Evaluation of Pollution Sources to Lake Glenville

Quarterly Report – August 2017

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Summary

Chemical and microbial analysis of water samples collected at Lake Glenville area sites help to characterize water quality in relation to potential sources of water pollution. Overall water quality, as evidenced by data collected on August 1, 2017, is acceptable but there is evidence to suggest the influence of agricultural activities on nutrient and *E. coli* concentrations. The observed nitrate concentrations are higher compared to those observed in May 2017, which is likely due to increased agricultural and livestock activities during the summer months. The next quarterly monitoring event will take place in November 2017. Results from that monitoring event will be evaluated individually and in relation to the results presented in this report to evaluate temporal changes in water quality and evaluate sources of pollution.

Methodology

Lake Glenville area samples were collected on Tuesday, August 1, 2017. At each sampling location, the following data were collected: creek name, time of sample collection, pH, dissolved oxygen, conductivity, air temperature, and water temperature. Weather conditions during the time of sample collection were also recorded. Samples were collected in triplicate at each site in labeled 2L Nalgene™ bottles and transported to Western Carolina University's Environmental Health lab on ice. Upon arrival to the Environmental Health lab, samples were analyzed for the following parameters within 6 hours: alkalinity, ammonia (NH_3), nitrates (NO_3), orthophosphates (as PO_4), total suspended solids (TSS), turbidity, and *E. coli*. Detailed explanations of laboratory analyses are available upon request.

Results

Acidity and Alkalinity: pH is used to measure acidity. The ambient water quality standard for pH is between 6.0 and 9.0, although natural pH in area streams generally ranges from 6.5-7.2. Values below 6.5 may indicate the effects of acid precipitation or other acidic inputs, and values above 7.5 may indicate industrial discharge. No pH readings below 6.5 were observed in any creek but a pH value above 7.5 was observed in Mills Creek (Figure 1).

Alkalinity is the measure of the pH buffering capacity of a water or soil. High alkalinity waters are generally better protected against acid inputs from sources such as acid rain, organic matter, and industrial effluent. Waters with an alkalinity below 30mg/L are considered to have low alkalinity. The observed mean alkalinity concentrations demonstrate low alkalinity in all monitored creeks (Figure 2). The lower alkalinity concentrations observed at Mills, Norton, Hurricane, and Cedar Creeks may account for their higher pH levels observed in those creeks as those waters have little buffering capacity and are more susceptible to changes in pH.

Figure 1. pH levels at each monitoring site, August 2017

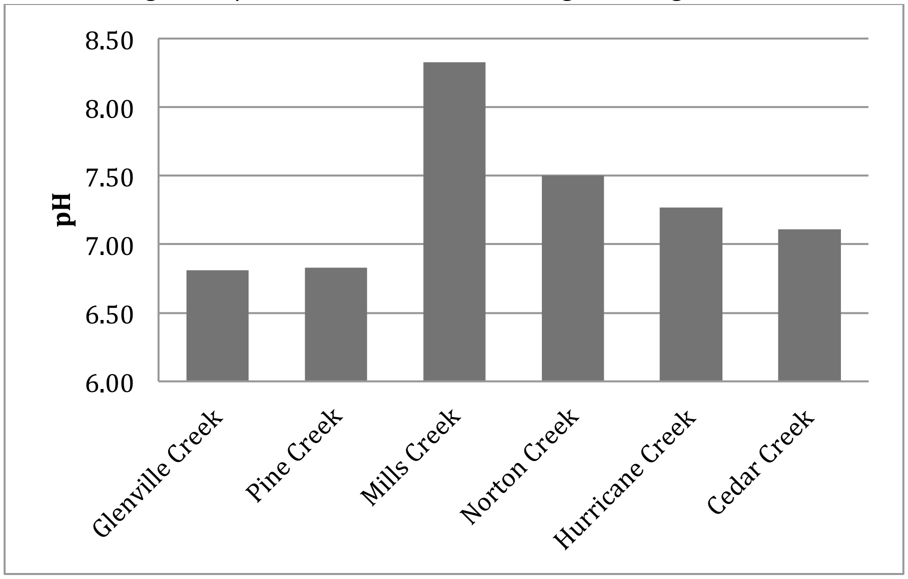
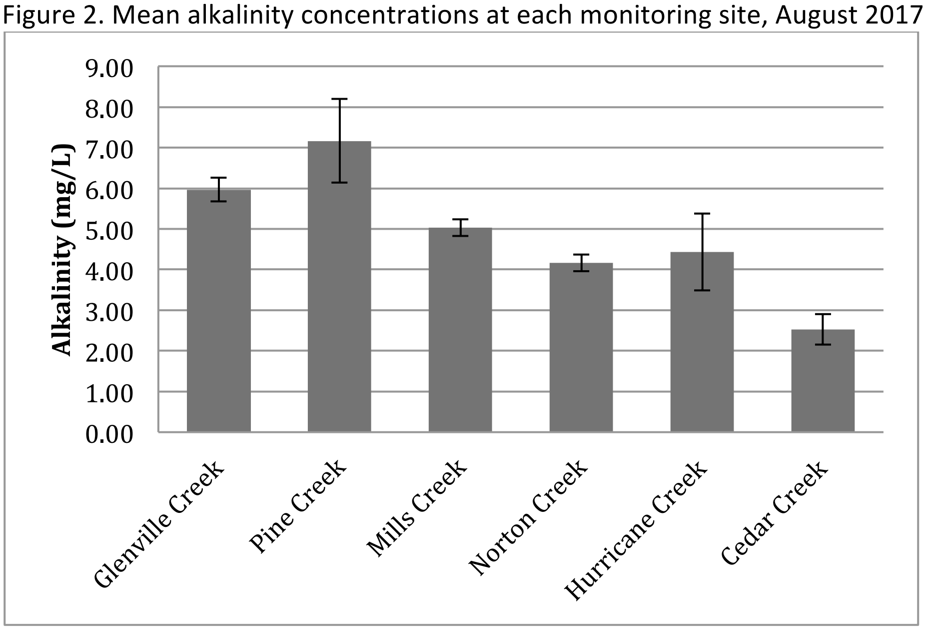


Figure 2. Mean alkalinity concentrations at each monitoring site, August 2017



Turbidity and Total Suspended Solids (TSS): Turbidity is a measure of visual water clarity and is a measure of the presence of suspended particulate matter. The standard for trout-designated waters is 10 NTU and the standard to protect other aquatic life is 50 NTU. Turbidity measurements in all creeks are below the 10 NTU trout-designated water standard (Figure 3). TSS quantifies solids by weight and is heavily influenced by a combination of stream flow and land disturbances. Although there is no legal standard for TSS, concentrations below 30mg/L are generally considered low. All monitoring sites exhibited low TSS concentrations (Figure 4). Moderately heavy precipitation events and land disturbance can increase turbidity and TSS concentrations. The undisturbed forested areas and presence of riparian zones likely influenced the low turbidity and TSS concentrations. No significant rainfall events occurred in the 7 days preceding sample collection.

Figure 3. Mean turbidity levels at each monitoring site, August 2017

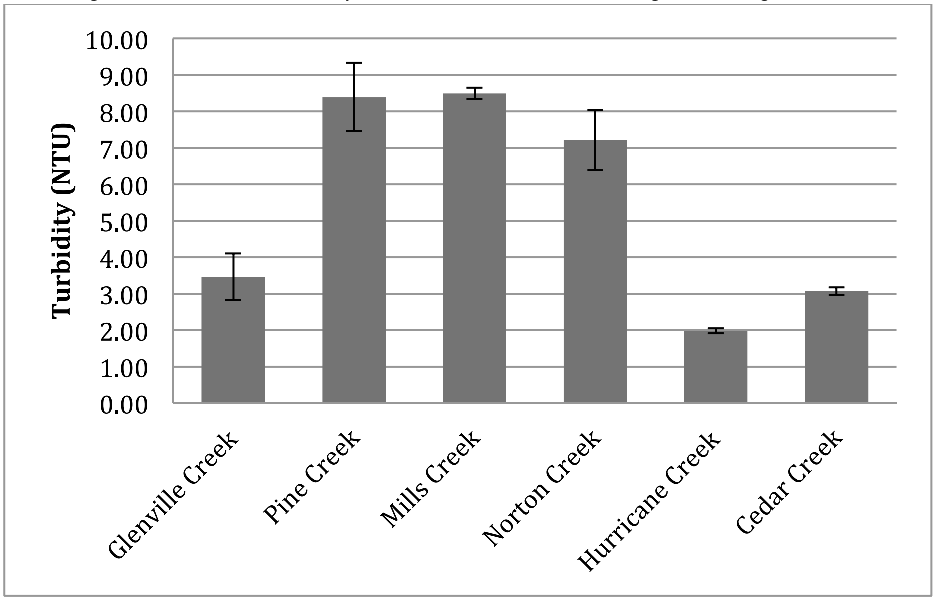
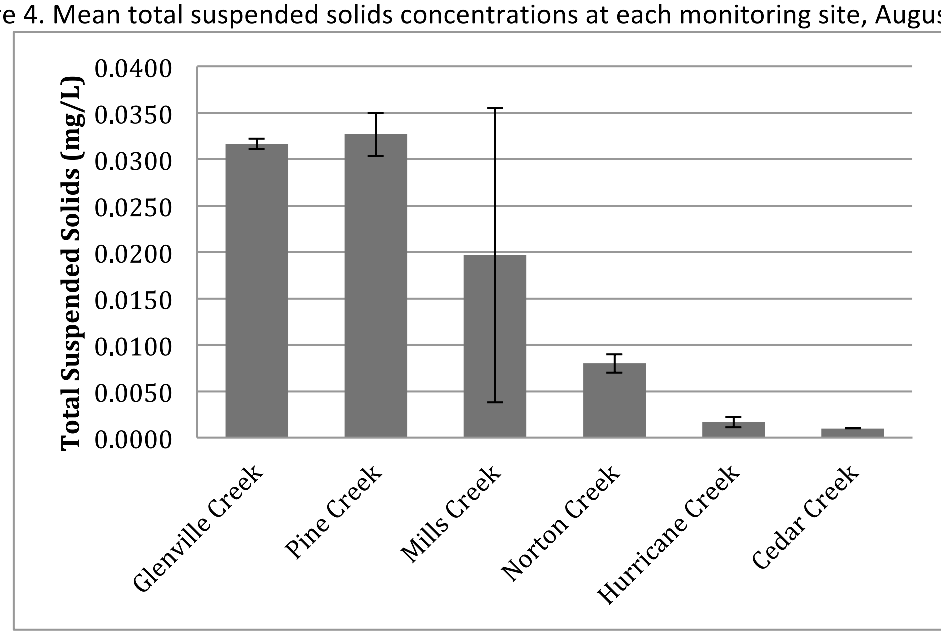


Figure 4. Mean total suspended solids concentrations at each monitoring site, August 2017



Conductivity: Conductivity is used to measure the ability of water to conduct an electrical current. Samples containing dissolved solids and salts will form ions that will conduct an electrical current and the concentration of dissolved ions in a sample determines conductivity. Inorganic dissolved solids such as chloride, nitrate, phosphate, calcium, sulfate, iron, sodium, and aluminum will affect conductivity levels and local geologic conditions will influence the types and extent of dissolved ions. Elevated levels of conductivity are most often seen in streams receiving wastewater discharge, urban runoff, or eroded soils. The observed conductivity levels at each monitoring site are relatively high considering the undisturbed forested landscape (Figure 5). The observed conductivity levels do not correlate with TSS or turbidity suggesting that the source of dissolved ions is not wastewater or soil runoff. However, conductivity levels continue to positively correlate with observed nitrate concentrations ($r^2 = 0.62$) to suggest that fertilizer runoff may be a contributing factor to elevated conductivity (Figure 6).

Figure 5. Conductivity levels at each monitoring site, August 2017

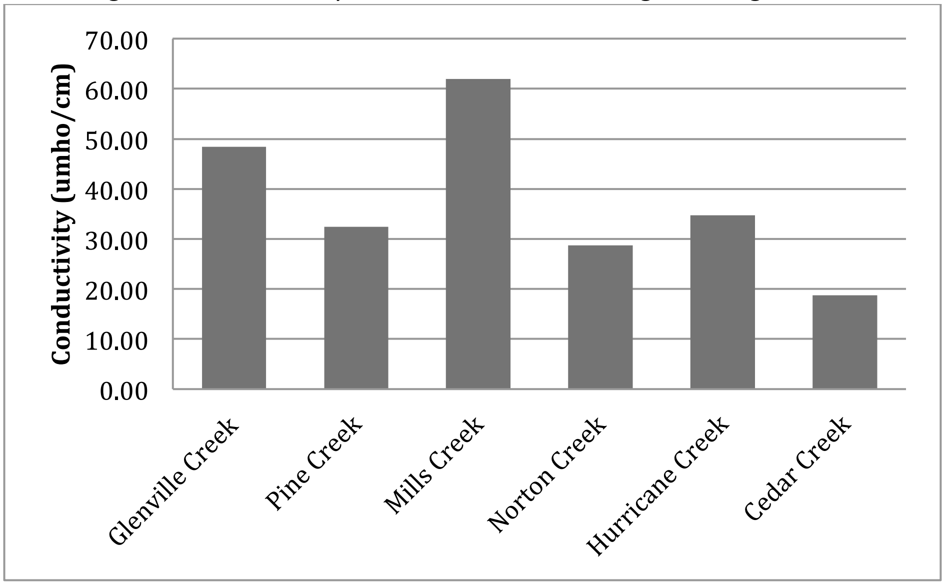
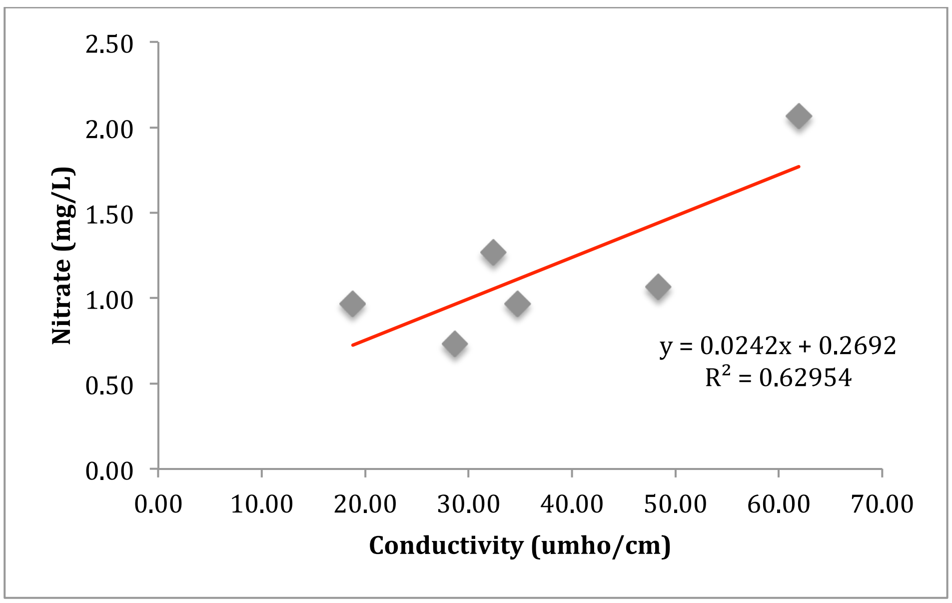


Figure 6. Correlation between conductivity and nitrate concentrations at each monitored site, August 2017



Nutrients (Orthophosphate [PO_4^{3-}], Ammonia [NH_3], and Nitrate [NO_3^-]): Phosphorous is an essential nutrient for aquatic plants and algae, and is typically the limiting nutrient in most aquatic systems thereby restricting plant growth in an ecosystem. Phosphorous is introduced into water systems from soil, wastewater treatment systems, failing septic systems, and runoff from fertilized land. Excessive phosphorous stimulates excessive plant growth and results in eutrophication, a condition that can result in dissolved oxygen depletion in an aquatic ecosystem. Orthophosphate is the amount of phosphorous that is immediately available to plants or algae for biological assimilation. Generally, orthophosphate levels below 0.05 mg/L are sufficient to prevent eutrophication.

There is no legal water quality standard for orthophosphate, but the Environmental Protection Agency (EPA) nutrient criteria for total phosphorous in rivers and streams in this ecoregion is 0.01 mg/L. Although orthophosphate is only one component of total phosphorous, observed concentrations at all monitored sites exceed the EPA nutrient criteria for total phosphorous (Figure 7). However, all sites demonstrated reduced orthophosphate concentrations compared to those observed in May 2017. The highest concentrations are observed at Pine Creek, which is located in proximity to agricultural activities suggesting that livestock waste storage may be a source of orthophosphate input. A slight correlation is observed between orthophosphate concentrations and turbidity, suggesting that soil erosion may be a source of orthophosphate input (Figure 8).

Ammonia is contained in decaying plant and animal remains and microbial decomposition of these organic wastes can release ammonia. The most likely sources of ammonia are agricultural runoff, livestock farming, septic drainage, and sewage treatment plants. The ambient concentration of ammonia in water is approximately 0.10 mg/L but concentrations are heavily influenced by water temperature and pH. No creek was observed to exceed this “norm” and no creek exceeds the ambient total ammonia toxicity standard of 1.9 mg/L (Figure 9).

Like phosphorous, nitrate serves as an algal nutrient and can contribute to excessive plant growth and eutrophication. Common sources of nitrate include septic drainage and fertilizer runoff from agricultural land and domestic lawns. The ability of nitrate to more readily dissolve in water contributes to its increased likelihood of traveling in surface waters. As a result, nitrate is a good indicator of sewage or animal waste input. There is no legal water quality standard for nitrate, but the EPA nutrient criteria for total nitrogen in rivers and streams in this ecoregion is 0.31 mg/L. Although nitrate is only one component of total nitrogen, observed concentrations at all monitored sites exceed the EPA nutrient criteria for total nitrogen (Figure 10). The lack of correlation between nitrate concentrations and TSS or turbidity suggesting that agricultural runoff of livestock wastes may be a source of nitrate. The observed nitrate concentrations are higher compared to those observed in May 2017, which is likely due to increased agricultural and livestock activities during the summer months.

Figure 7. Mean orthophosphate concentrations at each monitored site, August 2017

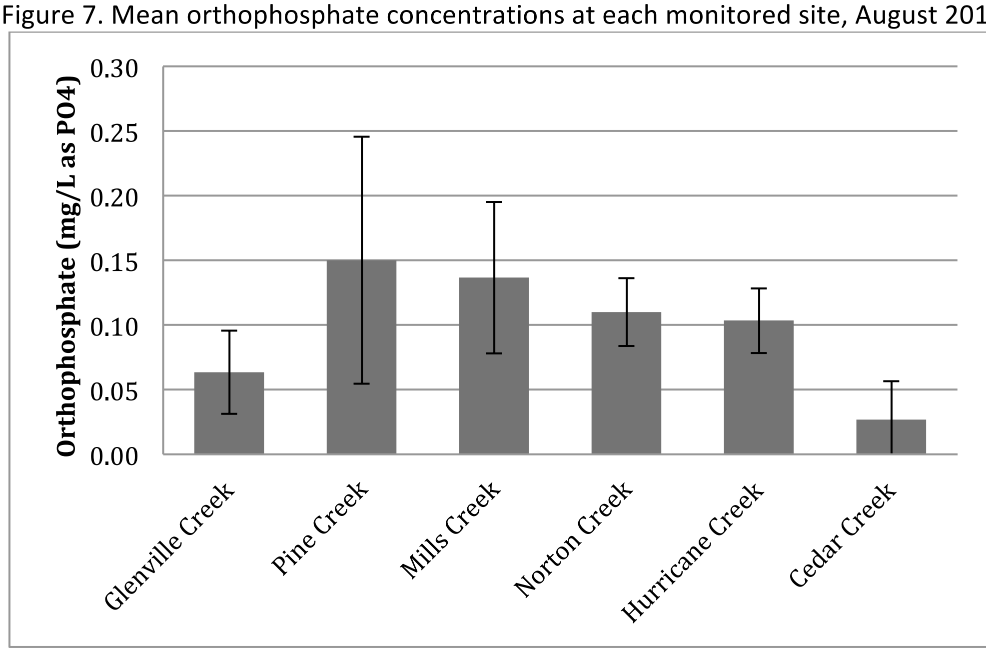


Figure 8. Correlation between turbidity and orthophosphate concentrations at each monitored site, August 2017

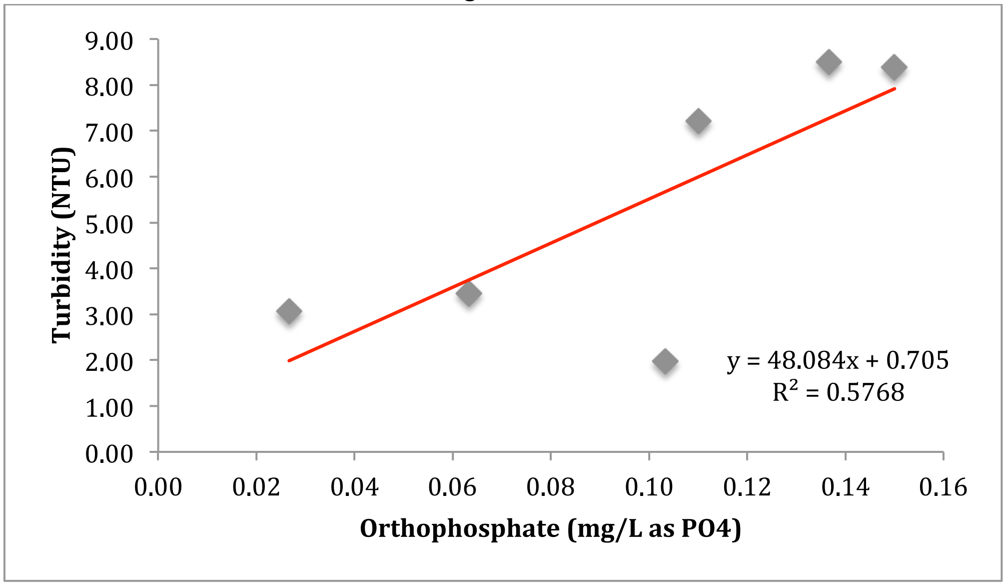


Figure 9. Mean ammonia concentrations at each monitored site, August 2017

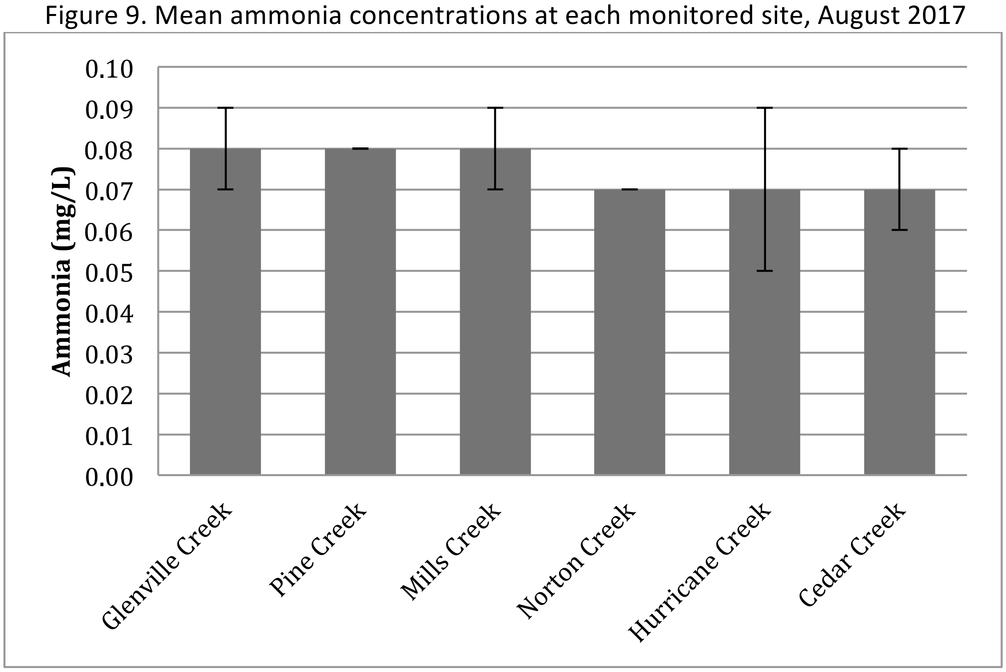
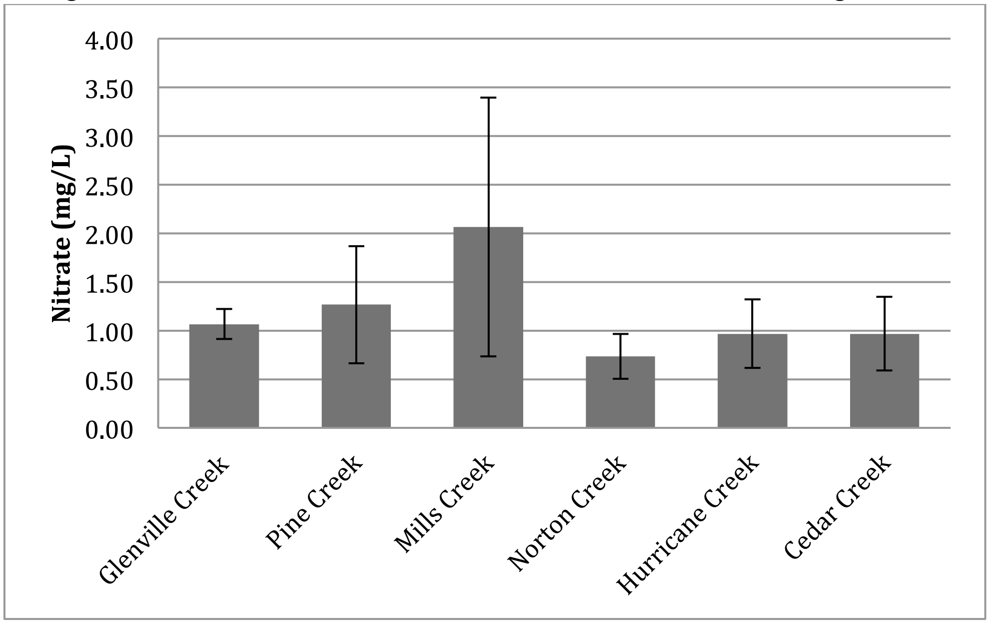


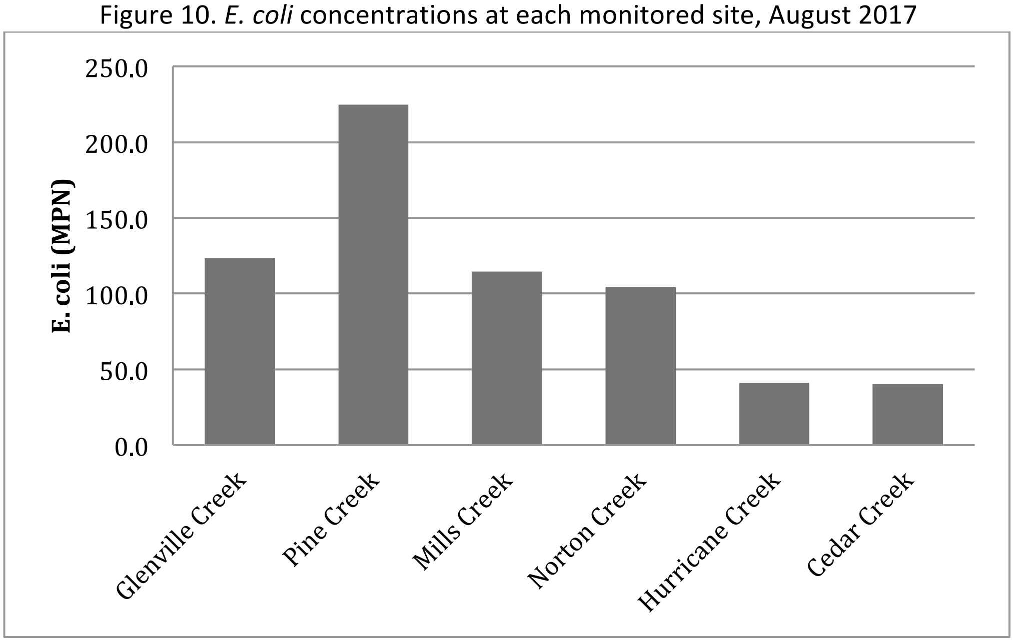
Figure 10. Mean nitrate concentrations at each monitored site, August 2017



***E. coli*:**

The potential presence of fecal pathogens in surface water is determined based on a surrogate measurement if fecal indicator organisms, including *E. coli*. The recreational standard for *E. coli* in the State of North Carolina is 200 CFU/100ml. With the exception of Pine Creek, all monitored sites exhibit *E. coli* concentrations below this standard. The presence of livestock and active agricultural activities upstream of Pine Creek and in Gem Creek, which discharges into Pine Creek, are likely contributing to the observed *E. coli* concentrations. *E. coli* concentrations in surface waters have been shown to be influenced in part by seasonality, and future sampling events will continue to monitor *E. coli* to identify possible influences of seasonality on fecal pollution in the creeks discharging into Lake Glenville.

Figure 10. *E. coli* concentrations at each monitored site, August 2017



Conclusions

Chemical and microbial analysis of water samples collected at Lake Glenville area sites help to characterize water quality in relation to potential sources of water pollution. Overall water quality, as evidenced by data collected on August 1, 2017, is acceptable but there is evidence to suggest the influence of agricultural activities on nutrient and *E. coli* concentrations. Higher pH in Mills, Norton, Hurricane, and Cedar Creeks may be influenced by a combination of discharges and low alkalinity. Relatively low turbidity and TSS concentrations are likely the result of undisturbed forested land use patterns and riparian buffers long the creeks. Correlation between turbidity and orthophosphate concentrations suggest that soil erosion and/or surface runoff is contributing to elevated orthophosphate concentrations. The lack of correlation between turbidity or TSS with ammonia or nitrate concentrations suggest that the introduction of livestock wastes, not soil erosion or surface runoff, is contributing to elevated nutrient concentrations. The next quarterly monitoring event will take place in November 2017. Results from that monitoring event will be evaluated individually and in relation to the results presented in this report to evaluate temporal changes in water quality and evaluate sources of pollution.