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Streamflow, Water Quality, and Constituent Loads and Yields, Scituate Reservoir Drainage Area, Rhode Island, Water Year 2020

Data Report 1192

U.S. Department of the Interior
U.S. Geological Survey

Cover. Photograph of Hemlock Brook, Rhode Island. Photograph by the U.S. Geological Survey.

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
liter (L)	0.03531	cubic foot (ft^3)
	Discharge	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
liter per day (L/d)	0.03531	cubic foot per day (ft^3/d)
	Mass	
kilogram (kg)	2.205	pound avoirdupois (lb)
metric ton (t)	1.102	ton, short [2,000 lb]
	Load	
gram per day (g/d)	0.0022	pound per day (lb/d)
kilogram per day (kg/d)	2.205	pound per day (lb/d)
metric ton per year (t/yr)	2205	pound per year (lb/yr)

Multiply	By	To obtain
	Yield	
kilogram per day per square mile ([kg/d]/mi^2)	2.590	kilogram per day per square kilometer ([kg/d]/km^2)
kilogram per day per square mile ([kg/d]/mi^2)	2.205	pound per day per square mile ([lb/d]/mi^2)
metric ton per year per square mile ([t/yr]/mi^2)	2.590	metric ton per year per square kilometer ([t/yr]/mi^2)
metric ton per year per square mile ([t/yr]/mi^2)	2205	pound per year per square mile ([lb/yr]/mi^2)

Datums

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

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

Supplemental Information

Concentrations of constituents in water are given in either milligrams per liter (mg/L) or colony forming units per 100 milliliters (CFU/100 mL).

Loads of bacteria in water are given in million colony forming units per day ([CFU×10^6]/d).

Yields of bacteria are given in million colony forming units per day per square mile ([(CFU×10^6)/d]/mi^2).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Color is given in platinum-cobalt units (PCU).

A water year is the period from October 1 to September 30 and is designated by the year in which it ends; for example, water year 2020 was from October 1, 2019, to September 30, 2020.

Abbreviations

MOVE.1	Maintenance of Variance Extension type 1
NWIS	National Water Information System
PW	Providence Water
USGS	U.S. Geological Survey
WY	water year

Streamflow, Water Quality, and Constituent Loads and Yields, Scituate Reservoir Drainage Area, Rhode Island, Water Year 2020

By Kirk P. Smith

Abstract

As part of a long-term cooperative program to monitor water quality within the Scituate Reservoir drainage area, the U.S. Geological Survey in cooperation with Providence Water (sometimes known as Providence Water Supply Board) collected streamflow and water-quality data in tributaries to the Scituate Reservoir, Rhode Island. Streamflow and concentrations of chloride and sodium estimated from records of specific conductance for 14 tributaries were used to calculate loads of chloride and sodium during water year 2020 (October 1, 2019, through September 30, 2020). Water-quality samples were collected by Providence Water at 37 sampling stations on tributaries to the Scituate Reservoir during water year 2020. These water-quality data are summarized by using values of central tendency and are used, in combination with measured (or estimated) streamflows, to calculate loads and yields of selected water-quality constituents for water year 2020 in this report.

Annual mean streamflows for monitoring stations in this study ranged from about 0.32 to 26.7 cubic feet per second during water year 2020. At the 14 continuous-record streamgages, tributaries transported about 2,200 metric tons of chloride and 1,400 metric tons of sodium to the Scituate Reservoir; annual chloride yields for the tributaries ranged from 13 to 110 metric tons per square mile, and annual sodium yields ranged from 8.8 to 6 metric tons per square mile. At the stations where water-quality samples were collected by Providence Water, the medians of the median daily loads were 220 kilograms chloride per day, 10 grams nitrite as nitrogen per day, 500 grams nitrate as nitrogen per day, 290 grams orthophosphate as phosphate per day, 55,000 million colony forming units of coliform bacteria per day, and less than 900 million colony forming units of *Escherichia coli* per day. The medians of the median yields were 76 kilograms chloride per day per square mile, 4.1 grams nitrite as nitrogen per day per square mile, 240 grams nitrate as nitrogen per day per square mile, 100 grams orthophosphate as phosphate per day per square mile, 31,000 million colony forming units of coliform bacteria per day per square mile, and less than 260 million colony forming units of *Escherichia coli* per day per square mile.

Introduction

The Scituate Reservoir is the primary source of drinking water for more than 60 percent of the population of Rhode Island. The Scituate Reservoir drainage area consists of six subbasins and covers an area of about 94 square miles in parts of the towns of Cranston, Foster, Glocester, Johnston, and Scituate, R.I. (fig. 1). The six subbasins are referred to in this report as the Barden Reservoir subbasin, "Direct Runoff" subbasin, Moswansicut Pond reservoir subbasin, Ponaganset Reservoir subbasin, "Regulating reservoir" subbasin, and Westconnaug Reservoir subbasin. Information about the water quality of the reservoir and its tributaries is important for management of the water supply and for the protection of human health. Providence Water (PW; sometimes known as Providence Water Supply Board), which is the agency responsible for the management and distribution of the Scituate Reservoir water supply, has been monitoring and assessing water quality in the reservoir and reservoir drainage area for more than 60 years.

Since 1993, the U.S. Geological Survey (USGS) has been cooperating with PW and the Rhode Island Department of Environmental Management to measure streamflow in tributaries to the Scituate Reservoir. Streamflow has been continuously measured at 10 streamgages in the drainage area (table 1) since 2009 by the USGS. Streamflow also was continuously measured at four streamgages from 2009 to 2014 and periodically measured at nine additional streamgages on tributaries in the drainage area. At 13 streamgages, daily mean streamflow has been estimated by using methods developed by the USGS (table 1; Hirsch, 1982). The USGS also has been continuously measuring specific conductance at 14 monitoring stations since 2009 (table 1). Equations that relate specific conductance to concentrations of chloride and sodium in stream water were developed as part of previous cooperative studies of the USGS and PW (Nimiroski and Waldron, 2002; Smith, 2015b, 2018a, 2022a; Spaetzel and Smith, 2022b). These equations, used together with measured (or estimated) streamflows, allow for nearly continuous estimation of chloride and sodium loads to the Scituate Reservoir.

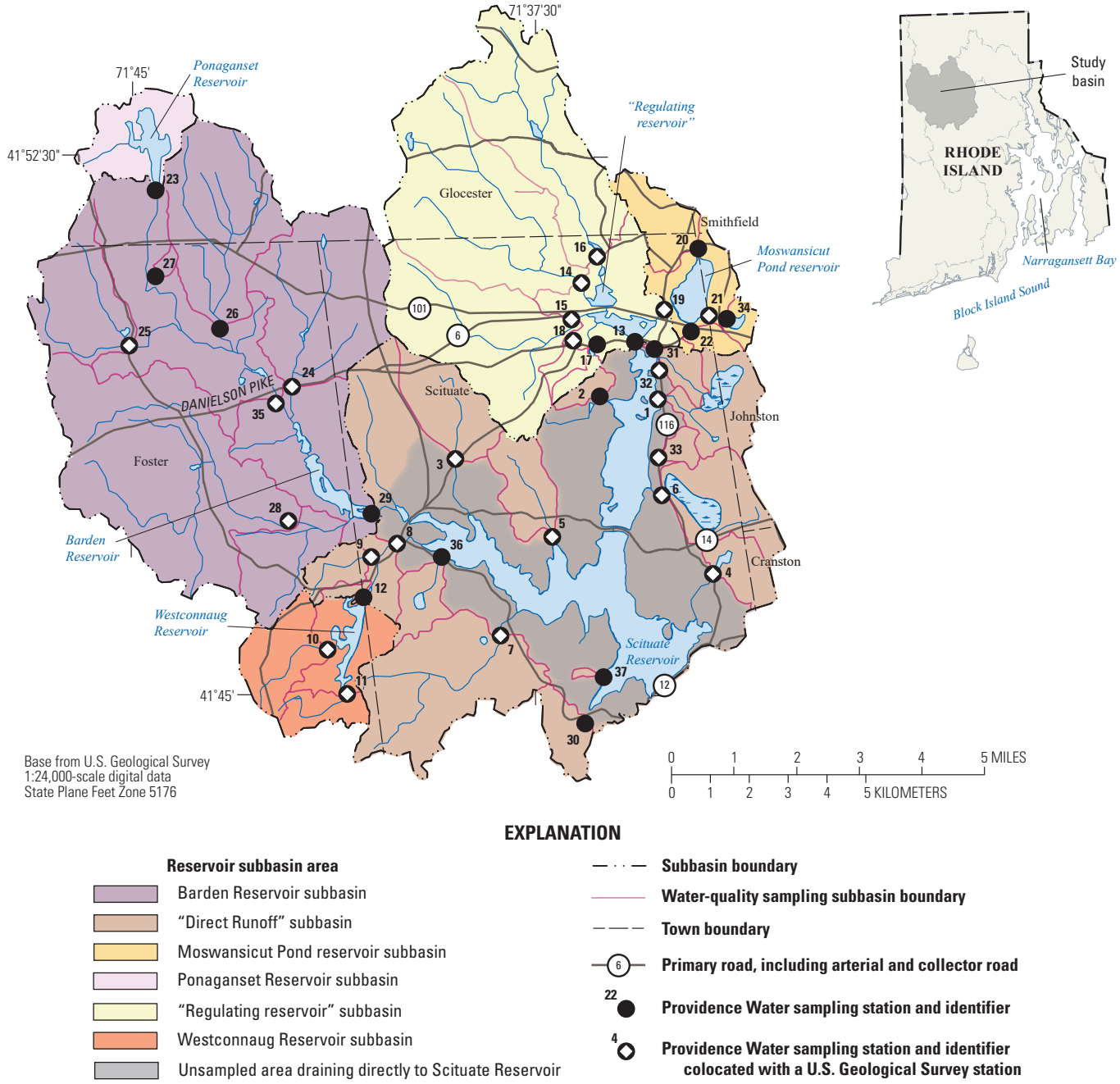

Figure 1. Map showing locations of tributary-reservoir subbasins and stations in the Scituate Reservoir drainage area, Rhode Island, in water year 2020. Modified from Breault (2009).

Table 1. Providence Water water-quality sampling stations and corresponding U.S. Geological Survey streamgages, in the Scituate Reservoir drainage area, Rhode Island, and data collection and monitoring statistics for October 1, 2019, to September 30, 2020.

[Alternate station names given for stations where different historical names were used for the same sampling location by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; mi^2, square mile; WQ, water quality; M, monthly; Q, quarterly; Y, yes; N, no]

PW station number	USGS station number	USGS station short name	Alternate name	Drainage area (mi^2)	Frequency of WQ sample collection by PW	Number of samples collected by PW[1]	Daily estimated Na and Cl loads	Streamflow data availability	Specific conductance data availability
			Barden Reservoir subbasin						
24	01115190	Dolly Cole Brook	—	4.9	M	11	Y	Continuous	Continuous
25	01115200	Shippee Brook	—	2.37	Q	3	N	Estimated	None
26	01115185	Winsor Brook	—	4.33	Q	3	N	Estimated	None
27	011151845	Unnamed tributary to Ponaganset River	Unnamed brook B, unnamed brook west of Winsor Brook	0.10	Q	3	N	None	None
28	01115265	Barden Reservoir	Hemlock Brook	8.72	M	12	Y	Continuous	Continuous
29	01115271	Ponaganset River	Barden Stream	33.0	M	11	N	None	None
35	01115187	Ponaganset River	—	14.0	M	11	Y	Continuous	Continuous
			Direct runoff subbasin						
1	01115180	Brandy Brook	—	1.57	M	12	N	Estimated	None
2	01115181	Unnamed tributary 2 to Scituate Reservoir	Unnamed brook north of Bullhead Brook	0.22	Q	2	N	None	None
3	01115280	Cork Brook	—	1.87	M	11	Y	Continuous	Continuous
4	01115400	Kent Brook	Betty Pond Stream	0.85	M	11	N	Estimated	None
5	01115184	Spruce Brook	—	1.26	Q	3	Y	Estimated	Continuous
6	01115183	Quonopaug Brook	—	1.96	M	10	Y	Continuous	Continuous
7	01115297	Wilbur Hollow Brook	—	4.33	M	12	Y	Estimated	Continuous
8	01115276	Westconnaug Brook	Westconnaug Reservoir	5.18	M	11	Y	Continuous	Continuous
9	01115275	Bear Tree Brook	—	0.62	Q	4	Y	Estimated	Continuous
30	01115350	Unnamed tributary 4 to Scituate Reservoir	Coventry Brook, Knight Brook	0.79	Q	3	N	None	None
31	01115177	Toad pond	—	0.03	Q	1	N	None	None
32	01115178	Unnamed tributary 1 to Scituate Reservoir	Pine Swamp Brook	0.45	Q	3	N	Estimated	None
33	01115182	Unnamed tributary 3 to Scituate Reservoir	Halls Estate Brook	0.28	Q	3	N	Estimated	None
36	—	Outflow from King Pond	—	0.76	Q	3	N	None	None
37	—	Fire tower stream	—	0.03	Q	3	N	None	None

Table 1. Providence Water water-quality sampling stations and corresponding U.S. Geological Survey streamgages, in the Scituate Reservoir drainage area, Rhode Island, and data collection and monitoring statistics for October 1, 2019, to September 30, 2020.—Continued

[Alternate station names given for stations where different historical names were used for the same sampling location by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; mi², square mile; WQ, water quality; M, monthly; Q, quarterly; Y, yes; N, no]

PW station number	USGS station number	USGS station short name	Alternate name	Drainage area (mi²)	Frequency of WQ sample collection by PW	Number of samples collected by PW[1]	Daily estimated Na and Cl loads	Streamflow data availability	Specific conductance data availability
			Moswansicut Pond reservoir subbasin						
19	01115170	Moswansicut stream	—	3.25	M	12	Y	Continuous	Continuous
20	01115160	Unnamed tributary 1 to Moswansicut Pond reservoir	Blanchard Brook	1.18	M	9	N	None	None
21	01115165	Unnamed tributary 2 to Moswansicut Pond reservoir	Brook from Kimball Reservoir	0.30	Q	3	N	Estimated	None
22	01115167	Unnamed tributary 3 to Moswansicut Pond reservoir	—	0.10	M	9	N	None	None
34	01115164	Unnamed tributary from Kimball Reservoir	Kimball Stream	0.27	Q	4	N	None	None
			Ponaganset Reservoir subbasin						
23	011151843	Ponaganset Reservoir	—	1.92	M	9	N	None	None
			Regulating reservoir subbasin						
13	01115176	Unnamed water body at Horseshoe dam	Regulating reservoir	22.1	M	11	N	None	None
14	01115110	Huntinghouse Brook	—	6.29	M	10	Y	Continuous	Continuous
15	01115114	Rush Brook	—	4.70	M	9	Y	Continuous	Continuous
16	01115098	Peeptoad Brook	Harrisdale Brook	4.97	M	11	Y	Continuous	Continuous
17	01115119	Dexter Pond	Paine Pond	0.22	Q	3	N	None	None
18	01115120	Unnamed tributary to Regulating reservoir	Unnamed brook A	0.28	Q	3	Y	Estimated	Continuous
			Westconnaug Reservoir subbasin						
10	01115274	Westconnaug Brook	—	1.48	M	10	N	Estimated	None
11	01115273	Unnamed tributary to Westconnaug Reservoir	Unnamed brook south of Westconnaug Reservoir	0.72	Q	4	N	Estimated	None
12	011152745	Unnamed tributary to Westconnaug Brook	Unnamed brook north of Westconnaug Reservoir	0.16	Q	3	N	None	None

[1]Not all samples were analyzed for all water-quality properties or constituents.

In 2020, PW regularly, either monthly or quarterly, visited fixed sites on 37 tributaries within the Scituate Reservoir drainage area and collected water-quality samples. Compiled and tabulated streamflow (measured or estimated by the USGS) and water-quality data (collected by PW) have been published in Breault and others (2000), Nimiroski and others (2008), Breault (2009), Breault and Campbell (2010a–d), Breault and Smith (2010), Smith and Breault (2011), and Smith (2013, 2014, 2015a, b, 2016, 2018a–d, 2019a, b, 2021, 2022a, b), Smith and Spaetzel (2021), and Spaetzel and Smith (2022a, b).

This report presents data on streamflow, water quality, and loads and yields of selected constituents for water year (WY) 2020 in the Scituate Reservoir drainage area (a water year is the period from the previous October 1 to September 30 of the designated year). Data were collected in past studies by the USGS in cooperation with PW and the Rhode Island Department of Environmental Management. This report summarizes measured and estimated streamflows for the 10 continuous-record and 13 partial-record streamgages in the drainage area. Estimated monthly and annual loads and yields of chloride and sodium are presented for the 14 streamgages at which specific conductance is continuously monitored by the USGS. Summary statistics for water-quality data collected by PW for 37 sampling stations (table 1) during WY 2020 also are presented, and these data were used to calculate loads and yields of selected water-quality constituents where flow data were available. Water-quality data related to the Scituate Reservoir drainage area have been published serially by the USGS since 2000 (Breault and others, 2000). The presentation and content of this report has been replicated from Breault (2009), with annually updated methods, data, and interpretations (Breault and Campbell, 2010a–d; Breault and Smith, 2010; Smith and Breault, 2011; Smith 2013, 2014, 2015a, 2016, 2018a, b, 2019a, 2022a).

Streamflow Data Collection and Estimation

Streamflow was measured or estimated by the USGS at 23 streamgages (table 1). Measured and estimated streamflows are necessary to estimate water volume and water-quality constituent loads and yields from tributary basins. Stream gage height was measured every 10 minutes at most continuous-record streamgages. Streamflow was computed with a gage height to discharge relation (known as a rating), which was developed on the basis of periodic manual measurements of streamflow. Daily mean streamflow at a streamgage was calculated by dividing the total volume of water that passed the streamgage each day by 86,400 (the number of seconds in a day). Periodic manual streamflow measurements at partial-record streamgages were used concurrently with continuous-record measurements from streamgages in nearby hydrologically similar drainage areas to estimate a continuous daily record at the partial-record streamgages. Specifically, daily streamflow records for the 13 partial-record sites in the Scituate Reservoir drainage area (table 1) were estimated by using the Maintenance of Variance Extension type 1 (MOVE.1) method, as described by Ries and Friesz (2000), Smith (2015b), and Spaetzel and Smith (2022b); data needed to estimate streamflows at partial-record sites were retrieved from the USGS National Water Information System (NWIS; U.S. Geological Survey, 2023). The upper and lower 90-percent confidence limits for the estimated mean annual streamflows, as described by Tasker and Driver (1988), are listed in table 2. These USGS data indicate that there is a 90-percent chance that the estimated mean annual streamflow is between the upper and lower 90-percent confidence limits.

Continuous-record streamgages were operated and maintained by the USGS during WY 2020 (fig. 1; table 1). Streamflow data for these streamgages were collected at 10- or 15-minute intervals (near-real-time streamflow data), were updated at 1-hour intervals on the internet, and are available through the NWIS web interface (U.S. Geological Survey, 2023). Error associated with measured streamflows was generally within about 15 percent as noted in the annual water year summary for each USGS streamgage (U.S. Geological Survey, 2023).

Table 2. Measured or estimated annual mean streamflow for tributary streams in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023; Spaetzel and Smith, 2022b). Stations are shown on figure 1. PW, Providence Water; USGS, U.S. Geological Survey; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, cubic foot per second per square mile]

PW station number	USGS station number	Annual mean streamflow (ft^3/s)	Upper 90–percent confidence interval (ft^3/s)	Lower 90–percent confidence interval (ft^3/s)	Annual mean streamflow yield ($[ft^3/s]/mi^2$)
Barden Reservoir subbasin					
24	01115190	7.81	8.79	6.84	1.59
25	01115200	7.00	22.8	2.15	2.96
26	01115185	9.43	21.2	4.18	2.18
28	01115265	12.0	13.1	10.9	1.38
35	01115187	26.7	29.6	23.8	1.91
Direct Runoff subbasin					
1	01115180	2.78	5.89	1.31	1.77
3	01115280	3.25	3.69	2.82	1.74
4	01115400	1.46	6.59	0.33	1.72
5	01115184	1.80	4.03	0.80	1.43
6	01115183	3.49	3.86	3.12	1.78
7	01115297	7.23	14.9	3.51	1.67
8	01115276	8.60	9.22	7.98	1.66
9	01115275	1.52	2.60	0.88	2.45
32	01115178	0.59	1.11	0.32	1.32
33	01115182	0.32	0.74	0.14	1.14
Moswansicut Pond reservoir subbasin					
19	01115170	5.48	5.90	5.05	1.69
21	01115165	0.54	1.15	0.25	1.79
Regulating reservoir subbasin					
14	01115110	10.5	11.9	9.08	1.67
15	1115114	7.88	9.05	6.72	1.68
16	01115098	8.69	9.85	7.54	1.75
18	01115120	0.55	2.41	0.13	1.98
Westconnaug Reservoir subbasin					
10	01115274	3.25	7.78	1.36	2.20
11	01115273	1.90	5.02	0.72	2.63

Water-Quality Data Collection and Analysis

Water-quality data were collected by the USGS and PW. Concentrations of sodium and chloride were estimated by the USGS from continuous records of specific conductance from 14 of the 23 streamgages. Water-quality samples were collected monthly or quarterly at 37 sampling stations in the Scituate Reservoir drainage area by PW during WY 2020 as part of a long-term sampling program (table 1).

Data Collected by the U.S. Geological Survey

Three or more water-quality samples were collected by the USGS at each of the 14 streamgages equipped with continuous specific conductance monitors in the Scituate Reservoir drainage area during WY 2020 (table 1), except from unnamed brook A, Cork Brook, and Huntinghouse Brook (USGS stations 01115120, 01115280, and 01115110, respectively; PW stations 18, 3, and 14, respectively) where samples were not collected during the summer because the streambeds were dry. Samples were collected in the centroid of the streams during the fall, winter, and summer months. Water

samples were processed in the USGS New England Water Science Center laboratory in Northborough, Massachusetts, at the conclusion of scheduled sampling. After the processing, the samples were packed in ice and shipped overnight to the USGS National Water Quality Laboratory in Lakewood, Colorado. Analytical results and parameter codes for the USGS water-quality samples are available through the NWIS web interface (U.S. Geological Survey, 2023); these include specific conductance and dissolved concentrations of sodium, calcium, magnesium, potassium, chloride, and sulfate.

The USGS collected and analyzed continuous-record specific conductance data at 14 streamgages (fig. 1; table 1). Measurements of specific conductance were recorded automatically at 10- or 15-minute intervals at each streamgage. Measurements were made by using an instream probe and standard USGS methods for continuous water-quality monitoring at streams (Wagner and others, 2006). The specific conductance measurement data are available through the NWIS web interface (U.S. Geological Survey, 2023).

Concentrations of chloride and sodium were estimated from continuous measurements of specific conductance by using equations that were developed by the USGS to relate specific conductance to concentrations of chloride and sodium, as follows:

$$C_{Cl}=SPC^{m}\times b \text{ and} \quad (1)$$

$$C_{Na}=SPC^{m}\times b, \quad (2)$$

where

C_{Cl} is the chloride concentration, in milligrams per liter;

C_{Na} is the sodium concentration, in milligrams per liter;

SPC is the specific conductance, in microsiemens per centimeter;

m is the slope from the MOVE.1 analysis (table 3); and

b is the intercept from the MOVE.1 analysis (table 3).

These regression equations were developed by using the MOVE.1 method (also known as the line of organic correlation; Helsel and Hirsch, 2002) on the basis of concurrent measurements of specific conductance (USGS parameter code 90095) along with chloride (USGS parameter code 00940) and sodium (USGS parameter code 00930) concentrations measured in water-quality samples collected by the USGS from tributaries in the Scituate Reservoir drainage area during WY 2000, WY 2005, and WYs 2009–22 (table 3; U.S. Geological Survey, 2023).

MOVE.1 was chosen for regression analysis to maintain variance (Hirsch and Gilroy, 1984). Under some circumstances, specific conductance records were unavailable, possibly because of the following reasons: a sensor malfunctioned, was affected by debris, fouling, or ice, or was not submerged during low flow. In these cases, values of specific conductance were estimated by proportional distribution between recorded values. In general, the period of specific conductance record when streamflow occurred that was unavailable for each USGS station represents a small fraction of the record period for WY 2020 (table 3).

Data Collected by Providence Water

Water-quality samples were collected by PW at 37 fixed stations on tributaries draining to the Scituate Reservoir during WY 2020. Samples were typically taken monthly at 19 stations and quarterly at another 18 stations (table 1). Water-quality samples were not collected during specific weather conditions; instead, a periodic water-quality sampling schedule was followed so that water-quality samples would be representative of various weather conditions. However, sometimes samples could not be collected because tributaries at the sampling stations were dry or frozen. When possible, water-quality samples were collected by dipping the sample bottle into the tributary at the center of flow (Richard Blodgett, PW, written commun., 2005). Samples were transported on ice to the PW water-quality laboratory at the P.J. Holton Water Purification Plant in Scituate. Water-quality properties and constituent concentrations were measured by using unfiltered water samples. These water-quality properties included pH, alkalinity, color, turbidity, and concentrations of chloride, nitrite, nitrate, orthophosphate, and *E. coli* and total coliform bacteria; these data collected by PW are published in Smith and Spaetzel (2021). In this report, orthophosphate is the name for compounds with only one PO_4 unit, whereas phosphate is used to name any compound having one or more PO_4 units. Analytical methods used for the determination of values or concentrations of pH, color, turbidity, alkalinity, and chloride are documented by Baird and others (2018). Concentrations of nitrite were determined by U.S. Environmental Protection Agency method 353.2 (U.S. Environmental Protection Agency, 1993). Concentrations of nitrate were determined by Standard Method 4500–NO_3 (Holm and others, 2018). Concentrations of orthophosphate were determined by the Hach Phos-Ver Method (Hach Method 8048; Hach Company, 2000). Standard Method 9223 was used for the determination of concentrations of bacteria (Best and others, 2018).

Water-quality samples were collected by PW during a wide range of flow conditions. The WY 2020 daily mean flow-duration curves for USGS streamgages Hemlock Brook (USGS station 01115265; PW station 28) and Winsor Brook (USGS station 01115185; PW station 26), are shown in figure 2. The curves represent the percentage of time that each flow duration was equaled or exceeded at the respective

Table 3. Regression equation coefficients used to estimate concentrations of chloride and sodium from values of specific conductance for U.S. Geological Survey streamgage stations in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023). Constituent concentrations, continuous specific conductance, and parameter codes are available in National Water Information System (U.S. Geological Survey, 2023). Locations of stations are shown in figure 1. U.S. Geological Survey (USGS) parameter codes: specific conductance, 90095; chloride, 00940; sodium, 00930. PW, Providence Water]

		Samples used in analyses		Chloride			Sodium			Percentage of specific conductance record unavailable where streamflow is greater than zero
PW station number	USGS station number	Sample date range	Sample count	Slope	Intercept	Standard error of regressions (percent)	Slope	Intercept	Standard error of regressions (percent)	
24	01115190	03/08/2000; 03/29/2005; 01/22/2009 to 11/16/2021	39	1.1630	0.10812	3.3	1.1051	0.08833	5.3	16
28	01115265	03/28/2001; 03/30/2005; 01/22/2009 to 11/16/2021	40	1.1459	0.11636	3.5	1.0547	0.10919	5.6	4.5
35	01115187	03/28/2001; 03/29/2005; 01/22/2009 to 11/15/2021	39	1.1785	0.09824	4.1	1.0970	0.08864	5.4	1.1
3	01115280	03/08/2000; 03/30/2005; 01/22/2009 to 11/15/2021	38	1.1956	0.08857	3.2	1.0800	0.09416	5.0	17
5	01115184	03/05/2009 to 11/16/2021	36	1.2396	0.06766	4.0	1.0899	0.08277	4.8	4.5
6	01115183	03/08/2000; 03/30/2005; 01/22/2009 to 11/15/2021	49	1.1728	0.08720	4.2	1.1921	0.04741	5.9	0.61
7	01115297	03/28/2001; 03/30/2005; 01/22/2009 to 11/15/2021	39	1.0389	0.14192	4.0	0.85947	0.19964	5.7	2.3
8	01115276	01/22/2009 to 11/16/2021	36	1.0901	0.14386	2.7	1.0291	0.12116	3.7	0.09
9	01115275	03/08/2000; 03/30/2005; 01/22/2009 to 11/15/2021	38	1.0578	0.17900	2.3	1.0809	0.09349	3.2	1.5
19	01115170	03/08/2000; 03/29/2005; 01/22/2009 to 11/15/2021	45	1.2121	0.07585	2.4	1.2117	0.04525	2.7	2.3
14	01115110	03/28/2001; 03/29/2005; 01/22/2009 to 11/16/2021	45	0.9960	0.18085	7.4	0.9272	0.14989	7.8	0.21
15	01115114	01/22/2009 to 11/15/2021	52	1.1363	0.11603	3.8	1.0679	0.10090	5.4	2.2
16	01115098	03/28/2001; 03/29/2005; 01/22/2009 to 11/15/2021	39	1.2422	0.06467	4.2	1.0567	0.09967	6.3	3.4
18	01115120	01/22/2009 to 11/15/2021	30	1.1620	0.09866	2.7	1.1455	0.06225	3.4	21

stations; the flows at each station on days when water-quality samples were collected are represented by the plotted points superimposed on the curves. At Hemlock Brook, samples were collected at flow rates that are exceeded between 0.4 percent of the time and 99 percent of the time; this range indicates that the water-quality samples collected in WY 2020 represent nearly the entire range of the flow conditions during that water year. Samples collected only on a quarterly schedule at Winsor Brook (in WY 2020, only three samples were collected) were collected during flow rates that are exceeded between 27 percent of the time and 74 percent of the time; this range of flow rates excludes the flow conditions for both the lower and upper flow range at Winsor Brook during WY 2020 (fig. 2).

Estimating Daily, Monthly, and Annual Loads and Yields

Daily, monthly, and annual chloride and sodium loads (in kilograms) were estimated for all streamgages for which continuous-streamflow and specific-conductance data were available for WY 2020. Daily flow-weighted concentrations of chloride and sodium were calculated by multiplying instantaneous flows by concurrent concentrations of chloride and sodium (estimated from measurements of specific conductance) for each day and dividing the sum by the total flow for that day. At the four instrumented monitoring stations, where continuous flow was unavailable (table 1), daily mean concentrations of chloride and sodium were calculated from

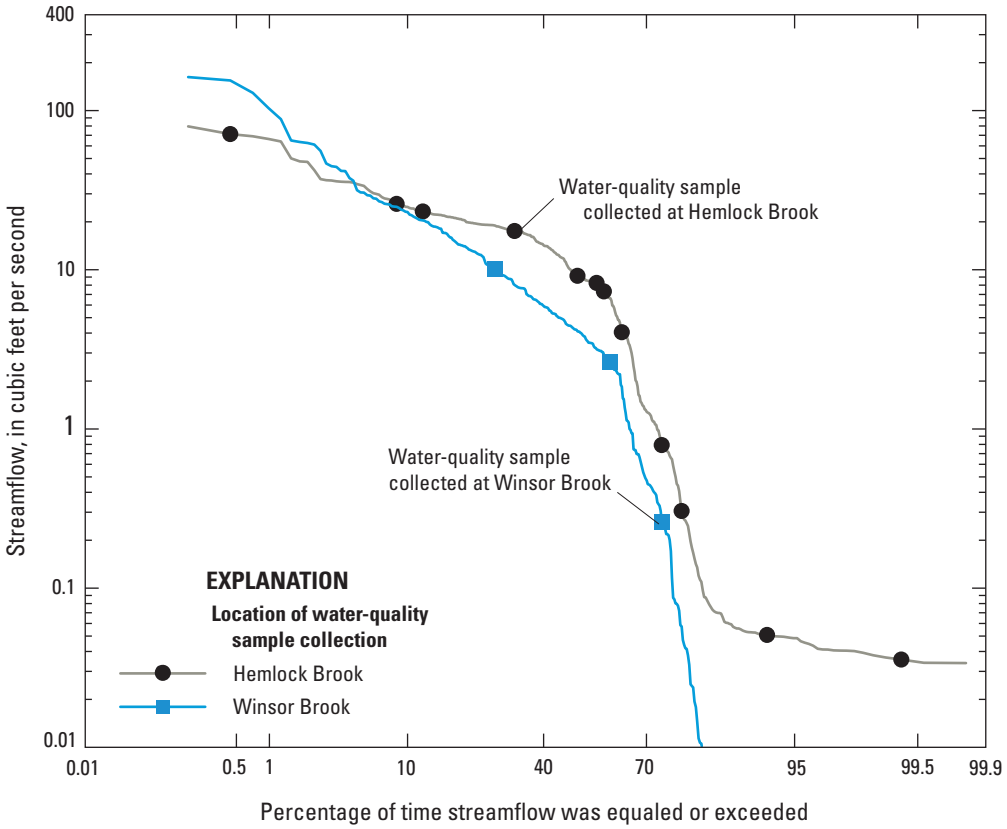

Figure 2. Graph showing flow-duration curves and streamflow on the dates (represented by points) when water-quality samples were collected at the U.S. Geological Survey streamgages Hemlock Brook (station 01115265) and Winsor Brook (station 01115185), in Foster, Rhode Island, for water year 2020. Locations of stations are shown on figure 1. Modified from Breault (2009).

the daily mean value of specific conductance for each day. The latter method may result in less accurate concentrations because instantaneous measurements of specific conductance may change (decrease or increase) with surface-water runoff; however, the variability of instantaneous measurements of specific conductance at these streamgages was generally small and daily mean values did not differ substantially from daily flow-weighted values estimated during prior water years when instantaneous flow data were available. Daily loads of chloride and sodium were estimated by multiplying daily flow-weighted concentrations of chloride and sodium (in milligrams per liter) by daily discharge (in liters per day). Daily data were summed to estimate monthly or annual loads.

Daily loads of water-quality constituents (in samples collected by PW) were calculated for all sampling dates during WY 2020 (table 4, in back of report) for which periodic- or continuous-streamflow data were available (table 1). These loads were calculated by multiplying constituent concentrations (in milligrams or colony forming units per liter) in single samples by the daily discharge (in liters per day) for the day on which each sample was collected. The flows, which in some cases were estimates, were assumed to be representative of the flow at the time of the sample collection. Loads (in million colony forming units per day, kilograms per day, or grams per day) and yields (in million colony forming units per day per square mile, kilograms per day per square mile, or grams per day per square mile) were calculated for bacteria, chloride, nitrite, nitrate, and orthophosphate. Censored data (concentrations reported as less than method detection limits) were replaced with concentrations equal to one-half the method detection limit.

Streamflow

Monitoring streamflow is a necessary step to measure the volume of water and estimate constituent loads to the Scituate Reservoir. The Ponaganset River is the largest monitored tributary to the Scituate Reservoir. Mean annual streamflow at the streamgage on the Ponaganset River (USGS station 01115187, PW station 35) for the entire period of its operation (mean of the annual mean streamflows for the period of record, WYs 1995–2019) before WY 2020 was 29.0 cubic feet per second (ft^3/s; U.S. Geological Survey, 2023). During WY 2020, the annual mean streamflow of 26.7 ft^3/s was just above the 25th percentile (26.2 ft^3/s) for the period of record (fig. 3). Daily mean streamflows were within the 10th and 90th percentile of all mean daily streamflows for WYs 1995–2019 and were similar to the median daily streamflows throughout much of the water year, departing higher in the late spring and summer months (fig. 3). The other long-term continuous-record streamgage in the Scituate Reservoir drainage area is the Peeptoad Brook streamgage (USGS station 01115098; PW station 16). The mean annual streamflow at the Peeptoad Brook streamgage for the period of record (WYs 1995–2019) before WY 2020 was 10.5 ft^3/s (U.S. Geological Survey, 2023). The annual mean streamflow at the Peeptoad Brook streamgage during WY 2020 also was lower than the mean annual streamflow for its period of record at 8.69 ft^3/s. The annual mean measured or estimated streamflows for the other monitoring stations in this study ranged from about 0.32 to 12.0 ft^3/s (table 2).

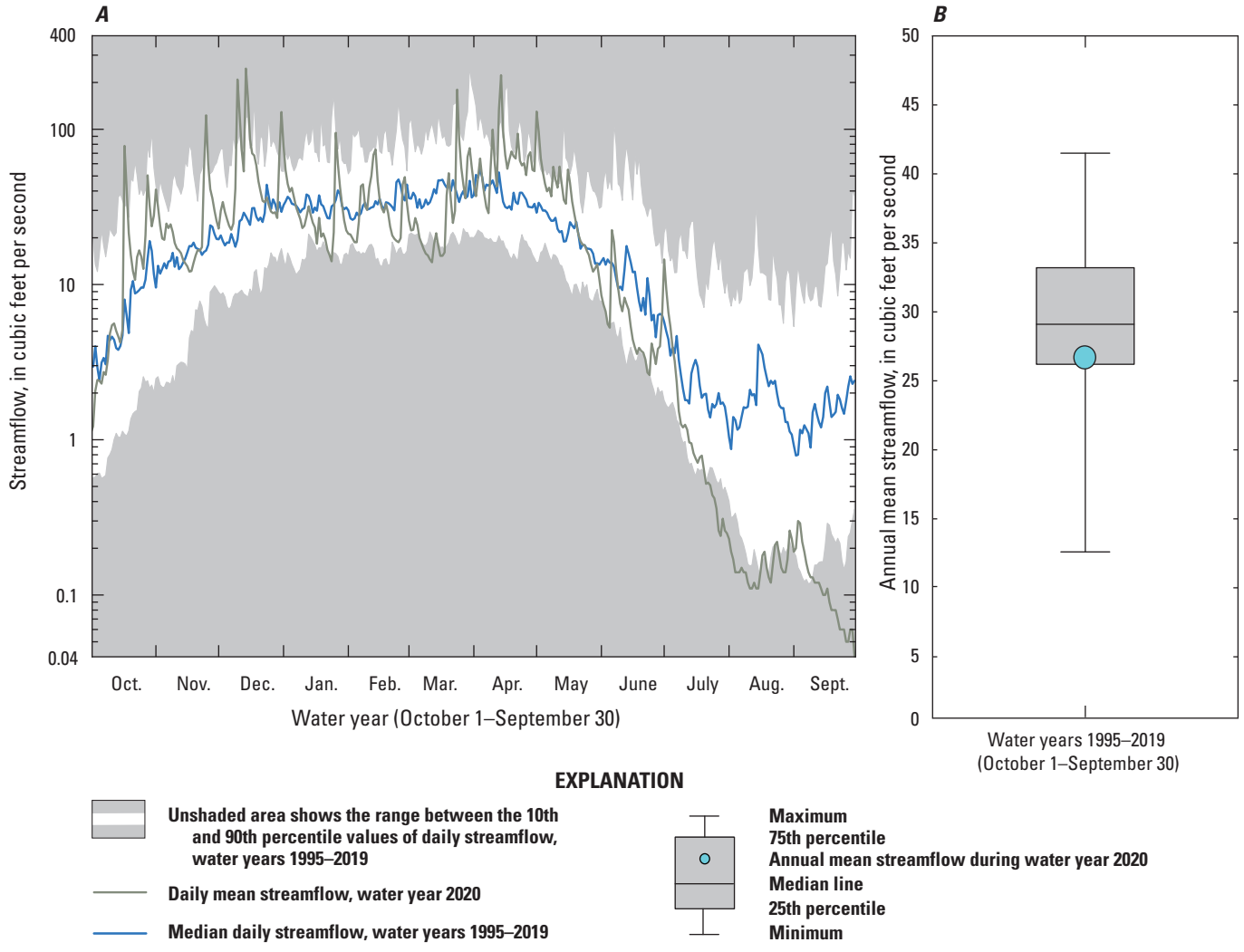

Figure 3. Hydrologic data taken at the U.S. Geological Survey streamgage on the Ponaganset River in Foster, Rhode Island (01115187); *A*, Graph showing measured daily mean streamflow for October 1, 2019, through September 30, 2020, and the 10th percentile, median, and 90th percentile values of daily streamflow for October 1, 1994, through September 30, 2019; and *B*, Boxplot showing annual mean streamflow during water year 2020 and the distribution of mean annual streamflows for water years 1994–2019. Location of station is shown on figure 1. Modified from Breault (2009).

Water Quality and Constituent Loads and Yields

Water-quality conditions in the Scituate Reservoir drainage area are described by summary statistics for water-quality properties, constituent concentrations, and estimated constituent loads and yields. Loads and yields measure the rates at which masses of constituents are transferred to the reservoir by tributaries. Tributaries with high flows tend to have high loads because the greater volume of water can carry more of the constituent to the reservoir per unit time than tributaries with low flows. Yield represents the constituent load per unit of drainage area and is calculated by dividing the load estimated for a streamgage by the drainage area for the monitoring station. Yields are useful for comparison among streamgages that have different drainage areas because each basin size and therefore total streamflow volume is normalized. Yields also are useful for examining potential differences among basin properties that may contribute to water quality in the reservoir.

Summary statistics include means and medians. For some purposes, median values are more appropriate because they are less likely to be affected by high or low concentrations (or outliers). Medians are especially important to use for summarizing a relatively limited number of values. In contrast, continuously monitored streamflow and loads of chloride and sodium (estimated from measurements of specific conductance), datasets that include a large number of values, are better summarized in terms of means because large datasets are more resistant to the effects of outliers than small datasets. Mean values also are particularly appropriate for measuring loads because outlier values, which typically represent large flows, are important to include in estimates of constituent masses delivered to receiving waters.

Uncertainties associated with measuring streamflow and specific conductance and with chloride and sodium sample collection, preservation, and analysis produce uncertainties in load and yield estimates. The load and yield estimates presented in the text and tables are the most likely values for chloride and sodium inputs from tributaries or their drainage basins, based on the available data and analysis methods. It may be best to discuss loads and yields in terms of a range within which the true values lie; however, the most likely values of loads and yields are presented for ease of discussion and presentation. The range within which the true values lie depends on the uncertainties in individual measurements of streamflow and concentration, which are difficult to quantify with the available information. The uncertainties associated with streamflow are commonly assumed to affect load and yield calculations more than the errors associated with measuring specific conductance or chemical analysis, and the uncertainties associated with estimated streamflow are greater than those associated with measured streamflow. The most likely values of loads and yields presented in the tables and text are sufficient for planning-level analysis of water quality in tributaries and their drainage basins.

Chloride and Sodium Loads and Yields Estimated From Specific-Conductance Monitoring Data

Chloride and sodium are constituents of special concern in the Scituate Reservoir drainage area; chloride is difficult to remove from finished drinking water and can affect the taste; and sodium is a constituent of potential concern for human health; some people on restricted diets might need to limit their sodium intake. Chloride and sodium are major constituents of road salt used for deicing, and several major roadways cross the Scituate Reservoir drainage area. State Routes 12 and 14 cut across the main body of the reservoir, and Route 116 parallels the eastern limb of the reservoir (fig. 1). Nimiroski and Waldron (2002) indicated that tributaries in basins with State-maintained roads had substantially higher concentrations of chloride and sodium than tributaries in basins with low road density, presumably because of deicing activities. Smith (2015b) indicated relations between concentrations of chloride collected from the tributaries to the Scituate Reservoir and total impervious area of the respective subbasins were significant; and Spaetzel and Smith (2022b) found 32 significant upward trends in tributary chloride concentrations at the 37 stations during WYs 1983–2019.

Monthly mean concentrations were calculated by dividing the total monthly load by the total discharge for the month. Estimated monthly mean chloride concentrations in tributaries of the Scituate Reservoir drainage area ranged from 7.1 to 123 milligrams per liter (mg/L) and estimated monthly mean sodium concentrations ranged from 5.1 to 70 mg/L (table 5). The highest monthly mean concentrations of chloride and sodium were estimated to be 123 and 70 mg/L, respectively, in the unnamed tributary to Regulating reservoir (USGS station 01115120; PW station 18) in both April and July 2020. The estimated monthly mean concentrations at most stations were greater during the late summer months, particularly August and September, compared with the estimated monthly mean concentrations during the winter months. Estimated monthly mean concentrations peaked in October at the beginning of the water year for Dolly Cole Brook (USGS station 01115190; PW station 24) and Moswansicut stream (USGS station 01115170; PW station 19). Peak estimated mean concentrations for Rush Brook (USGS station 01115114; PW station 15) occurred in June; and mean concentrations peaked in July for Hemlock Brook (USGS station 01115265; PW station 28), Wilbur Hollow Brook (USGS station 01115297; PW station 7), and for the unnamed tributary to Regulating reservoir (USGS station 01115120; PW station 18). The estimated monthly mean concentrations for chloride (12 mg/L) and sodium (7.6 mg/L) in Wilbur Hollow Brook were the same in July and September; likewise, monthly mean concentrations for chloride (123 mg/L) and sodium (70 mg/L) in the unnamed tributary to Regulating reservoir were the same in April and July.

Table 5. Monthly mean concentrations of chloride and sodium estimated from continuous measurements of specific conductance in the Scituate Reservoir drainage area, Rhode Island, October 1, 2019, through September 30, 2020.

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023). Locations of stations are shown on figure 1. Monthly mean concentrations were calculated by dividing the monthly load by the total discharge for the month. PW, Providence Water; USGS, U.S. Geological Survey; Cl, chloride; Na, sodium; mg/L, milligram per liter; —, not applicable]

PW station number	USGS station number	October 2019		November 2019		December 2019		January 2020		February 2020	
		Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)
Barden Reservoir subbasin											
24	01115190	28	17	27	17	23	14	25	15	25	15
28	01115265	31	19	23	14	21	13	27	16	24	15
35	01115187	23	14	21	13	17	11	20	12	20	12
Direct Runoff subbasin											
3	01115280	41	24	43	25	36	21	40	23	35	21
5	01115184	33	19	26	16	24	14	21	13	21	13
6	01115183	32	19	36	22	27	16	30	18	32	19
7	01115297	10	6.9	9.3	6.3	7.1	5.1	8.6	5.9	9.0	6.2
8	01115276	22	14	20	13	17	11	19	12	19	12
9	01115275	53	32	52	31	45	27	51	30	53	31
Moswansicut Pond reservoir subbasin											
19	01115170	56	33	56	33	56	33	55	33	55	33
Regulating reservoir subbasin											
14	01115110	13	7.8	12	7.7	11	6.6	12	7.2	12	7.2
15	01115114	31	19	29	18	41	25	39	24	30	19
16	01115098	37	22	38	23	36	22	28	17	29	18
18	01115120	73	42	71	41	52	30	48	28	59	34
Mean		34	21	33	20	29	18	30	18	30	18

Annual mean concentrations were calculated by dividing the total annual load by the total discharge for the year. The highest annual mean concentrations of chloride and sodium were estimated to be 59 and 34 mg/L, respectively, in the unnamed tributary to Regulating reservoir (USGS station 01115120; PW station 18; table 6). The relatively high annual mean concentrations of 51 mg/L of chloride and 30 mg/L of sodium in Bear Tree Brook (USGS station 01115275; PW station 9) are the result of residual chloride and sodium leaching to groundwater from a formerly uncovered salt storage pile (Nimiroski and Waldron, 2002). Annual mean concentrations of 54 mg/L of chloride and 32 mg/L of sodium estimated at Moswansicut stream (USGS station 01115170; PW station 19) also were relatively high (table 6). The stations on the Moswansicut Pond reservoir and the unnamed tributary to Regulating reservoir are in the more developed, northeastern part of the Scituate Reservoir drainage area (fig. 1.)

During WY 2020, the Scituate Reservoir received about 2,200 metric tons of chloride and 1,400 metric tons of sodium from tributaries that are equipped with instrumentation capable of continuously monitoring specific conductance (table 6). The highest annual chloride and sodium loads in the Scituate Reservoir drainage area during WY 2020 were estimated to be 420 and 270 metric tons, respectively, at the Ponaganset River station (USGS station 01115187; PW station 35; table 6). Monthly estimated chloride and sodium loads were both highest or tied for highest in December for 8 of the 14 stations (table 7). Monthly estimated chloride and sodium loads for Rush Brook (USGS station 01115114; PW station 15) were highest in September 2020 (table 7). Hemlock Brook (USGS station 01115265; PW station 28), Peeptoad Brook (USGS station 01115098; PW station 16), and unnamed tributary to Regulating reservoir (USGS station 01115120; PW station 18) had similar or the same loads in January as the loads in December; and Quonopaug Brook (USGS station 01115183; PW station 6) and Huntinghouse Brook (USGS station 01115110; PW station 14) had similar or the same loads in April as December (table 7). Monthly estimated chloride and sodium loads for Wilbur Hollow Brook (USGS Station 01115297; PW station 7), Moswansicut stream (USGS station 01115170; PW station 19), Westconnaug Brook

Table 5. Monthly mean concentrations of chloride and sodium estimated from continuous measurements of specific conductance in the Scituate Reservoir drainage area, Rhode Island, October 1, 2019, through September 30, 2020.—Continued

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023). Locations of stations are shown on figure 1. Monthly mean concentrations were calculated by dividing the monthly load by the total discharge for the month. PW, Providence Water; USGS, U.S. Geological Survey; Cl, chloride; Na, sodium; mg/L, milligram per liter; —, not applicable]

March 2020		April 2020		May 2020		June 2020		July 2020		August 2020		September 2020	
Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)	Cl (mg/L)	Na (mg/L)
Barden Reservoir subbasin													
23	14	19	12	19	12	24	15	22	14	24	15	25	15
21	13	15	10	18	11	29	18	38	22	36	22	34	20
17	11	15	9	16	10	20	12	22	14	29	18	28	17
Direct Runoff subbasin													
33	20	27	16	27	16	30	18	40	24	49	28	55	31
21	13	17	11	17	11	23	14	32	19	60	32	67	35
30	18	24	14	26	16	35	21	55	34	69	42	98	60
8.9	6.1	8.1	5.7	9.1	6.2	11	7.5	12	7.6	11	7.5	12	7.6
19	12	17	11	18	12	25	16	30	19	32	20	26	17
52	31	45	27	49	29	64	38	76	45	82	49	85	51
Moswansicut Pond reservoir subbasin													
53	32	52	31	51	30	53	32	55	33	55	33	55	33
Regulating reservoir subbasin													
10	6.0	8.9	5.6	10	6.4	14	8.4	15	8.9	15	9.2	34	20.8
23	14	30	18	42	26	58	35	41	24	45	26	38	23
34	21	39	23	40	24	40	24	44	25	61	35	69	40
95	54	123	70	59	34	95	54	123	70	0.0	0.0	0.0	0.0
31	19	31	19	29	17	37	22	43	26	41	24	45	26

(USGS station 01115276; PW station 8), and Bear Tree Brook (USGS station 01115275; PW station 9) were highest in April (table 7).

During WY 2020, estimated annual loads of chloride and sodium at the continuous streamgage stations were less than the median estimated annual loads for WYs 2009–19 for 9 of the 14 USGS stations (fig. 4) and the sum of these annual loads during WY 2020 were 37 percent lower than the sum of annual loads estimated during the previous water year (Smith, 2022b). From December through April, the sum of the monthly estimated loads of chloride and sodium for the respective drainage areas upstream from each streamgage accounted for about 60 to 80 percent of the annual load of chloride and sodium, except at Rush Brook (USGS station 01115114; PW station 15), where this period only accounted for 45 percent of the annual load for the drainage area of this streamgage (table 7). The Ponaganset River (USGS station 01115187; PW station 35), which accounts for 22 percent of the combined drainage area upstream from the 14 USGS streamgage stations, accounted for 19 percent of the combined annual load of chloride and sodium for the 14 USGS streamgage stations. Rush Brook, having about one third of the drainage area of Ponaganset River (table 1) but nearly twice the impervious area (Spaetzel and Smith, 2022b), had the second highest percentage (14 percent of the combined annual load of chloride and sodium) for the respective drainage area (table 6).

The highest annual chloride and sodium yields were 110 and 66 metric tons per year per square mile ([t/yr]/mi^2; table 6), respectively, measured at Bear Tree Brook (USGS station 01115275; PW station 9) in a small subbasin (0.62 square mile). These high yields were the result, in part, from chloride and sodium groundwater contamination (Nimiroski and others, 2008). Chloride and sodium yields at 30 and 19 (t/yr)/mi^2, respectively for Ponagaset River (USGS station 01115187; PW station 35), which is the largest subbasin in the Scituate Reservoir watershed, were less than one third of the yields for Bear Tree Brook. The estimated annual mean yields of chloride and sodium for the drainage area upstream from the 14 USGS streamgage stations were 35 and 22 (t/yr)/mi^2 (table 6), respectively. These estimated annual mean yields of chloride and sodium for WY 2020 were substantially less than the estimated annual mean yields of chloride and sodium in the three prior water years (fig. 5) and among the lowest since WY 2009.

Table 6. Estimated annual mean chloride and sodium concentrations, loads, and yields of streamgage stations in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023). Locations of stations are shown on figure 1. Annual mean concentrations were calculated by dividing the annual load by the total discharge for the year; annual mean yields were calculated by dividing the sum of individual loads by the sum of the drainage area. PW, Providence Water; USGS, U.S. Geological Survey; Cl, chloride; mg/L, milligram per liter; Na, sodium; t/yr, metric tons per year; (t/yr)/mi², metric tons per year per square mile; —, not applicable]

PW station number	USGS station number	Concentration		Load		Yield	
		Cl (mg/L)	Na (mg/L)	Cl (t/yr)	Na (t/yr)	Cl ([t/yr]/mi²)	Na ([t/yr]/mi²)
Barden Reservoir subbasin							
24	01115190	22	14	160	98	32	20
28	01115265	22	14	230	140	27	17
35	01115187	18	11	420	270	30	19
Direct Runoff subbasin							
3	01115280	34	20	99	59	53	32
5	01115184	22	13	35	21	28	17
6	01115183	29	17	89	53	45	27
7	01115297	8.6	5.9	55	38	13	8.8
8	01115276	19	12	150	94	28	18
9	01115275	51	30	69	41	110	66
Moswansicut Pond reservoir subbasin							
19	01115170	54	32	260	160	81	48
Regulating reservoir subbasin							
14	01115110	10	6.5	98	61	16	10
15	01115114	31	19	220	130	46	28
16	01115098	36	21	280	170	56	33
18	01115120	59	34	29	17	100	60
Scituate Reservoir drainage area							
Mean concentration or yield		30	18	—	—	35	22
Total load		—	—	2,200	1,400	—	—

Physical and Chemical Properties and Daily Loads and Yields Estimated From Data Collected by Providence Water

PW routinely measured four water-quality properties (pH, color, turbidity, and alkalinity), and concentrations of chloride, nitrite, nitrate, orthophosphate, total coliform bacteria, and *E. coli* bacteria in monthly or quarterly samples of tributary water. These data are general indicators of water-quality conditions in the Scituate Reservoir drainage area.

Physical and Chemical Properties

Physical and chemical properties including pH, turbidity, alkalinity, and color were routinely measured to determine water quality in each of the six subbasins in the Scituate Reservoir drainage area (table 8) by PW. Specifically, pH is a measure of the acidity of the water; color can be an indirect measure of the amount of organic carbon dissolved in the water column; turbidity is an indirect measure of suspended particles; and alkalinity is a measure of the buffer capacity of water.

The median pH in tributaries in the Scituate Reservoir drainage area ranged from 5.8 to 7.1; the median of the medians for all stations was 6.4. Median values of color ranged from 8 to 160 platinum-cobalt units; the median for all stations was 50 platinum-cobalt units. Median values of turbidity ranged from 0.26 to 13 nephelometric turbidity units; the median for all stations was 0.69 nephelometric turbidity unit. Median alkalinity values in tributaries were low, ranging from 2.5 to 15 mg/L as calcium carbonate; the median for all stations was 6.6 mg/L alkalinity as calcium carbonate (table 8).

Constituent Concentrations and Daily Loads and Yields

Fecal indicator bacteria, chloride, and nutrients such as nitrogen and phosphorus are commonly detected in natural water; at elevated concentrations, these constituents can cause or contribute to water-quality impairments. Fecal indicator bacteria, which are found in the intestines of warm-blooded animals, may indicate impairment from sewage contamination or from livestock or wildlife that defecate in or near the stream margin. Chloride originates in tributary stream water from precipitation, weathering, or human activities such as waste disposal, use of septic systems, and road deicing. Sources of nutrients in tributary stream water include atmospheric deposition, leaching of naturally occurring organic material, discharge of groundwater that is enriched with nutrients from septic-system leachate, and runoff contaminated with fertilizer or animal waste. The ultimate intended use of water in the tributaries is drinking water, which must meet specific water-quality standards. For this reason, PW closely monitors concentrations of these constituents in tributaries. Median concentrations, loads, and yields of water-quality constituents are listed in tables 8, 9, and 10.

Bacteria

Median concentrations of total coliform bacteria were above the detection limit (1 colony forming unit per 100 milliliters [CFU/100 mL]) at all sites (table 8). Median concentrations of *E. coli* were equal to or greater than a detection limit of 10 CFU/100 mL (which is the highest detection limit of the median values) at 19 of the 37 stations (including a single median [<15] estimated from a censored value and a non-censored value). However, only censored median concentrations of *E. coli* less than 10 CFU/100 mL were available from the other 18 stations. Total coliform bacteria concentrations were greater than *E. coli* concentrations (as expected because total coliform is a more inclusive measure than *E. coli*); the medians of median concentrations for all sites in the drainage area were 1,200 CFU/100 mL for total coliform bacteria and 10 CFU/100 mL for *E. coli* (table 8). The highest median concentration of total coliform bacteria, 17,000 CFU/100 mL, was at the water body known locally as "Toad pond" (USGS station 01115177; PW station 31) in the Direct Runoff subbasin. Median concentrations of total coliform bacteria exceeded 2,000 CFU/100 mL at six other stations including Ponaganset River (USGS station 01115187; PW station 35), Spruce Brook (USGS station 01115184; PW station 5), Bear Tree Brook (USGS station 01115275; PW station 9), unnamed tributary 4 to Scituate Reservoir (USGS station 01115350; PW station 30), unnamed tributary 2 to Moswansicut Pond reservoir (USGS station 01115165; PW station 21), and unnamed tributary to Westconnaug Reservoir (USGS station 01115273; PW station 11). Median concentrations of total coliform bacteria were lowest at Westconnaug Brook (USGS station 01115276; PW station 8). The highest median concentration of *E. coli*, 210 CFU/100 mL (table 8), also was at Toad pond.

Median daily loads and yields of total coliform bacteria and *E. coli* varied by two orders of magnitude or more (tables 9 and 10). The median daily loads of total coliform bacteria for all subbasins in the Scituate Reservoir drainage area ranged from 5,700 to 450,000 million colony forming units per day ([CFU×10^6]/d), and yields ranged from 4,000 to 120,000 million colony forming units per day per square mile ([(CFU×10^6)/d]/mi^2); *E. coli* loads ranged from less than 35 to 12,000 (CFU×10^6)/d, and yields ranged from less than 110 to 5,700 ([CFU×10^6]/d)/mi^2 (table 9). The highest median daily yield of total coliform bacteria at 120,000 ([CFU×10^6]/d)/mi^2 was at Shippee Brook (USGS station 01115200; PW station 25), and the highest median daily yield of *E. coli* of 5,700 ([CFU×10^6]/d)/mi^2 occurred at unnamed tributary 2 to Moswansicut Pond reservoir (USGS station 01115165; PW station 21; table 10). Although relatively high for sampling stations in the Scituate Reservoir subbasin, median daily bacteria yields at these stations were low to moderate for yields of indicator bacteria in sewage-contaminated stream water or stream water affected by stormwater runoff in an urban environment (Breault and others, 2002).

Table 7. U.S. Geological Survey monthly estimated chloride and sodium loads by sampling station, in the Scituate Reservoir drainage area, Rhode Island, October 1, 2019, through September 30, 2020.

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023). Alternate station names are listed in parentheses for stations where different historical names were used for the same sampling location by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; Cl, chloride; t, metric ton; Na, sodium; —, not applicable]

PW station number	USGS station number	October 2019		November 2019		December 2019		January 2020		February 2020	
		Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)
Barden Reservoir subbasin											
24	01115190	6.6	4.1	11	7.0	36	22	21	13	19	12
28	01115265	7.2	4.3	20	13	50	31	50	31	34	21
35	01115187	25	15	41	25	81	51	49	31	46	29
Direct Runoff subbasin											
3	01115280	5.9	3.5	9.3	5.4	24	14	15	8.8	10	6.0
5	01115184	1.6	0.90	3.8	2.3	7.6	4.6	5.6	3.4	4.2	2.6
6	01115183	5.2	3.1	5.1	3.0	15	9.2	13	8.0	12	7.1
7	01115297	3.5	2.4	2.9	2.0	8.1	5.8	8.0	5.5	7.0	4.8
8	01115276	6.5	4.1	8.7	5.6	20	13	18	11	16	10
9	01115275	2.7	1.6	4.0	2.4	9.5	5.6	8.6	5.1	7.7	4.6
Moswansicut Pond reservoir subbasin											
19	01115170	16	9.4	17	10	41	24	32	19	28	17
Regulating reservoir subbasin											
14	01115110	4.6	2.9	7.9	4.9	21	13	10	6.5	11	6.7
15	01115114	14	8.9	44	27	27	17	28	17	28	17
16	01115098	27	16	35	21	37	22	35	22	21	13
18	01115120	2.6	1.5	2.5	1.4	3.0	1.7	6.7	3.8	3.0	1.7
Total load		130	78	210	130	380	230	150	87	250	150

Table 7. U.S. Geological Survey monthly estimated chloride and sodium loads by sampling station, in the Scituate Reservoir drainage area, Rhode Island, October 1, 2019, through September 30, 2020.—Continued

[Data were collected by the U.S. Geological Survey (U.S. Geological Survey, 2023). Alternate station names are listed in parentheses for stations where different historical names were used for the same sampling location by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; Cl, chloride; t, metric ton; Na, sodium; —, not applicable]

March 2020		April 2020		May 2020		June 2020		July 2020		August 2020		September 2020	
Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)	Cl (t)	Na (t)
Barden Reservoir subbasin													
19	12	28	18	13	8.3	2.6	1.6	0.86	0.54	0.054	0.034	0.021	0.013
22	14	23	15	20	13	6.9	4.2	1.1	0.64	0.15	0.087	0.14	0.082
48	30	73	46	46	29	9.5	5.9	3.4	2.1	0.35	0.21	0.25	0.15
Direct Runoff subbasin													
11	6.8	15	9.1	7.1	4.4	1.4	0.83	0.41	0.24	0.19	0.11	0.16	0.09
3.5	2.1	3.9	2.4	3.0	1.9	1.1	0.67	0.29	0.17	0.11	0.062	0.13	0.067
11	6.8	15	9.1	9.3	5.6	1.6	0.97	0.65	0.39	0.070	0.042	0.006	0.003
7.0	4.8	10	7.2	6.8	4.6	1.3	0.85	0.36	0.24	0.036	0.024	0.002	0.001
17	11	24	16	17	11	6.8	4.3	5.0	3.1	4.3	2.7	2.9	1.8
8.3	4.9	12	6.9	8.3	4.9	3.0	1.8	2.2	1.3	1.9	1.1	1.6	0.95
Moswansicut Pond reservoir subbasin													
29	17	51	31	31	18	11	6.4	5.3	3.2	0.69	0.41	0.48	0.29
Regulating reservoir subbasin													
11	7.0	20	12	12	7.3	1.2	0.72	0.17	0.10	0.002	0.001	11	7.0
36	23	22	14	4.3	2.6	0.30	0.20	13	7.8	28	16	67	40
9.4	5.7	4.2	2.5	0.18	0.11	0.02	0.01	0.68	0.39	1.3	0.73	9.7	5.6
0.10	0.10	0.005	0.003	3.0	1.7	0.090	0.052	0.005	0.003	<0.001	<0.001	<0.001	<0.001
230	150	300	190	180	110	47	28	33	20	37	22	93	56

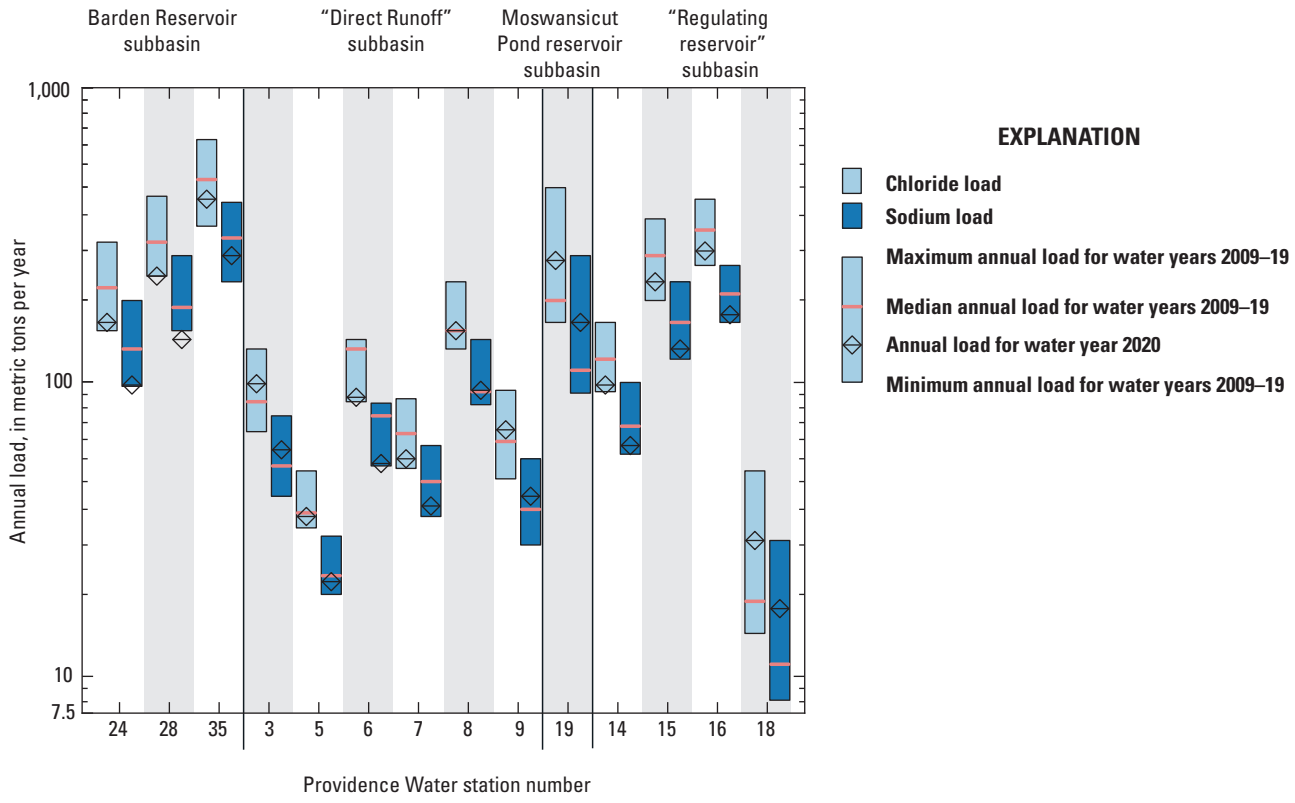

Figure 4. Graph showing annual loads of chloride and sodium estimated from streamflow and specific conductance data for water year 2020 and associated minimum, maximum, and median annual loads for water years 2009–19 at 14 Providence Water sampling stations with continuous-record U.S. Geological Survey water quality data in the Scituate Reservoir drainage area, Rhode Island. Locations of stations are shown on figure 1; station information is shown in table 1. Modified from Smith (2016).

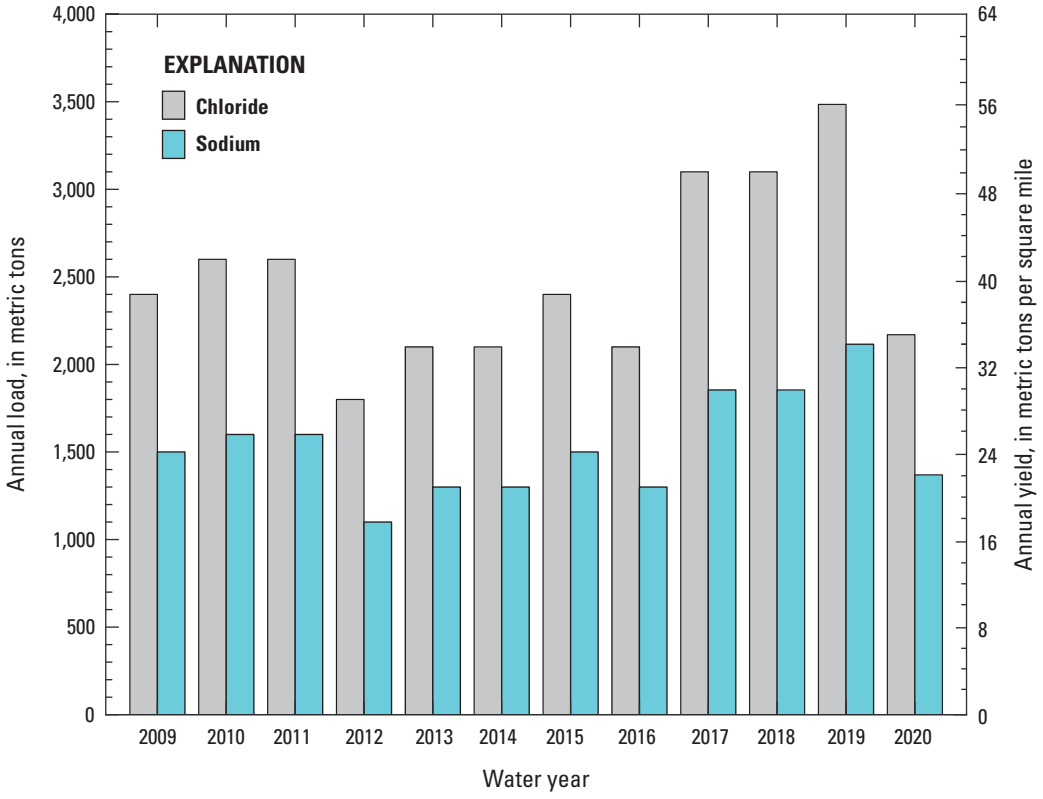

Figure 5. Bar chart showing estimated annual loads and estimated annual yields of chloride and sodium estimated from continuous measurements of streamflow and specific conductance for water years 2009–20 for the area upstream from 14 Providence Water sampling stations in the Scituate Reservoir drainage area, Rhode Island. Locations of stations are shown on figure 1; station information is shown in table 1. Modified from Smith (2019a).

Table 8. Median values for water-quality data collected at Providence Water stations in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; PCU, platinum-cobalt units; NTU, nephelometric turbidity units; CFU/100 mL, colony forming units per 100 milliliters; *E.coli*., *Escherichia coli*; mg/L, milligrams per liter ; $CaCO_3$, calcium carbonate; N, nitrogen; PO_4, phosphate; <, less than; —, no data]

PW station number	USGS station number	Properties			Constituents						
		pH	Color (PCU)	Turbidity (NTU)	Total coliform bacteria (CFU/100 mL)	*E. coli* (CFU/100 mL)	Alkalinity (mg/L as $CaCO_3$)	Chloride (mg/L)	Nitrite (mg/L as N)	Nitrate (mg/L as N)	Orthophosphate (mg/L as PO_4)
Barden Reservoir subbasin											
24	01115190	6.4	55	0.72	1,300	10	4.4	24.8	0.001	0.07	0.03
25	01115200	6.3	70	0.98	1,700	20	3.1	12.7	0.002	<0.05	0.03
26	01115185	6.4	50	0.56	1,900	31	4.5	22.5	0.002	0.08	0.04
27	011151845	6.0	25	0.27	620	<10	4.2	13.3	<0.001	0.21	0.02
28	01115265	6.3	100	0.68	760	10	5.7	28.3	0.002	0.07	0.06
29	01115271	6.6	45	0.66	460	<10	4.8	23.1	0.001	<0.05	0.03
35	01115187	6.4	50	0.89	2,500	20	4.4	22.8	0.001	0.07	0.03
Direct Runoff subbasin											
1	01115180	7.0	63	1.2	1,200	<10	11	14.3	0.002	0.24	0.06
2	01115181	6.2	8	0.26	200	<15	5.3	80.6	0.001	0.45	1.24
3	01115280	6.6	45	0.37	660	<10	5.8	45.0	0.001	0.19	0.04
4	01115400	6.5	25	0.50	1,600	<10	7.2	6.50	0.001	<0.05	0.03
5	01115184	6.3	50	0.54	2,100	31	6.0	28.1	0.002	0.26	0.05
6	01115183	6.7	100	1.0	1,200	36	13	38.3	0.002	0.27	0.05
7	01115297	6.3	78	0.81	1,400	20	8.9	11.3	0.002	<0.06	0.03
8	01115276	6.4	20	0.51	86	<10	3.4	13.3	0.001	<0.05	0.02
9	01115275	6.8	43	0.69	2,800	21	9.6	67.9	0.002	0.69	0.03
30	01115350	6.2	50	0.47	2,100	120	6.3	28.6	0.001	0.09	0.03
31	01115177	6.3	120	13.00	17,000	210	10	7,000	0.018	0.99	0.03
32	01115178	6.7	130	1.3	1,400	<10	11	15.0	0.002	0.4	0.07
33	01115182	6.4	35	0.54	1,100	<10	11	12.5	0.001	0.22	0.03
36	—	6.5	25	0.41	640	<10	3.6	7.60	0.001	0.06	0.03
37	—	5.8	25	0.26	180	<10	2.5	9.60	<0.001	<0.05	0.05
Moswansicut Pond reservoir subbasin											
19	01115170	7.1	19	0.6	150	<10	10	57.4	0.001	0.07	0.03
20	01115160	6.4	160	0.77	590	10	8.3	65.2	0.003	0.10	0.08
21	01115165	6.6	30	1.20	2,200	120	15	49.6	0.003	0.66	0.05
22	01115167	6.7	24	0.90	1,700	<10	15	57.7	0.005	0.9	0.06
34	01115164	6.4	93	1.30	930	<10	14	43.6	0.003	<0.05	0.03
Ponaganset Reservoir subbasin											
23	011151843	6.4	15	0.48	400	<10	3.3	18.9	0.001	<0.05	0.02
Regulating reservoir subbasin											
13	01115176	6.9	37	0.88	290	<10	11	39.8	0.001	<0.05	0.03
14	01115110	6.6	56	0.96	1,200	52	6.6	14.2	0.002	0.11	0.04
15	01115114	6.7	85	0.94	1,300	31	7.6	37.3	0.002	0.12	0.05
16	01115098	6.7	47	0.86	1,100	<10	13	40.3	0.001	0.08	0.03
17	01115119	6.2	56	0.46	680	10	9.0	37.7	0.001	<0.05	0.04
18	01115120	6.5	55	0.7	800	130	12	65.6	0.001	0.43	0.07

Table 8. Median values for water-quality data collected at Providence Water stations in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.—Continued

[Data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; PCU, platinum-cobalt units; NTU, nephelometric turbidity units; CFU/100 mL, colony forming units per 100 milliliters; *E.coli*., *Escherichia coli*; mg/L, milligrams per liter ; $CaCO_3$, calcium carbonate; N, nitrogen; PO_4, phosphate; <, less than; —, no data]

PW station number	USGS station number	Properties			Constituents						
		pH	Color (PCU)	Turbidity (NTU)	Total coliform bacteria (CFU/100 mL)	*E. coli* (CFU/100 mL)	Alkalinity (mg/L as $CaCO_3$)	Chloride (mg/L)	Nitrite (mg/L as N)	Nitrate (mg/L as N)	Orthophosphate (mg/L as PO_4)
Westconnaug Reservoir subbasin											
10	01115274	6.1	26	0.68	1,200	<10	4.4	18.0	0.001	<0.05	0.02
11	01115273	6.2	78	0.82	3,300	70	5.8	9.80	0.003	<0.05	0.10
12	011152745	6.2	30	0.74	320	<10	5.1	14.7	0.001	<0.05	0.06
Scituate Reservoir drainage area											
Minimum		5.8	8	0.26	86	<10	2.5	6.5	<0.001	<0.05	0.02
Median		6.4	50	0.69	1,200	10	6.6	24.8	0.001	0.08	0.03
Maximum		7.1	160	13	17,000	210	15	80.6	0.018	0.99	1.24

Chloride and Sodium

Median chloride concentrations among PW stations ranged from 6.5 to 80.6 mg/L. The highest median concentration was collected at unnamed tributary 2 to Scituate Reservoir (USGS station 01115181; PW station 31); however, the highest single concentration (7,000 mg/L) was measured in the only sample collected at Toad pond (PW station 31; table 8). Toad pond is a small water body having a drainage area of 0.03 square mile (table 1), in the village of North Scituate, south of Route 6 and west of Route 116, in Scituate, R.I. The sample was collected in December 2019 and the high chloride concentration likely reflects salt-laden runoff entering the small pond at or before the time of sample collection. The median of median concentrations for all sites in the drainage area was 24.8 mg/L (table 8). Median daily chloride loads and yields estimated from samples collected by PW varied among monitoring stations in the drainage area (tables 9 and 10). Ponaganset River (USGS station 01115187; PW station 35) had the largest median daily chloride load at 1,100 kilograms per day (table 9). The largest median daily chloride yield was determined to be 260 kilograms per day per square mile at unnamed tributary 2 to Moswansicut Pond reservoir (USGS station 01115165; PW station 21; table 10). The median daily chloride yield for monitored areas within the drainage area was 76 kilograms per day per square mile.

Nutrients

Median concentrations of nitrite and nitrate (table 8) were 0.001 and 0.08 mg/L as nitrogen, respectively. The highest median concentrations of nitrite (0.018 mg/L as nitrogen) and nitrate (0.99 mg/L as nitrogen) were measured in a sample collected at Toad pond (USGS station 01115177; PW station 31). The median concentration of orthophosphate for the entire study area (table 8) was 0.03 mg/L as phosphate. The maximum median concentration of orthophosphate was 1.24 mg/L as phosphate measured in a sample collected at unnamed tributary 2 to Scituate Reservoir (USGS station 01115181; PW station 2). Median daily nitrite loads were largest at Ponaganset River (USGS station 01115187; PW station 35) at 58 grams per day (g/d; table 9). Median daily nitrate loads were largest at Peeptoad Brook (USGS station 01115098; PW station 16) at 4,400 g/d as nitrogen. Median daily orthophosphate loads were largest (1,500 g/d as phosphate) at Huntinghouse Brook (USGS station 01115110; PW station 14; table 9). The largest median daily yields for nitrite, nitrate, and orthophosphate were 19 grams per day per square mile ([g/d]/mi^2) as nitrogen, and 4,000 (g/d)/mi^2 as nitrogen, and 310 (g/d)/mi^2 as phosphate, respectively, at unnamed tributary 2 to Moswansicut Pond reservoir (USGS station 01115165; PW station 21; table 10). The medians of median daily loads and yields were 10 g/d and 4.1 (g/d)/mi^2 for nitrite as nitrogen, 500 g/d and 240 (g/d)/mi^2 for nitrate as nitrogen, and 290 g/d and 100 (g/d)/mi^2 for orthophosphate as phosphate, respectively.

Table 9. Median daily loads of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Concentration data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations are shown on figure 1. USGS, U.S. Geological Survey; (CFU×10^6)/d; million colony forming units per day; *E. coli*, *Escherichia coli*; kg/d, kilogram per day; g/d, grams per day; N, nitrogen; PO_4, phosphate; —, not applicable]

PW station number	USGS station number	Total coliform bacteria ([CFUx10^6]/d)	*E. coli* ([CFUx10^6]/d)	Chloride (kg/d)	Nitrite (g/d as N)	Nitrate (g/d as N)	Orthophosphate (g/d as PO_4)
			Barden Reservoir subbasin				
24	01115190	150,000	<1,100	370	16	430	340
25	01115200	290,000	<870	220	35	<440	520
26	01115185	450,000	7,700	560	49	<1,300	990
28	01115265	100,000	2,200	540	43	<510	1,000
35	01115187	260,000	<4,000	1,100	58	<2,900	1,400
			Direct Runoff subbasin				
1	01115180	65,000	<390	87	12	1,100	250
3	01115280	33,000	<350	310	5.9	500	170
4	01115400	7,700	<97	12	1.9	49	24
5	01115184	55,000	230	85	3.8	300	76
6	01115183	45,000	1,000	260	8.4	1,800	320
7	01115297	120,000	3,900	140	22	<360	430
8	01115276	29,000	<930	220	19	<490	370
9	01115275	43,000	290	110	2.6	950	47
32	01115178	14,000	<87	15	1.7	78	52
33	01115182	5,700	<35	8.6	0.69	110	21
			Moswansicut Pond reservoir subbasin				
19	01115170	13,000	<490	550	10	600	290
21	01115165	31,000	1,700	77	5.6	1,200	94
			Regulating reservoir subbasin				
14	01115110	310,000	12,000	480	35	<2,400	1,500
15	01115114	180,000	4,300	1,000	29	3,100	900
16	01115098	140,000	<1,300	1,000	28	4,400	520
18	01115120	6,500	1,100	52	0.81	240	35
			Westconnaug Reservoir subbasin				
10	01115274	55,000	<210	81	3.6	89	110
11	01115273	31,000	<270	11	3.4	<28	43
			Scituate Reservoir drainage area				
Minimum		5,700	<35	8.6	0.69	<28	21
Median		55,000	<900	220	10	500	290
Maximum		450,000	12,000	1,100	58	4,400	1,500

Table 10. Median daily yields of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Concentration data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations shown on figure 1. USGS, U.S. Geological Survey; ([CFU×10^6]/d)/mi^2; million colony forming units per day per square mile; *E. coli*, *Escherichia coli*; N, nitrogen; PO_4, phosphate; (kg/d)/mi^2, kilogram per day per square mile; (g/d)/mi^2, gram per day per square mile; —, none]

PW station number	USGS station number	Total coliform bacteria ([CFUx10^6]/mi^2)	*E. coli* ([CFUx10^6]/mi^2)	Chloride ([kg/d]/mi^2)	Nitrite ([g/d]/mi^2 as N)	Nitrate ([g/d]/mi^2 as N)	Orthophosphate ([g/d]/mi^2 as PO_4)
Barden Reservoir subbasin							
24	01115190	31,000	<220	76	3.3	88	69
25	01115200	120,000	<370	93	15	<190	220
26	01115185	100,000	1,800	130	11	<300	230
28	01115265	12,000	250	62	4.9	<58	110
35	01115187	19,000	<290	79	4.1	<210	100
Direct Runoff subbasin							
1	01115180	41,000	<250	55	7.3	690	160
3	01115280	18,000	<190	170	3.2	270	91
4	01115400	9,100	<110	14	2.2	58	28
5	01115184	44,000	180	67	3.0	240	60
6	01115183	23,000	510	130	4.3	890	160
7	01115297	28,000	900	32	5.1	<83	99
8	01115276	5,600	180	42	3.7	<95	71
9	01115275	69,000	470	170	4.1	1,500	76
32	01115178	31,000	<190	33	3.8	170	120
33	01115182	20,000	<130	31	2.5	390	75
Moswansicut Pond reservoir subbasin							
19	01115170	4,000	<150	170	3.2	180	89
21	01115165	100,000	5,700	260	19	4,000	310
Regulating reservoir subbasin							
14	01115110	48,000	1,900	76	5.5	<380	240
15	01115114	38,000	910	210	6.2	660	190
16	01115098	28,000	<260	200	5.6	890	100
18	01115120	23,000	3,900	190	2.9	860	130
Westconnaug Reservoir subbasin							
10	01115274	37,000	<140	54	2.4	60	74
11	01115273	43,000	<380	16	4.7	<39	59
Scituate Reservoir drainage area							
Minimum		4,000	<110	14	2.2	<39	28
Median		31,000	<260	76	4.1	240	100
Maximum		120,000	5,700	260	19	4,000	310

Summary

Since 1993, the U.S. Geological Survey (USGS), in cooperation with Providence Water (PW; sometimes known as Providence Water Supply Board), has maintained a long-term cooperative water-quality monitoring program within the Scituate Reservoir drainage area, Rhode Island. PW also has been independently monitoring and assessing water quality in the reservoir and reservoir drainage area for more than 60 years. Together, the data collected by the USGS and PW are used to calculate concentrations, loads, and yields of chloride, sodium, nutrients, and bacteria for tributaries within Scituate Reservoir drainage area on an annual basis.

During water year (WY) 2020, which is defined as the period from October 1, 2019, to September 30, 2020, the U.S. Geological Survey measured or estimated streamflow at 23 streamgages; 14 of these streamgages are equipped with instrumentation capable of continuously monitoring water level, specific conductance, and water temperature. Water-quality samples, that are analyzed for dissolved concentrations of major ions (including chloride and sodium), were periodically collected by the USGS at each of the 14 streamgages. Concentrations of chloride and sodium in water samples collected during WY 2020 and in prior WYs were used to support and refine relations between each ion and specific conductance. Monthly and annual concentrations, loads, and yields were estimated for the 14 streamgages by using equations to relate specific conductance to concentrations of chloride and sodium, and with measured or estimated streamflow data.

At 14 of the 23 USGS streamgages, where both streamflow and continuous specific conductance data were available, estimated monthly mean chloride concentrations ranged from 7.1 to 123 milligrams per liter (mg/L) and estimated monthly mean sodium concentrations ranged from 5.1 to 70 mg/L in tributaries of the Scituate Reservoir drainage area. The highest annual mean concentrations of chloride and sodium were estimated to be 59 and 34 mg/L, respectively, in the unnamed tributary to the water body known as "Regulating reservoir" (USGS station 01115120; PW station 18) in the more developed, northeastern part of the Scituate Reservoir drainage area. An estimated 2,200 metric tons of chloride and 1,400 metric tons of sodium were transported to the Scituate Reservoir during WY 2020; annual chloride yields for tributaries in the drainage area ranged from 13 to 110 metric tons per square mile, and annual sodium yields ranged from 8.8 to 66 metric tons per square mile. Estimated annual mean yields of chloride and sodium for WY 2020 were substantially less than the estimated annual mean yields of chloride and sodium in the three prior WYs and among the lowest since WY 2009.

PW collected water-quality samples at 37 sampling stations, which also include the 14 USGS continuous-record streamgages, during WY 2020 as part of their long-term sampling program in the Scituate Reservoir drainage area. Water-quality samples were analyzed by PW for pH, color, turbidity, alkalinity, and for concentrations of chloride, nutrients, and bacteria. Water-quality data collected by PW were summarized by using values of central tendency and are used in combination with periodic- or continuous-streamflow data available at 23 of the 37 sampling stations to calculate loads and yields of chloride, nutrients, and bacteria for WY 2020.

For water samples collected by PW, the median of the median pH values for samples from all stations on tributaries in the Scituate Reservoir drainage area was 6.4; the median value for color was 50 platinum-cobalt units; the median value for turbidity was 0.69 nephelometric turbidity unit; and the median concentration for alkalinity was 6.6 mg/L as calcium carbonate. In this report, orthophosphate is the name for compounds with only one PO_4 unit, whereas phosphate is used to name any compound having one or more PO_4 units. The medians of the median concentrations for water samples from all stations were the following: 24.8 mg/L chloride, 0.001 mg/L as nitrite as nitrogen, 0.08 mg/L nitrate as nitrogen, 0.03 mg/L orthophosphate as phosphate, 1,200 total coliform bacteria colony forming units per 100 milliliters, and 10 *Escherichia coli* colony forming units per 100 milliliters. The medians of the median daily loads were 220 kilograms per day chloride, 10 grams per day nitrite as nitrogen, 500 grams per day nitrate as nitrogen, 290 grams per day orthophosphate as phosphate, 55,000 million coliform bacteria colony forming units per day, and less than 900 million *Escherichia coli* colony forming units per day. The medians of the median yields were 76 kilograms chloride per day per square mile, 4.1 grams nitrite as nitrogen per day per square mile, 240 grams nitrate as nitrogen per day per square mile, 100 grams orthophosphate as phosphate per day per square mile, 31,000 million coliform bacteria colony forming units per day per square mile, and less than 260 million *Escherichia coli* colony forming units per day per square mile.

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Table 4. Daily loads of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.

[Data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations shown on figure 1. USGS, U.S. Geological Survey; ft^3/s, cubic foot per second; CFU×10^6/d; million colony forming units per day; *E. coli*, *Escherichia coli*; kg/d, kilogram per day; g/d, gram per day as N, gram per day as nitrogen; g/d, gram per day; <, less than; >, greater than]

PW station number	USGS station number	Date	Daily mean streamflow (ft^3/s)	Total coliform bacteria ([CFUx10^6]/d)	*E. coli* ([CFUx10^6]/d)	Chloride (kg/d)	Nitrite (g/d as N)	Nitrate (g/d as N)	Orthophosphate (g/d as phosphate)
Barden Reservoir subbasin									
24	01115190	10/04/2019	0.24	6,000	59	17	0.59	<15	18
		11/25/2019	17	530,000	50,000	1,000	83	<1,000	4,200
		12/06/2019	6.5	93,000	1,600	430	16	<400	480
		01/29/2020	12	210,000	<1,500	710	29	2,100	870
		02/20/2020	8.6	120,000	<1,100	540	21	1,500	630
		03/06/2020	6.0	150,000	<730	370	15	1,000	290
		04/03/2020	13	410,000	<1,600	730	32	<800	1,600
		05/21/2020	4.6	160,000	<570	230	23	<280	340
		06/05/2020	1.9	180,000	11,000	110	14	430	180
		07/16/2020	0.32	18,000	490	17	1.5	130	15
		08/20/2020	0.01	1,500	36	0.61	0.024	3.7	0.49
25	01115200	11/26/2019	16	320,000	7,700	520	77	<960	1,100
		03/19/2020	7.2	290,000	<870	220	35	<440	520
		06/23/2020	0.15	10,000	120	4.1	0.74	36	7.4
26	01115185	11/26/2019	21	450,000	42,000	1,100	100	<1,300	1,000
		03/19/2020	10	480,000	7,700	560	49	1,900	990
		06/23/2020	0.26	13,000	130	20	1.3	270	32
28	01115265	10/08/2019	0.79	9,300	190	75	1.9	<48	<9.7
		11/12/2019	8.3	59,000	2,000	590	41	<510	1,600
		12/10/2019	71	13,000,000	420,000	3,500	520	8,700	8,700
		01/23/2020	18	160,000	<2,100	1,500	86	4,900	1,700
		02/12/2020	26	160,000	<3,200	1,500	130	—	2,500
		03/10/2020	9.2	110,000	2,200	610	45	1,600	670
		04/16/2020	23	330,000	<2,800	1,000	110	<1,400	4,500
		05/29/2020	7.3	360,000	7,300	490	54	<450	1,100
		06/10/2020	4.0	92,000	5,000	290	30	710	890
		07/14/2020	0.30	7,000	75	28	1.5	150	45
		08/11/2020	0.04	4,800	36	3.2	0.17	20	6.1
		09/08/2020	0.05	2,500	25	3.4	0.12	26	6.2
35	01115187	10/04/2019	2.4	260,000	3,700	160	5.9	<150	1,200
		11/25/2019	120	7,500,000	670,000	6,300	610	16,000	48,000
		12/06/2019	24	250,000	5,800	1,300	58	3,700	2,300
		01/29/2020	33	460,000	<4,000	1,700	80	7,400	1,600
		02/20/2020	29	200,000	<3,500	1,700	71	7,300	1,400
		03/06/2020	20	180,000	<2,400	1,100	49	4,500	980
		04/03/2020	47	510,000	<5,800	2,300	120	<2900	2,300
		05/21/2020	22	1,800,000	11,000	1,000	110	<1300	1,600
		06/05/2020	5.3	590,000	5,300	300	26	850	510
		07/16/2020	0.76	91,000	580	43	3.7	270	37
		08/20/2020	0.13	10,000	97	9.4	0.31	30	9.4

Table 4. Daily loads of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.—Continued

[Data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations shown on figure 1. USGS, U.S. Geological Survey; ft^3/s, cubic foot per second; $CFU \times 10^6/d$; million colony forming units per day; *E. coli*, *Escherichia coli*; kg/d, kilogram per day; g/d, gram per day as N, gram per day as nitrogen; g/d, gram per day; <, less than; >, greater than]

PW station number	USGS station number	Date	Daily mean streamflow (ft^3/s)	Total coliform bacteria ($[CFU \times 10^6]/d$)	*E. coli* ($[CFU \times 10^6]/d$)	Chloride (kg/d)	Nitrite (g/d as N)	Nitrate (g/d as N)	Orthophosphate (g/d as phosphate)
Direct Runoff subbasin									
1	01115180	10/01/2019	0.33	4,700	<40	16	0.81	230	65
		11/05/2019	2.6	95,000	1,900	89	13	810	940
		12/06/2019	3.0	100,000	730	110	22	1,300	730
		01/22/2020	2.3	59,000	<280	92	11	1,400	280
		02/04/2020	2.5	64,000	<310	84	12	1,400	490
		03/03/2020	2.8	110,000	<350	98	14	1,600	210
		04/07/2020	3.6	85,000	890	110	18	1,300	360
		05/18/2020	3.9	93,000	<470	110	19	1,300	280
		06/02/2020	1.3	65,000	2,700	45	9.5	860	190
		07/07/2020	0.57	25,000	430	20	2.8	380	98
		08/04/2020	0.08	5,300	19	3.0	0.19	47	7.5
		09/01/2020	0.10	1,800	<12	3.8	0.23	69	9.3
3	01115280	10/03/2019	0.03	750	<4	5.3	0.08	5.5	6.4
		11/07/2019	2.4	28,000	<300	330	5.9	380	470
		12/12/2019	7.1	140,000	1,700	750	17	1,800	170
		01/09/2020	3.5	45,000	<430	400	8.6	1,900	260
		02/18/2020	3.5	33,000	<420	400	8.5	1,900	250
		03/05/2020	2.9	31,000	<350	310	7.0	1,300	70
		04/21/2020	6.9	110,000	1,700	610	17	1,500	1,000
		05/19/2020	2.3	34,000	<280	190	5.5	420	220
		06/04/2020	0.75	17,000	<91	68	1.8	500	91
		07/02/2020	0.43	62,000	1,900	44	2.1	230	64
		08/06/2020	0.06	22,000	160	8.4	0.14	42	4.3
4	01115400	10/01/2019	0.02	2,600	<2.9	0.52	0.057	<1.4	0.57
		11/05/2019	0.83	19,000	200	12	2.0	<51	61
		12/06/2019	1.1	7,700	<130	18	2.6	<66	79
		01/22/2020	0.69	4,200	<84	13	1.7	<42	17
		02/04/2020	0.79	4,200	<97	12	1.9	<49	97
		03/03/2020	1.0	6,300	<120	19	2.4	<61	24
		04/07/2020	1.5	61,000	<190	24	3.8	<94	300
		05/18/2020	1.7	140,000	<210	22	4.2	<100	83
		06/02/2020	0.25	34,000	<31	3.9	0.61	<15	18
		07/07/2020	0.06	8,100	30	0.88	0.15	<3.7	5.9
		08/04/2020	0.00	220	0.45	0.04	0.004	<0.11	0.13
5	01115184	10/31/2019	1.2	63,000	940	85	9.1	300	180
		03/17/2020	1.6	55,000	<190	91	3.8	1,300	76
		06/26/2020	0.30	19,000	230	21	1.5	190	37

Table 4. Daily loads of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.—Continued

[Data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations shown on figure 1. USGS, U.S. Geological Survey; ft^3/s, cubic foot per second; CFU×10^6/d; million colony forming units per day; *E. coli*, *Escherichia coli*; kg/d, kilogram per day; g/d, gram per day as N, gram per day as nitrogen; g/d, gram per day; <, less than; >, greater than]

PW station number	USGS station number	Date	Daily mean streamflow (ft^3/s)	Total coliform bacteria ([CFUx10^6]/d)	*E. coli* ([CFUx10^6]/d)	Chloride (kg/d)	Nitrite (g/d as N)	Nitrate (g/d as N)	Orthophosphate (g/d as phosphate)
Direct Runoff subbasin—Continued									
6	01115183	10/01/2019	0.2	5,100	74	23	1.1	43	26
		11/05/2019	1.0	49,000	1,000	150	6.8	830	510
		12/06/2019	2.4	61,000	580	240	12	1,700	700
		01/22/2020	2.7	35,000	2,600	270	6.6	3,400	260
		02/04/2020	4.2	41,000	1,000	340	10	3,800	310
		03/03/2020	4.0	30,000	<530	360	11	3,600	320
		04/07/2020	4.6	130,000	7,200	350	23	2,600	450
		05/18/2020	4.0	260,000	9,600	280	20	1,800	390
		06/02/2020	0.77	69,000	2,100	67	5.7	590	110
		07/07/2020	0.08	16,000	300	13	0.80	26	16
7	01115297	10/03/2019	0.83	33,000	<100	39	4.0	<50	61
		11/07/2019	4.0	120,000	11,000	110	20	<240	690
		12/12/2019	16	360,000	47,000	330	78	2,700	390
		01/09/2020	11	47,000	<1,300	280	27	4,300	800
		02/18/2020	10	51,000	2,400	240	24	3,700	470
		03/05/2020	9.3	120,000	4,600	260	46	2,800	910
		04/21/2020	15	200,000	7,200	370	36	<900	1,100
		05/19/2020	7.9	530,000	10,000	170	39	<480	580
		06/04/2020	2.0	150,000	6,500	66	9.8	<120	200
		07/02/2020	0.74	180,000	3,200	24	7.3	<46	91
		08/06/2020	0.11	6,400	54	3.9	0.27	19	11
		09/03/2020	0.03	1,500	8.4	1.1	0.084	5.6	1.7
8	01115276	10/18/2019	8.1	43,000	2,000	220	20	<490	200
		11/18/2019	3.7	7,300	<450	120	<4.5	710	270
		12/27/2019	10	21,000	<1,200	320	24	1,500	1,200
		01/24/2020	7.6	7,700	<930	260	19	<470	370
		02/21/2020	11	22,000	<1,300	370	26	<650	520
		03/20/2020	13	20,000	<1,600	420	31	<790	630
		04/17/2020	23	47,000	<2,800	660	56	<1,400	1,100
		05/27/2020	6.9	29,000	<850	200	17	<420	680
		06/16/2020	3.1	38,000	<380	100	7.5	<190	150
		07/24/2020	1.9	91,000	<230	61	4.6	<110	180
		08/21/2020	1.6	67,000	<200	58	4.0	<100	200
9	01115275	10/31/2019	1.1	100,000	280	140	5.5	1,200	140
		03/17/2020	1.3	39,000	<160	200	3.2	2,100	65
		06/26/2020	0.39	46,000	300	72	1.9	700	29
		08/27/2020	0.26	13,000	330	55	0.63	650	19
32	01115178	10/30/2019	0.41	14,000	<50	15	2.0	<25	70
		03/06/2020	0.72	20,000	<87	26	1.7	700	52
		06/22/2020	0.07	9,900	110	2.9	1.1	78	20

Table 4. Daily loads of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.—Continued

[Data from Spaetzel and Smith (2021). Water-quality data are from samples collected and analyzed by Providence Water (PW). Locations of stations shown on figure 1. USGS, U.S. Geological Survey; ft^3/s, cubic foot per second; CFU×10^6/d; million colony forming units per day; *E. coli*, *Escherichia coli*; kg/d, kilogram per day; g/d, gram per day as N, gram per day as nitrogen; g/d, gram per day; <, less than; >, greater than]

PW station number	USGS station number	Date	Daily mean streamflow (ft^3/s)	Total coliform bacteria ([CFUx10^6]/d)	*E. coli* ([CFUx10^6]/d)	Chloride (kg/d)	Nitrite (g/d as N)	Nitrate (g/d as N)	Orthophosphate (g/d as phosphate)
Direct Runoff subbasin—Continued									
33	01115182	10/29/2019	0.35	14,000	260	7.5	0.85	<21	34
		02/26/2020	0.28	3,000	<35	8.6	0.69	170	21
		06/11/2020	0.22	5,700	<27	11	0.53	110	16
Moswansicut Pond reservoir subbasin									
19	01115170	10/15/2019	0.09	2,900	<11	14	0.23	<5.7	2.3
		11/19/2019	2.4	2,400	<290	340	5.8	330	120
		12/19/2019	12	52,000	21,000	1,600	30	2,700	300
		01/16/2020	5.8	2,900	2,900	840	14	1,400	290
		02/25/2020	5.0	1,200	<610	720	24	1,300	370
		03/12/2020	3.9	6,000	<470	540	9.5	1,000	190
		04/09/2020	9.3	12,000	<1,100	1,300	23	1,700	690
		05/22/2020	4.6	14,000	<570	640	11	870	790
		06/11/2020	4.2	130,000	<510	560	21	<260	410
		07/09/2020	0.97	50,000	<120	130	2.4	<60	140
		08/13/2020	0.14	14,000	<18	20	0.35	<8.8	39
		09/10/2020	0.10	37,000	48	14	0.24	<5.9	NA
21	01115165	12/02/2019	0.57	31,000	1,700	69	4.2	65	97
		03/26/2020	0.88	28,000	<110	140	8.6	2,200	86
		05/15/2020	0.77	65,000	3,800	77	5.6	1,200	94
Regulating reservoir subbasin									
14	01115110	10/17/2019	52	>31,000,000	16,600,000	1,500	770	8,700	13,000
		11/08/2019	7.7	230,000	5,800	320	19	<470	750
		12/16/2019	32	650,000	67,000	1,100	78	6,600	2,300
		01/28/2020	14	150,000	18,000	660	35	3,700	2,500
		02/27/2020	24	650,000	43,000	630	120	7,300	2,300
		03/13/2020	7.1	70,000	1,700	260	34	2,200	520
		04/10/2020	42	1,800,000	42,000	1,000	200	<2,600	8,200
		05/28/2020	4.0	380,000	5,100	130	19	1,100	390
		06/12/2020	1.5	40,000	1,100	180	15	1,000	260
		07/23/2020	0.026	3,900	210	0.90	0.13	8.5	1.9
15	01115114	10/17/2019	55	>33,000,000	17,600,000	4,200	1,600	17,000	19,000
		11/08/2019	5.7	180,000	4,300	680	28	<350	840
		12/16/2019	18	330,000	14,000	1,600	45	5,400	900
		01/28/2020	11	140,000	2,700	1,000	27	3,100	1,300
		02/27/2020	23	650,000	60,000	1,700	110	5,000	1,700
		03/13/2020	5.9	92,000	4,300	930	29	1,800	580
		04/10/2020	28	930,000	43,000	1,900	130	3,400	4,700
		05/28/2020	1.9	85,000	<230	230	9.1	600	180
		06/12/2020	1.4	67,000	2,400	220	10	750	170

Table 4. Daily loads of bacteria, chloride, nitrite, nitrate, and orthophosphate in the Scituate Reservoir drainage area, Rhode Island, from October 1, 2019, through September 30, 2020.—Continued

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PW station number	USGS station number	Date	Daily mean streamflow (ft^3/s)	Total coliform bacteria ($[CFUx10^6]/d$)	*E. coli* ($[CFUx10^6]/d$)	Chloride (kg/d)	Nitrite (g/d as N)	Nitrate (g/d as N)	Orthophosphate (g/d as phosphate)
Regulating reservoir subbasin—Continued									
16	01115098	10/17/2019	47	>28,000,000	3,300,000	4,700	230	5,900	3,400
		11/08/2019	7.0	56,000	<860	820	17	<430	520
		12/16/2019	32	740,000	<3,900	3,100	77	11,000	1,500
		01/28/2020	12	110,000	5,700	1,100	28	5,200	850
		02/27/2020	11	140,000	<1,300	1,100	27	4,400	1,300
		03/13/2020	10	140,000	<1,200	1,000	49	4,700	490
		04/10/2020	30	770,000	46,000	2,500	150	7,700	1,500
		05/28/2020	7.9	670,000	<970	610	39	1,200	390
		06/12/2020	3.3	280,000	1,600	280	16	<200	320
		07/23/2020	0.78	50,000	190	73	1.9	150	96
		08/18/2020	0.11	6,400	<13	11	0.27	<6.7	8.0
18	01115120	12/02/2019	0.33	6,500	1,100	53	0.81	350	24
		01/09/2020	0.21	1,700	<25	52	0.50	240	35
		05/15/2020	0.35	12,000	3,300	50	1.7	240	110
Westconnaug Reservoir subbasin									
10	01115274	10/08/2019	0.17	4,700	220	5.0	0.42	<11	<2.1
		11/12/2019	1.6	21,000	<200	53	3.9	<98	120
		12/10/2019	34	1,100,000	52,000	1,600	160	<2,100	1,600
		01/23/2020	1.5	32,000	<180	96	3.6	<90	72
		02/12/2020	6.1	130,000	<740	390	15	—	300
		03/10/2020	1.5	77,000	<180	94	3.6	<89	36
		04/16/2020	8.9	82,000	<1,100	360	22	<550	1,500
		05/29/2020	1.2	300,000	570	67	2.8	<71	110
		06/09/2020	0.82	25,000	<100	25	2.0	<50	—
		08/11/2020	0.00	320	1.9	0.13	0.010	<0.24	0.19
11	01115273	10/22/2019	0.68	24,000	330	17	5.0	<42	33
		03/23/2020	1.8	47,000	<210	52	8.6	290	1,400
		06/29/2020	0.24	38,000	690	5.6	1.7	<14	52
		08/28/2020	0.01	800	46	0.09	0.047	<0.39	1.6

For more information about this report, contact:
Director, New England Water Science Center
U.S. Geological Survey
10 Bearfoot Road
Northborough, MA 01532
dc_nweng@usgs.gov
or visit our website at
https://www.usgs.gov/centers/new-england-water

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