Regression Equations for Estimating Flood Flows for the 2-, 10-, 25-, 50-, 100-, and 500-Year Recurrence Intervals in Connecticut

By Elizabeth A. Ahearn

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Conversion Factors and Datum

Multiply	By	To obtain
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
cubic foot (ft^3)	0.02832	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Vertical coordinate information is referenced to the *North American Vertical Datum of 1988 (NAVD 88).*

Horizontal coordinate information is referenced to the *North American Datum of 1983 (NAD 83).*

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Abstract

Multiple linear-regression equations were developed to estimate the magnitudes of floods in Connecticut for recurrence intervals ranging from 2 to 500 years. The equations can be used for nonurban, unregulated stream sites in Connecticut with drainage areas ranging from about 2 to 715 square miles. Flood-frequency data and hydrologic characteristics from 70 streamflow-gaging stations and the upstream drainage basins were used to develop the equations. The hydrologic characteristics—drainage area, mean basin elevation, and 24-hour rainfall—are used in the equations to estimate the magnitude of floods. Average standard errors of prediction for the equations are 31.8, 32.7, 34.4, 35.9, 37.6 and 45.0 percent for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals, respectively. Simplified equations using only one hydrologic characteristic—drainage area—also were developed. The regression analysis is based on generalized least-squares regression techniques.

Observed flows (log-Pearson Type III analysis of the annual maximum flows) from five streamflow-gaging stations in urban basins in Connecticut were compared to flows estimated from national three-parameter and seven-parameter urban regression equations. The comparison shows that the three- and seven- parameter equations used in conjunction with the new statewide equations generally provide reasonable estimates of flood flows for urban sites in Connecticut, although a national urban flood-frequency study indicated that the three-parameter equations significantly underestimated flood flows in many regions of the country. Verification of the accuracy of the three-parameter or seven-parameter national regression equations using new data from Connecticut stations was beyond the scope of this study.

A technique for calculating flood flows at streamflow-gaging stations using a weighted average also is described. Two estimates of flood flows—one estimate based on the log-Pearson Type III analyses of the annual maximum flows at the gaging station, and the other estimate from the regression equation—are weighted together based on the years of record at the gaging station and the equivalent years of record value determined from the regression. Weighted averages of flood flows for the 2-, 10-, 25-, 50-, 100-, and 500- year recurrence intervals are tabulated for the 70 streamflow-gaging stations used in the regression analysis. Generally, weighted averages give the most accurate estimate of flood flows at gaging stations.

An evaluation of the Connecticut's streamflow-gaging network was performed to determine whether the spatial coverage and range of geographic and hydrologic conditions are adequately represented for transferring flood characteristics from gaged to ungaged sites. Fifty-one of 54 stations in the current (2004) network support one or more flood needs of federal, state, and local agencies. Twenty-five of 54 stations in the current network are considered high-priority stations by the U.S. Geological Survey because of their contribution to the long-term understanding of floods, and their application for regional-flood analysis. Enhancements to the network to improve overall effectiveness for regionalization can be made by increasing the spatial coverage of gaging stations, establishing stations in regions of the state that are not well-represented, and adding stations in basins with drainage area sizes not represented. Additionally, the usefulness of the network for characterizing floods can be maintained and improved by continuing operation at the current stations because flood flows can be more accurately estimated at stations with continuous, long-term record.

Introduction

Floods are among the most destructive and costly natural disasters in the United States *(*http://www.fema.gov/library*)*. In Connecticut, floods historically have caused millions of dollars in damages—in terms of property, disrupted business, and personal trauma. During the 1992 flood that affected the western and central coastal areas of Connecticut, three persons lost their lives as a result of flooding, property damages were estimated at $4.6 million (in 1992 dollars), and 26 homes were destroyed (D. Glowacki, Connecticut Department of Environmental Protection, written comm., 2004). Flooding affects every community (169 towns) in Connecticut and continues to be a constant threat in the 21st century. The most severe floods in terms of magnitude, extent, loss of life, and property damages in Connecticut during the 20th century took place in September 1938, August 1955, October 1955, and June 1982. The September 1938, August 1955, and October 1955 floods were caused by major hurricanes and characterized by intense rainfall, significant flooding, and severe damages. The September 1938 flood resulted in hundreds of lives lost and damages of about $100 million (Paulson and others, 1940). The August 1955 flood resulted in 87 deaths and property damages of about $100 million in Connecticut (Bogart, 1960). The October 1955 flood resulted in 17 deaths and state damages of about $36 million

(Bogart, 1960). The June 1982 flood resulted in 11 deaths and damages of about $250 million (L.R. Johnston Associates, 1983). The most notable floods in Connecticut since 1620 are listed chronologically in "Historical Floods in New England" (Thomson and others, 1964). Information on memorable floods also can be found in Weiss (1991). Consequently, a better understanding of the flood magnitude and likelihood of flood flows will provide information for the safe design of structures along rivers, the effective management of flood-prone areas, and development of flood-insurance-rate maps.

The U.S. Geological Survey (USGS) uses flood-regionalization procedures to relate flood characteristics to watershed and climatic characteristics through the use of regression analysis. Flood-regionalization procedures provide a means of predicting or estimating flood flows at stream sites where little or no streamflow information is available. Traditionally, Connecticut has been considered to be one hydrologic region and statewide regression equations are used to estimate flood flows at stream sites. Flood-regionalization studies are performed periodically because additional data improve the accuracy of the regression equations. Various USGS reports provide equations for estimating the magnitude and frequency of floods on unregulated streams in Connecticut. Since the last study (Weiss, 1983), an additional 20+ years of annual maximum flow data have been collected, the guidelines for computing station flood-frequency curves (Interagency Advisory Committee on Water Data, 1982) were updated, and newer regression procedures—generalized-least-squares—have become available. Generalized-least-squares regression accounts for error in flood characteristics because of unequal record lengths at gaging stations and the correlation of flood characteristics between sites (Stedinger and Tasker, 1985; 1986). These factors warrant revision of techniques previously used.

In an effort to provide updated information for regulatory, planning, and design activities in Connecticut, the USGS is conducting a three-part study, in cooperation with the Connecticut Department of Transportation (DOT) and the Connecticut Department of Environmental Protection (DEP), to improve flood-flow statistics for Connecticut. In the first part of the study, flood-flow statistics were estimated for 128 streamflow-gaging stations in Connecticut for 1.5-, 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals (Ahearn, 2003, http://water.usgs.gov/pubs/wri/wri034196). In the second part of the study (this report), regional regression equations were developed to estimate flood flows at nonurban, unregulated stream sites in Connecticut. The third planned part of the study will implement a World Wide Web application, named StreamStats, which includes an automated geographic information system (GIS) procedure that measures the hydrologic characteristics and solves regression equations to estimate flood-flow statistics for user-selected sites in Connecticut. The web application also will include the flood flows for 128 USGS streamflow-gaging stations from the first part of the study.

Purpose and Scope

This report presents new statewide regression equations that can be used to estimate the magnitude and frequency of floods for nonurban, unregulated streams in Connecticut. The equations can be used to estimate the magnitude of flows for the 2-, 10-, 25-, 50-, 100-, and 500-recurrence intervals. The equations were developed by incorporating flood-frequency estimates (see appendix 1) from the first phase of the study (Ahearn, 2003) with an analysis of 22 drainage-basin and climatic characteristics. Statistical procedures—ordinary-least-squares regression and generalized least-squares regression—were used in the regional analysis. This report updates and supersedes previously published flood-flow frequency studies for stream sites in Connecticut.

This report also provides (1) a comparison of observed flood flows from streamflow-gaging stations to flood flows estimated from the national regression equations for urban basins, (2) a technique for calculating flood flows for streamflow-gaging stations using a weighted average, and (3) an evaluation of the streamflow-gaging network for characterizing floods in Connecticut.

Throughout this report, flood flow refers to the flood flow of a specified recurrence interval, such as the 2, 10, 25, 50, 100, and 500 year; annual maximum flow refers to the annual maximum flow for the water year; and periods of record for streamflow-gaging stations are given in water years. A water year is the 12-month period beginning October 1 and ending September 30, is designated by the calendar year in which it ends; for example, the 12-month period ending September 30, 2004, is called the 2004 water year.

Previous Studies

Several studies by USGS that provide equations for estimating the magnitude and frequency of flood-flows in Connecticut have been published. The earliest regional analysis of flood flows was made by Bigwood and Thomas (1955), who presented methods for estimating the mean-annual flood based on drainage area and basin slope. Weiss (1975) provided a method for estimating flood-flow magnitudes at 2- and 100-year recurrence intervals for urbanized and nonurbanized basins in Connecticut. Regional equations in the 1975 report included drainage area, 24-hour rainfall, main channel stream length, and main channel slope as explanatory variables to estimate flood-flow magnitudes. Weiss (1983) updated the regional regression analysis of flood flows by incorporating additional streamflow data and evaluating geologic characteristics. Weiss used multiple regression analysis to define the relation between flood flows and some hydrologic characteristics (drainage area, 24-hour rainfall for selected recurrence intervals, main channel length, main channel slope, and the percentage of the basin underlain by coarse-grained stratified deposits) at recurrence intervals of 2, 10, 25, 50, and 100 years, for unregulated streams in Connecticut. Previous studies were limited to basin or hydrologic characteristics that could be readily measured from topographic maps.

Description of the Study Area

Connecticut encompasses an area of 5,009 square miles (mi^2) and can be divided into four physiographic regions: western uplands (northwestern part of the state), eastern uplands (northeastern part of the state), central valley (central part of the State), and coastal lowlands. The western uplands generally have the steepest topography in the state; land-surface elevations range from about 500 to 2,300 ft above NAVD 88 with average slopes of about 11 percent. Land-surface elevations in the eastern uplands range from about 500 to 1,300 ft above NAVD 88 with average slopes of about 8 percent. Topographic relief along the coastal lowland and central valley generally is low with land-surface elevations ranging from 0 to about 500 ft above NAVD 88. Average slopes along the coastal and central lowlands are less than 7 percent.

The climate in Connecticut generally is temperate and humid, with four distinct seasons. Prevailing westerly winds alternately transport cool, dry, continental-polar, and warm, moist, maritime-tropical air masses into the region, resulting in frequent weather changes. Major storms are usually (1) coastal storms of extratropical origin; (2) frontal storms moving northeasterly along the Appalachian Mountains; or (3) tropical cyclones, including hurricanes, that tend to provide the majority of high intensity rains during summer and fall (Weiss, 1983). Localized thunderstorms tend to provide short-term (hours) intensive rainfall and are prevalent during the summer (Miller and others, 2003). Precipitation is distributed fairly evenly throughout the year and averages about 45 inches (in.) annually (based on long-term data from 1920 to 1996). The climate is moderated by maritime influences along coastal regions. Regional differences in topography, elevation, and proximity to the ocean can result in a substantial areal variation in snowfall amounts. Mean snowfall ranges from 30 in. along coastal areas, to 40 in. inland, to 60 in. in the northwestern part of the state (Miller and others, 2003). Average annual temperatures range from 51.7 °F in coastal areas (Bridgeport) to 49.9 °F in the central valley (Hartford) (http://met-www.cit.cornell.edu/ccd/nrmavg.html).

Land cover in Connecticut is highly mixed, with forests dominating the north, and densely populated urban areas featured prominently along the southwestern coastal and central valley region. Most of the land cover in Connecticut can be classified as forested, that is, characterized by little urban development or low population density. Based on the National Land Cover Data (NLCD) for the early 1990s at a 30-m (meter) resolution grid for Connecticut, 59.1 percent of the land cover is categorized as forest (deciduous, evergreen and mixed forest), 5.0 percent is categorized as urban (commercial, industrial and high population density), 11.6 percent is categorized as suburban (low population density), and 24.3 percent is categorized as other.

The surficial geologic materials of Connecticut, described by Stone and others (1992; in press), are primarily glacial deposits. Unconsolidated glacial deposits of varying thickness blanket the bedrock surface across most of the state. Glacial till is the most widespread surficial deposit and is generally thin (less than 15 ft thick). Till was deposited directly by glacial ice and is a nonsorted material ranging in grain size from clay to large boulders. Glacial stratified deposits occur primarily in valleys both inland and along the coast of Connecticut; these materials were laid down by glacial meltwater in streams and lakes and consist of layers of gravel, sand, silt, and clay. These materials are most widespread in the broad central Connecticut Valley and along the coast. Thick, permeable glacial stratified deposits cover much of the area in the broad valleys of the state. Till, bedrock, and fine-grained stratified deposits (very fine sand, silt and clay) generally have low permeability in comparison to the coarse-grained stratified deposits, which generally have high permeability.

Estimating Flood Flows at Stream Sites in Nonurban Basins

Regression equations can be used to estimate flood flows for nonurban, unregulated stream sites. The equations statistically relate the magnitude and frequency of floods for a group of data-collection (streamflow-gaging) stations to the drainage-basin and climatic characteristics of the upstream drainage areas. In this report, the combined drainage-basin and climatic characteristics are called hydrologic characteristics. The hydrologic characteristics were selected on the basis of their potential relation to flood flows, results of previous studies in similar hydrologic regions, and on the ability to measure the hydrologic characteristics using digital datasets with GIS technology. A database for the regional analysis was developed using active and discontinued streamflow-gaging stations, and populated with flood-flow frequency estimates for selected recurrence intervals for the gaging stations and the hydrologic characteristics of the basins upstream from each station.

Data Used in the Regression Analysis

Flood-flow frequency estimates for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals were computed for 128 streamflow-gaging stations by fitting the Pearson Type III distribution to the logarithms of the annual maximum flows (largest instantaneous streamflow for each water year) using the guidelines in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982). Of these, flood-flow frequency estimates from 70 streamflow-gaging stations (24 active and 46 inactive) (fig. 1; table 1, at back of report) were suitable for use in the regression analysis. Stations were selected for the regression analysis using the following criteria: (1) the station has a

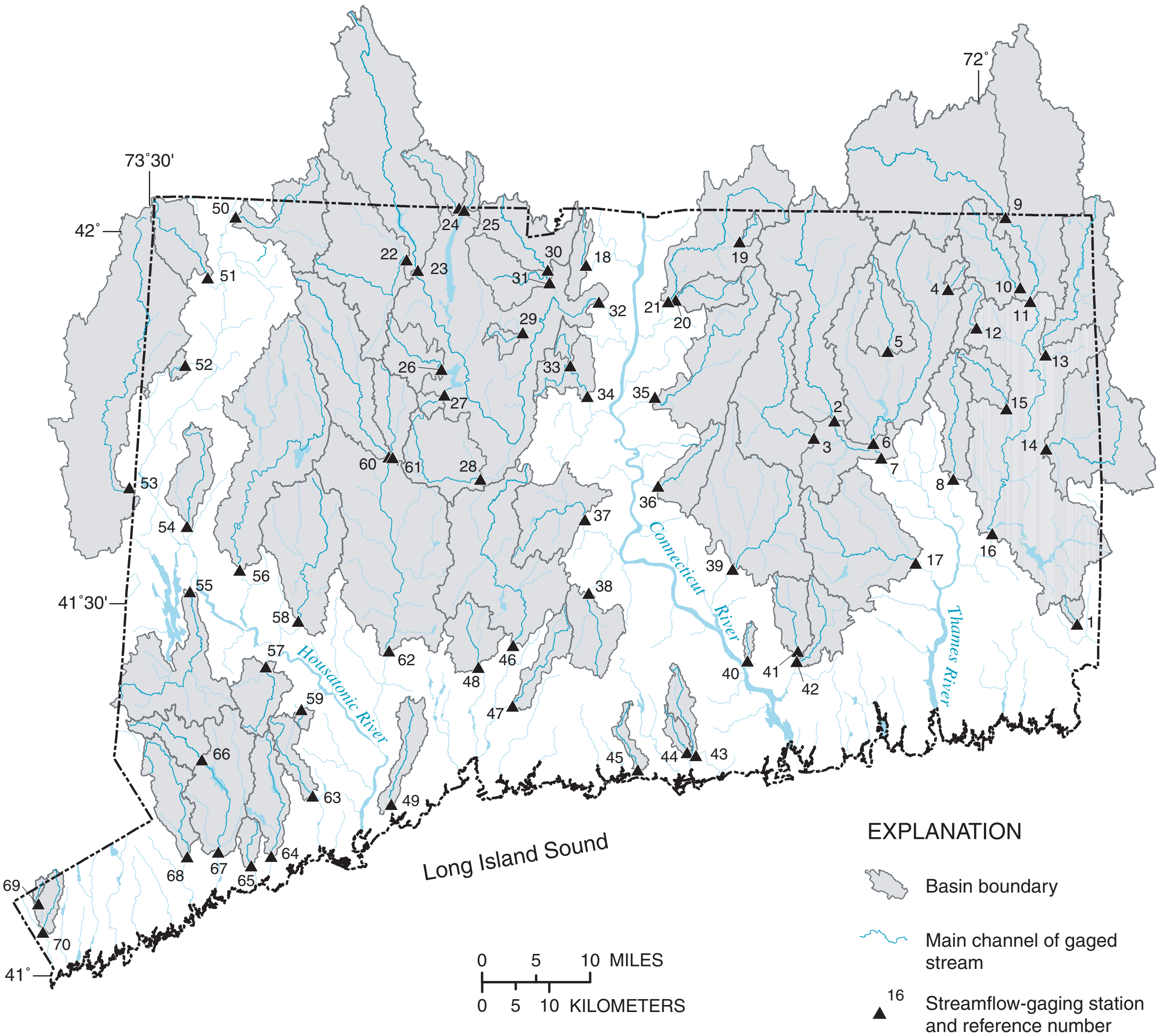

Figure 1. Locations of the 70 streamflow-gaging stations with upstream drainage basins used to develop regional regression equations for estimating flood flows at stream sites in Connecticut.

Reference number	U.S. Geological Survey streamflow-gaging station	
	Number	Name
1	01118300	Pendleton Hill Brook near Clarks Falls
2	01119500	Willimantic River near Coventry
3	01120000	Hop River near Columbia
4	01120500	Safford Brook near Woodstock Valley
5	01121000	Mount Hope River near Warrenville
6	01122000	Natchaug River at Willimantic
7	01122500	Shetucket River near Willimantic
8	01123000	Little River near Hanover
9	01124000	Quinebaug River at Quinebaug
10	01125490	Little River at Harrisville
11	01125500	Quinebaug River at Putnam
12	01125600	Mashamoquet Brook at Abington
13	01126000	Fivemile River at Killingly
14	01126500	Moosup River at Moosup
15	01126600	Blackwell Brook near Brooklyn
16	01127000	Quinebaug River at Jewett City
17	01127500	Yantic River at Yantic
18	01184100	Stony Brook near West Suffield
19	01184300	Gillette Brook at Somers
20	01184490	Broad Brook at Broad Brook
21	01184500	Scantic River at Broad Brook
22	01186500	Still River at Robertsville
23	01187000	West Branch Farmington River at Riverton
24	01187300	Hubbard River near West Hartland
25	01187400	Valley Brook near West Hartland
26	01187800	Nepaug River near Nepaug
27	01188000	Burlington Brook near Burlington
28	01189000	Pequabuck River at Forestville
29	01189200	Stratton Brook near Simsbury
30	01189390	East Branch Salmon Brook at Granby
31	01189500	Salmon Brook near Granby
32	01190000	Farmington River at Rainbow
33	01190600	Wash Brook at Bloomfield
34	01191000	North Branch Park River at Hartford
35	01192500	Hockanum River near East Hartford
36	01192650	Roaring Brook at Hopewell
37	01192700	Mattabasset River at East Berlin
38	01192883	Coginchaug River at Middlefield
39	01193500	Salmon River near East Hampton
40	01193800	Hemlock Valley Brook at Hadlyme
41	01194000	Eightmile River at North Plain
42	01194500	East Branch Eightmile River near North Lyme
43	01195000	Menunketesuck River near Clinton
44	01195100	Indian River near Clinton
45	01195200	Neck River near Madison
46	01196500	Quinnipiac River at Wallingford
47	01196580	Muddy River near North Haven
48	01196620	Mill River near Hamden
49	01196700	Wepawaug River at Milford
50	01198500	Blackberry River at Canaan
51	01199050	Salmon Creek at Lime Rock
52	01199200	Guinea Brook at West Woods Road at Ellsworth
53	01200000	Tenmile River near Gaylordsville
54	01201190	West Aspetuck River at Sand Road near New Milford
55	01201500	Still River near Lanesville
56	01203000	Shepaug River near Roxbury
57	01203510	Pootatuck River at Sandy Hook
58	01204000	Pomperaug River at Southbury
59	01204800	Copper Mill Brook near Monroe
60	01206000	Naugatuck River near Thomaston
61	01206500	Leadmine Brook near Thomaston
62	01208500	Naugatuck River at Beacon Falls
63	01208850	Pequonnock River at Trumbull
64	01208925	Mill River near Fairfield
65	01208950	Sasco Brook near Southport
66	01208990	Saugatuck River near Redding
67	01209500	Saugatuck River near Westport
68	01209700	Norwalk River at South Wilton
69	01211700	East Branch Byram River at Round Hill
70	01212100	East Branch Byram River at Riversville

minimum of 10 years of continuous-record data (stations with less than 10 years of data may not provide a sufficient sampling of the variation of the population); (2) no substantial effects of flood-control regulation are observed in the basins (basins with usable storage of more than 4.5 million cubic feet (103 acre-ft) per square mile are considered to have substantial effects of flood-detention (Benson, 1962)); (3) no substantial effects of urbanization or other man-made influences, such as channel improvements, are observed in the basins (basins with more than 15 percent of the land cover designated as high-density residential, commercial, or industrial are considered urbanized); and (4) the station has its upstream drainage basin within Connecticut or extending no more than 20 mi (miles) outside the Connecticut state border.

Not all stations that meet the criteria listed above were selected for use in the study; for example, stations where the stage-discharge relation was not reasonably well-defined at high (flood) flows were not used. The 70 stations selected for regression analysis represent good spatial coverage of streams in Connecticut (fig. 1). The lengths of record (number of years streamflow data was collected at a station) for the stations range from 10 to 75 years with an average of 37 years (fig. 2).

Hydrologic characteristics that were considered to be potentially important factors affecting flood flows, and, therefore, useful in developing equations for predicting flood flows, were selected by USGS with input from state cooperators (DOT and DEP; table 2). Twenty-two hydrologic characteristics were quantified for the 70 basins being studied and were divided into two groups: drainage-basin characteristics (basin morphology, land cover, soils, and geology) and climatic characteristics (average rainfall and rainfall frequency and duration). Statistical summaries of the hydrologic characteristics are presented in table 3. All the characteristics were determined from digital map data. The digital data include, but are not limited to, (1) drainage subbasins at 1:24,000 scale (Connecticut Drainage Basin Boundaries); (2) elevation from USGS Digital Elevation Models (DEMs) at 1:24,000 scale from the USGS National Elevation Dataset (U.S. Geological Survey, 2001); (3) land cover at 1:24,000 scale from the USGS National Land Cover Dataset (U.S. Geological Survey, 2000); (4) soil characteristics at 1:250,000 scale from STATSGO soil characteristics (U.S. Geological Survey, 1997; Natural Resources Conservation Service, 1991); (5) surficial geology at 1:250,000 scale from Surficial Materials Map of Connecticut (Stone and others, 1992); (6) centerline hydrography for Connecticut at 1:24,000 scale developed by Connecticut DEP (Danenberg and Bogar, 1994); (7) mean annual rainfall characteristics (Daly, 2000; Randall, 1996); and (8) maximum 24-hour and 6-hour rainfall characteristics (Miller and others, 2003; B.N. Belcher, Northeast Regional Climate Center, written commun., 2003).

Subbasins were aggregated to the streamflow-gaging stations on 1:24,000 USGS topographic maps (Connecticut Drainage Basin Boundaries). Where a gaging station was located within a subbasin (not at the subbasin outlet), the basin boundary was digitized from the gaging station to the subbasin boundary. Centerline hydrography data was used to determine the total length of streams, in miles, for each basin. Centerline hydrography data was developed from digital line graph (DLG) datasets (Danenberg and Bogar, 1994). For the majority of the quadrangles used to create the centerline hydrography, intermittent and perennial channels were aggregated into one category. Average slope of the basins and minimum, maximum, and

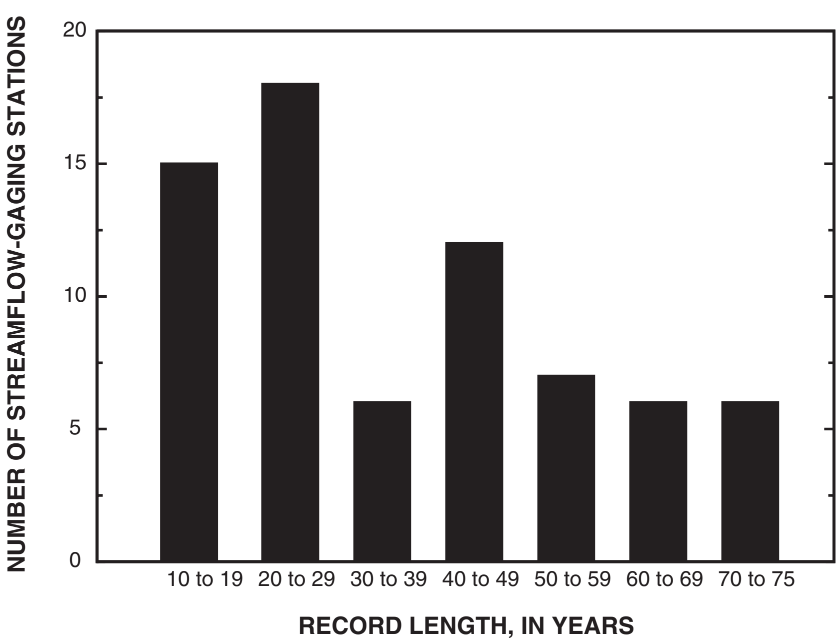

Figure 2. The lengths of record for 70 streamflow-gaging stations used to develop regression equations for estimating flood flows at stream sites in Connecticut.

Table 2. Description of hydrologic characteristics used in the development of regression equations to estimate flood flows in Connecticut.

[NAVD 88, North American Vertical Datum of 1988; DEM, digital elevation model]

Hydrologic characteristic	Definition
DRAINAGE-BASIN CHARACTERISTICS	
Basin Morphology (10 variables)	
Drainage area	Drainage area that contributes to surface runoff, in square miles
Main channel length	Main channel length measured along channel from streamflow-gaging station to the headwaters of the channel following the channel with the largest upstream area, in miles
Main channel slope	Main channel slope using main channel length and associated upstream and downstream elevation points, in feet per mile
Basin perimeter	Perimeter following the basin boundary, in miles
Total length of streams	Total length of perennial channels in the basin, in miles
Basin shape factor	Main channel length squared divided by the drainage area
Maximum basin elevation	Maximum basin elevation in the drainage basin derived from the intersection of basin polygon coverages and DEMs, in feet above NAVD 88
Mean basin elevation	Mean basin elevation in the drainage basin derived from the intersection of basin polygon coverages and DEMs, in feet above NAVD 88
Elevation range	Maximum basin elevation minus the minimum basin elevation (at the streamflow-gaging station), in feet
Mean basin slope	Mean basin slope in the drainage basin derived from the intersection of basin polygon coverages and DEMs, in percent
Land Cover (4 variables)	
Forest	Area of basin classified as forested (deciduous forest, deciduous shrubland, evergreen forest and mixed forest were aggregated into forest), in percent
Water	Area of basin classified as water, in percent
Wetland	Area of basin classified as wetland (woody wetlands and emergent herbaceous were aggregated into wetlands), in percent
Storage	Area of lakes, ponds, reservoirs and wetlands in a basin, in percent
Soils (2 variables)	
Hydrologic soil index	Hydrologic soil groups A through D
Soil drainage index	Soils drainage index 1-8, code identifying the natural drainage condition of the soil and refers to the frequency and duration of periods when the soil is free of saturation
Geology (2 variables)	
Coarse-grained stratified glacial deposits	Area of basin classified as coarse-grained (sand and gravel) stratified glacial deposits and coarse-grained stratified deposits over fine-grained (very fine sand, silt, and clay) stratified deposits, in percent
Glacial till	Area of basin classified as glacial till, in percent
CLIMATIC CHARACTERISTICS	
Rainfall (4 variables)	
Mean-annual rainfall, 1951-80	Mean-annual rainfall for 1951-1980, in inches
Mean-annual rainfall, 1961-90	Mean-annual rainfall for 1961-1990, in inches
24-hour rainfall (inches)	Maximum 24-hour rainfall having recurrence interval of 2-, 10-, 25-, 50-, 100-, and 500-year, in inches
6-hour rainfall (inches)	Maximum 6-hour rainfall having recurrence interval of 2-, 10-, 25-, 50-, 100-, and 500- year, in inches

Table 3. Statistical summary of hydrologic characteristics used in the development of regression equations to estimate flood flows in Connecticut.

[Hydrologic characteristics in bold represent the explanatory variables used in the final regression equations. NAVD 88, North American Vertical Datum of 1988]

Hydrologic characteristic	Maximum	75th percentile	Median	Mean	25th percentile	Minimum	Number of observa-tions
DRAINAGE-BASIN CHARACTERISTICS							
Drainage area (square miles)	715	78.4	28.8	75.2	12.3	1.69	70
Main channel length (miles)	77.5	21.9	12.7	16.9	8.67	2.29	70
Main channel slope (feet per mile)	141	58.8	42.1	46.7	25.7	9.40	70
Basin perimeter (miles)	228	57.4	33.7	47.2	23.2	6.94	70
Total length of streams (miles)	1,850	179	66.2	183	35.0	5.63	[1]69
Basin shape factor	12.1	7.38	5.48	5.83	4.08	1.58	70
Maximum basin elevation (feet above NAVD 88)	2,450	1,290	997	1,080	773	360	70
Mean basin elevation (feet above NAVD 88)	1,310	736	525	590	371	169	70
Elevation range (feet)	2,080	1,040	723	840	565	218	70
Mean basin slope (percent)	14.6	9.49	8.07	8.52	7.15	4.82	70
Forest (percent)	94.7	76.3	68.2	67.1	58.3	32.4	70
Water (percent)	5.34	2.53	1.54	1.78	0.72	0.10	70
Wetland (percent)	10.2	8.14	6.95	6.71	5.37	0.47	70
Storage (percent)	13.7	10.5	8.40	8.49	7.02	1.71	70
Hydrologic soil index	3.00	2.71	2.60	2.61	2.53	2.16	70
Soil drainage index	3.90	3.54	3.49	3.46	3.36	2.95	70
Coarse-grained stratified glacial deposits (percent)	63.1	19.9	10.5	14.6	6.56	0.59	[2]61
Glacial till (percent)	98.8	88.2	84.3	78.7	71.3	31.8	[2]61
CLIMATIC CHARACTERISTICS							
Mean annual rainfall, 1951-80 (inches)	50.7	48.4	47.8	47.5	46.6	43.1	70
Mean annual rainfall, 1961-90 (inches)	52.9	49.9	48.8	48.7	47.7	43.9	70
2-year, 24-hour rainfall (inches)	3.82	3.62	3.45	3.44	3.25	2.95	70
10-year, 24-hour rainfall (inches)	5.53	5.26	5.17	4.97	4.61	4.15	70
25-year, 24-hour rainfall (inches)	7.00	6.54	6.37	6.14	5.60	4.93	70
50-year, 24-hour rainfall (inches)	8.36	7.70	7.37	7.21	6.49	5.62	70
100-year, 24-hour rainfall (inches)	9.99	9.10	8.60	8.46	7.56	6.41	70
2-year, 6-hour rainfall (inches)	2.56	2.47	2.37	2.17	2.29	2.37	[3]69
10-year, 6-hour rainfall (inches)	3.65	3.56	3.43	3.20	3.32	3.43	[3]69
25-year, 6-hour rainfall (inches)	4.55	4.40	4.32	3.86	4.07	4.25	[3]69
50-year, 6-hour rainfall (inches)	5.35	5.19	5.09	4.60	4.75	5.00	[3]69
100-year, 6-hour rainfall (inches)	6.35	6.13	6.00	5.24	5.65	5.90	[3]69

[1]Compatible (digital) hydrography maps not available for U.S. Geological Survey station 01200000, Tenmile River near Gaylordsville, Conn.

[2]Compatible (digital) geology maps not available for nine stations with basins that extend into other states.

[3]Compatible 6-hour rainfall data not available for U.S. Geological Survey station 01200000, Tenmile River near Gaylordsville, Conn.

mean land-surface elevations of the basins were determined by use of the 30-m National Elevation Dataset, 1:24,000 scale (U.S. Geological Survey, 2001). Some basin characteristics were combined to determine additional characteristics for use in the regression analysis. These characteristics included (1) basin shape, computed by main channel length squared, divided by drainage area ((main channel length ^{2})/drainage area), and (2) range, in feet, computed by subtracting the minimum basin elevation from the maximum basin elevation.

Land cover was defined using the National Land Cover Data (NLCD) for the early 1990s at a 30-m resolution grid (U.S. Geological Survey, 2000). Although there are a total of 17 subcategories within the national land-cover dataset, not all subcategories were used in the regression analysis of flood flows. Land-cover categories used include forest, water, wetlands, and urban. The subcategories water and wetlands were aggregated into the subcategory storage. Each of the five land-cover subcategory was tested in the regression analysis.

Soil hydrologic group classifications used in the analysis are contained in the 1:250,000-scale State Soil Geographic (STATSGO) data (Natural Resources Conservation Service, 1991; U.S. Geological Survey, 1997) and are based on generalized soils maps. Detailed county-level digitized soils data are not available for all of Connecticut; therefore, the more generalized STATSGO data were used to characterize soils.

Climatic data consist of (1) mean annual rainfall for the period 1951–1980; (2) mean-annual rainfall for the period 1961–1990; (3) maximum 24-hour rainfall for the 2-, 10-, 25-, 50-, and 100-year recurrence intervals and; (4) maximum 6-hour rainfall for the 2-, 10-, 25-, 50-, and 100-year recurrence intervals. Mean-annual rainfall data for the period 1951–1980 was computed as spatially weighted values of rainfall for each basin using contour data converted to grided estimates at a 1,000-ft resolution (Randall, 1996). Mean-annual rainfall data for the period 1961–1990 was computed using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) developed by Oregon State University as part of the Natural Resources Conservation Service (NRCS) Spatial Climatic Mapping Project (Daly, 2000). A non-proprietary PRISM GIS map of mean annual rainfall for the State of Connecticut (derived on the basis of rainfall data collected from 1961 to 1990) was downloaded from the NRCS PRISM Web site (http://www.ftw.nrcs.usda.gov/prism/ prismdata_state.html). The NRCS PRISM map was loaded into a GIS application and interpolated to 1,000-ft grids. Basin-wide averages of mean annual rainfall (in inches) were computed for each study basin by averaging the values of all 1,000-ft grids within the bounds of the drainage basin on an area basis.

The 24-hour and 6-hour rainfall data are based on records from 73 daily-record stations and 71 separate hourly record stations in Connecticut and adjacent parts of New York, Massachusetts, and Rhode Island using the entire period of record available for each station. Initial analysis of the 24-hour and 6-hour rainfall curves from Miller (2003) were scanned, georeferenced, and digitized. The 24-hour rainfall was selected for detailed analysis. The 24-hour rainfall values (B.N. Belcher, Northeast Regional Climate Center, written commun., 2003) were estimated for 0.2-degree evenly spaced points (about every 12 mi) across the state by the Northeast Regional Climate Center using a Cressman analysis. These data were then recompiled by USGS using GIS to develop 24-hour rainfall values at a finer scale of about 1,000 ft.

Analytical Procedures for Regression Analysis

Multiple-linear regression analysis was used to determine which hydrologic characteristics best explain the variations in flood flows and to develop equations to predict flood flows, such as the 100-year flood discharge, at ungaged stream sites. Multiple regression analysis provides a mathematical equation of the relation between a response variable (flood-flow frequency estimate for the gaging station) and two or more explanatory variables (drainage-basin and climatic characteristics). The regression equation is generally reported in the following forms:

$$\log_{10} Y_T = b_0 + b_1 \log_{10} X_1 + b_2 \log_{10} X_2 + \ldots (b_n \log_{10} X_n)\,, \quad (1)$$

or

$$Y_T = 10^{b_0} (X_1^{b_1})(X_2^{b_2})\ldots(X_n^{b_n}) \quad (2)$$

where

Y_T is the response variable (flood flow having T-year recurrence interval),

X_1 *to* X_n are explanatory variables (drainage-basin and climatic characteristics), and

b_0 *to* b_n are regression coefficients estimated through generalized-least-squares procedures (described in section “Regression Analysis Using Generalized-Least-Squares”).

The flood-flow frequency estimates and hydrologic characteristics used in a linear regression typically are log-normally distributed, and transformation of the variables to logarithms usually is necessary to satisfy the regression assumptions (described in section “Diagnostic Evaluation of the Regression Models”). Logarithmic (base-10) transformations were made of the flood flows and drainage-basin and climatic characteristics to linearize the relation between the explanatory variables (drainage-basin and climatic characteristics) and response variable (flood flows), to obtain equal variance about the regression line, and to help achieve normality.

Correlations Between Explanatory Variables

Because many drainage-basin and climatic characteristics exhibit some degree of dependence, a correlation matrix of the logarithms of the hydrologic characteristics was used initially to evaluate the amount of dependence among variables. The coefficient of determination, denoted as R^2, represents the fraction of variability in y that can be explained by the variability in x. An R^2 value of 1.00 means perfect correlation, a value of -1.00 means perfect inverse correlation, and a value of 0.00 means no correlation or complete independence. Several explanatory variables showed relatively high correlation: drainage area and total length of streams (R^2=0.99), drainage area and perimeter (R^2=0.99), drainage area and main channel length (R^2=0.96), perimeter and main channel length (R^2=0.97), maximum elevation and range (R^2=0.85), 24-hour rainfall and 6-hour rainfall (R^2=0.85), and mean annual rainfall 1951–1980 and mean annual rainfall 1961–1990 (R^2=0.80). All the variables were tested in the regression, and the explanatory variables that had high correlation with flood flows and low correlation with other explanatory variables were selected for further analysis. Of the original 22 variables, 11 variables were selected for further analysis: drainage area, main channel slope, basin shape, mean basin elevation, average basin slope, forest, storage, soil index, drainage index, average annual rainfall 1961-1990, and the 24-hour rainfall for 2-, 10-, 25-, 50-, and 100-year recurrence intervals.

Regression Analysis Using Ordinary-Least-Squares

Ordinary-least-squares regression (OLS) was used for selecting the explanatory variables that would appear in the final regression equations (Helsel and Hirsch, 1992). In OLS regression, equal weight is given to all stations in the analysis regardless of record length and the possible correlation of the flood-flow frequency estimates among stations. Variable selection was done using an “all-possible regression” procedure with the commercial statistics and data-management software S-Plus (Insightful, Inc., 2000). The all-possible regression procedure was used to find the best possible subsets of explanatory variables based on the Mallow’s Cp statistic as an initial criterion for discriminating among models. The models with the lowest Cp value generated from the all-possible regression procedure were then analyzed on the basis of the following statistics:

- Adjusted-R^2 (adj-R^2) measures the proportion of variation that is explained by the explanatory variables in the regression model. In contrast to R^2, the adj-R^2 is adjusted for the number of variables in the model and the size of the sample.
- Mean square error (MSE) is a measure of how much the calculated value will differ from the true value. It is known as the sample model error variance of the estimates for the streamflow-gaging stations included in the analysis (Reis and Friesz, 2000).
- Mallow’s Cp statistic is an estimate of the standardized mean square error of prediction. Cp statistic is a compromise between maximizing the explained variance by including all relevant variables and minimizing the standard error by keeping the number of variables as small as possible (Helsel and Hirsch, 1992).
- Predicted Residual Sum of Squares (PRESS) statistic is a validation-type estimator of error (Helsel and Hirsch, 1992). PRESS uses n-1 observations to develop the equation, then estimates the value of the one left out. The process is repeated for each observation and the prediction errors are squared and summed.

Different models from the OLS regression were compared based on adj-R^2, MSE, Mallow’s Cp, and the PRESS statistics. The models with a smaller MSE, Mallow’s Cp, and PRESS statistic and higher adj-R^2 were preferred. In addition to the above-listed statistical parameters used for identifying the best combination of explanatory variables, the explanatory variables were selected on the basis of (1) statistical significance at the 95-percent confidence level, (2) correlations among the explanatory variables, (3) how the explanatory variables might affect flood flows, (4) ease of measuring the variables using GIS, and (5) an analysis of the residuals. Explanatory variables that had a 95-percent probability of effectiveness were classified as significant, and variables that had a 99-percent probability of effectiveness were classified as highly significant. If an explanatory variable was significant or highly significant, but had only a small effect on the standard error (arbitrarily chosen as less than a 3-percent change), it was left out of the model. Potential explanatory variables for the final models were further checked for redundant (considered highly correlated among themselves) and were not both (all) included.

An all-possible regression was performed on 70 streamflow-gaging stations to determine the best combination of explanatory variables to use in the final regression equations. The explanatory variables used in the all-possible regression include: drainage area, main channel slope, basin shape, mean basin elevation, average basin slope, forest, storage, soil index, drainage index, average annual rainfall from 1961 to 1990, and the 24-hour rainfall for 2-, 10-, 25-, 50- and 100-year recurrence interval. Previous studies (Weiss, 1983) in Connecticut have shown that multiple-regression methods have successfully related flood flows to geology. The geologic characteristics were excluded from this analysis because the digital geologic maps for the adjacent states of New York, Massachusetts, and Rhode Island are not compatible with Connecticut’s digital geologic maps. Because the geologic characteristics in the state vary with elevation, it is assumed that the geologic characteristics can be indirectly evaluated with the drainage-basin characteristics—mean basin elevation and soil index.

Results of the all-possible regression on the 70 gaging stations indicate that drainage area, 24-hour rainfall for selected recurrence intervals, and mean basin elevation are the best explanatory variables to predict flood flows at ungaged stream sites in Connecticut. The explanatory variables in the models were found to be statistically significant at the 95-percent confidence level or better, were not correlated with other explanatory variables, and improved the standard errors by more than 3 percent.

Regression Analysis Using Generalized-Least-Squares

Generalized-least-squares (GLS) regression, as described by Stedinger and Tasker (1985), was used to compute the final regression coefficients in the models (equations) and evaluate the models determined from the OLS regression. GLS regression is a more specialized method of regression that accounts for time-sampling error (a function of record length) and cross-correlation between stations, which is not accounted for in OLS regression techniques. The USGS computer program GLSNET (available at http://water.usgs.gov/software/surface_water) was used to compute the regression coefficients. GLSNET also provides model diagnostics that were used to evaluate the adequacy of the models.

Stedinger and Tasker (1985) found that GLS regression equations are more accurate and provide a better estimate of the accuracy of the equations than OLS regression equations when streamflow records at gaging stations are of different and widely varying lengths and when concurrent flows at different stations are correlated. GLS regression techniques give less weight to streamflow-gaging stations that have shorter records than other stations. In addition, GLS regression techniques give less weight to those stations where concurrent flood flows are correlated with other stations (Hodgkins, 1999). Results of the GLS equations were compared with the previously published equations (Weiss, 1983) and were found to have smaller standard errors associated with the regression.

Diagnostic Evaluation of the Regression Models

Diagnostic checks were done to test the model adequacy and check whether the assumptions underlying the regression model are valid. The basic assumptions for a regression model include: (1) the equation adequately describes the relation between the response and explanatory variables, (2) the mean of the residual error is zero, (3) the variance of the residual error is constant and independent of the values of X_n, the explanatory variables, (4) the residual errors are normally distributed, and (5) the residual errors are independent of one another (Helsel and Hirsch, 1992). Overall, the model appears to fit the data reasonably well and adequately describes the relation between the response and explanatory variables. There was no evidence that any of the model assumptions have been violated. The model shows no curvature or changing variance. The residuals show a slight departure from normality, but it was not considered significant.

Diagnostic checks included looking for outliers and influential observations. The presence of outliers is a subtle form of non-normality. Influential observations are data that substantially change the fit of the regression line. Influence of an individual observation on the regressions was measured with Cook's D statistic. Cook's D statistic is a measure of the change in the parameter estimates when an observation is deleted from the regression analysis. No influential observations were found with Cook's D statistic that appreciably altered the slope of the regression line. Statistical output of the regression program GLSNET was used to check possible problems with influential observations (high leverage sites) and outliers. The station leverage and standard residual values for the 70 observations from GLSNET showed no problems with high leverage or outliers.

The relations among the explanatory variables in the final models were investigated for problems with collinearity by computing variance-inflation factors (VIF) for each explanatory variable. VIF values express the ratio of the actual variance of the coefficient of the explanatory variable to its variance if it were independent of the explanatory variables (Cavalieri and others, 2000). VIF values greater than 5 indicate that a explanatory variable is so highly correlated to other explanatory variables that it is an unreliable explanatory variable and should not be included in the equations because the equations may provide erroneous results. None of the explanatory variables for this study had a VIF value greater than 5.

Evaluation of Possible Hydrologic Subregions

Hydrologic regions of homogeneous flood characteristics in Connecticut were evaluated primarily through an analysis of the areal distribution of the regression residuals for the 10- and 100-year frequencies. The residuals are defined as the differences between the computed (predicted) values from the regression equations and the flood estimates based on the log Pearson Type III analysis of the annual maximum flows at the gaging station (observed flood flows). If the residuals show geographical biases, subdividing Connecticut into smaller hydrologic regions for analysis possibly can improve the accuracy of the regression; however, a balance is needed between isolating hydrologically similar regions and meeting minimum sample-size requirements.

The residuals from the statewide regression model (equation) were plotted at the centroid of their respective drainage basins to look for geographical biases in the regression model (fig. 3). Regions with large positive residuals mean that observed flood flows are greater than computed flood flows (regression equations underestimate the flood flow), and regions with large negative residuals mean that the observed flood flows are lower than computed flood flows (regression equations overestimate the flood flow). Regions where the regression equations consistently overestimate or underestimate the flood flows can indicate the regional relation is inadequate and biased; subsequently, separate regression analysis would be performed for each subregion. In this study, the residuals from the statewide regression model do not show apparent geographical biases or regions with either large positive or negative residuals. Therefore, Connecticut was considered one region, and only one set of regression equations was developed to estimate flood flows in Connecticut.

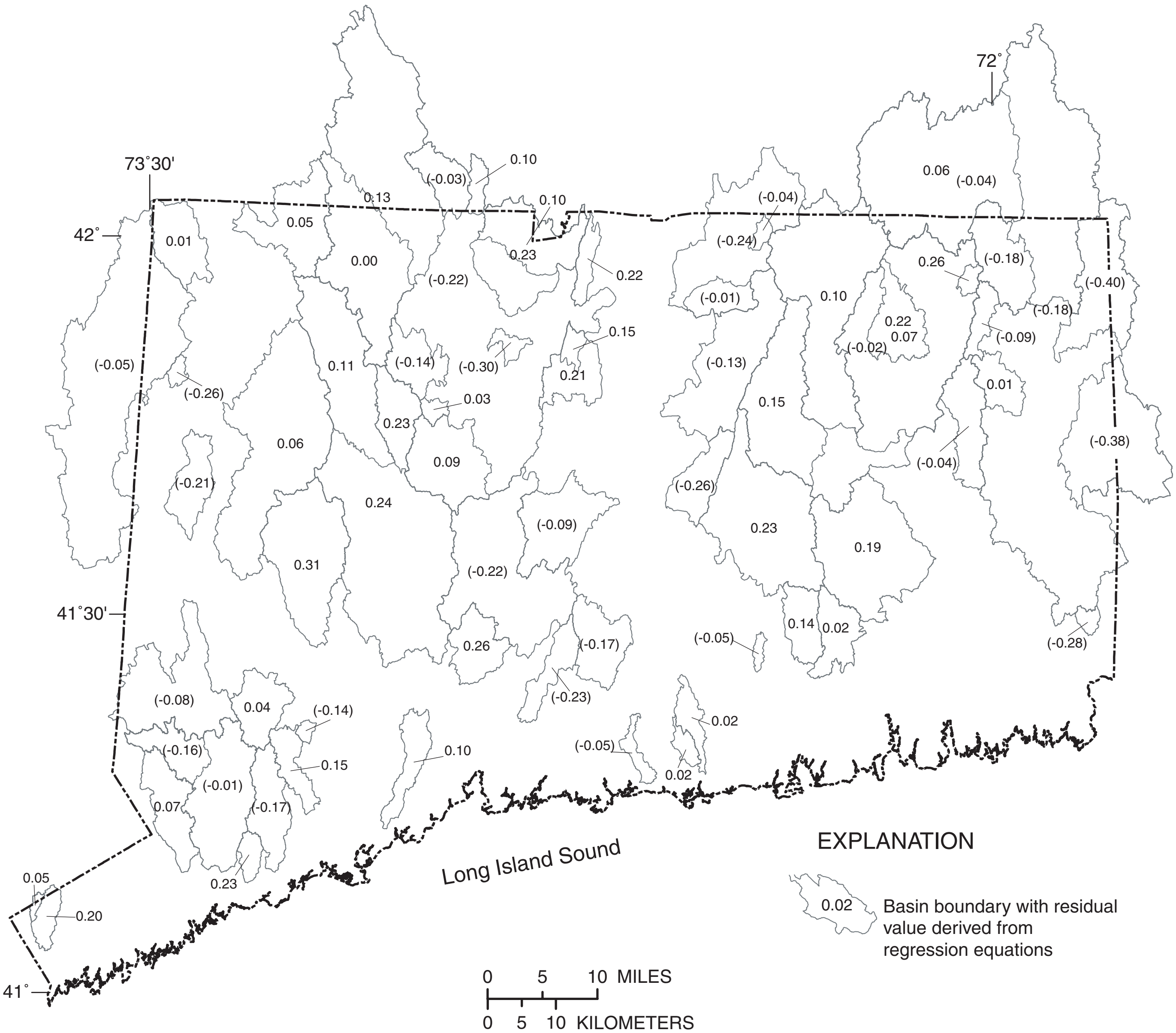

Figure 3. Residuals values derived from regression equations (using drainage area, 24-hour rainfall for the 100-year recurrence interval, and mean basin elevation as explanatory variables) for estimating flood flows at stream sites in Connecticut. [Residual values are plotted at the centroid of each basin; because some basins are nested within larger basins, some values may appear to overlap each other or to be missing.]

Results of the Regression Analysis

Regression equations were developed to estimate flood-flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals (table 4). The explanatory variables in the final regression equations are drainage area, 24-hour rainfall, and mean basin elevation (appendix 2). The variables represent the most efficient combination for explaining flood flows with the smallest number of variables, as indicated by the average standard error of regression (SE_r), standard error of prediction (SE_p), the adjusted R-squared (adj-R^2), and the average equivalent years of record (AEYR) (table 4). These four measures of accuracy are discussed in a later section of the report "Accuracy of the Regression Equations." Although regression equations are traditionally used at ungaged sites, the equations also can be used at gaged sites with very short periods of record (less than 10 years).

The regression equations explain 93 to 89 percent of the variation of the magnitude of the floods for recurrence intervals of 2- to 100-year flood flows, respectively, and 83 percent of the variation of the magnitude of the floods for the 500-year recurrence interval. The explanatory variable—drainage area—was found to be the most important variable and explains 85 percent of the variation in flood flows at the 100-year recurrence interval. Drainage area is physically related to the magnitude of the flow. Generally, larger drainage basins generate larger flood flows than smaller drainage basins. The other two explanatory variables—24-hour rainfall and mean basin elevation—explain an additional 4.0 percent of the variance in flood flows at the 100-year recurrence interval.

Rainfall is the primary cause of floods and generally is one of the most important predictors of flood flows in regional regression equations. The 24-hour rainfall value was found to be the second most important hydrologic characteristics (after drainage area) affecting flood flows in Connecticut (fig. 4). The 24-hour rainfall shows a positive correlation to the flood flows and is statistically significant at the 99-percent confidence level for all recurrence intervals.

Table 4. Regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100,- and 500-year recurrence intervals at stream sites in nonurban basins in Connecticut and their accuracy.

[Q_X, flood discharge for selected recurrence intervals in cubic feet per second; DA, drainage area in square miles; P_X, 24-hour rainfall for x-recurrence interval in inches; EL, mean basin elevation in feet; adj-R^2, adjusted-R square (or adjusted coefficient of determination) index value; SE_r , standard error of regression in percent; SE_p, standard error of prediction in percent; AEYR, average equivalent years of record]

Flood-flow regression equations for given recurrence intervals from 2 to 500 years	Adjusted-R square (adj-R^2)	Standard error of regression (SE_r)	Standard error of prediction (SE_p)	Average equivalent years of record (AEYR)
		Average (range), in percent	Average (range), in percent	
Q_2=0.329 $(DA)^{0.769}$ $(P_2)^{2.947}$ $(EL)^{0.262}$	0.93	30.4 (34.9 to -25.9)	31.8 (36.8 to -26.9)	3.5
Q_{10}=0.510 $(DA)^{0.776}$ $(P_{10})^{2.485}$ $(EL)^{0.260}$	.92	30.7 (35.2 to -26.1)	32.7 (37.9 to -27.5)	8.1
Q_{25}=0.947 $(DA)^{0.784}$ $(P_{25})^{2.064}$ $(EL)^{0.243}$	.91	31.9 (36.9 to -27.0)	34.4 (40.2 to -28.7)	10.9
Q_{50}=1.37 $(DA)^{0.790}$ $(P_{50})^{1.826}$ $(EL)^{0.235}$	.90	33.1 (38.5 to -27.8)	35.9 (42.1 to -29.6)	12.7
Q_{100}=1.86 $(DA)^{0.799}$ $(P_{100})^{1.628}$ $(EL)^{0.231}$	.89	34.6 (40.5 to -28.8)	37.6 (44.4 to -30.8)	14.3
[1]Q_{500}= 107 $(DA)^{0.790}$ $(EL)^{0.204}$	.83	41.9 (50.3 to -33.5)	45.0 (54.7 to -35.4)	14.9

[1]Q_{500} equation used only two variables because P_{500} was not available.

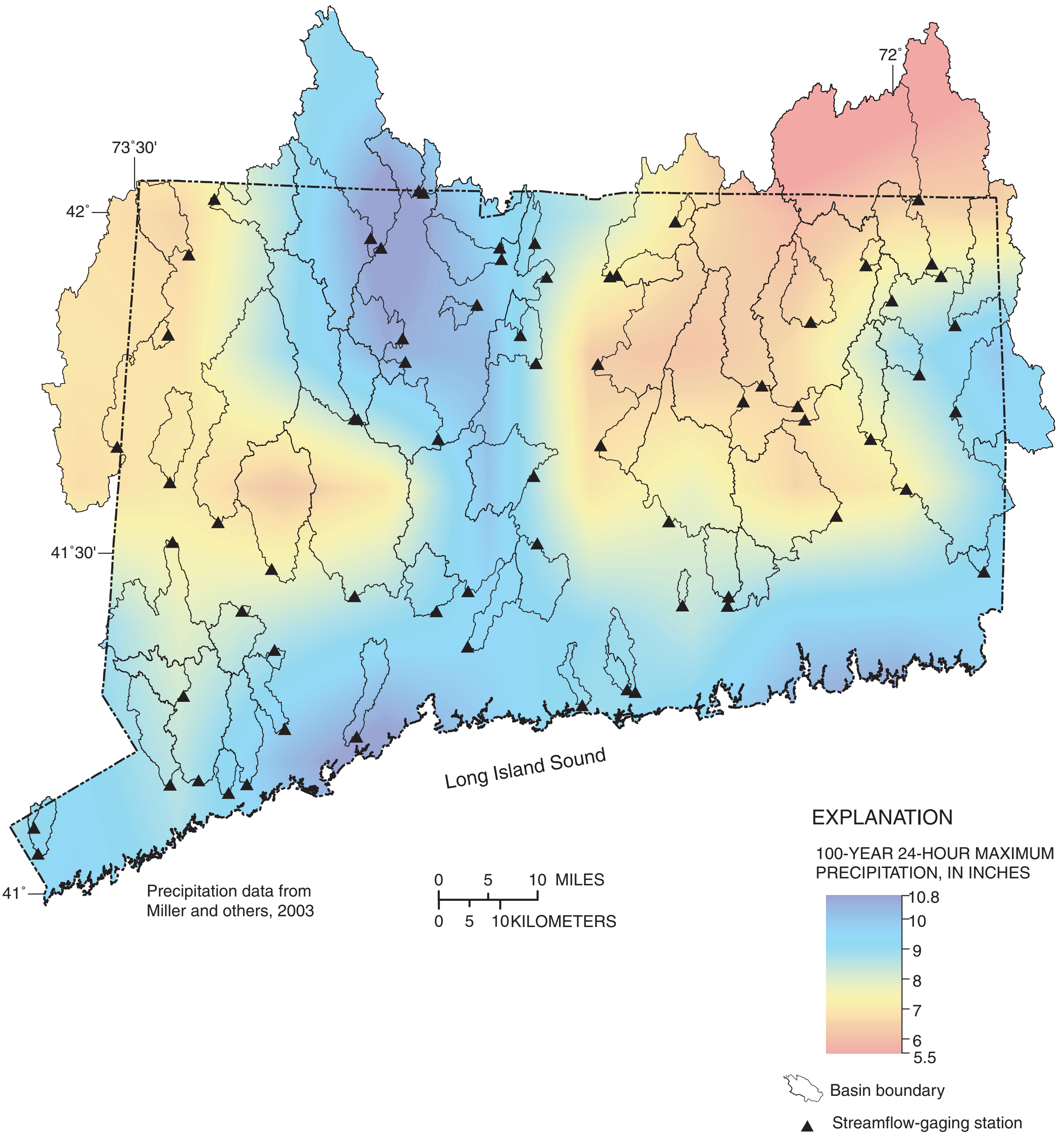

Figure 4. Distribution of 24-hour rainfall for a 100-year recurrence interval with locations of the 70 streamflow-gaging stations used to develop regression equations for estimating flood flows at stream sites in Connecticut.

Mean basin elevation is an explanatory variable that is not in itself a direct cause of variation in flood flows; however, it proved to be an important factor affecting flood flows (fig. 5). Regional differences in elevation affect the type of precipitation that occurs. Average snowfall is about 30 in. along the coast, 40 in. inland, and 60 in. in the northwestern corner of the state (Miller and others, 2003). Snow affects streamflow by temporary storage of precipitation. Also, temperature, vegetation, wind, radiation, basin and main channel slope vary with elevation, and their effects are evaluated indirectly, at least in part, by mean basin elevation. The explanatory variable—mean basin elevation—shows a positive correlation to flow and is statistically significant at the 95-percent confidence level for the 2-, 10-, 25-, 50-, and 100-year recurrence intervals.

The 6-hour rainfall and mean annual rainfall were two other climatic variables studied. The 24-hour rainfall was a slightly better explanatory variable than the 6-hour rainfall. Mean-annual rainfall (1961–1990), an explanatory variable that describes the general climate, shows a stronger correlation to the 2-year flood flows than the 24-hour rainfall. For consistency, the 24-hour rainfall was used in the final equations for all recurrence intervals including the 2-year recurrence interval. At the 500-year recurrence interval, 24-hour rainfall data are not available; therefore, the regression equation to estimate the 500-year flood flow was developed using only two of the explanatory variables—drainage area and mean basin elevation. Mean basin elevation is not statistically significant (p-value = 0.13) at the 500-year recurrence interval; however, for consistency in the equations, mean basin elevation was included in the final 500-year equation.

The regression results indicated that the explanatory variable—total lengths of streams—is as good or slightly better an explanatory variable than drainage area for some recurrence intervals. Total lengths of streams is a summation of the lengths of all the streams, in miles, in a basin (designated as a solid blue line on 1:24,000 USGS topographic maps). Total lengths of streams affects not only the magnitude of the flood, but the timing of the flood, which is not as precisely accounted for with the variable drainage area. Although total lengths of streams explained slightly more of the flood-flow variation than drainage area for some recurrence intervals, drainage area was selected for use in the final equations, primarily because it is easier to measure.

Accuracy of the Regression Equations

The most frequently used measures of accuracy of regression equations are the standard error of regression (also commonly called the standard error of estimate) and the standard error of prediction. The standard error of regression, reported in percent, is a measure of the variation between the regression estimates and the observed floods from the streamflow-gaging station used in deriving the regression equations; or in other words, measures the scatter of the observed values around the regression line. The average standard error of regression is, by definition, one standard deviation on each side of the regression equation; about 67 percent of the data are contained within this range. In other words, there is a 67-percent probability that the value estimated from the regression equations is within the range of the standard error of the regression. The average standard errors of regression computed for the regression equations for the 2- to 100-year recurrence interval range from 30.4 to 34.6 percent (table 4). The standard error of prediction, reported in percent, is a measure of the accuracy of the regression equations when predicting values for basins not used in the analysis. The standard error of prediction is generally slightly higher than the standard error of regression. The standard errors of prediction ranges from 31.8 to 37.6 percent for the 2- to 100-year recurrence interval (table 4). The largest standard errors are associated with equations where the flood flow records are considerably shorter than the recurrence interval used in the prediction (for example, the 100-year flood). There is a 67-percent probability that the true value at a site is within the range of the standard error of prediction.

The adequacy of the regression equations also was measured using the adjusted-R^2 and average equivalent years of record (AEYR). The adj-R^2 can be interpreted as the proportion of the variance in the response variable accounted for by the number of explanatory variables and takes the size of the sample into effect. The AEYR represents the average number of years of gaging-station data needed to achieve results with accuracy equal to the regression equations. The AEYR is a function of the accuracy of the regression equations, the recurrence interval, and the average variance and skew of the annual flood flows at streamflow-gaging stations (Hardison, 1971).

Limitations of the Regression Equations

The regression equations are statistical models determined from digital data using GIS technology. When applying the regression equations, the explanatory variables should be computed by the same methods that were used to develop the equations, and the explanatory variables should be derived using the same or comparable methods as those documented in this report. Using more or less accurate methods of computing the explanatory variables (for example, determining the mean basin elevation using grid sampling from topographic maps) can result in flood-flow frequency estimates of unknown accuracy.

Ranges (maximum and minimum) of explanatory variables used in the final equations are presented in table 3. Extrapolating beyond the range of explanatory variables used in the study to values higher or lower is tenuous. In multiple-regression analysis, it is possible to be within the observed range of every variable of the sample data and still be considered an extrapolation because the variables jointly define the region of the observed data (for example, variables need to be within the gray area of all plots shown in figure 6). If the explanatory variables (drainage area, 24-hour rainfall, and mean basin elevation) used in the regression equations are outside the ranges used to develop these equations (fig. 6), then the accuracy

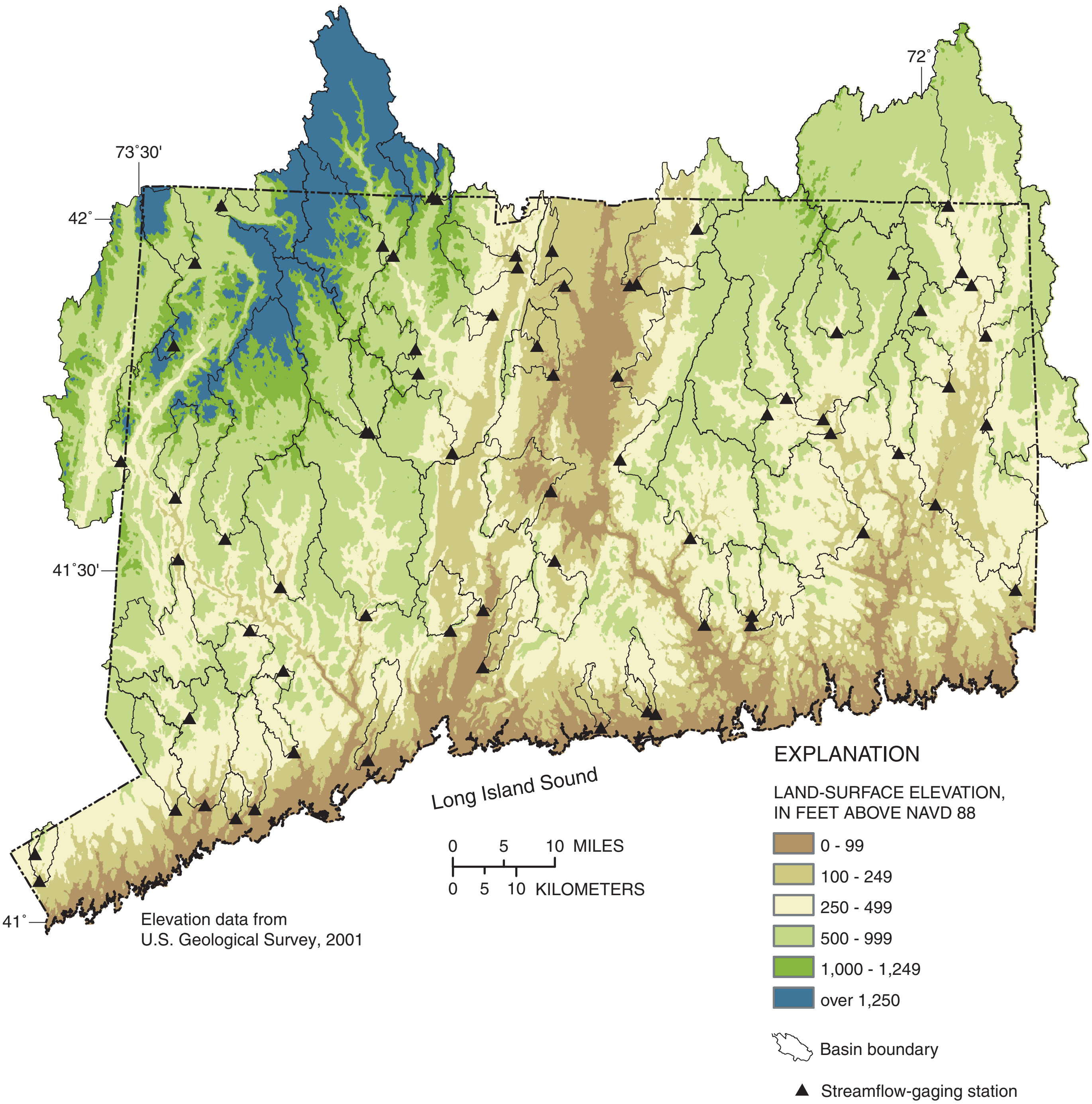

Figure 5. Land-surface elevations with locations of the 70 streamflow-gaging stations used to develop regression equations for estimating flood flows at stream sites in Connecticut.

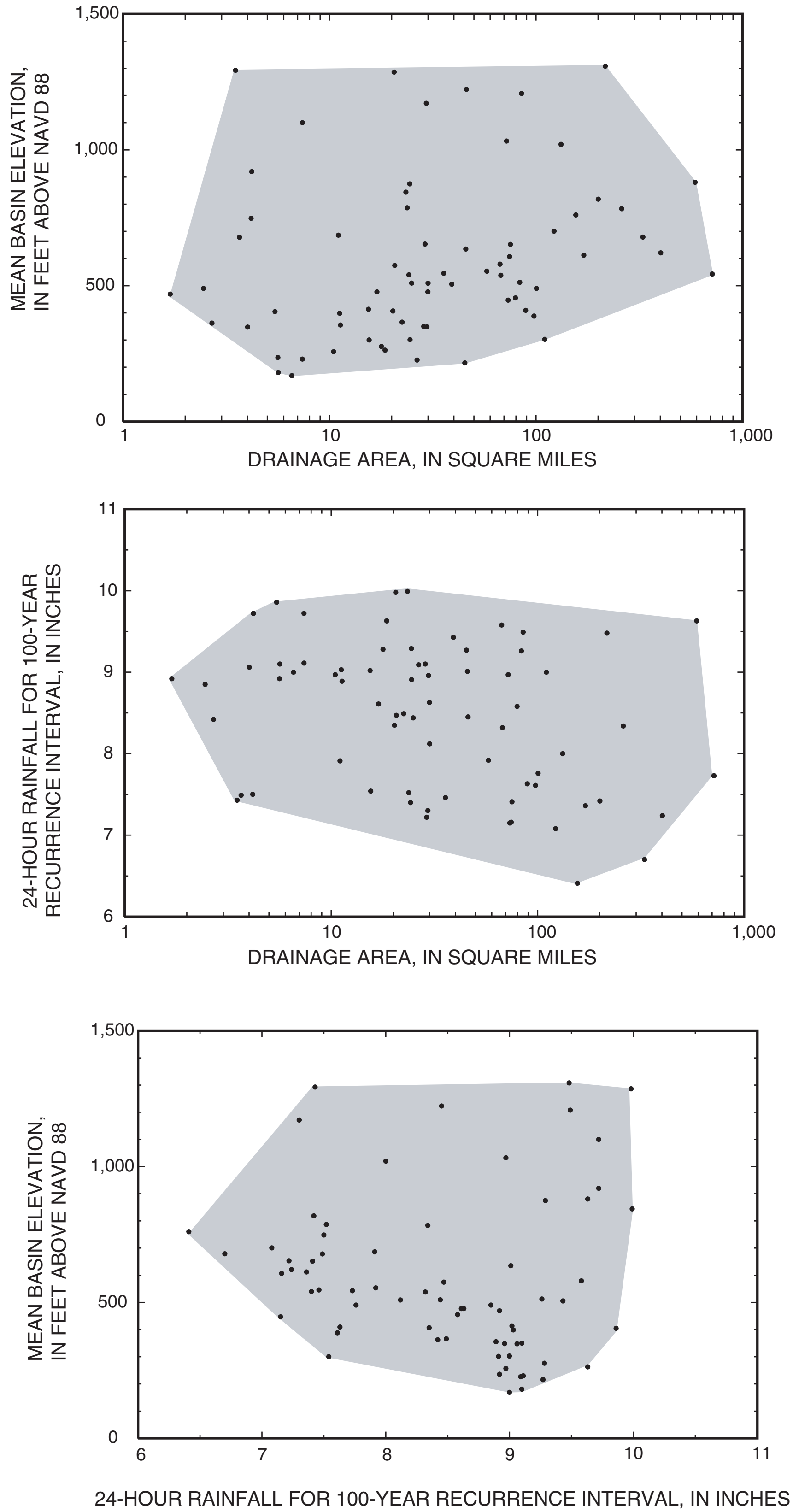

Figure 6. Two-dimensional ranges of explanatory variables for the regression equations for estimating flood flows at stream sites in Connecticut.

of the flood flows from the equations is unknown.

The regression equations presented in this report were derived on the basis of flood-flow data and drainage-basin and climatic characteristics of nonurban drainage basins with no appreciable flood-control regulation. Applying these equations to significantly regulated basins or urbanized basins will yield results of unknown error.

Simplified Regression Equations

Simplified regression equations provide estimates of flood flows that are easier to calculate, although less accurate, than those computed by the regression equations shown in table 4. The simplified regression equations contain only one basin characteristic—drainage area. Generally, average standard errors for the simplified equations are about 4 percent higher than for the full regression equations. For example, the average standard error of regression for the 100-year flood is 38.7 percent for the simplified regression equations and 34.6 percent for the full regression equation. In addition to the simplified regression equations being easier to apply, the drainage area exponents can be useful in transferring flood flows upstream and downstream from a gaged site according to the ratio of the ungaged site's drainage area to ungaged site's drainage area, raised to the exponent power (Wandle, 1983). The simplified regression equations for recurrence intervals of 2, 10, 25, 50, 100, and 500 years and adj-R^2, standard error of regression, standard error of prediction, and AEYR are presented in table 5.

Web Application for Solving the Regression Equations

A World Wide Web application, named StreamStats (http://water.usgs.gov/osw/programs/streamstats.html), is planned as the last phase of this study. The Web application will incorporate the new regression equations and provide flood-flow frequency estimates for most unregulated streams sites in Connecticut. The Web application will include (1) a mapping tool that allows users to specify locations on streams where flood-flow statistics are needed; (2) a database that includes flood-flow frequency statistics, hydrologic characteristics, location, and descriptive information for all USGS streamflow-gaging stations used in the Connecticut flood-flow frequency study; and (3) an automated GIS procedure that measures the hydrologic characteristics and solves the regression equations to estimate flood-flow statistics for user-selected sites.

Table 5. Simplified regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100,- and 500-year recurrence intervals at stream sites in nonurban basins in Connecticut and their accuracy.

[Q_X, flood flows for selected recurrence intervals in cubic feet per second; DA, drainage area in square miles; adj-R^2, adjusted-R square (or adjusted coefficient of determination) index value; SE_r , standard error of regression in percent; SE_p, standard error of prediction in percent; AEYR, average equivalent years of record]

Simplified regression equations for selected recurrence intervals	Adjusted-R square (adj-R^2)	Standard error of regression (SE_r) Average (range), in percent	Standard error of prediction (SE_p) Average (range), in percent	Average equivalent years of record (AEYR)
Q_2= 67.6 $(DA)^{0.755}$	0.90	34.5 (40.3 to -28.7)	35.5 (41.6 to -29.4)	2.9
Q_{10}= 151 $(DA)^{0.757}$	.88	35.3 (41.4 to -29.2)	36.8 (43.3 to -30.2)	6.6
Q_{25}= 200 $(DA)^{0.765}$	.87	36.4 (42.8 to -30.0)	38.2 (45.2 to -31.1)	9.2
Q_{50}= 237 $(DA)^{0.774}$	.86	37.4 (44.1 to -30.6)	39.3 (46.8 to -31.9)	11.0
Q_{100}= 276 $(DA)^{0.781}$	.85	38.7 (45.9 to -31.4)	40.7 (48.7 to -32.8)	12.5
Q_{500}= 369 $(DA)^{0.804}$	.82	42.6 (51.4 to -33.9)	45.2 (54.9 to -35.4)	15.1

Estimating Flood Flows at Stream Sites in Urban Basins

Urbanization can sometimes increase runoff because the drainage system often is altered by straightening and enlarging the channel, installing storm sewers and curb-and gutter systems, or converting land surface from pervious to impervious surfaces. These alterations can change the magnitude and timing of the runoff, and ultimately, facilitate faster runoff with an increase in floods. Some aspects of urbanization can decrease an area's flood potential by storing runoff in detention ponds and releasing it slowly. Also, road embankments, bridges, and culverts can act as dams by causing temporary storage of runoff behind the structures. Evaluating the effects of urbanization on the magnitude and frequency of flood flows involves many factors.

A national study of flood magnitude and frequency in urban areas that evaluated many of the factors listed above was conducted by the USGS to develop methods for estimating flood-flow characteristics at ungaged stream sites in urban basins. Urban basins are defined as those that have at least 15 percent of their drainage area covered with some type of commercial, industrial, or residential development. Two sets of regression equations (seven-parameter and three-parameter) were developed to estimate flood discharges for ungaged stream sites for urban basins with recurrence intervals from 2 to 500 years (Sauer and others, 1983). The national equations are described in USGS Water-Supply Paper (WSP) 2207 and are based on urban runoff data from 199 basins in 56 cities and 31 States. The three- and seven-variable regression equations are shown in table 6; these regression equations are referred to as the "urban" regression equations. The standard error of regression and the standard error of prediction are discussed in a later section of the report "Accuracy and Limitations of the National Urban Regression Equations."

Subsequent to the development of the national urban equations, an urban flood-frequency study (Sauer, 1985) indicated that the three-parameter equations are biased and significantly underestimated flood flows in many regions of the country. It is unknown if the three-parameter equations are appropriate for Connecticut because the second study did not include stations in Connecticut or the Northeast. Sauer's second study (1985) did show that the seven-parameter equations are unbiased in the areas tested.

Table 6. National regression equations for estimating flood flows the 2-, 10-, 25-, 50-, 100,- and 500-year recurrence intervals in urban basins and their accuracy.

[From Sauer and others, 1983; standard errors are based on 199 streamflow-gaging stations nationwide. UQ_X, urban flood-discharge for selected recurrence intervals in cubic feet per second; A, drainage area in square miles; SL, main channel slope in feet per mile; R_2, 2-hour rainfall for a 2-year recurrence interval, in inches; ST, drainage-basin storage, in percent; BDF, basin development factor; IA, impervious surface area in percent; RQ_X, flood discharge from regression equations for Connecticut in cubic feet per second; SE_r , standard error of regression in percent; SE_p, standard error of prediction in percent; --, not available]

Flood-flow regression equations for given recurrence interval (recurrence intervals from 2 to 500 years)	Standard error of regression (SE_r) Average (range), in percent	Standard error of prediction (SE_p) Average (range), in percent
Seven-variable equations		
$UQ_2 = 2.35\ (A)^{0.41}\ (SL)^{0.17}\ (R_2{+}3)^{2.04}\ (ST{+}8)^{-0.65}\ (13{-}BDF)^{-0.32}\ (IA)^{0.15}\ (RQ_2)^{0.47}$	38 (46 to -31)	44 (54 to -35)
$UQ_{10} = 2.99\ (A)^{0.32}\ (SL)^{0.15}\ (R_2{+}3)^{1.75}\ (ST{+}8)^{-0.57}\ (13{-}BDF)^{-0.30}\ (IA)^{0.09}\ (RQ_{10})^{0.58}$	38 (45 to -31)	45 (55 to -35)
$UQ_{25} = 2.78\ (A)^{0.31}\ (SL)^{0.15}\ (R_2{+}3)^{1.76}\ (ST{+}8)^{-0.55}\ (13{-}BDF)^{-0.29}\ (IA)^{0.07}\ (RQ_{25})^{0.60}$	40 (48 to -32)	--
$UQ_{50} = 2.67\ (A)^{0.29}\ (SL)^{0.15}\ (R_2{+}3)^{1.74}\ (ST{+}8)^{-0.53}\ (13{-}BDF)^{-0.28}\ (IA)^{0.06}\ (RQ_{50})^{0.62}$	42 (50 to -34)	--
$UQ_{100} = 2.50\ (A)^{0.29}\ (SL)^{0.15}\ (R_2{+}3)^{1.76}\ (ST{+}8)^{-0.52}\ (13{-}BDF)^{-0.28}\ (IA)^{0.06}\ (RQ_{100})^{0.63}$	44 (54 to -35)	53 (66 to -40)
$UQ_{500} = 2.27\ (A)^{0.29}\ (SL)^{0.16}\ (R_2{+}3)^{1.86}\ (ST{+}8)^{-0.54}\ (13{-}BDF)^{-0.27}\ (IA)^{0.05}\ (RQ_{500})^{0.63}$	49 (61 to -38)	--
Three-variable equations		
$UQ_2 = 13.2\ (A)^{0.21}\ (13{-}BDF)^{-0.43}\ (RQ_2)^{0.73}$	43 (51 to -34)	44 (54 to -35)
$UQ_{10} = 9.51\ (A)^{0.16}\ (13{-}BDF)^{-0.36}\ (RQ_{10})^{0.79}$	41 (49 to -33)	43 (51 to -34)
$UQ_{25} = 8.68\ (A)^{0.15}\ (13{-}BDF)^{-0.34}\ (RQ_{25})^{0.80}$	43 (51 to -34)	--
$UQ_{50} = 8.04\ (A)^{0.15}\ (13{-}BDF)^{-0.32}\ (RQ_{50})^{0.81}$	44 (54 to -35)	--
$UQ_{100} = 7.70\ (A)^{0.15}\ (13{-}BDF)^{-0.32}\ (RQ_{100})^{0.82}$	46 (57 to -36)	49 (61 to -38)
$UQ_{500} = 7.47\ (A)^{0.16}\ (13{-}BDF)^{-0.30}\ (RQ_{500})^{0.82}$	52 (65 to -39)	--

Definitions of Equation Variables

The definitions listed below are modified from Sauer and others (1983):

UQ_x - The flood flow, in cubic feet per second, for the urban drainage basin for recurrence interval x; for example, UQ_2 = 2-year urban flood flow, UQ_5 = 5-year urban flood flow.

A - The contributing drainage area, in square miles (not square kilometers). In urban areas, drainage systems sometimes cross topographic divides. Such drainage-area changes should be accounted for when computing A. This process may require field inspections.

SL - The main channel slope, in feet per mile, measured from points that are 10 percent and 85 percent of the main channel length upstream from the study site. The main channel, where two channels join, is the one that drains the largest area. The main channel length is measured as the distance from the study site to the basin divide. For sites where SL is greater than 70 ft/mi, 70 ft/mi is used in the equations.

R_2 - The rainfall, in inches, for the 2-hour 2-year recurrence interval. Determined from National Weather Service Technical Publication No. 40 (1961).

ST - Drainage basin storage, the areal percentage of the drainage basin occupied by lakes, reservoirs, and wetlands. In-channel storage of a temporary nature caused by detention ponds, roadway embankments, or other structures is not included in the computation of ST. This variable should be computed from USGS topographic maps (not U.S. Fish and Wildlife Service National Wetland Inventory maps or by other methods) for this particular computation.

IA - The percentage of the drainage basin occupied by impervious surfaces, such as houses, buildings, streets, and parking lots. This variable should be computed from the best available maps or aerial photographs. Field inspections to supplement the maps are useful.

RQ_x - The flood flow, in cubic feet per second, for an equivalent (nonurban) drainage basin for recurrence interval x. For Connecticut, the equations in table 4 should be used to calculate RQ_x.

BDF - The basin development factor, an index of the prevalence of the drainage factors: (a) storm sewers, (b) channel modifications, (c) impervious channel linings, and (d) curb-and-gutter streets. The range of BDF is from 0 to 12. A value of zero for BDF indicates that the above drainage factors are not prevalent, but it does not necessarily mean the basin is nonurbanized. A value of 12 indicates full development of the drainage factors throughout the basin.

BDF can be determined from drainage maps and field inspections of the drainage basin. After the basin has been delineated on a topographic map, the basin is divided into upper, middle, and lower thirds on the same map. Each third contains approximately one-third of the drainage area and drains the upper, middle, or lower reaches of the basin. Because travel time is considered when drawing the lines separating the basin into thirds, distances along main streams and tributaries can be marked to help locate the boundaries of the basin thirds. This drawing of the boundaries means that not all thirds of the basin have equal travel distances but that within each third, the travel distances of two or more streams are about equal. Because precise definition of the lines dividing the basin into thirds is not considered necessary, the lines can generally be drawn on the drainage map by eye, without precise measurements. Schematic diagrams of three typical basin shapes and their division into thirds are shown in figure 7. Complex basin shapes and drainage patterns are sometimes encountered and would require more judgment to subdivide.

Within each drainage-basin third, four aspects of the drainage system are evaluated; each aspect is assigned a code. The guidelines for determining the drainage-system codes are not intended to be precise measurements. Measurements should be checked in the field to obtain the best estimates.

1. Channel modifications - If channel modifications such as straightening, enlarging, deepening, and clearing are prevalent for the main drainage channels and principal tributaries (those that drain directly into the main channel) in a basin third, then a code of 1 is assigned. Any or all of these modifications would qualify for a code of 1. To be considered prevalent, at least 50 percent of the main drainage channels and principal tributaries must be modified to some degree over natural conditions. If channel modifications are not prevalent, then a code of zero is assigned.

2. Channel linings - If more than 50 percent of the length of the main drainage channel and principal tributaries in each basin third has been lined with an impervious material, such as concrete, then a code of 1 is assigned to this aspect. If less than 50 percent of these channels are lined, then a code of zero is assigned. The presence of channel linings would obviously indicate the presence of channel modifications as well. Therefore, this presence is an added factor that indicates a more highly developed drainage system.

3. Storm drains (storm sewers) - Storm drains are defined as enclosed drainage structures (usually pipes), frequently used on the secondary tributaries (those that drain directly into the principal tributaries) where the drainage is received directly from streets or parking lots. Many of these drains empty into open channels; however, in some basins they empty into channels enclosed as box or pipe culverts. When more than 50 percent of the secondary tributaries within a drainage-basin third consist of storm drains, then a code of 1 is assigned to this aspect; if less than 50 percent of the secondary tributaries consist of storm drains, then a code of zero is assigned. It should be noted that if 50 percent or more of the main drainage channels and principal tributaries are enclosed, then the aspects of channel modifications and channel linings also would be assigned a code of 1.

4. Curb-and-gutter streets - If more than 50 percent of a sub-area (third) is urbanized (covered by residential, commercial, and (or) industrial development) and if more than 50 percent of the streets and highways in the drainage-basin third are constructed with curbs and gutters, then a code of 1 is assigned to this aspect. Otherwise, it is assigned a code of zero.

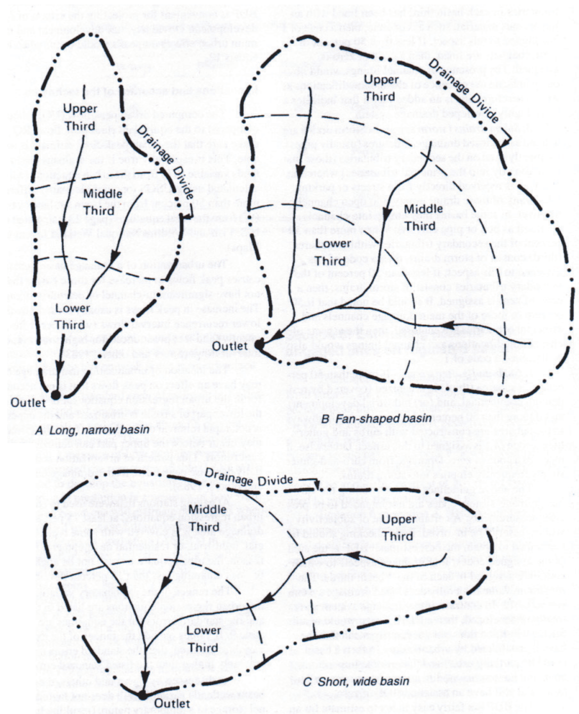

Figure 7. Typical drainage-basin shapes and subdivision into basin thirds. (From Sauer and others, 1983, fig. 2.)

Drainage from curb-and-gutter streets frequently empties into storm drains.

BDF is calculated as the sum of the codes assigned to the four drainage aspects in each of the basin thirds. The maximum value for a fully developed drainage system would be 12; if the drainage system were totally undeveloped, then the BDF would be zero. Such a condition does not necessarily mean that the basin is unaffected by urbanization. A basin could be partially urbanized, have some impervious area, and have some modification of secondary tributaries and still have an assigned BDF of zero.

The BDF is a fairly easy index to estimate for an existing urban basin. The 50-percent guideline usually will not be difficult to evaluate because many urban areas tend to use the same design criteria and therefore have similar drainage aspects. Also, the BDF is convenient for projecting the effects of future development. Full development and maximum urban effects on floods would occur when the BDF is 12.

Accuracy and Limitations of the National Urban Regression Equations

As previously stated, the average standard error of regression is, by definition, one standard deviation on each side of the regression equation, and so there is a 67-percent probability that the true value of a flood flow at a site (a site where a flood flow is being estimated) will be within the average standard error of regression range. The average standard errors of prediction in table 6 were computed by Sauer and others (1983) using a validation method (split sampling).

The urbanization of a drainage basin generally causes flood flows to increase for those basins that do not have appreciable in-channel or detention storage. The increase in flood flows is usually most dramatic for lower recurrence interval flows (which occur frequently) and less pronounced for higher recurrence interval flows (Sauer and others, 1983). The location of urbanization in a drainage basin may have an effect on flood flows that is not accounted for in the urban regression equations. For example, if the lower part of a basin is urbanized and the upper part is not, rapid removal of floodwaters from the lower part may occur before the upper part can contribute appreciable runoff. This pattern of urbanization could potentially decrease flood flows from a drainage basin (Sauer and others, 1983). The computed urban flood flow (UQ_X) should be compared to the equivalent nonurban flood flow (RQ_X) to make sure that the urban flood-flow estimate is reasonable.

The ranges of the explanatory variables used in the urban regression equations are shown in table 7. Drainage basins of the streamflow-gaging stations that were used to develop the urban regression equations had at least 15 percent of their drainage area covered with some type of commercial, industrial, or residential development. For this reason, the urban equations may not be applicable to basins containing less than 15-percent developed land. The standard errors of the regression are higher for the three-variable urban equations than for the seven-variable urban equations, but the three-variable equations are easier to apply. The standard errors of prediction for the two sets of urban equations are comparable. If values outside the ranges of the explanatory variables are used, then the standard errors may be considerably higher than the listed standard errors (table 6). As discussed by Sauer and others (1983), the drainage-basin storage variable (ST) does not include in-channel storage of a temporary nature (resulting from detention ponds, roadway embankments, or other structures). This type of storage tends to reduce flood flows. Reservoir- and channel-routing techniques should be applied to determine the effect that temporary in-channel storage has on flood flows in an urbanized basin.

Table 7. Ranges of explanatory variables used in the national regression equations for estimating flood-flow statistics at stream sites in urban basins.

[From Sauer and others, 1983]

Explanatory variable	Units	Minimum	Maximum
Area (A)	Square miles	0.2	100
Main channel slope (SL)	Feet per mile	3.0	[1]70
2-hour rainfall for 2-year recurrence interval (R_2)	Inches	.2	2.8
Storage (ST)	Percent	0	11
Basin development factor (BDF)	None	0	12
Impervious area (IA)	Percent	3	50

[1]Maximum value of slope for use in urban equations is 70 feet per mile, although numerous drainage basins used in the national study had values as high as 500 feet per mile.

Comparison of Flood-Flow Estimates From the Urban Equations To Observed Flows in Connecticut

Development of new regression equations based on streamflow-gaging stations in Connecticut to estimate flood flows in urban basins in Connecticut was beyond the scope of this study; however, a limited analysis (based on five stations) of the national urban regression equations was done as part of this project. Although it is unknown if the three-variable equations are biased in the northeastern states, both the three- and seven-variable regression equations were used to estimate the effects of urbanization on the magnitude and frequency of flood flows in Connecticut.

In Connecticut, six drainage basins with USGS streamflow-gaging stations were identified as urban, based on the criterion of having at least 15 percent of the drainage basin with commercial, industrial, or high- intensity residential development (Civco, 1998). One station—USGS station 01190200, Mill River at Newington—was later omitted because an undetermined amount of flow is diverted outside the basin during large rainfall events. Flood-flow frequency estimates in urban basins were derived from the three- and seven-parameter urban regression equations and compared to the observed flows (frequency curves) from the streamflow-gaging stations (table 8). The observed flows are based on log-Pearson Type III procedures described in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) using station skews. A comparison of the 2-, 10-, 25-, 50-, 100-, and 500-year observed flows to the estimated flows from the urban regression equations shows the three- and seven-variable urban equations used in conjunction with the new equations for Connecticut generally provide reasonable estimates of flood flows (table 8). At four of the five stations, flood-flow estimates derived from the three- and seven-variable equations are within 15- and 25-percent of the observed 100-year flows, and 30- and 15-percent of the observed 10-year flows, respectively. One station—USGS station 01195490, Quinnipiac River at Southington—was an outlier and the estimated flood flows from the three and seven-variable urban equations and nonurban regression equations did not compare well with the observed flood flows. The station has a short length of record (1988-2001); hence, the observed flows for this station, particularly for higher frequencies (greater than 10 years), are less reliable. Also, there may be appreciable storage in the headwaters. Temporary storage can cause the observed flows to be substantially less than the predicted flows from the regression equations. The user should be aware that this is a limited analysis of the urban equations and their application in Connecticut because it was based on only five sites. No attempt was made to test for biases in the three- or seven-variable equations using Connecticut data.

Table 8. Flood-frequency computations for urban basins in Connecticut.

[The seven- and three-parameter national equations are described in Sauer and others, 1983. DA, drainage area in square miles; P_X, 24-hour rainfall for selected recurrence interval in inches; EL, mean basin elevation in feet above NAVD 88; SL, main channel slope in feet per mile; R_2, 2-hour 2-year rainfall from National Weather Service maps (1961); ST, drainage-basin storage, in percent; BDF, basin development factor; IA, impervious surface in percent; RQ_X, flood discharge from regression equations for Connecticut, in cubic feet per second; UQ_X, flood discharge from urban regression equation, in cubic feet per second]

		U.S. Geological Survey streamflow-gaging station (period of record)				
	Variable	01190100 Piper Brook (1955; 1958-1984)	01190500 S. Branch Park River (1936-1972; 1974-1981)	01191500 Park River (1936-1962)	01195490 Quinnipiac River (1988-2001)	01208873 Rooster River (1978-2001)
Basin characteristics used in regression equations	DA	14.4	40.4	73.7	17.8	10.7
	P_2	3.67	3.61	3.56	3.61	3.61
	P_{10}	5.42	5.32	5.25	5.3	5.36
	P_{25}	6.78	6.64	6.55	6.61	6.73
	P_{50}	8.03	7.85	7.74	7.81	7.99
	P_{100}	9.52	9.29	9.16	9.23	9.5
	EL	258	230	219	260	249
	SL	26.7	21.9	18.6	11.4	37.6
	R_2	1.6	1.6	1.6	1.6	1.65
	ST	5.7	3.9	3.6	3.3	1.3
	BDF	4	4	5	1	5
	IA	21.9	21.3	18.6	18	27.7

Table 8. Flood-frequency computations for urban basins in Connecticut. —Continued

[The seven- and three-parameter national equations are described in Sauer and others, 1983. DA, drainage area in square miles; P_X, 24-hour rainfall for selected recurrence interval in inches; EL, mean basin elevation in feet above NAVD 88; SL, main channel slope in feet per mile; R_2, 2-hour 2-year rainfall from National Weather Service maps (1961); ST, drainage-basin storage, in percent; BDF, basin development factor; IA, impervious surface in percent; RQ_X, flood discharge from regression equations for Connecticut, in cubic feet per second; UQ_X, flood discharge from urban regression equation, in cubic feet per second]

	Variable	U.S. Geological Survey streamflow-gaging station (period of record)				
		01190100 Piper Brook (1955; 1958-1984)	01190500 S. Branch Park River (1936-1972; 1974-1981)	01191500 Park River (1936-1962)	01195490 Quinnipiac River (1988-2001)	01208873 Rooster River (1978-2001)
Connecticut regression equations (for nonurban, unregulated basins; see table 4)	RQ_2	506	1,030	1,560	568	380
	RQ_{10}	1,140	2,360	3,590	1,280	874
	RQ_{25}	1,540	3,210	4,940	1,720	1,190
	RQ_{50}	1,860	3,930	6,090	2,100	1,450
	RQ_{100}	2,220	4,730	7,380	2,500	1,730
	RQ_{500}	2,730	6,030	9,600	3,240	2,140
Urban seven-parameter regression equations	UQ_2	738	1,660	2,600	739	857
	UQ_{10}	1,510	3,370	5,270	1,530	1,670
	UQ_{25}	1,940	4,350	6,880	1,970	2,120
	UQ_{50}	2,330	5,220	8,270	2,380	2,530
	UQ_{100}	2,780	6,300	10,100	2,830	3,000
	UQ_{500}	3,260	7,560	12,200	3,430	3,560
Urban three-parameter regression equations	UQ_2	846	1,770	2,850	851	679
	UQ_{10}	1,720	3,600	5,760	1,760	1,380
	UQ_{25}	2,180	4,570	7,360	2,230	1,760
	UQ_{50}	2,640	5,650	9,160	2,740	2,140
	UQ_{100}	3,150	6,850	11,200	3,270	2,550
	UQ_{500}	3,890	8,790	14,700	4,250	3,150
Observed discharges using log-Pearson Type III analysis of streamflow-gaging station data	Q_2	745	1,500	2,150	461	1,140
	Q_{10}	1,630	3,660	4,590	785	1,800
	Q_{25}	2,160	5,160	6,460	949	2,070
	Q_{50}	2,590	6,480	8,220	1,070	2,250
	Q_{100}	3,050	7,980	10,400	1,200	2,410
	Q_{500}	4,220	12,300	17,200	1,490	2,740

Weighted Averages of Flood Flow for Streamflow-Gaging Stations

For streamflow-gaging stations, a weighted average of two independent flood-flow frequency estimates provides the most accurate estimate of flood flows for the station. One estimate is derived from the log-Pearson Type III analyses of the annual flood flows at the gaging station, and the other estimate is from the regression equation. The two estimates are weighted based on the years of record at the gaging station and the equivalent years of record value assigned to the equation (table 4). The weighted average is particularly more accurate than a non-weighted average at gaging stations with a short period of record. According to guidelines (Interagency Advisory Committee on Water Data, 1982), if two independent estimates (one computed from the gaging-station data and one from the regression equation) are weighted inversely proportional to their variances, the variance of the weighted average is less than the variance of either estimate.

Three flood-flow estimates for the 2-, 10-, 25-, 50-, 100-, and 500-recurrence intervals are provided for the 70 streamflow-gaging stations used in the regional analysis of flood-flow characteristics for Connecticut: (1) a weighted average (W) of the two flood-flow frequency estimates (table 9; note that values shown in table 9 are the anti-logarithmic transformations of the weighted averages); (2) the flood-flow frequency estimate computed from a log-Pearson Type III analysis of the annual flood flows from the gaging station (G); and (3) the flood-flow frequency estimate computed from the regression equations (R). The weighted average flood flow (Q_{wt}) (in base-10 logarithms) is computed from the following equation:

$$Q_{wt} = \frac{(Q_{gage} \times N) + (Q_{reg} \times AEYR)}{(N + AEYR)}, \quad (3)$$

where

Q_{gage} is the gaging-station flood flow (in base-10 logarithms) for a given recurrence interval, calculated by log-Pearson Type III analysis,

N is the number of annual flood flows at a gaging station (table 9),

Q_{reg} is the regression-equation flood flow (in base-10 logarithms) calculated by the methods described earlier in the section “Estimating Flood Flows at Nonurban, Unregulated Stream Sites,” and

$AEYR$ is the average equivalent years of record for the appropriate regression equations (table 4).

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01118300	Pendleton Hill Brook nr Clarks Falls	4.01	1959-2001	43	W	135	263	342	407	476	632
					G	132	242	303	351	402	528
					R	182	412	552	668	788	1,060
01119500	Willimantic River nr Coventry	122	1932-2001	70	W	2,160	5,120	7,360	9,410	11,900	20,400
					G	2,160	5,170	7,520	9,730	12,400	20,900
					R	2,270	4,740	6,400	7,850	9,520	18,200
01120000	Hop River nr Columbia	74.5	1933-1984	52	W	2,010	4,260	5,720	6,970	8,370	13,200
					G	2,040	4,450	6,070	7,470	9,050	13,600
					R	1,570	3,230	4,300	5,260	6,310	11,900
01120500	Safford Brook nr Woodstock Valley	4.17	1951-1981	31	W	317	586	747	882	1,020	1,560
					G	338	659	860	1,030	1,210	1,710
					R	177	374	500	605	714	1,280
01121000	Mount Hope River nr Warrenville	29.0	1938, 1941-2001	62	W	1,010	2,180	2,990	3,710	4,520	7,380
					G	1,030	2,280	3,180	4,000	4,950	7,840
					R	758	1,570	2,110	2,570	3,060	5,740
01122000	Natchaug River at Willimantic (flood control after 1951)	170	1931-1951	21	W	3,090	6,660	9,340	11,800	14,700	25,500
					G	3,110	6,820	9,770	12,600	16,100	27,500
					R	2,960	6,280	8,560	10,500	12,800	22,900
01122500	Shetucket River nr Willimantic (flood control after 1951)	401	1904-1906, 1920-1921, 1929-1951	28	W	6,080	12,200	16,800	20,800	25,600	42,800
					G	6,120	12,300	16,900	21,100	26,100	41,600
					R	5,750	12,000	16,400	20,300	24,800	45,300
01123000	Little River nr Hanover	30.0	1936, 1938, 1952-2001	52	W	877	1,820	2,420	2,920	3,460	5,020
					G	881	1,820	2,410	2,900	3,430	4,870
					R	826	1,820	2,450	3,000	3,590	5,600
01124000	Quinebaug River at Quinebaug (flood control after 1959)	156	1932-1959	28	W	1,950	4,600	6,700	8,670	11,000	21,500
					G	1,900	4,510	6,700	8,880	11,600	21,100
					R	2,450	4,940	6,690	8,220	10,000	22,400
01125490	Little River at Harrisville	35.7	1936, 1938, 1962-1976	17	W	707	1,480	2,010	2,450	2,940	4,600
					G	682	1,350	1,760	2,090	2,440	3,380
					R	842	1,810	2,480	3,040	3,660	6,530

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.—Continued

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01125500	Quinebaug River at Putnam (flood control after 1959)	329	1930-1959	30	W	3,850	8,460	11,800	14,800	18,300	31,700
					G	3,790	8,300	11,600	14,500	18,000	28,500
					R	4,390	9,090	12,500	15,500	19,000	39,400
01125600	Mashamoquet Brook at Abington	11.0	1963-1976	14	W	423	824	1,070	1,280	1,490	2,180
					G	434	815	1,020	1,180	1,340	1,730
					R	382	839	1,140	1,390	1,660	2,700
01126000	Fivemile River at Killingly	57.8	1936, 1938-1984	48	W	698	1,480	2,030	2,500	3,040	4,500
					G	669	1,330	1,750	2,100	2,490	3,560
					R	1,260	2,840	3,940	4,880	5,940	9,570
01126500	Moosup River at Moosup	83.5	1933-1984	52	W	1,510	3,020	4,010	4,860	5,790	7,840
					G	1,480	2,810	3,610	4,260	4,970	6,840
					R	1,950	4,760	6,660	8,290	10,100	12,600
01126600	Blackwell Brook nr Brooklyn	17.0	1962-1976	15	W	515	1,240	1,720	2,120	2,570	3,740
					G	515	1,260	1,760	2,180	2,660	3,970
					R	515	1,210	1,670	2,050	2,470	3,520
01127000	Quinebaug River at Jewett City (flood control after 1964)	715	1919-1964	46	W	7,710	16,100	22,400	27,900	34,400	54,300
					G	7,640	15,600	21,300	26,400	32,300	50,100
					R	8,730	19,500	27,400	34,200	42,400	69,500
01127500	Yantic River at Yantic	89.2	1931-2001	71	W	2,600	5,510	7,420	9,080	10,900	16,900
					G	2,640	5,740	7,860	9,730	11,800	18,000
					R	1,900	3,830	5,090	6,170	7,380	12,700
01184100	Stony Brook nr West Suffield	10.5	1955, 1960-2001	43	W	397	1,000	1,440	1,830	2,280	3,580
					G	405	1,060	1,560	2,030	2,580	4,300
					R	313	750	1,050	1,290	1,560	2,120
01184300	Gillette Brook at Somers	3.66	1960-1984	25	W	129	286	387	473	565	889
					G	126	273	367	446	533	770
					R	153	328	437	530	627	1,130
01184490	Broad Brook at Broad Brook	15.6	1938, 1962-1976, 1982-2001	36	W	414	844	1,110	1,320	1,560	2,300
					G	417	848	1,100	1,300	1,520	2,070
					R	380	824	1,130	1,390	1,670	2,990

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.—Continued

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01184500	Scantic River at Broad Brook	97.7	1929-1984	56	W	1,100	2,400	3,350	4,180	5,160	8,110
					G	1,070	2,260	3,080	3,800	4,640	7,080
					R	1,670	3,690	5,130	6,390	7,810	13,500
01186500	Still River at Robertsville (flood control after 1961)	85.1	1936, 1938, 1949-1961	15	W	2,800	6,770	9,530	12,000	14,800	20,400
					G	2,880	7,110	10,300	13,200	16,700	27,400
					R	2,480	6,190	8,560	10,700	13,000	15,200
01187000	West Branch Farmington River at Riverton	217	1930-1956	27	W	6,340	16,600	24,600	32,200	41,400	65,400
					G	6,590	18,100	28,100	38,200	51,100	96,300
					R	4,670	12,400	17,800	22,500	27,900	32,400
01187300	Hubbard River nr West Hartland	20.6	[1]1938-1954, 1955, 1957-2001	64	W	1,240	2,730	3,630	4,380	5,180	6,880
					G	1,270	2,820	3,750	4,510	5,320	7,410
					R	795	2,130	3,020	3,780	4,610	5,020
01187400	Valley Brook nr West Hartland	7.39	[1]1940-1954, 1955-1972	33	W	350	1,030	1,520	1,950	2,440	3,660
					G	350	1,060	1,610	2,130	2,740	4,640
					R	347	898	1,260	1,560	1,880	2,170
01187800	Nepaug River nr Nepaug	23.4	[1]1922-1954, 1955, 1958-1984	61	W	851	2,030	2,810	3,470	4,210	5,880
					G	843	1,990	2,750	3,390	4,110	6,080
					R	1,000	2,380	3,200	3,900	4,650	5,110
01188000	Burlington Brook at Burlington	4.20	1932-2001	70	W	293	694	934	1,130	1,330	1,810
					G	294	702	953	1,160	1,370	1,930
					R	276	627	823	982	1,150	1,340
01189000	Pequabuck River at Forestville	45.7	1938, 1942-2001	61	W	1,640	3,760	5,270	6,620	8,210	12,700
					G	1,650	3,840	5,470	6,960	8,740	14,200
					R	1,400	3,170	4,270	5,220	6,270	8,170
01189200	Stratton Brook nr Simsbury	5.44	1964-1984	21	W	147	381	541	674	820	1,090
					G	134	316	432	528	633	912
					R	261	616	833	1,010	1,200	1,390
01189390	East Branch Salmon Book at Granby	39.1	1955-1956, 1964-1976	15	W	811	2,510	3,920	5,240	6,810	10,800
					G	764	2,450	4,080	5,810	8,130	16,900
					R	1,050	2,620	3,710	4,640	5,660	6,900

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.—Continued

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01189500	Salmon Brook nr Granby[2]	66.9	1947-1963	17	W	1,880	5,240	7,940	10,500	13,600	21,400
					G	1,930	5,780	9,500	13,400	18,800	38,900
					R	1,680	4,260	6,010	7,520	9,200	10,800
01190000	Farmington River at Rainbow (flood control after 1968)	590	1928, 1936-1968	34	W	7,380	19,400	29,400	39,000	50,800	80,300
					G	7,120	18,100	27,300	36,500	48,000	87,500
					R	10,400	26,200	37,200	46,800	58,200	65,900
01190600	Wash Brook at Bloomfield	5.64	1955, 1959-1971	14	W	197	466	663	837	1,030	1,580
					G	198	476	702	921	1,190	2,100
					R	193	449	615	754	896	1,210
01191000	North Branch Park River at Hartford (flood control after 1962)	26.5	1936-1962	27	W	1,080	2,230	3,020	3,720	4,530	6,810
					G	1,150	2,460	3,430	4,330	5,400	8,760
					R	692	1,600	2,200	2,700	3,250	4,310
01192500	Hockanum River nr East Hartford	73.3	1920-1921, 1929-2001	75	W	1,060	2,260	3,040	3,700	4,440	6,670
					G	1,050	2,200	2,940	3,550	4,220	6,040
					R	1,320	2,830	3,870	4,770	5,790	11,000
01192650	Roaring Brook at Hopewell	24.2	1962-1976	15	W	533	1,010	1,330	1,620	1,930	3,060
					G	507	852	1,060	1,240	1,430	1,960
					R	663	1,380	1,830	2,220	2,640	4,790
01192700	Mattabesset River at East Berlin	45.3	1962-1979, [3]1995-1998	22	W	1,520	2,720	3,420	4,010	4,630	5,910
					G	1,590	2,780	3,400	3,880	4,360	5,530
					R	1,140	2,550	3,470	4,240	5,080	6,510
01192883	Coginchaug River at Middlefield	29.7	[4]1962-1980; 1981-2001	40	W	763	1,630	2,140	2,560	3,000	4,040
					G	747	1,550	2,010	2,370	2,750	3,690
					R	977	2,060	2,700	3,250	3,830	5,140
01193500	Salmon River nr East Hampton	101	1929-2001	73	W	2,700	6,240	8,860	11,300	14,100	23,800
					G	2,730	6,460	9,390	12,200	15,500	26,300
					R	2,200	4,550	6,010	7,270	8,700	14,500
01193800	Hemlock Valley Brook at Hadlyme	2.69	1961-1976	16	W	125	256	335	398	464	658
					G	123	245	314	368	424	563
					R	132	280	368	440	515	778

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.—Continued

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01194000	Eightmile River at North Plain	20.2	1938-1984	46	W	843	1,770	2,350	2,850	3,390	4,990
					G	861	1,850	2,500	3,060	3,680	5,400
					R	638	1,360	1,810	2,200	2,610	3,920
01194500	East Branch Eightmile River nr North Lyme	22.4	1938-1982	45	W	646	1,360	1,910	2,420	3,010	4,900
					G	645	1,350	1,900	2,430	3,070	5,180
					R	661	1,450	1,950	2,380	2,840	4,160
01195000	Menunketesuck River nr Clinton	11.3	1938, 1942-1967, 1982	28	W	412	887	1,220	1,510	1,840	2,790
					G	410	873	1,210	1,520	1,890	3,020
					R	431	935	1,240	1,490	1,760	2,410
01195100	Indian River nr Clinton	5.62	1982-2001	20	W	182	426	601	754	926	1,420
					G	176	405	578	738	930	1,530
					R	219	482	646	780	920	1,280
01195200	Neck River nr Madison	6.57	1962-1982	21	W	190	429	592	730	880	1,280
					G	183	401	548	675	818	1,230
					R	236	513	686	831	979	1,350
01196500	Quinnipiac River at Wallingford	110	1931-2001	71	W	2,110	4,210	5,480	6,520	7,640	10,300
					G	2,100	4,100	5,260	6,180	7,140	9,610
					R	2,400	5,300	7,210	8,840	10,700	14,100
01196580	Muddy River nr North Haven	17.8	1963-1976	14	W	703	1,190	1,500	1,750	2,020	2,580
					G	712	1,080	1,280	1,440	1,590	1,990
					R	668	1,400	1,830	2,180	2,560	3,280
01196620	Mill River nr Hamden	24.5	1969-1970, 1979-2001	25	W	926	2,210	3,100	3,870	4,740	7,380
					G	946	2,420	3,580	4,670	5,980	10,200
					R	793	1,680	2,220	2,670	3,150	4,290
01196700	Wepawaug River at Milford	18.6	1962-1984	23	W	657	1,530	2,150	2,700	3,320	4,820
					G	667	1,580	2,280	2,930	3,700	6,100
					R	593	1,390	1,900	2,330	2,780	3,350
01198500	Blackberry River at Canaan (flood control after 1961)	46.0	1949-1961	13	W	1,700	3,760	5,070	6,210	7,470	10,800
					G	1,830	4,190	5,740	7,070	8,550	12,600
					R	1,310	3,160	4,380	5,430	6,610	9,400

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.—Continued

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01199050	Salmon Creek at Lime Rock	29.4	1949, 1955, 1962-2001	42	W	595	1,530	2,270	2,960	3,790	6,690
					G	588	1,510	2,250	2,970	3,850	6,750
					R	684	1,640	2,340	2,930	3,610	6,540
01199200	Guinea Brook at West Woods Rd at Ellsworth	3.50	1960-1981	22	W	103	231	318	393	473	736
					G	96	199	262	314	369	517
					R	151	345	472	579	693	1,240
01200000	Tenmile River nr Gaylordsville	200	1930-1987, 1992-2001	68	W	2,980	6,950	9,860	12,500	15,600	25,200
					G	2,983	6,945	9,832	12,450	15,510	24,740
					R	2,910	6,950	10,000	12,700	15,800	27,600
01201190	West Aspetuck River at Sand Rd nr New Milford	23.8	1963-1972	10	W	419	1,070	1,540	1,950	2,400	4,010
					G	360	842	1,180	1,480	1,820	2,800
					R	648	1,430	1,970	2,420	2,920	5,100
01201500	Still River nr Lanesville	67.6	1932-1966, [5]1967-1984	53	W	1,260	3,080	4,360	5,480	6,760	10,600
					G	1,220	2,940	4,190	5,320	6,630	10,600
					R	2,180	4,170	5,260	6,190	7,250	10,800
01203000	Shepaug River nr Roxbury	132	1931-1984	54	W	2,960	7,140	10,300	13,400	17,000	28,800
					G	2,960	7,210	10,600	14,000	18,000	31,500
					R	3,020	6,670	9,020	11,100	13,500	20,800
01203510	Pootatuck River at Sandy Hook	25.0	1966-1984	19	W	1,250	2,260	2,770	3,180	3,610	4,900
					G	1,290	2,390	2,970	3,410	3,860	4,940
					R	1,040	1,980	2,460	2,870	3,310	4,850
01204000	Pomperaug River at Southbury	75.3	1933-2001	69	W	2,750	6,100	8,400	10,400	12,800	20,800
					G	2,810	6,490	9,190	11,600	14,600	23,400
					R	1,790	3,600	4,740	5,720	6,840	12,200
01204800	Copper Mill Brook nr Monroe	2.45	1959-1976	18	W	151	278	347	402	456	596
					G	148	257	312	352	391	483
					R	166	330	414	484	554	768
01206000	Naugatuck River nr Thomaston	71.9	1931-1959	29	W	3,120	6,600	8,990	11,100	13,600	20,300
					G	3,260	7,120	10,000	12,600	15,800	25,600
					R	2,200	5,040	6,780	8,300	10,000	12,900

Table 9. Weighted flood-frequency estimates for selected recurrence intervals at streamflow-gaging stations in Connecticut and the flood-flow estimates derived from the regression equations and a log-Pearson Type III analysis of the annual maximum flows at the streamflow-gaging station.—Continued

[Method (for estimating flood flow): W, weighted averages; G, streamflow-gaging station log-Pearson Type III analysis; R, regression estimate. Weighted flood-frequency estimates are generally more accurate than nonweighted estimates at stations with short periods of record. Flood-flow frequency estimates are based on 10 or more years of unregulated flow record. Stations with flood control were defined as basins with usable storage of more than 4.5 million cubic feet per square mile. Flood-flow frequency values are rounded to three significant figures. mi^2, square miles; N, number of annual peak flows at gaging station; ft^3/s, cubic feet per second; nr, near]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record used in analysis	Number of flood flows (years) (N)	Method	Flood-flow frequency estimates for given recurrence interval (ft^3/s)					
Number	Name					2 years	10 years	25 years	50 years	100 years	500 years
01206500	Leadmine Brook nr Thomaston	24.5	1931-59, [6]1960-1984	54	W	1,220	3,160	4,590	5,920	7,470	12,100
					G	1,240	3,320	5,010	6,640	8,640	15,200
					R	989	2,250	2,990	3,620	4,310	5,330
01208500	Naugatuck River at Beacon Falls (flood control after 1959)	260	1920-1959	40	W	8,270	18,800	26,000	32,500	40,000	63,400
					G	8,620	20,700	29,900	38,400	48,500	80,200
					R	5,170	11,500	15,500	19,200	23,300	33,700
01208850	Pequonnock River at Trumbull	15.5	1955, 1962-1984	24	W	718	1,610	2,150	2,600	3,080	4,380
					G	732	1,720	2,380	2,950	3,580	5,340
					R	629	1,320	1,710	2,040	2,390	3,180
01208925	Mill River nr Fairfield	28.6	1973-2001	29	W	702	1,620	2,180	2,620	3,090	4,130
					G	679	1,530	2,020	2,390	2,780	3,740
					R	928	2,010	2,660	3,210	3,820	5,000
01208950	Sasco Brook nr Southport	7.38	1960-2001	42	W	271	708	1,050	1,360	1,730	2,880
					G	270	728	1,120	1,500	1,970	3,580
					R	279	614	823	996	1,180	1,570
01208990	Saugatuck River nr Redding	20.7	1962-2001	40	W	607	1,290	1,690	2,000	2,340	3,220
					G	586	1,220	1,580	1,860	2,160	2,900
					R	899	1,730	2,160	2,540	2,940	4,280
01209500	Saugatuck River nr Westport	79.5	1933-1967	35	W	1,600	4,060	5,740	7,180	8,800	13,400
					G	1,540	3,950	5,680	7,220	8,990	14,200
					R	2,290	4,600	5,940	7,080	8,350	11,800
01209700	Norwalk River at South Wilton	29.9	1956, 1963-2001	40	W	1,020	2,300	3,120	3,830	4,600	6,830
					G	1,010	2,320	3,220	4,000	4,880	7,390
					R	1,080	2,180	2,800	3,330	3,900	5,520
01211700	East Branch Byram River at Round Hill	1.69	1960-1975	16	W	102	227	304	368	433	615
					G	100	225	306	376	452	663
					R	109	232	301	357	413	568
01212100	East Branch Byram River at Riversville	11.2	1963-1984	22	W	550	1,310	1,750	2,100	2,470	3,440
					G	567	1,450	2,020	2,490	3,000	4,340
					R	453	985	1,300	1,560	1,840	2,450

[1]Discharge is a maximum daily average.
[2]Gaging station formerly published under the name West Branch Salmon Brook at Granby, Connecticut.
[3]1995–1998 streamflow data collected at station 01192704, Mattabesset River at Rt. 372 at East Berlin adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).
[4]1962–1980 streamflow data collected at station 01192890, Coginchaug River at Rockfall adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).
[5]1967–1984 streamflow data collected at station 01201510, Still River at Lanesville adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).
[6]1960–1984 streamflow data collected at station 01206400, Leadmine Brook near Harwinton adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).

Evaluation of the Streamflow-Gaging Network for Characterizing Flood Flows

The statewide streamflow-gaging network is a multipurpose network funded by federal, state, and local agencies to meet numerous water-resources management goals. The streamflow-gaging network is a major component of many hydrologic investigations, including (1) water-resources design, (2) regional flood analysis, flood warning, and flood-plain mapping, (3) water-supply evaluation, (4) stream classification and restoration, (5) water-quality management, (6) aquatic-habitat improvements, (7) enhanced operations of dams, (8) long-term environmental change, (9) verification and calibration of hydrologic models, and (10) watershed analysis. During the last 10 or 15 years, uncertainties in funding and other factors have led to a fragmented network of stations with shorter periods of record on which to improve the flood-frequency estimates. Questions as to whether an adequate number of gaging stations are in operation across the State, and as to whether the full range of geographic and hydrologic conditions are represented by the current network, have been raised by state and local water-resource agencies. To address these concerns, a streamflow-gaging network evaluation was performed as part of this study. Although the network serves many purposes, this evaluation focuses on whether the number of gaging stations and range of geographic and hydrologic conditions represented by the network are adequate to meet federal and state goals related to regional flood analysis. Regional flood analysis is used to transfer flood characteristics, such as the 100-year flood discharge, from gaged to ungaged sites by relating flood characteristics to basin or climatic characteristics. It is important to emphasize that data from discontinued streamflow-gaging stations continue to provide information for characterizing floods and are used in regional flood analysis. An evaluation that summarizes the variety of users and uses of flow data at each individual station currently in operation was beyond the scope of this study.

The current (2004) network in Connecticut consists of 54 streamflow-gaging stations. Overall, the majority of the stations (51 of 54) in the network meet one or more federal, state or local agency needs for information on floods: flood forecasting (hazard warning), flood-plain mapping and management, operation and management of flood-control reservoirs, engineering design, evaluation of stream stability and scour, verification and calibration of hydrologic models, and flood research. About 20 stations with real-time telemetry are used by the National Weather Service and Connecticut DEP to issue flood warnings ensuring that lives and property are protected during floods. Another 10 stations are used for the operation and management of flood-control reservoirs by the U.S. Army Corps of Engineers. Only three stations were identified as providing minimum information for characterizing floods.

Because the number of ungaged basins will always far exceed the number of gaged basins, a core set of USGS streamflow-gaging stations that can be used for transferring flood characteristics from gaged to ungaged sites is needed. Core stations are most representative of natural hydrologic conditions, have long periods of record, and represent various hydrologic, geologic, and physiographic regions of the state. Data from core stations often are used as substitute (or surrogate) stations for other locations where no streamflow-gaging stations are present. Generally, these stations have important value for flood applications and meet the needs of many federal and state flood-management goals.

Twenty-five stations in the current network that are unregulated (not affected by appreciable flood control) and have long periods of record (greater than 10 years) are considered core stations and can be used for regional flood analysis. The USGS considers the 25 core stations high-priority stations because of their scientific value for improving our understanding of floods. Only 24 of the 25 core stations were used in the regional regression analysis of nonurban basins; one station (01203600 Nonnewaug River at Minortown) was deleted from the analysis because the stage-discharge relation is not yet well-defined at high flows. This station is a core station because it represents natural (flood) flow conditions and can be used for future regional flood analysis. Two additional stations (01201487 Still River at Brookfield Center and 01203805 Weekeepeemee River at Hotchkissville) in the current network will be considered core stations in time with continued operation, but as of 2004, the periods of record associated with these two stations are less than 10 years. Three other stations (01195490 Quinnipiac River at Southington, 01208873 Rooster River at Fairfield, and 01209901 Rippowam River near Stamford) in the current network can be used for urban flood analysis and also considered to be high priority because of their scientific value to the understanding of floods in urbanized areas.

Conducting regional flood analysis requires long-term records of streamflow from a diverse set of locations. Flood characteristics may vary substantially between regions because of differences in the climate, elevation, land cover, geology, and topography. To improve the transfer information for floods from gaged to ungaged sites, the streamflow-gaging network should include: (1) stations that represent different physiographic regions and the regional basins, (2) stations that are operated for extended periods of time (greater than 10 years), and (3) stations that represent various combinations of basin sizes, land-cover types, and hydrologic and geologic characteristics. To evaluate whether the number of gaging stations and range of geographic and hydrologic conditions are adequately represented by the current network, the spatial coverage of the network, the length of record of the gaging stations, and the drainage-basin characteristics associated with the gaging stations were assessed (table 10). Data layers of topography, geology, land cover, and rainfall were used to evaluate the spatial coverage and the drainage-basin characteristics represented by these stations. The goal of this network evaluation is to define geographical gaps, check for possible overlaps in the current network, and develop strategies for improving the network coverage for transferring flood characteristics.

Table 10. Streamflow-gaging stations in the current (2004) network that most represent natural hydrologic conditions for regional flood analysis in Connecticut.

[Table includes 27 stations for regional analysis of nonurban basins and 3 stations for regional analysis of urban basins. Latitude/longitude given in degrees (°), minutes (’) and seconds (”)]

Station number	Station name	Drainage area (square miles)	Period of record (water year)	Latitude/ Longitude	Town
		Pawcatuck River Basin			
01118300	Pendleton Hill Brook near Clarks Falls, Conn.	4.01	1959-2004	Lat 41°28’30”, long 71°50’03”	North Stonington
		Thames River Basin			
01119500	Willimantic River near Coventry, Conn.	122	1932-2004	Lat 41°45’02”, long 72°15’56”	Mansfield
01121000	Mount Hope River near Warrenville, Conn.	29.0	1938, 1941-2004	Lat 41°50’37”, long 72°10’08”	Ashford
01123000	Little River near Hanover, Conn.	30.0	1936, 1938, 1952-2004	Lat 41°40’16”, long 72°03’11”	Canterbury
01127500	Yantic River at Yantic, Conn.	89.2	1931-2004	Lat 41°33’32”, long 72°07’18”	Norwich
		Connecticut River Basin			
01184100	Stony Brook near West Suffield, Conn.	10.5	1955, 1960-2004	Lat 41°57’39”, long 72°42’38”	Suffield
01184490	Broad Brook at Broad Brook, Conn.	15.6	1938, 1962-1976, 1982-2004	Lat 41°54’50”, long 72°32’58”	East Windsor
01187300	Hubbard River near West Hartland, Conn.	20.6	[1]1938-1954, 1955, 1957-2004	Lat 42°02’15”, long 72°56’22”	Hartland
01188000	Burlington Brook near Burlington, Conn.	4.20	1932-2004	Lat 41°47’10”, long 72°57’54”	Burlington
01189000	Pequabuck River at Forestville, Conn.	45.7	1938, 1942-2004	Lat 41°40’24”, long 72°53’59”	Bristol
01192500	Hockanum River near East Hartford, Conn.	73.3	1920-1921, 1929-2004	Lat 41°46’60”, long 72°35’13”	East Hartford
01192883	Coginchaug River at Middlefield, Conn.	29.7	[2]1981-2004	Lat 41°31’12”, long 72°42’22”	Middlefield
01193500	Salmon River near East Hampton, Conn.	101	1929-2004	Lat 41°33’08”, long 72°26’56”	East Hampton
01194500	East Branch Eightmile River near North Lyme, Conn.	22.4	1938-1982, 2002-2004	Lat 41°25’39”, long 72°20’06”	Lyme
		South-Central Coastal Basins			
01195100	Indian River near Clinton, Conn.	5.62	1982-2004	Lat 41°18’21”, long 72°31’52”	Clinton
01195490	Quinnipiac River at Southington, Conn.[3]	17.8	1988-2004	Lat 41°36’13”, long 72°52’59”	Wallingford
01196500	Quinnipiac River at Wallingford, Conn.	110	1931-2004	Lat 41°22’07”, long 72°50’30”	Wallingford
01196620	Mill River near Hamden, Conn.	24.5	1969-1970, 1979-2004	Lat 41°25’15”, long 72°54’12”	Hamden
		Housatonic River Basin			
01199050	Salmon Creek at Lime Rock, Conn.	29.4	1949, 1955, 1962-2004	Lat 41°56’32”, long 73°23’28”	Salisbury
01200000	Tenmile River near Gaylordsville, Conn.	200	1930-1933, 1935-1987, 1992-2004	Lat 41°39’32”, long 73°31’44”	Wingdale, N.Y.
01201487	Still River at State Route 7 at Brookfield Center, Conn.	62.3	[4]2002-2004	Lat 41°27’58”, long 73°24’13”	Brookfield

Table 10. Streamflow-gaging stations in the current (2004) network that most represent natural hydrologic conditions for regional flood analysis in Connecticut.—Continued

[Table includes 27 stations for regional analysis of nonurban basins and 3 stations for regional analysis of urban basins. Latitude/longitude given in degrees (°), minutes (’) and seconds (”)]

Station number	Station name	Drainage area (square miles)	Period of record (water year)	Latitude/ Longitude	Town
			Housatonic River Basin—Continued		
01203600	Nonnewaug River at Minortown, Conn.	17.7	1955, 1963-1976, 1979, 2001- 2004	Lat 41°34’32”, long 73°10’45”	Woodbury
01203805	Weekeepeemee River at Hotchkissville, Conn.	26.8	[5]1979, 2001-2004	Lat 41°33’26”, long 73°12’57”	Woodbury
01204000	Pomperaug River at Southbury, Conn.	75.3	1933-2004	Lat 41°28’54”, long 73°13’29”	Southbury
			Southwest Coastal Basins		
01208873	Rooster River at Fairfield, Conn. [3]	10.6	1978-2004	Lat 41°10’47”, long 73°13’10”	Trumbull
01208925	Mill River near Fairfield, Conn.	28.6	1973-2004	Lat 41°09’55”, long 73°16’13”	Fairfield
01208950	Sasco Brook near Southport, Conn.	7.38	1960-2004	Lat 41°09’10”, long 73°18’21”	Westport
01208990	Saugatuck River near Redding, Conn.	20.7	1962-2004	Lat 41°17’40”, long 73°23’42”	Redding
01209700	Norwalk River at South Wilton, Conn.	29.9	1956, 1963-2004	Lat 41°09’50”, long 73°25’11”	Wilton
01209901	Rippowam River at Stamford, Conn.[3]	34.0	1976, 1978-82, 2002-2004	Lat 41°03’59”, long 73°32’59”	Stamford

[1]Annual maximum flow for these water years is a maximum daily average.
[2]Annual maximum data for 1962–1980 collected at station 01192890, Coginchaug River at Rockfall, drainage area of 34.7 square miles.
[3]Station data can be used for urban flood-frequency analysis.
[4]Less than 10 years of record. Annual maximum data for 1932–1966 collected at station 01201500, Still River near Lanesville, drainage area of 67.5 square miles; for 1967–1971 collected at station 01201510, Still River at Lanesville, drainage area of 69.8 square miles.
[5]Less than 10 years of record.

Spatial Coverage

The spatial coverage of the core stations in the network (in 2004) contains large gaps (fig. 8). The gaps are in the central and southeastern coastal regions (a band about 10 to 15 mi inland from Long Island Sound), the northwestern region, and the far northeastern regions of the state. In addition, 10 regional basins that are unaffected by extensive flood-control regulation (and, therefore, potentially valuable for estimating floods) are ungaged: Fivemile River Basin (drainage area 76.6 mi^2), Moosup River Basin (drainage area 89.3 mi^2). Pachaug River Basin (drainage area 63.1 mi^2), Scantic River Basin (drainage area 114 mi^2), Park River Basin (drainage area 76.2 mi^2), Mattabessett River Basin (drainage area 108 mi^2), Hollenbeck River Basin (drainage 42.3 mi^2), Candlewood River Basin (drainage 40.4 mi^2), Aspetuck River Basin (drainage area 50.6 mi^2), and Shepaug River Basin (drainage area 156 mi^2). One subregional basin—Hop River Basin, with a drainage area of 80.2 mi^2—is identified in the spatial coverage analysis because of its size.

Record Lengths

The longer the period of record for a station, the greater the accuracy in estimating flood probabilities, especially those in the 50- to 100-year recurrence interval. Estimates based on shorter periods of record are generally not used because they may be more representative of a particular series of unusually wet or dry years. Ten years of flood-flow values is generally accepted as a minimum requirement for developing a flood-probability estimate (Interagency Advisory Committee on Water Data, 1982). The continuous operation of stations has fluctuated from year to year. Streamflow-gaging stations are often discontinued or have breaks in the systematic record. It must be emphasized that the continuity of the record of the gaging station also increases the value of the data from the station. Although there are considerably fewer streamflow-gaging stations operating today than in the early 1970s that can be used to transfer flood information from gaged to ungaged sites in Connecticut, the streamflow-gaging records are longer and therefore improve some of the uncertainty in estimating the magnitude and frequency of floods.

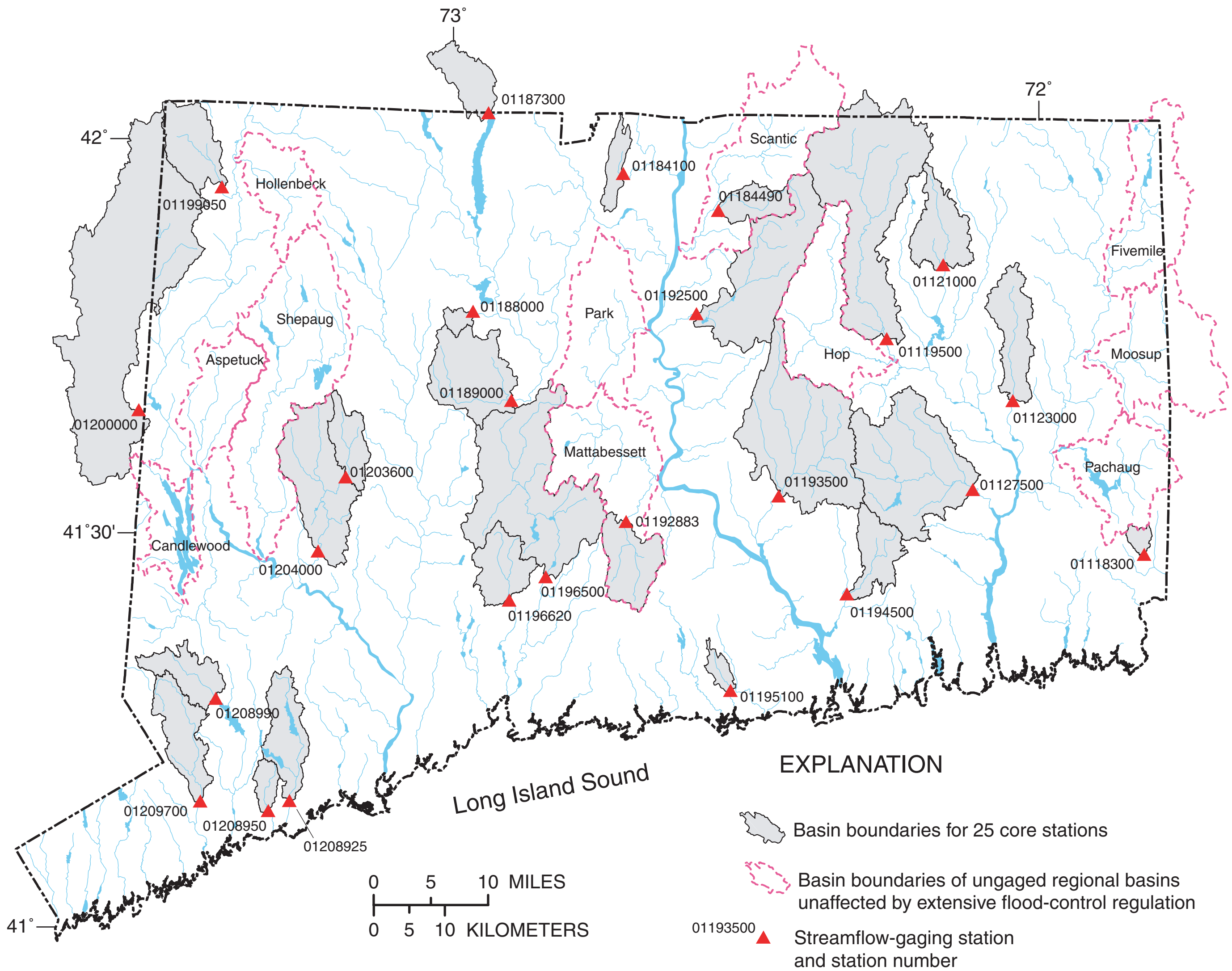

Figure 8. Locations of the 25 core streamflow-gaging stations for flood analysis of nonurban basins, and ungaged regional basins unaffected by extensive flood-control regulation in Connecticut. [Hop River Basin is a subregional basin.]

As of water year 2004, the number of years of record associated with the 25 core stations ranges from 23 to 78 years with an average of 54 years. Eight stations have record lengths longer than 70 years, 3 stations have record lengths from 50 to 70 years; 11 stations have record lengths from 30 to 50 years; and 3 stations have record lengths less than 30 years. About 15 percent of the core stations in the current network have gaps in their systematic records.

Drainage-Basin Characteristics

The streamflow-gaging network is designed to cover a wide range of selected basin characteristics and represent various stream types and basins—from steep, mountainous streams to low gradient, meandering streams; from small streams to large rivers; and from mostly forested to urban environments. Regionalization studies in New England have shown that the most common drainage basin and climatic characteristics used to estimate flows are drainage area, main channel slope, 24-hour rainfall, mean basin elevation, percentage of basin area covered by forest, and percentage of basin area classified as coarse-grained stratified glacial deposits.

The core stations in the current (2004) network represent a narrow range of stream types and basin characteristics for Connecticut. For example, the range of basin sizes in the current network is small (fig. 9). No basins have drainage areas smaller than 4.0 mi^2 or larger than 200 mi^2, and only three basins have drainage areas from 35 to 70 mi^2 or larger than 125 mi^2 (fig. 9). The distribution of drainage areas is skewed to smaller size basins partly because many larger basins in Connecticut have streamflows that are regulated by flood-control dams and these basins cannot be used to estimate regional flood-flow characteristics.

Mean basin elevation and main channel slope appear to be adequately represented by the current network of core stations, except that stations at higher elevations (above a mean of 800 ft above NAVD 88) or in mountainous terrain where main channel slopes can be greater than 75 ft/mi are not well represented (fig. 9 and 10). Of the 25 core stations, mean basin elevations range from 230 to 1,290 ft; only four stations have a mean basin elevation above 800 ft and a main channel slope greater than 75 ft/mi. The distribution of mean basin elevation and main channel slope is slightly skewed to stations with elevations from 200 to 650 ft and lower gradient channel slopes from 10 to 70 ft/mi. Many basins with mean elevations less than 200 ft are tidally affected and cannot be used to estimate regional flood-flow characteristics.

Urban basins are not well represented by the network of core stations. Currently, only three gaging stations (01195490—Quinnipiac River at Southington, 01208873—Rooster River at Fairfield, and 01209910—Rippowam River at Stamford) that cover a combined drainage area of 62.5 mi^2 represent urban basins in Connecticut. Urban basins, as defined for this study, have more than 15 percent of their drainage area designated as commercial, industrial, or high-intensity residential development. In Connecticut, 255 mi^2 of the land cover is classified as commercial, industrial, or high-intensity residential development. The total area of the drainage basins associated with the 255 mi^2 of urban land cover is considerable greater. By contrast, forested basins are better represented, except for basins with more than 75-percent forest cover and less than 40-percent forest cover (figs. 9 and 11).

Coarse-grained stratified glacial deposits in Connecticut are concentrated along streams and in the valleys and, therefore, do not make up a large percentage of the surficial geologic deposits in the state. Although a small percentage of the Connecticut's surficial geologic materials consists of coarse-grained stratified glacial deposits, the percentage of basin area containing more than 15-percent coarse-grained stratified glacial deposits appears to be slightly underrepresented by the core stations (fig. 9). About two-thirds of the basins have less than 15-percent coarse-grained stratified glacial deposits.

Overall, the network is near or is at its minimum capability to adequately support the critical needs of engineers and water-resources managers in federal, state, and local agencies. Enhancements to the network to improve overall effectiveness for characterizing floods can be made by increasing the density of gages, establishing stations in regions that are not well-represented, and maintaining the continuity of the records. It should be pointed out that no core station was identified that duplicates or only slightly improves information available from another core station.

The effectiveness of the active network to estimate flood flows could be increased by reactivating streamflow-gaging stations that were previously discontinued and (or) by augmenting the network with a crest-stage gaging station network, thereby increasing the percentage of drainage area covered by gaging stations in different physiographic regions. A crest-stage gaging station is one where discrete measurements of flood stage and streamflow are collected over a period of time without continuous data being recorded or computed (Buchanan and Somers (1968). Generally, the cost of installing, maintaining, and operating a crest-stage gaging station is about 10 to 20 percent the cost of a continuous-record gaging station. Reactivated (discontinued) gaging stations and crest-stage gaging stations can be used to fill spatial gaps in the network and provide current statistical information on floods.

The network evaluation discussed above does not represent a complete evaluation of the capacity of the streamflow-gaging network to meet all federal, state, and local agency needs for streamflow information, nor does it reflect an assessment of the full range of streamflow-gaging stations uses and needs. No attempt was made to evaluate the economic elements of the network. A complete evaluation of the network to meet all needs for streamflow information was beyond the scope of this study.

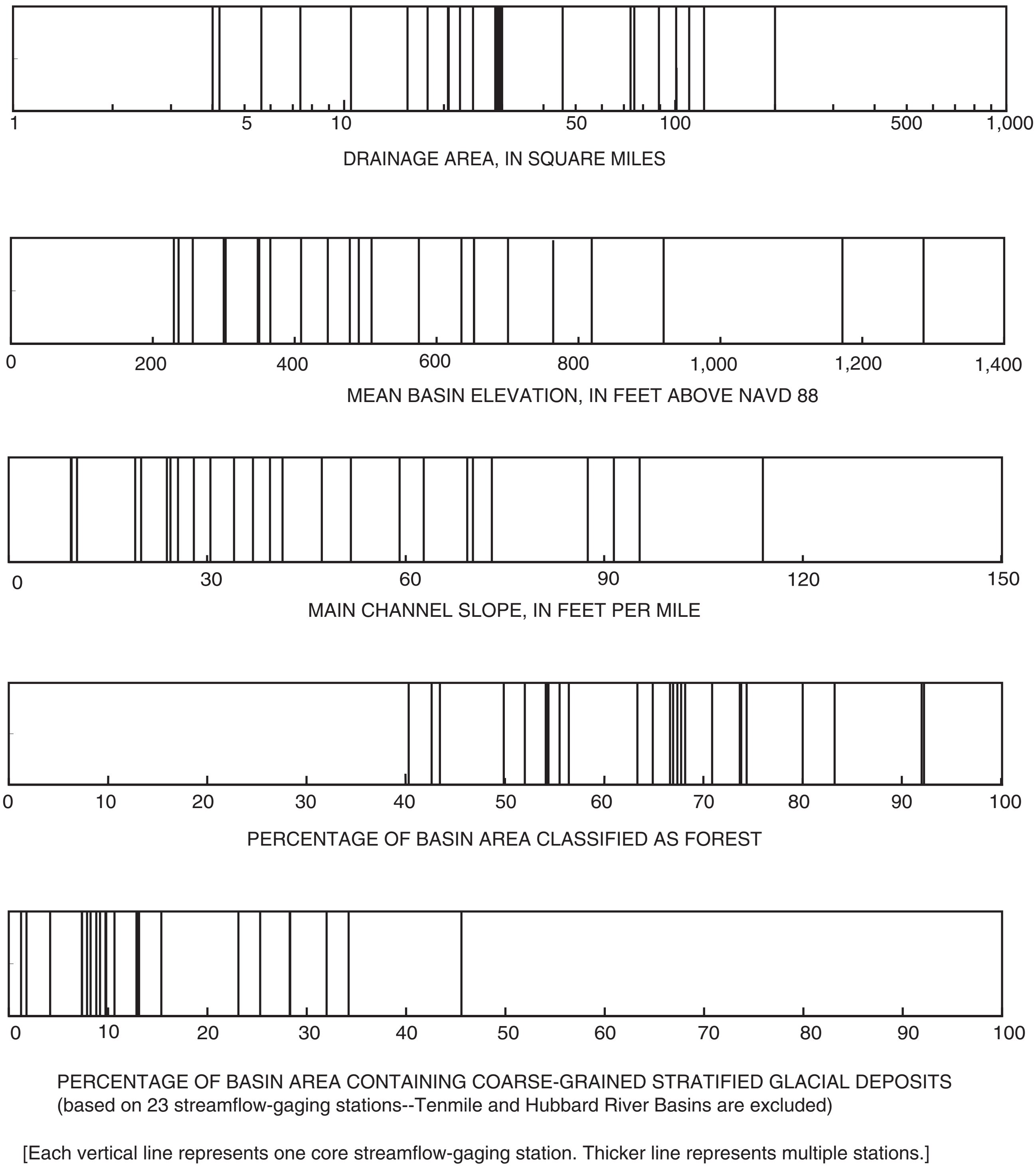

Figure 9. The distribution of the basin characteristics of the 25 core streamflow-gaging stations for flood analysis in Connecticut.

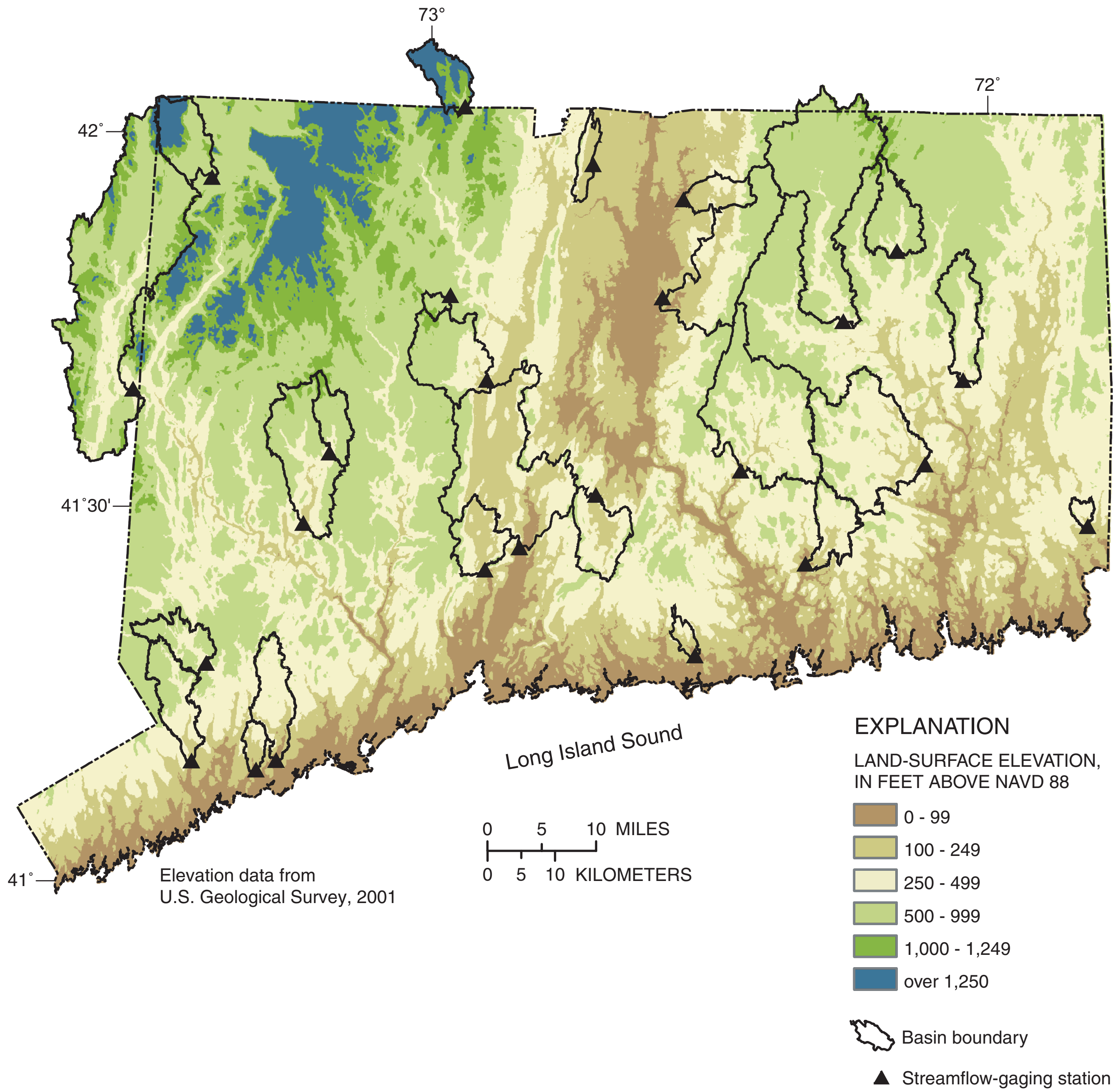

Figure 10. Land-surface elevations with locations of the 25 core streamflow-gaging stations for flood analysis in Connecticut.

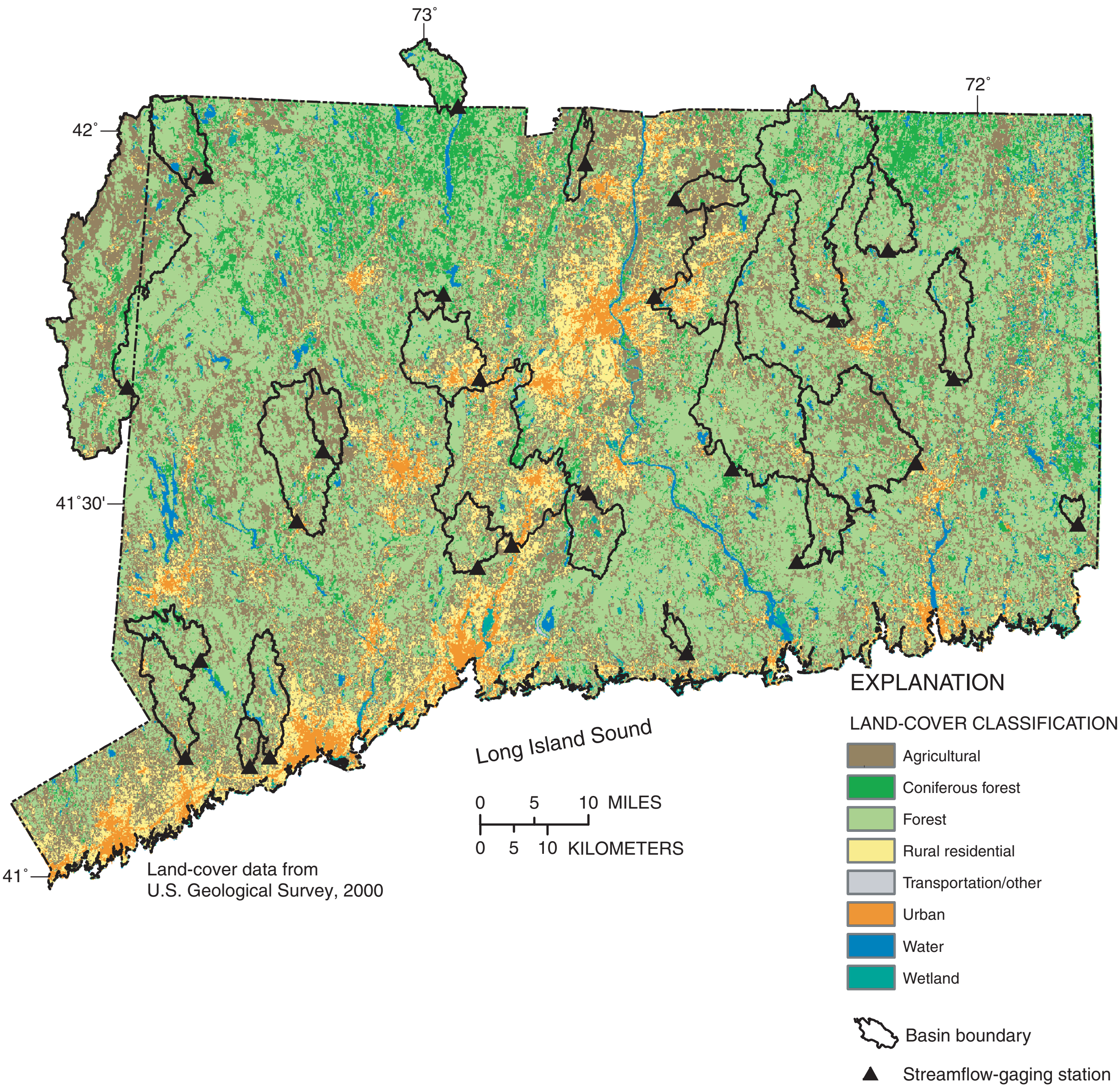

Figure 11. Land-cover data with locations of the 25 core streamflow-gaging stations for flood analysis in Connecticut.

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Summary and Conclusions

Updated regression equations for calculating the magnitude of flood flows in Connecticut for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals were developed by the U.S. Geological Survey, in cooperation with the Connecticut Department of Transportation and Department of Environmental Protection. Flood-flow frequency data and hydrologic characteristics from 70 streamflow-gaging stations and the upstream drainage basins were used to develop the equations using generalized least-squares regression analysis. The final equations were chosen on the basis of Mallow Cp statistic, the Predicted Residual Sum of Squares statistic, adjusted R-squared, the degree of collinearity, and an analysis of the regression residuals. The equations relate flood flows to three hydrologic characteristics—drainage area, 24-hour rainfall, and mean basin elevation—that were determined using digital data. Average standard errors of prediction for the regression equations range from 31.8 (2-year frequency) to 45.0 percent (500-year frequency). The final equations were compared to previously published equations and generally were found to be more accurate. The regression equations are suitable for estimating flood flows for nonurban, unregulated stream sites where flood-control structures or other man-made factors do not appreciably affect the natural flood flows. The equations should be used within the range of the explanatory variables used to develop the equations. Furthermore, the characteristics should be determined in a manner as consistent as possible with the methods used in this study to preserve the statistical validity of the estimating procedures. Simplified equations using only one hydrologic characteristic—drainage area—also were developed.

The applicability of previously developed, national three and seven-variable regression equations designed for urban basins used in conjunction with the new statewide equations was evaluated. Observed flows were compared to flows estimated from the three- and seven-variable urban regression equations at five streamflow-gaging stations in urban basins. The comparison shows that both the three- and seven-variable urban equations generally provide reasonable estimates of flood flows; however, this result is not an indication that the national equations provide unbiased estimates of flood flows in Connecticut. Future studies could attempt to verify the accuracy of the three-variable urban regression equations and (or) develop more simplified urban regression equations than the seven-variable regression equations for the northeastern United States.

Flood flows were computed for 70 streamflow-gaging stations for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals using a weighted average. The weighted average was determined by combining the flood-flow frequency estimate from a log-Pearson Type III analysis of the annual maximum flood flows for a gaging station with the estimate from the regression equations. Generally, a weighted average provides the best estimate of flood flows, particularly for stations with short length of records.

It is important that water-resource managers, planners, engineers, and emergency management officials have the most accurate and current statistical information on floods. The streamflow-gaging station network was studied to evaluate the capacity of the network to provide better estimates of floods at ungaged sites in Connecticut. Increasing the spatial coverage of streamflow-gaging stations to include stations in basins that are not well represented, as well as continuing operations at the core stations, will increase the capacity of the network to provide a better understanding of flood flows in the region. Enhancements to the current network could include adding gaging stations with drainage-basin sizes not well represented (drainage basins less than 4.0 square miles (mi^2), from 35 to 70 mi^2, and greater than 125 mi^2), and adding stations in regions not well represented (mountainous terrain, coastal areas, and urban areas). Further enhancements to the streamflow-gaging network could include adding crest-stage gaging stations or reactivating discontinued gaging stations.

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Table 1

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
1	01118300	Pendleton Hill Brook near Clarks Falls, Conn.	Lat 41°28'30", long 71°50'03"	North Stonington	New London County, Hydrologic Unit 01090005, on left bank just upstream from twin culverts on Grindstone Hill Road, 0.1 mi west of State Route 49 in the township of North Stonington, 1.6 mi northwest of Clarks Falls, and 3.4 mi northeast of village of North Stonington.
2	01119500	Willimantic River near Coventry, Conn.	Lat 41°45'02", long 72°15'56"	Mansfield	Tolland County, Hydrologic Unit 01100002, on left bank 700 ft upstream from bridge on State Route 31, 1 mi downstream from Mill Brook, 2.4 mi southeast of South Coventry, 2.8 mi upstream from Hop River and 6.3 mi upstream from mouth.
3	01120000	Hop River near Columbia, Conn.	Lat 41°43'39", long 72°18'09"	Columbia	Tolland County, Hydrologic Unit 01100002, 1,500 ft downstream from Hop River Village near Columbia.
4	01120500	Safford Brook near Woodstock Valley, Conn.	Lat 41°55'35", long 72°03'35"	Woodstock	Windham County, Hydrologic Unit 01100002, on right bank at downstream side of bridge on Hopkins Road, 0.3 mi downstream from Bradford Brook, 0.3 mi upstream from mouth, and 2 mi southwest of West Woodstock.
5	01121000	Mount Hope River near Warrenville, Conn.	Lat 41°50'37", long 72°10'08"	Ashford	Windham County, Hydrologic Unit 01100002, on left bank 250 ft downstream from Knowlton Brook, 700 ft upstream from bridge on State Route 89, 1.8 mi south of Warrenville, and 3.2 mi southwest of Ashford.
6	01122000	Natchaug River at Willimantic, Conn.	Lat 41°43'11", long 72°11'46"	Windham	Windham County, Hydrologic Unit 01100002, on left bank at upstream side of bridge on State Route 66, 1 mi northeast of Willimantic, 1.6 mi upstream from mouth, and 3.7 mi downstream from Mansfield Hollow Dam.
7	01122500	Shetucket River near Willimantic, Conn.	Lat 41°42'01", long 72°10'57"	Windham	Windham County, Hydrologic Unit 01100002, on right bank at downstream side of Bingham Bridge on Plains Road, 500 ft upstream from Penn. Central Co. railroad bridge, 500 ft downstream from Potash Brook, 1.3 mi downstream from confluence of Willimantic and Natchaug Rivers, 1.5 mi southeast of Willimantic, and 17 mi upstream from mouth.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
8	01123000	Little River near Hanover, Conn.	Lat 41°40'16", long 72°03'11"	Canterbury	Windham County, Hydrologic Unit 01100002, on left bank 800 ft upstream from bridge on Hanover Road, 0.7 mi downstream from Peck Brook, 2.3 mi northeast of Hanover, and 6.5 mi upstream from mouth.
9	01124000	Quinebaug River at Quinebaug, Conn.	Lat 42°01'20", long 71°57'22"	Thompson	Windham County, Hydrologic Unit 01100001, on right bank at Quinebaug, 500 ft upstream from bridge on State Route 197, 0.2 mi downstream from Massachusetts-Connecticut State line, 7.8 mi upstream from French River, and at river mile 46.
10	01125490	Little River at Harrisville, Conn.	Lat 41°55'40", long 71°55'49"	Putnam	Windham County, Hydrologic Unit 01100001, at bridge on Tripp Road, 0.5 mi east of Harrisville.
11	01125500	Quinebaug River at Putnam, Conn.	Lat 41°54'33", long 71°54'48"	Putnam	Windham County, Hydrologic Unit 01100001, on right bank at Putnam, 0.15 mi downstream from Little River, 0.3 mi upstream from former railroad bridge, 2.8 mi downstream from French River, 3.0 mi downstream from West Thompson Dam, and 36 mi upstream from mouth.
12	01125600	Mashamoquet Brook at Abington, Conn.	Lat 41°52'27", long 72°00'34"	Pomfret	Windham County, Hydrologic Unit 01100001, at bridge on Taft Pond Road, 1 mi north of Abington.
13	01126000	Fivemile River at Killingly, Conn.	Lat 41°50'14", long 71°53'08"	Killingly	Windham County, Hydrologic Unit 01100001, at Penn. Central Railroad Co. bridge, 0.6 mi south of Killingly.
14	01126500	Moosup River at Moosup, Conn.	Lat 41°42'38", long 71°53'10"	Plainfield	Windham County, Hydrologic Unit 01100001, at Kaman Aircraft Corp. at Moosup.
15	01126600	Blackwell Brook near Brooklyn, Conn.	Lat 41°45'55", long 71°57'24"	Brooklyn	Windham County, Hydrologic Unit 01100001, on left bank 75 ft upstream from bridge on State Highway 169, 1.5 mi south of Brooklyn.
16	01127000	Quinebaug River at Jewett City, Conn.	Lat 41°35'52", long 71°59'05"	Griswold	New London County, Hydrologic Unit 01100001, on left bank behind high school on Slater Avenue at Jewett City, 570 ft downstream from outlet of canal from Wedgewood Mills at mouth of Pachaug River, 1,000 ft downstream from railroad bridge and at river mile 6.1.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
17	01127500	Yantic River at Yantic, Conn.	Lat 41°33’32”, long 72°07’18”	Norwich	New London County, Hydrologic Unit 01100003, on left bank at Yantic, 700 ft downstream from stone-arch highway bridge, 1 mi downstream from Susquetonscut Brook, and 4.8 mi upstream from mouth.
18	01184100	Stony Brook near West Suffield, Conn.	Lat 41°57’39”, long 72°42’38”	Suffield	Hartford County, Hydrologic Unit 01080205, at bridge on South Grand Street, 2.1 mi south of West Suffield.
19	01184300	Gillette Brook at Somers, Conn.	Lat 41°59’31”, long 72°26’04”	Somers	Tolland County, Hydrologic Unit 01080205, at twin culverts on Battle Street, 0.7 mi northeast of Somers.
20	01184490	Broad Brook at Broad Brook, Conn.	Lat 41°54’50”, long 72°32’58”	East Windsor	Hartford County, Hydrologic Unit 01080205, on left bank just upstream from bridge on State Route 191 (Mill Street) at Broad Brook, 0.5 mi upstream from mouth.
21	01184500	Scantic River at Broad Brook, Conn.	Lat 41°54’42”, long 72°33’46”	East Windsor	Hartford County, Hydrologic Unit 01080205, 300 ft upstream from bridge on State Highway 191, at Broad Brook.
22	01186500	Still River at Robertsville, Conn.	Lat 41°58’01”, long 73°02’02”	Colebrook	Litchfield County, Hydrologic Unit 01080207, on left bank 1,500 ft downstream from Sandy Brook, 1 mi southeast of Robertsville, 1 mi northwest of Riverton, and 1 mi upstream from mouth.
23	01187000	West Branch Farmington River at Riverton, Conn.	Lat 41°57’14”, long 73°00’50”	Barkhamsted	Litchfield County, Hydrologic Unit 01080207, on right bank 0.4 mi downstream from Still River, 0.6 mi south of Riverton.
24	01187300	Hubbard River near West Hartland, Conn.	Lat 42°02’15”, long 72°56’22”	Hartland	Hartford County, Hydrologic Unit 01080207, on left bank at Massa-chusetts-Connecticut Stateline, 800 ft upstream from bridge on State Route 20, 0.5 mi upstream from confluence with Valley Brook, and 2.6 mi northeast of West Hartland.
25	01187400	Valley Brook near West Hartland, Conn.	Lat 42°02’04”, long 72°55’48”	Hartland	Hartford County, Hydrologic Unit 01080207, on right bank just upstream from bridge on State Highway 20, 0.25 mi south of Massa-chusetts-Connecticut State Line, 0.3 mi upstream from confluence with Hubbard River, and 2.25 mi northeast of West Hartland.
26	01187800	Nepaug River near Nepaug, Conn.	Lat 41°49’15”, long 72°58’13”	New Hartford	Litchfield County, Hydrologic Unit 01080207, beside U.S. Highway 202, 0.2 mi upstream from Nepaug Reservoir.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
27	01188000	Burlington Brook near Burlington, Conn.	Lat 41°47'10", long 72°57'54"	Burlington	Hartford County, Hydrologic Unit 01080207, on left bank 1.2 mi north of Burlington, 3 mi upstream from mouth, 2,000 ft east of the intersection of Covey Road and Hotchkiss Road, and 3 mi southwest of Collinsville.
28	01189000	Pequabuck River at Forestville, Conn.	Lat 41°40'24", long 72°53'59"	Bristol	Hartford County, Hydrologic Unit 01080207, on left bank 500 ft upstream from bridge on Central Street, 0.2 mi downstream from Copper Mine Brook, and 6.5 mi upstream from mouth.
29	01189200	Stratton Brook near Simsbury, Conn.	Lat 41°52'12", long 72°49'27"	Simsbury	Hartford County, Hydrologic Unit 01080207, at bridge on Farms Village Road, 400 ft upstream from mouth, and 1.0 mi west of Simsbury.
30	01189390	East Branch Salmon Brook at Granby, Conn.	Lat 41°57'15", long 72°46'46"	Granby	Hartford County, Hydrologic Unit 01080207, on right bank at downstream side of bridge on State Highway 20, 0.5 mi upstream from West Branch Salmon Brook, and 1.8 mi downstream from Manitook Lake.
31	01189500	Salmon Brook near Granby, Conn.	Lat 41°56'15", long 72°46'34"	East Granby	Hartford County, Hydrologic Unit 01080207, on left bank 50 ft upstream from railroad bridge, 0.5 mi downstream from confluence of East and West Branches Salmon Brook.
32	01190000	Farmington River at Rainbow, Conn.	Lat 41°54'40", long 72°41'17"	Windsor	Hartford County, Hydrologic Unit 01080207, on left bank at Rainbow, 300 ft downstream from Stevens Paper Mill, 0.4 mi downstream from Farmington River Power Co. dam, 1.3 mi upstream from Poquonock, 6.4 mi downstream from Salmon Brook, and at river mile 8.2.
33	01190600	Wash Brook at Bloomfield, Conn.	Lat 41°49'33", long 72°44'21"	Bloomfield	Hartford County, Hydrologic Unit 01080205, on right bank just upstream from bridge on Gabb Road, 0.4 mi south of Bloomfield.
34	01191000	North Branch Park River at Hartford, Conn.	Lat 41°47'02", long 72°42'32"	Hartford	Hartford County, Hydrologic Unit 01080205, on right bank 60 ft downstream from stone-arch bridge on Albany Avenue in Hartford, and 3 mi upstream from confluence with South Branch Park River.
35	01192500	Hockanum River near East Hartford, Conn.	Lat 41°46'60", long 72°35'13"	East Hartford	Hartford County, Hydrologic Unit 01080205, on left bank at end of Preston Street, 0.2 mi upstream from bridge on Walnut Street, 1.5 mi downstream from Hop Brook, and 2.8 mi east of East Hartford.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
36	01192650	Roaring Brook at Hopewell, Conn.	Lat 41°39'49", long 72°34'54"	Glastonbury	Hartford County, Hydrologic Unit 01080205, at bridge on Matson Hill Road at Hopewell.
37	01192700	Mattabasset River at East Berlin, Conn.	Lat 41°37'08", long 72°42'46"	Berlin	Hartford County, Hydrologic Unit 01080205, at bridge on Berlin Street, at East Berlin.
38	01192883	Coginchaug River at Middlefield, Conn.	Lat 41°31'12", long 72°42'22"	Middlefield	Middlesex County, Hydrologic Unit 01080205, on right bank just upstream from Cider Mill Road, 0.5 mi northeast of Middlefield, and 0.75 mi upstream from Wadsworth Falls.
39	01193500	Salmon River near East Hampton, Conn.	Lat 41°33'08", long 72°26'56"	East Hampton	Middlesex County, Hydrologic Unit 01080205, on left bank at Route 16 Bridge, 450 ft downstream from New London-Middlesex County line, 300 ft downstream from Comstock Bridge, 0.7 mi downstream from Dickinson Creek, and 3.5 mi southeast of East Hampton.
40	01193800	Hemlock Valley Brook at Hadlyme, Conn.	Lat 41°25'43", long 72°25'23"	East Haddam	Middlesex County, Hydrologic Unit 01080205, on right bank just upstream from culvert on Bone Mill Road at Hadlyme, 0.5 mi upstream from mouth.
41	01194000	Eightmile River at North Plain, Conn.	Lat 41°26'29", long 72°19'58"	East Haddam	Middlesex County, Hydrologic Unit 01080205, at bridge on State Highway 82, at North Plain.
42	01194500	East Branch Eightmile River near North Lyme, Conn.	Lat 41°25'39", long 72°20'06"	Lyme	New London County, Hydrologic Unit 01080205, on left bank at State Route 156 bridge, 0.7 mi south of intersection of State Route 82, 0.4 mi upstream from confluence of Eightmile River, and 5.5 mi above mouth.
43	01195000	Menunketesuck River near Clinton, Conn.	Lat 41°18'07", long 72°30'55"	Clinton	Middlesex County, Hydrologic Unit 01100004, on right bank at Fairy Dell, 100 ft downstream from Cobb's Bridge, 1.7 mi north of Clinton, 2.4 mi downstream from Kelseytown Reservoir, and 4.9 mi upstream from mouth.
44	01195100	Indian River near Clinton, Conn.	Lat 41°18'21", long 72°31'52"	Clinton	Middlesex County, Hydrologic Unit 01100004, on right downstream side of bridge at Hurd Bridge Road, 2.0 mi north of Clinton.
45	01195200	Neck River near Madison, Conn.	Lat 41°16'58", long 72°37'08"	Madison	New Haven County, Hydrologic Unit 01100004, on left bank just upstream from culvert on Fort Path Road, 1.2 mi west of Madison, and 3.5 mi upstream from mouth.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
46	01196500	Quinnipiac River at Wallingford, Conn.	Lat 41°26'58", long 72°50'29"	Wallingford	New Haven County, Hydrologic Unit 01100004, on right bank on Wilbur Cross Highway, 0.8 mi downstream from bridge on Quinnipiac River in Wallingford, and 2.0 mi upstream from Wharton Brook.
47	01196580	Muddy River near North Haven, Conn.	Lat 41°22'07", long 72°50'30"	North Haven	New Haven County, Hydrologic Unit 01100004, at bridge on Velvet Street, 2 mi southeast of North Haven.
48	01196620	Mill River near Hamden, Conn.	Lat 41°25'14", long 72°54'10"	Hamden	New Haven County, Hydrologic Unit 01100004, 150 ft downstream from bridge on Mount Carmel Avenue, 0.4 mi downstream from Eaton's Brook, and 2.5 mi north of Hamden.
49	01196700	Wepawaug River at Milford, Conn.	Lat 41°14'10", long 73°03'28"	Milford	New Haven County, Hydrologic Unit 01100004, 50 ft downstream from bridge on Walnut Street, at Milford.
50	01198500	Blackberry River at Canaan, Conn.	Lat 42°01'26", long 73°20'31"	North Canaan	Litchfield County, Hydrologic Unit 01100005, on right bank at bridge on U.S. Highway 44, at Canaan.
51	01199050	Salmon Creek at Lime Rock, Conn.	Lat 41°56'32", long 73°23'28"	Salisbury	Litchfield County, Hydrologic Unit 01100005, on left bank 300 ft upstream from bridge on Uptown Salisbury Road, 0.6 mi north of Lime Rock, and 3.0 mi upstream from mouth.
52	01199200	Guinea Brook at West Woods Road at Ellsworth, Conn.	Lat 41°49'28", long 73°25'48"	Sharon	Litchfield County, Hydrologic Unit 01100005, on left bank just upstream from culvert on West Woods Road, 0.4 mi southwest of Ellsworth, 3 mi west of Cornwall Bridge, and 4.5 mi southeast of Sharon.
53	01200000	Tenmile River near Gaylordsville, Conn.	Lat 41°39'32", long 73°31'44"	Dover, N.Y.	Dutchess County, Hydrologic Unit 01100005, 1.2 mi upstream from New York-Connecticut stateline, 1.7 mi upstream from mouth.
54	01201190	West Aspetuck River at Sand Road near New Milford, Conn.	Lat 41°36'29", long 73°25'29"	New Milford	Litchfield County, Hydrologic Unit 01100005, at downstream side of bridge on Sand Road, off Long Mountain Road, 1,000 ft west of State Highway 129, 1 mi northwest of Wellsville, and 2 mi north of New Milford.
55	01201500	Still River near Lanesville, Conn.	Lat 41°31'12", long 73°25'06"	New Milford	Litchfield County, Hydrologic Unit 01100005, on left bank on upstream side of highway bridge, 0.25 mi east of U.S. Highway 7, 1.1 mi south of Lanesville, 3 mi upstream from mouth, and 4 mi south of New Milford.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
56	01203000	Shepaug River near Roxbury, Conn.	Lat 41°32’59”, long 73°19’47”	Roxbury	Litchfield County, Hydrologic Unit 01100005, at Wellers Bridge, 1.2 mi southwest of Roxbury.
57	01203510	Pootatuck River at Sandy Hook, Conn.	Lat 41°25’12”, long 73°16’56”	Newtown	Fairfield County, Hydrologic Unit 01100005, at bridge on Church Hill Road, at Sandy Hook.
58	01204000	Pomperaug River at Southbury, Conn.	Lat 41°28’54”, long 73°13’29”	Southbury	New Haven County, Hydrologic Unit 01100005, on right bank 200 ft upstream from bridge on Poverty Road, 800 ft downstream from Bullet Hill Brook, 0.6 mi west of Southbury, and 5.8 mi upstream from mouth.
59	01204800	Copper Mill Brook near Monroe, Conn.	Lat 41°21’46”, long 73°13’06”	Monroe	Fairfield County, Hydrologic Unit 01100005, on right bank just upstream from twin culverts on Hammertown Road, 700 ft upstream from mouth, 1.2 mi west of State Highway 111, 2.2 mi northwest of Monroe, and 2.2 mi east of Botsford.
60	01206000	Naugatuck River near Thomaston, Conn.	Lat 41°42’14”, long 73°03’54”	Thomaston	Litchfield County, Hydrologic Unit 01100005, on right bank near downstream side of Twomile Bridge, 250 ft downstream from railroad bridge, 0.4 mi upstream from Leadmine Brook.
61	01206500	Leadmine Brook near Thomaston, Conn.	Lat 41°42’07”, long 73°03’27”	Thomaston	Litchfield County, Hydrologic Unit 01100005, on left bank 10 ft downstream from highway bridge, 0.4 mi upstream from mouth.
62	01208500	Naugatuck River at Beacon Falls, Conn.	Lat 41°26’31”, long 73°03’47”	Beacon Falls	New Haven County, Hydrologic Unit 01100005, on left bank at downstream side of bridge on Bridge Street at Beacon Falls, 0.4 mi upstream from Bronson Brook, and at river mile 10.1.
63	01208850	Pequonnock River at Trumbull, Conn.	Lat 41°14’48”, long 73°11’51”	Trumbull	Fairfield County, Hydrologic Unit 01100006, at bridge on Daniels Farm Road at Trumbull.
64	01208925	Mill River near Fairfield, Conn.	Lat 41°09’55”, long 73°16’13”	Fairfield	Fairfield County, Hydrologic Unit 01100006, on right bank just downstream from bridge on Duck Farm Road, 1.5 mi north of Fairfield, 14.0 mi downstream from headwater of Mill River.
65	01208950	Sasco Brook near Southport, Conn.	Lat 41°09’10”, long 73°18’21”	Westport	Fairfield County, Hydrologic Unit 01100006, on left downstream abutment of bridge on Hulls Farm Road, 1.5 mi northwest of Southport.

Table 1. Descriptions of 70 streamflow-gaging stations used to develop statewide regression equations for estimating flood flows for the 2-, 10-, 25-, 50-, 100-, and 500-year recurrence intervals at stream sites in Connecticut.—Continued

[lat, latitude; long, longitude; mi^2, square miles; mi, miles; ft, feet; right and left bank are referenced facing downstream; see table 9 or appendix 1 for period of record]

U.S. Geological Survey streamflow-gaging station					
Reference number (see fig. 1)	Station number	Station name	Lat/Long	Town	Location
66	01208990	Saugatuck River near Redding, Conn.	Lat 41°17'40", long 73°23'42"	Redding	Fairfield County, Hydrologic Unit 01100006, on right downstream side of bridge on State Route 53, 100 ft south of intersection of State Routes 53 and 107, 0.8 mi upstream from Saugatuck Reservoir, and 1.0 mi southwest of Redding.
67	01209500	Saugatuck River near Westport, Conn.	Lat 41°10'15", long 73°21'53"	Westport	Fairfield County, Hydrologic Unit 01100006, on left bank on Old Ford Road (Clinton Avenue), 400 ft downstream from West Branch, 600 ft downstream from Aspetuck River, 2 mi north of Westport, and 5.5 mi upstream from mouth.
68	01209700	Norwalk River at South Wilton, Conn.	Lat 41°09'50", long 73°25'11"	Wilton	Fairfield County, Hydrologic Unit 01100006, on right bank at upstream side of bridge on Kent Road at South Wilton, 2.5 mi north of Norwalk.
69	01211700	East Branch Byram River at Round Hill, Conn.	Lat 41°05'57", long 73°40'59"	Greenwich	Fairfield County, Hydrologic Unit 01100006, at bridge on John Street, 0.8 mi west of Round Hill.
70	01212100	East Branch Byram River at Riversville, Conn.	Lat 41°03'39", long 73°40'29"	Greenwich	Fairfield County, Hydrologic Unit 01100006, at bridge on Riversville Road just downstream from Merritt Parkway, 0.2 mi upstream from mouth.

Appendix 1

Appendix 1. Peak-flow frequency estimates for streams in Connecticut for selected recurrence intervals.

[Revised from Ahearn, 2003, table 1. Peak-flow frequency estimates based on 10 or more years of unregulated flow record. Period of record includes historical information outside the period of systematic data collection at or near a gaging station. Period of record in italics represents period when flows were affected by flood-control regulation. regulated, flood-control reservoir affects flow (regulated indicates that the drainage area upstream from the gaging station has more than 4.5 million cubic feet of usable storage per mile (Benson, 1962)); mi^2, square miles; ft^3/s, cubic feet per second; nr, near; rev, revised; e, estimated]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record (water years)	Peak-flow frequency estimates for given recurrence interval (ft^3/s)							Maximum known peak flow	
Number	Name			1.5 years	2 years	10 years	25 years	50 years	100 years	500 years	Date	Flow (ft^3/s)
				PAWCATUCK RIVER BASIN								
01118300	Pendleton Hill Brook nr Clarks Falls	4.02	1959-2001	108	132	242	303	351	402	528	06/05/1982	rev 304
				SOUTHEAST COASTAL BASINS								
01118750	Haleys Brook nr Old Mystic	4.37	1962-1984	75	96	234	346	453	585	rev 1,020	06/05/1982	720
01127800	Fourmile River nr E Lyme	4.30	1961-1984	80	96	194	267	334	415	668	06/05/1982	1,280
				THAMES RIVER BASIN								
01119255	Delphi Brook nr Staffordville	2.59	1964-1976	62	88	260	394	517	664	1,110	12/21/1973	310
01119300	Roaring Brook nr Staffordville	5.61	1960-1984	198	258	559	736	877	1,030	1,400	06/05/1982	920
01119360	Conat Brook at W Willington	2.40	1964-1983	46	59	129	174	212	254	370	01/25/1979	150
01119450	Eagleville Brook at Storrs	0.36	1953-1969	74	84	123	141	153	165	192	05/12/1968	123
01119500	Willimantic River nr Coventry	121	1932-2001	1,680	2,160	5,170	7,520	9,730	12,400	20,900	08/19/1955	24,200
01119600	Ash Brook nr N Coventry	2.79	1960-1970	134	151	224	261	289	317	385	04/02/1970	260
01119820	Skungamaug River at N Coventry	24.7	1963-1975	420	556	1,400	2,050	2,640	3,330	5,470	12/21/1973	1,800
01120000	Hop River nr Columbia	74.8	1933-1984	1,610	2,040	4,450	6,070	7,470	9,050	13,600	06/06/1982	6,940
01120500	Safford Brook nr Woodstock Valley	4.15	1951-1981	275	338	659	860	1,030	1,210	1,710	08/19/1955	1,000
01121000	Mount Hope River nr Warrenville	28.6	1938, 1941-2001	816	1,030	2,280	3,180	4,000	4,950	7,840	08/19/1955	5,590
01121300	Fenton River at E Willington	11.4	1964-1976	272	349	720	933	1,100	1,280	1,720	12/21/1973	750
01122000	Natchaug River at Willimantic (regulated)	170	1931-1951, *1952-2001*	2,540	3,110	6,820	9,770	12,600	16,100	27,500	09/21/1938	32,000
01122500	Shetucket River nr Willimantic (regulated)	404	1904-1906, 1920-1921, 1929-1951, *1952-2001*	6,000	6,120	12,300	16,900	21,100	26,100	41,600	09/21/1938	e 52,200
01122680	Merrick Brook nr Scotland	5.21	1960-1984	211	274	639	894	1,120	1,380	2,130	06/05/1982	1,020
01123000	Little River nr Hanover	30.0	1936, 1938, 1952-2001	698	881	1,820	2,410	2,900	3,430	4,870	06/06/1982	rev 2,960
01124000	Quinebaug River at Quinebaug (regulated)	155	1932-1959, *1960-2001*	1,520	1,900	4,510	6,700	8,880	11,600	21,100	08/19/1955	[1]49,300
01124151	Quinebaug River at W. Thompson (regulated)	172	1967-2001, *1920-1940*	Entire period of record regulated for flood control							04/10/1987	2,820
01125300	English Neighborhood Brook at N Woodstock	4.66	1962-1984	130	187	547	805	1,030	1,290	2,020	06/05/1982	1,200
01125490	Little River at Harrisville	35.8	1936, 1938, 1962-1976	548	682	1,350	1,760	2,090	2,440	3,380	03/19/1936	2,520
01125500	Quinebaug River at Putnam (regulated)	328	1930-1959, *1960-2001*	rev 3,040	rev 3,790	8,300	11,600	14,500	18,000	28,500	08/19/1955	[2]48,000
01125600	Mashamoquet Brook at Abington	11.1	1963-1976	350	434	815	1,020	1,180	1,340	1,730	02/02/1973	820
01125650	Wappoquia Brook nr Pomfret	4.20	1964-1984	167	203	389	508	609	721	1,030	04/02/1970	rev 550
01125900	Cady Brook at E Putnam	8.29	1964-1984	231	309	721	979	1,190	1,420	2,020	01/26/1978	950
01126000	Fivemile River at Killingly	57.8	1936, 1938-1984	542	669	1,330	1,750	2,100	2,490	3,560	07/24/1938	2,480
01126500	Moosup River at Moosup	83.6	1933-1984	1,210	1,480	2,810	3,610	4,260	4,970	6,840	03/12/1936	rev 4,260
01126600	Blackwell Brook nr Brooklyn	17.0	1962-1976	384	515	1,260	1,760	2,180	2,660	3,970	04/02/1970	1,100
01126700	Kitt Brook nr Canterbury	11.1	1964-1976	176	206	344	421	481	544	703	02/02/1973	400
01126950	Pachaug River at Pachaug	53.0	1936, 1938, 1961-1973	502	596	1,010	1,230	1,400	1,570	2,000	09/21/1938	1,970
01127000	Quinebaug River at Jewett City (regulated)	713	1919-1964, *1965-2001*	6,270	7,640	15,600	21,300	26,400	32,300	50,100	08/20/1955	40,700
01127100	Broad Brook nr Preston City	12.5	1961-1976	292	341	556	672	762	855	1,080	09/21/1961	620
01127400	Susquetonscut Brook at Yantic	15.7	1962-1976	378	434	655	761	838	914	1,090	04/02/1970	700

Appendix 1. Peak-flow frequency estimates for streams in Connecticut for selected recurrence intervals.—Continued

[Revised from Ahearn, 2003, table 1. Peak-flow frequency estimates based on 10 or more years of unregulated flow record. Period of record includes historical information outside the period of systematic data collection at or near a gaging station. Period of record in italics represents period when flows were affected by flood-control regulation. regulated, flood-control reservoir affects flow (regulated indicates that the drainage area upstream from the gaging station has more than 4.5 million cubic feet of usable storage per mile (Benson, 1962)); mi^2, square miles; ft^3/s, cubic feet per second; nr, near; rev, revised; e, estimated]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record (water years)	Peak-flow frequency estimates for given recurrence interval (ft^3/s)							Maximum known peak flow	
Number	Name			1.5 years	2 years	10 years	25 years	50 years	100 years	500 years	Date	Flow (ft^3/s)
01127500	Yantic River at Yantic	89.3	1931-2001	2,100	2,640	5,740	7,860	9,730	11,800	18,000	09/21/1938	e 13,500
01127700	Trading Cove Brook nr Thamesville	8.46	1961-1974	286	361	758	1,010	1,220	1,450	2,070	02/02/1973	940
01127760	Hunts Brook at Old Norwich Rd. at Quaker Hill	11.5	1964-1976	195	244	512	686	835	1,000	1,460	06/19/1972	650
CONNECTICUT RIVER BASIN												
01183990	Jawbuck Brook nr Hazardville	2.16	1967-1976	42	50	89	111	129	147	196	01/28/1976	88
01184000	Connecticut River at Thompsonville	9,660	1929-2001	Peak-flow frequency estimates available upon request							03/20/1936	282,000
01184100	Stony Brook nr W Suffield	10.4	1955, 1960-2001	303	405	1,060	1,560	2,030	2,580	4,300	08/19/1955	e 6,000
01184260	Namerick Brook nr Warehouse Point	2.70	1964-1984	176	229	505	677	819	972	1,380	12/21/1973	620
01184300	Gillette Brook at Somers	3.60	1960-1984	98	126	273	367	446	533	770	09/27/1975	375
01184490	Broad Brook at Broad Brook	15.5	1938, 1962-1976, 1982-2001	329	417	848	1,100	1,300	1,520	2,070	09/27/1975	1,140
01184500	Scantic River at Broad Brook	98.2	1929-1984	859	1,070	2,260	3,080	3,800	4,640	7,080	08/19/1955	13,300
01186000	W Branch Farmington River at Riverton (regulated)	131	1955-1968, *1969-2001*	1,560	2,030	5,660	9,050	12,600	17,300	35,000	08/19/1955	57,200
01186100	Mad River at Winsted (regulated)	18.5	1955, 1957-1961, *1962-1969*	Less than 10 years of unregulated flow							08/19/1955	10,200
01186500	Still River at Robertsville (regulated)	85.0	1936, 1938, 1949-1961, *1962-2001*	2,200	2,880	7,110	10,300	13,200	16,700	27,400	08/19/1955	44,000
01187000	W Branch Farmington River at Riverton	217	1930-1956	5,010	6,590	18,100	28,100	38,200	51,100	96,300	08/19/1955	101,000
01187300	Hubbard River nr W Hartland	19.9	[3]1938-1954, 1955, 1957-2001	971	1,270	2,820	3,750	4,510	5,320	7,410	08/19/1955	e 10,500
01187400	Valley Brook nr W Hartland	7.03	[3]1940-1954, 1955-1972	245	350	1,060	1,610	2,130	2,740	4,640	08/19/1955	5,400
01187800	Nepaug River nr Nepaug	23.5	[3]1922-1954, 1955, 1958-1984	637	843	1,990	2,750	3,390	4,110	6,080	08/19/1955	e 10,000
01187850	Clear Brook nr Collinsville	0.59	[3]1922-1954, 1955-1973	10	14	35	50	64	81	130	08/19/1955	56
01187980	Farmington River at Collinsville (regulated)	360	1928, 1936, 1938, 1955, 1963-1968, *1969-1977*	Less than 10 years of unregulated flow							08/19/1955	140,000
01188000	Burlington Brook at Burlington	4.10	1932-2001	217	294	702	953	1,160	1,370	1,930	08/19/1955	1,690
01188090	Farmington River at Unionville (regulated)	378	1978-2001, *1920-1940*	Entire period of record regulated for flood control							03/23/1980	20,300
01188100	Roaring Brook at Unionville	7.60	1962-1984	142	194	518	755	967	1,210	1,930	06/05/1982	900
01189000	Pequabuck River at Forestville	45.8	1938, 1942-2001	1,290	1,650	3,840	5,470	6,960	8,740	14,200	08/19/1955	11,700
01189200	Stratton Brook nr Simsbury	5.13	1964-1984	100	134	316	432	528	633	912	06/05/1982	390
01189390	E Branch Salmon Book at Granby	39.5	1955-1956, 1964-1976	555	764	2,450	4,080	5,810	8,130	16,900	08/19/1955	e 27,000
01189500	Salmon Brook nr Granby[4]	67.4	1947-1963	1,440	1,930	5,780	9,500	13,400	18,800	38,900	08/19/1955	e 40,000
01189995	Farmington River at Tariffville (regulated)	577	1913-1939, *1971-2001*	Peak-flow frequency estimates not determined at this site							09/22/1938	29,900
01190000	Farmington River at Rainbow (regulated)	590	1928, 1936-1968, *1969-1986*	5,540	7,120	18,100	27,300	36,500	48,000	87,500	08/19/1955	69,200
01190050	Podunk River at Wapping	4.34	1962-1976	77	93	184	247	303	368	557	09/26/1975	320
01190070	Connecticut River at Hartford	10,493	1905-2001	Peak-flow frequency estimates available upon request								
01190100	Piper Brook at Newington Junction[5]	14.6	1955, 1958-1984	571	745	1,630	2,160	2,590	3,050	4,220	10/03/1979	2,400
01190200	Mill Brook at Newington	2.65	1955, 1958-1984	159	217	489	636	745	854	1,110	10/03/1979	650
01190300	Trout Brook at W Hartford (regulated)	14.6	1955, 1958-1963, *1964-1972*, *1975, 1980*	Less than 10 years of unregulated flow							08/19/1955 10/03/1979	3,300

Appendix 1. Peak-flow frequency estimates for streams in Connecticut for selected recurrence intervals.—Continued

[Revised from Ahearn, 2003, table 1. Peak-flow frequency estimates based on 10 or more years of unregulated flow record. Period of record includes historical information outside the period of systematic data collection at or near a gaging station. Period of record in italics represents period when flows were affected by flood-control regulation. regulated, flood-control reservoir affects flow (regulated indicates that the drainage area upstream from the gaging station has more than 4.5 million cubic feet of usable storage per mile (Benson, 1962)); mi^2, square miles; ft^3/s, cubic feet per second; nr, near; rev, revised; e, estimated]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record (water years)	Peak-flow frequency estimates for given recurrence interval (ft^3/s)							Maximum known peak flow	
Number	Name			1.5 years	2 years	10 years	25 years	50 years	100 years	500 years	Date	Flow (ft^3/s)
01190500	S Branch Park River at Hartford[5]	39.9	1936-1972, 1974-1981	1,130	1,500	3,660	5,160	6,480	7,980	12,300	10/03/1979	5,630
01190600	Wash Brook at Bloomfield	5.54	1955, 1959-1971	156	198	476	702	921	1,190	2,100	08/19/1955	3,000
01191000	N Branch Park River at Hartford (regulated)	26.8	1936-1962, *1963-1996*	943	1,150	2,460	3,430	4,330	5,400	8,760	08/19/1955	10,000
01191500	Park River at Hartford[5]	72.5	1936-1962	1,770	2,150	4,590	6,460	8,220	10,400	17,200	08/19/1955	14,000
01191900	Charter Brook nr Crystal Lake	8.51	1965-1984	203	275	647	869	1,050	1,230	1,700	09/12/1971	rev 620
01192500	Hockanum River nr E Hartford	73.4	1920-1921, 1929-2001	826	1,050	2,200	2,940	3,550	4,220	6,040	09/21/1938	5,160
01192600	S Branch Salmon Brook at Buckingham	0.94	1961-1976	18	24	66	99	130	167	285	09/19/1972	115
01192650	Roaring Brook at Hopewell	24.3	1962-1976	439	507	852	1,060	1,240	1,430	1,960	04/02/1970	1,240
01192700	Mattabesset River at E Berlin	46.5	1962-1979, [6]1995-1998	1,310	1,590	2,780	3,400	3,880	4,360	5,530	02/03/1970	2,980
01192800	Parmalee Brook nr Durham	2.79	1960-84	174	215	397	494	569	645	830	01/25/1979 06/05/1982	517
01192883	Coginchaug River at Middlefield	29.8	1962-1980; [7]1981-2001	581	747	1,550	2,010	2,370	2,750	3,690	04/16/1996	2,260
01193120	Ponset Brook nr Higganum	5.72	1962-1977, 1982	188	246	598	855	1,090	1,360	2,160	06/05/1982	1,700
01193250	Judd Brook nr Colchester	3.93	1962-1979	116	157	403	578	732	908	1,420	01/25/1979	625
01193300	Blackledge River nr Gilead	6.75	1960-1984	161	198	366	459	532	608	798	06/05/1982	480
01193500	Salmon River nr E Hampton	100	1929-2001	2,140	2,730	6,460	9,390	12,200	15,500	26,300	06/06/1982	18,500
01193800	Hemlock Valley Brook at Hadlyme	2.62	1961-1976	97	123	245	314	368	424	563	03/06/1963	270
01194000	Eightmile River at N Plain	20.1	1938-1984	679	861	1,850	2,500	3,060	3,680	5,400	06/06/1982	5,200
01194500	E Branch Eightmile River nr N Lyme	22.3	1938-1982	536	645	1,350	1,900	2,430	3,070	5,180	06/06/1982	5,170
				SOUTH CENTRAL COASTAL BASINS								
01195000	Menunketesuck River nr Clinton	11.2	1938, 1942-1967, 1982	448	410	873	1,210	1,520	1,890	3,020	06/06/1982 09/21/1938	3,210 [8]4,600
01195100	Indian River nr Clinton	5.68	1982-2001	140	176	405	578	738	930	1,530	06/05/1982	2,600
01195200	Neck River nr Madison	6.55	1962-1982	144	183	401	548	675	818	1,230	06/05/1982	1,040
01195490	Quinnipiac River at Southington[5]	17.4	1988-2001	384	461	785	949	1,070	1,200	1,490	06/06/1992	876
01196500	Quinnipiac River at Wallingford	110	1931-2001	1,690	2,100	4,100	5,260	6,180	7,140	9,610	06/06/1982	8,200
01196580	Muddy River nr N Haven	18.0	1963-1976	626	712	1,080	1,280	1,440	1,590	1,990	02/03/1970	1,300
01196600	Willow Brook nr Cheshire	9.34	1960-1983	210	278	780	1,230	1,690	2,290	4,410	06/06/1982	3,000
01196620	Mill River nr Hamden	24.5	1969-1970, 1979-2001	718	946	2,420	3,580	4,670	5,980	10,200	06/06/1982	5,580
01196700	Wepawaug River at Milford	18.4	1962-1984	520	667	1,580	2,280	2,930	3,700	6,100	06/06/1982	5,020
				HOUSATONIC RIVER BASIN								
01198500	Blackberry River at Canaan (regulated)	45.9	1949-1961, *1962-1981*	1,400	1,830	4,190	5,740	7,070	8,550	12,600	08/19/1955	14,200
01198860	Deming Brook nr Huntsville	1.08	1971-1984	62	91	309	495	676	900	1,630	03/21/1980	520
01199000	Housatonic River at Falls Village	634	1913-2001	5,250	6,260	11,600	15,100	18,100	21,400	30,800	01/01/1949	23,900
01199050	Salmon Creek at Lime Rock	29.4	1949, 1955, 1962-2001	450	588	1,510	2,250	2,970	3,850	6,750	08/19/1955	6,300
01199150	Furnace Brook at Cornwall Bridge	13.3	1945, 1949, 1955, 1962-1976	229	312	921	1,460	1,990	2,680	5,050	08/19/1955	4,060
01199200	Guinea Brook at W Woods Rd at Ellsworth	3.50	1960-1981	76	96	199	262	314	369	517	12/21/1973	319
01200500	Housatonic River at Gaylordsville	996	1901-1914, 1924, 1928-2001	8,660	10,600	21,200	28,100	33,900	40,500	58,900	08/19/1955	51,800

Appendix 1. Peak-flow frequency estimates for streams in Connecticut for selected recurrence intervals.—Continued

[Revised from Ahearn, 2003, table 1. Peak-flow frequency estimates based on 10 or more years of unregulated flow record. Period of record includes historical information outside the period of systematic data collection at or near a gaging station. Period of record in italics represents period when flows were affected by flood-control regulation. regulated, flood-control reservoir affects flow (regulated indicates that the drainage area upstream from the gaging station has more than 4.5 million cubic feet of usable storage per mile (Benson, 1962)); mi^2, square miles; ft^3/s, cubic feet per second; nr, near; rev, revised; e, estimated]

U.S. Geological Survey streamflow-gaging station		Drainage area (mi^2)	Period of record (water years)	Peak-flow frequency estimates for given recurrence interval (ft^3/s)							Maximum known peak flow	
Number	Name			1.5 years	2 years	10 years	25 years	50 years	100 years	500 years	Date	Flow (ft^3/s)
01201190	W Aspetuck River at Sand Rd nr New Milford	23.8	1963-1972	276	360	842	1,180	1,480	1,820	2,800	08/05/1969	1,090
01201500	Still River nr Lanesville	67.5	1932-1966, [9]1967-1984	938	1,220	2,940	4,190	5,320	6,630	10,600	10/16/1955	7,980
01201890	Pond Brook nr Hawleyville	11.9	1963-1976	316	425	1,100	1,600	2,050	2,580	4,170	09/26/1975	1,400
01201930	Marshepaug River nr Milton	9.24	[10]1968-1981	182	224	392	472	530	588	713	12/22/1973	474
01202500	Shepaug River at Woodville	38.0	1936-1988	956	1,280	3,120	4,320	5,340	6,460	9,530	08/19/1955	13,800
01202700	Butternut Brook nr Litchfield	2.42	1960-1984	176	229	506	677	817	968	1,360	02/02/1973	630
01203000	Shepaug River nr Roxbury	132	1931-1984	2,320	2,960	7,210	10,600	14,000	rev 18,000	31,500	08/19/1955	50,300
01203100	Jacks Brook nr Roxbury Falls	7.90	1961-1984	410	542	1,230	1,650	2,000	2,370	3,330	09/26/1975	e 1,600
01203510	Pootatuck River at Sandy Hook	24.8	1966-84	1,040	1,290	2,390	2,970	3,410	3,860	4,940	01/25/1979	2,720
01203600	Nonnewaug River at Minortown	17.7	1955, 1963-1979, 2001	1,070	1,460	3,740	5,320	6,680	8,220	12,600	08/19/1955	e 10,000
01203700	Wood Creek nr Bethlehem	3.39	1962-1984	154	197	458	649	824	1,030	1,650	02/02/1973	e 700
01204000	Pomperaug River at Southbury	75.1	1933-2001	2,210	2,810	6,490	9,190	11,600	14,600	23,400	08/19/1955	29,400
01204800	Copper Mill Brook nr Monroe	2.45	1959-1976	122	148	257	312	352	391	483	02/02/1973	255
01205500	Housatonic River at Stevenson	1,544	1924-1925, 1928-2001	15,400	20,000	45,200	61,700	75,700	91,200	134,000	10/16/1955	75,800
01205600	W Branch Naugatuck River at Torrington (regulated)	33.8	1955, 1957-1961, *1962-1996*	Less than 10 years of unregulated flow							08/19/1955	16,500
01205700	E Branch Naugatuck River at Torrington (regulated)	13.6	1955, 1957-1963, *1964-1996*	Less than 10 years of unregulated flow							08/19/1955	8,550
01206000	Naugatuck River nr Thomaston	71.0	1931-1959	2,630	3,260	7,120	10,000	12,600	15,800	25,600	08/19/1955	41,600
01206500	Leadmine Brook nr Thomaston	24.3	1931-59, [11]1960-1984	938	1,240	3,320	5,010	6,640	8,640	15,200	08/19/1955	10,400
01206900	Naugatuck River at Thomaston (regulated)	99.8	1955, *1960-2001*	Less than 10 years of unregulated flow							08/19/1955	53,400
01208013	Branch Brook nr Thomaston (regulated)	20.8	1971-2001, *1920-1940*	Entire period of record regulated for flood control							06/08/1982	805
01208100	Hancock Brook nr Terryville	1.18	1960-1981	95	118	219	274	315	357	459	09/26/1975	300
01208400	Hop Brook nr Middlebury	9.43	1955, 1962-1975	333	436	1,050	1,480	1,870	2,310	3,610	08/19/1955	1,700
01208420	Hop Brook nr Naugatuck (regulated)	16.3	1955, *1970-2001*	Less than 10 years of unregulated flow							08/19/1955	2,650
01208500	Naugatuck River at Beacon Falls (regulated)	260	1920-1959, *1960-2001*	6,700	8,620	20,700	29,900	38,400	48,500	80,200	08/19/1955	106,000
01208700	Little River at Oxford	4.54	1960-1984	186	243	600	870	1,120	1,420	2,340	06/05/1982	1,350
	SOUTHWEST COASTAL BASINS											
01208850	Pequonnock River at Trumbull	15.6	1955, 1962-1984	555	732	1,720	2,380	2,950	3,580	5,340	10/16/1955	e 4,500
01208873	Rooster River at Fairfield[5]	10.6	1978-2001	959	1,140	1,800	2,070	2,250	2,410	2,740	04/09/1980	2,170
01208900	Patterson Brook nr Easton	1.21	1960-1984	61	72	116	139	156	173	214	06/05/1982	148
01208925	Mill River nr Fairfield	28.6	1973-2001	507	679	1,530	2,020	2,390	2,780	3,740	04/10/1980	1,800
01208950	Sasco Brook nr Southport	7.38	1960-2001	205	270	728	1,120	1,500	1,970	3,580	06/19/1972	1,640
01208990	Saugatuck River nr Redding	21.0	1962-2001	456	586	1,220	1,580	1,860	2,160	2,900	03/25/1969	1,860
01209500	Saugatuck River nr Westport	79.8	1933-1967	1,140	1,540	3,950	5,680	7,220	8,990	14,200	10/16/1955	14,800
01209600	Comstock Brook at N Wilton	3.50	1960-1975	116	137	251	325	388	459	659	09/26/1975	440
01209700	Norwalk River at S Wilton	30.0	1956, 1963-2001	778	1,010	2,320	3,220	4,000	4,880	7,390	10/16/1955	e 12,000
01209770	Fivemile River nr Norwalk	8.96	1956, 1962-1984	431	536	1,130	1,540	1,890	2,300	3,470	10/16/1955	e 3,250
01211700	E Branch Byram River at Round Hill	1.69	1960-1975	78	100	225	306	376	452	663	06/19/1972	245
01212100	E Branch Byram River at Riversville	11.1	1963-1984	409	567	1,450	2,020	2,490	3,000	4,340	06/19/1972	1,700

[1]Peak flow augments by release of storage from dam failure.
[2]Peak flow affected by dam failure.
[3]Peak flow for these water years is a maximum daily average.
[4]Gaging station formerly published under the name West Branch Salmon Brook at Granby, Connecticut.
[5]Discharge is affected by urbanization or channelization.
[6]1995–1998 streamflow data collected at station 01192704, Mattabessett River at Rt. 372 at East Berlin, adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Department of Transportation, January 2000).
[7]1962–1980 streamflow data collected at station 01192890, Coginchaug River at Rockfall adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).
[8]Peak flow affected by dam failure.
[9]1967–1984 streamflow data collected at station 01201510, Still River at Lanesville adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).
[10]Peak flow frequency estimates based on water years 1972-81.
[11]1960–1984 streamflow data collected at station 01206400, Leadmine Brook near Harwinton adjusted to site (data transferred using transfer equation 6.12, Drainage Manual, Connecticut Dept. of Transportation, January 2000).

Appendix 2

Appendix 2. Hydrologic characteristics for streamflow-gaging stations used in the regression analysis for Connecticut.

[Hydrologic characteristics determined using digital data sets (Connecticut Drainage Basin Boundaries, USGS Digital Elevation Models, and 24-hour rainfall from the Northeast Regional Climate Center) and GIS technology. Elevations referenced to North American Vertical Datum of 1988. mi^2, square miles; ft, foot; in., inches; DA, drainage area in square miles; EL, mean basin elevation in feet; P_X, 24-hour rainfall for x-recurrence interval in inches]

U.S. Geological Survey streamflow-gaging station		Hydrologic characteristics						
Number	Name	Drainage area (mi^2)	Mean basin elevation (ft)	2-year, 24-hour rainfall (inches)	10-year, 24-hour rainfall (inches)	25-year, 24-hour rainfall (inches)	50-year, 24-hour rainfall (inches)	100-year, 24-hour rainfall (inches)
		DA	EL	P_2	P_{10}	P_{25}	P_{50}	P_{100}
01118300	Pendleton Hill Brook near Clarks Falls	4.01	348	3.53	5.20	6.48	7.66	9.06
01119500	Willimantic River near Coventry	122	701	3.20	4.44	5.34	6.15	7.08
01120000	Hop River near Columbia	74.5	607	3.25	4.51	5.41	6.23	7.16
01120500	Safford Brook near Woodstock Valley	4.17	748	3.23	4.56	5.56	6.46	7.50
01121000	Mount Hope River near Warrenville	29.0	653	3.23	4.50	5.43	6.27	7.22
01122000	Natchaug River at Willimantic	170	612	3.25	4.55	5.51	6.37	7.36
01122500	Shetucket River near Willimantic	401	621	3.25	4.51	5.44	6.28	7.24
01123000	Little River near Hanover	30.0	508	3.37	4.84	5.94	6.95	8.12
01124000	Quinebaug River at Quinebaug	156	760	3.06	4.15	4.93	5.62	6.41
01125490	Little River at Harrisville	35.7	546	3.22	4.54	5.54	6.43	7.46
01125500	Quinebaug River at Putnam	329	679	3.10	4.25	5.10	5.85	6.70
01125600	Mashamoquet Brook at Abington	11.0	686	3.28	4.70	5.79	6.77	7.91
01126000	Fivemile River at Killingly	57.8	554	3.25	4.68	5.77	6.76	7.92
01126500	Moosup River at Moosup	83.5	512	3.45	5.18	6.53	7.78	9.26
01126600	Blackwell Brook near Brooklyn	17.0	477	3.35	4.94	6.17	7.28	8.61
01127000	Quinebaug River at Jewett City	715	543	3.26	4.64	5.69	6.63	7.73
01127500	Yantic River at Yantic	89.2	409	3.43	4.76	5.74	6.62	7.63
01184100	Stony Brook near West Suffield	10.5	256	3.39	5.06	6.36	7.55	8.97
01184300	Gillette Brook at Somers	3.66	678	3.21	4.55	5.54	6.44	7.49
01184490	Broad Brook at Broad Brook	15.6	300	3.22	4.57	5.57	6.48	7.54
01184500	Scantic River at Broad Brook	97.7	389	3.22	4.58	5.60	6.53	7.61
01186500	Still River at Robertsville	85.1	1210	3.45	5.23	6.62	7.93	9.49
01187000	West Branch Farmington River at Riverton	217	1310	3.33	5.12	6.55	7.88	9.48
01187300	Hubbard River near West Hartland	20.6	1290	3.38	5.27	6.80	8.24	9.98
01187400	Valley Brook near West Hartland	7.39	1100	3.38	5.21	6.68	8.06	9.72
01187800	Nepaug River near Nepaug	23.4	844	3.67	5.53	7.00	8.36	9.99
01188000	Burlington Brook near Burlington	4.20	920	3.68	5.48	6.89	8.18	9.72
01189000	Pequabuck River at Forestville	45.7	635	3.54	5.19	6.46	7.63	9.01
01189200	Stratton Brook near Simsbury	5.44	405	3.63	5.47	6.92	8.26	9.86
01189390	East Branch Salmon Brook at Granby	39.1	506	3.41	5.17	6.57	7.87	9.43
01189500	Salmon Brook Near Granby	66.9	580	3.44	5.24	6.66	7.99	9.58
01190000	Farmington River at Rainbow	590	880	3.48	5.28	6.71	8.04	9.63
01190600	Wash Brook at Bloomfield	5.64	181	3.49	5.18	6.48	7.68	9.10
01191000	North Branch Park River at Hartford	26.5	227	3.52	5.20	6.49	7.68	9.09
01192500	Hockanum River near East Hartford	73.3	447	3.17	4.44	5.36	6.19	7.15
01192650	Roaring Brook at Hopewell	24.2	540	3.29	4.60	5.55	6.41	7.40
01192700	Mattabesset River at East Berlin	45.3	216	3.64	5.34	6.65	7.85	9.27
01192883	Coginchaug River at Middlefield	29.7	348	3.70	5.32	6.54	7.66	8.96
01193500	Salmon River near East Hampton	101	490	3.44	4.82	5.82	6.72	7.76

Appendix 2. Hydrologic characteristics for streamflow-gaging stations used in the regression analysis for Connecticut. —Continued

[Hydrologic characteristics determined using digital data sets (Connecticut Drainage Basin Boundaries, USGS Digital Elevation Models, and 24-hour rainfall from the Northeast Regional Climate Center) and GIS technology. Elevations referenced to North American Vertical Datum of 1988. mi^2, square miles; ft, foot; in., inches; DA, drainage area in square miles; EL, mean basin elevation in feet; P_X, 24-hour rainfall for x-recurrence interval in inches]

U.S. Geological Survey streamflow-gaging station		Hydrologic characteristics						
Number	Name	Drainage area (mi^2)	Mean basin elevation (ft)	2-year, 24-hour rainfall (inches)	10-year, 24-hour rainfall (inches)	25-year, 24-hour rainfall (inches)	50-year, 24-hour rainfall (inches)	100-year, 24-hour rainfall (inches)
		DA	EL	P_2	P_{10}	P_{25}	P_{50}	P_{100}
01193800	Hemlock Valley Brook at Hadlyme	2.69	362	3.50	5.02	6.17	7.20	8.42
01194000	Eightmile River at North Plain	20.2	407	3.49	4.99	6.12	7.15	8.35
01194500	East Branch Eightmile River Near North Lyme	22.4	366	3.47	5.01	6.17	7.24	8.49
01195000	Menunketesuck River near Clinton	11.3	355	3.60	5.22	6.45	7.57	8.89
01195100	Indian River near Clinton	5.62	236	3.56	5.19	6.44	7.57	8.92
01195200	Neck River near Madison	6.57	169	3.61	5.25	6.50	7.65	9.00
01196500	Quinnipiac River at Wallingford	110	303	3.61	5.24	6.50	7.65	9.00
01196580	Muddy River near North Haven	17.8	276	3.79	5.47	6.75	7.91	9.28
01196620	Mill River near Hamden	24.5	302	3.67	5.28	6.50	7.61	8.91
01196700	Wepawaug River at Milford	18.6	263	3.62	5.41	6.81	8.10	9.63
01198500	Blackberry River at Canaan	46.0	1220	3.26	4.83	6.03	7.14	8.45
01199050	Salmon Creek at Lime Rock	29.4	1170	2.95	4.28	5.30	6.22	7.30
01199200	Guinea Brook at West Woods Rd at Ellsworth	3.50	1290	3.05	4.40	5.42	6.34	7.43
01200000	Tenmile River near Gaylordsville	200	819	3.02	4.37	5.40	6.33	7.42
01201190	West Aspetuck River at Sand Rd near New Milford	23.8	787	3.17	4.52	5.54	6.45	7.52
01201500	Still River near Lanesville	67.6	538	3.77	5.22	6.28	7.22	8.32
01203000	Shepaug River near Roxbury	132	1020	3.34	4.78	5.86	6.85	8.00
01203510	Pootatuck River at Sandy Hook	25.0	510	3.82	5.30	6.37	7.34	8.44
01204000	Pomperaug River at Southbury	75.3	653	3.37	4.66	5.60	6.44	7.41
01204800	Copper Mill Brook near Monroe	2.45	490	3.77	5.35	6.53	7.60	8.85
01206000	Naugatuck River near Thomaston	71.9	1030	3.51	5.16	6.42	7.59	8.97
01206500	Leadmine Brook near Thomaston	24.5	875	3.60	5.31	6.63	7.85	9.29
01208500	Naugatuck River at Beacon Falls	260	783	3.44	4.95	6.08	7.13	8.34
01208850	Pequonnock River at Trumbull	15.5	413	3.72	5.35	6.58	7.70	9.02
01208925	Mill River near Fairfield	28.6	350	3.67	5.32	6.58	7.73	9.10
01208950	Sasco Brook near Southport	7.38	230	3.61	5.27	6.55	7.72	9.11
01208990	Saugatuck River near Redding	20.7	575	3.78	5.26	6.35	7.33	8.47
01209500	Saugatuck River near Westport	79.5	456	3.73	5.25	6.38	7.40	8.58
01209700	Norwalk River at South Wilton	29.9	478	3.71	5.25	6.39	7.43	8.63
01211700	East Branch Byram River at Round Hill	1.69	469	3.62	5.24	6.47	7.60	8.92
01212100	East Branch Byram River at Riversville	11.2	398	3.63	5.28	6.53	7.68	9.03