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Continuous Stream Discharge, Salinity, and Associated Data Collected in the Lower St. Johns River and Its Tributaries, Florida, 2016

Open-File Report 2018–1108

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

Cover. Front: U.S. Geological Survey (USGS) site 02246621, Trout River near Jacksonville, Florida. Photo by Corin Downs. Back: Site 022462002, Durbin Creek near Fruit Cove, Florida. Photos by Patrick J. Ryan.

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RYAN K. ZINKE, Secretary

U.S. Geological Survey
James F. Reilly II, Director

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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 (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32.$$

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 (µS/cm at 25 °C).

Abbreviations

ppt	parts per thousand
PVC	polyvinyl chloride
SJRWMD	St. Johns River Water Management District
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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Abstract

The U.S. Army Corps of Engineers, Jacksonville District, plans to deepen the St. Johns River channel in Jacksonville, Florida, from 40 to 47 feet along 13 miles of the river channel, beginning at the mouth of the river at the Atlantic Ocean, to accommodate larger, fully loaded cargo vessels. The U.S. Geological Survey installed continuous data-collection stations to monitor discharge, salinity, and associated parameters at 22 sites prior to the commencement of dredging. The U.S. Geological Survey monitored stage and discharge at 13 sites, and water temperature, specific conductance, and salinity at 15 sites; some sites included all parameters.

This report contains information pertinent to the data collection sites from their installation date to September 2016, with additional information and data from Hurricane Matthew in October 2016. Site installations began in October 2015; all sites were installed and began collecting data by January 2016. All data available for each site after October 2015 are included in this report.

Discharge and salinity ranged widely during the data collection period, which included the effects of Hurricane Hermine in September 2016 and Hurricane Matthew in October 2016. Of the tributaries, annual mean discharge was greatest at Ortega River, followed by Cedar River, Julington Creek, Durbin Creek, and Clapboard Creek. Annual mean salinity for the main-stem sites indicates that salinity decreases with distance upstream, which is expected. The closest tributary site to the Atlantic Ocean (Clapboard Creek) produced the highest annual mean salinity of the tributaries, and Durbin Creek salinity was the lowest of all monitoring locations.

Introduction

The St. Johns River flows 310 miles (mi) northward along 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 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, and the U.S. Army Corps of Engineers (USACE) plans to deepen the first 13 river miles, starting at the mouth (USACE, 2014).

Salinity models indicate that the harbor deepening may cause changes in salinity in part of the study area, potentially causing salinity stress in some wetlands and submerged aquatic vegetation, and changes in some fish and macroinvertebrate distributions (USACE, 2014). Environmental constraints required by permit include the collection of water 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 (FDEP, 2016). The U.S. Geological Survey (USGS) was responsible for constructing, instrumenting, and monitoring all parameters at gage locations listed in the permit that were not already being monitored by other agencies as of January 2016. This report describes the sites and briefly summarizes the data collected during the first year of the study.

The streamflow and water-quality gage network was used to collect baseline data in the St. Johns River and its tributaries prior to dredging and will be used to monitor changes, if any, during and after the dredging is completed. This report provides an overview of the data from 22 surface-water discharge and (or) water-quality stations along the St. Johns River and its tributaries under predredging conditions, specifically, from January to September 2016 (figs. 1 and 2), and during Hurricane Matthew in October 2016. The report includes documentation of the sites and methods used to compute discharge and salinity, and lists the parameters measured at each site. The data collected in the project area can be found on the USGS National Water Information System website (https://waterdata.usgs.gov/nwis).

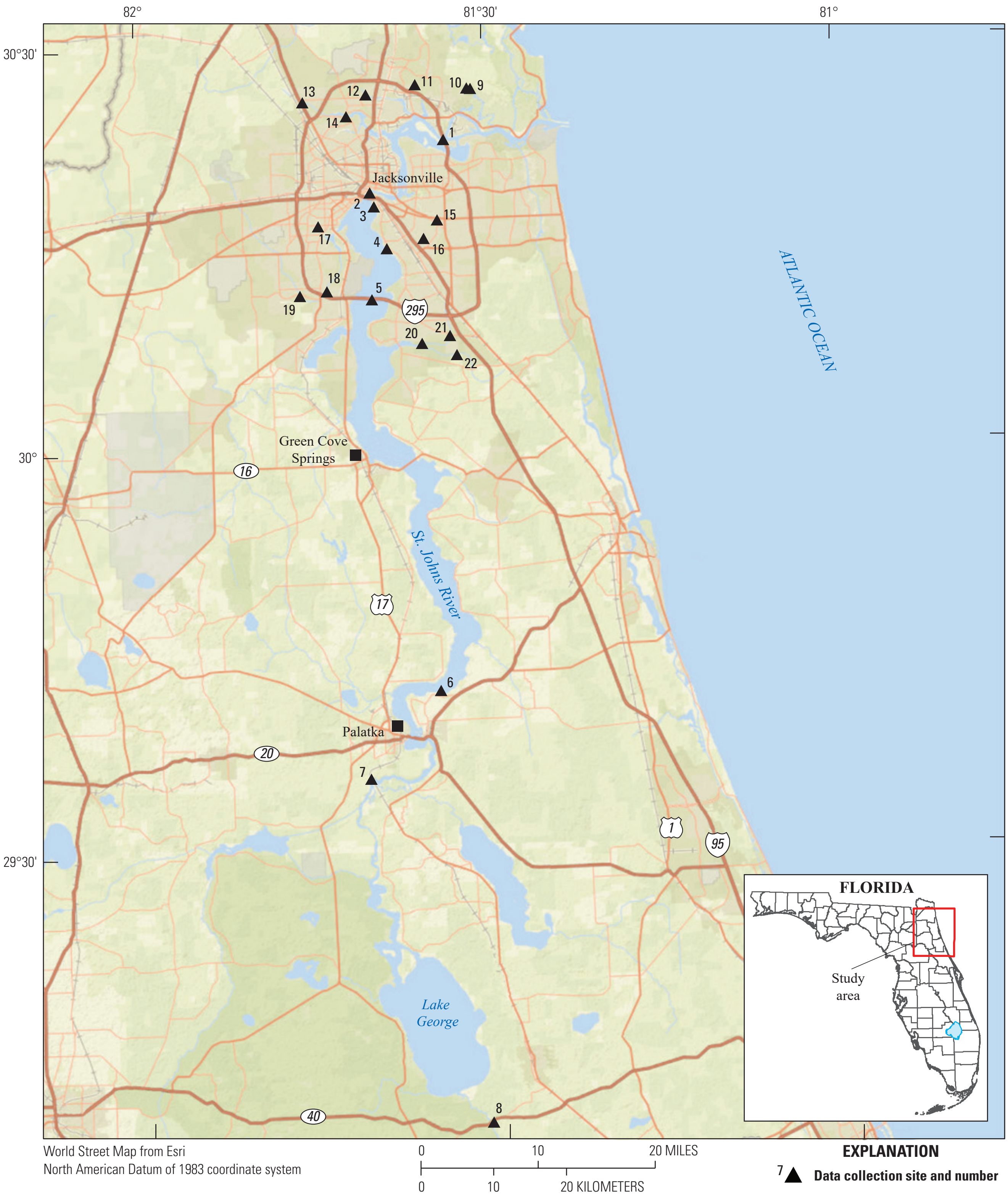

Figure 1. U.S. Geological Survey data collection sites on the St. Johns River and its tributaries.

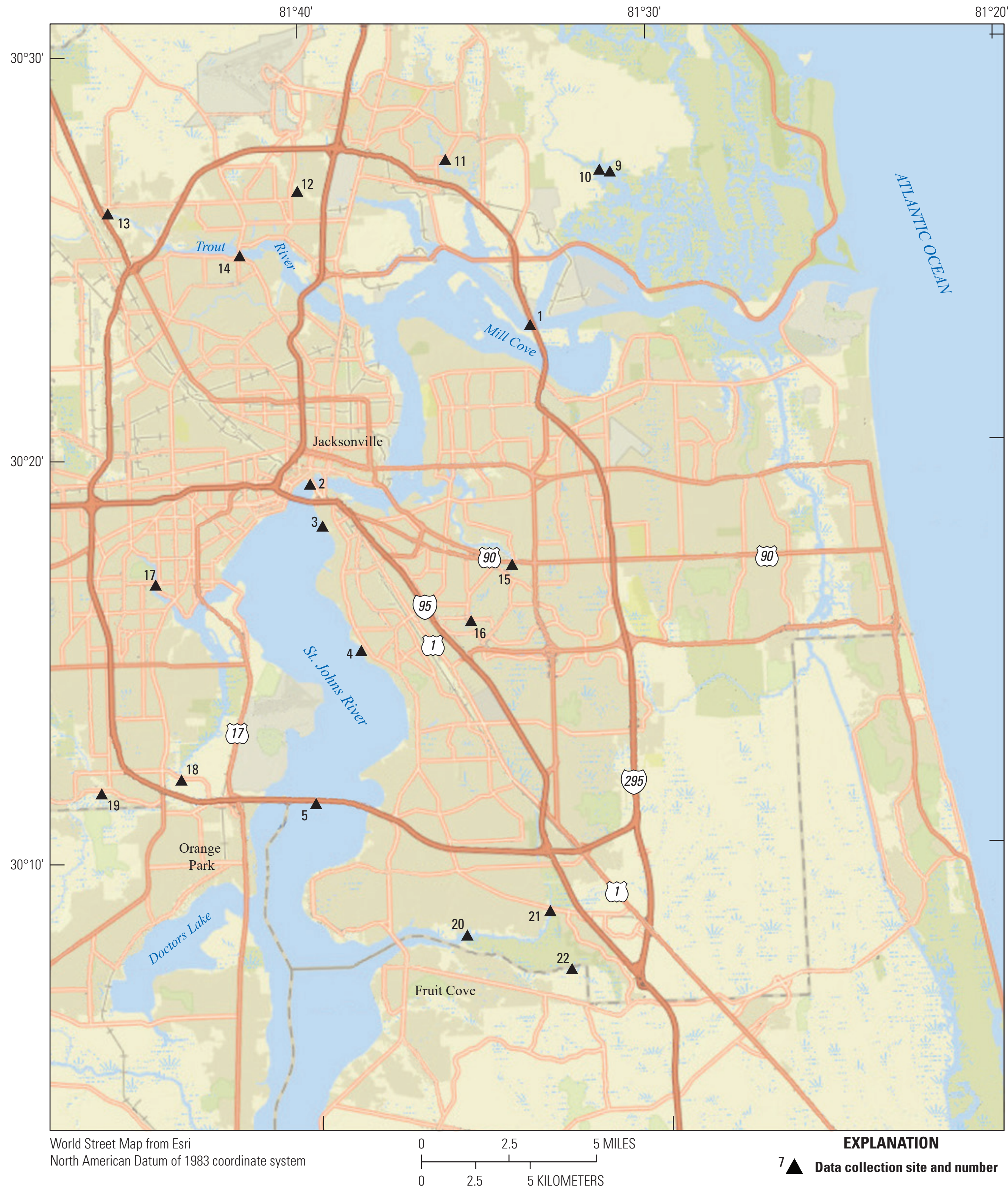

Figure 2. U.S. Geological Survey data collection sites on the St. Johns River tributaries.

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 tributaries of the St. Johns River (table 1). For some stations along the St. Johns River, water temperature and specific conductance data were collected beginning in January 2016, but salinity data were computed beginning in October 2016.

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, 2010). Discharge was routinely measured using various types of equipment, depending on depth, velocity, and environmental conditions, in accordance with USGS standards (Turnipseed and Sauer, 2010). Because of tidal and (or) wind effects, discharge (in cubic feet per second) was computed using the index-velocity method at most sites, in accordance with USGS techniques and methods (Levesque and Oberg, 2012). The index-velocity method was used for discharge calculation for all sites unless otherwise specified in this report. Where applicable, discharge data were filtered using the Godin low-pass filter to remove principal tidal frequencies from unit values. 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 are a combination of freshwater flows and water storage caused by higher and lower mean sea levels and storm surges from hurricanes or tropical storms. Discharge was computed using a stage-discharge rating at a few sites where a substantive tidal influence was not present (Rantz and others, 1982).

Water temperature (in degrees Celsius) and specific conductance (in microsiemens per centimeter at 25 degrees Celsius) were measured at or less than 1-hour intervals in accordance with USGS techniques and methods (Wagner and others, 2006). Water-quality meters were installed in situ at sites having freshwater environments and were monitored at 15-minute intervals. To reduce fouling caused by the harsh saltwater environment, some sites utilized a pump and intake system in which the meter was housed in the shelter inside a polyvinyl chloride (PVC) chamber. In this case, water was pumped into the chamber for 1 to 2 minutes before the measurement, and the chamber drains in-between measurement intervals. 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. Salinity (in parts per thousand) was calculated using a rating table to convert specific conductance, in microsiemens per centimeter, to salinity, in parts per thousand (Wagner and others, 2006).

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. A missing data gap greater than 2 hours in the calculated discharge record, therefore, results in a missing data gap of 3 days in the tidally filtered discharge record. Missing water-quality data at sites using a pump setup are usually a result of power or pump failure, preventing 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 are used to calculate salinity. In either case, the affected values are not used, creating gaps in the final record.

Rainfall data for Duval, Putnam, and Volusia Counties in 2016 were accessed 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 (http://webapub.sjrwmd.com/agws10/hydroreport/). Jacksonville Harbor and all streamflow stations included in this study are located within Duval County, except the St. Johns River sites at Astor (Volusia County) and Buffalo Bluff (Putnam County).

Quantile plots were created to show percentiles for annual mean discharge data collected at monitoring sites that have long-term record (10 years or more) and a full contemporary year of data. The quantile plots group the annual mean discharge by water year. For this report, the 2016 water year includes data from October 1, 2015, to September 30, 2016; therefore, not all sites included in this report had sufficient data to include in the quantile plot, because they were installed after October 1. The resulting plots show how the annual mean discharge compares with that of previous years. For discharges affected by tidal fluctuations, annual mean tidally filtered discharge was used to construct the plot.

Description of St. Johns River Main-Stem Sites

All sites on the main stem of the St. Johns River have substantive tidal influence, and the discharge is calculated and tidally filtered. The farthest upstream discharge monitoring site of the St. Johns River is in Astor, FL at the State Road 40 Bridge (table 1; river mile 127). Approximately 37 mi downstream, stage and discharge are also collected on the St. Johns River at Buffalo Bluff (river mile 90). Stage and discharge for both of these sites are currently collected in cooperation with the SJRWMD. Tidally filtered discharge values have been computed since 1994 at both Astor and Buffalo Bluff. The farthest upstream water-quality monitoring station along the St. Johns River is located at Dancy Point (river mile 71). In cooperation with SJRWMD, water temperature and specific conductance data are currently collected at an approximate depth of 11.5 ft below the average high tide level.

Table 1. U.S. Geological Survey data collection sites and parameters measured on the main stem of the St. Johns River and its tributaries.

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

Map number	USGS site number	USGS site name	Discharge	Gage height	Temperature	Specific conductance	Salinity	River mile
St. Johns River								
1	302309081333001	St Johns River Dames Point Bridge at Jacksonville, Fla.	--	--	x	x	x	10
2	02246500	St. Johns River at Jacksonville, Fla.	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 Pt near Jacksonville, Fla.	--	--	x	x	x	29
5	301124081395901	St. Johns River Buckman Bridge at Jacksonville, Fla.	--	--	x	x	x	34
6	294213081345300	St. Johns River at Dancy Point near Spuds, Fla.	--	--	x	x	x	71
7	02244040	St. Johns River at Buffalo Bluff near Satsuma, Fla.	x	x	--	--	--	90
8	02236125	St. Johns River at Astor, Fla.	x	x	--	--	--	127
Tributaries								
9	02246825	Clapboard Creek near Jacksonville, Fla.	x	x	--	--	--	NA
10	302657081312400	Clapboard Creek ab Buckhorn Bluff near Jacksonville, Fla.	--	--	x	x	x	NA
11	02246804	Dunn Creek at Dunn Creek Rd near Eastport, Fla.	x	x	x	x	x	NA
12	02246751	Broward River below Biscayne Blvd near Jacksonville, Fla.	x	x	x	x	x	NA
13	302609081453300	Trout River below US 1 at Dinsmore, Fla.	--	--	x	x	x	NA
14	02246621	Trout River near Jacksonville, Fla.	x	x	--	--	--	NA
15	02246518	Pottsburg Creek at US 90 near S. Jacksonville, Fla.	x	x	x	x	x	NA
16	02246515	Pottsburg Creek near South Jacksonville, Fla.	x	x	--	--	--	NA
17	02246459	Cedar River at San Juan Avenue at Jacksonville, Fla.	x	x	x	x	x	NA
18	301204081434900	Ortega River Salinity at Jacksonville, Fla.	--	--	x	x	x	NA
19	02246318	Ortega River at Kirwin Road near Jacksonville, Fla.	x	x	--	--	--	NA
20	300803081354500	Julington Creek at Hood Landing near Bayard, Fla.	--	--	x	x	x	NA
21	02246160	Julington Creek at Old St August Rd near Bayard, Fla.	x	x	--	--	--	NA
22	022462002	Durbin Creek near Fruit Cove, Fla.	x	x	x	x	x	NA

A water-quality monitoring station located at Buckman Bridge (river mile 34) collects water temperature and specific conductance at two depths using one water-quality monitoring meter and separate pump intakes. All water-quality parameters are collected at approximate depths of 8 ft (top) and 16 ft (bottom) below the average high tide level, with one water-quality meter using a pump setup. Water-quality monitoring stations at Christopher Point (river mile 29) and Marco Lake (river mile 25) collect water temperature, specific conductance, and salinity at an approximate depth of 4 ft below the average high-tide level for each location. These sites are relatively shallow, having average depths 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 collects discharge. Stage and discharge were previously collected before the dredging study began, but water temperature, specific conductance, and salinity data collection began in October 2015 at an approximate depth of 11 ft below the average high tide level. Tidally filtered discharge values have been computed since 1996. A water-quality monitoring station at Dames Point Bridge in Jacksonville (river mile 10) collects water temperature and specific conductance data. All water-quality data are collected at approximate depths of 15 ft (top) and 22 ft (bottom) below the average high tide level using one water-quality meter and pump setup.

Description of Tributary Sites

A monitoring station on Julington Creek at Old St. Augustine Road collects stage and discharge data 6.7 mi upstream from the confluence with the St. Johns River (table 1). A nearby water-quality monitoring station collecting water temperature, specific conductance, and salinity data at an approximate depth of 3.5 ft below the average high tide level is located approximately 3 miles downstream of 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 collected 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 Blvd (Kirwin Road), 11 mi upstream from the confluence of the St. Johns River. Discharge has been computed at this location for intermittent periods 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. The water-quality monitoring station collecting water temperature, specific conductance, and salinity data 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 on the Ortega River. Tidal influence is shown in the salinity data during times of low flow or increased stage in the St. Johns River.

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

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

The monitoring station for Trout River collects stage and discharge at Lem Turner Road, 5 mi upstream from the confluence of the St. Johns River. Water temperature, specific conductance, and salinity are collected at an approximate depth of 6 ft below the average high-tide level at a location 4.3 mi upstream. Broward River is monitored for stage, discharge, water temperature, specific conductance, and salinity near Biscayne Blvd., 6.3 mi upstream from the confluence of the St. Johns River. The water-quality parameters are collected 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 at elevated stages.

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 the St. Johns River. The monitoring station for Clapboard Creek collects stage and discharge near Sheffield Road, 4.5 mi upstream from the confluence of the St. Johns River. Water temperature, specific conductance, and salinity are collected at a location 0.5 miles upstream. The water-quality parameters are collected 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 wind effects from the St. Johns River owing to the proximity to the river and ocean.

Results

Because of the large project area and diversity of sites, a wide range of discharge and salinity was measured during the period. As expected, lower salinities were measured at the tributary sites farthest from the ocean, and higher salinities were measured during periods of low flow in the St. Johns River. Duval County experienced a relatively dry summer during 2016, compared to the long-term average monthly rainfall. Rainfall for Duval County from January 2016 to September 2016 ranged from 1.1 inches (in.) below average in February to 3.9 in. above average in July, and the total monthly rainfall was 9.6 in. below average, based on monthly rainfall data from SJRWMD (2017). Rainfall for Putnam and Volusia Counties was similar, totaling 7.4 and 5.9 in. below the average monthly total, respectively (SJRWMD, 2017). The average monthly rainfall for each county is shown in figures 3–5.

Daily discharge and salinity plots, where applicable, for the study period included in this report (January–September 2016) are presented in the following sections. Some stations were installed prior to January 2016; data for those sites are shown beginning in October 2015, at the start of the 2016 water year. 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 website (https://waterdata.usgs.gov/nwis). Annual mean discharges are specified only for stations having at least an entire year of discharge record.

St. Johns River at Astor, Florida

Daily tidally filtered discharge at Astor ranged from −3,450 to 7,020 cubic feet per second (ft^3/s) during the period from October 2015 to September 2016 (fig. 6), with an annual mean flow of 2,780 ft^3/s. Comparison of historical annual mean tidally filtered flows indicates that the 2016 streamflow is at the 48th percentile; the median tidally filtered flow for the period of record is 2,820 ft^3/s (fig. 7). The annual mean flow for 1994 was not used in the quantile plot, because the period of record for that year begins in February. The subsequent 22 years of discharge record were, therefore, used to construct the quantile plot.

St. Johns River at Buffalo Bluff Near Satsuma, Florida

The St. Johns River at Buffalo Bluff recorded the highest instantaneous discharge for the 23-year period of record (27,700 ft^3/s) on September 2, 2016, as a result of rainfall from the outer bands of Hurricane Hermine. Daily tidally filtered discharge at Buffalo Bluff ranged from −9,750 to 15,800 ft^3/s during the period from October 2015 to September 2016, with an annual mean flow of 4,320 ft^3/s (fig. 8). Comparison of historical annual mean tidally filtered flows indicates that the 2016 streamflow is at the 50th percentile and equal to the median tidally filtered flow for the period of record beginning in 1994 (fig. 9).

St. Johns River at Christopher Point Near Jacksonville, Florida

The salinity at Christopher Point ranged from 0.3 to 20.3 parts per thousand (ppt), with a median of 3.7 ppt and mean of 4.4 ppt during the period from January 2016 to September 2016 (fig. 10). Weekly salinity fluctuations are common and caused by rainfall, tides, and wind.

St. Johns River Below Marco Lake at Jacksonville, Florida

The salinity at Marco Lake ranged from 0.4 to 27.5 ppt, with a median of 7.2 ppt and mean of 7.8 ppt during the period from January to September 2016 (fig. 11). Similar to Christopher Point, weekly salinity fluctuations are common and caused by rainfall, tides, and wind.

St. Johns River at Jacksonville, Florida

Daily tidally filtered discharge at the St. Johns River at Jacksonville station ranged from −34,800 to 33,600 ft^3/s during the period from October 2015 to September 2016, with an annual mean flow of 1,570 ft^3/s (fig. 12). Salinity ranged from 0.3 to 28.9 ppt, with a median of 6.9 ppt and mean of 8.2 ppt over this same period (fig. 13). Comparison of historical annual mean tidally filtered flows indicates that the 2016 streamflow is at the 13th percentile; the median tidally filtered flow for the period of record is 5,380 ft^3/s (fig. 14). Annual mean tidally filtered streamflow record was used from 1996 onward because of data-collection gaps in the historical data prior to 1996.

Julington Creek at Old St. Augustine Road Near Bayard, Florida

Daily tidally filtered discharge at Julington Creek ranged from −10.6 to 197 ft^3/s during the period from October 2015 to September 2016, with an annual mean flow of 23.5 ft^3/s (fig. 15). Multiple small rises in discharge occurred during the period as a result of rainfall, but the tidally filtered flows remained below 50 ft^3/s for most of the period because of the rapid recessions.

Julington Creek at Hood Landing Near Bayard, Florida

The salinity at Julington Creek at Hood Landing ranged from 0.1 to 4.0 ppt, with a median of 0.2 ppt and mean of 0.5 ppt during the period from October 2015 to

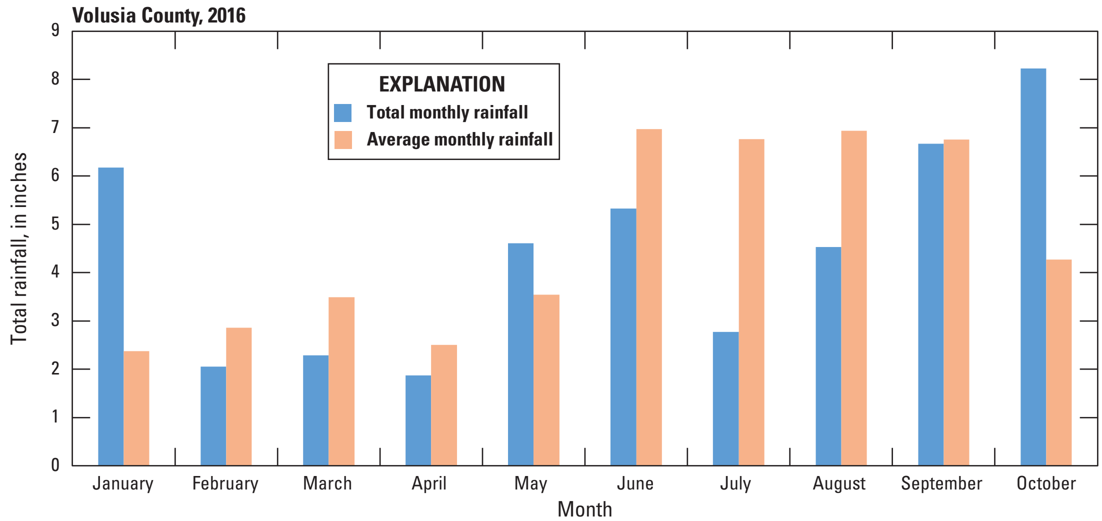

Figure 3. Monthly rainfall for Volusia County (SJRWMD, 2017).

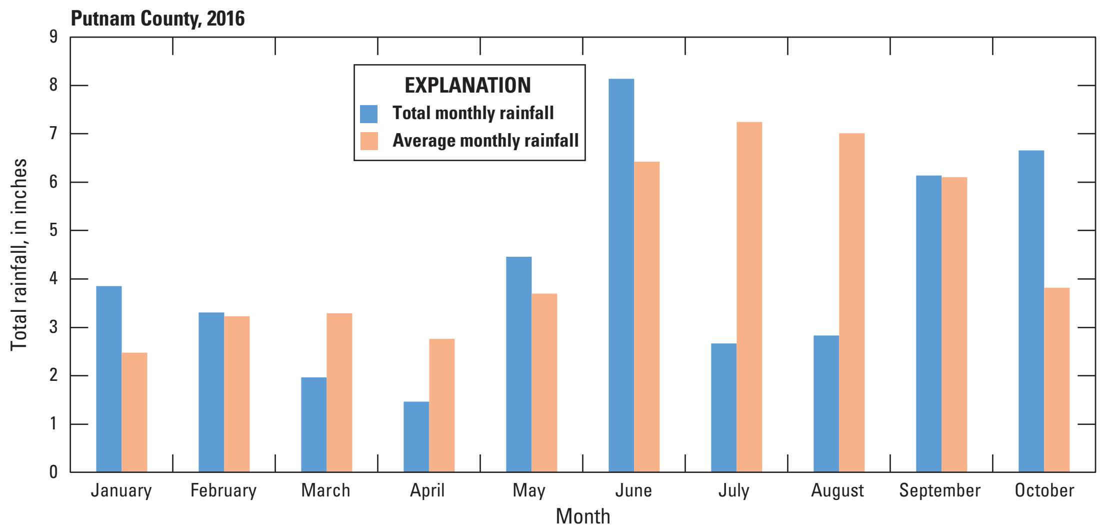

Figure 4. Monthly rainfall for Putnam County (SJRWMD, 2017).

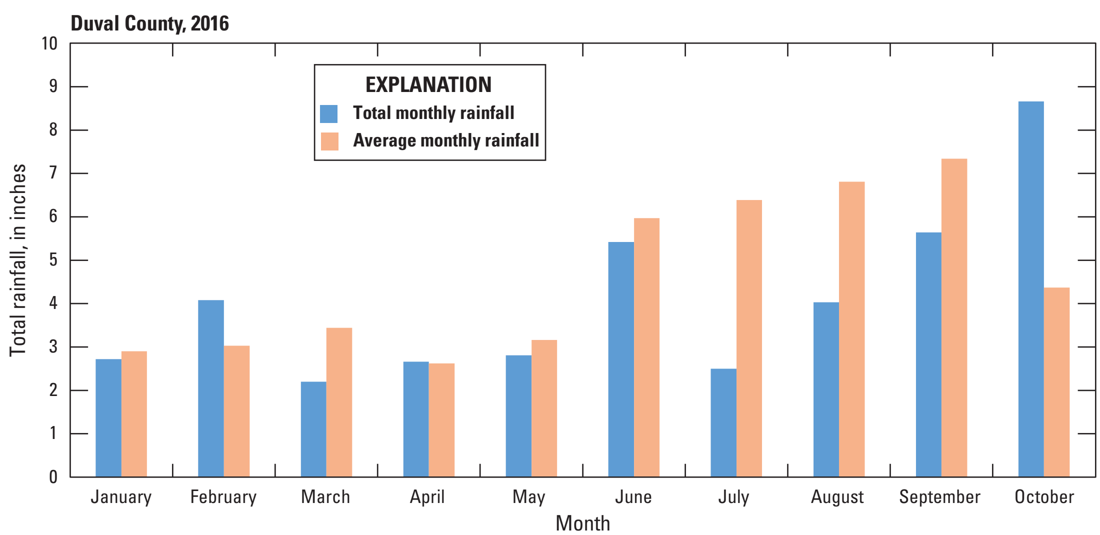

Figure 5. Monthly rainfall for Duval County (SJRWMD, 2017).

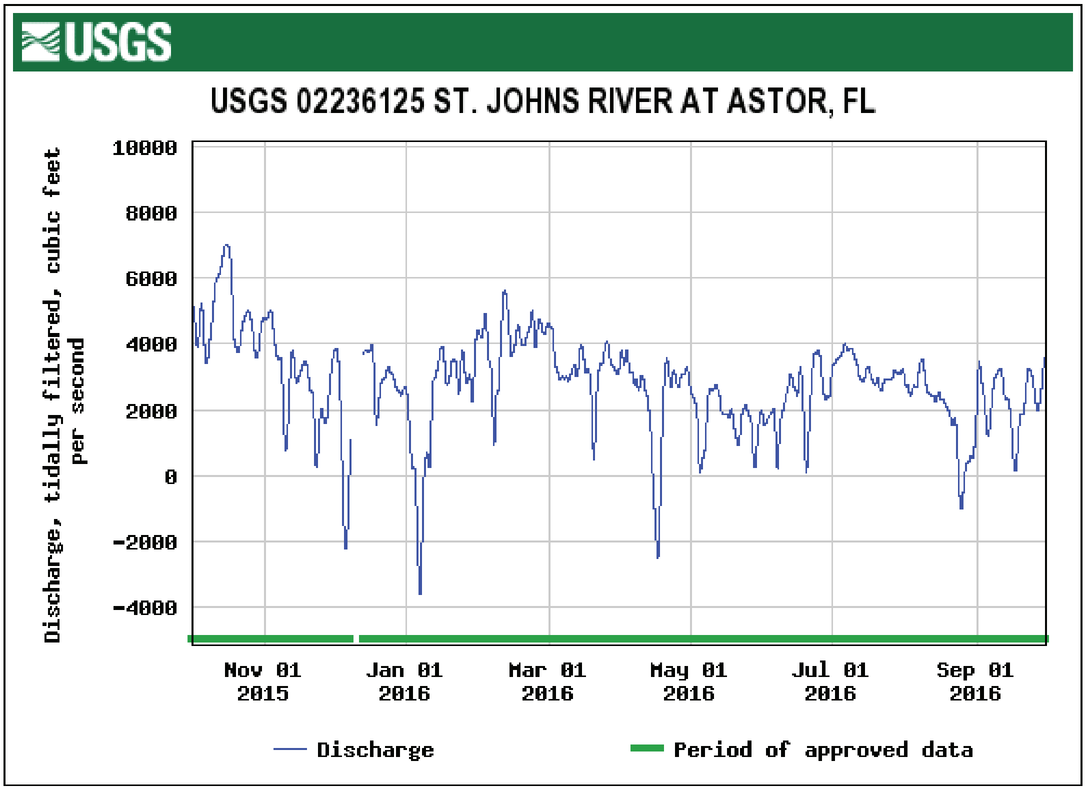

Figure 6. Daily tidally filtered discharge for St. Johns River at Astor, Florida.

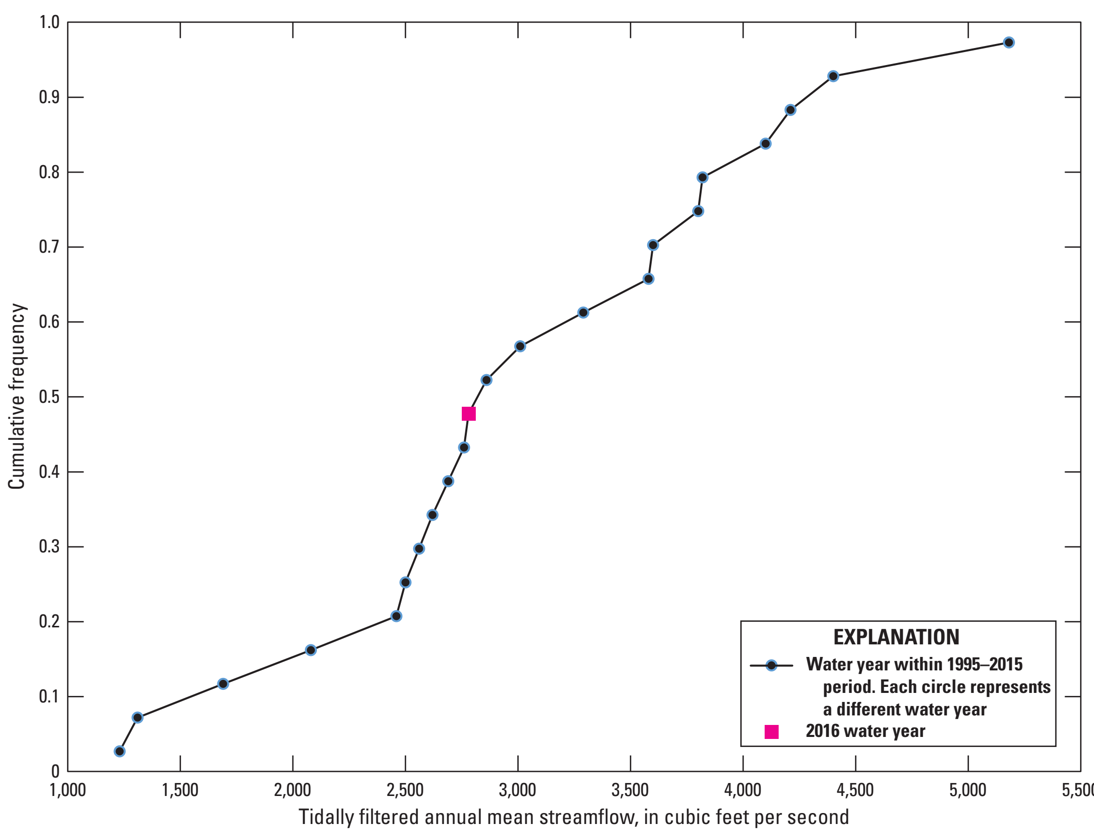

Figure 7. Annual mean tidally filtered streamflow at St. Johns River at Astor, Florida.

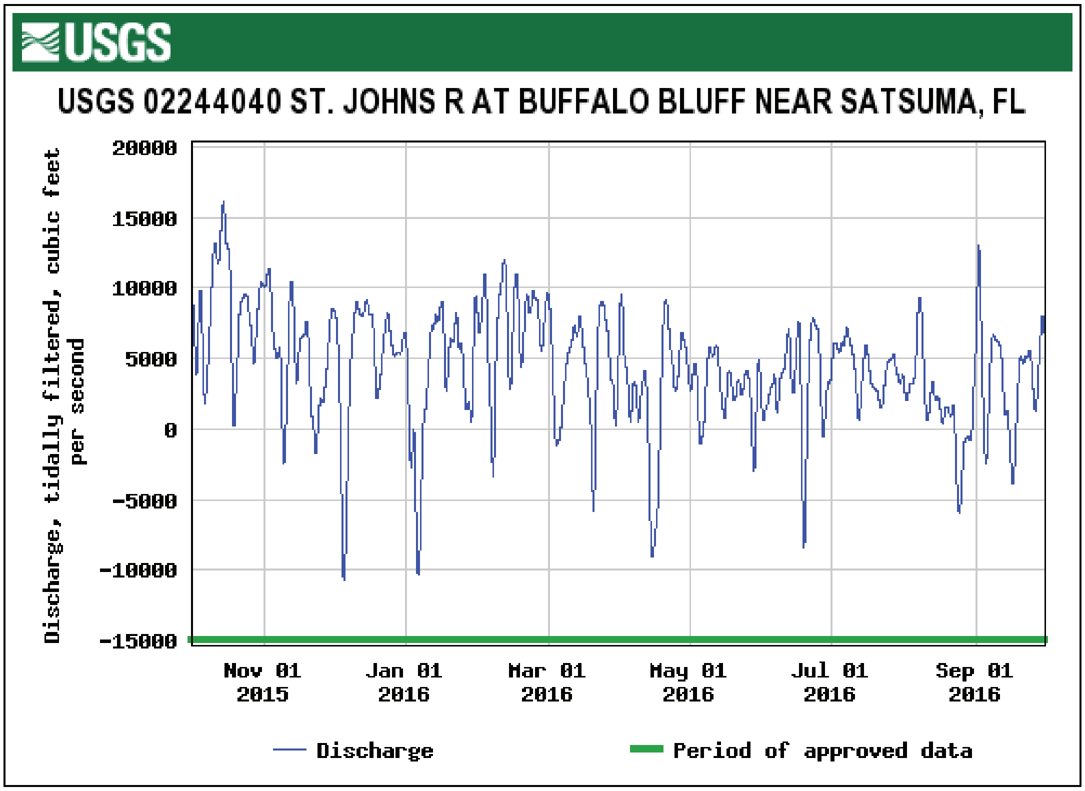

Figure 8. Daily tidally filtered discharge for St. Johns River at Buffalo Bluff near Satsuma, Florida.

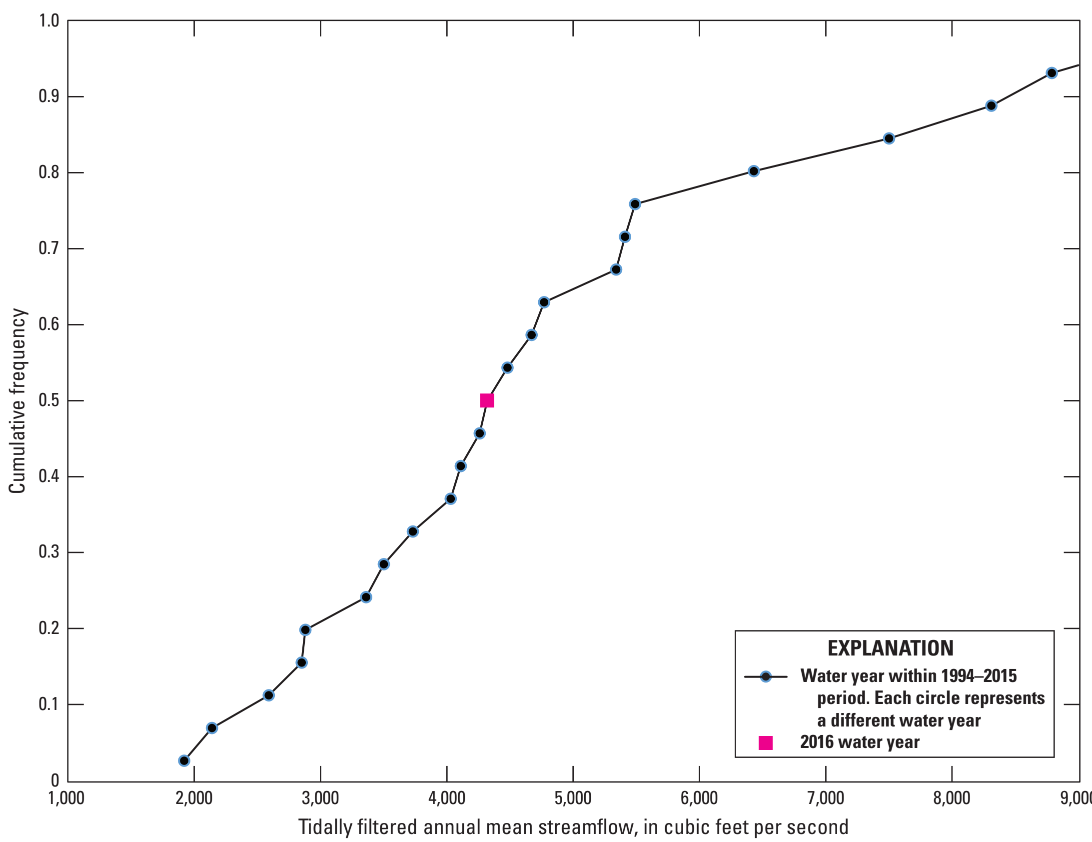

Figure 9. Annual mean tidally filtered streamflow at St. Johns River at Buffalo Bluff near Satsuma, Florida.

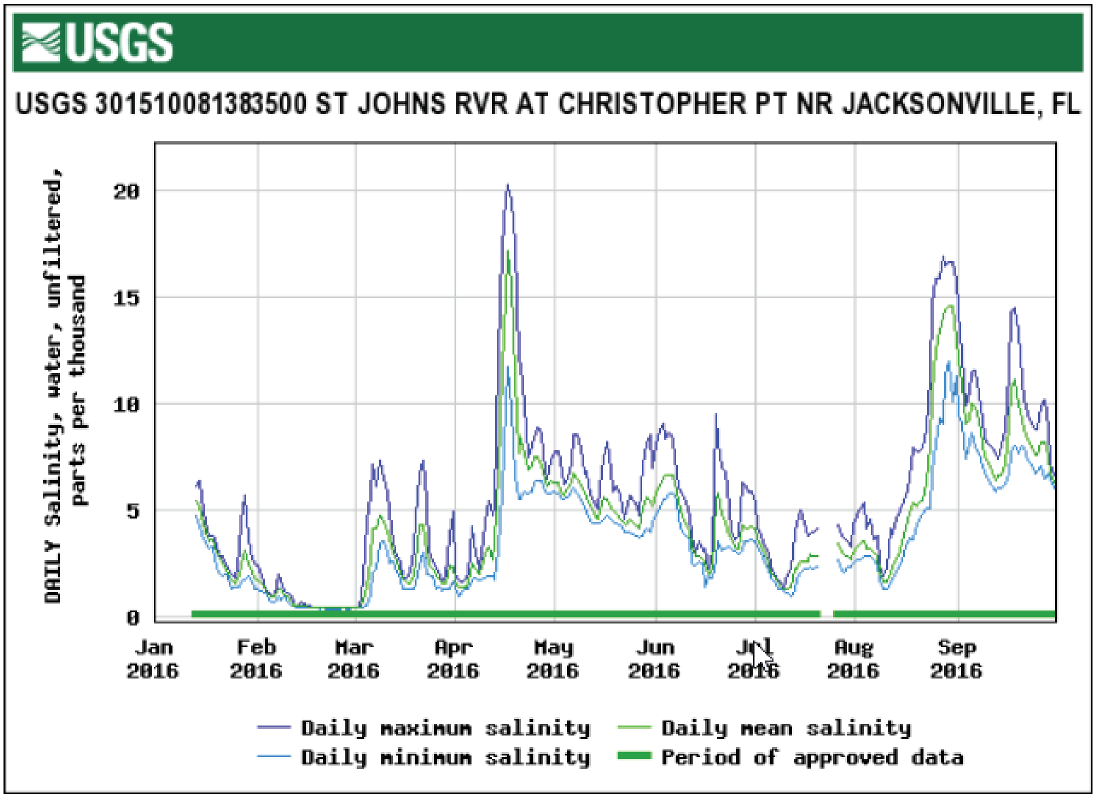

Figure 10. Daily maximum, minimum, and mean salinity for St. Johns River at Christopher Point near Jacksonville, Florida.

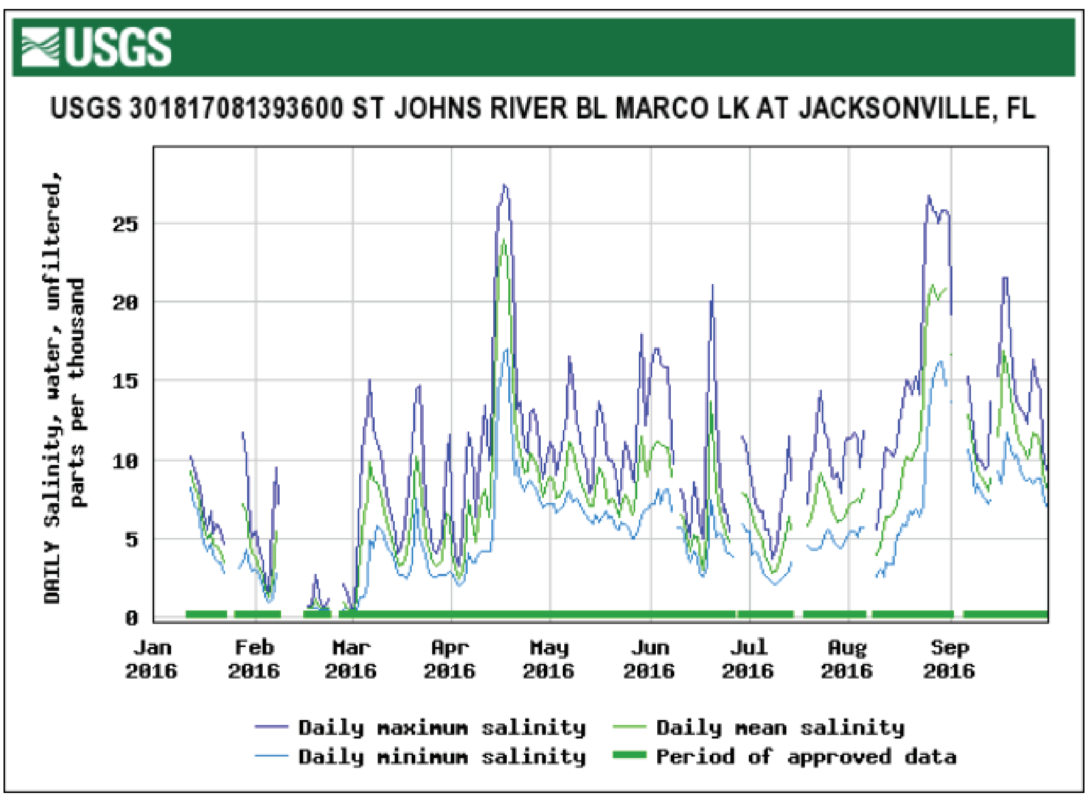

Figure 11. Daily maximum, minimum, and mean salinity for St. Johns River below Marco Lake at Jacksonville, Florida.

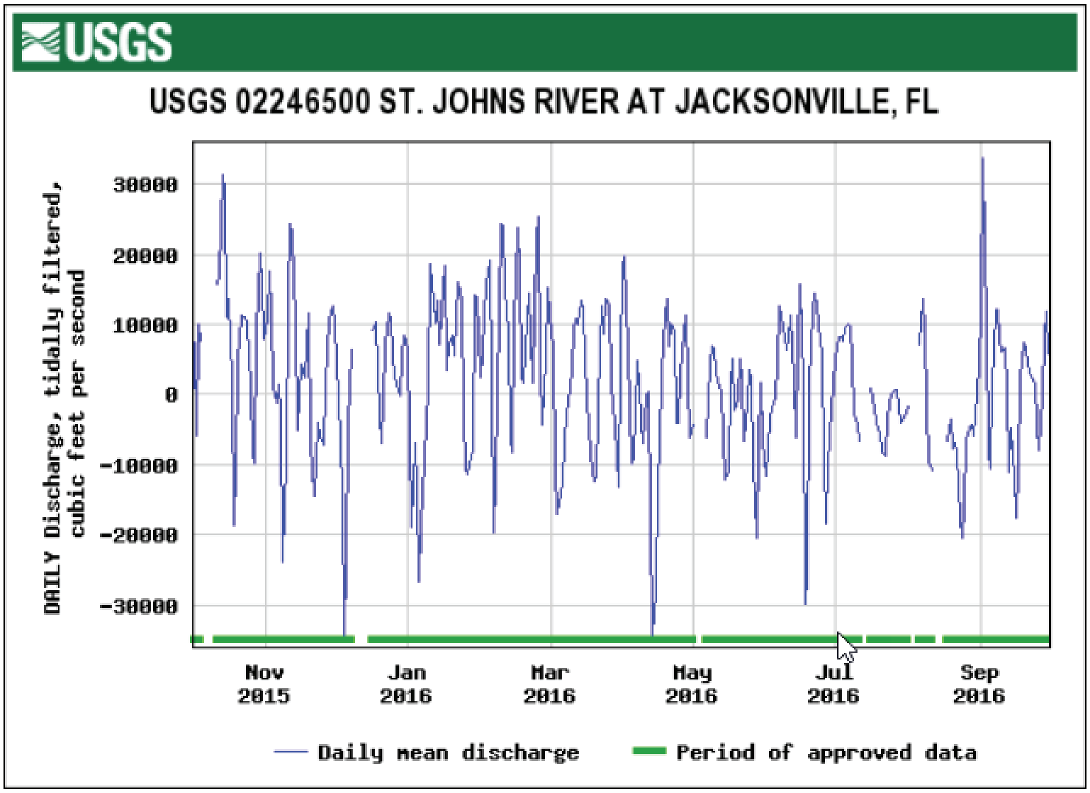

Figure 12. Daily tidally filtered discharge for St. Johns River at Jacksonville, Florida.

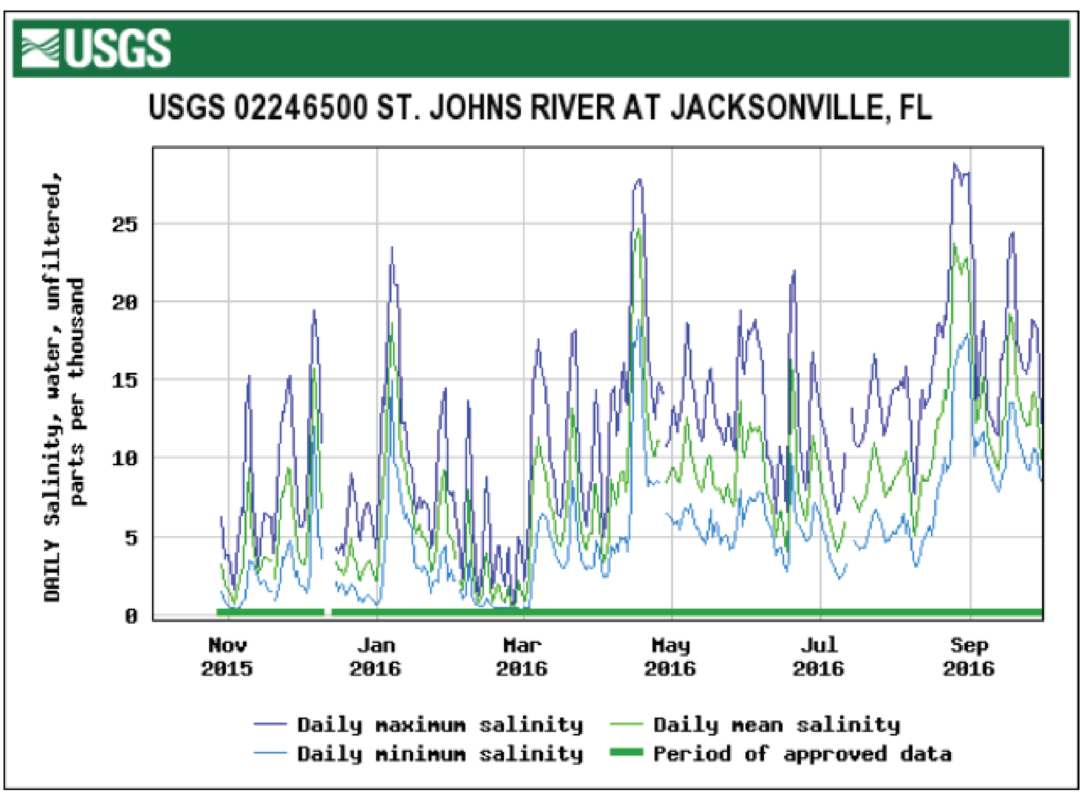

Figure 13. Daily maximum, minimum, and mean salinity for St. Johns River at Jacksonville, Florida.

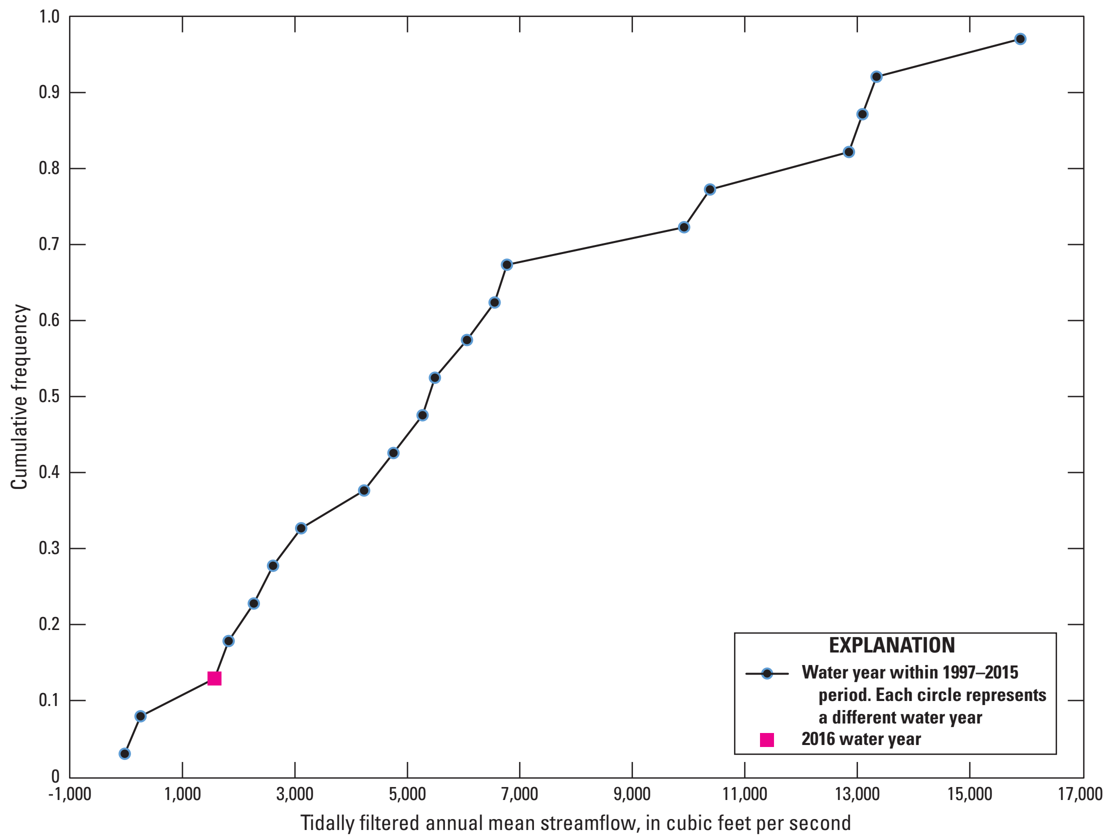

Figure 14. Annual mean tidally filtered streamflow at St. Johns River at Jacksonville, Florida.

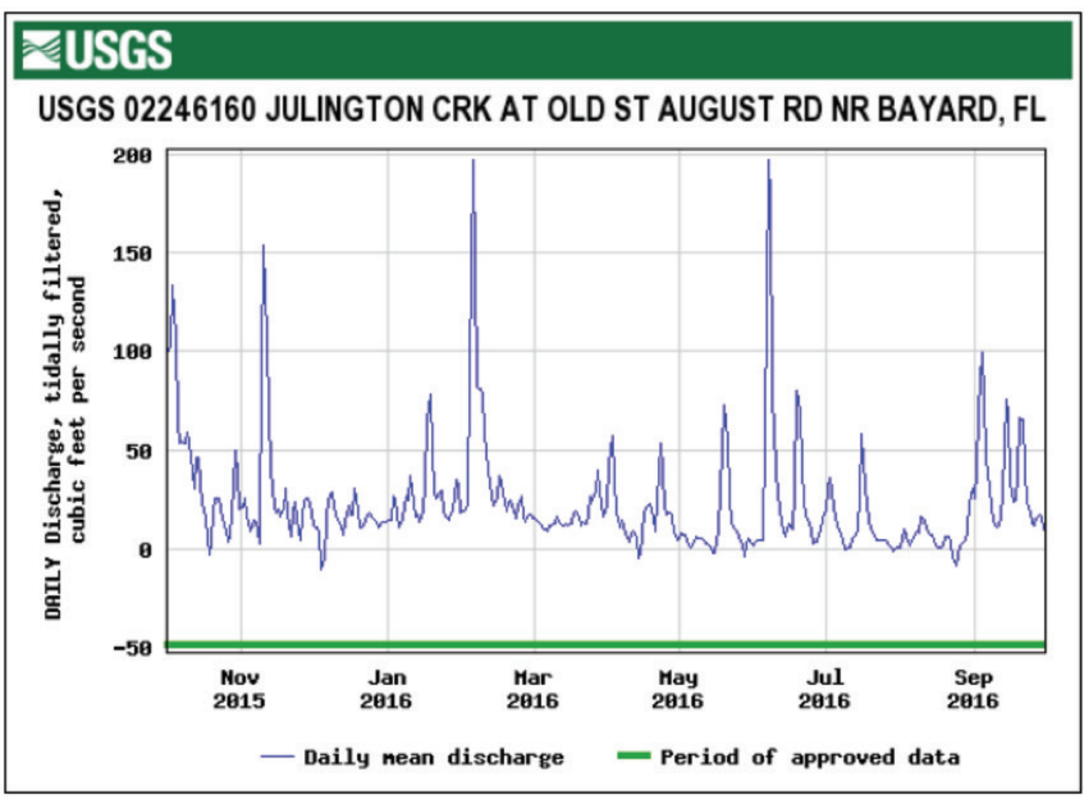

Figure 15. Daily tidally filtered discharge for Julington Creek at Old St. Augustine Road near Bayard, Florida.

September 2016 (fig. 16). The salinity increased above 0.5 ppt during two extended periods between April–May 2016 and August–September 2016. The salinity decreased when flow increased through Julington Creek, which is most likely attributed to freshwater from rainfall.

Durbin Creek Near Fruit Cove, Florida

Daily tidally filtered discharge at Durbin Creek ranged from −42 to 210 ft^3/s, with an annual mean of 22.5 ft^3/s during the period from October 2015 to September 2016 (fig. 17). Salinity ranged from 0.1 to 0.6 ppt, with a median and mean of 0.1 ppt over this period (fig. 18). Daily tidal fluctuations were observed in the salinity values.

Ortega River at Kirwin Road Near Jacksonville, Florida

Daily discharge for Ortega River ranged from 4.7 to 601 ft^3/s from October 2015 to September 2016, with an annual mean of 40.9 ft^3/s (fig. 19). Discharge exceeded 10 ft^3/s most of the year, except during low-flow periods in May, July, and September.

Ortega River Salinity at Jacksonville, Florida

The salinity at Ortega River ranged from 0.0 to 10.2 ppt, with a median of 0.1 ppt and mean of 0.4 ppt during the period from October 2015 to September 2016 (fig. 20). The highest salinity values were observed in May and September during periods of low discharge in Ortega River.

Cedar River at San Juan Avenue at Jacksonville, Florida

Daily tidally filtered discharge at Cedar River ranged from −66 to 498 ft^3/s, with an annual mean flow of 23.7 ft^3/s during the period from October 2015 to September 2016 (fig. 21). Salinity ranged from 0.1 to 17.2 ppt, with a median of 1.4 ppt and mean of 2.8 ppt (fig. 22). Salinity peaked above 10 ppt three times during periods of low flow and rainfall (fig. 5).

Pottsburg Creek Near South Jacksonville, Florida

Daily discharge for Pottsburg Creek at Bowden Road ranged from 3.0 to 246 ft^3/s from September 2015 to September 2016, with an annual mean flow of 14.7 ft^3/s (fig. 23). Multiple rises in discharge exceeding 100 ft^3/s occurred during this period, followed by sharp recessions as a result of the relatively small drainage area.

Pottsburg Creek at U.S. 90 Near South Jacksonville, Florida

Daily tidally filtered discharge at Pottsburg Creek at U.S. 90 ranged from −13 to 194 ft^3/s, with an annual mean flow of 16.5 ft^3/s during the period from November 2015 to September 2016 (fig. 24). Salinity ranged from 0.1 to 11.9 ppt, with a median of 0.5 ppt and mean of 1.3 ppt during the period from October 2015 to September 2016 (fig. 25). No major flow events occurred during the period, and peak salinity exceeded 10 ppt during parts of April, August, and September during periods of below average freshwater flow.

Trout River Near Jacksonville, Florida

Daily tidally filtered discharge at Trout River ranged from −228 to 810 ft^3/s from January to September 2016 (fig. 26). Noticeable discharge rises occurred in early February and mid-April during periods of above average rainfall in Duval County. Prolonged periods of negative flow occurred during periods of low rainfall, especially in July and August (fig. 5).

Trout River Below U.S. 1 at Dinsmore, Florida

The salinity at Trout River below U.S. 1 ranged from 0.0 to 12.1 ppt, with a median of 4.8 ppt and mean of 4.4 ppt during the period from January to September 2016 (fig. 27). Daily mean salinity remained above 5 ppt, except from January to April and during part of September when rainfall lowered the salinity in the river (fig. 5).

Broward River Below Biscayne Blvd. Near Jacksonville, Florida

Daily tidally filtered discharge at Broward River ranged from −26 to 289 ft^3/s, with an annual mean flow of 17.3 ft^3/s during the period from October 2015 to September 2016 (fig. 28). Salinity ranged from 0.0 to 17.2 ppt, with a median of 1.9 ppt and mean of 2.7 ppt (fig. 29). Discharge was relatively consistent during the period, with two peaks of daily tidally filtered discharge exceeding 200 ft^3/s (fig. 28). Increases in salinity occur during periods of low rainfall, and as freshwater flows increase, salinity decreases, as observed in early November (fig. 5).

Dunn Creek at Dunn Creek Road Near Eastport, Florida

Daily tidally filtered discharge at Dunn Creek ranged from −6.8 to 84 ft^3/s during the period from January 2016 to September 2016 (fig. 30). Salinity ranged from 0.1 to 18.3 ppt, with a median of 2.4 ppt and mean of 3.1 ppt over this period (fig. 31). Increases in salinity occur during periods of low rainfall, and as freshwater flows increase, salinity decreases, as observed in mid-May and early August (fig. 5).

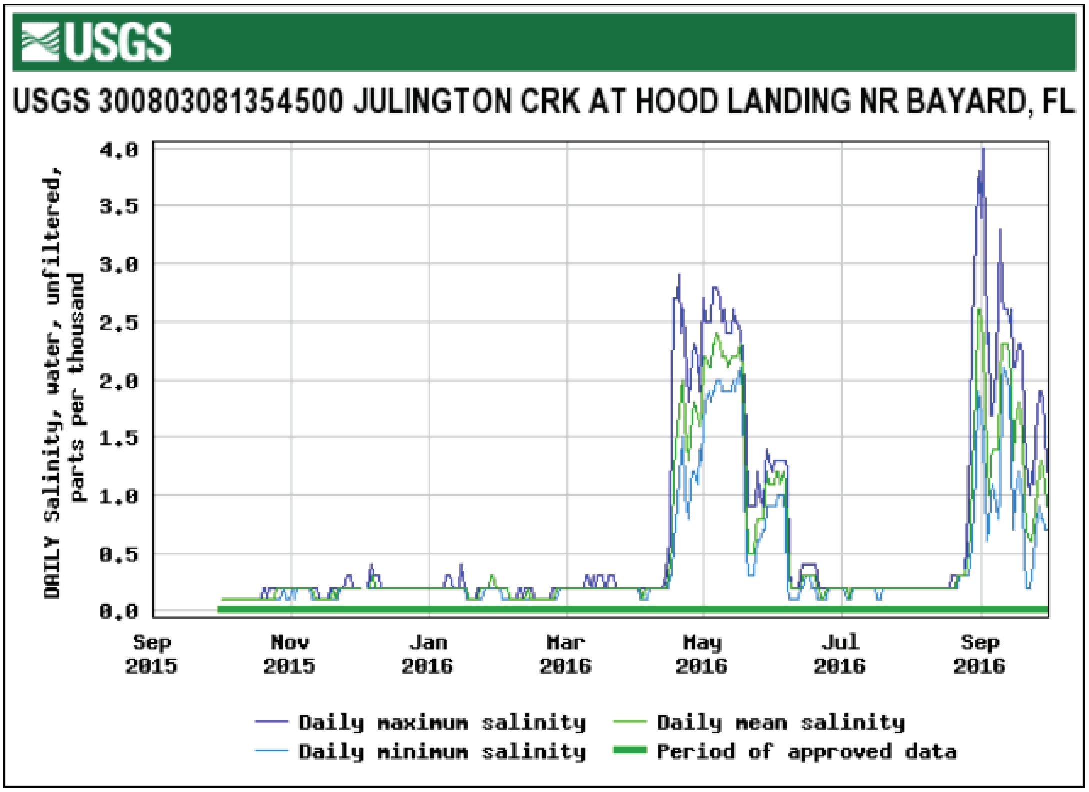

Figure 16. Daily maximum, minimum, and mean salinity for Julington Creek at Hood Landing near Bayard, Florida.

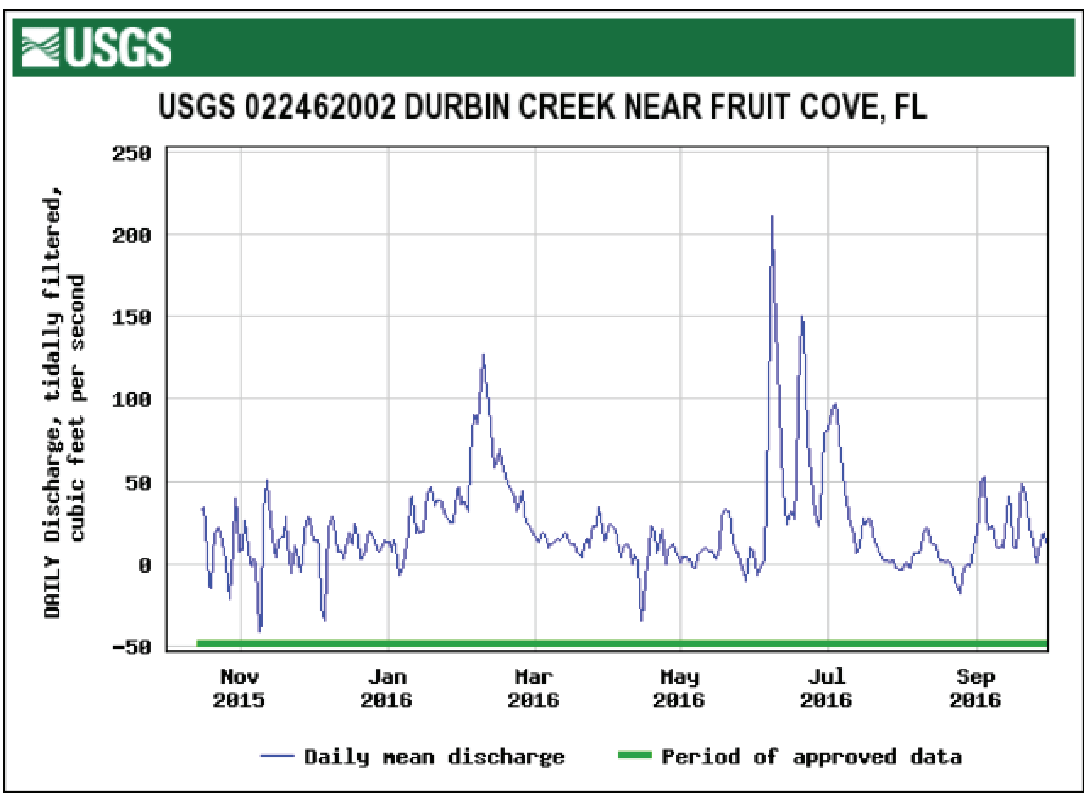

Figure 17. Daily tidally filtered discharge for Durbin Creek near Fruit Cove, Florida.

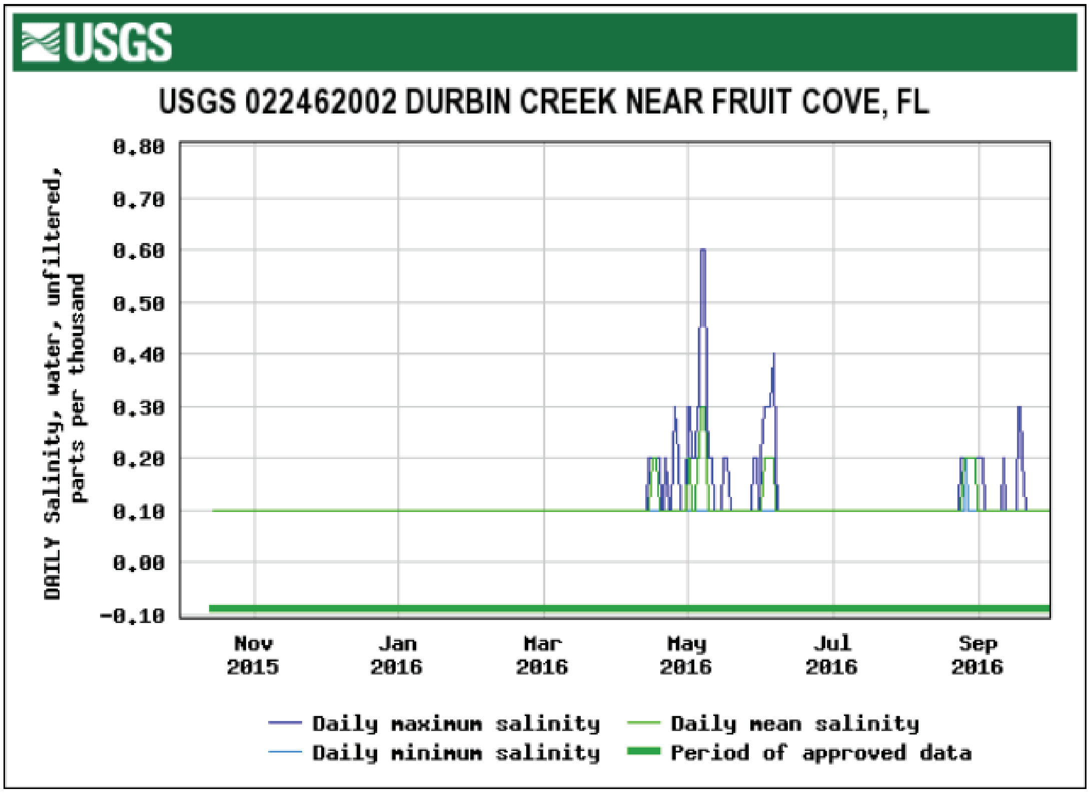

Figure 18. Daily maximum, minimum, and mean salinity for Durbin Creek near Fruit Cove, Florida.

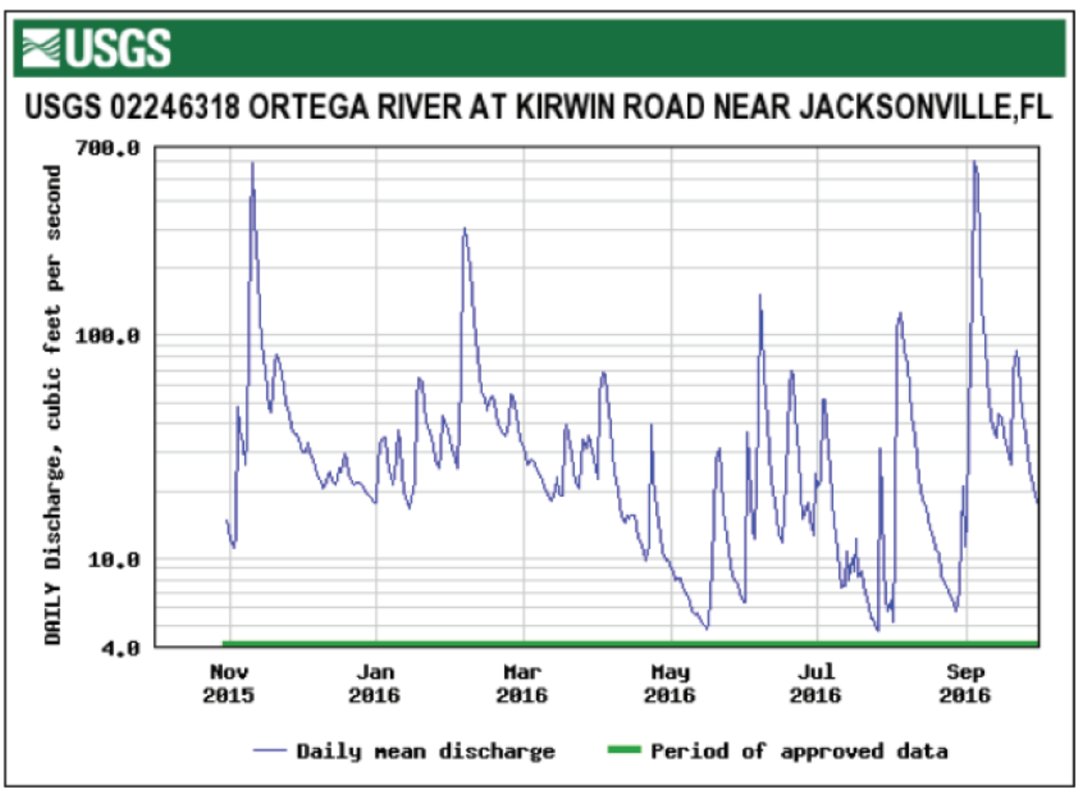

Figure 19. Daily discharge for Ortega River at Kirwin Road near Jacksonville, Florida.

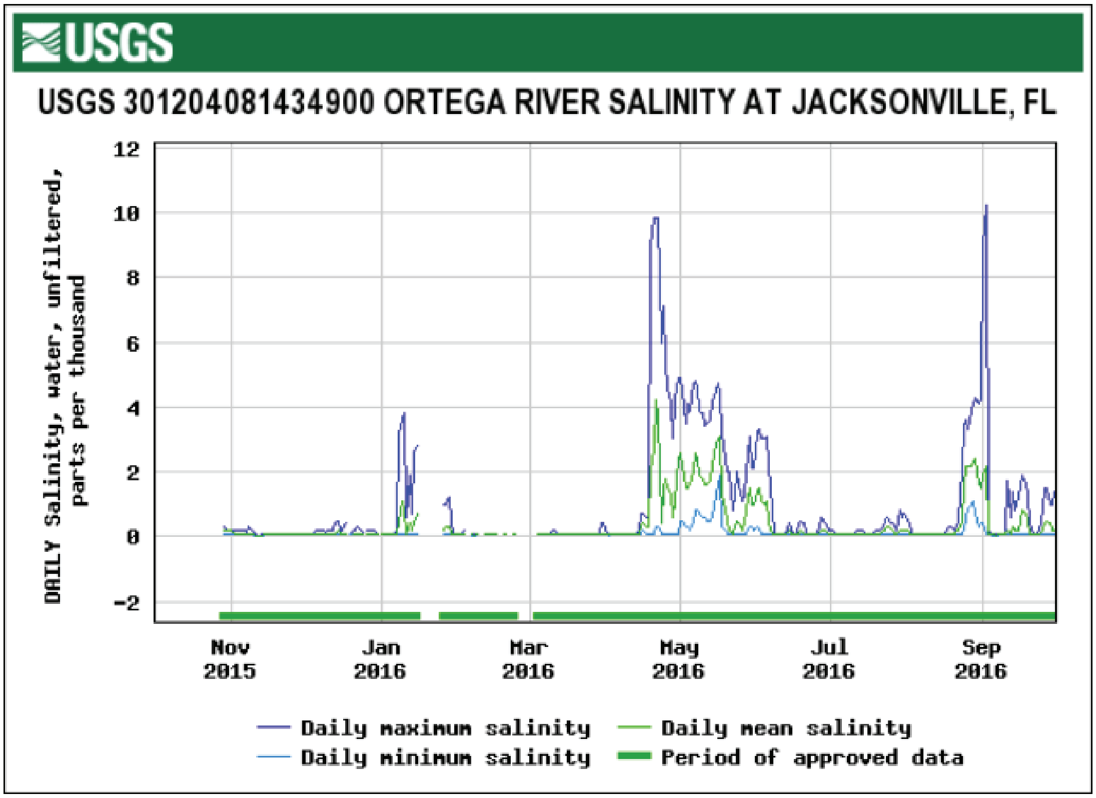

Figure 20. Daily maximum, minimum, and mean salinity for Ortega River salinity at Jacksonville, Florida.

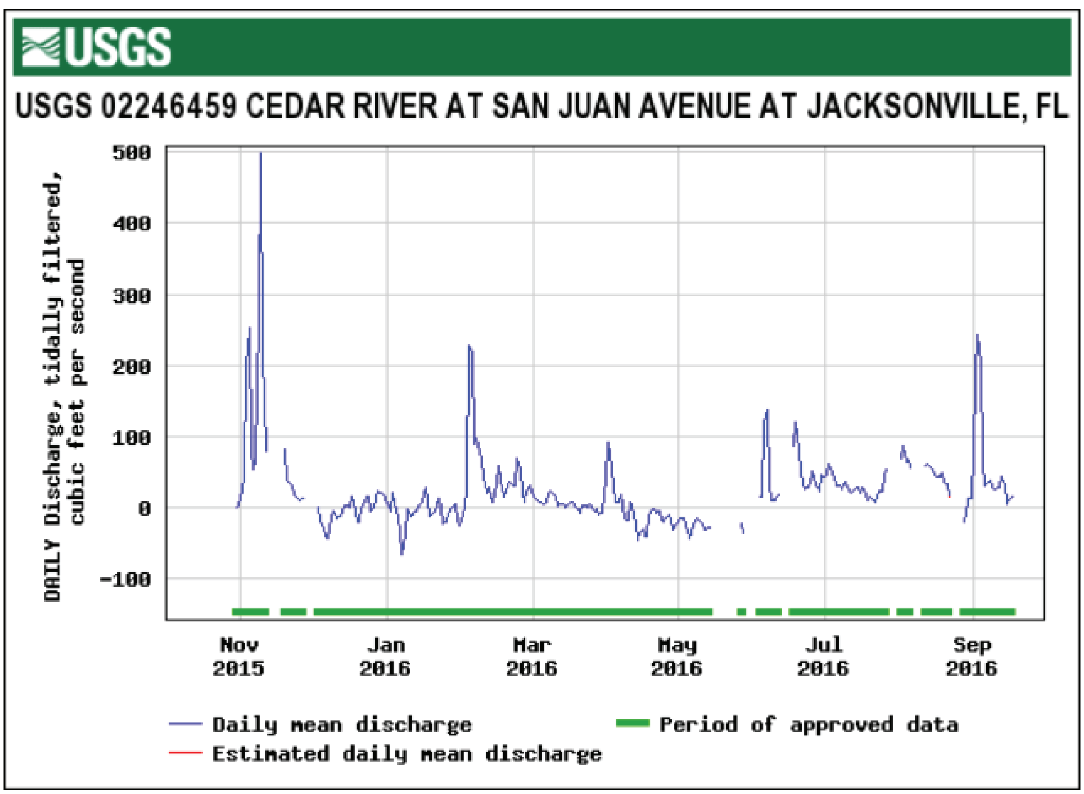

Figure 21. Daily tidally filtered discharge for Cedar River at San Juan Avenue at Jacksonville, Florida.

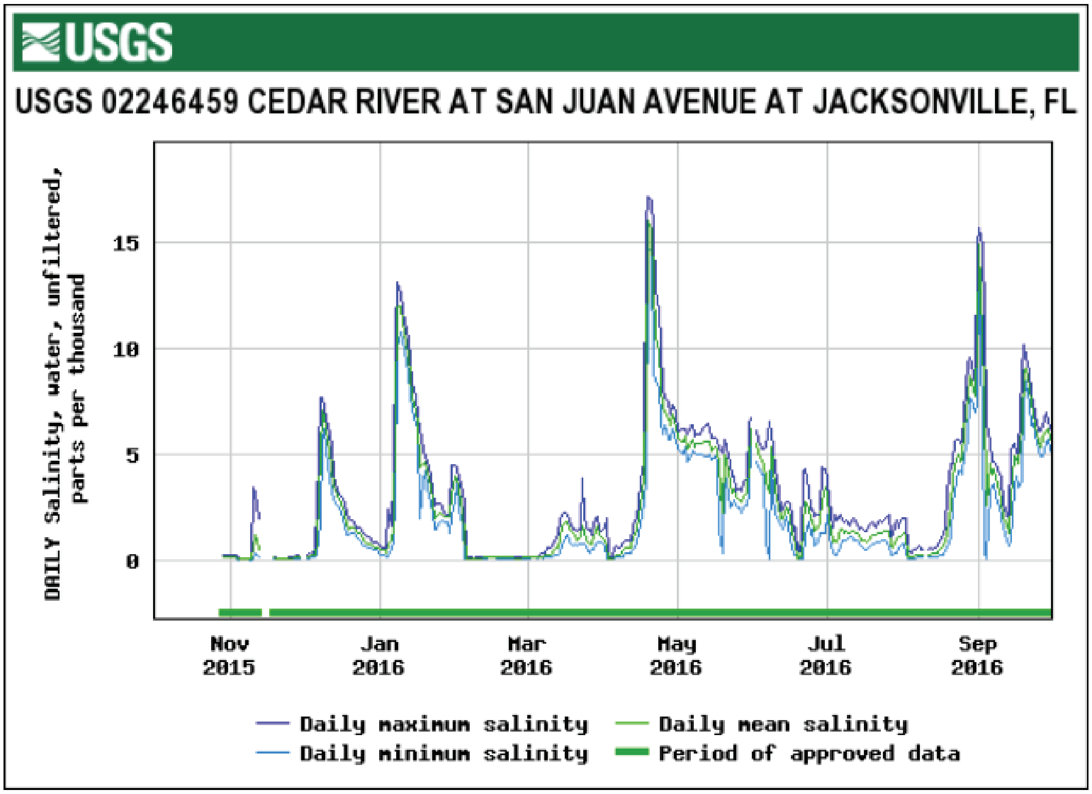

Figure 22. Daily maximum, minimum, and mean salinity for Cedar River at San Juan Avenue at Jacksonville, Florida.

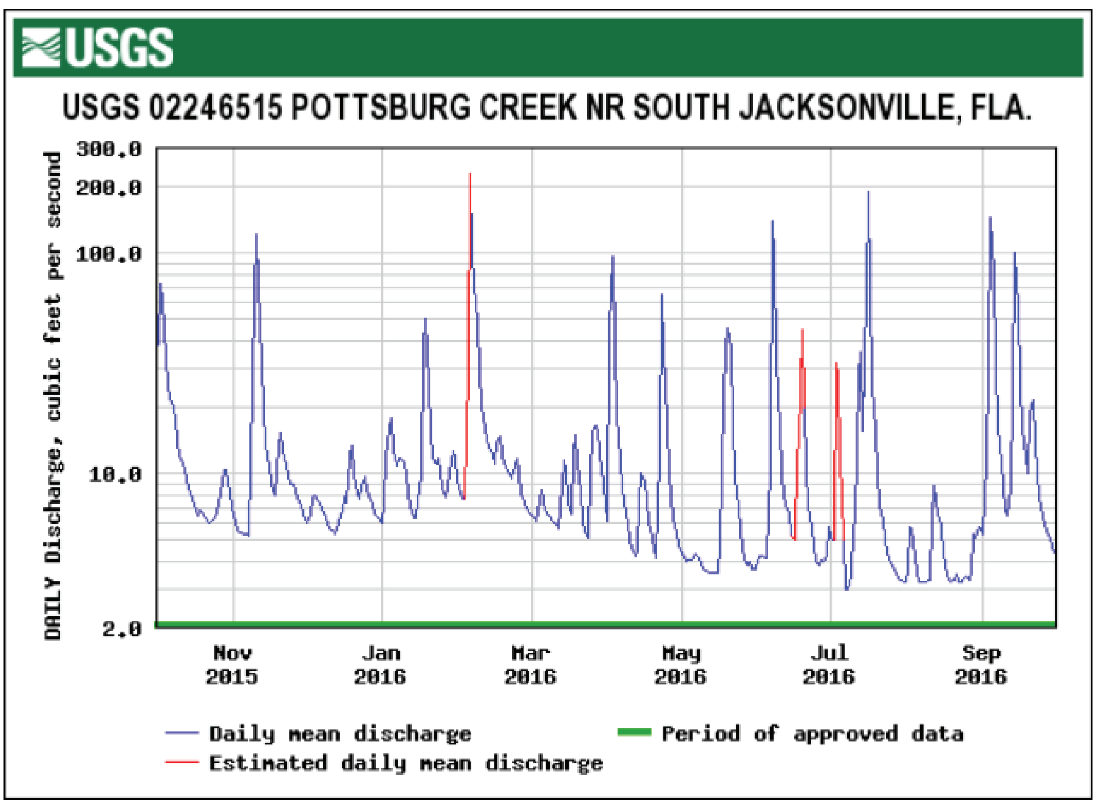

Figure 23. Daily discharge for Pottsburg Creek near South Jacksonville, Florida.

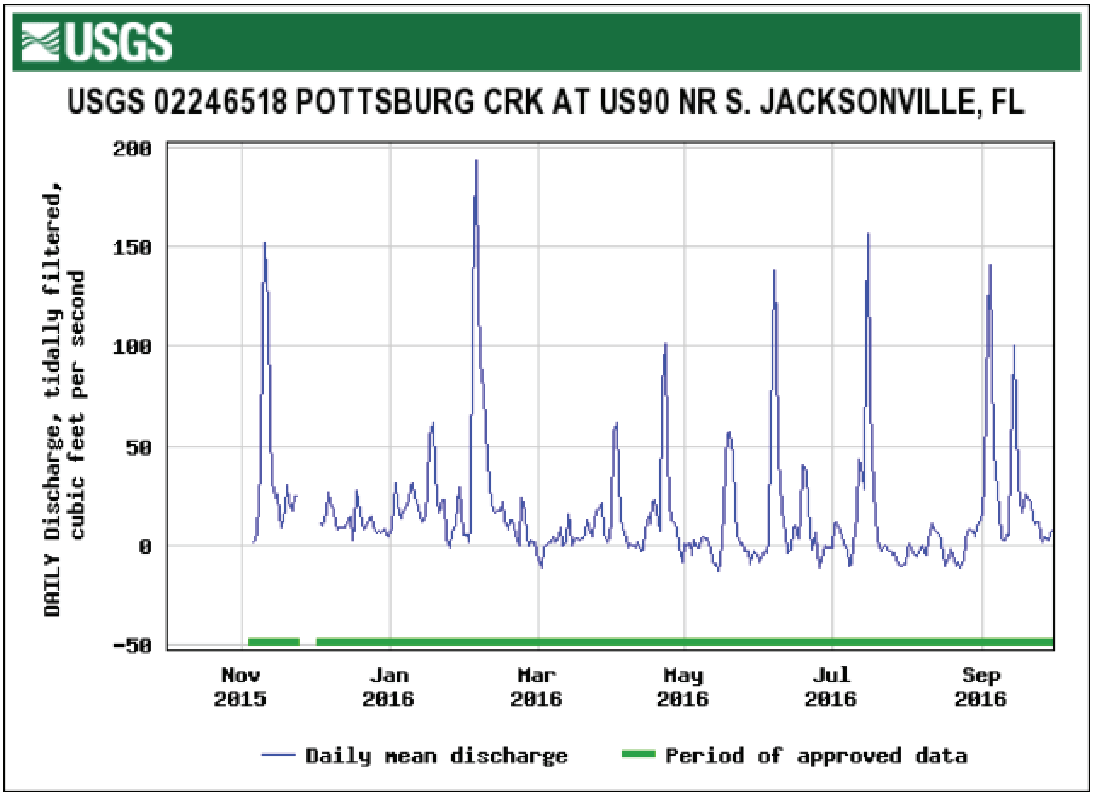

Figure 24. Daily tidally filtered discharge for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

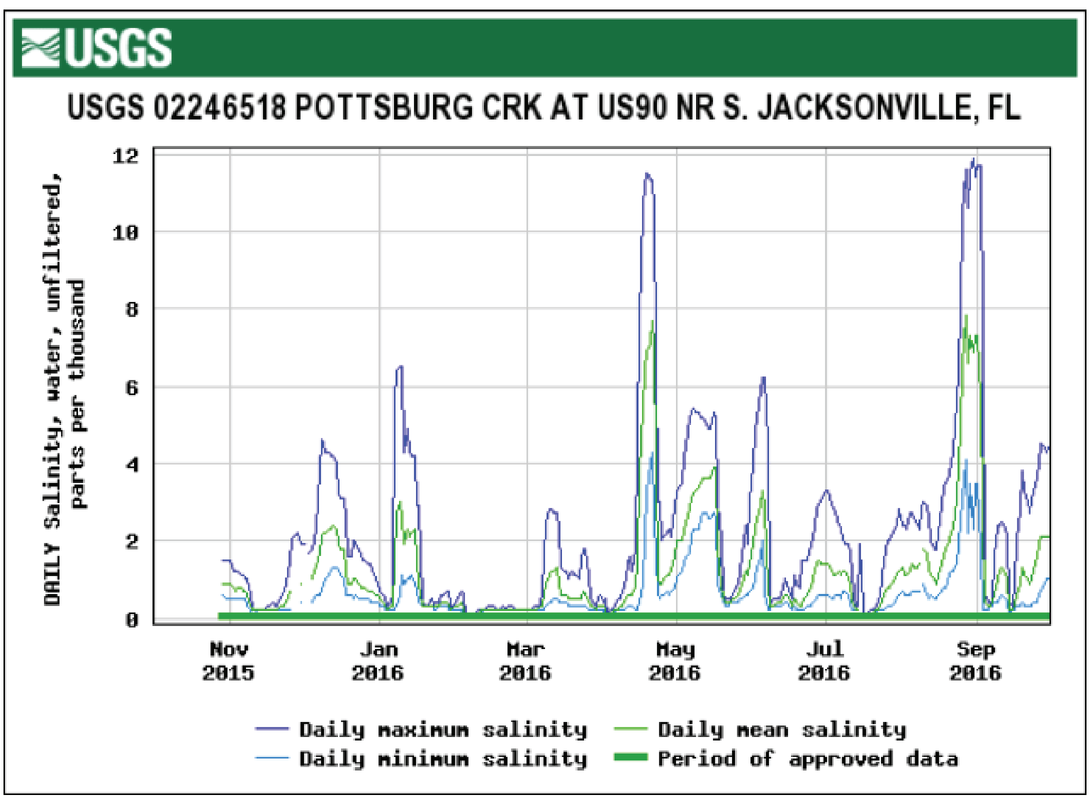

Figure 25. Daily maximum, minimum, and mean salinity for Pottsburg Creek at U.S. 90 near South Jacksonville, Florida.

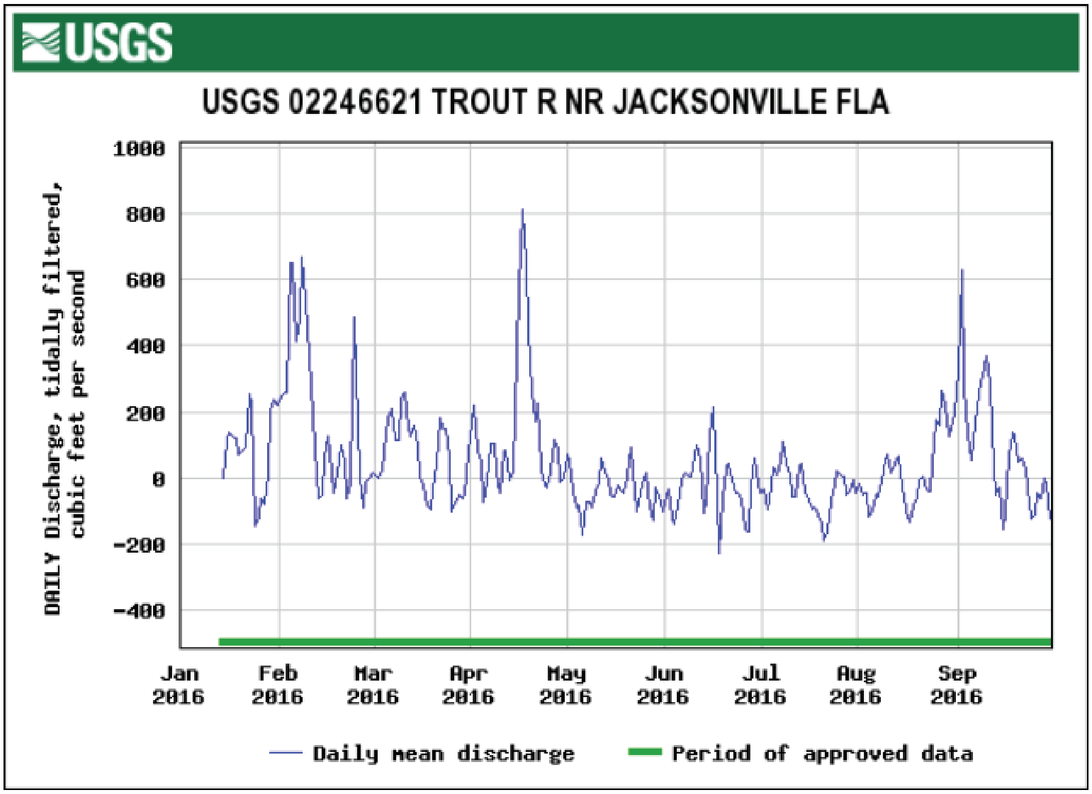

Figure 26. Daily tidally filtered discharge for Trout River near Jacksonville, Florida.

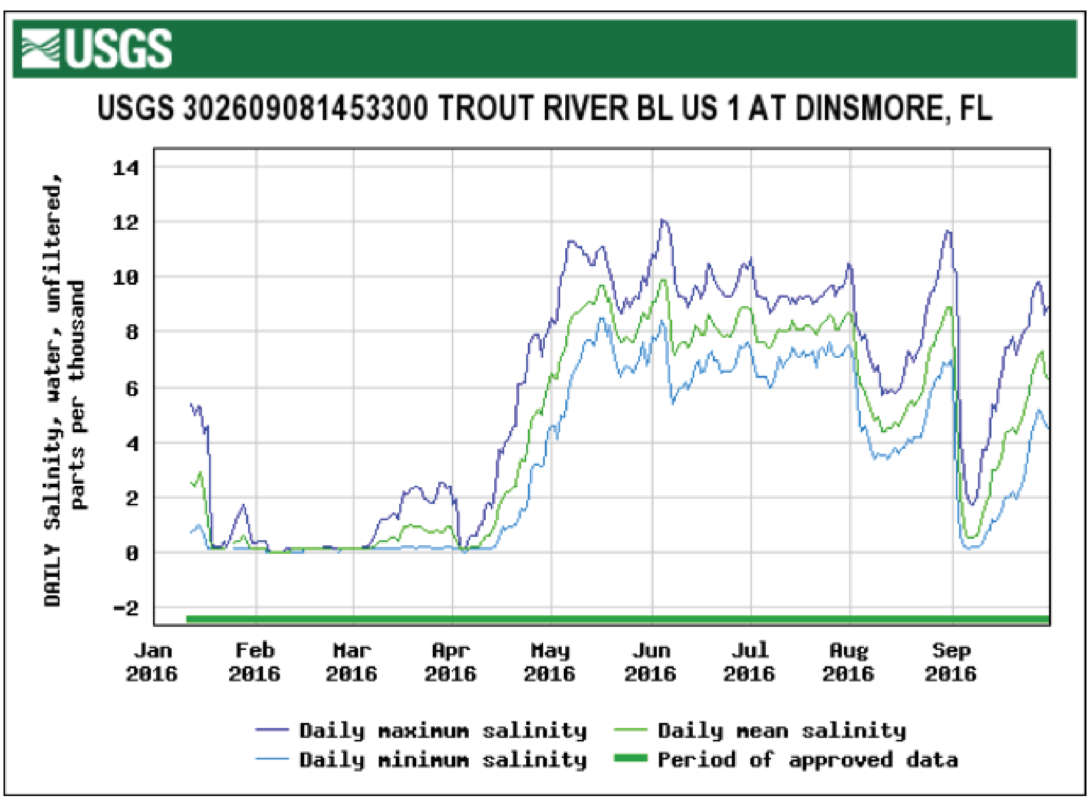

Figure 27. Daily maximum, minimum, and mean salinity for Trout River below U.S. 1 at Dinsmore, Florida.

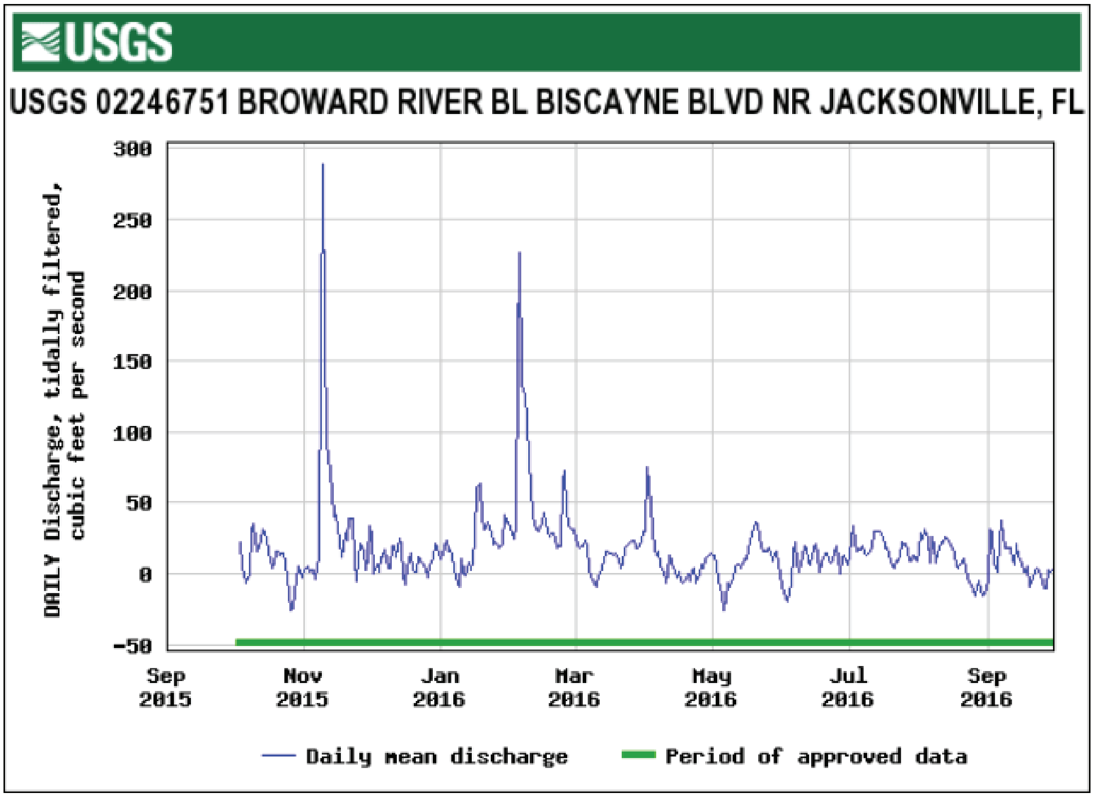

Figure 28. Daily tidally filtered discharge for Broward River below Biscayne Blvd. near Jacksonville, Florida.

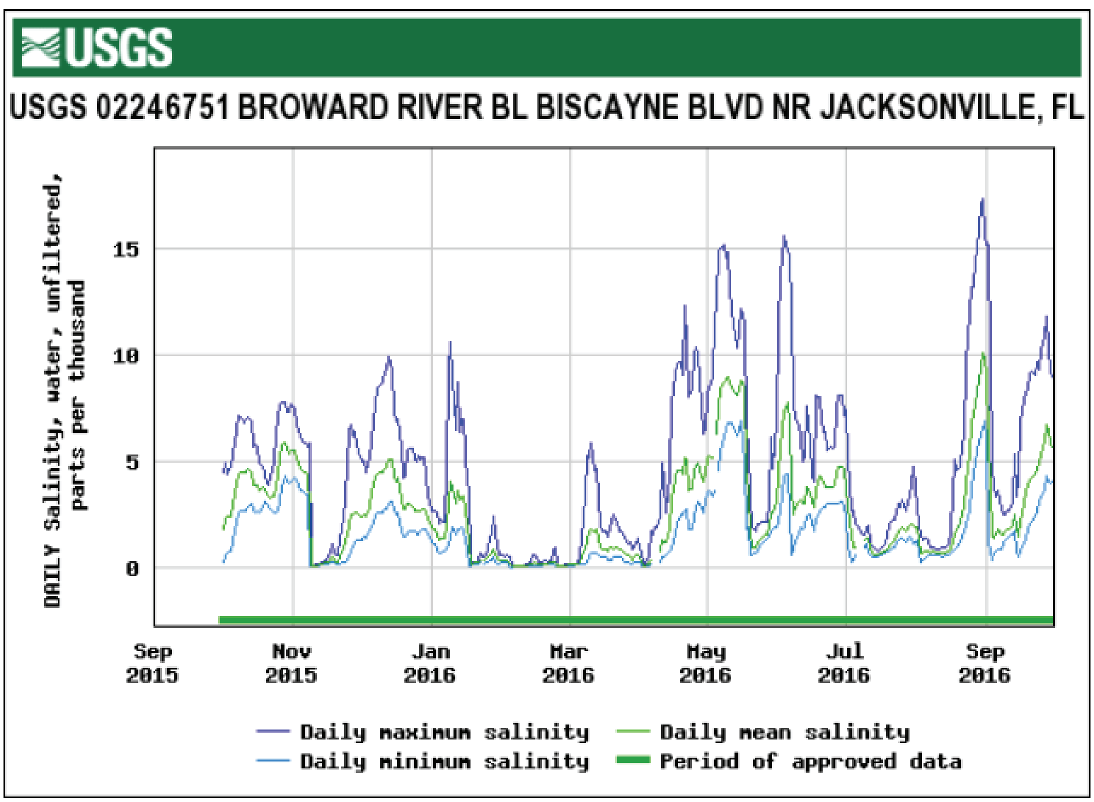

Figure 29. Daily maximum, minimum, and mean salinity for Broward River below Biscayne Blvd. near Jacksonville, Florida.

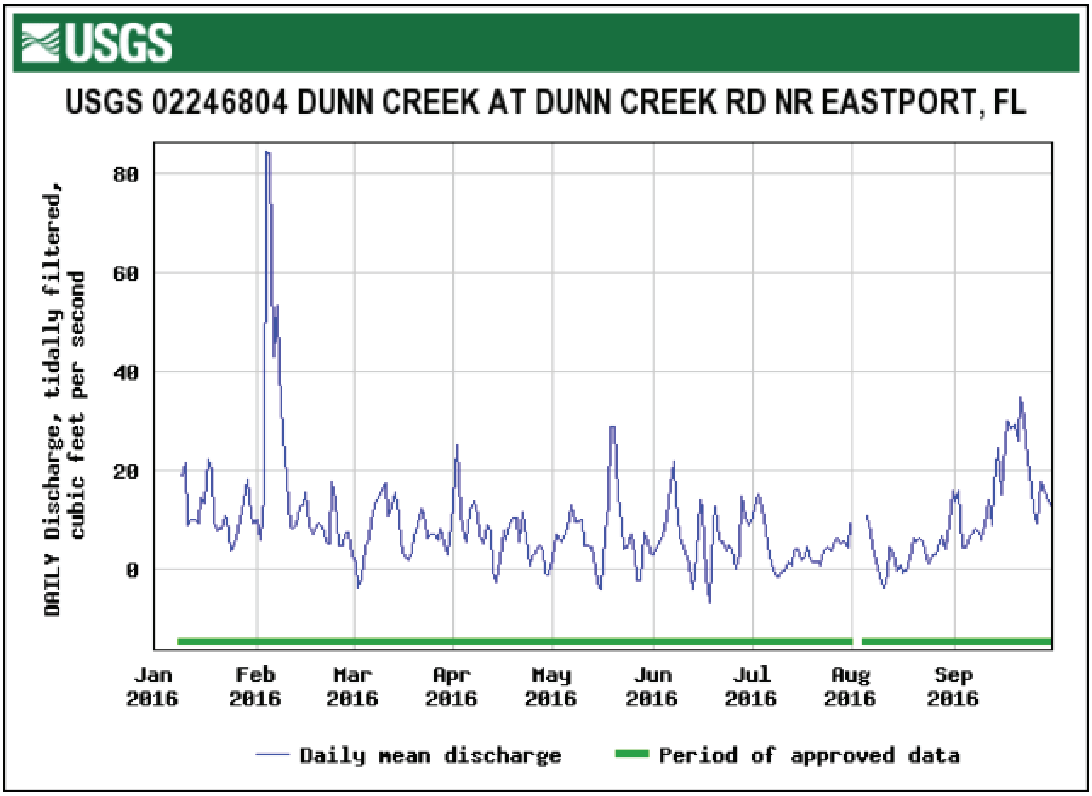

Figure 30. Daily tidally filtered discharge for Dunn Creek at Dunn Creek Road near Eastport, Florida.

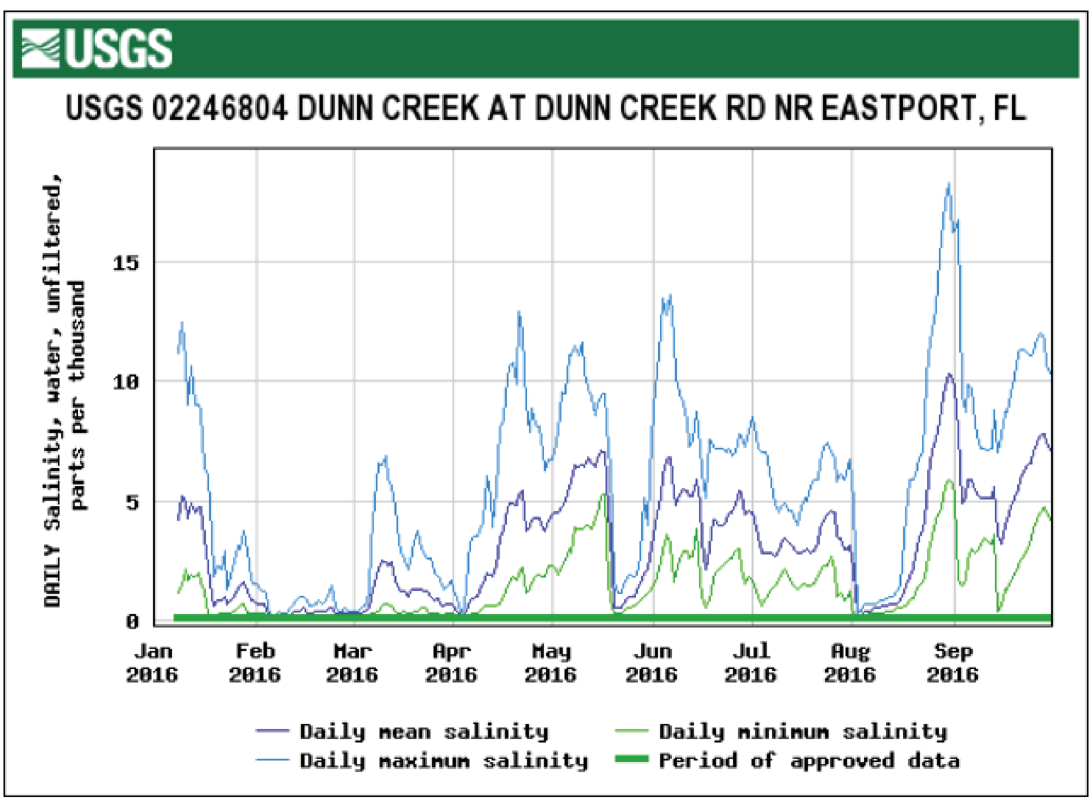

Figure 31. Daily maximum, minimum, and mean salinity for Dunn Creek at Dunn Creek Road near Eastport, Florida.

Clapboard Creek Near Jacksonville, Florida

Daily tidally filtered discharge at Clapboard Creek ranged from −129 to 256 ft^3/s, with an annual mean flow of 1.7 ft^3/s during the period from October 2015 to September 2016 (fig. 32). Negative daily tidally filtered discharge occurred every month.

Clapboard Creek Above Buckhorn Bluff Near Jacksonville, Florida

Salinity at Clapboard Creek ranged from 4.2 to 33.8 ppt, with a median of 23.4 ppt and mean of 22.6 ppt during the period from January to September 2016 (fig. 33). Rainfall in the drainage area decreases salinity, such as during February 2016 when rainfall in Duval County was 1 in. above average and salinity was at a minimum (fig. 5).

Hurricane Matthew

The most notable hydrologic event that occurred in the study area during 2016 was Hurricane Matthew on October 7–8, 2016. Strong northeast winds pushed water from the Atlantic Ocean into the St. Johns River, while heavy rains increased stage and discharge and lowered salinities at all sites. Maximum gage heights and discharges, as well as minimum salinities, were measured at that time in the project area. October 2016 rainfall was 4.3 in. above the average October total because of the effects of Hurricane Matthew (SJRWMD, 2017). The St. Johns River at Jacksonville site recorded the highest instantaneous discharge (211,000 ft^3/s on October 8, 2016) of its 23-year period of record (fig. 34). This record discharge was mostly a product of the storm surge from Hurricane Matthew, as indicated by the increase in salinity on October 7, 2016 (fig. 35). The effects of heavy rainfall were evident at the Cedar River site, where the instantaneous discharge peaked at more than 3,000 ft^3/s (fig. 36) and salinity decreased to 0.0 ppt, while the hurricane passed just off the coast (fig. 37).

Discharge and Salinity Site Comparison

Analysis of the annual mean tidally filtered discharge along the main stem indicates that measured flow was lowest at the farthest downstream site, Acosta Bridge (fig. 38). Of the tributaries, Ortega River annual mean discharge was greatest; followed by Cedar River, Julington Creek, and Durbin Creek discharges, whose annual mean values were similar to one another; and lastly by Clapboard Creek discharge, which was lowest (fig. 39). Annual mean salinity for the main-stem sites indicates that salinity decreases with distance upstream, which is expected (fig. 40). Clapboard Creek produced the highest annual mean salinity of the tributaries because of its proximity to the Atlantic Ocean. Durbin Creek salinity was the lowest of all monitoring locations and slightly lower than that of Ortega River and Julington Creek (fig. 41).

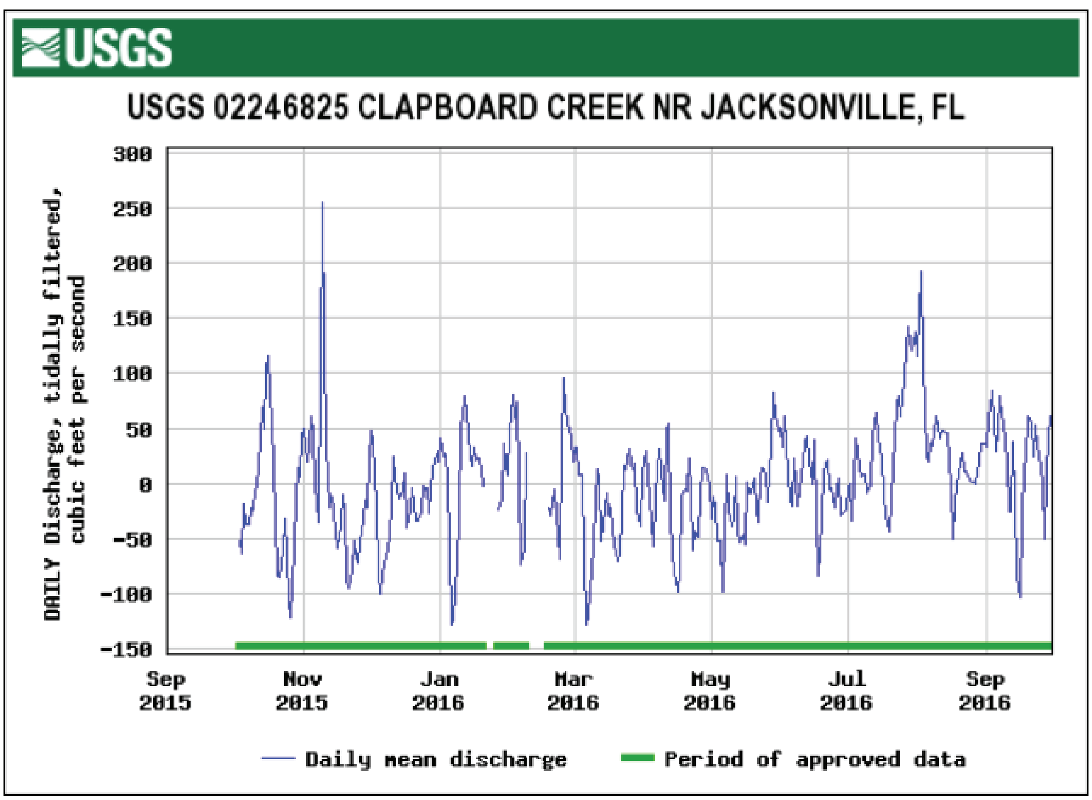

Figure 32. Daily tidally filtered discharge for Clapboard Creek near Jacksonville, Florida.

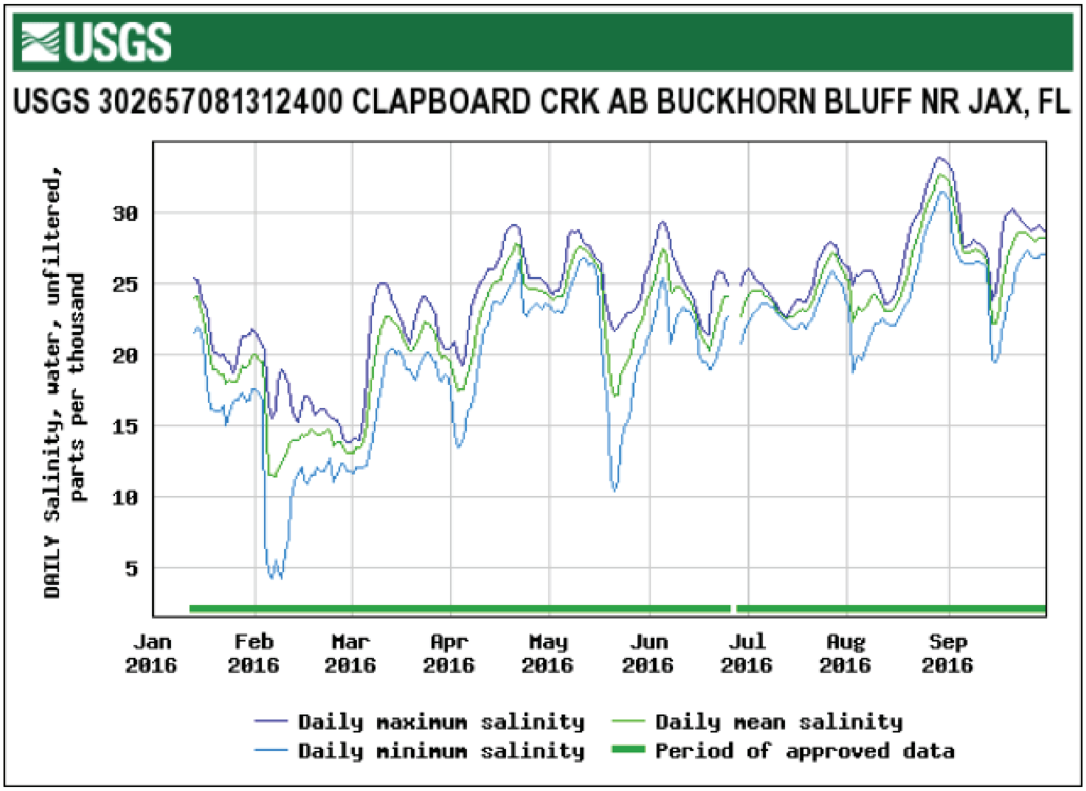

Figure 33. Daily maximum, minimum, and mean salinity for Clapboard Creek above Buckhorn Bluff near Jacksonville, Florida.

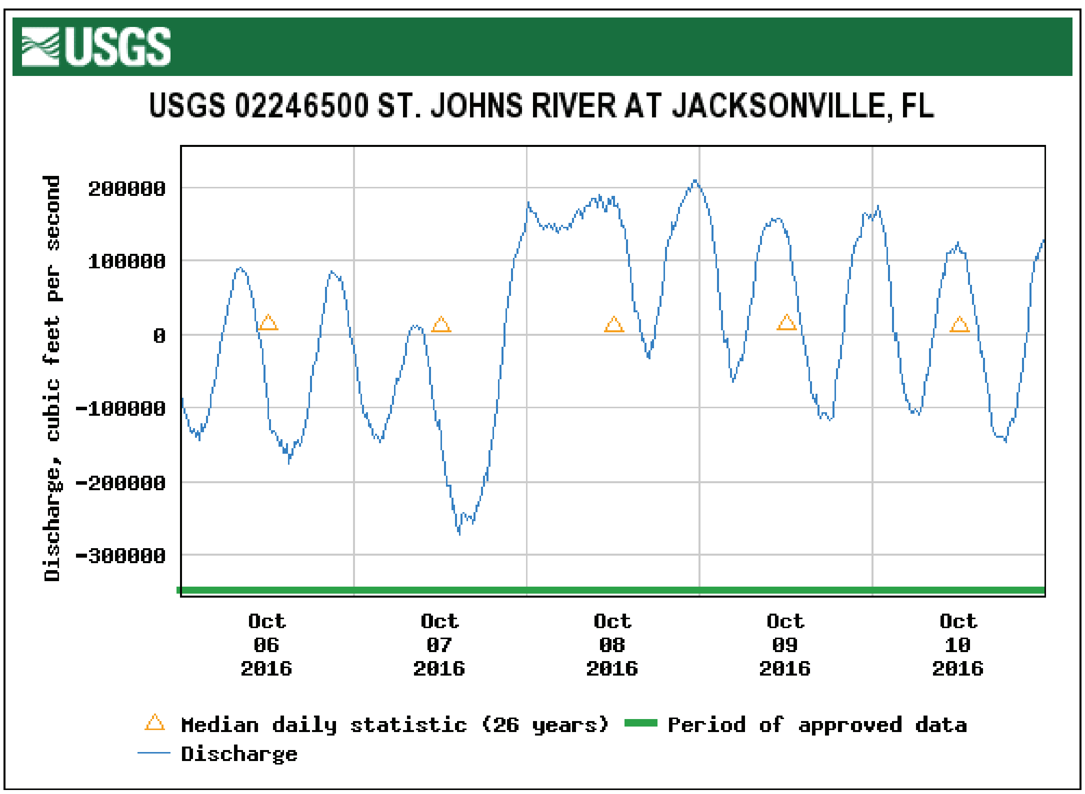

Figure 34. Instantaneous discharge during Hurricane Matthew at St. Johns River at Jacksonville, Florida.

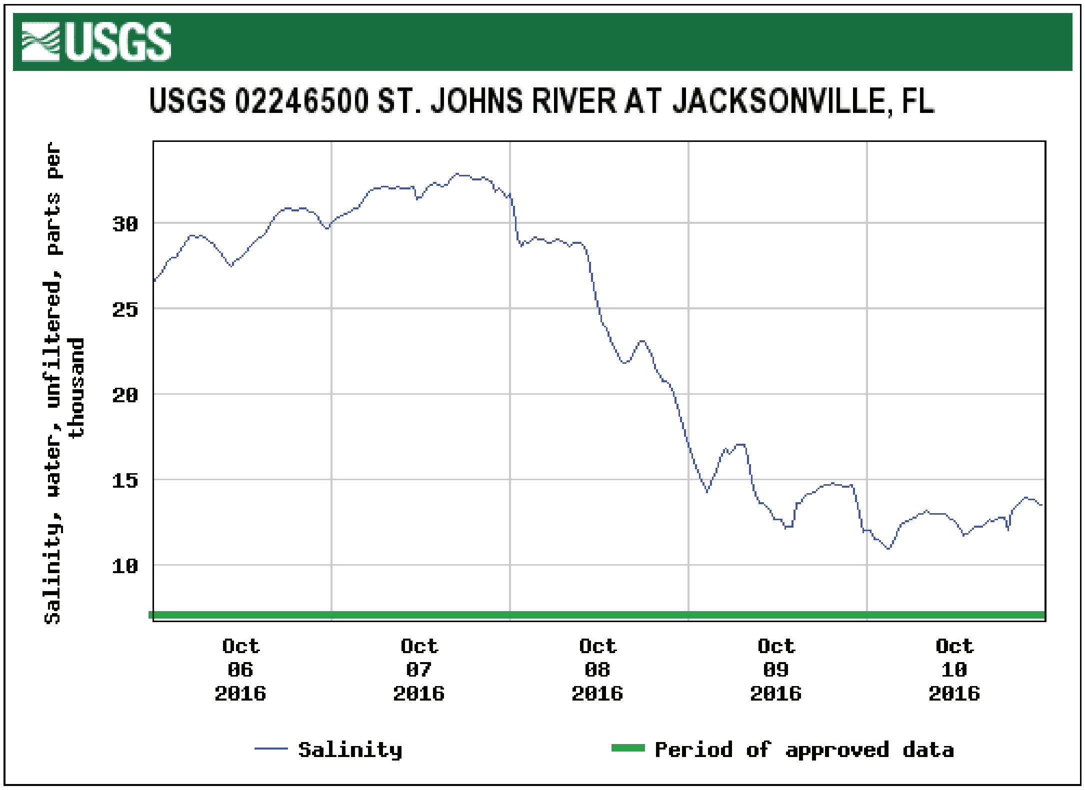

Figure 35. Instantaneous salinity during Hurricane Matthew at St. Johns River at Jacksonville, Florida.

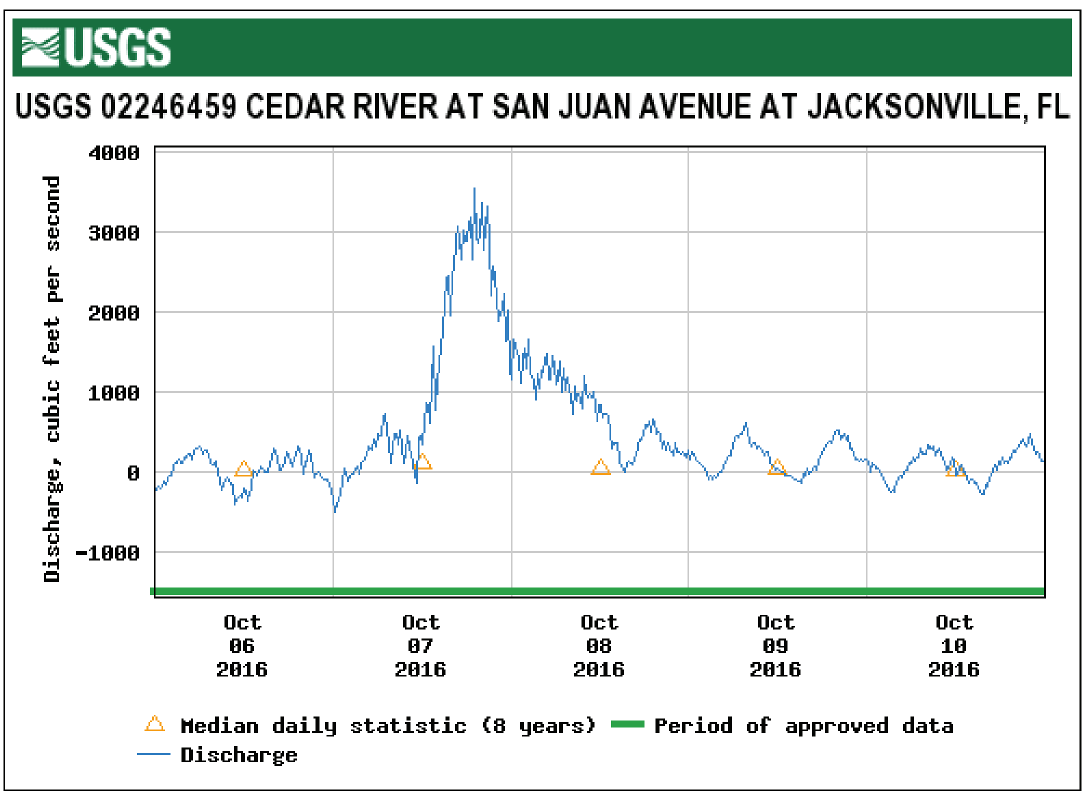

Figure 36. Instantaneous discharge during Hurricane Matthew at Cedar River at San Juan Avenue at Jacksonville, Florida.

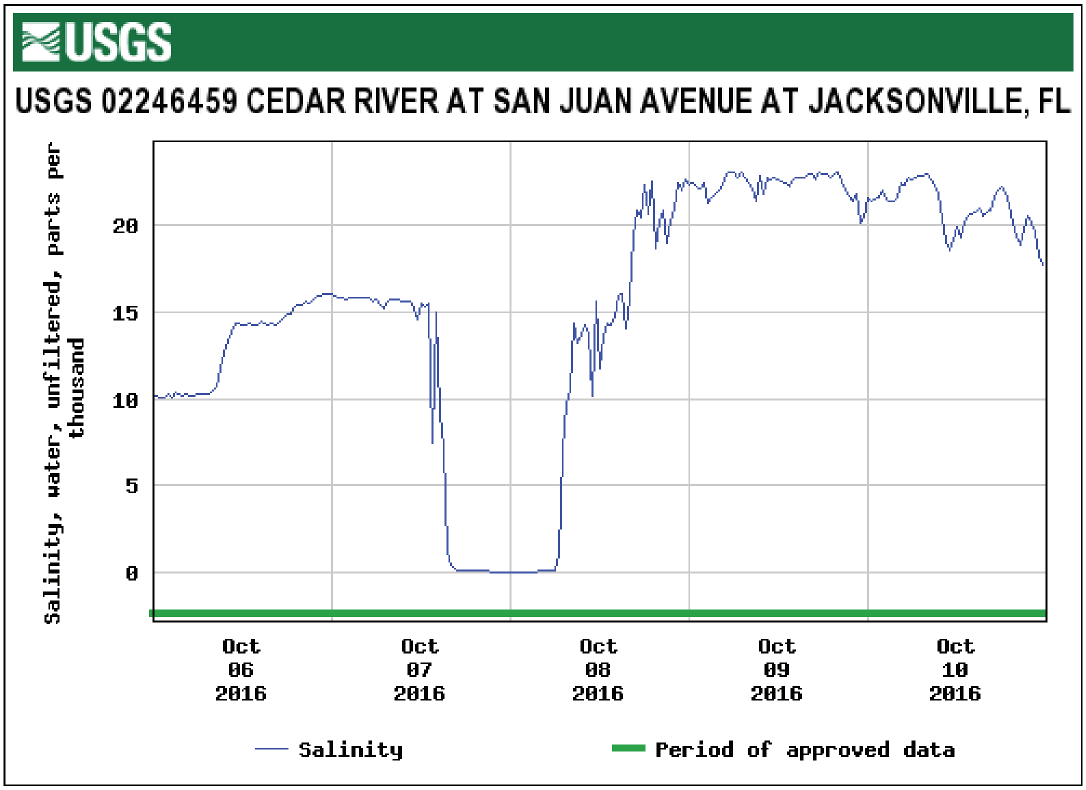

Figure 37. Instantaneous salinity during Hurricane Matthew at Cedar River at San Juan Ave at Jacksonville, Florida.

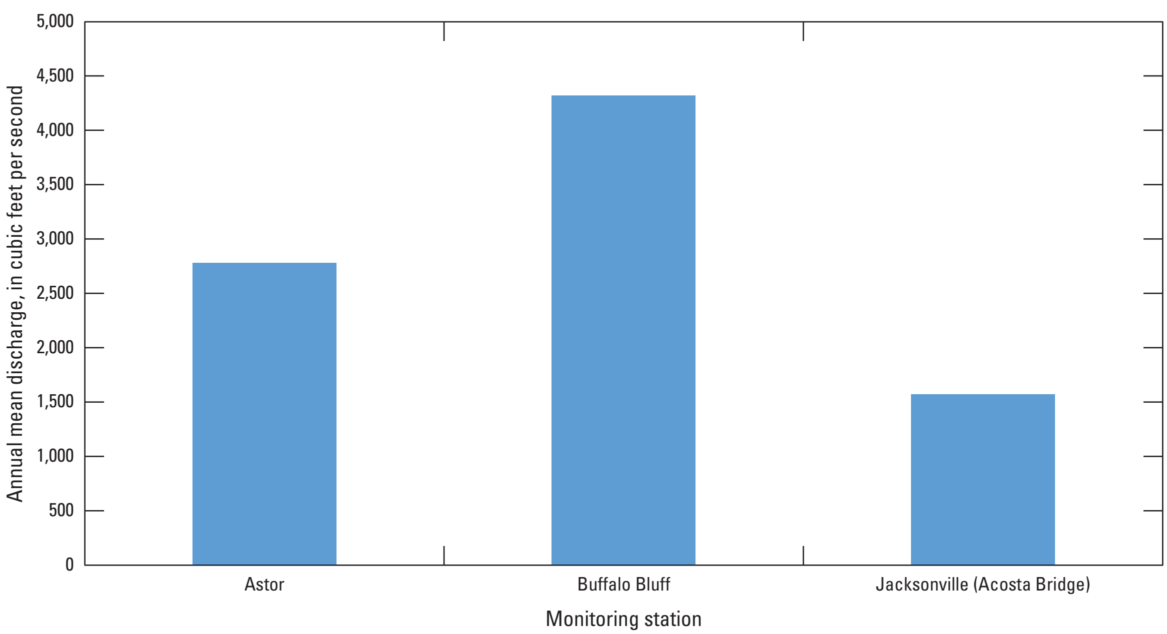

Figure 38. St. Johns River main-stem monitoring stations annual mean discharge for the 2016 water year.

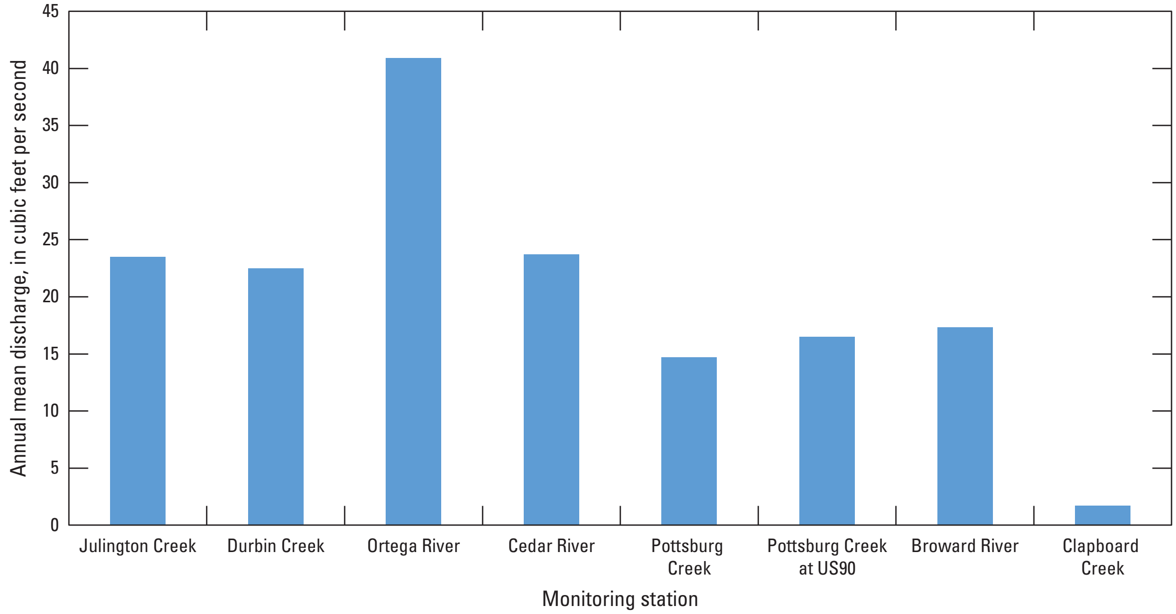

Figure 39. St. Johns River tributary monitoring stations annual mean discharge for the 2016 water year.

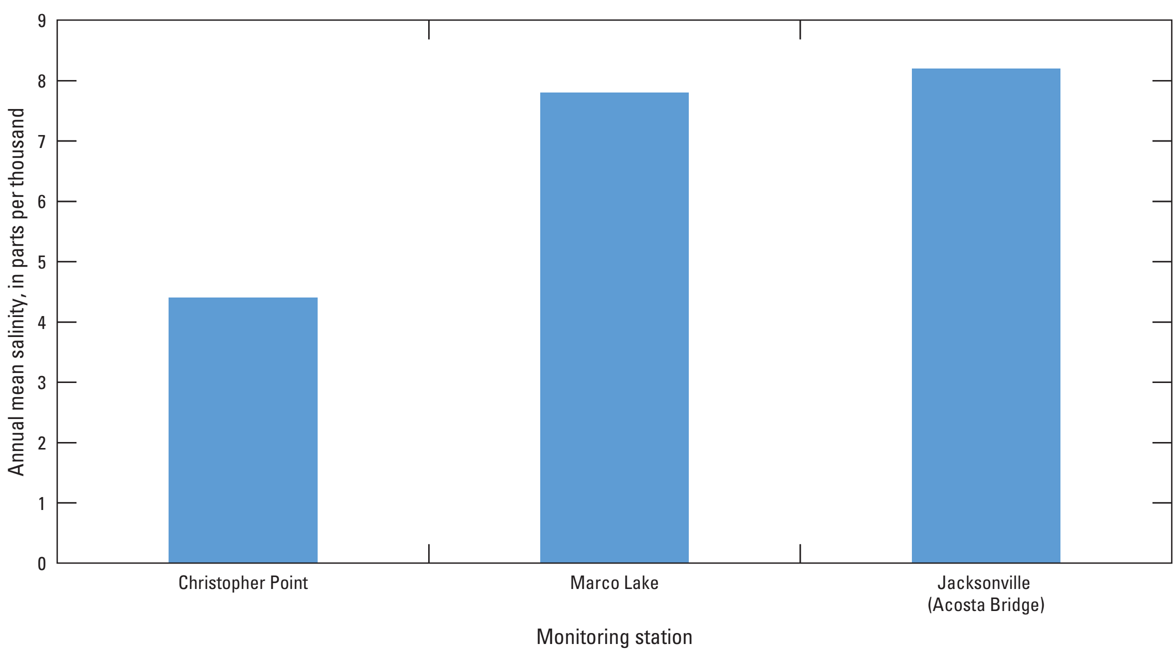

Figure 40. St. Johns River main-stem monitoring stations annual mean salinity for the 2016 water year.

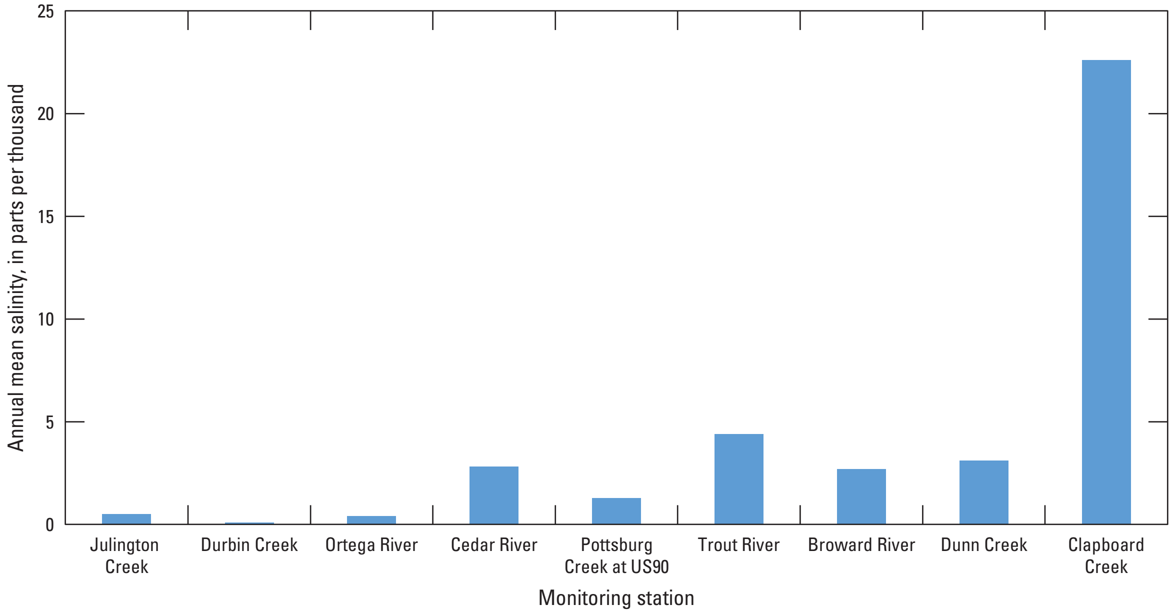

Figure 41. St. Johns River tributary monitoring stations annual mean salinity for the 2016 water year.

Summary

The U.S. Geological Survey collected baseline data during January–September 2016 at 22 sites on the St. Johns River and its tributaries. This data collection period occurred prior to commencement of dredging by the U.S. Army Corps of Engineers as part of its project to deepen the first 13 river miles of Jacksonville Harbor. Stage and discharge data were collected at 13 sites, and water temperature and specific conductance data were collected at 15 sites; some sites included all parameters. Salinity was calculated for each site where water temperature and specific conductance data were collected. Data were collected over a wide range of hydrologic conditions, including a period of below-average rainfall in Duval, Putnam, and Volusia Counties in the summer, and periods of storm surge and above-average rainfall associated with both Hurricane Hermine and Hurricane Matthew.

The annual mean discharge at Ortega River was greatest of the tributaries; followed by Cedar River, Julington Creek, Durbin Creek, and Clapboard Creek. Annual mean salinity for the main-stem sites indicates that salinity decreases with distance upstream from the ocean, which is expected. The closest tributary site to the Atlantic Ocean (Clapboard Creek) produced the highest annual mean salinity of the tributaries, and Durbin Creek salinity was the lowest of all monitoring locations and slightly lower than that of Ortega River and Julington Creek.

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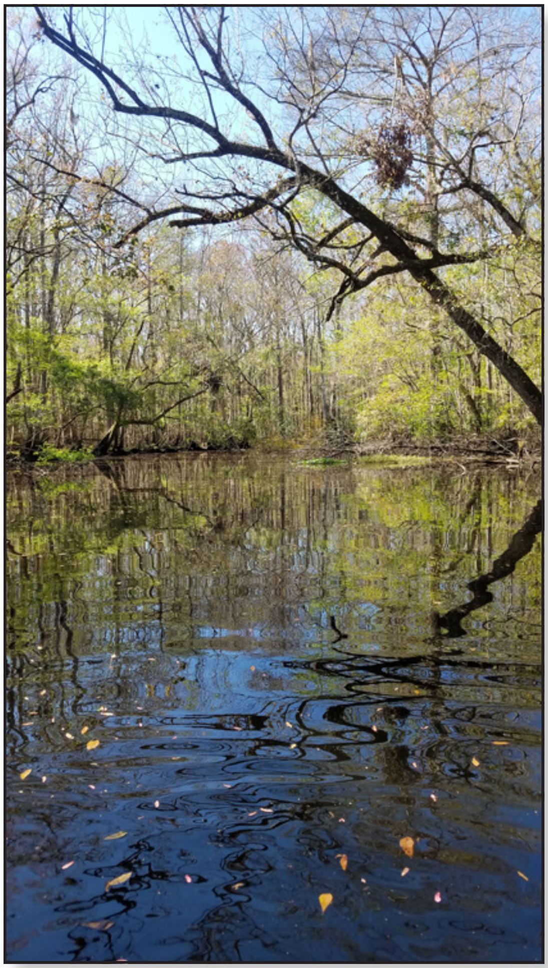

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