natural conditions, such as a climatic climax community.

e. An ecological community significantly illustrating the process of succession and restoration to natural condition following disruptive change.

f. A habitat supporting a vanishing, rare or restricted species.

g. A relic flora or fauna persisting from an earlier period.

h. A seasonal haven for concentrations of native birds and animals, or a vantage point for observing concentrated populations, such as a constricted migration route.

2. State Scientific and Natural Areas should embrace a sufficiently comprehensive unit as to:

a. Permit the effective management of a continuing representation of the inherent natural values.

b. Permit effective research or educational functions consistent with preservation of the basic values.

3. Scientific and Natural Areas usually involve lesser acreage than State Parks and are not intended to support a broad range of visitor use programs.

4. Scientific and Natural Areas may be established as separate areas or as sub-areas within larger components, such as State parks, forests, wildlife management areas, etc., but will be administered by the agency having jurisdiction over the larger unit. Areas not within larger components shall be managed by the most appropriate agency listed under "E".

5. If a Scientific and Natural Area contains significant historic or prehistoric resources, management of those resources shall be patterned after the Historical Areas component to the extent compatible with management and use objectives. These resources or values are most appropriate to the Historical Areas component and shall not constitute the primary basis for establishing Scientific and Natural Areas.

6. There will be three types of Scientific and Natural Areas. The designation for each site will be determined by the resource values.

A: Research Unit—Use is limited to programs conducted by qualified scientists and graduate and post-graduate students. A written permit is required for all use.

B: Educational Unit—Permitted uses include all Type A activities in addition to K-12 and undergraduate college programs. A written permit is required only for specimen collection.

C: Public Use Unit—Permitted uses include all Type A and B activities in addition to interpretive programs for the benefit of the general public. Interpretive programs shall be conducted by the administering agency.

Redesignation from one type to another shall not be made without the consent of the Scientific and Natural Area Committee or without a public hearing at a time and place designated by public notice. Such notice shall be published once in a legal newspaper in each county in which the lands are situated at least seven days in advance of the hearing date.

C. LOCATION AND DISTRIBUTION

1. The primary determinant of the location for Scientific and Natural Areas will be the geographic occurance of the resource to be protected and studied. These resources are not necessarily distributed throughout the State with any degree of uniformity.

We cannot, at this time, assign a limit on the number or a pattern for the distribution of Scientific and Natural Areas. Approximately 300 sites were mentioned in "A Study of Minnesota's Natural Areas." M.O.R.R.C. Staff Report No. 2, 1965. Additional potential sites were discovered during the Project 80 Inventory and from other studies. The Minnesota Chapter of the Nature Conservancy, Inc. is currently embarking on a detailed statewide program of identifying all potential Scientific and Natural Areas through actual field survey utilizing private funds. When this survey is complete, the State can develop a meaningful distribution pattern and priority program for acquisition.

2. The ultimate system of Scientific and Natural Areas should seek to preserve a truly representative sample of the various resources outlined in B-1. The relative merits of each potential site for research, education, or public interpretation should be determined by the Advisory Committee.

3. Priority for acquisition (protection) shall be determined for the three types of Scientific and Natural Areas by:

a. Significance—a measurement of the public value to be derived from research, education, or public interpretation programs.

b. Integrity—the present resemblance of a site to its original condition when European man first arrived in Minnesota.

c. Scarcity—the original or remaining geographic distribution of the resource or particular combination of resources inherent to a site.

d. Unique attributes—the largest, the deepest, etc.

e. Degree of endangerment.

f. Accesibility to permitted users—Accessibility is not normally considered an important criteria in determining the location of these areas. In fact, it can be detrimental. However, in the Educational Unit, good accessibility can be an important factor. If two sites have equal value as Educational Units, the site nearest to a large base of students is most likely to be used more often and should receive the higher priority for acquisition.

D. MANAGEMENT PRINCIPLES

1. Resource Management: Management will be directed at preserving and perpetuating those resources having exceptional scientific and educational value, protecting them from unnatural influences. A resource management plan, including rules and regulations, will be prepared for each Area by the Scientific and Natural Area Advisory Committee and presented to the Commissioner of the Department of Natural Resources for promulgation. The members of the Advisory Committee will be appointed by the Commissioner and will include a balanced representation by professionals from the various natural sciences.

2. Resource Use: Resource use shall be dictated by the limitation of the basic resource. In no case shall any use be permitted that impairs that resource.

Emphasis will be placed on research and educational functions. In those areas that permit, interpretive services may be provided for the general public.

Written use permits, when required, shall be issued by the Commisioner, Department of Natural Resources. The Commissioner in consultation with the Advisory Committee, shall determine the merit and restrictions of each use permit.

3. Physical Development: Physical development shall be limited to the facilities absolutely necessary for protection, research, and educational projects, and, where appropriate, for interpretive services.

E. ADMINISTRATIVE AGENCY

Division of Parks and Recreation

Division of Lands and Forestry

Division of Game and Fish

University of Minnesota

Quasi-Public Organizations

Overall coordination shall be provided by a staff ecologist (Department of Natural Resources) with advice and consent from the Commissioner and the Advisory Committee.

SOURCE: Minnesota Resource Potentials in State Outdoor Recreation, Project 80, Staff Report No. 1, 1971 (Available: DNR, SPA)

EXHIBIT P

DNR LAKE CLASSIFICATION
(Indexed to Plate 14)

ANOKA COUNTY Additional Lakes Listed at end of exhibit

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
2-1	——	107		NE	II	R21, 22, T31, S19, 30; 24, 25
2-2	Higgins	143		NE	IV	R21, 22, T32, 33, S6; 31, 1, 31
2-3	Otter	511		RD	Fish	R22, T30, 31, S3, 4; 35, 36
2-4	Peltier	483		NE	Fish	R22, T31, S2, 10, 11, 14, 15
2-5	George Watch	528		RD	IV	R22, T31, S10, 15, 16, 21
2-6	Centerville	464		RD	Fish	R22, T31, S14, 15, 22, 23
2-7	Forsham	230		NE	IV	R22, T31, S17, 20
2-8	Rice	433		NE	IV	R22, T31, S19, 20, 29, 30
2-9	Reshanau	304		RD	VA	R22, T31, S20, 21, 28, 29
2-12	Cedar	214		NE	III	R22, T31, S27, 33, 34
2-13	Baldwin	220		NE	VA	R22, T31, S30, 31
2-14	Amelia	178		NE	IV	R22, T31, S35
2-15	Rondeau	594		NE	IV	R22, T31, 32, S2, 3, 10; 34, 35
2-16	Howard	436		NE	IV	R22, T32, S13, 14, 24
2-19	Tamarack	355		NE	IV	R22, T32, S27, 34
2-21	Tamarack	100		NE	IV	R22, T33, S3, 4, 9, 10
2-22	Island	100		NE	IV	R22, T33, S4, 9
2-26	Linwood	567	Dam	RD	Fish	R22, T33, S8, 9, 16-18
2-32	Little Coon	87		NE	IV	R22, T33, S29, 32
2-34	Martin	218	Dam	GD	Fish	R22, T33-34, S3, 4; 33, 34
2-41	——	61		RD	IV	R22, 23, T31, S25, 36
2-42	Coon	1507	Dam	GD	Fish	R22, 23, T32, 35 S-var.
2-43	Rice	633		NE	IV	R22, 23, T33, S18, 19; 13, 24
2-45	Golden	50		GD	Fish	R23, T31, S25, 36
2-47	——	16		RD	VA	R23, T31, S36
2-52	Netta	162		RD	Fish	R23, T32, S9, 10, 15, 16
2-53	Ham	193	Dam	RD	Fish	R23, T32, S16, 17, 20, 21
2-55	Lone Pine	315		NE	III	R23, T33, S2, 3, 10, 11
2-57	Neds	150		NE	IV	R23, T33, S9, 16
2-59	Deer	249		NE	IV	R23, T33, S15, 16, 21, 22
2-62	Goose	213		NE	IV	R23, T33, S23, 26
2-67	Minard	124		RD	VA	R23, T34, S29-31
2-71	Spring	91		RD	Fish	R23, 24, T30, S1, 12, 6, 7
2-72	Laddie	77		RD	VA	R23, 24, T30, 31, S32; 1
2-75	Moore	110	Artificial Lake w/dam	RD	IV	R24, T30, S13, 14, 23, 24

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
2-84	Crooked	130	Dam	GD	Fish	R24, T31, 32, S4; 33
2-89	Round	417		RD	VA	R24, T32, S20, 29
2-91	George	542	Dam	NE	III	R24, T33, S3-10, 15-17
2-92	Grass	106		NE	III	R24, T33, S10, 11, 14, 15
2-97	Mud	189		NE	III	R24, T33, S21, 22, 27, 28
2-98	Swan Marsh	112		NE	III	R24, T33, S25
2-100	Smith	327		NE	III	R24, T34, S23, 26
2-105	Mud	107		NE	VA	R24, 25, T33, S6, 7; 1, 12
2-110	Itasca	136		NE	IV	R25, T32, S17-20
2-130	Pickerel	274		NE	VA	R25, T33, S15, 21, 22
2-133	East Twin	116		NE	Fish	R25, T33, S19

CARVER COUNTY Additional Lakes Listed at end of exhibit

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
10-1	Rice Marsh	310		NE	IV	R22, 23, T116, S18; 13
10-2	Riley	467		RD	Fish	R22, 23, T116, S19, 30; 24, 25
10-6	Lotus	254		GD	Fish	R23, T116, S1, 12
10-7	Lucy	116		RD	Fish	R23, T116, S2, 3, 10, 11
10-9	Minnewashta	763		RD	Fish	R23, T116, S4, 5, 8, 17
10-12	Ann	120		RD	Fish	R23, T116, S10, 11
10-13	Susan	93		RD	Fish	R23, T116, S13, 14
10-14	Hazeltine	236		NE	Fish	R23, T116, S21, 22
10-15	Virginia	239		RD	VA	R23, T116-117, S6; 31
10-18	Schutz	140		RD	Fish	R23, 24, T116, S7; 1, 12
10-19	Bavaria	201		GD	Fish	R23, 24, T116, S19, 30; 24
10-29	Miller	145		NE	Fish	R24, T115, S7, 8
10-31	Gaystock	105		NE	IV	R24, T115, S11
10-41	Zumbra	221		RD	Fish	R24, T116, S1, 2, 11
10-42	Parley	470		RD	Fish	R24, T116, S4, 5, 8, 9
10-43	Lunsten	64		NE	Fish	R24, T116, S9
10-44	Auburn	356		RD	Fish	R24, T116, S10, 11, 14, 15
10-45	Steiger	281		RD	Fish	R24, T116, S11, 12, 13
10-48	Waterman	277		RD	Fish	R24, T116, S14, 22, 23
10-52	Reitz	111		NE	Fish	R24, T116, S19, 20
10-53	Piersons	340		RD	Fish	R24, T116, S21, 22, 27, 28
10-54	Marsh	164		NE	IV	R24, T116, S26, 27
10-56	Stone	177		NE	Fish	R24, T116, 117, S2; 35
10-58	Maria	169		NE	IV	R24, 25, T115, S31; 36
10-59	Waconia	3196		GD	Fish	R24, 25, T116, S-var.

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
10-62	––	109		NE	IV	R25, T114, S6, 7
10-63	Assumption	132		NE	III	R25, T114, S7
10-66	Winkler	129		NE	VA	R25, T115, S4, 9
10-67	Barlous	187	Dam	NE	III	R25, T115, S5-8
10-69	Benton	115		GD	IV	R25, T115, S11-14
10-78	Rice	347		NE	IV	R25, T115, 116, S5, 6; 31, 32
10-79	Donders	103		NE	Fish	R25, T116, S3, 4, 9, 10
10-82	Swan	192		NE	Fish	R25, T116, S9, 10, 15, 16
10-84	Burandt	138		RD	Fish	R25, T116, S14, 15, 22, 25
10-86	Patterson	558		NE	IV	R25, T116, S19, 20, 29, 32
10-88	Hydes	212	Dam	RD	Fish	R25, T116, S30, 31, 32
10-89	Goose	407		NE	VA	R25, T116, 117, S3-5; 8, 9; 33
10-91	––	253		NE	III	R25, T117, S5-8
10-93	Oak	185		NE	IV	R25, T117, S11, 14
10-94	Mud	215		NE	VA	R25, T117, S13, 14
10-95	Swede	423		NE	IV	R25, T117, S15, 21, 22, 23
10-98	Buck	100		NE	IV	R25, T117, R23-26
10-103	Berliner	222	Dam	NE	NIII,SIV	R25, 26, T116, S7; 12, 13
10-105	Young America	110		NE	IV	R26, T115, S1, 11, 12
10-108	Tiger	575		NE	IV	R26, T115, S4, 8-10, 15, 16
10-109	Barnes	175		NE	IV	R26, T115, S12, 13
10-110	Brand	134		NE	IV	R26, T115, S14, 15, 22, 23
10-111	––	105		NE	III	R26, T115, S19
10-116	––	167		NE	III	R26, T116, S21, 22, 28
10-121	Eagle	230	Dam	NE	VA	R26, T116, S34, 35
DAKOTA COUNTY	Additional Lakes Listed at end of exhibit					
19-1	Mud Hen	744		NE	IV	R16, T114, S3, 4, 9, 10
19-4	Isabella	97	Mississippi Backwater	RD	VA	R17, T115, S27
19-5	Pool 2	915	River Impoundment	GD	Fish	R, T, S-var.
19-6	Byllesby	2255	Reservoir	RD	Fish	R18, T114, S8-10, 15-16
19-17	––	135		NE	III	R20, T112, S29, 30
19-20	Chub	261		NE	III	R20, T113, S-var.
19-21	Alimagent	113		RD	VA	R20, T115, S20, 29
19-26	Marion	489		RD	Fish	R20, 21, T114, S-var.
19-27	Crystal	290		RD	Fish	R20, 21, T114, 115, S31, 32; 36; 6
19-30	Kingsley	35		NE	VA	R21, T114, S1, 2
19-31	Orchard	243	Dam	RD	Fish	R21, T114, S2, 11
19-50	Sunfish	49		RD	Fish	R22, T28, S30, 31
19-52	Schmidt	59		RD	VA	R22, T28, S31, 32
19-78	Gun Club	519		NE	VA	R23, T27, 28, S4, 5; 32, 33
19-79	Pickeral	103		NE	IV	R23, T28, S12, 13

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
19-80	Rodgers	116		RD	IV	R23, T28, S26, 35
19-81	Augusta	41		RD	VA	R23, T28, S27, 34
19-82	Lamay	36		NE	IV	R23, T28, S-var.
19-83	Black Dog	647		GD	IV	R23, 24, T27, S-var.
HENNEPIN COUNTY	Additional Lakes Listed at end of exhibit					
27-1	Snelling	110		None	VA	R23, T28, S28, 29, 32
27-2	Long Meadow	1425		NE	IV	R23, 24, T27, S-var.
27-3	Pool 1	845	River Impoundment	GD	Fish	R23, 24, T28-29, S-var.
27-11	Oxboro	23		GD	VA	R24, T27, S10, 15
27-13	Nine Mile	219	Dam	NE	IV	R24, T27, S28-31
27-16	Harriet	337		GD	Fish	R24, T28, S8, 9, 16, 17
27-18	Hiawatha	165		GD	Fish	R24, T28, S28, 33
27-19	Nokomis	199		GD	Fish	R24, T28, S13, 14, 23, 24
27-21	Grass	155		RD	III	R24, T28, S21, 27, 28
27-23	Mother	310		NE	IV	R24, T28, S23-26
27-24	Legion	22		NE	III	R24, T28, S23-26
27-26	Wood	165		RD	III	R24, T28, S28, 33
27-31	Calhoun	416		GD	Fish	R24, T28, 29, S4, 5; 32, 33
27-33	St. Anthony Falls Pond	459		GD	II	R24, T29, S-var.
27-34	Crystal	74		RD	Fish	R24, T29, S5, 6
27-35	Sweeny-Twin	96	Dam	RD	Fish	R24, T29, S18, 19
27-37	Wirth	37		NE	Fish	R24, T29, SW20
27-39	Cedar	167		GD	Fish	R24, T29, S29, 32
27-40	Lake of the Isles	157		GD	Fish	R24, T29, S32, 33
27-42	Twin	201		GD	Fish	R24; 21, T29; 118, S-var.
27-43	Coon Rapids Pool	706	Reservoir	GD	Fish	R24; 21, T-var., S-var.
27-47	Bush	207		RD	Fish	R21, T116, S19, 20, 29, 30
27-48	Hyland	87		NE	VA	R21, T116, S29, 32
27-52	Hannan	38		RD	III	R21, T117, SW7
27-54	Meadowbrook	22		NE	VA	R21, T117, SE20
27-58	Ryan	32		RD	Fish	R21, T118, SE10
27-59	Palmer	325		NE	IV	R21, T119, S26, 27, 34, 35
27-60	——	38		NE	III	R21, T119, 120, S5; 32
27-62	Anderson	431		RD	VA	R21-22, T116, S18, 19; 12, 24
27-66	Lemans	91		NE	IV	R21, 22, T120, S30; 25
27-67	Bryant	199		RD	Fish	R22, T116, S2, 11
27-70	Mitchell	116		NE	Fish	R22, T116, S7, 17, 18
27-76	Red Rock	83		RD	Fish	R22, T116, S16, 21
27-78	Staring	155		RD	Fish	R22, T116, S21, 22
27-79	Neill	170		RD	III	R22, T116, S23-25

EXHIBIT P WATER RESOURCES

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
27-80	Grass	580		NE	IV	R22, T116, S32-34
27-81	Island	163		RD	Fish	R22, T116-117, S4; 33
27-93	Glen	180	Dam	RD	Fish	R22, T117, S34
27-95	Gleason	167		RD	Fish	R22, T117-118, S5; 32
27-98	Bass	175		GD	Fish	R22, T118, S2
27-104	Medicine	924	Dam	RD	Fish	R22, T118, 119, S14, 23-26
27-107	Parkers	92		RD	Fish	R22, T118, S28, 33
27-111	Eagle	470	Dam	RD	Fish	R22, T118, 119, S1, 2; 25, 35, 36
27-112	Mud	102		NE	IV	R22, T119, S2
27-116	Rice	306		NE	IV	R22, T119, S15, 16, 22, 23
27-117	Weaver	155		GD	Fish	R22, T119, S17-20
27-118	Fish	221		RD	Fish	R22, T119, S21, 22, 27, 28
27-119	Cedar Island	88		RD	VA	R22, T119, S26, 27
27-122	Goose	62		NE	IV	R22, T119, 120, S2; 35
27-125	Diamond	408		RD	VA	R22, T120. S19, 20
27-126	——	197		NE	III	R22, T120, S19, 20
27-127	French	352		NE	VA	R22, T120, S19, 29, 30
27-128	Hayden	374		NE	VA	R22, T120, S23-27
27-132	Rice	727		NE	IV	R22-23, T116, S31, 32; 36
27-133	Minnetonka	28,400		GD	Fish	R22-24, T116, 117, S-var.
27-134	Mooney	111		RD	VA	R22-23, T118, S30; 25
27-135	Grass	168		NE	IV	R22, 23, T120, S18, 19, 13, 26
27-137	Christmas	523	Dam	RD	Fish	R23, T116, 117, S2; 35, 36
27-154	Katrina	497		NE	IV	R23, T118, S19, 20, 29, 30
27-158	Holy Name	80		RD	VA	R23, T118, C24
27-160	Lona	279	Dam	RD	Fish	R23, T118, S26, 34, 35
27-162	Classen	13		RD	Fish	R23, T118, SW27
27-169	Cowley	78		NE	VA	R23, T120, S16, 21
27-171	Sylvan	137		RD	VA	R23, T120, S20
27-175	Henry	77		NE	IV	R23, T120, S28, 29, 32, 33
27-176	Independence	828		RD	Fish	R23, 24, T118, S-var.
27-178	Ox Yoke	186		NE	IV	R24, T117, S5, 6
27-179	Little Long	104		RD	Fish	R24, T117, S9, 15, 16
27-181	Dutch	170		RD	Fish	R24, T117, S14, 15
27-182	Langdon	168		RD	Fish	R24, T117, S14, 23
27-184	Whaletail	582		RD	Fish	R24, T117, S16, 17, 20, 21
27-186	Mud	177		NE	IV	R24, T117, S32
27-188	Mud	349		NE	VA	R24, T118, S8, 9, 16, 17
27-191	Sarah	586		RD	Fish	R24, T118, 119, S1-2; 34-35
27-192	Rebecca	290		NE	Fish	R24, T118, 119, S5; 31-23
27-194	Schwappauff	102		NE	IV	R24, T119, S14

EXHIBIT P WATER RESOURCES

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
RAMSEY COUNTY						
62-1	Silver	134		RD	Fish	R21, 22, T29, S6; 1
62-2	Bald Eagle	1995		GD	Fish	R21, 22 T30, 31, S-var.
62-4	Pig's Eye	511		NE	IV	R22, T28, S10, 11, 14, 5, 23
62-6	Kohlman	84		RD	VA	R22, T29, S4
62-7	Gervais	234		GD	Fish	R22, T29, S4, 5, 8, 9
62-13	Phalen	193		GD	Fish	R22, T29, S16, 21
62-16	Beaver	65	Dam	GD	VA	R22, T29, S25, 26
62-18	Deep	65		NE	Fish	R22, T30, S5, 6
62-19	Black	120		NE	IV	R22, T30, S8, 9
62-24	Birch	127		RD	VA	R22, T30, S15, 16, 21, 22
62-27	Gilfillan	86	Dam	NE	VA	R22, T30, SW17
62-28	Sucker	59		NE	Fish	R22, T30, S19
62-34	Goose	152		NE	VA	R22, T30, S22, 23
62-38	Vadnais	477		RD	Fish	R22, T30, S30, 31, 32
62-43	Wilkinson	601		NE	IV	R22, T30, 31, S4, 5; 34
62-46	Pleasant	585		RD	Fish	R22, 23, T30, S7, 8, 18; 12, 13
62-47	Crosby	46		NE	IV	R23, T28, S7, 8, 18; 12, 13
62-54	McCarron	71		GD	Fish	R23, T29, S13
62-55	Como	69		NE	VA	R23, T29, S23, 26
62-56	Owasso	360		GD	Fish	R23, T29, 30, 31, S1, 2; 35, 36
62-57	Josephine	110	Dam	GD	Fish	R23, T29, 30, S3; 34
62-59	Marsden	291		none	IV	R23, T30, S3, 10, 14, 15
62-61	Turtle	444	Dam	GD	Fish	R23, T30, S11, 14
62-67	Long	184		GD	Fish	R23, T30, S17, 18, 20
62-70	Round	122	Dam	RD	Fish	R23, T30, S21
62-73	Snail	195		RD	Fish	R23, T30, S23, 24
62-78	Johanna	211		RD	Fish	R23, T30, S33, 34
62-83	Silver	142		RD	Fish	R23, 24, T30, S31; 36
SCOTT COUNTY Additional Lakes Listed at end of exhibit						
70-1	Rice	249		NE	IV	R20, 21, T113, S7, 18; 12, 13
70-6	——	105		NE	IV	R21, T113, S27
70-12	——	143		NE	IV	R21, T114, S16, 17, 20, 21
70-13	——	116		NE	III	R21, T114, S19, 20, 29, 30
70-22	Cleary	137		NE	VA	R21, T114, S7; 12

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
70-23	––	155		NE	III	R21, 22, T114, S19; 24
70-24	Kane	276		NE	IV	R21, 22, T114, S19, 30; 24, 25
70-25	Rice	195		NE	III	R21, 22, T115, S6, 7; 1, 12
70-26	Lower Prior	820		GD	Fish	R21, 22, T115, S-var.
70-27	––	319		NE	IV	R22, T112-113, S3; 34, 35
70-29	St. Catherine	122		NE	IV	R22, T113, S2
70-31	Bradshaw	391		NE	II	R22, T113, S9, 10, 15, 16
70-35	Lennon	204		NE	IV	R22, T113, S11-13
70-42	––	120		NE	IV	R22, T113, S20, 21
70-48	––	193		NE	II	R22, T113, S30, 31
70-49	––	203		NE	IV	R22, T113, S32, 33
70-50	McMahon	136		NE	Fish	R22, T113, 114, S1; 35, 36
70-52	Cynthia	195	Dam	NE	IV	R22, T113, 114, S4, 5; 32; 13
70-54	Spring	690	Dam	GD	Fish	R22, T114, S3-5, 8-10
70-59	––	129		NE	III	R22, T114, S9, 16
70-60	Rice	107		NE	IV	R22, T114, S27, 28
70-69	Fish	175		RD	Fish	R22, T114, S3, 4
70-71	Garberg Marsh	105		NE	III	R22, T114, S3, 4
70-72	Upper Prior	326		GD	Fish	R22, T114, 115, S2-4; 34, 35
70-73	Howard	101		NE	III	R22, T114, 115, S5; 32
70-74	Dean	128		NE	IV	R22, T115, S10, 14, 15
70-83	––	155		NE	II	R22, T115, S31
70-87	Fisher	262		NE	III	R22, T115, 116, S1, 2; 35, 36
70-88	Blue	200		NE	IV	R22, T115, 116, S2, 3; 35
70-90	Hickey	105		NE	II	R22, 23, T113, S7; 12
70-91	Cedar	749	Dam	RD	Fish	R22, 23, T113, S-var.
70-92	––	123		NE	II	R22, 23, T113, S30; 25
70-94	Sutton	463		NE	IV	R22, 23, T114, S-var.
70-95	O'Dowd	256		RD	Fish	R22, 23, T115, S19, 30; 25
70-98	Pleasant	269		NE	VA	R23, T113, S10, 11, 15
70-104	––	137		NE	IV	R23, T113, S22, 27
70-110	Geis	185		NE	III	R23, T114, S11, 12, 14
70-113	Mill Pond	17		RD	VA	R23, T114, S19
70-116	Strunks	103	Artificial Lake	NE	III	R23, T114, S11, 12, 14
70-118	Gifford	98	Depot	NE	VA	R23, T115, S16, 17, 20, 21
70-120	Thole	131		RD	Fish	R23, T115, S25, 26
70-123	––	111		NE	––	R24, T113, S11-14
70-124	––	110		NE	II	R24, T113, S20
70-128	Carrs	101		NE	II	R24, T113, S27, 28
70-130	––	107		NE	II	R24, T113, S29, 32

MAP NO.	NAME	ACRES	STRUCTURES	PUBLIC WATERS DNR*	WETLAND TYPES DNR*	LOCATION
70-139	Clarks	316		NE	VA	R25, T113, S21, 22, 27, 28
70-140	Mahoney's Marsh	118		NE	II	R25, T113, S24, 25
WASHINGTON COUNTY	Additional Lakes Listed at end of exhibit					
82-1	St. Croix	12,160		NE	Fish	R20, T26-30, S-var.
82-4	Edith	75		RD	Fish	R20, T28, S4, 9
82-20	McKusick	46		RD	Fish	R20, T30, S20, 28, 29
82-21	Long	96		RD	IV	R20, T30, S30, 31
82-23	Lily	52		RD	Fish	R20, T30, S32, 33
82-26	Mud	82		NE	VA	R20, T31, S7, 8, 17, 18
82-31	Terrapin	127		NE	N-VA,S-IV	R20, T31, S10, 11, 14, 15, 22
82-36	Turtle	35		NE	VA	R20, T31, NC17
82-46	Square	193		RD	Fish	R20, T31, S23, 26
82-49	Big Carnellian	444		RD	Fish	R20, T31, S26, 34, 35
82-52	Big Marine	1577		RD	Fish	R20, T31, 32, S5, 20, 29-34
82-54	Bone	206		RD	Fish	R20, T32, S4, 5, 8, 9
82-56	German	109		NE	IV	R20, T32, S7, 18
82-59	Goose	83		NE	Fish	R20, T32, S11, 14
82-64	Fish	48		NE	VA	R20, T32, S21, 28
82-65	Hay	33		NE	III	R20, T32, S22, 23, 26, 27
82-67	Sand	46		NE	Fish	R20, T32, S26
82-89	Markgrafs	46		NE	IV	R21, T28, S2, 3, 10, 11
82-91	Mud	103		RD	IV	R21, T28, S6
82-92	Powers	57		NE	VA	R21, T28, S10, 11
82-94	Colby	11		NE	VA	R21, T28, S15, 22
82-101	DeMontreville	156		RD	Fish	R21, T29, S4, 5, 9
82-103	Olson	100		RD	VA	R21, T29, S8, 9
82-104	Jane	159		RD	Fish	R21, T29, S9, 10
82-106	Elmo	317		RD	Fish	R21, T29, S13, 14, 23, 24, 26
82-109	Eagle Point	143		NE	IV	R21, T29, S22, 27
82-115	Tanners	73		GD	Fish	R21, T29, S31
82-118	Long	78		RD	Fish	R21, T29, 30, S5; 32
82-122	Pine Tree	174		RD	Fish	R21, T30, S8
82-138	Horseshoe	91		NE	IV	R21, T31, S3, 4
82-140	Oneka	381		NE	IV	R21, T31, S9, 16
82-146	Rice	277		NE	IV	R21, T31, S16, 21, 22, 27, 28
82-147	Egg	106		RD	IV	R21, T31, S20, 29
82-153	Sunset	124		NE	Fish	R21, T31, S27, 34, 35
82-159	Forest	2206		GD	Fish	R21, T32, S-var.

EXHIBIT R

ARCHAEOLOGICAL SITES
(Indexed to Plate 27)

COUNTY: ANOKA

		LOCATION		
NUMBER	FEATURE	T.	R.	NOTES
1	Howard Lake Mounds	32	22	All sites are burial mounds unless otherwise noted. Actual site locations are confidential.
2	Centerville Lake Mounds	31	22	
3	Unnamed	31	22	
4	Unnamed	31	22	
5	Unnamed	32	22	
6	Unnamed	32	24	
7	Unnamed	33	24	
8	Anderson	32	22	Habitation
9	Unnamed	34	33	
10	Unnamed	33	22	
11	Unnamed	32	23	Bison Kill Site
12	Unnamed	32	23	Possible Bison Kill Site
13	Unnamed	33	22	
14	Unnamed	33	24	

COUNTY: CARVER

1	Unnamed	114,115	23	2 sites
2	Unnamed	115	23	
3	Unnamed	115	23	2 sites
4	Unnamed	116	23	
5	Unnamed	116	25	
6	Arboretum	116	23	
7	Goose Lake Site	116	25	Habitation
8	Wacholtz Site	116	25	
9	Unnamed	116	25	
10	Trende Site	115	24	Habitation
11	Miller Lake Site	115	24	Habitation, Burial Site

COUNTY: DAKOTA

1	Middle & Late Woodlands	115	18	Habitation
	Ranelius	115	18	Village
	Bremer Site	115	18	Village
2	Hamm Site	115	18	
	Bremer Site	115	18	
3	Lee Mill Cave	115	18	Rock Shelter
4	Nininger	115	17	
5	Unnamed	27	23	
6	Unnamed	28	22	2 Sites
7	Unnamed	28	22	
8	Unnamed	28	22	
9	Unnamed	28	23	2 sites

EXHIBIT R

		LOCATION		
NUMBER	FEATURE	T.	R.	NOTES
10	Unnamed	28	23	
11	Unnamed	28	23	
12	Unnamed	112	20	
13	Unnamed	112	19	
14	Unnamed	112	19	
15	Kennealy Site	27	23	Historic Burials
16	Black Dog Burial Site	27	23	Burials
17	Freitag Site	115	17	Burial Mounds
18	Unnamed	112	20	Lithic Scatter
19	New Hope Cantonment	28	23	Cantonment
COUNTY: HENNEPIN				
1	Davis Mound	27	24	
2	Findlay Mounds Group 1	27	24	
	Findlay Mounds Group 2	27	24	
	Unnamed	27	24	
2	Brown's Mounds-Eck Mounds	116	22	
3	Halpin Mounds	117	23	
4	Unnamed	115	21	
5	Unnamed	115	21	2 sites
6	Unnamed	27	23	
7	Unnamed	27	24	
8	Mahoney Mounds and two other sites	27	24	One site includes 9 circular mounds
9	Palmer Mounds, Group 1	27	24	
10	Hopkins Mounds	27	24	
11	Bloomington Ferry Mounds	116	21	
12	Palmer Mounds, Group 2	116	22	
13	Unnamed	116	22	
14	Kempton Group	116	22	
15	Fieldmann Mounds	116	22	
16	Unnamed	116	22	
17	Unnamed	116	22	
18	Unnamed	116	22	
19	Gifford Mounds	117	23	
20	Shaver Mounds	117	23	
21	Unnamed	117	22	
22	Wyman Mound	117	23	
23	Preston Haglin Mound	117	23	Includes 2 other sites
24	Unnamed	117	23	3 sites
25	Unnamed	117	23	7 sites, including Crystal Bay Groups 2 and 3
26	Unnamed	117	23	
27	Unnamed	117	23	2 sites, including Spotes mound
28	Unnamed	117	23	2 sites
29	Unnamed	117	23	
30	Unnamed	117	23	
31	Unnamed	117	23	
32	Unnamed	117	23	

EXHIBIT R

FEATURES OF ARCHAEOLOGICAL, CULTURAL AND HISTORIC INTEREST

NUMBER	FEATURE	LOCATION		NOTES
		T.	R.	
33	Willis Mound Group	117	23	
34	Unnamed	117	24	5 sites including Bartlett Group No. 2
35	Unnamed	117	24	
36	Unnamed	117	24	2 sites
37	Baker Mound Group	117	24	
38	Malmstem Mound	117	24	
39	Unnamed	117	24	
40	Medicine Lake Mounds	118	22	
41	Unnamed	118	23	
42	Unnamed	118	23	
43	Unnamed	118	24	2 sites
44	Unnamed	118	24	
45	Unnamed	119	21	
46	Unnamed	119	22	
47	Unnamed	119	22	
48	Unnamed	119	22	
49	Unnamed	119	22	
50	Unnamed	119	22	
51	Unnamed	119	24	2 sites
52	Unnamed	119	24	2 sites
53	Unnamed	120	121	
54	Unnamed	120	22	
55	Unnamed	120	22	
56	Trussel, Hayden Mounds	120	22	2 sites
57	Unnamed	121	22	
58	Unnamed	116	22	
59	Unnamed	118	24	
60	Unnamed	27	24	Village
61	McMillan	117	23	
62	Fort Snelling	28	23	Fort
63	Mitchell Lake Site	116	22	Campsite
COUNTY: RAMSEY				
1	Unnamed	28	22	
2	Unnamed	28	22	
3	Unnamed	29	22	
4	Unnamed	29	22	
5	Unnamed	30	22	
6	Unnamed	30	23	
7	Unnamed	29	22	

EXHIBIT R

FEATURES OF ARCHAEOLOGICAL, CULTURAL AND HISTORIC INTEREST

COUNTY: SCOTT

NUMBER	FEATURE	LOCATION T.	 R.	NOTES
1	Huber Mound	115	22	2 sites
2	Shakopee Village	115	22	
3	Unnamed	113	25	3 sites
4	Unnamed	113	25	4 sites
5	Unnamed	113	25	3 sites
6	Unnamed	113	25	
7	Unnamed	113	25	
8	Prior Lake Mounds	114	22	
9	Unnamed	114	22	
10	Unnamed	115	21	3 sites
11	Unnamed	115	23	
12	Steele Mounds	115	22	
13	Unnamed	115	22	
14	Unnamed	115	23	
15	Unnamed	115	23	
16	Unnamed	115	23	2 sites
17	Unnamed	115	23	

COUNTY: WASHINGTON

1	Shilling Site	27	21	Habitation
2	Michaud Mounds	27	21, 22	
3	Sheffield, McKee Sites	31	19	Village, Mississippian Oneota
4	Leslie Cave	32	19	Rock Shelter
5	Unnamed	26	20	
6	Unnamed	26	20	
7	Curry	27	21	
8	Unnamed	27	21, 22	
9	Unnamed	28	20	
10	Unnamed	29	20	
11	Unnamed	30	20	
12	Sheffield	31	19	
13	Unnamed	31	19	
14	Unnamed	31	19	
15	Unnamed	31	19	
16	Unnamed	32	19	
17	Unnamed	32	19	
18	Unnamed	26	20	
19	Unnamed	32	21	
20	Harvey Site	30	20	Rock Shelter (Mid Woodland)
21	Larson Plant Floodplain Site	27	22	Temporary Camp (Prehistoric Woodland)
22	Unnamed	29	20	Habitation
23	Unnamed	30	20	Habitation

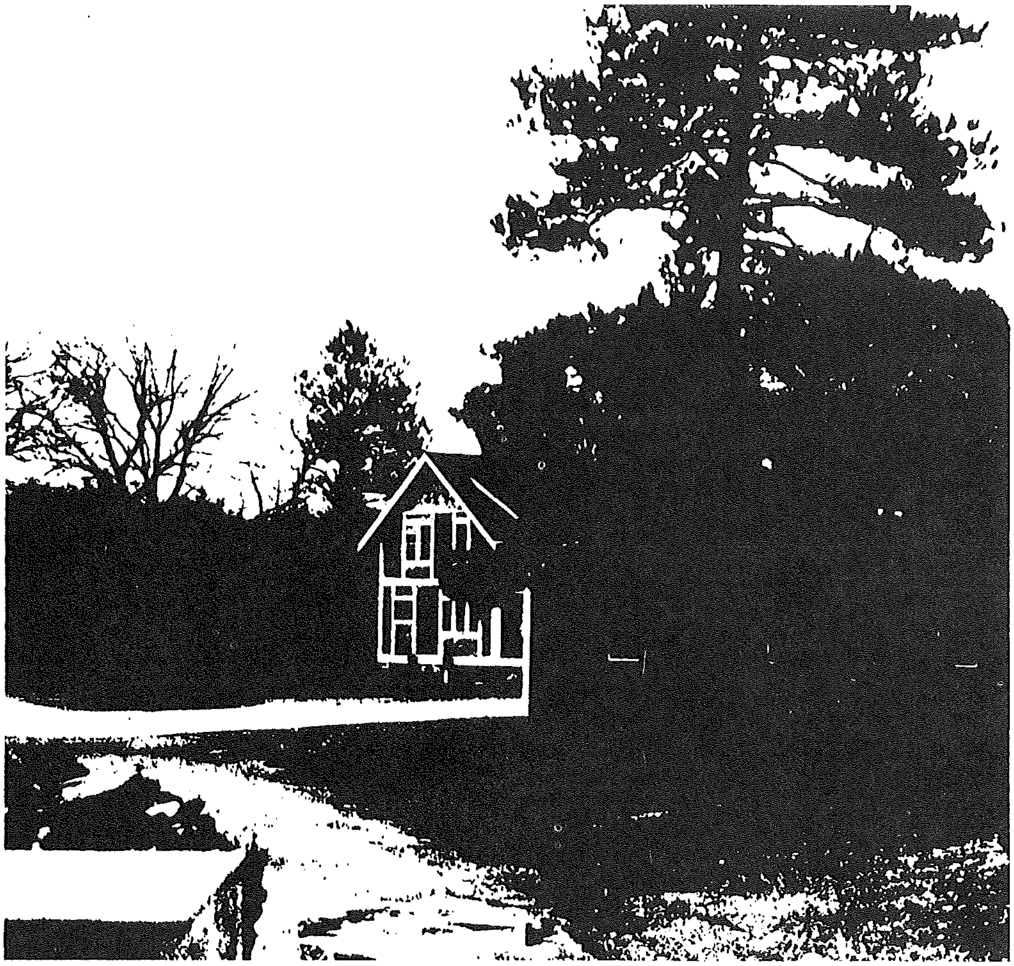


EXHIBIT T

METROPOLITAN RECREATION OPEN SPACE SYSTEM (20)

COMPONENT	USE	SERVICE AREA	SITE	SITE ATTRIBUTES	SITE LOCATION
MINI-PARK	Specialized facilities that serve a concentrated or limited population or specific group such as tots or senior citizens; may be in locations such as apartment complexes, town-house developments, or commerical centers.	Less than 1/4 mile	Less than 1 acre		
NEIGHBORHOOD PARK PLAYGROUND	Area for intense recreational activites such as field games, court games, crafts, apparatus area, skating, neighborhood centers.	1/4 to 1/2 mile radius to serve a population of 4,000 to 5,000 (neighborhood)	10-25 acres	Physiography suited for intense development.	Proximity to elementary schools.
COMMUNITY PLAYFIELD	Area for intense recreational facilities such as athletic fields and swimming pools; could include neighborhood use.	3-5 neighborhoods (community*)	25-50 acres	Physiography suited for intense development.	Proximity to secondary school and other public facilities.
COMMUNITY PARK	Area of natural or ornamental quality for outdoor recreation such as walking, viewing, sitting, picnicking; could have some field and court games.	3-5 neighborhoods (community*)	25-50 acres	Affords natural features with varied physiographic interest.	Proximity to community facilities & where resources are available.
REGIONAL PARK	Area of natural or ornamental quality for nature-oriented outdoor recreation such as picnicking, boating, fishing, swimming, skiing, hiking, & camping.	3-5 communities*	200-500 acres (100 acre minimum)	Complete natural setting contiguous to water bodies or water courses where possible.	Where natural resource occurs – particularly water.
REGIONAL PARK RESERVE	Area of natural quality for nature-oriented outdoor recreation such as viewing and studying nature, wildlife habitat, conservation, camping, picnicking, hiking, & fishing.	County Multi-county	1000 + acres; sufficient area to encompass the resource envisioned for preservation.	Diversity of unique resources, i.e., topography, lakes, streams, marshes, flora, fauna.	Where resource occurs.
LINEAR PARK (Trails, parkways)	Area developed for one or more varying modes of recreational travel such as hiking, biking, snowmobiling, horseback riding, crosscountry skiing, canoeing, & driving.		Sufficient width to provide maximum protection of resource & maximum use; sufficient length to accomplish purpose.	Utilize man-made &/or natural linear resources such as utility corridors, rights-of-way, drainage ways, bluff lines, vegetation patterns, and roads.	Where linear resource occurs. Link components of recreation system. Link other community facilities such as schools, library, and commercial areas.
HISTORIC PARK	Area which preserves, maintains, and interprets buildings, sites, and objects of historical and archeological significance.		Sufficient area to encompass facility or resource.	Historically significant – represent the broad cultural, political, economic, military, or social history; associated with historical figure; architectural specimen; major archeological site. Large enough to protect all significant resources.	Where resource occurs; where event occurred.
SPECIAL USE	Area providing specilized or single purpose recreational activities such as golf courses, nature centers, marinas, zoos, conservatories, arboretum, arenas, gun clubs.		Specific standard applicable to desired use.	Appropriate to particular special use.	Site where needed and appropriate.

EXHIBIT U

EXISTING REGIONAL RECREATION FACILITIES (20)

Facility	Acres	Fishing	Swimming	Boating	Canoeing	Sailing	Water Skiing	Hiking	Picnicking	Camping	Horseback Riding	Bicycling	Ski Touring	Downhill Skiing	Snow Shoeing	Snowmobiling	Skating	Interpretive
Coon Rapids Dam Reg. Pk.	386			X	X													
Lake Rebecca Pk. Res.	1,990	X	X	X		X		X	X				X		X			
Morris T. Baker Pk. Res.	2,712	X	X	X	X	X	X	X	X	X	X		X					
Elm Creek Pk. Res.	5,000		X						X				X					X
Crow Hassan Pk. Res.	2,609				X													
Bunker Prairie Reg. Pk.	1,600							X	X	X	X					X		
*Rush Lake Reg. Pk.	208																	
Phalen-Keller-Gervais Reg. Pk.	659	X	X	X	X	X	X	X	X			X	X		X	X	X	
*Grass-Vadnais Pk. Res.	1,556																	
*Lino Lakes Pk. Res.	2,900																	
*Otter Lake Reg. Pk.	526																	
*Lake Elmo Reg. Pk.	1,600																	
*Lilydale Reg. Pk.	320																	
*Lebanon Hills Reg. Pk.	2,261	X	X		X			X	X									
Lake Byllesby Reg. Pk.	224	X	X	X		X	X		X							X		
*Spring Lake Reg. Pk.	1,532																	
Anderson Lakes Pk. Res.	1,596							X	X		X	X	X	X				X
*Murphy-Hanrehan Pk. Res.	1,750																	
James Wilkie Pk. Res.	1,120										X							
Theodore Wirth Reg. Pk.	744	X	X	X	X			X	X			X	X	X	X		X	
Carver Pk. Res.	3,200							X	X	X			X					X
Mpls. Chain of Lakes Reg. Pk.	402	X	X	X	X	X		X	X			X					X	
Nokomis-Hiawatha Reg. Pk.	388	X	X	X	X			X	X			X					X	
Minnehaha Reg. Pk.	171							X	X									
Como Reg. Pk.	451	X	X	X	X	X		X	X			X	X	X	X	X	X	
Battle Creek Reg. Pk.	566							X	X		X		X	X	X	X		
Harriet Island Reg. Pk.	63	X		X	X	X	X	X	X			X		X	X	X	X	
Hidden Falls-Crosby Reg. Pk.	539							X	X									
*Rice Creek Trail	989																	
Baylor Reg. Pk.	201	X	X	X					X	X								X
Lake Sarah Reg. Pk.	176																	
Medicine Lake		X	X		X	X												
Mississippi Riverfront Park Complex (State-Owned)	24																	
William O'Brien Park	1,341	X	X		X			X	X	X								
*Afton State Park	1,648																	
Fort Snelling Park	2,500	X	X	X	X			X	X		X		X			X		
*Mn. River-Valley Trail								X	X		X		X		X	X		
Luce Line Trail								X	X		X	X	X		X	X		

*These facilities are currently undeveloped and are in the process of being acquired.

EXHIBIT V

PROPOSED SITES—REGIONAL OPEN SPACE SYSTEM (20)

CODE	SITE NAME	GENERAL LOCATION
1	Rum River	Andover and Oak Grove Township, Anoka County
2	Lake George	Northern Oak Grove Township, Anoka County
3	St. Francis Hills	St. Francis and Burns Township, Anoka County
4	Linwood-Island Lake	Linwood Township, Anoka County
5	Big Marine Lake	New Scandia Township, Washington County
6	Square Lake	May Township, Washington County
7	South Washington County Park	City of Cottage Grove, Washington County
8	Upper Grey Cloud Island	Mississippi River, Washington County
9	Hampton Woods	Castle Rock Township, Dakota County
10	Miesville Ravine	Douglas Township, Dakota County
11	Byllesby Reservoir	Randolph Township, Dakota County
12	Spring Lake	City of Prior Lake, Scott County
13	Comache	Credit River Township, Scott County
14	Cedar Lake	Helena Township, Scott County
15	Lake Minnewashta	City of Chanhassen, Carver County
16	Lake Waconia	City of Waconia and Laketown Township, Carver County
17	Bryant Lake	City of Eden Prairie, Hennepin County
18	Riley Lake	City of Eden Prairie, Hennepin County
19	Whaletail Lake	City of Minnetrista, Hennepin County
20	Fish-Eagle Lake	City of Maple Grove, Hennepin County
21	Coon Rapids Dam	City of Brooklyn Park, Hennepin County and City of Coon Rapids, Anoka County
22	Mississippi Islands	North of I-694, Hennepin and Anoka Counties
23	Pig's Eye	City of St. Paul, Ramsey County
24	Mississippi Riverfront Park	City of Minneapolis, Hennepin County

EXHIBIT W

FIVE YEAR CAPITAL IMPROVEMENT PROGRAM FOR REGIONAL RECREATION OPEN SPACE (20)

ACQUISITION 1977[1]

FACILITY	PRIORITY	COST
Medicine Lake RP, Hennepin[16]	Ia	$ 450,000
Fish Lake RP, Hennepin	Ia	720,000
Lake Minnewashta RP, Carver	Ia	2,500,000
Coon Rapids Dam RP, Anoka[3]	Ia	200,000
Bunker Hills RP, Anoka	Ia	85,000
Bryant Lake RP, Eden Prairie	Ia	306,000
Comache RP, Scott	Ia	540,000
Spring Lake RP, Scott	Ia	114,000
Rum River Central RP, Anoka	Ia	237,000
Subtotal		$ 5,152,000
15% contingency		772,800
TOTAL		$ 5,924,800
Mississippi Riverfront RP, Mpls.[8]	Ib	8,565,000
Pig's Eye RP, Ramsey[4]	Ib	1,512,792
Crosby Farms RP, St. Paul	Ib	103,000
Fish Hatchery RP, St. Paul	Ib	160,000
Subtotal		$ 10,340,792
15% contingency		1,551,118
TOTAL		$ 11,891,810
Demonstration Trail, Hennepin	Ic	270,000
15% contingency		40,500
TOTAL		$ 310,500
Bush Lake RP, Bloomington[3]	Id	110,000
Lebanon Hills RP, Dakota	Id	413,300
Spring Lake RP, Dakota	Id	482,200
Grass-Vadnais PR, Ramsey	Id	220,000
Otter Lake RP, Ramsey	Id	561,979
Murphy-Hanrehan PR, Scott	Id	225,000
Lake Elmo PR, Wash. Co.[17]	Id	345,000
Morris T. Baker PR, Hennepin	Id	180,000
Carver PR, Hennepin	Id	171,000
Lake Rebecca RP, Hennepin	Id	90,000
Hyland Lake RP, Hennepin	Id	68,000
Subtotal		$ 2,866,479
15% contingency		429,971
TOTAL		$ 3,296,450
Eagle Lake RP, Hennepin	IIa	90,000
Mississippi River Access, Hennepin [7]	IIa	45,000
Subtotal		$ 135,000
15% contingency		20,250
TOTAL		$ 155,250
Waconia RP, Carver[10]	IIIa	200,000
Byllesby RP, Dakota	IIIa	499,000
Lake Riley RP, Eden Prairie	IIIa	115,000
Lake Sarah RP, Hennepin	IIIa	67,500
Island Lake RP, Anoka	IIIa	114,000
Subtotal		$ 995,500
15% contingency		149,325
TOTAL		$ 1,144,825
So. Washington Co. PR, Wash. Co.	IIIb	100,000
15% contingency		15,000
TOTAL		$ 115,000
In Holdings		2,001,556
15% contingency		300,233
TOTAL		$ 2,301,789

DEVELOPMENT 1977[2]

FACILITY	PRIORITY	COST
Lake Harriet RP, Mpls.	Ia	$ 1,386,000
Lake of the Isles, Mpls.	Ia	1,226,700
No. Mississippi RP, Mpls.[8]	Ia	90,000
Wirth Park RP, Mpls.	Ia	328,500
Phalen Park RP, St. Paul	Ia	630,000
Hidden Falls/Crosby Farm RP, St. Paul	Ia	768,954
Lebanon Hills RP, Dakota	Ia	385,000
Spring Lake RP, Dakota	Ia	125,000
Grass-Vadnais PR, Ramsey	Ia	362,000
Lilydale RP, Ramsey	Ia	148,500
Otter Lake RP, Ramsey	Ia	49,500
Rice Creek-Rush Lake-Long Lake RP[3], Ramsey	Ia	121,000
Byllesby RP, Dakota	Ia	150,000
Murphy-Hanrehan PR, Scott	Ia	505,750
Battle Creek RP, Ramsey	Ia	1,277,650
Keller RP, Ramsey	Ia	231,220
Elm Creek PR, Hennepin	Ia	423,000
Morris T. Baker PR, Hennepin	Ia	270,000
Lake Rebecca PR, Hennepin	Ia	310,500
Bush Lake RP, Bloomington[3]	Ia	332,740
Subtotal		$ 9,122,014
15% contingency		1,368,302
TOTAL		$ 12,490,316
So. Washington Co. PR, Wash. Co.	Ic	60,000
Bryant Lake RP, Eden Prairie	Ic	70,000
Bunker Hills RP, Anoka	Ic	45,500
Subtotal		$ 175,000
15% contingency		26,325
TOTAL		$ 201,825
Island Lake RP, Anoka	IIIa	85,500
Baylor RP, Carver	IIIa	30,000
Minnewashta RP, Carver	IIIa	16,000
Waconia RP, Carver[10]	IIIa	33,000
Byllesby RP, Dakota	IIIa	124,000
Spring Lake RP, Scott[6]	IIIa	330,000
Subtotal		$ 618,500
15% contingency		92,775
TOTAL		$ 711,275

EXHIBIT W (CONT'D)

ACQUISITION 1978

FACILITY	PRIORITY	COST
Comache RP, Scott	Ia	$ 585,000
Medicine Lake RP, Hennepin	Ia	225,000
Fish Lake RP, Hennepin[7]	Ia	135,000
Spring Lake RP, Scott	Ia	57,000
Subtotal		$ 1,002,000
15% contingency		150,300
TOTAL		$ 1,152,300
Mississippi Riverfront RP, Mpls.[8]	Ib	1,225,000
Pig's Eye RP, Ramsey[4]	Ib	555,063
Subtotal		$ 1,780,063
15% contingency		267,009
TOTAL		$ 2,047,072
Rice Creek RP, Anoka	Id	84,000
Bush Lake RP, Bloomington[3]	Id	110,000
Spring Lake RP, Dakota	Id	279,000
Murphy-Hanrehan PR, Scott	Id	67,500
Lake Elmo PR, Wash. Co.	Id	219,000
Lake Rebecca PR, Hennepin	Id	180,000
Hyland Lake PR, Hennepin	Id	68,000
Subtotal		$ 1,007,500
15% contingency		151,125
TOTAL		$ 1,158,625
Coon Rapids Dam RP, Anoka[3]	IIa	300,000
Bryant Lake RP, Eden Prairie	IIa	140,000
Eagle Lake RP, Hennepin	IIa	90,000
Mississippi River Access Islands RP, Hennepin[7]	IIa	45,000
Subtotal		$ 575,000
15% contingency		86,250
TOTAL		$ 661,250
Bunker Hills RP, Anoka	IIb	188,700
15% contingency		28,305
TOTAL		$ 217,005
Rum River Central RP, Anoka	IIIa	30,000
Waconia RP, Carver[10]	IIIa	300,000
Byllesby RP, Dakota	IIIa	312,000
Lake Riley RP, Eden Prairie	IIIa	800,000
Lake George RP, Anoka	IIIa	600,000
Whaletail Lake RP, Hennepin[7]	IIIa	180,000
Lake Sarah RP, Hennepin[7]	IIIa	54,000
Subtotal		$ 2,276,000
15% contingency		341,400
TOTAL		$ 2,617,400
So. Washington Co. RP, Wash. Co.[11]	IIIb	20,000
15% contingency		3,000
TOTAL		$ 23,000
In Holdings		1,039,355
15% contingency		155,903
TOTAL		$ 1,195,258

DEVELOPMENT 1978

FACILITY	PRIORITY	COST
North Mississippi RP, Mpls.[8]	Ia	$ 90,000
Wm. Berry Lake Harriet RP, Mpls.	Ia	247,500
Mississippi Riverfront Park, Mpls.[8]	Ia	1,687,500
Cherokee RP, St. Paul	Ia	220,589
Indian Mounds RP, St. Paul	Ia	275,000
Harriet Island RP, St. Paul	Ia	1,099,516
Lebanon Hills RP, Dakota	Ia	375,500
Spring Lake RP, Dakota	Ia	143,000
Lilydale RP, Ramsey	Ia	297,550
Grass-Vadnais RP, Ramsey	Ia	241,450
Otter Lake RP, Ramsey	Ia	386,100
Rice Creek-Rush Lake-Long Lake RP[3], Ramsey	Ia	322,053
Murphy-Hanrehan PR, Scott[6]	Ia	180,000
Lake Elmo PR, Wash. Co.[13]	Ia	700,000
Byllesby RP, Dakota [18]	Ia	150,000
Hyland Lake PR, Hennepin[3]	Ia	221,000
Battle Creek RP, Ramsey	Ia	112,200
Keller RP, Ramsey	Ia	113,740
Elm Creek PR, Hennepin	Ia	1,411,000
Morris T. Baker PR, Hennepin	Ia	21,250
Lake Rebecca PR, Hennepin	Ia	590,750
Carver PR, Hennepin	Ia	157,250
Bush Lake RP, Bloomington[3]	Ia	245,500
Subtotal		$ 9,288,448
15% contingency		1,393,267
TOTAL		$10,681,715
So. Washington Co. PR, Wash. Co.[13]	Ic	150,000
Bunker Hills RP, Anoka	Ic	411,500
Lake Minnewashta RP, Carver	Ic	98,000
Bryant Lake RP, Eden Prairie	Ic	850,000
Medicine Lake RP, Hennepin	Ic	756,500
Subtotal		$ 2,266,000
15% contingency		339,900
TOTAL		$ 2,605,900
Rum River Central RP, Anoka	IIIa	96,000
Baylor RP, Carver	IIIa	181,500
Waconia RP, Carver[10]	IIIa	152,000
Byllesby RP, Dakota	IIIa	239,000
Comache RP, Scott	IIIa	153,000
Grey Cloud RP, Wash. Co.[13]	IIIa	20,000
James Wilkie PR, Hennepin[7]	IIIa	29,750
Subtotal		$ 871,250
15% contingency		130,687
TOTAL		$ 1,001,937

EXHIBIT W (CONT'D)

ACQUISITION 1979

FACILITY	PRIORITY	COST
Mississippi Riverfront Park, Mpls.[8]	Ib	$ 1,100,000
15% contingency		165,000
TOTAL		$ 1,265,000
Bush Lake RP, Bloomington[3]	Id	100,000
Spring Lake RP, Dakota	Id	23,300
Murphy-Hanrehan PR, Scott	Id	67,500
Lake Elmo PR, Wash. Co.	Id	500,000
Lake Rebecca PR, Hennepin	Id	90,000
Hyland Lake PR, Hennepin[3]	Id	68,000
Subtotal		$ 848,800
15% contingency		127,320
TOTAL		$ 976,120
Minnewashta RP, Carver	IIa	200,000
Medicine Lake RP, Hennepin	IIa	135,000
Eagle Lake RP, Hennepin	IIa	180,000
Mississippi River Access Islands[7], Hennepin	IIa	45,000
Subtotal		$ 560,000
15% contingency		84,000
TOTAL		$ 644,000
Island-Linwood Lake RP, Anoka	IIIa	480,000
Waconia RP, Carver[10]	IIIa	150,000
Byllesby RP, Dakota	IIIa	69,500
Lake Riley RP, Eden Prairie	IIIa	267,500
Whaletail RP, Hennepin[7]	IIIa	202,500
Spring Lake RP, Scott	IIIa	100,000
Subtotal		$ 1,269,500
15% contingency		190,425
TOTAL		$ 1,459,925
Baylor RP, Carver	IIIb	75,000
So. Washington Co. PR, Wash. Co.	IIIb	455,000
Subtotal		$ 530,000
15% contingency		79,500
TOTAL		$ 609,500
In Holdings		967,142
15% contingency		145,071
TOTAL		$ 1,112,213

DEVELOPMENT 1979

FACILITY	PRIORITY	COST
Cedar Lake RP, Mpls.	Ia	$ 283,500
Battle Creek RP, St. Paul	Ia	1,650,000
Fish Hatchery RP, St. Paul[5]	Ia	550,000
Crosby Farms RP, St. Paul	Ia	205,640
Lilydale RP, St. Paul	Ia	544,544
Chain of Lakes PR, Anoka	Ia	820,000
Anderson Lakes PR, Eden Prairie[3]	Ia	500,000
Grass-Vadnais PR, Ramsey	Ia	535,700
Bush Lake RP, Bloomington[3]	Ia	92,000
Lebanon Hills RP, Dakota	Ia	371,320
Otter Lake RP, Ramsey	Ia	376,486
Rice Creek,-Rush Lake-Long Lake RP[3], Ramsey	Ia	536,910
Battle Creek RP, Ramsey	Ia	414,920
Keller RP, Ramsey	Ia	72,325
Lilydale RP, Ramsey	Ia	553,850
Spring Lake RP, Dakota	Ia	108,000
Elm Creek RP, Hennepin	Ia	1,066,750
Morris T. Baker PR, Hennepin	Ia	1,089,000
Lake Rebecca PR, Hennepin	Ia	46,750
Carver PR, Hennepin	Ia	85,000
Murphy-Hanrehan PR, Scott[6]	Ia	561,000
Lake Elmo PR, Washington[13]	Ia	300,000
Subtotal		$10,763,695
15% contingency		1,614,554
TOTAL		$12,378,249
So. Washington Co. PR, Wash. Co.[13]	Ic	225,000
Minnewashta RP, Carver	Ic	39,000
Subtotal		$ 264,000
15% contingency		39,600
TOTAL		$ 303,600
Baylor RP, Carver	IIIa	93,000
Waconia RP, Carver[10]	IIIa	77,000
Byllesby RP, Dakota	IIIa	224,500
Big Marine RP, Wash Co.[11,13]	IIIa	20,000
Lake Sarah RP, Hennepin[7]	IIIa	255,000
Subtotal		$ 669,500
15% contingency		100,425
TOTAL		$ 769,925

EXHIBIT W (CONT'D)

ACQUISITION 1980

FACILITY	PRIORITY	COST
Minneapolis Riverfront Park, Mpls.[8]	Ib	$ 1,100,000
15% contingency		165,000
TOTAL		$ 1,265,000
Bush Lake RP, Bloomington[3]	Id	100,000
Murphy-Hanrehan PR, Scott	Id	45,000
Lake Rebecca PR, Hennepin	Id	45,000
Subtotal		$ 190,000
15% contingency		28,500
TOTAL		$ 218,500
Coon Rapids Dam RP, Anoka[3]	IIa	140,000
Medicine Lake RP, Hennepin	IIa	112,500
Eagle Lake RP, Hennepin	IIa	135,000
Mississippi River Access Islands, Hennepin[7]	IIa	45,000
Subtotal		$ 432,500
15% contingency		64,875
TOTAL		$ 497,375
Waconia RP, Carver[10]	IIIa	100,000
Lake Riley RP, Eden Prairie	IIIa	200,000
Spring Lake RP, Scott	IIIa	90,000
Subtotal		$ 390,000
15% contingency		58,500
TOTAL		$ 448,500
Crow-Hassan PR, Hennepin	IIIb	13,500
So. Washington Co. PR, Wash.	IIIb	700,000
Subtotal		$ 713,500
15% contingency		107,025
TOTAL		$ 820,525
In Holdings		856,052
15% contingency		128,407
TOTAL		$ 984,459

DEVELOPMENT 1980

FACILITY	PRIORITY	COST
East River Flats RP, Mpls	Ia	$ 315,000
Minnehaha RP, Mpls.	Ia	567,000
N. Mississippi River Park, Mpls.[8]	Ia	567,000
Mississippi Riverfront Park, Mpls.[8]	Ia	360,000
Como Park RP, St. Paul[5]	Ia	6,050,000
Battle Creek RP, Ramsey	Ia	140,525
Keller RP, Ramsey	Ia	67,100
Hyland Lake PR, Hennepin[3]	Ia	55,250
Grass-Vadnais PR, Ramsey	Ia	121,000
Bush Lake RP, Bloomington[3]	Ia	201,640
Lebanon Hills RP, Dakota	Ia	96,000
Lilydale RP, Ramsey	Ia	720,148
Otter Lake RP, Ramsey	Ia	205,700
Rice Creek-Rush Lake-Long Lake RP[3], Ramsey	Ia	504,720
Spring Lake RP, Dakota	Ia	63,000
Morris T. Baker PR, Hennepin	Ia	136,000
Lake Rebecca PR, Hennepin	Ia	841,500
Carver PR, Hennepin	Ia	896,750
Murphy-Hanrehan PR, Scott[6]	Ia	510,000
Lake Elmo PR, Washington[13]	Ia	390,000
Subtotal		$12,808,333
15% contingency		1,921,250
TOTAL		14,729,583
So. Washington Co. PR, Wash.[13]	Ic	140,000
Minnewashta RP, Carver	Ic	48,000
Fish Lake RP, Hennepin[7]	Ic	841,500
Subtotal		$ 1,029,500
15% contingency		154,425
TOTAL		$ 1,183,925
Spring Lake, Scott	IIIa	450,500
Waconia RP, Carver[10]	IIIa	140,000
Byllesby RP, Dakota	IIIa	32,000
Baylor RP, Carver	IIIa	23,000
Crow-Hassan PR, Hennepin	IIIa	510,000
Subtotal		$ 1,155,500
15% contingency		173,325
TOTAL		$ 1,328,825

EXHIBIT W (CONT'D)

Five-Year Capital Improvement Program for Regional Trails

	1977	1978	1979	1980	1981	Total
Corridor Acquisition and Development	$ 1,200,000	$ 1,550,000	$ 1,550,000	$ 1,550,000	$ 1,550,000	$ 7,400,000
Parkways (Mpls.)	657,000	367,000	1,380,000	–	–	2,404,000
Total	$ 1,857,000	$ 1,917,000	$ 2,039,000	$ 1,550,000	$ 1,550,000	$ 9,804,000
					15% contingency	1,470,600
					Total	$11,274,600

Five-Year Capital Improvement Program for Regional Special Use Sites

	1977	1978	1979	1980	1981
Acquisition and Development	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000	$ 2,000,000

Five-Year Program for System Studies

	1977	1978	1979	1980	1981
System Studies	$ 200,000	$ 200,000	$ 200,000	$ 100,000	$ 100,000

Summary Total for Five-Year Capital Improvement Program

	1977	1978	1979	1980	1981	Total
Acquisition	$ 25,140,524	$ 9,071,910	$ 6,066,758	$ 4,234,359	$ 4,227,862	$ 48,741,413
Development	13,403,416	14,289,552	13,451,774	17,242,333	6,772,356	65,159,431
Trail Corridor	2,135,550	2,204,550	2,344,830	1,782,500	1,782,500	10,249,930
Special Use	2,000,000	2,000,000	2,000,000	2,000,000	2,000,000	10,000,000
System Studies	200,000	200,000	200,000	100,000	100,000	800,000
Total	$ 42,879,490	$ 27,766,012	$ 24,063,362	$ 25,359,192	$ 14,882,538	$134,950,774 GRAND TOTAL

EXHIBIT W (CONT'D)

ACQUISITION 1981

FACILITY	PRIORITY	COST
Minneapolis Riverfront Park, Mpls.[8]	Ib	$ 1,100,000
15% contingency		165,000
TOTAL		$ 1,265,000
Bush Lake RP, Bloomington[3]	Id	100,000
Murphy-Hanrehan PR, Scott	Id	45,000
Lake Rebecca PR, Hennepin	Id	67,500
Subtotal		$ 212,500
15% contingency		31,875
TOTAL		$ 244,375
Medicine Lake RP, Hennepin	IIa	112,500
Eagle Lake RP, Hennepin	IIa	135,000
Mississippi River Access Islands, Hennepin[7]	IIa	45,000
Subtotal		$ 292,500
15% contingency		43,875
TOTAL		$ 336,375
Niger Lake RP, Anoka[14]	IIIa	900,000
Lake Riley RP, Eden Prairie	IIIa	300,000
Subtotal		$ 1,200,000
15% contingency		180,000
TOTAL		$ 1,380,000
In Holdings		871,402
15% contingency		130,710
TOTAL		$ 1,002,112

DEVELOPMENT 1981

FACILITY	PRIORITY	COST
North Mississippi Phase II, Mpls.[8]	Ia	$ 540,000
Battle Creek RP, Ramsey	Ia	188,980
Keller RP, Ramsey	Ia	72,600
Grass-Vadnais PR, Ramsey	Ia	48,800
Bush Lake RP, Bloomington[3]	Ia	100,000
Lebanon Hills RP, Dakota	Ia	194,000
Coon Rapids Dam RP, Hennepin[3]	Ia	891,500
Lilydale RP, Ramsey	Ia	168,806
Otter Lake RP, Ramsey	Ia	75,350
Rice Creek-Rush Lake-Long Lake RP[3], Ramsey	Ia	250,470
Spring Lake RP, Dakota	Ia	24,500
Elm Creek PR, Hennepin	Ia	990,250
Morris T. Baker PR, Hennepin	Ia	688,500
Murphy-Hanrehan PR, Scott[6]	Ia	510,000
Lake Elmo PR, Washington[13]	Ia	300,000
Subtotal		$ 5,043,756
15% contingency		756,563
TOTAL		$ 5,800,319
So. Washington Co., Wash.[13]	Ic	100,000
Minnewashta RP, Carver	Ic	54,000
Eagle Lake RP, Hennepin[7]	Ic	391,000
Subtotal		$ 545,000
15% contingency		81,750
TOTAL		$ 626,750
Baylor RP, Carver	IIIa	20,000
Waconia RP, Carver[10]	IIIa	113,000
Byllesby RP, Dakota	IIIa	10,000
Crow-Hassan RP, Hennepin	IIIa	157,250
Subtotal		$ 300,250
15% contingency		45,037
TOTAL		$ 345,287

NOTES:

1. Acquisition: prior to acquisition grants, master plans for each site must be approved including specific boundaries, parcels and acreages.
2. Development: prior to development grants, master plans for each site must be approved including a development concept plan and cost estimates.
3. Subject to receipt and approval of joint master plan for sites.
4. Subject to study and resolution of the question of the appropriate type of facility for this site.
5. Subject to receipt and approval of amendments to St. Paul master plans, including concept plans.
6. Subject to receipt and approval of amendment to Hennepin-Scott master plans, including,concept plans for these sites.
7. Subject to receipt and approval of amendment to Hennepin master plan, including concept plans for these sites.
8. Subject to receipt and approval of master plan including concept plan from Minneapolis.
9. Subject to receipt and approval of concept plan for Demonstration Trail.
10. Subject to receipt and approval of amendment to Carver master plan.
11. This money is for options at site.
12. This item is for a scenic easement which is recommended to be treated as a demonstration project.
13. Subject to receipt and approval of amendment to Washington County master plan.
14. Subject to receipt and approval of amendment to Anoka County master plan.
15. All trail funding requests to be prioritized upon adoption of Regional Trails Policy Plan Amendment. In addition all trail funding contingent upon receipt and approval of master plan amendments.
16. The abbreviation RP stands for regional parks.
17. The abbreviation PR stands for park reserves.
18. Structural repair of the Byllesby Dam only.

EXHIBIT X

CURRENT STATUS OF THE OPEN SPACE PLAN, 1977 (20)

Priorities

When judgments must be made between projects within a single priority, decisions will be based on the timing and amount of expected use, and the need for the project within that sector as defined in this Policy Plan.

First Priority

Acquisition	Development
Ia. Parcels in regional parks or park reserve sites that are under intense pressure from development.	Ia. Existing regional parks *in the Fully Developed Area,* (including redevelopment of regional parks in the central city) *and development of the Immediate Action sites.***
Ib. Lakeshore and riverfront in regional park sites *in the Fully Developed Area.**	Ib. Multi-use trail demonstration project.
Ic. Trails for demonstration projects on multi-use trails.	Ic. Existing regional parks and park reserves in or adjacent to the *Urban Service Area.*
Id. *Critical parcels in Immediate Action sites.***	

Second Priority

Acquisition	Development
IIa. *Lakeshore and riverfront in regional parks in the Area of Planned Urbanization.*	IIa. Regional trail corridors *in the developed and urbanizing areas.*
IIb. Regional parks *in the Urban Service Area.*	
IIc. Regional trails in developed and urbanizing areas.	

Third Priority

Acquisition	Development
IIIa. *Lakeshore and riverfront in regional park sites in the Rural Area.*	IIIa. Existing regional parks and park reserves *in the Rural Area.*
IIIb. Regional parks and park reserves *in the Rural Area.*	IIIb. Regional trail corridors *in the Rural Area.*
IIIc. Regional trail corridors *in the Rural Area.*	

---

* All word changes from those adopted in the Recreation Open Space Policy Plan are italicized.

** Immediate Action sites are all park sites included in the 1974 acquisition and development Grant Program for Regional Parks. These are:

1. Anderson Lakes-Bloomington
2. Anderson Lakes-Eden Prairie
3. Morris T. Baker Park Reserve
4. Carver Park Reserve
5. Coon Rapids Dam Park
6. Elm Creek Park Reserve
7. Grass Lake-Vadnais Park
8. Hyland Park Reserve
9. Lake Elmo Park Reserve
10. Lebanon Hills Park Reserve
11. Lilydale Park
12. Lino Lakes Park
13. Murphy-Hanrehan Park Reserve
14. Otter Lake Park
15. Rebecca Park Reserve
16. Rice Creek-Anoka Co.
17. Rice Creek-Rush Lake-Long Lake Park-Ramsey County
18. Spring Lake Park

BASELINE ENVIRONMENTAL INVENTORY / GEOLOGY AND GEOMORPHOLOGY
TWIN CITIES METROPOLITAN AREA

Plate 1

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

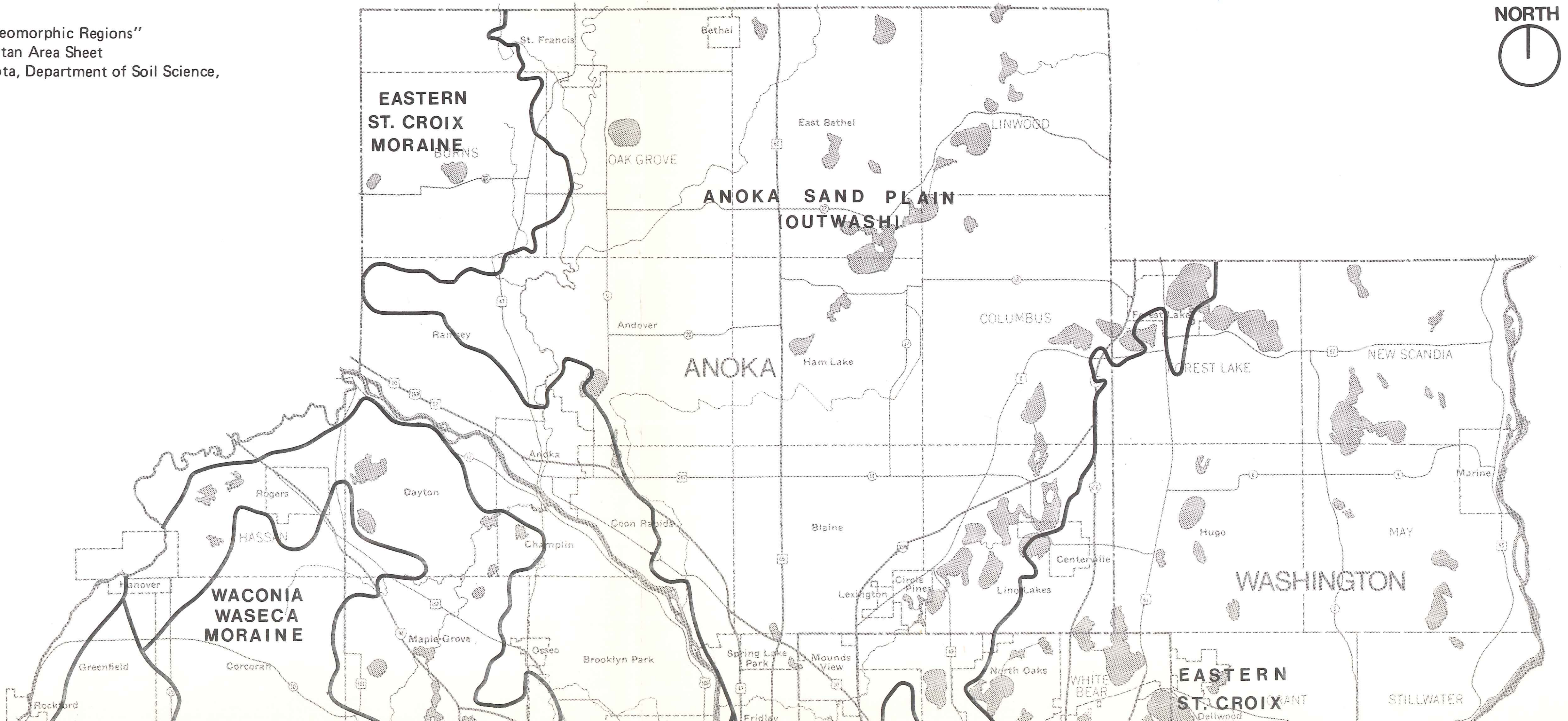
Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: "Soil Landscape and Geomorphic Regions"
Twin Cities Metropolitan Area Sheet
University of Minnesota, Department of Soil Science,
1974.



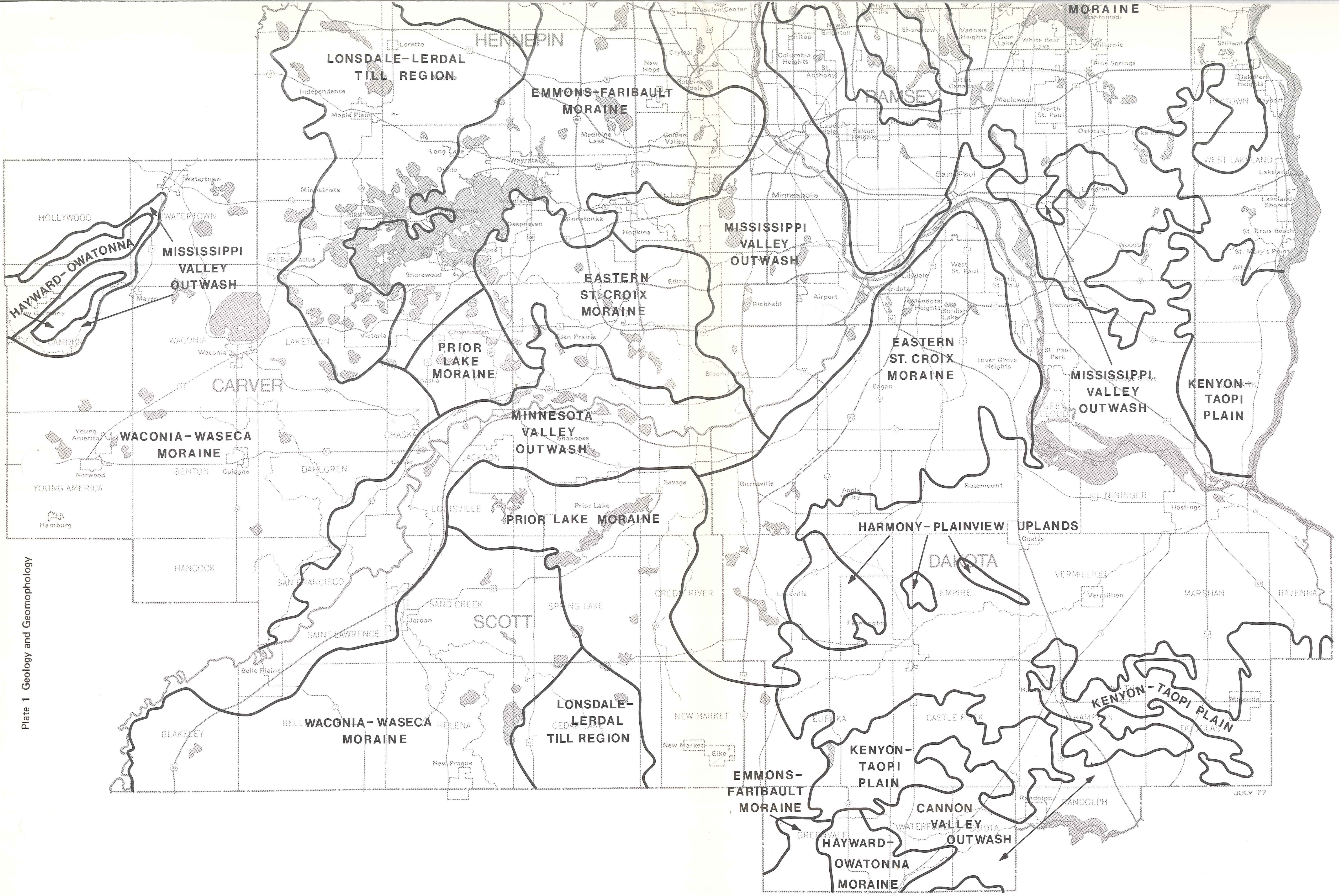


Plate 1 Geology and Geomophology

BASELINE ENVIRONMENTAL INVENTORY / ELEVATIONS
TWIN CITIES METROPOLITAN AREA

Legend

▨

▤

Plate 2

201 working for water quality
Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

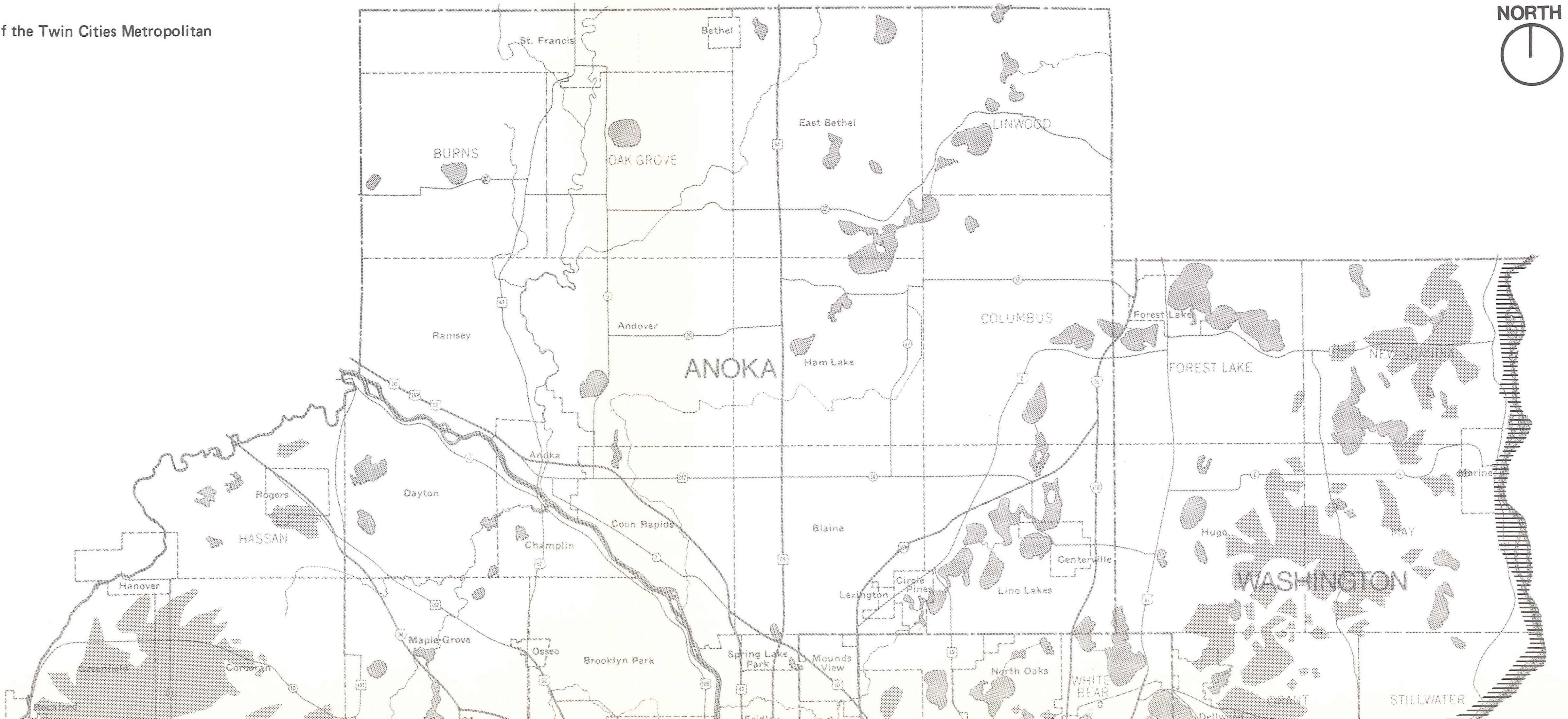
Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: MWCC Topography of the Twin Cities Metropolitan Area.



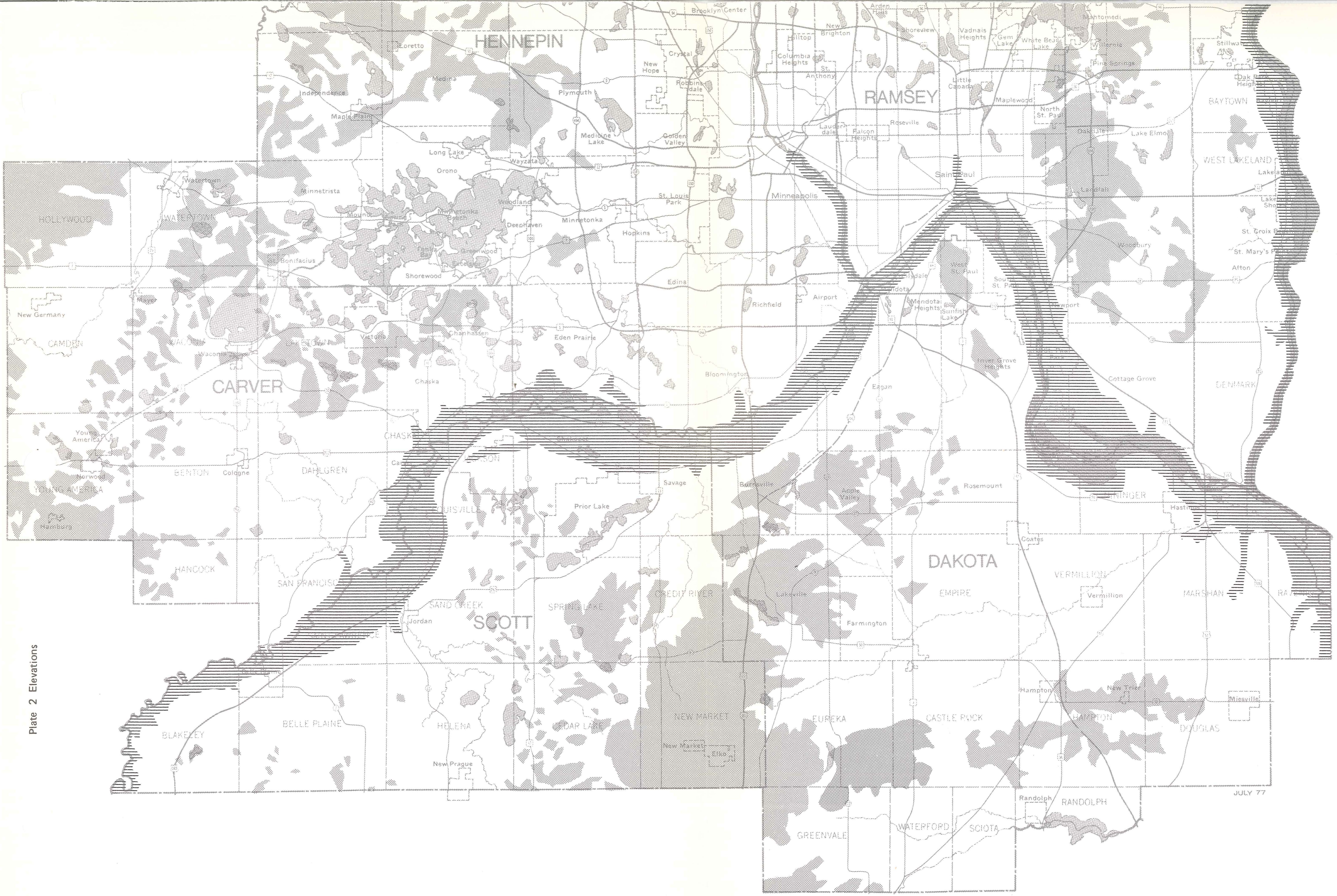


Plate 2 Elevations

BASELINE ENVIRONMENTAL INVENTORY / SLOPES
TWIN CITIES METROPOLITAN AREA

Plate 3

working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

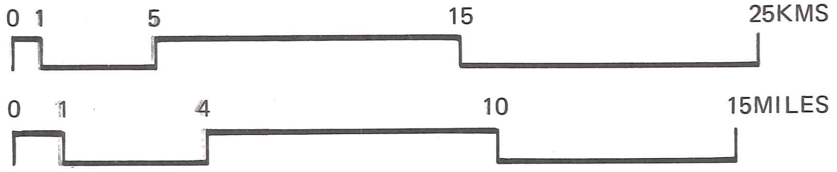
Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

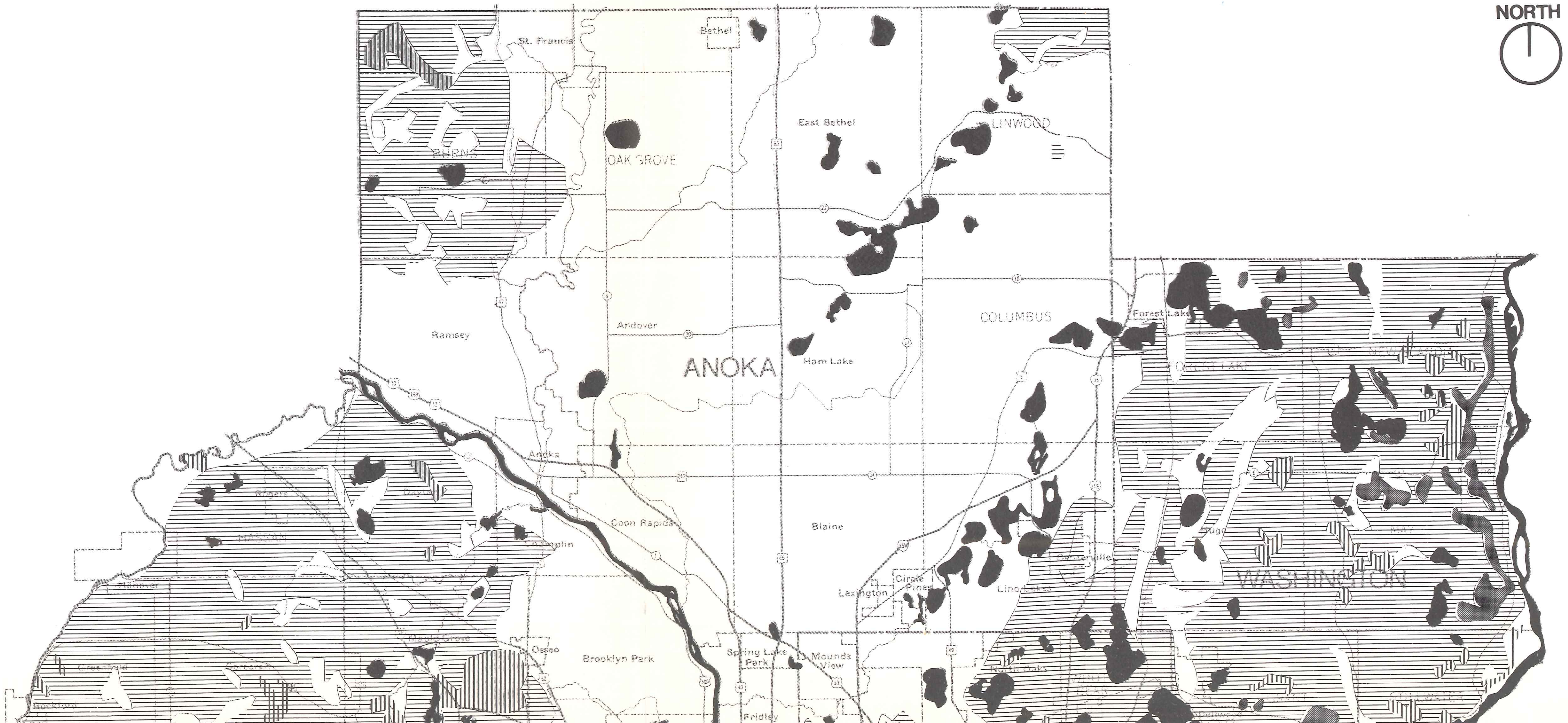
Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

☐ 0- 6% Slope
▤ 6-12% Slope
▥ 12-18% Slope
▨ 18+% Slope



Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.



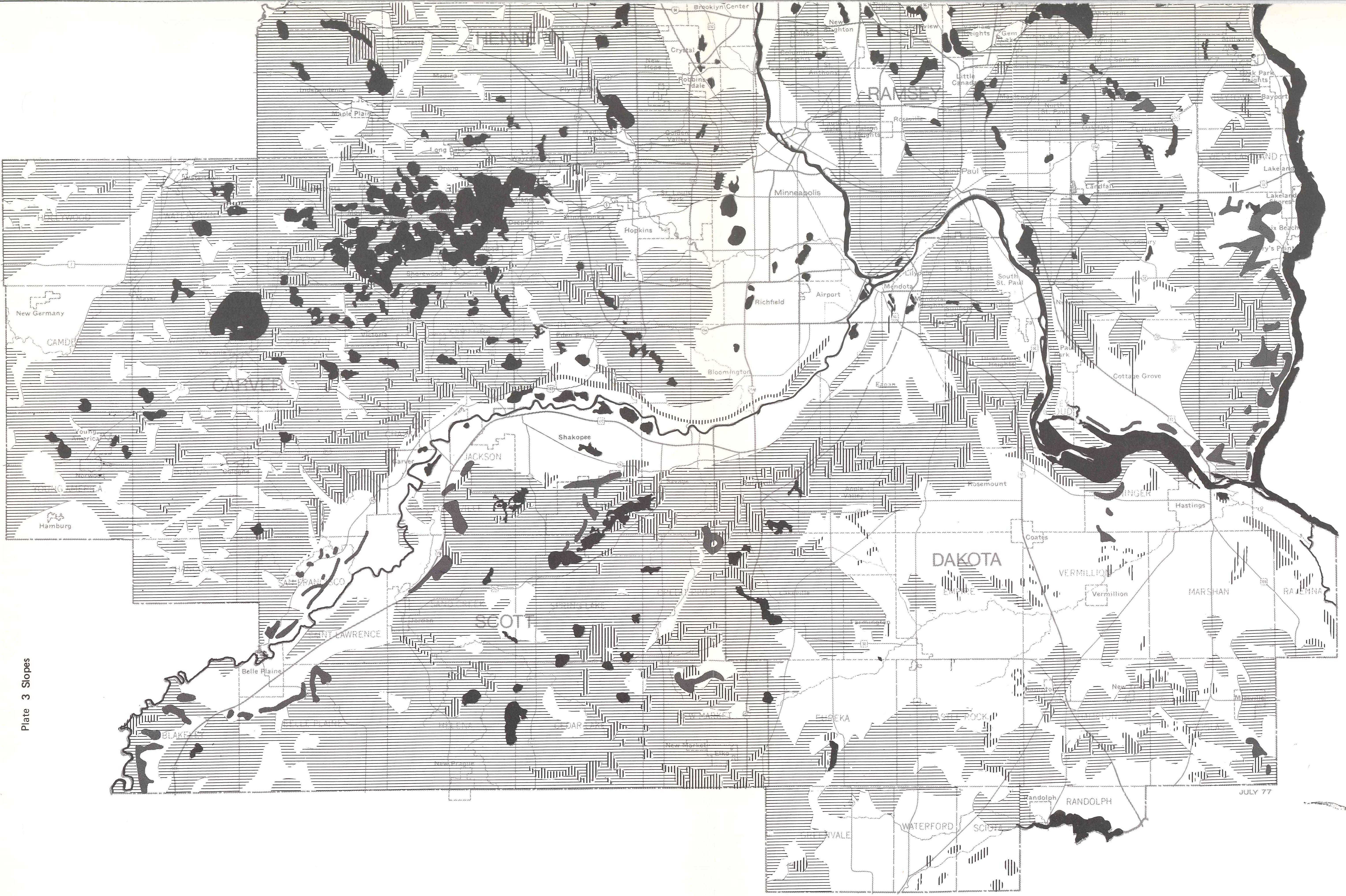


Plate 3 Slopes

BASELINE ENVIRONMENTAL INVENTORY / GEOLOGICAL FEATURES
TWIN CITIES METROPOLITAN AREA

Plate 4

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

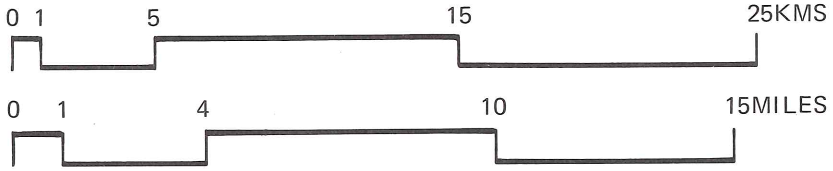
InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

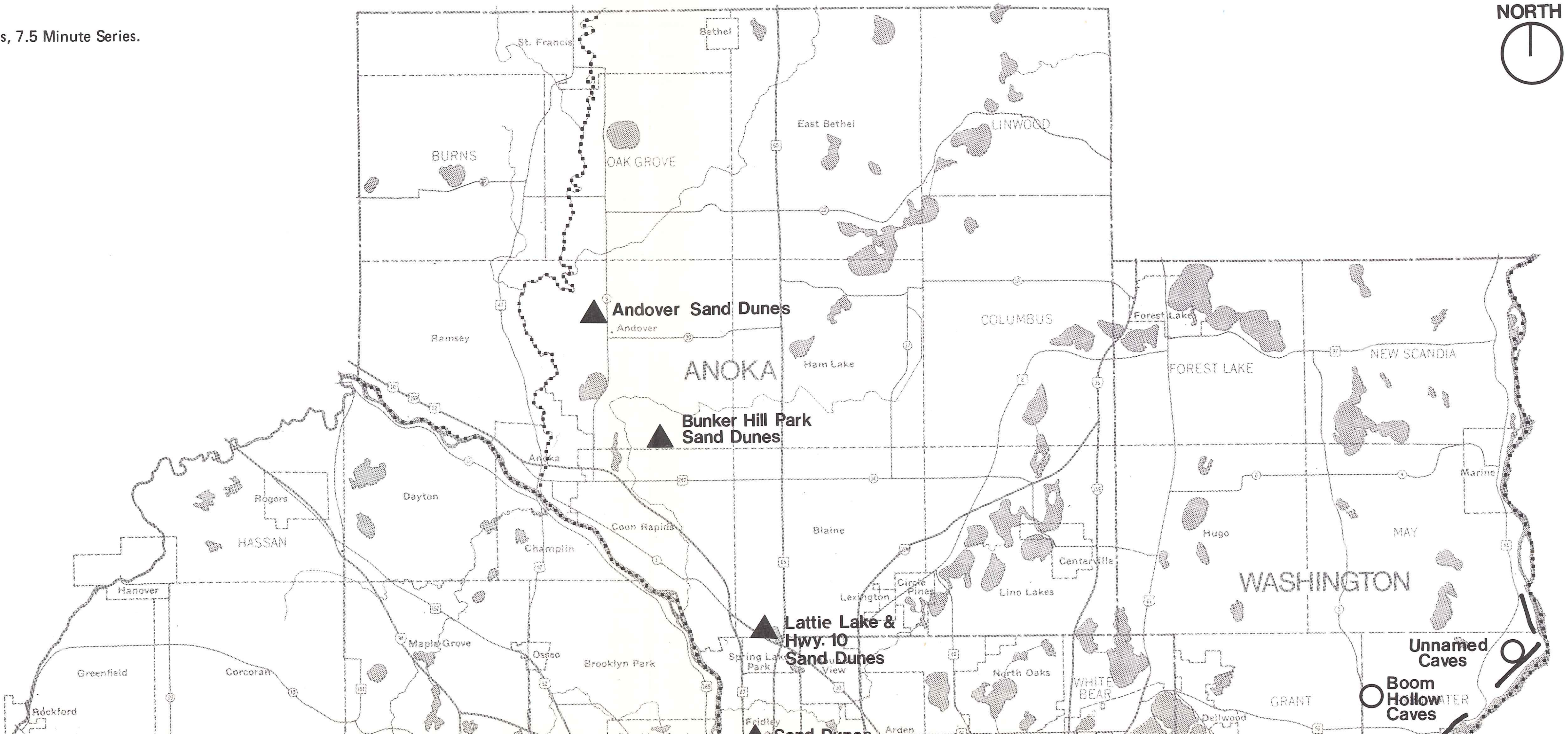
Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

△	Quarry	⋯	Sand and/or Rocks and Rubble River Bottom
▲	Sand Dune	xxxx	Sand and Organic Sludge River Bottom
□	Rapids and Falls	▨	Organic Sludge Deposit
○	Cave	////	Gorge
●	Spring	⁓	Bluff



SOURCES: USGS Quadrangle Maps, 7.5 Minute Series.



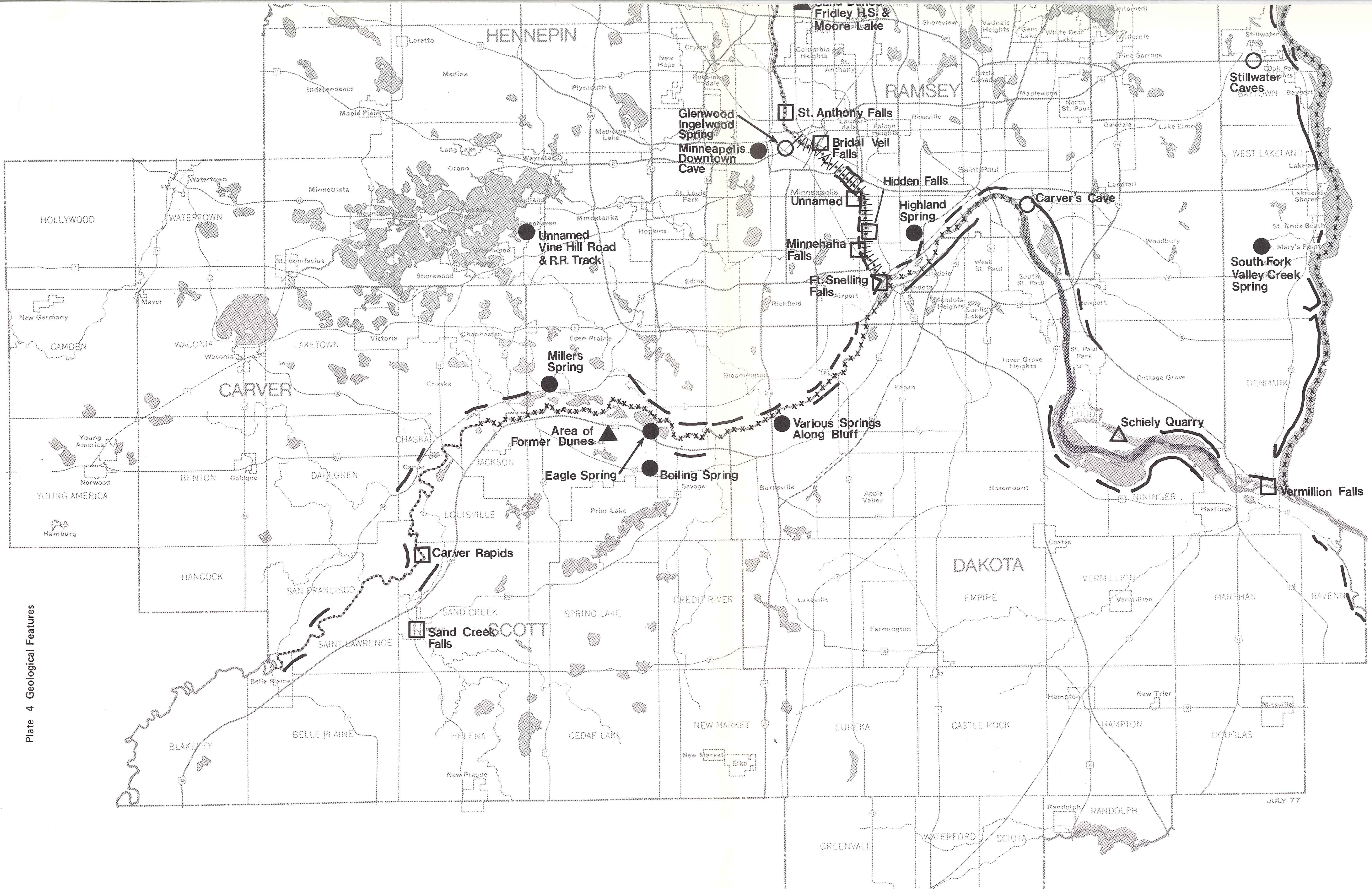


Plate 4 Geological Features

BASELINE ENVIRONMENTAL INVENTORY / FLOWAGE OF LAKES AND RIVERS
TWIN CITIES METROPOLITAN AREA

Plate 5

2⊜1
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

→ Arrows indicate direction of flow

— Major Watershed Boundaries

0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES. USGS Quadrangle Maps, 7.5 Minute Series

NORTH

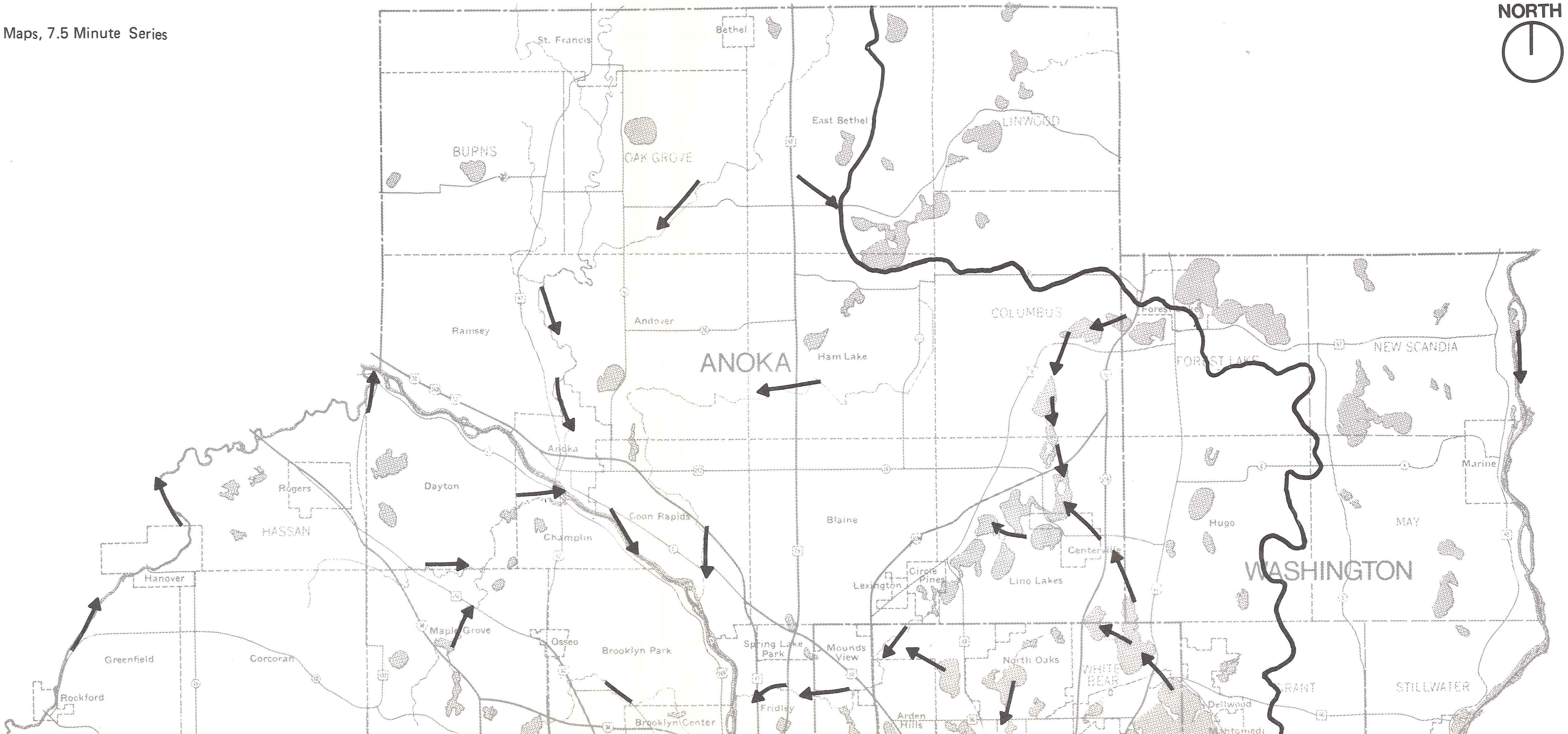


Plate 5 Flowage of Lakes and Rivers

BASELINE ENVIRONMENTAL INVENTORY / SUBWATERSHED DRAINAGE
TWIN CITIES METROPOLITAN AREA

Plate 6

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

→ Arrows indicate direction of flow

- - - Minor Watershed Boundaries

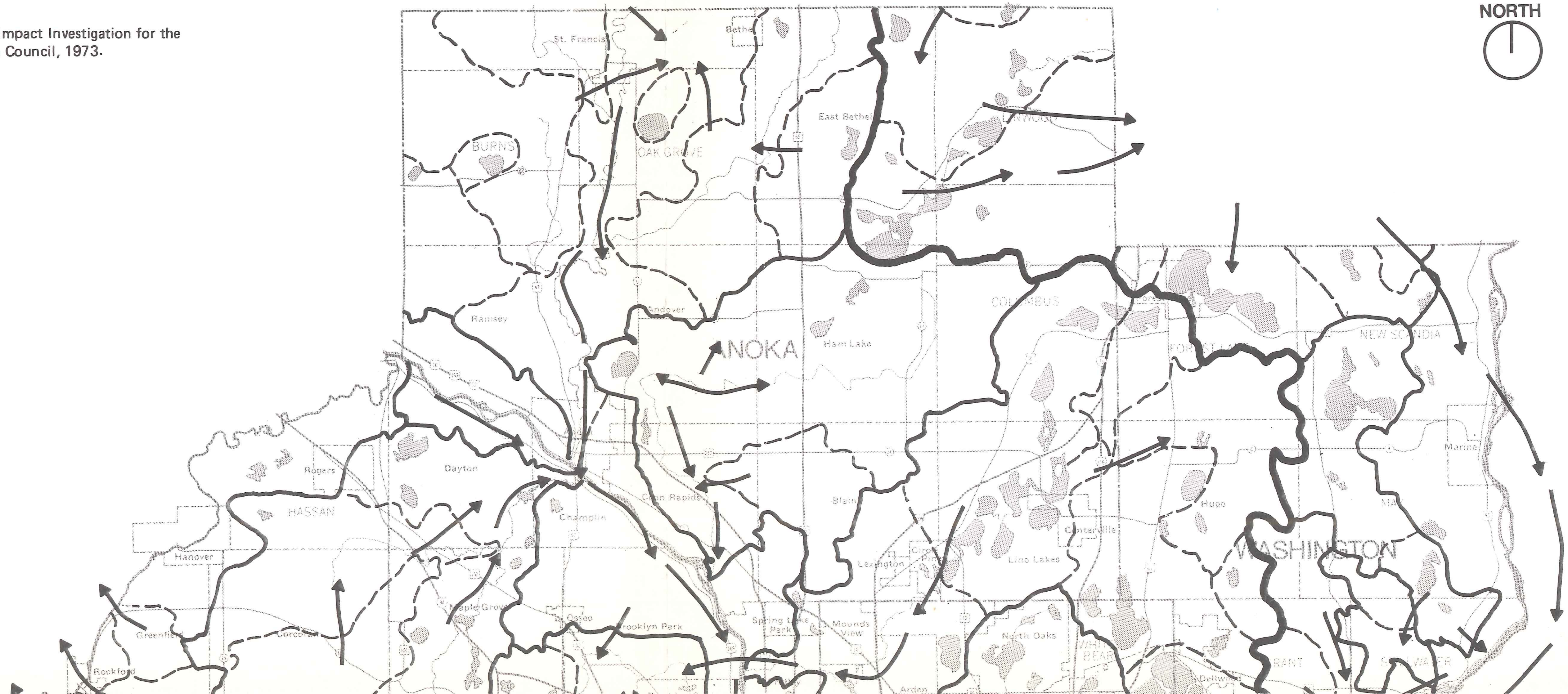
━ Major Watershed Boundaries.

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: Stormwater Impact Investigation for the Metropolitan Council, 1973.



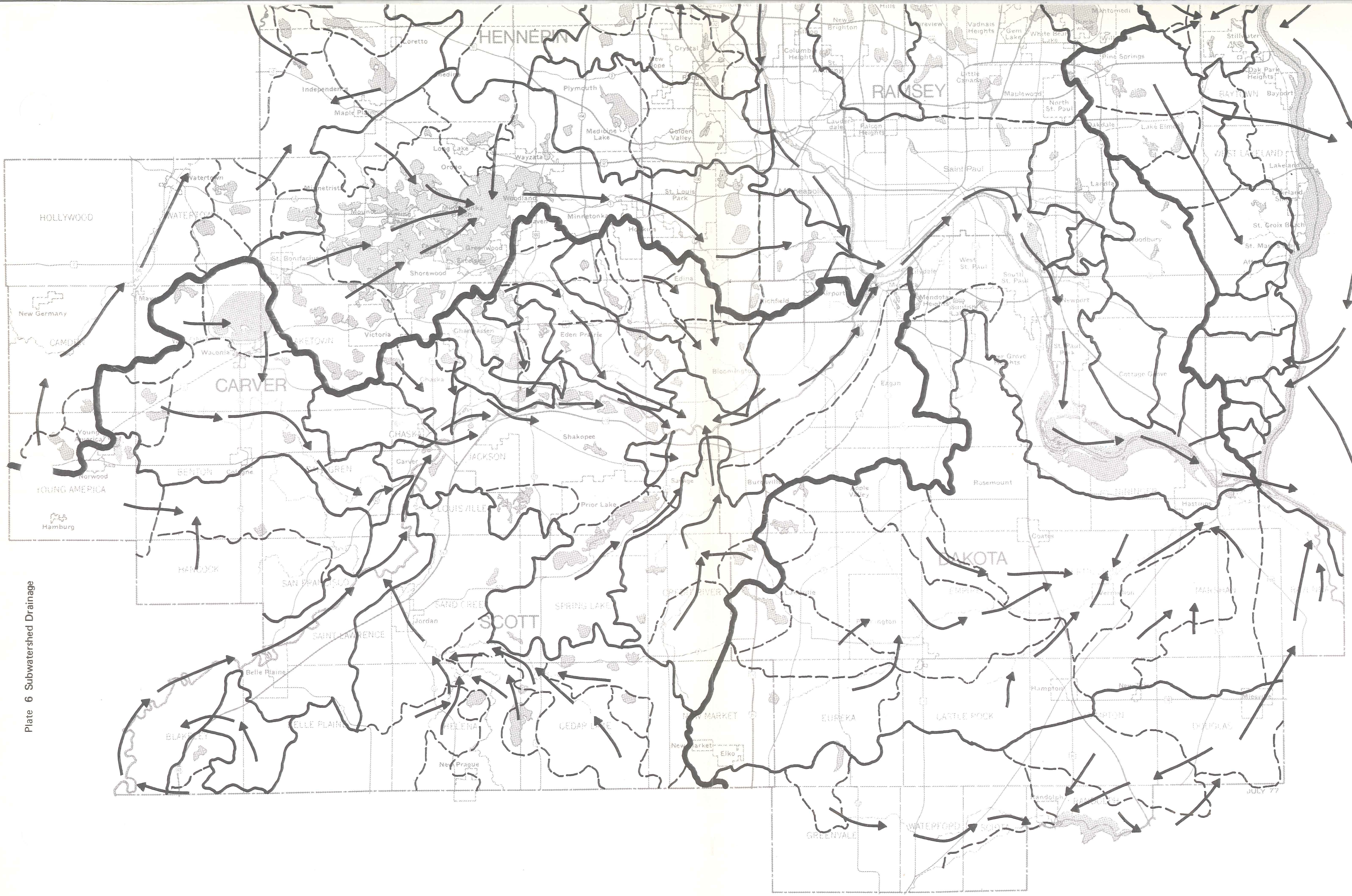


Plate 6 Subwatershed Drainage

BASELINE ENVIRONMENTAL INVENTORY / MAJOR FLOODPLAINS (100 YEAR) TWIN CITIES METROPOLITAN AREA

Plate 7

Legend

▨ Floodplain

Metropolitan Waste Control Commission

201 working for water quality

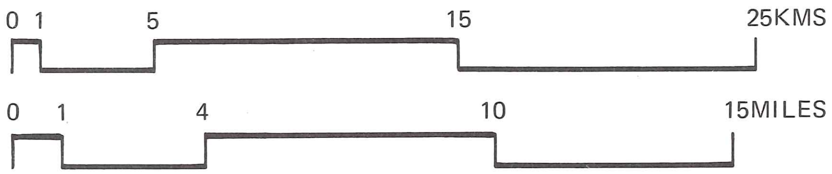
350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

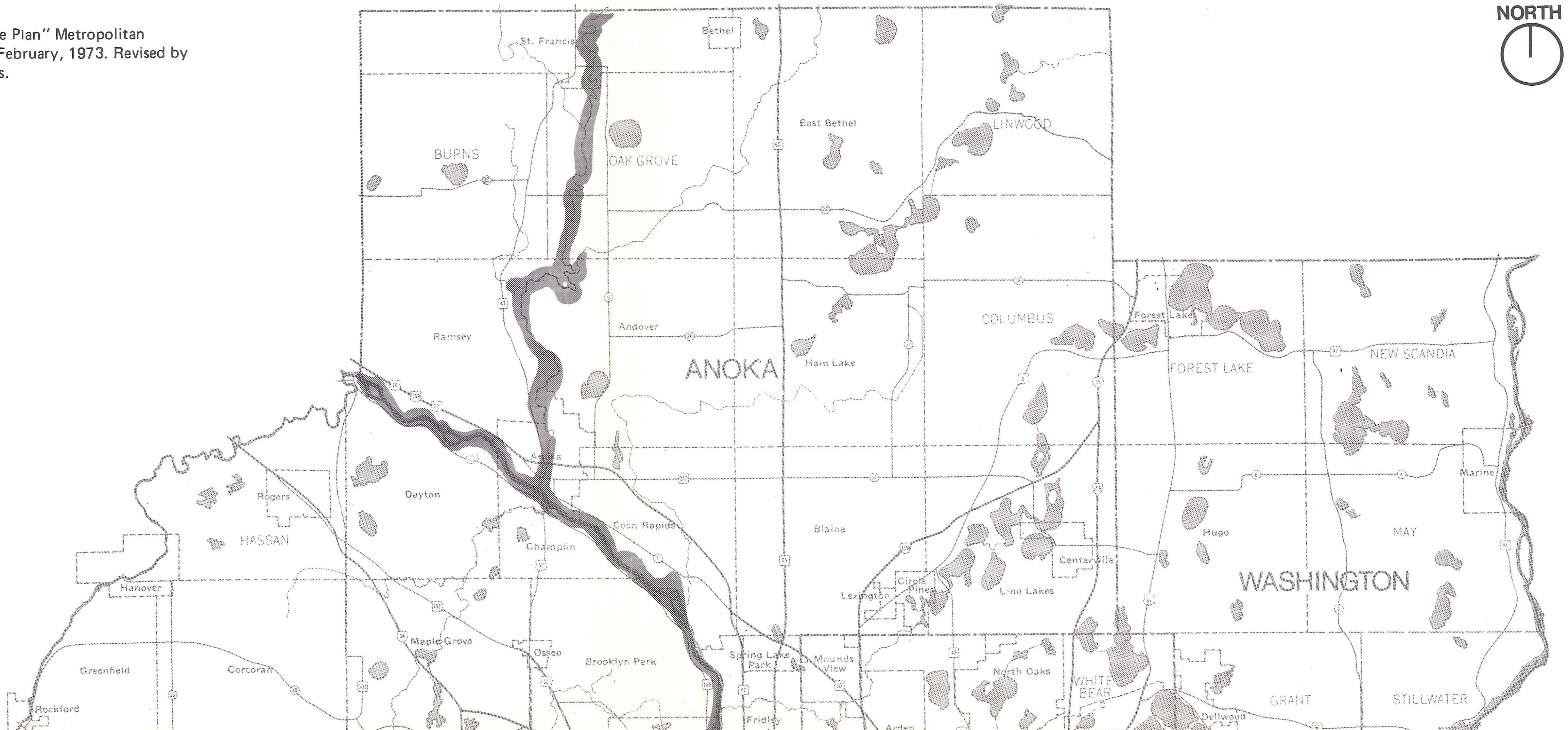
InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota



Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: "Protection Open Space Plan" Metropolitan Development Guide, February, 1973. Revised by Hickok and Associates.



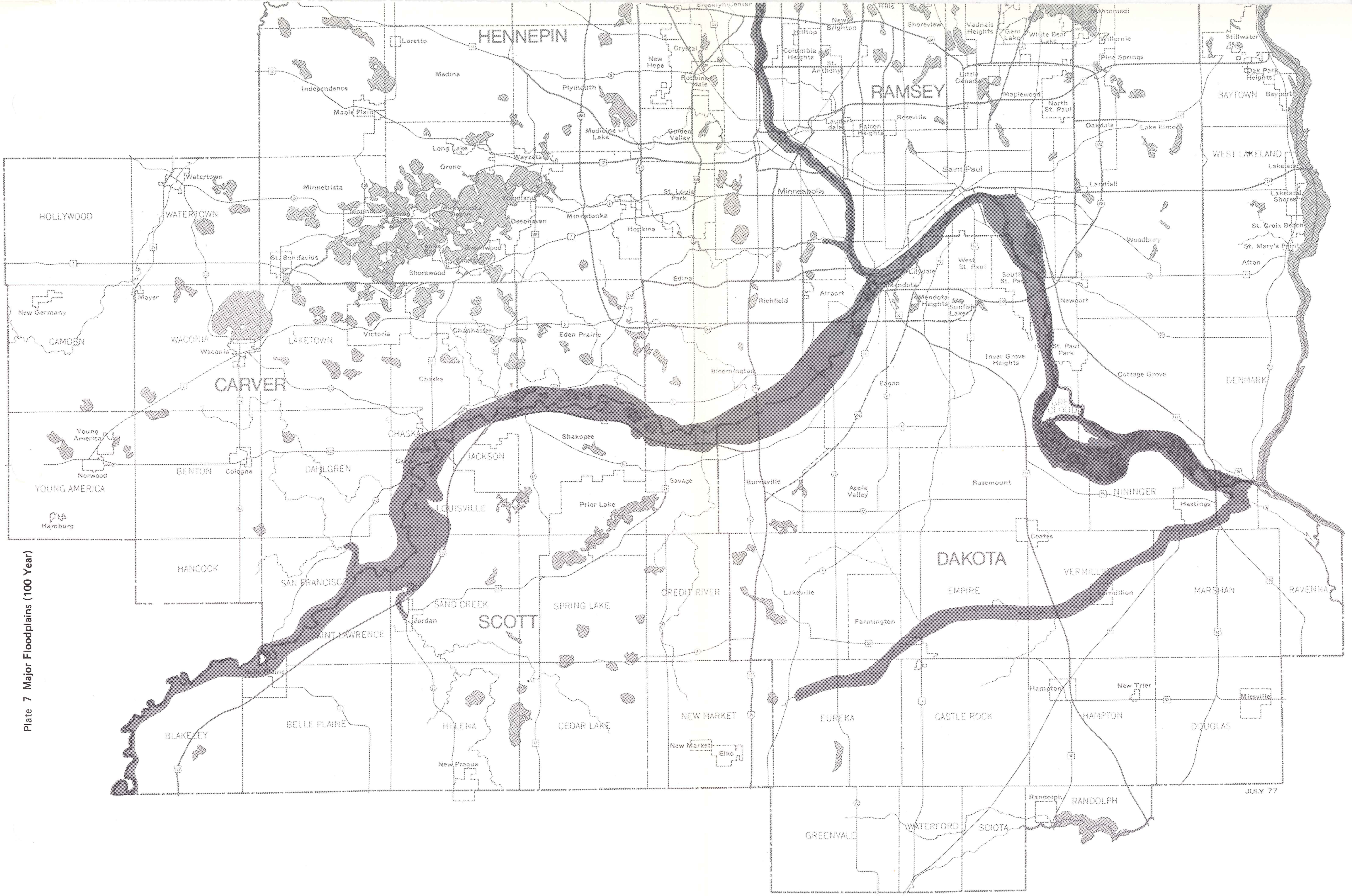


Plate 7 Major Floodplains (100 Year)

BASELINE ENVIRONMENTAL INVENTORY / RUNOFF AND PHOSPHORUS INCREASES 1970-2000
TWIN CITIES METROPOLITAN AREA

Plate 8

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

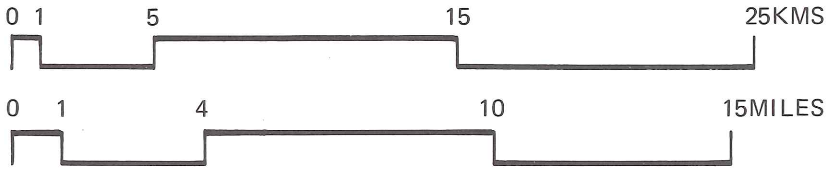
InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

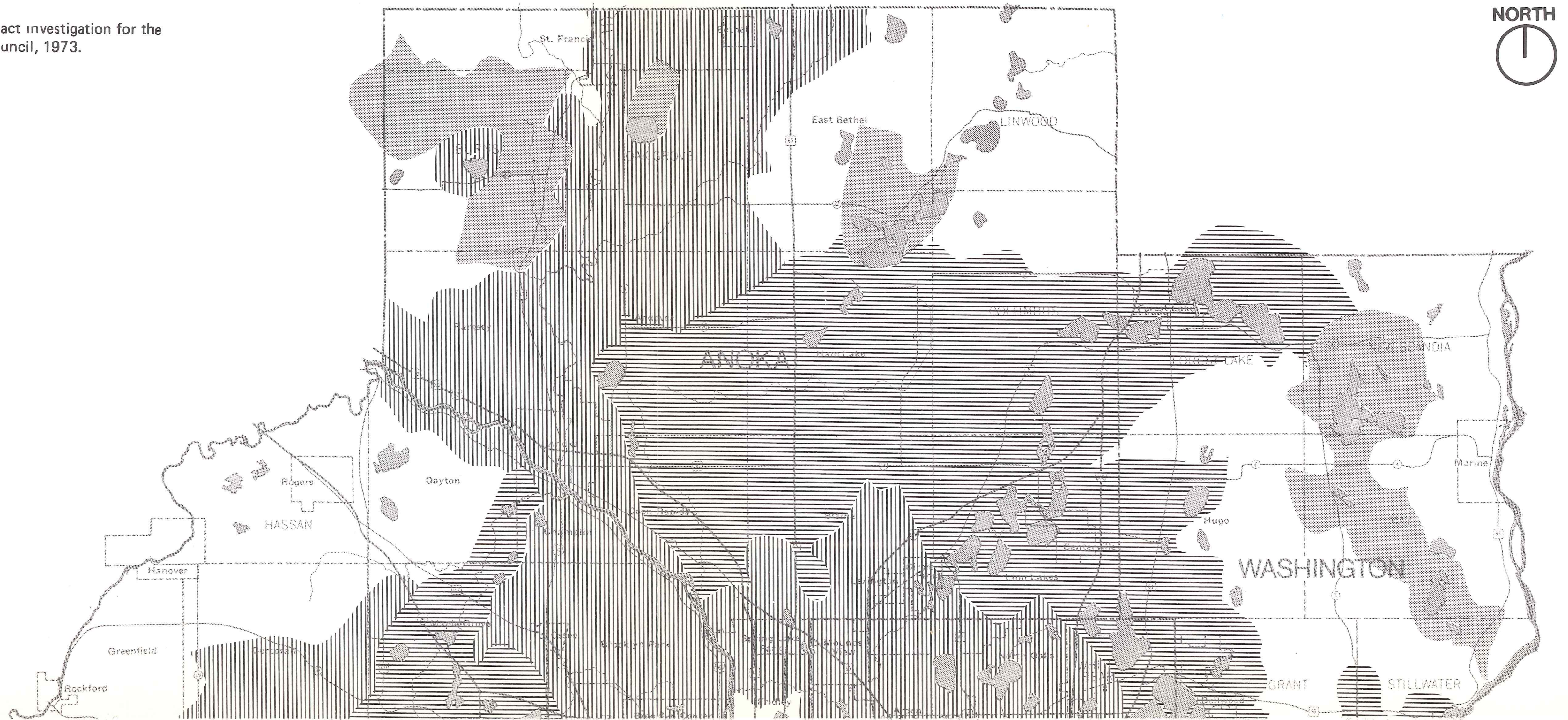
Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

- □ No Projected Increase
- ▒ Significant Phosphorous Increase
- ▥ Significant Runoff Increase
- ▤ Significant Phosphorous and Runoff Increase



SOURCES: Stormwater Impact investigation for the Metropolitan Council, 1973.



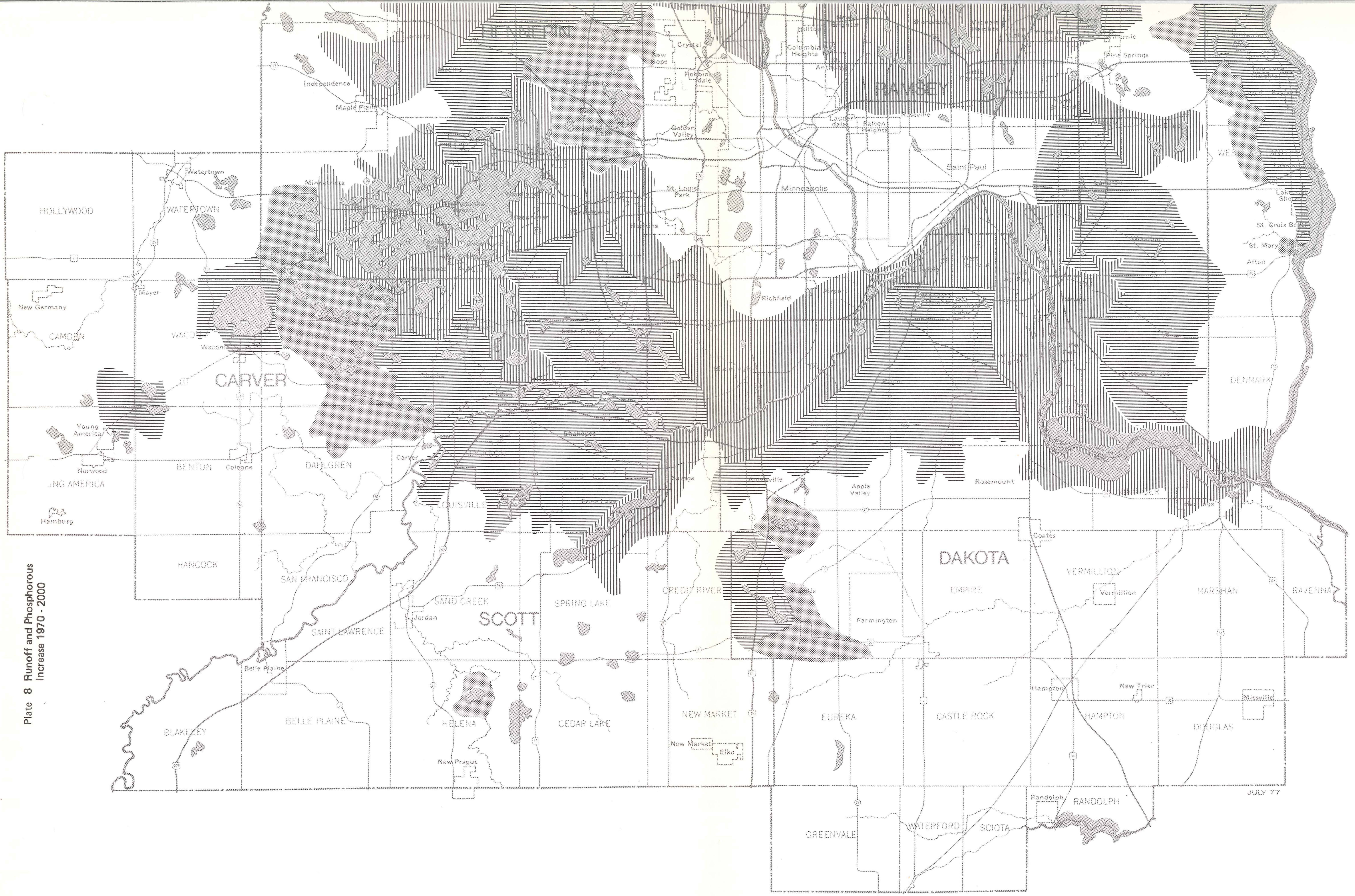


Plate 8 Runoff and Phosphorous Increase 1970 - 2000

BASELINE ENVIRONMENTAL INVENTORY / WETLANDS, 1977
TWIN CITIES METROPOLITAN AREA

Legend

Plate 9

▥ Wetlands

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: "Protection Open Space Plan" Metropolitan Development Guide, February, 1973. Revised by Hickok and Associates.

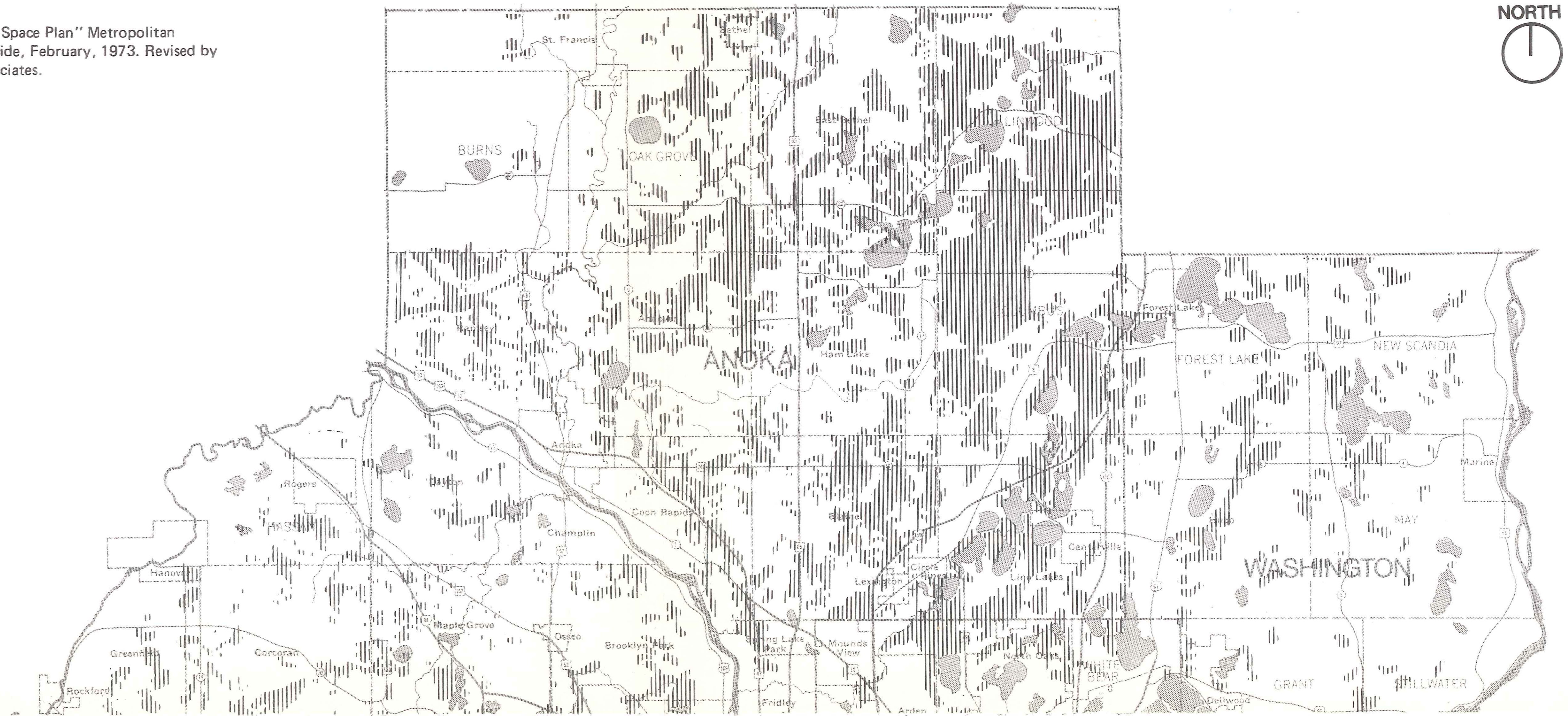


Plate 9 Wetlands, 1977

BASELINE ENVIRONMENTAL INVENTORY / PRESETTLEMENT VEGETATION
TWIN CITIES METROPOLITAN AREA

Plate 10

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

- □ Wet Prairies, Marshes, and Sloughs
- ▤ Big Woods
- ▥ Prairie
- ▩ Conifer Bogs and Swamps
- ░ Oak Openings and Barrens
- ▤ River-Bottom Forest
- ▒ Aspen—Oak Land

0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES: "Original Vegetation of Minnesota" Francis J. Marschner, 1930. Published by USDA North Central Forest Experiment Station, 1974. Available at NCFES, Univeristy of Minnesota, St. Paul.

Plate 10 Presettlement Vegetation

BASELINE ENVIRONMENTAL INVENTORY / EXISTING VEGETATION CONDITIONS
TWIN CITIES METROPOLITAN AREA

Plate 11

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

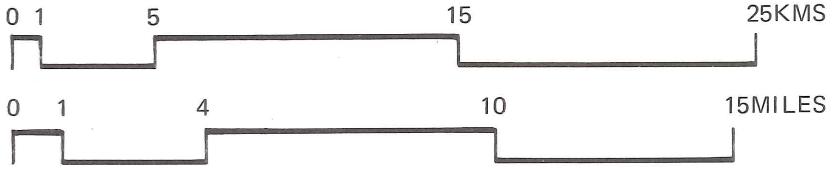
Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

- □ Urban/Residential
- ░ Cultivated Land, Pasture, and Meadow
- ▥ Urban Wetlands
- ▤ Urban Forest
- ▤ Forest
- ▥ Marsh Wetlands
- ▦ Forested Wetlands, Swamps



Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: Twin Cities Metropolitan Area Land Use, 1974" Based on Earth Resources Technology Satellite. Minnesota State Planning Agency.

"Protection Open Space Plan (Generalized Locations)" --Wetlands. Metropolitan Development Guide, February 1973.

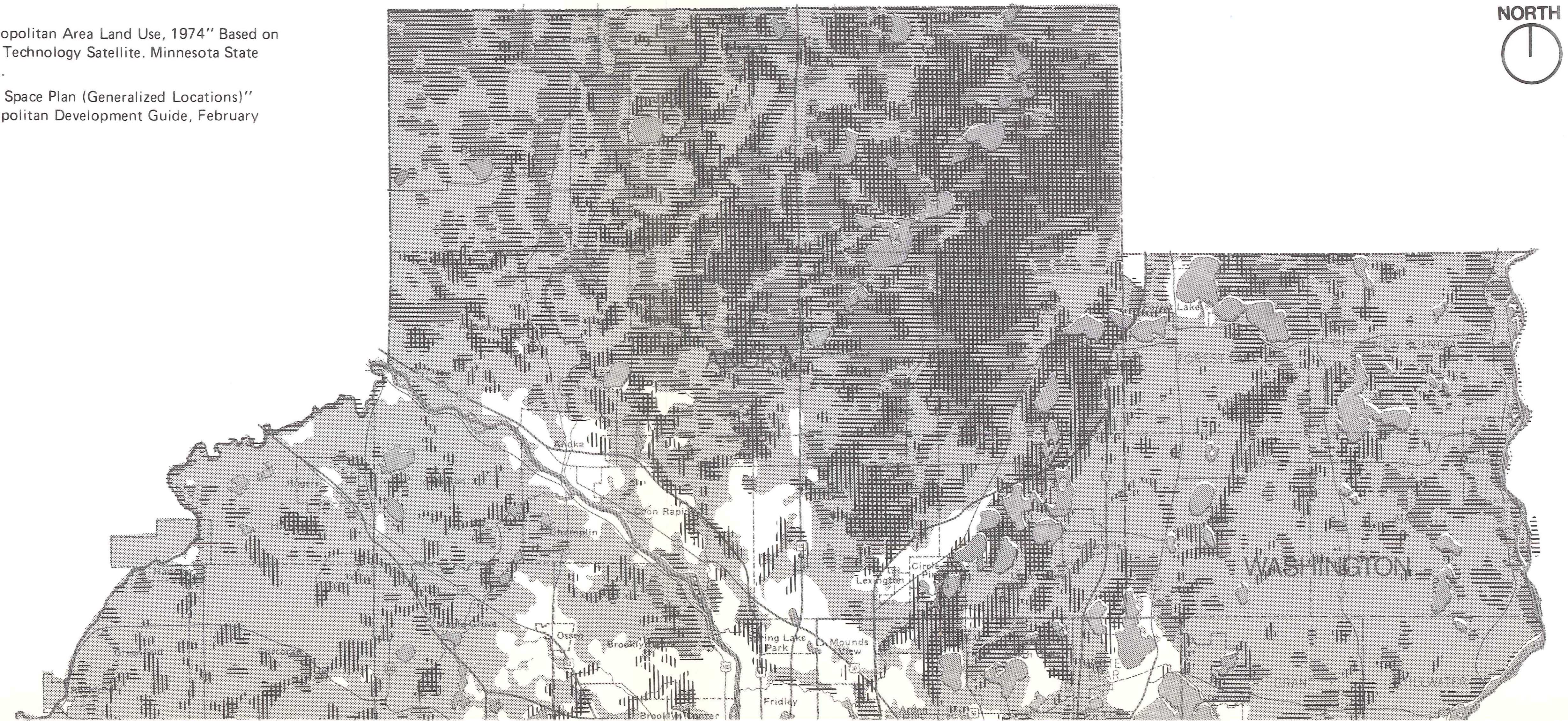
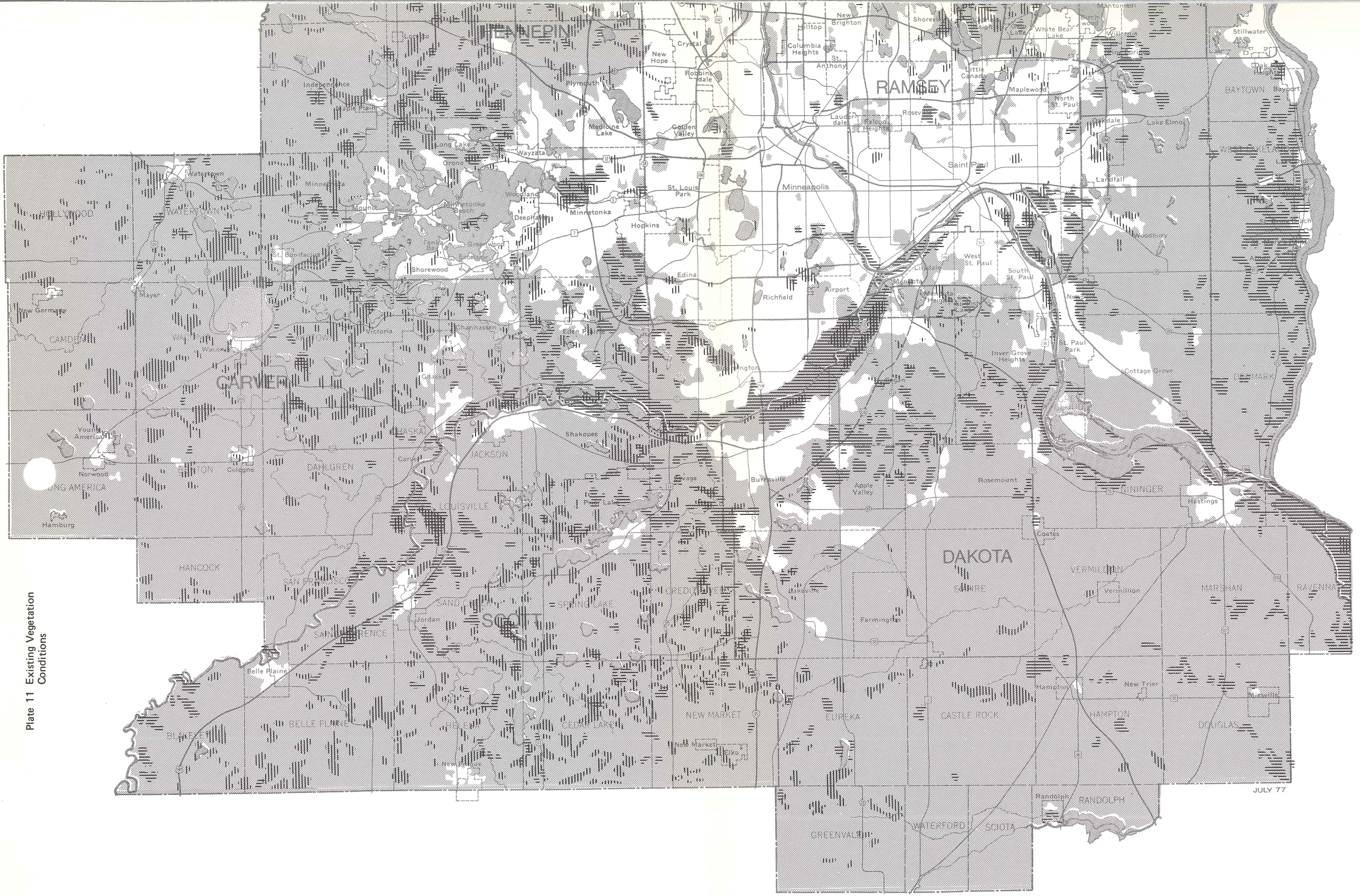


Plate 11 Existing Vegetation Conditions



BASELINE ENVIRONMENTAL INVENTORY / VEGETATION OF SPECIAL SIGNIFICANCE
TWIN CITIES METROPOLITAN AREA

Plate 12

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

- ▨ ◇3 Wildlife Habitat Value
- ▥ ◇3 Scenic Timber
- ▤ ◇3 Scientific or Educational Value
- ☐3 Wildlife Management Area
- ③ Environmental Education Area

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

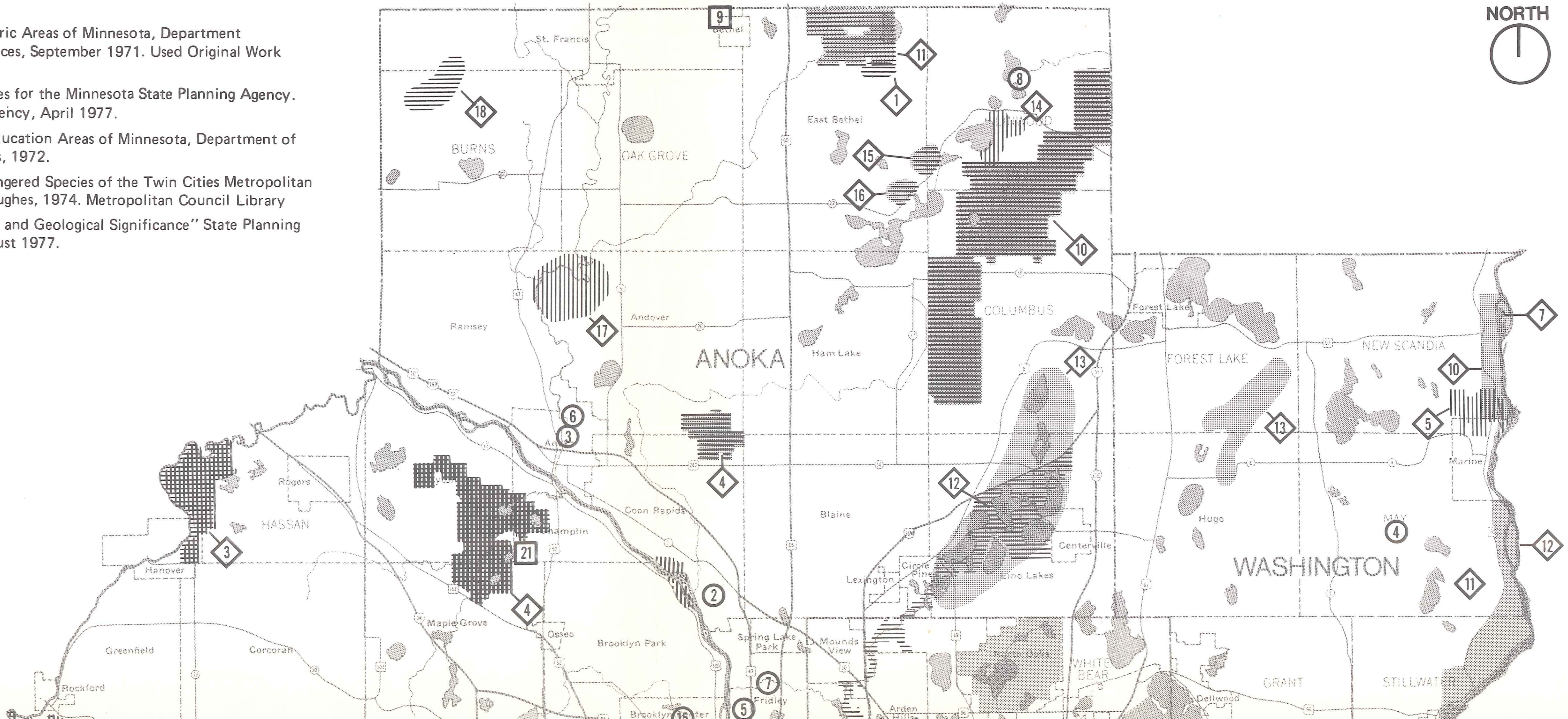
SOURCES: Natural and Historic Areas of Minnesota, Department of Natural Resources, September 1971. Used Original Work Maps.

"Listing of Variables for the Minnesota State Planning Agency. State Planning Agency, April 1977.

Environmental Education Areas of Minnesota, Department of Natural Resources, 1972.

"Unique and Endangered Species of the Twin Cities Metropolitan Area". Gordon Hughes, 1974. Metropolitan Council Library

"Sites of Biological and Geological Significance" State Planning Agency File, August 1977.



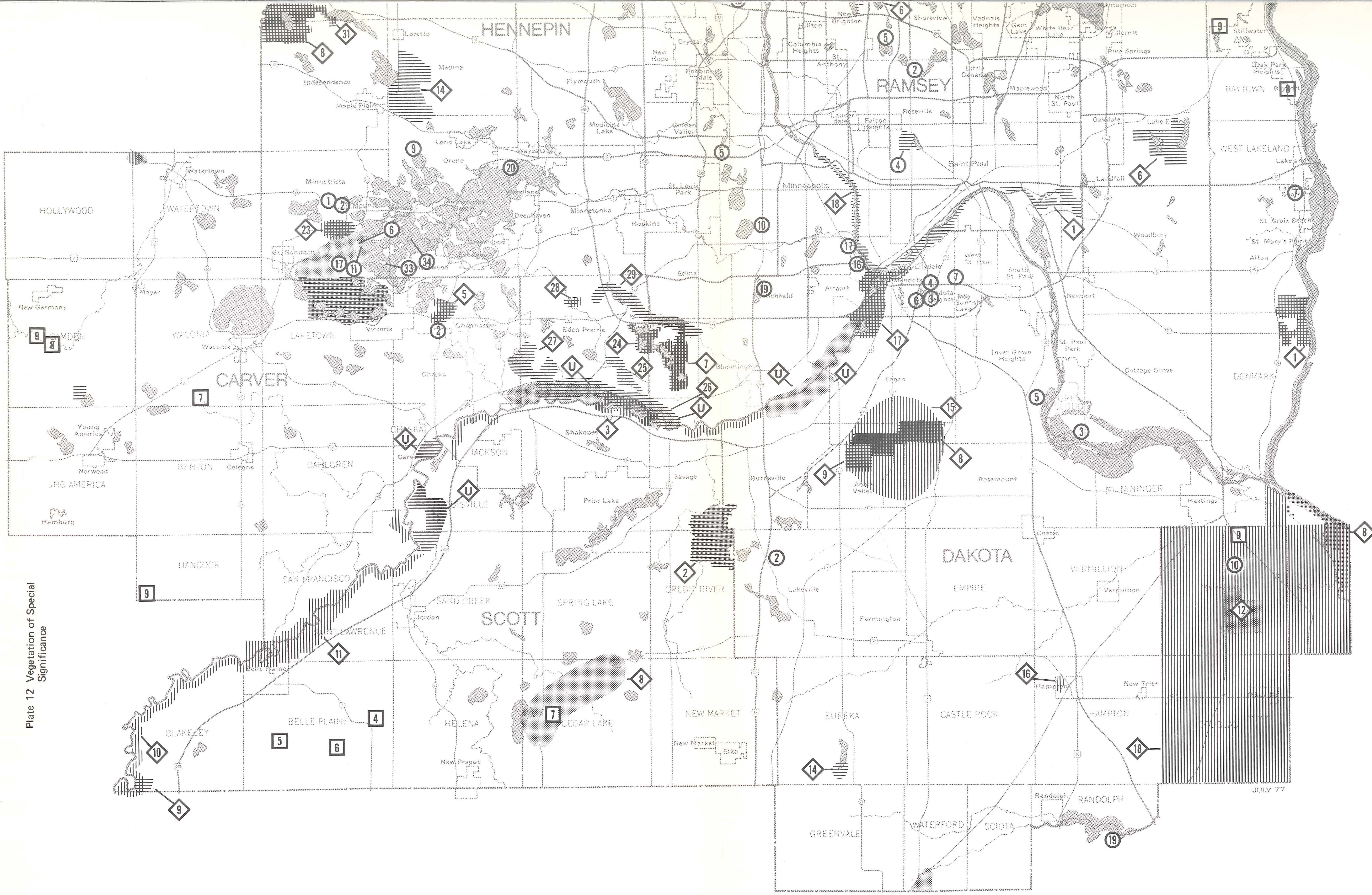


Plate 12 Vegetation of Special Significance

BASELINE ENVIRONMENTAL INVENTORY / SELECTED SENSITIVE AREAS
TWIN CITIES METROPOLITAN AREA

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Plate 13

Legend

▨	Floodplains	△8	Proposed SNA on Acquisition Schedule
▥	Wetlands	◇12	SNA not on Acquisition Schedule
▨	Erodible Slopes	○10	Other Biological Sites
□6	Designated Scientific Natural Area (SNA)	□13	Unique Features
◇10	Nature Conservancy Tracts		

0 1 5 15 25KMS

0 1 4 10 15MILES

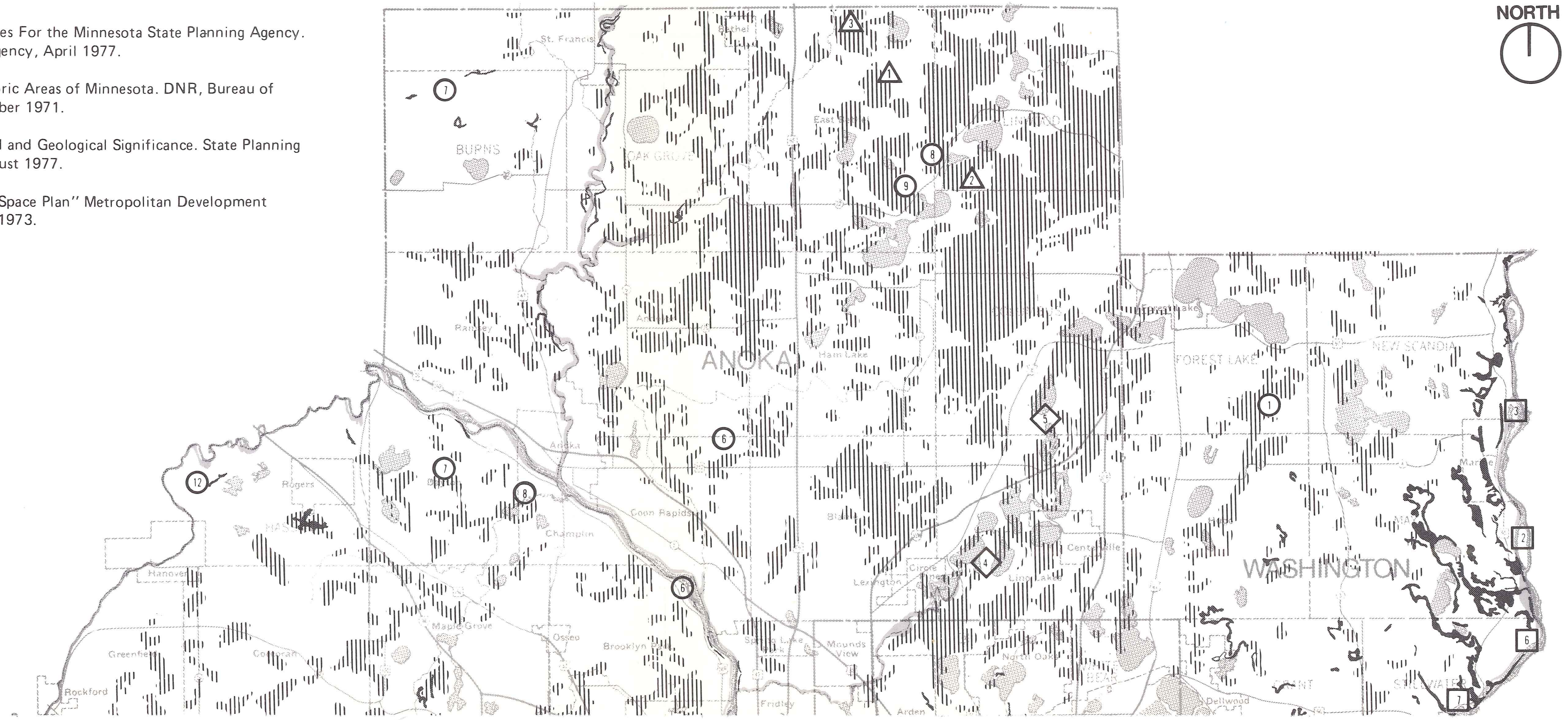
Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: Listing of Variables For the Minnesota State Planning Agency. State Planning Agency, April 1977.

Natural and Historic Areas of Minnesota. DNR, Bureau of Planning, September 1971.

Sites of Biological and Geological Significance. State Planning Agency File, August 1977.

"Protection Open Space Plan" Metropolitan Development Guide, February 1973.



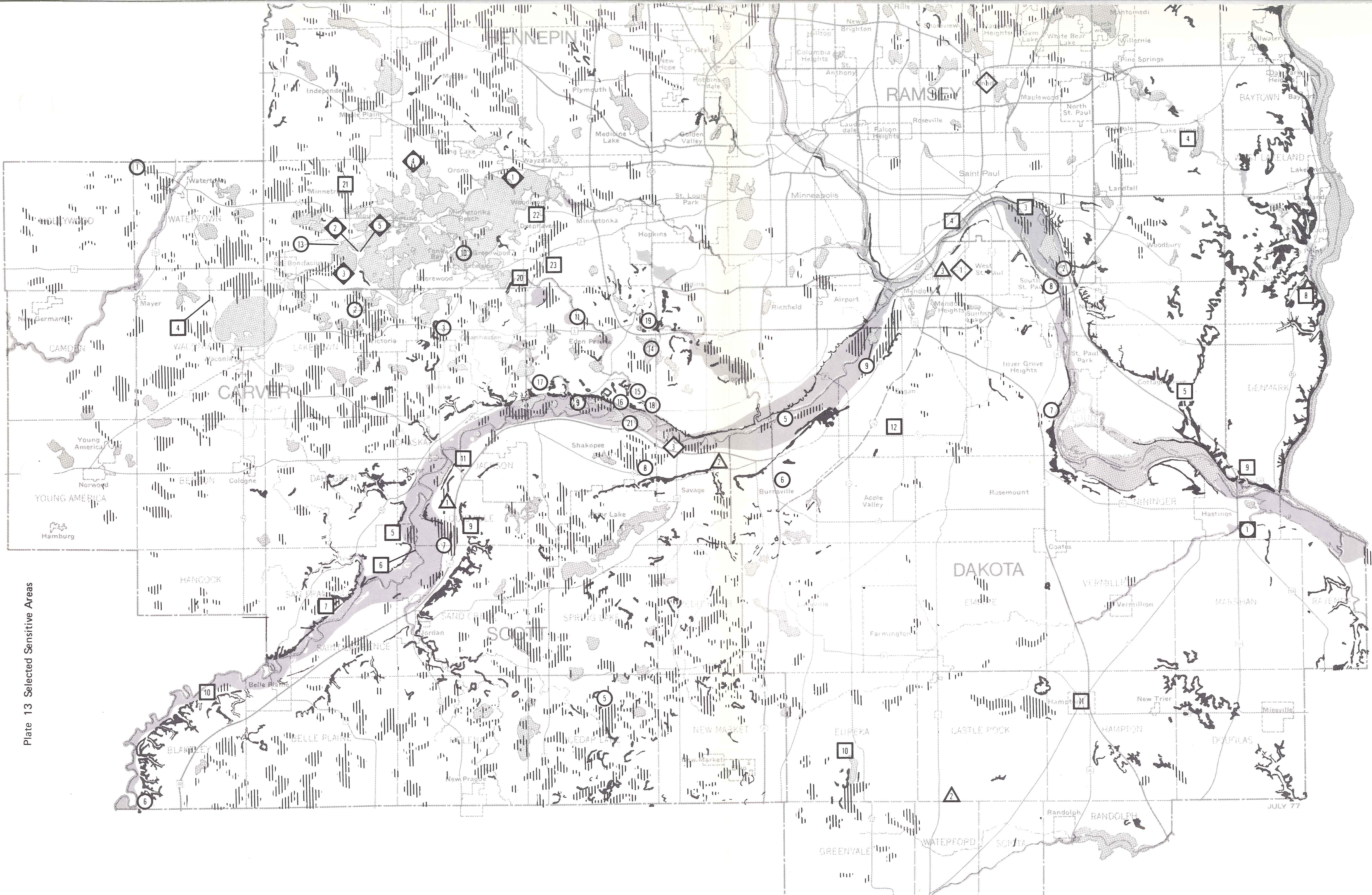


Plate 13 Selected Sensitive Areas

BASELINE ENVIRONMENTAL INVENTORY / LAKES
TWIN CITIES METROPOLITAN AREA

Plate 14

201 working for water quality
Metropolitan Waste Control Commission
350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates
Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.
Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

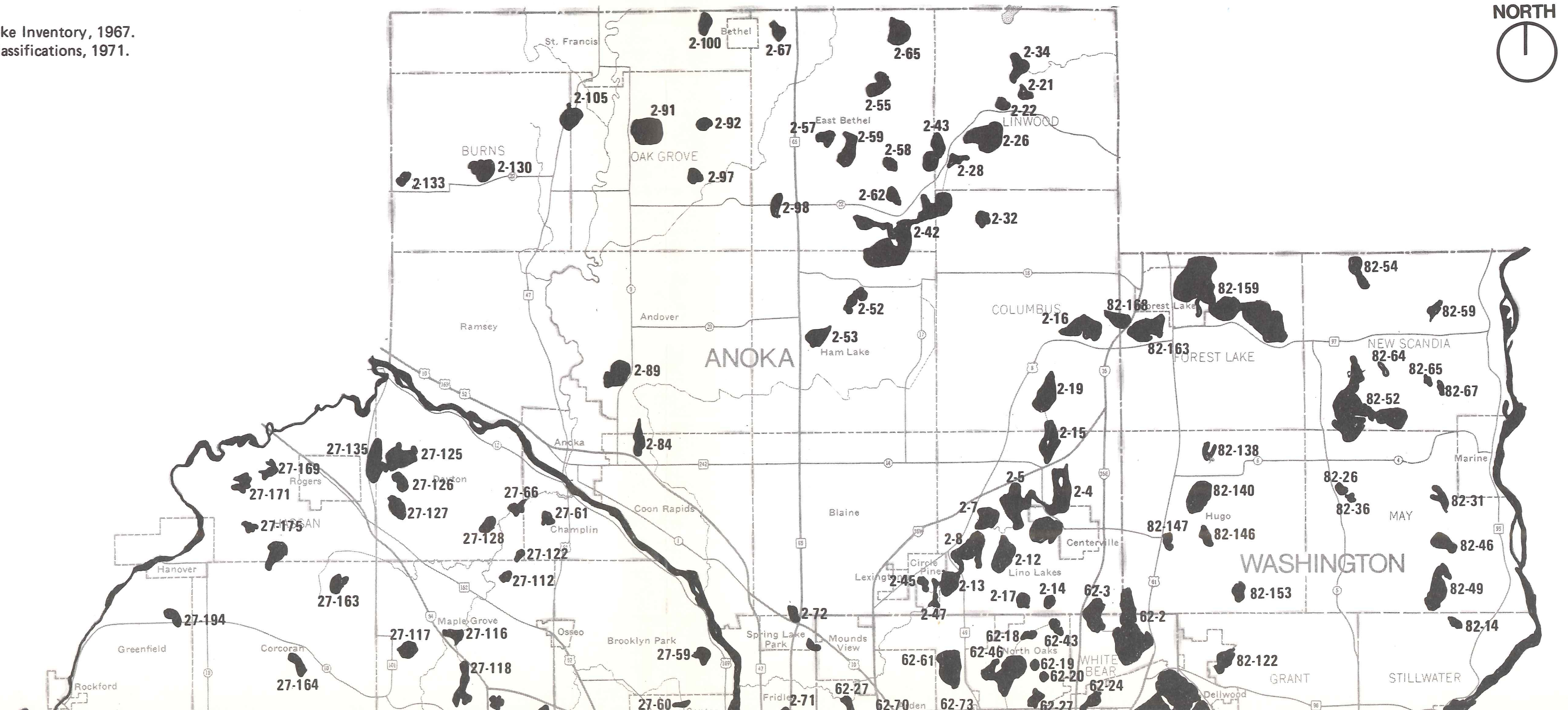
Legend

27-101	DNR Lakes Classification

0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES: Metropolitan Lake Inventory, 1967.
Public Waters Classifications, 1971.



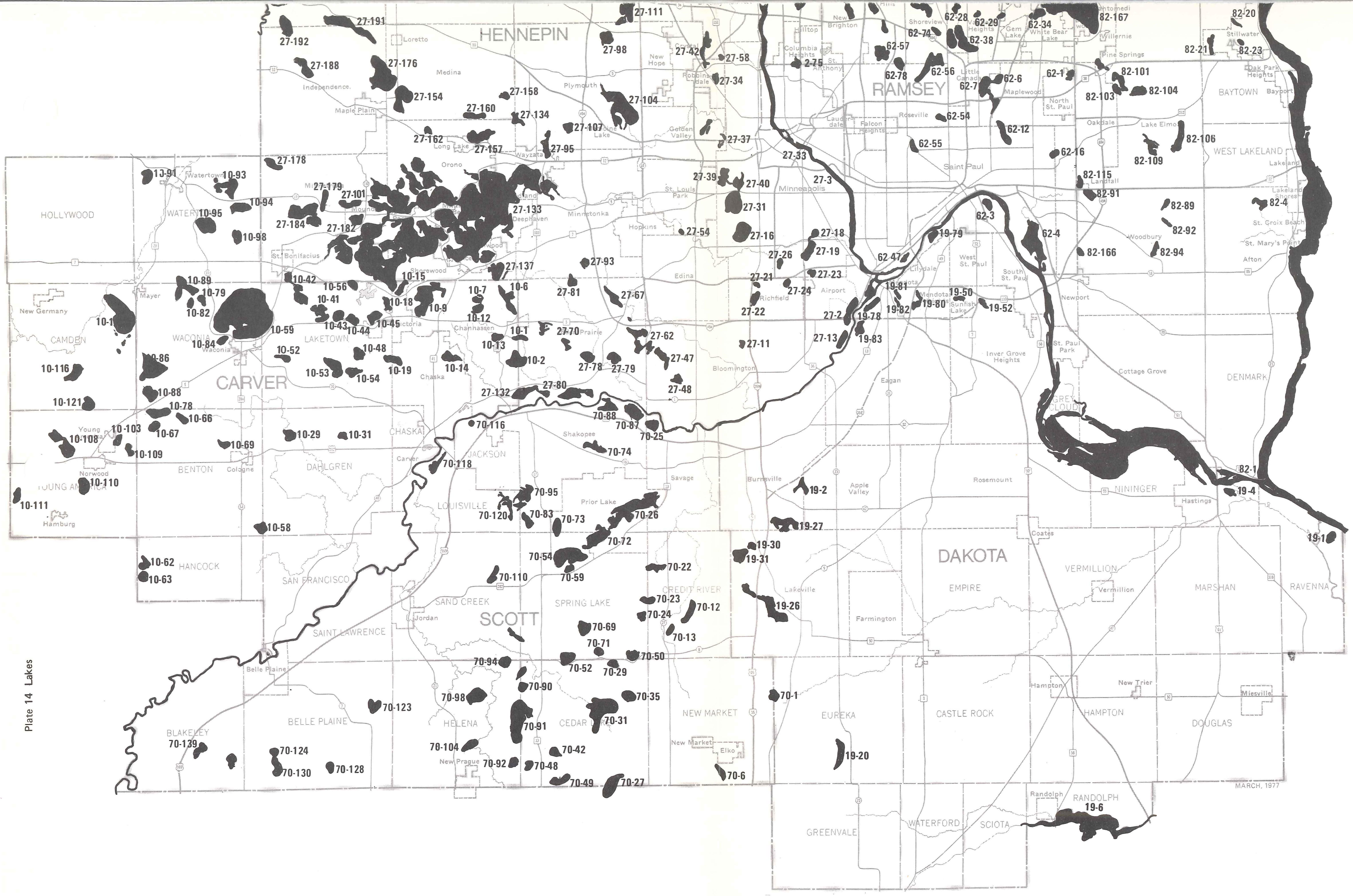


Plate 14 Lakes

BASELINE ENVIRONMENTAL INVENTORY / RIVER CLASSIFICATIONS TWIN CITIES METROPOLITAN AREA

Legend

Plate 15

[O] Length of River Affected

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

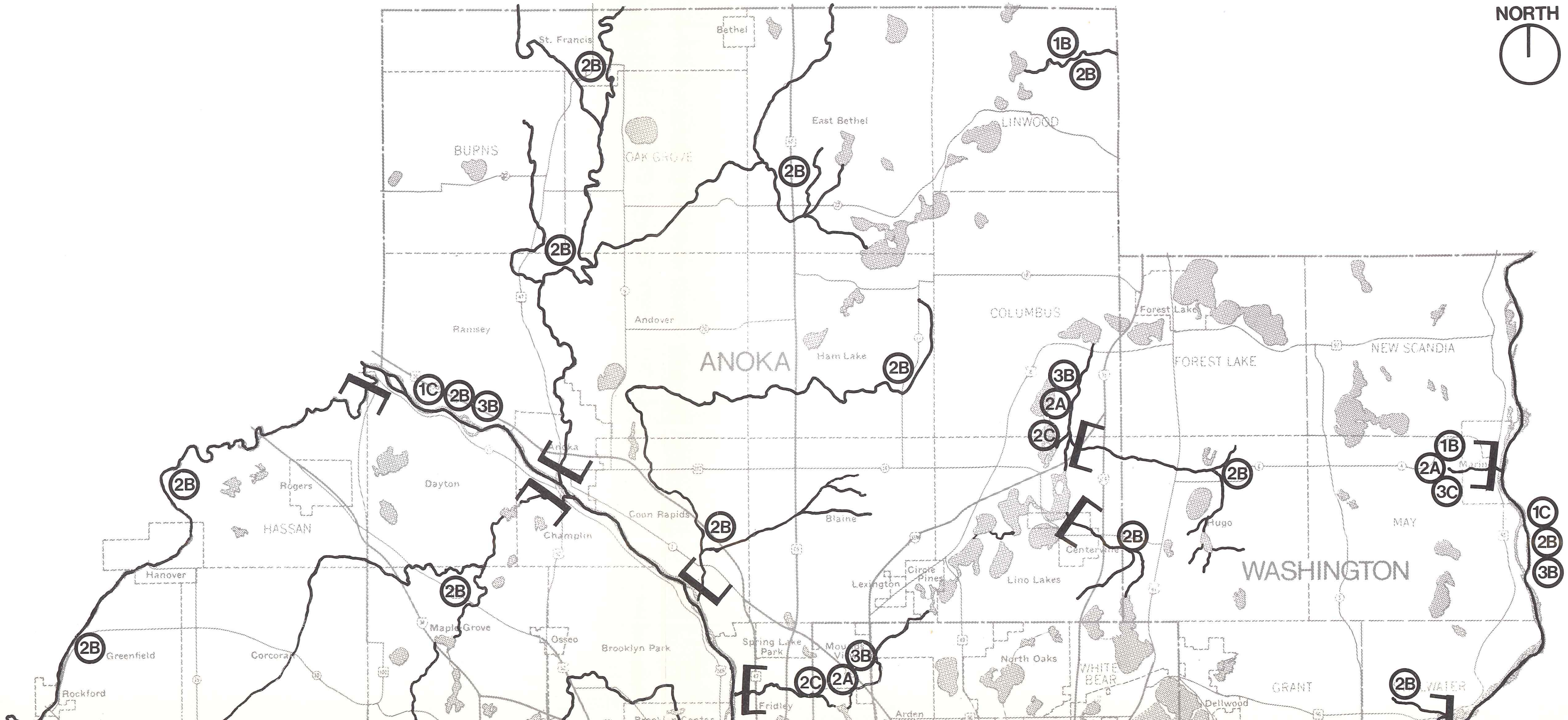
Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: WPC 22, 1973.



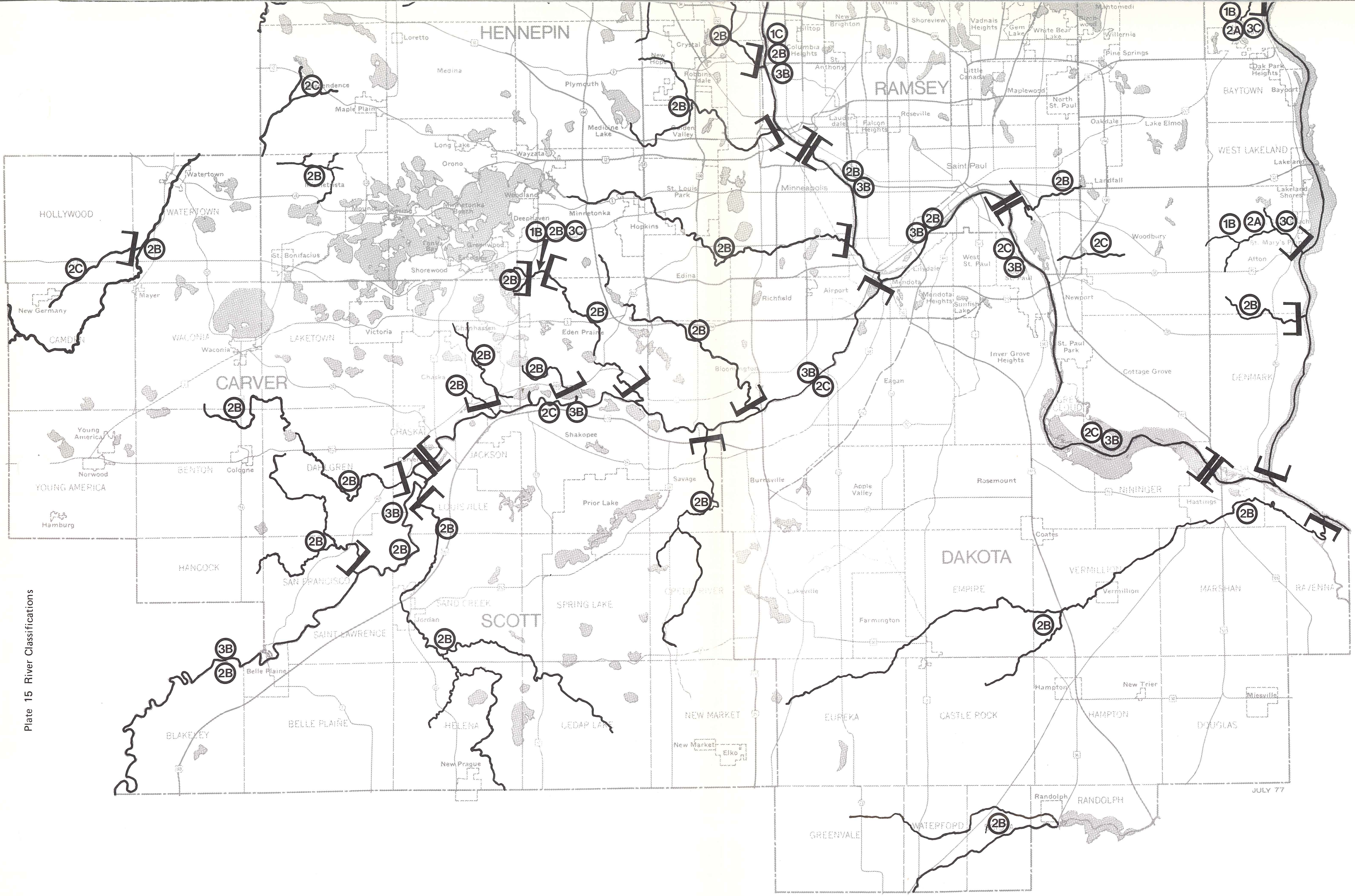


Plate 15 River Classifications

BASELINE ENVIRONMENTAL INVENTORY / TRANSPORTATION NOISE SOURCES TWIN CITIES METROPOLITAN AREA

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

Plate 16

- ▨ Airports
- ▩ Rail Switching
- • • • • • • Railroad L_{10} 200′
- ● ● ● ● ● Railroad L_{10} 500′
- ●●●●●●●● Highway L_{10} 800-1600′
- ⬤⬤⬤⬤⬤ Highway L_{10} > 1600′

0 1 5 15 25KMS

0 1 4 10 15MILES

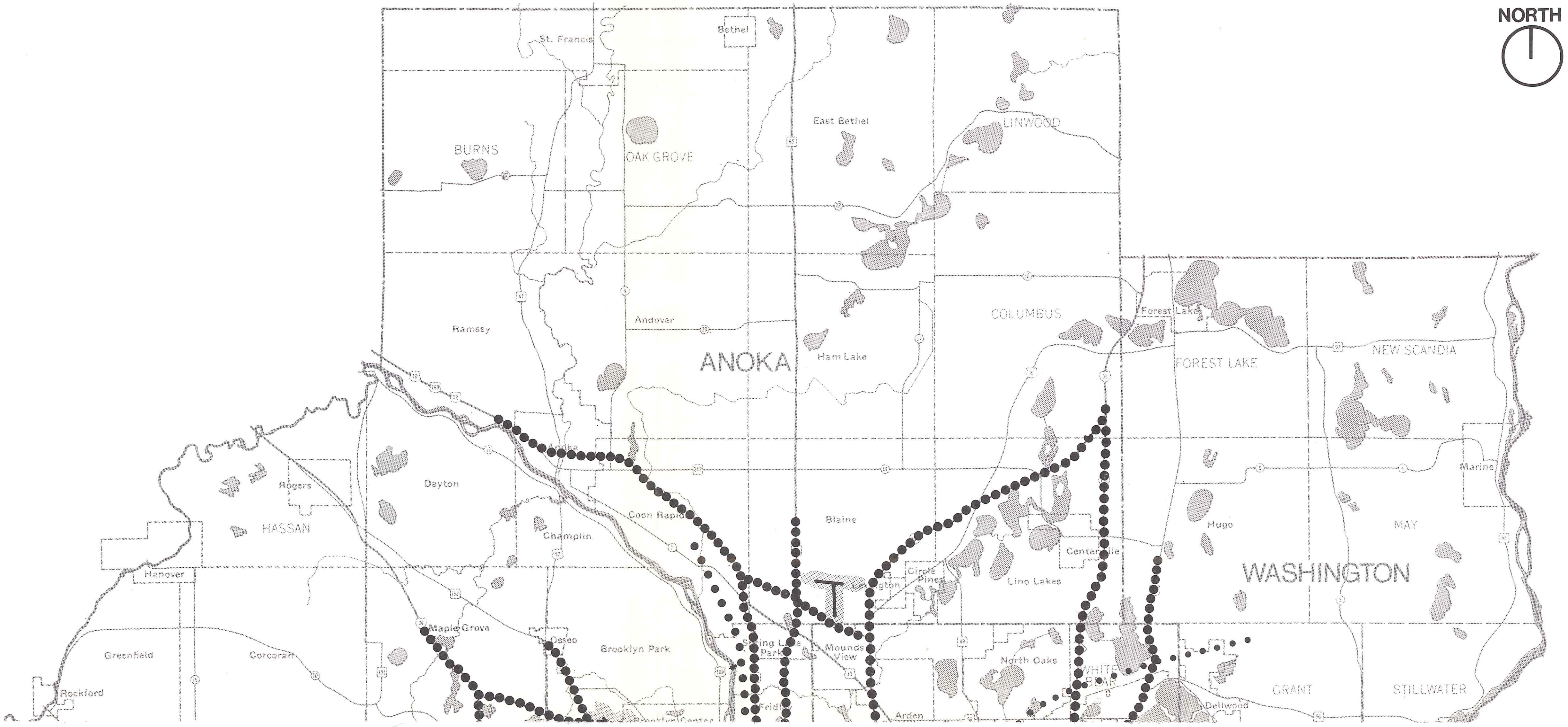


Plate 16 Transportation Noise Sources

BASELINE ENVIRONMENTAL INVENTORY / WATER ACCESS TWIN CITIES METROPOLITAN AREA

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

Plate 17

● Public Access
○ Marina
▲ Barge Terminal
☐ Rail Yard
▬ Dam

0 1 5 15 25KMS

0 1 4 10 15MILES

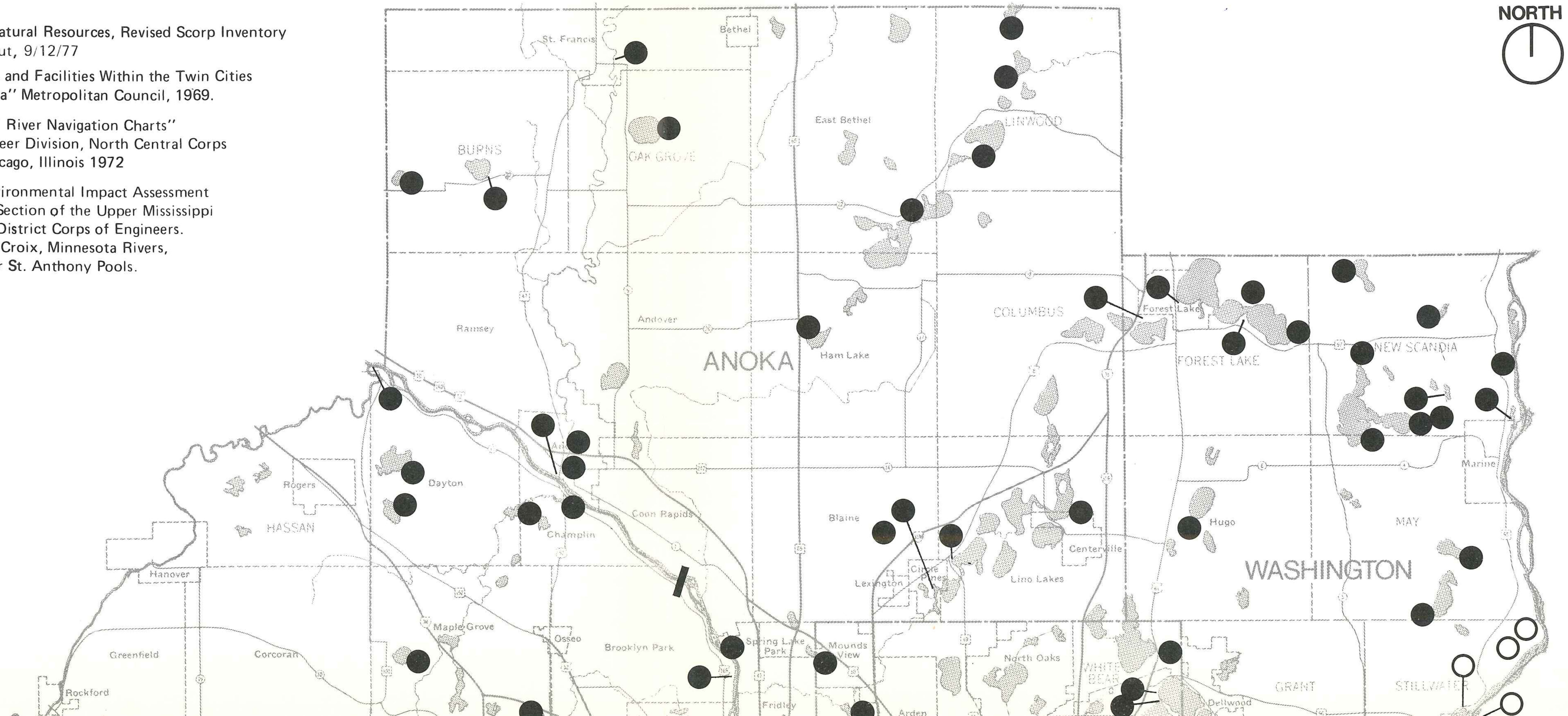
Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: Department of Natural Resources, Revised Scorp Inventory Computer Printout, 9/12/77

"Physical Features and Facilities Within the Twin Cities Metropolitan Area" Metropolitan Council, 1969.

"Upper Mississippi River Navigation Charts" U.S. Army Engineer Division, North Central Corps of Engineers. Chicago, Illinois 1972

"Final Report Environmental Impact Assessment of the Northern Section of the Upper Mississippi River". St. Paul District Corps of Engineers. Pools 1, 2, 3, St. Croix, Minnesota Rivers, Upper and Lower St. Anthony Pools. November, 1973



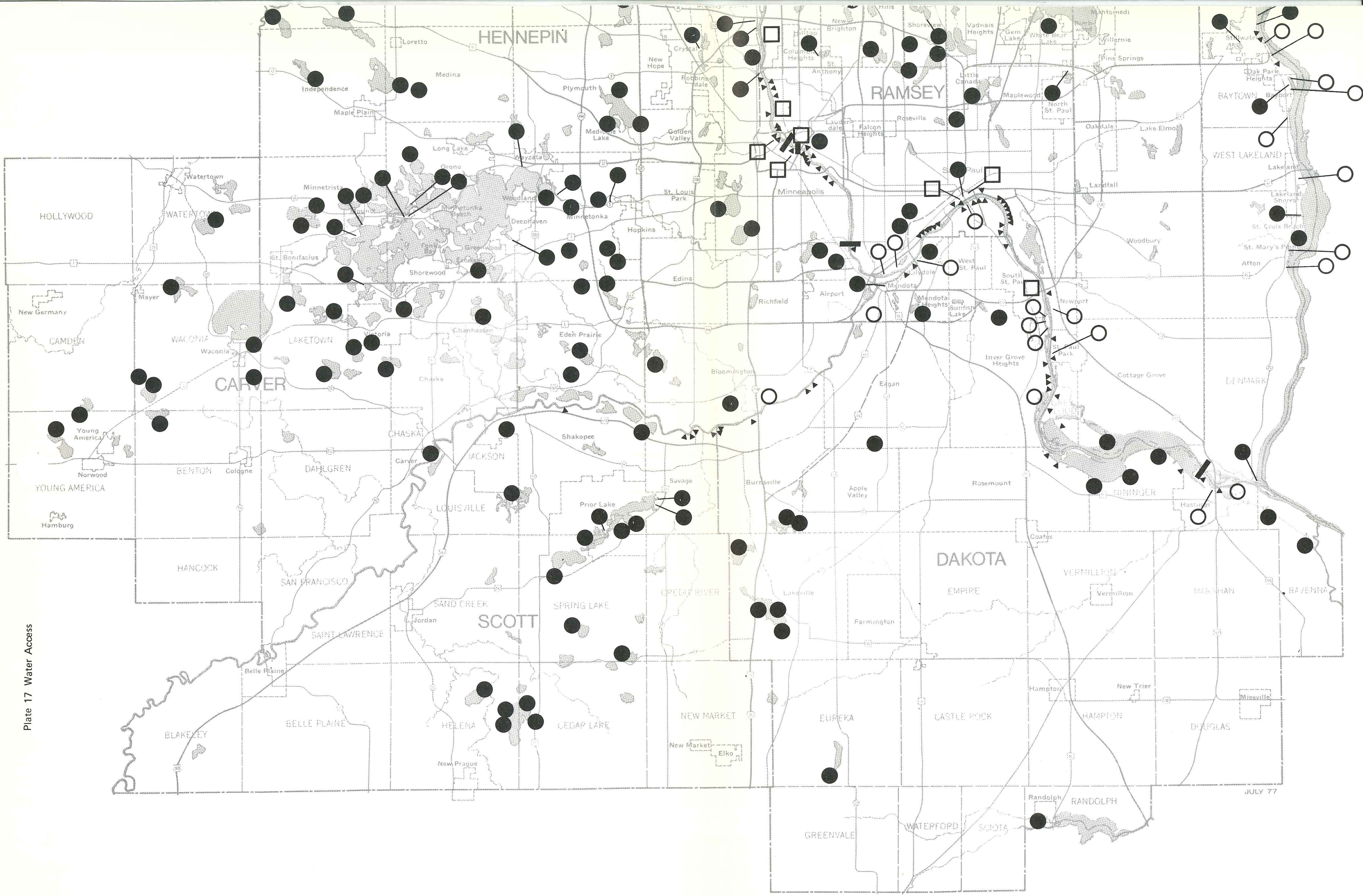


Plate 17 Water Access

BASELINE ENVIRONMENTAL INVENTORY / CRITICAL EROSION AND DEPOSITION AREAS
TWIN CITIES METROPOLITAN AREA

Plate 18

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

▨	Floodplains
▨	Erodible Slopes
Ⓐ	Sand and Rubble Bottom
Ⓑ	Sand and Organic Sludge
Ⓒ	Organic Sludge

0 1 5 15 25KMS

0 1 4 10 15MILES

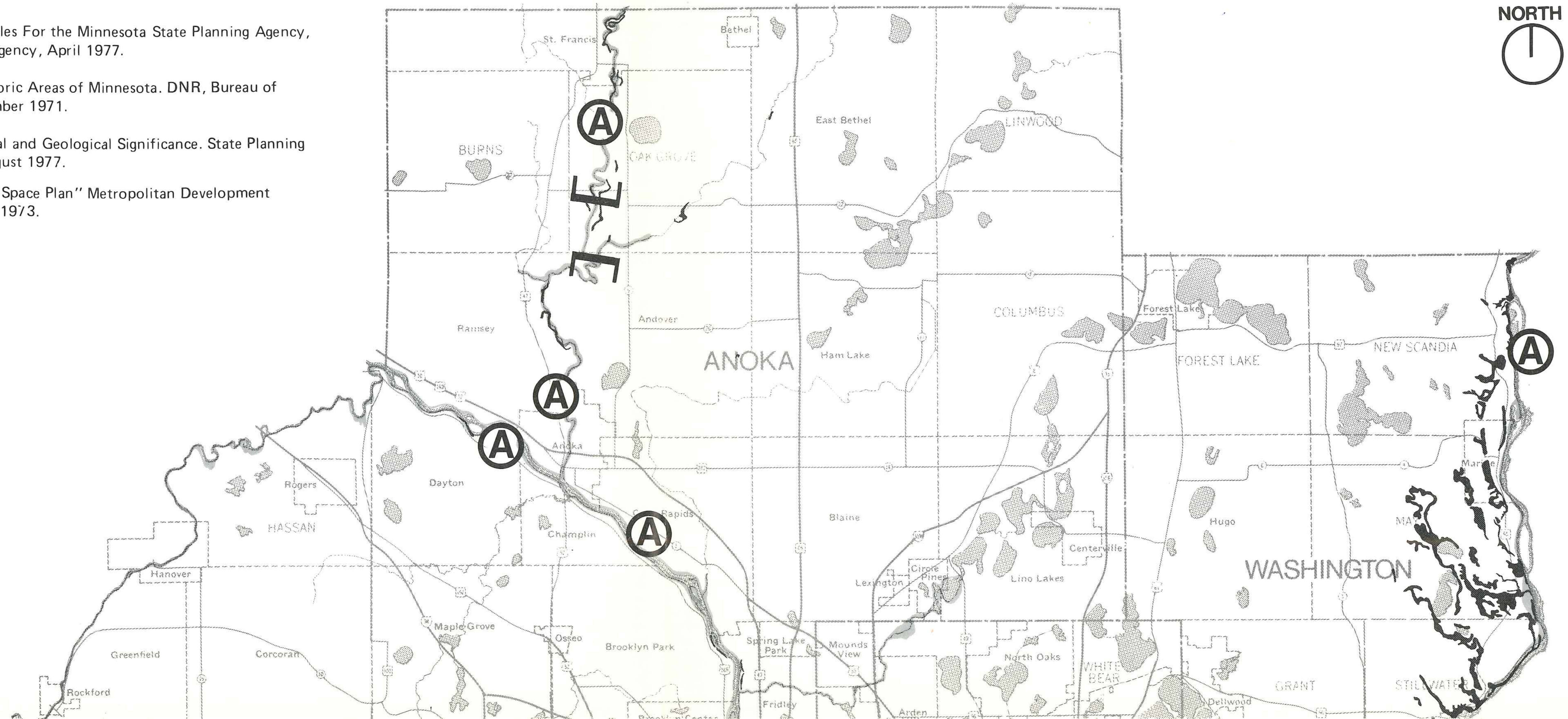
Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: Listing of Variables For the Minnesota State Planning Agency, State Planning Agency, April 1977.

Natural and Historic Areas of Minnesota. DNR, Bureau of Planning, September 1971.

Sites of Biological and Geological Significance. State Planning Agency File, August 1977.

"Protection Open Space Plan" Metropolitan Development Guide. February 1973.



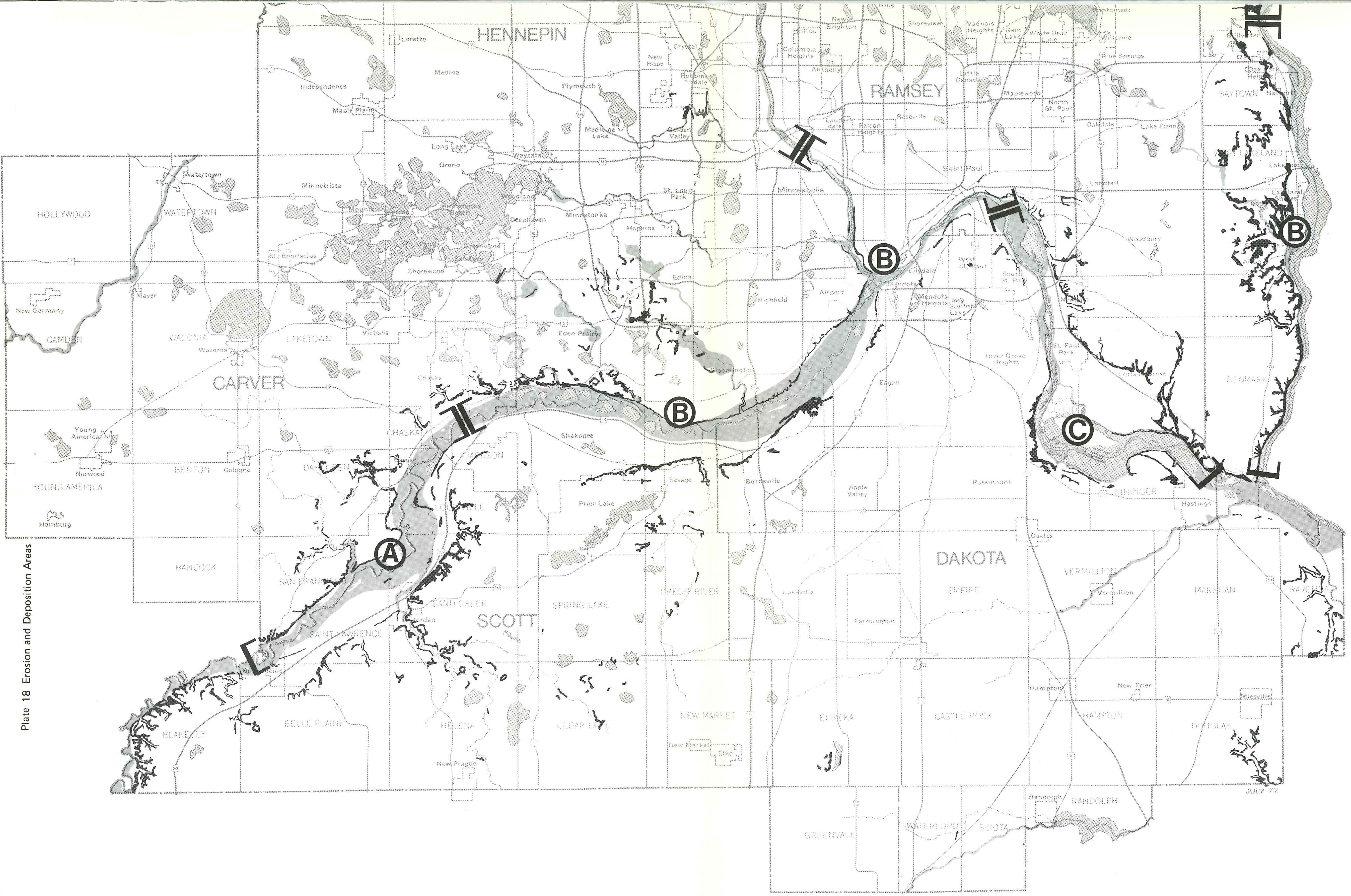


Plate 18 Erosion and Deposition Areas

BASELINE ENVIRONMENTAL INVENTORY / LAND USE
TWIN CITIES METROPOLITAN AREA

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

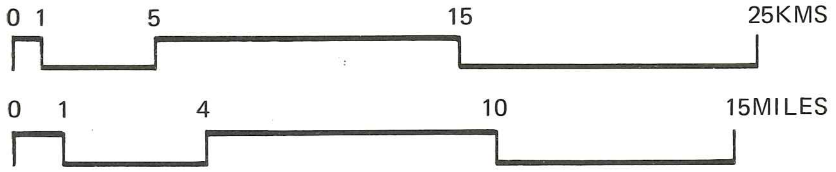
Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

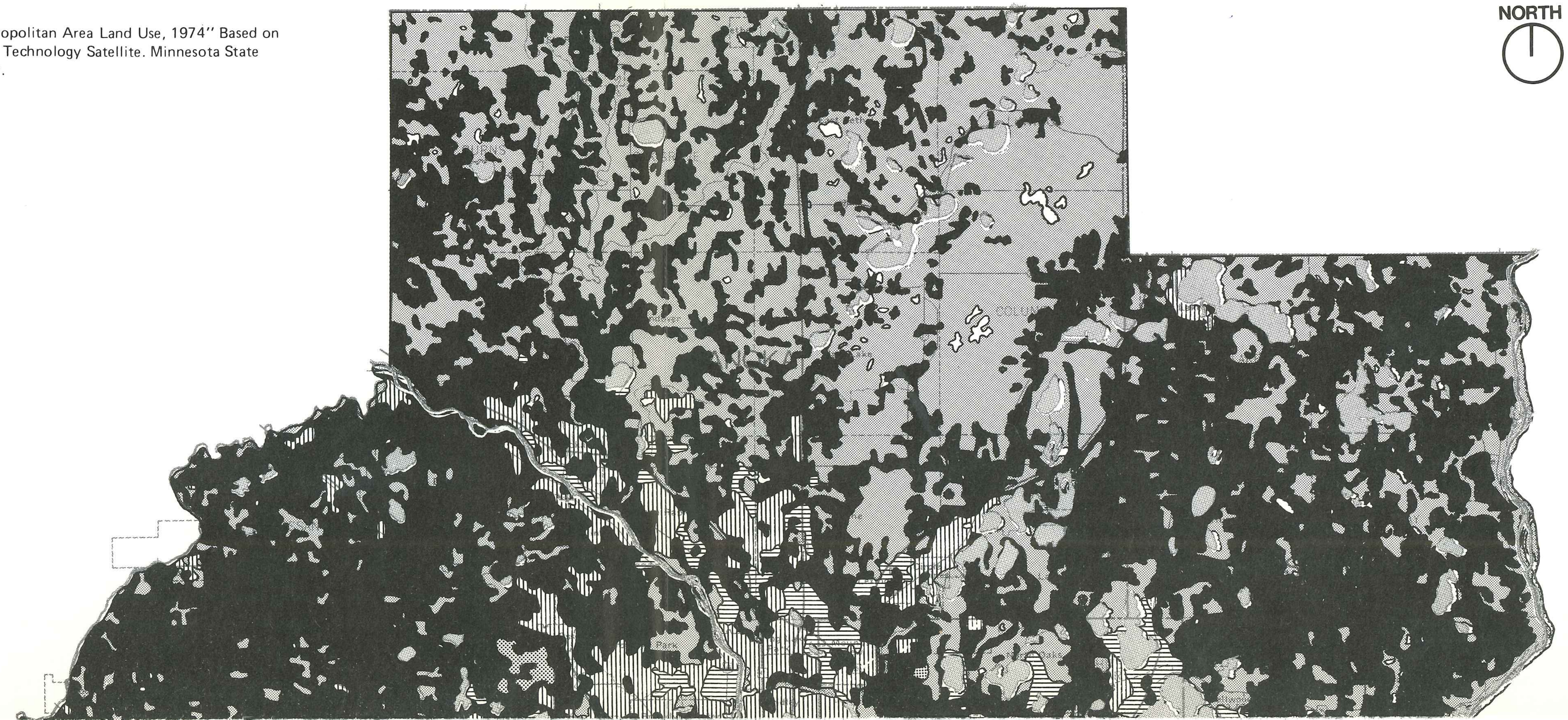
Legend

Plate 19

▤	Residential 1	▒	Commercial
▥	Residential 2	■	Open and Cultivated Land
░	Forest		
▒	Extractive		
▥	Central Business District		



SOURCES: "Twin Cities Metropolitan Area Land Use, 1974" Based on Earth Resources Technology Satellite. Minnesota State Planning Agency.



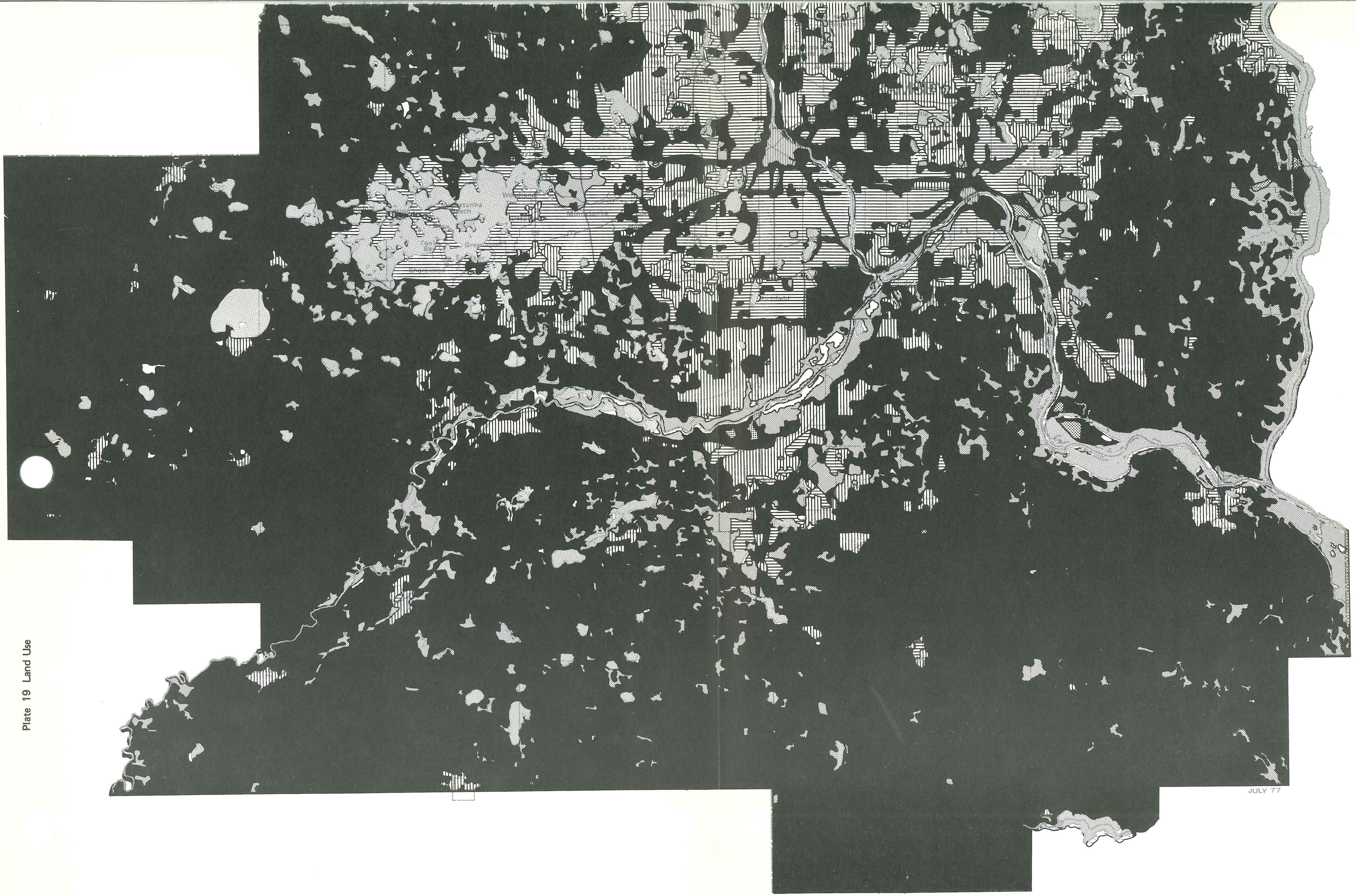


Plate 19 Land Use

BASELINE ENVIRONMENTAL INVENTORY/ TRANSPORTATION SYSTEMS
TWIN CITIES METROPOLITAN AREA

Plate 20

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

Major Roadways
Major Railroads
⑫ Industrial Parks
Airports
•••••••• Barge Channels (9 Feet or wider)
Rail Lines Proposed for Abandonment
Rail Lines Anticipated Subject of Abandonment Application Within 3 Years

0 1 5 15 25KMS
0 1 4 10 15MILES

SOURCES: "Airports System Plan" Metropolitan Framework Guide, March 1973.
"1990 Metropolitan Highway System Plan" Metropolitan Framework Guide, January 1977.
"Minnesota Railroad Map" Minnesota Department of Highways, January 1976.

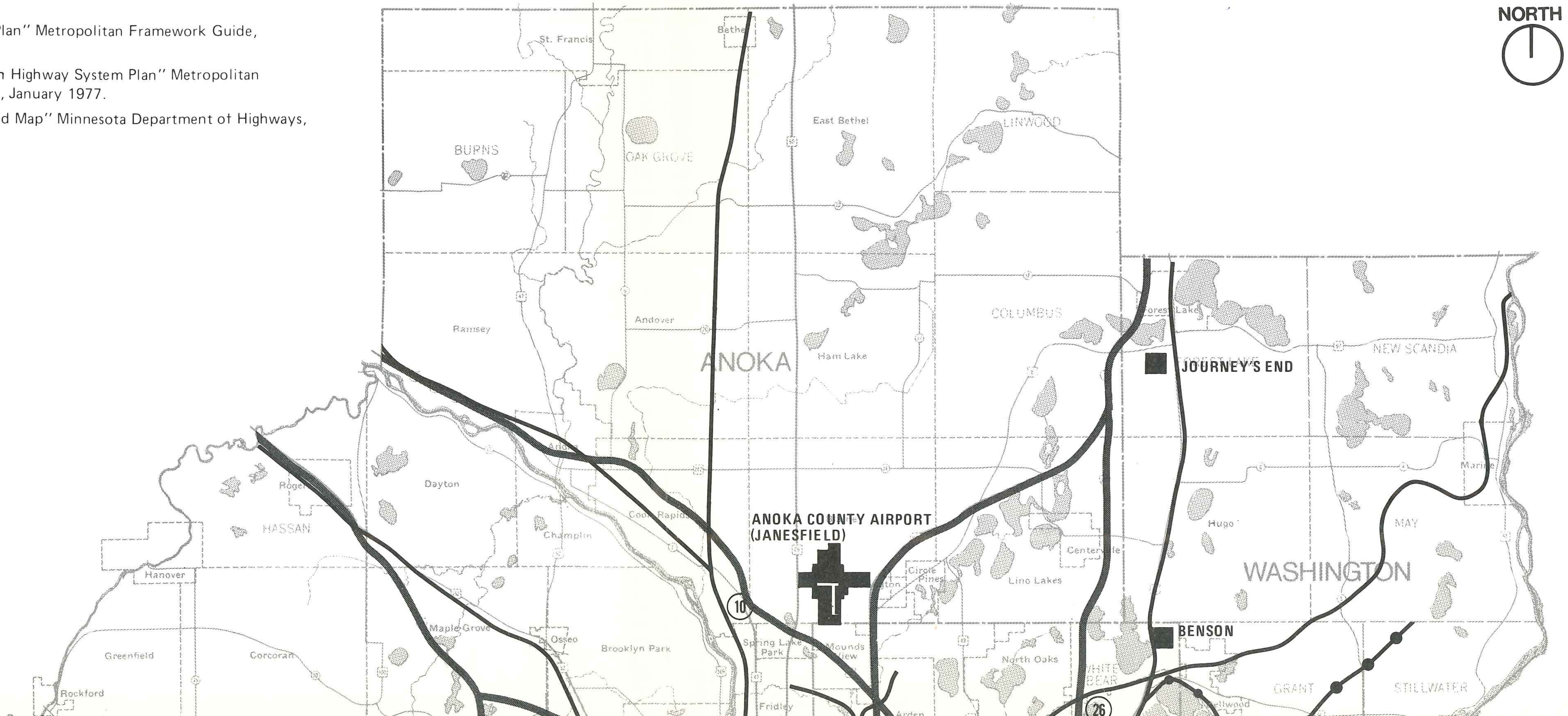


Plate 20 Transportation Systems

BASELINE ENVIRONMENTAL INVENTORY / SEWAGE AND SOLID WASTE DISPOSAL SITES
TWIN CITIES METROPOLITAN AREA

Plate 21

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

■	Sanitary Landfill	△	Special Use Incinerator
●	Sewage Treatment Plant		
▲	Transfer Station		
□	Special Use Landfill		
○	Recycling Station		

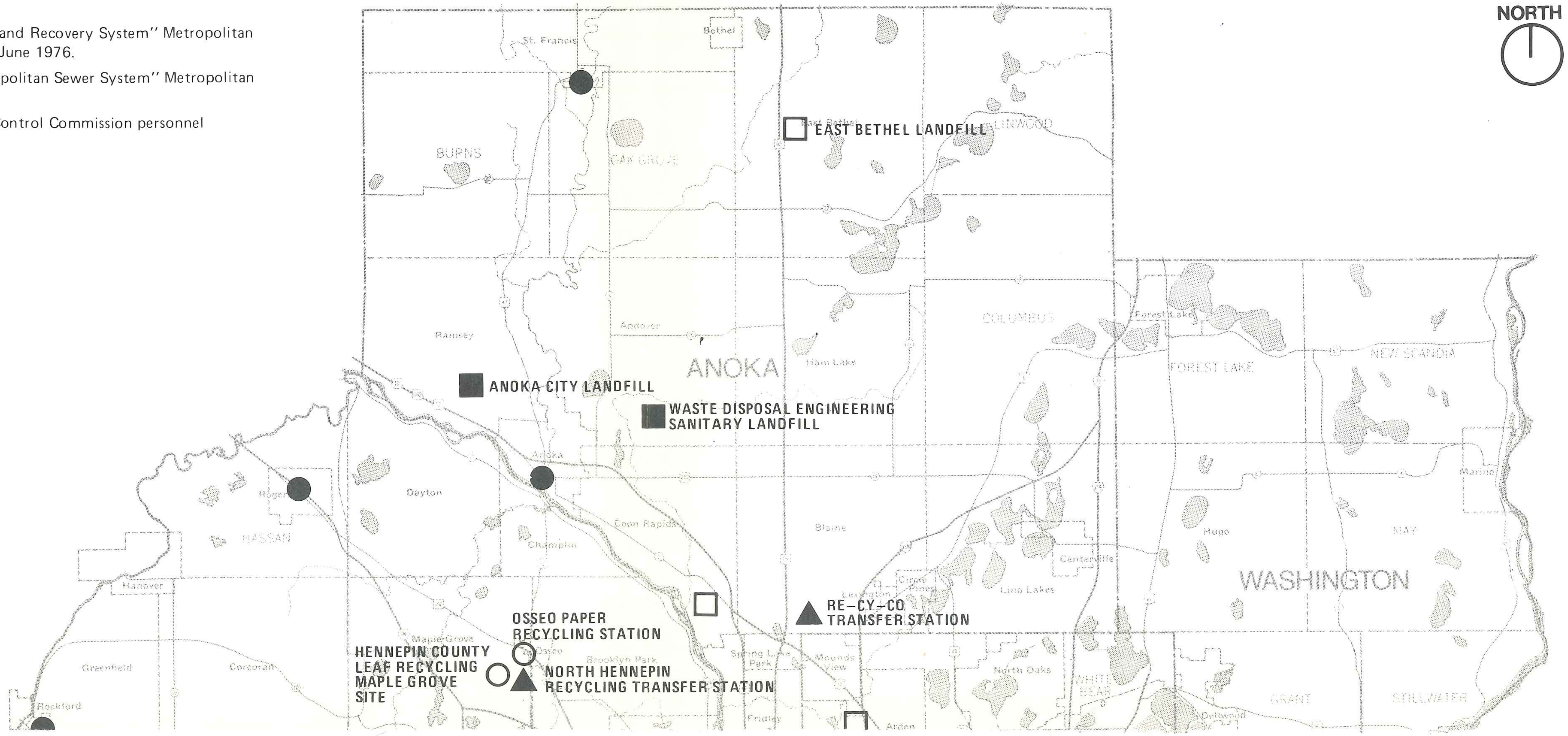
0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES: "Solid Waste Disposal and Recovery System" Metropolitan Development Guide, June 1976.

"January 1976—Metropolitan Sewer System" Metropolitan Development Guide.

Metropolitan Waste Control Commission personnel



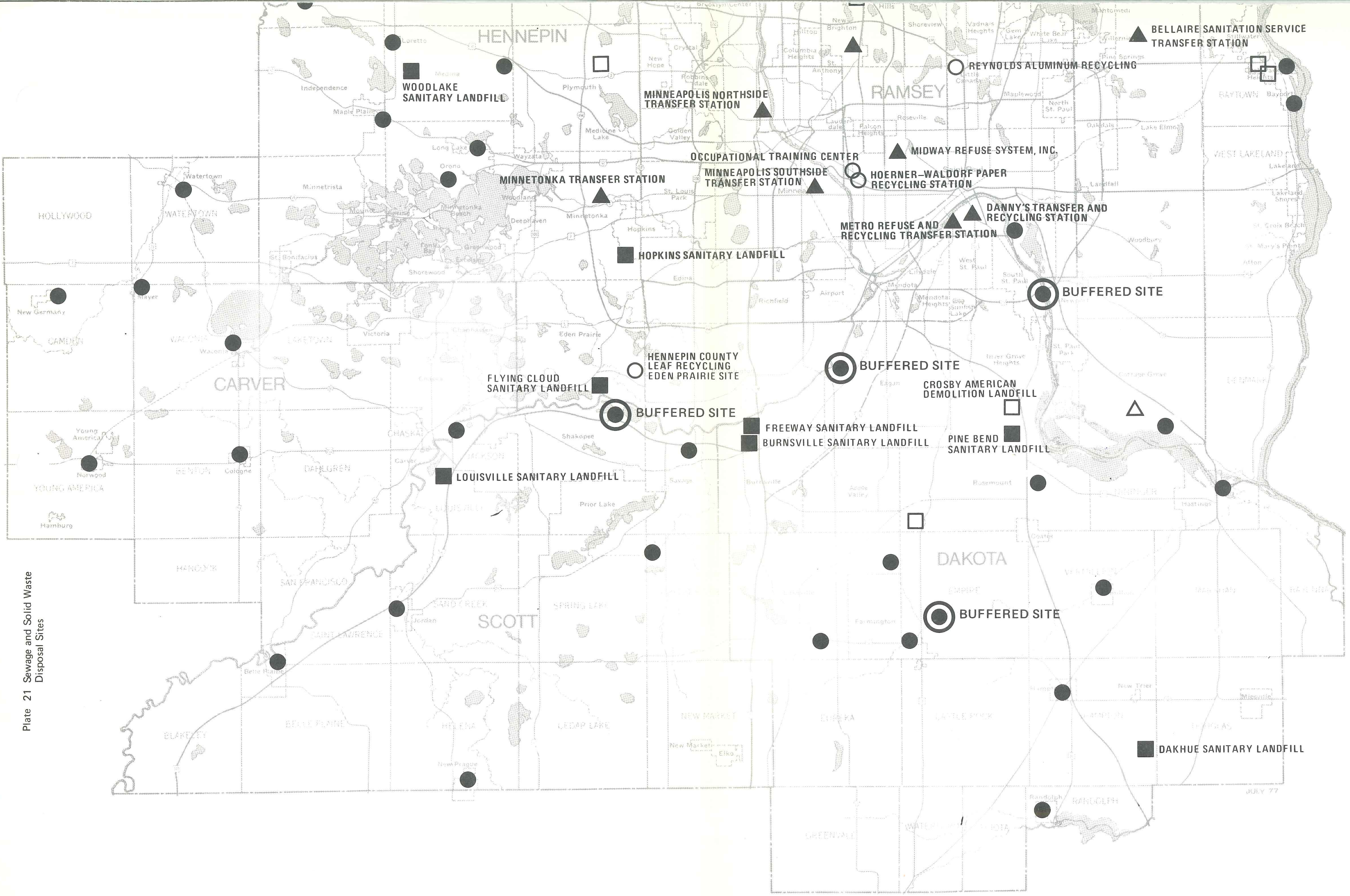


Plate 21 Sewage and Solid Waste Disposal Sites

BASELINE ENVIRONMENTAL INVENTORY / REGIONAL PARKS AND OPEN SPACE, 1977
TWIN CITIES METROPOLITAN AREA

Plate 22

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

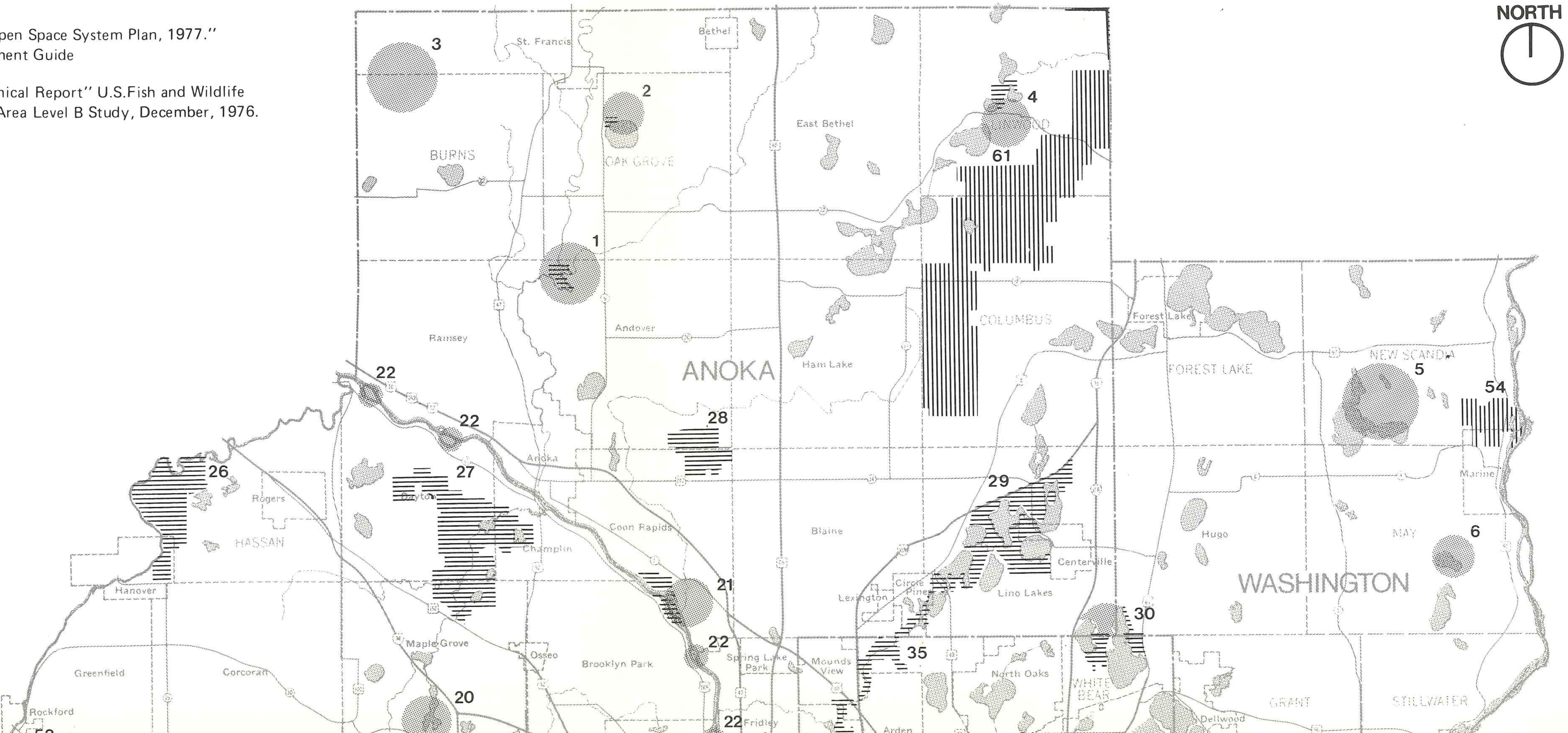
░ Proposed Regional Parks and Park Reserves
▥ Existing and Authorized State Lands
▤ Existing and Funded Regional Recreation Open Space
▒ Minnesota Valley National Wildlife Recreation Area (U.S. Fish and Wildlife)

0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES: "Regional Recreation Open Space System Plan, 1977." Metropolitan Development Guide

"Fish and Wildlife Technical Report" U.S.Fish and Wildlife Minneapolis—St. Paul Area Level B Study, December, 1976.



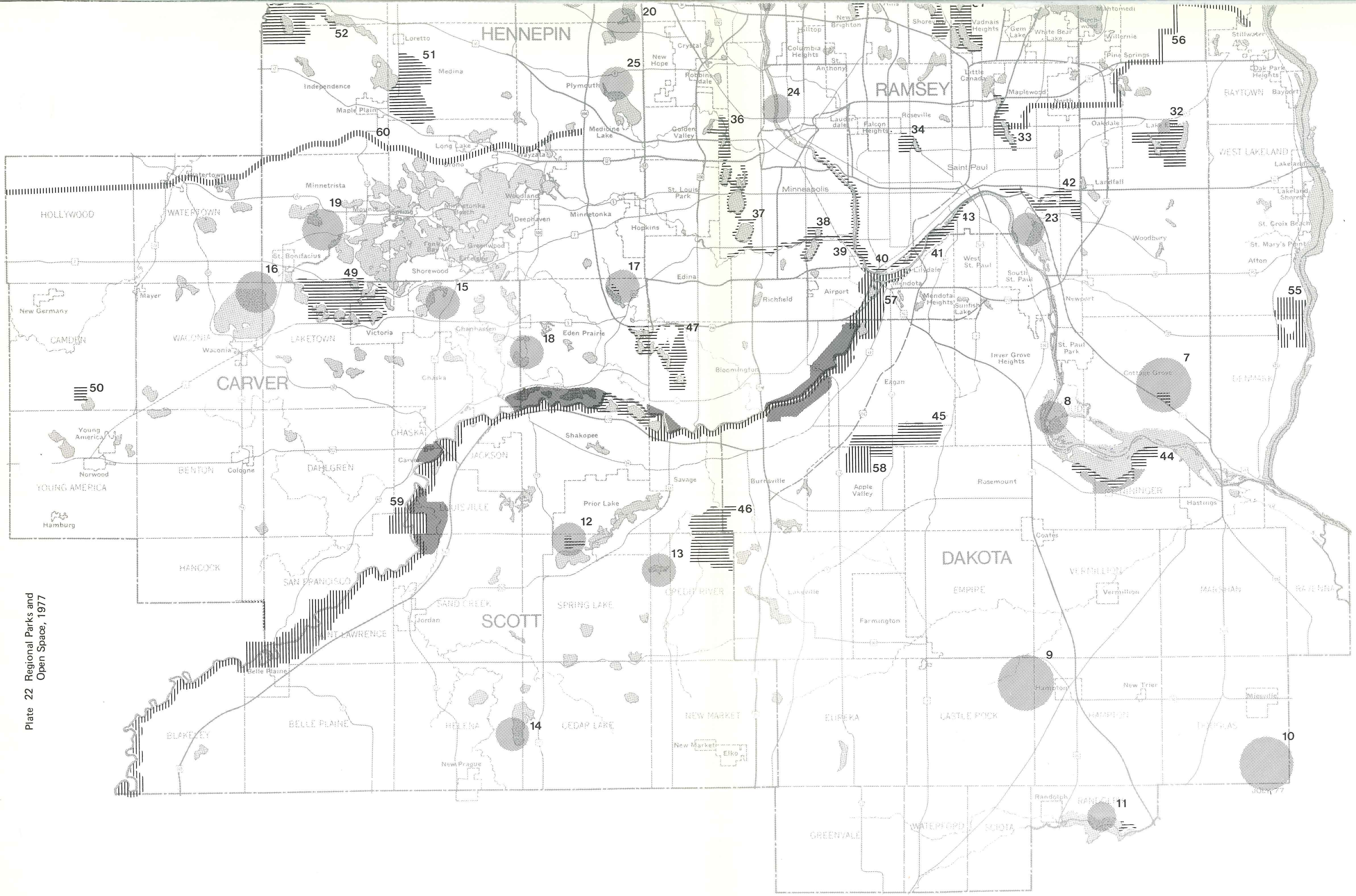


Plate 22 Regional Parks and Open Space, 1977

BASELINE ENVIRONMENTAL INVENTORY / AGRICULTURAL LAND
TWIN CITIES METROPOLITAN AREA

Plate 23

working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

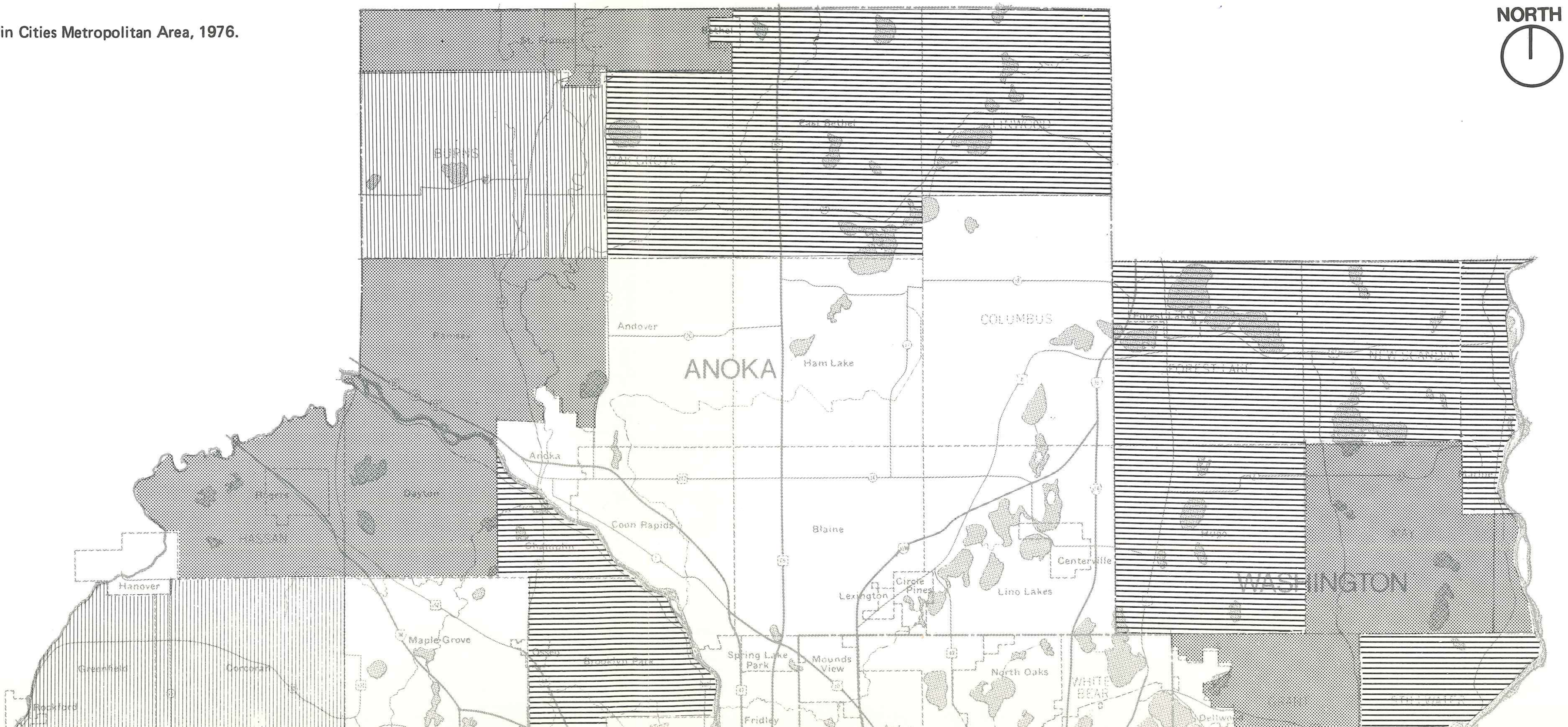
☐	Less than 25%
▤	25 - 50%
▩	50 - 70%
▥	Greater than 70%

0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES: Agriculture in the Twin Cities Metropolitan Area, 1976.

NORTH



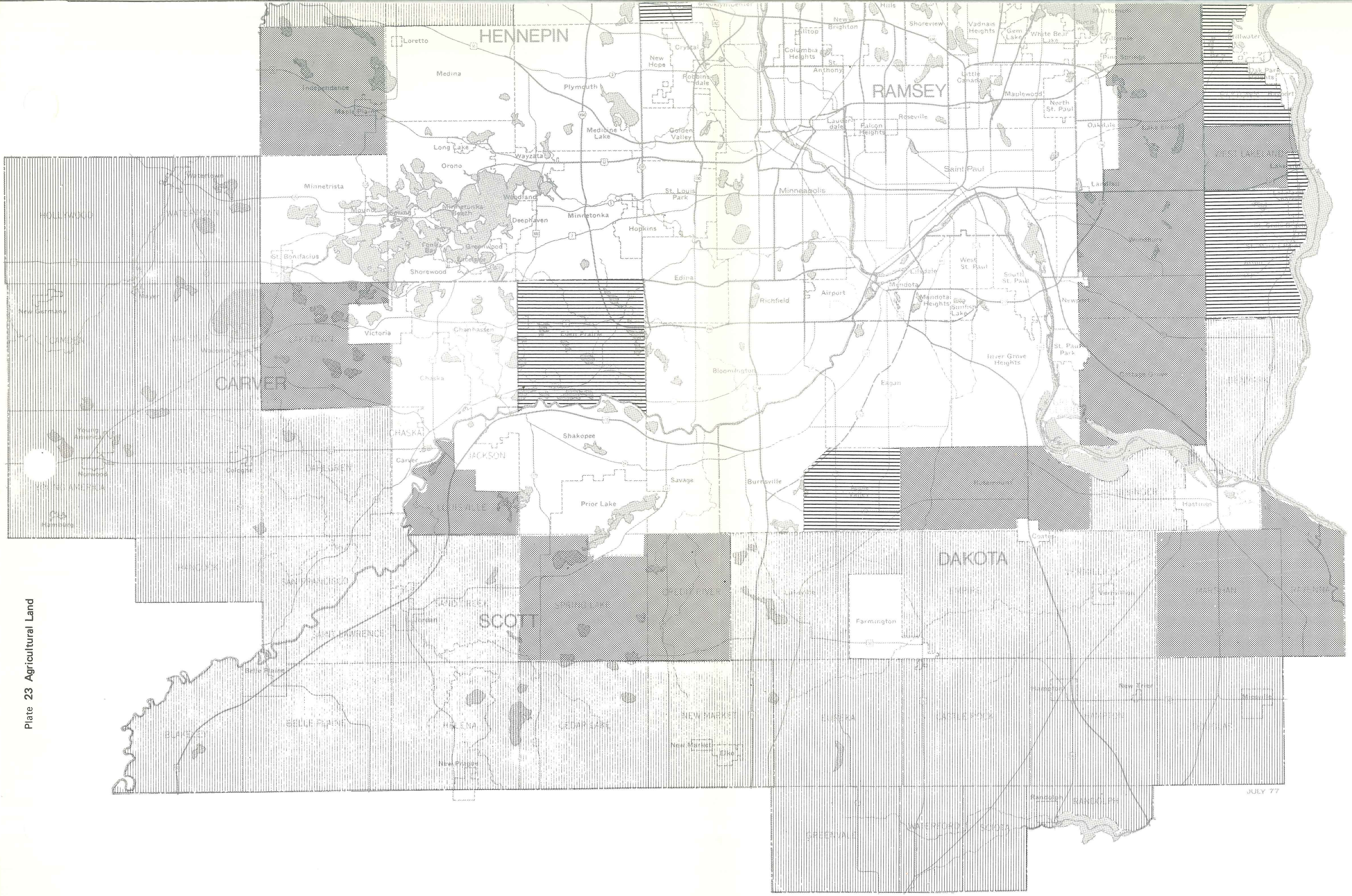


Plate 23 Agricultural Land

BASELINE ENVIRONMENTAL INVENTORY / LAND VALUE (AGRICULTURAL)
TWIN CITIES METROPOLITAN AREA

Plate 24

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Legend

▤ $200 - 400
▥ $400 - 600
░ $600 - 800
▒ $800 +
☐ Agriculture Insignificant

0 1 5 15 25KMS

0 1 4 10 15MILES

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

SOURCES: Minnesota Rural Agricultural Land Value, 1976.

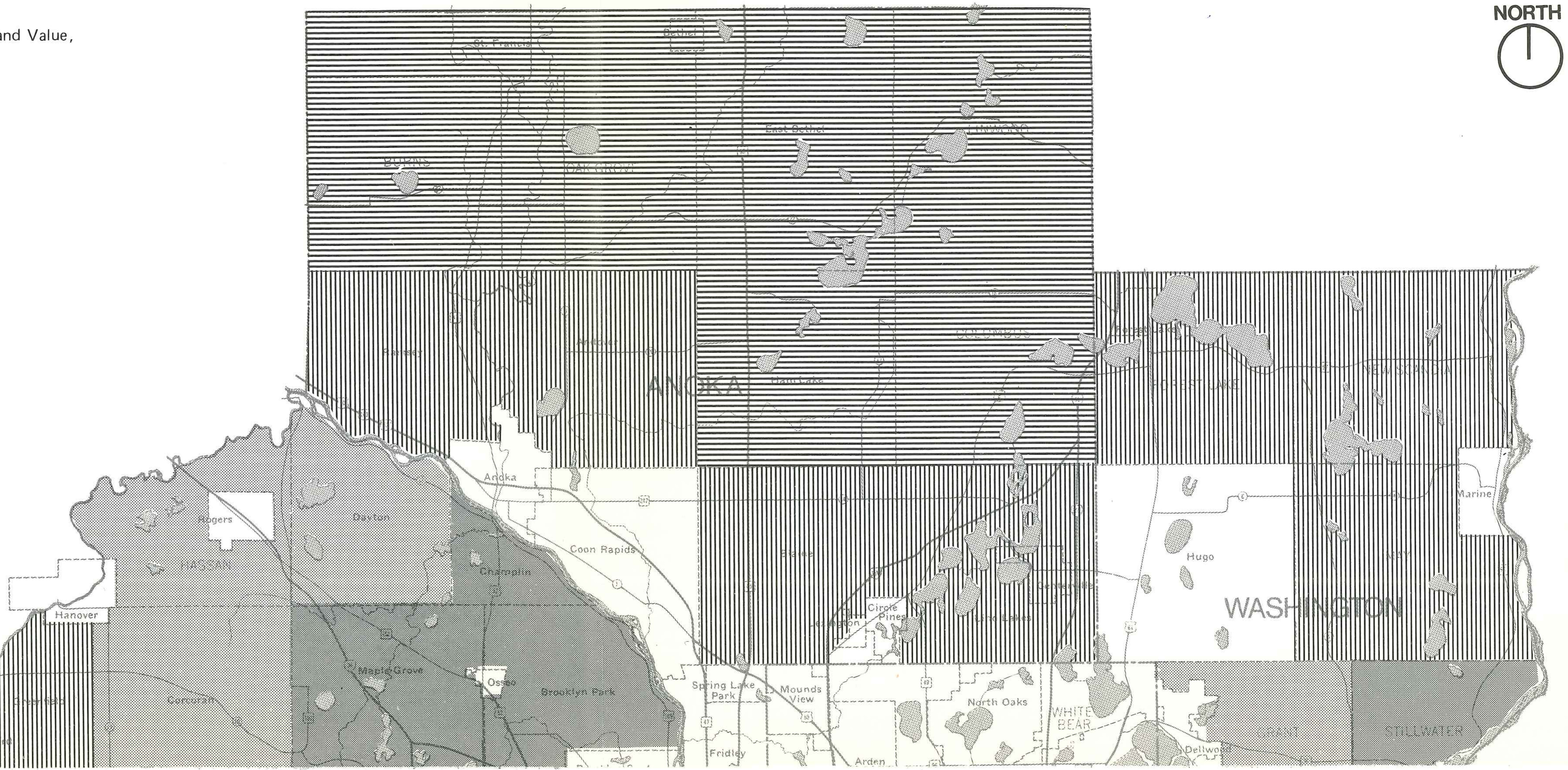
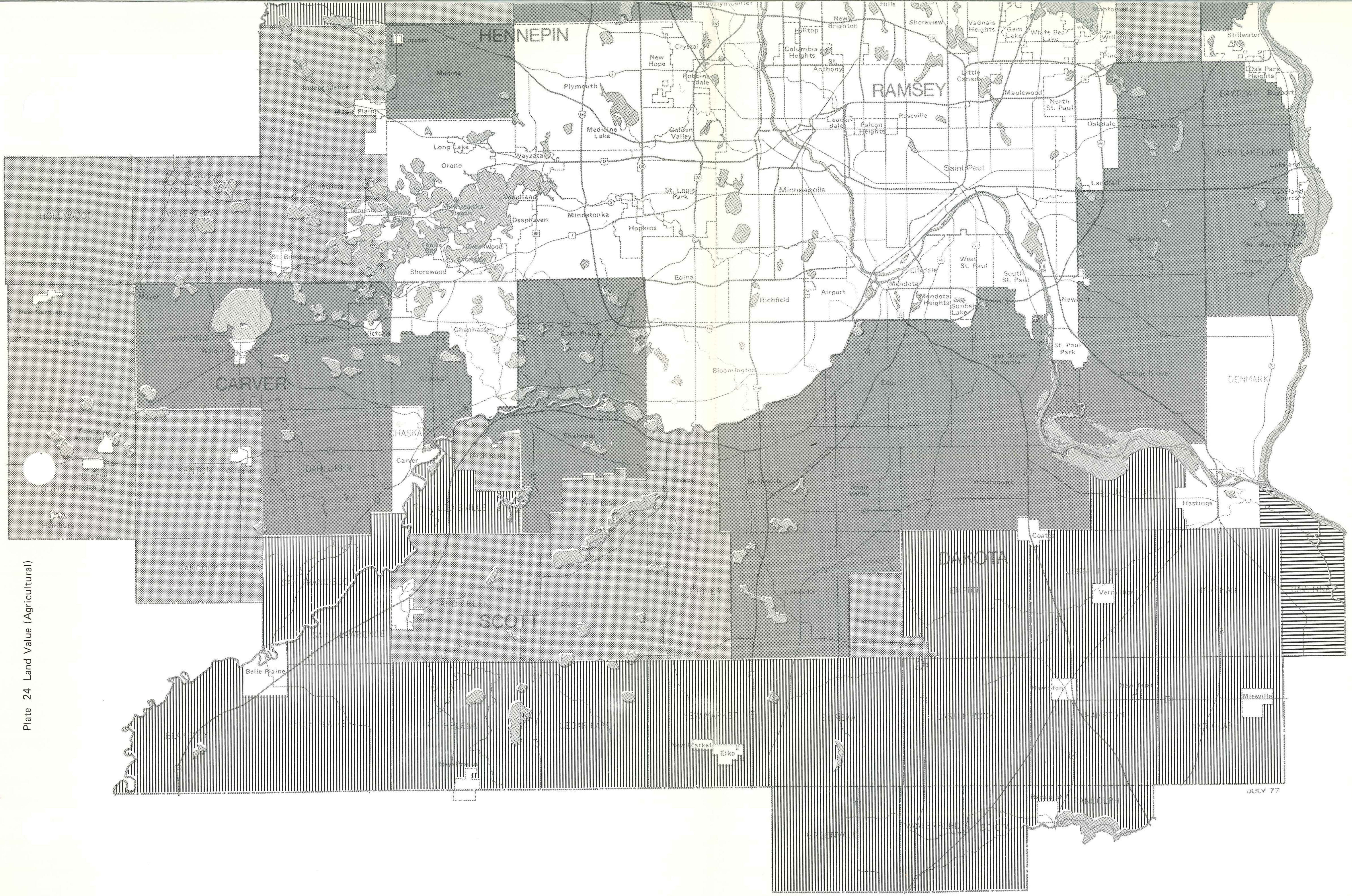


Plate 24 Land Value (Agricultural)



BASELINE ENVIRONMENTAL INVENTORY / SPECIALIZED FARMING LOCATIONS
TWIN CITIES METROPOLITAN AREA

Plate 25

201
working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

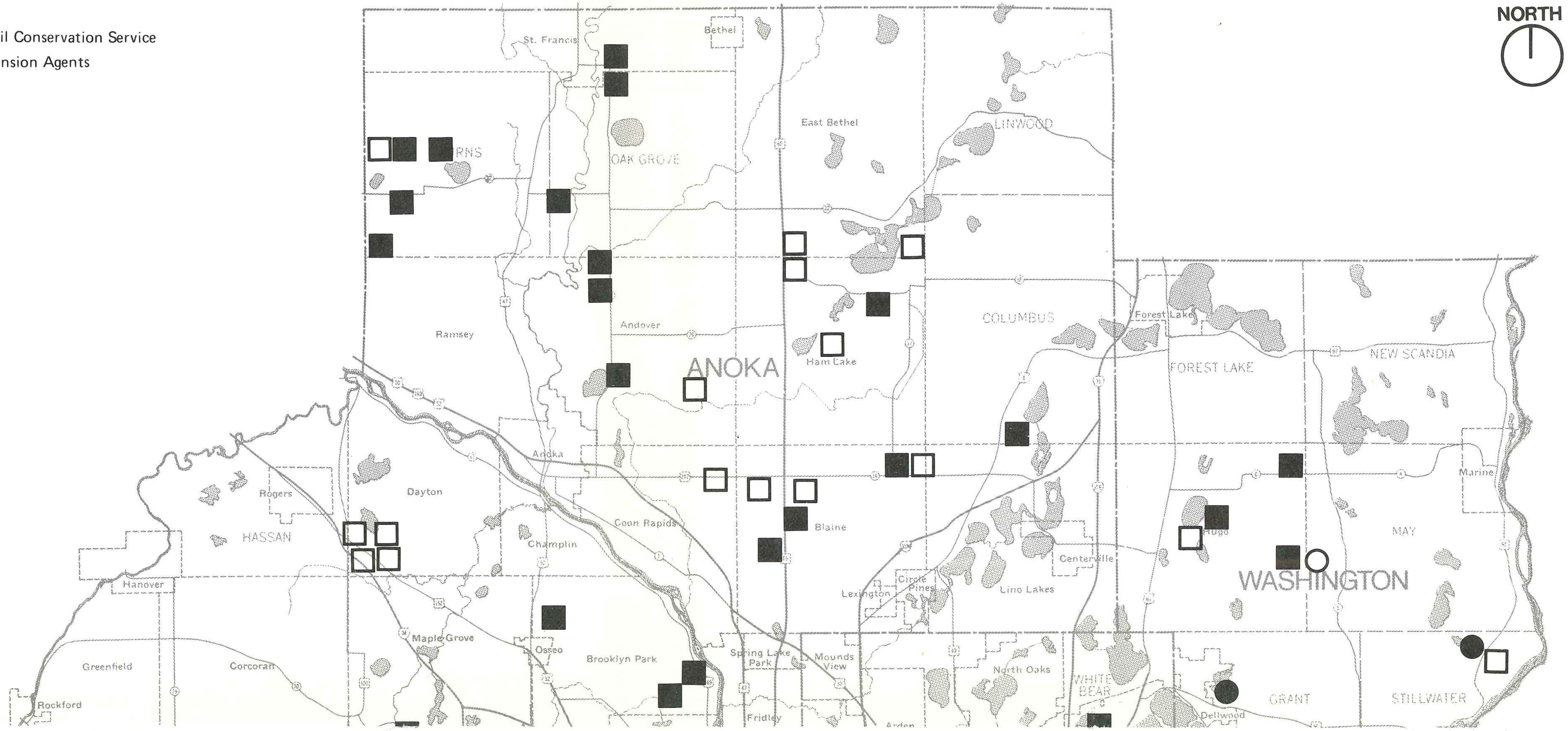
Legend

■	Truck Farm Vegetables and Berries	△	Vineyard
□	Sod		
●	Orchard		
○	Nursery		
▲	Christmas Tree		

0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCE: Metropolitan County Soil Conservation Service
Offices and County Extension Agents



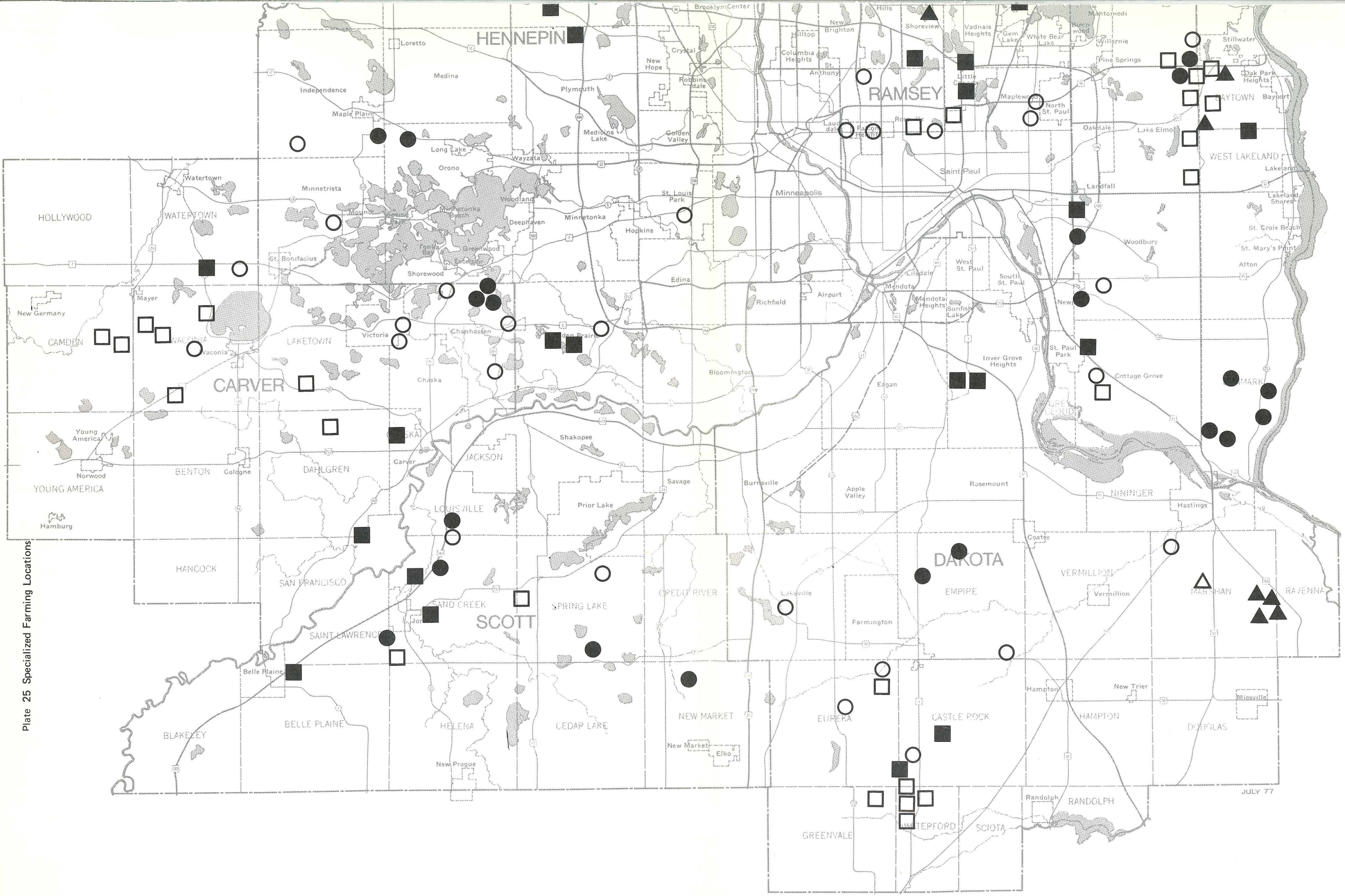


Plate 25 Specialized Farming Locations

BASELINE ENVIRONMENTAL INVENTORY / AESTHETIC, SCARCE, AND UNIQUE FEATURES
TWIN CITIES METROPOLITAN AREA

Plate 26

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

◇7	Nature Conservacy Tracts
◇11	SNA not on Acquisition Schedule
△9	Proposed SNA on Acquisition Schedule
④	Other Biological Sites
9	Unique Features
● 10	Water Features
③	Caves— The number indicates the number of caves in the area.

0 1 5 15 25KMS

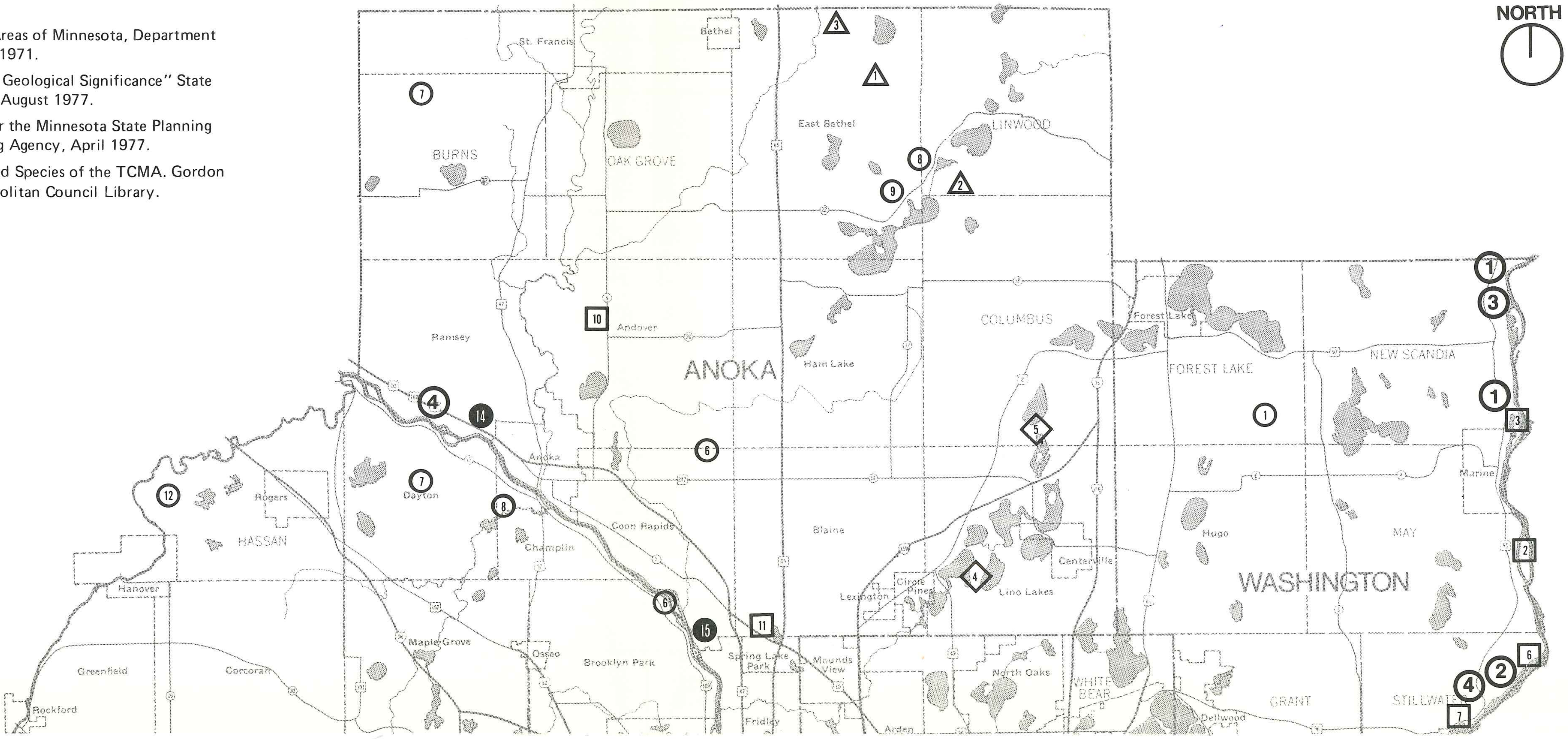
0 1 4 10 15MILES

SOURCES: Natural and Historic Areas of Minnesota, Department of Natural Resources, 1971.

"Sites of Biological and Geological Significance" State Planning Agency File, August 1977.

Listing of Variables for the Minnesota State Planning Agency. State Planning Agency, April 1977.

Unique and Endangered Species of the TCMA. Gordon Hughes, 1974. Metropolitan Council Library.



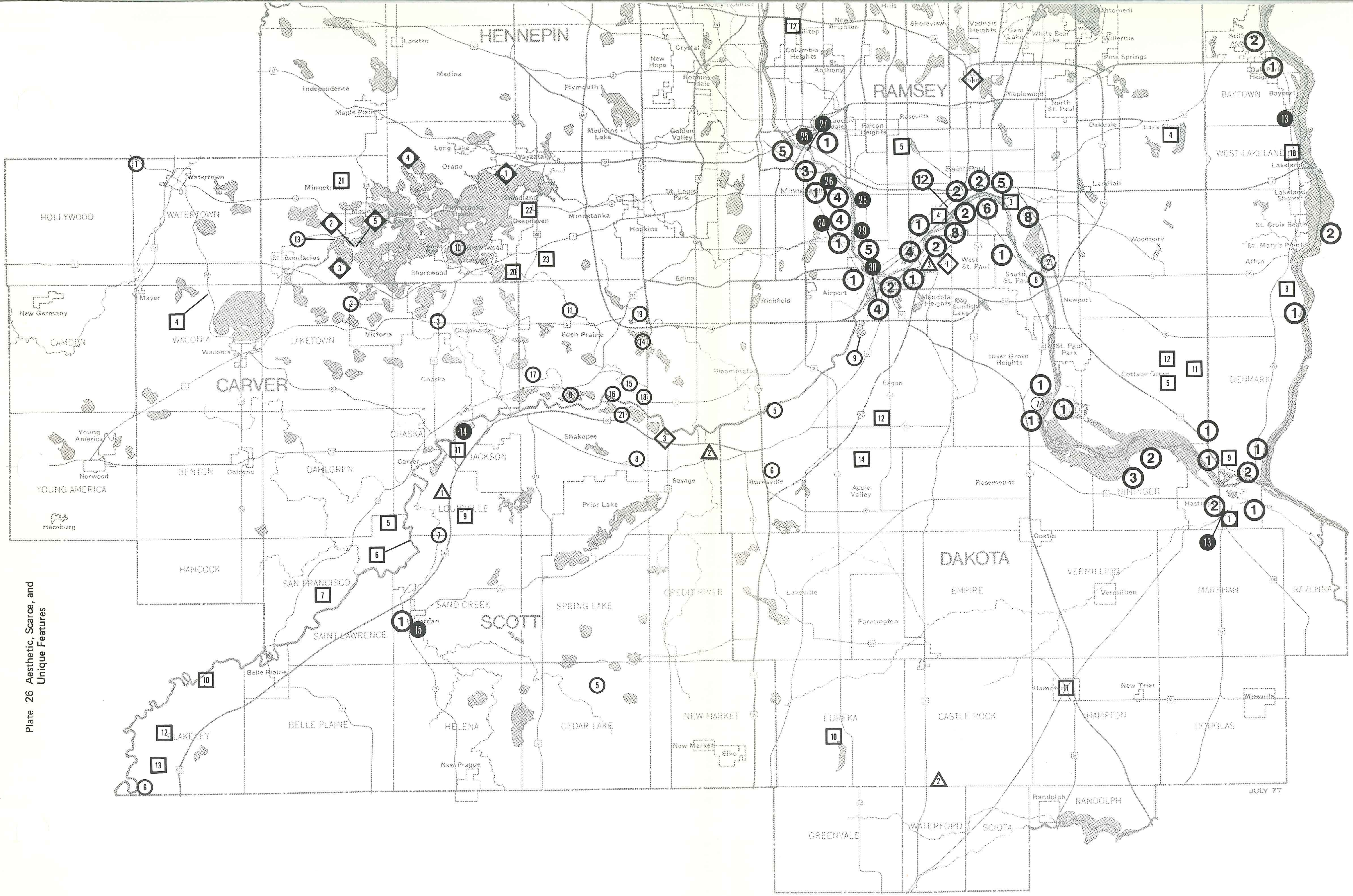


Plate 26 Aesthetic, Scarce, and Unique Features

BASELINE ENVIRONMENTAL INVENTORY / HISTORICAL AND ARCHAEOLOGICAL SITES
TWIN CITIES METROPOLITAN AREA

Plate 27

201 working for water quality

Metropolitan Waste Control Commission

350 Metro Square Building
St. Paul, Minnesota 55101

E. A. Hickok & Associates

Hydrologists
Engineers
Wayzata, Minnesota

InterDesign Inc.

Architects. Graphic Designers.
Landscape Architects
Minneapolis, Minnesota

Funded in part through a grant from the U.S. EPA under the Construction Grants Program (Section 201) of PL 92-500.

Legend

- ● 7 Historic Sites
- ☐ 5 Historic Sites of Local Significance
- ○ 5 Archeological Sites

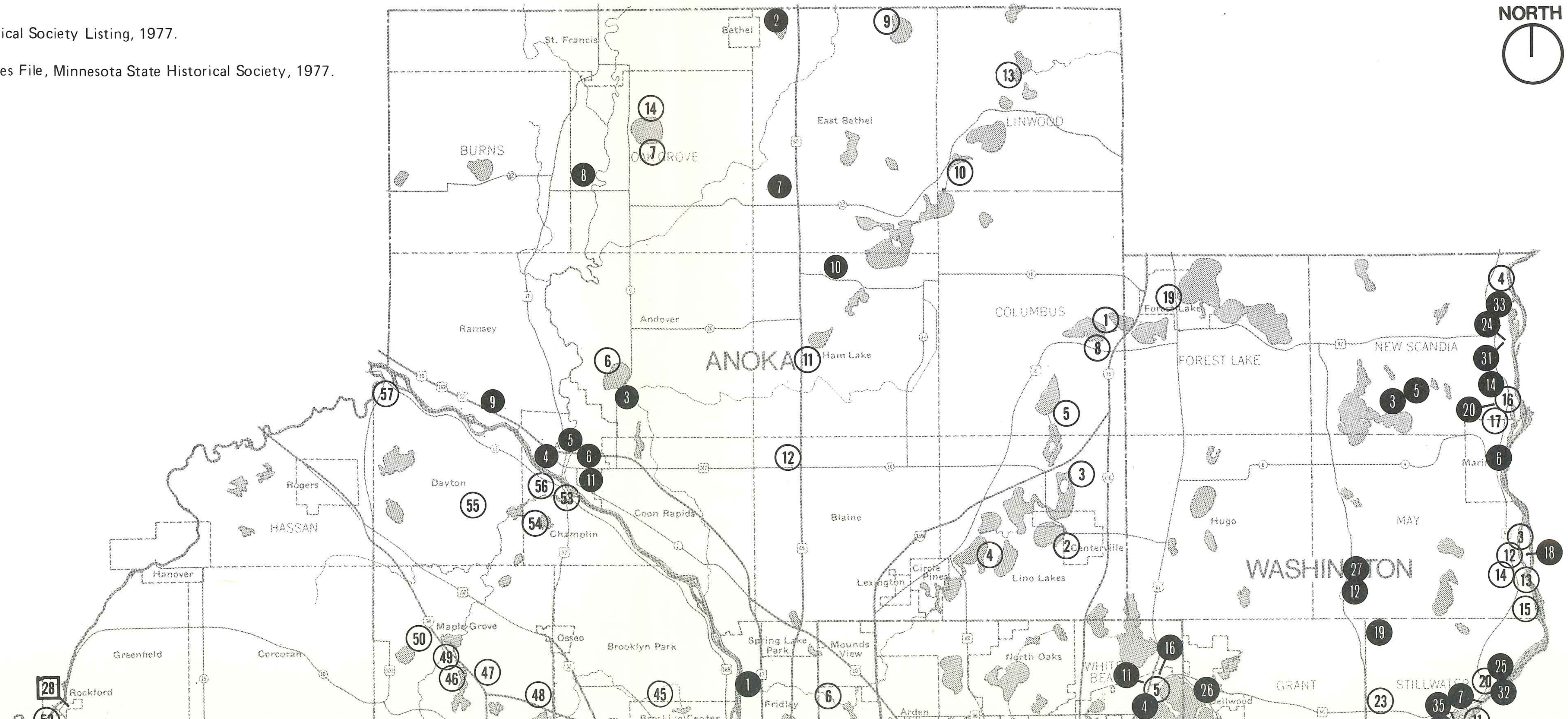
0 1 5 15 25KMS

0 1 4 10 15MILES

SOURCES: Minnesota Historical Society Listing, 1977.

Archeological Sites File, Minnesota State Historical Society, 1977.

NORTH



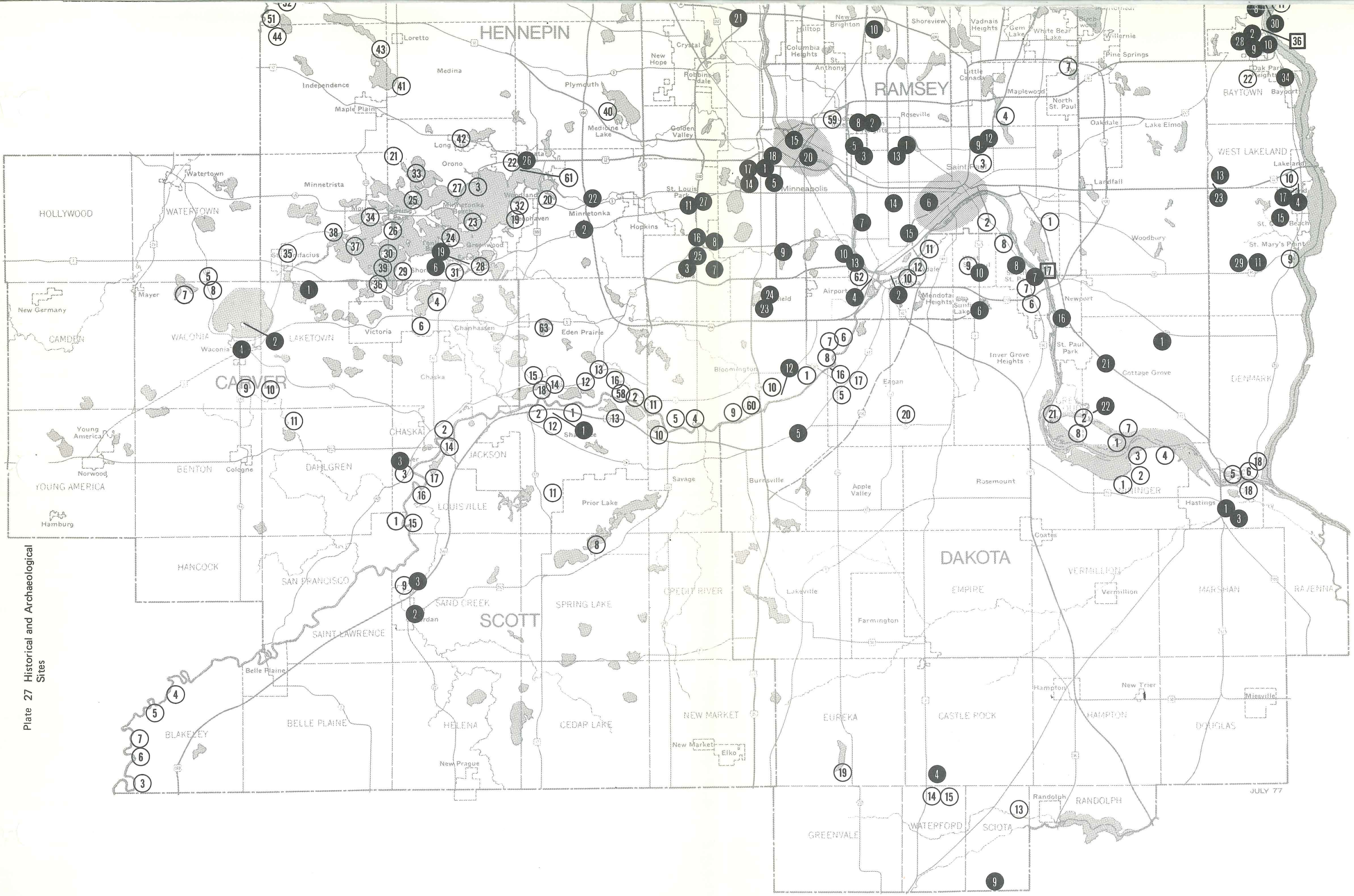


Plate 27 Historical and Archaeological Sites

ADDENDA

PAGE	COMMENTS
ii	Under Section 1, "Precipitation" is found on page **33.** Under Section 1, "Wind" is found on page **37.** Under Section 1, References are found on page **46.**
v	Under Section 14, "Federal Open Space Policy" is found on page **261.** Under Section 14, "State Open Space Policy" is found on page **262.** Under Section 16, omit reference to **Species of Special Consideration.**
vi	Under Section 17, add **Bacteria, page 308.** Under Section 17, "Additional References" is found on page **313.** Under Section 17, "Contacts" is found on page **315.**
ix	Figure 11–18 is found on page **187.**
x	Figures 11–19 and 11–20 are found on page **188.** Figures 11–21 and 11–22 are found on page **189.** The title for Figure 11–23 should read **Fecal Coliform at Anoka 1971–1976.**
xiv	Table 15–5 is found on page **273.**
52	The title for Table 3–1 should read **Geologic Units and Their Water-Bearing Characteristics (41).** Omit source at bottom.
55–59	Figures 3–2 through 3–12 should read **A′, B′, C′** rather than A^1, B^1, C^1.
90	The abbreviation AVE should read **AVG** (Average) on Table 5–11.
103	The word "course" on Figure 6–1 should read **coarse.**
115, 117–124, 126, 127	The source for Figures 7–2 through 7–12 should read **Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area, 1974.**
116	The source for Table 7–1 should read **Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area, 1974.**
161	The source of Figure 10–4 is found at the bottom of page **161.**
169, 171	Tables 11–3 and 11–5 refer to areas shown on **Plate 15.**
180–193	The source for Figures 11–4 to 11–26 should read **Water Quality Reports, 1971 – 1976.**
213	Omit source and title at bottom of page.
231, 233, 238	The direction arrow should indicate North being toward the right hand side of the page.
238	Symbols shown are indexed to the key in Figure 13–9.

ADDENDA

PAGE	COMMENTS
263–267	In reference section, "TCMA" should read **Metropolitan Area.**
277–284	On Figures 16–1 through 16–9, arrows indicate the appropriate side of the range boundary line for each species.
328	The map indicating "Soils with Severe Limitations for Urban Development" is found in **Exhibit C.**
341	The word "disappear" in line one should read **disappears.**
343	The "Source of Information" for Mississippi River should read **Environmental Assessments, East and South Minnesota River Pool; 1976.**
343	The "Source of Information" for Rum River should read **Environmental Assessments, Minnesota River Pool, 1976.**
344	The "Streambed Composition" for the Cannon River should read ... **where sediments overlie stratified silt and sand.**
344	The "Streambed Composition" for the Minnesota River should read **... Chaska to Mississippi — mixture of sand and organic sludge.**
345	Exhibits **C and D, Section 4—Soils** are found at the end of the appendices. In Exhibit B, under "Source of Information", parentheses around a number refer to the reference citation in Section 3 found on page **65.**
	The "Source of Information" for Eagle Creek should read **Fish and Wildlife Technical Report, 1976 (7). Tom Waters, U of M Wildlife and Fisheries.**
347	Under Tamarack and White Cedar Swamp Community, the Dominant Shrubs and Herbs should read: **Alder (Alnus rugosa)** **Red osier dogwood (Cornus stolonifera)** **Labrador Tea (Ledum groenlandicum)** **Goldthread (Coptis trifolia)** **Twinflower (Linnaea borealis)**
	Under Oak Savanna Community, Dominant Tree Species, Burr Oak should read **Bur Oak**
349	Under White Oak Forest Community, Dominant Tree Species, Burr Oak should read **Bur Oak**
	Under Northern Pin Oak Forest Community, Dominant Tree Species, Burr Oak should read **Bur Oak**

ADDENDA

PAGE	COMMENTS
	Add Source for Exhibit E: **Unique and Endangered Plants and Animals in the Twin Cities Metropolitan Area, 1974.**
354	The abbreviation "Env" refers to **Environmental Education Centers.**
	The sources for Exhibit G should correspond to those listed on **Plate 12.**
360	Under Cyprinidae – minnows and carps, Silver Chub should read **Silver chub.**
361	"Exhibit L" at the top of the page should read **Exhibit I.**
365	"Yell.–cr Night H." should read **Yellow-crowned Night Heron.**
	The habitat of the Wood Duck should read **A2–3.**
367	The habitat of the Short-billed Dowitcher should read **H–1.**
368	The habitat of the Nighthawk should read **E, F.**
370	The habitat of the American Pipit should read **C.**
377	Under "COUNTY: DAKOTA – 1 Hastings Scientific and Natural Areas" add comma between **"proposed"** and **"Maple".**
394–400	Exhibit Q title should read **Aesthetic, Educational, Scarce and Unique Features.**
398	Under "Ramsey County Proposed Scientific and Natural Area Not on Schedule," Langton Lake Area should read **Langdon Lake Area.**
408	Under "Minneapolis Historic Area," Lohmar House, the location should read **1514 Dupont Avenue South.**