

TABLE 3.—Maximum free air wind velocities (m. p. s.), for different sections of the United States, based on pilot balloon observations during October 1938

Section	Surface to 2,500 meters (m. s. l.)				Between 2,500 and 5,000 meters (m. s. l.)				Above 5,000 meters (m. s. l.)						
	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m), m. s. l.	Date	Station
Northeast ¹	39.2	SW	2,140	26	Cleveland, Ohio	39.0	SW	3,700	19	Cleveland, Ohio	39.0	WNW	9,880	15	Cleveland, Ohio.
East-Central ²	30.2	WSW	2,230	26	Cincinnati, Ohio	31.0	W	3,490	26	Cincinnati, Ohio	50.0	SW	6,840	24	Greensboro, N. C.
Southeast ³	28.2	WNW	2,500	27	Spartanburg, S. C.	34.6	SW	5,000	24	Charleston, S. C.	46.0	SW	6,960	24	Charleston, S. C.
North-Central ⁴	29.1	NNE	1,000	14	Huron, S. Dak.	41.8	NNW	4,930	26	Fargo, N. Dak.	43.0	W	9,130	13	Fargo, N. Dak.
Central ⁵	35.4	W	2,390	5	Evansville, Ind.	36.8	NNW	3,230	27	Moline, Ill.	54.0	WNW	11,930	25	Evansville, Ind.
South-Central ⁶	29.2	S	1,530	17	Amarillo, Tex.	26.6	NW	3,910	23	Oklahoma City, Okla.	45.0	W	12,330	21	Oklahoma City, Okla.
Northwest ⁷	34.8	SE	820	28	Medford, Oreg.	35.0	SSW	2,880	28	Pendleton, Oreg.	59.2	NE	9,380	8	Billings, Mont.
West-Central ⁸	35.2	S	2,100	14	Salt Lake City, Utah	34.4	SSW	3,000	15	Salt Lake City, Utah	78.0	SW	7,960	17	Denver, Colo.
Southwest ⁹	27.6	SSW	2,500	15	Las Vegas, Nev.	50.0	SSW	3,540	15	Las Vegas, Nev.	59.2	WSW	14,040	18	Albuquerque, N. Mex.

¹ Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.

² Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.

³ South Carolina, Georgia, Florida, and Alabama.

⁴ Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.

⁵ Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.

⁶ Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.

⁷ Montana, Idaho, Washington, and Oregon.

⁸ Wyoming, Colorado, Utah, northern Nevada, and northern California.

⁹ Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

By BENNETT SWENSON

No floods occurred during the month of October 1938 with the exception of floods in the upper Mississippi Basin and in the lower Rio Grande which were a continuation of overflows that began in September. The flood in the upper Mississippi will be discussed below. The overflow in the Rio Grande was limited to the extreme lower reach of the river. Flood stage was exceeded at Mercedes and Brownsville, Tex., from September 29 to October 3 and crested on October 1 at a stage of 22.0 feet at the former station and 18.6 feet at the latter. The principal damage in this flood was caused by a break in the main levee, on the American side of the river, about 2 or 3 miles above Brownsville, Tex., resulting in inundation of approximately 1,200 acres of land. The total damage has been estimated at \$2,500.

The upper Mississippi flood resulted from heavy rains over southern Minnesota, southern Wisconsin, northern Illinois, and central and northern Iowa. The flood was largely a tributary flood, with the Chippewa, Black, Wisconsin, Zumbro, and Whitewater Rivers particularly, experiencing unusually severe floods. The heavy rains began about September 5 and continued until September 14, and occurred again from the 17th to the 19th, but the rains of the latter period were not generally as intense and did not have a great effect on the high water except to prolong it somewhat. Figure 1 shows the distribution of precipitation from September 5 to 14. The data used in the preparation of the isohyets may be found in *Climatological Data*.

A meteorological analysis of the storm shows that the rainfall was caused primarily by a strong influx of moist tropical air from the south and southwest overrunning a wedge of cold polar air to the north and northeast over the extreme upper portion of the Mississippi Valley. This condition persisted almost entirely from September 5 to 14.

The front at the surface lay in a general east-west direction approximately over the southern boundaries of Minnesota and Wisconsin and remained almost stationary from the 5th to the 12th. A series of active waves moving along this front produced frequent rains during this

period. On the 12th a mass of polar air moved in from the northwest and the front was displaced slightly to the southeast, resulting in clearing weather temporarily. However, on the morning of the 13th another wave had advanced northeastward to southwestern Iowa accompanied by moderately heavy precipitation. This disturbance moved slowly eastward from that point followed by a large mass of dry polar air which dominated the upper Mississippi region by the evening of September 14.

The stream of tropical air which invaded the upper Mississippi Valley from September 5 to 14 was maintained by a large anticyclone situated over extreme eastern United States and extending to high elevations. At 14,000 feet the center was located approximately over western Tennessee and dominated most of the eastern half of the country. The persistence of this anticyclone prevented any marked invasion of polar air except in the extreme upper portion of the Mississippi Basin until the 14th, when the anticyclone weakened considerably at high levels and was displaced to the southward and southeastward. At the same time a low at high levels moved eastward over the Lake region and brought in cold air from the northwest over most of the Mississippi Valley.

The flood was unusual in that floods rarely occur at that season of the year in the upper Mississippi Basin, the flood season extending usually from March to June. Table 1 presents crest stages at various points on the principal streams together with comparative data.

The following reports have been submitted by the officials in charge at the various river district offices in the upper Mississippi Valley:

LA CROSSE, WIS., RIVER DISTRICT

Whitewater and Zumbro Rivers in Minnesota.—An intense local flood of short duration occurred in the Whitewater River area from September 6th to 9th. Two storms of over 2 inches of rain produced disastrous floods in this valley which caused considerable loss to bridges, highways, crops, and a few buildings. Flood damage was greatest at Weaver, Minn., also considerable damage occurred at Elba and Beaver, Minn.; the latter town was isolated and had the highest stage recorded in years. Rains of great in-

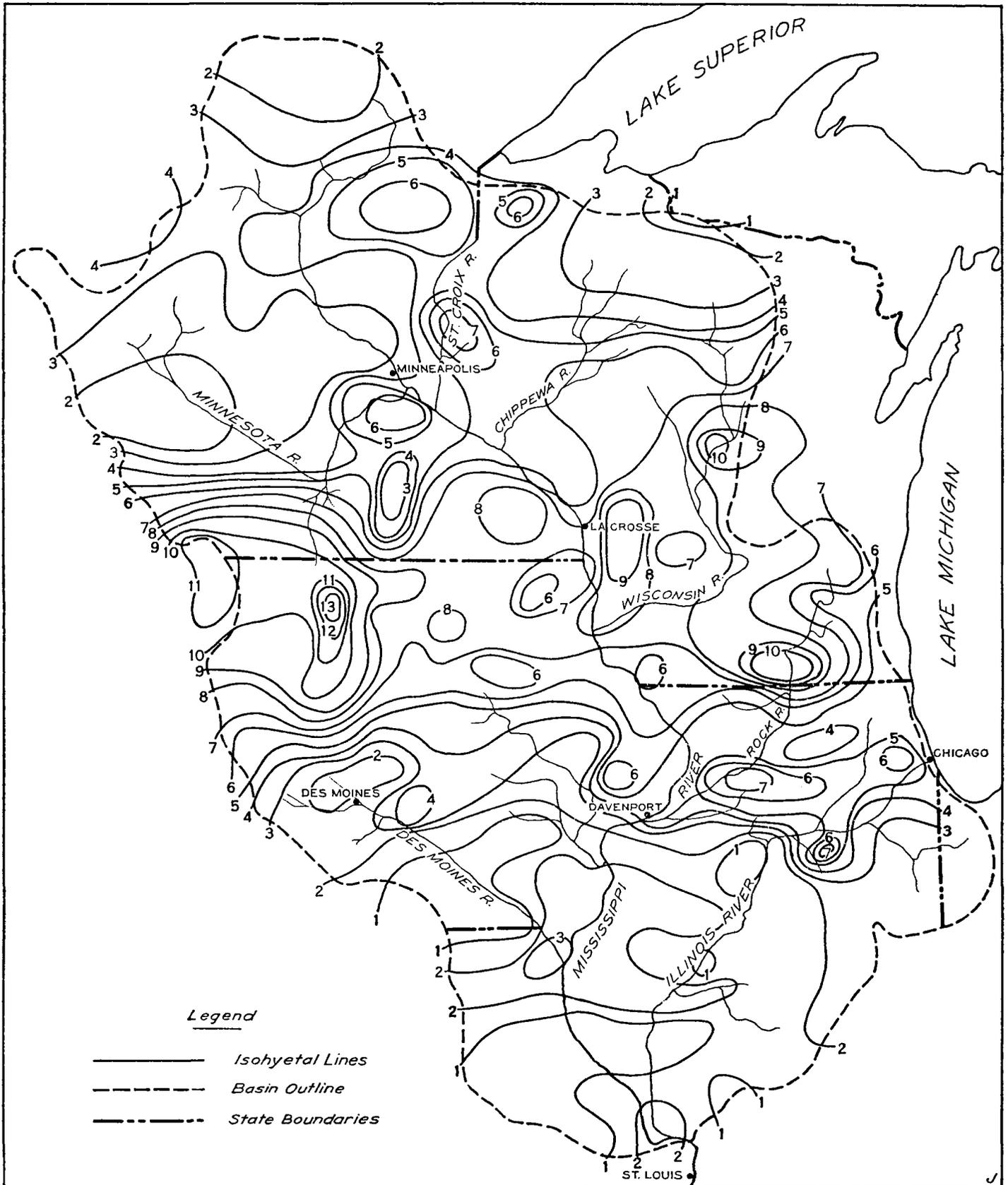


FIGURE 1.—Total precipitation over upper Mississippi Basin, September 5 to 14, 1938, inclusive.

tensity were centered over this part of Minnesota on the 6th and 8th. The Zumbro River also was over its banks, but little damage was reported from this section. Total damage to the White-water and Zumbro areas is placed at \$30,000 for highways and bridges; crops, \$40,000; buildings, \$20,000; and livestock, \$2,000.

Black River in Wisconsin.—In the Black River Valley and particularly in the vicinity of Black River Falls, Wis., one of the greatest floods in the history of this valley occurred from September 10 to 12. It was comparable to the flood of 1911, when a section of the Hatfield Dam was carried away. Damage to the Hatfield Dam at this time was reported as \$2,000. Damage to property in the Black River Valley probably reaches \$20,000, but highways and crops suffered most. Highway losses may be estimated at \$30,000 as the cost necessary to repair. Losses to crops, such as corn and potatoes in the field, exceed \$15,000.

Root River in Minnesota.—The area drained by the Root River received nearly as heavy rains as the Whitewater section but damage here was limited to crops and highways. Crop losses in this valley probably exceed \$10,000 and losses to highways about the same. The north branch of the Root River had the highest stages, resulting in suspension of train service, and roads were washed out in many places. It was reported that, at the greatest flood height, water was so deep in corn fields that only the top of the stalks showed above water.

Chippewa River in Wisconsin.—The flood in the Chippewa River was one of the worst in the history of that valley. The peak stages in the lower Chippewa occurred from September 11 to 12. Water reached the highest stage since 1884. A condition which intensified the flood here was the fact that artificial storage at the hydro-electric dams above was at too great a volume to hold additional head, and the entire surface run-off had to be released in too short a time. A flood at this time of the year is rare, and although warnings were telegraphed on the morning of the 10th to Durand, Wis., on the basis of excessive rains and increased flow at the dams above, losses to livestock pasturing in the lower valley were heavy. The crest of the flood at Durand was reached about 3 p. m. of the 11th, with a crest stage of 15.2 feet and a streamflow of over 100,000 cubic feet per second.

Mississippi River from mouth of St. Croix to La Crosse, Wis.—In the main channel of the Mississippi from Hastings, Minn., to Lake Pepin the damage was relatively light as stages in this section of the valley did not reach flood volume; the rainfall from tributaries emptying into the main river here was about one-half of that in the area southward from Lake Pepin. From the mouth of the Chippewa southward to the lower limits of the district bottom lands were inundated. The only place where flood stages were reached in the lower section was at La Crosse, with a crest of 12.27 feet on the morning of the 15th. High water in the vicinity of La Crosse was mainly due to the exceptionally large discharge of the Black River. Crest of high water from the Chippewa did not reach here until the Black River had begun to recede, a circumstance which was fortunate and lessened peak flow. Damage at Winona, Minn. (28 miles north of La Crosse), was small and was due to seepage into basements. At La Crosse the damage to property was less than \$10,000. Highways and crops suffered in La Crosse, Trempealeau, Vernon, Buffalo, and Jackson Counties. These may be roughly estimated at about \$20,000 in each of those counties and crop damage in all of them at \$100,000.

Source of Flood.—The flood during the middle of September in the La Crosse district may be classed as a tributary flood, and damage was greater in money loss from excessive rains and resulting washouts than from actual high water. Heavy and general rains extending over the period of September 5th to 14th resulted in very rapid rises in the tributary streams. Flashy floods occurred in the smaller tributaries such as the Whitewater, Zumbro, La Crosse, and Root Rivers and floods of longer duration in the Chippewa and Black Rivers. Excessive rains, particularly from the 6th to the 11th, were mainly responsible for flood conditions. Their high intensity and occurrence at a time when the soil was heavily saturated with moisture from abnormally heavy rainfall during the summer resulted in a large percentage of run-off. There was a definite concentration of rainfall of over 8 inches, in the period September 5th to 14th, over the area of the Root River drainage and extending north to the Whitewater Valley and in Wisconsin, in La Crosse, and Trempealeau Counties. Another marked area of heavy rainfall appears over the Chippewa Basin and centered over the Red Cedar River drainage, and another in the Black River Basin. These rains resulted in a rapidly forming flood, the intensity of which was greatest in the tributary streams. Stages in these tributaries, especially in the Chippewa, were the highest recorded for many years.

DUBUQUE, IOWA, RIVER DISTRICT

Wisconsin River.—Review of the individual reports received from various points along the Wisconsin River shows that losses were most severe at scattered points in the middle reaches. This erratic

condition as to flood loss distribution results from the topographic features of much of the Wisconsin Valley. Some extensive portions are wholly marsh or wasteland, and the arable land is also low and subject to overflow in times of severe floods.

It is to be noted that the heaviest classified losses occurred in matured and prospective crops, and it is believed that these losses have been the heaviest of record for the region. The total loss exceeds \$900,000, of which about \$675,000 was to matured and prospective crops. In explanation, this flood in the Wisconsin River was the most severe of record, new high records being recorded at Knowlton, Portage, and undoubtedly at many points below Portage, from which the Weather Bureau has not been obtaining reports or gage records. No flood occurred, however, at and above Merrill, Wis. At Portage the crest exceeded the previous record by more than 1 foot. In addition to the unprecedented severity of the flood, it must be borne in mind that it came approximately at harvest time, when nearly all crops were matured, but too early for the harvesting to be accomplished.

Turkey River in Iowa.—The flood plain of the Turkey River is narrow. Therefore practically all of the lowlands farms are small. They are subject to frequent overflow, but mostly in spring. Reports from this region were scattered and mostly unsatisfactory and estimates of monetary losses are not available. Lowland crops, however, were practically a 100-percent loss, especially in the lower reaches.

Mississippi River from La Crosse, Wis., to Dubuque, Iowa.—In marked contrast to the high crop losses in the Wisconsin and Turkey River valleys, flood losses caused by the Mississippi from below La Crosse to Dubuque, \$30,700, were comparatively light. This was the result of two main factors:

Much of the bottom land flooded has been acquired by the Federal Government in connection with the upper Mississippi Valley canalization project, and consequently comparatively little farm planting was done on many such bottom lands which formerly were tilled. Another reason for much of the bottom land not being in crops was the fact that high water of the spring of 1938 was of such long duration that planting was impracticable.

Backwaters destroyed considerable acreages of sweet corn in tributary valleys, and also washed out island gardens. The Dubuque airport was completely inundated to a depth of more than 3 feet at the time of the crest. It was unserviceable as a landing field for a period of about 12 days.

DAVENPORT, IOWA, RIVER DISTRICT

The flood on the Mississippi occurring in September 1938 is the second flood which occurred in any month except March, April, May, or June at Davenport since records began in 1860. The other flood was recorded on October 13 to November 3, 1881.

Heavy to excessive rains began over the upper Mississippi Basin September 5th or 6th and continued until the 14th. They began again on the 17th and continued through the 19th. The second period of rains was considerably lighter than the first but coming on already swollen streams materially increased already high crests for this season of the year. The fact that the first heavy rains were spread over a period of about 9 days lessened crests which might be expected from the totals had they occurred in shorter periods.

The heaviest totals for the period September 1–20, 1938, occurred over southwestern Minnesota and northwestern Iowa, where they exceeded 10.00 inches and in portions of Iowa and Wisconsin, where they exceeded 13.00 inches. They shaded off from these areas to totals less than 2.00 inches in southeastern Iowa. The rises resulting in the flood started on stages slightly above normal for September.

The flood on the Cedar-Iowa River was local and the total loss has been estimated at \$3,500. Flood conditions prevailed along the entire Rock River and resulted in losses amounting to \$230,000, of which \$200,000 was to matured crops. Along the main channel of the Mississippi from Dubuque to Keithsburg, Ill., a loss of about \$121,000 was reported.

DES MOINES, IOWA, RIVER DISTRICT

Des Moines River.—Rarely, if ever, have heavy rains in the upper drainage basin of the Des Moines River above Fort Dodge, Iowa, produced enough volume of water to cause overflow on the lower lands down nearly to Ottumwa, Iowa, and never had this occurred in September until 1938. The flat topography of the upper drainage basin is not conducive to rapid run-off and as a rule the rains, however heavy, accumulate to form ponds of large total area in which the water slowly settles into the ground.

During August, rains in that area had been light, but the total rainfall of April, May, June, and July had been considerably above normal. In 3 days, September 5th–8th, 4 to 7 inches of rain occurred with only moderate run-off, but this had scarcely settled

from the surface, or run into the streams, till there was another 4-day period with rains of 4 to 6 inches, most of which came on the 12th and 14th. Fortunately, no important rains occurred in either of these periods below Boone, Iowa, on the Des Moines River, or below Jefferson, Iowa, on the Raccoon River. If the same rainfall had occurred in the lower Raccoon and middle Des Moines valleys serious floods would probably have followed.

The highest stage at Boone was 23.1 feet at 3:55 p. m., September 18. This is 3.1 feet above flood stage and has seldom been exceeded. The highest water of record, May 1903, would have read 26.9 on the present gage and the high water of June 5, 1918, would have read 24.1 on this gage. The lowest lands were flooded from Boone nearly to Ottumwa. At Des Moines the highest stage was 14.7 feet at 3 p. m., September 20. This is the highest September stage of record, but 2.3 feet below the flood stage along the city front. However, there was much overflow just above and below the city, particularly at Sycamore Park and Waukonsa Beach where some of the residents were obliged to move. At Tracy, the highest stage was 14.95 feet, 3 p. m., of the 23d, to 7 a. m., of the 24th, about 1 foot higher than flood stage. At Eddyville the highest stage was 15.8 feet at 7 a. m. of the 24th, and there was considerable overflow on the west bank. At Ottumwa the highest stage was nearly 9 feet, not quite bankful.

There was no very high water in the Raccoon River below Perry, Iowa. The highest stage reached at Van Meter, Iowa, was 10.7 feet about midnight of the 14th and there was another slight crest of 9.9 feet at 7 a. m. of the 21st, flood stage 13 feet.

Damage was mostly to corn, matured but not yet harvested, however there was some damage to other crops and to fences, roads, bridges, and buildings. The total damage along the Des Moines River and its tributaries from the headwaters to Ottumwa was \$72,852, while the total amount saved by warnings was \$16,600.

KEOKUK, IOWA, RIVER DISTRICT

Mississippi River from Keithsburg, Ill., to Louisiana, Mo.—Stages in this portion of the river were at, or above flood stage, from 10 to 16 days, however, losses were comparatively light, totaling about \$12,500. Inasmuch as the flood originated some distance upstream it was possible to issue warnings considerably in advance and precautions were taken which probably were responsible for the slight damage.

A report on the September flood in New England will be presented in a later issue of the REVIEW.

TABLE 1.—Crest stages along upper Mississippi River and tributaries and comparative data

[All dates in September unless otherwise specified]

Station and river	Flood stage	Above flood stages—dates		Crest		Previous September record	
		From--	To--	Stage	Date	Stage	Year
Mankato, Minn.-----	<i>Minnesota River</i> Feet 19			15.7	7 a. m., 19	11.4	1906
Durand, Wis.-----	<i>Chippewa River</i> 11			15.2	3 p. m., 11		
Thellman, Minn.-----	<i>Zumbro River</i>			38.5	11		
Beaver, Minn.-----	<i>Whitewater River</i>			92.0	10		
Galesville, Wis.-----	<i>Black River</i> 10	10	15	13.7	12		
Merrill, Wis.-----	<i>Wisconsin River</i> 11			9.6	10	10.3	1928
Knowlton, Wis.-----	12	9	13	19.9	2-4 a. m., 11	16.9	1928
Wisconsin Rapids, Wis.-----	12	11	12	13.35	6 p. m., 11 5 a. m., 12	11.3	1912
Wisconsin Dells, Wis.-----	16	13	16	18.8	14		
Portage, Wis.-----	17	13	18	20.5	4 p. m., 14	18.1	1928
Moline Bridge, Ill.-----	<i>Rock River</i> 10	9	Oct. 5	11.9	18, 20, 22-26	9.0	1931
Janesville, Iowa.-----	<i>Cedar River</i>			7.9	16		
Cedar Rapids, Iowa.-----	13			6.9	21	9.1	1915
Wapello, Iowa.-----	<i>Iowa River</i> 10			5.8	7 a. m., 24	11.8	1926
Augusta, Iowa.-----	<i>Skunk River</i> 15			4.2	17	19.9	1926
Van Meter, Iowa.-----	<i>Raccoon River</i> 13			10.7	15	18.8	1926
Boone, Iowa.-----	<i>Des Moines River</i> 20	16	20	23.1	4 p. m., 18	18.6	1926
Des Moines, Iowa.-----	17			14.7	3 p. m., 20	13.2	1926
Tracy, Iowa.-----	14			14.95	3 p. m., 23 7 a. m., 24		
Ottumwa, Iowa.-----	9	25	25	9.0	7 a. m., 25	12.3	1926
Keosauqua, Iowa.-----	20			9.0	25		
Fort Ripley, Minn.-----	<i>Mississippi River</i> 10			5.2	14	6.8	1928
Minneapolis, Minn.-----	16			7.1	15		
St. Paul, Minn.-----	14			4.5	24	11.9	1903
Hastings, Minn.-----	18			6.8	16		
Red Wing, Minn.-----	14			9.5	14	11.9	1903
Reads, Minn.-----	12			9.7	14	11.0	1903
Winona, Minn.-----	13			11.8	15	8.1	1926
La Crosse, Wis.-----	12	13	16	12.3	7 a. m., 15	13.3	1903
Prairie du Chien, Wis.-----	18	18	20	18.4	1 p. m., 18	16.7	1903
Dubuque, Iowa.-----	18	18	25	20.5	Noon, 20	17.4	1903
Clinton, Iowa.-----	16	19	28	18.3	22-23	11.1	1928
La Claire, Iowa.-----	10	19	28	11.6	23	10.8	1903
Davenport, Iowa.-----	15	21	27	15.8	24	13.7	1903
Muscatine, Iowa.-----	15	20	Oct. 1	18.5	24	13.9	1903
Keithsburg, Ill.-----	12	20	do	14.3	25		
Keokuk, Iowa.-----	12	21	Oct. 3	16.4	Noon, 26	13.4	1926
Quincy, Ill.-----	14	21	Oct. 4	18.3	27	14.8	1926
Hannibal, Mo.-----	13	20	Oct. 6	18.1	8 a. m., 27	14.9	1926
Louisiana, Mo.-----	12	21	Oct. 5	16.3	28	14.0	1926

¹ Highest stage previously recorded was 19.5 feet, April 1922.
² Warning stage.

³ Highest stage previously recorded was 19.2 feet, October 1911.
⁴ Record incomplete.