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THE OHIO VALLEY FLOOD OF MARCH-APRIL, 1913

(INCLUDING COMPARISONS WITH SOME EARLIER FLOODS)

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By A. H. HORTON and H. J. JACKSON.

INTRODUCTION.

In no year since 1873 has Ohio River failed, at some point along its course, to overflow its banks and flood large areas of adjoining bottom lands, and in some years this flooding has been five times repeated. So relatively little precise information is available concerning the floods previous to 1873 that their intensity can not be fairly compared with that of later floods, but among the subsequent floods three are preeminent—that of February, 1884, that of March–April, 1907, and, last and greatest, that of March–April, 1913.

Problems connected with the improvement, regulation, and use of the Ohio and its tributaries have been under consideration for more than a century, but none of the numerous philosophic and scientific reports that discuss these problems contain any consecutive records of discharge, and, largely because of this lack of base data, the problems seem little nearer solution now than they were 50 years ago. The small amount of progress made is shown by comparing the numerous reports on floods published during the last 60 years. The discussion that followed the publication of Ellet's notable report [1] in 1853 and that which followed Leighton's report [2] in 1908 on reservoir control afford a particularly striking example. Although more than 50 years had elapsed between the two reports sufficient data upon which to base definite conclusions had not been collected.

The differences in opinion concerning the treatment of the problem of the improvement of the Ohio have been in the past and are now due chiefly to attempts to draw conclusions from insufficient data and to consider special phases of the subject without attention to other phases. Unless systematic studies of all the various factors which enter into the problem are made, the arguments that have been

[1] Ellet, Charles, jr., The Mississippi and Ohio rivers: containing plans for the protection of the delta from inundation and investigation of the practicability and cost of improving the navigation of the Ohio and other rivers by means of reservoirs; Philadelphia, 1853. The discussion appeared in the Journal of the Franklin Institute of Philadelphia between 1853 and 1857.

[2] Leighton, M. O., The relation of water conservation to flood prevention and navigation along Ohio River: Inland Waterways Comm., Prel. Rept., pp. 451-490, 1908. Discussions appeared in Am. Soc. Civil Eng. Trans. (Chittenden, H. M.), vol. 62, pp. 245 et seq.; Eng. News; and other periodicals.

carried on during the last half century will continue indefinitely to occupy the time and attention of everyone interested.

The data essential to such systematic studies comprise—

1. Records of stream flow at carefully selected points.
2. General topographic maps of the entire area.
3. Detailed maps of areas where possible improvement can be made.
4. A study of present works for the improvement of the river and its tributaries and their effects.
5. A study of the municipal and other developments along the rivers and their effects on regimen.

Of these the data of greatest immediate importance are records of stream flow. The others are of such character that they can be readily collected at any time, but the collection of stream-flow data should be started without further delay, for not only are they essential in studying past and present conditions and in planning improvements, but they are also indispensable to the efficient operation of any works that may be constructed, and their value will depend largely on the length of time over which they extend. Moreover, the opportunity for obtaining much valuable information concerning the flood of March–April, 1913, will soon be lost, and it is manifestly unwise to await the recurrence of disaster in order to collect the data necessary to the formulation of plans for flood control.

Investigations of stream flow are now in progress by the United States Geological Survey in many parts of the Ohio River basin, and can readily be extended to cover the whole area.

SCOPE OF REPORT.

A review of the various published and manuscript reports relating to the Ohio and its tributaries shows that disconnected and incomplete records of stage, discharge, and other factors relative to flow have been kept at many points in the Ohio River basin. A report based on the careful study and analysis of these records supplemented by new data would give much information in regard to the flow of Ohio River during the last 70 years, including, for several points, records of the flow continuous for 50 years. In preparation for such a report the Geological Survey has, for the last five years, as opportunity presented, collected many of the records necessary for the correlation and interpretation of back records, but before the report can be completed, it will be necessary to analyze thoroughly all the available records and to collect some additional hydrometric data.

Meanwhile such flood data as can be prepared with the records and funds at present available are here published for the convenience of the public and particularly of the engineering profession, and to emphasize the necessity of immediately starting, on a comprehensive scale, the collection of stream-flow data in the Ohio Valley.

The data given for the recent flood are as complete as it is possible to make them at this time, but much more similar information should be collected and published. The facts concerning other floods are presented primarily for comparison with those concerning the flood of 1913, for it is obvious that the problem of flood control can not be solved by studying any one flood.

The report shows, in a limited way, what can and should be done in collecting the hydrometric data necessary for a complete report upon the floods that continuously menace the Ohio Valley, to the end that a definite decision may be reached as to the best and most economical means of preventing damage by floods.

ACCURACY AND RELIABILITY OF DATA.

It has not been possible to expend on the preparation of this preliminary report the same amount of care and study that would be necessary in the preparation of a complete and final report, but all gage heights have been carefully checked against the records from which they were obtained, and any discrepancies that may be later revealed by close study and investigation of original records will probably be comparatively small. Discharge data, in so far as the rating curves used in their determination are concerned, are well within the required degree of accuracy. No detailed study of the records as published has been made, and no attempt has been made to adjust any of the data to even partly eliminate seeming inconsistencies.

ACKNOWLEDGMENTS.

Special acknowledgment is due to the United States Weather Bureau for published and advance data on precipitation and floods, particularly for rainfall records and most of the gage heights and miscellaneous data relating to river stations given in this report, and to the Corps of Engineers, United States Army, for published and unpublished gage heights at numerous locks and dams and for some miscellaneous data derived from reports on river surveys. Data obtained from municipal and local authorities in many cities and towns, from county and State departments, and from railroad and traction companies throughout the Ohio Valley form so large a part of this report that it has not been deemed expedient to attempt to give individual acknowledgments throughout the text. All such courtesies are, however, here gratefully acknowledged.

DIVISION OF WORK.

The field records from which the discharge data were prepared were collected under the direction of A. H. Horton, district engineer, assisted by R. H. Bolster, W. G. Hoyt, H. J. Jackson, C. T. Bailey, Wm. N. O'Neill, J. C. Dort, and P. S. Monk.

The ratings were prepared by A. H. Horton, district engineer, R. H. Bolster, hydraulic engineer, and H. J. Jackson, assistant engineer.

The computations were made by A. H. Horton and H. J. Jackson, assisted by G. C. Stevens, H. D. Padgett, C. L. Batchelder, and M. I. Walters.

The rainfall maps for the floods of 1884 and 1913 were prepared by Henry Gannett, geographer.

The outline and general plan of the report was made by John C. Hoyt, under whose direction the studies were made and the completed data prepared for publication by A. H. Horton and H. J. Jackson.

The report was edited by Mrs. B. D. Wood.

DEFINITION OF TERMS.

The volume of water flowing in a stream—the "run-off" or "discharge"—is expressed in various terms, each of which has become associated with a certain class of work. These terms may be divided into two groups—(1) those which represent a rate of flow, as second-feet, gallons per minute, miner's inches, and run-off in second-feet per square mile, and (2) those which represent the actual quantity of water, as run-off in depth in inches and in acre-feet. The units used are second-feet, second-feet per square mile, and run-off in millions of cubic feet, run-off in inches and in acre-feet. They may be defined as follows:

"Second-foot" is an abbreviation for cubic foot per second and is the unit for the rate of discharge of water flowing in a stream 1 foot wide, 1 foot deep, at a rate of 1 foot per second. It is generally used as a fundamental unit from which others are computed by the use of the factors given in the following table of equivalents.

"Second-feet per square mile" is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the run-off is distributed uniformly both as regards time and area.

"Run-off in inches" is the depth to which the drainage area would be covered if all the water flowing from it in a given period were conserved and uniformly distributed on the surface. It is used for comparing run-off with rainfall, which is usually expressed in depth in inches.

"Acre-foot" is equivalent to 43,560 cubic feet, and is the quantity required to cover an acre to the depth of 1 foot. It is commonly used in connection with storage for irrigation work.

CONVENIENT EQUIVALENTS.

The following is a list of convenient equivalents for use in hydraulic computations:

Table for converting discharge in second-feet per square mile into run-off in depth in inches over the area.

Discharge in second-feet per square mile.	Run-off in inches.				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	0.03719	1.041	1.079	1.116	1.153
2	.07438	2.083	2.157	2.231	2.306
3	.11157	3.124	3.236	3.347	3.459
4	.14876	4.165	4.314	4.463	4.612
5	.18595	5.207	5.393	5.578	5.764
6	.22314	6.248	6.471	6.694	6.917
7	.26033	7.289	7.550	7.810	8.070
8	.29752	8.331	8.628	8.926	9.223
9	.33471	9.372	9.707	10.041	10.376

NOTE.—For partial month multiply the values for one day by the number of days.

Table for converting discharge in second-feet into run-off in acre-feet.

Discharge in second-feet.	Run-off in acre-feet.				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	1.983	55.54	57.52	59.50	61.49
2	3.967	111.1	115.0	119.0	123.0
3	5.950	166.6	172.6	178.5	184.5
4	7.934	222.1	230.1	238.0	246.0
5	9.917	277.7	287.6	297.5	307.4
6	11.90	333.2	345.1	357.0	368.9
7	13.88	388.8	402.6	416.5	430.4
8	15.87	444.3	460.2	476.0	491.9
9	17.85	499.8	517.7	535.5	553.4

NOTE.—For partial month multiply the values for one day by the number of days.

Table for converting discharge in second-feet into run-off in millions of gallons.

Discharge in second-feet.	Millions of gallons.				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	0.6463	18.10	18.74	19.39	20.04
2	1.293	36.20	37.448	38.78	40.08
3	1.939	54.30	56.22	58.17	60.12
4	2.585	72.40	74.96	77.56	80.16
5	3.232	90.50	93.70	96.95	100.2
6	3.878	108.6	112.4	116.3	120.2
7	4.524	126.7	131.2	135.7	140.3
8	5.170	144.8	149.9	155.1	160.3
9	5.817	162.9	168.7	174.5	180.4

NOTE.—For partial month multiply the values for one day by the number of days.

Table for converting discharge in second-feet into run-off in millions of cubic feet.

Discharge in second-feet.	Millions of cubic feet.				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	.0864	2.419	2.506	2.592	2.678
2	.1728	4.838	5.012	5.184	5.356
3	.2592	7.257	7.518	7.776	8.034
4	.3456	9.676	10.02	10.37	10.71
5	.4320	12.10	12.53	12.96	13.39
6	.5184	14.51	15.04	15.55	16.07
7	.6048	16.93	17.54	18.14	18.75
8	.6912	19.35	20.05	20.74	21.42
9	.7776	21.77	22.55	23.33	24.10

NOTE.—For partial month multiply the values for one day by the number of days.

1 second-foot equals 40 California miner's inches (law of Mar. 23, 1901).
1 second-foot equals 38.4 Colorado miner's inches.
1 second-foot equals 40 Arizona miner's inches.
1 second-foot equals 7.48 United States gallons per second; equals 448.8 gallons per minute; equals 646,317 gallons for one day.
1 second-foot equals 6.23 British imperial gallons per second.
1 second-foot for one year covers 1 square mile 1.131 feet or 13.572 inches deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre-feet.
100 California miner's inches equals 18.7 United States gallons per second.
100 California miner's inches equals 96.0 Colorado miner's inches.
100 California miner's inches for one day equals 4.96 acre-feet.
100 Colorado miner's inches equals 2.60 second-feet.
100 Colorado miner's inches equals 19.5 United States gallons per second.
100 Colorado miner's inches equals 104 California miner's inches.
100 Colorado miner's inches for one day equals 5.17 acre-feet.
100 United States gallons per minute equals 0.223 second-foot.
100 United States gallons per minute for one day equals 0.442 acre-foot.
1,000,000 United States gallons per day equals 1.55 second-feet.
1,000,000 United States gallons equals 3.07 acre-feet.
1,000,000 cubic feet equals 22.95 acre-feet.
1 acre-foot equals 325,850 gallons.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-foot per year.
1 foot equals 0.3048 meter.
1 mile equals 1.60935 kilometers.
1 mile equals 5,280 feet.
1 acre equals 0.4047 hectare.
1 acre equals 43,560 square feet.

1 acre equals 209 feet square, nearly.
1 square mile equals 2.59 square kilometers.
1 cubic foot equals 0.0283 cubic meter.
1 cubic foot equals 7.48 gallons.
1 cubic foot of water weighs 62.5 pounds.
1 cubic meter per minute equals 0.5886 second-foot.
1 horsepower equals 550 foot-pounds per second.
1 horsepower equals 76 kilogram-meters per second.
1 horsepower equals 746 watts.
1 horsepower equals 1 second-foot falling 8.80 feet.
1⅓ horsepower equals about 1 kilowatt.

To calculate water power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheel realizing 80 per cent of theoretical power.

CAUSES OF FLOODS IN THE OHIO VALLEY.

Disastrous floods have resulted from the following causes, acting either alone or in conjunction:

1. Excessive rainfall.
2. The rapid melting of accumulated snow.
3. The failure of reservoirs.
4. The forming and breaking of ice jams.
5. The breaking of levees.

In the Ohio Valley floods have been caused mainly by early spring rains, often occurring in conjunction with the melting of accumulated snow and ice. The flood of 1884 affords a good example of this combination of the effects of rainfall and melting snow. Of the 46 floods above the danger line on record at Cincinnati, Ohio, only three occurred outside of the four months January, February, March, and April—one in December, 1847, the second in May, 1865, and the third in August, 1875. Data concerning the principal floods in the Ohio Valley are presented in Tables 1 and 2.

Table 1 shows the date and crest stage of each rise recorded as above the danger line and the number of times the danger line was passed at six stations on the Ohio River. In general, values on the same horizontal line represent the same flood, but where values for different floods are on the same line the differences in dates are sufficiently obvious to avoid confusion. It should be noted that at Marietta 35 feet instead of 25 feet (danger line) was used as the limiting stage.

TABLE 1.—*Stages, in feet, of floods above danger line, at selected stations on Ohio River.*

Year.	Pittsburgh, Pa.[a] Danger line, 22 ft. Max. 35.5, Mar. 15, 1907. Min. −1.3, Sept. 28, 1881.		Wheeling, W. Va. Danger line, 36 ft. Max. 53.1, Feb. 7, 1884. Min. −0.3, Aug. 27-28, 1893.		Marietta, Ohio. Stages above 35 ft.[b] Max. 58.3, Mar. 29, 1913. Min. 1.6, — — —		Cincinnati, Ohio. Danger line, 50 ft. Max. 71.1, Feb. 14, 1884. Min. 1.9, Sept. 17-19, 1881.		Evansville, Ind. Danger line, 35 ft. Max. 48.8, Feb. 19, 1884. Min. −0.3, Nov. 7-8, 1895.		Paducah, Ky. Danger line, 43 ft. Max. 54.3, Apr. 7, 1913. Min. −0.7, Oct. 30-Nov. 4, 1895.	
	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.
1773								[c]76				
1806	Apr. 10	33.9										
1810	Nov. 9	32.0										
1813	Jan. —	29.0										
1816	Feb. —	33.0										
1832	Feb. 10	35.0					Feb. 18	[d]64.3		46.3		
1840	Feb. 1	26.8	Feb. 11	38								
1846	Mar. 15	25.0										
1847	Feb. 2	26.9										
1847	Dec. 12	24.0	Dec. 15	38.5			Dec. 17	63.6				
1848	Dec. 22	23.0										
1849			May 9	39.0								
1851	Sept. 20	30.9										
1852	Apr. 6	25.0										
1852	Apr. 19	31.9										
1858	May 27	26.0										
1859	Apr. 28	22.0					Feb. 23	55.3				
1860	Apr. 12	29.7										
1860	Nov. 4	22.0										
1861	Sept. 29	31.0										
1862	Jan. 21	30.0	Jan. 21	40.5			Jan. 24	57.3				
1862							Apr. 13	51.4				
1862	Apr. 22	27.9					Apr. 26	52.2				
1865	Mar. 4	24.5					Mar. 7	[d]56.3				
1865	Mar. 18	31.4					May 14	51.2				
1867	Feb. 15	22.0					Feb. 22	54.1				
1867	Mar. 13	23.5					Mar. 14	[d]55.8			Mar. 21	52.0
1868	Mar. 18	22.0										
1870							Jan. 19	55.3				
1873	Dec. 14	25.7	Dec. 15	38.5	Dec. 16	38.5						
1874	Jan. 8	22.2	Jan. 9	36.5	Jan. 9	37.7			Jan. 15	37.2		
1874									Feb. 28	39.2		
1874									Apr. 16	37.2		
1874									Apr. 23	36.4	Apr. 24	48.7
1874									May 5	38.6		
1875									Mar. 4–5	35.8		
1875									Mar. 22	36.6	Mar. 21	44.3
1875					Aug. 3	35.3	Aug. 6	55.3	Aug. 9–10	41.9		
1876	Sept. 19	25.0							Jan. 3	37.9		
1876							Jan. 29	51.8	Jan. 31	43.3	Feb. 5	44.9
1876									Feb. 19	37.8		
1876									Apr. 3	35.4		
1877	Jan. 17	24.6					Jan. 20	[d]53.8	Jan. 23–24	41.5		
1878	Dec. 11	24.5										
1879									Dec. 30–31	37.3		
1880									Jan. 12	37.0		
1880							Feb. 17	[d]53.2	Feb. 21	42.1		
1880									Mar. 14	39.0	Mar. 22–23	44.0
1880									May 3	35.2		
1881	Feb. 11	23.2	Feb. 12	38.8	Feb. 14	39.3	Feb. 16	50.6	Feb. 19	38.9		
1881	June 10	27.1	June 11	39.5								
1882									Jan. 18	40.9	Jan. 31, Feb. 2	48.8
1882					Feb. 23	35.0	Feb. 21	[d]58.6	Feb. 24	44.9	Feb. 26	50.0
1882									Mar. 28	38.0		
1882									May 20	36.0		
1883	Feb. 5	24.8										
1883	Feb. 8	28.0			Feb. 9	43.7	Feb. 15	[d]66.3	Feb. 19	47.8	Feb. 25	50.7
1883									Apr. 10–12	38.8		
1883									Dec. —	([e])		

[a] From report Pittsburgh Flood Commission.
[b] Danger line, 25 feet. Used 35 feet in this report.
[c] From traditions.
[d] Crest.
[e] December, 1883, no record. Gage height Jan. 1, 1884, equals 39.0.

TABLE 1.—*Stages, in feet, of floods above danger line, at selected stations on Ohio River*—Continued.

Year.	Pittsburgh, Pa. Danger line, 22 ft. Max. 35.5, Mar. 15, 1907. Min. −1.3, Sept. 28, 1881.		Wheeling, W. Va. Danger line, 36 ft. Max. 53.1, Feb. 7, 1884. Min. −0.3, Aug. 27–28, 1893.		Marietta, Ohio. Stages above 35 ft. Max. 58.3, Mar. 29, 1913. Min. 1.6, ———		Cincinnati, Ohio. Danger line, 50 ft. Max. 71.1, Feb. 14, 1884. Min. 1.9, Sept. 17–19, 1881.		Evansville, Ind. Danger line, 35 ft. Max. 48.8, Feb. 19, 1884. Min. −0.3, Nov. 7–8, 1895.		Paducah, Ky. Danger line, 43 ft. Max. 54.3, Apr. 7, 1913. Min. −0.7, Oct. 30–Nov. 4, 1895.	
	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.
1884	Feb. 6	a33.3	Feb. 7	a53.1	Feb. 9	a52.8	Feb. 14	a71.1	Feb. 19	a48.8	Feb. 23	a54.2
1884									Mar. 18–21	39.7	Mar. 23	45.9
1885	Jan. 17	23.0							Jan. 23	37.5		
1886	Apr. 7	22.8					Apr. 9	a55.8	Apr. 14	43.4	Apr. 17	50.4
1887	Feb. 12	22.0					Feb. 5	a56.3	Feb. 8–9	43.2	Feb. 12–13	43.1
1887	Feb. 27	22.0					Mar. 1	54.6	Mar. 5	43.1	Mar. 8	46.8
1887									Apr. 28–29	38.3		
1888	July 11	22.0							Apr. 3–4	35.2		
1888	Aug. 22	26.0										
1889	June 1	24.0										
1890									Jan. 24	38.9		
1890									Feb. 14	37.0		
1890							Mar. 1	56.8	Mar. 5	43.9	Mar. 11	48.5
1890	Mar. 23	24.3					Mar. 26	a59.2	Mar. 30–31	44.4	Apr. 2–3	47.2
1890	May 24	22.0										
1891									Jan. 8–10	37.0		
1891	Jan. 3	23.2							Feb. 10	39.1		
1891	Feb. 18	31.3	Feb. 19	44.9	Feb. 20	43.8	Feb. 25	57.3	Mar. 2	42.8	Mar. 1	45.5
1891									Apr. 9–10	37.2		
1892	Jan. 15	23.0							Apr. 25–28	38.2		
1893	Feb. 8	24.0			Feb. 11	36.4	Feb. 20	a54.9	Feb. 24	41.8	Feb. 27	44.3
1893	Feb. 11	22.0							May 5, 10–11	40.3	May 13	44.2
1894	May 22	23.2										
1895	Jan. 8	25.8							Jan 17–18	35.5		
1896	July 26	23.0							Apr. 7–8	38.8		
1897									Feb. 12–13	35.5		
1897	Feb. 24	29.5	Feb. 24	36.8	Feb. 25	36.0	Feb. 26	a61.2	Mar. 2–3	43.6	Mar. 24–25	50.9
1898							Jan. 26	52.2	Jan. 28	43.1	Jan. 30–31	43.8
1898	Mar. 24	28.9	Mar. 24	44.2	Mar. 25	47.5	Mar. 29	61.4	Apr. 2–3	44.8	Apr. 6	47.3
1899									Jan. 18	39.1		
1899	Mar. 6	22.0					Mar. 8	a57.4	Mar. 12	42.7		
1899							Apr. 1	51.6	Apr. 5	40.4	Apr. 4–5	43.8
1900	Nov. 27	27.7										
1901	Apr. 7	22.1										
1901	Apr. 21	27.5	Apr. 22	40.8	Apr. 23	41.4	Apr. 27	59.7	Apr. 30, May 1	41.8		
1901	Dec. 16	25.8										
1902									Feb. 5	35.8		
1902	Mar. 1	32.4	Mar. 2	42.6	Mar. 3	38.4	Mar. 5	50.9	Mar. 11	40.0		
1902									Dec. 22	40.0		
1903	Feb. 5	24.0							Feb. 11	39.8		
1903									Feb. 23	40.7		
1903	Mar. 1	28.9	Mar. 2	40.0	Mar. 3	38.6	Mar. 5	a53.2	Mar. 11	42.4	Mar. 15–16	47.6
1903									Apr. 22–23	36.0		
1904	Jan. 23	30.0	Jan. 24	43.9	Jan. 25	40.8						
1904	Mar. 4	26.9	Mar. 4	37.8	Mar. 5	37.8			Mar. 14	36.2		
1904	Mar. 8	23.2							Apr. 3–4	39.8	Apr. 4	44.7
1905	Mar. 22	29.0	Mar. 22	42.3	Mar. 23	40.4			Mar. 17	37.4		
1905	Dec. 4	23.5							May 19–20	35.6		
1906							Apr. 2	a50.4	Apr. 6	41.1		
1907									Jan. 7–8	40.3		
1907	Jan. 20	23.3	Jan. 20	36.1			Jan. 21	a65.2	Jan. 24–25	46.2	Jan. 28	45.7
1907	Mar. 15	35.5	Mar. 15	a50.1	Mar. 16	a48.7	Mar. 19	62.1	Mar. 23	43.8		
1907	Mar. 20	22.4										
1908	Feb. 16	30.7	Feb. 17	42.6	Feb. 18	a39.1	Feb. 20	a51.3	Feb. 24	40.9		
1908					Mar. 5	36.4	Mar. 12	a53.4	Mar. 15	41.5		
1908	Mar. 20	27.3	Mar. 21	38.4	Mar. 21	a36.4	Apr. 4	a55.9	Apr. 8–9	42.2		
1908									May 12–13	37.6		
1909	Feb. 25	22.3			Feb. 26	35.0	Feb. 28	54.6	Mar. 2	43.2	Mar. 5–6	44.5
1909	May 1	22.2							May 10	35.7		
1910	Jan. 19	22.8							Jan. 27	38.6		

a Crest.

TABLE 1.—*Stages, in feet, of floods above danger line, at selected stations on Ohio River*—Continued.

Year.	Pittsburgh, Pa. Danger line, 22 ft. Max. 35.5, Mar. 15, 1907. Min. −1.3, Sept. 28, 1881.		Wheeling, W. Va. Danger line, 36 ft. Max. 53.1, Feb. 7, 1884. Min. −0.3, Aug. 27–28, 1893.		Marietta, Ohio. Stages above 35 ft. Max. 58.3, Mar. 29, 1913. Min. 1.6, ———		Cincinnati, Ohio. Danger line, 50 ft. Max. 71.1, Feb. 14, 1884. Min. 1.9, Sept. 17–19, 1881.		Evansville, Ind. Danger line, 35 ft. Max. 48.8, Feb. 19, 1884. Min. −0.3, Nov. 7–8, 1895.		Paducah, Ky. Danger line, 43 ft. Max. 54.3, Apr. 7, 1913. Min. −0.7, Oct. 30–Nov. 4, 1895.	
	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.	Date.	Stage.
1910	May 1	22.0	Mar. 3	37.3	Mar. 4	39.6	Mar. 7	51.8	Mar. 10	39.7		
1911	Jan. 15	23.8	Jan. 16	a36.1								
1911	Jan. 31	b25.2							Feb. 9	38.8		
1911									Apr. 17	38.4		
1912									Mar. 3	36.3		
1912	Mar. 22	b28.1	Mar. 23	c38.4			Mar. 27	b53.4	Mar. 31	42.6		
1912							Apr. 5–6	51.7			Apr. 8–11	49.9
1912									May 3	d35.8		
1913	Jan. 9	b31.3	Jan. 10	44.2								
1913	Jan. 13	b26.3	Jan. 13	39.0	Jan. 13	42.6	Jan. 14	b62.2	Jan. 20	46.7	Jan. 25	47.6
1913	Mar. 28	b30.4	Mar. 28	b51.1	Mar. 29	b58.3	Apr. 1	b69.8	Apr. 5	b48.4	Apr. 7	b54.3
Number of times above danger line	82		28		e25		46		86		29	

a Falling. No reading Jan. 15.
b Crest.
c Rising. No reading Mar. 24.
d Rising. No reading May 4.
e 5 crests subsequent to March, 1905, reported: "Gages under water." No readings available. Probably 2 of these were above 35 feet.

Table 2 gives the highest stage shown by regular gage readings (or the crest stage if known) at certain stations for each of a number of floods from 1880 to 1913, selected by taking all floods whose crest stages at Cincinnati were above 58 feet. (See Table 1 for dates.) The flood of 1912 reached a crest stage of only 53.2 feet at Cincinnati, but is included in the table because of its recent occurrence and the importance of its effect on the lower Mississippi. The gage heights at other stations are for the crests corresponding to the crests at Cincinnati and therefore do not necessarily represent the maximum stages for the years considered at all the stations. In some years—as, for example, 1897 and 1912—two crests were recorded on the tributaries about the time of the rise on the main stream. In such event the crest believed to be the more nearly comparable with that on the Ohio was selected. A study of the floods prior to 1880 can be made from Table 1. The maximum stage given at each station is the highest of which there is authentic record.

These tables show clearly that danger from flood is ever present on the Ohio. In every year for more than 40 years the river passed the danger line at some of the six stations selected.

TABLE 2.—*Gage heights, in feet, for principal floods of Ohio and tributary rivers from 1880 to 1913.*[a]

No.	River and station.	1882	1883	1884	1890	1897	1898	1901	1907 (Jan.)	1907 (Mar.)	[b] 1912	1913 (Jan.)	1913 (Mar.-Apr.)[c]	Maximum.	
														Stage.	Date.
	Main stream.														
	Ohio:														
1	Pittsburgh, Pa.	21.8	28.0	c 33.3	24.3	29.5	28.9	27.5	23.3	c 35.5	28.1	c 31.3	30.4	c 35.5	Mar. 15, 1907
2	Beaver Dam (No. 6), Pa.					37.7	22.0	37.7	33.7	47.1	c 38.0	42.3	46.6	47.1	Do.
3	Wheeling, W. Va.	31.1	35.8	c 53.1	3[illegible].2	36.8	44.2	40.8	36.1	c 50.1	d 38.4	44.2	51.1	c 53.1	Feb. 7, 1884
4	Marietta, Ohio	35.0	43.7	c 52.8	33.5	36.0	47.5	41.4		e c 48.7		e f 42.6	e 58.3	e c 58.3	Mar. 29, 1913
5	Parkersburg, W. Va.			c 53.9	35.0	c 37.9	c 48.2	c 43.9	c 40.1	c 51.6	36.5	g 42.7	58.9	c 58.9	Do.
6	Point Pleasant, W. Va.	42.6	c 53.2	c 60	c 48.1	52.3	51.2	53.0	c 52.2	54.8	43.0	50.3	62.8	c 62.8	Mar. 30, 1913
7	Huntington, W. Va.	47.0		c 64.8				57.4	57.8	58.4	48.1	c 54.7	66.4	c 66.4	Do.
8	Catlettsburg, Ky.		c 59.3	c 66.2		58.5	56.0	c 59.1	c 60.0	c 60.4	49.4	56.0	67.7	c 67.7	Mar. 31, 1913
9	Portsmouth, Ohio			c 66.3	c 56.0	c 59.0	c 57.4	c 58.4	c 60.9	c 60.8	51.0	58.2	67.9	c 67.9	Do.
10	Maysville, Ky.			65.7					60.3	59.2	49.9	57.3	66.4	c 66.4	Do.
11	Cincinnati, Ohio	c 58.6	c 66.3	c 71.1	c 59.2	c 61.2	61.4	59.7	c 65.2	c 62.1	53.2	c 62.2	69.8	c 71.1	Feb. 14, 1884
12	Louisville, Ky. (lower)	63.0	70.1	c 72.0	61.1	61.0	62.0	c 58.8	c 67.0	c 61.6	54.3	c 65.1	70.6	c 72.0	Feb. 16, 1884
13	Evansville, Ind.	44.9	47.8	c 48.8	44.4	43.6	44.8	41.8	46.2	43.8	42.6	46.4	48.4	c 48.8	Feb. 19, 1884
14	Mount Vernon, Ind.			51.7	46.3	44.7	48.3	41.7	48.5	45.0	43.9	c 48.2	52.9	c 52.9	Apr. 5, 1913
15	Paducah, Ky.	50.0	50.7	c 54.2	47.2	50.9	47.3	39.4	45.7	42.3	49.9	47.6	54.3	c 54.3	Apr. 7, 1913
16	Cairo, Ill.	51.9	c 52.2	51.8	48.7	51.6	49.8	43.2	c 50.4	c 46.2	54.0	48.9	54.8	c 54.8	Apr. 4, 8, 1913
	Tributaries.														
	Allegheny:														
1	Warren, Pa.				5.5	2.5	7.6	10.0	6.0	7.2	12.0	10.1	15.2	c 17.4	March, 1865
2	Freeport, Pa.	18.3	30.5	30.0	15.7	14.7	25.3	23.0	c 17.7	c 28.0	23.3	27.4	31.9	c 32.7	Feb. 18, 1891
	Monongahela:														
3	Greensboro, Pa.				27.0	33.0	21.2	17.3	c 31.0	27.2	20.9	h 20.3	18.7	c 39	July 10, 1888
4	Lock No. 4, Pa.				31.8	36.0	24.7	25.5	36.6	37.4	27.7	29.5	25.2	c 42	July 11, 1888
5	Cheat, Morgantown, W. Va.										c 10.3	9.7	8.2		
	Youghiogheny:														
6	Confluence, Pa.	10.5	13.8	9.9	10.9	13.0	8.1	8.5	c 13.4	c 18.6	10.3	8.3	5.6	c 18.6	Mar. 14, 1907
7	West Newton, Pa.					c 22.0	10.9	12.0	15.4	c 28.2	22.7	13.7	9.7	c 28.2	Do.
8	Muskingum, Zanesville, Ohio				11.4		35.9	24.3	25.3	30.4	22.8	25.6	51.8	c 51.8	Mar. 27, 1913
9	Little Kanawha, Dam No. 4, W. Va. (upper gage)									18.6	16.9	c i 18.1	19.5		

a The heights given represent the highest stages recorded, not invariably the crest heights.
b Two crests at most stations (Mar.-Apr., 1912); used higher.
c Crest.
d Highest recorded (rising). No observation Mar. 24.
e Obtained from readings on lower lock No. 1 gage by subtracting 1.6 feet.
f Jan. 13.
g 45.1, Jan. 13.
h 22.7, Jan. 12.
i 19.0, Jan. 12.

TABLE 2.—*Gage heights, in feet, for principal floods of Ohio and tributary rivers from 1880 to 1913*—Continued.

No.	River and station.	1882	1883	1884	1890	1897	1898	1901	1907 (Jan.)	1907 (Mar.)	1912	1913 (Jan.)	1913 (Mar.-Apr.) *a*	Maximum. Stage.	Maximum. Date.
	New:														
10	Radford, Va.							18.4			*a* 10.4	4.0	15.0	*a* 37	Sept. 15, 1878
11	Hinton, W. Va.	9.2	7.5	*a* 10.6	*a* 7.5	*a* 14.8	7.6	*a* 18.0	7.5	6.5	9.0	4.8	14.5	*a* 23	Sept. 13, 1878
12	Fayette, W. Va.					27.6	17.8				*a* 31.8	18.2	36.5	*a* 53	Sept., 1878
	Kanawha:														
13	Kanawha Falls, W. Va.	*a* 16.4	*a* 16.0	*a* 19.5	*a* 14.8	*a* 28.5	13.9	*a* 30.0	*a* 17.8	*a* 13.5	16.5	12.3	27.5	*a* 37.8	Sept. 14, 1878
14	Charleston, W. Va.	*a* 26.5	*a* 26.0	*a* 29.0	31.0	41.1	19.6	*a* 36.4	*a* 30.0	*a* 21.0	24.6	21.5	34.8	*a* 46.9	Sept. 28, 1861
15	Greenbrier, Alderson, W. Va.					16.9	8.0	9.1			*a* 13.0	7.5	19.4	*a* 19.4	Mar. 27, 1913
16	Big Sandy, Louisa (Lock No. 3), Ky. (upper gage)			44.1	38.0	44.6	24.6	34.5	39.0	29.6	*a* 38.6	*b* 25.6	42.8		
17	Scioto, Columbus, Ohio							3.6	17.3	19.0	16.0	15.5	22.9	*a* 22	Mar. 25, 1913
18	Licking, Falmouth, Ky.				24.7	27.0	17.6	*a* 20.2	28.5	28.1	22.3	34.4	34.1	*a* 37.8	Feb. 24, 1909
	Miami:														
19	Dayton, Ohio					5.9	18.3	3.4	12.0	15.2	13.8	11.0	29.0	*a* 29.0	Mar. 26, 1913
20	Hamilton, Ohio						21.2			*a* 20.3	*a* 12.8	10.0	34.6	*a* 34.6	Do.
	Kentucky:														
21	Highbridge, Ky.							24.4	25.7	20.0	25.0	33.0	34.6	34.6	Mar. 27, 1913
22	Frankfort, Ky.		42		31.0			25.1	29.6	20.6	25.6	*c* 34.8	38.3	*a* 44	Feb., 1878
23	Green, Lock No. 2, Ky. (upper gage)									33.2	29.4	35.5	31.2		
	Wabash:														
24	Terre Haute, Ind.		27.7			18.4			24.7	17.3	19.7	21.2	31.2	31.2	Mar. 27, 1913
25	Mount Carmel, Ill.				22.0	26.4	*a* 27.1	13.5	24.5	23.0	23.2	24.3	31.0	*a* 31.0	Mar. 30, 1913
	Cumberland:														
26	Nashville, Tenn.	38.3	41.6	47.2	[illegible].0	48.7	23.9	37.8	28.2	38.9	*a* 46.6	48.4	44.9	*a* 55.3	Jan. 22, 1882
27	Clarksville, Tenn.							41.2	38.8	45.3	53.6	*d* 55.5	50.9	60.6	Jan., 1882
	Tennessee:														
28	Knoxville, Tenn.		8.5	16.1	14.6	22.5		16.2	3.6	8.0	17.0	3.4	21.6	39	March, 1875
29	Chattanooga, Tenn.	30.3	17.6	36.8	27.2	37.9	18.0	26.5	8.0	18.4	30.2	17.9	33.3	58.6	Mar. 11, 1867
30	Florence, Ala.	21.8	12.0	24.2	16.1	32.5	11.6	16.3	5.7	14.5	*a* 19.6	*a* 15.0	18.5	32.5	Mar. 19, 1897
31	Johnsonville, Tenn.	43.8	29.0	44.4	37.7	48.0	21.7	*a* 24.7	14.5	25.4	35.4	*a* 30.1	33.3	48	1882 Mar. 24, 1897

a Crest. *b* 27.5, Jan. 8. *c* 33.7, Jan. 9. *d* 55.9, Jan. 9.

HISTORY OF THE FLOOD OF MARCH-APRIL, 1913.

GENERAL CAUSES.

The flood of March-April, 1913, beginning on March 23 (Easter Sunday), was caused solely by excessive precipitation over a comparatively large area, as a result of which great volumes of water were literally dumped into the rivers of northern Indiana and Ohio, especially the Miami, Scioto, and Muskingum, which attained such overwhelming proportions and spread such sudden and far-reaching disaster and ruin. (See Table 3 and Pl. III, p. 20.) Only a small share of the damage can be ascribed to the failure of dams, for no large dams failed. These northern tributaries, hitherto comparatively impotent in creating extreme floods on the Ohio itself, were the chief and direct sources of the water which caused the destructively high stages during this flood on the main stream from Marietta, Ohio, to Maysville, Ky., and probably on down to Cairo, Ill. It is probable that the stages on the lower Ohio were increased by the effects of the levees constructed on the Mississippi at and below Cairo. Plate I (frontispiece) shows typical conditions on the main Ohio during this flood and the destruction along the northern tributaries.

It should be kept in mind that, in conjunction with this unprecedented flow from the northern tributaries of the Ohio, the eastern and southern tributaries were discharging very large quantities of water. The stages reached on these other tributaries were much higher than in ordinary floods but much lower than previously recorded maxima.

On the Ohio the rise was extremely rapid from March 25 to 29 at all points above Louisville. Crest stages were reached from Pittsburgh to Wheeling on March 28, and followed very quickly at other points from Marietta to Louisville, the crest passing the latter city on April 1. From Evansville to Cairo the rise was much less rapid, the crest not passing into the Mississippi until April 8.

The almost inconceivable damage wrought by the flood was unquestionably increased in a very great measure by the works of man in the channels, along the banks, and across the river valleys. Although the presence of the enormous volume of water may be considered nothing more nor less than "an act of God," still a large share of the blame for the resulting damage must be laid to man, not only for the positive harm done by the works of municipal and rural improvement. but also because of the entire absence of any comprehensive engineering works built for the prevention of such damage by floods.

In considering the cause of the flood the condition of the ground just prior to the flood and the amount of water already in the river channels should be noted. The ground was not frozen but was practically saturated by previous rains and so did not offer means of storing any considerable amount of the water and thereby tending to prevent its rapid discharge into the streams. It is extremely doubtful, however, if ground storage, even under the most favorable conditions, would have had any material effect in reducing this flood because of the intensity of the precipitation. No time was available in which the ground, even if it had not been saturated, might absorb the rain. In addition to these conditions, so favorable to rapid run-off, the river channels were fairly well filled, none of the tributaries being low, the main Ohio being at ordinary stage above Parkersburg and at comparatively high stage below Parkersburg. Plate II shows typical street scenes at Parkersburg and Marietta during this flood.

PRECIPITATION AND TEMPERATURE.

The two storms of March 23 to 27, 1913, which caused the flood, were preceded by a storm of moderate intensity, which passed down the St. Lawrence Valley March 22 and which had been accompanied by sufficient precipitation over the Ohio basin to moisten the soil and to cause it to become quickly saturated by the heavier rains that followed.

The distribution of the rainfall in the five days from March 23 to 27, as determined from rainfall records at a large number of stations, is shown on Plate III, which shows also principal streams, towns, and rainfall and gaging stations. The amount of precipitation, daily and total, for the same period at certain selected stations is shown in Table 3.

TABLE 3.—*Precipitation, in inches, at selected stations in or near Ohio River basin for Mar. 23–27, 1913.*

No.	Station.	Mar. 23.	Mar. 24.	Mar. 25.	Mar. 26.	Mar. 27.	Total.
	Ohio.						
1	Toledo	0.00	2.44	2.68	0.34	0.68	6.14
2	Circleville	0.20	1.50	2.00	2.30	0.40	6.40
3	Columbus	0.00	0.60	2.62	2.72	1.00	6.94
4	Cleveland	0.00	1.96	2.88	1.26	0.98	7.08
5	Sandusky	a 2.20	1.58	2.05	0.95	0.40	7.18
6	Cincinnati	a 0.00	2.21	4.15	1.11	0.00	7.47
7	Dayton	b 0.50	2.90	3.30	1.50	0.80	9.00
8	Bangorville	0.90	2.00	5.20	1.60	0.90	10.60
9	Marion	1.40	2.00	4.40	1.90	1.00	10.70
10	Bellefontaine	1.40	1.50	5.60	2.10	0.50	11.10
	Indiana.						
11	Notre Dame	0.00	1.42	0.84	0.00	....	....
12	Terre Haute	0.46	0.99	2.67	0.15	0.29	4.56
13	Anderson	b 2.34	1.50	2.51	0.50	0.14	6.99
14	Fort Wayne	0.00	2.76	1.92	0.07	0.61	5.36
15	Evansville	0.00	1.07	1.48	2.71	0.32	5.58
16	Indianapolis	0.17	1.53	3.41	0.48	0.42	6.01
17	Elliston	0.00	1.10	6.10	1.20	0.20	8.60
18	Madison	0.36	2.74	3.67	2.27	T.	9.04
19	Shoals	T.	0.37	6.66	1.80	0.45	9.28
	Illinois.						
20	La Salle	a 1.07	0.14	0.17	T.	T.	1.38
21	Peoria	0.23	1.03	0.06	0.01	0.09	1.42
22	Chicago	0.00	1.36	0.08	0.04	....	1.48
23	Springfield	0.62	0.72	2.22	....	0.24	3.80
24	Cairo	0.00	0.06	1.56	2.72	0.26	4.60

a Readings for 24 hours, midnight to midnight.
b Readings for 24 hours, 7 p. m. to 7 p. m.

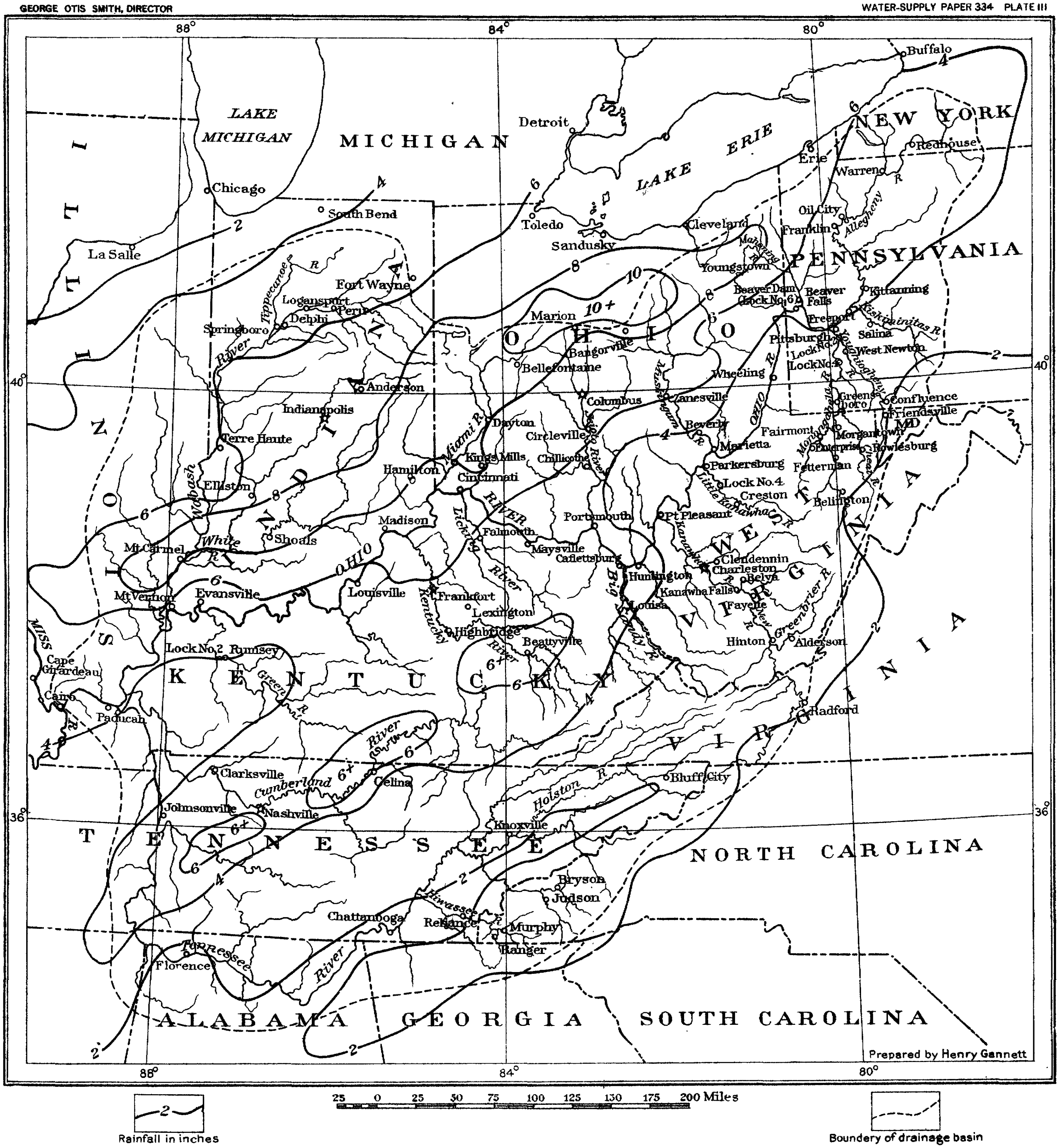
NOTE.—All other stations, readings 8 a. m. to 8 a. m.

A. SECOND STREET, MARIETTA, OHIO, DURING FLOOD OF MARCH-APRIL, 1913, AFTER WATER HAD FALLEN.

Mark on house shows crest height; note wrecked verandas.

B. MARKET STREET, PARKERSBURG, W. VA., DURING FLOOD OF MARCH-APRIL, 1913.

Detail view of street shown at center in Plate I, *A*.



MAP SHOWING RAINFALL IN OHIO RIVER BASIN, MARCH 23-27, 1913

TABLE 3.—*Precipitation, in inches, at selected stations in or near Ohio River basin for Mar. 23–27, 1913*—Continued.

No.	Station.	Mar. 23.	Mar. 24.	Mar. 25.	Mar. 26.	Mar. 27.	Total.
	Kentucky.						
25	Maysville	0.00	T.	0.16	2.03	1.29	3.48
26	Lexington	0.00	0.21	1.79	2.46	0.01	4.47
27	Falmouth	0.00	0.00	0.30	3.23	0.96	4.49
28	Frankfort	0.00	0.00	0.11	3.35	1.06	4.52
29	Louisville	T.	0.15	4.95	0.87	T.	5.97
30	Beattyville	0.00	0.00	0.00	3.04	3.28	6.32
	Tennessee.						
31	Chattanooga	0.00	0.00	T.	0.17	1.54	1.71
32	Knoxville	0.00	0.00	0.00	0.25	2.17	2.42
33	Nashville	0.00	T.	T.	2.32	0.65	2.97
	Missouri.						
34	St. Louis	[a] 1.06	3.59	0.39	0.80	0.01	5.85
	Michigan.						
35	Detroit	0.00	1.30	1.26	0.24	0.60	3.40
	Pennsylvania.						
36	Harrisburg	0.00	0.00	0.23	0.58	2.04	2.85
37	Pittsburgh	T.	0.20	0.72	1.72	0.86	3.50
38	Erie	0.00	1.32	2.76	1.02	1.04	6.14
	West Virginia.						
39	Parkersburg	0.00	0.08	0.05	1.60	1.28	3.01

[a] Readings for 24 hours, midnight to midnight.

The first of the two storms of March 23–27 developed on the morning of the 22d over the far West, with a center over Nevada. During the succeeding 24 hours this disturbance moved slowly eastward, gathering energy, and at 8 a. m. on the 23d was central over Colorado. By this time it was well developed and was attended by rains over Indiana, Illinois, and portions of Iowa and Wisconsin.

During the day of the 23d the storm moved east-northeastward, and at 8 p. m., seventy-fifth meridian time, was central slightly to the northeast of Omaha, Nebr. The rain area had advanced to the region of the lower Lakes, western New York, and western Pennsylvania, so that at this hour precipitation was taking place over practically the entire drainage basin of Ohio River.

Meanwhile, as the center of the storm was drifting slowly eastward from the neighborhood of Nebraska during the afternoon and early night of the 23d, a number of small tornadic storms formed in Michigan, Indiana, Illinois, Iowa, and Nebraska. Several towns and cities received more or less damage from these concentrated disturbances, including Council Bluffs, Iowa, and Terre Haute, Ind., but by far the most terrible infliction from any of these tornadoes, in that numerous lives were lost, occurred at Omaha, Nebr.

During the night of March 23–24 the precipitation area of the main storm extended eastward, and on the morning of Monday, the 24th, had reached the Atlantic Ocean. The rain was becoming excessive in many places, especially over the height of land separating the basins of Ohio River and southern Lake Erie.

The first storm was central at 8 a. m. on March 24 over and to the north of the upper Lakes. Thence it moved northeastward, and by 8 p. m. was far down in the St. Lawrence Valley, with an area of high pressure in its rear.

Early on March 24 another disturbance had formed over the southwest and was developing into an elongated trough of low pressure, which rapidly extended eastward, and at night of the 24th was attended by rain as far in advance of this second storm as the rear of the precipitation area of the first storm.

Here another factor must be taken into consideration. In advance of the first storm which caused the tornadoes of the 23d, a great bank of high pressure moved eastward across the Atlantic States and into the ocean. It settled over the Bermudas and there remained practically stationary until the 27th. Thus while the second storm from the West was pressing eastward during the 24th, an area of high pressure existed off the Atlantic coast and another area was spreading eastward from the region of the Great Lakes. At 8 p. m. on the 24th these two areas of high pressure were separated only by a lane of low pressure, which extended northeast-southwest over the Ohio basin and connected the approaching with the vanishing storm. The rain area of this new storm, while continuous with that of the preceding storm, was also attended by heaviest precipitation over the region already flooded or threatened with flood. Heavy rains continued throughout the night of Monday–Tuesday (24–25), and by 8 a. m. on the 25th the amount of rainfall at some river stations in north-central Ohio exceeded 6 inches.

On the morning of the 25th a shallow trough of low pressure, with centers over Arkansas and the Ohio Valley, extended from New England to Texas. The temperature was at freezing or below in northern Indiana and Illinois and snows were taking the place of the rains to the north and west. Owing to the persistence of the area of high pressure along the Northern States, the storm was checked in its forward movement and continued to flood the Ohio Valley.

During Tuesday, the 25th, the rain area spread southward and precipitation became heavier toward the east. Reports to the United States Weather Bureau at 8 a. m. on Wednesday, March 26, showed little change in the storm area since the previous morning, but during the 26th the southern portion of the trough of low pressure moved eastward from the Mississippi Valley, so that by the morning of the 27th (Thursday) it lay north and south from New York to North Carolina and the precipitation had turned to snow over the Ohio Valley. By this time the area of high pressure over Canada was proceeding into the ocean and the bank of high pressure over the Bermudas was slowly giving way. Consequently, the storm that had so long poured its waters upon the endangered region was able to advance more freely and by the morning of the 28th was passing rapidly northeastward from New England.

Thus it is seen that these two storms passed in succession, with the peculiar condition that one disturbance followed the other so closely that the rain areas of the two blended, concentrating over the same portion of the country and creating the most disastrous flood in the history of the Ohio Valley.

The best idea of the intensity and distribution of the combined storms over the drainage basins in the Ohio Valley may be gained from a study of Plate III (p. 20).

It should be noted that no extremely low temperatures existed immediately before, during, or after this flood; that the ground in Indiana and Ohio, and in fact all of the Ohio Valley, was not frozen and, further, that there was no snow or ice stored in any part of the Ohio River drainage basin. A more complete meteorologic history of these storms, with charts, will be found in the publications of the United States Weather Bureau, from which much of the above information was taken.

PROGRESS OF THE FLOOD.

The progress of the flood is shown clearly by the graphic representation of gage heights on Plates IV and V and by Tables 4, 5, 11, and 12 (pp. 25, 26, 48, 49).

The Miami, the most westerly of the tributaries from the State of Ohio, was the first large stream to reach alarming proportions. A large measure of the attention drawn to this river, and more particularly to Dayton, the principal city along its banks, is due to this fact. Plate VI gives typical views of Dayton immediately after the flood. At Dayton a crest stage of 29.0 feet—about 8.0 feet higher than the crest of any other known flood at that place (21.3 feet in 1866)—was reached about 1 a. m. March 26. The crest reached Hamilton about 3 a. m. on the same day, the maximum stage being 34.6 feet, about 13.5 feet higher than the previously recorded maximum (21.2 feet March 24, 1898). On Scioto River, whose headwaters adjoin those of Miami River, crest stages occurred practically simultaneously with those on the Miami. At Columbus (drainage area less than two-thirds of that above Dayton) the crest of 22.9 feet, only 1.6 feet greater than the previous maximum (21.3 feet March 23, 1898), occurred at noon on March 25, and at Chillicothe the crest of 37.8 feet, 9.5 feet higher than the previous maximum (28.3 feet March 24, 1898), was reached at 11 a. m., March 26. The flood followed quickly on Muskingum River, the largest and most easterly of the three principal streams in the State of Ohio. At Zanesville a maximum of 51.8 feet occurred in the early morning of March 27, just 15 feet higher than the highest stage previously on record (36.8 feet March 24, 1898). At Beverly, only 20 miles from the mouth of the Muskingum, the crest of 46.5 feet, about 11 feet above the maximum (35 feet March, 1898), was reached on March 27.

Thus it will be noted that although the progress of the storms was from the mouth toward the source of Ohio River, the crests from the northern tributaries in the State of Ohio reached the main stream within a period of about 24 hours of each other and within from three to four days of the very beginning of the precipitation. This accounts for the extreme rapidity of the rise on the Ohio from Marietta to Portsmouth, as shown on Plate IV. By the night of March 27 and the morning of the 28th crests from all tributaries of the Ohio above the Kanawha had reached the main stream. Flow from portions of the Monongahela system came in later than most of the others, which accounts for the lagging of the crest at Pittsburgh. Crest stages occurred at Pittsburgh, Beaver Dam, and Wheeling on March 28 but were below previously recorded maxima. Crests from the remaining tributaries reached the Ohio on March 28, with the exception of those from the Wabash, Cumberland, and Tennessee rivers. (The crest of April 5 on Green River was due to backwater.) Crest stages on Ohio River from Marietta to Louisville were reached successively March 29 to April 1, as shown by Table 11 (p. 48).

The effect of the northern tributaries in Ohio on the stages of the main stream is most marked from Marietta to Maysville, and throughout this portion of the Ohio new high-water records were established. Muskingum River was more instrumental than any other single tributary in causing the record-breaking stages on the Ohio, as shown by the fact that previously recorded maxima were surpassed at Marietta and Parkersburg by 5 to 5.5 feet, the greatest other increase being 2.8 feet at Point Pleasant. Previous maximum stages at Cincinnati, Louisville, and Evansville were not surpassed by the flood of March-April, 1913. Crests from Wabash, Cumberland, and Tennessee rivers reached the Ohio on March 29 and 30. The effect of the Wabash and its tributaries, which broke all previous high-water records, is shown at Mount Vernon, Paducah, and Cairo, at which places, particularly at Mount Vernon, all previously recorded maxima were exceeded. The Cumberland and Tennessee were not in extreme flood during the period of maximum stage at Cairo. Stages at Cairo and points on the Ohio within the influence of backwater from the Mississippi were no doubt increased by the levees at and below Cairo, all of which held during this flood.

STAGE AND DISCHARGE.

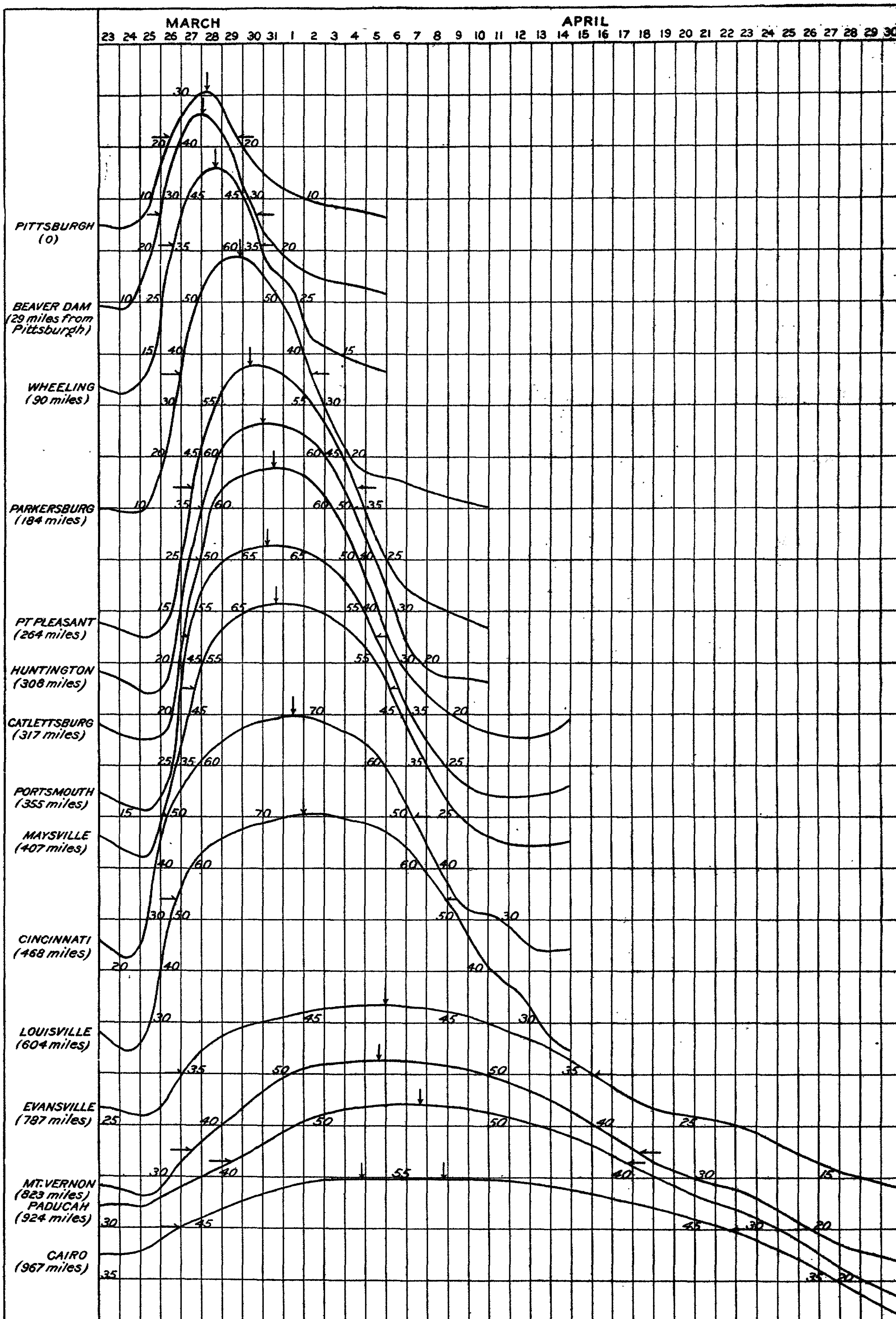
Records of stage, obtained from records of the United States Geological Survey, United States Weather Bureau, and United States Engineer Corps, for periods sufficiently long to cover the entire flood of March-April, 1913, are presented in Tables 4 and 5. The gage heights represent one reading each day taken about 7 or 8 a. m. Some of the data were taken from advance publications and records quickly prepared and may be subject to slight revision.

A. MIAMI STREET CANAL BRIDGE, DAYTON, OHIO, AFTER THE FLOOD OF MARCH-APRIL, 1913.

Note the dead horse on bridge rail.

B. POST OFFICE, DAYTON, OHIO, AFTER THE FLOOD OF MARCH-APRIL, 1913.

Dead horse in front of left radiator.



FLOOD HYDROGRAPHS (GAGE HEIGHTS) FOR 15 STATIONS ON OHIO RIVER DURING THE FLOOD OF MARCH-APRIL, 1913.

The distance of each station below Pittsburgh and the danger line (indicated by horizontal arrows) are shown. For gage heights see Table 4, page 25.

TABLE 4.—*Gage height, in feet, at stations on Ohio River for flood of March–April, 1913.*

No.	Station.	March.												April.										
		20	21	22	23	24	25	26	27	23	29	30	31	1	2	3	4	5	6	7	8	9	10	11
1	Pittsburgh, Pa.	5.8	5.3	5.3	4.8	4.5	7.8	20.1	28.1	30.4	24.8	17.8	13.7	11.4	9.6	8.6	7.9	7.1	6.5	6.2	5.7	4.9	4.5	4.3
2	Beaver Dam (No. 6), Pa.	11.1	10.2	9.7	9.1	9.0	17.0	34.0	44.8	46.3	40.7	30.0	22.2	18.2	15.8	14.1	13.5	12.5	11.6	11.1	10.5	9.7	9.0	8.8
3	Wheeling, W. Va.	11.0	9.8	8.8	8.3	7.5	11.5	30.5	45.5	50.8	50.0	43.0	32.1	28.3	18.3	15.5	13.9	12.8	11.5	10.5	9.5	9.3	7.0	7.8
4	Parkersburg, W. Va.	13.0	11.5	10.5	10.0	9.5	10.0	22.1	43.0	54.9	58.7	57.9	53.8	47.5	38.1	27.2	19.5	16.5	15.8	14.2	12.9	11.8	10.9	10.5
5	Point Pleasant, W. Va.	19.8	16.6	14.1	12.3	11.1	10.1	13.2	34.1	50.6	60.2	62.8	62.2	60.1	55.2	49.6	42.0	31.7	22.6	18.2	16.4	14.4	12.9	11.4
6	Huntington, W. Va.	25.2	21.7	19.7	17.9	16.1	14.1	17.2	39.4	54.5	63.8	66.0	66.4	65.2	63.7	58.4	51.0	41.0	30.0	21.1	18.0	17.2	16.7	16.2
7	Catlettsburg, Ky.	25.5	22.1	19.5	17.3	15.8	15.5	17.2	41.1	57.5	65.1	66.3	67.7	a66.5	a65.3	a60.7	53.2	43.5	33.5	27.0	22.6	19.7	17.5	16.1
8	Portsmouth, Ohio	27.8	24.4	21.5	19.1	17.4	16.1	21.9	51.0	61.9	65.8	67.0	67.9	67.5	66.0	63.2	59.0	51.6	43.0	34.7	28.0	23.3	20.1	19.0
9	Maysville, Ky.	29.2	26.0	23.1	20.3	18.4	17.1	28.8	44.3	57.5	62.8	65.2	66.0	66.3	65.7	63.7	60.6	55.8	48.7	40.7	33.2	26.7	22.5	20.7
10	Cincinnati, Ohio	32.5	30.0	27.5	24.7	22.6	29.3	50.3	57.2	62.6	66.0	67.9	69.2	69.8	69.5	68.0	66.0	63.3	57.8	50.5	42.8	34.9	31.3	30.5
11	Louisville, Ky. (Lower)	32.7	31.2	29.7	27.3	24.6	28.6	48.1	59.3	64.2	66.7	68.3	69.3	70.2	70.5	70.1	69.2	68.3	66.4	63.2	58.3	51.5	44.5	39.5
12	Evansville, Ind.	27.0	27.6	28.4	28.3	27.5	26.0	30.1	36.6	40.4	43.0	44.4	45.4	46.4	47.2	47.8	48.2	48.3	48.1	47.9	47.5	46.7	45.8	44.4
13	Mount Vernon, Ind.	26.2	27.0	27.7	27.9	27.2	26.3	29.0	34.3	38.2	41.2	43.9	47.4	50.1	51.5	52.3	52.7	52.9	52.8	52.5	52.1	51.4	50.7	49.3
14	Paducah, Ky.	31.3	32.0	33.6	34.3	34.4	34.3	36.9	38.5	40.7	42.6	44.7	47.0	49.6	51.5	52.7	53.5	53.9	54.1	54.2	54.0	53.6	53.0	52.4
15	Cairo, Ill.	35.2	36.8	39.0	39.9	40.3	40.9	43.5	45.5	47.4	49.1	50.7	52.0	53.2	54.1	54.5	54.7	54.7	54.7	54.7	54.7	54.6	54.5	54.4

No.	Station.	April.																			Crest.		
		12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Stage.	Date.	Time.
1	Pittsburgh, Pa.	4.1	4.7	5.4	5.9																30.4	Mar. 28	6.00 a. m.
2	Beaver Dam (No. 6), Pa.	9.1	9.8	10.5	11.2																46.6	..do..	1.00 a. m.
3	Wheeling, W. Va.	7.8	8.2	9.2	9.8																51.1	..do..	4.00 p. m.
4	Parkersburg, W. Va.	10.8	10.9	11.1	12.0																58.9	Mar. 29	8.00 p. m.
5	Point Pleasant, W. Va.	11.6	12.0	13.9	17.7																62.8	Mar. 30	8.00 a. m.
6	Huntington, W. Va.	16.0	16.0	16.7	20.8																66.4	..do..	12.00 p. m.
7	Catlettsburg, Ky.	15.6	15.9	17.0	20.6																67.7	Mar. 31	11.00 a. m.
8	Portsmouth, Ohio	19.0	19.4	20.0	22.0																67.9	..do..	5.00 a. m.
9	Maysville, Ky.	19.5	19.5	19.7	20.7																66.4	..do..	3.00 p. m.
10	Cincinnati, Ohio	27.3	24.0	24.1	24.3																69.8	Apr. 1	12.00 m.
11	Louisville, Ky. (Lower).	36.4	31.0	26.0	24.2	24.0	23.8	26.0	29.0	29.4											70.6	..do..	12.00 p. m.
12	Evansville, Ind.	42.7	41.1	39.3	36.8	34.3	31.8	29.8	28.0	27.1	26.6	25.9	24.6	22.8	21.0	19.1	17.4	15.9	14.7	13.7	48.4	Apr. 5	12.00 p. m.
13	Mount Vernon, Ind.	47.9	46.1	44.2	42.1	39.6	37.2	34.7	32.2	30.7	29.4	28.2	27.0	25.1	22.8	20.4	18.3	16.5	15.4		52.9	..do..	4.00 p. m.
14	Paducah, Ky.	51.5	50.1	49.0	47.3	45.6	43.7	41.8	39.8	37.7	36.2	34.7	33.2	31.5	29.5	27.5	24.2	22.0	19.8	17.9	54.3	Apr. 7	4.00 p. m.
15	Cairo, Ill.	54.1	53.6	53.0	52.3	51.5	50.7	49.8	48.8	47.6	46.4	45.2	43.7	42.2	40.3	38.7	36.3	33.9	31.6	29.6	54.8	Apr. 4, 8	7.00 p. m.

a Obtained by comparison with Huntington.

TABLE 5.—*Gage height, in feet, at stations on streams*

No.	River and station.	March.												April.	
		20	21	22	23	24	25	26	27	28	29	30	31	1	2
	Allegheny:														
1	Redhouse, N. Y.	5.2	5.0	4.8	6.2	8.8	10.8	12.7	12.6	12.2	11.0	9.6	8.7	7.2	6.5
2	Warren, Pa.	3.0	2.7	2.4	2.2	3.8	8.0	14.1	14.8	14.1	12.5	10.2	8.2	6.9	5.7
3	Franklin, Pa.	4.1	3.7	3.5	3.2	6.1	11.6	22.0	21.1	19.5	15.3	12.2	9.7	8.2	6.9
4	Freeport, Pa.	7.6	7.0	6.5	6.2	5.9	16.2	26.4	31.9	29.5	23.5	19.0	15.4	13.2	11.4
	Tygart:														
5	Belington, W. Va.	3.8	3.7	3.7	3.4	3.3	3.0	3.2	6.9	10.5	6.8	5.3	4.9	4.4	4.0
6	Fetterman, W. Va.	5.2	5.2	5.0	4.7	4.6	4.6	5.1	9.0	13.4	9.4	7.2	6.4	6.0	5.6
	Monongahela:														
7	Fairmont, W. Va.	15.2	15.0	15.1	15.0	14.9	14.8	14.8	20.2	22.4	19.1	16.9	16.4	15.8	15.3
8	Greensboro, Pa.	8.4	8.2	8.0	7.9	7.8	7.7	8.0	14.6	18.7	13.6	10.8	9.7	9.2	8.6
9	Lower Lock No. 4, Pa.	9.5	9.1	8.8	8.5	8.2	9.0	10.0	16.2	25.2	20.2	14.8	12.3	11.1	10.2
10	Upper Lock No. 2, Pa.	12.1	11.8	12.1	11.9	11.8	11.6	12.9	19.5	23.6	19.1	14.8	13.1	12.5	11.9
11	West Fork, Enterprise, W. Va.	2.8	2.6	2.4	2.2	2.1	2.1	3.0	14.5	11.8	5.8	4.4	3.7	3.1	2.8
12	Cheat, Morgantown, W. Va.	3.9	3.7	3.6	3.5	3.5	3.3	3.6	7.0	8.2	5.9	5.0	4.6	4.3	4.0
	Youghiogheny:														
13	Confluence, Pa.	1.6	1.8	1.6	1.3	1.3	1.1	1.6	4.9	4.8	3.5	2.9	2.5	2.4	2.0
14	West Newton, Pa.	2.1	2.1	2.0	1.8	1.5	1.3	2.2	7.4	8.5	5.7	4.3	3.6	3.1	2.7
15	Beaver, Beaver Falls, Pa.	4.9	4.7	4.6	4.4	6.6	13.2	16.7	17.4	15.1	12.0	8.9	6.8	5.2	5.7
16	Mahoning, Youngstown, Ohio.	0.9	0.7	0.6	0.5	4.7	15.5	....	....	....	10.4	3.0	1.8	1.6	1.4
17	Tuscarawas, Canal Dover, Ohio.	....	....	....	....	2.3	7.0	13.0	15.0	16.1	9.0	7.0	5.0	3.0	3.0
	Muskingum:														
18	Zanesville, Ohio.	10.2	10.1	9.9	9.7	9.9	21.2	....	51.8	....	....	34.0	30.0	24.5	20.2
19	Beverly, Ohio.	8.4	8.0	7.9	7.6	7.7	16.6	....	c46.5	....	....	....	....	26.0	19.6
20	Mohican, Pomerene, Ohio.	3.6	3.7	4.0	3.9	4.0	21.0	....	....	a18.0	a16.0	a14.0	a13.0	(d)	(d)
	Little Kanawha:														
21	Creston, W. Va.	3.4	3.2	3.1	3.1	2.9	2.8	4.2	16.0	18.9	9.5	5.5	4.5	4.1	3.7
22	Upper Dam No. 4, W. Va.	10.6	10.5	10.5	10.4	10.3	10.2	10.7	17.9	19.2	18.2	17.4	13.6	11.0	10.8
	New:														
23	Radford, Va.	4.9	4.5	4.6	4.6	4.4	4.4	4.3	10.0	12.8	7.6	6.1	5.6	5.1	4.7
24	Hinton, W. Va.	3.5	3.3	3.2	3.1	3.0	2.9	2.8	6.5	11.6	7.2	5.7	4.6	4.0	3.6
25	Fayette, W. Va.	7.0	7.0	7.5	7.4	5.2	4.9	4.7	11.8	a35.0	21.2	12.1	10.5	9.1	7.1
	Kanawha:														
26	Kanawha Falls, W. Va.	5.7	5.2	4.8	4.5	4.1	2.7	3.4	7.6	26.3	15.9	10.5	7.6	6.5	5.8
27	Charleston	7.0	6.5	6.0	5.9	5.7	5.5	5.5	10.2	33.2	30.1	21.0	19.0	17.0	13.7
28	Greenbrier, Alderson	3.4	3.2	3.1	3.0	2.8	2.8	2.8	10.0	16.3	6.6	4.9	4.2	3.8	3.4
29	Gauley, Belva	4.5	4.2	4.0	3.8	3.6	3.4	3.4	8.0	11.8	7.4	6.4	5.7	5.0	4.6
30	Elk, Clendenin	4.8	4.6	4.6	4.2	4.0	3.9	5.0	14.1	17.2	10.5	7.3	6.3	5.5	5.0
31	Big Sandy (Upper Lock No. 3), Louisa, Ky.	8.0	7.3	7.4	7.0	6.6	6.1	12.8	29.5	42.0	39.5	35.0	35.3	34.5	33.0
	Scioto:														
32	Columbus, Ohio	4.4	4.5	4.4	4.8	6.2	21.9	20.9	19.7	17.4	14.7	12.0	9.6	8.3	6.4
33	Chillicothe, Ohio	1.6	1.6	1.6	1.6	1.6	11.9	c37.8	....	....	24.6	16.0	12.0	11.4	11.1
34	Licking, Falmouth, Ky	3.7	3.8	3.9	4.2	4.0	3.6	29.1	33.8	32.2	23.6	20.1	19.0	17.0	12.2
	Miami:														
35	Dayton, Ohio	2.7	2.8	3.0	3.0	7.0	a24.0	b28.1	b22.2	b15.7	11.0	9.1	7.3	6.6	5.8
36	Hamilton, Ohio	2.8	3.0	3.0	3.0	4.8	19.7	c34.6	25.0	19.2	14.8	....	....	....	....
	Kentucky:														
37	Highbridge, Ky.	11.3	10.9	11.5	11.4	11.3	11.1	21.0	34.0	33.4	33.5	33.5	27.3	14.5	12.2
38	Frankfort, Ky.	8.7	8.8	8.6	8.7	8.5	8.5	15.8	35.2	38.3	37.5	37.2	35.1	26.8	10.2
39	Green, Upper Lock No. 2, Ky.	11.3	11.3	15.5	13.5	14.0	13.8	19.5	23.0	24.5	25.8	27.2	28.8	30.0	30.6
	Wabash:														
40	Terre Haute, Ind.	6.8	6.0	7.1	7.0	14.5	19.5	27.0	31.2	30.8	29.2	26.8	24.0	22.0	20.7
41	Mount Carmel, Ill.	13.4	12.2	11.9	13.4	13.6	18.3	21.4	23.0	24.8	27.8	31.0	30.2	29.2	28.2

a Approximate. b Calculated from careful measurements. c Crest stage, not regular reading.

tributary to Ohio River for flood of March–April, 1913.

April.													Crest.			No.
3	4	5	6	7	8	9	10	11	12	13	14	15	Stage.	Date.	Time.	
6.1	6.0	6.6	6.0	5.9	5.6	5.4	5.6	5.6	5.6	5.3	5.2	5.2	[e]12.7	Mar. 26	12.00 m....	1
4.9	4.0	4.0	4.0	4.0	3.7	3.3	3.1	3.0	2.9	3.3	3.0	2.7	15.2	...do.....	5.00 p.m..	2
5.9	5.3	5.1	5.2	4.9	4.6	4.2	3.9	3.8	4.5	4.5	4.2	4.1	[e]22.0	...do.....	8.00 a.m...	3
10.0	9.2	8.4	8.3	8.2	7.4	7.0	6.5	6.3	6.5	7.4	7.5	7.5	31.9	Mar. 27	6.30 a.m...	4
4.0	3.8	3.8	3.7	3.6	3.5	3.5	3.5	3.4	3.5	3.5	3.4	3.5	10.5	Mar. 28	7.00 a.m...	5
5.1	5.0	4.8	4.7	4.6	4.6	4.4	4.4	4.3	4.4	4.7	5.2	6.0	[e]13.4	Mar. 27	5.00 p.m...	6
15.2	15.1	14.9	14.9	14.8	14.8	14.8	14.8	14.7	15.0	15.2	15.2	15.6	23.6	...do.....	7.00 p.m..	7
8.4	8.2	8.0	7.9	7.9	7.8	7.8	7.7	7.7	7.8	8.0	8.6	8.2	[e]18.7	Mar. 28	8.00 a.m...	8
11.0	9.8	9.3	8.9	8.8	8.4	8.2	8.9	9.0	9.2	9.8	10.0	11.2	[e]25.2	...do.....	8.00 a.m...	9
12.3	12.2	11.7	11.4	11.4	11.0	10.8	10.5	10.5	11.2	11.4	11.7	12.4	23.8	...do	11.00 a.m..	10
2.7	2.6	2.4	2.1	2.0	1.9	1.8	1.7	2.5	2.9	2.7	2.6	2.3	16.2	Mar. 27	3.00 p.m..	11
4.0	3.8	3.6	3.6	3.4	3.4	3.3	.....	3.0	3.5	3.5	4.9	4.6	[e]8.2	Mar. 28	8.00 a.m...	12
3.3	2.8	2.5	2.0	1.8	1.7	1.6	1.4	1.1	1.7	1.8	2.8	3.2	5.6	Mar. 27	2.00 p.m...	13
4.8	4.2	3.6	2.9	2.4	2.2	2.0	1.7	1.6	1.9	2.1	2.8	3.4	9.7	...do.....	During night.	14
5.5	5.5	5.5	5.4	5.1	4.8	4.6	4.4	4.5	5.4	5.3	5.2	5.7	17.4	...do.....	6.00 a.m...	15
1.3	1.6	1.8	1.9	1.4	1.0	0.8	0.7	1.2	2.1	1.6	1.7	1.7	......	....	....	16
3.8	3.7	3.4	3.0	2.8	2.4	2.2	2.0	2.0	2.5	2.5	2.0	2.0	16.2	Mar. 28	12.00 m....	17
17.5	16.2	17.5	17.6	16.7	14.2	13.0	12.3	12.3	13.0	12.8	14.8	14.7	51.8	Mar. 27	Early morning.	18
15.5	14.0	15.6	16.1	14.3	12.6	11.4	10.5	10.3	11.1	11.0	12.2	12.9	46.5	...do.....	....	19
(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	[e]26.0	Mar. 25	2.00 p.m...	20
3.4	3.2	3.2	3.0	2.9	2.9	2.8	2.8	2.8	3.8	4.3	3.8	3.8	20.4	Mar. 28	5.00 a.m...	21
10.6	10.5	10.5	10.4	10.3	10.2	10.2	10.2	10.2	11.0	11.3	11.0	10.9	19.5	...do.....	6.00 a.m...	22
4.6	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.2	5.4	8.0	7.7	6.0	15.0	Mar. 27	8.00 p.m...	23
3.4	3.3	3.1	2.9	2.8	2.7	2.6	2.6	2.6	2.9	5.2	6.7	6.0	14.5	Mar. 28	10.00 p.m..	24
6.2	5.1	4.9	4.9	4.7	4.7	4.5	3.8	4.2	4.2	9.8	17.9	14.3	36.5	...do.....	Early morning.	25
5.2	4.6	4.2	4.0	3.6	3.2	3.1	3.0	2.8	3.0	4.2	11.7	11.7	27.5	...do.....	2.00 a.m...	26
9.0	6.0	5.9	5.5	5.5	5.3	7.0	7.0	7.0	7.3	8.0	12.0	14.0	34.8	...do.....	4.00 p.m...	27
3.2	3.1	3.0	2.8	2.8	2.6	2.6	2.6	2.5	2.9	8.6	7.2	7.8	19.4	Mar. 27	6.00 p.m...	28
4.2	3.8	3.8	3.6	3.5	3.3	3.2	3.1	3.1	3.2	4.4	4.4	9.6	15.0	...do.....	3.00 p.m...	29
4.7	4.5	4.3	4.2	4.0	3.8	3.8	3.8	3.7	4.2	4.1	4.5	6.1	21.3	...do.....	During night.	30
29.5	22.6	14.4	8.6	7.2	6.4	5.9	5.6	5.7	5.9	5.9	5.8	10.7	42.8	Mar. 28	12.00 m....	31
6.0	11.2	11.2	8.8	6.8	5.4	4.0	5.0	7.0	6.7	5.8	8.7	7.6	22.9	Mar. 25	12.00 m....	32
8.7	8.5	11.0	12.9	10.9	8.2	7.1	6.0	6.6	9.0	10.5	11.9	12.1	37.8	Mar. 26	11.00 a.m..	33
4.7	4.7	4.0	3.5	3.3	3.1	3.0	2.9	8.6	4.0	4.5	4.3	4.0	34.1	Mar. 27	1.30 p.m...	34
5.4	9.5	10.2	7.1	5.9	5.2	4.7	5.5	8.7	8.0	8.6	9.7	7.8	29.0	Mar. 26	1.00 a.m...	35
[a]7.0	[a]13.0	11.0	6.3	5.3	5.5	.....	.....	.....	.....	.....	.....	.....	34.6	...do.....	3.00 a.m...	36
11.5	11.1	10.8	10.7	10.5	10.3	10.2	10.1	10.2	10.4	10.6	10.6	10.7	[e]34.6	Mar. 27	7.00 a.m...	37
9.0	8.6	8.3	8.3	8.0	7.9	7.8	7.8	8.9	8.0	8.2	8.2	8.2	38.3	Mar. 28	5.00 a.m...	38
30.9	31.1	31.2	31.1	31.0	30.7	30.3	29.9	29.0	28.3	27.6	27.0	26.0	[e]31.2	Apr. 5	8.00 a.m...	39
19.4	18.6	17.6	16.9	16.0	15.5	14.7	14.9	15.4	15.8	15.9	16.0	16.2	[e]31.2	Mar. 27	7.00 a.m...	40
27.2	26.4	25.7	24.9	24.2	23.6	23.0	22.6	22.3	22.0	21.7	21.4	21.1	31.0	Mar. 30	7.00 a.m...	41

[d] Gage washed away.   [e] Highest recorded, may not be crest.

TABLE 5.—*Gage height, in feet, at stations on streams*

No.	River and station.	March.												April.	
		20	21	22	23	24	25	26	27	28	29	30	31	1	2
42	White, West Branch Elliston, Ind.	.....	.....	.....	.....	11.8	23.8	27.8	31.3	30.4	28.6	26.5	24.1	23.0	22.4
43	White, East Branch Shoals..............	6.2	6.0	7.4	8.0	8.8	21.6	29.5	37.0	42.2	41.7	39.6	36.8	33.8	30.5
	Cumberland:														
44	Celina, Tenn......	13.7	9.9	10.5	9.9	11.2	10.7	22.0	38.8	45.2	46.2	48.2	47.9	44.7	38.6
45	Nashville.........	28.5	23.4	21.5	17.4	17.5	16.2	25.0	39.3	42.7	42.8	43.5	44.4	44.8	44.9
46	Clarksville.........	32.1	30.9	29.7	24.4	20.6	20.1	31.6	47.3	50.5	50.5	49.6	49.3	49.1	49.1
47	French Broad, Asheville, N. C.	1.8	1.2	2.4	1.8	1.5	1.6	2.1	5.2	4.0	4.3	3.3	2.5	2.0	1.6
	Tennessee:														
48	Knoxville, Tenn..	4.8	4.2	4.5	4.8	4.2	3.5	3.2	7.3	20.9	20.1	12.1	7.8	5.7	4.7
49	Chattanooga......	17.5	13.1	12.9	12.9	12.3	11.2	10.1	13.3	25.4	31.2	33.1	32.9	26.9	17.1
50	Florence, Ala.....	17.5	18.5	18.0	16.0	13.7	12.0	10.7	13.7	14.0	15.7	16.0	16.5	17.2	17.7
51	Johnsonville, Tenn	25.4	26.3	27.5	28.0	28.5	28.4	29.4	32.1	33.0	33.3	32.7	32.1	31.3	30.5

tributary to Ohio River for flood of March-April, 1913—Continued.

April.													Crest.			No.
3	4	5	6	7	8	9	10	11	12	13	14	15	Stage.	Date.	Time.	
20.2	19.8	20.0	19.6	18.7	17.0	16.0	17.6	18.6	21.7	22.6	22.9	22.0	a 31.3	Mar. 27	7.00 a.m...	42
28.0	26.8	25.2	22.5	21.1	20.9	19.7	19.0	18.0	17.4	17.9	19.3	19.9	42.2	Mar. 28	7.00 a.m...	43
19.6	10.2	8.7	7.8	7.3	6.9	6.3	5.7	6.5	7.0	7.2	7.4	8.1	48.6	Mar. 30	2.30 p.m...	44
44.8	44.1	40.0	27.5	15.3	12.5	11.8	11.4	13.8	13.0	12.0	11.8	11.6	44.9	Apr. 2	7.00 a.m...	45
49.1	49.0	48.8	46.5	38.2	29.3	23.7	20.6	19.1	19.6	17.5	15.9	14.7	50.9	Mar. 28	5.00 p.m...	46
1.6	1.4	1.4	1.2	1.1	1.0	1.0	0.9	1.7	3.7	3.5	2.7	2.8	a 5.2	Mar. 27	8.00 a.m...	47
4.0	3.4	3.2	3.0	2.7	2.5	2.4	2.3	2.3	2.4	2.9	4.2	4.4	21.6	Mar. 28	3.00 p.m...	48
12.5	10.9	9.9	9.2	8.5	8.0	7.6	7.2	6.9	6.8	6.7	7.0	7.8	33.3	Mar. 30	12.00 m...	49
17.9	17.6	15.3	11.5	9.1	7.7	7.0	6.3	6.0	5.9	5.5	5.2	5.2	a 18.5	Mar. 21	7.00 a.m...	50
30.6	30.9	31.4	31.7	31.4	30.0	27.5	25.9	25.4	23.7	21.8	19.9	18.0	33.3	Mar. 29	7.00 a.m...	51

a Highest recorded; may not be crest.

It should be noted that at Cairo the flood of March-April, 1913, was 0.8 foot higher than the previous maximum (54.0 feet April 6–7, 1912), and 3.0 feet higher than the 1884 flood, whereas at Paducah the 1913 flood surpassed the previous maximum, the 1884 flood, by only 0.1 foot. It is also interesting to note that at Cairo the flood of 1912 was 2.2 feet higher than the flood of 1884, whereas at Paducah the flood of 1912 was 4.4 feet lower than that of 1884.

The distinguishing feature of the recent flood at and below Evansville is the long duration of the stage. (See Pl. IV, p. 24.) The maximum stage at Cairo occurred on April 4 and 8, 1913, and during these five days the stage was within 0.1 foot of the maximum.

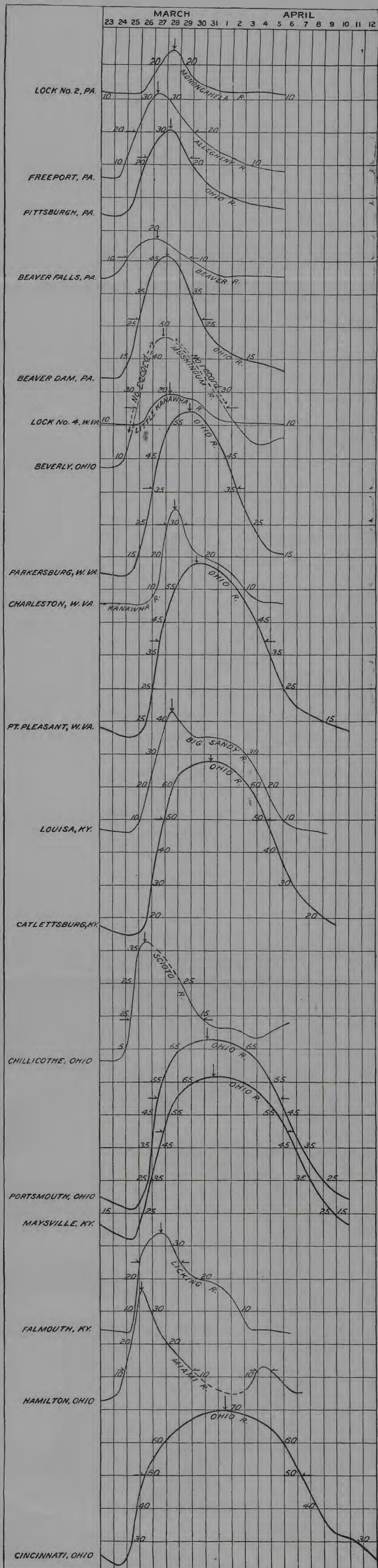
The daily discharge during the recent flood at six stations on Ohio River is given in Tables 13 and 14 (pp. 52, 66), and summaries of the flood-flow records are given in Tables 15, 16, and 17 (pp. 75, 78, 80). Unfortunately it is impossible to give discharge data for the tributaries because practically no discharge rating tables are available which cover the extremely high stages reached during this flood. The study of the distribution of the run-off over the drainage basin and the effect of the various tributaries on the main stream will have to be made from the rainfall map (Plate III, p. 20), the gage-height records on the tributaries, and the discharge data at the six stations on the main stream.

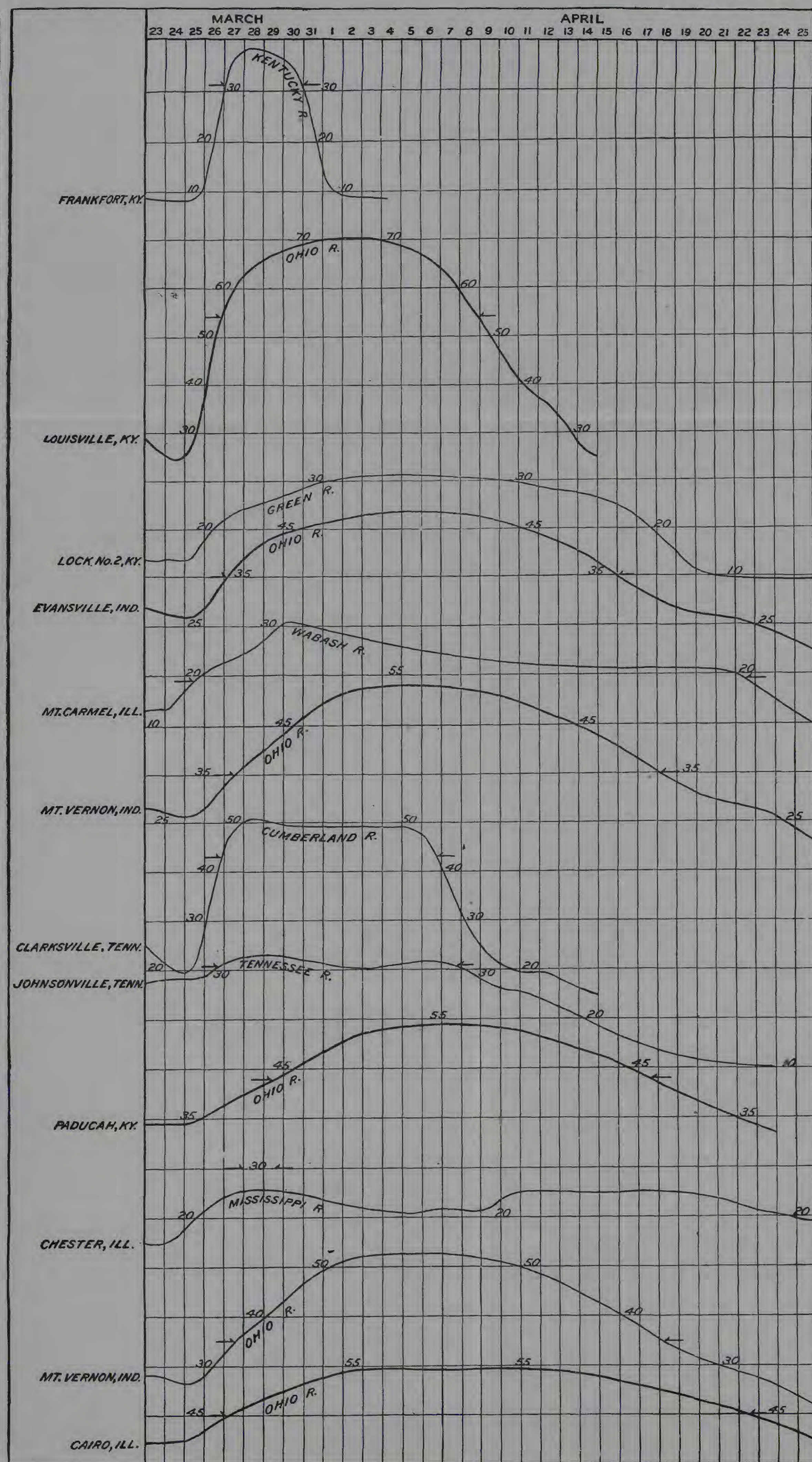
The maximum daily discharge during the 1913 flood at the six stations given in Table 17 (p. 80) ranged from 448,000 second-feet (18.1 second-feet per square mile) at Wheeling, W. Va., to 769,000 second-feet (8.49 second-feet per square mile) at Louisville, Ky. The maximum daily rate of flow was greater at Catlettsburg, Ky., than at Cincinnati, Ohio, 151 miles farther downstream, and was greater at Louisville, Ky., than at Evansville, Ind., 183 miles below. These are not necessarily inconsistencies, however, and are due mainly to differences in channel capacity.

The total discharge for the flood ranged from 252,000 million cubic feet at Wheeling to 1,210,000 million cubic feet at Evansville. It will be noted (Pl. III) that the run-off from the area over which the precipitation was more than 10 inches enters the Ohio above Louisville.

The discharge is more fully discussed on pages 47–84 and a complete statement of the enormous damage caused by this flood is presented on pages 84–87.

Typical street scenes in Hamilton, Ohio, during and after the flood are shown in Plate VII. Plates VIII and IX show flood views of Wheeling, W. Va., and Belpre, Ohio.





FLOOD HYDROGRAPHS (GAGE HEIGHTS) FOR STATIONS ON OHIO RIVER AND TRIBUTARY STREAMS DURING THE FLOOD OF MARCH-APRIL, 1913.

The hydrographs are, as a rule, arranged in downstream order and those for tributaries are grouped above the Ohio River hydrograph for the station most affected by the flow from the tributaries. Note that Scioto River is tributary to the Ohio below Portsmouth, the Miami below Cincinnati, and the Wabash below Mount Vernon. The hydrographs of these tributaries were arranged out of their natural place to show the effect, if any, of the flow from these tributary streams upon Ohio River stages at the points mentioned, even though they enter below these points. Crests are indicated by vertical arrows, danger line stages by horizontal arrows. For gage heights see Tables 4 and 5, pages 25, 26.

A. HIGH STREET, HAMILTON, OHIO, AT DAYBREAK MARCH 26, 1913.

Note the height of flood on posts of boulevard lights.

B. SAME STREET AFTER THE FLOOD.

Looking toward Miami River.

A. "THE ISLAND," WHEELING, W. VA., DURING THE FLOOD OF MARCH-APRIL, 1913.

"The Island" is the chief residential section of Wheeling.

B. VIEW LOOKING NORTH ON MARKET STREET, WHEELING, W. VA., FROM BALTIMORE & OHIO RAILROAD VIADUCT, DURING THE FLOOD OF MARCH-APRIL, 1913.

Corner of Baltimore & Ohio Railroad station at extreme right.

BELPRE, OHIO, DURING THE FLOOD OF MARCH-APRIL, 1913.

FLOOD OF MARCH-APRIL, 1907.

CAUSES.

The flood of March–April, 1907, was caused by excessive rains and melting snow on the drainage areas above Pittsburgh, and by heavy rains on the tributaries that enter the Ohio from the north below Pittsburgh. These conditions produced the high stage at Pittsburgh and high stages on all the northern tributaries. This flood may be briefly described as an up-river rise which passed down the river on top of bank-full or more than bank-full stages at all points, which were produced, primarily, by floods from the northern tributaries and, to a lesser extent, by medium floods on the southern tributaries. The soil had been saturated by a flood in January, and the high temperatures during the rain of March 4–14 had decidedly increased the run-off by melting the snow on the ground.

PRECIPITATION AND TEMPERATURE.

The daily and total precipitation for the period March 4–14, 1907, which caused the peak rise of the flood of March–April, 1907, are shown in Table 6, but not the entire amount of precipitation which caused the whole flood. The totals, therefore, are not comparable with the total discharge during the flood as given in Tables 15 and 16 (pp. 75, 78). The stations are the same as those used for Table 3, where records were available, otherwise the nearest stations maintained during the period were used. The numbers show corresponding stations. This table is chiefly valuable for comparison with Tables 3 and 9, which show the rainfall for the floods of 1913 and 1884, respectively, at the same points. No rainfall map was made for this flood.

TABLE 6.—*Precipitation, in inches, at selected stations in or near Ohio River basin, Mar. 4–14, 1907.*

No.	Station.	March.											Total.
		4	5	6	7	8	9	10	11	12	13	14	
	Ohio.												
1	Toledo	......	T.	......	0.20	......	......	0.23	......	0.20	0.21	T.	0.84
2	Circleville	......	0.05	......	.03	......	......	.28	......	.73	3.45	0.99	5.53
3	Columbus	......	......	T.	T.	0.01	0.05	.18	0.05	.95	2.33	.01	3.58
4	Cleveland	T.	T.	0.02	.12	.03	......	.35	......	.32	.31	.01	1.16
5	Sandusky	......	T.	T.	.04	......	......	.25	......	.41	.36	T.	1.06
6	Cincinnati	0.25	.04	T.	.10	......	.09	.12	.02	2.60	4.59	.01	7.82
7	Dayton	......	.04	......	......	T.	T.	.29	.03	.82	3.10	.18	4.46
8	Bangorville	......	......	T.	.12	......	......	.25	......	.61	1.98	......	2.96
9	Marion	......	......	......	......	......	......	.38	......	......	1.67	.67	2.72
10	Bellefontaine	......	......	......	.05	.04	......	.11	......	.41	1.68	.41	2.70
	Indiana.												
11	South Bend [a]	......	......	T.	.05	......	.16	......	.05	.15	.10	......	.51
12	Terre Haute	......	.60	......	T.	......	......	......	......	1.02	.46	.32	2.40
13	Anderson	......	T.	......	T.	T.	T.	.26	......	1.22	2.10	T.	3.58

[a] Near Notre Dame.

TABLE 6.—*Precipitation, in inches, at selected stations in or near Ohio River basin, Mar. 4–14, 1907*—Continued.

No.	Station.	March.											Total.
		4	5	6	7	8	9	10	11	12	13	14	
	Indiana—Continued.												
14	Fort Wayne	......	......	......	0.03	......	......	0.37	......	0.55	0.62	0.05	1.62
15	Evansville	......	......	0.47	.03	......	0.26	.2	T.	.43	1.73	......	3.12
16	Indianapolis	0.12	......	......	.01	......	.13	.21	0.30	.96	1.19	......	2.92
17	Elliston	......	......	......	......	......	......	......	......	......	......	......	......
18	Madison	.05	0.54	......	.25	......	.07	.31	1.55	2.35	.75	......	5.87
19	Washington, Paoli, Mean [a]	.10	.03	......	.29	......	([b])	.34	......	.58	3.24	.32	4.90
	Illinois.												
20	La Salle	......	......	T.	.02	......	.20	.04	.02	.05	.01	......	.34
21	Peoria	.10	.01	.01	T.	......	.60	.11	.25	.13	.06	......	1.27
22	Chicago	......	......	T.	.06	......	.05	......	.05	.01	.06	......	.23
23	Springfield	.19	.02	T.	T.	......	.50	.10	.73	.81	.08	......	2.43
24	Cairo	T.	......	.19	.03	......	.54	.01	......	T.	1.58	......	2.35
	Kentucky.												
25	Maysville	......	.40	......	.30	0.05	......	.71	.05	.16	1.68	1.50	4.85
26	Lexington	.23	.14	.04	.18	T.	.28	.33	......	.91	1.08	.48	3.67
27	Falmouth	......	.52	......	.27	......	......	.64	......	.70	1.42	1.42	4.97
28	Frankfort	......	.49	......	.23	.02	......	1.01	.03	.13	.69	1.00	3.60
29	Louisville	.19	.09	.08	.44	......	.45	.48	......	.78	2.03	.04	4.58
30	Beattyville	......	.26	......	.44	.06	......	.22	.06	.11	.35	1.48	2.98
	Tennessee.												
31	Chattanooga	......	......	......	.46	......	T.	.49	......	......	......	.80	1.75
32	Knoxville	......	......	......	.71	......	.02	.74	......	......	......	1.11	2.58
33	Nashville	......	......	......	.55	......	.42	.18	......	T.	.65	.70	2.50
	Missouri.												
34	St. Louis	......	......	.20	......	......	.22	.05	.51	.17	.12	......	1.27
	Michigan.												
35	Detroit	......	......	T.	T.	.04	......	......	......	.25	.04	.01	.34
	Pennsylvania.												
36	Harrisburg	T.	.18	......	T.	.12	......	.66	......	.02	.80	.32	2.10
37	Pittsburgh	.01	.06	T.	.03	.11	.01	.25	......	.57	1.53	.34	2.91
38	Erie	.01	.01	T.	.12	.12	......	T.	......	.11	.33	.12	.82
	West Virginia.												
39	Parkersburg	.01	.05	......	.03	.01	.02	.45	......	1.16	.91	1.13	3.77

[a] Near Shoals. [b] Amount included in following day.

The areas of greatest rainfall are indicated indirectly by the hydrographs of the Ohio River and its more important tributaries presented in Plate XI (p. 34). These areas are at the headwaters above Pittsburgh, on the tributaries that enter the river from the north below Pittsburgh, and in the northern section of Kentucky. The temperature during and preceding the heavy rain was much above normal, so that the snow on the ground melted quickly and ran rapidly into the streams during the period of maximum rainfall. The rainfall over West Virginia and eastern Kentucky, drained by Kanawha, Guyandotte, and Big Sandy rivers, was not heavy.

GENERAL FEATURES.

There were two floods on Ohio River during 1907, the first in January and the second in March. The January flood had hardly passed into the Mississippi before the rains that were to cause the second flood began over the headwaters of the Ohio. The two floods differed materially in character, in that the January flood was very moderate above the mouth of the Kanawha, while the March flood was very much the reverse. Stages beyond all previous records were reached at Pittsburgh and on Youghiogheny River. The conditions preceding the precipitation above Pittsburgh for the two floods did not differ greatly, except that immediately preceding the rains of March 13 and 14 the ground was covered with from 4 to 8 inches of moist, heavy snow, while in January there was no snow immediately preceding the rains. The rainfall was somewhat greater during the January flood, but in March differences in distribution combined with the high temperatures and the rapid melting of the snow over the Allegheny, Kiskiminitas, and Youghiogheny basins produced a volume of water that more than compensated for the deficiency in precipitation. The greater part of the heavy rains fell on March 13 and 14, when the snow on the Allegheny and Monongahela, under the influence of abnormally high temperatures, was melting rapidly and running into the streams. From the mouth of the Kanawha to the Scioto the stages of the two floods were practically the same; below the mouth of the Scioto the March stages were 1 to 5 feet lower than those in January, on account of the small amount of water contributed by Kanawha, Guyandotte, and Big Sandy rivers, in whose basins in West Virginia and eastern Kentucky the rainfall was comparatively light.

An examination of the rainfall and gage records shows that the March flood at Pittsburgh can be attributed to the enormous volume of water caused by the excessive rains and melting of snow on March 12–14 over the Kiskiminitas and Youghiogheny basins. The Monongahela contributed largely, but no water of consequence came from the Allegheny above the Kiskiminitas. The crest stage at Pittsburgh was 35.5 feet, exceeding by half a foot all previous records and the 1913 crest stage by 5.1 feet. The flood of 1907 established the fact that a disastrous flood can occur at Pittsburgh without the aid of Allegheny River above the Kiskiminitas.

From the mouth of Beaver River to Parkersburg, W. Va., the flood was remarkable for the rapidity of the increase in stage. From Parkersburg to Cairo the conditions were similar to those which prevailed in the January flood except that the maximum stages below Portsmouth were from 1 to 5 feet lower than in January.

An examination of Plate XI shows that Muskingum, Scioto, Miami, and Wabash rivers, all tributaries from the north, were at more than ordinary flood stages, and the southern tributaries were at comparatively low flood stages. Note the stages of the Kanawha at Charleston, Big Sandy at Louisa (probably affected by backwater after March 15), the Licking at Falmouth, the Kentucky at Frankfort, the Green at Lock No. 2 (under backwater), and the Cumberland and Tennessee at Clarksville and Johnsonville, respectively. The low stages on the southern tributaries had much to do with decreasing the flood stage below Portsmouth, as large volumes of water passed from the main Ohio into the lower reaches of the southern tributaries, thus decreasing the maximum stages along the Ohio.

The Pittsburgh Flood Commission, in its report, states that if the 43 reservoirs investigated had been in operation above Pittsburgh the crest stage at Wheeling during the flood of March–April, 1907, would have been reduced 14.5 feet, which would have made the stage 35.6 feet or 0.4 foot below the danger line.

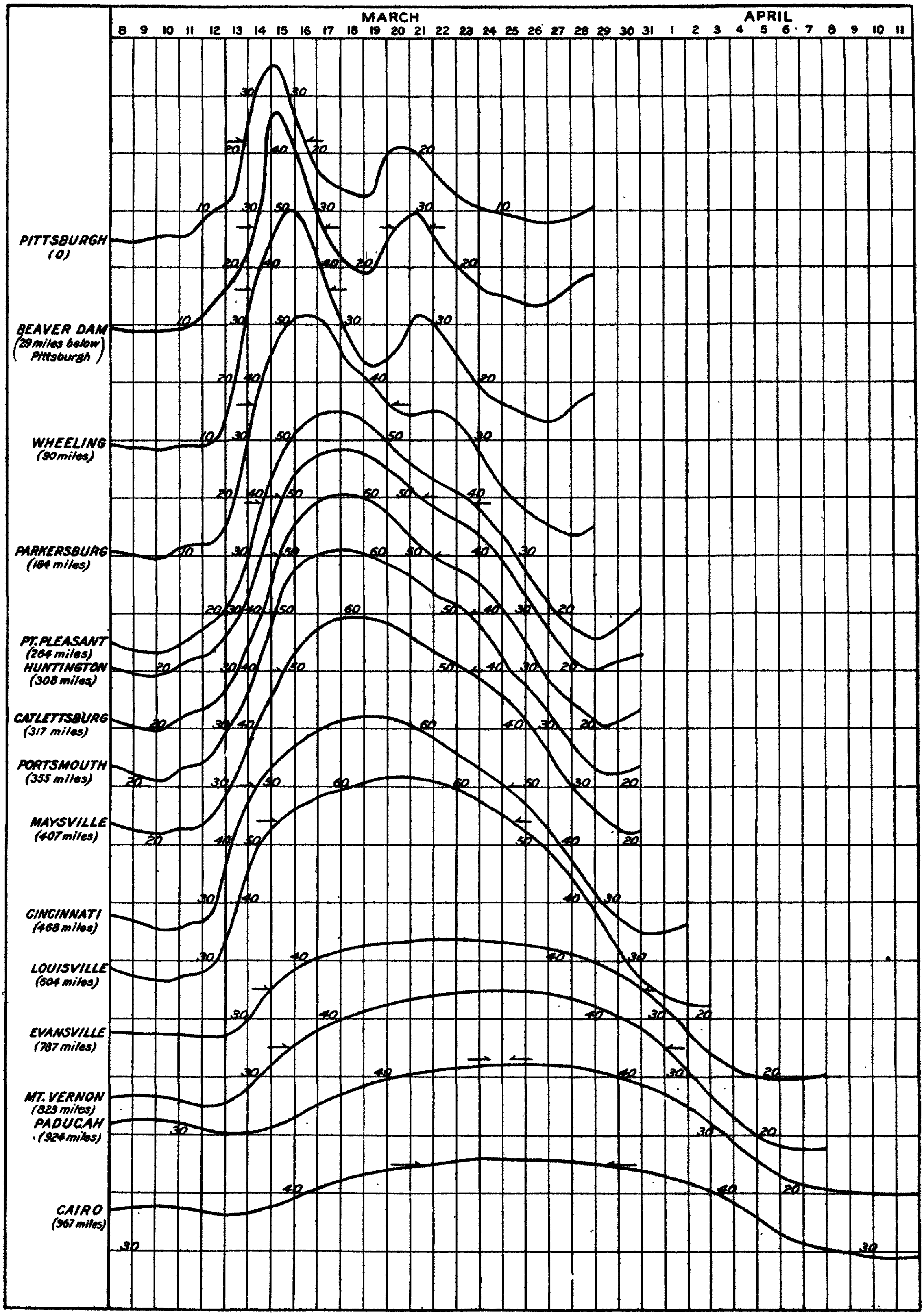
Much of the discussion both for and against the use of reservoirs for flood prevention has been based largely on philosophic speculation, and many arguments have been advanced in substantiation of preconceived opinions, but as the conclusions of the Pittsburgh Flood Commission are based on careful studies they should be given full consideration in systematic investigations of flood control.

STAGE AND DISCHARGE.

Tables 7 and 8 give daily gage heights taken from records of the United States Geological Survey, the United States Weather Bureau, and the United States Engineer Corps, for periods sufficiently long to cover the entire flood of March–April, 1907. Graphic representations of these gage heights appear on Plates X and XI. The gage heights represent one reading each day taken about 7 or 8 a. m. So far as records were available the stations used are the same as those used for Tables 4 and 5.

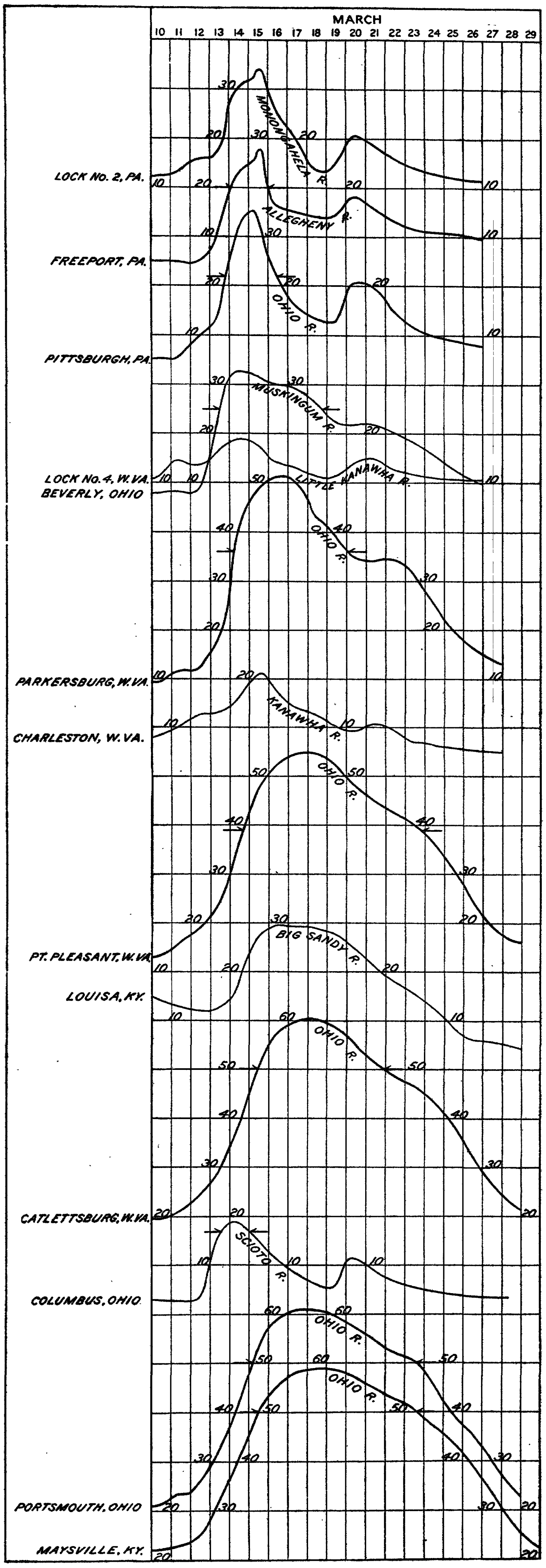
TABLE 7.—*Gage height, in feet, at stations on Ohio River during flood of March–April, 1907.*

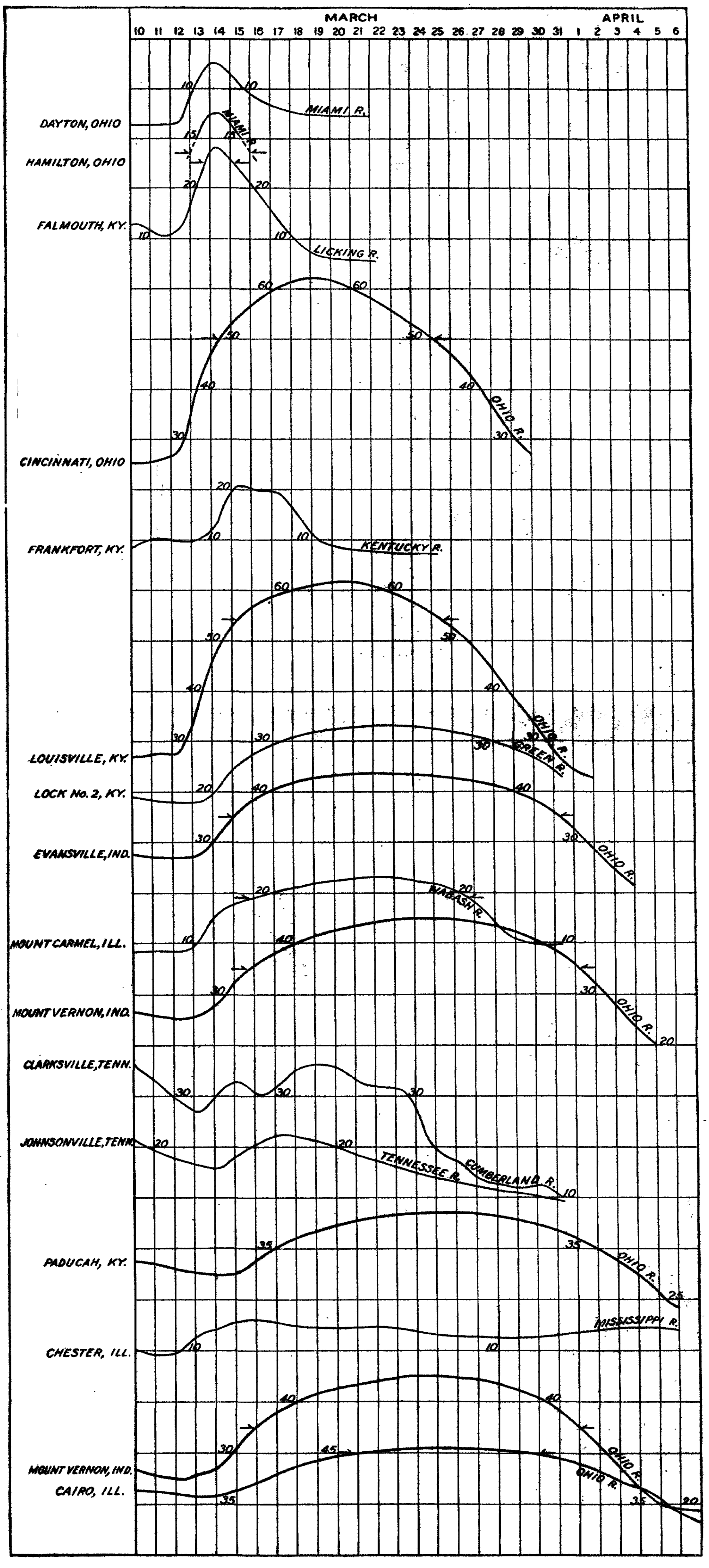
Date.	Pittsburgh, Pa.	Beaver Dam, Pa.	Wheeling, W. Va.	Parkersburg, W. Va.	Point Pleasant, W. Va.	Huntington, W. Va.	Catlettsburg, Ky.	Portsmouth, Ohio.	Maysville, Ky.	Cincinnati, Ohio.	Louisville, Ky. (Lower.)	Evansville, Ind.	Mount Vernon, Ind.	Paducah, Ky.	Cairo, Ill.
Mar. 1	5.0	8.6	8.1	10.0	12.4	18.0	19.0	19.5	19.3	22.3	22.4	20.5	19.0	21.3	29.1
2	5.2	9.1	8.3	9.8	13.7	19.8	20.6	21.2	20.2	22.8	23.2	22.3	20.8	24.0	30.8
3	6.1	10.2	9.2	10.4	14.7	20.4	23.0	24.0	23.2	25.6	24.5	23.9	22.1	26.8	32.7
4	7.7	12.0	10.4	10.9	14.9	22.9	24.0	25.4	24.9	27.7	26.6	24.7	23.6	29.0	34.5
5	6.5	11.3	11.4	12.0	16.5	22.8	23.8	25.2	25.3	28.6	28.9	25.4	24.7	30.5	35.8
6	5.4	10.2	10.3	12.0	16.8	22.2	23.0	24.4	25.0	28.9	29.8	26.3	25.5	31.4	36.5
7	5.2	9.8	9.6	11.1	15.7	21.6	22.5	24.0	24.4	28.3	29.4	27.2	26.0	31.8	37.0
8	4.9	9.3	9.2	10.7	14.5	20.4	21.4	23.0	23.7	27.7	28.4	27.8	26.6	32.3	37.4
9	4.7	8.8	8.8	10.0	13.4	19.2	20.0	21.7	22.5	26.6	27.4	27.8	27.2	32.6	37.7
10	5.3	9.2	8.5	9.6	13.3	19.6	19.9	21.0	21.8	25.3	26.6	27.5	26.5	32.6	37.8



FLOOD HYDROGRAPHS (GAGE HEIGHTS) FOR 15 STATIONS ON OHIO RIVER DURING THE FLOOD OF MARCH-APRIL, 1907.

Shows the distance of each station below Pittsburgh and the danger line (indicated by horizontal arrows) at each station. For gage heights see Table 7, page 34.





FLOOD HYDROGRAPHS (GAGE HEIGHTS) FOR STATIONS ON OHIO RIVER AND TRIBUTARY STREAMS DURING THE FLOOD OF MARCH-APRIL, 1907.

The hydrographs are, as a rule, arranged in downstream order and the tributaries are grouped above the Ohio River station on which the flow from the tributaries has the most effect. As far as possible the stations and tributaries are the same as those shown on Plate V, but the station at Columbus on the Scioto takes the place of the Chillicothe station, and the Dayton station replaces the Hamilton station on the Miami, as there is no record at Chillicothe for 1907 and only three daily readings at Hamilton for 1907. Scioto River is tributary to the Ohio below Portsmouth, the Miami below Cincinnati, and the Wabash below Mount Vernon. The hydrographs of these tributaries are arranged out of their natural place to show the effect, if any, of the tributary streams upon Ohio River stages at the stations mentioned, even though the streams are tributary below these stations. Danger line stages indicated by horizontal arrows. For gage heights see Tables 7 and 8, pages 34, 36.

TABLE 7.—*Gage height, in feet, at stations on Ohio River during flood of March–April, 1907*—Continued.

Date.	Pittsburgh, Pa.	Beaver Dam, Pa.	Wheeling, W. Va.	Parkersburg, W. Va.	Point Pleasant, W. Va.	Huntington, W. Va.	Catlettsburg, Ky.	Portsmouth, Ohio.	Maysville, Ky.	Cincinnati, Ohio.	Louisville, Ky. (Lower.)	Evansville, Ind.	Mount Vernon, Ind.	Paducah, Ky.	Cairo, Ill.
Mar. 11	5.6	9.5	9.3	11.9	15.8	21.7	22.5	23.6	22.8	26.3	27.3	27.3	25.7	32.0	37.5
12	9.8	13.0	9.5	12.2	18.4	23.1	23.8	24.9	24.4	27.3	27.4	27.2	25.0	31.0	36.9
13	12.7	17.9	17.5	18.0	22.7	28.0	28.6	31.5	31.0	41.0	36.9	27.4	26.3	30.1	36.3
14	30.8	......	37.9	37.0	34.3	36.6	37.2	39.5	39.7	50.3	48.5	31.3	28.8	30.8	37.1
15	35.1	47.1	47.8	48.1	46.4	48.4	49.0	52.2	48.2	54.1	54.4	36.3	33.5	31.7	38.2
16	22.8	37.8	48.9	51.4	52.4	55.2	57.2	58.6	55.1	57.6	57.0	39.0	36.3	33.9	39.9
17	15.7	25.8	38.0	50.9	54.7	57.9	59.8	60.5	58.3	60.2	58.7	40.9	38.8	36.0	41.5
18	13.4	20.5	27.9	43.6	54.8	58.4	60.4	60.8	59.2	61.6	60.1	42.0	40.4	37.6	42.7
19	12.5	19.1	22.8	40.0	52.7	57.2	59.6	59.8	59.0	62.1	61.2	42.7	41.7	38.8	43.6
20	21.0	26.7	25.1	35.0	48.7	54.5	56.4	58.1	57.8	61.3	61.5	43.2	42.7	39.8	44.3
21	20.2	29.7	31.8	34.2	44.9	50.6	52.3	55.6	55.1	59.8	61.2	43.5	43.5	40.7	44.9
22	15.6	23.4	29.3	34.7	42.7	47.7	49.0	52.4	52.9	57.5	60.4	43.7	44.2	41.4	45.5
23	11.8	18.7	23.0	32.0	40.5	45.5	47.0	51.0	50.5	54.8	58.9	43.8	44.8	41.9	45.9
24	10.1	15.7	17.9	26.0	36.8	43.0	44.0	46.8	47.6	52.3	56.8	43.6	45.0	42.2	46.1
25	9.3	14.6	15.8	20.4	31.3	37.7	39.6	40.0	44.8	49.4	54.4	43.2	45.0	42.3	46.1
26	8.2	13.2	13.9	16.6	25.1	31.6	33.5	36.6	40.3	45.7	51.4	42.7	44.6	42.2	46.0
27	7.9	14.6	13.0	14.5	20.0	26.0	27.2	31.3	34.8	41.0	47.7	41.9	43.8	42.0	45.8
28	9.3	17.6	16.5	13.4	16.9	21.0	23.8	25.8	29.1	35.3	42.9	41.0	43.3	41.5	45.5
29	11.0	19.1	18.9	16.1	16.5	20.4	20.5	22.3	24.6	30.1	37.0	39.6	41.8	40.7	45.1
30	10.5	18.4	19.7	19.1	19.0	22.0	21.9	22.2	22.2	26.3	31.0	37.8	40.1	39.7	44.5
31	9.3	16.0	18.0	19.4	20.7	23.0	24.0	24.0	23.0	24.7	26.1	34.9	37.6	38.3	43.8
Apr. 1	......	......	......	......	......	......	......	......	......	......	......	31.1	34.5	36.5	42.8
2	......	......	......	......	......	......	......	......	......	......	......	26.7	30.2	34.4	41.5
3	......	......	......	......	......	......	......	......	......	......	......	23.1	25.8	31.4	39.9
4	......	......	......	......	......	......	......	......	......	......	......	21.0	22.3	27.9	37.6
5	......	......	......	......	......	......	......	......	......	......	......	20.1	19.6	24.7	35.0
6	......	......	......	......	......	......	......	......	......	......	......	19.9	18.9	22.4	32.5
7	......	......	......	......	......	......	......	......	......	......	......	19.7	18.7	21.2	31.0
8	......	......	......	......	......	......	......	......	......	......	......	21.2	19.0	20.9	30.4
9	......	......	......	......	......	......	......	......	......	......	......	18.5	18.2	20.3	29.6
10	......	......	......	......	......	......	......	......	......	......	......	17.7	17.5	19.7	29.0
11	......	......	......	......	......	......	......	......	......	......	......	17.6	17.1	19.6	28.8
12	......	......	......	......	......	......	......	......	......	......	......	18.5	17.6	20.0	29.0
13	......	......	......	......	......	......	......	......	......	......	......	19.6	18.5	20.6	29.3
14	......	......	......	......	......	......	......	......	......	......	......	20.1	19.4	21.0	29.9
15	......	......	......	......	......	......	......	......	......	......	......	19.8	19.1	21.2	30.5
Crest:															
Stage.	35.5	47.1	50.1	51.6	54.8	58.4	60.4	60.8	59.2	62.1	61.6	43.8	45.0	42.3	46.2
Date.	15	15	15	16	18	18	18	18	18	18	20	23	24–25	25	24
Time.	5 a.m.	(a)	9 p.m.	2.30 p.m.	(a)	(a)	......	......	(a)	11 p.m.	10.30 a.m.	(a)	(a)	(a)	4 p.m.

[a] Highest recorded—may not be crest.

TABLE 8.—*Gage height, in feet, at stations on rivers tributary to Ohio River for flood of March–April, 1907.*

No.	River and station.	March. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	Allegheny:																	
1	Redhouse, N. Y.	(a)	3.5	(a)	(a)	(a)	(a)	(a)	(a)	3.2	3.2	3.3	3.3	3.7	5.6	7.1	7.2	7.6
2	Warren, Pa.	(a)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.6	3.5	6.2	6.0	6.5
3	Franklin, Pa.	(a)	5.8	6.6	6.8	6.8	6.5	6.3	5.9	5.6	5.2	5.3	4.1	4.3	8.0	8.4	8.8	8.2
4	Freeport, Pa.	4.2	4.5	5.4	6.6	6.6	6.2	5.7	5.1	5.0	4.9	4.9	5.0	9.7	22.4	25.7	16.5	15.0
	Monongahela:																	
5	Fairmont, W. Va.	16.9	16.5	16.3	16.9	16.5	16.5	16.4	16.3	16.9	16.8	21.5	19.8	23.0	24.5	22.2	19.0	17.1
6	Greensboro, Pa.	10.2	10.0	11.3	10.7	9.7	9.4	9.1	8.9	9.7	10.0	14.6	14.1	18.7	27.2	21.0	14.2	11.2
7	Lower Lock No. 4, Pa.	11.8	11.3	12.7	13.0	11.6	10.6	10.4	9.9	10.2	11.4	13.9	19.2	21.0	37.4	35.0	22.6	15.5
8	Upper Lock No. 2, Pa.	12.5	12.5	13.0	13.0	12.6	12.2	12.0	11.7	11.8	12.4	13.1	16.0	17.1	30.2	32.3	26.4	20.6
9	Cheat, Rowlesburg, W. Va.	3.1	3.2	5.4	4.8	4.2	4.0	3.8	3.9	4.0	3.9	6.2	5.0	8.4	8.2	7.6	5.0	4.2
	Youghiogheny:																	
10	Confluence, Pa.	2.0	3.3	3.6	3.2	3.1	3.1	3.0	2.8	3.0	2.6	2.8	2.2	11.0	17.2	11.4	7.0	5.0
11	West Newton, Pa.	3.1	3.1	4.7	4.0	3.2	2.9	2.6	2.5	3.1	2.9	3.1	3.0	7.9	26.3	21.9	10.5	7.6
12	Tuscarawas, Canal Dover, Ohio	....	....	....	....	....	....	....	....	....	....	....	3.5	5.0	9.5	9.5	6.5	4.5
	Muskingum:																	
13	Zanesville, Ohio	9.5	9.8	12.1	12.9	11.7	11.0	10.4	10.1	10.0	9.8	9.9	10.1	17.7	30.4	30.3	28.3	28.2
14	Beverly, Ohio	7.6	8.1	9.7	10.9	10.2	9.2	8.6	8.3	8.0	7.9	8.4	8.1	20.7	33.0	32.0	30.3	29.5
	Little Kanawha:																	
15	Creston, W. Va.	5.0	4.5	4.2	3.9	3.7	3.5	3.9	3.9	3.8	4.3	12.8	8.9	14.0	18.6	16.7	8.4	6.0
16	Upper Dam No. 4, W. Va.	11.7	11.5	11.5	11.5	11.4	11.2	11.2	11.1	11.1	11.1	14.8	13.6	16.0	18.6	18.0	14.0	13.1
17	New, Hinton, W. Va.	4.6	4.9	6.0	5.2	4.4	4.2	4.2	4.2	4.8	4.6	5.2	5.6	5.1	5.8	6.5	5.5	4.6
	Kanawha:																	
18	Kanawha Falls, W. Va.	7.7	7.6	10.0	9.2	7.4	9.2	6.2	6.0	7.2	7.5	8.8	10.0	9.5	11.7	13.0	10.6	8.2
19	Charleston, W. Va.	8.7	8.5	11.8	11.0	8.4	7.8	7.4	7.3	7.6	8.3	10.0	12.7	13.8	15.7	20.9	17.7	14.2
20	Big Sandy, Louisa (Upper Lock No. 3), Ky.	....	....	....	....	....	....	....	....	....	14.5	13.1	11.9	12.4	15.5	26.5	29.6	29.2
21	Scioto, Columbus, Ohio	(a)	3.6	3.6	3.6	3.4	3.4	3.2	3.0	3.0	3.0	3.0	3.0	15.0	19.0	16.2	11.4	8.8
22	Licking, Falmouth, Ky.	8.0	9.0	11.8	10.0	8.0	7.0	7.0	9.0	11.0	13.0	10.7	11.5	20.0	28.1	24.2	19.3	14.0
	Miami:																	
23	Dayton, Ohio	2.5	2.5	4.2	3.5	3.1	3.0	2.9	2.8	2.8	2.8	2.8	2.8	10.8	15.2	11.8	8.0	6.2
24	Hamilton, Ohio	....	....	....	....	....	....	....	....	....	....	....	....	14.5	20.0	16.3	....	....
	Kentucky:																	
25	Highbridge, Ky.	18.4	18.5	18.4	17.6	16.4	14.3	13.2	13.2	13.3	13.5	14.5	13.8	14.8	19.6	20.0	19.6	18.5
26	Frankfort, Ky.	11.3	12.1	12.1	13.1	12.8	11.6	9.3	9.0	9.0	9.0	10.3	9.8	10.2	13.5	20.6	19.8	19.4
27	Green, Upper Lock No. 2, Ky.	15.1	16.1	16.5	17.0	17.6	18.1	19.1	19.4	19.3	18.7	18.3	17.8	17.9	20.8	25.6	27.8	29.8
	Wabash:																	
28	Terre Haute, Ind.	2.8	2.8	3.0	3.2	3.8	3.8	3.8	3.6	3.4	3.2	3.2	4.0	10.6	14.0	15.2	16.3	16.8
29	Mount Carmel, Ill.	5.6	5.5	5.4	5.4	5.3	5.8	6.2	7.9	8.4	8.4	8.3	8.2	10.1	16.3	18.1	19.3	20.4

	Cumberland:																	
30	Celina, Tenn.	30.9	30.0	30.9	31.5	31.1	26.2	19.0	14.7	13.1	13.3	13.8	13.5	15.2	18.7	25.6	28.4	29.2
31	Nashville, Tenn.	33.2	37.3	38.9	38.5	38.4	37.7	36.0	33.8	28.9	24.4	25.0	23.0	22.6	24.5	29.6	29.8	30.9
32	Clarksville, Tenn.	40.0	42.7	45.0	45.3	44.9	44.3	45.0	42.8	41.2	35.0	32.5	29.0	26.8	31.0	32.7	30.0	32.5
33	French Broad, Asheville, N. C.	.0	.4	1.0	.5	.2	.1	.1	.2	.1	.1	.4	.3	.2	.1	.3	.3	.2
	Tennessee:																	
34	Knoxville, Tenn.	4.3	6.5	8.0	7.8	6.0	4.6	4.0	4.0	4.2	4.8	6.2	7.0	6.8	5.7	5.9	6.2	6.0
35	Chattanooga, Tenn.	10.4	12.3	17.2	18.4	16.9	14.5	11.2	9.6	9.5	9.5	10.0	12.0	12.3	11.9	12.1	12.6	12.2
36	Florence, Ala.	7.7	12.5	14.0	14.4	14.5	14.5	13.6	12.0	9.8	8.5	8.3	8.3	8.5	8.5	11.0	11.0	11.0
37	Johnsonville, Tenn.	10.0	15.6	21.6	24.4	25.4	25.1	24.6	24.0	22.8	20.6	18.8	17.5	16.4	15.7	18.8	21.1	22.5

No.	River and station.	March.														Crest.		
		18	19	20	21	22	23	24	25	26	27	28	29	30	31	Stage.	Date.	Time.
	Allegheny:																	
1	Redhouse, N. Y.	7.8	7.6	7.9	7.5	7.1	7.7	7.7	7.4	7.1	7.5	8.4	8.0	7.4	6.8	8.4	28	(b)
2	Warren, Pa.	6.5	6.0	6.8	6.4	5.5	5.9	5.9	5.7	5.1	5.5	7.2	7.0	6.0	5.3	7.2	28	(b) (c)
3	Franklin, Pa.	8.3	7.5	8.2	7.9	7.0	7.8	6.5	6.5	5.5	5.6	8.0	8.9	8.0	6.5	10.8	14	4 p. m.
4	Freeport, Pa.	14.2	14.1	18.4	16.0	13.4	11.5	11.0	10.9	10.0	10.0	12.7	14.0	13.0	11.4	28.0	15	
	Monongahela:																	
5	Fairmont, W. Va.	16.5	16.4	18.6	20.1	17.8	16.7	16.1	15.6	15.5	15.3	15.3	15.1	15.0	14.9	25.6	14	3 p. m.
6	Greensboro, Pa.	10.1	9.7	17.3	15.2	12.4	10.4	9.4	8.9	8.5	8.2	8.1	8.1	7.9	7.8	27.2	14	(c)
7	Lower Lock No. 4, Pa.	12.6	11.8	22.6	21.2	17.1	13.1	11.7	10.0	9.2	8.7	8.5	8.5	8.0	7.7	37.4	14	(c)
8	Upper Lock No. 2, Pa.	14.0	14.2	20.7	19.2	16.1	14.0	13.3	12.2	11.7	11.6	11.6	11.4	11.3	10.8	34.1	15	1 p. m.
9	Cheat, Rowlesburg, W. Va.	3.8	3.4	7.8	5.8	4.6	4.0	3.6	3.3	3.0	2.9	2.9	2.8	2.6	2.4	9.2	14	6 p. m.
	Youghiogheny:																	
10	Confluence, Pa.	3.6	3.6	12.0	6.6	4.6	3.7	3.4	3.0	2.6	2.6	2.4	2.2	2.0	1.9	18.6	14	
11	West Newton, Pa.	6.6	6.4	19.4	11.5	7.4	5.7	4.7	3.9	3.3	3.1	3.2	3.0	2.8	2.4	28.2	14	
12	Tuscarawas, Canal Dover, Ohio	3.3	3.0	5.2	5.0	3.2	2.2	1.7	......	......	......	......	......	......	......	10.2	15	During day.
	Muskingum:																	
13	Zanesville, Ohio	25.6	22.0	24.0	23.1	21.4	20.1	17.3	14.3	12.5	11.7	13.0	13.8	14.1	13.3	30.4	14	(c)
14	Beverly, Ohio	27.0	22.6	21.9	22.1	20.3	18.6	16.3	13.3	10.9	9.9	10.7	11.5	12.1	11.5	33.0	14	(c)
	Little Kanawha:																	
15	Creston, W. Va.	4.6	4.3	11.0	12.0	6.4	5.9	5.0	4.5	4.2	3.9	3.8	3.8	3.8	3.8	18.6	14	(c)
16	Upper Dam No. 4, W. Va.	11.5	11.2	14.0	15.1	12.8	12.0	11.3	10.9	10.7	10.5	10.5	10.3	10.2	10.2	18.6	14	(c)
17	New, Hinton, W. Va.	4.0	3.7	3.5	5.2	4.2	3.5	3.2	3.0	2.8	2.7	2.6	2.5	2.5	2.6	6.5	15	(c)
	Kanawha:																	
18	Kanawha Falls, W. Va.	6.6	5.8	6.1	8.2	7.5	5.9	5.0	4.4	3.9	3.6	3.4	3.3	3.1	2.8	13.5	15	
19	Charleston, W. Va.	12.8	10.7	9.1	10.8	9.8	7.2	6.6	6.0	5.7	5.2	5.1	4.8	5.2	6.5	21.0	15	5 p. m.
20	Big Sandy, Louisa (Upper Lock No. 3), Ky.	29.1	28.0	25.3	21.5	18.4	16.1	13.2	9.4	6.1	5.8	5.2	......	......	......	29.6	16	(c)
21	Scioto, Columbus, Ohio	6.5	5.6	11.6	9.0	7.5	5.6	4.8	4.3	3.8	3.6	3.9	3.9	3.6	3.5	19.0	14	(c)
22	Licking, Falmouth, Ky.	9.0	6.5	6.0	5.7	5.5	5.3	5.0	4.5	4.0	3.5	3.0	2.5	2.2	2.0	28.1	14	(c)

a Frozen. b Note time of crest at Pittsburgh, Pa. c Maximum recorded may not be crest.

TABLE 8.—*Gage height, in feet, at stations on rivers tributary to Ohio River for flood of March–April, 1907*—Continued.

No.	River and station.	March.														Crest.		
		18	19	20	21	22	23	24	25	26	27	28	29	30	31	Stage.	Date.	Time.
	Miami:																	
23	Dayton, Ohio	5.0	4.6	4.6	4.5	4.1	3.5	3.1	2.8	2.8	2.6	2.4	2.0	2.0	2.0	15.2	14	(*a*)
24	Hamilton, Ohio	......	......	......	......	......	......	......	......	......	......	......	......	......	......	20.3	14	
	Kentucky:																	
25	Highbridge, Ky	16.0	14.5	12.4	11.1	10.9	10.8	10.7	10.7	10.6	10.4	10.2	10.0	10.0	10.0	20.0	15	(*a*)
26	Frankfort, Ky	14.9	9.8	8.6	8.1	7.7	7.4	7.2	7.0	6.9	6.7	6.7	6.5	6.5	6.4	20.6	15	(*a*)
27	Green, Upper Lock No. 2, Ky.	31.0	31.9	32.5	32.9	33.2	33.1	32.8	32.4	31.5	30.6	29.4	27.9	25.9	22.9	33.2	22	(*a*)
	Wabash:																	
28	Terre Haute, Ind	17.2	17.3	16.8	15.8	13.8	11.8	9.7	8.2	7.2	6.4	6.1	7.0	9.9	11.9	17.3	19	(*a*)
29	Mount Carmel, Ill	21.3	22.0	22.4	22.9	23.0	22.9	22.2	21.6	19.8	17.5	12.5	10.3	9.8	9.8	23.0	22	(*a*)
	Cumberland:																	
30	Celina, Tenn	25.2	18.9	14.1	11.6	10.0	8.8	7.9	7.1	6.5	5.9	5.5	5.2	5.0	4.7	29.2	17	(*a b*)
31	Nashville, Tenn	31.7	31.3	28.9	24.4	19.7	16.1	14.0	12.6	11.8	11.3	10.9	10.5	10.3	10.1	31.7	18	(*a b*)
32	Clarksville, Tenn	35.8	36.2	35.5	32.3	31.7	31.4	24.1	18.0	16.9	13.4	12.4	11.9	12.4	9.9	36.2	19	(*a b*)
33	French Broad, Asheville, N.C.	.1	.1	.1	.0	.0	.0	−.1	−.1	−.2	.1	.0	−.1	−.2	.2	.3	15–16	(*a b*)
	Tennessee:																	
34	Knoxville, Tenn	5.0	4.5	4.0	3.7	3.4	3.0	2.9	2.7	2.7	2.5	2.5	2.3	2.2	2.2	6.2	16	(*a b*)
35	Chattanooga, Tenn	11.5	10.6	9.3	8.4	7.7	7.1	6.6	6.1	5.9	5.7	5.5	5.4	5.2	5.0	12.6	16	(*a b*)
36	Florence, Ala	10.0	9.9	9.0	8.2	7.5	6.5	6.0	5.5	5.0	4.6	4.2	4.0	3.9	3.7	11.0	15–17	(*a b*)
37	Johnsonville, Tenn	21.8	20.7	19.4	18.2	17.1	15.9	14.8	13.9	13.0	12.1	11.3	10.8	10.1	9.3	22.5	17	(*a b*)

a Maximum recorded may not be crest.

b Note time of crest at Paducah, Ky.

The discharge during the flood of March–April, 1907, at six different points along the river and the volume of water above the danger line and above other stages are shown in Tables 16 and 17 (pp. 78, 80). The maximum daily discharge for the flood of 1907 ranged from 424,000 second-feet at Wheeling to 633,000 second-feet at Louisville; the maximum run-off per square mile ranged from 17.1 at Wheeling to 5.46 at Evansville. The total volume of water for the entire flood varied from 337,000 million cubic feet at Wheeling to 1,030,000 million cubic feet at Evansville. The number of days the flood was above the danger line varied from 4 days at Wheeling to 16 at Evansville.

FLOOD OF 1884.

CAUSES.

The flood of February, 1884, reached stages at all points on Ohio River which have been exceeded at Pittsburgh only by the flood of 1907, at Cairo by the flood of 1912, and at all points on the Ohio from Marietta to Maysville, and at Mount Vernon, Paducah, and Cairo by the flood of 1913.

The causes of this flood were precipitation above the normal over the southern part of the Ohio basin during the month of January, the large amount of snow on the ground at the headwaters and over the basin as a whole the latter part of the same month, the impervious condition of the ground due to the unusually low temperatures that occurred during January in all sections of the basin, the warm weather that occurred the first part of February, and the heavy, warm rains that fell from February 3 to 14 throughout the drainage basin.

The warm rains melted the snow, and as the ground was frozen practically all the water reached the watercourses quickly and thus produced the high stages that occurred throughout the length of the river.

PRECIPITATION AND TEMPERATURE.

The daily and total precipitation from February 3 to 14, 1884, the period of rainfall that caused the peak rise, are shown in Table 9 (p. 41), but not the entire amount of precipitation that caused the whole flood. The total precipitation given is not comparable with the total discharge during the flood given in Tables 15, 16, and 17 (pp. 75, 78, 80). The stations used are the same as those used for Tables 3 and 6 where records are available. No records were substituted for those at the stations in Table 3 for which no records for 1884 were available.

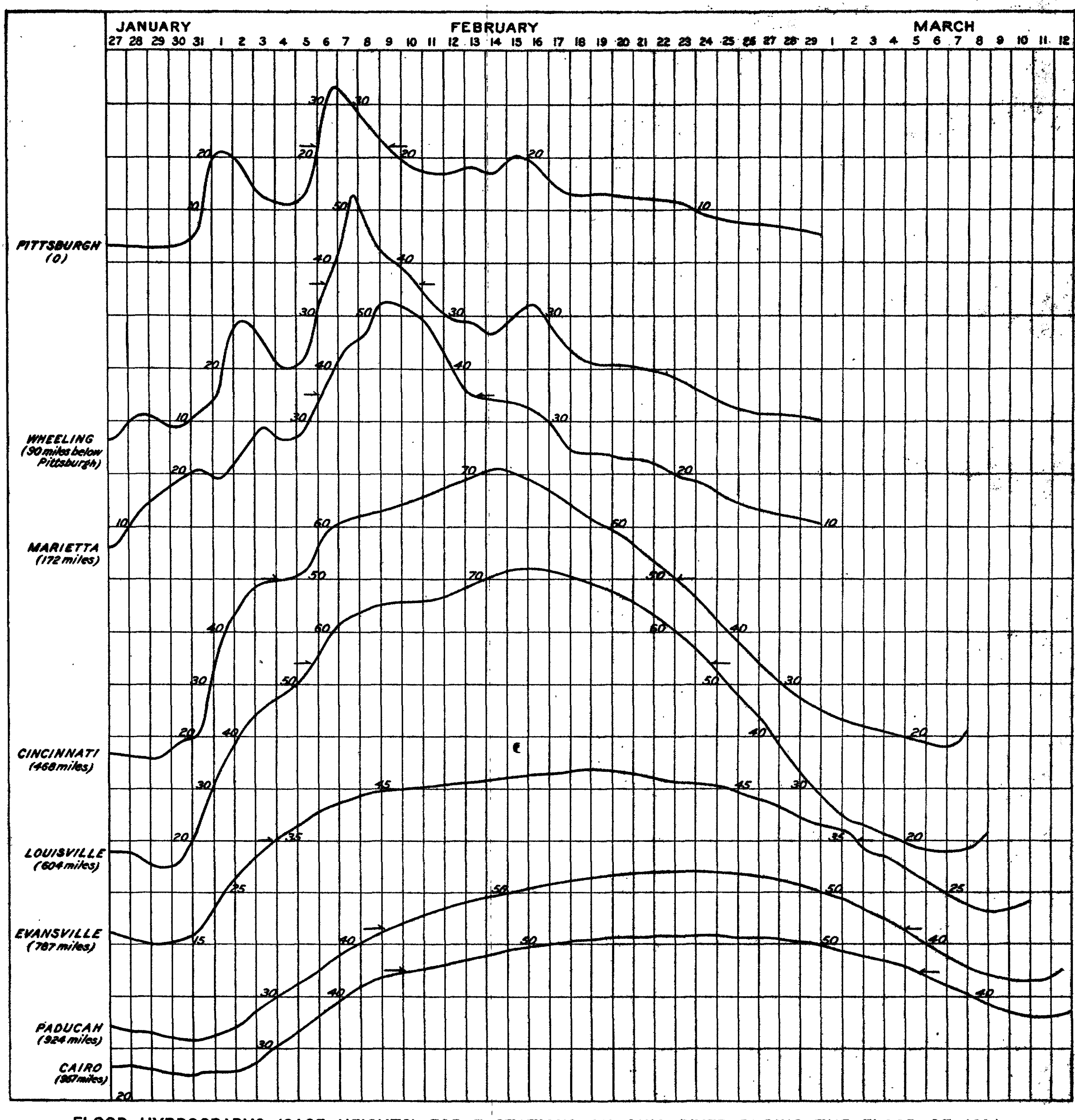
The scarcity of rainfall records for the period February 3 to 14 has made the preparation of a rainfall map extremely difficult, but the distribution of the 12 days' rain is shown on Plate XII, which represents the drainage area of Ohio River, including the principal streams, towns, rainfall and gaging stations, and lines of equal rainfall for the period.

The temperature during January was very low. In Ohio the mean for the month was about 10° below normal; in Kentucky the mean broke all previous low records; and in Tennessee the mean was the lowest in 20 years. The lowest temperature recorded in Tennessee was 16° below zero; in Ohio the minimum recorded was 34° below zero; and in Indiana −28° was recorded. The rainfall map for January, 1884, in the publications of the United States Weather Bureau shows that there was a total precipitation of 2 to 4 inches over practically the entire Ohio basin, 4 to 6 inches on the basin of the Allegheny and south of Ohio River, 6 to 8 inches over the basins of Cumberland and Tennessee rivers, and more than 8 inches on a wide belt extending northeastward across central Tennessee. Much of this precipitation was in the form of snow, which, owing to the unusually low temperatures during January, was on the ground at the end of the month, especially at the higher altitudes at the sources of the streams. Near the end of January a warm wave extended over that part of the basin adjacent to the river and was followed by colder weather. The ground was frozen throughout the basin, thus making the soil impervious; there was a large amount of snow on the ground; the warm weather and rains the latter part of January had melted some of the snow and the water was running into the streams. The cold weather the first of February checked the run-off considerably in the upper part of the basin, but the warm weather and rain began a few days after the 1st and continued to the 14th. During the period February 3 to 14, as shown by Plate XII, the rainfall was more than 4 inches over practically the entire basin, while over large parts of the basin in Kentucky and Tennessee there were over 6 inches, with records of 8, 8.1, and 8.2 inches at three widely separated stations in those States.

GENERAL FEATURES.

An examination of Table 9 (p. 41) shows that there were two storms in the period from February 3 to 14, one February 3 to 9 and the other February 10 to 14. Plate XIII shows the effects of these two storms and the thaw and rain the latter part of January. The effect of the January rain and thaw is shown by the crests that occurred at Pittsburgh on February 1, and the effect apparently shows as far down as Louisville, where the volume of water from the southern tributaries (the Big Sandy, Licking, and Kentucky), and the Muskingum and Scioto on the north, had raised the Ohio to flood stage. The rains from the 3d to the 9th caused the river at Pittsburgh to rise rapidly, from 11 feet on the 4th to 33 feet on the 6th;

MAP SHOWING RAINFALL IN OHIO RIVER BASIN, FEB. 3-14, 1884



FLOOD HYDROGRAPHS (GAGE HEIGHTS) FOR 7 STATIONS ON OHIO RIVER DURING THE FLOOD OF 1884.

Shows the distance of each station below Pittsburgh and the danger line (indicated by horizontal arrows) at each station. For gage heights see Table 10, page 42.

the rise was also very rapid at Wheeling, the stage increasing from 20 feet on the 4th to 53 feet on the 7th. The hydrographs on Plate XIII indicate that the rise caused by the rain of February 3–9 was general all along the river and that the run-off from the rain of the period from the 10th to the 14th reached the main river before the up-river water had entirely passed.

TABLE 9.—*Precipitation, in inches, at selected stations in or near Ohio River basin, February 3–14, 1884.*

No.	Station.	3	4	5	6	7	8	9	10	11	12	13	14	Total.
	Ohio.													
1	Toledo		0.04	0.90	0.28		0.07	0.08		0.10	0.37	0.19		2.03
2	Circleville [a]													
3	Columbus		.58	55	1.40	0.07		.07	0.02	.26	.06	.55	0.02	3.58
4	Cleveland	0.01	.31	1.22	.63	.01	.04	.51		.45	.15	.57	.02	3.92
5	Sandusky		.20	1.04	.65	.05	.06	.30		.83	.32	.42	.04	3.91
6	Cincinnati		1.35	1.56	1.65	.23	T.	.06	.14	.59	.06	1.18		6.82
7	Dayton		.55	.56	1.42		.12	.17	.02	.16	.33	.90	.02	4.25
8	Bangorville [a]													
9	Marion [a]													
10	Bellefontaine [a]													
	Indiana.													
11	Notre Dame [a]													
12	Terre Haute		2.13	.83			.59		.17	.12				3.84
13	Anderson [a]													
14	Fort Wayne		1.00		.25				.18			1.25		2.68
15	Evansville [a]													
16	Indianapolis		.43	.81	.63	.04	.09	.31	.04	.08	.77	.17		3.37
17	Elliston [a]													
18	Madison [a]													
19	Shoals [a]													
	Illinois.													
20	La Salle [a]													
21	Peoria	.95				.01	.10		.22	1.08	.10			2.46
22	Chicago		.60	.32	.03	T.	.01	.15		.10	1.13	.15	T.	2.49
23	Springfield		.57	.37	.03	.03	.16	.12	.10	.40	1.14	.40		3.32
24	Cairo	T.	.07	1.17	1.24	.18	.25	.03	.51	.11	.13	.43		4.12
	Kentucky.													
25	Maysville [a]													
26	Lexington [a]													
27	Falmouth [a]													
28	Frankfort		1.23	.40	1.91	.70		.10		.97	.03	1.25		6.59
29	Louisville		.89	2.38	1.73	.63	T.	.14	.61	.60	.27	.77	T.	8.02
30	Beattyville [a]													
	Tennessee.													
31	Chattanooga	.01			.04	3.19	1.21	.52	.12	.01		1.23	.05	6.38
32	Knoxville	.13	.22		.01	1.53	.78	1.97	.33	.02		.61	.38	5.98
33	Nashville		.04		1.73	.68	.74	.44	.25	.01	.53	1.08	.01	5.51
	Missouri.													
34	St. Louis	T.	1.32	.40	.37	.02	.24	.03	.08	.25	1.15	.16		4.02
	Michigan.													
35	Detroit	.05	.09	.12	.21	.09	.11	.23	.02	.15	.36	.19	.06	1.68
	Pennsylvania.													
36	Harrisburg [a]													
37	Pittsburgh		.45	.76	80	.34	.01	.04	.13	.53	.06	.14	.18	3.44
38	Erie	T.	.01	1.05	.50	.01	.02	.40		.37	.25	.59	.28	3.48
	West Virginia.													
39	Parkersburg [a]													

[a] No record.

The part each tributary played in producing the flood of 1884 on the Ohio can not be definitely stated, as there are few records of gage readings on the main tributaries in that year, but Table 9 and Plates XII and XIII indicate general floods throughout the basin. As a rule, the tributaries were not so high as during the flood of the previous year, and only the Big Sandy and the Muskingum reached record stages. It seems probable that more water came from the southern tributaries than from the northern.

It has been concluded without going into a detailed study of the subject, which is not warranted in this paper, that the floods on practically all the tributaries in 1884 occurred about the same time and this caused the channel of the Ohio to be quickly filled to the danger line at all points. At the same time the lower reaches of all the tributaries were filled so that the water from the upper Ohio had no opportunity of flowing into the storage basins sometimes provided by the lower stretches of the large tributaries. This also must have had a decided effect in producing the extraordinary stages of this flood. A brief discussion of these natural reservoirs is presented on pages 45–46.

The Pittsburgh Flood Commission states in its report upon flood control that if the 43 reservoirs investigated in its studies had been in operation at the time of the flood of 1884 the crest stage at Wheeling would have been reduced by 13.1 feet, to a stage of 40 feet, or only 4 feet above the danger line.

STAGE AND DISCHARGE.

The daily gage heights from January 25 to March 12, 1884, at stations on Ohio River used in Table 4, so far as available are presented in Table 10. Gage heights at Marietta replace the record at Parkersburg. For comparing the stages on tributaries for which few records are available, Table 9 and Plate XII (p. 40) will be found useful.

TABLE 10.—*Gage height, in feet, at stations on Ohio River during flood of 1884.*

Date.	Pittsburgh, Pa.	Wheeling, W. Va.	Marietta, Ohio.	Cincinnati, Ohio.	Louisville, Ky. (lower).	Evansville, Ind.	Paducah, Ky.	Cairo, Ill.
Jan. 25	3.7	6.8	6.5	18.3	19.3	18.6	26.7	27.4
26	3.4	6.6	6.5	17.5	18.0	17.7	24.7	26.8
27	3.3	7.0	6.5	16.6	17.8	16.8	24.3	26.6
28	3.3	11.0	12.2	16.1	17.5	15.7	23.3	26.3
29	3.1	10.8	16.1	15.8	15.0	14.7	22.9	25.7
30	3.3	8.8	18.6	18.8	15.8	15.7	22.0	25.0
31	6.0	11.9	21.0	30.6	23.5	18.0	21.8	25.6
Feb. 1	21.0	16.2	19.2	38.4	34.0	24.0	22.8	25.6
2	19.5	29.2	24.1	45.6	40.6	29.0	24.7	26.0
3	12.8	26.0	29.0	49.3	45.5	32.8	28.1	28.7
4	11.3	20.0	26.5	50.1	48.3	36.3	31.0	31.8
5	13.0	21.5	28.3	52.5	51.6	38.3	33.2	34.2
6	29.0	35.0	36.2	58.8	57.6	41.2	36.3	37.0
7	31.5	46.0	44.1	61.6	62.8	42.5	39.0	40.3
8	27.0	47.0	47.2	62.5	64.1	44.2	41.2	42.3
9	22.2	41.2	52.8	63.7	65.6	44.8	43.1	43.8
10	18.8	38.0	51.2	64.8	65.7	45.2	44.7	44.9

Table 10.—*Gage height, in feet, at stations on Ohio River during flood of 1884*—Continued.

Date.	Pitts-burgh, Pa.	Wheel-ing, W. Va.	Marietta, Ohio.	Cincin-nati, Ohio.	Louis-ville, Ky. (lower).	Evans-ville, Ind.	Paducah, Ky.	Cairo, Ill.
Feb. 11	17.0	33.0	48.0	66.3	66.0	45.6	46.3	45.8
12	17.4	29.5	41.2	68.2	67.1	46.1	47.4	46.6
13	18.4	29.0	35.0	69.7	68.8	46.3	48.6	47.4
14	17.2	26.5	34.2	71.0	70.5	46.8	49.5	48.2
15	20.6	30.0	33.5	70.2	71.7	47.2	50.4	49.0
16	18.9	32.5	32.0	68.4	72.0	47.5	51.2	49.7
17	14.8	28.0	29.0	66.1	71.3	47.8	52.0	50.3
18	12.8	22.5	24.0	63.5	70.1	48.0	52.6	50.8
19	13.2	20.8	24.0	60.5	68.5	48.0	....	51.2
20	12.8	20.8	23.0	58.9	67.1	47.7	53.6	51.5
21	12.4	20.0	22.8	55.9	65.2	47.5	54.0	51.7
22	12.0	19.3	21.7	52.1	62.5	46.5	54.2	51.8
23	11.5	17.8	19.2	48.8	59.2	46.2	54.2	51.8
24	9.0	15.1	18.5	45.4	55.7	46.0	54.2	51.8
25	8.2	13.5	16.0	41.2	51.0	45.3	53.8	51.7
26	7.5	12.2	14.0	37.0	46.4	43.6	53.5	51.5
27	7.3	11.2	13.0	33.0	42.6	42.5	52.8	51.2
28	6.8	11.2	12.0	29.3	36.2	41.0	52.0	50.7
29	6.3	10.5	11.2	26.6	31.5	38.7	50.9	50.2
Mar. 1	5.2	9.8	10.5	24.5	27.1	37.6	49.9	49.5
2	4.8	8.4	9.8	22.9	23.9	36.5	48.1	48.6
3	4.3	7.8	8.6	21.2	22.6	32.4	46.2	47.7
4	4.3	7.3	8.0	20.6	20.5	31.7	44.2	46.6
5	4.1	7.3	7.6	19.5	19.0	29.0	41.8	45.2
6	3.8	7.2	7.4	18.2	18.0	26.0	39.3	43.5
7	3.2	7.2	7.2	18.0	18.0	24.0	36.8	41.6
8	3.9	7.0	7.3	24.0	19.0	22.0	35.0	39.8
9	10.5	7.8	8.6	31.0	24.0	21.4	33.6	38.1
10	15.8	16.0	10.0	36.5	31.5	22.2	33.0	36.8
11	12.9	21.0	18.0	40.0	36.5	23.8	33.0	36.1
12	13.8	21.2	23.2	46.6	42.5	30.2	34.4	36.4
Crest:								
Stage	33.3	53.1	52.8	71.1	72.0	48.8	54.2	51.8
Date	Feb. 6	Feb. 7	Feb. 9	Feb. 14	Feb. 16	Feb. 19	Feb. 23	Feb. 22–24

The discharge during the flood at four different points on the Ohio is shown in Tables 16 and 17. The maximum daily discharge of the flood of 1884 varied from 401,000 second-feet at Wheeling to 792,000 second-feet at Louisville; the maximum run-off per square mile varied from 16.2 second-feet at Wheeling to 6.29 second-feet at Evansville. The total discharge for the entire flood period varied from 474,000 million cubic feet at Wheeling to 1,690,000 million cubic feet at Evansville. The stage was above the danger line 4 days at Wheeling, 19 days at Cincinnati and Louisville, and 28 days at Evansville. The discharge in excess of that at danger line and at other stages is discussed on pages 74, 83–84.

COMPARISON OF THE FLOODS IN THE OHIO VALLEY.

CAUSES.

The direct cause of the floods of March–April, 1913, March–April, 1907, and February, 1884, was heavy rainfall.

The rain that caused the flood of 1913 was exceptionally heavy through the northern part of the basin, amounting to 10 inches or more on the divide in northern Ohio. The winter had been mild and open, the ground was without snow, was not frozen, and was already saturated with water by the heavy rains of January and the rains of the first part of March, so that practically the entire rainfall rapidly reached the streams. When the rains that caused the flood began the river channels were fairly well filled, none of the tributaries being low; the main Ohio above Parkersburg was at ordinary stages and below Parkersburg at comparatively high stages.

The flood of March–April, 1907, was also caused by heavy rains in the northern part of the basin and over the headwaters above Pittsburgh. A flood in January had reached higher stages below Portsmouth than the March flood, so that the soil was saturated and in a condition favorable to rapid run-off. The month of February was warm and open. There was a heavy snowfall over the headwaters above Pittsburgh, which was melting rapidly, because of the high temperature at the time of the greatest rainfall. The main Ohio above Huntington was at ordinary stages when the rains began, while below Huntington the stage was above ordinary, with stages increasing toward Cairo. The tributaries were, as a rule, at ordinary or low stages, with the exception of Cumberland and Tennessee rivers, which were above ordinary stages.

The cause of the flood of 1884 was a warm rain throughout the main basin, but conditions previous to this flood were different from those prior to either of the other two floods. The month of January was very cold, with a heavy snowfall throughout the basin, so that at the beginning of the rains which produced the flood there were large quantities of snow at the headwaters and the ground was frozen solid so that no appreciable amount of the rainfall could be absorbed—a condition as favorable for rapid run-off as that afforded by a saturated soil. The Ohio at Pittsburgh was at ordinary stage at the beginning of the rain; at Wheeling it was above the ordinary, and thence on down the river was at or near flood stages, probably caused by the rains and thaw in the later part of January. Below Marietta the high stages were probably due to the second period of rain which was general throughout the basin. The run-off from this second period of rain reached the river before the water from Pittsburgh had entirely passed, and produced the maximum stages which occurred all along the river during this flood.

The flood of 1913 stands out from its predecessors especially because of the exceptional magnitude and intensity of the storms which were its direct cause and because the greatest damage was done along tributaries which in the past had not been particularly effective in the creation of the floods on Ohio River. The area of maximum rainfall represents that part of the basin in which the topography and other conditions are generally believed to be least favorable to flood control by impounding reservoirs alone. Whether or not this is true in proportion to the size of the rivers in this area in Illinois, Indiana, and Ohio can be determined only from detailed surveys.

PLACE OF ORIGIN.

The flood of 1913 originated in the northern part of the basin, especially in the comparatively small area at the headwaters of Muskingum, Scioto, Miami, and Wabash rivers. The southern tributaries contributed a fair proportion of the water in the main stream, but the four tributaries above mentioned are responsible for the great damage and loss of life and for the high stages reached on the Ohio at and below Marietta.

The flood of March–April, 1907, had its origin principally in the area above Pittsburgh and in the northern tributaries.

The flood of 1884 was general throughout the basin. (See hydrographs, Pl. XIII.) The flood crest occurred at Pittsburgh on February 6, and as it proceeded downstream it apparently rode on top of the high stages resulting from the general rain that produced the flood at Pittsburgh and was aided and increased by the second period of general rain of February 10–14.

PROGRESS.

The difference in the rates of progression of the flood waves during the three floods is marked. The crest of the flood of 1913 reached Pittsburgh March 28 at 6 a. m. and Cincinnati April 1 at 12 noon, 4 days and 6 hours later. The crest from Pittsburgh reached Cairo April 8 at about 7 p. m., about 11½ days later than at Pittsburgh. The crest of the flood of March–April, 1907, reached Pittsburgh March 15 at 5 a. m., Cincinnati on the 18th at 11 p. m., 3 days and 18 hours later, and Cairo on the 24th at 4 p. m., 9 days and 11 hours later than at Pittsburgh. The flood of 1884 reached its crest at Pittsburgh on February 6; at Cincinnati February 14, 8 days later; at Cairo February 22–24, 17 days later.

RECORD STAGES.

Record stages during the flood of 1913 occurred at Marietta, Parkersburg, Huntington, Catlettsburg, Portsmouth, Maysville, Mount Vernon, Paducah, and Cairo. The flood of 1907 produced record stages at Pittsburgh and at Beaver Dam. The flood of 1884 still holds the record for stages at Wheeling, Cincinnati, Louisville, and Evansville. (See Table 11, p. 48.)

The duration of each flood and the number of days each was above the danger line and other stages at different points are shown in Table 16 (p. 78). The duration of each flood is more or less an arbitrary value. Effort was made to begin and end each flood period in a well-defined trough at low or medium stages.

EFFECTS OF TRIBUTARIES.

Tributaries either increase the stage of the main river, keep it at a high stage, or reduce the stage, the effect depending on the amount of water flowing in them. A maximum flood stage on a tributary increases the stage on the main stream. Under some conditions the stage on the main stream is simply maintained at the same relative stage by the flow from a tributary. When a large tributary is at a low or relatively low stage, the stage on the main river near the mouth of the tributary is reduced very materially for two reasons—first, a large amount of water passes from the main stream into the lower reaches of the tributary, where it is temporarily stored, and, second, the tributary is not yielding sufficient water to fill to the increased stage the main channel below. The large capacity of the channels on the lower reaches of tributaries becomes apparent on considering the distances that the flood waters of 1884 would have extended, if the tributaries had been empty—approximately 33 miles up the Muskingum and 73 miles up the Kanawha. At Louisa, 26 miles up the Big Sandy, there would have been a depth of 18 feet on top of the upper pool; the flood would have reached about 25 miles up the Licking, 65 miles up the Kentucky, 108 miles up the Green, and at Clarksville, on the Cumberland, 126 miles above its mouth, the stage would have been 12 feet on the gage. At Johnsonville, on the Tennessee, 95 miles from its mouth, the gage would have read 24 feet. The lower reaches of many of the large tributaries at flood stages are of considerable width, perhaps 2 or 3 miles.

FUTURE FLOODS.

It has been pointed out that the flood of 1913 was caused by storms that progressed from the lower to the upper end of the drainage basin, permitting the water from the lower tributaries to run off and get out of the way in the main stream before the water from the upper end of the basin entered the Ohio and reached the part affected by the tributaries nearer the mouth. This, fortunately, is the general trend of storms in the Ohio Valley, but it must be borne in mind that a severe storm whose path would be the reverse—that is, from the source toward the mouth—though not probable, is entirely possible. In such a storm the direction of progress would be the same as the direction of flow and the magnitude of the resulting disaster can not be predicted. It is also possible that a larger area of maximum precipitation than that of the storms of March 23–27, 1913, may occur over the Ohio basin and its location could be much less fortunate than that of these storms. For example, the results if the area of 10-inch precipitation of the storms of March, 1913, had been central over Portsmouth, instead of being on the northern rim of the basin, can be estimated only by extending the damage and loss in the congested and comparatively small area of the present flood to the lowlands of the entire basin, and probably to the lower Mississippi. The condition is not pleasant to contemplate, but it is possible.

A flood on the Ohio in conjunction with floods on the upper Mississippi and the Missouri, which of course is also possible, as excessive rains in this locality are not peculiar to any season, would probably produce a calamity on the lower Mississippi unprecedented in the history of this or any other country. With this possibility in view all who have studied the situation agree that there should be no further delay in establishing a complete system of river control that will insure systematic cooperation between the National Government, the States, and local interests.

STAGE AND DISCHARGE.

Data for comparing the stage and discharge of the floods in the Ohio River valley are presented in Tables 11 to 18, inclusive.

Tables 11 and 12 give the crest stages as determined from the available data for the floods of 1884, March–April, 1907, and March–April, 1913. The daily gage heights for each of these floods are given in Tables 4, 5, 7, 8, and 10 (pp. 25, 26, 34, 36, 42).

Maximum stages prior to March, 1913, and the differences in gage heights of the March–April, 1913, crests from previous maxima are also given in Tables 11 and 12.

The fact that the column of crest stages prior to March, 1913, in Table 12, shows no general flood indicates that the highest stages on the tributaries are usually due to local storms covering relatively small areas. The storms of March, 1913, were exceptional in this respect, maximum stages during the flood of 1913 occurring at stations on tributaries over a comparatively large area.

The column of "Records available" gives the year in which published records, or records readily obtainable, began. Records prior to these years may possibly exist but they were not discovered by brief search.

The column of "Distance of station above mouth" gives the distance in miles of any given station above the mouth of the stream on which it is located. For example, the distance of Shoals is measured from the junction of the East and West branches of White River and the Wabash, since the West Branch is considered the headwater stream of White River.

In general, the drainage areas were taken directly from the publications of the United States Weather Bureau, reducing the values to three significant figures. Elevation of zero of gage above mean sea level, unless otherwise noted, and stage of danger line were also taken from the publications of the Weather Bureau. These stages of danger line were used in computations at all points except Marietta, Ohio. At Marietta (danger line 25 feet) a gage height of 35 feet was used in the computations because it is more nearly comparable with the danger line stages at other points on the upper Ohio, especially Parkersburg.

TABLE 11.—*Crest stages, in feet, for selected floods and miscellaneous data at stations on Ohio River.*

Station.	Miscellaneous data.					Crest stages.									Difference of March–April, 1913, crest from previous maximum.
	Records available since about year—	Distance below Pittsburgh (miles).	Drainage area (square miles).	Elevation, zero of gage above mean sea level (feet).	Danger line (feet).	1884.		March–April, 1907.		March–April, 1913.			Prior to March, 1913.		
						Stage.	Date.	Stage.	Date.	Stage.	Date.	Time.	Stage.	Date.	
Pittsburgh, Pa.	1854	0	19,000	697.2	22.0	33.3	Feb. 6	35.5	Mar. 15	30.4	Mar. 28	6.00 a. m.	35.5	Mar. 15, 1907	−5.1
Beaver Dam (No. 6), Pa. (lower gage).	1885	29	22,800	655.9	27.0	....	....	47.1	Mar. 15	46.6	Mar. 28	1.00 a. m.	47.1	Mar. 15, 1907	−0.5
Wheeling, W. Va.	1838	90	24,800	610.6	36.0	53.1	Feb. 7	50.1	Mar. 15	51.1	Mar. 28	4.00 p. m.	53.1	Feb. 7, 1884	−2.0
Marietta, Ohio.	1873	172	34,700	[g]568.8	[f]25.0	52.8	Feb. 9	[i]48.7	Mar. 16	[i]58.3	Mar. 29	6.00 a. m.	52.8	Feb. 9, 1884	+5.5
Parkersburg, W. Va.	1888	184	[b]37,700	561.6	36.0	53.9	Feb. 9	51.6	Mar. 16	58.9	Mar. 29	8.00 p. m.	53.9	Feb. 9, 1884	+5.0
Point Pleasant, W. Va.	1873	264	[c]52,500	509.4	39.0	60.0	Feb. —	[a]54.8	Mar. 18	62.8	Mar. 30	8.00 a. m.	60.0	Feb. —, 1884	+2.8
Huntington, W. Va.	1879	308	55,200	491.0	50.0	64.8	Feb. 9	[a]58.4	Mar. 18	66.4	Mar. 30	12.00 p. m.	64.8	Feb. 9, 1884	+1.6
Catlettsburg, Ky.	1887	317	[d]60,300	487.3	50.0	66.2	Feb. 12	[a]60.4	Mar. 18	67.7	Mar. 31	11.00 a. m.	66.2	Feb. 12, 1884	+1.5
Portsmouth, Ohio.	1887	355	[e]68,300	470.9	50.0	66.3	Feb. 12	[a]60.8	Mar. 18	67.9	Mar. 31	5.00 a. m.	66.3	Feb. 12, 1884	+1.6
Maysville, Ky.	1892	407	69,500	446.7	50.0	65.7	Feb. 14	[a]59.2	Mar. 18	66.4	Mar. 31	3.00 p. m.	65.7	Feb. 14, 1884	+0.7
Cincinnati, Ohio.	1858	468	75,800	429.8	50.0	71.1	Feb. 14	62.1	Mar. 18	69.8	Apr. 1	12.00 m.	71.1	Feb. 14, 1884	−1.3
Louisville, Ky. (lower gage).	1871	604	90,600	[h]376.0	54.0	72.0	Feb. 16	61.6	Mar. 20	70.6	Apr. 1	12.00 p. m.	72.0	Feb. 16, 1884	−1.4
Evansville, Ind.	1873	787	106,000	329.2	35.0	48.8	Feb. 19	[a]43.8	Mar. 23	48.4	Apr. 5	12.00 p. m.	48.8	Feb. 19, 1884	−0.4
Mount Vernon, Ind.	1888	823	106,700	315.1	35.0	51.7	Feb. 22	[a]45.0	Mar. 24–25.	52.9	Apr. 5	4.00 p. m.	51.7	Feb. 22, 1884	+1.2
Paducah, Ky.	1873	924	202,000	286.3	43.0	54.2	Feb. 23	[a]42.3	Mar. 25	54.3	Apr. 7	4.00 p. m.	54.2	Feb. 23, 1884	+0.1
Cairo, Ill.	1858	967	203,000	270.9	45.0	51.8	Feb. 22–24.	46.2	Mar. 24	54.8	Apr. 4, 8	7.00 p. m.	54.0	Apr. 6–7, 1912	+0.8

[a] Highest recorded stage, may not be crest.
[b] Includes Little Kanawha River.
[c] Includes Kanawha River.
[d] Includes Big Sandy River.
[e] Includes Scioto River.
[f] 35.0 feet used in this report (see Tables 11, 16, and 17) because more nearly comparable with danger lines at other stations, particularly Parkersburg, W. Va.
[g] Old Weather Bureau gage; elevation zero of lower lock No. 1 gage is 567.2 feet.
[h] U. S. Engineer Corps levels; others from U. S. Weather Bureau.
[i] From readings on lower lock No. 1 gage by subtracting 1.6 feet.

TABLE 12.—*Crest stages, in feet, for selected floods and miscellaneous data at stations on streams tributary to Ohio River.*

River and station.	Miscellaneous data: Records available since about (year)—	Distance of station above mouth (miles).	Tributary to (river)—	Distance of mouth below Pittsburgh (miles).	Drainage area above station (square miles).	Elevation of zero of gage above mean sea level (feet).	Danger line (feet).	Crest stages: 1884: Stage.	1884: Date.	March-April, 1907: Stage.	March-April, 1907: Date.	March-April, 1913: Stage.	March-April, 1913: Date.	March-April, 1913: Time.	Prior to March, 1913: Stage.[a]	Prior to March, 1913: Date.	Difference of March-April, 1913, crest from previous maximum.
Allegheny:																	
Redhouse, N. Y.	1903	212	Headwaters of Ohio.	0	1,640					8.4	Mar. 28	[b]12.7	Mar. 26	12.00 m.			
Warren, Pa.	1884	177			3,060	1,170.5	14			[b]7.2	do	15.2	do	5.00 p.m.	17.4	Mar. —, 1865	− 2.2
Franklin, Pa.	1905	114			5,800	957.3	15			10.8	Mar. 14	[b]22.0	do	8.00 a.m.		Mar. 17, 1865	
Freeport, Pa.	1873	29			9,220	741.0	20	30.0	Feb. 6	28.0	Mar. 15	31.9	Mar. 27	6.30 a.m.	32.7	Feb. 18, 1891	− .8
Tygart:																	
Belington, W. Va.	1907	62	Headwaters of Monongahela.		390	[c]1,679.9						10.5	Mar. 28	7.00 a.m.	20.3	July, —, 1912	− 9.8
Fetterman, W. Va.	1907	18			1,340	[c]957.9						[b]13.4	Mar. 27	5.00 p.m.	[d]21.5	Jan. 30, 1911	− 8.1
Monongahela:																	
Fairmont, W. Va.	1892	119	Ohio	0	2,320	840.4	25			25.6	Mar. 14	23.6	do	7.00 p.m.	37	July 10, 1888	−13
Greensboro, Pa.	1888	81			4,570	768.0	18			[b]27.2	do	[b]18.7	Mar. 28	8.00 a.m.	39	do	−20
Lock No. 4 (lower), Pa.	1885	40			5,430	719.0	28			[b]37.4	do	[b]25.2	do	do	42	July 11, 1888	−17
Lock No. 2 (upper) Pa.	(?)	12			7,130	[e]707.0				34.1	Mar. 15	23.8	do	11.00 a.m.			
West Fork: Enterprise, W. Va.	1907	12	Monongahela		750	[c]869.9						16.2	Mar. 27	3.00 p.m.	[f]33	—— —, 1888	−17
Cheat:																	
Rowlesburg, W. Va.	1884	36	do		890	1,375.3	14			9.2	Mar. 14	[b]7.7	Mar. 28	8.00 a.m.	22	July 10, 1888	−14
Morgantown, W. Va.	1899	4			1,380							[b]8.2	do	do			
Youghiogheny:																	
Confluence, Pa.	1883	59	Monongahela		782	1,324.0	10	9.9	Feb. 5	18.6	Mar. 14	5.6	Mar. 27	2.00 p.m.	18.6	Mar. 14, 1907	−13.0
West Newton, Pa.	1890	15			1,550	746.5	23			28.2	do	9.7	do	During night.	28.2	do	−18.5
Beaver: Beaver Falls, Pa.	1908	3	Ohio	25	3,030	731.2	11					17.4	do	6.00 a.m.	15.4	Jan. 22, 1904	+ 2.0

[a] Highest available; probably maximum.
[b] Maximum recorded stage; may not be crest.
[c] U. S. G. S. levels; others from U. S. Weather Bureau.
[d] Highest since establishment of station.
[e] U. S. Engineer Corps levels.
[f] Approximate.

TABLE 12.—*Crest stages, in feet, for selected floods and miscellaneous data at stations on streams tributary to Ohio River*—Continued.

River and station.	Miscellaneous data.							Crest stages.									Difference of March–April, 1913, crest from previous maximum.
								1884.		March–April, 1907.		March–April, 1913.			Prior to March, 1913.		
	Records available since about (year)—	Distance of station above mouth (miles).	Tributary to (river)—	Distance of mouth below Pittsburgh (miles).	Drainage area above station (square miles).	Elevation of zero of gage above mean sea level (feet).	Danger line (feet).	Stage.	Date.	Stage.	Date.	Stage.	Date.	Time.	Stage.[a]	Date.	
Mahoning: Youngstown, Ohio.	1908	16	Beaver		958	821.3	5								15.8	Jan. 21, 1904	
Tuscarawas: Canal Dover, Ohio.	1905	47	Headwaters of Muskingum.		1,120	[b]880.0	8			10.2	Mar. 15	16.2	Mar. 28	12.00 m.	12		+ 4
Muskingum:																	
Zanesville, Ohio	1887	70	Ohio	171	6,470	665.9	25			[c]30.4	Mar. 14	51.8	Mar. 27	Early a. m.	36.8	Mar. 24, 1898	+15.0
Beverly, Ohio	1887	20			7,200	602.6	25			[c]33.0	..do	46.5	..do		35	Mar. —, 1898	+11.
Mohican: Pomerene, Ohio.	1910	16	Muskingum		1,490							[c]26.0	Mar. 25	2.00 p. m.	[d]14.4	Mar. 30, 1912	+11.6
Little Kanawha:																	
Creston, W. Va.	1900	48	Ohio	184	1,300		20			[c]18.6	Mar. 14	20.4	Mar. 28	5.00 a. m.	25.8	Apr. 20, 1901	− 5.4
Dam No. 4 (upper), W. Va.	(?)	32			1,580	[e]603.2				[c]18.6	..do	19.5	..do	6.00 a. m.			
New:																	
Radford, Va.	1898	139	Headwaters of Kanawha.		2,720	1,712.7	17					15.0	Mar. 27	8.00 p. m.	[b]37	Sept. 15, 1878	−22
Hinton, W. Va.	1877	61			6,220	1,348.2	14	10.6	Feb. 9	[c]6.5	Mar. 15	14.5	Mar. 28	10.00 p. m.	23	Sept. 13, 1878	− 9
Fayette, W. Va.	1895	12			6,800	[f]838.4						36.5	..do	Early a. m.	[b]53	Sept. —, 1878	−17
Kanawha:																	
Kanawha Falls, W. Va.	1877	95	Ohio	265	8,300	[f]618.7	25	19.5	Feb. 10	13.5	Mar. 15	27.5	..do	2.00 a. m.	37.8	Sept. 14, 1878	−10.3
Charleston, W. Va.	1873	58			8,790	554.4	30	29.0	Feb. 11	21.0	..do	34.8	..do	4.00 p. m.	46.9	Sept. 28, 1861	−12.1
Greenbrier: Alderson, W. Va.	1895	19	New		1,340							19.4	Mar. 27	6.00 p. m.	18.2	Nov. 26, 1900	+ 1.2
Gauley: Belva, W. Va.	1908	6	Kanawha		1,420	[f]663.5						15.0	..do	3.00 p. m.	[b]19	Jan. 30, 1911	− 4
Elk: Clendenin, W. Va.	1908	21	..do		1,240	[f]588.7						21.3	..do	During night.	31.9	—— —, 1889	−10.6
Big Sandy: Louisa, Ky. (Upper Lock No. 3).	1896	26	Ohio	317	3,780	[e]518.8		44.1	Feb. 11	29.6	Mar. 16	42.8	Mar. 28	12.00 m.			
Scioto:																	
Columbus, Ohio	1897	110	..do	356	1,570	693.3	17			[c]19.0	Mar. 14	22.9	Mar. 25	..do	21.3	Mar. 23, 1898	+ 1.6
Chillicothe, Ohio	1907	58			4,370	595.5	14					37.8	Mar. 26	11.00 a. m.	28.3	Mar. 24, 1898	+ 9.5
Licking: Falmouth, Ky.	1887	30	Ohio	468	2,900	512.2	25			[c]28.1	Mar. 14	34.1	Mar. 27	1.30 p. m.	37.8	Feb. 24, 1909	− 3.7

Miami:																	
Dayton, Ohio	1892	77	do	489	2,490	724.1	18			[c]15.2	do	29.0	Mar. 26	1.00 a.m.	21.3	— —, 1866	+ 7.7
Hamilton, Ohio	1904	33			3,580	561.5	12			20.3	do	34.6	do	3.00 a.m.	21.2	Mar. 24, 1898	+13.4
Kentucky:																	
Highbridge, Ky	1901	117	Ohio	543	5,030	505.4	17			[c]20.0	Mar. 15	[c]34.6	Mar. 27	7.00 a.m.	33.0	Jan. 8, 1913	+ 1.6
Frankfort, Ky	1898	65			5,510	464.8	31			[c]20.6	do	38.3	Mar. 28	5.00 a.m.	44	Feb. —, 1878	− 6
Green: Lock No. 2 (upper), Ky.	1899	63	Ohio	779	7,420	355.6				[c]33.2	Mar. 22	[c]31.2	Apr. 5	8.00 a.m.			
Wabash:																	
Terre Haute, Ind	1904	171	do	840	12,200	447.3	16			[c]17.3	Mar. 19	[c]31.2	Mar. 27	7.00 a.m.	27.7	Feb. 18, 1883	+ 3.5
Mount Carmel, Ill	1884	75			26,300	373.0	19			[c]23.0	Mar. 22	31.0	Mar. 30	do	28.3	Aug. 7, 1875	+ 2.7
West Branch of White: Elliston, Ind.	1908	93	Headwaters of White.		4,070	473.9	21					[c]31.3	Mar. 27	do	29.6	Mar. 5, 1897	+ 1.7
East Branch of White: Shoals, Ind.	1903	42	White		4,900	444.0	25					42.2	Mar. 28	do	34.1	Mar. 30, 1904	+ 8.1
Cumberland:																	
Celina, Tenn	1903	383	Ohio	911	8,230	[b] 494.0	45			[c]29.2	Mar. 17	48.6	Mar. 30	2.30 p.m.	52	Feb. 27 and 28, 1890.	− 3
Nashville, Tenn	1873	193			11,600	366.0	40	47.2	Feb. 15	[c]31.7	Mar. 18	44.9	Apr. 2	7.00 a.m.	55.3	Jan. 22, 1882	−10.4
Clarksville, Tenn	1900	126			13,400	328.0	43			[c]36.2	Mar. 19	50.9	Mar. 28	5.00 p.m.	60.6	Jan. —, 1882	− 9.7
French Broad: Asheville, N. C	1903	144	Headwaters of Tennessee.		987	1,950.5	4			[c].3	Mar. 15–16	[c]5.2	Mar. 27	8.00 a.m.	10.6		− 5.4
Tennessee:																	
Knoxville, Tenn	1883	635	Ohio	924	8,990	793.8	12	16.1	Feb. 10	[c]6.2	Mar. 16	21.6	Mar. 28	3.00 p.m.	39	Mar. —, 1875	−17
Chattanooga, Tenn	1874	452			21,400	617.8	33	36.8	Feb. 11	[c]12.6	do	33.3	Mar. 30	12.00 m.	58.6	Mar. 11, 1867	−25.3
Florence, Ala	1871	255			30,000	400.8	18	24.2	Feb. 15	[c]11.0	Mar. 15–17	[c]18.5	Mar. 21	7.00 a.m.	32.5	Mar. 19, 1897	−14.0
Johnsonville, Tenn	1875	95			36,700	315.9	31	44.4	Feb. 28	[c]22.5	Mar. 17	33.3	Mar. 29	do	48	1882 and Mar. 24, 1897.	−15

[a] Highest available; probably maximum.
[b] Approximate.
[c] Maximum recorded stage; may not be crest.
[d] Highest since establishment of station.
[e] U. S. Engineer Corps levels.
[f] U. S. G. S. levels; others from U. S. Weather Bureau.

The dates covered by the gage heights in Table 13 include the day previous and the day following the low point in the trough at the beginning and end of each rise. The periods in the table are intended to cover the entire rise and, in general, the stage at the end is practically the same as the stage at the beginning of the period selected. Effort was made to select well-defined troughs. The dates covered by the daily discharge begin and end on the day of lowest gage height in the trough at the beginning and end of the flood.

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913.*

Day.	February.		March.		Day.	January.		February.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1859.					1862.				
1			46.9	367,000	1			31.8	
2			44.2	335,000	2				
3			40.2	290,000	3				
4			36.8	255,000	4				
5			32.7	214,000	5	11.9			
6			29.8	187,000	6	11.7	44,700		
7			27.1	162,000	7	12.1	47,000		
8	20.8		26.8	160,000	8	13.8	57,200		
9	19.2	95,500	26.0	153,000	9	15.0	65,000		
10	19.4	97,000	25.4	147,000	10	15.7	69,700		
11	19.8	100,000	25.0	144,000	11	17.2	80,400		
12	20.8	108,000	25.0	144,000	12	17.9	85,600		
13	22.1	119,000	25.9		13	20.8	108,000		
14	22.1	119,000			14	22.0	118,000		
15	20.8	108,000			15	24.2	137,000		
16	24.8	142,000			16	28.3	173,000		
17	28.2	173,000			17	33.2	219,000		
18	36.2	249,000			18	36.4	251,000		
19	43.9	331,000			19	41.7	307,000		
20	51.2	419,000			20	48.1	381,000		
21	54.0	454,000			21	52.3	432,000		
22	55.2	470,000			22	55.2	470,000		
23	55.3	471,000			23	56.1	482,000		
24	54.2	457,000			24	57.3	497,000		
25	52.4	434,000			25	56.5	487,000		
26	51.1	417,000			26	53.9	453,000		
27	49.1	393,000			27	48.8	389,000		
28	48.1	381,000			28	41.6	306,000		
29					29	34.2	229,000		
30					30	29.5	184,000		
31					31	27.0	162,000		

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	February.		March.		May.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1865.						
1			41.5	304,000		
2			41.6	306,000		
3			40.9	298,000	16.2	
4			44.8	342,000	16.0	71,800
5			49.5	398,000	16.4	74,600
6			53.4	446,000	21.5	114,000
7			55.8	478,000	25.4	147,000
8			56.2	483,000	27.3	164,000
9			54.8	465,000	31.2	200,000
10			52.2	431,000	34.8	235,000
11			47.7	376,000	41.5	304,000
12			42.4	314,000	46.5	362,000
13			38.2	269,000	49.1	393,000
14			35.8	245,000	51.2	419,000
15			34.5	232,000	50.8	414,000
16			33.1	218,000	49.1	393,000
17			33.9		45.5	350,000
18					40.8	297,000
19					36.0	247,000
20					35.3	240,000
21					30.5	194,000
22	25.3				25.8	151,000
23	24.4	138,000			23.8	133,000
24	24.7	141,000			23.6	132,000
25	25.3	146,000			23.0	126,000
26	36.0	247,000			29.1	
27	40.2	290,000				
28	40.7	296,000				
29						
30						
31						

Day.	February.		March.			
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1867.						
1			44.8	342,000	44.8	
2			42.8	319,000	42.8	319,000
3			42.8	319,000	42.8	319,000
4			44.8		44.8	342,000
5					48.2	382,000
6					50.5	410,000
7					51.8	426,000
8					52.2	431,000
9					52.8	439,000
10					53.6	449,000
11					53.6	449,000
12	29.1				52.7	437,000
13	28.2	173,000			54.5	461,000
14	29.7	186,000			55.4	472,000
15	40.0	288,000			55.7	476,000
16	45.0	344,000			55.1	468,000
17	49.3	395,000			53.3	445,000
18	50.6	411,000			49.8	401,000
19	51.0	416,000			44.0	333,000
20	51.8	426,000			37.4	261,000
21	53.3	445,000			31.5	203,000
22	54.1	456,000			27.8	169,000
23	53.3	445,000			26.8	160,000
24	52.2	431,000			29.2	
25	49.8	401,000				
26	47.5	374,000				
27	46.8	365,000				
28	46.3	359,000				
29						
30						
31						

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	January.		February.		Day.	July.		August.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1870.					1875.				
1			29.2	182,000	1			37.0	257,000
2			26.5	157,000	2			43.0	321,000
3			24.1	136,000	3			47.9	379,000
4			22.1	119,000	4			51.0	416,000
5			20.4	105,000	5			53.6	449,000
6			19.0	93,900	6			55.3	471,000
7			17.8	84,900	7			55.1	468,000
8			16.8	77,500	8			52.9	440,000
9			15.9	71,100	9	13.3		48.8	389,000
10			15.2	66,300	10	12.4	48,700	42.2	312,000
11	24.3		14.5	61,600	11	14.6	62,300	35.4	241,000
12	22.4	121,000	14.2	59,700	12	14.9	64,300	28.9	179,000
13	25.8	151,000	14.4	61,000	13	16.7	76,800	23.6	132,000
14	26.3	155,000			14	23.8	133,000	20.3	104,000
15	29.9	188,000			15	34.2	229,000	18.3	88,600
16	39.2	280,000			16	35.8	245,000	16.7	76,800
17	42.2	312,000			17	36.6	253,000	15.9	71,100
18	54.4	459,000			18	34.9	236,000	15.2	66,300
19	55.2	470,000			19	31.0	198,000	14.2	59,700
20	54.8	465,000			20	26.5	157,000	14.2	59,700
21	54.4	459,000			21	24.8	142,000	14.2	59,700
22	53.8	452,000			22	25.2	145,000	14.0	58,400
23	51.5	422,000			23	32.8	215,000	13.8	57,200
24	48.2	382,000			24	36.2	249,000	13.7	56,500
25	46.5	362,000			25	37.8	265,000	13.5	55,300
26	43.8	330,000			26	37.5	262,000	12.7	50,500
27	39.9	287,000			27	36.2	249,000	12.1	
28	37.4	261,000			28	35.4	241,000		
29	35.7	244,000			29	36.4	251,000		
30	33.8	225,000			30	35.9	246,000		
31	31.7	205,000			31	34.8	235,000		

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	January.		February.		Day.	January.		February.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1876.					1877.				
1			45.3	348,000	1			18.2	87,900
2			45.8	353,000	2			17.3	81,200
3			43.8	330,000	3			18.7	
4			40.9	298,000	4				
5			37.5	262,000	5				
6			33.4	221,000	6				
7			29.8	187,000	7	10.7			
8			27.8	169,000	8	10.2	36,600		
9			27.2	163,000	9	10.8	39,800		
10			32.2		10	11.2	41,900		
11	17.2				11	13.3	54,100		
12	16.0	71,800			12	16.0	71,800		
13	16.7	76,800			13	20.2	103,000		
14	18.2	87,900			14	32.4	212,000		
15	20.1	102,000			15	30.8	197,000		
16	21.1	110,000			16	38.5	272,000		
17	20.3	104,000			17	46.5	362,000		
18	19.9	101,000			18	52.1	430,000		
19	28.1	172,000			19	52.9	440,000		
20	27.0	162,000			20	53.2	444,000		
21	29.7	186,000			21	53.2	444,000		
22	30.4	193,000			22	50.8	414,000		
23	35.2	239,000			23	47.7	376,000		
24	41.0	299,000			24	44.8	342,000		
25	43.2	323,000			25	41.1	300,000		
26	44.8	342,000			26	37.1	258,000		
27	44.8	342,000			27	32.8	215,000		
28	48.2	382,000			28	28.0	171,000		
29	51.8	426,000			29	24.5	139,000		
30	49.8	401,000			30	21.3	112,000		
31	46.8	365,000			31	19.8	100,000		

Day.	February.		Day.	February.		March.	
	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1880.			1881.				
1			1			23.0	126,000
2			2			21.2	111,000
3			3			20.7	107,000
4			4			21.2	
5			5				
6			6	18.0			
7			7	16.2	73,200		
8			8	18.1	87,100		
9	14.7		9	26.3	155,000		
10	14.1	59,000	10	33.2	219,000		
11	14.2	59,700	11	33.2	219,000		
12	15.7	69,700	12	35.3	240,000		
13	26.0	153,000	13	41.8	308,000		
14	40.0	288,000	14	46.6	363,000		
15	48.6	387,000	15	49.4	397,000		
16	52.3	432,000	16	50.6	411,000		
17	53.1	443,000	17	50.1	405,000		
18	52.0	429,000	18	47.5	374,000		
19	49.8	401,000	19	44.3	336,000		
20	45.7	352,000	20	41.5	304,000		
21	40.3	291,000	21	41.0	299,000		
22	35.5	242,000	22	41.6	306,000		
23	30.8	197,000	23	40.2	290,000		
24	27.8	169,000	24	37.2	259,000		
25	25.8	151,000	25	35.2	239,000		
26	24.8	142,000	26	30.8	197,000		
27	24.5	139,000	27	27.3	164,000		
28	24.4	138,000	28	24.8	142,000		
29	25.0						

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	February.		Day.	February.		Day.	March.	
	Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.
1882.			1882.			1882.		
1			16	44.7	341,000	1	39.1	279,000
2			17	47.8	377,000	2	33.7	224,000
3			18	50.3	408,000	3	28.7	177,000
4			19	52.6	436,000	4	25.3	146,000
5			20	54.4	459,000	5	24.2	137,000
6	29.2		21	58.1	508,000	6	26.0	
7	27.0	162,000	22	57.8	504,000	7		
8	27.5	166,000	23	55.6	475,000	8		
9	28.5	175,000	24	53.9	453,000	9		
10	33.2	219,000	25	52.9	440,000	10		
11	37.0	257,000	26	51.7	425,000	11		
12	39.3	281,000	27	48.8	389,000	12		
13	41.3	302,000	28	44.2	335,000	13		
14	46.2	358,000				14		
15	45.5	350,000				15		

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1883.						
1			29.1	181,000	28.4	174,000
2			28.2	173,000	26.2	154,000
3			26.8	160,000	24.4	138,000
4			29.7	186,000	23.2	128,000
5			31.2	200,000	21.4	113,000
6			29.6	185,000	20.0	102,000
7			42.8	319,000	19.0	93,900
8			52.3	432,000	18.9	93,200
9			57.1	495,000	20.0	
10			59.0	520,000		
11			60.7	543,000		
12			63.4	579,000		
13			64.9	600,000		
14			65.4	606,000		
15			66.1	616,000		
16			64.3	591,000		
17			62.3	564,000		
18			60.4	539,000		
19			59.0	520,000		
20			57.6	501,000		
21			55.9	479,000		
22			53.5	448,000		
23			49.5	398,000		
24			45.0	344,000		
25			41.9	309,000		
26			39.5	283,000		
27	25.7		34.3	230,000		
28	24.9	143,000	31.4	202,000		
29	25.5	148,000				
30	27.1	162,000				
31	28.8	178,000				

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1884.						
1			38.4	271,000	24.5	139,000
2			45.6	351,000	22.9	125,000
3			49.3	395,000	21.2	111,000
4			50.1	405,000	20.6	106,000
5			52.5	435,000	19.5	97,700
6			58.8	517,000	18.2	87,900
7			61.6	555,000	18.0	86,400
8			62.5	567,000	24.0	
9			63.7	583,000		
10			64.8	598,000		
11			66.3	618,000		
12			68.2	644,000		
13			69.7	664,000		
14			71.0	682,000		
15			70.2	671,000		
16			68.4	647,000		
17			66.1	616,000		
18			63.5	581,000		
19			60.5	540,000		
20			58.9	519,000		
21			55.9	479,000		
22			52.1	430,000		
23			48.8	389,000		
24			45.4	349,000		
25			41.2	301,000		
26			37.0	257,000		
27			33.0	217,000		
28	16.1		29.3	183,000		
29	15.8	70,400	26.6	158,000		
30	18.8	92,400				
31	30.6	195,000				

Day.	March.		April.		May.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1886.						
1			45.1	345,000	13.3	
2			49.5	398,000		
3			52.4	434,000		
4			53.5	448,000		
5			53.7	450,000		
6			54.2	457,000		
7			54.3	458,000		
8			55.2	470,000		
9			55.7	476,000		
10			55.5	474,000		
11			54.6	462,000		
12			53.2	444,000		
13	12.4		52.7	437,000		
14	12.3	48,100	49.9	403,000		
15	12.4	48,700	45.8	353,000		
16	12.7	50,500	41.7	307,000		
17	13.0	52,300	37.3	260,000		
18	13.4	54,700	32.9	216,000		
19	13.8	57,200	28.9	179,000		
20	14.2	59,700	25.9	152,000		
21	14.8	63,600	23.2	128,000		
22	16.4	74,600	21.2	111,000		
23	21.9	117,000	19.6	98,500		
24	27.2	163,000	17.9	85,600		
25	29.7	186,000	16.4	74,600		
26	30.5	194,000	15.6	69,000		
27	30.5	194,000	14.7	63,000		
28	29.5	184,000	14.0	58,400		
29	30.8	197,000	13.5	55,300		
30	36.5	252,000	13.0	52,300		
31	40.0	288,000				

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1887.						
1			41.7	307,000	54.6	462,000
2			39.5	283,000	54.3	458,000
3			47.2	370,000	52.9	440,000
4			54.1	456,000	49.8	401,000
5			56.0	480,000	45.2	346,000
6			56.2	483,000	40.2	290,000
7			55.3	471,000	39.5	283,000
8			53.1	443,000	35.2	239,000
9			49.8	401,000	33.8	225,000
10			46.0	356,000	37.1	
11			44.2	335,000		
12			44.6	340,000		
13			45.3	348,000		
14			45.6	351,000		
15	12.2		46.6	363,000		
16	11.4	43,000	48.1	381,000		
17	12.2	47,600	48.5	386,000		
18	12.7	50,500	49.2	394,000		
19	12.8	51,100	50.0	404,000		
20	13.1	52,900	48.7	388,000		
21	13.0	52,300	47.5	374,000		
22	13.4	54,700	46.0	356,000		
23	15.1	65,600	43.8	330,000		
24	21.7	115,000	a 41.7	307,000		
25	23.7	132,000	42.5	315,000		
26	25.5	148,000	46.0	356,000		
27	31.7	205,000	52.9	440,000		
28	36.0	247,000	54.2	457,000		
29	39.7	285,000				
30	42.8	319,000				
31	42.8	319,000				

Day.	February.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1890.						
1			56.8	491,000	42.0	310,000
2			56.7	490,000	39.9	287,000
3			55.3	471,000	39.6	284,000
4			52.2	431,000	38.4	271,000
5			47.8	377,000	37.8	265,000
6			42.6	317,000	37.6	263,000
7			36.5	252,000	37.8	265,000
8			31.3	201,000	37.7	264,000
9			27.0	162,000	37.0	257,000
10			24.0	135,000	36.6	253,000
11			a 23.3	129,000	35.3	240,000
12			30.5	194,000	34.1	228,000
13			34.6	233,000	34.4	231,000
14			41.6	306,000	35.7	244,000
15	32.8		43.2	323,000	35.9	246.000
16	30.9	197,000	45.1	345,000	34.7	234,000
17	30.9	197,000	47.9	379,000	32.0	208,000
18	33.3	220,000	48.8	389,000	29.2	182,000
19	35.4	241,000	48.0	380,000	28.4	174,000
20	40.8	297,000	46.5	362,000	28.3	173,000
21	43.0	321,000	45.5	350,000	27.2	163,000
22	43.2	323,000	47.0	368,000	25.2	145,000
23	43.0	321,000	52.0	429,000	23.7	132,000
24	41.7	307,000	56.3	484,000	21.3	112,000
25	42.0	310,000	58.7	516,000	19.7	99,300
26	49.4	397,000	59.1	521,000	18.9	93,200
27	53.2	444,000	58.0	507,000	25.0	
28	55.7	476,000	57.3	497,000		
29			55.0	467,000		
30			51.2	419,000		
31			46.6	363,000		

a This day common to first and second floods.

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1891.						
1			33.6	223,000	50.3	408,000
2			38.9	277,000	46.6	363,000
3			43.2	323,000	40.5	294,000
4			45.6	351,000	35.4	241,000
5			47.5	374,000	32.7	214,000
6			47.9	379,000	33.6	223,000
7			46.9	367,000	33.8	225,000
8			44.6	340,000	32.8	215,000
9			41.5	304,000	35.4	
10			40.8	297,000		
11			41.3	302,000		
12			43.9	331,000		
13			46.3	359,000		
14			46.3	359,000		
15			45.1	345,000		
16			44.6	340,000		
17			45.5	350,000		
18			41.8	308,000		
19			41.5	304,000		
20			44.4	337,000		
21			49.7	400,000		
22			53.4	446,000		
23			55.2	470,000		
24			56.7	490,000		
25			57.3	497,000		
26			57.2	496,000		
27			55.8	478,000		
28			53.8	452,000		
29						
30	25.9					
31	25.0	144,000				

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1893.						
1			29.3	179,000	21.5	110,000
2			32.0	204,000	20.7	104,000
3			33.5	218,000	20.6	103,000
4			34.2	225,000	21.8	
5			33.8	221,000		
6			33.7	220,000		
7			36.0	243,000		
8			36.4	247,000		
9			35.3	236,000		
10			39.9	283,000		
11			45.3	343,000		
12			47.3	367,000		
13			48.5	381,000		
14			49.5	393,000		
15			52.7	432,000		
16			53.0	436,000		
17			51.7	420,000		
18			51.3	415,000		
19			52.5	430,000		
20			54.6	457,000		
21			54.6	457,000		
22			51.8	421,000		
23			46.8	361,000		
24			40.2	286,000		
25			33.5	218,000		
26			28.1	168,000		
27			24.2	133,000		
28			22.2	116,000		
29	10.3					
30	23.5	127,000				
31	26.5	154,000				

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	February.		March.		Day.	March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1897.					1898.				
1			55.6	470,000	1			56.5	482,000
2			49.9	398,000	2			54.1	450,000
3			43.2	319,000	3			51.2	414,000
4			37.8	261,000	4			47.6	370,000
5			35.5	238,000	5			42.9	315,000
6			43.1	318,000	6			37.6	259,000
7			39.2	276,000	7			32.3	207,000
8			32.5	209,000	8			27.3	161,000
9			40.0		9			25.6	145,000
10					10	15.2		23.7	129,000
11					11	15.0	62,300	22.0	114,000
12					12	15.2	63,600	20.5	102,000
13					13	17.8	81,900	19.4	93,900
14					14	18.3	85,600	19.3	93,200
15					15	17.0	76,100	20.0	98,500
16					16	18.0	83,400	20.6	103,000
17					17	20.0	98,500	20.4	102,000
18					18	23.5	127,000	20.3	101,000
19	30.6				19	27.1	159,000	21.1	107,000
20	29.1	177,000			20	31.8	202,000	21.3	109,000
21	29.5	181,000			21	38.5	268,000	20.9	106,000
22	41.0	295,000			22	41.9	304,000	20.8	105,000
23	50.4	404,000			23	44.1	329,000	20.1	99,300
24	56.0	475,000			24	49.2	389,000	19.9	97,700
25	59.4	520,000			25	51.8	421,000	18.8	89,400
26	61.1	542,000			26	54.6	457,000	17.0	76,100
27	60.9	540,000			27	57.9	500,000	16.5	72,500
28	59.2	517,000			28	59.8	525,000	20.8	
29					29	61.4	547,000		
30					30	60.2	531,000		
31					31	58.6	509,000		

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	February.		March.		April.		May.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1899.								
1			37.2	255,000	51.6	419,000	15.4	65,000
2			38.9	272,000	51.1	412,000	15.6	66,300
3			39.3	277,000	47.9	374,000	15.2	63,600
4			38.4	267,000	44.0	328,000	14.5	59,000
5			44.0	328,000	39.4	278,000	13.8	54,700
6			50.3	403,000	34.5	228,000	13.2	51,100
7			55.1	463,000	29.7	183,000	12.9	49,300
8			57.2	491,000	26.9	157,000	12.7	48,100
9			56.9	487,000	26.5	154,000	13.0	49,900
10			54.9	461,000	27.9	166,000	13.9	
11			51.4	416,000	29.3	179,000		
12			46.6	358,000	30.3	188,000		
13			41.0	295,000	30.6	191,000		
14			35.6	239,000	29.8	184,000		
15			33.2	215,000	28.3	170,000		
16			28.4	171,000	26.4	153,000		
17	12.3		25.9	148,000	24.2	133,000		
18	11.5	41,000	a 24.2	133,000	22.8	121,000		
19	12.6	47,600	24.8	138,000	21.5	110,000		
20	14.9	61,600	29.0	176,000	20.7	104,000		
21	25.8	147,000	32.3	207,000	19.7	96,200		
22	32.1	205,000	36.1	244,000	18.5	87,100		
23	34.6	229,000	40.0	284,000	17.3	78,200		
24	35.6	239,000	40.5	289,000	15.8	67,600		
25	35.9	242,000	39.4	278,000	15.0	62,300		
26	36.2	245,000	37.8	261,000	14.9	61,600		
27	39.0	274,000	35.6	239,000	14.6	59,700		
28	38.6	269,000	35.2	235,000	14.5	59,000		
29			39.0	274,000	14.4	58,400		
30			45.2	342,000	14.2	57,200		
31			50.0	399,000				

Day.	April.		Day.	May.	
	Gage height.	Discharge.		Gage height.	Discharge.
1901.			1901.		
16	25.8		1	51.2	414,000
17	23.9	131,000	2	46.0	351,000
18	24.8	138,000	3	40.0	284,000
19	26.3	152,000	4	33.3	216,000
20	31.1	196,000	5	27.4	162,000
21	40.7	291,000	6	23.0	123,000
22	47.9	374,000	7	20.0	98,500
23	53.2	439,000	8	17.5	79,700
24	56.4	480,000	9	16.7	73,900
25	55.4	467,000	10	16.4	71,800
26	59.5	521,000	11	16.3	71,100
27	59.7	524,000	12	16.7	
28	59.2	517,000	13		
29	57.7	497,000	14		
30	55.0	462,000	15		
31					

a Common to first and second floods.

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	February.		March.		Day.	February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1902.					1903.				
1			39.6	280,000	1			38.0	263,000
2			44.8	337,000	2			44.4	333,000
3			48.6	382,000	3			49.0	387,000
4			50.4	404,000	4			51.6	419,000
5			50.9	410,000	5			53.1	437,000
6			50.7	408,000	6			52.9	435,000
7			50.0	399,000	7			51.0	411,000
8			48.5	381,000	8			50.4	404,000
9			47.2	365,000	9			50.0	399,000
10			48.8	385,000	10			47.6	370,000
11			45.5	345,000	11			49.2	389,000
12			44.7	336,000	12			49.5	393,000
13			43.0	317,000	13			49.8	397,000
14			41.8	303,000	14			50.2	401,000
15			41.0	295,000	15			50.1	400,000
16			40.0	284,000	16			48.6	382,000
17			39.5	279,000	17			46.3	355,000
18			39.2	276,000	18			43.3	320,000
19			39.1	275,000	19			39.1	275,000
20			38.4	267,000	20			35.7	240,000
21			36.5	248,000	21			30.9	194,000
22	8.6		33.3	216,000	22			27.9	166,000
23	8.4	25,900	30.3	188,000	23			26.2	151,000
24	8.6	26,800	27.2	160,000	24			26.4	
25	11.0	38,700	24.4	135,000	25				
26	14.1	56,500	21.8	113,000	26	26.5	154,000		
27	22.5	119,000	19.8	97,000	27	25.2	142,000		
28	33.8	221,000	18.2	84,900	28	31.4	198,000		
29			16.4	71,800	29				
30			16.6		30				
31					31				

Day.	March.		Day.	April.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.
1906.			1906.			1906.		
16			1	48.8	385,000	17	28.9	175,000
17			2	50.2	401,000	18	29.6	182,000
18			3	49.8	397,000	19	29.7	183,000
19			4	47.6	370,000	20	29.0	176,000
20			5	46.5	357,000	21	28.0	167,000
21			6	42.8	314,000	22	26.4	153,000
22			7	38.3	266,000	23	24.0	132,000
23			8	33.7	220,000	24	21.7	112,000
24			9	30.3	188,000	25	19.9	97,700
25	29.2		10	28.5	172,000	26	19.0	90,900
26	27.9	166,000	11	27.9	166,000	27	17.9	82,700
27	31.6	200,000	12	27.4	162,000	28	17.3	78,200
28	33.5	218,000	13	27.2	160,000	29	16.1	69,700
29	32.3	207,000	14	27.3	161,000	30	16.5	
30	35.2	235,000	15	28.5	172,000	31		
31	44.8	337,000	16	29.9	184,000			

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	December, 1906.		January, 1907.		February.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906–7.										
1			29.2	178,000	20.5	102,000			25.4	144,000
2			31.0	195,000	22.5				26.3	152,000
3			36.0	243,000					26.4	153,000
4			41.7	302,000					25.6	145,000
5			43.2	319,000					24.3	134,000
6			41.2	297,000					22.8	121,000
7			38.8	271,000					21.0	106,000
8			38.1	264,000					20.5	102,000
9			39.0	274,000			26.6		23.0	
10			38.7	270,000			25.3	143,000		
11			38.3	266,000			26.3	152,000		
12			39.4	278,000			27.3	161,000		
13			42.3	309,000			41.0	295,000		
14			44.0	328,000			50.3	403,000		
15			47.2	365,000			54.1	450,000		
16			51.1	412,000			57.6	496,000		
17			55.7	471,000			60.2	531,000		
18			59.4	520,000			61.6	550,000		
19			61.9	554,000			62.1	556,000		
20			64.1	583,000			61.3	546,000		
21			65.1	597,000			59.8	525,000		
22			64.6	590,000			57.5	495,000		
23			63.2	571,000			54.8	459,000		
24			61.2	544,000			52.3	427,000		
25			58.1	503,000			49.4	392,000		
26			54.0	449,000			45.7	348,000		
27			48.0	375,000			41.0	295,000		
28	20.0		40.9	294,000			35.3	236,000		
29	18.0	83,400	32.8	212,000			30.1	186,000		
30	18.5	87,100	27.0	158,000			26.3	152,000		
31	24.6	137,000	22.0	114,000			24.7	138,000		

Day.	February.		March.		April.		May.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1908.								
1			a 21.7	112,000	37.2	255,000	22.7	
2			29.0	176,000	46.5	357,000		
3			34.8	231,000	53.1	437,000		
4			37.7	260,000	55.7	471,000		
5			41.0	295,000	54.9	461,000		
6			44.4	333,000	51.8	421,000		
7			48.4	380,000	46.7	359,000		
8			50.5	405,000	40.4	288,000		
9			51.6	419,000	36.5	248,000		
10			52.4	429,000	34.6	229,000		
11			53.2	439,000	33.0	213,000		
12			53.2	439,000	35.8	241,000		
13	22.4		51.9	422,000	39.0	274,000		
14	21.0	106,000	49.5	393,000	40.5	289,000		
15	34.5	228,000	45.0	340,000	40.0	284,000		
16	42.2	308,000	41.8	303,000	39.4	278,000		
17	45.0	340,000	37.5	258,000	36.5	248,000		
18	46.8	361,000	34.8	231,000	35.1	234,000		
19	49.2	389,000	34.8	231,000	32.0	204,000		
20	51.1	412,000	38.0	263,000	30.0	185,000		
21	50.9	410,000	41.0	295,000	28.6	173,000		
22	49.0	387,000	44.5	334,000	27.4	162,000		
23	45.0	340,000	47.5	369,000	27.0	158,000		
24	40.0	284,000	48.9	386,000	26.5	154,000		
25	33.8	221,000	48.2	377,000	26.1	150,000		
26	30.8	193,000	44.8	337,000	25.1	141,000		
27	27.6	163,000	41.7	302,000	25.3	143,000		
28	24.0	132,000	36.9	252,000	24.7	138,000		
29	22.3	117,000	32.5	209,000	23.1	124,000		
30			31.4	198,000	21.5	110,000		
31			b 31.0	195,000				

a Common to first and second floods. b Common to second and third floods.

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	February.		March.		Day.	February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.		Gage height.	Discharge.	Gage height.	Discharge.
1909.					1910.				
1			54.1	450,000	1			43.2	319,000
2			51.8	421,000	2			41.2	297,000
3			48.5	381,000	3			43.4	321,000
4			44.0	328,000	4			46.8	361,000
5			39.1	275,000	5			49.3	391,000
6	14.0		34.9	232,000	6			51.0	411,000
7	13.6	53,500	33.5	218,000	7			51.8	421,000
8	13.5	52,900	33.4	217,000	8			51.0	411,000
9	14.5	59,000	34.6	229,000	9			49.5	393,000
10	16.3	71,100	42.1	307,000	10			47.3	367,000
11	19.5	94,700	42.3	309,000	11			44.8	337,000
12	23.8	130,000	42.1	307,000	12			41.8	303,000
13	26.6	154,000	40.7	291,000	13			38.5	268,000
14	27.7	164,000	39.3	277,000	14	14.7		34.4	227,000
15	30.0	185,000	37.0	253,000	15	14.4	58,400	30.6	191,000
16	30.8	193,000	34.7	230,000	16	16.0	69,000	27.2	160,000
17	31.8	202,000	32.1	205,000	17	20.4	102,000	24.4	135,000
18	34.9	232,000	29.3	179,000	18	22.8	121,000	22.2	116,000
19	38.2	265,000	26.6	154,000	19	27.5	162,000	20.5	102,000
20	39.9	283,000	24.0	132,000	20	31.0	195,000	19.3	93,200
21	39.9	283,000	22.0	114,000	21	33.1	214,000	18.1	84,100
22	38.4	267,000	20.2	100,000	22	35.6	239,000	16.9	75,300
23	36.6	249,000	18.6	87,900	23	37.2	255,000	16.0	69,000
24	48.1	376,000	17.6	80,400	24	38.0	263,000	15.4	65,000
25	52.2	426,000	17.2	77,500	25	36.8	251,000	14.8	61,000
26	53.9	448,000	17.6		26	34.8	231,000	14.9	
27	54.3	453,000			27	34.5	228,000		
28	54.6	457,000			28	43.5	322,000		
29					29				
30					30				
31					31				

Day.	March.		Day.	March.		Day.	April.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.
1912.			1912.			1912.			1912.		
1			16	42.6	312,000	1	46.8	361,000	16	25.9	148,000
2			17	44.0	328,000	2	46.8	361,000	17	24.0	132,000
3			18	45.4	344,000	3	49.0	387,000	18	24.8	138,000
4			19	46.6	358,000	4	50.5	405,000	19	24.2	133,000
5			20	47.0	363,000	5	51.7	420,000	20	25.4	
6			21	46.5	357,000	6	51.7	420,000	21		
7			22	47.0	363,000	7	50.7	408,000	22		
8			23	45.2	342,000	8	48.6	382,000	23		
9	20.2		24	45.8	349,000	9	45.5	345,000	24		
10	19.2	92,400	25	50.2	401,000	10	41.4	299,000	25		
11	20.4	102,000	26	52.2	426,000	11	37.3	256,000	26		
12	22.4	118,000	27	53.2	439,000	12	33.9	222,000	27		
13	25.4	144,000	28	52.8	434,000	13	31.5	199,000	28		
14	28.6	173,000	29	51.6	419,000	14	29.8	184,000	29		
15	37.2	255,000	30	50.6	406,000	15	27.6	163,000	30		
			31	48.1	376,000						

TABLE 13.—*Daily gage height, in feet, and discharge, in second-feet, of Ohio River at Cincinnati, Ohio, for all floods above the danger line (50 feet) from 1859 to 1913*—Contd.

Day.	December, 1912.		January, 1913.		February.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1912-13.										
1			11.0	38,700	36.1	244,000			69.8	660,000
2			12.9	49,300	32.4	208,000			69.5	656,000
3			17.9	82,700	28.9	175,000			68.0	636,000
4			20.6	103,000	26.8	156,000			66.0	609,000
5			22.2	116,000	26.5	154,000			63.3	573,000
6			23.0	123,000	27.9				57.8	499,000
7			27.3	161,000					50.5	405,000
8			37.0	253,000					42.8	314,000
9			44.3	331,000					34.9	232,000
10			48.4	380,000					31.3	197,000
11			51.8	421,000					30.5	190,000
12			58.6	509,000					27.3	161,000
13			61.1	543,000					24.0	132,000
14			61.9	554,000					24.1	
15			61.5	548,000						
16			61.1	543,000						
17			60.9	540,000						
18			60.6	536,000						
19			56.0	475,000						
20			51.6	419,000						
21			49.0	387,000						
22			47.1	364,000						
23			45.5	345,000			24.7			
24			48.4	380,000			22.6	120,000		
25			47.5	369,000			29.3	179,000		
26			46.6	358,000			50.3	403,000		
27	8.8		46.0	351,000			57.2	491,000		
28	8.7	27,300	45.6	346,000			62.6	563,000		
29	9.5	31,100	44.2	330,000			66.0	609,000		
30	10.3	35,100	42.2	308,000			67.9	635,000		
31	10.8	37,600	39.4	278,000			69.2	652,000		

Records in which two consecutive rises went above the danger line overlap one day, as, for example, March 31, 1908.

The daily discharge was determined by using the gage height at the time of the regular reading as the mean gage height for the day, and therefore differs during periods of large diurnal fluctuation from the daily discharge that would be obtained by using a mean gage height computed from a number of observations taken during each day, as, for example, from the record of an automatic gage. In general the only days on which more than one reading was available were those during the crest periods. It has been thought best, therefore, to use the regular reading as the mean for the day, and it is probable that no material error in the total discharge for the flood has been thereby introduced.

The rating tables used in the computations of daily discharge in all tables are provisional and subject to revision on a more complete study of the data than was possible in the preparation of this preliminary report. It is thought, however, that the tables are essentially correct and that changes resulting from any future revisions will be comparatively small, especially at the high stages covered by these tables. (See Table 18, p. 82.)

Table 14 contains data similar to those in Table 13 for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913, at Wheeling, W. Va., Parkersburg, W. Va., Catlettsburg, Ky., Louisville, Ky., and Evansville, Ind.

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913.*

Wheeling, W. Va.

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1884.						
1			16.2	94,000	9.8	44,700
2			29.2	208,000	8.4	34,700
3			26.0	178,000	7.8	30,300
4			20.0	126,000	7.3	26,900
5			21.5	138,000	7.3	26,900
6			35.0	265,000	7.2	26,200
7			46.0	388,000	7.2	26,200
8			47.0	401,000	7.0	25,000
9			41.2	332,000	7.8	
10			38.0	297,000		
11			33.0	245,000		
12			29.5	211,000		
13			29.0	206,000		
14			26.5	183,000		
15			30.0	216,000		
16			32.5	240,000		
17			28.0	197,000		
18			22.5	147,000		
19			20.8	132,000		
20			20.8	132,000		
21			20.0	126,000		
22			19.3	120,000		
23			17.8	107,000		
24			15.1	85,000		
25	6.8		13.5	72,500		
26	6.6	22,300	12.2	62,500		
27	7.0	25,000	11.2	55,000		
28	11.0	53,300	11.2	55,000		
29	10.8	51,900	10.5	49,600		
30	8.8	37,500				
31	11.9	60,100				

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913*—Continued.

Wheeling, W. Va.—Continued.

Day.	December, 1906.		January, 1907.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906–7.								
1			17.0	101,000			14.9	83,500
2			19.8	124,000			12.3	63,200
3			18.9	116,000			10.9	52,500
4			16.3	94,800			9.8	44,700
5			16.6	97,300			9.0	39,000
6			18.2	110,000			8.6	36,000
7			18.8	116,000			8.0	31,900
8			16.7	98,000			8.0	
9			16.6	97,300	8.8		8.1	
10			20.2	127,000	8.5	35,300		
11			24.0	160,000	9.3	41,000		
12			21.0	134,000	9.5	42,500		
13			19.9	125,000	17.5	105,000		
14			26.3	181,000	37.9	296,000		
15			28.0	197,000	47.8	411,000		
16			31.4	230,000	48.9	424,000		
17			28.9	205,000	38.0	297,000		
18			27.2	189,000	27.9	196,000		
19			31.6	231,000	22.8	150,000		
20			36.1	277,000	25.1	170,000		
21			35.9	275,000	31.8	233,000		
22			29.3	209,000	29.3	209,000		
23			21.9	142,000	23.0	151,000		
24			16.9	100,000	17.9	108,000		
25			13.1	69,500	15.8	90,800		
26			10.9	52,500	13.9	75,800		
27	7.0		9.9	45,400	13.0	68,600		
28	6.9	24,300	9.7	44,000	16.5	96,400		
29	7.2	26,200	8.3	34,000	18.9	116,000		
30	10.8	51,900	7.9	31,000	19.7	123,000		
31	15.6	89,100	[a]7.6	29,000	18.0	109,000		

Day.	March.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.
1913.			1913.		
16			1	28.3	200,000
17			2	18.3	111,000
18			3	15.5	88,200
19			4	13.9	75,800
20			5	12.8	67,100
21			6	11.5	57,000
22			7	10.5	49,600
23	8.3		8	9.5	42,400
24	7.5	28,300	9	9.3	41,000
25	11.5	57,000	10	7.0	25,000
26	30.5	220,000	11	7.8	
27	45.5	383,000	12		
28	50.8	448,000	13		
29	50.0	439,000	14		
30	43.0	353,000	15		
31	32.1	236,000			

[a] Gage height 7.9 on Feb. 1.

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913*—Continued.

Parkersburg, W. Va.

Day.	December, 1906.		January, 1907.		February.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906–7.										
1			17.4	114,000	10.0				17.6	116,000
2			19.3	132,000					14.9	89,000
3			20.4	142,000					12.7	69,500
4			19.9	138,000					11.4	57,500
5			19.8	136,000					10.0	46,000
6			20.7	145,000					9.4	40,000
7			21.6	154,000					9.2	38,500
8			21.2	150,000					9.2	
9			23.9	177,000			10.0		9.8	
10			23.9	177,000			9.6	42,000		
11			24.5	184,000			11.9	62,000		
12			25.0	189,000			12.2	64,500		
13			29.3	233,000			18.0	120,000		
14			27.8	217,000			37.0	318,000		
15			32.0	262,000			48.1	453,000		
16			34.4	289,000			51.4	495,000		
17			36.3	311,000			50.9	488,000		
18			38.4	335,000			43.6	397,000		
19			38.0	330,000			40.0	353,000		
20			39.3	346,000			35.0	295,000		
21			39.9	352,000			34.2	286,000		
22			39.1	342,000			34.7	292,000		
23			34.8	293,000			32.0	262,000		
24			28.0	219,000			26.0	199,000		
25			23.0	168,000			20.4	142,000		
26			19.2	130,000			16.6	106,000		
27	8.4		16.1	101,000			14.5	86,000		
28	7.8	27,000	14.0	81,000			13.4	75,000		
29	11.0	54,000	12.0	63,000			16.1	101,000		
30	10.6	50,500	10.4	49,500			19.1	129,000		
31	13.8	80,000	8.5	33,000			19.4	132,000		

Day.	March.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.
1913.			1913.		
16			1	47.5	445,000
17			2	38.1	331,000
18			3	27.2	210,000
19			4	19.5	134,000
20			5	16.5	105,000
21			6	15.8	98,000
22			7	14.2	83,000
23	10.0		8	12.9	71,000
24	9.5	41,000	9	11.8	61,000
25	10.0	46,000	10	10.9	53,000
26	22.1	160,000	11	10.5	50,000
27	43.0	390,000	12	10.8	
28	54.9	540,000	13		
29	58.7	589,000	14		
30	57.9	579,000	15		
31	53.8	526,000			

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March-April, 1907, and March-April, 1913*—Continued.

Catlettsburg, Ky.

Day.	December, 1906.		January, 1907.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906-7.								
1			25.7	153,000			24.6	143,000
2			27.7	172,000			23.8	136,000
3			29.6	191,000			22.4	124,000
4			30.4	200,000			20.4	107,000
5			31.6	212,000			18.4	92,000
6			30.0	196,000			17.0	82,000
7			29.4	189,000			18.3	
8			29.6	191,000	21.4			
9			30.7	203,000	20.0			
10			32.8	226,000	19.9	103,000		
11			33.9	239,000	22.5	124,000		
12			33.7	236,000	23.8	136,000		
13			38.0	287,000	28.6	181,000		
14			41.0	324,000	37.2	277,000		
15			42.7	345,000	49.0	426,000		
16			47.8	410,000	57.2	532,000		
17			52.4	470,000	59.8	566,000		
18			55.4	509,000	60.4	574,000		
19			59.0	555,000	59.6	564,000		
20			59.9	568,000	56.4	522,000		
21			58.4	548,000	52.3	469,000		
22			56.4	522,000	49.0	426,000		
23			53.0	477,000	47.0	400,000		
24			50.6	446,000	44.0	362,000		
25			45.0	374,000	39.6	306,000		
26			37.0	274,000	33.5	233,000		
27	15.0		28.0	175,000	27.2	167,000		
28	13.5	59,500	21.8	119,000	23.8	136,000		
29	15.0	69,000	17.5	85,500	20.5	108,000		
30	22.0	120,000	15.0	69,000	21.9	120,000		
31	24.0	138,000	[a] 14.0	62,500	24.0	138,000		

Day.	March.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.
1913.			1913.		
16			1	[b] 66.5	654,000
17			2	[b] 65.3	638,000
18			3	[b] 60.7	578,000
19			4	53.2	480,000
20			5	43.5	356,000
21			6	33.5	234,000
22			7	27.0	165,000
23			8	22.6	126,000
24	15.8		9	19.7	101,000
25	15.5	72,000	10	17.5	85,500
26	17.2	83,000	11	16.1	75,500
27	41.1	325,000	12	15.6	72,500
28	57.5	536,000	13	15.9	
29	65.1	636,000	14		
30	66.3	652,000	15		
31	67.7	669,000			

[a] Gage height on Feb. 1 is 14.5.
[b] Gage heights Apr. 1, 2, and 3 obtained by comparison with Huntington.

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913*—Continued.

Louisville, Ky. (Lower gage.)

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1884.						
1			34.0	272,000	27.1	198,000
2			40.6	350,000	23.9	165,000
3			45.5	412,000	22.6	153,000
4			48.3	449,000	20.5	133,000
5			51.6	493,000	19.0	119,000
6			57.6	577,000	18.0	111,000
7			62.8	652,000	18.0	111,000
8			64.1	671,000	19.0	
9			65.6	694,000		
10			65.7	695,000		
11			66.0	700,000		
12			67.1	716,000		
13			68.8	742,000		
14			70.5	769,000		
15			71.7	787,000		
16			72.0	792,000		
17			71.3	781,000		
18			70.1	762,000		
19			68.5	738,000		
20			67.1	716,000		
21			65.2	688,000		
22			62.5	648,000		
23			59.2	600,000		
24			55.7	550,000		
25			51.0	485,000		
26			46.4	424,000		
27			42.6	375,000		
28	17.5		36.2	297,000		
29	15.0	85,400	31.5	244,000		
30	15.8	92,000				
31	23.5	162,000				

Day.	December, 1906.		January, 1907.		February.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906–7.						
1			27.8	205,000	23.0	157,000
2			32.4	254,000	22.0	147,000
3			39.8	340,000	23.0	
4			45.4	411,000		
5			48.1	446,000		
6			47.0	432,000		
7			44.2	395,000		
8			41.0	355,000		
9			40.8	353,000		
10			40.5	349,000		
11			39.7	339,000		
12			40.0	343,000		
13			43.2	383,000		
14			44.4	398,000		
15			47.3	436,000		
16			51.6	493,000		
17			55.7	550,000		
18			58.9	595,000		
19			61.7	636,000		
20			64.2	673,000		
21			66.1	701,000		
22			66.9	713,000		
23			66.8	712,000		
24			65.8	697,000		
25			64.2	673,000		
26			61.4	632,000		
27			57.7	578,000		
28	20.6		52.4	504,000		
29	19.0	119,000	44.8	403,000		
30	19.4	123,000	36.2	297,000		
31	22.0	147,000	27.9	206,000		

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913*—Continued.

Louisville, Ky.—Continued.

Day.	February.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.						
1			22.6	153,000	23.0	157,000
2			23.5	162,000	22.4	151,000
3			24.3	169,000	22.6	153,000
4			26.8	195,000	23.4	161,000
5			28.6	213,000	23.0	157,000
6			29.8	226,000	21.8	145,000
7			29.2	220,000	20.2	130,000
8			28.2	209,000	19.2	121,000
9			27.4	201,000	19.2	121,000
10			26.7	193,000	21.2	
11			27.4	201,000		
12			27.4	201,000		
13			39.2	333,000		
14			49.8	469,000		
15			55.0	540,000		
16			57.8	580,000		
17			59.0	597,000		
18			60.3	616,000		
19			61.2	629,000		
20			61.5	633,000		
21			61.0	626,000		
22			60.1	613,000		
23	15.8		57.8	580,000		
24	15.6	90,300	56.4	560,000		
25	15.8	92,000	53.9	525,000		
26	17.4	105,000	50.8	483,000		
27	19.4	123,000	47.0	432,000		
28	21.6	143,000	41.4	360,000		
29			35.6	290,000		
30			29.8	226,000		
31			24.6	172,000		

Day.	March.		Day.	April.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.
1913.			1913.			1913.		
16			1	70.2	764,000	16	24.0	166,000
17			2	70.5	769,000	17	28.8	164,000
18			3	70.1	762,000	18	26.0	
19			4	69.2	748,000	19		
20			5	68.3	735,000	20		
21			6	66.4	706,000	21		
22			7	63.2	658.000	22		
23	27.3		8	58.3	587,000	23		
24	24.6	172,000	9	51.5	492,000	24		
25	28.6	213,000	10	44.5	399,000	25		
26	48.1	446,000	11	39.5	337,000	26		
27	59.3	601.000	12	36.4	300,000	27		
28	64.2	673,000	13	31.0	239,000	28		
29	66.7	710.000	14	26.0	186,000	29		
30	68.3	735,000	15	24.2	168,000	30		
31	69.3	750,000						

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913*—Continued.

Evansville, Ind.

Day.	January.		February.		March.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1884.						
1			24.0	224,000	37.6	455,000
2			29.0	300,000	36.5	434,000
3			32.8	365,000	32.4	358,000
4			36.3	430,000	31.7	346,000
5			38.3	468,000	29.0	300,000
6			41.2	526,000	26.0	253,000
7			42.5	552,000	24.0	224,000
8			44.2	587,000	22.0	196,000
9			44.8	600,000	21.4	188,000
10			45.2	608,000	22.2	
11			45.6	616,000		
12			46.1	627,000		
13			46.3	631,000		
14			46.8	642,000		
15			47.2	650,000		
16			47.5	657,000		
17			47.8	663,000		
18			48.0	667,000		
19			48.0	667,000		
20			47.7	661,000		
21			47.5	657,000		
22			46.5	635,000		
23			46.2	629,000		
24			46.0	625,000		
25			45.3	610,000		
26			43.6	575,000		
27			42.5	552,000		
28	15.7		41.0	522,000		
29	14.7	110,000	38.7	476,000		
30	15.7	120,000				
31	18.0	146,000				

Day.	December, 1906.		January, 1907.		February.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1906–7.						
1			21.7	192,000	39.0	482,000
2			24.0	224,000	36.6	436,000
3			30.0	317,000	33.8	383,000
4			35.1	407,000	30.6	
5			37.9	461,000	29.5	
6			39.6	494,000	28.3	
7			40.3	508,000	27.7	
8			40.3	508,000	27.1	
9			39.9	500,000	26.2	
10			39.5	492,000	25.4	
11			38.8	478,000	23.6	
12			38.4	470,000	22.0	
1			38.3	468,000	20.2	
14			38.5	472,000	18.9	
15			39.0	482,000	18.0	
16			39.8	498,000	17.4	
17			40.7	516,000	17.1	
18			42.0	542,000	16.7	
19			43.4	571,000	16.1	
20			44.2	587,000	15.6	
21			44.9	602,000	15.2	
22			45.4	612,000	14.7	
23			45.9	623,000	14.6	
24			46.2	629,000	14.4	
25			46.2	629,000	14.7	
26			46.1	627,000		
27			45.9	623,000		
28			45.5	614,000		
29	23.4		44.8	600,000		
30	20.4	175,000	43.5	573,000		
31	21.0	183,000	41.7	536,000		

TABLE 14.—*Daily gage height, in feet, and daily discharge, in second-feet, of Ohio River at selected stations for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913*—Continued.

Evansville, Ind.—Continued.

Day.	February.		March.		April.	
	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
1907.						
1			20.5		31.1	336,000
2			22.3		26.7	264,000
3			23.9		23.1	211,000
4			24.7		21.0	183,000
5			25.4		20.1	172,000
6			26.3		19.9	169,000
7			27.2		19.7	167,000
8			27.8		21.2	186,000
9			27.8		18.5	152,000
10			27.5		17.7	143,000
11			27.3		17.6	141,000
12			27.2	271,000	18.5	
13			27.4	275,000		
14			31.3	339,000		
15			36.3	430,000		
16			39.0	482,000		
17			40.9	520,000		
18			42.0	542,000		
19			42.7	556,000		
20			43.2	567,000		
21			43.5	573,000		
22			43.7	577,000		
23	14.6		43.8	579,000		
24	14.4		43.6	575,000		
25	14.7		43.2	567,000		
26	16 0		42.7	556,000		
27	17.5		41.9	540,000		
28	19.0		41.0	522,000		
29			39.6	494,000		
30			37.8	459,000		
31			34.9	404,000		

Day.	March.		Day.	April.		Day.	April.	
	Gage height.	Discharge.		Gage height.	Discharge.		Gage height.	Discharge.
1913.			1913.			1913.		
16			1	46.4	633,000	16	34.3	393,000
17			2	47.2	650,000	17	31.8	348,000
18			3	47.8	663,000	18	29.8	313,000
19			4	48.2	671,000	19	28.0	284,000
20			5	48.3	674,000	20	27.1	270,000
21			6	48.1	669,000	21	26.6	
22			7	47.9	665,000	22	25.9	
23			8	47.5	657,000	23	24.6	
24	27.5		9	46.7	640,000	24	22.8	
25	26.0	253,000	10	45.8	621,000	25	21.0	
26	30.1	318,000	11	44.4	591,000	26		
27	36.6	436.000	12	42.7	556,000	27		
28	40.4	510,000	13	41.1	524,000	28		
29	43.0	562,000	14	39.3	488,000	29		
30	44.4	591,000	15	36.8	439,000	30		
31	45.4	612,000						

Table 15 contains a summary of flood-flow records of Ohio River at Cincinnati, Ohio, for all floods above danger line (50 feet) from 1859 to 1913 given in Table 13. The total discharge of the entire flood represents the entire volume of the run-off for the period from trough to trough. The maximum daily discharge is the discharge obtained from the maximum daily gage height and is therefore not the maximum rate of discharge that occurred during the flood unless the maximum daily gage height happens to represent the crest stage. The total discharge for the period when the stage was above 50 feet is the total discharge for the number of whole days during which the regular daily gage-height reading was above 50 feet. For most periods this total will not be identical with that which would have been obtained by constructing a hydrograph of discharge and taking from it the total discharge above the stage of 50 feet. The values in this table, however, are as close as the number of observations warrant, and the errors thus introduced are more or less compensating.

The excess discharge during the period when the stage was above 50 feet is the difference obtained by subtracting from the total discharge for the period the total discharge that would result if the stage remained at 50 feet for the number of days in the period. This excess represents the volume by which the flow at Cincinnati would have had to be reduced during these periods in order to keep the stage from going above 50 feet. The explanation of the discharge data during periods when the stage was above 54 and 57 feet is identical with the above, 54 or 57 being substituted for 50 feet. The stages selected are those at danger line, 4 feet above danger line, and 7 feet above danger line.

TABLE 15.—*Summary of flood-flow records of Ohio River at Cincinnati, Ohio, for all floods above danger line (50 feet) for 1859 to 1913.*

[Drainage area, 75,800 square miles.]

Number.	Dates of floods.	Entire flood.			Maximum daily discharge.			Period when stage was above—								
		Number of days.	Total discharge.		Date.	Second-feet.	Second-feet per square mile.	50 feet (399,000 second-feet).[a]			54 feet (449,000 second-feet).[a]			57 feet (488,000 second-feet).[a]		
			Million cubic feet.	Average in second-feet per square mile.				Number of days.	Discharge in million cubic feet. Total.	Excess.[b]	Number of days.	Discharge in million cubic feet. Total.	Excess.[b]	Number of days.	Discharge in million cubic feet. Total.	Excess.[b]
1	1859—Feb. 9-Mar. 12	32	699,000	3.34	Feb. 23	471,000	6.21	7	270,000	25,400	3	121,000	3,110			
2	1862—Jan. 6-31	26	539,000	3.17	Jan. 24	497,000	6.56	6	244,000	34,300	4	167,000	10,400	1	42,900	346
3	1865—Feb. 23-Mar. 16	22	593,000	4.11	Mar. 8	483,000	6.37	5	199,000	24,500	3	123,000	5,530			
4	1865—May 4-25	22	446,000	3.09	May 14	419,000	5.53	2	72,000	2,160						
5	1867—Feb. 13-Mar. 3	19	596,000	4.79	Feb. 22	456,000	6.02	7	262,000	17,500	1	39,400	173			
6	1867—Mar. 2-23	22	713,000	4.95	Mar. 15	476,000	6.28	12	463,000	44,500	4	162,000	5,270			
7	1870—Jan. 12-Feb. 12	32	643,000	3.07	Jan. 19	470,000	6.20	6	236,000	26,200	4	160,000	3,200			
8	1875—July 10-Aug. 26	48	823,000	2.62	Aug. 6	471,000	6.21	4	194,000	19,400	2	81,100	2,680			
9	1876—Jan. 12-Feb. 9	29	589,000	3.10	Jan. 29	426,000	5.62	1	36,800	1,900						
10	1877—Jan. 8-Feb. 2	26	496,000	2.91	Jan. 20-21	444,000	5.86	5	188,000	13,100						
11	1880—Feb. 10-28	19	392,000	3.15	Feb. 17	443,000	5.84	3	113,000	7,950						
12	1881—Feb. 7-Mar. 3	25	530,000	3.24	Feb. 16	411,000	5.42	2	70,500	691						
13	1882—Feb. 7-Mar. 5	27	759,000	4.29	Feb. 21	508,000	6.70	9	355,000	40,800	4	168,000	11,200	2	87,400	2,250
14	1883—Jan. 28-Mar. 8	40	1,110,000	4.23	Feb. 15	616,000	8.13	15	694,000	170,000	13	618,000	108,000	12	577,000	65,500
15	1884—Jan. 29-Mar. 7	39	1,270,000	4.97	Feb. 14	682,000	9.00	19	929,000	266,000	16	819,000	192,000	15	778,000	139,000
16	1886—Mar. 14-Apr. 30	48	925,000	2.94	April 9	476,000	6.28	11	433,000	48,900	6	242,000	6,310			
17	1887—Jan. 16-Feb. 24	40	976,000	3.72	Feb. 6	483,000	6.37	5	202,000	27,000	4	163,000	6,390			
18	1887—Feb. 24-Mar. 9	14	434,000	4.73	Mar. 1	462,000	6.09	5	195,000	20,500	3	119,000	1,300			
19	1890—Feb. 16-Mar. 11	24	649,000	4.13	Mar. 1	491,000	6.48	6	242,000	32,700	4	167,000	9,680			
20	1890—Mar. 11-Apr. 26	47	1,170,000	3.80	Mar. 26	521,000	6.87	8	332,000	52,500	6	259,000	23,200	4	176,000	5,960
21	1891—Jan. 31-Mar. 8	37	1,090,000	4.50	Feb. 25	497,000	6.56	8	323,000	43,600	5	210,000	13,900	2	85,800	605
22	1893—Jan. 30-Mar. 3	33	787,000	3.64	Feb. 20-21	457,000	6.03	8	300,000	23,800	2	79,000	1,380			
23	1897—Feb. 20-Mar. 8	17	531,000	4.77	Feb. 26	543,000	7.16	7	300,000	58,400	6	265,000	32,100	4	183,000	14,500
24	1898—Mar. 11-Apr. 27	48	900,000	2.86	Mar. 29	547,000	7.22	10	418,000	73,100	8	346,000	35,300	5	226,000	14,900
25	1899—Feb. 18-Mar. 18	29	664,000	3.49	Mar. 8	491,000	6.48	6	235,000	28,300	4	164,000	9,160	1	42,400	259
26	1899—Mar. 18-May 9	53	771,000	2.22	Apr. 1	419,000	5.53	2	71,800	2,850						
27	1901—Apr. 17-May 11	25	616,000	3.76	Apr. 27	524,000	6.91	9	372,000	63,100	7	300,000	28,100	4	178,000	9,240

[a] Discharge values used prior to September, 1891, are as follows: 50 feet, 404,000 second-feet, 54 feet, 454,000 second-feet, and 57 feet, 493,000 second-feet.

[b] Excess discharge is difference between total discharge for period and total discharge for same number of days at stages of danger line, 4 feet above danger line, and 7 feet above danger line, respectively.

TABLE 15.—*Summary of flood-flow records of Ohio River at Cincinnati, Ohio, for all floods above danger line (50 feet) for 1859 to 1913*—Continued.

Number.	Dates of floods.	Entire flood.			Maximum daily discharge.			Period when stage was above—								
		Number of days.	Total discharge.		Date.	Second-feet.	Second-feet per square mile.	50 feet (399,000 second-feet).			54 feet (449,000 second-feet).			57 feet (488,000 second-feet).		
			Million cubic feet.	Average in second-feet per square mile.				Number of days.	Discharge in million cubic feet.		Number of days.	Discharge in million cubic feet.		Number of days.	Discharge in million cubic feet.	
									Total.	Excess.		Total.	Excess.		Total.	Excess.
28	1902—Feb. 23-Mar. 29	35	737,000	3.22	Mar. 5	410,000	5.41	3	106,000	2,160						
29	1903—Feb. 26-Mar. 23	26	727,000	4.27	do	437,000	5.77	5	182,000	9,590						
30	1906—Mar. 26-Apr. 29	35	617,000	2.69	Apr. 2	401,000	5.29	1	34,600	173						
31	1906—7—Dec. 29-Feb. 1	35	995,000	4.34	Jan. 21	597,000	7.88	11	501,000	121,000	9	426,000	77,100	8	386,000	48,200
32	1907—Mar. 10-Apr. 8	30	777,000	3.96	Mar. 19	556,000	7.34	11	470,000	90,600	9	398,000	49,000	7	320,000	24,500
33	1908—Feb. 14-Mar. 1	17	389,000	3.49	Feb. 20	412,000	5.44	2	71,000	2,070						
34	1908—Mar. 1-31	31	831,000	4.10	Mar. 11-12	439,000	5.79	6	221,000	13,700						
35	1908—Mar. 31-Apr. 30	31	659,000	3.25	Apr. 4	471,000	6.21	4	155,000	16,800	2	80,500	2,940			
36	1909—Feb. 7-Mar. 25	47	946,000	3.07	Feb. 28	457,000	6.03	6	229,000	22,600	3	118,000	1,120			
37	1910—Feb. 15-Mar. 25	39	751,000	2.94	Mar. 7	421,000	5.55	3	107,000	3,970						
38	1912—Mar. 10-Apr. 1	41	1,060,000	3.95	Mar. 27	439,000	5.79	6	218,000	11,300						
39	1912—Apr. 2-19				Apr. 5-6	420,000	5.54	4	143,000	4,920						
40	1912-13—Dec. 28-Feb. 5	40	1,000,000	3.82	Jan. 14	554,000	7.31	10	440,000	94,900	8	367,000	56,700	7	326,000	30,800
41	1913—Mar. 24-Apr. 13	21	770,000	5.60	Apr. 1	660,000	8.71	13	639,000	190,000	11	569,000	142,000	11	569,000	105,000

Table 16 contains a summary of flood-flow records of Ohio River at Wheeling, Parkersburg, Catlettsburg, Cincinnati, Louisville, and Evansville, for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913, given in Table 14. Data in Table 16 are arranged so as to bring out a comparison of the flow of the different floods at each station. The data in this table are similar to the data in Table 15 and the explanation is identical, with the proper changes in the values for danger line, 4 feet above danger line, and 7 feet above danger line at the different stations.

Table 17 contains a summary of flood-flow records of Ohio River for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913, at Wheeling, Parkersburg, Catlettsburg, Cincinnati, Louisville, and Evansville, identical with that in Table 16, but arranged so as to bring out a comparison of the flow at the different stations for the given floods.

TABLE 16.—*Summary of flood-flow records of Ohio River at Wheeling, Parkersburg, Catlettsburg, Cincinnati, Louisville, and Evansville for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913.*

Wheeling, W. Va.

[Danger line, 36 feet. Drainage area, 24,800 square miles.]

Dates of floods.	Entire flood.			Maximum daily discharge.			Period when stage was above—								
							36 feet (276,000 sec.-ft.).			40 feet (319,000 sec.-ft.).			43 feet (353,000 sec.-ft.).		
	No. of days.	Total discharge.		Date.	Second-feet.	Second-feet per square mile.	No. of days.	Discharge in million cubic feet.		No. of days.	Discharge in million cubic feet.		No. of days.	Discharge in million cubic feet.	
		Million cubic feet.	Average in second-feet per square mile.					Total.	Excess.a		Total.	Excess.a		Total.	Excess.a
1884, Jan. 26–Mar. 5	40	474,000	5.53	Feb. 8	401,000	16.2	4	123,000	27,100	3	96,900	14,200	2	68,200	7,170
1906–7, Dec. 28–Jan. 31	35	366,000	4.88	Jan. 20	277,000	11.2	1	23,900	86	0	....	....	0	....	....
1907, Mar. 10–Apr. 7	29	337,000	5.42	Mar. 16	424,000	17.1	4	123,000	28,000	2	72,100	17,000	2	72,100	11,100
1913, Mar. 24–Apr. 10	18	252,000	6.53	Mar. 28	448,000	18.1	4	140,000	44,800	4	140,000	30,000	3	110,000	18,200

Parkersburg, W. Va.

[Danger line, 36 feet. Drainage area, 37,700 square miles.]

							36 feet (306,000 sec.-ft.).			40 feet (353,000 sec.-ft.).			43 feet (390,000 sec.-ft.).		
1906–7, Dec. 28–Jan. 31	35	536,000	4.70	Jan. 21	352,000	9.34	6	174,000	15,600	0	....	....	0	....	....
1907, Mar. 10–Apr. 7	29	463,000	4.90	Mar. 16	495,000	13.1	6	216,000	57,700	4	158,000	36,400	4	158,000	23,600
1913, Mar. 24–Apr. 11	19	390,000	6.30	Mar. 29	589,000	15.6	7	294,000	109,000	6	265,000	82,200	5	231,000	63,000

Catlettsburg, Ky.

[Danger line, 50 feet. Drainage area, 60,300 square miles.]

							50 feet (438,000 sec.-ft.).			54 feet (491,000 sec.-ft.).			57 feet (530,000 sec.-ft.).		
1906–7, Dec. 28–Jan. 31	35	813,000	4.46	Jan. 20	568,000	9.42	8	354,000	51,100	5	233,000	21,300	3	144,000	7,000
1907, Mar. 10–Apr. 6	28	653,000	4.48	Mar. 18	574,000	9.52	6	279,000	51,800	5	238,000	26,200	4	193,000	10,000
1913, Mar. 25–Apr. 12	19	565,000	5.71	Mar. 31	669,000	11.1	8	418,000	116,000	7	377,000	80,000	7	377,000	56,400

Cincinnati, Ohio.

[Danger line, 50 feet. Drainage area, 75,800 square miles.]

							50 feet (399,000 sec.-ft.) [b]			54 feet (449,000 sec.-ft.) [b]			57 feet (488,000 sec.-ft.) [b]		
1884, Jan. 29–Mar. 7	39	1,270,000	4.97	Feb. 14	682,000	9.00	19	929,000	266,000	16	819,000	192,000	15	778,000	139,000
1906–7, Dec. 29–Feb. 1	35	995,000	4.34	Jan. 21	597,000	7.88	11	501,000	121,000	9	426,000	77,100	8	386,000	48,200
1907, Mar. 10–Apr. 8	30	777,000	3.96	Mar. 19	556,000	7.34	11	470,000	90,600	9	398,000	49,000	7	320,000	24,500
1913, Mar. 24–Apr. 13	21	770,000	5.60	Apr. 1	660,000	8.71	13	639,000	190,000	11	569,000	142,000	11	569,000	105,000

Louisville, Ky. (lower gage).

[Danger line, 54 feet. Drainage area, 90,600 square miles.]

							54 feet (526,000 sec.-ft.).			58 feet (583,000 sec.-ft.).			61 feet (626,000 sec.-ft.).		
1884, Jan. 29–Mar. 7	39	1,590,000	5.21	Feb. 16	792,000	8.74	19	1,150,000	284,000	17	1,050,000	194,000	16	998,000	133,000
1906–7, Dec. 29–Feb. 2	36	1,310,000	4.65	Jan. 22	713,000	7.87	11	619,000	119,000	9	521,000	67,800	8	470,000	37,100
1907, Mar. 10–Apr. 9	31	964,000	3.97	Mar. 20	633,000	6.99	10	516,000	61,700	6	321,000	18,700	2	109,000	864
1913, Mar. 24–Apr. 17	25	1,080,000	5.52	Apr. 2	769,000	8.49	13	795,000	204,000	13	795,000	140,000	11	692,000	97,100

Evansville, Ind.

[Danger line, 35 feet. Drainage area, 106,000 square miles.]

							35 feet (406,000 sec.-ft.).			39 feet (482,000 sec.-ft.).			42 feet (542,000 sec.-ft.).		
1884, Jan. 29–Mar. 9	41	1,690,000	4.50	Feb. 18–19	667,000	6.29	28	1,420,000	437,000	23	1,220,000	265,000	21	1,130,000	149,000
1906–7, Dec. 30–Feb. 3	36	1,510,000	4.58	Jan. 24–25	629,000	5.93	30	1,390,000	334,000	26	1,230,000	149,000	12	630,000	67,900
1907, Mar. 12–Apr. 11	31	1,030,000	3.63	Mar. 23	579,000	5.46	16	738,000	177,000	13	619,000	77,900	8	393,000	18,500
1913, Mar. 25–Apr. 20	27	1,210,000	4.89	Apr. 5	674,000	6.36	20	1,020,000	322,000	18	948,000	199,000	15	817,000	114,000

[a] Excess discharge is difference between total discharge for period and total discharge for same number of days at stages of danger line, 4 feet above danger line, and 7 feet above danger line, respectively.

[b] Discharge values used for Cincinnati prior to September, 1891, are as follows: 50 feet, 404,000 second-feet; 54 feet, 454,000 second-feet; and 57 feet, 493,000 second-feet.

TABLE 17.—*Summary of flood-flow records of Ohio River for floods of 1884, January, 1907, March–April, 1907, and March–April, 1913, at Wheeling, Parkersburg, Catlettsburg, Cincinnati, Louisville, and Evansville.*

1884.

Station.	Entire flood.				Maximum daily discharge.			Period when stage was above— Danger line.			4 feet above danger line.			7 feet above danger line.		
	Date.	Number of days.	Total discharge. Million cubic feet.	Total discharge. Average in second-feet per square mile.	Date.	Second-feet.	Second-feet per square mile.	Number of days.	Discharge in million cubic feet. Total.	Discharge in million cubic feet. Excess.[a]	Number of days.	Discharge in million cubic feet. Total.	Discharge in million cubic feet. Excess.[a]	Number of days.	Discharge in million cubic feet. Total.	Discharge in million cubic feet. Excess.[a]
Wheeling, W. Va.	Jan. 26–Mar. 5	40	474,000	5.53	Feb. 8	401,000	16.2	4	123,000	27,100	3	96,900	14,200	2	68,200	7,170
Parkersburg, W. Va.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Catlettsburg, Ky.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cincinnati, Ohio	Jan. 29–Mar. 7	39	1,270,000	4.97	Feb. 14	682,000	9.00	19	929,000	266,000	16	819,000	192,000	15	778,000	139,000
Louisville, Ky.	Jan. 29–Mar. 7	39	1,590,000	5.21	Feb. 16	792,000	8.74	19	1,150,000	284,000	17	1,050,000	194,000	16	998,000	133,000
Evansville, Ind.	Jan. 29–Mar. 9	41	1,690,000	4.50	Feb. 18–19	667,000	6.29	28	1,420,000	437,000	23	1,220,000	265,000	21	1,130,000	149,000

January, 1907.

Station.	Date.	Number of days.	Million cubic feet.	Average in second-feet per square mile.	Date.	Second-feet.	Second-feet per square mile.	Number of days.	Total.	Excess.[a]	Number of days.	Total.	Excess.[a]	Number of days.	Total.	Excess.[a]
Wheeling, W. Va.	Dec. 28–Jan. 31	35	366,000	4.88	Jan. 20	277,000	11.2	1	23,900	86	...	...	...	...	...	...
Parkersburg, W. Va.	Dec. 28–Jan. 31	35	536,000	4.70	Jan. 21	352,000	9.34	6	174,000	15,600	...	...	...	...	...	...
Catlettsburg, Ky.	Dec. 28–Jan. 31	35	813,000	4.46	Jan. 20	568,000	9.42	8	354,000	51,100	5	233,000	21,300	3	144,000	7,000
Cincinnati, Ohio	Dec. 29–Feb. 1	35	995,000	4.34	Jan. 21	597,000	7.88	11	501,000	121,000	9	426,000	77,100	8	386,000	48,200
Louisville, Ky.	Dec. 29–Feb. 2	36	1,310,000	4.65	Jan. 22	713,000	7.87	11	619,000	119,000	9	521,000	67,800	8	470,000	37,100
Evansville, Ind.	Dec. 30–Feb. 3	36	1,510,000	4.58	Jan. 24–25	629,000	5.93	30	1,390,000	334,000	26	1,230,000	149,000	12	630,000	67,900

March-April, 1907.

Wheeling, W. Va.	Mar. 10-Apr. 7	29	337,000	5.42	Mar. 16	424,000	17.1	4	123,000	28,000	2	72,100	17,000	2	72,100	11,100
Parkersburg, W. Va.	Mar. 10-Apr. 7	29	463,000	4.90	Mar. 16	495,000	13.1	6	216,000	57,700	4	158,000	36,400	4	158,000	23,600
Catlettsburg, Ky.	Mar. 10-Apr. 6	28	653,000	4.48	Mar. 18	574,000	9.52	6	279,000	51,800	5	238,000	26,200	4	193,000	10,000
Cincinnati, Ohio	Mar. 10-Apr. 8	30	777,000	3.96	Mar. 19	556,000	7.34	11	470,000	90,600	9	398,000	49,000	7	320,000	24,500
Louisville, Ky.	Mar. 10-Apr. 9	31	964,000	3.97	Mar. 20	633,000	6.99	10	516,000	61,700	6	321,000	18,700	2	109,000	864
Evansville, Ind.	Mar. 12-Apr. 11	31	1,030,000	3.63	Mar. 23	579,000	5.46	16	738,000	177,000	13	619,000	77,900	8	393,000	18,500

March-April, 1913.

Wheeling, W. Va.	Mar. 24-Apr. 10	18	252,000	6.53	Mar. 28	448,000	18.1	4	140,000	44,800	4	140,000	30,000	3	110,000	18,200
Parkersburg, W. Va.	Mar. 24-Apr. 11	19	390,000	6.30	Mar. 29	589,000	15.6	7	294,000	109,000	6	265,000	82,200	5	231,000	63,000
Catlettsburg, Ky.	Mar. 25-Apr. 12	19	565,000	5.71	Mar. 31	669,000	11.1	8	418,000	116,000	7	377,000	80,000	7	377,000	56,400
Cincinnati, Ohio	Mar. 24-Apr. 13	21	770,000	5.60	Apr. 1	660,000	8.71	13	639,000	190,000	11	569,000	142,000	11	569,000	105,000
Louisville, Ky.	Mar. 24-Apr. 17	25	1,080,000	5.52	Apr. 2	769,000	8.49	13	795,000	204,000	13	795,000	140,000	11	692,000	97,100
Evansville, Ind.	Mar. 25-Apr. 20	27	1,210,000	4.89	Apr. 5	674,000	6.36	20	1,020,000	322,000	18	948,000	199,000	15	817,000	114,000

NOTE.—See Table 16 for stage and discharge at danger line, 4 feet above danger line, and 7 feet above danger line.

[a] Excess discharge is difference between total discharge for period and total discharge for same number of days at stages of danger line, 4 feet above danger line, and 7 feet above danger line, respectively.

Table 18 gives ratios of the drainage area and of total discharge during selected floods for each station as compared with each of the other stations in the table. The drainage area ratio is always less than unity because the value for the station having the smaller drainage area is always placed in the numerator. The ratios of total discharge are the fractional parts that the total flow at each station is of the total flow at each of the other stations. In general, these discharge ratios are always less than unity because the discharge for the station with the smaller drainage area is always placed in the numerator. The values of total flow used in computing these ratios are given in Tables 15 and 16. The ratios afford a rough check on the applicability and accuracy of the rating curves for the periods and the range of stage for which they were used. A very close agreement among such ratios can not be expected because of the variable factors involved, such as, for example, the intensity and distribution of rainfall.

TABLE 18.—*Ratios of total discharge during selected floods at various points on Ohio River.*

Wheeling.

[Drainage area, 24,800 square miles.]

Station.	Drainage area ratio.	Flood of— 1884	1906-7	1907	1913
Wheeling					
Parkersburg	0.66		0.68	0.73	0.65
Catlettsburg	.41		.45	.52	.45
Cincinnati	.33	0.37	.37	.43	.33
Louisville	.27	.30	.28	.35	.23
Evansville	.23	.28	.24	.33	.21

Parkersburg.

[Drainage area, 37,700 square miles.]

Station.	Drainage area ratio.	Flood of— 1884	1906-7	1907	1913
Wheeling	0.66		0.68	0.73	0.65
Parkersburg					
Catlettsburg	.63		.66	.71	.69
Cincinnati	.50		.54	.60	.51
Louisville	.42		.41	.48	.36
Evansville	.36		.35	.45	.32

Catlettsburg.

[Drainage area, 60,300 square miles.]

Station.	Drainage area ratio.	Flood of— 1884	1906-7	1907	1913
Wheeling	0.41		0.45	0.52	0.45
Parkersburg	.63		.66	.71	.69
Catlettsburg					
Cincinnati	.80		.82	.84	.73
Louisville	.67		.62	.68	.52
Evansville	.57		.54	.63	.47

TABLE 18.—*Ratios of total discharge during selected floods at various points on Ohio River*—Continued.

Cincinnati.

[Drainage area, 75,800 square miles.]

Station.	Drainage area ratio.	Flood of— 1884	1906-7	1907	1913
Wheeling	0.33	0.37	0.37	0.43	0.33
Parkersburg	.50		.54	.60	.51
Catlettsburg	.80		.82	.84	.73
Cincinnati					
Louisville	.84	.80	.76	.81	.71
Evansville	.72	.75	.66	.75	.64

Louisville.

[Drainage area, 90,600 square miles.]

Station.	Drainage area ratio.	Flood of— 1884	1906-7	1907	1913
Wheeling	0.27	0.30	0.28	0.35	0.23
Parkersburg	.42		.41	.48	.36
Catlettsburg	.67		.62	.68	.52
Cincinnati	.84	.80	.76	.81	.71
Louisville					
Evansville	.85	.94	.87	.94	.89

Evansville.

[Drainage area, 106,000 square miles.]

Station.	Drainage area ratio.	Flood of— 1884	1906-7	1907	1913
Wheeling	0.23	0.28	0.24	0.33	0.21
Parkersburg	.36		.35	.45	.32
Catlettsburg	.57		.54	.63	.47
Cincinnati	.72	.75	.66	.75	.64
Louisville	.85	.94	.87	.94	.89
Evansville					

The maximum daily discharges shown by these tables indicate the extremely large amounts of water that would have to be carried by the channels between proposed levees along the Ohio. For designing such levees flood-flow data should be collected in much greater detail. The number of days the water would have stood against the levees at various stages is also indicated by the tables.

The figures in the columns headed "Excess" show the quantities of water to be held back above the stations during the periods indicated to have kept the river below danger line, at 4 feet above the danger line, and at 7 feet above danger line. For example (Table 15), to have kept the highest flood on record at Cincinnati (1884) below the danger line it would have been necessary to hold back, at the proper time, above Cincinnati 226,000 million cubic feet of water—the accumulated excess during the 19 days that the stage was above the danger line. This, however, is the maximum, and it should be noted that from 1859 to 1913 the excess was greater than 140,000 million cubic feet on only two occasions. It should be further noted that no excess above 57 feet is as much as 140,000 million cubic feet, and that only two are greater than 100,000 million cubic feet.

The total capacity of the 43 reservoir sites above Pittsburgh, investigated in 1912 by the Pittsburgh Flood Commission, is 80,500 million cubic feet, and the total capacity of 17 selected projects of the 43 above Pittsburgh is 59,500 million cubic feet. Preliminary investigations during 1908 by the United States Geological Survey in the Kanawha River drainage area discovered 17 reservoir sites with a total storage capacity of about 280,000 million cubic feet. In addition to these there are many other available reservoir sites on the tributaries of Ohio River above Cincinnati. It is probable, however, that greater storage capacity than that indicated will be required to control fully the floods on the Ohio, for all the floods do not originate on the same tributaries, and sufficient reservoir capacity should therefore be provided to control floods on two or more combinations of tributaries. The data now at hand, however, are too meager to warrant conclusions. They simply show the necessity for complete investigations to determine how much storage is available on the various tributaries, what effect storage on certain tributaries and sets of tributaries would have on the flow in the main stream as well as on the tributaries, and whether or not, on the whole, such storage reservoirs are feasible as a means of flood control in the Ohio Valley.

The differences in the values of excess at the different stations for stages of danger line, 4 feet above danger line, and 7 feet above danger line, show the advantages to be gained by raising the danger line at different cities, either by building levees or by moving out of the sections subject to overflow.

The hydrographs of gage heights (Pls. IV, V, X, XI, XIII) indicate to some extent the effect of the tributaries on the main stream and vice versa but are not to be compared in value for studies of the problems of flood control with similar hydrographs and data based upon discharge instead of upon gage heights. Thus at every turn the absolute necessity for data relative to stream flow becomes apparent.

DAMAGE CAUSED BY FLOOD OF MARCH-APRIL, 1913.

Estimates of damage caused by the flood of March-April, 1913, in the Ohio Valley are given in Table 19. These estimates were prepared by the United States Geological Survey from information received in response to circular letters sent to the officials of about 200 cities and towns of about 5,000 population or over, from which about 120 replies were received. These replies gave estimates of losses sustained by the municipalities and some of the smaller towns in their immediate vicinity. The two largest single items received were from Dayton, Ohio, and Hamilton, Ohio, the total amounts being $100,000,000 and $15,000,000, respectively. Some of the most serious losses were only vaguely expressed. For example, it was reported that at Hamilton, Ohio, two-thirds of the town was covered by water and about 300 houses were swept away; and that at Portsmouth, Ohio, four-fifths of the city was inundated. Such estimates were not included in the tables from which the totals given in Table 19 were obtained. It will be readily appreciated that accurate estimates of flood losses are, at best, difficult to obtain and can hardly be expected to result from the method that the Survey was forced to follow because of the lack of means to make a study at closer range. However, the estimates given are believed to be reliable so far as they go, and they should be of considerable value in showing the vast amount of money lost because of a single flood, thus giving some idea of the amount of funds that it is wise and proper to expend in order to prevent the recurrence of such losses.

TABLE 19.—*Estimate of damages in Ohio Valley by flood of March-April, 1913.*

[Total population, 14,400,000; drainage area, 203,000 square miles.]

State.	Towns which reported.[a]	Lives lost.	Buildings flooded.	Bridges destroyed.	Damages.	
					Total.	Municipal and county improvements.[b]
Illinois	11	2	380	....	$1,003,750	$7,250
Indiana	47	39	15,450	180	15,480,143	3,113,900
Kentucky	24	1	6,721	6	1,881,500	130,000
New York	1	0	200	8	150,000	10,000
Ohio	94	367	33,833	220	[c]143,197,492	7,296,083
Pennsylvania	7	2	690	4	2,935,000	22,000
Tennessee	1	0	100	1	50,000	....
West Virginia	21	4	2,669	....	3,477,500	82,950
Total	206	415	60,043	419	168,175,385	10,662,183
Total damage to railroads					12,221,671	....
Total damage to traction lines					476,041	....
Total (including railroads and traction lines)					180,873,097	....

[a] Includes smaller towns reported by officials to whom requests for estimates were sent.
[b] Waterworks, sewers, roads, county bridges, street railways, etc.
[c] Includes $150,000 for State canals in Ohio.

The damage caused by the flood of March-April, 1913, was probably the largest that has resulted from any one flood in the history of the Ohio Valley. The damage as depicted in the public press at the time of the flood was not overdrawn, nor could it be, for the conditions at Dayton, Middletown, Hamilton, Piqua, Zanesville, and other interior towns and in cities along Ohio River were beyond description. While this was due primarily to the record-breaking stages reached by the rivers at so many places, the fact that the flood was most severe on streams that had hitherto been comparatively free from extreme floods explains a considerable amount of the damage. In other words, the localities flooded the most were those that least expected, and were therefore least prepared to cope with the unprecedented stages. In its relief work in connection with this flood the Red Cross Society expended $2,343,601, and the expenditures from local relief funds amounted to about $600,000. These items are not included in Table 19.

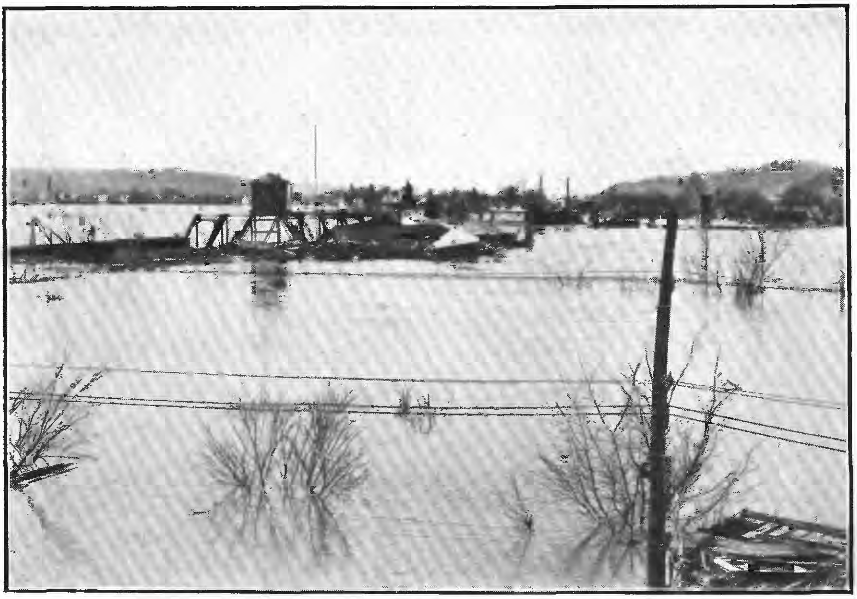
The estimate of railroad losses represents nine systems and the traction losses were compiled from information from 65 companies. The estimates given are for actual damage only and do not include even all of such losses. No estimates of economic losses are given, although some were received. The losses of revenue by the railroad and traction companies probably amounted to at least one-half or two-thirds of the actual losses and possibly more. A discussion of flood losses in general follows. That the actual losses resulting from the flood of March-April, 1913, will greatly exceed $200,000,000 there seems to be little doubt. However, any estimate of the total amount of damage considering all phases would, especially at this time, be simply a guess.

The damage caused by floods may be divided into two classes—actual and economic. Under "actual damage" are classed direct physical losses that are tangible and apparent, a portion of which may be measured in terms of the expenditure required to restore the thing damaged to approximately its condition before the flood; the rest may be measured in terms of the monetary value of the thing lost or destroyed. Plates XIV, XV, and XVI illustrate effects that may be classified under "actual damage." Under the classification "economic damage" are placed those indirect losses that are, in a sense, presumptive. These include losses due to suspension of business and social relations in the flooded area and in places having such relations with that area; losses due to decreased confidence in the security of the localities flooded—especially the towns and cities, which may be termed lost prestige; losses due to general depression and decreased initiative throughout the flooded districts; and losses due to a materially decreased property valuation.

In addition to these losses, there is a loss of wild animal life of which it is practically impossible to get any idea.

Finally, the pitiful loss of human life is the most serious of all. Although a valuation is sometimes placed upon human life, it seems that any attempt to judge this loss in terms of money is entirely out of place here. In addition to the direct loss of life, there is the indirect loss due to ill health, sickness, and death resulting from the unsanitary and unhealthful conditions which follow all floods. Plate XVII gives two views at Hamilton, Ohio, showing localities where actual loss of life, animal and human, was narrowly averted.

The damage by flood results directly from two things, simple inundation and the effects of the current. It is questionable which of the two causes the more damage. In simple inundation probably the most damage is caused by the yellow, slimy, fine, penetrating mud that is deposited everywhere. The effect of this mud in cities is almost inconceivable. There may be some gain in fertilization when it is deposited on farm land, but it is open to question whether



A. DURING THE FLOOD.

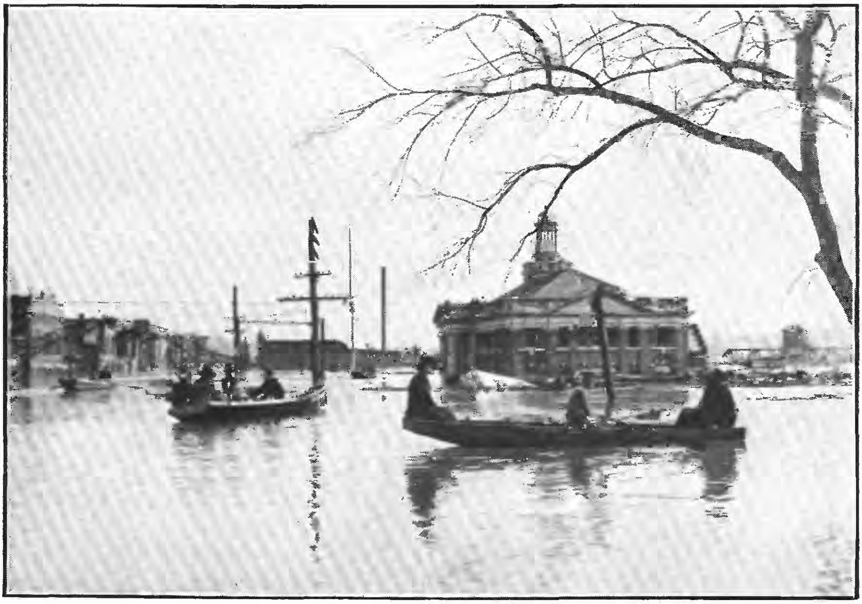
Note the large amount of drift piled against the remaining span.

B. AFTER THE FLOOD.

The mass of iron work at the right is part of the Putnam Street bridge and was carried at least 500 feet by the current.

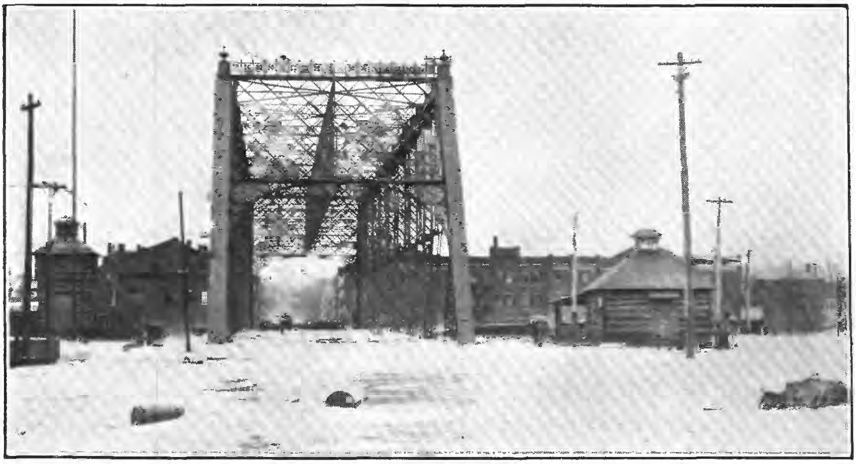
RAILROAD BRIDGE OVER MUSKINGUM RIVER AT MARIETTA, OHIO, MARCH-APRIL, 1913.

A. FOURTH STREET AND BAPTIST CHURCH, MARIETTA, OHIO, MARCH 30, 1913.



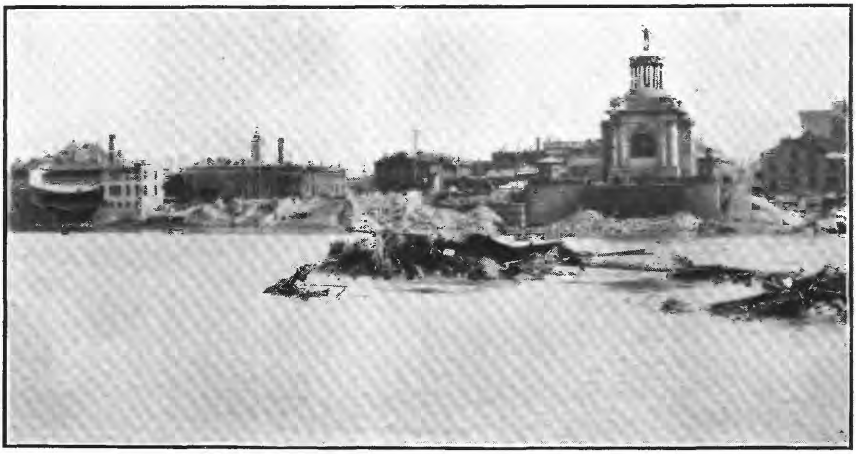
B. POST OFFICE, FRONT STREET, MARIETTA, OHIO, MARCH 30, 1913.

This post office was supposed to have been built out of reach of any flood, but there was 8 feet of water in it March 30.



A

B



C

HIGH STREET BRIDGE OVER MIAMI RIVER AT HAMILTON, OHIO, MARCH-APRIL, 1913

A, *B*, Before failure; *C*, View from right bank below bridge, showing part of the remains of the bridge. The United States Geological Survey gage was located near this ridge. easureme ts of discharge were made

A. RILEY'S ISLAND, MIAMI RIVER, BELOW HAMILTON, OHIO, MARCH 26, 1913.

This view shows the crest of the flood. The arrow indicates a point from which four persons were rescued after 32 hours.

B. HIGH STREET, HAMILTON, OHIO, DURING FLOOD OF MARCH-APRIL, 1913.

The horse in this picture was blind but was rescued.

A. SOUTH B STREET, HAMILTON, OHIO, AFTER THE FLOOD OF MARCH-APRIL, 1913.

This view shows the effects of the current upon a paved side street.

B. RAILROAD CROSSING AT SOUTH HAMILTON, OHIO, AFTER THE FLOOD OF MARCH-APRIL, 1913.

or not its value as a fertilizer outweighs even the damage it does on the farm, to say nothing of its effect in cities and towns. Any consideration of this benefit to farm land appears simply an attempt to discover some small benefit in connection with the enormous loss.

The effects of the current are noted principally in the sweeping away of bridges, houses, and other structures, in the tearing up of city streets, and the erosion of agricultural land—the top soil in many places being entirely washed away and nothing but a barren gravel bed left in the place of fertile land. Plate XVIII illustrates some of the effects of current in Hamilton, Ohio. (See also Pl. XIV, *B*, and Pl. XXII, *B*, p. 89.)

In considering damage by flood, it should be borne in mind that damage resulting from floods of a given and constant magnitude (for example) are ever increasing because of increases in the value of the areas flooded and of their contents.

Thus, with the added possibility of floods of greater magnitude than have ever occurred in the past, it would seem wise and proper that a generous interpretation should be placed upon the amount of money to be expended for purposes of flood control in the Ohio Valley.

PREVENTION OF DAMAGE BY FLOODS.

It is not the purpose of this report to attempt to make specific recommendations as to the means of flood prevention or to present arguments in favor of any one scheme as opposed to others, but the report would be incomplete without some reference to methods of preventing damage by floods and to the means that may be devised for flood control. A distinction is made between the prevention of floods and the prevention of damage by floods in order to bring out more forcibly the obvious idea that excessive precipitation—that is, the presence of excessively large volumes of surface waters in river basins—can not be prevented by any means now known to man; the thing to strive for is to prevent the great damage done by flood water all along its course.

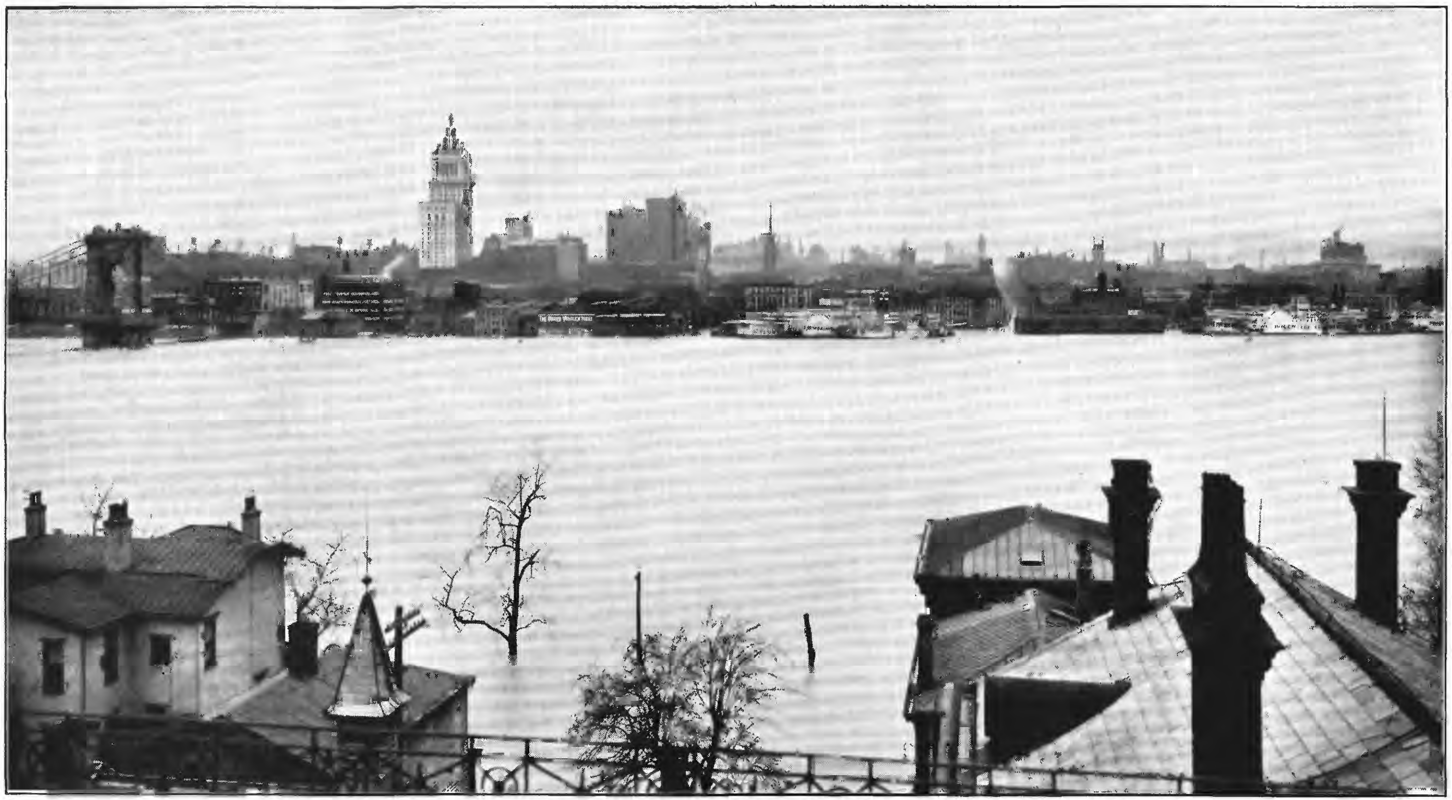
The two means of preventing damage by floods that have received the most attention and that are unquestionably the best and most reliable are levees and reservoirs. For full discussion and rational and conclusive consideration of either of these proposed means as applied to the Ohio Valley, data more complete than those at present available are necessary. It seems desirable, however, to point out some features concerning which there is much misunderstanding.

Great weight has been given, for example, to the supposed comparatively low cost of building earthen embankment levees. A more complete estimate of the cost of levees for the Ohio Valley, including damages, should be made before positive statements showing low cost of earthen embankments are published, and careful consideration should be given to the cost of levees of the type necessary around the many large cities along the Ohio and to costs of reconstruction. One item at one city will serve as an illustration. (See Pls. XIX and XX.) At Cincinnati, Ohio, about 53 trunk-line sewers enter the river. It is understood that in designing the improved and expensive sewer system now being built for that city no provision has been made to keep out the flood waters of Ohio River, the design having been based on past and present conditions of flood flow from the area drained by the sewers, and many of the outlets to the Ohio will be below the present high water stage of the river. The construction of adequate levees would increase the flood stage and if water is to be kept from the city would involve either the rebuilding of the whole system below the increased flood stage or the construction of gates to prevent the entrance of river water into the sewers. The cost of such changes can be determined only by complete and unbiased investigation. It is conceivable that such an investigation would not show the levee scheme in the favorable light pictured by its advocates. A similarly complete and unbiased investigation of the cost of reservoirs should be made before they are either approved or condemned on the score of cost.

It has been said that the failure of some of the levees on the lower Mississippi during the flood of 1912 is no valid argument against the building of a properly constructed levee line. This is true, but the statement applies with equal force to properly constructed reservoirs for flood control. The fact that some defective or inadequate dams have failed should not be used as a bogey to scare everyone away from any consideration of control by reservoirs, any more than the failure of inadequate levees should be used for the same purpose with reference to levees. Such an attitude, generally adopted, would stop most of the engineering work of the country—nothing would be built up because of the fear that it might topple down with disastrous consequences.

In considering control by reservoirs the fact should be kept clearly in mind that their purpose is not to withhold all the flow during floods. The main purpose of river channels is to carry off the water. The idea in reservoir control, however, is to store enough water at the proper times to keep the floods below certain stages, that is, to take the top off the floods—to hold back that part of the natural flow that does the damage. If this fact be not kept clearly in mind a consideration of the enormous quantities involved is likely to be very misleading.

The proper method of handling reservoirs in restraining floods in order that they may have the desired effect is a most important factor in the problem of control by reservoirs. This may readily be determined by computation if the necessary data are available. Records



OHIO RIVER AT CINCINNATI, OHIO, APRIL 4, 1913.

Shows height of water on pier of suspension bridge (on left) between Cincinnati and Covington. The crest of the flood was about 4 feet higher than this. Photograph taken from Newport, Ky., just above the mouth of Licking River.

OHIO RIVER AT CINCINNATI, OHIO, APRIL 4, 1913.

Looking downstream from suspension bridge between Cincinnati and Newport, Ky. The crest of the flood was about 4 feet higher than is shown in the photograph.

A. JUST BEFORE FAILURE.

B. DURING FAILURE.

C. IMMEDIATELY AFTER FAILURE.

CINCINNATI, HAMILTON & DAYTON RAILROAD BRIDGE OVER MIAMI RIVER AT HAMILTON, OHIO, MARCH 25, 1913.

A. REMAINS OF CINCINNATI, HAMILTON & DAYTON RAILROAD BRIDGE AT HAMILTON, OHIO.

Note that there was much less left of the bridge when this view was taken than when that shown in Plate XXI, *C*, was taken.

B. SECOND AND COURT STREETS, HAMILTON, OHIO, ON THE MORNING OF MARCH 25, 1913.

This illustration is especially good in showing the velocity of the current through the streets. The strong current was one of the most destructive features of the flood in Hamilton.

of discharge are of utmost importance in this connection. The much discussed question as to whether or not the sources of the water that causes the floods on the Ohio River are susceptible to control by reservoirs can be definitely answered only by a systematic determination of the discharge at numerous points on the tributary streams as well as on the Ohio. In like manner, computations of such features as the height of the proposed levees and the proper distance between them—that is, the necessary channel capacity to carry off the water—can be made only after a large amount of data have been collected, data concerning river discharge forming a most necessary part.

Many of the conditions incident to the advance of civilization have been pointed out as the causes of damage by floods, and the conclusion has been drawn that a reversion to the original state of affairs would solve the problem of flood control. Deforestation has been most fully discussed in this respect. Whatever the real effects of the forests on floods and the possibilities of favorably altering such effects may be, the benefits of reforestation, apart from the specific purpose of flood control, are so obvious that arguments against it would seem to have scarcely more than academic interest. Agricultural and municipal developments have come in for a large share of the blame for damage by floods. Such of these developments as are legitimate have come to stay, and it is idle to be concerned with their effects except to provide means of taking care of them. To encroachment on natural channels much of the damage by floods is ascribed, and here is undoubtedly one of the most fruitful sources of damage. For this condition the greed of man is largely to blame. This is evidenced by the procedure usually followed in building bridges, the effort being made to build them at the least possible cost of construction and maintenance, to this end the length of spans being reduced to a minimum. This results in putting abutments farther and farther out into the stream, placing numerous piers in the channel itself, and reducing the total opening for the stream beyond all reasonable limits by constructing, as approaches, earthen embankments that act simply as dams in times of flood. The same greed or, perhaps, false economy is shown by building factories, manufacturing plants, and even residences out to the limit of ordinary low stage and thus forming the most effective barriers to the free flow of the streams when in flood. This greed is heavily punished by the first disastrous flood. Plates XXI and XXII, *A*, show the destruction of a railroad bridge at Hamilton. This is simply typical of many other bridges, municipal as well as railroad. All stream channels should be cleared of obstructions and made ample as carriers of flood waters, and rigid laws, strictly enforced, should prohibit any further encroachment on waterways.

A noteworthy suggestion in connection with the reduction of damage by floods advocates the removal of places of business or residence from areas subject to repeated inundation, so as to restore to the river channel that which belongs to it. To accomplish this it has been further suggested that the cities take over the abandoned properties, paying an equitable price and making arrangements that will enable the occupants, especially the poor, to relocate out of harm's way. In this way the danger line at many cities could be raised and the volume of flood waters that would have to be taken care of materially reduced. In addition it has been suggested that such areas be converted by the cities into river-front parks, so that they will serve a useful purpose and still offer no obstruction to the flood flow of the river. This may seem a Utopian dream, but the idea contains much that is worthy of consideration.

The United States Weather Bureau has done and is doing a most valuable work in issuing timely and accurate warnings of floods and forecasts of flood heights and their rate of progression. This service has saved almost inestimable loss in areas about to be flooded, not only of live stock and goods but also of human life. An extension of this service to cover the entire country would unquestionably result in a still greater saving of life and property. Those people who insist upon remaining or are forced by their circumstances to remain in areas subject to repeated floods should be more fully educated to a proper appreciation of the value of flood warnings in order that they may more generally heed such warnings in time.

Probably no system of river control will prove a panacea for all the ills incident to disastrous floods, and no combination of systems can be expected to prevent all damage by extreme floods. In fact, one of the most important points to be decided is just how large a flood it is economical to provide against. The best solution may prove to be a combination of reservoirs and levees, the function of the reservoirs in extreme floods being, as pointed out above, to hold back the last straw that breaks the levee's back.

That much can be done to aid in flood protection is recognized by all, but the extent to which levees and reservoirs would have been effective in the present flood can not be estimated with the information now available.

Emphasis is laid on the importance of thoroughly considering the combined effect of all the factors on the floods which have taken place in the past. That any one of the proposed remedial works would not have been absolutely effective for a particular flood does not imply that its consideration should be eliminated. Furthermore, the possibility that protective works would have afforded comparatively little assistance on the northern tributaries in Ohio during the present unprecedented flood need not necessarily condemn all such works, as the saving from numerous ordinary floods may warrant the necessary expenditure to construct the desired improvements.

Whatever may be the merits of the respective schemes there can be no doubt of the absolute necessity for a comprehensive plan of action. To be effective any system of control must treat Ohio River and its tributaries as a unit, with due regard to the effect of such control of the Ohio on the Mississippi below Cairo. To make such a comprehensive system of control practicable, efficient, and successful, a central organization for the control of rivers is needed. Such a central organization would necessarily have to be Federal, but it could not be successful, in so far as the problem under immediate consideration is concerned, without broad-minded, hearty, and unselfish cooperation on the part of the States, counties, municipalities, and private interests throughout the Ohio Valley.

The value of the prevention of damage by floods can hardly be overestimated. It is not to be measured by considering only the value of actual damage by floods in the past. Not only must the loss of human life and animal life be considered, but also the increase in the value of property and the enormously valuable increased confidence that would result from the assurance that flood protection up to a certain limit could be absolutely relied upon. This phase of the situation was illustrated in a timely manner by the campaign of advertising followed by a certain city in the Ohio Valley during the recent flood, which guaranteed immunity from floods to industries that could be prevailed upon to move to that city. The ability to make such a guaranty would be a most valuable asset to every city or community in the Ohio Valley now subject to damage by floods.

CONCLUSION.

Before any comprehensive study can be made of the various problems connected with floods in the Ohio River drainage basin, it will be necessary to have full information in regard to the quantity of water carried, not only by the Ohio itself, but also by the larger tributaries. The data must give complete information in regard to the distribution of this water, both as to drainage area and as to time. Therefore a long-time record is especially essential, as the variations in flow from year to year are large.

The fact that studies of the flood of 1913 will always be limited in scope, because of lack of sufficient data in regard to stream flow, not only during this flood but also during earlier floods that must be compared with the present, shows the importance of maintaining gaging stations on the principal streams in areas where important problems are to be solved, in order that the data may be available when needed. Stream-flow data, unlike data collected by surveys and other kinds of engineering work, can not be collected in a short time. Periods of floods and low water pass rapidly, and years may elapse before there is another opportunity to collect records in regard to such periods. It is to be sincerely hoped that the earnest recommendations made by all who have investigated and studied the present flood and the question of flood control will not meet the fate of previous similar recommendations, such as those made after the flood of 1884, but that proper steps will at once be taken to obtain the data so much needed for the study and solution of the important problem of flood control.

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