UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

MAGNITUDE AND FREQUENCY OF FLOODS IN THE SHENANDOAH VALLEY OF VIRGINIA

Open File

VIRGINIA DIVISION OF MINERAL RESOURCES
LIBRARY

BY

RICHARD H. TICE

CHARLOTTESVILLE, VIRGINIA

MAY 1950

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

MAGNITUDE AND FREQUENCY OF FLOODS IN THE SHENANDOAH VALLEY OF VIRGINIA

BY

RICHARD H. TICE

CHARLOTTESVILLE, VIRGINIA

MAY 1950

Except for pages noted, = gift from U.S.G.S. Surface Water Branch Feb. 1960.

CONTENTS

	Page
Abstract	1
Introduction	1
Flood Frequencies at Gaging Stations	4
Frequency Plotting	5
Regional Composite Curve	6
Estimation of Flood Frequencies at Ungaged Points	7
Application	7
Acknowledgements	10
Magnitude and Frequencies	10
South River at Waynesboro	12
South River at Harriston	14
Middle River near Grottoes	16
North River near Burketown	18
South Fork Shenandoah River near Lynnwood	20
South Fork Shenandoah River near Front Royal	22
North Fork Shenandoah River at Cootes Store	24
North Fork Shenandoah River near Strasburg	26
Cedar Creek near Winchester	28
Passage Creek at Buckton	30
Shenandoah River at Millville	32

ILLUSTRATIONS

Figure 1.	Sketch Map of Shenandoah River Basin	3
2.	Composite Frequency Distribution Curve	9
3.	Mean Annual Floods for Various Drainage Areas	10
Table 1.	List of Gaging Stations	2
2.	Ratios of Measured Floods to Station Mean Annual Flood	8

this page = Veritax copy
made at VDMR
2-11-60

MAGNITUDE AND FREQUENCY OF FLOODS IN THE SHENANDOAH VALLEY OF VIRGINIA

By Richard H. Tice

ABSTRACT

This report presents the existing stream-flow data on flood magnitudes and frequencies in the Shenandoah River Basin. The station records are combined to give a frequency relationship applicable to the basin so that estimates of flood frequencies on ungaged streams in the basin can be made.

INTRODUCTION

The purpose of this report is to present data that will be useful in the design of structures within reach of flood waters. It was prepared under a cooperative agreement between the Virginia Department of Highways and the United States Geological Survey to make hydrologic investigations useful in bridge and culvert designs. Flood frequencies have been found especially helpful in problems involving economic considerations such as design of bridge clearances, channel capacities and roadbed levels, where costs must be balanced against flood damage. Where great damage to property and lives would result from failure, as in many dams, the danger involved in determining the design flood by extrapolation of flood-frequency graphs must be strongly emphasized.

There are twelve gaging stations in the Shenandoah River Basin with records long enough to be useful in flood frequency studies. Eleven of these records were used in this study. South Fork Shenandoah River near Luray was not included as its records include substan-

This page - Verifax copy made at VDMR 2-18-60

to p. 4

TABLE I

LIST OF GAGING STATIONS

Station Number	Stream	Location	Drainage Area Square Miles	Period of Record
1	South River	At Waynesboro	144	July 1928 to September 1949
2	South River	At Harriston	222	February 1925 to September 1949
3	Middle River	Near Grottoes	360	February 1925 to September 1949
4	North River	Near Burketown	375	June 1926 to September 1949
5	South Fork Shenandoah River	Near Lynnwood	1,076	September 1930 to September 1949
6	South Fork Shenandoah River	Near Luray	1,377	April 1923 to September 1930 October 1938 to September 1949
7	South Fork Shenandoah River	At Front Royal	1,638	September 1930 to September 1949
8	North Fork Shenandoah River	At Cootes Store	215	February 1925 to September 1949
9	North Fork Shenandoah River	Near Strasburg	772	March 1925 to September 1949
10	Cedar Creek	Near Winchester	101	June 1937 to September 1949
11	Passage Creek	At Buckton	87	April 1932 to September 1949
12	Shenandoah River	At Millville, W. Va.	3,040	August 1928 to September 1949

This page: Verifax copy made at VDMP 2-15-60

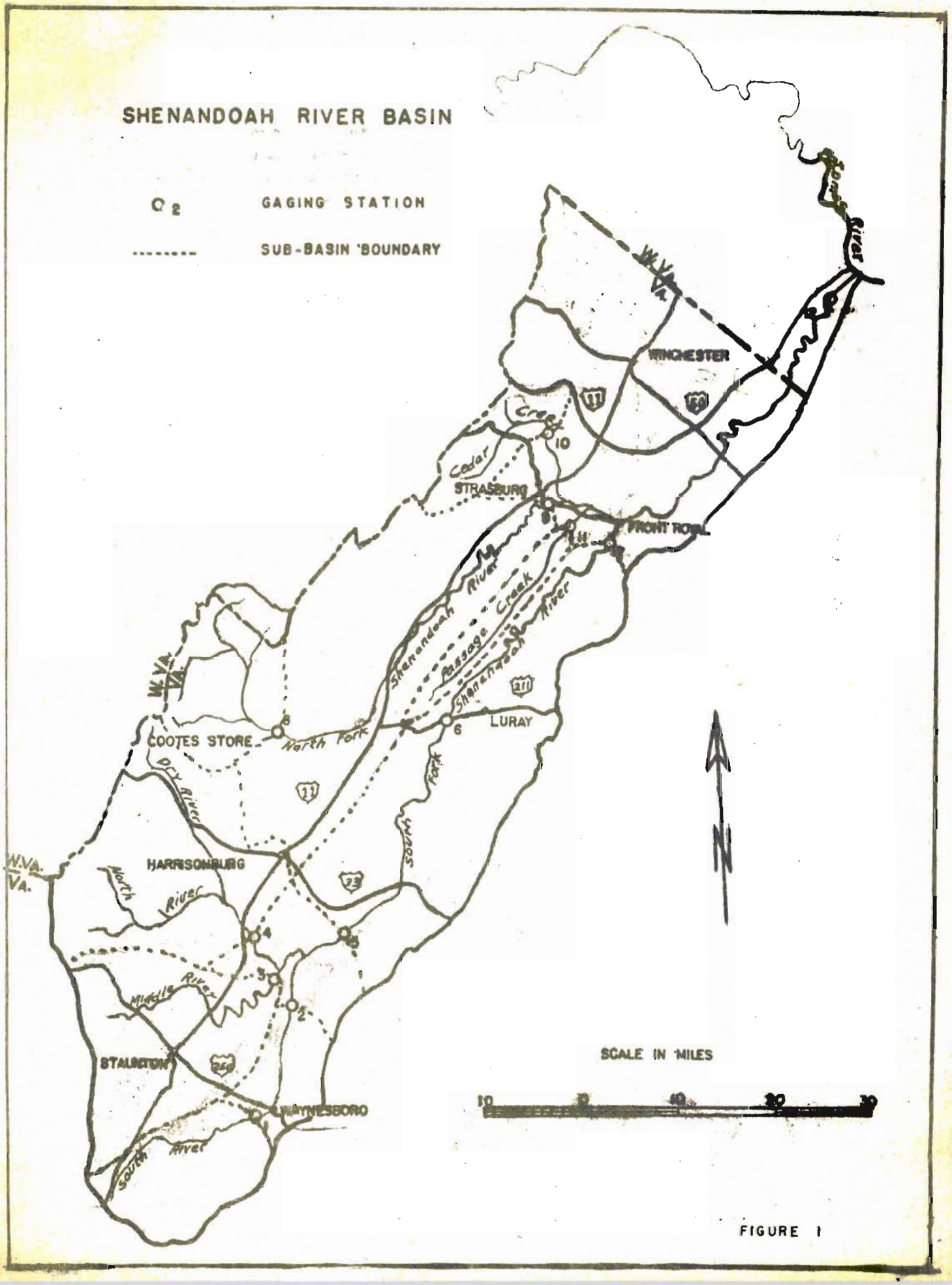

SHENANDOAH RIVER BASIN
GAGING STATION
SUB-BASIN BOUNDARY
WINCHESTER
STRASBURG
FRONT ROYAL
LURAY
COOTES STORE
HARRISONBURG
STAUNTON
WAYNESBORO
Cedar Creek
Shenandoah River
Passage Creek
North Fork
South Fork
Dry River
North River
Middle River
South River
W.VA.
VA.
SCALE IN MILES
10
20
30

FIGURE 1

tially the same water as do the stations upstream and downstream. Table I is a list of the gaging stations with the station number used in this report, the drainage area, and period of record, and figure 1 is a sketch map showing the locations of the stations.

FLOOD FREQUENCIES AT GAGING STATIONS

There are two kinds of flood series, annual floods and partial duration series. An annual flood is defined as the highest peak discharge in a water year. The two methods give essentially identical results for intervals greater than 10 years. Because of the greater simplicity of the annual flood method, it is used in this report. Data is available for floods above a selected base for the Shenandoah River Basin in the files of the U. S. Geological Survey, Charlottesville, Virginia. For recurrence intervals of less than 10 years that might be used for cofferdams and for overflow sections on secondary roads, the following table can be used to determine the design flood from the annual flood series:

Recurrence Interval in Years	
Annual Floods	Partial Duration Series
1.10	0.41
1.25	.62
1.50	.91
1.75	1.18
2.00	1.45
2.50	2.0
5.0	4.6
10.0	9.5
15.0	14.5
20.0	20.0

FREQUENCY PLOTTING

The U. S. Geological Survey has adopted a simple formula for plotting the recurrence intervals, in years, for flood data: $\frac{N+1}{M}$ where N equals the number of years of record and M equals the relative magnitude of the flood beginning with the largest as 1. The data is plotted on a special form developed by Powell [1] for analysis of flood frequencies by the Gumbel method [2]. The same formula can be used for partial duration series using semi-log graph paper for plotting.

Where data of historical floods are available the same formula is used to determine the plotting position except N is taken as the number of years for which the data is known to be the greatest.

The period of record for most of the gaging stations in the Shenandoah River Basin is 24 years. This period is rather short for making good single-station analysis. The curve shown on the station plots is that of a composite for the entire Shenandoah River Basin. Although this curve may miss the station data for some of the gaging stations, we believe it is better than can be drawn from a single-station record because of the random nature of small samples.

---

1 Powell, R.W., A simple method of estimating flood frequencies, Civil Engineering pp. 105-6, Feb. 1943.

2 Gumbel, E.J., Floods estimated by probability method, Engrg. News Rec., June 14, 1945

This page - Verifax copy made at VDMT 2-18-60

THE REGIONAL COMPOSITE CURVE

As 24 years of record was too short a period to give the best results, it was considered advisable to combine all the records in the region. The method of combining the records in this report was that of reducing all the annual flood peaks to dimensionless terms and taking the median of the 11 station records. The dimensionless terms were computed by obtaining the ratios of the individual floods to the station mean flood for the 24-year period 1925 to 1949. Table 2 is a listing of the data in this manner. The mean flood was arbitrarily taken as the flood with a recurrence interval of 2.33 years according to the Gumbel method. In order to use data for all stations for the same period of 24 years, values of floods for stations having less than 24 years of record were estimated using a correlation curve with stations having a complete record for the 24 years. The estimated floods were not used directly but were used to find the probable order of the recorded floods in the 24-year period of 1925 to 1949. For instance, at South River at Waynesboro the record is for 1927 to 1949. For the period 1925 to 1949 the 1926 annual flood was probably the 19th and the 1927 flood the 12th highest. Thus, in table 2 the 12th and 19th positions for South River at Waynesboro were taken as unknown. The computations for this regional composite flood-frequency distribution are shown in table 2 and the plotted curve as figure 2. On the basis of historical data the largest and second largest floods were plotted as the highest in 79 years and second highest in 53 years, respectively.

This page = Veritax copy made at VDMR 2-18-60.

ESTIMATION OF FLOOD FREQUENCIES AT UNGAGED POINTS

Figure 2 shows the flood-frequency distribution for streams in the Shenandoah River Basin. In order to use this distribution curve, it is necessary to estimate the mean annual flood for the point on a stream where the flood frequency is desired. Factors which affect the mean annual flood are drainage area, topography, shape of drainage basin, and channel storage. In a hydrologically homogeneous region such as the Shenandoah Valley, the most important factor is drainage area which is also the most readily available.

Figure 3 shows the mean annual flood discharge plotted against the drainage area. From the curve drawn, estimates of the mean flood for streams of 100 square miles and over can be made. The mean flood thus determined can be multiplied by the flood ratios of figure 2 to obtain the discharge for any selected frequency.

APPLICATION

The curve showing peak discharge against drainage area for the 2.33 year recurrence flood, figure 3, is based on 11 stations ranging from 87 to 3,040 square miles. Most of the data plots reasonably close to the drawn line, however, the North Fork Shenandoah River plots off. This is probably because of one or more of the other factors such as the shape of the drainage area.

This report includes data for the Shenandoah River Basin only. Piedmont Virginia and other portions of the Great Valley of Virginia may be different, and this report should not be used except for the Shenandoah River Basin.

this page = Verifax copy made at VDMR 2-18-60

TABLE 2 - RATIOS OF MEASURED FLOODS TO STATION MEAN ANNUAL FLOOD 1925-1949 SHENANDOAH RIVER BASIN

Order of Magnitude	Station Number 1	2	3	4	5	7	8	9	10	11	12	Median	Plotting Position (years)
1	2.40	3.50	3.06	6.59	3.48	4.81	5.26	7.69	7.33	7.50	5.90	5.26	80
2	2.10	1.80	2.62	4.74	3.27	3.74	4.26	6.85	6.00	4.39	3.85	3.85	27
3	2.10	1.77	2.10	3.89	2.33	1.96	1.96	1.94	—	2.27	2.24	2.06	8.33
4	1.99	1.74	1.68	2.38	1.86	1.91	1.93	1.85	—	1.81	1.70	1.86	6.25
5	1.26	1.71	1.67	2.03	1.83	1.76	1.68	1.65	1.43	1.59	1.58	1.67	5.00
6	1.23	1.43	1.56	1.33	1.60	1.73	1.66	1.60	—	1.38	1.44	1.50	4.17
7	1.23	1.32	1.48	1.21	1.58	1.48	1.54	1.35	—	—	—	1.40	3.57
8	1.20	1.26	1.21	1.13	1.48	1.43	1.42	1.20	—	1.10	1.03	1.21	3.13
9	1.20	1.26	1.20	1.11	—	.852	1.32	1.11	—	—	—	1.20	2.78
10	1.18	1.21	1.12	.953	.804	.852	1.20	1.09	1.08	.952	1.02	1.08	2.50
11	1.09	.973	1.08	.900	—	—	.952	.854	—	—	.895	.952	2.27
12	—	.973	.851	.783	.752	.737	.804	.768	.993	.938	.882	.812	2.08
13	.610	.924	.761	.755	.752	—	.749	.748	.983	.761	.869	.758	1.92
14	.550	.924	.718	.737	—	—	.749	.718	—	—	—	.728	1.78
15	.530	.600	.648	.708	.687	.652	.632	.678	.843	—	—	.652	1.67
16	.428	.600	.528	.616	—	.644	.554	.551	.743	.646	.815	.608	1.56
17	360	.544	.527	.537	.613	—	.528	.543	—	.646	—	.540	1.47
18	.356	.420	.478	.534	—	.448	.516	.523	—	.604	.562	.516	1.39
19	—	.403	.404	.524	.461	.444	.514	.518	—	.589	.549	.514	1.32
20	.270	.386	.369	.499	.391	—	.484	.518	.583	.500	.462	.473	1.25
21	202	.212	.326	.416	.367	.356	.445	.518	.560	.503	.421	.416	1.20
22	.189	.202	.319	—	.327	.341	.301	.477	—	—	.332	.323	1.14
23	.174	.191	.274	.357	.240	.257	.271	.311	.413	.210	.315	.271	1.09
24	.143	.151	.212	.294	.227	.206	.168	.214	.175	.206	.188	.206	1.04
Mean Flood (cfs)	5,000	6,600	8,000	9,500	23,000	27,000	9,500	11,000	[illegible]	[illegible]	39,000		

This page is Verifax copy made at VDMR 2-18-60

File Number

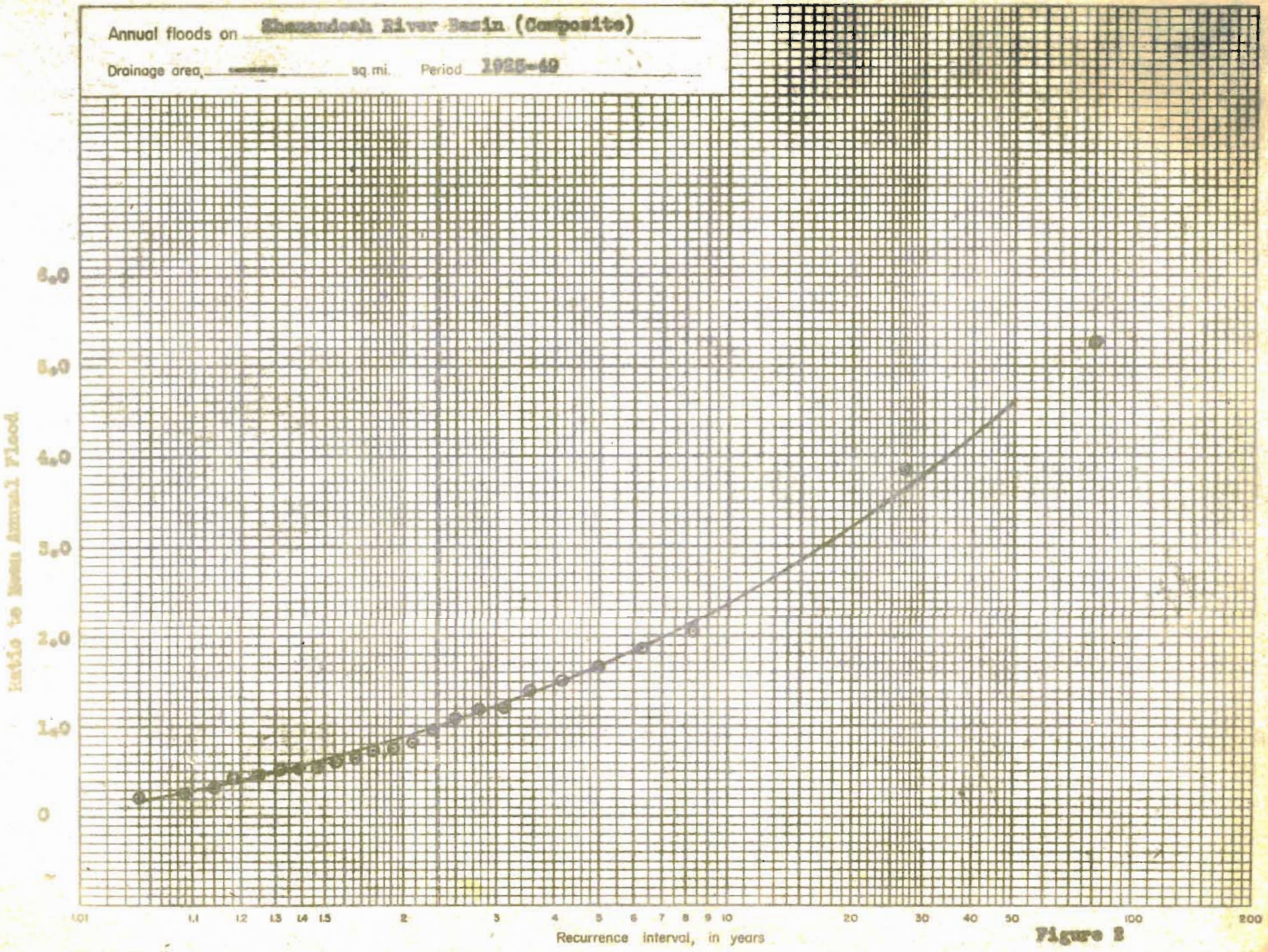


Figure 2

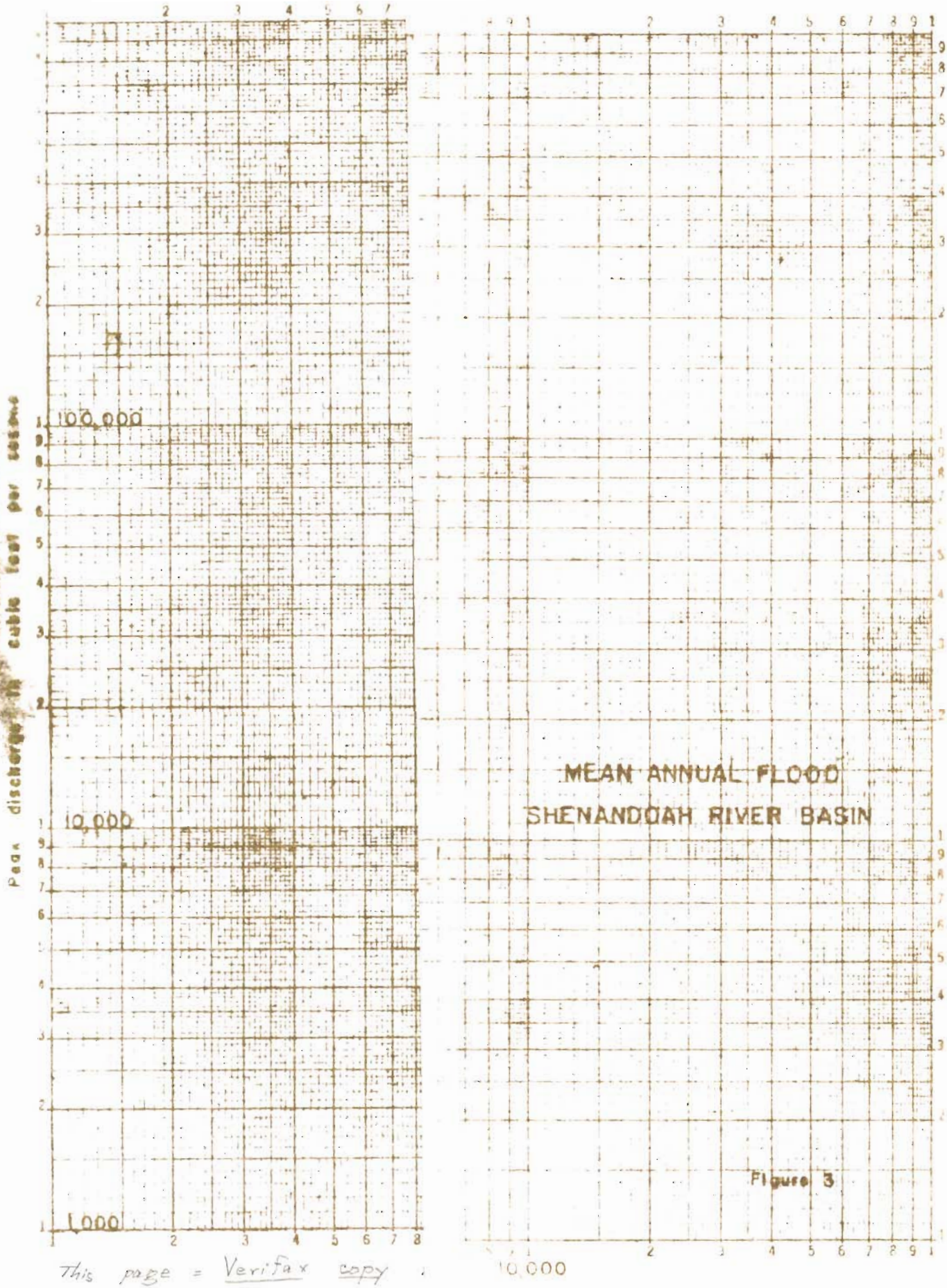
This report presents gage heights and discharges for the annual floods at the gaging stations. The method advanced for estimating frequencies at ungaged points presents discharge only. Each site is a problem in itself as far as stage is concerned. A wide river channel may pass more water for a given stage than a narrower channel. The U. S. Geological Survey office at Charlottesville has considerable data in their files which would be of aid in converting from discharges obtained from this report to stage at numerous points in the Shenandoah River Basin.

ACKNOWLEDGEMENTS

The data in this report were compiled and prepared in the Charlottesville, Virginia office of the U. S. Geological Survey in cooperation with the Virginia Department of Highways under the direction of D. S. Wallace, District Engineer. The procedures used were outlined by Tate Dalrymple, Hydraulic Engineer, of the Washington, D. C. office of the Geological Survey. The compilations and preparations for the report were done by R. H. Tice, Hydraulic Engineer, and E. H. Ogilvie, Engineering Aid. O. D. Mussey, Hydraulic Engineer, aided in the assembly of the work.

MAGNITUDE AND FREQUENCIES

Annual flood data for 11 stream-gaging stations in the Shenandoah River Basin are presented. The data are for the maximum instantaneous peak discharge. Records for each gaging station have been reviewed critically for accuracy and consistency in the light of present stand-



MEAN ANNUAL FLOOD
SHENANDOAH RIVER BASIN

Figure 3

This page = Verifax copy

ards and practices. In some instances figures of discharge have been used that differ from previously published figures. These differences may be due to revision of the rating curve on the basis of more accurate information or to the use of graphs constructed from nonrecording gage readings in place of the readings themselves as used originally.

The values of peak discharge are plotted based on the period of record for the individual station. The drawn curves are based on the composite for the basin adjusted to the period 1925 - 49.

The data are listed by water years ending September 30.

COOTES STORE, VIRGINIA
FLOOD OF OCTOBER 1942

Station No. 1

Flood data for South River at Waynesboro, Va.
Drainage area 144 square miles. Period of record: July 1928-Sept. 30, 1949.
Gage: Continuous recorder: Datum elevation: 1,277.13 ft. m.s.l.
The maximum flood listed is known to be the greatest in at least 79 years.

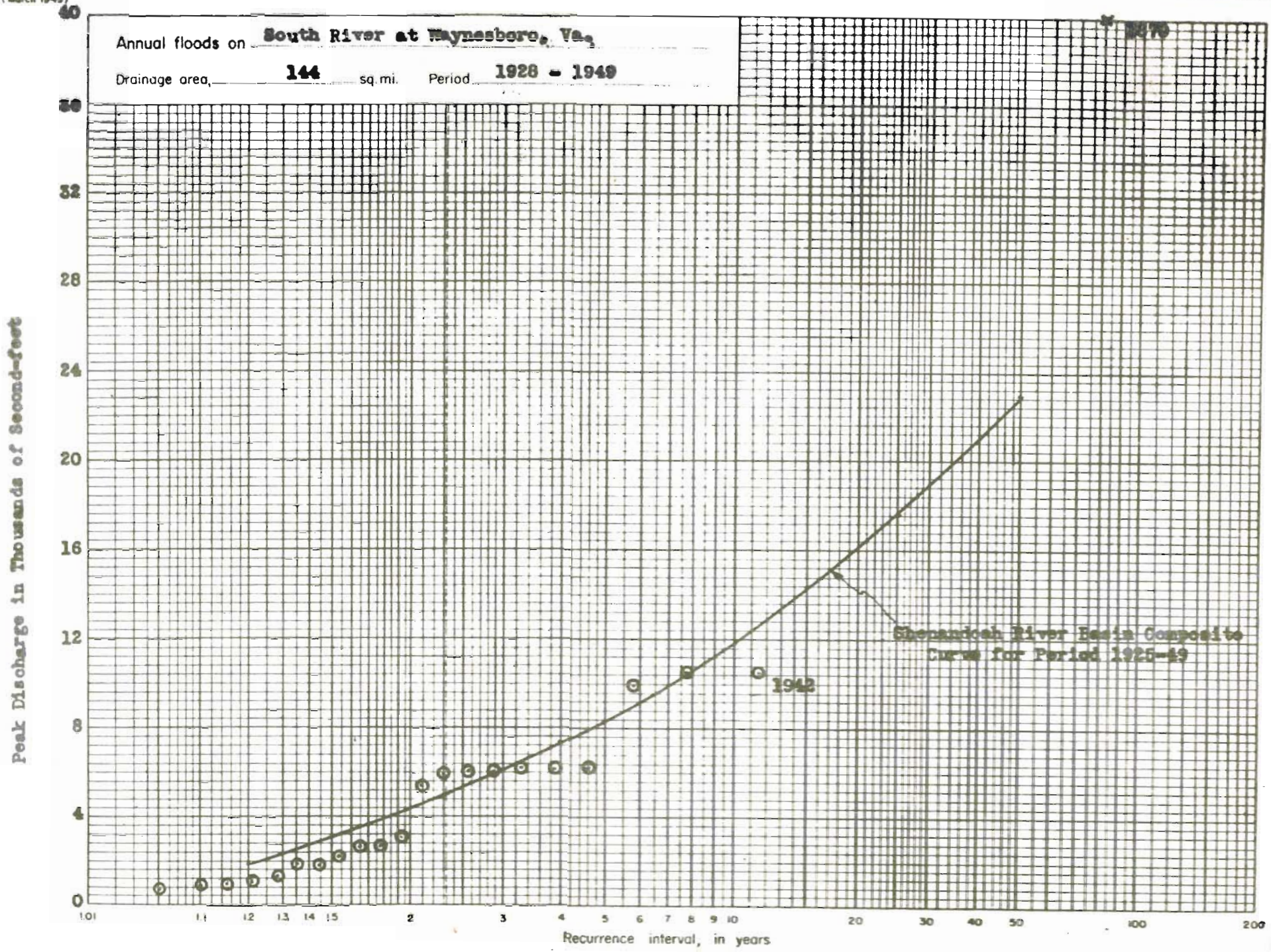
Calendar Year	Month	Day	Gage Height (feet)	Discharge (Second-feet)	Annual Floods Order (M)	Annual Floods Recurrence Interval (years)
1870	Sept.	30		40,000 *		80
1928	Sept.	20	11.02	6,140	6	3.83
1929	May	2	7.52	2,730	13	1.77
1929	Oct.	22	7.90	3,050	12	1.92
1931	Aug.	22	5.32	1,350	18	1.28
1932	Mar.	28	4.26	870	21	1.10
1932	Oct.	17	10.98	6,140	7	3.29
1934	Sept.	16	7.39	2,650	14	1.64
1934	Dec.	1	10.92	6,020	8	2.88
1936	Mar.	17	13.90	10,500	2	11.5
1937	Apr.	26	10.88	6,020	9	2.56
1937	Oct.	19	6.18	1,800	16	1.44
1939	Aug.	19	4.40	945	20	1.15
1940	Aug.	16	13.9	10,500	3	7.67
1940	Dec.	29	4.63	1,010	19	1.21
1942	May	16	10.77	5,920	10	2.30
1942	Oct.	15	14.8	12,000	1	23.0
1944	Sept.	19	11.06	6,290	5	4.60
1945	Sept.	18	13.6	9,970	4	5.75
1946	May	5	4.34	715	22	1.05
1947	Mar.	14	6.19	1,780	17	1.35
1948	Apr.	1	6.71	2,140	15	1.53
1949	June	18	10.44	5,440	11	2.09

* House Document No. 622-1946.

9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 1



Station No. 2

Flood data for South River at Harriston, Va.
Drainage area 222 square miles. Period of record: Feb. 15, 1925 - Sept. 30, 1949.
Gage: Non-recording 1925-1938; Recording since 1938. Datum elevation: 1,127.29 ft. m.s.l.
The maximum flood listed is known to be the greatest since 1924.

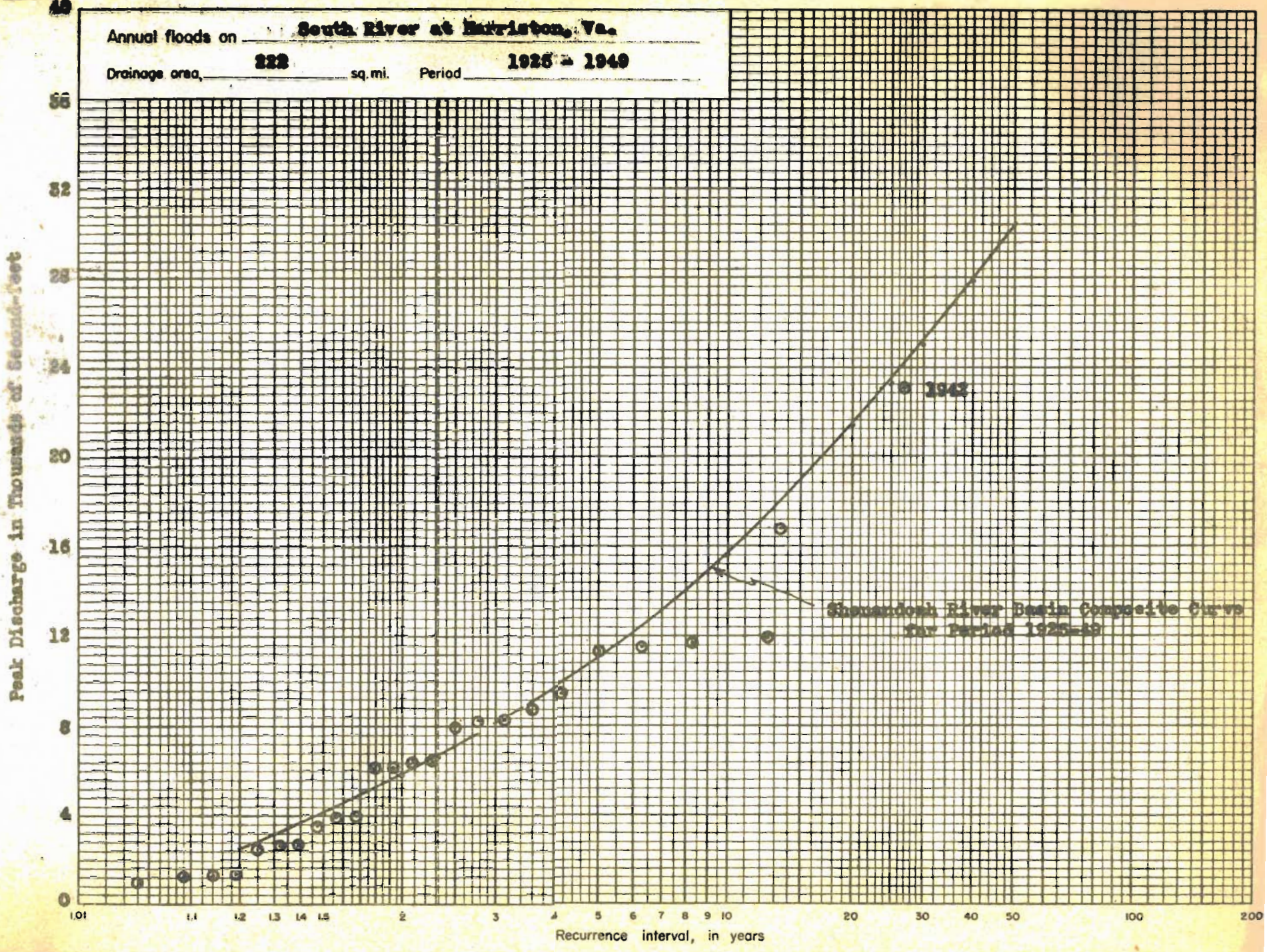
Calendar Year	Month	Day	Gage Height (feet)	Discharge (Second-feet)	Annual Floods Order (M)	Recurrence Interval (years)
1924	May		15.1	16,800	* 2	13.5
1926	Jan.	17	7.5	2,770	18	1.39
1926	Nov.	16	10	6,100	14	1.79
1928	Sept.	20	11.9	9,460	6	4.16
1929	Apr.	16	10.2	6,420	12	2.08
1929	Oct.	22	10	6,100	13	1.92
1931	Aug.	22	7.3	2,550	20	1.25
1932	Mar.	28	5.9	1,330	22	1.14
1932	Oct.	17	11.5	8,700	7	3.57
1934	Sept.	16	8.5	3,960	16	1.56
1934	Dec.	1	11.3	8,340	8	3.12
1936	Mar.	18	13.07	11,900	2	12.5
1937	Apr.	26	13.0	11,700	3	8.33
1937	Nov.	13	8.2	3,590	17	1.47
1939	Aug.	19	5.64	1,260	23	1.09
1940	Aug.	16	12.91	11,500	4	6.25
1941	Apr.	5	6.00	1,400	21	1.19
1942	May	16	10.21	6,420	11	2.27
1942	Oct.	15	17.2	23,100	* 1	27
1944	Sept.	19	11.33	8,340	9	2.78
1945	Sept.	18	12.8	11,300	5	5.0
1946	May	5	5.26	998	24	1.04
1947	Mar.	14	7.53	2,660	19	1.32
1948	Feb.	14	8.52	3,960	15	1.67
1949	June	18	11.06	7,980	10	2.50

* Since 1924

9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 2



Station No. 3

Flood data for Middle River near Grottoes, Va.
Drainage area 360 square miles; Period of Record 1925 - 1949
Gage Manual February 1925 to September 1938. Datum elevation 1,061.2 ft. m.s.l.
The maximum flood listed is known to be the greatest in at least 72 years (or since 1877).

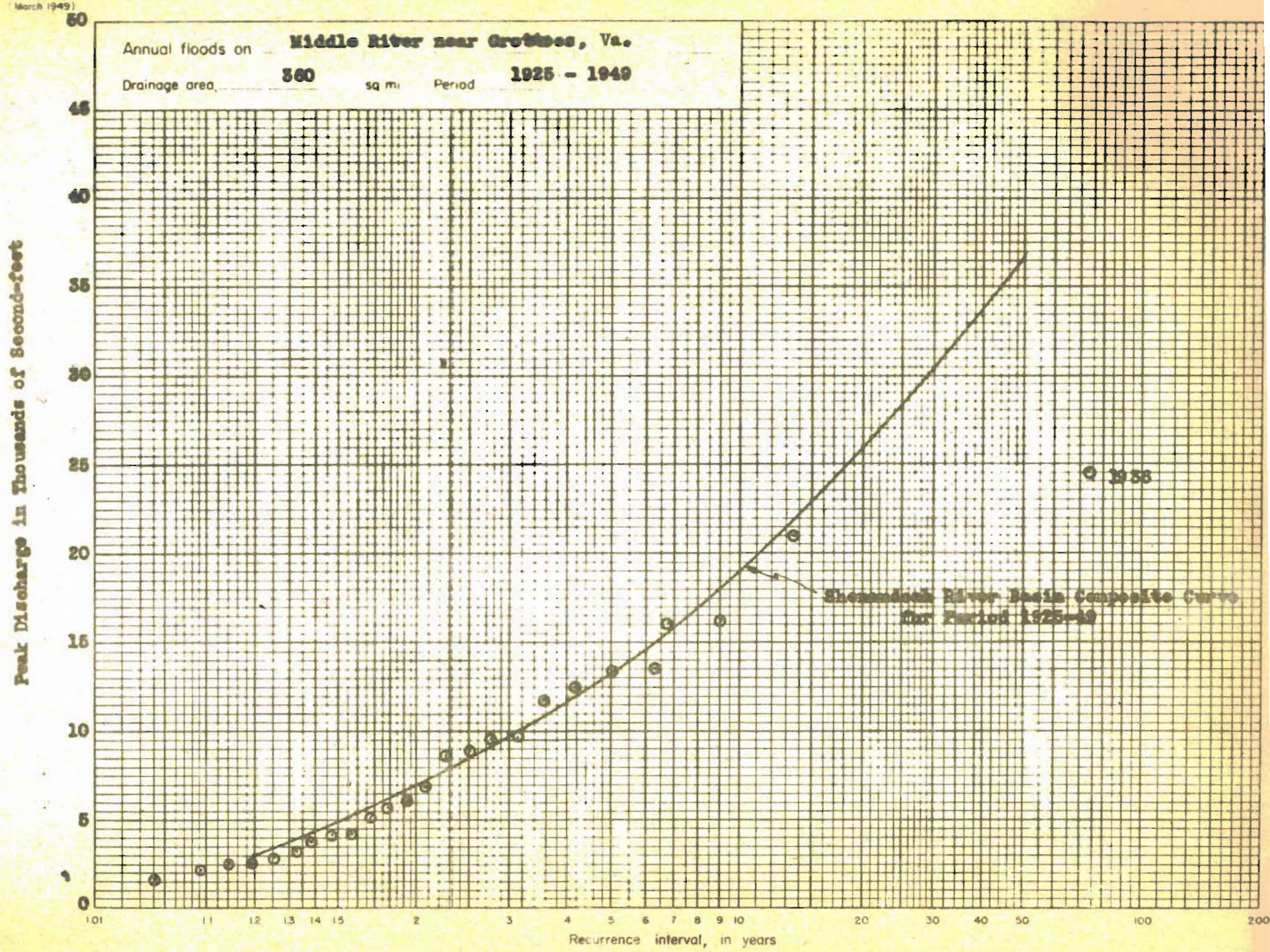
Calendar Year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Recurrence Interval (years)
1924	May		22.8	16,200	* 3	9.0
1926	Jan.	18	9.7	3,230	19	1.32
1927	Apr.	22	8.8	2,610	21	1.19
1928	Aug.	17	12.9	5,740	14	1.79
1929	Apr.	16	13.3	6,090	13	1.92
1929	Oct.	2	9.3	2,950	20	1.25
1931	Aug.	23	8.7	2,550	22	1.14
1932	Mar.	28	11	4,220	17	1.47
1932	Oct.	18	17	9,560	9	2.78
1934	Mar.	3	11	4,220	16	1.56
1934	Dec.	31	20.6	13,500	4	6.25
1936	Mar.	18	28.57	24,500	** 1	73
1937	Apr.	26	17.1	9,660	8	3.13
1937	Oct.	20	16.1	8,660	11	2.27
1939	Feb.	4	12.15	5,180	15	1.67
1940	Aug.	16	19.81	12,500	6	4.16
1941	Apr.	5	8.14	2,190	23	1.09
1942	May	22	19.08	11,800	7	3.57
1942	Oct.	15	26.3	21,000	* 2	13.5
1944	Sept.	19	14.10	6,810	12	2.08
1945	Sept.	18	20.5	13,400	5	5.00
1945	Dec.	31	7.18	1,700	24	1.04
1947	Mar.	14	10.50	3,820	18	1.39
1948	Feb.	14	16.40	8,960	10	2.50
1949	June	18	22.74	16,100	* 4	6.75

* Since 1924
** Since 1877

9-178a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR – GEOLOGICAL SURVEY – WATER RESOURCES DIVISION

File Number 3



Station No. 4

Flood data for North River near Burketown, Va.
Drainage area: 375 square miles. Period of record: 1926 - 1949
Gage: Manual 1926 - 1938. Datum elevation 1,103.49 ft. m.s.l.
The maximum flood listed is known to be the greatest in at least 72 years (or since 1877).

Calendar Year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Annual Floods Recurrence Interval (years)
1924	May		22.5	24,400	* 4	6.50
1926	Nov.	16	10.3	7,440	12	2.00
1928	Aug.	16	9.5	6,730	15	1.60
1929	Apr.	16	10	7,170	13	1.85
1929	Oct.	22	9.8	7,000	14	1.72
1931	July	23	7.56	5,070	18	1.33
1932	Mar.	28	7.5	4,980	19	1.26
1933	Apr.	17	11.5	8,550	11	2.18
1934	Sept.	16	8.5	5,850	16	1.50
1934	Dec.	1	19.5	19,300	5	4.8
1936	Mar.	17	26.7	37,000	* 3	8.00
1937	Apr.	26	15	12,600	6	4.00
1937	Oct.	19	12	9,050	10	2.40
1939	July	30	15.20	10,500	9	2.67
1940	June	14	16.07	11,500	7	3.43
1941	Apr.	5	7.76	3,390	22	1.09
1942	May	22	23.37	22,600	4	6.00
1942	Oct.	15	32.4	45,000	+ 2	27
1944	May	7	9.77	5,100	17	1.41
1945	Sept.	18	15.38	10,700	8	3.00
1946	May	4	6.65	2,790	23	1.04
1947	July	17	8.48	3,950	21	1.14
1948	Feb.	14	9.40	4,740	20	1.20
1949	June	18	36.3	62,600	++ 1	73

* Since 1924
\+ Since 1896
++ Since 1877

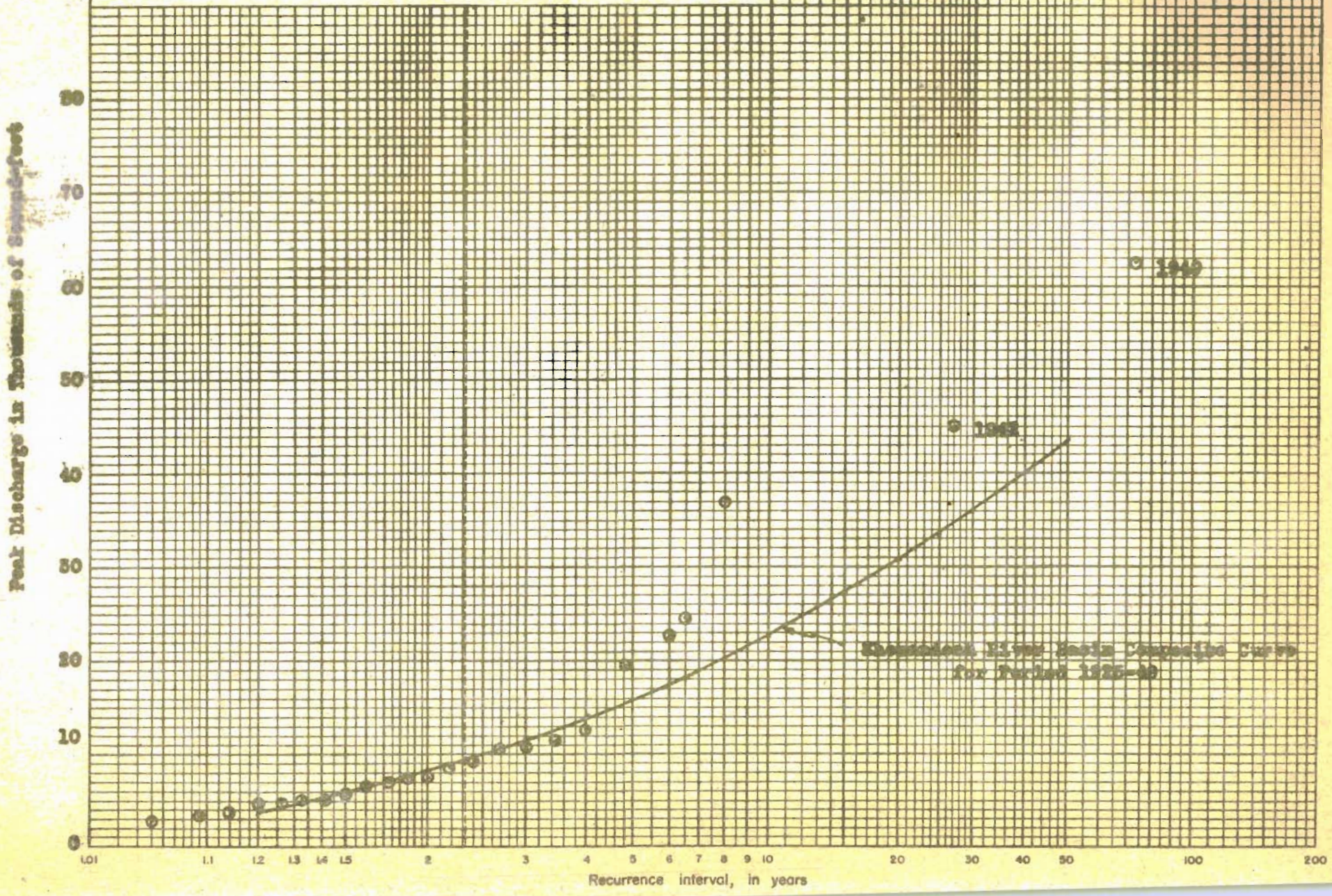
9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 4

Annual floods on North River near Burketown, Va.

Drainage area, 375 sq. mi. Period 1926 - 1949



Station No. 5

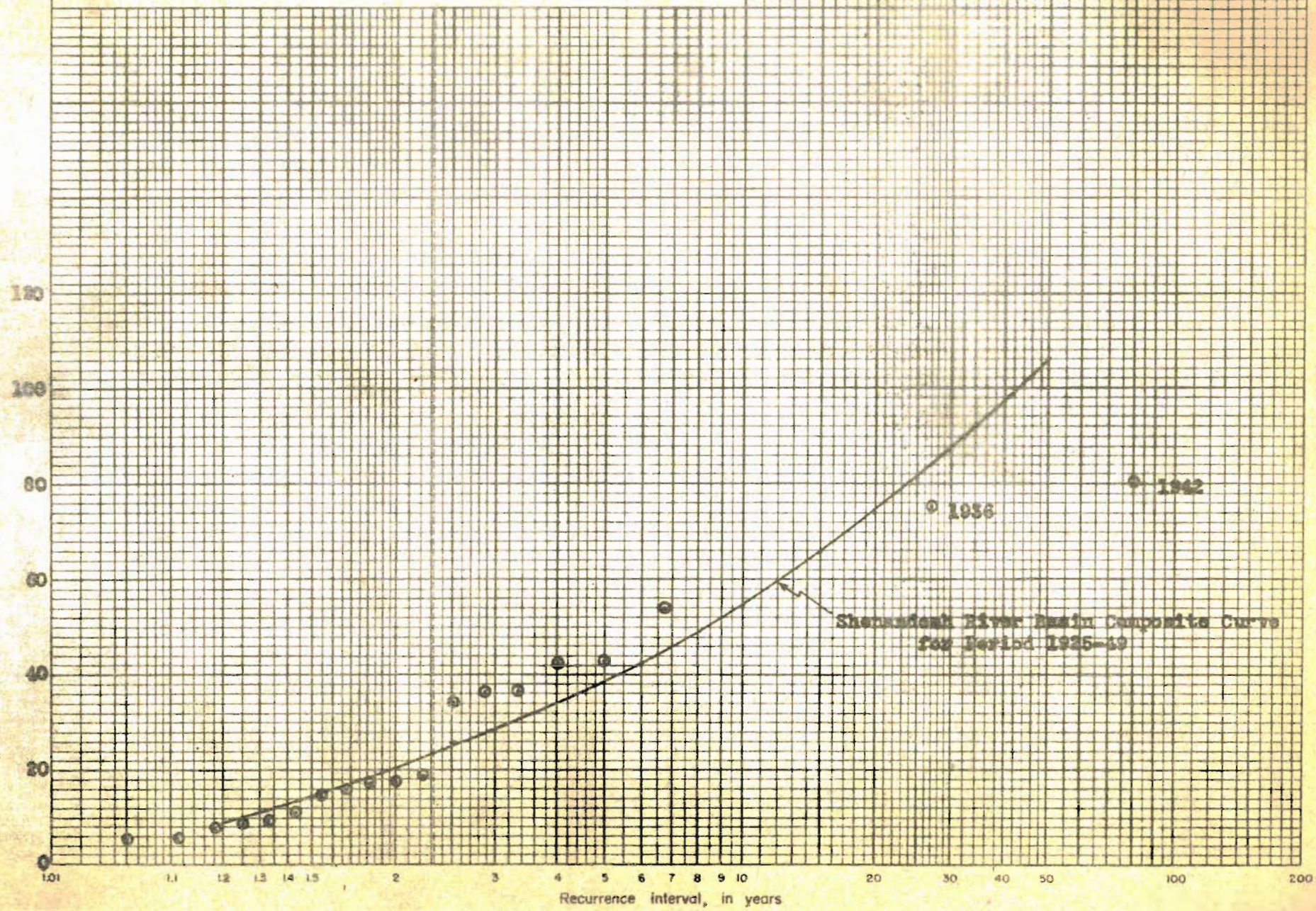
Flood data for South Fork Shenandoah River near Lynnwood, Va.
Drainage area: 1080 square miles. Period of record: Oct. 1930 - Sept. 1949.
Gage: Recording. Datum elevation: 1013.13 ft. m.s.l.
The maximum flood listed is known to be the greatest in at least 79 years (or since 1870).

Calendar Year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Recurrence Interval (years)	Remarks
1931	Aug.	23	7.80	5,220	19	1.05	
1932	Mar.	28	10.62	8,990	15	1.33	
1933	Apr.	17	14.73	17,300	11	1.82	
1934	Sept.	17	10.18	8,430	16	1.25	
1934	Dec.	1	21.62	42,200	5	4.00	
1936	Mar.	18	26.57	75,200	* 2	27	About equal to 1870 and 1896
1937	Apr.	26	20.48	36,800	6	3.33	
1937	Oct.	20	14.72	17,300	10	2.00	
1939	Feb.	4	13.20	14,100	13	1.54	
1940	Aug.	17	19.86	34,000	8	2.50	
1941	Apr.	5	9.30	7,520	17	1.18	
1942	May	22	20.37	36,300	7	2.86	
1942	Oct.	15	27.2	80,000	** 1	80	
1944	Sept.	19	13.98	15,800	12	1.67	
1945	Sept.	18	21.7	42,800	4	5.00	
1946	May	5	8.00	5,530	18	1.11	
1947	Mar.	15	11.44	10,600	14	1.43	
1948	Feb.	14	15.2	18,500	9	2.22	
1949	June	18	23.62	53,600	3	6.67	

* Since 1896
** Since 1870

Annual floods on South Fork Shenandoah River nr. Lynnwood, Va.

Drainage area, 1076 sq. mi. Period 1930 - 1949



Station No. 7

Flood data for South Fork Shenandoah River at Front Royal, Va.
Drainage area: 1638 square miles. Period of record: September 1930 to September 1949.
Gage: Recording. Datum elevation: 469.38 ft. m.s.l.
The maximum flood listed is known to be the greatest in at least 79 years (or since 1870).

Calendar Year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Annual Floods Recurrence Interval (years)	Remarks
1931	Aug.	24	5.12	5,550	19	1.05	
1932	May	13	8.23	12,100	14	1.43	
1933	Apr.	18	11.65	23,000	9	2.22	
1934	Sept.	18	7.18	9,620	16	1.25	
1934	Dec.	2	17.99	47,400	5	4.00	
1936	Mar.	18	26.01	101,000	* 2	40	Highest at time since 1870
1937	Apr.	27	18.94	51,500	4	5.00	
1937	Oct.	21	11.65	23,000	10	2.00	
1939	Feb.	5	9.90	17,400	13	1.54	
1940	Aug.	17	15.86	38,700	8	2.50	
1941	Apr.	6	6.96	9,220	17	1.18	
1942	May	23	16.20	39,900	7	2.85	
1942	Oct.	16	34.8	130,000	* 1	80	
1944	Sept.	20	10.00	17,600	12	1.67	
1945	Sept.	19	17.8	46,600	6	3.33	
1946	May	5	5.94	6,930	18	1.11	
1947	Mar.	15	8.12	12,000	15	1.33	
1948	Feb.	15	10.70	19,900	11	1.82	
1949	June	19	19.15	52,900	3	6.67	

* Since 1870

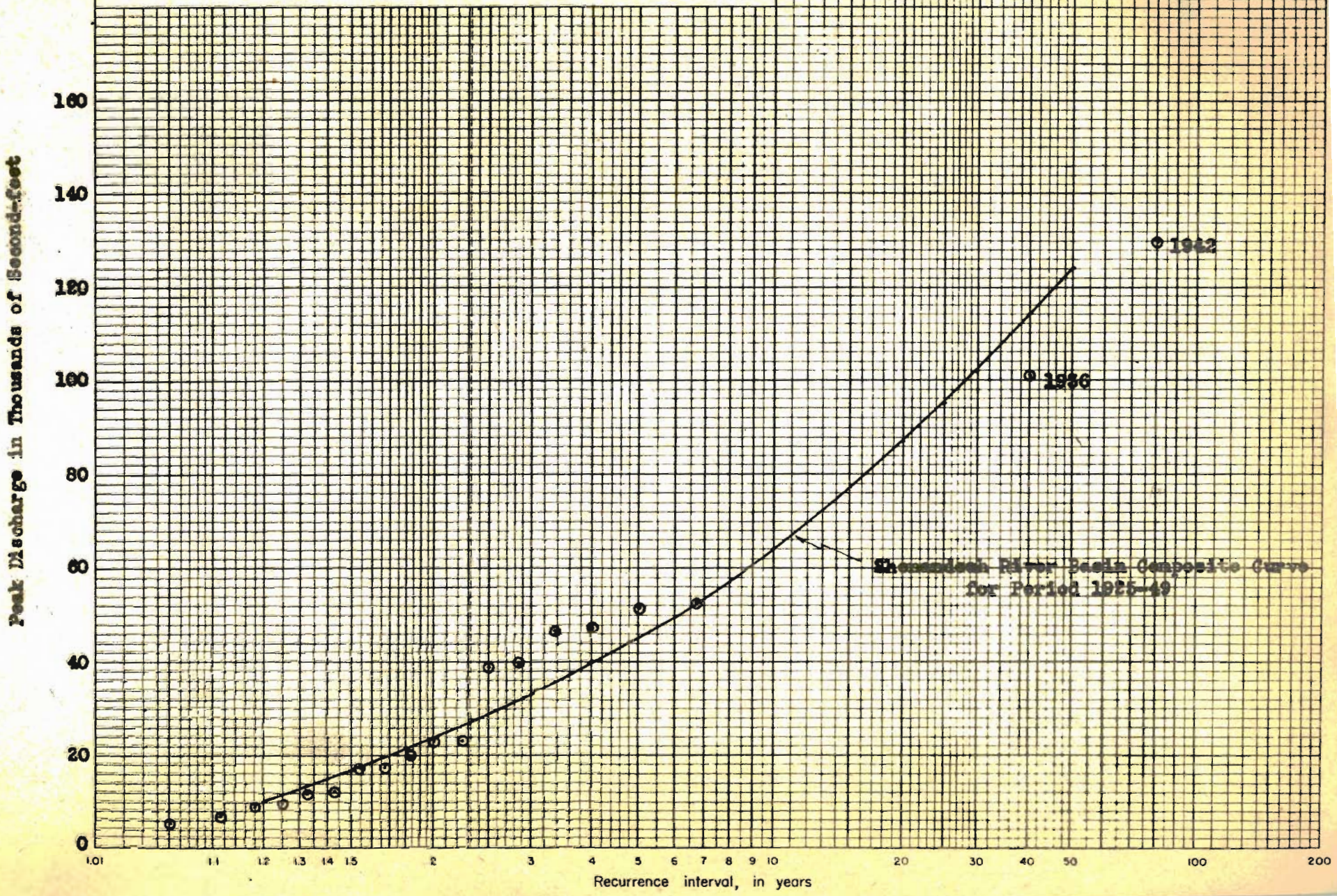
9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 7

Annual floods on South Fork Shenandoah River at Front Royal, Va.

Drainage area, 1658 sq mi. Period 1930 - 1949



Station No. 8

Flood data for North Fork Shenandoah River at Cootes Store, Va.
Drainage area: 215 square miles. Period of record: March 1925 to September 1949.
Gage: Chain: March 1925 to November 1937. Datum elevation 1051.8 ft.m.s.l.
The maximum flood listed is known to be the greatest in at least 113 years (or since 1836).

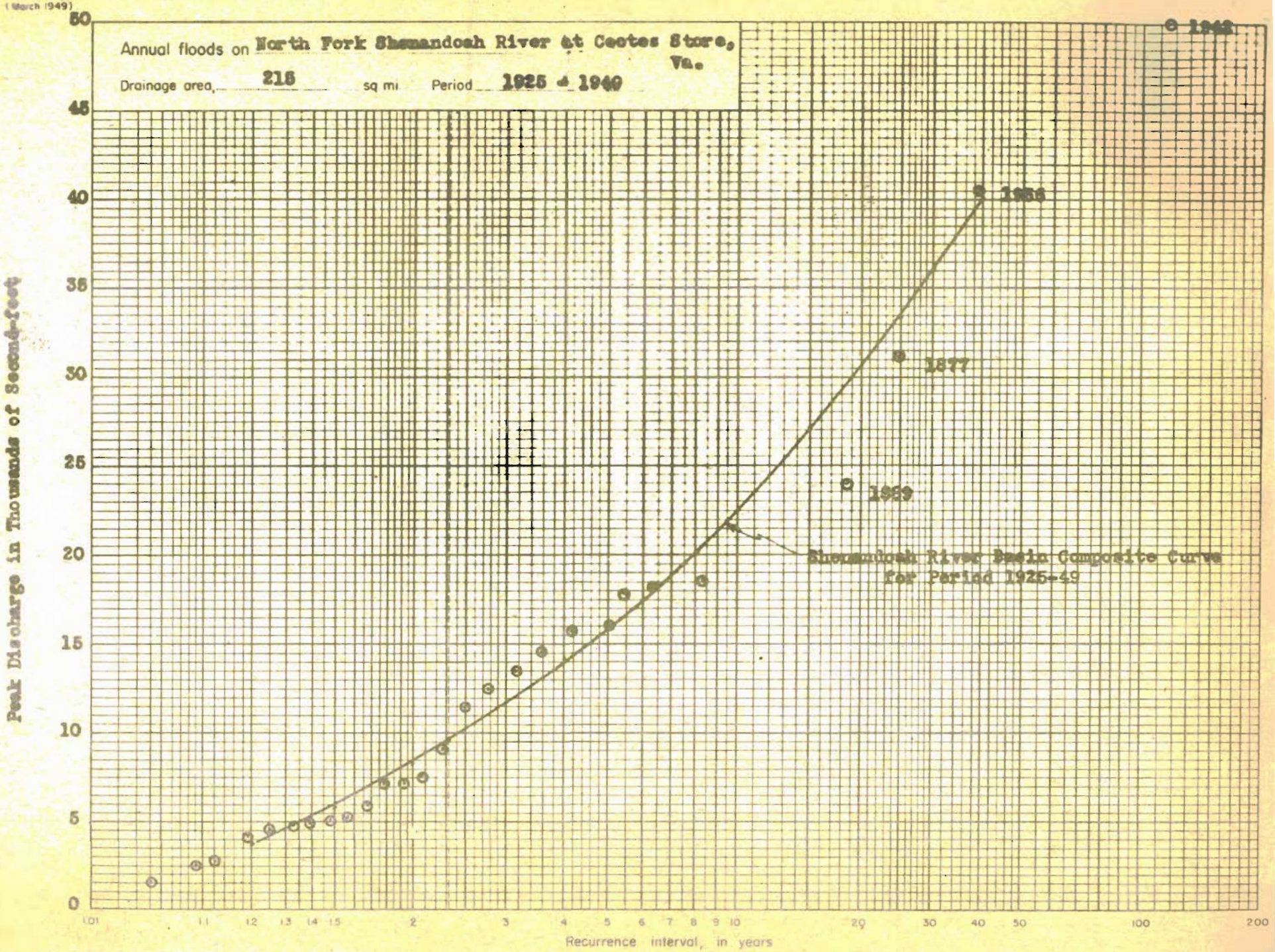
Calendar Year	Month	Day	Gage Height (feet)	Discharge (second-feet)		Annual Floods Order (M)	Recurrence Interval (years)	Remarks
1877	Nov.		20.9	31,200	**	3	24.8	High-water marks from local resident
1889	May		18.8	24,000	**	4	18.5	
1924	May		16.7	17,800	+	5	5.4	
1926	Aug.	25	9.6	4,230		21	1.19	
1926	Nov.	16	14.0	11,400		10	2.50	
1928	Apr.	30	11.0	6,000		15	1.67	
1929	Apr.	16	15.4	14,600		7	3.57	
1929	Oct.	22	14.5	12,500		9	2.78	
1931	Aug.	23	7.0	1,600		24	1.04	
1932	Feb.	4	10.2	4,880		19	1.32	
1933	Apr.	17	11.7	7,120		13	1.92	
1934	Sept.	16	8.5	2,860		22	1.14	
1934	Dec.	1	16	16,000		5	5.00	
1936	Mar.	17	23.25	40,500	**	2	37	
1937	Apr.	25	17	18,600		3	8.33	
1937	Oct.	28	10.0	4,600		20	1.25	
1939	Feb.	3	12.84	9,040		11	2.27	
1940	May	31	11.74	7,120		14	1.78	
1941	Apr.	5	10.26	5,020		17	1.47	
1942	May	22	16.93	18,300		4	6.25	
1942	Oct.	15	25.3	50,000	*	1	114	Highest since 1836
1944	May	24	11.45	7,640		12	2.08	
1945	Sept.	18	15.9	15,800		6	4.16	
1946	May	4	9.73	5,260		16	1.56	
1947	Mar.	14	7.28	2,570		23	1.09	
1948	Aug.	11	9.35	4,900		18	1.39	
1949	June	28	14.84	13,500		8	3.12	

* In 113 years
** In 73 years
\+ In 25 years

9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 8



Station No. 9

Flood data for North Fork Shenandoah River near Strasburg, Va.
Drainage area: 772 square miles. Period of record March 1925 to September 30, 1949
The maximum flood listed is known to be the greatest since 1924.

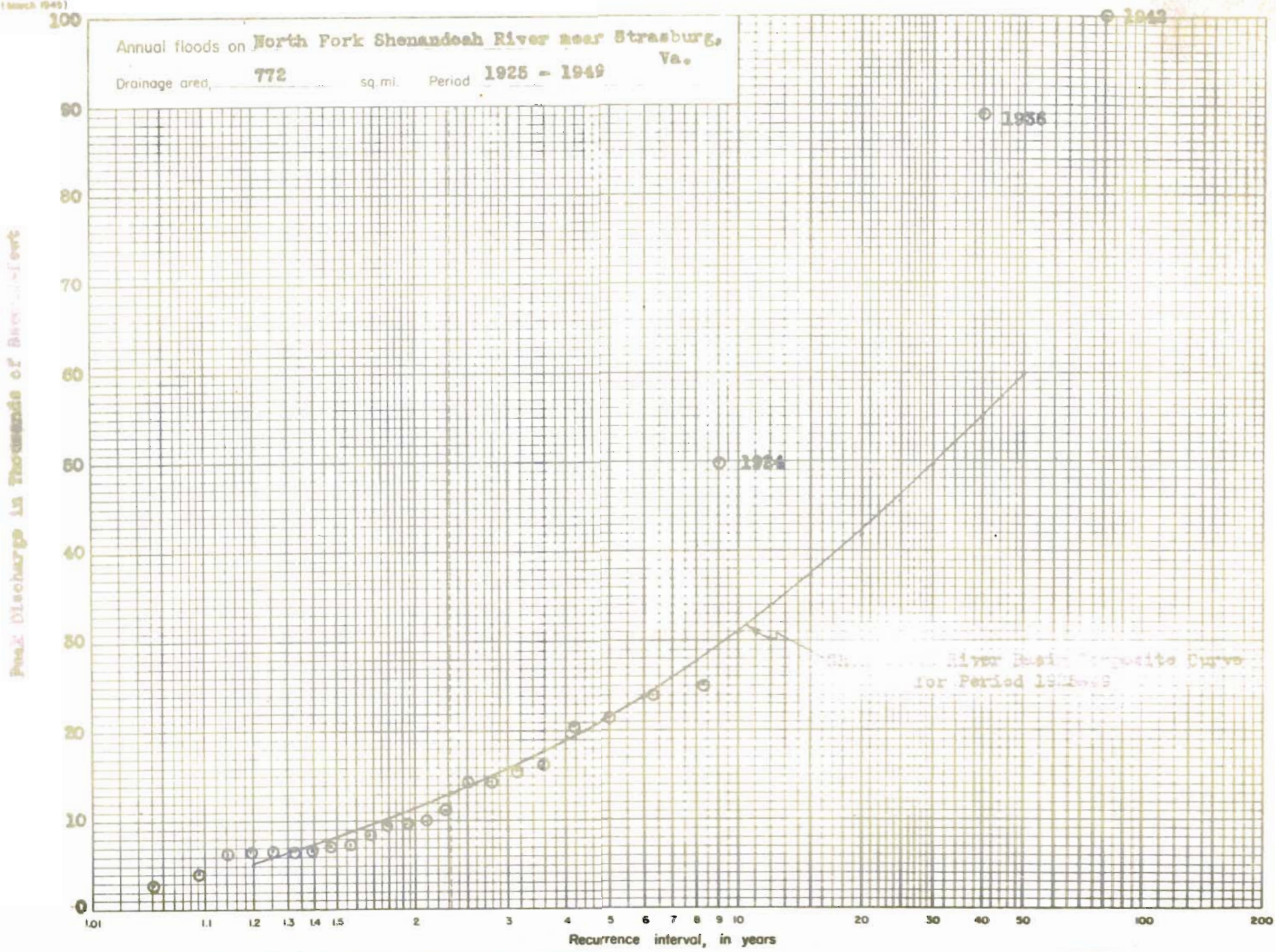
Calendar Year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Other (M)	Recurrence Interval (years)	Remarks
1924	May	12	25.7	49,900	** 3	9.0	
1926	Aug.	26	9.8	7,060	17	1.47	
1926	Nov.	17	12.2	9,330	14	1.79	
1928	May	1	15.5	14,200	10	2.50	
1929	Apr.	17	16.3	15,600	8	3.12	
1929	Nov.	19	9.9	6,800	18	1.39	
1931	Aug.	23	5.50	2,780	24	1.04	
1932	May	13	12.72	9,980	12	2.08	
1933	Apr.	21	16.65	16,200	7	3.57	
1934	Sept.	17	9.32	6,200	22	1.14	
1934	Dec.	2	18.99	20,800	6	4.17	
1936	Mar.	18	30.21	89,000	* 2	40	Was considered highest since 1870
1937	Apr.	26	20.93	25,200	3	8.33	
1937	Oct.	29	13.48	11,100	11	2.27	
1939	Feb.	4	15.65	14,400	9	2.78	
1940	June	1	10.02	6,740	21	1.19	
1941	Apr.	6	10.42	7,160	16	1.56	
1942	May	23	19.28	21,400	5	5.0	
1942	Oct.	16	31.2	100,000	* 1	80	
1944	May	7	11.80	8,810	15	1.67	
1945	Sept.	19	20.4	24,000	4	6.25	
1946	May	5	10.02	6,740	20	1.25	
1947	Mar.	15	7.29	4,040	23	1.09	
1948	Feb.	15	9.96	6,740	19	1.32	
1948	Oct.	6	12.50	9,720	13	1.92	

* Since 1870
** Since 1924

9-179a
Flood data plot
(March 1946)

UNITED STATES DEPARTMENT OF THE INTERIOR – GEOLOGICAL SURVEY – WATER RESOURCES DIVISION

File Number



Station No. 10

Flood data for Cedar Creek near Winchester, Va.
Drainage area: 101 square miles. Period of record: 1938 - 1949.
Gage: Recording. Datum elevation: 647.09 ft. m.s.l.
The maximum flood listed is believed to be the greatest in at least 79 years (or since 1870).

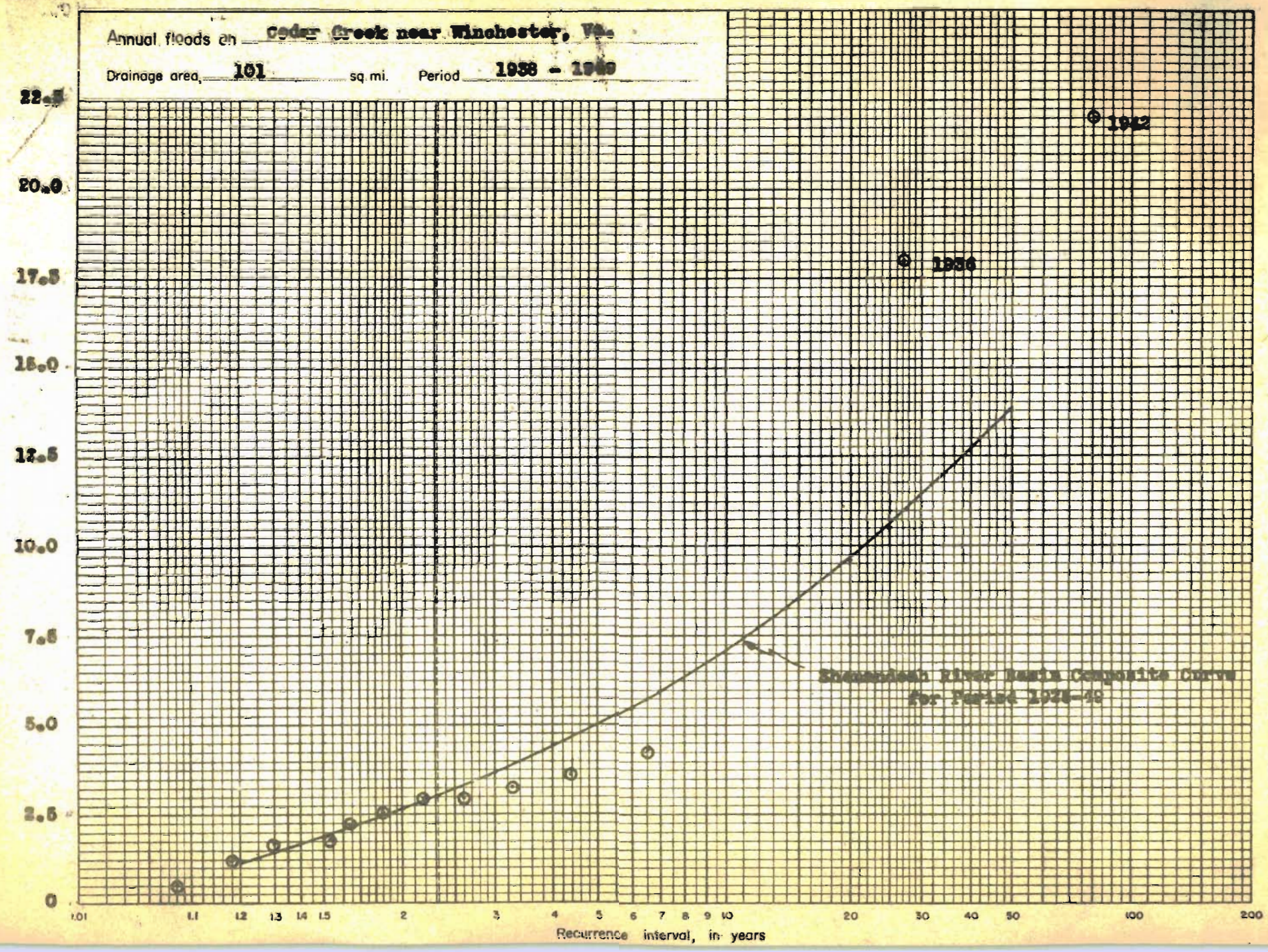
Calendar year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Annual Floods Recurrence Interval (years)	Remarks
1936	Mar.		25	18,000	** 2	27	High-water mark
1937	Oct.	28	11.32	3,660	3	4.33	
1939	Feb.	3	10.38	3,250	4	3.25	
1940	June	12	9.81	2,980	5	2.60	
1941	Apr.	5	8.80	2,530	7	1.86	
1942	May	22	10.45	2,950	6	2.16	
1942	Oct.	15	27.0	22,000	* 1	80	
1944	May	7	7.33	1,680	10	1.30	
1945	Sept.	18	13.37	4,290	2	6.50	
1946	June	2	8.73	2,230	8	1.62	
1947	May	18	3.95	526	12	1.08	
1948	Apr.	14	6.14	1,240	11	1.18	
1948	Dec.	30	7.51	1,750	9	1.53	

* Since 1870
** Since 1896

9-179a
d data plot
arch 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 10



Station No. 11

Flood data for Passage Creek at Buckton, Va.
Drainage area: 87 square miles. Period of record April 4, 1932.
Gage: Non-recording 1933-37. Datum elevation: 525.14 ft. m.s.l.
The maximum flood listed is believed to be the greatest in at least 79 years (or since 1870).

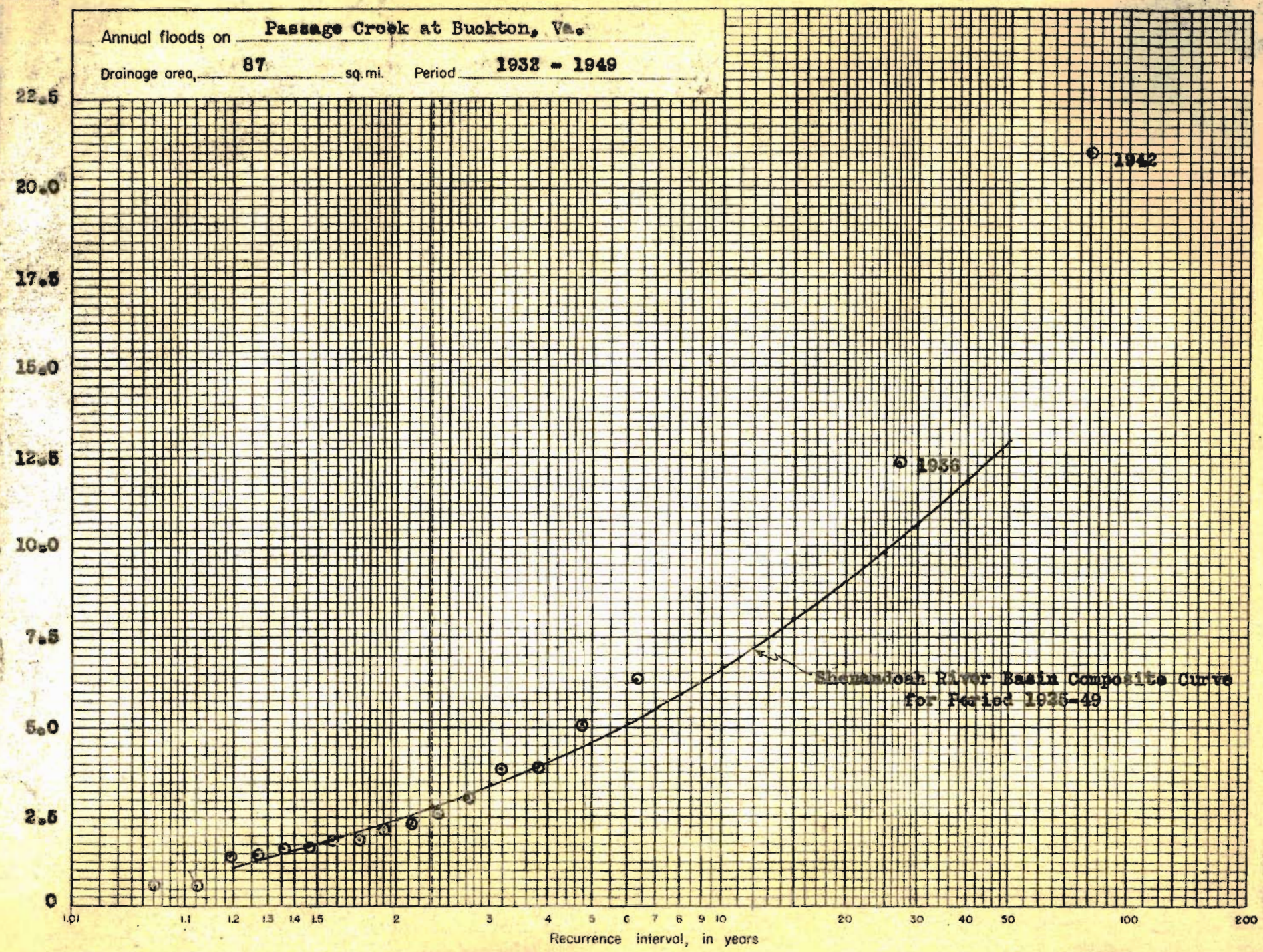
Calendar year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Recurrence Interval (years)
1932	May	12	7.3	3,090	7	2.71
1933	Apr.	21	8.0	3,860	6	3.16
1934	Mar.	3	4.5	588	17	1.12
1934	Dec.	1	10	6,360	3	6.33
1936	Mar.	17	14.29	12,300	** 2	27
1937	Apr.	26	9.0	5,060	4	4.75
1937	Oct.	28	7.39	1,810	11	1.73
1939	Feb.	4	8.37	2,610	8	2.38
1940	June	12	8.00	2,290	9	2.11
1941	Apr.	5	6.85	1,400	16	1.19
1942	May	22	7.76	2,130	10	1.90
1942	Oct.	15	15.5	21,000	* 1	80
1944	May	7	7.27	1,690	13	1.46
1945	Sept.	18	9.80	3,900	5	3.80
1946	May	4	7.22	1,650	14	1.36
1947	May	1	5.50	576	18	1.06
1948	Feb.	14	7.88	1,400	15	1.27
1949	July	8	7.21	1,810	12	1.58

* Since 1870
** Since 1896

9-179a
Flood data plot
(March 1949)

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 11



Station No. 12

Flood data for Shenandoah River at Millville, W. Va.
Drainage area: 3,040 square miles. Period of record: Aug. 1928-Sept.1947.
Gage: Recorder 1928-1947. Datum elevation 293.00 ft. m.s.l.
The maximum flood listed is known to be the greatest since 1870.

Calendar year	Month	Day	Gage Height (feet)	Discharge (second-feet)	Annual Floods Order (M)	Recurrence Interval (years)
1870			a 26.4	151,000	* 2	40
1877			b 24.4	130,000	* 4	20
1889			b 24.4	130,000	* 5	16
1896				c 105,000	* 7	11.4
1924				d 125,000	* 6	13.3
1929	Apr.	17	13.70	34,900	9	2.22
1929	Oct.	24	10.25	22,000	13	1.53
1931	Aug.	24	6.05	7,710	19	1.05
1932	May	13	12.55	33,900	11	1.82
1933	Apr.	21	13.7	39,900	8	2.50
1934	Sept.	18	7.6	12,300	18	1.11
1934	Dec.	2	17.6	66,400	4	5.0
1936	Mar.	18	26.36	150,000	* 3	26.7
1937	Apr.	27	20.2	87,400	3	6.66
1937	Oct.	29	12.7	34,400	10	2.00
1939	Feb.	5	12.2	31,800	12	1.66
1940	Aug.	18	13.7	40,100	7	2.85
1941	Apr.	7	9.16	18,000	15	1.33
1942	May	24	16.28	56,100	6	3.33
1942	Oct.	16	32.4	230,000	* 1	80
1944	May	8	10.13	21,400	14	1.43
1945	Sept.	20	17.10	61,800	5	4.00
1946	May	6	7.86	13,200	17	1.18
1947	Mar.	16	8.79	16,400	16	1.25

a From W.S.P. reported practically same stage as 1936. Information at Berrys Ferry (2-12-43) indicates 1870 2' higher than 1936.

b Notes at Berrys Ferry (2-12-43) indicate 1889 & 1877 about equal and several feet lower than 1870.

c During period of record. W. S. P. 800.

d From W. B. gage at Riverton and relation curve.

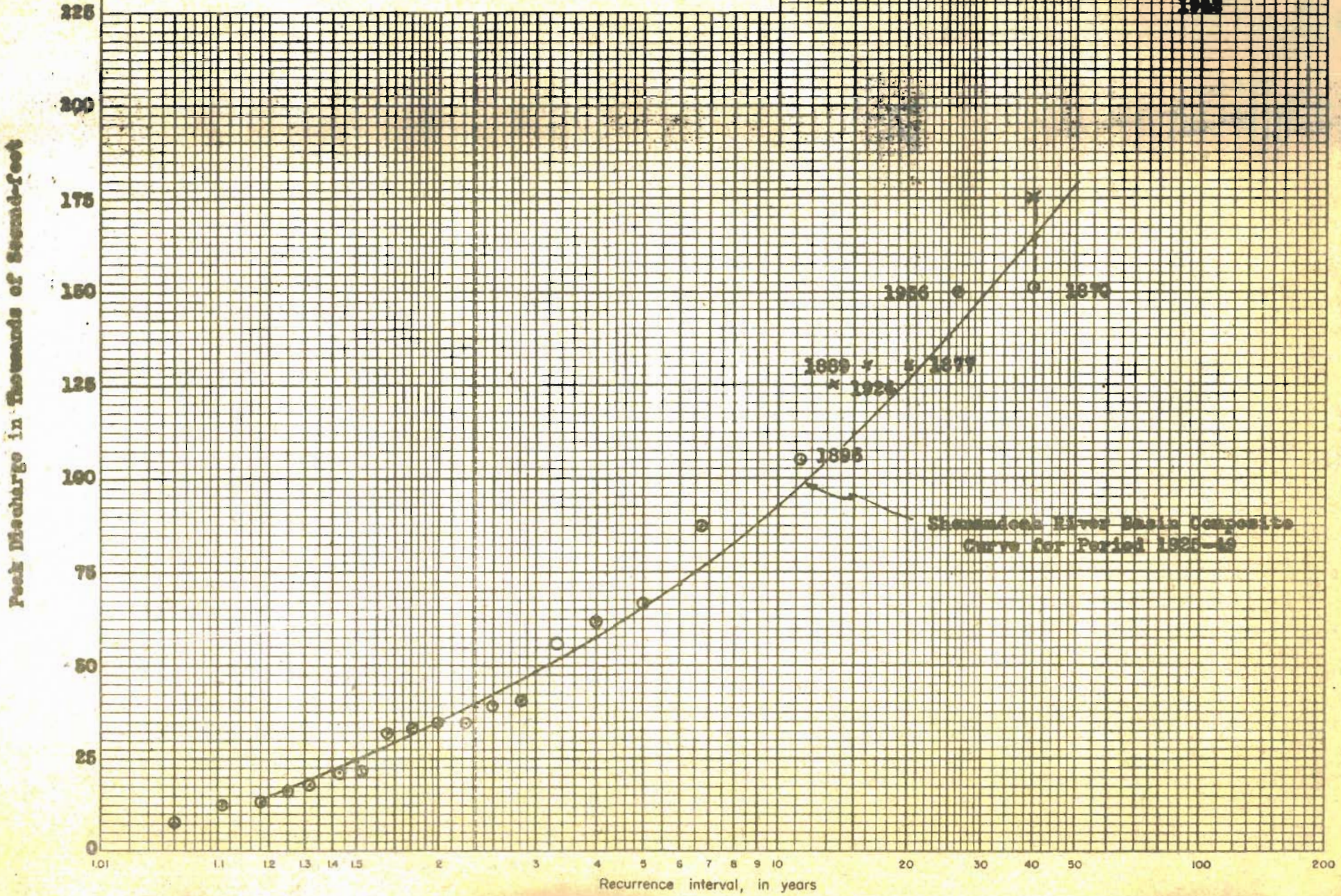
* For the period 1870 to 1949.

UNITED STATES DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY — WATER RESOURCES DIVISION

File Number 12

Annual floods on Shenandoah River at Millville, W. Va.

Drainage area, 3,040 sq. mi. Period 1928 - 1949



VIRGINIA DIVISION OF MINERAL RESOURCES
LIBRARY