



Fixed-Station Water-Quality Monitoring at Congaree National Park

Data Summary 2011

Natural Resource Data Series NPS/2013/NRDS—2013/457



ON THE COVER

Water-quality monitoring station at bridge over Cedar Creek at Congaree National Park. Photograph by Theresa Thom.

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Summary and Key Findings

In 2006 Congaree National Park (CONG), in conjunction with the Southeast Coast Network (SECN) Inventory and Monitoring Program, began collecting water-quality data at Cedar Creek as part the NPS Vital Signs Monitoring Program. The continuous monitoring data station is located approximately one mile south of the visitor center and collects water temperature, dissolved oxygen, pH, salinity, specific conductance, turbidity and water-level data every 30 minutes following the methods of Wenner and Geist (2001). This publication summarizes data collected from January 1, 2011 to December 31, 2011. The CONG fixed-station water-quality monitoring site is part of the SECN water-quality monitoring program, which collects data in the vicinity of eight parks located along the southeastern U.S. coast (DeVivo et al. 2008). Information collected by this monitoring program may be used to help park managers make better-informed decisions by understanding trends and variability related to water-quality conditions in park waters. Summary data are presented in annual data reports published by the SECN. Significant findings for 2011 are as follows:

- The 2011 continuous data record includes several periods of flagged data, primarily due to equipment malfunctions. Dissolved oxygen values were the most often flagged parameter.
- Water temperature ranged 1.6–30.5°C (34.88–86.9°F). The lowest monthly average temperature of 6.0°C (42.8°F) occurred in January, and the highest monthly average of 28.2°C (82.76°F) occurred in July.
- Specific conductance values ranged from 21 to 70 $\mu\text{S}/\text{cm}$. The baseline level for specific conductance in Cedar Creek is approximately 25 $\mu\text{S}/\text{cm}$. A majority of spikes in specific conductance were associated with rain and/or runoff events. A period of elevated specific conductance was noted during the first week of April and coinciding with near-bankfull flows on the Congaree River indicating possible backwater effects at the station.
- Dissolved oxygen concentrations ranged from a low of 4.7 mg/L in July to 11.1 mg/L in February. Forty-one individual readings were below 5.0 mg/L, but only one daily average was lower than the South Carolina freshwater standard of 5.0 mg/L; the daily average dissolved oxygen reading for July 22 was 4.98 mg/L. The lowest monthly average was in June (5.1 mg/L) and the highest monthly average was in January (10.6 mg/L): however, only 2% of readings were used during the month of January (the remaining data were flagged). The next highest monthly average was observed in December (9.8 mg/L) where 63% of the readings were used.
- pH values ranged between 5.6 and 6.6, with 55% of measurements (5,839/10,595) below the South Carolina standard of 6.0 for freshwater. The lowest monthly average for pH was 5.9, occurring in May, August, September and December. The highest monthly average was 6.2 in January. Elevated pH values were noted during the first week of April due possibly to backwater from the mainstem of the Congaree River during a high flow event.
- Turbidity values were generally low in Cedar Creek throughout much of the year. Elevated mean daily turbidity values above 50 NTUs (the South Carolina turbidity standard for freshwater) were observed six times during 2011, with all exceedences occurring during, and

after, summer rainfall events. The lowest monthly average for turbidity was 2.1 NTUs in January, and the highest monthly average was 22.8 NTUs in June.

Introduction

In 2006 the SECN began collecting water-quality data on Cedar Creek to provide additional data to help assess water-quality conditions and determine short- and long-term trends in water-quality conditions within Congaree National Park (Figure 1). This site was chosen as a long-term fixed water-quality monitoring site because of its proximity to an existing U.S. Geological Survey gaging station (USGS gaging station # 02169672) as well as to provide managers with additional water quality and hydrologic information on a stream representative of those draining the Congaree River floodplain. The SECN monitoring station was established in 2006 and moved to the upstream side of the bridge in 2009 for logistical reasons. This report provides a summary of data collected at this site from January 1 to December 31, 2011 and provides a snapshot of conditions to park managers as well as information on short-term and seasonal variability in water-quality parameters in the vicinity of Congaree National Park.

Congaree National Park

Congaree National Park is adjacent to the Congaree and Wateree rivers in southeast Richland County, South Carolina, approximately 20 miles southeast and downstream of the capital city of Columbia (Figure 1). Encompassing 26,027 acres, the Park protects old-growth trees and diverse plant and animal life within the largest intact expanse of old-growth bottomland hardwood forest remaining in the United States. Periodic flood waters from the adjacent rivers flow through the bottomland forest in winter and spring, carrying the nutrients and sediments that nourish and rejuvenate this unique floodplain ecosystem. Nearly 90 species of trees grow within the Park, with many that are recognized as national and state champions for their size. Forested wetlands, oxbow lakes, and slow moving creeks and sloughs provide superb habitat for fish, birds, reptiles, mammals and other aquatic life. The diversity of flora and fauna, tall tree canopy, champion trees, and intact floodplain ecosystem earned the Park the designation of an International Biosphere Reserve, National Natural Landmark, Globally Important Bird Area, Wetland of International Importance through the Ramsar Convention, and congressionally designated Wilderness Area (NPS 2012).

Congaree National Park is drained by two major tributaries that meander through a spatially complex network of channel features such as abandoned meander channels, oxbow lakes as well as artificial dikes built to divert flows. These features are located throughout the Congaree River floodplain and support lateral and vertical hydrologic exchanges between the river and the floodplain (Meitzen 2011).

Congaree National Park Fixed Station Water Quality

Southeast Coast Network
National Park Service
U.S. Department of the Interior

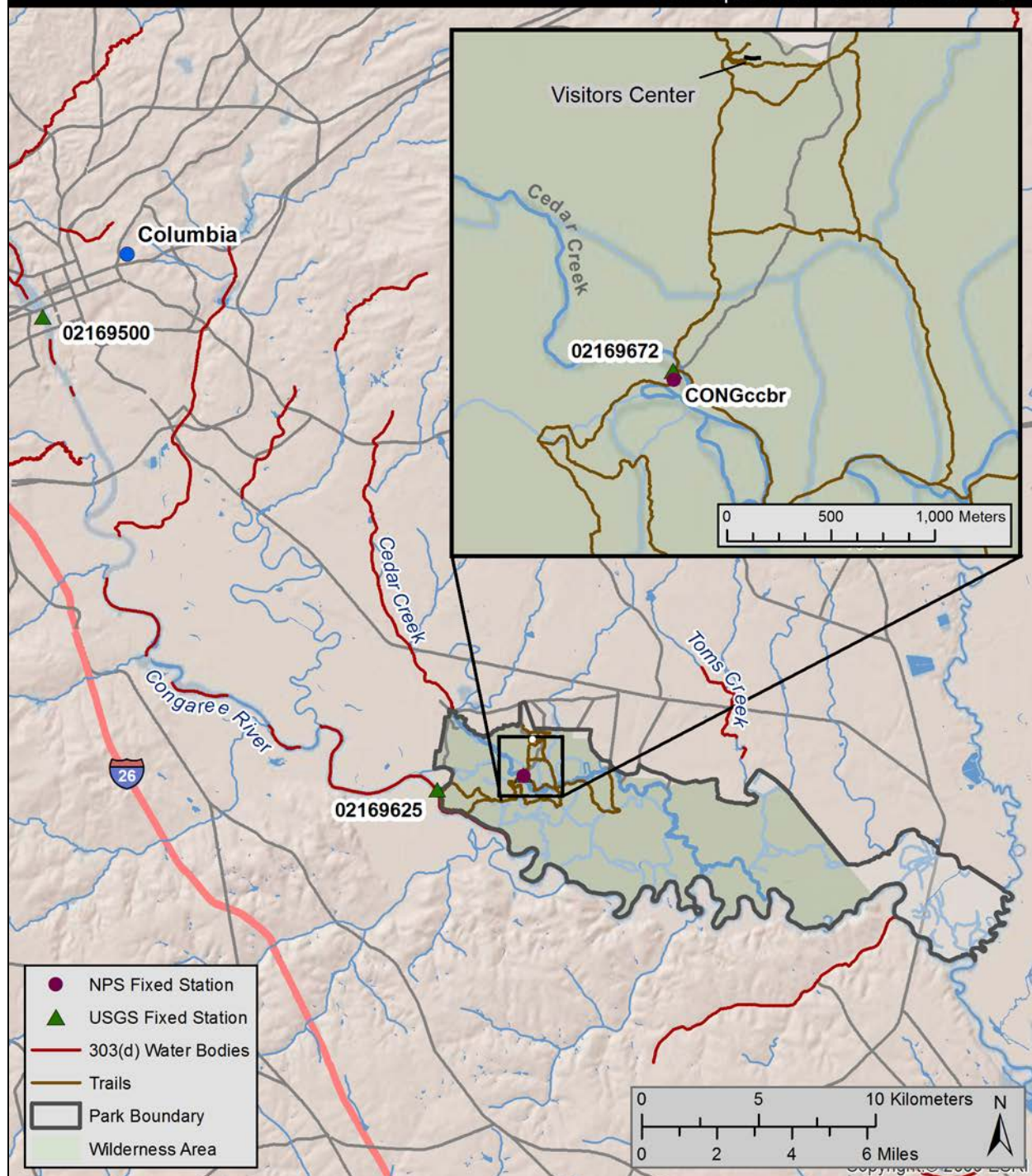


Figure 1. Location of continuous water-quality monitoring station at Congaree National Park in South Carolina.

Cedar Creek is the largest floodplain tributary that flows through Congaree National Park (e.g. Shelley et al., 2012). The floodplain portion of Cedar Creek in Congaree National Park is formed by the confluence of two upland creeks called Cedar and Meyers Creeks. The combined upland watershed represented by these two creeks is 11 km (6.8 mi) wide, 23 km (14.3 mi) long, and covers more than 170 km² (65 mi²). Although, the water-quality standards promulgated by the State of South Carolina do not differentiate between different types of freshwater streams, what is considered normal water quality in a coastal plain blackwater stream can be quite different than what is considered normal for a non-blackwater system. Cedar Creek is a “black water” system characterized by clear, tea-colored water associated with organic acids leached by groundwater percolating through the soil profile. This translates into relatively high dissolved organic carbon values and relatively low values for dissolved oxygen, conductivity, alkalinity, and pH (e.g. Birch, 1984; Maluk and Abrahamsen, 1999; Andersen et al., 2010; NPS, unpublished data). Blackwater streams can also become highly turbid during rain events when fine sediments that have settled onto the stream’s benthos in the gentle, slow moving currents of base-flow are mobilized and become suspended in the water column as the streams stage increases. As with other blackwater streams, during high flow events, upland watershed runoff, intra-floodplain runoff, and back-flooding of the Congaree River lead to increases in the suspended sediment concentration as well as other changes in water quality (e.g. Birch, 1984). The State of South Carolina acknowledges that certain water bodies may have normally occurring conditions that are outside the range set forth in its water quality standards.

Cedar Creek supports diverse aquatic communities and provides recreational opportunities (mainly canoeing and fishing) for Park visitors. In 2006 waters of Cedar Creek within Congaree National Park were reclassified from a general “freshwater” classification to an Outstanding Resource Waters (ORW), and a portion of Cedar Creek was upgraded to Outstanding National Resource Waters (ONRW), the first such designation of its kind in South Carolina (SC DHEC 2006). Cedar Creek outside of the Park boundary is classified as freshwater, from the Park boundary to Wise Lake is classified as ORW (this is the section that the water-quality station is on), and from Wise Lake to the confluence of the Congaree River is classified as ONRW. Portions of three water bodies (Congaree River, Tom’s Creek and Cedar Creek) adjacent to Congaree National Park are 303(d) listed as impaired or threatened for a variety of reasons (Figure 1; U. S. Environmental Protection Agency 2011). The Congaree River has been listed for elevated levels of fecal coliform for recreational purposes. The upstream section of Cedar Creek, before it enters the Park boundary, has been listed for not meeting the criteria for macroinvertebrates communities in 2008 and 2010. Sections of Tom’s Creek have been listed for elevated levels for fecal coliform, macroinvertebrate communities, and pH values.

Weather and Hydrologic Setting

Regional precipitation and temperature departures (NOAA 2012), daily precipitation data (National Climate Data Center 2012), and discharge data from the mainstem of the Congaree River (USGS gaging station #020169500) are made available in this report as contextual information to aid in the interpretation of changes and patterns observed in water-quality data. Please refer to Wright (2012) and Jones and Gregory (2012) for more details on weather and hydrologic parameters surrounding the Park.

Average monthly air temperatures at Columbia Metro Airport weather station ranged from 41.7–85.5°F (5.4–29.7°C). The average annual temperature was 66.0°F (18.9°C). The highest average

monthly maximum air temperature was 96.4°F (35.8°C) in July 2011 and the lowest average monthly minimum air temperature was 30.8°F (-0.7°C) in January 2011. Growing season length was calculated to be 231 days at this station, with the last spring freeze occurring on March 12th and the earliest fall freeze occurring on October 30th. Comparisons of 2011 air temperature data to the 30-year air temperature average at Columbia Metro Airport, show that January and October were colder than average for both $T_{\max}$ and $T_{\min}$ (Figure 2), though not outside the range of variation for the long-term average. In contrast (with the exception of $T_{\min}$ in November), air temperatures for the rest of the year were warmer than average at both stations, though not outside the range of variation for the long-term average.

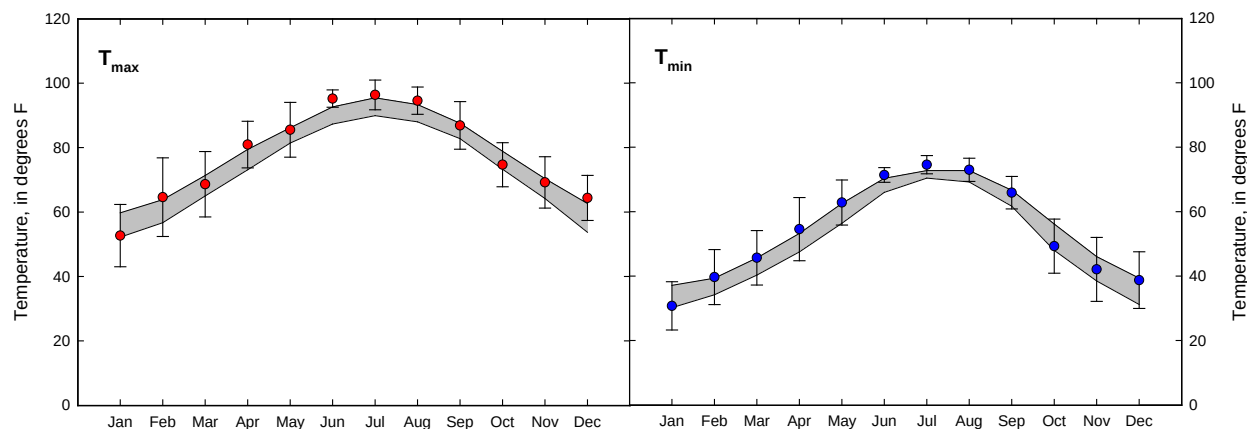


Figure 2. Average monthly air temperature during 2011 and the 30-year (1981 – 2010) average for Columbia Metro Airport station. Units = °F. Points indicate the 2011 average monthly maximum and minimum temperatures. Error bars indicate +/- standard deviation. The dual solid lines bound the standard deviation around the 30-year (1981-2010) mean monthly temperature.

Monthly precipitation in 2011 at the Columbia Metro Airport station ranged from 1.11 – 6.17 inches (28.2 – 156.7 mm), with the lowest precipitation occurring in December and the highest precipitation occurring in July (Figure 3). Total precipitation in 2011 was 36.63 inches (930.4 mm). Comparisons of 2011 precipitation data to the 30-year average at Columbia Metro Airport station show that February, March, April and July experienced higher than average precipitation (Figure 3), although 2011 monthly total precipitation was never higher than the 75th percentile of the 30-year average. Precipitation during the rest of 2011 was lower than average with January and December experiencing lower precipitation than the 25th percentile of the 30-year average. Total annual precipitation was 36.63 inches (930.4 mm) during 2011, which is 7.96 inches (202.2 mm) below normal (Wright 2012).

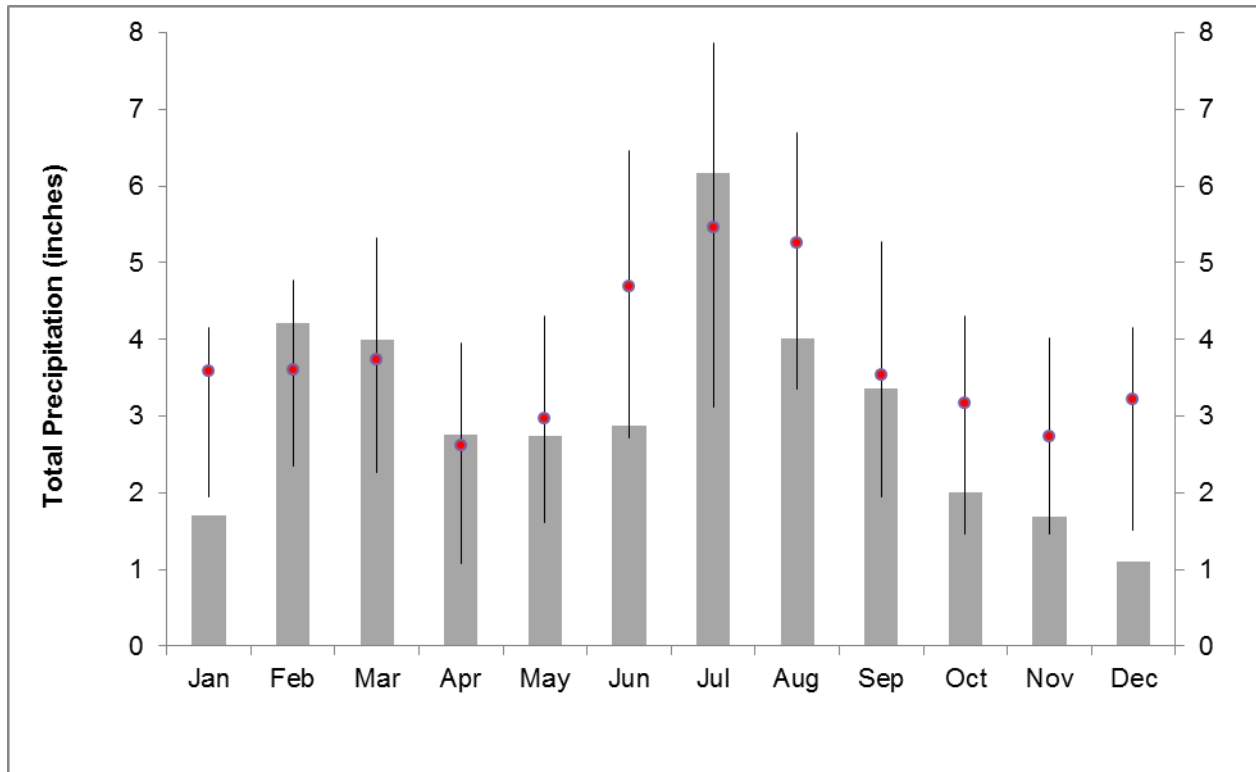


Figure 3. Total monthly precipitation during 2011 and the 30-year (1981 - 2010) monthly averages for Columbia Metro Airport station. The gray columns represent 2011 total monthly precipitation. The red circles represent the 30-year average; the lines indicate the 25th and 75th percentile of the 30-year normal data for each month.

Flows on the Congaree and Wateree rivers near the Park were much higher during the spring months from March to May and during December (Jones and Gregory 2012). Flows on the Congaree River near CONG were below the historical range of variation (<25th percentile for all observations since 1939) during much of the time from June to November (Figure 4). Two times during March and April, however, flow was above the 75th percentile for what is typically observed on the Congaree (Figure 4). Average timing of peak extreme low flows occurred during late summer on the Congaree River and fall on the Wateree.

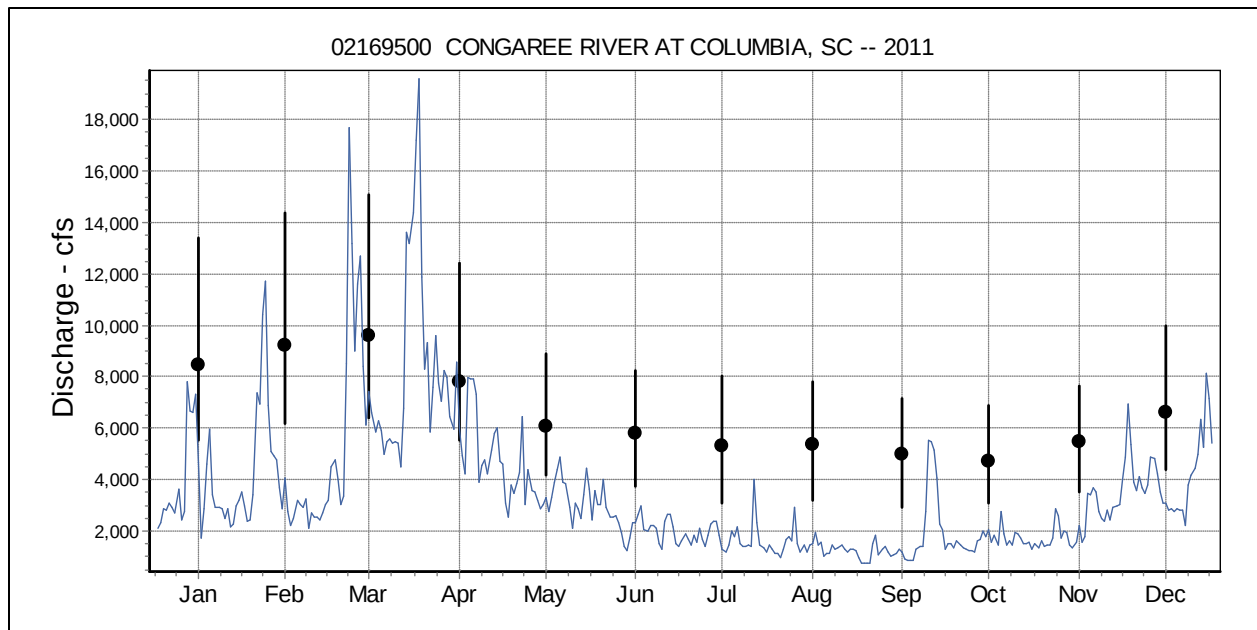


Figure 4. Daily flow (blue line), historical median monthly flow (dots), and interquartile range (error bars) for the Congaree River at Columbia, SC (USGS 02169500) in 2011 (from Jones and Gregory 2012).

Methods

The Southeast Coast Network's (SECN) monitoring effort is composed of collecting data from a permanent fixed-station continuous data logger at Bridge B over Cedar Creek (site CONGccbr; Table 1). The data logger (data sonde) monitors select water-quality parameters continuously at 30-minute intervals. Data collection methods are based on those employed by the National Estuarine Research Reserve Program (Wenner and Geist 2001); the efforts at CONG are part of a water-quality monitoring network operated at eight park units throughout the SECN. Detailed field and lab standard operating procedures and methods have been published in Gregory et al. (2013), which are briefly described below.

Table 1. Continuous water-quality monitoring site location and period of record at Congaree National Park.

Name	Location Description	Location (lat / long)	Period of Record
CONGccbr	Bridge "B" over Cedar Creek	33.8147 / -80.7811	8/9/2006 to present

Continuously-collected data includes dissolved oxygen, pH, specific conductance, temperature, depth and turbidity. Readings for these parameters are collected at 30-minute intervals using a YSI data sonde (Model 6600) which is deployed in three- to five-week intervals. The data collection platform consists of a 4-inch diameter PVC tube attached vertically to the handrail with the sonde suspended within and approximately one meter from the creek bottom (Figure 5). Water is allowed to freely circulate via openings cut into the PVC housing. A carriage bolt is inserted through the housing at the submerged end to prevent instrument loss should the attachment hardware fail. The sonde guard is covered with plastic mesh to prevent fish, invertebrates, and detritus from entering which could skew measurements or damage the instrument's probes. Additional details on site selection and installation procedures are reported in Gregory et al. (2013).

Prior to deployment, the data sonde is calibrated by Congaree staff according to YSI recommendations for pH (two-point calibration), dissolved oxygen, specific conductance, depth and turbidity (two-point calibration; YSI 2011), with additional instructions provided by Gregory et al. (2013). After instrument retrieval, data sondes are returned to the laboratory where post-deployment readings are made using calibration standards to evaluate the accuracy and validity of the data collected for that deployment period. All pre-deployment and post-retrieval calibration information is recorded on calibration data sheets that are archived at SECN office locations. After post-retrieval processing is complete, the sonde is cleaned, reconditioned, and readied for redeployment with methods outlined by YSI (2011). Performance specifications of the YSI 6600 are shown in Table 2.

Data generated during the deployment period are reviewed and certified by SECN staff prior to publication. During the data review process data may be flagged (marked as suspect) for a variety of reasons including the presence of heavy fouling on equipment, lack of post-calibration data, and/or readings outside of equipment specifications. All flagged data remain in the data set, but are excluded from analysis, including all tables and figures presented herein. On rare

occasions data are deleted from the data set such as in the case of probe failure or the sonde being out of the water during deployment.

Table 2. Performance specifications of YSI 6600 EDS data logger deployed at continuous monitoring site (YSI 2011).

Parameter	Range	Resolution	Accuracy
Temperature	-5–50°C	0.01°C	+/- 0.15°C
Specific Conductance	0–100 mS/cm	0.001 to 0.1 mS/cm; range dependent	+/- 0.5% of reading + 0.001 mS/cm
Dissolved Oxygen (% saturation)	0–500%	0.1%	0 to 200%: +/- 2% of reading or 2% air saturation, whichever is greater
Dissolved Oxygen (mg/L)	0–50 mg/L	0.01 mg/L	0 to 20 mg/L: +/- 2% of reading or 0.2 mg/L whichever is greater
pH	0 to 14 units	0.01 units	+/- 0.2 unit
Turbidity	0–1000 NTU	0.1 NTU	+/- 2% of reading or 0.3 NTU, whichever is greater.
Depth	0–9 m (0–30 ft)	0.001m (0.001ft)	+/- 0.018m (+/- 0.06 ft)



Figure 5. Continuous data collection platform on Cedar Creek in Congaree National Park. Photo by Katie Ivins, SECN staff.

Results

Figures 6–10 are graphical depictions of the daily mean data for the entire data collection period by parameter. Minimum and maximum values for each month with the mean and standard deviation are provided in Table 3. The percentage of values field indicates the level of completeness of the monthly data sets used for calculating mean, maximum and minimum statistics, and equals the number of data points collected (i.e., not missing or flagged) divided by the total number of expected points for a complete month of data. For those months where all of the data were missing and/or flagged, the percentage of values is 0% and no statistics (mean, maximum or minimum) are presented. When the percentage of values is low, the statistics (mean, maximum and minimum) may be less accurate than months where all data were used in the calculation of summary statistics.

The water-quality standards set by the State of South Carolina (SC DHEC 2008) were exceeded on a few occasions for dissolved oxygen, pH and turbidity. No individual readings for dissolved oxygen were below the minimum single-reading standard of 4.0 mg/L. Dissolved oxygen concentrations ranged from a low of 4.7 mg/L in July to 11.1 mg/L in February. One daily average was lower than the South Carolina freshwater standard of 5.0 mg/L; the daily average dissolved oxygen reading for July 22 was 4.98 mg/L. Forty-one individual readings were below 5.0 mg/L. The lowest monthly average was in June (5.1 mg/L) and the highest monthly average was in January (10.6 mg/L); however, only 2% of readings were used during the month of January (the remaining data were flagged). The next highest monthly average was observed in December (9.8 mg/L) where 63% of the readings were used.

South Carolina does not set a daily or monthly average for pH, but has established an acceptable range of 6.0 to 8.5 (SC DHEC 2008). During 2011, values for pH ranged between 5.6 and 6.6, with 55% of measurements (5,839/10,595) below the 6.0 standard. The lowest monthly average for pH was 5.9, occurring in May, August, September and December. The highest monthly average was 6.2 in January. Elevated pH values were noted during the first week of April due possibly to backwater from the mainstem of the Congaree River during a high flow event.

The State of South Carolina has set the limit for turbidity as not to exceed 50 NTUs provided existing uses are maintained (SC DHEC 2008). Turbidity values were generally low in Cedar Creek throughout much of the year, but mean daily turbidity values above 50 NTUs were observed six times during 2011, with all exceedences occurring during, and after, summer rainfall events. The lowest monthly average for turbidity was 2.1 NTUs in January, and the highest monthly average was 22.8 NTUs in June.

Table 3. Monthly minimum, maximum and mean values for parameters collected by the YSI 6-series data sonde at Congaree National Park (CONGccbr). Standard deviation (stdev) of the mean values are provided in parentheses. Percentage of values for each month indicates the number data points collected during one calendar month of data collection / total number of expected points for a complete month of data.

	Temperature (°C)	Specific Conductance (µs/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)
January 2011 (Expected count 1,488)					
Actual Count	1,487	1,487	24	1,463	1,487
Minimum	1.66	24	10.52	6.12	1.00
Mean (stdev)	6.0 (1.9)	25.7 (0.6)	10.6 (0.0)	6.20 (0.00)	2.10 (1.00)
Maximum	10.12	28	10.66	6.29	31.10
Percentage Valid	100%	100%	2%	98%	100%
February 2011 (Expected count 1,344)					
Actual Count	1,344	1,344	1,344	594	1,344
Minimum	5.75	25	7.59	5.94	1.40
Mean (stdev)	10.9 (3.4)	28.6 (2.1)	9.6 (0.9)	6.0 (0.0)	7.3 (4.7)
Maximum	18.41	33	11.05	6.14	30.10
Percentage Valid	100%	100%	100%	44%	100%
March 2011 (Expected count 1,488)					
Actual Count	1,488	1,488	1,488	1,488	1,487
Minimum	10.03	27	6.12	5.96	2.90
Mean (stdev)	15.4 (2.4)	30.3 (2.1)	8.1 (0.7)	6.1 (0.1)	6.9 (3.4)
Maximum	21.38	36	9.76	6.34	18.70
Percentage Valid	100%	100%	100%	100%	100%
April 2011 (Expected count 1,440)					
Actual Count	1,440	1,440	1,440	1,440	1,331
Minimum	11.85	27	5.38	5.70	3.80
Mean (stdev)	19.4 (3.0)	34.7 (8.6)	6.5 (0.5)	6.0 (0.2)	12.8 (19.0)
Maximum	24.86	67	7.53	6.58	448.20
Percentage Valid	100%	100%	100%	100%	92%
May 2011 (Expected count 1,488)					
Actual Count	1,488	1,488	1,488	960	,1371
Minimum	18.27	27	5.15	5.71	3.60
Mean (stdev)	23.0 (2.4)	29.7 (2.1)	6.2 (0.5)	5.9 (0.1)	17.1 (21.5)
Maximum	27.60	36	7.31	6.09	358.60
Percentage Valid	100%	100%	100%	65%	92%
June 2011 (Expected count 1,440)					
Actual Count	1,440	1,440	260	0	1,064
Minimum	25.25	24	4.85	--	2.10
Mean (stdev)	27.3 (0.8)	28.3 (3.2)	5.10 (0.10)	--	22.8 (25.5)
Maximum	29.49	44	5.38	--	270.00
Percentage Valid	100%	100%	18%	0%	74%

Table 3. Continued.

	Temperature (°C)	Specific Conductance (µs/cm)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)
July 2011 (Expected count 1,488)					
Actual Count	1,488	1,488	889	889	888
Minimum	25.71	22	4.73	5.69	1.40
Mean (stdev)	28.2 (1.0)	24.7 (1.9)	5.6 (0.3)	6.1 (0.1)	9.9 (7.0)
Maximum	30.49	38	6.33	6.37	88.90
Percentage Valid	100%	100%	60%	60%	60%
August 2011 (Expected count 1,488)					
Actual Count	1,488	1,488	880	1,488	1,488
Minimum	24.83	23	5.12	5.47	3.10
Mean (stdev)	27.4 (1.2)	25.8 (2.6)	5.7 (0.2)	5.9 (0.1)	12.9 (7.9)
Maximum	30.46	37	6.16	6.04	51.30
Percentage Valid	100%	100%	59%	100%	100%
September 2011 (Expected count 1,440)					
Actual Count	1,440	1,440	747	693	1,440
Minimum	19.72	21	5.86	5.85	0.70
Mean (stdev)	23.8 (1.9)	25.8 (4.2)	6.7 (0.6)	5.9 (0.0)	7.7 (9.9)
Maximum	27.93	46	7.72	6.03	103.60
Percentage Valid	100%	100%	52%	48%	100%
October 2011 (Expected count 1,488)					
Actual Count	1,488	1,488	983	505	1,350
Minimum	12.59	25	6.30	5.82	3.00
Mean (stdev)	17.5 (2.1)	27.6 (2.1)	7.5 (0.3)	6.0 (0.0)	5.9 (4.0)
Maximum	22.90	35	8.36	6.00	28.90
Percentage Valid	100%	100%	66%	34%	91%
November 2011 (Expected count 1,440)					
Actual Count	1,269	1,269	745	524	1,269
Minimum	10.45	24	6.82	5.92	0.70
Mean (stdev)	13.6 (1.7)	26.5 (1.7)	8.4 (0.6)	6.0 (0.0)	3.1 (1.1)
Maximum	17.90	31	9.28	6.03	15.60
Percentage Valid	88%	88%	52%	36%	88%
December 2011 (Expected count 1,488)					
Actual Count	1,488	1,488	937	551	1,488
Minimum	8.17	25	8.46	5.82	3.40
Mean (stdev)	10.9 (1.5)	27.0 (1.2)	9.8 (0.4)	5.9 (0.0)	6.9 (2.7)
Maximum	15.21	31	10.47	5.99	26.10
Percentage Valid	100%	100%	63%	37%	100%

Anomalies and Missing Data

Table 4 provides a listing of data anomalies within the dataset. Anomalous or missing data may be due to several factors, including equipment malfunction or operator error. No corrections were applied to data; questionable data were flagged in the data system, causes were noted, and the data were not considered in analyses.

Table 4. Description of anomalous and deleted data and associated periods of record for the data collection platform on Cedar Creek (CONGccbr) at Congaree National Park during 2011.

Parameter	Anomaly Description	Start Date, Time	End Date, Time
Dissolved Oxygen	Dissolved Oxygen data was marked suspect due to unknown probe malfunction.	1/1/2011 12:00:00 AM	1/31/2011 11:00:00 AM
	DO data suspect due to an optical wiper malfunction.	6/6/2011 10:00:00 AM	7/13/2011 11:00:00 AM
		8/19/2011 8:00:00 AM	9/15/2011 10:00:00 AM
		10/21/2011 11:30:00 AM	11/11/2011 10:00:00 PM
		12/20/2011 12:30:00 PM	12/31/2011 11:59:00 PM
pH	pH data marked suspect due to probe drift.	1/31/2011 12:00:00 PM	2/16/2011 2:30:00 PM,
		9/15/2011 10:30:00 AM	10/21/2011 11:00:00 AM
		11/15/2011 11:30:00 AM	12/20/2011 12:00:00 PM
	Data is suspect due to an unknown sonde malfunction.	5/21/2011 12:00:00 AM	6/6/2011 9:30:00 AM,
		6/6/2011 10:00:00 AM	7/13/2011 11:00:00 AM
Turbidity	Turbidity data marked suspect due to lone spike, less than 1,000 but more than 200 from previous and following readings.	3/3/2011 6:30:00 AM	3/3/2011 6:30:00 AM
		4/24/2011 3:00:00 AM	4/24/2011 3:00:00 AM
		4/25/2011 8:00:00 PM	4/25/2011 8:00:00 PM
		7/15/2011 10:00:00 PM	7/15/2011 10:00:00 PM
	Turbidity data marked suspect due to spikes of 1000 NTU or higher. Spiking turbidity data could be a result of direct interference from a foreign body and/or the EDS wiper parking over the optics.	4/17/2011 5:00:00 AM	4/17/2011 5:00:00 AM
		4/24/2011 2:30:00 PM	4/24/2011 2:30:00 PM
		6/11/2011 4:30:00 PM	6/11/2011 4:30:00 PM
	Turbidity readings marked suspect due to heavy fouling on and around probes during deployment.	4/28/2011 8:00:00 PM	5/3/2011 10:00:00 AM
		10/18/2011 2:30:00 PM	10/21/2011 11:00:00 AM
	Data marked suspect due to optical wiper malfunction.	6/23/2011 4:30:00 AM	7/13/2011 11:00:00 AM
All	Data was deleted due to unknown sonde malfunction.	11/11/2011 10:00:00 PM	11/15/2011 11:00:00 AM

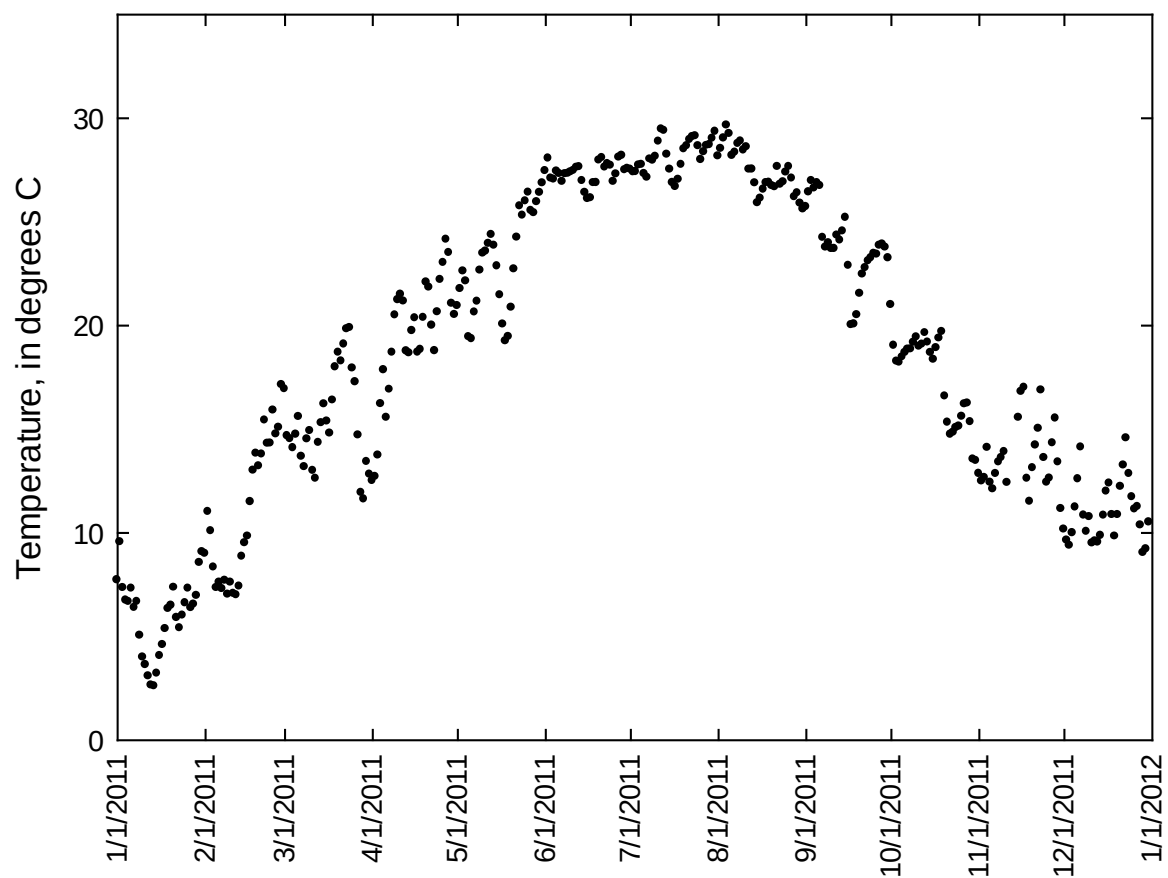


Figure 6. Mean daily water temperature on Cedar Creek (CONGccbr) in Congaree National Park during 2011.

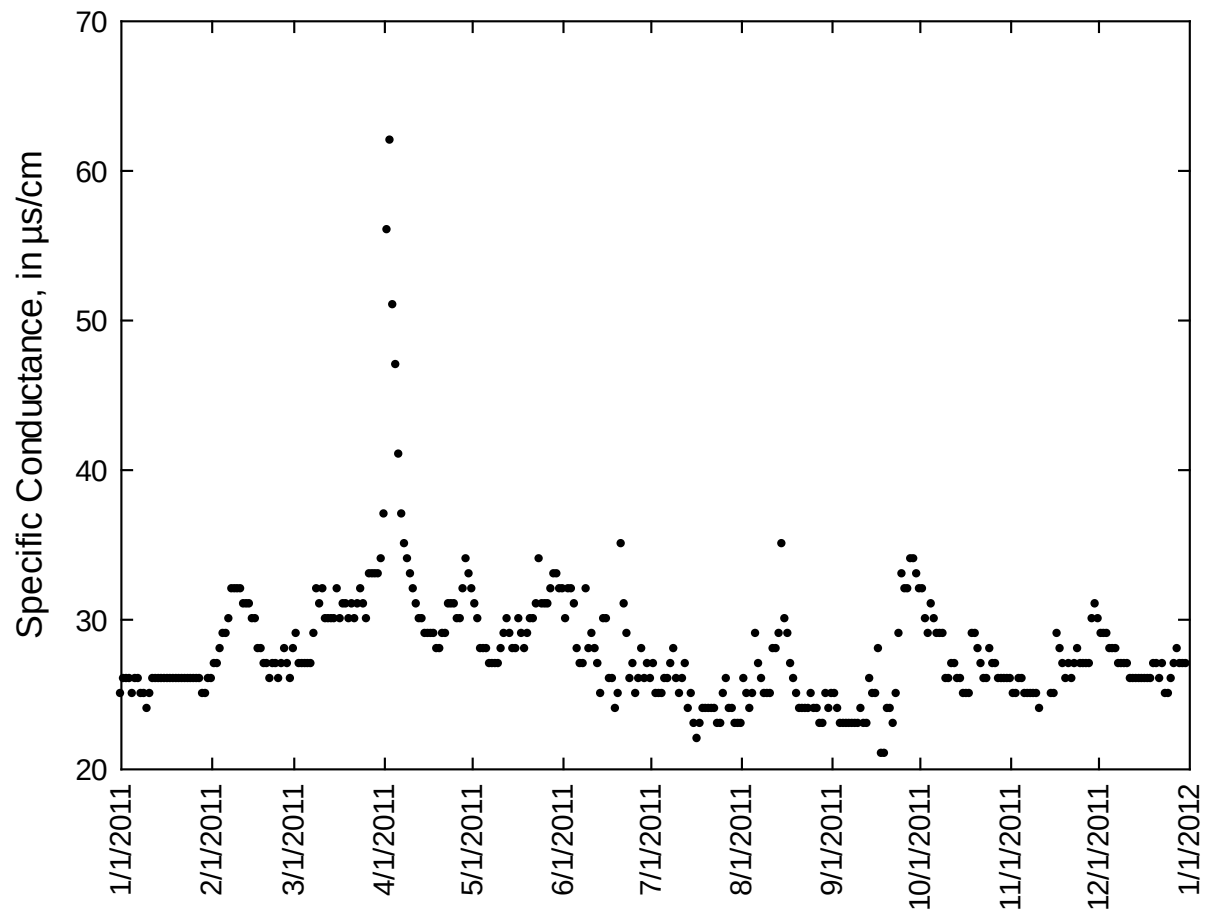


Figure 7. Mean daily specific conductance on Cedar Creek (CONGccbr) in Congaree National Park during 2011.

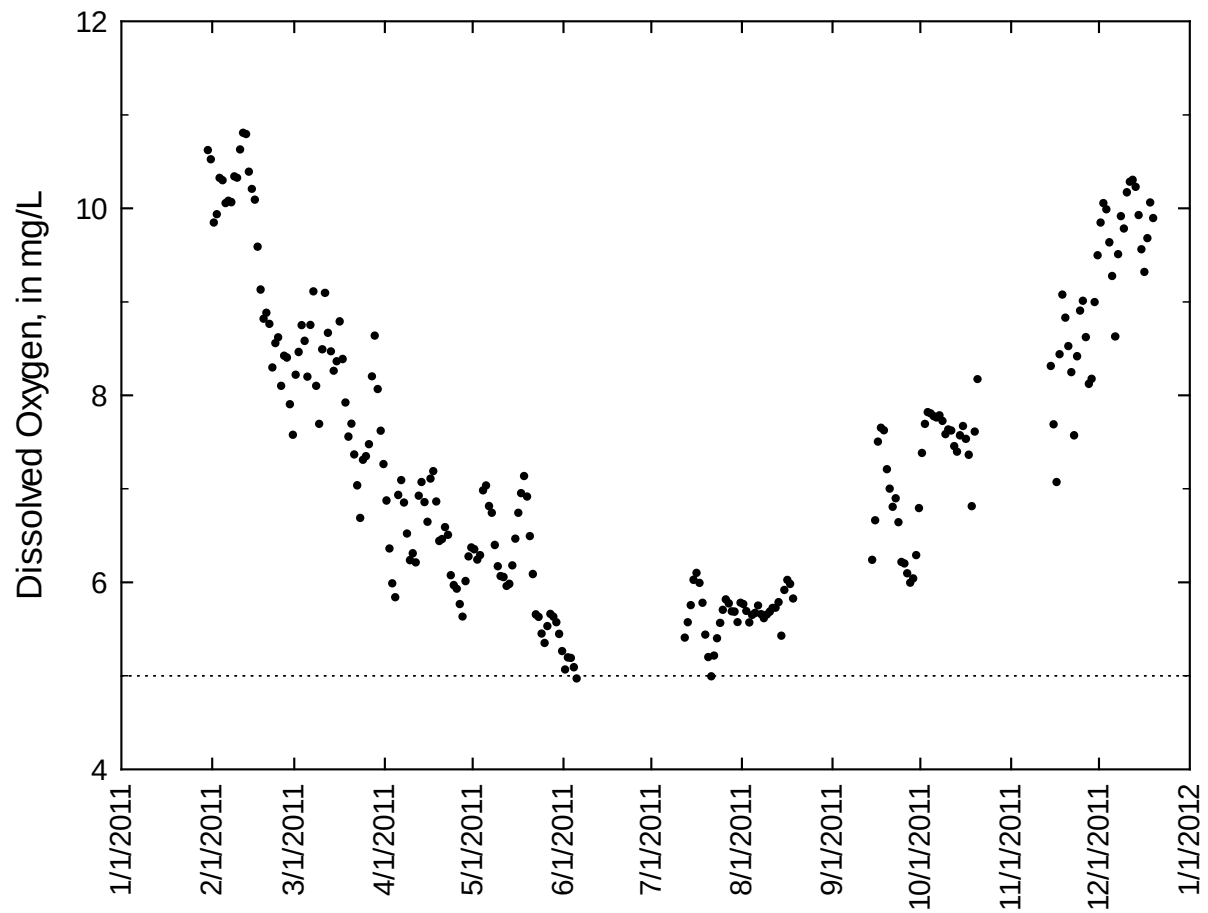


Figure 8. Mean daily dissolved oxygen on Cedar Creek (CONGccbr) in Congaree National Park during 2011. Dotted line indicates the South Carolina standard of 5 mg/L for minimum average daily dissolved oxygen concentrations in freshwater.

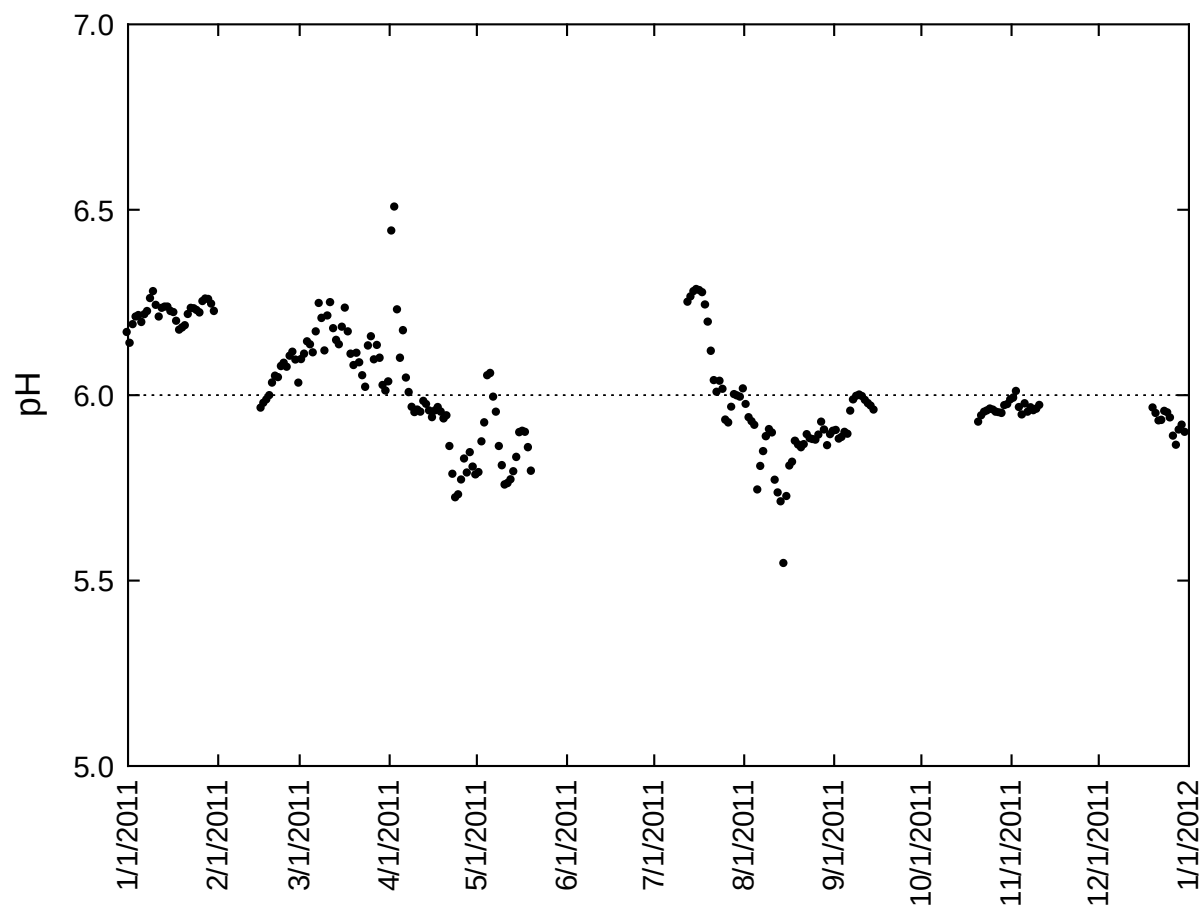


Figure 9. Mean daily pH on Cedar Creek (CONGccbr) in Congaree National Park during 2011. Dotted line indicates the South Carolina standard of 6 for minimum pH levels in freshwater.

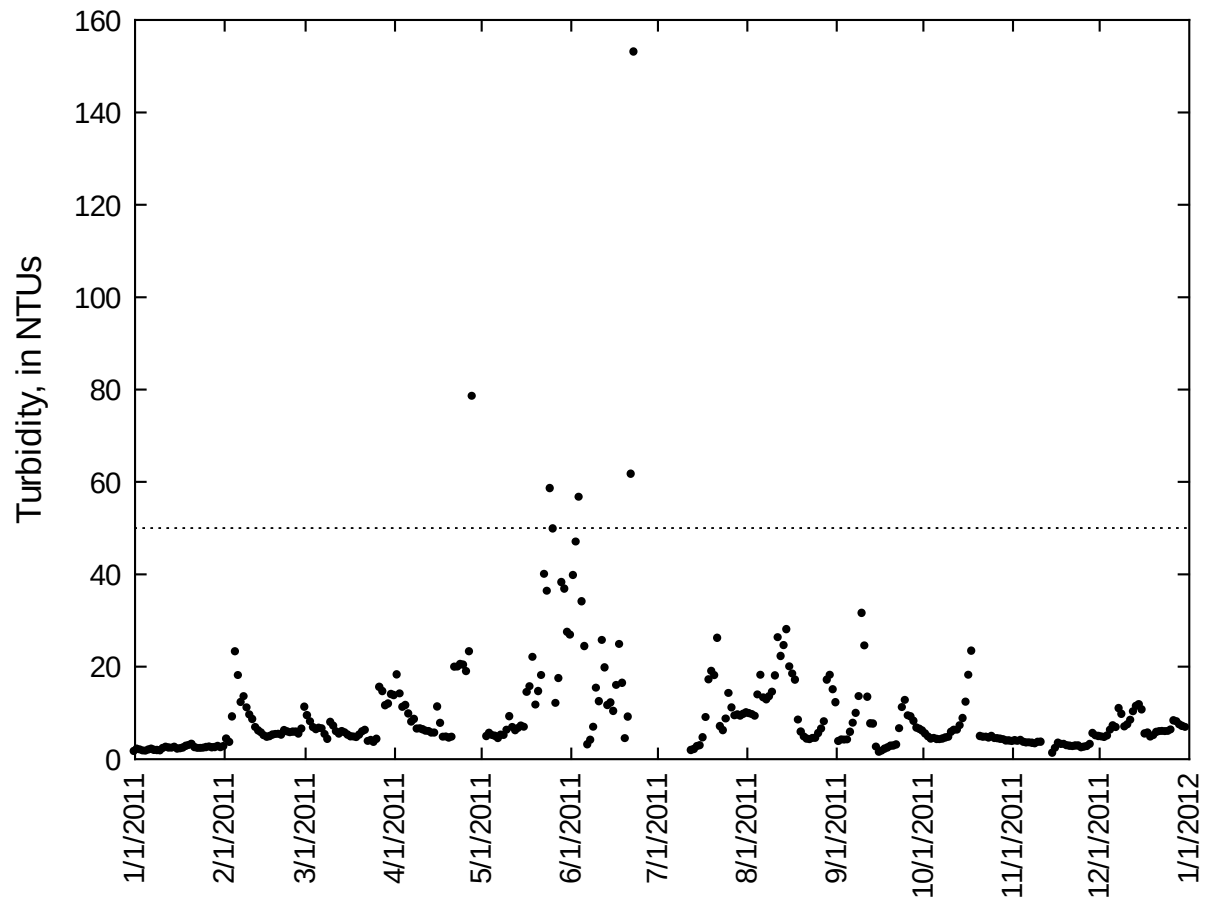


Figure 10. Mean daily turbidity on Cedar Creek in Congaree National Park during 2011. Dotted line indicates the South Carolina standard of 50 NTUs for maximum turbidity levels in freshwater.

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