Preliminary Stage and Streamflow Data at Selected U.S. Geological Survey Streamgages in Maine and New Hampshire for the Flood of October 30–31, 2017

By Richard G. Kiah and Nicholas W. Stasulis

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datum

Vertical coordinate information is referenced to the Sea Level Datum of 1929 also known as the National Geodetic Vertical Datum of 1929 (NGVD29).
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).
Elevation, as used in this report, refers to distance above the vertical datum.

Abbreviations

NWS	National Weather Service
USGS	U.S. Geological Survey

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Abstract

Rainfall from a storm on October 24–27, 2017, and Tropical Storm Philippe on October 29–30, created conditions that led to flooding across portions of New Hampshire and western Maine. On the basis of streamflow data collected at 30 selected U.S. Geological Survey (USGS) streamgages in the Androscoggin River, Connecticut River, Merrimack River, and Saco River Basins, the storms caused minor to moderate flooding in those basins on October 30–31, 2017. During the storms, the USGS deployed hydrographers to take discrete measurements of streamflow. The measurements were used to confirm the stage-to-streamflow relation (rating curve) at the selected USGS streamgages. Following the storms, hydrographers documented high-water marks in support of indirect measurements of streamflow. Seven streamgages with greater than 50 years of streamflow data recorded preliminary streamflow peaks within the top five for the periods of record. Twelve streamgages recorded preliminary peak streamflows greater than an estimate of the 100-year streamflow based on drainage area.

Introduction

The flood of October 30–31, 2017 was the result of frequent and abundant rainfall over the same geographic area for an extended period. On October 24–27, 2017, a storm produced rainfall over most of Maine and New Hampshire, saturating soils and decreasing infiltration capacities. A substantial and rapid drop in air pressure on October 29–30, 2017, referred to as a bombogenesis, produced damaging winds and large amounts of rainfall. The additional rainfall and associated runoff produced flooding across parts of New Hampshire and western Maine. Most of this rain fell in a 12-hour period and was in addition to 4 to 8 inches of rain that fell the week before.

The U.S. Geological Survey (USGS), in cooperation with Federal, State, and local agencies, collects water resources data at streamgages in Maine and New Hampshire each year. These data are valuable for developing an improved understanding of the water resources of the United States. To make these data readily available to interested parties outside the USGS, preliminary stage and streamflow data at continuous record streamgages are available in near real-time through the USGS National Water Information System (NWIS; U.S. Geological Survey, 2017). Preliminary data are provisional and subject to revision until they have been fully reviewed and received final approval. Publication of the final streamflow data is done through NWIS following further analysis of the hydraulic characteristics and the stability of those characteristics at each streamgage.

The purpose of this report is to provide preliminary information documenting the peak stages and streamflows for select rivers and streams in Maine and New Hampshire that are part of the USGS streamgaging network and were affected by flooding from the October 30–31 storm (fig. 1). These peak streamflows are placed into context by ranking them with other annual flood peaks for the period of record at each streamgage as well as historic floods that might precede USGS systematic records. The National Weather Service (NWS) flood stage information is also provided for sites where a NWS flood stage has been defined (table 1).

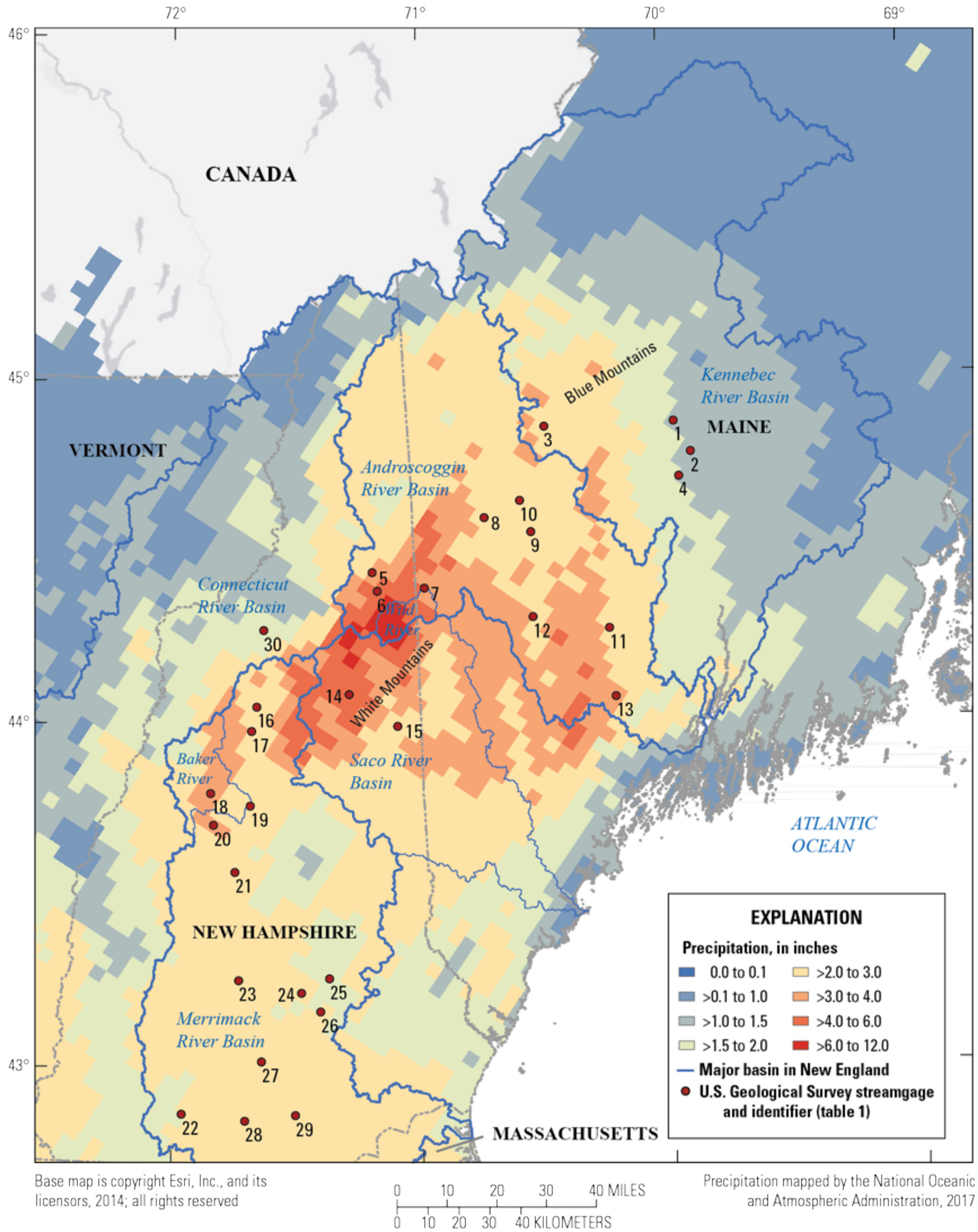

Figure 1. Selected U.S. Geological Survey real-time streamgages in Maine and New Hampshire and rainfall totals for October 29–30, 2017.

Study Area

Streamgage data documented in this report are part of the USGS Real-Time Data Network for Maine and New Hampshire. The 30 selected streamgages used in this report are adjacent to the Atlantic Ocean in the New England Upland and White Mountain physiographic provinces through the White Mountains of New Hampshire and the Blue Mountains of western Maine (fig. 1; Olcott, 1995). Land-surface elevations of the gaged watersheds range from at mean sea level for many of the watersheds to more than 6,200 feet above mean sea level at Mount Washington in New Hampshire. Average annual precipitation in the area is in the 40- to 50-inch range, with averages greater than 50 inches in the higher elevations of the White Mountains (Olcott, 1995).

General Weather Conditions: Antecedent Conditions and Rainfall

On October 17, 86 percent of Maine and New Hampshire was in an Abnormally Dry or Moderate Drought intensity (National Drought Mitigation Center, 2017). These prolonged drought intensities were reduced after a low-pressure system passed through Maine and New Hampshire on October 24–27. This low-pressure system produced widespread rainfall totals of 2 to 4 inches, with increased amounts of 4 to 8 inches through the White Mountains of New Hampshire and in western and eastern Maine (Thomas Hawley, National Weather Service, written commun., November 7, 2017). Because of the existing drought conditions before this rain storm, there was no substantial river flooding; however, the large amount of rainfall saturated the soil and increased streamflows to above average conditions at many streamgages leading into the October 29–30 storm.

Following the October 24–27 rainfall, Tropical Storm Philippe, which was a weak and poorly organized cyclone, moved northeast from Florida up the Atlantic coast, and the moisture that accompanied the storm fed into a cold front that was advancing from the Midwest. The merger of these two systems on October 28–29 led to a bombogenesis, which produced damaging winds in addition to the heavy rains brought by the storm (Trotter, 2017).

The rainfall associated with the October 29–30 storm produced rainfall totals of 1.5 to 4 inches over most of New Hampshire and central, western, and southern Maine. At the high elevations of the White Mountains in northern New Hampshire and in western Maine rainfall of 4 to 7 inches was observed (fig. 1). Most of this rain fell in a 12-hour period from October 29–30 (Thomas Hawley, National Weather Service, written commun., November 2, 2017). This heavy rainfall led to bridge and road closings and catastrophic damage to private residences along the Baker River in west central New Hampshire (fig. 1, near streamgage 18).

Methods Used To Collect Streamflow Data

The USGS currently [2017] operates 69 real-time streamgages in Maine and 52 in New Hampshire to characterize hydrologic conditions in each State. A typical USGS streamgage measures and records stream stage at 5- or 15-minute intervals using established techniques (Rantz and others, 1982; Sauer and Turnipseed, 2010) and estimates streamflow based on a relation of discrete measurements of streamflow and the recorded stage. This stage-to-streamflow relation is referred to as the rating curve. The USGS routinely collects discrete measurements of streamflow (fig. 2) using established techniques (Rantz and others, 1982; Sauer and Turnipseed, 2010; Mueller and others, 2013).

Figure 2. U.S. Geological Survey (USGS) hydrographers using an acoustic Doppler current profiler to measure streamflow at USGS streamgage 01054200, Wild River at Gilead, Maine, on October 30, 2017. A sounding weight and current meter are attached to the profiler to stabilize the equipment and to serve as a backup measurement technique; photograph by Anthony Underwood, USGS.

To confirm the rating curve, streamflow measurements are collected over the range of observed hydrologic conditions at a streamgage. During the October 30–31 flood, USGS hydrographers made 49 streamflow measurements at 31 streamgages in Maine and New Hampshire to verify, update, or extend existing rating curves. Performing direct measurements of streamflow was not possible at some sites because of the flashiness of the stream or unsafe conditions. To help define the peak streamflow at these sites, indirect measurements of the peak streamflow were estimated using methods defined by the USGS (Benson and Dalrymple, 1967; Dalrymple and Benson, 1967; Matthai, 1967). Following the October 30–31 flood, USGS hydrographers documented and surveyed the water-surface profiles from high-water marks and channel characteristics (fig. 3) at seven streamgages for the computation of peak streamflow by indirect methods.

Figure 3. A U.S. Geological Survey (USGS) hydrographer (opposite bank of river) surveying high-water marks and channel characteristics for use in an indirect measurement of peak streamflow at USGS streamgage 01074520, East Branch Pemigewasset River at Lincoln, New Hampshire, on November 25, 2017; photograph by Richard Kiah, USGS.

Flood of October 30–31

Flooding on October 30–31 was widespread; the areas affected included parts of southwestern New Hampshire, the White Mountains of New Hampshire, and the Blue Mountains of western Maine. Four streamgages in Maine reached the NWS flood stage (table 1), and minor flooding was reported in the Androscoggin River and Kennebec River Basins. Flooding in New Hampshire was more widespread than in Maine; 11 streamgages in New Hampshire reached NWS flood stage and experienced minor to moderate flooding in the Androscoggin River, Connecticut River, Merrimack River, and Saco River Basins (table 1).

In total, 30 streamgages were selected for this report to provide context for the flooding. To gain a historical perspective on the relative magnitude of the October 30–31 flood, peak streamflows were ranked against previously recorded peaks of record (table 1). Twenty of the 30 selected streamgages have more than 50-years of streamflow record. Seven of these long-term streamgages recorded preliminary streamflow peaks within the top five for their periods of record. Many rivers reached historic streamflow levels during this flood. For example, the Wild River at Gilead, Maine, produced the second largest streamflow in the 53-years of record, whereas the Baker River near Rumney, N.H., produced the largest streamflow since 1942 (fig. 4; table 1).

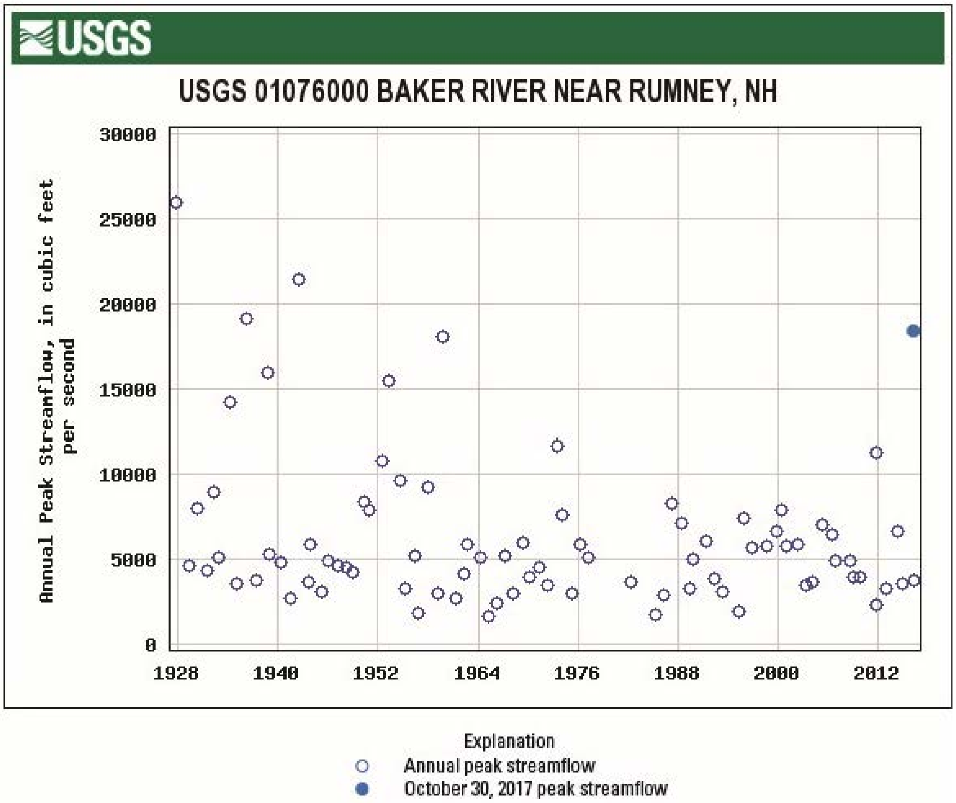

Figure 4. Annual peak streamflow at U.S. Geological Survey (USGS) streamgage 01076000, Baker River near Rumney, N.H. for water years 1927 to 2016 and preliminary peak streamflow for October 30, 2017; screenshot is from the USGS National Water Information System (U.S. Geological Survey, 2017).

Comparison of Flood of October 30–31 to Past Floods

Collection of systematic streamflow records enables comparison of recent events to past floods through statistical analysis or estimation of the probability of flooding at specific streamgage locations. Long-term streamflow records are important for understanding the probability of flooding as the characteristics of the watershed change with factors such as land-use change and climate variability.

Although the computation of annual exceedance probabilities for the October 30–31 flood is outside the scope of this report, it is possible to gain perspective on the relative magnitude by comparison to regional analyses (fig. 5). Recorded peak streamflows relative to the contributing drainage area are shown in figure 5. Envelope lines for regional maximum potential streamflows (Crippen and Bue, 1977) and for maximum recorded streamflows in and adjacent to New Hampshire as well as a regression line relating 100-year discharge (Q_{100}; Olson, 2008) to drainage area (A) have been included. The equation for the 100-year streamflow based on drainage area is as follows:

$$Q_{100} = 219A^{0.8}. \tag{1}$$

Although regional regression estimates based only on drainage area have large confidence intervals, they do provide context on the relative distribution of streamflows per unit area of drainage (Olson, 2008) and are especially valuable for evaluating sites with short-term systematic record.

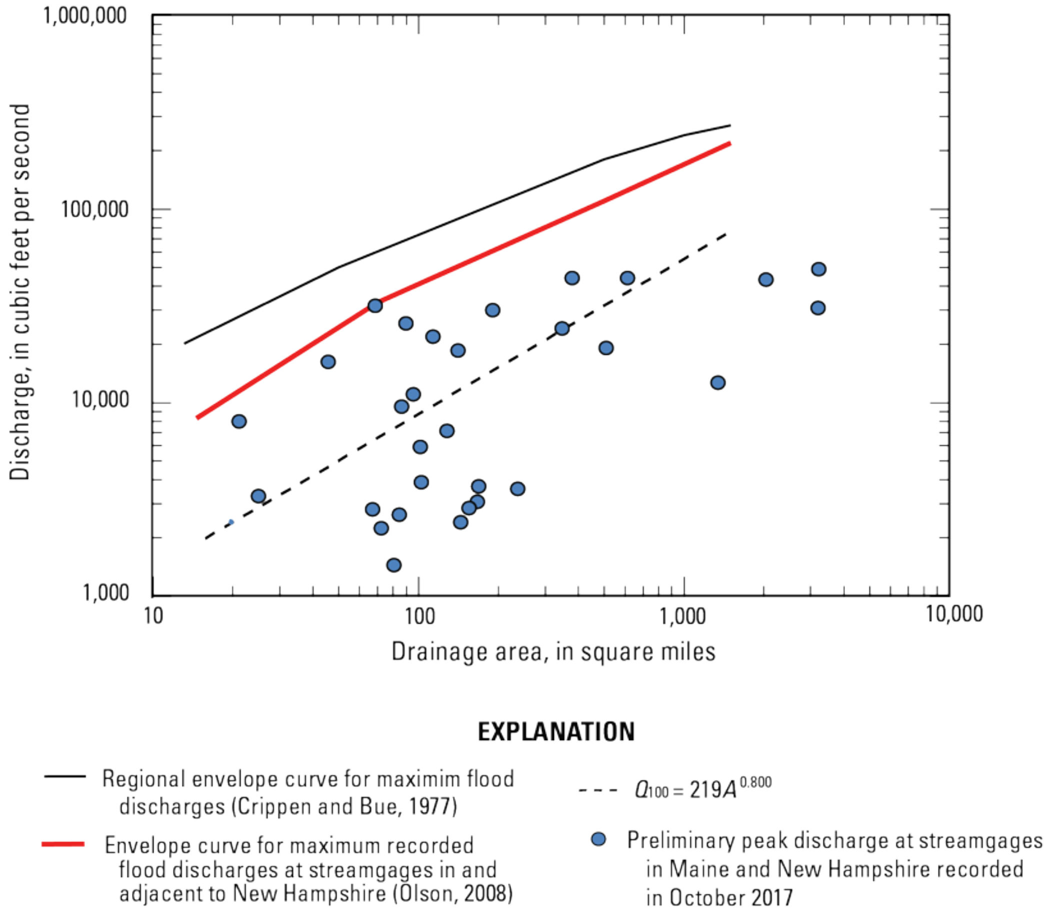

Figure 5. Preliminary peak streamflows for selected U.S. Geological Survey streamgages in Maine and New Hampshire relative to the contributing drainage area, with envelope lines (from Crippen and Bue, 1977 and Olson, 2008) and a regression line (dashed line; equation shown on line; from Olson, 2008) relating the 100-year discharge (Q_{100}) to drainage area (A).

All recorded streamflows were less than the maximum potential streamflow, and the Wild River at Gilead, Maine (streamgage 01054200) recorded a streamflow similar to the maximum recorded streamflows in and adjacent to New Hampshire (fig. 5, red line). Of the 30 streamgages used for the analysis in this report, 12 preliminary peaks exceeded the 100-year discharge estimates (Olson, 2008), which is a situation similar to what was recorded for flooding in August 28 to September 2, 2011, related to Tropical Storm Irene, when three streamgages approached or exceeded the maximum recorded streamflows in and adjacent to New Hampshire (Kiah and others, 2013) and 17 recorded peak streamflows greater than the 100-year discharge estimates based on drainage area (Olson, 2008).

U.S. Geological Survey (USGS) hydrographer standing on flooded Bridge Street in Plymouth, New Hampshire, on October 30, 2017, preparing to make a discharge measurement of the Pemigewasset River at Plymouth (USGS station 01076500) ; photograph by Richard Kiah, USGS.

Summary

A low-pressure system passed through Maine and New Hampshire on October 24–27, 2017 and produced widespread rainfall totals of 2 to 4 inches, with localized amounts of 4 to 8 inches, saturating the soil and causing above average streamflow conditions at many streamgages. On October 29, Tropical Storm Philippe moved up the Atlantic coast where the moisture from the tropical storm fed into a cold front that was advancing from the Midwest, leading to a bombogenesis, The resulting storm produced rainfall of as much as 8 inches in the mountainous areas of Maine and New Hampshire on October 29–30, and led to flooding on October 30–31 in the Androscoggin River, Connecticut River, Merrimack River, and Saco River Basins, as was determined by characterizations by 30 selected U.S. Geological Survey (USGS) streamgages in those basins. This report summarizes the flooding on October 30–31 in preliminary terms for peak stream stage and streamflow.

Flooding on October 30–31 was widespread in parts of southwestern New Hampshire, through the White Mountains of New Hampshire, and into the Blue Mountains of Maine. Of the 20 streamgages with long-term records (greater than 50 years), 7 recorded preliminary peak streamflows ranked in the highest five for their periods of record. Twelve streamgages recorded preliminary peak streamflows greater than the 100-year flood estimates for streamflow based on drainage area.

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Table 1. Preliminary peak stage and streamflow data collected at select streamgages in Maine and New Hampshire for the flood of October 30–31, 2017.

[Orange shading indicates streamgages where the peak stage was greater than the National Weather Service (NWS)-established flood stage; red shading indicates streamgages where the peak stage was greater than the NWS-established moderate flood stage. NWS, National Weather Service; mi^2, square mile; ft, foot; ft^3/s, cubic foot per second; ME, Maine; NH, New Hampshire; —, data not available]

Site number, (fig. 1)	Station number	Station name	Drainage area (mi^2)	NWS flood stage (ft)	Preliminary peaks, October 30–31, 2017				Historical (period of record) peak		
					Date	Stage (ft)	Streamflow (ft^3/s)	Rank[a]	Number of water years	Water year	Streamflow (ft^3/s)
Kennebec River Basin											
1	01047000	Carrabasset River near North Anson, ME	353	15	10/30/2017	17.71	23,800	6	91	1987	50,700
2	01047150	Kennebec River near Madison, ME	3,245	—	10/30/2017	10.40	30,400	6	7	2010	53,100
3	01047200	Sandy River near Madrid, ME	25.3	—	10/30/2017	9.89	3,260	2	8	2011	5,210
4	01048000	Sandy River near Mercer, ME	516	12	10/31/2017	11.39	18,900	26	81	1987	51,100
Androscoggin River Basin											
5	01054000	Androscoggin River near Gorham, NH	1,361	8	10/30/2017	8.05	12,500	38	104	1923	21,900
6	01054114	Peabody River at Gorham, NH	46.27	—	10/30/2017	13.53	16,000	1	4	2013	11,400
7	01054200	Wild River at Gilead, ME	69.6	—	10/30/2017	15.94	31,100	2	53	2011	37,800
8	01054300	Ellis River at South Andover, ME	130	—	10/30/2017	18.20	7,070	4	35	2003	7,830
9	01054500	Androscoggin River at Rumford, ME	2,068	15	10/31/2017	16.18	42,400	13	124	1936	74,000
10	01055000	Swift River near Roxbury, ME	96.9	7	10/30/2017	10.45	10,900	14	87	1959	16,800
11	01055500	Nezinscot River at Turner Center, ME	169	—	10/31/2017	5.60	3,050	42	70	1953	13,900
12	01057000	Little Androscoggin River near South Paris, ME	73.5	—	10/30/2017	7.88	2,230	51	95	1987	9,340
13	01059000	Androscoggin River near Auburn, ME	3,263	13	10/31/2017	13.84	48,100	22	88	1936	135,000
Saco River Basin											
14	010642505	Saco River at River Street, at Bartlett, NH	91	—	10/30/2017	13.93	25,300	2	7	2011	29,100
15	01064500	Saco River at Conway, NH	385	9	10/30/2017	15.85	48,600	2	93	2011	58,200
Merrimack River Basin											
16	01074520	East Branch Pemigewasset River at Lincoln, NH	115	—	10/30/2017	10.90	21,600	3	55[b]	2011	29,300
17	01075000	Pemigewasset River at Woodstock, NH	193	9	10/30/2017	13.54	29,600	5	72	2011	53,700

Site number, (fig. 1)	Station number	Station name	Drainage area (mi²)	NWS flood stage (ft)	Preliminary peaks, October 30–31, 2017				Historical (period of record) peak		
					Date	Stage (ft)	Streamflow (ft³/s)	Rank[a]	Number of water years	Water year	Streamflow (ft³/s)
					Merrimack River Basin—Continued						
18	01076000	Baker River near Rumney, NH	143	10	10/30/2017	14.72	18,300	3	82	1927	25,900
19	01076500	Pemigewasset River at Plymouth, NH	622	13	10/30/2017	19.77	43,200	8	113	1936	65,400
20	01077400	Cockermouth River below Hardy Brook, at Groton, NH	21.4	—	10/30/2017	11.82	7,860	1	8	2011	5,260
21	01078000	Smith River near Bristol, NH	85.8	8	10/30/2017	8.39	2,620	16	98	1936	8,100
22	01082000	Contoocook River at Peterborough, NH	68.1	5.5	10/30/2017	6.10	2,790	4	69	2007	4,110
23	01086000	Warner River at Davisville, NH	146	8	10/30/2017	8.08	2,390	22	58	2006	8,640
24	01089100	Soucook River at Pembroke Rd, near Concord, NH	81.9	11	10/31/2017	9.81	1,440	12	28	2006	5,110
25	01089500	Suncook River at North Chichester, NH	157	7	10/30/2017	10.34	2,820	21	68	1936	12,900
26	01089925	Suncook River at NH28, near Suncook, NH	240	—	10/31/2017	289.36	3,560	1	1	2016	2,610
27	01091000	South Branch Piscataquog River near Goffstown, NH	104	—	10/30/2017	9.20	3,850	5	49	2007	8,800
28	01093852	Souhegan River (Site WLR1) near Milford, NH	103	9	10/30/2017	11.19	5,860	2	12	2007	6,950
29	01094000	Souhegan River at Merrimack, NH	171	9	10/31/2017	8.14	3,670	38	103	1936	16,900
					Connecticut River Basin						
30	01137500	Ammonoosuc River at Bethlehem Junction, NH	87.6	8	10/30/2017	11.37	9,440	4	77	1995	11,300

[a]Rank of the maximum instantaneous peak streamflow measured during water year 2018 compared with all systematic and historic annual peaks recorded through water year 2016.

[b]Number of years of historic peaks includes discontinued station 01074500 East Branch Pemigewasset River near Lincoln, New Hampshire.