

NEW ORLEANS FORECAST DISTRICT.

Quiet weather conditions prevailed and no storm warnings were issued or required. Small-craft warnings, displayed on the central coast of Texas on the 9th, were justified.—*R. A. Dyke.*

DENVER FORECAST DISTRICT.

No special warnings were required or issued during the month, except fire-weather warnings which were distributed for the entire district on the evening of the 7th, when an area of low barometric pressure of considerable intensity was central in Montana and northern Idaho. On the morning of the 8th a maximum wind velocity of 42 miles per hour was reported at El Paso, and on the evening of the same date 30 miles at Albuquerque and 44 miles per hour at Cheyenne. The highest wind velocities for the month at Denver and Grand Junction, 38 miles per hour, also occurred on the 8th.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

All storms from the North Pacific during the month moved inland at a high latitude and did not materially affect the weather in this district.

Thunderstorms occurred in the Sierra Nevada and Plateau region from the 4th to the 6th, and again from the 17th to the 23d.

On the 2d the temperature at Roseburg, Oreg., reached 104°, equaling the record for the month at that station.

A peculiar feature of the month was the absence of northwesterly gales along the central California coast. Usually these are of nearly daily occurrence at Point Reyes, but this month, instead of strong northwesterly gales, light south to southwest winds prevailed for days at a time. The observer informed me he could find no similar record for so many consecutive days in July.

Fire-weather warnings were issued in northern California on the 14th and 26th, and were verified.—*G. H. Willson.*

RIVERS AND FLOODS.

By H. C. FRANKENFIELD, Meteorologist.

Moderate floods occurred in the rivers of the South Atlantic States on account of frequent rains after the middle of the month. Warnings were issued wherever and whenever necessary, and no damage of consequence resulted. There were no other floods east of the Mississippi River except a short and harmless one in the upper Connecticut River on July 2. There were, however, several overflows of small streams at different times caused by torrential local rains. These occurred in Southern New England and the Middle Atlantic States, and the aggregate losses were more than \$1,000,000, mostly in northeastern Pennsylvania, where the storm was the fourth destructive one within four weeks.

The destructive floods of the month occurred in the rivers of northwest Missouri, where all the rivers and smaller streams overflowed their banks after the torrential rains of July 9 and 10. At Maryville 10.82 inches of rain fell during the 24 hours ending at 7 a. m. July 10, at Chillicothe 5.18 inches fell on July 9 and 10, and at Brunswick 3.34 inches on the same dates.

The larger rivers that were in flood were the Grand, Nishnabotna, Nodaway, One Hundred and Two, and

Platte, and it was reported that the latter was 1½ miles in width in places on July 12.

Crops suffered enormously, bridges and roads were washed away, railroad tracks were torn up, and traffic generally interrupted. Between 8,000 and 10,000 acres of farm lands were inundated, and the losses will run into millions of dollars. The losses from the Grand River flood alone were reported as having been about \$2,000,000.

Warnings were sent out on July 10 as soon as the first reports of heavy rain had been received, but, although the flood conditions did not become serious until early morning of July 12, many farmers were unable to get their wheat out of the lowlands. Some worked all day and throughout the night and succeeded in saving a considerable quantity of wheat, but many thousands of bushels were carried down the swollen rivers. It was impossible to convince numbers of farmers that a destructive flood could occur in July, and these lost everything. However, as a whole, both farmers and others were quick to action as soon as the warnings had been received, and many have expressed their gratitude and thanks for the timely and accurate warnings, which were distributed largely by telephone. By 9:40 a. m. July 10, or within one hour after the warnings had been received at the Weather Bureau Office at St. Joseph, they had been repeated to more than 100 farmers living in the One Hundred and Two River Valley in Andrew, Buchanan, and Platte Counties.

The following report on the flood in the Grand River of Missouri was prepared by Mr. M. W. Hayes, meteorologist in charge of the Weather Bureau Office, St. Louis, Mo.:

THE GRAND RIVER FLOOD OF JULY, 1922.

The basin of the Grand River extends from south central Iowa southward to the Missouri River. It is a comparatively flat area, containing 7,891 square miles and sloping from an elevation of about 1,000 feet above mean sea level in Iowa to about 700 feet at Chillicothe and about 650 feet at the mouth of the river. There are two distinct sub-basins extending as far southward as Chillicothe: the easterly one contains 2,194 square miles and is of an elongated shape; the distance from Chillicothe to its upper end in Iowa is 125 miles. The westerly sub-basin has an area of 2,664 square miles, while the distance from Chillicothe northwestward to its upper extremity is 20 miles less than the length of the easterly division. These two subbasins combined form an area that is almost rectangular except for an acute angle—the upper part of the easterly division—that extends well up into Iowa. Chillicothe is in the southeastern corner of the area.

Rainfall in extreme northern Missouri and south central Iowa is at times unusually excessive in periods varying in duration from two or three days to a week between May 15 and July 15. From 1909 to 1922, inclusive, there have been five years (1909, 1915, 1917, 1919, and 1922) in which rainy periods have given precipitation ranging in amount from 4 to 12 inches over a large part of the watershed above Chillicothe.

In comparing flood heights in the Grand below Chillicothe the influence of the Missouri River has to be considered, for a high Missouri checks the discharge of the lower Grand, while a low Missouri permits a rapid discharge and cuts the flood height in the lower river very materially. For purposes of comparison the Chillicothe stages alone are considered. The Chillicothe gauge is a very short distance below the confluence of the east and west branches of the river and is too far away from the mouth of the main stream to be affected in any material way by Missouri River stages.

The highest flood known in the Grand and its two principal tributaries that meet at Chillicothe occurred in July, 1909. In that year a period of rains began on July 5 and continued at an excessive rate for three days. In most of the drainage basin above Chillicothe 4 to 11 inches of rain fell.

The second highest flood was in June, 1917. The rain that caused it began on June 1 and, with the exception of the 3d, fell daily through the 6th. The amounts ranged from 4.34 to 7.47 inches. As in the case of the 1909 flood, the heaviest rain was a short distance south of the Iowa line, and the lightest was in the lower part of the drainage area.

The third highest was in July, 1922. The rainfall had been deficient since the latter days of May, and both the Grand River system and the Missouri River were low on July 9, when excessive rains began over the northwestern part of the Grand River basin. In less than 24

hours 10 to more than 12 inches of rain fell in the extreme northwest part of the westerly subdrainage area above Chillicothe. In the remainder of the basin 3 to 6 inches fell. Most of the rain, and probably enough to cause a disastrous flood, fell in the 24 hours ending at 7 a. m. of the 10th. A very rapid rise began in the tributary streams on the 10th, and in the main stream as far south as Chillicothe on the 11th. Very high stages were general, except near the mouth of the river. The bottoms are broad throughout the system; all of them above Chillicothe were covered, and below the widely inundated area extended almost to the Missouri River. The water receded slowly, as is usual in this system, thus augmenting the seriousness of the situation.

The stage of the Missouri River was moderate throughout the flood in the Grand, and the discharge near the mouth of the Grand was sufficiently rapid to keep the maximum stage down to a level that was not more than 5 feet above bankful.

There are three rainfall charts inclosed.¹ They show the precipitation that caused the floods of July, 1909, June, 1917, and July, 1922. There is also forwarded herewith a tabular statement of the annual maximum stages of the Grand River at Chillicothe.

WARNINGS ISSUED.

At 10 a. m. of July 10, the following telegraphic warnings were issued: To Pattonsburg, Gallatin, and Trenton, Mo.—Heavy rains upstream. River will rise rapidly and pass bankful stage.

To Chillicothe.—Heavy rains upstream. Grand will rise rapidly, passing flood stage in 36 hours.

To Brunswick.—Heavy rains over Grand, and in northwest Missouri. River will pass flood stage by Wednesday (12th).

At 3 p. m. of the same day, after receipt of additional rainfall reports, further warnings were telegraphed as follows:

To Pattonsburg, Gallatin, Trenton, and Chillicothe, Mo.—Very heavy rains falling in northern counties from Putnam to Nodaway. Amounts sufficient to give high flood. Disseminate widely.

To Brunswick.—Very heavy rains falling in northern counties from Putnam to Nodaway. Amounts sufficient to cause high flood above Brunswick. Rise at Brunswick depends upon action of Missouri, which can not be estimated until Tuesday (11th).

On the 11th a stage of 14 feet was forecast for Brunswick.

On the 12th a crest stage of 30 feet was forecast for Chillicothe, and the river observer at that place was asked to disseminate the information as widely as possible.

When the first warnings were telegraphed the stages were low. The Chillicothe stage was 5.3 feet, which is 12.7 feet below bankful stage. All of the warnings were given as thorough a dissemination as possible. The Chillicothe Chamber of Commerce and the telephone companies in the basin spread the information among the farmers by telephone. The time that was available for the driving of live stock out of the bottoms and moving the shocked wheat was ample. Most of those having property of this kind in exposed places began to move it upon receipt of the first warning. There were some, however, who were doubtful that the river would rise high enough to cause any damage, and lost all of their bottom wheat and most of their live stock running in the bottoms.

Thousands of acres of growing corn were a total loss. Some corn on the edge of the flooded area survived the inundation, but in most of the bottom land the crop was covered three to six days and was killed. On account of the lateness of the season, replanting had to be confined to a few forage crops.

There was one human life lost during the flood, that of a boy of 17, who was drowned on July 12 while driving cattle from flooded lowlands near Brimson, Grundy County.

The following is a tabulation of the statistical reports concerning flood losses and the value of the warnings in Daviess, Grundy, Livingston, Carroll, and Chariton Counties, Mo.:

Damage to highways, bridges, farm buildings, etc.	2	\$80,000
Loss of crops, which may or may not have been housed		530,000
Loss of prospective crops, 57,300 acres	1,432	500
Loss of livestock or other movable property	2	11,500
Loss due to suspension of business, including wages of employees		87,000
Money value of property saved by warnings	1,790	000

Highest stages at Chillicothe for 1909 and for 1915 to 1922, inclusive. There are no records for the period 1910 to 1914, inclusive.

	Stage.		Stage.
1909	33.6	1919	29.8
1915	30.1	1920	26.9
1916	27.0	1921	19.2
1917	31.5	1922	30.5
1918	21.0		

¹ Not reproduced.

² For Livingston County only.

There is inclosed herewith a copy of resolutions adopted by the Chamber of Commerce of Chillicothe, Mo., expressing its appreciation of the work of the Weather Bureau in connection with this flood.

THE HIGHWAY CITY—THE CHAMBER OF COMMERCE—COURTESY TOWN—CHILICOTHE, MO.

BOARD OF DIRECTORS' MEETING, JULY 13, 1922—A RESOLUTION OF APPRECIATION TO ST. LOUIS WEATHER BUREAU.

Whereas the warning sent out by telegraph through the local station representative by the Government Weather Bureau at St. Louis, giving from 30 to 36 hours' notice in advance of a 30-foot flood stage in the Grand River Valley in Livingston County, caused by a heavy down-pour about July 10th, in the northwest part of the State; and

Whereas said telegram contained the further warning to all farmers and others in the lowlands to make every effort to save their harvested crops, their live stock, and to remove same to the higher lands; and

Whereas many of our farmers heeded the warning and did save some of their crops and nearly all their live stock, while others, we regret to say, did not heed the warnings; and

Whereas the Chillicothe Chamber of Commerce, by the information contained in said Government Weather Bureau warning, was put in a position to cooperate in distributing this information to our rural district lowland farmers: Therefore be it

Resolved, At this a regular board of directors' meeting, held on the above date (motion made by E. O. Welch, seconded by W. C. Arnold, and passed unanimously), "That a proper resolution be prepared by the secretary commending the Government Weather Bureau office at St. Louis for furnishing advanced report and warning to the people of Livingston County from 30 to 36 hours, relative to the recent flood, so that they could get their stock and crops out of the lowlands prior to the arrival of the flood. And also to request that if the Government office at St. Louis will furnish the chamber of commerce with a copy of all future information of this nature which comes to their local representative, the chamber will be able to facilitate in getting this information out over the county much quicker."

BOARD OF DIRECTORS,
By HARRY W. GRAHAM, *Secretary*.

There was also a general overflow of the smaller streams of northeastern Nebraska on July 30, and according to press reports towns and farm lands were damaged to the extent of \$1,000,000.

The rise in the Arkansas River and tributaries from the Wichita district southward was not serious except in the Little Arkansas River. The total damage reported was about \$55,000, of which about \$40,000 was in crops. Warnings were issued well in advance of the rises.

ANNUAL RISE OF THE COLUMBIA RIVER, 1922.

By R. C. MIZE, Meteorologist, Portland, Oreg.

Reports at the end of March showed practically the entire season's snowfall on the ground in the mountain areas. The depth was about average, the snow somewhat less compact than usual, streams unusually low, and the soil fairly well filled with moisture. Forecast was made at that time that with normal temperature conditions there should be a crest of about 20 feet at Portland, and that this stage might be exceeded should there be 10 days or more of continued hot weather late in May or early in June.

At the end of May an usually hot spell prevailed, the last four days of the month showing an excess of 56° above normal. At this time the river was 5 feet lower than on the same date of the preceding year. Moderately hot weather continued until June 8, by which time the stage was but 2 feet lower than that of one year before. The crest was reached at Portland on the average date, June 11. The flood stage was reached on May 21, one day later than the average, and continued six days less than the average. The crest was 0.1 foot higher than