INTRODUCTION

Purpose and Scope

A flood-plain study was made by the U.S. Geological Survey in cooperation with the Minnesota Department of Natural Resources along a 21-mile reach of the Mississippi River extending from mile 866.8 near Coon Rapids Dam upstream to mile 888.0 just west of Elk River, Minn. Floods along this reach of the Mississippi River, which includes municipalities and unincorporated areas of Anoka, Hennepin, Sherburne, and Wright Counties, have damaged the agricultural and transportation industries as well as private and industrial developments. The most recent notable floods occurred in 1965 and 1969 (Anderson and Schwob, 1970). Despite documented evidence of flood hazards, development of flood-prone areas has continued. The addition of structures on the flood plain increases the potential for flood damage. Structural constriction of flood-plain areas decreases the capacity of the floodway to carry flood flows and causes higher water-surface elevations upstream.

The Minnesota Legislature passed the Flood-Plain Management Act in 1969 and amended it in 1973. This Act adds impetus to the regulation of flood-plain areas by requiring local units of government to adopt, enforce, and administer flood-plain management ordinances within their respective jurisdictions whenever sufficient data are available to formulate such regulations. Under the Act, the Minnesota Department of Natural Resources is given responsibility to collect and distribute information relating to flooding and flood-plain management, establish standards for local regulations, and assist local governmental units in flood-plain management activities.

A flood-plain management program requires reliable technical data to (1) define flood-plain limits, (2) determine flood-protection elevations, and (3) evaluate the potential increases in flood elevations that would result from development of flood-plain areas. The effect of changes within the flood plain in any given area can extend a considerable distance upstream.

The primary purpose of this report is to provide the technical information needed for making land-use decisions designed to minimize flood damages. The hydrologic data contained herein can be used to evaluate the extent, depth, and frequency of flooding. The effects of encroachment by development within the limits of proposed floodways are evaluated and incorporated into flood-protection elevation profiles. All elevations in this report are referred to NGVD (National Geodetic Vertical Datum of 1929).

Acknowledgment

Acknowledgment is made to U.S. Army Corps of Engineers-St. Paul District, Hennepin County Park Reserve District, Northern States Power Company, the City of Anoka, and the Minnesota Department of Natural Resources for providing historical flood information and other data.

EXPLANATION OF TERMS[1]

Regional flood – A flood which is representative of large floods known to have occurred in Minnesota and reasonably characteristic of a flood with a 100-year recurrence interval.

Recurrence interval – As applied to flood events, recurrence interval is the average interval of time, in years, between occurrences of a flood of a given magnitude.

Probability – The inverse of recurrence interval. Thus, a flood of specified magnitude having a 20-year recurrence interval has a 5 percent chance and a 100-year flood has a 1 percent chance of being equaled or exceeded in any year.

Flood plain – Areas adjoining a watercourse which have been or hereafter may be covered by the regional (100-year) flood.

Flood-protection elevation – The elevation corresponding to a point not less than 1 foot above the water-surface profile associated with the regional (100-year) flood plus any increases in flood stage attributable to planned encroachments on the flood plain.

Floodway – The channel of a watercourse and those parts of the adjoining flood plains which are reasonably required to carry and discharge the regional (100-year) flood.

CONVERSION FACTORS

The following factors may be used to convert the inch-pound units published herein to the International System of units (SI).

Multiply	By	To Obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre	4,047.0	square meter (m^2)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

[1] Explanation of terms is taken from or is in agreement with "Rules and Regulations of the Department of Natural Resources Relating to Statewide Standards and Criteria for Management of Flood Plain Areas of Minnesota, 1970." Minnesota Regulation NR 85-93.

DESCRIPTION OF FLOOD-PLAIN AREAS

There are approximately 1,300 acres (2 mi^2) of flood plains in the study reach. High stream banks downstream from Anoka confine large flows, and little flood plain exists there. At Anoka the high banks are interrupted by the Rum River channel and by areas with low banks and gently sloping flood plains. Flood-plain areas become progressively larger, and reaches with high banks diminish, upstream from Anoka. Meandering of the channel has formed several islands. These are most numerous near the mouth of the Elk River. All the islands are wooded and undeveloped.

Mississippi River floods affect short reaches along tributary streams near their mouths. Stage increases due only to flood flows on the tributary are not as great as those caused by backwater from high stages on the Mississippi River. Backwater conditions occur along the Rum, Crow, and Elk Rivers. Flood-plain areas extending upstream to the first structure along these tributaries are included in flood plains of the Mississippi River in this report.

Development of flood-plain areas occurred first at the mouth of tributary streams. Four early developments which expanded and incorporated now comprise the older parts of the cities of Anoka, Champlin, Dayton, and Elk River. Presently, the residential development within the horseshoe bend of the channel opposite Elk River, Minn., is unincorporated. Flood-plain areas between major tributaries have developed more slowly and many of these areas remain in agricultural use.

Major uses of the flood plain are agricultural, recreational (parks), and residential. Table 1 lists those uses by community. For purpose of this report, streets in residential areas are included in residential development. Parks, campgrounds and islands are included as open space with agricultural uses. In addition to the flood-plain areas listed in table 1, approximately 24 acres of flood plain are used by U.S. Highways 10, 52 and 169 and the junction of those highways with Minnesota Route 101 in Elk River; 12 acres are used for Minnesota Route 101 in Wright County; and about 6 acres of flood plain are used around the Anoka Sewage Treatment Plant.

Table 1 – Residential and open-space uses of flood-plain lands

Community	Residential development (acres)	Agricultural and open space use (acres)
Anoka	26	102
Champlin	13	51
Coon Rapids	0	3
Dayton	3	208
Ramsey	17	46
Elk River	14	336
Wright County, (unincorporated)	166	276
Total	239	1022

HISTORIC FLOODS

Streamflow records pertaining to the study reach have been collected by the U.S. Geological Survey at two gaging stations. One of these stations was located at the City of Elk River, immediately below the mouth of the Elk River, where data were obtained continuously during 1916-56. Flood elevations since 1956 were furnished by the Corps of Engineers or were estimated on basis of records for stations downstream. From figure 1, it is apparent that many floods affecting the Elk River area have occurred during the 63-year period of record extending through 1978 (Anderson and Burmeister, 1970). Ice jams, usually associated with the lower flood flows, create backwater conditions that increase flood heights. Peak elevations affected by ice jams are noted in figure 1.

The highest and most damaging flood of record occurred in 1965 when the Mississippi River flowed across the bend south of Elk River, Minn., washed out a highway and destroyed many homes. Areas in Dayton and Anoka also were inundated (Johnson, 1966). During the 1969 flood, an extensive emergency dike prevented severe flooding and damage in the Elk River, Minn., area.

Downstream from Elk River, flood-flow characteristics are significantly influenced by major tributary inflow from the Crow River entering at Dayton and the Rum River at Anoka. Records of these combined flows have been collected on the Mississippi River at river mile 864.8 near Anoka since 1931. The magnitude and distribution of floods in the reach downstream from the Rum River are illustrated in figure 2 for the period 1931-78.

Records of Mississippi River flood stages were obtained at the mouth of the Rum River in Anoka for 24 years while Northern States Power Company operated the dam and powerplant downstream. These records show that ice jams formed during the ice-breakup period on the rising limb of snowmelt hydrographs. The most severe ice-backwater condition occurred in April 1965. The practice of draining the pool for the winter, initiated in the fall of 1968, eliminates formation of a heavy ice sheet at normal pool level and lowers the water-surface elevation at which ice jams form in the reach between the dam and Anoka. When ice jams form, several feet of backwater occur before normal pool level is reached. As a result, backwater from ice jams in the pool area does not affect frequency relations at the elevation of the 10-year recurrence interval, or greater, flood in the Anoka-Champlin area.

Ice jams in the area of small islands upstream from Elk River, Minn., in December 1971 resulted in very high stages that extended upstream beyond the study area.

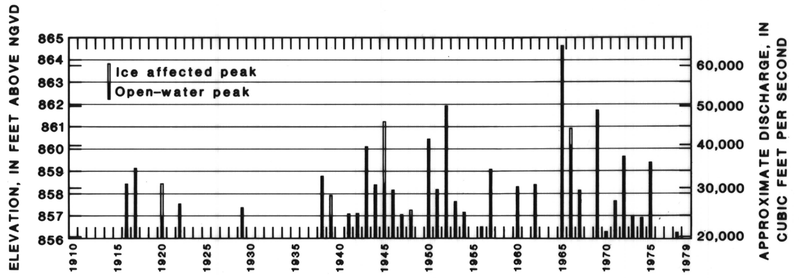

Figure 1.--Annual floods above 20,000 cubic feet per second, Mississippi River at Elk River, Minn., 1916-78

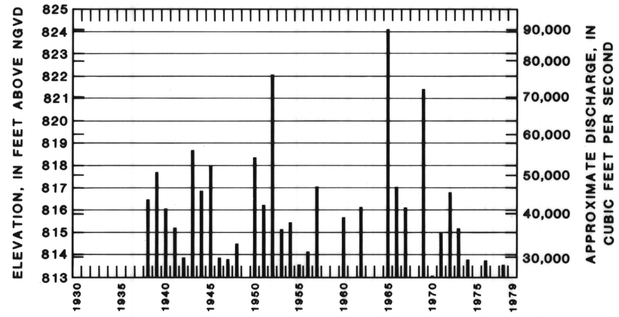

Figure 2.--Annual floods above 25,000 cubic feet per second, Mississippi River near Anoka, Minn., 1931-78

REGIONAL AND 500-YEAR FLOODS

Minnesota's Flood-Plain Management Act (Minnesota Statues, Chapter 104) provides that the regional (100-year) flood shall serve as a basis for delineation of the minimum limits of the flood plains for regulatory purposes. Thus, the regional flood becomes a prime controlling factor in defining the areas for which land-use controls are required. Also when sufficient technical information is available to estimate the magnitude of floods larger than the regional flood, the information is to be made available for use by the public. Thus, profiles and approximate boundaries of the 100- and 500-year floods have been included in this report.

DISCHARGE-FREQUENCY RELATIONS

Streamflow data collected at the two gaging stations provide the basis for defining the 100- and 500-year floods. A statistical analysis of annual maximum flood discharges resulted in a frequency curve from which recurrence intervals were determined. Recurrence intervals of flood flows at the two gaging stations are shown in figure 3. Estimates of the regional flood discharges in the study reach are listed in table 2. Discharges upstream and downstream from major tributaries were obtained by adjusting discharge estimates from the gaging station frequency curves on the basis of drainage area. Estimates of regional flood discharges have been coordinated with those determined by the U.S. Army Corps of Engineers.

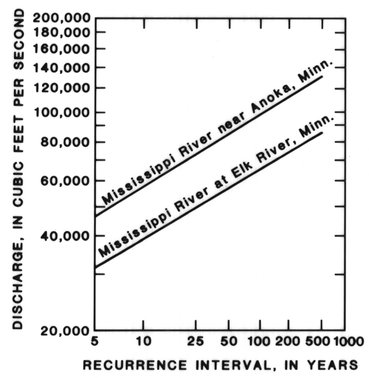

Figure 3.--Frequency of flood discharges, Mississippi River at Elk River and at Anoka, Minn.

Table 2 – Mississippi River regional flood discharge estimates

Reach location	Drainage Area (mi^2)	Discharge (ft^3/s)
Mile 888.0 to the Elk River	13,800	61,000
Elk River to the Crow River	14,500	66,000
Crow River to the Rum River	17,300	85,500
Downstream from the Rum River	18,900	98,000
At mile 866.8	19,000	98,000

ELEVATION-FREQUENCY RELATIONS

Elevation-discharge relations derived from streamflow data collected at Elk River, Minn., were used to convert the discharge-frequency relation into an elevation-frequency curve. Because of the history of ice jams in that vicinity, an independent elevation-frequency analysis was also made using the annual peak gage-height record. This analysis indicated that backwater from ice does not have a significant or well-defined effect on floods equal to or greater than the regional flood at Elk River, Minn.; therefore, the elevation-frequency relation derived from flow-frequency was used. An elevation-frequency curve, based on computed water-surface profiles, was defined for the Mississippi River at the Anoka Sewage Disposal Plant located at the mouth of the Rum River. Flood elevations of the Mississippi River corresponding to selected recurrence intervals at Elk River, Minn., and at the Anoka Sewage Disposal Plant can be obtained from figures 4 and 5, respectively. The curves are based on channel and flood-plain conditions existing in 1973. No significant changes in the channel or effective conveyance area of the flood plain have taken place to this date (1973-79).

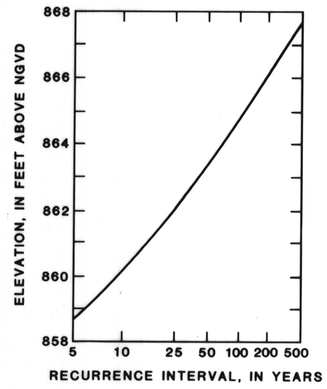

Figure 4.--Frequency of flood elevations on the Mississippi River at Elk River, Minn.

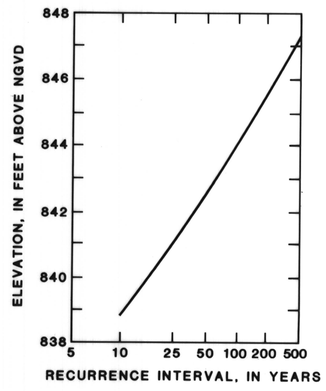

Figure 5.--Frequency of flood elevations on the Mississippi River at Anoka, Minn.

FLOOD-PLAIN AREAS OF THE MISSISSIPPI RIVER, MILE 866.8 to MILE 888.0

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