

U. S. DEPARTMENT OF COMMERCE

WEATHER BUREAU

TECHNICAL PAPER NO. 25

Rainfall Intensity-Duration-Frequency Curves

**For Selected Stations in the
United States, Alaska, Hawaiian Islands, and Puerto Rico**

U. S. DEPARTMENT OF COMMERCE

SINCLAIR WEEKS, *Secretary*

WEATHER BUREAU

F. W. REICHELDERFER, *Chief*

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United States, Alaska, Hawaiian Islands, and Puerto Rico

HYDROLOGIC SERVICES DIVISION

COOPERATIVE STUDIES SECTION

In cooperation with

CORPS OF ENGINEERS, U. S. ARMY

and

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



WASHINGTON, D. C.

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INTRODUCTION

This paper presents a set of rainfall intensity-duration curves for durations of 5 minutes to 24 hours, and return periods of 2, 5, 10, 25, 50 and 100 years for each of 203 U. S. Weather Bureau stations.

Much of the data analysed for these curves is a by-product of work done on transfer of funds from the military construction investigational program of the Corps of Engineers, and Watershed Improvement and Flood Prevention program of the Soil Conservation Service. The project was conducted under the supervision of J. L. Paulhus and Walter T. Wilson, former and present Chiefs of the Cooperative Studies Section of the Hydrologic Services Division, W. E. Hiatt, Chief. David M. Hershfield was project leader, assisted by N. M. Kauffman, L. L. Weiss, and A. R. Pagan. Computations and other work were done by Annie Laurie Criss, Lillian C. Langdon, Edith E. Marlowe and Bonnie R. True, drafting by C. W. Gardner. Max A. Kohler, A. L. Shands and H. C. S. Thom acted as consultants.

The data are almost entirely from tipping-bucket gages, with some data from weighing-recorders. No evaluation was made of gage exposures, or changes in gage exposure at the stations. The 60-minute data are not for clock-hour, but for the 60 consecutive minutes having the maximum total precipitation each year, and similarly for other durations. Some of the curves, particularly for those stations with relatively short records, have been smoothed slightly.

The curves in the diagrams are spaced according to the Fisher-Tippett Type I (Gumbel) distribution¹. For discussion of other distributions, and transformations among them, reference is made to the bibliography appearing in a paper by Chow².

The curves in this paper are from the annual series (maximum value for each year) which for many applications is less appropriate than the partial-duration series³. The partial-duration series includes all the high values and recog-

nizes that the second-highest of some year might exceed the highest of some other year. For the partial-duration series a distribution could be fitted and extrapolated, as for the annual series, but the processing of partial-duration data is very laborious.

On the basis of a selected sample of 50 precipitation stations, empirical factors have been found for transforming the annual series to the partial-duration series. To transform values from the curves in this paper to corresponding partial-duration values, multiply them by the following factors:

2-year return period, 1.13
5-year return period, 1.04
10-year return period, 1.01

For longer return periods the differences between the two series are regarded as insignificant.

When rainfall intensity-frequency data are needed at a point an appreciable distance from the nearest long-record station, it is usually better to use local data than to interpolate solely among the sparse first-order stations. Local data will usually include a few station-years of recorder data and some long records of daily data. These local data can be exploited by relating the local short-record rainfall intensity data to the corresponding longer record data from nearby first-order stations, and relating the local values of daily rainfall to the characteristic intensity-duration curves of the nearby first-order stations. These methods are illustrated in Weather Bureau Technical Paper No. 24, Parts I and II of which cover the United States from Denver west^{4,5}.

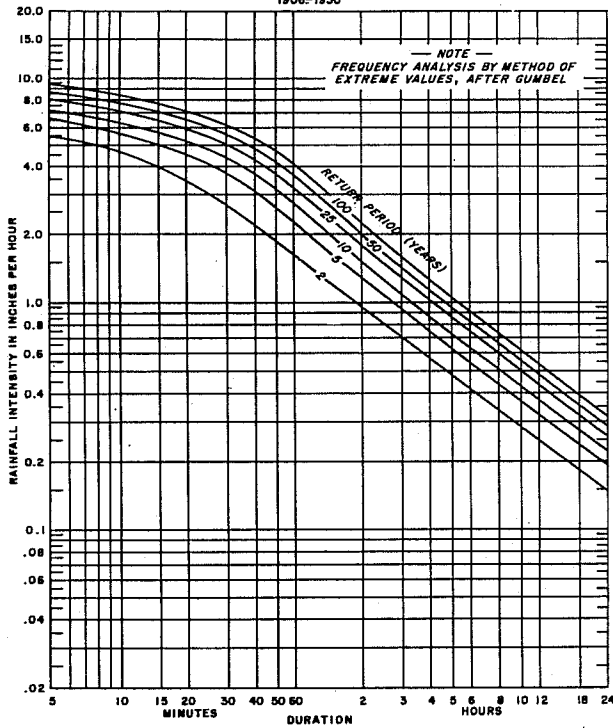
Comparison of data from Technical Paper No. 24 with data in this paper will show differences in most instances because the data in Technical Paper No. 24 are based on the partial-duration series, with the results subjected to considerable areal generalization and smoothing of the relationships.

REFERENCES

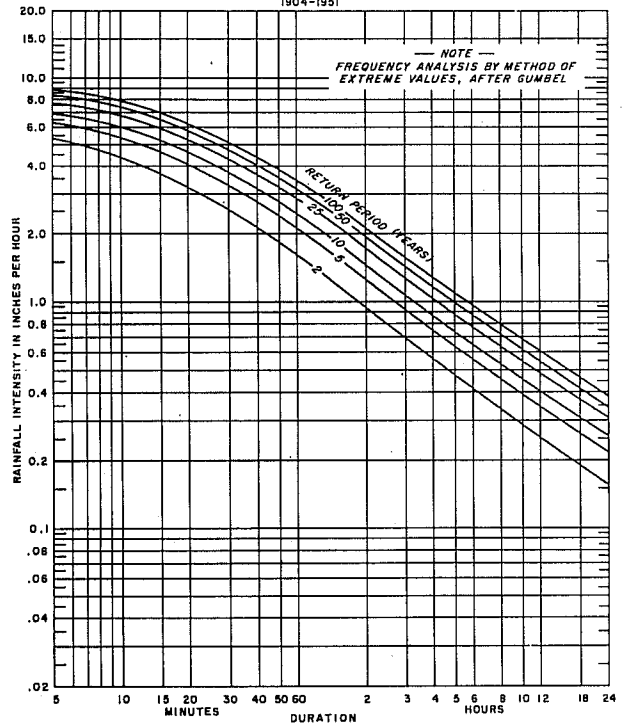
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2. Ven Te Chow, "The log-probability law and its engineering applications," Proceedings, American Society Civil Engineers, Separate No. 536, vol. 80, November 1954.
3. W.B. Langbein, "Annual floods and the partial-duration series," Transactions American Geophysical Union, vol. 30, no. 6, 1949, pp. 879-881.
4. U. S. Weather Bureau, "Rainfall intensities for local drainage design in the United States, Part I, West of the 115th Meridian," Technical Paper No. 24, Washington, D. C., August 1953. (Revised February 1955).
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RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

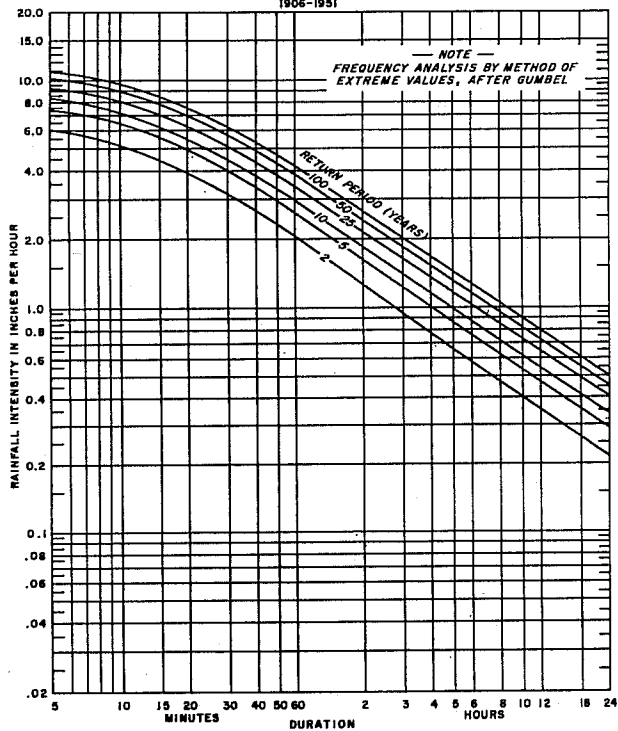
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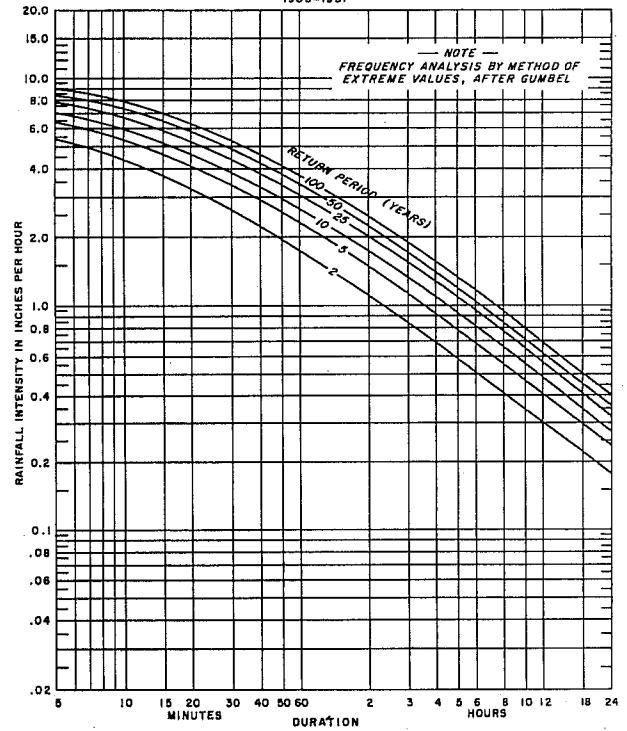
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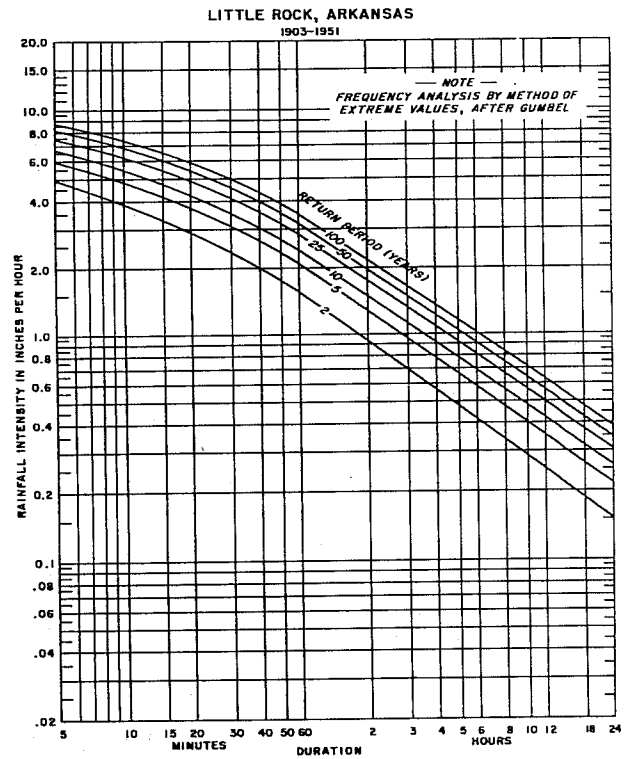
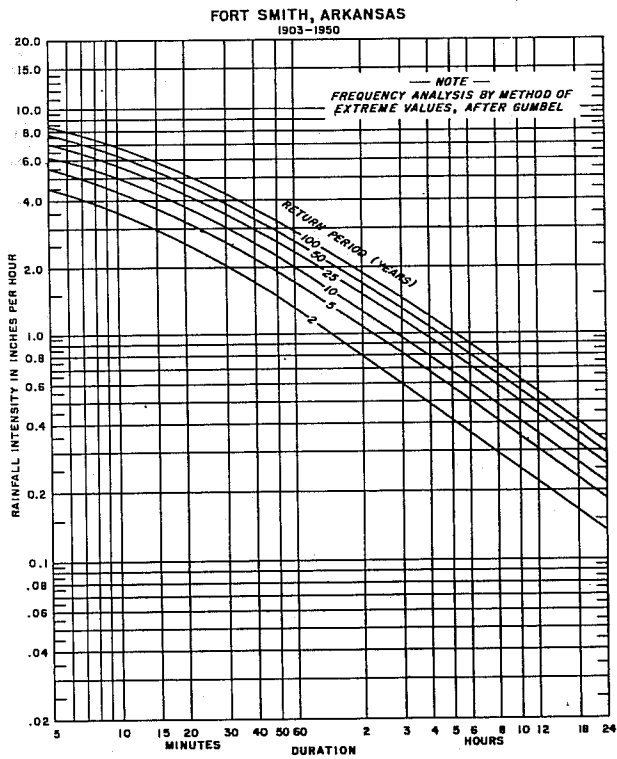
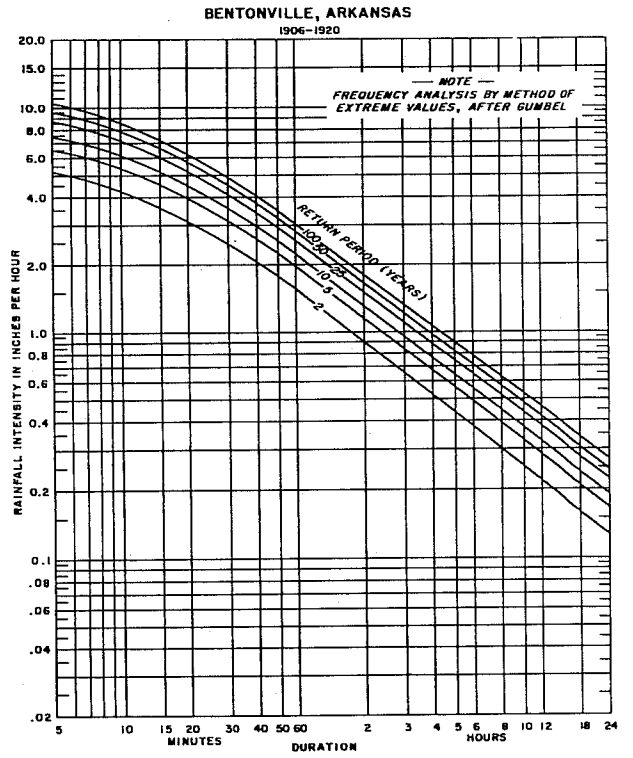
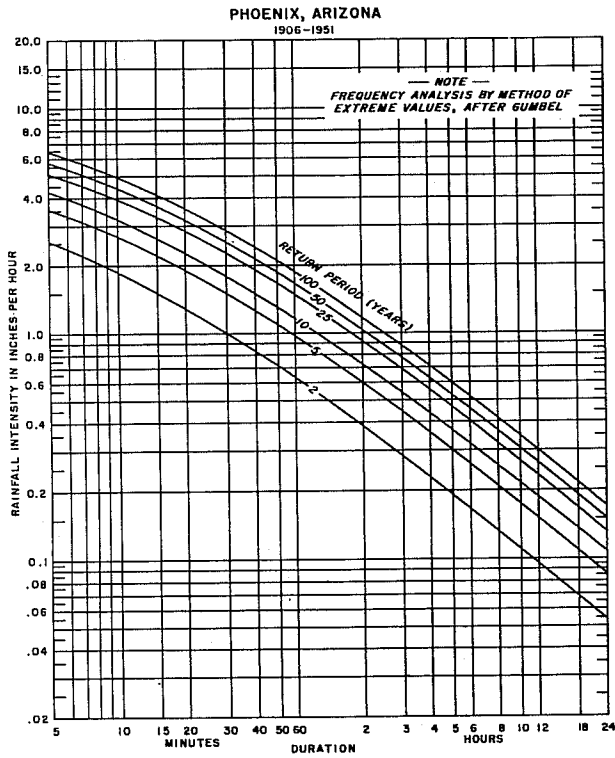
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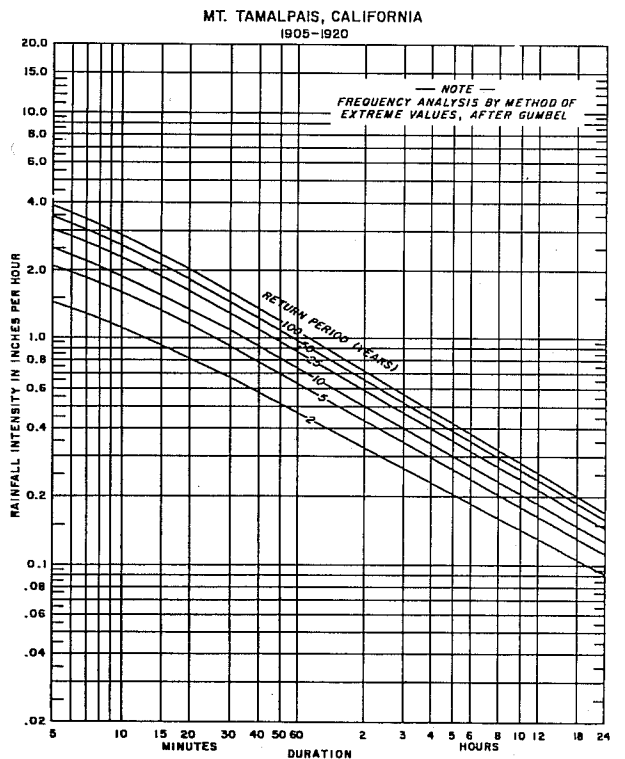
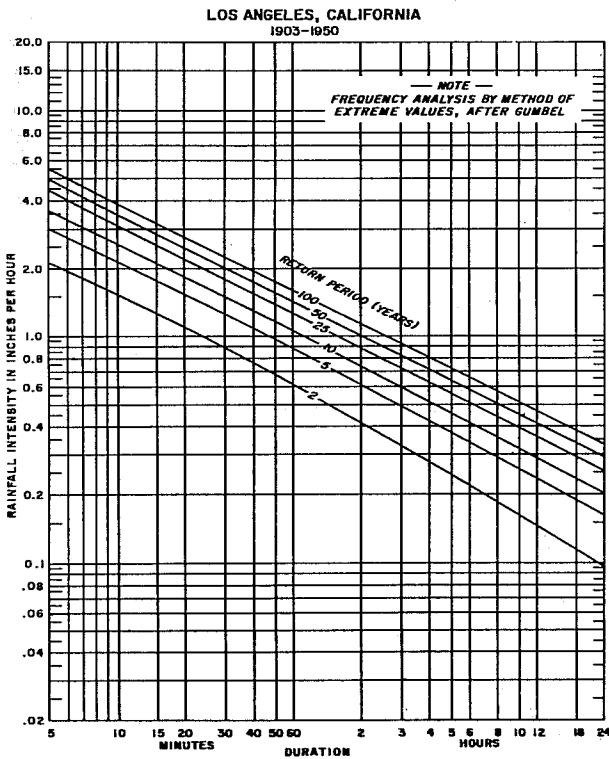
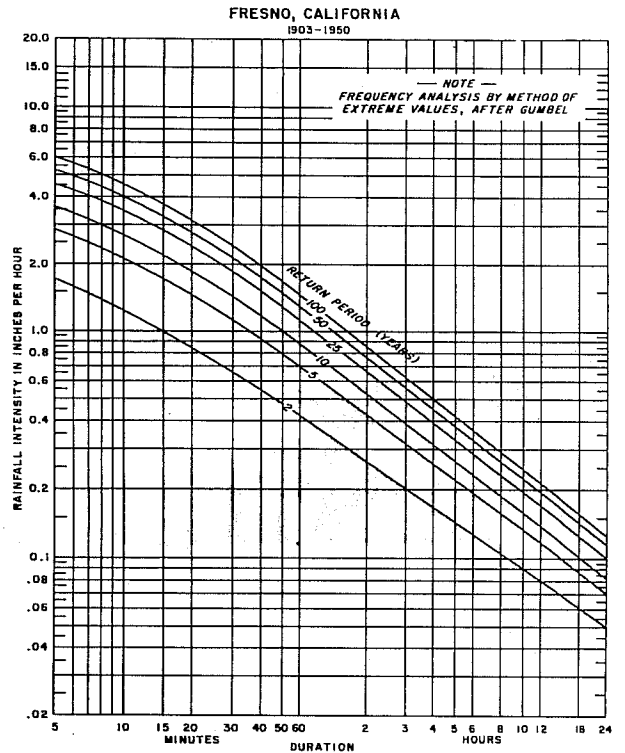
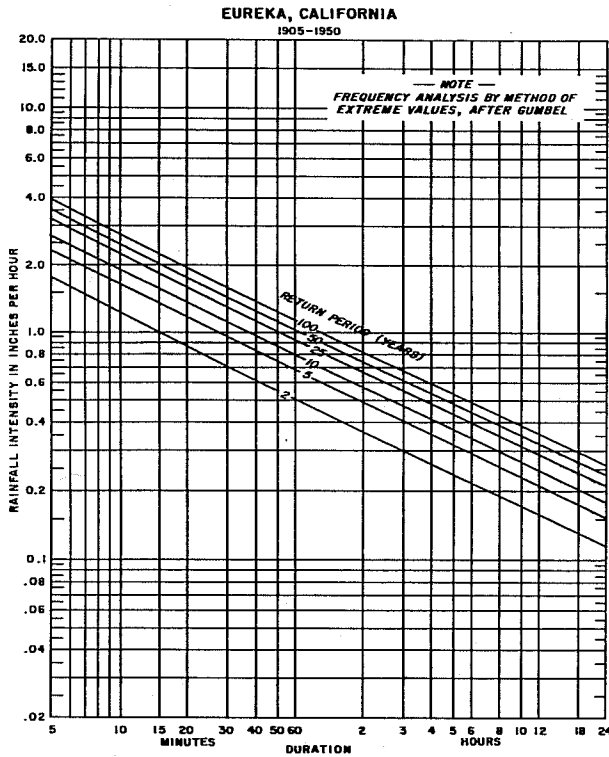
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RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

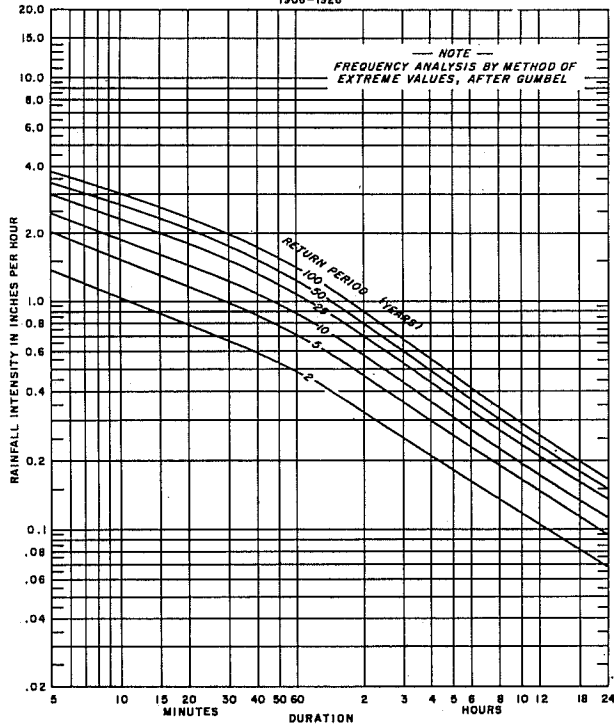


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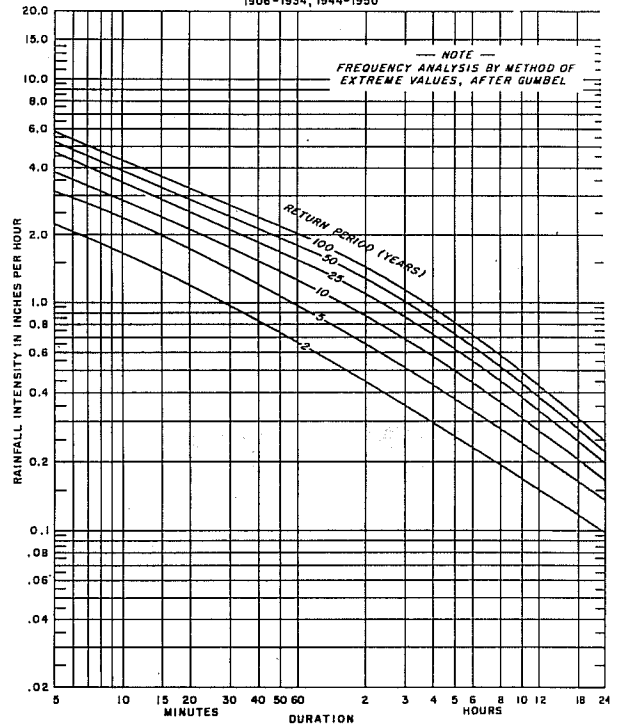


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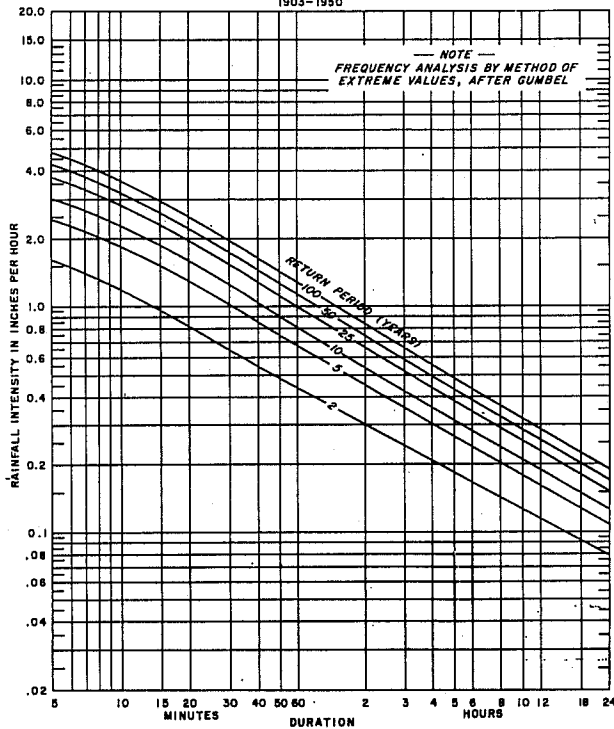
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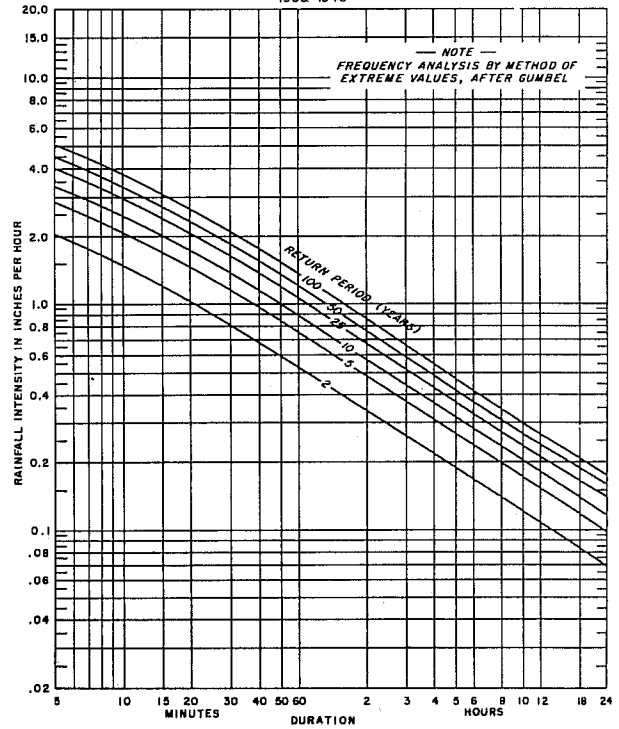
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1903-1950

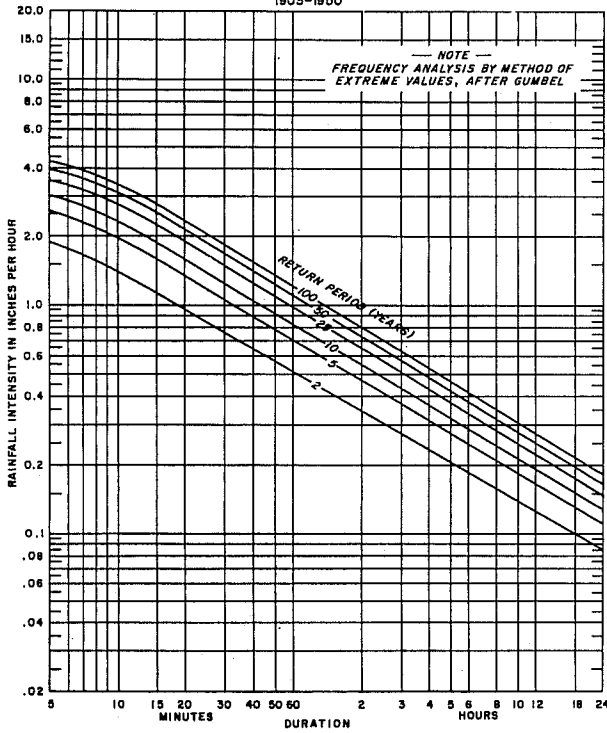


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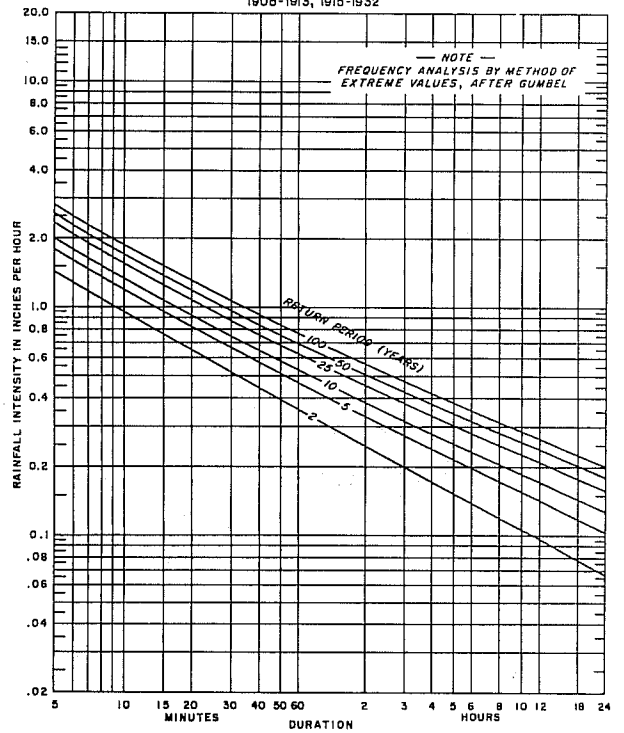


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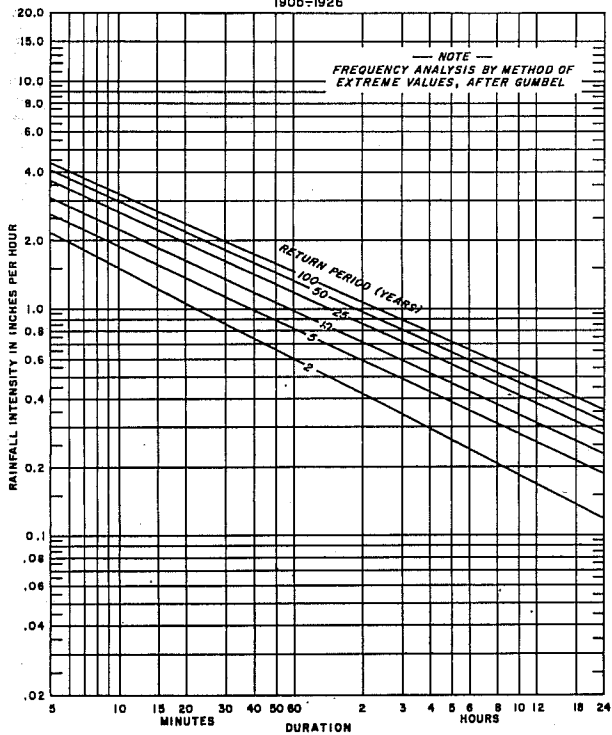
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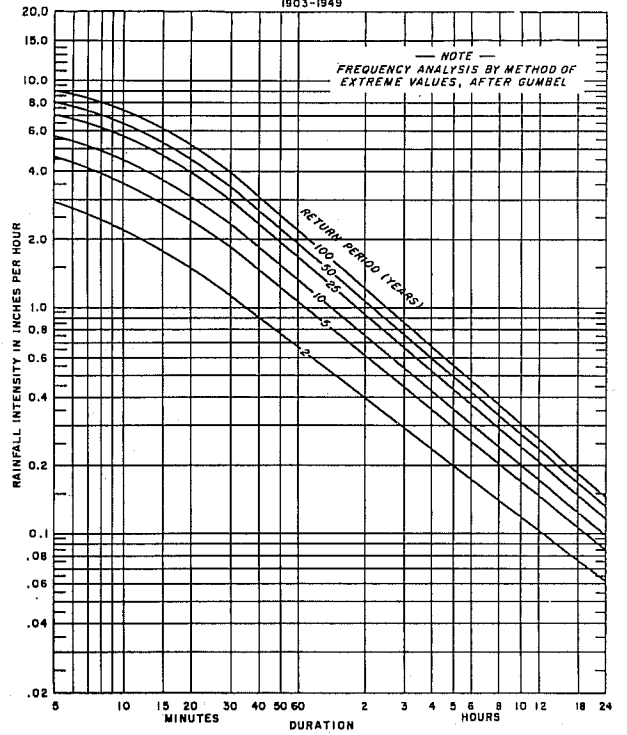
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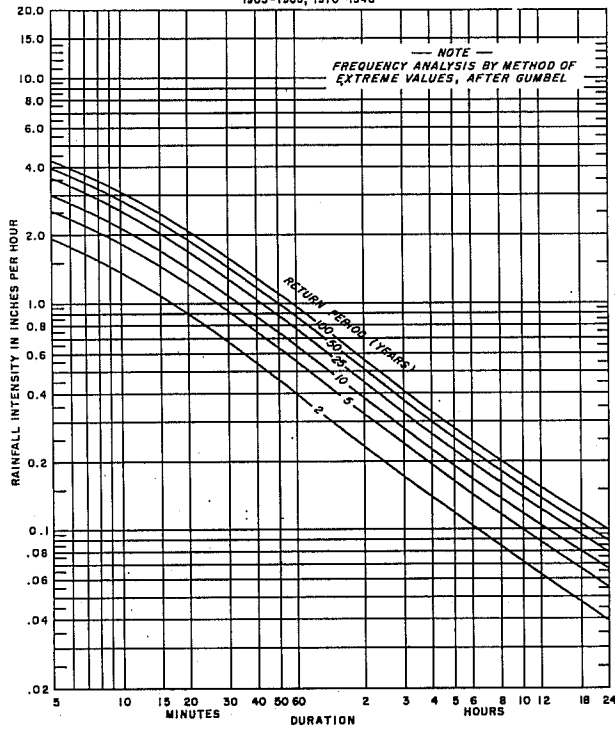


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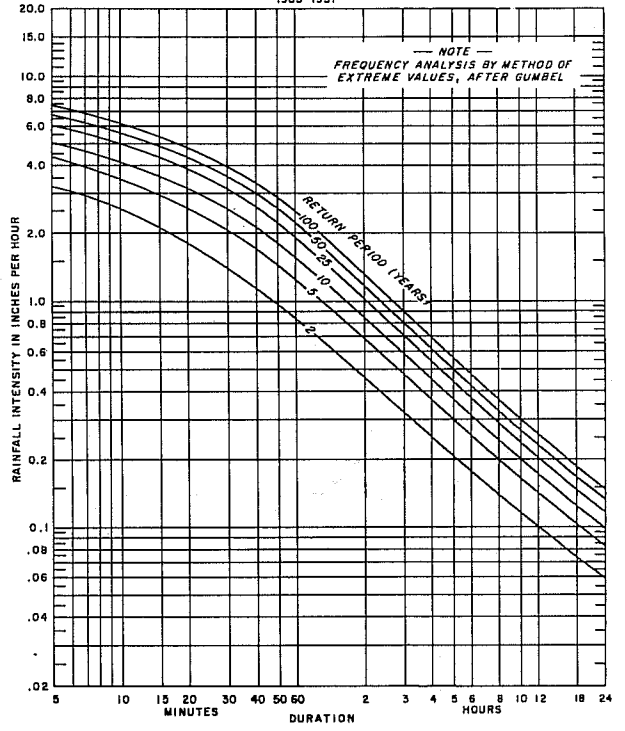


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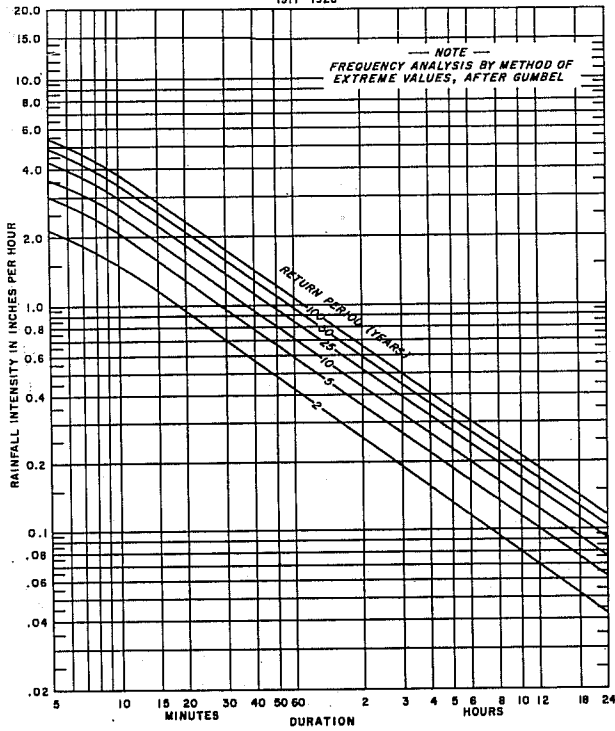
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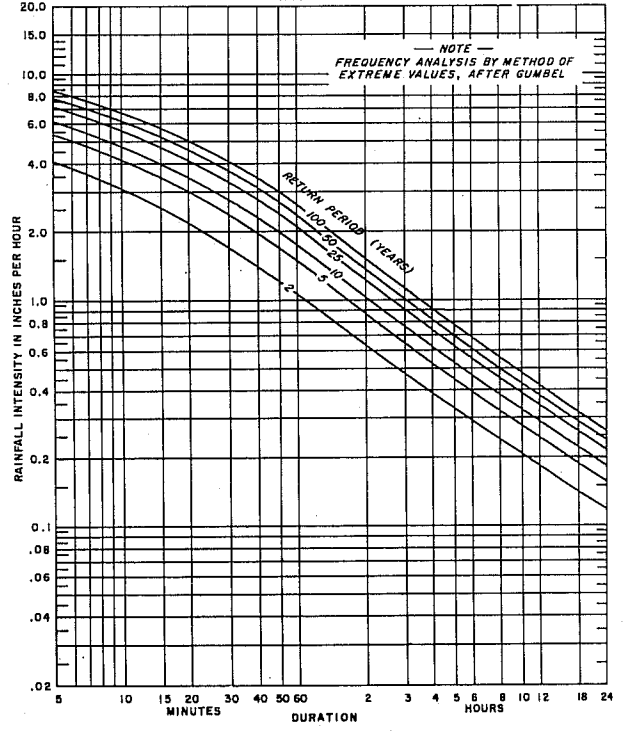
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1911-1926

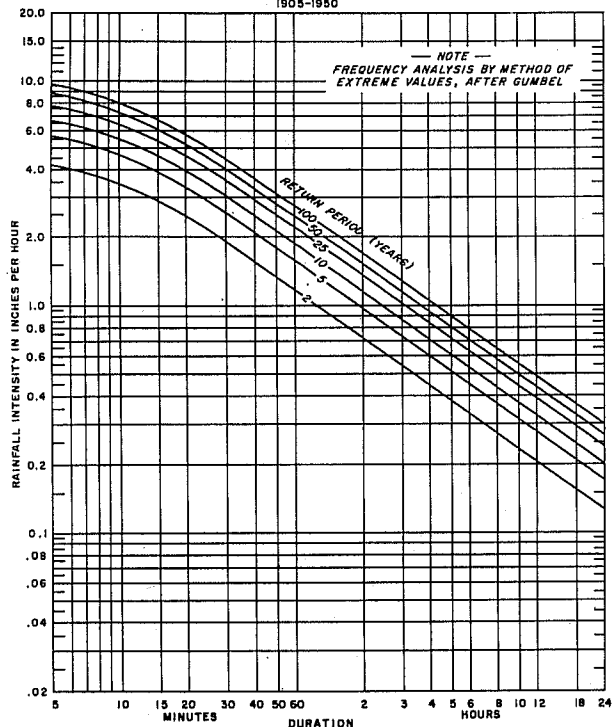


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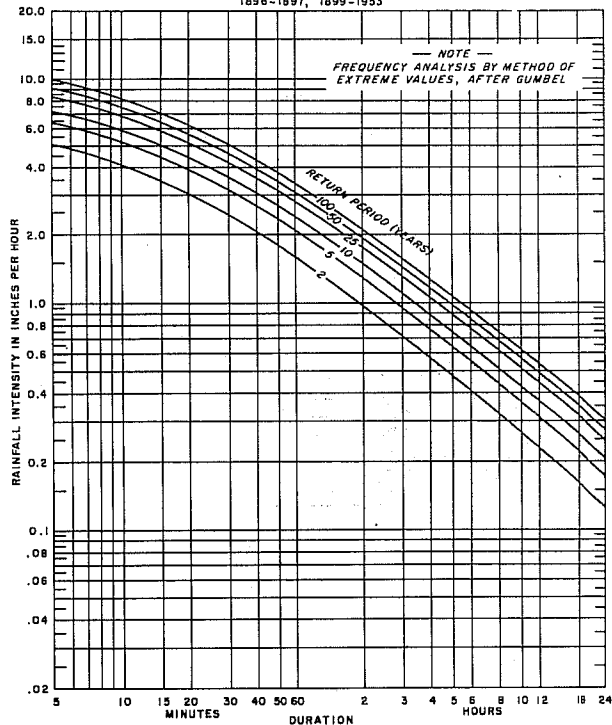


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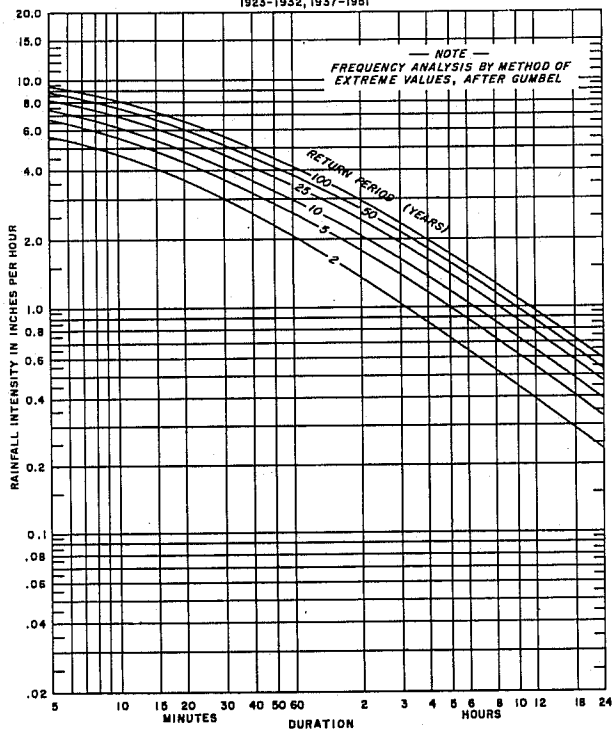
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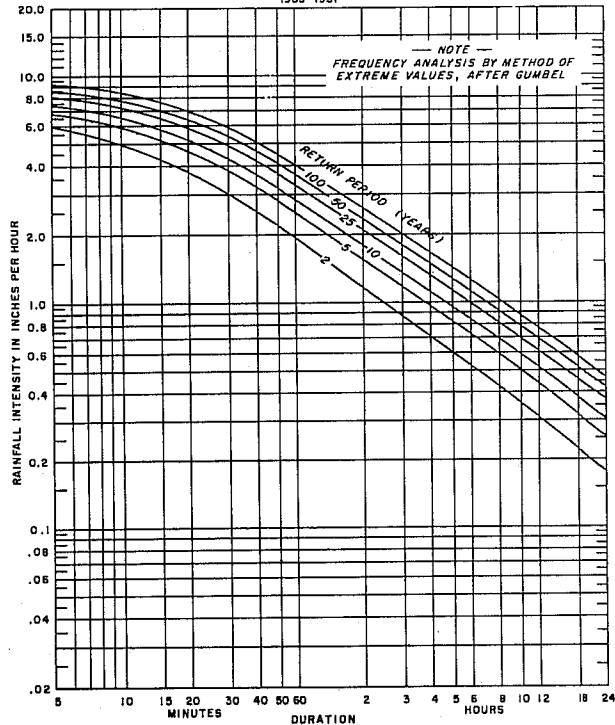
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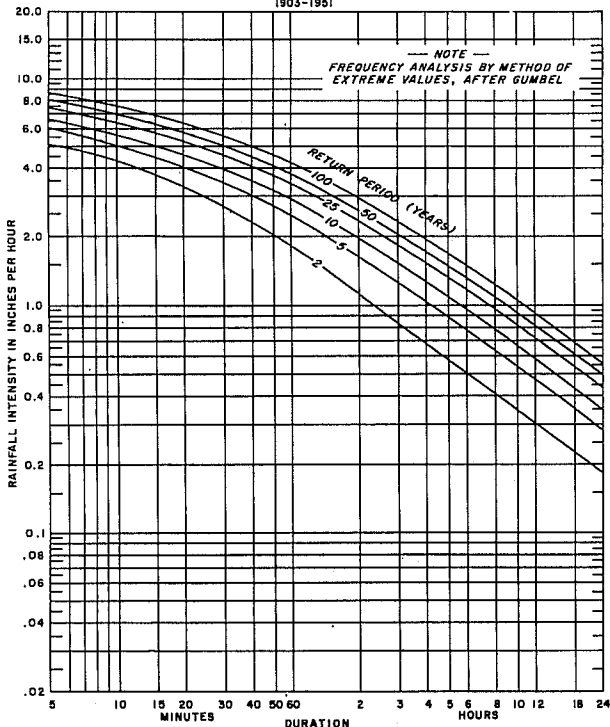


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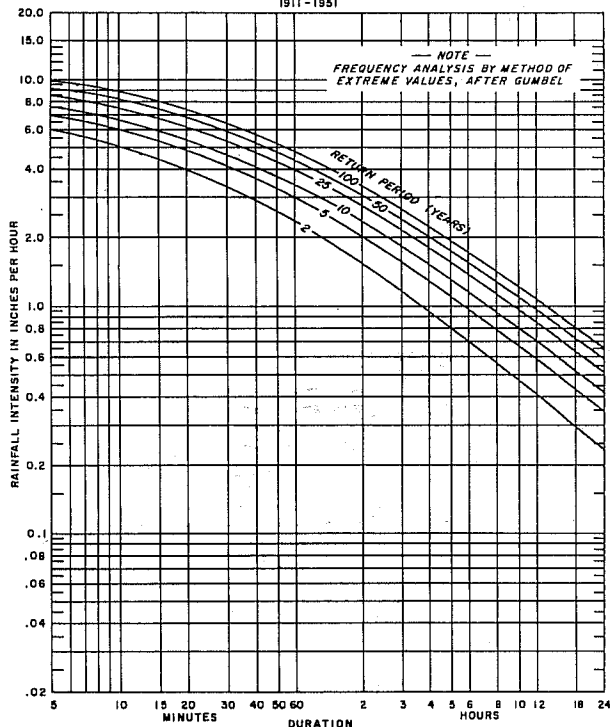


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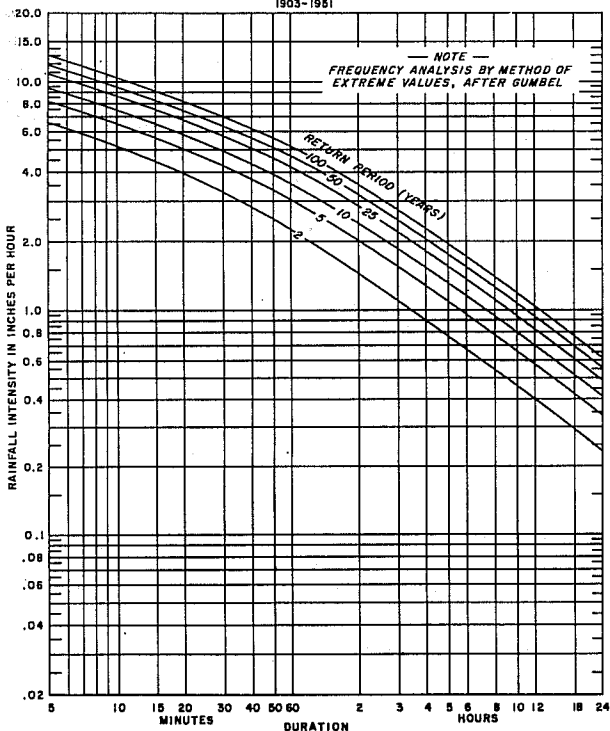
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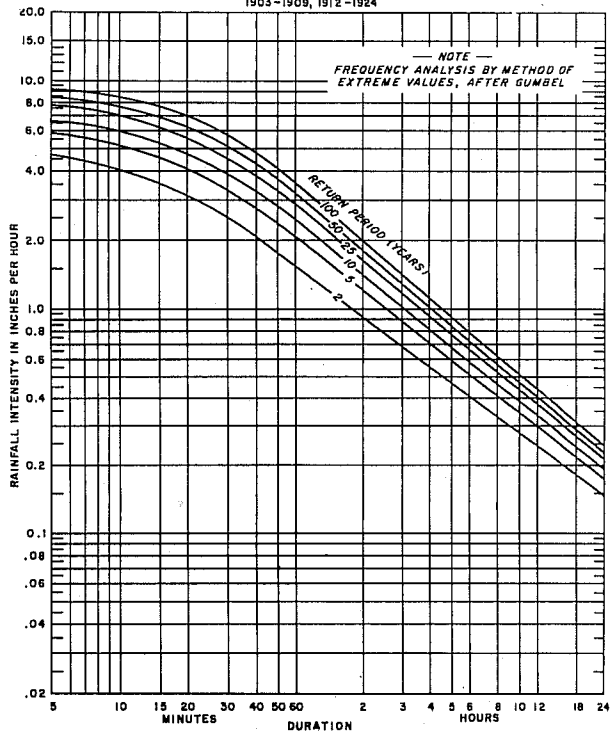
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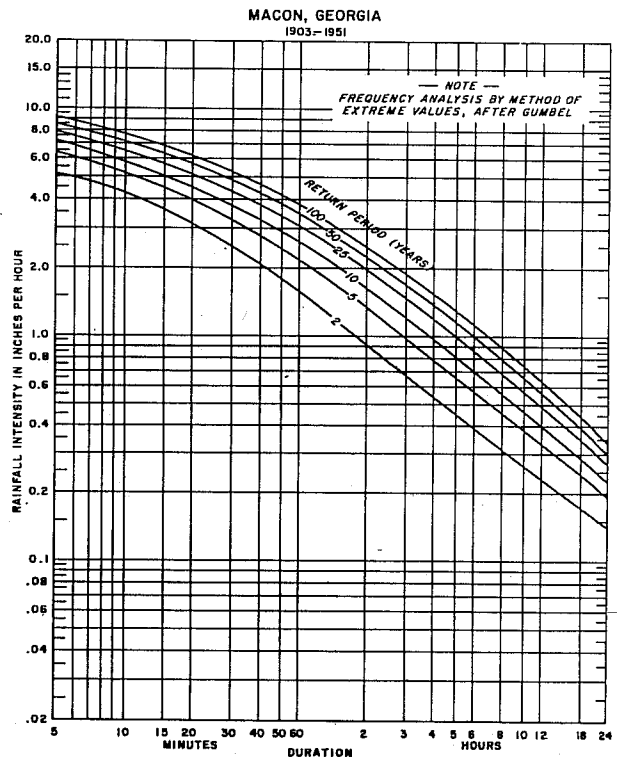
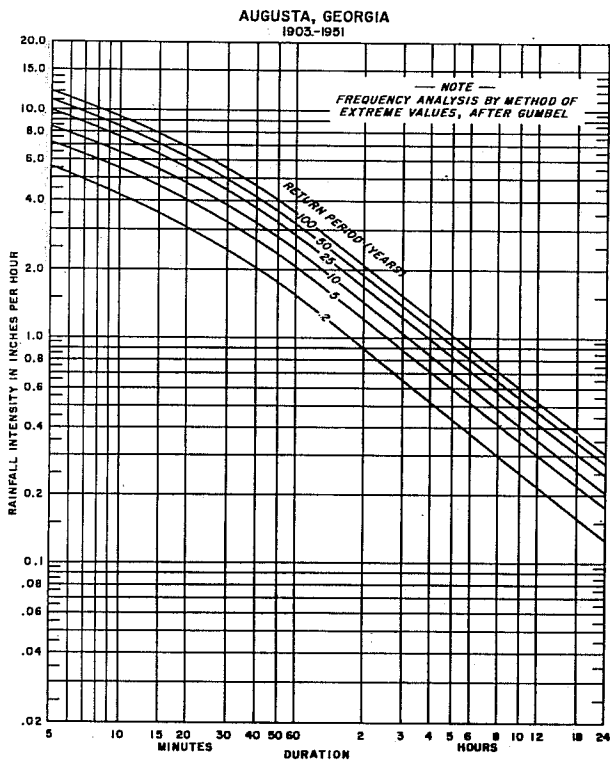
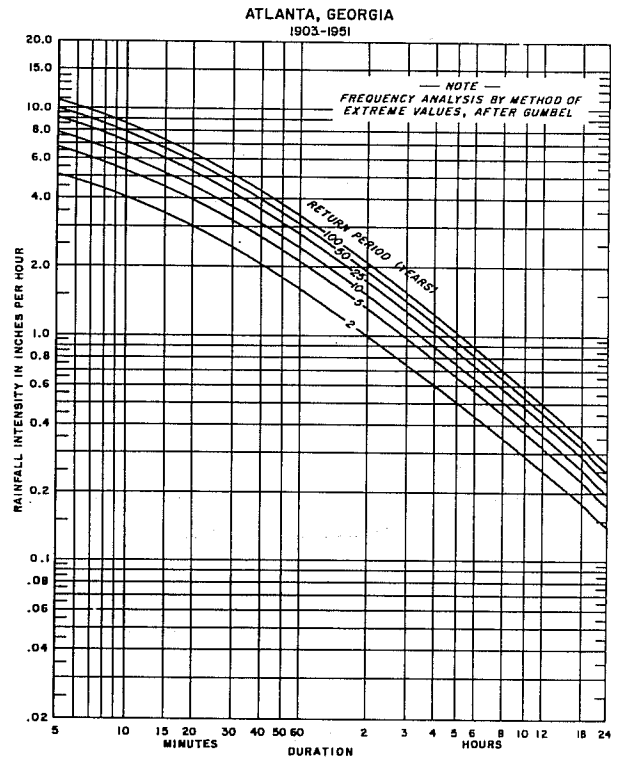
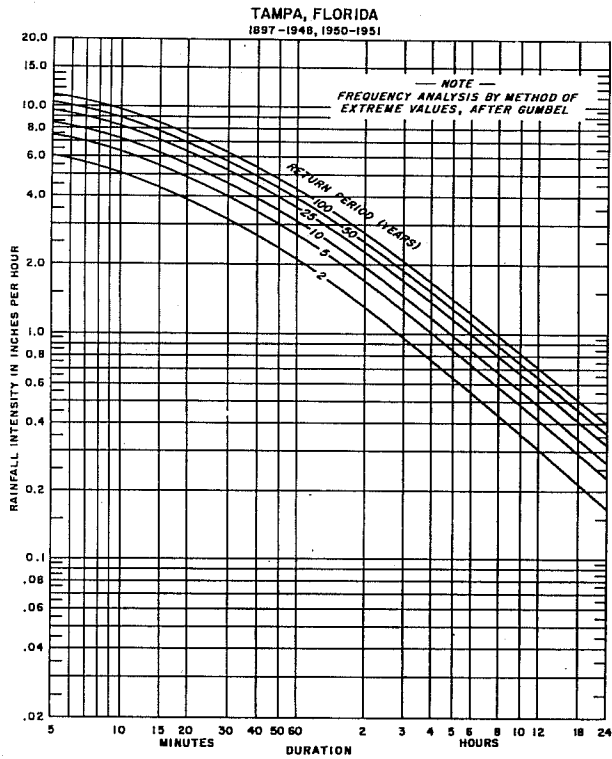
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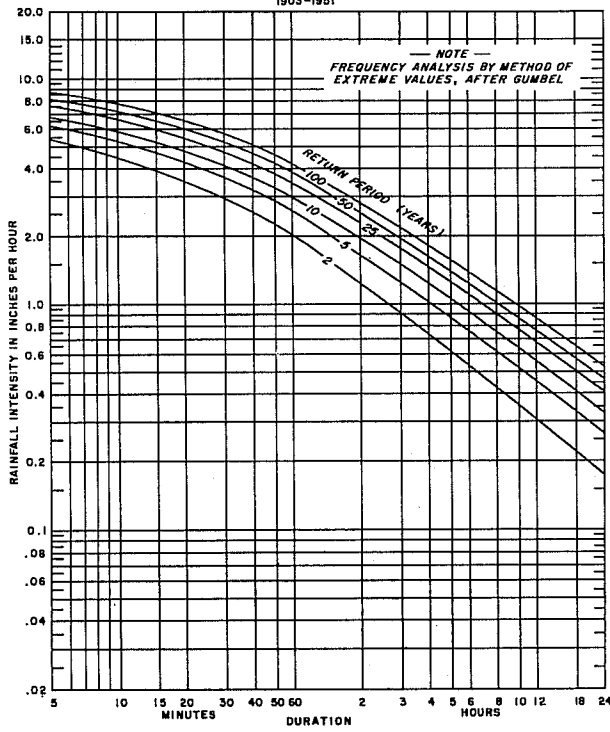
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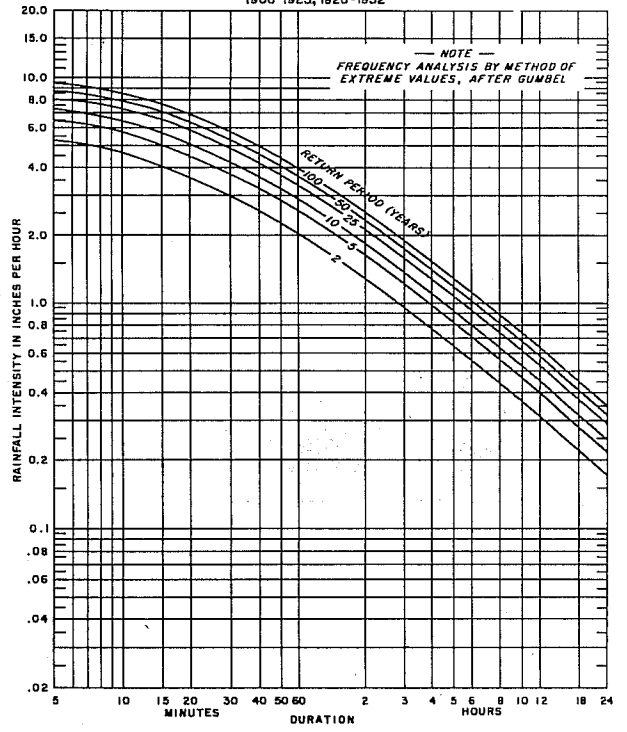
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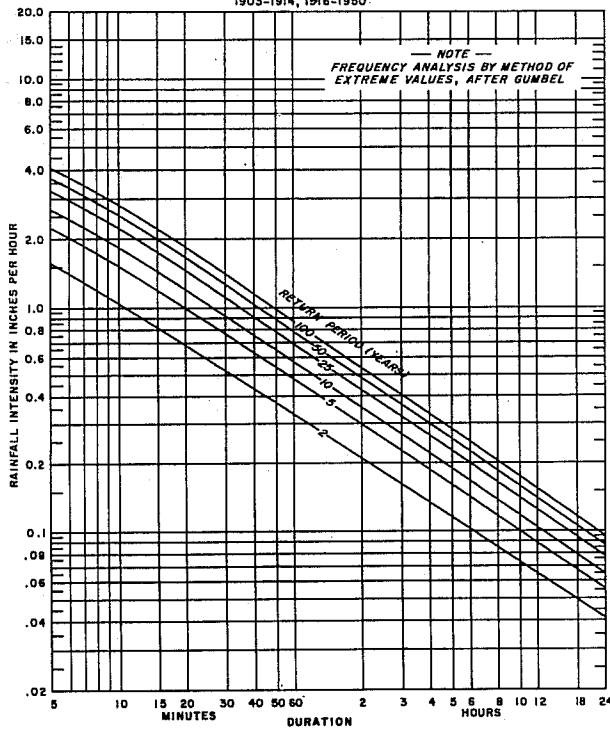
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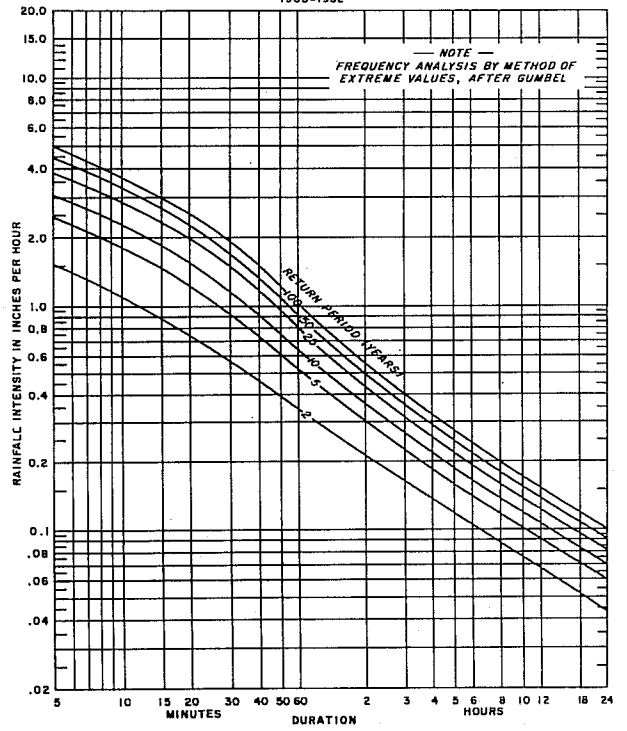
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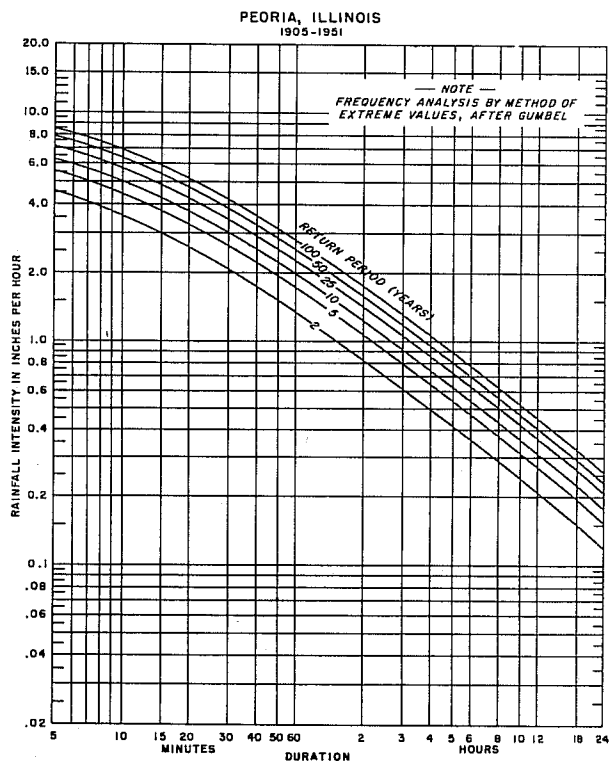
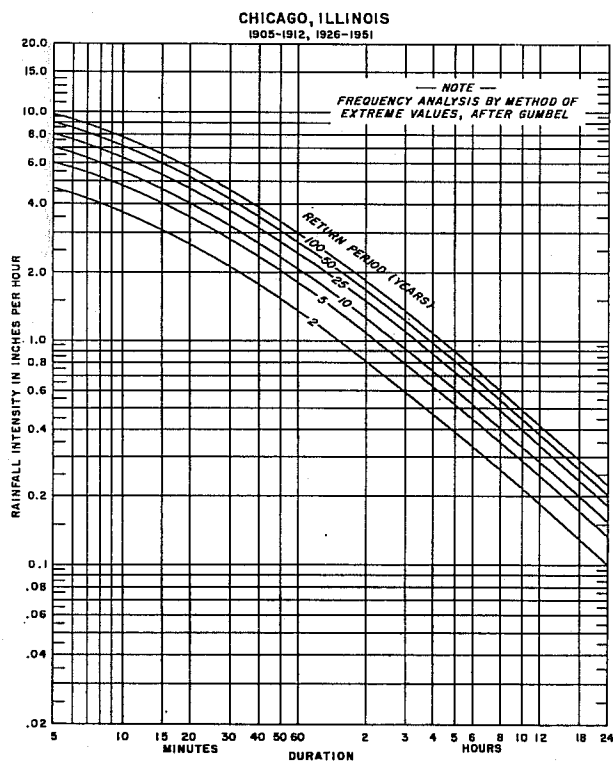
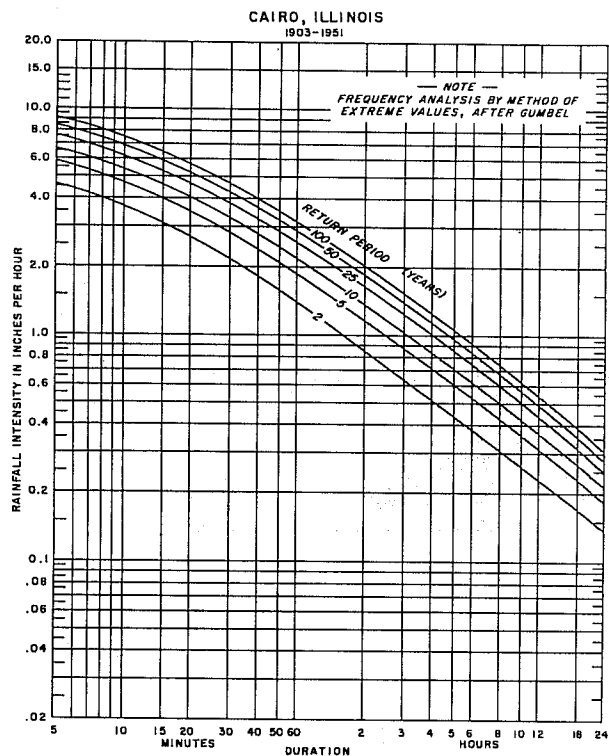
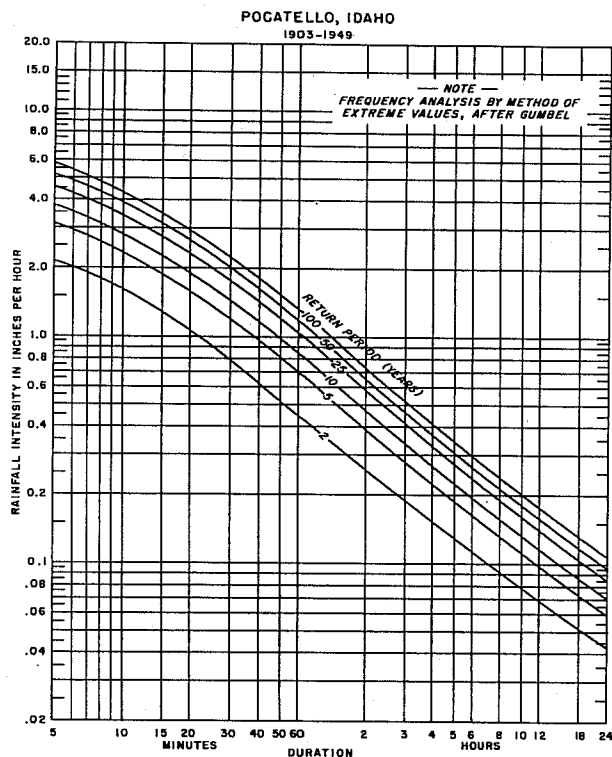
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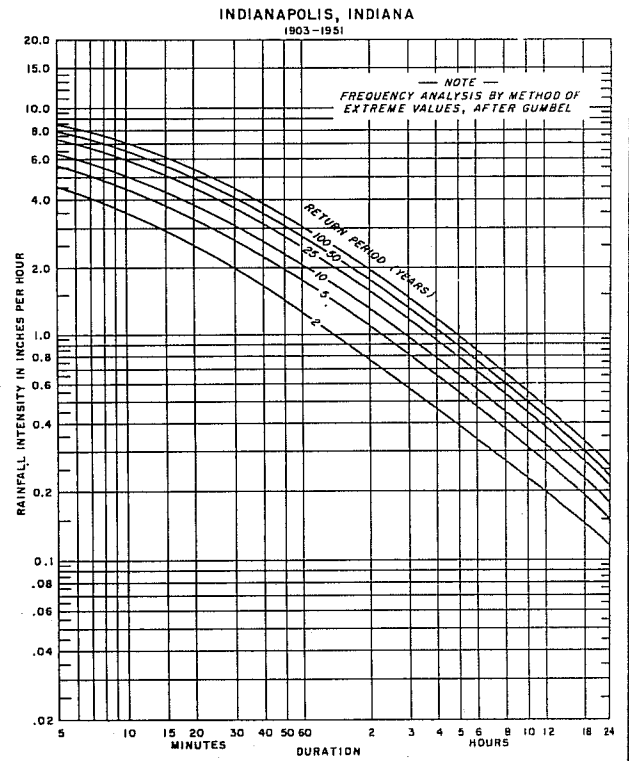
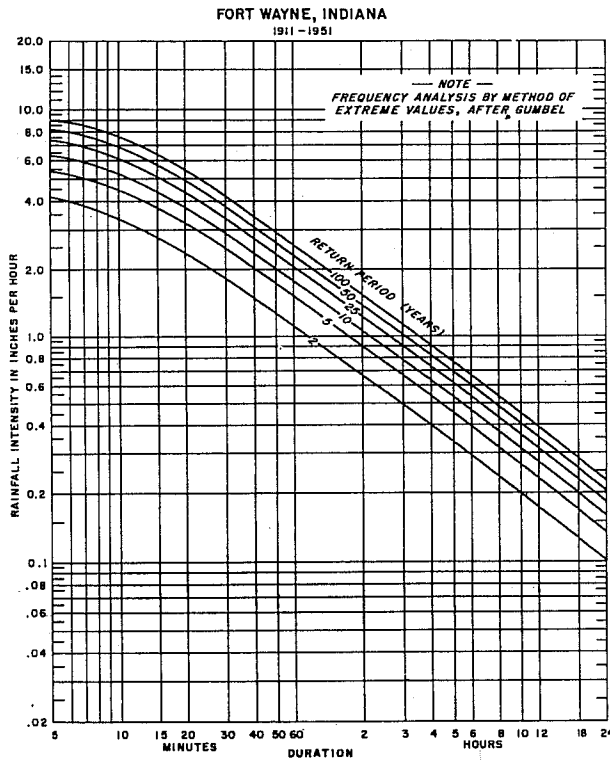
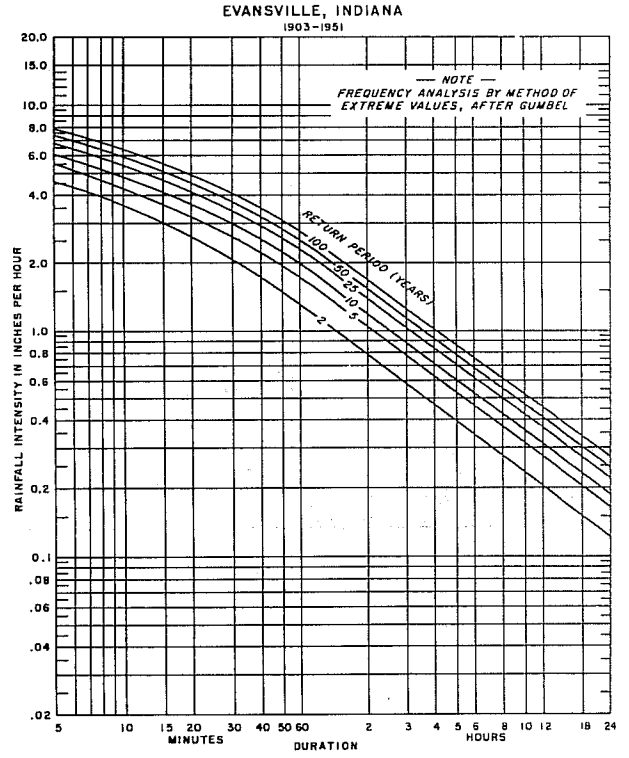
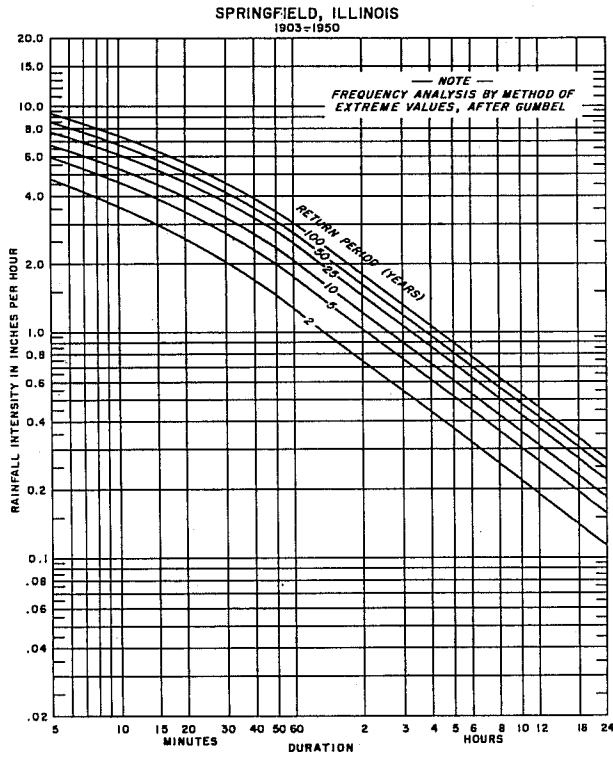
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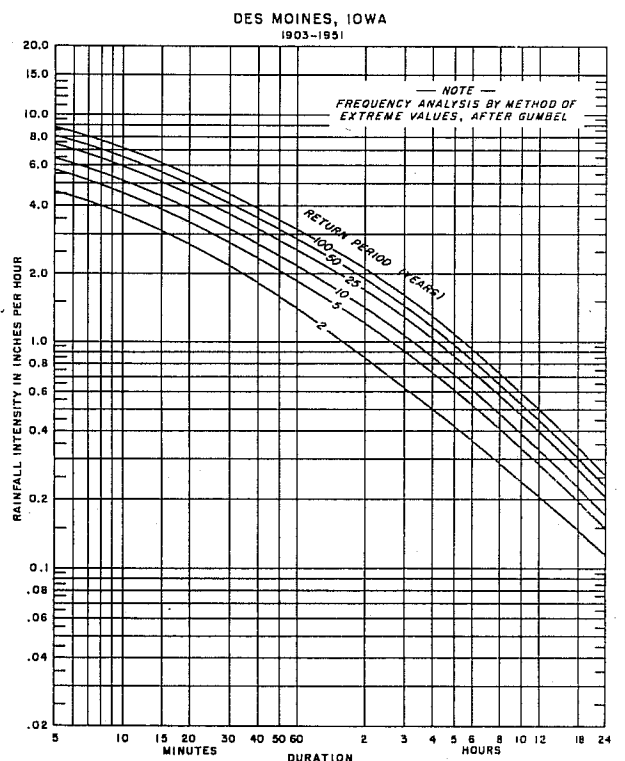
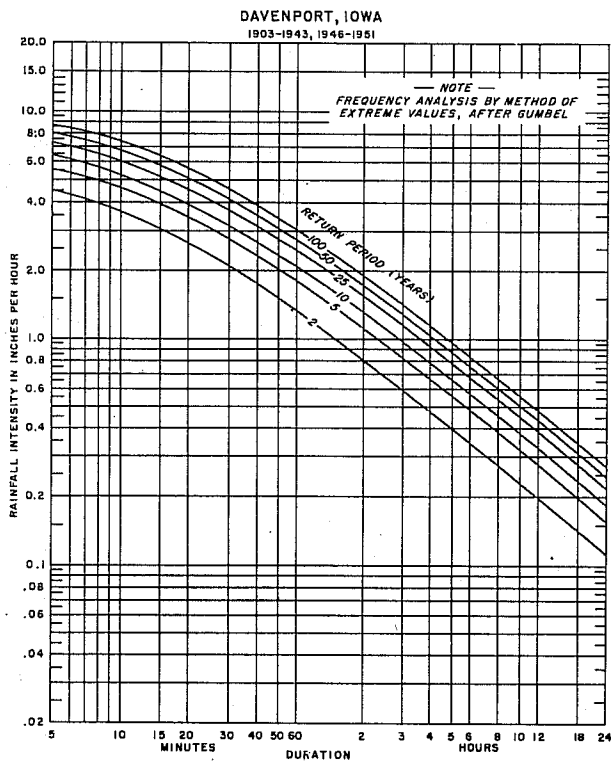
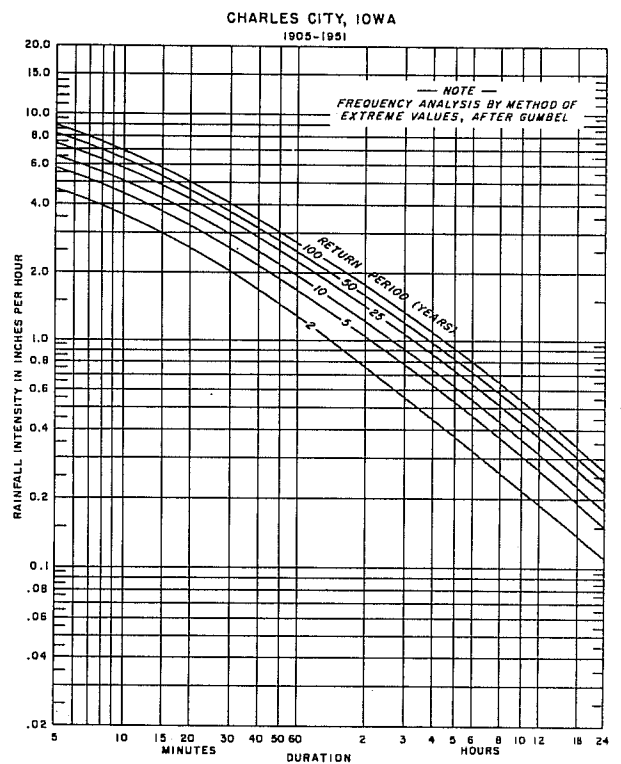
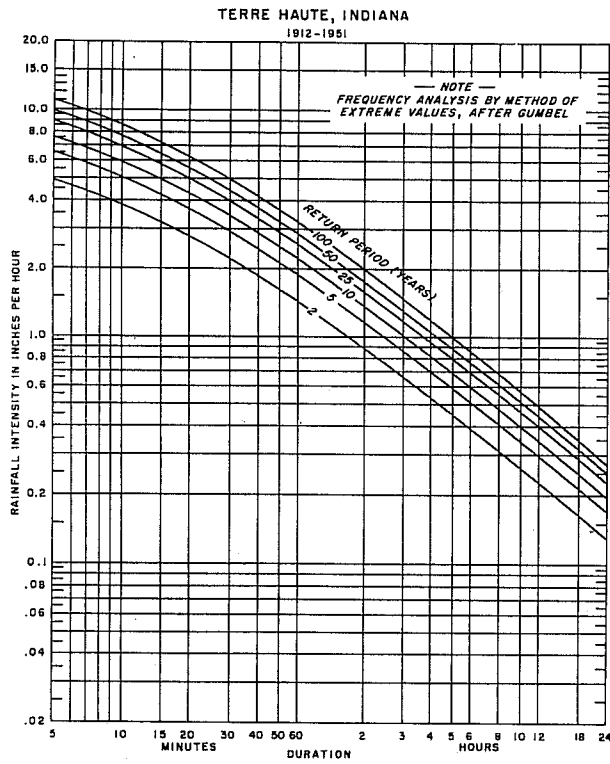
RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



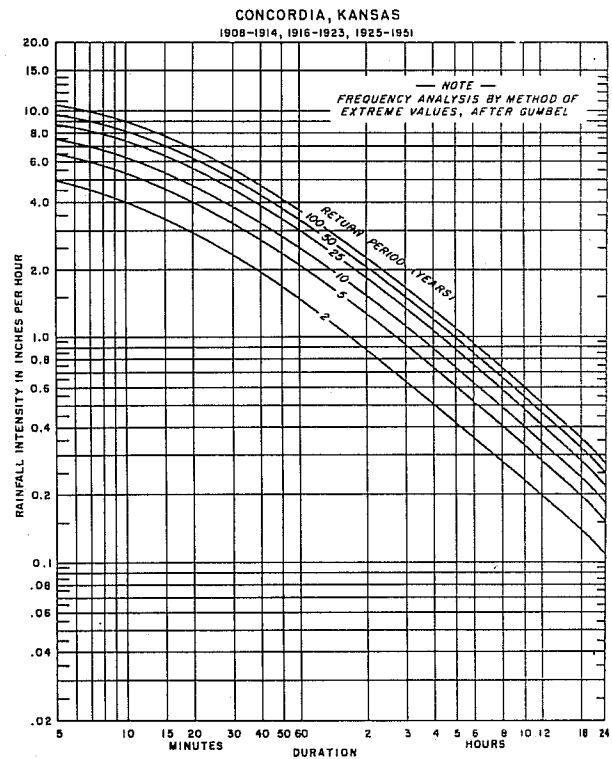
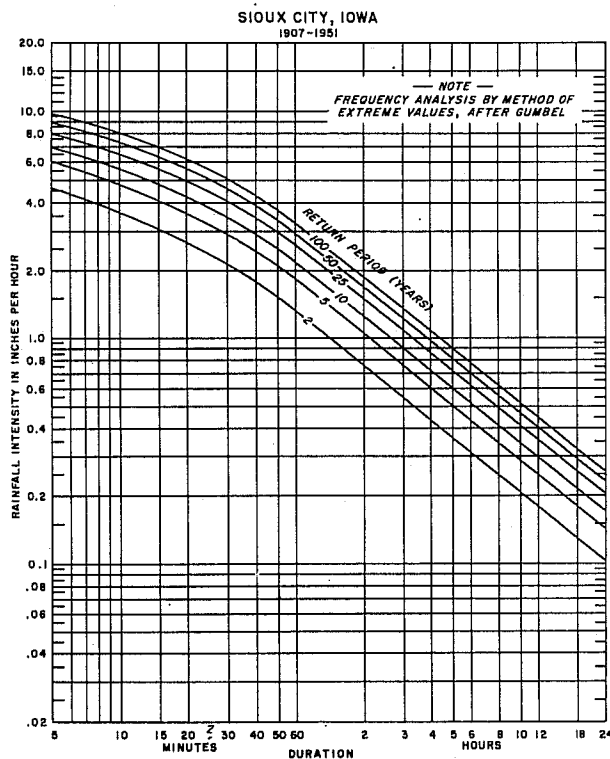
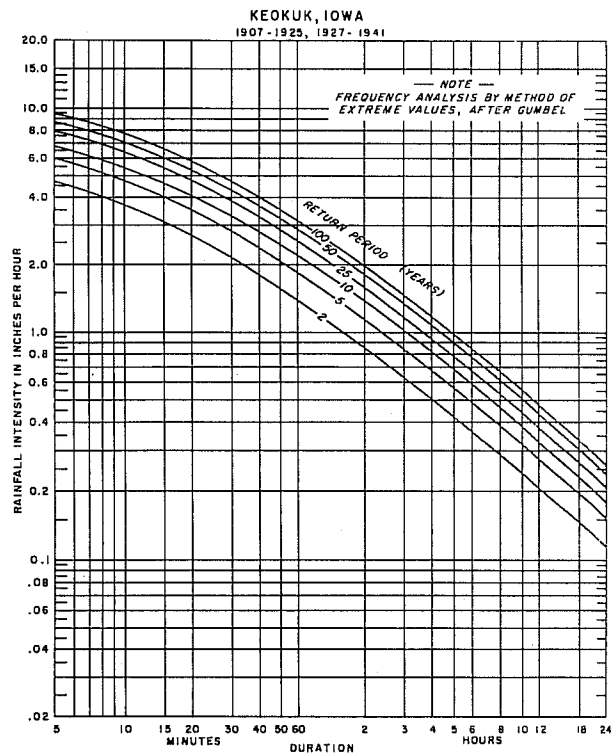
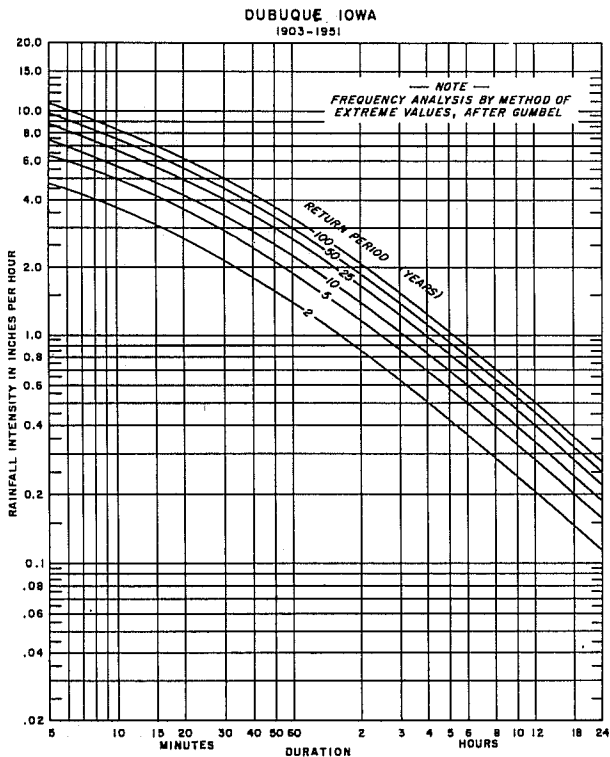
RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

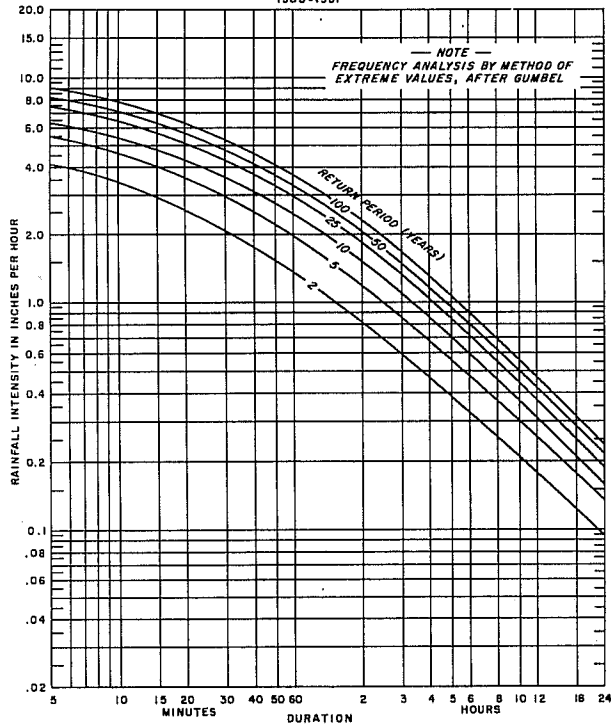


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

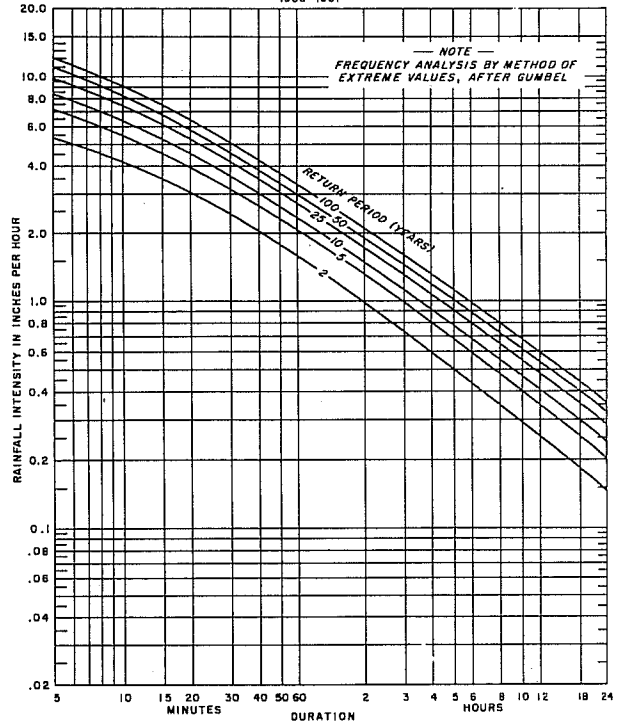


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

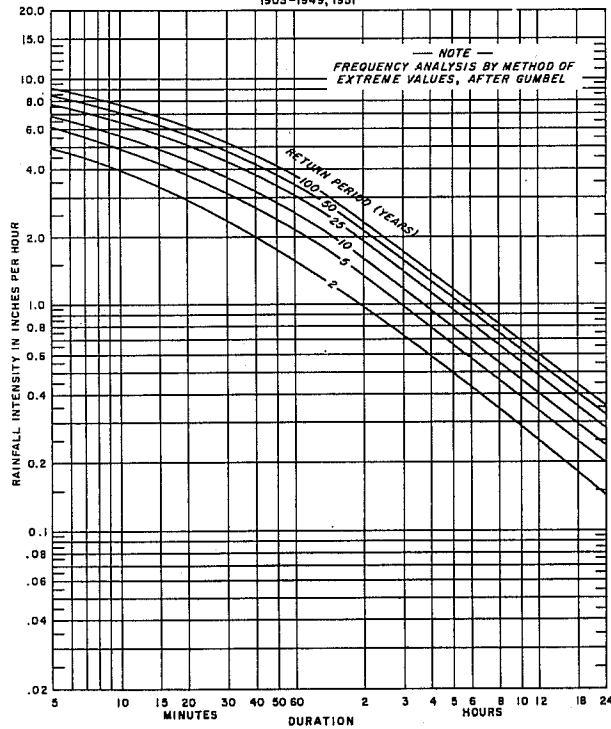
DODGE CITY, KANSAS
1905-1951



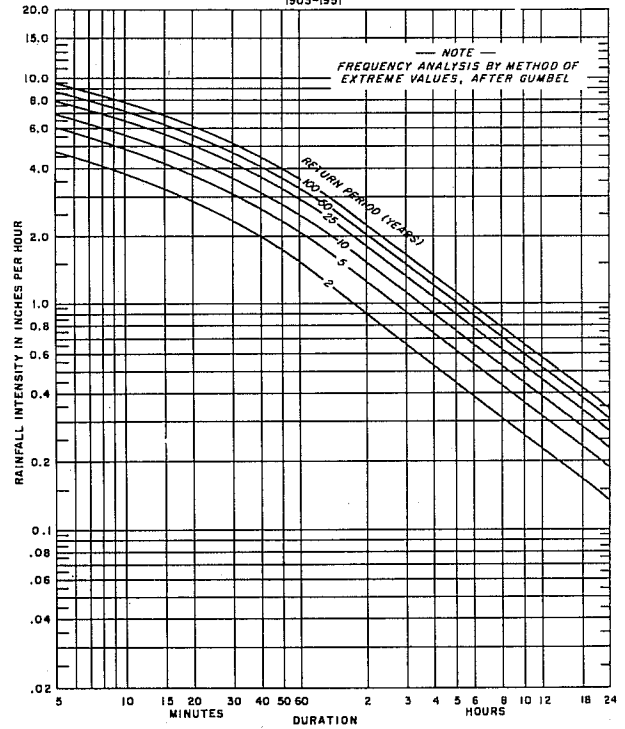
IOLA, KANSAS
1906-1931



TOPEKA, KANSAS
1903-1949, 1951

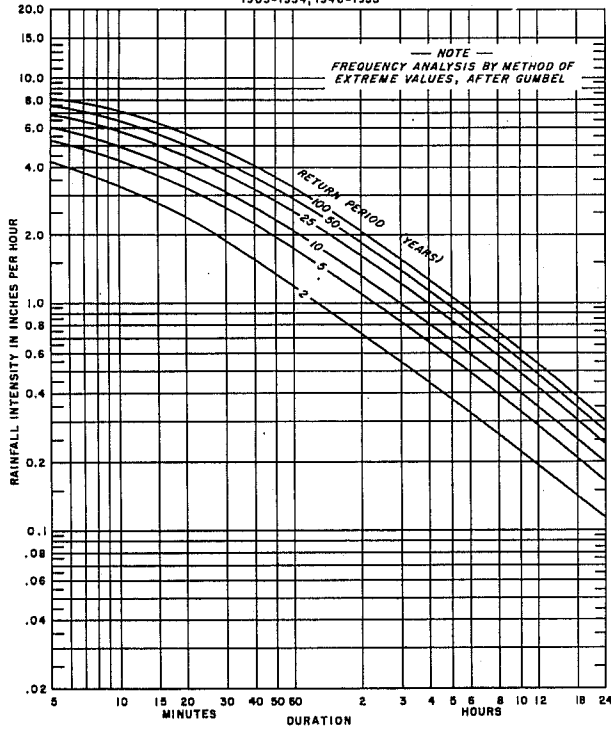


WICHITA, KANSAS
1903-1951

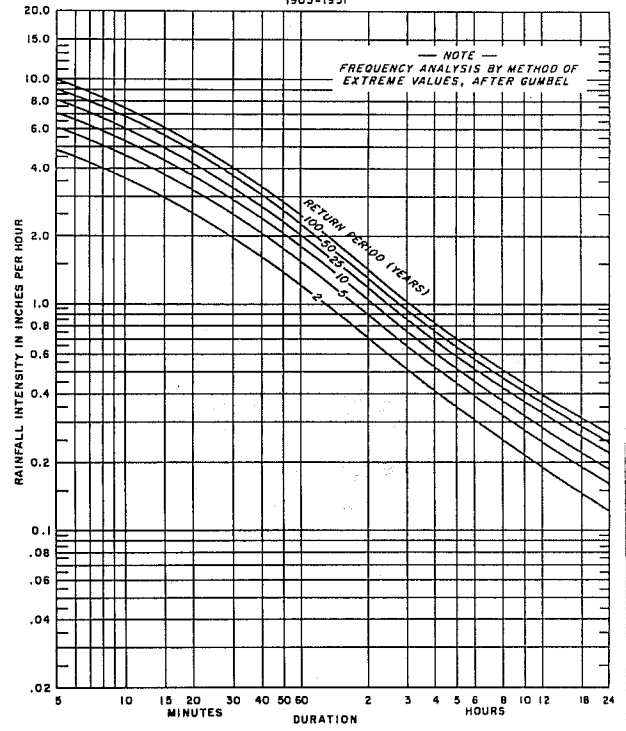


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

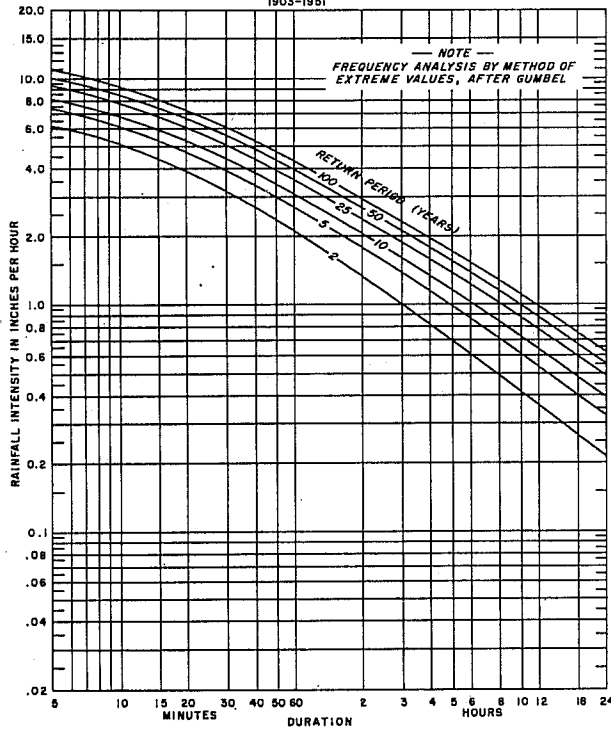
LEXINGTON, KENTUCKY
1903-1934, 1946-1953



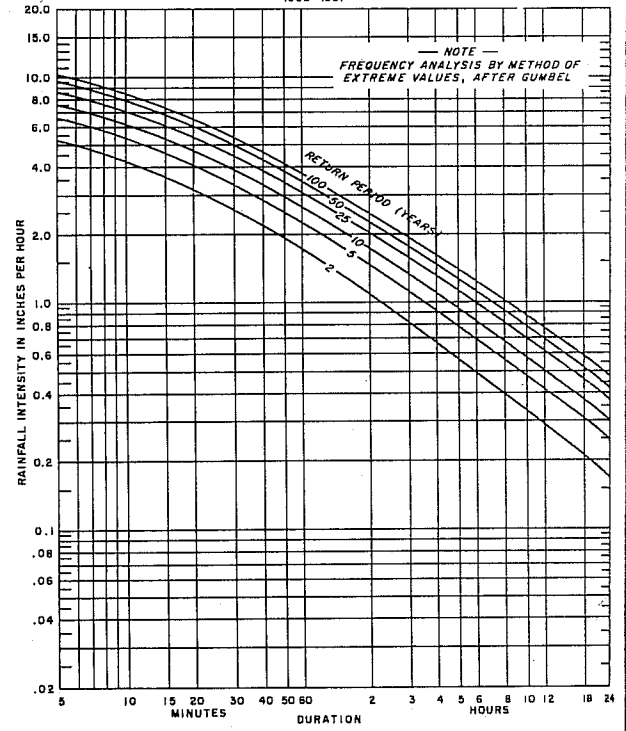
LOUISVILLE, KENTUCKY
1903-1951



NEW ORLEANS, LOUISIANA
1903-1951

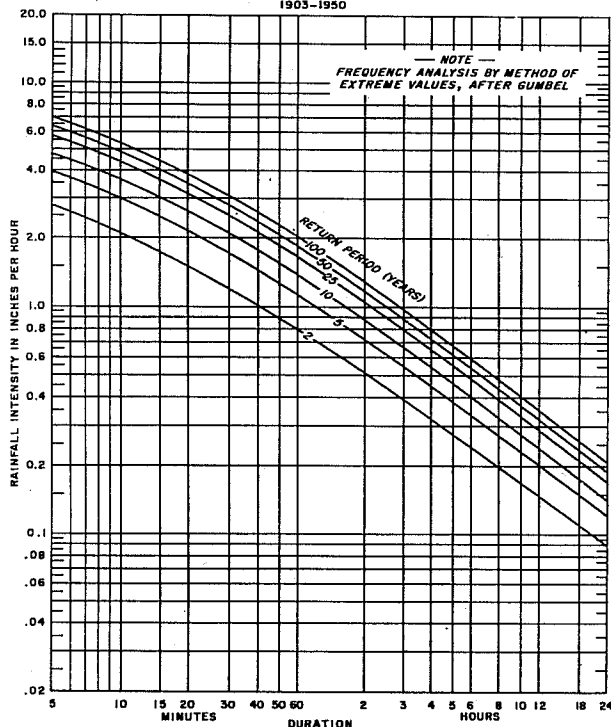


SHREVEPORT, LOUISIANA
1903-1951

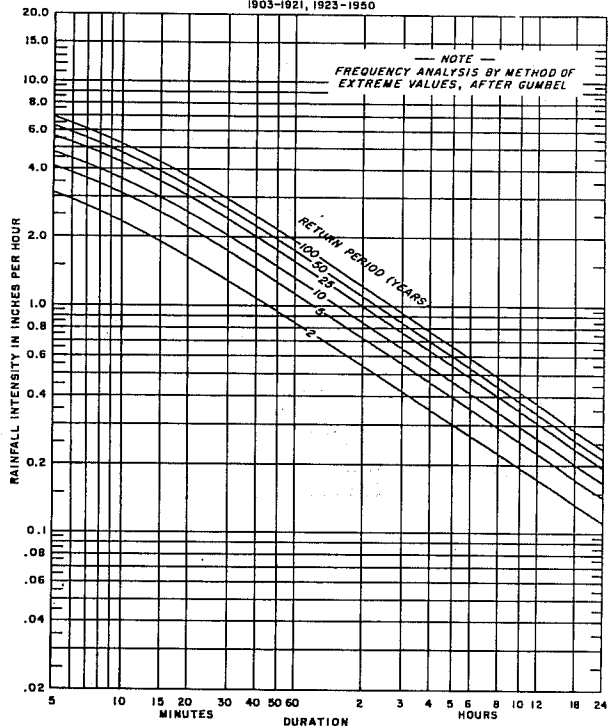


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

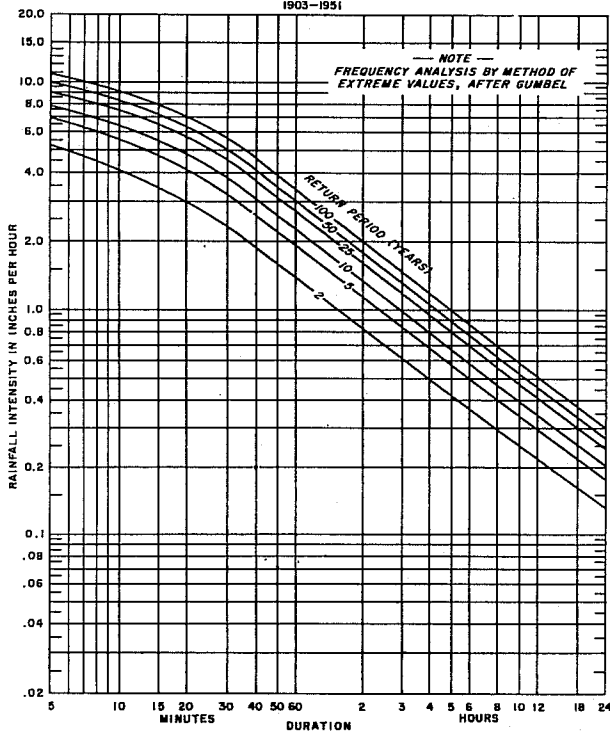
EASTPORT, MAINE
1903-1950



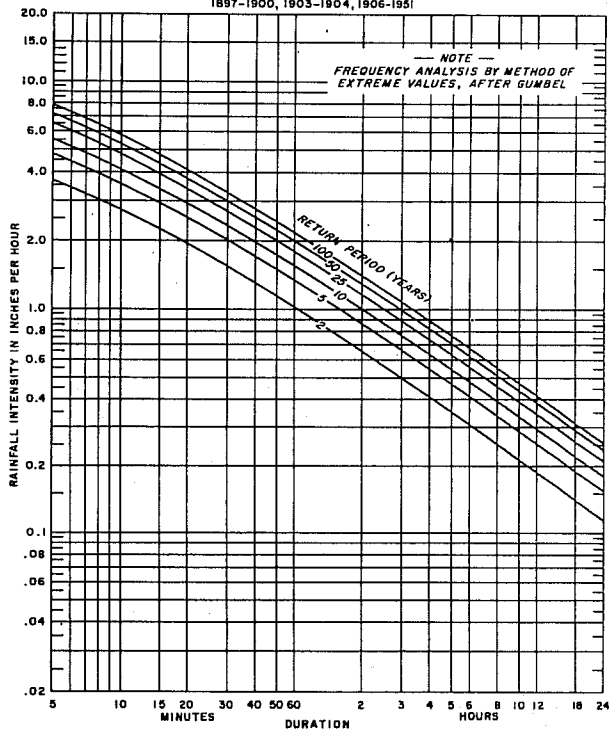
PORTLAND, MAINE
1903-1921, 1923-1950



BALTIMORE, MARYLAND
1903-1951

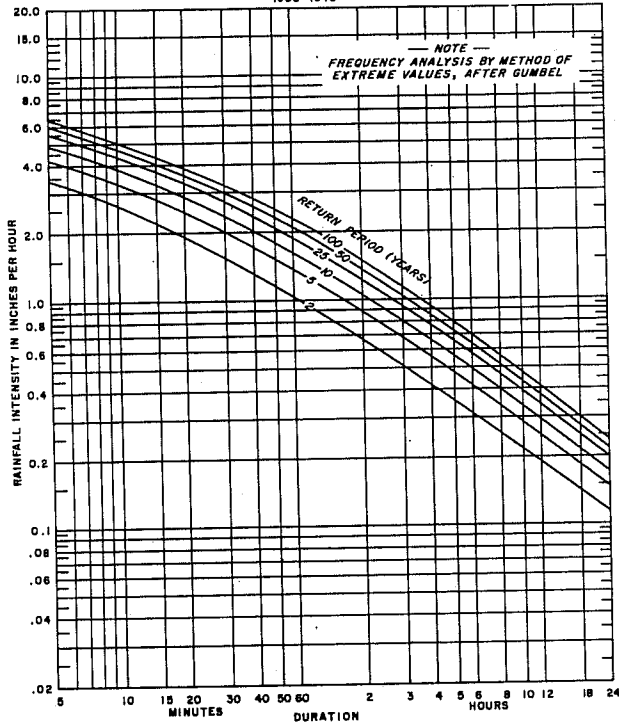


BOSTON, MASSACHUSETTS
1897-1900, 1903-1904, 1906-1951

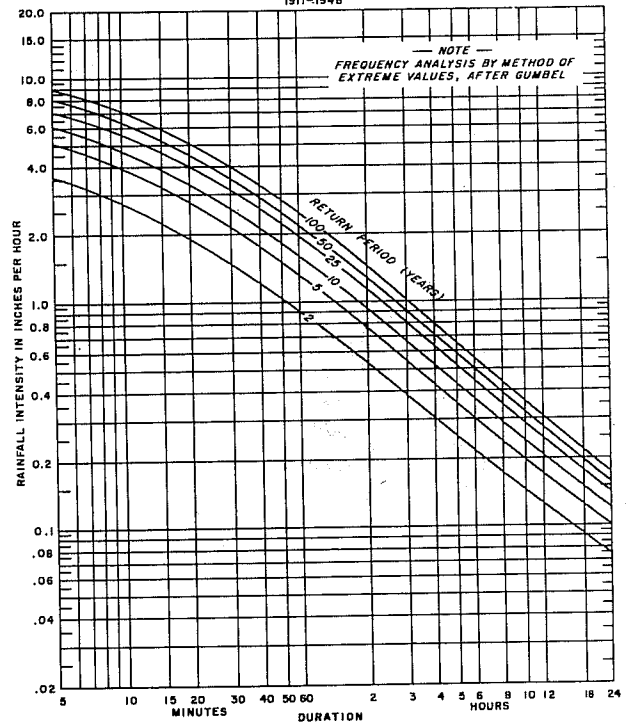


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

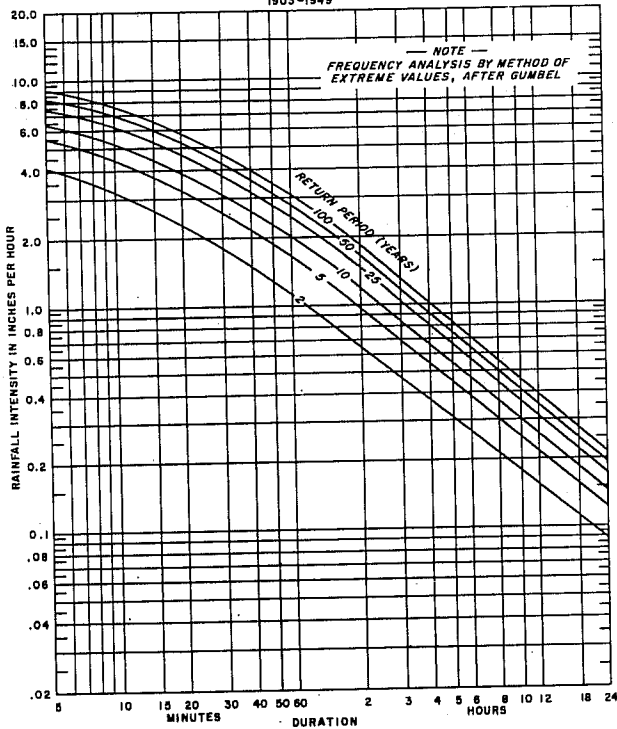
NANTUCKET, MASSACHUSETTS
1903-1948



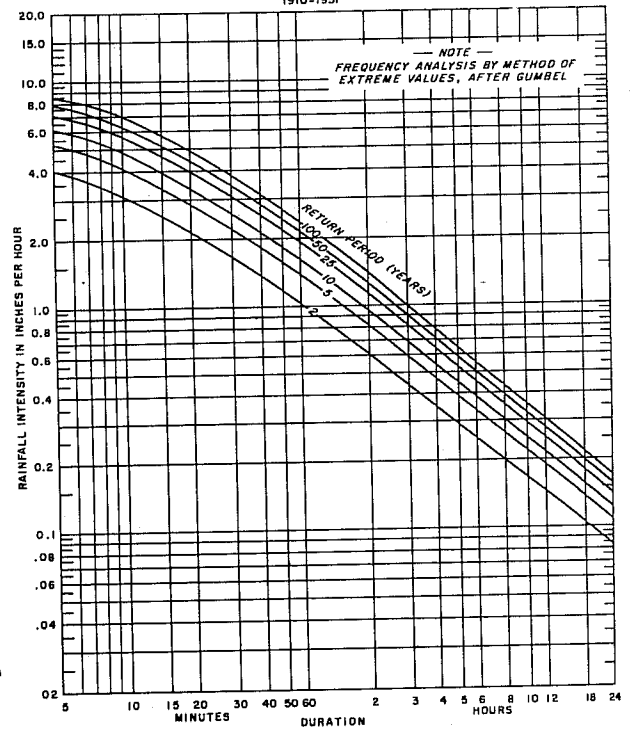
ALPENA, MICHIGAN
1911-1948



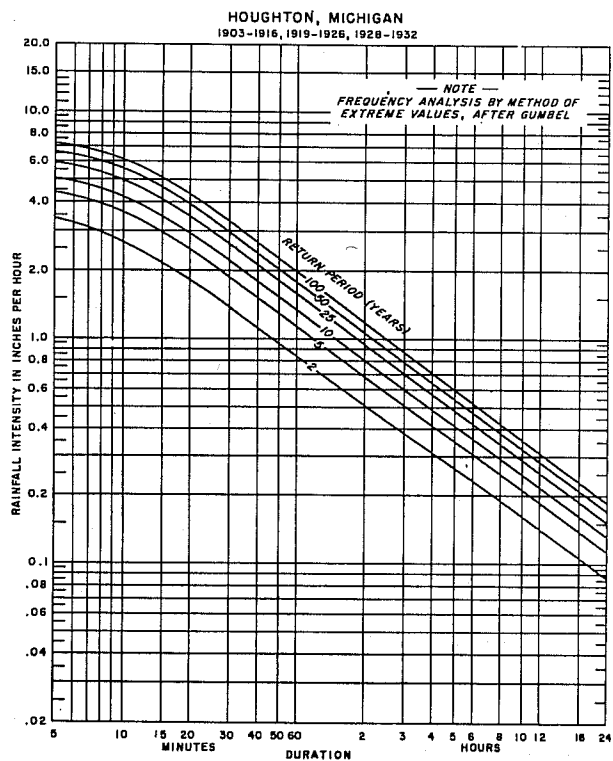
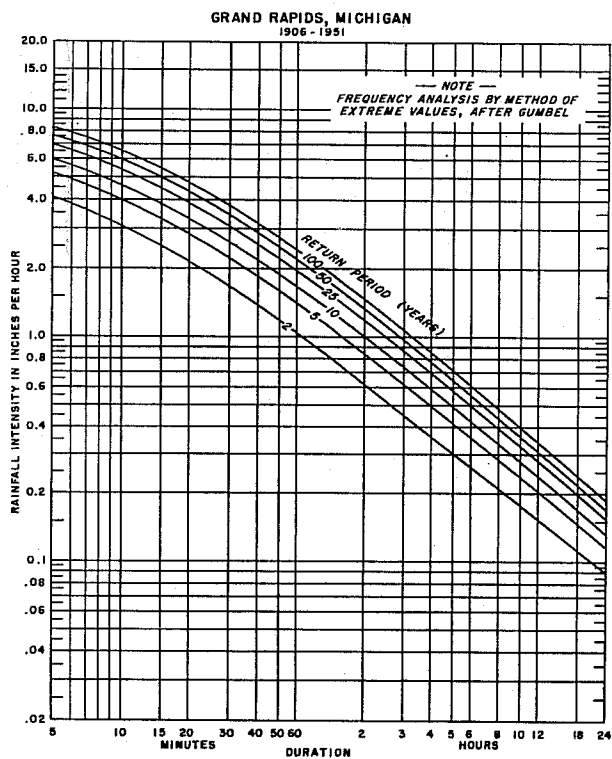
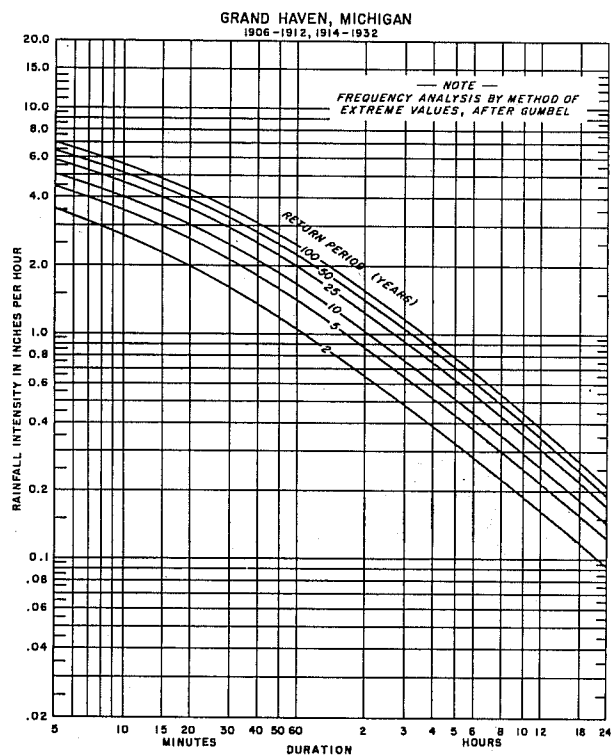
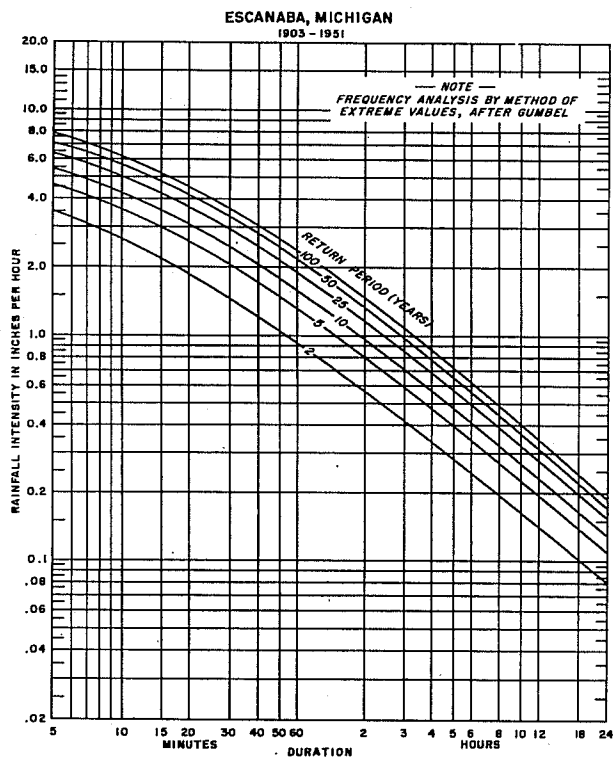
DETROIT, MICHIGAN
1903-1949



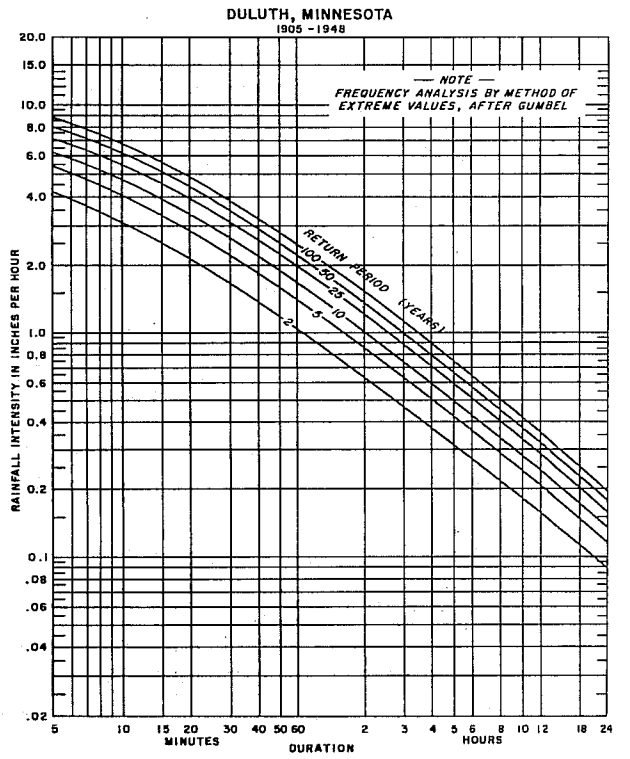
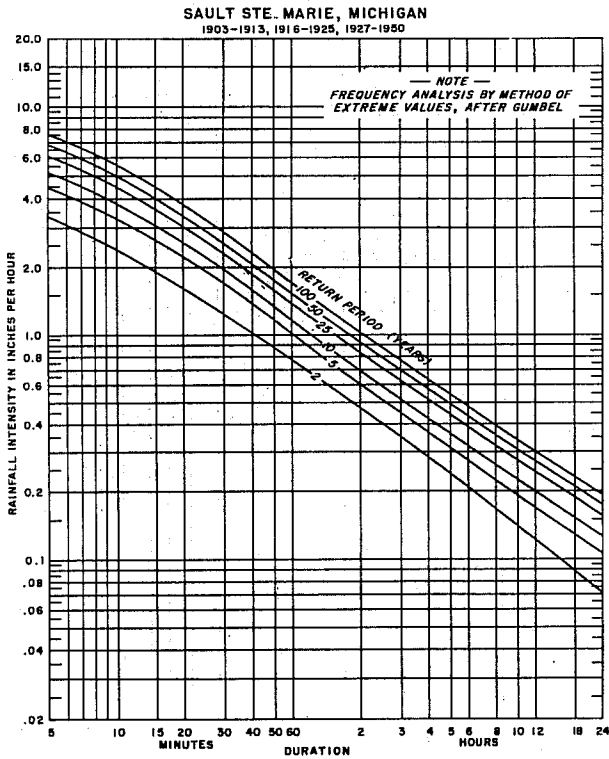
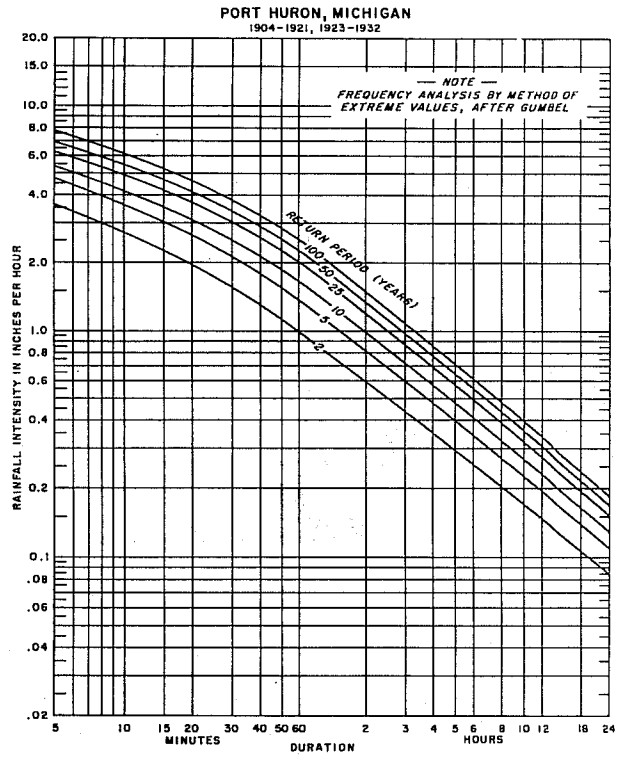
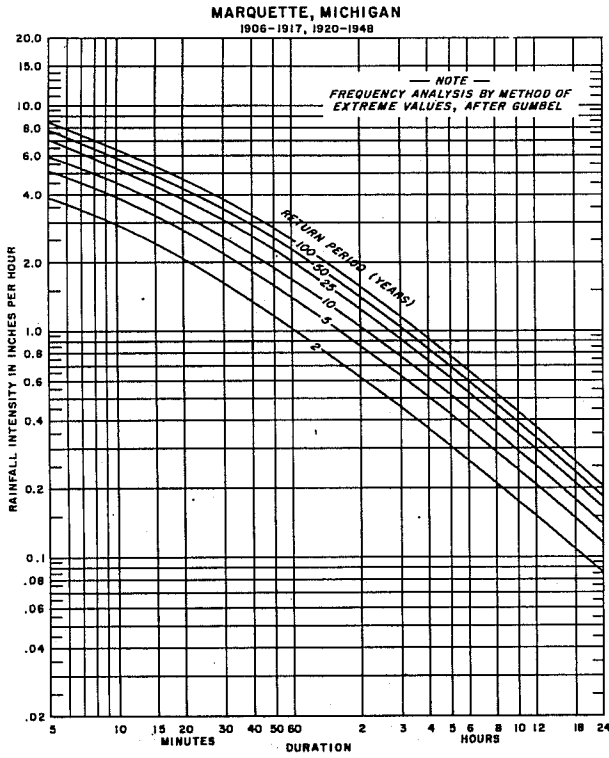
EAST LANSING, MICHIGAN
1910-1951



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

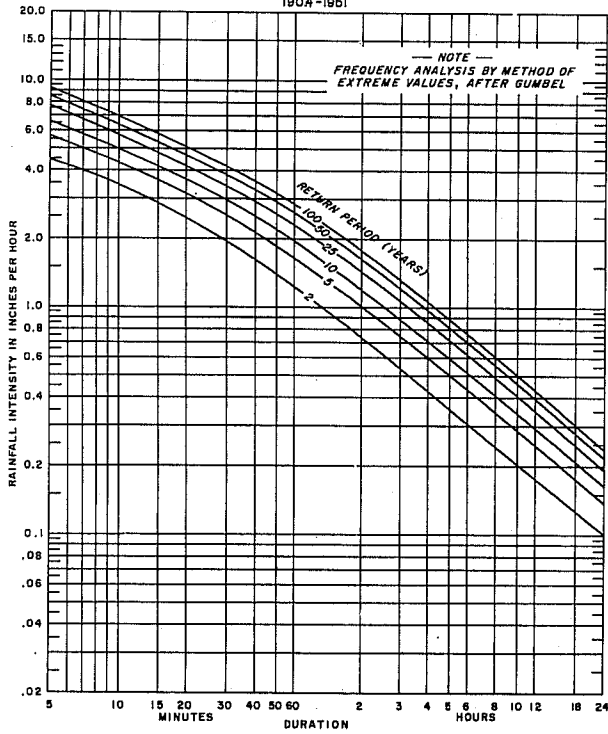


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

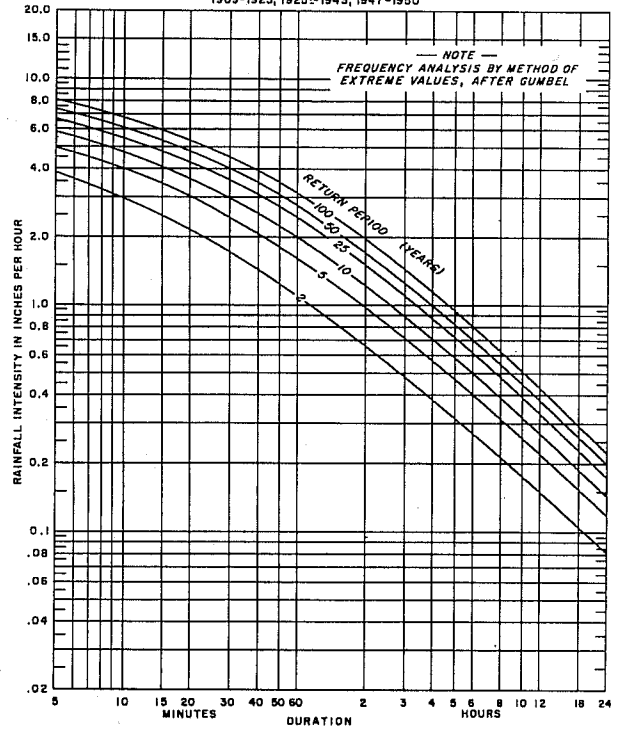


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

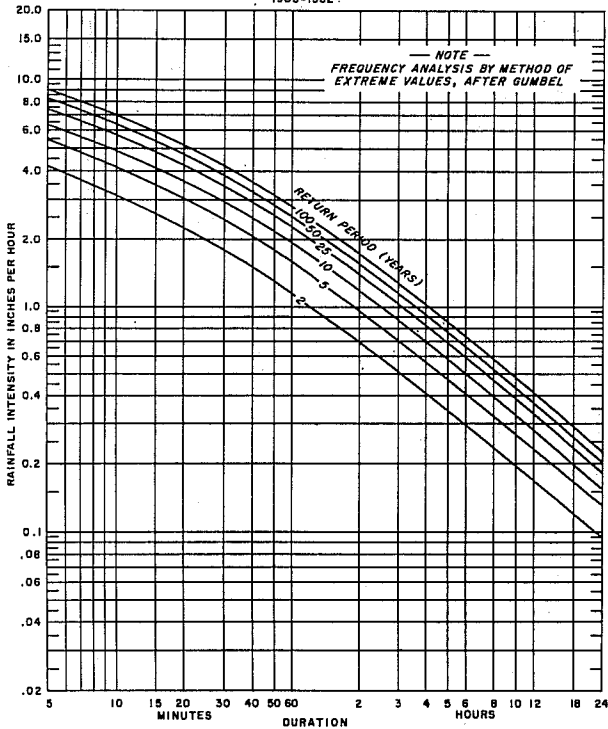
MINNEAPOLIS, MINNESOTA
1904-1951



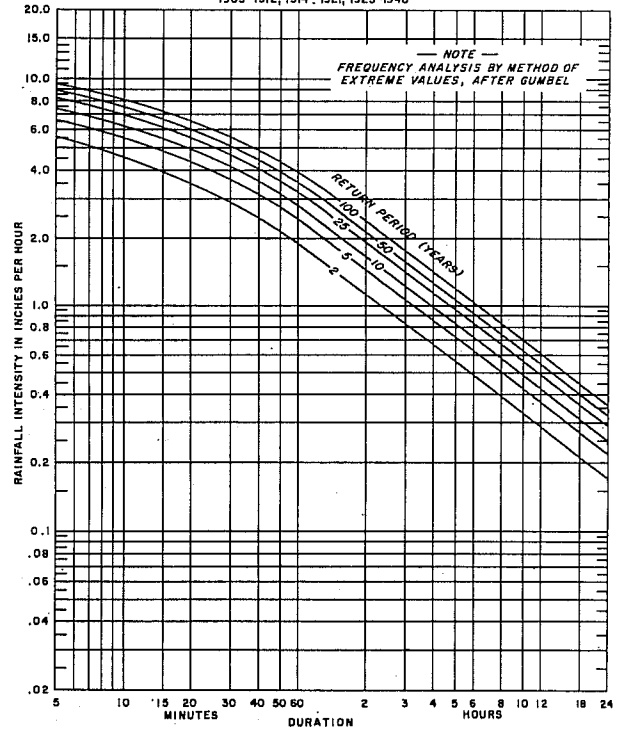
MOORHEAD, MINNESOTA
1909-1923, 1925-1943, 1947-1950



ST. PAUL, MINNESOTA
1903-1932

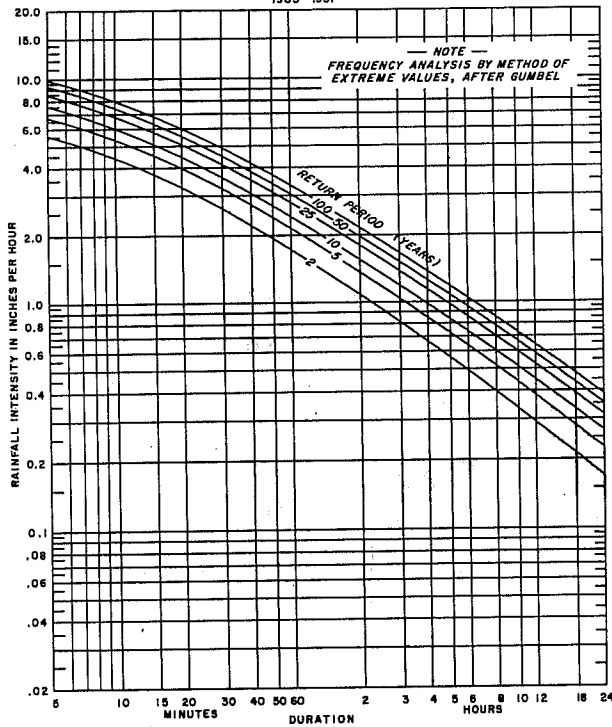


MERIDIAN, MISSISSIPPI
1903-1912, 1914-1921, 1923-1948

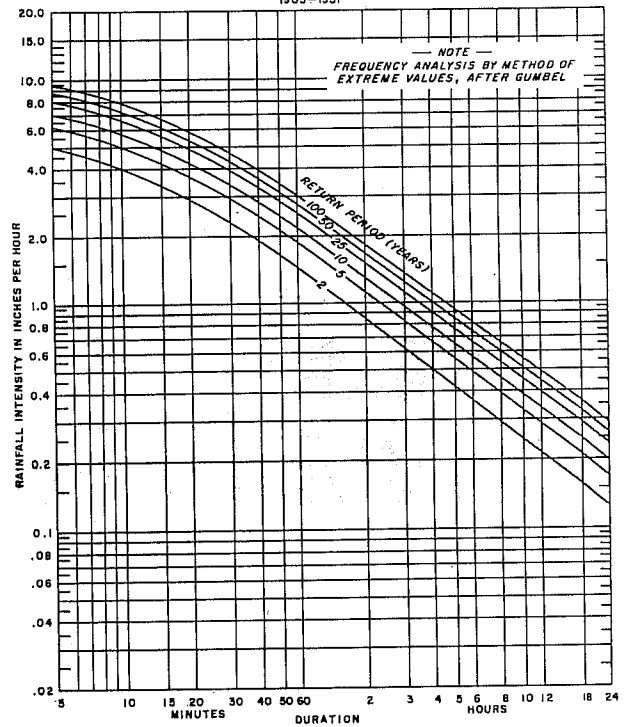


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

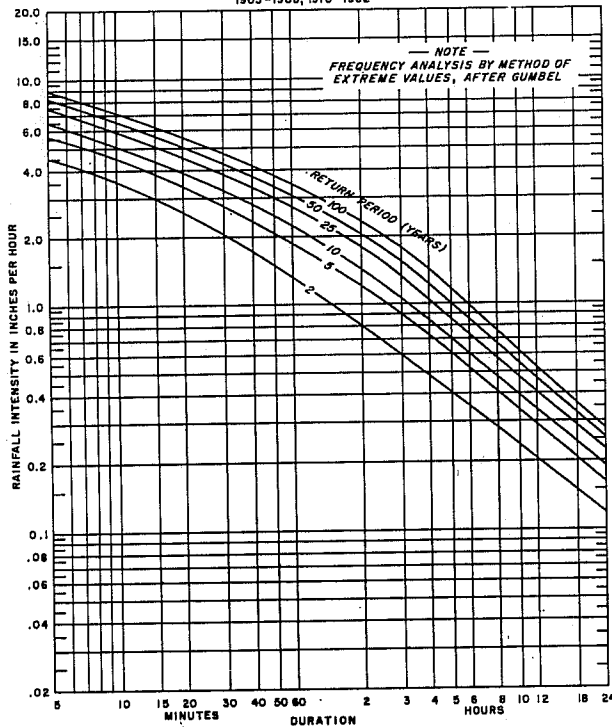
VICKSBURG, MISSISSIPPI
1903-1951



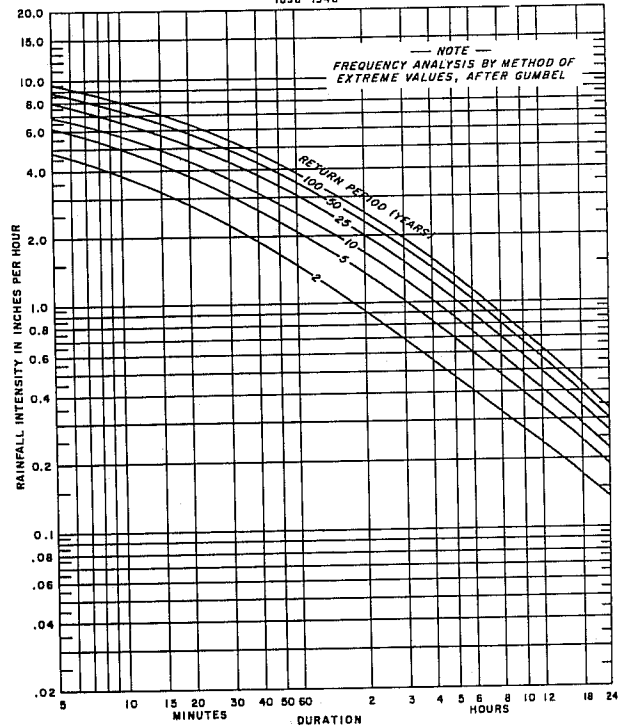
COLUMBIA, MISSOURI
1903-1951



HANNIBAL, MISSOURI
1903-1908, 1910-1932

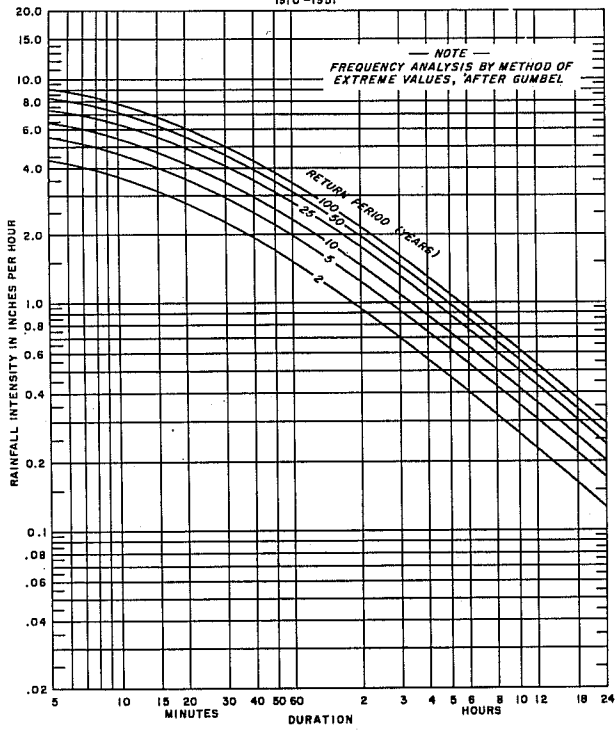


KANSAS CITY, MISSOURI
1896-1948

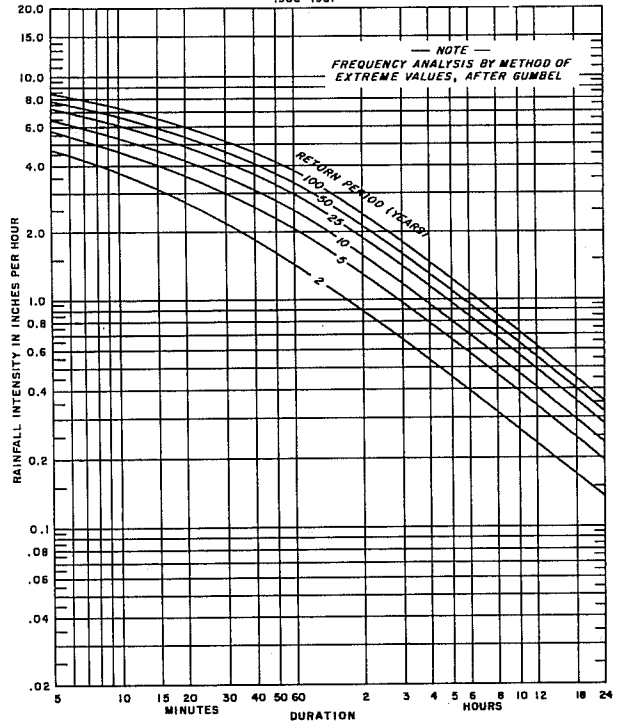


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

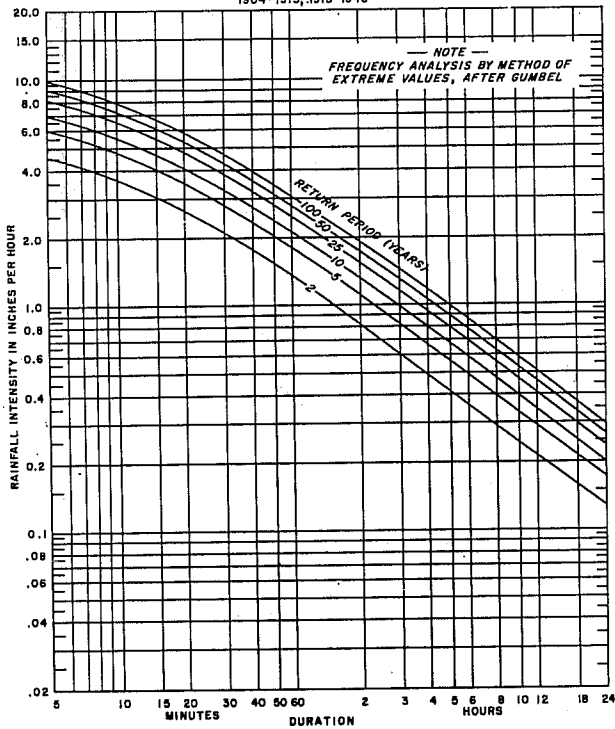
ST JOSEPH, MISSOURI
1910-1951



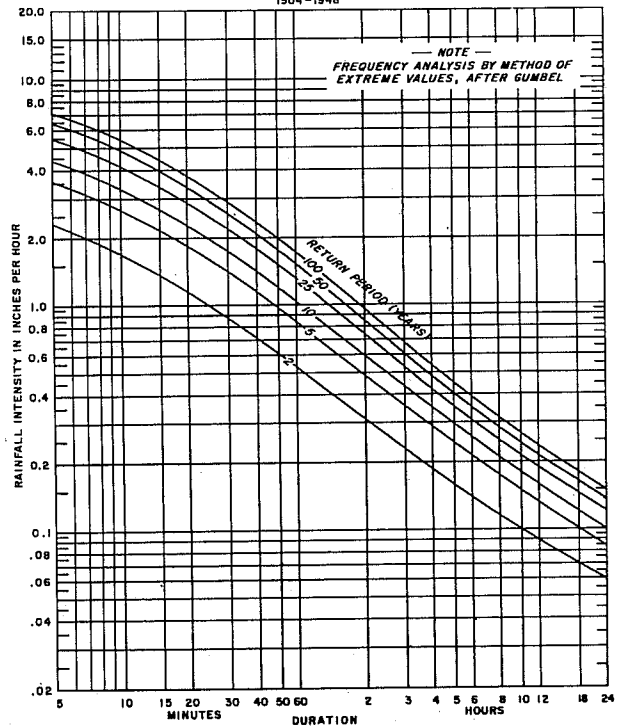
ST. LOUIS, MISSOURI
1903-1951



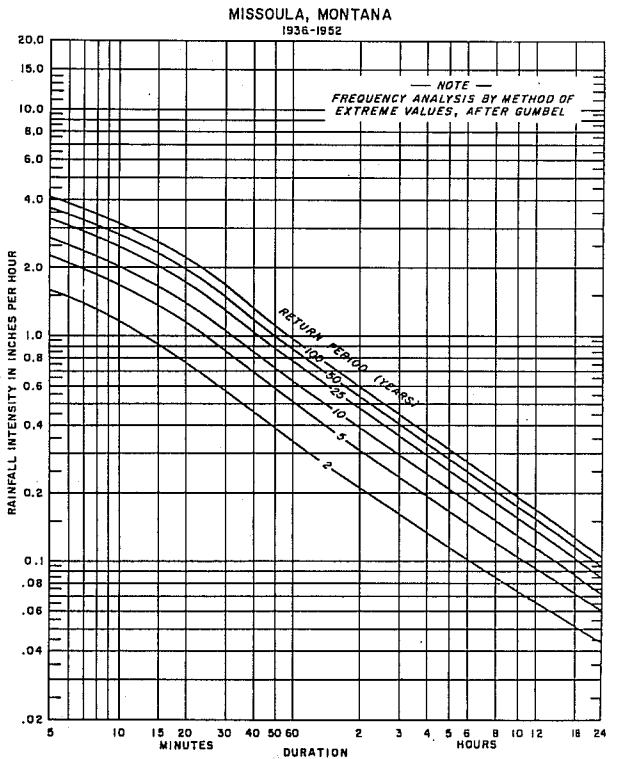
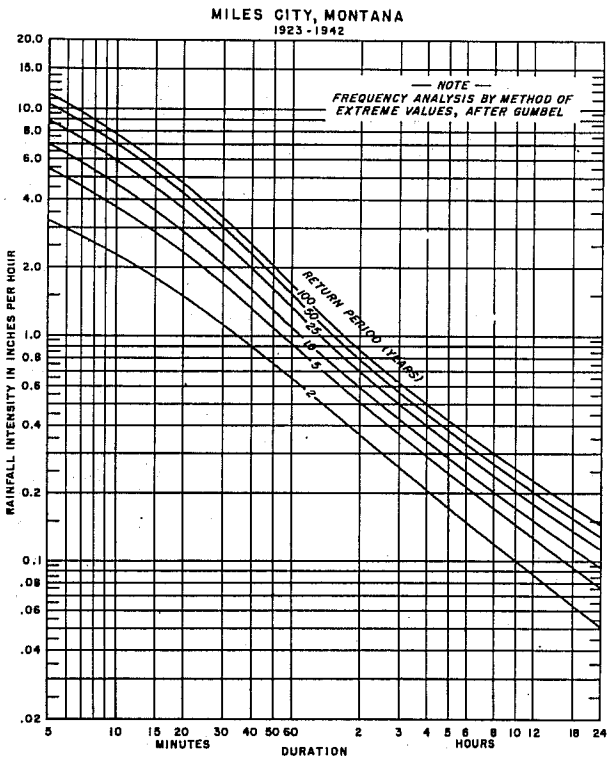
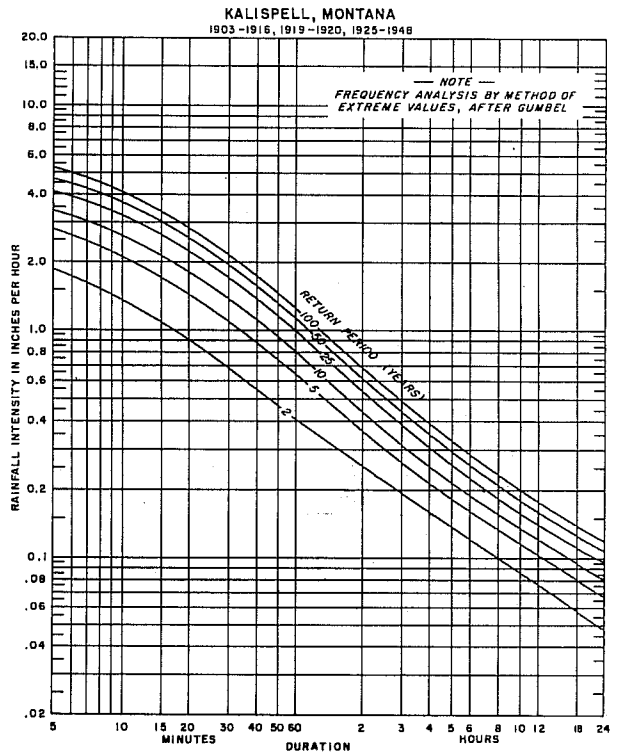
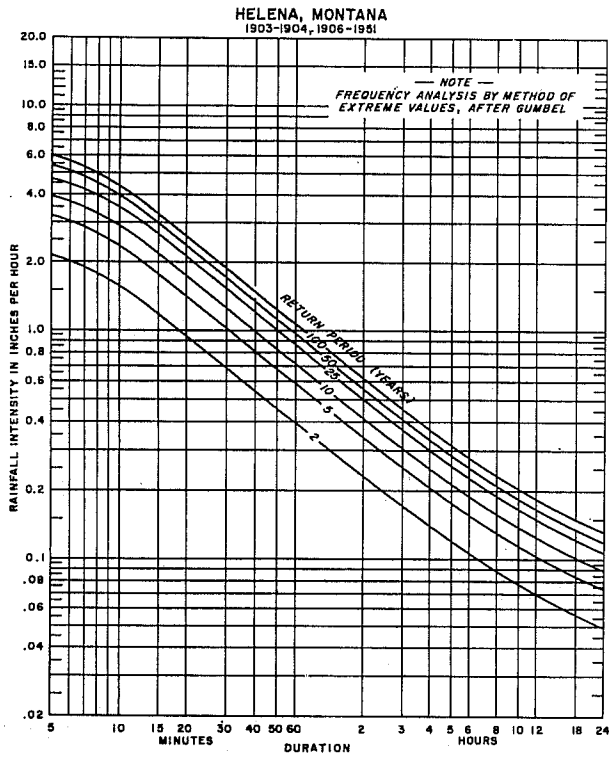
SPRINGFIELD, MISSOURI
1904-1913, 1915-1948



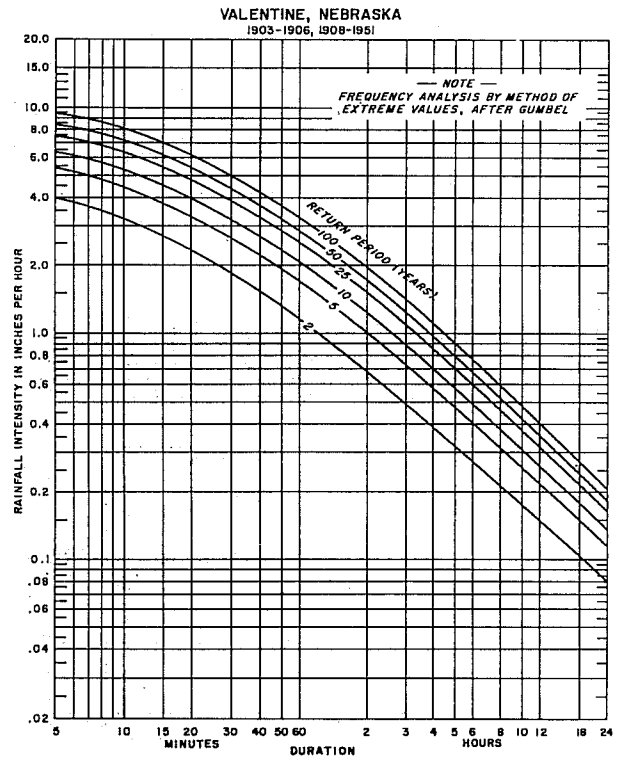
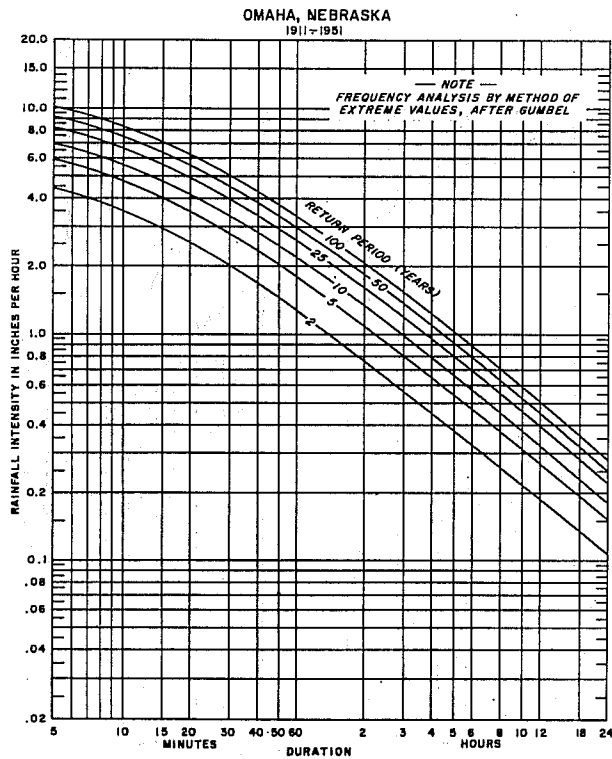
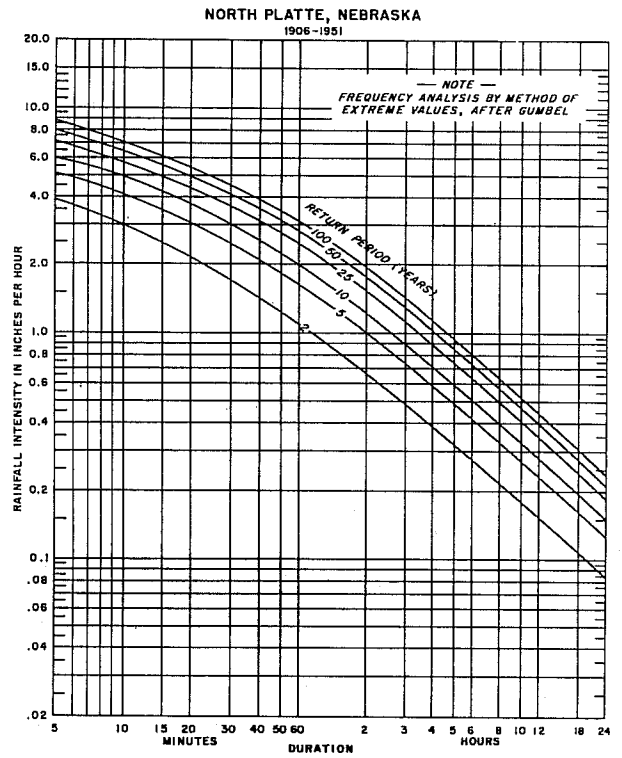
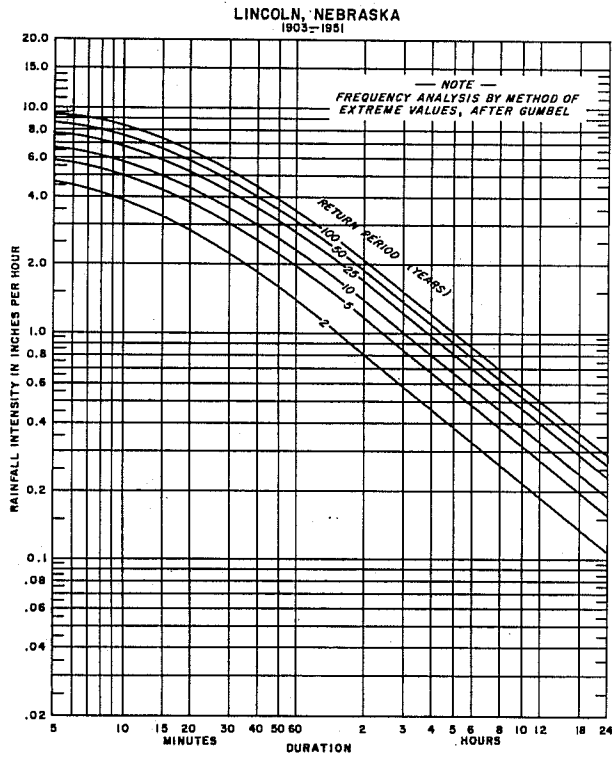
HAVRE, MONTANA
1904-1948



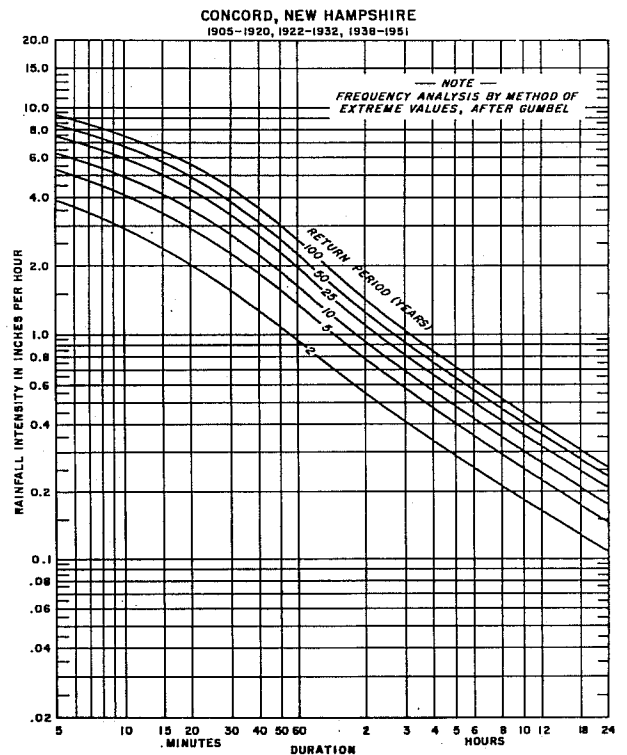
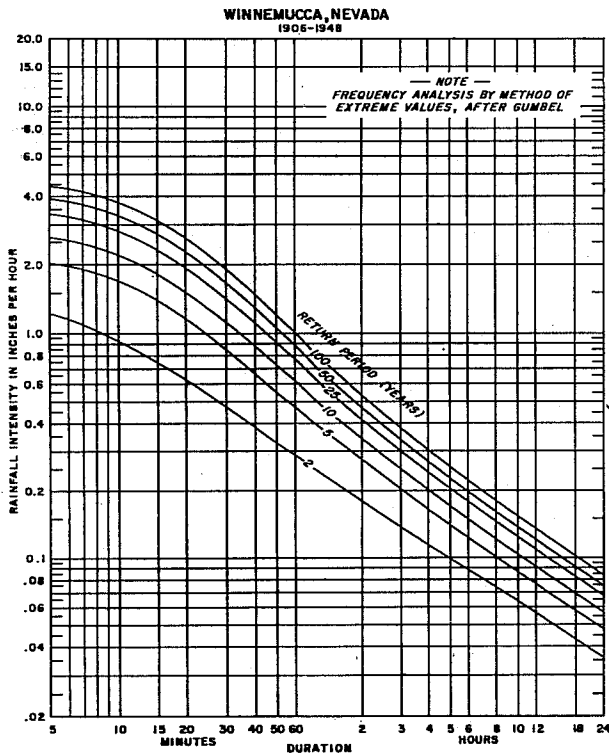
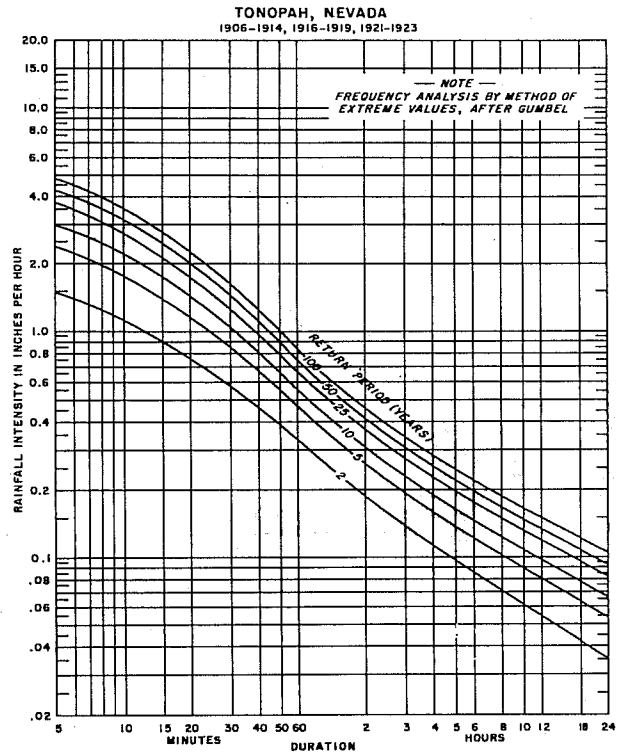
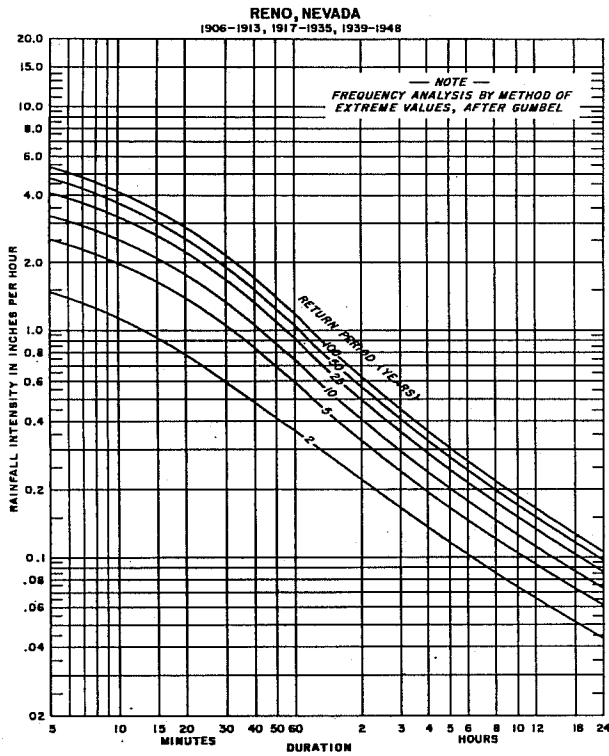
RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

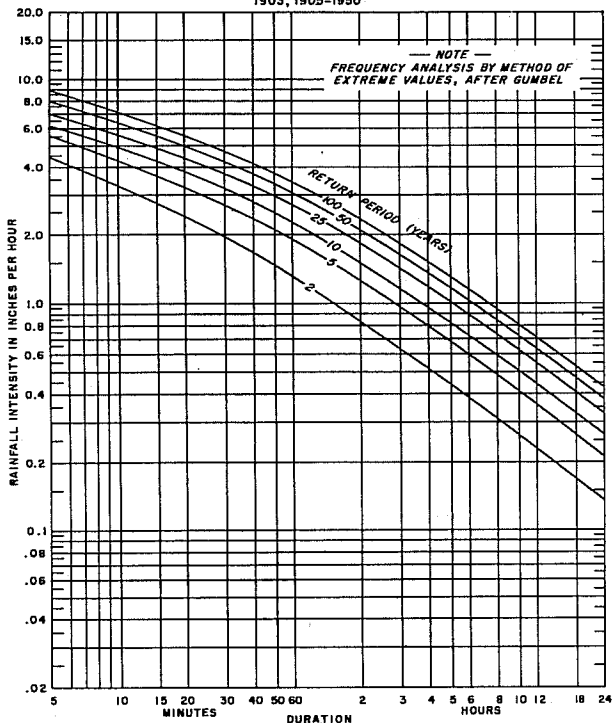


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

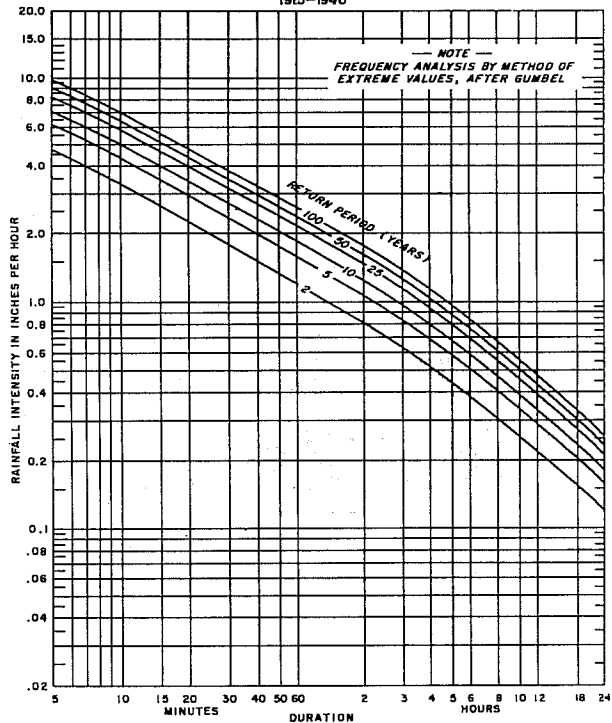


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

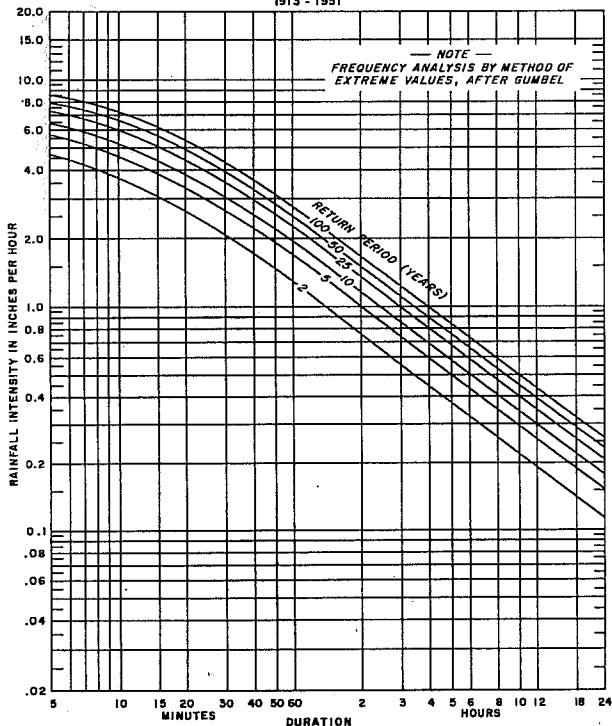
ATLANTIC CITY, NEW JERSEY
1903, 1905-1950



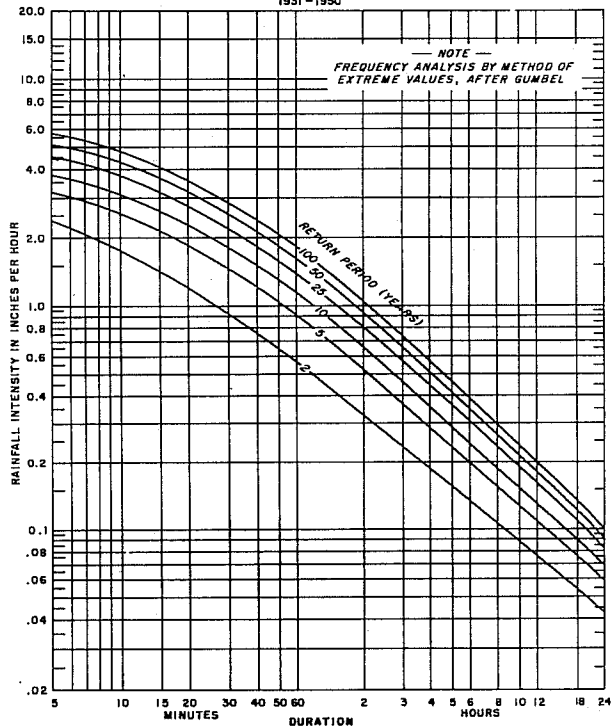
SANDY HOOK, NEW JERSEY
1915-1940



TRENTON, NEW JERSEY
1913-1951

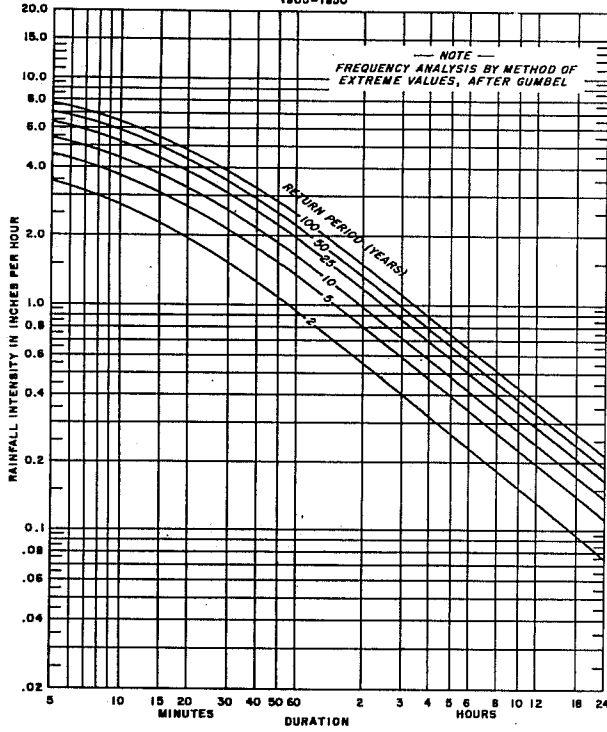


ALBUQUERQUE, NEW MEXICO
1931-1950

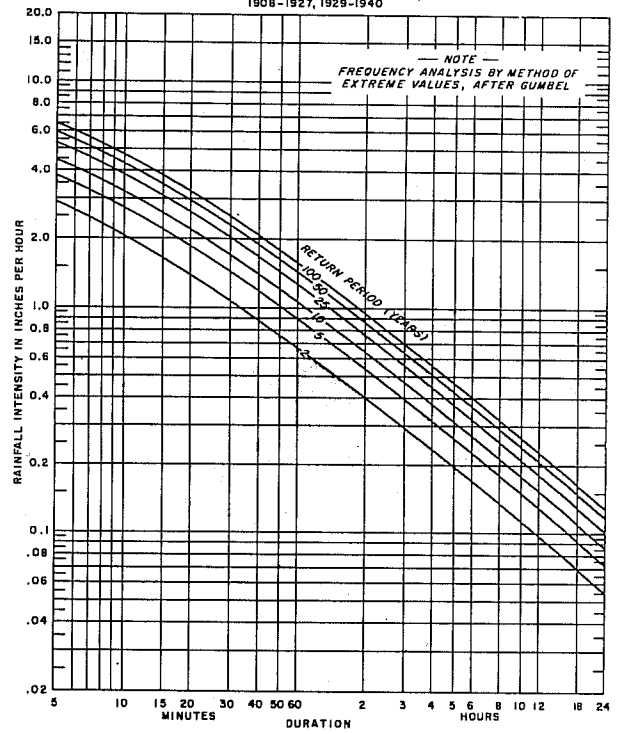


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

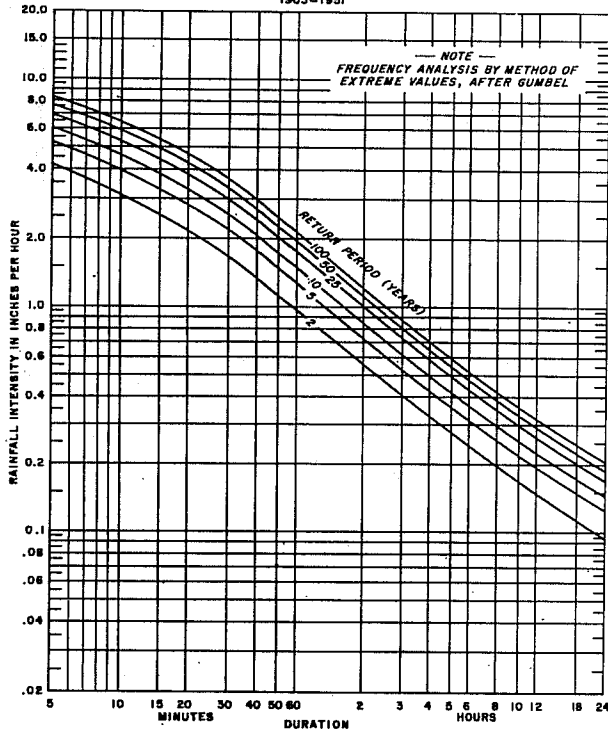
ROSWELL, NEW MEXICO
1906-1980



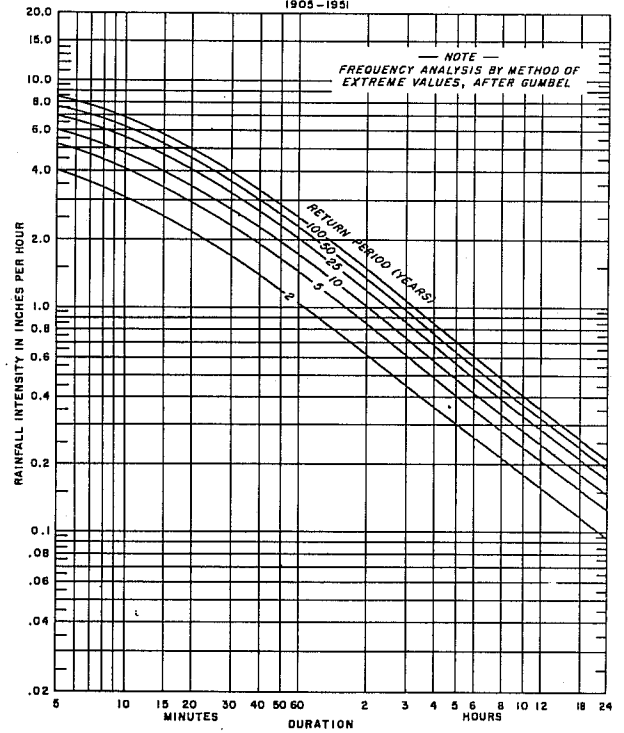
SANTA FE, NEW MEXICO
1908-1927, 1929-1940



ALBANY, NEW YORK
1903-1951

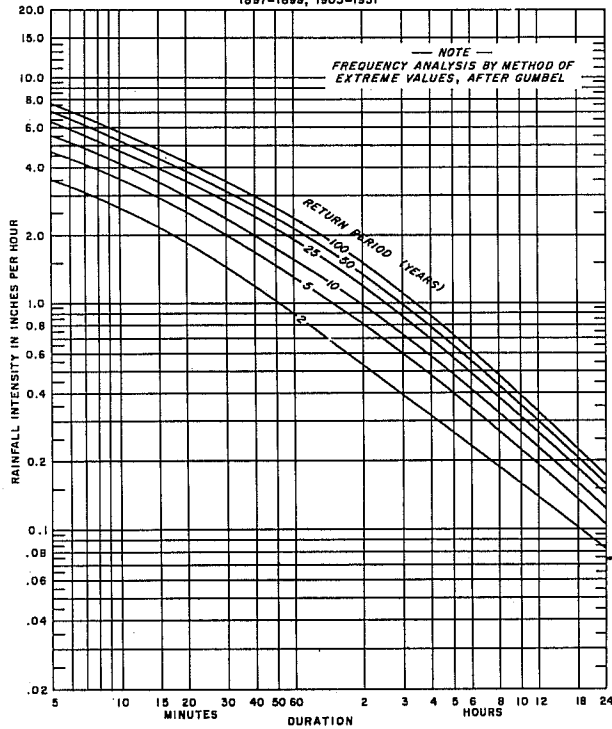


BINGHAMTON, NEW YORK
1901-1951

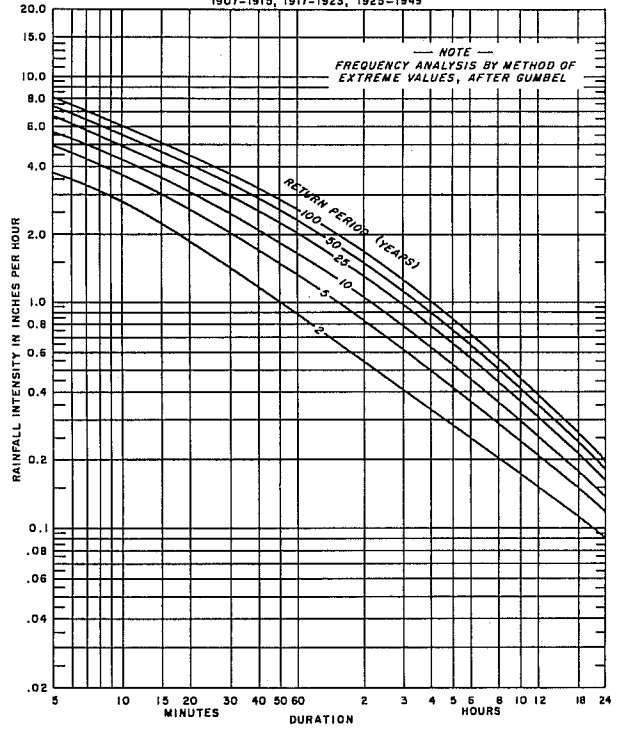


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

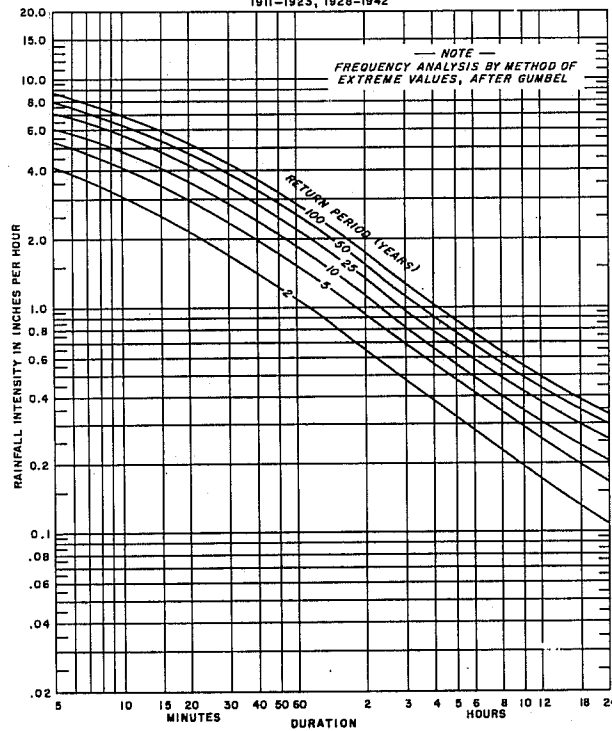
BUFFALO, NEW YORK
1897-1899, 1903-1951



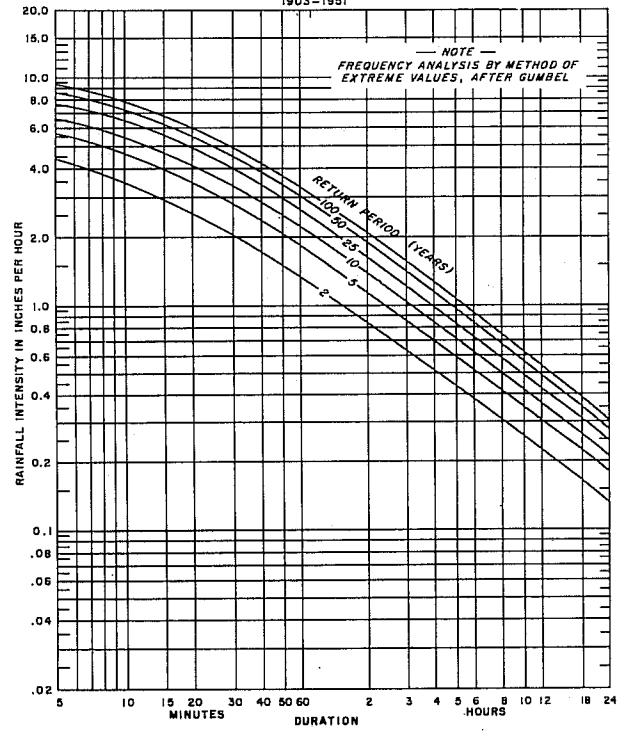
CANTON, NEW YORK
1907-1913, 1917-1923, 1925-1949



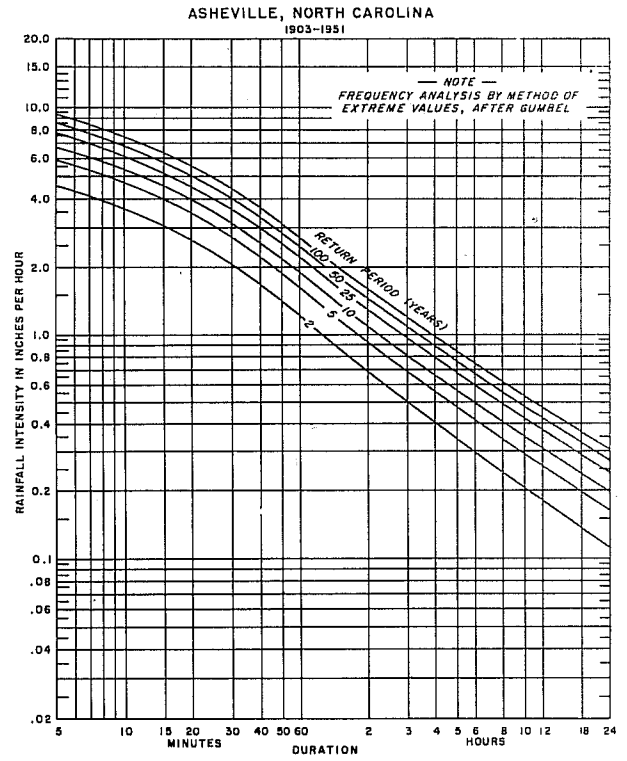
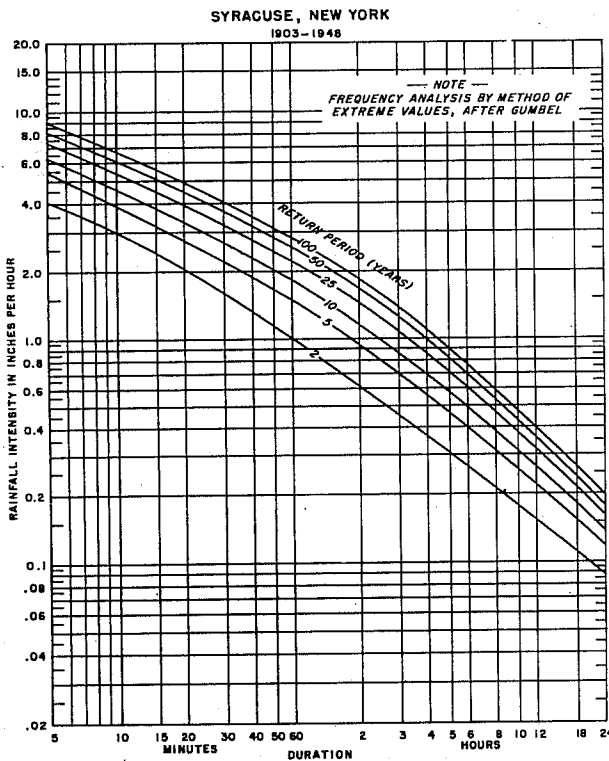
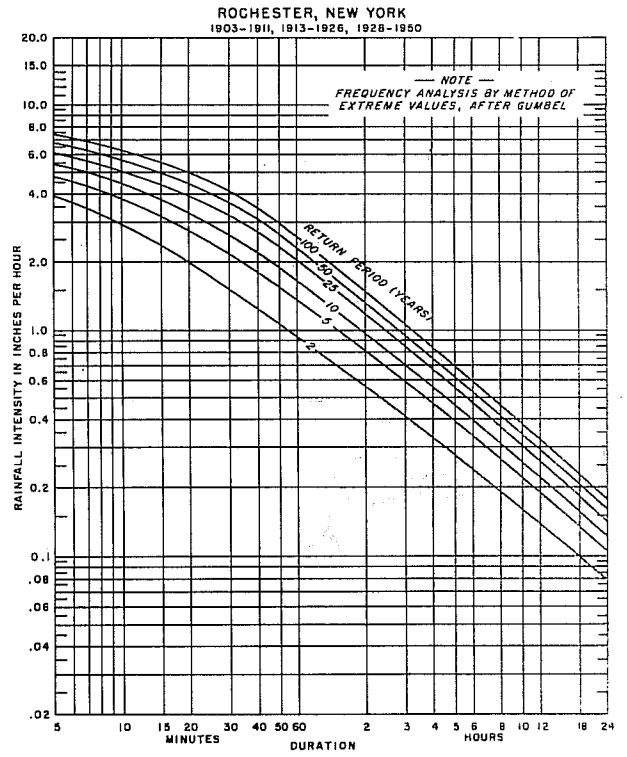
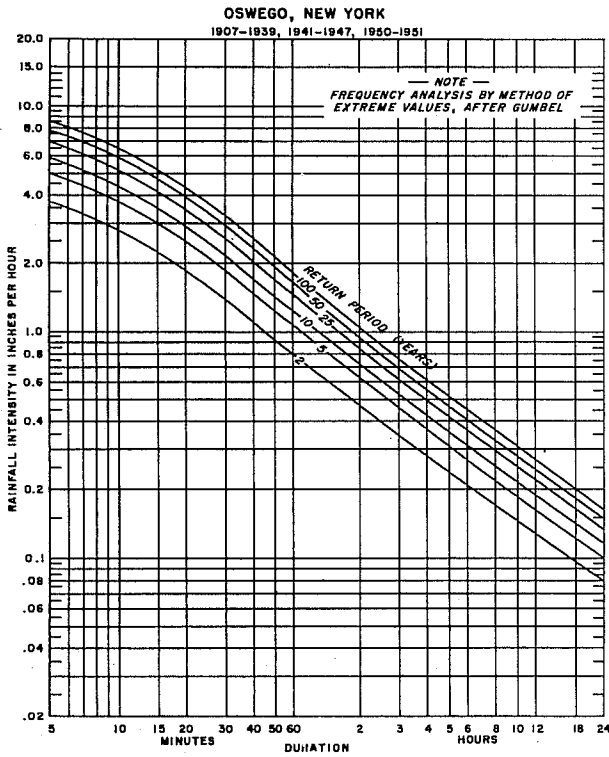
ITHACA, NEW YORK
1911-1923, 1928-1942



NEW YORK, NEW YORK
1903-1951

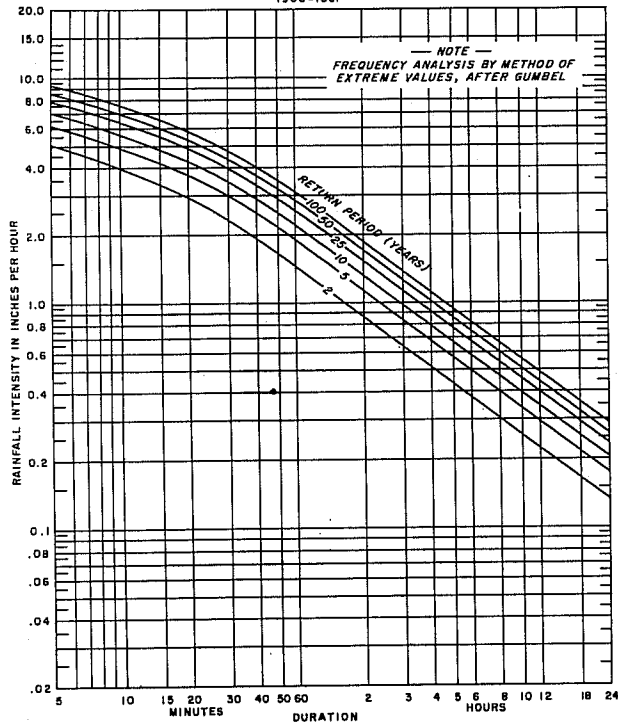


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

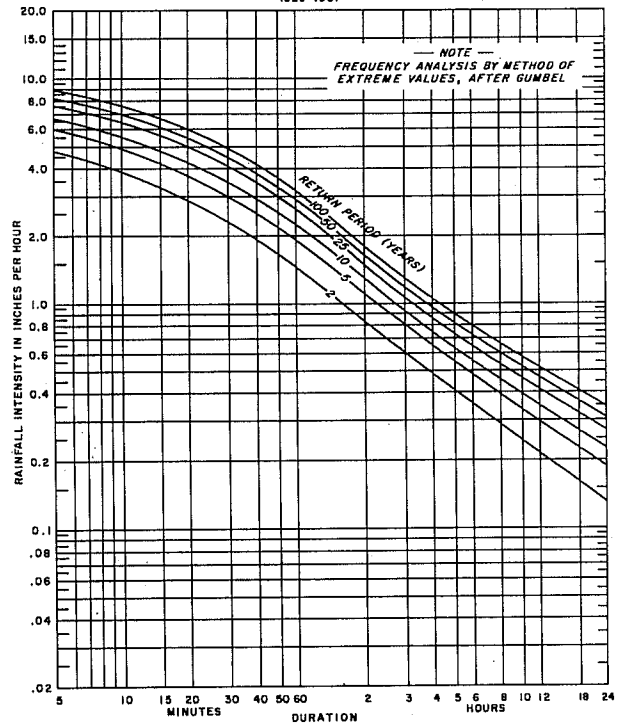


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

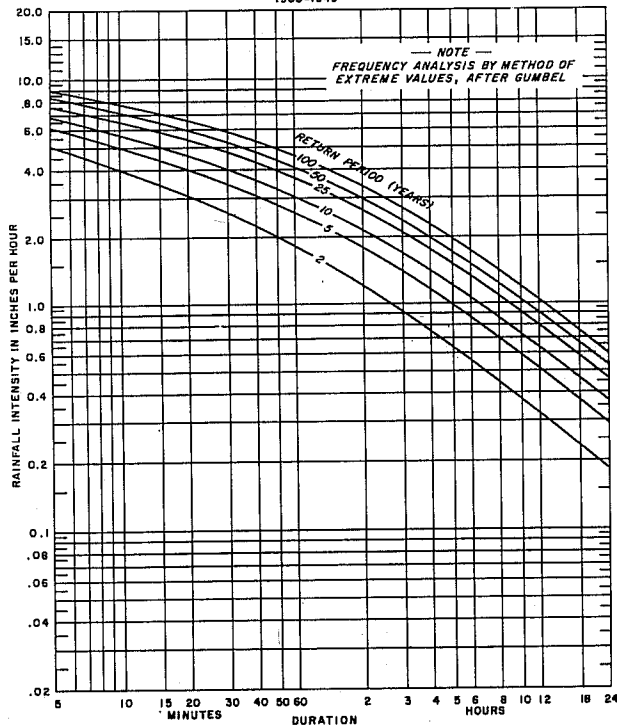
CHARLOTTE, NORTH CAROLINA
1903-1951



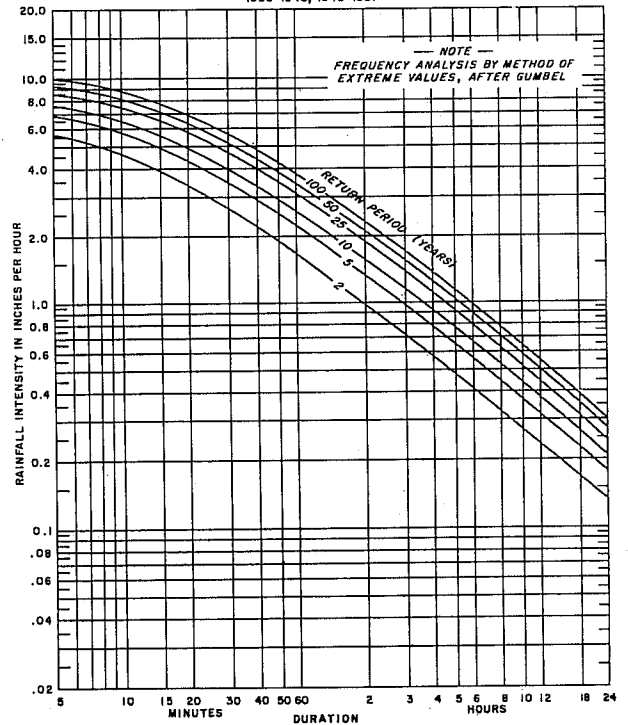
GREENSBORO, NORTH CAROLINA
1929-1951



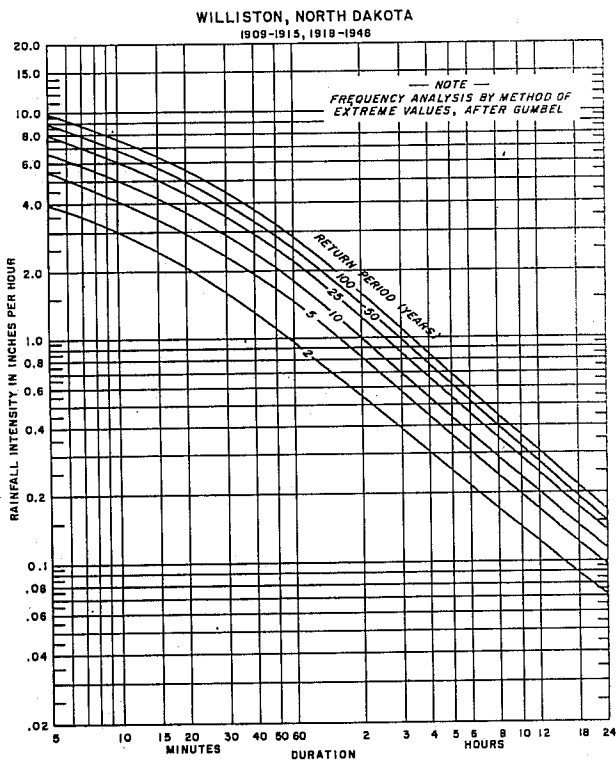
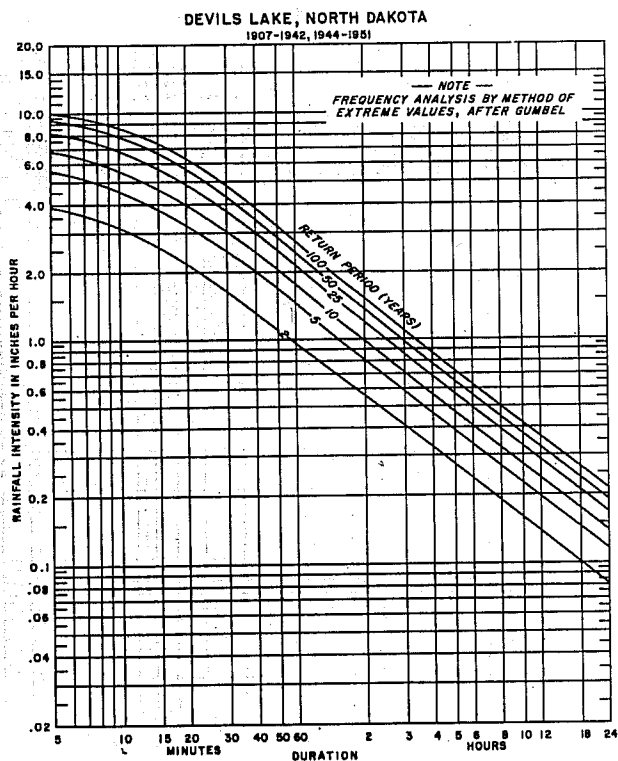
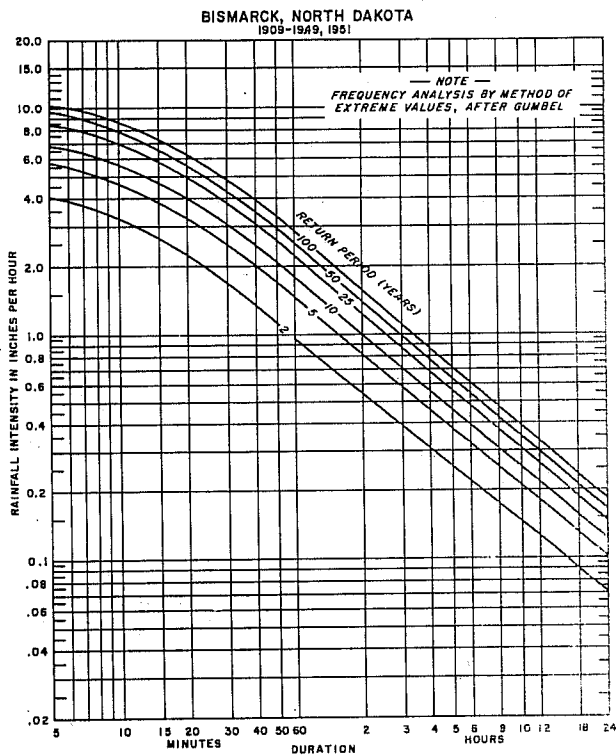
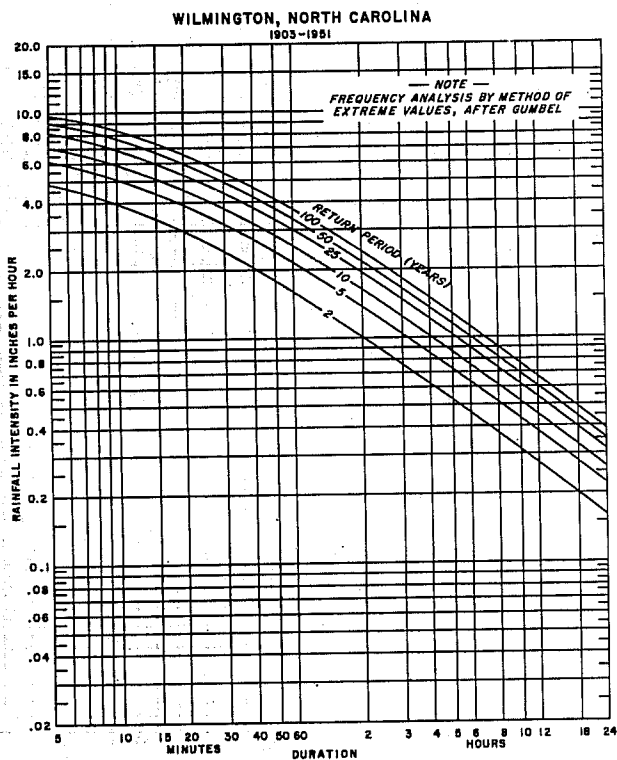
HATTERAS, NORTH CAROLINA
1905-1949



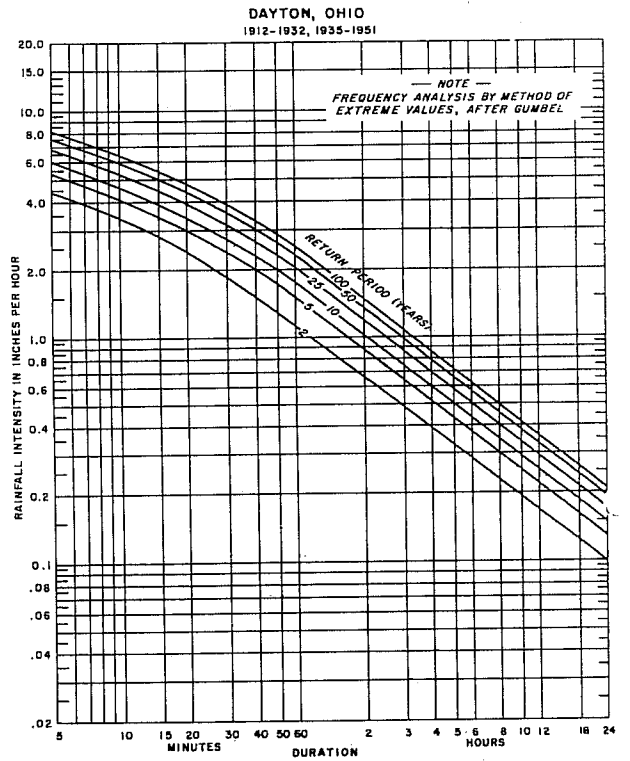
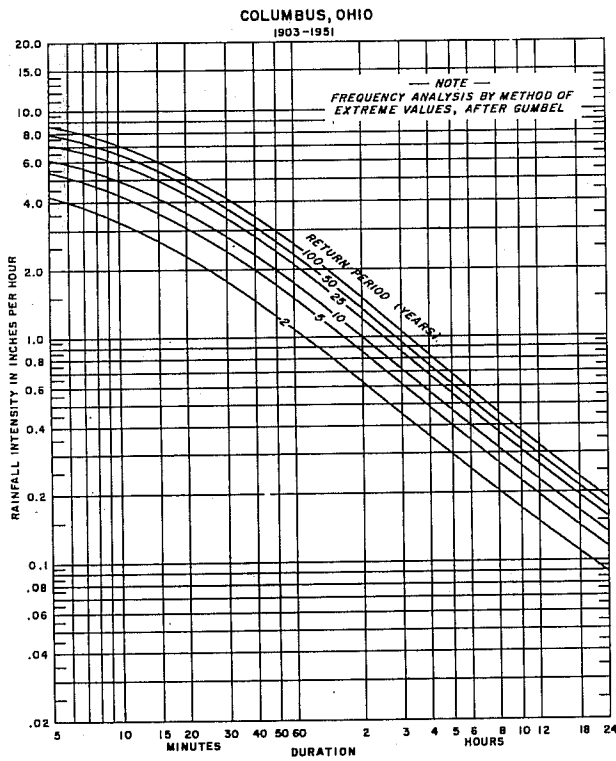
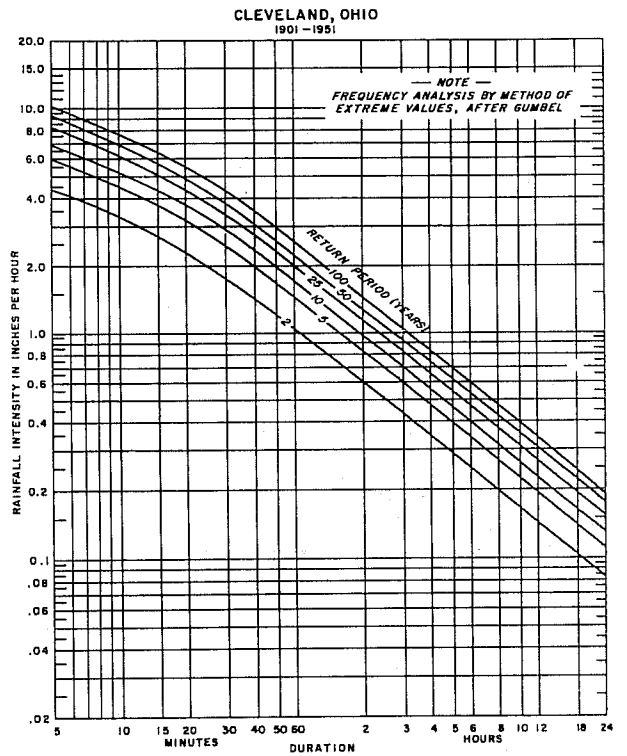
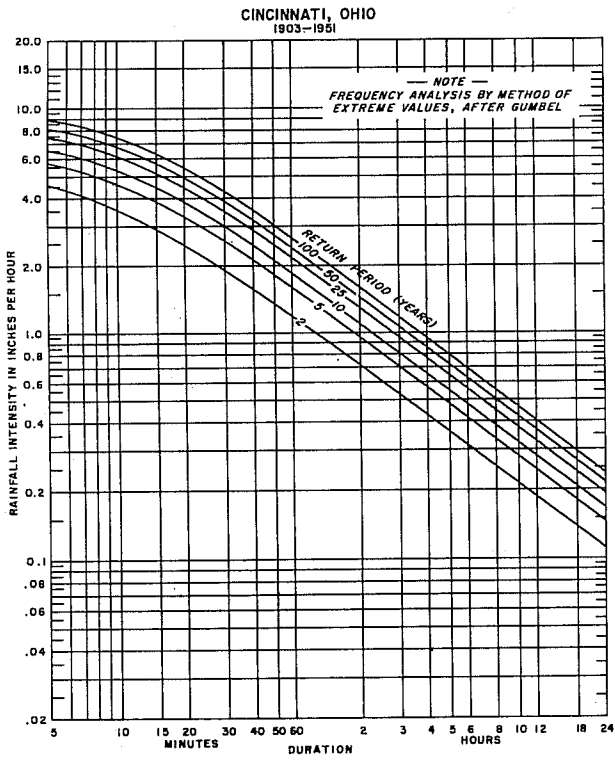
RALEIGH, NORTH CAROLINA
1903-1943, 1945-1951



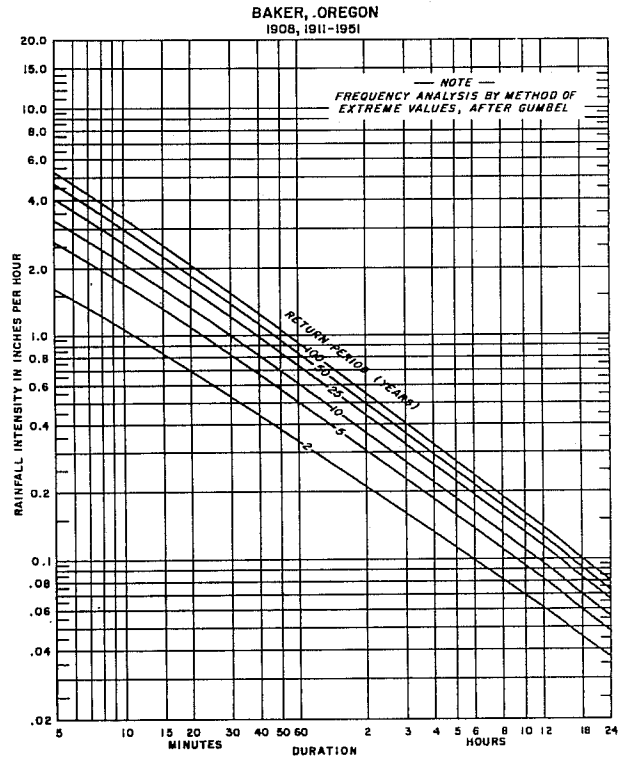
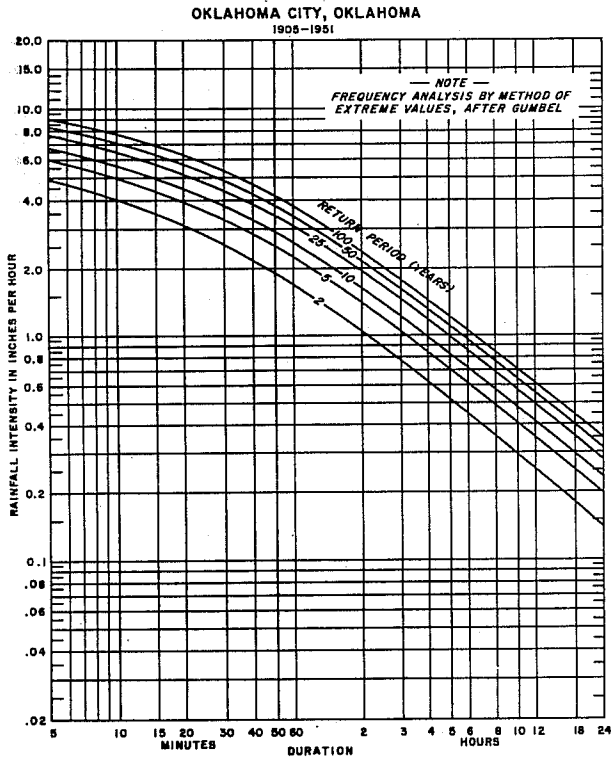
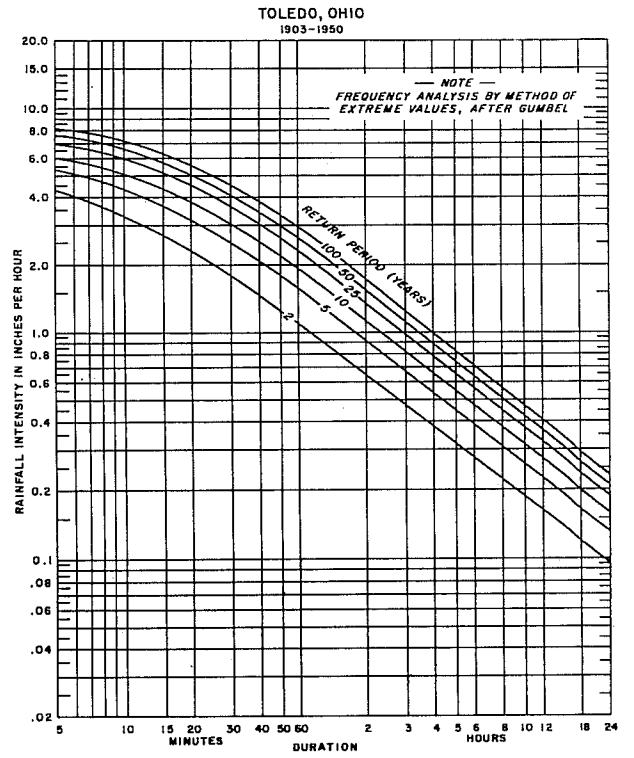
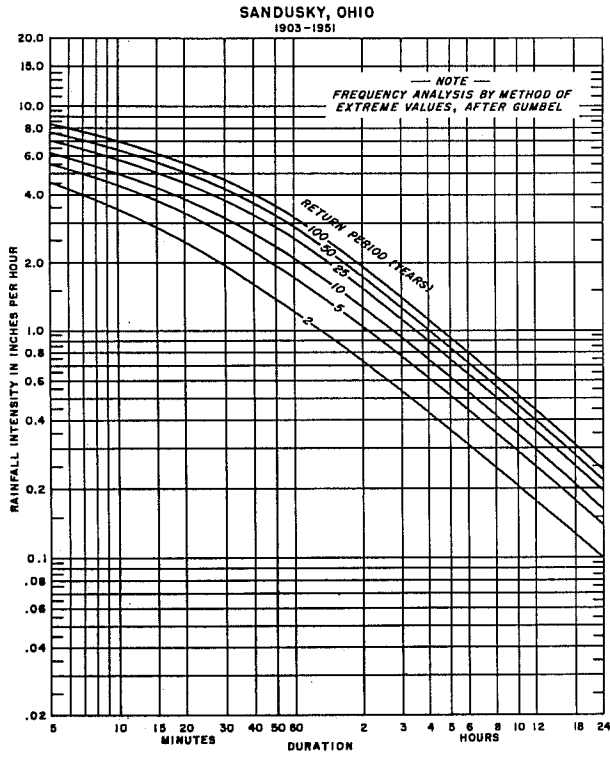
RAINFALL INTENSITY-DURATION-FREQUENCY CURVES



RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

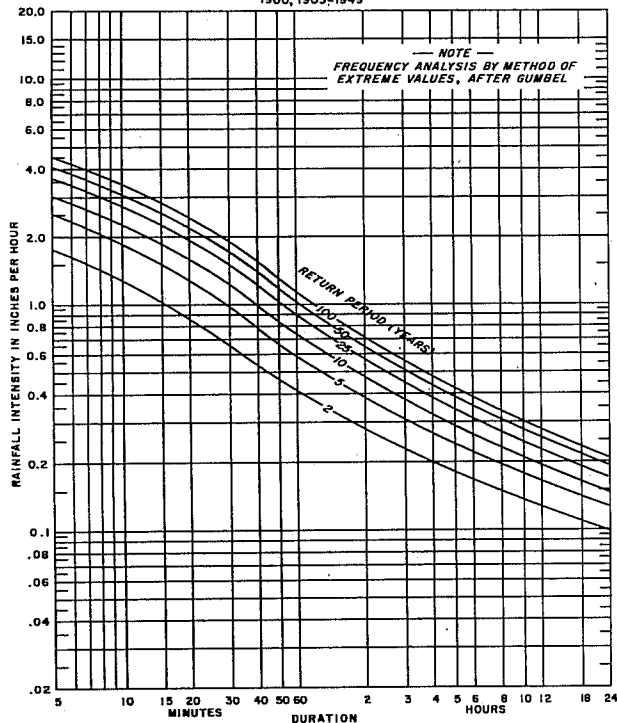


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

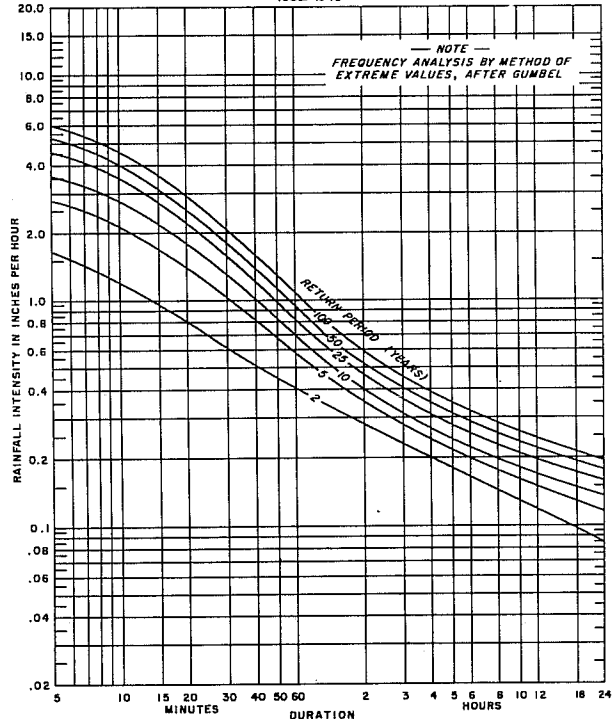


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

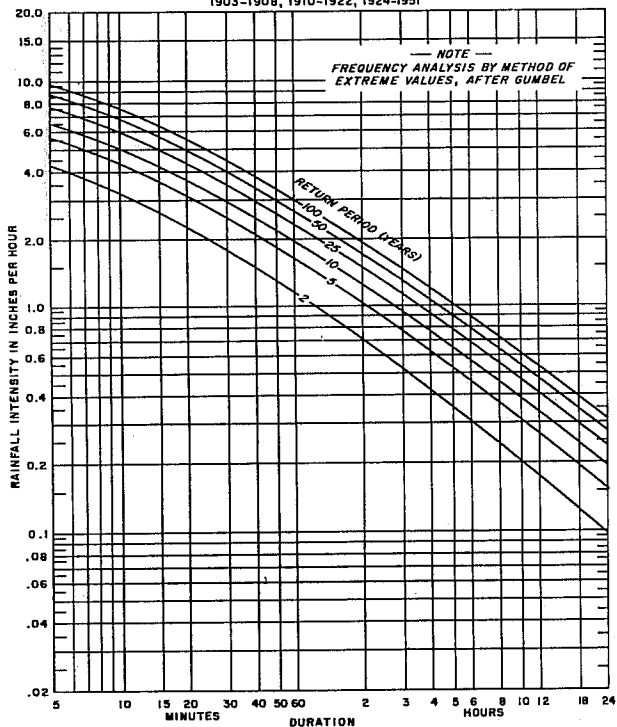
PORTLAND, OREGON
1900, 1903-1949



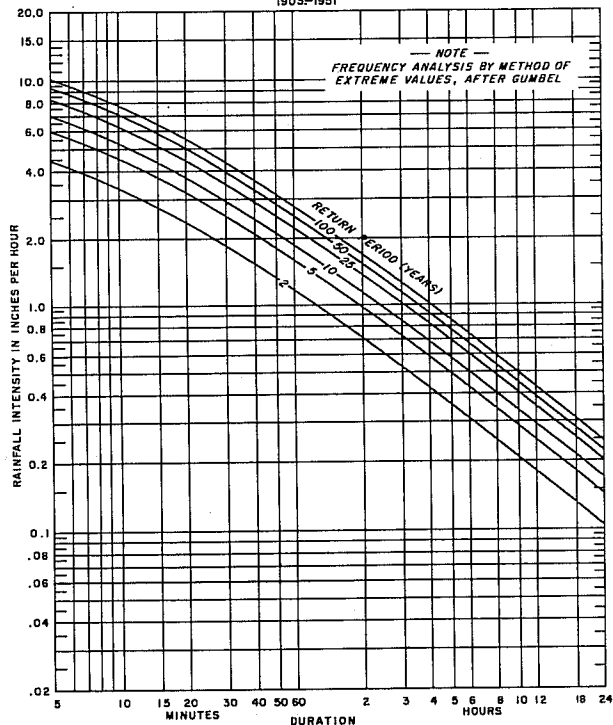
ROSEBURG, OREGON
1905-1948



ERIE, PENNSYLVANIA
1903-1908, 1910-1922, 1924-1951

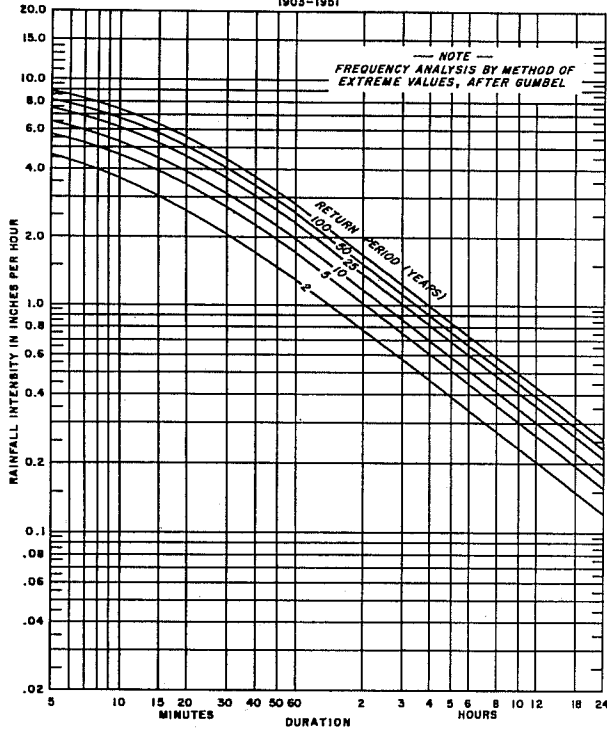


HARRISBURG, PENNSYLVANIA
1903-1951

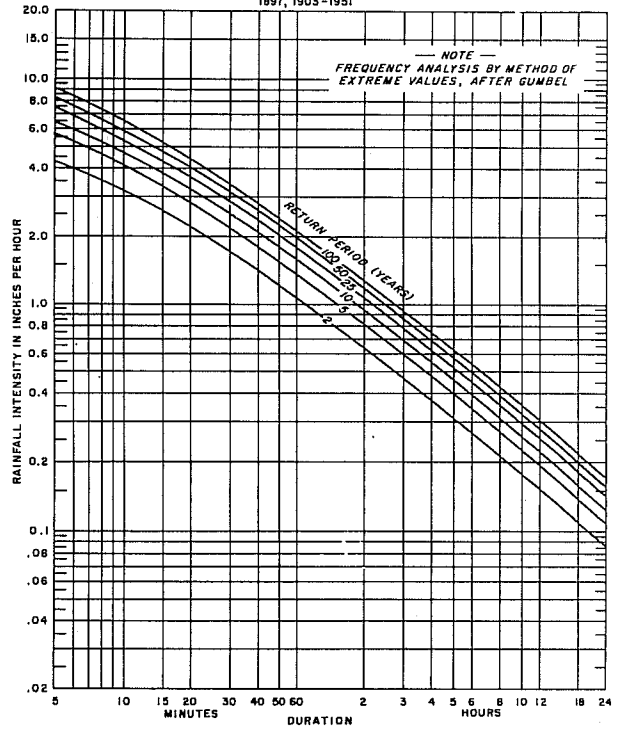


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

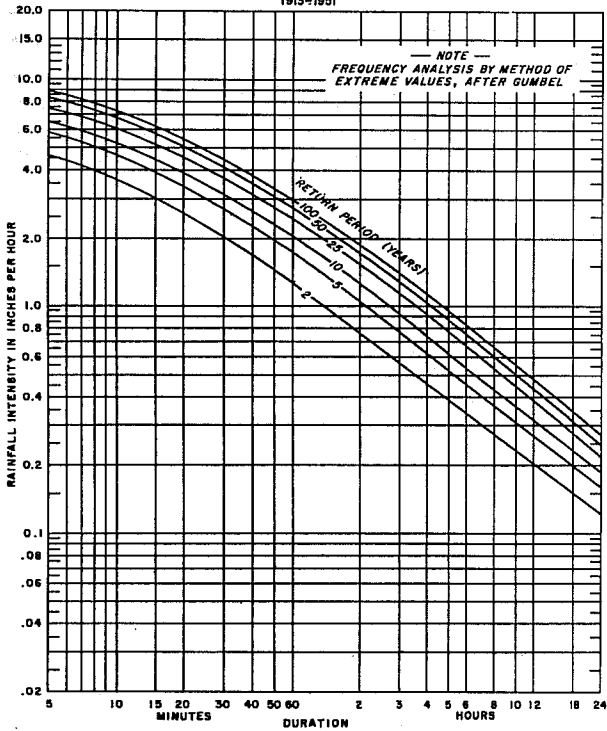
PHILADELPHIA, PENNSYLVANIA
1903-1951



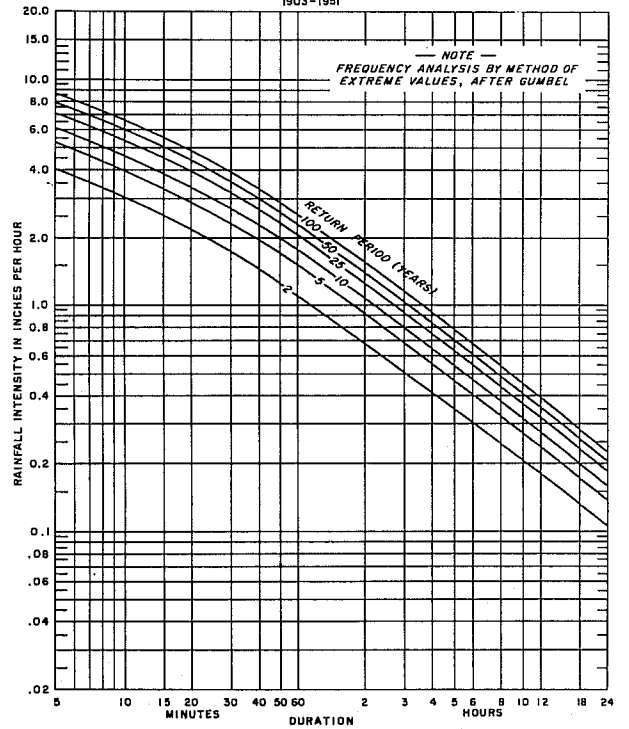
PITTSBURGH, PENNSYLVANIA
1897, 1903-1951



READING, PENNSYLVANIA
1913-1951

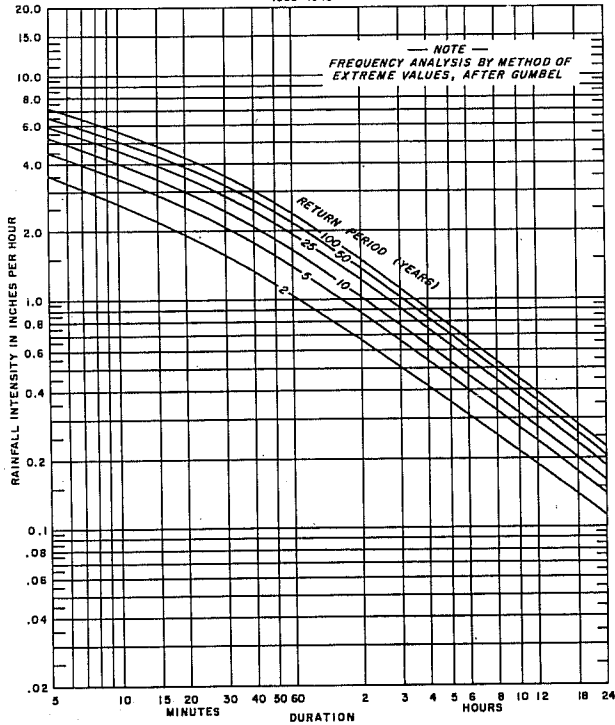


SCRANTON, PENNSYLVANIA
1903-1951

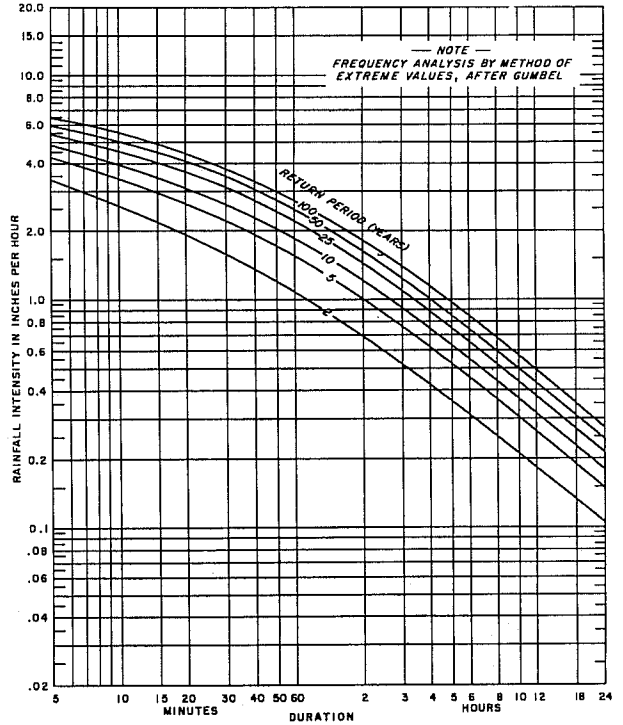


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

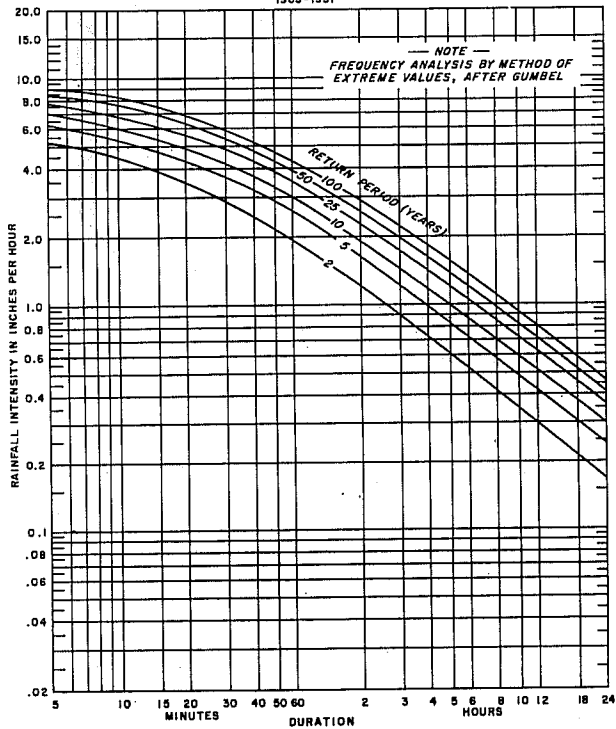
BLOCK ISLAND, RHODE ISLAND
1903-1948



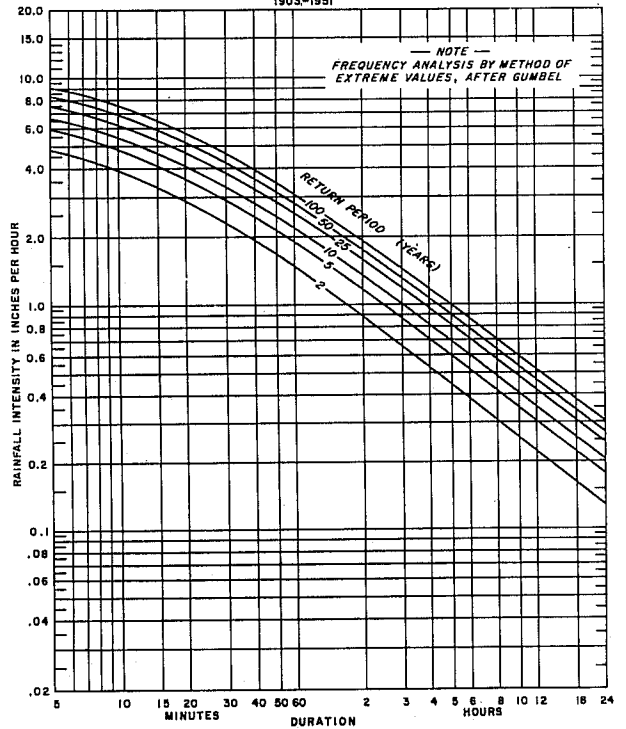
PROVIDENCE, RHODE ISLAND
1903-1951



CHARLESTON, SOUTH CAROLINA
1903-1951

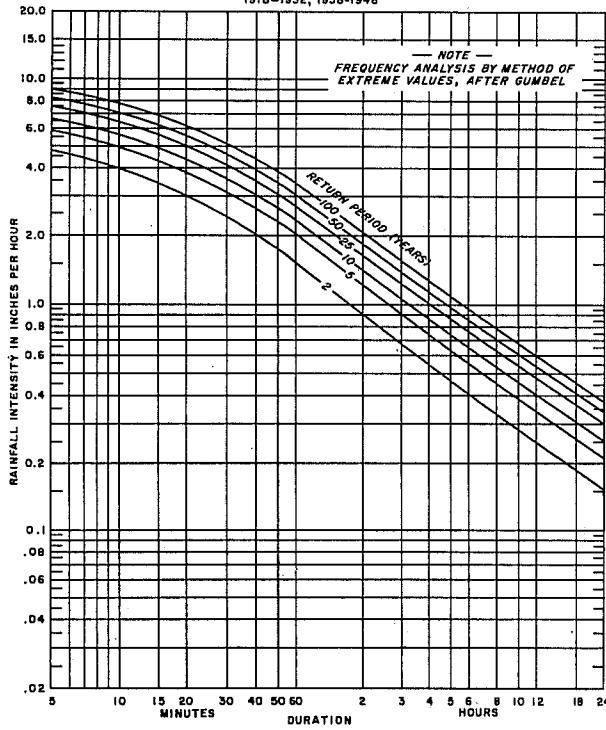


COLUMBIA, SOUTH CAROLINA
1903-1951

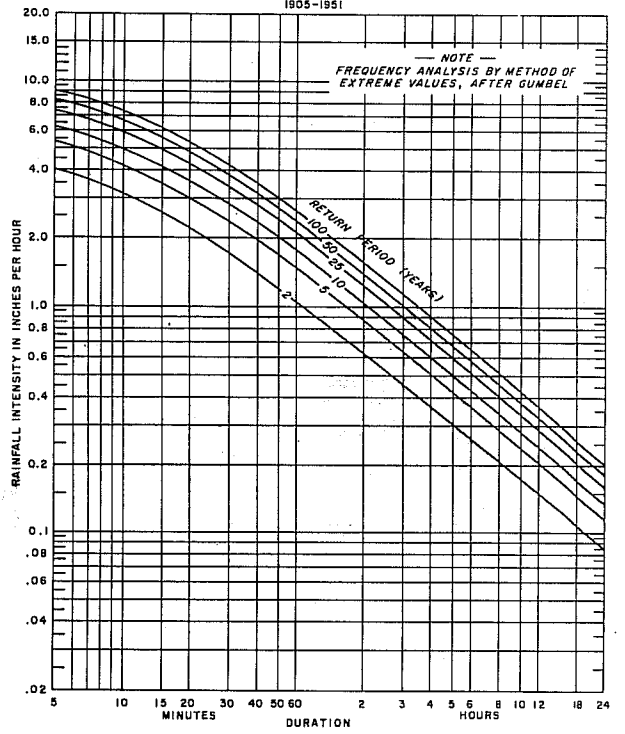


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

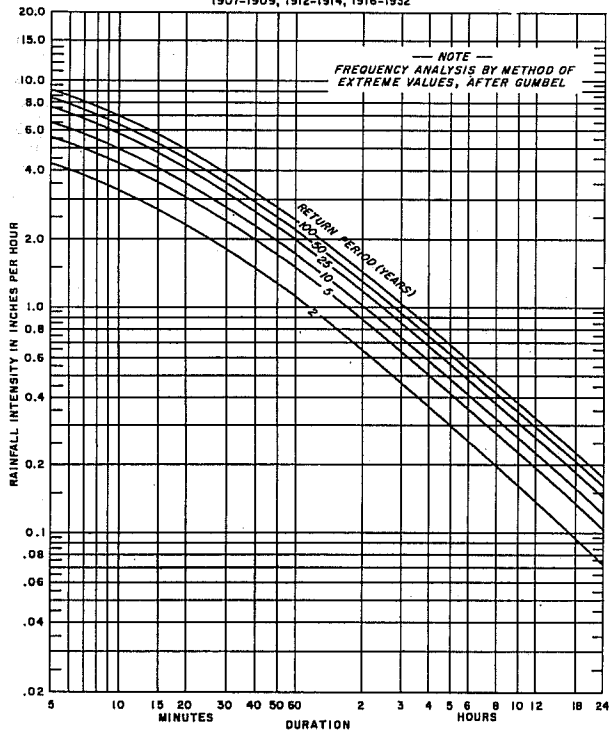
GREENVILLE, SOUTH CAROLINA
1918-1922, 1938-1948



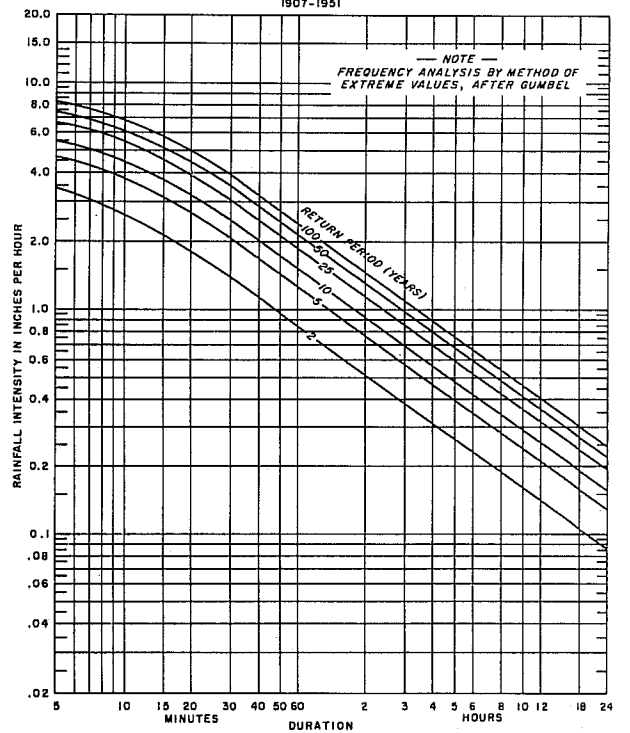
HURON, SOUTH DAKOTA
1905-1951



PIERRE, SOUTH DAKOTA
1907-1909, 1912-1914, 1916-1932

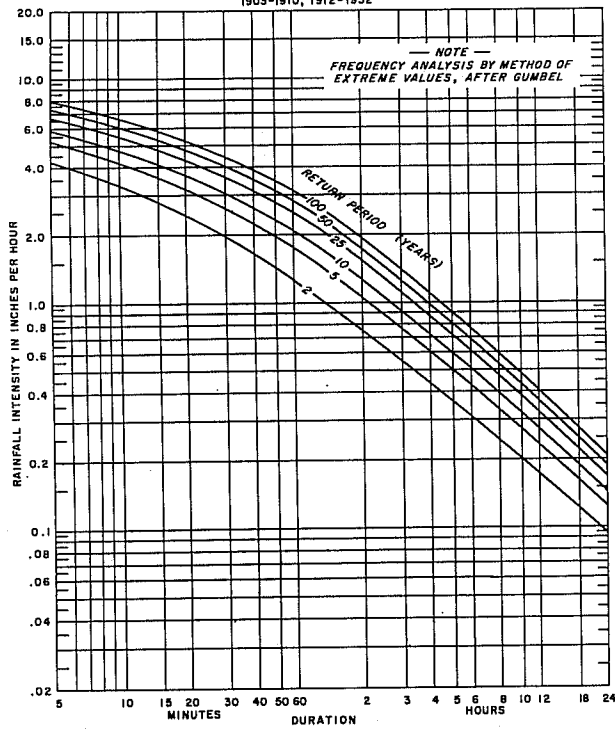


RAPID CITY, SOUTH DAKOTA
1907-1951

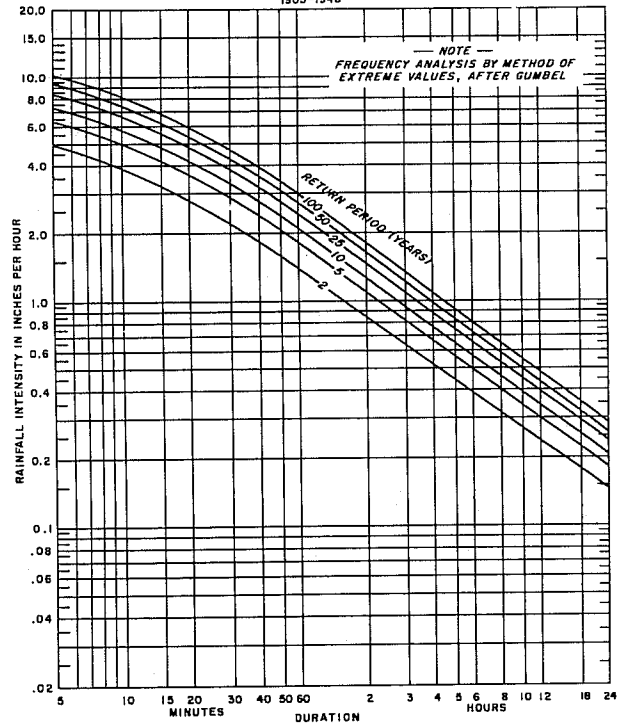


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

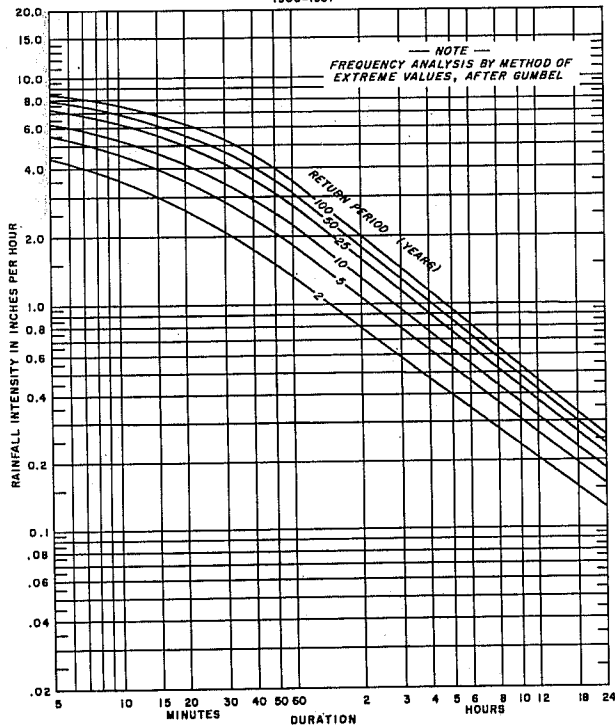
YANKTON, SOUTH DAKOTA
1903-1910, 1912-1932



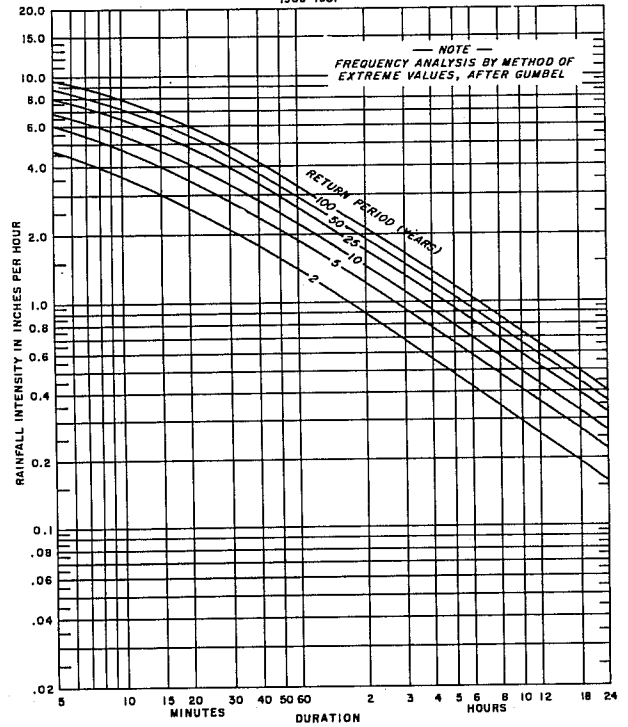
CHATTANOOGA, TENNESSEE
1903-1948



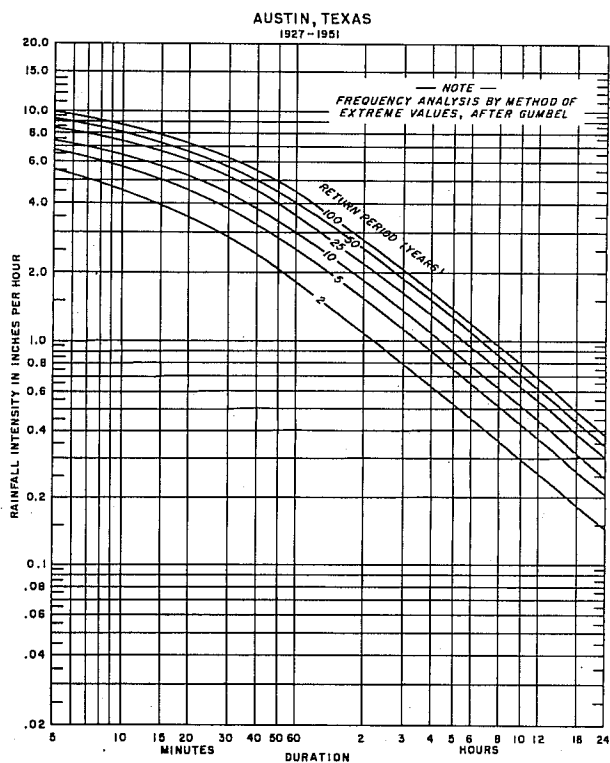
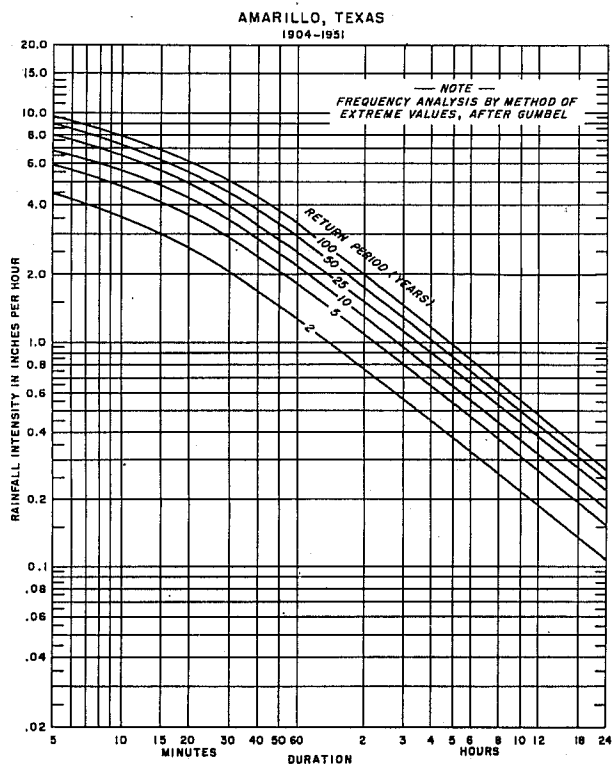
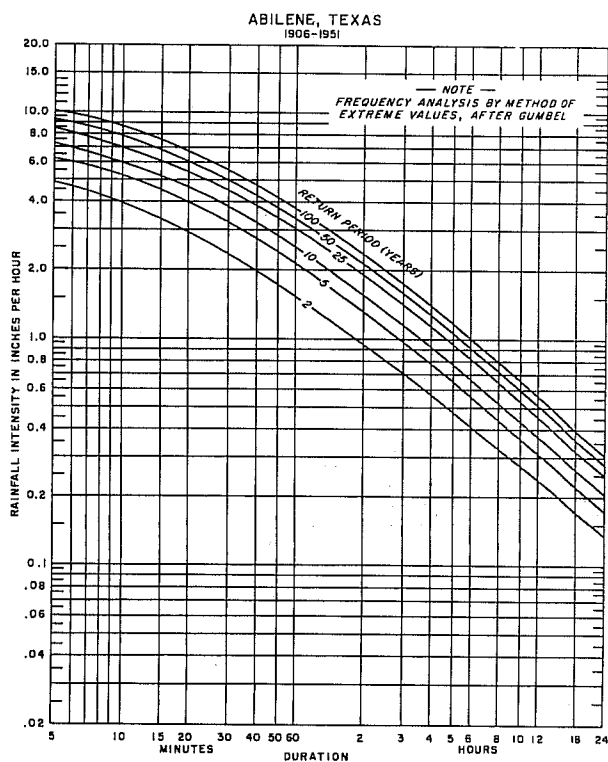
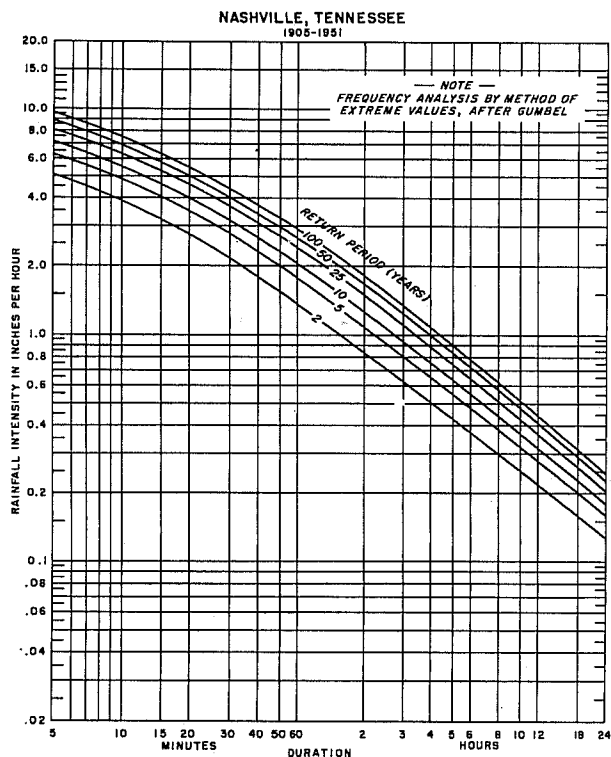
KNOXVILLE, TENNESSEE
1903-1951



MEMPHIS, TENNESSEE
1903-1951

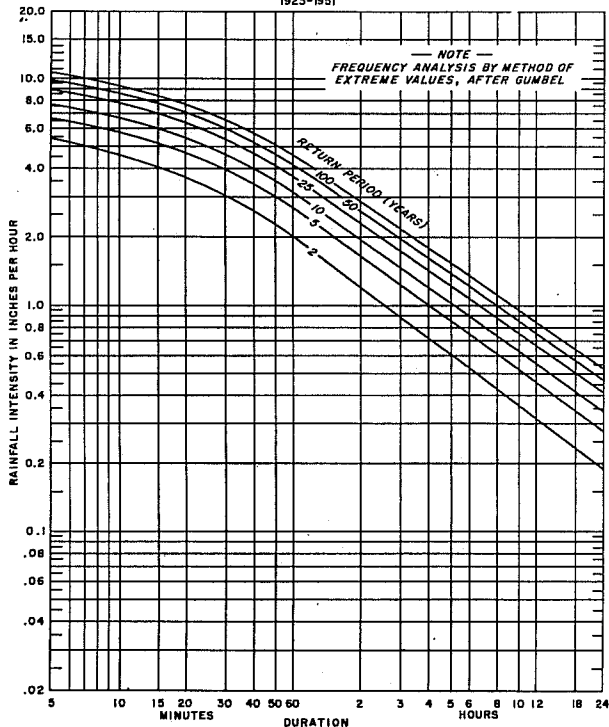


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

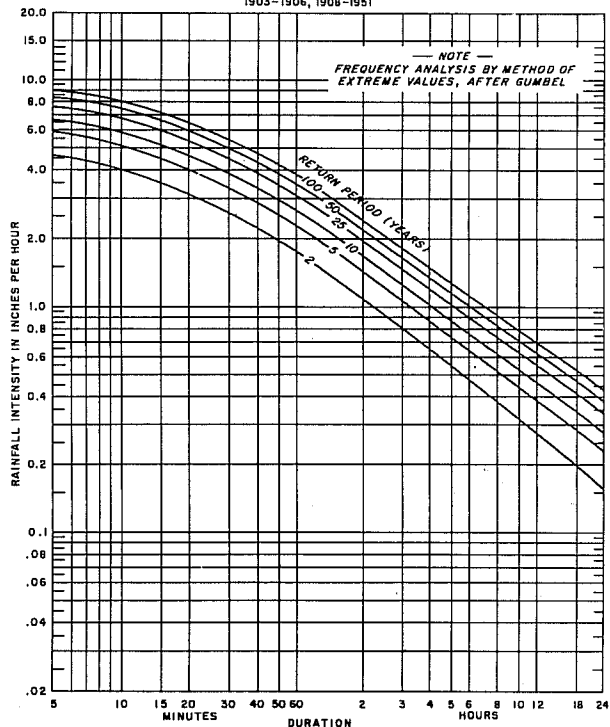


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

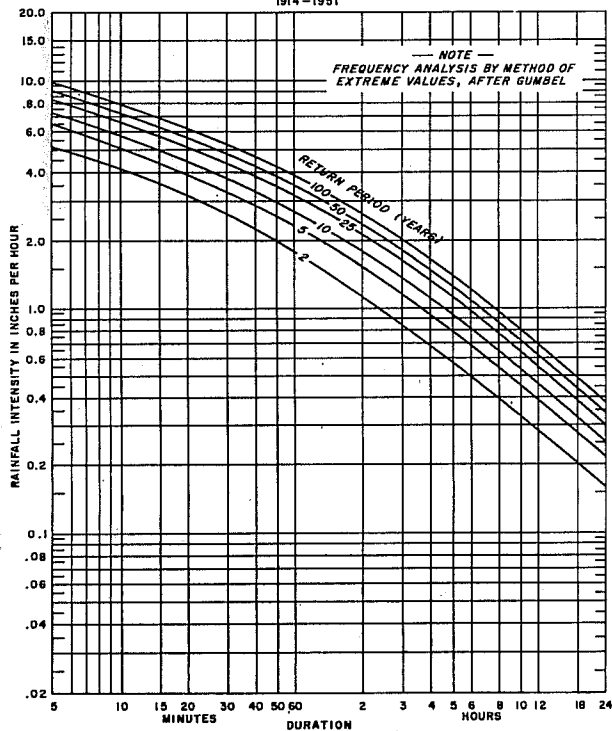
BROWNSVILLE, TEXAS
1923-1951



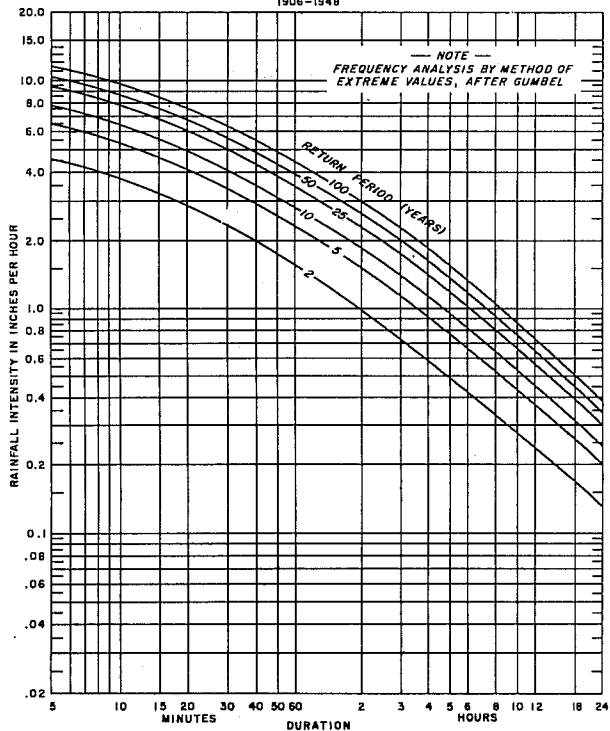
CORPUS CHRISTI, TEXAS
1903-1906, 1908-1951



DALLAS, TEXAS
1914-1951

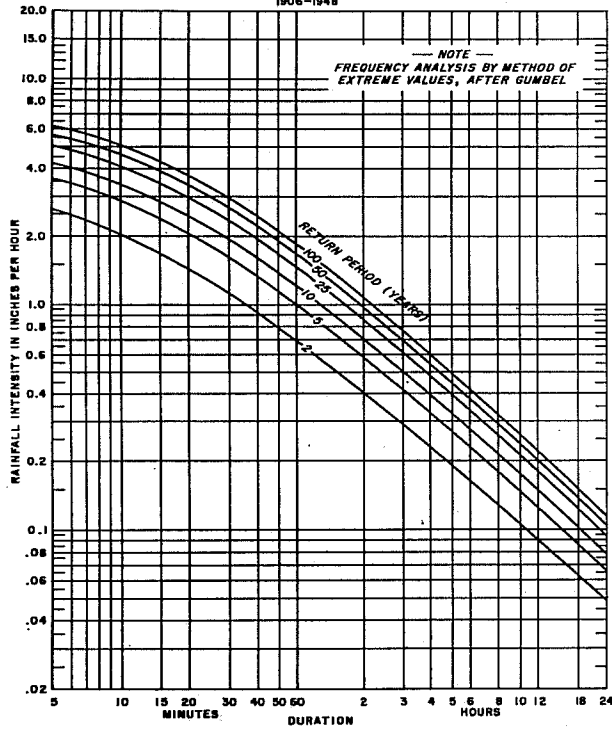


DEL RIO, TEXAS
1906-1948

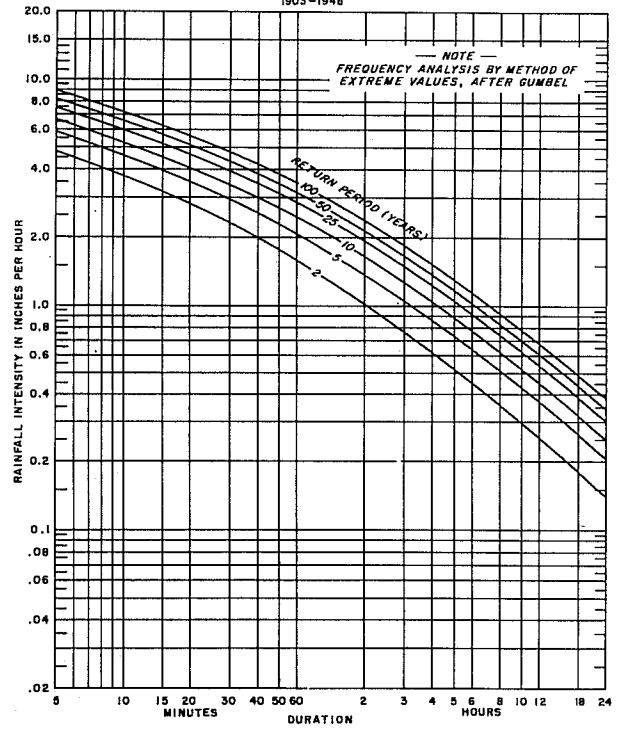


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

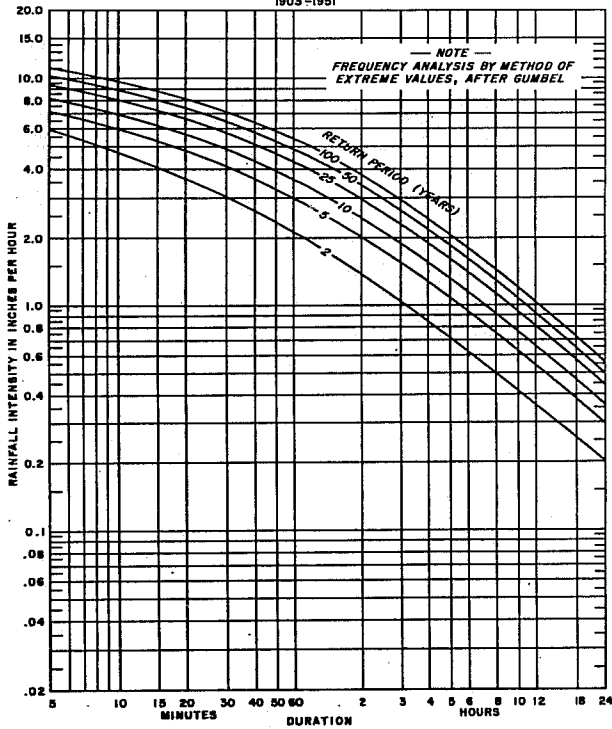
EL PASO, TEXAS
1906-1948



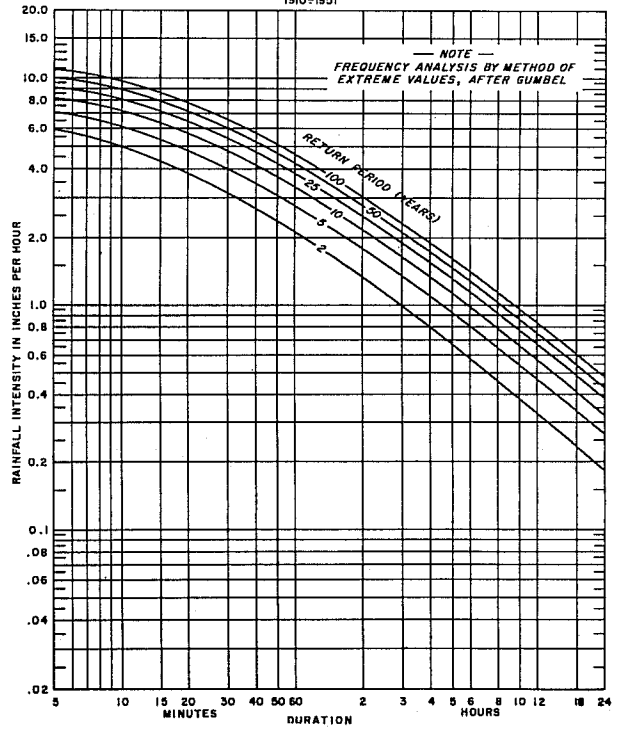
FORT WORTH, TEXAS
1903-1948



GALVESTON, TEXAS
1903-1951

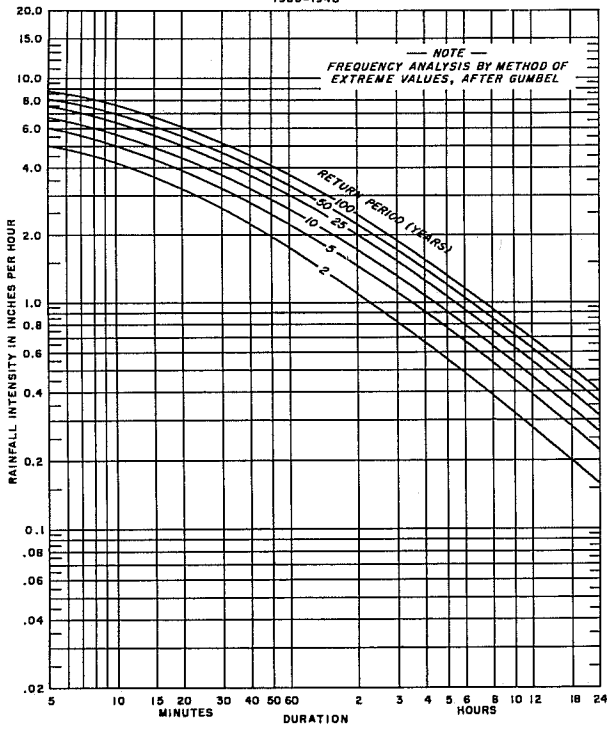


HOUSTON, TEXAS
1910-1951

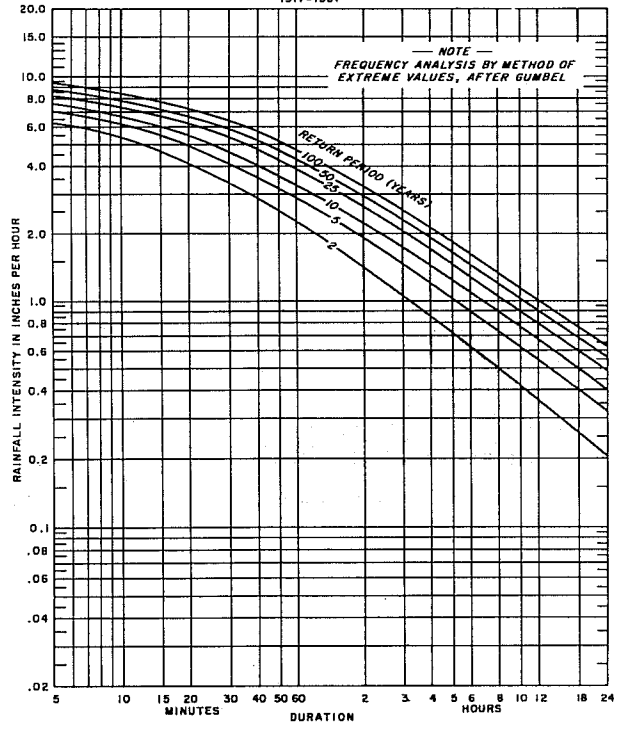


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

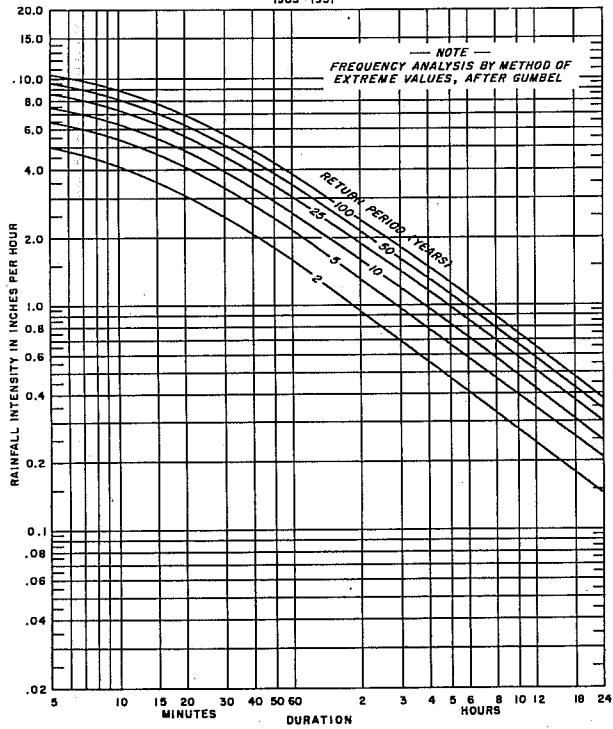
PALESTINE, TEXAS
1905-1948



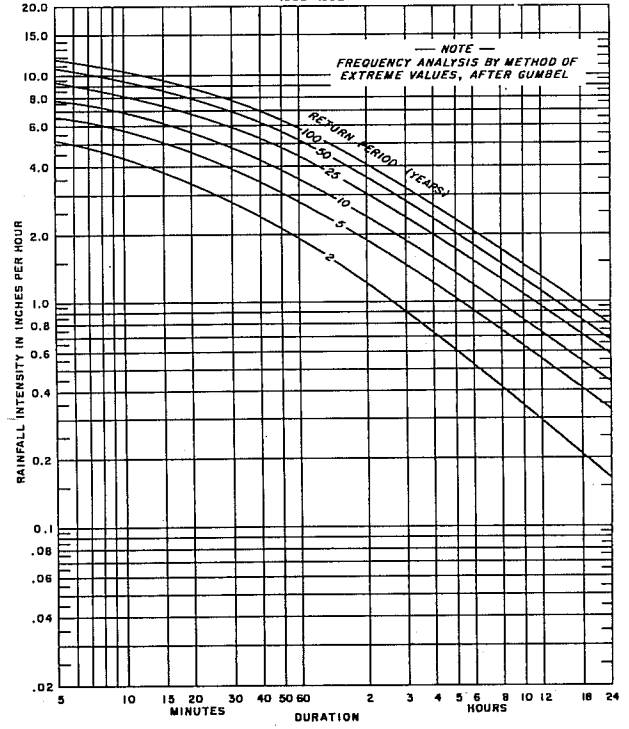
PORT ARTHUR, TEXAS
1917-1951



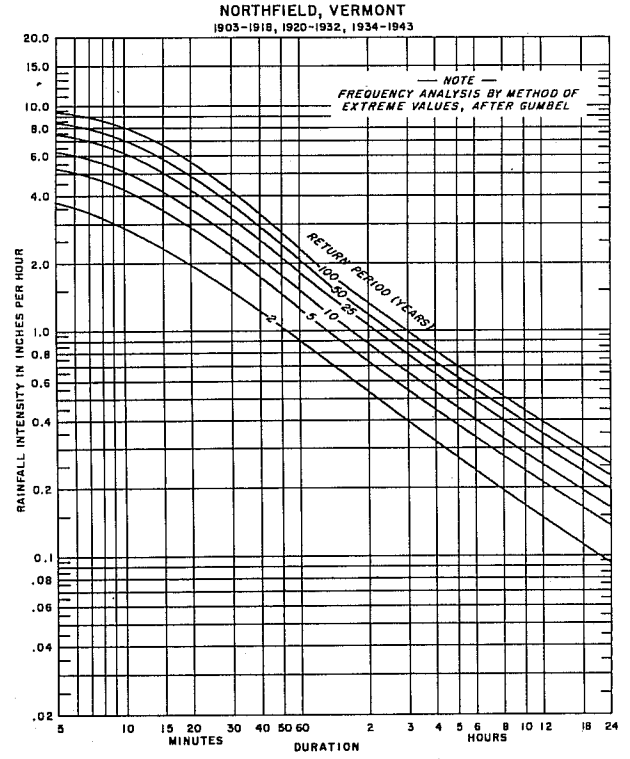
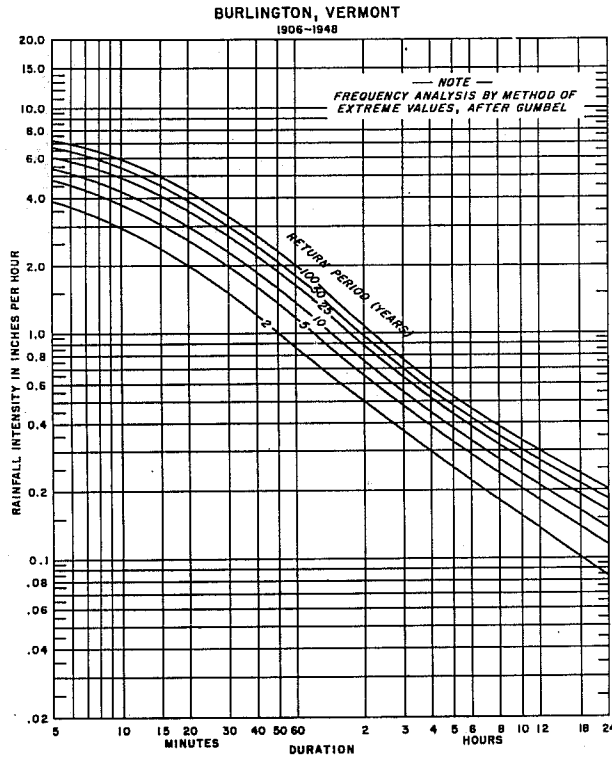
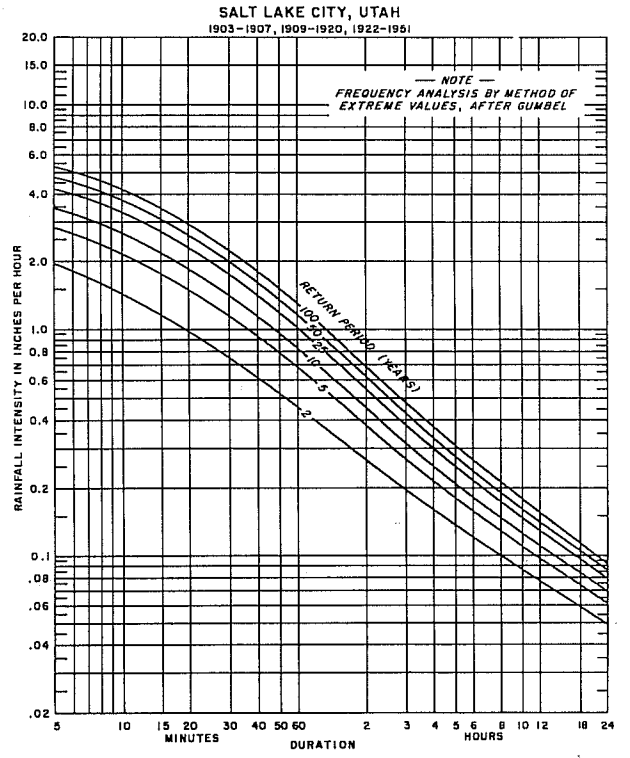
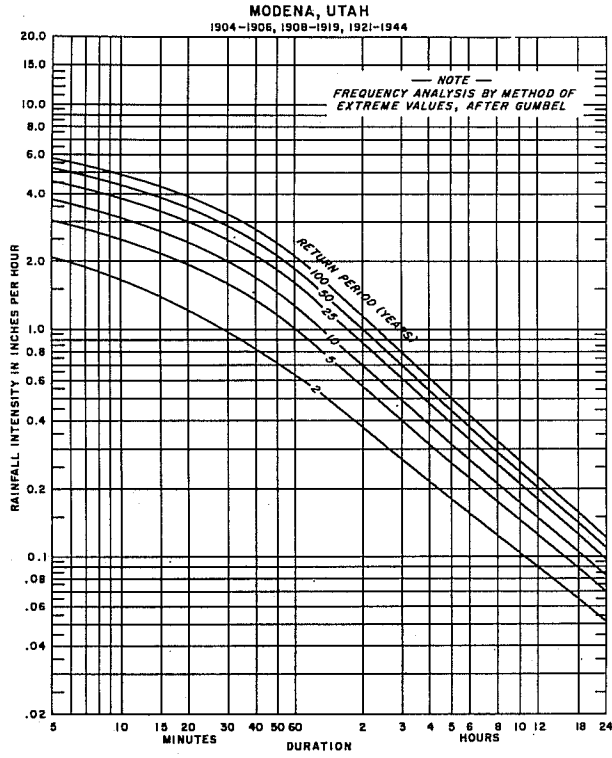
SAN ANTONIO, TEXAS
1903-1951



TAYLOR, TEXAS
1903-1932

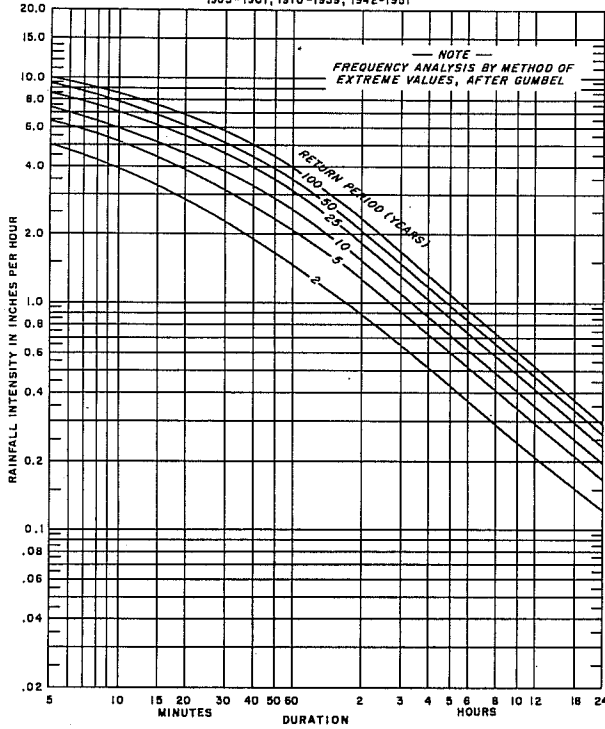


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

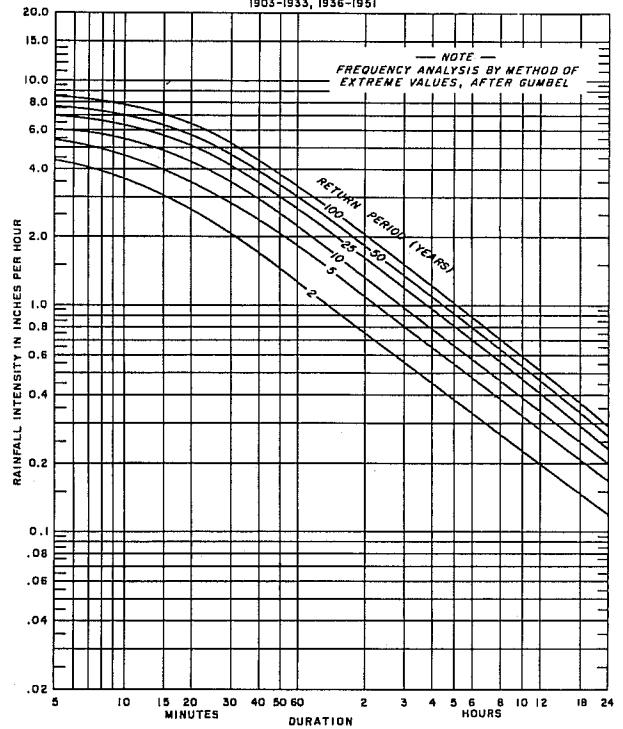


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

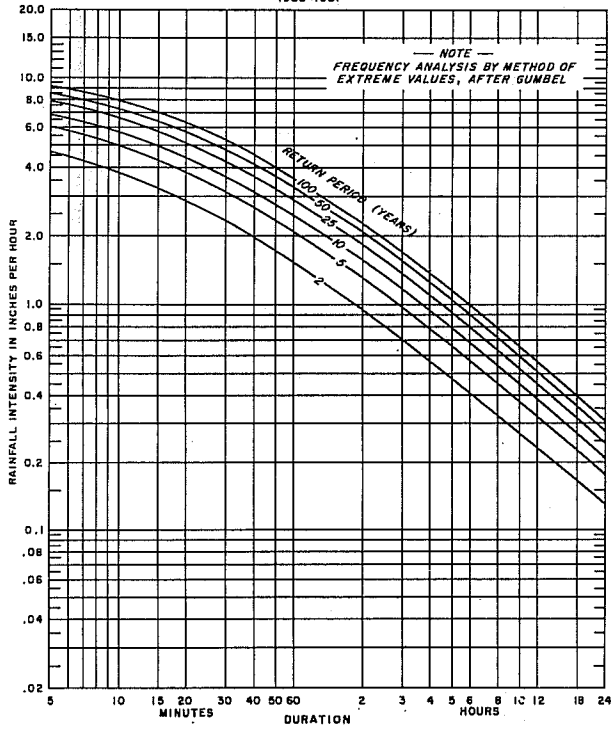
CAPE HENRY, VIRGINIA
1903-1907, 1910-1939, 1942-1951



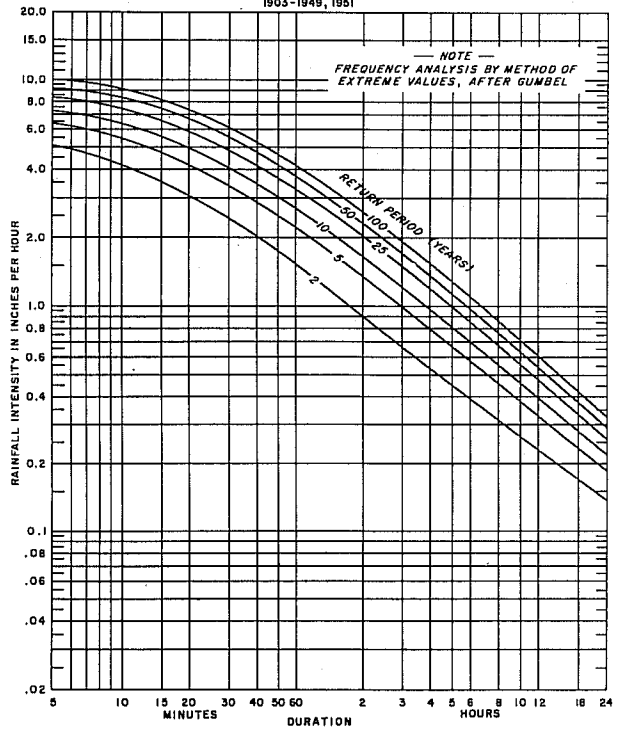
LYNCHBURG, VIRGINIA
1903-1933, 1936-1951



NORFOLK, VIRGINIA
1903-1951

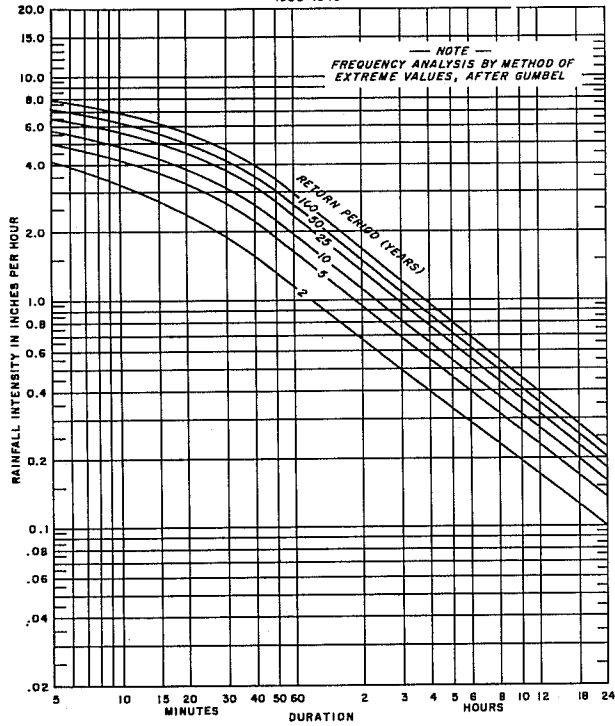


RICHMOND, VIRGINIA
1903-1949, 1951

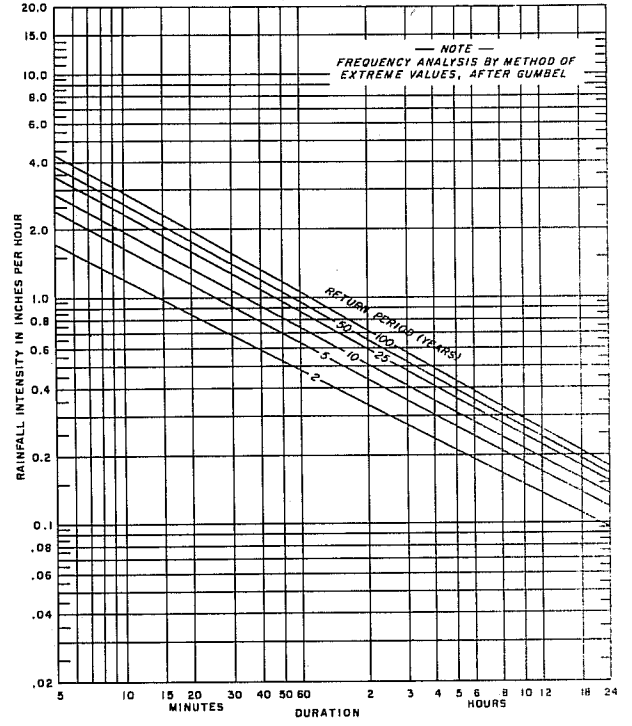


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

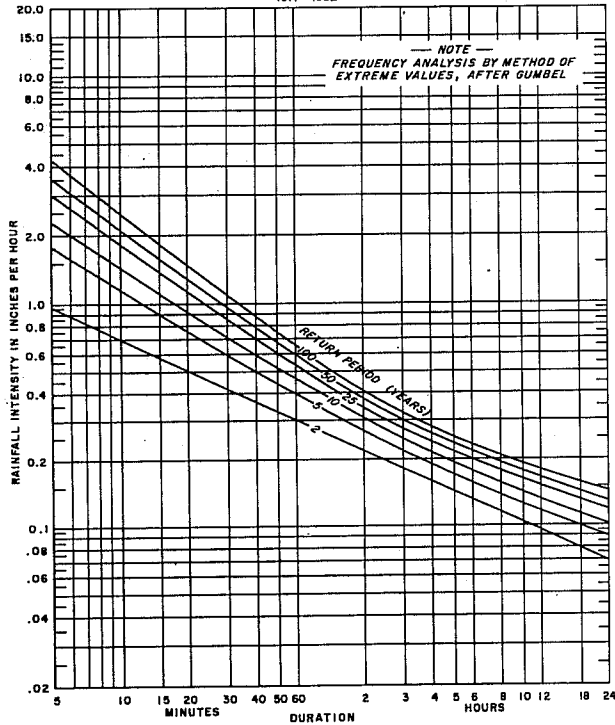
WYTHEVILLE, VIRGINIA
1903-1940



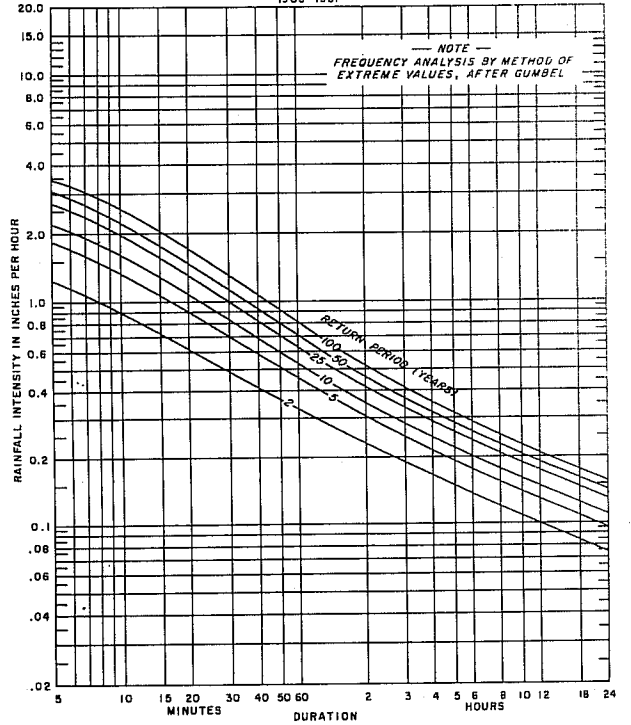
NORTH HEAD, WASHINGTON
1903-1948



PORT ANGELES, WASHINGTON
1917-1932

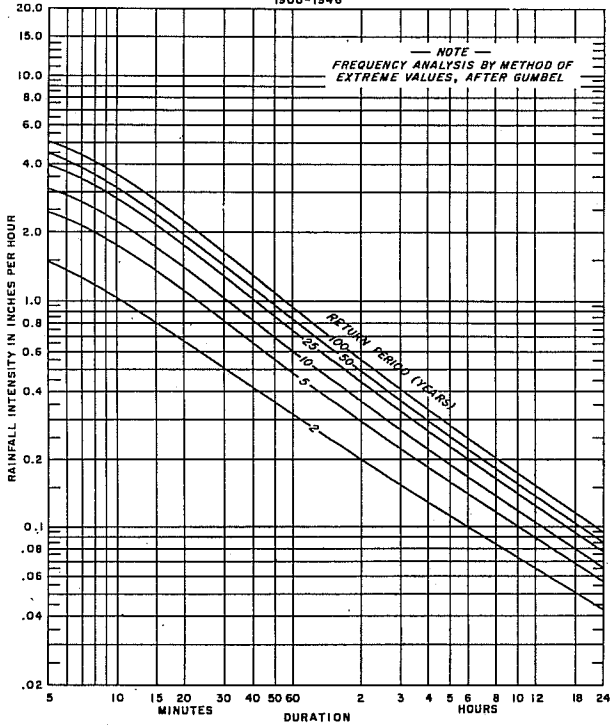


SEATTLE, WASHINGTON
1903-1951

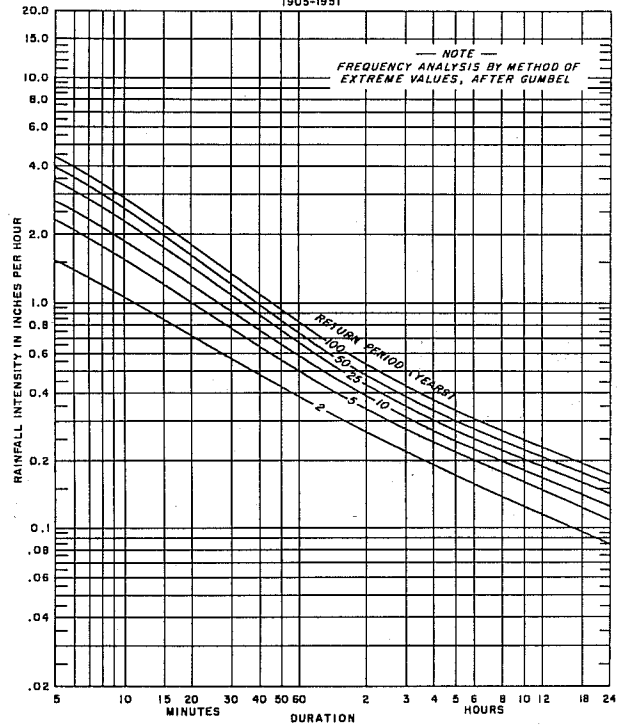


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

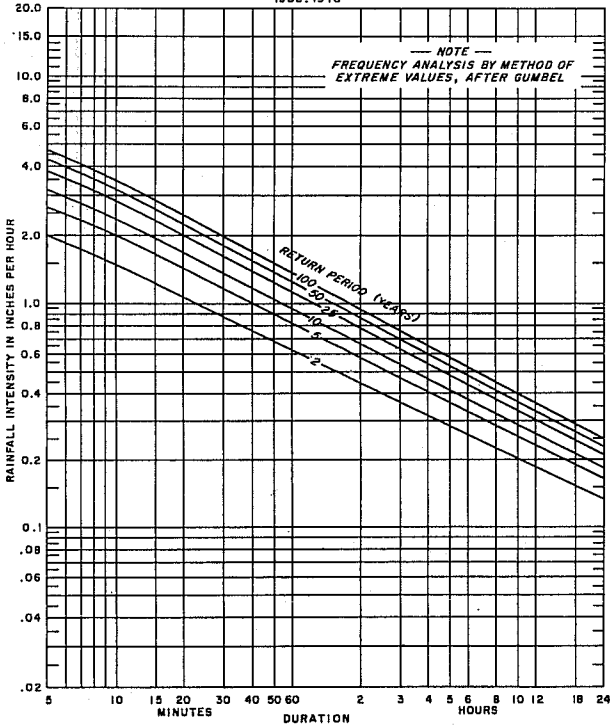
SPOKANE, WASHINGTON
1900-1946



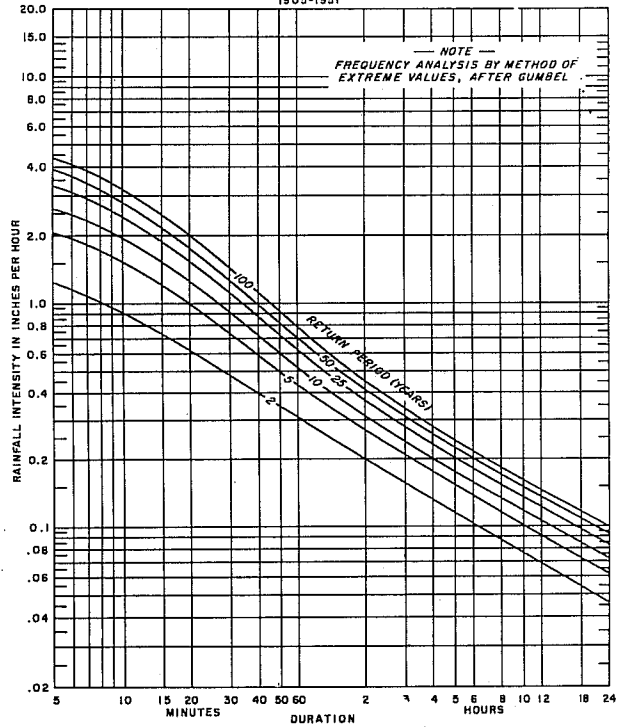
TACOMA, WASHINGTON
1905-1951



TATOOSH ISLAND, WASHINGTON
1903-1948

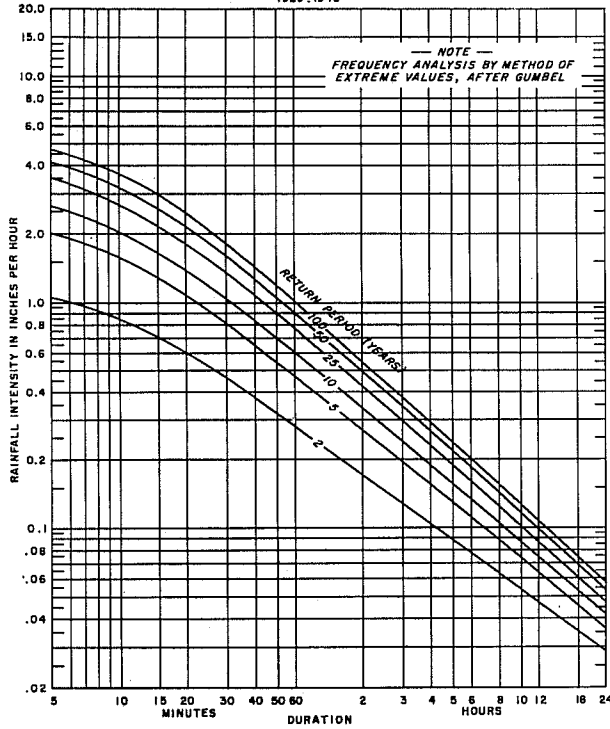


WALLA WALLA, WASHINGTON
1905-1951

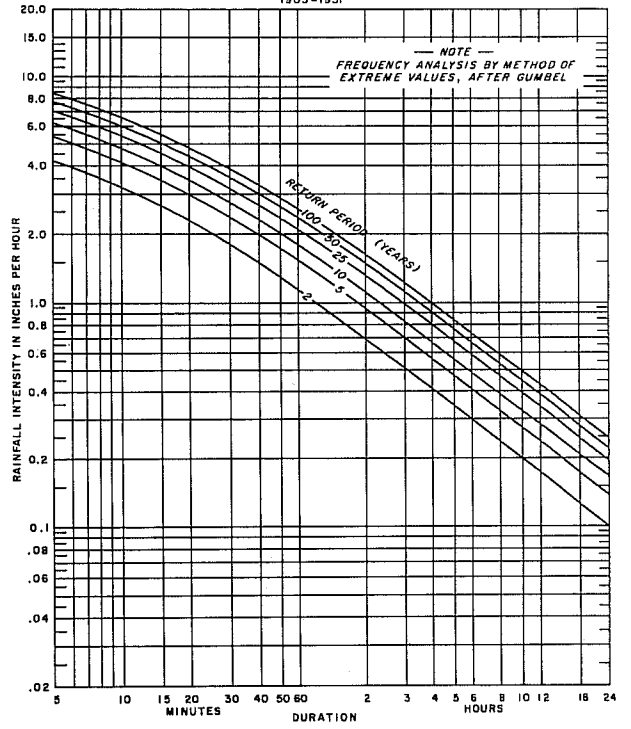


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

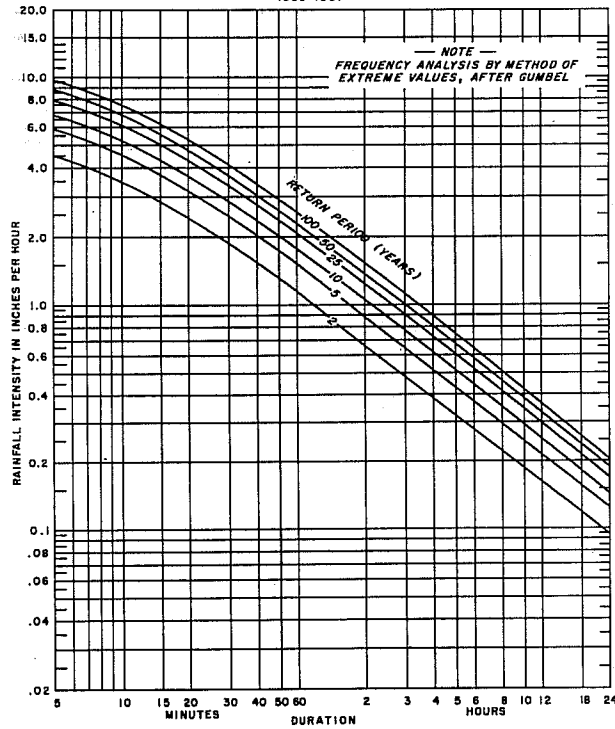
YAKIMA, WASHINGTON
1929-1948



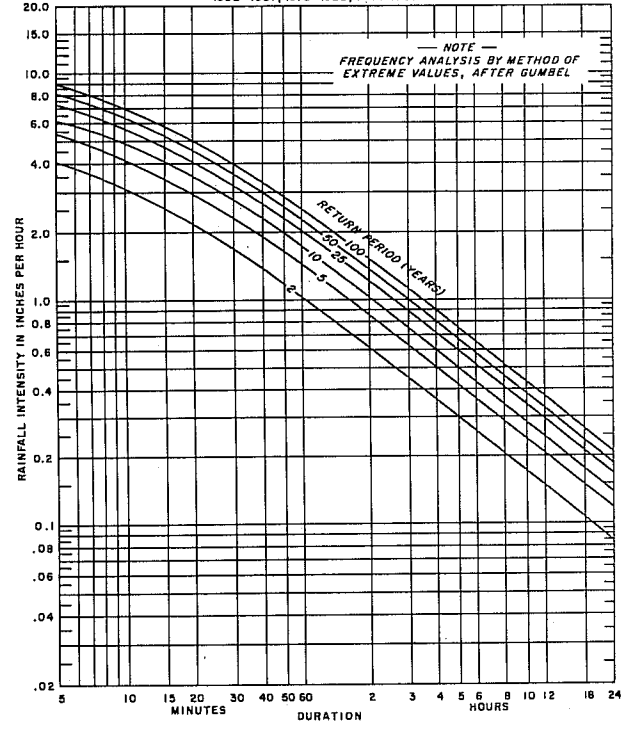
ELKINS, WEST VIRGINIA
1903-1951



PARKERSBURG, WEST VIRGINIA
1903-1951

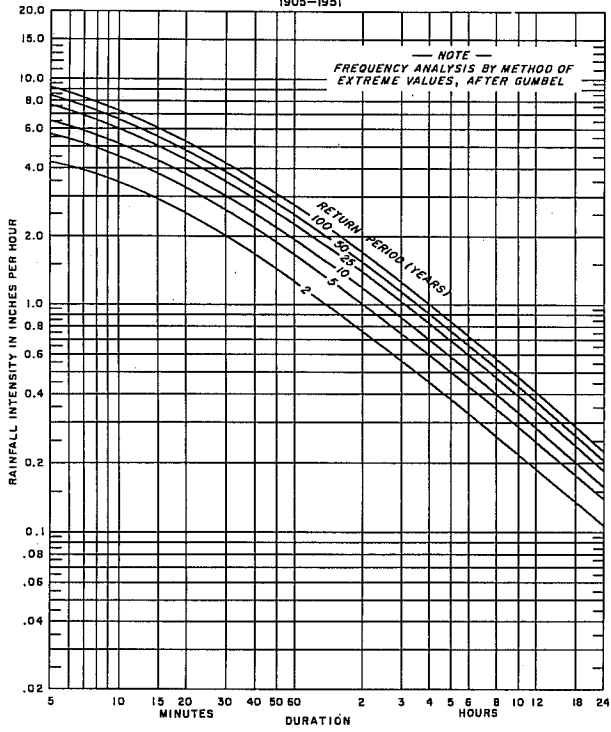


GREEN BAY, WISCONSIN
1902-1907, 1910-1922, 1944-1951

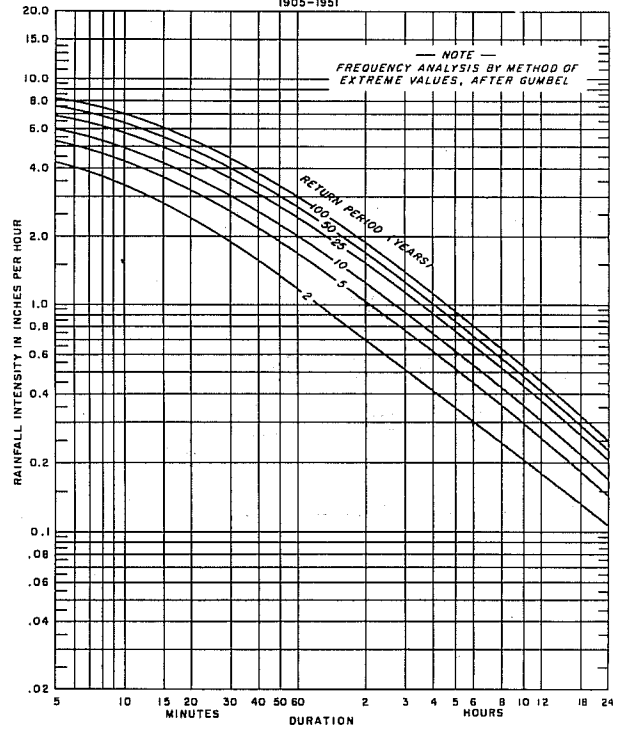


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

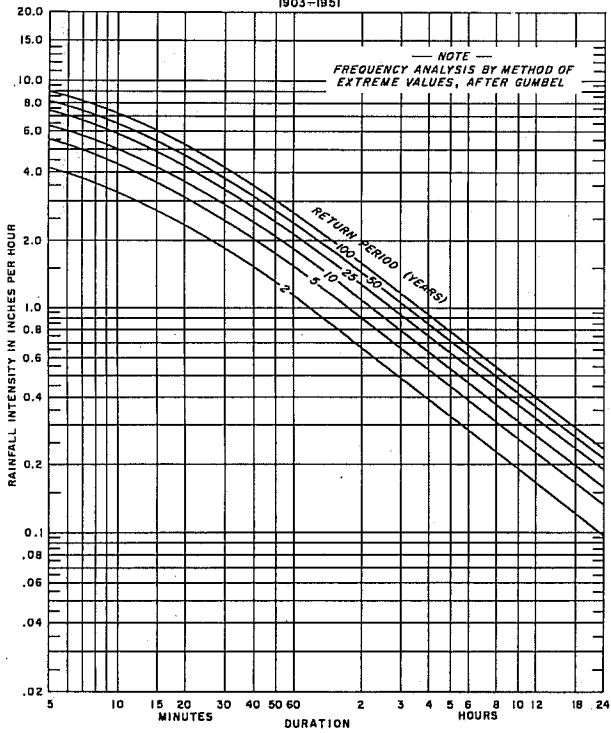
LA CROSSE, WISCONSIN
1905-1951



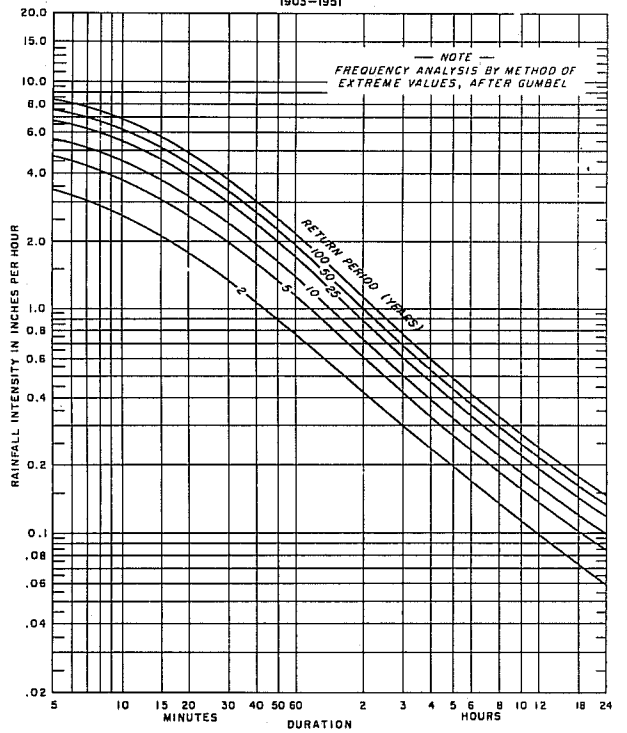
MADISON, WISCONSIN
1905-1951



MILWAUKEE, WISCONSIN
1903-1951

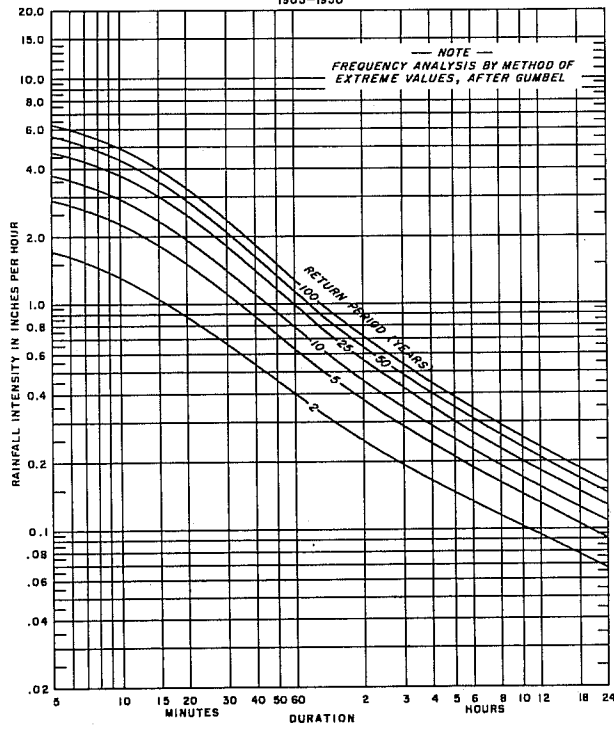


CHEYENNE, WYOMING
1903-1951

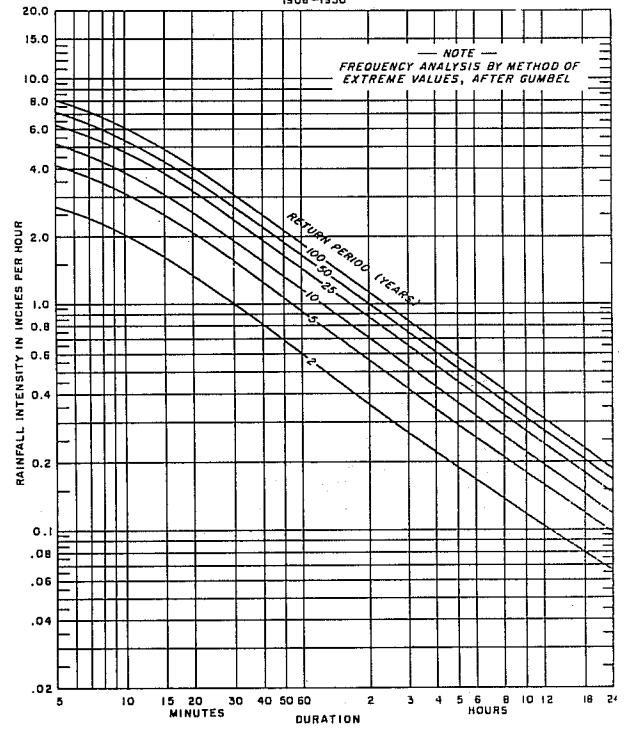


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

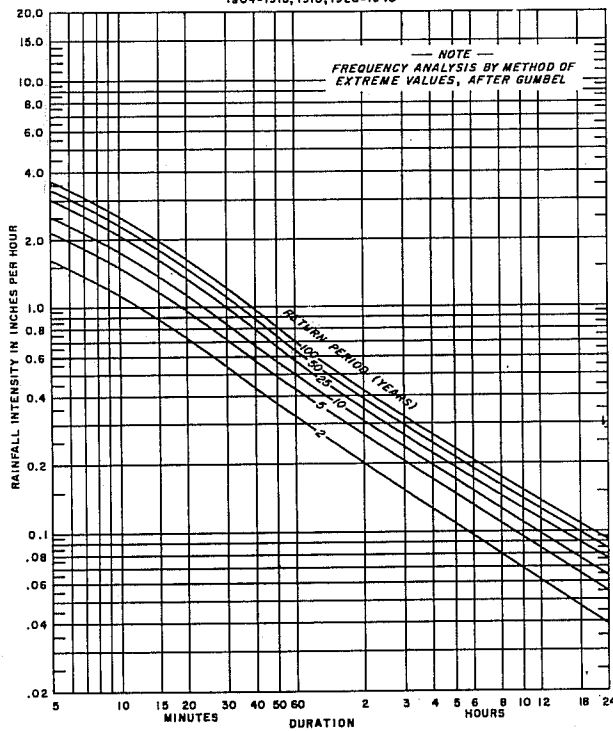
LANDER, WYOMING
1905-1950



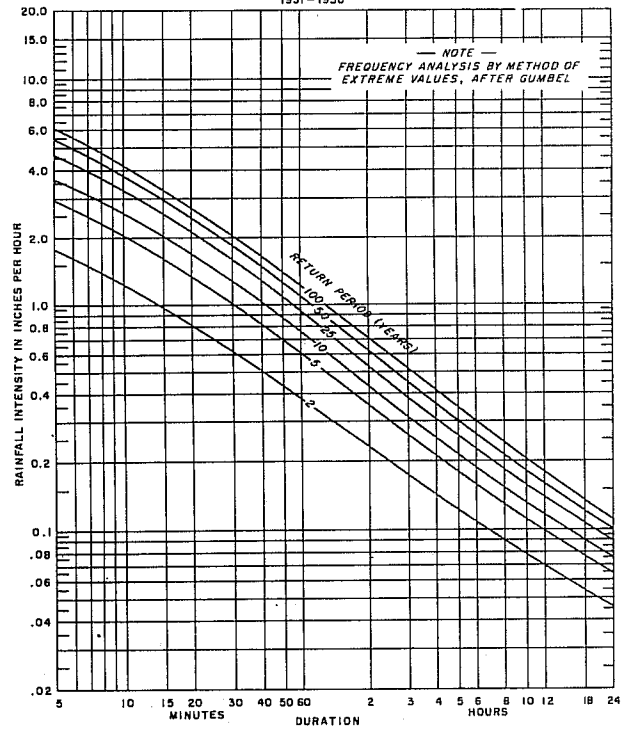
SHERIDAN, WYOMING
1908-1950



YELLOWSTONE PARK, WYOMING
1904-1915, 1918, 1920-1940

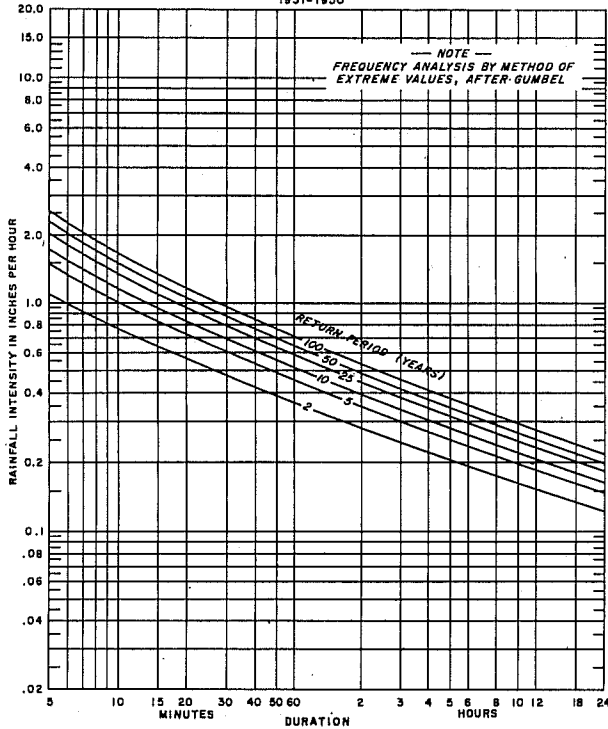


FAIRBANKS, ALASKA
1931-1950

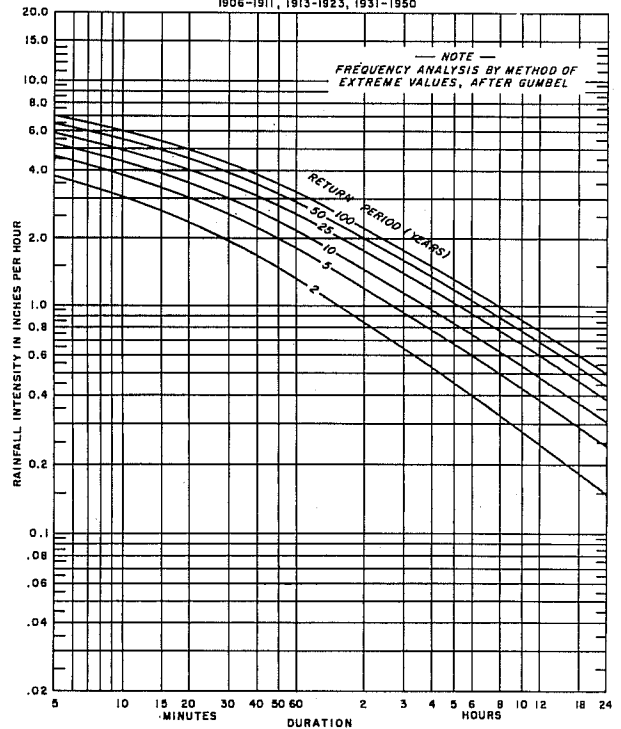


RAINFALL INTENSITY-DURATION-FREQUENCY CURVES

JUNEAU, ALASKA
1931-1950



HONOLULU, T. H.
1906-1911, 1913-1923, 1931-1950



SAN JUAN, PUERTO RICO
1931-1950

