Evaluation of Pollution Sources to Lake Glenville
Quarterly Report – December 2018

Kimberlee K Hall, PhD
Environmental Health Program, Western Carolina University

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 December 6, 2018, is acceptable but there is evidence to suggest the influence of soil erosion and runoff events on water quality. With the exception of total suspended solids and nitrate concentrations, all measured parameters exhibited lower concentrations compared to those observed in September 2018. The next quarterly monitoring event will take place in February 2019. 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 Thursday, December 6, 2018. 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. Pine and Mills Creeks exhibited pH readings above 7.5 while the pH readings of the remaining creeks were comparable to area streams. All December 2018 pH measurements were lower compared to September 2018 pH readings and all pH observations are within the North Carolina water quality standard for freshwater aquatic life (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). Historically low alkalinity concentrations in these creeks may account for the observed fluctuations in pH as the waters have little buffering capacity and are therefore more susceptible to changes in pH.

Figure 1. pH levels at each monitoring site, December 2018

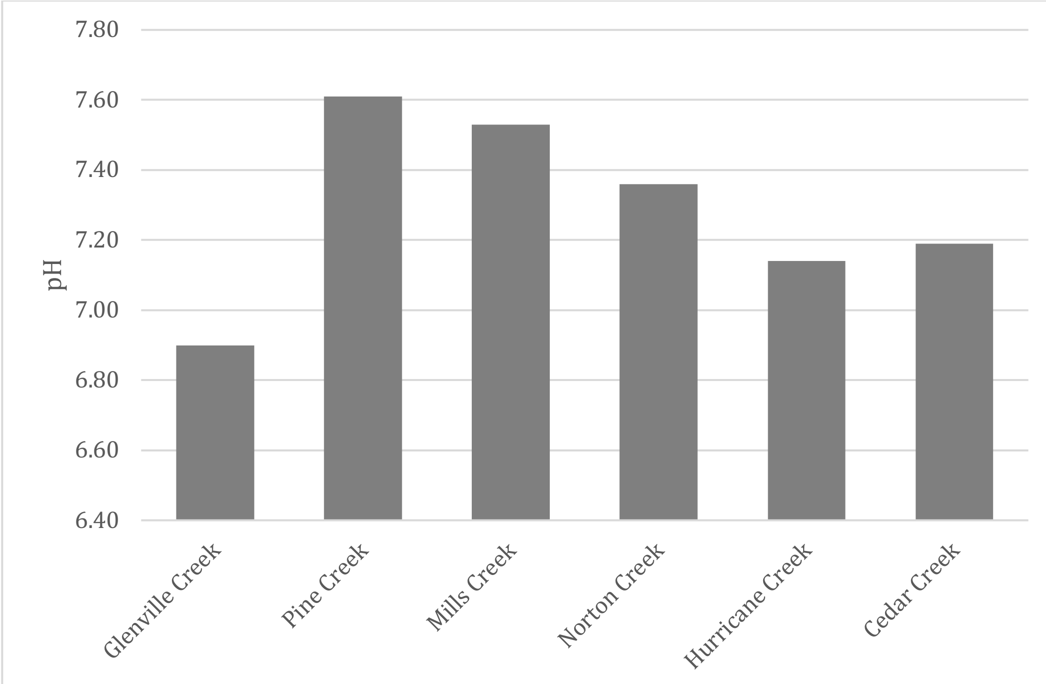
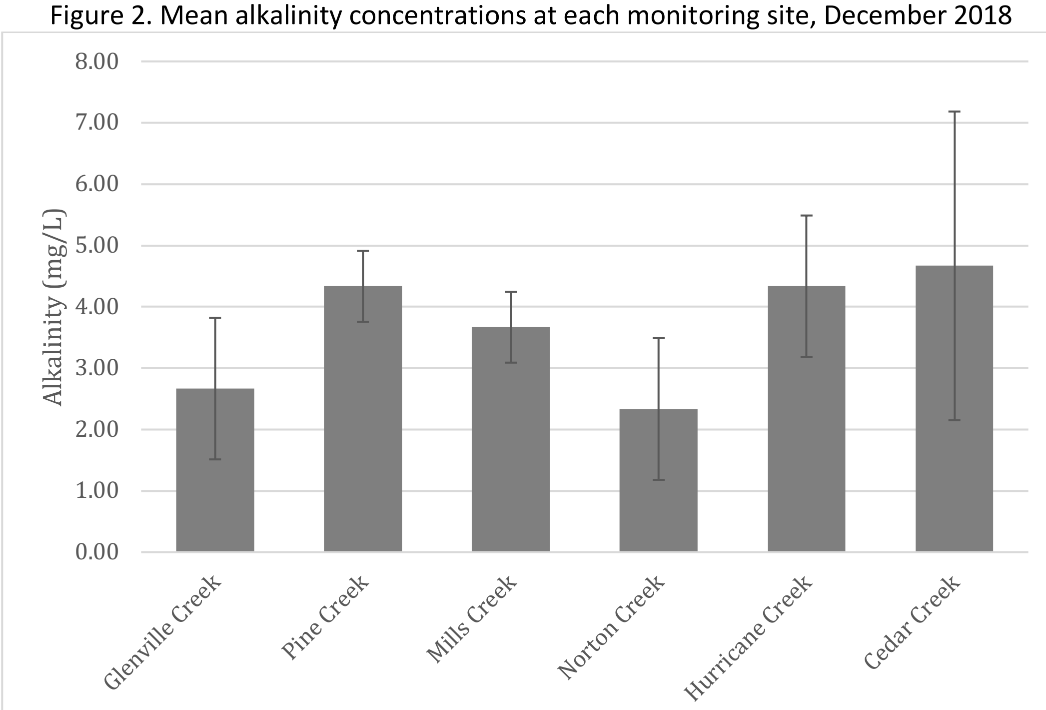


Figure 2. Mean alkalinity concentrations at each monitoring site, December 2018



Turbidity and Total Suspended Solids (TSS): Turbidity is a measure of visual water clarity and 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). While moderately heavy precipitation events and land disturbance can increase turbidity and TSS concentrations, the undisturbed forested areas and presence of riparian zones in the Lake Glenville area likely help prevent significant increases in turbidity and TSS particulates during rainfall and runoff events.

Figure 3. Mean turbidity levels at each monitoring site, December 2018

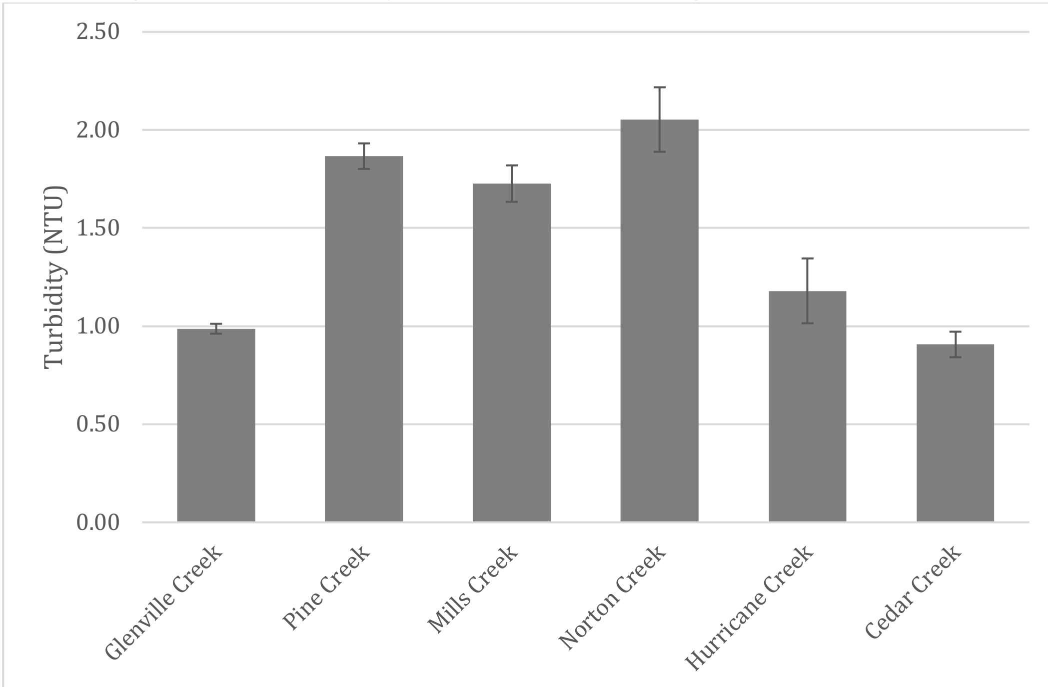
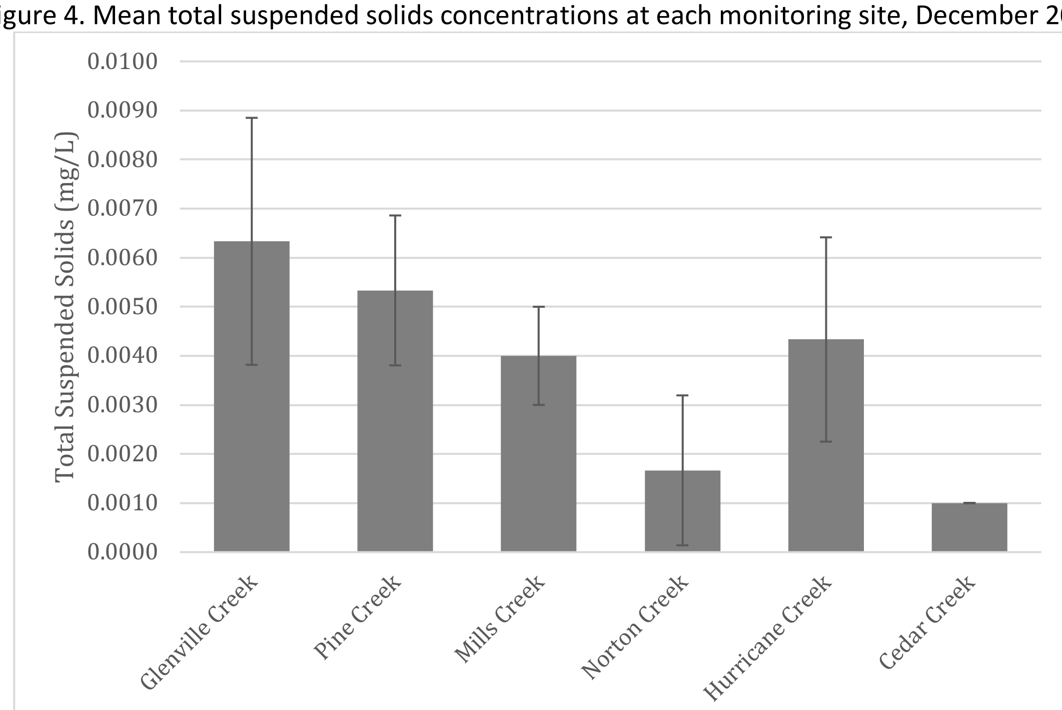


Figure 4. Mean total suspended solids concentrations at each monitoring site, December 2018



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) and are lower compared to the conductivity measurements observed in September 2018, likely due to colder water temperatures. The observed conductivity levels correlate with TSS, suggesting that the source of dissolved ions is associated with soil erosion (Figure 6).

Figure 5. Conductivity levels at each monitoring site, December 2018

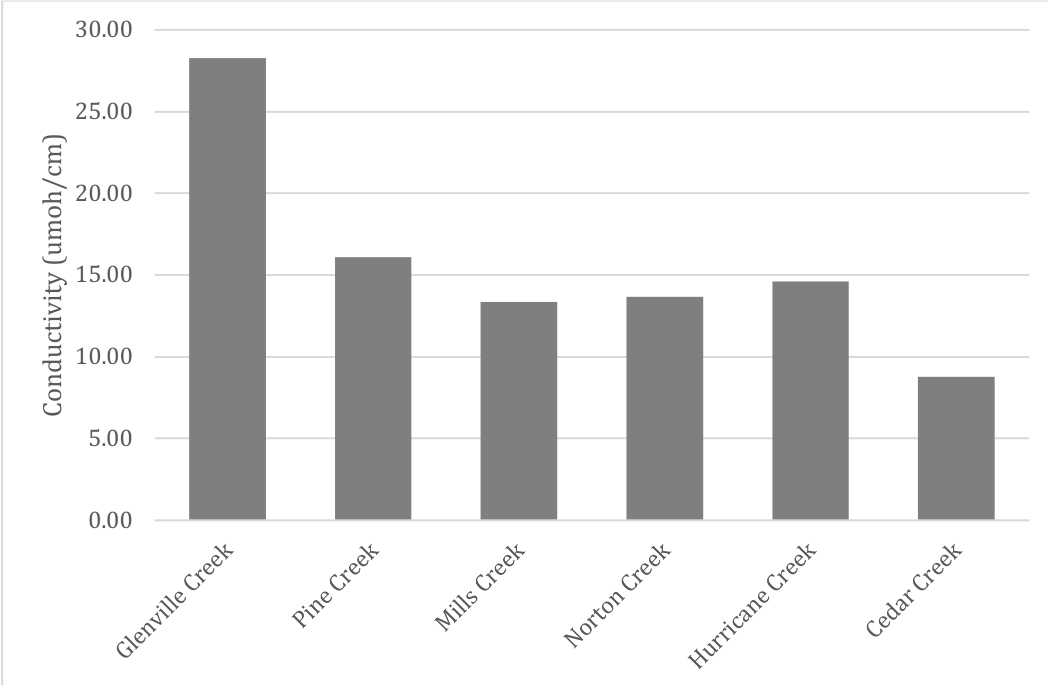
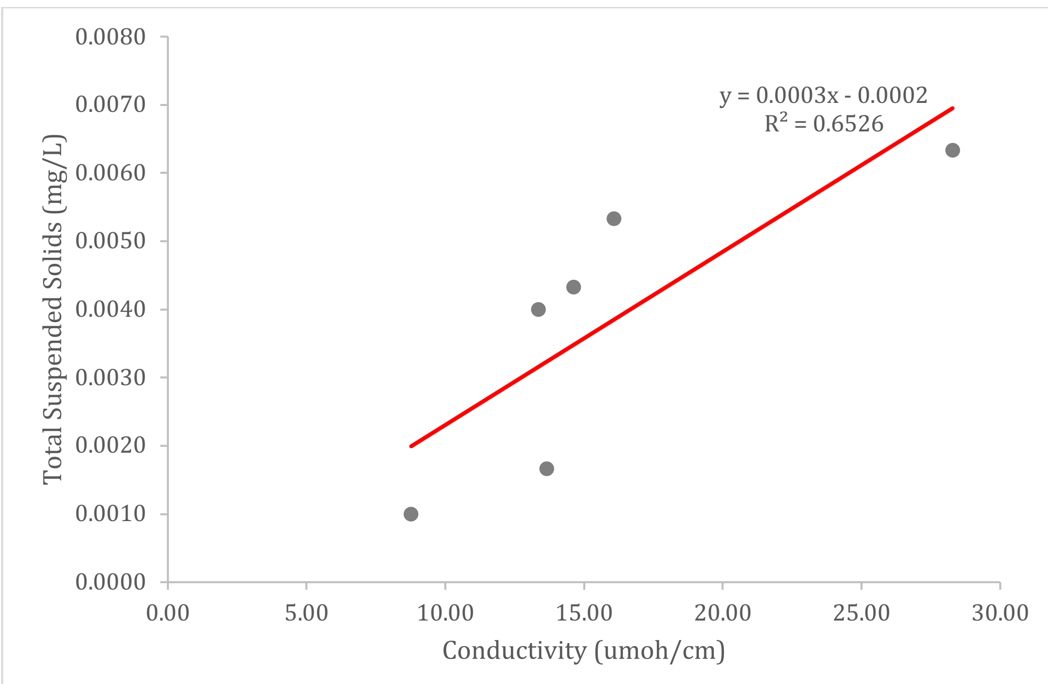


Figure 6. Correlation between conductivity and TSS concentrations at each monitoring site, December 2018



Nutrients (Orthophosphate [PO_4^{3-}], Ammonia [NH_3], and Nitrate [NO_3^-]): Phosphorus 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. Phosphorus is introduced into water systems from soil, wastewater treatment systems, failing septic systems, and runoff from fertilized land. Excessive phosphorus 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 phosphorus 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 phosphorus 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). Pine, Mills, and Norton Creeks exhibited a decrease in orthophosphate concentrations while Glenville, Hurricane, and Cedar Creeks exhibited an increase in orthophosphate concentrations compared to those observed in September 2018. Orthophosphate concentrations are correlated with conductivity (Figure 8) and total suspended solids (Figure 9) which suggests that orthophosphate concentrations may be associated with soil erosion and runoff.

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, with higher temperatures and pH leading to more nitrogen being present in the form of ammonia. No creek exceeded the ambient concentration "norm" (Figure 10). The low water temperatures and neutral pH values likely contributed to the decreased ammonia concentrations and elevated nitrate concentrations as compared to those observed in September 2018.

Like phosphorus, 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 in all creeks exceeded the EPA nutrient criteria for total nitrogen (Figure 11). With the exception of Cedar Creek, the observed nitrate concentrations are higher than those observed in September 2018. Observed nitrate concentrations are strongly correlated with turbidity which suggesting that, like orthophosphates, soil erosion and runoff may be a source of nitrate.

Figure 7. Mean orthophosphate concentrations at each monitored site, December 2018

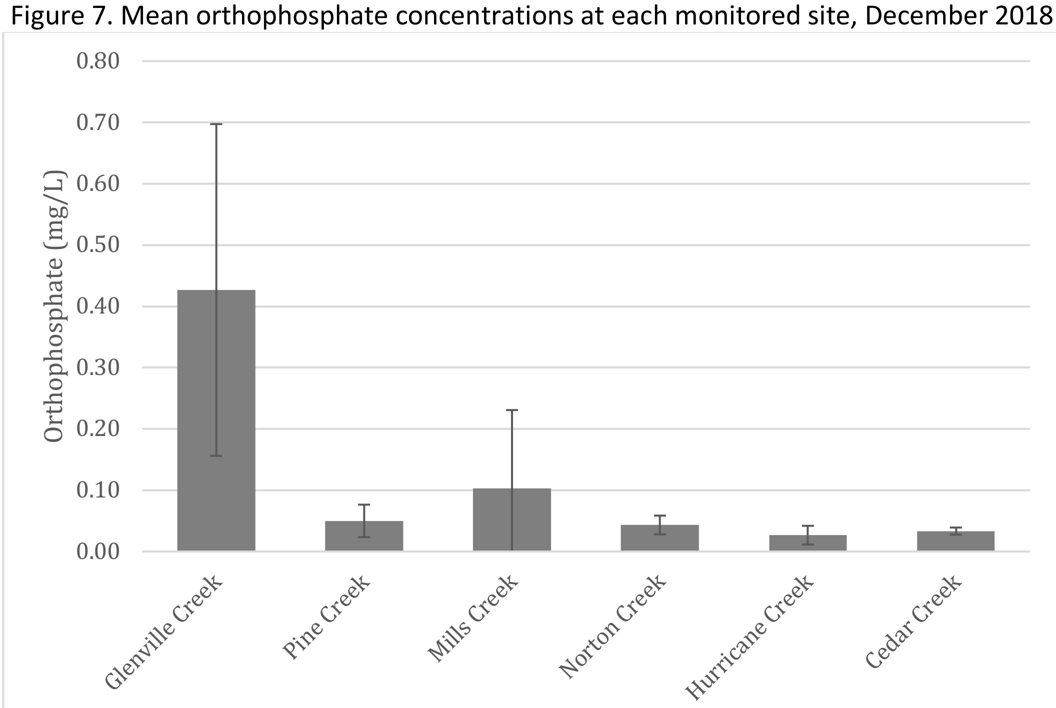


Figure 8. Correlation between orthophosphate and conductivity concentrations at each monitoring site, December 2018

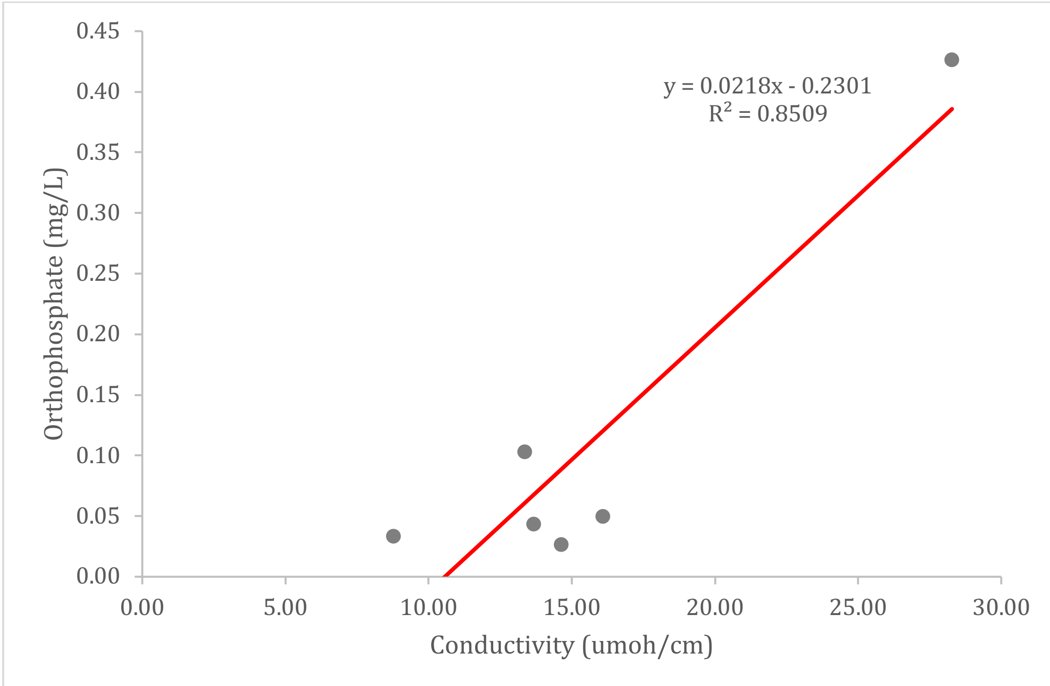


Figure 9. Correlation between orthophosphate and total suspended solids concentrations at each monitoring site, December 2018

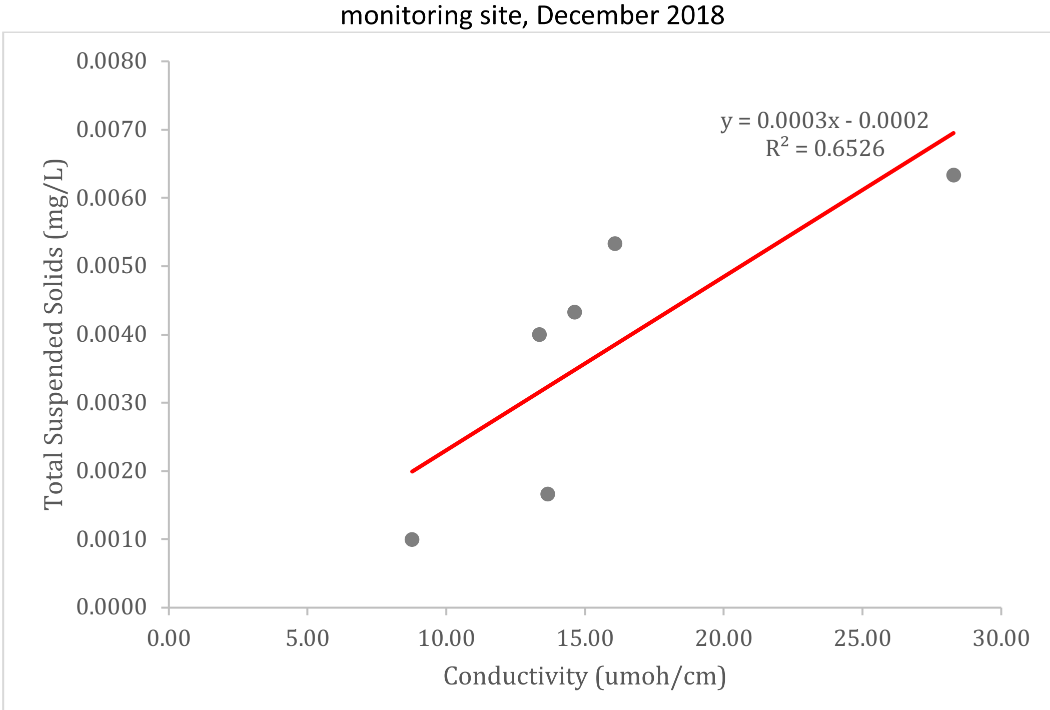


Figure 10. Mean ammonia concentrations at each monitored site, December 2018

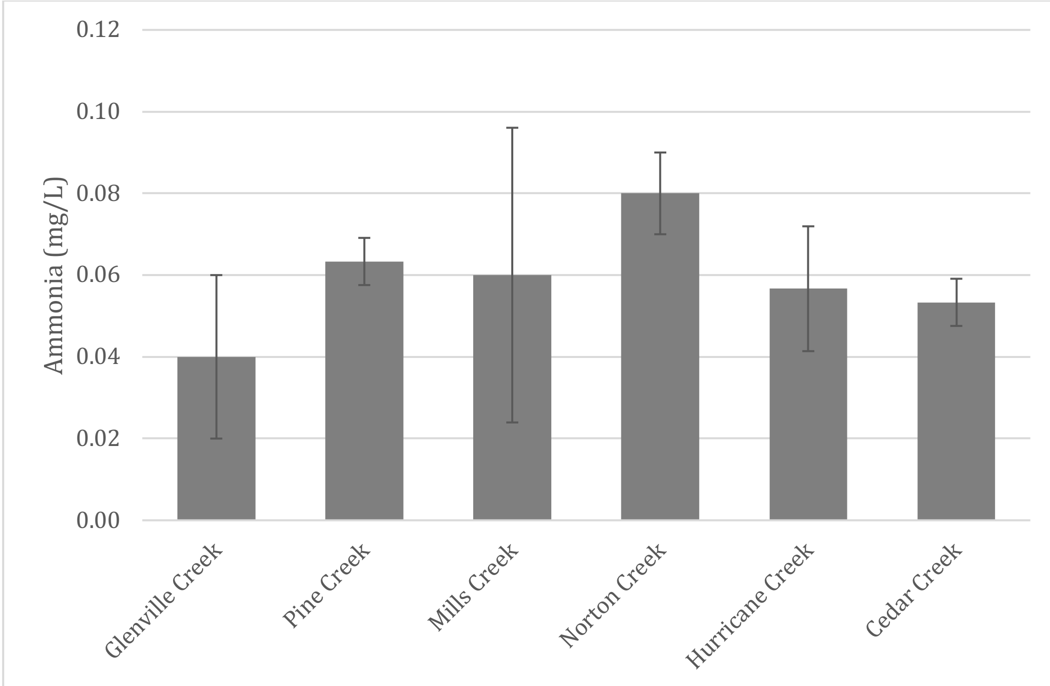


Figure 11. Mean nitrate concentrations at each monitored site, December 2018

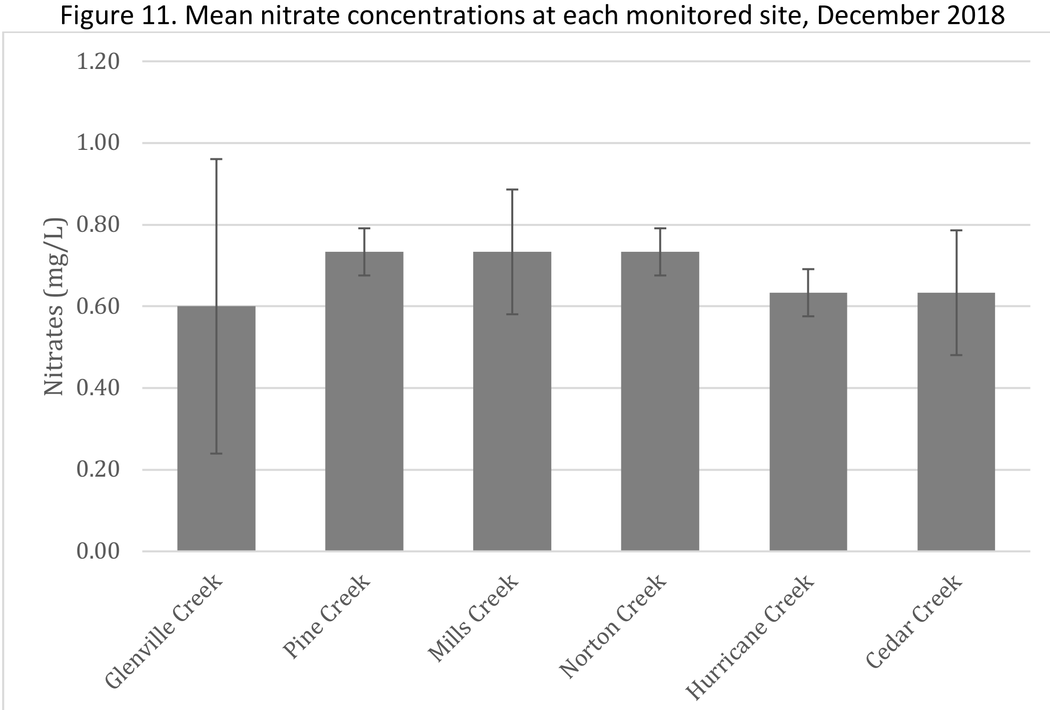
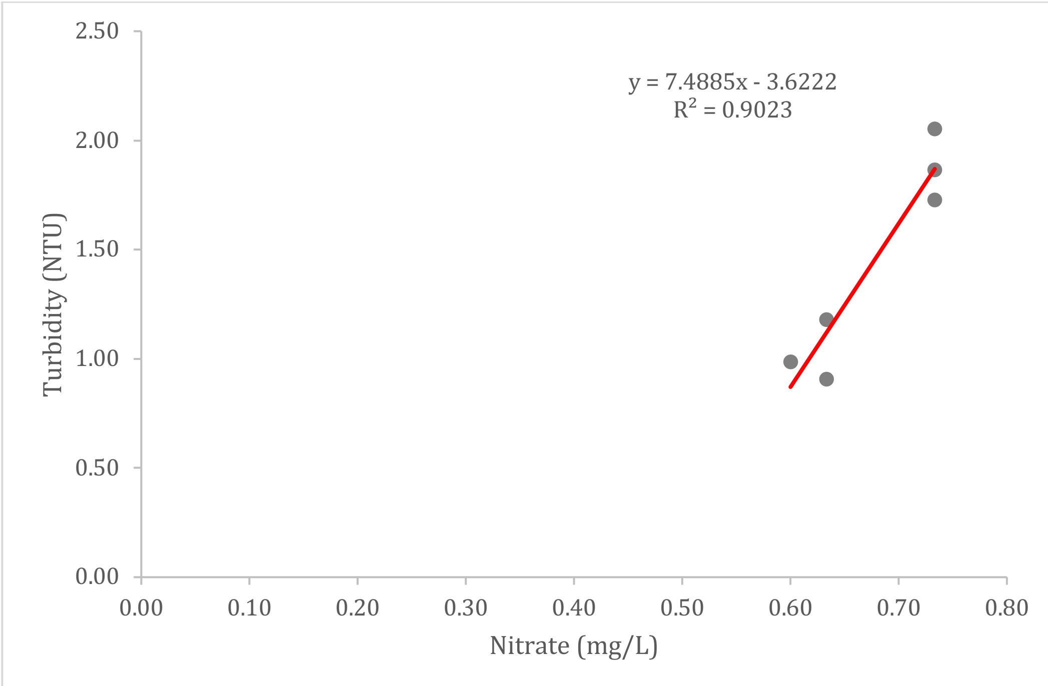


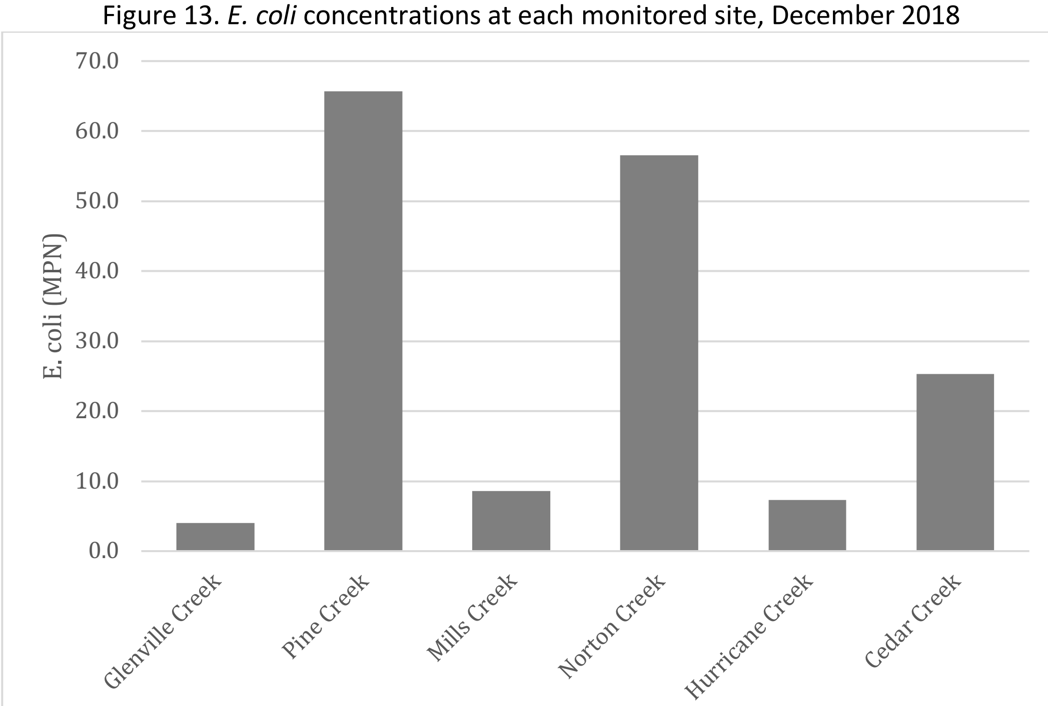
Figure 12. Correlation between nitrate concentrations and turbidity at each monitoring site, December 2018



***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. No creek exhibited *E. coli* concentrations above this regulatory standard (Figure 13). *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 and agricultural activity on fecal pollution in the creeks discharging into Lake Glenville.

Figure 13. *E. coli* concentrations at each monitored site, December 2018



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 December 6, 2018, is acceptable but there is evidence to suggest the influence of soil erosion and runoff events on water quality. The next quarterly monitoring event will take place in February 2019. 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.