Water Quality Assessment

of the Crooked Creek Watershed

Evan Jurick

Environmental Studies / Warren Wilson College

Dr. Mark Brenner, Robert Hastings, Dr. Mary Bulan

Spring 2018

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Introduction

The global landscape has been drastically altered by humans at an increasing rate since the industrial revolution. It's estimated that between one-third to one-half of all land on earth has been altered by human activities such as agriculture, land clearing, urbanization, ect.(Vitousek et al., 1997)[1]. These alterations to the physical topography of land can cause significant change in storm water movement, sediment runoff, nutrient runoff, and a number of other environmental issues leading to water pollution.

Nutrient runoff is the most critical pollutant source to freshwater lakes and ponds in the U.S., while sediment runoff is the most critical pollutant to rivers and streams (U.S. Environmental Protection Agency, 2002). Deposition of nutrients into lentic systems poses a problem because it can lead to eutrophication within both lentic and lotic systems associated with the body of water. Eutrophication is the process associated with unnatural plant and algae growth, due to excessive nutrient availability, and subsequent crash in dissolved oxygen (DO) levels as decomposition takes place(Ansari et. al., 2011)[3]. This process can lead to a sharp decline of biodiversity in both rivers and lakes.

Sediment runoff is of particular concern in mountainous watersheds where streams are characterized as shallow, rocky, and possessing low turbidity. Sediment is defined as any clay, sand, silt, or soil particle that is able to settle to the bottom of a water body. Sedimentation in streams can be defined two ways: the concentration of suspended sediment or the amount of sedimentation on the stream bed (Hedrick et al., 2013). Sedimentation can cause a decline in biota spawning, due to smothering of eggs, and loss of habitat availability for young fish. Egg and fry survival of brook trout, the native salmonid of the Appalachian Mountains, has been shown to respond negatively to bed surfaces with 20-25 percent sediment coverage (Hausle & Coble, 1976). Due to environmental impacts, sediment runoff should be mitigated in regards to construction and land alterations, and is regulated as such.

It is the task of environmental agencies and associations to monitor water quality and protect environmental health. The Lake James Environmental Association (LJEA) is a non-profit organization in Western North Carolina that is committed to the health and beauty of Lake James. LJEA was formed in 1973 with the intent of stopping the construction of a wastewater treatment plant, designed to release 3 million gallons of treated sewage daily, just upstream of the lake. The opposition was successful and the EPA denied a discharge permit for the location. The organization now seeks to ensure the health of the watershed by hosting annual cleanups, monitoring flood events, and conducting water quality testing.

Lake James is a man-made reservoir filled by the Catawba and Linville rivers with a watershed area of 380 square miles. Lake James is the furthest upstream of the Catawba Chain of Lakes, all created to generate electricity and owned by Duke Energy. A 2013 study by the North Carolina Division of Water Quality found Lake James to exhibit oligotrophic qualities based on calculated North Carolina Trophic State Index (NCTSI) scores. Though the study found biological productivity to be low, monitoring nutrient levels within the watershed is an important cautionary step as the trophic status of lakes is often subject to change.

Though the Lake James Environmental Association carefully monitors the health of the lake and its watershed, data has not been collected for several tributaries of the upper watershed. Due to LJEA's strong connection to the community and outreach to students and volunteers, I was able to partner with LJEA and collect data in part of this upper watershed.

I was asked to conduct research in the Crooked Creek watershed. The Crooked Creek tributary flows into the Catawba river just southeast of Old Fort, NC. Below is a map showing the location of Lake James and the Crooked Creek Watershed.

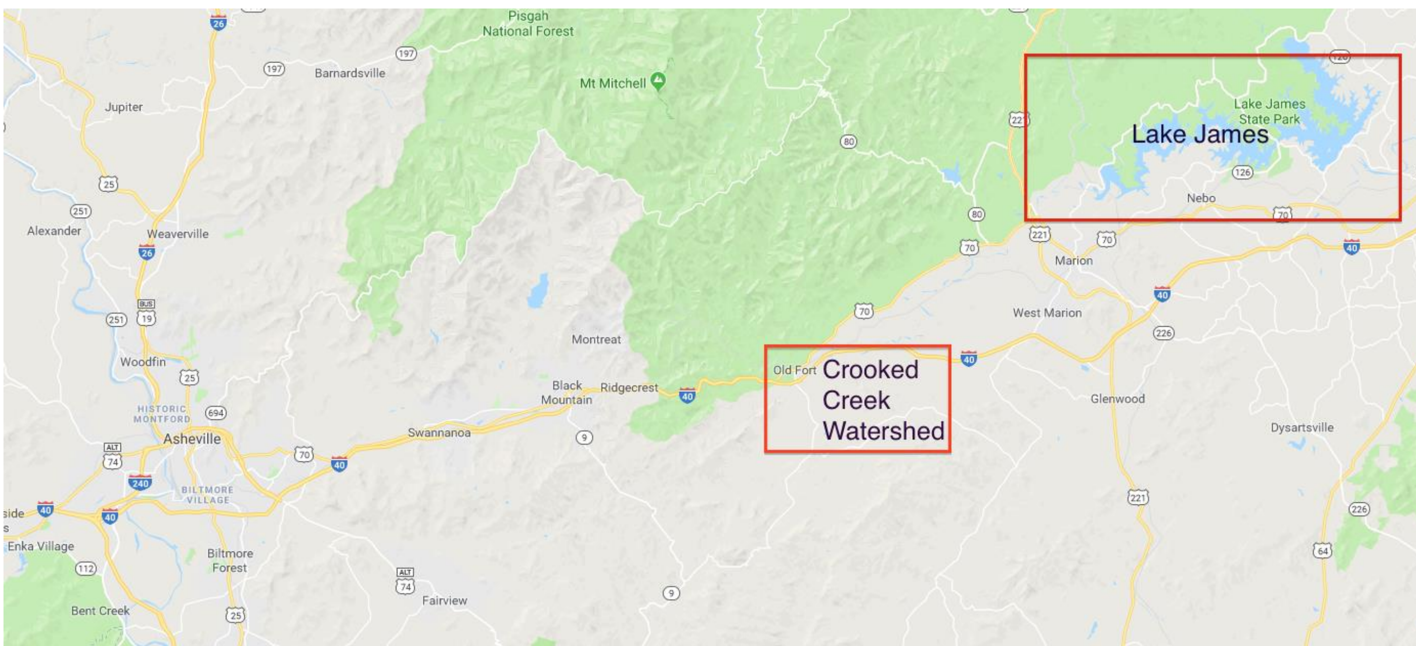

Figure 1. This map shows where the Crooked Creek watershed is located in regards to Lake James and Asheville, NC.

The watershed area is roughly 40 square miles, consisting of mostly agricultural land, and steep sloping secondary forest. Crooked Creek has long been inhabited by people, both Native American and western settlers. Due to Crooked Creeks proximity to the town of Old

Fort, believed to have been originally established as a large plantation in the early 1700's, it is important to recognize that the area has experienced multiple centuries of inhabitation by industrially civilized tenants. Documentation of settlers building grain mills along crooked creek have been recorded and demonstrate the proliferation of land clearing and alteration to the landscape that likely went on in the late 1800s. The area was likely logged and altered to a considerable degree. The present day land use is categorized by mostly agricultural and residential purposes. The area likely follows the model of traditional agricultural methods and employs traditional tillage and traditional cattle grazing methods. This study hypothesizes that the cleared agricultural lands in the area have high soil compaction due to traditional agriculture methods and therefore may produce high surface runoff of both sediment and nutrients during rainstorm events.

Methods

Below (*figure 2)* is a watershed area map created using Buncombe GIS. While the watershed is in McDowell County, the online Buncombe GIS tool proved to be a useful tool in shaping an approximate watershed. Contour lines and streams were used to determine the relative size and shape of the watershed. The approximate area was found to be 37 square miles.

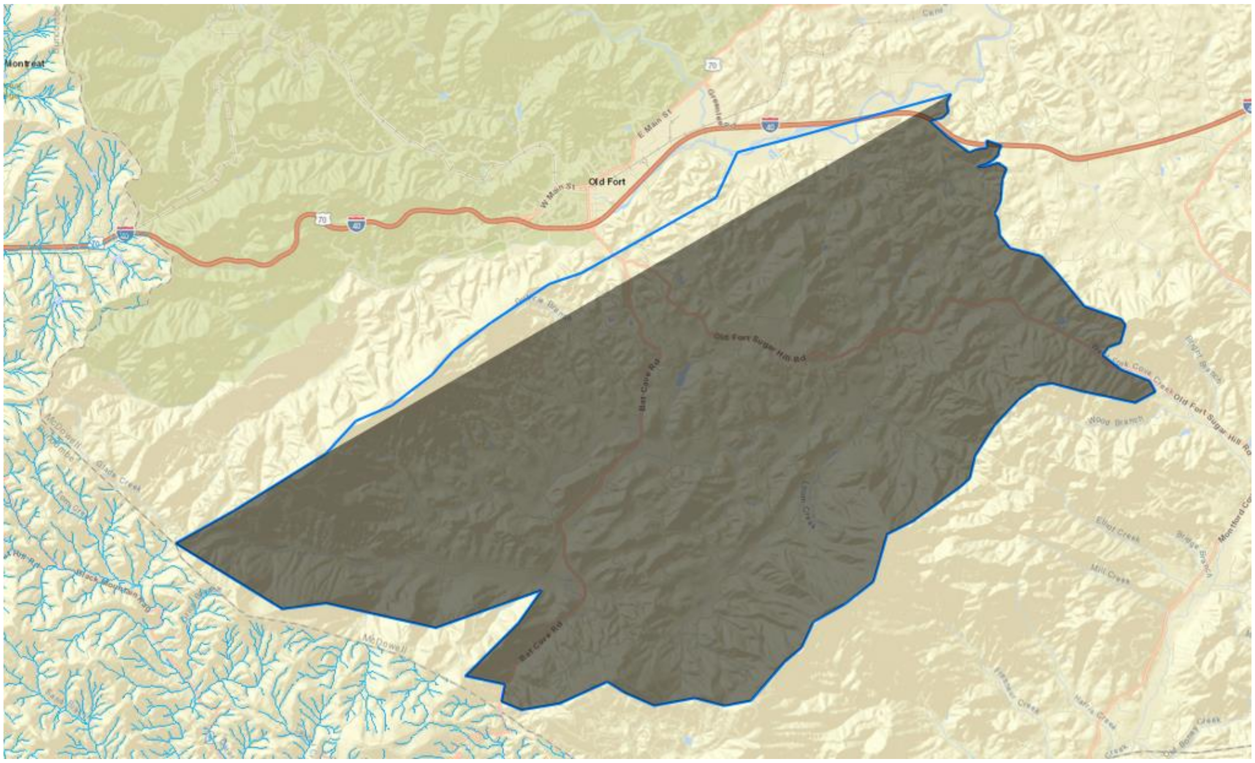

Figure 2. This map was created using the online Buncombe County GIS service. This is a rough estimate of total watershed area equal to 37 square miles.

Based on a google map of the Crooked Creek watershed, six sample location sites were chosen and marked. Site 1 was chosen due to its ease of access and close proximity to the intake at the Catawba River. Site 1 was the furthest downstream sampling site. Sites 3, 4, and 5 are located under bridges along Crooked Creek. Site 5 was the furthest upstream sampling site. Sites 2 and 6 are tributaries of Crooked Creek that were easily accessible. Locations were chosen based on ease of access under bridges and culverts, and subsequent location upwards into watershed from previous samples. Each location was also chosen to account for the influence of different tributaries on the overall water quality of Crooked Creek. Below is a map displaing a 3-D representation of the watershed and the location of the six sampling sites (*figure 3).*

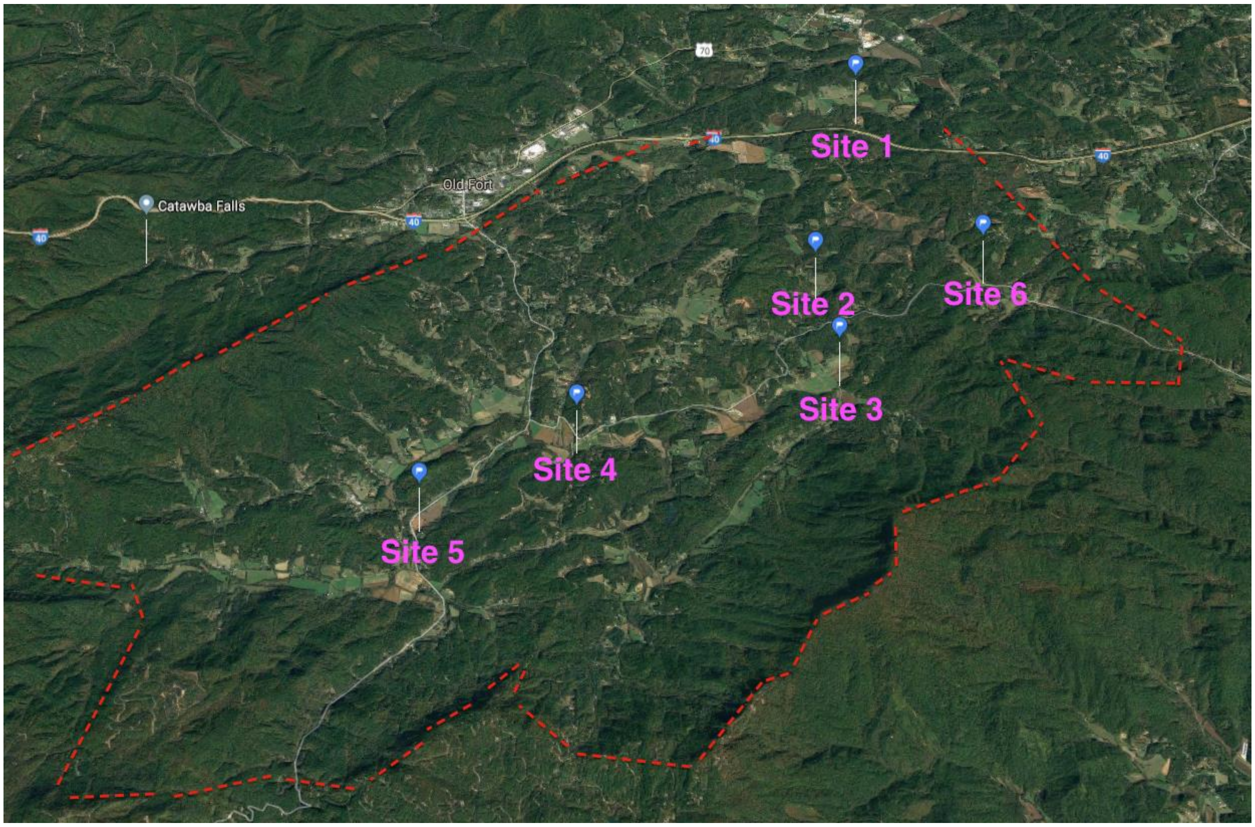

Figure 3. This map shows the six sample sites within the watershed. Site 1 is the furthest downstream, whereas site 5 is the furthest upstream.

Six 1 liter sample collection bottles were labeled as site 1 through 6 and placed in a cooler. The collection point at each site was selected based on ease of access to the stream. Grab samples were collected standing downstream of the collection bottle. The bottles were quickly submerged, filled, and capped in a consistent fashion. pH was measured in situ and recorded on the bottle labels. These samples were put on ice while in the field and stored in a refrigerator upon return to the Warren Wilson College campus.

A number of water quality parameters were tested for the Crooked Creek samples. The analytes tested were NH_3, NO_3, and PO_4. NH_3 content was analyzed using the reagent K_2HgI_4, commonly called Nessler's reagent. One milliliter of Hach brand Nessler reagent was added to 25 mL of each sample and analyzed using a Hach DR/2010 spectrophotometer at a wavelength of 400 nm. NO_3 content was analyzed using Hach NitraVer 5 Nitrate Reagent packs. One pack was emptied into 25 mL of each sample and analyzed using a Hach DR/2000 spectrophotometer at a wavelength of 425 nm. PO_4 was analyzed using Hach PhosVer 3 Phosphate Reagent packs and a DR 3900 spectrophotometer. One pack was emptied into 10 mL of each sample and analyzed. All three procedures used pre-programmed standard curves and a blank. These water quality parameters were chosen based upon LJEA's prior data collection and the instruments available in the Warren Wilson College facilities.

Further, total suspended solids, pH, and conductivity analysis was performed for each site. Total suspended solids was quantified by filtering each sample through a pre-weighed filter paper, placing it in a drying oven overnight, and then weighing again. The standard method of analysis, via *Standard Methods for the Examination of Water and Wastewater* (Rice; Bridgewater, 2012) was followed. A HANNA brand pocket pH meter was used in the field and a Vernier brand conductivity probe was used in the lab.

The USGS Catawba River flow at Pleasant Gardens, which is the closest downstream USGS monitoring station to the Crooked Creek Watershed, was recorded for each sampling date and relative time.

Data was statistically analyzed using paired t-tests comparing the furthest upstream and downstream samples. This comparison was done using NH_3, NO_3, PO_4 and TSS data. The null hypothesis in these t-tests states that no significant difference between upstream and downstream samples exists. Further, pH and conductivity data were analyzed by running descriptive statistics and simply reporting high or low value results. Data was reported in a format similar to the spreadsheet format provided by LJEA. This spreadsheet included month/day/year of each analysis, flow rate (1-4), rain rate (1-4), Catawba River flow (ft/s^3), and each water quality parameter measured.

Results

This study had 4 sample dates, with varying flow rates from 300 ft/s^3 - 1200 ft/s^3. Each sample date produced 36 data points. TSS data is displayed on the table in *Figure 4* and plotted in *Figure 5*. pH data produced a mean of 7.5, median of 7.6, mode of 7.9 , range of 1.3, with a minimum of 6.9 , and maximum of 8.2 (*figure 7)*. Conductivity data produced a mean of 63.8, median of 47.1, mode of 43.1, range of 132.3, with a minimum of 33.2, and maximum of 165.5 (*Figure 8)*.

The paired t-tests comparing furthest upstream and downstream samples produced P-values of 0.17 for NH_3, .08 for NO_3, .81 for PO_4 and .247 for TSS (*figure 9*).

Flow of Catawba (ft/s^3)	300	375	800	1200
Downstream (site 1)(mg/L)	7.1	33.8	208.4	475
Tributary (site 2) (mg/L)	2.7	18	140.6	1052.4
Site 3 (mg/L)	8	30.8	375	495
Site 4 (mg/L)	8	28	148.4	736
Upstream(site 5) (mg/L)	3.3	18.1	68.5	452.5
Tributary(site 6) (mg/L)	1.5	14.5	110.7	581.8

Figure 4. This table shows the TSS values for each site and the corresponding flow rate during sampling.

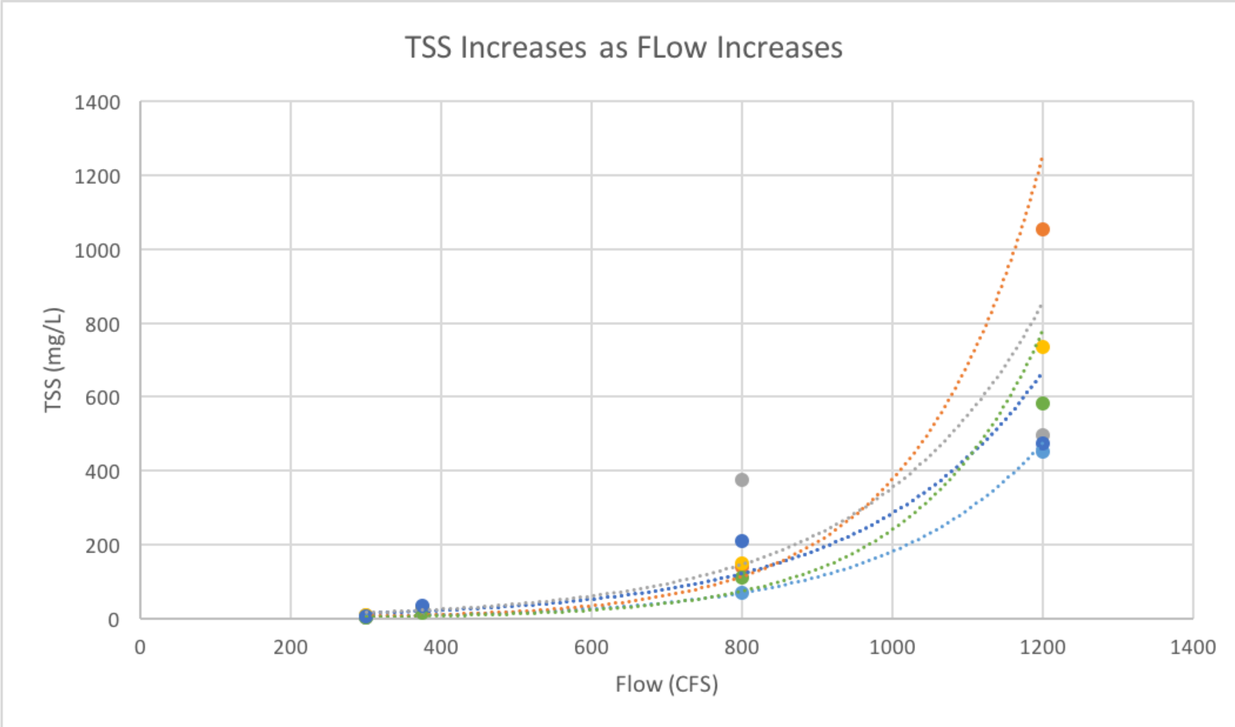

Figure 5. This graph plots all TSS data based on TSS (mg/L) and the flow (ft/s[3]) of the Catawba River during sampling.

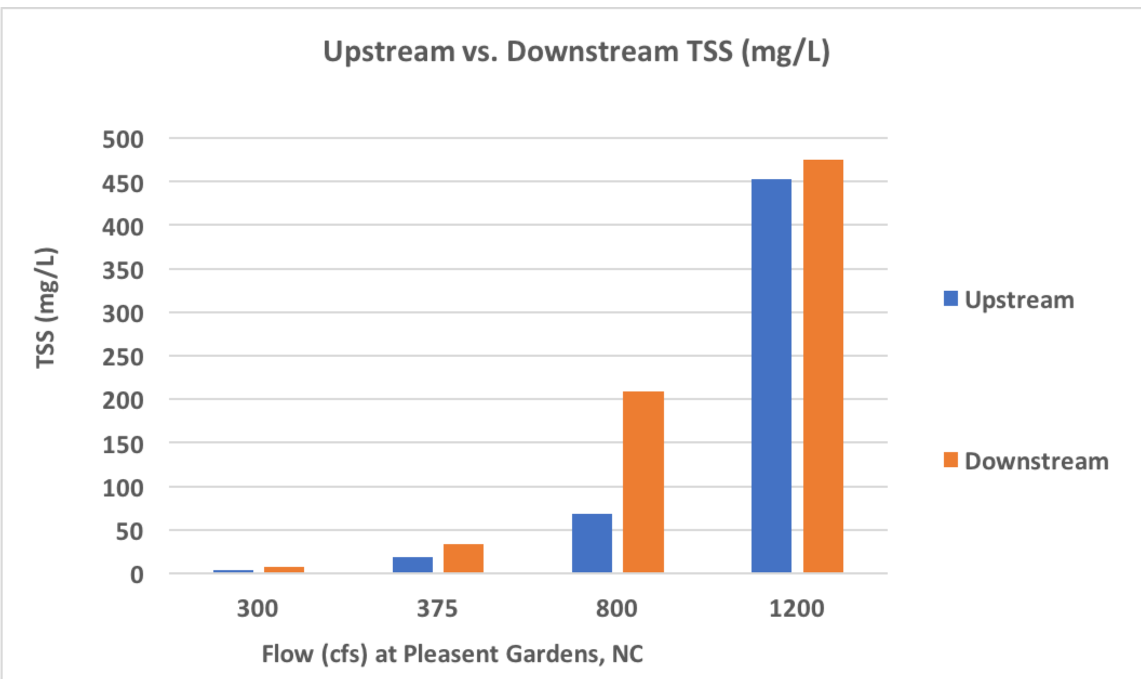

Figure 6. This graph plots the furthest upstream and downstream samples based on TSS (mg/L) and the flow (ft/s[3]) of the Catawba River during sampling.

pH Stats	
Mean	7.5
Median	7.6
Mode	7.9
Range	1.3
Minimum	6.9
Maximum	8.2

Figure 7. This table gives descriptive statistics of pH including mean, median, mode, range, minimum, and maximum.

Conductivity Stats	Conductivity (umhos/cm)
Mean	63.8
Median	47.1
Mode	43.1
Range	132.3
Minimum	33.2

Maximum	165.5

Figure 8. This table gives descriptive statistics of conductivity including mean, median, mode, range, minimum, and maximum.

NH3	NO3	PO4	TSS
0.168	0.08	0.809	0.247

Figure 9. P-values of a two tailed T-test between the downstream and upstream samples of Crooked Creek.

Discussion

The data does not produce any significant results, meaning we fail to reject the null hypothesis; however, we can see trends in the TSS data and suggest a cautionary status of the watershed. Results from the NH_3, NO_3, and PO_4 data do not suggest any significant differences between upstream and downstream samples, nor do the data follow any concerning trends *(Figure 9).* pH and conductivity results were within acceptable quality parameters and suggest no trends *(figures 7 and 8)*.

The reported TSS data consistently increase from upstream to downstream sample sites, in all sampled weather conditions. *Figure 5* displays all TSS data, plotted with flow rate on the x-axis and TSS on the y-axis. All plotted trend lines create exponential curves, demonstrating the increasing sediment runoff into Crooked Creek and its tributaries as rainfall increases. This demonstrates the overall increase of sediment runoff as rainfall increases. *Figure 6* displays a comparison of the furthest upstream and downstream Crooked Creek samples. The downstream site had more solids/sediment than the upstream site in every weather condition.

This trend suggests that sediment content of Crooked Creek increases as tributaries discharge runoff during rain events. More data is needed to produce any statistically significant results. This trend is expected during rainstorm events, and therefore, access to more data of the surrounding tributary watersheds of Lake James could provide insight into the relative significance of these values.

The Catawba River and Lake James do not appear to be threatened by sediment or nutrient runoff in the Crooked Creek watershed. The raw data and analysis will be given to LJEA for their consideration. If further monitoring is deemed within consideration by the Lake James Environmental Association, sites 1 and 5, the furthest upstream and downstream sample sites, seem to be good indicators of sediment and nutrient runoff in the watershed.

Acknowledgments

This study would like to thank the Lake James Environmental Association for providing funding and support for this mutually beneficial student research project. I would also like to thank Marshall Taylor, of LJEA, for his consistent correspondence and prompt responses throughout this partnership.

Citations

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