Water-Supply Characteristics of Streams in the Delaware River Basin and in Southern New Jersey

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1669-N

Water-Supply Characteristics of Streams in the Delaware River Basin and in Southern New Jersey

By C. H. HARDISON *and* R. O. R. MARTIN

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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WATER-SUPPLY CHARACTERISTICS OF STREAMS IN THE DELAWARE RIVER BASIN AND IN SOUTHERN NEW JERSEY

By C. H. Hardison and R. O. R. Martin

ABSTRACT

The annual low flows at short-term stream-gaging stations in the Delaware River basin are compared with the annual low flows at long-term stations to determine the magnitude and frequency of annual low flows at 95 stream-gaging stations for the period 1913–53. Flow-duration curves for essentially the same period of years are shown for 23 of the stations. For 19 of the stations the low-flow frequency curves are used to estimate the magnitude and frequency of storage required to maintain selected draft rates.

Median values of annual low flow at the 95 stations range from 0.02 million gallons per day per square mile to 0.65 million gallons per day per square mile and vary widely even between stations on adjacent streams. The annual 7-day low flow for the 20-year recurrence interval averages about half that for the 2-year recurrence interval (median annual 7-day flow) and ranges from 25 to 79 percent.

The median annual 7-day low flow, when expressed as flow per square mile, is a good index of the allowable draft for selected amounts of storage required at selected recurrence intervals. For a storage of 20 million gallons per square mile at a 10-year recurrence interval, the allowable draft for all but 2 of the 19 stations analyzed plots within 10 percent of the average relation based on data for the 19 stations.

INTRODUCTION

The usefulness of the streams in the Delaware River basin depends largely on the amount of flow during low-flow periods. Because the amount of low flow varies from year to year as well as from stream to stream, wise development requires knowledge of both the frequency distribution of annual low flows and the effect of physical differences between streams. In the analyses in this report, seven long-term records are used to evaluate the year to year variation in low flow and many short-term records are used to determine the variation between streams, so that the low-flow characteristics can be estimated for the sites of most gaging stations. This report includes a summary of these estimates and a description of the methods used in making them. The analyses were made as part of a Geological Survey project to supplement material on general geology and ground water that was being prepared for a report on the Delaware River basin (U.S. Army Corps of Engineers, 1960). Some of the results presented here also were used in another Geological Survey report on the water resources of the basin (Parker and others, 1964).

The basic data used in the analyses are described first, and then the methods used in analyzing the flow-duration curves and low-flow frequency curves are discussed. A final section presents a method of estimating draft-storage relationships at ungaged sites, and tabulated results are consolidated at the end of the report.

BASIC DATA FOR THE ANALYSES

The basic data for the analyses presented in this report are the records of discharge collected at stream-gaging stations in the Delaware River basin and southern New Jersey. Streamflow records have been collected at over 130 sites in the area, but records from only 95 of these sites are used in the analyses. Records from the other sites are not used because either (1) only a short record had been collected, (2) the flow was regulated, or (3) the record tends to duplicate information obtained at 1 of the 95 sites.

The location of the 95 gaging stations used in the analyses is shown on figure 1; the names of the gaging stations are given in table 6, and the station descriptions are given in a report on the compilation of records (U.S. Geol. Survey, 1960). Stations indicated as pivot stations on figure 1 have long-term records that are used to evaluate the frequency distribution of annual low flows. The indicated index stations generally have shorter records than do the pivot stations, but longer records than at most of the other stations shown on figure 1.

A 40-year period ending in 1953 was used as a reference period because it was the longest period for which suitable records were available or could be estimated for the seven pivot stations. The reference period ends near the close of a 20-year period with a fairly consistent pattern of regulation from upstream reservoirs and before regulation and diversion for the New York City water supply began to affect streamflow in the Delaware River basin. To complete the records for the full reference period at the pivot stations, 14 months of discharge for station 74 (Perkiomen Creek at Graterford) were estimated by relation with station 86 (Brandywine Creek at Chadds Ford, Pa.), 15 years of record for station 58 (Lehigh River at Bethlehem, Pa.) were adjusted for estimated inflow between an upstream and a downstream site, and 17 years of record for station 29 (Lackawaxen River at Hawley, Pa.) were estimated by relation with the

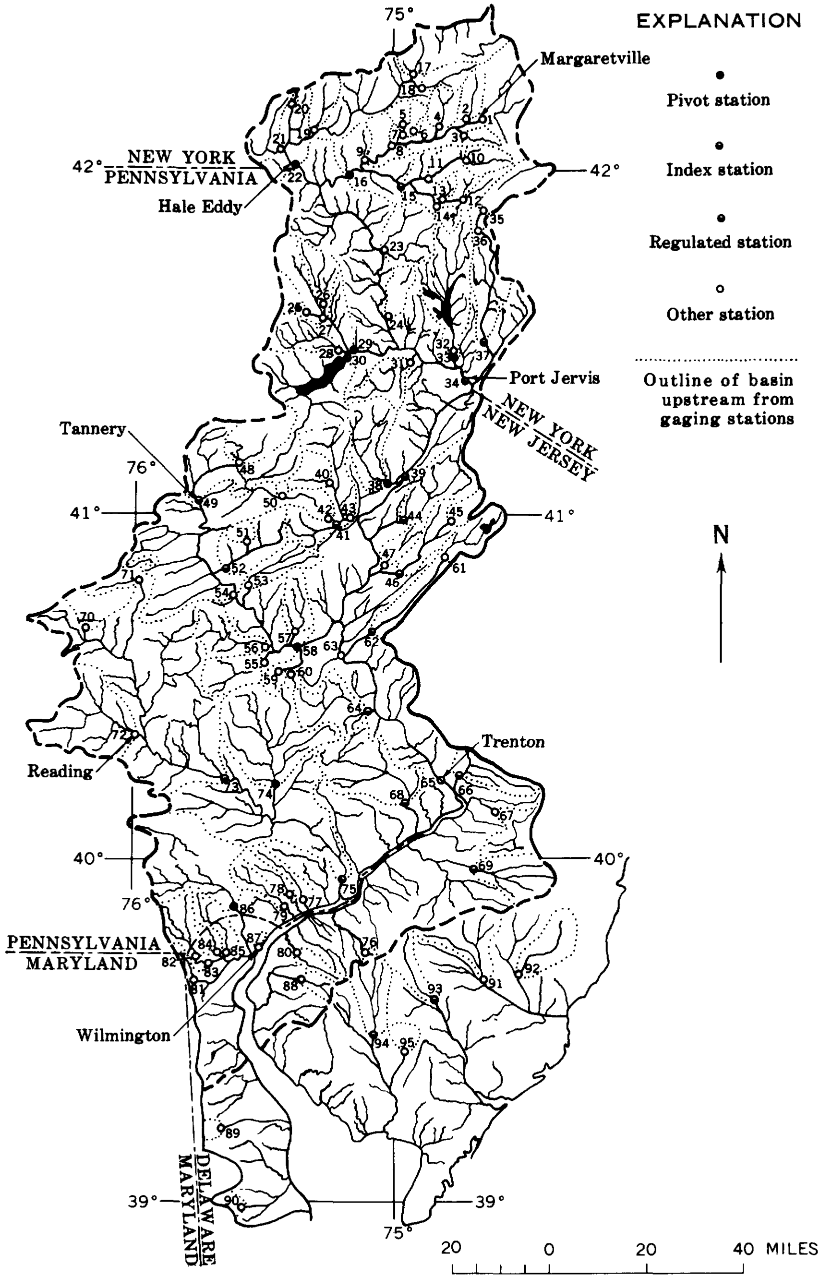

Figure 1.—Map of Delaware River basin showing location of stream-gaging stations and basin outlines.

flow at the site of a former gaging station that had about 30 percent less drainage area. (Records for October 1918–December 1920 at the former station were computed for this report on the basis of gage heights, discharge measurements, weather records, and records for nearby stations.)

Annual low-flow summaries computed by electronic computer were used for all 7 pivot stations, 10 of the 15 index stations, and for the 6 regulated stations. These summaries give the lowest mean flow during each year for periods of 7, 15, 30, 60, 120, and 183 consecutive days (table 1); they also give the number of days each year that the daily discharge fell between selected class limits (table 2). The annual low flows are the lowest flows in each climatic year starting

TABLE 1.—*Annual low-flow data for station 7600 on Brandywine Creek at Chadds Ford, Pa.*

Year	Lowest mean discharge, in cubic feet per second, for indicated number of consecutive days					
	7	15	30	60	120	183
1912	129.1	135.5	150.0	197.4	225.1	253.8
1913	134.6	152.8	167.9	189.8	222.1	236.3
1914	100.4	104.3	110.5	115.9	139.8	195.3
1915	166.0	173.1	205.7	208.9	247.8	293.2
1916	136.7	146.9	156.3	168.3	183.5	232.8
1917	122.7	126.1	136.5	156.2	193.4	207.7
1918	91.1	94.6	99.3	104.4	105.3	115.8
1919	147.1	185.3	231.4	264.0	345.2	379.9
1920	142.9	145.4	154.6	178.6	229.9	264.6
1921	77.7	85.9	92.1	97.9	117.7	139.3
1922	95.0	97.2	99.6	101.6	112.5	140.5
1923	99.7	105.6	113.5	131.4	153.1	173.1
1924	122.9	130.7	147.5	188.4	208.8	250.2
1925	77.4	83.9	100.6	108.9	131.8	155.7
1926	102.1	124.9	139.2	164.7	186.9	205.3
1927	147.9	156.3	192.0	232.0	280.7	324.4
1928	198.6	238.3	252.8	267.7	289.7	337.4
1929	85.7	97.1	109.6	137.3	196.6	232.4
1930	66.7	67.5	71.1	81.9	91.0	103.3
1931	100.9	104.6	108.2	111.7	127.7	175.3
1932	51.3	52.2	57.9	77.0	102.2	154.1
1933	178.3	199.9	214.2	258.0	299.7	354.8
1934	147.1	160.4	205.6	229.9	261.3	285.5
1935	164.1	186.4	198.5	243.3	300.9	326.8
1936	102.9	109.2	115.1	124.0	135.9	164.3
1937	127.7	129.5	131.7	187.8	199.9	262.2
1938	213.6	219.9	246.3	275.4	344.2	375.7
1939	151.4	154.8	167.9	182.3	207.8	230.4
1940	122.7	129.6	146.4	168.0	194.2	246.2
1941	57.7	58.9	63.6	71.2	87.9	104.1
1942	105.7	110.9	149.4	159.6	219.7	305.3
1943	75.1	76.0	83.0	99.8	147.1	197.1
1944	57.3	58.7	65.3	94.7	130.6	157.3
1945	190.9	205.0	218.7	254.4	322.6	351.3
1946	157.9	164.5	168.5	183.8	214.0	239.0
1947	102.0	104.6	108.0	133.8	182.8	244.1
1948	201.9	212.1	229.0	251.5	332.2	383.1
1949	111.4	114.2	121.8	126.6	134.6	163.6
1950	145.6	148.3	179.5	217.9	245.0	273.6
1951	94.1	98.3	111.3	119.8	160.3	224.0
1952	167.9	173.2	178.1	200.2	281.4	390.5

April 1 and ending the following March 31; thus, the low-flow periods in fall and winter are considered in the same year as the low flows of the preceding summer. The segregation by class limits that was used to compute the flow-duration curves is for water years ending September 30. Therefore, in this report, the reference period for the annual low flows is April 1, 1913–March 31, 1953 (climatic years 1913–52), and the reference period for the flow-duration curves is October 1, 1913–September 30, 1953 (water years 1914–53).

For the other 72 gaging stations used in this report, the lowest 7- and 30-day discharges for each year were computed manually from the records of daily discharge. Records for these stations were analyzed only to the extent of obtaining indices of annual low flow, except for station 15 (Beaver Kill at Cooks Falls, N.Y.) and station 39 (Flat Brook near Flatbrookville, N.J.) for which the annual low flows for the other lengths of period were also computed manually.

Annual low flows for 274-day periods were computed from the monthly mean discharge for the 7 pivot stations and 12 index stations for which annual low-flow data for periods of 183 consecutive days were available. The lowest 9-month average was used for convenience even though the average for the lowest 274-day period would have been somewhat lower. Also, each 9-month period used was restricted to a single climatic year beginning April 1 even though a lower 9-month period could have been obtained by using a few months from the preceding year or the following year.

Annual low flows for 365-day periods for the seven pivot stations and one index station were computed from monthly mean discharge by a method that allowed 2 months overlap in computing the average for independent periods. The lowest 12-month average of the entire record was assigned order number 1, and the second lowest 12-month average, which could include no more than two of the months used in the average for the lower order number, was assigned order number 2. This process was repeated to obtain the minimum 365-day discharge for successively higher order numbers. The minimum discharge for 365 consecutive days is actually less than that for 12 consecutive months, but the difference is probably small compared with the difference that would be introduced by a change in the arbitrary amount of overlap allowed in selecting independent events.

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TABLE 2.—*Annual duration-table data for station 7600 on Brandywine Creek at Chadds Ford, Pa.*

Year	Number of days in class for indicated lower limit of class discharge, in cubic feet per second																		
	48.0	63.0	83.0	110.0	140.0	190.0	250.0	340.0	440.0	590.0	780.0	1,000.0	1,400.0	1,800.0	2,400.0	3,100.0	4,200.0	5,400.0	7,300.0
1912				16	39	23	69	85	64	33	18	5	2	8	1	2	1		
1913			2	12	55	58	57	40	62	40	13	15	7	1	2	1			
1914			2	27	79	68	77	50	24	22	4	2	3	5	2				
1915			26	34	6	40	110	45	51	25	9	8	2	2	3	1		3	
1916					47	63	126	59	40	12	4	9	2	3	1				
1917				28	107	62	89	44	13	11	2	1	3	4	1				
1918			51	60	95	50	56	20	4	11	5	5		3	1	3	1		
1919		1	62	11	49	36	77	58	29	17	4	11	2	5	1	2			
1920				1	33	61	104	60	42	32	9	13	2	5	1	2			1
1921		9	20	31	76	41	107	45	13	10	6	5	2						
1922		5	47	49	57	72	41	38	23	14	6	8	2	1	1	1			
1923			82	85	25	54	67	26	11	5	2	2	4	2					
1924			14	9	36	49	37	38	88	50	15	11	10	3	3	3			
1925	1	13	21	46	65	89	49	35	24	9	3	6		1	1		1	1	
1926		1	29	65	101	61	55	12	17	7	5	2	3	5		2			
1927				1	49	55	92	82	43	18	7	9	6	2		1			
1928					3	1	28	103	124	53	24	10	5	6	5	4			
1929		2	24	22	27	60	106	42	37	23	3	11	1	3	3	1			
1930		37	25	15	48	76	59	50	30	13	3	5	2	2					
1931	2	49	56	60	78	40	30	16	11	8	7	5	2				1		
1932	19	23	78	46	68	40	46	17	10	10	5	2	1			1			
1933	4	8	3	7	32	56	71	48	50	32	20	17	7	1	5	2	1		1
1934				1	34	101	96	66	35	10	5	11	2	1	3				
1935					21	109	85	49	50	26	7	10	3	2	2		1		
1936			14	38	34	55	39	61	33	29	25	16	6	6	5	4		1	
1937			1	69	60	42	48	71	37	16	15	3		3					
1938				16	4	71	142	62	27	16	6	6	6	5	2	1		1	
1939					57	53	101	31	28	42	26	17	3	3	2	2			
1940				30	117	55	40	48	31	18	8	10	4	1	2		2		
1941	9	14	27	30	65	30	84	48	23	13	6	11	2	2	1				
1942	7	34	53	54	69	57	46	11	10	8	9	1	2	1	2			1	
1943		18	23	14	21	32	63	89	55	22	6	11	6	4		1			
1944	16	12	30	44	72	57	39	33	27	12	9	7	3	1	3		1		
1945			18	32	37	74	84	47	27	18	11	8	2	6			1		
1946					12	80	106	78	44	22	5	8	3	2	3	1		1	
1947				14	102	76	94	40	24	5	6	3	1						
1948			18	14	6	60	58	56	71	32	21	16	7	4	2	1			
1949			3	29	40	59	54	37	57	32	31	14	5	2	1	1			
1950			2	52	85	55	83	33	25	16	4	6	2	1	1				
1951			16	24	61	37	49	59	63	27	12	7	4	3	1	1	1		

1952	--------	--------	14	11	3	42	51	30	79	57	36	19	9	6	4	4	1	--------	--------
1953	--------	--------	5	32	42	47	25	32	48	51	37	24	11	4	5	1	1	--------	--------
Total days	58	226	766	1,129	2,117	2,347	2,940	1,994	1,604	927	459	370	149	119	70	43	13	8	2
Accumulative days	15,341	15,283	15,057	14,291	13,162	11,045	8,698	5,758	3,764	2,160	1,233	774	404	255	136	66	23	10	2
Percent of accumulative total days	100.0	99.6	98.1	93.2	85.8	72.0	56.7	37.5	24.5	14.1	8.0	5.0	2.6	1.7	0.9	0.4	0.1	0.1	0.0

FLOW-DURATION CURVES

The flow-duration curves for each long-term station were smoothed by comparison with the flow-duration curves for other long-term stations, and the flow-duration curves for several short-term stations were extended to the reference period October 1913–September 1953 by relation with one or more long-term stations. The smoothing of the curves for the long-term stations amounted to changes of only a few percent, as illustrated by the observed flow-duration data for stations 16 and 86 plotted on figures 2 and 3; but the extending of the short-term records produced an appreciable change in some of the curves, as illustrated by the observed flow-duration data for the period 1936–53 at station 64 plotted on figure 3. The flow-duration curves were extended by use of a relation based on discharge of equal percent duration at pairs of gaging stations, following the method described by Searcy (1959, p. 14–17).

For regulated stations, the flow-duration curves for the regulated part of the record were extended to the reference period to represent what the flow would have been had the same pattern of regulation affected the flow during the entire reference period. For regulated stations that had a considerable record before regulation started, flow duration curves for the unregulated part of the record were extended to the reference period to represent what the flow would have been without regulation.

The results of the flow-duration-curve analysis are presented in tables 3 and 4 and on figures 2–5. In table 3 the discharge is expressed in million gallons per day per square mile for only those stations with unregulated flow; the results in table 4 are expressed in cubic feet per second for both regulated and unregulated flow.

The flow-duration curves plotted in figures 2 and 3 for 17 stations show considerable similarity in shape. The most outstanding exception is the curve for station 64, Tohickon Creek at Pipersville, Pa., which is unusually steep. The two curves with the flattest slope are those for stations 69 and 94, which are on streams that drain from the Coastal Plain area in New Jersey. Flow-duration data for stations 41 and 66 were omitted from table 3 because of the possible effect of regulation by mills and hydro-power plants, but the plotting of the duration curves for these stations on figures 2 and 3 indicates that any such effect is probably minor.

The curves for six regulated stations are shown in figure 4, and those for regulated conditions at two of these stations are compared with curves for natural conditions in figure 5. Duration curves for regulated conditions are applicable only so long as the pattern of regulation remains the same as that during the period on which the curves are based. New sources of regulation or a change in the type of regulation from an existing development would alter the flow-duration curves.

LOW-FLOW FREQUENCY CURVES

All the low-flow frequency curves presented in this report have been adjusted to the reference period April 1913–March 1953 (climatic years 1913–52). In addition, the curves for each long-term station have been smoothed by comparison with the low-flow frequency data for other long-term stations. The results are listed in tables 5 and 6 and are illustrated in figure 7.

The distribution of annual low flow at each of the seven long-term stations in the basin (shown as pivot stations on fig. 1) and one long-term station outside the basin (Monocacy River near Frederick, Md.) was compared with that at two or more other long-term stations and smoothed as described in the next few paragraphs. Because each of these stations was in turn used as the center of a group of stations, they are called pivot stations in this report. They are also pivotal in that they are the critical stations on which the analyses for all other stations in the basin depend.

The smoothing of the frequency distribution of annual low flow at the seven pivot stations was accomplished by plotting arrayed annual minimum discharge at pairs of pivot stations on logarithmic paper, as in figure 6. The lowest 7-day discharge at one of the stations during the period 1913–52 was plotted against the lowest 7-day discharge at the other stations, and then the second lowest 7-day annual minimum was plotted against the second lowest at the other station and so on until the highest of the 7-day annual minimums at each station were plotted against each other. Similar plots were made of the arrayed annual minimum flow for periods of progressively greater length, such as the 15-day and 30-day periods. Lines of relation were drawn to average the plotted points for each length of period, with some consideration being given to the slope and position of the relation lines for the other length periods. For most of the relations, the lines for the different periods tend to converge at high discharges.

Lines of relation such as those illustrated in figure 6 were used to transpose low-flow frequency experience from one pivot station to another. The transposed data for each order number was averaged with the observed data at the station and used to define the low-flow frequency curves shown in figure 7. Smoothing the low-flow frequency curves by this method results in curves that average the observed data (solid circles in figure 7), but which depart considerably from individual points or groups of points.

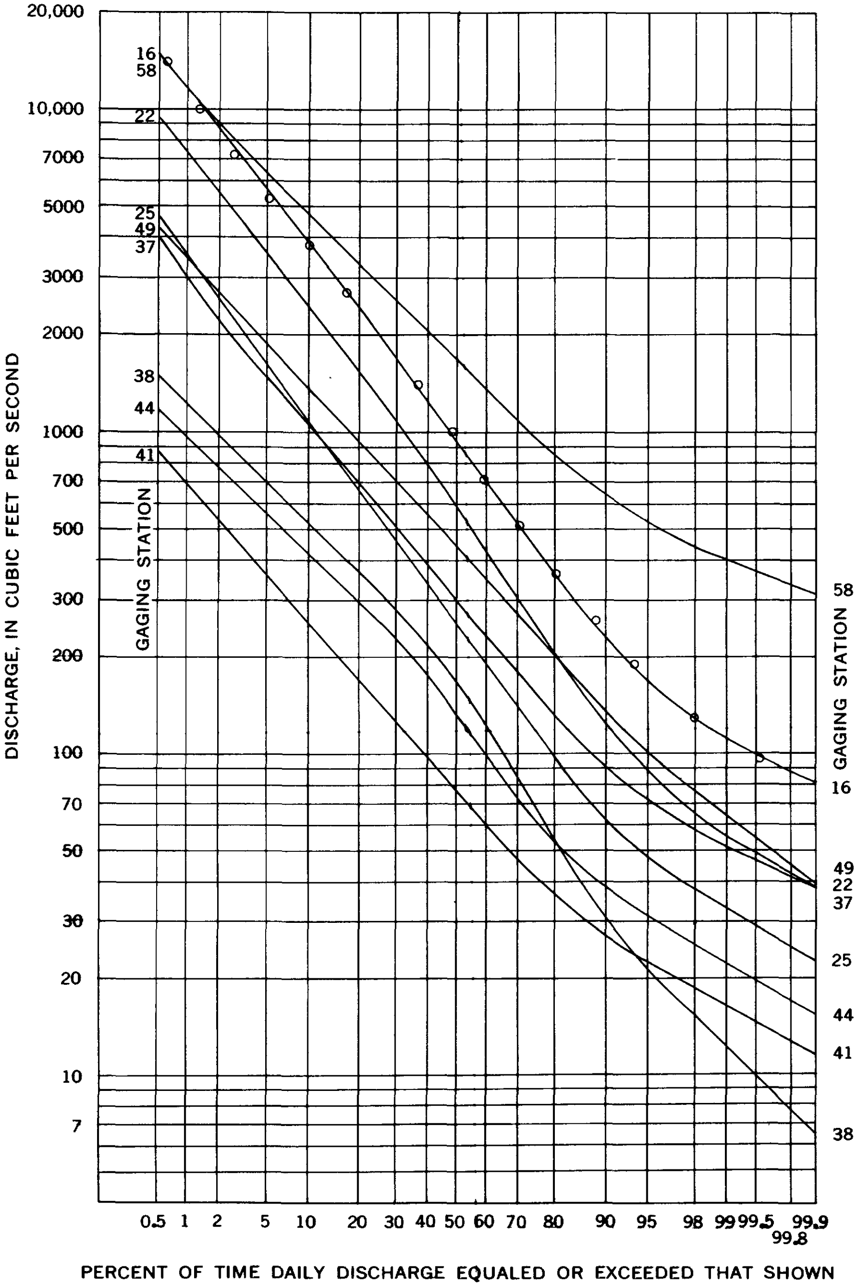

FIGURE 2.—Flow-duration curves for nine stream-gaging stations in the upper part of Delaware River basin. Data adjusted to period October 1, 1913–September 30, 1953, on basis of long-term stream-flow records. Circles represent data from observed records 1914–53 for station 16.

The plotting of the four lowest points for the 120-day discharge in figure 6 (four lowest squares) demonstrates the need for smoothing the observed data. It is obvious from the way these four points plot that either the lowest 120-day flow observed at the Chadds Ford station is unusually high or that the lowest at the Graterford station is unusually low. The relation line is drawn to express this interpretation so that when the experience at one of the stations is transposed through this relation and averaged with the observed flow at the other station the answer is a compromise of the experience at both stations. (In this example, the transposed discharge is 65 cfs (cubic feet per second).) It is for this reason that the curve for the 120-day period at the 40-year recurrence interval in figure 7 is considerably lower than the observed discharge of 88 cfs.

The lower end of the smoothed frequency curves for Brandywine Creek at Chadds Ford was verified by comparison with annual low flows for a 68-year period on Perkiomen Creek at Graterford, Pa., the longest record in the Delaware River basin. The 7- and 183-day annual low flows for the period 1885–1952 at the Graterford station, transposed to the Chadds Ford station by the curves of relation shown in figure 6, are shown on figure 7. They are plotted one log cycle higher than the family of curves and are shown for comparison with smoothed curves for 7 and 183 days that also have been raised one log cycle. The data for the longer period (plotted as circles) average about 5 percent higher than the smoothed curves, although the slope and shape are essentially the same. Annual low-flow frequency curves for 57 years of record on the Monocacy River near Frederick, Md., have also been transposed to the Chadds Ford station (fig. 7) and provide a further verification of the lower end of the smoothed frequency curves.

The relation lines shown in figure 6 reflect differences in flow characteristics that are due to differences in topography, geology, and climate, not to variation in the chance occurrence of hydrologic events. Comversely, the transposed data represent an array of annual low flows that would have occurred had the sequence of hydrologic events been reversed in two basins. Use of the combination of

Map No.	*Stream-gaging station*	*Drainage area (sq mi)*
16	East Branch Delaware River at Fishs Eddy, N.Y	783
22	West Branch Delaware River at Hale Eddy, N.Y	593
29 [1]	Lackawaxen River at Hawley, Pa	290
37	Neversink River at Oakland Valley, N.Y	222
38	Bush Kill at Shoemakers, Pa	117
41	McMichaels Creek at Stroudsburg, Pa	64.4
44	Paulins Kill at Blairstown, N.J	126
49	Lehigh River at Tannery, Pa	322
58	Lehigh River at Bethlehem, Pa	1,279

[1] Shown as No. 25 in figure 2.

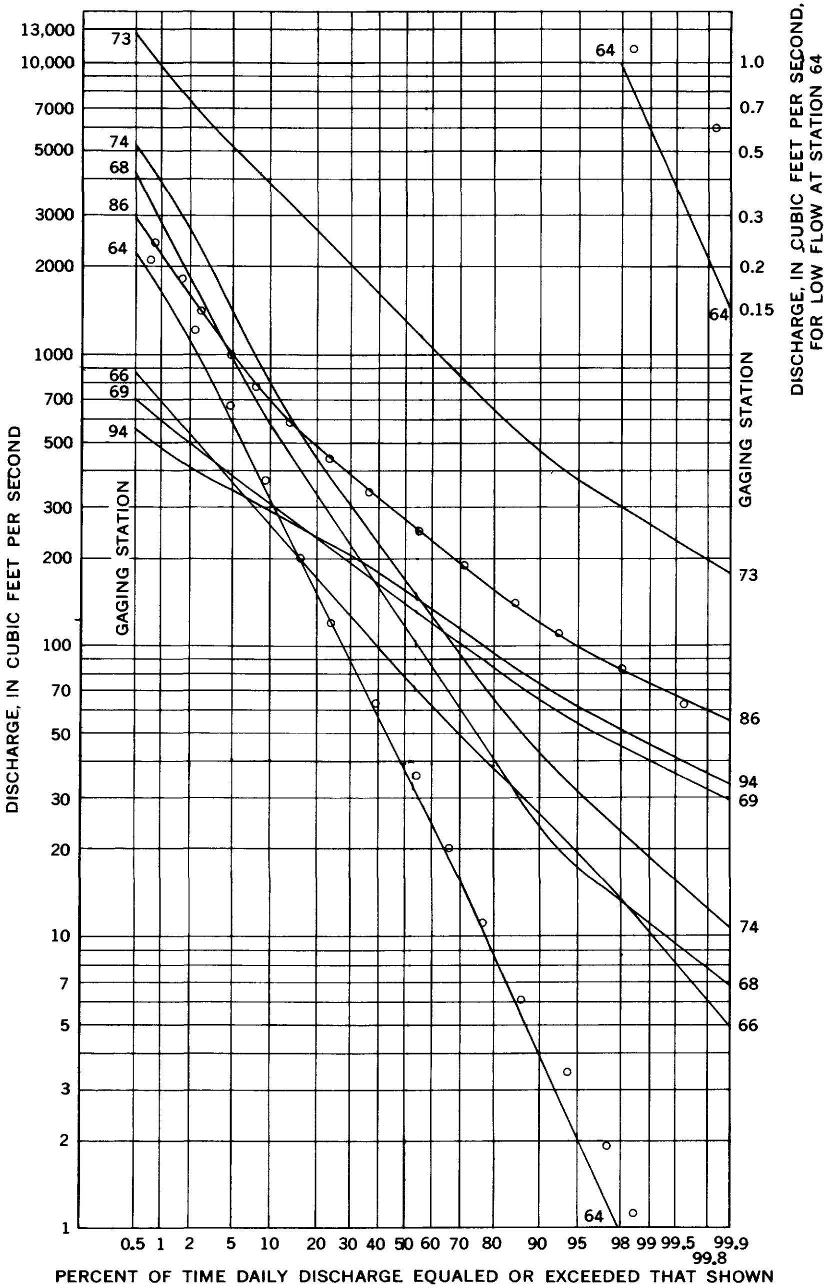

FIGURE 3.—Flow-duration curves for eight stream-gaging stations in the lower part of Delaware River basin. Data adjusted to period October 1, 1913–September 30, 1953, on basis of long-term stream-flow records. Circles represent data from observed records 1914–53 for station 86 and 1936–53 for station 64.

transposed and observed data helps to smooth the low-flow frequency curves more satisfactorily than would be possible using only the observed data. If the relation curve is drawn through the mean of the points for a given period of days, the use of this method affects only the shape of the frequency curve, not its position at the 2-year recurrence interval. A further smoothing of the curves is made by considering the shape and slope of the data for the other low-flow periods when the curves are drawn on graph paper as in figure 7.

Low-flow frequency curves for the 15 index stations were extended by relating the annual low flows to the annual low flows at one or more pivot stations for the concurrent period of record (pl. 1); relation curves for stations 46, 52, and 93 were drawn for the 7- and 30-day annual low flows only. Relation lines thus drawn were used to transpose the smoothed low-flow frequency curves from the pivot stations to the index stations by assuming that the relation curves were the same as those that would have been defined by records for the full reference period. Even though the relation lines on plate 1 are actually but an estimate of the long-term position, they can be used to obtain a better approximation of the low-flow frequency curves for the period 1913–52 than could be obtained by an analysis of only the observed data for 1936–52.

The arrayed data shown on plate 1 are plotted in the same manner as in figure 6, but the relation curves are not used merely to smooth the low-flow frequency data; they are used to extend them. Therefore, there must be some correlation between the annual low flows at the two stations if the procedure is to result in an improved estimate. The coefficient of correlation for each relation between a pivot station and an index station was estimated graphically by plotting the 7-day annual low flows for concurrent years as shown in the right half of plate 1. The relations shown in the left half were used only when the coefficient of correlation was greater than 0.70.

One of the reasons for requiring at least a minimum degree of correlation is that the relation line defined by the arrayed data is unregressed. The regressed line of relation computed by the least-squares method is also shown in the right half of plate 1 for comparison.

Map No.	*Stream-gaging station*	*Drainage area (sq. mi.)*
64	Tohickon Creek near Pipersville, Pa	97.4
66	Assunpink Creek at Trenton, N.J	89.4
68	Neshaminy Creek at Langhorne, Pa	210
69	N. B. Rancocas Creek at Pemberton, N.J	111
73	Schuylkill River at Pottstown, Pa	1,147
74	Perkiomen Creek at Graterford, Pa	279
86	Brandywine Creek at Chadds Fords, Pa	287
94	Maurice River at Norma, N.J	113

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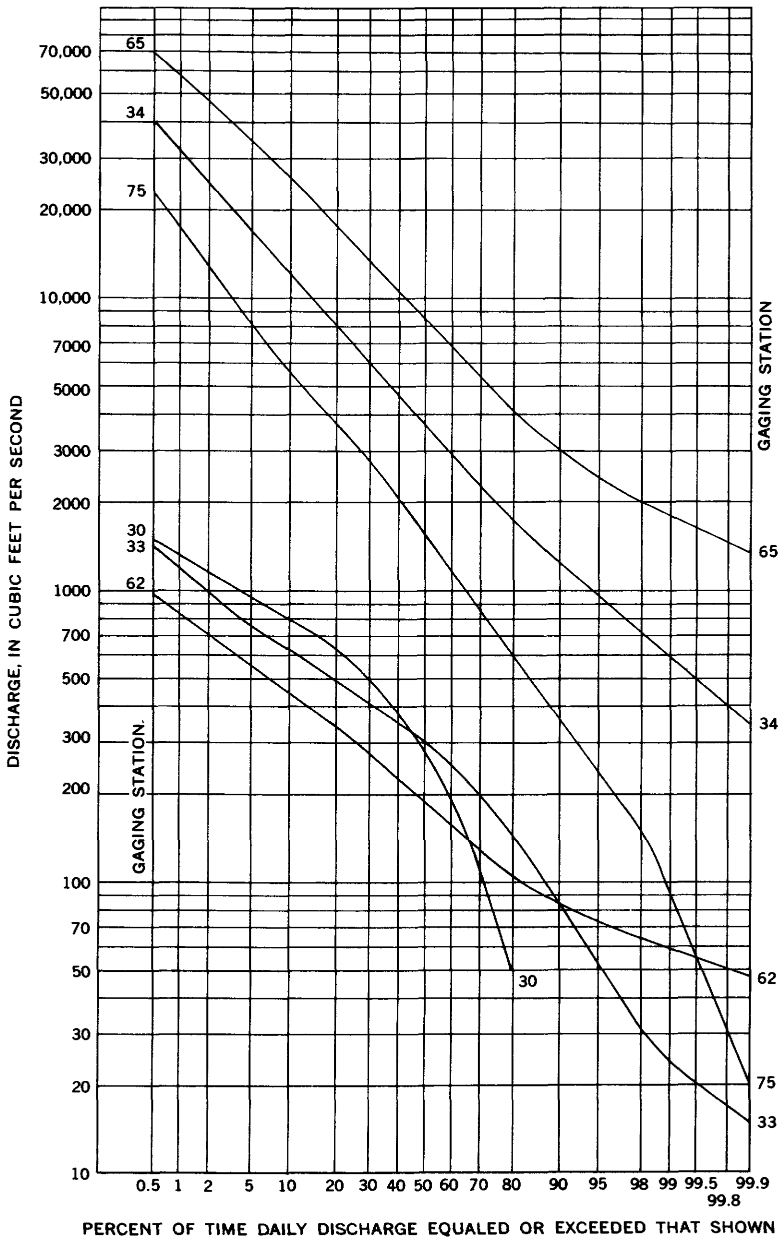

FIGURE 4.—Flow-duration curves for six stream-gaging stations affected by regulation and diversion in Delaware River basin. Duration curves are based on the pattern of regulation during the period of regulated record and are adjusted to the period October 1, 1913–September 30, 1953, on the basis of long-term streamflow records.

The use of this line would tend to give a flatter low-flow frequency curve than would the unregressed line. Theoretically, neither the regressed nor the unregressed line give the correct result without adjustment. When the coefficient of correlation is greater than 0.7, however, the use of the unregressed line, even without adjustment, gives low-flow frequency curves that are more reliable than those based only on the observed record.

Unregressed lines of relation were used to extend the low-flow frequency curves for most of the index stations, and the results are summarized in tables 5 and 6. Indices of low flow for the other stations listed in table 6 were obtained by similarly relating their 7- and 30-day annual low flows to those of an index station or pivot station. Some of the relations were so good that satisfactory estimates could be made from a relation based on only 4 years of overlapping record. The indices of natural low flow for station 52 (Pohopoco Creek near Parryville, Pa.) that are shown in table 6 were obtained by relating the regulated annual minimums to the annual minimums adjusted for storage and diversion.

The discharge given for the 20-year recurrence interval in table 6 is an indication of the flow available without storage. A little storage would be required to develop the minimum 7-day flow shown in the table, and a little more would be required to develop the 30-day flow; but the amount required could probably be provided by storage in the stream channel near the intake.

The ratio of the 7-day discharge at the 20-year recurrence interval to that at the 2-year recurrence interval is shown in table 6 for possible use in hydrologic studies. The ratio averages about 0.50 and ranges from 0.25 to 0.79. The adjusted ratio is the observed ratio divided by the formula $1.53Q_2^{0.19}$ to adjust for the effect of difference in the median annual low flow per square mile (Q_2). The coefficient of correlation of the relation between median annual low flow and the observed ratio is 0.58, and the standard error of estimate is about 18 percent.

The low flow at seven of the stations listed in table 5 was affected by regulation during part of the reference period 1913–52. For two of these stations (stations 30 and 34), enough record was available from before regulation to permit an estimate of the preregulation low-flow

Map No.	*Stream-gaging station*	*Drainage area (sq. mi.)*
30	Wallenpaupack Creek at Wilsonville, Pa	228
33	Mongaup River near Mongaup, N.Y	202
34	Delaware River at Port Jervis, N.Y	3,076
62	Musconetcong River near Bloomsbury, N.J	143
65	Delaware River at Trenton, N.J	6,780
75	Schuylkill River at Philadelphia, Pa	1,893

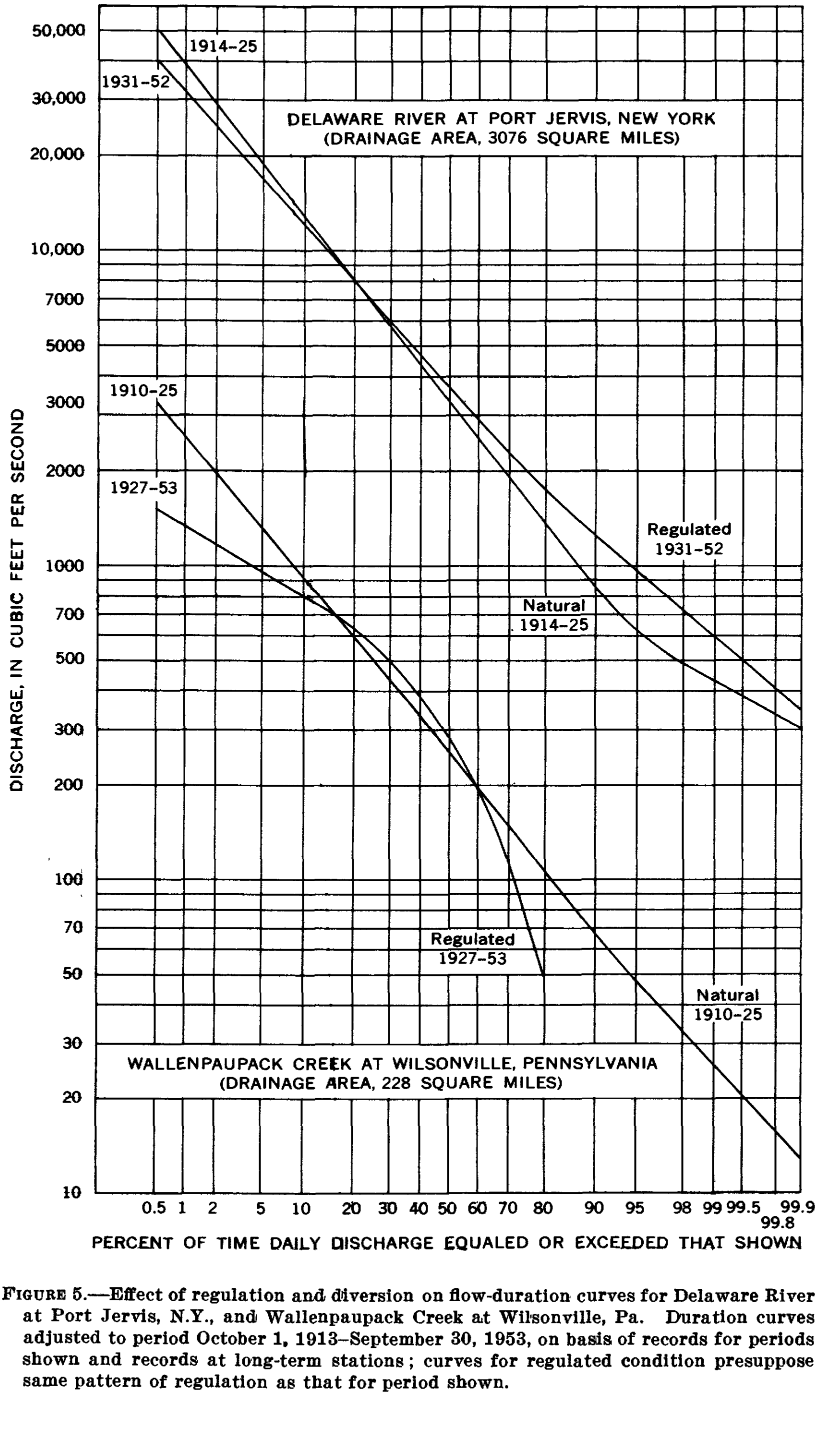

FIGURE 5.—Effect of regulation and diversion on flow-duration curves for Delaware River at Port Jervis, N.Y., and Wallenpaupack Creek at Wilsonville, Pa. Duration curves adjusted to period October 1, 1913–September 30, 1953, on basis of records for periods shown and records at long-term stations; curves for regulated condition presuppose same pattern of regulation as that for period shown.

characteristics. For the other five stations, the results represent the low-flow frequency for the pattern of regulation that occurred during the correlation period adjusted to the hydrologic conditions during the reference period. The results for regulated conditions are shown only in cubic feet per second, as discharge per square mile would have little significance. Annual low flows for periods of 7 or more consecutive days at stations 41 and 66 were assumed to be free from the effects of regulation even though the daily discharge used in the flow duration analysis may have been affected. The flow at some of the other stations shown in table 5 has become regulated since 1953. Low-flow frequency data for three regulated stations (stations 61, 63, and 71) in addition to the seven listed in table 5 are listed in table 6.

STORAGE-REQUIRED FREQUENCY CURVES

The storage-required frequency curves presented in this report show the frequency with which storage equal to or greater than selected amounts would be required to maintain selected rates of regulated flow. The curves, which were computed from the low-flow frequency curves previously discussed, are summarized in table 7 and are plotted on figures 8 and 9. The frequency with which given amounts of storage is required provides a basis for obtaining an economic balance between the cost of the storage and the loss caused by an insufficient supply.

Comparison of the draft-storage curves on figures 8 and 9 shows that on a per-square-mile basis there is less variation in storage required between stations in the upper part of the Delaware River basin than in the lower part. For a storage required of 20 million gallons per square mile at a recurrence interval of 10 years, the spread in draft rate at 11 stations in the upper part of the basin is only about 50 percent as compared to a more than twofold spread among 8 stations in the lower part.

The storage-required computations used in this report are based on frequency-mass curves such as that shown in figure 10. The curved line in this figure is based on discharge data taken from the low-flow frequency curves. The volume of discharge for the 60-day period, for example, was obtained by multiplying the 60-day discharge for a 10-year recurrence interval at station 15 (table 5) (0.172 mgd per sq mi) by 60 days to obtain 10.3 million gallons per square mile. Similar computations for other periods of consecutive days provide the data needed to define the frequency-mass curve. Draft rates for selected amounts of storage were computed as shown in figure 10 and were plotted on frequency curves such as those in figure 11.

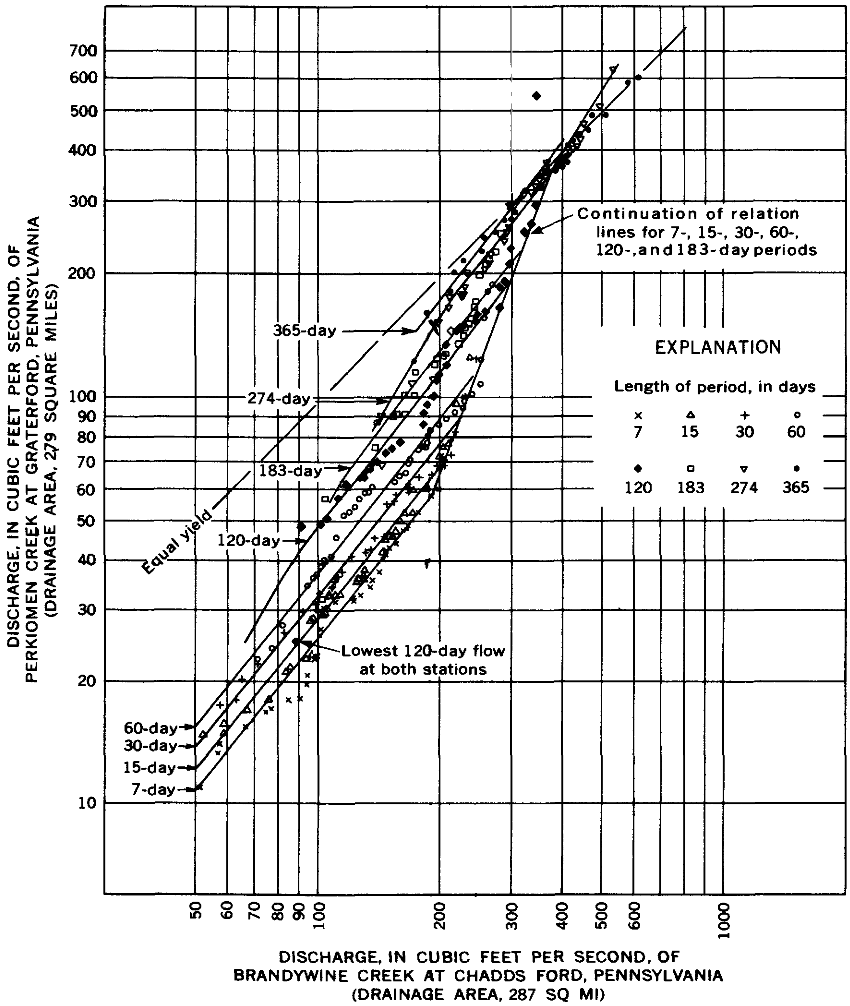

FIGURE 6.—Relation of arrayed annual minimum discharge at two pivot stations in Delaware River basin, 1913–52.

Storage-required frequency curves were computed for all stations for which the low-flow frequency curves had been computed beyond the 30-day period, except for the six regulated stations. Thus, storage-required curves are given for all 7 of the pivot stations (fig. 1) and for 12 of the 15 index stations.

The method used in this report for obtaining storage required neglects the loss due to evaporation and seepage from the reservoir that would be needed to provide the storage, and it neglects a bias of about 10 percent that results from the use of the frequency-mass curve. All the neglected factors tend to make the computed amount of required storage smaller than it should be. Therefore, the storage-required figures presented in this report would have to be increased before being used in a final design. They may be used, however, for reconnaissance planning and for comparison between stations.

The bias in the use of the frequency-mass curve arises from assuming that a critical period of definite length can be assigned to each draft rate and recurrence interval. Under actual conditions, however, the length of the critical period for a given draft rate and recurrence interval varies about the average value for that draft rate and recurrence interval. In figure 10, for example, the critical period (length of time to maximum drawdown) for a draft of 0.50 mgd per sq mi at a recurrence interval of 10 years is 129 days. If the amount of storage required each year were computed from yearly mass curves, however, the length of the critical period for a 10-year recurrence interval would very likely differ somewhat from 129 days, and this difference would cause the amount of storage required to be greater than that for 129 days.

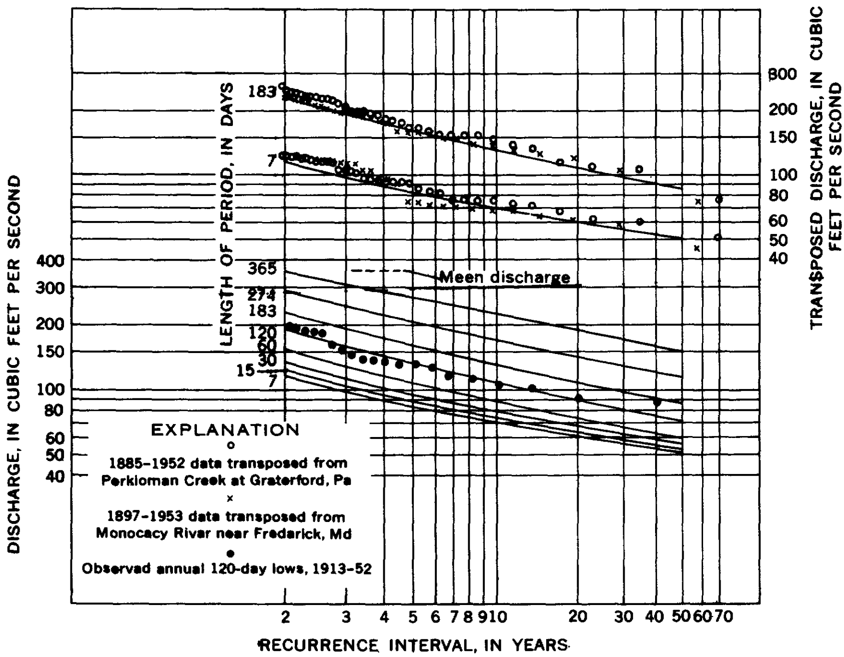

FIGURE 7.—Low-flow frequency curves for Brandywine Creek at Chadds Ford, Pa., 1913–52. Curves represent distribution of annual minimum flows for indicated lengths of period.

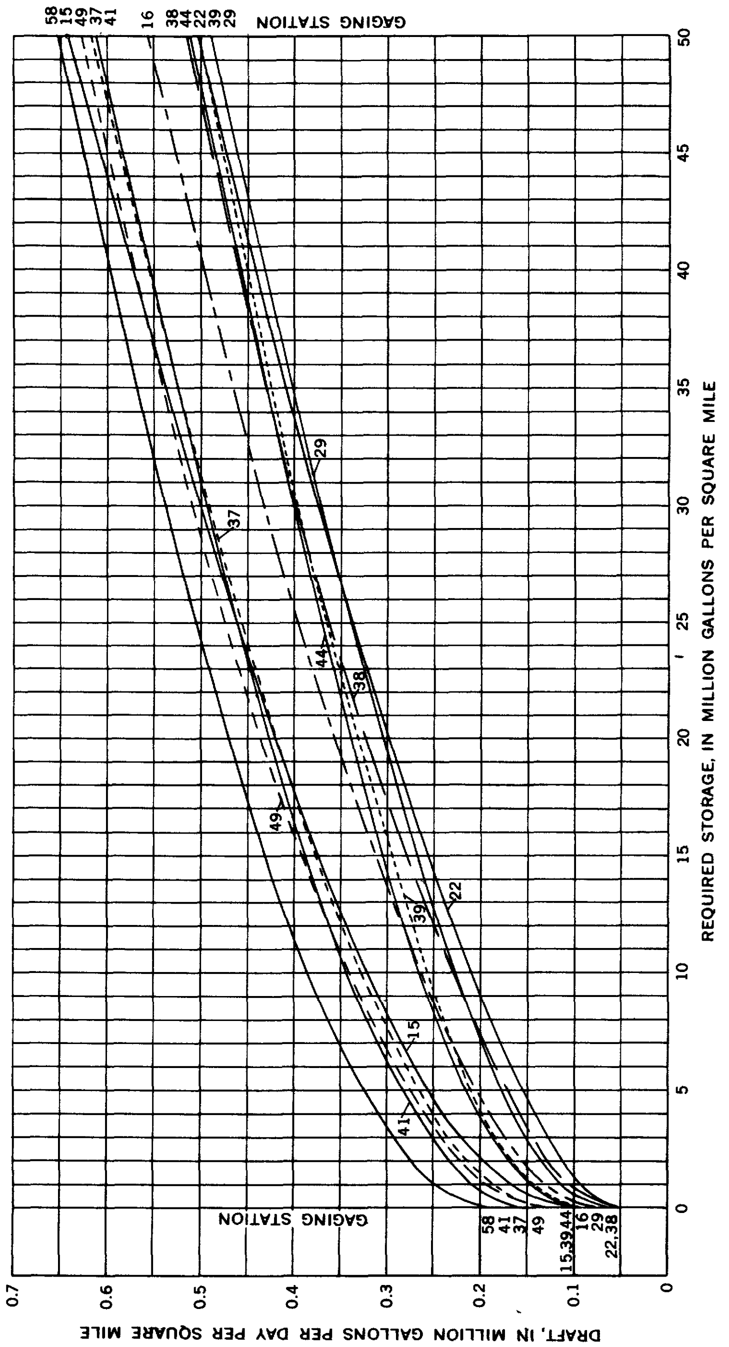
GAGING STATION
REQUIRED STORAGE, IN MILLION GALLONS PER SQUARE MILE
DRAFT, IN MILLION GALLONS PER DAY PER SQUARE MILE

FIGURE 8.—Draft-storage curves for a 10-year recurrence interval at 11 stream-gaging stations in the upper part of Delaware River basin as computed from low-flow frequency data. Storage is uncorrected for reservoir seepage, evaporation, and computation procedure, all of which tend to increase the amount of storage required. Low-flow frequency data used in computation of draft-storage curves are adjusted to the period April 1913–March 1953 on the basis of long-term streamflow records.

Map No.	*Stream-gaging station*	*Drainage area (sq mi)*	*Mean discharge 1921–50 (mgd per sq mi)*
15	Beaver Kill at Cooks Falls, N.Y	241	1.502
16	E. Br. Delaware River at Fishs Eddy, N.Y	783	1.362
22	W. Br. Delaware River at Hale Eddy, N.Y	593	1.155
29	Lackawaxen River at Hawley, Pa	290	1.085
37	Neversink River at Oakland Valley, N.Y	222	1.389
38	Bush Kill at Shoemakers, Pa	117	1.271
39	Flat Brook near Flatbrookville, N.J	65.1	1.052
41	McMichaels Creek at Stroudsburg, Pa	64.4	1.234
44	Paulins Kill at Blairstown, N.J	126	.964
49	Lehigh River at Tannery, Pa	322	1.307
58	Lehigh River at Bethlehem, Pa	1,279	1.132

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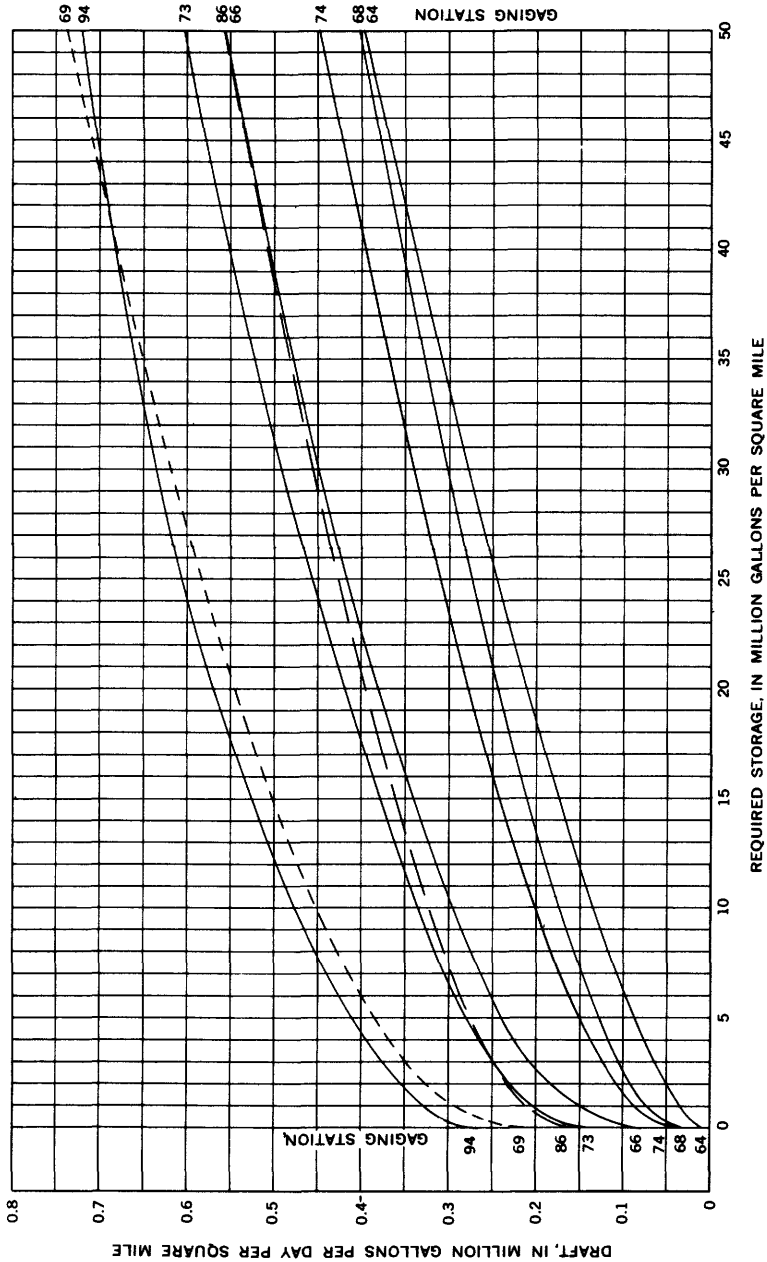
GAGING STATION
REQUIRED STORAGE, IN MILLION GALLONS PER SQUARE MILE
DRAFT, IN MILLION GALLONS PER DAY PER SQUARE MILE
94
69
86
73
66
74
68
64

FIGURE 9.—Draft-storage curves for a 10-year recurrence interval at eight stream-gaging stations in the lower part of Delaware River basin as computed from low-flow frequency data. Storage is uncorrected for reservoir seepage, evaporation, and computation procedure, all of which tend to increase the amount of storage required. Low-flow frequency data used in computation of draft-storage curves are adjusted to the period April 1913–March 1953 on the basis of long-term streamflow records.

Map No.	*Stream-gaging station*	*Drainage area (sq mi)*	*Mean discharge 1921–50 (mgd per sq mi)*
64	Tohickon Creek near Pipersville, Pa	97.4	0.889
66	Assunpink Creek at Trenton, N.J	89.4	.839
68	Neshaminy Creek near Langhorne, Pa	210	.794
69	N. Br. Rancocas Creek at Pemberton, N.J	111	.937
73	Schuylkill River at Pottstown, Pa	1,147	1.054
74	Perkiomen Creek at Graterford, Pa	279	.839
86	Brandywine Creek at Chadds Ford, Pa	287	.833
94	Maurice River at Norma, N.J	113	.909

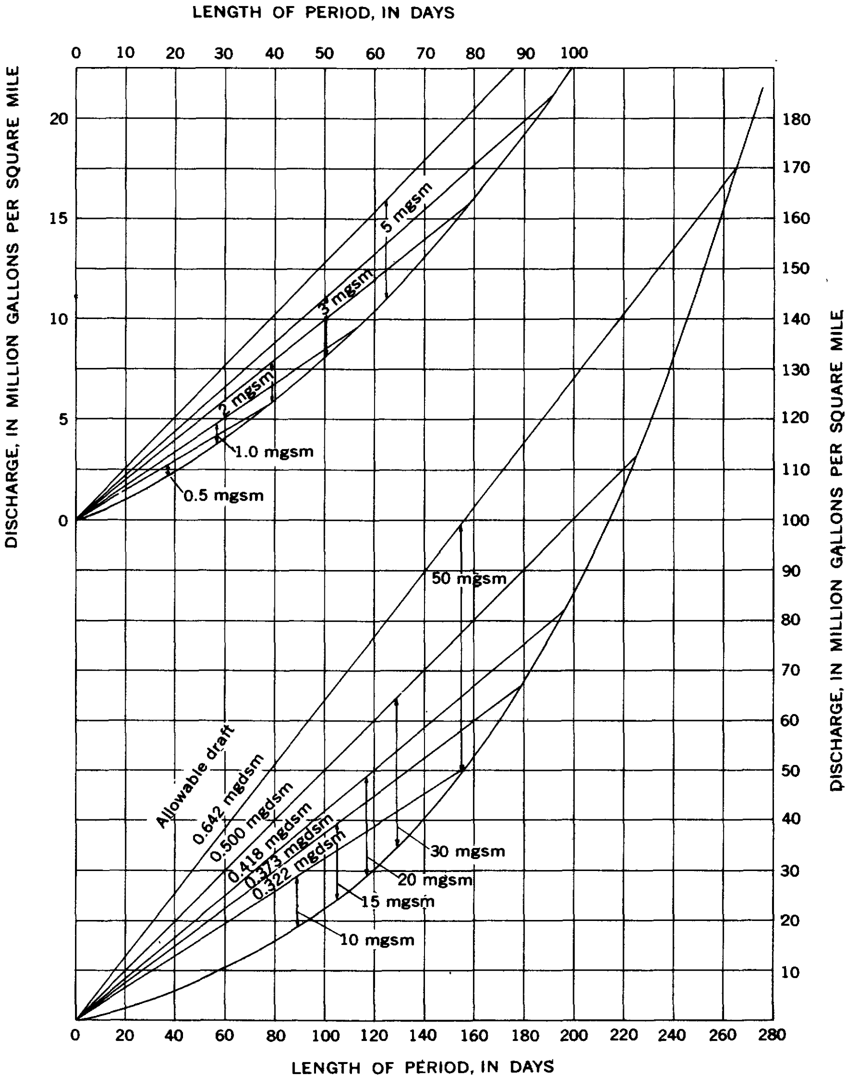

FIGURE 10.—Frequency-mass curve and draft-storage lines for a 10-year recurrence interval, Beaver Kill at Cooks Falls, N.Y. Curve represents volume of discharge for indicated length of period. Draft rates are determined by the slope of the draft line, and corresponding storage is determined by the maximum vertical distance to the curve. For example, for a 10-year recurrence interval a storage capacity of 30 million gallons per square mile allows a draft of 0.50 mgd per sq mi.

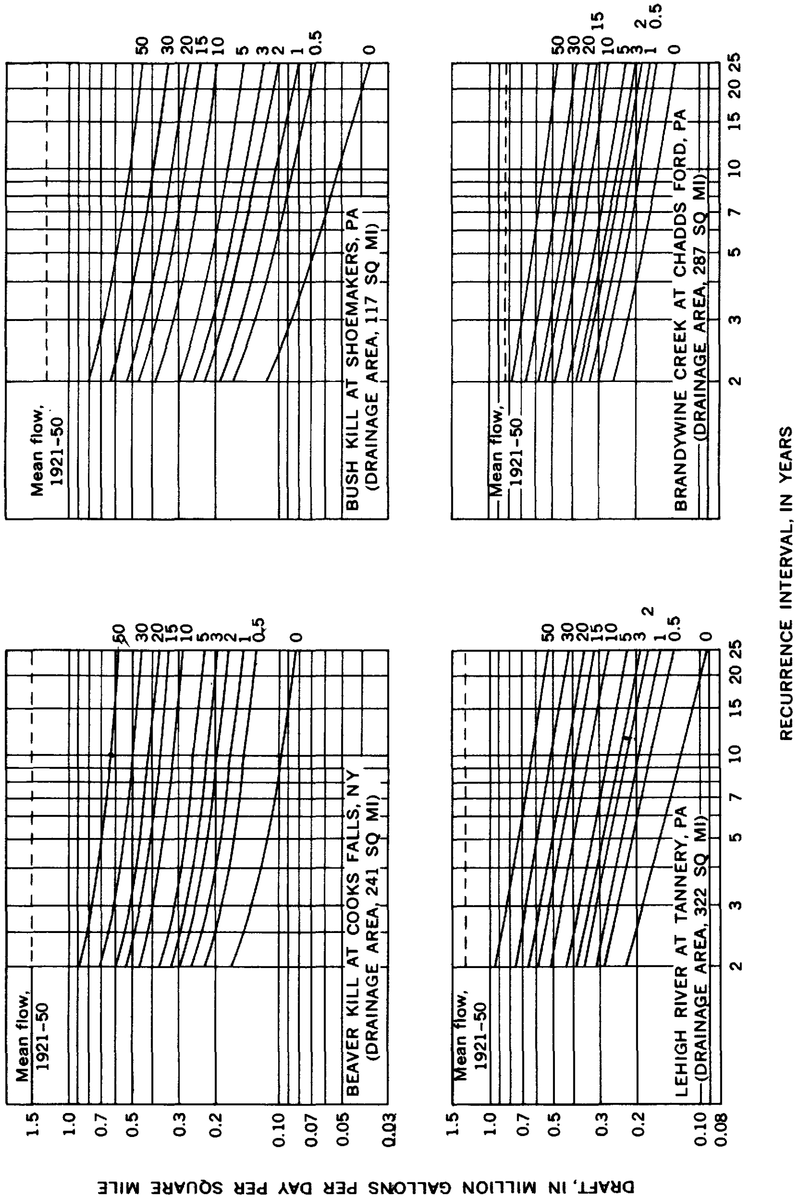

FIGURE 11.—Storage-required frequency curves for four stream-gaging stations in Delaware River basin. Parameters indicate the amount of storage, in million gallons per square mile. Storage is uncorrected for reservoir seepage, evaporation, and computation procedure, all of which tend to increase the amount of storage required. Low-flow frequency data used in computation of draft-storage curves are adjusted to the period April 1913–March 1953 on the basis or long-term streamflow records.

AREAL DRAFT-STORAGE RELATIONSHIPS

The amount of storage required to provide selected rates of allowable draft can be estimated from the median annual 7-day low flow and the size of the drainage area by use of curves such as those shown in figure 12. Each of the curves in the lower part of figure 12 is defined by the data for 19 stations, illustrated by the circles for a storage of 20 million gallons per square mile. The scatter of the circles, all but two of which are within 10 percent of the curve, is typical of the scatter of the points that define the other curves in the lower part of the figure. Values of median annual low flow used to define these curves were obtained from table 6, and values of storage and allowable draft were obtained from table 7. The scatter of the points used to define these curves is due largely to true differences between stations, in which case the storage figures shown in table 7 are more reliable than values obtained from the curves.

The curves in the upper left-hand part of figure 12 are based on the curves in the lower left-hand part; either family of curves gives the same answer. Similar families of curves for a recurrence interval of 25 years are shown on the right side of figure 12. The storage required shown by the curves in figure 12 is subject to the same bias and assumptions as the storage shown in figures 8 and 9 as well as to the inaccuracy shown by the scatter of the points on the left side of figure 12. The curves for zero storage are based on minimum 7-day flows at

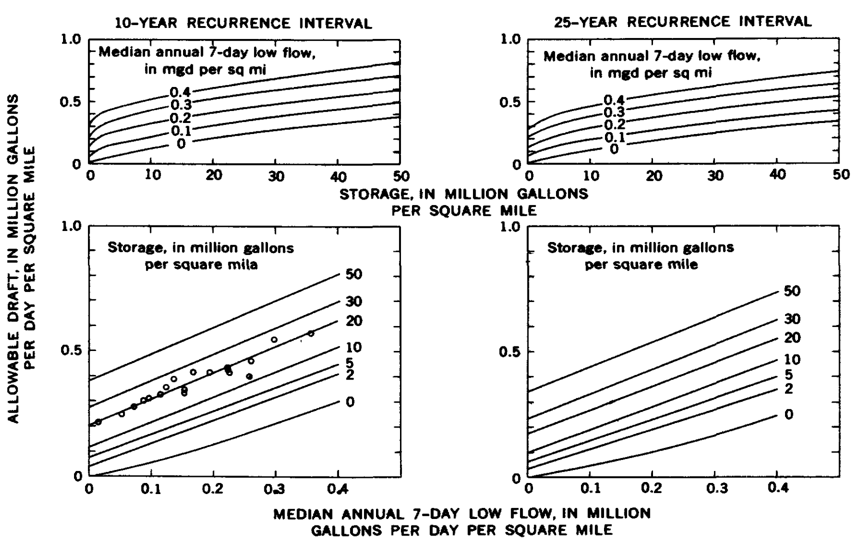

FIGURE 12.—Areal draft-storage relationships for 10- and 25-year recurrence intervals as a function of median annual low flow, Delaware River basin. Circles are computed values from table 7 for a storage of 20 million gallons per square mile.

the 10- and 25-year recurrence intervals and thus neglect the small amount of storage that would be required to regulate the flow within the minimum 7 days. The curves in figure 12 should not be used for streams outside the Delaware River basin without verification of their applicability.

For most stream-gaging stations in the Delaware River basin, the amount of storage required can be estimated by using the median annual 7-day low flow shown in table 6 and in figure 13 as an index to enter the curves in figure 12. For example, the left side of figure 12 shows that a stream with a median annual low flow of 0.10 mgd per sq mi would require storage of 50 million gallons per square mile at the 10-year recurrence interval to give an allowable draft of 0.5 mgd per sq mi, whereas a stream with a median annual low flow of 0.4 mgd per sq mi would require less than 10 mgd per sq mi to give the same draft rate per square mile. As the curves in figure 12 are not defined above 0.4 mgd per sq mi, the storage required for the three sites with the highest indices cannot be estimated in this way.

Estimating the amount of storage required for ungaged sites in the Delaware River basin requires that an estimate be made of the median annual low flow, but the variation in the values shown on figure 13 points out the danger of making such estimates without some observed basic data at the site. The median annual low flows for the 95 stations range from 0.02 to 0.65 mgd per sq mi and vary widely between adjacent streams in all parts of the basin despite a general tendency to increase from north to south. A few discharge measurements made when the flow of a stream is not affected by runoff from current rainfall would help identify the low-flow characteristics of the stream and thus go far toward improving the estimate of median annual low flow.

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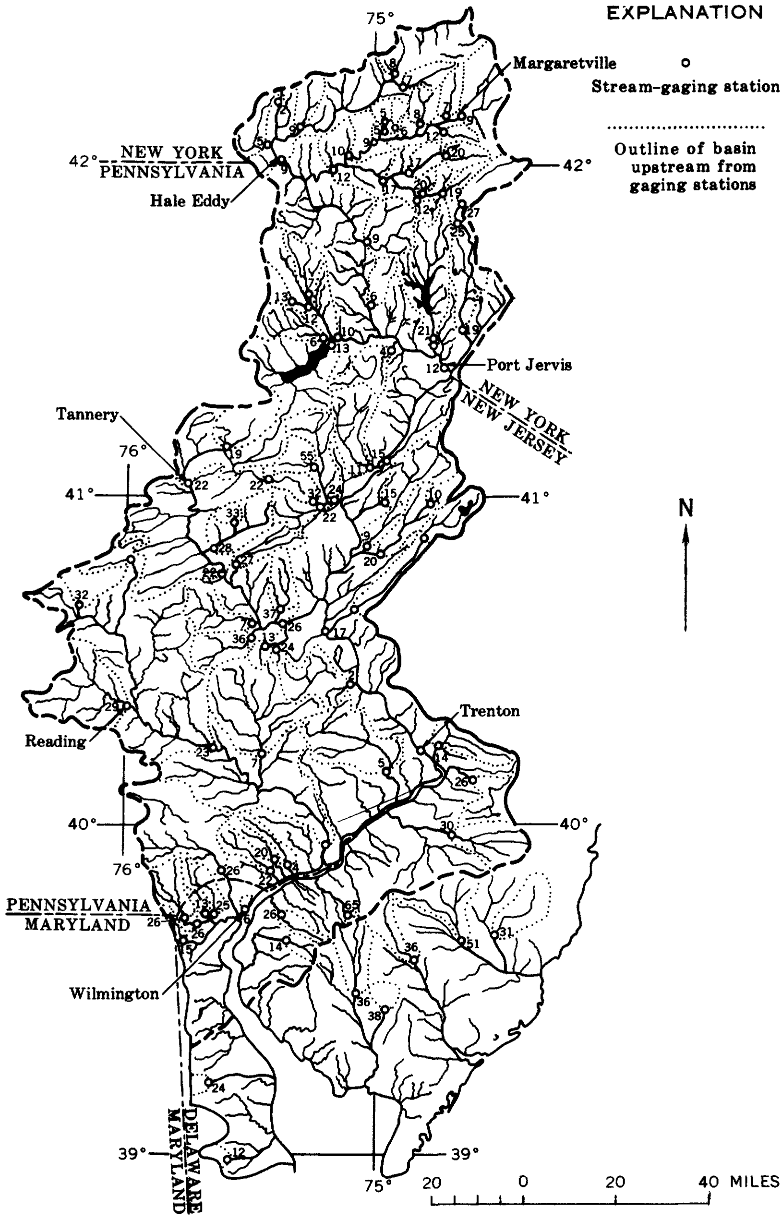

FIGURE 13.—Map of median annual low flow for Delaware River basin showing minimum 7-day discharge, in hundredths of a million gallons per day per square mile, at the 2-year recurrence interval for unregulated stream-gaging stations.

Table 3.--Duration of daily flow per square mile at stream-gaging stations in Delaware River basin

[Data are adjusted to period October 1, 1913, to September 30, 1953, on basis of long-term streamflow records]

Number on fig. 1	Stream-gaging station	Drainage area (square miles)	Flow, in million gallons per day per square mile, which was equaled or exceeded for indicated percent of time												
			0.5	2	10	30	50	70	80	90	95	98	99	99.5	99.9
16	East Branch Delaware River at Fishs Eddy, N. Y.	783	12.464	7.181	3.178	1.420	0.797	0.437	0.307	0.192	0.141	0.107	0.0924	0.0825	0.0677
22	West Branch Delaware River at Hale Eddy, N. Y.	593	10.463	5.995	2.670	1.199	.643	.339	.229	.138	.0992	.0730	.0616	.0540	.0425
29	Lackawaxen River at Hawley, Pa............	290	10.475	5.795	2.452	1.047	.579	.321	.223	.143	.109	.0847	.0740	.0653	.0508
30	Wallenpaupack Creek at Wilsonville, Pa.....	228	9.326	5.584	2.608	1.239	.726	.422	.300	.191	.134	.0927	.0723	.0573	.0363
34	Delaware River at Port Jervis, N. Y.......	3,076	10.548	6.093	2.689	1.217	.698	.401	.288	.180	.132	.102	.0893	.0798	.0628
37	Neversink River at Oakland Valley, N. Y....	222	11.529	6.405	2.999	1.432	.862	.518	.381	.265	.211	.169	.151	.137	.111
38	Bush Kill at Shoemakers, Pa...............	117	8.286	5.469	2.928	1.591	.939	.475	.307	.174	.119	.0856	.0691	.0558	.0370
44	Paulins Kill at Blairstown, N. J..........	126	5.950	3.909	2.129	1.164	.677	.379	.277	.195	.160	.131	.114	.102	.0790
49	Lehigh River at Tannery, Pa...............	322	8.731	5.480	2.750	1.389	.869	.542	.407	.275	.205	.155	.130	.110	.0793
58	Lehigh River at Bethlehem, Pa.............	1,279	7.580	4.548	2.426	1.314	.859	.556	.437	.328	.270	.226	.205	.188	.158
64	Tohickon Creek near Pipersville, Pa.......	97.4	15.063	7.366	2.090	.601	.250	.105	.0597	.0265	.0134	.00650	.00392	.00246	.000942
68	Neshaminy Creek near Langhorne, Pa.........	210	13.388	5.725	1.760	.677	.354	.186	.125	.0720	.0523	.0400	.0335	.0286	.0204
69	North Branch Rancocas Creek at Pemberton, N. J.	111	4.076	2.888	1.770	1.118	.815	.594	.489	.378	.314	.262	.233	.211	.172
73	Schuylkill River at Pottstown, Pa.........	1,147	7.100	4.226	2.169	1.138	.744	.479	.366	.265	.213	.171	.148	.130	.0992
74	Perkiomen Creek at Greaterford, Pa........	279	12.394	6.371	1.900	.723	.398	.299	.153	.0996	.0741	.0533	.0436	.0361	.0248
86	Brandywine Creek at Chadds Ford, Pa.......	287	6.756	3.648	1.565	.890	.624	.437	.356	.275	.225	.188	.168	.153	.125
94	Maurice River at Norma, N. J..............	113	3.174	2.374	1.642	1.161	.875	.646	.538	.419	.352	.293	.260	.235	.189

Table 4.--Duration of daily flow at stream-gaging stations in Delaware River basin

[Data are adjusted to period October 1, 1913, to September 30, 1953, on basis of long-term streamflow records]

Number on fig. 1	Stream-gaging station	Drainage area (square miles)	Flow, in cubic feet per second, which was equaled or exceeded for indicated percent of time												
			0.5	2	10	30	50	70	80	90	95	98	99	99.5	99.9
16	East Branch Delaware River at Fishs Eddy, N. Y. (natural flow).	783	15,100	8,700	3,850	1,720	965	530	372	232	171	130	112	100	82.0
22	West Branch Delaware River at Hale Eddy, N. Y. (natural flow).	593	9,600	5,500	2,450	1,100	590	311	210	127	91.0	67.0	56.5	49.5	39.0
29	Lackawaxen River at Hawley, Pa. (natural flow).	290	4,700	2,600	1,100	470	260	144	100	64.0	49.0	38.0	33.2	29.3	22.8
30	Wallenpaupack Creek at Wilsonville, Pa. (natural flow).	228	3,290	1,970	920	437	256	149	106	67.5	47.3	32.7	25.5	20.2	12.8
30	Wallenpaupack Creek at Wilsonville, Pa. (as regulated 1927-52).	228	1,500	1,180	805	498	288	115	49.8	0	0	0	0	0	0
33	Mongaup River near Mongaup, N. Y. (as regulated 1940-52).	202	1,420	988	628	409	300	198	142	82.8	52.2	30.9	24.1	20.3	14.8
34	Delaware River at Port Jervis, N. Y. (natural flow).	3,076	50,200	29,000	12,800	5,790	3,320	1,910	1,370	858	628	485	425	380	299
34	Delaware River at Port Jervis, N. Y. (as regulated 1931-52).	3,076	40,400	24,900	12,100	6,000	3,680	2,280	1,750	1,250	965	722	595	497	345
37	Neversink River at Oakland Valley, N. Y. (natural flow).	222	3,960	2,200	1,030	492	296	178	131	91.0	72.5	58.0	51.9	47.0	38.2
38	Bush Kill at Shoemakers, Pa. (natural flow).	117	1,500	990	530	288	170	86.0	55.5	31.5	21.5	15.5	12.5	10.1	6.7
41	McMichaels Creek at Stroudsburg, Pa. (natural flow).	64.4	888	540	258	128	77.0	48.2	37.5	27.8	22.7	18.7	16.4	14.8	11.7
44	Paulins Kill at Blairstown, N. J. (natural flow).	126	1,160	762	415	227	132	73.8	54.0	38.1	31.1	25.6	22.3	19.9	15.4
49	Lehigh River at Tannery, Pa. (natural flow).	322	4,350	2,730	1,370	692	433	270	203	137	102	77.2	64.6	55.0	39.5
58	Lehigh River at Bethlehem, Pa. (natural flow).	1,279	15,000	9,000	4,800	2,600	1,700	1,100	865	650	535	447	406	372	312
62	Musconetcong River near Bloomsbury, N. J. (as regulated 1922-52).	143	968	705	445	275	189	128	104	84.0	73.0	64.0	59.2	55.0	47.2

64	Tohickon Creek near Pipersville, Pa. (natural flow).	97.4	2,270	1,110	315	90.5	37.7	15.8	9.00	4.00	2.02	.98	.59	.37	.142
65	Delaware River at Trenton, N. J. (as regulated 1936-52).	6,780	69,800	47,500	26,000	13,400	8,500	5,380	4,140	3,030	2,440	2,000	1,800	1,630	1,340
66	Assunpink Creek at Trenton, N. J. (natural flow).	89.4	870	532	258	128	78.2	49.5	38.0	26.3	19.5	13.7	10.4	8.20	5.00
68	Neshaminy Creek near Langhorne, Pa. (natural flow).	210	4,350	1,860	572	220	115	60.5	40.5	23.4	17.0	13.0	10.9	9.30	6.63
69	North Branch Rancocas Creek at Pemberton, N. J. (natural flow).	111	700	496	304	192	140	102	84.0	65.0	53.9	45.0	40.1	36.2	29.5
73	Schuylkill River at Pottstown, Pa. (natural flow).	1,147	12,600	7,500	3,850	2,020	1,320	850	650	470	378	304	263	230	176
74	Perkiomen Creek at Greaterford, Pa. (natural flow).	279	5,350	2,750	820	312	172	95.0	66.0	43.0	32.0	23.0	18.8	15.6	10.7
75	Schuylkill River at Philadelphia, (as regulated 1932-52).	1,893	22,800	12,800	5,580	2,780	1,550	862	598	360	238	148	91.0	55.8	20.0
86	Brandywine Creek at Chadds Ford, Pa. (natural flow).	287	3,000	1,620	695	395	277	194	158	122	100	83.5	74.5	68.0	55.5
94	Maurice River at Norma, N. J. (natural flow).	113	555	415	287	203	153	113	94.0	73.3	61.5	51.2	45.5	41.0	33.0

Table 5.--Magnitude and frequency of annual low flow at stream-gaging stations in Delaware River basin

[Annual minimum flow for indicated recurrence interval and indicated period of consecutive days are adjusted to period April 1913 to March 1953 on basis of long-term streamflow records]

Number on fig. 1	Stream-gaging station	Drainage area (square miles)	Period (consecutive days)	Lowest average flow, in cubic feet per second, for indicated recurrence interval, in years						Lowest average flow, in million gallons per day per square mile, for indicated recurrence interval, in years					
				1.1	2	5	10	25	50	1.1	2	5	10	25	50
15	Beaver Kill at Cooks Falls, N. Y.	241	7	134	62.5	41.5	36.2	30.6	27.0	0.359	0.168	0.111	0.0971	0.0821	0.0724
			15	155	73.5	48.7	42.5	36.0	32.0	.416	.197	.131	.114	.0965	.0858
			30	188	87.0	57.5	50.0	42.0	37.0	.504	.233	.154	.134	.113	.0992
			60	255	108	72.0	64.0	54.5	49.0	.684	.290	.193	.172	.146	.131
			120	400	178	109	93.5	77.0	67.0	1.073	.477	.292	.251	.206	.180
			183	530	264	173	143	116	100	1.421	.708	.464	.383	.311	.268
			274	655	410	299	250	201	171	1.757	1.100	.802	.670	.539	.459
			365	720	540	422	364	308	272	1.931	1.448	1.132	.976	.826	.729
16	East Branch Delaware River at Fishs Eddy, N. Y.	783	7	325	150	101	90	77	70	.268	.124	.0834	.0743	.0636	.0578
			15	380	172	116	102	88	78	.314	.142	.0958	.0842	.0726	.0644
			30	465	207	134	119	101	90	.384	.171	.111	.0982	.0834	.0743
			60	640	268	173	151	128	113	.528	.221	.143	.125	.106	.0933
			120	1,080	450	270	230	187	160	.891	.371	.223	.190	.154	.132
			183	1,440	700	428	350	285	245	1.189	.578	.353	.289	.235	.202
			274	1,800	1,130	780	650	530	450	1.486	.933	.644	.537	.437	.371
			365	2,090	1,590	1,240	1,040	850	730	1.725	1.312	1.024	.858	.702	.603
22	West Branch Delaware River at Hale Eddy, N. Y.	593	7	181	82.0	51.0	44.0	37.5	33.2	.197	.0894	.0556	.0480	.0409	.0362
			15	208	92.0	56.0	48.5	41.0	37.0	.227	.100	.0610	.0529	.0447	.0403
			30	264	111	66.0	56.0	47.5	42.0	.288	.121	.0719	.0610	.0518	.0458
			60	390	152	86.5	72.0	60.0	53.0	.425	.166	.0943	.0785	.0654	.0578
			120	632	275	152	120	96.0	81.0	.689	.300	.166	.131	.105	.0883
			183	845	445	270	213	160	130	.921	.485	.294	.232	.174	.142
			274	1,120	730	505	405	314	260	1.221	.796	.550	.441	.342	.283
			365	1,330	985	750	630	501	425	1.450	1.074	.817	.687	.546	.463
29	Lackawaxen River at Hawley, Pa.	290	7	99.0	43.5	31.5	28.0	24.2	22.0	.221	.0969	.0702	.0624	.0539	.0490
			15	118	49.5	35.5	32.0	27.5	25.0	.263	.110	.0791	.0713	.0613	.0557
			30	146	59.5	41.5	37.0	32.0	29.0	.325	.133	.0925	.0825	.0713	.0646
			60	202	77.0	51.0	45.5	39.5	35.5	.450	.172	.114	.101	.0880	.0791
			120	322	128	74.5	64.0	55.0	50.0	.718	.285	.166	.143	.123	.111
			183	424	198	118	96.0	82.0	73.0	.945	.441	.263	.214	.183	.163
			274	525	319	220	182	144	122	1.170	.711	.490	.406	.321	.272
			365	618	445	352	302	250	216	1.377	.992	.784	.673	.557	.481

30	Wallenpaupack Creek at Wilsonville, Pa. (natural flow; correlation period 1910-24).	228	7	100	47.4	35.2	30.6	25.7	22.4	.283	.134	.0998	.0867	.0729	.0635
			15	117	52.3	39.0	33.8	28.0	24.5	.332	.148	.111	.0958	.0794	.0695
			30	142	60.0	43.9	37.9	31.3	27.2	.403	.170	.124	.107	.0887	.0771
			60	209	82.1	51.9	44.5	37.0	32.1	.592	.233	.147	.126	.105	.0910
			120	310	134	77.0	63.2	52.5	45.5	.879	.380	.218	.179	.149	.129
			183	387	188	118	96.0	74.4	61.9	1.097	.533	.334	.272	.211	.175
30	Wallenpaupack Creek at Wilsonville, Pa. (regulated; results represent observed data 1927-52 without correlation).	228	7	106	35.8	5.38	0	0	0	.....	.....	.....	.....	.....	.....
			15	160	84.0	16.5	3.97	0	0	.....	.....	.....	.....	.....	.....
			30	.212	111	42.2	22.4	0	0	.....	.....	.....	.....	.....	.....
			60	.258	172	84.8	43.8	0	0	.....	.....	.....	.....	.....	.....
			120	.328	241	146	93.0	0	0	.....	.....	.....	.....	.....	.....
			183	.402	280	164	115	0	0	.....	.....	.....	.....	.....	.....
33	Mongaup River near Mongaup, N. Y. (regulated; results based on pattern of regulation during correlation period 1940-52).	202	7	190	105	66.0	52.0	41.6	35.8	.....	.....	.....	.....	.....	.....
			15	210	120	76.9	61.0	48.9	41.1	.....	.....	.....	.....	.....	.....
			30	239	138	90.1	73.5	58.6	50.0	.....	.....	.....	.....	.....	.....
			60	279	160	105	84.2	67.8	57.5	.....	.....	.....	.....	.....	.....
			120	318	181	120	99.7	79.4	66.9	.....	.....	.....	.....	.....	.....
			183	370	229	162	136	109	91.5	.....	.....	.....	.....	.....	.....
34	Delaware River at Port Jervis, N. Y. (natural flow; correlation period 1914-25).	3,076	7	1,300	551	377	331	287	257	.273	.116	.0792	.0695	.0603	.0540
			15	1,570	640	422	377	324	290	.330	.134	.0887	.0792	.0681	.0609
			30	1,930	767	503	449	386	343	.406	.161	.106	.0943	.0811	.0721
			60	2,770	1,060	650	565	480	427	.582	.223	.137	.119	.101	.0897
			120	3,940	1,590	959	821	681	600	.828	.334	.202	.173	.143	.126
			183	5,210	2,500	1,500	1,210	1,010	883	1.095	.525	.315	.254	.212	.186
34	Delaware River at Port Jervis, N. Y. (regulated; results based on pattern of regulation during correlation period 1931-52).	3,076	7	1,740	973	713	620	520	455	.....	.....	.....	.....	.....	.....
			15	1,990	1,060	765	662	558	489	.....	.....	.....	.....	.....	.....
			30	2,320	1,210	900	780	663	587	.....	.....	.....	.....	.....	.....
			60	2,890	1,420	1,050	920	780	693	.....	.....	.....	.....	.....	.....
			120	4,060	2,000	1,390	1,200	1,020	900	.....	.....	.....	.....	.....	.....
			183	4,900	2,610	1,790	1,550	1,310	1,170	.....	.....	.....	.....	.....	.....
37	Neversink River at Oakland Valley, N. Y. (natural flow; correlation period 1929-52).	222	7	128	66.0	49.2	44.2	38.9	35.0	.373	.192	.143	.129	.113	.102
			15	139	72.0	54.8	48.5	42.0	37.8	.405	.210	.160	.141	.122	.110
			30	178	85.0	60.2	54.0	47.0	42.0	.518	.247	.175	.157	.137	.122
			60	224	103	72.0	64.0	55.8	50.0	.652	.300	.210	.186	.162	.146
			120	351	157	100	87.0	73.8	65.0	1.022	.457	.291	.253	.215	.189
			183	442	219	142	122	103	90.0	1.287	.638	.413	.355	.300	.262
			274	562	350	250	208	164	138	1.636	1.019	.728	.606	.477	.402

Table 5.--Magnitude and frequency of annual low flow at stream-gaging stations in Delaware River basin--Continued

Number on fig. 1	Stream-gaging station	Drainage area (square miles)	Period (consecutive days)	Lowest average flow, in cubic feet per second, for indicated recurrence interval, in years						Lowest average flow, in million gallons per day per square mile, for indicated recurrence interval, in years					
				1.1	2	5	10	25	50	1.1	2	5	10	25	50
38	Bush Kill at Shoemakers, Pa.	117	7	61.5	20.7	12.2	9.30	6.65	5.20	0.340	0.114	0.0674	0.0514	0.0367	0.0287
			15	71.0	23.8	13.8	10.6	7.60	5.95	.392	.131	.0762	.0586	.0420	.0329
			30	88.0	28.5	16.4	12.7	9.05	7.05	.486	.157	.0906	.0702	.0500	.0389
			60	122	40.5	22.0	16.9	12.1	9.40	.674	.224	.122	.0934	.0668	.0519
			120	183	70.0	37.4	28.2	20.3	15.8	1.011	.387	.207	.156	.112	.0873
			183	232	103	57.5	44.0	31.5	24.7	1.282	.569	.318	.243	.174	.136
			274	290	175	117	90.0	64.5	50.5	1.602	.967	.646	.497	.356	.279
			365	331	234	178	150	121	103	1.828	1.293	.983	.829	.668	.569
39	Flat Brook near Flatbrookville, N. J.	65.1	7	30.0	15.3	11.3	9.80	8.12	7.02	.298	.152	.112	.0973	.0806	.0697
			15	33.8	16.5	12.1	10.5	8.70	7.60	.336	.164	.120	.104	.0864	.0755
			30	41.0	18.3	13.3	11.5	9.60	8.32	.407	.182	.132	.114	.0953	.0826
			60	57.0	22.3	15.8	13.6	11.3	9.80	.566	.221	.157	.135	.112	.0973
			120	85.2	33.4	21.2	18.0	15.0	13.1	.846	.332	.210	.179	.149	.130
			183	108	48.0	28.5	23.4	19.3	16.8	1.072	.477	.283	.232	.192	.167
			274	135	81.5	54.5	42.0	31.1	25.8	1.340	.809	.541	.417	.309	.256
41	McMichaels Creek at Stroudsburg, Pa.	64.4	7	42.0	22.2	17.1	15.2	13.0	11.7	.422	.223	.172	.153	.130	.117
			15	47.2	24.7	18.4	16.3	14.0	12.4	.474	.248	.185	.164	.140	.124
			30	52.0	26.5	20.0	17.7	15.0	13.4	.522	.266	.201	.178	.151	.134
			60	64.2	32.0	23.4	20.3	17.0	15.0	.644	.321	.235	.204	.171	.151
			120	84.6	41.2	30.5	26.6	22.3	19.5	.849	.413	.306	.267	.224	.196
			183	105	55.7	39.5	34.0	28.2	24.8	1.054	.559	.396	.341	.283	.249
			274	140	88.0	62.6	52.7	42.8	36.4	1.405	.883	.628	.529	.430	.365
44	Paulins Kill at Blairstown, N. J.	126	7	58.0	29.8	22.2	19.0	15.7	13.6	.298	.153	.114	.0975	.0805	.0698
			15	64.4	32.6	23.8	20.4	16.9	14.7	.330	.167	.122	.105	.0867	.0754
			30	74.0	36.0	26.4	22.8	18.9	16.2	.380	.185	.135	.117	.0969	.0831
			60	98.0	44.4	31.0	26.8	22.1	19.2	.503	.228	.159	.137	.113	.0985
			120	143	63.0	42.1	36.0	29.8	25.5	.734	.323	.216	.185	.153	.131
			183	185	85.5	54.8	46.4	38.0	33.0	.949	.439	.281	.238	.195	.169
			274	229	138	93.0	76.0	60.0	50.1	1.175	.708	.477	.390	.308	.257
46	Pequest River at Pequest, N. J.	108	7	60.5	33.4	25.0	21.2	17.4	15.0	.362	.200	.150	.127	.104	.0898
			30	76.2	40.0	28.5	24.8	20.5	17.9	.456	.239	.171	.148	.123	.107

49	Lehigh River at Tannery, Pa.	322	7	198	111	78.0	62.0	46.0	37.0	.397	.223	.157	.124	.0923	.0743
			15	218	123	88.0	70.2	53.5	44.0	.438	.247	.177	.141	.107	.0883
			30	253	141	100	79.8	60.0	48.0	.508	.283	.201	.160	.120	.0963
			60	347	176	122	96.5	71.0	57.0	.696	.353	.245	.194	.143	.114
			120	482	260	173	134	96.0	75.8	.967	.522	.347	.269	.193	.152
			183	600	338	230	177	128	100	1.204	.678	.462	.355	.257	.201
			274	768	491	350	280	210	170	1.542	.986	.703	.562	.422	.341
52	Pohopoco Creek near Parryville, Pa. (regulated; results based on pattern of regulation during correlation period 1945-55).	109	7	68.5	37.2	25.2	20.4	15.5	12.6	.....	.....	.....	.....	.....	.....
			30	91.0	50.0	35.0	27.9	21.1	17.1	.....	.....	.....	.....	.....	.....
58	Lehigh River at Bethlehem, Pa.	1,279	7	790	515	420	370	315	280	.399	.260	.212	.187	.159	.141
			15	885	555	455	400	345	305	.447	.280	.230	.202	.174	.154
			30	1,060	615	485	426	365	325	.536	.311	.245	.215	.184	.164
			60	1,330	715	550	485	415	365	.672	.361	.278	.245	.210	.184
			120	1,760	960	700	600	500	440	.889	.485	.354	.303	.253	.222
			183	2,170	1,240	890	755	625	548	1.097	.627	.450	.382	.316	.277
			274	2,650	1,640	1,210	1,040	850	740	1.339	.829	.611	.526	.430	.374
			365	3,080	2,100	1,660	1,400	1,170	1,000	1.556	1.061	.839	.707	.591	.505
62	Musconetcong River near Bloomsbury, N. J. (regulated; results based on pattern of regulation during correlation period 1922-52).	143	7	103	70.0	58.8	52.8	46.0	41.4	.....	.....	.....	.....	.....	.....
			15	116	73.8	62.0	55.9	49.0	44.2	.....	.....	.....	.....	.....	.....
			30	129	79.9	65.7	59.3	52.2	47.8	.....	.....	.....	.....	.....	.....
			60	155	89.9	72.1	65.3	57.8	52.1	.....	.....	.....	.....	.....	.....
			120	198	116	88.2	79.9	69.8	62.5	.....	.....	.....	.....	.....	.....
			183	240	139	105	94.2	82.6	74.8	.....	.....	.....	.....	.....	.....
64	Tohickon Creek near Pipersville, Pa.	97.4	7	8.20	2.42	1.36	1.05	.760	.600	.0544	.0161	.00902	.00697	.00504	.00398
			15	10.8	2.96	1.62	1.26	.918	.720	.0717	.0196	.0107	.00836	.00609	.00478
			30	16.4	4.35	2.28	1.72	1.23	.958	.109	.0289	.0151	.0114	.00816	.00636
			60	32.7	8.20	4.00	2.95	2.00	1.50	.217	.0544	.0265	.0196	.0133	.00995
			120	70.0	22.8	11.2	7.78	5.00	3.60	.464	.151	.0743	.0516	.0332	.0239
			183	111	46.8	26.5	18.8	12.0	8.65	.737	.311	.176	.125	.0796	.0574
			274	162	88.0	57.0	42.9	29.5	22.3	1.075	.584	.378	.285	.196	.148
65	Delaware River at Trenton, N. J. (regulated; results based on pattern of regulation during correlation period 1936-52).	6,780	7	4,080	2,320	1,820	1,600	1,350	1,190	.....	.....	.....	.....	.....	.....
			15	4,660	2,520	1,970	1,710	1,450	1,290	.....	.....	.....	.....	.....	.....
			30	5,450	2,910	2,240	1,970	1,650	1,470	.....	.....	.....	.....	.....	.....
			60	6,800	3,500	2,600	2,280	1,920	1,700	.....	.....	.....	.....	.....	.....
			120	9,450	4,750	3,340	2,930	2,480	2,190	.....	.....	.....	.....	.....	.....
			183	11,300	6,000	4,270	3,710	3,160	2,790	.....	.....	.....	.....	.....	.....

Table 5.--Magnitude and frequency of annual low flow at stream-gaging stations in Delaware River basin--Continued

Number on fig. 1	Stream-gaging station	Drainage area (square miles)	Period (consecutive days)	Lowest average flow, in cubic feet per second, for indicated recurrence interval, in years						Lowest average flow, in million gallons per day per square mile, for indicated recurrence interval, in years					
				1.1	2	5	10	25	50	1.1	2	5	10	25	50
66	Assunpink Creek at Trenton, N. J.	89.4	7	35.5	19.0	14.3	12.4	10.4	9.0	0.257	0.137	0.103	0.0896	0.0752	0.0651
			15	39.9	22.0	15.8	13.7	11.5	10.0	.288	.159	.114	.0990	.0831	.0723
			30	48.3	26.0	18.6	16.2	13.5	11.8	.349	.188	.134	.117	.0976	.0853
			60	68.0	36.9	25.5	22.0	18.2	15.9	.492	.267	.184	.159	.132	.115
			120	90.0	49.0	34.9	30.1	25.2	22.2	.651	.354	.252	.218	.182	.160
			183	112	64.0	47.1	39.7	32.0	27.1	.810	.463	.341	.287	.231	.196
			274	142	87.8	64.2	54.2	43.9	37.5	1.027	.635	.464	.392	.317	.271
68	Neshaminy Creek near Langhorne, Pa.	210	7	46.2	17.5	11.0	9.20	7.26	6.18	.142	.0539	.0339	.0283	.0223	.0190
			15	55.0	20.2	12.5	10.5	8.43	7.20	.169	.0622	.0385	.0323	.0259	.0222
			30	71.0	26.0	16.1	13.3	10.7	9.02	.219	.0800	.0496	.0409	.0329	.0278
			60	100	37.8	22.2	18.7	15.0	12.8	.308	.116	.0683	.0576	.0462	.0394
			120	150	56.0	35.2	29.0	22.6	18.8	.462	.172	.108	.0893	.0696	.0579
			183	207	90.0	56.2	44.6	35.0	29.0	.637	.277	.173	.137	.108	.0893
			274	310	158	102	78.5	56.4	44.1	.954	.486	.314	.242	.174	.136
69	North Branch Rancocas Creek at Pemberton, N. J.	111	7	73.0	51.0	41.0	(1/)	(1/)	(1/)	.425	.297	.239	.....	.....	.....
			15	80.0	56.0	45.0	39.8	35.0	31.9	.466	.326	.262	.232	.204	.186
			30	91.0	64.0	50.5	45.0	38.8	35.0	.530	.373	.294	.262	.226	.204
			60	109	74.4	59.0	51.5	44.0	39.4	.635	.433	.344	.300	.256	.229
			120	136	92.5	74.0	65.0	55.5	49.2	.792	.539	.431	.378	.323	.286
			183	160	114	90.8	80.0	67.0	59.0	.932	.664	.529	.466	.390	.344
			274	186	134	110	95.9	80.8	71.0	1.083	.780	.640	.558	.470	.413
73	Schuylkill River at Pottstown, Pa.	1,147	7	680	401	306	263	220	190	.383	.226	.172	.148	.124	.107
			15	750	430	321	278	230	202	.423	.242	.181	.157	.130	.114
			30	838	478	350	300	250	218	.472	.269	.197	.169	.141	.123
			60	1,050	578	412	349	278	238	.592	.326	.232	.197	.157	.134
			120	1,430	778	545	447	350	292	.806	.438	.307	.252	.197	.165
			183	1,770	1,030	740	595	450	370	.997	.580	.417	.335	.254	.208
			274	2,220	1,340	940	760	580	470	1.251	.755	.530	.428	.327	.265

74	Perkiomen Creek at Graterford, Pa.	279	7	62.5	30.7	20.0	16.0	12.4	10.5	.145	.0711	.0463	.0371	.0287	.0243
			15	74.0	36.3	23.7	18.8	14.7	12.0	.171	.0841	.0549	.0436	.0341	.0278
			30	96.0	47.2	30.0	23.3	17.9	14.7	.222	.109	.0695	.0540	.0415	.0341
			60	141	67.0	41.6	32.2	24.2	19.7	.327	.155	.0964	.0746	.0561	.0456
			120	228	108	66.0	51.0	37.2	29.4	.528	.250	.153	.118	.0862	.0681
			183	324	163	103	78.0	56.0	43.5	.751	.378	.239	.181	.130	.101
			274	450	252	168	130	94.0	74.0	1.042	.584	.389	.301	.218	.171
			365	590	366	262	210	159	129	1.367	.848	.607	.486	.368	.299
75	Schuylkill River at Philadelphia, Pa. (regulated; results based on pattern of regulation during correlation period 1932-52).	1,893	7	743	309	148	91.0	49.4	31.1	.....	.....	.....	.....	.....	.....
			15	830	349	170	105	58.0	37.1	.....	.....	.....	.....	.....	.....
			30	1,050	443	219	138	76.5	49.2	.....	.....	.....	.....	.....	.....
			60	1,330	572	290	184	104	68.1	.....	.....	.....	.....	.....	.....
			120	1,890	845	460	307	186	128	.....	.....	.....	.....	.....	.....
			183	2,470	1,170	670	468	295	210	.....	.....	.....	.....	.....	.....
86	Brandywine Creek at Chadds Ford, Pa.	287	7	189	115	83.0	70.0	58.0	50.5	.426	.259	.187	.158	.131	.114
			15	204	123	87.5	73.0	60.5	53.0	.459	.277	.197	.164	.136	.119
			30	222	134	95.0	79.0	64.5	56.0	.500	.302	.214	.178	.145	.126
			60	254	153	108	88.0	70.0	59.0	.572	.345	.243	.198	.158	.133
			120	306	190	132	107	85.0	71.0	.689	.428	.297	.241	.191	.160
			183	356	228	161	131	102	86.0	.802	.513	.363	.295	.230	.194
			274	425	284	207	171	133	122	.957	.640	.466	.385	.300	.252
			365	500	352	269	225	178	150	1.126	.793	.606	.507	.401	.338
93	Great Egg Harbor River at Folsom, N. J.	56.3	7	44.5	31.7	27.4	25.0	22.4	20.8	.511	.364	.315	.287	.257	.239
			30	53.8	37.2	31.2	28.6	25.7	23.8	.618	.427	.358	.328	.295	.273
94	Maurice River at Norma, N. J.	113	7	90.0	62.2	51.0	46.0	40.0	36.0	.515	.356	.292	.263	.229	.206
			15	97.0	66.5	54.0	48.3	42.0	38.0	.555	.380	.309	.276	.240	.217
			30	106	70.8	57.5	51.5	44.9	40.2	.606	.405	.329	.295	.257	.230
			60	120	80.0	64.2	56.5	48.3	42.8	.636	.458	.367	.323	.276	.245
			120	152	101	80.0	70.2	60.0	53.0	.869	.578	.458	.402	.343	.303
			183	172	117	94.0	82.2	69.8	60.8	.984	.669	.538	.470	.399	.348
			274	198	134	107	94.0	80.0	71.0	1.132	.766	.612	.538	.458	.406

1/ Minimum 7-day discharge less than 40 cfs affected by regulation.

Table 6.--Indices of low-flow frequency at stream-gaging stations in Delaware River basin

[Indices are annual minimum flows for indicated recurrence interval and indicated period of consecutive days adjusted to period from April 1913 to March 1953 on basis of long-term streamflow records]

Number on fig. 1	Stream-gaging station	Correlation period	Drainage area (square miles)	Lowest mean flow, in cubic feet per second, for indicated period of consecutive days and for indicated recurrence interval, in years				Lowest mean flow, in million gallons per day per square mile, for indicated period of consecutive days and for indicated recurrence interval, in years				Ratio of 7-day discharges	
				7-day		30-day		7-day		30-day		Observed 1/	Adjusted 2/
				2 yr	20 yr	2 yr	20 yr	2 yr	20 yr	2 yr	20 yr		
1	East Branch Delaware River at Margaretville, N. Y.	1937-54	163	23.0	10.6	34.2	15.3	0.0912	0.0420	0.136	0.0607	0.461	0.47
2	Platte Kill at Dunraven, N. Y........	1942-54	34.7	3.89	1.42	5.94	2.43	.0725	.0264	.111	.0453	.364	.39
3	Mill Brook at Arena, N. Y............	1937-54	25.0	4.60	1.83	6.35	3.23	.119	.0473	.164	.0835	.397	.39
4	Tremper Kill near Shavertown, N. Y...	1937-54	33.0	3.95	.990	5.62	2.15	.0774	.0194	.110	.0421	.251	.26
5	Terry Clove Kill near Pepacton, N. Y.	1937-54	14.1	1.16	.446	1.88	.680	.0532	.0204	.0862	.0312	.383	.43
6	Fall Clove Kill near Pepacton, N. Y..	1942	10.9	.960	.496	1.32	.680	.0569	.0296	.0783	.0403	.517	.57
7	Coles Clove Kill near Pepacton, N. Y.	1945-52	28.0	2.16	.940	3.35	1.36	.0499	.0217	.0773	.0314	.435	.49
8	East Branch Delaware River at Downsville, N. Y.	1941-53	373	53.3	26.3	76.5	36.0	.0924	.0456	.133	.0624	.494	.50
9	East Branch Delaware River at Harvard, N. Y.	1935-54	443	68.1	33.9	97.0	46.3	.0994	.0495	.142	.0675	.498	.50
10	Beaver Kill near Turnwood, N. Y......	1949-54	40.8	12.9	6.60	18.0	9.07	.204	.105	.285	.144	.515	.50
11	Beaver Kill at Craigie Clair, N. Y...	1937-54	82	21.2	10.8	29.5	14.8	.167	.0851	.233	.117	.510	.46
12	Willowemoc Creek at Debruce, N. Y....	1949-51	40.9	12.1	6.94	16.0	8.97	.191	.110	.253	.142	.576	.51
13	Willowemoc Creek near Livingston Manor, N. Y.	1938-54	63	19.2	11.1	25.1	14.4	.197	.114	.258	.148	.579	.51
14	Little Beaver Kill near Livingston Manor, N. Y.	1924-52	19.8	3.62	1.46	5.76	2.38	.118	.0477	.188	.0777	.404	.39
15	Beaver Kill at Cooks Falls, N. Y.....	1913-52	241	62.5	32.0	87.0	43.9	.168	.0858	.233	.118	.511	.46

16	East Branch Delaware River at Fishs Eddy, N. Y.	1913-52	783	150	80.0	207	106	.124	.0660	.171	.0875	.532	.51
17	West Branch Delaware River at Delhi, N. Y.	1937-54	142	16.8	8.10	24.5	11.2	.0765	.0369	.112	.0510	.482	.51
18	Little Delaware River near Delhi, N. Y.	1938-54	49.8	5.71	2.56	7.93	3.30	.0741	.0332	.103	.0428	.448	.48
19	Trout Creek at Cannonsville, N. Y.....	1941-54	49.5	6.58	3.07	8.90	3.90	.0859	.0401	.116	.0509	.467	.48
20	Cold Spring Brook at China, N. Y......	1935-54	1.51	.0442	.0189	.0802	.0320	.0189	.00809	.0343	.0137	.428	.59
21	Oquaga Creek at Deposit, N. Y.........	1941-54	66	4.75	1.54	7.42	2.20	.0465	.0151	.0727	.0215	.325	.37
22	West Branch Delaware River at Hale Eddy, N. Y.	1913-52	593	82.0	39.0	111	49.2	.0894	.0425	.121	.0536	.475	.48
23	Callicoon Creek at Callicoon, N. Y....	1941-54	111	14.8	7.55	21.0	10.2	.0862	.0440	.122	.0594	.510	.53
24	Tenmile River at Tusten, N. Y.........	1946-54	45.0	4.22	2.42	5.78	3.24	.0606	.0348	.0830	.0465	.574	.63
25	West Branch Lackawaxen River at Prompton, Pa.	1945-55	59.7	12.0	7.42	15.6	9.58	.130	.0803	.169	.104	.618	.59
26	Dyberry Creek at Dyberry, Pa..........	1944-55	63.2	7.20	3.70	10.5	5.25	.0736	.0378	.107	.0537	.514	.55
27	Lackawaxen River near Honesdale, Pa...	1949-55	164	30.0	18.6	39.1	24.0	.118	.0733	.154	.0946	.621	.60
28	Middle Creek near Hawley, Pa..........	1945-52	78.4	7.40	3.80	10.8	5.40	.0610	.0313	.0890	.0445	.513	.56
29	Lackawaxen River at Hawley, Pa........	1913-52	290	43.5	25.0	59.5	33.4	.0969	.0557	.133	.0744	.575	.58
30	Wallenpaupack Creek at Wilsonville, Pa.	1910-24	228	47.4	26.8	60.0	32.9	.134	.0760	.170	.0933	.567	.54
30	...............do 3/..................	....	228	35.8	0	111	12	.....	.....	.....	.....	.....	....
31	Shohola Creek near Shohola, Pa........	1919-27	82.0	4.87	1.78	8.60	3.01	.0384	.0140	.0678	.0237	.365	.44
32	Mongaup River near Rio, N. Y..........	1909-11	190	61.0	44.0	73.3	52.1	.208	.150	.249	.177	.721	.63
33	Mongaup River near Mongaup, N. Y. d...	1940-52	202	105	43.7	138	62.0	.....	.....	.....	.....	.....	....
34	Delaware River at Port Jervis, N. Y...	1914-25	3,076	551	298	767	400	.116	.0626	.161	.0840	.540	.52
34	...............do 4/..................	1931-52	3,076	973	540	1,210	692	.....	.....	.....	.....	.....	....
35	Neversink River at Halls Mills, N. Y..	1938-48	68	28.6	15.9	40.5	21.6	.272	.151	.385	.205	.555	.46

See footnotes at end of table.

Table 6.--Indices of low-flow frequency at stream-gaging stations in Delaware River basin

Number on fig. 1	Stream-gaging station	Correlation period	Drainage area (square miles)	Lowest mean flow, in cubic feet per second, for indicated period of consecutive days and for indicated recurrence interval, in years				Lowest mean flow, in million gallons per day per square mile, for indicated period of consecutive days and for indicated recurrence interval, in years				Ratio of 7-day discharges	
				7-day		30-day		7-day		30-day		Observed 1/	Adjusted 2/
				2 yr	20 yr	2 yr	20 yr	2 yr	20 yr	2 yr	20 yr		
36	Neversink River at Neversink, N. Y...	1942-52	91.9	35.3	20.3	47.0	25.3	0.248	0.143	0.331	0.178	0.577	0.48
37	Neversink River at Oakland Valley, N. Y.	1929-52	222	66.0	40.0	85.0	48.5	.192	.116	.247	.141	.604	.53
38	Bush Kill at Shoemakers, Pa..........	1913-52	117	20.7	7.22	28.5	9.85	.114	.0399	.157	.0544	.350	.34
39	Flat Brook near Flatbrookville, N. J.	1924-52	65.1	15.3	8.46	18.3	10.0	.152	.0844	.182	.0993	.553	.51
40	Paradise Creek at Henryville, Pa.....	1909-11 1913-14	30.2	25.6	9.02	27.5	9.62	.548	.193	.589	.206	.352	.26
41	McMichaels Creek at Stroudsburg, Pa..	1912-38	64.4	22.2	13.5	26.5	15.7	.223	.135	.266	.158	.605	.52
42	Pocono Creek near Stroudsburg, Pa....	1911-19	38.0	18.5	6.46	25.5	8.80	.315	.110	.434	.150	.349	.28
43	Brodhead Creek at Minisink Hills, Pa.	1951-55	259	94.0	51.1	113	61.1	.235	.128	.282	.152	.545	.46
44	Paulins Kill at Blairstown, N. J.....	1922-52	126	29.8	16.4	36.0	19.8	.153	.0841	.185	.102	.550	.51
45	Pequest River at Huntsville, N. J...	1940-52	31.4	5.00	2.00	6.52	2.58	.103	.0412	.134	.0531	.400	.40
46	Pequest River at Pequest, N. J.......	1922-52	108	33.4	18.2	40.0	21.5	.200	.109	.239	.129	.545	.48
47	Beaver Brook near Belvidere, N. J....	1923-52	36.2	5.10	1.45	7.30	2.04	.0911	.0259	.130	.0364	.284	.29
48	Lehigh River at Stoddartsville, Pa...	1944-55	91.7	27.0	11.3	35.0	14.8	.190	.0796	.247	.104	.419	.37
49	Lehigh River at Tannery, Pa..........	1915-52	322	111	49.2	141	64.0	.223	.0988	.283	.128	.443	.38
50	Dilldown Creek near Long Pond, Pa....	1949-55	2.39	.818	.364	1.10	.492	.221	.0984	.297	.133	.445	.38

51	Wild Creek at Hatchery, Pa...........	1941-52	16.8	8.62	4.18	10.7	5.28	.332	.161	.412	.203	.485	.39
52	Pohopoco Creek near Parryville, Pa....	1945-55	109	46.8	21.4	62.1	28.8	.278	.127	.368	.171	.457	.38
52	................do 4/................	1945-55	109	37.2	16.7	50.0	22.5	.....	.....	.....	.....	.....	....
53	Aquashicola Creek at Palmerton, Pa....	1940-52	76.7	32.2	16.2	41.3	20.9	.271	.137	.348	.176	.506	.42
54	Lehigh River at Walnutport, Pa........	1947-55	889	302	134	405	181	.220	.0974	.294	.132	.443	.38
55	Little Lehigh Creek near Allentown, Pa.	1946-55	80.8	45.0	19.6	59.5	25.2	.360	.157	.476	.202	.436	.35
56	Jordan Creek at Allentown, Pa........	1945-55	75.8	7.76	2.66	15.0	3.86	.0662	.0227	.128	.0329	.343	.37
57	Monocacy Creek at Bethlehem, Pa.......	1949-55	44.5	25.3	11.3	34.0	15.2	.367	.164	.494	.221	.447	.35
58	Lehigh River at Bethlehem, Pa.........	1913-52	1,279	515	330	615	378	.260	.167	.311	.191	.642	.54
59	Saucon Creek at Lanark, Pa...........	1948-52	12.0	2.43	1.41	3.28	1.80	.131	.0759	.177	.0969	.579	.55
60	South Branch Saucon Creek at Friedensville, Pa.	1948-52	10.6	3.90	2.54	4.91	3.09	.238	.155	.299	.188	.651	.55
61	Musconetcong River near Hackettstown, N. J. 4/	1922-52	70.0	23.2	13.0	31.8	17.7	.....	.....	.....	.....	.....	....
62	Musconetcong River near Bloomsbury, N. J. 4/	1922-52	143	70.0	47.8	79.9	54.0	.....	.....	.....	.....	.....	....
63	Delaware River at Riegelsville, N. J..	1914-25	6,328	1,640	1,060	2,070	1,300	.168	.108	.211	.133	.643	.58
63	................do 4/................	1931-52	6,328	2,390	1,410	2,910	1,760	.....	.....	.....	.....	.....	....
64	Tohickon Creek near Pipersville, Pa...	1936-52	97.4	2.42	.825	4.35	1.33	.0161	.00547	.0289	.00883	.340	.49
65	Delaware River at Trenton, N. J. 4/....	1931-52	6,780	2,320	1,400	2,910	1,710	.....	.....	.....	.....	.....	....
66	Assunpink Creek at Trenton, N. J......	1924-52	89.4	19.0	10.8	26.0	14.0	.137	.0781	.188	.101	.570	.54
67	Crosswicks Creek at Extonville, N. J..	1940-50	83.6	34.2	21.2	44.0	26.2	.264	.164	.340	.203	.621	.52
68	Neshaminy Creek near Langhorne, Pa....	1935-52	210	17.5	7.72	26.0	11.3	.0539	.0238	.0800	.0348	.442	.50
69	North Branch Rancocas Creek at Pemberton, N. J.	1922-52	111	51.0	32.9	64.0	40.0	.297	.192	.373	.233	.646	.53
70	Schuylkill River at Pottsville, Pa....	1944-55	53.4	26.0	14.2	32.8	17.6	.315	.172	.397	.213	.546	.44

See footnotes at end of table.

Table 6.--Indices of low-flow frequency at stream-gaging stations in Delaware River basin--Continued

Number on fig. 1	Stream-gaging station	Correlation period	Drainage area (square miles)	Lowest mean flow, in cubic feet per second, for indicated period of consecutive days and for indicated recurrence interval, in years				Lowest mean flow, in million gallons per day per square mile, for indicated period of consecutive days and for indicated recurrence interval, in years				Ratio of 7-day discharges	
				7-day		30-day		7-day		30-day			
				2 yr	20 yr	2 yr	20 yr	2 yr	20 yr	2 yr	20 yr	Observed 1/	Adjusted 2/
71	Little Schuylkill River at Tamaqua, Pa.	1920-52	42.9	8.95	2.42	13.8	3.74	.....	.....	.....	.....	.....	....
72	Tulpehocken Creek near Reading, Pa...	1951-55	211	94.1	49.9	109	55.8	.288	.153	.334	.171	.531	.44
73	Schuylkill River at Pottstown, Pa....	1936-52	1,147	401	230	478	260	.226	.130	.269	.147	.575	.49
74	Perkiomen Creek at Graterford, Pa....	1913-52	279	30.7	13.1	47.2	19.0	.0711	.0303	.109	.0440	.426	.45
75	Schuylkill River at Philadelphia, Pa. 4/	1932-52	1,893	309	57.2	443	88.2	.....	.....	.....	.....	.....	....
76	Mantua Creek at Pitman, N. J........	1940-52	6.75	6.78	5.18	7.79	5.75	.649	.496	.746	.551	.764	.54
77	Crum Creek at Woodlyn, Pa...........	1931-36	33.3	2.29	.897	5.41	1.82	.0444	.0175	.105	.0353	.392	.46
78	Ridley Creek at Moylan, Pa..........	1932-52	31.9	9.88	3.93	14.8	6.18	.200	.0796	.300	.125	.398	.35
79	Chester Creek near Chester, Pa.......	1931-52	61.1	20.6	10.1	24.4	11.4	.218	.107	.258	.121	.491	.42
80	Oldmans Creek near Woodstown, N. J...	1932-39	19.3	7.82	5.20	9.92	6.46	.262	.174	.332	.216	.664	.55
81	Christina River at Coochs Bridge, Del.	1943-54	20.5	4.68	1.91	5.80	2.25	.148	.0602	.183	.0709	.407	.38
82	White Clay Creek above Newark, Del...	1952-54	66.7	26.3	13.9	30.6	15.5	.255	.135	.297	.150	.529	.44
83	White Clay Creek near Newark, Del....	1943-54	87.8	34.8	18.4	40.4	20.6	.256	.135	.297	.152	.527	.44
84	Mill Creek at Stanton, Del..........	1931-33	12.3	2.52	1.32	3.90	2.00	.132	.0694	.205	.105	.526	.50
85	Red Clay Creek at Wooddale, Del......	1943-54	47.0	18.4	11.2	22.3	13.6	.253	.154	.307	.187	.609	.51

86	Brandywine Creek at Chadds Ford, Pa...	1913-52	287	115	60.5	134	67.9	.259	.136	.302	.153	.525	.44
87	Shellpot Creek at Wilmington, Del.....	1946-54	7.46	.648	.228	.828	.272	.0561	.0198	.0717	.0236	.353	.39
88	Salem River at Woodstown, N. J........	1942-52	14.6	3.05	1.48	5.40	2.54	.135	.0655	.239	.112	.485	.46
89	Leipsic River near Cheswold, Del......	1943-54	9.2	3.48	2.16	4.00	2.48	.244	.152	.281	.174	.623	.53
90	Murderkill River near Felton, Del.....	1932-33	14.4	2.77	1.55	3.34	1.81	.124	.0696	.150	.0812	.561	.54
91	Batsto River at Batsto, N. J..........	1928-52	70.5	55.2	43.7	62.8	48.0	.506	.401	.576	.440	.792	.59
92	East Branch Wading River at Harrisville, N. J.	1931-52	64.0	31.0	22.5	39.0	27.5	.313	.227	.394	.278	.725	.59
93	Great Egg Harbor River at Folsom, N. J.	1926-52	56.3	31.7	23.0	37.2	26.2	.364	.264	.427	.301	.725	.58
94	Maurice River at Norma, N. J..........	1932-52	113	62.2	41.2	70.8	46.2	.356	.236	.405	.264	.663	.53
95	Manantico Creek near Millville, N. J..	1932-52	22.3	13.2	6.36	17.7	12.0	.383	.184	.513	.348	.480	.38

1/ Computed from data shown in this table.

2/ Adjusted for the effect of difference in unit yield; minimum 7-day discharge of 0.1 million gallons per day per square mile at the 2-year recurrence interval used as a base.

3/ Regulated; results based on observed data for the period 1927-52 without correlation.

4/ Regulated; results based on pattern of regulation during correlation period.

Table 7.--Storage-required frequency at stream-gaging stations in Delaware River basin as computed from low-flow frequency data

[Frequency data used are adjusted to the period April 1913 to March 1953 on basis of long-term streamflow records. Storage is uncorrected for reservoir seepage and evaporation and for computation procedure, all of which tend to increase the amount of storage required]

Number on fig. 1	Stream-gaging station	Drainage area (square miles)	Recurrence interval (years)	7-day natural flow (mgd per sq mi)	Allowable draft, in million gallons per day per square mile, for indicated storage, in million gallons per square mile									
					0.5	1	2	3	5	10	15	20	30	50
15	Beaver Kill at Cooks Falls, N. Y.	241	2	0.168	0.222	0.261	0.299	0.325	0.366	0.460	0.535	0.597	0.711	0.891
			5	.111	.162	.188	.217	.241	.276	.344	.402	.455	.544	.698
			10	.0971	.147	.169	.199	.221	.256	.322	.373	.418	.500	.642
			25	.0821	.128	.147	.173	.195	.227	.284	.331	.373	.448	.579
16	East Branch Delaware River at Fishs Eddy, N. Y.	783	2	.124	.176	.202	.237	.266	.305	.383	.449	.507	.610	.784
			5	.0834	.125	.146	.174	.192	.225	.288	.341	.388	.471	.611
			10	.0743	.115	.133	.155	.174	.205	.264	.313	.355	.432	.556
			25	.0636	.100	.115	.138	.156	.186	.235	.279	.317	.386	.507
22	West Branch Delaware River at Hale Eddy, N. Y.	593	2	.0894	.130	.153	.185	.209	.250	.288	.391	.450	.548	.717
			5	.0556	.0859	.103	.125	.144	.176	.233	.284	.330	.415	.560
			10	.0480	.0789	.0929	.112	.128	.156	.209	.255	.298	.375	.503
			25	.0409	.0685	.0811	.0969	.111	.135	.185	.229	.270	.337	.446
29	Lackawaxen River at Hawley, Pa.	290	2	.0969	.143	.166	.196	.219	.256	.328	.386	.440	.536	.693
			5	.0702	.106	.127	.148	.163	.189	.241	.289	.332	.407	.535
			10	.0624	.0987	.115	.135	.151	.178	.227	.268	.304	.371	.489
			25	.0539	.0865	.101	.122	.137	.161	.207	.247	.282	.346	.452
37	Neversink River at Oakland Valley, N. Y.	222	2	.192	.243	.270	.310	.340	.382	.455	.529	.592	.703	.870
			5	.143	.192	.208	.236	.251	.287	.357	.409	.452	.538	.671
			10	.129	.169	.186	.214	.235	.266	.328	.377	.417	.491	.617
			25	.113	.152	.169	.193	.211	.240	.292	.337	.374	.446	.569
38	Bush Kill at Shoemakers, Pa.	117	2	.114	.162	.189	.224	.252	.300	.385	.462	.524	.630	.798
			5	.0674	.104	.124	.152	.171	.203	.269	.324	.371	.455	.587
			10	.0514	.0857	.104	.126	.144	.172	.230	.278	.323	.396	.516
			25	.0367	.0667	.0800	.100	.117	.145	.194	.234	.270	.333	.446
39	Flat Brook at Flatbrookville, N. J.	65.1	2	.152	.190	.211	.241	.264	.305	.370	.429	.485	.579	.725
			5	.112	.147	.162	.189	.207	.236	.289	.335	.372	.439	.553
			10	.0973	.129	.143	.167	.185	.212	.259	.293	.331	.395	.500
			25	.0806	.112	.125	.145	.161	.188	.224	.264	.296	.356	.460
41	McMichaels Creek at Stroudsburg, Pa.	64.4	2	.223	.280	.298	.332	.360	.405	.463	.520	.571	.657	.804
			5	.172	.214	.236	.264	.285	.316	.377	.429	.471	.549	.667
			10	.153	.191	.210	.234	.250	.283	.344	.389	.424	.494	.613
			25	.130	.167	.182	.201	.219	.248	.302	.346	.384	.447	.549
44	Paulins Kill at Blairstown, N. J.	126	2	.153	.200	.220	.248	.269	.311	.389	.445	.481	.565	.704
			5	.114	.152	.168	.192	.210	.240	.298	.337	.374	.438	.553
			10	.0975	.131	.147	.169	.188	.217	.268	.307	.339	.400	.512
			25	.0805	.114	.127	.147	.163	.191	.236	.270	.302	.360	.466

49	Lehigh River at Tannery, Pa.	322	2	.223	.286	.310	.351	.383	.434	.517	.589	.650	.758	.946
			5	.157	.211	.238	.272	.292	.328	.402	.460	.510	.596	.731
			10	.124	.173	.195	.222	.241	.275	.342	.392	.435	.508	.628
			25	.0923	.133	.154	.176	.193	.222	.272	.318	.358	.423	.528
58	Lehigh River at Bethlehem, Pa.	1,279	2	.260	.321	.344	.379	.408	.444	.527	.590	.645	.737	.882
			5	.212	.260	.280	.309	.329	.363	.428	.479	.523	.598	.723
			10	.187	.230	.250	.275	.293	.327	.387	.432	.468	.538	.653
			25	.159	.202	.217	.242	.258	.284	.337	.377	.414	.481	.587
64	Tohickon Creek near Pipersville, Pa.	97.4	2	.0161	.0455	.0600	.0830	.103	.137	.207	.261	.312	.403	.559
			5	.00902	.0314	.0420	.0592	.0740	.100	.150	.196	.238	.312	.440
			10	.00697	.0250	.0348	.0516	.0648	.0878	.134	.174	.211	.278	.397
			25	.00504	.0218	.0298	.0440	.0557	.0747	.114	.149	.182	.242	.351
66	Assunpink Creek at Trenton, N. J.	89.4	2	.137	.188	.213	.250	.286	.343	.418	.473	.518	.601	.733
			5	.103	.141	.163	.200	.227	.266	.324	.373	.416	.491	.613
			10	.0896	.125	.150	.182	.206	.240	.294	.342	.381	.449	.555
			25	.0752	.112	.132	.160	.180	.213	.265	.306	.339	.393	.486
68	Neshaminy Creek near Langhorne, Pa.	210	2	.0539	.0938	.113	.142	.165	.197	.255	.297	.337	.413	.544
			5	.0339	.0682	.0812	.102	.118	.144	.192	.231	.268	.333	.448
			10	.0283	.0595	.0723	.0917	.106	.129	.172	.210	.243	.301	.403
			25	.0223	.0484	.0611	.0787	.0919	.112	.151	.185	.216	.271	.356
69	North Branch Rancocas Creek at Pemberton, N. J.	111	2	.297	.357	.392	.438	.471	.522	.603	.663	.706	.787	.932
			5	.239	.294	.322	.358	.387	.428	.497	.552	.596	.674	.803
			10	.211	.267	.295	.325	.348	.385	.453	.502	.543	.620	.737
			25	.186	.237	.260	.288	.309	.339	.401	.449	.487	.555	.652
73	Schuylkill River at Pottstown, Pa.	1,147	2	.226	.276	.301	.336	.365	.409	.493	.553	.603	.683	.834
			5	.172	.212	.231	.258	.278	.313	.383	.433	.475	.553	.687
			10	.148	.188	.206	.231	.247	.278	.335	.377	.418	.491	.603
			25	.124	.159	.173	.190	.204	.231	.281	.321	.359	.419	.508
74	Perkiomen Creek at Graterford, Pa.	279	2	.0711	.119	.143	.174	.199	.238	.310	.368	.417	.500	.642
			5	.0463	.0857	.104	.129	.146	.176	.235	.278	.318	.390	.510
			10	.0371	.0706	.0848	.108	.125	.152	.201	.241	.277	.342	.449
			25	.0287	.0583	.0712	.0891	.103	.126	.167	.205	.237	.294	.390
86	Brandywine Creek at Chadds Ford, Pa.	287	2	.259	.304	.337	.369	.389	.427	.491	.549	.595	.673	.785
			5	.187	.227	.246	.273	.292	.326	.380	.423	.463	.527	.623
			10	.158	.193	.211	.232	.248	.276	.323	.361	.395	.456	.557
			25	.131	.161	.172	.189	.203	.225	.273	.309	.339	.387	.475
94	Maurice River at Norma, N. J.	113	2	.356	.412	.438	.469	.500	.542	.620	.686	.738	.826	.940
			5	.292	.341	.361	.388	.411	.449	.524	.578	.624	.699	.793
			10	.263	.311	.329	.355	.375	.408	.477	.526	.570	.636	.720
			25	.229	.272	.290	.309	.330	.359	.422	.470	.507	.562	.638