DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF MASSACHUSETTS DIVISION OF WATER RESOURCES
BOSTON, MASSACHUSETTS

HYDROLOGIC INVESTIGATIONS
ATLAS HA–693 (SHEET 2 of 4)

SURFACE WATER

SURFACE WATER

STREAM-GAGING STATIONS

Drainage area, period of record, maximum instantaneous discharge, and average discharge are shown for the following U.S. Geological Survey stream-gaging stations:

Ware River near Barre

Drainage area: 55.1 mi².
Period of record: July 1946 to September 1983.
Maximum instantaneous discharge for period of record: 1,890 ft³/s October 16, 1955.
Maximum instantaneous discharge since construction of Barre Falls Reservoir in 1958: 1230 ft³/s March 14, 1979.
Average discharge for water years 1947–82: 92.5 ft³/s (adjusted for storage).

Ware River at Intake Works, near Barre

Drainage area: 96.3 mi².
Period of record: January 1928 to September 1983.
Maximum instantaneous discharge for period of record: 14,000 ft³/s September 21, 1938.
Maximum daily discharge since construction of Barre Falls Reservoir in 1958: 1570 ft³/s March 6, 14, 1979.
Average discharge for water years 1929–82: 166 ft³/s (adjusted for storage).

Ware River at Gibbs Crossing

Drainage area: 197 mi².
Period of record: August 1912 to September 1983.
Maximum instantaneous discharge for period of record: 22,700 ft³/s September 21, 1938.
Maximum instantaneous discharge since construction of Barre Falls Reservoir in 1958: 5,050 ft³/s March 6, 1979.
Average discharge for water years 1931–82: 280 ft³/s (affected by storage and diversions).

Moose Brook near Barre

Drainage area: 4.63 mi².
Period of record: October 1962 to September 1974.
Maximum instantaneous discharge for period of record: 309 ft³/s December 21, 1973.
Average discharge for water years 1963-74: 6.80 ft³/s.

Hop Brook near New Salem

Drainage area: 3.39 mi².
Period of record: October 1947 to September 1982.
Maximum instantaneous discharge for period of record: 289 ft³/s October 24, 1959.
Average discharge for water years 1948-82: 6.13 ft³/s.

East Branch Swift River near Hardwick

Drainage area: 43.7 mi².
Period of record: January 1937 to September 1983.
Maximum instantaneous discharge for period of record: 6,780 ft³/s September 21, 1938.
Average discharge for water years 1938–82: 69.1 ft³/s.

Cadwell Creek near Pelham

Drainage area: 0.60 mi².
Period of record: July 1961 to September 1983.
Maximum instantaneous discharge for period of record: 46 ft³/s March 6, 1979.
Average discharge for water years 1962–82: 1.14 ft³/s.

Cadwell Creek near Belchertown

Drainage area: 2.55 mi².
Period of record: July 1961 to September 1983.
Maximum instantaneous discharge for period of record: 271 ft³/s March 6, 1979.
Average discharge for water years 1962–82: 4.81 ft³/s.

Swift River at West Ware

Drainage area: 189 mi².
Period of record: October 1912 to September 1983.
Maximum instantaneous discharge for period of record: 7,590 ft³/s March 19, 1936.
Maximum instantaneous discharge since construction of Quabbin Reservoir in 1939: 1870 ft³/s April 30, 1956.
Average discharge for water years 1913–39 (prior to completion of Quabbin Reservoir): 314 ft³/s.
Average discharge for water years 1940–82: 91.4 ft³/s (affected by storage and diversions).

Sevenmile River near Spencer

Drainage area: 8.68 mi².
Period of record: October 1960 to September 1983.
Maximum instantaneous discharge for period of record: 412 ft³/s March 18, 1968.
Average discharge for water years 1961–82: 14.3 ft³/s.

Quaboag River at West Brimfield

Drainage area: 150 mi².
Period of record: August 1912 to September 1983:
Maximum instantaneous discharge for period of record: 12,800 ft³/s August 19, 1955.
Average discharge for water years 1913–82: 244 ft³/s.

Chicopee River at Indian Orchard

Drainage area: 693 mi².
Period of record: August 1928 to September 1983.
Maximum instantaneous discharge for period of record: 45,200 ft³/s September 21, 1938.
Average discharge for water years 1929–82: 900 ft³/s, (affected by storage and diversions).

HIGH FLOW

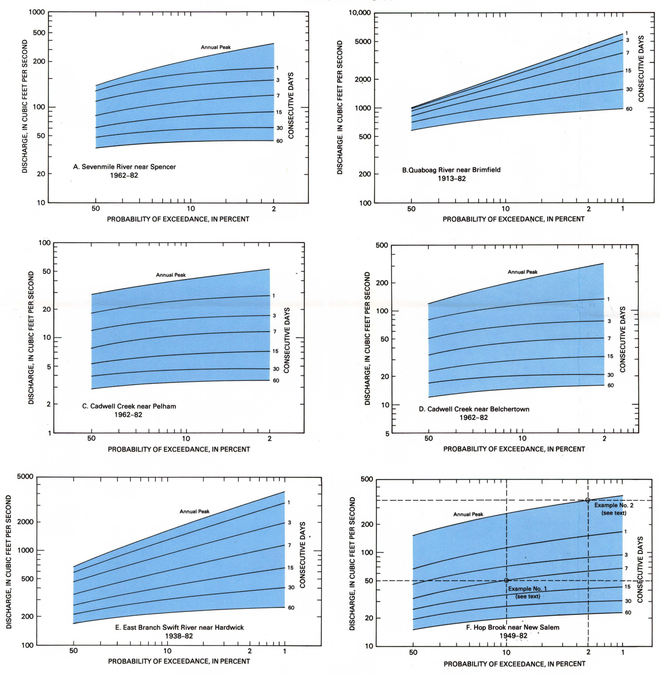

Figure 5.—**Annual peak and flood volume frequency curves for selected sites:**

A. Sevenmile River near Spencer
B. Quaboag River at West Brimfield
C. Cadwell Creek near Pelham
D. Cadwell Creek near Belchertown
E. East Branch Swift River near Hardwick
F. Hop Brook near New Salem

HIGH FLOW

Major floods have played a prominent role in the history of the Chicopee River basin. The two greatest floods of record occurred in 1936 and 1955. Flood profiles and high-water marks for the Quaboag, Swift, Ware, and Chicopee Rivers have been published for the March 1936 flood (Grover, 1937). High-water marks for the Quaboag, Ware, and Chicopee Rivers have been published for the August 1955 flood (Bogart, 1960).

Flood control has improved since the construction of the Ware River intake works in 1931. Emergency flood-control measures are authorized by the U.S. Army Corps of Engineers at the Ware River intake works, which diverts water from the Ware River to the Quabbin aqueduct, for use as municipal supply. In the Swift River basin, Quabbin Reservoir, with a 412,000 Mgal storage capacity, has retarded floodwaters since 1939. A flood-control dam was built on the Ware River near Barre in 1958 by the U.S. Army Corps of Engineers to further reduce flood damage in the basin.

Probability curves of maximum annual peak discharges and highest average discharges for the indicated number of consecutive days are shown for various stream-gaging stations in figure 5. These flood-frequency curves are used for flood-inundation and flood-control reservoir-capacity studies. The following examples demonstrate use of the Hop Brook gaging station probability curves:

Example No. 1: The probability that the average discharge for the 7 highest consecutive days of a water year exceeding 50 ft³/s is 10 percent.

Example No. 2: There is a 2 percent chance during any water year that the annual peak will exceed 360 ft³/s.

Flood insurance studies showing the existence and severity of flood hazards have been published by the Federal Emergency Management Agency for most of the communities in the basin. These studies show the peak discharges, areas of flood inundation and elevations of the 100-year and 500-year floods for major streams.

Flood information is essential to the economic design of flood control and riverine structures. Equations for estimating the magnitude and frequency of floods in central Massachusetts have been developed by Wandle (1983). The equations apply to ungaged sites where flood flows are basically natural and are within the extremes of the available data, and where drainage area is between 0.25 mi² and 260 mi². They do not apply to sites either where flood flows are significantly affected by diversion, urbanization, and regulation, or where the usable manmade storage is more than 4.5 Mft³/mi² of drainage area above the site.

The following equations provide estimates of annual peak discharges corresponding to the 0.5, 0.2, 0.1, 0.04, 0.02, and 0.01 annual exceedance probabilities:

$$Q_{0.5} = 41.11A^{0.760}S_t^{0.097}$$
$$Q_{0.2} = 65.17A^{0.755}S_t^{0.139}$$
$$Q_{0.1} = 84.98A^{0.760}S_t^{0.166}$$
$$Q_{0.04} = 114.9A^{0.775}S_t^{0.195}$$
$$Q_{0.02} = 141.9A^{0.785}S_t^{0.217}$$
$$Q_{0.01} = 172.7A^{0.797}S_t^{0.237}$$

Where,

Q_t is the peak discharge, in cubic feet per second, for the specified exceedance probability, t (0.5, 0.2, 0.1, 0.04, 0.02, 0. 01);
A is the drainage area, in square miles; and
St is the storage index which is the area of swamps, lakes, and ponds, expressed as a percentage of the drainage area plus 0.5.

Additional explanation and examples of how to determine flood-frequency estimates are given in Wandle (1983).

Regression equations for determining the magnitude and frequency of urban floods were developed by Sauer and others (1983). These equations should be used in the urbanized, ungaged areas of Springfield and Chicopee. The equations use flood-frequency estimates from equations by Wandle (1983) in conjunction with topographic and climatic characteristics, land-use variables, and indices of urbanization.

FLOW DURATION

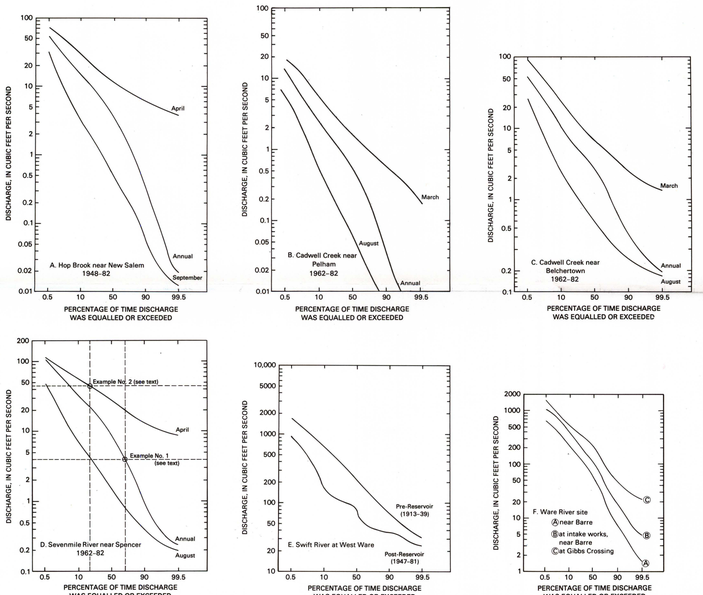

Figure 6.—**Flow-duration curves for selected sites:**

A. Hop Brook near New Salem.
B. Cadwell Creek near Pelham.
C. Cadwell Creek near Belchertown.
D. Sevenmile River near Spencer.
E. Swift River at West Ware.
F. Ware River sites.

FLOW DURATION

Flow-duration curves of the stream-gaging stations in the Chicopee River basin (fig. 6) show the percentage of time a particular discharge was equalled or exceeded. The climatic, geologic, and hydrologic characteristics of a basin determine the shape of a duration curve. These characteristics include precipitation, snowmelt, evapotranspiration, topography, channel storage, ground-water storage, and regulation of flow. The curves for Hop Brook near New Salem, Cadwell Creek near Pelham, Cadwell Creek near Belchertown, and Sevenmile River near Spencer also show the months of highest and lowest median monthly flows.

The duration curves for the Swift River at West Ware show the differences in flow between a natural flow period (1913–39) and a regulated flow period (1947–81) after the construction of Quabbin Reservoir. The Ware River duration curves primarily show the relationship between drainage area and streamflow along the reach of the stream at three gaging-station locations. The annual period used in the duration curves is the water year, the 12-month period ending September 30 of the year designated. The following two examples refer to the flow-duration curve for the Sevenmile River near Spencer:

Example No. 1: A flow of 4 ft³/s is equalled or exceeded 70 percent of the time throughout the year.

Example No. 2: The flow equals or exceeds 40 ft³/s ≥ 20 percent of the time during the month of April.

DIVERSIONS

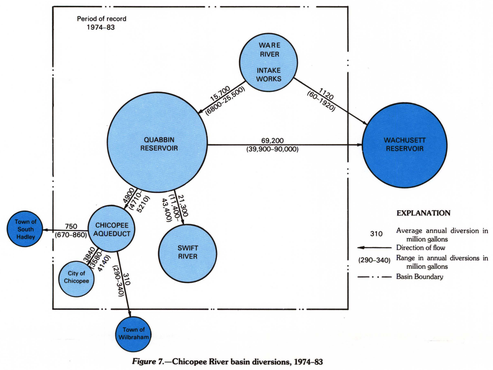

Figure 7.—**Chicopee River basin diversions, 1974–83**

DIVERSIONS

Average annual diversions and regulations of the Chicopee River basin for the period 1974–83 are shown in figure 7. The Quabbin Reservoir is the center of diversion activity. The largest diversion from Quabbin Reservoir is to Wachusett Reservoir via the Quabbin Aqueduct. The reservoir provides about 60 percent of the public-water supply for the Boston Metropolitan Water District. Quabbin water is also diverted to the Chicopee Aqueduct for the public-water supply of the city of Chicopee and the towns of South Hadley and Wilbraham. A minimum daily release of 20 Mgal from the Quabbin Reservoir to the Swift River is required by law for low-flow augmentation.

Water from the Ware River may be diverted to Quabbin Reservoir or to Wachusett Reservoir through the intake works on the Quabbin Aqueduct in the town of Barre by the Metropolitan District Commission. Diversion from the river is limited to periods when flows exceed 85 Mgal/d and is not permitted between June 15 and October 15 without the permission of the U.S. Army Corps of Engineers. No diversions are permitted between June 1 and November 30 without the permission of the State Board of Health.

LOW FLOW

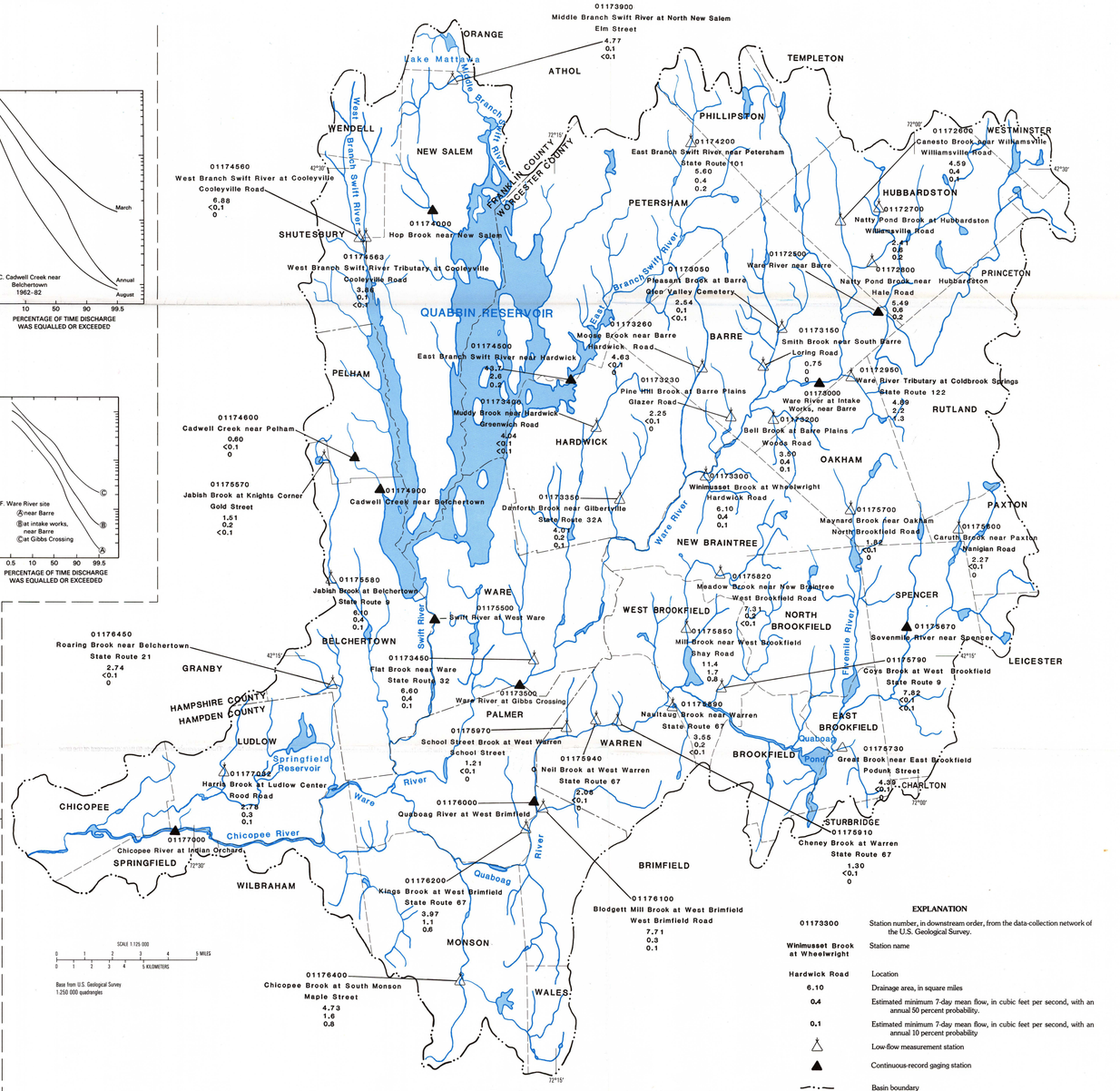

Figure 8.—**Stream measurement sites and low-flow estimates**

EXPLANATION

01173300	Station number, in downstream order, from the data-collection network of the U.S. Geological Survey.
Winimusset Brook at Wheelwright	Station name
Hardwick Road	Location
6.10	Drainage area, in square miles
0.4	Estimated minimum 7-day mean flow, in cubic feet per second, with an annual 50 percent probability.
0.1	Estimated minimum 7-day mean flow, in cubic feet per second, with an annual 10 percent probability
△	Low-flow measurement station
▲	Continuous-record gaging station
	Basin boundary
	City or town boundary
	County boundary

LOW FLOW

Low-flow information is essential to evaluate the potential use of streams for water supply, waste disposal, recreation, and fish habitat.

Annual probability curves of the lowest average daily discharges for the indicated number of consecutive days are shown for selected stream-gaging stations in figure 9. The annual period used in the analysis of low flows is the climatic year—the 12-month period ending March 31 of the designated year.

Example: For the Quaboag River at West Brimfield, the probability that the average discharge during the lowest 30 consecutive days of a climatic year being less than 25 ft³/s is 20 percent.

The 7-day, 10 percent probability low flow is used as an index in water-quality standards to ensure that flows of streams are adequate to dilute waste discharges. A regression method was used to correlate the baseflow measurements at low-flow stations with the long-term gaging-station records of Cadwell Creek near Belchertown, East Branch Swift River near Hardwick, Hop Brook near New Salem, Quaboag River at West Brimfield, and Sevenmile River near Spencer. Estimates of the annual minimum 7-day low flows having an annual probability of 10 and 50 percent were developed from data collected during 1980–82, and from a drought period (1960–66), and are shown in figure 8. The 7-day 10 percent probability low flow is zero for stream sites with drainage areas less than 1 mi².

During low-flow periods, the relation between streamflow and drainage area differs (1) from one stream to another and (2) between sites on a single stream. The values for the 7-day, 10 and 50 percent probability are site specific and should not be used to estimate values at any other stream sites. The major cause of nonuniformity between natural-flowing streams during low-flow periods is the difference in ground-water storage. Other natural causes include differences in surface storage, evaporation, transpiration, precipitation, geology, and water-table slope. Ground-water pumping, changes in land use, regulation and diversion of streamflow, and other activities of man also can cause nonuniformity.

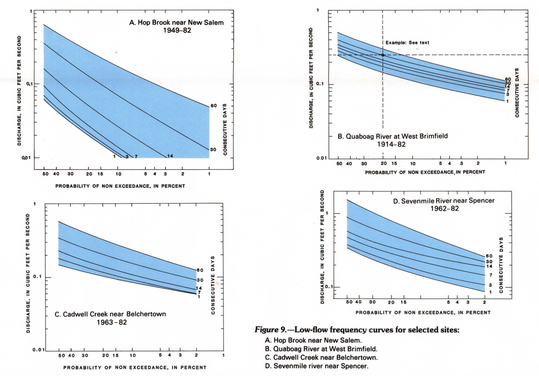

Figure 9.—**Low-flow frequency curves for selected sites:**

A. Hop Brook near New Salem.
B. Quaboag River at West Brimfield.
C. Cadwell Creek near Belchertown.
D. Sevenmile river near Spencer.

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WATER RESOURCES OF THE CHICOPEE RIVER BASIN, MASSACHUSETTS

by

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