FLOODS OF AUGUST 7-8, 1979, IN CHAUTAUQUA COUNTY, NEW YORK, WITH HYDRAULIC ANALYSIS OF CANADAWAY CREEK IN THE VILLAGE OF FREDONIA

By Richard Lumia and William H. Johnston

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND ABBREVIATIONS

The following factors may be used to convert inch-pound units of measurement in this report to International System of Units (SI).

Multiply inch-pound	By	To obtain SI unit
	Length	
inch (in.)	25.4	millimeter (mm)
	0.0254	meter (m)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)

DATUM

Unless stated otherwise, all elevations are referenced to National Geodetic Vertical Datum of 1929 (NGVD of 1929), which is a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

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ABSTRACT

Extensive flooding of streams in Chautauqua County, N.Y., on August 7-8, 1979 after severe thunderstorms resulted in one death and millions of dollars worth in property damage. Severe flooding was reported on Canadaway Creek in Fredonia, where the peak discharge was computed to be 12,000 cubic feet per second. The recurrence interval of this discharge is estimated to be greater than 100 years (exceedance probability less than 0.01).

A hydraulic analysis of the flood in Fredonia indicated that a debris jam at the Water Street bridge caused the water level (as determined from floodmarks) immediately upstream from the bridge to be 2.9 feet higher than the level computed for unobstructed (without debris) flow conditions. The 50-year and 100-year flood discharges at the Water Street bridge were computed to be 4,430 cubic feet per second and 5,280 cubic feet per second, respectively, and the corresponding computed water levels just upstream from the bridge (under unobstructed flow conditions) were 7.3 feet and 5.9 feet lower, respectively, than the level observed during the August 7-8, 1979 flood.

INTRODUCTION

On August 7-8, 1979, precipitation from a line of intense thunderstorms caused flash flooding along several streams in Chautauqua County and resulted in one death and millions of dollars worth in damage to highways, bridges, and private property. The thunderstorms moved southeastward from Lake Erie through Chautauqua County into Pennsylvania (fig. 1). The duration of storm precipitation was 2.5 to 3.0 hours, and recorded rainfall within the county was as much as 5.90 inches at Sinclairville (National Oceanic and Atmospheric Administration, 1979a). Recorded rainfall indicates that the greatest rainfall intensity was at the headwaters of the Canadaway, Cassadaga, and Conewango Creek basins (fig. 2). Floodflows determined by indirect methods at four sites within these basins were estimated to have a recurrence interval greater than 100 years (exceedance probability less than 0.01).

Flooding of Canadaway Creek caused significant damage in the Village of Fredonia. Hydraulic analyses of Canadaway Creek were made for the August 1979 flood and for flood discharges of selected recurrence intervals. The Water Street bridge area in Fredonia was studied in detail to evaluate the effect of a debris jam observed during the storm at the upstream face of the bridge. Results of the analyses are presented as flood profiles showing water-surface elevations along the stream in Fredonia.

Purpose and Scope

As part of a continuing program with the New York State Department of Transportation to document major floods in the State, the U.S. Geological Survey compiled hydrologic data on the August 7-8, 1979 floods in Chautauqua County. This report documents that storm and subsequent flooding and presents flood discharges of several streams as well as flood profiles of Canadaway Creek in Fredonia for floods of 2-, 10-, 50-, and 100-year recurrence intervals and for the flood of August 7-8, 1979. A hydraulic analysis of Canadaway Creek in the Village of Fredonia is included to aid in evaluating the extent of flooding and the effects of a debris jam at the Water Street bridge on flood levels upstream from the bridge.

Acknowledgments

New York State Department of Transportation provided cross-sectional data and topographic maps (1 inch = 50 ft with 1-ft contour interval) of the study reach of Canadaway Creek and data on the geometry of an old arch bridge at Water Street that was replaced in 1972.

The Buffalo District of the U.S. Army Corps of Engineers provided hydrologic data related to the storm and flood of August 7-8, 1979, including high-water marks in the Village of Fredonia, discharge computations, and rainfall data and radar maps obtained from the National Weather Service in Buffalo, N.Y.

DESCRIPTION OF AREA

Chautauqua County, a 1,069-mi^2 area in western New York, is bordered on the east by Cattaraugus and Erie Counties, on the north by Lake Erie, and on the south and west by Pennsylvania (fig. 1). Chautauqua County is characterized by moderate relief and rolling landscape. Land-surface elevation ranges from 572 ft at Lake Erie to about 2,150 ft near the southeastern corner of the county.

Most of the county is part of the Allegheny Plateau, with sharp divides between valleys. The plateau ends in an irregular escarpment at the Lake Erie Plain, a few miles southeast of Lake Erie. The Lake Erie Plain ranges in elevation from 572 ft at Lake Erie to about 850 ft at the base of the bordering escarpment.

Most of the county is drained by creeks tributary to the Allegheny River. The remainder of the county, primarily a 5- to 10-mi band along Lake Erie, is drained by streams tributary to the lake. Major streams within the county include Canadaway Creek, which drains to Lake Erie, and Conewango and Cassadaga Creeks and Chadakoin River, which drain to the Allegheny River in Pennsylvania. Chadakoin River is the outlet from Chautauqua Lake. Cattaraugus Creek, on the northeast border of Chautauqua County (fig. 1), drains into Lake Erie.

Unconsolidated glacial deposits cover nearly all the bedrock in the county. The covering is thin on hilltops and hillsides and thickest (including alluvium) in the larger valleys. Several morainal ridges and lakes as well as numerous drumlins were formed during glaciation through a combination of erosion and deposition (Muller, 1963).

The upper part of Canadaway Creek basin drains drumlin topography consisting of relatively impermeable till at elevations of 1,400 to 2,000 ft. In the lower part of the basin, the stream flows northwestward through an upland valley underlain by unconsolidated silty clay lake sediments. At about 1,100 ft elevation (about 4 mi southeast of Fredonia), the streambed drops down the escarpment onto the wider valley floor of alluvium and continues to Lake Erie. The streambed elevation of Canadaway Creek at U.S. Route 20 in the Village of Fredonia is about 695 ft.

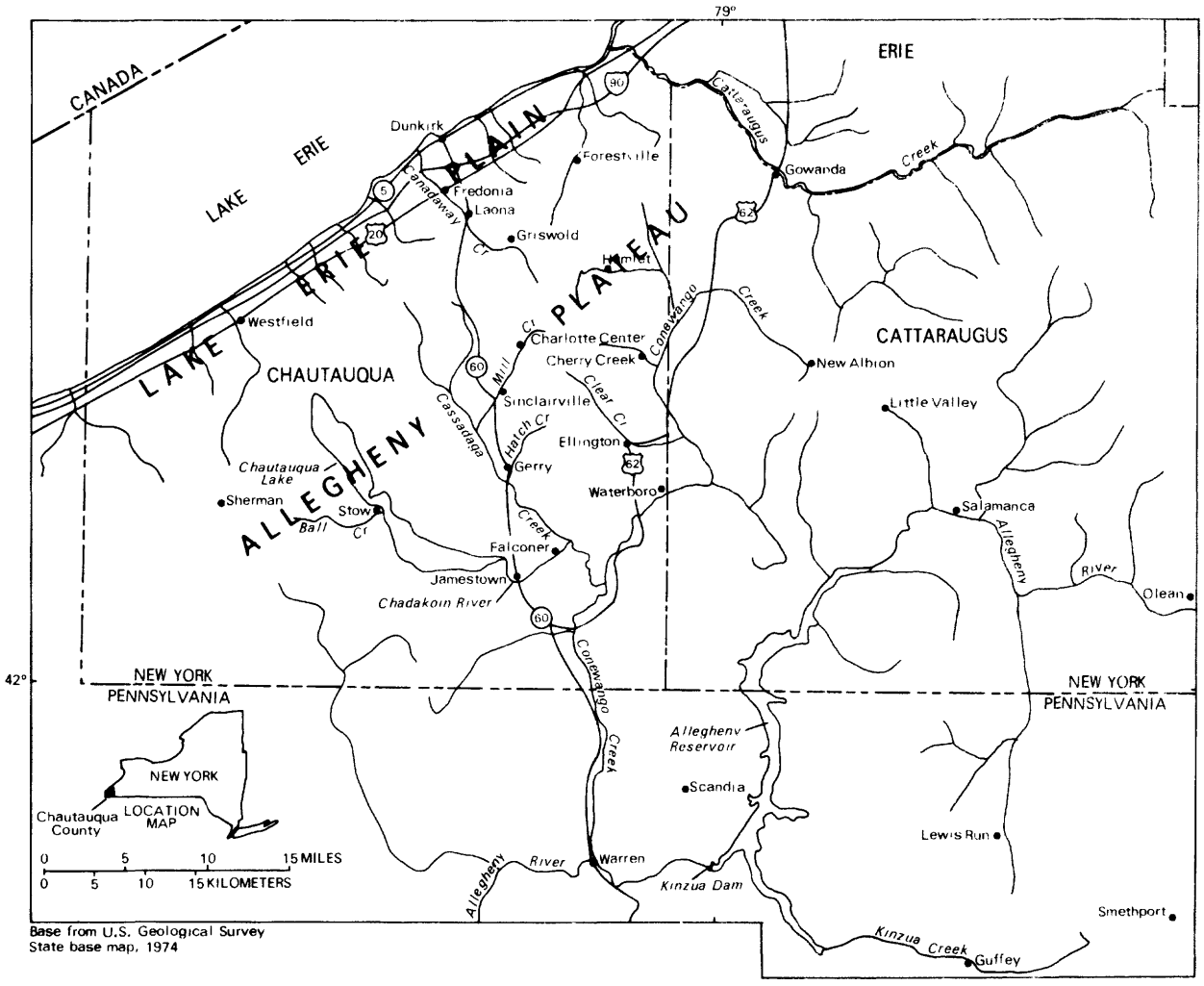


Figure 1.--Location and major geographic features of Chautauqua County.

The climate of the area is the humid continental type. Average annual precipitation ranges from 38 inches in the northern part of the county to about 42 inches in the east and southeast. Distribution is fairly uniform throughout the year. Severe thunderstorms are common during the summer. Thunderstorm severity may be increased at times by the orographic effect of the escarpment.

STORM AND FLOODS OF AUGUST 7-8, 1979

On August 7, 1979 a line of thunderstorms moved southeastward from Lake Erie through Chautauqua County into Pennsylvania. The heaviest amounts of rainfall were recorded near the divide between the Canadaway, Cassadaga, and Conewango Creeks drainage basins (fig. 2) as a result of orographic lifting in the area. Most of the rain fell within a 3-hour period (9:00 p.m. to 12:00 midnight on August 7). Thunderstorm cells repeatedly developed as the storm continued southeastward into Pennsylvania. Significant amounts of rain had fallen during the week before the storm; for example, 3.06 inches of precipitation was recorded in Fredonia during the previous week. Therefore, antecedent moisture conditions were high immediately before the storm and probably contributed to the flooding.

In parts of Chautauqua County, debris carried by streams jammed several bridges and culverts and increased the severity of the flooding. Damage in Chautauqua County was estimated to be $10 million ($5 million in the Village of Fredonia alone). A total of 42 bridges and culverts were destroyed or damaged, and 23 sections of road were washed out. One death was directly attributed to the storm (Dunkirk-Fredonia Evening Observer, 1979).

Flooding was localized. Severe flooding occurred along Canadaway Creek from Dunkirk to Laona (fig. 1), and several farm-road bridges near Laona were washed away. In Fredonia (see fig. 5), heavy damage was reported in the Water Street bridge area, and first-floor flooding occurred along Norton Place. Low sections of road were inundated near bridges on Risley Street and VanBuren Road in Fredonia. Route 5 near Dunkirk was closed for 3 hours, as was Willow Road where the railroad underpass, just downstream, was reportedly flooded by 5 to 6 feet of water.

In the Conewango Creek basin (fig. 1), Cherry Creek inundated many streets and yards in the Village of Cherry Creek and caused first-floor flooding of buildings on the low-lying east side of town. Clear Creek damaged six county bridges and washed out a temporary bridge on State Route 62 in Ellington.

In the Cassadaga Creek basin, Mill Creek caused flooding of a trailer park in Sinclairville and damaged eight town and county bridges and the State Route 60 bridge in Sinclairville. Hatch Creek damaged the bridge on County Road 50 and overflowed State Route 60 in Gerry.

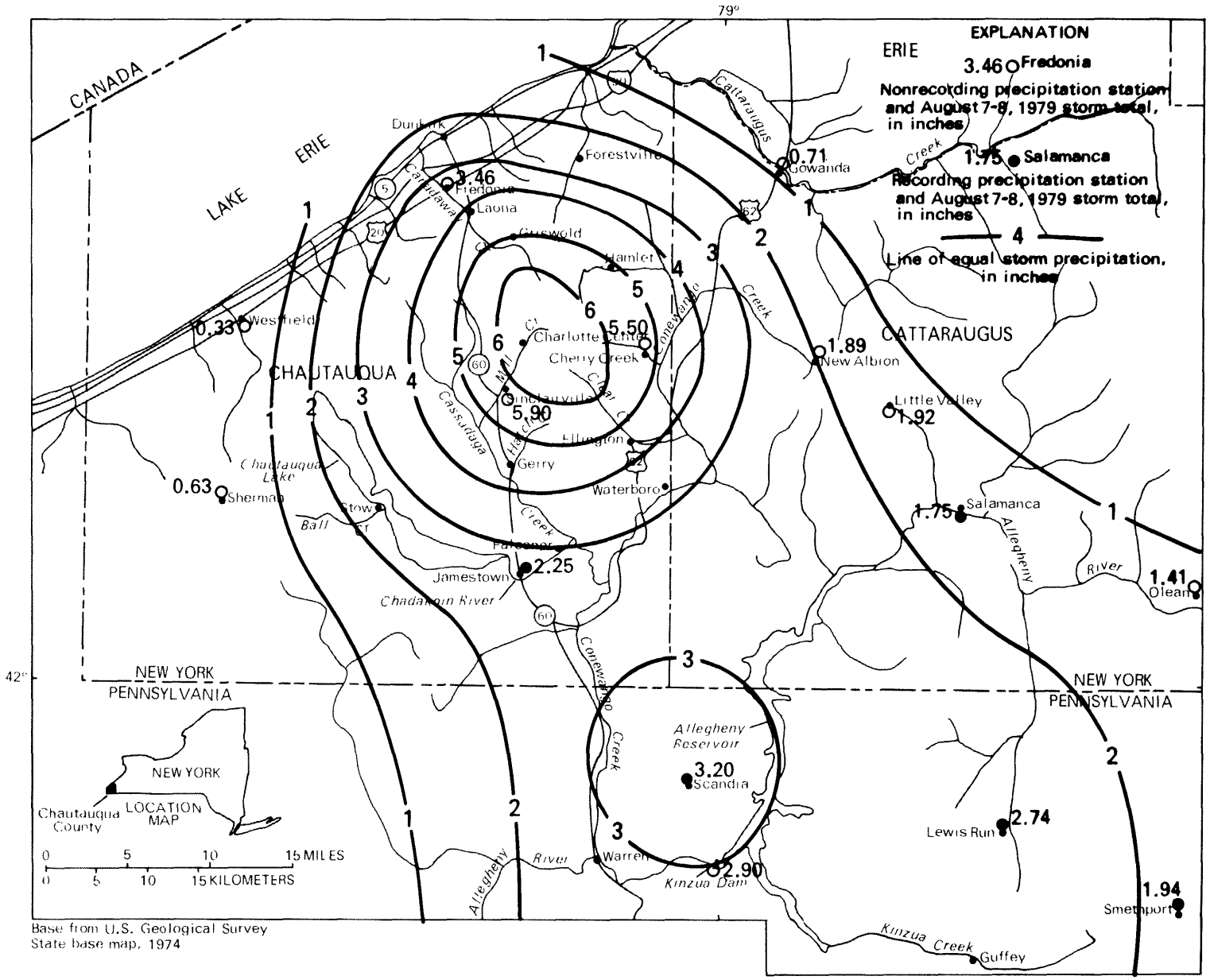


Figure 2.--Recorded precipitation during storm of August 7-8, 1979. (Data from National Oceanic and Atmospheric Administration, 1979.)

Precipitation

The National Weather Service[1] reported for the night of August 7, 1979:

> ".... a cluster of very heavy thunderstorms with strong winds and heavy rains which originally produced a tornado in Ontario, Canada moved on to ravage Chautauqua County. Sinclairville received 5.9 inches of rain in about two hours."

Figure 2 shows rainfall totals at several precipitation gages in the area and estimated lines of equal precipitation. Reports by local residents and data from precipitation records indicate that the duration of the storm was 2 to 3 hours, between 9 p.m. and midnight on August 7.

The most intense rainfall occurred near the headwaters of Canadaway Creek (fig. 2). From radar maps and recorded rainfall data provided by the National Weather Service, the U.S. Army Corps of Engineers estimated the average precipitation over the Canadaway Creek basin upstream from Fredonia to be greater than 4.0 inches (M. Mohr, written commun., June 1982). Rainfall-frequency relationships for the basin upstream of Fredonia for 2-hour and 3-hour durations (U.S. Weather Bureau, 1961) are given in table 1. In Chautaugua County, rainfall having a recurrence interval of 100 years and storm durations of 6-, 12-, and 24-hours is 3.6, 4.3, and 4.9 inches, respectively (U.S. Weather Bureau, 1961).

Table 1.--Rainfall-frequency relationships for storms of 2- and 3-hour duration, Fredonia, New York.

[Data from U.S. Weather Bureau, 1961]

Recurrence interval (years)	Depth for 2-hour duration (inches)	Depth for 3-hour duration (inches)
2	1.2	1.4
5	1.6	1.8
10	1.9	2.1
25	2.3	2.5
50	2.5	2.7
100	2.8	3.0

[1] National Oceanic and Atmospheric Administration, 1979b, p. 13.

Flood Discharges and Frequency

The U.S. Geological Survey maintains few stream-gaging stations in Chautauqua County and surrounding areas (fig. 3). Two are recording gages--Conewango Creek at Waterboro (03013000) and Chadakoin River at Falconer (03014500), and three are crest-stage gages--West Branch Conewango Creek tributary near Hamlet (03012837), Ball Creek at Stow (03013800), and Walnut Creek tributary near Forestville (04213399) in Chautaugua County. No significant peak stage was recorded at the Walnut Creek tributary site during the August 1979 storm. Peak-discharge data collected at gaging stations in the county and surrounding area are presented in table 2; also included are four sites at which indirect discharge measurements were made after the storm. The indirect measurement for Canadaway Creek at Fredonia was made by the U.S. Army Corps of Engineers by the slope-area method (Dalrymple and Benson, 1967); the remaining three indirect measurements were made by the U.S. Geological Survey by the contracted-opening method (Matthai, 1967).

Recurrence intervals for the August 1979 flood discharges on several streams in the region are given in table 2. The discharge frequency relationship of a streamflow-measurement site is generally expressed in terms of recurrence interval or exceedance probability. Recurrence interval is, conceptually, the average time interval between the actual occurrence of floods of greater magnitude. Exceedance probability, the reciprocal of recurrence interval, is the probability that a flood of specified magnitude will be exceeded in any one year. The recurrence intervals listed for gaging stations in table 2 are based on the frequency curves computed for these stations by methods described in Zembrzuski and Dunn (1979).

Flood-frequency curves for the four indirect measurement sites were developed by procedures outlined in Zembrzuski and Dunn (1979) for ungaged rural streams and are shown in fig. 4. These curves indicate that the recurrence interval of the August 7-8, 1979 flood at all four sites was greater than 100 years.

FLOOD PROFILES OF CANADAWAY CREEK

During the August 7-8, 1979 flood, the most extensive damage was caused by flooding of Canadaway Creek in the Village of Fredonia. Hydrologic and hydraulic analyses were made to determine the magnitude of this flood and of floods of selected recurrence intervals to aid in evaluating the extent of flooding in Fredonia. A detailed hydraulic analysis of the Water Street bridge area was made to evaluate the effects of a debris jam that had formed during the August 1979 flood.

Water-surface profiles of the 2-, 10-, 50-, and 100-year floods and the flood of August 7-8, 1979 were developed by use of the standard step-backwater method (Chow, 1959). A 0.93-mi reach from Risley Street to Water Street (fig. 5) was investigated. The Geological Survey's computer program E431 (Shearman, 1976) was used in the step-backwater analyses. Results of the analyses are discussed in the following paragraphs.

Table 2.--Summary of flood discharges and frequencies at sites in study area during flood of August 7-8, 1979.

[Locations shown in fig. 3.]

Station number	Stream and measurement site	Drainage area (mi^2)	Period of record	Maximum known flood				Maximum during August 1979				Recurrence interval (years)
				Date	Gage height (ft)	Discharge (ft^3/s)	[(ft^3/s)/mi^2]	Date	Gage height (ft)	Discharge (ft^3/s)	[(ft^3/s)/mi^2]	
				ALLEGHENY RIVER BASIN								
03011800	Kinzua Creek near Guffey, Pa.	46.4	1966-81	6/22/72	8.99	5,200	112	8	5.55	1,220	26.3	<2
03012837	West Branch Conewango Creek tributary near Hamlet, N.Y.	6.84	1977-81	9/14/79	18.42	860	126	7	18.72	820	120	10
03013000	Conewango Creek at Waterboro, N.Y.	290	1939-81	4/ 7/47	11.35	8,600	29.7	9	8.24	2,670	9.2	<2
1/03013068	Mill Creek at Charlotte Center, N.Y.	7.01	--	--	--	--	--	7	--	6,060	864	>100
1/03013110	Hatch Creek at Gerry, N.Y.	6.11	--	--	--	--	--	7	--	2,900	475	>100
03013800	Ball Creek at Stow, N.Y.	9.06	1974-81	9/14/79	21.88	2,000	221	8	13.42	25	2.8	2/
03014500	Chadakoin River at Falconer, N.Y.	194	1935-81	9/14/79	4.93	2,250	11.6	7	2.41	783	4.0	2/
				LAKE ERIE BASIN								
1/04213371	Canadaway Creek near Griswold, N.Y.	2.19	--	--	--	--	--	7	--	1,880	858	>100
1/0421337540	Canadaway Creek at Fredonia, N.Y.	30.6	--	--	--	--	--	7	--	3/12,000	426	>100
04213500	Cattaraugus Creek at Gowanda, N.Y.	432	1940-81	3/ 7/56	14.14	34,600	79.4	8	2.03	353	0.8	2/

1/ Indirect discharge measurement site.

2/ Minor rise; considerably less than annual peak.

3/ Determined by U.S. Army Corps of Engineers.

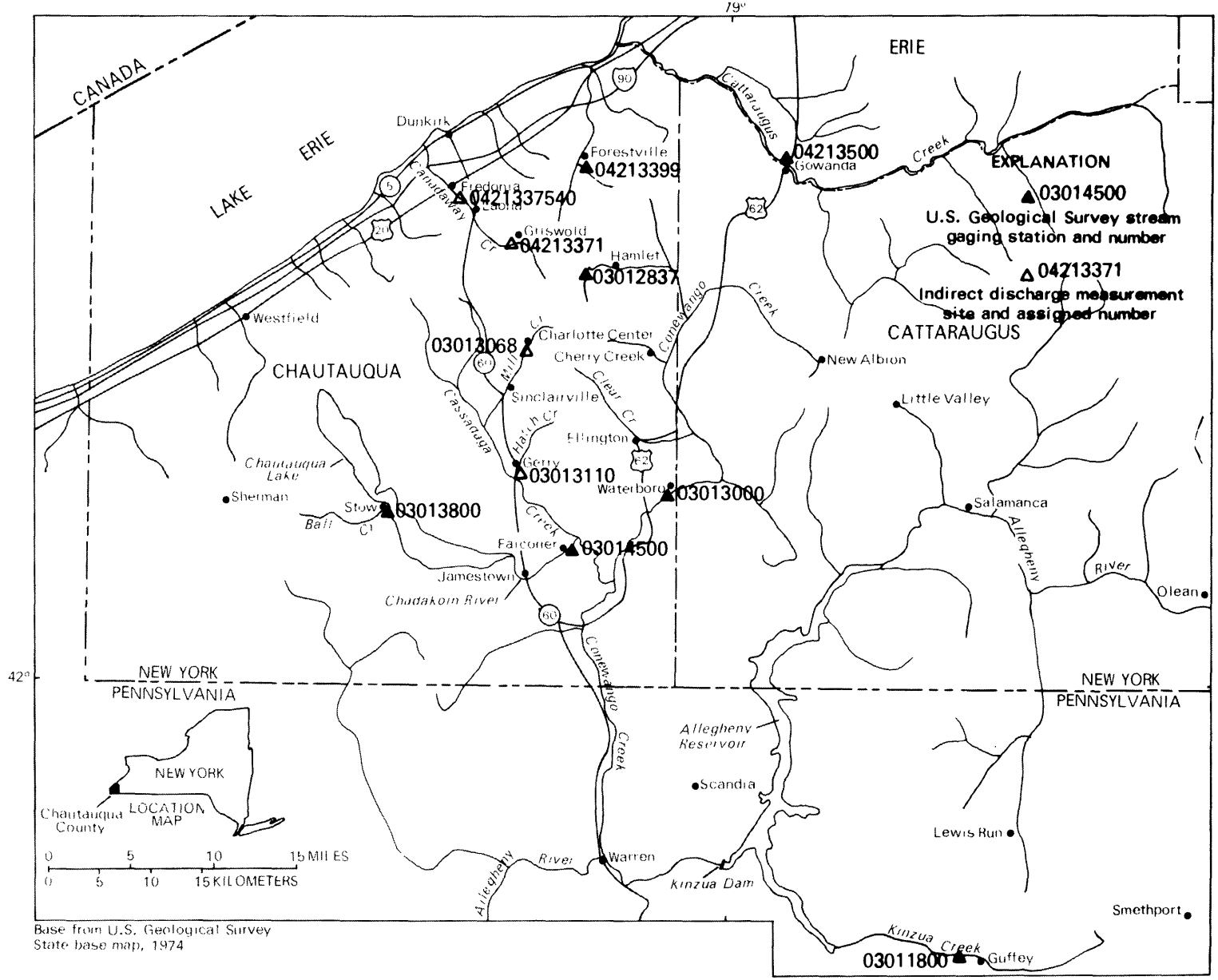


Figure 3.--Location of gaging stations and indirect-measurement sites in study area.

Flood Discharges of Canadaway Creek

Peak discharges on Canadaway Creek upstream from Fredonia at selected recurrence intervals (2, 10, 50, and 100 years) were calculated by methods described in Zembrzuski and Dunn (1979). The resulting flood-frequency curve at the Water Street bridge (drainage area 30.6 mi^2) is represented by the upper curve (Canadaway Creek at Fredonia) in figure 4. Discharge values with associated standard error of estimates of the regression equations for the 2-, 10-, 50-, and 100-year floods at the Water Street bridge are listed in table 3.

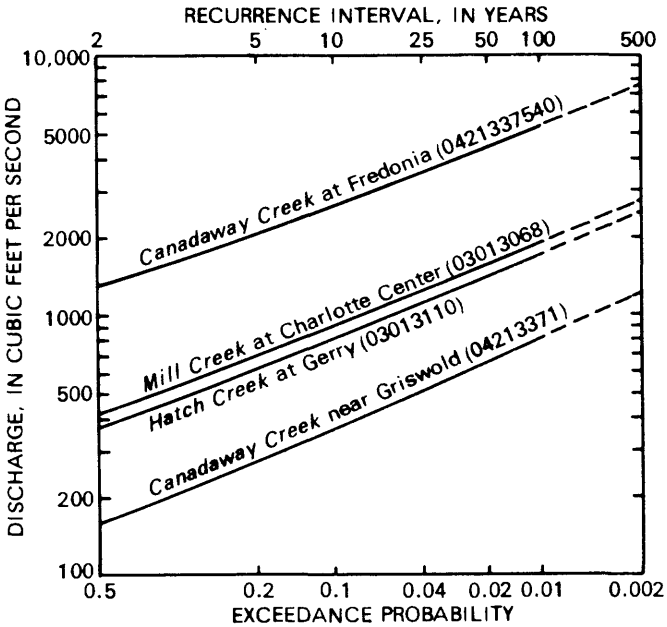


Figure 4.

Flood-frequency curves for four indirect measurement sites in Chautauqua County.

Table 3.--Discharge values at Water Street bridge for floods of selected recurrence intervals.

Recurrence interval (years)	Discharge[1] (ft^3/s)	Standard error of estimate of regression equation (percent)
2	1,300	39.5
10	2,790	37.4
50	4,430	40.8
100	5,280	42.8

[1] Calculated by techniques described in Zembrzuski and Dunn (1979).

Discharge of the August 7-8, 1979 flood on Canadaway Creek in Fredonia was computed through indirect methods by the U.S. Army Corps of Engineers (M. Mohr, written commun., June 1982). The slope-area method (Dalrymple and Benson, 1967) was used with floodmarks from a reach of Canadaway Creek between Webster Road and the abandoned railroad bridge just upstream from Fredonia. The flood discharge was computed to be about 12,000 ft^3/s. This flow was verified by the Geological Survey by a contracted-opening indirect measurement (Matthai, 1967) based on floodmarks near the Risley Street bridge in Fredonia. The flood-frequency values in table 3 indicate that the recurrence interval of the August 1979 flood (12,000 ft^3/s) in Fredonia was greater than 100 years. This and the other flows listed in table 3 for selected recurrence intervals were used for the hydraulic analysis of Canadaway Creek in Fredonia.

Hydraulic Analysis of Canadaway Creek

Hydraulic Data

Data on land-surface elevations along Canadaway Creek in Fredonia were provided by the New York State Department of Transportation (NYSDOT). Overbank land-surface elevation data were compiled by NYSDOT by photogrammetric methods based on aerial photographs taken in May 1982. Land-surface elevations of the main channel for selected cross sections were surveyed and provided by NYSDOT; geometry of bridges was determined by the Geological Survey. Cross-section locations were selected by the Geological Survey after a field inspection.

Topographic maps with 1-foot contour intervals (scale 1 in = 50 ft) of the study reach in Fredonia were provided by NYSDOT. Overbank land-surface elevations at each cross section were determined from these maps and were merged with channel-section data into composite valley cross sections. Locations of the cross sections are shown in figure 5.

The conveyance of each cross section and friction losses in the reach between adjacent sections are influenced significantly by Manning's roughness coefficient, n (Chow, 1959). Original estimates of roughness coefficients for the study reach were established by field inspection in June 1982. Minor adjustments to these estimated roughness coefficients were made during calibration of the step-backwater model (discussed below). Summer foliage conditions were used in the model. The roughness coefficients (n values) used in the final model ranged from 0.030 to 0.040 for the main channel and 0.045 to 0.100 for overbank flow areas.

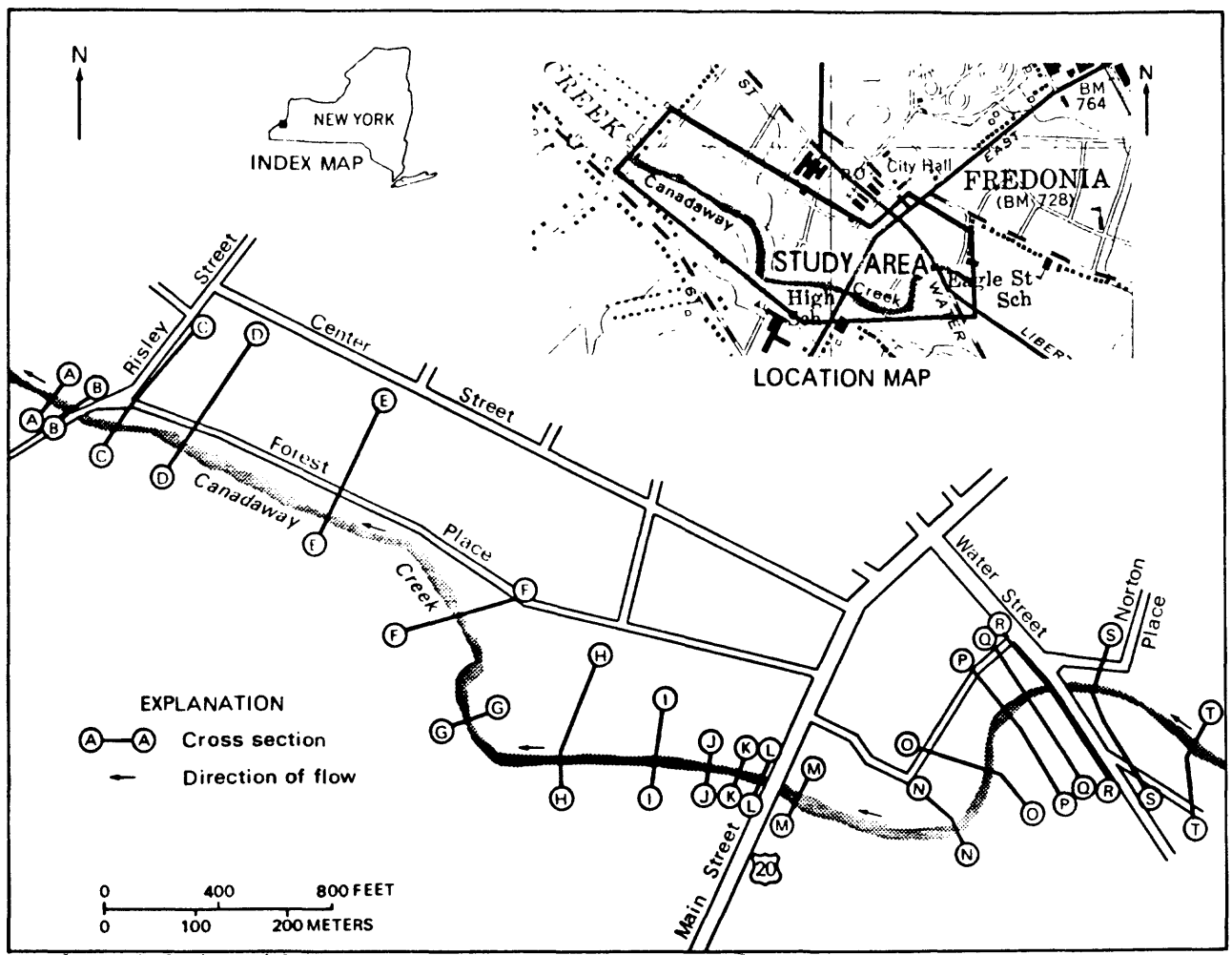
Step-backwater Analysis

Flood profiles for the August 1979 flood and for floods of selected recurrence intervals were developed by step-backwater analysis (Chow, 1959). The analysis included a 0.93-mi reach of Canadaway Creek from Risley Street (section A) to Water Street (section T); this reach and section locations are shown in figure 5.

Starting water-surface elevations at the most downstream cross section for the 2-, 10-, 50-, and 100-year floods were determined by normal depth

computations (Davidian, 1983). The starting elevation for the flood of August 1979 was based on floodmark information in Fredonia, provided by the U.S. Army Corps of Engineers (M. Mohr, written commun., June 1982). Seven floodmarks were available in the study reach. The step-backwater model was considered to be adequately calibrated when the computed water-surface elevations for the August 1979 flood agreed (about ± 0.5 ft) with the Corps' floodmarks. The calibration process required minor adjustment of roughness coefficients and slight revisions of cross-section data to better reflect effective overbank flow areas.

Discharges for floods of selected recurrence intervals were used with the calibrated step-backwater model to develop 2-, 10-, 50-, and 100-year water-surface-elevation profiles. These profiles and the profile for the August 1979 flood are shown in figure 6 with streambed elevation and location of



Base from U.S. Geological Survey
Dunkirk, NY, 1:24,000, 1979

Figure 5.--Locations of cross sections on Canadaway Creek in Fredonia.

cross sections, floodmarks, and bridges. Only profiles for unobstructed flow conditions are shown in figure 6 for the 2-, 10-, 50-, and 100-year floods.

Three profiles upstream from the Water Street bridge are included in figure 6 for the flood discharge of August 1979; they are shown in detail in the upper part of the figure inset. The upper profile shows the water-surface elevation that resulted from the debris jam at the upstream face of the bridge. The lower profile shows computed water-surface elevations for unobstructed (without debris) flow conditions. The analysis indicates that the debris caused the water-surface elevation at the approach cross section (S) to be 2.9 ft higher than the computed results for unobstructed conditions. The middle profile, which represents the water-surface elevations that would have resulted upstream from the former arched bridge (replaced in 1972) under unobstructed flow conditions, is discussed below.

In calibrating the step-backwater model for the reach upstream from Water Street, the August 1979 flood discharge (12,000 ft^3/s) was used in a simulation of the debris jam. The cross-sectional area of the Water Street bridge opening was reduced in the model until the resulting upstream water-surface

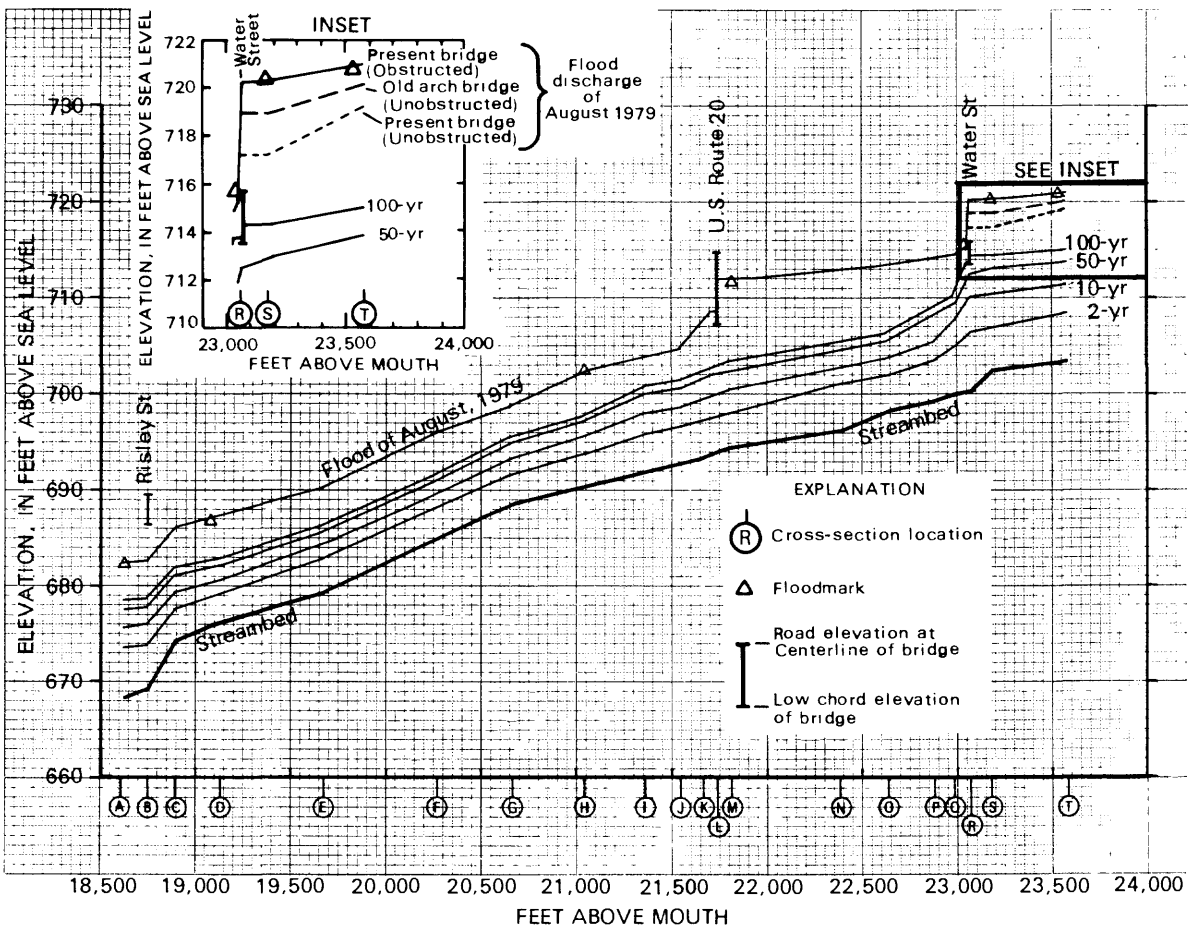


Figure 6.--Water-surface-elevation profiles for Canadaway Creek in Fredonia. (Cross-section locations are shown in fig. 5.)

elevations matched the August 1979 floodmarks. The computed water-surface elevations at cross sections S and T, resulting from reduction of cross-sectional area of the bridge opening (simulated debris jam), are plotted in figure 7. When unobstructed, the cross-sectional area of the bridge opening is 741 ft^2. To match the floodmarks at sections S and T, about 35 percent of the available bridge area was eliminated. The photograph in figure 8 shows the debris at the upstream face of Water Street bridge after the flood had receded (Dunkirk-Fredonia Evening Observer, 1979).

An additional analysis of the Water Street bridge site was made from data on an old bridge (replaced in 1972) at the site of the present bridge. The major differences between the two structures are (1) the present bridge has a rectangular opening, whereas the old bridge was arched, and (2) the present bridge has a single pier in the center of the channel, whereas the old bridge did not. The old-bridge flow conditions were investigated only in terms of unobstructed flow. The result of the analysis is depicted by the middle the profile in the upper part of the inset in figure 6. With the old bridge in place, the computed water-surface elevation (718.9 ft) at section S (fig. 6) during a flood discharge equivalent to that of August 1979 (12,000 ft^3/s) would be 1.6 ft higher than the elevation (717.3 ft) resulting from the present bridge under unobstructed conditions. Water-surface elevations computed for floods of selected recurrence intervals at section S with the present bridge did not differ by more than 0.2 ft from elevations resulting from the old arched bridge.

SUMMARY

A severe storm on August 7-8, 1979 in Chautauqua County resulted in flooding of streams and millions of dollars worth in damage to bridges, highways, and private property. Floodwater from Canadaway Creek caused severe damage in Fredonia. Peak discharge of Canadaway Creek at Fredonia was computed by indirect methods to be 12,000 ft^3/s. The recurrence interval of this discharge and discharges of streams at three other indirect-measurement sites in the county exceeds 100 years. Severe flooding was localized, as evidenced by peak discharges with recurrence intervals of less than 2 years on several other streams in the area.

Hydraulic analysis of Canadaway Creek in Fredonia indicated that a debris jam at the Water Street bridge during the August 1979 flood resulted in the water-surface elevation (established from floodmarks) upstream from the bridge to be 2.9 ft higher than the elevation computed for unobstructed flow conditions. The computed 50-year and 100-year flood elevations (for unobstructed flow conditions) are 7.3 ft and 5.9 ft lower, respectively, than the elevation observed during the August 7-8, 1979 flood.

Geometric data on a former arch bridge at Water Street were used in conjunction with the August 1979 flood discharge (12,000 ft^3/s) to compute the flood stage. Results of step-backwater computations indicate that, for unobstructed flows, the computed water-surface elevation just upstream from the former arch bridge would have been 1.6 ft higher than that upstream from the present bridge. The old bridge was evaluated only in terms of unobstructed flow conditions.

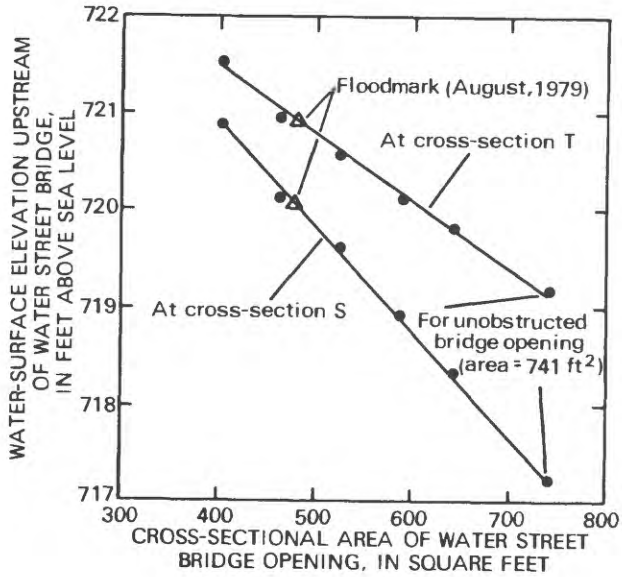


Figure 7.

Water-surface elevation at cross sections S and T in relation to simulated debris jam at Water Street bridge. (Locations are shown in fig. 5.)

Figure 8.--Debris at upstream side of Water Street bridge subsequent to flooding of Canadaway Creek in Fredonia, N.Y., August 7-8, 1979. (Photo courtesy of Evening Observer, Wednesday, Aug. 8, 1979, Dunkirk, N.Y.)

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