

Prepared in cooperation with the U.S. Army Corps of Engineers

# **Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2021**

Open-File Report 2022–1111



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By Patrick J. Ryan

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

## U.S. Geological Survey, Reston, Virginia: 2023

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### Suggested citation:

Ryan, P.J., 2023, Continuous stream discharge, salinity, and associated data collected in the lower St. Johns River and its tributaries, Florida, 2021: U.S. Geological Survey Open-File Report 2022–1111, 48 p., <https://doi.org/10.3133/ofr20221111>.

### Associated data for this publication:

U.S. Geological Survey, 2022, USGS water data for the Nation: U.S. Geological Survey National Water Information System database, <https://doi.org/10.5066/F7P55KJN>.

ISSN 2331-1258 (online)



## Acknowledgments

The author thanks the data collection personnel from the U.S. Geological Survey for their help collecting and analyzing the streamflow and water-quality data.



## Contents

Acknowledgments .....	iii
Abstract .....	1
Introduction .....	1
Methods .....	3
Methods of Data Collection and Processing .....	3
Description of St. Johns River Main-Stem Sites .....	6
Description of Tributary Sites .....	6
Results .....	7
Rainfall .....	7
Main-Stem Sites .....	9
Tributary Sites .....	23
Discharge and Salinity Site Comparison .....	40
Summary .....	47
References Cited .....	47

## Figures

1. Map showing U.S. Geological Survey data collection sites on the St. Johns River and its tributaries .....	2
2. Map showing U.S. Geological Survey data collection sites in Clay, Duval, and St. Johns Counties, Florida .....	4
3. Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Duval County .....	8
4. Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Clay County .....	8
5. Graph showing 2021 water year monthly rainfall and mean monthly rainfall for St. Johns County .....	8
6. Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Putnam County .....	9
7. Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Volusia County .....	9
8. Hydrograph showing daily mean tidally filtered discharge for St. Johns River at Astor, Florida .....	10
9. Quantile plot showing annual mean tidally filtered streamflow data for St. Johns River at Astor, Florida .....	10
10. Hydrograph showing daily mean tidally filtered discharge for St. Johns River at Buffalo Bluff near Satsuma, Florida .....	11
11. Graph showing daily maximum, minimum, and mean salinity for St. Johns River at Buffalo Bluff near Satsuma, Florida .....	12
12. Quantile plot showing annual mean tidally filtered streamflow data for St. Johns River at Buffalo Bluff near Satsuma, Florida .....	12
13. Boxplot showing salinity data for St. Johns River at Buffalo Bluff near Satsuma, Florida .....	13
14. Graph showing daily maximum, minimum, and mean salinity for St. Johns River at Dancy Point near Spuds, Florida .....	13

15.	Boxplot showing salinity data for St. Johns River at Dancy Point near Spuds, Florida .....	14
16.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River at Racy Point near Hastings, Florida .....	14
17.	Boxplot showing salinity data for St. Johns River at Racy Point near Hastings, Florida .....	15
18.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River Shands Bridge near Green Cove Springs, Florida.....	15
19.	Boxplot showing salinity data for St. Johns River Shands Bridge near Green Cove Springs, Florida .....	16
20.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River below Shands Bridge near Green Cove Springs, Florida.....	16
21.	Boxplot showing salinity data for St. Johns River below Shands Bridge near Green Cove Springs, Florida .....	17
22.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River above Buckman Bridge at Jacksonville, Florida .....	17
23.	Boxplot showing salinity data for St. Johns River above Buckman Bridge at Jacksonville, Florida.....	18
24.	Graph showing daily maximum, minimum, and mean salinity for top location of St. Johns River Buckman Bridge at Jacksonville, Florida .....	19
25.	Graph showing daily maximum, minimum, and mean salinity for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida.....	19
26.	Boxplot showing salinity data for top location of St. Johns River Buckman Bridge at Jacksonville, Florida .....	20
27.	Boxplot showing salinity data for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida .....	20
28.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River at Christopher Point near Jacksonville, Florida.....	21
29.	Boxplot showing salinity data for St. Johns River at Christopher Point near Jacksonville, Florida.....	21
30.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River below Marco Lake at Jacksonville, Florida.....	22
31.	Boxplot showing salinity data for St. Johns River below Marco Lake at Jacksonville, Florida.....	22
32.	Hydrograph showing daily mean tidally filtered discharge for St. Johns River at Jacksonville, Florida.....	23
33.	Graph showing daily maximum, minimum, and mean salinity for St. Johns River at Jacksonville, Florida .....	24
34.	Quantile plot showing annual mean tidally filtered streamflow data for St. Johns River at Jacksonville, Florida .....	24
35.	Boxplot showing salinity data for St. Johns River at Jacksonville, Florida .....	25
36.	Graph showing daily maximum, minimum, and mean salinity for top location of St. Johns River Dames Point Bridge at Jacksonville, Florida .....	25
37.	Graph showing daily maximum, minimum, and mean salinity for bottom location of St. Johns River Dames Point Bridge at Jacksonville, Florida.....	26
38.	Boxplot showing salinity data for top location of St. Johns River at Dames Point Bridge at Jacksonville, Florida .....	26
39.	Boxplot showing salinity data for bottom location of St. Johns River at Dames Point Bridge at Jacksonville, Florida .....	27

40.	Hydrograph showing daily mean tidally filtered discharge for Julington Creek at Old St. Augustine Road near Bayard, Florida.....	27
41.	Graph showing daily maximum, minimum, and mean salinity for Julington Creek at Hood Landing near Bayard, Florida.....	28
42.	Boxplot showing salinity data for Julington Creek at Hood Landing near Bayard, Florida .....	29
43.	Hydrograph showing daily mean tidally filtered discharge for Durbin Creek near Fruit Cove, Florida .....	29
44.	Graph showing daily maximum, minimum, and mean salinity for Durbin Creek near Fruit Cove, Florida .....	30
45.	Boxplot showing salinity data for Durbin Creek near Fruit Cove, Florida .....	30
46.	Hydrograph showing daily mean discharge for Ortega River at Kirwin Road near Jacksonville, Florida .....	31
47.	Quantile plot showing peak streamflow at Ortega River at Kirwin Road near Jacksonville, Florida.....	31
48.	Graph showing daily maximum, minimum, and mean salinity for Ortega River salinity at Jacksonville, Florida .....	32
49.	Boxplot showing data for Ortega River salinity at Jacksonville, Florida.....	32
50.	Hydrograph showing daily mean tidally filtered discharge for Cedar River at San Juan Avenue at Jacksonville, Florida .....	33
51.	Graph showing daily maximum, minimum, and mean salinity for Cedar River at San Juan Avenue at Jacksonville, Florida .....	33
52.	Boxplot showing salinity data for Cedar River at San Juan Avenue at Jacksonville, Florida.....	34
53.	Hydrograph showing daily mean discharge for Pottsburg Creek near South Jacksonville, Florida.....	35
54.	Quantile plot showing peak streamflow at Pottsburg Creek near South Jacksonville, Florida.....	35
55.	Hydrograph showing daily mean tidally filtered discharge for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida .....	36
56.	Graph showing daily maximum, minimum, and mean salinity for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida .....	36
57.	Boxplot showing salinity data for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.....	37
58.	Hydrograph showing daily mean tidally filtered discharge for Trout River near Jacksonville, Florida.....	37
59.	Graph showing maximum, minimum, and mean daily salinity for Trout River below U.S. 1 at Dinsmore, Florida .....	38
60.	Boxplot showing salinity data for Trout River below U.S. 1 at Dinsmore, Florida.....	38
61.	Hydrograph showing daily mean tidally filtered discharge for Broward River below Biscayne Boulevard near Jacksonville, Florida .....	39
62.	Graph showing daily maximum, minimum, and mean salinity for Broward River below Biscayne Boulevard near Jacksonville, Florida .....	39
63.	Boxplot showing salinity data for Broward River below Biscayne Boulevard near Jacksonville, Florida .....	40
64.	Hydrograph showing daily mean tidally filtered discharge for Dunn Creek at Dunn Creek Road near Eastport, Florida.....	41
65.	Graph showing daily maximum, minimum, and mean salinity for Dunn Creek at Dunn Creek Road near Eastport, Florida.....	41

66. Boxplot showing salinity data for Dunn Creek at Dunn Creek Road near Eastport, Florida .....42

67. Hydrograph showing daily mean tidally filtered discharge for Clapboard Creek near Jacksonville, Florida .....42

68. Graph showing daily maximum, minimum, and mean salinity for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida .....43

69. Boxplot showing salinity data for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.....43

70. Graph showing annual mean tidally filtered discharge at St. Johns River main-stem monitoring sites.....44

71. Graph showing annual mean discharge at St. Johns River tributary monitoring sites.....44

72. Graph showing annual rainfall for Duval, Clay, St. Johns, Putnam, and Volusia Counties.....45

73. Graph showing annual mean salinity at St. Johns River main-stem monitoring sites....46

74. Graph showing annual mean salinity at St. Johns River tributary monitoring sites .....46

Tables

1. U.S. Geological Survey data collection sites on the main stem of the St. Johns River and its tributaries and parameters published during the 2021 water year.....5

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Flow rate		
cubic foot per second (ft³/s)	0.02832	cubic meter per second (m³/s)
Speed		
miles per hour (mi/h)	1.609	kilometers per hour (km/h)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: °F = (1.8 × °C) + 32.

Datum

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

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

## Supplemental Information

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius ( $\mu\text{S}/\text{cm}$  at 25 °C).

## Abbreviations

JAXPORT	Jacksonville Port Authority
NOAA	National Oceanic and Atmospheric Administration
ppt	parts per thousand
SJRWMD	St. Johns River Water Management District
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey





# Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2021

By Patrick J. Ryan

## Abstract

The U.S. Army Corps of Engineers, Jacksonville District, is deepening the St. Johns River channel in Jacksonville, Florida, by 7 feet along 13 miles of the river channel beginning at the mouth of the river at the Atlantic Ocean, in order to accommodate larger, fully loaded cargo vessels. The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, monitored stage, discharge, and (or) water temperature and salinity at 26 continuous data collection stations in the St. Johns River and its tributaries.

This is the sixth annual report by the U.S. Geological Survey on data collection for the Jacksonville Harbor deepening project. Prior reports in this series documented data collected from October 2015 to September 2020. This report contains information pertinent to data collection during the 2021 water year, from October 2020 to September 2021. There were no modifications this year to the previously installed monitoring network. Data at each station were compared for the length of the project and on a yearly basis to show the annual variability of discharge and salinity in the project area.

Discharge and salinity varied widely during the 2021 water year data collection period, which included above-average rainfall for four of the five counties in the study area. Total annual rainfall for all counties ranked third among the annual totals computed for the 6 years considered for this study. Annual mean discharge at Durbin Creek was highest among the tributaries, followed by Trout River, Clapboard Creek, Ortega River, Pottsborg Creek at U.S. 90, Julington Creek, Pottsborg Creek near South Jacksonville, Dunn Creek, Cedar River, and Broward River, whose annual mean discharge was lowest. Annual mean discharge at 7 of the 10 tributary monitoring sites was higher for the 2021 water year than for the 2020 water year, and the computed annual mean flow at Clapboard Creek was the highest over the 6 years considered for this study. The annual mean discharge for each of the main-stem sites was higher for the 2021 water year than for the 2020 water year and ranked second among the annual totals computed for the 6 years considered for this study.

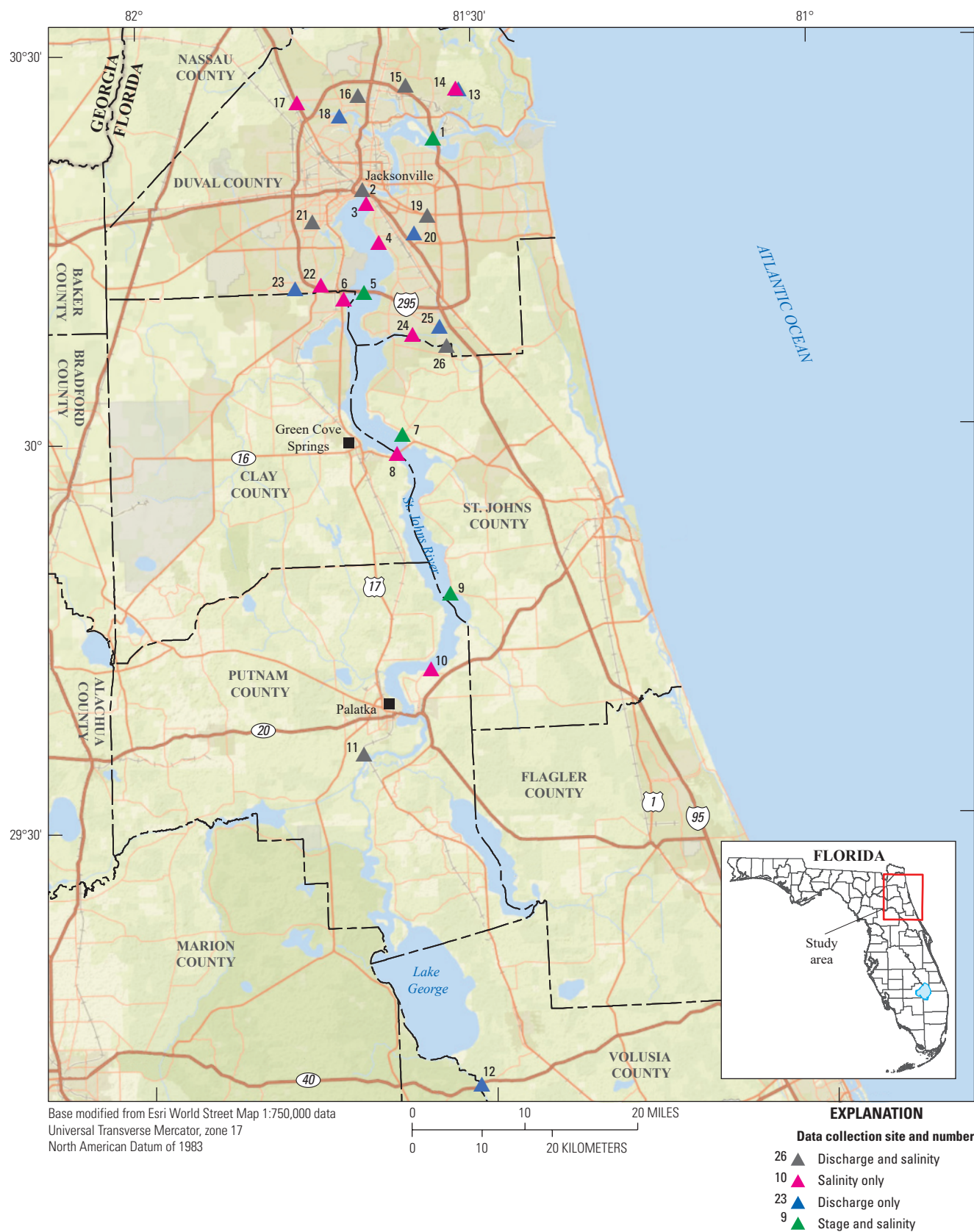
Among the tributary sites, annual mean salinity was highest at Clapboard Creek, the site closest to the Atlantic Ocean, and was lowest at Durbin Creek, the site farthest from the ocean. Annual mean salinity data from the main-stem sites on the St. Johns River indicate that salinity decreased with distance upstream from the ocean, which was expected. Relative to annual mean salinity calculated for the 2020 water year, annual mean salinity at all monitoring locations was lower for the 2021 water year except at the tributary site of Durbin Creek, which remained the same. The 2021 annual mean salinity at all sites ranked second lowest since the beginning of the study in 2016 except at Julington Creek and Racy Point, which tied for lowest, and Durbin Creek, which had the same value for each year.

## Introduction

The St. Johns River flows 310 miles (mi) northward through the eastern half of Florida, through Jacksonville, and into the Atlantic Ocean ([fig. 1](#)). The river consists of lakes, marshes, and seagrass beds, as well as the main river channel (herein referred to as the “main stem”) that, near its mouth, can accommodate cruise ships and cargo vessels with access to the Atlantic Ocean. Jacksonville Harbor is located along the first 20 river miles, beginning at the mouth of the St. Johns River where it empties into the Atlantic Ocean. Jacksonville Harbor currently can only accommodate small cargo vessels or large cargo vessels loaded below maximum capacity because of the authorized channel depth of 40 feet (ft). Dredging an additional 7 ft will allow the port to accommodate larger, fully loaded vessels. Beginning at the mouth, the U.S. Army Corps of Engineers (USACE) plans to deepen the first 13 river miles (USACE, 2014). Dredging construction began February 2018 (Jacksonville Port Authority [JAXPORT], 2018).

Salinity models indicate that the harbor deepening may alter salinity in part of the study area, potentially causing (1) salinity stress in some wetlands and submerged aquatic vegetation and (2) changes in some fish and macroinvertebrate distributions (USACE, 2014). Surface-water monitoring, required by permit, includes the collection of water

## 2 Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries



**Figure 1.** U.S. Geological Survey data collection sites on the St. Johns River and its tributaries. Map image is the intellectual property of Esri and is used herein under license. Copyright 2021 Esri and its licensors. All rights reserved.

temperature, salinity, and (or) stage, velocity, and streamflow data for at least 6 months prior to dredging, continuously throughout dredging, and for 10 years following dredging (Florida Department of Environmental Protection, 2016). The U.S. Geological Survey (USGS), in cooperation with the USACE, is responsible for monitoring all parameters at the gage locations listed in the permit that were not already being monitored by other entities as of January 2016, the beginning of the initial data collection period (Florida Department of Environmental Protection, 2016). The streamflow and water-quality monitoring network was used to collect baseline data in the St. Johns River and its tributaries prior to dredging and can be used to discern changes, if any, during and after dredging.

This report provides an overview of the data collected from 26 surface-water discharge and water-quality sites along the St. Johns River and its tributaries (1) under predredging conditions and (2) during the fourth year of dredging and sixth year of the study, specifically from October 2020 to September 2021 (figs. 1 and 2). The report documents the data collection sites, methods used to compute discharge and salinity, and parameters monitored at each site. The first 5 years of the study are described in Ryan (2018, 2019, 2020a, b, 2022).

The data collected during this study are available from the USGS National Water Information System database (USGS, 2022).

## Methods

The methods of data collection and processing, as well as the sites used for data collection, are described in the following sections. The descriptions of data collection sites are separated into those along the St. Johns River and those along its tributaries (table 1).

### Methods of Data Collection and Processing

Stage data (gage height, in feet, referenced to the North American Vertical Datum of 1988) were collected at 15-minute intervals using various types of equipment, depending on location requirements, in accordance with USGS standards (Sauer and Turnipseed, 2010a). Discharge was routinely measured by using various types of equipment, depending on depth, velocity, and environmental conditions, in accordance with USGS standards (Sauer and Turnipseed, 2010b). Because of tidal and (or) wind effects, discharge was computed, in cubic feet per second, using the index-velocity method at most sites, in accordance with USGS techniques and methods (Levesque and Oberg, 2012). Discharge was computed using a stage-discharge relation at a few sites where tidal influence was not substantial (Rantz and others, 1982). Where applicable, discharge data were filtered by using the Godin low-pass filter to remove principal tidal frequencies from unit values (Godin, 1972). By convention, the USGS designates

ebb (seaward) flow as positive flow and flood (landward) flow as negative flow. The residuals are not total freshwater flows, but instead, a combination of seaward freshwater flows from the watershed and landward saltwater flows from the marine environment, along with storm surges from hurricanes or tropical storms.

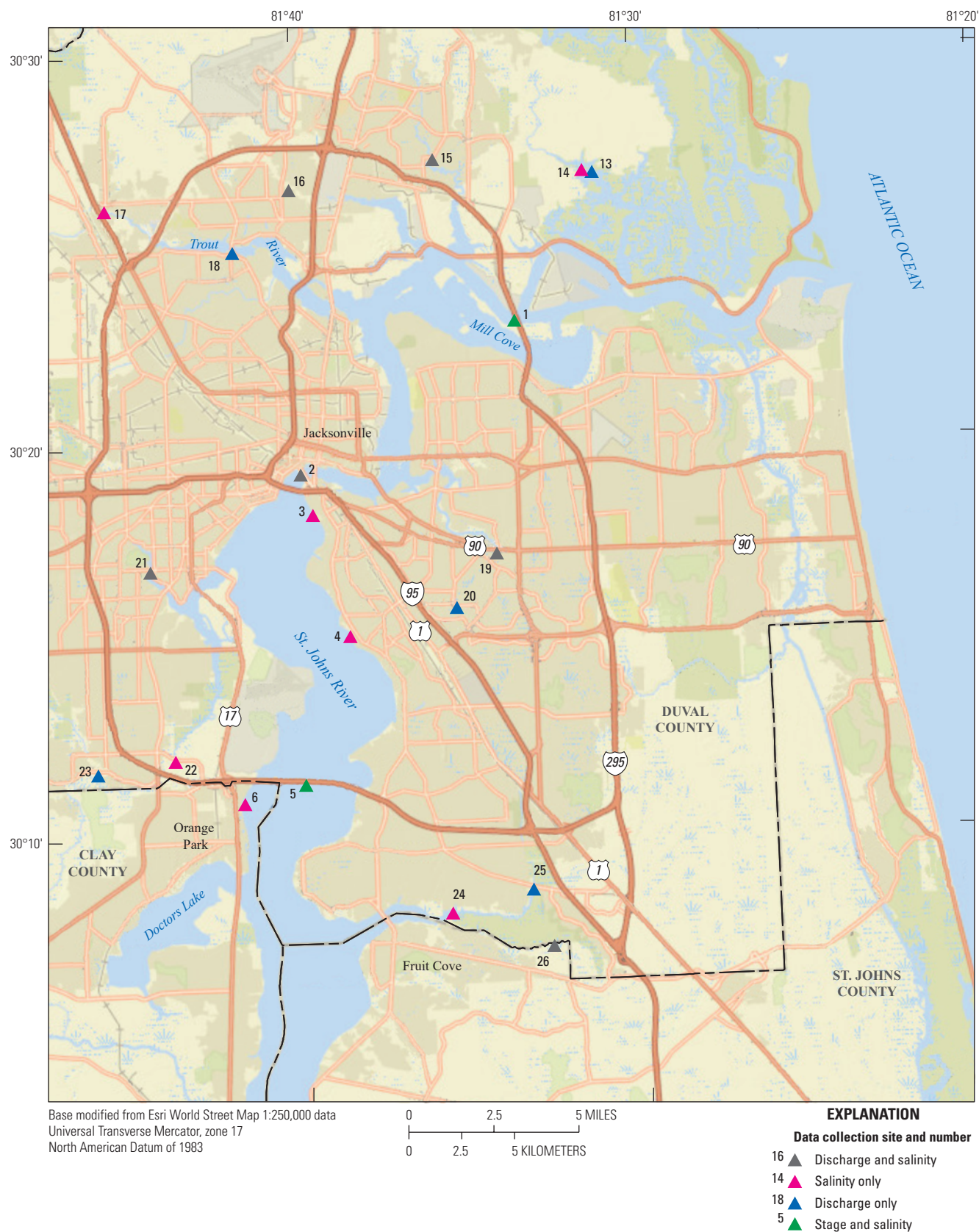
Water temperature, in degrees Celsius, and specific conductance, in microsiemens per centimeter at 25 degrees Celsius, were measured at intervals of 1 hour or less in accordance with USGS techniques and methods (Wagner and others, 2006). Water-quality meters were installed in situ at sites in freshwater environments. A pump and intake system was installed at sites in harsh saltwater environments to reduce fouling. This setup consisted of a meter housed inside a polyvinyl chloride chamber in a shelter. In this case, water was pumped into the chamber for 1–2 minutes before each measurement and drained from the chamber between measurements. The recording interval was reduced to one measurement per hour because of the power requirements for the pump setup. Because the chamber drains between measurements, water-quality parameters can be measured at multiple levels with one meter, if necessary. A rating table was used to convert specific conductance, in microsiemens per centimeter, to salinity, in parts per thousand (Wagner and others, 2006). Salinity was calculated for every site where water temperature and specific conductance were measured.

Missing discharge data can usually be attributed to equipment malfunction, either with the stage sensor or velocity meter (if the index-velocity method is used). For tidally filtered discharge calculation, the Godin low-pass filter requires 35 hours of continuous data before and after each data point (Godin, 1972). A data gap greater than 2 hours, therefore, results in a data gap of 3 days in the tidally filtered discharge record. For sites that include a pump setup, missing water-quality data are usually a consequence of power or pump failure, which prevents water from filling the chamber where the meter is housed. Biological fouling is a more common problem with meters installed in situ, where algal growth and crustaceans can affect the conductance measurement port or the temperature probe, both of which provide data used to calculate salinity. In either case, the affected values are not used, creating gaps in the final record.

Rainfall data for Duval, Clay, St. Johns, Putnam, and Volusia Counties in 2021 were obtained from the St. Johns River Water Management District (SJRWMD), which provides details about how average monthly rainfall data are compiled for counties in their district (SJRWMD, 2022). The period of record rainfall data to determine a long-term countywide average was compiled using National Oceanic and Atmospheric Administration (NOAA) rain gages in central and north Florida through 2009. Jacksonville Harbor and all monitoring sites included in this study are located within Duval County, except the St. Johns River sites at Astor in Volusia County, Dancy Point and Buffalo Bluff in Putnam County, Racy Point and Shands Bridge in St. Johns County, and above Buckman Bridge near the left bank in Clay County (fig. 1; table 1).



#### 4 Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries



**Figure 2.** U.S. Geological Survey data collection sites in Clay, Duval, and St. Johns Counties, Florida. Map image is the intellectual property of Esri and is used herein under license. Copyright 2021 Esri and its licensors. All rights reserved.

**Table 1.** U.S. Geological Survey data collection sites on the main stem of the St. Johns River and its tributaries and parameters published during the 2021 water year.

[USGS, U.S. Geological Survey; x, parameter measured; --, parameter not measured; NA, not applicable]

Map number	USGS site number	USGS site name	Dis-charge	Gage height	Velo-city	Temper-ature	Specific conduc-tance	Salinity	River mile
St. Johns River									
1	302309081333001	St Johns River Dames Point Bridge at Jacksonville, Fla.	--	x	x	x	x	x	10
2	02246500	St. Johns River at Jacksonville, Fla.	x	x	x	x	x	x	23
3	301817081393600	St. Johns River below Marco Lake at Jacksonville, Fla.	--	--	--	x	x	x	25
4	301510081383500	St. Johns River at Christopher Point near Jacksonville, Fla.	--	--	--	x	x	x	29
5	301124081395901	St. Johns River Buckman Bridge at Jacksonville, Fla.	--	x	--	x	x	x	34
6	301057081414800	St. Johns River above Buckman Bridge at Jacksonville, Fla.	--	--	--	x	x	x	35
7	02245340	St. Johns River below Shands Bridge near Green Cove Springs, Fla.	--	x	--	x	x	x	49
8	295856081372301	St. Johns River Shands Bridge near Green Cove Springs, Fla.	--	--	--	x	x	x	50
9	02245290	St. Johns River at Racy Point near Hastings, Fla.	--	x	--	x	x	x	64
10	294213081345300	St. Johns River at Dancy Point near Spuds, Fla.	--	--	--	x	x	x	71
11	02244040	St. Johns River at Buffalo Bluff near Satsuma, Fla.	x	x	--	x	x	x	90
12	02236125	St. Johns River at Astor, Fla.	x	x	--	--	--	--	127
Tributaries									
13	02246825	Clapboard Creek near Jacksonville, Fla.	x	x	--	--	--	--	NA
14	302657081312400	Clapboard Creek above Buckhorn Bluff near Jacksonville, Fla.	--	--	--	x	x	x	NA
15	02246804	Dunn Creek at Dunn Creek Road near Eastport, Fla.	x	x	--	x	x	x	NA
16	02246751	Broward River below Biscayne Boulevard near Jacksonville, Fla.	x	x	--	x	x	x	NA
17	302609081453300	Trout River below U.S. 1 at Dinsmore, Fla.	--	--	--	x	x	x	NA
18	02246621	Trout River near Jacksonville, Fla.	x	x	--	--	--	--	NA
19	02246518	Pottsburg Creek at U.S. 90 near South Jacksonville, Fla.	x	x	--	x	x	x	NA
20	02246515	Pottsburg Creek near South Jacksonville, Fla.	x	x	--	--	--	--	NA
21	02246459	Cedar River at San Juan Avenue at Jacksonville, Fla.	x	x	--	x	x	x	NA
22	301204081434900	Ortega River Salinity at Jacksonville, Fla.	--	--	--	x	x	x	NA
23	02246318	Ortega River at Kirwin Road near Jacksonville, Fla.	x	x	--	--	--	--	NA
24	300803081354500	Julington Creek at Hood Landing near Bayard, Fla.	--	--	--	x	x	x	NA
25	02246160	Julington Creek at Old St August Road near Bayard, Fla.	x	x	--	--	--	--	NA
26	022462002	Durbin Creek near Fruit Cove, Fla.	x	x	--	x	x	x	NA

Quantile plots were created to show percentiles for annual discharge data collected at monitoring sites that have at least 10 years of record and a full contemporary year of data. The quantile plots group the annual peak discharges by water year. For this report, the 2021 water year includes data from October 1, 2020, to September 30, 2021. The resulting plots show how the 2021 water year discharge at a given station compares with that of previous water years. For discharges affected by tidal fluctuations, annual mean tidally filtered discharge was used to construct the plot.

Boxplots were created to provide a visual reference of median, interquartile range, and other useful statistics. These boxplots were constructed using all approved unit values of salinity and show salinity differences between water years.

## Description of St. Johns River Main-Stem Sites

All sites on the main stem of the St. Johns River have substantive tidal influence, and therefore, the calculated discharge is tidally filtered. No changes were made to the monitoring network during this year of the study.

The farthest upstream discharge monitoring site on the St. Johns River is in Astor, Fla., at the State Road 40 Bridge (table 1; river mile 127). Approximately 37 mi downstream, discharge is also calculated for the St. Johns River at Buffalo Bluff (river mile 90). Tidally filtered discharge values have been computed since 1994 at both Astor and Buffalo Bluff. Water temperature and specific conductance are measured at Buffalo Bluff at an approximate depth of 6 ft below the average high-tide level. Another water-quality monitoring station along the St. Johns River is located downstream at Dancy Point (river mile 71), where water temperature and specific conductance are measured at an approximate depth of 11.5 ft below the average high-tide level. Stage, water temperature, and specific conductance are monitored farther downstream near the right bank of the St. Johns River at Racy Point (river mile 64). The water-quality parameters are measured at an approximate depth of 2.5 ft below the average high-tide level. Water temperature and specific conductance are collected near the channel of the St. Johns River at Shands Bridge (river mile 50). This location was historically monitored from April 1995 to September 2001 at multiple depths and from April 2008 to September 2009 at the middle depth. The meter was reinstalled in May 2018 at the middle-depth location of 10 ft below the average high-tide level. Just downstream near the right bank, stage, water temperature, and specific conductance are measured at an approximate depth of 8.5 ft below the average high-tide level at the St. Johns River below Shands Bridge (river mile 49).

A monitoring station is located near the left bank of the St. Johns River just upstream from Buckman Bridge. Water temperature and specific conductance are measured at an approximate depth of 4 ft below the average high-tide level at this station, St. Johns River above Buckman Bridge (river mile 35). A monitoring station at Buckman Bridge (river mile 34)

near the main channel measures stage, water temperature, and specific conductance. The water-quality parameters are measured with separate pump setups and intakes at two different depths to measure possible stratification. One water-quality meter is used in the chamber and monitors both water properties at each depth. All water-quality parameters are monitored at approximate depths of 8 ft (top) and 16 ft (bottom) below the average high-tide level. Water-quality monitoring stations at Christopher Point (river mile 29) and Marco Lake (river mile 25) measure water temperature and specific conductance at an approximate depth of 4 ft below the average high-tide level for each location. These sites are characterized by relatively shallow water having an average depth of less than 6 ft and represent river conditions in seagrass beds near the shore.

The St. Johns River at Jacksonville, Fla., data collection station, located near downtown Jacksonville at Acosta Bridge (river mile 23), is the farthest downstream gage that calculates discharge. Stage and discharge were previously monitored before the dredging study began, but water temperature and specific conductance data collection began in October 2015 at an approximate depth of 11 ft below the average high-tide level. The monitoring equipment was moved to the center of the channel in April 2018 because of fender construction, and the intake was installed at a new depth of 17 ft below the average high-tide level. Velocity and streamflow direction data collection were added in October 2017. Tidally filtered discharge values have been computed since 1996. A monitoring station at Dames Point Bridge in Jacksonville (river mile 10) measures stage, velocity, water temperature, and specific conductance; calculation of salinity began in October 2016. All water-quality data are collected at approximate depths of 15 ft (top) and 22 ft (bottom) below the average high-tide level by using one water-quality meter and pump setup with separate intakes, similar to those used at the station at Buckman Bridge to measure possible stratification. At Dames Point, the collection of stage data began in October 2017, and the collection of velocity and streamflow direction data began in May 2018.

## Description of Tributary Sites

No changes to the tributary monitoring network occurred during this year of the study. A monitoring station on Julington Creek at Old St. Augustine Road calculates discharge 6.7 mi upstream from the confluence of Julington Creek and the St. Johns River (table 1). A nearby water-quality monitoring station measures water temperature and specific conductance at an approximate depth of 3.5 ft below the average high-tide level and is located approximately 3 mi downstream from Old St. Augustine Road on Julington Creek at Hood Landing.

Durbin Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity 3.5 mi upstream from the confluence with Julington Creek and 6.8 mi upstream from the confluence with the St. Johns River. The water-quality parameters are measured at an approximate



depth of 3 ft below the average high-tide level. These locations are all tidally influenced, but large amounts of rainfall, resulting in increased discharge, can obscure the tidal signal.

Ortega River is monitored for stage and discharge at Argyle Forest Boulevard (Kirwin Road), 11 mi upstream from the confluence of the Ortega and St. Johns Rivers. Discharge has been computed intermittently at this location since 2002, and a stage-discharge rating was used for discharge computation during the study period, as no tidal influence is apparent in the stage data. A water-quality monitoring station that measures water temperature and specific conductance at an approximate depth of 6.5 ft below the average high-tide level is located at the bridge on Collins Road approximately 3 mi downstream from Kirwin Road at the Ortega River. Tidal influence is evident in the salinity data during times of low flow or increased stage in the St. Johns River.

The monitoring station on Cedar River measures stage, water temperature, and specific conductance at San Juan Avenue, 1.5 mi upstream from the confluence of the Cedar and St. Johns Rivers. The water-quality parameters are monitored at an approximate depth of 6 ft below the average high-tide level. Historical, tidally filtered discharge values have been computed intermittently since 2002. Wind, tide, and rainfall all substantively affect flow and salinity at Cedar River, and vertically stratified, bidirectional flow is commonly measured when strong winds occur opposite the direction of flow.

The station at Pottsburg Creek near South Jacksonville measures stage and is 7.3 mi upstream from the confluence of Pottsburg Creek and the St. Johns River. A stage-discharge rating was used for discharge computation during the study period. The data indicate tidal influence when stage is very low in the creek and elevated in the St. Johns River, but discharge measurements confirm the validity of the stage-discharge relation. Pottsburg Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity at U.S. 90, 5.2 mi upstream from the confluence of Pottsburg Creek and the St. Johns River. The water-quality parameters are monitored at an approximate depth of 4 ft below the average high-tide level. This location has a more pronounced tidal signal than the upstream location on Pottsburg Creek, and discharge and salinity are affected primarily by rainfall and elevated stage in the river.

The monitoring station for Trout River calculates discharge at Lem Turner Road, 5 mi upstream from the confluence of the Trout and St. Johns Rivers. Water temperature and specific conductance are measured 9.3 mi upstream from the confluence at an approximate depth of 6 ft below the average high-tide level. Broward River is monitored for stage, discharge, water temperature, specific conductance, and salinity near Biscayne Boulevard, 6.3 mi upstream from its confluence with the St. Johns River. The water-quality parameters are monitored at an approximate depth of 4.5 ft below the average high-tide level. Discharge and salinity at these stations have a pronounced tidal signal, even when stage is elevated.

Dunn Creek is monitored for stage, discharge, water temperature, specific conductance, and salinity at Dunn Creek Road, 5.3 mi upstream from the confluence of Dunn Creek and the St. Johns River. The monitoring station for Clapboard Creek calculates discharge near Sheffield Road, 4.5 mi upstream from the confluence of Clapboard Creek and the St. Johns River. Water temperature and specific conductance are measured at a location 0.5 mi upstream. The water-quality parameters are monitored at approximate depths of 5.5 and 6.5 ft below the average high-tide level. Discharge and salinity fluctuations at these stations are dependent on rainfall in the relatively small drainage area and on wind effects from the St. Johns River, owing to the proximity of the sites to the river and Atlantic Ocean.

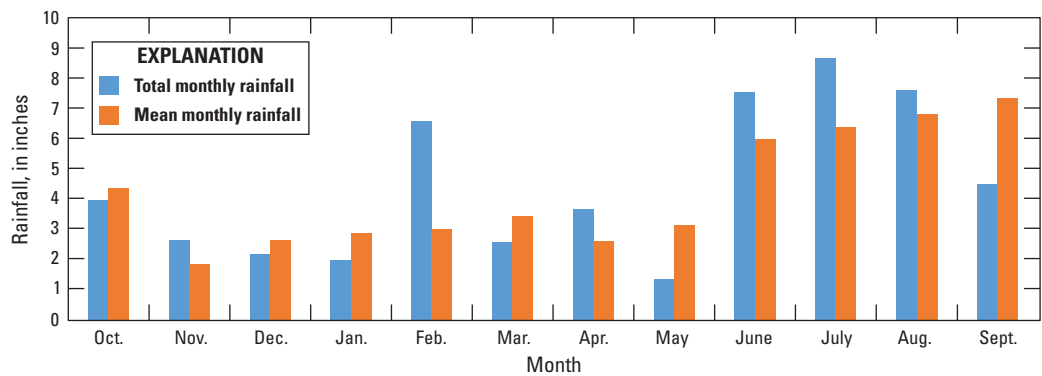
## Results

Discharge and salinity varied widely during the 2021 water year because of the large study area and diversity of sites. As expected, salinities were lowest at the tributary sites farthest from the ocean and highest during periods of low flow in the St. Johns River. Discharge also increased at both the tributary and main-stem sites during periods of increased rainfall.

Data at each station was compared for the length of the project and on a yearly basis to show the annual variability of discharge and salinity in the project area. Rainfall, daily discharge, and salinity plots for the 2021 water year (October 2020–September 2021) are presented in the following sections where applicable. A year refers to a water year in these sections unless otherwise noted. Daily discharge is tidally filtered at sites where substantive tidal fluctuations occur. Salinity values are not filtered and include daily maximum, minimum, and mean values. Instantaneous values can be accessed via the USGS National Water Information System database (USGS, 2022). Annual mean discharges are calculated only for sites having at least an entire year of discharge record. The annual mean is not calculated for partial years of record when stations were installed. Quantile plots are only available for sites with a minimum of 10 years of stream-flow record.

## Rainfall

Duval County rainfall for the 2021 water year (October 2020–September 2021) was 2.8 inches (in.) above the long-term average (SJRWMD, 2022). Monthly total rainfall ranged from 2.8 in. below average in September to 3.6 in. above average in February (fig. 3). Duval County annual rainfall ranked third compared to the cumulative long-term average of the five counties included in this study (SJRWMD, 2022). Annual rainfall averaged 5.7 in. and 0.6 in. above average for Clay and St. Johns Counties, respectively (SJRWMD, 2022). The highest monthly rainfall total for Clay County

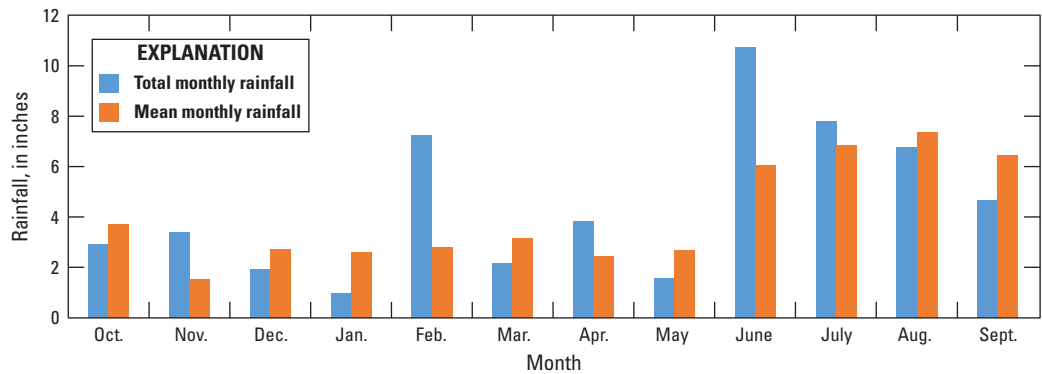


**Figure 3.** Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Duval County (St. Johns River Water Management District [SJRWMD], 2022).

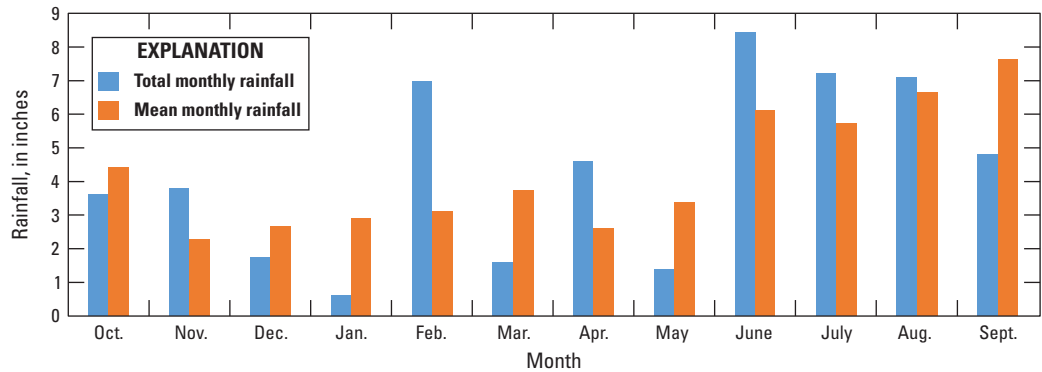
occurred in June and was 4.7 in. above average, and the highest positive monthly departure for St. Johns County, 3.9 in. above average, occurred in February. The lowest monthly rainfall totals for the two counties occurred in September and were 1.8 in. below average for Clay County and 2.8 in. below average for St. Johns County (figs. 4 and 5). Of the five

counties compared for this study, Clay County ranked second, and St. Johns County ranked fourth for rainfall totals in the 2021 water year.

Rainfall totals for Putnam and Volusia Counties were 6.8 in. above and 1.2 in. below their average yearly totals, respectively (SJRWMD, 2022). Rainfall for Putnam County ranged from 5.2 in. above average in June to 2.7 in. below



**Figure 4.** Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Clay County (St. Johns River Water Management District [SJRWMD], 2022).



**Figure 5.** Graph showing 2021 water year monthly rainfall and mean monthly rainfall for St. Johns County (St. Johns River Water Management District [SJRWMD], 2022).



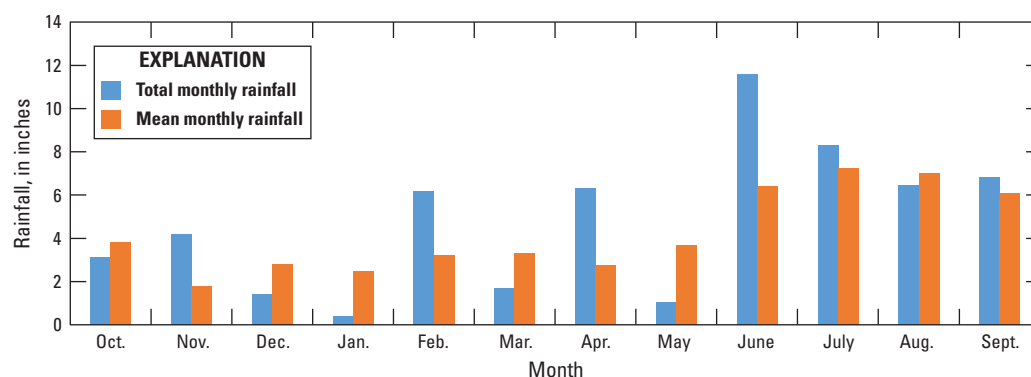
average in May (fig. 6). Rainfall for Volusia County ranged from 3.6 in. above average in November to 2.7 in. below average in March (fig. 7). Of the five counties compared for this study, Putnam County ranked first, and Volusia County ranked fifth for rainfall totals in the 2021 water year. Rainfall for each of the five counties was below the average monthly total from December to January.

## Main-Stem Sites

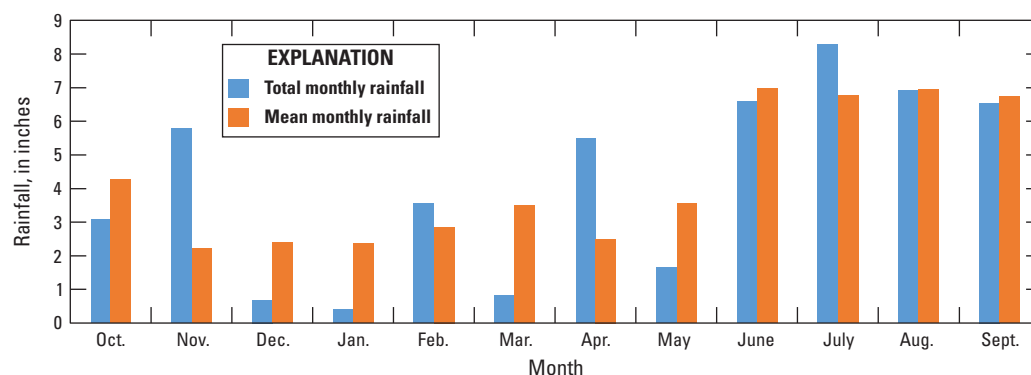
The parameters collected on the main stem of the St. Johns River are affected by many factors, including tidal influence, rainfall, and wind. Heavy rainfall typically increases discharge and decreases salinity, and the tidal influence introduces more fluctuations than a nontidal system. Strong northerly or easterly winds can increase salinity in the St. Johns River as ocean water with higher salinity is pushed upstream and can lower or even produce negative discharge for multiple days. When the wind calms or changes direction, discharge typically increases sharply as this ocean water and other tributary inflows exit the river.

*St. Johns River at Astor, Florida*—Daily tidally filtered discharge at Astor ranged from  $-4,960$  to  $8,810$  cubic feet per second ( $\text{ft}^3/\text{s}$ ) during the 2021 water year, with an annual mean of  $3,390 \text{ ft}^3/\text{s}$  (fig. 8). Tidally filtered discharge was estimated for 22 days in October, and 4 days in February. A comparison of historical annual mean tidally filtered flows indicated that 2021 streamflow was at the 65th percentile of the 27 years of record; the median tidally filtered annual mean flow for the period of record is  $2,860 \text{ ft}^3/\text{s}$  (fig. 9). The lowest discharge occurred in March, which also had the lowest deficit of monthly rainfall compared to the average monthly rainfall in Volusia County (fig. 7).

*St. Johns River at Buffalo Bluff near Satsuma, Florida*—Daily tidally filtered discharge at Buffalo Bluff ranged from  $-18,800$  to  $16,400 \text{ ft}^3/\text{s}$  during the 2021 water year, with an annual mean of  $5,940 \text{ ft}^3/\text{s}$  (fig. 10). Salinity ranged from 0.2 to 0.6 parts per thousand (ppt) over this same period, with a median and mean of 0.4 ppt (fig. 11). There were 2 days of missing salinity data in October caused by equipment malfunction and 1 day each in January, April, June, and August caused by missing data during site inspections when the meter was calibrated. A comparison of historical annual mean tidally filtered flows indicated that 2021 streamflow was at the 77th



**Figure 6.** Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Putnam County (St. Johns River Water Management District [SJRWMD], 2022).



**Figure 7.** Graph showing 2021 water year monthly rainfall and mean monthly rainfall for Volusia County (St. Johns River Water Management District [SJRWMD], 2022).

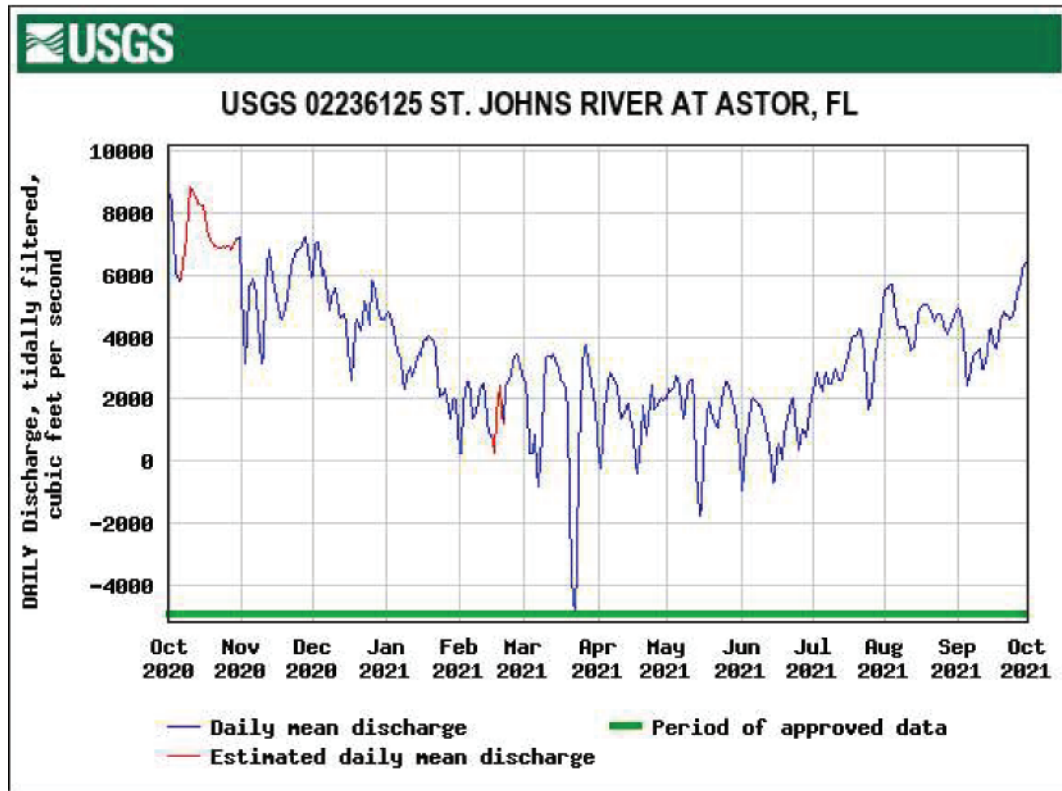


Figure 8. Daily mean tidally filtered discharge for St. Johns River at Astor, Florida.

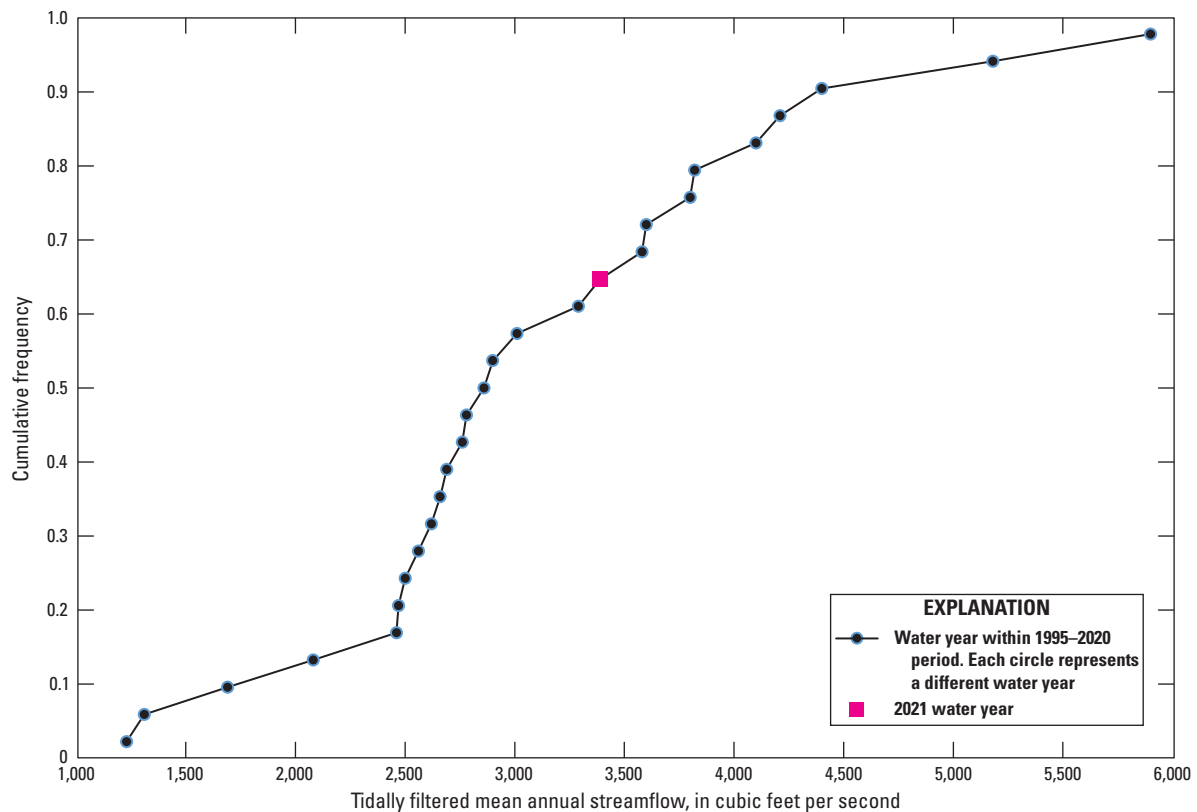
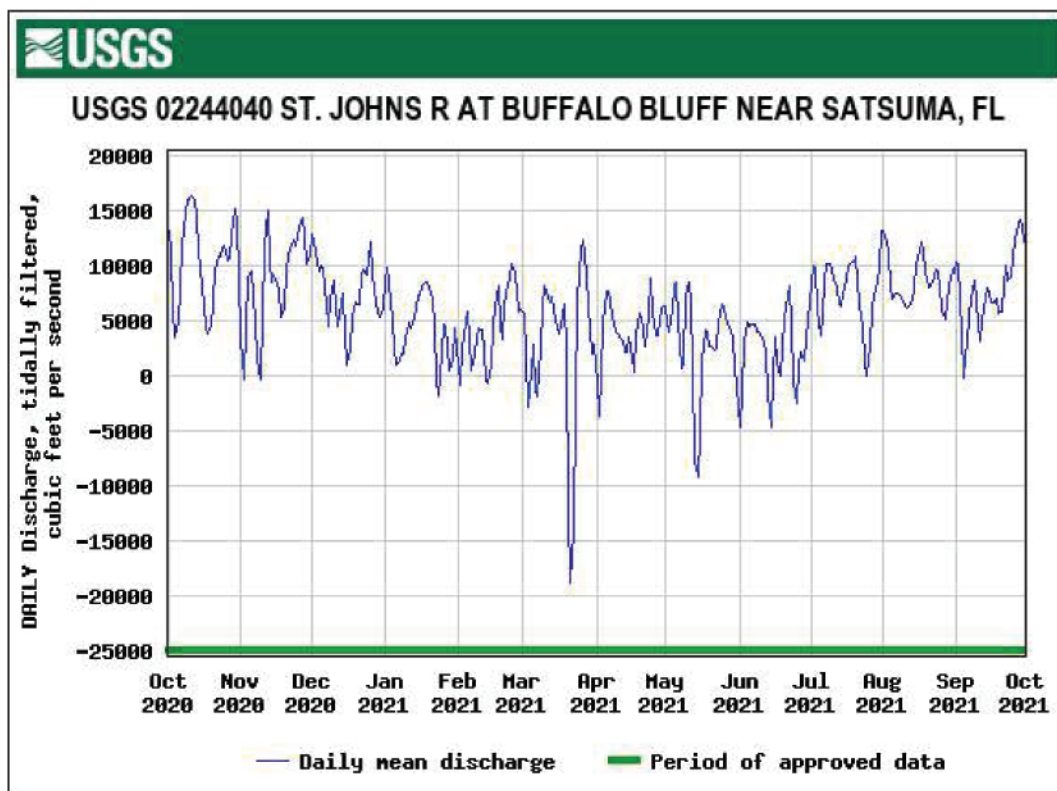
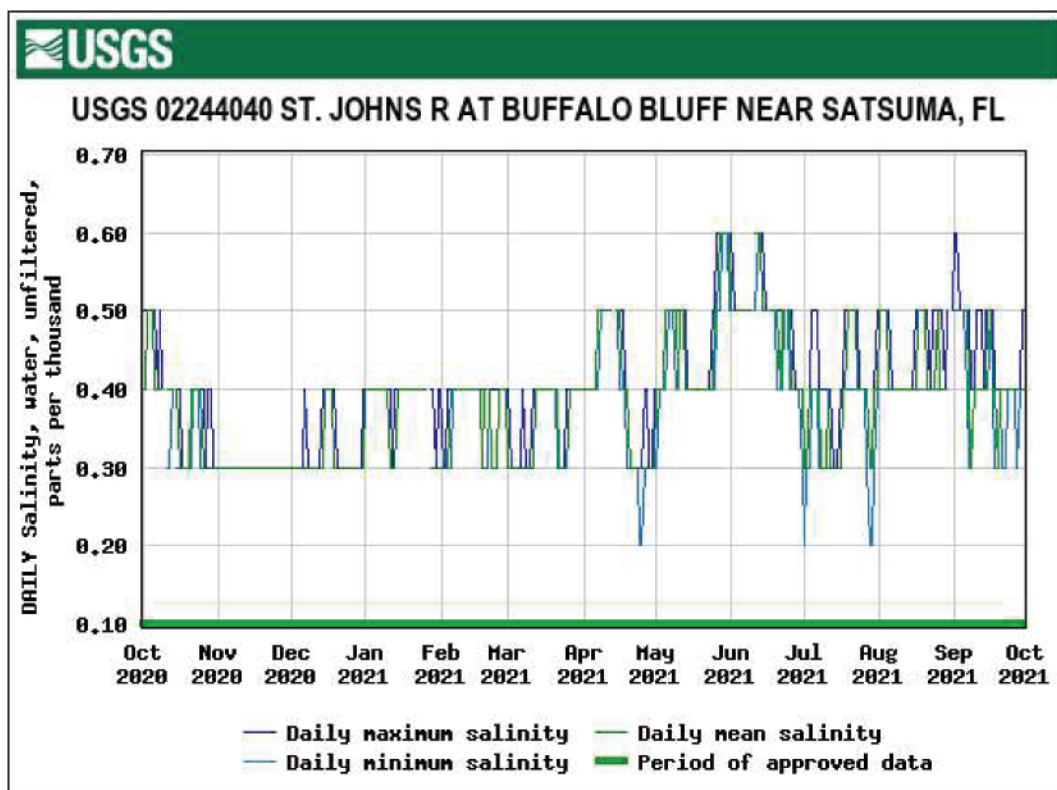


Figure 9. Annual mean tidally filtered streamflow data for St. Johns River at Astor, Florida.



**Figure 10.** Daily mean tidally filtered discharge for St. Johns River at Buffalo Bluff near Satsuma, Florida.



**Figure 11.** Daily maximum, minimum, and mean salinity for St. Johns River at Buffalo Bluff near Satsuma, Florida.

percentile of the 28 years of record; the median tidally filtered flow for the period of record is 4,580 ft<sup>3</sup>/s (fig. 12). The lowest tidally filtered discharge for the 2021 water year occurred in March during a period of below-average rainfall in Putnam County (fig. 6). The annual mean and median salinity are within 0.2 ppt for the 5 years that salinity was calculated in the study (fig. 13).

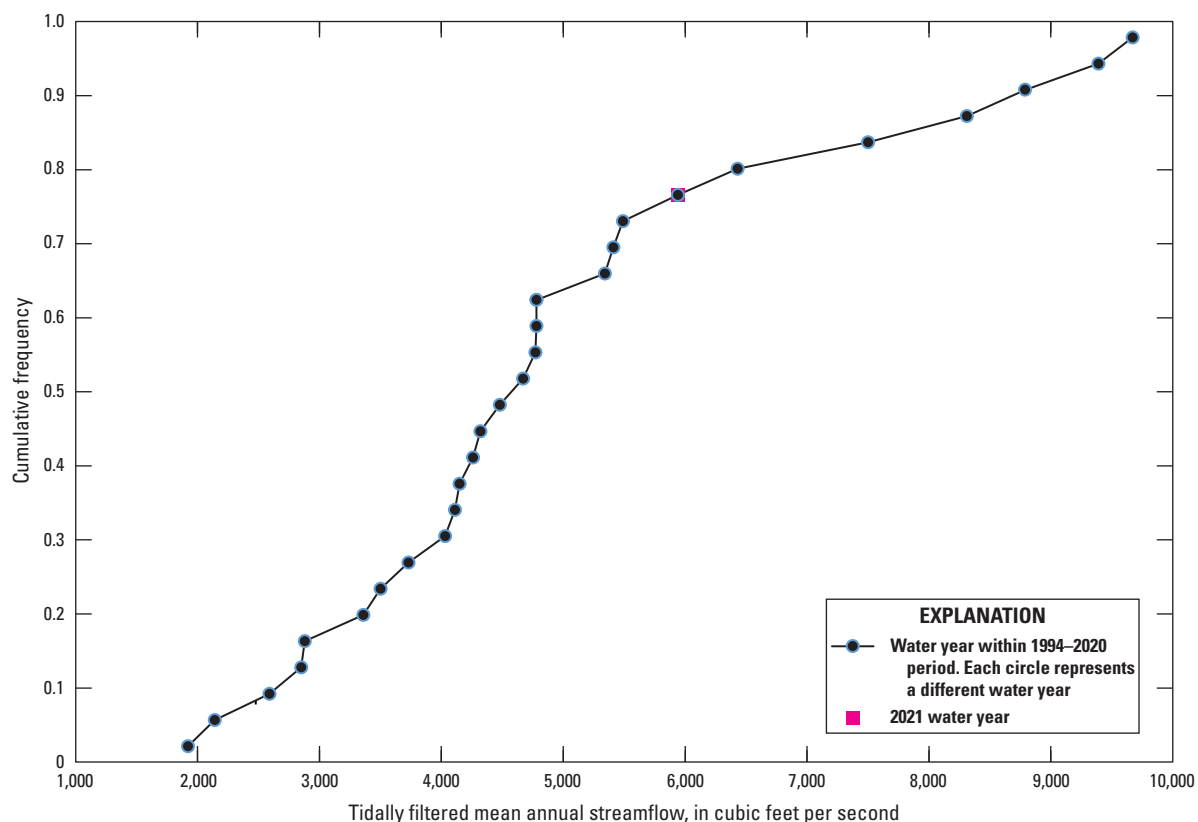
*St. Johns River at Dancy Point near Spuds, Florida*—Salinity on the St. Johns River at Dancy Point ranged from 0.2 to 0.5 ppt during the 2021 water year, with a median of 0.3 ppt and mean of 0.4 ppt (fig. 14). There were 11 days of missing salinity data in April and 4 days in June caused by equipment malfunction. The salinity data show fluctuations caused by tidal effects and rainfall, and a gradual increase from May to June. The annual mean and median salinity are within 0.2 ppt for the 5 years salinity was calculated in the study (fig. 15).

*St. Johns River at Racy Point near Hastings, Florida*—Salinity on the St. Johns River at Racy Point ranged from 0.2 to 0.5 ppt during the 2021 water year, with a median and mean of 0.3 ppt (fig. 16). There was 1 day of missing salinity data in December, 28 days in January, and 1 day in June caused by equipment malfunction. Computed salinity at Racy Point remained steady the entire year, with a small peak in June. The 2021 median and mean salinity tied for the lowest over the 4 years considered for this study (fig. 17).

*St. Johns River Shands Bridge near Green Cove Springs, Florida*—Salinity on the St. Johns River Shands Bridge ranged from 0.3 to 2.5 ppt during the 2021 water year, with a median and mean of 0.4 ppt (fig. 18). There were 3 days of missing salinity data in August caused by equipment malfunction. Salinity peaked in late March when below-average rainfall occurred in St. Johns County (fig. 5). A boxplot of salinity data for the 4 years of the study shows the second-highest maximum and mean salinity for 2021 (fig. 19).

*St. Johns River below Shands Bridge near Green Cove Springs, Florida*—Salinity on the St. Johns River below Shands Bridge ranged from 0.3 to 2.2 ppt during the 2021 water year, with a median and mean of 0.4 ppt (fig. 20). Like Shands Bridge, salinity peaked in late March when below-average rainfall occurred in St. Johns County (fig. 5). The 2021 median salinity tied for second among those computed for the 5 years of the study, and the 2021 mean salinity tied for third (fig. 21).

*St. Johns River above Buckman Bridge at Jacksonville, Florida*—Salinity on the St. Johns River above Buckman Bridge ranged from 0.2 to 11 ppt during the 2021 water year, with a median of 0.4 ppt and mean of 1.0 ppt (fig. 22). There were 8 days of missing salinity data in October, 3 days in November, 18 days in May, and 15 days in June caused by equipment malfunction. Daily maximum salinity peaked above 10 ppt in late March when below-average rainfall occurred in Clay County (fig. 4), and sustained wind speeds



**Figure 12.** Annual mean tidally filtered streamflow data for St. Johns River at Buffalo Bluff near Satsuma, Florida.

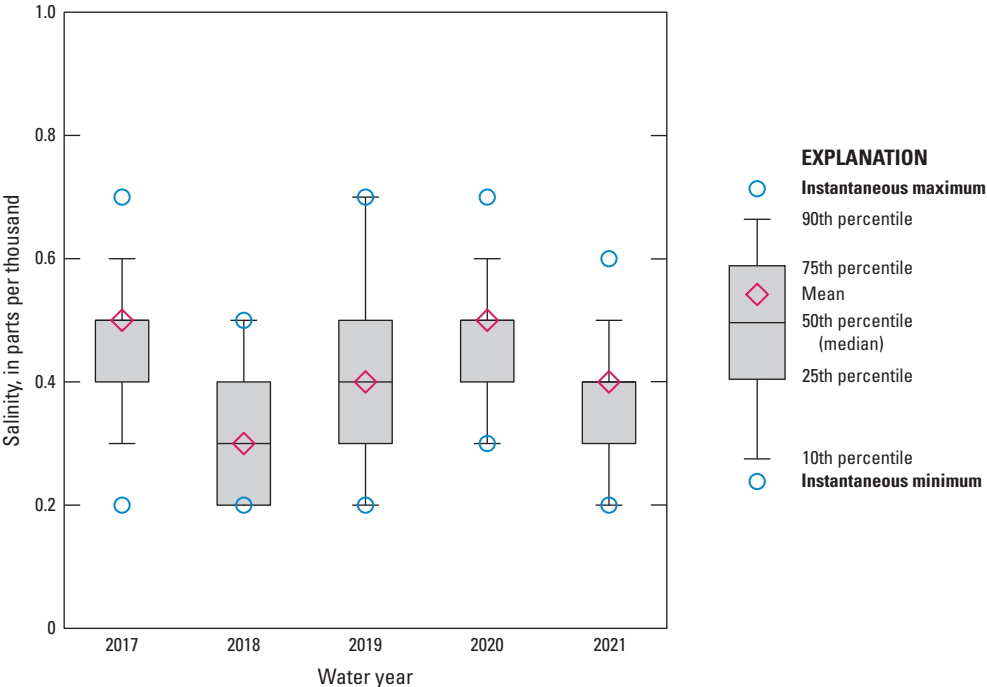


Figure 13. Salinity data for St. Johns River at Buffalo Bluff near Satsuma, Florida.

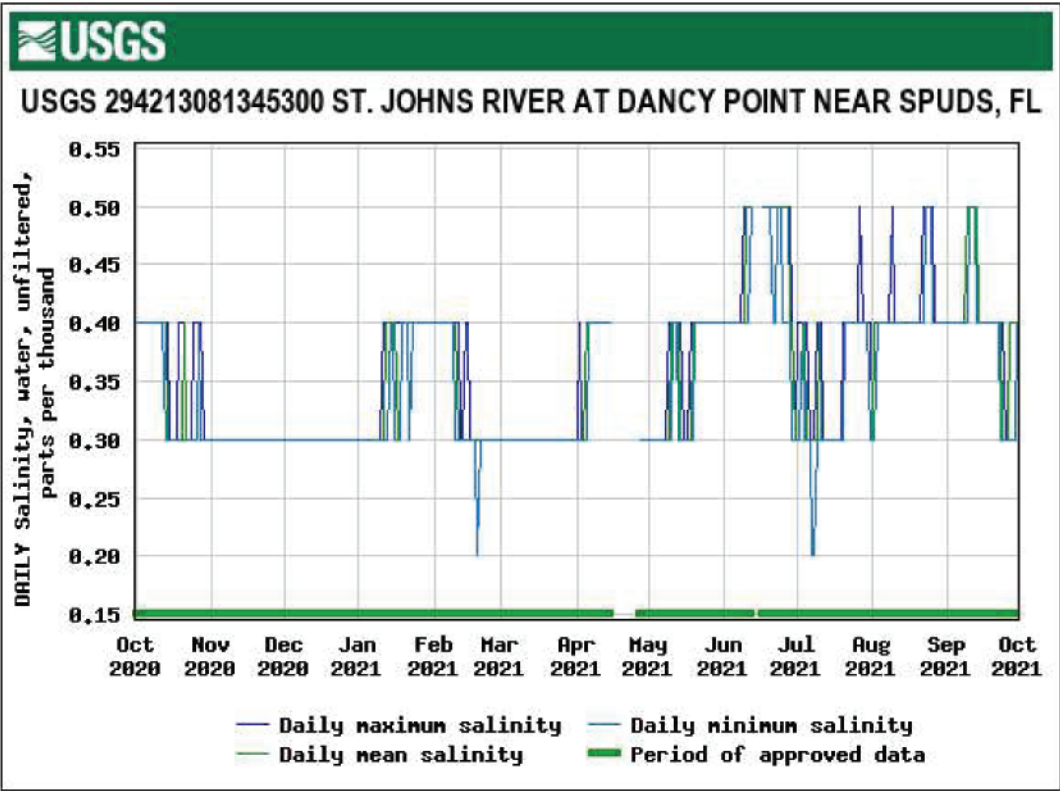


Figure 14. Daily maximum, minimum, and mean salinity for St. Johns River at Dancy Point near Spuds, Florida.

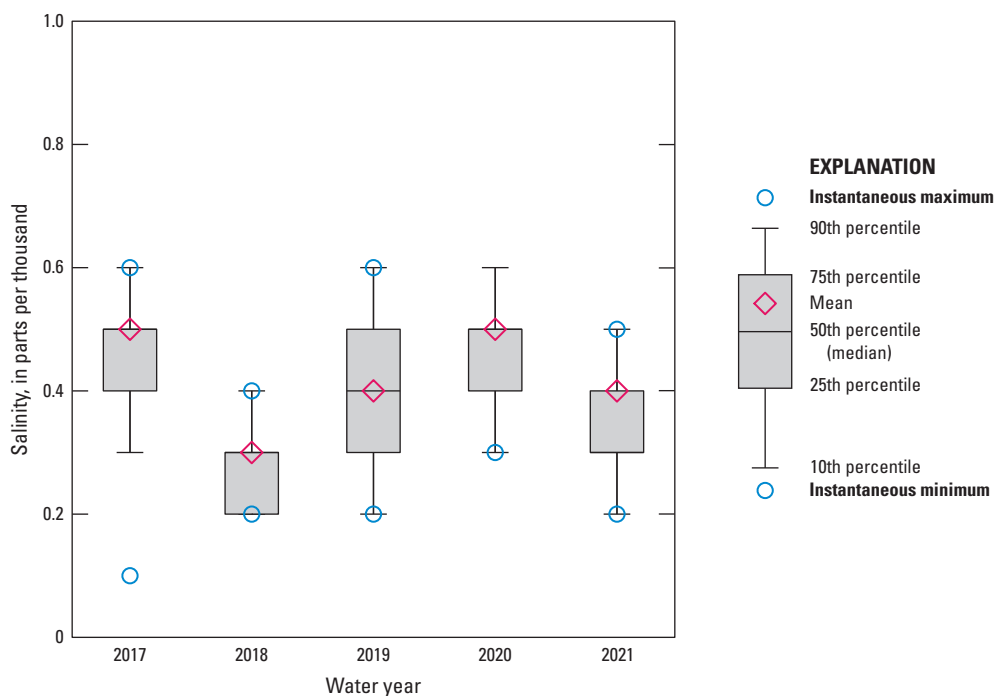


Figure 15. Salinity data for St. Johns River at Dancy Point near Spuds, Florida.

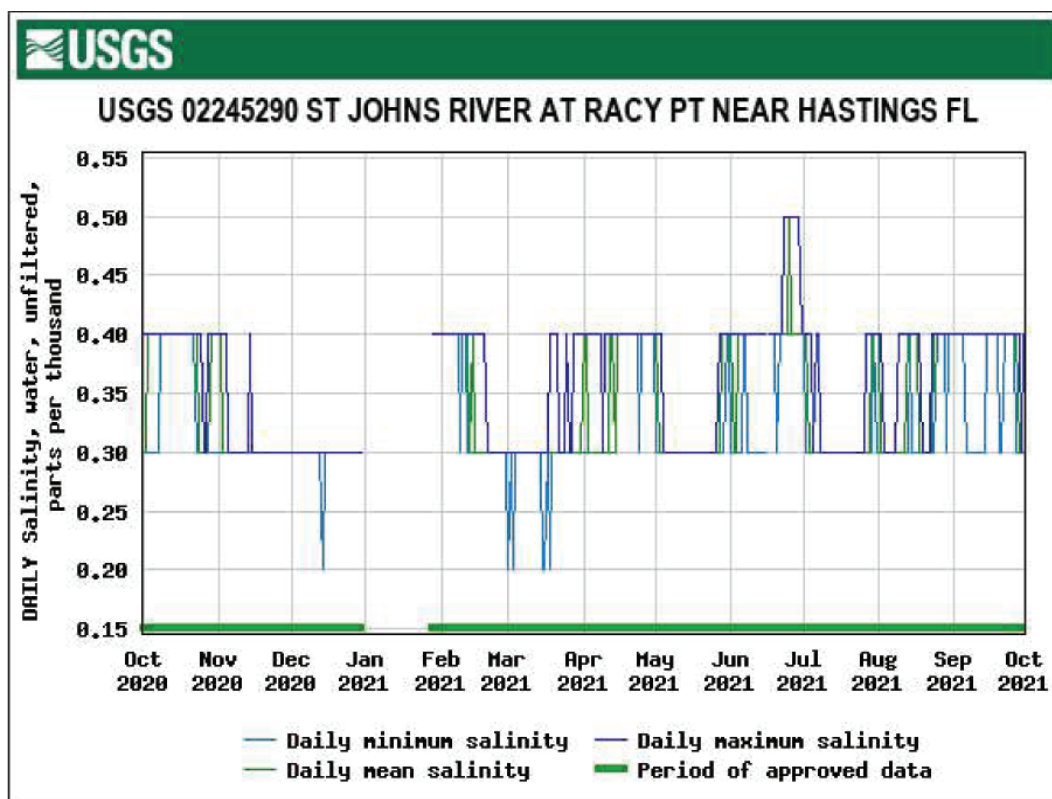


Figure 16. Daily maximum, minimum, and mean salinity for St. Johns River at Racy Point near Hastings, Florida.



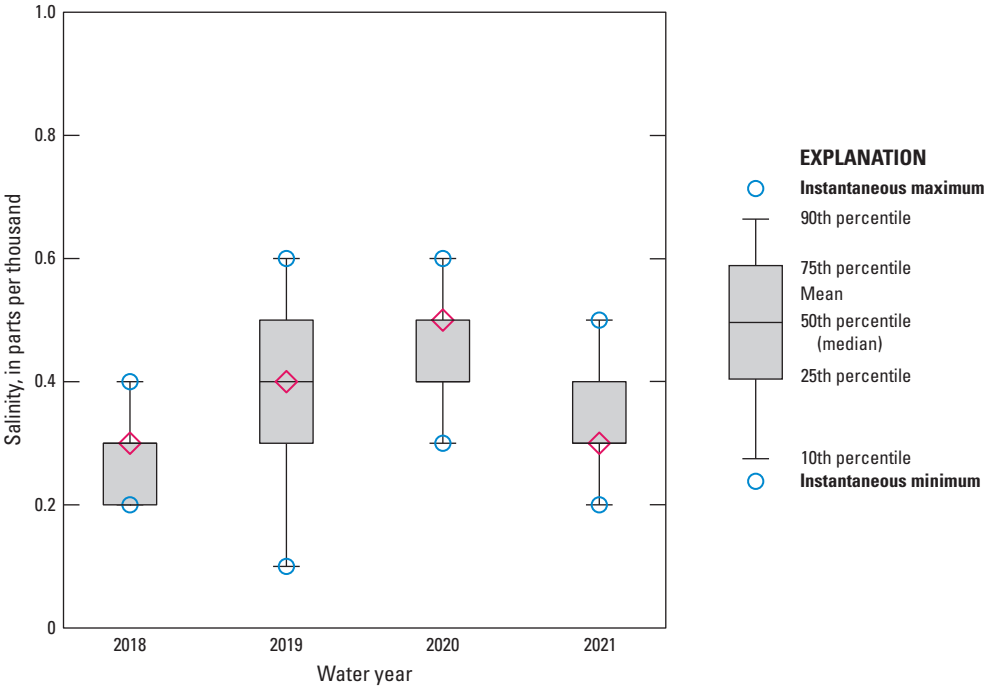


Figure 17. Salinity data for St. Johns River at Racy Point near Hastings, Florida.

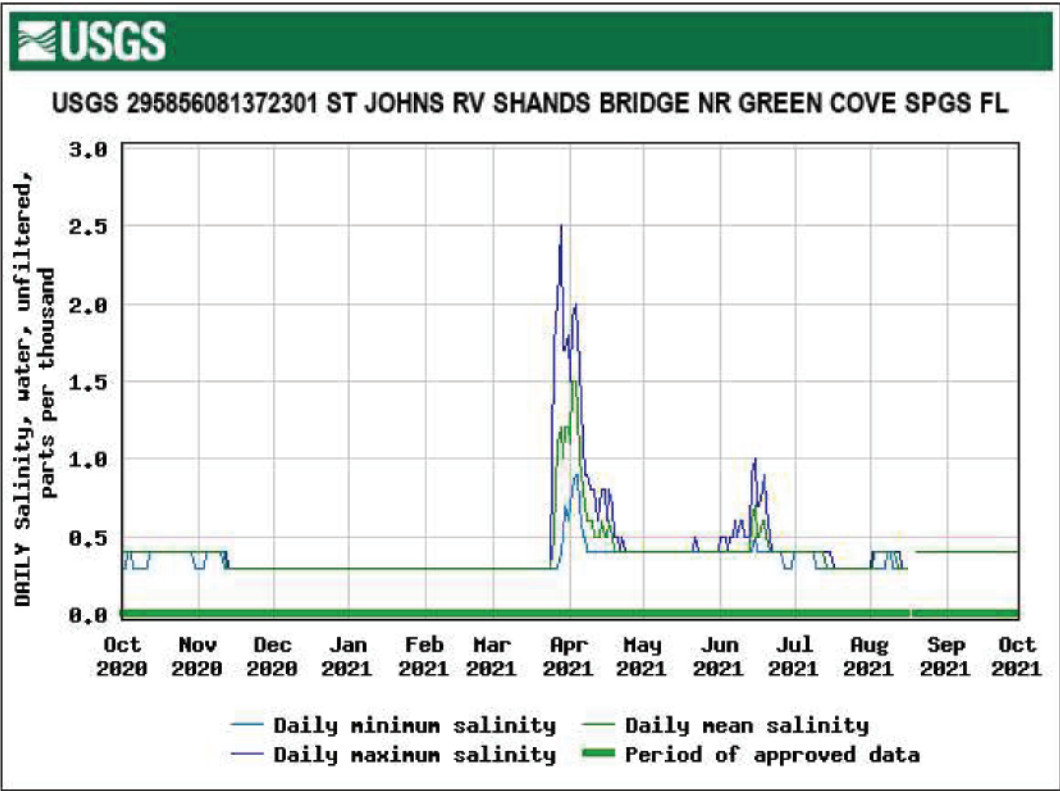
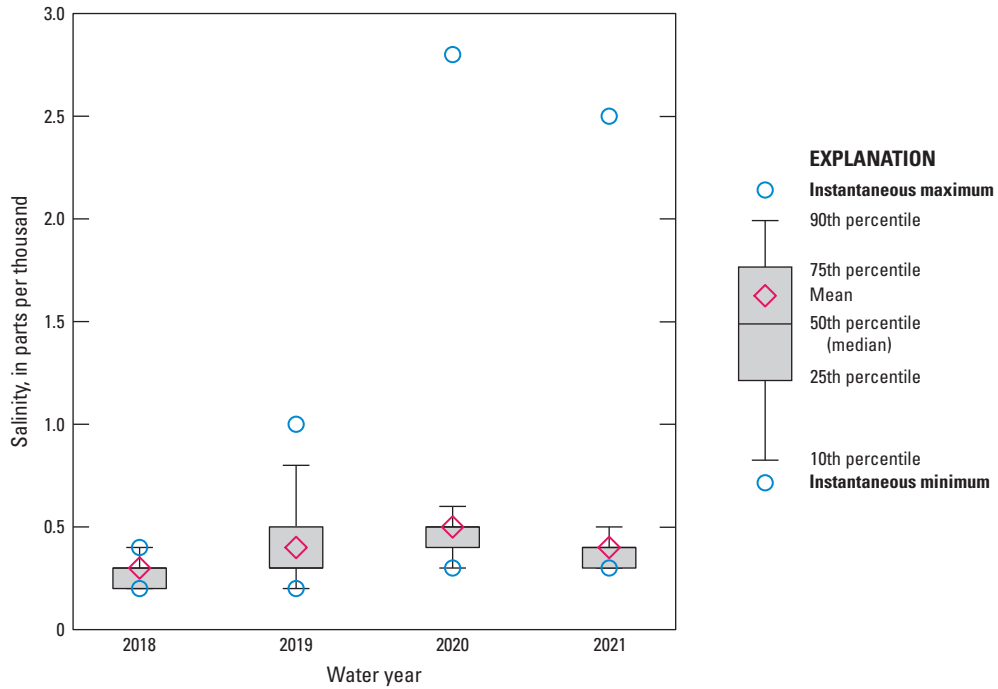
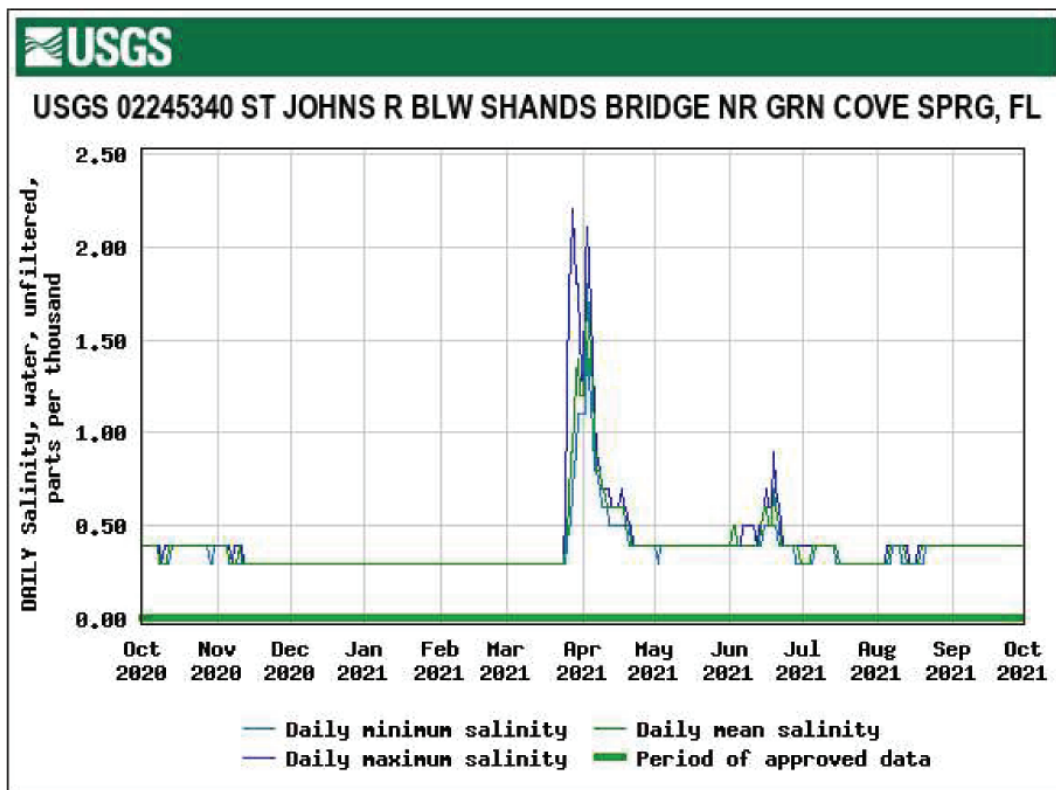


Figure 18. Daily maximum, minimum, and mean salinity for St. Johns River Shands Bridge near Green Cove Springs, Florida.

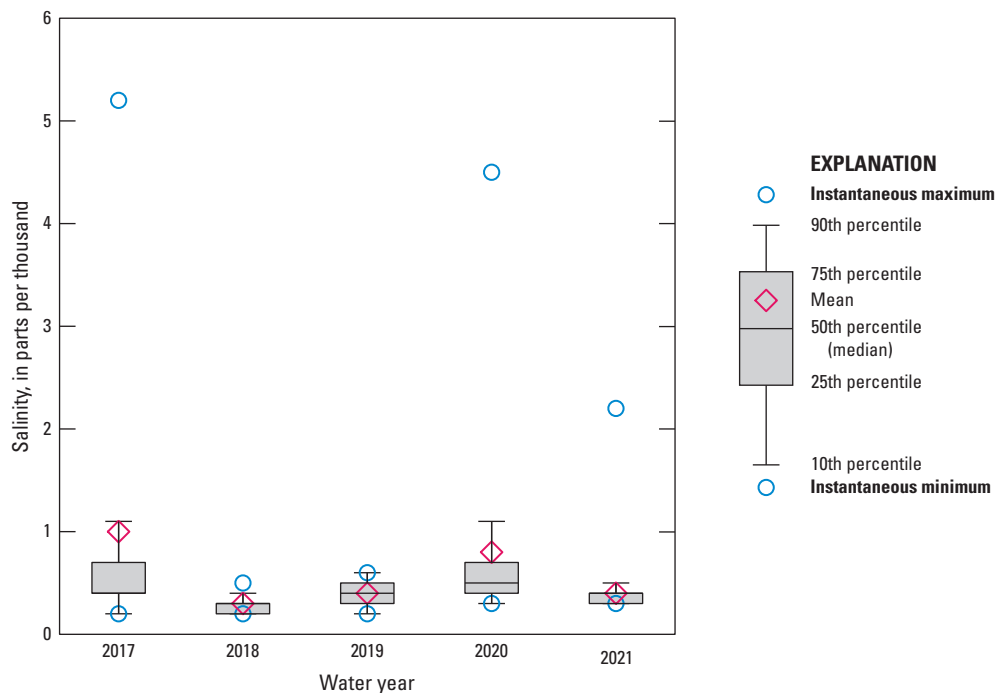


**Figure 19.** Salinity data for St. Johns River Shands Bridge near Green Cove Springs, Florida.

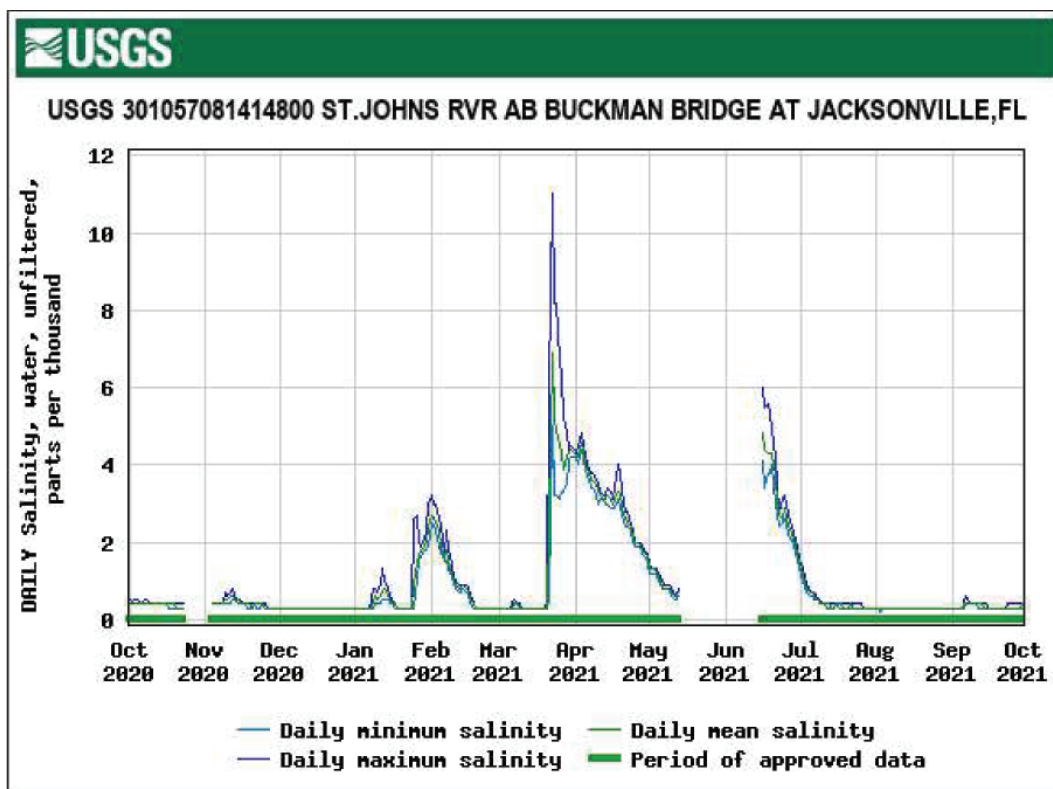


**Figure 20.** Daily maximum, minimum, and mean salinity for St. Johns River below Shands Bridge near Green Cove Springs, Florida.





**Figure 21.** Salinity data for St. Johns River below Shands Bridge near Green Cove Springs, Florida.



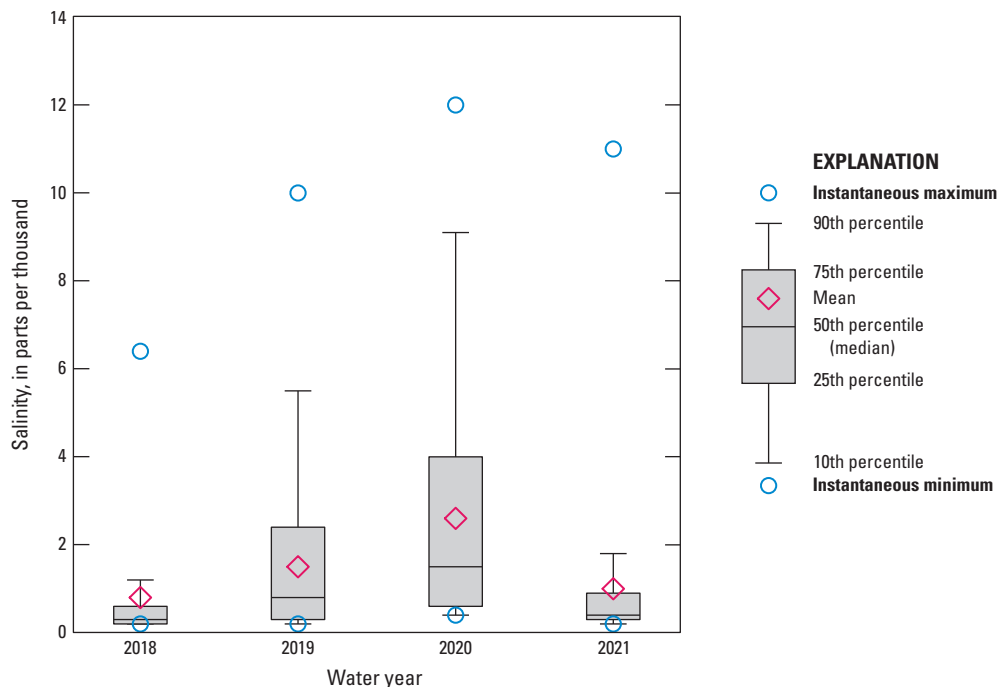
**Figure 22.** Daily maximum, minimum, and mean salinity for St. Johns River above Buckman Bridge at Jacksonville, Florida.

above 30 miles per hour (mi/h) from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station for multiple consecutive days (NOAA, 2022). The median and mean salinity for 2021 both ranked third among those computed for the 4 years of the study, although the 2018 record is incomplete because the monitoring station was installed that year (fig. 23).

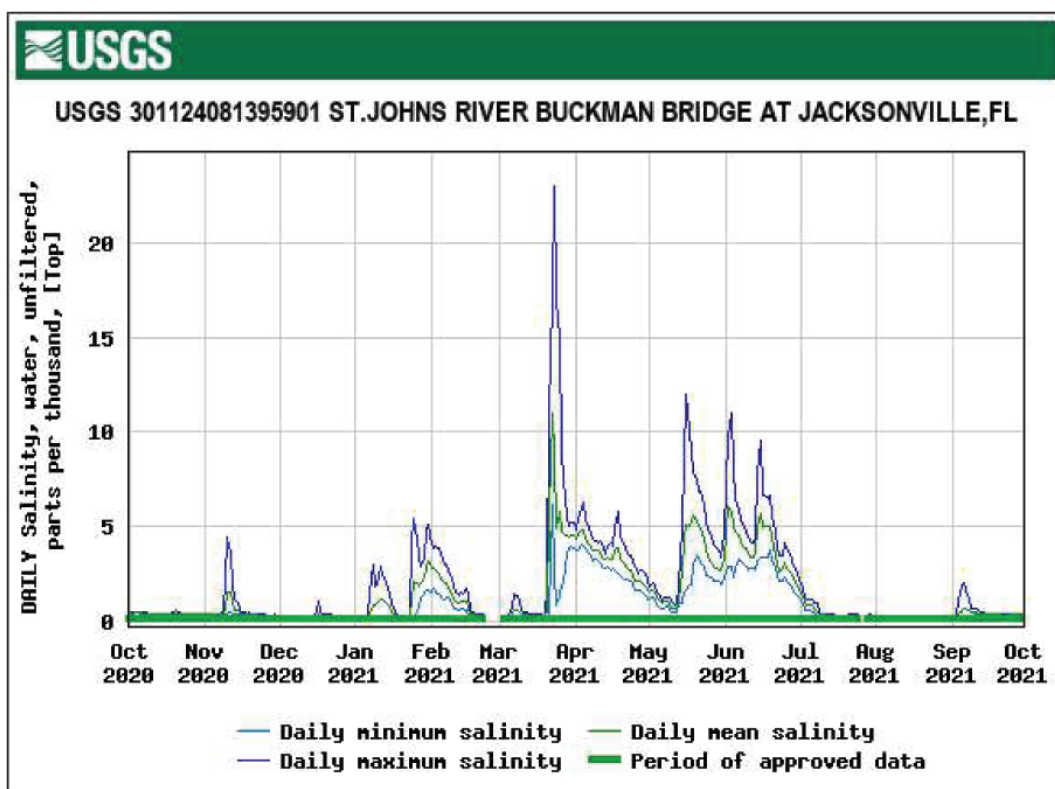
*St. Johns River Buckman Bridge at Jacksonville, Florida*—Salinity on the St. Johns River at Buckman Bridge ranged from 0.3 to 23 ppt for the top location during the 2021 water year, with a median of 0.4 ppt and mean of 1.4 ppt, and from 0.3 to 24 ppt for the bottom location, with a median of 0.4 ppt and mean of 1.8 ppt (figs. 24 and 25). The monitoring station did not record water-quality data at the top location for 8 days from February to March and 3 days in July, and at the bottom location for 34 days from October to November and 8 days from February to March because of equipment malfunction. Salinity during the year was generally lower at the top location relative to the bottom. Salinity at both locations peaked in late March when below-average rainfall occurred in Duval and Clay Counties (figs. 3 and 4), and sustained wind speeds above 30 mi/h from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station for multiple consecutive days (NOAA, 2022). The 2021 median and mean salinity at both the top and bottom locations ranked fourth among those computed for the 5 years of the study (figs. 26 and 27).

*St. Johns River at Christopher Point near Jacksonville, Florida*—Salinity at Christopher Point ranged from 0.2 to 25 ppt during the 2021 water year, with a median of 1.1 ppt and mean of 2.3 ppt (fig. 28). The monitoring station did not record water-quality data for 4 days in December, 2 days in February, 1 day in March, and 7 days in July. The annual maximum salinity occurred in late March when below-average rainfall occurred in Duval County (fig. 3), and sustained wind speeds above 30 mi/h from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station for multiple consecutive days (NOAA, 2022). The 2021 maximum salinity tied for first among those computed for the 6 years of the study, and the median and mean salinity both ranked fifth (fig. 29).

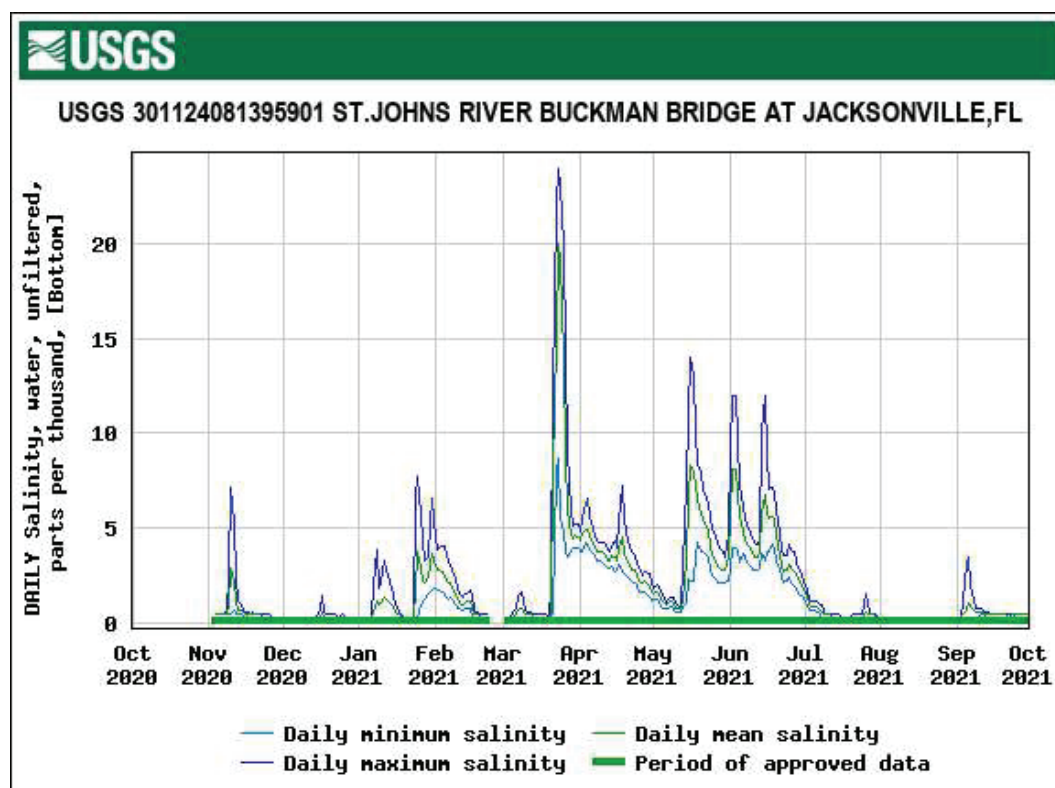
*St. Johns River below Marco Lake at Jacksonville, Florida*—Salinity at Marco Lake ranged from 0.2 to 27 ppt during the 2021 water year, with a median of 2.5 ppt and mean of 3.9 ppt (fig. 30). Salinity was not computed for 3 days in December, 5 days in January, and 6 days in June because of equipment malfunction. As at the Christopher Point site, the annual maximum salinity at this site occurred in late March when below-average rainfall occurred in Duval County (fig. 3), and sustained wind speeds above 30 mi/h from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station for multiple consecutive days (NOAA, 2022). The 2021 median and mean salinity ranked fifth among those computed for the 6 years of the study (fig. 31).



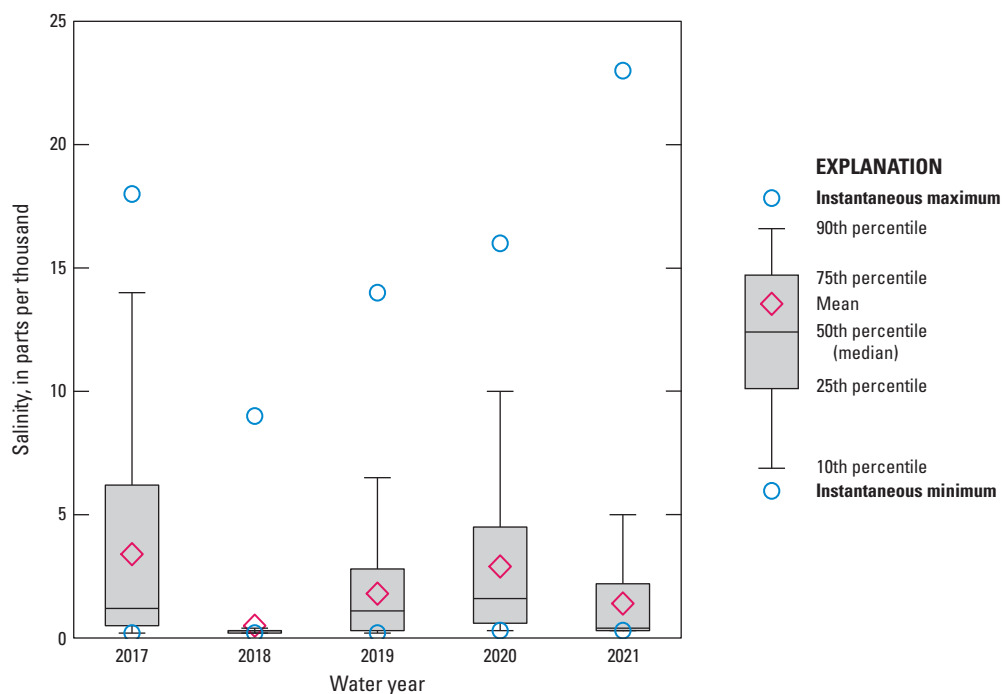
**Figure 23.** Salinity data for St. Johns River above Buckman Bridge at Jacksonville, Florida.



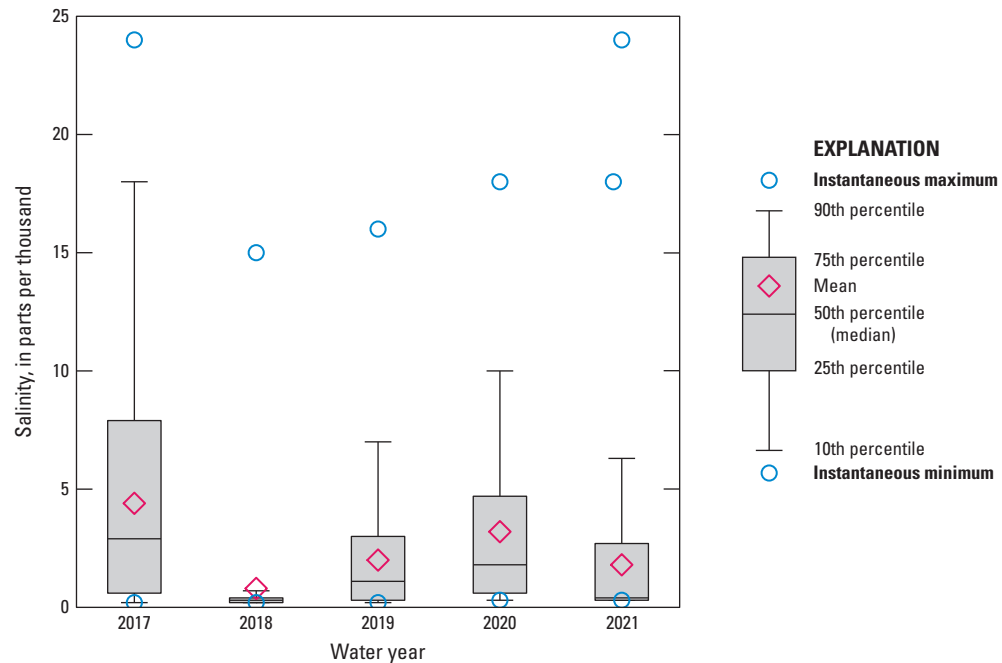
**Figure 24.** Daily maximum, minimum, and mean salinity for top location of St. Johns River Buckman Bridge at Jacksonville, Florida.



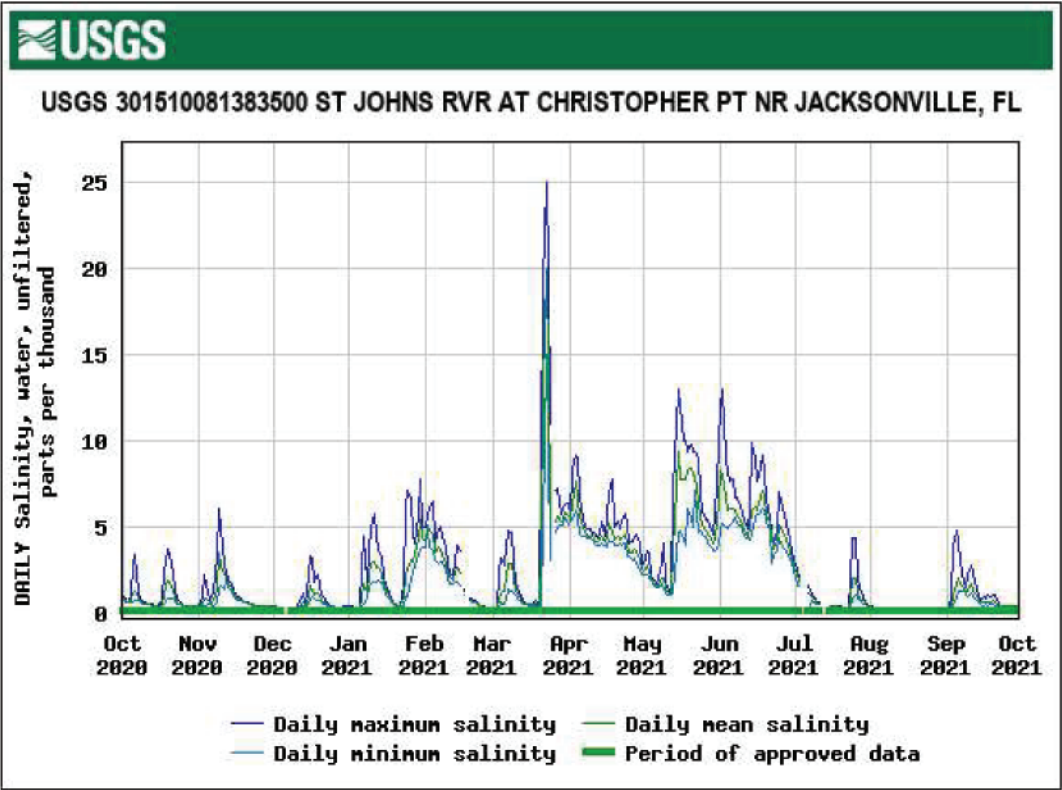
**Figure 25.** Daily maximum, minimum, and mean salinity for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida.



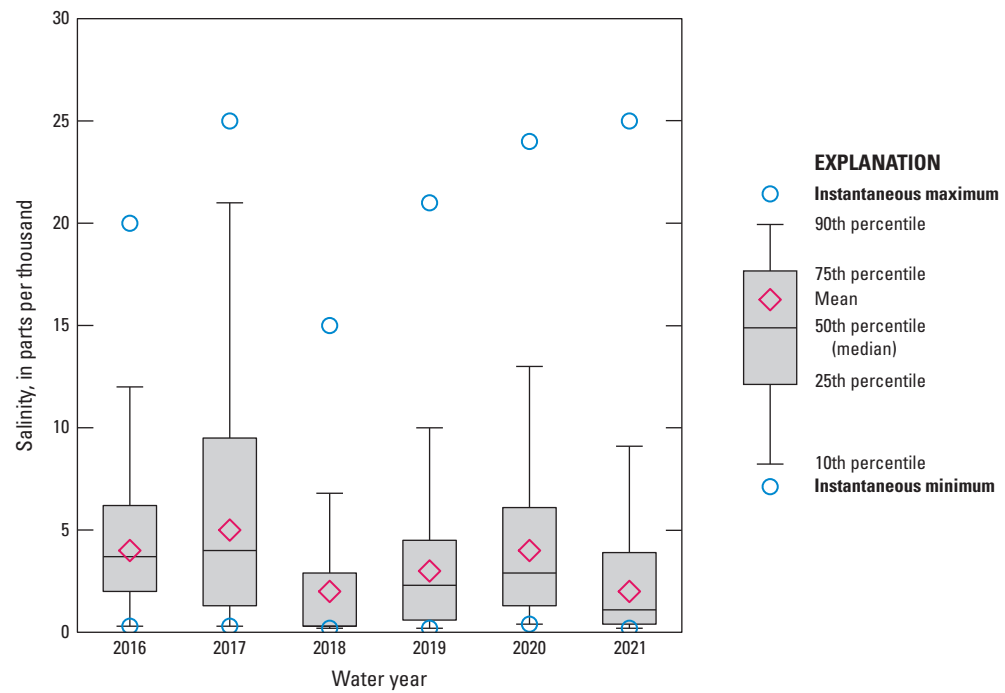
**Figure 26.** Salinity data for top location of St. Johns River Buckman Bridge at Jacksonville, Florida.



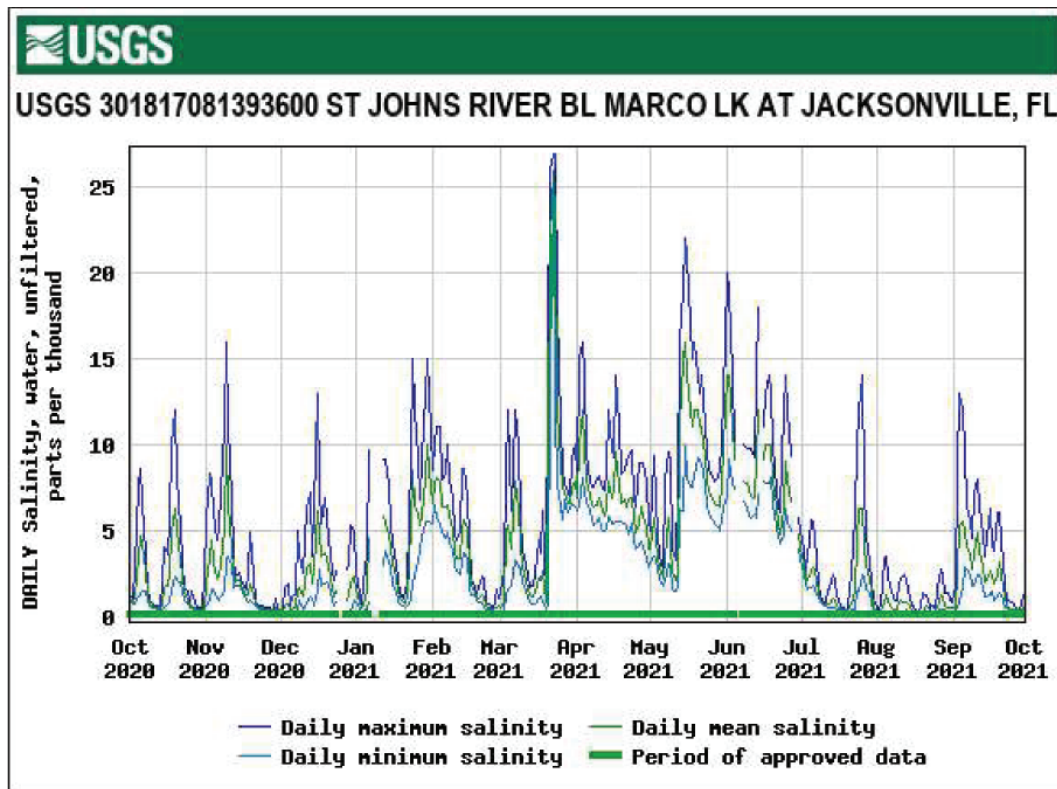
**Figure 27.** Salinity data for bottom location of St. Johns River Buckman Bridge at Jacksonville, Florida.



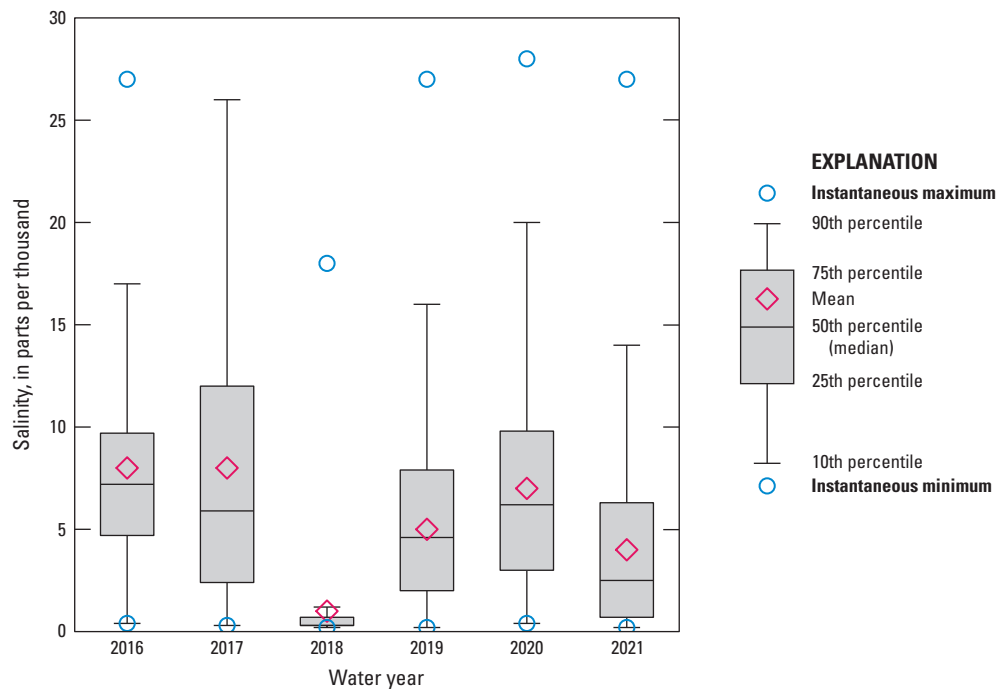
**Figure 28.** Daily maximum, minimum, and mean salinity for St. Johns River at Christopher Point near Jacksonville, Florida.



**Figure 29.** Salinity data for St. Johns River at Christopher Point near Jacksonville, Florida.



**Figure 30.** Daily maximum, minimum, and mean salinity for St. Johns River below Marco Lake at Jacksonville, Florida.



**Figure 31.** Salinity data for St. Johns River below Marco Lake at Jacksonville, Florida.



*St. Johns River at Jacksonville, Florida*—Daily tidally filtered discharge at the St. Johns River at Jacksonville site ranged from  $-55,200$  to  $38,700$  ft<sup>3</sup>/s during the 2021 water year, with an annual mean of  $8,590$  ft<sup>3</sup>/s (fig. 32). Salinity ranged from  $0.2$  to  $28$  ppt over this same period, with a median of  $3.9$  ppt and mean of  $5.1$  ppt (fig. 33). Salinity was not computed for 8 days in June and 3 days in July, and tidally filtered discharge was not computed for 10 days in June because of equipment malfunction. A comparison of historical annual mean tidally filtered flows indicated that the 2021 streamflow was at the 74th percentile of the 25 years of record; the median tidally filtered flow for the period of record is  $5,830$  ft<sup>3</sup>/s (fig. 34). Annual mean tidally filtered streamflow record was used from 1997 onward because of data collection gaps in the historical data prior to 1997. Salinity exceeded  $25$  ppt and the lowest tidally filtered discharge was computed in late March when below-average rainfall occurred in Duval County (fig. 3), and sustained wind speeds above  $30$  mi/h from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station for multiple consecutive days (NOAA, 2022). The 2021 mean and median salinity ranked 5th among those computed for the 6 years of the study (fig. 35).

*St. Johns River Dames Point Bridge at Jacksonville, Florida*—Salinity on the St. Johns River at Dames Point Bridge ranged from  $2.9$  to  $34$  ppt for the top location during the 2021 water year, with a median and mean of  $20$  ppt, and from  $2.9$  to  $34$  ppt for the bottom location, with a median of  $22$  ppt and mean of  $21$  ppt (figs. 36 and 37). Salinity was not calculated for 2 days in January at both locations, 6 days

in December and 12 days in September at the top location, and for 8 days in August at the bottom location because of equipment malfunction. Salinity during the year was generally lower at the top location relative to the bottom and fluctuated weekly at both locations because of upstream conditions. The 2021 mean and median salinity at both locations ranked fourth among those calculated for the 5 years of the study (figs. 38 and 39).

## Tributary Sites

The parameters collected on the tributaries of the St. Johns River are mainly affected by rainfall and, at most sites, by tidal fluctuations. Heavy rainfall typically increases discharge and decreases salinity, and the tidal influence introduces more daily fluctuation at tidal sites than at nontidal sites. Like the main stem, tributaries of the St. Johns River are also affected by strong easterly winds. Because of their distance from the ocean, tributary sites and main-stem sites farther upstream require prolonged or extremely strong winds, such as those from a hurricane, to experience increased salinity.

*Julington Creek at Old St. Augustine Road near Bayard, Florida*—Daily tidally filtered discharge at Julington Creek ranged from  $-24.3$  to  $227$  ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of  $42.0$  ft<sup>3</sup>/s (fig. 40). The highest discharge peak in 2021 occurred in February as a result of above-average rainfall in Duval County (fig. 3).

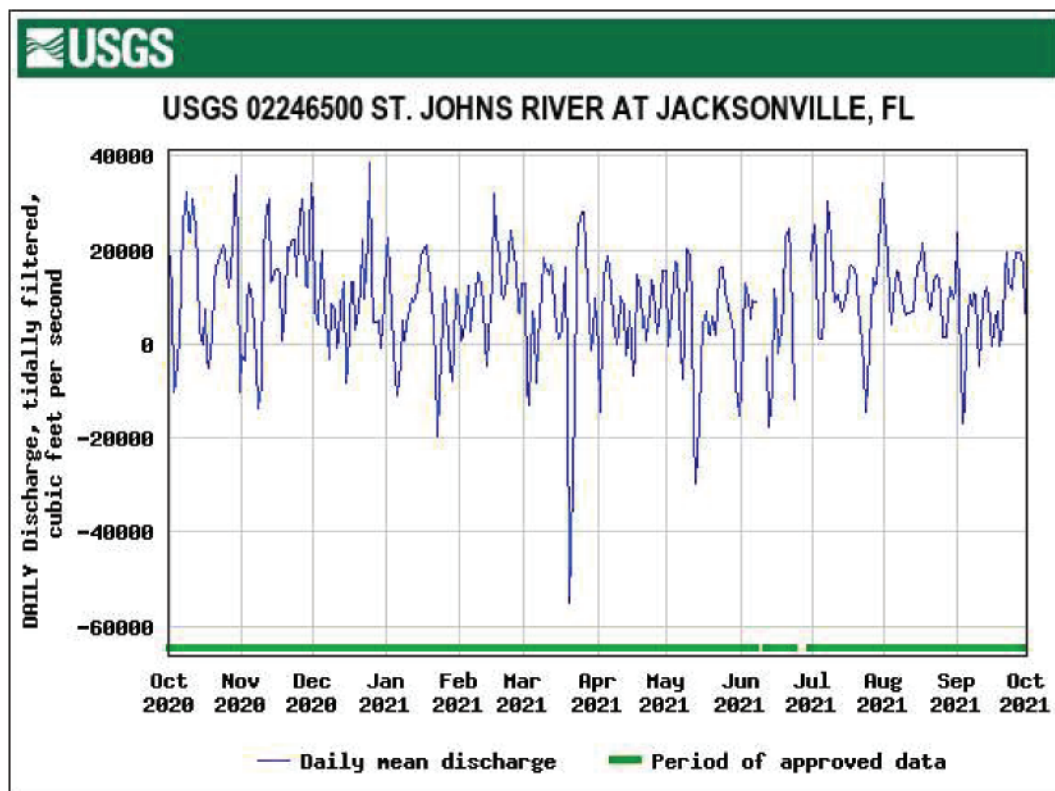
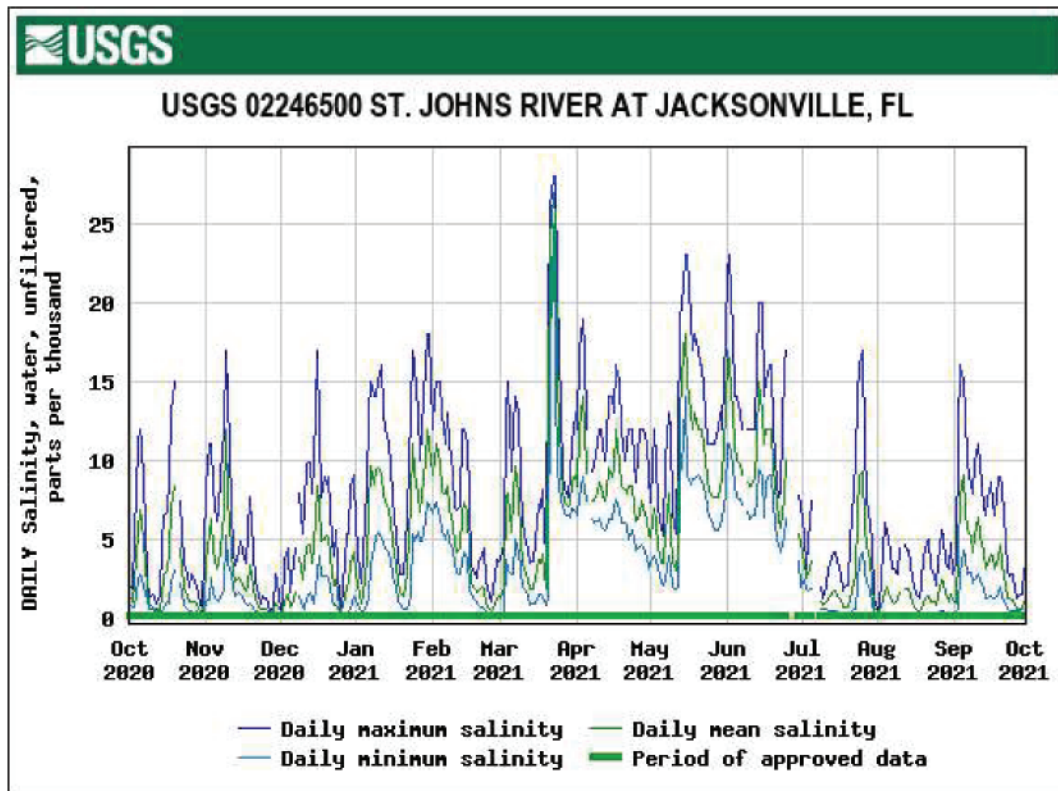
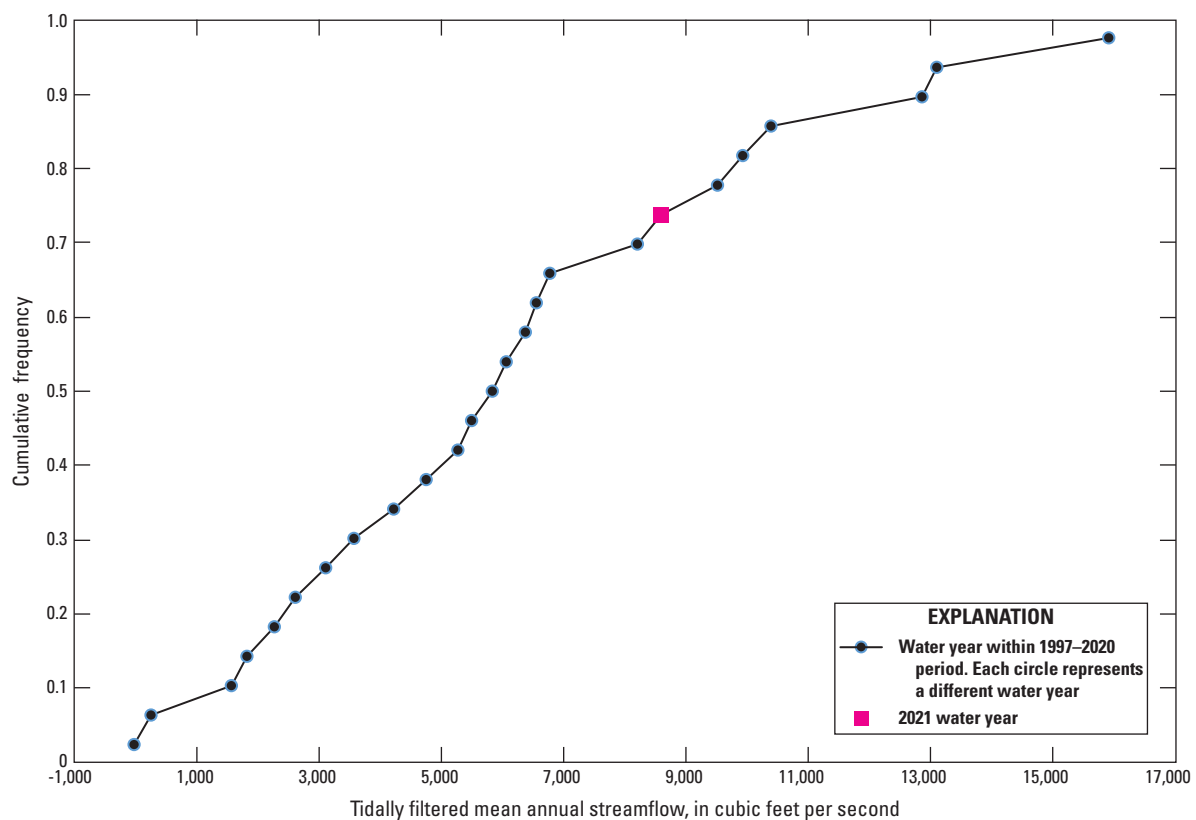


Figure 32. Daily mean tidally filtered discharge for St. Johns River at Jacksonville, Florida.



**Figure 33.** Daily maximum, minimum, and mean salinity for St. Johns River at Jacksonville, Florida.



**Figure 34.** Annual mean tidally filtered streamflow data for St. Johns River at Jacksonville, Florida.



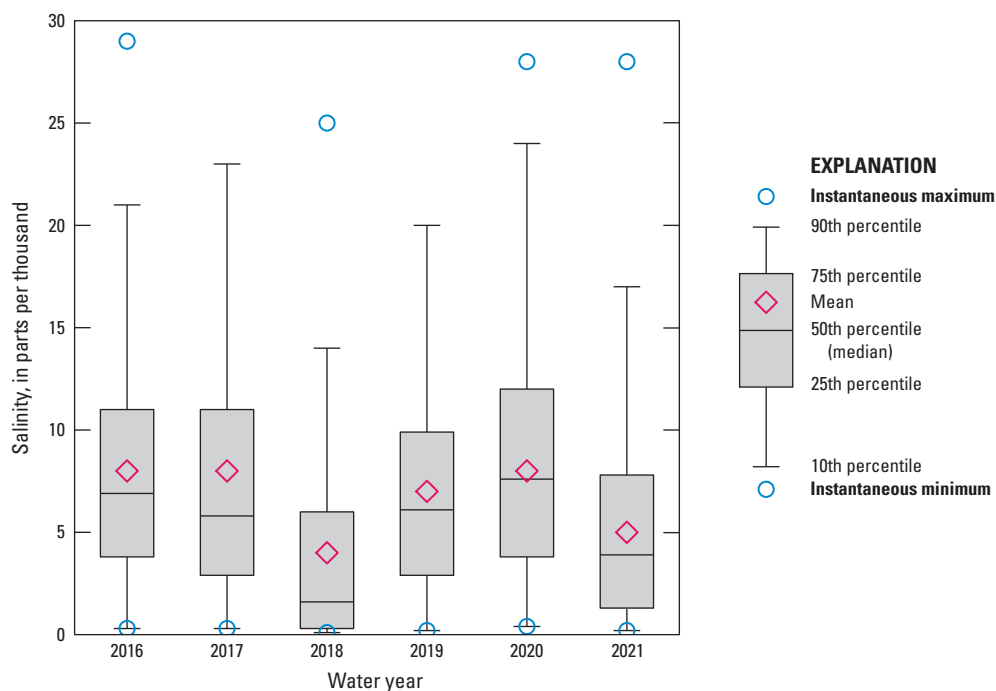


Figure 35. Salinity data for St. Johns River at Jacksonville, Florida.

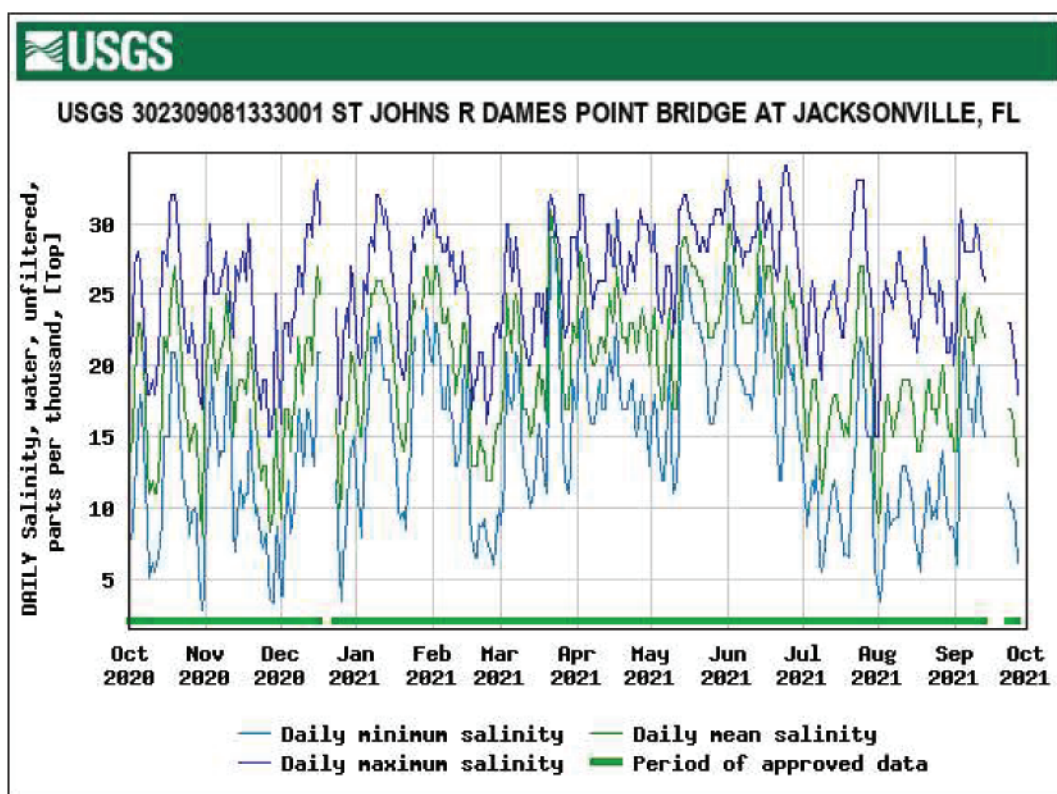
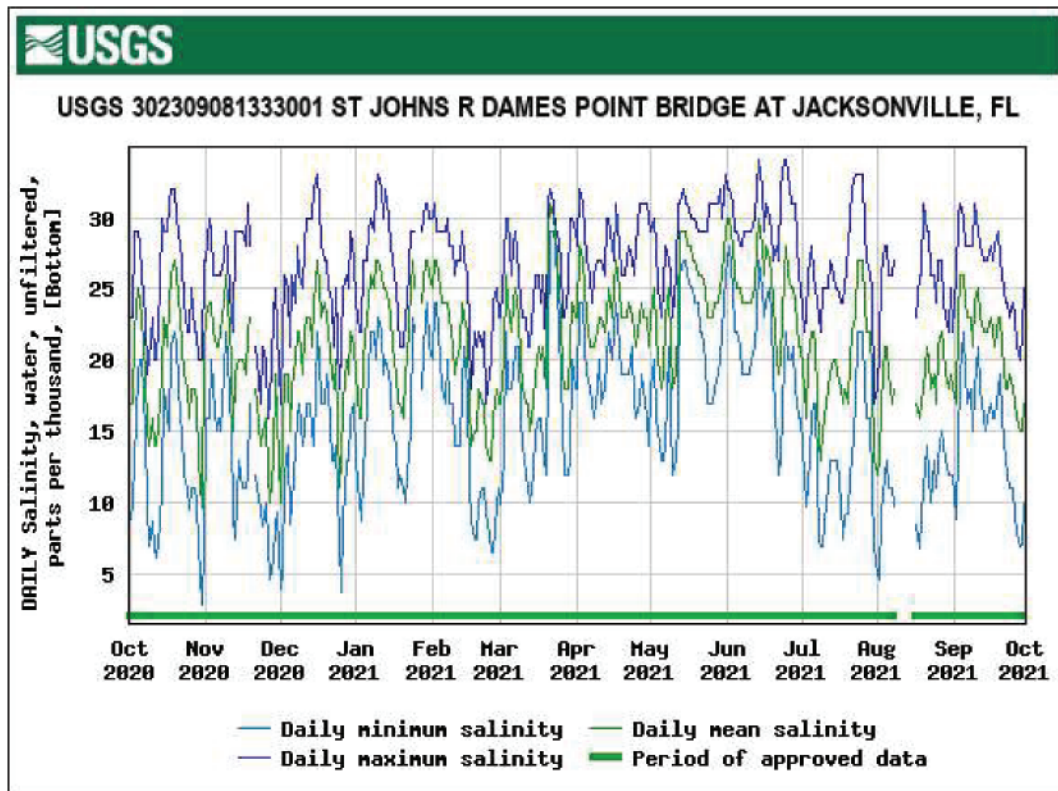
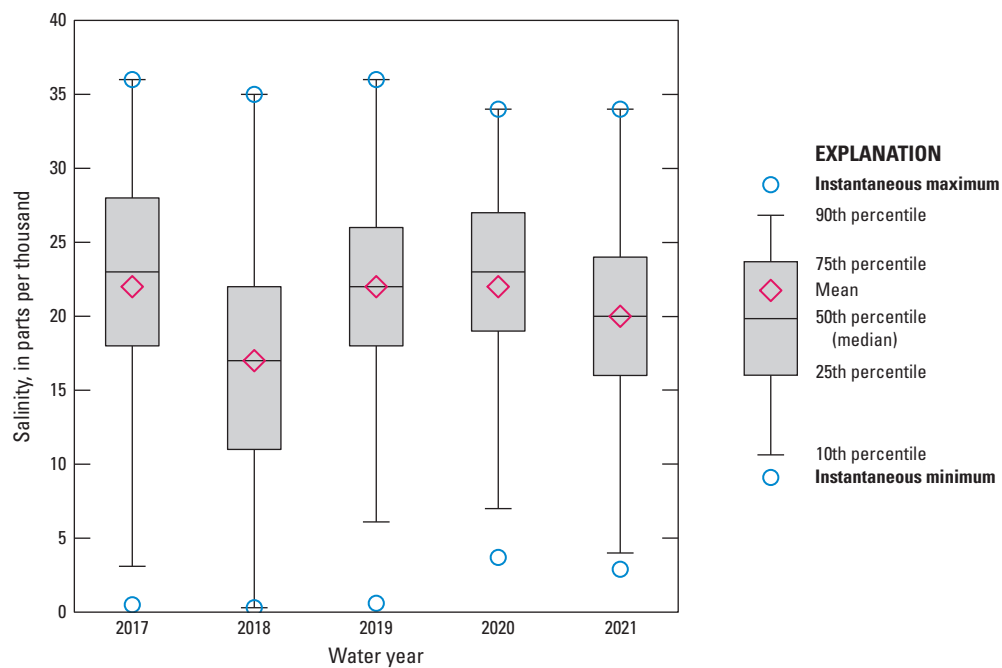


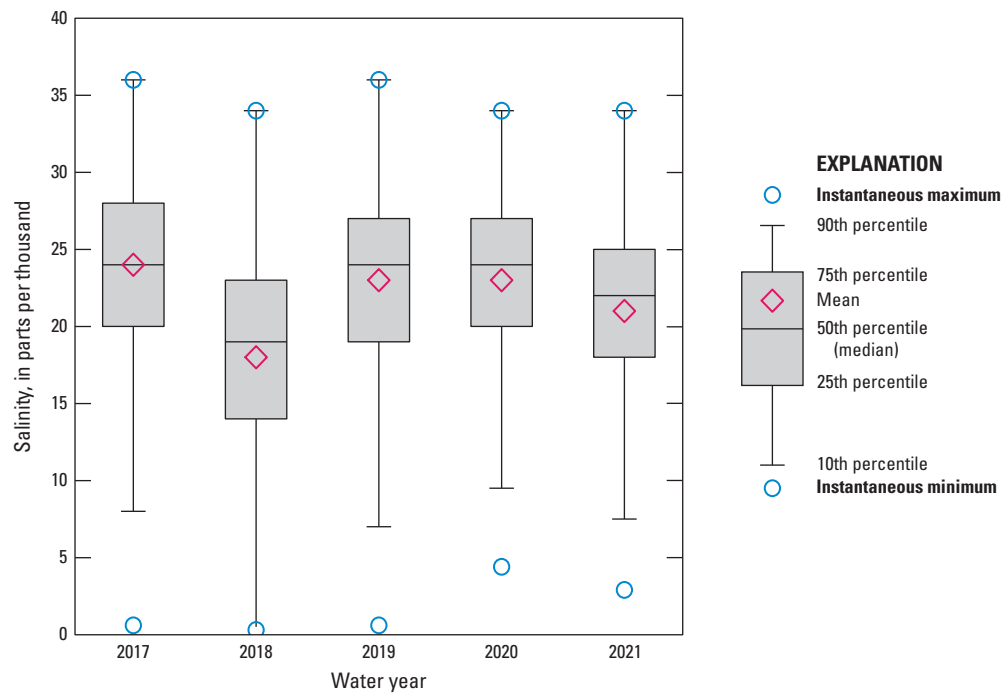
Figure 36. Daily maximum, minimum, and mean salinity for top location of St. Johns River Dames Point Bridge at Jacksonville, Florida.



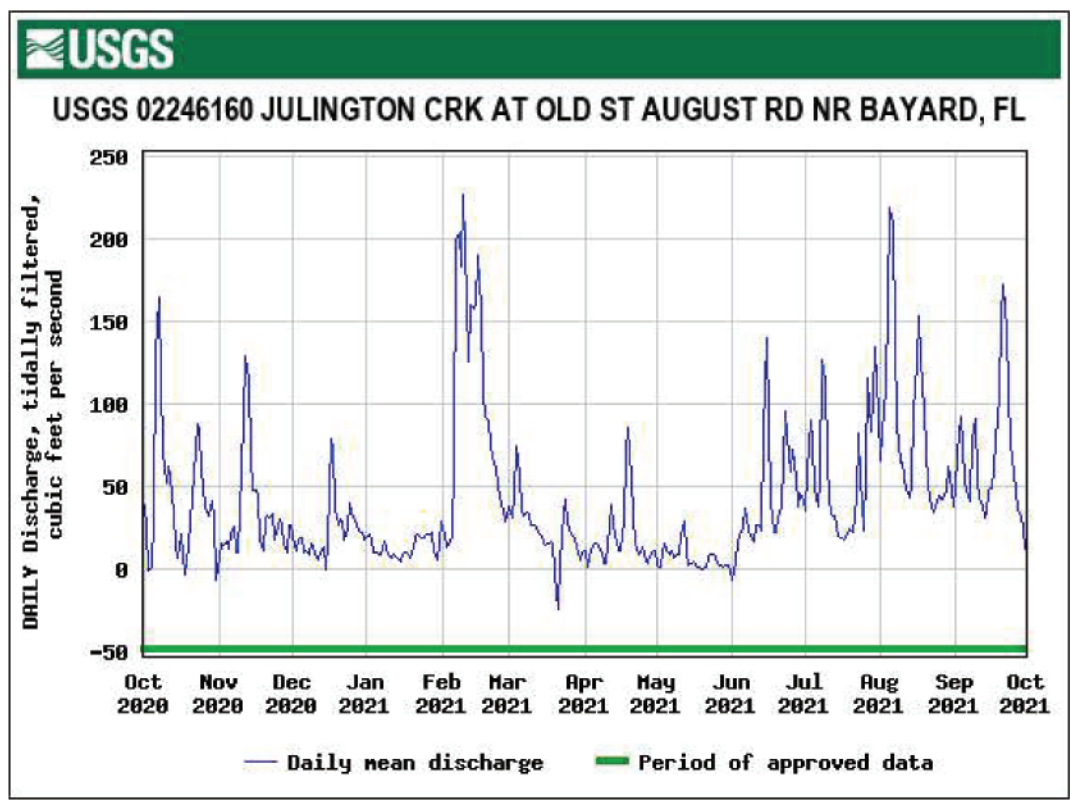
**Figure 37.** Daily maximum, minimum, and mean salinity for bottom location of St. Johns River Dames Point Bridge at Jacksonville, Florida.



**Figure 38.** Salinity data for top location of St. Johns River at Dames Point Bridge at Jacksonville, Florida.



**Figure 39.** Salinity data for bottom location of St. Johns River at Dames Point Bridge at Jacksonville, Florida.



**Figure 40.** Daily mean tidally filtered discharge for Julington Creek at Old St. Augustine Road near Bayard, Florida.

*Julington Creek at Hood Landing near Bayard, Florida*—Salinity at Julington Creek at Hood Landing ranged from 0.1 to 1.6 ppt during the 2021 water year, with a median of 0.1 ppt and mean of 0.2 ppt (fig. 41). The salinity peaked in early April during low flows (fig. 40) after below-average rainfall in March in Duval County (fig. 3). The 2021 median salinity tied for lowest among those computed for the 6 years of the study, and the mean tied for fourth (fig. 42).

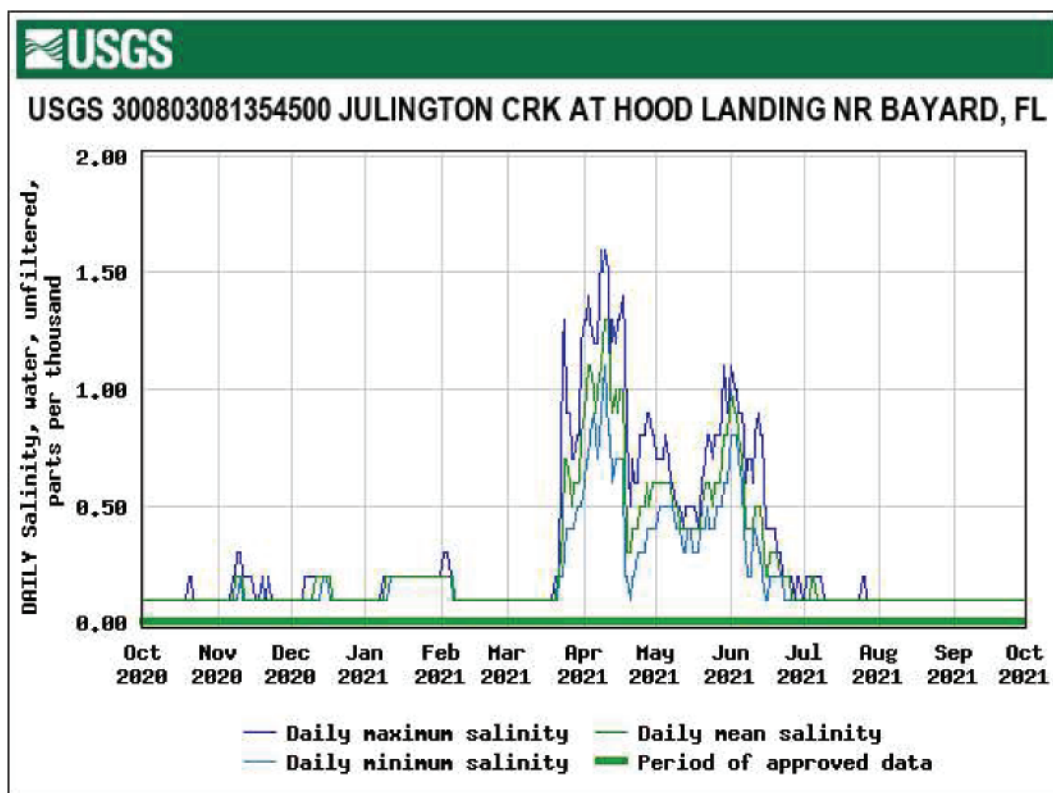
*Durbin Creek near Fruit Cove, Florida*—Daily tidally filtered discharge at Durbin Creek ranged from  $-32.4$  to  $839$  ft<sup>3</sup>/s during the 2021 water year, with an annual mean of  $84.5$  ft<sup>3</sup>/s (fig. 43). The highest discharge peak in 2021 was also the second-highest peak on record and occurred in February as a result of above-average rainfall in St. Johns County (fig. 5). Discharge was not computed for 7 days in July because of equipment malfunction. Salinity ranged from 0.0 to 0.2 ppt, with a median and mean of 0.1 ppt (fig. 44). The boxplot for Durbin Creek salinity data in 2021 shows the same mean and median for all 6 years of the study; the maximum salinity ranked fifth among those computed for the 6 years of the study (fig. 45). The boxplot includes no whiskers because of the low and steady salinities of freshwater flows through the creek.

*Ortega River at Kirwin Road near Jacksonville, Florida*—Daily discharge for Ortega River ranged from  $4.50$  to  $679$  ft<sup>3</sup>/s during the 2021 water year, with an annual mean

of  $66.5$  ft<sup>3</sup>/s (fig. 46). The largest discharge peak at Ortega River occurred in July when above-average rainfall occurred in Duval County (fig. 3). The peak streamflow for the period of record ranked in the 32d percentile of the 14 years of record (fig. 47). The peak streamflow record does not include 2016, which has an incomplete record because the monitoring station was installed that year.

*Ortega River salinity at Jacksonville, Florida*—Salinity at Ortega River ranged from 0.0 to 15 ppt during the 2021 water year, with a median of 0.1 ppt and mean of 0.3 ppt (fig. 48). Salinity was not calculated for 5 days in June and 38 days from July to September because of equipment malfunction. Peak maximum daily salinity values were calculated in late March when below-average rainfall occurred in Duval County (fig. 3), and the St. Johns River at Jacksonville station computed negative tidally filtered discharge (fig. 32). The 2021 maximum salinity ranked the highest among those calculated for the 6 years of the study, and the mean salinity ranked fifth (fig. 49).

*Cedar River at San Juan Avenue at Jacksonville, Florida*—Daily tidally filtered discharge at Cedar River ranged from  $-73.8$  to  $345$  ft<sup>3</sup>/s during the 2021 water year, with an annual mean of  $19.8$  ft<sup>3</sup>/s (fig. 50). Salinity ranged from 0.0 to 14 ppt, with a median of 0.2 ppt and mean of 1.0 ppt (fig. 51). Salinity was not calculated for 7 days in



**Figure 41.** Daily maximum, minimum, and mean salinity for Julington Creek at Hood Landing near Bayard, Florida.

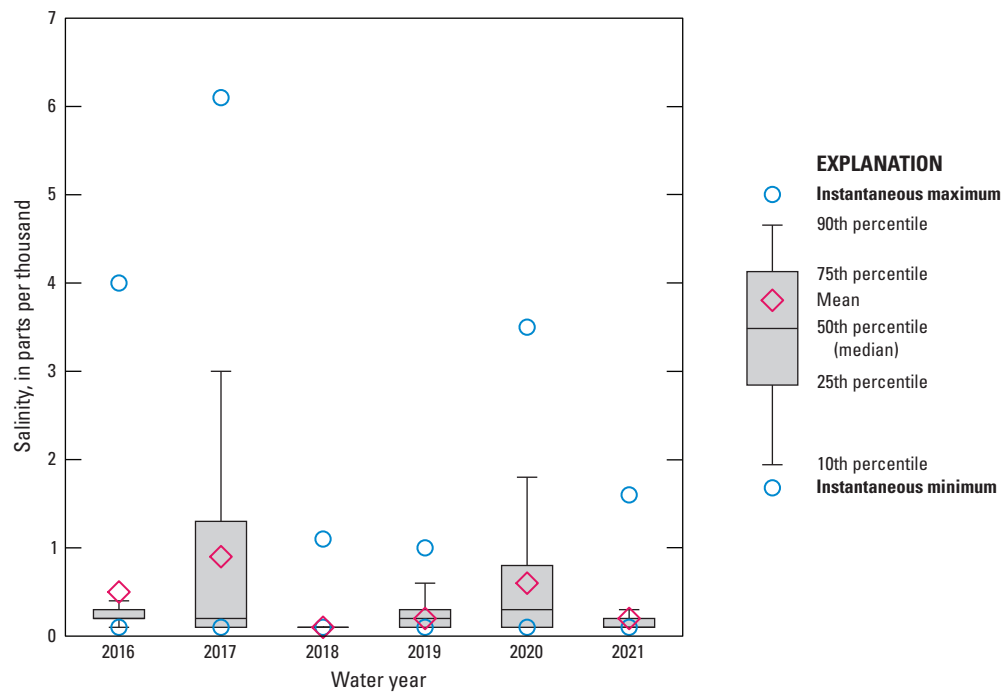


Figure 42. Salinity data for Julington Creek at Hood Landing near Bayard, Florida.

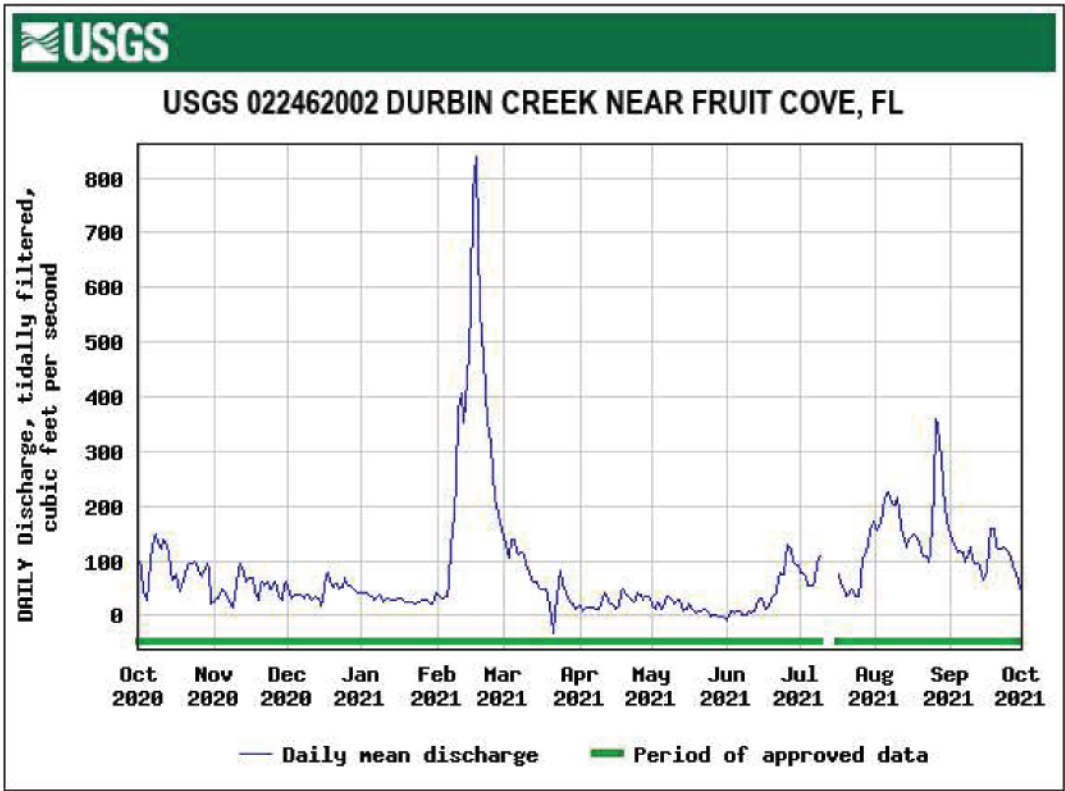
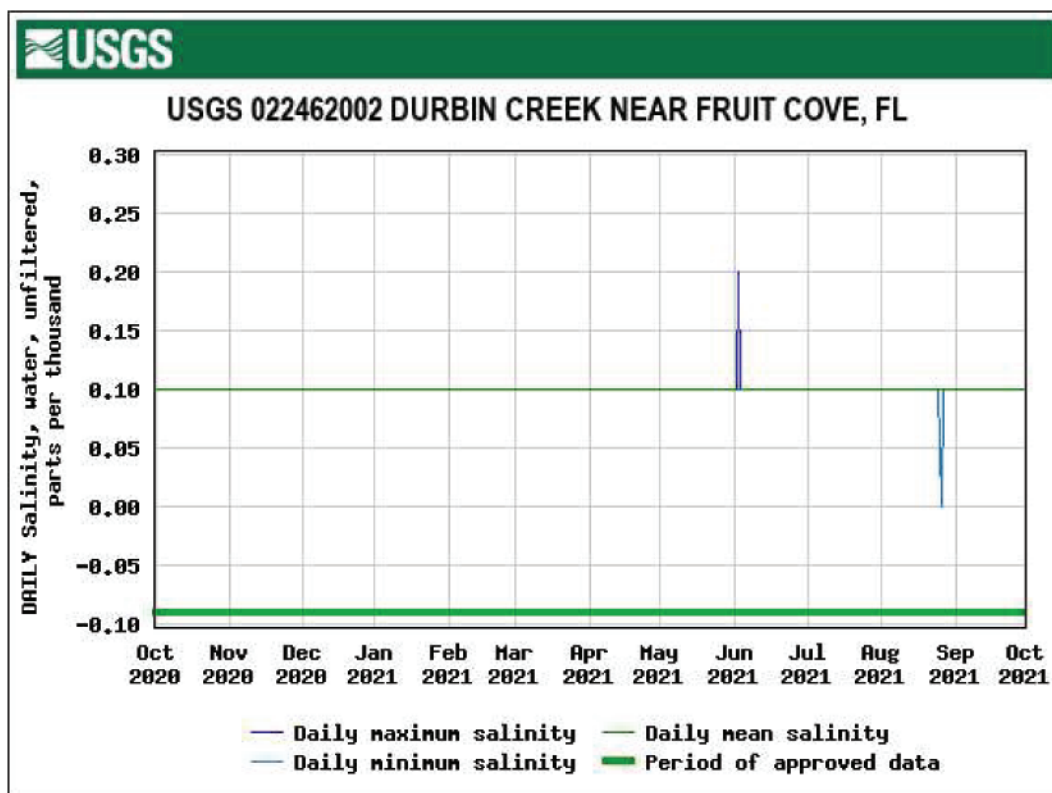
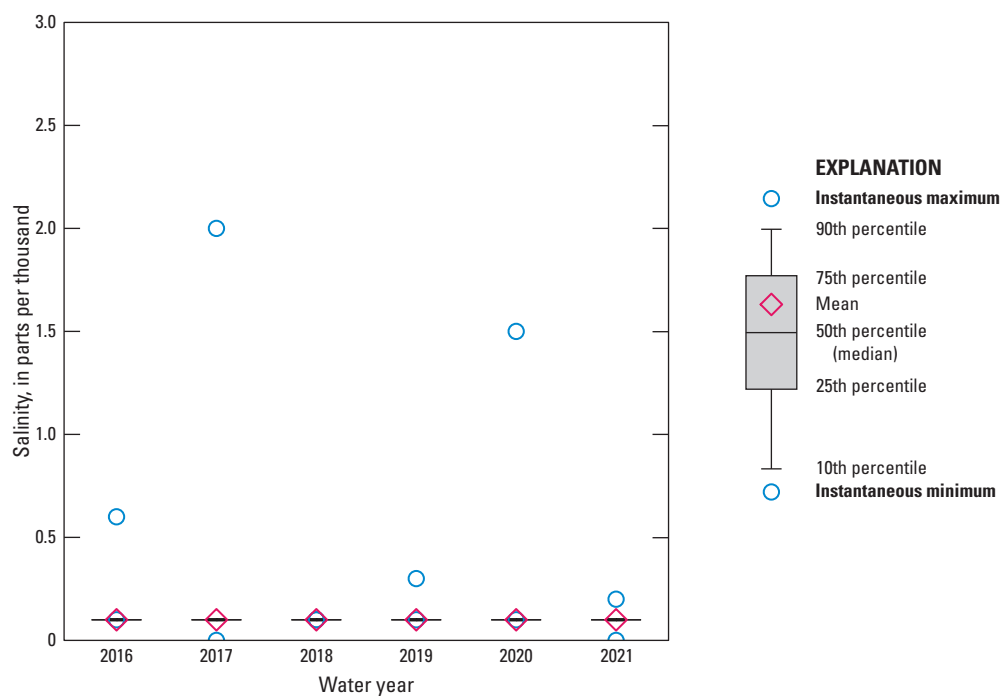


Figure 43. Daily mean tidally filtered discharge for Durbin Creek near Fruit Cove, Florida.



**Figure 44.** Daily maximum, minimum, and mean salinity for Durbin Creek near Fruit Cove, Florida.



**Figure 45.** Salinity data for Durbin Creek near Fruit Cove, Florida.



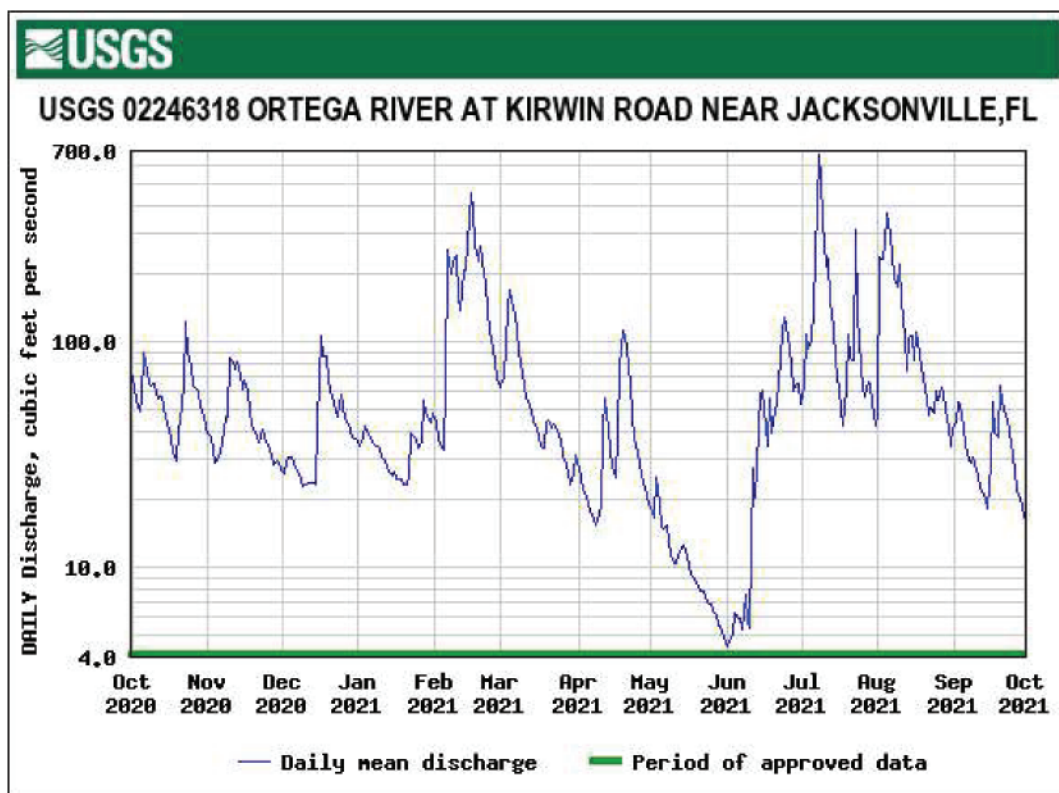


Figure 46. Daily mean discharge for Ortega River at Kirwin Road near Jacksonville, Florida.

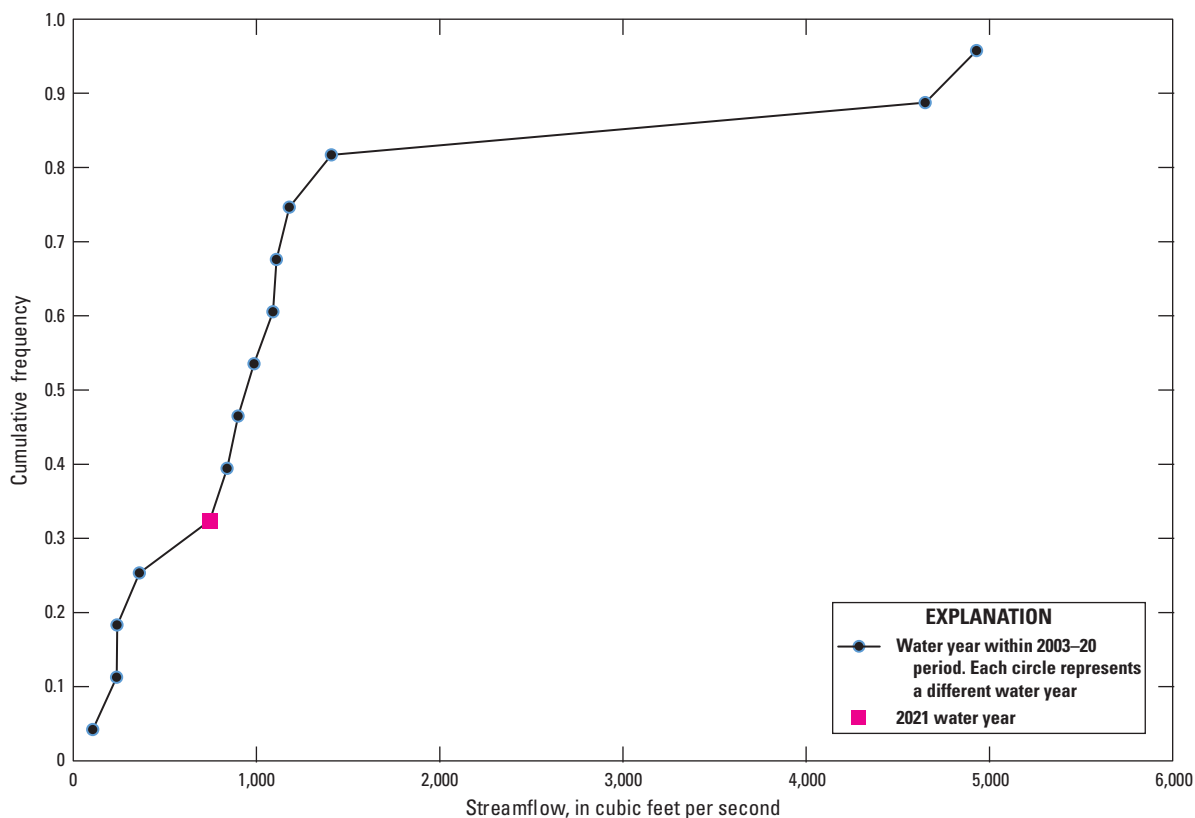
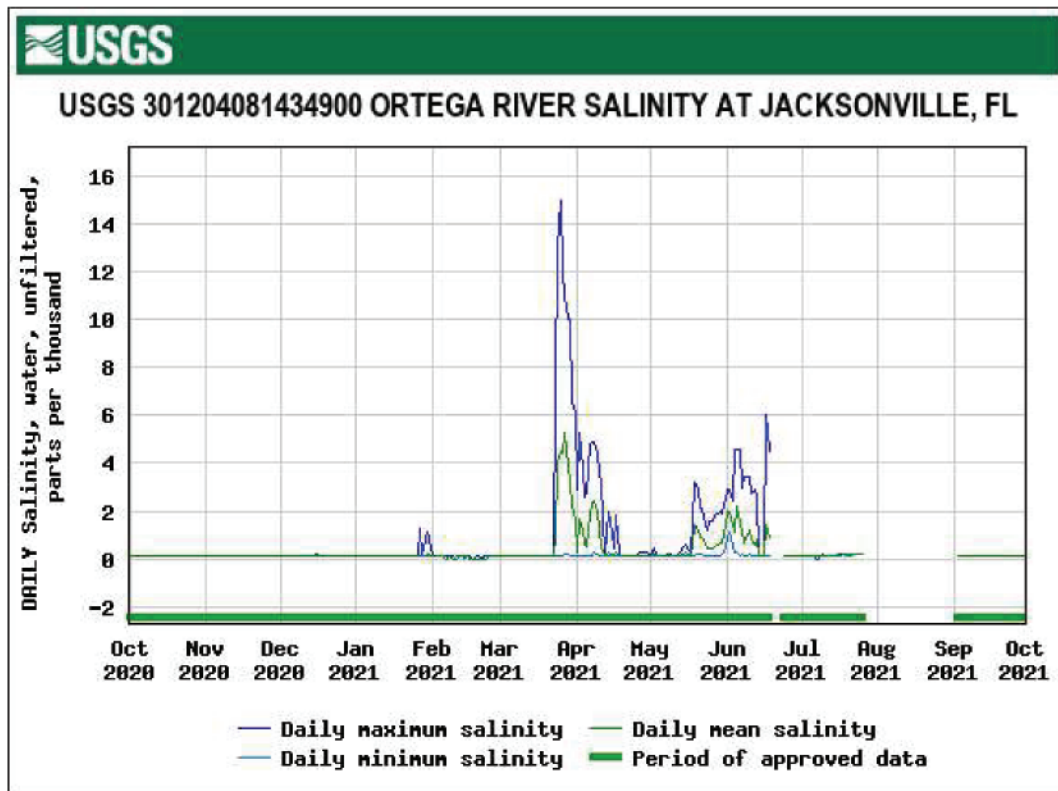
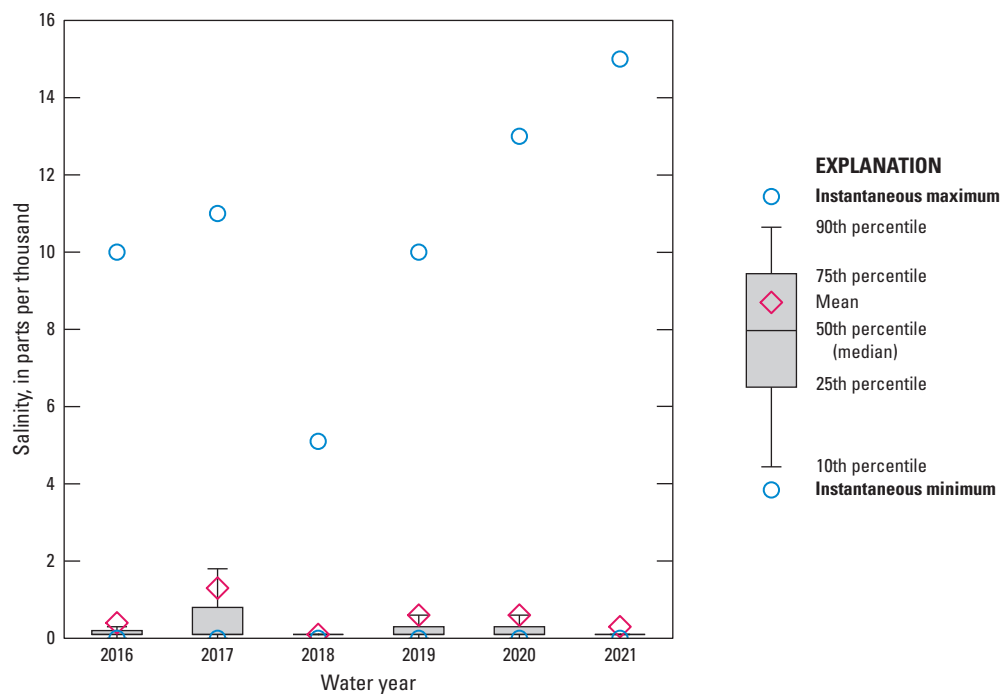


Figure 47. Peak streamflow at Ortega River at Kirwin Road near Jacksonville, Florida.

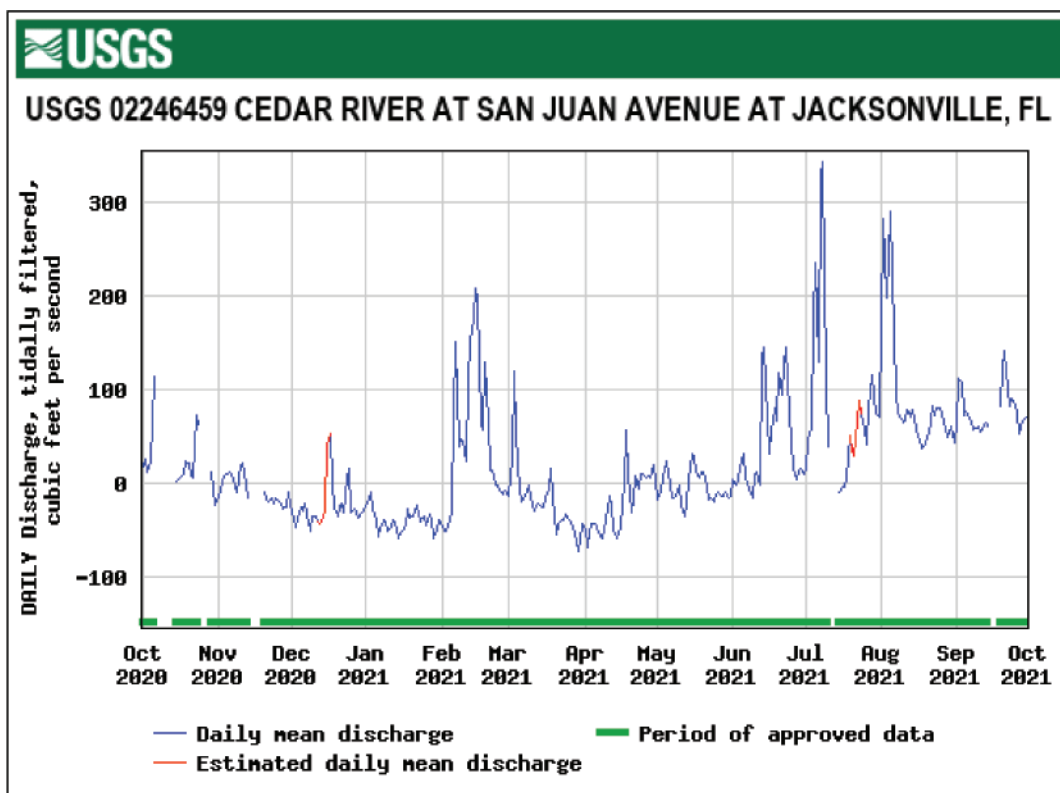


**Figure 48.** Daily maximum, minimum, and mean salinity for Ortega River salinity at Jacksonville, Florida.

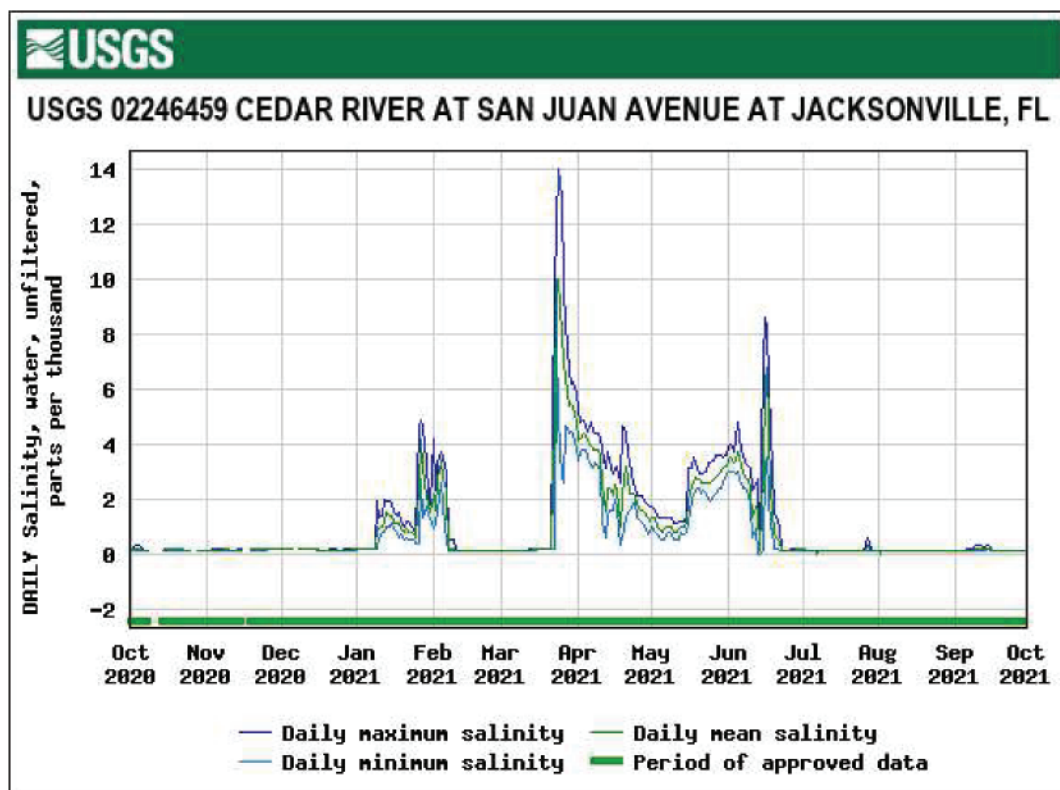


**Figure 49.** Data for Ortega River salinity at Jacksonville, Florida.





**Figure 50.** Daily mean tidally filtered discharge for Cedar River at San Juan Avenue at Jacksonville, Florida.



**Figure 51.** Daily maximum, minimum, and mean salinity for Cedar River at San Juan Avenue at Jacksonville, Florida.

October and 3 days in November, and daily tidally filtered discharge was not calculated for 12 days in October, 6 days in November, 4 days in July, 4 days in September, and was estimated for 4 days in both December and July because of equipment malfunction. As at Ortega River, the peak discharge at Cedar River occurred during a sharp rise in July when above-average rainfall occurred in Duval County (fig. 3). The 2021 mean and median salinity ranked fifth among those computed for the 6 years of the study (fig. 52).

*Pottsborg Creek near South Jacksonville, Florida*—Daily discharge for Pottsborg Creek at Bowden Road ranged from 2.44 to 388 ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of 30.1 ft<sup>3</sup>/s (fig. 53). Discharge was estimated for 2 days in July because of vandalism to the equipment. Daily mean discharge peaked above 200 ft<sup>3</sup>/s in February and July, both of which had above-average rainfall in Duval County (fig. 3). The peak streamflow for the period of record ranked in the 41st percentile of the 11 years of record (fig. 54).

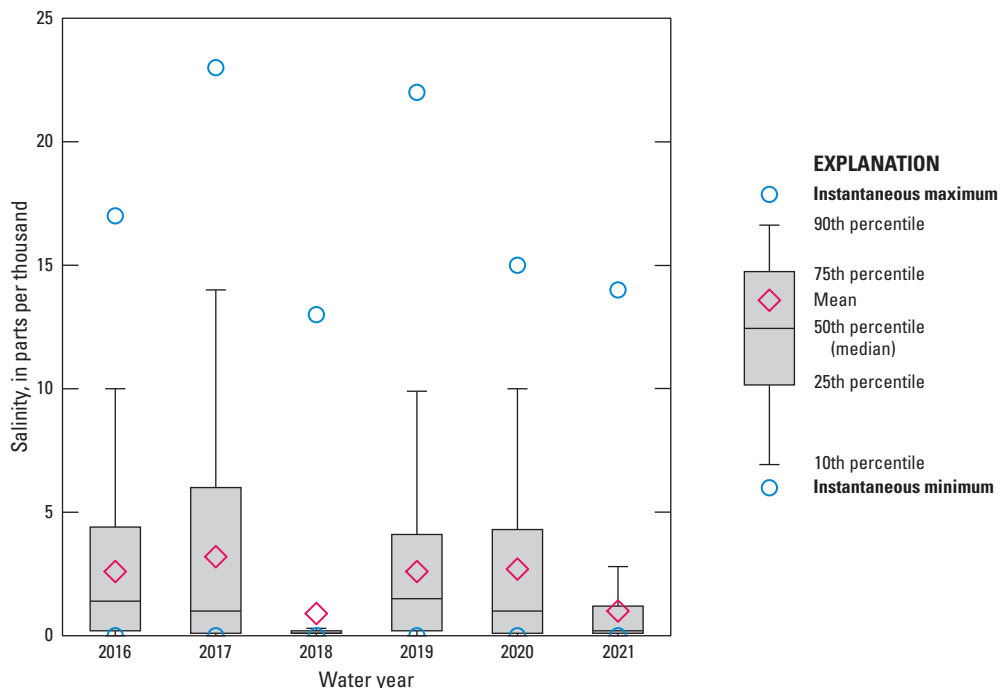
*Pottsborg Creek at U.S. 90 near South Jacksonville, Florida*—Daily tidally filtered discharge at Pottsborg Creek at U.S. 90 ranged from 4.26 to 394 ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of 50.6 ft<sup>3</sup>/s (fig. 55). Daily tidally filtered discharge was not calculated for 4 days in January and 9 days in July because of equipment malfunction. The daily discharge peaked one time over 300 ft<sup>3</sup>/s in early February when above-average rainfall occurred in Duval County (fig. 3). Salinity ranged from 0.1 to 17 ppt, with a median of 0.2 ppt and mean of 0.8 ppt (fig. 56). Peak salinity occurred in late March during periods of below-average rainfall in Duval County (fig. 3) and reverse flow in the St. Johns River at Jacksonville (fig. 32). The 2021 median salinity tied

with 2018 for last; the mean ranked fifth, but the maximum salinity was the highest among those computed for the 6 years of the study (fig. 57).

*Trout River near Jacksonville, Florida*—Daily tidally filtered discharge at Trout River ranged from -219 to 1,070 ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of 83.3 ft<sup>3</sup>/s (fig. 58). Daily tidally filtered discharge was not calculated for 5 days in April because of equipment malfunction. The daily discharge exceeded 600 ft<sup>3</sup>/s in February, July, and August, and the peak that occurred in July ranked fourth among those computed for the 6 years of the study.

*Trout River below U.S. 1 at Dinsmore, Florida*—Salinity at Trout River below U.S. 1 ranged from 0.0 to 9.9 ppt during the 2021 water year, with a median of 0.1 ppt and mean of 1.0 ppt (fig. 59). Daily maximum salinity values peaked above 8 ppt from May to June (fig. 59). The 2021 mean salinity ranked fifth among those calculated for the 6 years of the study, and the median tied with 2018 for fifth (fig. 60).

*Broward River below Biscayne Blvd. near Jacksonville, Florida*—Daily tidally filtered discharge at Broward River ranged from -32.3 to 365 ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of 16.7 ft<sup>3</sup>/s (fig. 61). Daily tidally filtered discharge was not calculated for 9 days from October to November because of equipment malfunction. Discharge was relatively consistent during the period, with four peaks of daily tidally filtered discharge exceeding 200 ft<sup>3</sup>/s. Salinity ranged from 0.0 to 10 ppt, with a median of 0.3 ppt and mean of 0.8 ppt (fig. 62). Salinity remained below 8 ppt most of the year, but it was exceeded in March, May, and June (fig. 62). The 2021 median, mean, and maximum salinity ranked fifth among those calculated for the 6 years of the study (fig. 63).



**Figure 52.** Salinity data for Cedar River at San Juan Avenue at Jacksonville, Florida.

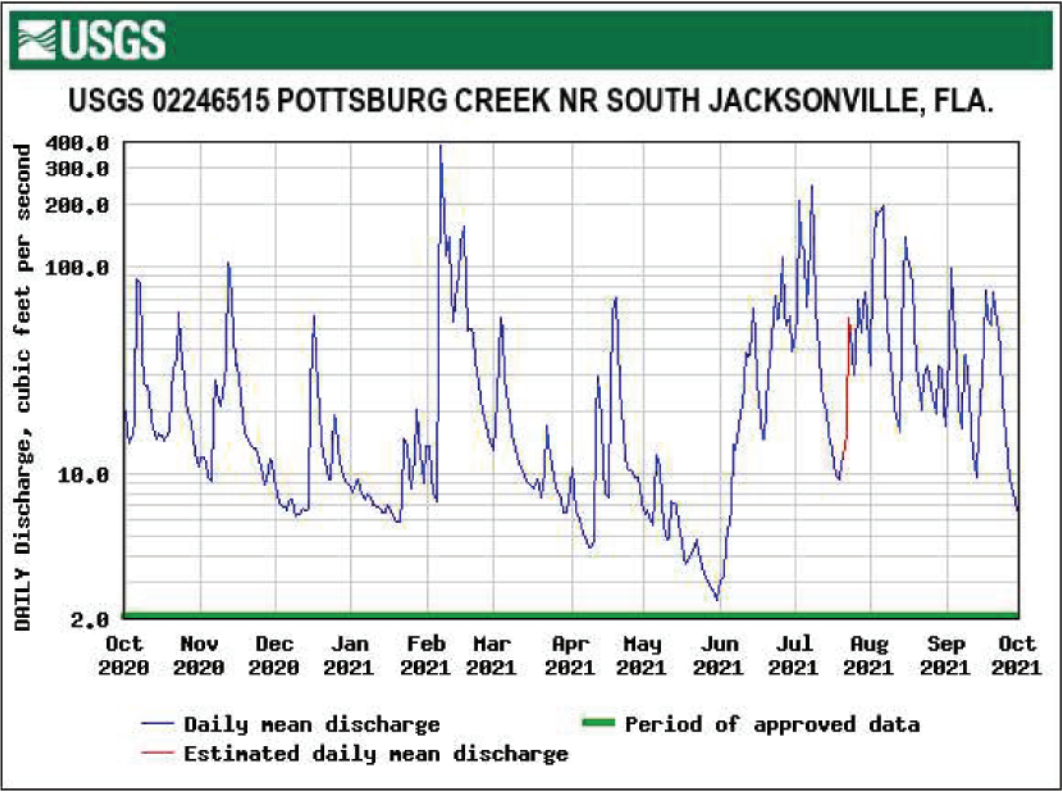


Figure 53. Daily mean discharge for Pottsburg Creek near South Jacksonville, Florida.

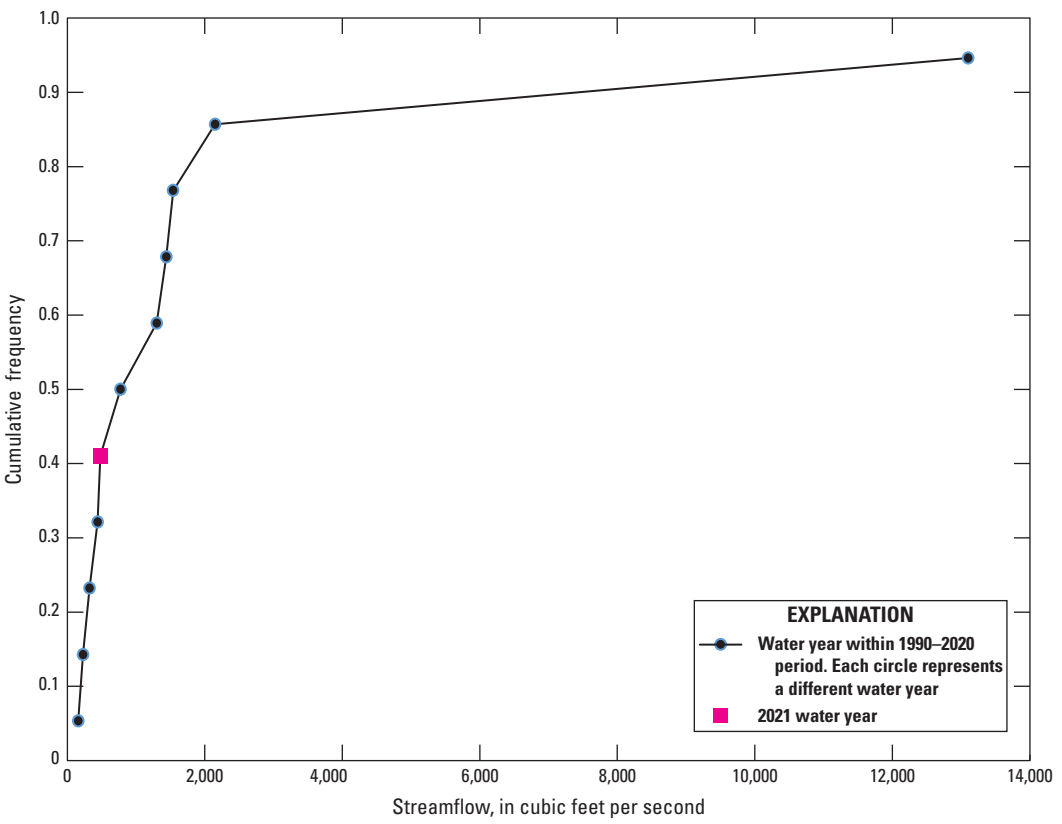
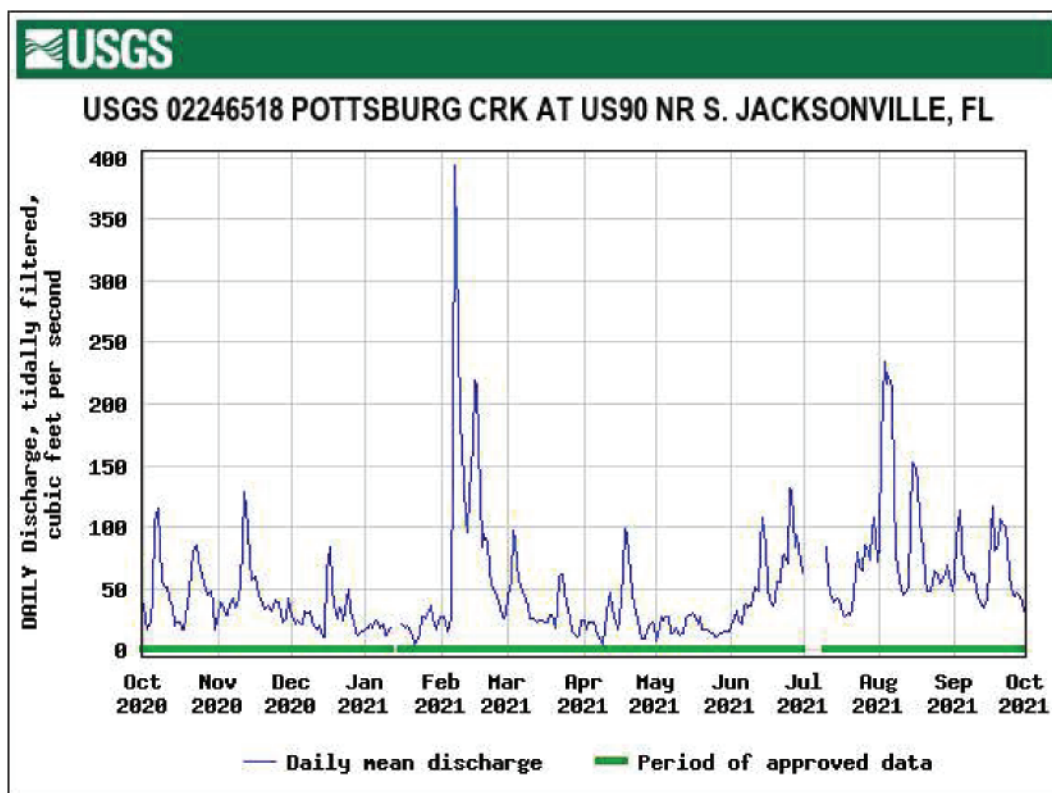
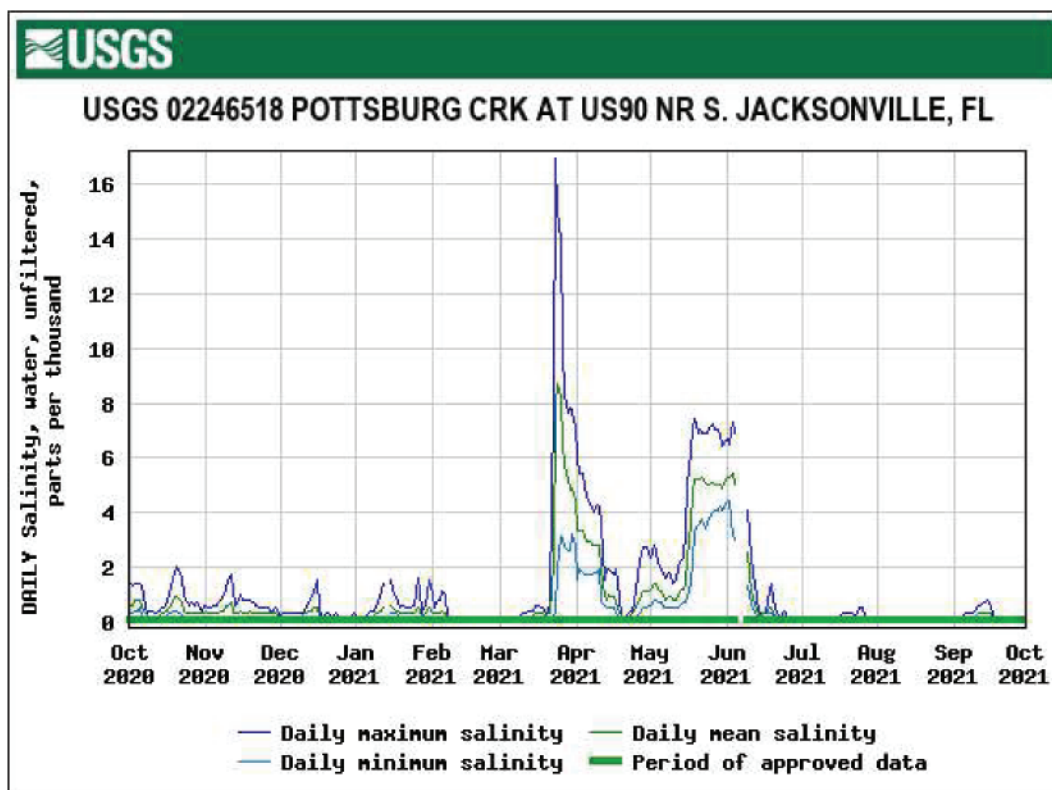


Figure 54. Peak streamflow at Pottsburg Creek near South Jacksonville, Florida.



**Figure 55.** Daily mean tidally filtered discharge for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.



**Figure 56.** Daily maximum, minimum, and mean salinity for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

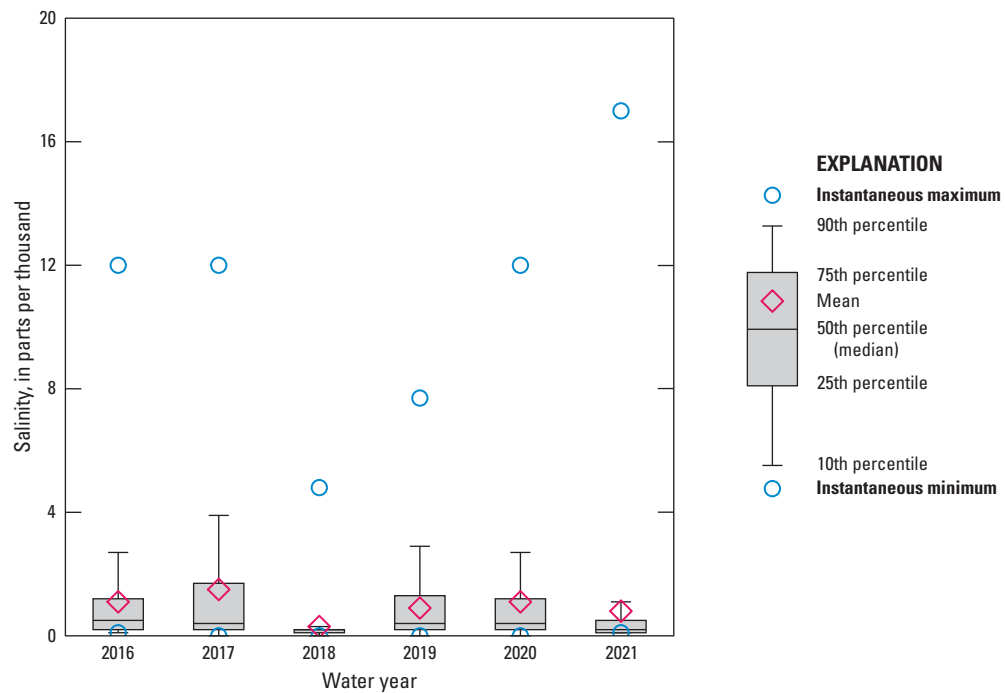


Figure 57. Salinity data for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

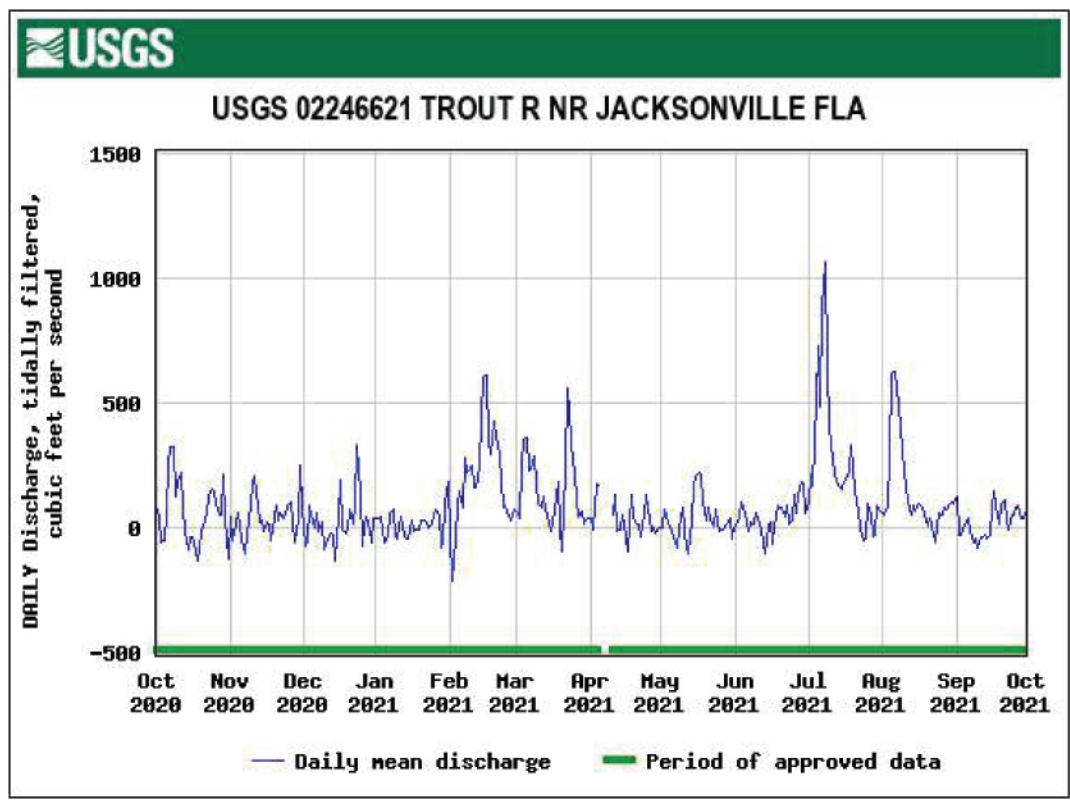


Figure 58. Daily mean tidally filtered discharge for Trout River near Jacksonville, Florida.

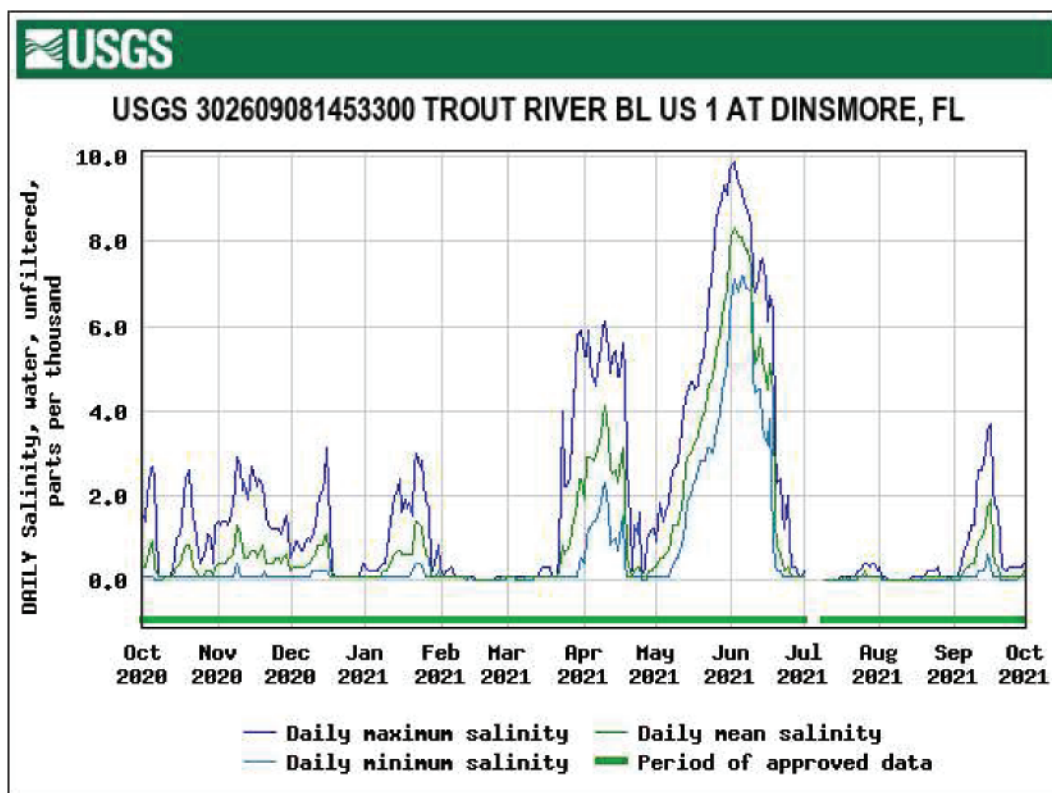


Figure 59. Maximum, minimum, and mean daily salinity for Trout River below U.S. 1 at Dinsmore, Florida.

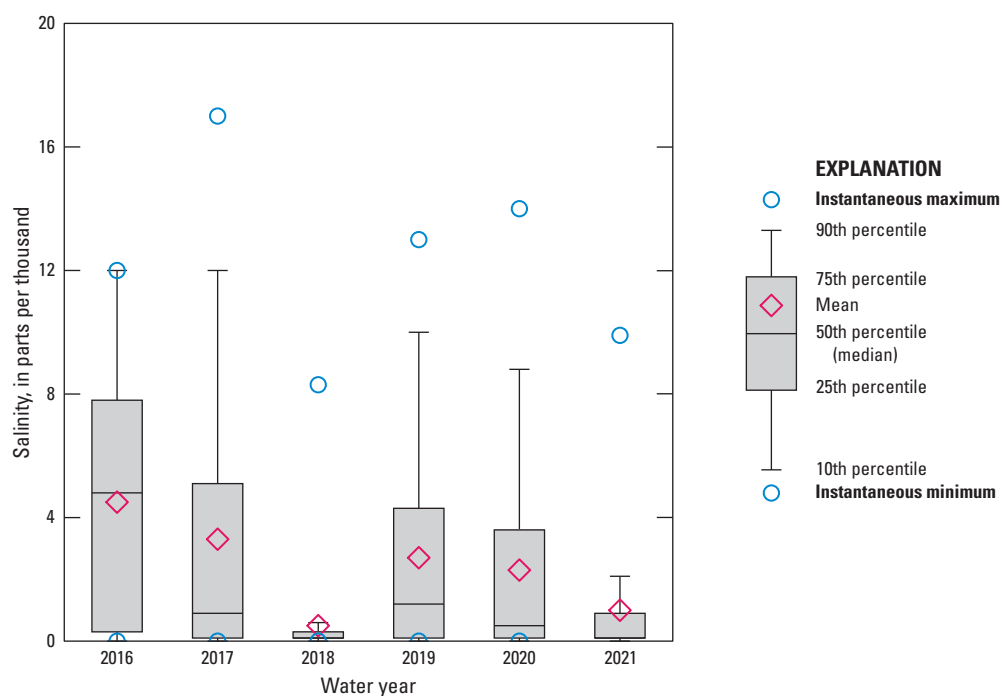
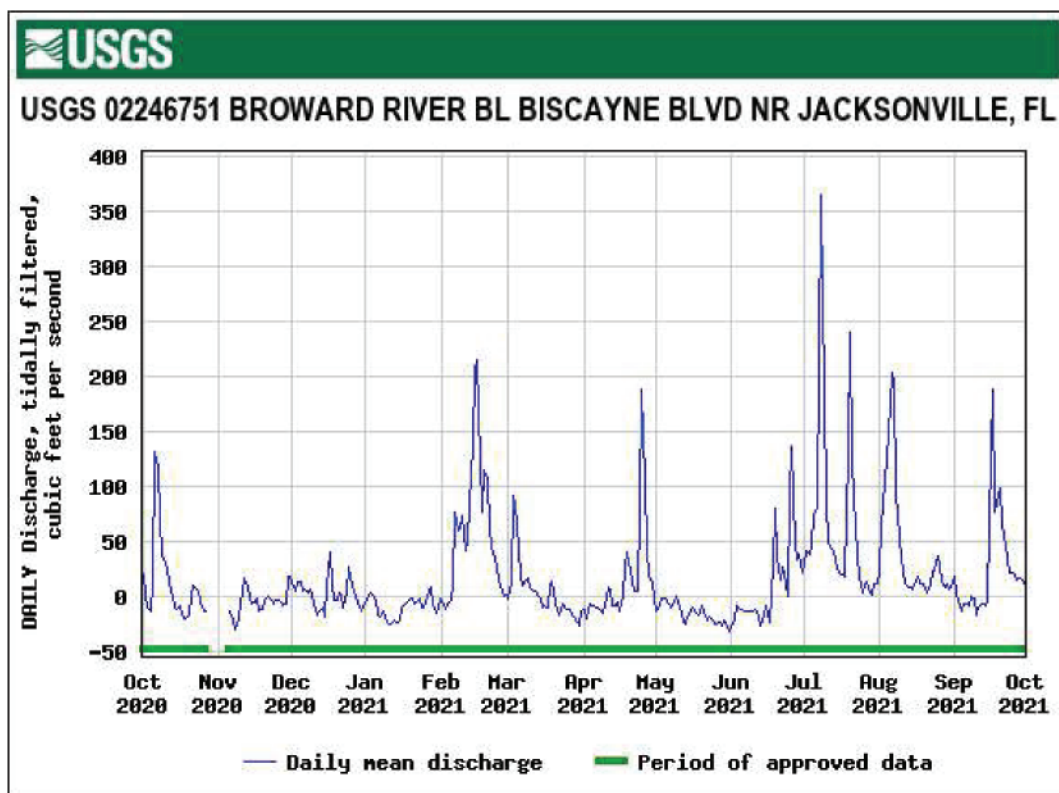
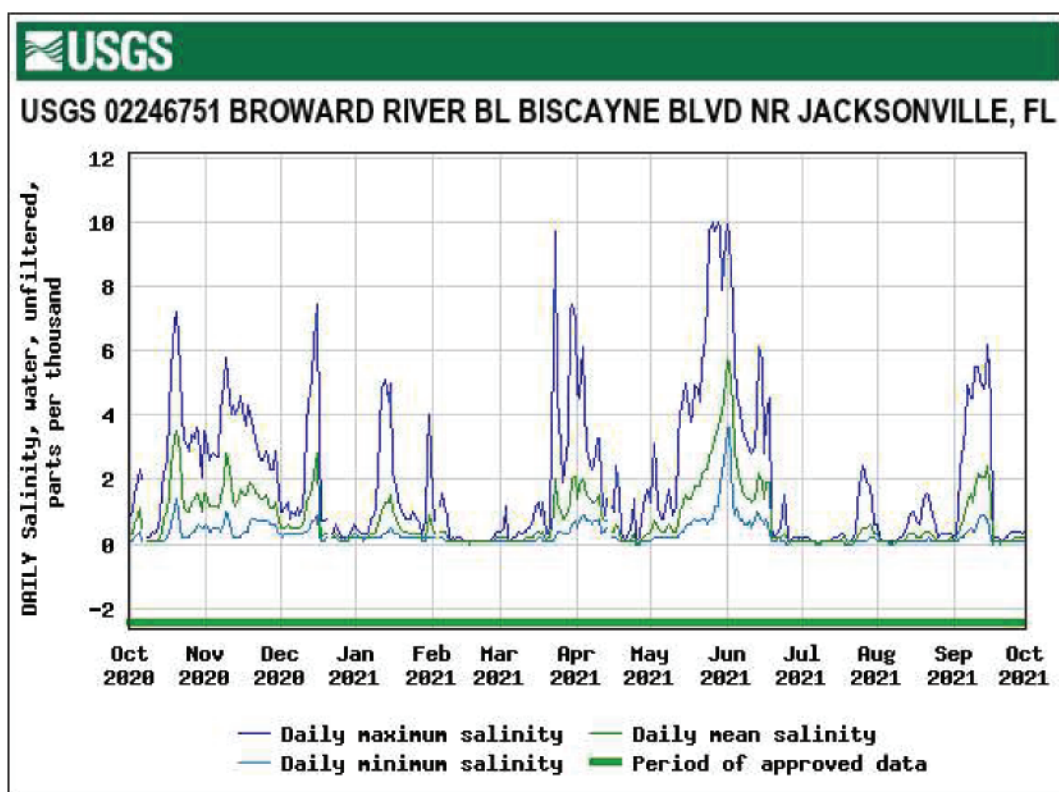


Figure 60. Salinity data for Trout River below U.S. 1 at Dinsmore, Florida.



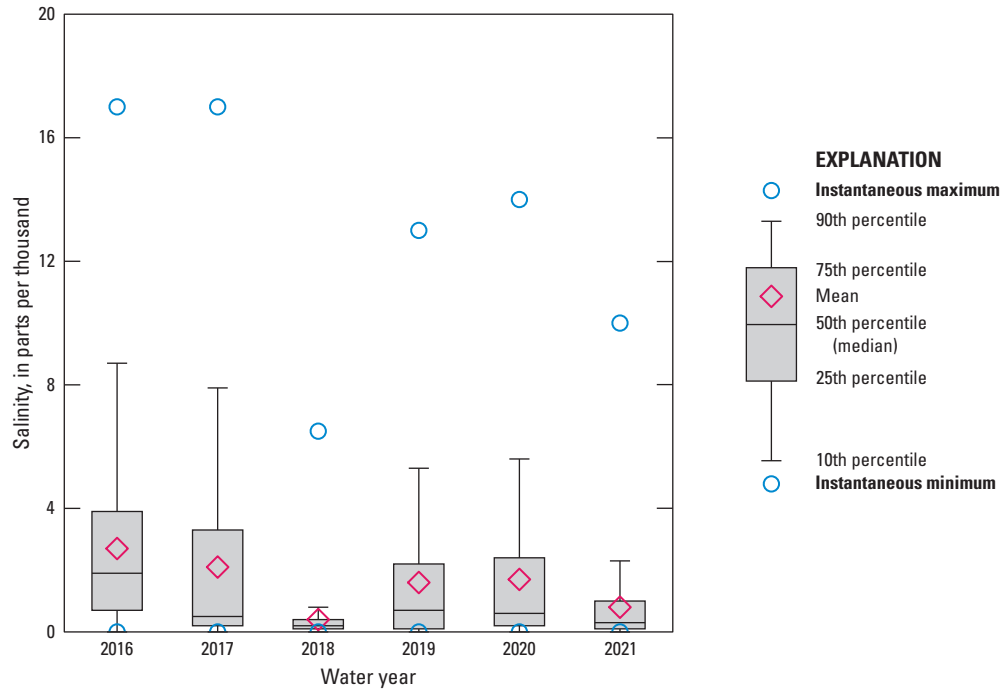


**Figure 61.** Daily mean tidally filtered discharge for Broward River below Biscayne Boulevard near Jacksonville, Florida.



**Figure 62.** Daily maximum, minimum, and mean salinity for Broward River below Biscayne Boulevard near Jacksonville, Florida.





**Figure 63.** Salinity data for Broward River below Biscayne Boulevard near Jacksonville, Florida.

*Dunn Creek at Dunn Creek Road near Eastport, Florida*—Daily tidally filtered discharge at Dunn Creek ranged from 2.50 to 98.1 ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of 24.5 ft<sup>3</sup>/s (fig. 64). Daily tidally filtered discharge was not calculated for 4 days in October, 6 days in April, 5 days in June, 4 days in July, and was estimated for 4 days in October because of equipment malfunction. The daily tidally filtered discharge peaked over 90 ft<sup>3</sup>/s in February and July, the 2 months with the highest departure from average rainfall in Duval County (fig. 3). Salinity during the 2021 water year ranged from 0.1 to 13 ppt, with a median of 1.4 ppt and mean of 2.1 ppt (fig. 65). The 2021 mean and maximum salinity ranked fifth among those calculated for the 6 years of the study, and the median salinity ranked fourth (fig. 66). Salinity was not calculated for 2 days in October because of equipment malfunction.

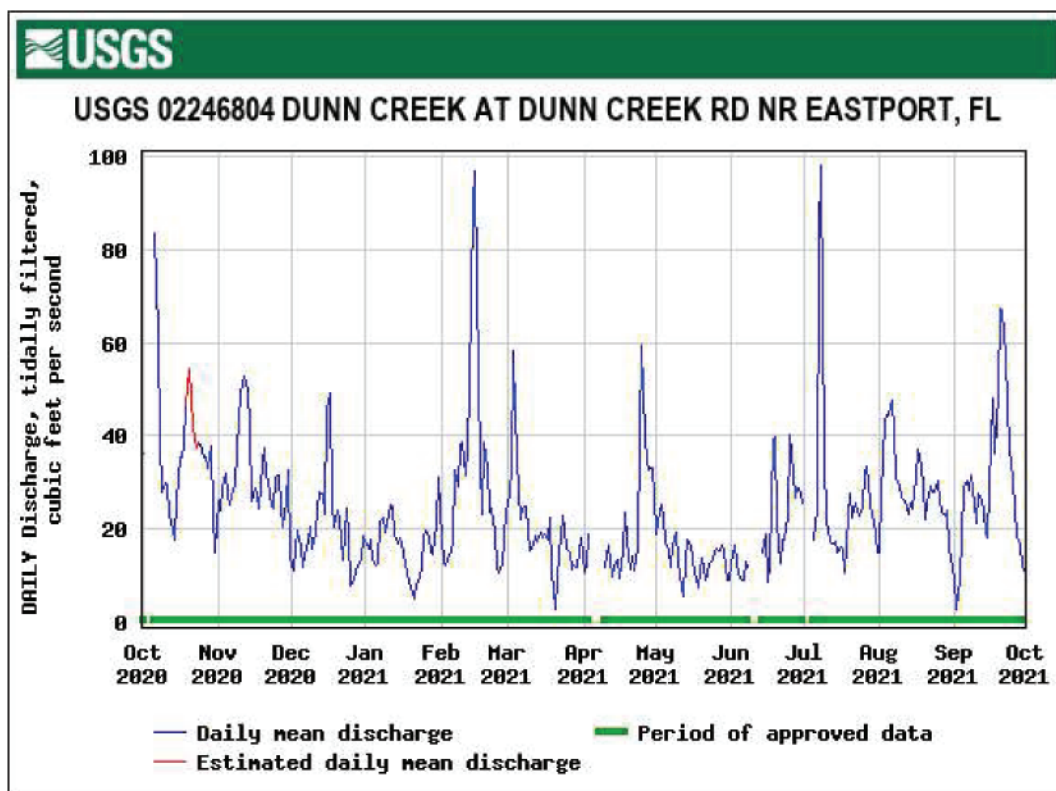
*Clapboard Creek near Jacksonville, Florida*—Daily tidally filtered discharge at Clapboard Creek ranged from –145 to 222 ft<sup>3</sup>/s during the 2021 water year, with an annual mean flow of 77.9 ft<sup>3</sup>/s (fig. 67). Tidally filtered discharge peaked above 200 ft<sup>3</sup>/s three times from October to November, and the annual mean flow ranked first for the 6-year period of record considered for this study. The lowest tidally filtered discharge was computed in late March when below-average rainfall occurred in Duval County (fig. 3), and sustained wind speeds above 30 mi/h from the northeast were recorded at NOAA weather station Jacksonville Naval Air Station for multiple consecutive days (NOAA, 2022).

*Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida*—Salinity at Clapboard Creek ranged from 3.9 to 28 ppt during the 2021 water year, with a median

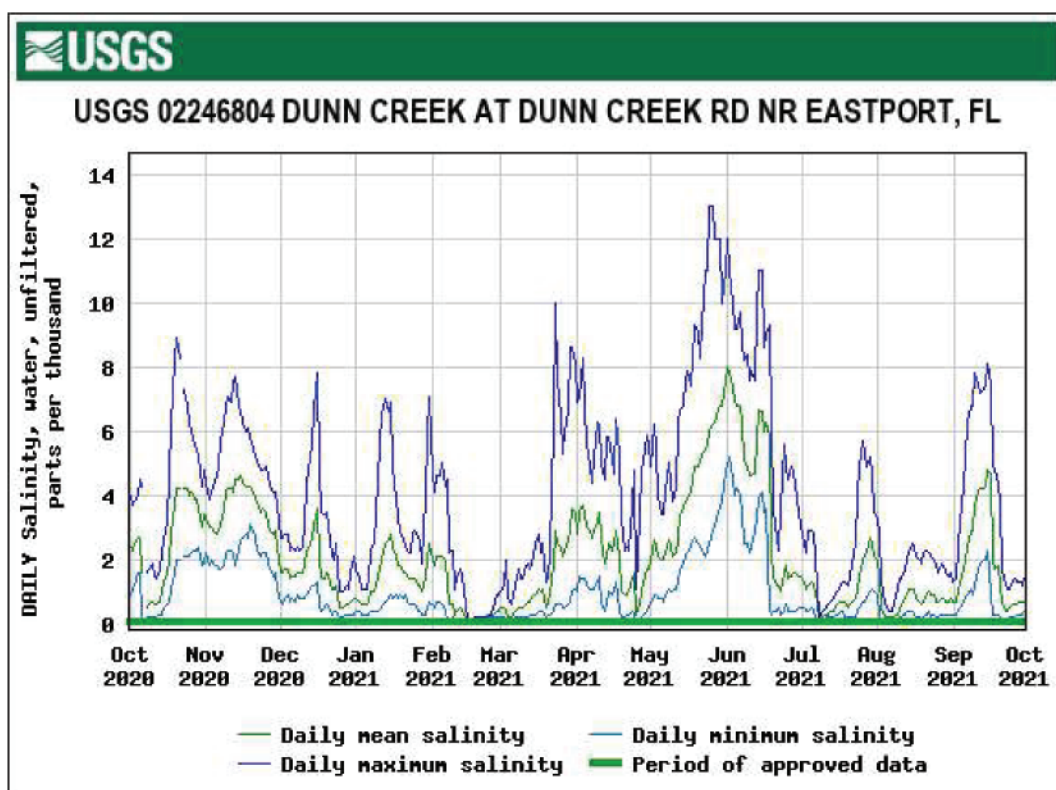
and mean of 18 ppt (fig. 68). The minimum salinity occurred in February when rainfall in Duval County was the highest monthly departure from average (fig. 3). The 2021 median and mean salinity ranked fifth among those calculated for the 6 years of the study (fig. 69).

## Discharge and Salinity Site Comparison

Analysis of the annual mean tidally filtered discharge for the 2021 water year along the main stem of the St. Johns River indicates that streamflow increased with distance downstream, as expected (fig. 70). Relative to the 2020 water year, annual mean discharge for the 2021 water year was higher at all main-stem sites. Over the 6 years considered for this study, the second-highest annual mean discharge was computed at all three main-stem sites. Of the tributaries, annual mean discharge was highest at Durbin Creek, followed by Trout River, Clapboard Creek, Ortega River, Pottsburg Creek at U.S. 90, Julington Creek, Pottsburg Creek near South Jacksonville, Dunn Creek, Cedar River, and Broward River, whose annual mean was lowest (fig. 71). Annual mean discharge at 7 of the 10 tributary monitoring sites was higher for the 2021 water year than for the 2020 water year, and the computed annual mean flow at Clapboard Creek was the highest over the 6 years considered for this study (fig. 71). The countywide annual rainfall for the 2021 water year was above the average in four of the five counties, higher in three of the five counties for the 2021 water year relative to the 2020 water year, and ranked third among the annual rainfall totals for the past 6 years (fig. 72).



**Figure 64.** Daily mean tidally filtered discharge for Dunn Creek at Dunn Creek Road near Eastport, Florida.



**Figure 65.** Daily maximum, minimum, and mean salinity for Dunn Creek at Dunn Creek Road near Eastport, Florida.

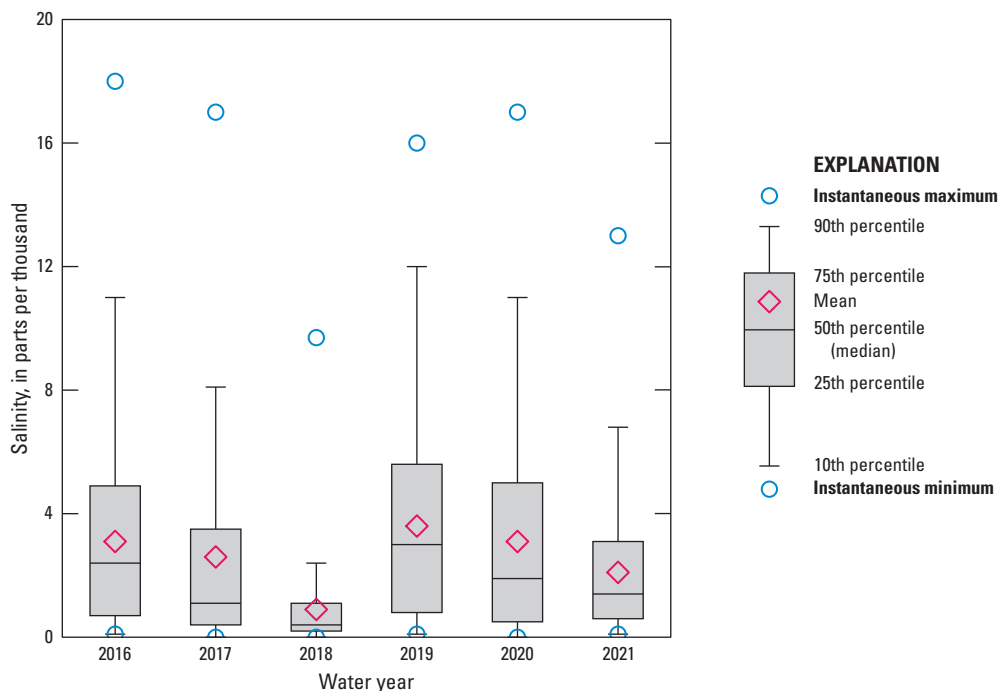


Figure 66. Salinity data for Dunn Creek at Dunn Creek Road near Eastport, Florida.

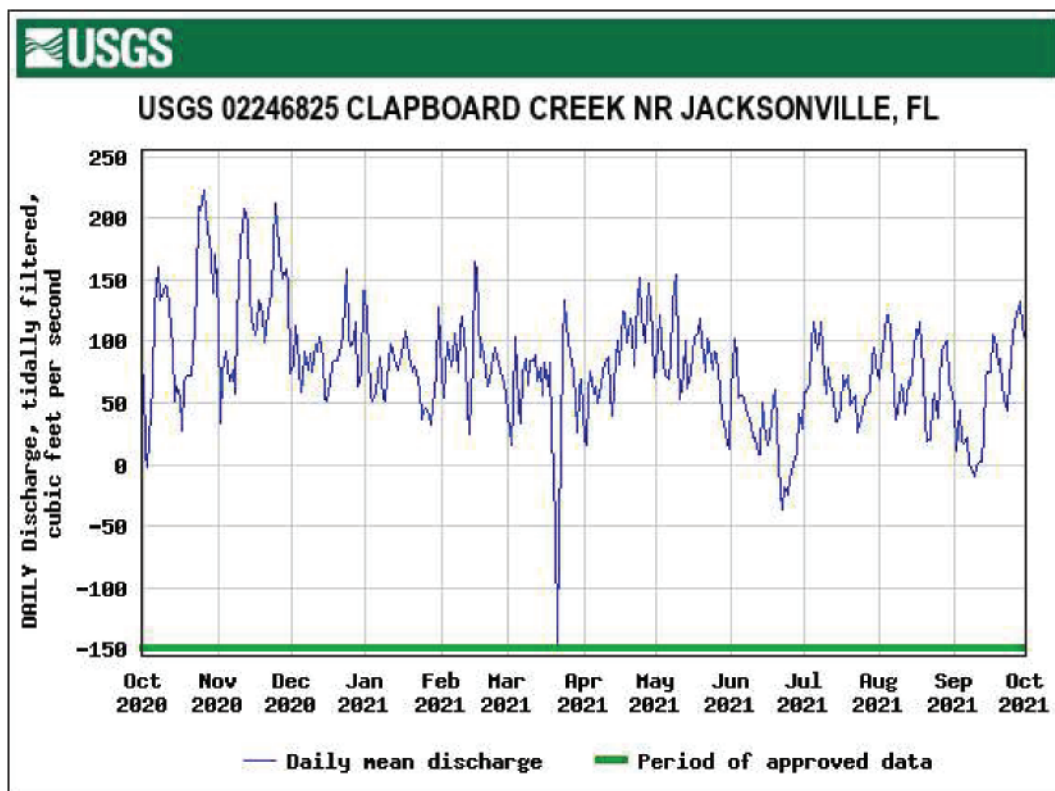
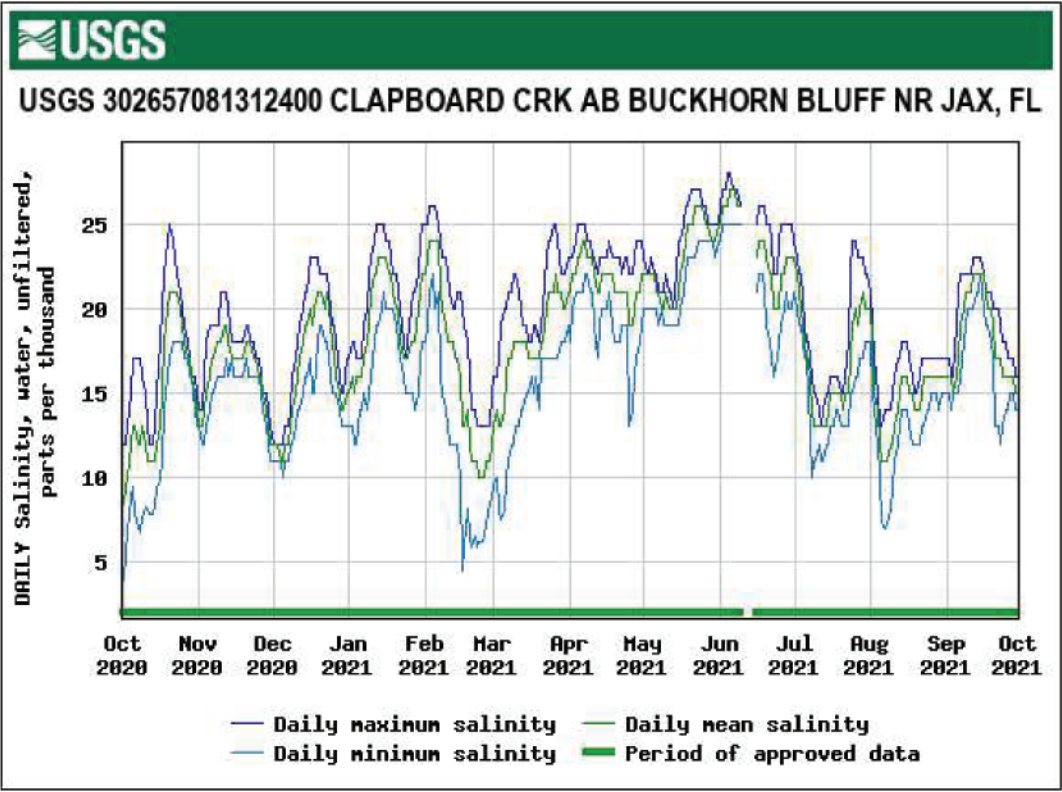
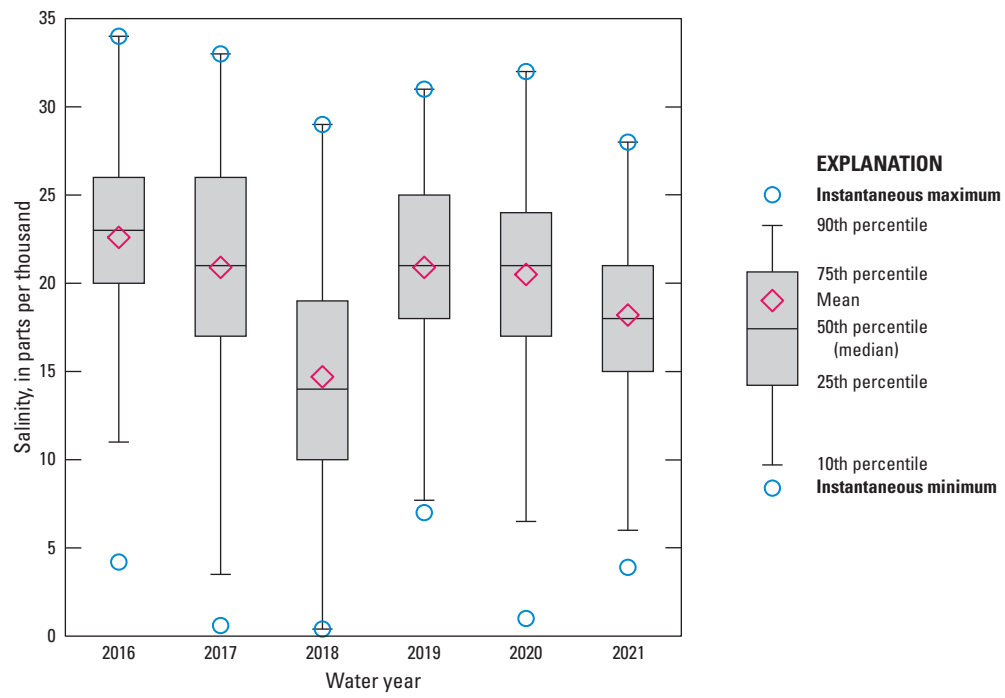


Figure 67. Daily mean tidally filtered discharge for Clapboard Creek near Jacksonville, Florida.



**Figure 68.** Daily maximum, minimum, and mean salinity for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.



**Figure 69.** Salinity data for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.

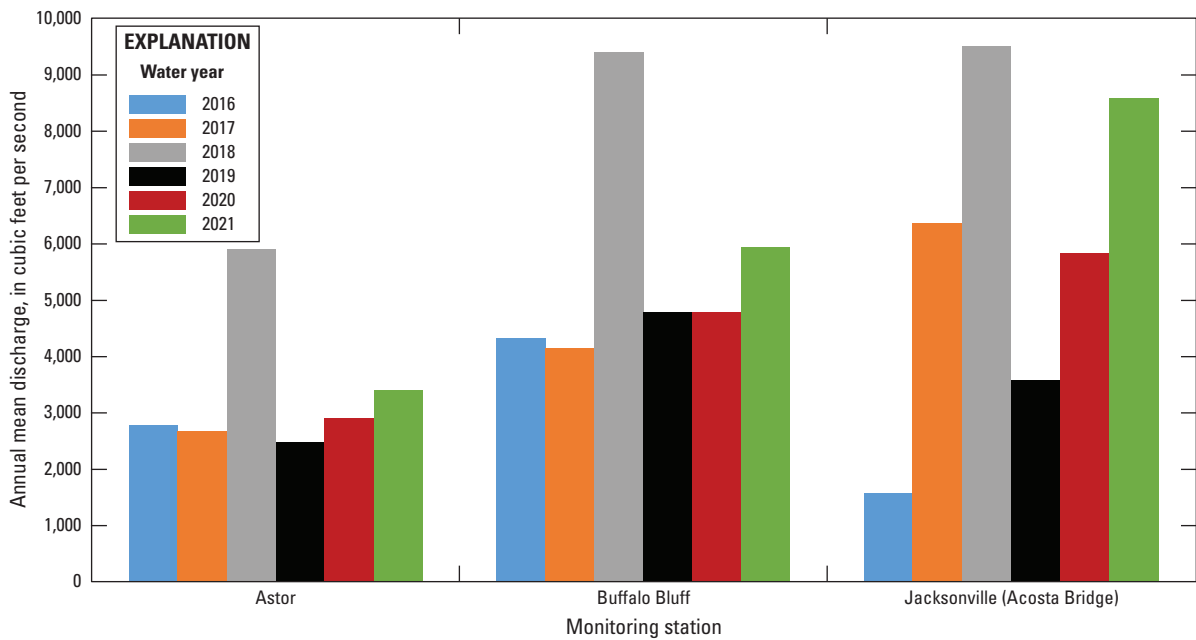


Figure 70. Annual mean tidally filtered discharge at St. Johns River main-stem monitoring sites.

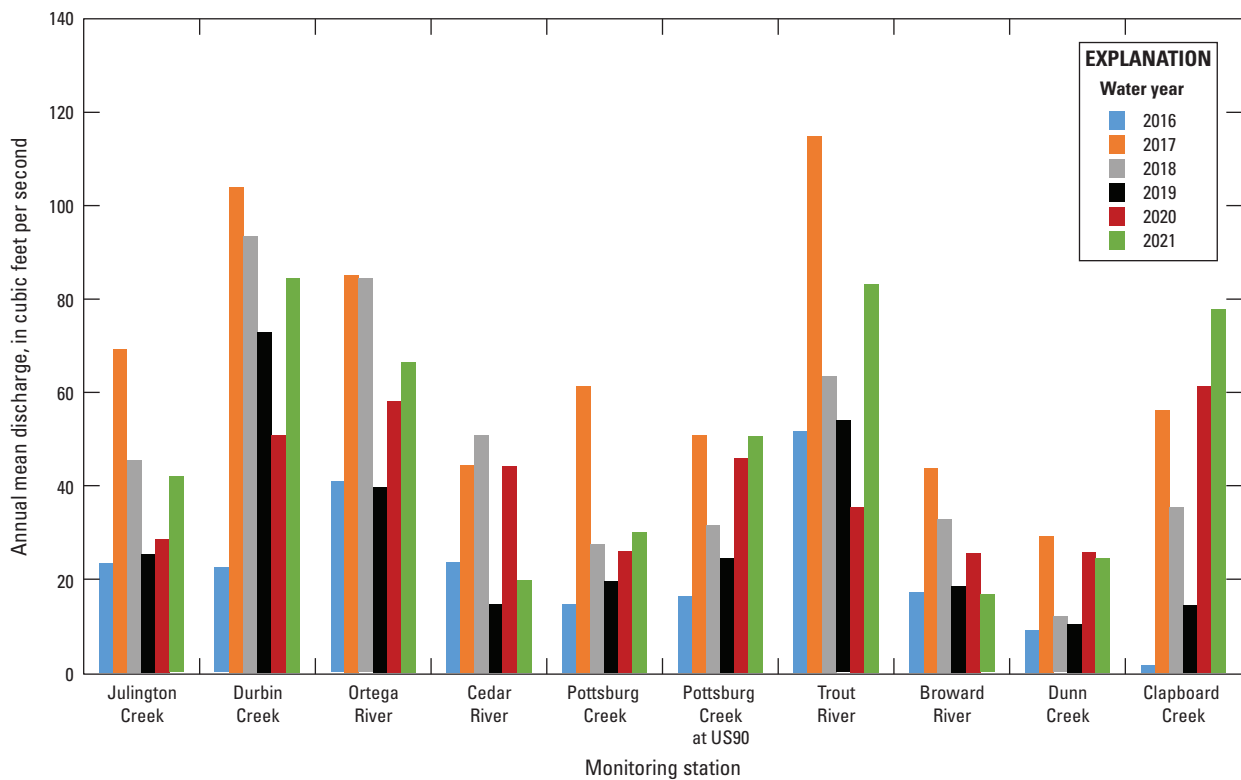
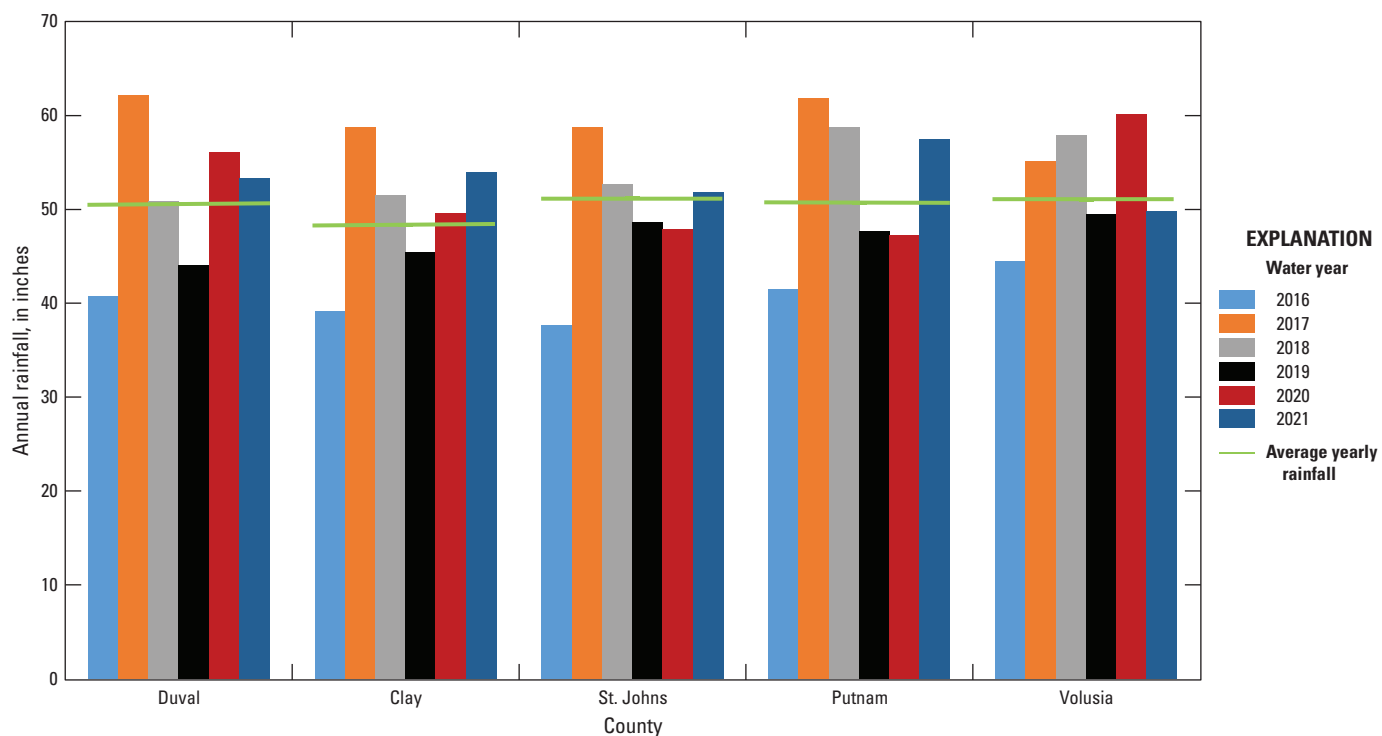


Figure 71. Annual mean discharge at St. Johns River tributary monitoring sites.



**Figure 72.** Annual rainfall for Duval, Clay, St. Johns, Putnam, and Volusia Counties.

Annual mean salinity for the main-stem sites generally decreased with distance upstream, which was expected (fig. 73). Of all sites in 2021, Dames Point had the highest annual mean salinities, which were 20 ppt near the surface and 21 ppt near the bottom of the water column. The 2021 annual mean salinity was lower than that of 2020 at all main-stem sites (fig. 73). The 2021 salinity at the main-stem sites, when compared to all years of the study, ranked second-lowest except at Racy Point, which tied for lowest.

Clapboard Creek had the highest annual mean salinity (18 ppt) of all tributaries in 2021 because of its proximity to the Atlantic Ocean. Durbin Creek salinity (0.1 ppt) was the

lowest of all monitoring locations and was slightly lower than those of Julington Creek (0.2 ppt) and Ortega River (0.3 ppt) (fig. 74). A simple comparison of annual mean salinity at tributary sites between the 2020 and 2021 water years indicates salinity was lower in 2021 at all locations except Durbin Creek, which remained the same (fig. 74). The 2021 mean salinity at the tributary sites, when compared to the preceding 5 years of the study, ranked fifth at all sites except Durbin Creek, which remained the same at 0.1 ppt for all 6 years.

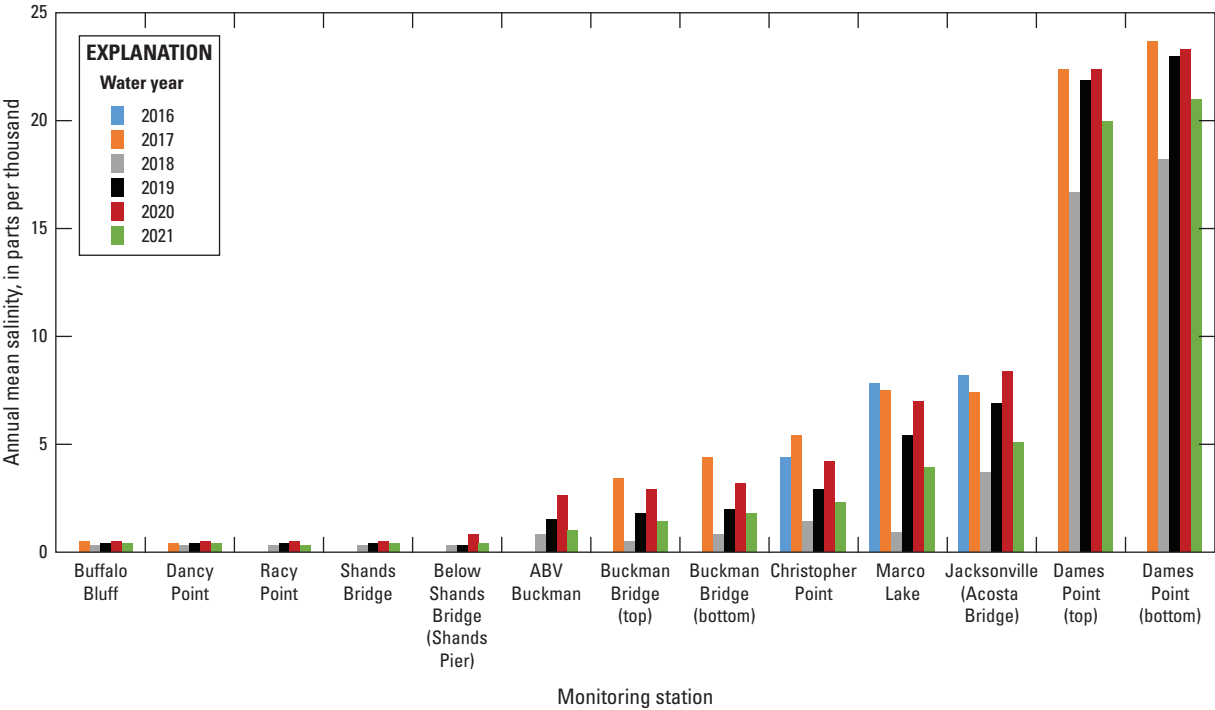


Figure 73. Annual mean salinity at St. Johns River main-stem monitoring sites.

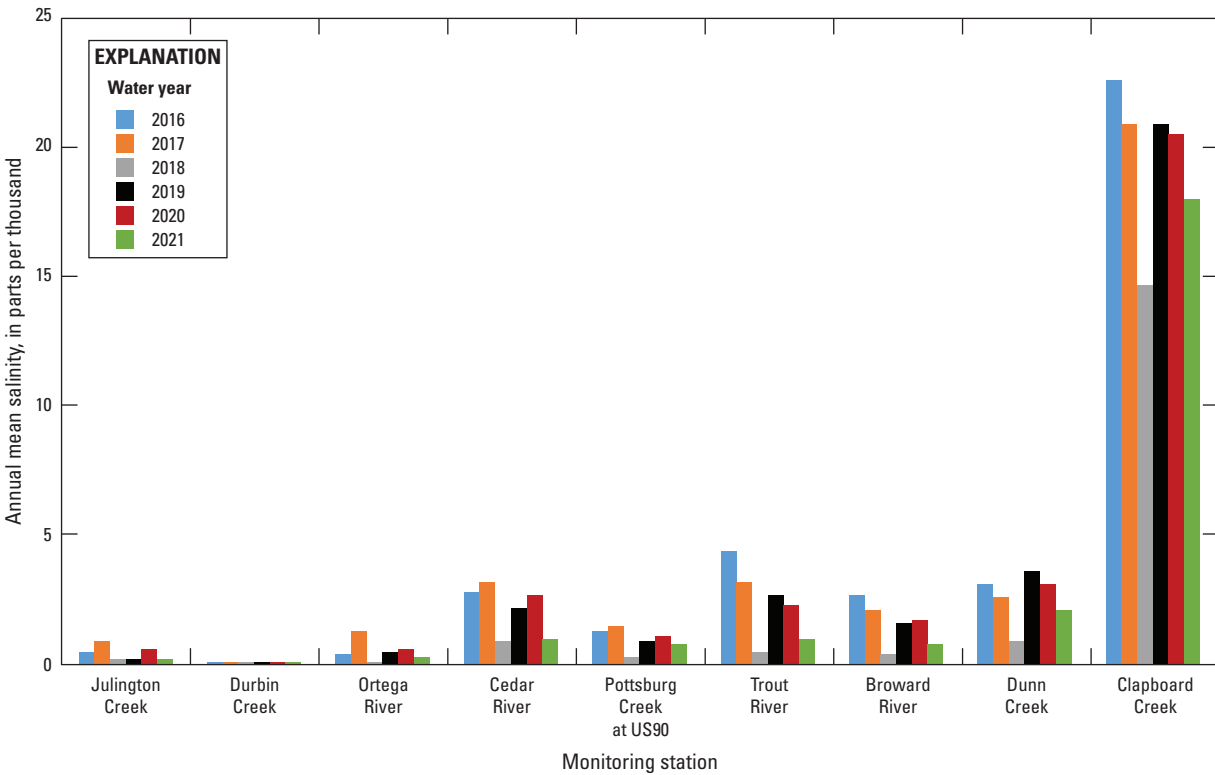


Figure 74. Annual mean salinity at St. Johns River tributary monitoring sites.



## Summary

The U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, collected data during the 2021 water year, from October 2020 to September 2021, at 26 sites on the St. Johns River and its tributaries. This period of data collection was concurrent with river dredging, which was initiated in February 2018 by the U.S. Army Corps of Engineers as part of the project to deepen the first 13 river miles of Jacksonville Harbor. Data collection began in the 2016 water year, and this is the sixth annual report of the study. Stage was measured at 17 sites, discharge was calculated at 13 sites, and water temperature and specific conductance data were collected at 20 sites; all parameters were measured at some sites. Salinity was calculated for each site where water temperature and specific conductance data were collected. Data were collected over a range of hydrologic conditions, including above-average annual rainfall in Duval, Clay, St. Johns, and Putnam Counties and a period of low rainfall and strong northeast winds that resulted in minimum salinities in many main-stem sites in March. Many factors—such as wind, rainfall, and hurricanes—can influence flow and salinity within the study area.

The annual mean tidally filtered discharge for the 2021 water year increased with distance downstream, as expected, along the main stem of the St. Johns River. The second-highest annual mean discharge over the 6 years considered for this study was computed at all three main-stem sites. The 2021 annual mean salinity was lower than that of 2020 at all main-stem sites. The 2021 salinity at the main-stem sites, when compared to all years of the study, ranked second-lowest except at Racy Point, which tied for lowest.

Of the tributaries, annual mean discharge was highest at Durbin Creek, followed by Trout River, Clapboard Creek, Ortega River, Pottsborg Creek at U.S. 90, Julington Creek, Pottsborg Creek near South Jacksonville, Dunn Creek, Cedar River, and Broward River, whose annual mean was lowest. Annual mean discharge at 7 of the 10 tributary monitoring sites was higher for the 2021 water year than for the 2020 water year, and the computed annual mean flow at Clapboard Creek was the highest over the 6 years considered for this study. The 2021 annual mean salinity was lower than that of 2020 at all locations except Durbin Creek, which remained the same. The 2021 annual mean salinity at the tributary sites, when compared to all 6 years of the study, ranked fifth at all sites except Julington Creek, which tied for last, and Durbin Creek, which had the same value every year. The annual rainfall total for Duval County ranked third among those computed for the 6 years considered for this study.

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Publishing support provided by  
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