Project ID #15-0425

Proctor Creek Watershed Monitoring Addendum: Stormwater Report

Fulton County, GA

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1.0 Introduction

The Proctor Creek Watershed Monitoring study was designed to provide baseline data for water quality parameters throughout the Proctor Creek watershed. The primary goals were to assess current surface water conditions, during both baseflow and stormflow, and to identify any constituents which may exceed water quality standards. Baseflow sampling events included *in situ* water quality measurements, surface water and sediment sampling for chemical parameters, stream discharge calculations, macroinvertebrate and habitat assessments, and fish tissue analyses. Fifteen locations were monitored quarterly for two years, in order to account for potential seasonal and/or inter-annual variability, and to establish a sufficient database for statistical analyses and modeling efforts. Results of the quarterly monitoring efforts and biological sampling events are provided in the Proctor Creek Watershed Monitoring Summary Report (USEPA 2018b).

The stormwater sampling component of this study was included to characterize changes in water quality with increased discharge during storm events, compared to baseflow conditions. This component was conducted by the United States Geological Survey (USGS) with EPA funds associated with an amendment to the Interagency Agreement established for installation and maintenance of two stream gauging stations in Proctor Creek. Additional work performed under the amendment included both field collection and laboratory analysis of stormwater samples from six precipitation events between July 2017 and October 2018. All data were collected following the study design, sampling methods, and quality assurance procedures detailed in an addendum to the Proctor Creek Monitoring Study Quality Assurance Project Plan (USEPA 2017). Results of the stormwater sampling events are provided in this report.

2.0 Methods

2.1 Site Description

The Proctor Creek watershed (HUC 031300020101) is located entirely within the City of Atlanta in Fulton County, GA. Its headwaters begin near the city center, then the stream flows northwest for approximately 9 miles to its confluence with the Chattahoochee River just west of Interstate-285 (Figure 1). The Chattahoochee joins the Flint River at the Georgia-Florida border to form the Apalachicola, then drains across the Florida panhandle to the Gulf of Mexico.

Multiple types of point and nonpoint source pollution exist throughout the Proctor Creek watershed, which drains approximately 10,000 acres of land. The headwaters, most of which are either piped underground or channelized aboveground, receive urban runoff from the west side of downtown Atlanta, including large complexes such as the Atlanta University Center, the Georgia World Congress Center, the Philips Arena and the Mercedes-Benz Stadium. Two combined sewer overflow (CSO) facilities are located just west of downtown: North Avenue CSO and the now-decommissioned Greensferry CSO. Norfolk Southern railroad runs along the northern boundary of the watershed, with a large freight yard near the mid-point of Proctor Creek. Several landfills, automotive salvage yards, and illegal trash dumps are located throughout the basin. There are also dense residential and commercial neighborhoods with high proportions of impervious surface, as well as industrial areas at the downstream end of the watershed (ARC 2009).

2.2 Study Design

A partnership with USGS was initiated by EPA in September 2015 for stream gauge operations during the first year of the monitoring study, which was continued until the conclusion of stormwater sampling at the end of October 2018. In addition to the existing gauge at Jackson Parkway (#02336526), a second was installed at a previously-gauged location on Hortense Way (#02336517) and a third was installed at Spring Street (#023365218) on the largest tributary, which flows into Proctor Creek from the south (Figure 1). These stations profiled discharge from the upper watershed, the lower watershed below the confluence of the largest tributary, as well as that tributary. Continuous water level and discharge data were collected at each of the gauges, with precipitation and *in situ* parameters (temperature, pH, specific conductance, dissolved oxygen and turbidity) recorded at the Jackson Parkway gauge only.

Stormwater samples for chemical analysis were collected at the three gauge locations (Table 1) during rain events, using refrigerated Teledyne ISCO autosamplers, with the goal of capturing the event from the starting point through at least two-thirds of the falling limb of the hydrograph. For these purposes, a rain event is defined as a minimum of 0.3 inches of rain in the watershed following a dry period of at least 72 hours. Three events were targeted during the ‘winter’ season (November-April) and three during the ‘summer’ season (May-October). The Spring Street location was sampled less frequently, since previous data had shown fewer parameters of concern in that tributary during baseflow conditions. Storm sampling is subject to multiple factors, including but not limited to budget, personnel, equipment, and weather conditions. Therefore, several events were not captured concurrently at all stations or were captured only partially, in addition to the six complete sampling events across seasons. However, all data are included in this report, with comparisons made between or among stations where concurrent data are available.

2.3 Field Sampling Methods

All samples and field measurements were collected according to the USGS National Field Manual for the Collection of Water-Quality Data (USGS, various dates). Autosamplers were deployed at the beginning of each storm event and programmed to collect flow-weighted aliquots to yield a single composite sample. Each composite sample was collected in a single glass container and kept refrigerated in the dark until homogenized and subsampled for individual analyte groups. All sampling equipment and bottles were pre-cleaned according to procedures listed in Chapter A4 of the USGS Field Manual, with cleaning agents appropriate for target analytes. Samples were preserved, handled and shipped according to procedures listed in Chapter A5 of the USGS Field Manual. Table 2 lists all parameters collected during this study, as well as field or laboratory methods used for each analyte group.

2.4 Analytical Methods

All chemical analyses were performed by USGS at the National Water Quality Laboratory in Denver, CO, in accordance with their Quality Management System (QMS; Maloney 2005). This laboratory is certified under the National Environmental Laboratory Accreditation Program. Procedures for such requirements as test method validation, equipment calibration and standards, quality control and assurance, laboratory decontamination, waste disposal, and corrective actions are specified in the QMS. A complete list of analytes, with associated methods, analyte-specific reporting limits, and state water quality criteria, is provided in Appendix A.

2.5 Quality Control

Quality control (QC) activities performed with field operations are described in the USGS Field Manual (USGS, various dates). Field QC samples included bottle blanks for each analyte group prior to the start of sampling, then an equipment rinse blank for each of the three autosamplers used during the study. Additionally, one field duplicate was collected for each parameter, with duplicates staggered by parameter across sampling dates due to limited volume in the composite sample. Laboratory QC activities include use of techniques such as blanks, matrix spikes, surrogates, second column confirmation, laboratory control samples, and/or initial and continuing calibration verifications, as described in Appendix B of the Quality Management System (Maloney 2005).

2.6 Data Analysis

Water chemistry data were compared to those criteria in Georgia's Water Quality Standards (WQS) applicable to Proctor Creek, which has a designated use of Fishing. WQS include freshwater aquatic life criteria at both chronic and acute exposure levels, calculated using hardness concentrations at each station and conversion formulae for total recoverable metals where applicable, as well as standards which apply at discharge above 7-day, 10-year minimum flow conditions (7Q10) and above annual average flow conditions (Ga. Comp. R. & Regs. r. 391-3-6-.03). Since Proctor Creek is not used as a drinking water source, water chemistry data were not compared to state drinking water standards. Precipitation data were obtained from the USGS rain gauges at Hortense Way and Jackson Parkway, available online from the USGS National Water Information System interface at http://waterdata.usgs.gov. Total rainfall at each station was summed over the course of each storm event.

Spearman's Rank correlations were calculated to determine the strength of relationships between relevant continuous variables. A surrogate value of half the reporting limit was used for non-detects in dissolved phosphorus, total organic carbon, and total suspended solids. All other non-detects were omitted from correlations, rather than using a surrogate value, since many parameters were reported as estimates below the reporting limit and reporting limits were sometimes different across dates. Although some sampling dates included data collected at two or three locations in the same watershed, these data points were treated as independent observations for statistical purposes, as each varied in the timing of collection as well as hydrological parameters. Data were analyzed using the statistical software R, version 3.6.2 (R Core Team 2019), and are reported as Spearman's ρ at a significance level of $p < 0.01$.

3.0 Results

3.1 Storm Events

3.1.1 Sampling Dates

Samples were collected between July 2017 and October 2018, with baseflow data collected at all three stations at the beginning of the study and at both Jackson and Hortense at the conclusion (Table 3). A total of eleven storm events were captured, with one at all three stations, five at Jackson and Hortense concurrently, and two at Spring and Hortense concurrently. Each event was targeted to sample the rising limb of the hydrograph, and at least part of the falling limb, when possible. This was typically a collection window of several hours, but total sample time varied according to field conditions and sampling logistics. Furthermore, the sampling periods for stations sampled concurrently were typically offset due to the time required to travel to each station to set up and break down equipment. It was not always possible to begin collections at the onset of a storm, or to capture the peak discharge. In one case, the first wave of a large storm event (10/10/18) was sampled at Jackson, while the latter portion of the storm was sampled the next day at both Jackson and Hortense, which allowed for comparisons between the beginning and end of the event at the Jackson station. Graphs of discharge data from the Jackson gauge, provided in Appendix B, illustrate the unique hydrologic conditions for each storm event, as well as indicate the collection start time for each location sampled during that event.

3.1.2 Precipitation and Discharge

Total precipitation amounts, stream stage statistics, and mean discharge for each sampling event are summarized in Table 3. Total precipitation includes precipitation amounts from the previous day as well as the day of sampling, summarized from the Jackson station only. Maximum stream stage and mean discharge data were obtained for the day of sampling; however, maximum stage data were not available for Spring, so stage data are provided from measurements recorded during sample collection. The dry period was calculated as the number of consecutive days with less than 0.3" of precipitation between storm events. For example, the event sampled on 2/7/18 occurred approximately 72 hours after the previous storm, which is shown as a dry period of 2 days.

Additional precipitation and discharge data are shown in Table 4, which includes precipitation totals specific to Hortense. Since Spring did not have a rain gauge, precipitation data from Jackson were applied to Spring, as the two stations are less than a mile apart. Stream stage and discharge readings were also recorded at the time of each sampling event at Spring and Hortense, but were only recorded at Jackson for baseflow samples and on 2/26/18. Therefore, mean data from the collection period are shown for the remaining sampling events at Jackson, as well as for one missing stage measurement at Hortense (10/26/18) and two missing discharge measurements at Spring (7/31/17, 8/31/17).

Total precipitation was correlated with both mean discharge ($\rho=0.80$) and maximum stage ($\rho=0.76$). However, individual analytical parameters were more strongly correlated with discrete discharge, turbidity, total suspended solids (TSS), and suspended sediment (SS) (Table 5). This was likely because these measurements were more representative of hydrologic conditions during the actual time period sampled, rather than metrics summarizing the entire storm event, since only a subset of each storm was captured.

To verify that annual average (or higher) flow conditions were present during the storm events, annual average discharge was calculated for Jackson and Hortense, whereas annual discharge data are not available for Spring. Annual average discharge is approximately 18 cfs at Jackson, calculated over 14 years of data (2005-2018), and approximately 11 cfs at Hortense, calculated over 3 years of data (2004-2006). Mean discharge at each station was above the associated annual average value during all storm events sampled. Thus, water quality criteria applicable at or above annual average flow are relevant to stormwater data collected during this study at Jackson and Hortense, and it is reasonable to infer that they are also relevant at Spring.

3.2 Surface Water Data

3.2.1 *In Situ* Data

A summary of data from *in situ* measurements is provided in Table 4. Total suspended solids (TSS) and suspended sediment (SS) data are also included here, as they are closely related to turbidity measurements (ρ=0.90 and 0.96, respectively). Specific conductance ranged from 52 to 280 µS/cm across stations, with values less than 200 µS/cm during all but one storm event. Turbidity ranged from approximately 22-321 FNU during storms and <10 FNU during baseflow. Overall, values for these parameters were generally higher at Jackson than Hortense or Spring. Measurements of pH were circumneutral, from 6.31-7.62, with one reading of 8.1 during baseflow conditions at Jackson. Water temperature and dissolved oxygen (DO) were measured at the Jackson station as part of the routine monitoring at that site, shown as daily means, whereas these parameters were only measured at Hortense and Spring at the time of sample collection. Temperature and DO varied throughout the sampling period according to season, and there were no excursions above or below water quality criteria.

3.2.2 Inorganic Water Chemistry

Nutrients were relatively similar across or between stations on shared sampling dates (Table 6, Figure 3). Total nitrogen (TN) data were variable compared to baseflow data from this study as well as mean values from quarterly baseflow data collected in 2015-2017 (USEPA 2018b). However, total phosphorus (TP) data were consistently, and often several-fold, higher than baseflow concentrations. Both nutrients were more strongly related to discrete discharge measurements (TN, ρ=0.50; TP, ρ=0.68) and turbidity levels (TN, ρ=0.68; TP, ρ=0.94), which were measured during sample collection rather than summed or averaged over the course of the event, than with precipitation totals or mean discharge. Nutrient relationships with total suspended solids (TSS) and suspended sediment (SS) were similar to those with turbidity. Total organic carbon (TOC) was also significantly correlated with measurements of discrete discharge and suspended particulates. As expected, the relative fractions of organic nitrogen (TON) and particulate phosphorus (PP) also increased during storms, compared to baseflow (61% vs. 23% TON; 71% PP vs. 58%).

The following metals were all below the reporting limit on all sampling dates: barium, beryllium, bromide, cobalt, mercury, molybdenum, nickel, selenium, silver, tin and yttrium. Several metals were often above water quality criteria for protection of aquatic life, which vary according to hardness concentrations. Copper and zinc were above both chronic and acute criteria on several sampling dates, and cadmium and lead were above either the chronic or acute criterion depending on the date (Table 7). However, there were also some results for cadmium and copper that were below reporting limits that were higher than some of the calculated criteria, so potential exceedances could not be assessed for those samples. On 10/8/17 at Jackson, chromium was slightly above the chronic criterion for Chromium III, calculated to be 11 µg/L compared to a value of 19 µg/L for that sample, but the analytical method does not distinguish among the different forms of chromium. Thallium was above the annual average criterion of 0.47 µg/L on 10/23/17 at Spring and 10/26/18 at Hortense. This criterion is below the typical reporting limit of 2.0 µg/L for thallium, but detections were identified below that level for most dates, including two baseflow samples to which the standard does not apply. Other classical parameters and metals were present throughout the watershed, but do not have associated WQS (Table 7).

As with nutrients, many metals were more correlated with turbidity, TSS and SS than with precipitation or discharge. In particular, aluminum, iron, lead, manganese, titanium and zinc were all strongly linked to increased SS (Table 5). Other significant correlations included antimony, arsenic and vanadium. In contrast, other analytes that comprise the bulk of specific conductance measurements were higher during baseflow, then relatively similar in concentration across storm events. These included chloride, fluoride, calcium, magnesium, potassium and sodium. Neither specific conductance nor these component ions were correlated with parameters related to precipitation, discharge, or the various measurements of suspended material.

3.2.3 Organic Water Chemistry

A full suite of organic analytes, which included pesticides, PCBs, and semi-volatile organics, were analyzed for each sampling event. In many cases, the minimum reporting limits (MRLs) were higher than the respective water quality criteria. However, some compounds were identified below the reporting limit on certain dates, and a subset of those were above annual average criteria. Summaries of detected compounds are provided in Table 8 (Pesticides and PCBs) and Table 9 (Semi-Volatiles). These included the pesticides alpha-chlordane, gamma-chlordane, dieldrin, heptachlor and DDT, as well as the PCB Aroclors 1254 and 1260. Each of these compounds was above the 7Q10 criterion on at least one sampling date, with the PCB criterion applicable to Total Aroclor concentrations. Alpha-BHC and DDE were above the annual average criterion on one or two dates, respectively. The majority of semi-volatile compounds detected are those classified as polycyclic aromatic hydrocarbons (PAHs), common in automotive fluids and road runoff, seven of which were above the annual average criterion on at least one storm sampling date: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene. Six of these were above the annual average criteria on several dates. On other dates, the reporting limit was five times higher and/or these parameters were not analyzed, so additional occurrences may have been missed.

It was difficult to analyze organic parameters in relation to storm metrics, because of patchy detections which were often below the reporting limit. A few sampling events were also missing semi-volatile data, including all parameters on 1/28/18 and a subset of parameters on 6/26/18 and 10/10/18. Furthermore, reporting limits for some parameters varied according to batch quality control or other factors. The laboratory may not have been able to quantify below the reporting limit for certain batches, so there is a possibility that some low-level concentrations were not identified. Regardless, there were no detections of any organic parameters in samples collected during baseflow, except low concentrations of diesel range organics below the reporting limit of 200 µg/L on 10/30/18. Also, concentrations of semi-volatile organics were generally higher at Jackson than at Hortense and/or Spring, and higher at Hortense than Spring, when detected during the same sampling event.

4.0 Discussion

The sampling method employed to collect stormwater data provided an average concentration of each parameter during the sampling period, which was variable depending on the size and duration of the storm event. Sampling logistics also affected the sampling window, as it is difficult to capture events when they span hours outside of typical field work schedules. Therefore, the portion and amount of the storm sampled was different for each event, which complicates making direct comparisons across events. For example, the 'first flush' of contaminants from surface runoff, which occurs during the initial period of a storm in the rising limb of the hydrograph, was captured for some events but not others. Characteristics of individual storm events also differ according to intensity and duration, which causes inherent variation even among consistent sampling windows. Furthermore, the period of dryness between rain events affects the level of potential contaminants that build up on impervious surfaces, which are then washed into receiving waters during the next storm (Horowitz 2009).

Evidence of these differences was present in the dataset. When the sample captured a steep rise in the hydrograph, indicating heavy rain, concentrations of most parameters were higher (*e.g.*, 10/28/17, 2/7/18, 3/11/18, 9/26/18). When the sample was collected after some rain had already occurred, or there was a more gradual rise in the hydrograph, concentrations were lower (*e.g.*, 8/31/17, 9/11/17, 2/26/18). Notably, one relatively intense rain event was sampled at Jackson during both the beginning and the end, on October 10-11, 2018. Concentrations of most parameters were much higher on October 10 than October 11. Also, nutrients were generally higher upstream (Hortense) than downstream (Jackson) when concentrations were elevated at the beginning of a storm, whereas concentrations declined overall and were more similar between stations towards the end of a storm.

Additionally, certain parameters that were summarized for each event, like total precipitation, maximum stage and mean discharge, had less relevance than those measured at the actual sample collection time or water chemistry data analyzed from the sample itself. Most analytes exhibited stronger correlations with instantaneous discharge measurements than with mean discharge or total precipitation. However, the strongest relationships were observed with suspended sediment, which was measured from the sample and typically tracks closely with discharge, as streambed and bank sediments are transported in the water column during high flow. Suspended sediment includes silts and clays, which have high surface areas and chemical properties that allow some species of nutrients, many trace metals, and certain organic compounds to adsorb to them (Horowitz 1985, Warren *et al.* 2003). Turbidity and TSS were both similarly, but less significantly, correlated with the same parameters as suspended sediment.

While this study did not distinguish between dissolved and sediment-associated contaminants, concentrations of nutrients and metals were higher during storms and strongly correlated with suspended sediment. The most significant correlations occurred with total phosphorus, total organic nitrogen, and the metals aluminum, arsenic, iron, manganese, lead, titanium, vanadium and zinc, many of which are known to adsorb to sediments (Horowitz 2008). These metals were all several-fold higher during storm conditions compared to baseflow and likely originated from the areas where concentrations were high during the quarterly monitoring (USEPA 2018b). During baseflow conditions, lead was consistently higher in tributaries at Lindsay Street, the North Avenue CSO outfall (North CSO) and the West Highlands neighborhood, as well as the main channel of Proctor Creek at and below Hortense Way (Figure 2). Iron was primarily elevated at North CSO and Lillian Cooper Park, manganese was high at North CSO and West Highlands, and zinc reached the highest concentrations at Lindsay Street. Other metals were low or below detection during baseflow (*e.g.*, arsenic, vanadium), or generally increased from upstream to downstream in Proctor Creek (*e.g.*, aluminum, titanium). Aluminum, lead and zinc had also been elevated during the quarterly monitoring period on two sample dates which followed rain events. Results of this study were consistent with previous findings in the Atlanta area, where over 75% of the annual flux of total phosphorus and many metals occurs in association with suspended sediment, and more than 90% occurs during stormflow (Horowitz *et al.* 2008, Horowitz 2009).

Copper, lead and zinc were above acute and/or chronic exposure criteria in the majority of stormwater samples, whereas cadmium and thallium were above criteria less frequently. Chronic criteria are defined as the "highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects" (Ga. Comp. R. & Regs. r. 391-3-6-.03(3)). Although it is unlikely that exposure was maintained at these levels for more than 4 days, acute criteria provide exposure limits for much shorter time periods (an average of one hour), so excursions above acute levels during storm events are likely a concern for aquatic organisms. There is a current remediation effort by EPA to remove lead-contaminated soils in the vicinity of the Lindsay Street neighborhood, from historical smelting operations and other industrial sources (Miller 2020), which will hopefully reduce lead runoff into Proctor Creek.

Of the targeted organic compounds, 10 pesticides, 2 PCB Aroclors, and 19 semi-volatile compounds were detected in stormwater samples. Fourteen of these were above 7Q10 and/or annual average criteria on one or more dates. Dieldrin and both alpha- and gamma-chlordane had been found at many locations in the watershed during baseflow quarterly monitoring, on the three sample dates that included surface water analysis of organic compounds (USEPA 2018b). These, as well as most of the remaining organics detected during storm events, had also been found in sediment samples collected in September 2015, largely in the upper watershed adjacent to downtown Atlanta (USEPA 2016). As with many of the elevated metals, nearly all organic compounds identified in this study are commonly associated with sediment (USEPA 1997, Warren *et al.* 2003). Thus, contaminants are entering Proctor Creek from various sources in the watershed, but also become bound to sediments that are then resuspended during storm events. Sediment-associated contaminants can be toxic to benthic organisms as well as bioaccumulate in the food chain to higher trophic levels, where they can threaten wildlife and impact human health (USEPA 2000). During fish sampling events associated with the quarterly monitoring study, dieldrin, heptachlor epoxide and PCB Aroclor 1254 were all found at harmful concentrations in fish tissue, prompting fish consumption advisories for several species in Proctor Creek (USEPA 2018a, GAEPD 2018).

5.0 Conclusions

This component of the monitoring study was included to assess water quality during storm conditions, as well as compare stormwater data to the baseflow data collected quarterly in Proctor Creek from September 2015 to July 2017 (USEPA 2018b). Results presented here expand on and elucidate findings of the baseflow quarterly monitoring effort. Nutrients, especially organic nitrogen and particulate phosphorus, were elevated above baseflow concentrations during storm events, as were 10 different metals, especially those known to adhere to sediments. Of the metals, copper, lead and zinc were frequently detected above the acute exposure criteria for protection of aquatic life. Potentially harmful concentrations of organochlorine pesticides and PCBs were also detected during several storm events. Nearly all of the constituents found at higher concentrations in stormwater were identified as probable contaminants during the baseflow monitoring study, in surface water, sediment and/or fish tissue samples collected throughout the watershed.

The parameters found at elevated concentrations in Proctor Creek are characteristic of urban streams across the country, which typically have higher nutrients, pesticides and PAHs (Paul & Meyer 2001), as well as a range of heavy metals (*e.g.*, Sansalone & Buchberger 1997). Urban environments contain a mixture of high-density residential, commercial and industrial areas, with large portions of impervious surface in the form of buildings, roads and parking lots. In Atlanta, contaminants such as automotive fluids, exhaust, fertilizers and pesticides can enter Proctor Creek via surface runoff from the urban center, as well as from the small tributaries draining a variety of land uses in the watershed. During periods of lower flow, sediment-associated contaminants are also stored in the streambed, and can become resuspended during the next rain event. Thus, storms are linked to both introduction and transport of many contaminants in the watershed. Stormwater sampling is therefore an important component of water quality assessments, especially in urban streams such as Proctor Creek.

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Table 1: Stormwater sampling locations at USGS gauging stations.

Station ID	Description of Location	GPS Coordinates (DD)	
		Latitude	Longitude
Spring	Proctor Creek Tributary at Spring Street	33.78849	-84.46597
Hortense	Proctor Creek at Hortense Place	33.77562	-84.44072
Jackson	Proctor Creek at James Jackson Parkway	33.79461	-84.47417

Table 2: Data collected at USGS gauging stations during storm events.

Parameter	Analyte Group	Analytical Methods
surface water chemistry	nutrients	EPA 350.1, EPA 351.2, EPA 353.2, EPA 365.2, SM 5310B
	classicals, hardness, total suspended solids, suspended sediment	EPA 300.0, SM 2340C, SM 2540D, ASTM D3977-97
	total recoverable metals	EPA 200.7, EPA 200.8, EPA 245.1, EPA 6010C
	pesticides and PCBs	SW 8081B, SW 8082A
	semi-volatile organics	SW 8015D, SW 8270D
in situ water quality*	temperature, pH, specific conductance, dissolved oxygen, turbidity	data recorded by USGS gauging station
surface water flow	stream stage, stream discharge, precipitation**	

**In situ* data continuously recorded at Jackson station only. *In situ* data at Spring and Hortense collected manually at time of sampling.
**No precipitation data collected at Spring.

Table 3: Precipitation, stage and discharge (Q) data for each sampling event at Jackson, Hortense and Spring. Data highlighted in blue indicate a baseflow sample, while dates highlighted in green indicate samples collected during the rising limb and/or peak of the hydrograph. Precipitation data are from the Jackson rain gauge, and include precipitation amounts from the previous day. Maximum stage data were not available for Spring; gauge height data were obtained at the time of sample collection.

Sample Date	Dry Period (days)	Total Precip. (inches)	Peak Time (HH:MM)	Peak Q (cfs)	Jackson		Hortense		Spring	
					Max Gauge Height (ft)	Mean Q (cfs)	Max Gauge Height (ft)	Mean Q (cfs)	Height at Sample (ft)	Mean Q (cfs)
7/28/17		0.01			3.42	6				
7/31/17		0.00					1.12	2	4.14	0
8/31/17	21	1.40	8:15	122			3.15	20	5.27	8
9/11/17	5	2.54	18:15	1090	8.37	270				
10/8/17	25	1.87	12:30	503	6.73	92				
10/23/17	14	1.40	12:30	876			5.85	51	5.98	23
10/28/17	4	0.69	19:45	189	5.32	29				
1/28/18	5	1.23	15:00	379	6.26	95				
2/7/18	2	1.16	11:15	919	7.96	155	5.14	83	6.16	33
2/26/18	13	0.91	5:45	225	5.53	45	3.21	21		
3/11/18	9	0.85	10:15	271	5.77	66	3.30	27		
9/26/18	34	0.51	19:00	276	5.78	25	4.44	19		
10/10/18	11	3.54	20:30	951	8.67	164				
10/11/18	0	4.62	2:15	3040	11.61	345	8.01	96		
10/26/18	13	0.69	11:45	109	4.75	34	2.48	16		
10/30/18		0.00			3.07	2	1.17	2		

Table 4: *In situ* data, as well as total suspended solids (TSS) and suspended sediment (SS) data, for each sampling event. Values with grey shading indicate that the parameter was not detected at or above that reporting limit. Dates highlighted in blue indicate baseflow samples, whereas dates highlighted in green indicate those samples which captured the rising limb and/or peak of the hydrograph.

Date	Station	Total Precip. (inches)	Stream Stage (feet)	Discharge (cfs)	Water Temp. (°C)	D.O. (mg/L)	pH (S.U.)	Specific Cond. (µS/cm)	Turbidity (FNU)	TSS (mg/L)	SS (mg/L)
7/31/17	Spring	0	4.14	1	21.4	7.4	7.5	232	2	2	4
	Hortense	0	1.11	2	22.5	7.8	7.5	245	2	2	3
7/28/17	Jackson	0	3.19	6	26.0	7.6	8.1	280	7	2	7
10/30/18	Hortense	0	1.27	2	13.3	10.4	7.4	239	3	2	4
	Jackson	0	3.06	2	12.2	10.2	7.5	244	2	2	3
8/31/17	Spring	1.4	5.27	10	22.1	8.0	7.1	78	69	84	
	Hortense	1.0	2.10	38	22.3	7.9	6.9	71	31	46	
9/11/17	Jackson	2.5	4.91	270	16.9	8.3	6.8	125	76	160	187
10/8/17	Jackson	1.9	4.20	92	22.4	6.6	7.1	113	302	1100	757
10/23/17	Spring	1.4	5.98	28	19.1	8.7	7.0	52	180	180	319
	Hortense	1.4	2.56	79	20.1	8.1	7.1	68	61	55	116
10/28/17	Jackson	0.7	3.54	29	14.3	9.2	7.6	139	66	89	98
1/28/18	Jackson	1.2	4.43	95	10.6	10.1	7.4	276	34	52	66
2/7/18	Spring	1.2	6.16	102	12.2	10.2	7.4	56	110	45	172
	Hortense	1.5	4.69	469	13.1	10.1	7.2	56	150	120	327
	Jackson	1.2	4.53	155	11.2	10.0	7.6	126	242	74	602
2/26/18	Hortense	1.1	1.98	27	15.0	9.3	7.1	73	42	26	37
	Jackson	0.9	3.94	81	15.9	9.0	7.1	91	42	39	41
3/11/18	Hortense	0.8	3.09	170	12.8	9.9	7.2	75	74	93	71
	Jackson	0.9	4.17	66	12.5	9.6	7.2	122	131	240	
9/26/18	Hortense	0.5	3.58	226	25.0	7.3	6.3	74	100	200	225
	Jackson	0.5	3.47	25	24.0	6.9	6.7	164	202	320	524
10/10/18	Jackson	3.5	4.12	164	23.2	7.8	6.5	96	321	880	893
10/11/18	Hortense	4.4	1.67	14	22.5	7.7	6.7	110	22	8	15
	Jackson	4.6	5.08	345	22.6	7.7	7.3	118	39	24	49
10/26/18	Hortense	1.0	1.61	50	13.0	9.7	7.5	77	42	52	59
	Jackson	0.7	3.82	34	12.7	9.6	7.5	110	38	34	65

Table 5: Spearman's Rank correlation data for relevant continuous variables. Values are Spearman's Rho, with correlations significant at $p < 0.01$ highlighted in grey.

	Total Precip.	Discrete Discharge	Mean Discharge	Gauge Height	Max Gauge Height	Turbidity	Total Suspended Solids	Suspended Sediment
Discrete Discharge	0.37							
Mean Discharge	0.80	0.62						
Gauge Height	0.40	0.53	0.50					
Max Gauge Height	0.76	0.44	0.93	0.64				
Turbidity	0.48	0.73	0.55	0.63	0.54			
Total Suspended Solids	0.41	0.68	0.43	0.50	0.47	0.90		
Suspended Sediment	0.53	0.74	0.58	0.61	0.58	0.96	0.94	
Total Nitrogen	0.26	0.50	0.42	0.40	0.48	0.68	0.66	0.72
Total Organic Nitrogen	0.17	0.72	0.36	0.49	0.46	0.83	0.82	0.87
Nitrate/Nitrite	-0.44	-0.46	-0.21	-0.39	-0.05	-0.58	-0.56	-0.59
Ammonia	0.06	-0.05	-0.37	0.23	-0.58	0.08	0.08	0.03
Total Phosphorus	0.46	0.68	0.45	0.54	0.47	0.94	0.94	0.95
Dissolved Phosphorus	0.52	0.33	0.33	0.11	0.27	0.42	0.34	0.39
Total Organic Carbon	0.45	0.60	0.57	0.58	0.65	0.68	0.65	0.71
Sp. Conductance	-0.46	-0.38	-0.21	-0.20	0.01	-0.44	-0.36	-0.45
Chloride	-0.62	-0.21	-0.37	-0.23	-0.32	-0.33	-0.25	-0.37
Fluoride	-0.11	0.07	0.01	-0.17	-0.15	-0.05	0.17	0.02
Sulfate	-0.44	-0.52	-0.33	-0.27	-0.16	-0.52	-0.39	-0.44
Aluminum	0.50	0.75	0.66	0.56	0.62	0.94	0.87	0.93
Antimony	0.36	0.61	0.45	0.42	0.48	0.71	0.60	0.76
Arsenic	0.17	0.48	0.36	0.50	0.49	0.86	0.80	0.90
Cadmium	0.35	-0.49	0.22	0.71	0.67	0.59	0.36	0.38
Calcium	-0.42	-0.43	-0.23	-0.16	0.02	-0.39	-0.33	-0.40
Chromium	0.46	0.14	0.42	0.41	0.52	0.75	0.55	0.81
Copper	-0.11	0.06	-0.07	-0.16	0.32	0.64	0.65	0.66
Iron	0.41	0.76	0.55	0.56	0.53	0.94	0.92	0.97
Lead	0.30	0.70	0.37	0.48	0.34	0.96	0.93	0.97
Magnesium	-0.30	-0.17	-0.04	-0.02	0.21	-0.02	0.01	0.01
Manganese	0.32	0.69	0.44	0.47	0.47	0.87	0.91	0.93
Potassium	0.11	0.04	0.24	0.16	0.48	0.26	0.25	0.39
Sodium	-0.42	-0.33	-0.20	-0.27	-0.03	-0.43	-0.35	-0.47
Strontium	-0.36	-0.49	-0.21	-0.20	0.05	-0.42	-0.38	-0.44
Thallium	-0.12	-0.39	-0.31	-0.08	-0.14	0.01	0.05	-0.16
Titanium	0.20	0.69	0.43	0.47	0.45	0.89	0.84	0.95
Vanadium	-0.12	0.01	-0.14	0.17	0.09	0.92	0.74	0.95
Zinc	0.05	0.69	0.30	0.47	0.35	0.83	0.82	0.87

Table 6: Analytical data for nutrients and classical parameters. All values are shown in mg/L. Highlighted values indicate that the parameter was not detected above that reporting limit. Values that were above the detection limit but below the reporting limit are shown, where available. Dates highlighted in blue indicate baseflow samples, whereas dates highlighted in green indicate those samples which captured the rising limb and/or peak of the hydrograph.

			Nitrate/	Nitrogen		Phosphorus		Organic				Hardness
		Ammonia	Nitrite	Organic	Total	Dissolved	Total	Carbon	Chloride	Fluoride	Sulfate	(as $CaCO_3$)
7/31/17	Spring	0.1	0.80	0.40	1.20	0.023	0.052	2.9	16	0.29	16	80
	Hortense	0.06	0.81	0.21	1.08	0.005	0.021	2	14	0.32	25	84
7/28/17	Jackson	0.1	0.80	0.27	1.07	0.005	0.015	2.5	12	0.31	33	100
10/30/18	Hortense	0.1	1.40	0.20	1.60	0.017	0.026	1.7	14	0.45	24	88
	Jackson	0.22	0.86	0.27	1.08	0.023	0.013	2.1	12	0.41	27	88
8/31/17	Spring	0.23	0.28	0.64	1.15	0.050	0.240	10	2.8	0.5	7.4	160
	Hortense	0.17	0.34	0.57	1.08	0.042	0.140	6.7	2.7	0.47	22	220
9/11/17	Jackson	0.1		1.20		0.032	0.320	15	5.5	0.1	11	270
10/8/17	Jackson	0.1	0.15	3.80	4.05	0.042	0.600	8.8	4.9	0.5	11	5
10/23/17	Spring	0.89	0.30	0.51	1.70	0.056	0.410	8.4	0.9	0.5	6.0	24
	Hortense	0.04	0.29	0.96	1.29	0.053	0.270	8.3	2.6	0.5	4.6	40
10/28/17	Jackson	0.05	0.50	0.63	1.18	0.030	0.130	8.9	5.9	0.5	13	44
1/28/18	Jackson	0.04	0.67	0.66	1.37	0.011	0.110	5.4	49	0.54	16	72
2/7/18	Spring	0.07	0.38	1.13	1.58	0.065	0.200	9.6	2.3	0.34	4.2	48
	Hortense	0.26	0.19	1.44	1.89	0.052	0.290	4.9	6.3	0.31	2.3	52
	Jackson	0.06	0.52	2.24	2.82	0.031	0.390	11	7.6	0.37	11	48
2/26/18	Hortense	0.1	0.26	0.54	0.90	0.050	0.120	6.0	4.9	0.09	4.3	28
	Jackson	0.1	0.27	0.27	0.64	0.035	0.120	6.0	5.0	0.10	5.9	28
3/11/18	Hortense	0.12	0.31	1.08	1.51	0.048	0.220	6.3	8.3	0.48	4.4	20
	Jackson	0.06	0.51	1.54	2.11	0.036	0.310	14	7.5	0.42	11	40
9/26/18	Hortense	0.20	0.55	2.50	3.25	0.160	0.400	15	3.7	0.5	5.2	40
	Jackson	0.02	0.58	3.80	4.38	0.052	0.490	11	8.8	0.5	16	60
10/10/18	Jackson	0.08	0.36	2.10	2.56	0.049	0.440	8.9	3.9	0.5	8.4	60
10/11/18	Hortense	0.02	0.84	0.49	1.35	0.087	0.092	5.8	2.9	0.5	9.7	40
	Jackson	0.1	0.92	0.44	1.42	0.089	0.110	33	2.2	0.36	13	48
10/26/18	Hortense	0.09	0.40	0.39	0.88	0.064	0.120	5.4	3.7	0.5	6.0	76
	Jackson	0.13	0.45	0.37	0.95	0.048	0.093	7.5	4.7	0.5	9.5	44

Table 7: Analytical data for total recoverable metals. All values are shown in µg/L. Values highlighted in grey indicate that the parameter was not detected above that reporting limit. Values highlighted in orange or yellow are above the corresponding acute or chronic criterion for that parameter. Dates highlighted in blue indicate baseflow samples, whereas dates highlighted in green indicate those samples which captured the rising limb and/or peak of the hydrograph.

		Aluminum	Antimony	Arsenic	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Potassium	Sodium	Strontium	Thallium	Titanium	Vanadium	Zinc
acute criteria				340	**		**	**		**						0.47*			**
chronic criteria				150	**		**	**		**									**
7/31/17	Spring	48	2.5	1.5	1	21000	10	100	500	0.54	3500	34	3800	17000	110	2	10	50	100
	Hortense	57	2.5	1.5	1	25000	10	100	270	0.78	4500	27	4100	14000	100	2	10	50	100
7/28/17	Jackson	210	1.0	1.0	1	30000	10	100	290	0.97	4800	29	5800	15000	110	2	4.6	50	100
10/30/18	Hortense	51	5	3	2	23000	10	100	230	2	4600	23	4200	13000	110	0.52	1.9	50	19
	Jackson	62	1.5	3	2	24000	10	100	160	2	4500	17	4000	13000	110	0.57	10	50	15
8/31/17	Spring	1600	1.9	1.0	1	8400	4	100	2100	16	1200	150	3700	3200	39	2	58	50	41
	Hortense	1300	1.5	1.0	1	7800	6	100	2000	12	1300	130	3200	2900	33	0.18	67	50	55
9/11/17	Jackson		2.0	1.5	1	14000	8	16	6500	23	3100	440	4500	6600	61	2	240	12	79
10/8/17	Jackson	17000	2.8	3.9	0.7	17000	19	58	23000	96	6000	1200	8700	6300	72	0.40	870	41	300
10/23/17	Spring	9200	1.5	5.9	3.9	7800	6.9	24	8000	32	1900	230	4700	1600	33	3.6	290	16	120
	Hortense	2600	2.2	1.3	1	8500	3.5	29	4100	21	1700	250	3900	3100	35	2	150	9.9	140
10/28/17	Jackson	1700	2.5	1.2	1	16000	2.1	17	2300	15	2900	170	3900	7000	65	2	65	50	310
1/28/18	Jackson		1.0	7.5	5	17000	2.2	100	2600	10	3000	150	4000	30000	70	0.31	97	50	46
2/7/18	Spring	5800	1.7	1.3	1	7100	6.8	19	5000	21	1400	130	3600	2600	29	0.24	180	13	110
	Hortense	6600	3.0	2.0	1	5500	6	25	6200	44	1200	190	2800	5200	22	0.22	210	16	140
	Jackson	13000	5.8	2.4	0.4	16000	15	40	14000	54	4200	510	5100	8000	69	0.38	580	31	230
2/26/18	Hortense		1.4	0.9	1	7100	10	100	1800	8.1	1000	56	2600	4700	28	2	65	50	26
	Jackson		1.2	1.0	1	11000	1.9	100	2200	10	1800	90	3000	5300	46	0.18	71	50	88
3/11/18	Hortense	3600	1.5	1.1	0.3	7600	3.4	28	4800	20	1500	170	2400	6500	32	0.26	180	9.0	78
	Jackson	5900	1.6	1.9	0.4	15000	6.8	31	8700	35	3400	460	3900	8000	65	0.29	310	13	140
9/26/18	Hortense	13000	1.7	2.4	0.3	7300	2.6	54	9300	43	1900	500	6400	3100	28	2	320	20	160
	Jackson	19000	2.4	12	0.7	18000	13	68	20000	93	5000	1700	7800	8700	78	0.31	660	42	280
10/10/18	Jackson	32000	2.0	3.4	0.6	12000	25	59	23000	90	4600	1100	7400	4600	63	0.28	930	55	290
10/11/18	Hortense	1400	5	1.0	1	14000	10	100	990	3.9	2400	25	4400	17000	100	2	30	50	23
	Jackson	3500	5	1.5	1	13000	4.1	100	2000	5.2	1900	47	4800	3100	61	2	90	8.1	27
10/26/18	Hortense	3200	1.4	3	2	7700	2.7	20	2800	13	1300	180	2900	3200	35	0.62	99	50	66
	Jackson	3400	5	3	2	11000	3	100	2700	7.7	2000	200	4400	5300	55	4	100	50	51

*The criterion for thallium is a limit of 0.47 µg/L at or above annual average flow conditions, applicable during all sampling events except at baseflow.

**Acute and chronic criteria were calculated using hardness values according to Ga. Comp. R. & Regs. r.391-3-6-.03(5)(e)(ii).

Table 8: Analytical data for pesticides and PCBs. All values are shown in µg/L. Values highlighted in grey indicate that the parameter was not detected above that reporting limit. Values highlighted in orange or yellow are above the corresponding 7Q10 and/or annual average criterion for that parameter. Dates highlighted in blue indicate baseflow samples, whereas dates highlighted in green indicate those samples which captured the rising limb and/or peak of the hydrograph.

		alpha-Chlordane	alpha-Endosulfan	alpha-BHC	delta-BHC	Dieldrin	gamma-Chlordane	Heptachlor	Lindane	p,p'-DDE	p,p'-DDT	Aroclor 1254	Aroclor 1260	Total Aroclors
7Q10		0.0043	0.056			0.056	0.0043	0.0038	0.95		0.001			0.014
annual average			89	0.0049		0.000054		0.000079	1.8	0.00022	0.00022			0.000064
7/31/17	Spring	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Hortense	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
7/28/17	Jackson	0.01	0.01	0.01		0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
10/30/18	Hortense	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
8/31/17	Spring	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.042	0.042
	Hortense	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
9/11/17	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
10/8/17	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.06	0.06
10/23/17	Spring	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Hortense	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
10/28/17	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
1/28/18	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
2/7/18	Spring	0.01	0.01	0.0078	0.011	0.01	0.01	0.0054	0.018	0.01	0.01	0.1	0.1	0.1
	Hortense	0.0047	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Jackson	0.01	0.01	0.01	0.0075	0.01	0.01	0.0058	0.01	0.01	0.01	0.1	0.1	0.1
2/26/18	Hortense	0.01	0.013	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Jackson	0.01	0.021	0.01	0.01	0.01		0.01	0.01	0.01	0.01	0.1	0.1	0.1
3/11/18	Hortense	0.01	0.01	0.01	0.01	0.01	0.011	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Jackson	0.01	0.01	0.01	0.01	0.01	0.027	0.01	0.01	0.01	0.01	0.1	0.1	0.1
9/26/18	Hortense	0.01	0.01	0.01	0.01	0.0075	0.0052	0.01	0.01	0.01	0.0094	0.097	0.1	
	Jackson	0.01	0.01	0.01	0.01	0.0073	0.0034	0.01	0.01	0.0041	0.01	0.07	0.053	0.12
10/10/18	Jackson	0.012	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0078	0.0085	0.1	0.1	0.1
10/11/18	Hortense	0.01	0.01	0.01	0.01	0.0084	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
10/26/18	Hortense	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1
	Jackson	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.1

Most values reported were above the detection limit but below the reporting limit. Reporting limits varied slightly among dates, and are rounded for clarity.

Table 9: Analytical data for semi-volatile organic compounds. All values are shown in µg/L. Values highlighted in grey indicate that the parameter was not detected above that reporting limit. Values highlighted in orange are above the corresponding annual average criterion for that parameter. Dates highlighted in blue indicate baseflow samples, whereas dates highlighted in green indicate those samples which captured the rising limb and/or peak of the hydrograph.

Date	Site	Diesel range organics	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthene	Anthracene	Benzo[a]anthracene	Benzo[a]pyrene	Benzo[b]fluoranthene	Benzo[ghi]perylene	Benzo[k]fluoranthene	Bis(2-ethylhexyl) phthalate	Carbazole	Chrysene	Dibenzo[a,h]anthracene	Fluoranthene	Fluorene	Indeno[1,2,3-cd]pyrene	Naphthalene	Phenanthrene	Pyrene
annual average					990	40000	0.018	0.018	0.018		0.018	2.2		0.018	0.018	140	5300	0.018			4000
7/31/17	Spring	190		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	5	5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Hortense	2		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	5	5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7/28/17	Jackson	190		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	5	5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
10/30/18	Hortense	33	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
	Jackson	70	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
8/31/17	Spring	950	0.2	0.2	0.2	0.2	0.13	0.2	0.2	0.2	0.2	1.3	0.9	0.049	0.2	0.088	0.2	0.18	0.2	0.2	0.078
	Hortense	430	0.2	0.2	0.2	0.2	0.17	0.069	0.2	0.098	0.2	1.1	0.93	0.11	0.2	0.19	0.2	0.21	0.2	0.2	0.15
9/11/17	Jackson	760	0.099	0.12	0.2	0.2	0.2	0.11	0.23	0.14	0.2	1.4	5	0.12	0.2	0.23	0.2	0.24	0.2	0.14	0.2
10/8/17	Jackson	740	0.23	0.2	0.2	0.057	0.17	0.21	0.41	0.2	0.15	0.75	5	0.29	0.2	0.39	0.094	0.2	0.2	0.21	0.34
10/23/17	Spring	620	0.084	0.095	0.2	0.2	0.17	0.2	0.2	0.2	0.2	5	5	0.084	0.2	0.19	0.2	0.2	0.27	0.084	0.8
	Hortense	2000	0.2	0.2	0.2	0.2	0.19	0.23	0.57	0.35	0.26	0.94	5	0.34	0.2	0.6	0.2	0.2	0.2	0.19	1.1
10/28/17	Jackson	230	0.2	0.1	0.2	0.2	0.18	0.2	0.2	0.2	0.2	5	5	0.098	0.2	0.21	0.2	0.2	0.2	0.12	0.77
2/7/18	Spring	640	0.11	0.19	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.1	5	0.2	0.2	0.24	0.2	0.2	0.28	0.13	0.3
	Hortense	440	0.2	0.11	0.2	0.072	0.2	0.2	0.2	0.2	0.2	5	5	0.2	0.2	0.94	0.2	0.2	0.13	0.38	0.81
	Jackson	710	0.15	0.25	0.14	0.12	0.53	0.2	0.2	0.44	0.2	1.6	5	0.72	0.2	1.3	0.11	0.37	0.25	0.32	0.96
2/26/18	Hortense	370		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	5	5	0.2	0.2	0.18	0.2	0.2	0.2	0.2	0.2
	Jackson	470		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	5	5	0.2	0.2	0.27	0.2	0.2	0.2	0.2	0.22
3/11/18	Hortense	200	0.2	0.2	0.2	0.2	0.22	0.22	1.3	0.95	0.19	5	5	0.42	0.92	0.64	0.2	0.95	0.2	0.16	0.5
	Jackson	640	0.1	0.13	0.09	0.2	0.34	0.37	1.5	1	0.23	1.5	5	0.59	0.91	0.8	0.2	1	0.2	0.26	0.79
9/26/18	Hortense	1300		1	1	1						2	1		1		1	0.50	1	0.3	0.6
	Jackson	1400		1	1	1						2	10		1		1		1		
10/10/18	Jackson	1400	1	1	1	1						2	11		1		1	1	1	1	0.5
10/11/18	Hortense	440	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
	Jackson	530		1	1	1	1	1	1	1	1	2	11	1	1	1	1	1	1	1	1
10/26/18	Hortense	440	1	1	1	1	1	1	0.3	1	1	2	1	1	1	0.3	1	1	1	1	1
	Jackson	510	0.4	0.4	1	1	1	1	1	1	1	2	10	1	1	1	1	1	0.3	0.2	1

Values above the detection limit but below the reporting limit are shown, where available. Reporting limits varied slightly among dates, and are rounded for clarity.

Figure 1: Study site location in Fulton County, GA. The Proctor Creek watershed drains to the Chattahoochee River, which flows across the Florida panhandle to the Gulf of Mexico.

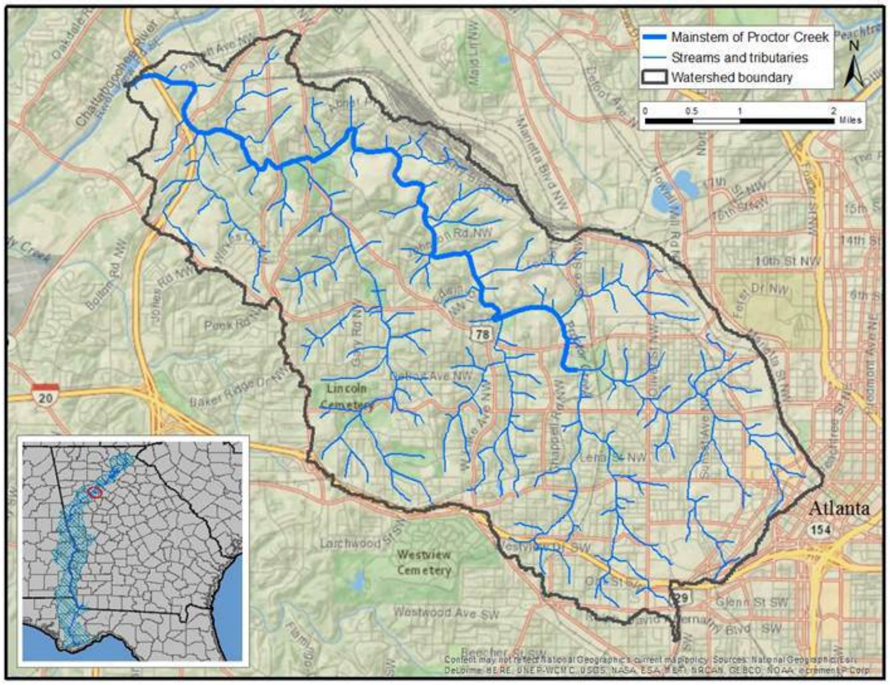


Figure 2: Map of sampling locations in the Proctor Creek watershed, with USGS gauge stations at Spring, Hortense and Jackson shown in red. The darker blue line indicates the mainstem of Proctor Creek, with tributaries shown in lighter blue.

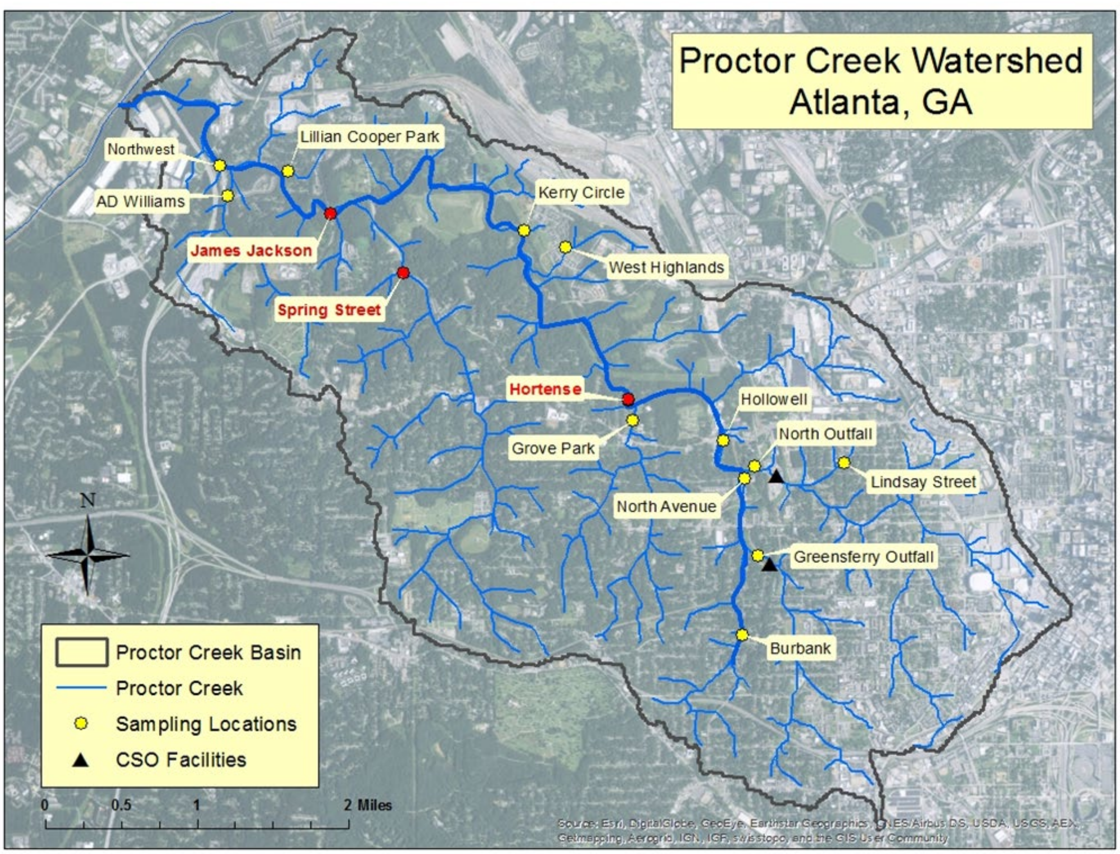
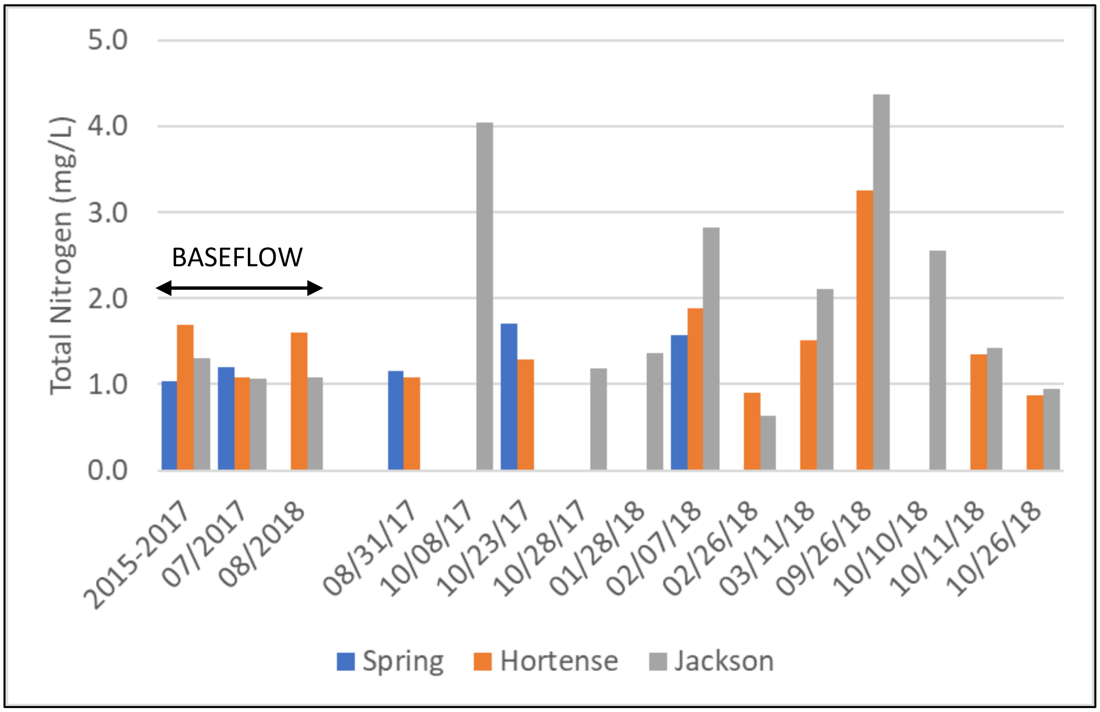
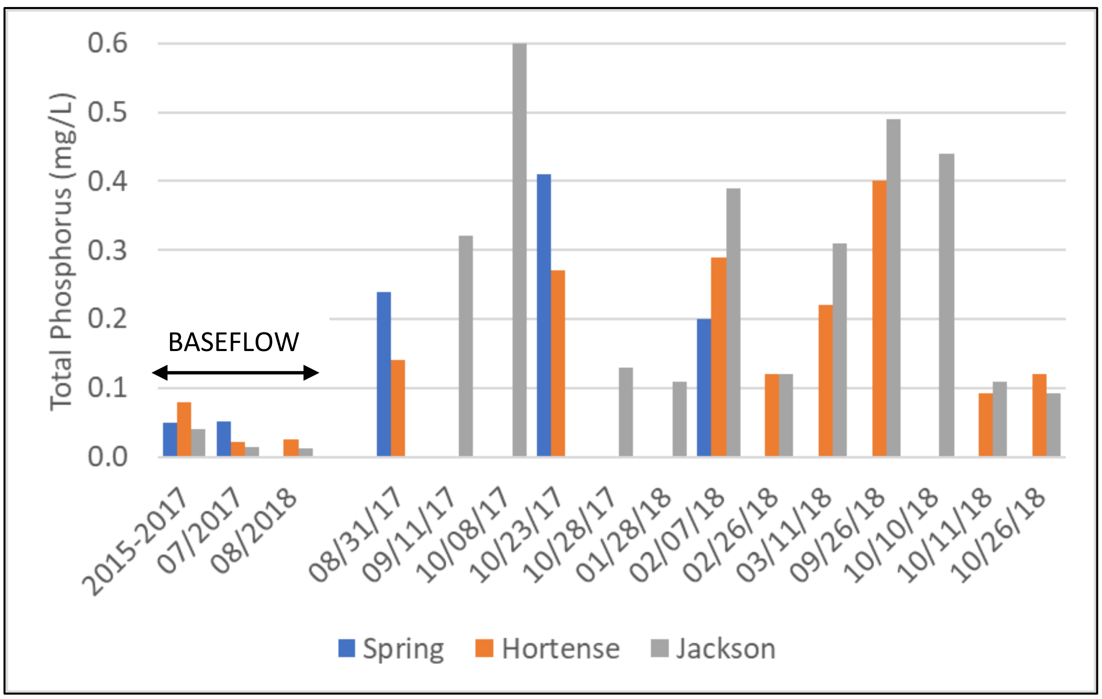


Figure 3: Total nitrogen and total phosphorus concentrations across stations and sampling events. The first three dates are baseflow data from the quarterly monitoring study (average of 8 data points from 2015-2017), the two July 2017 events at the beginning of this study, and the October 2018 event at the end of this study.





APPENDIX A

Methods, routine minimum reporting limits (MRL) for water and sediment matrices, and water quality standards (WQS) for each of the parameters analyzed during this study, according to analyte group. Highlighted analytes were not found above the MRL indicated in any stormwater samples during this study. WQS are shown where applicable only, for annual average criteria unless otherwise indicated. 1Q10 = one-day 10-year minimum low flow. 7Q10 = 7-day 10-year minimum low flow.

NUTRIENTS & CLASSICALS

Analyte	Method	MRL (mg/L)
Ammonia	EPA 350.1	0.1
Bromide	EPA 300.0	0.25
Chloride	EPA 300.0	0.1
Fluoride	EPA 300.0	0.5
Hardness	SM 2340C	5
Nitrate+Nitrite	EPA 353.2	0.05
Sulfate	EPA 300.0	0.1
Total Dissolved Phosphorus	EPA 365.2	0.005
Total Kjeldahl Nitrogen	EPA 351.2	0.1
Total Organic Carbon	SM 5310B	2
Total Phosphorus	EPA 365.2	0.005
Total Suspended Solids	SM 2540D	2
Suspended Sediment	ASTM D3977-97	2

* WQS for these metals are calculated using the total hardness of the water body. Formulae are listed in Ga. Comp. R. & Regs. r. 391-3-6-.03(5)(e)(ii). Values shown assume a hardness of 50 mg/L CaCo3.

TOTAL RECOVERABLE METALS

Analyte	Method	MRL (µg/L)	WQS (µg/L)
Aluminum	EPA 200.7	100	
Antimony	EPA 200.8	5	640
Arsenic	EPA 200.8	2	50 1Q10 = 340 **7Q10 = 150**
Barium	EPA 200.7	200	
Beryllium	EPA 200.7	5	
Cadmium*	EPA 200.8	1	1Q10 = 1.0 **7Q10 = 0.15**
Calcium	EPA 200.7	1000	
Chromium III*	EPA 200.7	10	1Q10 = 320 **7Q10 = 42**
Chromium VI*	EPA 200.7	10	1Q10 = 16 **7Q10 = 11**
Cobalt	EPA 200.7	20	
Copper*	EPA 200.7	100	1Q10 = 7.0 **7Q10 = 5.0**
Iron	EPA 200.7	300	
Lead*	EPA 200.8	2	1Q10 = 30 **7Q10 = 1.2**
Magnesium	EPA 200.7	1000	
Manganese	EPA 6010C	20	
Mercury*	EPA 245.1	0.2	1Q10 = 1.4 **7Q10 = 0.012**
Molybdenum	EPA 200.7	10	
Nickel*	EPA 200.7	100	1Q10 = 260 **7Q10 = 29**
Potassium	EPA 200.7	400	
Selenium	EPA 200.8	5	**7Q10 = 5**
Silver	EPA 200.7	20	
Sodium	EPA 200.7	1000	
Strontium	EPA 200.7	100	
Thallium	EPA 200.8	2	0.47
Tin	EPA 200.7	200	
Titanium	EPA 200.7	10	
Vanadium	EPA 200.7	50	
Yttrium	EPA 200.7	100	
Zinc*	EPA 200.7	100	1Q10 = 165 **7Q10 = 65**

PESTICIDES			
Analyte	**Method**	**MRL (µg/L)**	**WQS (µg/L)**
4,4'-DDD (p,p'-DDD)	SW 8081B	0.01	0.00031
4,4'-DDE (p,p'-DDE)	SW 8081B	0.01	0.00022
4,4'-DDT (p,p'-DDT)	SW 8081B	0.01	0.00022 **7Q10 = 0.001**
Aldrin	SW 8081B	0.01	0.00005
Dieldrin	SW 8081B	0.01	0.000054 **7Q10 = 0.056**
Endosulfan I (alpha)	SW 8081B	0.01	89 **7Q10 = 0.056**
Endosulfan II (beta)	SW 8081B	0.01	89 **7Q10 = 0.056**
Endosulfan Sulfate	SW 8081B	0.01	89 **7Q10 = 0.056**
Endrin	SW 8081B	0.01	0.060 **7Q10 = 0.036**
Endrin aldehyde	SW 8081B	0.01	0.30
Endrin ketone	SW 8081B	0.01	
Heptachlor	SW 8081B	0.01	0.000079 **7Q10 = 0.0038**
Heptachlor epoxide	SW 8081B	0.01	0.000039 **7Q10 = 0.0038**
Methoxychlor	SW 8081B	0.01	**7Q10 = 0.03**
Toxaphene	SW 8081B	0.2	0.00028 **7Q10 = 0.0002**
alpha-BHC	SW 8081B	0.01	0.0049
alpha-Chlordane	SW 8081B	0.01	0.00081 **7Q10 = 0.0043**
gamma-Chlordane	SW 8081B	0.01	
beta-BHC	SW 8081B	0.01	0.017
delta-BHC	SW 8081B	0.01	
gamma-BHC (Lindane)	SW 8081B	0.01	1.8 **1Q10 = 0.95**

PCB AROCLORS			
Analyte	**Method**	**MRL (µg/L)**	**WQS (µg/L)**
PCB Aroclor 1016	SW 8082A	0.1	for all PCBs: 0.000064 **7Q10 = 0.014**
PCB Aroclor 1221	SW 8082A	0.1	
PCB Aroclor 1232	SW 8082A	0.1	
PCB Aroclor 1242	SW 8082A	0.1	
PCB Aroclor 1248	SW 8082A	0.1	
PCB Aroclor 1254	SW 8082A	0.1	
PCB Aroclor 1260	SW 8082A	0.1	
PCB Aroclor 1262	SW 8082A	0.1	
PCB Aroclor 1268	SW 8082A	0.1	

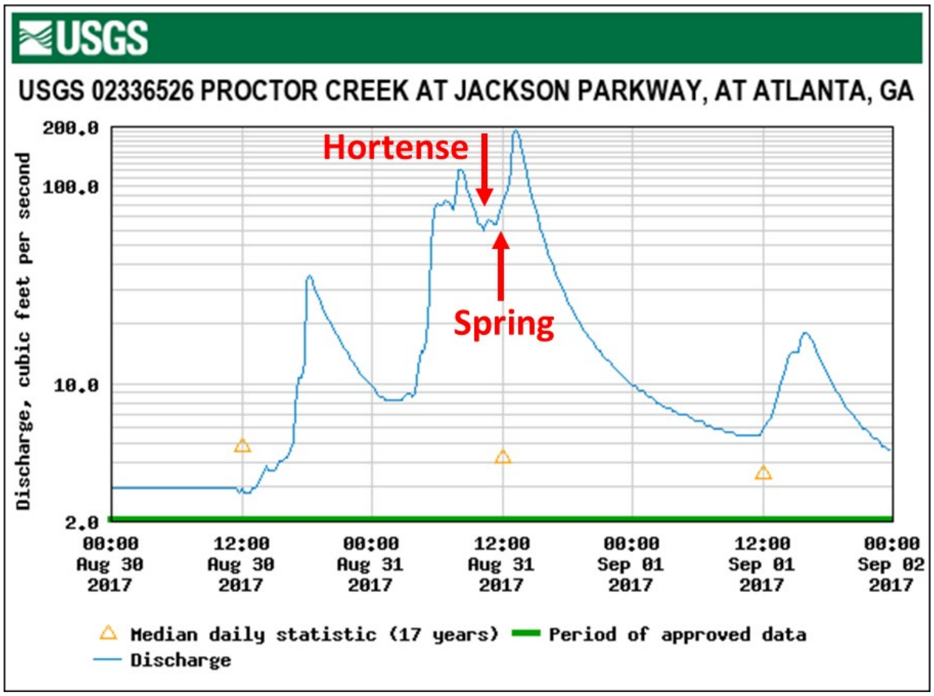
SEMI-VOLATILE ORGANICS					
Analyte	MRL (µg/L)	WQS (µg/L)	Analyte	MRL (µg/L)	WQS (µg/L)
1,1-Biphenyl	5		Benzo(g,h,i)perylene	0.2	
1,2,4-Trichlorobenzene	5	70	Benzo(k)fluoranthene	0.2	0.018
1,4-Dioxane	1		Benzyl butyl phthalate	5	1900
1-Methylnaphthalene	0.2		Bis(2-chloroethoxy)methane	5	
2,3,4,6-Tetrachlorophenol	5		Bis(2-chloroethyl) ether	5	0.53
2,4,5-Trichlorophenol	5		Bis(2-chloroisopropyl) ether	5	65000
2,4,6-Trichlorophenol	4	2.4	Bis(2-ethylhexyl) phthalate	5	2.2
2,4-Dichlorophenol	5	290	Caprolactam	5	
2,4-Dimethylphenol	5	850	Carbazole	5	
2,4-Dinitrophenol	25	5300	Chrysene	0.2	0.018
2,4-Dinitrotoluene	5	3.4	o-Cresol	5	
2,6-Dinitrotoluene	5		Di-n-butylphthalate	5	4500
2-Chloronaphthalene	5	1600	Di-n-octylphthalate	5	
2-Chlorophenol	5	150	Dibenz(a,h)anthracene	0.2	0.018
2-Methyl-4,6-dinitrophenol	10	280	Dibenzofuran	4	
2-Methylnaphthalene	0.2		Diesel Range Organics	200	
2-Nitroaniline	5		Diethyl phthalate	5	44000
2-Nitrophenol	5		Dimethyl phthalate	5	1100000
3,3'-Dichlorobenzidine	20	0.028	Fluoranthene	0.2	140
3-Nitroaniline	10		Fluorene	0.2	5300
4-Bromophenyl phenyl ether	5		Hexachlorobenzene (HCB)	5	0.00029
4-Chloro-3-methylphenol	5		Hexachlorobutadiene	5	18
4-Chloroaniline	10		Hexachlorocyclopentadiene (HCCP)	5	1100
4-Chlorophenyl phenyl ether	5		Hexachloroethane	5	3.3
4-Nitroaniline	10		Indeno (1,2,3-cd) pyrene	0.2	0.018
4-Nitrophenol	25		Isophorone	5	960
Acenaphthene	0.2	990	Naphthalene	0.2	
Acenaphthylene	0.2		Nitrobenzene	3	690
Acetophenone	5		Pentachlorophenol	5	3.0 **7Q10=15**
Anthracene	0.2	40000	Phenanthrene	0.2	
Atrazine	5		Phenol	5	857000 **7Q10=300**
Benzaldehyde	5		Pyrene	0.2	4000
Benzo(a)anthracene	0.2	0.018	n-Nitroso di-n-Propylamine	5	0.51
Benzo(a)pyrene	0.2	0.018	n-Nitrosodiphenylamine	5	6.0
Benzo(b)fluoranthene	0.2	0.018			

All semi-volatile compounds were analyzed by Method SW 8270D, except Diesel Range Organics, analyzed by Method SW 8015D.

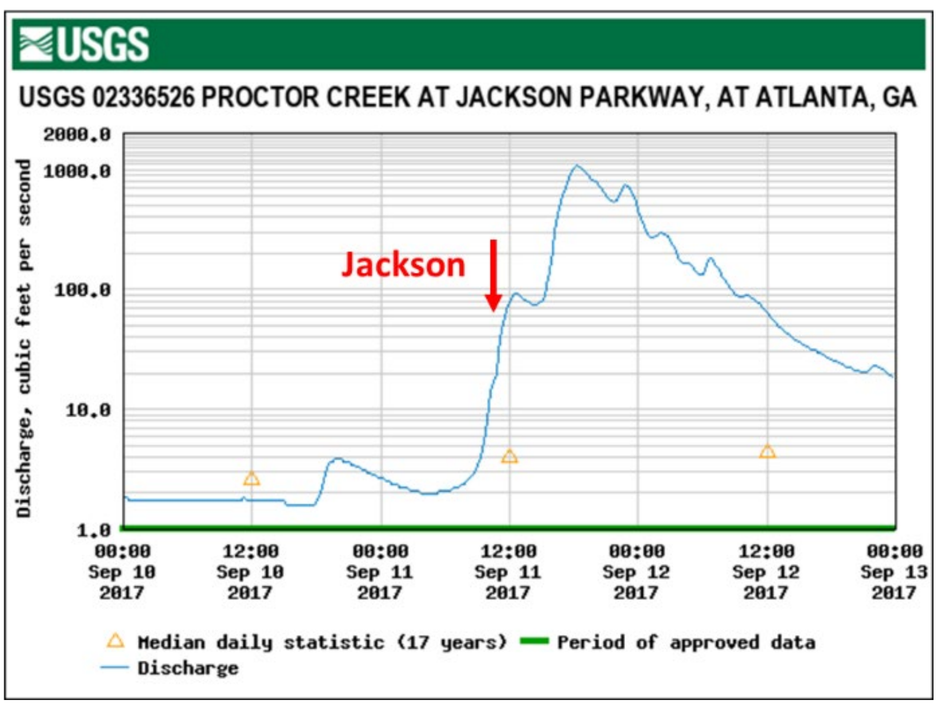
APPENDIX B

Discharge graphs for each stormwater sampling event, including the day prior to and the day following each sampling date. Arrows indicate the approximate sample start time at each station. Note that discharge data are from the Jackson station only, to provide a visual representation of the storm event. Actual discharge data for Hortense and Spring are shown in Tables 3 & 4.

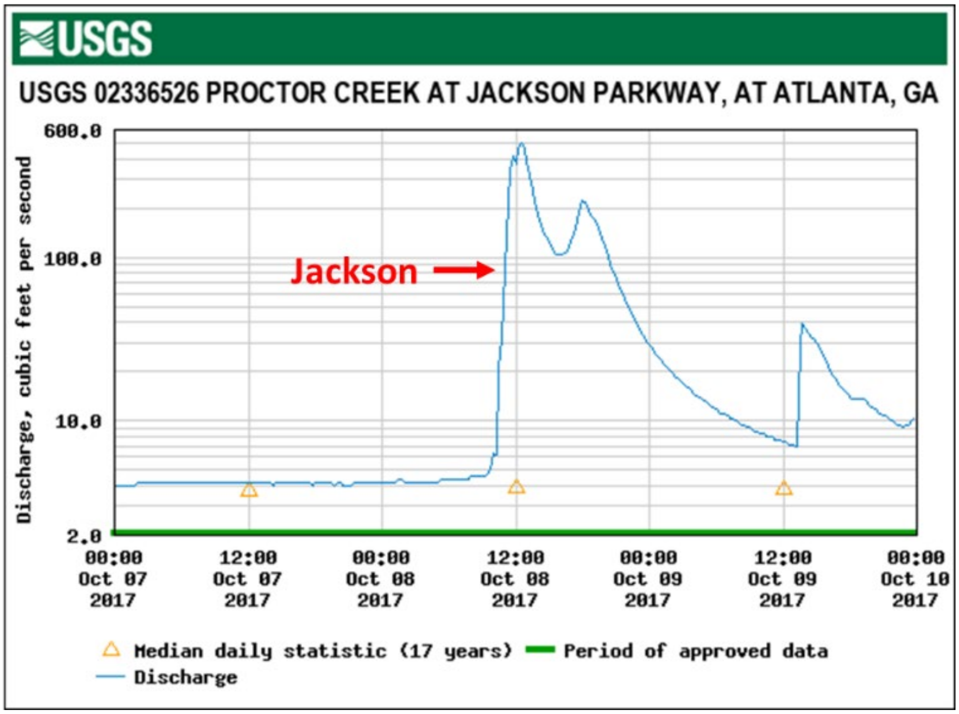
August 31, 2017



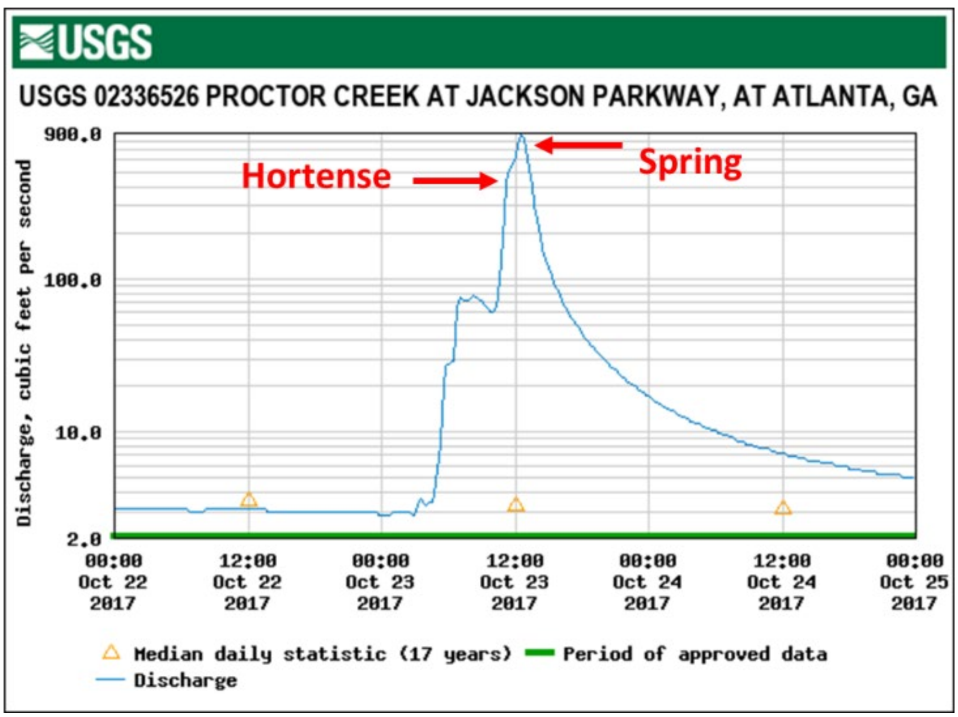
September 11, 2017



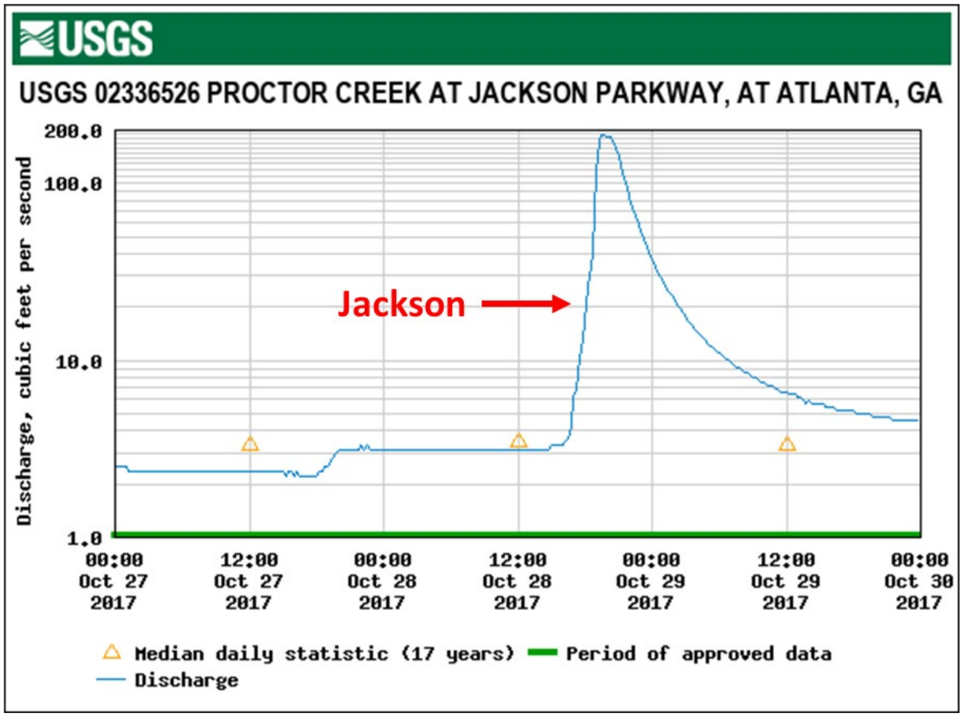
October 8, 2017



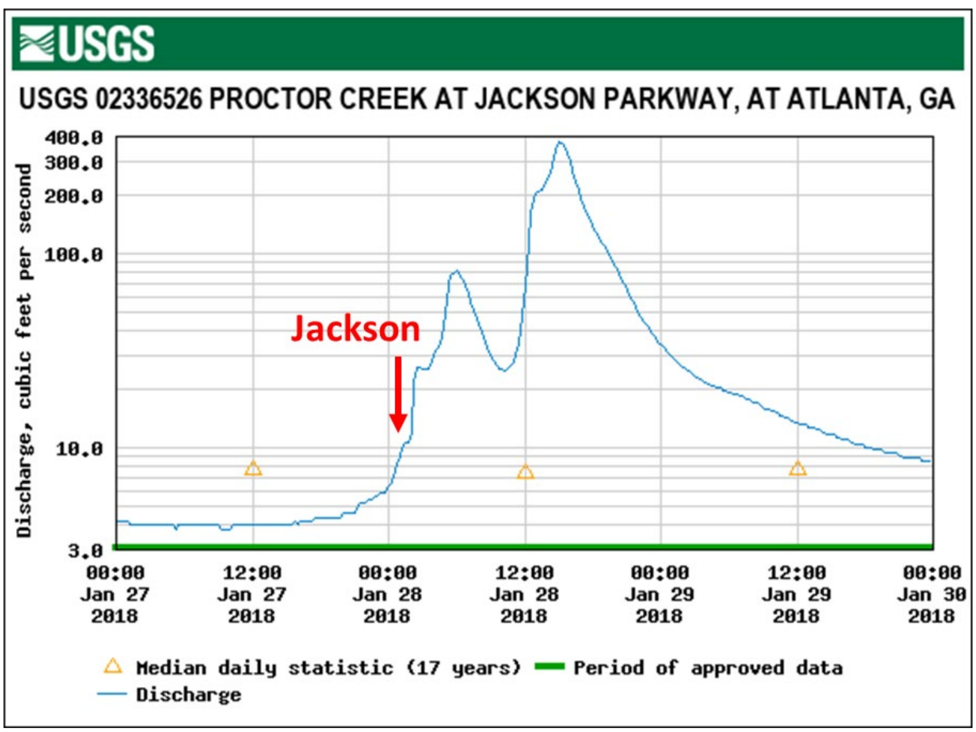
October 23, 2017



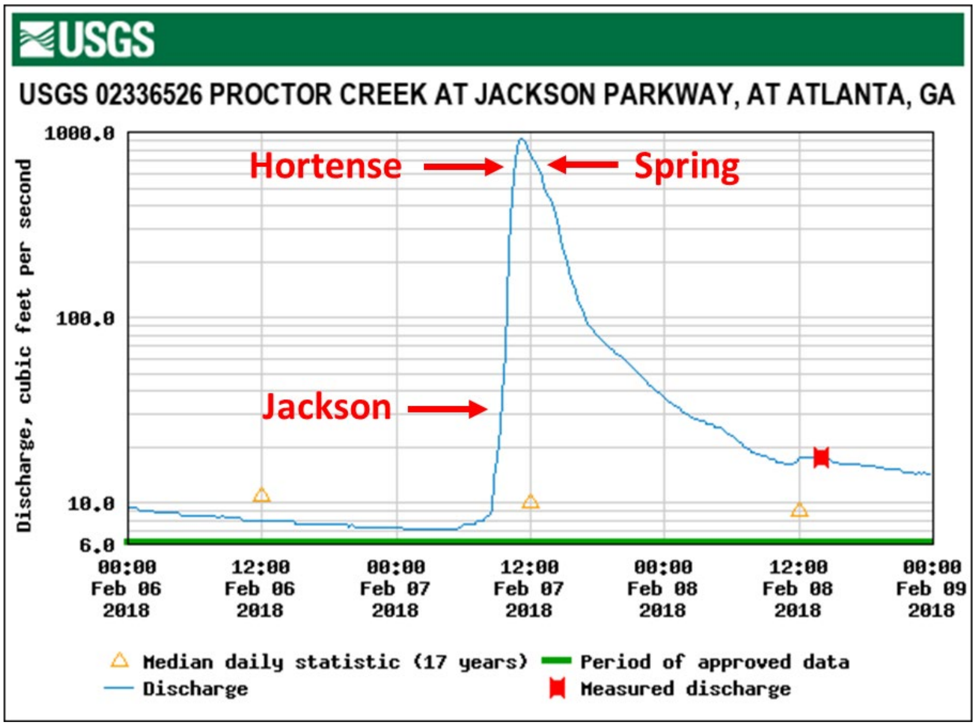
October 28, 2017



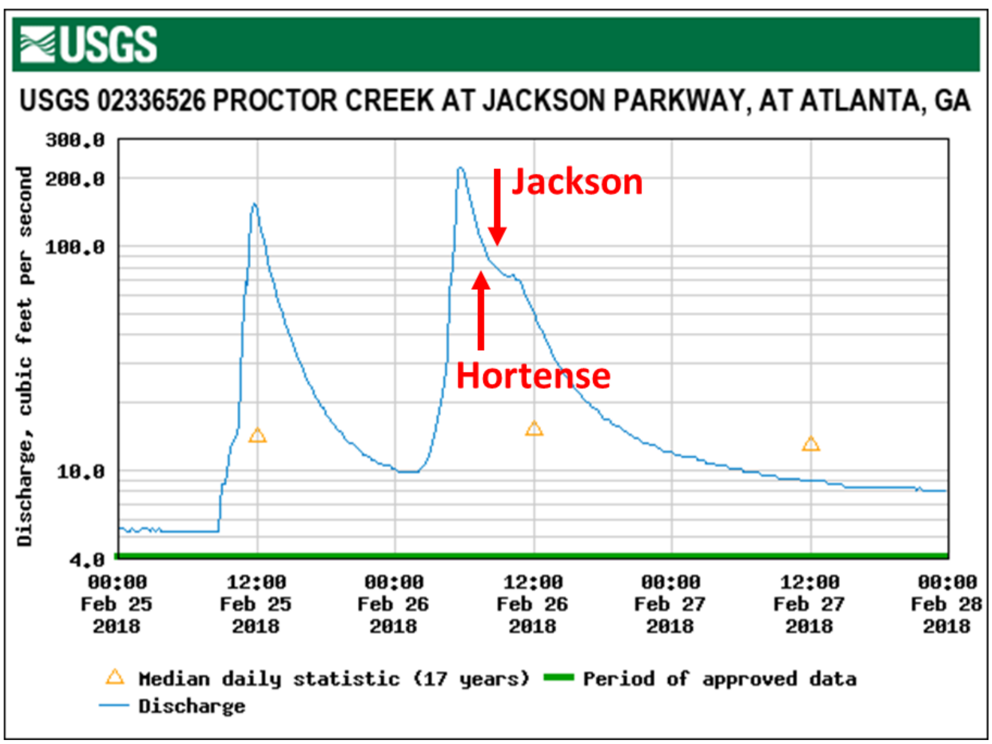
January 28, 2018



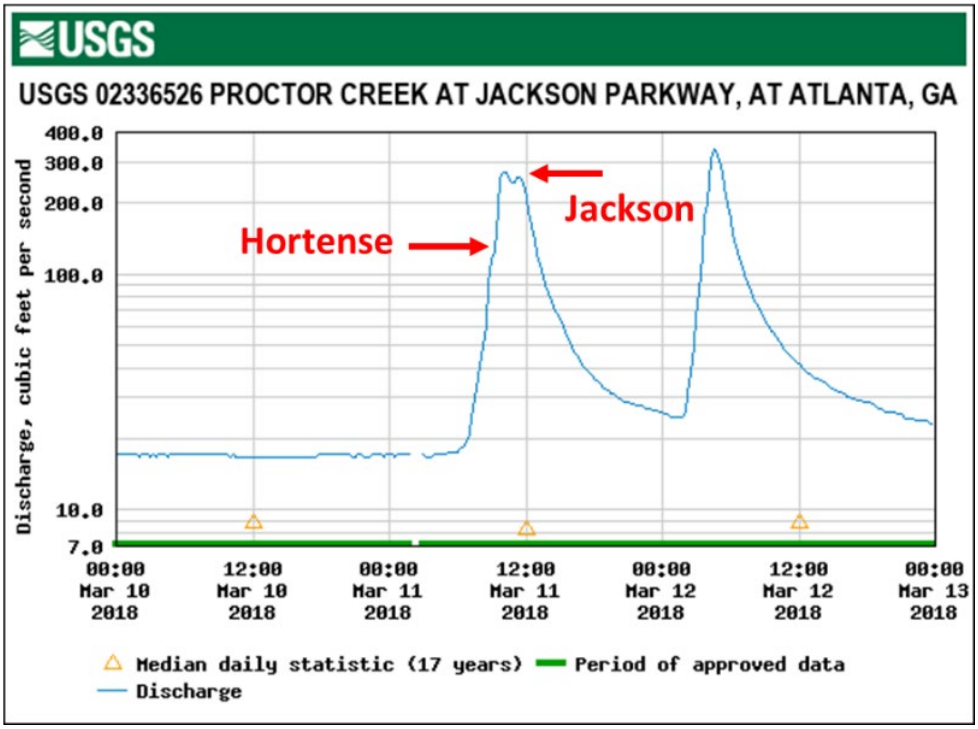
February 7, 2018



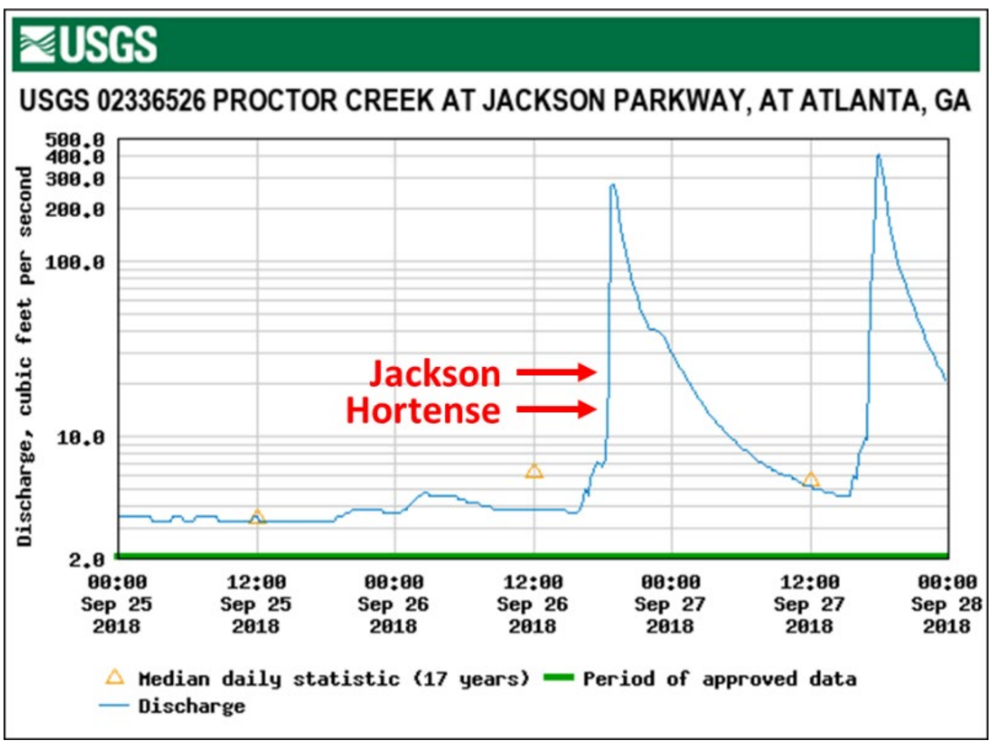
February 26, 2018



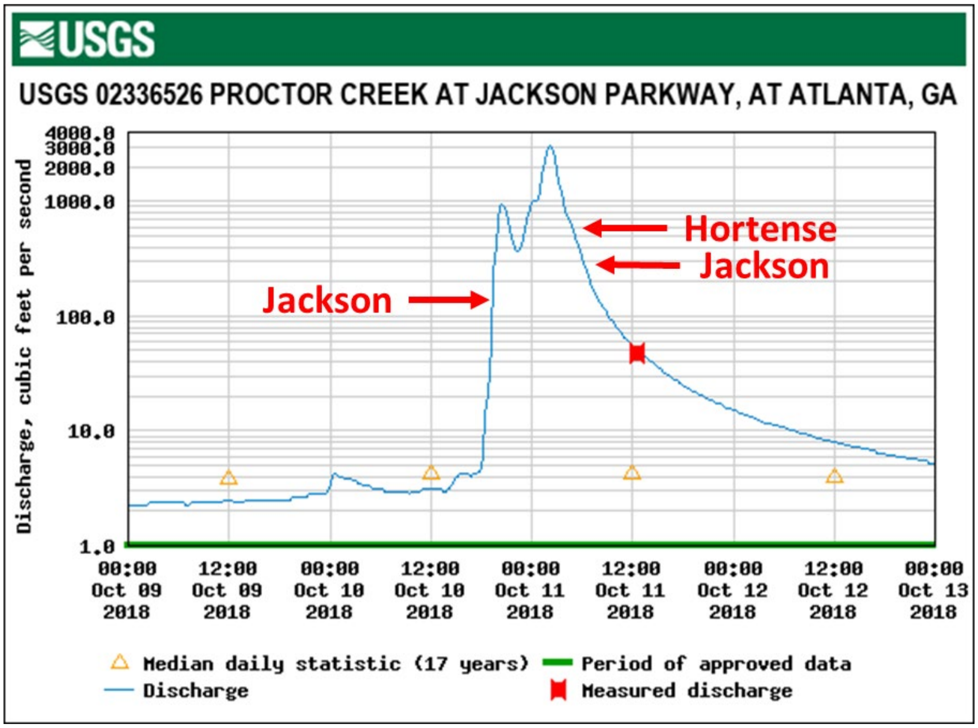
March 11, 2018



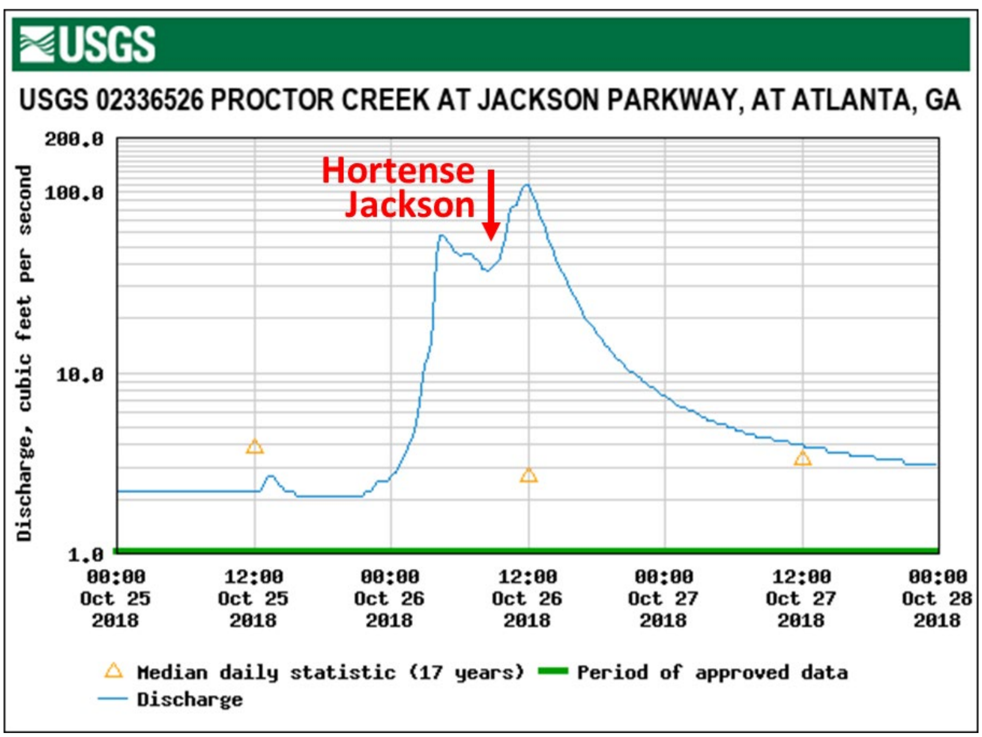
September 26, 2018



October 10-11, 2018



October 26, 2018



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