TETRA TECH

MEMO

To:	Sean Martin, Town Administrator, Town of White Lake, NC
Cc:	
From:	Shannon Brattebo and Dr. Harry Gibbons
Date:	May 27, 2021
Subject:	Review of White Lake Water Quality Conditions and Potential Management with Alum

Sean Martin, town administrator for the Town of White Lake, NC, reached out to Tetra Tech in early May 2021 regarding concern over the water quality of White Lake. During February – April 2021, algal biovolumes and productivity in White Lake had greatly increased, resulting in low water clarity (secchi disk transparency of 0.75 m in April), high chlorophyll *a* concentrations (11.3 to 16.3 µg/L) and high pH (7.6 to 8.6 units in April). The Town of White Lake was concerned that water quality conditions observed in February – April 2021 were a precursor to a potential large cyanobacteria bloom and poor water quality conditions similar to what was observed in 2017 and spring 2018. By early May 2018, there was a very large cyanobacteria bloom in White Lake which caused pH to increase to a maximum of 9.6 (possibly even higher) due to the excessive photosynthesis. White Lake has a very low buffering capacity with alkalinity around 4 mg $CaCO_3$/L, which makes it very susceptible to changes in pH due to photosynthetic activity.

At the request of the Town of White Lake, Tetra Tech personnel (Shannon Brattebo, PE and Dr. Harry Gibbons) reviewed recent and historic water quality and phytoplankton data for White Lake to determine whether conditions in February – April 2021 warranted in-lake management with aluminum sulfate (alum).

A low-dose alum treatment was conducted in May 2018 during the large cyanobacteria bloom to reduce phosphorus concentrations within the lake and strip the phytoplankton out of the water column, effectively reducing photosynthesis. The alum treatment was successful and reduced total phosphorus (TP) concentrations within the lake from around 60 µg/L to near or below 20 µg/L according to data collected by North Carolina Department of Environmental Quality (NC DEC). The treatment also initially reduced mean chlorophyll *a* from 52 µg/L to 28 µg/L. Chlorophyll *a* averaged just over 8 µg/L for the remainder of 2018. Water clarity increased dramatically following the alum treatment and pH dropped significantly to more normal levels – 5.5 to 7.0.

The recent water quality and phytoplankton data for White Lake, currently, do not support a recommendation for an alum treatment in the spring/early summer of 2021. Nor does the recent data support the implementation of an annual maintenance alum treatment program for White Lake. The implementation of such a program would require extended water quality monitoring to track potential nutrient dynamic changes within the lake and watershed.

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The algal bloom that occurred during February – April 2021 was dominated by green algae and specifically by very small, single-celled desmids (personnel communication with Diane Lauritsen, Limnosciences). This was the same taxon that bloomed in July 2013 after extreme rainfall events, similar to conditions in early 2021. The phytoplankton diversity was quite high in February – April 2021 and the biovolume of cyanobacteria species remained quite low (personnel communication with Diane Lauritsen, Limnosciences). This contrasts with conditions in 2017 and 2018 when cyanobacteria dominated the large bloom.

Diane Lauristen with Limnosciences communicated to Tetra Tech on May 20th, 2021 that the algal bloom in White Lake had dissipated and water quality conditions were back to more normal levels, similar to what had been observed the past couple of years; pH around 6.5, dissolved oxygen saturation in the low 90s, and secchi depth (transparency) had increased from 0.75 to 1.75 m.

Phosphorus concentrations in White Lake remained relatively low in February – April 2021, with mean concentrations ranging from 25 and 26 µg/L in February and March to 39 µg/L in April. There was a small increase in TP in April 2021 but this was most likely due to the large amount of phytoplankton in the lake and the increase in recycling of phosphorus. Phosphorus concentrations have remained low in White Lake following the 2018 alum treatment. Mean TP ranged from 13 to 27 µg/L and 19 to 24 µg/L in 2019 and 2020, respectively. Given the relatively low TP concentrations, phosphorus does not appear to be the driver of the algal bloom in February – April 2021 and therefore the use of alum to reduce phosphorus and control the bloom is not warranted.

Most likely the bloom of small single-celled desmids in early 2021 were fueled by the increased input of nutrients from the large precipitation events in January and February. Precipitation usually contains high levels of nitrogen compared to phosphorus. Limnosciences reported that the mean total nitrogen (TN) concentration in February – April 2020 precipitation was 331 µg/L compared to just 12 µg/L of TP. The dominate forms of nitrogen in precipitation during February – April 2020 were nitrate+nitrite (61 µg/L) and ammonium (124 µg/L). Both forms of nitrogen are readily available for uptake by phytoplankton and assuming nutrient concentrations in precipitation in 2021 were similar, most likely fueled the early 2021 bloom of green algae. Mean TN concentrations in White Lake appear to be slightly increasing ranging from 304 to 719 µg/L in 2019, to 474 to 774 µg/L in 2020, and 577 to 787 µg/L in early 2021. This is consistent with the information reported by Limnosciences that there appears to be a dramatic increase in TN in White Lake such that recent TN:TP ratios (mean 29.4) are very similar to the TN/TP ratio in precipitation measured in February – April 2020 (27.7). These ratios are well above the N:P ratio of 7:1 that would indicate nitrogen limitation, and, with the relatively low TP concentrations in the lake, the current ratio enables the growth of other algal species rather than cyanobacteria.

In a memo titled "Changes in White Lake Nutrients Over Time", Limnosciences reports that concentrations of TP in White Lake averaged 17 µg/L in June 1974, less than 10 µg/L in June 1998, and less than 20 µg/L in June 2013 compared to June 2020 when TP averaged just slight more at 25 µg/L. In the same memo, Limnosciences reports that concentrations of TN in White Lake averaged 211 µg/L in June 1974, 110 µg/L in June 1998 and June 2003, and then jumped to 390 µg/L in June 2013. In June 2020, TN concentrations in White Lake were 757 µg/L, 3.5 times higher than they were in 1974.

An alum treatment would remove algal cells from the water column and therefore reduce the concentration of TN within the lake. However, an alum treatment does not permanently bind nitrogen

to aluminum as it does with phosphorus. The nitrogen contained within the algal cells that were stripped from the water column would recycle back into the water column as the cells decomposed in the lake sediments. This would be the case with any flocculant (poly-aluminum chloride, alum, polymers) used to remove the algae and particulates from the water column.

It became apparent during our review of the recent and historical data that White Lake is currently a very dynamic lake that is greatly influenced by weather and extreme weather events. Small increases in nutrient loading (either from the watershed or through precipitation) will cause big changes in the productivity of the lake, as was seen in 2017 and 2018 when phosphorus concentrations were higher than normal and cyanobacteria dominated the phytoplankton community. Decreased water clarity, as was observed in 2017 and 2018, also enables and promotes the growth of cyanobacteria. White Lake also has a very low buffering capacity making it susceptible to large changes in pH with increases in photosynthesis. At this point it appears that the lake is attempting to find a new equilibrium given the dramatic increase in its source water pH as well as land uses changes within the watershed.

White Lake historically had a very low pH range, 4.5 to 5. In Frey (1949), the pH of White Lake was reported as 4.9. In the 1980s, 1990s, and 2000s, the NC DEC measured pH in the lake around 3.3 to 5.3. Recent data collected in 2019 and 2020 show a pH range between 6.2 to 7.3. The increase in pH is most likely due to the dramatic increase in pH in precipitation in the region. The primary source water for White Lake (>90% of the lake volume) is precipitation. The pH in precipitation has increased from about 4.5 to around 5.8 from 1978 to 2017 as illustrated in Figure 1. According to Frey (1949), White Lake had very little phytoplankton as was to be expected given is acidic conditions. White Lake may currently be in a state of transition as pH within the precipitation begins to stabilize causing pH in the lake to have a "new normal" much higher than 4.5 to 5.0. The productivity of White Lake will change with the "new normal" pH and as mentioned earlier will be more susceptible to dramatic changes based on weather events, increased nutrient loadings, and watershed land uses.

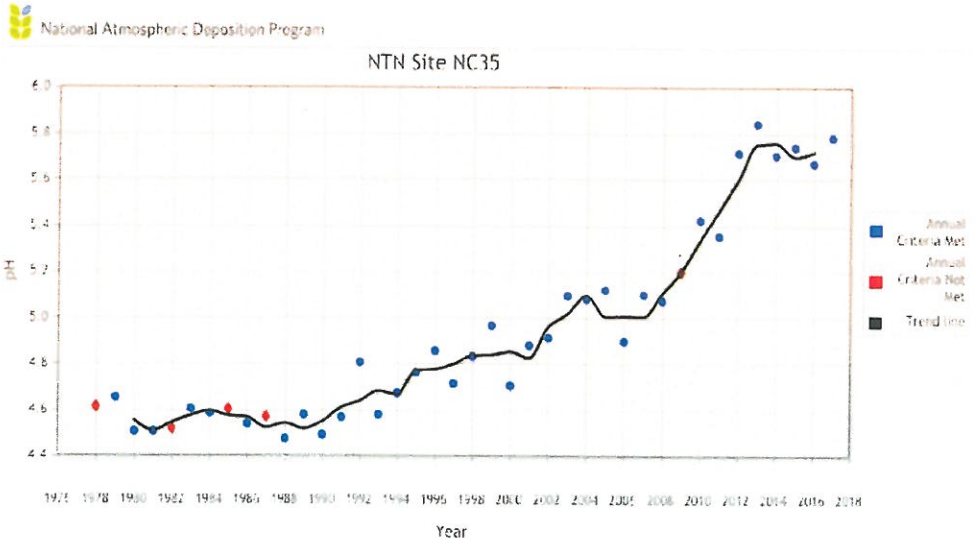

Figure 1. pH in precipitation measured at Clinton, NC. (Figure provided by Limnosciences/Envirochem, Inc.; Lauristen and Ehrlich, 2019)

Recommendations

Tetra Tech would like to offer the following recommendations to refine the management of White Lake going forward.

- We would like to recommend that the Town of White Lake continue its on-going water quality monitoring efforts and phytoplankton analysis. The current monitoring program provides incredibly valuable information that allows for real time management of the lake and helps to understand the lake's dynamic nature.
- We would like to also recommend that a paleolimnological study be conducted on the sediments of White Lake. A paleolimnological study would involve collecting sediment cores, 50 to 100 cm long, and conducting an analysis on the historic phytoplankton assemblage over the past 300 years. This study would provide a greater understanding of how productive the lake was naturally, prior to human influences and acid rain. This study would also provide insight regarding shifts in the phytoplankton community throughout time and provide a greater understanding of "background" or "natural" conditions that could be used to develop management goals.

Data Sources/References

Frey, D.G. 1949. Morphometry and hydrography of some natural lakes of the North Carolina costal plain: The bay lake as a morphometric type. Journal of the Elisha Mitchell Scientific Society. 65(1):1-37.

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