UNITED STATES DEPARTMENT OF THE INTERIOR

NOTABLE LOCAL FLOODS OF 1939

Part 2. FLOOD OF JULY 5, 1939

IN EASTERN KENTUCKY

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 967-B

UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

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by

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By Floyd F. Schrader

ABSTRACT

In a period of a few hours during the night of July 4-5, 1939, there occurred in eastern Kentucky an exceptionally severe storm attended by precipitation reaching cloudburst proportions. The storm was somewhat limited in areal extent and principally affected the counties of Lewis, Fleming, Carter, Rowan, Elliott, Menifee, Morgan, Wolfe, Magoffin, and Breathitt in the upper reaches of the Kentucky, Licking, and Little Sandy River Basins and Tygarts Creek Basin. The resultant runoff from the storm produced flood stages and discharges on the small streams of this region exceeding any previously witnessed, and the computed unit discharges for headwater and small tributary streams were higher than any heretofore obtained in Kentucky. Although the runoff was intense at many locations, it was apparently greatest in the Triplett and Frozen Creek areas in Rowan and Breathitt Counties.

Descriptions of the rainfall, including such phrases as "continuous sheets of water" and "creating a complete lack of visibility," indicate that the intensity was exceptionally high for short periods and that in some localities this intense rate of rainfall was maintained for a period of almost an hour.

The conditions of stream channels and overflow sections was considered evidence of the unusually high rates of flow. These indications of exceptional runoff were verified by measurements of discharge, principally by the slope-area method. The field data for the computations were obtained shortly after the flood at a number of places in the Triplett and Frozen Creek Basins. The drainage areas at the various locations ranged from less than 5 square miles to 75 square miles, and the results computed by the slope-area method showed a peak discharge exceeding 2,000 second-feet per square mile on one or more small streams draining areas of less than 10 square miles.

There were no stream-gaging stations in the area of high runoff, and accordingly no record was available showing the rapid rise and recession of the flood on any of the small streams. Except for one station with a drainage area of 140 square miles, none of the drainage areas for the half dozen or more gaging stations in the general region were less than 350 square miles.

According to a survey by the Corps of Engineers, United States Army, the damage resulting from the storm and flood was caused principally by the high velocities and extreme flows in overflow channels and by the heavy deposits of debris. The greatest damage occurred in the vicinity of Jackson in Breathitt County, of Morehead in Rowan County, and in parts of Lewis and Carter Counties. The damage in these four counties was estimated at nearly $2,000,000. A total of 78 persons lost their lives over the entire storm area.

INTRODUCTION

The storm of July 4-5, 1939, in eastern Kentucky was of brief duration but extreme intensity, and it produced unusual flood flows in the streams of Carter, Rowan, Elliott, Morgan, Wolfe and Breathitt Counties over parts of the Kentucky and Licking River Basins and Tygarts Creek Basin. The storm commenced late in the evening of July 4, reached maximum intensity during the early morning hours of July 5, and had passed before daybreak. The unusual occurrence is described as a series of violent thunderstorms accompanied by continuous and brilliant lightning and extremely hard rains. The exceptionally heavy downpours resulted in rainfall depths for the brief storm period probably exceeding any previously known for a similar period in Kentucky. Although reliable measurements of rainfall depths at or near the center of the storm were not available, it was estimated on the basis of descriptions by local residents and reliable information in adjacent areas that depths of rainfall exceeding 12 inches and possibly approaching 20 inches occurred at the center of the storm. The rainfall was so intense that it was described as creating a complete lack of visibility.

The area that produced high flood runoff was irregular in shape, roughly 10 to 20 miles wide and 60 miles long, and extended northward from the vicinity of Jackson in Breathitt County, east-central Kentucky, nearly to the center of Lewis County, adjacent to the Ohio River. Frozen and Triplett Creeks, tributaries of North Fork Kentucky River and Licking River, respectively, probably produced the greatest rates of flow, although there were indications on many other small streams that exceptionally high discharges occurred there also.

Stream-flow records were obtained from a few gaging stations on the main streams or large tributary streams of the Kentucky and Licking Rivers. The smallest drainage area of any of these gaging stations was 140 square miles and the next smallest 363 square miles. Several of the stations were on the edge of the area of high runoff. Only small parts of the several drainage areas for these stations were affected by the storm; most of the stream flows at the gaging stations came from those parts of the basins where the runoff was relatively light. Accordingly, no continuous stream-flow record directly reflected the unusual flood conditions on the small tributary streams. Information for these gaging stations is provided in other sections of the report.

The damage and loss of life from the storm and flood, considering the small size of area affected and the relatively sparse population, were exceptionally large. Although rural property and crops suffered the greatest damage, transportation facilities were disrupted, communication lines were torn down, and stores, merchandise, homes and schools were destroyed or damaged. (See pls. 7, 8.) Most of the damage was caused by the high velocity and large flow in overflow channels and by deposits of debris. Some damage to crops and soil was caused by surface and gully erosion. The greatest damage occurred in the vicinity of Jackson in Breathitt County, of Morehead in Rowan County, in the southeastern part of Lewis County, and in the southwestern part of Carter County. Over the entire storm area 78 persons lost their lives. The greatest loss of life occurred near Jackson, Ky., the greatest property damage in

Morehead, Ky., and the greatest crop damage in Lewis and Carter Counties. A survey of the damage in Breathitt, Rowan, Lewis, and Carter Counties indicated that the total loss in those four counties was approximately $2,000,000. The smaller losses in Bath, Johnson, Wolfe, Mason, and Clark Counties were not estimated. The information on flood losses and damages contained herein is based on a survey conducted by field parties of the Cincinnati District Office, Corps of Engineers, United States Army.

In view of the outstanding characteristics of this flood it was considered desirable to prepare a report containing all information available on both the storm and the flood. Before undertaking such a report, thorough consideration was given to the uncertainties regarding the exact amount of the extraordinary rainfall and runoff that were associated with this storm and flood. The data for the slope-area measurements of discharge indicate a degree of uncertainty regarding the interpretation of some of the essential base data that subjects the results to a margin of error that seems unusually high. Perhaps the principal reason for this uncertainty was caused by the inability to obtain adequate base data.

The opportunities for securing data during the storm and flood were extremely limited, owing to the short duration and to the fact that they occurred at night and were confined to so small an area. Consequently, the data presented are the result of subsequent surveys. Within the region of intense precipitation there were no trained or experienced observers to report on the storm, but many inhabitants provided vivid descriptions and furnished information on the rainfall, such as the depth of water found in uncovered pails, tubs, jars, and other containers.

In view of the uncertainties concerning the interpretation and reliability of the base data this report has been prepared to show by description and quantitative generalities, rather than by statistics and specific quantities, the magnitude of the storm and flood.

ACKNOWLEDGMENTS

The Cincinnati District Office, Corps of Engineers, United States Army, has furnished a substantial part of the information for this report, including descriptions on which much of the written material is based. Practically all of the data on precipitation was collected and compiled in that office. Most of the data on rainfall collected by trained observers was furnished by the United States Weather Bureau.

Base data obtained by the Geological Survey were collected under the direction of F. M. Veatch, district engineer until March 12, 1940, and the report was prepared under the direction of J. V. B. Wells, district engineer since March 13, 1940. This work was performed in connection with the program of stream-gaging carried on in the State of Kentucky in cooperation with the Kentucky Department of Highways, J. L. Donaldson, commissioner, and with financial assistance by the Corps of Engineers, United States Army.

R. W. Davenport, chief of the Division of Water Utilization, and Hollister Johnson, engineer, Albany district, provided valuable advice and assistance in directing the general outline and final preparation of the

report and in collecting the field data and computing the results. The personnel of the Louisville district assisted in the collection and compilation of data.

DESCRIPTION OF STORM

The characteristics of the storm are well defined because its unusual aspects attracted the attention of many people. Although generally considered as a single storm, it actually consisted of a series of thunderstorms accompanied by almost continuous lightning and thunder, which were noticeable for a considerable time before the storm. The lightning was described as continuous lightning and sheet lightning and by several observers as the most persistent they had ever witnessed. The thunder preceding the storm was a low rumble and at the height of the storm is reported to have shaken the earth. The lightning was so continuous that, despite the fact that the storm occurred at night in most localities, the cloud formations could be viewed without difficulty in what is described as a purplish hue. Although in a turbulent state, these cloud formations had a distinct outline and could be seen approaching from the north at a rapid rate.

On the edge of the storm area winds reached gale proportions such that buildings were damaged and in several places were entirely destroyed. Reports indicate that there was relatively little wind outside of the storm area, and observers at the storm centers reported that little or no wind accompanied the rainfall. According to information obtained from weather stations, the prevailing direction of the wind was to the southwest on the northeast side of the storm area, to the northeast on the southwest side, and variable on the northwest and southeast sides.

The meteorology of the storm has been described as follows:[1]

On July 2 a widespread stagnant anticyclone circulation was associated with typical warm dry weather over eastern United States. * * *

The synoptic data for the period July 3-5, inclusive, show a slow eastward progression of a weak cold front. This front did not produce sharp wind shifts at the surface, but scanty radiosonde data suggest that aloft the front was followed by a narrow tongue of cold air. On the night of July 4-5, this tongue was being displaced southeastward across Ohio and Indiana. * * * The cold air was being rotated cyclonically around a center in southern Michigan, while to the southeast the warm air was undergoing an anticyclonic rotation. The net result of the two circulations was to produce a field of strong convergence over eastern Kentucky, which in turn caused the vertical motions necessary to set off the convective energy and to produce the rainfall. * * *

The displacements of the centers of convergence and rainfall coincide. Over small areas the average rate of radial inflow from the surface to 8,000 feet for a period of 12 hours was approximately 5 miles per hour. Such inflow velocities are sufficient to explain the rates of precipitation for the 6-hour period over the storm area as a whole, but the intense rainfall near the center of the storm would require either higher rates of inflow or the transport into the area of suspended liquid water. Either one or both of these could be possible in such a circumstance.

Analysis of the mean motion in the layer from 8,000 to 12,000 feet above the storm area showed weak outflow velocities before and weak inflow velocities after 10 p.m. Velocity profiles computed from the above data indicate that the upper limit

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[1] "Maximum possible precipitation over the Ohio River Basin above Pittsburgh, Pa.," prepared by the Hydrometeorological Section of the Weather Bureau in cooperation with the Corps of Engineers, U. S. Army, June 16, 1941: Hydrometeorological Report No 2, pp. 56-62, Vicksburg, Miss. [1942].

of the convergence layer had risen approximately 1,000 feet to a height somewhat in excess of 10,000 feet.

The outstanding features of this storm were:

a. A large supply of convectively unstable tropical maritime air, retaining its original characteristics and transported into the region by a widespread stagnant circulation previously accompanied by dry weather.

b. A flow of relatively colder air into the area from the north or northwest.

c. The interaction of these currents to produce a center of intense convergence.

d. The explosive release of energy in the tropical air after saturation.

RAINFALL

The rates of precipitation produced by this storm were extremely high and exceeded any known to have occurred previously in the region affected. The rainfall is described by observers as having been so intense that it was impossible to see objects only a few feet away. People caught out in the storm were compelled to stop before reaching shelter because of the lack of visibility. Numerous accounts were given of runoff that covered the sloping ground in sheets. Although the rain did not fall at a continuous high rate throughout the storm, high rates apparently were maintained in some localities for periods as long as an hour. These periods of sustained intensity occurred near the end of the storm. During such periods the rainfall was alternately in the form of large drops and of continuous sheets of water similar to those coming from the eaves of a roof.

A great deal of information was obtained from inhabitants of the storm area on the nature and extent of precipitation. From this information the average length of the period of rainfall in the storm area was determined to be about 3 hours. In some localities the rain commenced as early as 9 a.m. on July 4 and in other localities ended as late as 6 a.m. on July 5. However, the consensus of reports shows that the rainfall was principally concentrated in a 3-hour period from 1 a.m. to 4 a.m. on July 5.

As the storm occurred at night, much of the information on the duration of rainfall is somewhat inexact, and several observations at the center of the storm area (showing extremely brief periods of rainfull during the early morning hours) are probably of questionable accuracy. Data on the beginning and ending of rainfall on the night of July 4, 1939, as compiled from statements of local residents, are listed below:

Location	*Duration of rainfall*
Portsmouth, Greenup County	1:30 a.m. to 4:30 a.m. July 5
Vanceburg, Lewis County	6:15 p.m. to 10:30 p.m. July 4
Mount Sterling, Montgomery County	3 a.m. to 6 a.m. July 5
Olive Hill, Carter County, 11 miles west of	10:30 p.m. July 4 to 12:30 a.m. July 5
Grayson, Carter County	9 p.m. to 11 p.m. July 4
Morehead, Rowan County	11 p.m. July 4 to 12:30 a.m. July 5
Frenchburg, Menifee County	1:30 a.m. to 3:45 a.m. July 5
Wellington, Menifee County	10 p.m. July 4 to 2 a.m. July 5
Maytown, Morgan County	2 a.m. to 3 a.m. July 5
Index, Morgan County	11 p.m. July 4 to 3 a.m. July 5
Bowen, Powell County, (Peckerwood CCC camp)	2 a.m. to 5:30 a.m. July 5
Hazel Green, Wolfe County	1 a.m. to 3 a.m. July 5

Location	*Duration of rainfall*
Daysboro, Wolfe County	1 a.m. to 4 a.m. July 5
Trent, Wolfe County	1 a.m. to 4 a.m. July 5
Stillwater, Wolfe County ½ mile south of	12 p.m. July 4 to 5 a.m. July 5
Salyersville, Magoffin County	1 a.m. to 5 a.m. July 5
Town Flat, Magoffin County	12 p.m. July 4 to 3 a.m. July 5
Wilhurst, Breathitt County	11:30 p.m. July 4 to 3:30 a.m. July 5
Near Taulbee, Breathitt County, 9½ miles above Blanton Bridge	1:30 a.m. to 3:30 a.m. July 5
Near Taulbee, Breathitt County, 5 miles above Blanton Bridge	1 a.m. to 4 a.m. July 5
Near Taulbee, Breathitt County, 1½ miles above Blanton Bridge	1 a.m. to 4 a.m. July 5
Near Frozen Creek, Breathitt County, on Strong Fork	2 a.m. to 4 a.m. July 5
Near Frozen Creek, Breathitt County, ¼ miles from Strong Fork School	1:30 a.m. to 4 a.m. July 5
Jackson, Breathitt County	3 a.m. to 6 a.m. July 5
Jackson, Breathitt County	3:30 a.m. to 6:30 a.m. July 5
Quicksand, Breathitt County	3 a.m. to 6 a.m. July 5
Near Rousseau, Breathitt County, on Quicksand Creek	2:30 a.m. to 4 a.m. July 5
Near Stevenson, Breathitt County, on Meatscaffold Creek	1 a.m. to 4 a.m. July 5
Near Quicksand, Breathitt County, on South Fork of Quicksand Creek	2:30 a.m. to 5 a.m. July 5

As there were no rainfall stations within the region of most intense precipitation, field parties were assigned to obtain from local residents all available information on rainfall depth. The greater number of the measurements represent the depth of water collected in pails, tubs, jars, and other containers, which were generally near the residence or other buildings on the property. As most of these containers were in daily use by their owners, they had been emptied of their contents before the field parties could obtain first-hand information. Consequently, very few direct measurements of the depth of water were obtained, and most of the data collected consisted of statements and estimates by residents concerning the depth of water, conditions of exposure, and other factors. Much of this information is of little value if each observation is considered separately, but it is valuable in the aggregate for study of the storm as a whole.

It would appear that with plentiful observations of the rainfall, reliable determination of the maximum depth would be relatively simple. However, there was a wide range in the quality of the observations, many of which were obtained by untrained persons and were undoubtedly affected to such an extent by local conditions or other factors that it was necessary to reject them as unreliable. This was particularly true of a few observations indicating extraordinary depths near the center of the storm area. Nevertheless, the data unquestionably indicate that the rainfall was extraordinarily deep over relatively large central areas during the brief storm period.

As the available information was not sufficient to establish definitely the maximum rainfall depths it was believed desirable to indicate the possible extent of the maximum. An analysis showed that the rainfall probably exceeded 12 inches and that it may have been as much as 20 inches at the center of the storm. A few observations greatly exceeded

12 inches but were not accepted as reliable because of unfavorable conditions under which they were obtained and their poor correlation with adjacent data. However, these observations were considered in estimating the possible maximum depths at the center of the storm. Other factors that were considered in estimating the possible extent of the maximum depth are the very unusual runoff and the fact that such a storm usually has near its center one or more relatively small areas in which the rainfall depth greatly exceeds the depth in the surrounding area.

In order to classify the rainfall data on a uniform basis it was necessary to establish certain criteria that could be applied to any of the observations, irrespective of the depth of rainfall reported. Accordingly, all observations were first separated into two classifications — (1) those acceptable for use in the report and (2) those to be rejected and omitted from the report.

The comparatively small number of observations rejected included all those obtained under one or more of the following unfavorable conditions: Receptacle under tree, on porch or porch step, or near building; receptacle leaked or was not empty prior to storm; receptacle not seen, and not of standard shape, or dimensions not known; rough approximation of depth of water reported where receptacle and its location were not seen by field party; and poor correlation with adjacent data, that is, the reported depth of rainfall differed too widely from several acceptable observations in the immediate vicinity.

The large group of accepted observations was subdivided into four smaller groups, A–D, with each observation classified either as of acceptable reliability or uncertain reliability and, also, according to the method of ascertaining depth of water in receptacle. In general, observations were considered of acceptable reliability if the depth was measured (group A) or if the receptacle overflowed and if the receptacle and its location were observed by the field party (group B). Observations considered to be of uncertain reliability included all those obtained under the following conditions: Depth an estimate or approximation, or reported measurement of doubtful accuracy (group C); receptacle overflowed, but receptacle and its location not observed by field party (group D). All measurements of rainfall reported by Weather Bureau stations were automatically classified in group A.

The table of rainfall data that follows includes all observations accepted, classified in the four groups, A to D, according to the procedure outlined in the preceding paragraph. For each observation listed, information is given on the location, depth of rainfall, and method of measurement. The location of each point of observation is shown by a solid circle on plate 9, with the reference number given in the first column of the table. Where more than one observation was made at the same location only one number appears on the map, but each observation is listed separately in the table with an added reference letter as "26a, 26b." For all observations the depth of rainfall in inches was computed by taking into account the depth of water in the container, the shape and dimensions of the container, and the area of the top opening. Where the container was of standard shape and size but was not seen by the field party, a similar container was measured.

Rainfall during night of July 4-5, 1939, in eastern Kentucky, as compiled from statements of local residents and from U. S. Weather Bureau records[1]

Group A.—Acceptable reliability: Measured depth

No. on pl. 9	Location: County	Location: Drainage basin	Rainfall (inches)	Method of measurement
1	Lewis	Ohio River	1.5	U. S. Weather Bureau gage at Vanceburg, Ky.
2	Greenup	do	.2	U. S. Weather Bureau gage at Greenup, Ky.
3	Carter	Little Sandy River	2.8	U. S. Weather Bureau gage at Grayson, Ky.
4	do	Tygarts Creek	4.4	Measured in lard can by editor of local paper.
5	do	do	9.8	Measured in stone crock by field party.
6	Fleming	Licking River	1.2	U. S. Weather Bureau gage at Flemingsburg, Ky.
7	Rowan	Triplett Creek	7.3	Measured in No. 3 washtub by sawmill owner.[2]
8	do	do	6.7	Measured in No. 2 washtub by local resident.
9	do	do	7.4	U. S. Weather Bureau gage at CCC camp near Morehead, Ky.
10	do	do	5.3	Measured in bucket by local resident.
11	do	Licking River	2.6	U. S. Weather Bureau gage at Farmers, Ky.
12	Bath	do	3.1	U. S. Weather Bureau gage at Yale, Ky.
13	Menifee	do	4.1	U. S. Weather Bureau gage at CCC camp near Frenchburg, Ky.
14	Morgan	do	3.0	Measured in pail by local resident.
15	Magoffin	do	3.8	U. S. Weather Bureau gage at Salyersville, Ky.
16	Wolfe	North Fork Kentucky River	6.9	Measured in No. 2 washtub by local resident.
17	do	do	4.2	Measured in pail by local resident.
18	Powell	Red River	2.8	U. S. Weather Bureau gage at CCC camp at Bowen, Ky.
19	Clark	Kentucky River	1.4	U. S. Weather Bureau gage at Winchester, Ky.
20	Estill	do	2.9	U. S. Weather Bureau gage at Ravenna, Ky.
21	Lee	do	1.0	U. S. Weather Bureau gage at Willow, Ky.
22	do	do	1.1	U. S. Weather Bureau gage at Heidelberg, Ky.
23	Breathitt	North Fork Kentucky River	3.8	U. S. Weather Bureau gage at Jackson, Ky.
24	do	do	4.3	U. S. Weather Bureau gage at Quicksand, Ky.
25	Perry	do	1.1	U. S. Weather Bureau gage at Hazard, Ky.

Group B.—Acceptable reliability: Overflowed receptacle

No. on pl. 9	County	Drainage basin	Rainfall (inches)	Method of measurement
26a	Elliott	Little Sandy River	7.0+	Wooden box reported overflowed.
26b	do	do	14.5+	50-lb. lard can reported overflowed.
27a	do	do	9.4+	No. 2 washtub reported overflowed.
27b	do	do	9.8+	Steel barrel reported overflowed.
28a	Rowan	Triplett Creek	9.8+	No. 3 washtub reported overflowed.
28b	do	do	7.2+	Stove kettle reported overflowed.
29	do	do	6.8+	Rain gage at forest fire tower found full.
30	do	do	5.8+	Oil measure reported rained full.
31	do	do	6.9+	8-lb. lard pail reported about full.
32	do	do	5.0+	Aluminum cooker reported overflowed.
33	do	do	9.4+	No. 2 washtub reported overflowed.
34a	do	Craney Creek	8.9+	Square washtub reported rained full.
34b	do	do	8.4+	Well bucket reported rained full.
35	do	do	9.4+	No. 2 washtub reported overflowed.
36a	do	do	9.4+	Do.
36b	do	do	14.0+	50-lb. lard can reported overflowed.
37	Morgan	do	8.8+	Iron kettle reported overflowed.
38	do	do	9.0+	Garbage pail reported overflowed.
39	do	Licking River	7.8+	Iron kettle reported overflowed.
40	do	do	10.6+	Do.
41	do	do	8.0+	Do.
42	Wolfe	Red River	8.5+	Do.
43	do	do	9.0+	Gravel pan reported rained full.
44	do	do	8.6+	Iron kettle reported rained full.
45a	do	do	7.1+	Iron kettle reported overflowed.

Rainfall during night of July 4-5, 1939, in eastern Kentucky—Continued

Group B.—Acceptable reliability: Overflowed receptacle—Continued

No. on pl. 9	Location		Rainfall (inches)	Method of measurement
	County	Drainage basin		
45b	Wolfe	Red River	11.0+	Wooden tub reported overflowed.
46a	do	do	9.4+	No. 2 washtub reported rained full.[2]
46b	do	do	7.3+	10-qt. pail reported rained full.[2]
46c	do	do	12.0+	Rise in water tank measured by local resident.[3]
47	do	do	7.2+	8-lb. lard pail reported overflowed.
48	Breathitt	Frozen Creek	9.4+	No. 2 washtub reported overflowed.[2]
49	do	do	9.8+	Indications that No. 3 washtub rained full.
50	do	do	9.4+	No. 2 washtub reported rained full.
51	do	do	6.9+	10-qt. bucket reported rained full.
52	do	do	7.0+	No. 10 bucket reported rained full.
53	do	Quicksand Creek	5.9+	Iron kettle reported overflowed.
54	do	do	3.2+	Stone bowl reported overflowed.
Group C.—Uncertain reliability: Depth estimated, or measurement of doubtful accuracy				
55	Lewis	Kinniconick Creek	6.5	Garbage pail approximately ½ full.
56	do	do	7.9	Iron kettle filled to 2 in. from top.
57	Carter	Tygarts Creek	5.5	Estimated 7 inches deep in No. 3 washtub.[2]
58	Elliott	Little Sandy River	.8	About 3 inches in round iron kettle.
59	do	do	6.9	Measured in No. 2 washtub by local resident.[2]
60	do	do	9.2	Do.[2]
61	do	do	10.0	50-lb. lard can filled to about 4 in. from top.[2]
62a	Lawrence	Blaine Creek	5.0	Measured in No. 2 washtub by local resident.
62b	do	do	4.4	Oval iron kettle about ⅔ full.
63	Rowan	Triplett Creek	4.6	Estimated No. 3 washtub ½ full.
64	do	do	5.6	Indicated mark in No. 1 washtub by maid.
65	do	do	7.2	Small tub almost full.
66	do	do	5.7	Estimated depth in well bucket.
67	do	do	7.4	Measured to doubtful water mark in stone jar.
68	do	do	8.0	Measured in No. 2 washtub by local resident.[2]
69	do	do	6.7	Indicated depth in No. 3 washtub.[2]
70	do	do	5.1	Indicated depth to water mark in tub.
71	do	do	13.9	Indicated depth in 12 gallon stone churn.
72	do	do	11.5	Garbage pail filled to about 2 inches from top.
73	do	Craney Creek	6.4	Indicated depth in No. 3 washtub.[2]
74	do	Licking River	3.8	Estimated iron kettle about ½ full.
75	Menifee	do	9.3	No. 3 washtub filled to about ½ inch from top.[2]
76	Morgan	do	6.2	No. 2 washtub filled to rings in tub.[2]
77	do	do	6.9	No. 3 washtub filled to about 3 inches from top.[2]
78	do	do	7.4	No. 2 washtub filled to about 2 inches from top.[2]
79	do	do	8.1	Indicated depth in 2 qt. fruit jar.
80	do	do	6.4	No. 3 washtub about ⅔ full.[2]
81	do	do	1.6	Estimated 2 inches in No. 2 washtub.[2]
82	do	do	2.2	Estimated 3 inches in No. 2 washtub.[2]
83	Wolfe	Red River	5.1	No. 2 washtub filled to about 4½ inches from top.[2]
84	do	do	8.4	No. 2 washtub filled to about 1 inch from top.[2]
85	do	North Fork Kentucky River	6.0	Measured in bathtub by local resident.[2]
86	do	do	3.4	4-lb. lard pail about ⅔ full.[2]
87	do	Red River	5.0	Measured in No. 2 washtub by local resident.[2]
88	Powell	do	1.2	Estimated 2 inches in No. 10 bucket.[2]
89	Clark	Kentucky River	4.4	Estimated 6 inches in No. 10 bucket.
90	Breathitt	North Fork Kentucky River	4.8	Indicated depth in iron kettle by local resident.
91	do	do	11.9	Indicated 2 inches from top of 20-gal. iron kettle.
92	do	do	8.9	No. 2 washtub filled to about ½ inch from top.[2]
93	do	do	3.3	Estimated 4½ inches in No. 2 washtub.

Rainfall during night of July 4-5, 1939, in eastern Kentucky—Continued

Group D.—Uncertain reliability: Overflowed receptacle but not observed by field party

No. on pl. 9	Location		Rainfall (inches)	Method of measurement
	County	Drainage basin		
94	Carter	Tygarts Creek	7.5+	No. 10 bucket reported rained full.[2]
95	Elliott	Little Sandy River	9.4+	No. 2 washtub reported overflowed.[2]
96	Fleming	Licking River	7.3+	10-qt. pail reported overflowed.[2]
97	Rowan	Triplett Creek	9.4+	No. 2 washtub reported overflowed.[2]
98	do	do	5.6+	Bucket reported rained full.[2]
99	do	do	5.9+	Do.[2]
100	do	do	9.4+	No. 2 washtub reported rained full.[2]
101	do	do	7.5+	No. 10 bucket reported rained full.[2]
102	do	do	9.8+	No. 3 washtub reported rained full.[2]
103	do	Craney Creek	9.8+	Do.[2]
104	Menifee	Licking River	9.4+	No. 2 washtub reported rained full.[2]
105	Morgan	do	9.8+	No. 3 washtub reported rained full.[2]
106	do	do	9.4+	No. 2 washtub reported overflowed.[2]
107	do	do	9.4+	Do.[2]
108	do	do	9.4+	No. 2 washtub reported rained full.[2]
109	do	do	9.8+	No. 3 washtub reported rained full.[2]
110	do	do	9.0+	Half bushel measure reported rained full.[2]
111	Wolfe	Red River	9.4+	No. 2 washtub reported overflowed.[2]
112	do	do	9.4+	Do.[2]
113	do	do	12.5+	5-gallon bucket reported rained full.[2]
114	do	do	9.4+	No. 2 washtub reported overflowed.[2]
115	do	do	9.4+	No. 2 washtub reported rained full.[2]
116	do	do	9.4+	Do.[2]
117	do	do	9.4+	No. 2 washtub reported overflowed.[2]
118	do	do	6.0+	Stone jar reported overflowed.[2]
119	Breathitt	Frozen Creek	9.4+	No. 2 washtub reported rained full.[2]
120	do	do	9.4+	No. 2 washtub reported overflowed.[2]
121	do	do	9.8+	No. 3 washtub reported overflowed.[2]
122	do	do	7.3+	10-qt. pail reported overflowed.[2]
123	do	Quicksand Creek	9.4+	No. 2 washtub reported overflowed.[2]

[1] Except as indicated by footnote reference, location of receptacle during storm was observed by field party of Corps of Engineers, U. S. Army, and receptacle was seen and measured, or its dimensions were reliably determined.
[2] Receptacle and location during storm not observed by field party.
[3] No. 46c, at same location as 46a, b, can also be classified in group A.

The accompanying map (pl. 9) shows by small black circles the location of all observations of rainfall listed in the preceding table of rainfall data, with the corresponding reference number. Lines of equal depth of rainfall (isohyetals) were constructed on the basis of all information on rainfall depths and show equal depth for each inch of rainfall up to 8 inches. In view of the uncertainty concerning the exact amount of rainfall in the central areas of the storm no attempt was made to define the isohyetals for depths above 8 inches. To indicate the probable range in depth in the general area between the 8-inch isohyetal and the center of the storm, the figures *8″-12″* are shown in that area. For the maximum depth at the center of the storm area the designation *over 12″* has been used to indicate that depths exceeding 12 inches probably occurred in the general central area.

The areas contained within the isohyetals showing rainfall depths of 4, 6, and 8 inches have been planimetered and the results are set forth below:

Isohyetal (inches)	*Area contained within isohyetal (square miles)*
4	1,838
6	1,160
8	443

Two separate 8-inch isohyetals are shown on the map (pl. 9), enclosing a total area of 443 square miles, of which approximately half is contained in each area.

According to Hydrometeorological Report No. 2:[2]

Isohyets, covering a rather large area, could be drawn with reasonable reliability for values as high as 7 and 8 inches. When the storm type is taken into consideration it can be inferred that intense centers occurred within those isohyets. This inference seems to be justified by slope discharge measurements, especially those made in the Frozen Creek watershed.

FLOOD DISCHARGE

GENERAL FEATURES

The runoff resulting from the concentration of heavy rainfall was very unusual with respect to the extremely high rates of flow that occurred from small areas at the center of the storm. Flood stages and discharges on the smaller streams exceeded any previously witnessed, and the rates of flow in headwater and small tributary streams were greater than any heretofore recorded for similar-sized streams in Kentucky. Abundant evidence of the passage of extremely large flood flows was provided by the condition of stream channels and overflow sections and the large deposition of debris. (See pls. 10, 11.) As the flood was of short duration in the night and early morning and was limited to a comparatively small area, it was impossible to obtain first-hand information on the flood runoff. As a result, all data on rates of flow and most of the information on the behaviour and effects of the floodwaters, were obtained from field observations and measurements made subsequent to the event.

The region affected by the unusual flood covered an area of almost 1,000 square miles, principally in Lewis, Carter, Rowan, Elliott, Morgan, Wolfe, and Breathitt Counties. As the greatest rates of flow apparently were experienced in the Frozen and Triplett Creek areas, principal attention was devoted to the flood discharges in those areas.

Frozen Creek drains an area of 55 square miles entirely in Breathitt County and flows in a southwesterly direction to enter North Fork Kentucky River about 4 miles northwest of Jackson, Ky. Triplett Creek drains an area of 188 square miles entirely in Rowan County and also flows in a southwesterly direction to enter Licking River near the town of Farmers, Ky. However, the drainage area of Triplett Creek above the mouth of North Fork Triplett Creek is only 74 square miles, and all investigations of peak flow were made at locations above the mouth of North Fork.

The Frozen and Triplett Creek areas have a similar rugged topography, with hillsides ranging up to foothill mountains such that a drop in elevation of 500 feet in half a mile from ridge tops to stream beds is not uncommon. The steep hillside slopes, the lack of appreciable topsoil, and vegetation consisting chiefly of second-growth timber are all conducive to rapid runoff. Although the topography and stream patterns in the two areas are similar, the flood-flow characteristics of the two streams are somewhat different. There is a noticeable difference in the width of flood plains, Triplett Creek having a flood plain several times wider than that of Frozen Creek for corresponding drainage areas.

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[2] Maximum possible precipitation over the Ohio River Basin above Pittsburgh, Pa., prepared by the Hydrometeorological Section of the Weather Bureau in cooperation with the Corps of Engineers, U. S. Army, June 16, 1941: Hydrometeorological Report No. 2, p. 69, fig. 6.07, Vicksburg, Miss. [1942].

At Morehead on Triplett Creek the storm commenced with unusual force about 11 p.m. on July 4. Shortly thereafter the normal stream channel overflowed, and the stream rose at an even rate the next 2 hours. The rate of rise began to accelerate about 1 a.m. on July 5, and from that time until the crest was reached 1 hour later the rise was very rapid. The rapid rise shortly before cresting was estimated by one observer as "a rise of 7 feet in 11 minutes." Another observer estimated that "the stream rose 10 to 15 feet in less than half an hour."

The sudden rise of Frozen Creek was described as even more abrupt than that of Triplett Creek and was said to have been almost immediate and in the form of a flood wave. Local residents vividly described the rapid rise as "an approaching wall of water which billowed up like clouds"; "a 15-foot wall of water crashing down the valley"; and "like thunder with livestock, pieces of houses, and countless other things all being whirled together on the breast of the torrent as if in a great mixing pot." It was estimated that in one place the water rose 20 feet in 10 minutes. The depths of water at the many sections investigated with field measurements ranged from 12 to 28 feet. The tributaries of Frozen Creek crested between 3:30 a.m. and 3:45 a.m. on July 5 while main Frozen Creek crested at the mouth about 1 hour later.

PEAK DISCHARGE MEASUREMENTS

As it was impossible to obtain direct measurements of the flood flow in the areas of high runoff, the next best method for obtaining this information was by the slope-area method. Accordingly, field parties were sent out, all possible information was collected, and computations and interpretations of the data were made. Field conditions on these particular streams were extremely unfavorable for use of the slope-area method and made it impossible to secure adequate base data. As a result the discharges obtained were inconsistent. The measurements must be regarded as approximations and their use restricted accordingly. The divergence between resultant discharges for comparable drainage areas was such that differences in discharges ranging from 50 to 100 percent were obtained from separate measurements having comparable drainage areas on the same stream or adjacent areas. Because of doubt of their accuracy, the specific results were omitted from this report.

Various factors influence the accuracy of these measurements. Unfavorable conditions were encountered in the selection of satisfactory channel reaches and the determination of accurate water-surface profiles. The best reaches were selected, but almost all of them were only approximately straight, were nonuniform in area, and were joined by bends within relatively short distances. Because of the varying physical conditions within each reach, such as kind and amount of vegetation, meandering and nonuniform channels, and great amounts of debris, a wide range in opinion was possible as to the proper roughness coefficients to be used.

The flood waters rose and fell so rapidly that the flood crest did not leave a clearly defined profile. As the force of the flood flows so radically changed the character of the vegetation, it is possible that the high-water profile may have resulted from the highly obstructed channel prior to the peak flow rather than from peak flow through a fairly well cleared channel. Although there was tributary inflow into the reaches, it is assumed that the peak of such flow had passed before the occurrence of the peak in the main stream. Such tributary inflow, however, may have affected the main-stream water-surface profile, especially as determined for very small drainage areas.

Measurements of peak flow were made at 16 locations in the Triplett and Frozen Creek Basins, of which 10 were made by the Geological Survey and 6 by the engineering staff of the Cincinnati office, Corps of Engineers, United States Army. The "Summary" that follows presents general descriptive material pertaining to the flood-discharge measurements made by the Geological Survey. Following these descriptions is a table showing probable maximum rates of flow for drainage areas of different sizes in the flood area, based on the results of the flood-flow determinations. The location of all 16 measuring points is shown on plate 9 by means of open circles to differentiate them from the solid circles used to designate the location of gaging stations.

SUMMARY

MEASUREMENTS BY GEOLOGICAL SURVEY

The brief descriptions given herein provide pertinent information on the location of flood-flow measurements made by the Geological Survey and the nature of the field data. Each description includes name of stream, drainage area, location of point of measurement, method of measurement, nature of channel and adjoining terrain, floodmarks, and a statement concerning the accuracy of base data.

Triplett Creek.—Drainage area 3.5 square miles; at Hayes, Rowan County, Ky., at mouth of Buffalo Branch; contracted-opening method; discharge through Chesapeake & Ohio Railway culvert, stream approaches at right angles to culvert, Buffalo Creek enters directly at culvert, poor definition of drop through culvert and approach slopes of water surface; base data poor.

Johnson Fork.—Drainage area 5.3 square miles, tributary to Boone Fork; at Wilhurst, Breathitt County, Ky., ¼ mile upstream from mouth; slope-area method; reach of channel fairly straight but joined by bend a short distance downstream, reach contracting, wide overflow, both banks clean and smooth; few high-water marks, slope poorly defined; base data poor.

Johnson Fork.—Drainage area 5.3 square miles, tributary to Boone Fork; at Wilhurst, Breathitt County, Ky., ¼ mile upstream from mouth; slope-area method; reach of channel adjacent to that of preceding location but includes bend at each end, other channel characteristics and water-surface profile data same as preceding location; base data poor.

Christy Creek.—Drainage area 11.5 square miles, tributary to Triplett Creek; 1 mile upstream from Christy, Rowan County, Ky., ½ mile downstream from Seas Branch; slope-area method; reach of channel straight but curved a short distance beyond each end, cornfields on both banks, slight overflow on right bank and wide overflow on left bank, cross section reasonably uniform; several high-water marks, slope fairly well defined; base data fair.

Cope Fork.—Drainage area 11.8 square miles, tributary to Frozen Creek; 1 mile downstream from Keck, Breathitt County, Ky., about ½ mile upstream from mouth; slope-area method; reach of channel fairly straight but sharp bend located short distance downstream, cross section slightly expanding, wide overflow on right bank and field badly eroded, little overflow on steep left bank; high-water marks scattered, slope uncertain; base data poor.

Frozen Creek.—Drainage area 22.9 square miles; in Breathitt County, Ky., ¾ mile upstream from Blanton Bridge and mouth of Cope Fork; slope-area method; reach of channel fairly straight but joined by sharp bends a short distance from each end, bridge just upstream from reach, cross section contracting, wide overflow on right bank and cornfield partly eroded, no overflow on left bank; few high-water marks, slope poorly defined; base data poor.

Frozen Creek.—Drainage area 23.3 square miles; in Breathitt County, Ky., ½ mile upstream from Blanton Bridge and mouth of Cope Fork; slope-area method; reach of channel fairly straight but sharp bend just upstream from reach, cross section slightly expanding, wide overflow in smooth field on left bank; no overflow on steep right bank; many high-water marks, slope fairly well defined; base data fair or better.

Frozen Creek.—Drainage area 23.3 square miles; in Breathitt County, Ky., ½ mile upstream from Blanton Bridge and mouth of Cope Fork; slope-area method; reach of channel adjacent to that of previous location and channel characteristics similar; base data fair or better.

Frozen Creek.—Drainage area 55.1 square miles; at Frozen Creek, Breathitt County, Ky., ½ mile upstream from mouth; slope-area method; reach of channel straight, cross section uniform, reach 500 feet downstream from highway bridge and 1,500 feet upstream from railroad bridge, no overflow on steep left bank, slight overflow on clean right bank; many high-water marks somewhat scattered, slope fairly well defined; base data good.

Triplett Creek.—Drainage area 74.4 square miles; at Bluestone, Rowan County, Ky., 1¼ miles upstream from North Fork; slope-area method; reach of channel straight but joined by curved channel at ends, cross section expanding, wide overflow, brush, and cornfield on left bank, no overflow on right bank, railroad embankment; a few high-water marks, slope only fairly defined; base data fair or better.

MEASUREMENTS BY CORPS OF ENGINEERS

The flood flow measurements by the Corps of Engineers were made at five locations in Frozen Creek Basin and at one location in Triplett Creek Basin, as follows:

Triplett Creek.—Drainage area 3.5 square miles; at Hayes, Rowan County, at mouth of Buffalo Branch; contracted-opening method.

Boone Fork.—Drainage area 7.4 square miles; ¼ mile upstream from Johnson Fork, Breathitt County; slope-area method.

Cope Fork.—Drainage area 9.4 square miles; 2½ miles from mouth, Breathitt County; slope-area method.

Frozen Creek.—Drainage area 19.0 square miles; 3.3 miles upstream from Blanton Bridge, Breathitt County; slope-area method.

Frozen Creek.—Drainage area 23.4 square miles; ½ mile upstream from Blanton Bridge, Breathitt County; slope-area method.

Frozen Creek.—Drainage area 55.2 square miles; at mouth of Frozen Creek, Breathitt County; slope-area method.

ESTIMATES OF MAXIMUM RATE OF FLOOD FLOW

In summarizing the information on flood flows an analysis was made of the relation of peak flows to drainage areas, due consideration being given to the qualifying descriptions, and probable maximum rates of discharge for the flood were derived. On this basis, probable maximum rates of flood flow were estimated for drainage areas ranging from 5 to 75 square miles for the area of high runoff on July 4-5, 1939, and this information is presented as follows:

Drainage area (square miles)	*Probable maximum rates of flow (second-feet per square mile)*
5-10	2,000 or more
10-25	1,500 or more
25-50	1,000-1,500
50-75	1,000 or less

GAGING-STATION RECORDS

Stream-gaging stations in the main drainage basins were affected by the storm. Several of these were at the very edge of the storm area, and unfortunately none was so situated that flow at the station directly reflected the exceptional runoff. This fact is evidenced from an inspection of plate 9. The main storm area producing the unusual depth of rainfall was long, narrow, and irregular in shape and was so located with respect to the main drainage basins that the divides between basins were straddled or only segments across the narrow part of the basin were affected. Consequently, crest stages and peak discharges at these gaging stations, although of unusual magnitude, were not outstanding and nowhere exceeded the previous maximum. Gaging-station records were obtained at the following locations on main streams or principal tributary streams in Kentucky affected by the storm:

Little Sandy River near Grayson.
Licking River near Salyersville.
Licking River at Yale.
Licking River at Farmers.
Licking River at Blue Lick Springs.
North Fork Kentucky River at Jackson.
Kentucky River at Lock 14 at Heidelberg.
Kentucky River at Lock 10 near Winchester.
Red River at Clay City.

Information on crest stages and peak discharges at the various gaging stations is given in the table that follows. Reference numbers in the first column of this table correspond to the numbers designating large solid circles (as opposed to small solid circles designating the location of rainfall observations) plotted on plate 9 to indicate the location of stream-gaging stations.

Descriptions of the gaging stations and related information, including extremes of stage and discharge and records of daily discharge are given in the annual reports on the surface water supply of the United States, part 3, Ohio River Basin, published by the Geological Survey.

Flood discharges in eastern Kentucky for the flood of July 5, 1939

No.	Stream and place of determination	Drainage area (square miles)	Period of record	Maximum flood previously known				Maximum during present flood			
				Date	Gage height (feet)	Discharge		Time	Gage height (feet)	Discharge	
						Second-feet	Second-feet per square mile			Second-feet	Second-feet per square mile
	Little Sandy River Basin										
1	Little Sandy River near Grayson, Ky.	[1]398	1938-39	Feb. 4, 1939	26.25	18,400	46.2	July 6, 9 a.m.[2]	16.7	5,500	13.8
	Licking River Basin										
2	Licking River near Salyersville, Ky.	[1]140	1938-39	Feb. 3, 1939	25.4	14,300	102	July 5, 12 m. to 7 p.m.	19.2	3,710	26.5
3	Licking River at Yale, Ky.	[1]709	1938-39	Feb. 3, 1939	31.11	19,300	27.2	July 5, 8 p.m.	29.0	15,000	21.2
4	Licking River at Farmers, Ky.	[1]826	1928-31, 1938-39	Feb. 3, 1939	24.8	22,200	26.9	July 5, 8 a.m.	[3]25.4	[4]20,000	24.2
5	Licking River at Blue Lick Springs, Ky.	1,740	1938-39	Feb. 3, 1939[5]	36.37	24,800	14.3	July 9, 9 a.m.	33.3	22,000	12.6
	Kentucky River Basin										
6	North Fork Kentucky River at Jackson, Ky.	[1]1,105	1928-31, 1936-39	Feb. 4, 1939	42.10	46,800	42.3	July 5, 5 p.m.	20.3	14,800	13.4
7	Kentucky River at lock 14, at Heidelberg, Ky.	[1]2,648	1925-31, 1938-39	Feb. 4, 1939	35.6	110,000	41.5	July 5, 9 p.m. to July 6, 2 a.m.	18.4	32,400	12.2
8	Kentucky River at lock 10, near Winchester, Ky.	3,960	1909-39	Feb. 6, 1939	34.7	85,200	21.5	July 7, 1 a.m.	21.1	45,200	11.4
9	Red River at Clay City, Ky.	363	1930-32, 1938-39	July 15, 1938	22.8	21,100	58.1	July 6, 4 a.m.	22.3	19,800	54.5

[1] Supersedes figure published in Water-Supply Paper 873.
[2] Secondary crest occurred at 5 a.m. July 5 (gage height, 15.6 feet; discharge, 4,880 second-feet).
[3] Occurred at 12 m.
[4] Approximate; stage-discharge relation affected by backwater.
[5] Greater flood occurred in January 1937.

In the Little Sandy River Basin only the extreme headwater area was affected by the intense storm, and the rise at the gaging station near Grayson was not of unusual magnitude.

In the Licking River Basin the drainage area above Salyersville had unusual precipitation only in the extreme western part, and the mean rainfall over the entire area was not of unusual proportions. Between Salyersville and Yale over half the intervening drainage area produced a high runoff, and the area between Yale and Farmers, although relatively small, also gave a high runoff. In the large area between Farmers and Blue Lick Springs only Triplett Creek and a small adjacent area contributed to flood flow and most of the area was relatively noncontributing.

North Fork Kentucky River had relatively little flood runoff from the drainage area above Jackson, except from a small area in the immediate vicinity of Jackson, chiefly Quicksand Creek. Most of the drainage area between Jackson and the mouth of North Fork Kentucky River contributed high runoff, but the effect of this flood flow was not directly reflected at the gaging station on Kentucky River at lock 14 at Heidelberg because of the large noncontributing areas on Middle Fork and South Fork Kentucky River.

Likewise on Red River, which is tributary to Kentucky River, the drainage area in the headwaters produced high flood flows, but with a major portion of the area above the gaging station at Clay City producing only minor runoff, the headwater flood flows were dissipated, with the result that the flood rise at Clay City was not of unusual proportions.

The hydrographs, figures 6 and 7, show the flood rise and recession at several of the gaging stations. Graphs of stage (fig. 7) for the gaging stations at Yale, Farmers, Blue Lick Springs, Jackson, Heidelberg, and Clay City were constructed on the basis of twice-daily gage readings by the gage observer and numerous readings by engineers. The discharge graphs (fig. 6) were constructed on the basis of the stage graphs and the stage-discharge relation, except for the station at Salyersville, which was reproduced from the recording-gage record obtained at that station.

The rapid concentration of flood flows on tributary streams and thence to main streams resulted in backwater on the main streams for considerable distances. This effect was evident to a great extent at the gaging station on Licking River at Farmers, where the effect of Triplett Creek entering only a short distance downstream from the gage was felt, and to a lesser extent on Licking River at Yale, which was also apparently affected by the abrupt rise on Triplett Creek, as there are no major tributary streams entering Licking River between Yale and Farmers. As this backwater effect created some doubt as to the correct discharge hydrographs for the gaging stations at Yale and Farmers, these hydrographs have not been reproduced.

The abrupt rise on several small tributaries of North Fork Kentucky River caused backwater on that stream for considerable distances. Frozen Creek, which enters North Fork Kentucky River a few miles downstream from Jackson and which was estimated to have attained a mean velocity of 13 feet per second at the mouth, caused considerable backwater on the main stream. Quicksand Creek, which enters a short distance upstream from Jackson, caused backwater on North Fork Kentucky River as far as Haddix, 7 miles upstream.

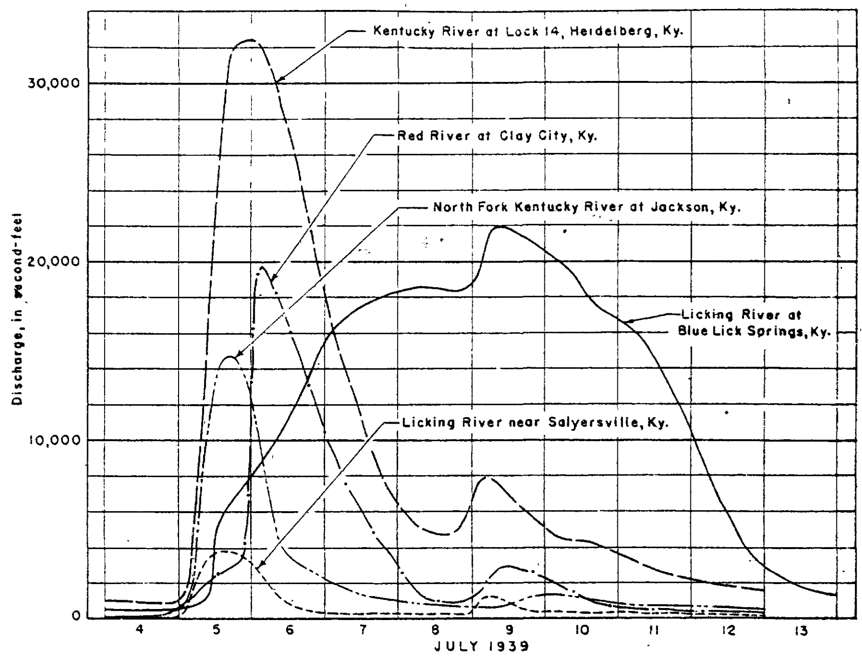


Figure 6.—Discharge hydrographs at gaging stations in Kentucky and Licking River Basins.

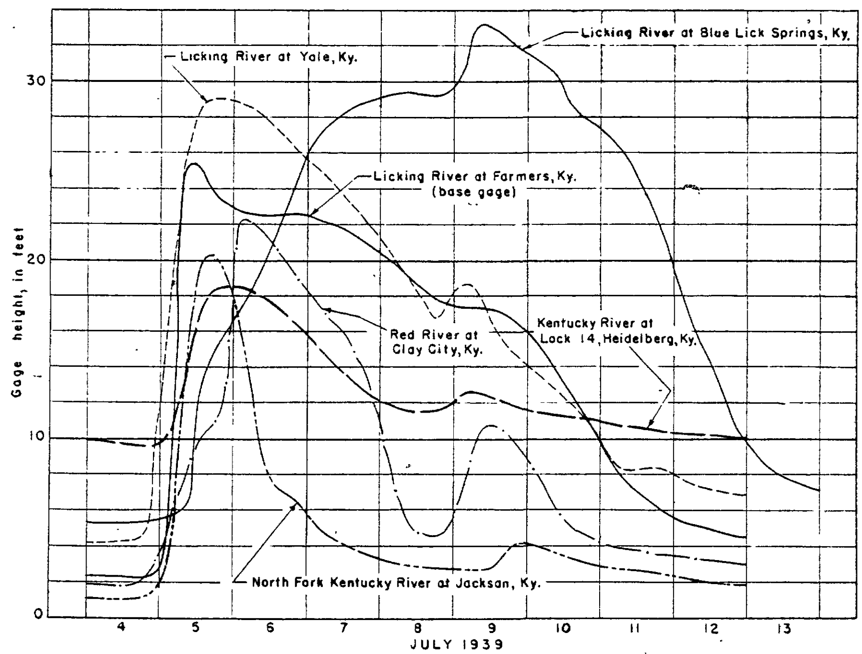


Figure 7.—Stage hydrographs at gaging stations in Kentucky and Licking River Basins.

A. HOME OVERTURNED BY FORCE OF FLOOD FLOW.
Triplett Creek at base of hill in background.

B. STORE FRONTING ON RAILROAD STREET FORCED FROM FOUNDATION AND MOVED TO FAIRBANKS AVENUE.

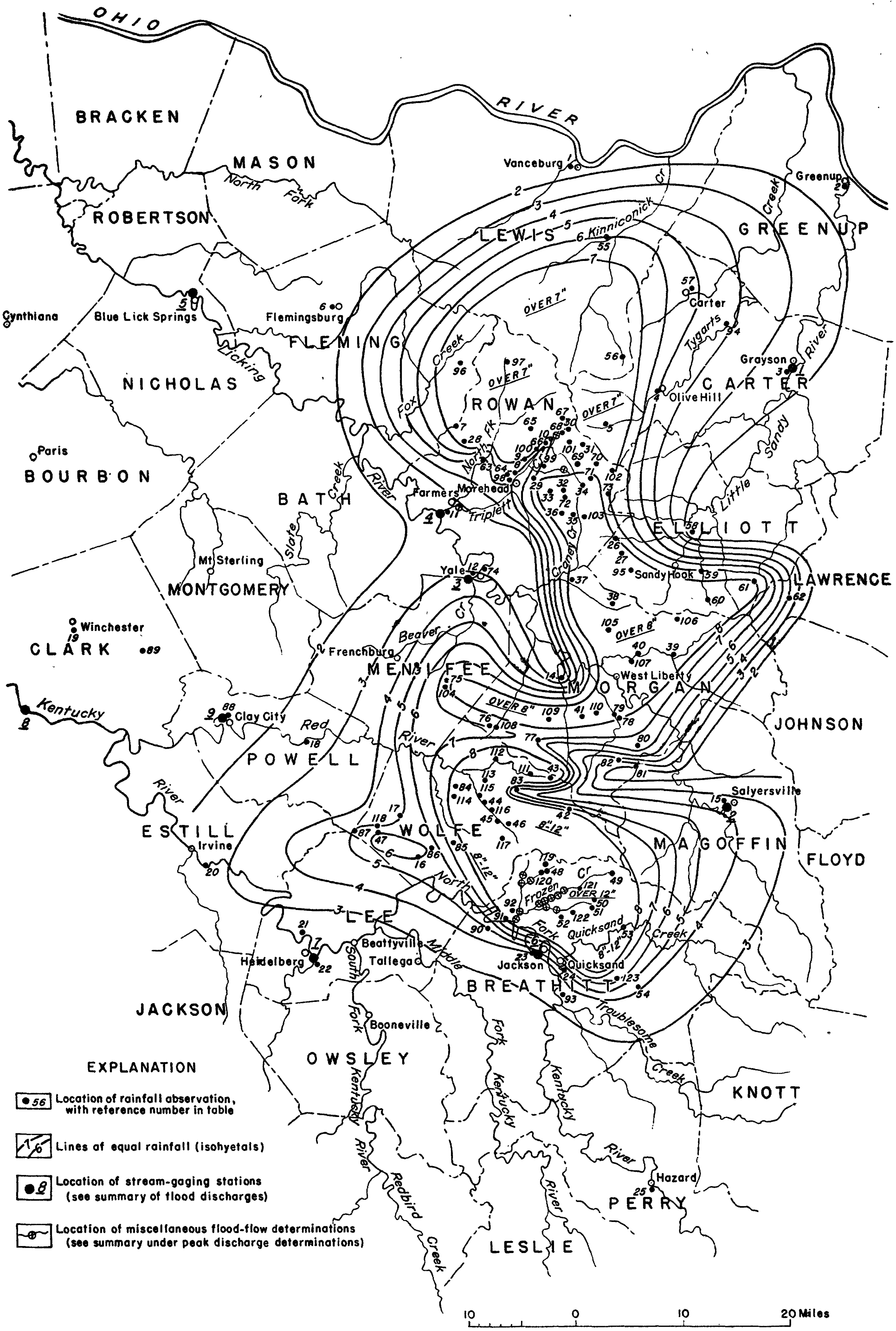
DAMAGE TO BUILDINGS IN MOREHEAD BY FLOODWATERS OF TRIPLETT CREEK.

Photographs taken between 11:30 a.m. and 12 m. on July 5, 1939.
Courtesy Corps of Engineers, U. S. Army.

A. WASH-OUT OF RAILROAD BRIDGE ON TRIPLETT CREEK NEAR MOREHEAD.
Bridge on spur line of Chesapeake & Ohio Railway was forced from foundations by floating house. Courtesy Corps of Engineers, U. S. Army.

B. VIEW OF COPE FORK IN FROZEN CREEK BASIN SHOWING REMAINS OF COCKRELL BRIDGE ON STATE HIGHWAY 15.
Steel truss bridge was carried several hundred feet downstream.
Courtesy Corps of Engineers, U. S. Army.

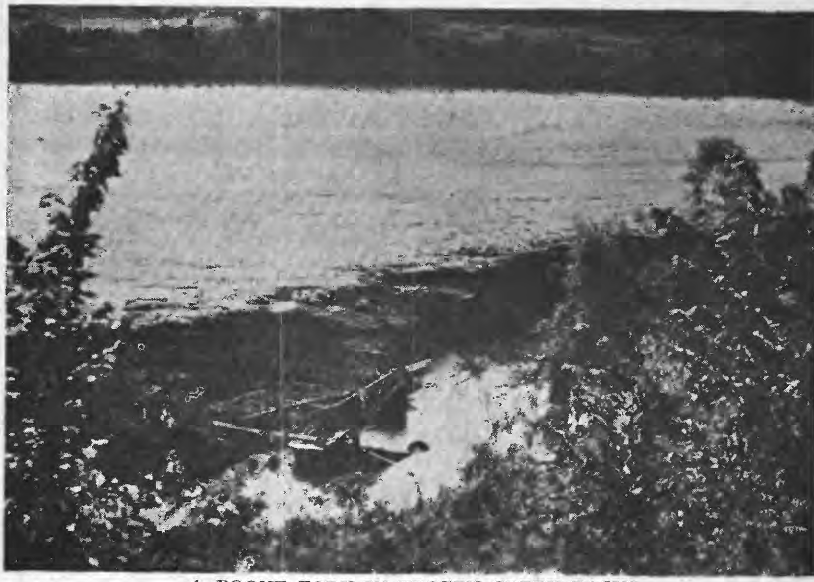
DAMAGE TO BRIDGES ON TRIPLETT CREEK AND COPE FORK.



MAP OF EASTERN KENTUCKY SHOWING LOCATION OF OBSERVATIONS OF RAINFALL AND ISOHYETALS FOR TOTAL PRECIPITATION JULY 4-5, 1939, AND LOCATION OF STREAM-GAGING STATIONS AND MISCELLANEOUS MEASUREMENTS OF FLOOD FLOW

A. RECEDING FLOODWATERS OF TRIPLETT CREEK.
View downstream showing North Fork entering at right. Photograph taken between 11:30 a.m. and 12 m. on July 5, 1939. Courtesy Corps of Engineers, U. S. Army.

B. FROZEN CREEK AT THE MOUTH.
View upstream from railroad bridge near North Fork Kentucky River showing sand deposits and stripped vegetation along banks. Photograph taken July 20, 1939.
Courtesy Corps of Engineers, U. S. Army.



A. BOONE FORK IN FROZEN CREEK BASIN.
View from State Highway 15 about 0.1 mile upstream from mouth showing thick deposit of mud on cornfield and automobile lying overturned in stream. Photograph taken July 9, 1939.
Courtesy Corps of Engineers, U. S. Army.

B. EROSION ON HILLSIDE IN WOLFE COUNTY.
View from State Highway 15 about 2 miles from Breathitt County Line. Photograph taken July 19, 1939. Courtesy Corps of Engineers, U. S. Army.

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