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

FLOODS ON ROCK RIVER IN NORTHEASTERN JEFFERSON 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 RD 16, 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 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 plains are incompatible with nature's requirements for flood plains, flood hazards will increase considerably.

Purpose and scope.—The purposes of this report are to present computed 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. This information is also useful in the planning and design of any facility located in the flood plain.

The report discusses a reach of the Rock River from the confluence of Johnson Creek to the Jefferson–Dodge County line, a distance of about 40 river miles. It completes the study of potential Rock River flooding in Jefferson County, the southwestern part having been evaluated previously by the U.S. Geological Survey (Shearman and Holmstrom, 1970). All analyses necessary to define potential flood conditions for the 40-mile study reach were made in accordance with minimum statewide standards and in accordance with accepted U.S. Geological Survey techniques.

Cooperation and acknowledgment.—This report is 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 Wisconsin Division of Highways, the Wisconsin Power and Light Company, Jefferson County, the City of Watertown, 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. The Rock River basin is described in detail in a report 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 the reach increases from about 675 square miles at the Jefferson–Dodge County line to 1,010 square miles above Johnson Creek, which enters the Rock River just north of County Highway B (See flood map).

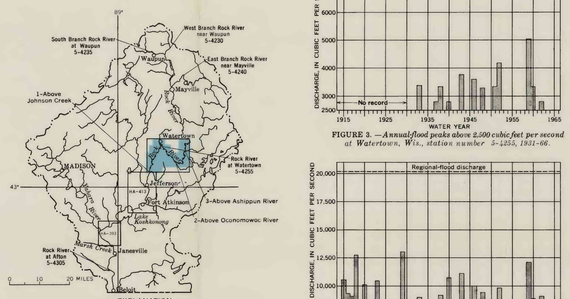

FIGURE 2.—*Rock River basin in Wisconsin. Flood maps in this study area indicated by HA number. HA-394 shaded.*

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

Rock River basin characteristics

Basin characteristics above station	Gaging station, number and location (fig. 2)				
	5-4205 Afton	5-4225 Watertown	5-4240 Mayville	5-4255 Waupun	5-4290 Waupun
Drainage area (square miles)	3,300	971	179	62.8	41.4
Main-channel slope (ft per mile)*	1.26	1.38	3.21	8.33	9.38
Lake and reservoir surface area (percent of drainage area)*	2.71	1.94	0.06	0.00	0.00

*From Erickson (1961).

In general, steeper slopes create higher 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, kettles and marshes in the glaciated surface, and a generally immature drainage system 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. The station at Watertown, located within the study reach, and the station at Afton, downstream from the study area, have similar basin characteristics. During their common period of record (1931–66), these stations have a very similar pattern of flood events. Therefore, the Afton station has been included to extend the flood-history discussion to the longest record in the basin. Figures 3 and 4 show the highest discharge for each year of record that flood flows exceeded a base discharge of 2,500 and 8,000 cfs (cubic feet per second) at Watertown and Afton, respectively. Also shown on each figure is the regional-flood discharge for that station.

Maximum recorded floods

Flood data	Gaging station, number and location (fig. 2)				
	5-4205 Afton	5-4225 Watertown	5-4240 Mayville	5-4255 Waupun	5-4290 Waupun
Period of record	1931–66	1931–66	1949–66	1946–66	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

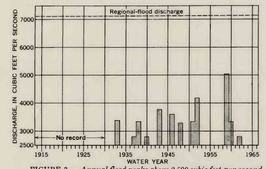

FIGURE 3.—*Annual-flood peaks above 2,500 cubic feet per second at Watertown, Wis., station number 5-4225, 1931–66.*

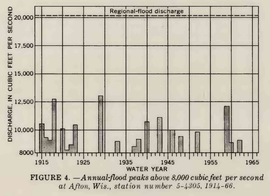

FIGURE 4.—*Annual-flood peaks above 8,000 cubic feet per second at Afton, Wis., station number 5-4205, 1931–66.*

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). This 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 recommendations of the U.S. Water Resources Council (1967), and Beard (1962). This method of analysis conforms with Department of Natural Resources standards.

Relations between the discharge and recurrence interval at Afton and Watertown are shown in figure 5. The record at Afton is included because of its length, but was not used for determining flood discharges in the study reach. Flood discharges for the 100-year recurrence interval (fig. 5) represent the regional-flood discharges at the Afton and Watertown gages.

[1]Now the Division of Environmental Protection.

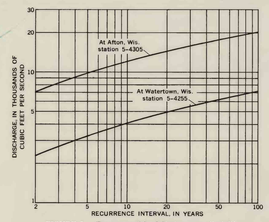

FIGURE 5.—*Frequency of flood discharges on Rock River.*

Floods 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 discharge.—Estimates of regional-flood discharges within the study reach must reflect the effects of storage and of tributary inflows. Examination of past floods on the Rock River and its tributaries indicates the following relationships between regional-flood discharges and drainage-area ratios between gaging stations. At key intermediate sites along the study reach downstream from Watertown, regional-flood discharges can be estimated by increasing the 100-year flood discharge at Watertown (fig. 5) in direct proportion to the drainage-area ratio. Upstream from Watertown, regional-flood discharges along the study reach can be estimated by reducing the Watertown discharge in direct proportion to the one-fourth power of the drainage-area ratio. A table of regional-flood discharges at specific sites 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)
5-4205: Afton gage	3,300	172.0	20,200
1: Above Johnson Creek	1,010	222.8	7,400
5-4225: Watertown gage	971	227.7	7,100
2: Above Ocononowoc River	794	248.4	6,800
3: Above Ashippun River	677	261.0	6,500

Regional-flood profile and flood map.—The regional-flood profile and the area that would be flooded 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 was determined by hydraulic-engineering analyses and was the basis for constructing the flood map.

The regional-flood profile was determined from 130 flood-plain cross sections and supplemental data which were obtained by field surveys. Figure 6 shows seven typical flood-plain cross sections that illustrate the differences in cross-section geometry in the study reach. Field data were supplemented by information from topographic maps, bridge plans, and plans of the two dams in Watertown. Roughness coefficients were estimated by field inspection. These data were used to determine the regional-flood profile by standard step-backwater computations.

The regional-flood profile for the study reach was determined in three parts: (1) from the southern limit of the study reach to the Lower Watertown Dam; (2) from the Lower Watertown Dam to the Upper Watertown Dam; and (3) from the Upper Watertown Dam to the county line. The regional-flood elevation at the confluence of Johnson Creek was determined in a previous study (Shearman and Holmstrom, 1970). Computation of the regional-flood profile from the southern limit of the study reach to the Lower Watertown Dam was based on this elevation. Step-backwater computations were not considered applicable between the two dams. The regional-flood elevation just upstream from the Lower Watertown Dam was determined by indirect methods (Hulsing, 1967). Between the dams, the regional-flood profile would be virtually parallel to the low-water profile. Indirect methods also were used to determine the regional-flood elevation just upstream from the Upper Watertown Dam. This elevation was the basis for computation of the regional-flood profile for the remainder of the study reach. The regional-flood profile for the entire study reach is shown in figure 7.

Regional-flood elevations exceed low-water elevations by: (1) 5 to 10 feet downstream from the Lower Watertown Dam; (2) 3.5 feet between the two dams; and (3) 4 to 11 feet upstream from the Upper Watertown Dam. A low-water profile obtained during the summer of 1968 is shown in figure 7.

The regional flood would affect numerous manmade structures within the study reach. Lower bridge members at five of the twenty bridge crossings would be submerged (fig. 7). Also, the north approach grade at Ocononowoc Street would be inundated and about 400 cfs of water would flow over the east approach grade at U.S. Highway 16 east of Ixonia. At Rock River Road, east of Ixonia, approximately 2,200 cfs would flow over the approach grades and the bridge deck. A small percentage of the discharge would flow around the north end of the Upper Watertown Dam.

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 regional-flood profile (fig. 7) to the topographic map. River miles on figure 7 correspond to the river miles on the flood map. The base map is a composite of U.S. Geological Survey 7½-minute topographic maps. Flood boundaries on the topographic map between surveyed cross sections were located by interpolating between the contour lines. If greater accuracy is required at a specific site, the flood boundary should be determined by leveling from a point of known elevation.

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

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 for several points along the study reach 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 much faster than will floods caused by snowmelt, or rainfall and snowmelt. For example, the flood of June 28, 1940, is the maximum recorded rainfall flood at the Watertown gaging station. This flood remained above 797 feet msl (feet above mean sea level) for 7 days. On the other hand, the 1959 flood was caused by a combination of rainfall and snowmelt. This flood remained above 797 feet msl at Watertown for 25 days.

About 80 percent of the annual flood peaks recorded at Watertown since 1932 occurred in the months from January through May. A flood as large as the regional flood probably would occur in these months and exceed 797 feet msl for about 30 days. Ice jams or bridges plugged with debris can considerably lengthen flood duration.

Floodwater velocities.—Computed average floodwater velocities for the regional-flood discharge range between 0.3 and 7.4 fps (feet per second). Average floodwater velocities south of Watertown (miles 224 to 236) would be from 0.3 to 1.5 fps, except at the bridges where the average velocities would be near 3.0 fps. In Watertown, downstream from the Lower Watertown Dam (miles 236 to 238), average velocities would range from 2.2 to 7.4 fps. Floodwater velocities were not computed for the reach between the two dams. In the steepest part of the study reach, upstream from the Upper Watertown Dam (miles 240 to 247), average velocities would generally be between 2.0 and 5.4 fps. Average floodwater velocities for the remainder of the study reach (miles 247 to 263) would be between 0.3 and 1.5 fps, except at the bridges where velocities of 3.3 to 5.1 fps would occur.

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.

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. It is possible that the regional-flood discharge could be exceeded. Also, ice jams or bridges plugged with debris can cause abnormally high stages that may far exceed stages caused by a much greater but unobstructed discharge.

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, Madison, Wis.

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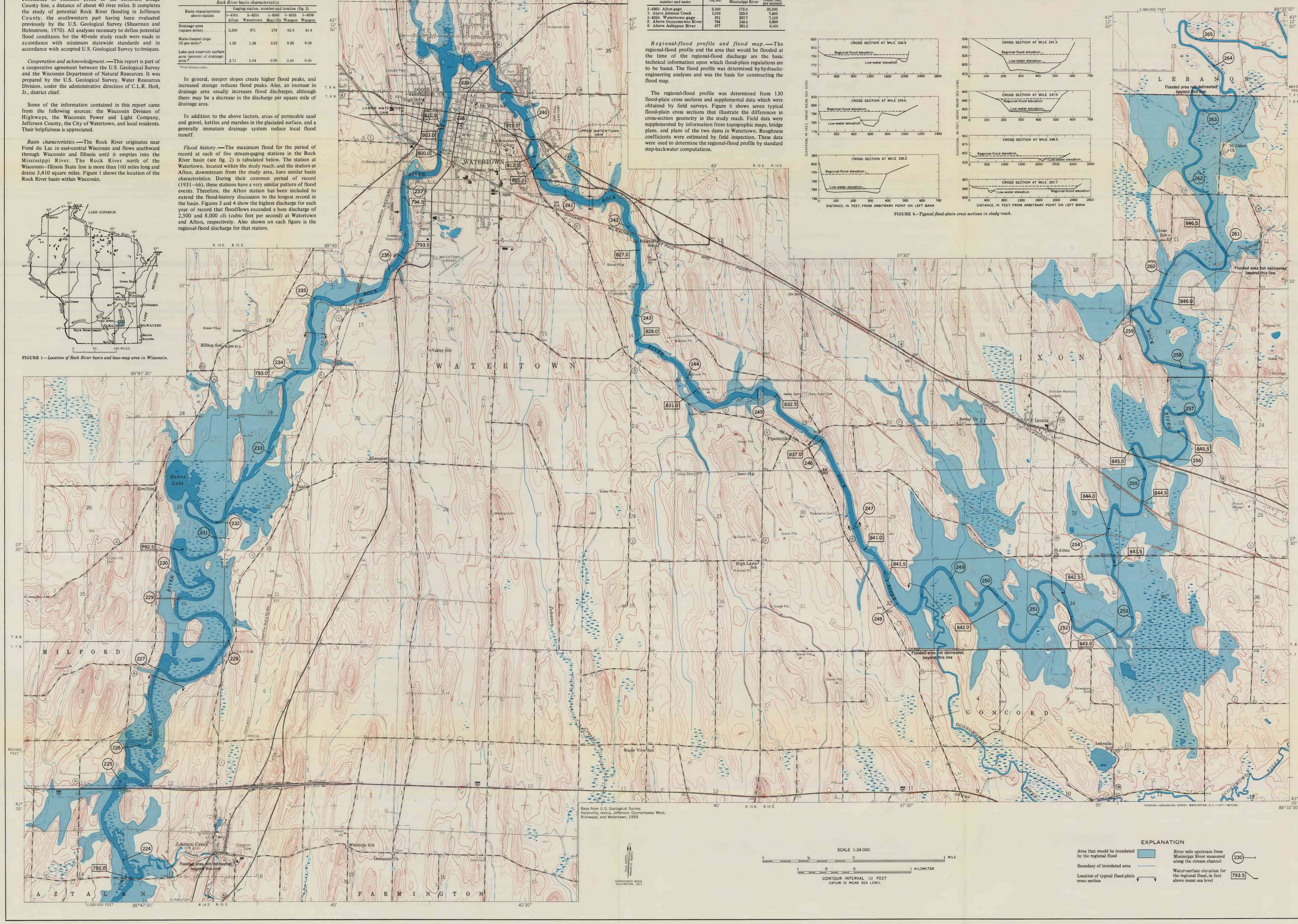

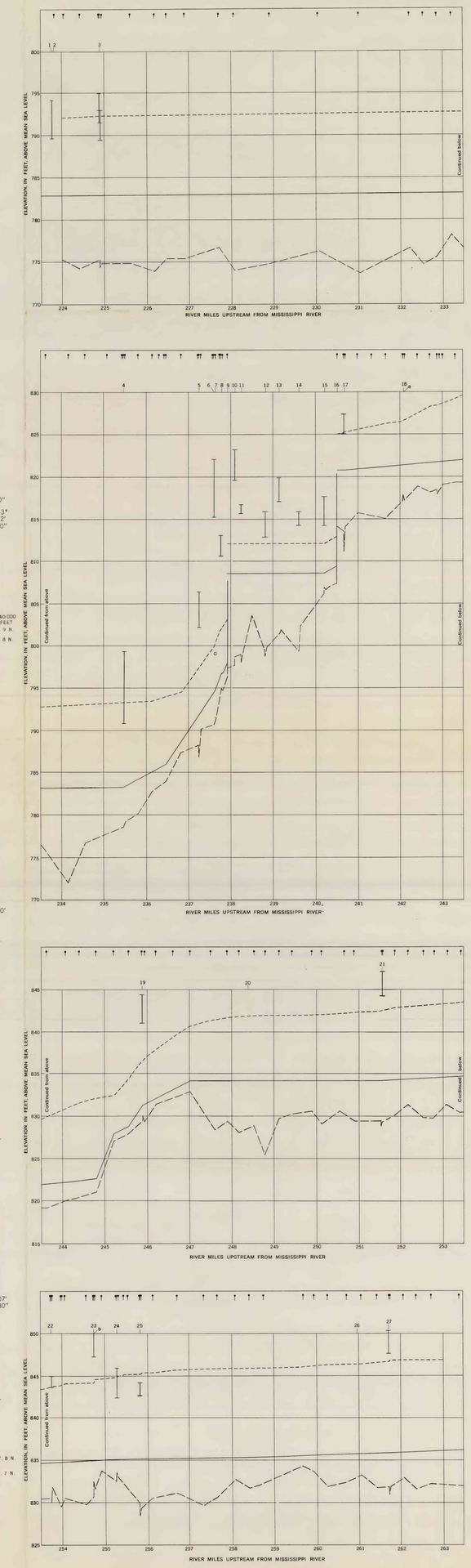

FIGURE 7.—*Rock River profiles in northeastern Jefferson County, Wisconsin.*

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By
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1971

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