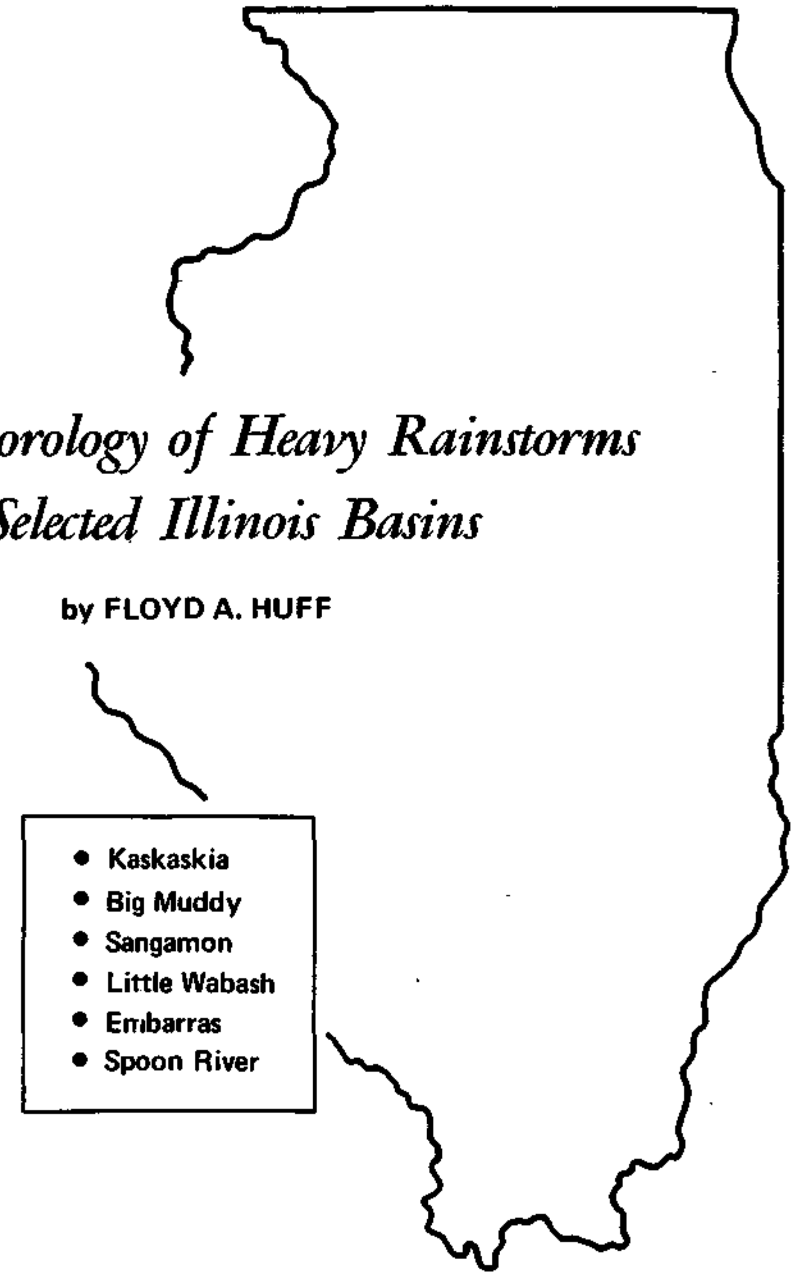
ISWS/RI -96/81

REPORT OF INVESTIGATION 96

STATE OF ILLINOIS

ILLINOIS DEPARTMENT OF ENERGY AND NATURAL RESOURCES



# *Hydrometeorology of Heavy Rainstorms in Selected Illinois Basins*

by FLOYD A. HUFF

- Kaskaskia
- Big Muddy
- Sangamon
- Little Wabash
- Embarras
- Spoon River

ILLINOIS STATE WATER SURVEY

CHAMPAIGN

1981

**REPORT OF INVESTIGATION 96**

# *Hydrometeorology of Heavy Rainstorms in Selected Illinois Basins*

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Title: Hydrometeorology of Heavy Rainstorms in Selected Illinois Basins.

Abstract: This report is a working guide for hydrologists and engineers who are concerned with the frequency distribution of rainfall and the patterns and characteristics of severe precipitation events for six major basins in Illinois: the Kaskaskia, Big Muddy, Sangamon, Little Wabash, Embarras, and Spoon Rivers. Included are: the frequency distribution of areal mean rainfall for return periods of 1 to 100 years and storm periods of 6 to 48 hours; the frequency distribution of areal mean rainfall for fixed subareas of each basin for areas of 10 to 400 square miles and storm periods of 1 to 48 hours; and the frequency distribution of areal mean rainfall for incremental areas of 25 to 1000 square miles and durations of 6 to 48 hours for non-specific areas of each basin (basin storm envelope values). Also described are certain storm characteristics that are mutually applicable to all six basins, such as storm orientation and shape and synoptic weather systems that produce the heavy storms.

Reference: Huff, Floyd A. Hydrometeorology of Heavy Rainstorms in Selected Illinois Basins. Illinois State Water Survey, Urbana, Report of Investigation 96, 1981.

Indexing Terms: Area-depth relations, climatology, heavy rainstorms, hydrometeorology, rainfall frequency distributions, rainfall intensity, storm characteristics, time distribution of rainfall.

**CHAMPAIGN**
**1981**

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*Printed by authority of the State of Illinois*
(SWS-12-81-225)

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## CONTENTS (Concluded)

# Part A. Description of Basin Studies

## INTRODUCTION

This report provides a working guide for hydrologists and engineers who are concerned with the frequency distribution of rainfall and the patterns and characteristics of severe precipitation events for six major basins in Illinois. These are the basins of the Kaskaskia, Big Muddy, Sangamon, Little Wabash, Embarras, and Spoon Rivers (figure A-l).

Extensive analyses of the distribution of extreme precipitation events in Illinois have been carried out as part of the meteorological research and services program of the Illinois State Water Survey since 1948 (Stout and Huff, 1962). As a result of these analyses, a large amount of information has been compiled on the time and space distribution of precipitation. Analytical and statistical techniques have been developed for new and better use of the existing data.

Because of these factors and interests in basin-related information on the design and operation of hydrologic structures, it was desirable, as well as feasible, to define hydrometeorological relations on a smaller areal scale than had been used previously. In most previous studies, Illinois has been treated as a unit area or the state has been divided into several climatological sections. For several hydrological applications, hydrometeorological analyses by major basins are needed and are preferable to climatic section analyses. All available data compiled by the Water Survey, the U. S. Weather Bureau (now National Weather Service), the Corps of Engineers, and others were used.

Investigations of the Kaskaskia Basin were undertaken as the initial effort to define the hydrometeorology of major Illinois basins. The approach evolved was followed in similar studies for the other five basins included in this report. After describing the types of analysis applied to each basin, the following six major sections address the six basins. The next section describes certain storm characteristics that are mutually applicable to all six basins, such as storm orientation and shape and synoptic weather systems that produce the heavy storms. This is followed by a section which compares various storm characteristics among the basins.

### Scope of Investigations

In carrying out the studies, calculations have been made of: the frequency distribution of areal mean rainfall for return periods of 1 to 100 years and storm periods of 6 to 48 hours; the frequency distribution of areal mean rainfall for fixed subareas of each basin for areas of 10 to 400 square miles and storm periods of 1 to 48 hours; and the frequency distribution of areal mean rainfall for incremental areas of 25 to 1000 square miles and durations of 6 to 48 hours for non-specific areas of each basin, that is, basin storm envelope values.

Data for the 75-year period, 1887-1961, were used in the frequency analyses, since analyses of outstanding storms during this period had been made in conjunction with earlier research projects at the Water Survey. Determination has been made of the characteristics of storm area-depth relations, which, in turn, provide a quantitative measure of the characteristics of the storm rainfall patterns. The orientation and shape of severe rainstorms, their monthly and seasonal distribution, the elapsed time between successive severe storms, and the synoptic features associated with them have been evaluated.

This report is devoted primarily to the presentation of results in a form convenient for application by hydrologists or other interested users. It is intended as a hydrological design and operational guide. Consequently, the methodology and techniques employed in the various studies are discussed only briefly, but in most cases references are cited in which the reader may obtain detailed information if desired.

### Acknowledgments

This report was prepared under the general direction of William C. Ackermann, Chief Emeritus of the Illinois State Water Survey, and Stanley A. Changnon, Jr., then Head of the Atmospheric Sciences Section and now Survey Chief. Much of the data that made the study possible was ob-

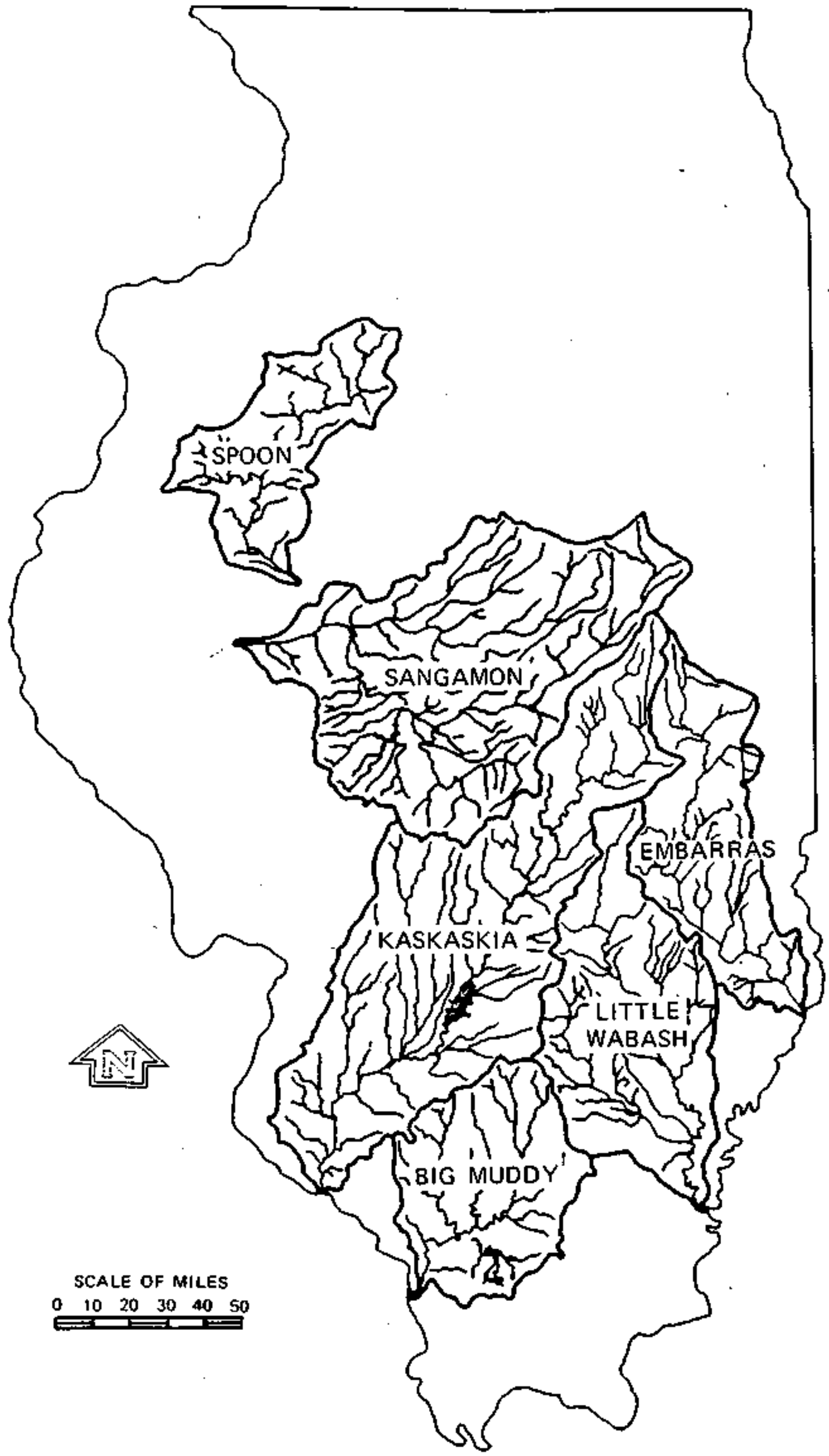



Figure 1. Location of the six basins in Illinois

tained from climatological records of the U. S. Weather Bureau (now the National Weather Service) and from original records of cooperative stations of the Weather Bureau. Detailed analyses of outstanding midwestern storms published by the Corps of Engineers were extremely helpful in the development of rainfall relations for the basins. The assistance of Lois Staggs, David Pingry, and Jay Stocks in performing many analyses required in the basin research is greatly appreciated. The extensive drafting required for this report was performed by John Brother and William Motherway. Technical editing was performed by Loreena Ivens and Tony Fitzpatrick. Marilyn Innes prepared the camera copy.

## DEFINITION OF TERMS

### Frequency Distribution of Point Rainfall

Normally, the frequency distribution of rainfall is expressed as the average time interval in years between rainfall amounts of a given magnitude for storm durations of various lengths in hours. This nomenclature is used throughout this report. Tables are used to show the frequency distribution of rainfall at any given *point* in the basins. Interpretation of each table is explained in the text for the Kaskaskia Basin (initial study).

The point rainfall relations are based on long-term records at first-order and cooperative stations of the U. S. Weather Bureau. Since the relationships were derived from point rainfall observations, they should be used only for point estimates; they should not be used to estimate the frequency distribution. of areal mean rainfall within the basin.

Also, it is important to understand that frequency distributions refer to average relationships over an extended period of time. For example, a "5-year storm" is expected to occur 20 times within a 100-year period; it is not implied that every 5-year period will have a rainstorm equivalent to the "5-year storm" indicated by the frequency distribution, or that no more than one of these storms will occur in any given 5 years. Data analyzed for this report show that occasionally more than one "5-year storm" may occur within the same month on a basin. Similar findings in the Chicago urban area were found in an earlier study (Huff and Vogel, 1976).

### Frequency Distribution of Areal Mean Rainfall

For most hydrologic applications, the frequency distribution of areal mean rainfall is preferable to point rainfall distributions. Areal distributions will be shown for the entire basin, and in the case of the elongated Kaskaskia, Little Wabash, and Embarras basins, for the upper and lower portions. Interpretation is the same as described above for point rainfall, except that the data apply to areas rather than to points within an area.

### Frequency Distribution of Mean Rainfall on Small Areas

These relations refer to the frequency distribution of areal mean rainfall over any selected specific area of 10 to 400 square miles within the basin. These selected areas are *fixed in space,* and, therefore, do not define the maximum storm amounts which may occur *somewhere* in the basin within a given recurrence interval.

### Frequency Distribution of Maximum Rainfall on Small Areas

The frequency distribution of the heaviest areal mean rainfall which may occur over any contiguous area of 20 to 1000 square miles within each basin is shown. These areas are not fixed in space — they may be located anywhere within the given basin and the location may or may not change from one storm to another. In essence, these frequency distributions represent maximum values of storm mean rainfall which will be recorded over small contiguous areas somewhere in the basin for given storm durations and average recurrence intervals. These are sometimes referred to in the literature as envelope values of rainfall.

### Area-Depth Curves

These curves, derived from planimetering of isohyetal maps, show the relationship between storm rainfall depth and area, and provide a mathematical expression of the areal rainfall distribution. The slope of the area-depth curve provides a measure of the storm rainfall gradient, and the y-intercept indicates the maximum rainfall within the given area. The area-depth relation is one of the fundamental relations used in storm studies and is applied by the hydrologist in storm runoff determinations.

### Storm Orientation

Since most individual storm elements have a component of motion from the west, the azimuth angle ascribed to each storm in the basin studies ranged from 180° to 360°. Thus, if a storm had an orientation along a line from 230° to 050°, the orientation was recorded as 230° in our computations, and consequently in the summary tables of basin storm orientations throughout this report. With the above orientations, our studies have shown that the major rain-producing cells within a storm will usually move from the SW, WSW, W, or WNW (Vogel and Huff, 1978).

### Synoptic Storm Types

The weather conditions associated with each of the severe rainstorms were classified according to five general synoptic weather types. Three types of frontal storms (cold, warm, and stationary) were used in the classification of synoptic types. With cold and warm fronts, the rainfall is associated with the approach and/or passage of the front or a minor wave on the front. Stationary fronts are those in which the rainfall is associated with overrunning of warm, moist air over cold air, or with minor waves traveling along a relatively stationary boundary between cold and warm air. Precipitation associated with the passage of a major cyclone was classified as a low center. Air mass storms include those which occur in a relatively homogeneous body of air without the presence of fronts.

### Seasons

Throughout this report, winter refers to the three months from December through February. Similarly, spring is March-May, summer is June-August, and fall is September-November, all the standard climatological divisions.

## COMPUTATION OF MEAN RAINFALL FREQUENCY DISTRIBUTIONS

### Total Basin Relations

In determination of the frequency distribution of average storm rainfall on a basin, all major 2-day rainstorms in the sampling period (usually 1887-1961) were used. Maps of each storm were drawn and planimetered and the basin average rainfall for the storm calculated. In some cases, this was done for both large sub-areas and for the entire basin.

The 2-day storm period was used as the analytical base in this study because our investigations have shown that nearly all of the severe rainstorms encompassing areas of 1000 square miles or more in Illinois initiate in the afternoon or evening and extend into the following morning. The reporting time for daily rainfall amounts at climatic network stations of the National Weather Service varies, but is most commonly about 6 pm. As a result, the heavy storm rainfalls are split into two consecutive daily amounts in the climatic data publications.

In each basin, the average rainfall for each storm was converted from 2-day to 48-hour amounts by multiplying by 1.02, the transformation factor listed by Huff and Neill (1959). Next, the storm average rainfall was multiplied by a gage density factor calculated for each decade. This factor was developed from studies of field-surveyed storms from 1951 through 1960 and by comparison of these storms with climatological network data (Huff and Semonin, 1960). The gage density factor is an empirical correction for underestimation of the maximum storm amounts that results from inadequate density of raingages in the normal climatological network during the sampling period. In the 1890-1899 decade, there were fewer than 100 raingages in Illinois, whereas by the 1950-1959 decade there were approximately 250. The areal average rainfalls, modified for calendar day and gage density factors, were then ranked, and the frequency distribution of 48-hour storms for each of the areal divisions was determined.

The next step was to determine the frequency distribution of basin average rainfall for storm periods of shorter duration. This was done through development of empirical relations between 48-hour rainfall amounts and amounts for shorter duration through use of a large number of Midwest storms analyzed by the U. S. Army Corps of Engineers (1945) for storm periods of 6 to 48 hours. These empirical relations developed from the Midwest storms were checked against a smaller sample of severe Illinois storms analyzed by the State Water Survey during 1951 through 1960, and it was found that the two sets of values corresponded closely. The empirical relations consist of two transformation factors, one for storm magnitude as measured by the areal mean rainfall for the 48-hour base period, and the other a storm duration factor. Application of these transformation factors to the frequency distribution of 48-hour average rainfall produced frequency distribution for periods of 6, 12, 18, 24, and 36 hours.

### Sub-Basin Relations for Small Fixed Areas

For hydrologic design application, it is frequently desirable to have knowledge of the frequency distribution of average rainfall over relatively small segments of a major basin. For example, such information is useful for structural design involving tributaries of the main stream. Through use of relations between point and areal mean rainfall on small areas developed by the U. S. Weather Bureau (Hershfield, 1961) and the point rainfall frequency relations for Illinois determined by Huff and Neill (1959), average rainfall relations were calculated for sub-areas of 10 to 400 square miles in the basin.

This procedure was necessary because long-term records of areal mean rainfall, which are necessary for the development of reliable frequency relations, are not available in sufficient quantity. This would require long-term records from dense raingage networks. However, during the past 25 years sufficient network data have become available, especially in Illinois, to develop generalized relations between equivalent magnitudes of point and areal mean rainfall for a given frequency on small fixed areas. The relations have been expressed in the terms of transformation factors that provide the average ratio of mean to point rainfall for a given frequency of occurrence. These are then applied to long-term point rainfall frequency relations to obtain estimates of equivalent mean rainfall frequency relations. This ratio has been found to be independent of recurrence interval and climatic divisions of the United States, but strongly related to areal size and storm duration. For example, the ratio for a 1-hour storm period is 0.93 on an area of 10 square miles and this decreases gradually to 0.64 on 400 square miles. Similarly, the average ratio increases with storm duration. As an example, on 10 square miles, the ratio increases from 0.93 for 1-hour storm periods to 0.98 for 24-hour rainfalls.

### Heaviest Mean Rainfall Occurrences on Small Sub-Areas of Basins

For a given recurrence interval, the heaviest mean rainfalls would not be expected to occur in the same place within a basin from one storm to another. Information on this subject is useful when hydraulic structures are to be designed with a low risk of failure. Therefore, analyses were performed to provide a measure of the maximum rainfall to be expected anywhere in each of the major basins under various conditions of areal size, storm duration, and recurrence interval.

In computing the frequency distribution of heaviest mean rainfalls, isohyetal maps of the heavy historical storms were used in conjunction with area-depth computations from the isohyetal patterns to record the maximum mean rainfall over contiguous sub-areas emanating out from the most intense storm center in the isohyetal pattern. This provides the mean rainfall over successively larger areas of the storm maximum rainfall proceeding outward from the storm center. These heaviest means for selected areas ranging from 25 to 1000 square miles within each major basin were then ranked, and the ranked data were used to compute mean rainfall frequency relations of maximum storm rainfall. As indicted earlier, these maximum rainfall areas varied in location between storms, so that the frequency relations, presented later for each basin, represent envelope values within any given recurrence interval. Modifications for calendar day, gage density, and storm duration variations were incorporated into these computations in the same manner as described previously for the basin mean rainfall relations.

## AREA-DEPTH RELATIONS

Area-depth relations are useful in hydraulic design problems, since they provide a measure of the basin mean rainfall, point maximum rainfall, and rainfall gradient in convenient mathematical terms. Basin area-depth relations were computed for each heavy storm having duration of 48 hours or less. From the storm area-depth computations, the average slope of these curves in each basin was determined for storms of various duration. The slope at any given point of the area-depth curve was specified as the ratio of the mean rainfall for the incremental area to the total basin mean. This provided a non-dimensional, normalizing procedure for combining storms of various intensity, or other pertinent characteristics, so as to obtain mean area-depth relations for use as a design guide by the hydrologist. The area-depth ratios (curve slopes) were modified for gage density changes.

Next, average area-depth slopes were determined for various storm periods, through use of empirical relations between 48-hour rainfall amounts and amounts for shorter durations at various incremental areas within storms. These empirical relations, as indicated previously, were determined from a large number of Midwest storms analyzed by the Corps of Engineers and from Illinois storms for which field surveys were conducted by the Water Survey.

Table B-6 (next section) provides an example of the output from the area-depth studies for the Kaskaskia Basin. Shown are slope factors for constructing average area-depth curves for engineering design applications, when the concern is for storm periods ranging from 6 to 48 hours on this major basin.

## TIME DISTRIBUTION OF STORM RAINFALL

### Time Distribution within Storms

An important consideration in the design of storm-sanitary sewer systems and other hydraulic structures is the time distribution of rainfall within storms. The time distribution can strongly influence the runoff characteristics, and, consequently, the flash flood potential. As part of the basin studies, investigation was made of the time distribution of rainfall in Illinois severe rainstorms of record for which detailed data were available to define the time distribution accurately. These relations are not expected to vary significantly within the state. They are equally applicable to the six basins investigated in this report.

### Time between Successive Severe Rainstorms

A problem sometimes confronting the hydrologist is how soon after a severe rainstorm may a second severe storm occur. As part of the basin research, an investigation of the elapsed time between severe rainstorms was undertaken. First, all storms in which the mean rainfall equaled or exceeded the value for a recurrence interval of 2 years were listed by date for the entire basin. From these tabulations, the frequency distribution of elapsed time between storms with mean rainfall equaling or exceeding the 2-year recurrence value was determined. This procedure was repeated for 5-year recurrence values. Although frequency distributions are presented in terms of average recurrence intervals, the storms which produce the rainfall amount assigned to a given recurrence interval do not occur with regularity. Thus, an average 2-year value may occur several times in one 2-year period, and then not occur again for 3, 4, or more years.

## Orientation of Storms

Because the rainfall-runoff relations on a watershed are affected appreciably by the orientation of the storms causing floods, investigation was made of the distribution of the orientation of the major axes of heavy rainstorms on the basins. The major axis of a storm reflects the movement of a storm across an area and shows the orientation of the core of heaviest rainfall within a given area. Normally, the severest floods are produced with storms moving parallel to the major axis of a basin, other factors being equal.

## Relation between Heavy Storms and Synoptic Weather

An investigation was made to determine whether widespread heavy rainstorms occur most frequently with a particular type of synoptic weather. Such information is pertinent to the development of forecasting techniques and should lead eventually to a better definition of the probability distribution of heavy storms. In this investigation, data were used for the 60-year period, 1901 through 1961. Adequate surface weather maps for the study were not available for the period 1887 through 1900. Published weather maps of the National Weather Service (daily maps and earlier series of northern hemisphere maps) were used to classify the storms. All storms in which the basin mean rainfall equaled or exceeded the 2-year frequency value within a 48-hour storm period were used in the synoptic weather analysis.

## Similarities and Difference between Basins

All six basins lie in relatively flat terrain so that topographic effects are not a major contributor to their storm rainfall characteristics. In general, the intensity of storm rainfall for a given recurrence interval tends to decrease from south to north in Illinois as shown in previous studies of point rainfall frequencies (Huff and Neill, 1959). Convective storms, which are the primary producer of severe rainstorms, occur over a longer portion of the year in the southern than in the northern portion of the state. Thus, the point rainfall frequency or the mean rainfall frequency on a fixed sub-area of given size in the Sangamon Basin in central Illinois (figure A-l) should be less than that on the Big Muddy Basin in extreme southern Illinois.

With regard to the storm characteristics under investigation, some will vary among basins in the same general precipitation climate, whereas others will not. Variable factors include the frequency of basin mean rainfall, the frequency of maximum rainfall, and area-depth relations. These differences are primarily related to basin size. For example, other factors being equal, the mean rainfall for a given return period will decrease with increasing basin size.

Other factors influencing the variable factors mentioned above are the shape and orientation of the basin. Thus, an elongated basin oriented SW-NE will tend to have larger rainfall amounts for a given frequency than a similar basin oriented N-S. In the first case, the majority of the heavy storm centers would have a longer trajectory over the SW-NE basin than over the N-S basin because of predominant storm movements in Illinois. Factors which should not vary significantly among basins in the same precipitation climate include point rainfall frequencies, mean rainfall frequencies over fixed sub-areas of the basins, storm orientation, seasonal distribution of storms, and synoptic storm types.

# Part B. The Kaskaskia Basin

In the Kaskaskia study, the basin was divided into two parts by a line perpendicular to the major axis of the basin through Vandalia (figure B-l). The upper portion contains approximately 2500 square miles and the lower portion encompasses approximately 3300 square miles. Hydrometeorological data were then compiled for the upper and lower portions of the basin, in addition to treatment of the entire basin as a unit area. This division was based on knowledge of the precipitation characteristics of the basin obtained from earlier unpublished Water Survey studies of heavy rainstorms in the state.

## Physiography and Climate

The Kaskaskia Basin (figure B-l) is relatively flat with elevations ranging from approximately 750 feet above mean sea level (MSL) at the source of the river in east central Illinois to 380 feet in southwestern Illinois where it empties into the Mississippi River. Except near the mouth of the river, surface gradients are relatively flat. The elongated major axis of the basin that extends 175 miles in a NE-SW direction exposes it to appreciable changes in climate within its boundaries.

The annual average precipitation ranges from 37 to 41 inches (figure B-2) and increases southward and eastward. Precipitation tends to be heaviest in spring during the 3-month period of April through June, and normally is driest in winter during December through February. Normally only 3 to 5 percent of the annual precipitation is snowfall, which averages 15 inches in the southern part of the basin and 21 inches in the northern part.

Severe weather events are common to the Kaskaskia Basin, especially the lower portion. The annual average frequency of thunderstorm days ranges from 54 in the extreme southern part of the basin to 47 in the extreme northern part (Changnon, 1957). Hail occurs most frequently in the west-central portion of the basin in the vicinity of Hillsboro (figure B-l), where a given point may except an average of three hail days per year (Huff and Changnon, 1959). A relatively large number of tornadoes have been recorded in the extreme southern and western portions of the Lower Kaskaskia near Sparta and Edwardsville, and in the extreme northern portion of the Upper Kaskaskia in the Urbana region (Wilson and Changnon, 1971). These three areas rank among the highest in tornado frequency in Illinois with 8 to 12 occurrences per 1000 square miles during the 1927-1952 period. The central portion of the Lower Kaskaskia in the region from Belleville to Centralia is located along the major axis of the most severe rainstorm belt in Illinois (Stout and Huff, 1962).

The average annual temperatures range from 52° F in the northern part of the basin to 57°F in the southern part. The hottest month usually is July with a range in normal mean temperatures of 75 to 78°F from north to south in the basin. In January, normally the coldest month, mean temperatures vary from 27 to 31°F from north to south.

## Frequency Distribution of Point Rainfall

Table B-l shows the frequency distribution of point rainfall in the Kaskaskia Basin for storm periods of 1 to 48 hours. The relations presented in table B-l are based on earlier studies by the Water Survey (Huff and Neill, 1959) and the U. S. Weather Bureau (Hershfield, 1961). The data are applicable to any selected point in the basin. Differences between the upper and lower portions are slight, so no division was made.

Use of table B-l is illustrated by the following example. Assume one wishes to determine the 12-hour point rainfall to be expected *on the average*

**Table B-1. Point Rainfall Frequency Relations on Kaskaskia Basin**

| *Storm duration (hours)* | *Depth (inches) equaled or exceeded for given recurrence interval (years)* 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| **1** | **1.4** | **1.7** | **1.9** | **2.5** | **3.1** | **3.6** |
| **2** | **1.7** | **2.0** | **2.3** | **2.9** | **3.7** | **4.4** |
| **3** | **1.9** | **2.3** | **2.7** | **3.3** | **4.1** | **4.9** |
| **6** | **2.3** | **2.7** | **3.2** | **4.0** | **4.9** | **5.9** |
| **12** | **2.6** | **3.3** | **3.8** | **4.8** | **5.8** | **7.0** |
| **18** | **2.8** | **3.6** | **4.2** | **5.3** | **6.4** | **7.8** |
| **24** | **3.1** | **3.9** | **4.6** | **5.8** | **7.0** | **8.4** |
| **48** | **3.4** | **4.2** | **5.0** | **6.3** | **7.5** | **9.0** |

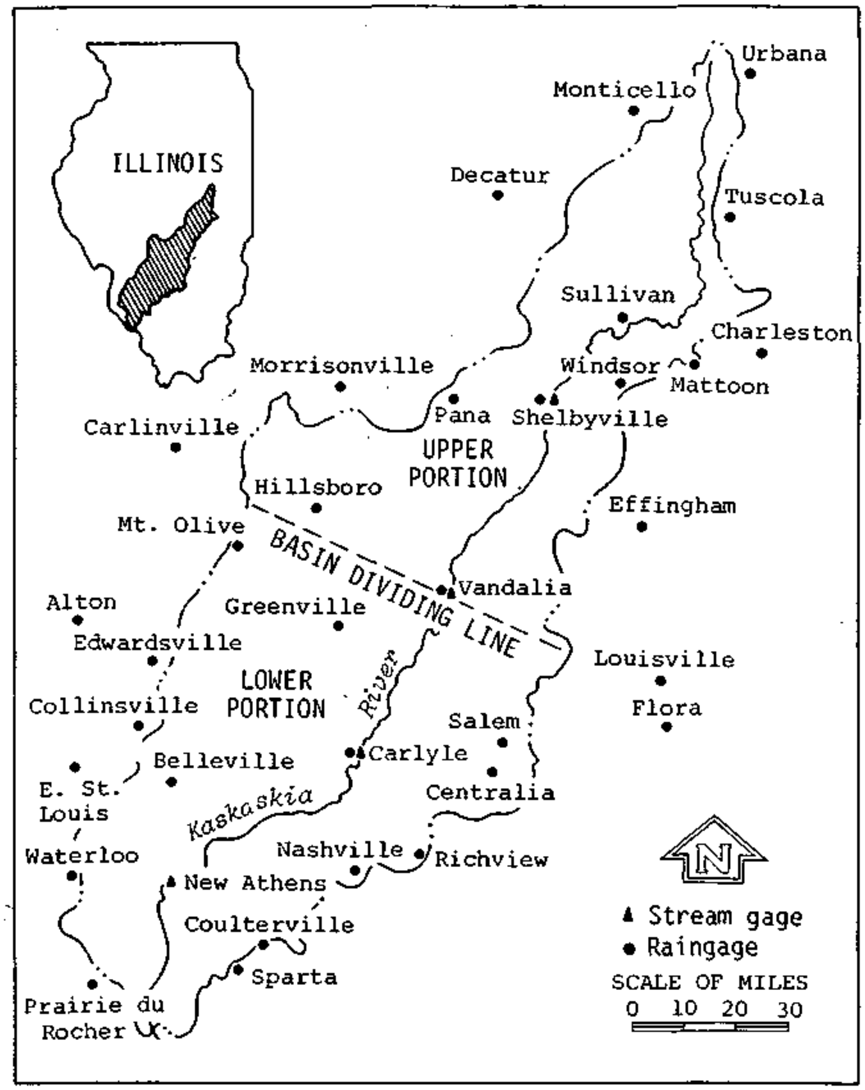



**Figure B-1. Location maps, Kaskaskia Basin**

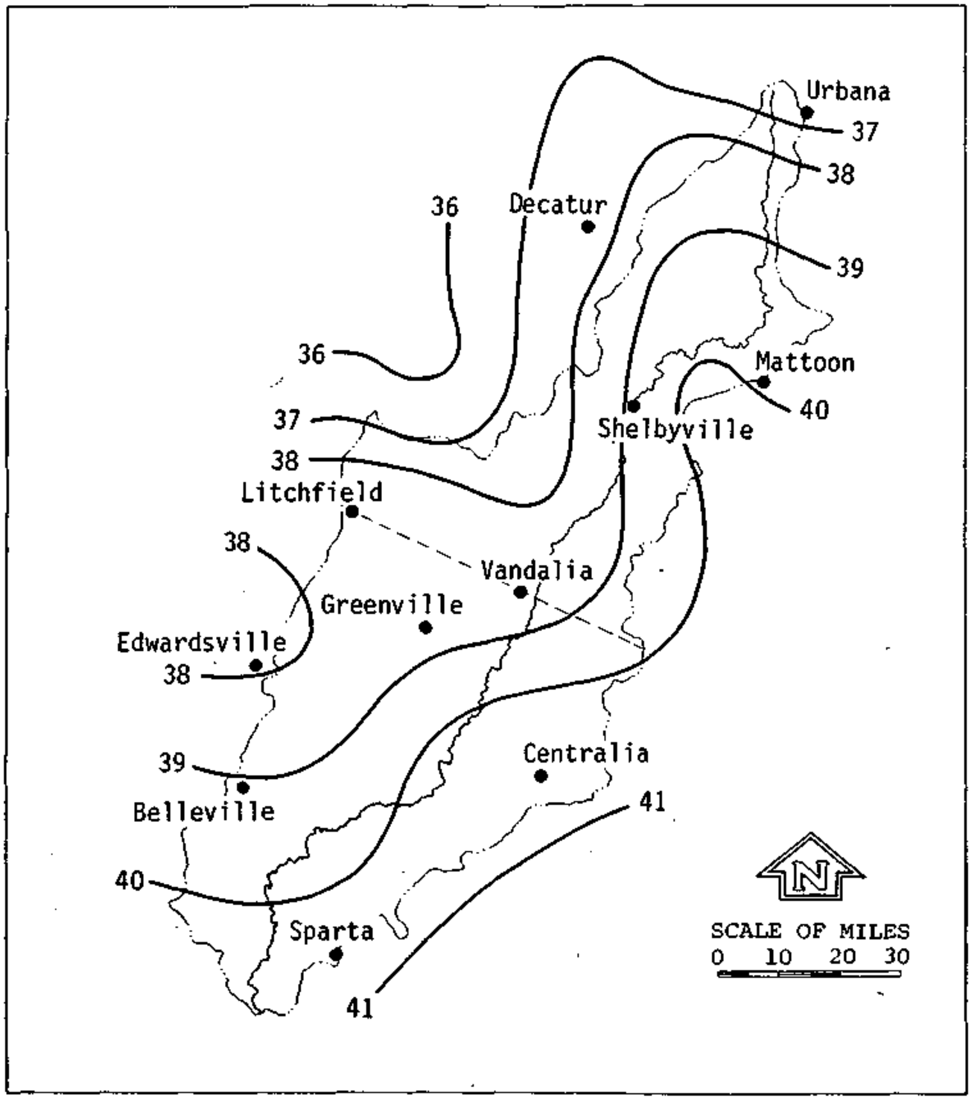



Figure B-2. Annual average precipitation, Kaskaskia Basin of once in 25 years at a point in the basin. Move down the column labeled "storm duration" to 12 and then move horizontally to the column for a recurrence interval of 25 years. This gives a value of 4.8 inches.

It is stressed that the data in table B-1 are for points within an area and should not be used to estimate the recurrence interval of areal mean rainfall over all, or a portion, of the basin. Such estimates will be provided in later sections of this report.

Also, the user is cautioned that the frequency data are for average conditions. Thus, the 25-year storm of 4.8 inches discussed above does not necessarily occur within every 25-year period and, conversely, more than one storm of this magnitude may occur in any given 2 5-year period. In a normal 100-year period, the 25-year storm should be equaled or exceeded four times.

## Frequency Distribution of Mean Storm Rainfall

### *Average Relations*

It was found that the frequency distribution of mean rainfall in the Upper Kaskaskia was closely approximated by a general equation of the form:

$$\log T = a + b\,R \qquad (1)$$

in which T is the frequency in years, R is the average rainfall depth, and a and b are regression constants. In the Lower Kaskaskia and for the entire basin, the best fit was obtained with a general equation of the form:

$$\log T = a + b \log R \qquad (2)$$

in which T, R, a, and b represent the same quantities as in equation 1.

### *Presentation of Results*

For the convenience of the user, the frequency distributions of average rainfall for each of the three Kaskaskia areas have been summarized in table B-2 for storm periods of 6 to 48 hours. For equal recurrence intervals, the average rainfall is greater in the Lower Kaskaskia than in the Upper Kaskaskia, and the difference becomes greater as the recurrence interval increases. This increasing difference with lengthening recurrence interval results primarily from the occurrence of three severe heavy rainstorms in the Lower Kaskaskia in which the basin mean rainfall exceeded that of any storm recorded in the Upper Kaskaskia. Data on these storms will be presented in a later section.

The interpretation of table B-2 is illustrated by the following example. Assume one wishes to determine the average storm rainfall for a 24-hour period that will occur *on the average* of once in 10 years over the 2500 square miles comprising the upper portion of the basin. Thus, for the Upper Kaskaskia, move down the recurrence interval column to 10. Then move horizontally to the column

**Table B-2. Basin Mean Rainfall Frequency Relations**

| *Recurrence interval (years)* | *Average rainfall depth (inches) equaled or exceeded for given storm period (hours)* | | | | | | |
|---|---|---|---|---|---|---|---|
| | *6* | *12* | *18* | *24* | *30* | *36* | *48* |
| ***Upper Kaskaskia*** | | | | | | | |
| 1 | 1.0 | 1.2 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 |
| 2 | 1.4 | 1.8 | 2.0 | 2.2 | 2.3 | 2.4 | 2.5 |
| 5 | 2.0 | 2.5 | 2.8 | 3.0 | 3.2 | 3.3 | 3.4 |
| 10 | 2.4 | 3.0 | 3.4 | 3.7 | 3.9 | 4.0 | 4.2 |
| 15 | 2.6 | 3.3 | 3.7 | 4.0 | 4.3 | 4.4 | 4.6 |
| 20 | 2.8 | 3.6 | 4.0 | 4.3 | 4.6 | 4.7 | 4.9 |
| 25 | 2.9 | 3.7 | 4.2 | 4.5 | 4.8 | 4.9 | 5.1 |
| 30 | 3.0 | 3.9 | 4.3 | 4.7 | 4.9 | 5.1 | 5.3 |
| 40 | 3.2 | 4.1 | 4.6 | 4.9 | 5.2 | 5.4 | 5.6 |
| 50 | 3.3 | 4.2 | 4.8 | 5.1 | 5.4 | 5.6 | 5.9 |
| 75 | 3.6 | 4.6 | 5.1 | 5.5 | 5.8 | 6.0 | 6.3 |
| 100 | 3.8 | 4.8 | 5.4 | 5.8 | 6.1 | 6.3 | 6.6 |
| ***Lower Kaskaskia*** | | | | | | | |
| 1 | 1.2 | 1.6 | 1.8 | 1.9 | 2.0 | 2.1 | 2.2 |
| 2 | 1.5 | 1.9 | 2.2 | 2.4 | 2.5 | 2.6 | 2.7 |
| 5 | 2.0 | 2.5 | 2.8 | 3.1 | 3.2 | 3.3 | 3.5 |
| 10 | 2.4 | 3.0 | 3.4 | 3.8 | 4.0 | 4.1 | 4.3 |
| 15 | 2.7 | 3.4 | 3.8 | 4.2 | 4.4 | 4.5 | 4.8 |
| 20 | 2.9 | 3.7 | 4.2 | 4.6 | 4.8 | 5.0 | 5.2 |
| 25 | 3.1 | 4.0 | 4.5 | 4.9 | 5.1 | 5.3 | 5.5 |
| 30 | 3.3 | 4.2 | 4.7 | 5.1 | 5.4 | 5.6 | 5.8 |
| 40 | 3.5 | 4.5 | 5.1 | 5.6 | 5.9 | 6.1 | 6.3 |
| 50 | 3.8 | 4.8 | 5.4 | 6.0 | 6.3 | 6.5 | 6.7 |
| 75 | 4.2 | 5.4 | 6.1 | 6.7 | 7.1 | 7.3 | 7.5 |
| 100 | 4.6 | 5.9 | 6.6 | 7.3 | 7.6 | 7.9 | 8.2 |
| ***Entire Kaskaskia*** | | | | | | | |
| 1 | 1.0 | 1.3 | 1.5 | 1.6 | 1.7 | 1.8 | 2.0 |
| 2 | 1.2 | 1.6 | 1.8 | 2.0 | 2.1 | 2.2 | 2.4 |
| 5 | 1.6 | 2.1 | 2.4 | 2.6 | 2.8 | 2.9 | 3.1 |
| 10 | 2.0 | 2.6 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 |
| 15 | 2.3 | 3.0 | 3.3 | 3.6 | 3.9 | 4.1 | 4.3 |
| 20 | 2.5 | 3.2 | 3.6 | 4.0 | 4.2 | 4.4 | 4.7 |
| 25 | 2.7 | 3.4 | 3.9 | 4.3 | 4.5 | 4.7 | 5.0 |
| 30 | 2.8 | 3.6 | 4.1 | 4.5 | 4.8 | 5.0 | 5.3 |
| 40 | 3.0 | 3.9 | 4.5 | 4.9 | 5.2 | 5.4 | 5.7 |
| 50 | 3.2 | 4.2 | 4.8 | 5.2 | 5.5 | 5.8 | 6.1 |
| 75 | 3.7 | 4.8 | 5.4 | 5.9 | 6.2 | 6.5 | 6.9 |
| 100 | 4.0 | 5.2 | 5.9 | 6.4 | 6.8 | 7.1 | 7.5 |

labeled 24 and read the value at that point. This gives 3.7 inches as the areal mean rainfall which will be equaled or exceeded during a 24-hour period on the average of once in 10 years, or 10 times in 100 years.

#### *Effect of Sampling Period*

For use in evaluation of the results of the Kaskaskia study, and in planning similar studies for other basins in the state, an analysis was made of the effect of sampling period length upon the frequency distribution of mean rainfall over a basin of moderate size. The Upper Kaskaskia (2500 square miles) was selected for this analysis.

The frequency distribution of average basin rainfall for 48-hour storms was calculated from data for 10, 20, 30, 40, 50, and 75-year periods, as shown in table B-3. This table shows that relatively small differences exist in the frequency distribution for recurrence intervals of 2 to 100 years calculated from the different base periods. This, in turn, indicates that a long record of rainfall is not necessary to determine the frequency distribution of average basin rainfall. Although the differences shown in table B-3 may be smaller than would normally be found if several basins were analyzed in the same manner, a record of 20 to 30 years is probably sufficient to calculate frequency distributions of average rainfall on basins of moderate size to a degree of accuracy compatible with other hydrologic measurements.

**Table B-3. Mean Rainfall Frequency Relations for 48-Hour Storms on Upper Kaskaskia, Based on Different Sampling Periods**

| Sampling period | Length of period (years) | Rainfall (inches) for given recurrence interval (years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| 1951-60 | 10 | 2.2 | 3.2 | 4.0 | 5.1 | 5.9 | 6.7 |
| 1941-60 | 20 | 2.5 | 3.4 | 4.1 | 5.0 | 5.7 | 6.4 |
| 1931-60 | 30 | 2.5 | 3.5 | 4.3 | 5.3 | 6.1 | 6.8 |
| 1921-60 | 40 | 2.5 | 3.4 | 4.2 | 5.0 | 5.8 | 6.4 |
| 1911-60 | 50 | 2.5 | 3.5 | 4.3 | 5.3 | 6.1 | 6.9 |
| 1887-60 | 75 | 2.5 | 3.4 | 4.2 | 5.1 | 5.9 | 6.6 |
| | | *Differences (%) from 1887-1960 values* | | | | | |
| 1951-60 | 10 | 12 | 6 | 5 | 0 | 0 | 2 |
| 1941-60 | 20 | 0 | 0 | 2 | 2 | 3 | 3 |
| 1931-60 | 30 | 0 | 3 | 2 | 4 | 3 | 3 |
| 1921-60 | 40 | 0 | 0 | 0 | 2 | 2 | 3 |
| 1911-60 | 50 | 0 | 3 | 2 | 4 | 3 | 5 |

### Frequency Distribution of Mean Rainfall on Small Areas

Table B-4 presents the results of the analyses in the form of frequency distributions for storm periods of 1 to 48 hours, recurrence intervals of 2 to 100 years, and areas of 10 to 400 square miles. The frequency data apply to any specific integral area within the basin, that is, any area of 10 to 400 square miles fixed in space.

Use of table B-4 is illustrated in the following example. Assume one wishes to determine the average rainfall for a 6-hour storm period that can be expected to be equaled or exceeded *on the average* of once in 25 years in an area of 100 square miles centered at Vandalia (see figure B-1). In table B-4, refer to the section labeled "6-Hour Storm Period." Move down the recurrence interval column to 25, then move horizontally to the columnfor 100 square miles. This gives a value of 3.4 inches. This procedure is repeated for any other combination of storm period, recurrence interval, and area desired by the user.

### Frequency Distribution of Heaviest Mean Rainfall on Small Areas

Table B-5 shows the frequency distribution of the heaviest areal mean rainfalls which occur over any integral area of 25 to 1000 square miles in the upper and lower portions of the basin for storm periods of 6 to 48 hours. As pointed out previously, these areas are not fixed in space — they may be located anywhere within the boundaries of the specified portion, and the locations may or may not change between convective storms.

The interpretation of table B-5 is illustrated by the following example. Assume one wishes to know what is the greatest average rainfall for a 12-hour period which will occur over an integral area of 100 square miles anywhere in the upper portion of the Kaskaskia Basin on an average of once in 25 years. In table B-5, under "12-hour storm peiod," move down the column labeled 100 square miles and read the value opposite 25 years. This value is 7.5 inches, and the interpretation is that once in 25 years, *on the average,* there will be an integral area of 100 square miles somewhere in this portion of the basin that will have a mean storm rainfall of 7.5 inches.

**Table B-4. Frequency Distribution of Areal Mean Rainfall for Specific Integral Areas on Kaskaskia Basin**

| *Recurrence interval (years)* | *Average depth (inches) equaled or exceeded for given area (square miles)* 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *1-Hour storm period* | | | | | | |
| 2 | 1.3 | 1.2 | 1.1 | 1.0 | 1.0 | 0.9 |
| 5 | 1.6 | 1.5 | 1.3 | 1.2 | 1.1 | 1.0 |
| 10 | 1.8 | 1.7 | 1.5 | 1.4 | 1.3 | 1.2 |
| 25 | 2.4 | 2.2 | 2.0 | 1.8 | 1.7 | 1.6 |
| 50 | 2.8 | 2.6 | 2.4 | 2.2 | 2.0 | 1.9 |
| 100 | 3.3 | 3.0 | 2.8 | 2.6 | 2.4 | 2.2 |
| *2-Hour storm period* | | | | | | |
| 2 | 1.7 | 1.6 | 1.5 | 1.4 | 1.3 | 1.2 |
| 5 | 2.0 | 1.8 | 1.7 | 1.6 | 1.5 | 1.4 |
| 10 | 2.3 | 2.1 | 2.0 | 1.9 | 1.8 | 1.6 |
| 25 | 2.8 | 2.6 | 2.5 | 2.3 | 2.2 | 2.1 |
| 50 | 3.5 | 3.3 | 3.1 | 2.9 | 2.7 | 2.6 |
| 100 | 4.2 | 3.9 | 3.7 | 3.5 | 3.3 | 3.1 |
| *3-Hour storm period* | | | | | | |
| 2 | 1.8 | 1.8 | 1.7 | 1.6 | 1.6 | 1.5 |
| 5 | 2.2 | 2.2 | 2.1 | 2.0 | 1.9 | 1.8 |
| 10 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 | 2.1 |
| 25 | 3.2 | 3.1 | 2.9 | 2.8 | 2.7 | 2.6 |
| 50 | 3.9 | 3.7 | 3.6 | 3.4 | 3.3 | 3.1 |
| 100 | 4.7 | 4.5 | 4.3 | 4.1 | 3.9 | 3.7 |
| *6-Hour storm period* | | | | | | |
| 2 | 2.3 | 2.2 | 2.1 | 2.0 | 2.0 | 1.9 |
| 5 | 2.7 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 |
| 10 | 3.1 | 3.0 | 2.9 | 2.8 | 2.7 | 2.6 |
| 25 | 3.8 | 3.7 | 3.6 | 3.4 | 3.3 | 3.2 |
| 50 | 4.7 | 4.5 | 4.4 | 4.3 | 4.1 | 3.8 |
| 100 | 5.6 | 5.4 | 5.2 | 5.0 | 4.8 | 4.7 |

| *Recurrence interval (years)* | *Average depth (inches) equaled or exceeded for given area (square miles)* 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *12-Hour storm period* | | | | | | |
| 2 | 2.6 | 2.5 | 2.4 | 2.4 | 2.3 | 2.2 |
| 5 | 3.1 | 3.0 | 3.0 | 2.9 | 2.8 | 2.8 |
| 10 | 3.7 | 3.6 | 3.6 | 3.5 | 3.4 | 3.3 |
| 25 | 4.6 | 4.5 | 4.4 | 4.3 | 4.2 | 4.1 |
| 50 | 5.6 | 5.4 | 5.3 | 5.2 | 5.1 | 5.0 |
| 100 | 6.7 | 6.5 | 6.4 | 6.2 | 6.1 | 6.0 |
| *18-Hour storm period* | | | | | | |
| 2 | 2.7 | 2.7 | 2.6 | 2.6 | 2.5 | 2.5 |
| 5 | 3.4 | 3.4 | 3.3 | 3.2 | 3.2 | 3.1 |
| 10 | 4.0 | 3.9 | 3.8 | 3.8 | 3.7 | 3.6 |
| 25 | 5.1 | 5.0 | 4.9 | 4.8 | 4.7 | 4.6 |
| 50 | 6.1 | 6.0 | 5.9 | 5.8 | 5.8 | 5.7 |
| 100 | 7.5 | 7.3 | 7.2 | 7.0 | 6.9 | 6.8 |
| *24-Hour storm period* | | | | | | |
| 2 | 3.0 | 3.0 | 2.9 | 2.9 | 2.8 | 2.7 |
| 5 | 3.7 | 3.6 | 3.6 | 3.5 | 3.5 | 3.4 |
| 10 | 4.4 | 4.4 | 4.3 | 4.3 | 4.2 | 4.1 |
| 25 | 5.6 | 5.5 | 5.4 | 5.3 | 5.2 | 5.2 |
| 50 | 6.7 | 6.6 | 6.5 | 6.4 | 6.3 | 6.2 |
| 100 | 8.1 | 7.9 | 7.8 | 7.7 | 7.6 | 7.5 |
| *48-Hour storm period* | | | | | | |
| 2 | 3.4 | 3.3 | 3.3 | 3.2 | 3.2 | 3.1 |
| 5 | 4.0 | 4.0 | 3.9 | 3.9 | 3.8 | 3.8 |
| 10 | 4.8 | 4.8 | 4.7 | 4.6 | 4.6 | 4.5 |
| 25 | 6.1 | 6.0 | 5.9 | 5.8 | 5.8 | 5.7 |
| 50 | 7.2 | 7.1 | 7.0 | 6.9 | 6.8 | 6.8 |
| 100 | 8.8 | 8.7 | 8.6 | 8.5 | 8.4 | 8.3 |

This area is not fixed in space — it may be located anywhere in the 2500 square miles and its location may or may not change from one occurrence to another. Conversely, in the preceding section, frequency distributions were shown for areas fixed in space within the basin, and the 12-hour, 25-year average rainfall for a fixed area of 100 square miles is 4.3 inches. This is 57 percent of the maximum value.

The maximum or envelope values of storm rainfall within a given basin, such as shown in table B-5, are the result of the non-uniform time distribution of rainstorms. For example, if all unit areas of smaller size within the 5800 square miles comprising the Kaskaskia Basin received an equal number of storms of equivalent intensity within periods of 2 to 100 years, table B-5 would not exist. That is, any area selected within the basin would have the same frequency distribution as any other area.

However, this is not how nature works. If the precipitation climate is the same throughout a given basin, then over a very long period of time (perhaps several hundred years) all smaller units of area within the given basin would experience the same total distribution of storms. However, when periods of relatively short length such as 25 to 50 years are analyzed for a basin, considerable variability may be found in the frequency distribution of rainfall for smaller sub-areas in the basin.

For example, in a given 25-year period, some integral areas of 100 square miles in the Kaskaskia Basin may receive their 50-year, 100-year, or longer storms, since these storms must occur sometime but rarely at the same time over a relatively large area. Conversely, some integral areas might receive less than an *average* 25-year storm in any given 25-year period. From the experience of several small areas over a period of 25 to 50 years, estimates of

**Table B-5. Frequency Distribution of Heaviest Mean Areal Rainfall on Basin Sub-Areas**

| | *Upper Kaskaskia* | | | | | | *Lower Kaskaskia* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Frequency (years)* | *Average depth (inches) for given area (square miles)* | | | | | | *Average depth (inches) for given area (square miles)* | | | | | |
| | *25* | *50* | *100* | *200* | *500* | *1000* | *25* | *50* | *100* | *200* | *500* | *1000* |
| *6-Hour storm period* | | | | | | | | | | | | |
| 2 | 3.5 | 3.3 | 3.1 | 2.9 | 2.5 | 2.1 | 3.5 | 3.3 | 3.1 | 2.9 | 2.5 | 2.1 |
| 5 | 4.4 | 4.2 | 3.9 | 3.6 | 3.1 | 2.7 | 4.5 | 4.3 | 4.0 | 3.7 | 3.2 | 2.8 |
| 10 | 5.5 | 5.2 | 4.9 | 4.5 | 3.9 | 3.3 | 5.7 | 5.4 | 5.0 | 4.6 | 4.0 | 3.4 |
| 25 | 7.0 | 6.6 | 6.2 | 5.7 | 4.9 | 4.3 | 7.5 | 7.1 | 6.6 | 6.1 | 5.3 | 4.6 |
| 50 | 7.8 | 7.5 | 7.0 | 6.4 | 5.5 | 4.7 | 9.1 | 8.6 | 8.0 | 7.4 | 6.4 | 5.6 |
| 100 | 9.0 | 8.6 | 8.0 | 7.4 | 6.4 | 5.5 | 11.4 | 10.8 | 10.1 | 9.3 | 8.0 | 7.0 |
| *12-Hour storm period* | | | | | | | | | | | | |
| 2 | 4.2 | 4.0 | 3.7 | 3.5 | 3.1 | 2.7 | 4.2 | 4.0 | 3.7 | 3.5 | 3.1 | 2.7 |
| 5 | 5.3 | 5.0 | 4.7 | 4.4 | 3.8 | 3.3 | 5.5 | 5.2 | 4.9 | 4.5 | 4.0 | 3.5 |
| 10 | 6.6 | 6.3 | 5.9 | 5.4 | 4.7 | 4.1 | 6.8 | 6.5 | 6.0 | 5.6 | 4.9 | 4.3 |
| 25 | 8.4 | 8.0 | 7.5 | 6.9 | 6.0 | 5.3 | 9.0 | 8.5 | 8.0 | 7.4 | 6.5 | 5.7 |
| 50 | 9.5 | 9.0 | 8.4 | 7.8 | 6.8 | 5.9 | 11.0 | 10.5 | 9.8 | 9.0 | 7.9 | 6.9 |
| 100 | 10.8 | 10.4 | 9.6 | 8.9 | 7.8 | 6.8 | 13.7 | 13.1 | 12.3 | 11.3 | 9.9 | 8.6 |
| *18-Hour storm period* | | | | | | | | | | | | |
| 2 | 4.6 | 4.4 | 4.1 | 3.8 | 3.3 | 2.9 | 4.6 | 4.4 | 4.1 | 3.8 | 3.4 | 3.0 |
| 5 | 5.9 | 5.6 | 5.2 | 4.8 | 4.2 | 3.7 | 6.0 | 5.7 | 5.3 | 5.0 | 4.4 | 3.8 |
| 10 | 7.1 | 6.8 | 6.4 | 5.9 | 5.2 | 4.5 | 7.3 | 6.9 | 6.6 | 6.1 | 5.4 | 4.7 |
| 25 | 9.2 | 8.8 | 8.2 | 7.5 | 6.6 | 5.8 | 9.7 | 9.2 | 8.8 | 8.1 | 7.1 | 6.2 |
| 50 | 10.2 | 9.8 | 9.1 | 8.4 | 7.4 | 6.4 | 12.0 | 11.3 | 10.7 | 9.8 | 8.7 | 7.6 |
| 100 | 11.8 | 11.3 | 10.5 | 9.7 | 8.6 | 7.5 | 15.0 | 14.2 | 13.4 | 12.4 | 10.9 | 9.5 |
| *24-Hour storm period* | | | | | | | | | | | | |
| 2 | 4.9 | 4.7 | 4.3 | 4.1 | 3.6 | 3.1 | 4.9 | 4.7 | 4.3 | 4.1 | 3.6 | 3.1 |
| 5 | 6.2 | 5.9 | 5.5 | 5.1 | 4.5 | 3.9 | 6.3 | 6.0 | 5.6 | 5.2 | 4.6 | 4.0 |
| 10 | 7.6 | 7.3 | 6.8 | 6.3 | 5.5 | 4.8 | 7.8 | 7.5 | 7.0 | 6.5 | 5.7 | 5.0 |
| 25 | 9.7 | 9.3 | 8.7 | 8.0 | 7.0 | 6.2 | 10.4 | 10.0 | 9.4 | 8.6 | 7.6 | 6.7 |
| 50 | 10.8 | 10.4 | 9.5 | 9.0 | 7.9 | 6.9 | 12.7 | 12.2 | 11.3 | 10.5 | 9.3 | 8.1 |
| 100 | 12.5 | 12.0 | 11.2 | 10.4 | 9.2 | 8.0 | 15.8 | 15.1 | 14.2 | 13.1 | 11.6 | 10.1 |
| *48-Hour storm period* | | | | | | | | | | | | |
| 2 | 5.4 | 5.1 | 4.8 | 4.4 | 3.9 | 3.4 | 5.4 | 5.1 | 4.8 | 4.5 | 3.9 | 3.5 |
| 5 | 7.0 | 6.7 | 6.3 | 5.8 | 5.0 | 4.4 | 7.0 | 6.7 | 6.3 | 5.8 | 5.1 | 4.5 |
| 10 | 8.7 | 8.2 | 7.7 | 7.1 | 6.3 | 5.5 | 8.7 | 8.3 | 7.8 | 7.3 | 6.4 | 5.6 |
| 25 | 10.5 | 10.1 | 9.4 | 8.7 | 7.6 | 6.7 | 11.6 | 11.0 | 10.4 | 9.6 | 8.5 | 7.5 |
| 50 | 12.1 | 11.5 | 10.8 | 10.0 | 8.8 | 7.7 | 14.1 | 13.4 | 12.7 | 11.7 | 10.4 | 9.1 |
| 100 | 13.8 | 13.1 | 12.4 | 11.5 | 10.1 | 8.8 | 17.5 | 16.7 | 15.8 | 14.7 | 12.9 | 11.4 |

the *average frequency distributions,* such as shown in table B-4, can be made. Maximum distributions, such as shown in table B-5, are then obtained from analyses of the abnormally high rainfalls experienced among smaller integral areas within the larger area of the basin.

## Area-Depth Relations on the Kaskaskia

*Average Relations*

From planimetered rainfall maps of heavy 48-hour storms in the 75-year sampling period, area-depth curves were constructed for each storm, and the average slope of these area-depth curves was determined. In all, 54 storms were analyzed for the upper portion, 58 for the lower portion, and 67 for the entire basin, or a grand total of 179 cases. Slopes were determined from ratios of average rainfall for selected incremental areas (10, 100, 1000 square miles, etc.) within the storm to the basin average rainfall. From these calculations, average ratios for the selected incremental areas within each of the three basin divisions were calculated. These ratios were then modified for gage density changes, through the method described earlier in Part A. Results are summarized in table B-6.

**Table B-6. Average Slope of Area-Depth Curves**

| Incremental areas (square miles) | Ratio of mean rainfall on incremental areas to basin mean rainfall for given storm duration (hours) 6 | 12 | 18 | 24 | 36 | 48 |
|---|---|---|---|---|---|---|
| *Upper Kaskaskia* | | | | | | |
| 25 | 1.99 | 1.87 | 1.84 | 1.79 | 1.77 | 1.75 |
| 50 | 1.89 | 1.79 | 1.75 | 1.71 | 1.69 | 1.67 |
| 100 | 1.80 | 1.71 | 1.68 | 1.64 | 1.62 | 1.60 |
| 200 | 1.68 | 1.61 | 1.58 | 1.55 | 1.53 | 1.53 |
| 500 | 1.47 | 1.43 | 1.40 | 1.38 | 1.36 | 1.36 |
| 1000 | 1.28 | 1.25 | 1.24 | 1.22 | 1.21 | 1.20 |
| 1500 | 1.15 | 1.14 | 1.13 | 1.12 | 1.11 | 1.10 |
| 2000 | 1.07 | 1.06 | 1.06 | 1.05 | 1.05 | 1.05 |
| 2500 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Lower Kaskaskia* | | | | | | |
| 25 | 2.11 | 1.95 | 1.89 | 1.87 | 1.81 | 1.80 |
| 50 | 2.01 | 1.88 | 1.81 | 1.79 | 1.74 | 1.72 |
| 100 | 1.92 | 1.79 | 1.75 | 1.73 | 1.68 | 1.66 |
| 200 | 1.79 | 1.70 | 1.65 | 1.63 | 1.59 | 1.57 |
| 500 | 1.59 | 1.52 | 1.48 | 1.46 | 1.44 | 1.43 |
| 1000 | 1.39 | 1.33 | 1.31 | 1.31 | 1.29 | 1.28 |
| 1500 | 1.25 | 1.23 | 1.21 | 1.20 | 1.19 | 1.18 |
| 2000 | 1.17 | 1.15 | 1.14 | 1.13 | 1.13 | 1.13 |
| 2500 | 1.09 | 1.08 | 1.08 | 1.08 | 1.07 | 1.07 |
| 3300 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Entire Kaskaskia* | | | | | | |
| 25 | 2.41 | 2.22 | 2.13 | 2.08 | 1.98 | 1.95 |
| 50 | 2.30 | 2.13 | 2.05 | 2.00 | 1.91 | 1.88 |
| 100 | 2.20 | 2.03 | 1.98 | 1.93 | 1.85 | 1.82 |
| 200 | 2.10 | 1.98 | 1.89 | 1.84 | 1.77 | 1.74 |
| 500 | 1.86 | 1.76 | 1.71 | 1.67 | 1.61 | 1.59 |
| 1000 | 1.64 | 1.58 | 1.54 | 1.53 | 1.47 | 1.46 |
| 1500 | 1.49 | 1.45 | 1.44 | 1.41 | 1.38 | 1.36 |
| 2000 | 1.40 | 1.37 | 1.35 | 1.34 | 1.31 | 1.29 |
| 2500 | 1.32 | 1.29 | 1.28 | 1.28 | 1.25 | 1.24 |
| 3500 | 1.20 | 1.18 | 1.17 | 1.17 | 1.16 | 1.15 |
| 4500 | 1.09 | 1.08 | 1.08 | 1.08 | 1.08 | 1.07 |
| 5800 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Use of table B-6 is illustrated by the following example. Assume, for engineering design purposes, that it is desired to determine the average area-depth relationship in 12-hour storms on the lower portion of the Kaskaskia (3300 square miles), and that the design is to be based upon the storm mean rainfall which is expected to occur on the average of once in 25 years. From table B-2, a value of 4.0 inches is obtained for the average 12-hour, 25-year storm oh the lower portion of the basin. Next, refer to table B-6 under the heading "Lower Kaskaskia." In the column for 12-hour storms, a series of ratios is listed for the incremental areas of 25 to 3300 square miles which are shown in the first column. Thus, to obtain the average rainfall over the 25 square miles with the heaviest storm amount, multiply 4.0 inches (the 3300 square miles mean) by 1.95, the slope factor for 25 square miles in 12-hour storms. This results in a 25 square mile mean of 7.8 inches. Repeat this procedure for each incremental area from 25 to 3300 square miles and the area-depth relationship shown in table B-7 is obtained.

Table B-7 then provides the best estimate of the average area-depth relationship in 12-hour storms with an average recurrence interval of 25 years on the lower portion of the Kaskaskia Basin, based upon data presently available for such determinations. Average area-depth relationships for other storm durations and recurrence intervals can be obtained by following the above procedure used in preparation of table B-7. Curves can be constructed, if desired. The average area-depth relations are closely approximated by a general equation of the form:

$$\log R = m + n A^{0.4}$$

in which R is average rainfall depth, A is area, m is maximum point rainfall, and n is the slope of the curve. Thus, the data in table B-7 will plot as a straight line, if log R is plotted against the 0.4-power of the area. For all practical purposes, linear interpolation can be used in table B-7 to obtain values for areas not listed.

*Relations in Outstanding Storms*

On June 14-15, 1957, one of the heaviest storms on record in Illinois had its major axis across the

**Table B-7. Average Area-Depth Relations in a 12-Hour, 25-Year Storm on the Kaskaskia**

| Area (square miles) | Average rainfall (inches) Upper | Lower | Entire |
|---|---|---|---|
| 25 | 6.9 | 7.8 | 7.6 |
| 50 | 6.6 | 7.5 | 7.2 |
| 100 | 6.3 | 7.2 | 6.9 |
| 200 | 6.0 | 6.8 | 6.7 |
| 500 | 5.3 | 6.1 | 6.0 |
| 1000 | 4.6 | 5.3 | 5.3 |
| 1500 | 4.2 | 4.9 | 4.9 |
| 2000 | 3.9 | 4.6 | 4.7 |
| 2500 | 3.7 | 4.3 | 4.4 |
| 3000 | | 4.1 | 4.2 |
| 3300 | | 4.0 | 4.1 |
| 4000 | | | 3.8 |
| 4500 | | | 3.6 |
| 5000 | | | 3.5 |
| 5800 | | | 3.4 |

Table B-8. Depth-Duration-Area Data in Heaviest Storms

| Storm period (hours) | Average depth (inches) for given area (square miles) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2500 | |
| *Upper Kaskaskia, June 27, 1957* | | | | | | | | | | |
| 3 | 4.2 | 4.0 | 3.8 | 3.5 | 3.0 | 2.5 | 2.2 | 1.9 | 1.7 | |
| 6 | 8.3 | 8.0 | 7.5 | 6.9 | 5.9 | 4.8 | 3.9 | 3.4 | 3.0 | |
| 12 | 11.5 | 11.2 | 10.6 | 9.9 | 8.6 | 7.1 | 6.1 | 5.3 | 4.8 | |
| 24 | 12.1 | 11.7 | 11.2 | 10.5 | 9.2 | 8.0 | 7.1 | 6.5 | 6.1 | |
| | 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2500 | 3300 |
| *Lower Kaskaskia, June 14, 1957* | | | | | | | | | | |
| 3 | 7.7 | 7.3 | 6.6 | 5.8 | 4.5 | 3.4 | 2.8 | 2.2 | 1.9 | 1.6 |
| 6 | 11.2 | 10.5 | 9.6 | 8.4 | 6.6 | 5.0 | 4.0 | 3.4 | 2.9 | 2.5 |
| 12 | 14.6 | 13.9 | 13.0 | 12.0 | 10.0 | 8.2 | 6.9 | 6.1 | 5.5 | 4.8 |
| 24 | 14.6 | 13.9 | 13.1 | 12.1 | 10.2 | 8.5 | 7.2 | 6.4 | 5.8 | 5.1 |

Lower Kaskaskia. Less than two weeks later on June 27-28, a similar storm took place on the Upper Kaskaskia. Detailed field surveys of these storms by the State Water Survey and comprehensive analyses of hydrometeorological factors associated with them were made by the Water Survey (Huff et al., 1958). Area-depth relations in these two storms for periods of 3 to 24 hours have been summarized in table B-8, and isohyetal patterns are shown in figures B-3 to B-6.

Actual duration of the June 14-15 storm was 15 hours, and the June 27-28 storm produced rainfall for 18 hours. On the basis of the average rainfall frequency relations in table B-6, the Upper Kaskaskia storm on June 27-28 was more severe with respect to its area of incidence than the Lower Kaskaskia storm on June 14-15. The 12-hour and 24-hour amounts on June 27-28 represent a 100-year storm on the Upper Kaskaskia and the 6-hour basin average of 3 inches represents a 30-year storm. In the Lower Kaskaskia storm on June 14-15, the 24-hour basin average of 5.1 inches is equivalent to a storm expected on the average of once in 40 years; the 12-hour amount of 4.8 inches represents a 50-year storm, and the 6-hour basin average of 2.5 inches is equivalent to a storm magnitude expected on the average of once in 13 years.

Figure B-7 shows hydrographs for the upper portion of the basin above Vandalia and for all of the basin above New Athens (see figure B-l) for the period prior to, during, and following the storms of June 14-15, and June 27-28, 1957. The average daily rainfall on all days with an average of 0.10 inch or more is shown also for the areas above the two streamgaging stations. The daily rainfall observations at the U. S. Weather Bureau stations used in preparing figure B-7 are usually made about 1800 CST; in the case of the two heavy June storms, the 2-day totals occurred within less than 24 hours, as pointed out earlier.

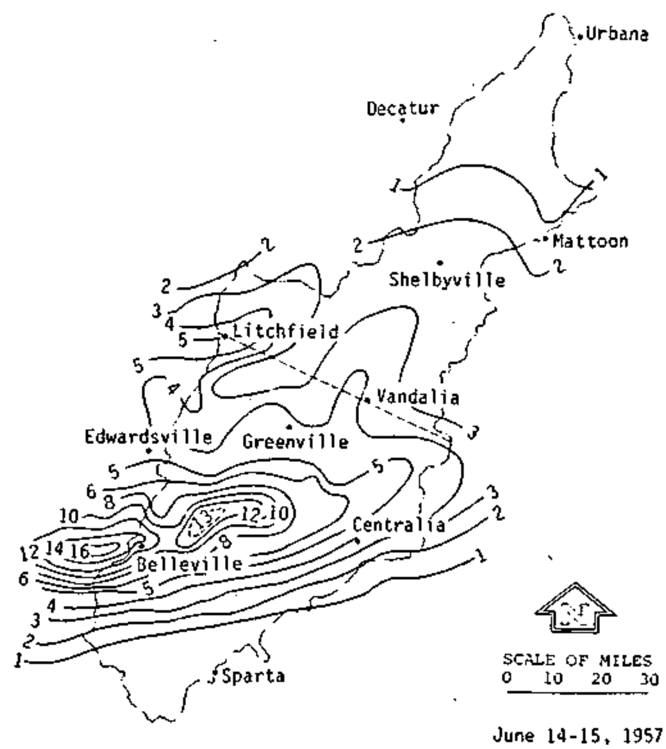



Figure B-3. Storm of June 14-15, 1957

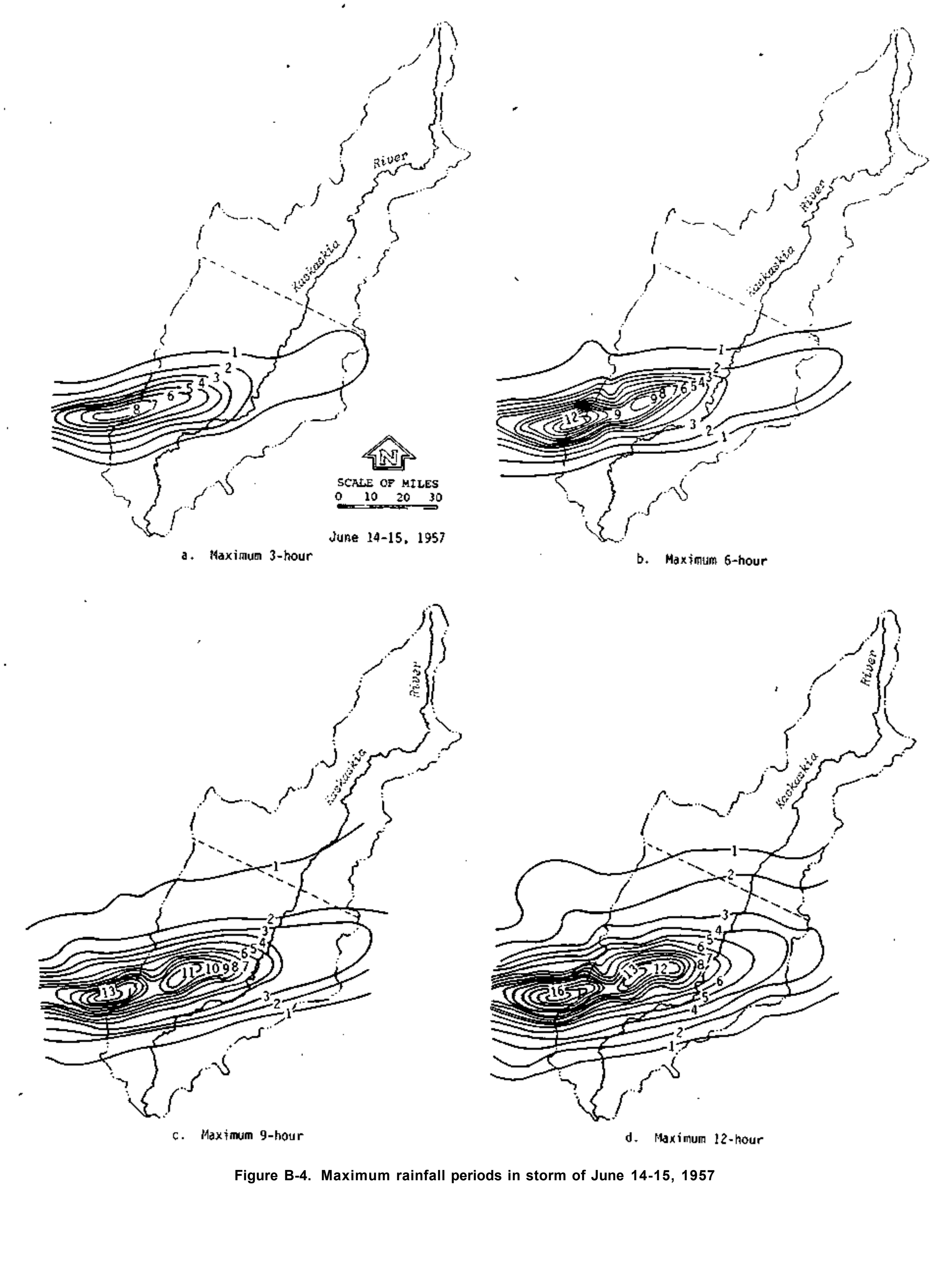



**Figure B-4. Maximum rainfall periods in storm of June 14-15, 1957**

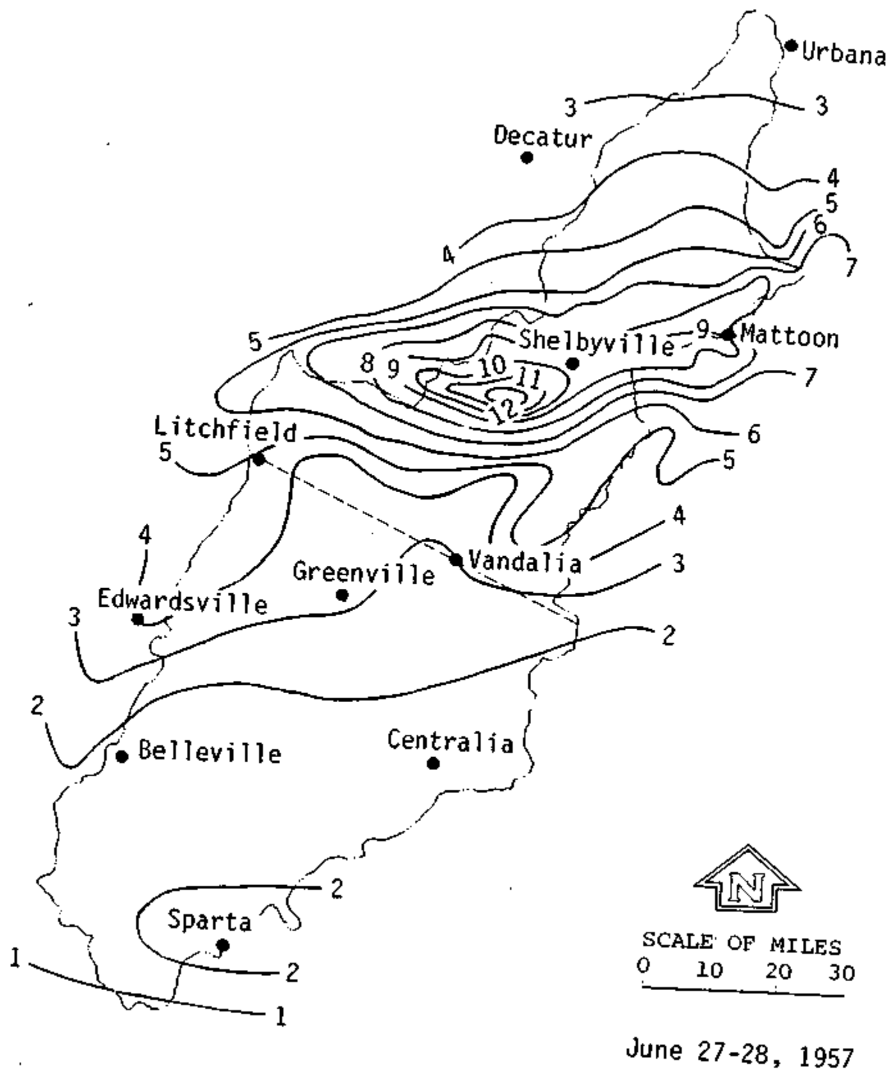



**Figure B-5. Storm of June 27-28, 1957**

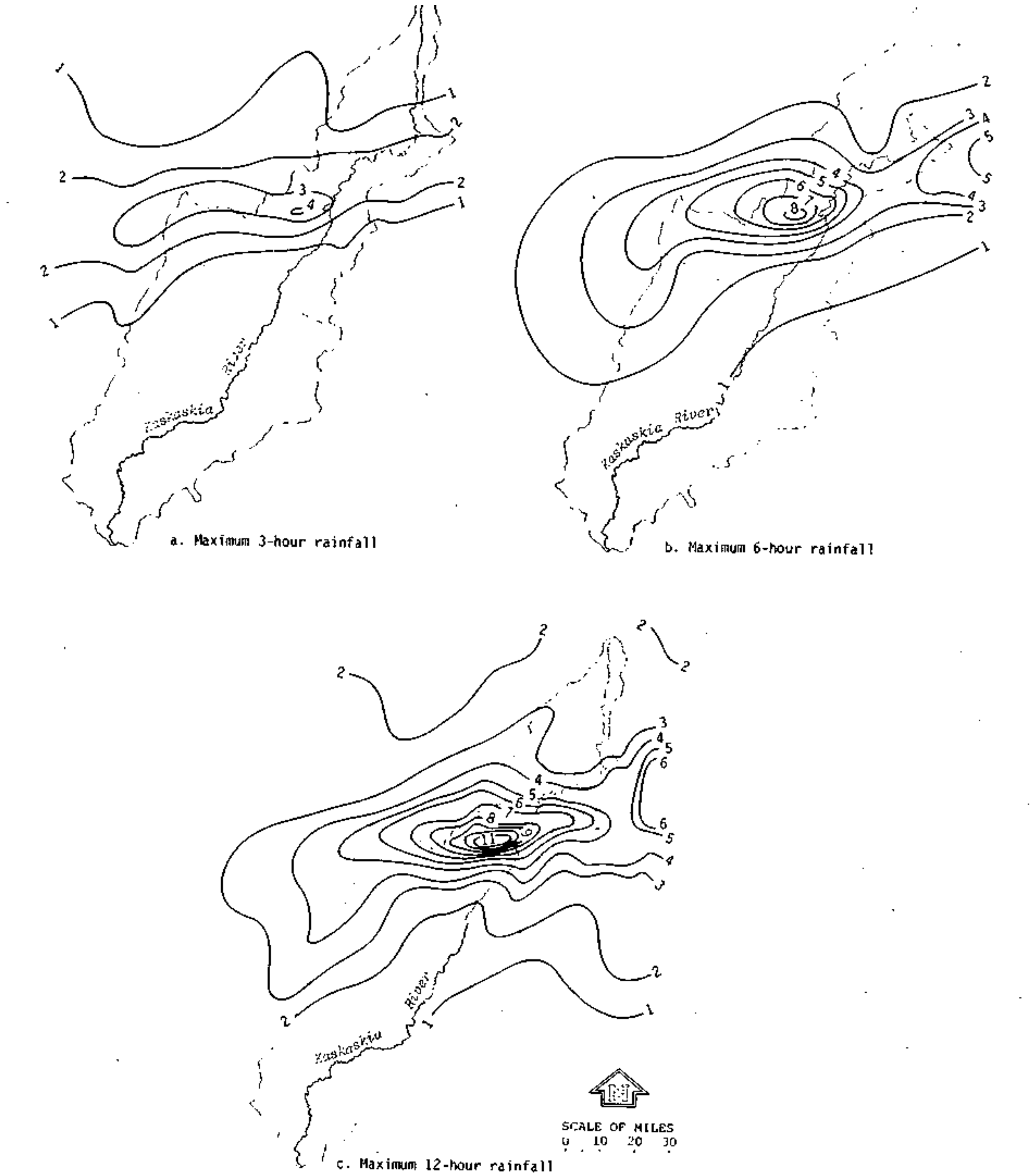



Figure B-6. Maximum rainfall periods in storm of June 27-28, 1957

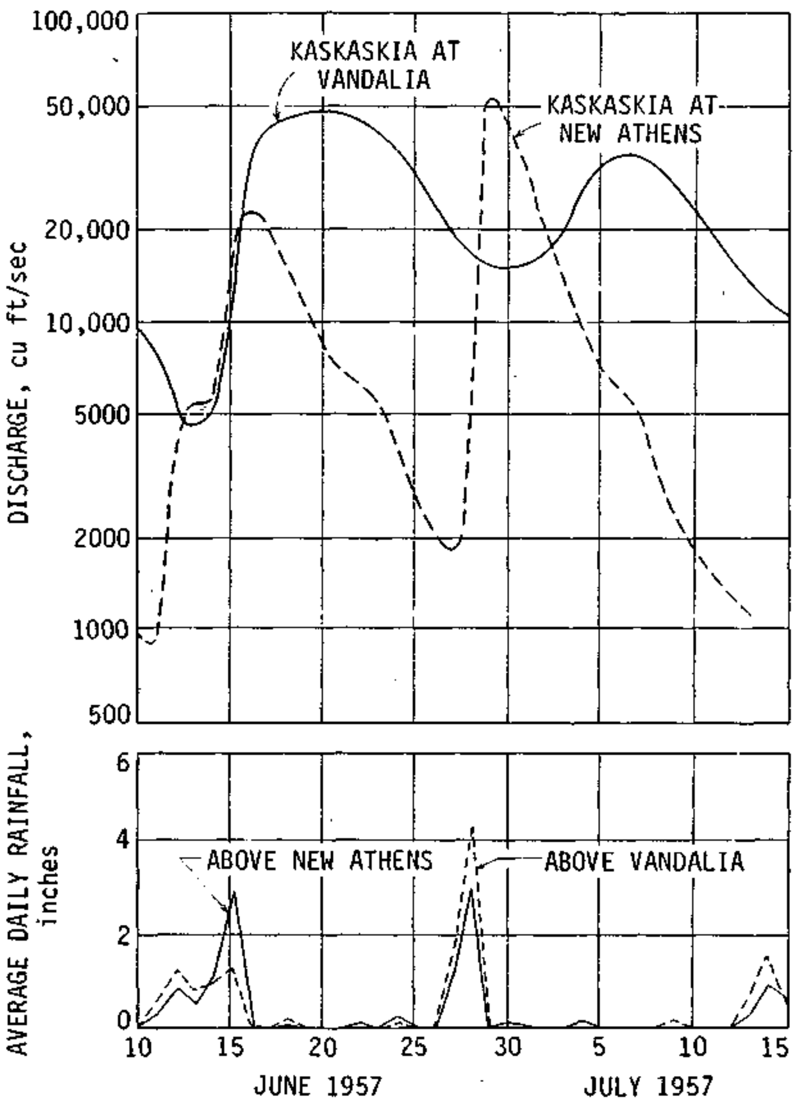



Figure B-7. Hydrographs and rainfall for Kaskaskia Basin during heavy storm periods in 1957

Figures B-8-B-16 show isohyetal patterns in other outstanding storms of 12 to 48-hour durations on the Kaskaskia basin in the period from 1900 to 1960. These patterns are based primarily on data from U. S. Weather Bureau records, and therefore do not have as great pattern detail or accuracy as the field-surveyed storms of table B-8 and figures B-3-B-6. However, original station records (Form 1009) of the Weather Bureau in the Kaskaskia region were thoroughly examined, and much information not available from published climatological data was obtained in this manner to aid in the isohyetal analyses. While these storm maps are not considered as reliable as those for the field-surveyed storms, they do provide additional information on the general magnitude of rainfall and characteristics of the patterns in severe rainstorms on the Kaskaskia basin. Table B-9 shows area-depth relationships in these storms.

#### Location of Storm Centers

The 67 storms used in the area-depth study for the entire basin were analyzed to determine whether heavy storms showed a tendency to maximize in specific regions of the basin. In this analysis, the location of the heaviest rainfall in the basin in each storm was plotted, as shown by the solid circles in figure B-17. If the heaviest basin rainfall was an extension of a center from another basin, the circle was placed on the border of the Kaskaskia. If more than one major center existed on the basin, each was plotted. Occasionally, the upper and lower portions would each have a major center in the same storm.

Figure B-17 shows three regions in which storm centers clustered during the sampling period from 1887 to 1963. One region extends across the upper portion of the basin in the region of Shelbyville. This region corresponds well with a moraine area of relatively high elevations with respect to the surrounding territory, and a relatively rapid change in elevation occurs from south to north in the path of the prevailing moist wind flow.

The second region of above normal occurrences of storm centers is in the lower part of the basin in the Belleville-Centralia area, and corresponds closely with the region of most frequent occurrence of stationary fronts in Illinois (Stout and Huff, 1962). The most severe rainstorms among the 67 used in this study occurred in this region. For example, the three 48-hour storms in which the basin mean rainfall exceeded 6 inches occurred in this area. Also, the storm of June 14-15, 1957, in which 6-hour to 12-hour amounts were the greatest on record for the basin, was centered in this region of the basin.

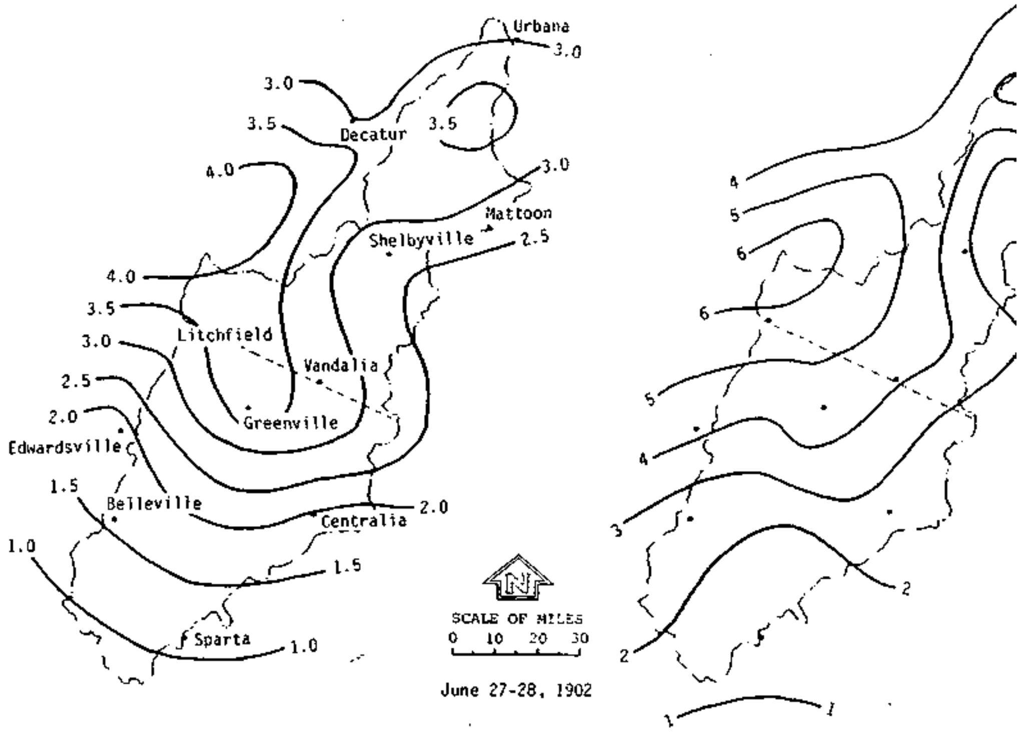
The third region of relatively frequent occurrence of storm centers is along and near the southern boundary of the basin (figure B-17). In this region, relatively steep topographic gradients are located to the southwest and west (Mississippi River bluffs) in the direction of moisture inflow from the Gulf of Mexico.

#### Monthly and Seasonal Distribution of Storms

Table B-10 shows the monthly distribution of heavy 48-hour storms for the upper, lower, and entire basin in the period from 1887 through 1961. In this analysis, all storms were used in which the areal average rainfall equaled or exceeded the amount to be expected once in 2 years, on the average, based upon the basin rainfall frequency study discussed previously. This method of selection provided 36 storms for each of the three areas.

Table B-10 indicates that March, June, and November are the months when heavy storms are most likely to occur in the upper basin. April and August are the months when the greatest number of heavy storms have been recorded in the lower portion of the basin, but June, September, and November have had nearly as frequent occurrences. For the entire basin treated as a unit, there was little difference between several months in the frequency of heavy storms. Although March has experienced five heavy storms in the 75-year sampling period, five other months have had four storms.

Table B-11 is similar to table B-10, except that the frequency of heavy storms is shown for 3-month instead of monthly periods. In all three basin areas the lowest frequency of heavy storms occurs in the winter months of December through February. No particular 3-month period stands out for high frequency of storms in the upper and lower basins; nearly equal frequencies are indicated in several of the 3-month periods from early spring to late fall. In table B-11, the upper portion of the basin shows evidence of a lull in the occurrences during midsummer to early fall. The lower portion shows a decrease in frequency in the May-July period. When treated as a single area, the entire basin indicates a preference for spring and fall occurrences.




a. 19-Hour period

b. 43-Hour period

Figure B-8. Storm of June 27-28. 1902

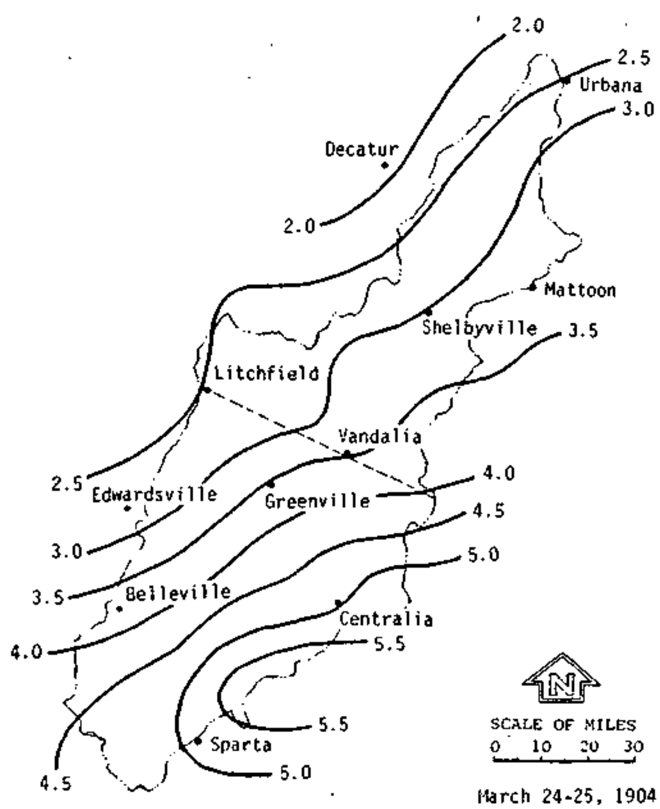



Figure B-9. Storm of March 24-25, 1904

## Table B-9. Area-Depth Relations in Outstanding Storms

*Average depth (inches) for given area (square miles)*

| Date | Duration (hours) | 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2500 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Upper Kaskaskia* | | | | | | | | | | |
| 6/28/02 | 19 | 4.2 | 4.2 | 4.1 | 4.0 | 3.8 | 3.6 | 3.4 | 3.3 | 3.2 |
| 6/27-28/02 | 43 | 6.8 | 6.7 | 6.5 | 6.2 | 5.7 | 5.2 | 4.8 | 4.5 | 4.3 |
| 8/19-20/15 | 20 | 5.5 | 5.4 | 5.4 | 5.3 | 5.2 | 4.9 | 4.6 | 4.2 | 3.9 |
| 8/19-21/15 | 33 | 7.1 | 7.1 | 7.0 | 6.8 | 6.7 | 6.3 | 5.8 | 5.4 | 5.1 |
| 10/26-27/19 | 24 | 3.6 | 3.6 | 3.5 | 3.3 | 3.0 | 2.6 | 2.2 | 1.9 | 1.6 |
| 10/25-27/19 | 48 | 6.7 | 6.6 | 6.5 | 6.4 | 6.1 | 5.7 | 5.4 | 5.1 | 4.7 |
| 9/8-9/26 | 12 | 8.8 | 8.7 | 8.5 | 8.3 | 7.6 | 6.6 | 5.8 | 5.0 | 4.4 |
| 4/22/44 | 15 | 5.5 | 5.4 | 5.3 | 5.1 | 4.7 | 4.3 | 4.0 | 3.8 | 3.6 |
| 5/16-17/43 | 24 | 4.3 | 4.2 | 4.1 | 3.9 | 3.5 | 3.1 | 2.8 | 2.6 | 2.4 |
| 5/16-18/43 | 48 | 5.8 | 5.7 | 5.6 | 5.4 | 5.0 | 4.7 | 4.3 | 4.1 | 3.9 |
| 1/3-4/50 | 12 | 3.5 | 3.4 | 3.3 | 3.2 | 3.0 | 2.8 | 2.6 | 2.5 | 2.4 |
| 1/3-4/50 | 24 | 5.9 | 5.8 | 5.7 | 5.5 | 5.2 | 4.8 | 4.5 | 4.3 | 4.1 |
| 6/27-28/51 | 12 | 4.7 | 4.6 | 4.4 | 4.2 | 3.8 | 3.3 | 3.0 | 2.8 | 2.6 |
| 6/27-28/51 | 24 | 5.2 | 5.1 | 5.0 | 4.8 | 4.4 | 4.0 | 3.7 | 3.5 | 3.3 |
| 6/26-28/51 | 48 | 5.6 | 5.5 | 5.4 | 5.3 | 5.0 | 4.8 | 4.5 | 4.3 | 4.1 |

| Date | Duration (hours) | 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2500 | 3300 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lower Kaskaskia* | | | | | | | | | | | |
| 3/24-25/04 | 25 | 6.1 | 6.0 | 5.9 | 5.7 | 5.4 | 5.0 | 4.8 | 4.6 | 4.4 | 4.2 |
| 3/24-25/13 | 48 | 4.8 | 4.7 | 4.6 | 4.6 | 4.4 | 4.2 | 4.1 | 4.0 | 3.9 | 3.8 |
| 9/16-17/05 | 20 | 9.1 | 8.7 | 8.4 | 7.8 | 6.7 | 5.7 | 5.1 | 4.6 | 4.2 | 3.6 |
| 10/17-18/05 | 12 | 7.5 | 7.1 | 6.7 | 6.0 | 5.1 | 4.4 | 3.9 | 3.6 | 3.3 | 2.9 |
| 8/19-20/15 | 20 | 7.6 | 7.5 | 7.3 | 7.0 | 6.6 | 6.1 | 5.8 | 5.5 | 5.3 | 5.0 |
| 8/19-21/15 | 33 | 7.9 | 7.8 | 7.8 | 7.7 | 7.6 | 7.4 | 7.1 | 6.8 | 6.6 | 6.2 |
| 1/28-30/16 | 48 | 5.8 | 5.7 | 5.6 | 5.3 | 4.9 | 4.5 | 4.2 | 4.0 | 3.8 | 3.5 |
| 8/12-13/16 | 32 | 5.8 | 5.7 | 5.7 | 5.6 | 5.4 | 4.9 | 4.5 | 4.2 | 4.0 | 3.7 |
| 10/26-27/19 | 24 | 6.7 | 6.6 | 6.4 | 6.2 | 5.8 | 5.3 | 5.0 | 4.7 | 4.5 | 4.2 |
| 10/25-27/19 | 48 | 9.8 | 9.7 | 9.6 | 9.5 | 9.2 | 8.6 | 8.3 | 8.0 | 7.8 | 7.4 |
| 5/16-17/43 | 24 | 5.7 | 5.6 | 5.3 | 5.0 | 4.2 | 3.2 | 2.6 | 2.1 | 1.8 | 1.4 |
| 5/16-18/43 | 48 | 7.6 | 7.4 | 7.1 | 6.7 | 5.7 | 4.5 | 3.8 | 3.3 | 2.9 | 2.5 |
| 8/15-16/46 | 24 | 13.7 | 13.6 | 13.4 | 13.1 | 12.2 | 10.7 | 9.3 | 8.3 | 7.4 | 6.0 |
| 8/14-16/46 | 48 | 18.1 | 18.0 | 17.8 | 17.5 | 17.1 | 16.2 | 14.6 | 13.1 | 11.8 | 9.7 |
| 1/3-4/50 | 12 | 6.5 | 6.3 | 6.0 | 5.7 | 5.0 | 4.3 | 3.9 | 3.6 | 3.4 | 3.1 |
| 1/3-4/50 | 24 | 7.4 | 7.1 | 6.8 | 6.4 | 5.9 | 5.4 | 5.0 | 4.7 | 4.5 | 4.2 |

| Date | Duration (hours) | 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2500 | 3500 | 4500 | 5800 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Entire Kaskaskia* | | | | | | | | | | | | | |
| 3/24-25/04 | 21 | 6.1 | 6.0 | 5.9 | 5.7 | 5.4 | 5.0 | 4.8 | 4.6 | 4.4 | 4.2 | 4.0 | 3.7 |
| 3/24-25/13 | 48 | 4.8 | 4.7 | 4.6 | 4.6 | 4.4 | 4.2 | 4.1 | 4.0 | 3.9 | 3.8 | 3.6 | 3.5 |
| 8/19-20/15 | 20 | 7.6 | 7.5 | 7.3 | 7.0 | 6.6 | 6.2 | 5.9 | 5.6 | 5.5 | 5.2 | 5.0 | 4.7 |
| 8/19-21/15 | 33 | 7.9 | 7.8 | 7.8 | 7.7 | 7.6 | 7.4 | 7.2 | 6.9 | 6.7 | 6.4 | 6.1 | 5.8 |
| 10/26-27/19 | 24 | 6.7 | 6.6 | 6.4 | 6.2 | 5.8 | 5.3 | 5.0 | 4.7 | 4.5 | 4.1 | 3.6 | 3.0 |
| 10/25-27/19 | 48 | 9.8 | 9.7 | 9.6 | 9.5 | 9.2 | 8.6 | 8.3 | 8.0 | 7.8 | 7.3 | 6.7 | 6.0 |
| 5/16-17/43 | 24 | 5.7 | 5.6 | 5.3 | 5.0 | 4.4 | 3.8 | 3.5 | 3.3 | 3.0 | 2.6 | 2.3 | 1.8 |
| 5/16-18/43 | 48 | 7.6 | 7.4 | 7.1 | 6.7 | 6.0 | 5.5 | 5.0 | 4.7 | 4.4 | 4.0 | 3.5 | 3.0 |
| 8/15-16/46 | 24 | 13.7 | 13.6 | 13.4 | 13.1 | 12.2 | 10.7 | 9.3 | 8.4 | 7.7 | 6.3 | 5.1 | 3.9 |
| 8/14-16/46 | 48 | 18.1 | 18.0 | 17.8 | 17.5 | 17.1 | 16.2 | 14.6 | 13.1 | 11.8 | 9.6 | 7.8 | 6.3 |
| 1/3-4/50 | 12 | 6.5 | 6.3 | 6.0 | 5.7 | 5.0 | 4.3 | 3.9 | 3.7 | 3.5 | 3.2 | 3.0 | 2.7 |
| 1/3-4/50 | 24 | 7.4 | 7.1 | 6.8 | 6.5 | 5.8 | 5.3 | 5.0 | 4.8 | 4.6 | 4.4 | 4.3 | 4.1 |

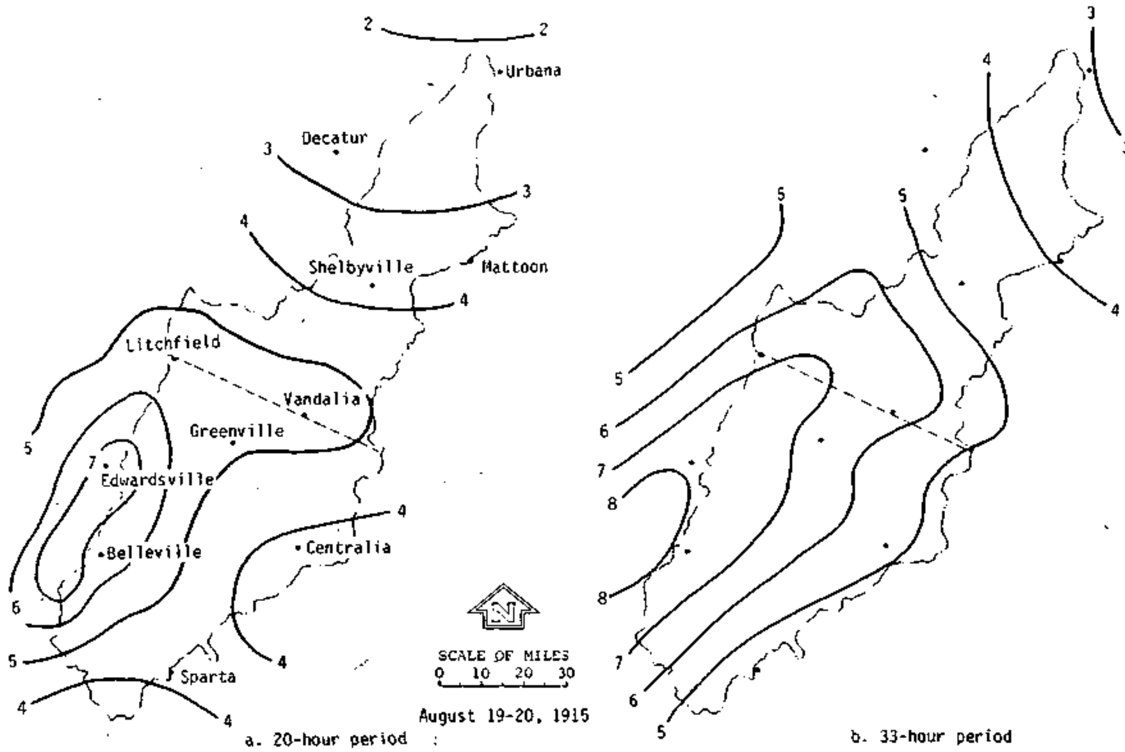



Figure B-10. Storm of August 19-20, 1915

### Table B-10. Monthly Distribution of 48-Hour Heavy Rainstorms

| *Month* | *Number of storms in given month* Upper portion | Lower portion | Entire basin |
|---|---|---|---|
| January | 2 | 3 | 3 |
| February | 0 | 1 | 1 |
| March | 6 | 3 | 5 |
| April | 2 | 5 | 3 |
| May | 3 | 2 | 3 |
| June | 6 | 4 | 4 |
| July | 3 | 1 | 1 |
| August | 2 | 5 | 4 |
| September | 3 | 4 | 4 |
| October | 4 | 3 | 4 |
| November | 5 | 4 | 4 |
| December | 0 | 1 | 0 |
| Total | 36 | 36 | 36 |

### Table B-11. Seasonal Distribution of 48-Hour Heavy Rainstorms

| *3-Month period* | *Number of storms in 3-month period* Upper portion | Lower portion | Entire basin |
|---|---|---|---|
| Jan-Mar | 8 | 7 | 9 |
| Feb-Apr | 8 | 9 | 9 |
| Mar-May | 11 | 10 | 11 |
| Apr-Jun | 11 | 11 | 10 |
| May-Jul | 12 | 7 | 8 |
| Jun-Aug | 11 | 10 | 9 |
| Jul-Sep | 8 | 10 | 9 |
| Aug-Oct | 9 | 12 | 12 |
| Sep-Nov | 12 | 11 | 12 |
| Oct-Dec | 9 | 8 | 8 |
| Nov-Jan | 7 | 8 | 7 |
| Dec-Feb | 2 | 5 | 4 |

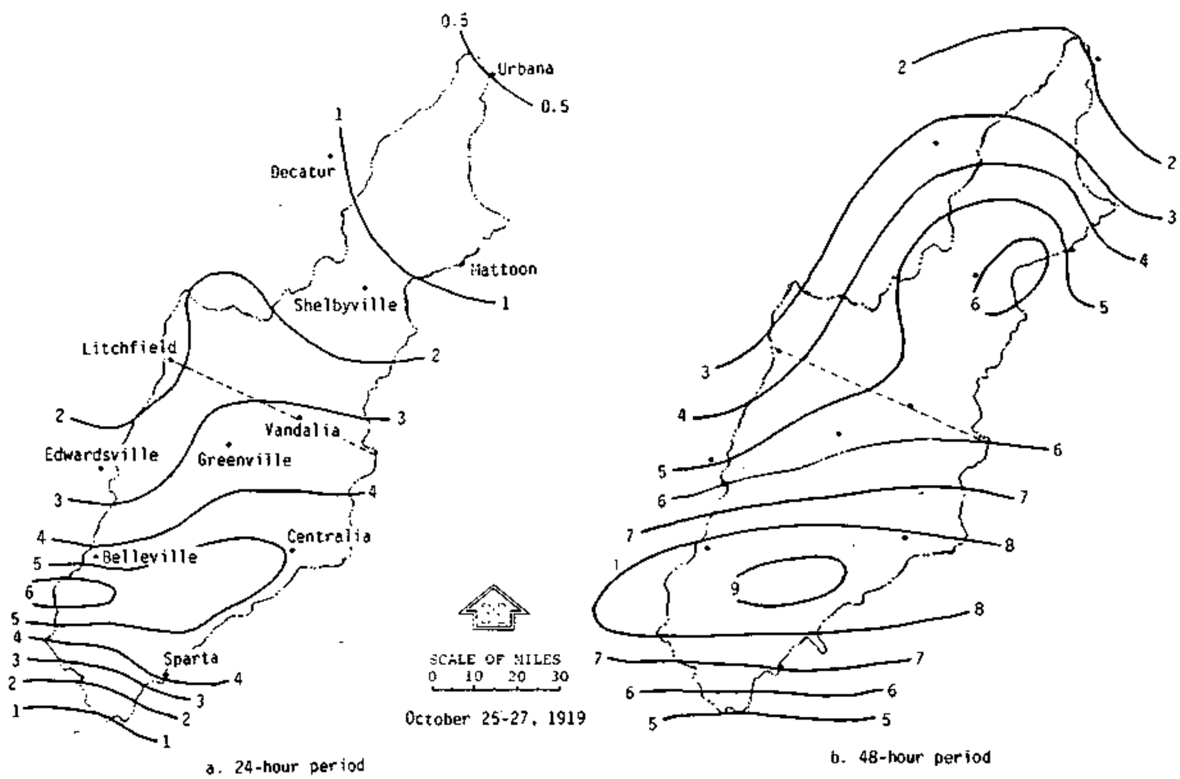



Figure B-11. Storm of October 25-27, 1919

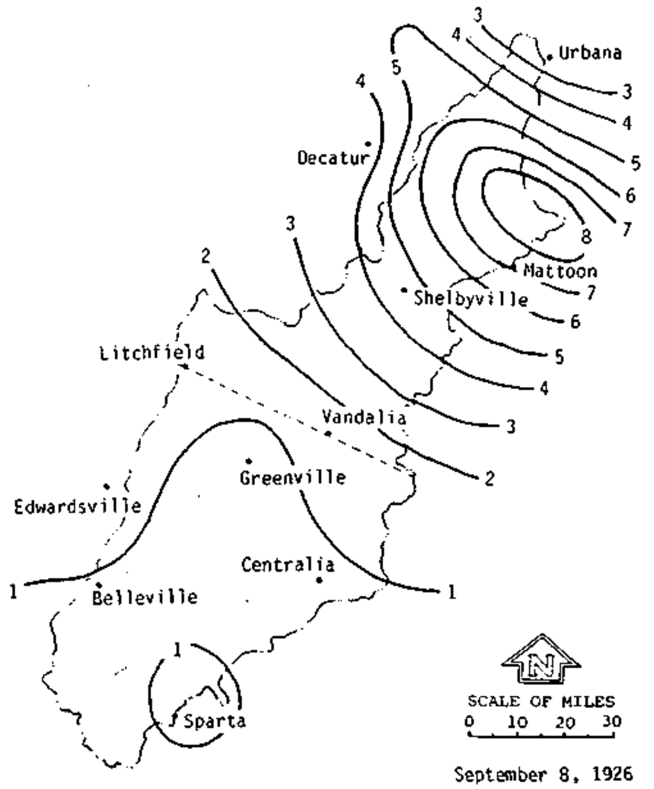



**Figure B-12. Storm of September 8, 1926**

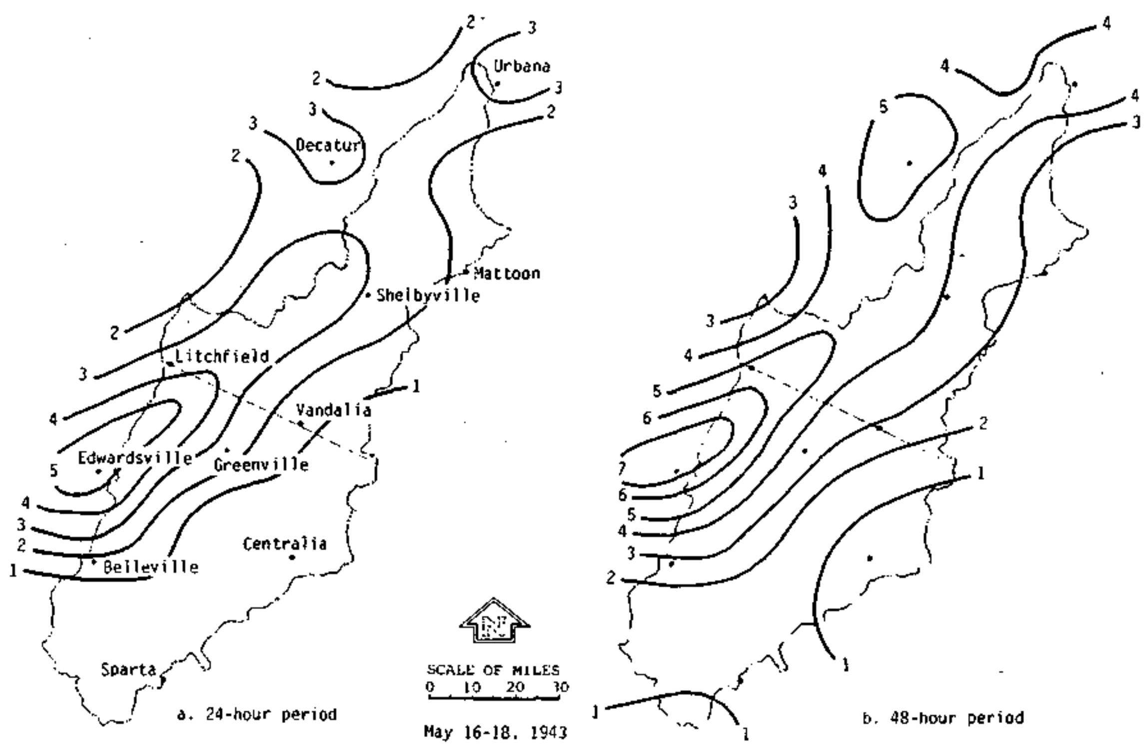



**Figure B-13. Storm of May 16-18, 1943**

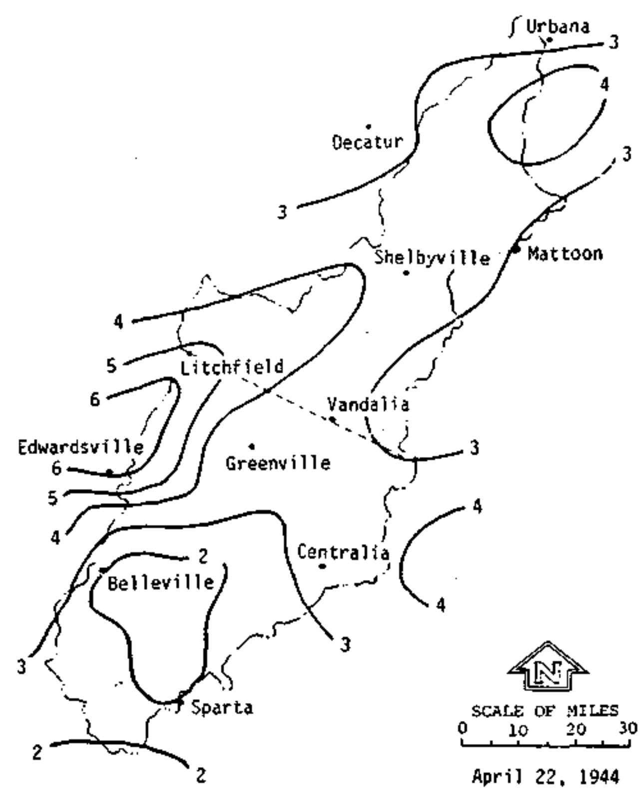



Figure B-14. Storm of April 22, 1944

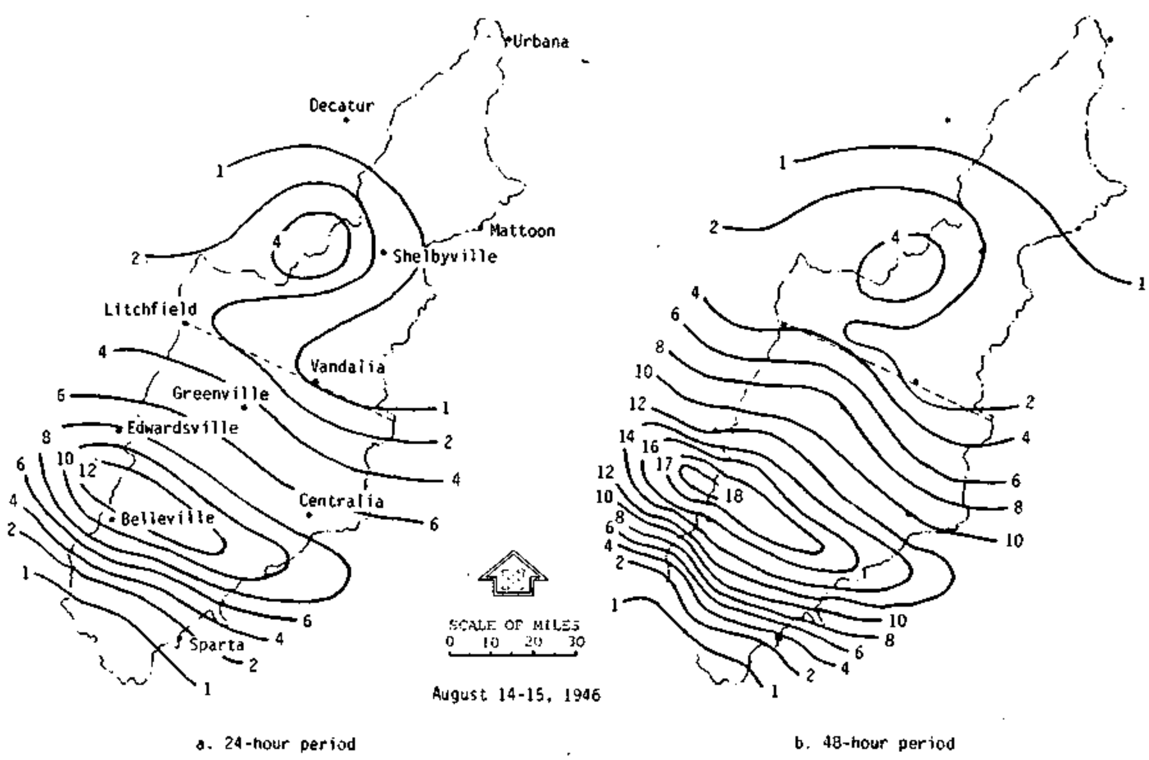



Figure B-15. Storm of August 14-16. 1946

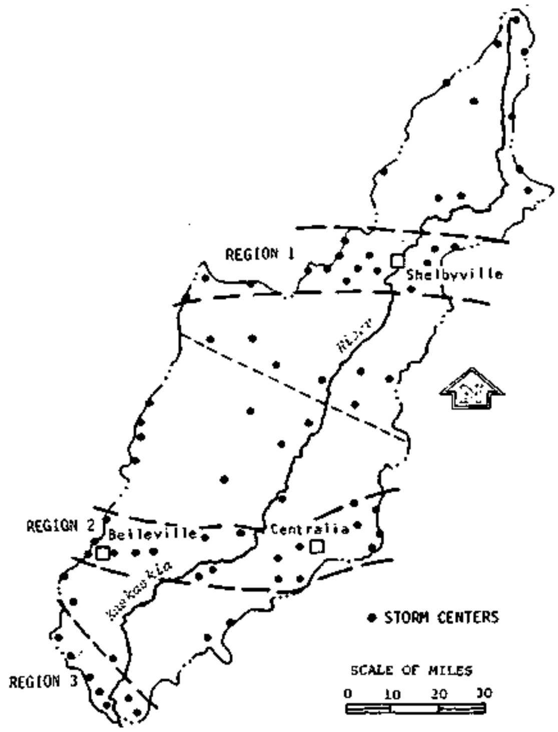
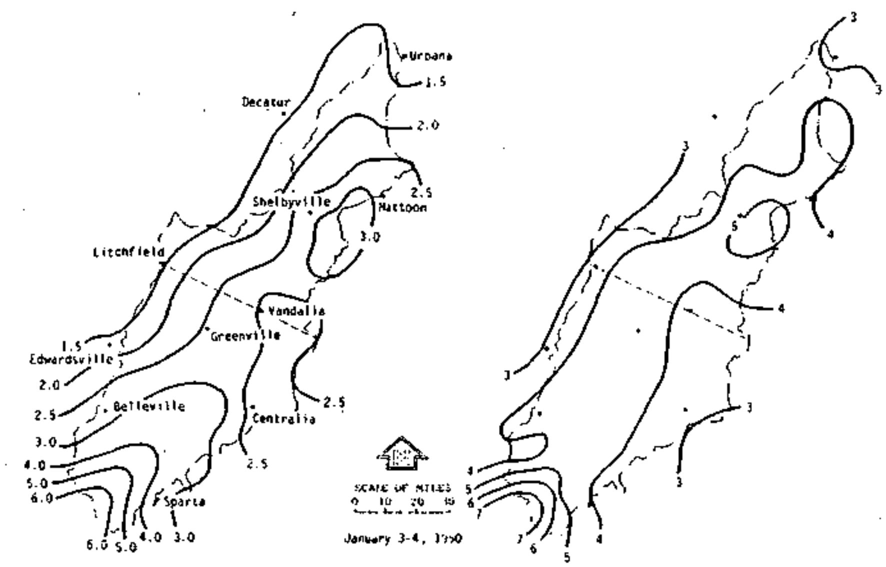



Figure B-16. Storm of January 3-4, 1950




a. Maximum 12-hour, 1300 Jan 3-0100 Jan 4

b. Maximum 24-hour, 0700 Jan 3-0700 Jan 4

Figure B-17. Location of heavy storm centers

# Part C. The Big Muddy Basin

The Big Muddy Basin is located in extreme southern Illinois where it drains an area of approximately 2400 square miles (figures C-l). The basin is relatively flat with elevations ranging from slightly over 300 feet MSL in the river valley in the southwestern portion of the basin to 700-750 feet in the extreme southern part of the basin. Except for the extreme southern and southwestern regions, the basin is very flat with elevations ranging from 350 to 500 feet MSL.

### Basin Climate

The annual average precipitation is 42.5 inches on the basin and increases from 40.5 inches in the northwestern part of the basin to 46 inches in the extreme southern part (figure C-2). A relatively steep gradient of annual precipitation is found in the southern part of the basin, in which a northward decrease from 46 to 43 inches occurs in less than 20 miles. Precipitation normally is the heaviest in the 3-month period of April, May, and June, in which the average basin rainfall is 12 inches. The driest period occurs most frequently from December through February; in this 3-month period, the average precipitation is 9 inches, with an increase from 8 inches in the northwest to 10.5 inches in the southeast (figure C-3a). Snowfall normally accounts for only 3 to 4 percent of the total annual precipitation, and averages 13 inches in the southern and southwestern parts of the basin and 14 to 15 inches in the northern and eastern parts.

The annual average frequency of thunderstorm days ranges from 56 in the extreme southern part of the basin to 53 in the northern part (Changnon, 1957). The basin lies in the region of Illinois in which thunderstorm frequency is greatest. The frequency of hailstorms is moderate with respect to the rest of Illinois. On the average, a given point in the basin can expect 2 to 3 days per year with hail (Huff and Changnon, 1959). The Big Muddy Basin lies east and southeast of the region of maximum tornado occurrences in Illinois (Wilson and Changnon, 1971). In the extreme western part of the basin, 2 to 4 tornadoes per 1000 square miles can be expected in an average 25-year period. This frequency increases to 5-6 per 1000 square miles in the eastern part of the basin. The zone in which severe rainstorms in Illinois are most frequent (South and Huff, 1962) crosses the Big Muddy Basin in a NW-SE direction from the vicinity of Nashville to the east central part of the basin.

The annual average temperature ranges from approximately 56.5°F in the northern part of the basin to near 58° in the southern part. Normally, the hottest month is July in which the monthly mean varies from 78° in the north to 79° in the south. In January, normally the coldest month, mean temperatures vary from 34° in the northern part of the basin to 36° in the southern part.

### Frequency Distribution of Point Rainfall

Table C-l shows the frequency distribution of point rainfall in the Big Muddy Basin for storm periods of 1 to 48 hours. The relations presented in this table are based upon studies by Huff and Neill (1959) and the U. S. Weather Bureau (Hershfield, 1961). The data are applicable to any selected point in the basin.

Use of table C-l is illustrated in the following example. Assume one wishes to determine the 12-hour point rainfall to be expected *on the average* of once in 25 years at Du Quoin (figure C-l). Move down the column labeled "storm duration" to 12;

**Table C-1. Point Rainfall Frequency Relations on Big Muddy Basin**

| *Storm duration (hours)* | *Depth (inches) equaled or exceeded for given recurrence interval (years)* 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 1 | 1.6 | 1.9 | 2.2 | 2.7 | 3.3 | 4.0 |
| 2 | 1.9 | 2.2 | 2.7 | 3.3 | 3.9 | 4.7 |
| 3 | 2.1 | 2.5 | 3.0 | 3.6 | 4.3 | 5.2 |
| 6 | 2.5 | 3.0 | 3.6 | 4.4 | 5.2 | 6.3 |
| 12 | 3.2 | 3.7 | 4.3 | 5.2 | 5.9 | 7.4 |
| 18 | 3.4 | 4.0 | 4.7 | 5.8 | 6.7 | 8.2 |
| 24 | 3.5 | 4.3 | 5.0 | 6.3 | 7.3 | 8.8 |
| 48 | 3.6 | 4.5 | 5.4 | 6.8 | 7.9 | 9.5 |

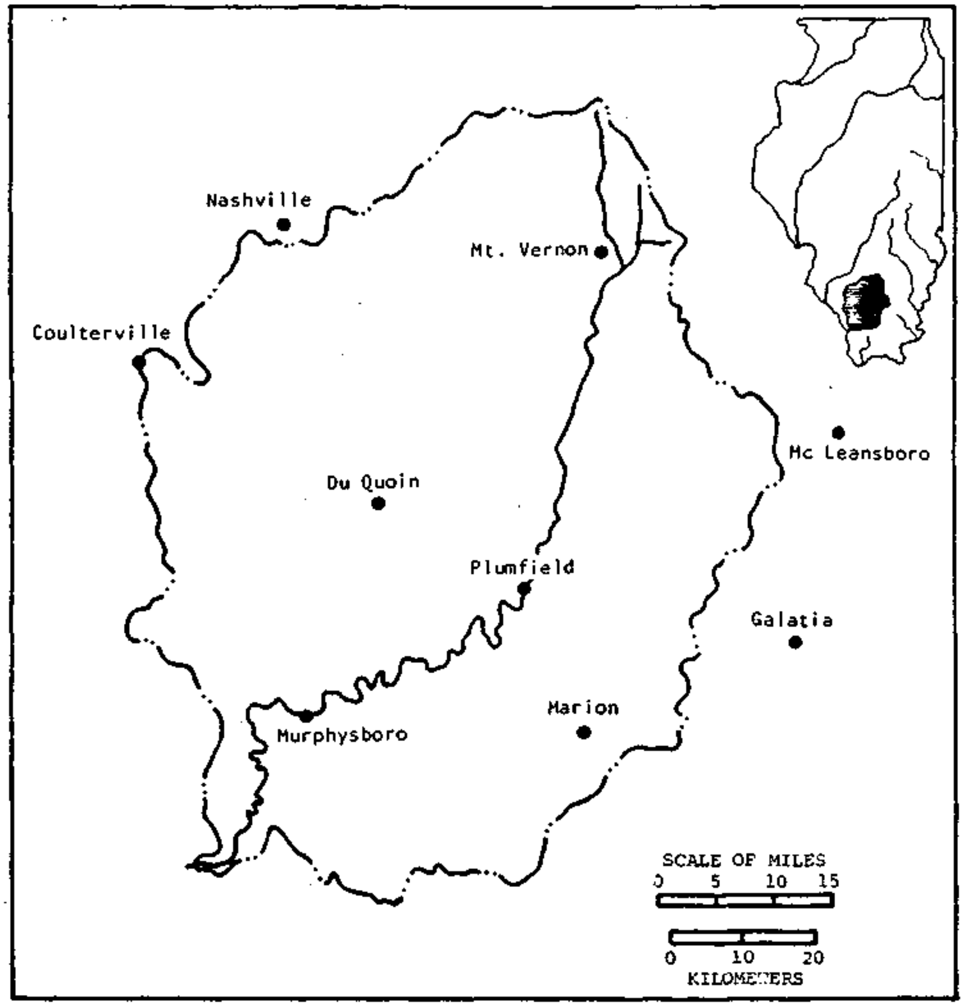



Figure C-1. Location map. Big Muddy Basin

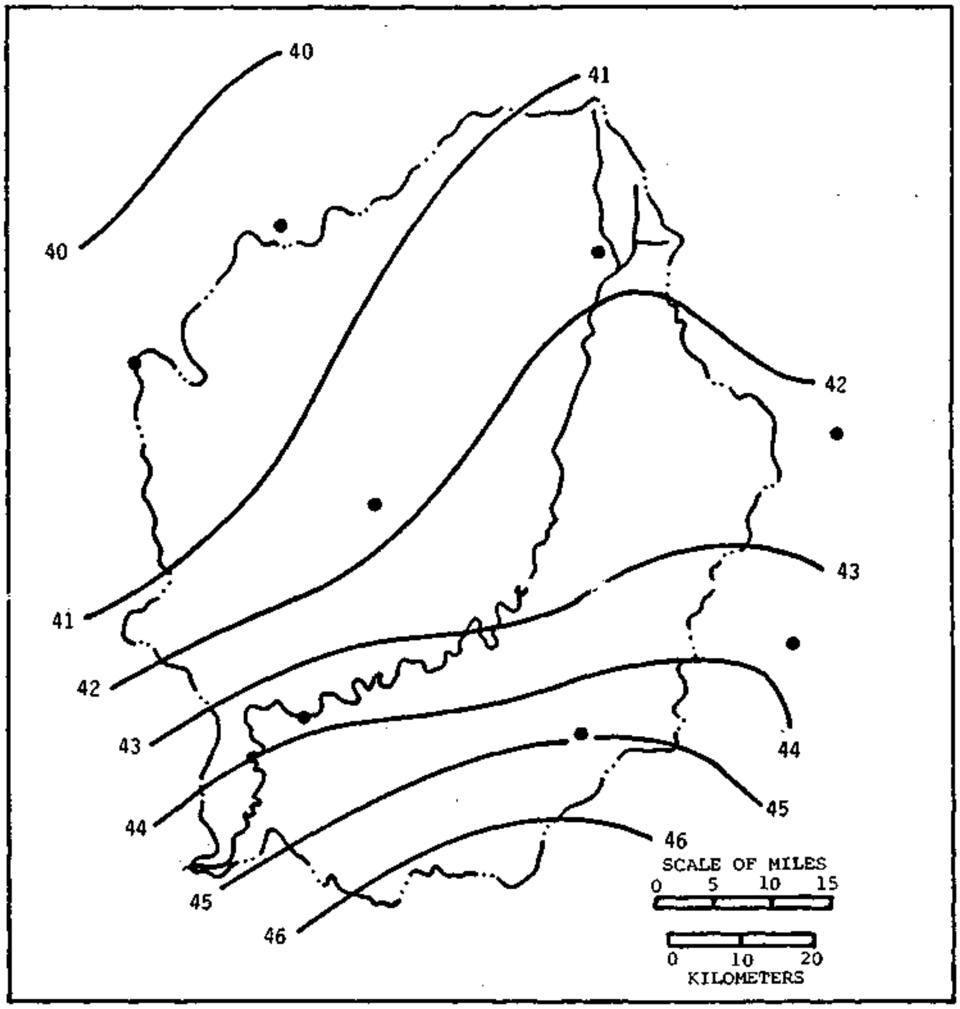



Figure C-2. Annual average precipitation. Big Muddy Basin

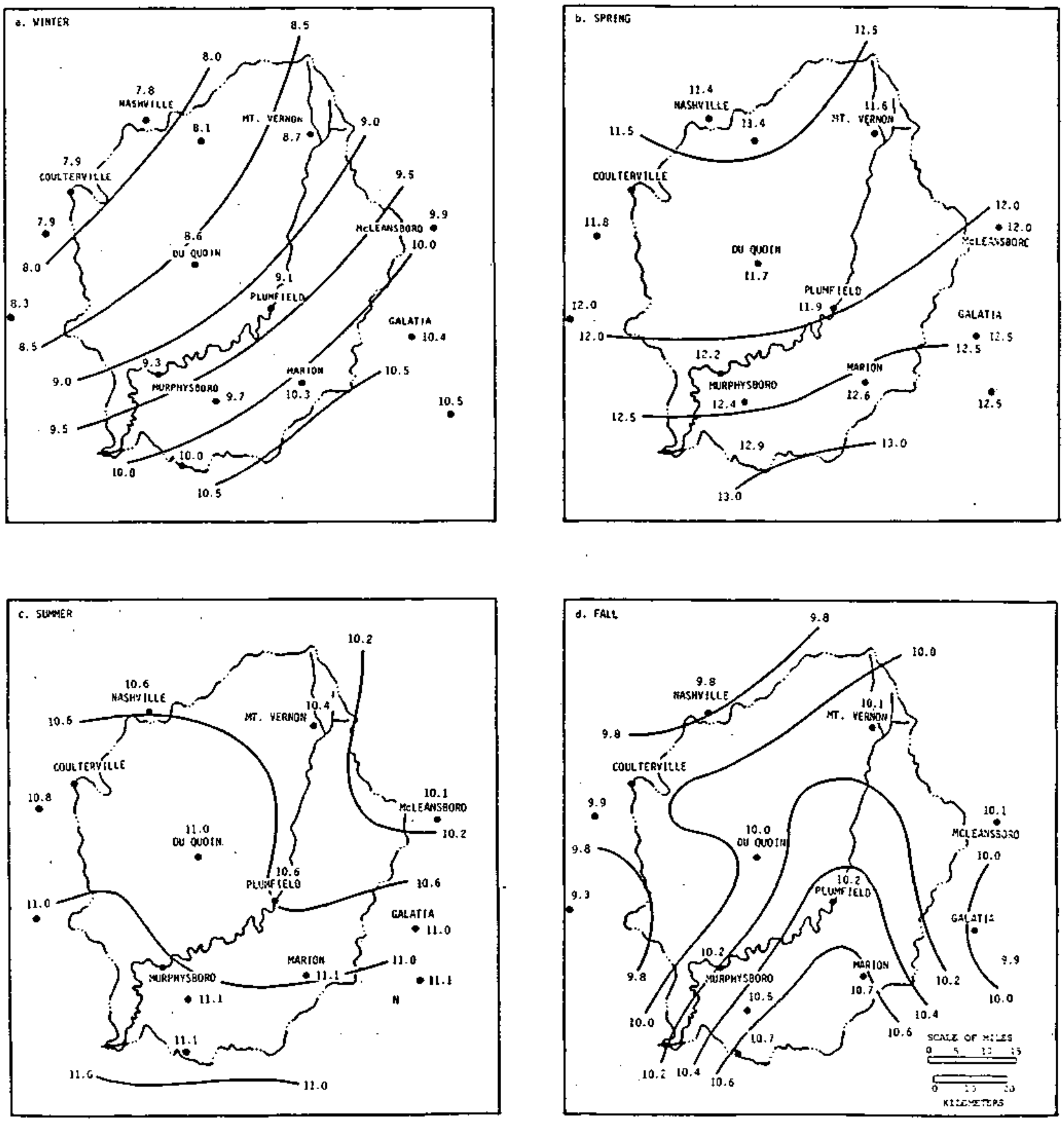



Figure C-3. Average precipitation by season. Big Muddy Basin then move horizontally to the column for a recurrence interval of 25 years and read the required value, which in this case is 5.2 inches. As pointed out in the section on definitions, *the data in table C-l apply to points only,* and should not be used for estimates of areal mean rainfall which will be provided in ensuing sections of this report.

**Table C-2. Basin Mean Rainfall Frequency Relations**

| *Recurrence interval (years)* | *Average rainfall depth (inches) equaled or exceeded for given storm period (hours)* 6 | 12 | 18 | 24 | 30 | 36 | 48 |
|---|---|---|---|---|---|---|---|
| 1 | 1.1 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 |
| 2 | 1.6 | 2.1 | 2.4 | 2.5 | 2.7 | 2.8 | 2.9 |
| 5 | 2.3 | 2.9 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 |
| 10 | 2.7 | 3.5 | 3.9 | 4.1 | 4.4 | 4.5 | 4.7 |
| 15 | 3.0 | 3.8 | 4.3 | 4.6 | 4.8 | 5.0 | 5.2 |
| 20 | 3.2 | 4.1 | 4.6 | 4.9 | 5.2 | 5.4 | 5.6 |
| 25 | 3.4 | 4.3 | 4.8 | 5.2 | 5.5 | 5.7 | 5.9 |
| 30 | 3.5 | 4.5 | 5.0 | 5.4 | 5.7 | 5.9 | 6.1 |
| 35 | 3.7 | 4.7 | 5.2 | 5.6 | 5.9 | 6.1 | 6.4 |
| 40 | 3.8 | 4.9 | 5.4 | 5.8 | 6.1 | 6.3 | 6.6 |
| 50 | 4.0 | 5.1 | 5.7 | 6.1 | 6.4 | 6.6 | 6.9 |
| 75 | 4.4 | 5.7 | 6.3 | 6.7 | 7.1 | 7.3 | 7.7 |
| 100 | 4.7 | 6.1 | 6.7 | 7.2 | 7.6 | 7.8 | 8.2 |

## Frequency Distribution of Storm Mean Rainfall

Tables C-2 to C-4 show frequency distributions of areal mean rainfall for the Big Muddy Basin. A description of how these tables were derived and their interpretation is contained in the first section of this report. Table C-2 shows the frequency of

**Table C-3. Frequency Distribution of Areal Mean Rainfall for Specific Integral Areas on Big Muddy Basin**

| *Recurrence interval (years)* | *Average depth (inches) equaled or exceeded for given area (square miles)* 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *1-Hour storm period* | | | | | | |
| 2 | 1.5 | 1.4 | 1.3 | 1.2 | 1.1 | 1.0 |
| 5 | 1.8 | 1.7 | 1.5 | 1.4 | 1.3 | 1.2 |
| 10 | 2.0 | 1.9 | 1.8 | 1.6 | 1.5 | 1.4 |
| 25 | 2.6 | 2.4 | 2.2 | 2.0 | 1.8 | 1.7 |
| 50 | 3.1 | 2.9 | 2.6 | 2.4 | 2.2 | 2.1 |
| 100 | 3.7 | 3.5 | 3.1 | 2.9 | 2.7 | 2.5 |
| *2-Hour storm period* | | | | | | |
| 2 | 1.8 | 1.8 | 1.6 | 1.5 | 1.4 | 1.3 |
| 5 | 2.1 | 2.0 | 1.9 | 1.8 | 1.6 | 1.5 |
| 10 | 2.5 | 2.5 | 2.3 | 2.2 | 2.0 | 1.9 |
| 25 | 3.1 | 3.0 | 2.8 | 2.6 | 2.4 | 2.3 |
| 50 | 3.7 | 3.6 | 3.4 | 3.1 | 2.9 | 2.8 |
| 100 | 4.5 | 4.4 | 4.1 | 3.7 | 3.5 | 3.3 |
| *3-Hour storm period* | | | | | | |
| 2 | 2.0 | 2.0 | 1.9 | 1.8 | 1.7 | 1.6 |
| 5 | 2.4 | 2.4 | 2.3 | 2.1 | 2.0 | 1.9 |
| 10 | 2.9 | 2.8 | 2.7 | 2.5 | 2.4 | 2.3 |
| 25 | 3.5 | 3.4 | 3.2 | 3.1 | 2.9 | 2.8 |
| 50 | 4.2 | 4.1 | 3.9 | 3.7 | 3.4 | 3.3 |
| 100 | 5.0 | 4.9 | 4.7 | 4.4 | 4.2 | 4.0 |
| *6-Hour storm period* | | | | | | |
| 2 | 2.4 | 2.4 | 2.3 | 2.2 | 2.1 | 2.0 |
| 5 | 2.9 | 2.9 | 2.8 | 2.7 | 2.6 | 2.5 |
| 10 | 3.5 | 3.5 | 3.3 | 3.2 | 3.1 | 3.0 |
| 25 | 4.3 | 4.2 | 4.1 | 3.9 | 3.7 | 3.6 |
| 50 | 5.1 | 5.0 | 4.8 | 4.6 | 4.5 | 4.3 |
| 100 | 6.1 | 6.0 | 5.8 | 5.6 | 5.4 | 5.2 |

| *Recurrence interval (years)* | *Average depth (inches) equaled or exceeded for given area (square miles)* 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *12-Hour storm period* | | | | | | |
| 2 | 3.1 | 3.1 | 3.0 | 2.9 | 2.8 | 2.7 |
| 5 | 3.6 | 3.6 | 3.5 | 3.4 | 3.3 | 3.2 |
| 10 | 4.2 | 4.2 | 4.0 | 3.9 | 3.8 | 3.7 |
| 25 | 5.1 | 5.0 | 4.9 | 4.7 | 4.6 | 4.5 |
| 50 | 5.8 | 5.7 | 5.5 | 5.4 | 5.2 | 5.1 |
| 100 | 7.3 | 7.2 | 7.0 | 6.8 | 6.6 | 6.4 |
| *18-Hour storm period* | | | | | | |
| 2 | 3.3 | 3.3 | 3.2 | 3.1 | 3.0 | 3.0 |
| 5 | 3.9 | 3.9 | 3.8 | 3.7 | 3.6 | 3.5 |
| 10 | 4.6 | 4.6 | 4.4 | 4.3 | 4.2 | 4.1 |
| 25 | 5.7 | 5.6 | 5.5 | 5.4 | 5.3 | 5.1 |
| 50 | 6.6 | 6.5 | 6.4 | 6.3 | 6.2 | 6.0 |
| 100 | 8.0 | 7.9 | 7.7 | 7.6 | 7.5 | 7.3 |
| *24-Hour storm period* | | | | | | |
| 2 | 3.4 | 3.4 | 3.3 | 3.2 | 3.1 | 3.1 |
| 5 | 4.2 | 4.2 | 4.1 | 4.0 | 3.9 | 3.9 |
| 10 | 4.9 | 4.9 | 4.8 | 4.7 | 4.5 | 4.5 |
| 25 | 6.2 | 6.2 | 6.0 | 5.9 | 5.8 | 5.7 |
| 50 | 7.2 | 7.2 | 7.0 | 6.8 | 6.7 | 6.6 |
| 100 | 8.6 | 8.6 | 8.4 | 8.2 | 8.1 | 8.0 |
| *48-Hour storm period* | | | | | | |
| 2 | 3.6 | 3.6 | 3.5 | 3.4 | 3.3 | 3.2 |
| 5 | 4.5 | 4.4 | 4.3 | 4.2 | 4.1 | 4.1 |
| 10 | 5.4 | 5.3 | 5.2 | 5.1 | 5.0 | 4.9 |
| 25 | 6.7 | 6.6 | 6.5 | 6.4 | 6.3 | 6.2 |
| 50 | 7.8 | 7.8 | 7.6 | 7.5 | 7.4 | 7.3 |
| 100 | 9.4 | 9.3 | 9.1 | 9.0 | 8.9 | 8.8 |

**Table C-4. Frequency Distribution of Areal Maximum Rainfall on Big Muddy Basin**

| *Recurrence interval (years)* | *Average depth (inches) for given area (square miles)* 25 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| *6-Hour storms* | | | | | | |
| 2 | 3.6 | 3.5 | 3.3 | 3.1 | 2.8 | 2.4 |
| 5 | 4.7 | 4.5 | 4.3 | 4.1 | 3.7 | 3.2 |
| 10 | 5.8 | 5.6 | 5.3 | 4.9 | 4.5 | 3.9 |
| 25 | 7.6 | 7.4 | 6.9 | 6.5 | 5.9 | 5.1 |
| 50 | 9.3 | 9.0 | 8.5 | 7.9 | 7.1 | 6.2 |
| 100 | 11.4 | 11.0 | 10.3 | 9.7 | 8.7 | 7.6 |
| *12-Hour storms* | | | | | | |
| 2 | 4.4 | 4.2 | 4.0 | 3.7 | 3.4 | 3.1 |
| 5 | 5.7 | 5.5 | 5.2 | 4.9 | 4.5 | 4.0 |
| 10 | 7.0 | 6.7 | 6.4 | 5.9 | 5.5 | 4.9 |
| 25 | 9.1 | 8.8 | 8.2 | 7.8 | 7.1 | 6.3 |
| 50 | 11.2 | 10.8 | 10.2 | 9.6 | 8.7 | 7.8 |
| 100 | 13.7 | 13.2 | 12.4 | 11.6 | 10.7 | 9.4 |
| *18-Hour storms* | | | | | | |
| 2 | 4.8 | 4.6 | 4.4 | 4.1 | 3.7 | 3.3 |
| 5 | 6.2 | 6.0 | 5.8 | 5.2 | 4.9 | 4.3 |
| 10 | 7.6 | 7.3 | 7.1 | 6.5 | 6.0 | 5.3 |
| 25 | 10.0 | 9.6 | 9.1 | 8.5 | 7.8 | 6.9 |
| 50 | 12.2 | 11.7 | 11.2 | 10.4 | 9.5 | 8.5 |
| 100 | 14.9 | 14.4 | 13.7 | 12.7 | 11.6 | 10.3 |
| *24-Hour storms* | | | | | | |
| 2 | 5.0 | 4.9 | 4.7 | 4.3 | 3.9 | 3.6 |
| 5 | 6.6 | 6.3 | 6.1 | 5.7 | 5.1 | 4.6 |
| 10 | 8.0 | 7.7 | 7.5 | 6.9 | 6.3 | 5.7 |
| 25 | 10.5 | 10.2 | 9.6 | 9.1 | 8.3 | 7.4 |
| 50 | 12.9 | 12.4 | 11.9 | 11.2 | 10.1 | 9.1 |
| 100 | 15.7 | 15.2 | 14.5 | 13.6 | 12.3 | 10.9 |
| *48-Hour storms* | | | | | | |
| 2 | 5.6 | 5.4 | 5.2 | 4.8 | 4.4 | 4.0 |
| 5 | 7.3 | 7.0 | 6.8 | 6.4 | 5.8 | 5.2 |
| 10 | 8.9 | 8.6 | 8.3 | 7.7 | 7.1 | 6.4 |
| 25 | 11.7 | 11.3 | 10.7 | 10.1 | 9.3 | 8.3 |
| 50 | 14.3 | 13.8 | 13.2 | 12.4 | 11.3 | 10.2 |
| 100 | 17.5 | 16.9 | 16.1 | 15.1 | 13.8 | 12.4 |

mean rainfalls for the entire basin and table C-3 shows similar relations for specific integral parts of the basin (areas up to 400 square miles fixed in space). Table C-4 shows the distribution of the heaviest mean rainfalls to be expected somewhere in the basin for contiguous sub-areas of 25 to 1000 square miles for a given recurrence interval and rain period.

Comparison of the mean rainfall frequencies for the Big Muddy and Kaskaskia Basins shows that the Lower Kaskaskia and Big Muddy have similar expectancies, especially in storms having durations of 24 to 48 hours. This is not surprising, since the Big Muddy is adjacent to the Lower Kaskaskia. However, the frequency distributions for small areas within the basins (tables C-3 and C-4) show mean rainfall for a given rain duration to be considerably greater in the Big Muddy, and this difference increases as the recurrence interval becomes longer.

## Area-Depth Relations

Table C-5 shows the average slope of area-depth curves in the -Big Muddy Basin for storm durations of 6 to 48 hours. These slope data can be used for constructing typical area-depth curves for storm mean rainfalls of various magnitudes. A description of how these slopes are derived and the application of the information in design problems are given in the Part A of this report.

An example of the potential use of the slope data in hydrologic design is shown in table C-6 which provides an average area-depth relation in a 12-hour storm having a recurrence interval of 25

**Table C-5. Average Slope of Area-Depth Curves on Big Muddy Basin**

| *Incremental area (square miles)* | *Ratio of mean rainfall on incremental areas to basin mean rainfall for given storm duration (hours)* 6 | 12 | 18 | 24 | 36 | 48 |
|---|---|---|---|---|---|---|
| 25 | 1.99 | 1.88 | 1.86 | 1.83 | 1.81 | 1.79 |
| 50 | 1.94 | 1.83 | 1.80 | 1.78 | 1.76 | 1.74 |
| 100 | 1.84 | 1.75 | 1.72 | 1.71 | 1.69 | 1.67 |
| 200 | 1.73 | 1.65 | 1.62 | 1.62 | 1.60 | 1.58 |
| 500 | 1.53 | 1.48 | 1.46 | 1.44 | 1.43 | 1.42 |
| 1000 | 1.32 | 1.29 | 1.28 | 1.28 | 1.27 | 1.26 |
| 1500 | 1.18 | 1.17 | 1.16 | 1.16 | 1.15 | 1.15 |
| 2000 | 1.07 | 1.07 | 1.07 | 1.07 | 1.06 | 1.06 |
| 2380 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Table C-6. Average Area-Depth Relations in a 12-Hour, 25-Year Storm on the Big Muddy**

| *Area (square miles)* | *Average rainfall (inches)* |
|---|---|
| 25 | 8.1 |
| 50 | 7.9 |
| 100 | 7.5 |
| 200 | 7.2 |
| 500 | 6.4 |
| 1000 | 5.5 |
| 1500 | 5.0 |
| 2000 | 4.6 |
| 2380 | 4.3 |

**Table C-7. Depth-Duration-Area Data in Storm of August 16-17, 1959, on the Big Muddy Basin**

| *Storm period (hours)* | *Ending time (CST)* | *Average depth (inches) for given area (square miles)* 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2380 |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 03 | 4.3 | 4.1 | 3.8 | 3.5 | 3.0 | 2.4 | 2.1 | 1.8 | 1.7 |
| 6 | 05 | 4.9 | 4.8 | 4.7 | 4.5 | 4.0 | 3.6 | 3.2 | 2.9 | 2.7 |
| 12 | 09 | 9.2 | 8.9 | 8.5 | 8.0 | 7.1 | 6.2 | 5.6 | 5.1 | 4.8 |
| 24 | 12 | 10.3 | 10.1 | 9.8 | 9.5 | 8.7 | 7.9 | 7.3 | 6.7 | 6.4 |

**Table C-8. Depth-Duration-Area Data, Little Egypt Network, August 16-17, 1959**

| *Storm period (hours)* | *Ending time (CST)* | *Average depth (inches) for given area (square miles)* 1 | 5 | 10 | 25 | 50 | 100 | 200 | 300 | 400 | 550 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 01 | 2.9 | 2.8 | 2.7 | 2.5 | 2.3 | 2.0 | 1.7 | 1.4 | 1.1 | 0.9 |
| 2 | 02 | 4.3 | 4.2 | 4.1 | 3.9 | 3.6 | 3.3 | 2.8 | 2.5 | 2.2 | 1.8 |
| 3 | 03 | 4.5 | 4.4 | 4.3 | 4.1 | 4.0 | 3.7 | 3.4 | 3.1 | 2.8 | 2.4 |
| 6 | 06 | 4.9 | 4.8 | 4.7 | 4.6 | 4.5 | 4.3 | 4.0 | 3.8 | 3.7 | 3.5 |
| 12 | 09 | 9.7 | 9.5 | 9.3 | 9.0 | 8.6 | 8.2 | 7.5 | 7.1 | 6.7 | 6.3 |
| 24 | 12 | 10.7 | 10.6 | 10.4 | 10.2 | 9.9 | 9.4 | 8.9 | 8.6 | 8.2 | 7.8 |

**Table C-9. Hourly Area-Depth Data, Little Egypt Network, August 16-17, 1959**

| *Hour ending (CST)* | *Average depth (inches) for given area (square miles)* 1 | 5 | 10 | 25 | 50 | 100 | 200 | 300 | 400 | 550 |
|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 1.10 | 1.04 | 1.00 | 0.93 | 0.87 | 0.78 | 0.63 | 0.52 | 0.43 | 0.32 |
| 18 | 1.30 | 1.25 | 1.20 | 1.12 | 1.03 | 0.92 | 0.78 | 0.70 | 0.62 | 0.52 |
| 19 | 0.76 | 0.72 | 0.70 | 0.66 | 0.61 | 0.53 | 0.44 | 0.36 | 0.29 | 0.20 |
| 20 | 0.47 | 0.45 | 0.42 | 0.40 | 0.37 | 0.32 | 0.26 | 0.20 | 0.16 | 0.12 |
| 21 | 0.75 | 0.72 | 0.70 | 0.67 | 0.62 | 0.55 | 0.47 | 0.39 | 0.32 | 0.27 |
| 22 | 1.28 | 1.23 | 1.20 | 1.13 | 1.04 | 0.93 | 0.78 | 0.65 | 0.52 | 0.38 |
| 23 | 0.36 | 0.35 | 0.33 | 0.31 | 0.30 | 0.28 | 0.24 | 0.20 | 0.18 | 0.16 |
| 24 | 1.32 | 1.25 | 1.18 | 1.07 | 0.96 | 0.78 | 0.59 | 0.49 | 0.42 | 0.33 |
| 01 | 2.92 | 2.81 | 2.71 | 2.54 | 2.33 | 2.04 | 1.67 | 1.36 | 1.15 | 0.92 |
| 02 | 2.17 | 2.11 | 2.06 | 1.97 | 1.87 | 1.71 | 1.50 | 1.30 | 1.09 | 0.85 |
| 03 | 1.15 | 1.12 | 1.09 | 1.06 | 1.00 | 0.92 | 0.82 | 0.76 | 0.68 | 0.59 |
| 04 | 1.15 | 1.09 | 1.06 | 1.00 | 0.92 | 0.82 | 0.69 | 0.58 | 0.48 | 0.35 |
| 05 | 1.33 | 1.28 | 1.24 | 1.17 | 1.08 | 0.96 | 0.81 | 0.67 | 0.54 | 0.37 |
| 06 | 1.60 | 1.45 | 1.37 | 1.19 | 1.05 | 0.94 | 0.76 | 0.62 | 0.49 | 0.37 |
| 07 | 1.76 | 1.69 | 1.64 | 1.57 | 1.46 | 1.32 | 1.11 | 0.97 | 0.85 | 0.66 |
| 08 | 2.41 | 2.32 | 2.26 | 2.13 | 1.99 | 1.80 | 1.52 | 1.30 | 1.11 | 0.87 |
| 09 | 1.49 | 1.43 | 1.38 | 1.29 | 1.20 | 1.05 | 0.88 | 0.73 | 0.60 | 0.43 |

years. The average basin rainfall for 25 years was obtained from table C-2. This was then used in conjunction with the 12-hour slope values of table C-5 to construct a curve from which table C-6 was obtained.

The slope relations for the Big Muddy in table C-C-5 do not vary much from those for the Upper Kaskaskia (table B-6). These two areas are similar in size, and the nearly equivalent slopes indicate that the spatial relative variability in heavy storms is similar in the Kaskaskia and Big Muddy Basins.

Area-depth relations in the outstanding storm of August 16-17, 1959, are presented in tables C-7 to C-9. Available data indicate that this is the heaviest storm to occur on the Big Muddy Basin in the 92 years of weather records (1887-1978), available at the time this report was prepared. The Little Egypt Network of 50 raingages in 550 square miles was located in the Big Muddy Basin and provided an unusual amount of information on the characteristics of this storm (Huff and Changnon, 1961).

Table C-7 shows area-depth relations in the August 1959 storm for periods of 3 to 24 hours in the Big Muddy Basin of 2380 square miles. Tables C-8 and C-9 show relations within the Little Egypt Network where the storm produced over 10 inches of rain at the storm core. The hourly area-depth relations in table C-9 show how the storm intensity fluctuated with time. Studies of outstanding storms in Illinois indicated that this storm provides a typical statistical model for hydrologic design problems that deal with protection against extreme storm rainfall events (Huff and Changnon, 1964). Isohyetal patterns for maximum 3-hour, 6-hour, 12-hour, and 24-hour rainfall in this storm are shown in figure C-4. Note the 10-inch centers on and west of the Little Egypt Network.

Table C-10 shows area-depth relations on the Little Egypt Network in a 4-day storm period (May 5-9, 1961) of unusual occurrence. Relations are presented for several partial storm periods in this 96-hour storm. The area-depth relations for the maximum 48-hour rainfall are shown for the entire basin in table C-l 1. Isohyetal patterns for maximum 6-, 12-, 24-, 48-, 72-, and 96-hour rainfall are shown for the May 1961 storm on the Little Egypt Network in figure C-5. The isohyetal pattern for maximum 48-hour rainfall on the basin (5/7, 0100 to 5/9, 0100) is presented in figure C-6. Most of the 4-day rainfall occurred during this 48-hour period, This is another of the most severe rainstorms ever observed on the Big Muddy Basin.

Area-depth relations in other selected storms of heavy intensity on the basin are also shown in table C-11. The isohyetal patterns in these storms are presented in figures C-7 to C-14.

### Monthly and Seasonal Distribution of Heavy Storms

Tables C-12 and C-l3 show the monthly and 3-monthly frequencies of storm rainfall which equaled

**Table C-10. Depth-Duration-Area Data, Little Egypt Network, May 5-9, 1961**

| *Duration (hours)* | Average rainfall depth (inches) for given area (square miles) *1* | *5* | *10* | *25* | *50* | *100* | *200* | *300* | *400* | *550* |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 4.62 | 4.37 | 4.20 | 3.92 | 3.57 | 3.23 | 2.93 | 2.62 | 2.40 | 2.18 |
| 12 | 5.08 | 4.85 | 4.70 | 4.46 | 4.12 | 3.83 | 3.56 | 3.26 | 3.05 | 2.82 |
| 18 | 5.82 | 5.71 | 5.63 | 5.45 | 5.28 | 4.98 | 4.59 | 4.33 | 4.05 | 3.74 |
| 24 | 5.87 | 5.77 | 5.70 | 5.52 | 5.38 | 5.09 | 4.73 | 4.48 | 4.23 | 3.93 |
| 30 | 6.37 | 6.28 | 6.21 | 6.08 | 5.94 | 5.73 | 5.47 | 5.24 | 5.06 | 4.78 |
| 36 | 8.42 | 8.29 | 8.22 | 8.02 | 7.81 | 7.52 | 7.10 | 6.80 | 6.53 | 6.20 |
| 48 | 8.68 | 8.55 | 8.48 | 8.28 | 8.07 | 7.78 | 7.37 | 7.07 | 6.80 | 6.47 |
| 60 | 10.61 | 10.48 | 10.38 | 10.27 | 9.94 | 9.62 | 9.16 | 8.82 | 8.52 | 8.15 |
| 72 | 10.72 | 10.60 | 10.52 | 10.32 | 10.11 | 9.83 | 9.40 | 9.10 | 8.84 | 8.51 |
| 96 | 11.32 | 11.20 | 11.12 | 10.93 | 10.73 | 10.46 | 10.06 | 9.75 | 9.50 | 9.15 |

**Table C- 11. Unmodified Area-Depth Relations on Big Muddy Basin**

| *Storm date* | *Duration (hours)* | Average depth (inches) for given area (square miles) *25* | *50* | *100* | *200* | *500* | *1000* | *1500* | *2380* |
|---|---|---|---|---|---|---|---|---|---|
| 3/24-25/04 | 25 | 6.8 | 6.8 | 6.7 | 6.5 | 6.2 | 5.8 | 5.4 | 4.7 |
| 10/4-5/10 | 48 | 9.7 | 9.6 | 9.4 | 9.2 | 8.9 | 8.4 | 7.8 | 6.6 |
| 10/4-5/10 | 60 | 10.8 | 10.7 | 10.6 | 10.3 | 10.0 | 9.4 | 8.6 | 7.4 |
| 3/24-25/13 | 45 | 6.9 | 6.9 | 6.8 | 6.7 | 6.5 | 6.0 | 5.7 | 5.1 |
| 8/20-21/15 | 36 | 5.4 | 5.4 | 5.3 | 5.2 | 5.0 | 4.7 | 4.5 | 4.1 |
| 10/25-27/19 | 48 | 8.8 | 8.7 | 8.6 | 8.5 | 8.1 | 7.2 | 6.0 | 4.5 |
| 3/10-11/35 | 48 | 6.6 | 6.6 | 6.5 | 6.4 | 6.2 | 5.9 | 5.7 | 5.3 |
| 8/15-16/46 | 24 | 13.6 | 13.4 | 13.1 | 12.7 | 11.7 | 10.2 | 8.8 | 6.3 |
| 8/14-16/46 | 48 | 15.4 | 15.2 | 14.8 | 14.0 | 12.7 | 11.4 | 9.7 | 7.3 |
| 5/21-23/57 | 48 | 7.9 | 7.8 | 7.7 | 7.5 | 6.9 | 5.8 | 5.1 | 4.2 |
| 5/7-9/61 | 48 | 8.8 | 8.7 | 8.6 | 8.3 | 7.8 | 7.2 | 6.8 | 6.1 |

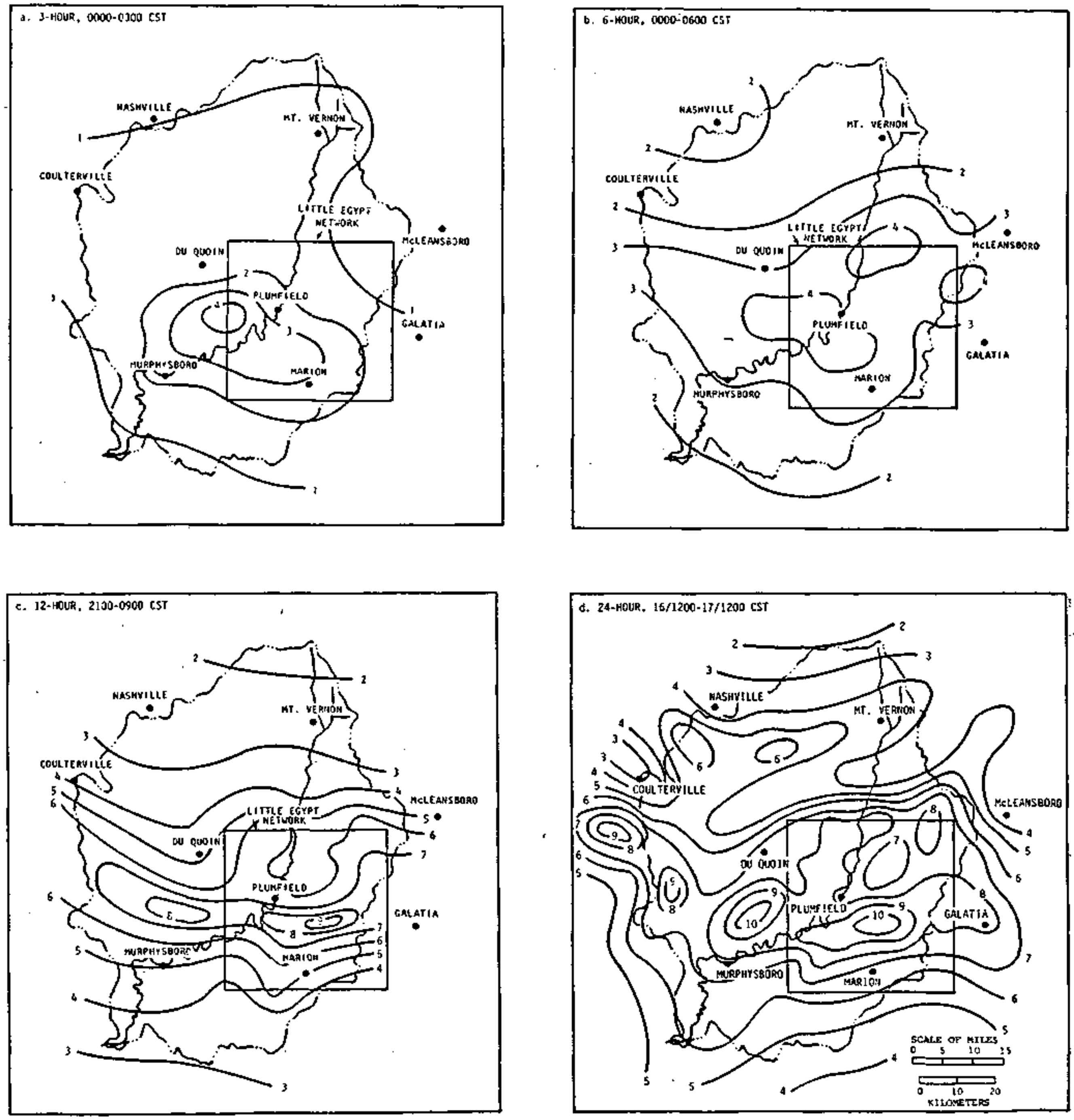



Figure C-4. Maximum sub-storm rainfalls on August 16-17, 1959

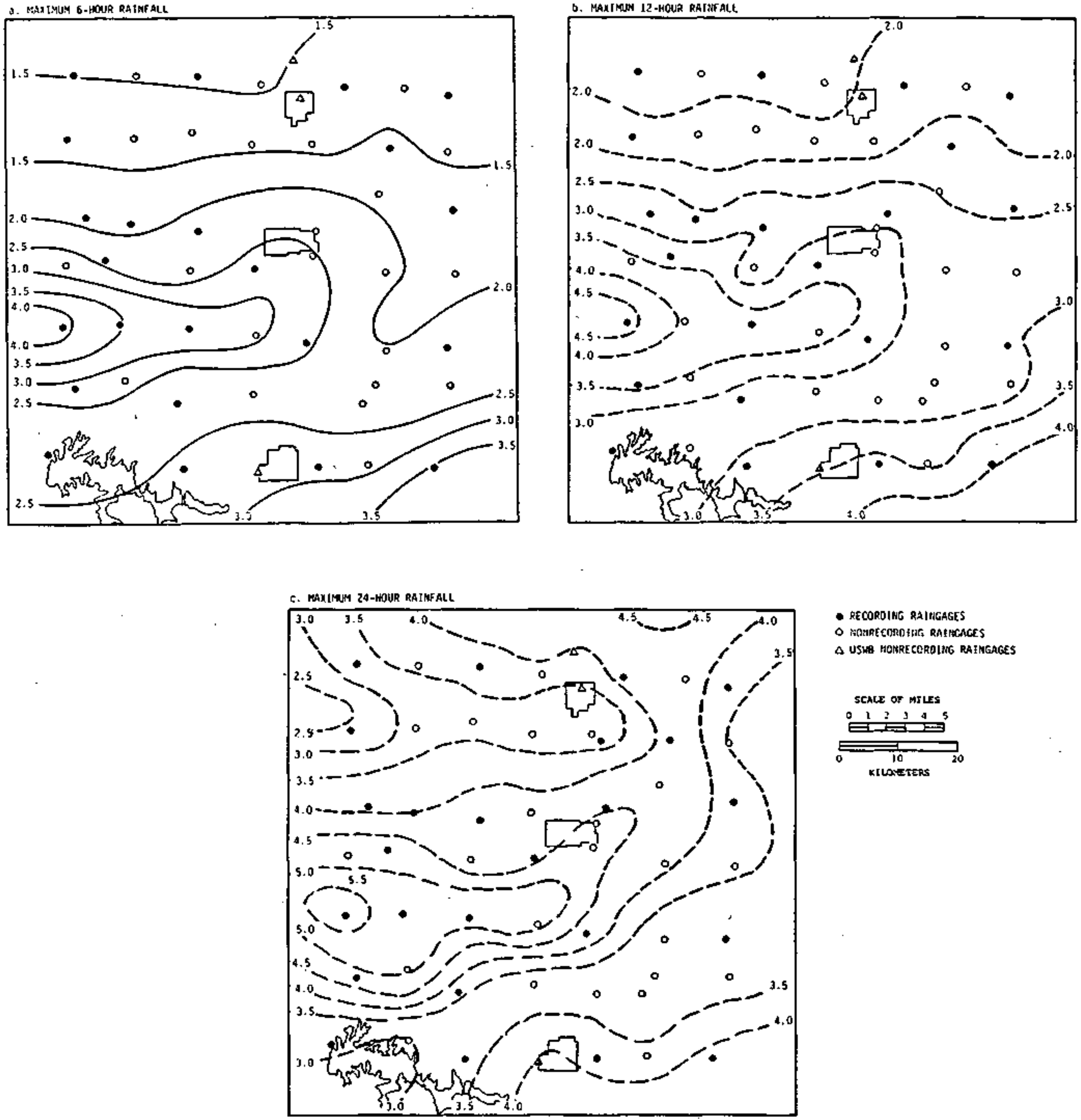



Figure C-5. Maximum sub-storm rainfalls on May 5-9, 1961

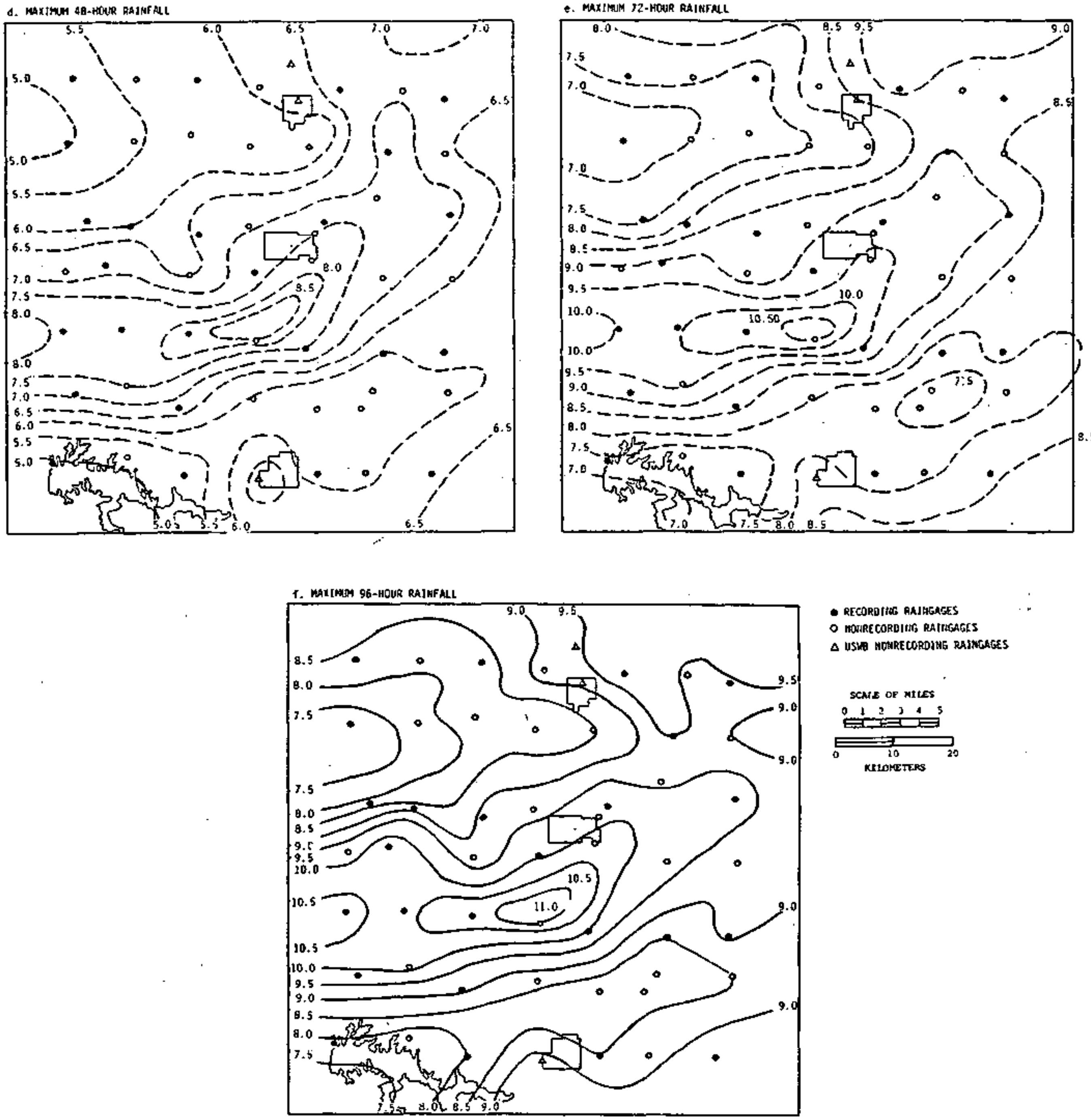



Figure C-5. Concluded

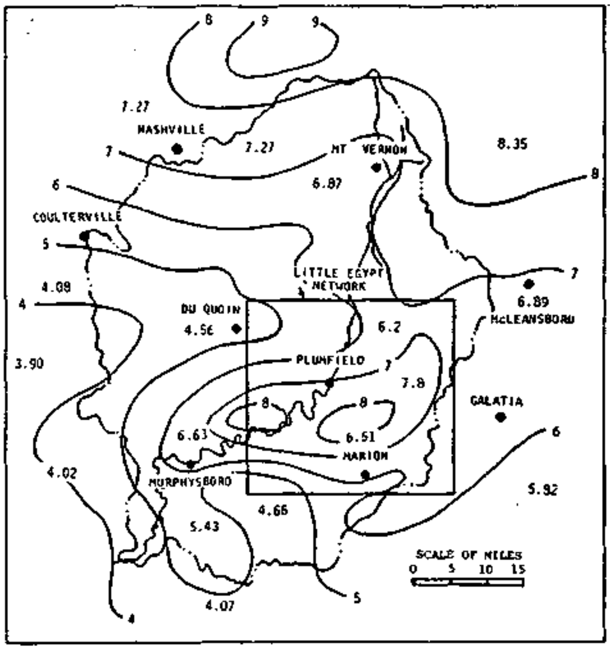



Figure C-6. Maximum 48-hour rainfall on May 7-9, 1961

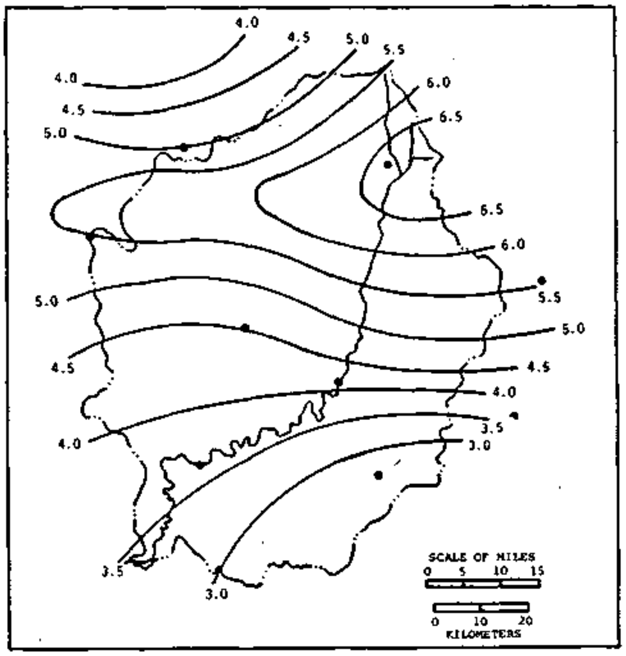



Figure C-7. Storm of March 24-25, 1904

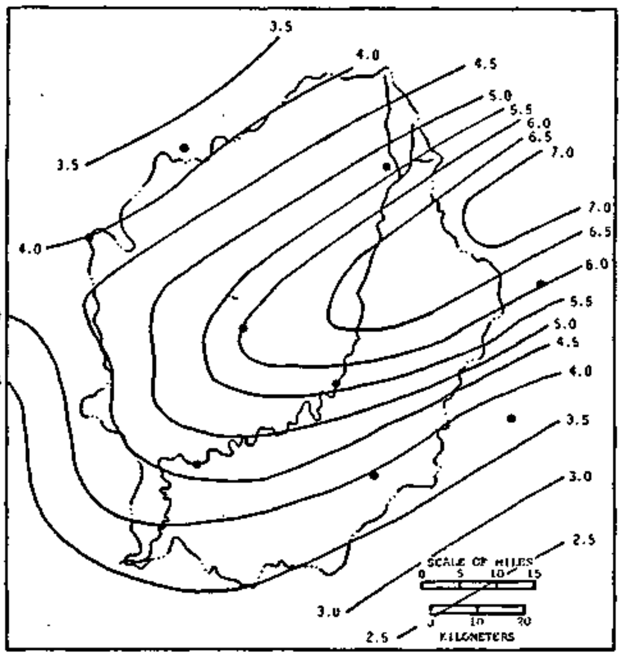



Figure C-8. Storm of March 24-25, 1913

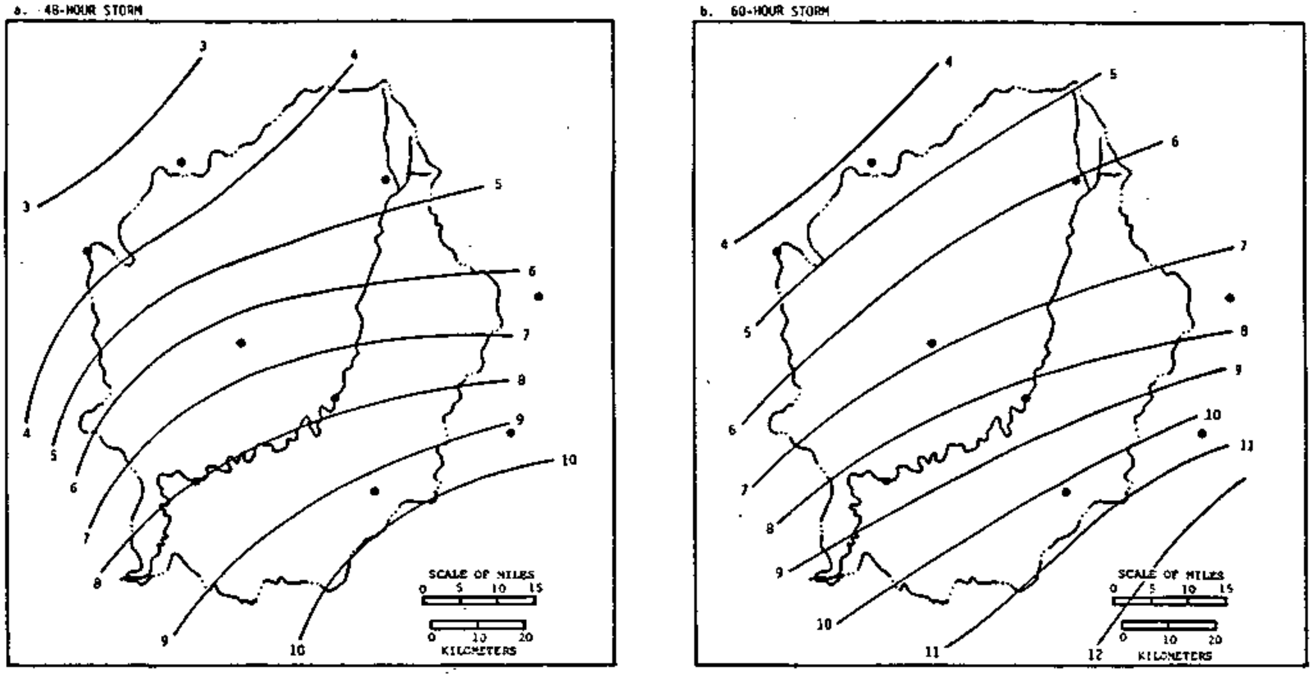



Figure C-9. Storm of October 3-6, 1910

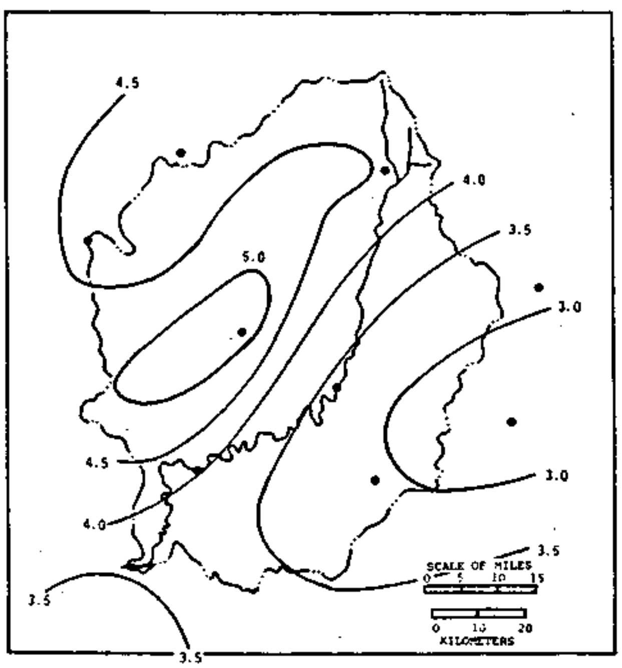



Figure C-10. Thirty-six hour storm of August 19-21, 1915

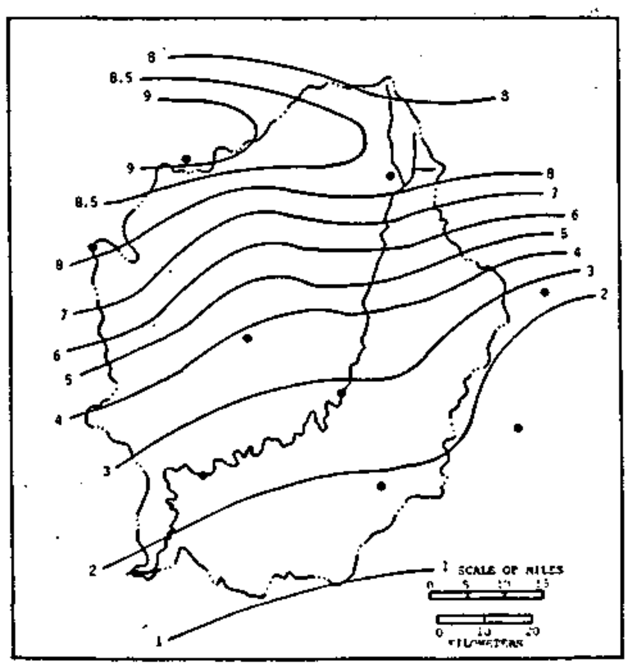



Figure C-11. Storm of October 26-27, 1919

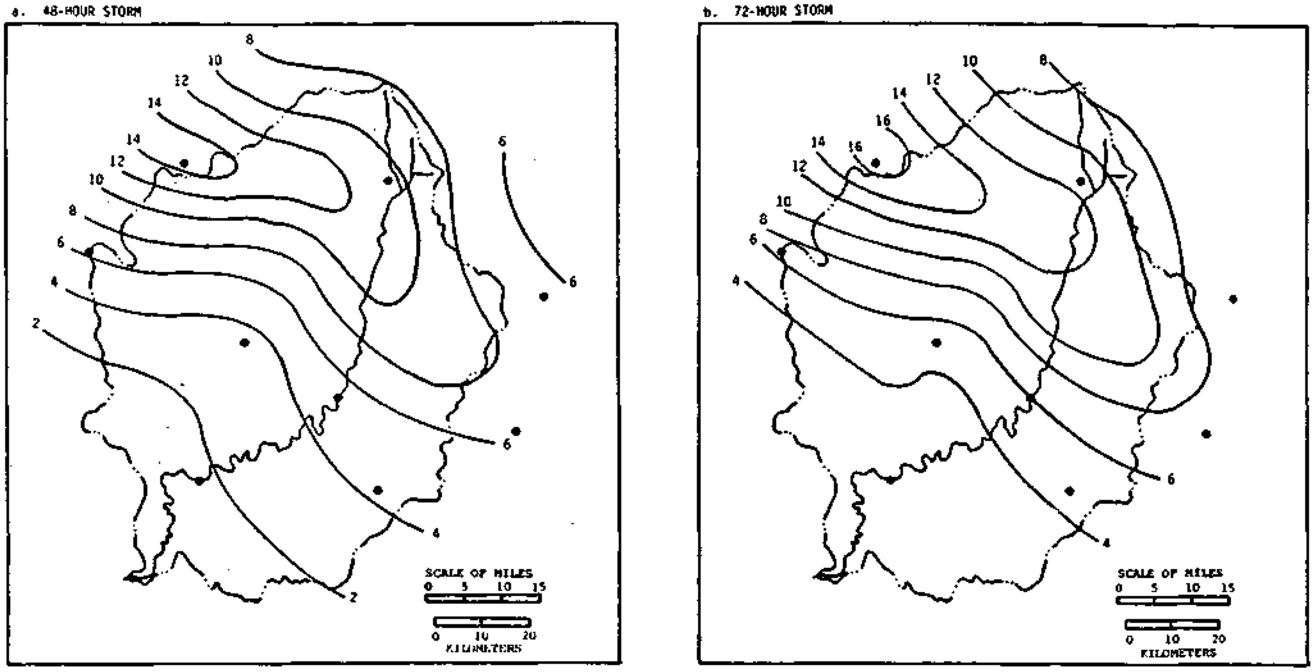



Figure C-12. Storm of August 14-16,1946

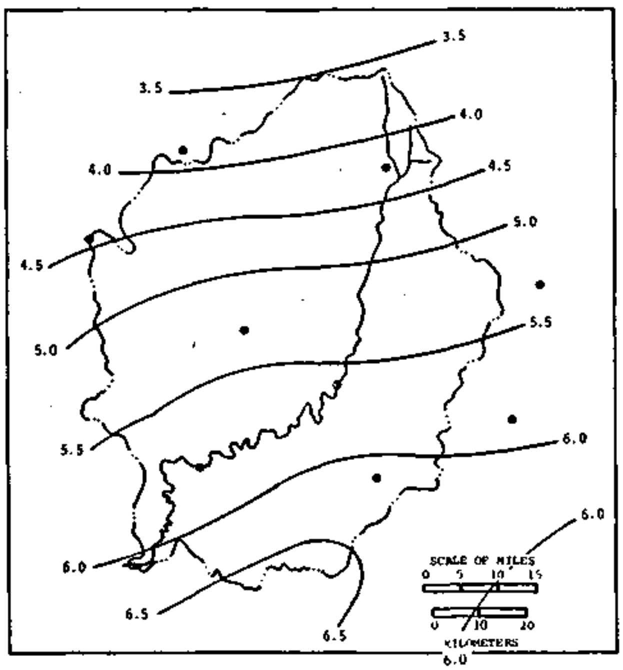



Figure C 13. Storm of March 10-11, 1935

**Table C-12. Monthly Distribution of 48-Hour Heavy Rainstorms**

| *Month* | *Number* | *Month* | *Number* |
|---|---|---|---|
| January | 5 | July | 3 |
| February | 1 | August | 5 |
| March | 3 | September | 3 |
| April | 5 | October | 4 |
| May | 4 | November | 1 |
| June | 2 | December | 2 |

**Table C-13. Seasonal Distribution of 48-Hour Heavy Rainstorms**

| *3-Month period* | *Number* | *3-Month period* | *Number* |
|---|---|---|---|
| Jan-Mar | 9 | Jul-Sep | 11 |
| Feb-Apr | 9 | Aug-Oct | 12 |
| Mar-May | 12 | Sep-Nov | 8 |
| Apr-Jun | 11 | Oct-Dec | 7 |
| May-Jul | 9 | Nov-Jan | 8 |
| Jun-Aug | 10 | Dec-Feb | 8 |

or exceeded the average 2-year recurrence value for 48-hour amounts. This method of analysis provided 38 qualifying storms. Since most of the heaviest storm amounts for shorter periods came out of these storms, the distribution can be considered typical also for storm periods of 6 to 48 hours. Maximum 1-hour to 3-hour amounts are most likely to occur in late spring to early fall.

Tables C-12 and C-13 show no strong domination by a particular month or season. Overall, these storms are most frequent in spring (March-May) and in late summer to early fall.

### Location of Storm Centers

Next, an analysis was made to determine what percentage of the 50 severe rainstorms had their heaviest rainfall concentrated in die upper portion of the basin, regardless of orientation. For this purpose, the basin was divided into four segments by lines drawn perpendicular to the major axis of the basin at equal intervals from the source to the mouth of the river, as shown in figure C-15. The location of the heaviest rainfall in, the basin was then indicated by the solid circles in figure C-15. Many of the heavy Big Muddy storms were extensions of storms centered on adjacent basins, as is readily apparent from the number of dots on the basin border.

Results of this analysis indicated a tendency for a disproportionate number of storms to have their heaviest rainfall near the mouth of the river. In this section, 32 percent of the storms maximized, whereas 22, 24, and 22 percent, respectively, maximized in Sections 1, 2, and 3. The greater frequency in Section 4 is due to a trend for heavy storms to be centered south of the Big Muddy Basin, since 11 of the 16 occurrences were associated with such storms. Excluding the border storm centers in figure C-15, a slight trend is indicated for storm centers within the basin to occur in a region extending northeastward from near the river mouth to the east central part of the watershed, as shown by the dashed line envelope of storm centers.

From a practical standpoint, it is concluded that the probability of a severe rainstorm being centered in the upper reaches of the basin is slightly less than in the lower reaches, but the difference is not sufficient to be incorporated into the design of hydraulic structures at this time.

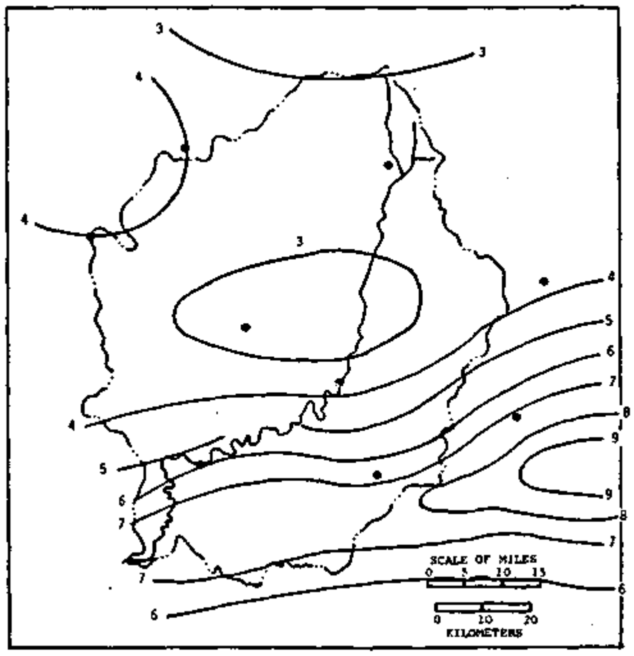



Figure C-14. Storm of May 21-23, 1957

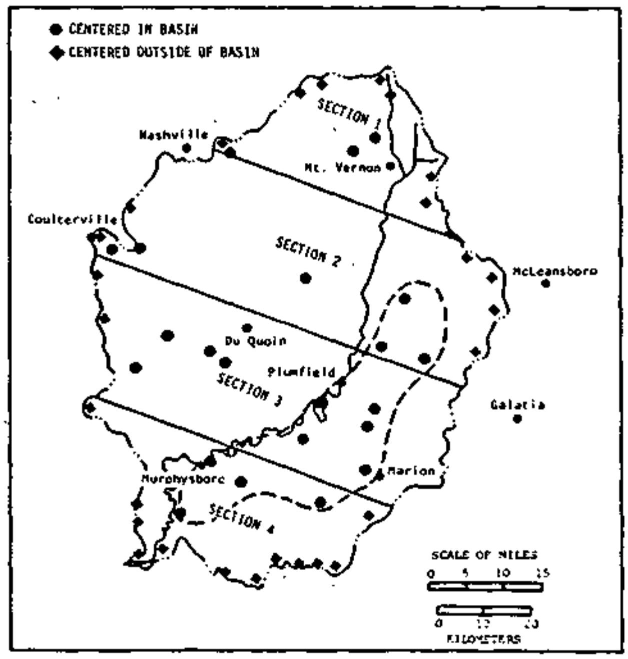



Figure C-15. Location of maximum rainfall in 50 heaviest storms

# Part D. The Sangamon Basin

The Sangamon Basin encompasses an area of approximately 5450 square miles in central Illinois (figure D-l). The Sangamon River discharges into the Illinois River. The topography of the basin is relatively flat with elevations ranging mostly from 550 to 700 feet MSL. A few hills exceed 800 feet MSL and these are mostly in the northeast part of the basin.

## Basin Climate

The annual average precipitation increases gradually from northwest to southeast across the basin with amounts ranging from slightly under 3 5 inches to approximately 38 inches (figure D-2). Basin mean is 36.40 inches. Figure D-3 shows seasonal precipitation distributions. Winter (December-February), spring (March-May), and fall (September-November) show the same general trend of increasing precipitation across the basin from west to east. Summer (June-August) has a very flat gradient of rainfall throughout the basin. The long-term seasonal means are 6.14, 10.85, 10.43, and 8.98 inches, respectively, for winter, spring, summer, and fall.

The average annual frequency of thunderstorm days is 49 with a narrow range from 48 in the northeast to 50 in the southwest part of the basin (Changnon, 1957). The annual hail frequency ranges from an average of 2 days per year in the northeast to 3 days per year in the southwest. The basin lies in a region of relatively high frequency of tornadoes (Wilson and Changnon, 1971).

The annual average temperature ranges from approximately 52.5°F in the extreme northern part of the basin to 54.5°F in the extreme south. The coldest month is January when the average temperature varies from 26° F in the northern part of the basin to 29°F in the southern part. During July, the warmest month, the temperature gradient is flat. The normal monthly mean varies only from 75.5°F in the northeast to 76.5°F in the southern part of the basin.

## Storm Precipitation Characteristics

In the series of tables and figures that follow (tables D-l-D-9; figures D-4-D-16), the distribution

**Table D-1. Point Rainfall Frequency Relations on the Sangamon Basin**

| *Storm duration (hours)* | *Depth (inches) equaled or exceeded for given recurrence interval (years)* 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 1 | 1.4 | 1.7 | 1.9 | 2.4 | 2.9 | 3.4 |
| 2 | 1.6 | 2.0 | 2.2 | 2.8 | 3.4 | 4.1 |
| 3 | 1.8 | 2.2 | 2.5 | 3.2 | 3.8 | 4.5 |
| 6 | 2.1 | 2.7 | 3.1 | 3.7 | 4.4 | 5.4 |
| 12 | 2.4 | 3.1 | 3.6 | 4.5 | 5.4 | 6.4 |
| 18 | 2.6 | 3.3 | 3.9 | 5.0 | 5.9 | 7.2 |
| 24 | 2.8 | 3.6 | 4.3 | 5.4 | 6.5 | 7.8 |
| 48 | 3.0 | 4.0 | 4.7 | 5.9 | 7.0 | 8.5 |

**Table D-2. Basin Mean Rainfall Frequency Relations on Sangamon Basin**

| *Recurrence interval (years)* | *Average rainfall depth (inches) equaled or exceeded for given storm period (hours)* 6 | 12 | 18 | 24 | 30 | 36 | 48 |
|---|---|---|---|---|---|---|---|
| 1 | 0.7 | 0.9 | 1.0 | 1.1 | 1.2 | 1.2 | 1.3 |
| 2 | 1.3 | 1.7 | 1.9 | 2.1 | 2.2 | 2.3 | 2.4 |
| 5 | 1.7 | 2.2 | 2.5 | 2.8 | 2.9 | 3.0 | 3.2 |
| 10 | 2.1 | 2.7 | 3.1 | 3.4 | 3.6 | 3.8 | 3.9 |
| 15 | 2.3 | 2.9 | 3.3 | 3.6 | 3.9 | 4.0 | 4.2 |
| 20 | 2.4 | 3.2 | 3.6 | 3.9 | 4.1 | 4.3 | 4.5 |
| 25 | 2.5 | 3.3 | 3.7 | 4.0 | 4.3 | 4.5 | 4.7 |
| 30 | 2.6 | 3.4 | 3.8 | 4.1 | 4.4 | 4.6 | 4.8 |
| 40 | 2.7 | 3.5 | 3.9 | 4.3 | 4.6 | 4.8 | 5.0 |
| 50 | 2.8 | 3.6 | 4.1 | 4.5 | 4.8 | 4.9 | 5.2 |
| 75 | 3.0 | 3.8 | 4.3 | 4.7 | 5.1 | 5.2 | 5.5 |
| 100 | 3.1 | 4.1 | 4.6 | 5.0 | 5.3 | 5.5 | 5.8 |

characteristics of severe rainstorms on the Sangamon Basin are presented. This information is presented in the same sequence as provided for the Kaskaskia and Big Muddy Basins in Parts B and C, and interpretation of the results is the same. Therefore, explanation of the contents and use of the various tables and maps will not be repeated.

In general, for a given frequency heavier point and areal mean rainfalls occur on the Kaskaskia and Big Muddy than on the Sangamon Basin. Comparison of area-depth slopes for the entire Kaskaskia and Sangamon, which are close to each other in size, indicates that rainfall gradients are similar in storms on the two basins. That is, the average spatial variability in rainfall during severe rainstorms is nearly equal.

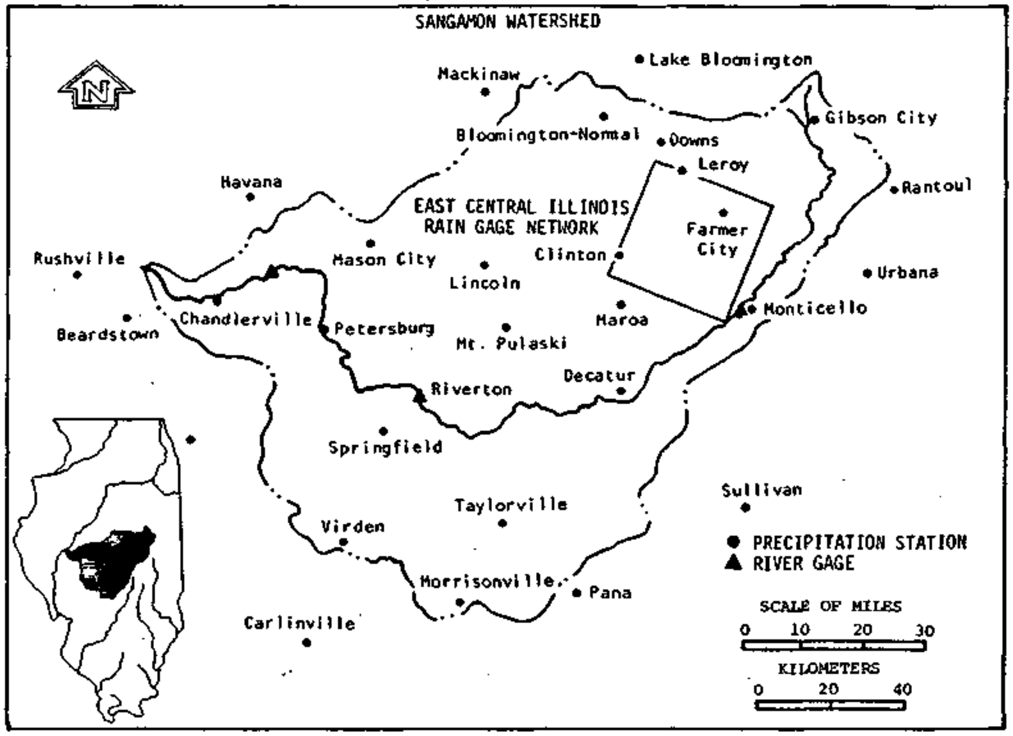



Figure D-1. Location map, Sangamon Basin

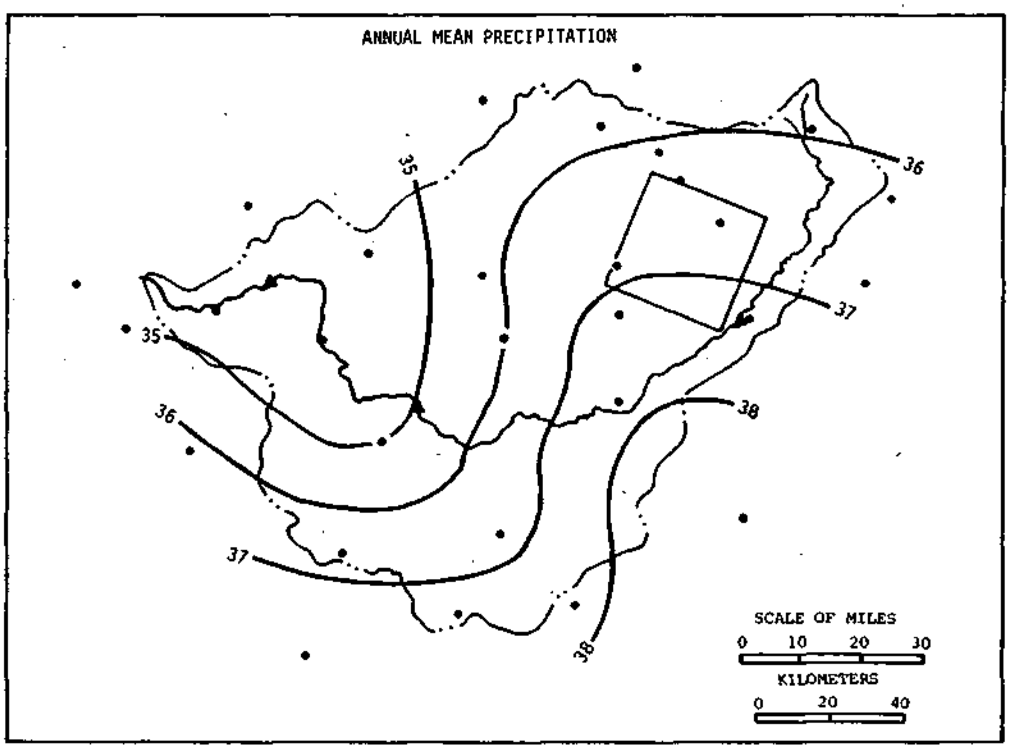



Figure 0-2. Average annual precipitation, Sangamon Basin

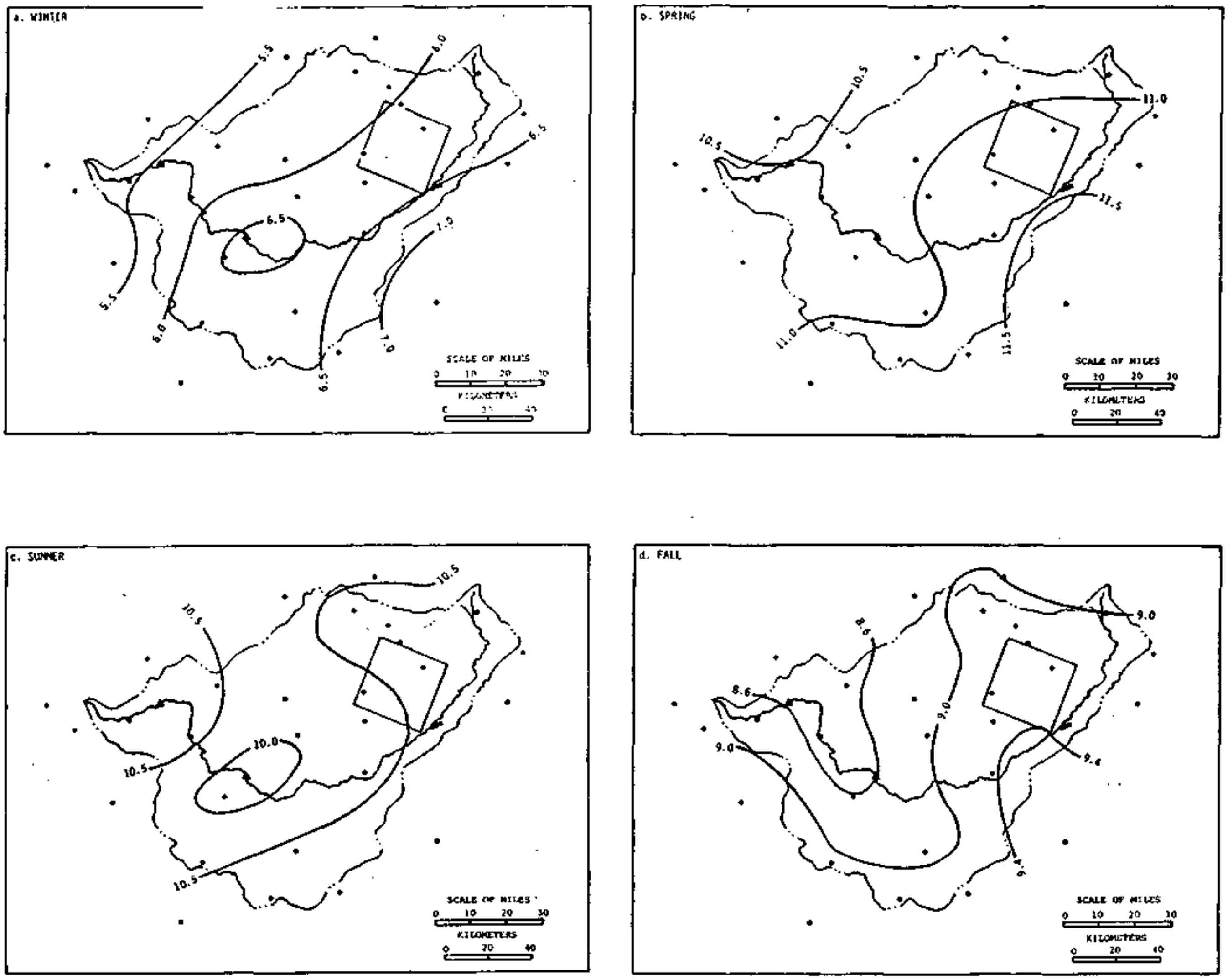



Figure D-3. Average precipitation by seasons, Sangamon Basin

### Table D-3. Frequency Distribution of Areal Mean Rainfall for Specific Integral Areas on Sangamon Basin

| Recurrence interval (years) | Average depth (inches) equaled or exceeded for given area (square miles) 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *1-Hour storm period* | | | | | | |
| 2 | 1.1 | 1.1 | 1.0 | 0.9 | 0.8 | 0.7 |
| 5 | 1.4 | 1.4 | 1.3 | 1.2 | 1.1 | 1.0 |
| 10 | 1.7 | 1.6 | 1.5 | 1.4 | 1.3 | 1.2 |
| 25 | 2.1 | 2.0 | 1.8 | 1.7 | 1.5 | 1.4 |
| 50 | 2.4 | 2.3 | 2.1 | 2.0 | 1.8 | 1.7 |
| 100 | 2.8 | 2.7 | 2.5 | 2.3 | 2.1 | 2.0 |
| *2-Hour storm period* | | | | | | |
| 2 | 1.3 | 1.3 | 1.2 | 1.1 | 1.0 | 1.0 |
| 5 | 1.7 | 1.7 | 1.5 | 1.4 | 1.3 | 1.3 |
| 10 | 2.0 | 2.0 | 1.8 | 1.7 | 1.6 | 1.5 |
| 25 | 2.6 | 2.5 | 2.3 | 2.2 | 2.0 | 1.9 |
| 50 | 3.0 | 2.9 | 2.7 | 2.6 | 2.4 | 2.3 |
| 100 | 3.6 | 3.5 | 3.3 | 3.1 | 2.8 | 2.7 |
| *3-Hour storm period* | | | | | | |
| 2 | 1.5 | 1.5 | 1.4 | 1.3 | 1.3 | 1.2 |
| 5 | 1.9 | 1.9 | 1.8 | 1.7 | 1.6 | 1.6 |
| 10 | 2.3 | 2.2 | 2.1 | 2.0 | 1.9 | 1.9 |
| 25 | 2.9 | 2.8 | 2.7 | 2.6 | 2.5 | 2.4 |
| 50 | 3.4 | 3.4 | 3.2 | 3.0 | 2.9 | 2.8 |
| 100 | 4.1 | 4.0 | 3.8 | 3.6 | 3.4 | 3.3 |
| *6-Hour storm period* | | | | | | |
| 2 | 1.8 | 1.8 | 1.7 | 1.6 | 1.6 | 1.5 |
| 5 | 2.3 | 2.3 | 2.2 | 2.1 | 2.0 | 1.9 |
| 10 | 2.8 | 2.8 | 2.7 | 2.5 | 2.4 | 2.3 |
| 25 | 3.5 | 3.5 | 3.3 | 3.2 | 3.1 | 2.9 |
| 50 | 4.2 | 4.1 | 4.0 | 3.8 | 3.7 | 3.5 |
| 100 | 5.0 | 4.9 | 4.8 | 4.5 | 4.3 | 4.1 |
| *12-Hour storm period* | | | | | | |
| 2 | 2.1 | 2.0 | 2.0 | 1.9 | 1.9 | 1.8 |
| 5 | 2.8 | 2.7 | 2.6 | 2.6 | 2.5 | 2.4 |
| 10 | 3.4 | 3.4 | 3.3 | 3.2 | 3.1 | 3.0 |
| 25 | 4.2 | 4.2 | 4.1 | 3.9 | 3.8 | 3.7 |
| 50 | 5.0 | 4.9 | 4.8 | 4.6 | 4.5 | 4.4 |
| 100 | 5.7 | 5.7 | 5.6 | 5.4 | 5.3 | 5.1 |
| *24-Hour storm period* | | | | | | |
| 2 | 2.6 | 2.6 | 2.5 | 2.5 | 2.4 | 2.4 |
| 5 | 3.3 | 3.3 | 3.2 | 3.1 | 3.1 | 3.0 |
| 10 | 3.9 | 3.9 | 3.8 | 3.7 | 3.7 | 3.6 |
| 25 | 5.0 | 5.0 | 4.8 | 4.7 | 4.7 | 4.6 |
| 50 | 6.0 | 5.9 | 5.8 | 5.7 | 5.6 | 5.6 |
| 100 | 7.1 | 7.0 | 6.9 | 6.8 | 6.7 | 6.6 |
| *48-Hour storm period* | | | | | | |
| 2 | 2.8 | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 |
| 5 | 3.6 | 3.6 | 3.5 | 3.5 | 3.4 | 3.4 |
| 10 | 4.3 | 4.3 | 4.2 | 4.2 | 4.1 | 4.1 |
| 25 | 5.5 | 5.4 | 5.4 | 5.3 | 5.2 | 5.2 |
| 50 | 6.5 | 6.5 | 6.4 | 6.3 | 6.2 | 6.1 |
| 100 | 7.7 | 7.7 | 7.6 | 7.5 | 7.4 | 7.3 |

### Table D-4. Frequency Distribution of Areal Maximum Rainfall on Sangamon Basin

| Recurrence interval (years) | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| *6-Hour storms* | | | | | | |
| 2 | 4.2 | 4.0 | 3.7 | 3.5 | 2.9 | 2.3 |
| 5 | 5.1 | 5.0 | 4.7 | 4.4 | 3.8 | 3.1 |
| 10 | 5.8 | 5.5 | 5.2 | 5.0 | 4.4 | 3.7 |
| 25 | 6.6 | 6.3 | 6.0 | 5.8 | 5.2 | 4.5 |
| 50 | 7.2 | 6.9 | 6.6 | 6.3 | 5.7 | 4.9 |
| 100 | 7.8 | 7.5 | 7.2 | 6.8 | 6.2 | 5.5 |
| *12-Hour storms* | | | | | | |
| 2 | 5.0 | 4.8 | 4.5 | 4.2 | 3.6 | 2.9 |
| 5 | 6.2 | 5.9 | 5.6 | 5.2 | 4.6 | 3.9 |
| 10 | 6.9 | 6.6 | 6.3 | 6.0 | 5.4 | 4.6 |
| 25 | 7.9 | 7.6 | 7.2 | 6.9 | 6.3 | 5.6 |
| 50 | 8.5 | 8.3 | 7.9 | 7.5 | 6.9 | 6.2 |
| 100 | 9.2 | 9.0 | 8.6 | 8.2 | 7.6 | 6.8 |
| *18-Hour storms* | | | | | | |
| 2 | 5.4 | 5.2 | 4.9 | 4.5 | 3.9 | 3.2 |
| 5 | 6.7 | 6.5 | 6.2 | 5.7 | 5.0 | 4.2 |
| 10 | 7.6 | 7.2 | 7.0 | 6.6 | 5.9 | 5.1 |
| 25 | 8.6 | 8.2 | 8.0 | 7.6 | 6.9 | 6.1 |
| 50 | 9.3 | 9.0 | 8.7 | 8.2 | 7.6 | 6.7 |
| 100 | 10.0 | 9.8 | 9.5 | 9.0 | 8.3 | 7.5 |
| *24-Hour storms* | | | | | | |
| 2 | 5.8 | 5.5 | 5.2 | 4.9 | 4.2 | 3.4 |
| 5 | 7.1 | 6.8 | 6.6 | 6.1 | 5.3 | 4.5 |
| 10 | 8.0 | 7.7 | 7.4 | 7.0 | 6.2 | 5.4 |
| 25 | 9.1 | 8.7 | 8.5 | 8.1 | 7.3 | 6.5 |
| 50 | 9.8 | 9.5 | 9.3 | 8.8 | 8.0 | 7.2 |
| 100 | 10.6 | 10.3 | 10.1 | 9.6 | 8.8 | 8.0 |
| *48-Hour storms* | | | | | | |
| 2 | 6.4 | 6.1 | 5.8 | 5.4 | 4.7 | 3.8 |
| 5 | 7.9 | 7.6 | 7.3 | 6.8 | 6.0 | 5.1 |
| 10 | 8.9 | 8.5 | 8.2 | 7.8 | 7.0 | 6.1 |
| 25 | 10.1 | 9.7 | 9.4 | 9.0 | 8.2 | 7.3 |
| 50 | 10.9 | 10.6 | 10.3 | 9.8 | 9.0 | 8.1 |
| 100 | 11.8 | 11.5 | 11.2 | 10.7 | 9.9 | 9.0 |

Table D-5. Average Slope of Area-Depth Curves on Sangamon Basin

| Incremental area (square miles) | Ratio of mean rainfall on incremental areas to basin mean rainfall for given storm duration (hours) 6 | 12 | 18 | 24 | 36 | 48 |
|---|---|---|---|---|---|---|
| 25 | 2.46 | 2.23 | 2.15 | 2.10 | 2.04 | 2.00 |
| 50 | 2.41 | 2.18 | 2.11 | 2.05 | 2.00 | 1.96 |
| 100 | 2.30 | 2.10 | 2.06 | 2.00 | 1.95 | 1.91 |
| 200 | 2.20 | 2.00 | 1.95 | 1.92 | 1.87 | 1.83 |
| 500 | 2.00 | 1.85 | 1.80 | 1.75 | 1.71 | 1.69 |
| 1000 | 1.77 | 1.66 | 1.62 | 1.59 | 1.56 | 1.54 |
| 1500 | 1.60 | 1.52 | 1.49 | 1.47 | 1.44 | 1.43 |
| 2000 | 1.48 | 1.42 | 1.40 | 1.38 | 1.36 | 1.35 |
| 2500 | 1.39 | 1.34 | 1.32 | 1.32 | 1.30 | 1.29 |
| 3500 | 1.24 | 1.19 | 1.19 | 1.18 | 1.18 | 1.17 |
| 4500 | 1.11 | 1.08 | 1.07 | 1.07 | 1.07 | 1.07 |
| 5450 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table D-6. Average Area-Depth Relations in a 12-Hour, 25-Year Storm on the Sangamon Basin

| Area (square miles) | Average rainfall (inches) |
|---|---|
| 25 | 7.4 |
| 50 | 7.2 |
| 100 | 6.9 |
| 200 | 6.6 |
| 500 | 6.1 |
| 1000 | 5.5 |
| 1500 | 5.0 |
| 2000 | 4.7 |
| 2500 | 4.4 |
| 3500 | 3.9 |
| 4500 | 3.6 |
| 5450 | 3.3 |

Table D-7. Unmodified Area-Depth Relations on Sangamon Basin

| Date | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2500 | 3500 | 4500 | 5450 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12/18/95 | 6.8 | 6.7 | 6.6 | 6.5 | 6.3 | 5.9 | 5.7 | 5.4 | 5.2 | 5.0 | 4.7 |
| 7/19-20/96 | 6.7 | 6.6 | 6.5 | 6.3 | 5.9 | 5.4 | 5.1 | 4.7 | 4.3 | 3.9 | 3.6 |
| 6/28-29/02 | 6.8 | 6.7 | 6.6 | 6.4 | 6.2 | 5.7 | 5.5 | 5.2 | 4.9 | 4.5 | 4.2 |
| 8/20-21/15 | 6.9 | 6.8 | 6.7 | 6.6 | 6.4 | 6.0 | 5.7 | 5.3 | 5.0 | 4.6 | 4.2 |
| 6/14-15/17 | 7.1 | 7.0 | 6.9 | 6.7 | 6.3 | 5.7 | 5.3 | 4.7 | 4.3 | 3.9 | 3.5 |
| 9/3-4/26 | 6.3 | 6.2 | 6.1 | 6.0 | 5.8 | 5.5 | 5.3 | 4.9 | 4.6 | 4.4 | 4.0 |
| 9/8-9/26 | 7.9 | 7.8 | 7.6 | 7.3 | 6.9 | 6.3 | 5.9 | 5.3 | 4.9 | 4.5 | 4.0 |
| 3/11-12/39 | 4.9 | 4.8 | 4.7 | 4.6 | 4.5 | 4.3 | 4.2 | 4.0 | 3.8 | 3.7 | 3.5 |
| 10/4-5/41 | 7.3 | 7.2 | 7.0 | 6.8 | 6.5 | 6.0 | 5.6 | 5.2 | 4.8 | 4.3 | 3.8 |
| 6/27-28/51 | 9.8 | 9.5 | 9.1 | 8.7 | 7.8 | 7.0 | 6.3 | 5.5 | 4.9 | 4.4 | 4.0 |
| 5/26-28/56 | 12.0 | 11.4 | 10.5 | 9.5 | 7.7 | 6.1 | 5.1 | 4.0 | 3.4 | 2.9 | 2.6 |
| 5/7-8/61 | 9.2 | 8.5 | 7.5 | 6.8 | 5.8 | 4.9 | 4.4 | 3.8 | 3.4 | 3.1 | 2.9 |

Table -D-8. Monthly Distribution of 48-Hour Heavy Storms on Sangamon Basin

| Month | Number | Month | Number |
|---|---|---|---|
| January | 0 | July | 4 |
| February | 1 | August | 2 |
| March | 4 | September | 8 |
| April | 1 | October | 3 |
| May | 4 | November | 2 |
| June | 7 | December | 1 |

Table D-9. Seasonal Distribution of 48-Hour Heavy Storms on Sangamon Basin

| 3-Month period | Number | 3-Month period | Number |
|---|---|---|---|
| Jan-Mar | 5 | Jul-Sep | 14 |
| Feb-Apr | 6 | Aug-Oct | 13 |
| Mar-May | 9 | Sep-Nov | 13 |
| Apr-Jun | 12 | Oct-Dec | 6 |
| May-Jul | 15 | Nov-Jan | 3 |
| Jun-Aug | 13 | Dec-Feb | 2 |

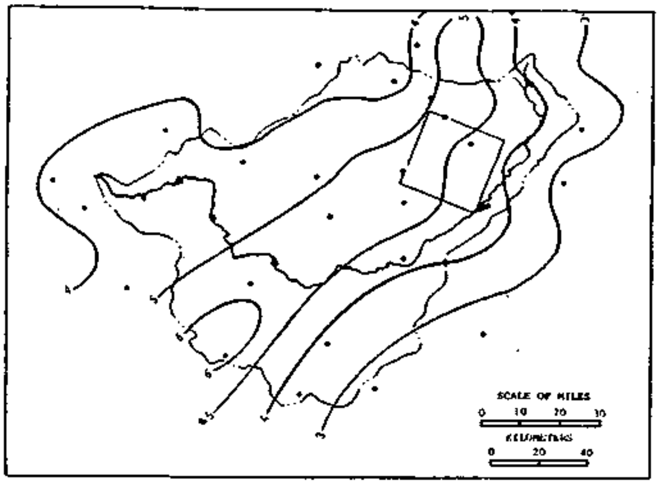



Figure D-4. Storm of December 18-19, 1895

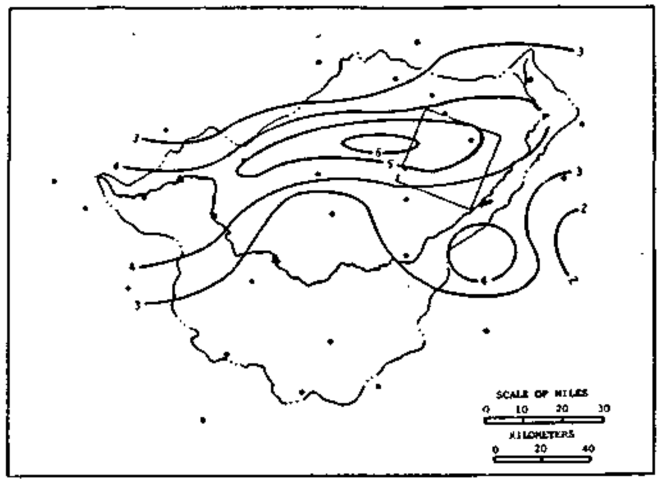



Figure D-5. Storm of July 19-20,1896

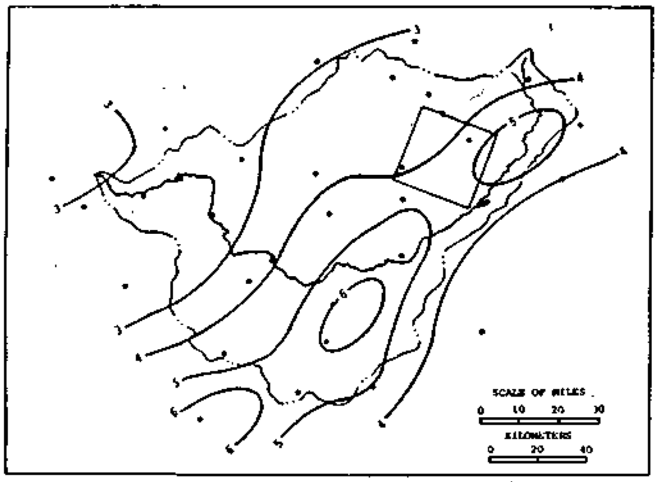



Figure D-6. Storm of June 28-29, 1902

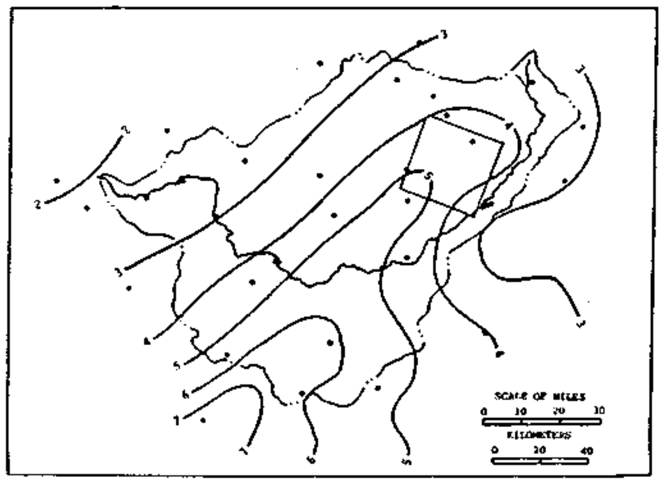



Figure D-7. Storm of August 20-21, 1915

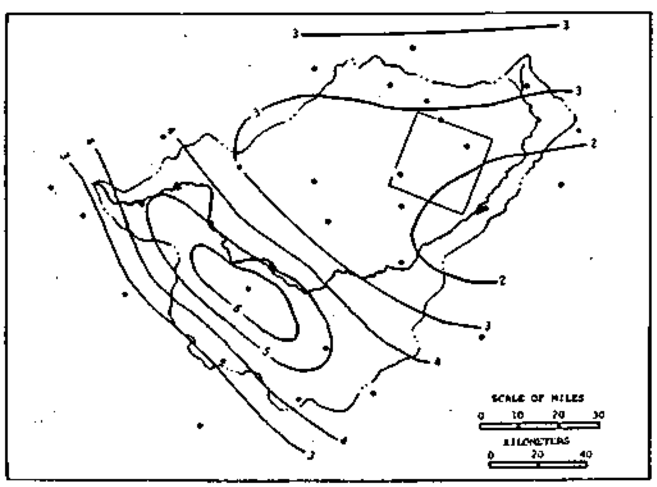



Figure D-8. Storm of June 14-15, 1917

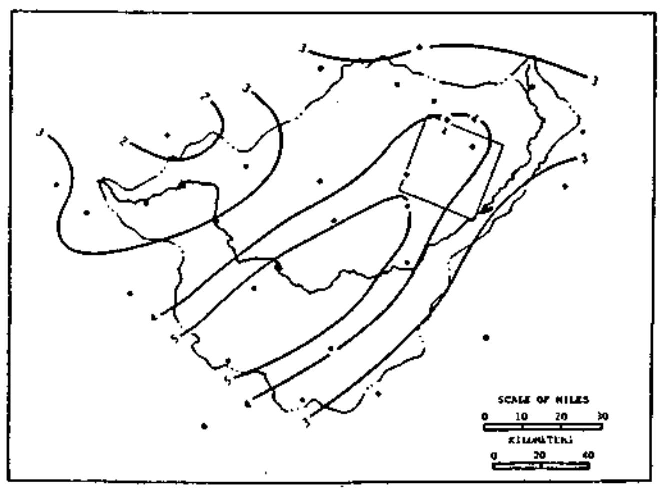



Figure D-9. Storm of September 3-4, 1926

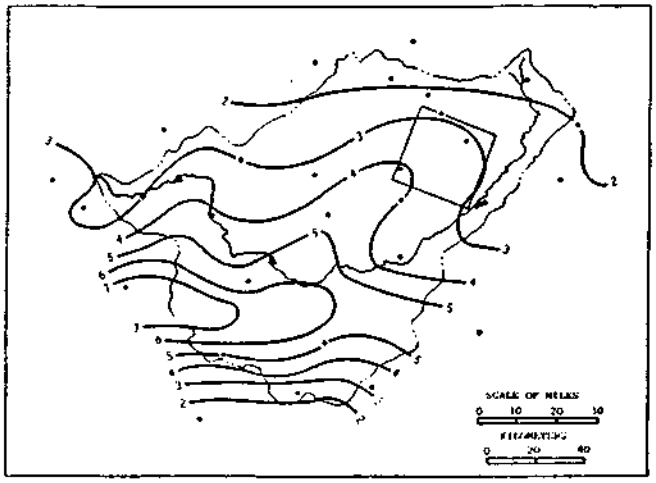


Figure D-10. Storm of September 8-9, 1926

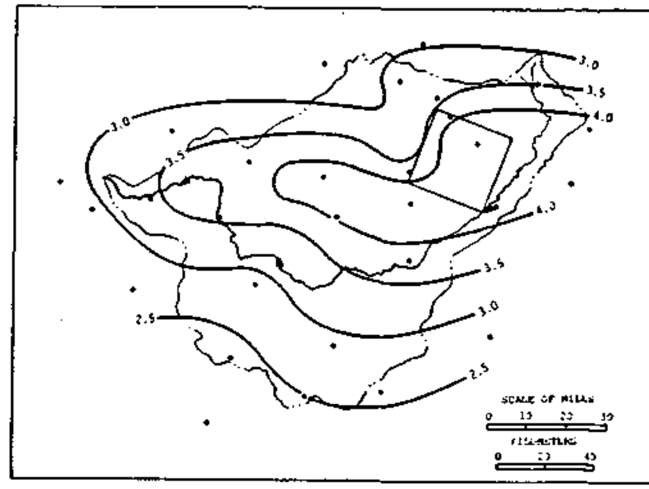


Figure D-11. Storm of March 11-12, 1939

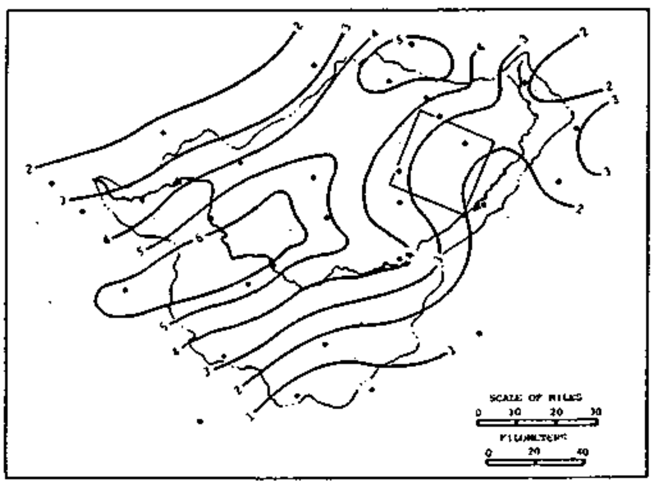


Figure D-12. Storm of October 4-5, 1941

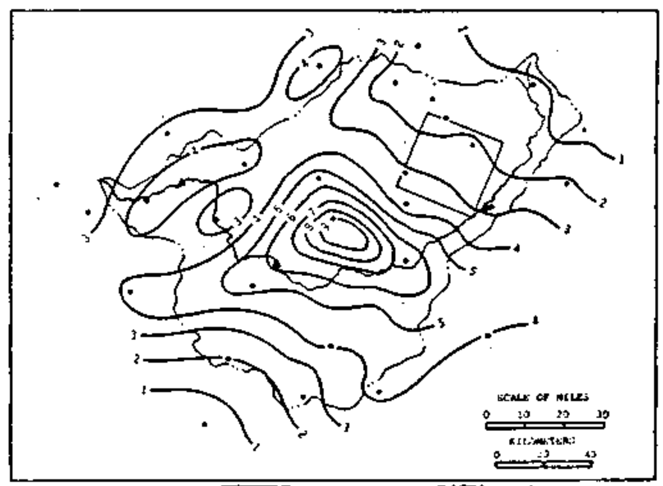


Figure D-13. Storm of June 27-28, 1951

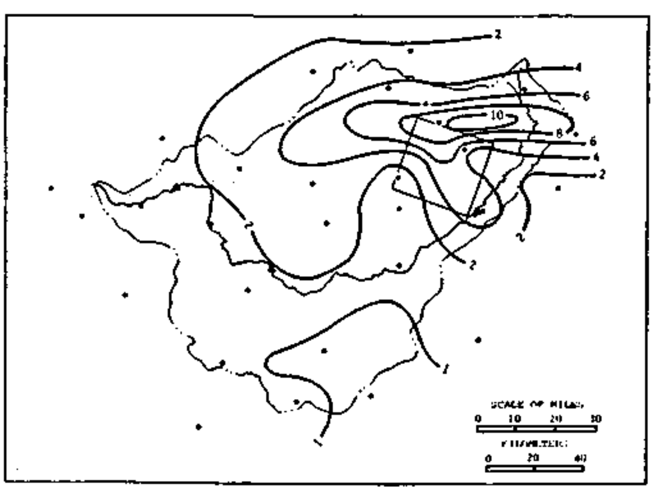


Figure D-14. Storm of May 26-28, 1956

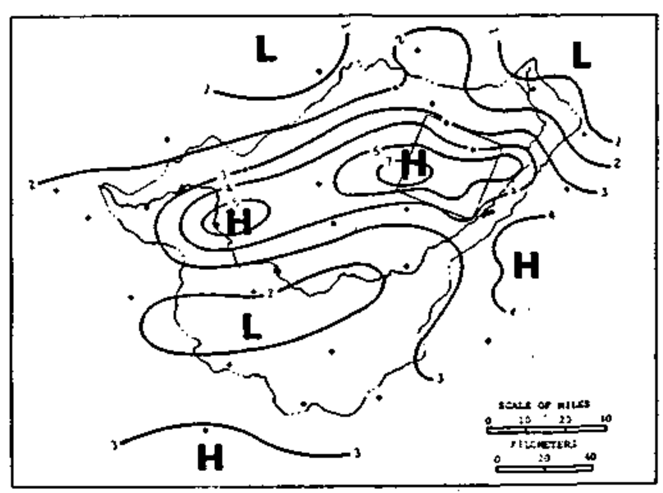



Figure D-15. Storm of May 7-8, 1961

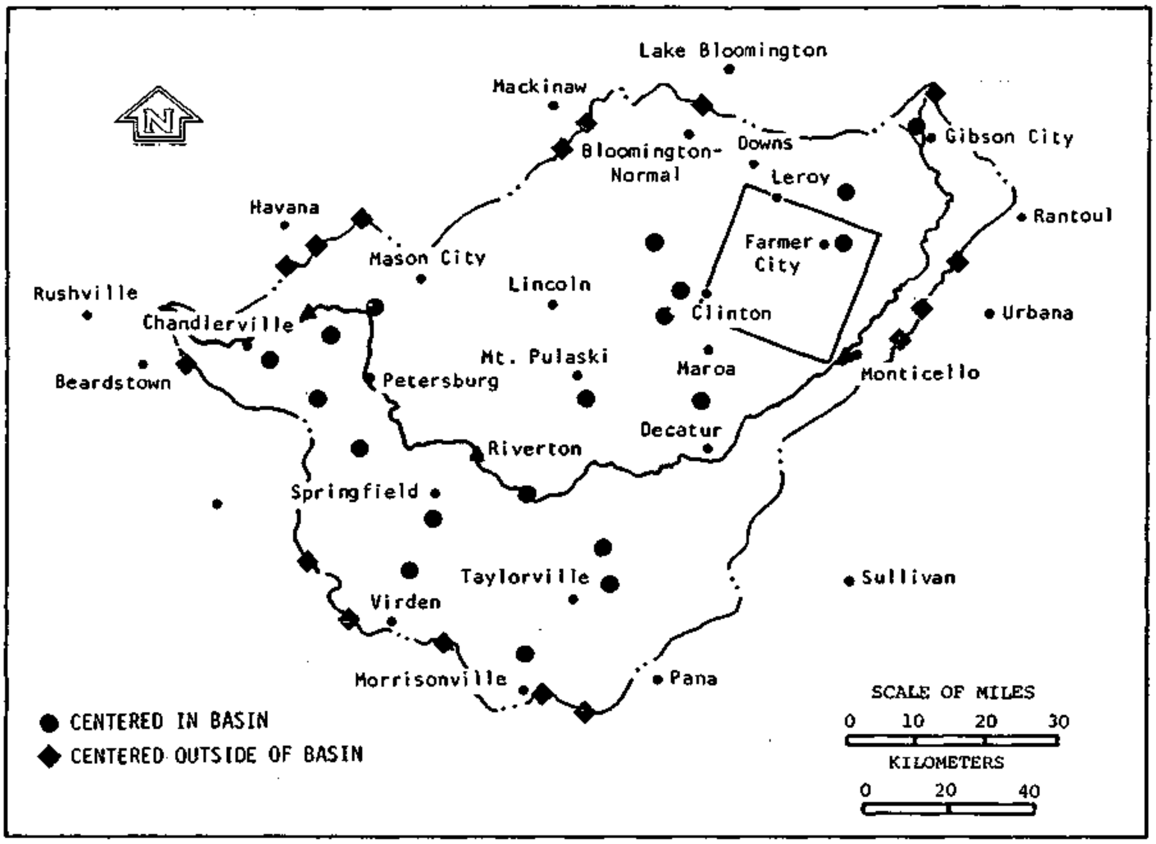



Figure D-16. Location of storm centers producing basin mean rainfall in excess of 2-year frequency value

# Part E. The Little Wabash Basin

The Little Wabash Basin (figure E-l) is located in the southeastern part of the state and has an area of approximately 3200 square miles. The Little Wabash discharges into the Wabash River near New Haven in White County. The topography of the basin is very flat with occasional small hills. Elevations are generally less than 600 feet MSL. Because of its elongated shape, the basin was divided into two parts for some of the meteorological analyses. The upper portion of the basin, as used in this report, encompasses 1510 square miles and the lower portion includes 1690 square miles.

## Basin Climate

The annual average precipitation increases from approximately 40 inches in the northern part of the basin to 44 inches in the extreme southern part (figure E-2). The basin annual mean is 41.36 inches. Figure E-3 shows the average seasonal precipitation. Winter and spring precipitation show the same general pattern as the annual distribution with a general north-south increase. However, the increase is more pronounced in winter. Summer has a very flat pattern with amounts ranging from 10.5 to 11.2 inches. The fall pattern is also very flat with amounts ranging from 9.6 inches in the extreme north to 10.0-10.2 in the southern portion of the basin.

The average annual frequency of thunderstorm days ranges from 49 in the northern part of the basin to 52 in the southern part (Changnon, 1957). The annual hail frequency averages 2-3 days per year (Huff and Changnon, 1959). The basin has an average frequency of tornado occurrences with respect to the rest of the state (Wilson and Changnon, 1971).

The annual average temperature varies from 53.5°F in the northern part of the basin to 57.0°F in the southern part. The monthly average temperature is lowest in January, when it varies from approximately 31°F to 35°F from the northern to southern parts of the basin. In July, the warmest month, the average varies from 77° F in the extreme north to 79° F in the extreme south.

## Storm Precipitation Characteristics

The distribution characteristics of very heavy rainstorms on the Little Wabash Basin are contained in the series of figures and tables that follow (figures E-4-E-14; tables E-l-E-9). These are presented in the same order and have the same interpretation as those for the other basins presented earlier in this report.

Comparison with the Lower Kaskaskia, which is approximately the same size as the entire Little Wabash, shows mean rainfall frequencies very similar for a given recurrence interval and storm rainfall period. Thus, for 24-hour storm periods, the 5-year frequencies are 3.1 inches on both basins. Similarly,

**Table E-1. Point Rainfall Frequency Relations on Little Wabash Basin**

| Storm duration (hours) | Depth (inches) equaled or exceeded for given recurrence interval (years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| *Upper Little Wabash Basin* | | | | | | |
| 1 | 1.4 | 1.7 | 1.9 | 2.5 | 3.1 | 3.6 |
| 2 | 1.7 | 2.0 | 2.3 | 2.9 | 3.7 | 4.4 |
| 3 | 1.9 | 2.3 | 2.7 | 3.3 | 4.1 | 4.9 |
| 6 | 2.3 | 2.7 | 3.2 | 4.0 | 4.9 | 5.9 |
| 12 | 2.6 | 3.3 | 3.8 | 4.8 | 5.8 | 7.0 |
| 18 | 2.8 | 3.6 | 4.2 | 5.3 | 6.4 | 7.8 |
| 24 | 2.9 | 3.8 | 4.5 | 5.8 | 7.0 | 8.4 |
| 48 | 3.1 | 4.0 | 4.9 | 6.3 | 7.5 | 9.1 |
| *Lower Little Wabash Basin* | | | | | | |
| 1 | 1.6 | 1.9 | 2.2 | 2.7 | 3.3 | 4.0 |
| 2 | 1.9 | 2.2 | 2.7 | 3.3 | 3.9 | 4.7 |
| 3 | 2.1 | 2.5 | 3.0 | 3.6 | 4.3 | 5.2 |
| 6 | 2.5 | 3.0 | 3.6 | 4.4 | 5.2 | 6.3 |
| 12 | 3.2 | 3.7 | 4.3 | 5.2 | 5.9 | 7.4 |
| 18 | 3.4 | 4.0 | 4.7 | 5.8 | 6.7 | 8.2 |
| 24 | 3.5 | 4.3 | 5.0 | 6.3 | 7.3 | 8.8 |
| 48 | 3.6 | 4.5 | 5.4 | 6.8 | 7.9 | 9.5 |
| *Entire Little Wabash Basin* | | | | | | |
| 1 | 1.5 | 1.8 | 2.1 | 2.6 | 3.2 | 3.8 |
| 2 | 1.8 | 2.1 | 2.5 | 3.1 | 3.8 | 4.6 |
| 3 | 2.0 | 2.4 | 2.9 | 3.5 | 4.2 | 5.1 |
| 6 | 2.4 | 2.9 | 3.4 | 4.2 | 5.1 | 6.1 |
| 12 | 2.9 | 3.5 | 4.1 | 5.0 | 5.9 | 7.2 |
| 18 | 3.1 | 3.8 | 4.5 | 5.6 | 6.6 | 8.0 |
| 24 | 3.2 | 4.1 | 4.8 | 6.1 | 7.2 | 8.6 |
| 48 | 3.4 | 4.3 | 5.2 | 6.6 | 7.7 | 9.3 |

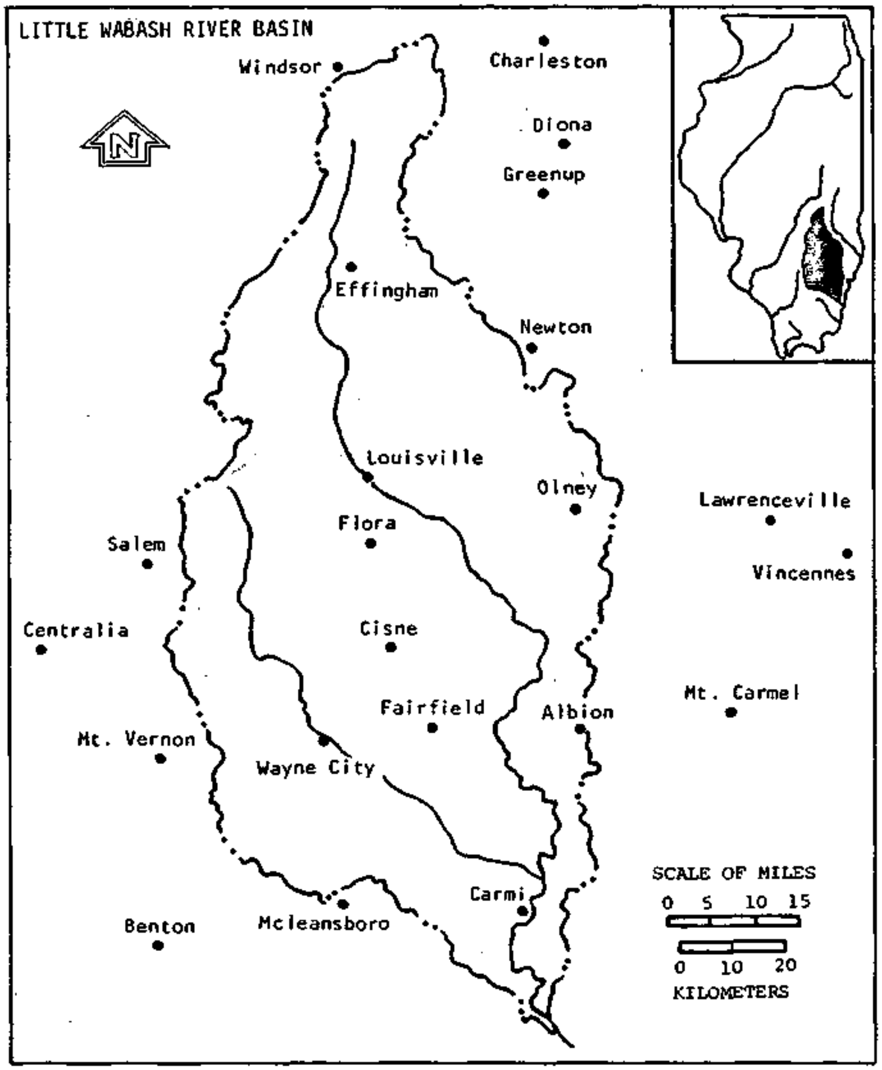



Figure E-1. Location map. Little Wabash Basin

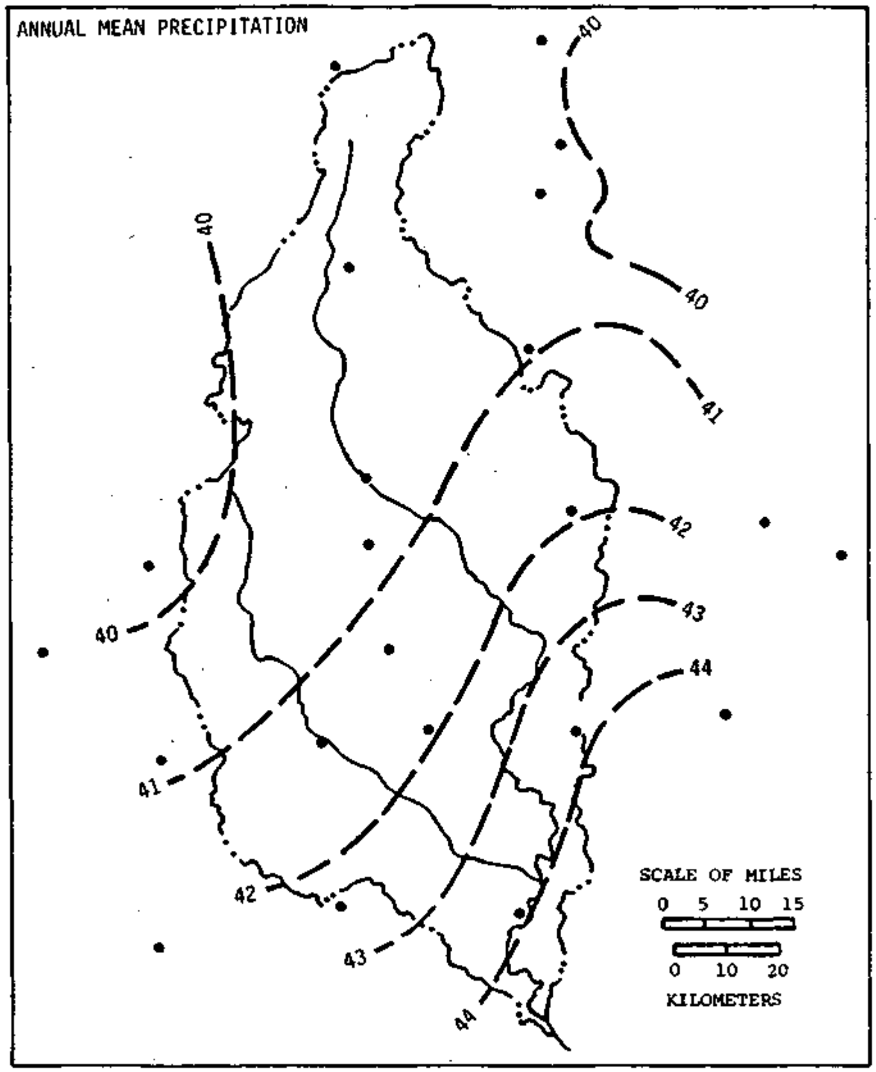



Figure E-2. Average annual precipitation, Little Wabash Basin

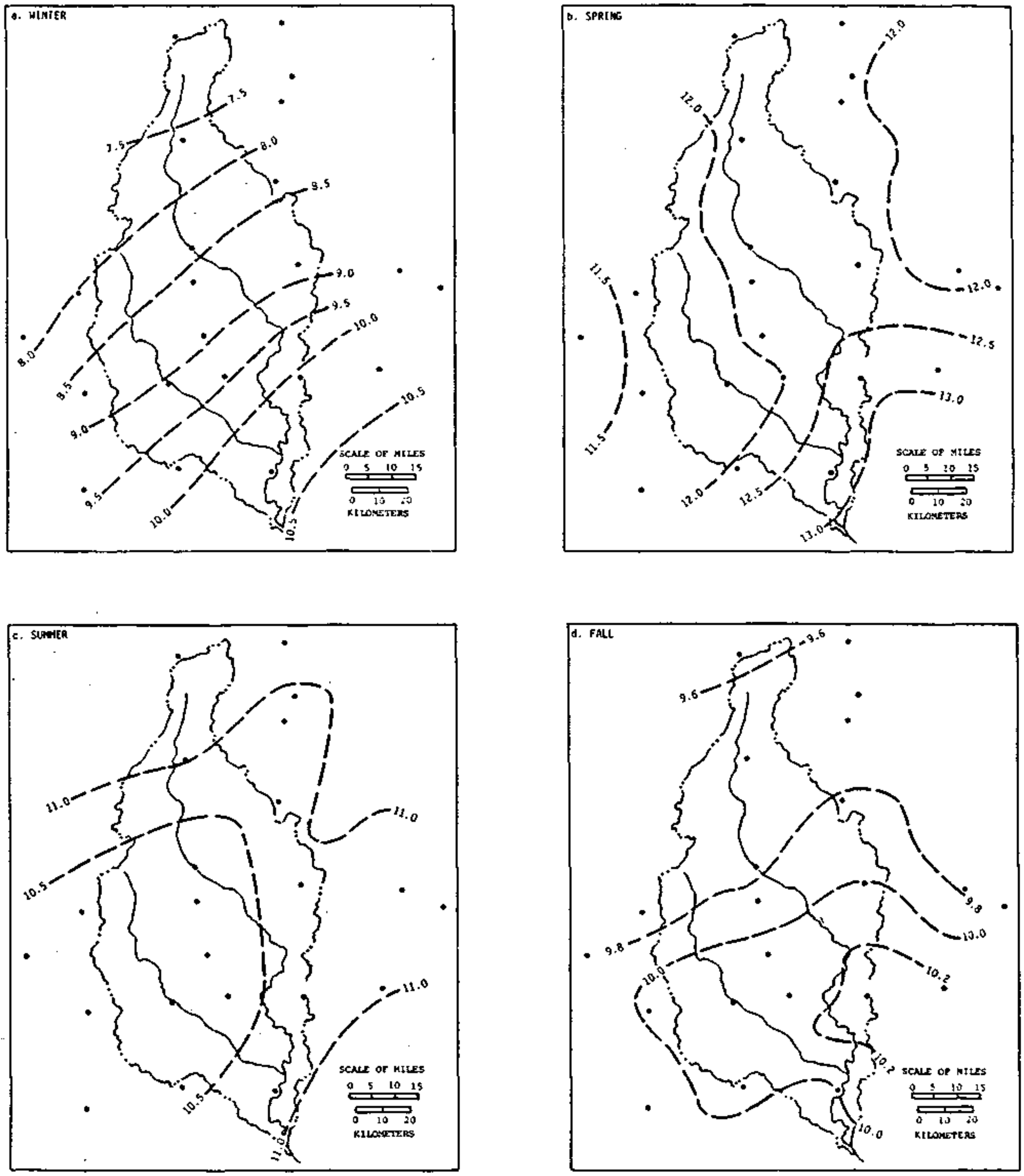



**Figure E-3. Average seasonal precipitation, Little Wabash Basin**

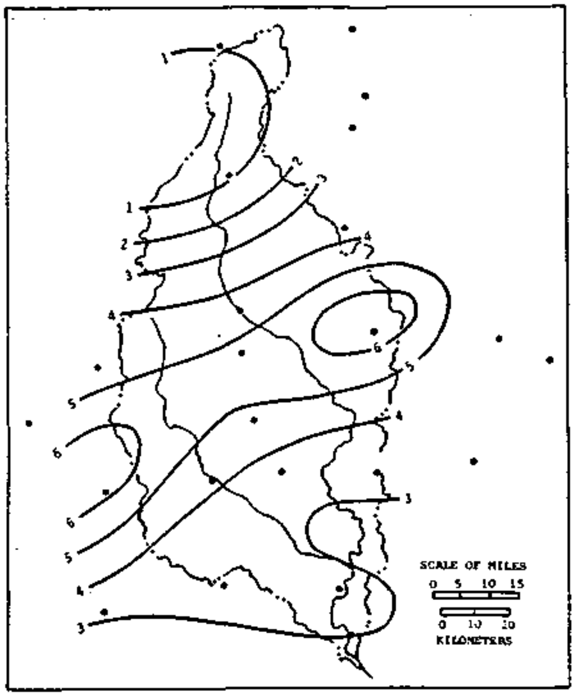



Figure E-4. Storm of July 19-20, 1896

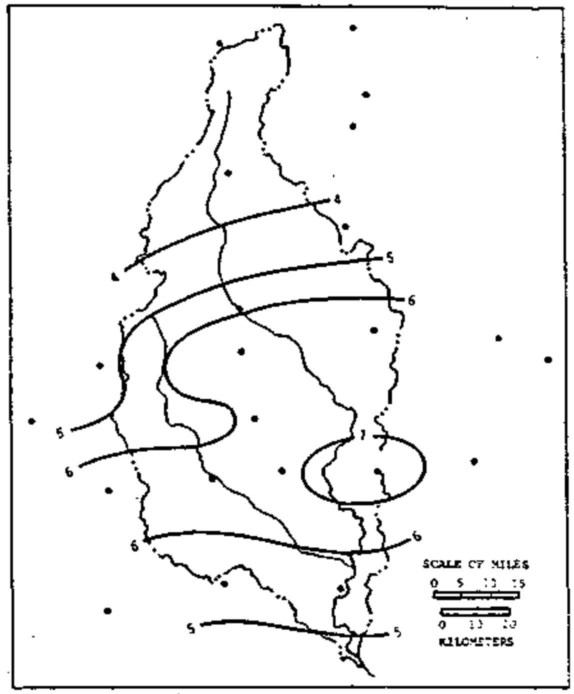


Figure E-5. Storm of March 25-26, 1904

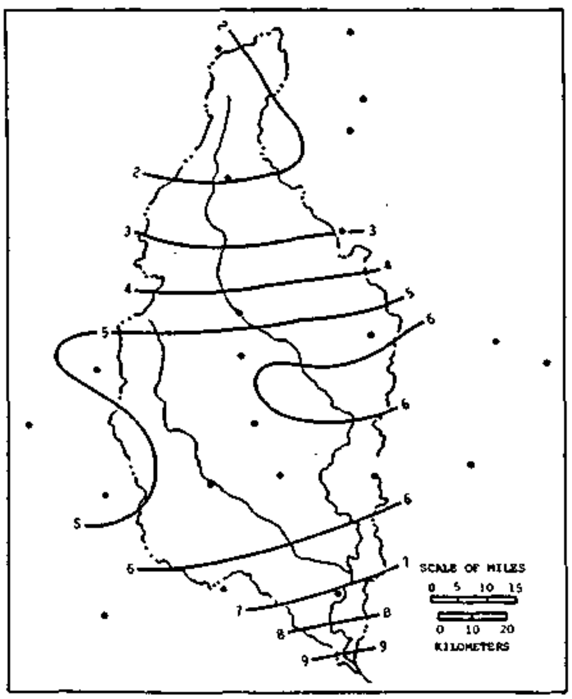



Figure E-6. Storm of October 4-5, 1910

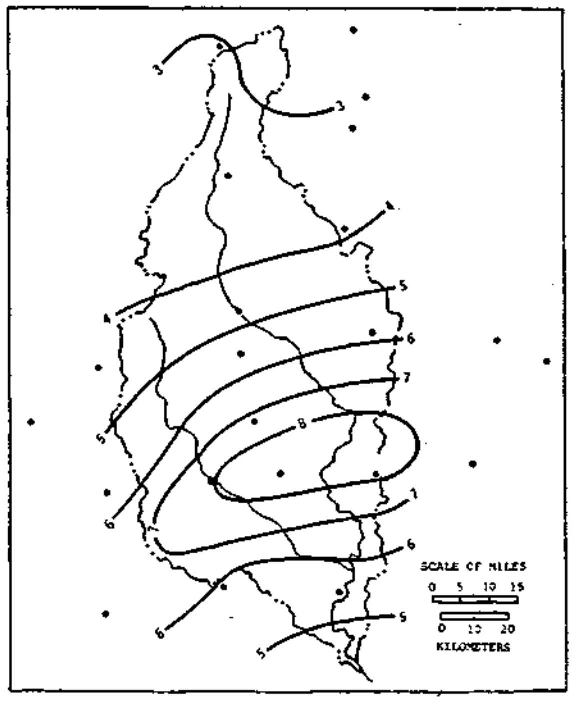



Figure E-7. Storm of March 24-25, 1913

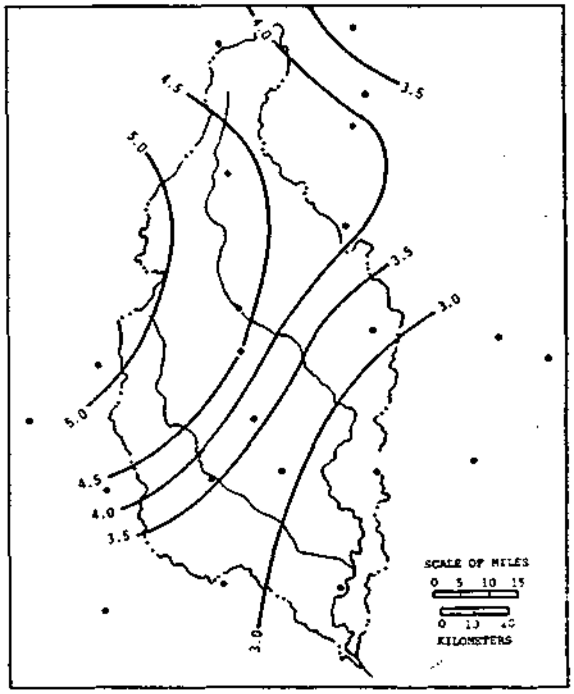



Figure E-8. Storm of August 20-21. 1915

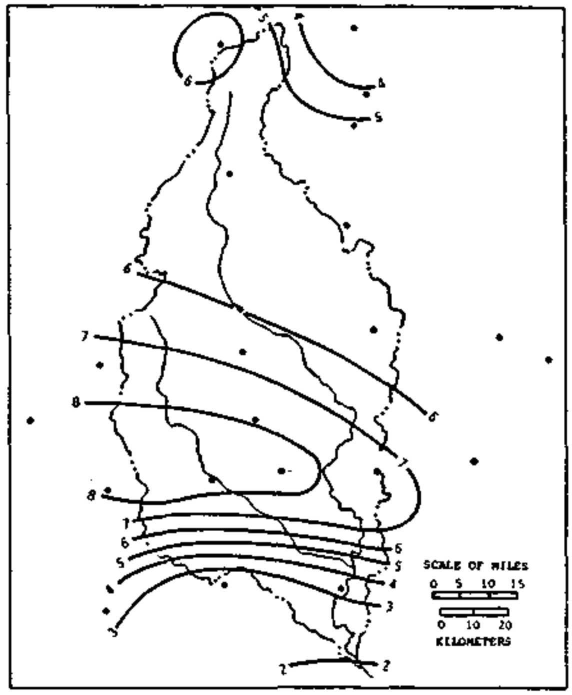



Figure E-9. Storm of October 26-27, 1919

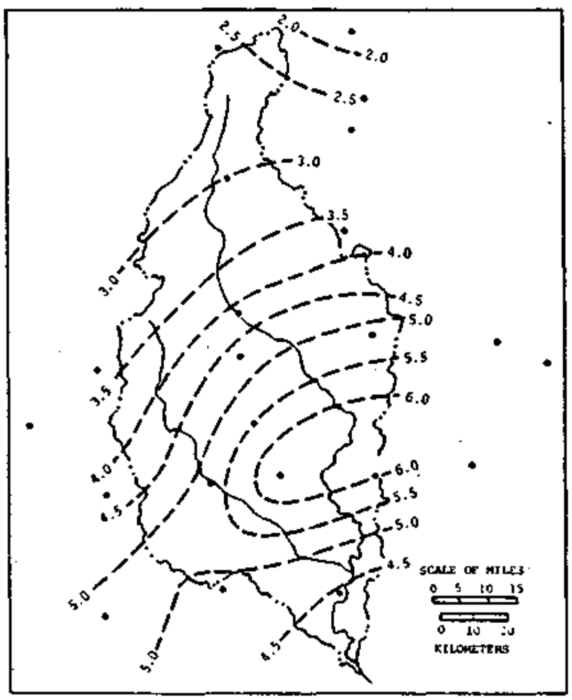



Figure E-10. Storm of September 1-2, 1931

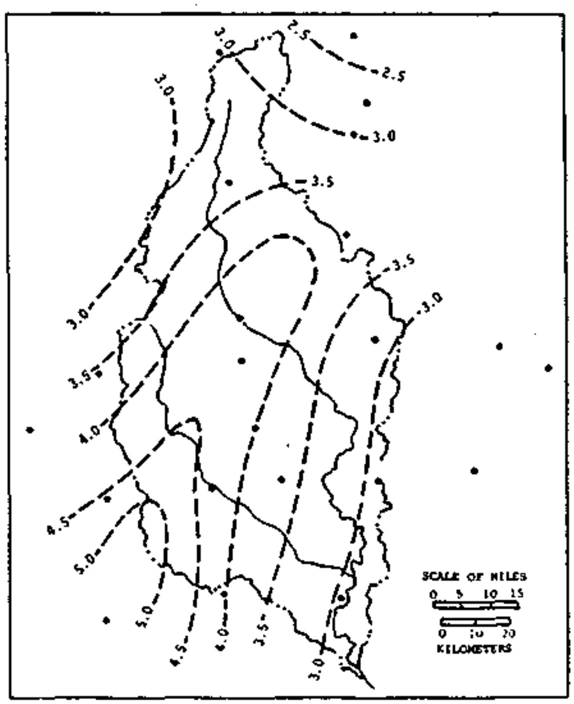



Figure E-11. Storm of November 21-22, 1934

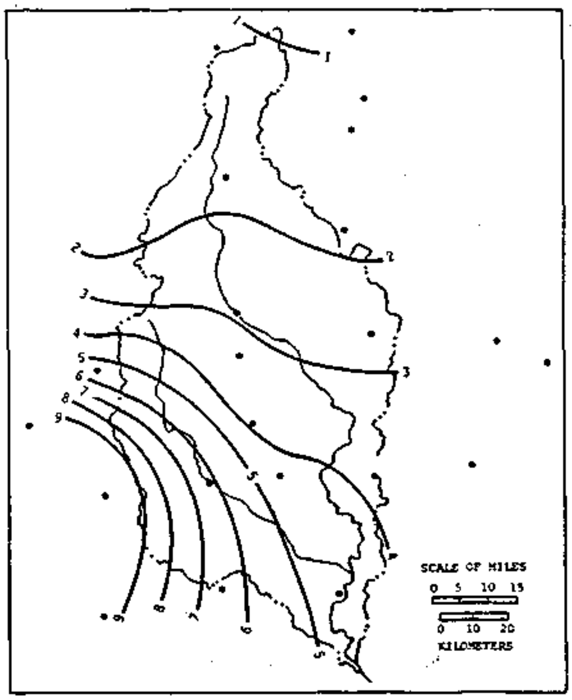



Figure E-12. Storm of August 15-16. 1946

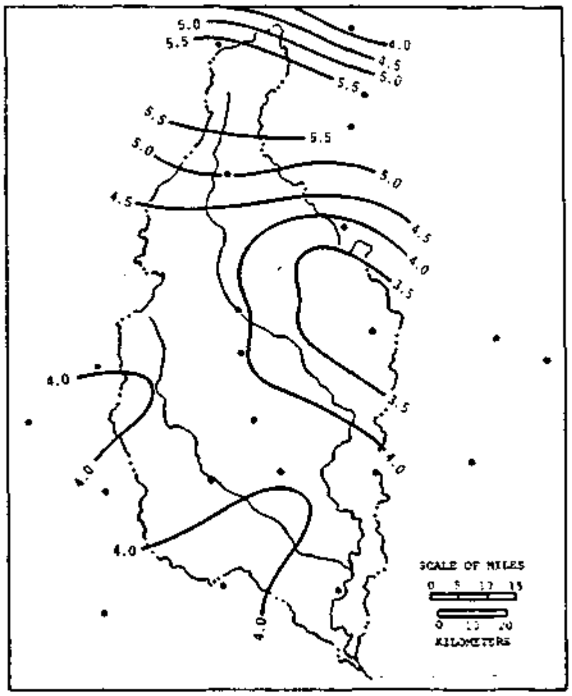



Figure E-13. Storm of January 3-4, 1950

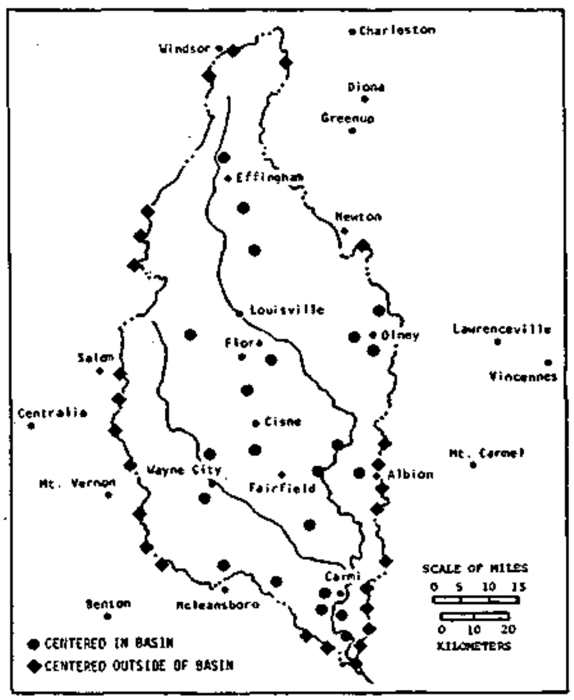



Figure E-14. Location of storm centers producing basin mean rainfall greater than 2-year frequency value the 25-year frequencies are 4.9 and 5.0 inches, respectively, on the Kaskaskia and Little Wabash, and the 50-year values are 6.0 and 5.7 inches. Point rainfall frequencies were also nearly equal on the two basins.

Storm rainfall gradients, as measured by area-depth-curve slopes, show somewhat steeper gradients, on the average, in the Little Wabash storms. For example, the ratio of the mean rainfall on the 100 square miles of heaviest rainfall to the basin mean rainfall had an average of 1.88 for 24-hour storm periods on the Little Wabash as opposed to 1.73 on the Lower Kaskaskia. Assuming average basin gradients in a storm having a mean rainfall of 3.0 inches on both basins, the mean rainfall over the 100 square miles around the storm center would be 5.6 inches on the Little Wabash and 5.2 inches on the Lower Kaskaskia. This is a difference of approximately 8 percent, and may not be significant for most hydrologic design applications.

**Table E-2. Basin Mean Rainfall Frequency Relations**

| *Recurrence interval (years)* | *Average rainfall depth (inches) equaled or exceeded for given storm period (hours)* 6 | 12 | 18 | 24 | 30 | 36 | 48 |
|---|---|---|---|---|---|---|---|
| *Upper Little Wabash Basin* | | | | | | | |
| 1 | .9 | 1.1 | 1.2 | 1.3 | 1.4 | 1.4 | 1.5 |
| 2 | 1.4 | 1.7 | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 |
| 5 | 1.9 | 2.5 | 2.7 | 2.9 | 3.1 | 3.2 | 3.3 |
| 10 | 2.4 | 3.1 | 3.4 | 3.6 | 3.8 | 3.9 | 4.1 |
| 15 | 2.7 | 3.5 | 3.8 | 4.0 | 4.3 | 4.4 | 4.6 |
| 20 | 2.9 | 3.7 | 4.0 | 4.3 | 4.6 | 4.7 | 4.9 |
| 25 | 3.1 | 3.9 | 4.3 | 4.6 | 4.8 | 5.0 | 5.2 |
| 30 | 3.2 | 4.1 | 4.4 | 4.8 | 5.0 | 5.2 | 5.4 |
| 35 | 3.3 | 4.2 | 4.6 | 4.9 | 5.2 | 5.4 | 5.6 |
| 40 | 3.4 | 4.3 | 4.7 | 5.0 | 5.3 | 5.5 | 5.7 |
| 50 | 3.5 | 4.5 | 4.9 | 5.3 | 5.6 | 5.8 | 6.0 |
| 75 | 3.8 | 4.8 | 5.2 | 5.6 | 6.0 | 6.1 | 6.4 |
| 100 | 4.0 | 5.1 | 5.6 | 6.0 | 6.3 | 6.5 | 6.8 |
| *Lower Little Wabash Basin* | | | | | | | |
| 1 | .9 | 1.1 | 1.2 | 1.3 | 1.4 | 1.4 | 1.5 |
| 2 | 1.5 | 2.0 | 2.1 | 2.3 | 2.4 | 2.5 | 2.6 |
| 5 | 2.4 | 3.0 | 3.3 | 3.5 | 3.7 | 3.8 | 4.0 |
| 10 | 3.0 | 3.8 | 4.1 | 4.4 | 4.7 | 4.8 | 5.0 |
| 15 | 3.4 | 4.3 | 4.7 | 5.0 | 5.3 | 5.5 | 5.7 |
| 20 | 3.6 | 4.6 | 5.0 | 5.4 | 5.7 | 5.9 | 6.1 |
| 25 | 3.8 | 4.8 | 5.2 | 5.6 | 6.0 | 6.1 | 6.4 |
| 30 | 4.0 | 5.0 | 5.5 | 5.9 | 6.2 | 6.4 | 6.7 |
| 35 | 4.1 | 5.3 | 5.7 | 6.2 | 6.5 | 6.7 | 7.0 |
| 40 | 4.2 | 5.4 | 5.9 | 6.3 | 6.7 | 6.9 | 7.2 |
| 50 | 4.4 | 5.6 | 6.2 | 6.6 | 7.0 | 7.2 | 7.5 |
| 75 | 4.8 | 6.1 | 6.6 | 7.1 | 7.5 | 7.8 | 8.1 |
| 100 | 5.1 | 6.5 | 7.1 | 7.6 | 8.0 | 8.3 | 8.6 |
| *Entire Little Wabash Basin* | | | | | | | |
| 1 | .8 | 1.1 | 1.2 | 1.3 | 1.4 | 1.4 | 1.5 |
| 2 | 1.3 | 1.7 | 1.9 | 2.1 | 2.2 | 2.3 | 2.4 |
| 5 | 2.0 | 2.6 | 2.9 | 3.1 | 3.3 | 3.5 | 3.6 |
| 10 | 2.5 | 3.2 | 3.6 | 3.9 | 4.2 | 4.3 | 4.5 |
| 15 | 2.8 | 3.6 | 4.1 | 4.4 | 4.7 | 4.8 | 5.0 |
| 20 | 3.0 | 3.9 | 4.4 | 4.7 | 5.0 | 5.2 | 5.4 |
| 25 | 3.2 | 4.1 | 4.6 | 5.0 | 5.3 | 5.5 | 5.7 |
| 30 | 3.3 | 4.2 | 4.8 | 5.1 | 5.5 | 5.7 | 5.9 |
| 35 | 3.5 | 4.5 | 5.0 | 5.4 | 5.8 | 6.0 | 6.2 |
| 40 | 3.5 | 4.5 | 5.1 | 5.5 | 5.9 | 6.0 | 6.3 |
| 50 | 3.7 | 4.8 | 5.3 | 5.7 | 6.1 | 6.3 | 6.6 |
| 75 | 4.0 | 5.1 | 5.8 | 6.2 | 6.6 | 6.8 | 7.1 |
| 100 | 4.2 | 5.4 | 6.1 | 6.5 | 7.0 | 7.2 | 7.5 |

**Table E-3. Frequency Distribution of Areal Mean Rainfall for Specific Integral Areas on Little Wabash Basin**

| Recurrence interval (years) | Average depth (inches) equaled or exceeded for given area (square miles) 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *1-Hour storm period* | | | | | | |
| 2 | 1.4 | 1.3 | 1.2 | 1.1 | 1.0 | 1.0 |
| 5 | 1.7 | 1.6 | 1.4 | 1.3 | 1.2 | 1.2 |
| 10 | 2.0 | 1.8 | 1.7 | 1.5 | 1.4 | 1.3 |
| 25 | 2.4 | 2.3 | 2.1 | 1.9 | 1.7 | 1.7 |
| 50 | 3.0 | 2.8 | 2.6 | 2.3 | 2.1 | 2.0 |
| 100 | 3.5 | 3.3 | 3.0 | 2.8 | 2.5 | 2.4 |
| *2-Hour storm period* | | | | | | |
| 2 | 1.7 | 1.7 | 1.5 | 1.4 | 1.3 | 1.3 |
| 5 | 2.0 | 2.0 | 1.8 | 1.7 | 1.6 | 1.5 |
| 10 | 2.4 | 2.3 | 2.2 | 2.0 | 1.9 | 1.8 |
| 25 | 2.9 | 2.9 | 2.7 | 2.5 | 2.3 | 2.2 |
| 50 | 3.6 | 3.5 | 3.3 | 3.0 | 2.8 | 2.7 |
| 100 | 4.4 | 4.3 | 4.0 | 3.7 | 3.4 | 3.3 |
| *3-Hour storm period* | | | | | | |
| 2 | 1.9 | 1.9 | 1.8 | 1.7 | 1.6 | 1.6 |
| 5 | 2.3 | 2.3 | 2.2 | 2.0 | 1.9 | 1.9 |
| 10 | 2.8 | 2.8 | 2.6 | 2.5 | 2.3 | 2.3 |
| 25 | 3.4 | 3.3 | 3.2 | 3.0 | 2.8 | 2.7 |
| 50 | 4.1 | 4.0 | 3.8 | 3.6 | 3.4 | 3.3 |
| 100 | 4.9 | 4.8 | 4.6 | 4.3 | 4.1 | 4.0 |
| *6-Hour storm period* | | | | | | |
| 2 | 2.3 | 2.3 | 2.2 | 2.1 | 2.0 | 2.0 |
| 5 | 2.8 | 2.8 | 2.7 | 2.6 | 2.5 | 2.4 |
| 10 | 3.3 | 3.3 | 3.1 | 3.0 | 2.9 | 2.8 |
| 25 | 4.1 | 4.0 | 3.9 | 3.7 | 3.6 | 3.4 |
| 50 | 4.9 | 4.9 | 4.7 | 4.5 | 4.3 | 4.2 |
| 100 | 5.9 | 5.9 | 5.6 | 5.4 | 5.2 | 5.0 |
| *12-Hour storm period* | | | | | | |
| 2 | 2.8 | 2.8 | 2.7 | 2.6 | 2.6 | 2.5 |
| 5 | 3.4 | 3.4 | 3.3 | 3.2 | 3.1 | 3.0 |
| 10 | 4.0 | 4.0 | 3.9 | 3.7 | 3.6 | 3.6 |
| 25 | 4.9 | 4.9 | 4.7 | 4.6 | 4.5 | 4.4 |
| 50 | 5.8 | 5.7 | 5.5 | 5.4 | 5.3 | 5.1 |
| 100 | 7.1 | 7.0 | 6.8 | 6.6 | 6.4 | 6.3 |
| *18-Hour storm period* | | | | | | |
| 2 | 3.0 | 3.0 | 2.9 | 2.9 | 2.8 | 2.8 |
| 5 | 3.7 | 3.7 | 3.6 | 3.5 | 3.5 | 3.4 |
| 10 | 4.4 | 4.4 | 4.2 | 4.1 | 4.1 | 4.0 |
| 25 | 5.5 | 5.4 | 5.3 | 5.2 | 5.1 | 5.0 |
| 50 | 6.5 | 6.4 | 6.2 | 6.1 | 6.0 | 5.9 |
| 100 | 7.8 | 7.8 | 7.5 | 7.4 | 7.3 | 7.1 |
| *24-Hour storm period* | | | | | | |
| 2 | 3.1 | 3.1 | 3.0 | 3.0 | 2.9 | 2.9 |
| 5 | 4.0 | 4.0 | 3.9 | 3.8 | 3.8 | 3.7 |
| 10 | 4.7 | 4.7 | 4.6 | 4.5 | 4.4 | 4.4 |
| 25 | 6.0 | 6.0 | 5.8 | 5.7 | 5.6 | 5.6 |
| 50 | 7.1 | 7.1 | 6.8 | 6.7 | 6.6 | 6.6 |
| 100 | 8.4 | 8.4 | 8.2 | 8.0 | 7.9 | 7.8 |
| *48-Hour storm period* | | | | | | |
| 2 | 3.4 | 3.4 | 3.3 | 3.2 | 3.2 | 3.2 |
| 5 | 4.3 | 4.3 | 4.1 | 4.0 | 4.0 | 4.0 |
| 10 | 5.1 | 5.1 | 5.0 | 4.9 | 4.8 | 4.8 |
| 25 | 6.5 | 6.5 | 6.3 | 6.2 | 6.1 | 6.1 |
| 50 | 7.6 | 7.6 | 7.4 | 7.2 | 7.2 | 7.2 |
| 100 | 9.2 | 9.2 | 8.9 | 8.7 | 8.6 | 8.6 |

**Table E-4. Frequency Distribution of Areal Maximum Rainfall on Little Wabash Basin**

| Recurrence interval (years) | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| *6-Hour storms* | | | | | | |
| 2 | 3.4 | 3.3 | 3.1 | 2.8 | 2.6 | 2.2 |
| 5 | 4.9 | 4.7 | 4.4 | 4.0 | 3.7 | 3.2 |
| 10 | 6.2 | 6.0 | 5.4 | 4.9 | 4.4 | 3.9 |
| 25 | 7.7 | 7.2 | 6.5 | 6.0 | 5.4 | 4.9 |
| 50 | 8.6 | 7.8 | 7.0 | 6.5 | 5.0 | 5.4 |
| 100 | 9.4 | 8.3 | 7.5 | 6.9 | 6.4 | 5.9 |
| *12-Hour storms* | | | | | | |
| 2 | 4.1 | 4.0 | 3.7 | 3.4 | 3.2 | 2.7 |
| 5 | 5.9 | 5.6 | 5.2 | 4.9 | 4.5 | 3.8 |
| 10 | 7.4 | 7.2 | 6.5 | 5.9 | 5.4 | 4.7 |
| 25 | 9.2 | 8.6 | 7.9 | 7.2 | 6.5 | 5.9 |
| 50 | 10.3 | 9.4 | 8.5 | 7.9 | 7.2 | 6.5 |
| 100 | 11.3 | 9.9 | 9.0 | 8.3 | 7.8 | 7.1 |
| *18-Hour storms* | | | | | | |
| 2 | 4.5 | 4.3 | 4.1 | 3.7 | 3.4 | 2.9 |
| 5 | 6.5 | 6.1 | 5.8 | 5.3 | 4.9 | 4.2 |
| 10 | 8.1 | 7.8 | 7.2 | 6.5 | 5.9 | 5.1 |
| 25 | 10.0 | 9.4 | 8.7 | 7.9 | 7.1 | 6.4 |
| 50 | 11.2 | 10.2 | 9.4 | 8.6 | 7.9 | 7.1 |
| 100 | 12.3 | 10.8 | 9.9 | 9.1 | 8.5 | 7.7 |
| *24-Hour storms* | | | | | | |
| 2 | 4.8 | 4.6 | 4.3 | 4.0 | 3.6 | 3.1 |
| 5 | 6.8 | 6.5 | 6.1 | 5.7 | 5.2 | 4.4 |
| 10 | 8.6 | 8.3 | 7.6 | 6.9 | 6.2 | 5.5 |
| 25 | 10.6 | 9.9 | 9.2 | 8.5 | 7.6 | 6.9 |
| 50 | 11.9 | 10.8 | 9.9 | 9.2 | 8.4 | 7.7 |
| 100 | 13.0 | 11.4 | 10.5 | 9.7 | 9.0 | 8.3 |
| *30-Hour storms* | | | | | | |
| 2 | 5.0 | 4.8 | 4.5 | 4.1 | 3.9 | 3.3 |
| 5 | 7.1 | 6.8 | 6.4 | 5.9 | 5.5 | 4.7 |
| 10 | 8.9 | 8.6 | 8.0 | 7.2 | 6.6 | 5.8 |
| 25 | 11.1 | 10.3 | 9.6 | 8.8 | 8.0 | 7.2 |
| 50 | 12.4 | 11.3 | 10.3 | 9.6 | 8.8 | 8.1 |
| 100 | 13.6 | 11.9 | 11.0 | 10.2 | 9.5 | 8.7 |
| *36-Hour storms* | | | | | | |
| 2 | 5.1 | 4.9 | 4.7 | 4.3 | 3.9 | 3.4 |
| 5 | 7.4 | 7.0 | 6.6 | 6.1 | 5.6 | 4.8 |
| 10 | 9.2 | 8.9 | 8.2 | 7.5 | 6.7 | 6.0 |
| 25 | 11.4 | 10.7 | 9.9 | 9.1 | 8.2 | 7.4 |
| 50 | 12.8 | 11.6 | 10.7 | 9.9 | 9.0 | 8.3 |
| 100 | 14.1 | 12.3 | 11.3 | 10.5 | 9.7 | 8.9 |
| *48-Hour storms* | | | | | | |
| 2 | 5.3 | 5.1 | 4.8 | 4.4 | 4.1 | 3.5 |
| 5 | 7.6 | 7.2 | 6.8 | 6.3 | 5.8 | 5.0 |
| 10 | 9.5 | 9.2 | 8.5 | 7.7 | 7.0 | 6.2 |
| 25 | 11.8 | 11.0 | 10.2 | 9.4 | 8.5 | 7.7 |
| 50 | 13.2 | 12.0 | 11.0 | 10.2 | 9.4 | 8.6 |
| 100 | 14.5 | 12.7 | 11.7 | 10.8 | 10.1 | 9.3 |

Table E-5. Average Slope of Area-Depth Curves

| Incremental areas (square miles) | Ratio of mean rainfall on incremental areas to basin mean rainfall for given storm duration (hours) 6 | 12 | 18 | 24 | 36 | 48 |
|---|---|---|---|---|---|---|
| *Upper Little Wabash* | | | | | | |
| 25 | 1.93 | 1.84 | 1.82 | 1.80 | 1.78 | 1.77 |
| 50 | 1.84 | 1.76 | 1.74 | 1.72 | 1.69 | 1.67 |
| 100 | 1.74 | 1.67 | 1.65 | 1.63 | 1.61 | 1.59 |
| 200 | 1.63 | 1.57 | 1.56 | 1.54 | 1.52 | 1.50 |
| 500 | 1.42 | 1.39 | 1.38 | 1.36 | 1.34 | 1.33 |
| 1000 | 1.19 | 1.18 | 1.17 | 1.17 | 1.15 | 1.14 |
| 1510 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Lower Little Wabash* | | | | | | |
| 25 | 1.97 | 1.87 | 1.85 | 1.83 | 1.81 | 1.79 |
| 50 | 1.81 | 1.72 | 1.71 | 1.68 | 1.67 | 1.65 |
| 100 | 1.68 | 1.59 | 1.61 | 1.59 | 1.56 | 1.55 |
| 200 | 1.56 | 1.47 | 1.46 | 1.47 | 1.45 | 1.43 |
| 500 | 1.34 | 1.29 | 1.29 | 1.27 | 1.26 | 1.26 |
| 1000 | 1.19 | 1.16 | 1.16 | 1.15 | 1.14 | 1.14 |
| 1500 | 1.08 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 1690 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Entire Little Wabash* | | | | | | |
| 25 | 2.44 | 2.25 | 2.21 | 2.17 | 2.11 | 2.05 |
| 50 | 2.27 | 2.11 | 2.07 | 2.04 | 1.97 | 1.90 |
| 100 | 2.20 | 1.92 | 1.90 | 1.88 | 1.85 | 1.82 |
| 200 | 1.93 | 1.81 | 1.78 | 1.76 | 1.72 | 1.68 |
| 500 | 1.69 | 1.62 | 1.60 | 1.58 | 1.55 | 1.52 |
| 1000 | 1.53 | 1.47 | 1.45 | 1.44 | 1.42 | 1.40 |
| 1500 | 1.42 | 1.37 | 1.36 | 1.35 | 1.32 | 1.30 |
| 2000 | 1.31 | 1.28 | 1.27 | 1.26 | 1.24 | 1.23 |
| 2500 | 1.20 | 1.18 | 1.17 | 1.16 | 1.15 | 1.14 |
| 3200 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table E-6. Average Area-Depth Relations in a 12-Hour, 25-Year Storm on the Little Wabash Basin

| Area (square miles) | Average rainfall (inches) Upper | Lower | Entire |
|---|---|---|---|
| 25 | 7.2 | 9.0 | 9.0 |
| 50 | 6.9 | 8.3 | 8.7 |
| 100 | 6.5 | 7.6 | 7.9 |
| 200 | 6.1 | 7.1 | 7.4 |
| 500 | 5.4 | 6.2 | 6.6 |
| 1000 | 4.6 | 5.6 | 6.0 |
| 1510 | 3.9 | 5.2 | 5.6 |
| 1690 | | 4.8 | 5.4 |
| 2000 | | | 5.2 |
| 2500 | | | 4.8 |
| 3200 | | | 4.1 |

Table E-7. Unmodified Area-Depth Relations for Entire Little Wabash Basin

| Date | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2500 | 3200 |
|---|---|---|---|---|---|---|---|---|---|---|
| 7/19-20/96 | 7.0 | 6.8 | 6.6 | 6.3 | 5.9 | 5.5 | 5.1 | 4.8 | 4.5 | 3.9 |
| 3/25-26/04 | 8.0 | 7.8 | 7.6 | 7.4 | 7.0 | 6.7 | 6.5 | 6.3 | 6.1 | 5.6 |
| 10/4-5/10 | 9.0 | 8.6 | 8.1 | 7.6 | 7.0 | 6.5 | 6.2 | 5.9 | 5.6 | 4.8 |
| 3/24-25/13 | 9.2 | 9.1 | 8.9 | 8.7 | 8.2 | 7.6 | 7.2 | 6.7 | 6.3 | 5.6 |
| 8/20-21/15 | 5.4 | 5.3 | 5.2 | 5.1 | 5.0 | 4.8 | 4.6 | 4.4 | 4.2 | 3.9 |
| 10/26-27/19 | 9.8 | 9.5 | 9.2 | 8.9 | 8.4 | 7.9 | 7.5 | 7.2 | 6.8 | 6.2 |
| 9/1-2/31 | 6.7 | 6.6 | 6.5 | 6.2 | 6.0 | 5.7 | 5.5 | 5.2 | 4.9 | 4.5 |
| 11/21-22/34 | 5.3 | 5.2 | 5.0 | 4.9 | 4.6 | 4.4 | 4.2 | 4.1 | 3.9 | 3.7 |
| 8/15-16/46 | 9.7 | 9.5 | 9.2 | 8.8 | 7.8 | 6.6 | 5.9 | 5.2 | 4.8 | 4.2 |
| 1/3-4/50 | 6.4 | 6.2 | 5.9 | 5.6 | 5.3 | 4.9 | 4.7 | 4.5 | 4.3 | 4.2 |

Table E-8. Monthly Distribution of 48-Hour Heavy Rainstorms

| Month | Number | Month | Number |
|---|---|---|---|
| January | 1 | July | 3 |
| February | 1 | August | 4 |
| March | 5 | September | 4 |
| April | 3 | October | 2 |
| May | 4 | November | 4 |
| June | 1 | December | 1 |

Table E-9. Seasonal Distribution of 48-Hour Heavy Rainstorms

| 3-Month period | Number | 3-Month period | Number |
|---|---|---|---|
| Jan-Mar | 7 | Jul-Sep | 11 |
| Feb-Apr | 9 | Aug-Oct | 10 |
| Mar-May | 12 | Sep-Nov | 10 |
| Apr-Jun | 8 | Oct-Dec | 7 |
| May-Jul | 8 | Nov-Jan | 6 |
| Jun-Aug | 7 | Dec-Feb | 3 |

# Part F. The Embarras Basin

The Embarras Basin is located in E to SE Illinois and has an area of approximately 2440 square miles. The terrain is very flat for the most part with occasional small hills reaching to 600 feet MSL along the river valley. The basin is oriented NNW-SSE with an elongated shape having an approximate 4:1 ratio between the major and minor axis. For some analysis purposes, the basin was divided into two parts (figure F-l). The upper portion has an area of 1125 square miles and the lower portion encompasses 1315 square miles.

## Basin Climate

The annual average precipitation varies from 42 inches in the extreme southern part of the basin to 37 inches in the extreme north (figure F-2). The basin mean is 40.08 inches. The average seasonal precipitation is portrayed in figure F-3. Winter precipitation shows a general increase from the northern to the southern part of the basin with a relatively strong gradient. Average amounts range from 6.5 inches in the north to over 9 inches in the extreme south. The variation in spring precipitation within the basin is considerably less than in winter. There is approximately a 1-inch variation from north to south. Only small differences in average rainfall occur in summer also. The range is only about 0.5 inch with the heaviest amounts in the western and southern portions of the basin. The fall pattern is similar to winter with a gradual increase in seasonal amounts from north to south. However, maximum differences are only about 1 inch.

The average annual frequency of thunderstorms ranges from 46 in the north to 49 in the southern part of the basin. This is less than the frequency in the Little Wabash, Lower Kaskaskia, and Big Muddy basins which lie to the W and SW of the Embarras. The annual average frequency of hail is approximately two days, which is moderate with respect to other Illinois basins. The northern extremity of the basin lies in a region of relatively frequent tornadoes, but the central and southern parts are in lower to moderate frequencies.

The annual average temperature varies from 52°F in the north to 55°F in the south. In the coldest month, January, the mean monthly temperature varies from 27°F in the extreme north to 31.5°F in the extreme southern part of the basin. During July, the hottest month, the mean temperature ranges from approximately 75.5°F in the north to 77.5°F in the south.

## Storm Precipitation Characteristics

The Embarras Basin lies directly east of the Little Wabash Basin. Both basins experience basinwide heavy rainstorms most frequently in spring and fall. Summer storms are often more intense at their centers, but cover much less area, on the average, than the spring and fall storms. The two basins are quite similar in their storm characteristics, but storms do tend to be slightly more intense on the Little Wabash, according to past experiences. Also,, winter storms have been more of a problem on the Embarras in the past than on the Little Wabash. Of the 48-hour storm periods in which the basin mean rainfall equaled or exceeded the 2-year recurrence-interval value, nearly twice as many have been recorded on the Embarras in winter. This trend is reversed in summer when the frequency of heavy storms is somewhat greater on the Little Wabash.

Storm precipitation characteristics for the Embarras are summarized in tables F-l to F-9 and figures F-l to F-14.

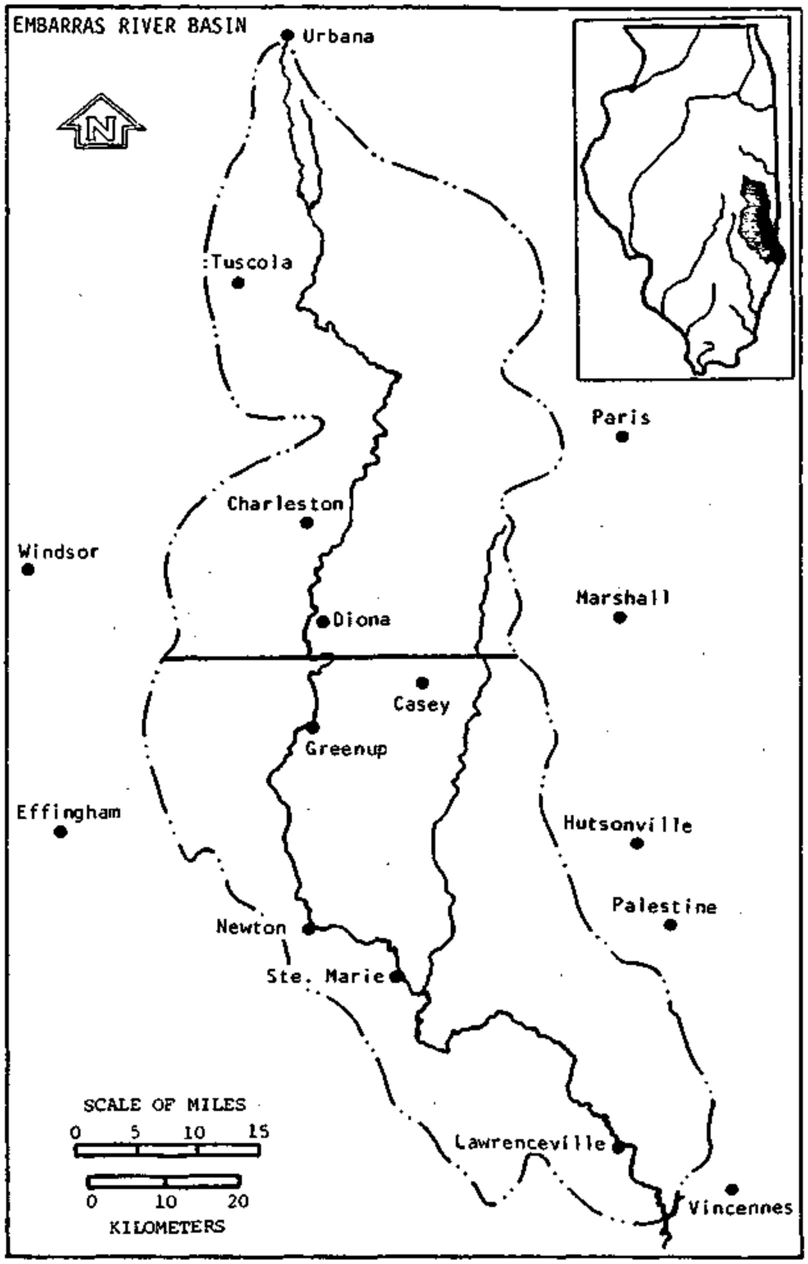



Figure F-1. Location map, Embarras Basin

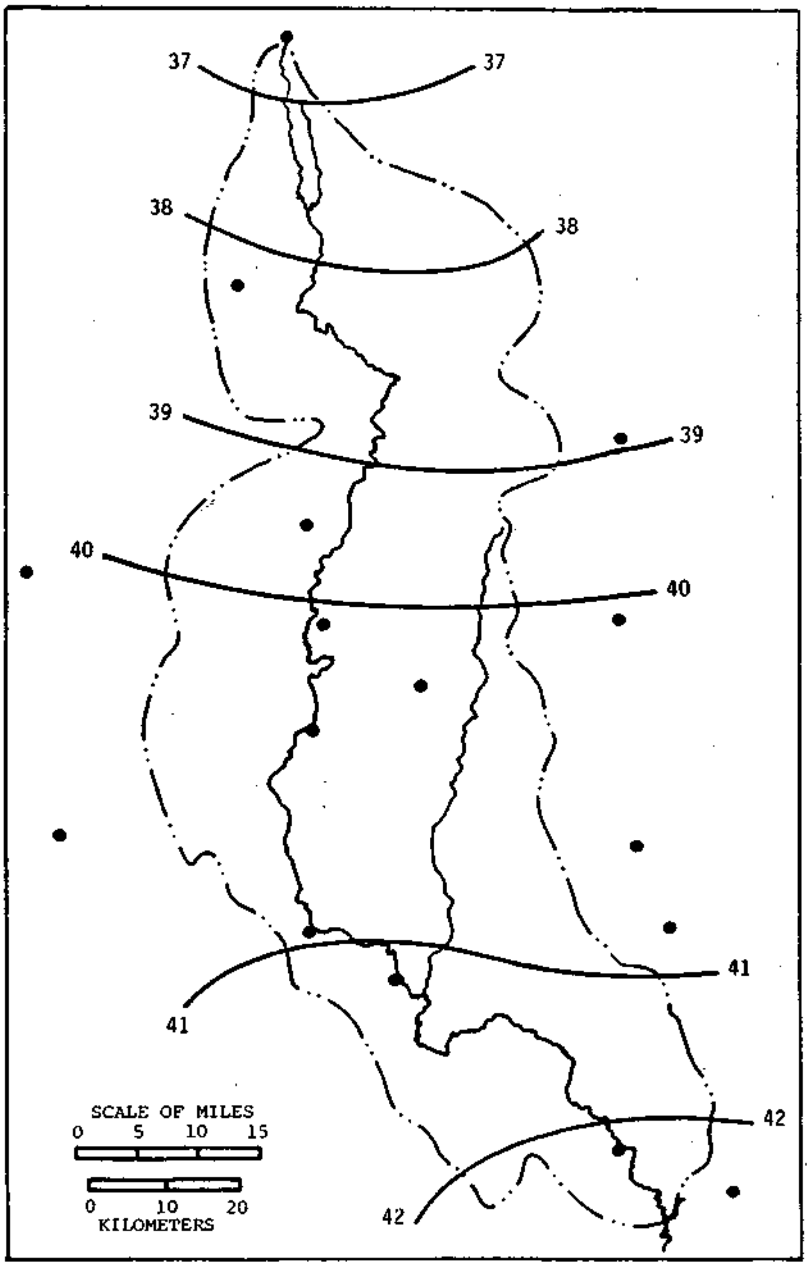



Figure F-2. Average annual precipitation, Embarras Basin

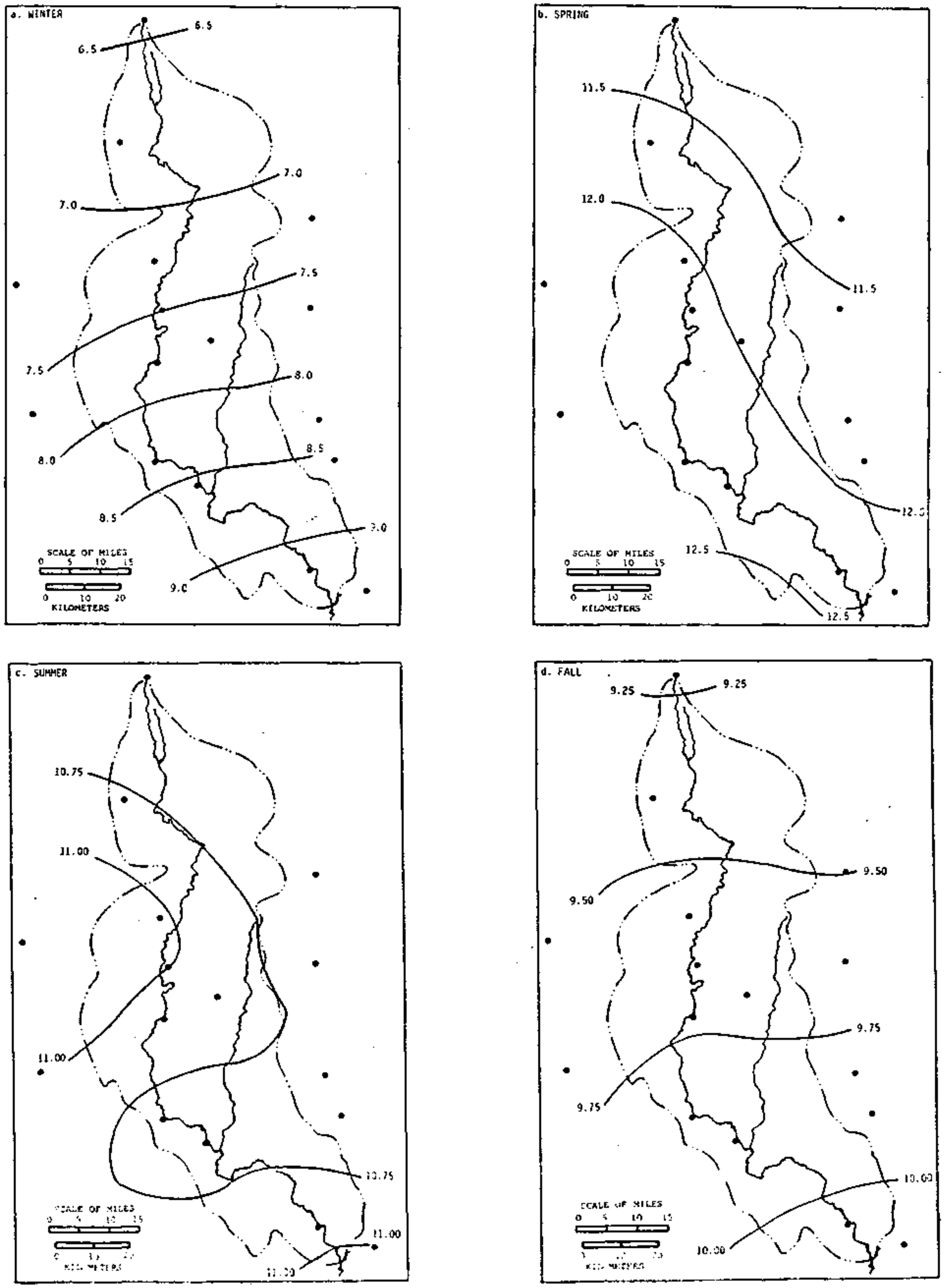



Figure F-3. Average seasonal precipitation, Embarras Basin

### Table F-1. Point Rainfall Frequency Relations on the Embarras Basin

| *Storm duration (hours)* | *Depth (inches) equaled or exceeded for given recurrence interval (years)* 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| 1 | 1.4 | 1.7 | 1.9 | 2.5 | 3.1 | 3.6 |
| 2 | 1.7 | 2.0 | 2.3 | 2.9 | 3.7 | 4.4 |
| 3 | 1.9 | 2.3 | 2.6 | 3.3 | 4.1 | 4.9 |
| 6 | 2.3 | 2.7 | 3.1 | 4.0 | 4.9 | 5.9 |
| 12 | 2.6 | 3.3 | 3.7 | 4.8 | 5.8 | 7.0 |
| 18 | 2.9 | 3.6 | 4.1 | 5.3 | 6.4 | 7.7 |
| 24 | 3.1 | 3.9 | 4.5 | 5.8 | 7.0 | 8.4 |
| 48 | 3.4 | 4.2 | 5.0 | 6.4 | 7.7 | 9.2 |

### Table F-2. Basin Mean Rainfall Frequency Relations

| *Recurrence interval (years)* | *Average rainfall depth (inches) equaled or exceeded for given storm period (hours)* 6 | 12 | 18 | 24 | 30 | 36 | 48 |
|---|---|---|---|---|---|---|---|
| *Upper Embarras* | | | | | | | |
| 1 | 0.8 | 0.9 | 1.0 | 1.0 | 1.1 | 1.2 | 1.3 |
| 2 | 1.4 | 1.8 | 2.0 | 2.1 | 2.2 | 2.3 | 2.4 |
| 5 | 2.0 | 2.4 | 2.7 | 2.8 | 2.9 | 3.0 | 3.3 |
| 10 | 2.4 | 2.9 | 3.2 | 3.3 | 3.5 | 3.6 | 3.9 |
| 15 | 2.6 | 3.2 | 3.5 | 3.7 | 3.8 | 3.9 | 4.2 |
| 20 | 2.8 | 3.4 | 3.7 | 3.9 | 4.1 | 4.2 | 4.5 |
| 25 | 2.9 | 3.6 | 3.9 | 4.1 | 4.3 | 4.5 | 4.6 |
| 30 | 3.0 | 3.7 | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 |
| 35 | 3.1 | 3.8 | 4.2 | 4.4 | 4.6 | 4.7 | 4.9 |
| 40 | 3.2 | 3.9 | 4.3 | 4.5 | 4.7 | 4.8 | 5.0 |
| 50 | 3.3 | 4.1 | 4.4 | 4.6 | 4.8 | 4.9 | 5.2 |
| 75 | 3.6 | 4.4 | 4.7 | 5.0 | 5.2 | 5.3 | 5.6 |
| 100 | 3.8 | 4.6 | 5.0 | 5.2 | 5.4 | 5.5 | 5.8 |
| *Lower Embarras* | | | | | | | |
| 1 | 0.7 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 |
| 2 | 1.5 | 1.8 | 1.9 | 2.1 | 2.2 | 2.3 | 2.4 |
| 5 | 2.1 | 2.6 | 2.8 | 3.0 | 3.1 | 3.2 | 3.4 |
| 10 | 2.5 | 3.1 | 3.4 | 3.6 | 3.8 | 3.9 | 4.1 |
| 15 | 2.7 | 3.4 | 3.7 | 4.0 | 4.2 | 4.3 | 4.5 |
| 20 | 2.9 | 3.6 | 4.0 | 4.2 | 4.5 | 4.6 | 4.8 |
| 25 | 3.0 | 3.8 | 4.2 | 4.4 | 4.7 | 4.8 | 5.0 |
| 30 | 3.1 | 3.9 | 4.3 | 4.6 | 4.9 | 5.0 | 5.2 |
| 35 | 3.2 | 4.0 | 4.4 | 4.7 | 5.0 | 5.2 | 5.3 |
| 40 | 3.3 | 4.1 | 4.5 | 4.8 | 5.1 | 5.3 | 5.4 |
| 50 | 3.4 | 4.3 | 4.7 | 5.0 | 5.3 | 5.5 | 5.6 |
| 75 | 3.6 | 4.5 | 5.0 | 5.3 | 5.7 | 5.8 | 6.0 |
| 100 | 3.7 | 4.7 | 5.2 | 5.5 | 6.0 | 6.1 | 6.3 |
| *Entire Embarras* | | | | | | | |
| 1 | 0.7 | 0.8 | 0.9 | 0.9 | 1.0 | 1.1 | 1.3 |
| 2 | 1.4 | 1.7 | 1.9 | 2.1 | 2.2 | 2.3 | 2.4 |
| 5 | 1.9 | 2.4 | 2.7 | 2.9 | 3.0 | 3.1 | 3.2 |
| 10 | 2.2 | 2.8 | 3.1 | 3.4 | 3.6 | 3.7 | 3.8 |
| 15 | 2.4 | 3.1 | 3.4 | 3.7 | 3.9 | 4.0 | 4.1 |
| 20 | 2.6 | 3.3 | 3.6 | 3.9 | 4.1 | 4.2 | 4.4 |
| 25 | 2.7 | 3.4 | 3.8 | 4.1 | 4.3 | 4.4 | 4.6 |
| 30 | 2.8 | 3.5 | 3.9 | 4.2 | 4.4 | 4.6 | 4.7 |
| 35 | 2.8 | 3.6 | 4.0 | 4.3 | 4.5 | 4.7 | 4.8 |
| 40 | 2.9 | 3.7 | 4.1 | 4.4 | 4.6 | 4.8 | 4.9 |
| 50 | 3.0 | 3.8 | 4.2 | 4.5 | 4.8 | 5.0 | 5.1 |
| 75 | 3.2 | 4.1 | 4.5 | 4.8 | 5.1 | 5.3 | 5.4 |
| 100 | 3.4 | 4.3 | 4.7 | 5.0 | 5.3 | 5.5 | 5.7 |

### Table F-3. Frequency Distribution of Areal Mean Rainfall for Specific Integral Areas on the Embarras Basin

| *Recurrence interval (years)* | *Average depth (inches) equaled or exceeded for given area (square miles)* 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *1-Hour storm period* | | | | | | |
| 2 | 1.3 | 1.2 | 1.1 | 1.0 | 0.9 | 0.9 |
| 5 | 1.6 | 1.5 | 1.4 | 1.2 | 1.1 | 1.1 |
| 10 | 1.8 | 1.7 | 1.5 | 1.4 | 1.3 | 1.2 |
| 25 | 2.3 | 2.2 | 2.0 | 1.8 | 1.7 | 1.6 |
| 50 | 2.9 | 2.7 | 2.5 | 2.3 | 2.1 | 2.0 |
| 100 | 3.3 | 3.1 | 2.9 | 2.6 | 2.4 | 2.3 |
| *2-Hour storm period* | | | | | | |
| 2 | 1.6 | 1.6 | 1.5 | 1.4 | 1.3 | 1.2 |
| 5 | 1.9 | 1.9 | 1.7 | 1.6 | 1.5 | 1.4 |
| 10 | 2.2 | 2.1 | 2.0 | 1.8 | 1.7 | 1.6 |
| 25 | 2.8 | 2.7 | 2.5 | 2.3 | 2.1 | 2.1 |
| 50 | 3.5 | 3.4 | 3.2 | 3.0 | 2.7 | 2.6 |
| 100 | 4.2 | 4.1 | 3.8 | 3.5 | 3.3 | 3.1 |
| *3-Hour storm period* | | | | | | |
| 2 | 1.8 | 1.8 | 1.7 | 1.6 | 1.5 | 1.5 |
| 5 | 2.2 | 2.2 | 2.1 | 2.0 | 1.8 | 1.8 |
| 10 | 2.5 | 2.5 | 2.3 | 2.2 | 2.1 | 2.0 |
| 25 | 3.2 | 3.1 | 3.0 | 2.8 | 2.6 | 2.6 |
| 50 | 4.0 | 3.9 | 3.7 | 3.5 | 3.3 | 3.2 |
| 100 | 4.8 | 4.7 | 4.4 | 4.2 | 3.9 | 3.8 |
| *6-Hour storm period* | | | | | | |
| 2 | 2.2 | 2.2 | 2.1 | 2.0 | 2.0 | 1.9 |
| 5 | 2.6 | 2.6 | 2.5 | 2.4 | 2.3 | 2.2 |
| 10 | 3.0 | 3.0 | 2.9 | 2.8 | 2.6 | 2.5 |
| 25 | 3.9 | 3.8 | 3.7 | 3.6 | 3.4 | 3.3 |
| 50 | 4.8 | 4.7 | 4.5 | 4.4 | 4.2 | 4.0 |
| 100 | 5.7 | 5.7 | 5.4 | 5.3 | 5.0 | 4.8 |
| *12-Hour storm period* | | | | | | |
| 2 | 2.5 | 2.5 | 2.4 | 2.4 | 2.3 | 2.3 |
| 5 | 3.2 | 3.2 | 3.1 | 3.0 | 2.9 | 2.9 |
| 10 | 3.6 | 3.6 | 3.5 | 3.4 | 3.3 | 3.2 |
| 25 | 4.7 | 4.7 | 4.5 | 4.4 | 4.3 | 4.2 |
| 50 | 5.7 | 5.6 | 5.5 | 5.3 | 5.2 | 5.0 |
| 100 | 6.9 | 6.8 | 6.6 | 6.4 | 6.2 | 6.1 |
| *18-Hour storm period* | | | | | | |
| 2 | 2.8 | 2.8 | 2.7 | 2.7 | 2.6 | 2.6 |
| 5 | 3.5 | 3.5 | 3.4 | 3.3 | 3.3 | 3.2 |
| 10 | 4.0 | 4.0 | 3.9 | 3.8 | 3.7 | 3.6 |
| 25 | 5.2 | 5.1 | 5.0 | 4.9 | 4.8 | 4.7 |
| 50 | 6.3 | 6.2 | 6.0 | 5.9 | 5.8 | 5.7 |
| 100 | 7.5 | 7.5 | 7.2 | 7.1 | 7.0 | 6.9 |
| *24-Hour storm period* | | | | | | |
| 2 | 3.0 | 3.0 | 2.9 | 2.9 | 2.9 | 2.8 |
| 5 | 3.8 | 3.8 | 3.7 | 3.6 | 3.6 | 3.5 |
| 10 | 4.4 | 4.4 | 4.3 | 4.2 | 4.1 | 4.1 |
| 25 | 5.7 | 5.7 | 5.5 | 5.4 | 5.3 | 5.3 |
| 50 | 6.9 | 6.9 | 6.6 | 6.5 | 6.4 | 6.4 |
| 100 | 8.2 | 8.2 | 8.0 | 7.8 | 7.7 | 7.6 |
| *48-Hour storm period* | | | | | | |
| 2 | 3.4 | 3.4 | 3.3 | 3.2 | 3.2 | 3.2 |
| 5 | 4.2 | 4.2 | 4.0 | 3.9 | 3.9 | 3.9 |
| 10 | 5.0 | 5.0 | 4.8 | 4.7 | 4.6 | 4.6 |
| 25 | 6.3 | 6.3 | 6.1 | 6.0 | 6.0 | 6.0 |
| 50 | 7.6 | 7.6 | 7.4 | 7.2 | 7.2 | 7.2 |
| 100 | 9.1 | 9.1 | 8.8 | 8.6 | 8.6 | 8.6 |

Table F-4. Frequency Distribution of Areal Maximum Rainfall on Embarras Basin

| Recurrence interval (years) | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| *6-Hour storms* | | | | | | |
| 2 | 2.7 | 2.7 | 2.6 | 2.3 | 2.1 | 1.8 |
| 5 | 4.0 | 3.9 | 3.6 | 3.5 | 3.2 | 2.7 |
| 10 | 4.9 | 4.7 | 4.4 | 4.2 | 3.7 | 3.2 |
| 25 | 6.0 | 5.8 | 5.3 | 5.1 | 4.3 | 3.7 |
| 50 | 6.8 | 6.5 | 6.0 | 5.6 | 4.8 | 4.0 |
| 100 | 7.5 | 7.3 | 6.7 | 6.2 | 5.2 | 4.4 |
| *12-Hour storms* | | | | | | |
| 2 | 3.2 | 3.2 | 3.1 | 2.8 | 2.6 | 2.3 |
| 5 | 4.8 | 4.7 | 4.4 | 4.2 | 3.8 | 3.3 |
| 10 | 5.9 | 5.7 | 5.3 | 5.1 | 4.5 | 4.0 |
| 25 | 7.3 | 6.9 | 6.4 | 6.1 | 5.3 | 4.6 |
| 50 | 8.2 | 7.8 | 7.2 | 6.8 | 5.9 | 5.0 |
| 100 | 9.0 | 8.7 | 8.0 | 7.5 | 6.4 | 5.5 |
| *18-Hour storms* | | | | | | |
| 2 | 3.5 | 3.5 | 3.4 | 3.0 | 2.9 | 2.5 |
| 5 | 5.3 | 5.1 | 4.8 | 4.6 | 4.2 | 3.7 |
| 10 | 6.5 | 6.2 | 5.9 | 5.5 | 5.0 | 4.3 |
| 25 | 7.9 | 7.6 | 7.1 | 6.6 | 5.8 | 5.0 |
| 50 | 8.9 | 8.5 | 8.0 | 7.4 | 6.4 | 5.5 |
| 100 | 9.9 | 9.5 | 8.8 | 8.1 | 7.0 | 6.0 |
| *24-Hour storms* | | | | | | |
| 2 | 3.7 | 3.7 | 3.6 | 3.2 | 3.0 | 2.7 |
| 5 | 5.6 | 5.4 | 5.1 | 5.0 | 4.4 | 3.9 |
| 10 | 6.8 | 6.6 | 6.2 | 5.9 | 5.3 | 4.6 |
| 25 | 8.4 | 8.0 | 7.5 | 7.1 | 6.1 | 5.3 |
| 50 | 9.4 | 9.0 | 8.5 | 7.9 | 6.8 | 5.9 |
| 100 | 10.4 | 10.1 | 9.4 | 8.7 | 7.4 | 6.4 |
| *30-Hour storms* | | | | | | |
| 2 | 3.9 | 3.9 | 3.8 | 3.4 | 3.2 | 2.8 |
| 5 | 5.8 | 5.6 | 5.4 | 5.2 | 4.7 | 4.1 |
| 10 | 7.1 | 6.9 | 6.5 | 6.2 | 5.5 | 4.9 |
| 25 | 8.7 | 8.4 | 7.8 | 7.4 | 6.5 | 5.6 |
| 50 | 9.9 | 9.4 | 8.8 | 8.3 | 7.1 | 6.2 |
| 100 | 10.9 | 10.5 | 9.8 | 9.1 | 7.8 | 6.8 |
| *36-Hour storms* | | | | | | |
| 2 | 4.0 | 4.0 | 3.9 | 3.5 | 3.3 | 2.9 |
| 5 | 6.0 | 5.8 | 5.5 | 5.3 | 4.8 | 4.2 |
| 10 | 7.4 | 7.1 | 6.7 | 6.4 | 5.7 | 5.0 |
| 25 | 9.0 | 8.6 | 8.1 | 7.7 | 6.6 | 5.8 |
| 50 | 10.2 | 9.7 | 9.1 | 8.5 | 7.3 | 6.3 |
| 100 | 11.3 | 10.9 | 10.1 | 9.4 | 8.0 | 6.9 |
| *48-Hour storms* | | | | | | |
| 2 | 4.1 | 4.1 | 4.0 | 3.6 | 3.4 | 3.0 |
| 5 | 6.2 | 6.0 | 5.7 | 5.5 | 5.0 | 4.4 |
| 10 | 7.6 | 7.3 | 6.9 | 6.6 | 5.9 | 5.2 |
| 25 | 9.3 | 8.9 | 8.3 | 7.9 | 6.9 | 6.0 |
| 50 | 10.5 | 10.0 | 9.4 | 8.8 | 7.6 | 6.6 |
| 100 | 11.6 | 11.2 | 10.4 | 9.7 | 8.3 | 7.2 |

Table F-5. Average Slope of Area-Depth Curves on Embarras River Basin

| Incremental areas (square miles) | Ratio of mean rainfall on incremental areas to basin mean rainfall for given storm duration (hours) 6 | 12 | 18 | 24 | 36 | 48 |
|---|---|---|---|---|---|---|
| *Upper Embarras* | | | | | | |
| 25 | 1.79 | 1.71 | 1.71 | 1.69 | 1.69 | 1.67 |
| 50 | 1.69 | 1.62 | 1.61 | 1.60 | 1.59 | 1.58 |
| 100 | 1.56 | 1.53 | 1.53 | 1.51 | 1.51 | 1.49 |
| 200 | 1.46 | 1.41 | 1.41 | 1.41 | 1.41 | 1.39 |
| 500 | 1.26 | 1.25 | 1.24 | 1.23 | 1.23 | 1.23 |
| 1000 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| 1125 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Lower Embarras* | | | | | | |
| 25 | 1.80 | 1.72 | 1.71 | 1.68 | 1.69 | 1.67 |
| 50 | 1.72 | 1.64 | 1.61 | 1.60 | 1.59 | 1.58 |
| 100 | 1.60 | 1.55 | 1.54 | 1.52 | 1.52 | 1.50 |
| 200 | 1.50 | 1.45 | 1.44 | 1.43 | 1.43 | 1.41 |
| 500 | 1.33 | 1.31 | 1.29 | 1.27 | 1.27 | 1.27 |
| 1000 | 1.12 | 1.12 | 1.10 | 1.10 | 1.10 | 1.10 |
| 1315 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Entire Embarras* | | | | | | |
| 25 | 2.21 | 2.07 | 2.01 | 1.99 | 1.96 | 1.94 |
| 50 | 2.14 | 2.01 | 1.95 | 1.92 | 1.90 | 1.88 |
| 100 | 2.02 | 1.90 | 1.87 | 1.84 | 1.82 | 1.80 |
| 200 | 1.89 | 1.78 | 1.73 | 1.73 | 1.71 | 1.69 |
| 500 | 1.68 | 1.60 | 1.56 | 1.53 | 1.52 | 1.52 |
| 1000 | 1.44 | 1.40 | 1.35 | 1.35 | 1.34 | 1.34 |
| 1500 | 1.28 | 1.25 | 1.21 | 1.20 | 1.21 | 1.21 |
| 2000 | 1.12 | 1.12 | 1.11 | 1.11 | 1.11 | 1.11 |
| 2440 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table F-6. Average Area-Depth Relations in a 12-Hour, 25-Year Storm on the Embarras Basin

| Area (square miles) | Average rainfall (inches) Upper | Lower | Entire |
|---|---|---|---|
| 25 | 6.2 | 6.5 | 7.0 |
| 50 | 5.8 | 6.2 | 6.8 |
| 100 | 5.5 | 5.9 | 6.5 |
| 200 | 5.1 | 5.5 | 6.1 |
| 500 | 4.5 | 5.0 | 5.4 |
| 1000 | 3.8 | 4.3 | 4.8 |
| 1125 | 3.6 | 4.1 | 4.7 |
| 1315 | | 3.8 | 4.5 |
| 1500 | | | 4.3 |
| 2000 | | | 3.8 |
| 2440 | | | 3.4 |

Table F-7. Unmodified Area-Depth Relations for Entire Embarras Basin

| Date | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 2000 | 2440 |
|---|---|---|---|---|---|---|---|---|---|
| 3/25-26/04 | 6.73 | 6.65 | 6.52 | 6.30 | 5.81 | 5.15 | 4.64 | 4.20 | 3.87 |
| 3/24-25/13 | 5.96 | 5.93 | 5.87 | 5.77 | 5.36 | 4.69 | 4.17 | 3.76 | 3.45 |
| 8/20-21/15 | 4.87 | 4.65 | 4.41 | 4.15 | 3.70 | 3.26 | 2.90 | 2.57 | 2.26 |
| 10/26-27/19 | 5.98 | 5.93 | 5.86 | 5.78 | 5.62 | 5.32 | 4.97 | 4.58 | 4.06 |
| 9/8-9/26 | 8.98 | 8.70 | 8.35 | 7.93 | 7.11 | 6.10 | 5.25 | 4.49 | 4.86 |
| 5/2-3/35 | 4.99 | 4.86 | 4.72 | 4.55 | 4.28 | 3.99 | 3.76 | 3.57 | 3.41 |
| 11/2-3/36 | 4.56 | 4.53 | 4.49 | 4.44 | 4.28 | 4.10 | 3.89 | 3.68 | 3.46 |
| 1/3-4/50 | 6.36 | 6.28 | 6.18 | 6.03 | 5.68 | 5.24 | 4.87 | 4.55 | 4.29 |
| 8/31-9/1/50 | 6.19 | 5.92 | 5.62 | 5.29 | 4.81 | 4.34 | 3.96 | 3.60 | 3.25 |
| 8/28-29/51 | 6.28 | 6.07 | 5.83 | 5.53 | 5.01 | 4.43 | 3.96 | 3.54 | 3.19 |

Table F-8. Monthly Distribution of 48-Hour Heavy Rainstorms

| Month | Number | Month | Number |
|---|---|---|---|
| January | 1 | July | 1 |
| February | 1 | August | 3 |
| March | 5 | September | 1 |
| April | 2 | October | 5 |
| May | 5 | November | 3 |
| June | 1 | December | 3 |

Table F-9. Seasonal Distribution of 48-Hour Heavy Rainstorms

| 3-Month period | Number | 3-Month period | Number |
|---|---|---|---|
| Jan-Mar | 7 | Jul-Sep | 5 |
| Feb-Apr | 8 | Aug-Oct | 9 |
| Mar-May | 12 | Sep-Nov | 9 |
| Apr-Jun | 8 | Oct-Dec | 11 |
| May-Jul | 7 | Nov-Jan | 7 |
| Jun-Aug | 5 | Dec-Feb | 5 |

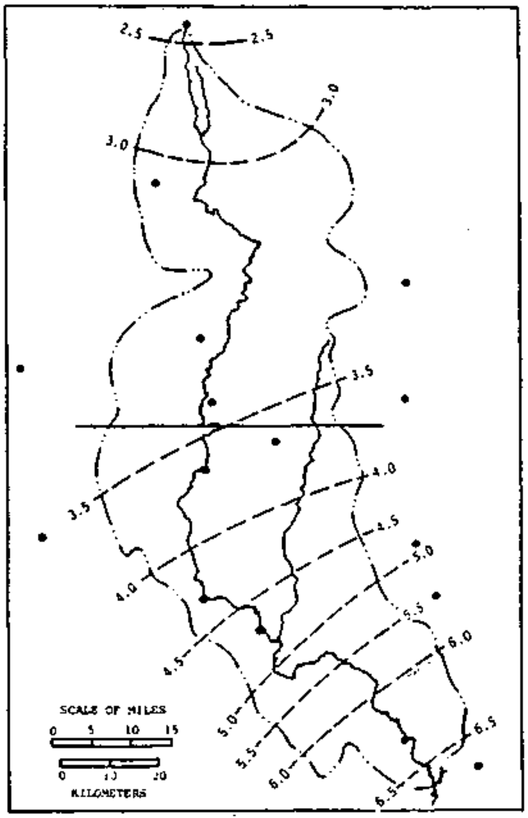



Figure F-4. Storm of March 25-26, 1904

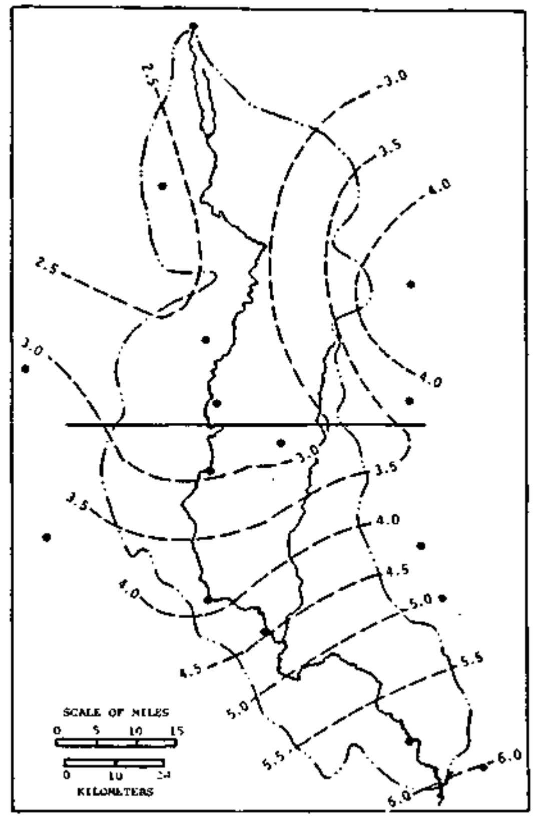



Figure F-5. Storm of March 24-25, 1913

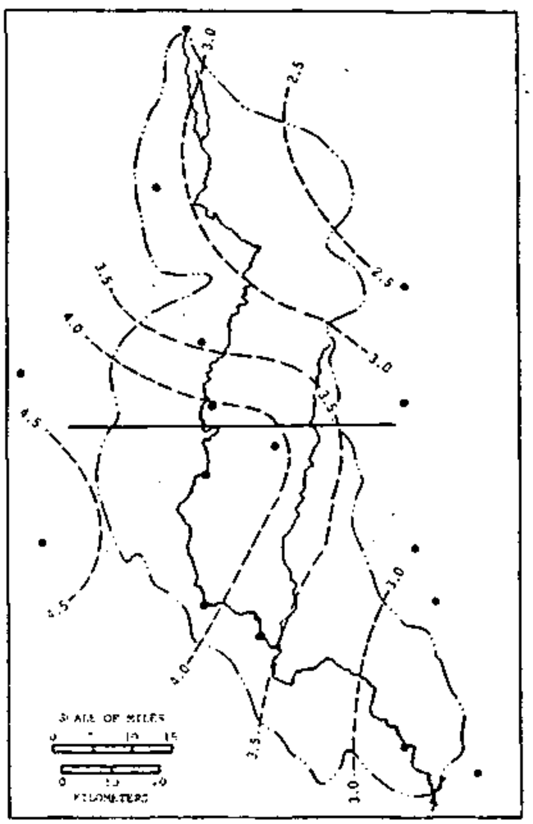



Figure F-6. Storm of August 20-21, 1915

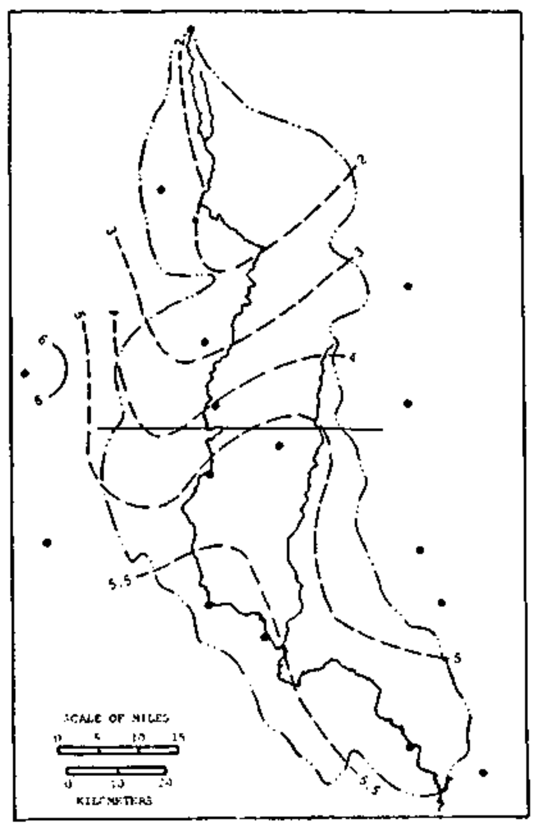



Figure F-7. Storm of October 26-27, 1919

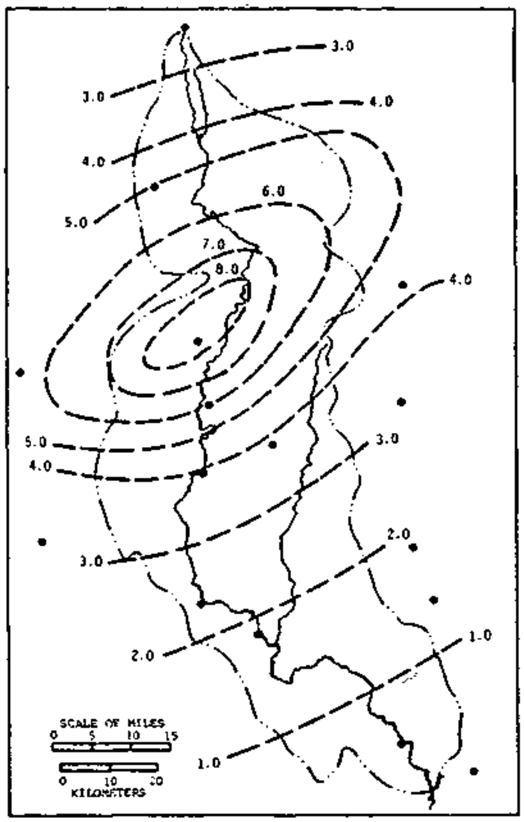


Figure F-8. Storm of September 8-9, 1926

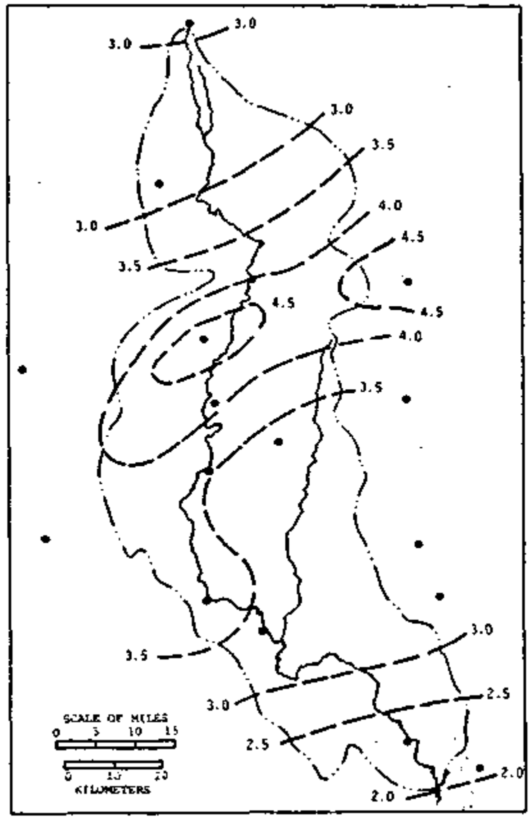


Figure F-9. Storm of May 2-3, 1935

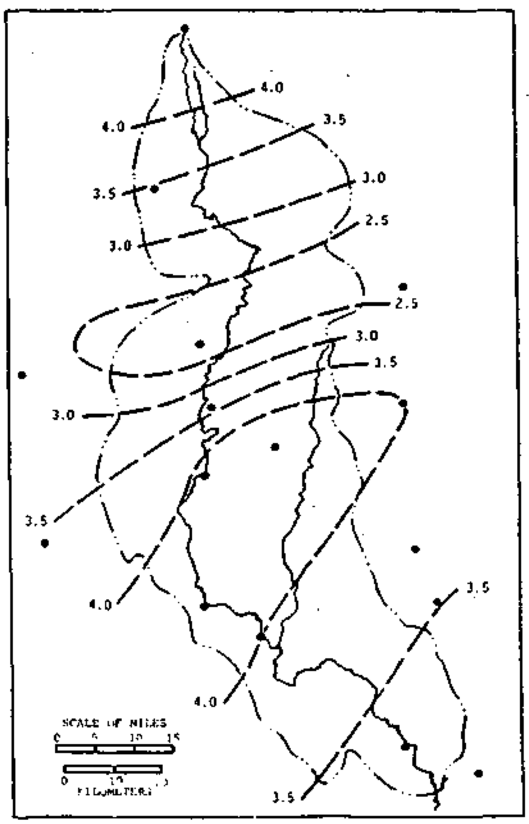


Figure F-10. Storm of November 2-3, 1936

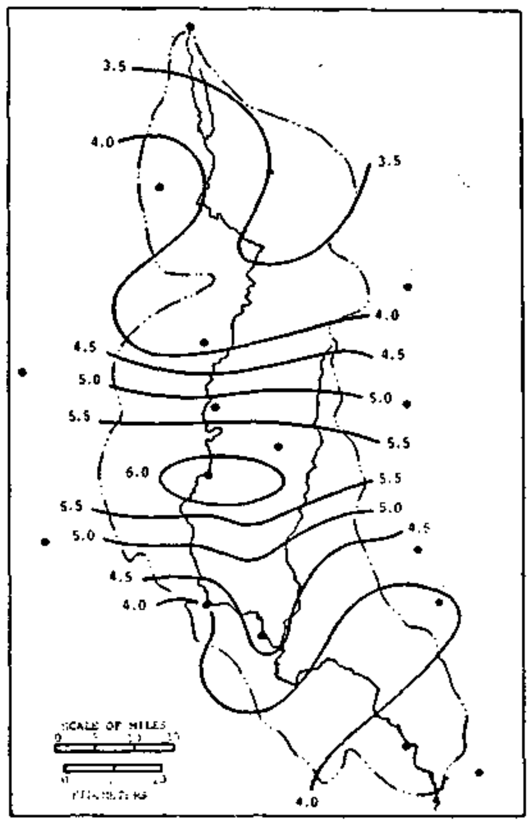


Figure F-11. Storm of January 3-4, 1950

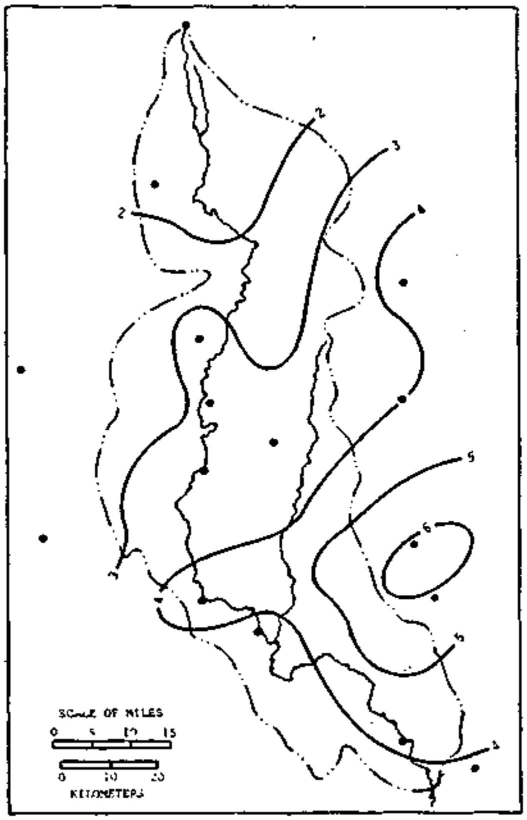



Figure F-12. Storm of August 31. 1950

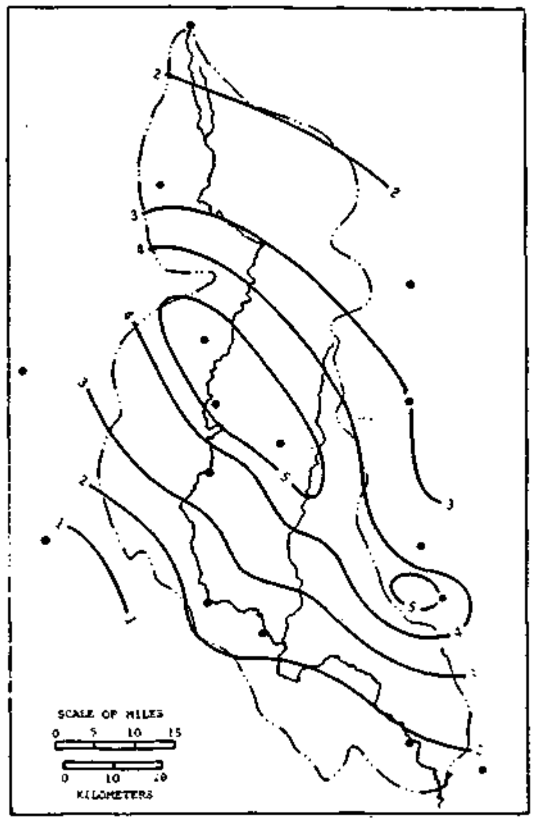



Figure F-13. Storm of August 28-29, 1951

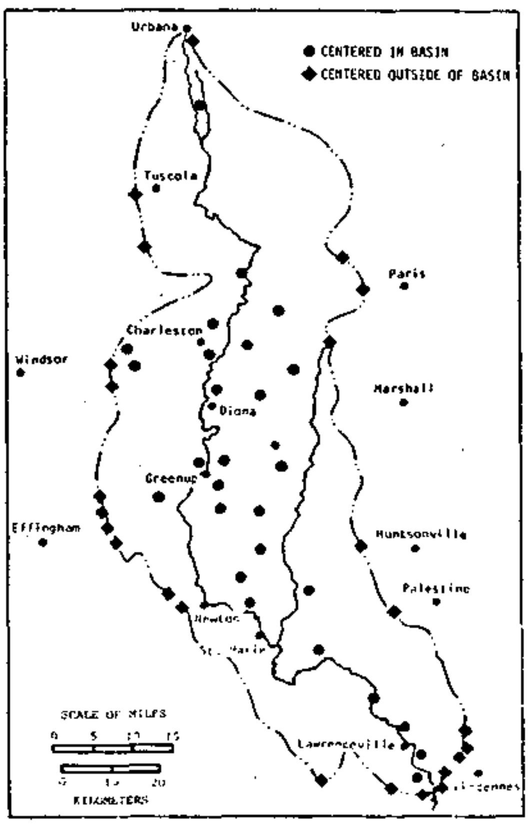



Figure F-14. Location of storm centers in 50 heaviest storms

# Part G. The Spoon River Basin

The Spoon River Basin has an area of 1855 square miles. The river discharges into the Illinois River at Havana in west central Illinois. The major axis of the basin is oriented NNE-SSW. The basin shape is elongated with an approximate ratio of 3:1 between length and width (figure G-l).

### Basin Climate

There is only a slight variation in annual mean temperature and precipitation in the basin. Mean annual temperature ranges only from approximtely 50.5°F in the north to 51.0°F in the south. Mean precipitation (figure G-2) varies from slightly under 34 inches to slightly over 35 inches.

Seasonally, the range in temperature and precipitation is small also. Figure G-3 shows the average precipitation patterns for winter, spring, summer, and fall. None shows differences exceeding 1 inch across the basin. Similarly, monthly mean temperatures do not vary much throughout the basin. In the coldest month, January, the mean ranges from about 23°F in the north to 24°F in the south. During July, the warmest month, the mean varies from approximately 74.5°F to 75.5°F.

The average annual frequency of thunderstorms varies from 47 to 49 within the basin (Changnon, 1957). On the average, the point frequency of hail is 2 days per year. Compared with the rest of the state, the tornado frequency is relatively low.

### Storm Precipitation Characteristics

Tables G-l to G-9 and figure G-l to G-14 provide a statistical description of heavy rainfall properties in the Spoon River Basin. The severe rainstorms tend to be concentrated more in summer in this basin than in the more southerly basins. Thus, approximately 40 percent of the storms producing a basin mean rainfall equaling or exceeding the 2-year recurrence value occur in summer in the Spoon River Basin compared with 26 percent in the Big Muddy Basin, the most southerly of the six basins studied. Conversely, heavy storms are very infrequent in the winter in the Spoon River area. Whereas 20 percent of the heaviest 48-hour storms have occurred in the winter in the Big Muddy, only 6 percent have been recorded in the Spoon River Basin where snowfall is the most frequent type of winter precipitation.

**Table G-1. Point Rainfall Frequency Relations on Spoon River Basin**

| Storm duration (hours) | Depth (inches) equaled or exceeded for given recurrence interval (years) | | | | | |
|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 25 | 50 | 100 |
| 1 | 1.4 | 1.7 | 1.9 | 2.4 | 2.9 | 3.4 |
| 2 | 1.6 | 1.9 | 2.2 | 2.8 | 3.4 | 4.0 |
| 3 | 1.7 | 2.1 | 2.5 | 3.2 | 3.7 | 4.4 |
| 6 | 2.0 | 2.6 | 3.0 | 3.7 | 4.4 | 5.2 |
| 12 | 2.3 | 3.0 | 3.6 | 4.5 | 5.3 | 6.2 |
| 18 | 2.6 | 3.3 | 3.8 | 4.9 | 5.9 | 6.9 |
| 24 | 2.8 | 3.6 | 4.2 | 5.3 | 6.4 | 7.5 |
| 48 | 3.0 | 4.0 | 4.7 | 5.9 | 7.0 | 8.4 |

**Table G-2. Basin Mean Rainfall Frequency Relations on Spoon River Basin**

| Recurrence interval (years) | Average rainfall depth (inches) equaled or exceeded for given storm period (hours) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 6 | 12 | 18 | 24 | 30 | 36 | 48 |
| 1 | 0.9 | 1.2 | 1.3 | 1.4 | 1.5 | 1.5 | 1.6 |
| 2 | 1.5 | 1.8 | 2.0 | 2.2 | 2.3 | 2.4 | 2.5 |
| 5 | 2.1 | 2.6 | 2.9 | 3.1 | 3.3 | 3.4 | 3.5 |
| 10 | 2.4 | 3.0 | 3.4 | 3.6 | 3.8 | 3.9 | 4.1 |
| 15 | 2.5 | 3.2 | 3.5 | 3.8 | 4.0 | 4.1 | 4.3 |
| 20 | 2.7 | 3.3 | 3.7 | 4.0 | 4.2 | 4.3 | 4.5 |
| 25 | 2.7 | 3.4 | 3.8 | 4.0 | 4.3 | 4.4 | 4.6 |
| 30 | 2.8 | 3.5 | 3.9 | 4.1 | 4.4 | 4.5 | 4.7 |
| 40 | 2.8 | 3.6 | 3.9 | 4.2 | 4.5 | 4.6 | 4.8 |
| 50 | 3.0 | 3.7 | 4.1 | 4.4 | 4.6 | 4.8 | 5.0 |
| 75 | 3.1 | 3.8 | 4.3 | 4.6 | 4.8 | 5.0 | 5.2 |
| 100 | 3.2 | 4.1 | 4.5 | 4.8 | 5.1 | 5.3 | 5.5 |

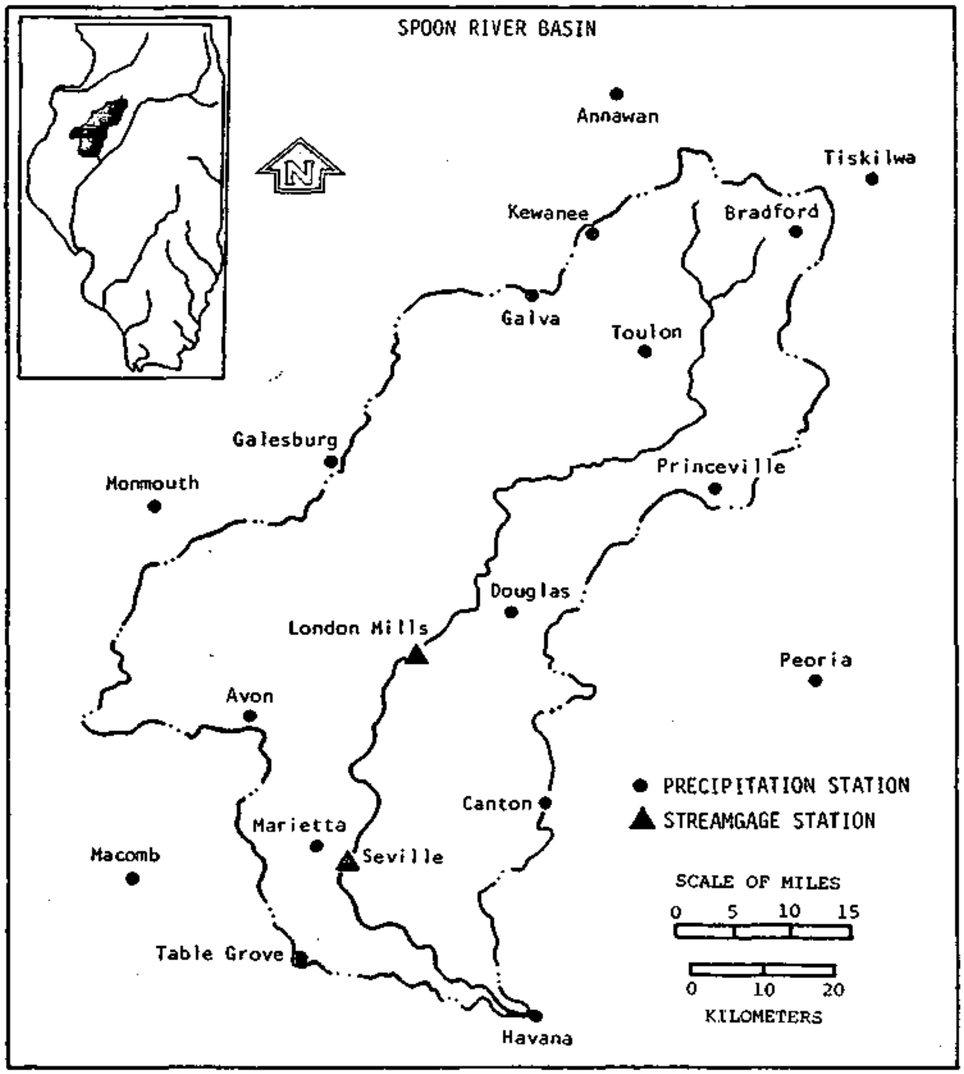



Figure G-1. Location map, Spoon River Basin,

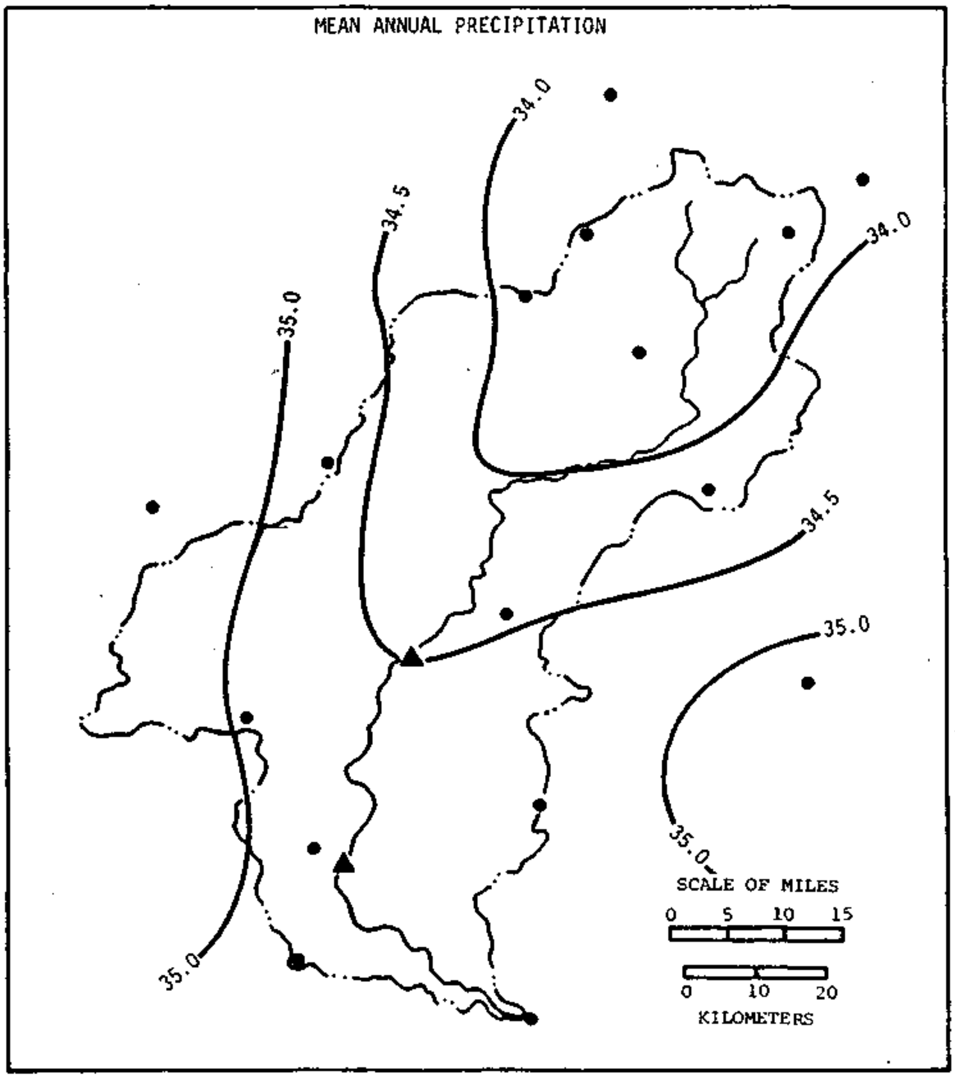



Figure G-2. Average annual precipitation, Spoon River Basin

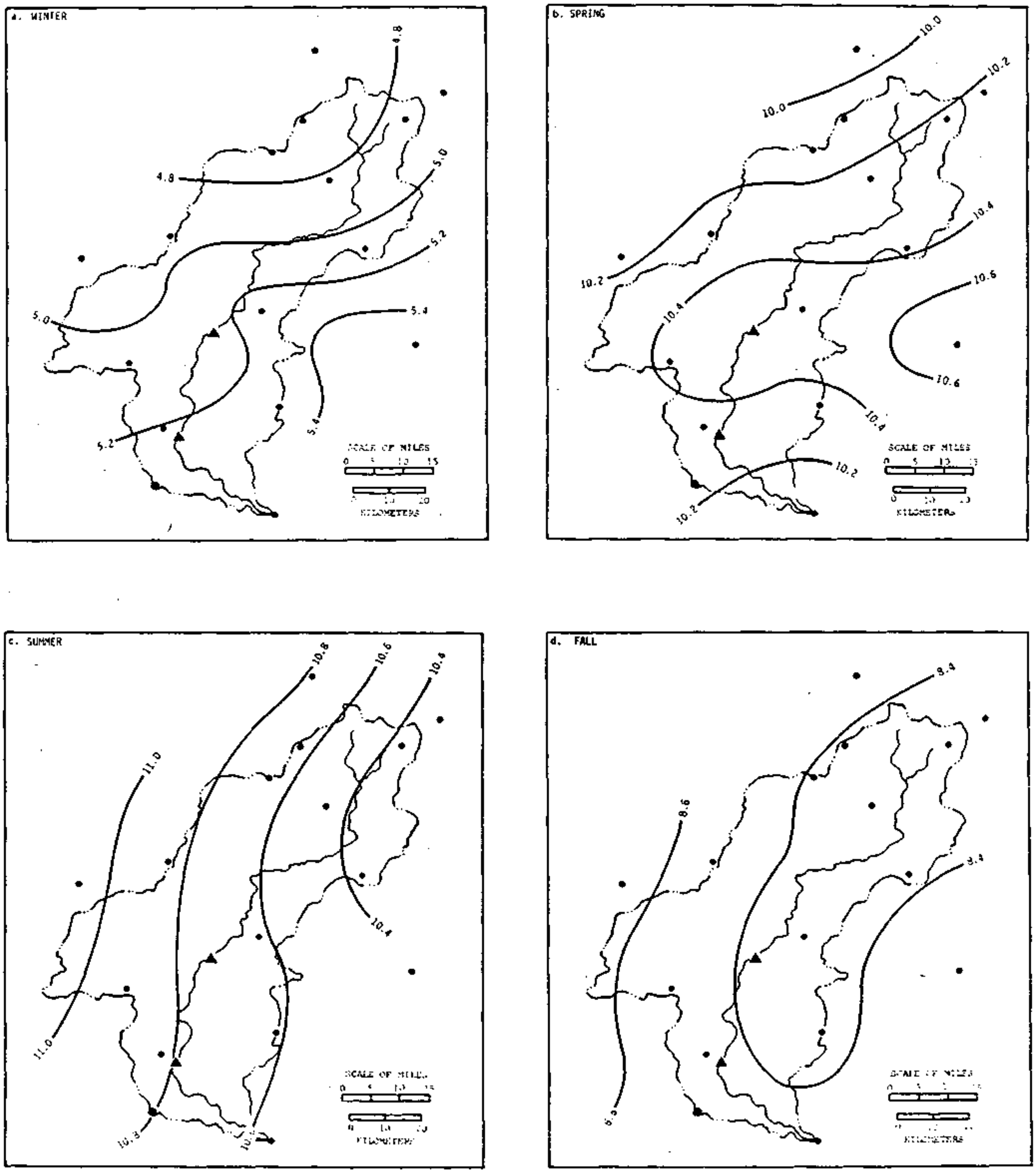



Figure G-3. Average seasonal precipitation, Spoon River Basin

Table G-3. Frequency Distribution of Areal Mean Rainfall for Specific Integral Areas on the Spoon River Basin

| *Recurrence interval (years)* | *Average depth (inches) equaled or exceeded for given area (square miles)* 10 | 25 | 50 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|
| *1-Hour storm period* | | | | | | |
| 2 | 1.3 | 1.2 | 1.1 | 1.0 | 0.9 | 0.9 |
| 5 | 1.6 | 1.5 | 1.4 | 1.2 | 1.1 | 1.1 |
| 10 | 1.8 | 1.7 | 1.5 | 1.4 | 1.3 | 1.2 |
| 25 | 2.2 | 2.1 | 1.9 | 1.8 | 1.6 | 1.5 |
| 50 | 2.7 | 2.5 | 2.3 | 2.1 | 1.9 | 1.9 |
| 100 | 3.2 | 3.0 | 2.7 | 2.5 | 2.3 | 2.2 |
| *2-Hour storm period* | | | | | | |
| 2 | 1.5 | 1.5 | 1.4 | 1.3 | 1.2 | 1.1 |
| 5 | 1.8 | 1.8 | 1.6 | 1.5 | 1.4 | 1.3 |
| 10 | 2.1 | 2.0 | 1.9 | 1.8 | 1.6 | 1.6 |
| 25 | 2.7 | 2.6 | 2.4 | 2.2 | 2.1 | 2.0 |
| 50 | 3.2 | 3.2 | 2.9 | 2.7 | 2.5 | 2.4 |
| 100 | 3.8 | 3.7 | 3.4 | 3.2 | 3.0 | 2.8 |
| *3-Hour storm period* | | | | | | |
| 2 | 1.6 | 1.6 | 1.5 | 1.4 | 1.4 | 1.3 |
| 5 | 2.0 | 2.0 | 1.9 | 1.8 | 1.7 | 1.6 |
| 10 | 2.4 | 2.4 | 2.2 | 2.1 | 2.0 | 2.0 |
| 25 | 3.1 | 3.0 | 2.9 | 2.7 | 2.6 | 2.5 |
| 50 | 3.6 | 3.5 | 3.3 | 3.1 | 3.0 | 2.9 |
| 100 | 4.3 | 4.2 | 4.0 | 3.7 | 3.5 | 3.4 |
| *6-Hour storm period* | | | | | | |
| 2 | 1.9 | 1.9 | 1.8 | 1.8 | 1.7 | 1.6 |
| 1.5 | 2.5 | 2.5 | 2.4 | 2.3 | 2.2 | 2.1 |
| 10 | 2.9 | 2.9 | 2.8 | 2.7 | 2.6 | 2.5 |
| 25 | 3.6 | 3.6 | 3.4 | 3.3 | 3.1 | 3.0 |
| 50 | 4.3 | 4.2 | 4.0 | 3.9 | 3.7 | 3.6 |
| 100 | 5.0 | 5.0 | 4.8 | 4.6 | 4.4 | 4.3 |
| *12-Hour storm period* | | | | | | |
| 2 | 2.3 | 2.2 | 2.2 | 2.1 | 2.0 | 2.0 |
| 5 | 2.9 | 2.9 | 2.8 | 2.7 | 2.7 | 2.6 |
| 10 | 3.5 | 3.5 | 3.4 | 3.3 | 3.2 | 3.1 |
| 25 | 4.4 | 4.4 | 4.2 | 4.1 | 4.0 | 3.9 |
| 50 | 5.2 | 5.1 | 5.0 | 4.8 | 4.7 | 4.6 |
| 100 | 6.1 | 6.0 | 5.8 | 5.6 | 5.5 | 5.4 |
| *18-Hour storm period* | | | | | | |
| 2 | 2.5 | 2.5 | 2.4 | 2.4 | 2.4 | 2.3 |
| 5 | 3.2 | 3.2 | 3.1 | 3.0 | 3.0 | 2.9 |
| 10 | 3.7 | 3.7 | 3.6 | 3.5 | 3.5 | 3.4 |
| 25 | 4.8 | 4.8 | 4.6 | 4.5 | 4.5 | 4.4 |
| 50 | 5.8 | 5.7 | 5.5 | 5.4 | 5.4 | 5.3 |
| 100 | 6.8 | 6.7 | 6.5 | 6.3 | 6.3 | 6.1 |
| *24-Hour storm period* | | | | | | |
| 2 | 2.7 | 2.7 | 2.7 | 2.6 | 2.6 | 2.5 |
| 5 | 3.5 | 3.5 | 3.4 | 3.3 | 3.3 | 3.3 |
| 10 | 4.1 | 4.1 | 4.0 | 3.9 | 3.9 | 3.8 |
| 25 | 5.2 | 5.2 | 5.0 | 4.9 | 4.9 | 4.8 |
| 50 | 6.3 | 6.3 | 6.1 | 6.0 | 5.9 | 5.8 |
| 100 | 7.4 | 7.4 | 7.1 | 7.0 | 6.9 | 6.8 |
| *48-Hour storm period* | | | | | | |
| 2 | 3.0 | 3.0 | 2.9 | 2.8 | 2.8 | 2.8 |
| 5 | 4.0 | 4.0 | 3.8 | 3.8 | 3.7 | 3.7 |
| 10 | 4.7 | 4.7 | 4.5 | 4.4 | 4.4 | 4.4 |
| 25 | 5.8 | 5.8 | 5.7 | 5.5 | 5.5 | 5.5 |
| 50 | 6.9 | 6.9 | 6.7 | 6.6 | 6.5 | 6.5 |
| 100 | 8.3 | 8.3 | 8.1 | 7.9 | 7.8 | 7.8 |

Table G-4. Frequency Distribution of Areal Maximum Rainfall on Spoon River Basin

| *Recurrence interval (years)* | *Average depth (inches) for given area (square miles)* 25 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| *6-Hour storms* | | | | | | |
| 2 | 3.4 | 3.2 | 3.0 | 2.8 | 2.3 | 1.9 |
| 5 | 4.6 | 4.3 | 4.0 | 3.6 | 3.1 | 2.6 |
| 10 | 5.5 | 5.1 | 4.8 | 4.4 | 3.7 | 3.1 |
| 25 | 6.6 | 6.2 | 5.9 | 5.3 | 4.5 | 3.5 |
| 50 | 7.5 | 7.1 | 6.6 | 6.0 | 5.0 | 3.8 |
| 100 | 8.4 | 7.9 | 7.4 | 6.7 | 5.4 | 4.0 |
| *12-Hour storms* | | | | | | |
| 2 | 4.1 | 3.8 | 3.5 | 3.3 | 2.8 | 2.4 |
| 5 | 5.5 | 5.1 | 4.8 | 4.4 | 3.8 | 3.3 |
| 10 | 6.6 | 6.2 | 5.7 | 5.2 | 4.5 | 3.9 |
| 25 | 8.0 | 7.5 | 6.9 | 6.4 | 5.5 | 4.4 |
| 50 | 9.0 | 8.5 | 7.9 | 7.2 | 6.1 | 4.7 |
| 100 | 10.1 | 9.5 | 8.8 | 8.1 | 6.6 | 4.9 |
| *18-Hour storms* | | | | | | |
| 2 | 4.4 | 4.2 | 3.9 | 3.6 | 3.0 | 2.6 |
| 5 | 6.0 | 5.6 | 5.3 | 4.8 | 4.1 | 3.6 |
| 10 | 7.1 | 6.7 | 6.3 | 5.7 | 5.0 | 4.2 |
| 25 | 8.7 | 8.2 | 7.7 | 7.0 | 6.0 | 4.8 |
| 50 | 9.8 | 9.3 | 8.7 | 7.9 | 6.6 | 5.1 |
| 100 | 11.0 | 10.4 | 9.7 | 8.8 | 7.2 | 5.4 |
| *24-Hour storms* | | | | | | |
| 2 | 4.7 | 4.4 | 4.1 | 3.9 | 3.2 | 2.8 |
| 5 | 6.3 | 5.9 | 5.6 | 5.1 | 4.4 | 3.8 |
| 10 | 7.6 | 7.1 | 6.7 | 6.1 | 5.3 | 4.5 |
| 25 | 9.2 | 8.6 | 8.1 | 7.5 | 6.3 | 5.2 |
| 50 | 10.3 | 9.8 | 9.2 | 8.5 | 7.0 | 5.5 |
| 100 | 11.6 | 11.0 | 10.3 | 9.4 | 7.7 | 5.8 |
| *48-Hour storms* | | | | | | |
| 2 | 5.2 | 4.9 | 4.6 | 4.3 | 3.6 | 3.1 |
| 5 | 7.0 | 6.6 | 6.2 | 5.7 | 4.9 | 4.3 |
| 10 | 8.4 | 7.9 | 7.4 | 6.8 | 5.9 | 5.1 |
| 25 | 10.2 | 9.6 | 9.0 | 8.3 | 7.1 | 5.8 |
| 50 | 11.5 | 10.9 | 10.2 | 9.4 | 7.9 | 6.2 |
| 100 | 12.9 | 12.2 | 11.4 | 10.5 | 8.6 | 6.5 |

Table G-5. Average Slope of Area-Depth Curves on Spoon River Basin

| Incremental areas (square miles) | Ratio of mean rainfall on incremental areas to basin mean rainfall for given storm duration (hours) 6 | 12 | 18 | 24 | 36 | 48 |
|---|---|---|---|---|---|---|
| 25 | 2.24 | 2.14 | 2.11 | 2.08 | 2.05 | 2.03 |
| 50 | 2.10 | 2.01 | 1.98 | 1.95 | 1.93 | 1.91 |
| 100 | 1.92 | 1.84 | 1.83 | 1.81 | 1.79 | 1.77 |
| 200 | 1.78 | 1.70 | 1.68 | 1.68 | 1.66 | 1.64 |
| 500 | 1.54 | 1.50 | 1.48 | 1.45 | 1.44 | 1.44 |
| 1000 | 1.29 | 1.28 | 1.27 | 1.26 | 1.25 | 1.25 |
| 1500 | 1.12 | 1.11 | 1.10 | 1.10 | 1.10 | 1.10 |
| 1854 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

Table G-6. Average Area-Depth Relations in a 12-Hour, 25-Year Storm on the Spoon River Basin

| Area (square miles) | Average rainfall (inches) |
|---|---|
| 25 | 7.3 |
| 50 | 6.6 |
| 100 | 6.3 |
| 200 | 5.8 |
| 500 | 5.1 |
| 1000 | 4.4 |
| 1500 | 3.8 |
| 1854 | 3.4 |

Table G-7. Unmodified Area-Depth Relations for Spoon River Basin

| Date | Average depth (inches) for given area (square miles) 25 | 50 | 100 | 200 | 500 | 1000 | 1500 | 1854 |
|---|---|---|---|---|---|---|---|---|
| 9/23-24/61 | 6.5 | 6.4 | 6.2 | 5.9 | 5.5 | 5.0 | 4.3 | 3.9 |
| 9/13-14/61 | 5.5 | 5.5 | 5.4 | 5.3 | 5.1 | 4.9 | 4.9 | 4.7 |
| 3/24-25/54 | 5.9 | 5.8 | 5.6 | 5.4 | 5.0 | 4.6 | 4.1 | 3.7 |
| 7/16-17/50 | 8.1 | 7.8 | 7.3 | 6.8 | 5.8 | 4.8 | 4.2 | 3.9 |
| 6/11-12/46 | 6.5 | 6.3 | 6.2 | 6.0 | 5.5 | 4.9 | 4.3 | 3.9 |
| 9/8-9/27 | 7.2 | 6.9 | 6.5 | 5.9 | 5.1 | 4.4 | 3.9 | 3.5 |
| 9/24-25/11 | 6.8 | 6.7 | 6.5 | 6.2 | 5.6 | 4.9 | 4.3 | 3.8 |
| 7/18-19/02 | 7.5 | 7.3 | 7.0 | 6.6 | 5.8 | 5.1 | 4.6 | 4.3 |
| 7/17-18/02 | 7.1 | 7.0 | 6.8 | 6.5 | 5.9 | 5.2 | 4.6 | 4.2 |
| 1/2-3/97 | 5.7 | 5.6 | 5.4 | 5.2 | 4.9 | 4.7 | 4.2 | 4.0 |

Table G-8. Monthly Distribution of 48-Hour Heavy Rainstorms

| Month | Number | Month | Number |
|---|---|---|---|
| January | 1 | July | 6 |
| February | 0 | August | 2 |
| March | 2 | September | 7 |
| April | 3 | October | 5 |
| May | 2 | November | 0 |
| June | 6 | December | 1 |

Table G-9. Seasonal Distribution of 48-Hour Heavy Rainstorms

| 3-Month period | Number | 3-Month period | Number |
|---|---|---|---|
| Jan-Mar | 3 | Jul-Sep | 15 |
| Feb-Apr | 5 | Aug-Oct | 14 |
| Mar-May | 7 | Sep-Nov | 12 |
| Apr-Jun | 11 | Oct-Dec | 6 |
| May-Jul | 14 | Nov-Jan | 2 |
| Jun-Aug | 14 | Dec-Feb | 2 |

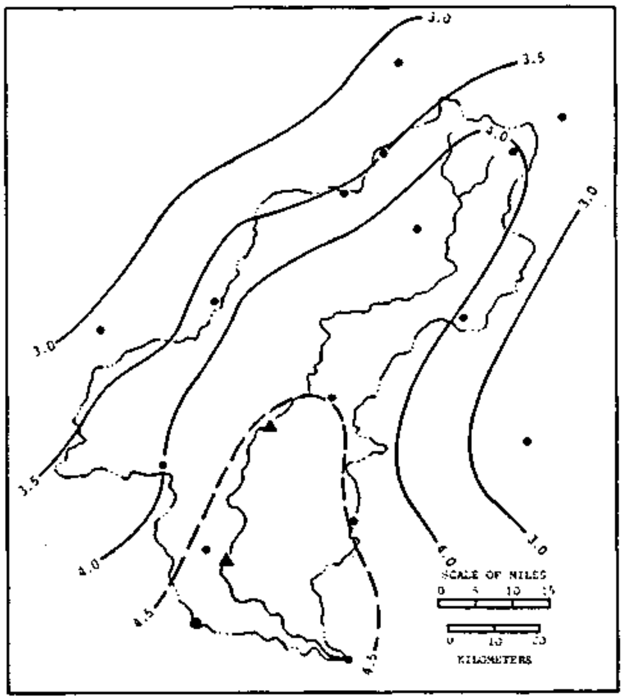



Figure G-4. Storm of January 1-2, 1897

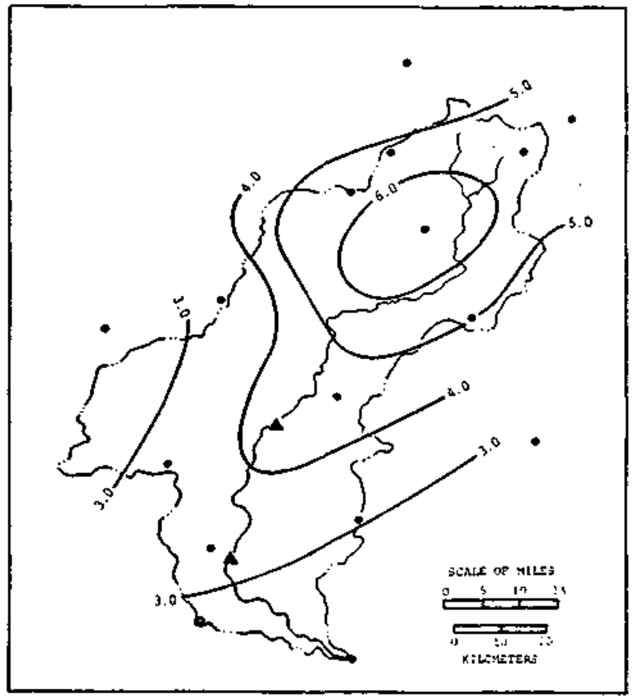



Figure G-5. Storm of July 17-18, 1902

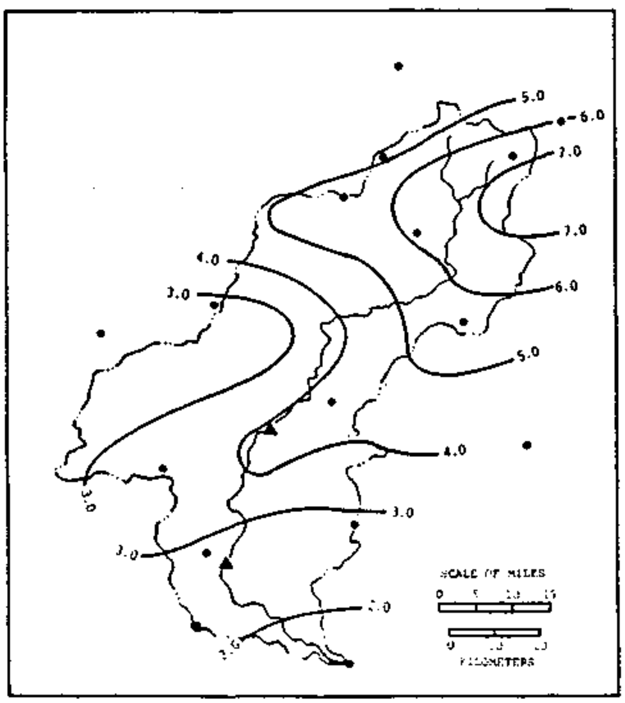



Figure G-6. Storm of July 18-19, 1902

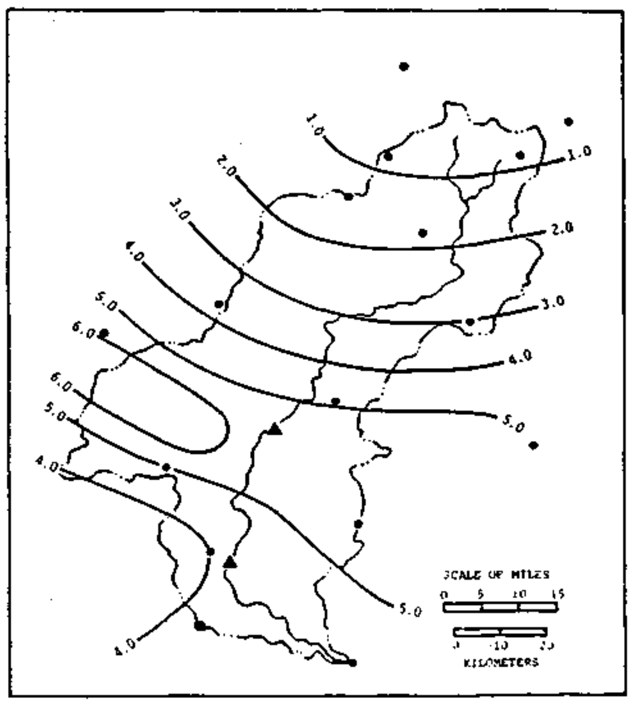



Figure G-7. Storm of September 24-25, 1911

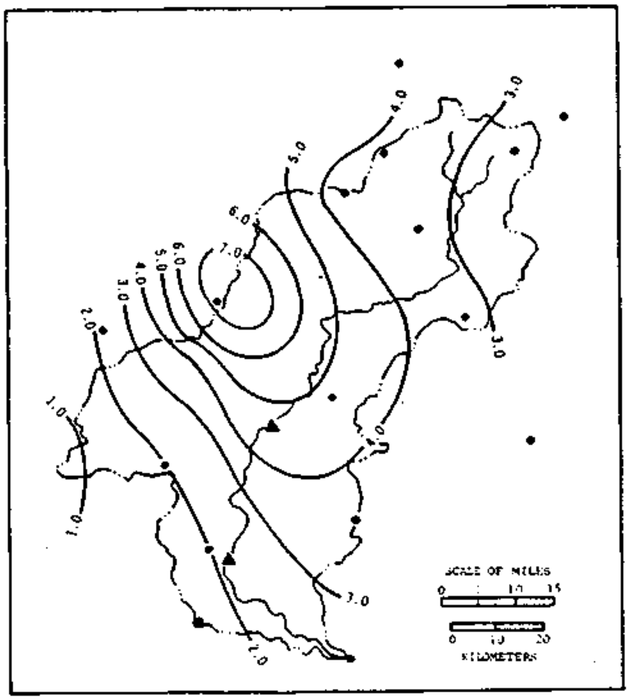



Figure G-8. Storm of September 8-9, 1927

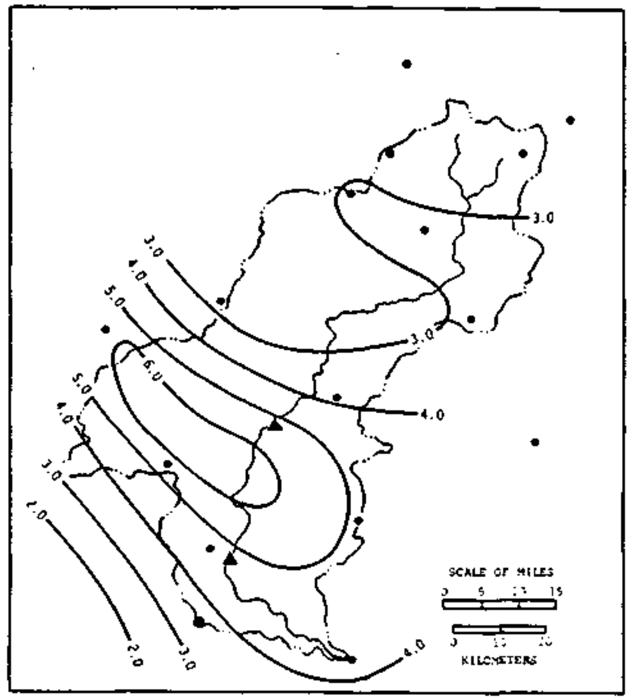



Figure G-9. Storm of June 11-12, 1946

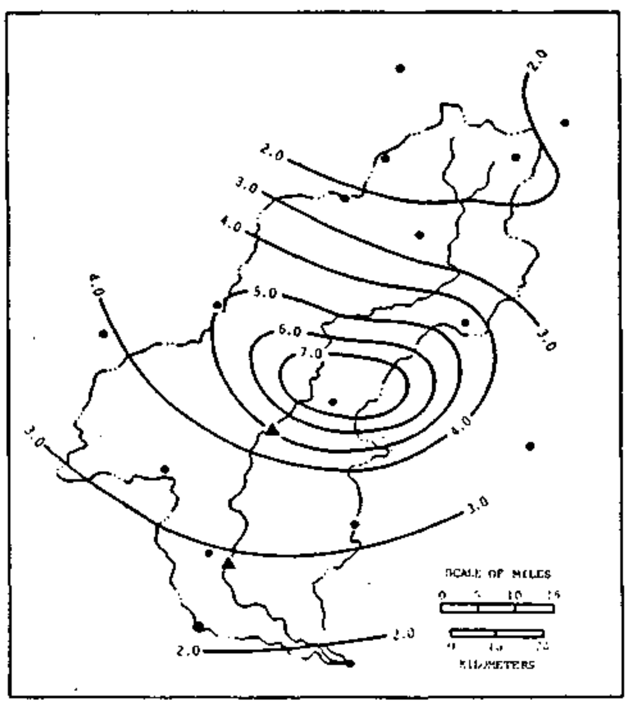



Figure G-10. Storm of July 16-17, 1950

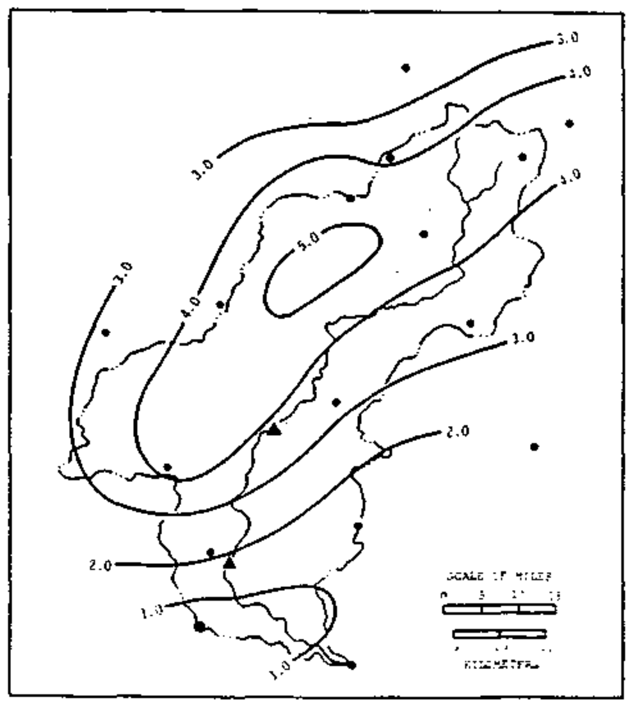


Figure G-11. Storm of March 24-25, 1954

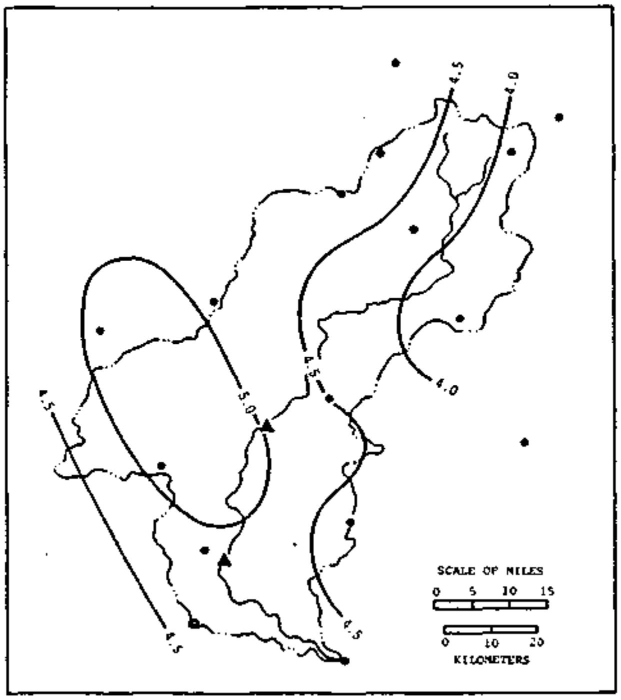



Figure G-12. Storm of September 13-14, 1961

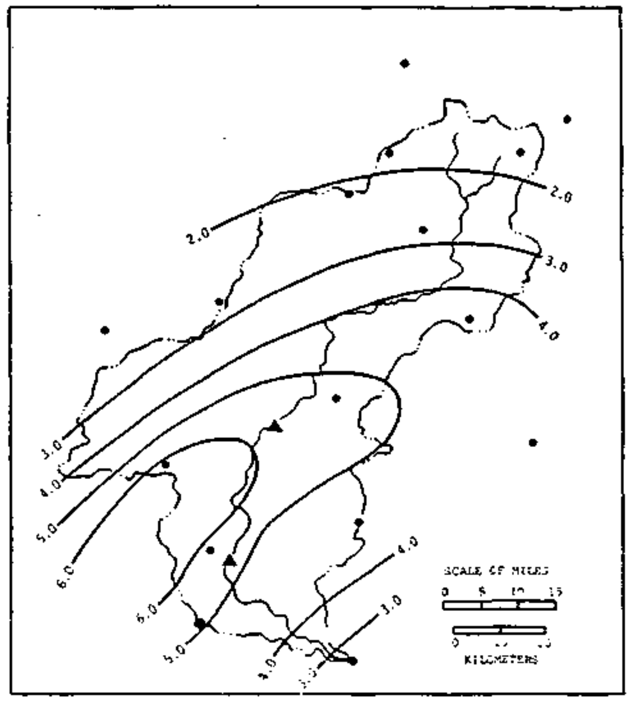



Figure G-13. Storm of September 23-24, 1961

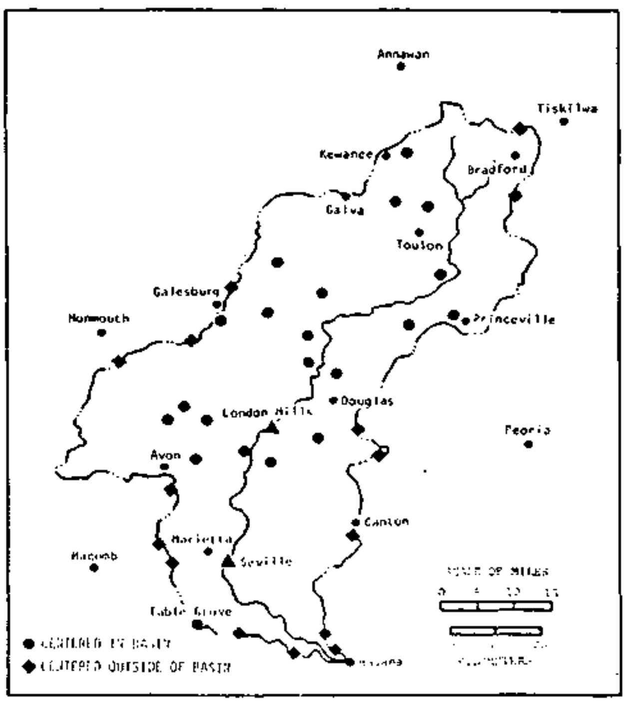



Figure G-14. Location of storm centers producing basin mean rainfall in excess of 2-year frequency value

# Part H. Storm Characteristics Mutually Applicable to All Basins

Analyses have shown that certain storm characteristics are similar for all basins regardless of size, location, or other differences. Although variations in these characteristics were found between basins, differences appeared to be randomly distributed and not related to meteorological or climatological factors. The variations probably represent sampling variations rather than real differences. Therefore, it was decided to average basin values to obtain more representative relationships for the 6-basin area.

## Orientation and Shape of Storms

For each basin, the 50 heaviest storms of record were used to develop a frequency distribution of storm orientations. Variations between basins showed no apparent relationship to basin size or differences in precipitation climate among the six basins. Averaging of the orientation data for all six basins produced the frequency distribution of azimuths shown in table H-1. As found in other Illinois storm studies (Huff and Semonin, 1960; Huff and Vogel, 1976), heavy rainstorms are most frequently oriented WSW to ENE, followed by SW-NE, and WNW-ESE orientations. The results in table H-1 agree well with those found for storms in northeastern Illinois by Huff and Vogel (1976).

Studies of the shape of storms in Illinois have shown that an elliptical shape is most frequently associated with the isohyetal patterns produced by severe rainstorms (Stout and Huff, 1962). Table H-2 shows average shapes, expressed as the ratio of the major to minor axis of the storm, for isohyetal centers encompassing areas of 100 to 10,000 square miles. The ratios are applicable to storms having durations of 6 to 48 hours.

**Table H-1. Orientation Distribution of Severe Rainstorms in 6-Basin Region**

| *Azimuth (degree)* | *Percent of storms* |
|---|---|
| 180-205 | 3 |
| 206-225 | 12 |
| 226-245 | 26 |
| 246-265 | 24 |
| 266-285 | 17 |
| 286-305 | 8 |
| 306-325 | 7 |
| 326-360 | 3 |

**Table H-2. Average Shape of Severe Rainstorms in Illinois**

| *Storm area enclosed (square miles)* | *Ratio, major to minor axis* |
|---|---|
| 100 | 2.27 |
| 200 | 2.56 |
| 500 | 2.92 |
| 1,000 | 3.19 |
| 2,000 | 3.47 |
| 5,000 | 3.72 |
| 10,000 | 4.08 |

## Synoptic Storm Types

The distribution of synoptic storm types was detemined through use of all storms having a basin mean rainfall exceeding the amount expected on an average of once in 2 years. Data from the six basins were combined, since there was no reason from meteorological considerations or examination of the data to separate them. Considerable variation existed, but it was randomly distributed and a reflection of sampling variation rather than basic differences in storm types.

Results are summarized in table H-3. Air mass storms were seldom associated with the rather large-scale basin storms, and this agrees with findings from our raingage network studies in various regions of Illinois. As shown in table H-3, they accounted for only 2 percent of the heavy storms for the combination of six basins. The most for any basin was six percent in the Big Muddy. The heavy basin storms were most frequently associated with stationary fronts. Combining the two categories of stationary fronts in table H-3, 34 percent were associated with this synoptic storm type. Cold frontal storms ranked second to stationary fronts in producing the severe storms studied on the six basins.

**Table H-3. Frequency Distribution of Synoptic Storm Types on Six Basins**

| *Storm type* | *Percent of total storms* |
|---|---|
| Cold front | 14 |
| Warm front | 6 |
| Stationary front | 15 |
| Cold plus warm front | 10 |
| Low center | 11 |
| Air mass storm | 2 |
| Cold front with waves | 11 |
| Warm front with waves | 12 |
| Stationary front with waves | 19 |
| All cold fronts | 25 |
| All warm fronts | 19 |
| All stationary fronts | 34 |

## Time Distribution of Heavy Rainfall

A study was made of the time distribution of rainfall in severe rainstorms in Illinois. In this study, the percentage of the 24-hour storm rainfall was calculated for selected incremental periods in each of the storms for which detailed field surveys were made (Stout and Huff, 1962). Results of this study are summarized in table H-4, which shows the percentage distribution for the 3-hour, 6-hour, and 12-hour periods of maximum rainfall in each storm for which adequate data were available to define the maximum rainfall.

Calculations were made for selected areas progressing outward from the storm core. Thus, in the storm of July 8-9, 1951, 63 percent of the total storm rainfall over the 25 square miles with the heaviest storm rainfall occurred during the 3-hour period of maximum intensity. Similarly, over the 500 square miles with the heaviest rainfall, 60 percent of the total storm rainfall was recorded in the 3-hour period of maximum rainfall, and oyer the 5000 square miles of heaviest rainfall, 45 percent of the storm total occurred in the 3-hour period of maximum rainfall.

Table H-4 shows considerable variability in the percentage distribution between individual storms, as expected. Median values are given for each incremental period, based upon all storms analyzed, and these values are considered most useful for hydrologic applications. Although based upon data for storms over several regions in the state, the data in table H-4 are representative of conditions on the six basins, since the time distribution relationship in storms should not vary appreciably throughout the state. Figure H-l is a graphical presentation of the median time distribution for selected areas within severe storms during maximum rainfall periods of 3 to 24 hours.

## Time between Successive Severe Rainstorms

Figure H-2 shows the frequency distribution of elapsed time between storms having average recurrence intervals of 2 and 5 years. The elapsed time in months is plotted against probability in percent. Curves were developed initially for each basin, but combined because differences were relatively small and randomly distributed among the basins.

Use of figure H-2 is illustrated by the following example. Assume one wishes to determine the probability of two storms with mean rainfall equaling or exceeding the average 2-year recurrence value following each other within a period of 1 month, 6 months, 12 months, and 24 months. Moving horizontally from the 1, 6, 12, and 24-month points on the y-axis to the 2-year curve gives the desired probabilities. The probability of two such storms following each other within 1 month is 4 percent, or one chance in 25 that the next 2-year or greater storm will occur within 1 month. Similarly, the probability is approximately 22 percent that the next storm will come within 6 months, 36 percent that it will occur within 12 months, and 61 percent that it will take place within 24 months. With a uniform time distribution, the 24-month probability would be 50 percent. However, the distribution is skewed because of the tendency for heavy storms to occur with greater than average frequency during wet periods and with subnormal frequency during drought periods.

### Table H-4. Time Distribution of Storm Rainfall

| Date | 25 | 50 | 100 | 200 | 500 | 1000 | 2000 | 5000 | 10,000 |
|---|---|---|---|---|---|---|---|---|---|
| | *Percent of 24-hour storm rainfall for given areas (square miles)* | | | | | | | | |
| *Maximum 3-Hour Rainfall* | | | | | | | | | |
| 7/8-9/51 | 63 | 64 | 64 | 64 | 60 | 58 | 55 | 45 | |
| 6/14-15/57 | 53 | 51 | 50 | 47 | 44 | 40 | 37 | 30 | |
| 6/27-28/57 | 36 | 36 | 37 | 36 | 36 | 36 | 37 | 37 | 37 |
| 7/12-13/57 | 45 | 45 | 45 | 44 | 42 | 41 | 39 | 36 | |
| 8/16-17/59 | 39 | 38 | 38 | 37 | 35 | 33 | 31 | 27 | 24 |
| Median | 45 | 45 | 45 | 44 | 42 | 40 | 37 | 36 | |
| *Maximum 6-Hour Rainfall* | | | | | | | | | |
| 7/8-9/51 | 99 | 97 | 97 | 97 | 97 | 96 | 97 | 95 | 93 |
| 10/9-10/54 | 45 | 45 | 44 | 44 | 43 | 42 | 42 | 40 | 39 |
| 5/26-28/56 | 78 | 78 | 75 | 73 | 71 | 66 | | | |
| 5/21-23/57 | 89 | 86 | 84 | 83 | 81 | 76 | 74 | 67 | |
| 6/14-15/57 | 76 | 74 | 72 | 69 | 65 | 60 | 54 | 46 | |
| 6/27-28/57 | 70 | 69 | 70 | 69 | 67 | 66 | 65 | 62 | 60 |
| 7/12-13/57 | 61 | 62 | 62 | 60 | 60 | 59 | 58 | 54 | |
| 7/14/58 | 86 | 85 | 85 | 88 | 79 | 81 | 76 | 87 | |
| 8/16-17/59 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 49 | 51 |
| Median | 76 | 74 | 72 | 69 | 67 | 66 | 62 | 58 | 55 |
| *Maximum 12-Hour Rainfall* | | | | | | | | | |
| 7/8-9/51 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 10/9-10/54 | 62 | 62 | 62 | 62 | 61 | 62 | 62 | 60 | 61 |
| 5/26-28/56 | 84 | 84 | 82 | 79 | 77 | 74 | | | |
| 5/21-23/57 | 92 | 91 | 90 | 89 | 87 | 84 | 79 | 75 | |
| 6/14-15/57 | 99 | 98 | 97 | 97 | 96 | 95 | 93 | 91 | 86 |
| 6/27-28/57 | 97 | 96 | 95 | 93 | 91 | 90 | 87 | 83 | 78 |
| 7/12-13/57 | 87 | 87 | 87 | 86 | 86 | 84 | 85 | 83 | |
| 7/14/58 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| 8/16-17/59 | 90 | 90 | 91 | 89 | 89 | 86 | 85 | 81 | 78 |
| Median | 91 | 91 | 91 | 89 | 87 | 86 | 85 | 83 | 78 |

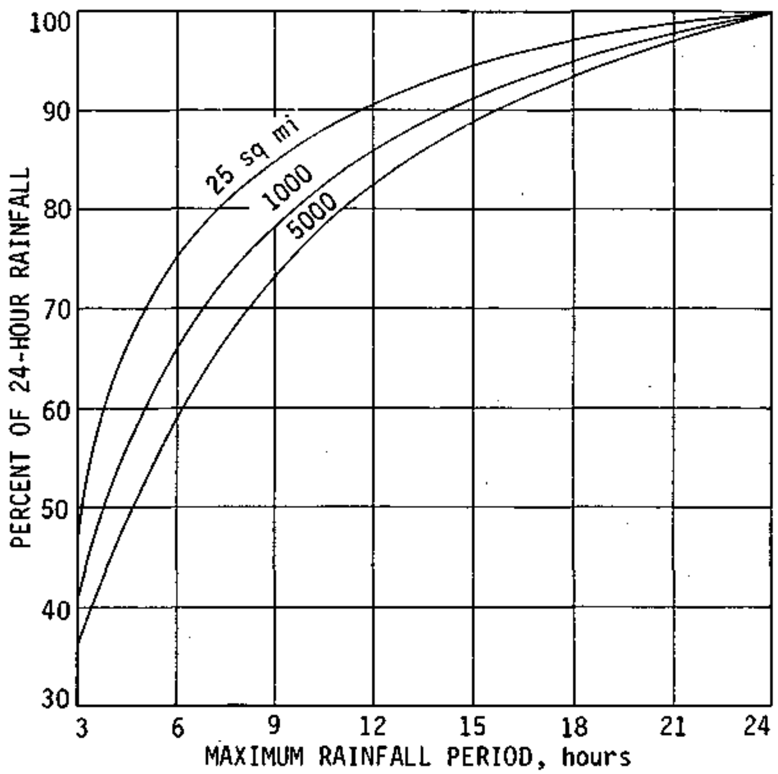



Figure H-1. Median time distribution for selected areas within severe storms during maximum rainfall periods

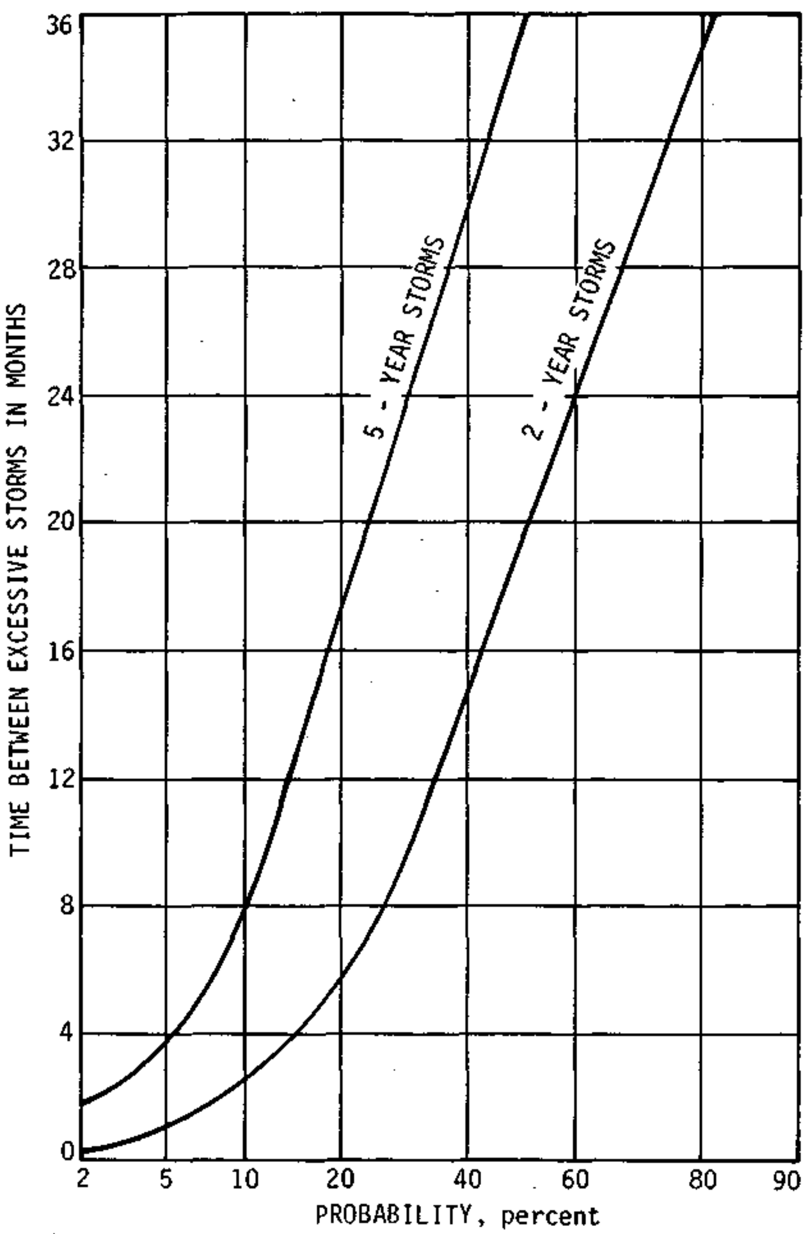



Figure H-2. Frequency distribution of time between storms

# Part I. Comparison of Storm Characteristics Among Basins

Analytical results from the six basins were examined to determine similarities and differences among them with respect to mean rainfall frequency distributions, the spatial distribution of storm rainfall as reflected in the area-depth relations, and the time distribution of storms as shown by their monthly and seasonal distribution. Findings are briefly summarized in the following paragraphs.

For comparison of mean rainfall frequency relations, the characteristics of 24-hour storm rainfalls have been used. Most of the heavy rainfall in the storms studied fell in 24 hours and less. Furthermore, the 24-hour relations reflect those for other storm periods, since the others were usually parts of the same storm systems as the 24-hour rainfalls.

### Basin Mean Rainfall Frequency

Table I-1 shows a comparison of mean rainfall frequency relations for each basin and partial basin area studied. As pointed out earlier, basin mean rainfall frequency is related to basin size, so that examination of similarities and differences must be done between areas of similar size. The Upper Kaskaskia, Big Muddy, and Embarras (entire basin) are approximately the same size. For a given recurrence interval, table I-1 shows the heaviest rainfall amounts in the Big Muddy, followed by the Upper Kaskaskia. The Big Muddy is the most southerly of these basins and has a longer convective rainfall period on a yearly basis than the other two basins. Also, temperatures tend to be higher and, therefore, the moisture-carrying potential greatest in the Big Muddy. Note that the rainfall differences become greater as the recurrence interval is increased. Whereas the maximum difference among the three basins is only 0.4 inch for the 2-year recurrence, it increases to 1.6 inches at a 50-year frequency and 2.2 inches at a 100-year occurrence. The heavier rainfalls in the Big Muddy are in agreement with the point rainfall frequency relationships derived by Huff and Neill (1959) which showed the heaviest point rainfall for a given frequency is in the extreme southern part of the state.

Other comparisons between areas of equivalent size in table I-1 show trends similar to those discussed above. The major differences in each case are with the longer recurrence intervals. Differences at the 2-year and 5-year levels are usually small and insignificant.

### Comparison between Fixed Sub-Areas within the Six Basins

A comparison of mean rainfall frequency values for three sizes of fixed sub-areas is presented in table I-2, based on 24-hour storm rainfalls. Only entire basins have been compared. The results support those in table I-1. For a given recurrence interval, rainfall amounts increase southward in the state. Thus, the largest amounts occur in the most southerly basin (Big Muddy) and the smallest in the two most northerly basins (Sangamon, Spoon).

### Sub-Area Envelopes of Maximum Rainfall

Another comparison involved mean rainfall frequency relations for envelope values of mean rainfall on basin sub-areas. This refers to the heaviest mean rainfalls that occurred *anywhere* in the basin for a given size of sub-area and recurrence interval. Again, this was done for 24-hour rainfall. Results are summarized for selected sub-areas in table I-3. As expected, trends are similar to those found in the previous two tables. However, differences are more pronounced. For example, the heaviest mean rainfall expected to occur on a contiguous area of 100 square miles, somewhere in the basin, during an average 50-year period is 11.9 inches for the Big Muddy compared with 9.3 and 9.2 inches, respectively, for the Sangamon and Spoon basins.

### Comparison of Area-Depth Relations between Basins

Table I-4 shows a comparison of average area-depth curve slopes for 24-hour rainfalls. The slope is a measure of the rainfall gradient in the storm, and, consequently, the spatial variability. Similar to table I-1, it is necessary to compare areas of

Table I-1. Comparison of Basin Mean Rainfall Frequency Relations for 24-Hour Storm Periods

| Basin | Area (square miles) | Area average depth (inches) for given recurrence (years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| Upper Kaskaskia | 2500 | 2.2 | 3.0 | 3.7 | 4.5 | 5.1 | 5.8 |
| Lower Kaskaskia | 3300 | 2.4 | 3.1 | 3.8 | 4.9 | 6.0 | 7.3 |
| Entire Kaskaskia | 5800 | 2.0 | 2.6 | 3.2 | 4.3 | 5.2 | 6.4 |
| Big Muddy | 2380 | 2.5 | 3.5 | 4.1 | 5.2 | 6.1 | 7.2 |
| Sangamon | 5450 | 2.1 | 2.8 | 3.4 | 4.0 | 4.5 | 5.0 |
| Upper Little Wabash | 1510 | 2.0 | 2.9 | 3.6 | 4.6 | 5.3 | 6.0 |
| Lower Little Wabash | 1690 | 2.3 | 3.5 | 4.4 | 5.6 | 6.6 | 7.6 |
| Entire Little Wabash | 3200 | 2.1 | 3.1 | 3.9 | 5.0 | 5.7 | 6.5 |
| Upper Embarras | 1125 | 2.1 | 2.8 | 3.3 | 4.1 | 4.6 | 5.2 |
| Lower Embarras | 1315 | 2.1 | 3.0 | 3.6 | 4.4 | 5.0 | 5.5 |
| Entire Embarras | 2440 | 2.1 | 2.9 | 3.4 | 4.1 | 4.5 | 5.0 |
| Spoon | 1855 | 2.5 | 3.5 | 4.1 | 4.6 | 5.0 | 5.5 |

Table I-2. Comparison of Mean Rainfall Frequency Relations for 24-Hour Storm Periods in Basin Fixed Sub-Areas of Various Sizes (specific integral areas)

| Basin | Mean rainfall (inches) for given frequency (years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| *25-Square-Mile Area* | | | | | | |
| Kaskaskia | 3.0 | 3.6 | 4.4 | 5.5 | 6.6 | 7.9 |
| Big Muddy | 3.4 | 4.2 | 4.9 | 6.2 | 7.2 | 8.6 |
| Sangamon | 2.6 | 3.3 | 3.9 | 5.0 | 5.9 | 7.0 |
| Little Wabash | 3.1 | 4.0 | 4.7 | 6.0 | 7.1 | 8.4 |
| Embarras | 3.0 | 3.8 | 4.4 | 5.7 | 6.9 | 8.2 |
| Spoon | 2.7 | 3.5 | 4.1 | 5.2 | 6.3 | 7.4 |
| *100-Square-Mile Area* | | | | | | |
| Kaskaskia | 2.9 | 3.5 | 4.3 | 5.3 | 6.4 | 7.7 |
| Big Muddy | 3.2 | 4.0 | 4.7 | 5.9 | 6.8 | 8.2 |
| Sangamon | 2.5 | 3.1 | 3.7 | 4.7 | 5.7 | 6.8 |
| Little Wabash | 3.0 | 3.8 | 4.5 | 5.7 | 6.7 | 8.0 |
| Embarras | 2.9 | 3.6 | 4.2 | 5.4 | 6.5 | 7.8 |
| Spoon | 2.6 | 3.3 | 3.9 | 4.9 | 6.0 | 7.0 |
| *400-Square-Mile Area* | | | | | | |
| Kaskaskia | 2.7 | 3.4 | 4.1 | 5.2 | 6.2 | 7.5 |
| Big Muddy | 3.1 | 3.9 | 4.5 | 5.7 | 6.6 | 8.0 |
| Sangamon | 2.4 | 3.0 | 3.6 | 4.6 | 5.6 | 6.6 |
| Little Wabash | 2.9 | 3.7 | 4.4 | 5.6 | 6.6 | 7.8 |
| Embarras | 2.8 | 3.5 | 4.1 | 5.3 | 6.4 | 7.6 |
| Spoon | 2.5 | 3.3 | 3.8 | 4.8 | 5.8 | 6.8 |

Table I-3. Comparison of Envelope Values of Mean Rainfall Frequencies for 24-Hour Storm Rainfall Periods in Basin Sub-Areas of Selected Sizes

| | Mean rainfall (inches) for given frequency (years) | | | | | |
|---|---|---|---|---|---|---|
| *Basin* | *2* | *5* | *10* | *25* | *50* | *100* |
| *25-Square-Mile Area* | | | | | | |
| Kaskaskia | 4.9 | 6.2 | 7.6 | 9.7 | 10.8 | 12.5 |
| Big Muddy | 5.0 | 6.6 | 8.0 | 10.5 | 12.9 | 15.7 |
| Sangamon | 5.8 | 7.1 | 8.0 | 9.1 | 9.8 | 10.6 |
| Little Wabash | 4.8 | 6.8 | 8.6 | 10.6 | 11.9 | 13.0 |
| Embarras | 3.7 | 5.6 | 6.8 | 8.4 | 9.4 | 10.4 |
| Spoon | 4.7 | 6.3 | 7.6 | 9.2 | 10.3 | 11.6 |
| *100-Square-Mile Area* | | | | | | |
| Kaskaskia | 4.3 | 5.5 | 6.8 | 8.7 | 9.5 | 11.2 |
| Big Muddy | 4.7 | 6.1 | 7.5 | 9.6 | 11.9 | 14.5 |
| Sangamon | 5.2 | 6.6 | 7.4 | 8.5 | 9.3 | 10.1 |
| Little Wabash | 4.3 | 6.1 | 7.6 | 9.2 | 9.9 | 10.5 |
| Embarras | 3.6 | 5.1 | 6.2 | 7.5 | 8.5 | 9.4 |
| Spoon | 4.1 | 5.6 | 6.7 | 8.1 | 9.2 | 10.3 |
| *500-Square-Mile Area* | | | | | | |
| Kaskaskia | 3.6 | 4.5 | 5.5 | 7.0 | 7.9 | 8.2 |
| Big Muddy | 3.9 | 5.1 | 6.3 | 8.3 | 10.1 | 12.3 |
| Sangamon | 4.2 | 5.3 | 6.2 | 7.3 | 8.0 | 8.8 |
| Little Wabash | 3.6 | 5.2 | 6.2 | 7.6 | 8.4 | 9.0 |
| Embarras | 3.0 | 4.4 | 5.3 | 6.1 | 6.8 | 7.4 |
| Spoon | 3.2 | 4.4 | 5.3 | 6.3 | 7.0 | 7.7 |

Table I-4. Comparison of Average Area-Depth Curve Slopes (Rainfall Gradient) for 24-Hour Storm Periods

| | *Area* | *Area ratio of incremental area to total area mean rainfall* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Basin* | *(square miles)* | *50* | *100* | *200* | *500* | *1000* | *1500* | *2000* |
| Upper Kaskaskia | 2500 | 1.71 | 1.64 | 1.55 | 1.38 | 1.22 | 1.12 | 1.05 |
| Lower Kaskaskia | 3300 | 1.79 | 1.73 | 1.63 | 1.46 | 1.31 | 1.20 | 1.13 |
| Entire Kaskaskia | 5800 | 2.00 | 1.93 | 1.84 | 1.67 | 1.53 | 1.41 | 1.34 |
| Big Muddy | 2380 | 1.78 | 1.71 | 1.62 | 1.44 | 1.28 | 1.16 | 1.07 |
| Sangamon | 5450 | 2.05 | 2.00 | 1.92 | 1.75 | 1.59 | 1.47 | 1.38 |
| Upper Little Wabash | 1510 | 1.72 | 1.63 | 1.54 | 1.36 | 1.17 | 1.00 | |
| Lower Little Wabash | 1690 | 1.68 | 1.59 | 1.47 | 1.27 | 1.15 | 1.07 | |
| Entire Little Wabash | 3200 | 2.04 | 1.88 | 1.76 | 1.58 | 1.44 | 1.35 | 1.26 |
| Upper Embarras | 1125 | 1.60 | 1.51 | 1.41 | 1.23 | 1.05 | | |
| Lower Embarras | 1315 | 1.60 | 1.52 | 1.43 | 1.27 | 1.10 | | |
| Entire Embarras | 2440 | 1.92 | 1.84 | 1.73 | 1.53 | 1.35 | 1.20 | 1.11 |
| Spoon | 1855 | 1.95 | 1.81 | 1.68 | 1.45 | 1.26 | 1.10 | |

similar size, since spatial variability is influenced by the size of the sampling area. Comparing the Big Muddy, Upper Kaskaskia, and the Embarras Basins, the north-south trend found in the mean rainfall frequency distributions does not emerge. Other comparisons of areas of equivalent size in table I-4 also show no distinct north-south trend. Furthermore, consideration of basin shape did not separate the basins. It appears that the differences for areas of equivalent size are more related to sampling variations than to differences in precipitation climate and basin shape among the six basins.

**Table I-5. Seasonal Distribution of Severe Rainstorms**

| Basin | Percent of all qualifying storms for given season | | | |
|---|---|---|---|---|
| | Winter | Spring | Summer | Fall |
| Kaskaskia | 11 | 31 | 25 | 33 |
| Big Muddy | 20 | 32 | 26 | 22 |
| Little Wabash | 9 | 36 | 25 | 30 |
| Embarras | 16 | 39 | 16 | 29 |
| Sangamon | 6 | 25 | 35 | 34 |
| Spoon | 6 | 20 | 40 | 34 |
| 6-Basins combined | 11 | 31 | 28 | 30 |

### Monthly and Seasonal Distribution of Severe Rainstorms

Analyses of the monthly frequency distribution of storms having a recurrence interval of 2 years or longer produced a rather erratic pattern. However, when the monthly data were combined to obtain seasonal distributions, a more distinct pattern emerged. This is brought out in table I-5 . All basins show a minimum frequency in winter, but the more northerly basins (Sangamon, Spoon) have a lesser probability than the others of receiving a heavy winter rainstorm. The probability is greatest in the Big Muddy, which is the most southerly basin. Similarly, the probability of a heavy storm in summer is greatest in the two most northerly basins. The Little Wabash, Embarras, and Big Muddy have their greatest storm frequency in spring. The Kaskaskia has a nearly equal maximum frequency in spring and fall.

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