DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

HYDROLOGIC INVESTIGATIONS
ATLAS HA-393

FLOODS ON ROCK RIVER IN NORTHERN ROCK COUNTY, WISCONSIN

Many flood plains in the Nation are being used uneconomically, and potential flood losses are increasing despite costly structures built to control floods. To enhance economical utilization of the flood plains in Wisconsin, the Wisconsin legislature incorporated flood-plain zoning legislation in the Wisconsin Water Resources Act (Section 31, Chapter 614, Laws of Wisconsin, 1965). This legislation gave the counties, cities, and villages the responsibility of enacting, administering, and enforcing reasonable and effective flood-plain regulations.

The Water Resources Act also delegated to the Wisconsin Department of Natural Resources the responsibility of guiding and coordinating the efforts of the local units of government. One phase of this responsibility was establishing and upgrading minimum statewide standards for flood-plain regulations. Minimum standards adopted in the Wisconsin Administrative Code, Chapter RD16, require that flood-plain regulations be based on sound technical evaluation of potential flooding (Wis. Dept. of Resource Development, 1968). To accomplish this goal for the entire State, the Department of Natural Resources (formerly Department of Resource Development) is coordinating the utilization of technical resources available from the U.S. Geological Survey and from several other Federal, State, and private agencies.

Past flood damages in the Rock River valley have been less severe than those along many other Wisconsin streams. This can be attributed to the irregular distribution of flood events and to the type of flood-plain development. However, much more severe floods may occur on the Rock River. Also, if additional uses of the flood plain are incompatible with nature's requirements for flood plains, flood hazards will increase considerably.

Purpose and scope.—The purposes of this report are to estimate the water-surface elevations and to define the areal limits of flood inundation for the regional flood (defined in Flood-frequency section); and to briefly discuss the depths, duration, and velocities of floodwaters. The areal limits of flooding on the flood map and the water-surface elevations on the flood profile are intended to aid local units of government in formulating flood-plain regulations compatible with Department of Natural Resources standards.

The report discusses a 12-mile reach of the Rock River from a point 2.3 miles upstream from U.S. Highway 14 to the outlet of Lake Koshkonong. It completes the study of potential Rock River flooding in Rock County. The U.S. Army Corps of Engineers (1968a and b) evaluated the flooding problems south of this study reach. All analyses necessary to define potential flood conditions for the 12-mile study reach were made in accordance with minimum statewide standards and using accepted U.S. Geological Survey techniques.

Cooperation and acknowledgment.—This report was prepared as part of a cooperative agreement between the U.S. Geological Survey and the Wisconsin Department of Natural Resources. It was prepared by the U.S. Geological Survey, Water Resources Division, under the administrative direction of C. L. R. Holt, Jr., district chief.

Some of the information contained in this report came from the following sources: the Rock Island District of the U.S. Army Corps of Engineers, the Wisconsin Department of Transportation, the Wisconsin Power and Light Company, the Rock County Planning and Zoning Commission, and local residents. Their helpfulness is appreciated.

Basin characteristics.—The Rock River originates near Fond du Lac in east-central Wisconsin and flows southward through Wisconsin and Illinois until it empties into the Mississippi River. The Rock River north of the Wisconsin-Illinois State line is more than 160 miles long and drains 3,410 square miles. Figure 1 shows the location of the Rock River basin within Wisconsin.

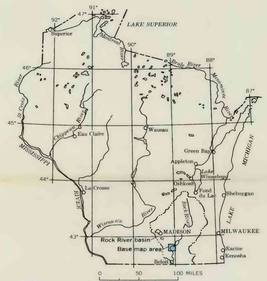

FIGURE 1.—*Location of Rock River basin and base-map area in Wisconsin.*

Characteristics of the basin include gently rolling topography, several marshy areas bordering the drainage network, and many natural lakes. A description of the Rock River basin is in a report now in preparation by the U.S. Geological Survey (Cotter and others, 1969).

The reach of the Rock River studied for this report is shown in figure 2. The drainage area for this reach increases from 2,500 square miles at the outlet of Lake Koshkonong to 3,170 square miles above the confluence of Marsh Creek, which enters the Rock River about 0.5 mile south of U.S. Highway 14. Because it is the only significant tributary near the southern end of the study reach, Marsh Creek was chosen as a convenient point for drainage-area determination.

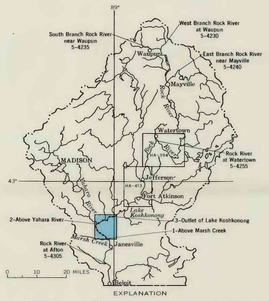

FIGURE 2.—*Rock River basin in Wisconsin. Flood maps in this study area indicated by* HA *number.* HA-393 *shaded.*

Many basin characteristics affect flood discharges. Among the more important basin characteristics are the size of the drainage area, the slope of the main channel, and the amount of storage available in lakes and reservoirs. These characteristics are summarized in the following table for the areas above the five selected gaging stations within the Rock River basin.

Rock River basin characteristics.

Basin characteristics above station	Gaging-station, number and location (fig. 2)				
	5-4305 Afton	5-4255 Watertown	5-4240 Mayville	5-4235 Waupun	5-4230 Waupun
Drainage area (square miles)	3,300	971	179	62.8	41.4
Main-channel slope (ft per mile)*	1.28	1.38	3.21	8.33	9.58
Lake and reservoir surface area (percent)*	2.71	1.94	0.06	0.00	0.00

*From Ericson (1961).

In general, steeper slopes create relatively high-flood peaks, and increased storage reduces flood peaks. Also, an increase in drainage area usually increases flood discharges, although there may be a decrease in the discharge per square mile of drainage area.

In addition to the above factors, areas of permeable sand and gravel, undrained depressions in the glaciated surface (kettles and marshes), and a generally immature drainage system tend to reduce local flood runoff.

Flood history.—The maximum flood for the period of record at each of five stream-gaging stations in the Rock River basin (see fig. 2) is tabulated below. Of these gaging stations, those at Afton and Watertown (fig. 2) are most closely related to the study reach by location and basin characteristics. Figures 3 and 4 show the highest discharge for each year of record that floodflows exceeded a base discharge of 2,500 and 8,000 cfs (cubic feet per second) at Watertown and Afton, respectively. During their common period of record (1931–66), these stations have a very similar pattern of flood events. Therefore, the records at Afton and Watertown were used to estimate flood discharges within the study reach where there are no streamflow data. Also shown on each figure is the regional-flood discharge for that station.

Maximum recorded floods.

	Gaging-station, number and location (fig. 2)				
	5-4305 Afton	5-4255 Watertown	5-4240 Mayville	5-4235 Waupun	5-4230 Waupun
Period of record	1914–66	1931–66	1949–66	1945–66	1949–66
Date of maximum flood	3–23,24–29	4–4–59	4–3–59	4–3–59	3–27–50
Maximum flood discharge (cubic feet per second)	13,000	5,030	3,400	1,500	949

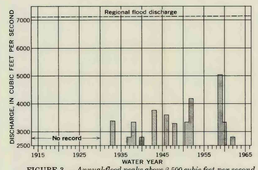

FIGURE 3.—*Annual-flood peaks above 2,500 cubic feet per second at Watertown, Wis., station number 5-4255, 1931–66.*

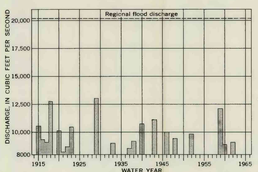

FIGURE 4.—*Annual-flood peaks above 8,000 cubic feet per second at Afton, Wis., station number 5-4305, 1914–66.*

Flood frequency.—Flood frequencies are stated in terms of their recurrence intervals or in terms of their probabilities of occurrence. The probability of occurrence is virtually the reciprocal of the recurrence interval for floods greater than the 10-year flood. For example, a flood with a recurrence interval of 25 years (25-year flood) will be equaled or exceeded on the average of once in 25 years. Such a flood has a 4-percent probability of occurring in any given year.

Flood-plain regulations in Wisconsin are to be based on flooding caused by the regional-flood discharge. The regional flood is defined as "...a flood determined by the Division of Resource Development[1] which is representative of large floods known to have occurred generally in Wisconsin and reasonably characteristic of what can be expected to occur on a particular stream." (Wis. Dept. of Resource Development, 1968, p. 94). The regional-flood discharge has an average frequency of occurrence of once in 100 years.

Reliable estimates of flood frequency can be made by statistical analysis of data covering a sufficient period of time. Flood-frequency analyses for this study were made in accordance with the uniform method recommended by the U.S. Water Resources Council (1967), with minor refinements suggested by Beard (1962). This method of analysis conforms with Department of Natural Resources standards.

[1]Now the Division of Environmental Protection.

Relations between the discharge and recurrence interval at Afton and Watertown are shown in figure 5. Flood discharges for the 100-year recurrence interval (fig. 5) represent the regional-flood discharges at the Afton and Watertown gages.

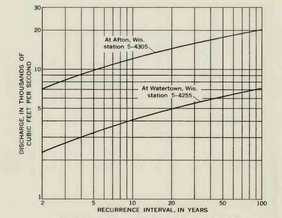

FIGURE 5.—*Frequency of flood discharges on Rock River.*

Flood-peak occurrences are irregularly distributed as indicated by the 53-year record at Afton (fig. 4). The 5-year flood at Afton has a peak discharge of 9,700 cfs as determined by the frequency analysis. In a 9-year period, 1915–23, this flow was equaled or exceeded four times. In a 10-year period, 1930–39, the annual flood peaks did not reach this magnitude. However, for the 53-year period of record, 1914–66, the 5-year flood has been equaled or exceeded 10 times. This is close to the expected long-term average of once in 5 years.

Regional-flood determination.—Estimates of regional-flood discharges within the study reach must reflect the effects of storage and of tributary inflows between the Watertown and Afton gaging stations. Examination of past flood behavior on the Rock River and its tributaries indicates that the most reliable estimate of regional-flood discharges which reflects storage and tributary inflow can be made on the basis of drainage-area ratios. Except for the southern part of the study reach, regional-flood discharges are estimated by reducing the 100-year flood discharge at Afton (fig. 5) in direct proportion to the decrease in drainage area at key intermediate sites along the study reach. The regional-flood discharge used for the southern end of the study reach is the discharge used by the U.S. Army Corps of Engineers (1968b). A table of regional-flood discharges is presented below.

Regional-flood discharges on Rock River.

Gaging station and key intermediate site (fig. 2), number and name	Drainage area (sq mi)	River miles upstream from Mississippi River	Regional-flood discharge (cubic feet per second)
5-4305: Afton gage	3,300	173.0	20,200
1: Above Marsh Creek	3,170	183.8	19,800
2: Above Yahara River	2,580	190.5	15,800
3: Outlet of Lake Koshkonong	2,500	196.7	15,300
5-4255: Watertown gage	971	237.7	7,130

Regional-flood profile and flood map.—The regional-flood profile and the flooded area that would exist at the time of the regional-flood discharge are the basic technical information upon which flood-plain regulations are to be based. The flood profile is determined by hydraulic-engineering analyses, and it is the basis for constructing the flood map.

To determine the regional-flood profile, over 30 flood-plain cross sections and supplemental data were obtained by field surveys. Figure 6 (at right) shows five typical flood-plain cross sections to illustrate the variation in cross-section geometry in the study reach. Field data were supplemented by information from topographic maps, bridge plans, and plans of Indianford Dam. Roughness coefficients were also obtained by field surveys. These data were used to determine the regional-flood profile by standard step-backwater computations. The water-surface elevation for the regional-flood discharge at the southern limit of the study reach was obtained from the U.S. Army Corps of Engineers (1968b). The computed flood profile is shown at right in figure 7.

A low-water profile for December 1967 is also shown in figure 7. Total drop in the low-water profile in the study reach is about 7 feet, and 6 feet of this drop occurs at Indianford Dam. Regional-flood elevations range from 11 to 14 feet higher than low-water elevations downstream from Indianford, and range from 8 to 10 feet higher than low-water elevations upstream from Indianford.

Computed regional-flood elevations exceed the 1959 flood elevations by 3.8 to 5.8 feet within the study reach. The 1959 flood is the highest discharge of record at Watertown and the third highest discharge of record at Afton. Computed regional-flood elevations and the 1959 high-water marks for 6 points within the study reach are listed in the following table.

Flood elevations in study reach.

River miles upstream from Mississippi River	Computed regional-flood elevation (feet above mean sea level)	1959 flood elevation (feet above mean sea level)	1959 high-water mark obtained from:
188.2	782.1	778.3	Local resident
192.4	783.7	779.1	Wisconsin Power and Light Company
192.4	784.0	780.0	Wisconsin Power and Light Company
194.1	784.9	779.1	Local resident
196.0	785.8	782.0	Local resident
197.4	786.4	781.5	Wisconsin Department of Transportation

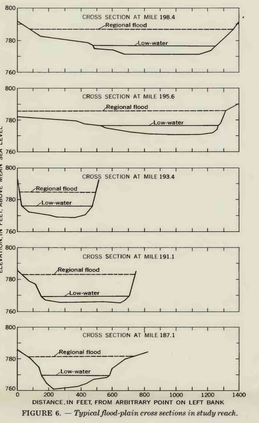

FIGURE 6.—*Typical flood-plain cross sections in study reach.*

The recorded high-water marks of 1959, although few and of limited reliability, plot on the same general slope as the computed profile (fig. 7) and lend confidence to the computations. Also, the computed profile appears to be a logical extension of the profile obtained by the U.S. Army Corps of Engineers (1968b).

The regional flood would submerge the lower bridge members at three of the five bridge crossings within the study reach, but it would not submerge the approach grades (fig. 7). At Indianford Dam the flood-gate structure would be overflowed by the regional-flood discharge.

The flood map shows the area that would be inundated by the regional flood. It was prepared by transferring the water-surface elevations from the computed profile (fig. 7) to the topographic map. The base map is an enlargement of U.S. Geological Survey 7½-minute topographic maps. A more workable map scale was provided by the enlargement, but it should not be interpreted as any more accurate than the standard 1:24,000 scale. Flood boundaries on the topographic map between surveyed cross sections were located by interpolating between the contour lines. If more accuracy is required at a specific site, the flood boundary should be determined by leveling from a point of known elevation. River miles on figure 7 correspond to river miles on the flood map.

Depth of flooding.—Depth of flooding at any site can be estimated by subtracting the ground elevation from the flood-profile elevation (fig. 7) at the same river mileage. To aid the reader in this estimation, regional-flood elevations of half a foot intervals are indicated on the flood map. Approximate ground elevations can be determined by interpolating between the contour lines on the topographic map. More accurate depths of flooding can be obtained if ground elevations are determined by leveling from a point of known elevation to the site of interest.

Duration of flooding.—Duration of flooding in the study reach will vary greatly, depending on the cause of the flood. Floods caused by rainfall will recede relatively fast, whereas floods caused by snowmelt, or rainfall and snowmelt, may have a longer duration. For example, the flood of August 26, 1940, is the maximum recorded rainfall flood at the Afton gaging station. This flood remained above bankfull stage for only 18 hours. On the other hand, the 1959 flood was caused by a combination of rainfall and snowmelt, and remained above bankfull stage at Afton for 31 days.

About 80 percent of the annual floods exceeding bankfull stage at Afton since 1914 occurred in the months of January through May. A flood magnitude such as the regional flood would probably occur in these months and have a duration in excess of 30 days. Ice jams or bridges plugged with debris can considerably lengthen flood duration.

Floodwater velocities.—The regional-flood discharge would create average floodwater velocities of about 2 to 3 fps (feet per second) throughout most of the study reach. Notable exceptions are a maximum average velocity in excess of 5 fps at Indianford Dam and a minimum average velocity of about 1 fps near the outlet of Lake Koshkonong. Also, average velocities of about 1.5 fps would occur in the vicinity of river mile 196 and between the mouth of the Yahara River and Indianford.

Future conditions.—The results of this study are based on conditions existing in 1968. Some factors that might cause deviations from the estimated potential flooding are:

1. Changes in land-use patterns. Such changes could alter runoff patterns and flood-frequency relations.
2. Changes in channel conditions. Such changes could result in a different water-surface profile for any given discharge.
3. Additional flood records may improve flood-frequency estimates.

It is possible that the regional-flood discharge could be exceeded. Also, ice jams or bridges plugged with debris can cause abnormally high stages for a given discharge. These stages may far exceed stages caused by a much greater but unobstructed discharge. Therefore, the flood profile and flood map in this report should not be regarded as a representation of the most severe flooding that might occur in the study reach.

Additional information.—Detailed information on the data in this report and information pertinent to floods throughout Wisconsin can be obtained from the U.S. Geological Survey, Water Resources Division, 1815 University Avenue, Madison, Wis.

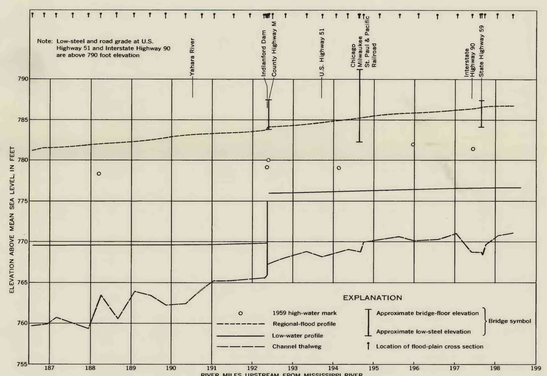

FIGURE 7.—*Rock River profiles in northern Rock County, Wisconsin.*

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Base from U.S. Geological Survey, 1:24,000; Milton, Edgerton, Cookesville, Janesville East and Janesville West, 1961; Footville 1962

SCALE 1:16 000
½ 0 ½ MILE
½ 0 ½ KILOMETER
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

APPROXIMATE MEAN DECLINATION, 1970

EXPLANATION
Area that would be inundated by the regional flood
Boundary of inundated area
Location of typical flood-plain cross section
River mile upstream from Mississippi River measured along the stream channel
Water-surface elevations for the regional flood, in feet above mean sea level

FLOODS ON ROCK RIVER IN NORTHERN ROCK COUNTY, WISCONSIN

By
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1970

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1970—W70224

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