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SIXTEEN YEAR STUDY OF MINNESOTA FLASH FLOODS



January 1988

**Minnesota Department of Natural Resources
Division of Waters
State Climatology Office
and
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Soil Science Department**

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AUTHORS:

Earl L. Kuehnast, is the former State Climatologist, Department of Natural Resources, St. Paul; James A. Zandlo is the current State Climatologist, Department of Natural Resources, St. Paul; Donald G. Baker is a professor in the Department of Soil Science, University of Minnesota, St. Paul.

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MINNESOTA FLASH FLOOD INDEX BEGINNING 1970

Storm No.	Year Day of Flood	Location/Information Data	
1	1970 May 27	Goodhue-Dakota-Wabasha Counties	11
2	1971 June 10-11	Renville & Nicollet Counties	12
3	1972 June 7-8	Madelia, Watonwan & 2 Counties	13
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8	1974 June 20-21	Southeast Minnesota, 5 Counties	21
9	1974 Jul 24	Millville, Wabasha County	22
10	1975 June 20-21	Hector, Renville County	23
11	1975 June 28-30	Clay County & 6 Counties & North Dakota	24
12	1975 Jul 1-2	Northwest Minnesota, 7 Counties	25
13	1975 Jul 4-5	Whitewater River, 3 Counties	26
14	1977 Aug 30-31	Twin Cities, 5 & Wisconsin Counties	27
15	1977 Sep 8-9	Pigeon River, Cook County	30
16	1977 Sep 24-25	Lake-Cook Counties	31
17	1977 Sep 30	Worthington 3 Counties & Iowa	32
18	1978 June 14	Albert Lea, Freeborn County	33
19	1978 June 30-Jul 1	Northern Ramsey County	34
20	1978 Jun 30-Jul 1	Northern Goodhue County	36
21	1978 Jun 30-July 1	Goodhue-Wabasha Counties	36
22	1978 June 30-Jul 1	Winona County	36
23	1978 June 30-July 1	Fillmore-Houston Counties	36
24	1978 Jul 5-6	Rochester-I, 3 Counties	37
25	1978 Jul 6-7	Stearns-Benson Counties	38
26	1978 July 16-17	Austin, Mower County	39
27	1978 Aug 22-23	Lake Itasca-Duluth, 5 Counties	40
28	1978 Aug 26-27	McLeod-Wright-Carver Counties	41
29	1978 Aug 26-27	So. St. Paul, Dakota County	42
30	1978 Sep 12	Rochester-II, 4 Counties & Wisconsin	43
31	1979 Jun 16	Chippewa-Swift Counties	44
32	1979 June 16	Rockville, Stearns County	45
33	1979 Jul 2-3	St. Louis-Itasca Counties	47
34	1979 Jul 30	Red Lake-Polk-Clearwater Counties	48
35	1979 Aug 20-21	Martin County & Iowa	49
36	1980 May 29-30	Fillmore-Mower-Winona Counties & Wisconsin	50
37	1980 Aug 29	Red Lake Falls-Baudette, 4 Counties	51
38	1980 Sep 3	North Aitkin-Cass Counties	52
39	1980 Sep 20	Fillmore-Winona & Wisconsin	53

MINNESOTA FLASH FLOOD INDEX BEGINNING 1970 (Cont'd)

Storm No.	Year Day of Flood	Location/Information Data	
40.....	1981 May 22.....	Clay-Norman Counties.....	54
41.....	1981 May 23.....	Milan, Chippewa-Swift Counties.....	55
42.....	1981 Jul 11.....	Rochester-III, 3 Counties.....	56
43.....	1981 Jul 11.....	Preston & 3 & Wisconsin.....	56
44.....	1981 Aug 25-26.....	Geneva, Freeborn-Steele Counties.....	57
45.....	1982 Jul 15.....	Warroad, Lake of the Woods County & Canada.....	58
46.....	1983 May 6-7.....	Lyon County.....	59
47.....	1983 Jun 21.....	Meeker & 4 Counties.....	60
48.....	1983 June 25-26.....	Benton-Stearns-Sherburne Counties.....	61
49.....	1983 Jun 30-Jul 1.....	Waseca-Steele-Dodge Counties.....	62
50.....	1983 Jul 2-3.....	Park Rapids & Counties.....	63
51.....	1983 Aug 20-21.....	Thief River Falls & 4 Counties.....	64
52.....	1983 Aug 25.....	LeSueur-Rice Counties.....	65
53.....	1985 Jun 25-26.....	Kittson-Roseau Counties.....	66
54.....	1985 Jul 17-18.....	Hubbard-Cass-Crow Wing Counties.....	67
55.....	1985 Jul 17-18.....	Wilkin-Ottertail Counties.....	68
56.....	1985 Sep 2-3.....	Carlton-Pine-Aitkin Counties.....	69
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58.....	1987 July 23-24.....	Western and South Central Twin Cities.....	71
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1. INTRODUCTION

This study provides climatological data and facts on 16 years of flash floods in Minnesota that occurred from 1970 through 1985. The information is based on 57 flash floods and includes data on their areal extent, maximum rainfall amounts, orientation, time of occurrence, probability of occurrence, and precipitation network history.

The definition of a flash flood as used here is the occurrence of 6-inches or more rainfall within a 24-hour period. The size of a flash flood is the measured area in square miles over which a 4-inch or more rainfall occurs. The rationale for using these two criteria is that a rainfall of six inches in a 24-hour period is near the 100-year return period in Minnesota and, second, a 4-inch and greater rainfall approximates the level at which newspaper reports indicate increased erosion or other economic damages are associated.

2. HISTORY

Documentation of flash floods across Minnesota prior to 1970 was made only for the most damaging floods. In the first 8 years of this study, 1970-1977, only the larger and more damaging storms could be documented, since the smaller flash floods passed between the rain gage network and could not be identified. During the last 8 years, 1978-1985, all flash floods as defined above are believed to be documented as a result of a marked increase in gage distribution and density. The documentation consists of collecting as many rainfall reports as possible from the raingage network. From these preliminary network reports a general outline of the flash flood is made from plotted data. The next step is to obtain reports from residents living near the 'core' of the flash flood (use of telephone is the most efficient method). Identification of the 'core' of the flash flood is most important. Unless a dense and well distributed rainfall network is available, few flash flood analyses can be made, since most can not be adequately identified. Case in point: the May 27-28, 1970, flash flood in Goodhue and Wabasha Counties in which extreme rainfall amounts failed to be observed by a formal rain gage network, but were found by a 'bucket survey' (see Minnesota Climatological Data for May, 1970, published by the National Climatic Data Center, Asheville, North Carolina). A 'bucket survey' is accomplished by direct contact with individuals, generally farmers, who measured the rainfall amounts using a gage or an estimate from pails or buckets left out of doors and which can serve as proxy gages. Analysis by bucket survey was the practice in Minnesota prior to 1971 and was generally made only when lives were lost or great economic damage occurred. Bucket surveys of the past were made mostly by National Weather Service personnel traveling from location to location, a costly and time consuming effort.

Minnesota has a history of establishing raingage networks in the metro Twin Cities area as well as statewide. To date there are 10 different precipitation networks operating in parts of the State. In addition to the statewide National Weather Service Cooperative Network two additional statewide networks have been established: the Future Farmers of America (FFA) in 1971 and the Soil and Water Conservation District (SWCD) in 1977 and 1978. The FFA network was established within school districts and is operated by high school students. Because the FFA network was spatially dense, it has done a good job in identifying flash floods occurring within the school districts and has proved to be a very rapid and efficient mechanism for acquiring rainfall data for flash floods. The FFA rain gage network has largely given way to the Soil and Water Conservation Districts (SWCD) precipitation network, which was established for climatological

data as well as operational use as, for example, flash floods. The network was initiated in 1977 and 1978 with an observer located, with some exceptions, every 12 miles across the state. The observations are taken on a 'year-round' basis. A reason for documenting all flash floods only in the last 8 years was that prior to this time there was a lack of data across the state. However, with the establishment of a statewide Soil and Water Conservation District precipitation network with rain gages every 12 miles beginning in 1977, adequate data to identify nearly all flash floods as defined above became available. An exception exists in part of north central and northeastern Minnesota where there is a lack of rain gages because of the sparse population. Presently, the SWCD network with 8 complete years of data together with data from 9 other networks provides the state of Minnesota with a most complete long term, well distributed, high density and large data set. It is unique for a state as a whole and something no other mid-west state can boast. The location of the reporting stations in the current Minnesota networks is shown in Figure 1.

a. GAGE DENSITY

Gage distribution from the SWCD network is nearly ideal. However, the distribution (as noted in Figure 1) shows areas which could be improved. The SWCD network began in 1977-78, and since then some counties have added observers, yet there are a few counties that have lost observers over time. Networks within the seven-county Twin Cities area give a gage density of one gage per 15 square miles, which is approximately 6 times that in the outstate area. However, there remains a need for observers in the business and industrial areas of the two cities. The State Forestry District and Deep Portage networks have provided additional coverage in the northern and central parts of the state.

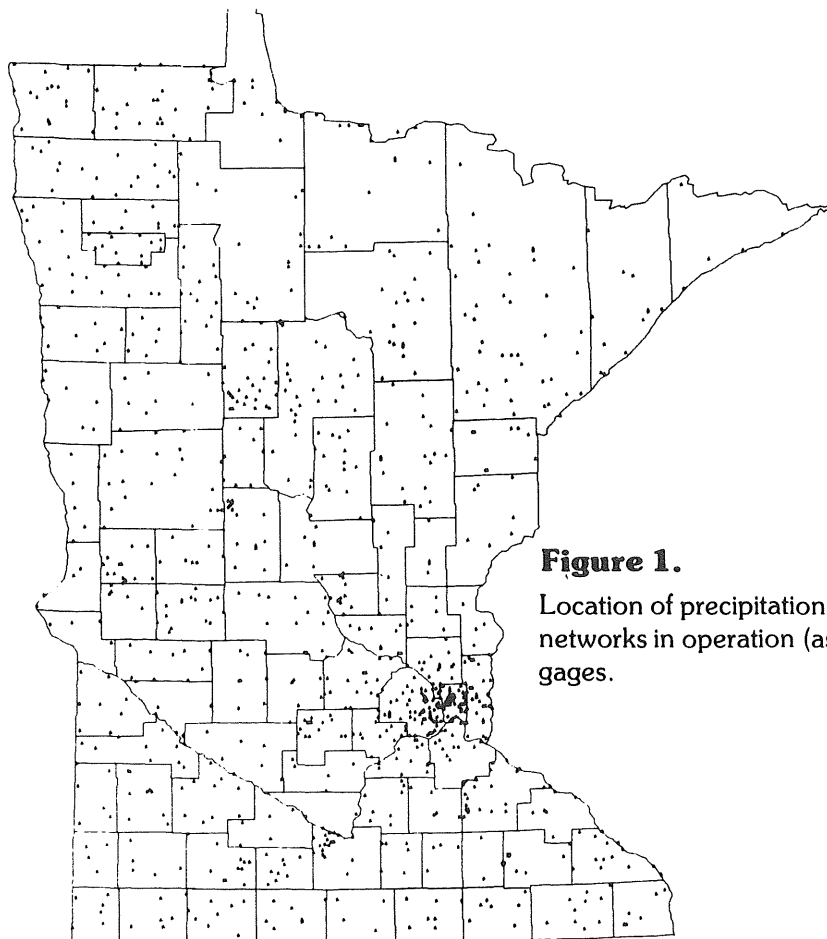


Figure 1.

Location of precipitation reporting stations in Minnesota. The ten networks in operation (as of July 1985), have a total of 1062 gages.

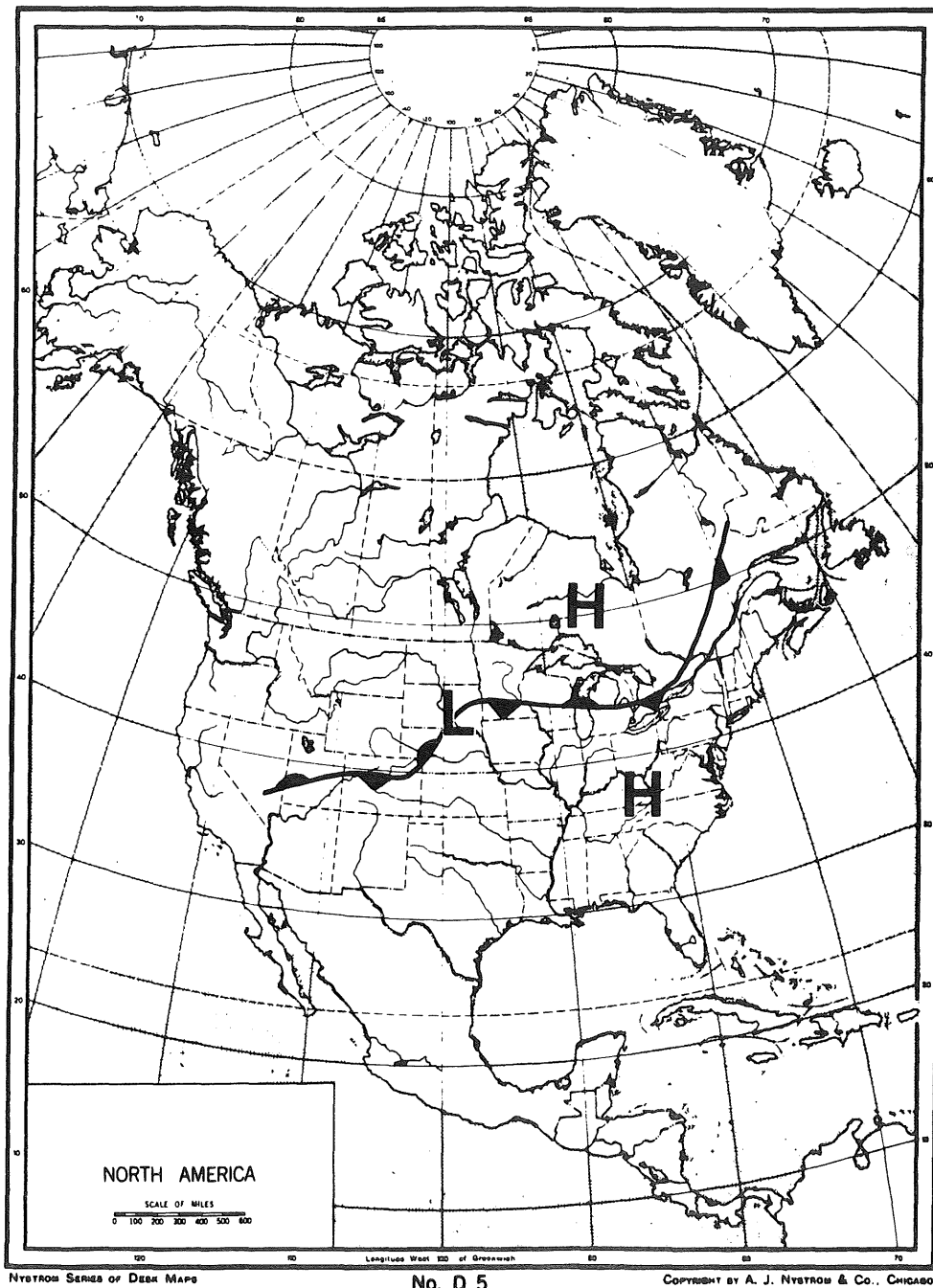


Figure 2. Basic surface synoptic weather pattern associated with Minnesota flash floods.

3. WEATHER PATTERNS ASSOCIATED WITH FLASH FLOODS

Weather patterns associated with flash floods show a number of similarities. When looking at the weather patterns at the surface and the upper atmosphere, specific combinations of patterns of the two exist for many Minnesota flash floods.

The basic surface pattern places a low pressure center or a wave in the Dakota's, with a cold front extending to the southwest of the low and a stationary front extending east or southeast across Minnesota where it separates two high pressure systems as illustrated in Figure 2. The two highs may cover the area from the Carolina's north to Hudson Bay. The location of the southern high pressure system is such that very moist Gulf of Mexico air is drawn northward into the stationary front across Minnesota. The low pressure system will generally remain in the Dakota's or move slowly eastward.

The basic upper air pattern shows a 500 millibar (18,000 foot level) upper air trough located in the Rockies or farther west with a high pressure ridge or center that can be located anywhere from Kansas to the Carolina's (Figure 3). It was noted that on the days of flash floods a weak ridging generally occurred over Minnesota. This upper air pattern shows flow from the southwest extending from the Rockies to the Dakota's with a somewhat weaker southwest upper air flow over Minnesota. The basic ingredients for flash floods in Minnesota therefore are: a southwesterly flow aloft with a good southerly surface gulf flow (providing the moisture) and a slow moving to nearly stagnant system (resulting in large concentrated precipitation amounts).

The weather pattern described above means energy from the slowing down of the moderate southwest flow as it moves over Minnesota can be transformed into convective activity or thunderstorms. With thunderstorms over the stationary front which is receiving very moist gulf air, flash floods can be expected to occur as long as this surface and upper air combination exists.

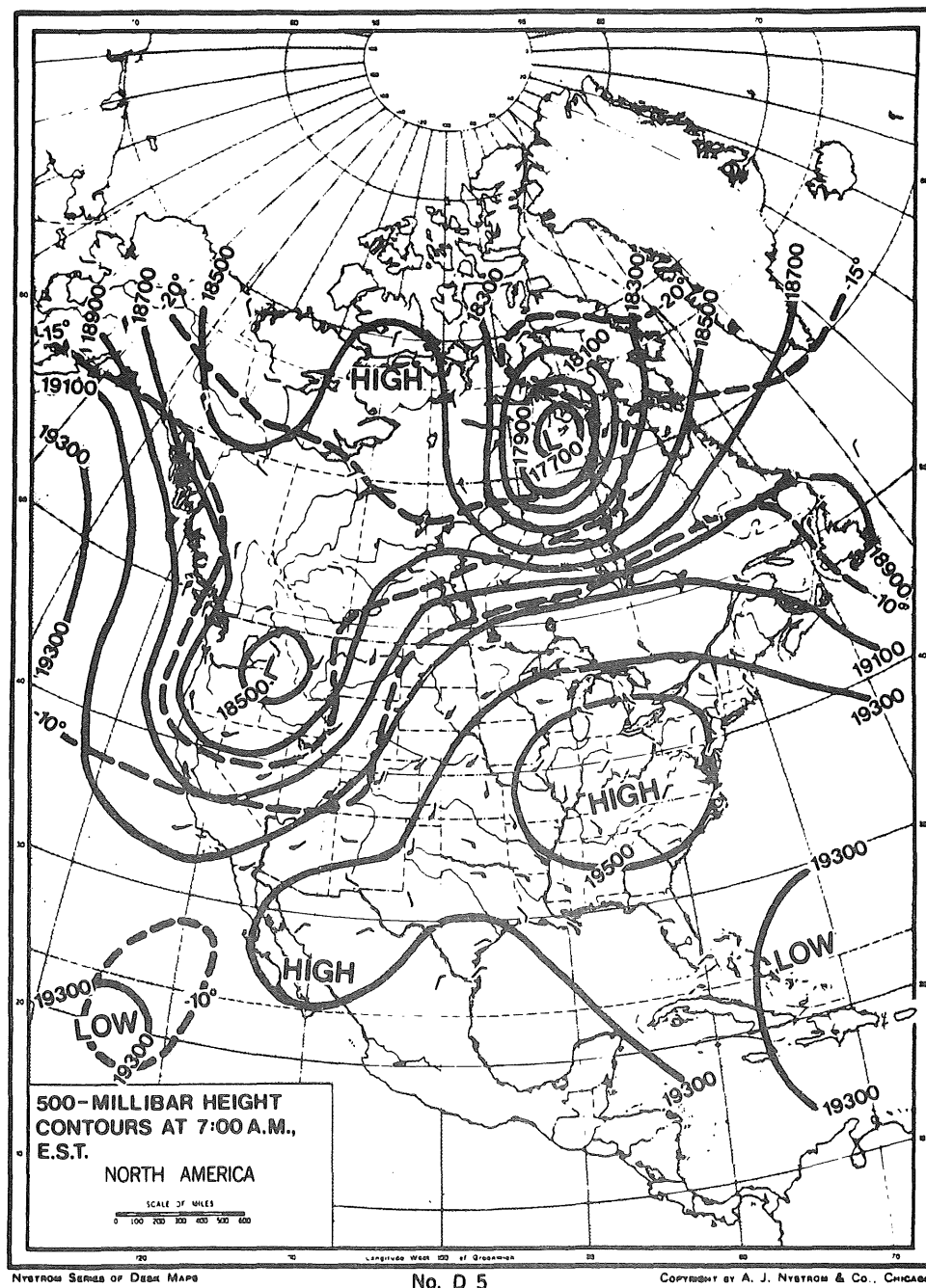


Figure 3. Basic upper air pattern associated with Minnesota flash floods.

4. TEMPORAL DISTRIBUTION

A. ANNUAL DISTRIBUTION OF FLASH FLOODS

All flash floods are believed to have been recognized and recorded in the last eight years, 1978 through 1985, which is the period the high density SWCD precipitation network has been in operation. Analysis of the last 16 years showed that there is no significant difference in the number of flash floods in the northern, the central, and the southern parts of the state.

If the last eight years are used to estimate annual averages we could expect for the state as a whole (Table 1): five flash floods annually or four flash flood-days annually.

Table 1. Annual Distribution of Flash Floods

<u>YEAR</u>	<u>NUMBER RECORDED</u>	<u>FLASH FLOOD DAYS</u>
1970	1	
1971	1	
1972	5	
1973	0	
1974	2	
1975	4	
1976	0	
1977	4	
Total 1970-77	17	
1978	13	8
1979	5	4
1980	4	4
1981	5	4
1982	1	1
1983	7	7
1984	0	0
1985	5	4
Total 1978-85	40	32 days
Average	5	4 days

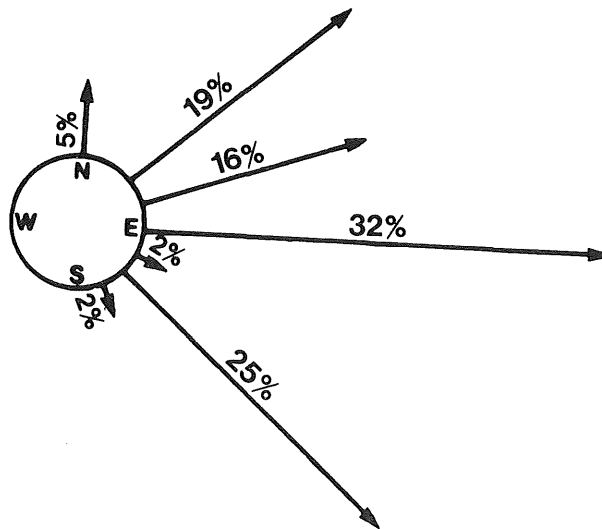
b. MONTHLY DISTRIBUTION OF FLASH FLOODS, 1970 — 1985

The monthly distribution of flash floods shows June with the greatest number with 17 or 30% of the annual total (Table 2). July is a close second with 16 or 28% of the total. The earliest flash flood occurred on May 6-7, 1983, in Lyon County and the latest on September 30, 1977, in Worthington, Nobles County. The most flash floods to occur in a 24-hour period was on June 30-July 1, 1978, when five separate flash flood cells evolved out of a huge complex storm extending from the Twin Cities southeast to the Iowa border. The median date of the flash flood season is July 11. This is not far from the warmest day of the year which, on the average, is July 23.

Table 2. Monthly distribution of Flash Floods 1970-1985

<u>Month</u>	<u>Number of Flash Floods</u>	<u>Percent of Flash Floods</u>
April	0	0%
May	5	9%
June	17	30%
July	16	28%
August	10	17%
September	9	16%
October	0	0%
Total	57	100%

Figure 4. Orientation of Flash Floods.



c. TIME OF DAY FLASH FLOODS COMMENCE 1970-1985

Analysis of 51 flash floods shows that 37% of them began between 6 PM and 8PM and over 50% began in the evening between 6PM to 11PM (Table 3). From midnight through 7AM some 27% of the flash floods begin. As a rule during the midnight to 7AM period the rains are generally of higher intensity but a shorter time frame. We are unable to offer a reason at this time, but more rapid cooling of the upper surface of thunderstorms during night hours (causing greater instability) and lesser winds may be a plausible explanation. The beginning times of the flash floods were acquired from both telephone contact with the observers, usually the day after the storm, and from the "Remarks Section" of the monthly report form each observer sends to the State Climatoloty Office.

For a typical mass curve of a flash flood (weighing rain gage chart), see Appendix for the June 30-July 1, 1978, storm. The curve on the chart shows the amount and time of occurrence.

**Table 3. Time of day Flash Floods Begin
1970-85**

<u>HOUR OF THE DAY</u>	<u>NUMBER OF FLASH FLOODS</u>
Midnight	2
01	
AM	2
02	2
03	3
04	0
05	2
06	0
07	3
08	0
09	0
10	3
11	1
Noon	0
01	
PM	1
02	2
03	2
04	2
05	0
06	13
07	6
08	4
09	1
10	0
11	2
TOTAL	51

5. AREAL DISTRIBUTION

a. ORIENTATION OF FLASH FLOODS

The orientation of flash floods, which is based on the surface rainfall isohyet maps, shows that the west to east rain storms number approximately one-third of the total (Table 4). The orientation of the flash floods, in general, shows where the stationary front is located. The bracketed section of Table 4 represents the orientation of two-thirds of the flash floods apparently take, while the single orientation, northwest through southeast represents, 25 percent. Analysis shows no significant orientation preference statewide, except that storms moving from the NW showed a slight increase in the southern part of the state. (See Figure 4).

Table 4. Flash Flood Orientation

<u>Direction</u>	<u>Number</u>	<u>Percent</u>
S to N	3	5%
SSW to NNE	0	0%
(SW to NE	11	19%)
(WSW to ENE	9	16%)
(W to E	18	32%)
WNW to ESE	1	2%
NW to SE	14	25%
NNW to SSE	1	2%
TOTAL	57	

b. SHAPES — “CIGAR” AND “OBLONG”

The shapes or outline designs of flash floods were grouped into two general shapes: “cigar” shape, when the length to width ratio was more than four to one, and an “oblong” shape, when the length to width ratio was less than four to one. About two-thirds of all flash floods were “cigar” shaped and one-third were “oblong”. The median dimensions were a 14-mile width and a 75-mile length for the “cigar” shape, and a 11-mile width and a 27-mile length for the “oblong” shape. Further investigation showed that the “oblong” shapes were on the average considerable smaller of the two, and they showed a poorer definition in a map analysis because of generally fewer rainfall observations as a whole. This may mean that some of the “oblong” shapes would show a “cigar” shape if more observations were available.

The areal distribution or rainfall pattern of flash floods result from slow moving moisture-laden thunderstorm cells. If a thunderstorm cell remained stationary a circular pattern would probably occur. Oblong shapes usually arise from very slow moving cells, while cigar shaped floods can occur from either slow moving cells of longer duration or several cells moving along the same path. An average cigar shaped flood is about 75 miles long and most of the rain falls in 3 to 9 hours. With a mean rainfall of 6 hours in duration and a cell length of 75 miles, a cell movement of about 12 mph is indicated.

c. AREA COVERED BY FLASH FLOOD EVENTS

The "area" referred to is that part of the flash flood covered by 4 inches or more of rain. The range in the area of the flash floods within this study is 25 square miles to 6800 square miles. The median size is approximately 600 square miles. The Rochester flash flood on July 5-6, 1978, is considered a typical flash flood. (see Appendix).

The four largest flash floods by area are listed in Table 5, and they occurred in the same period as the warmest summer temperatures that extend from June 21 to August 21 at Minneapolis-St. Paul Airport, with temperatures 70 degrees Fahrenheit and greater. Fifty-six percent of the flash floods occur at this time.

Table 5. The four largest "area" flash floods, 1970-85.

	<u>Date</u>	<u>Area in Square Miles</u>	<u>Location</u>
1	July 21-22, 1972	6800	Alexandria east into Wisconsin
2	June 28-29, 1975	6000	Southwest of Fargo to northeast of Fargo into Clay County, MN
3	July 1-2, 1975	4500	Kittson county southeast thru lower Beltrami county
4	August 22-23, 1978	4100	Lake Itasca to Duluth

6. MAXIMUM PRECIPITATION AMOUNT FOR FLASH FLOODS

The maximum rainfall amount known and recorded for each of the flash floods show a range from 6 inches to 14 inches (6-inches and greater for a 24-hour period is the definition of a flash flood). The median or the expected rainfall maximum amount for any "flash flood" is 7.2 inches. The larger rainfall amount flash floods occurred between June 21 and July 29 (Table 6). This is near the warmest day of the summer season. (July 23). The largest rainfall amount in a flash flood occurred on July 21-22, 1972.

Table 6. The four largest rainfall amounts of 57 flash floods.

	<u>Date</u>	<u>Area</u>	<u>Location of Greatest Amount</u>
1st	July 21-22, 1972	14.00 inches	10 miles southwest of Little Falls
2nd	July 28-29, 1975	13.00 inches	Northeast of Fargo near Ulen
3rd	June 21, 1983	12.00 inches	10 miles north of Litchfield
4th	July 11, 1981	10.04 inches	10 miles southwest of Rochester.

7. PROBABILITY OF OCCURENCE

a. FOUR-INCH RETURN PERIODS

Return periods for 4-inch or greater rainfalls associated with flash flood events have been computed from the data observed from 1978 through 1985. For the eight-year period all flash floods are considered to have been recorded. The calculation of a "4-inch rainfall area" return period based on data from this study is done here for illustrative purposes.

CALCULATION OF 4-INCH RAINFALL AREAS:

- (1. Total area of Minnesota = 84,068 square miles
- (2. Total 4-inch flash flood area in the last 8 years = 29,467 square miles.
- (3. Return Period $\frac{\text{Total Area}}{\text{Area/Year}} = \frac{84,068}{(29,469/8)} = 22.8 \text{ years}$

The U.S. Weather Bureau Technical Publication # 40 (Hershfield, D, 1961, "Rainfall Frequency Atlas of the United States", U.S. Department of Agriculture; "TP 40") shows the 10-year return period for a 24-hour rainfall across Minnesota from north to south to vary from 3.5 to 4.5 inches while the 25-year return period varies from 4 to 5 inches from north to south.

It is apparent that the 4-inch flash flood area return period of 22.8 years obtained in this study is comparable to the results in TP 40.

b. SIX — INCH RETURN PERIODS

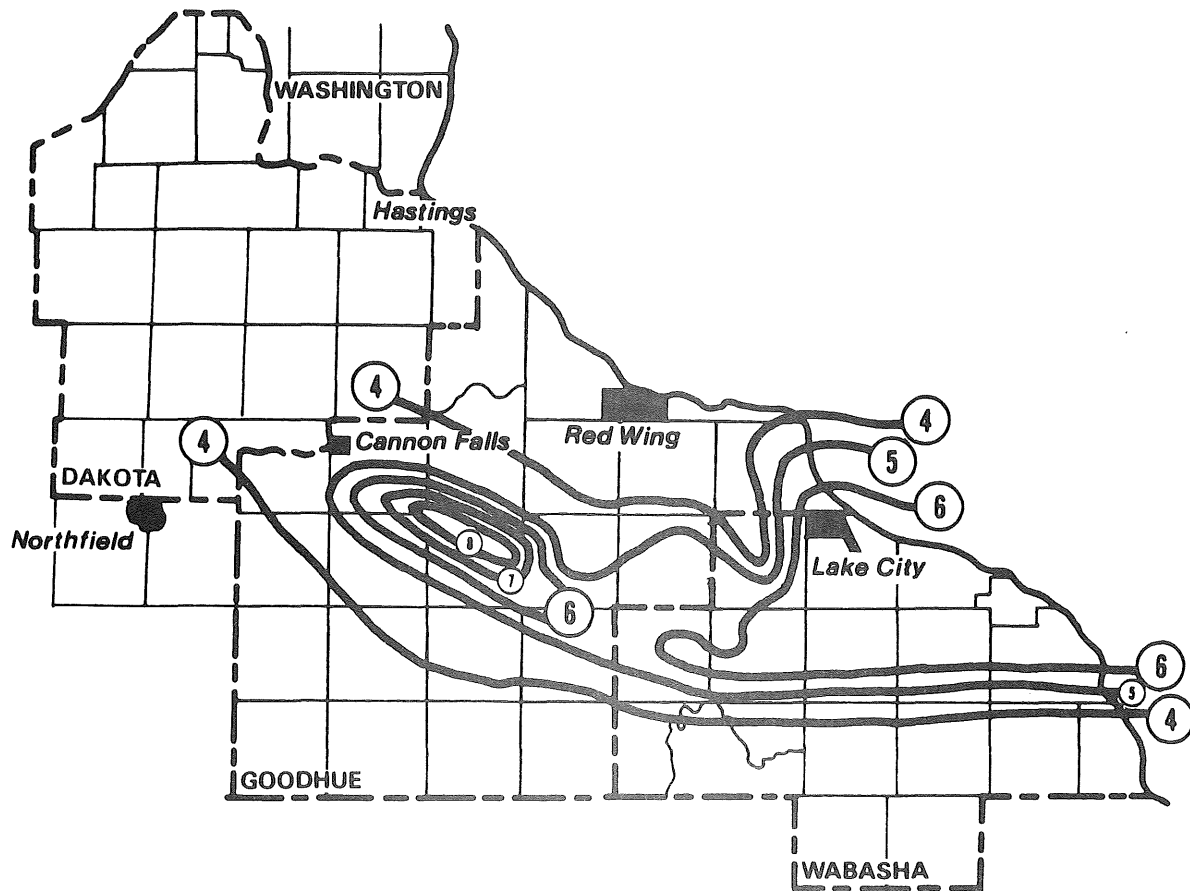
The return period for 6-inch per 24 hours rainfall has also been computed. The "6-inch rainfall areas" shown on the maps in this study were not measured for size because of a lack of 6-inch and greater observations necessary for the analysis. However, an estimate was made from a ratio of the 4-inch area to the 6-inch area from several flash floods. The ratio of the "6-inch rainfall area" compared to the larger "4-inch rainfall areas" is approximately 35 %, while for smaller "4-inch rainfall areas" the ratio is 15 %. Then using a mean of 25 % as the ratio of the "6-inch rainfall" to that of the known "4-inch rainfall area" a similar calculation for 6-inch and greater rainfall return periods was made for the last eight year period.

CALCULATION OF 6-INCH RAINFALL AREAS:

- 1.) Return Period $\frac{\text{Area}}{(\text{Area} \times \%)/\text{year}} = \frac{84,068}{(29,469 \times 25\%/8)} = 91.3 \text{ years}$

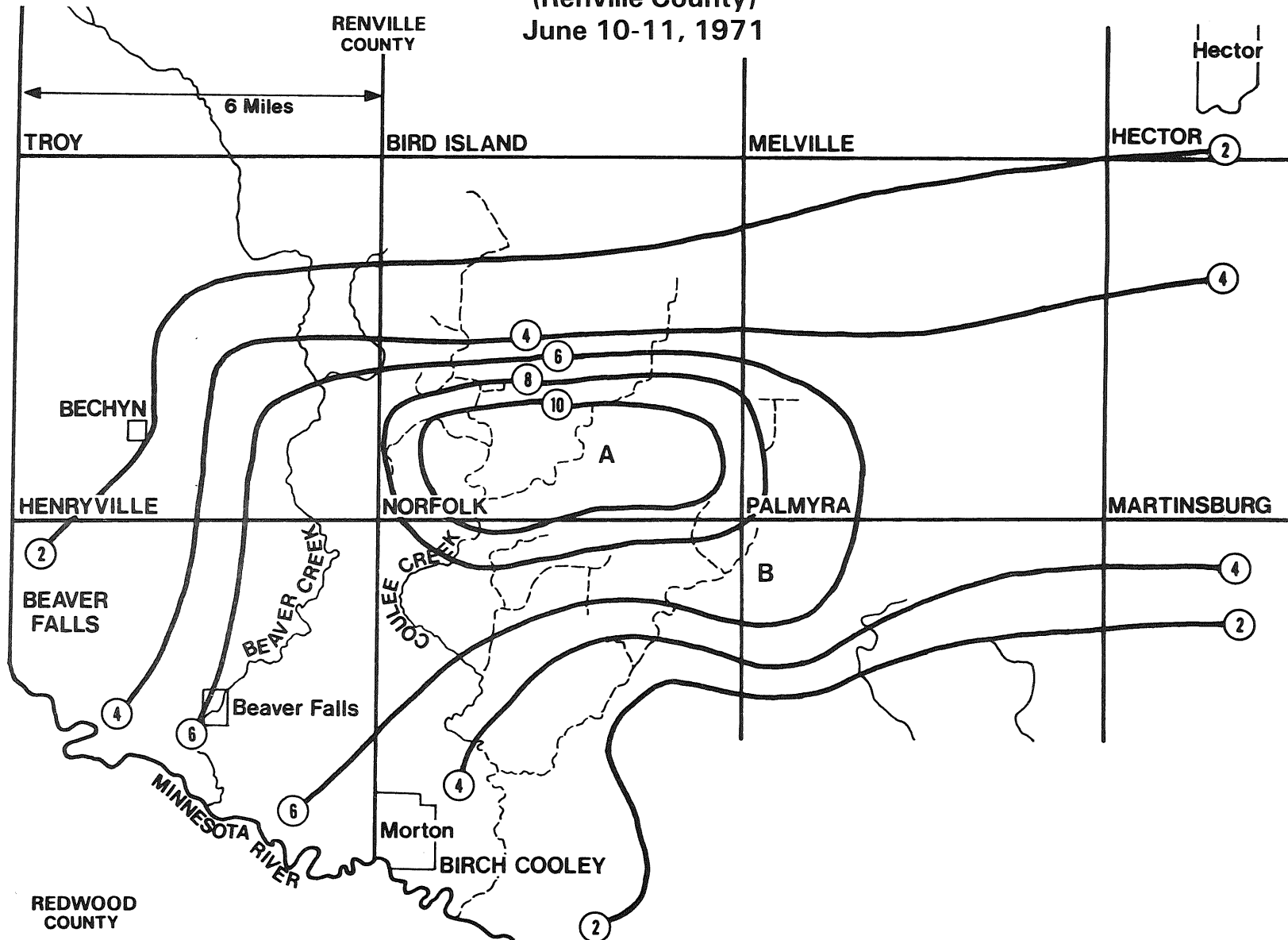
TP 40 shows the 100-year return period for 24-hour rainfall events across Minnesota from north to south to vary from 5 to 6.2 inches. The 91.3-year return period for a "6-inch rainfall area" obtained in this study is in reasonable agreement to TP 40. The similarity between the TP 40 point probabilities and the "6-inch area" probabilities shows that area frequency amounts can be substituted for point frequency amounts. As a result, the record period necessary to determine frequencies does not have to be as lengthy as normally required for point measurements.

FLASH FLOOD
(Goodhue & Wabasha Counties & Wisconsin)
May 27-28, 1970



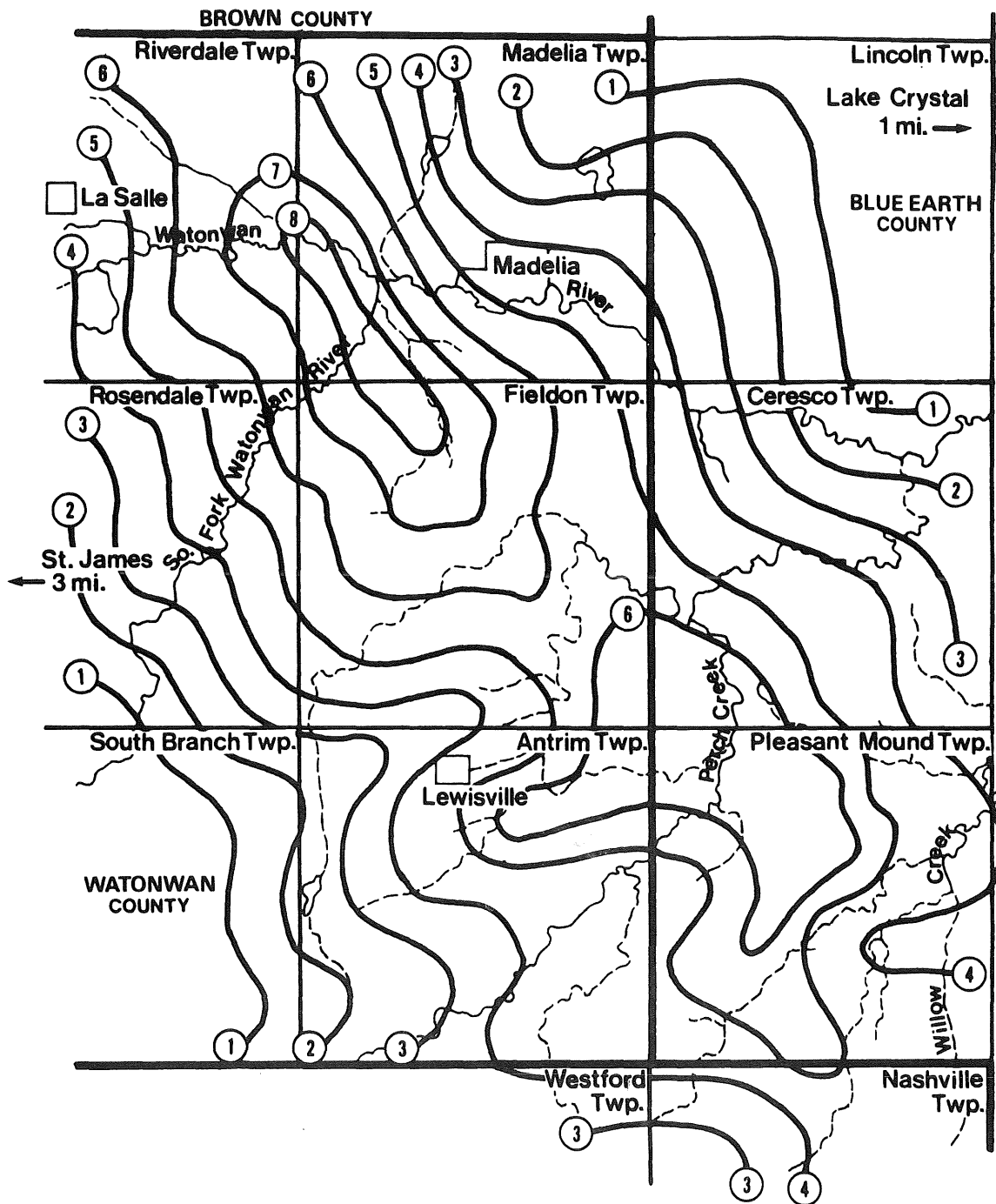
A flash flood in Goodhue-Wabasha Counties and into Wisconsin began about 4:30 PM May 27, 1970 and ended during the early morning hours on May 28. The greatest amount reported was 8.5 inches about 3 miles southeast of the small town of White Rock in Goodhue County. The area covered by 4 inches and greater was 720 square miles in Minnesota and about 280 square miles in Wisconsin. The flash flood caused 3 deaths, all from drowning.

FLASH FLOOD (Renville County) June 10-11, 1971



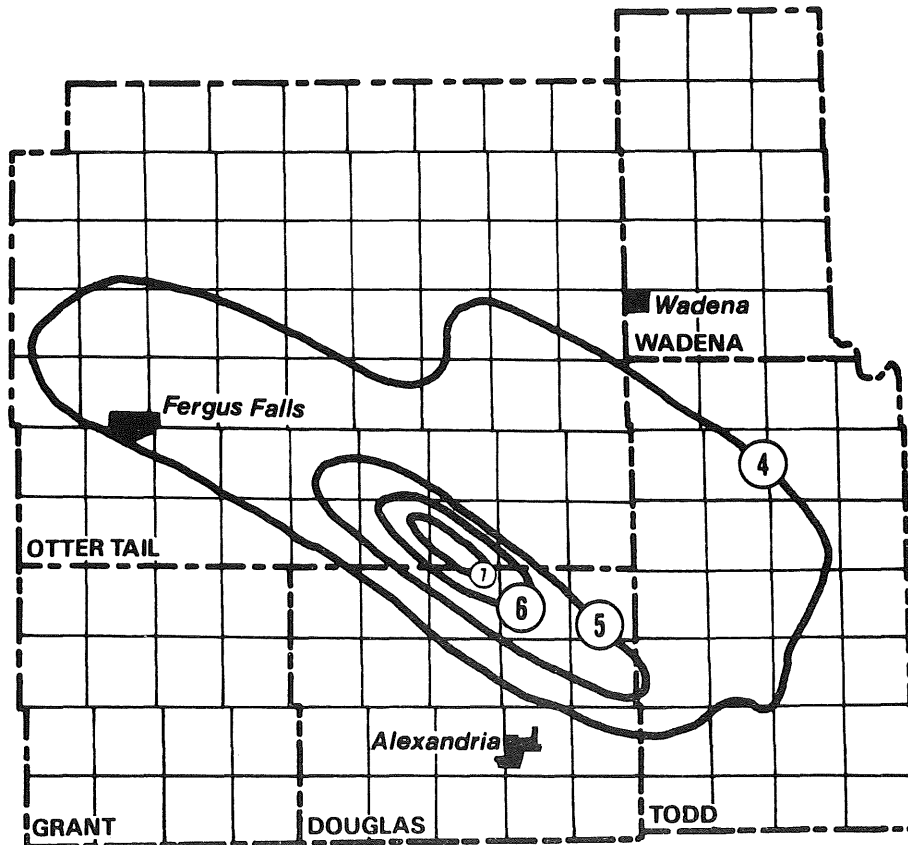
The heavy rains began about mid-afternoon on the 10th and continued into the early morning hours on the 11th. The greatest amount recorded was 10.3 inches. However, one observer noted a 13-inch tall paint can was full. The area covered by the 4-inch or more rainfalls was 140 square miles.

PRECIPITATION — SOUTHCENTRAL MN
June 7-8, 1972



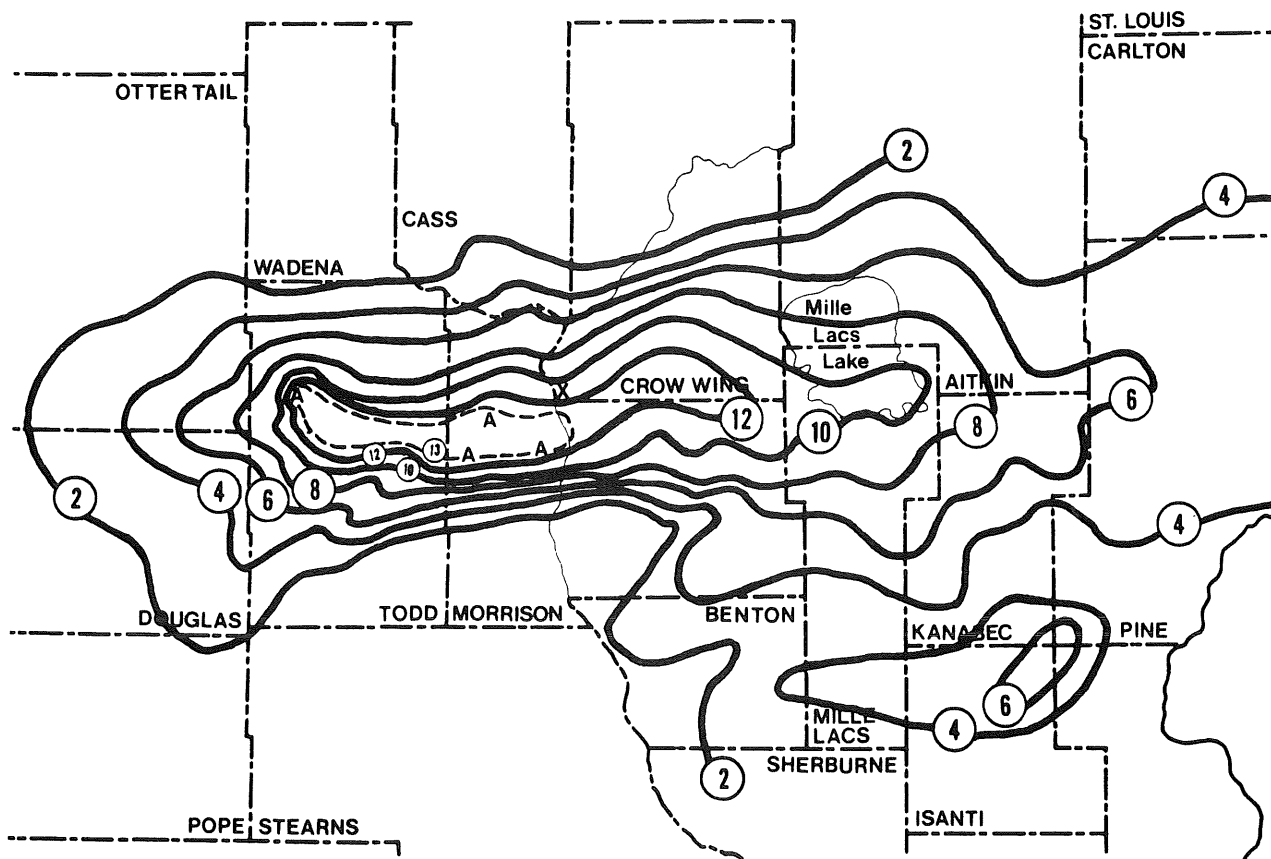
This map depicts the very heavy rainfalls, 5 to 8 inches, which occurred in southcentral Minnesota from about 8:00 PM on the 7th until 3:00 AM on the 8th. However, the 3-inch or more rainfall that caused flood damage across the area started just east of Sleepy Eye and extended south-southeast through Elmore into northern Iowa and generally on a line 10 miles wide. See the June 1972 Storm Data for Minnesota for damage.

FLASH FLOOD
(Ottertail, Douglas, & Todd Counties)
July 11-12, 1972



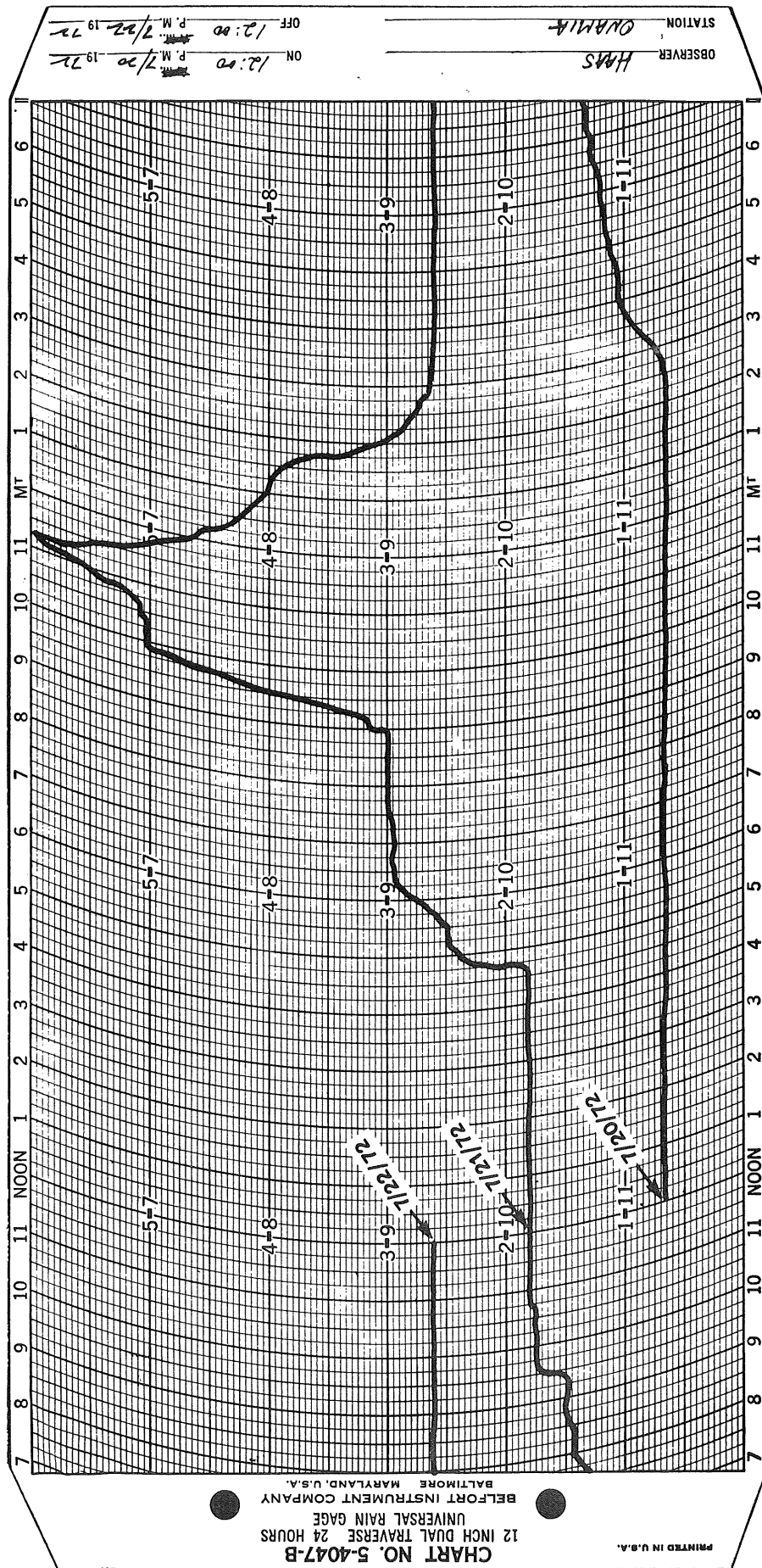
Flash flood rains began about 7 PM on July 11, 1972 and ended about 1:30 AM on the 12th. The greatest amount recorded was 7.5 inches, 4 miles north of Urbank. The area covered by 4-inch rains and greater was 1,250 square miles.

"GRAND DADDY" OF FLASH FLOODS
(Little Falls)
July 21-22, 1972



MOST DAMAGING FLASH FLOOD IN MINNESOTA'S
HISTORY: July 21st-22nd, 1972

The worst flash flood in Minnesota's history to date started about mid-afternoon on the 21st, in the west along the Otter Tail and Douglas County line and ended about daylight on the 22nd, south of Duluth along the Minnesota-Wisconsin Border. The rains fell generally in an 8 to 10-hour period at any one point. This flood caused the greatest monetary losses ever experienced in the State for a flash flood and also had the greatest 24-hour official rainfall amount ever recorded in Minnesota. Flood damages were estimated at \$20,000,000. The 24-hour rainfall at Fort Ripley was 10.84 inches, exceeding the previous all-time 24-hour rainfall for Minnesota of 10.75 inches on July 20, 1909 (at Beaulieu in Mahanomen County). The isohyet map was analyzed from 245 reports: 15 National Weather Service Cooperative Stations, 15 county civil defense officers' reports and about 210 reports from the Future Farmers of America Rainfall Project, a program organized by the State Education Department and operated by the high school agricultural instructors. These reports make this the most documented heavy rain-storm in the state's history.

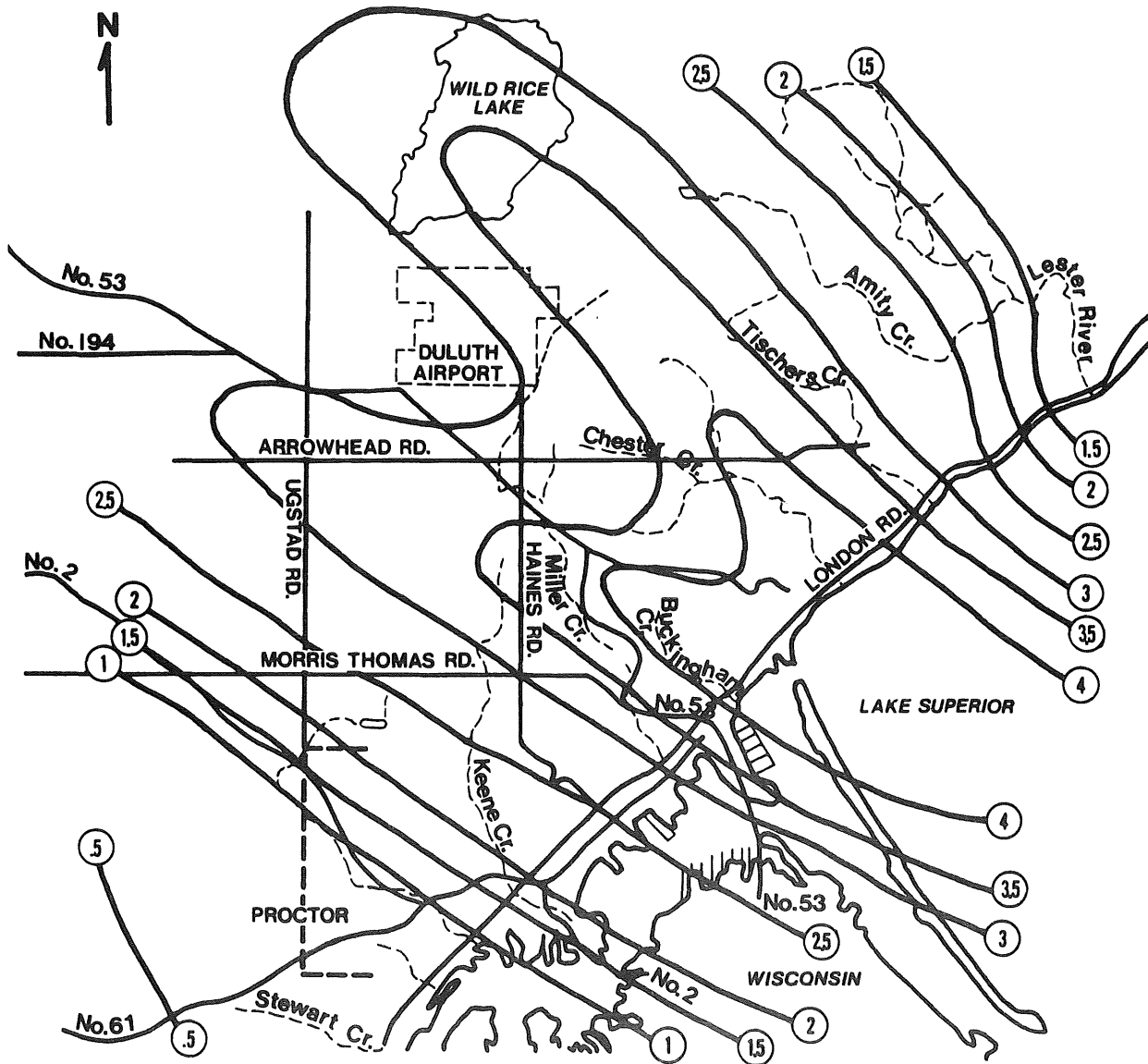


The eastern part of the rainfall area is spread out because during the latter part of the day (on the 22nd) additional heavy rainfalls occurred. Thus it was difficult to separate the two storms from each other. An interesting feature on the isohyet map in Morrison County is to compare the distance from 2" to 13" isohyet lines of the southern edge of the storm to the northern edge. The distance on the south is narrow and about $1/2$ that of the north, indicating a sharper edge to the storm on the south. The isohyet map shows the NWS Cooperative Weather Station at Fort Ripley (about 5 miles to the north of the center line of the intense part of the storm) which had in excess of 13 inches of rainfall. The 13-inch or more isohyet line was analyzed from 4 unofficial reports plus several "guess estimates". (The 13-inch locations are noted by "A") The storm probably covered a larger area of heavy rainfall than any other known storm to date in Minnesota. The 8-inch or greater rainfall started at Otter Tail, Douglas and Todd tri-county intersection and extended 90 miles east across Mille Lacs Lake. It averaged about 16 miles in width and the area measured was nearly 1,500 square miles.

Timely weather reports and forecasting coupled with fast action from local, county and state law enforcement and civil defense agencies saved many people from the hundreds of road washouts across the heavy rainfall area. Only one person drowned as he drove his car into a road washout. Every major highway was closed east of Alexandria to the Wisconsin Border, generally, from 3 to 16 days except Interstate 35 between Duluth and the Twin Cities.

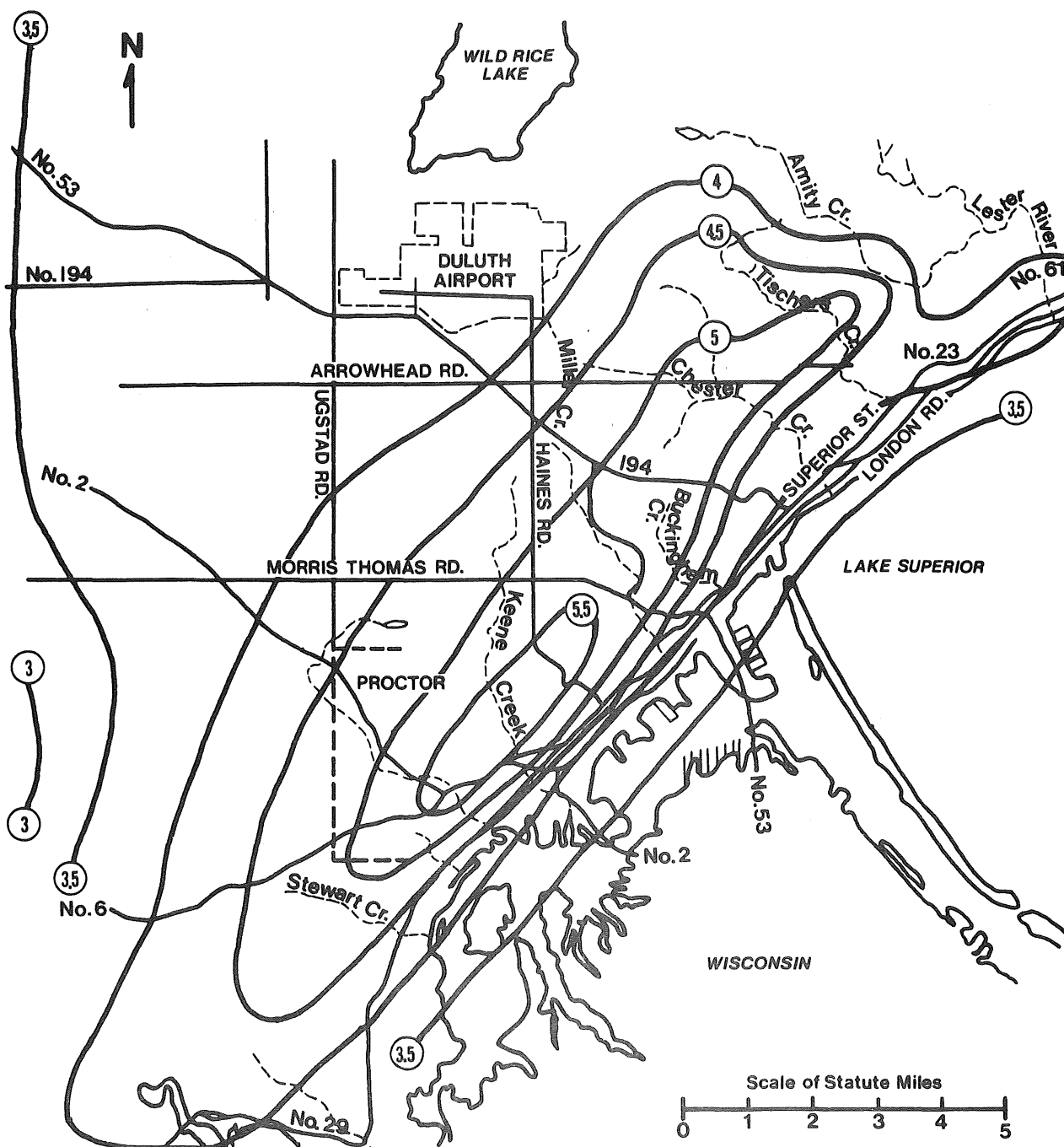
Comment: Statistics show that a $5-1/2$ inch 24-hour rainfall occurs at a point in Todd-Morrison Counties once every 100 years in Minnesota. It appears that this July is trying hard to change the statistics.

HEAVY RAINS IN DULUTH August 20, 1972



The isohyet map depicts the 2 to 4 inch heavy rainstorm passing through Duluth between 3:00 AM to 4:30 AM August 20, 1972. The storm caused the most damage in the history of Duluth (an estimated \$12,000,000). The severity of washouts of streets can be attributed to Duluth topography, an abrupt rise of the North Shore 800 feet within less than one mile. An additional factor contributing to the severity of this rainstorm is the 6.04 inches of rainfall falling the previous two weeks of which 3.82 inches fell on the 15th and 16th. This also caused a flash flood of minor portions. The prior rains saturated and weakened many streets and alleys and left many sewers partially clogged. All of this added to the destructiveness of the flash flood of the 20th. For additional information see the August 1972 Storm Data and the August 1972 National Climatological Data.

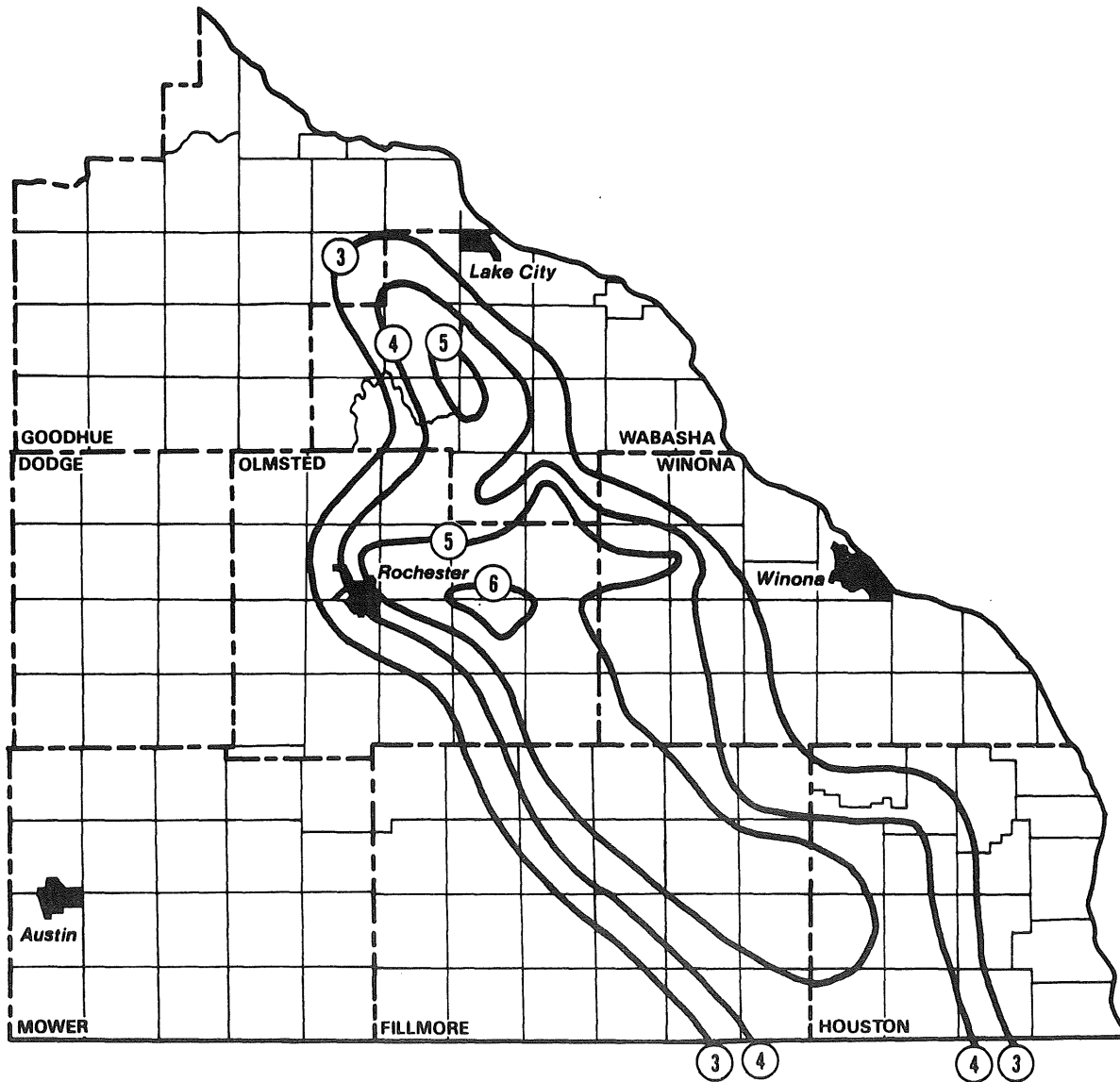
DULUTH FLASH FLOOD September 20, 1972



Flash floods in Duluth and along the North Shore on the 20th caused two deaths and about \$1,000,000 damage. This is the third Duluth and the second North Shore flash flood this summer. See August and September, 1972 Storm Data for Minnesota.

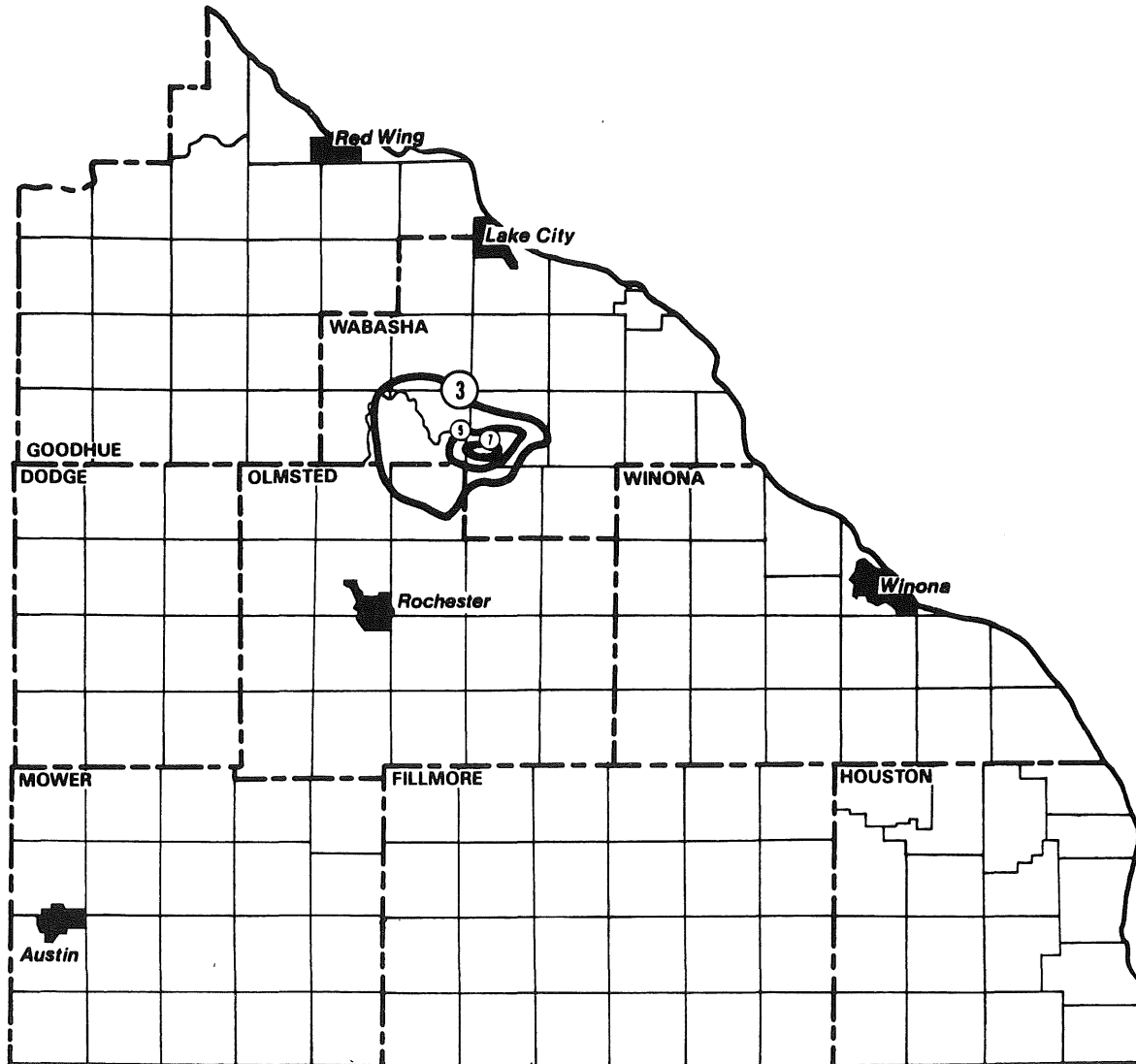
The isohyet map depicts a 4 to 5.5 inch heavy rainstorm in the Duluth Area between 4:00 AM to about 2:00 PM on September 20, 1972. The map indicates that the 5-inch isohyet is about 2 miles wide, paralleling and inland along the crest of the hill or ridge. Information from widely scattered Civil Defense reports, it is believed the above pattern exists along the entire North Shore Area.

SOUTHEAST FLASH FLOOD **June 20-21, 1974**



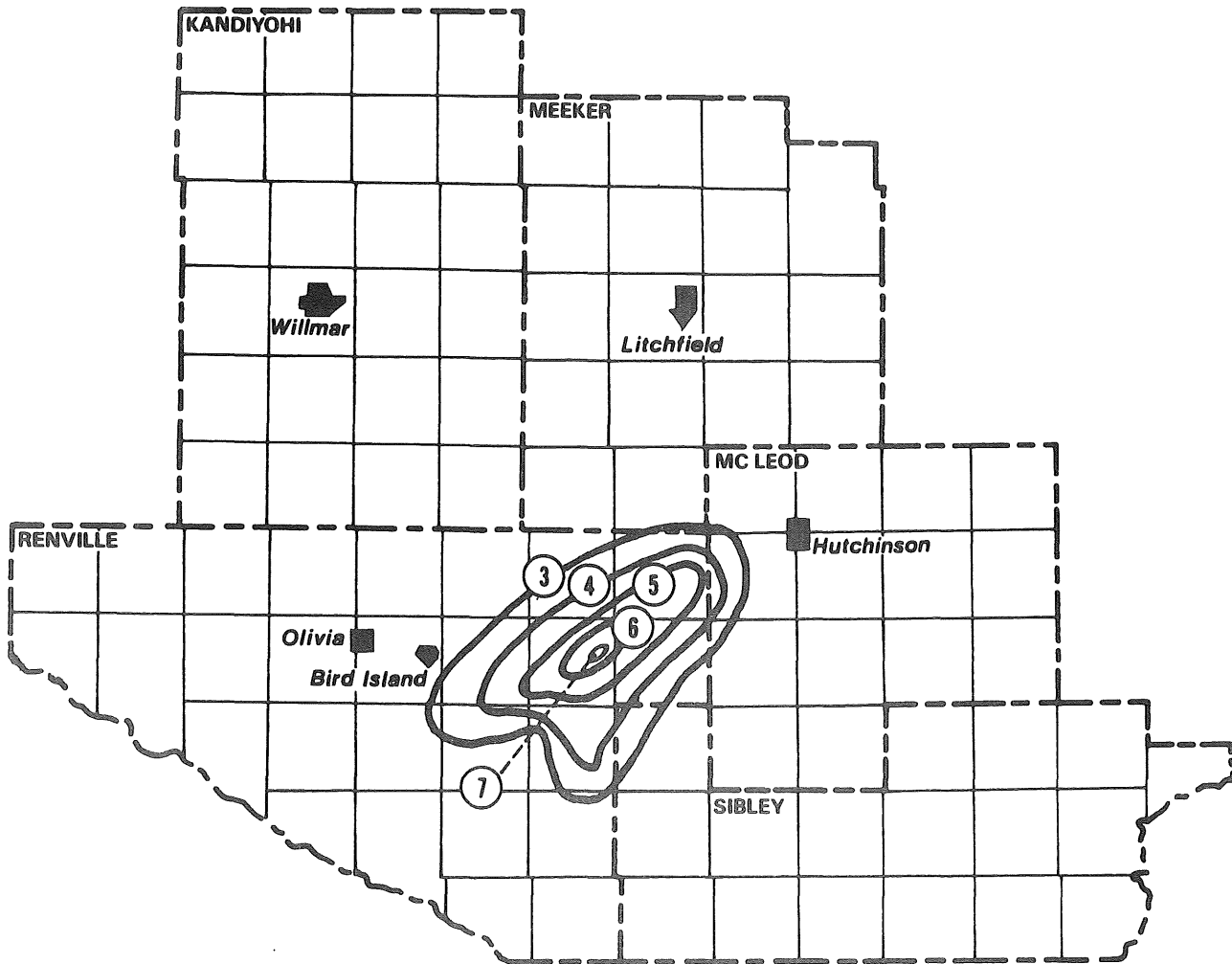
Heavy-rains began about 3 PM and continued on and off until about 1 AM on June 21st. The counties most effected were Olmsted, Wabasha, Winona, Fillmore and Houston. The greatest amount recorded was 6.25 inches at Eyota. The area covered by 4-inch rainfalls or more was about 1,150 square miles.

**MILLVILLE FLASH FLOOD
(Wabasha County)
July 24, 1974**



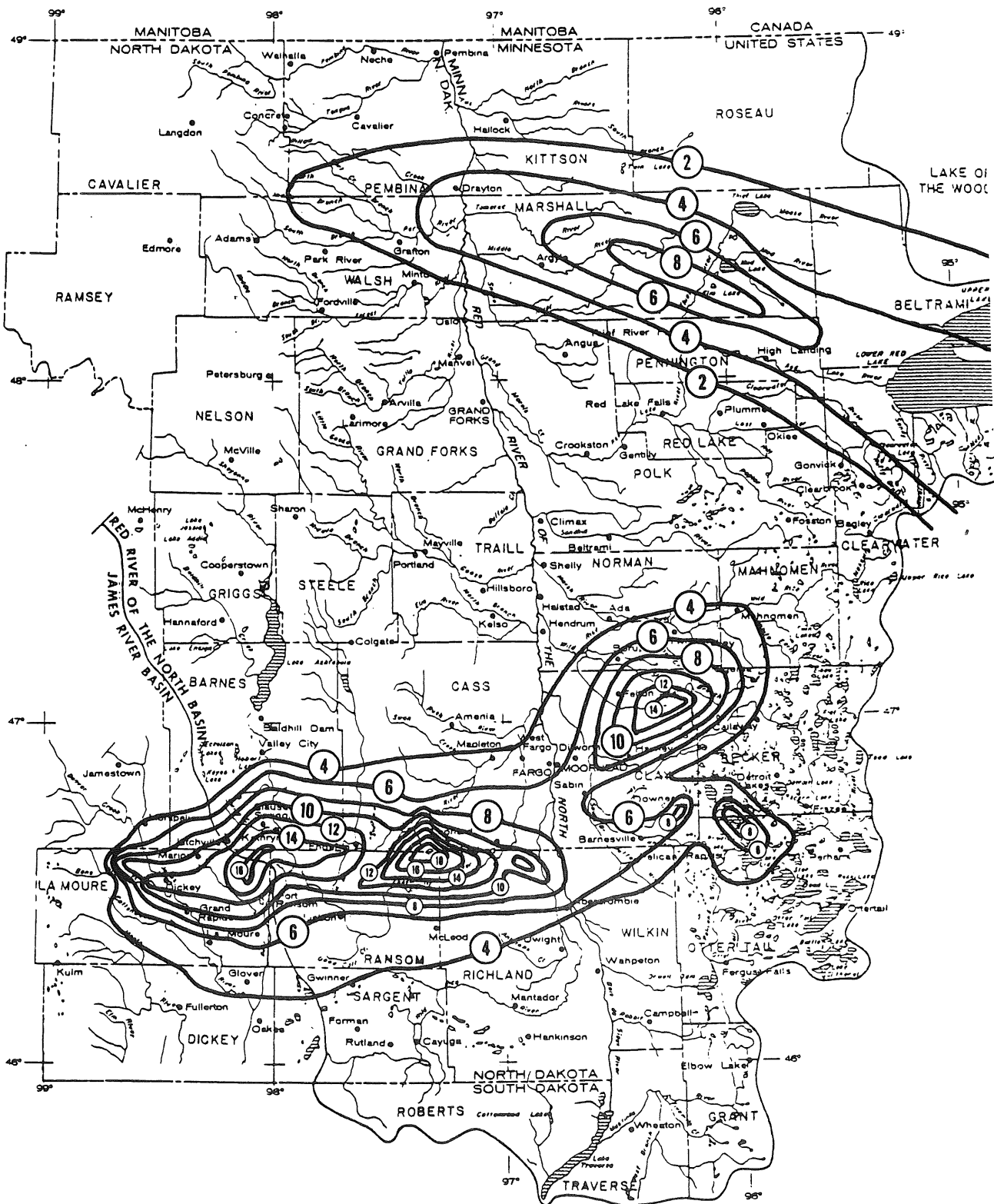
The heavy rains began about 6:30 PM and ended about 8 PM. The greatest amount recorded was 7.20 inches, 2 miles south of Millville. The 4-inch area covered about 25 square miles.

HECTOR FLASH FLOOD
(Renville County)
June 20-21, 1975



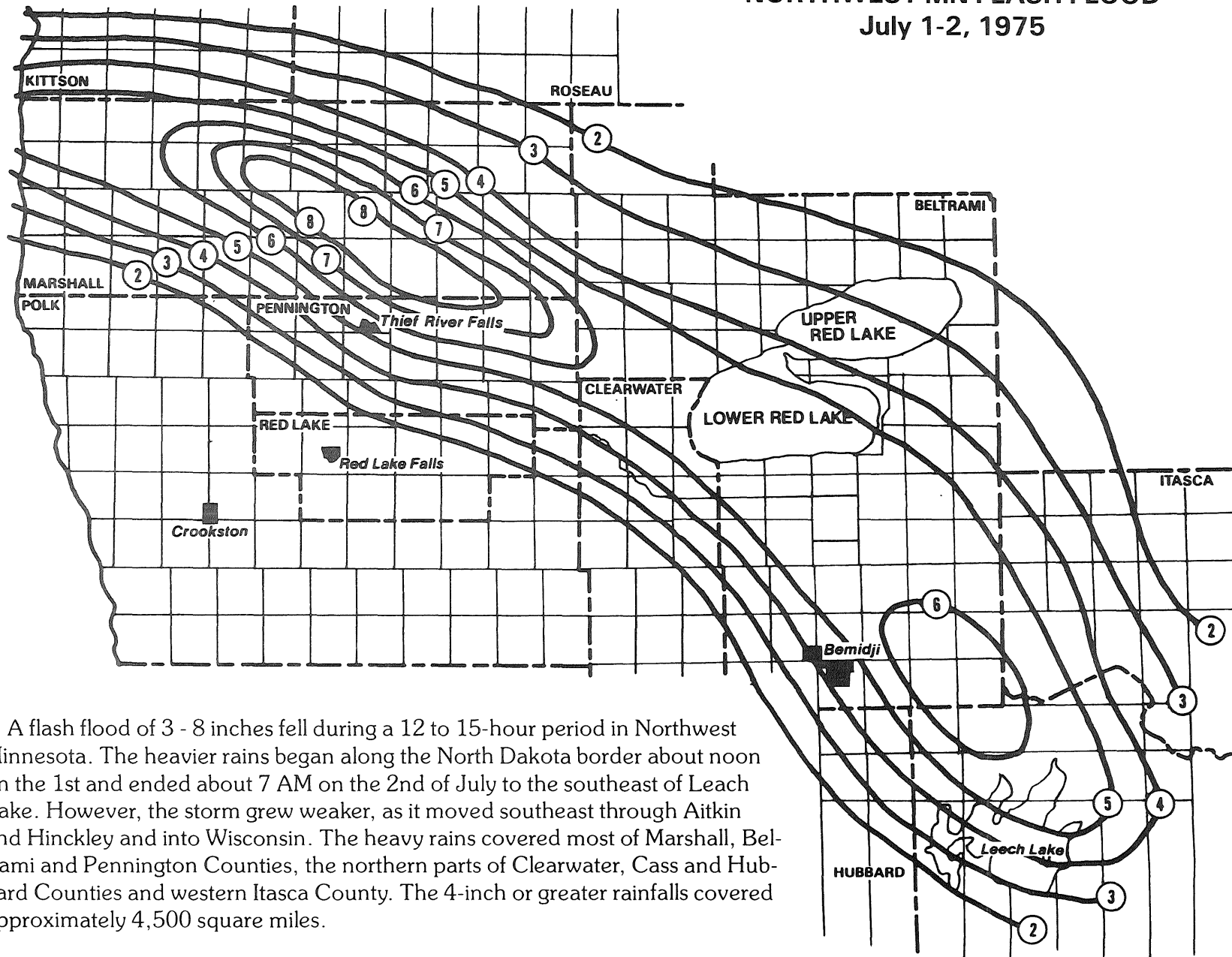
A flash flood of 2-7 inches fell during the evening of the 20th and the morning of the 21st of June in northeast Renville County. The storm was centered to the northeast of the town of Hector. The heaviest rainfall amount reported was 7 inches, 3 miles northeast of Hector. The 4-inch rainfall covered about 200 square miles. Damages to crops and by erosion was generally light, however, many basements were flooded.

FLASH FLOOD (Seven Counties in NW MN and North Dakota) June 28-30 and July 1-2, 1975



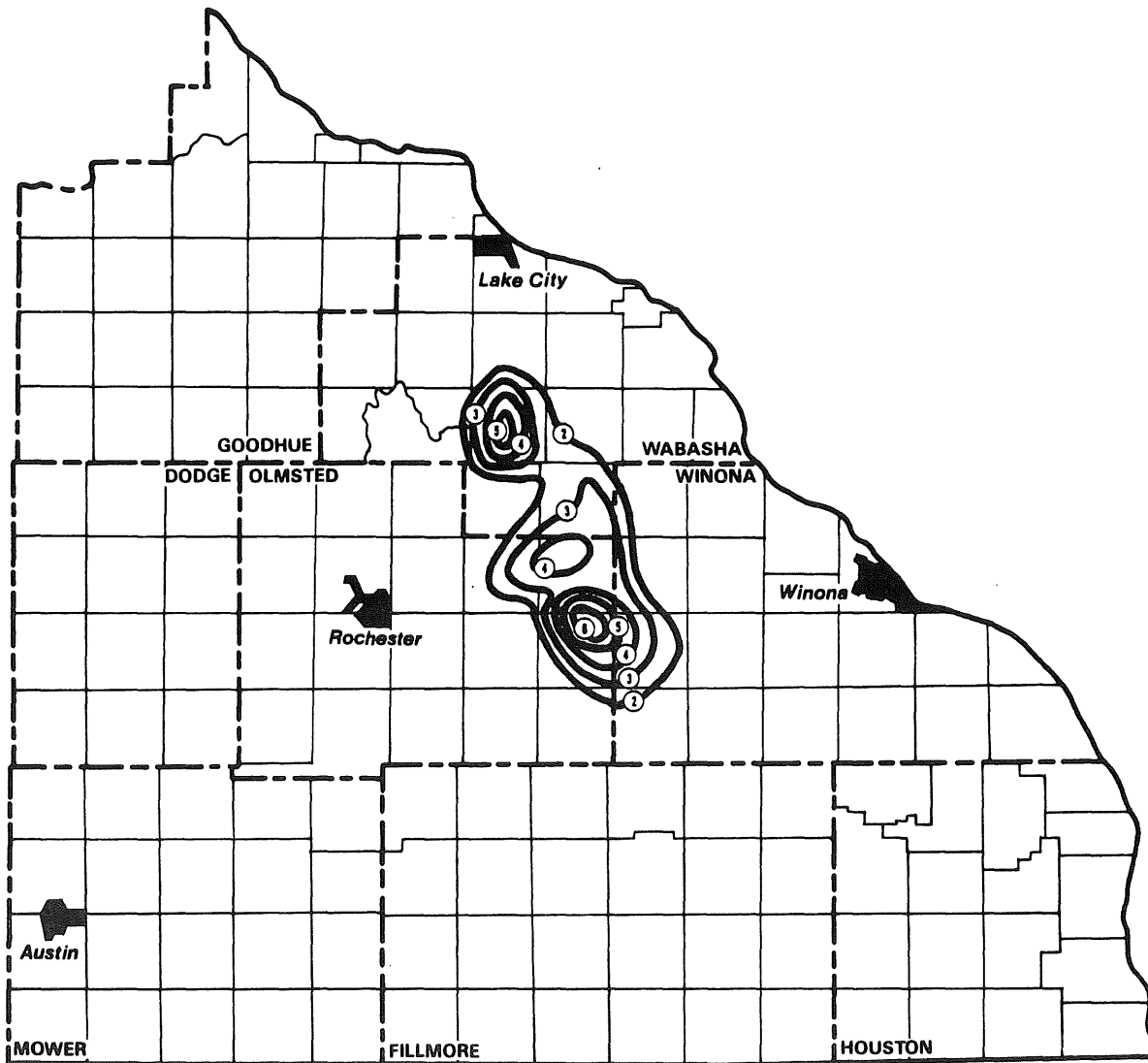
Isohyetal map of total rainfall (in inches) during the periods June 28-30 and July 1-2, 1975. (Based on data provided by National Oceanic and Atmospheric Administration, U.S. Dept. of Commerce, and by the Minnesota State Office of Climatology).

NORTHWEST MN FLASH FLOOD July 1-2, 1975



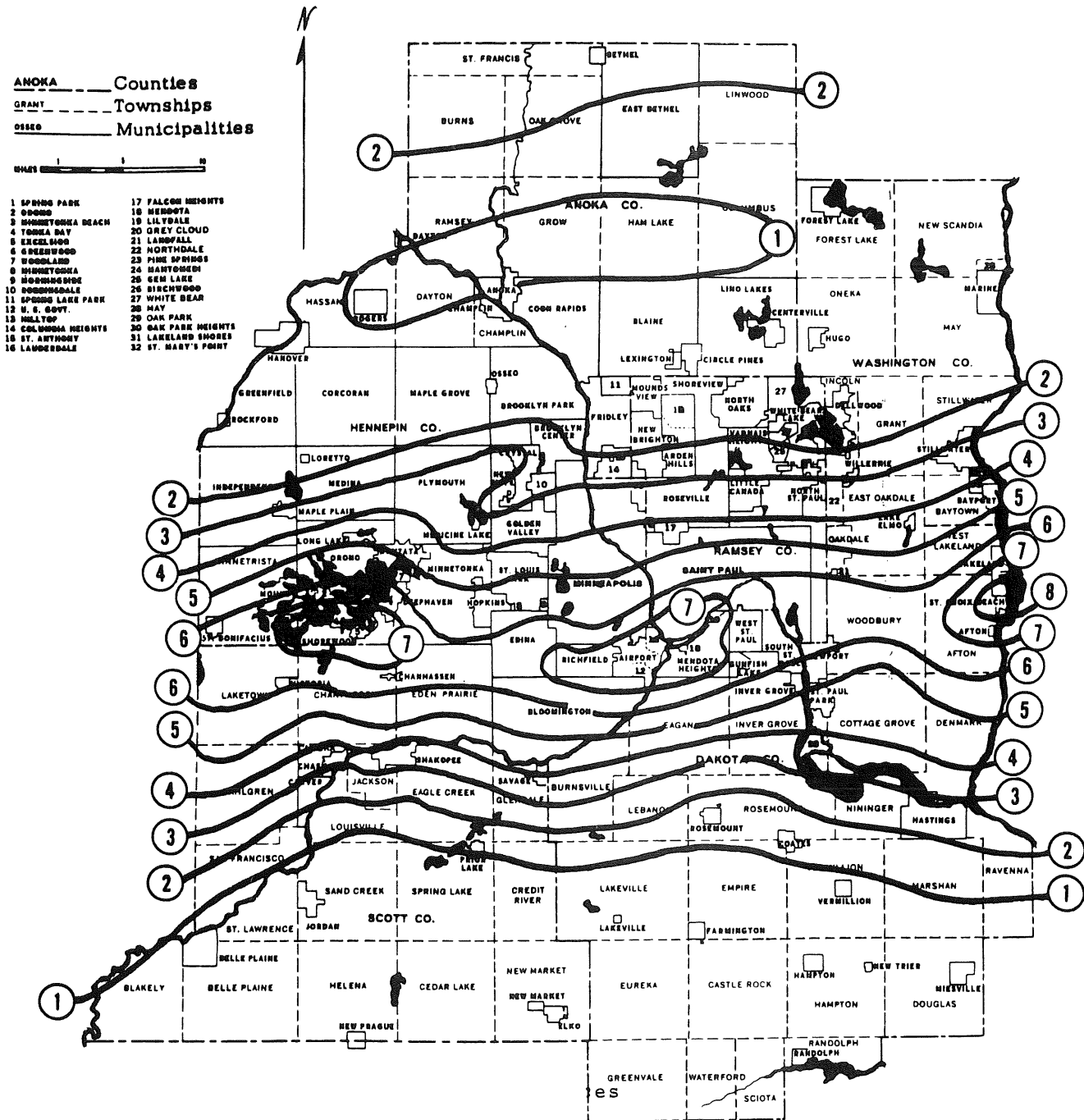
A flash flood of 3 - 8 inches fell during a 12 to 15-hour period in Northwest Minnesota. The heavier rains began along the North Dakota border about noon on the 1st and ended about 7 AM on the 2nd of July to the southeast of Leach Lake. However, the storm grew weaker, as it moved southeast through Aitkin and Hinckley and into Wisconsin. The heavy rains covered most of Marshall, Beltrami and Pennington Counties, the northern parts of Clearwater, Cass and Hubbard Counties and western Itasca County. The 4-inch or greater rainfalls covered approximately 4,500 square miles.

**WHITEWATER RIVER FLASH FLOOD
(Olmsted, Wabasha & Winona Counties)
July 4-5, 1975**

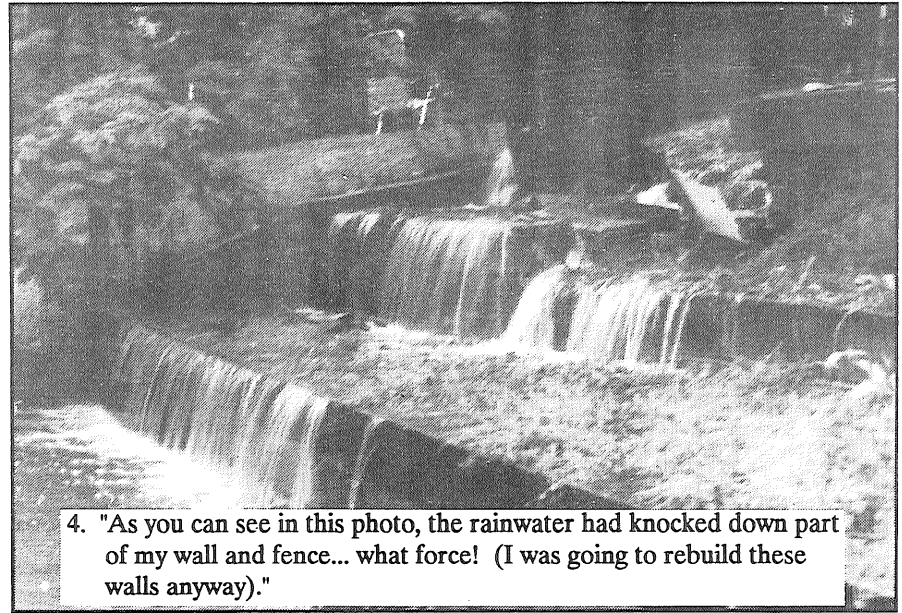
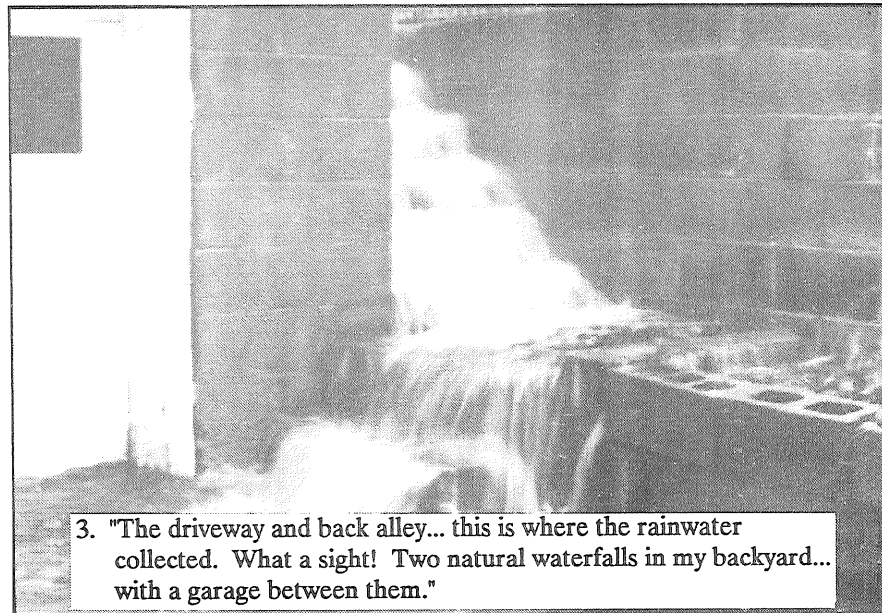
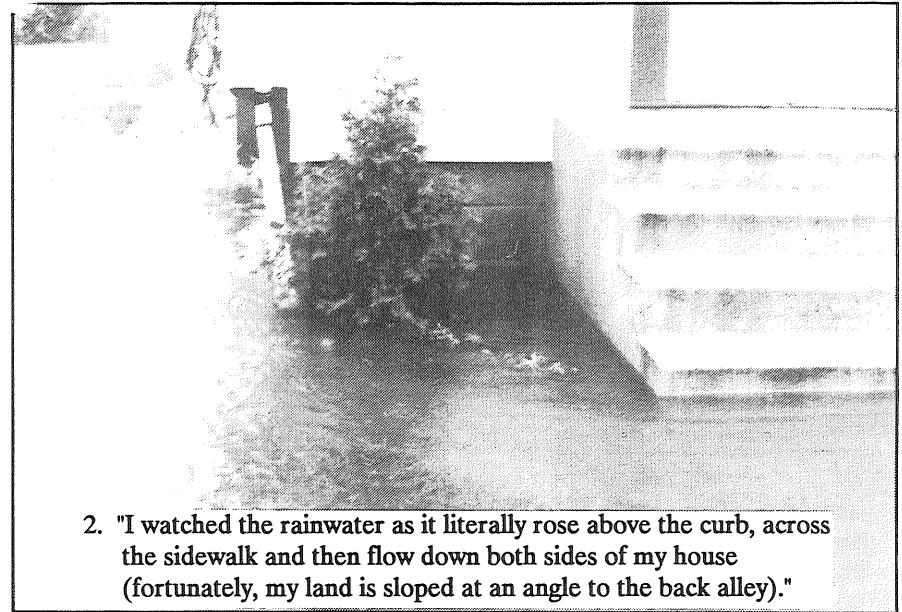
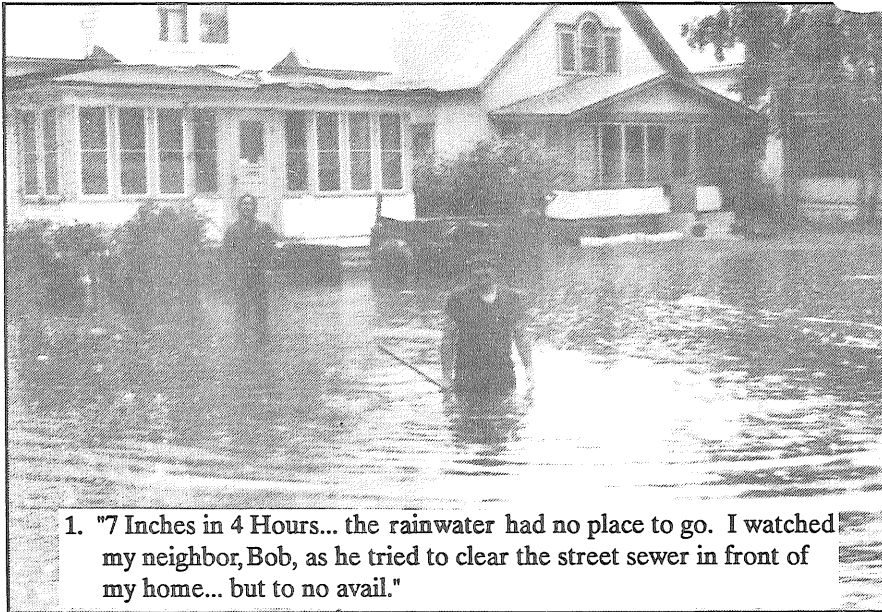


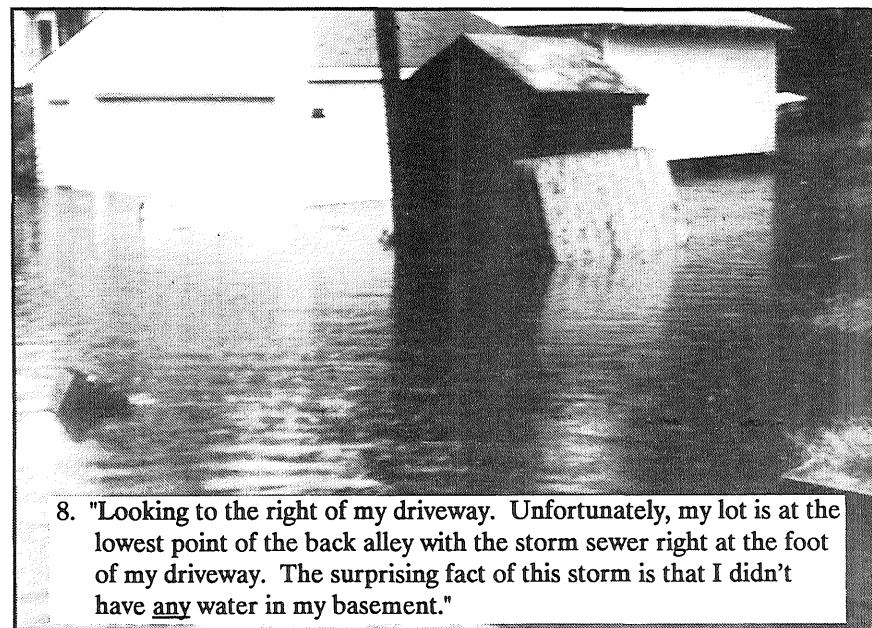
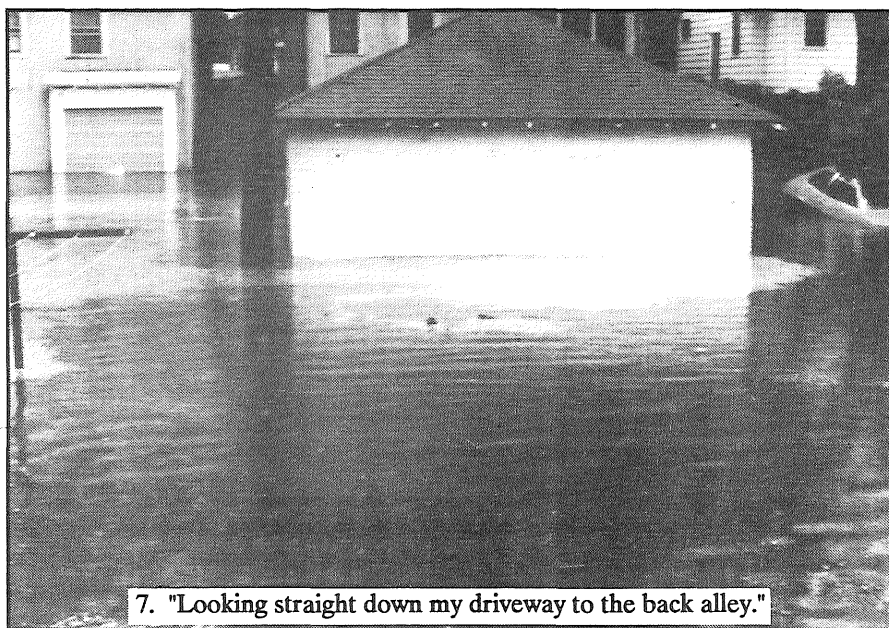
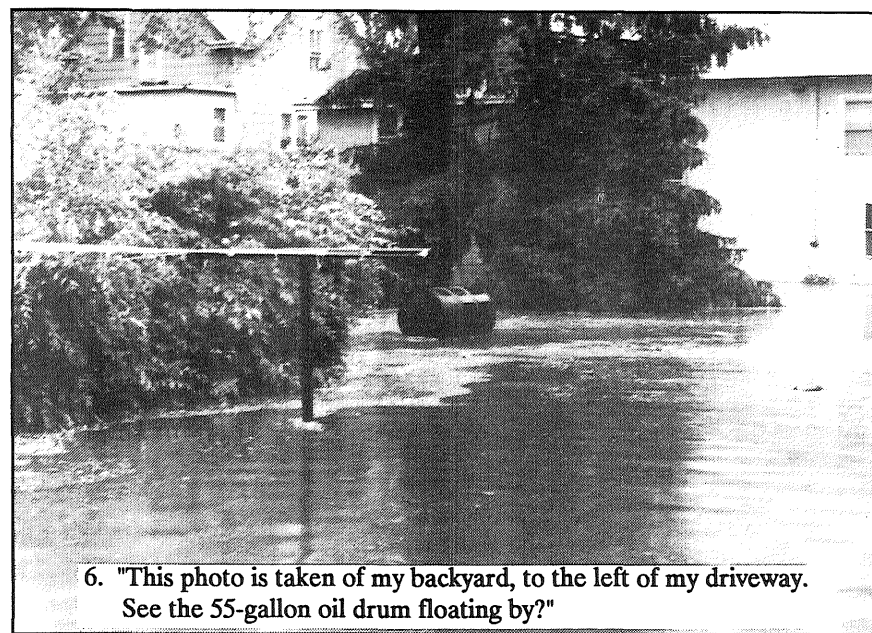
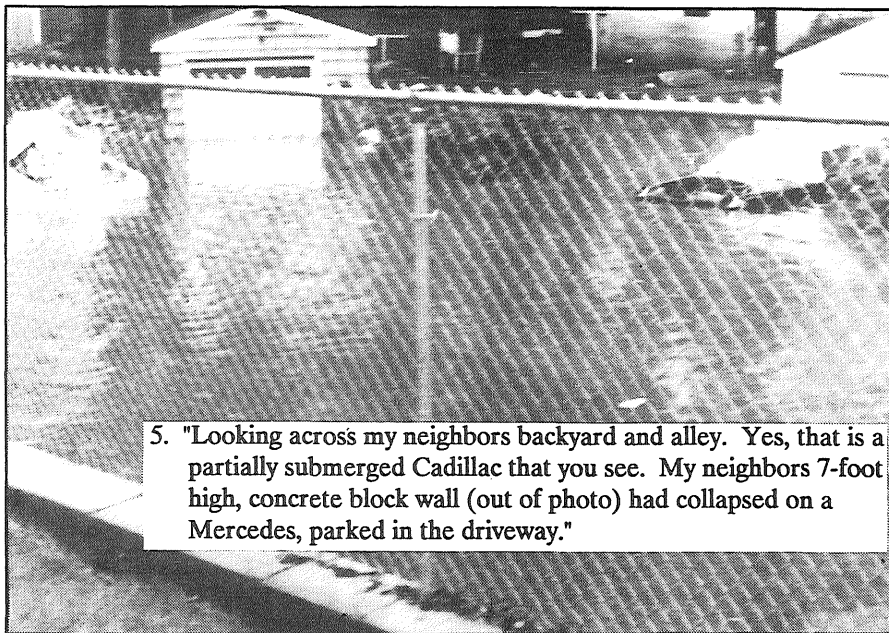
The greatest amount recorded was 6.4 inches on the Whitewater River 3 miles west southwest of Whitewater State Park. The area covered by 4-inches or more of rainfall was 50 square miles.

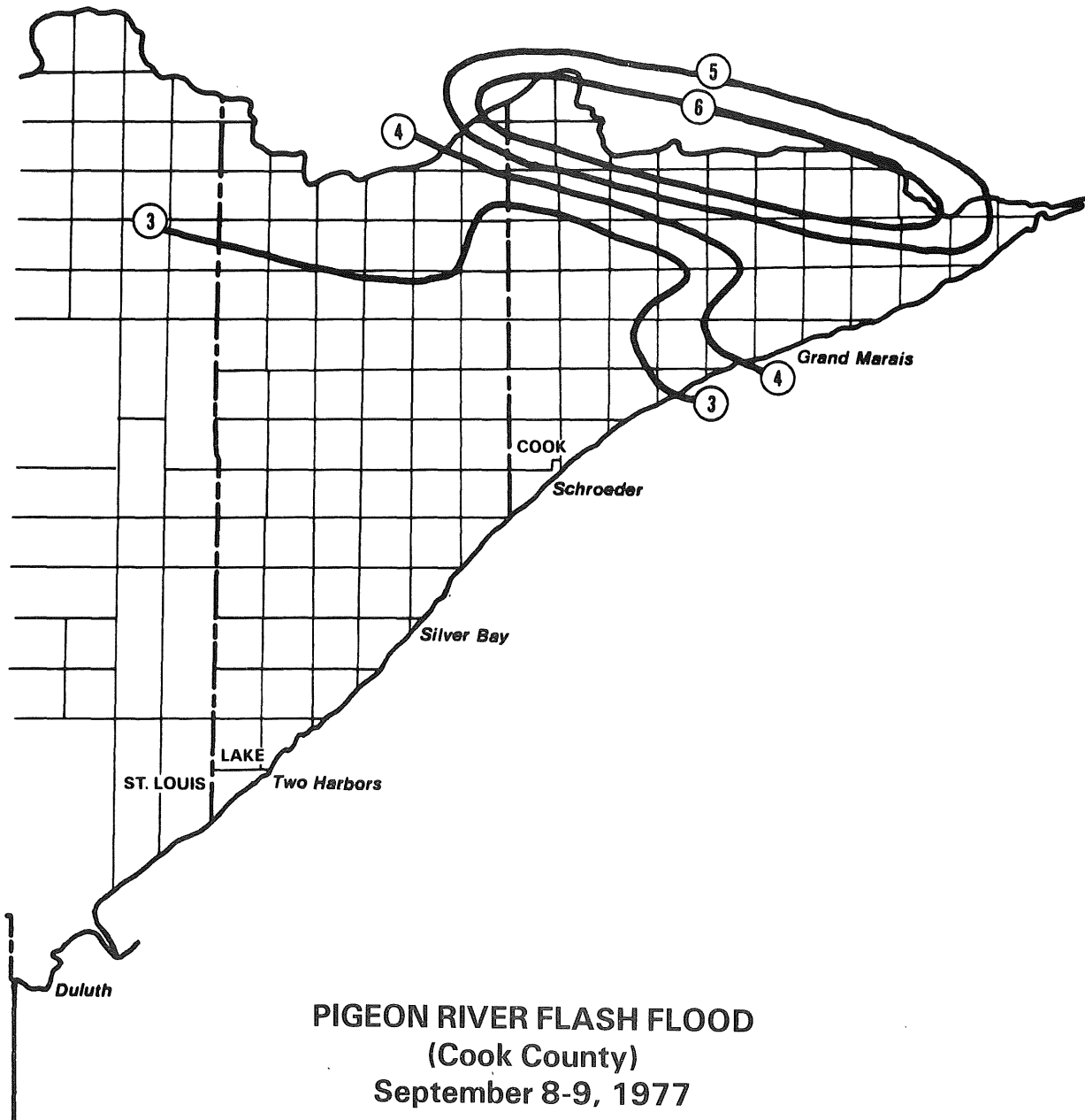
FLASH FLOOD (Minneapolis-St. Paul and Surrounding Area) August 30-31, 1977



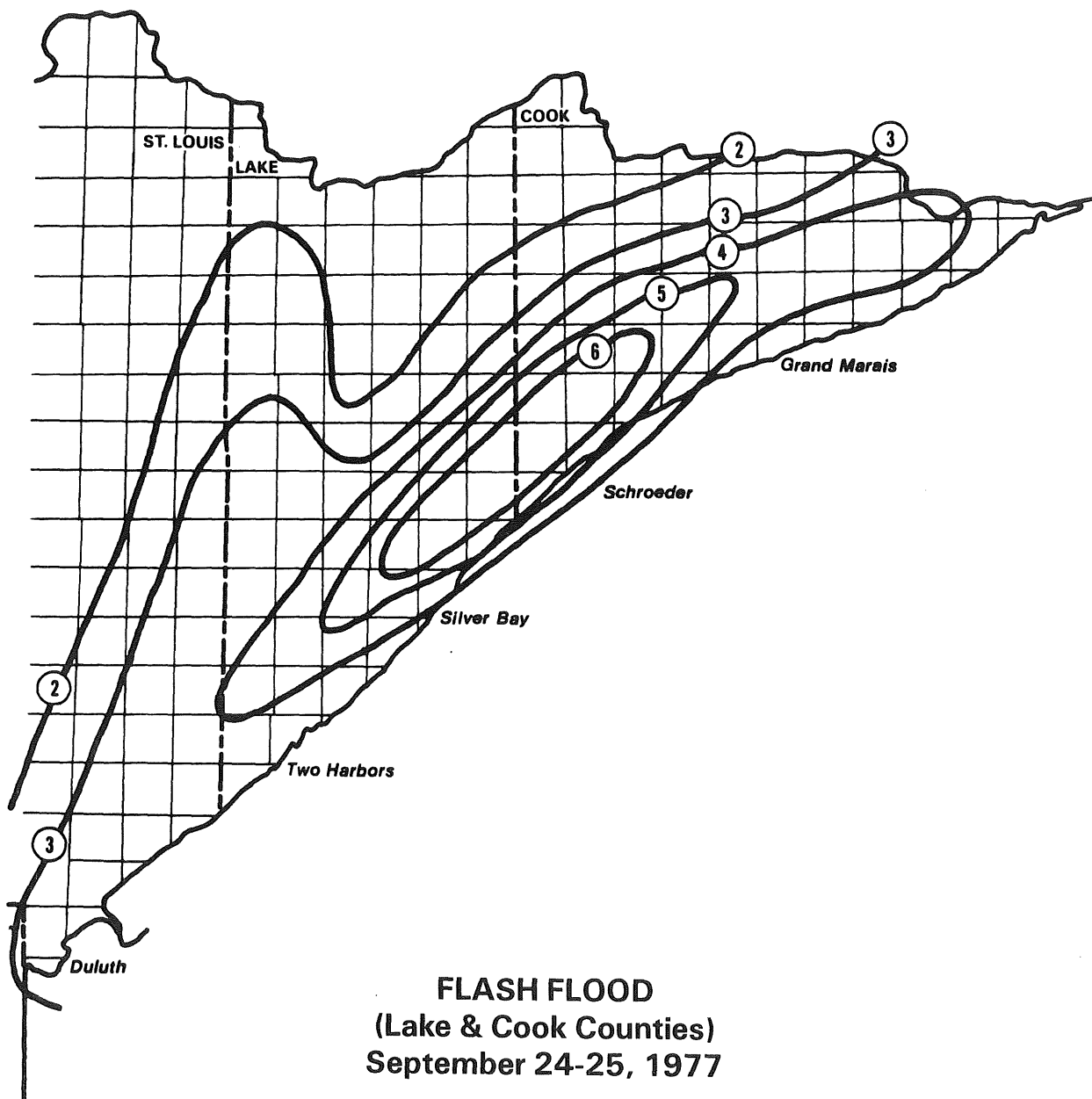
During the evening of August 30th and early morning hours of the 31st, a flash flood occurred in a period of about 4 hours. There were three relatively small areas that received more than 7 inches of rainfall. The first area is the southern shores of Lake Minnetonka; the second area, Richfield, Minneapolis-St. Paul International Airport, northern Bloomington, Mendota Heights, and the very southern parts of Minneapolis and St. Paul; the third area Afton, Lakeland, St. Croix Beach and east into Wisconsin. The 4-inch or more rainfall covered an area of 832 square miles in Minnesota. It began in northern Carver County, then east through southern Hennepin, southern Ramsey, northern Dakota and southern Washington counties. Local flooding was heavy in the 6 to 7-inch rainfall areas. For the flood analysis, 252 reports were used from several precipitation networks.





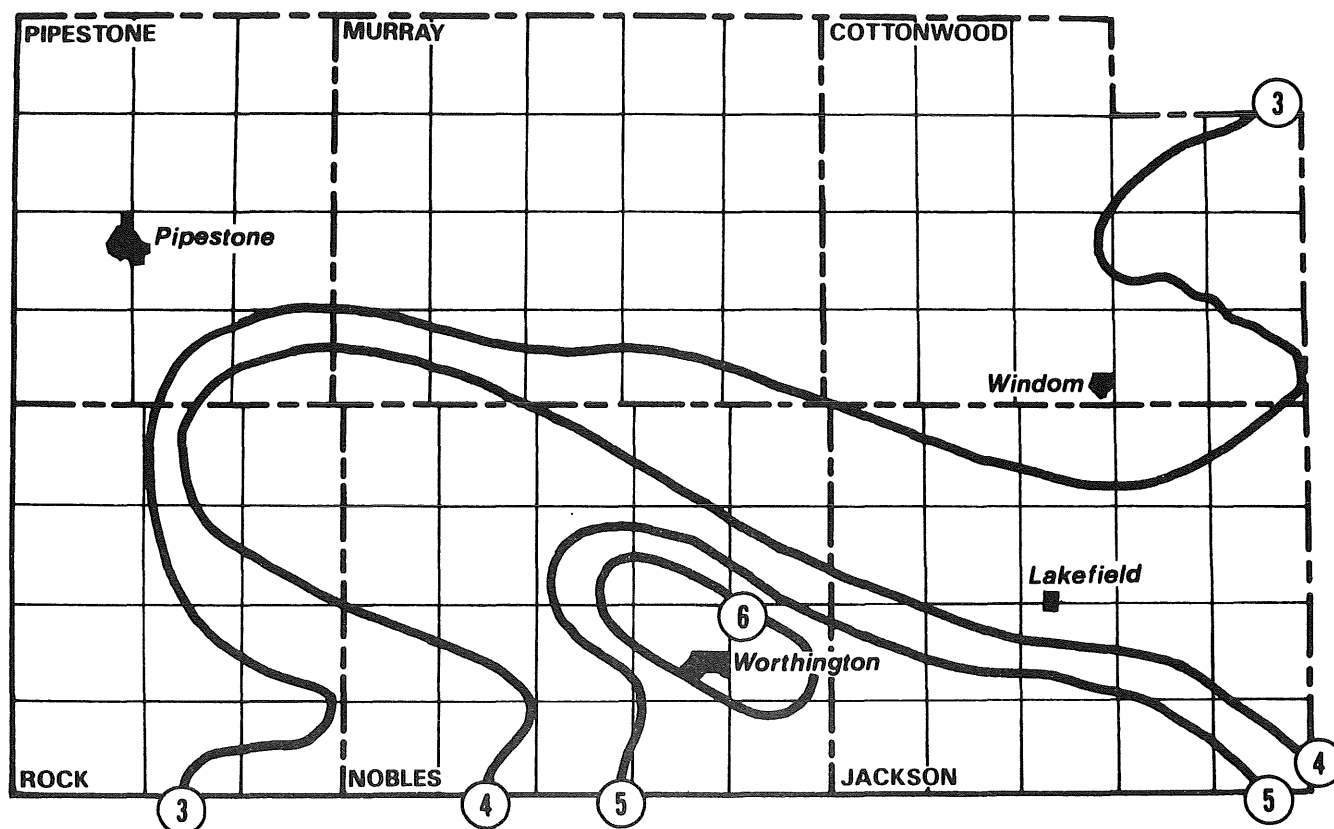


The greatest rainfall amount recorded was 6.66 inches at Popular Lake. The area covered by 4-inch rainfalls or more was about 1,000 square miles in Minnesota and about 1,000 square miles in Canada.



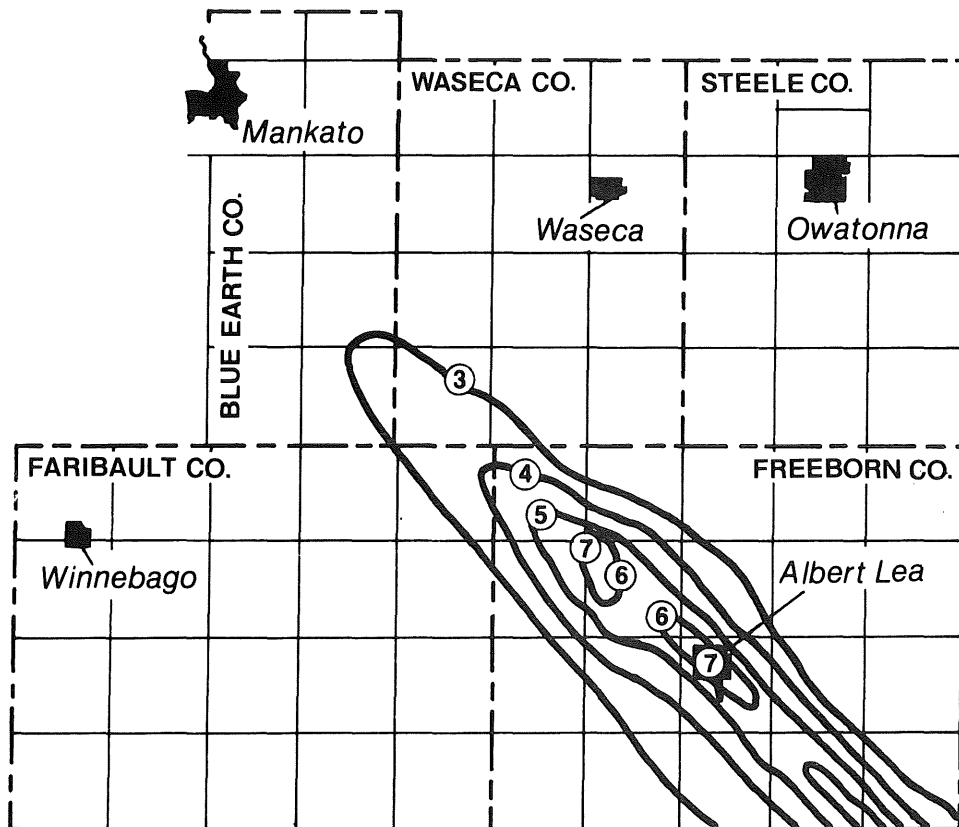
Heavy rains occurred on the evening of September 23rd and through the afternoon of the 24th along the north shore of Lake Superior. The heaviest amounts of 6 inches or more were generally inland from the shoreline, about 5 to 10 miles beginning in the Finland area and extending northeast about 40 miles. The 4-inch or more rainfall covered an area of 1,550 square miles.

WORTHINGTON FLASH FLOOD
(Nobles County)
September 30, 1977



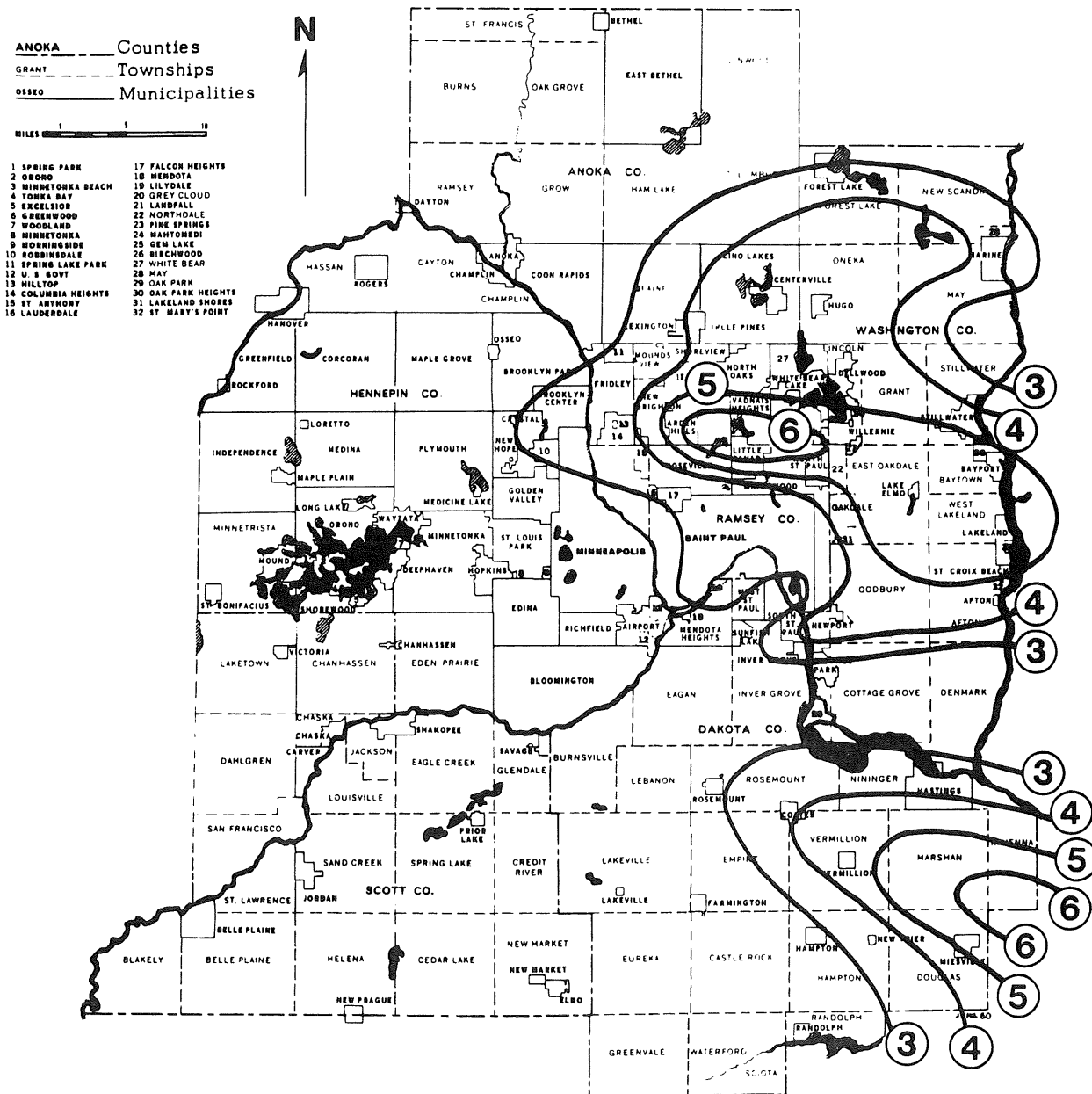
During a flash flood in the Worthington area, most of the rain fell between 1 AM and 5 PM on September 30, 1977. The heaviest amount reported was 6.6 inches at the NWS COOP station in Worthington. The 4-inch or more rainfall began in northeast Rock County and extended northwest-southeast through Nobles County into southwest and southern Jackson County. The 4-inch area covered 650 square miles in Minnesota.

ALBERT LEA FLASH FLOOD
(South Central MN)
June 14, 1978

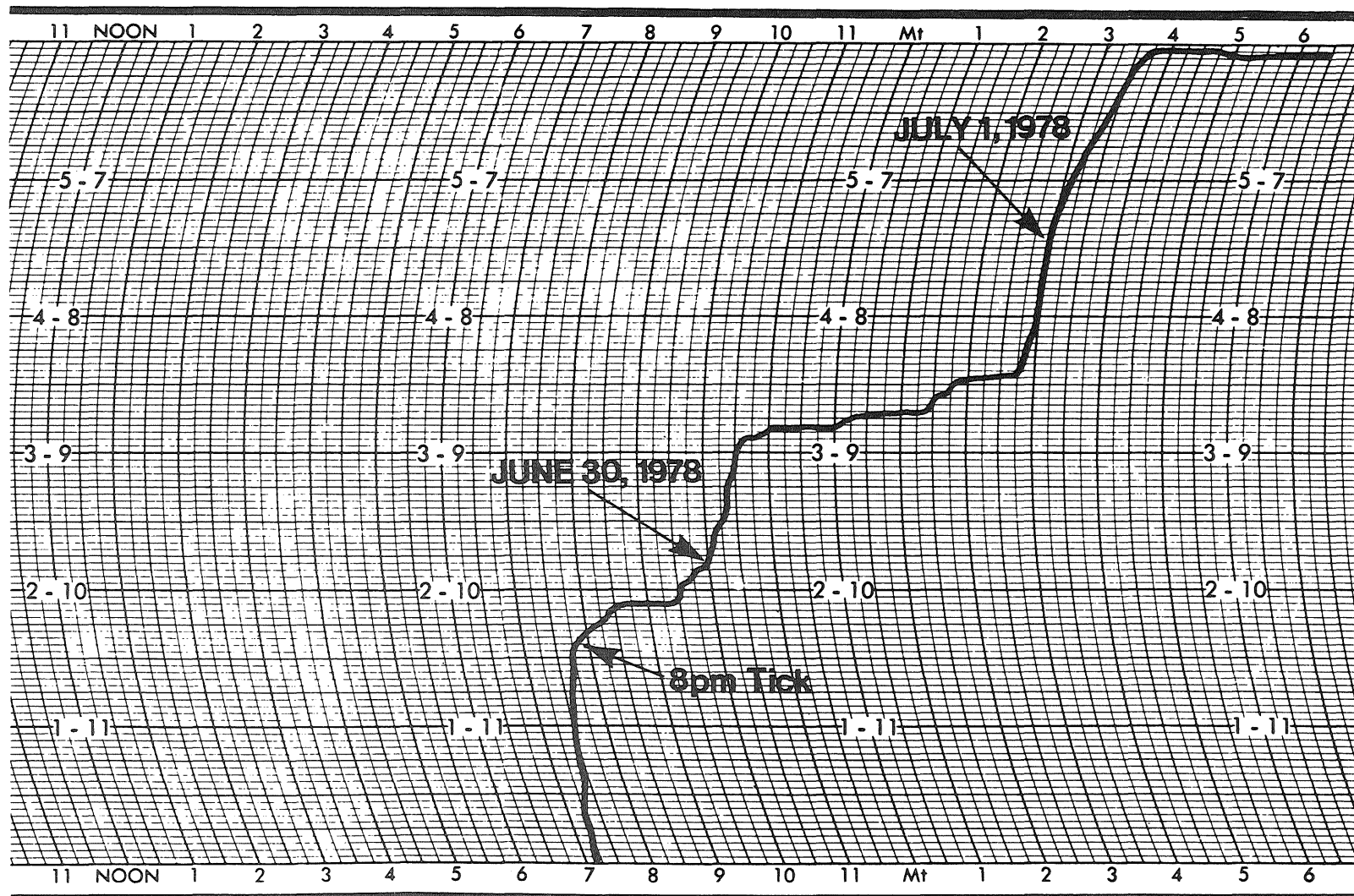


The Albert Lea flash flood occurred between 7 PM and midnight CDST on June 14, 1978. Two areas received over 7 inches of rainfall. Albert Lea reported 7.50 inches, and an area about 2 miles east of Freeborn in northwest Freeborn County reported 7.30 inches. More than 4 inches of rain fell on a 6 to 8 mile wide band from northwest Freeborn County through Albert Lea and Glenville into Iowa. This covers an area of 200 square miles. The isohyet map was plotted from 53 Future Farmers of America reports.

EASTCENTRAL FLASH FLOOD (Northern Suburbs of St. Paul) June 30 — July 1, 1978



Portions of the northern suburbs of St. Paul received heavy rains on the evening of June 30 and July 1, 1978. The largest observed rainfall was 6.7 inches in north central Ramsey County. Northern Ramsey County and north and central Washington County, a 400 square mile area, received greater than 4 inches of precipitation. Heavy rainshowers began in the area at approximately 7 PM CDST June 30 and continued intermittently until 4 AM July 1. These rainshowers were the northern part of a 140-mile long line of showers that extended from the Twin Cities to the Minnesota-Wisconsin-Iowa border.

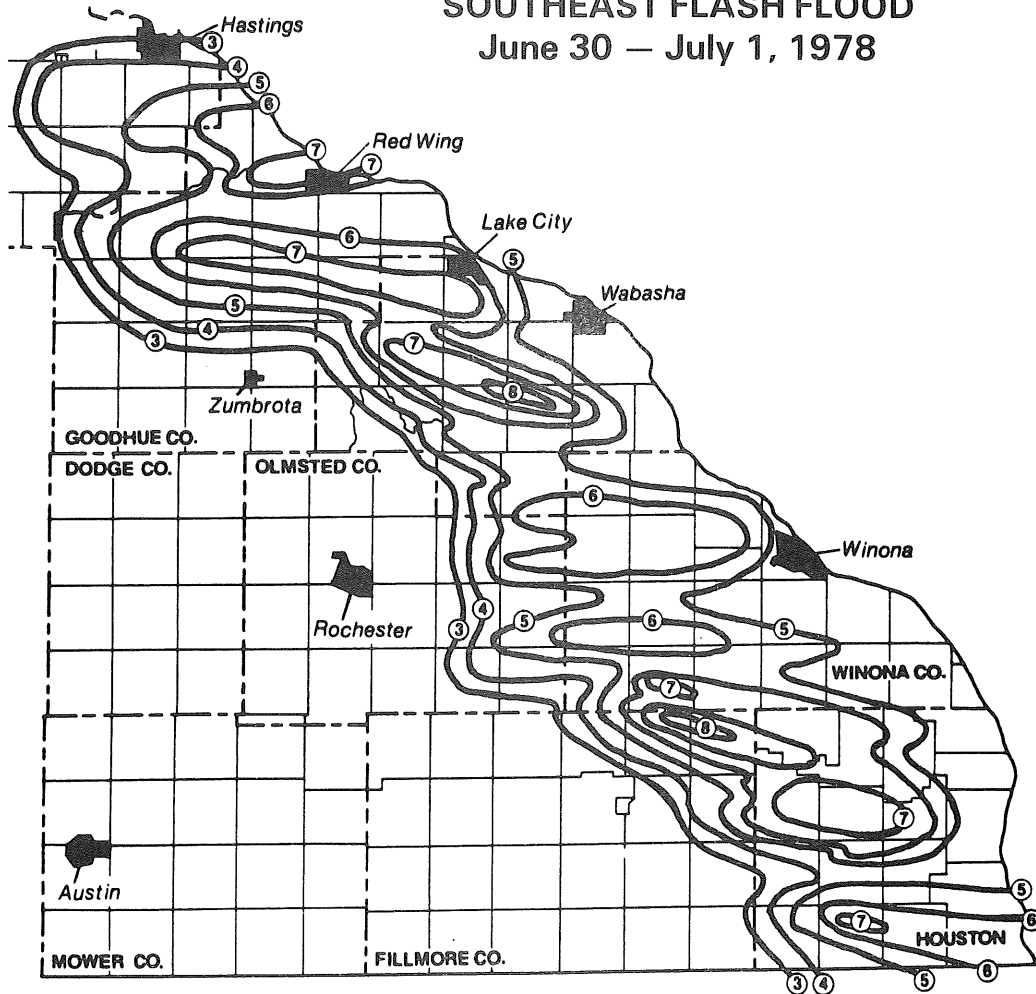


PRECIPITATION RECORD FROM 12" DUAL WEIGHING RAIN GAUGE

RAMSEY COUNTY

SHOREVIEW: TWP - 030N RGE - 23W SEC - 35

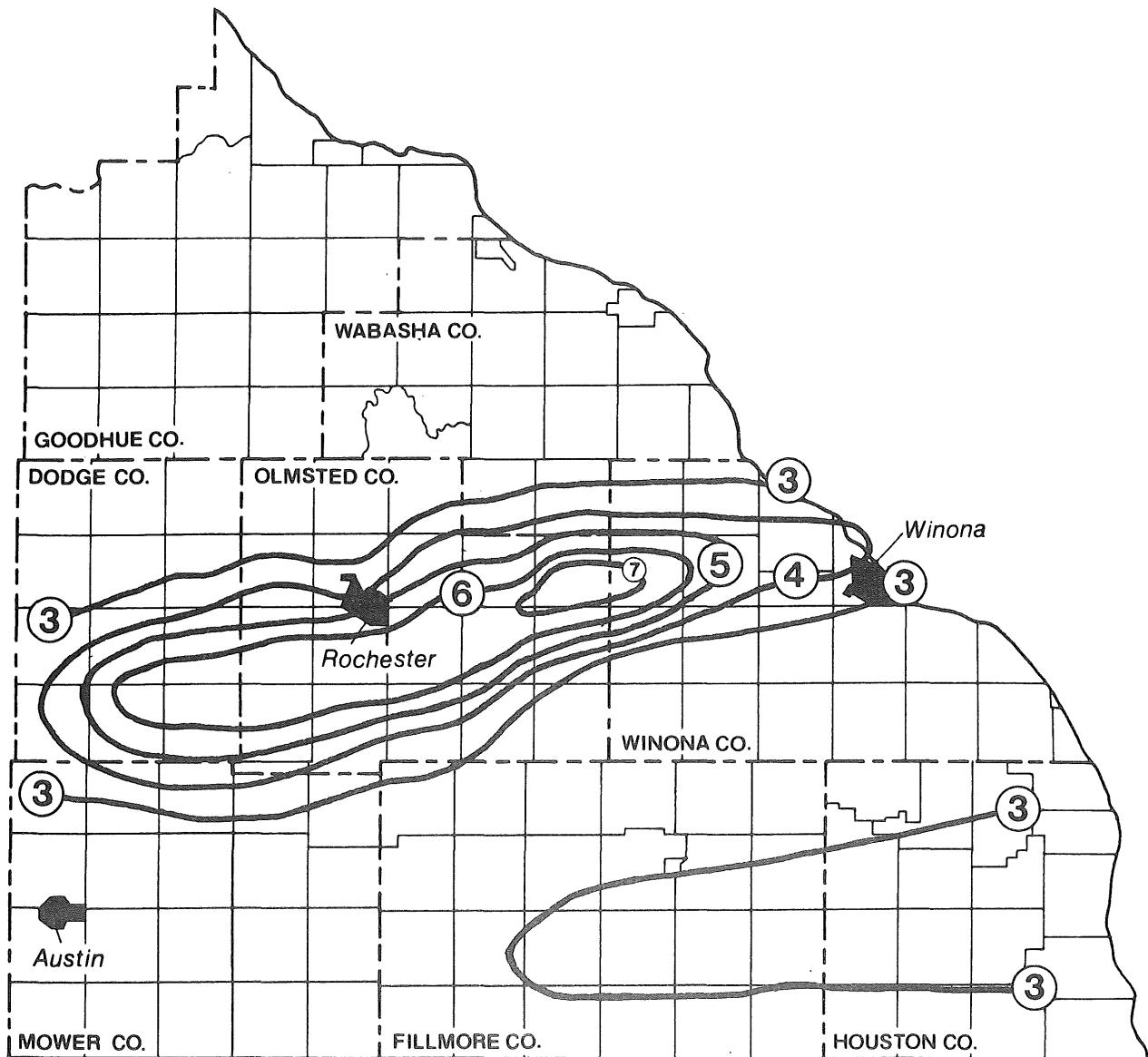
SOUTHEAST FLASH FLOOD June 30 — July 1, 1978



East and southeast Minnesota experienced widespread flash flooding on June 30 thru July 1, 1978. These floods differed from the usual flash flood pattern. A typical pattern has only one localized area of high-intensity precipitation, generally from a single cell. Seven to nine separate areas in east and southeast Minnesota had over 6 inches of precipitation on June 30-July 1 from several storm cells forming during a 14-hour period. Numerous heavy thunderstorms moved east to southeast from a 140-mile long line extending from western Ramsey County (the Twin Cities) to western Houston County (25 miles west of the Iowa-Minnesota-Wisconsin border). Radar shows heavy showers occurred from about 6 PM CDST June 30 until 1 AM July 1, and moderate showers continued across the area until approximately 7 AM July 1.

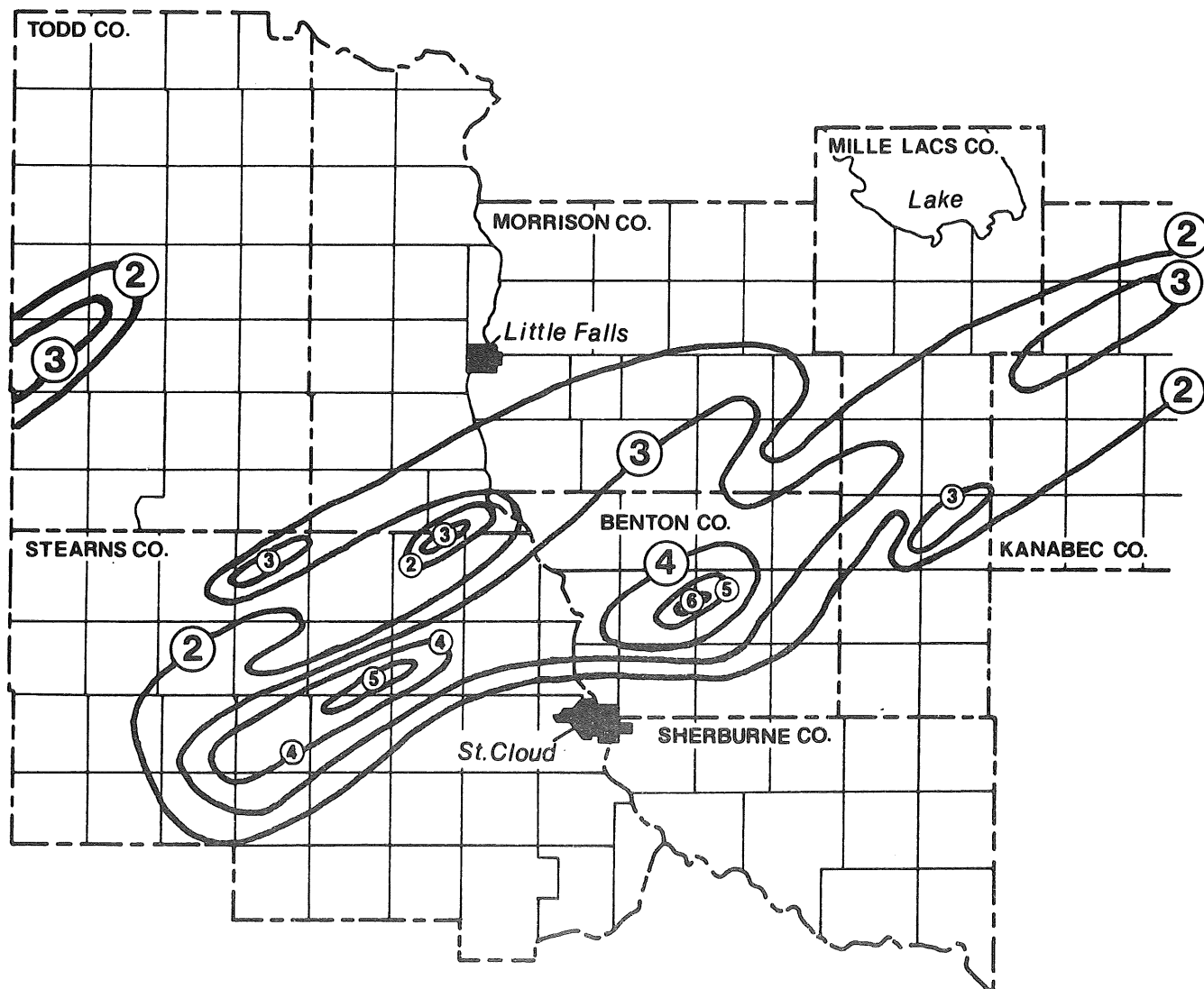
Portions of Ramsey, Dakota, Goodhue, Wabasha, Olmsted, Winona, Fillmore, and Houston Counties received over 6 inches of precipitation. A 6 or more inch rainfall is a 100-year or greater storm for this area. Greater than 8 inches of precipitation was reported in Mount Pleasant and Highland Townships in Wabasha County and in Arendahl and Rushford Townships in Fillmore County. The largest recorded amount was 8.68 inches. A 2,850 square mile area received greater than 4 inches of precipitation in Minnesota. Generally, the heaviest and most extensive rainfalls were across Goodhue, Wabasha, Winona, and Houston Counties. Northern Ramsey, central Washington, eastern Dakota, eastern Olmsted, and northeastern Fillmore also had extensive rainfalls. The above map was prepared from 115 precipitation reports. Flash flood areas for Ramsey and Washington Counties are drawn on a separate map.

SOUTHEAST FLASH FLOOD (Rochester Storm No. 1 & Austin Storm No. 1) July 5-6, 1978



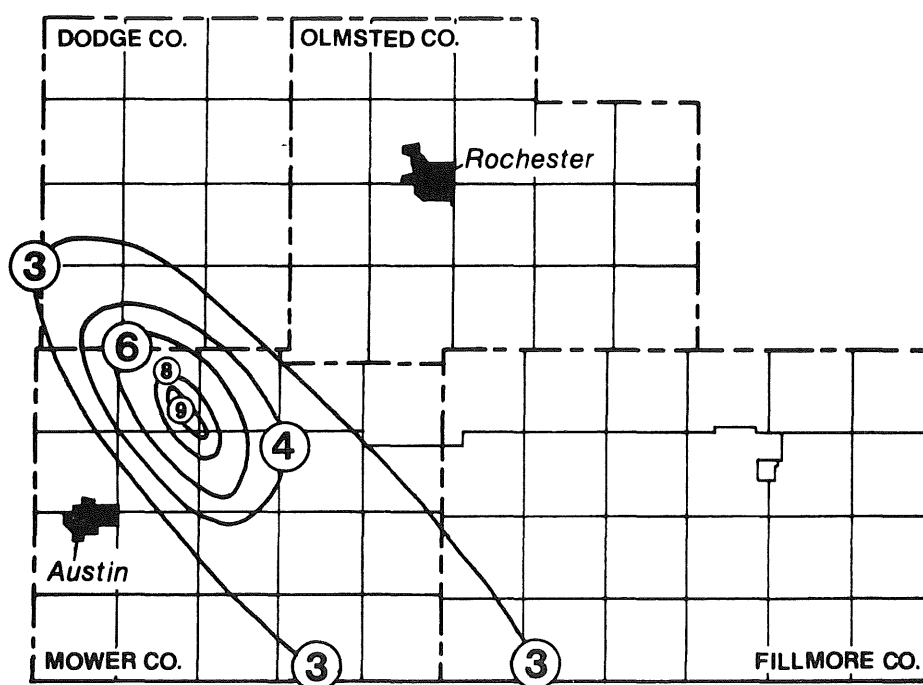
The flash flood for Rochester, Minnesota occurred from heavy rains of 6 inches or more. The storm began at Rochester airport at 5:53 PM CDST on July 5, 1978 and ended at 1:50 AM CDST on July 6, 1978. The National Weather Service weighing rain gage recorded in a 3-hour period, 5:53 PM CDST to 8:53 PM CDST, 4.99 inches of rain, which is well above the 100- year return period. The heaviest amount, 7.3 inches, occurred in Quincy Township in eastern Olmsted County. The 4-inch or more rainfall band was about 12-15 miles wide and 74 miles long and covered an area of 700 square miles. The line which oriented east-northeast began 25 miles west-southwest of Rochester and ended 50 miles east on the Minnesota-Wisconsin border. The map was prepared from 64 Future Farmer of America reports and 16 National Weather Service reports.

EAST-CENTRAL
(Benton, Stearns Counties)
July 6-7, 1978



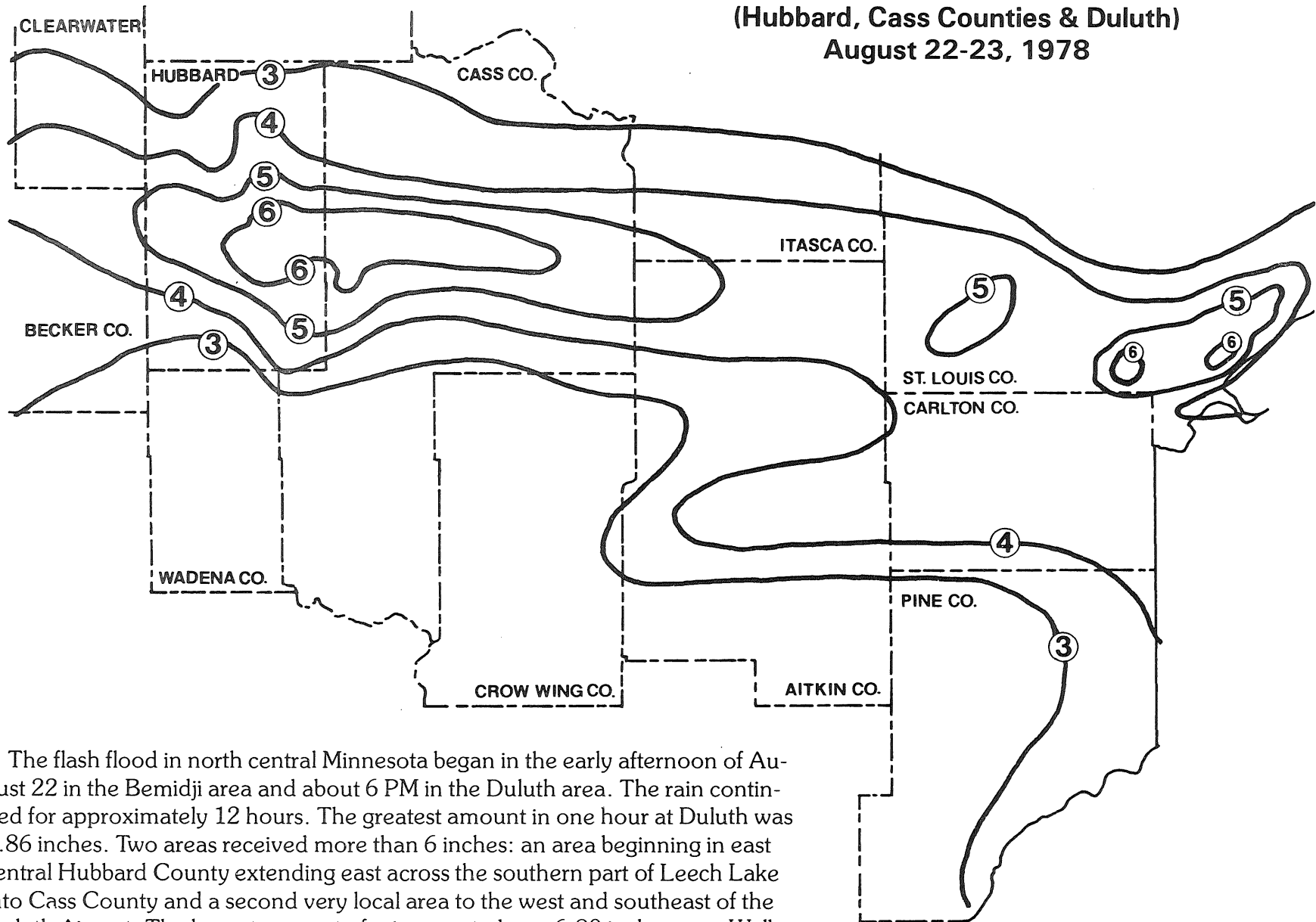
Benton and Stearns Counties received heavy rains on the evening of July 6-7, 1978. The rainshowers began at approximately 6:00 PM in Stearns County and at 6:45 PM CDST in Benton County. Radar indicates that maximum rainfall intensities occurred at approximately 7:00 PM. The rain ended about 9:00 PM. The largest amounts, greater than 5 inches, were reported in Mayhew Lake Township in Benton County and Avon and Albany Townships in Stearns County. A 110 square mile area received greater than 4 inches of precipitation.

AUSTIN STORM NO. 2
(Southeast MN)
July 16-17, 1978



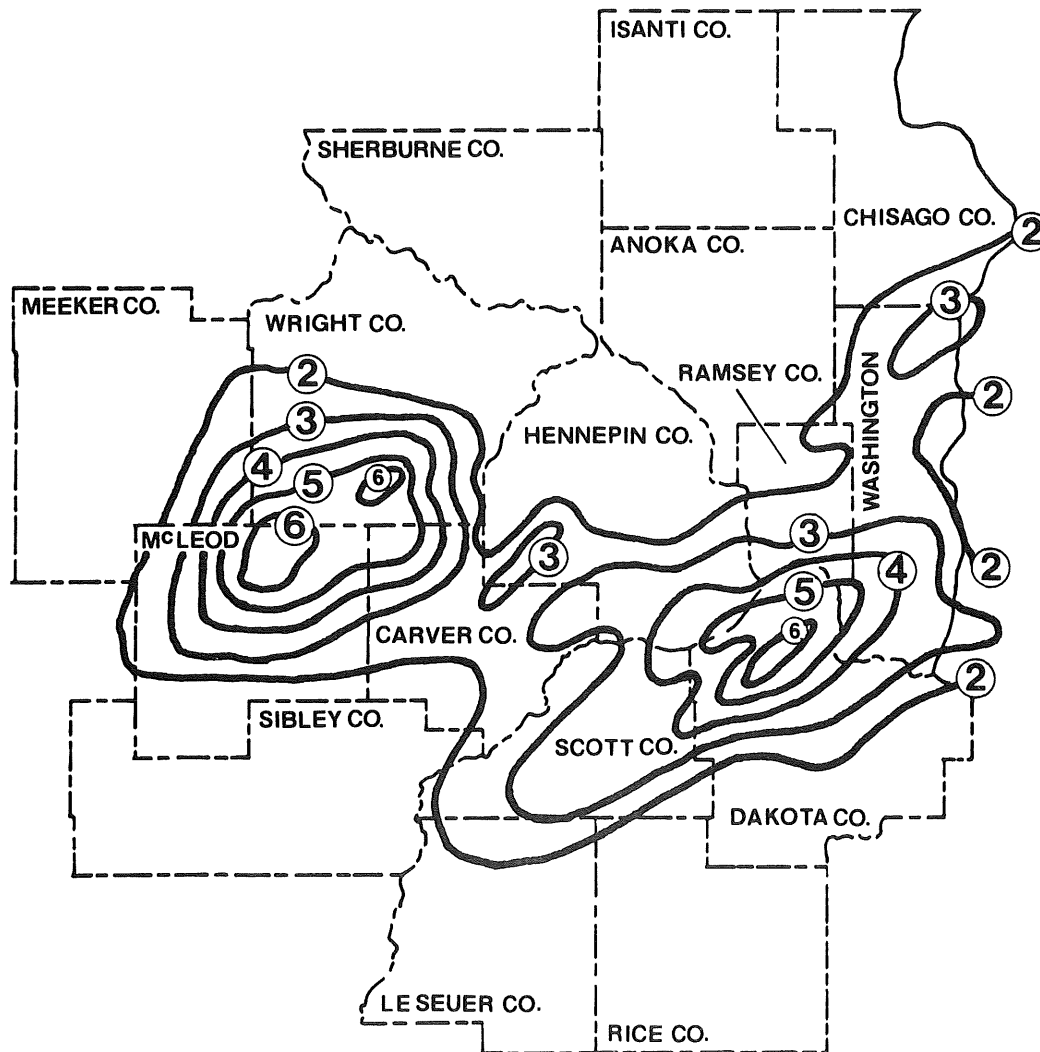
The flash flood at Austin, Minnesota, occurred from heavy rains of 8 inches or more. The rain began at approximately 9:00 PM CDST on July 16 and ended during the early morning hours of July 17. This was the second flash flood to occur in the headwaters of the Cedar River, north of Austin, in 11 days. Both floods resulted in record-breaking flood levels at Austin. The largest amount of rain reported was 9.50 inches in Watham Township (2 miles southwest of Sargeant) in northwestern Mower County. The 4-inch or greater rainfalls were oriented northwest to southeast and covered an area of 160 square miles.

NORTH CENTRAL FLASH FLOOD **(Hubbard, Cass Counties & Duluth)** **August 22-23, 1978**



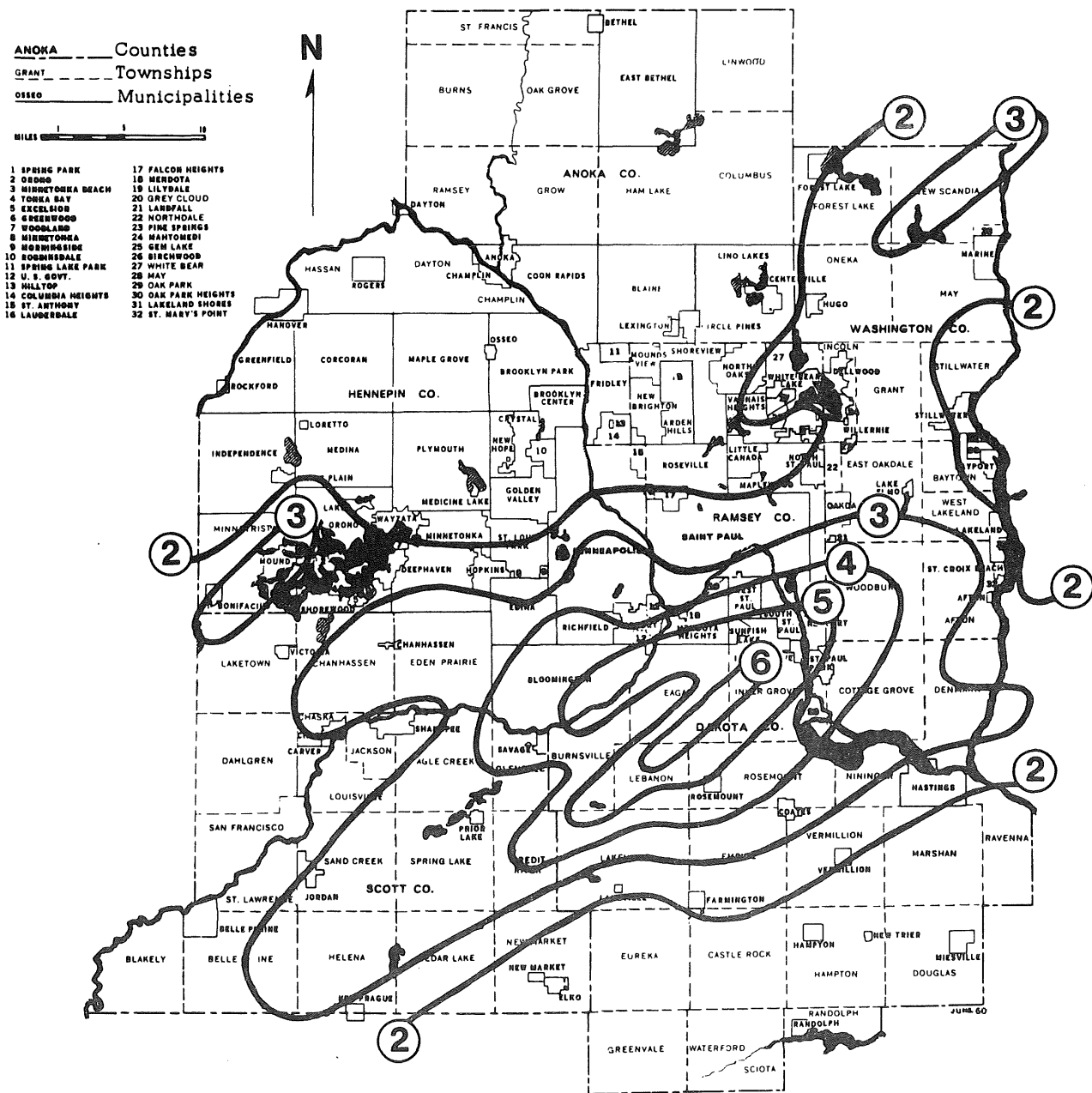
The flash flood in north central Minnesota began in the early afternoon of August 22 in the Bemidji area and about 6 PM in the Duluth area. The rain continued for approximately 12 hours. The greatest amount in one hour at Duluth was 0.86 inches. Two areas received more than 6 inches: an area beginning in east central Hubbard County extending east across the southern part of Leech Lake into Cass County and a second very local area to the west and southeast of the Duluth Airport. The largest amount of rain reported was 6.80 inches near Walker. The 4-inch or greater rainfalls were oriented toward the east at about 100 degrees and covered an area of 4,100 square miles.

EAST-CENTRAL
(McLeod, Wright Counties and Southern Twin Cities)
August 26-27, 1978



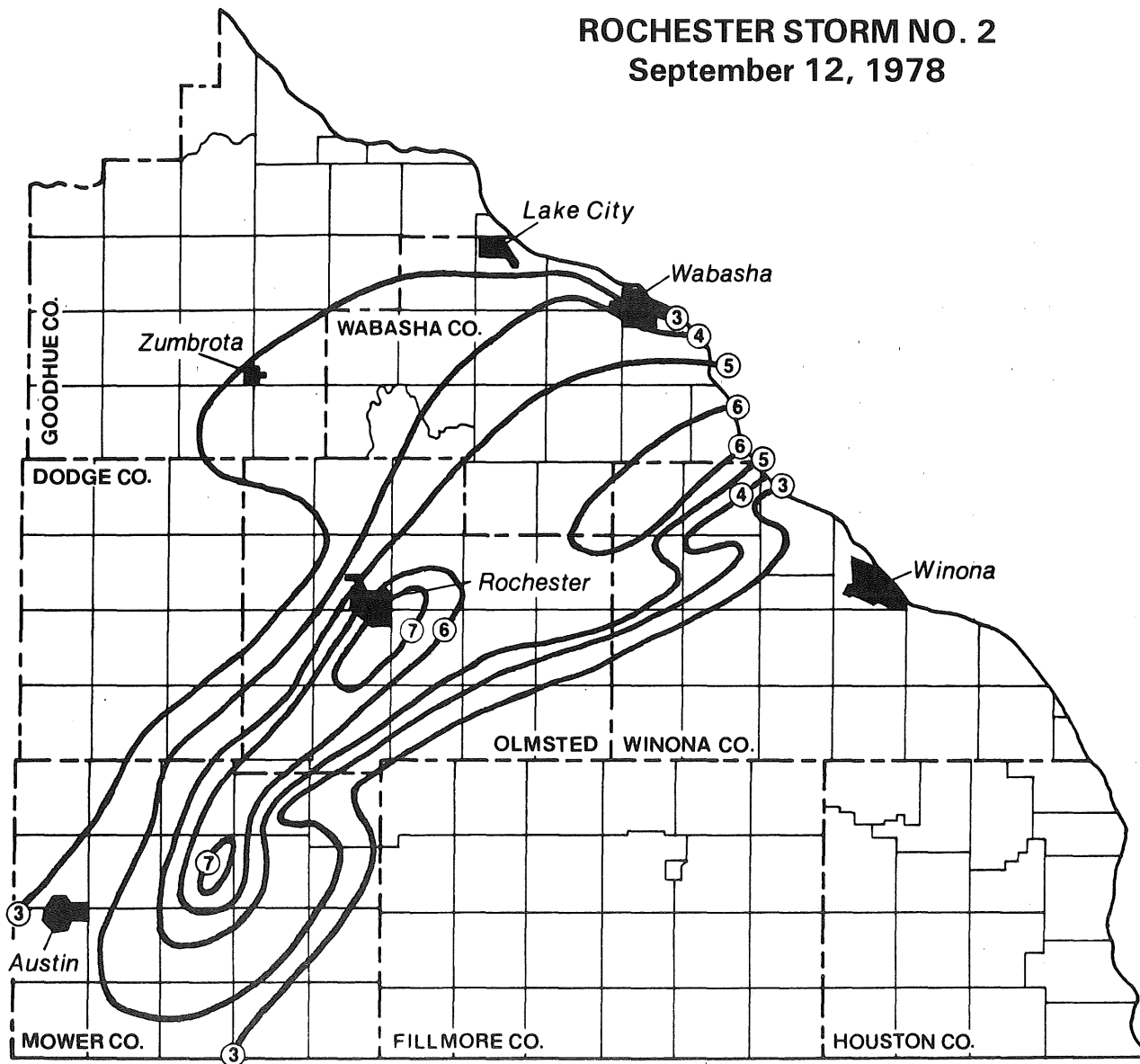
Flash floods occurred in central and east central Minnesota during the evening of August 26 and early morning hours of August 27. The rains began in northern McLeod and southern Wright Counties at 8 PM CDST and ended at about 2 AM August 27. Two small areas received more than 6 inches of rainfall: one area in northern McLeod County and another in southern Wright County. The heavy rains in the southern part of the Twin Cities began just before midnight and continued for about 6 hours. Rainfall amounts of 6 inches or more were received in Apple Valley and Eagan. The 4-inch or more rainfalls covered 365 square miles in McLeod and Wright counties and 265 square miles in the southern Twin Cities area. The map was prepared from 255 reports taken by volunteer observers throughout the area.

EASTCENTRAL FLASH FLOOD (McLeod, Wright Counties & Southern Twin Cities) August 26-27, 1978



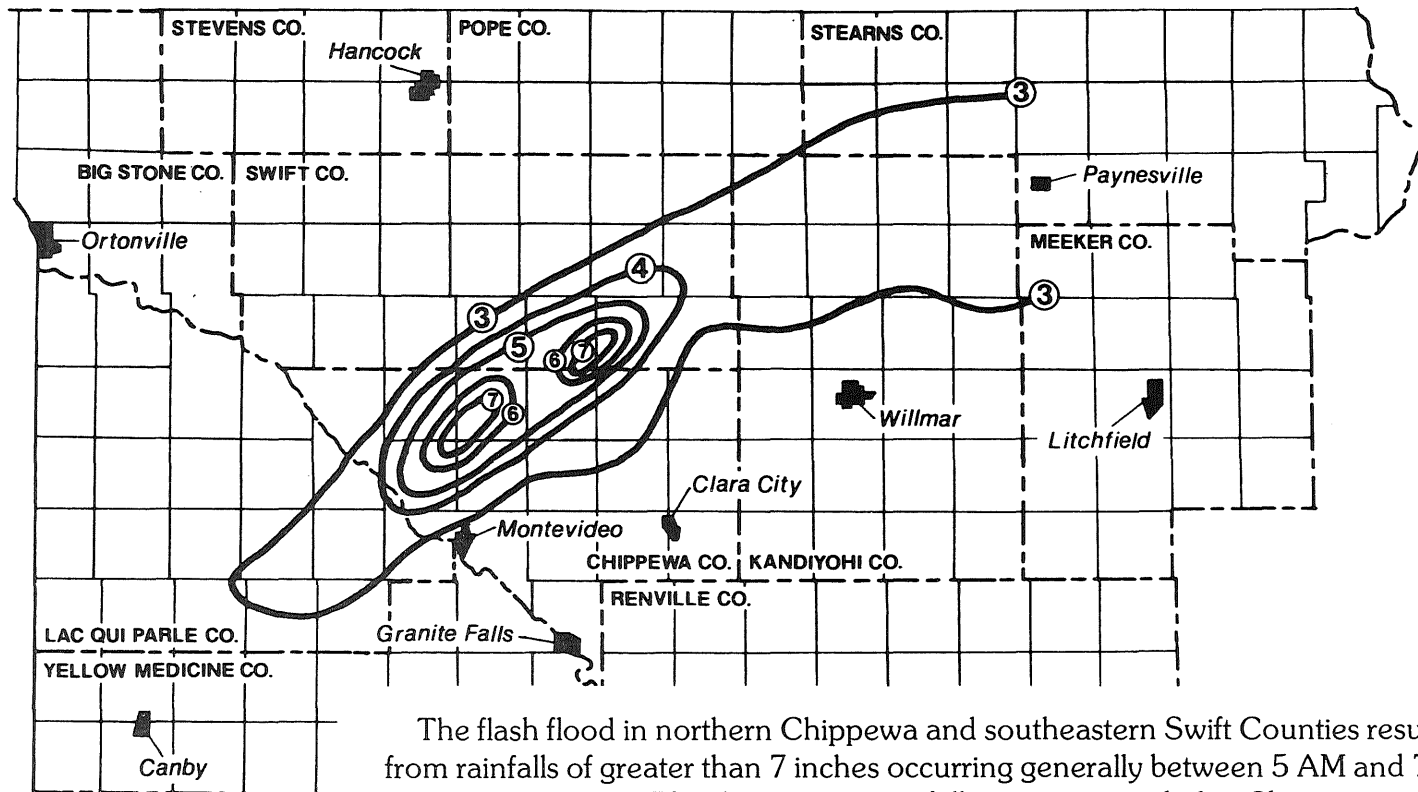
A flash flood occurred in the Twin Cities area during the evening of August 26 and early morning hours of August 27. The heavy rains in the southern part of the Twin Cities began just before midnight and continued for about 6 hours. Rain-fall amounts of 5 inches or more were received in Apple Valley and Eagan. The 4-inch or more rainfalls covered 265 square miles in the Twin Cities area.

ROCHESTER STORM NO. 2 September 12, 1978



The flash flood at Rochester, Minnesota occurred from heavy rains greater than 6 inches. The storm began about 10 AM CDST September 12, 1978 and ended about midnight. The hourly amounts for the first 6 hours, 10 AM to 4 PM, were 0.98", 0.16", 0.94", 0.64", 1.80" and 1.23". The heaviest amount of rainfall reported was 7.07 inches in downtown Rochester. The 4-inch or more rainfall band in Minnesota was about 12-24 miles wide and 80 miles long and covered 1,200 square miles. This was the second flash flood for Rochester during the summer. The July 5-6 flash flood recorded almost 5 inches of rain in 3 hours and this flood was over 5 inches in a 6-hour period.

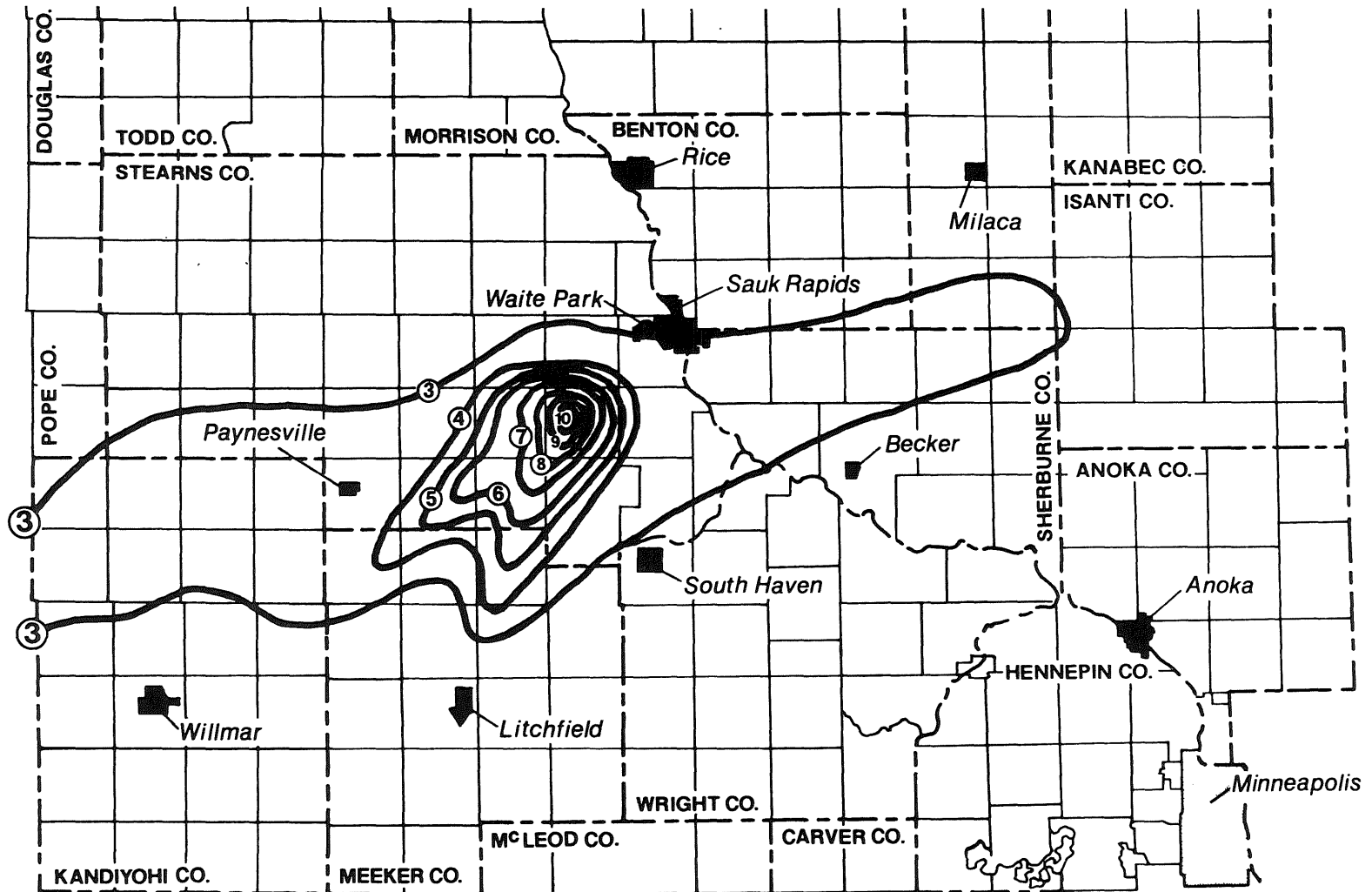
FLASH FLOOD (Northern Chippewa & Southeastern Swift Counties) June 16, 1979



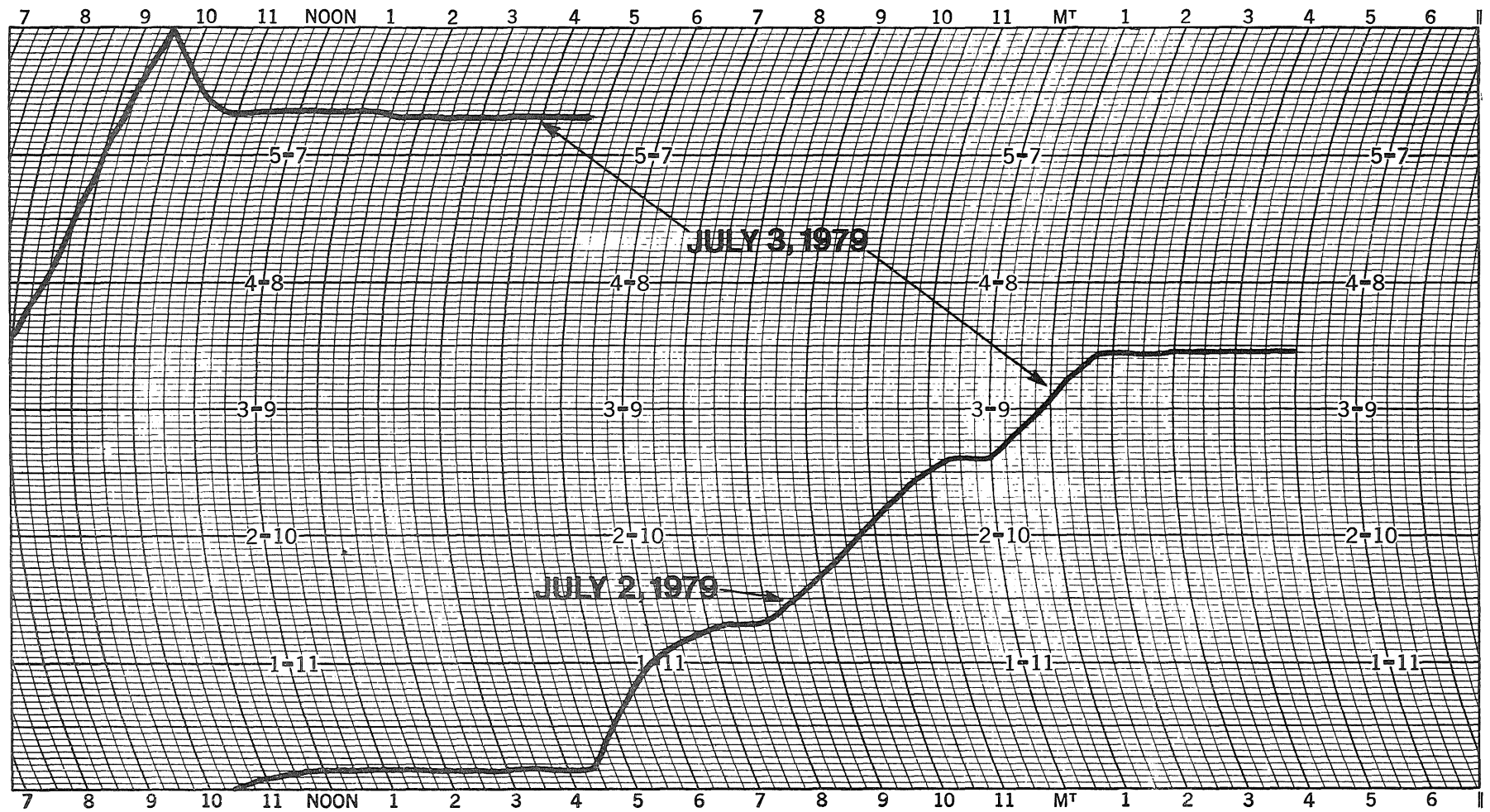
The flash flood in northern Chippewa and southeastern Swift Counties resulted from rainfalls of greater than 7 inches occurring generally between 5 AM and 7 AM on June 16, 1979. The greatest rainfall amount recorded in Chippewa County was 7.3 inches, 8 miles north of Montevideo and in Swift County, 8.1 inches, 6 miles southwest of Murdock. The 4-inch or greater rainfalls covered 260 square miles and defined the flooded area as relatively small compared to other flash flood areas. Basement flooding and some crop damage from erosion and flooding was noted within the area defined as having a 6-inch or greater rainfall.

It is interesting to note that exactly 20 years ago in June 16, 1957 a flash flood occurred over a much larger area of Chippewa and Swift Counties with the maximum precipitation occurring almost within the same isolines that took place in 1979. The maximum amounts in 1957 were 10 inches in Chippewa County and 11 inches in Swift County.

FLASH FLOOD (Southeast Stearns County) June 16, 1979



The flash flood in southeastern Stearns County followed intense rains between 7:30 AM to 9:30 AM on June 16, 1979. The greatest amount of rainfall unofficially noted was over 10 inches near Grand Lake, 2 miles south of Rockville. The 4-inch or greater rainfalls covered an area of 240 square miles. Flooding of roads and basements was common in the heavier rains areas.



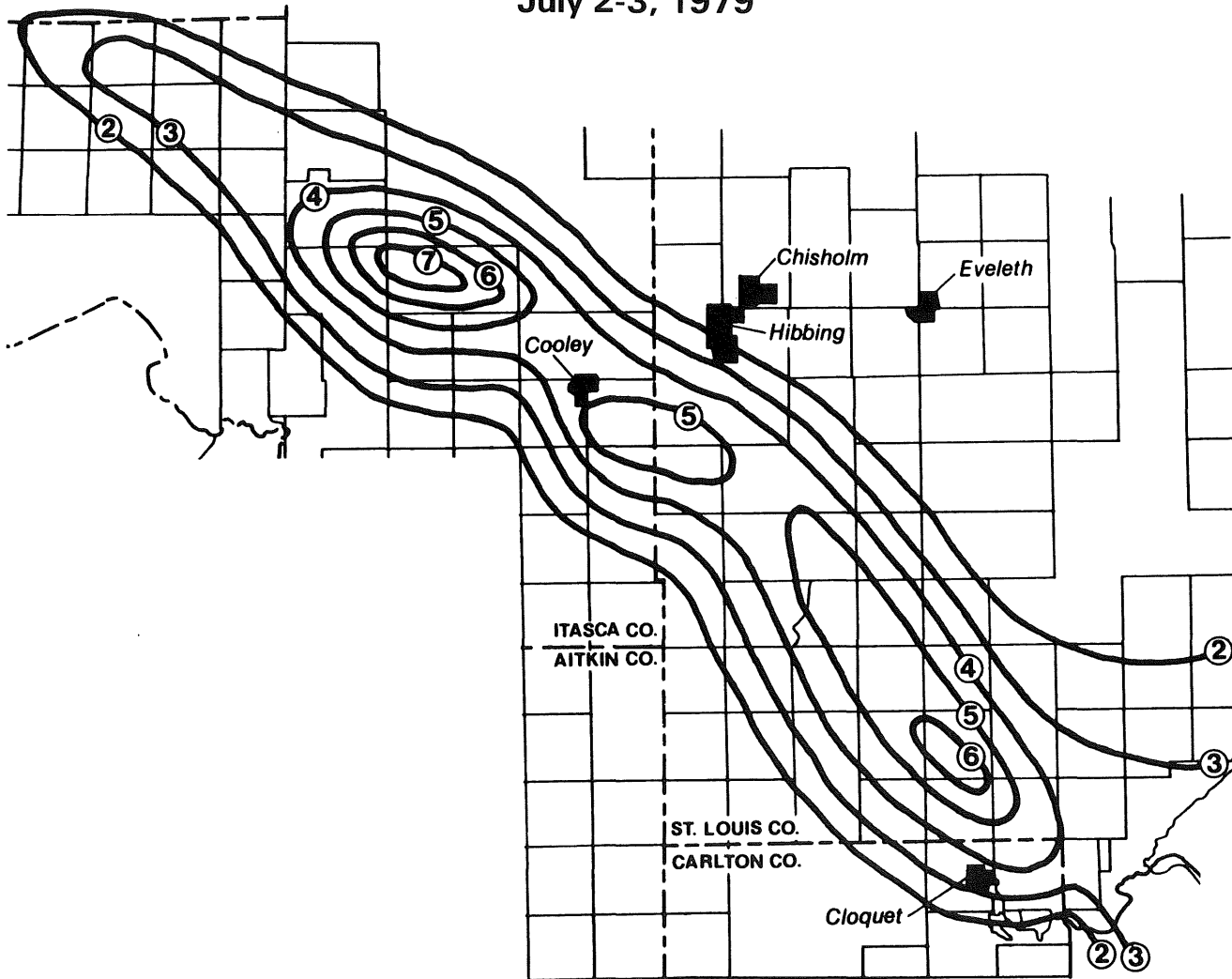
ITASCA COUNTY

Marcel Experimental Forest: **TWP-058N**

RGE-23W SEC-35

RECONSTRUCTED FROM 192-HOUR
(WEEKLY) 12-INCH DUAL TRAVERSE
GAGE

FLASH FLOOD (Central & Eastern Itasca Counties & Southern St. Louis County) July 2-3, 1979



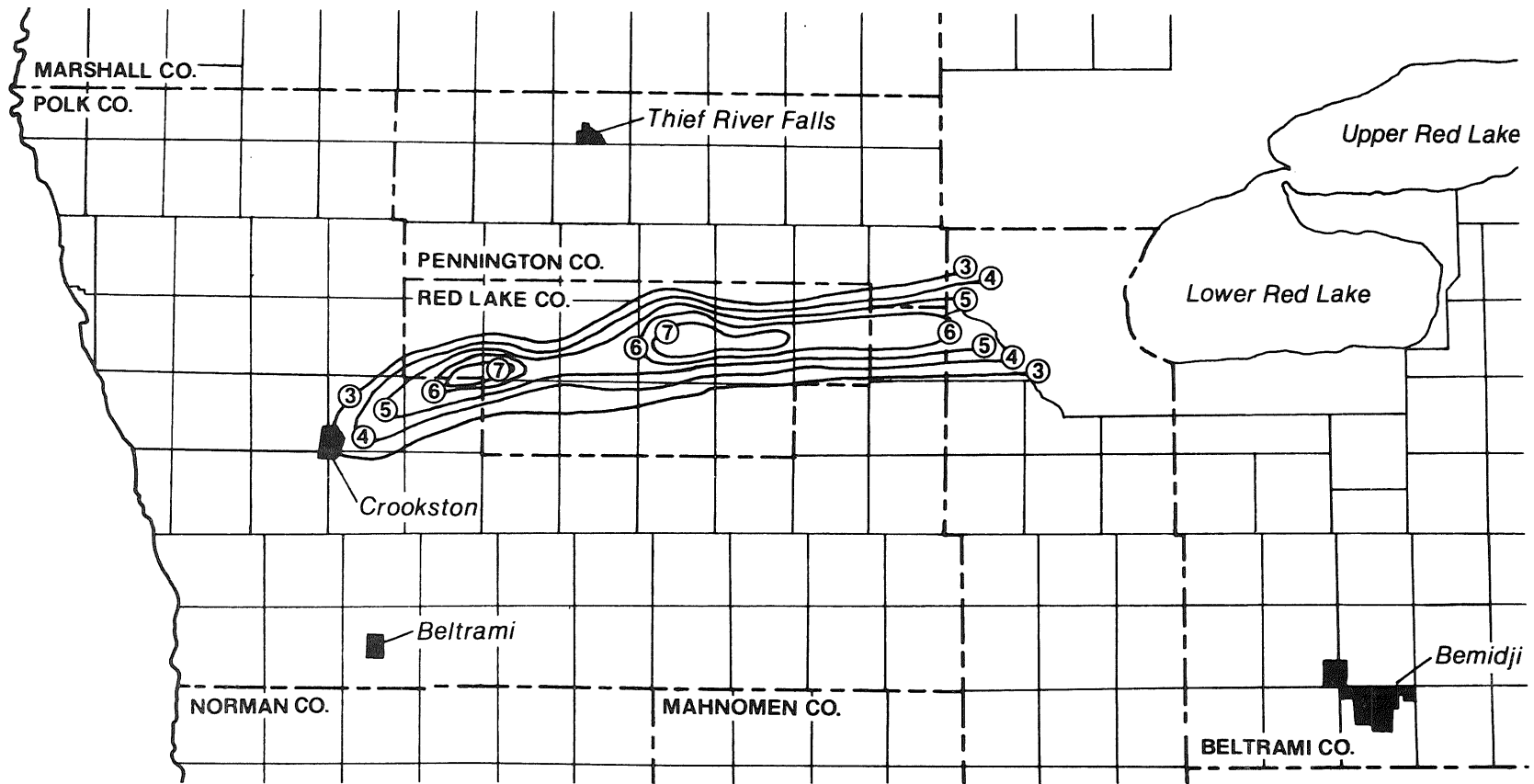
Flash floods occurred in central and eastern Itasca, and southern St. Louis Counties on July 2-3, 1979. The 4-inch or greater rainfalls were contained within a narrow band extending from north of Grand Rapids southeast 90 miles into the western suburbs of Duluth and covered an area of 935 square miles.

The rains fell between 10 AM on July 2 and 12 PM on July 3, most of it falling in two periods. Three and 16 hundredths inches fell between 4 PM on July 2 and 2 AM on July 3, and 3.4 inches fell between 7 AM and 11 AM on July 3.

There were three areas with rainfalls of greater than 5 inches. The first was in the Marcel Experimental Forest, 20 miles north of Grand Rapids with an observer on Spider Lake reporting 7.41 inches; the second was in the Swan Lake area, 6 miles south of Nashwauk in St. Louis County with an observer on Swan Lake reporting 5.75 inches; and the third was an elongated area from Meadowlands to west of Duluth with an observer on Grand Lake reporting 6.59 inches.

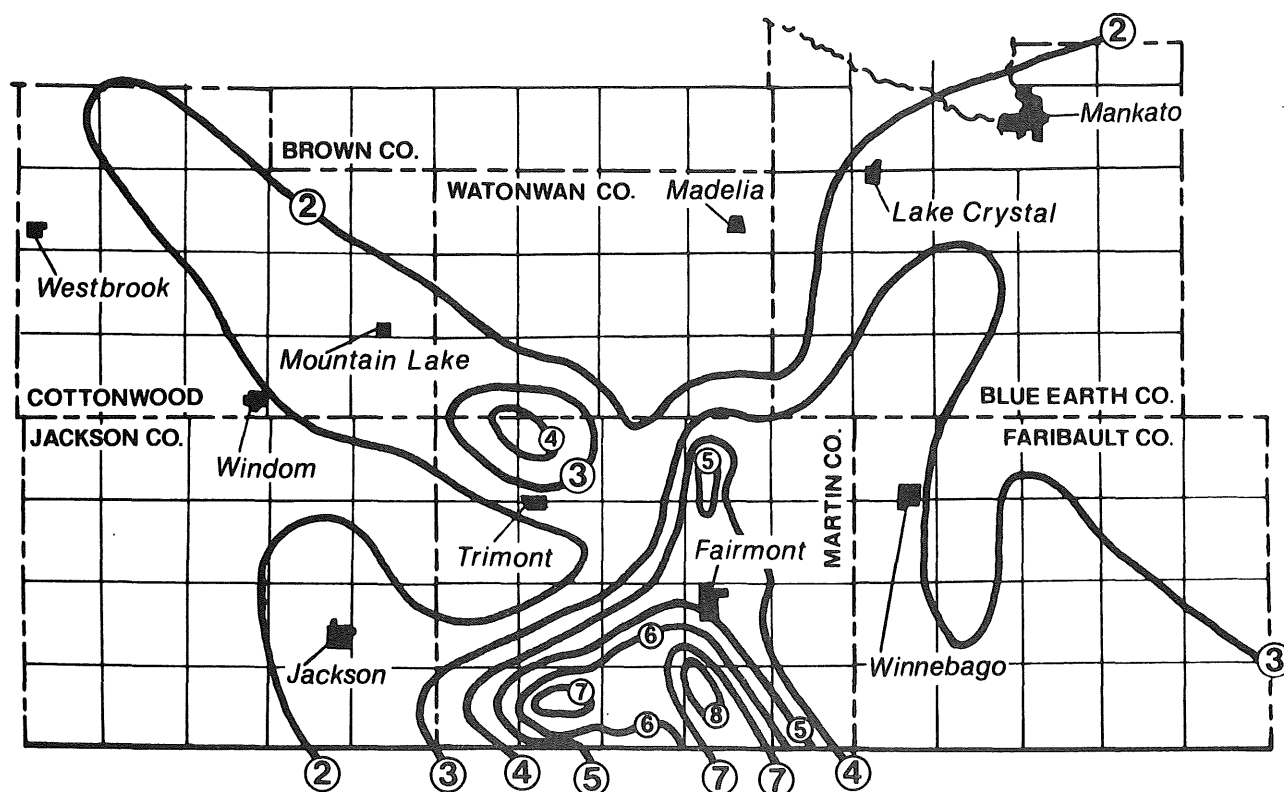
The heavy rains damaged roads and flooded basements.

FLASH FLOOD (Red Lake County) July 30, 1979



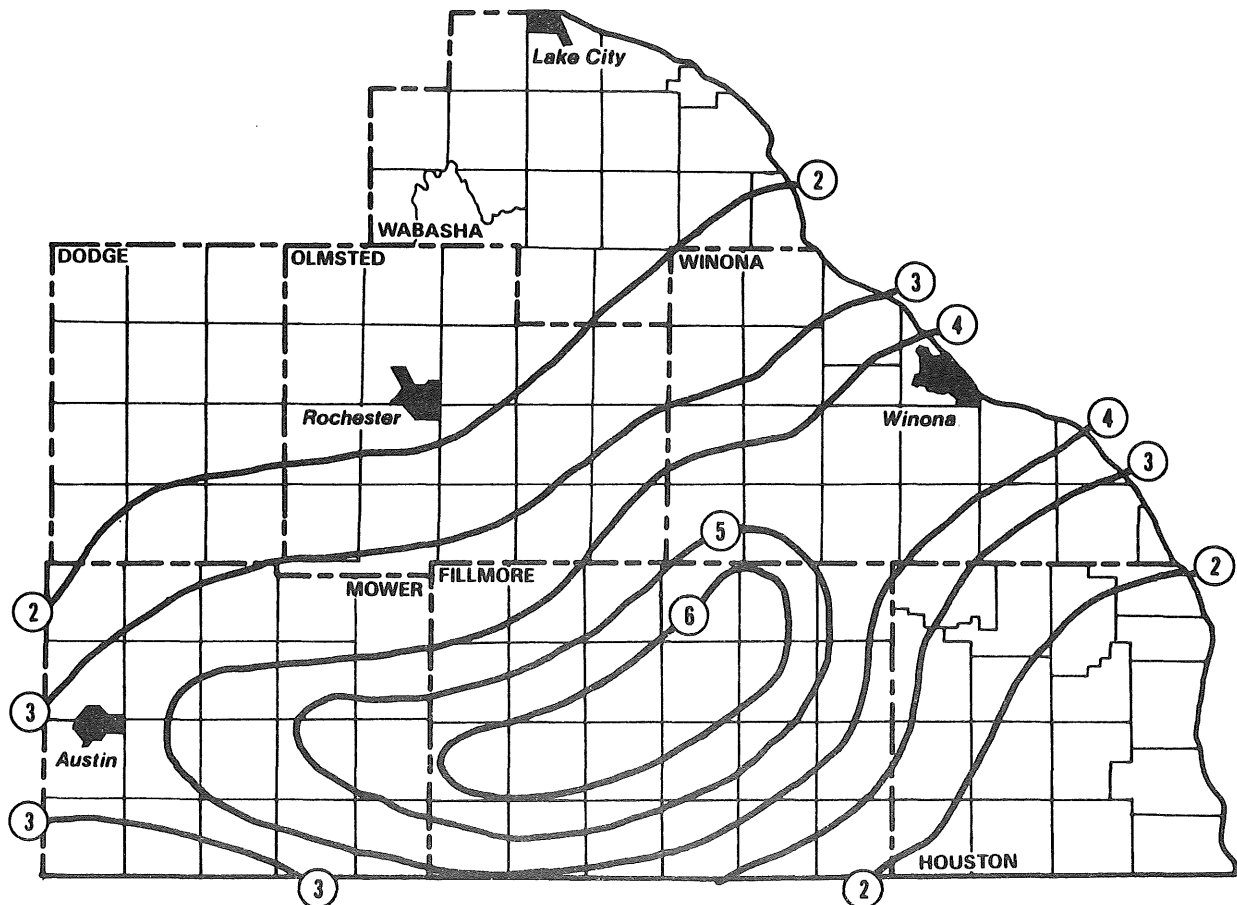
Flash floods in Red Lake County on the morning of July 30, 1979 resulted from heavy rainfall between 5 AM and 8 AM. The greatest rainfall recorded by the Soil and Water Conservation District Rain Gage network was 6.04 inches in western Equality Township about 3 miles north of Oklee. However, several unconfirmed reports of greater than 7 inches of rain are considered to be valid. The 4-inch or greater rainfalls covered an area of about 205 square miles. Some flooding of roads and basements occurred in the heavier rainfall areas and harvesting was delayed in these areas as well.

FLASH FLOOD (Southern Martin County) August 20-21, 1979



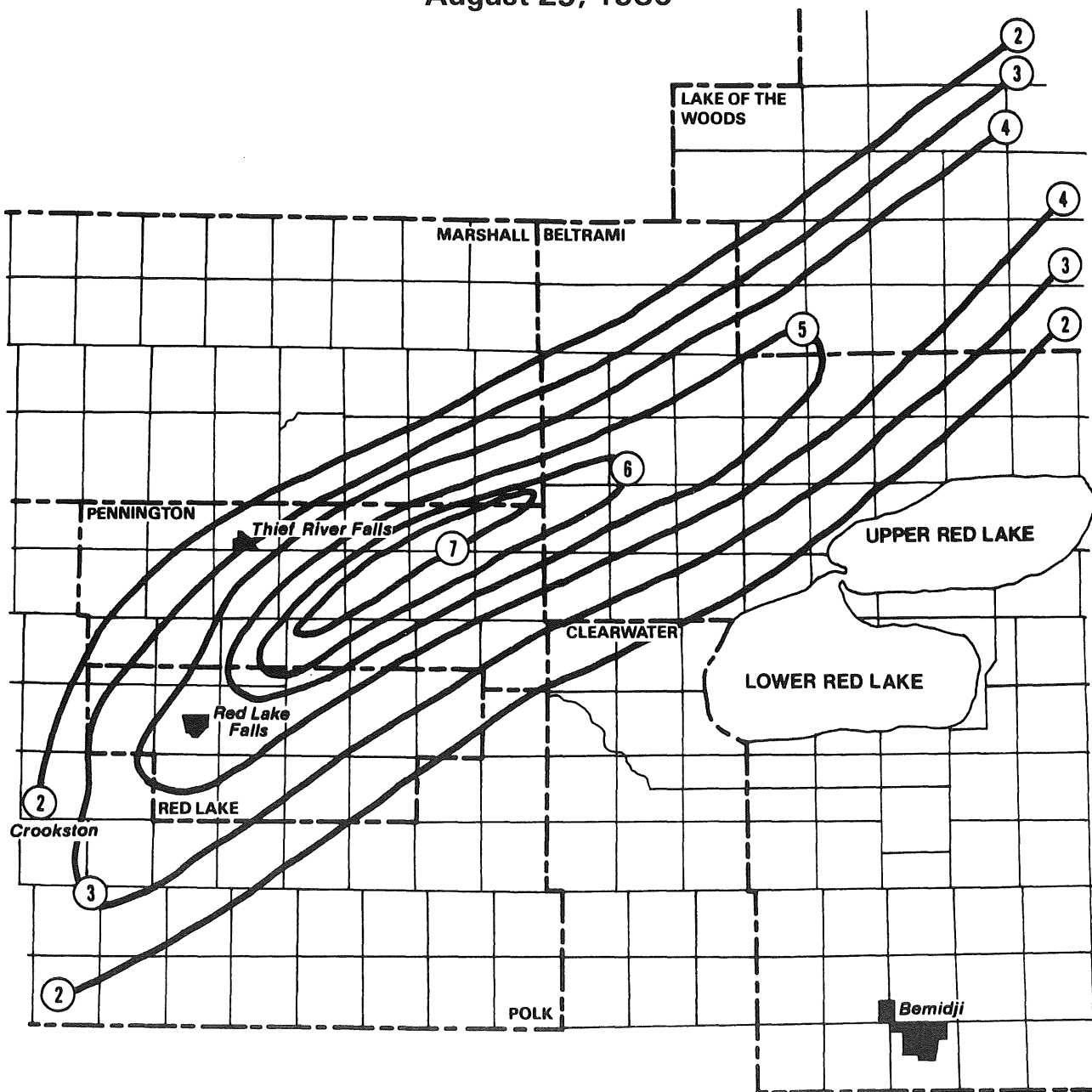
A flash flood occurred on August 20 and 21, 1979 in an area extending from Fairmont to Ceylon then southeast to Armstrong, Iowa. This flooding resulted from rain which fell between 7:00 and 10:00 PM on August 20. The greatest rainfall recorded was 8.5 inches in northwest Silver Lake Township. Four inches or more of rain occurred over an area in Minnesota of about 250 square miles with an additional area in Iowa. The heavy rains caused basement flooding, damage to secondary roads and crop losses. Some roads were under water into October.

FLASH FLOOD (Fillmore, Mower & Winona Counties & Wisconsin) May 29-30, 1980



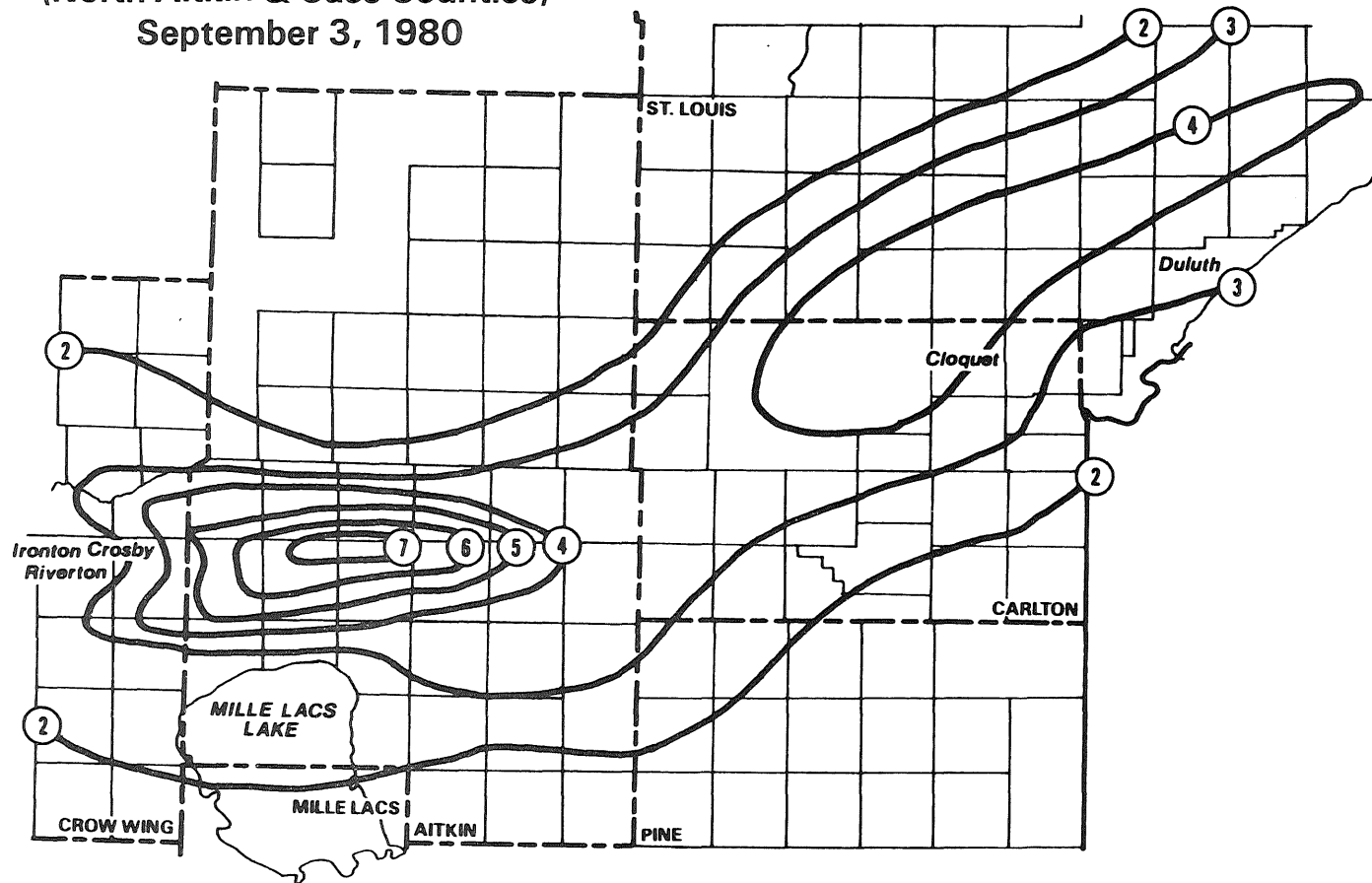
The flash flood in Fillmore County occurred between 8 PM on May 29th to 5 PM (LST) on May 30th. However, most of the rains fell between 8 PM and midnight on the 29th and the afternoon of the 30th. The heaviest amount recorded for the period was 6.65 inches in southwest Forestville township, Fillmore County. The 4-inch or more rain began in central Mower County east through Fillmore County and northeast through central Winona County and covered an area of 1,200 square miles.

FLASH FLOOD (Pennington County) August 29, 1980



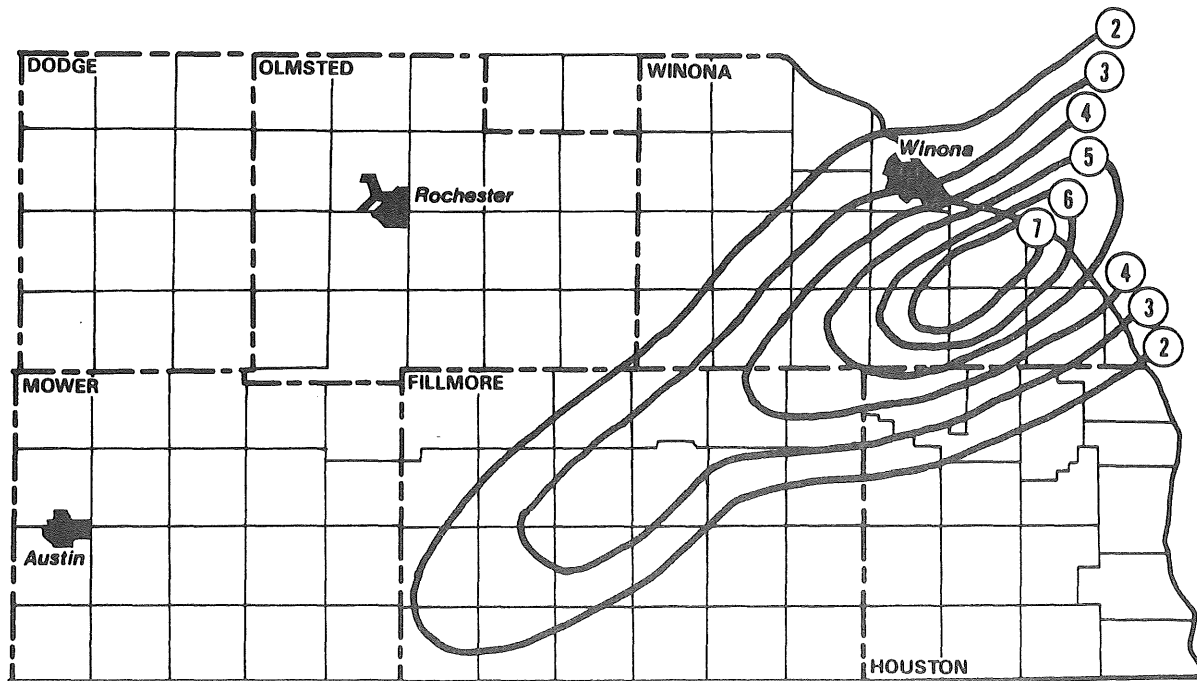
A flash flood through Pennington County began about 7 AM and ended about 8 PM on the 29th of August, 1980. The greatest rainfall recorded by the Soil and Water Conservation network was 6.8 inches in River Falls Township, Pennington County. However, several unconfirmed reports of 7 inches were reported and are considered to be valid. The 4-inch or greater rainfall covered a 15-mile wide band from Red Lake Falls to Baudette, an area about 1,200 square miles. Flooding damage was light because of the long spring and summer dry spell. However, the rains did delay harvests in the area.

FLASH FLOOD
(North Aitkin & Cass Counties)
September 3, 1980



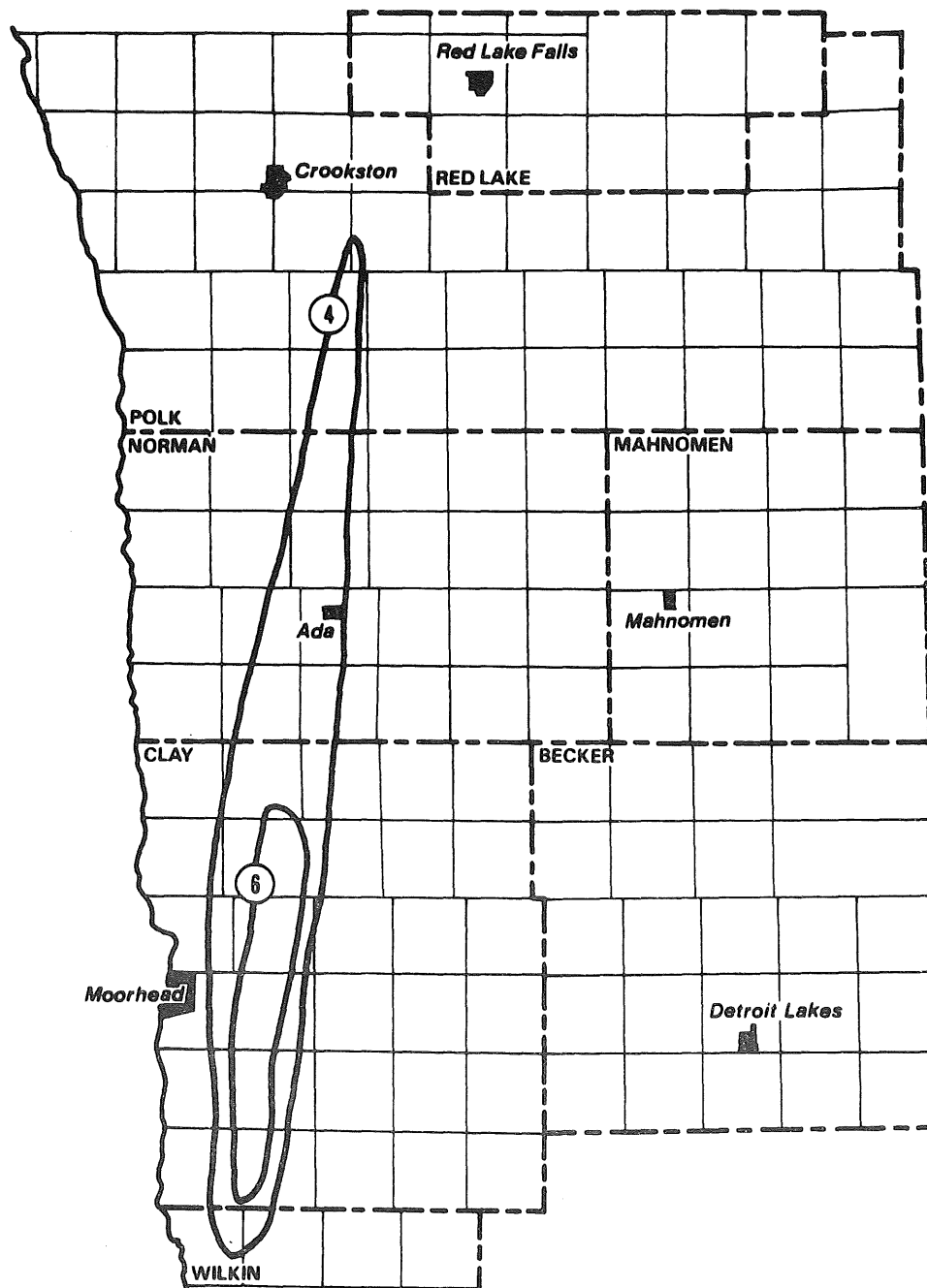
This flash flood occurred on 3 September, 1980 through central Aitkin County and heavy rains of 4 inches or more occurred in northern Carlton and southern St. Louis Counties. Most of the rains in Aitkin County occurred between 3 and 7 AM CDST, while the heavy rains in northern Carlton and southern St. Louis Counties and along the north shore in Lake County occurred between 5 PM and 11:30 PM CDST. The heaviest amount recorded in the Aitkin County flash flood was 7.27 inches in northwest Glen Township. The 4-inch and greater rainfalls in the Aitkin flash flood covered an area of 325 square miles and 400 square miles in the heavy rain area in Carlton and St. Louis Counties.

FLASH FLOOD
(Fillmore & Winona Counties)
September 20, 1980



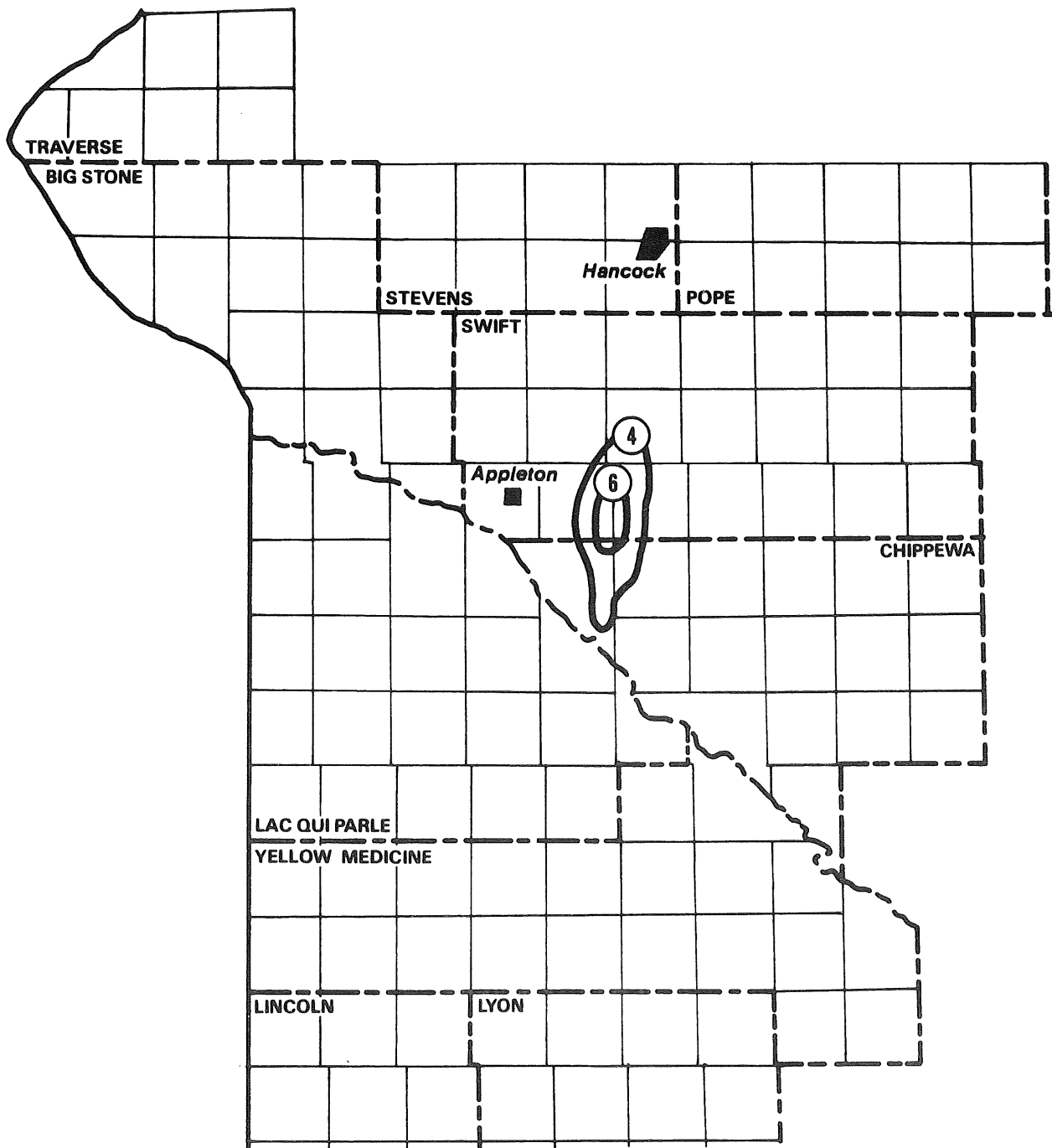
A flash flood occurred on September 20, 1980 through central Fillmore and southern and southeast Winona Counties. Most of the rain fell between 7:30 PM and 11:15 PM CDST. The heaviest amount recorded was 7.45 inches in southwest Homer township in Winona County. This flash flood occurred at the end of the wettest August and September rainfall amounts ever recorded in Winona, Fillmore and Houston Counties. Most of the flash flood area recorded 18 to 21 inches of precipitation for the two months. The 4-inch and greater rainfalls covered an area of 260 square miles in Minnesota. The small town of Pickwick suffered the greatest flood damage.

FLASH FLOOD
(Clay & Norman Counties)
May 22, 1981



This flash flood in Clay and Norman Counties began about 2 PM on the 22 May 1981, and ended about midnight. The greatest amount reported was 8.59 inches, about 1 mile east of Sabin. The 4-inch and greater area covered 415 square miles and the 6-inch and greater area covered 105 square miles.

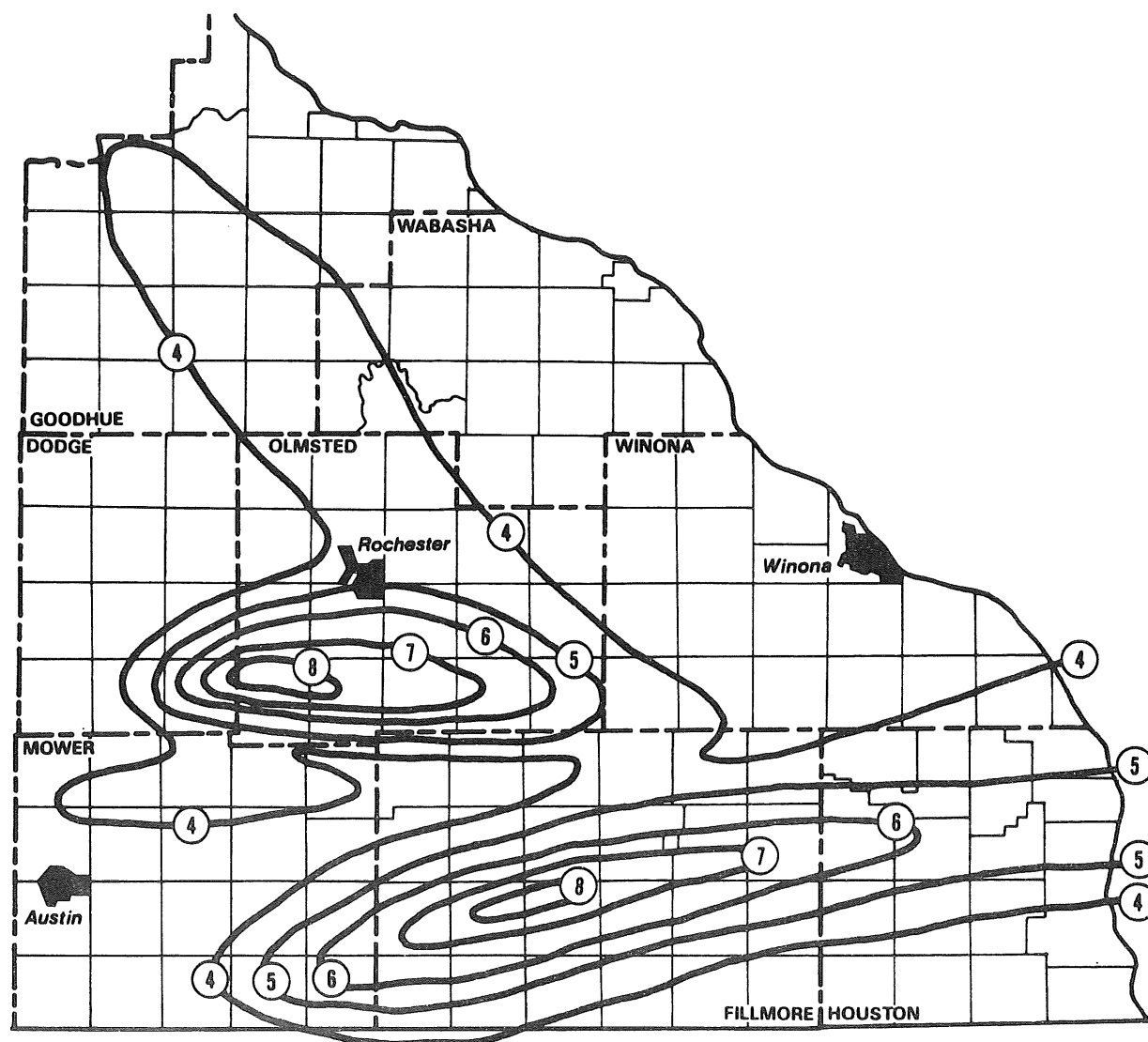
**FLASH FLOOD
(Swift & Chippewa Counties)
May 23, 1981**



The flash flood in Chippewa-Swift counties began during the late evening of May 23, 1981 and ended about midnight. The greatest amount reported was 7 inches, 3 miles north of Milan. The 4-inch and greater area covered 50 square miles.

ROCHESTER III & PRESTON FLASH FLOODS

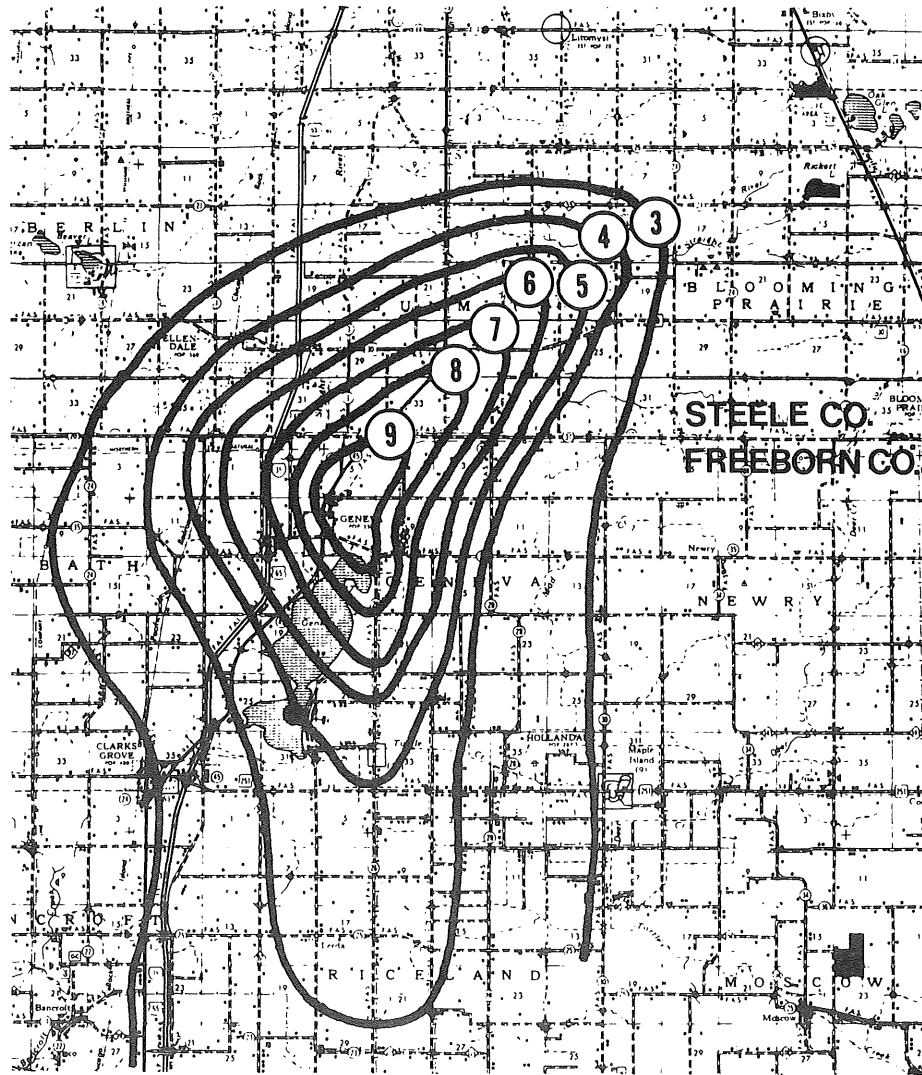
July 11, 1981



The Rochester III flash flood is the third 100-year type storm to occur at Rochester since July 5, 1978. (Six inches or more is considered a 100-year event). The flash flood on July 11, 1981 occurred generally in the southern part of Olmsted County and included the southern part of Rochester. About 6 inches of rain fell between 2 AM and 9 AM LDST. The National Weather Service (NWS) Station at Rochester Airport received a record-breaking 7.47 inches within a 24-hour period. An unofficial 11.04 inches was measured 7 miles west of the airport. The 4-inch or more rainfall area covered about 540 square miles, which was the smallest area of the three storms.

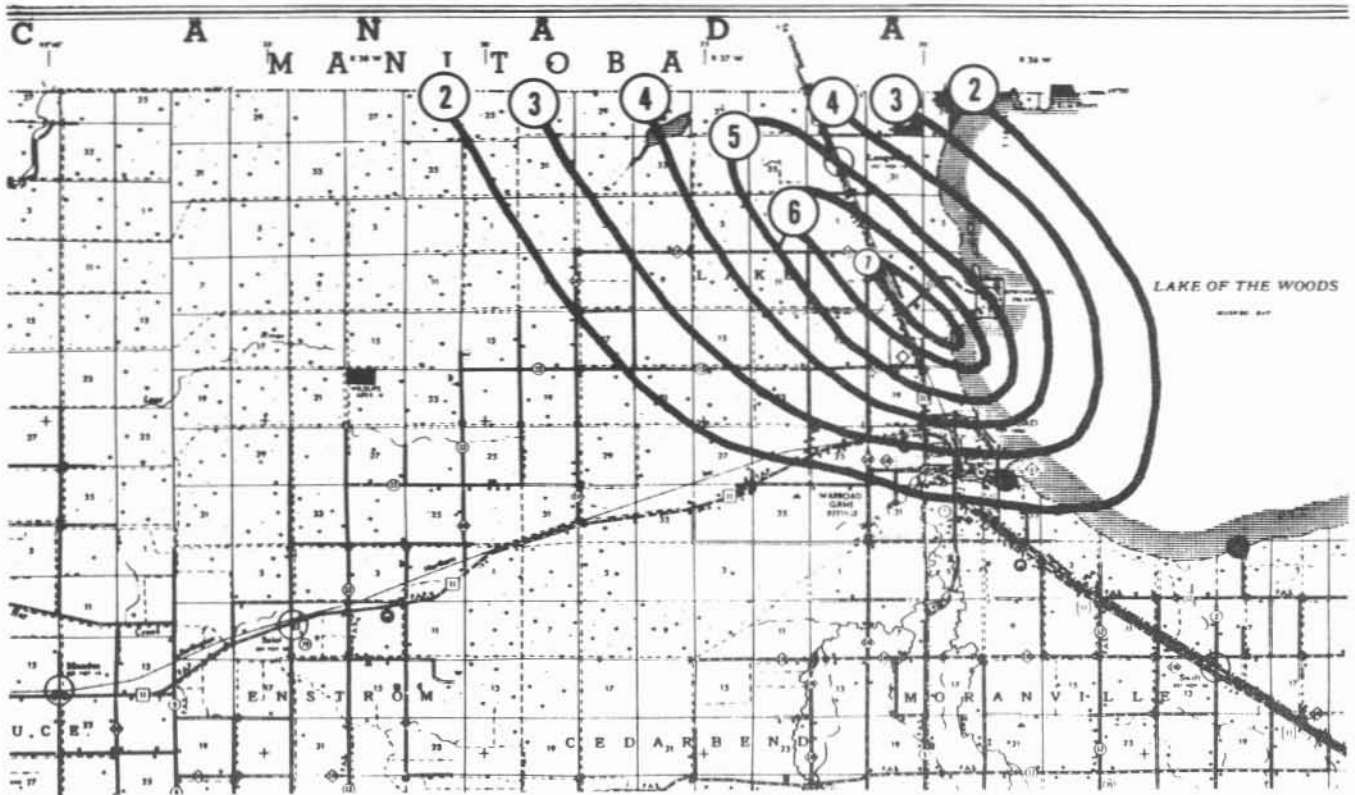
The Preston flash flood is the fourth 100 year-type storm to occur within Fillmore, Houston and southern Winona Counties since July 1, 1978. Preston reported 7.70 inches of rain within a 24-hour period. However, 5.70-inches fell between 3:40 and 6:00 AM LDST. The 4-inch or more rainfall area covered about 1080 square miles within Minnesota. The map was prepared from about 80 reports received from the NWS, DNR-Soil and Water Conservation Districts and the Future Farmers of America.

GENEVA FLASH FLOOD
(Steele & Freeborn Counties)
August 25-26, 1981



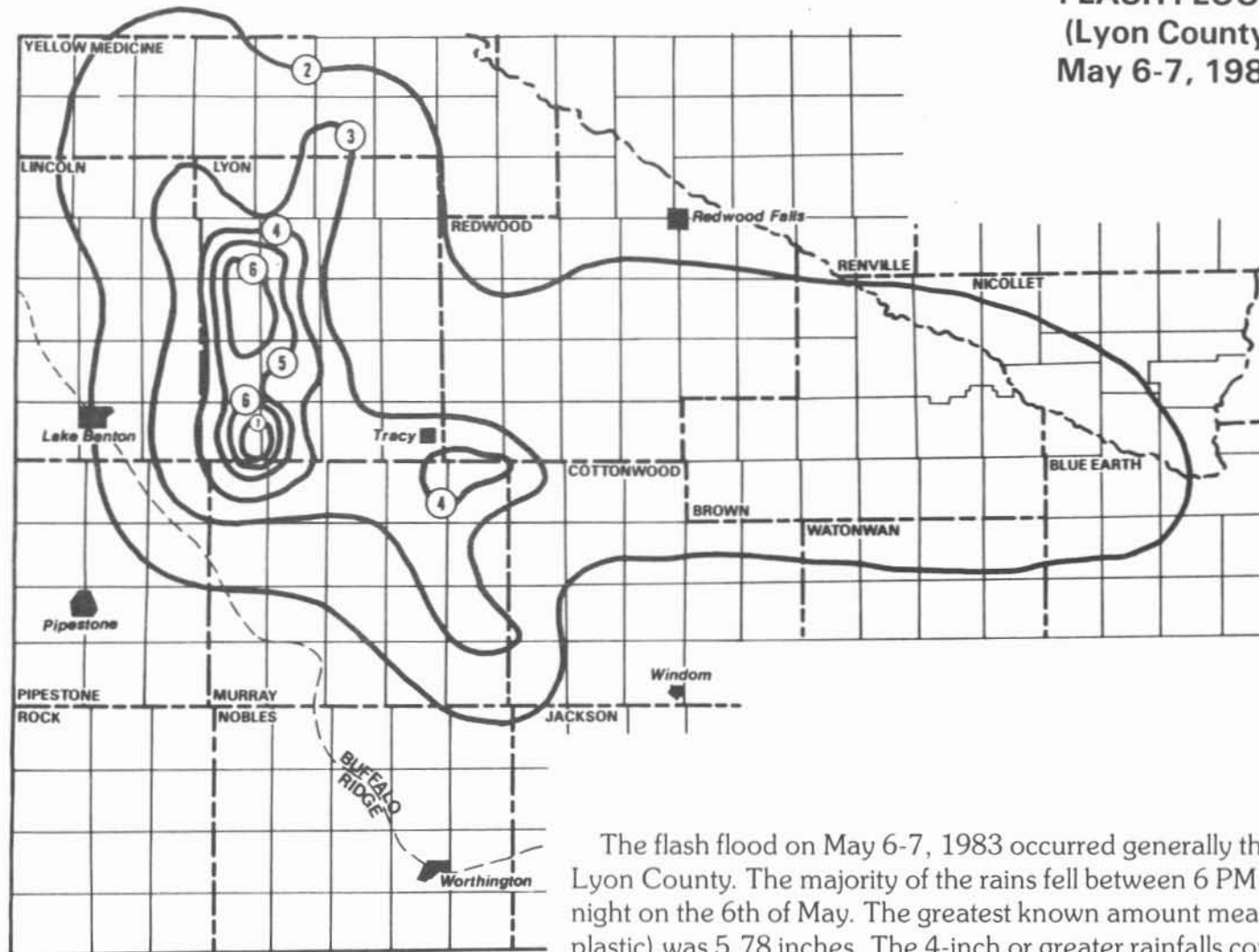
The Geneva flash flood occurred in southern Steele and northern Freeborn Counties. The storm began at 7:30 PM August 25th and ended at 1:00 AM on August 26, 1981. There were 27 reports used in the analysis; the greatest amount was 9.4 inches within the town of Geneva. The flash flood covered a small area but caused considerable crop damage particularly to the potato farmers. This, in part, was do to the wet conditions existing prior to the flash flood. The 4-inch rainfalls covered an area of 60 square miles.

WARROAD FLASH FLOOD (Roseau County) July 15, 1982



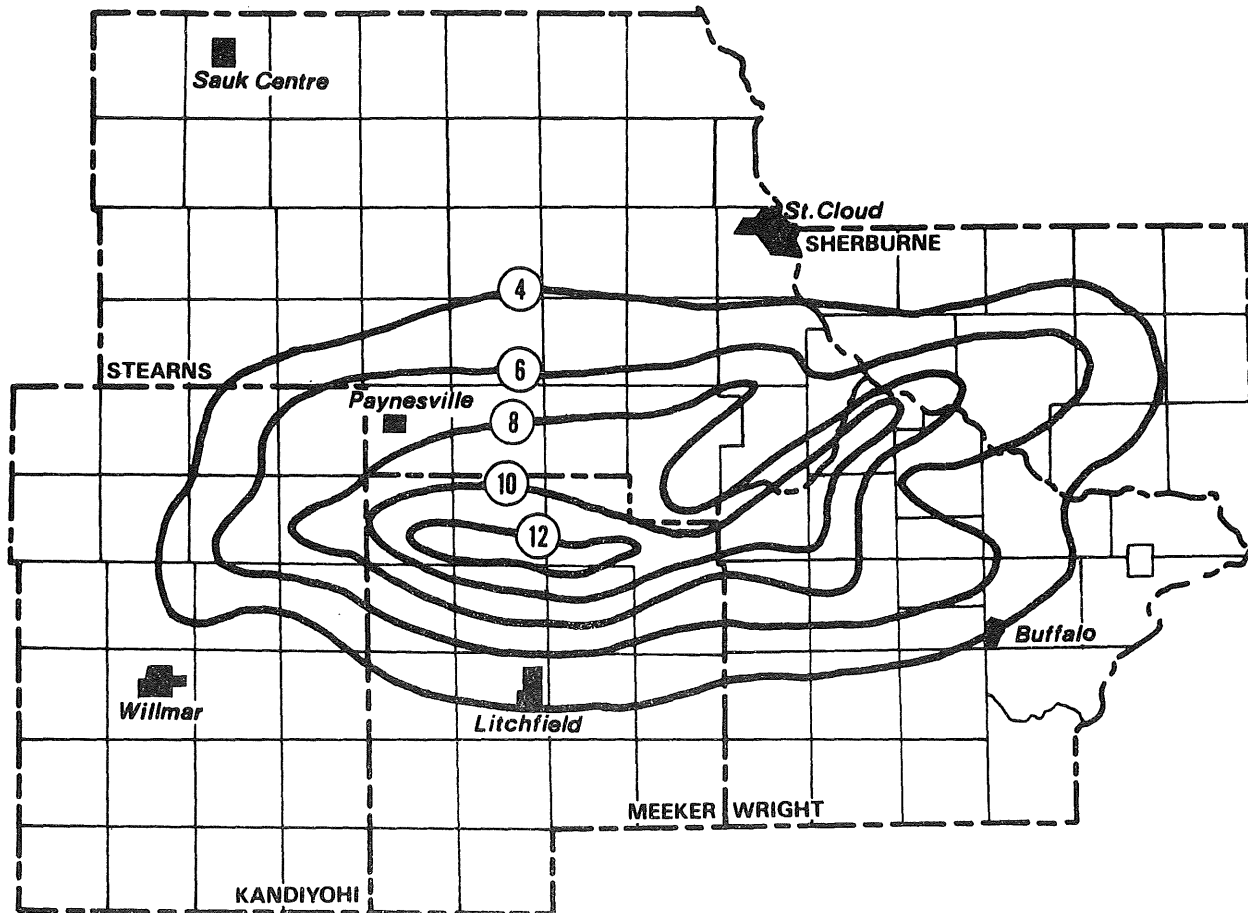
A Flash flood on July 15, 1982 occurred generally north of Warroad and extended into Canada, between 3 AM and 6:30 AM. The greatest rainfall recorded was 4.87 inches on Springsteel Island. Several flood unofficial reports stated 6 to 7 inches. This flash flood was quite small in that only 26 square miles received 4 inches or more of rainfall, while typical flash floods cover about 800 square miles. Some flooding damage to homes occurred and several fishing-type boats were sunk along the Lake of Woods shoreline from the wind and heavy rains.

FLASH FLOOD (Lyon County) May 6-7, 1983



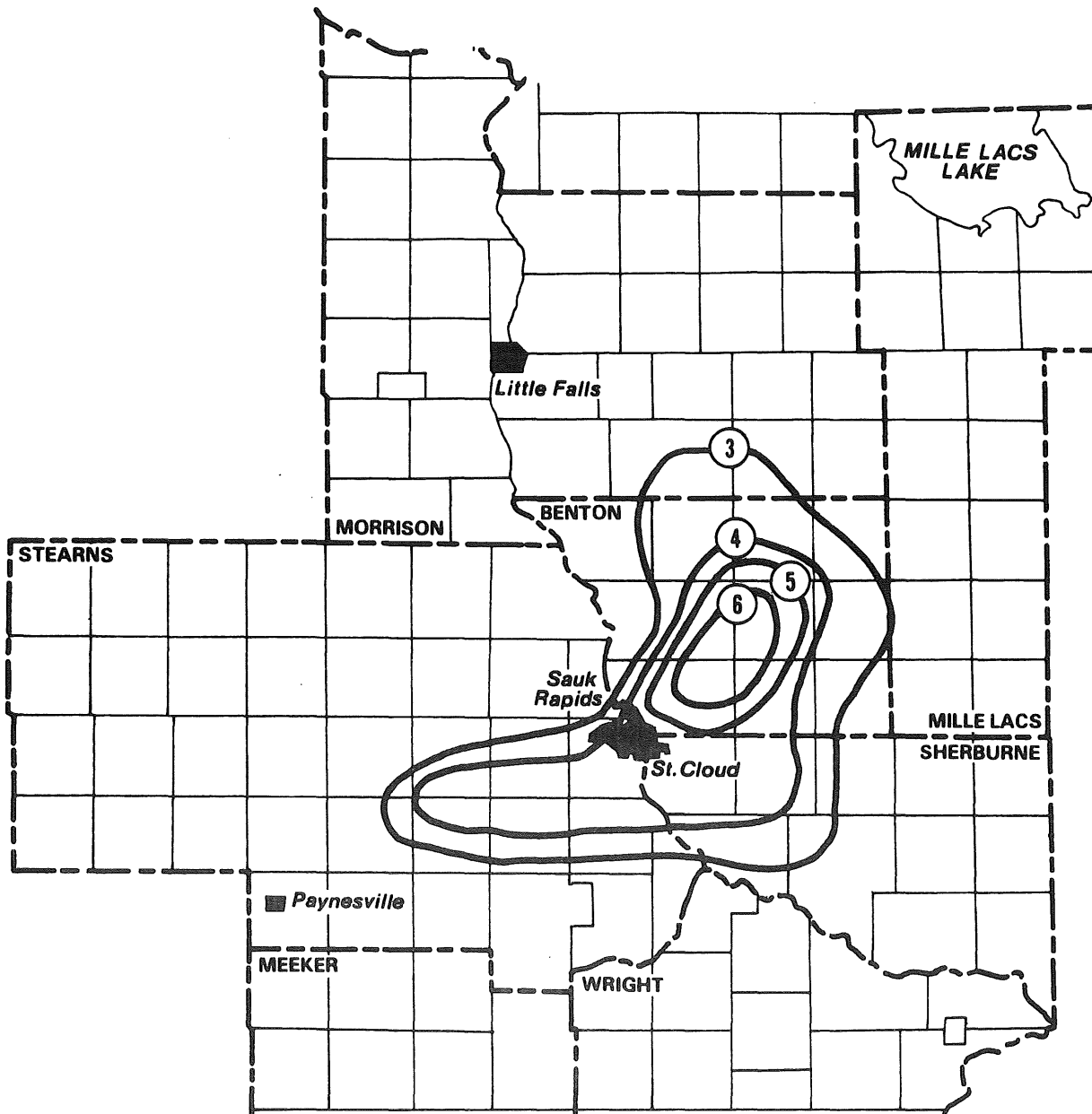
The flash flood on May 6-7, 1983 occurred generally thru most of western Lyon County. The majority of the rains fell between 6 PM and 10 PM on Friday night on the 6th of May. The greatest known amount measured in a rain gage (4" plastic) was 5.78 inches. The 4-inch or greater rainfalls covered an area of 265 square miles. The map was prepared from 51 reports. Downstream flooding was reported on the Cottonwood, Redwood and Yellow Medicine Rivers.

FLASH FLOOD
(Kandiyohi, Meeker, Stearns, Wright
& Sherburne Counties)
June 21, 1983



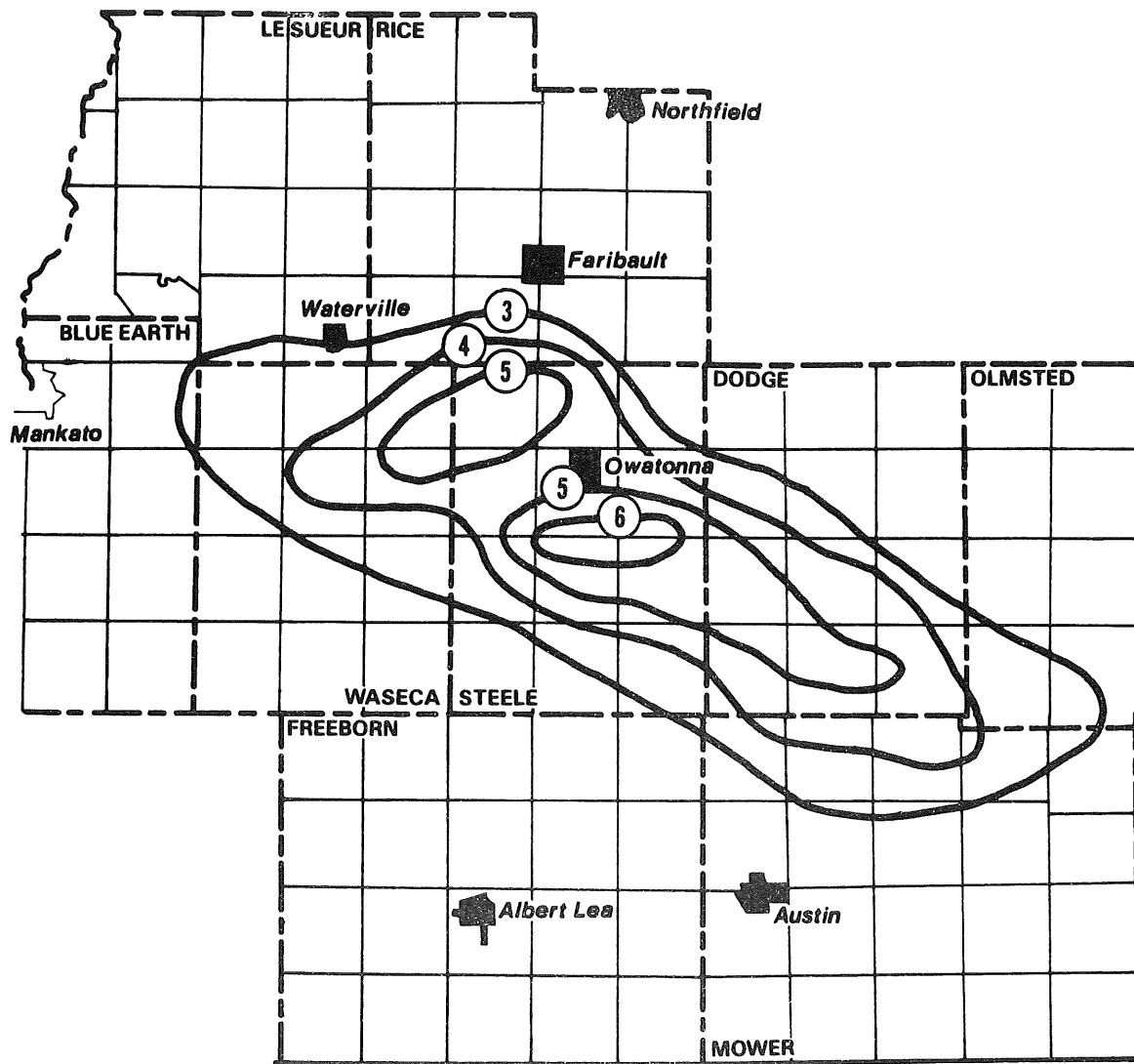
This flash flood occurred on June 21, 1983 and extended across 5 counties (Kandiyohi, Meeker, Stearns, Wright and Sherburne). Much of the rains fell in two periods, the first from 2 AM to 6 AM and the second from 11 AM to 2 PM. The greatest amount recorded in a Soil and Water Conservation District rain gage (4 inch dia, 11 inch high, plastic) was 9.68 inches, one mile west of Watkins in Meeker County. However, there were 3 locations in Meeker County that farmers reported an unofficial 12 inch amount. Four inches or more of precipitation occurred over a 1,330 square mile area, compared to 700 to 800 square miles for a typical flash flood (Rochester 1978). This report was prepared from 71 reports collected by the SWCD's in the above 5 counties.

FLASH FLOOD
(Stearns, Sherburne & Benton Counties)
June 25-26, 1983



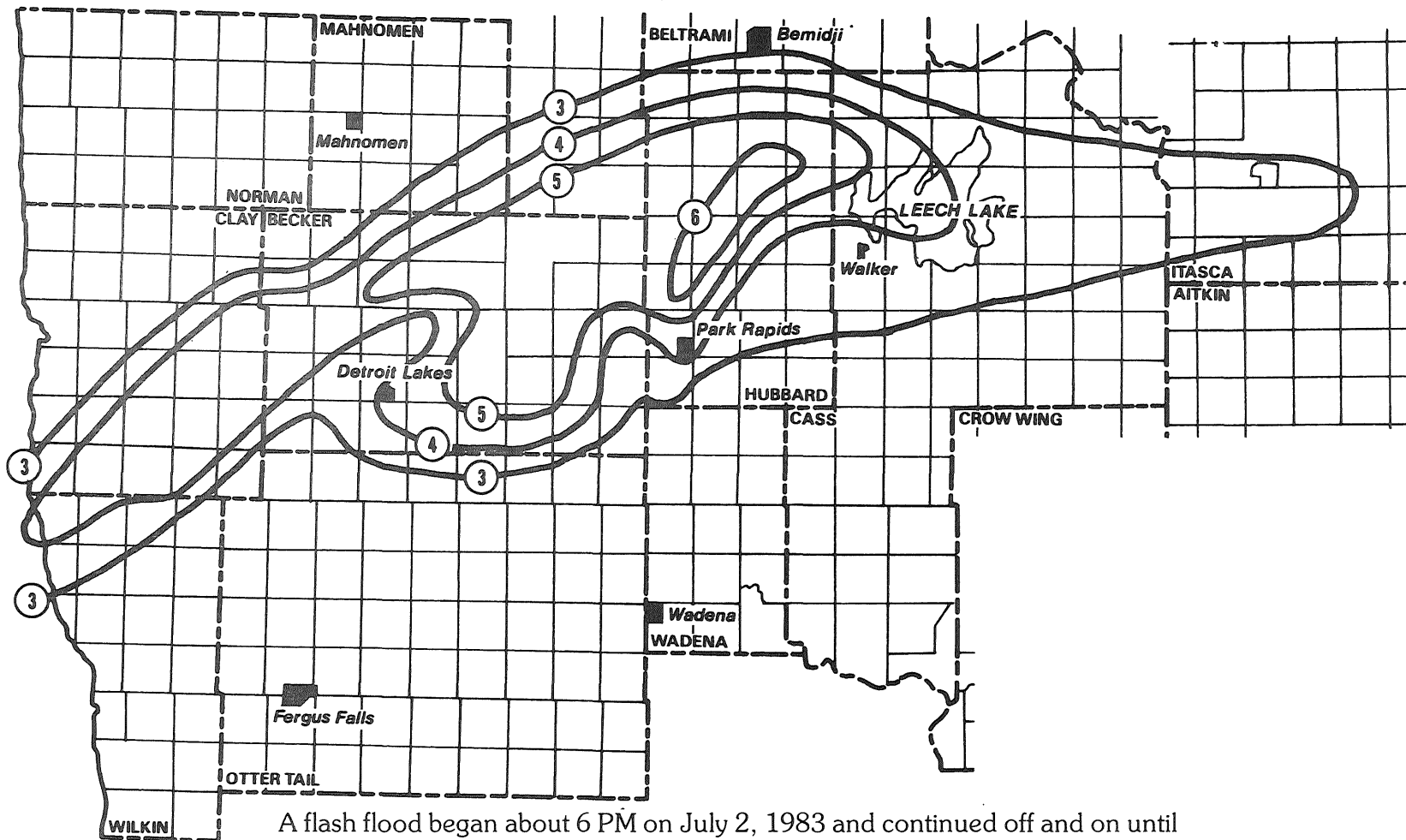
The flash flood occurred on June 25-26, 1983 through Stearns, Sherburne and Benton Counties. The rains began about 11 PM on the 25th and fell off and on until about 10 AM on the 26th. The heaviest rains fell in central Benton County with more than 6 inches. However, the areas of 4-inches and greater in Stearns and Sherburne Counties had had 4 to 6 inches of rain, 5 days before on June 21st. Four inches or more of precipitation occurred over a 350 square mile area. The report was prepared from 48 reports collected by the SWCD's from the above counties.

WASECA & OWATONNA AREA FLASH FLOOD
(Waseca & Steele Counties)
June 30 — July 1, 1983



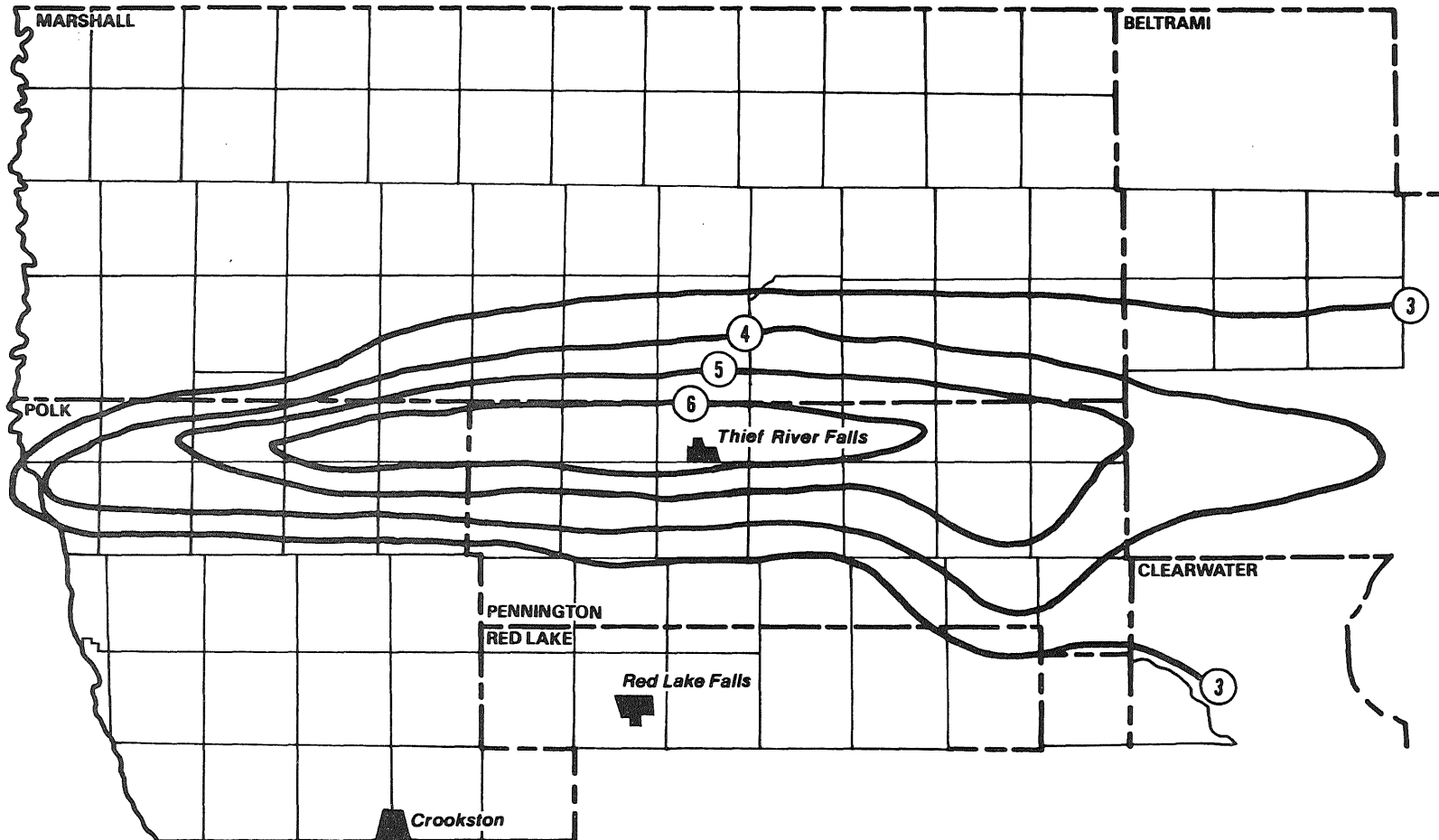
The flash flood began about 7 PM on June 30, 1983 and continued into the early hours of July 1, 1983. Most of the rain fell in about 3 hours before midnight. An unofficial amount of 6.1 inches was reported about 6 miles southeast of Owatonna in Aurora Township. Because of prior wet conditions there was considerable run-off. The 4-inch rainfall amounts covered an area of 550 square miles. This study was prepared from 56 reports collected by the Soil and Water Conservation Service Offices.

FLASH FLOOD (Clay, Becker, Hubbard & Cass Counties) July 2-3, 1983



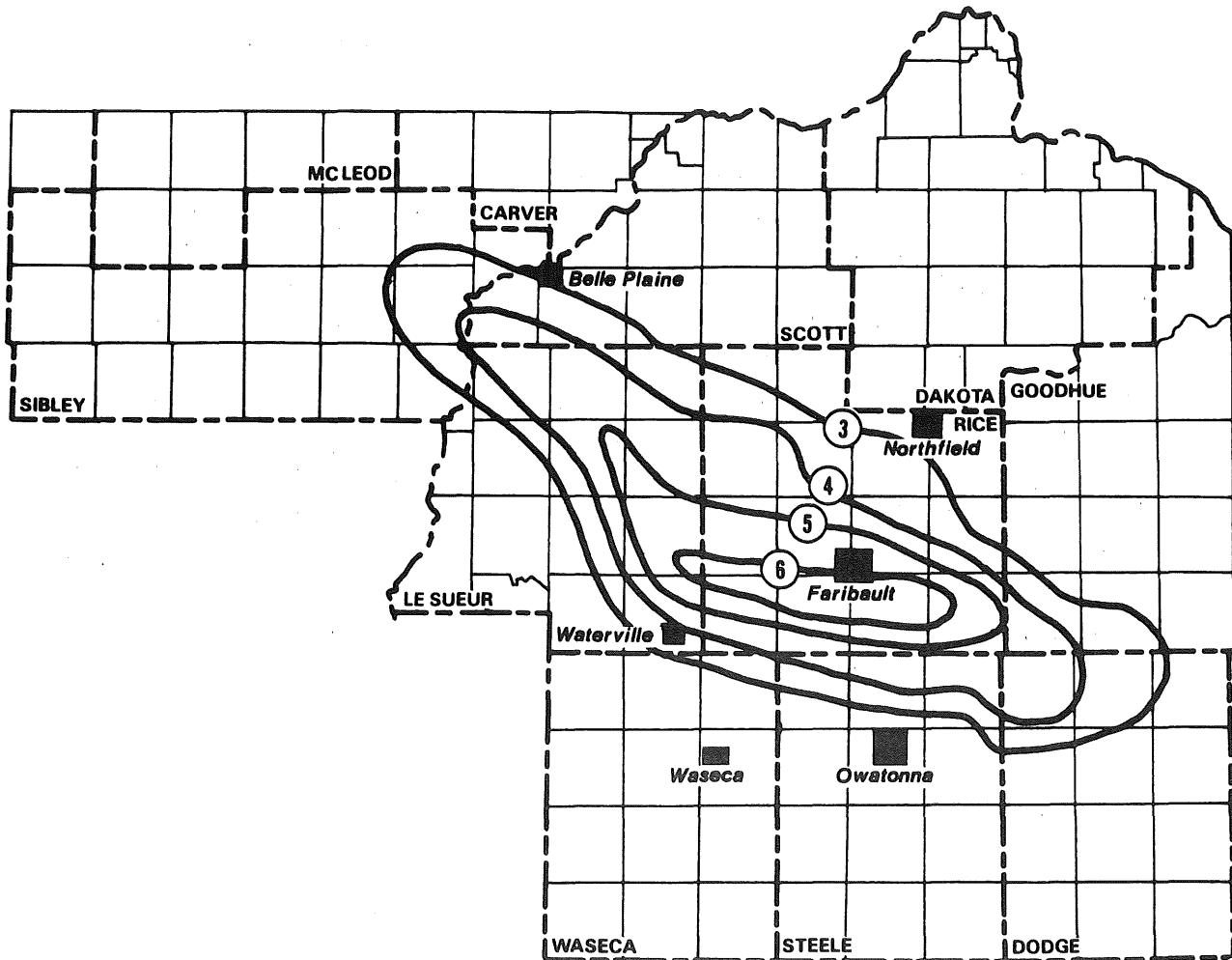
A flash flood began about 6 PM on July 2, 1983 and continued off and on until after midnight into the afternoon of July 3. Most of the rains fell the evening of July 2 before midnight. The heavy rain pattern was oriented to the northeast from central Becker County to north central Hubbard and then east into the northwest part of Cass County. The greatest amount of rainfall unofficially reported was 7.5 inches north of Park Rapids. The District Forestry Office gage at Guthrie recorded 6.25 inches, but the gage overflowed. A nearby unofficial gage recorded 7 inches. The 4-inch rainfall amount covered an area of 2,200 square miles, which is more than 2 1/2 times the average of flash floods in Minnesota.

THIEF RIVER FALLS FLASH FLOOD (Pennington County) August 20-21, 1983



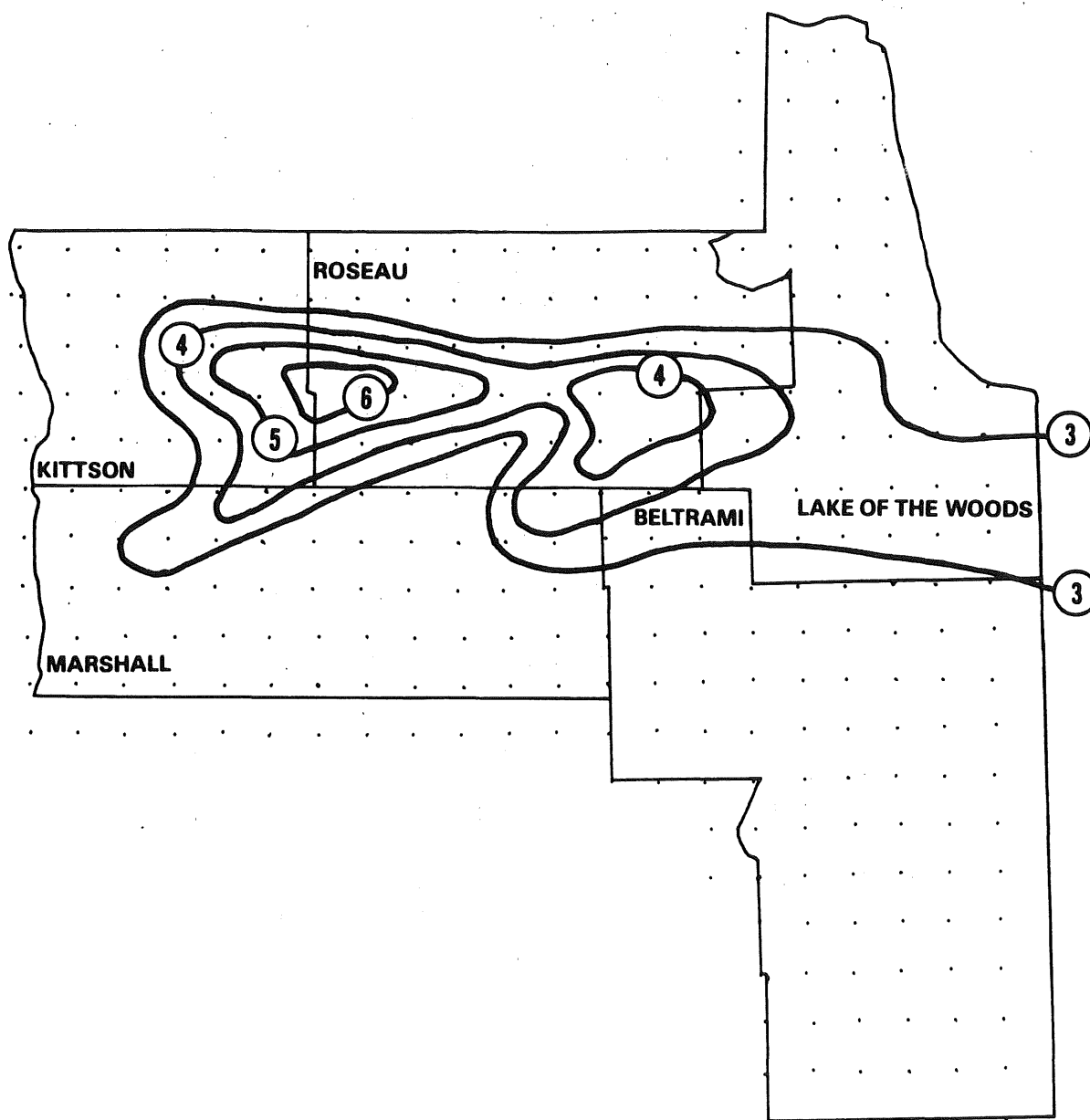
This flash flood began Saturday evening, August 20, 1983 about 6 PM in northwestern Polk County and ended in eastern Pennington and Beltrami Counties about 2 to 3 AM on August 21. Most of the rains fell during a 5-hour period. The greatest amount recorded by a Soil and Water Conservation District observer or National Weather Service cooperative observer was 6.97 inches at Thief River Falls. Four inches or more of precipitation occurred over a 880 square mile area. This study was prepared from 48 reports collected by the Soil and Water Conservation Districts and County Soil Conservation Service Offices.

FLASH FLOOD (LeSueur & Rice Counties) August 25, 1983



The flash flood on August 25, 1983 began about midnight with off and on showers and thunderstorms until about 6 AM. There were some light showers that continued into the early forenoon. The heavier rain patterns were oriented to the southeast from the northwest part of Le Sueur County to the northwest part of Dodge County. Six inches or more of rain fell across southern Rice County. An unofficial 7 inches was reported 4 miles southeast of Faribault. The 4-inch or greater rainfall amounts covered an area of 620 square miles. This study was prepared from 44 reports collected by the Soil and Water Conservation Districts and Soil Conservation Service Offices.

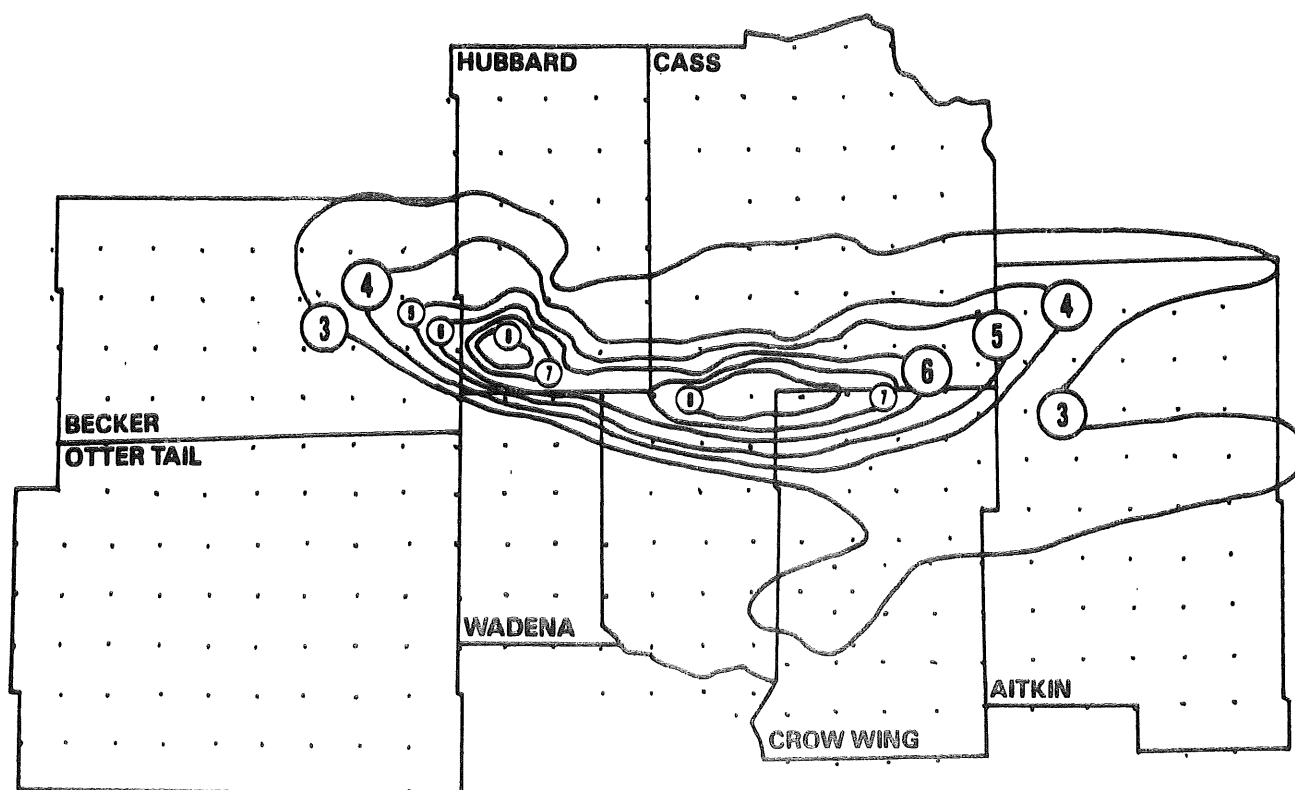
FLASH FLOOD
(Kittson & Roseau Counties)
June 25-26, 1985



Flash flood rains in Kittson and Roseau Counties began about 8 PM on the 24th of June and ended during the forenoon on the 25th. However, it did rain off and on into the 26th. (Most of the rains occurred before 8 AM on the 25th).

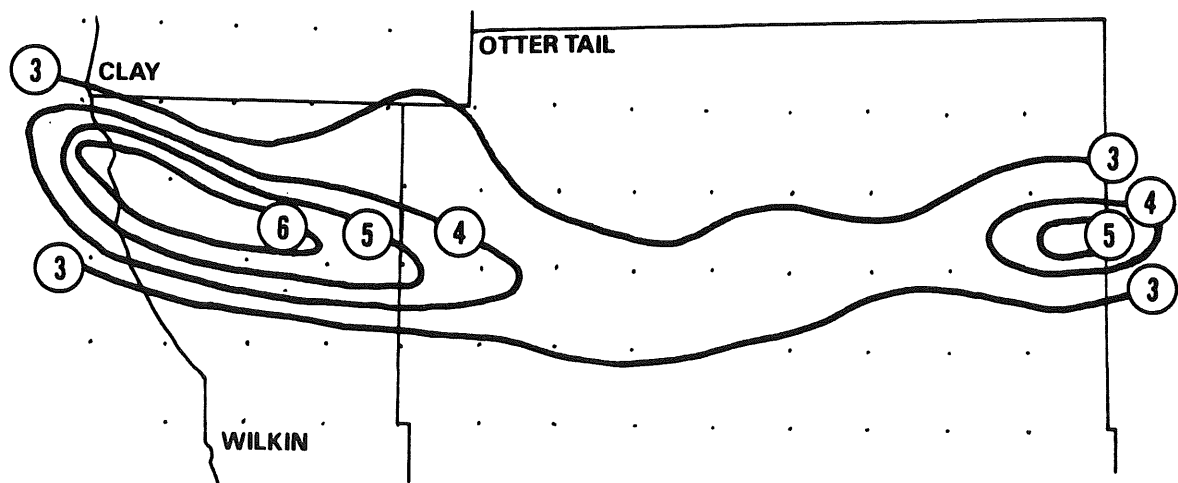
The 4-inch and greater area covered about 1,300 square miles. The heaviest amount reported was 6.05 inches in western Roseau County. Flood of ditches and fields was reported.

FLASH FLOOD
(Hubbard, Cass & Crow Wing Counties)
July 17-18, 1985



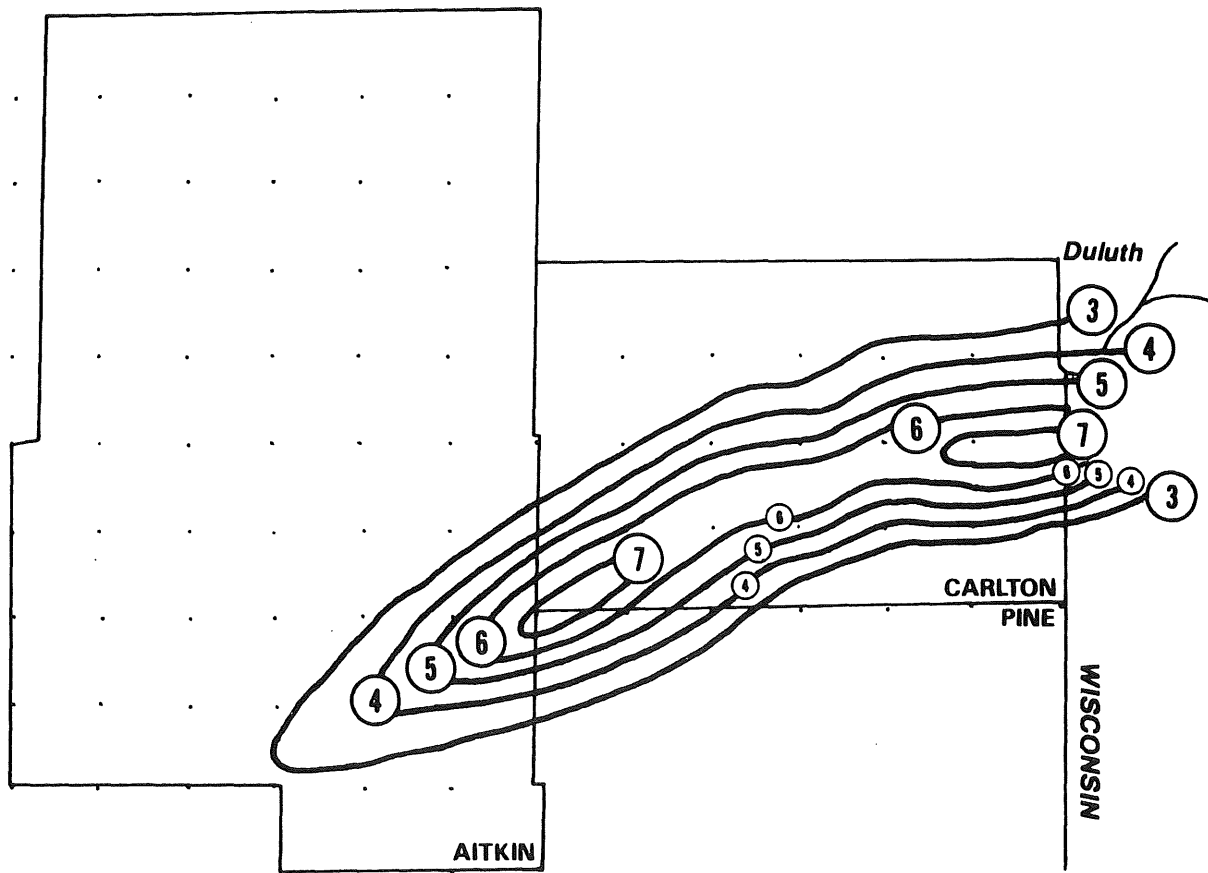
Flash flood rains began about 12:30 AM on the 17th and continued off and on until early forenoon of the 18th of July. The heavier rainfalls occurred during the afternoon and evening of the 17th and into the early morning hours of the 18th. The 4-inch and greater rainfall was a band 15 to 20 miles wide starting in the eastern part of Becker, southern Hubbard, central Cass, northern Crow Wing and into western Aitkin Counties. It covered an area of 1,200 square miles. The largest amounts recorded were 8.62 inches at Park Rapids and 8.36 inches near Backus and Pine River.

FLASH FLOOD
(Wilkin & Ottertail Counties)
July 17-18, 1985



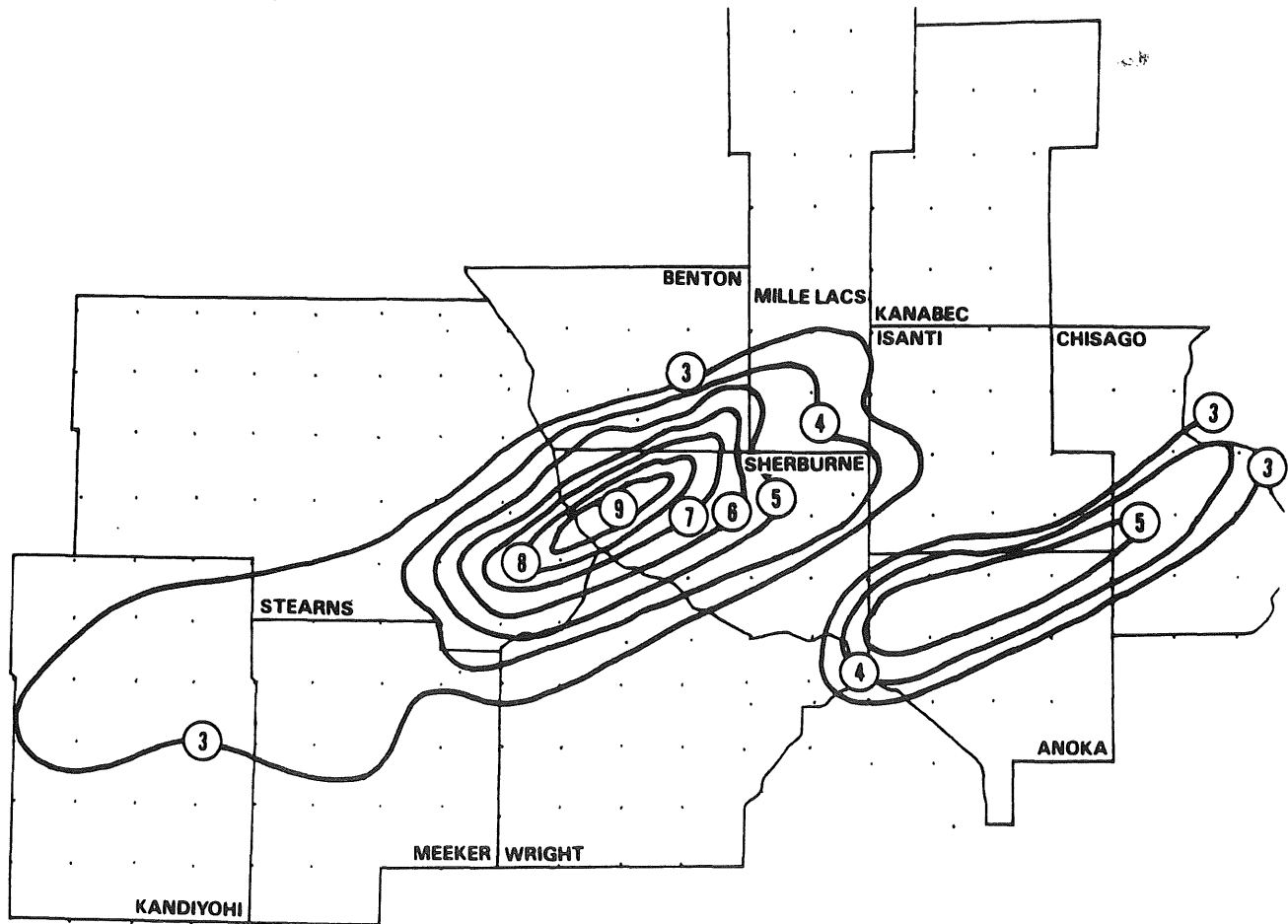
Flash flood rains began during the afternoon of the 17th of July. However, the heavier rains occurred during the evening and early morning hours. The rains ended on the forenoon of the 18th. The 4-inch or more rainfalls covered an area of 250 square miles. The greatest amount reported was 6.7 inches in north central Wilkin County.

FLASH FLOOD **(Carlton, Aitkin & Pine Counties)** **September 2-3, 1985**

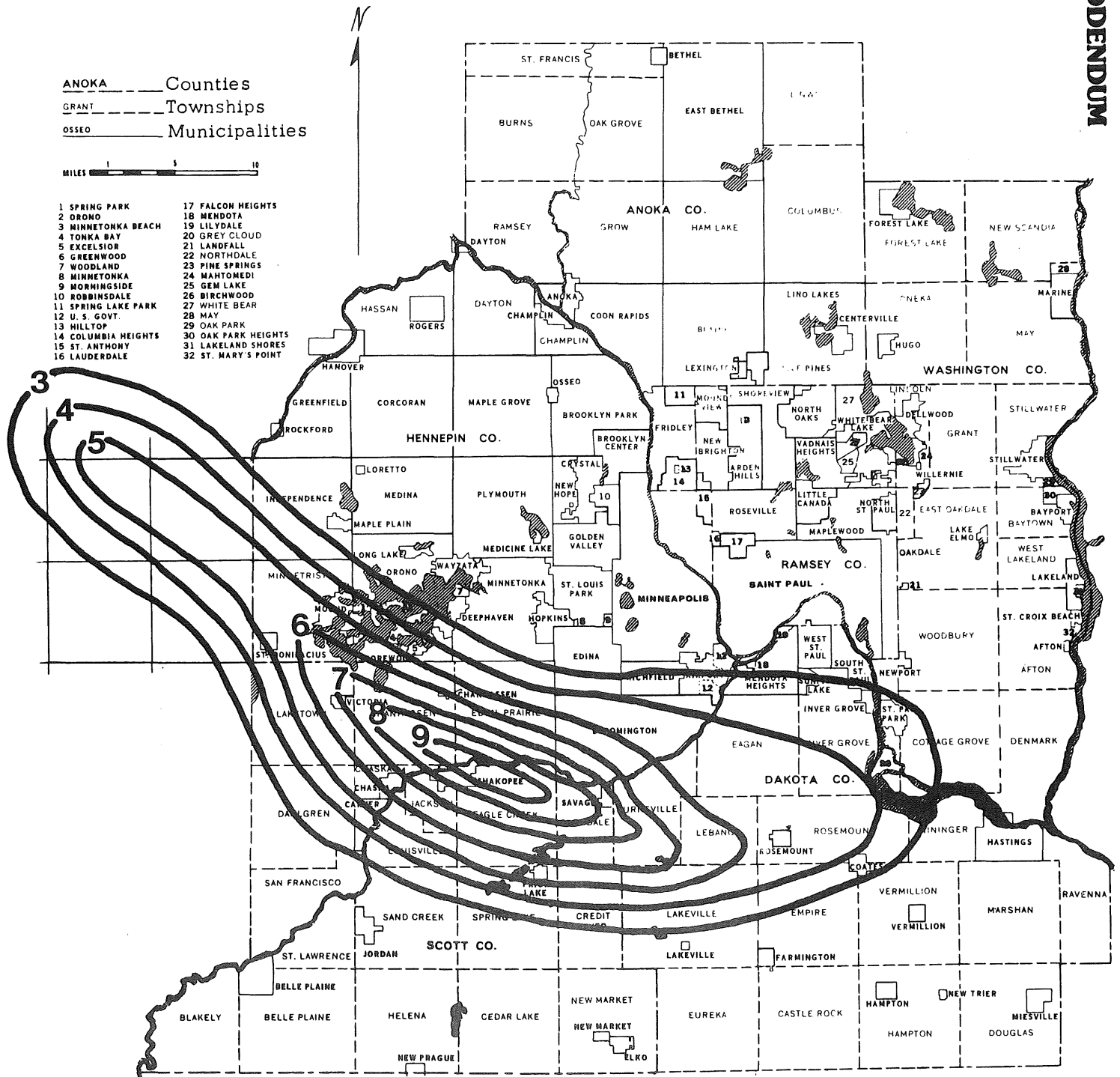


Flash flood rains in southeast Aitkin, northwest Pine and across Carlton Counties began about 10 AM on the 2nd of September and ended about 7 AM on the 3rd, though most of the rains fell between 7 PM and 2 AM. The 4-inch and greater rainfall amounts covered an area of 450 square miles. However, the storm continued well into Wisconsin. The greatest amounts recorded in Minnesota was 7.01 inches in the southwest and 7 inches along the Wisconsin border in Carlton County. The flash flood caused flooding across Carlton County and into Wisconsin. This flash flood was not considered as severe as the Moose Lake Flash Flood of July 1 thru 3, 1987. There were no precipitation records taken at that time in Moose Lake.

FLASH FLOOD & HEAVY RAINS
(Stearns, Wright, Sherburne, Benton,
Mille Lacs & Anoka Counties)
September 8-9, 1985



One to 2-inch rains first occurred throughout the area between 1 AM and 6 AM on the 8th of September, 1985. Afterward, very heavy rains occurred from about 7 PM on the 8th thru 7 AM on the 9th of September. The heaviest rains began generally in southern Stearns County and continued east thru Sherburne County and parts of Wright, Benton and Mille Lacs Counties. Another area receiving heavy rains during this 30-hour period was northern Anoka County with over 5 inches of rainfall. The 4-inch rainfall and greater covered an area about 750 square miles. The greatest amount recorded in the 30-hours was 9.21 inches in Sherburne County.



SHAKOPEE/CANTERBURY DOWNS, MINNESOTA FLASH FLOOD -- JULY 20-21, 1987

A flash flood occurred during the evening of July 20 into the early morning hours of July 21, 1987. The path began northwest of Lake Minnetonka in Wright county extending southeast through Shakopee to about the Rosemount area. The greatest amount reported was 9.00" from a recording 'Sierra Tipping bucket' gage at the Canterbury Downs race track near Shakopee. The area covered by 6 inches or more was 140 square miles while the area of 4 inches or more was 470 square miles. Prepared by Earl L. Kuehnast.

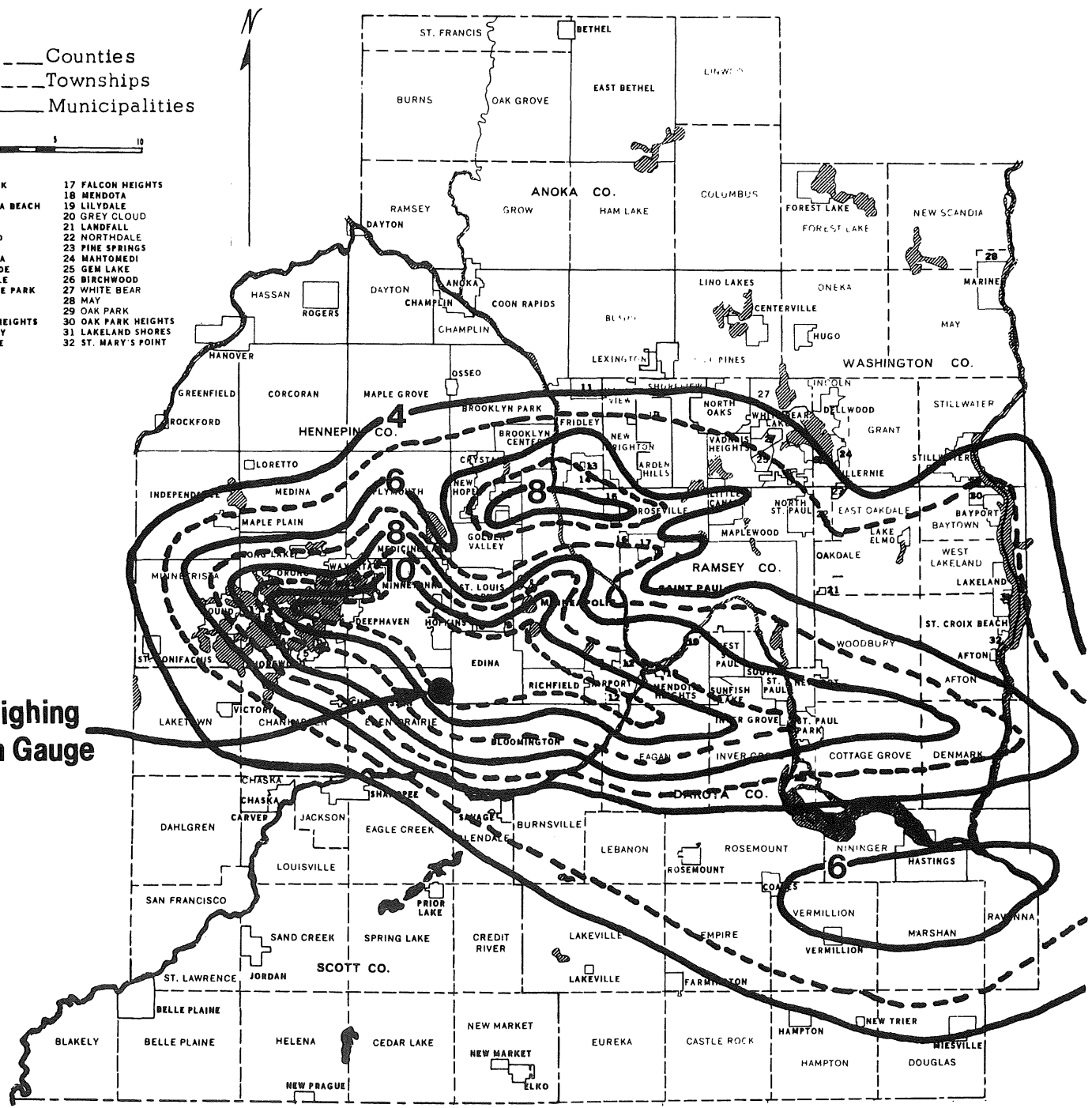
James A. Zandlo
Minnesota Department of Natural Resources
State Climatology Office

ANOKA _____ Counties
GRANT _____ Townships
OSSEO _____ Municipalities



- | | |
|---------------------|---------------------|
| 1 SPRING PARK | 17 FALCON HEIGHTS |
| 2 ORONO | 18 MENDOTA |
| 3 MINNETONKA BEACH | 19 LILYDALE |
| 4 TONKA BAY | 20 GREY CLOUD |
| 5 EXCELSIOR | 21 LANDFALL |
| 6 GREENWOOD | 22 NORTHDALE |
| 7 WOODLAND | 23 PINE SPRINGS |
| 8 MINNETONKA | 24 MAHOMET |
| 9 MORNINGSIDE | 25 GEM LAKE |
| 10 ROBBINSDALE | 26 BIRCHWOOD |
| 11 SPRING LAKE PARK | 27 WHITE BEAR |
| 12 U. S. GOVT. | 28 MAY |
| 13 HILLTOP | 29 OAK PARK |
| 14 COLUMBIA HEIGHTS | 30 OAK PARK HEIGHTS |
| 15 ST. ANTHONY | 31 LAKELAND SHORES |
| 16 LAUDERDALE | 32 ST. MARY'S POINT |

Weighing
Rain Gauge



WESTERN AND SOUTH CENTRAL TWIN CITIES FLASH FLOOD - JULY 23-24, 1987

The flash flood occurred generally between 7PM 23 July to 1AM 24 July, 1987. It's path was on a line from Lake Minnetonka east-southeast through Edina, Inver Grove Heights and into Wisconsin; with rain fall amounts from 6 inches to more than 11 inches. The greatest amount was 11.32 inches documented on a standard weighing rain gage. There were some greater unofficial amounts. Some 335 rainfall reports were used to draw the isohyet map. The area covered by 10 inches or more of rainfall was 93 square miles; 6 inches or more was 574 square miles and by 4 inches or more was 1460 square miles. Much of the 6 inch and greater rainfalls occurred over residential parts of the Twin Cities. To date an estimated 7000 homes have reported water damage. At this time the known costs of damages are approximately 25 million dollars.

This storm was preceded by 72 hours by a similarly oriented storm with totals exceeding 9 inches. The earlier storm fell mostly in adjacent areas to the south and west. However, two storm totals exceeded 16 inches in some areas.

The greatest official 24-hour rainfall amounts for the Twin Cities are as follows: 10.00" on July 23-24, 1987 ranks first, 7.80" in June 1892 ranks second, and 7.36" on August 30, 1977 ranks third. Prepared by Earl L. Kuehnast.

James A. Zandlo
Minnesota Department of Natural Resources
State Climatology Office