2020 Wolfeboro Waters
Water Quality Summary Report

The Wolfeboro Waters 2019 Assessment Subcommittee Summary Report describes what has been measured over the years in our lakes, why, how the results are interpreted, and watershed management plans (https://www.wolfeboronh.us/wolfeboro-waters-committee/pages/2019-assessment-summary-report). This report covers what has been done and learned since then in 2020 as well as assessment goals for 2021.

Executive Summary

While the pandemic limited some of our 2020 water quality assessment plans and has created difficulties and time delays in obtaining desired laboratory equipment and supplies, we have been able to advance our knowledge of Wolfeboro Waters conditions and trends including the risks of cyanobacteria, while actions were being taken to reduce nutrient runoff to our lakes.

- The Town of Wolfeboro voters approved warrants for several public works projects to reduce nutrient runoff to our lakes that were undertaken in 2020.
- Volunteer water sampling continued on Lake Winnipesaukee, Lake Wentworth, Crescent Lake, Rust Pond, and Mirror as part of the University of New Hampshire- Extension Service's LLMP program and the NH Department of Environmental Services' VLAP program. These lakes continue to be classified as having good water quality with limited biological growth (ogliotrophic), with the exception of Mirror Lake, which has moderate biological growth (mesotrophic).
- While cyanobacteria blooms were observed across NH in 2020, resulting in 25 NHDES Cyanobacteria Advisories and numerous warnings, there were none confirmed in Wolfeboro Waters.
- The World Health Organization released an 859 page Second edition to its Guide on Cyanobacteria. Among the many conclusions in the report was that there is no scientific evidence to support the hypothesis that there is a link between cyanobacteria blooms and ALS (Lou Gehrig's Disease) or Parkinson's Disease.
- The concentration of phosphorus in the water and/or sediment is a key element determining the amount of biological growth there is in most of our lakes, including cyanobacteria. Some cyanobacteria maybe influenced by the amount of nitrogen in the water. The growth in some of our waterbodies or portions of them maybe also be influenced by sediment flux and groundwater/septic systems.
- Stormwater runoff sources along our shores are the most important source of phosphorus being added to our lakes and are likely to result in local variations in biological growth.
- While most measurements of total phosphorus concentrations are made at deep water sites in our lakes during summer months, measurements nearer the shore in spring and autumn often show much higher concentrations.
- It is likely that conditions vary locally along the shoreline, depending upon the proximity to nutrient-rich streams and stormwater runoff, and, perhaps, also from shoreline sediment washed into the lake from waves from boats, high winds, and storms.
- With the assistance of senior scientists from Bigelow Lab, we have determined that the sediment along the shores of Winter Harbor is an important source of phosphorus stimulating biological growth on the bottom.
- With the assistance of senior scientists at Bigelow Lab and NHDES, we have identified several different types of cyanobacteria in Winter Harbor, including very tiny picocyanobacteria that do not produce surface blooms, all types of which have the potential to produce and release toxins into the water.
- We observed fuzzy-diffuse (cotton candy-like) balls in late summer in the water of Winter Harbor, referred to by some as metaphyton. Analysis of a sample containing metaphyton showed that it contained cyanobacteria.
- We have purchased a Biomeme Thermocycler, portable PCR device, that should enable us to measure within hours in Wolfeboro the relative concentrations of preselected cyanobacteria.

- We hope to conduct more detailed analyses of the concentrations of different forms of phosphorus and nitrogen in our water and sediment in conjunction with the relative concentrations of five or six specific cyanobacteria over time in 2021, focusing on Winter Harbor with representative samples from our other lakes for comparison.
- Among the other plans for 2021 is an effort to collect online voluntary observations of shoreline residents about local conditions in the water and on the lake bottom near them in order to get a better overview of local conditions around Wolfeboro Waters.

Effects of the Covid-19 Pandemic

The pandemic had numerous impacts on our assessment activities. For example, UNH labs were closed at times, the number of people who could meet in-person were limited, sampling kits could not be shared to the extent possible in previous years, collaborating scientists became ill with the disease, and laboratory equipment and supplies have been difficult to obtain as they have been allocated to pandemic related medical needs. As a result, we have not received all the laboratory results expected for 2020 and are awaiting equipment and supplies to enable us to carry out 2021 plans.

Nevertheless, actions have been taken to prevent and mitigate water quality problems, we have advanced our understanding of the issues facing our waterbodies, and people from across our community have been involved in these efforts.

2020 Prevention and Mitigation Actions

Voters in Wolfeboro approved warrant articles funding for the Public Works Department to undertake several Best Management Practices (BMPs) that were undertaken in 2020 to reduce stormwater runoff into Wolfeboro Waters. These include Phase 4 BMPs of the multi-year efforts with the Wentworth Watershed Association to implement the 2012 Lake Wentworth and Crescent Lake Management Plan and BMPs addressing nutrient runoff into Winter Harbor:

- BMPs at Camp Birchmont on Governor’s Shore on Lake Wentworth
- BMPs along a roadway and beach in the Wentworth Park neighborhood
- BMPs along Partridge Drive (Winter Harbor)
- BMPs at Carry Beach

The Wolfeboro Conservation Commission in 2020

- conserved land in the watersheds of Wolfeboro Waters through gifts and purchases of land, as well as receipt of conservation easements. These include:
- completing a Conservation Easement on 125 acres of land encompassing Whiteface Mountain that abuts the 42-acre Bridger Wildlife Easement. So, Wolfeboro now has 167 acres of permanently protected, contiguous forestland that are highly ranked by NH Fish & Game.
- contributed towards the Lakes Region Conservation Trust's purchase of 127 acres on Pleasant Mountain, which crosses the border into Wolfeboro and contains the headwaters to Wolfeboro's water supply.
- assisted the Eastern Lakes Region Housing Coalition in amending their Conservation Easement to place a new Easement protecting a wetland and enabling them to provide additional affordable housing to Wolfeboro's workforce.

Among private conservation efforts affecting Wolfeboro Waters was the donation by Don McBride, a local resident and President of the Land Bank of Wolfeboro-Tuftonboro to the Wentworth Watershed Association of a 23-acre parcel of land. The parcel is special because it has half mile frontage on Brewster Heath (acquired in 2019 by the Wentworth Watershed Association and being conserved) and 800 feet of shoreline on Crescent Lake.

Watershed Management Plans

A watershed management plan is a formal independent analysis of water quality status and trends in a waterbody, identifying concerns, sources of such concerns, and proposing goals for future mitigation and prevention actions. Such plans, conducted under the aegis of NHDES, once completed make such future mitigation and prevention actions eligible for contributions of state funds toward their costs. The following watershed management plans have been completed for Wolfeboro Waters:

Rust Pond (2007): (https://www.des.nh.gov/organization/commissioner/pip/publications/wd/documents/des-r-wd-07-24.pdf)
Rust Pond Rt 28 Boat Launch and North Inlet (2012)
https://www.lakesrpc.org/ckfinder/userfiles/files/Rust%20Pond%20Wolfeboro%20Subwatershed%20Management%20Plan%202012.pdf

Lake Wentworth and Crescent Lakes (2012):
{https://www.des.nh.gov/organization/divisions/water/wmb/was/documents/lake-wentworth- crescent-lake-wolfe.pdf }& {https://www.des.nh.gov/organization/divisions/water/wmb/was/documents/lake-wentworth-crescent-lake-wolfe-appendices.pdf }
(The Wentworth Watershed Association Plans to update the Watershed Management Plan in 2021.)

Mirror Lake (2012):
https://www.tuftonboro.org/sites/g/files/vyhlif5096/f/uploads/mirrorlakewmp_final_05222012web.pdf

Lake Winnipesaukee (Winter Harbor) (2020):
http://winnipesaukeegateway.org/lake-management/plan-4-moultonborough-bay-and-winter-harbor-wmp/introduction/

Proposed Wolfeboro Bay (including Back Bay) Watershed Management Plan: With the completion in 2020 of the two-year long watershed management plan that included the portion of Winter Harbor in Wolfeboro, the remaining portions of Lake Winnipesaukee in the town are the highest priority for watershed management planning in Wolfeboro Waters. A **Proposed Wolfeboro Bay (including Back Bay) Watershed Management Plan** has been endorsed by Wolfeboro Waters:
https://www.wolfeboronh.us/sites/g/files/vyhlif4071/f/uploads/wb_wmp_summary_3.18.21.pdf

Ongoing Volunteer Sampling for Water Quality Analyses

Wolfeboro lakes have participated in one or both of the major NH water quality analysis programs. In both of these programs local volunteers collect water samples and process them then they are sent either to the University of New Hampshire Extension Service Laboratory for analyses as part of its Lay Lakes Monitoring Program (LLMP) or NH Department of Environmental Services (NHDES) as part of its Voluntary Lake Assessment Program (VLAP). Lake Winnipesaukee, Lake Wentworth, Crescent Lake, and Mirror Lake have volunteers collecting samples for analysis in the UNH LLMP program. Rust Pond has volunteers collecting samples for analysis in the NHDES VLAP program, and Mirror Lake has volunteers collecting samples for analysis in both programs.

Results from these programs provide valuable data on the conditions and trends of our lakes, data that can be compared with other lakes across the state.

- Much of the LLMP and VLAP sampling is done at deep water sites in our lakes. The analyses of the samples from the deep site are primarily a measure of the status and trends of the whole waterbodies over years.
- Results in 2020 from the UNH LLMP and the NHDES VLAP programs continue to show Lake
- Winnipesaukee, Lake Wentworth, Crescent Lake, and Rust Pond as Ogliotrophic (having good water quality) and Mirror Lake as Mesotrophic (having intermediate water quality).

- Despite the drought and presumably less stormwater runoff, most of the lakes showed a small, but not statistically significant, increase in total phosphorus concentrations.
- Conductance and salinity measurements from VLAP continue to increase in our lakes, not a desirable trend, but not yet to damaging concentrations.
- Phycocyanin concentrations for 2020 samples, measures of the presence of cyanobacteria, are still pending from the UNH lab.

Local Observations and Knowledge Gained from the Research of Others

Gloeotrichia is the type of cyanobacteria that bloomed in Winter Harbor in late summer 2018. It, like most cyanobacteria, has the potential to produce cyanotoxins that are a risk to human (and pet) health. However, different cyanobacteria are associated with a wide variety of cyanotoxins. However, cyanobacteria that can produce cyanotoxins often do not in significant quantities and there is no way to predict if and when a bloom will release toxins and when it will not. (Several months after the 2018 bloom, it was determined that the concentration of cyanotoxins [two identified] did not pose a significant risk. (Bigelow Laboratory, NHDES, and other labs have the ability to get us toxin results from samples of cyanobacteria blooms more quickly in the future than were determined in 2018.)

In 2019, the heads of the Cyanobacteria Monitoring Collaborative brought a mobile laboratory to Wolfeboro and trained 80 people in cyanobacteria bloom identification. The Assessment Subcommittee of the former Wolfeboro Cyanobacteria Task Force developed a reporting protocol to respond to the identification of possible cyanobacteria blooms in Wolfeboro Waters.

- While cyanobacteria blooms were observed across NH in 2020, resulting in 25 NHDES Cyanobacteria Advisories and numerous warnings, there were none confirmed in Wolfeboro Waters.

Wolfeboro Waters Assessment Subcommittee members have continued to study research reports, read important guidance documents, and have conducted numerous additional analyses. In addition, members have consulted numerous experts from across New England, attended numerous meetings and presentations associated with water quality and cyanobacteria involving experts from across the country and around the world.

For example, there was a presentation by the lead of the World Health Organization's 859-page updated Guide on Cyanobacteria at a meeting of the Cyanobacteria Monitoring Collaborative (of which we are a member). https://www.who.int/publications/m/item/toxic-cyanobacteria-in-water---second-edition.
This major report provides guidance on the level of risks of several of different cyanotoxins. Particularly noteworthy was its analyses (Chapter 2 page 123-130) of the hypothesis that the cyanotoxin beta-methylamino-L-alanine (BMAA) is associated with Lou Gehrig's (ALS) and Parkinson's Disease. Such a link has been suggested for clusters of ALS cases in New Hampshire and is being studied by researchers at UNH and Dartmouth. The WHO, in considerable detail, concluded that there is no scientific evidence to support such a hypothesis. (Wolfeboro Waters has never suggested such a link.)

Recently, three subcommittee members met with Dr. Kathryn Cottingham, the Chair of the Dartmouth College Department of Biology and an expert on Gloeotrichia (Gloeo), the type of cyanobacteria that bloomed in Winter Harbor. Her research indicates archeological research in which she was involved has determined that Gloeo has been present in NH lakes for hundreds of years and that it was present in high concentrations during colonial times when much of the forests were cutdown and agriculture was a major portion of the economy. Dr. Cottingham also believes that Gloeo takes 'legacy' phosphorus from the sediment during much of its lifecycle and release excess phosphorus into the water when it rises to the surface for a brief part of its lifecycle and that the released phosphorus promotes other biological growth. She believes that Gloeo is a precursor to blooms of nastier cyanobacteria.

Ever since the cyanobacteria bloom in Winter Harbor in 2018, we have worked closely with NHDES' cyanobacteria program head, Dr. Amanda McQuaid. She has provided advice and invaluable insights, as well as informed us of important new scientific research results (including those of NHDES) and of noteworthy conferences and

organizations. Dr. McQuaid has also performed cyanotoxin analyses and characterized the biological make up of several of our samples. She has been trained with some of our subcommittee members by Bigelow Lab Senior Scientist Peter Countway on how to use our recently purchased portable Thermocycler PCR analytical device (see discussion below). She participated in our meeting at which we selected the specific types of cyanobacteria to monitor next year with the Thermocycler, discussing the types being seen in other NH lakes.

Other Analytical Results

The Assessment Subcommittee took advantage of scientific equipment that individual members have, as well as other equipment and supplies loaned to, given to, or owned by the town and in the possession of the Wolfeboro Waters Committee to conduct many additional analyses seeking to determine water quality status and trends, their causes, and options to preserve or enhance our waters.

Many of these analyses were conducted in Winter Harbor, which, in late August 2018, had the one cyanobacteria bloom ever in Wolfeboro that resulted in a NHDES Advisory urging people and their pets to avoid contact with the water. Winter Harbor was also chosen because more data are now available on a wide variety of parameters enabling us to refine our analytical methods, to identify new questions, and to start developing some answers. We hope to use the knowledge gained in Winter Harbor and its condition and trends to compare its conditions and trends to those of Wolfeboro's other waterbodies in the future.

The 2020 activities together with the knowledge gain in recent years, indicate the following (at least for Winter Harbor):

- Phosphorus is the key element that determines the extent of biological growth (and aging). It is also a, or the key, element in determining the extent of cyanobacteria.
- Total nitrogen concentrations in the water are high enough compared to those of total phosphorus, that nitrogen is not likely to be the limiting nutrient for most types of cyanobacteria.
- Sources of stormwater runoff are likely the most important contributors of phosphorus.
- Shallow shoreline locations in Winter Harbor generally have higher concentrations of phosphorus than in the center of the Harbor.
- The deep site sampling location in Winter Harbor is located over a "hole" likely created by receding glaciers. It is about 80 feet deep, whereas the rest of the harbor (80%) is 40 feet deep or less.
- Phosphorus concentrations in the lake are observed to be significantly higher, often above levels considered desirable, during the spring and fall months, particularly near the shore. So, deep water site phosphorus measurements made solely in June through September are not representative of concentrations along the shore, especially during non-summer months.
- Winter Harbor water stratifies over the summer into two zones that do not mix, with the divide (thermocline) between warmer water near the surface and colder water by the bottom at between 35 to 40 feet deep. Only a hole in the center of the harbor, representing less than 20% of the harbor, has deeper water (about 80 feet).
- The bottom layer of the water does not get much atmospheric oxygen from surface when the water is stratified. Bacteria on the bottom can eat any organic matter that has settled there using up oxygen in the process. If all the oxygen gets consumed, water at the bottom can become depleted of oxygen (anoxic) making the water uninhabitable by fish and changing the chemistry in the sediment to solubilize normally bound up phosphorus.
- In the autumn, when the water temperature of the surface water cools and starts to equalize with that on the bottom, the thermocline breaks down and all the water suddenly mixes, a process called turnover.
- In 2019, grab samples from the bottom of the deep site showed phosphorus concentrations reaching as high as 33.5 ug/L in early October 2019, while the surface concentration was 5.4 ug/L. However, the volume of water with the higher concentration of phosphorus was not large enough to significantly increase the overall phosphorus concentration in the Harbor upon turnover over the following ten day

(rising only 1 ug/L). Thus, the deep-water inventory (legacy) of phosphorus plus anoxic conditions are not a major source of higher concentration of phosphorus in shallower shoreline waters in the fall and spring.

- It is likely that conditions vary locally along the shoreline, depending upon the proximity of sources of nutrients to the lake, particularly from streams and stormwater runoff, and perhaps also from shoreline sediment washed into the lake from waves from boats, high winds, and storms.

Collaboration with Bigelow Laboratory for Ocean Sciences

The Bigelow Laboratory for Ocean Sciences in East Boothbay, Maine has expertise and equipment to study the chemistry and microorganisms in aquatic systems. While much of their research is on the marine environment, its senior scientists have been extending their expertise and special capabilities to study cyanobacteria and other hazardous microorganisms in freshwater systems. Wolfeboro Waters has been fortunate to be able to obtain Bigelow Lab expertise to help assess cyanobacteria in our lakes and the geochemistry that influences the types and concentrations of microorganisms such as cyanobacteria.

We have been particularly indebted to have Dr. Peter Countway, who grew up in our area, and who is an expert in the genetics of aquatic microorganisms and Dr. Michael Lomas, who is an expert in aquatic geochemistry as well as the Director of the National Center on Marine Algae and Microbiota advise us and work in support of us this past year.

Dr. Countway helped us to interpret the biological activity that we observed. He taught us how to collect and process samples for e-DNA metagenomic analyses showing us what types of cyanobacteria are present in our samples and in what relative concentrations. For example, he has able to confirm the presence of significant concentrations of very tiny picocyanobacteria, which do not form major surface blooms, but which have the ability to produce and release toxins. Dr. Countway also introduced us to the possible use of a portable PCR-based device to be able to analyze the relative concentrations of selected cyanobacteria within hours of sample collection. We have purchased such a device for future use.

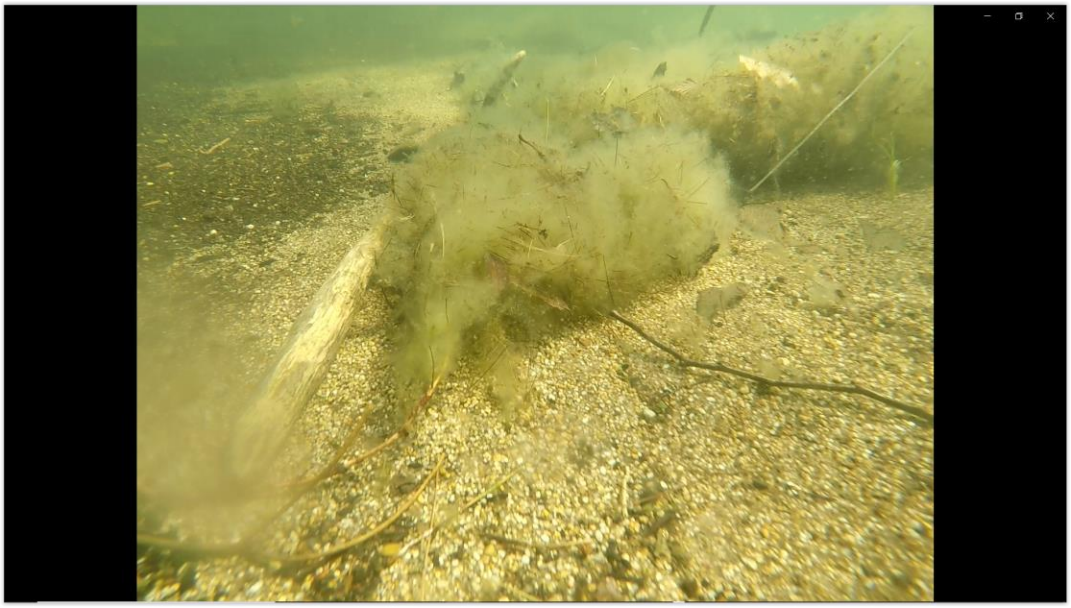
We also collected water and sediment samples that Dr Amanda McQuaid of NHDES assessed to identify their cyanobacteria content.

Benthic Flux Chamber

Dr. Lomas constructed six benthic (sediment) flux chambers that we put out in four different locations in Winter Harbor and drew samples from over several weeks to determine the extent to which phosphorus is entering the water column from the sediment or the sediment is taking phosphorus out and reducing the concentration in the water column (flux). He used models to predict the flux from sediment core samples and compared that to the flux measured in the chamber's water. He also analyzed the sediment core samples collected at several different locations in Winter Harbor over the summer to determine the concentrations of soluble reactive phosphorus and the concentrations of phosphorus in the fine (organic containing) sediments and in the course (generally inorganic) sediments.

The efforts in collaboration with Bigelow Labs and NHDES have led to the following insights:

- There are higher concentrations of phosphorus in Winter Harbor sediment and sediment water than in the water column above.
- Benthic flow chambers at four different shoreline locations in Winter Harbor over several weeks in Summer 2020 showed that phosphorus was entering the water column from the bottom. (Some of the same chemistry described above for the stratified deep-water may apply a few inches deep into the sediment and increase phosphorus availability to plants, algae, and cyanobacteria.)
- Estimates from numerous sediment core samples predicted such a flux of phosphorus from the sediment. They also show significant differences in the concentrations of the soluble reactive phosphorus in the pore water of the sediment, in the fine sediment, and in the coarse sediment, even within samples taken in close proximity. There certainly are differences in the sediments around the shore of Winter Harbor.



Metphyton?

- In 2020, we observed fuzzy-diffuse (cotton candy-like) balls, up to a foot or more in diameter, coming from or caught up in plants growing on the bottom of Winter Harbor. Some have called these fuzzy-diffuse balls metaphyton and indicated that they are harmless. We sampled one of the balls and had e-DNA analyses of it. The analysis showed that it contained, if it was not made of, cyanobacteria. Probably the concentrations of cyanobacteria in such diffuse masses are not a significant health risk, but they should be regarded with caution.
- We have found several types of cyanobacteria, other than Gloeotrichia, in Winter Harbor. One class of cyanobacteria found in relatively high concentrations are very tiny picocyanobacteria that do not produce the dramatic surface blooms that we have been taught to be on the lookout for. Yet, they, too, can release cyanotoxins.
- In addition, high concentrations of different cyanobacteria have been identified in and on the sediment. Some of these are the same types of cyanobacteria that form surface blooms, but that live parts of their life cycles in or on the sediment.
- Some cyanobacteria are primarily associated with blooms that form several feet below the surface of a lake (e.g., Planktothrix that has formed subsurface blooms in Mirror Lake).
- Some cyanobacteria live primarily on or in the sediment of the bottom of the lake. Some can appear as slime on the sand or rocks.

Green Algae, Cyanobacteria, or both?

- Some benthic cyanobacteria (those that live primarily of the bottom) may detach from the sand or rocks to which they were attached and form masses that float on or near the surface to the shore. These are sometime mistaken for green algae but may be toxic cyanobacteria. Mats have been observed in Winter Harbor. We will collect samples of these mats in the future to determine their make up and if they pose a cyanotoxin risks.
- Cyanotoxin analyses were made by NHDES and Bigelow Lab.
- We identified five or six types of cyanobacteria that we have determined or expect to be present in Wolfeboro Waters. We would like to assess the concentrations of these cyanobacteria over time, using the portable Thermocycler PCR device and to identify chemicals in the water or sediment that correlate most closely with their growth. The cyanobacteria selected are
    - Gloeotrichia (the cyanobacteria that bloomed in Winter Harbor in 2018)
    - Planktothrix/Oscillatoria (two names for a cyanobacteria that grows with limited light and can form blooms several feet below the water, as has occurred in Mirror Lake)
    - Microcystin (a commonly found cyanobacteria in New England freshwater lakes)
    - Dolichospermum/Anabaena (two very closely related cyanobacteria that have been observed to bloom in early summer in Winter Harbor)
    - One or two picocyanobacteria (Cyanobium, Synechococcus, and/or Aphanacapsa)

Assessment Plans for 2021

Wolfeboro Bay and Back Bay Watershed Management Plan: The Wolfeboro Waters Committee has endorsed having the Lake Winnipesaukee Association continue to oversee expert, independent watershed management plans on Lake Winnipesaukee by next studying Wolfeboro Bay and Back Bay/Front Bay. We anticipate conducting analyses in 2021 to support the development of the plan.
(https://www.wolfeboronh.us/sites/g/files/vyhlif4071/f/uploads/wb_wmp_summary_3.18.21.pdf)

Volunteer Surveys of Local Shoreline Water and Sediment Conditions: Nutrient containing stormwater runoff is a major concern across Wolfeboro Waters and such runoff enters our lakes at or near the shore. The overall conditions and trends of the water quality of our lakes can be assessed through regular monitoring at deep water sites. However, conditions along shorelines can vary significantly depending upon local sources of nutrients and other factors. For us, to know at least qualitatively, what the local water quality conditions are around the shores of Wolfeboro Waters, we are planning to undertake two different voluntary surveys. The first would be a simple short online survey of local observations of the water and bottom conditions by homes on the shores of

Wolfeboro Waters (e.g., plants, floating masses, slime, muck, or other biological growth on the bottom). The second would involve volunteers reporting observations over one or more summers at their homes or nearby location.

Correlating the Growth of Different Cyanobacteria with Nutrient Concentrations in the Water and Sediment: The availability of phosphorus and, to a lesser degree, nitrogen as well as the water temperature are the are the most important factors influencing the growth of cyanobacteria in our lakes. Phosphorus and nitrogen may be present in several different forms in streams flowing into our lakes, in the water columns, and in the lake bottom sediment. It is likely that different cyanobacteria prefer different forms of these elements as well as locations (e.g., sediment versus water column). To determine the drivers of growth for different potentially important cyanobacteria, we are seeking in 2021

- to determine the types and concentrations of the phosphorus and the nitrogen in the water, sediment, streams, and storm water runoff over the calendar year and
- to determine the relative concentrations of different cyanobacteria in the water and sediment over the same calendar year

In 2021, we will focus most of our measurements on Winter Harbor, seeking to determine correlations between the concentrations and sources of the different types of nitrogen and phosphorus and the concentrations of the selected types of cyanobacteria over time. Winter Harbor is the chosen location because we have existing information and data on both water quality and sediment concentrations and flux from which to work.

We are collecting samples from Lake Wentworth and Crescent Lake and expect to collect samples across the othe Wolfeboro Waters and over time upon which the cyanobacteria composition and relative concentrations will be determined for us by Bigelow Lab using e-DNA metagenomic analysis. At the same time samples will be collected that can be analyzed within hours for the five or six pre-selected cyanobacteria of interest using the portable Thermocycler.

Biomeme Franklin Thermocycler/PCR

Using the Thermocycler is not trivial. In addition to obtaining the Thermocycler itself, we need safety equipment, specialized laboratory equipment and reagents to process the samples and to conduct PCR analyses. Obtaining the necessary equipment and supplies has been a challenge because the Thermocycler and PCR are approved methods for Covid-19 analyses and thus are in great demand. In addition, several members on our committee will be trained by Bigelow scientists to use the Thermocycler in Wolfeboro.

- We will develop a guide, reviewed by Bigelow Labs, that provide standard methods we will use for sample collection, preservation (if needed), extraction, and preparation, as well as for use of the Thermocycler PCR, data interpretation, and recordkeeping.
- We plan to use the Thermocycler to measure the relative concentrations of the five or six selected cyanobacteria over time and determine water and sediment phosphorus (and nitrogen, as appropriate) concentrations at the same time and locations.
- We hope to identify correlations between the relative concentrations of the select cyanobacteria and the concentrations of the different forms of phosphorus and nitrogen that we measure

- We want to collect some samples from other Wolfeboro Waters in 2021 to see whether the cyanobacteria makeup and trends of those lakes are like those in Winter Harbor.
- We expect to use the more intensive analyses in Winter Harbor in combination with the of the comparative analyses from our other waters to plan analytical approaches and goals across Wolfeboro Waters in future years.

Identifying Additional Options to Reduce Phosphorus from Entering Our Lakes in Surface Runoff: Efforts to reduce the addition of nutrients to our lakes from stormwater runoff have focused on ways to slow the flow of water across their land and have it absorbed into the ground before entering our lakes. Having our lakes recharged by groundwater greatly reduces the addition of soluble and phosphorus containing sediment in water flowing across the surface of our land. There are several programs such as USEPA's "Soak Up the Rain Program"(https://www.epa.gov/soakuptherain), NH Lakes' "Lake Smart Program"(https://nhlakes.org/lakesmart/), and the Lake Winnipesaukee Association's "Keep Winni Blue Initiative" (https://www.winnipesaukee.org/take-action/) that help private property owners reduce nutrient runoff from stormwater. In addition, the Wolfeboro voters have funded warrants to enable the town's Public Works Department to undertake several Best Management Practice projects to reduce stormwater runoff. (2020 BMP projects are listed above.) In 2021, our assessment subcommittee along with the Wolfeboro Waters Mitigation and Prevention Subcommittee will seek to identify additional options that private property owners could use to remove or prevent phosphorus from entering streams before entering our lakes.

Pilot-testing a Means to Assess the Impacts of Big Waves and Boat Traffic on Washing Nutrients from Shores on our Lakes: Numerous shoreline owner have expressed concerns to us that large boat waves are washing, presumably nutrient-rich, soil along the edge of the lake into the water. They believe that such waves represent an important additional source of phosphorus to our waters. In response to this concern, members of our subcommittee hope to pilot-test in 2021 an observational survey combined with turbidity and total phosphorus water concentration measurements to see if such a methodology would be useful in assessing the shoreline and water quality impacts numerous and or big boat waves.

Acknowledgements

Wolfeboro Waters was established as a Town of Wolfeboro standing committee in 2020. It was preceded by a town ad hoc Cyanobacteria Task Force responding to an unexpected cyanobacteria bloom in Winter Harbor in late 2018. However, water quality assessments on our lakes have been ongoing for many years by our lake associations and their members participating with UNH and NHDES. More importantly, the quality of Wolfeboro Waters is the result of many nutrient and pollutant mitigation and prevention efforts led by the lake associations and the town, as well as of the many actions of individuals in our watershed.

- Wentworth Watershed Association (https://wentworthwatershed.org/)
- Lake Winnipesaukee Association (https://www.winnipesaukee.org/)
- Rust Pond Association (www.rustpond.org)
- Mirror Lake Protective Association (https://www.mirrorlakenh.org/)
- NH Lakes (https://nhlakes.org/)

This report is a 2020 snapshot of local water quality conditions and trends. Most of the water quality sampling and lake condition observations in the past and in 2020 were conducted by lake association volunteers, including:

Lake Winnipesaukee Association

Abigail Adams
Joanne Akie
Karen Zagula
Betsy Farley
Tom and Linda Davis
Phil Clarkson
Diana Frucci
David Schappel
David and Janice Shannon
Beth Marcoux

Lake Wentworth Watershed Association

(Lake samplers for Crescent Lake and Lake Wentworth)

John and Sarah Buttrick
Julie Brown
Tom Cookson
Dave and Deb Denby
Bob Donovan
Nancy Gilbert
David Gillett
Kevin Green
Lynn Johnson
Don Kretchmer
Rich Masse and Andrea Dudley
George Myers
Jack O'Conell

(Dive Team and Supporters)

Brett Conley
Chris Crocker
Bruce Gifford
Howie Hoyt
Rick Jakle
Lynn Johnson
John Lyeard
John Millay
Skip Oliver
Karen and Tom Ouhrabka
Colin Ross
Keith Scarlett
Jack Willard

(Weed Watchers)

Jen Baskin
Anne Blodgett
Zeke & Carol Bly
Bobbi Boudman
Ken Bowman
Jen and Eric Chinburg
Emilie Clark
Christine and Patrick Curry
Ed Dinsmore
Claire Donahue
Peter Galanis
Bruce Giffod
Tim Glennon
Susan Goodwin
Chuck Hallett
Eric and Sally Koch
Alex Koslovsky
Don Kretchmer
Andy Masko
Rich Masse
George and Marian Myers
Skip Oliver
Tom, Eric, and Suzy Ouhrabka
Heimiller
Joyce Pepin
Dan Ross
Mary Schillereff
Rick and Peg Skarinka
Bob Spear
Maggie Stier
Nancy van Lonkhuyzen

Rust Pond Association

Keith Simpson
Christie Parker
Rich Coan
Peter Colbath

Mirror Lake Protective Association

Mary Ann Murray
Richard and Nancy Byrd
Elizabeth Urda
Norma Milne
Tom and Claudia Bissett
Glenda Philbin
Doug Herrick
Jeanne Freeze
Joan and Stephen Scapicchio
Seamus Oscalaidhe
Tilna Urv
Gene Kelley
Lawrence Gil

Wolfeboro Waters

(Winter Harbor)

Andra Dekkers
Warren Muir

NH Lakes

NH Lakes has a Lake Host program with paid staff, supplemented by volunteers, often supplied by the applicable lake association. The focus of the Lake Host program is the identification and prevention of the introduction of invasive plants and animal on watercraft being put into the lake. However, the lake hosts also are important observers of water conditions. Some, but not all, of the lake hosts in Wolfeboro in 2020 were

Jan and Alan Hardman
Judy Crosley
Jane Goldthwait
Susan Goodwin
John Wall
Peter Warren
Jackson Boudman

Bigelow Laboratory for Ocean Sciences (www.bigelow.org), (see above) especially

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Presenters at Conferences by
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Drone Photographer and Runoff Source Assessor:
Peter Goodwin

Sampling Supplies and Processed Sample Transfer and Storage Locations:

GALA's Makers Mill	Dive Winnipesaukee

Respectfully Submitted, **July 26, 2021**

Wolfeboro Waters Assessment Subcommittee
Abigail Adams
Emilie Clark
Andra Dekkers
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Warren Muir, Chair
Linda Murray
Pat Tarpey, Alternate
Steve Wingate

* *

Appendices

Appendix A - 2020 LLMP Data for Wolfeboro Waters in Lake Winnipesaukee
Appendix B - 2020 LLMP Data for Lake Wentworth and Crescent Lake
Appendix C - 2020 VLAP Data for Rust Pond
Appendix D - 2020 Benthic Flux & Sediment Core Sample Phosphorus Analyses from Bigelow Labs
Appendix E - 2020 e-DNA Analyses of Winter Harbor Water Samples by Bigelow Labs
Appendix F – Cyanobacteria Identified by NHDES in 2020 Winter Harbor Sediment Sample
Appendix G – 2020 Mirror Lake Data