# MAGNITUDE AND FREQUENCY OF FLOODS IN SMALL DRAINAGE BASINS IN NORTH DAKOTA

U. S. GEOLOGICAL SURVEY

Water-Resources Investigations 19-75

Prepared in cooperation with the
North Dakata State Highway Department

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16. Abstracts

Methods are presented for estimating flood-peak discharges at 2- to 50-year recurrence intervals on North Dakota streams draining less than 100 square miles (259 square kilometres). For gaged sites, frequency estimates are provided directly. For ungaged sites, the method relates drainage area and(or) soil-infiltration index to peak discharges. The equations presented are for sites on streams with natural flow and are not applicable to urban areas or basins affected by man-made regulation.

Information is also provided on the maximum flood magnitude experienced.

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May 1975

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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## SELECTED FACTORS FOR CONVERTING ENGLISH UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

A dual system of measurement--English units and the International System (SI) of units--is given in this report. SI is a consistent system of units adopted by the Eleventh General Conference of Weights and Measures in 1960. Selected factors for converting English units to SI units are given below.

| Multiply English units | By | To obtain SI units |
|---|---|---|
| Inches | 25.4 | millimetres (mm) |
| Feet | .3048 | metres (m) |
| Miles | 1.609 | kilometres (km) |
| Square miles ($mi^2$) | 2.590 | square kilometres ($km^2$) |
| Cubic feet per second ($ft^3/s$) | .02832 | cubic metres per second ($m^3/s$) |
| Cubic feet per second per square mile [$(ft^3/s)/mi^2$] | .010935 | cubic metres per second per square kilometre [$(m^3/s)/km^2$] |
| Feet per mile (ft/mi) | .1894 | metres per kilometre (m/km) |
| Miles per square mile ($mi/mi^2$) | .6212 | kilometres per square kilometre ($km/km^2$) |

# MAGNITUDE AND FREQUENCY OF FLOODS FROM SMALL DRAINAGE BASINS IN NORTH DAKOTA

By Orlo A. Crosby

*ABSTRACT*

*This report describes methods for estimating flood-peak discharges having 2- to 50-year recurrence intervals on North Dakota streams draining less than 100 square miles (259 square kilometres). For gaged sites, frequency estimates are provided directly. For ungaged sites, flood peaks are estimated from multiple-regression equations using drainage-area size and, in two regions, soil-infiltration index as estimating variables. Nomographs provide simple solutions for the equations for flood-peak discharges having recurrence intervals of 10, 25, and 50 years. The methods described are not applicable to streams draining urban areas or basins affected by man-made regulation.*

*Information is also provided on the maximum flood magnitude experienced.*

## INTRODUCTION

Knowledge of the magnitude and frequency of floods is necessary in the planning and design of culverts, bridges and other hydraulic structures, and in the management of flood plains and flood waters. Only through the use of reliable estimates of a design flood can a structure be designed consistent with the requirements of economic feasibility, minimum risk to the populace, and least adverse environmental impact.

### Purpose and Scope

The purposes of this report are: (1) to provide a method of estimating the magnitude and frequency of floods for small unregulated streams in North Dakota; (2) to evaluate the reliability of the resulting estimates; and (3) to evaluate the adequacy of the peak discharge data being collected under the present program and to determine data acquisition needs in regard to future program operation.

The methods of estimating peak discharges described in this report are based on analyses of records from 84 crest-stage stations and 13 continuous-record gaging stations (see pl. 1, in pocket). Estimating methods apply only to sites on streams where flood flows are virtually unregulated and where the drainage area size is less than 100 $mi^2$ (259 $km^2$). Records from streams with significant regulation or diversion were not used in the analysis.

The standard error of estimate was determined for each equation developed and is used as the basis for judging the probable reliability of flood-peak estimates.

The constancy of relationships between floods of selected recurrence intervals and the basin or climatic variables was investigated to evaluate the adequacy of the data-collection program.

## Gaging-Station-Numbering System

Each gaging station and partial-record station has been assigned a number in downstream order in accordance with the permanent numbering system used by the Geological Survey. Numbers are assigned in a downstream direction along the main stream, and stations on tributaries between main-stream stations are numbered in the order they enter the main stream. A similar order is followed on other ranks of tributaries. The complete 8-digit number, such as 06342300, includes the part number "06" plus a 6-digit station number.

## Acknowledgments

This report was prepared by the U.S. Geological Survey in cooperation with the North Dakota State Highway Department.

Most of the flood data used in this report were collected by the U.S. Geological Survey through cooperative agreements with the North Dakota State Highway Department, W. R. Hjelle, Commissioner, and the North Dakota State Water Commission, Vernon Fahy, Chief Engineer.

Assistance in the form of funds or services was provided by other Federal agencies:

Corps of Engineers, U.S. Army,

International Joint Commission, U.S. Department of State,

Soil Conservation Service, U.S. Department of Agriculture,

Federal Highway Administration, U.S. Department of Transportation.

## Previous Studies

A report (McCabe and Crosby, 1959) was prepared utilizing all data available through 1955. That report was superseded by two reports in the water-supply paper series of the U.S. Geological Survey (Patterson, 1966 and Patterson and Gamble, 1968) that utilized data through 1961 and 1963, respectively; however, they contained very little information on floods from small drainage basins in North Dakota.

The reports by Patterson (1966) and Patterson and Gamble (1968) need to be referred to in making flood estimates for basins with drainage areas greater than 100 $mi^2$ (259 $km^2$). The estimates thus obtained for drainage areas near 100 $mi^2$ (259 $km^2$) will not agree with those obtained from the relationships described in this report (considered the more reliable) and the user may wish to use an averaged estimate.

A report by Crosby (1970) included a limited analysis of magnitude and frequency of North Dakota floods. That analysis was undertaken, however, for a specific purpose, which is unrelated to the practical and reliable estimation of flood magnitude and frequency for use in problems of land-use planning and structural design.

# METHODS OF ESTIMATING

The most reliable estimators of future floods generally are the frequency analyses of gaging-station records. The streamflow characteristics computed by a frequency analysis are listed in table 1 and may provide satisfactory estimates for planning and design purposes at or near the gage locations shown on plate 1, particularly where long-term records are available. Therefore, the estimating technique first includes a search for available flood-frequency data for the desired site.

Peak discharges for selected recurrence intervals at most ungaged sites on small streams in North Dakota can be determined as follow:

1. Locate the site on plate 1 and determine in which region the basin is located.

2. Choose the appropriate equation from table 2 or appropriate nomograph from figures 1 through 3.

3. Determine the required basin characteristics.

    (a) Drainage area (A) is the contributing drainage area in square miles, as determined by outlining the surface-water divide upstream from the point

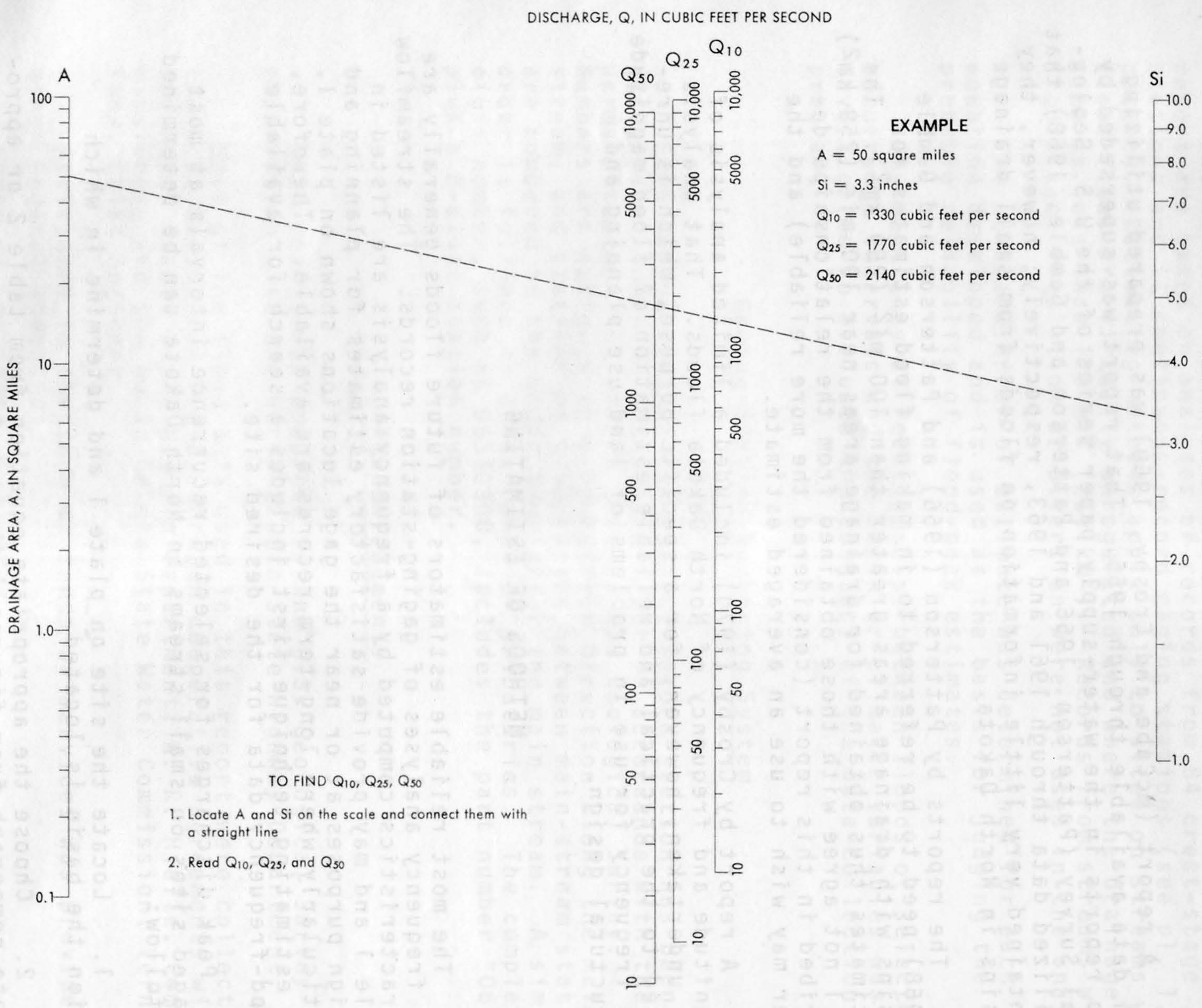


FIGURE 1.— Nomograph for determining peak discharges for floods in Region A with 10-year, 25-year, and 50-year recurrence intervals.

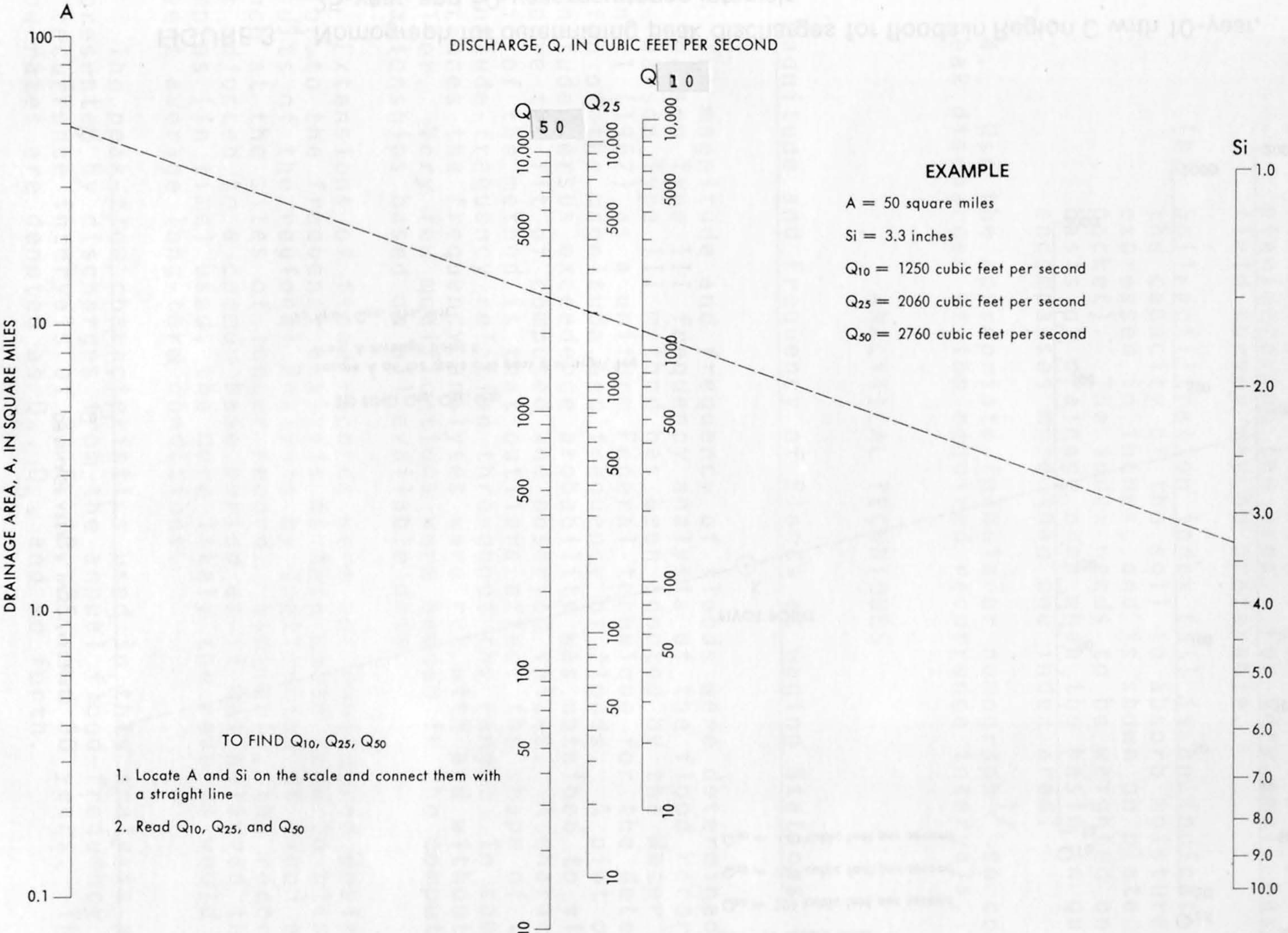


FIGURE 2.— Nomograph for determining peak discharges for floods in Region B with 10-year, 25-year, and 50-year recurrence intervals.

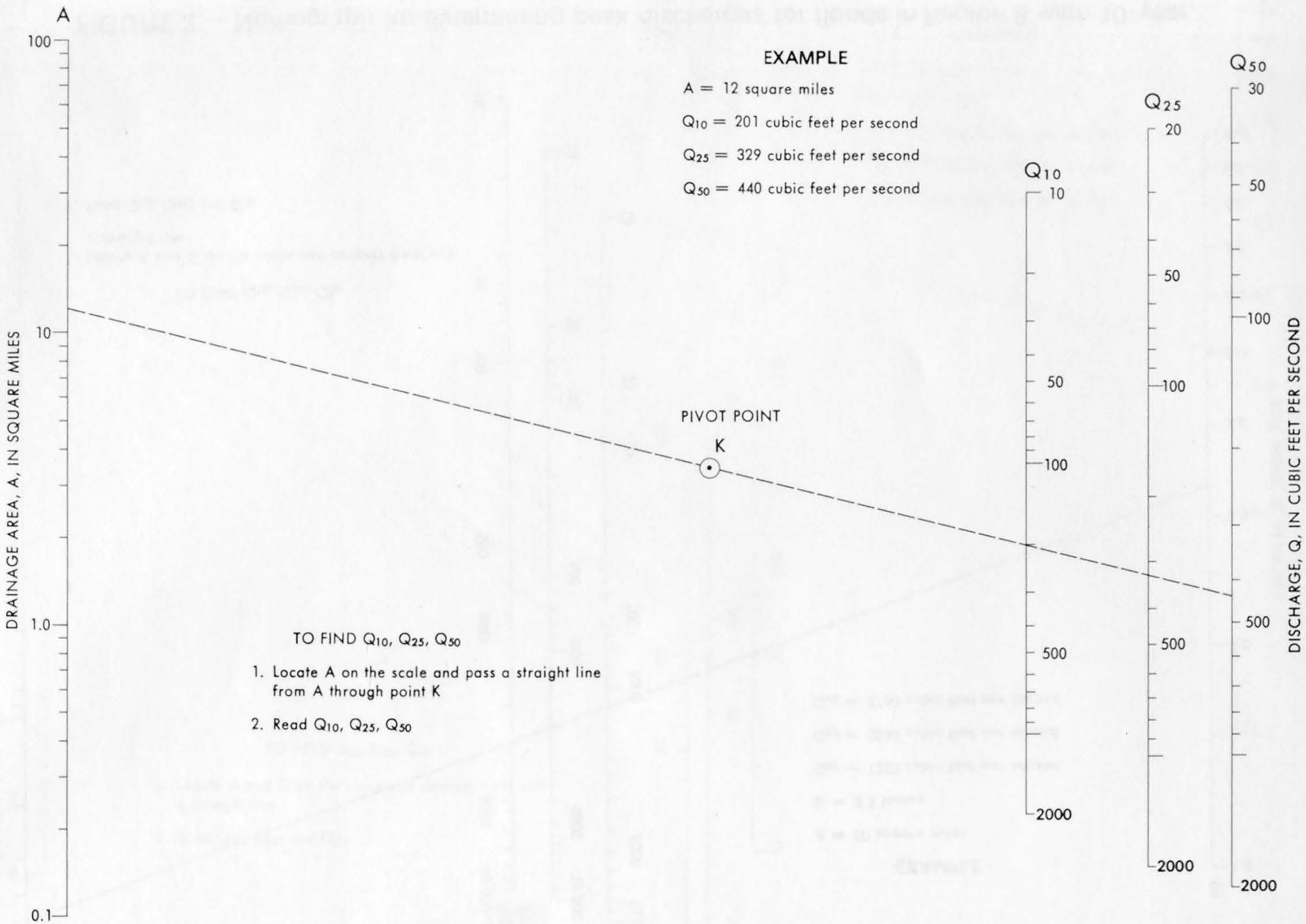


FIGURE 3.— Nomograph for determining peak discharges for floods in Region C with 10-year, 25-year, and 50-year recurrence intervals.

of interest on the best topographic map or the State Highway Department general highway maps, and planimetering the area. For very small basins a field survey may be preferable.

(b) Soil-infiltration index (Si) is an indication of the capacity of the soil to absorb moisture, expressed in inches, and is shown on plate 2 (in pocket). The index needs to be weighted on the basis of drainage area when the basin in question encompasses more than one index area.

4. Use the appropriate formula or nomograph 1/ to compute the peak discharges at the required recurrence intervals.

## ANALYTICAL TECHNIQUES

### Magnitude and Frequency of Floods at Gaging Stations

The magnitude and frequency of floods were determined from a log-Pearson Type III frequency analysis of the flood record. The log-Pearson Type III method has been adopted by the Water Resources Council (1967) as a uniform Federal technique for the determination of the magnitude and frequency of floods. A plot of magnitude versus exceedence probability was obtained to visually compare the fit of computed and observed values. A characteristic of the method is that outliers affect the shape of the magnitude-frequency relation throughout the range. In some instances the frequency analyses were run with and without an outlier. Very few modifications were needed in the computed relationships based on all available data.

Extensions of flood records were not considered desirable prior to the frequency analysis as this would tend to bias the results of the regional analysis by duplication of flood experience at the sites of longer record. Similarly, the records were not adjusted to a common base period as it was believed the more samples (in time) used, the more likely the results would represent average long-term conditions.

The peak-flow characteristics used in this analysis are represented by discharges from the annual flood-frequency curve at recurrence intervals of 2, 5, 10, 25, and 50 years. The peak-flow rates are denoted as $Q_2$, $Q_5$, and so forth.

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1/ The nomographs are not applicable for the corresponding metric units.

The reliability of frequency curves is related to the number of years of available flood record. The minimum number of years of record used to define floods of selected recurrence intervals in this study are:

| | | | | |
|---|---|---|---|---|
| Recurrence interval | 10 | 25 | 50 | 100 |
| Minimum years of record | 10 | 15 | 20 | 25 |

Magnitudes of floods for these recurrence intervals will have about equal reliability according to Hardison (1969). These standards were relaxed slightly by using most of the records collected under the crest-stage program (18 years) to define the 50-year flood. The peak discharge for selected frequencies for all stations considered in this study are given in table 1.

## Multiple-Regression Model

The regression model used in this analysis is of the form

$$Q_n = aA^bB^cC^d \ldots \qquad (1)$$

Where $Q_n$ is a flood discharge having an n-year recurrence interval:

A, B, and C are basin characteristics;

a is the regression constant; and

b, c, and d are coefficients defined by regression analysis.

Past experience has indicated the general applicability of this regression model--the log transform of which is linear--in hydrologic studies. The step-backward method of multiple regression was used to relate a selected flood characteristic to one or more basin characteristics to form the regression equation. In the initial equation all basin characteristics were related to a flood characteristic. The calculations were sequentially repeated with the least significant basin characteristic omitted each time until only the most significant one remained. The standard error of estimate, the statistical significance of each basin characteristic, and other statistical data were determined for each successive calculation. This process was repeated for each of the flood characteristics.

Further analysis was made using residuals based on regression equations for which all parameters in the relation had greater than a 0.05 significance level. The residual is an index of departure from the expected and is used to check for regional groupings that would indicate a poorly defined relation or an undetected variable. The regional boundaries on plate 1 were defined on the basis of residuals.

## Basin Characteristics Investigated in the Analysis

The basin characteristics tested in the regression analysis are given below. Some of the characteristics are poorly defined because much of the State is not covered by large-scale topographic maps, land use is continually changing and much of the aerial photographic coverage is 10 to 20 years old, and climatological and soils data are not available to the extent desired.

- Drainage area
- Main-channel slope
- Stream length
- Surface storage
- Soil-infiltration index
- Basin shape
- Annual snowfall
- 10-yr snowfall
- 100-yr snowfall
- Annual evaporation
- Thunderstorm days
- Stream density
- Basin elevation
- Forest cover
- Annual precipitation
- Rainfall intensity
- Maximum March temperature
- Minimum January temperature
- Maximum July temperature
- Upper basin slope
- Gage vicinity slope
- Cultivated area
- Main channel/wind aspect

## FLOODS OF RECORD

The maximum discharges of record for unregulated streams draining less than 500 $mi^2$ (1,300 $km^2$) are plotted against drainage area in figures 4, 5, and 6. The plots also include significant maximum discharges at miscellaneous sites. A curve of maximum flood experience of record is shown on each of the figures. The wide spread (three orders of magnitude) of flood peaks for a given drainage area suggests that adequate areal definition requires data at many sites.

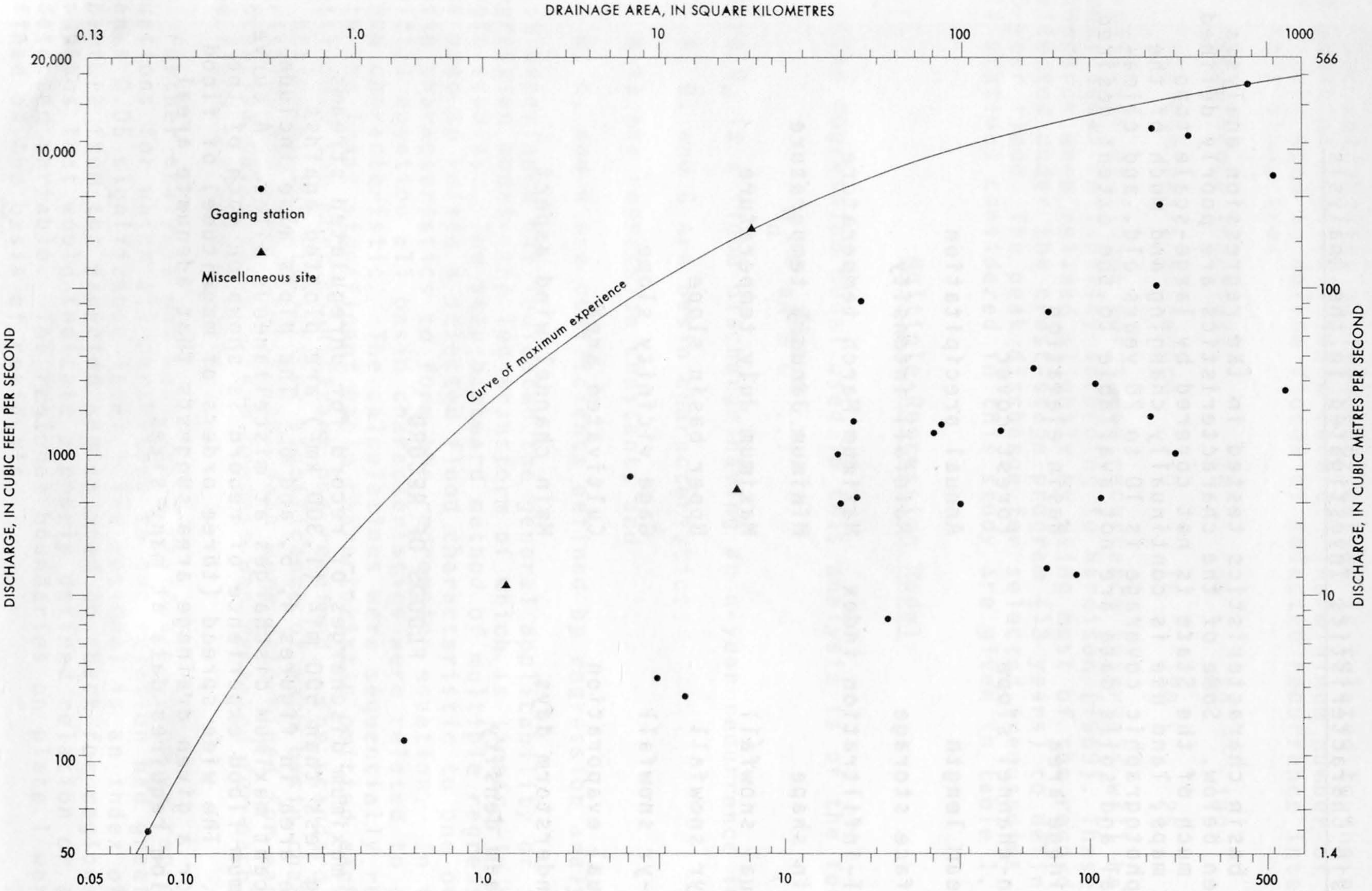


FIGURE 4. —Maximum known discharges in relation to drainage area in Region A.

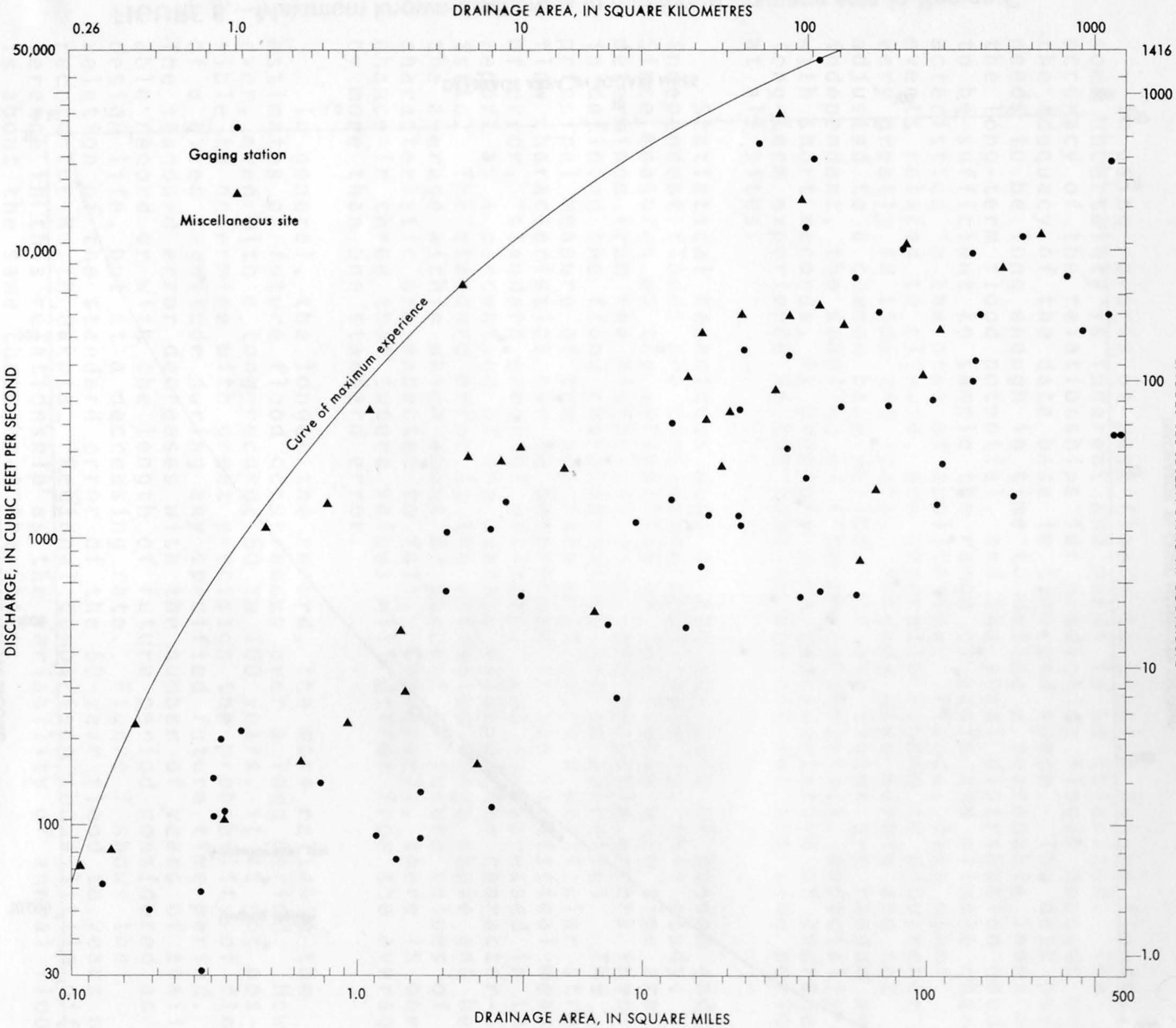


FIGURE 5.—Maximum known discharges in relation to drainage area in Region B.

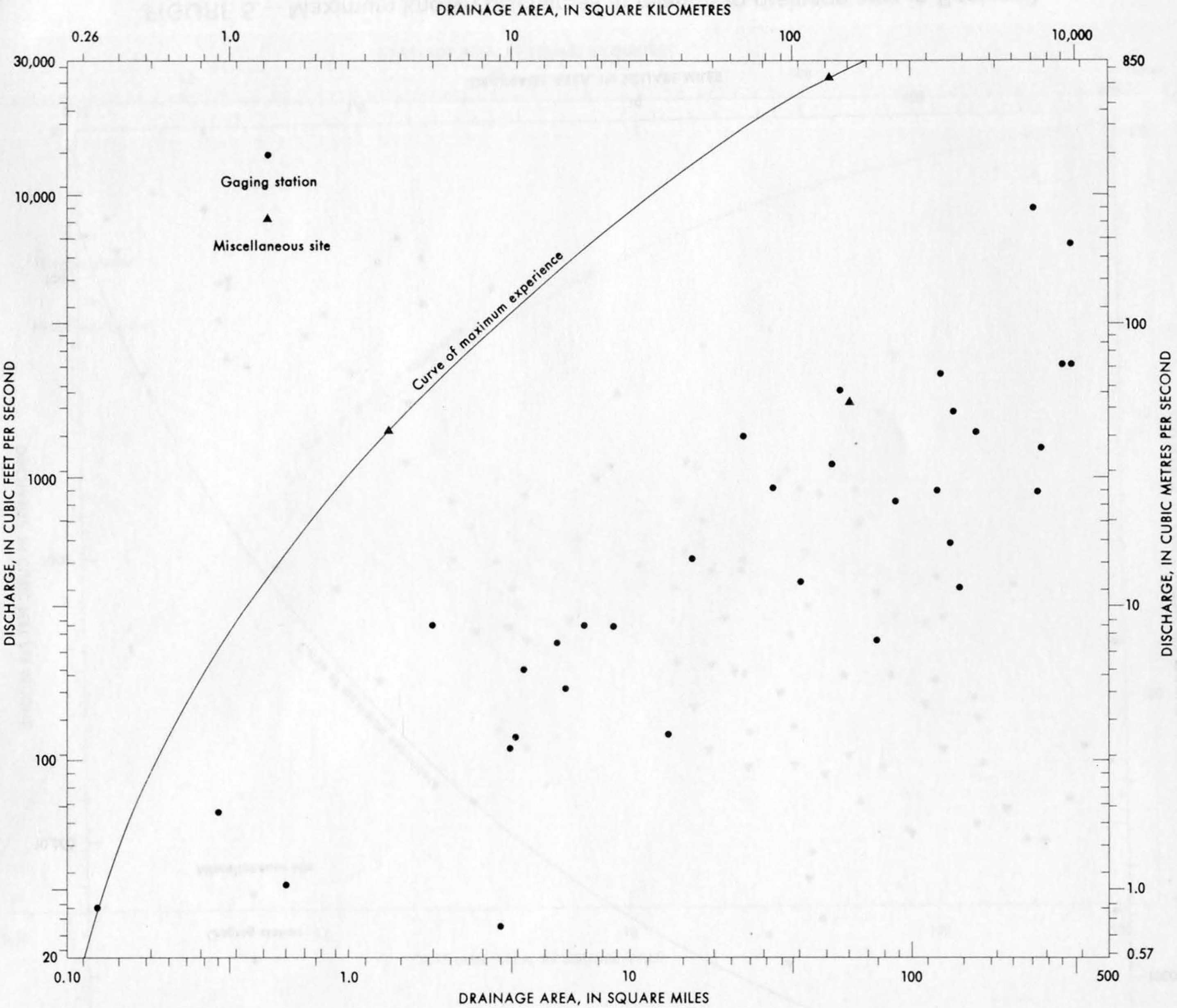


FIGURE 6.—Maximum known discharges in relation to drainage area in Region C.

## ACCURACY AND LIMITATIONS

In using records of past floods to predict future floods, some uncertainty is inherent and needs to be tolerated. The accuracy of the relationships for predicting floods depends on the adequacy of the data base in time and space. The data base needs to be long enough in time to define a reasonable index of the long-term flood potential, and the areal distribution needs to be sufficient to sample the range of basin and climate characteristics in the area of application. Floods, like other events related to climate, are generally random in occurrence and vary greatly in time and space. Records used herein are not adjusted to a common base period. If the floods are random and independent, the sampling of flow characteristics, especially with short records, is probably more representative of average long-term experience if the samples are not for the same period at all sites.

Statistical techniques used in the analysis of random and independent floods are considered applicable for this study. Since measures of the variability of the floods with time are determined from the historical data, the probable errors involved in defining the flood characteristics can be appraised. The principal measure of the accuracy with which a particular streamflow characteristics can be determined is the statistical measure of error, "standard error of estimate," and is expressed in this report as a percentage of the average value of the characteristic. The standard error is the estimated range above and below the average within which about 67 percent of future values of the characteristic are expected to fall. Conversely, there is one chance in three that future values will differ from the average by more than one standard error.

In general, the longer the record, the more reliable the estimates of future flood occurrences over a long period. However, even with a long record, 50 to 100 years, it is not possible to determine with great precision the probability of floods of a given magnitude during any specified future time period. The standard error decreases with the number of years of available record or with the length of future period considered as a design life, but at a decreasing rate. Figure 7 shows the relation of the standard error of the 50-year flood to years of record for North Dakota. Regional comparison shows little difference in this relationship as the variability of annual floods is about the same throughout the State.

The incremental economic value of additional years of record beyond a reasonable limit for planning and design of projects needs to be considered.

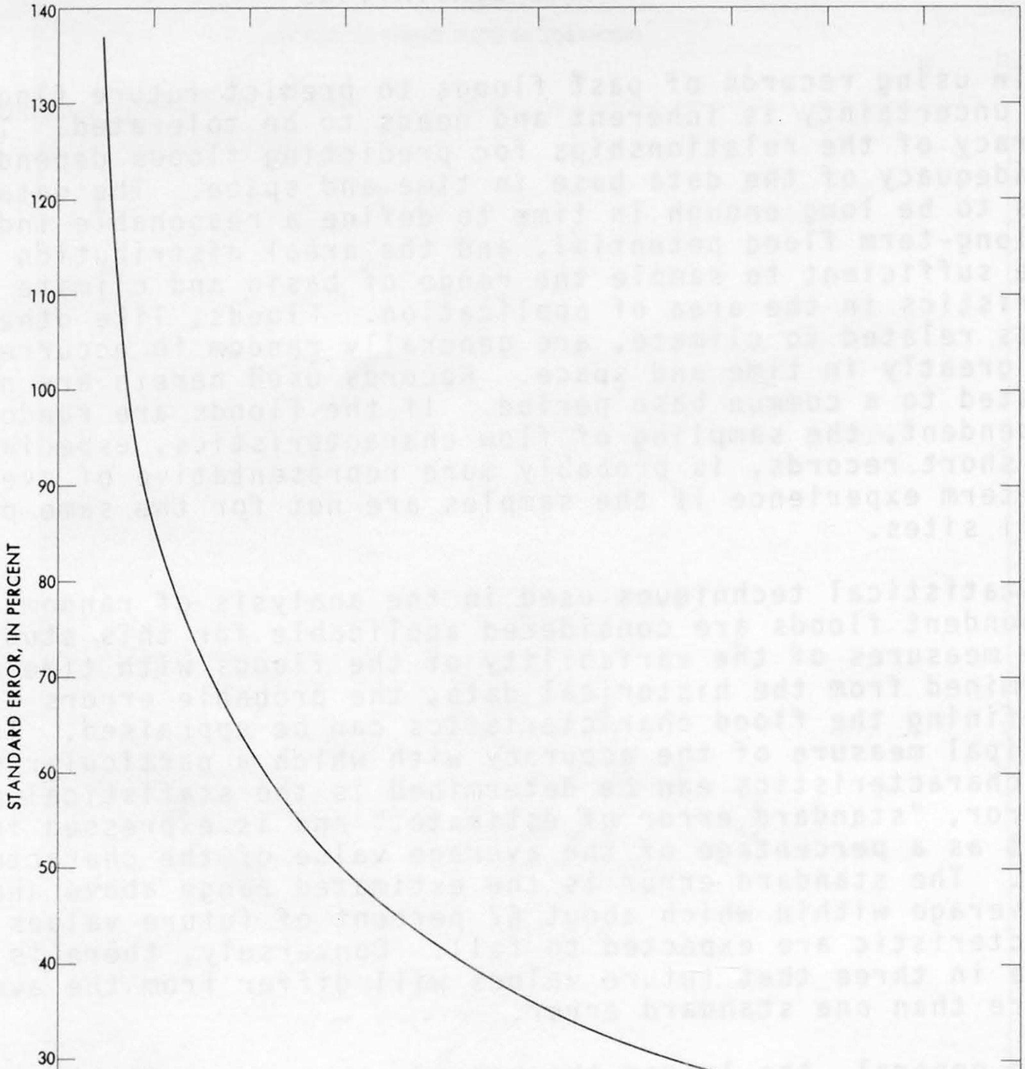


FIGURE 7.—Relation of standard error to years of record for the 50-year recurrence interval flood

This report is based on records of flood discharges from streams that are virtually unaffected by regulation or diversions. It is almost impossible to avoid areas with stock ponds so most records include their influence. The methods described herein are not applicable for streams subject to any other regulation or diversion without making allowances for the effects of these activities on the flood discharges. Effects of additional regulation need to be evaluated for the individual site.

The flood-frequency relation for a stream is altered considerably with urbanization. The effects of urbanization are not evaluated in this report and the methods described are not applicable in urban areas.

The methods in this report are applicable only for estimating flood magnitudes and frequencies for drainage areas less than 100 $mi^2$ (259 $km^2$).

## ADDITIONAL DATA ACQUISITION

The Federal Interagency Work Group, impaneled in 1971 by the Office of Water Data Coordination, U.S. Geological Survey, has recommended as an accuracy goal for flow characteristics--an accuracy equal to that with which the flow characteristic could be defined by 10 or more years of observed record at the site. The accuracy of the 50-year recurrence interval flood as stated in the statistical concept "standard error" is 86 percent (fig. 7). The average standard errors from the regression equations (table 2) range from 70 to 86 percent. Therefore, only a few of the stations need to be selected for an indefinite term of continued operation to detect long-term trends.

Effort could be directed toward preparation of a magnitude and frequency report by regression methods applicable to all drainage area sizes, as this would give some means of evaluating the accuracy of flood estimates for the larger basins.

Most small area drainage structures have some built-in upstream storage capacity. Consideration could be given to the installation of rainfall and runoff recorders at several sites for a period of time to define rainfall-runoff hydrographs to give the user of the data some indication of flood volumes from these areas.

TABLE 1.--Drainage areas, soil-infiltration indexes, flood discharges at selected frequencies, and maximum flows of record for gaging stations considered in this report

| Station number | Station name | Drainage area ($mi^2$) | Soil-infiltration index (inches) | Discharge ($ft^3/s$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Recurrence interval (years) | | | | | Maximum of record |
| | | | | 2 | 5 | 10 | 25 | 50 | |
| | Red River of the North basin | | | | | | | | |
| 05051800 | Grass Lake trib. nr Lidgerwood | 0.61 | 3.2 | 8.9 | 20 | 30 | 41 | 51 | 36 |
| 05051900 | Wild Rice River trib. nr Mantador | 4.3 | 3.2 | 5.1 | 25 | 66 | 214 | 495 | 210 |
| 05055200 | Big Coulee nr Maddock | 90 | 2.7 | 179 | 412 | 611 | 900 | 1,140 | 810 |
| 05055520 | Big Coulee nr Fort Totten | 7.7 | 3.3 | 84 | 155 | 214 | 301 | -- | 270 |
| 05056020 | Mauvais Coulee trib nr Bisbee | 8.9 | 2.6 | 18 | 78 | 162 | 335 | 537 | 300 |
| 05056040 | Mauvais Coulee trib No. 2 nr Cando | 17 | 2.8 | 59 | 191 | 319 | 508 | 664 | 520 |
| 05056060 | Mauvais Coulee trib No. 3 nr Cando | 129 | 2.8 | 161 | 665 | 1,110 | 1,650 | 2,020 | 2,300 |
| 05056080 | Mauvais Coulee trib No. 4 nr Bisbee | 53 | 2.8 | 81 | 322 | 611 | 1,120 | 1,650 | 1,100 |
| 05056900 | Sheyenne River trib nr Cooperstown | 15 | 2.4 | 343 | 661 | 854 | 1,060 | 1,180 | 1,000 |
| 05056950 | Sheyenne River trib No. 2 nr Cooperstown | .08 | 1.6 | 6.2 | 18 | 31 | 59 | 87 | 59 |
| 05059600 | Maple River nr Hope | 17.4 | 3.2 | 361 | 585 | 733 | 916 | 1,050 | 734 |
| 05059800 | Swan Creek nr Absaraka | 33 | 3.2 | 90 | 240 | 400 | 685 | 970 | 930 |
| 05059850 | Swan Creek trib nr Ayr | 4.0 | 3.2 | 18 | 54 | 91 | 153 | 211 | 120 |
| 05059900 | Swan Creek nr Casselton | 57 | 2.9 | 219 | 695 | 1,090 | 1,580 | 1,920 | 2,000 |
| 05059950 | Swan Creek trib nr Casselton | 14 | 2.0 | 43 | 116 | 187 | 300 | 399 | 225 |
| 05060500 | Rush River at Amenia | 116 | 3.2 | 288 | 649 | 964 | 1,440 | 1,840 | 1,690 |
| 05065700 | M. Br. Goose River nr Finley | 33 | 3.0 | 569 | 1,000 | 1,270 | 1,580 | -- | 1,250 |
| 05065800 | M. Br. Goose River trib nr Finley | 18 | 3.2 | 367 | 833 | 1,480 | 3,100 | -- | 3,200 |

| Station number | Station name | Drainage area (mi$^2$) | Soil-infiltration index (inches) | Discharge (ft$^3$/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Recurrence interval (years) | | | | | Maximum of record |
| | | | | 2 | 5 | 10 | 25 | 50 | |
| | Red River of the North basin (cont.) | | | | | | | | |
| 05082600 | English Coulee trib nr Grand Forks | 4.7 | 2.1 | 59 | 123 | 152 | 174 | 183 | 164 |
| 05082680 | Saltwater Coulee trib nr Grand Forks | 22 | 3.2 | 143 | 318 | 393 | 446 | 466 | 290 |
| 05082700 | Saltwater Coulee nr Emerado | 110 | 2.9 | 241 | 509 | 670 | 835 | 930 | 730 |
| 05082900 | Freshwater Coulee nr Emerado | 31 | 2.3 | 355 | 764 | 1,010 | 1,260 | 1,400 | 1,180 |
| 05083600 | M. Br. Forest River nr Whitman | 73 | 2.5 | 84 | 274 | 438 | 652 | -- | 425 |
| 05089100 | M. Br. Park River nr Union | 15 | 2.5 | 361 | 619 | 767 | 922 | -- | 700 |
| 05089200 | N. Br. Park River nr Gardar | 52 | 2.7 | 429 | 1,190 | 1,580 | 1,890 | 2,020 | 1,200 |
| 05089500 | Cart Creek at Mountain | 17 | 2.7 | 281 | 604 | 841 | 1,140 | 1,360 | 1,300 |
| 05089700 | Cart Creek at Crystal | 74 | 2.6 | 781 | 2,140 | 2,800 | 3,270 | 3,450 | 2,950 |
| 05089800 | Cart Creek trib nr Crystal | 3.8 | 2.2 | 60 | 103 | 121 | 134 | 140 | 187 |
| 05098700 | Hidden Island Coulee nr Hansboro | 27 | 2.5 | 144 | 404 | 647 | 1,020 | -- | 700 |
| 05098800 | Cypress Creek nr Sarles | 59 | 2.5 | 461 | 1,040 | 1,600 | 2,520 | -- | 1,920 |
| 05113450 | Long Creek trib No. 2 nr Crosby | 5.6 | 2.6 | 39 | 103 | 177 | 326 | 491 | 260 |
| 05113520 | Long Creek trib nr Crosby | .35 | 3.0 | 14 | 27 | 39 | 57 | 74 | 65 |
| 05116100 | Souris River trib. nr Burlington | .13 | 3.3 | 6.6 | 20 | 31 | 47 | 60 | 30 |
| 05116200 | Des Lacs River trib nr Donnybrook | 3.8 | 3.0 | 57 | 132 | 178 | 227 | 256 | 210 |
| 05116550 | Fuller Coulee at Foxholm | 5.9 | 3.0 | 64 | 166 | 255 | 386 | 493 | 280 |
| 05117200 | Souris River trib No. 2 nr Burlington | 2.0 | 3.3 | 29 | 89 | 152 | 255 | 349 | 300 |
| 05122500 | Willow Creek at Dunseith | 91 | 1.9 | 92 | 281 | 463 | 742 | 974 | 476 |

| Station number | Station name | Drainage area (mi²) | Soil-infiltration index (inches) | Discharge (ft³/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Recurrence interval (years) | | | | | Maximum of record |
| | | | | 2 | 5 | 10 | 25 | 50 | |
| | Red River of the North basin (cont.) | | | | | | | | |
| 05123300 | Oak Creek trib nr Bottineau | 3.1 | 3.0 | 125 | 356 | 551 | 815 | 1,020 | 851 |
| 05123350 | Oak Creek trib No. 5 nr Bottineau | .56 | 3.0 | 40 | 90 | 115 | 134 | 142 | 118 |
| 05123520 | Egg Creek nr Glenburn | 7.0 | 3.5 | 17 | 82 | 170 | 348 | 540 | 300 |
| 05123540 | Egg Creek nr Ruthville | 26 | 3.5 | 162 | 398 | 626 | 1,000 | 1,360 | 1,400 |
| 05123560 | Egg Creek trib nr Deering | 3.8 | 3.5 | 4.1 | 11 | 19 | 32 | 46 | 26 |
| 05123580 | Egg Creek nr Deering | 41 | 3.5 | 74 | 167 | 225 | 286 | 321 | 430 |
| 05123900 | Boundary Creek nr Landa | 170 | 2.5 | 184 | 579 | 1,120 | 2,370 | 3,950 | 3,580 |
| | Painted Woods Creek basin | | | | | | | | |
| 06329700 | Painted Woods Creek trib nr Williston | 0.37 | 3.7 | 8.5 | 33 | 65 | 134 | 214 | 110 |
| 06329800 | Painted Woods Creek nr Williston | 17 | 3.7 | 79 | 243 | 488 | 1,130 | 2,040 | 1,200 |
| 06329900 | Painted Woods Creek trib No. 2 nr Williston | 8.3 | 3.7 | 33 | 114 | 197 | 331 | 451 | 276 |
| | Sand Creek basin | | | | | | | | |
| 06330100 | Sand Creek at Williston | 38 | 3.7 | 141 | 492 | 892 | 1,620 | 2,320 | 1,600 |
| | White Earth River basin | | | | | | | | |
| 06331900 | White Earth River trib nr Tioga | 9.6 | 3.7 | 64 | 184 | 361 | 812 | 1,440 | 1,120 |
| 06332150 | White Earth River trib nr White Earth | .32 | 3.0 | 22 | 58 | 86 | 122 | 148 | 107 |

| Station number | Station name | Drainage area ($mi^2$) | Soil-infiltration index (inches) | Discharge ($ft^3/s$) Recurrence interval (years) 2 | 5 | 10 | 25 | 50 | Maximum of record |
|---|---|---|---|---|---|---|---|---|---|
| | **Little Missouri River basin** | | | | | | | | |
| 06335700 | Deep Creek nr Bowman | 0.29 | 3.9 | 12 | 26 | 40 | 63 | 86 | 58 |
| 06336100 | Sheep Creek trib nr Medora | .32 | 2.3 | 24 | 49 | 72 | 110 | 145 | 147 |
| 06336200 | Sheep Creek trib No. 2 nr Medora | .40 | 2.3 | 52 | 134 | 173 | 203 | 215 | 210 |
| 06336300 | Little Missouri River trib nr Medora | .34 | 2.3 | 3.3 | 15 | 36 | 93 | 187 | 200 |
| 06336400 | Jules Creek nr Medora | 3.8 | 2.3 | 211 | 421 | 547 | 680 | 758 | 629 |
| 06336980 | Little Missouri River trib nr Watford City | 2.1 | 2.3 | 283 | 717 | 1,060 | 1,520 | 1,850 | 1,050 |
| 06337100 | Spring Creek nr Watford City | 23 | 3.2 | 303 | 747 | 1,110 | 1,620 | 2,010 | 1,100 |
| | **Douglas Creek basin** | | | | | | | | |
| 06337600 | E. Br. Douglas Creek trib nr Garrison | 1.4 | 3.7 | 31 | 57 | 76 | 99 | 115 | 76 |
| | **Snake Creek basin** | | | | | | | | |
| 06337900 | Snake Creek trib nr Garrison | 1.2 | 3.5 | 13 | 29 | 46 | 77 | 109 | 92 |
| | **Knife River basin** | | | | | | | | |
| 06340200 | W. Br. Otter Creek nr Beulah | 26 | 3.0 | 299 | 493 | 641 | 849 | -- | 23,700 |
| 06340300 | Otter Creek nr Hannover | 43 | 3.0 | 605 | 823 | 896 | 942 | -- | 45,300 |

| Station number | Station name | Drainage area (mi$^2$) | Soil-infiltration index (inches) | Discharge (ft$^3$/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Recurrence interval (years) | | | | | Maximum of record |
| | | | | 2 | 5 | 10 | 25 | 50 | |
| | Square Butte Creek basin | | | | | | | | |
| 06342050 | Sq. Butte Creek at Center | 57 | 3.6 | 345 | 1,300 | 2,650 | 5,820 | 9,760 | 8,000 |
| 06342100 | Sq. Butte Creek trib No. 2 nr Center | 13 | 2.8 | 197 | 509 | 894 | 1,720 | 2,710 | 2,500 |
| 06342150 | Sq. Butte Creek trib nr Center | .19 | 2.8 | 15 | 28 | 35 | 41 | 45 | 51 |
| 06342250 | Sq. Butte Creek trib No. 3 nr Center | 1.7 | 2.8 | 44 | 83 | 110 | 143 | 165 | 130 |
| | Burnt Creek basin | | | | | | | | |
| 06342300 | Burnt Creek trib nr Baldwin | 3.0 | 2.8 | 147 | 417 | 654 | 990 | 1,250 | 1,080 |
| 06342350 | Burnt Creek trib No. 2 nr Baldwin | 2.1 | 2.8 | 106 | 291 | 468 | 748 | 993 | 652 |
| | Heart River basin | | | | | | | | |
| 06343200 | Heart River trib nr South Heart | .12 | 2.2 | 13 | 31 | 47 | 70 | 89 | 62 |
| 06344200 | Heart River trib nr Dickinson | 1.7 | 3.2 | 14 | 37 | 55 | 80 | 100 | 90 |
| 06345100 | Antelope Creek nr Dickinson | 69 | 2.3 | 578 | 2,780 | 5,070 | 8,310 | 10,700 | 6,100 |
| 06345200 | Antelope Creek trib nr New England | 13 | 3.2 | 177 | 615 | 1,070 | 1,790 | 2,430 | 1,360 |
| 06345300 | Antelope Creek trib (site (No. 2) nr New England | 22 | 3.2 | 326 | 875 | 1,170 | 1,410 | 1,520 | 1,200 |
| 06345700 | Government Creek nr Richardton | 33 | 3.2 | 273 | 1,000 | 1,930 | 3,760 | 5,770 | 4,300 |
| 06347100 | Wilson Creek nr Glen Ullin | 41 | 2.3 | 789 | 1,640 | 2,310 | 3,240 | -- | 20,800 |
| 06347200 | Hailstone Crk nr Bluegrass | 39 | 2.6 | 491 | 997 | 1,330 | 1,710 | -- | 12,000 |

| Station number | Station name | Drainage area (mi$^2$) | Soil-infiltration index (inches) | Discharge (ft$^3$/s) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Recurrence interval (years) | | | | | Maximum of record |
| | | | | 2 | 5 | 10 | 25 | 50 | |
| | Apple Creek basin | | | | | | | | |
| 06349100 | Dead Buffalo Lake trib nr Steele | 5.9 | 3.7 | 28 | 52 | 72 | 99 | 121 | 116 |
| 06349200 | W. Br. Long Lake Creek nr Hazelton | 16 | 3.6 | 71 | 343 | 634 | 1,060 | 1,410 | 798 |
| | Cannonball River basin | | | | | | | | |
| 06351650 | M. Fk. Cedar Creek nr Buffalo Springs | 33 | 3.3 | 301 | 656 | 1,090 | 2,020 | -- | 2,050 |
| 06351680 | White Butte Fork Cedar Creek nr Scranton | 43 | 3.1 | 390 | 746 | 879 | 963 | -- | 645 |
| 06353600 | Louise Creek trib nr Brisbane | .29 | 4.7 | 9.9 | 19 | 25 | 32 | 37 | 31 |
| 06353700 | Louise Creek trib nr Lark | .76 | 4.7 | 25 | 57 | 84 | 124 | 156 | 140 |
| 06353800 | Louise Creek trib No. 2 nr Lark | 7.7 | 3.2 | 30 | 99 | 194 | 406 | 676 | 500 |
| 06353900 | Louise Creek above Flasher | 110 | 3.7 | 258 | 743 | 1,190 | 1,860 | 2,430 | 1,300 |
| | Beaver Creek basin | | | | | | | | |
| 06354700 | Spring Creek nr Linton | 23 | 3.5 | 144 | 802 | 1,740 | 3,670 | 5,670 | 2,790 |
| 06354750 | Sand Creek trib nr Hazelton | 3.0 | 3.5 | 18 | 41 | 63 | 100 | 138 | 60 |
| 06354800 | Sand Creek nr Temvik | 23 | 2.7 | 151 | 702 | 1,580 | 3,700 | 6,550 | 4,500 |
| | Grand River basin | | | | | | | | |
| 06354885 | N. Fk. Grand River trib nr Bowman | 37 | 2.8 | 364 | 613 | 770 | 950 | -- | 621 |
| 06354900 | Spring Creek nr Bowman | 51 | 2.5 | 123 | 598 | 1,110 | 1,860 | 2,480 | 2,880 |
| 06354950 | Spring Creek trib nr Bowman | 15 | 2.5 | 59 | 175 | 304 | 535 | 777 | 488 |

| Station number | Station name | Drainage area (mi²) | Soil-infiltration index (inches) | Discharge (ft³/s) Recurrence interval (years) 2 | 5 | 10 | 25 | 50 | Maximum of record |
|---|---|---|---|---|---|---|---|---|---|
| | Grand River basin (cont.) | | | | | | | | |
| 06354985 | Alkali Creek nr Bowman | 58 | 2.5 | 376 | 621 | 714 | 778 | -- | 628 |
| 06355200 | Buffalo Creek trib nr Buffalo Springs | 3.4 | 3.0 | 29 | 147 | 324 | 698 | 1,150 | 1,320 |
| | James River basin | | | | | | | | |
| 06467600 | James River nr Manfred | 56 | 3.3 | 93 | 315 | 534 | 867 | 1,150 | 900 |
| 06467650 | James River trib nr Manfred | 37 | 3.3 | 21 | 100 | 215 | 463 | 750 | 375 |
| 06467800 | James River trib No. 3 nr Manfred | 20 | 2.0 | 16 | 53 | 89 | 144 | 191 | 150 |
| 06469600 | Mpls. Flats Creek trib nr Eldridge | 9.9 | 3.7 | 14 | 36 | 56 | 83 | 107 | 90 |
| 06470200 | Beaver Creek trib nr Eldridge | .19 | 3.3 | 9.0 | 23 | 34 | 47 | 56 | 45 |
| 06470300 | Beaver Creek nr Sydney | 62 | 3.3 | 119 | 486 | 884 | 1,520 | 2,060 | 1,010 |
| 06470400 | Buffalo Creek trib nr Sydney | 26 | 3.3 | 30 | 109 | 195 | 339 | 469 | 340 |

TABLE 2.--Summary of regression equations for estimating peak discharges in North Dakota

| Region | Regression equation | Standard error of estimate (percent) Average | Range |
|---|---|---|---|
| A | $Q_2 = 8A^{0.40}Si^{2.09}$ | 68 | -47 to +89 |
| | $Q_5 = 26A^{0.42}Si^{1.68}$ | 62 | -44 to +79 |
| | $Q_{10} = 43A^{0.42}Si^{1.50}$ | 64 | -45 to +82 |
| | $Q_{25} = 71A^{0.42}Si^{1.32}$ | 74 | -50 to +98 |
| | $Q_{50} = 94A^{0.42}Si^{1.24}$ | 86 | -54 to +144 |
| B | $Q_2 = 196A^{0.60}Si^{-1.74}$ | 74 | -50 to +99 |
| | $Q_5 = 465A^{0.63}Si^{-1.66}$ | 64 | -45 to +82 |
| | $Q_{10} = 626A^{0.64}Si^{-1.52}$ | 65 | -46 to +84 |
| | $Q_{25} = 766A^{0.65}Si^{-1.30}$ | 74 | -50 to +98 |
| | $Q_{50} = 848A^{0.65}Si^{-1.14}$ | 84 | -53 to +115 |
| C | $Q_2 = 13A^{0.46}$ | 85 | -54 to +115 |
| | $Q_5 = 34A^{0.51}$ | 72 | -50 to +96 |
| | $Q_{10} = 54A^{0.53}$ | 67 | -47 to +88 |
| | $Q_{25} = 86A^{0.54}$ | 67 | -47 to +87 |
| | $Q_{50} = 115A^{0.54}$ | 70 | -48 to +92 |

$Q_n$ = Peak discharge with a recurrence interval "n", in cubic feet per second;

A = Drainage area, in square miles;

Si = Soil infiltration index, in inches.

## SELECTED REFERENCES


Benson, M. A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geol. Survey Water-Supply Paper 1580-B, 64 p.

______1964, Factors influencing the occurrence of floods in the southwest: U.S. Geol. Survey Water-Supply Paper 1580-D, 72 p.

Crosby, O. A., 1970, Proposed streamflow data program for North Dakota: U.S. Geol. Survey open-file report, 68 p.

Environmental Science Services Administration, 1968, Climatic atlas of the United States: 80 p.

Hardison, C. H., 1969, Accuracy of streamflow characteristics: U.S. Geol. Survey Prof. Paper 650-D, p. 210-214.

McCabe, J. A., and Crosby, O. A., 1959, Floods in North and South Dakota, frequency and magnitude: U.S. Geol. Survey open-file report, 132 p.

Patterson, J. L., 1966, Magnitude and frequency of floods in the United States, pt. 6A, Missouri River basin above Sioux City, Iowa: U.S. Geol. Survey Water-Supply Paper 1679, 471 p.

Patterson, J. L., and Gamble, C. R., 1968, Magnitude and frequency of floods in the United States, pt. 5, Hudson Bay and upper Mississippi River basins: U.S. Geol. Survey Water-Supply Paper 1678, 546 p.

Thomas, D. M., and Benson, M. A., 1970, Generalization of streamflow characteristics: U.S. Geol. Survey Water-Supply Paper 1975, 55 p.

U.S. Weather Bureau, 1959, Climates of the States, North Dakota: Climatography of the United States no. 60-32, 16 p.

______1961, Rainfall frequency atlas of the United States: U.S. Weather Bureau Tech. Paper no. 40, 115 p.

______1962, Mean number of thunderstorm days in the United States: U.S. Weather Bureau Tech. Paper no. 19, 22 p.

______1964, Frequency of maximum water equivalent of March snow cover in north central United States: U.S. Weather Bureau Tech. Paper no. 50, 24 p.

Water Resources Council, 1967, A uniform technique for determining floodflow frequencies: Water Res. Council Bull. 15, 15 p.




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