Northeast Aquatic Research

March 2023

TO: Highland Lake Watershed Association
ATTN: Candy Perez
FROM: Hannah Moore
Re: Highland Lake 2022 Water Quality Results

Discussion of 2022 Water Quality Results

This summary letter presents the results of 2022 Highland Lake water quality monitoring, including water clarity, dissolved oxygen profiles, and water temperature profiles. Data was collected from three stations, North Bay, Center Bay, and South Bay. Also presented are the laboratory results from total phosphorus and total nitrogen testing, and phytoplankton enumeration.

Water Clarity

The goal for water clarity in Highland Lake is at least two months of Secchi disk depth measurements greater than 4 meters across the three stations during the sampling season (**Table 1**). Water clarity was generally poor in April and June at all three stations. Clarity improved notably by July, with readings ranging from 5 to 6 meters across the three stations. Water clarity was poor at North Bay from August through October, but improved in November. Oddly, the long-term trend shows that in November, North Bay has the best clarity of the three stations. Clarity was better than 4m from August through October at Center Bay and better than 4m in August and September at South Bay.

Table 1. 2022 Secchi disk depths and the long-term average for each station.

		Apr	Jun	Jul	Aug	Sep	Oct	Nov
North	**2022**	3.1	3.8	5.0	3.3	3.5	3.4	4.6
Middle	**2022**	2.8	3.1	6.0	4.4	4.4	4.4	3.8
South	**2022**	3.3	4.0	5.7	4.8	4.4	3.7	3.1
	Difference	*0.5*	*0.9*	*1.0*	*1.4*	*1.1*	*1.0*	*1.5*
North	*Average*	*3.6*	*4.0*	*4.2*	*3.7*	*4.1*	*3.7*	*3.7*
Middle	*Average*	*3.6*	*4.1*	*4.6*	*4.3*	*4.6*	*4.1*	*3.5*
South	*Average*	*3.6*	*4.2*	*4.6*	*4.5*	*4.5*	*3.8*	*3.1*
	Difference	*0*	*0.2*	*0.4*	*0.7*	*0.5*	*0.4*	*0.6*

*Green highlighted cells depict station with lowest Secchi depth that month.

Dissolved Oxygen and Water Temperature

As detailed in the 'Highland Lake 2020 Water Quality Report & Long-Term Data Assessment', dissolved oxygen below 1 mg/L (termed 'anoxic') should not occur above **4 meters** below the surface at North Bay, **9 meters** below the surface at Center Bay, and **8 meters** below the surface at South Bay.

In North Bay in 2022, the bottom water was oxygenated into June (**Table 2**). By July, anoxic water was present and shallower than the long-term mean. The anoxic boundary decreased slightly in August and decreased further in September. The bottom water returned to an oxygenated state in October and remained oxygenated through the last sampling event in November.

The bottom water was also oxygenated into June at Center Bay. Anoxic water was first recorded in July but was lower (better) than the long-term mean in both July and August. The anoxic boundary rose in the water column in September (reaching higher than the goal depth of 9 meters below the surface) and remained higher than the long-term mean through the last sampling event in November.

In South Bay, anoxic water was first recorded in July. The anoxic boundary fluctuated between being higher and lower than the long-term mean between July and October. The water at the bottom of South Bay was reoxygenated by the November sampling.

Table 2. 2022 anoxic boundary depths in meters below the surface*.

		Apr	Jun	Jul	Aug	Sep	Oct	Nov
North Bay	**2022**	None	None	6.97	6.7	7.8	None	None
	Target 4m	Y	Y	Y	Y	Y	Y	Y
Center Bay	**2022**	None	None	14.68	12.25	7.7	9.9	10.9
	Target 9m	Y	Y	Y	N	Y	Y	Y
South Bay	**2022**	None	None	9.67	10.7	8	10.9	None
	Target 8m	Y	Y	Y	N	Y	Y	Y

*Blue cells show instances when the anoxic boundary was deeper than the long-term mean. Red cells show instances when the anoxic boundary was shallower than the long-term mean.

Nutrients

Total Phosphorus

Surface-water total phosphorus (TP) thresholds have been established for the season and for each month using the long-term data set. Measured TP concentrations in Highland Lake in any one month should remain near or below that month's long-term average, and the seasonal average should be equal to or below the long-term average.

In 2022, the TP concentrations in the surface water at all three stations were higher than the lake-wide long-term mean in all months except November and South Bay in June (**Table 3**). The seasonal averages at the three stations were also higher than the long-term average. TP was highest on April 12th. Over 2" of rainfall were recorded on April 8th and ¼ inch of rain on April 10th. This amount of precipitation in a short period of time likely led to the increased TP concentrations on April 12th and suggests that the watershed is a primary source of nutrient loading to the lake.

Table 3. 2022 surface-water (1m) total phosphorus concentrations (ppb) and monthly lake-wide long-term average surface TP water concentrations.

	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Average
North Bay	24	13	11	17	18	11	6	14
Center Bay	18	12	14	13	16	15	5	13
South Bay	20	10	13	17	17	12	8	14
Lake-wide Surface Water Long-term Mean TP	*10.8*	*10.8*	*9*	*8.7*	*12.4*	*10.2*	*14.9*	11

* Red cells depict TP values that are greater than the long-term mean.

Total Nitrogen

The upper tolerable level for total nitrogen in surface-waters of Highland Lake is 250ppb. TN was elevated above this threshold at all three sampling stations in April, likely due to the extreme rain event a few days prior, as described above (**Table 4**). TN remained elevated at North Bay and Center Bay in June. All remaining samples were under the 250ppb threshold with the exception of the August 8th North Bay sample, which was just slightly elevated.

Table 4. 2022 surface-water (1m) total nitrogen concentrations. Red highlighted cells depict months when the concentration exceeded 250ppb. Green cells are stations with lowest TN value.

	Apr-12	Jun-10	Jul-15	Aug-8	Sep-16	Oct-11	Nov-3
North Bay	260	336	183	255	166	159	227
Center Bay	270	268	213	217	139	192	198
South Bay	258	189	191	204	159	232	124

* Red cells depict TN levels greater than the 250ppb threshold.

Chloride

Chloride is a naturally occurring element in the landscape and so is present to some degree in river flow. Chloride is also used to salt roads in the winter. Chloride has no direct biological interest so remains mostly unaltered in lake water - partitioning is due solely to hydrology and flushing. Chloride tends to be least of the three anions that are included in salinity / conductivity readings, along with sulfate and bicarbonate. Chloride will not accumulate in the sediments as there is no way to precipitate chloride out of the water column under these standard conditions. Chloride is also present in the atmosphere in Connecticut because of aerosol formation by the ocean.

Chloride data was collected from the three bays in October and November 2022 with results in **Table 5**. The values of 35± mg shows essentially equal concentrations lake-wide. These values appear high but no state-wide census of chloride values in the surface waters has been conducted. We measure chloride very rarely because it is not involved in the eutrophication process. Data show that chloride declined slightly at Middle and North bays by November, but South Bay showed a 38% decrease in chloride, most likely due to watershed dilution.

Table 5. 2022 surface-water (1m) chloride concentrations (mg/L).

	Oct-11	Nov-3
North Bay	34.7	33.8
Center Bay	35.8	33.4
South Bay	34.4	21.2

Phytoplankton

Diatoms dominated the phytoplankton community from April through August (**Figure 1**). Cyanobacteria was also present at low levels. Cyanobacteria was most abundant in April, at ~4,400 cells/mL. This is considered a low level with regard to relative probability of acute health effects resulting from exposure to cyanobacteria by the World Health Organization (WHO) (**Table 6**).

Algae counts were low across all groups from September through November.

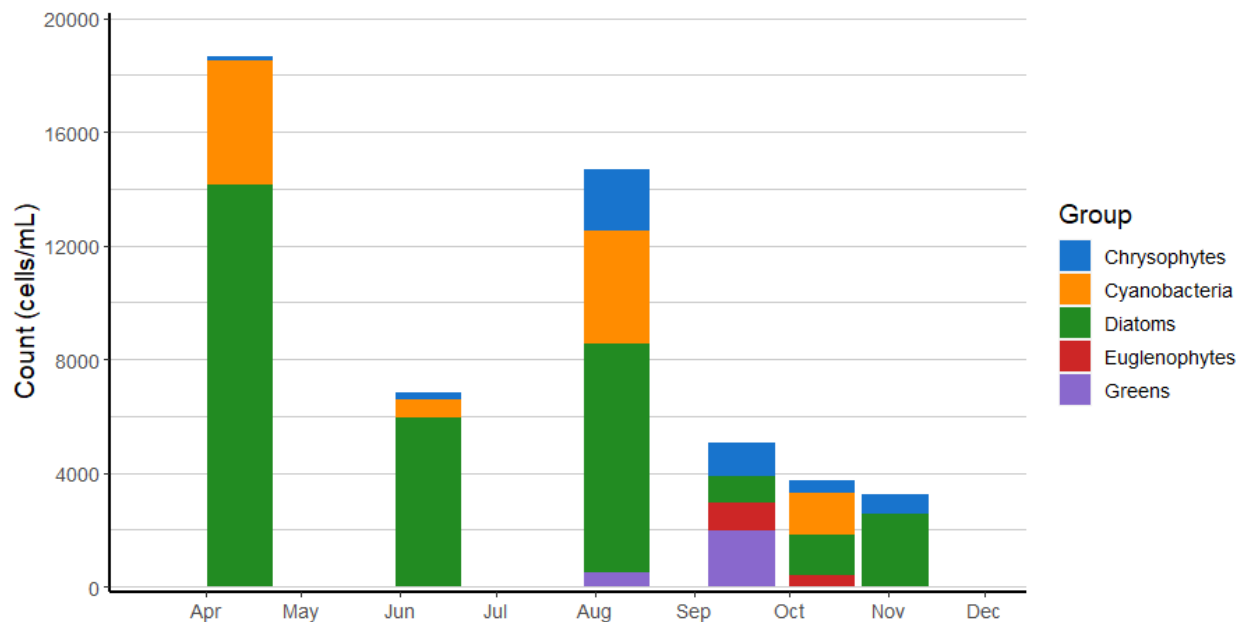*Figure 1. Phytoplankton counts at North Bay and Center Bay, July through November 2021.*

Table 6. WHO guidance values for the relative probability of health effects resulting from exposure to cyanobacteria.

Relative Probability of Acute Health Effects	Cyanobacteria Density (Cells/mL)
Low	< 20,000
Moderate	20,000-100,000
High	100,000-10,000,000
Very High	> 10,000,000

Conclusions / Recommendations

- Continue monthly water quality monitoring from April through November 2023.

- The Town and HLWA should continue efforts to reduce nutrient loading from the watershed, as detailed in the 'Highland Lake 2020 Water Quality Report & Long-Term Data Assessment'.

- If chloride concentration is a concern to the HLWA, the inlet streams should be sampled to determine the baseline chloride concentration coming in from the watershed. Increasing salt levels in the lake can also be measured by conductivity readings in the lake during the year and maintaining a continuous conductivity probe at the dam.