LAKE HOPATCONG TROUT HABITAT AND TAGGING STUDY – YEAR TWO

LAKE HOPATCONG, MORRIS AND SUSSEX COUNTIES, NEW JERSEY

Grant funding provided by the New Jersey Highlands Council

JULY 2024

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Cover photo provided by Ulla Vinkman of the Lake Hopatcong Commission Trout Committee

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1.0 INTRODUCTION

Lake Hopatcong is the largest lake in New Jersey, with a surface area of 2,686 acres and approximately 39 miles of shoreline. Located on the border of Morris and Sussex Counties, the lake is located entirely within the New Jersey Highlands in the headwaters of the Musconetcong River. With a maximum depth of 16.7 m and a mean depth of 5.6 m, the lake is dimictic and stably stratifies during the growing season each year. The lake provides regionally-significant environmental services and recreational opportunities; this includes fishing, boating, swimming, beach-use, and related activities centered on the use and aesthetics of the lake.

One of the most significant recreational draws to Lake Hopatcong is its trout fishery, recognized regionally by anglers and an important component of the local economy. Data collected over the past 30 years at the lake was recently analyzed and showed increasing surface water temperatures. This trend may suggest that the trout carryover habitat is being negatively impacted. Additionally, trout stocking practices at the lake have been modified over the last few decades and have shifted towards stocking smaller trout that are potentially more vulnerable to changes in water quality and habitat quality. Prior to the early 1980s, brown trout (*Salmo trutta*) approximately 12 inches in length or greater were the primary species of trout stocked in Lake Hopatcong. Over time, the size of the trout that were stocked in Lake Hopatcong were reduced to approximately 10 inches and included fewer brown trout. Following the unfortunate outbreak of furunculosis, a disease caused by the bacterium *Aeromonas salmonicida,* at the hatchery, only rainbow trout (*Oncorhynchus mykiss*) approximately 10 inches in length have been stocked by the state in Lake Hopatcong; rainbow trout are exclusively raised and stocked by the state due to their resistance to *Aeromonas salmonicida.* Together, these factors are viewed as potentially detrimental to the trout fishery.

Lake Hopatcong has a long history of trout stocking conducted under the supervision of angling clubs such as the Knee Deep Club and the New Jersey Division of Fish and Wildlife (NJDFW). The initial goal was to create a high-quality recreational trout fishery, a successful effort that resulted in the recognition of Lake Hopatcong as an outstanding trout fishery drawing a robust community of anglers from throughout the region and an important economic driver in the local economy.

Trout, including various species such as brown trout, rainbow trout, and the native brook trout (*Salvelinus fontinalis*), are considered coldwater fishes, with specialized habitat requirements. They require relatively high dissolved oxygen (DO) concentrations and cool water temperatures. In regard to those habitat requirements, the critical period is the high summer months near peak water temperatures. At that time of year trout holdover habitat, the portion of the lake that meets the temperature and DO requirements for trout, compresses as a result of increased surface water temperatures and oxygen depression in the deeper water column. A recent analysis of water quality data collected at Lake Hopatcong indicates increasing water temperatures, potentially resulting in a reduction of carryover habitat volume or duration which could impact carryover populations of trout from one year to the next.

Historically, the lake has exhibited good holdover habitat, as evidenced by the catches of older, large trout that survived through multiple growing seasons and were much larger than any stocked fish at the time of their introduction. Research indicates that larger and older trout have a higher tolerance of marginal habitat conditions like high water temperatures and low DO concentrations than smaller fish. In the past, relatively large brown trout, sufficient to garner substantial angler interest, were stocked at Lake Hopatcong. More recently, the Division of Fish and Wildlife has started to stock smaller rainbow trout. The stocking of smaller fish combined with potential impacts to trout carryover habitat have drawn concern about the viability of the trout fishery at the lake.

In response to these concerns regarding the current stocking of trout in Lake Hopatcong, the Lake Hopatcong Commission (LHC) Trout Committee was formed in 2021. The Lake Hopatcong Commission, in cooperation with the Lake Hopatcong Foundation (LHF) and the Knee Deep Club, initiated a three year trout tagging study. The study is focused on the introduction of larger trout to assess the long-term population dynamics of those stocked fish and the general health of the fishery. In particular, the Trout Committee is interested in the intersection between the stocking of larger brown trout and trout carryover habitat quality. 1,000 tagged brown trout, approximately 12-14 inches in length were released in Lake Hopatcong on 26 March 2022 to initiate the first year of the study. An additional 1,000 tagged brown trout were released in Lake Hopatcong on 26 March 2023 to kick off the second year of the study. Funding for all tagged trout was provided by the LHC, LHF, and the Knee Deep Club. Tagging provides valuable information that can be used to track populations over time, and develop estimates of capture, mortality, growth, and most importantly age. This information will be collected through angler creel surveys and self-reporting of trout tag data, to be overseen by the Trout Committee.

In addition to stocking fish and managing the tag and creel survey, the Trout Committee and other stakeholders also seek to better define carryover habitat in the lake. This includes habitat in the limnetic area (open waters) of the lake, as well as potential trout refuge habitat near seeps, springs, tributaries, or other attractant features around the shoreline. Together, these data can be used to assess the quality and character of trout carryover habitat in Lake Hopatcong, examine the success of stocking larger trout, and to identify habitat management, stocking practices, and conservation projects that can sustain a high-quality trout fishery in the future.

In summary, this study is predicated on the four following questions:

- Did the stocking of larger brown trout with higher environmental stress tolerance in Lake Hopatcong result in substantial carryover populations relative to the potential restriction of trout carryover habitat during the critical summer months?
- Were the temperature and DO requirements for carryover trout habitat available in Lake Hopatcong in 2023?
- Is there potential nearshore refuge habitat that may be utilized by brown trout during the summer season?
- Are there areas along the shoreline of the lake where watershed-based actions, including those identified or recommended in the Watershed Implementation Plan (WIP), should be prioritized to protect or enhance nearshore refuge habitat for brown trout? What are the characteristics that contribute to the existence of those habitats, and what actions could be implemented to preserve, protect, or improve those habitat features?

These questions were answered to an extent following the first year of the study; however, there were significant limitations for a few reasons. In 2022, the returns from the creel survey were limited and only 14 tagged fish were reported. However, this is largely assumed to be a result of limited participation from the angling community due to a lack of knowledge of the study; this is particularly true for the spring of 2022, which is the most popular season for trout fishing, as the study was just beginning. The Trout Committee has increased their efforts in marketing the study to the Lake Hopatcong community which resulted in increased participation in 2023. Additionally, 2022 was one of the hottest and driest summers on record at Lake Hopatcong and the surrounding region. This resulted in limited trout habitat during the peak summer months; there were two sampling events in 2022 where there was no carryover brown trout habitat present at the time of sampling. The climatic conditions experienced over the course of the 2022 season were abnormal, even with the warming climate, and the results from the second year of the study show improved trout habitat in Lake Hopatcong.

To answer these questions, there were five main tasks completed as part of this study. These efforts were similar to those conducted in 2022 with a few modifications. These tasks include:

- *In-situ* water quality data was collected over the course of six sampling events from July through late August at five deep stations throughout the lake to track carryover brown trout habitat during the critical summer months. These six events were supplemented with the routine lake monitoring data collection activities performed monthly, such that eight events were conducted over the roughly two month period and bound by two additional monthly events in June and September.
- The entire shoreline of the lake was evaluated over the course of the six sampling events for potential trout refuge habitat. This sampling included the collection of *in-situ* sampling data as well as evaluation of the physical structure along the shoreline. The entire shoreline was sampled again in 2023, but the sampling was focused on locations that showed the best potential for trout habitat during the hot and dry 2022 season.
- All accessible inlet streams that provide at least moderate flow to Lake Hopatcong were sampled during two sampling events in 2023; in 2022, only one day was dedicated to stream sampling. The additional time that was made available by focusing on fewer locations around the shoreline of the lake were allocated to the stream sampling.
- All available creel survey and fish tag data collected in 2023 that was made available by the LHC Trout Committee was analyzed to understand various trends in the population dynamics of stocked brown trout.
- Data collected during the first two years of this study was compared to identify any possible trends. Emphasis was placed on weather data, given the stark difference between the dry 2022 and wet 2023 seasons. It is understood that at least one more year of high-frequency data is needed to develop a more robust three-year database that will allow for a more complete analysis, particularly in regard to how the weather influences trout habitat in Lake Hopatcong.

This project was funded by a grant issued by the New Jersey Highlands Council.

2.0 TROUT HABITAT WATER QUALITY DATA

This section of the report will provide an overview of how the State of New Jersey classifies waters relative to trout and the habitat requirements specific to the different classifications. The classification of Lake Hopatcong will be included. This section will also include the sampling methodology for the collection of the limnetic and nearshore water quality and habitat data over the course of the 2023 season. Weather data from the 2023 season will then be explored as it relates to the water quality conditions observed. Finally, results and analyses from the limnetic and nearshore water quality sampling program will be discussed.

2.1 CLASSIFICATION OF NEW JERSEY WATERS

The New Jersey Surface Water Quality Standards (SWQS), N.J.A.C. 7:9B, establishes the policies, stream classifications, and surface water quality criteria necessary to protect the quality of New Jersey's surface waters. The SWQS establish designated uses (ex: drinking water supply, recreation, etc.) for the State's surface waters, classify waters based on those uses (e.g: FW1, FW2-TP, etc.), and set water quality criteria that protect the designated uses for each water classification. Freshwaters are designated as FW1 waters (not subject to any man-made wastewater discharges) or FW2 waters (the general surface water classification applied to all other freshwaters except Pinelands waters). FW1 waters are nondegradation waters set aside for posterity because of their unique ecological significance. FW2 waters are further classified based on their ability to support trout, which thrive in cooler temperatures. Trout classifications include trout production (FW2-TP), trout maintenance (FW2-TM), and nontrout (FW2-NT).

Trout production waters means waters designated for use by trout for spawning or nursery purposes during their first summer. Trout production waters have strict habitat requirements, including both temperature and DO criteria. Trout maintenance means waters designated for the support of trout throughout the year. While not as strict as trout production habitat requirements, the requirements for trout maintenance waters are still stringent and generally represent high quality waters.

Lake Hopatcong is classified as a FW2-TM waterbody. The NJDEP defines the DO requirements of trout maintenance waters as, "24-hour average not less than 6.0 mg/L. Not less than 5.0 mg/L at any time." There is also an upper temperature threshold for trout maintenance waterbodies. The NJDEP defines temperature requirements of trout maintenance as, "shall not exceed a daily maximum of 25.0 °C or rolling seven-day average of the daily maximum of 23.0 °C, unless due to natural conditions." This language guards against activities like the release of heated wastewater which could raise water temperature. The increase in water temperatures in recent years is believed to be largely climate driven, although loss of riparian vegetation and increases in impervious coverage may also be linked to temperature increase. Princeton Hydro typically classifies optimal trout habitat as waters with temperatures less than 24.0 °C at DO concentrations in excess of 5.0 mg/L, while carryover habitat is defined at temperatures between 24.0 °C and 26.0 °C at more than 5.0 mg/L.

To slightly complicate matters, the New Jersey Coldwater Fisheries Management Plan (New Jersey Division of Fish and Wildlife, 2005) has a slightly different temperature and DO classification for lakes that are defined as trout maintenance. Per the Coldwater Fisheries Management Plan, "To support trout lakes must have, throughout the year, a layer of water with favorable conditions of temperature (21.0 °C or less) and dissolved oxygen (4.0 mg/L or greater). Surveyed lakes that meet this criteria [in August] are classified as trout maintenance." Under this classification, temperature requirements are much more stringent while DO requirements are less stringent.

Because this study is interested in carryover trout habitat in Lake Hopatcong, the carryover habitat temperature and DO requirements of between 24.0 °C and 26.0 °C at more than 5.0 mg/L will form the basis of this evaluation criteria. However, the water quality figures presented in the report will present two different horizontal lines that represent the lower boundary of carryover trout habitat based on DO requirements of 4.0 mg/L and 5.0 mg/L. The discussions will largely be predicated on a lower DO threshold of 5.0 mg/L unless the difference in depth between the two thresholds is significant.

2.2 WATER QUALITY SAMPLING METHODOLOGY

2.2.1 LIMNETIC WATER QUALITY SAMPLING

Water quality events specific to this study consisted of six monitoring events. Water quality monitoring was conducted at five stations during each sampling event, including Byram Bay, Halsey Island, Mid-Lake, Great Cove, and King's Cove. A map with approximate sampling locations is provided in Appendix I. The lake was sampled on 5 July, 11 July, 17 July, 1 August, 7 August, and 14 August. Five additional monitoring events were conducted as part of the long-term baseline monitoring that has been occurring in Lake Hopatcong over the past 30+ years. These sampling events were conducted on 11 May, 13 June, 24 July, 21 August, and 18 September. There were twelve sampling stations associated with these monitoring events, ST-1 – ST-12. While most of these stations are in different locations than the stations that were monitored as part of this study, a few of the stations were included in both. For example, ST-2 represents Mid-Lake, ST-4 represents King's Cove, and ST-8 represents Great Cove. A second map with approximate sampling locations for these events is also provided in Appendix I.

The sampling conducted during the events specific to this study only included *in-situ* data collection. The *in-situ* data were collected in profile, at approximately 1.00 m intervals, and consisted of temperature, specific conductance, DO concentration, DO percent saturation, and pH. *In-situ* data were collected with an In-Situ Aqua TROLL 500 water quality meter. This meter was calibrated according to manufacturer's specifications prior to sampling. In addition, Princeton Hydro monitored transparency with a Secchi disk.

2.2.2 NEARSHORE AND STREAM WATER QUALITY SAMPLING AND HABITAT ASSESSMENT

For the nearshore analysis, the lake's shoreline was divided into roughly four sectors. Please note that although the shoreline was divided into four sectors, the shoreline sampling was conducted over the course of six sampling events. There were a few instances when there was not enough time to finish a sector, so the remaining section was sampled the next time Princeton Hydro was on Lake Hopatcong. While the entire shoreline of the lake was assessed visually from a boat, areas with less developed shorelines and subwatersheds or closer proximity to greater depths were given increased scrutiny. Increased scrutiny was given to locations that showed the best potential for trout habitat during the hot and dry 2022 season. Prior to the surveys, aerial photographs, maps, and other data sources were reviewed, as were knowledgeable lake users, to identify potential target areas.

The surveys focused on taking *in-situ* profiles, for the same parameters as the limnetic sampling, at 0.50 – 1.00 m intervals along the shoreline and in areas that contain the physical characteristics described above. These sites were GPS located. If water quality appeared to satisfy trout habitat demands, particularly if it was cooler than the limnetic portion of the lake, some additional profiles were collected to try to better define the bounds of the feature in relation to the shoreline. Additionally, a portion of two of the sampling days was dedicated to traveling around the shoreline of the lake in a vehicle to sample inlet streams for the same *in-situ* water quality parameters. A map with approximate sampling locations is provided in Appendix I.

2.3 WEATHER ANALYSIS

The following section will discuss the climatic conditions observed during the 2023 season compared to the long-term normal. It should be noted that 'normal' refers to the monthly averages over the 30-year period from 1991 – 2020. Princeton Hydro primarily utilized temperature data gathered through CLIMOD2 (http://climod2.nrcc.cornell.edu/) for this analysis. There were 43 days in which the weather data from CLIMOD2 was missing; data for those 43 days were gathered through TuTiempo (Climate - Climate data (tutiempo.net)). The weather station utilized for this analysis, from both websites, was Aeroflex-Andover Airport.

Table 2.1 includes various monthly temperature and precipitation metrics at Lake Hopatcong relative to normal conditions, represented as the average from 1991 – 2020. The temperature metrics represent the mean daily values over the course of the month, while the monthly precipitation represents the total rainfall for the month. For the monthly temperature and precipitation metrics, the higher value (2023 vs. long-term normal) is highlighted red. In addition to monthly metrics, additional weather data is provided for each sampling event from July – August. These additional data include temperature and precipitation data on the day of the sampling event, and the average temperature and accumulated rainfall of the preceding two and seven days.

Table 2.1: Lake Hopatcong Weather Summary 2023

Month		Mean Max. Temp		Mean Min. Temp		Mean Avg. Temp		Precip
		°F	°C	°F	°C	°F	°C	in
May	2023	*75.4*	*24.1*	45.0	7.2	*60.0*	*15.6*	2.30
	Norm	71.0	21.7	*48.0*	*8.9*	59.5	15.3	*3.83*
June	2023	*81.4*	*27.4*	55.3	13.0	*68.5*	*20.3*	*8.70*
	Norm	79.1	26.2	*57.1*	*13.9*	68.1	20.1	4.54
July	2023	*88.0*	*31.1*	*67.5*	*19.7*	*77.6*	*25.3*	*9.00*
	Norm	83.6	28.7	61.8	16.6	72.7	22.6	5.06
August	2023	*81.9*	*27.7*	*62.6*	*17.0*	*72.2*	*22.3*	*5.90*
	Norm	81.5	27.5	60.1	15.6	70.8	21.6	4.85
September	2023	70.4	21.3	52.2	11.2	61.1	16.1	*9.30*
	Norm	*74.4*	*23.6*	*52.4*	*11.3*	*63.4*	*17.4*	4.32
5-Jul	2023.07.05	95.0	35.0	70.0	21.1	82.5	28.1	0.00
	2-Day Prior	90.0	32.2	71.0	21.7	79.3	26.3	0.00
	Week Prior	86.6	30.3	65.7	18.7	75.8	24.3	0.61
11-Jul	2023.07.11	88.0	31.1	61.0	16.1	74.5	23.6	0.00
	2-Day Prior	84.0	28.9	67.0	19.4	75.5	24.2	3.62
	Week Prior	88.9	31.6	70.0	21.1	78.9	26.1	3.62
17-Jul	2023.07.17	88.0	31.1	72.0	22.2	80.0	26.7	0.00
	2-Day Prior	86.5	30.3	71.5	21.9	79.0	26.1	1.52
	Week Prior	88.7	31.5	67.3	19.6	78.0	25.6	3.11
24-Jul	2023.7.24	88.0	31.1	65.0	18.3	76.5	24.7	0.00
	2-Day Prior	87.0	30.6	62.0	16.7	74.5	23.6	0.00
	Week Prior	86.7	30.4	66.6	19.2	76.6	24.8	0.40
1-Aug	2023.08.01	82.0	27.8	58.0	14.4	70.0	21.1	0.00
	2-Day Prior	82.0	27.8	59.0	15.0	71.1	21.7	0.02
	Week Prior	87.6	30.9	66.0	18.9	76.6	24.8	1.42
7-Aug	2023.08.07	85.0	29.4	69.0	20.6	77.0	25.0	0.89
	2-Day Prior	87.0	30.6	64.5	18.1	75.8	24.3	0.00
	Week Prior	83.1	28.4	60.7	15.9	71.9	22.2	0.02
14-Aug	2023.08.14	89.0	31.7	65.0	18.3	77.0	25.0	0.20
	2-Day Prior	88.0	31.1	65.0	18.3	76.5	24.7	0.42
	Week Prior	84.1	29.0	65.0	18.3	74.6	23.7	1.41
21-Aug	2023.08.21	89.0	31.7	65.0	18.3	77.0	25.0	0.00
	2-Day Prior	82.5	28.1	57.0	13.9	69.8	21.0	0.00
	Week Prior	83.9	28.8	64.0	17.8	73.9	23.3	2.01

Mean maximum temperatures represent the average maximum temperature recorded during each day of the month. The mean minimum temperatures represent the average minimum temperature recorded during each day of the month. The mean average temperatures represent the average temperature recorded during each 24-hour period for the entire month.

Mean average temperatures were warmer from May - August relative to the long-term averages but July was the only month that was significantly warmer; July 2023 had mean average temperature of 77.6 °F compared with the long-term average of 72.7 °F. September was the only month with a mean average temperature cooler than the long-term average, with a 2023 temperature of 61.1 °F compared to 63.4 °F. Mean maximum temperatures followed the same pattern, but both May and July had mean maximum temperatures in 2023 that were at least 4.0 °F higher than the long term-average; September 2023 was 4.0 °F cooler than the long-term average. Mean minimum temperatures in May and June 2023 were 3.0 °F and 1.8 °F cooler than the long-term averages, respectively, indicating greater daily temperature variability in 2023.

May was the only month where total precipitation was slightly lower than the long-term average. The remainder of the season was extremely wet, with over 8.00 inches of precipitation in each of June, July, and September. There was also a lot of precipitation in August, with a total of 5.90 inches relative to the long-term average of 4.85 inches. Much of the rain in 2023 fell during discrete rain events, with 18 days from May – September with over 0.5 inches of precipitation. There were nine days from May – September with over 1.00 inch of precipitation, one day with 2.54 inches, and two days with over 3.00 inches. Thus, the 2023 growing season was extremely wet, with a total of 35.20 inches of precipitation compared to the long-term average of 22.60 inches.

The sampling event-specific weather data was particularly useful in evaluating how much of an effect the local weather had on temperature, thermal stratification, and DO concentrations in Lake Hopatcong. The 2023 season was cooler and much wetter than 2022 which provides insight into the thermal properties, and as a result the distribution of DO, under contrasting climatic conditions. This section will focus on the 2023 data, but an inter-annual analysis is provided later in the report.

Lake Hopatcong had at least 4.5 m of available brown trout habitat at the Mid-Lake station during nine of the 11 sampling events in 2023. The only two dates with significantly reduced brown trout habitat were 17 July and 24 July, with 2.00 m and 0.25 m, respectively; these two dates represent the critical period of the 2023 season. It appears that both temperature and precipitation played an important role in influencing the thermal properties and resulting availability of trout habitat in 2023.

The atmospheric mean minimum, maximum, and average temperatures in the week prior to the 11 July, 17 July, and 24 July sampling events decreased slightly over each successive event. Water temperatures in the epilimnion continued to rise, however, and available brown trout habitat decreased accordingly. Total precipitation for the week prior to each of these sampling events also decreased, and storm events often have a moderating effect on water temperature changes. There was 3.62 inches of rain the week prior to the 11 July sampling event, 3.11 inches the week prior to the to the 17 July sampling event, but only 0.40 inches the week prior to the 24 July sampling event. Potentially of even more importance, there was 3.61 inches of precipitation two days prior to the 11 July sampling event, 1.52 inches the two days prior to the 17 July sampling event, and no precipitation the two days prior to the 24 July sampling event. Total trout habitat at the Mid-Lake station was 4.80 m, 2.00 m, and 0.25 m during these three events, respectively. Trout habitat was reduced during the 17 July and 24 July sampling events due to an increase in temperatures in the upper epilimnion, with temperatures exceeding 26.0 °C in the upper 2.30 m on 17 July and the upper 4.30 m on 24 July.

Although atmospheric temperatures did decrease slightly over this three week period, they remained higher than water temperatures. Furthermore, the amount of precipitation two days prior to each sampling event also decreased significantly allowing the upper water column to warm. It appears that precipitation had a large influence on the thermal regimes during the 2023 summer and that small windows lacking precipitation were linked with increasing water temperatures. In addition to the direct cooling effect of rainwater on surface water temperatures during the summer months, there is also less solar irradiance during storms events because of the increased cloud coverage.

Figure 2.1 below presents daily temperature and precipitation in the Lake Hopatcong region from May – September.

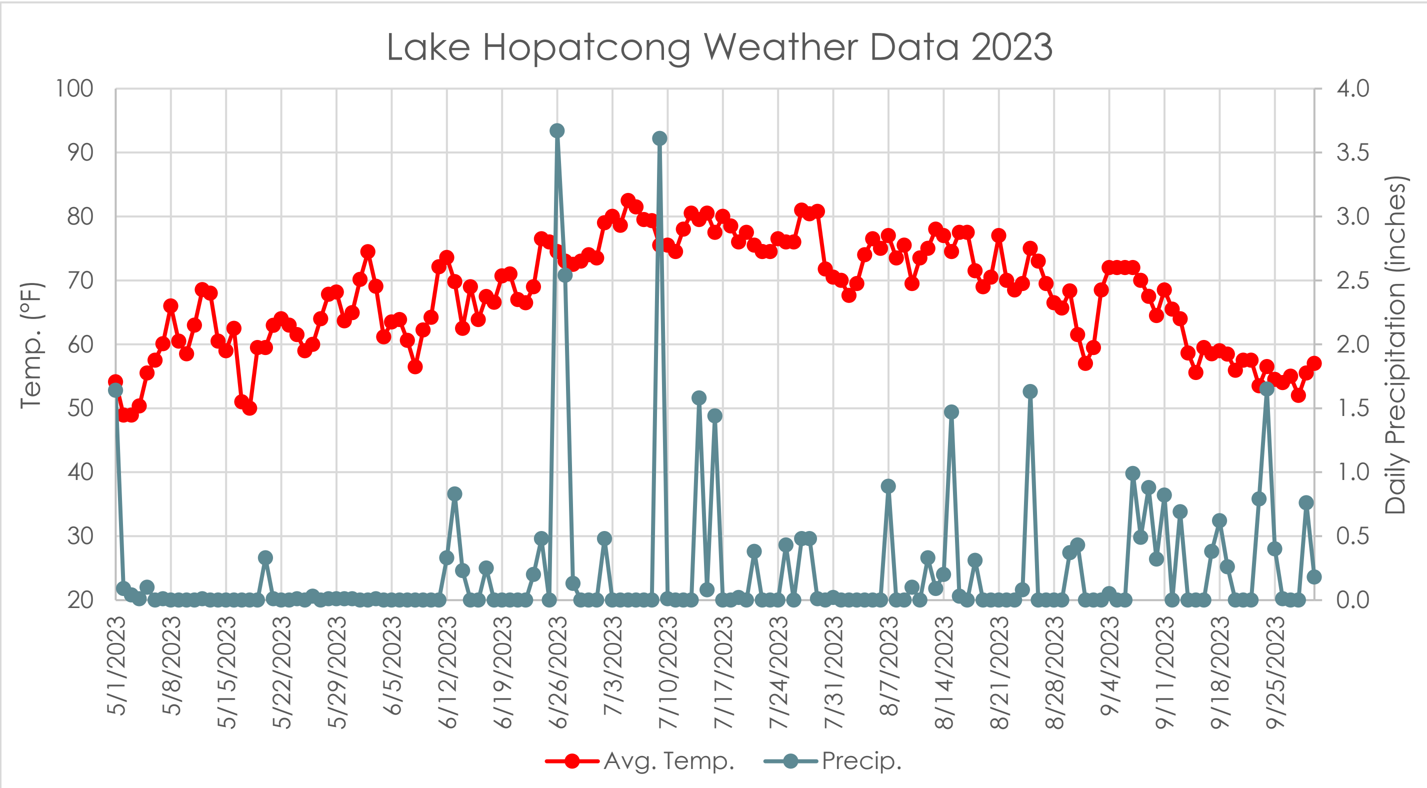


Figure 2.1: Daily temperature and precipitation in the Lake Hopatcong Region from May – September 2023

2.4 LIMNETIC WATER QUALITY ANALYSIS

2.4.1 TROUT HABITAT AVAILABILITY BY EVENT

A brief summary of thermal and DO properties in relation to brown trout carryover habitat in Lake Hopatcong is presented for each sampling event below. The habitat range and total habitat listed for each date is predicated on a lower DO bound of 5.0 mg/L. However, if there were significant differences in available habitat between the two DO thresholds, it is noted in the text summaries. Figures 2.2 – 2.12 are provided after these summaries to help visualize the compression and expansion of carryover trout habitat over the course of the 2023 growing season. Lower DO thresholds of 4.0 mg/L and 5.0 mg/L are provided in these figures. Tables with the full *in-situ* sampling results from all eleven monitoring events are provided in Appendix II.

11 May 2023

Habitat Range (ST-2): 0.00 m to 10.70 m

Total Habitat (ST-2): 10.70 m

The lake was still in the early stages of the annual growing season thermal stratification pattern in late May. Following the spring mixing event, in which temperatures were uniform throughout the lake, surface waters warmed rapidly as the ambient air temperatures and exposure to the sun both increased. During this time, the warmer upper water layer (epilimnion), transition zone (metalimnion or thermocline), and a cold, deep water layer (hypolimnion) had only recently formed. As a result, DO concentrations remained oxic (DO > 2.0 mg/L) throughout the entire waterbody. However, although DO concentrations remained oxic, they had already begun to drop below the lower brown trout DO limit of 5.0 mg/L in the deeper waters. As such, carryover brown trout habitat was present in the upper 10.70 m of the lake on 11 May 2023.

Once the hypolimnion is formed in a relatively deep lake like Lake Hopatcong, it is essentially cut off from the surface waters until the fall mixing event due to differences in water density. As a result, the deeper waters cannot be replenished with atmospheric oxygen that is circulating throughout the mixed epilimnion. In productive lakes such as Lake Hopatcong, the hypolimnion continually loses oxygen throughout the season due to bacterial decomposition of organic matter. As such, the lake will continue to lose dissolved oxygen in the hypolimnion as moving towards peak summer stratification and until the lake experiences turnover.

13 June 2023

Habitat Range (ST-2): 0.00 m to 6.95 m

Total Habitat (ST-2): 6.95 m

By mid-June, the surface temperatures of the Mid-Lake station had increased by over 3.0 °C relative to the 11 May event. Water temperatures deeper in the epilimnion (4.00-6.00 m) had increased to a greater degree as this upper layer continued to mix, resulting in a more defined thermal stratification pattern. Water temperatures throughout the lake remained well below the upper temperature threshold of 26.0 °C during this time. However, DO concentrations decreased rapidly below the epilimnion at the Mid-Lake station and anoxic (DO < 1.0 mg/L) conditions were observed at a depth of 9.00 m and below. ST-9 (Byram Cove) was the only other station where anoxic conditions were observed, beginning at a depth of 6.00 m. Only two of 11 stations established lower bounds of trout habitat during this event as a result of depressed DO concentrations, including ST-2 (Mid-Lake) and ST-9. The lower DO bounds for the Mid-Lake and Byram Cove stations were 6.95 m and 4.30 m, respectively.

5 July 2023

Habitat Range (ST-2): 0.30 m to 5.30 m

Total Habitat (ST-2): 5.00 m

During the 5 July event all stations exceeded 26.0 °C at the surface; however, temperatures fell below this threshold shortly below the surface at all stations. At the Mid-Lake station, the water temperature fell below the 26.0 °C threshold at a depth of 0.30 m. The lake was well stratified, and at all stations with sufficient depth (excluding the shallow King's Cove station) the lake was anoxic in the hypolimnion. Low DO established a lower bound of trout habitat at all five stations. The lower carryover brown trout habitat bound varied between 2.30 m at King's cove down to 5.30 m at the Mid-Lake station.

11 July 2023

Habitat Range (ST-2): 0.00 m to 4.80 m

Total Habitat (ST-2): 4.80 m

Surface water temperatures decreased slightly during the 11 July event at all stations following significant rainfall, resulting in carryover brown trout habitat at the surface of all stations except Byram Bay. However, the persistence of thermal stratification resulted in a sharp decline in DO concentrations below the epilimnion, raising the lower carryover trout habitat bound at all stations. This caused a decrease in total carryover trout habitat at most stations. Excluding King's Cove, which has a total depth of 3.20 m and carryover trout habitat throughout the water column, the lower bound varied between 4.00 m in Byram Bay down to 5.00 m in Great Cove.

17 July 2023

Habitat Range (ST-2): 2.30 m to 4.30 m

Total Habitat (ST-2): 2.00 m

The 17 July event showed a marked change in available trout habitat. During the preceding event, the approximate bounds extended from the surface to a depth of approximately 5.00 m depending on location in the lake. During the 17 July event it shrank significantly. At all five of the primary sampling stations surface temperatures exceeded the 26.0 °C threshold. As such, the upper bound moved down and varied between 1.30 m and 4.00 m reflecting significant warming of the epilimnion; there was no upper bound in Byram Bay because there was no available habitat. The lower bound also decreased at all stations from the persistent thermal stratification and loss of DO in the hypolimnion and lower thermocline. However, Byram Bay was the only station where there was no available carryover brown trout habitat. Available trout habitat was also significantly reduced in Great Cove, available only between 4.00 m and 4.30 m, but there was still 2.00 m of available habitat at the Mid-Lake station. On 18 July 2022, trout habitat thickness was just 0.45 m at the Mid-Lake Station covering the depths from roughly 3.75 m to 4.20 m; thus, there was more available habitat at the Mid-Lake station in 2023.

This obviously marks a critical time for trout in the lake. While there is no suggestion that contravening these bounds causes immediate death, these conditions do represent acute stressors to the fish.

24 July 2023

Habitat Range (ST-2): 4.05 m to 4.30 m

Total Habitat (ST-2): 0.25 m

A significant decrease in available carryover brown trout habitat was observed on 24 July. Of the twelve stations monitored, only five stations had available habitat, all of which was compressed. At the Mid-Lake station, total available habitat was reduced to 0.25 m, from a depth of 4.05 m to 4.30 m. Surface water temperatures at the Mid-Lake station actually declined slightly over the preceding week, from 26.8 °C to 26.5 °C. However, water temperatures in the lower epilimnion increased enough to exceed the 26.0 °C threshold, resulting in a loss of habitat from the top down. The position of the top of the thermocline remained constant over the preceding week as did the lower bound of available trout habitat at 4.30 m.

While this obviously represents a critical time for trout in the lake, there were signs that the thermocline would soon begin to migrate downwards which would expand the depth of the epilimnion and potentially provide some thermal refuge near the bottom of the epilimnion. However, any additional thermal refuge would still be dependent on air temperatures and solar radiation; if the ambient air temperatures continued to rise or remain elevated, the epilimnion as a whole would continue to warm since this upper layer is continually mixed. Conversely, if air temperatures were to decrease over the following week, it could result in a deepening of the thermocline and an increase in the size of the epilimnion. In 2022, temperatures remained extremely elevated into August which caused a further loss of habitat.

1 August 2023

Habitat Range (ST-2): 0.00 m to 5.80 m

Total Habitat (ST-2): 5.80 m

As during the previous two events, this early August event exhibited a marked change in available trout habitat in the lake, but this event showed a considerable expansion. First, there was a slight cooling at all stations near the surface, and all stations but Great Cove fell back under the 26.0 °C threshold thereby extending the habitat to the surface at those locations. The cooling, however, was not consistent throughout the epilimnion, and in fact, as a result of warming near the top of the thermocline and within the upper metalimnion, the epilimnion expanded and the thermocline migrated down through the water column. This was a predicted result consistent with water quality patterns recorded over time and a good illustration of metalimnetic erosion, the slow downward migration of the thermocline. Expansion of the epilimnion means that deeper portions of the water column were starting to mix and become oxygenated. During the previous event, carryover trout habitat was significantly reduced throughout the lake. However, trout habitat became widely available during this event, with an average lower DO bound of 5.30 m. At the Mid-Lake station, which has been used as the benchmark for understanding these data, habitat thickness increased to 5.80 m, from the surface (0.00 m) to 5.80 m depth.

Overall, this was positive news, although the results were tempered somewhat because temperatures in the epilimnion remained high and small increases could substantially affect the assessed habitat. Conditions were still stressful for the fish on 1 August but could no longer be described as critical.

7 August 2023

Habitat Range (ST-2): 0.00 m to 4.50 m

Total Habitat (ST-2): 4.50 m

There was a technical issue with the specific conductance probe during the sampling effort which resulted in erroneous DO concentrations. However, the DO percent saturation was working correctly, and this data was used in conjunction with the temperature data to calculate DO concentrations in mg/L. Thus, while this calculation is accurate, the DO concentration data from this event was not measured directly in the field. It is not expected that the calculation resulted in any significant changes to the extent of available trout habitat.

Surface water temperatures decreased relative to the previous monitoring event on 1 August, with a temperature of 24.9 °C at the Mid-Lake station. This represented the first monitoring event since the 2023 trout habitat monitoring began that surface water temperatures were below 25.0 °C. The decrease in temperature did result in a less defined and smaller epilimnion relative to the previous week. This led to some of the anoxic water that was previously confined to the hypolimnion on 1 August to mix with water in the upper thermocline on 7 August. This resulted in a slight shrinking of available trout habitat over the past week at the Mid-Lake station, from 5.80 m on 1 August to 4.80 m on 7 August. It is important to note that although the trout habitat in the epilimnion shrunk over the past week, the water was cooler than the previous week, resulting in more favorable conditions for trout.

Available carryover trout habitat did increase in Byram Bay and Halsey Island, with habitat at both stations extending from the water surface down to a depth of approximately 6.00 m.

14 August 2023

Habitat Range (ST-2): 0.00 m to 6.00 m

Total Habitat (ST-2): 6.00 m

Surface water temperatures decreased slightly relative to the previous monitoring event on 7 August, with a temperature of 24.7 °C at the Mid-Lake station. This marks the second consecutive sampling event in which surface temperatures were below 25.0 °C at this station. The epilimnion expanded over the preceding week at the Mid-Lake station, extending down to a depth of approximately 6.00 m. The thicker epilimnion resulted in a larger volume of water with DO above 5.0 mg/L. Additionally, the upper 4.00 m remained below 25.0 °C and the lower 2.00 m of the epilimnion remained below 24.0 °C, resulting in more favorable conditions for trout at Mid-Lake. The available trout habitat increased over the past week, from approximately 4.50 m on 7 August to 6.00 m on 14 August; this was the largest volume of available trout habitat recorded in Lake Hopatcong since the 2023 trout water quality habitat sampling was initiated.

21 August 2023

Habitat Range (ST-2): 0.00 m to 5.70 m

Total Habitat (ST-2): 5.70 m

Surface water temperatures remained relatively consistent with the previous monitoring event on 14 August, with a temperature of 24.5 °C at the Mid-Lake station. This marks the third consecutive sampling event in which surface temperatures were below 25.0 °C at Mid-Lake. The epilimnion also remained relatively consistent over the past week at this station, extending down to a depth of approximately 6.00 m. The extent of available trout habitat also remained relatively consistent, and the upper 3.00 m remained below 25.0 °C and the lower 3.00 m of the epilimnion remained below 24.0 °C at Mid-Lake. The available trout habitat decreased slightly over the past week at this station, from approximately 6.00 m on 14 August to 5.70 m on 21 August. Available carryover brown trout habitat largely increased throughout the lake during this event, extending from the surface to the bottom at eight stations and down to a depth of at least 5.00 m at all stations of sufficient depth. This event marked the completion of the weekly sampling schedule that was initiated at the beginning of July.

18 September 2023

Habitat Range (ST-2): 0.00 m to 6.45 m

Total Habitat (ST-2): 6.45 m

Water temperatures cooled significantly since the previous monitoring event, with surface temperatures below 22.50 °C at all stations. The lake was still stratified at the Mid-Lake station with the epilimnion extending to 6.00 m, and available carryover trout habitat increased slightly, resulting in available habitat in the upper 6.45 m. All other stations had available trout habitat from the surface to the bottom, with the exception of ST-9 (Byram Cove) which had a DO concentration of 4.5 mg/L at a depth of 7.0 m.

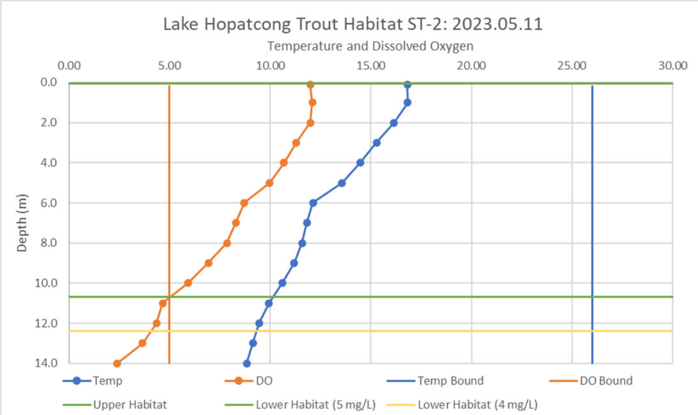


Figure 2.2: Habitat Range: 0.00 m to 10.70 m, Total Habitat: 10.70 m (5 mg/L), 12.40 m (4 mg/L)

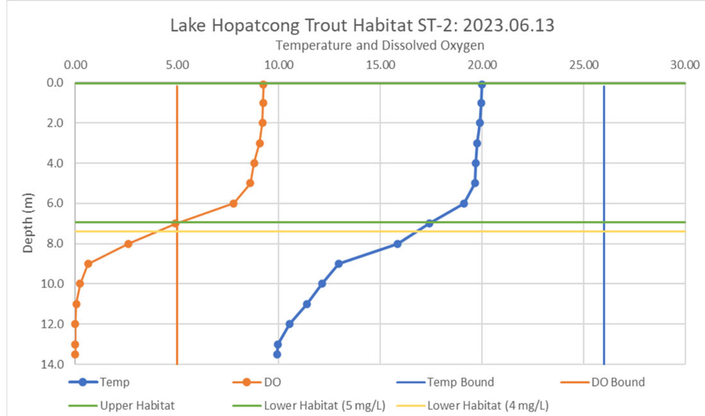


Figure 2.3: Habitat Range: 0.00 m to 6.95 m, Total Habitat: 6.95 m (5 mg/L), 7.40 m (4 mg/L)

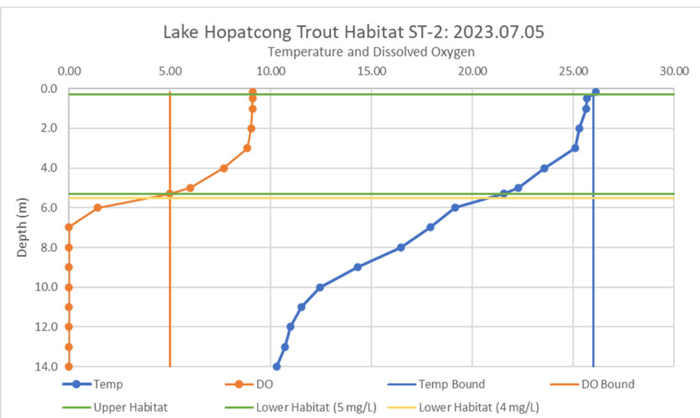


Figure 2.4: Habitat Range: 0.30 m to 5.30 m, Total Habitat: 5.0 m (5 mg/L), 5.20 m (4 mg/L)

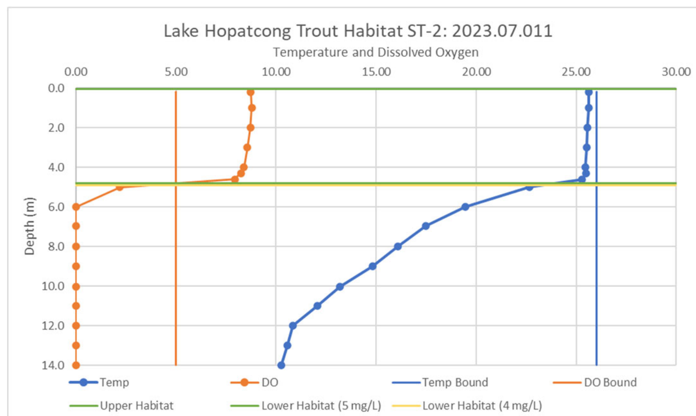


Figure 2.5: Habitat Range: 0.00 m to 4.80 m, Total Habitat: 4.80 m (5 mg/L), 4.90 m (4 mg/L)

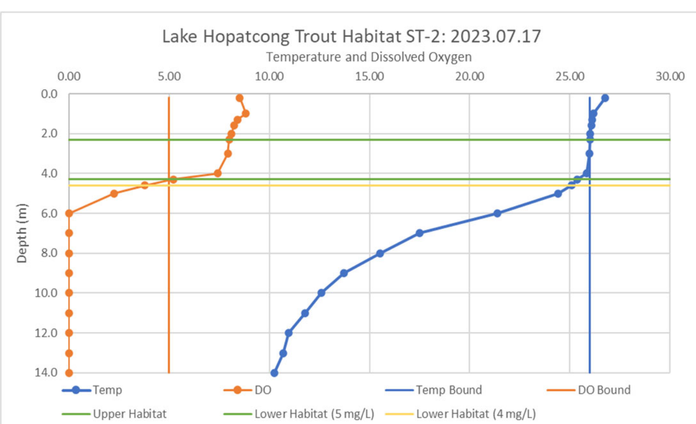


Figure 2.6: Habitat Range: 2.30 m to 4.30 m, Total Habitat: 2.0 m (5 mg/L), 2.30 m (4 mg/L)

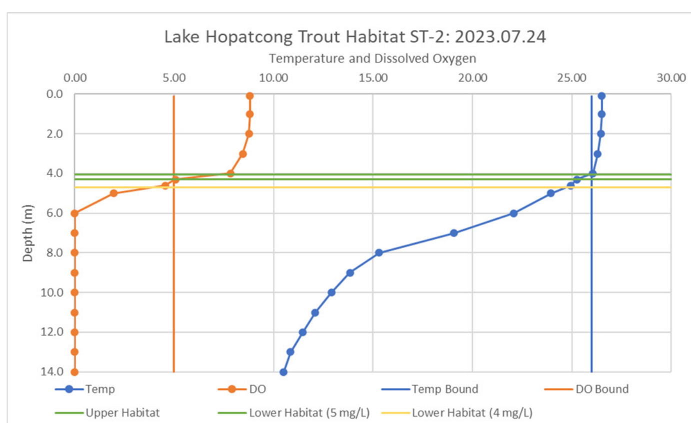


Figure 2.7: Habitat Range: 4.05 m to 4.30 m, Total Habitat: 0.25 m (5 mg/L), 0.65 m (4 mg/L)

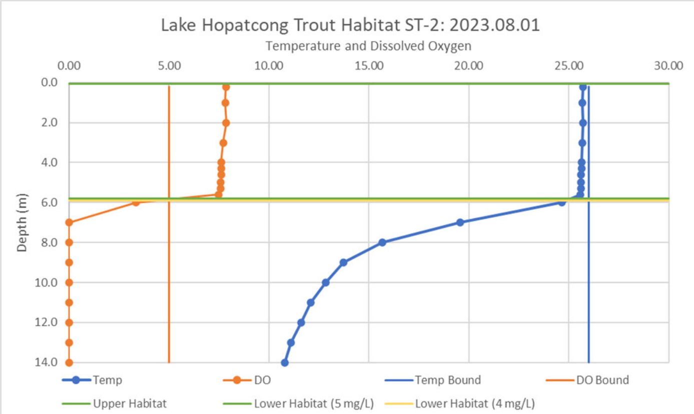


Figure 2.8: Habitat Range: 0.00 m to 5.80 m, Total Habitat: 5.80 m (5 mg/L), 5.90 m (4 mg/L)

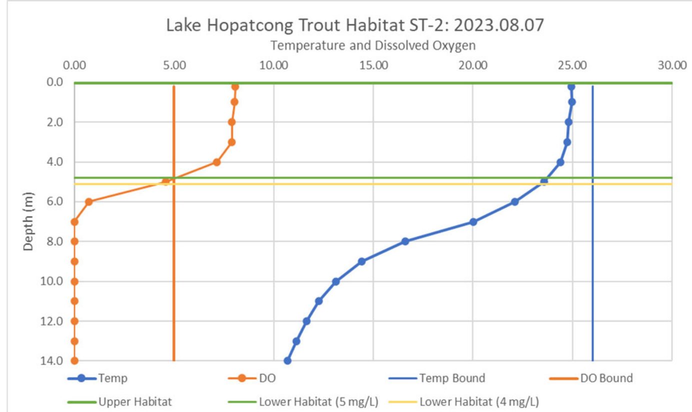


Figure 2.9: Habitat Range: 0.00 m to 4.80 m, Total Habitat: 4.80 m (5 mg/L), 5.10 m (4 mg/L)

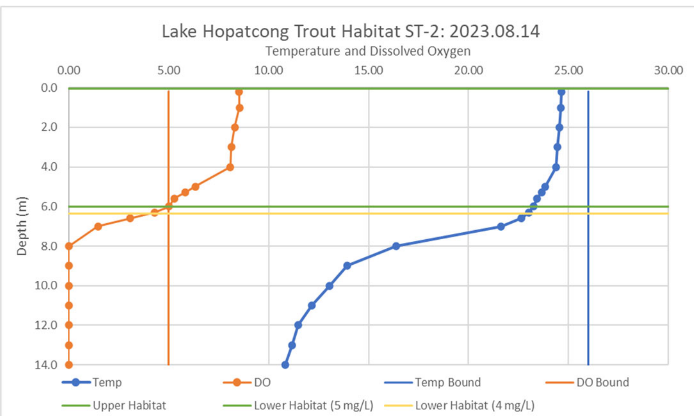


Figure 2.10: Habitat Range: 0.00 m to 6.00 m, Total Habitat: 6.00 m (5 mg/L), 6.35 m (4 mg/L)

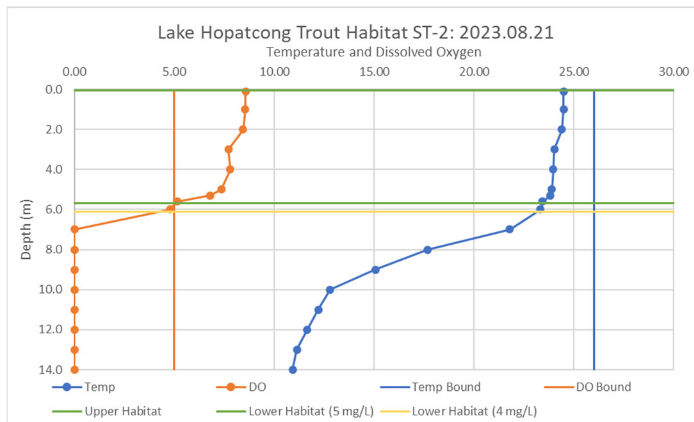


Figure 2.11: Habitat Range: 0.00 m to 5.70 m, Total Habitat: 5.70 m (5 mg/L), 6.10 m (4 mg/L)

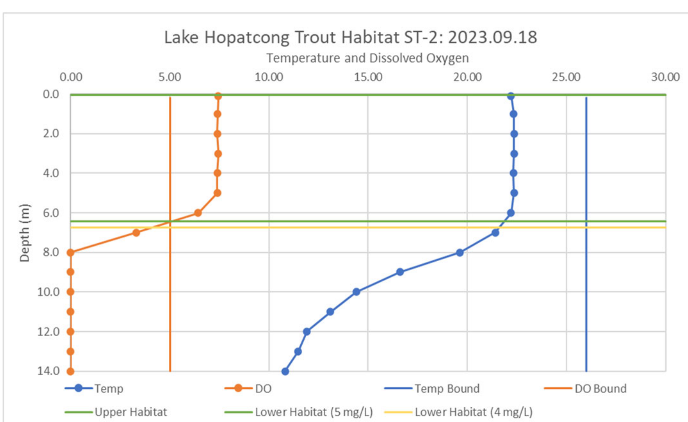


Figure 2.12: Habitat Range: 0.00 m to 6.45 m, Total Habitat: 6.45 m (5 mg/L), 6.75 m (4 mg/L)

2.4.2 TROUT HABITAT AVAILABILITY SUMMARY

A few additional figures are provided here to provide succinct visual summaries of some of the major factors that influence trout carryover habitat availability. Figures 2.13 and 2.14 include temperature and DO isopleths, which help to better illustrate the relationship between thermal stratification and DO concentrations throughout the season. These isopleth figures are meant to illustrate the seasonal continuum of the relationship between thermal stratification and DO concentration and how trout habitat becomes compressed from both the bottom (DO) and top (temperature) of the water column during the summer months. The dark red area on Figure 2.13 represents the portion of the water column where temperatures are too warm to sustain carryover trout habitat while the orange and red areas on Figure 2.14 represent the portion of the water column where DO concentrations are too low to support carryover trout habitat.

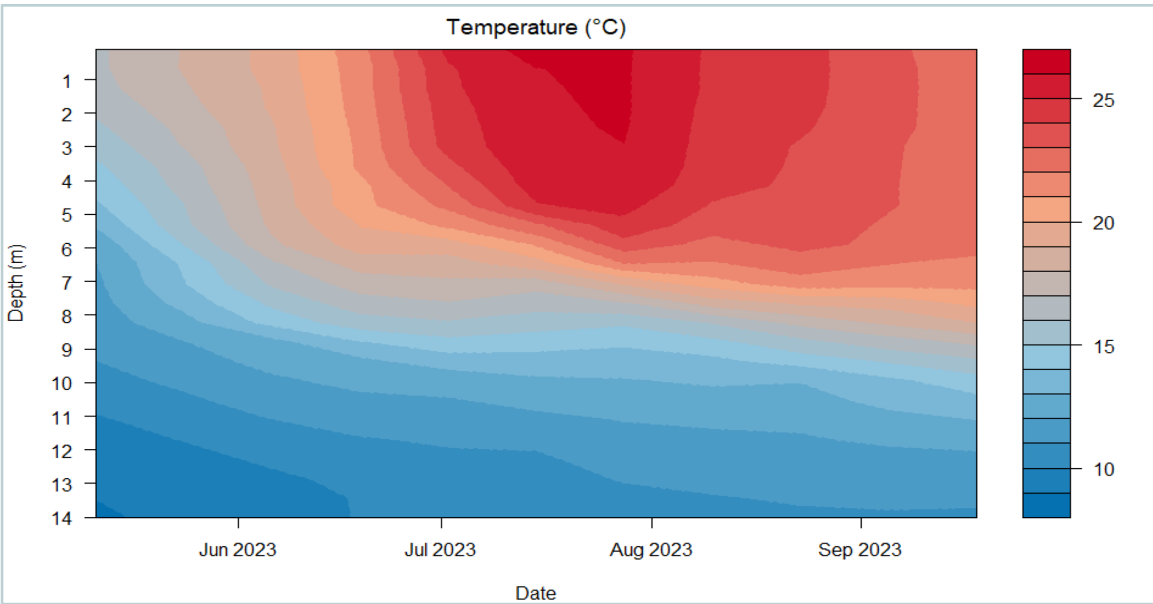


Figure 2.13: Temperature isopleths at the Mid-Lake station throughout the 2023 season

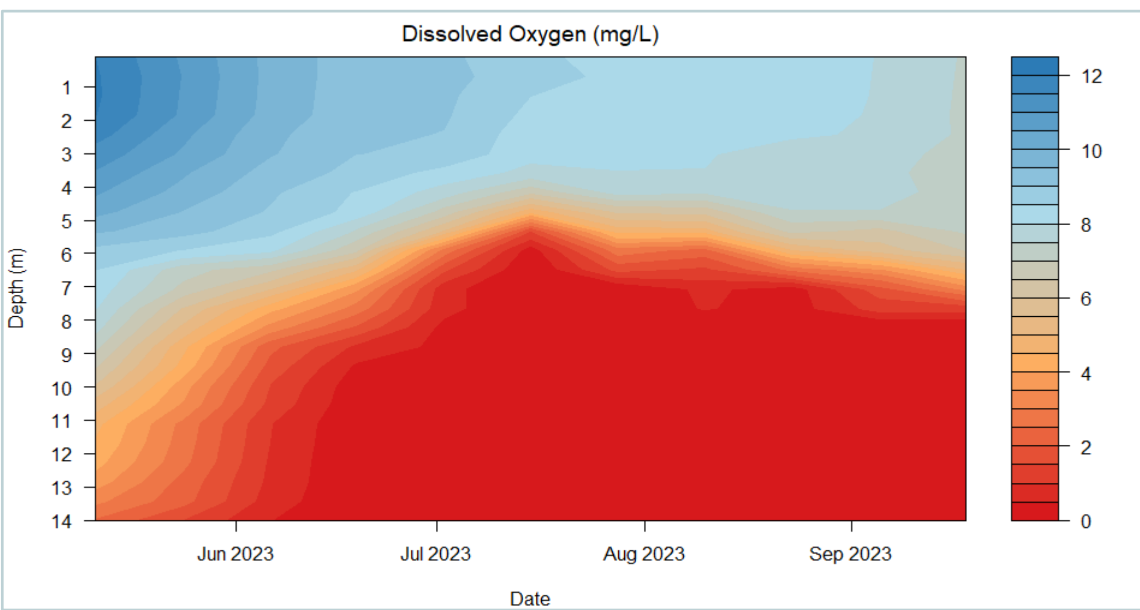


Figure 2.14: Dissolved oxygen isopleths at the Mid-Lake station throughout the 2023 season

Figure 2.15 provides the depths of the upper and lower boundaries of available carryover brown trout habitat during each monitoring event.

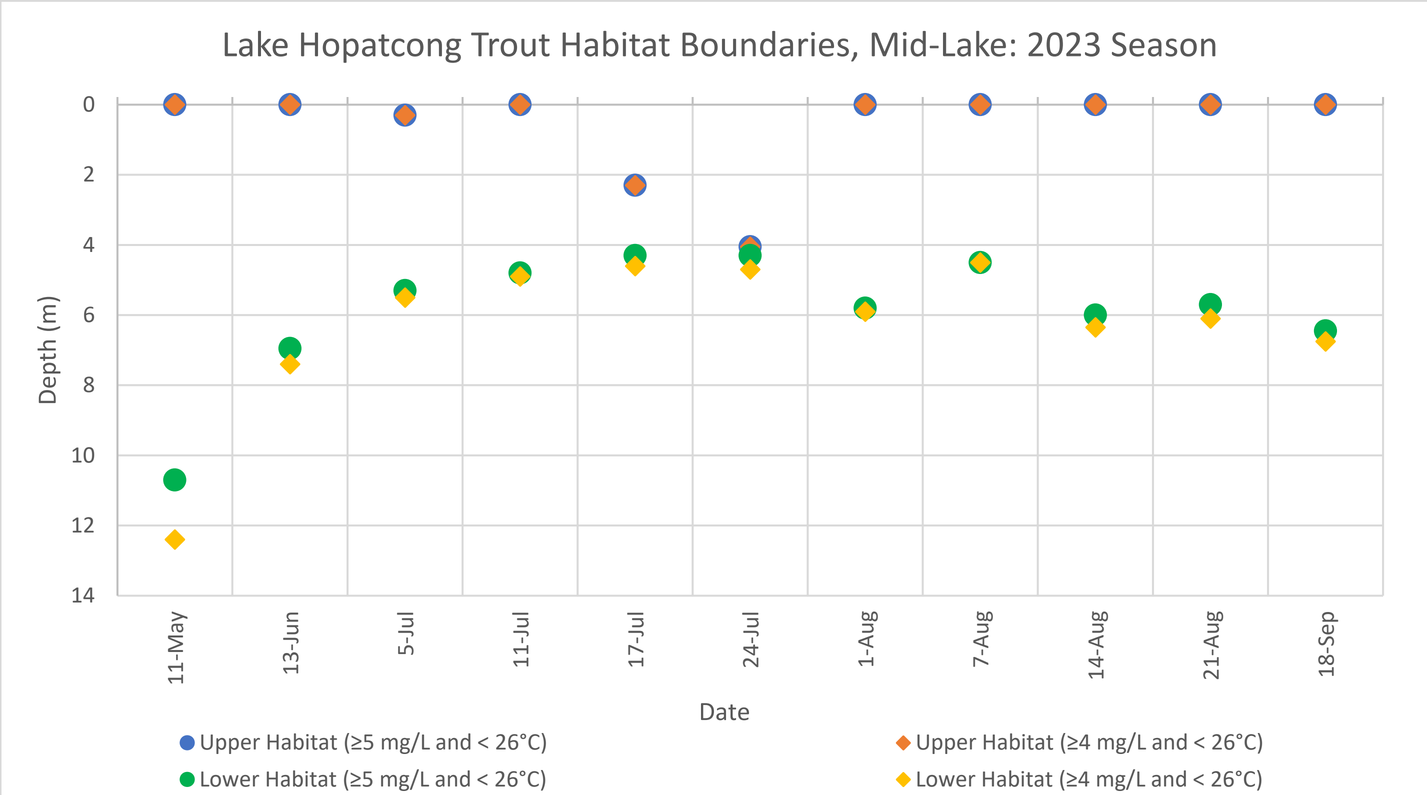


Figure 2.15: Upper and lower trout habitat boundaries at the Mid-Lake station throughout the 2023 season

Figure 2.16 displays the net vertical extent of available trout habitat during each monitoring event, which is the difference between the lower boundary and upper boundary from Figure 3. Unsurprisingly, brown trout carryover habitat was extensive at the beginning and end of the season but became compressed during the second half of July. Unlike the 2022 season, there were no sampling events in 2023 where there was no available carryover brown trout habitat in the lake. There was one instance on 24 July where available habitat was significantly reduced to a small band in the epilimnion approximately 0.25 m thick. However, by the following week, available habitat increased to 5.80 m due to a slight decrease in water temperature in the epilimnion.

This indicates that carryover brown trout habitat availability is dynamic on a weekly and likely diel basis during the peak summer months as surface water temperatures cool at night and warm during the day. In reality, conditions that do not meet these strict habitat criteria are not immediately lethal to fish but should be viewed on a continuum of stress; increasing departure from those criteria, reflected in higher temperatures and lower DO concentrations, represent increasingly more stressful and damaging conditions to the fish.

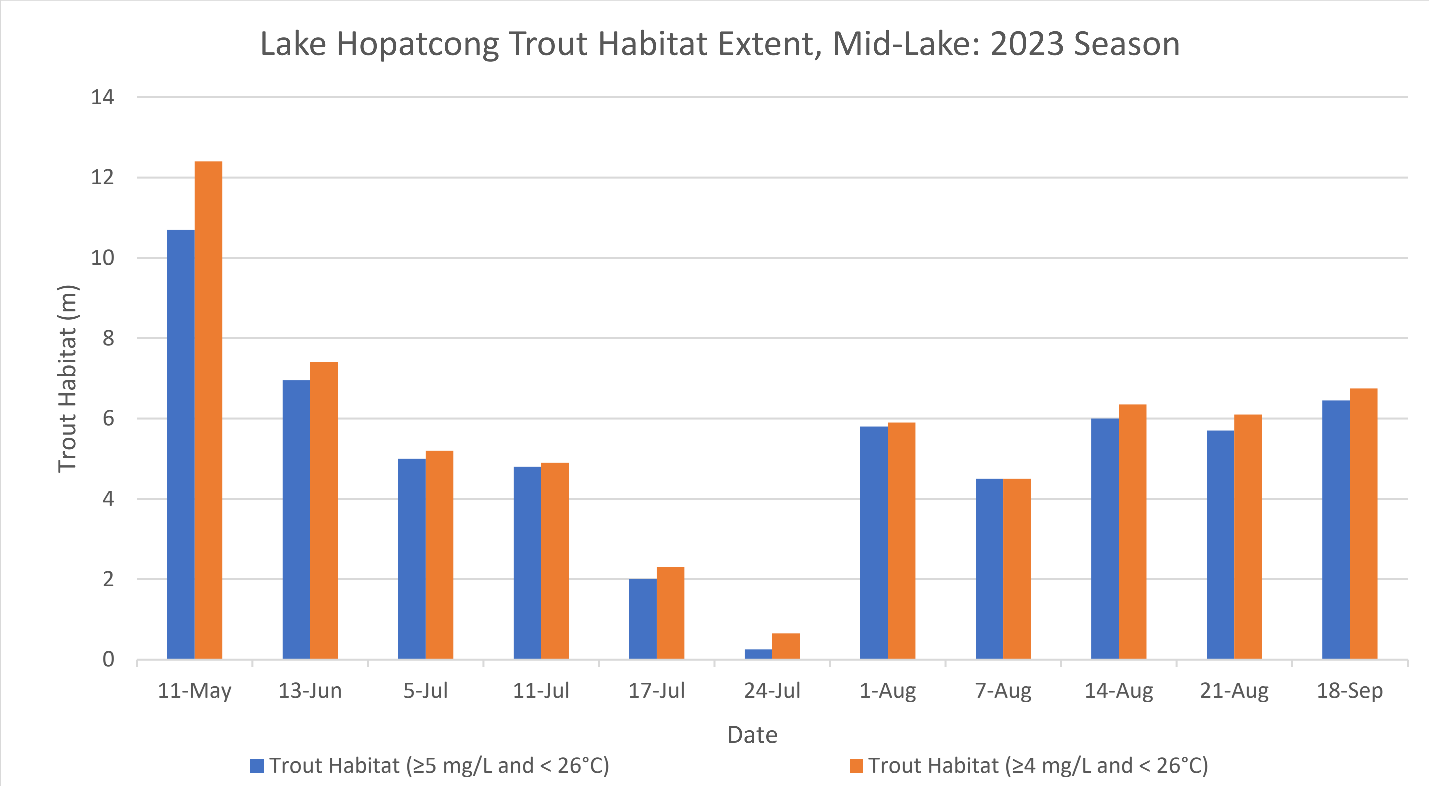


Figure 2.16: Trout carryover habitat extent at the Mid-Lake station throughout the 2023 season

Figure 2.17 was developed to display the data from Figures 2.15 and 2.16 in a succinct visual summary. A scale from 0.0 – 2.0 was developed to represent a range of carryover trout habitat in Lake Hopatcong. A 0.0 on the scale represents available carryover trout habitat, based on the 2023 temperature and DO data, while a 2.0 represents non-available trout habitat. A color schematic was developed along with this scale to visually represent trout habitat availability throughout the season. The 2023 water quality data was converted to this binary scale and all of the data values, represented by different shades of red, displayed by dates in between sampling events was interpolated. For example, if the surface of the lake had temperature and DO values conducive for carryover trout habitat on a sampling date, but the next sampling date did not, the first sampling event would be represented by a 0.0 on the scale while the following date would be represented by a 2.0; the data values in between these two dates is interpolated and would include the range of values between 0.0 and 2.0. The range of values between 0.0 and 2.0 represent a continuum of habitat availability, with increasing values representing increased stress on the fish. It is evident from the 2023 water quality data that the carryover trout habitat availability is dynamic during the hot summer months.

Figure 2.17 is particularly useful in visualizing how trout habitat conditions progress throughout the summer months. For example, even though there was 5.80 m of available habitat on 1 August because epilimnetic temperatures were below the 26.0 °C threshold, temperatures were still relatively elevated and ranged between 25.6 °C at 5.60 m and 25.7 °C at the surface. While carryover trout habitat was technically present during the time of sampling, the elevated temperatures were still less than ideal for the trout, which is why this time period was represented by values between 0.0 and 2.0.

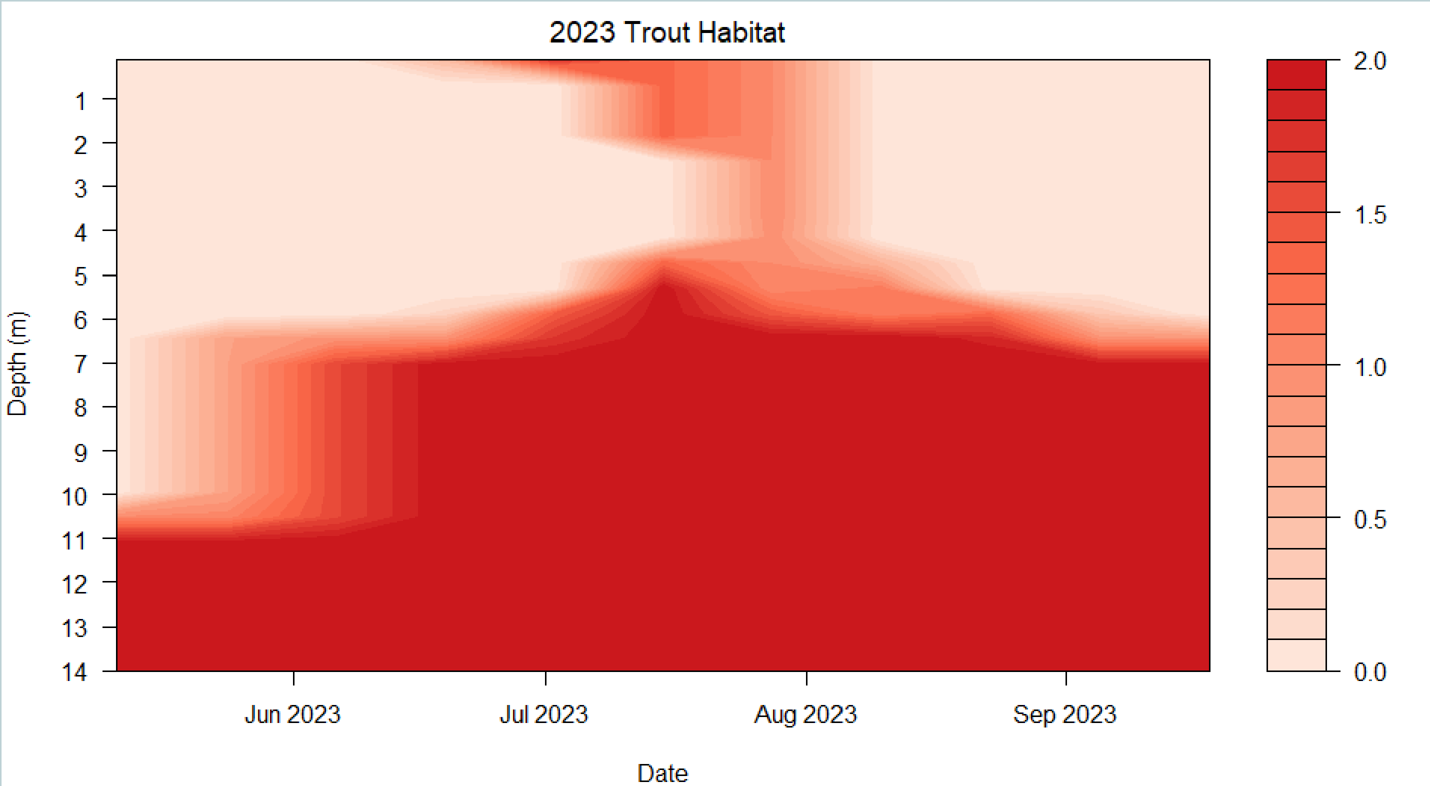


Figure 2.17: Trout habitat availability isopleth. 0 represents available habitat and 2.0 represents no habitat

The use of strict thresholds in determining habitat quality does present a problem in explaining the findings; in reality the habitat quality and availability should be viewed along a spectrum. This is one of the benefits of using isopleths to interpret the data as they indicate the dynamics of the system in space time as shown in Figure 2.13, 2.14, and 2.17. Fundamentally, departure from those threshold values used for analysis and time spent outside those bounds represents increasingly difficult conditions for the fish and higher risk of mortality.

2.5 INTERANNUAL ANALYSIS

This section provides an interannual analysis of the limnetic water quality data collected during the first two years of the study. First, average monthly air temperatures and monthly precipitation totals from the first two years of the study are discussed, along with the 30-year averages. Given the stark difference between the hot and dry 2022 and wet 2023 seasons, it is evident that the weather patterns had a significant effect on limnetic water quality data as it pertains to carryover trout habitat.

2.5.1 INTERANNUAL WEATHER ANALYSIS

The temperature and precipitation data utilized in this analysis is the same data discussed in the Weather Analysis section of the 2022 and 2023 reports. As a reminder, Princeton Hydro primarily utilized temperature data gathered through CLIMOD2 (http://climod2.nrcc.cornell.edu/) for this analysis. Any data gaps from CLIMOD2 were supplemented with data gathered through TuTiempo (Climate - Climate data (tutiempo.net)). The weather station utilized for this analysis, from both websites, was Aeroflex-Andover Airport.

This section will not attempt to discuss the driving forces behind the contrasting weather patterns experienced in 2022 and 2023. The point of this weather analysis is to lay the foundation for the comparison of the limnetic data.

Figure 2.18 presents the average monthly temperatures from May through September in 2022, 2023, and the 30-year average. Figure 2.19 presents the monthly precipitation totals over the same period.

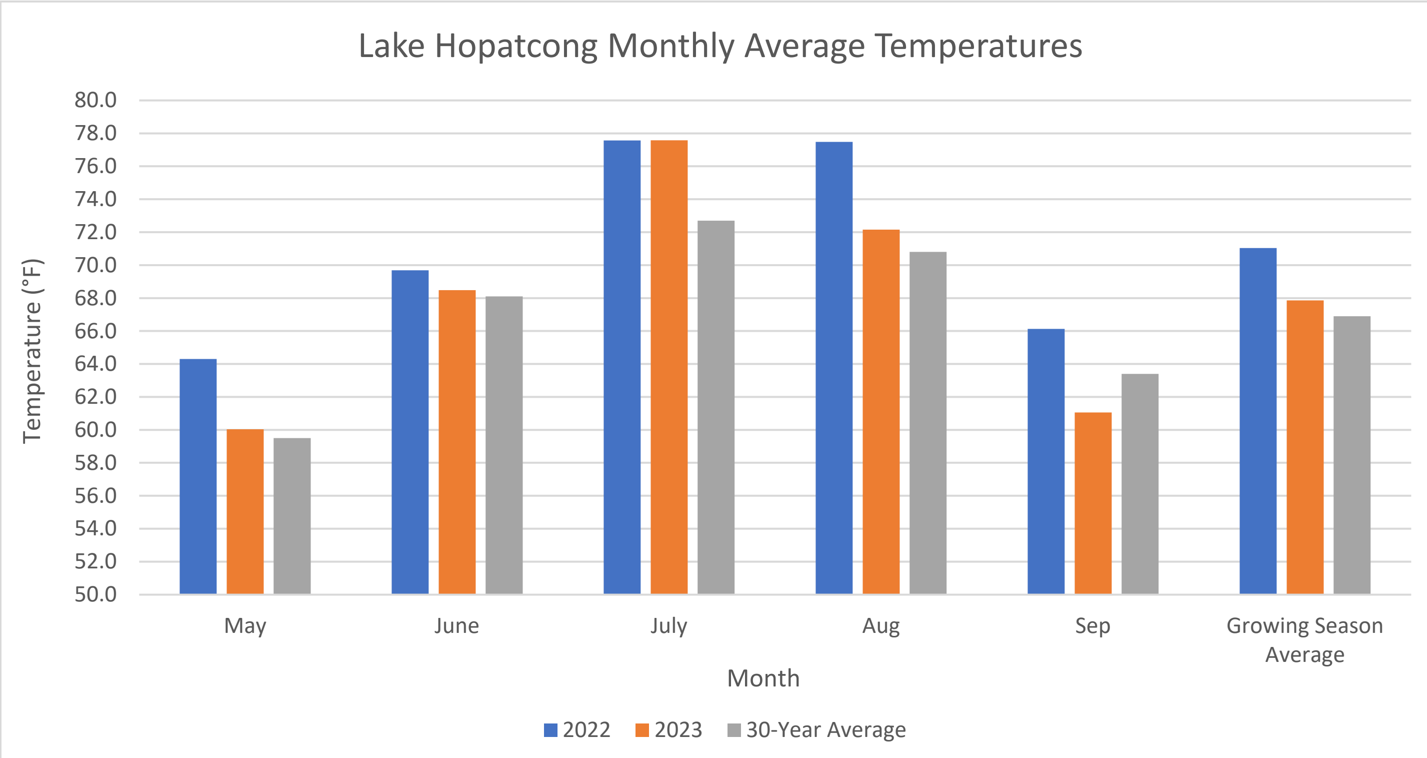


Figure 2.18: Average growing season monthly temperatures in 2022, 2023, and the 30-year average

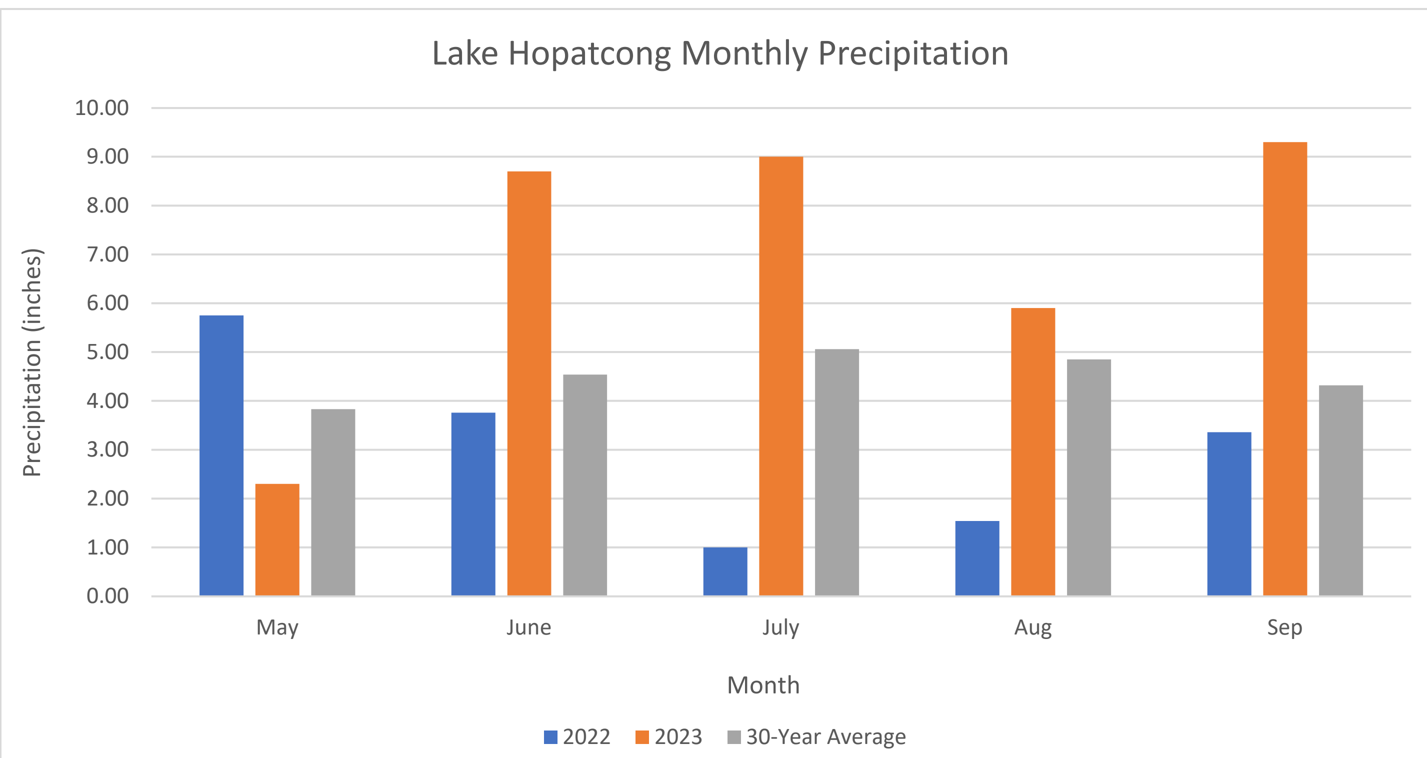


Figure 2.19: Monthly precipitation in 2022, 2023, and the 30-year average

Average monthly temperatures were warmer in 2022 than in 2023 during all months besides July; both years had an average monthly temperature of 77.6 °F in July. Temperature disparities were the greatest in May, August, and September, with respective positive temperature departures of 4.3 °F, 5.3 °F, and 5.0 °F in 2022. The growing season average monthly temperature was 71.0 °F in 2022 and 67.9 °F in 2023, a difference of 3.1 °F. The growing season average monthly temperature from 1991 – 2020 is 66.9 °F; thus, even though 2022 was significantly cooler than 2023, it was still warmer than the long-term average.

Monthly precipitation was greater in 2023 than 2022 during all months besides May; in fact, the first part of 2023 was quite dry. Precipitation was similar to the long-term average in May and June of 2022 before an extremely dry July and August in which only 2.54 inches of rain fell. Conversely, May 2023 was actually slightly drier than the long-term average before a historically wet rest of the growing season with over 8.00 inches of precipitation each in June, July, and September. August also had above average precipitation in 2023, with a total of 5.90 inches relative to the long-term average of 4.85 inches. Much of the rain in 2023 fell during discrete rain events, with 18 days from May – September with over 0.5 inches of precipitation. There were nine days from May – September with over 1.00 inch of precipitation, one day with 2.54 inches, and two days with over 3.00 inches. The 2023 growing season was extremely wet, with a total of 35.20 inches of precipitation while the 2022 growing season was extremely dry, with a total of 15.41 inches; the long-term average is 22.60 inches.

2.5.2 INTERANNUAL LIMNETIC WATER QUALITY ANALYSIS

The different weather conditions experienced in 2022 and 2023, which can be viewed as two extremes, especially as it pertains to precipitation, resulted in different thermal regimes during the summer months. Since carryover trout habitat is dependent on temperature and DO, which are both influenced by the thermal structure of a waterbody, carryover habitat was more widely available during the second half of the cooler and wetter 2023 summer.

Figure 2.20 presents the vertical extent of carryover trout habitat at the Mid-Lake station during each monitoring event in 2022 and 2023, represented by the vertical bars and the y-axis on the left side of the figure. Figure 2.20 also presents surface water temperatures during each event, represented by the blue and green lines and the y-axis on the right side of the figure. Finally, the upper temperature threshold of 26.0 °C that can support carryover trout habitat is represented by the horizontal red line and the y-axis on the right side of the figure.

Figure 2.21 presents the depths of the upper and lower boundaries of available carryover brown trout habitat during each monitoring event in 2022 and 2023. The 2022 monitoring events are represented by blue and purple circles while the 2023 monitoring events are represented by red and orange diamonds. Please note that there was available habitat during all of the 2023 monitoring events. However, the July (4) and August (2) sampling events in 2022 had no available habitat.

The final monitoring event in 2022 was conducted on 6 October while the final event in 2023 was conducted on 18 September, hence the large difference between surface water temperature and available habitat between the years. The lake had almost completely mixed by 6 October 2022, resulting in a much a larger and cooler oxygenated epilimnion.

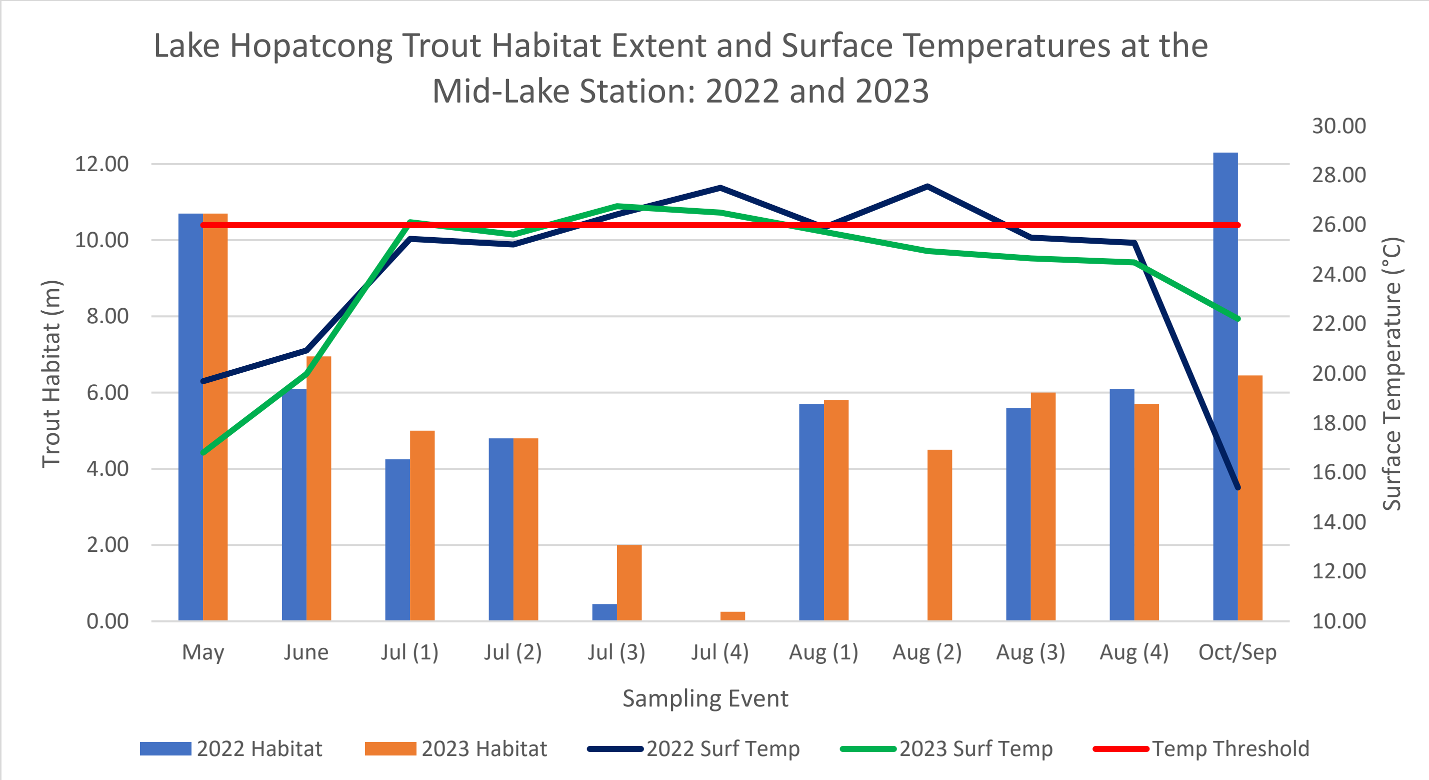


Figure 2.20: Trout carryover habitat extent and surface temperatures throughout the 2022 and 2023 seasons

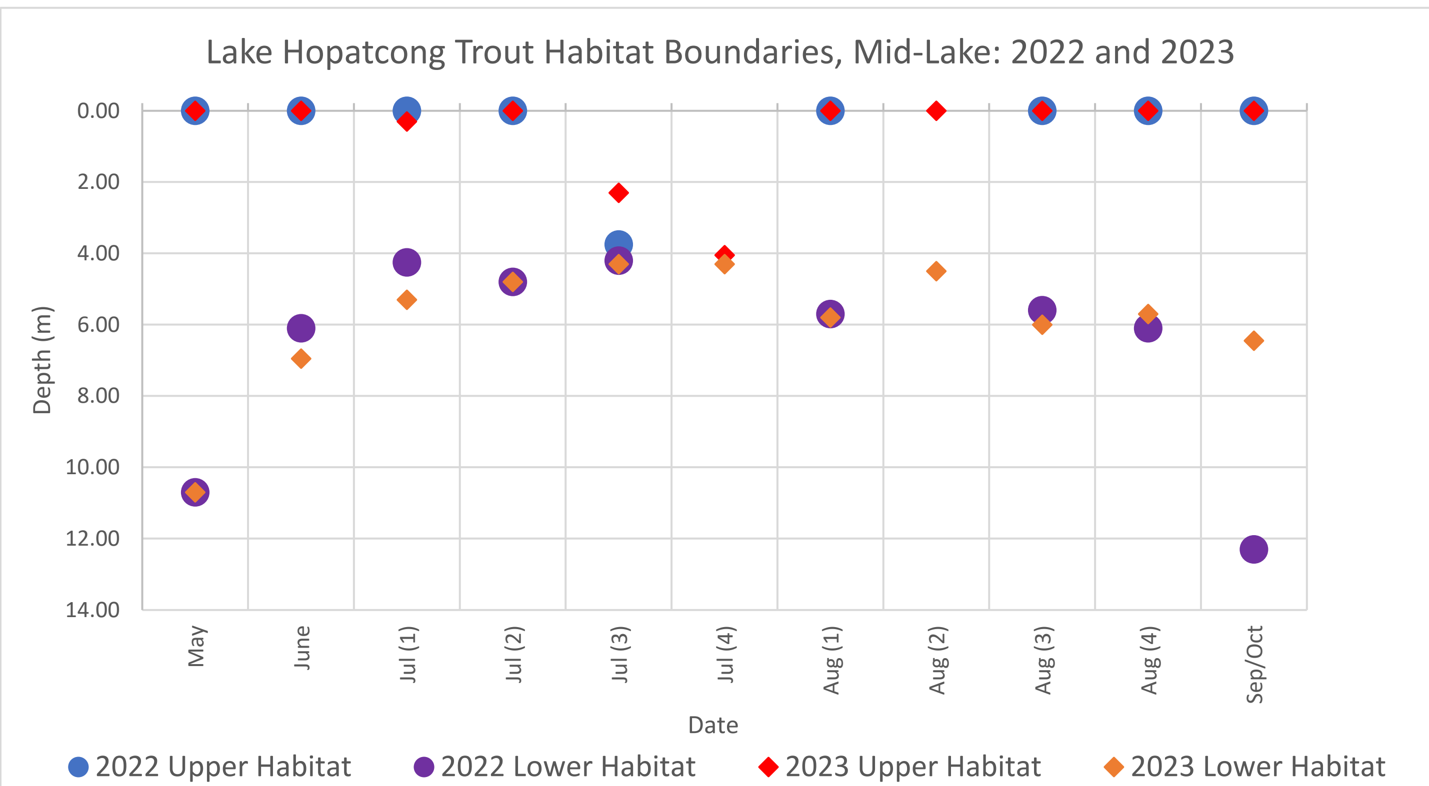


Figure 2.21: Upper and lower trout habitat boundaries throughout the 2022 and 2023 seasons

Despite higher monthly average temperatures in May and June of 2022, and the same monthly average temperature in July of both years, surface water temperatures were actually slightly higher during the first two July monitoring events in 2023. However, this did not result in a loss of carryover trout habitat in 2023 because surface water temperatures remained below the 26.0 °F threshold for supporting carryover trout habitat. In fact, the total amount of carryover trout habitat was actually greater during the first July monitoring event in 2023 despite the slightly higher surface water temperature; 5.00 m in 2023 and 4.25 m in 2022. This could possibly be the result of the cooler water temperatures in May and June of 2023 which resulted in a slightly larger epilimnion. There was 4.80 m of carryover trout habitat at the Mid-Lake station, extending from the surface down to a depth of 4.80 m, during the second July monitoring event in 2022 and 2023.

Carryover trout habitat became compressed during the third July monitoring event during both years. This was a result of increased water temperatures near the surface and the upward migration of the thermocline that resulted in a loss of oxygen at a shallower depth. This habitat compression during the third July monitoring event was much more severe in 2022 than in 2023, with respective total habitat availability of 0.45 m and 2.00 m. The fourth July monitoring event marked the most critical time of the season during both years. In 2022, there was no carryover trout habitat available because temperatures in the epilimnion exceeded 26.0 °C. Carryover trout habitat did not fully disappear in 2023 during the final week of July, but it was extremely compressed as a result of epilimnetic temperatures above 26.0 °C with total availability of only 0.25 m.

The first August monitoring event exhibited a marked change in available trout habitat during both years. There was a slight cooling at the surface, with temperatures of 25.90 °C and 25.72 °C in 2022 and 2023, respectively. This cooling occurred throughout the epilimnion, resulting in the downward migration of the thermocline and increased DO concentrations above 5.0 mg/L at depths of 5.70 m and 5.80 m in 2022 and 2023, respectively. Interestingly, the first August monitoring event was proceeded by a shrinking of the available carryover trout habitat during the second week of August in both 2022 and 2023; however, the extent of this habitat compression was significantly different between years. In 2022, water temperatures increased significantly, with a surface temperature of 27.56 °C, resulting in the complete loss of carryover trout habitat. In 2023, surface temperatures actually decreased during the second August monitoring event, but the thermocline migrated upwards resulting in the loss of DO and the slight shrinking of carryover trout habitat to the upper 4.50 m.

Surface temperatures decreased with each successive monitoring event beginning during the third week of August in 2022 and 2023. As such, there was at least 5.00 m of carryover trout habitat during each monitoring event for the remainder of 2022 and 2023.

In summary, carryover trout habitat started to become significantly compressed during the third week of July in 2022 and 2023 and became critical during the final July monitoring event during both years. However, temperatures remained elevated with little precipitation in August of 2022, resulting in the complete loss of trout habitat during the second August monitoring event. The average monthly temperature decreased over 5.0 °C from July to August in 2023, resulting in the maintenance of over 4.00 m of carryover trout habitat. Temperatures throughout the epilimnion were approximately 1.0 °C cooler during the third August monitoring event in 2023 relative to 2022. Thus, it is obvious that the cooler and wetter July and August resulted in much better carryover trout habitat conditions in the limnetic portion of Lake Hopatcong. Although improved relative to the 2022 summer, conditions from the third July monitoring event through the first August monitoring event, even though technically available, were still stressful to trout because of the elevated temperatures.

2.6 NEARSHORE AND STREAM WATER QUALITY AND HABITAT ANALYSIS

2.6.1 SUMMARY OF NEARSHORE WATER QUALITY DATA

Table 2.2 presents a summary of the total number (N) of nearshore sites that were sampled during each event. The number of sampling sites that supported carryover trout habitat (n) during each sampling event is also provided. Finally, the total depth of available carryover habitat at the Mid-Lake Station during each event is also provided as a reference. Please note that this analysis only utilized the DO threshold of 5.0 mg/L. However, the limiting factor at almost all of the nearshore sites was temperature rather than DO because of the shallow depth associated with most nearshore sites. Anoxic conditions are not typically observed in Lake Hopatcong in areas of the lake less than at least 3.00 m. However, that is not a rule and anoxic conditions can at times and under certain circumstances be observed in shallow areas of the lake. Tables with the full *in-situ* sampling results from all eleven monitoring events are provided in Appendix III.

The percentage of total nearshore sites that supported carryover trout habitat was variable by location and sampling event in July but improved significantly in August. It is important to note that no nearshore sites were sampled on 24 July because the sampling event was one of the routine water quality monitoring events rather than a specific trout habitat monitoring event. 24 July was the date with the least amount of limnetic trout habitat availability, and nearshore trout habitat likely would have been significantly reduced as well. Six of the 16 (38%) nearshore sites sampled on 17 July supported carryover trout habitat, representing the most critical time of nearshore trout habitat availability during the 2023 season; Mid-Lake carryover habitat was reduced to 2.00 m on this date. None of the 16 sites sampled on 17 July had available trout habitat in the upper 1.0 m of the water column, as temperatures were very high, mostly ranging between 26.0 °C - 28.0 °C. 12 of the 23 (52%) nearshore sampling sites on 5 July supported carryover habitat with no available habitat in the upper 1.00 meter of the water column at any station. Carryover habitat was present in at least 70% of the nearshore sampling sites during each of the 3 August monitoring events.

Table 2.2: Summary of nearshore sampling in Lake Hopatcong

Date	Total Sites N	Carryover Habitat n	Mid-Lake Carryover Habitat Meters
7/5/2023	23	12	5.00
7/11/2023	2	2	4.80
7/17/2023	16	6	2.00
8/1/2023	32	23	5.80
8/14/2023	31	31	6.00
8/21/2023	6	6	5.70

2.6.2 NEARSHORE ANALYSIS

Figure 2.22 presents the temperature departures from all nearshore sampling points relative to the temperature at the Mid-Lake station on the same day. Positive values indicate that the nearshore site was warmer than the Mid-Lake station, while negative values indicate the near shore station was cooler. Please note that this includes all sampling points from the nearshore sites, not just the surface temperature. For example, if a nearshore site was 2.00 m deep, temperature data was collected at the surface, 1.00 m, and just above the sediment, for a total of three data points. If the nearshore station was deeper than 2.00 m, the temperature data below a depth of 2.00 m was compared with the respective depth from the Mid-Lake station on that same day. The station numbers correspond with the figures provided in Appendix I.

Similar to the 2022 season, the majority of the temperature data from the nearshore sampling stations were warmer than the respective deep station, although there were a number of instances where the nearshore temperatures were cooler, and a few instances with significantly cooler water. Also similar to the 2022 season, the entire shoreline was sampled again in 2023, but more attention was given to locations that showed the best potential for trout habitat during the hot and dry 2022 season. Sections of shoreline north of Brady Bridge showed some of the best potential in 2022 which is where extra attention was given in 2023. In-lake areas in proximity to the inlet streams were also given increased scrutiny because they have been proven to be sources of significantly cooler water.

The three datapoints from 11 July that range from 3.3 °C to 4.9 °C cooler than the Mid-Lake station were collected at two nearshore stations (24 and 25) in the very back of Great Cove along the eastern shoreline, adjacent to the New Jersey State Police building; the measured temperature range for these three points is 20.74 °C – 22.31 °C. Neither station was particularly deep, with maximum depths between 1.50 – 2.00 m. Surface temperatures were only 0.2 °C – 0.6 °C cooler than the Mid-Lake station, but the significant temperature departures were measured at depths of approximately 1.00 – 1.50 m. Nearshore station 24, which had the two greatest temperature departures, was located approximately 20 feet from the stream site S-4, a pipe that drains a small tributary; additional information on S-4 is provided in the following section. Nearshore station 25 was located approximately 250 feet further in-lake from station 24. Subsurface temperatures were still significantly cooler than the Mid-Lake station at this location, though they were warmer than station 24; temperatures ranged from 25.42 °C at the surface to 22.31 °C at 1.5 m. Temperatures were continuously monitored for a few minutes as the boat traveled further in-lake, but no significant temperature departures were observed much past nearshore station 24.

Nearshore station 23, located halfway between stations 24 and 25, was sampled on 5 July and only a minor negative temperature departure of 1.9 °C was observed at a depth of 1.5 m; a positive temperature departure of 0.2 °C was measured at the surface on the same date. A review of the weather data shows that no rain fell within the two days prior to the 5 July sampling event but approximately 3.62 inches of rain fell within the two days prior to the 11 July sampling event. Thus, the temperature data from these two dates indicate that the increased tributary flow from the 3.62-inch rain event had significant cooling effects in the immediate vicinity of the inlet pipe, and moderate cooling effects as far away as approximately 250 feet. Groundwater influence in this area following the large storm also likely had a positive effect on trout habitat. It is not known how long this nearshore cooling effect lasted but it was restricted to a small area relative to the size of Lake Hopatcong. Nonetheless, it did provide an area of short-term refuge for trout.

On 9 October 2022, a large (approximately 18 inch) brown trout was captured in the lake. The angler was fishing off of a dock located in proximity to nearshore site 21, which is located along the southern shore of the cove where nearshore stations 24 and 25 are located; stream site S-4 discharges into this cove. While this trout wasn't tagged, it still illustrates that large brown trout can and do survive even during harsh conditions; 2022 was one of the hottest and driest summers on record, yet the fish survived. The fish (Photo 2.1) had the characteristic coloring of a healthy brown trout, rather than the silver coloring that is typical of brown trout living in lakes and feeding primarily on forage fish such as alewife (*Alosa pseudoharengus*). This may indicate that the brown trout captured in October 2022 had taken refuge in one of the inlet streams and was able to feed on insects, macroinvertebrates, and other sources of food present in a lotic environment.

Photo 2.1: Brown trout captured 9 October 2022

Nearshore stations 35 – 39, located along the southeast shoreline from just south of Brady Bridge up to the Espanong Road Bridge, were sampled on 17 July. All of these stations had moderate negative temperature departures ranging between 2.0 °C – 2.9 °C cooler than the Mid-Lake Station below the surface; the surface of each station had moderate positive temperature departures (warmer water) than the Mid-Lake station. The measured subsurface temperatures for these stations ranged between 23.9 °C – 25.8 °C, resulting in carryover habitat at each station. The stream sampling site S-11 discharges into Lake Hopatcong approximately 1,000 feet to the southeast of nearshore station 35. Additionally, the outflow from Lake Shawnee (stream sampling site S-5) flows through the Jefferson Canals and mixes with the main body of Lake Hopatcong just northeast of Brady Bridge in the vicinity of nearshore sites 36 – 39. There was approximately 3.11 inches of precipitation the week prior to the 17 July sampling event and 1.52 inches of precipitation the two days prior. These cooler subsurface temperatures in proximity to these two tributaries were likely influenced by the cooler precipitation and groundwater flux.

Nearshore sites 49 – 57 were all cooler than the Mid-Lake station on 1 August. These stations are located at the very northern end of the lake, from N Alpine Drive, up through Bright's Cove, and west to Woodport Bay. The nearshore stations located in Bright's Cove over to Woodport Bay were the coolest, with subsurface negative temperature departures exceeding 1.2 °C at six stations. Two streams discharge into Bright's Cove and one stream discharges into Woodport Bay. Stream sites S-6 and S-7, which are located in the two streams that discharge into Bright's Cove, were cooler than the Mid-Lake stations when they were sampled on 11 July and 14 August. Thus, similar to the other nearshore stations with significant negative temperature departures sampled in July, the proximity to streams appears to provide a source of cooler subsurface water during the hot summer months. Approximately 1.42 inches of precipitation fell during the preceding week.

The nearshore stations sampled on 14 August and 21 August were consistently warmer or similar to temperatures at the Mid-Lake station during the respective sampling event. However, it is important to note that temperatures throughout the lake had already begun to cool by 14 August, and 100% of the nearshore sites sampled during the latter half of August had available carryover trout habitat. Thus, although temperatures were not significantly cooler than the Mid-Lake station, they were cool enough to support carryover trout habitat.

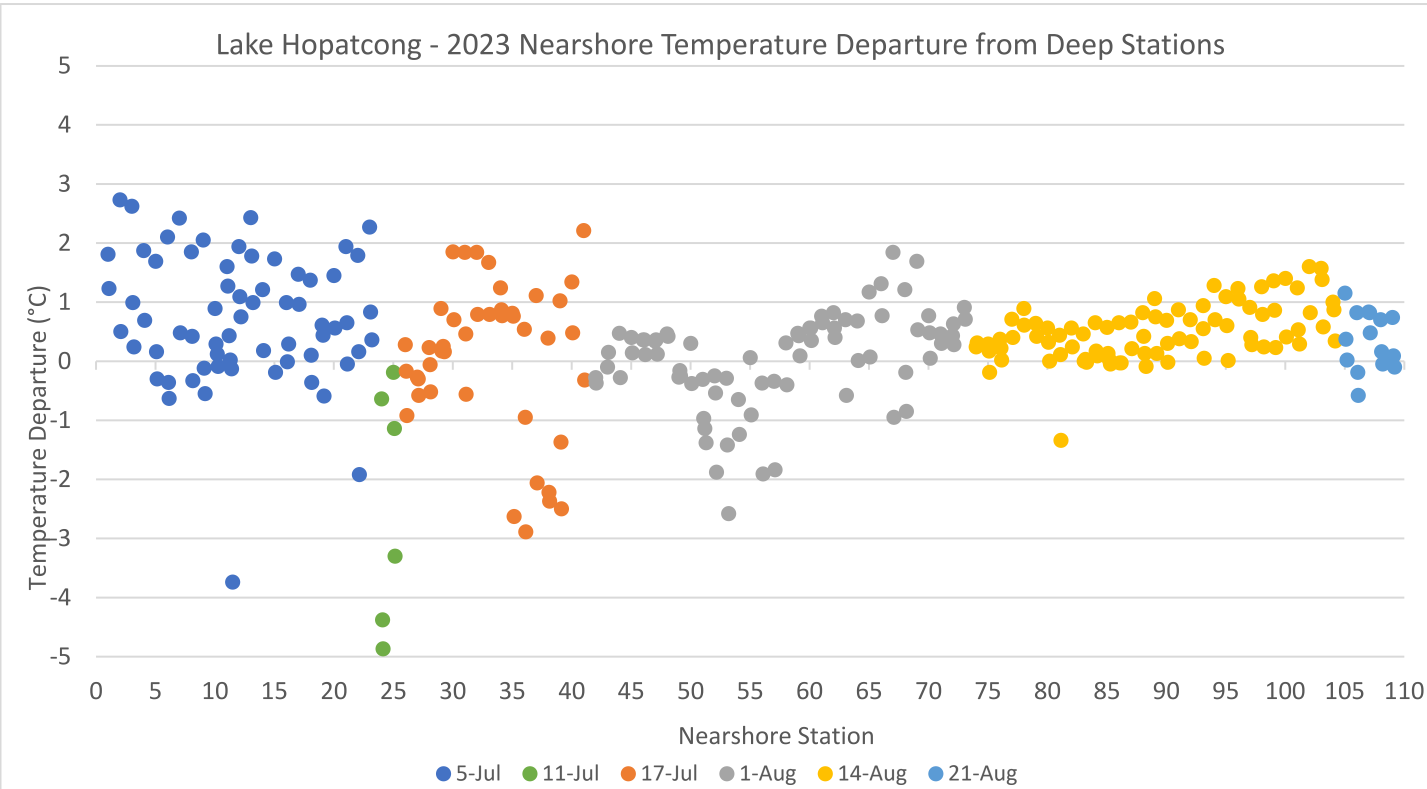


Figure 2.22: Nearshore temperature departures from the Mid-Lake Station throughout the 2023 season

2.6.3 STREAM ANALYSIS

12 streams that discharge into Lake Hopatcong were sampled on 11 July and ten streams were sampled on 14 August (Appendix I). Stream sites S-1 – S-10 remained consistent with the 2022 study and sites S-11 – S-13 were added in 2023; some of these sites were dry in 2022 because of the lack of precipitation. S-9 was not accessed in 2023 because it is located on private property. Additionally, sites S-4 and S-13 were not sampled on 14 August due to access issues or safety concerns.

All sites had significantly more flow than the 2022 sampling event that was conducted in the middle of a dry summer on 16 August 2022. A review of the *in-situ* data from both years reveals elevated specific conductivity values which is indicative of groundwater influence (Table 2.3). Specific conductivity is a direct measure of the ability to conduct electricity and is an indirect measure of the concentration of dissolved solids in solution.

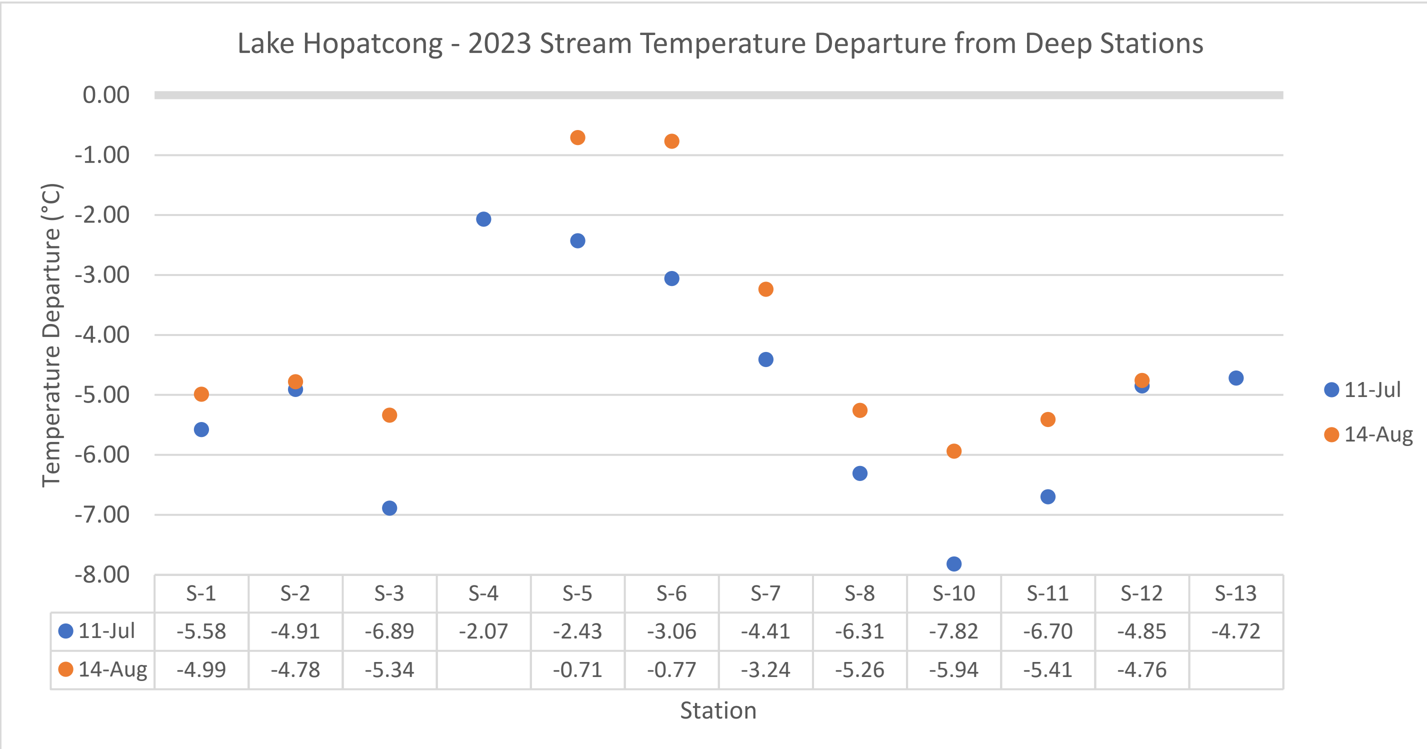
As groundwater moves through soil, it dissolves some of the minerals and salts which raises the specific conductivity of the water. The upper saturation boundary is known as the water table. Groundwater seeps into streams and waterways and provides what is known as baseflow. This provides a source of water to streams during periods of dry weather. The water table is not static and moves downward during periods of dry weather due to evapotranspiration in the soil and discharge to stream channels. When the local water table drops below the elevation of the stream channel there is no longer groundwater exchange to support baseflow. Some of the stream sites that were visited in 2022 were completely dry, meaning that the water table had receded to below a depth that would provide baseflow to the stream. The streams that did have water in 2022 were all extremely low flow, but the water table was still high enough to maintain minimal baseflow. This water is often much cooler than ponded surface waters during the summer months because the soil insulates the groundwater from the heat at the surface. Specific conductance values were still elevated at some sites in 2023 compared with the water in Lake Hopatcong but they were much lower than the 2022 values due to the increased influence of precipitation and a resulting dilutionary effect during the 2023 season.

Table 2.3: Lake Hopatcong 2023 Inlet Stream *In-Situ* Data

Date	Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
		m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
7/11/2023	S-1	0.2	20.03	764.6	8.03	91.8	7.12
	S-2	0.2	20.70	700.5	8.60	99.2	7.49
	S-3	0.2	18.72	304.4	8.54	94.6	7.38
	S-4	0.2	23.54	445.7	8.76	106.7	8.00
	S-5	0.2	23.18	55.0	7.23	87.2	7.29
	S-6	0.2	22.55	163.3	8.24	985.0	7.14
	S-7	0.2	21.20	414.6	8.39	97.7	7.57
	S-8	0.2	19.30	408.2	8.05	90.3	7.29
	S-10	0.2	17.79	1,547.0	9.37	102.3	8.10
	S-11	0.2	18.91	611.9	8.49	94.5	7.64
	S-12	0.2	20.76	958.5	8.38	96.9	7.76
	S-13	0.2	20.89	1,057.0	8.23	96.7	7.67
8/14/2023	S-1	0.2	19.66	475.0	8.16	92.9	7.27
	S-2	0.2	19.87	547.1	8.74	99.6	7.58
	S-3	0.2	19.31	538.4	8.15	91.8	7.37
	S-5	0.2	23.94	102.5	7.53	92.7	7.35
	S-6	0.2	23.88	186.3	8.02	98.6	7.49
	S-7	0.2	21.41	403.8	8.24	96.7	7.82
	S-8	0.2	19.39	326.8	7.70	86.8	7.22
	S-10	0.2	18.71	1,352.5	9.16	102.2	8.23
	S-11	0.2	19.24	519.6	8.41	94.6	7.52
	S-12	0.2	19.89	817.8	8.45	96.4	7.73

The cooler water that the streams provide to the lake is important for carryover trout habitat. As these cooler streams discharge into the lake, they can create localized areas within the lake that are cooler than the surrounding lake water. While it was not a surprise during the 2022 study that the streams provided a source of cooler water to the lake, it was not known how much flow there would be due to the 2022 drought. Although most of the streams were reduced to low baseflow, they were still an important source of cool water for the lake. The stream data collected in 2022 was utilized during the 2023 study and nearshore sites in proximity to these inlets were given increased attention. The nearshore data collected in 2023 proved that these streams did indeed create localized areas within the lake that were significantly cooler than surrounding areas. Thus, it is important to continue to analyze these sites and determine which areas provide the best possible conditions for carryover trout habitat.

Figure 2.23 below illustrates the temperature departures from stream sites relative to the surface water temperature at Mid-Lake Station on 11 July and 14 August 2023. All sites were cooler than the Mid-Lake station and nine sites were over 4.0 °C cooler than the Mid-Lake Station in July and seven in August.



	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-10	S-11	S-12	S-13
11-Jul	-5.58	-4.91	-6.89	-2.07	-2.43	-3.06	-4.41	-6.31	-7.82	-6.70	-4.85	-4.72
14-Aug	-4.99	-4.78	-5.34		-0.71	-0.77	-3.24	-5.26	-5.94	-5.41	-4.76	

Figure 2.23: Stream temperature departures from the surface temperature of the Mid-Lake station

S-1 is located in Glen Brook just upstream of Memorial Pond in Mount Arlington and was 5.6 °C cooler than the Mid-Lake station in July and 5.0 °C cooler in August. This station was sampled to serve as a reference point to compare with S-2 which was sampled further downstream. S-1 discharges into Memorial Pond directly downstream of where it was sampled before discharging into Glen Brook and eventually into Lake Hopatcong via a large pipe adjacent to Memorial Beach. There was approximately 6 – 9 inches of water at the thalweg and flow throughout the entire stream channel; this was distinctly different than 2022 when there was only a trickle and most of the water was pooled in small depressions (Photos 2.2 and 2.3).

Photos 2.2 – 2.3: S-1 in August 2022 (left) and August 2023 (right)

S-2 was sampled in Glen Brook just upstream of the Memorial Beach parking lot at the furthest point downstream before it flows under the parking lot. The stream was 4.9 °C cooler than the Mid-Lake station in July and 4.8 °C cooler in August. S-2 was only slightly warmer than S-1 during both sampling events; this is a positive sign because S-2 was over 3.0 °C warmer than S-1 in 2021. There was significantly more flow at S-2 in 2023 which was likely a contributing factor to the cooler temperatures. Memorial Pond acts as a settling pond, removing sediment and nutrients before discharging downstream. While this is an important service for the overall management of Lake Hopatcong, the increased retention time in the pond increases the temperature of the water. It was hypothesized in 2022 that Memorial Pond may have even more of a warming effect during normal flow periods. While 2023 had significantly more precipitation than the long-term summer average, the pond had less of a warming effect than 2022. Thus, Glen Brook was providing an important source of cool water in 2023. The section of Glen Brook upstream of S-2 does lack a riparian buffer, and addressing this would provide more shade and potentially cool water temperatures even more.

Photos 2.4 – 2.5: Glen Brook upstream of S-2 in August 2022 (left) and August 2023 (right)

S-3 was sampled in an unnamed tributary in front of Edith M. Decker Elementary School and the water temperature were 6.9 °C cooler than the Mid-Lake station in July and 5.3 °C cooler in August. There was approximately 12 inches of water just upstream of the culvert on 11 July; however, water was not flowing through the pipe. It is possible that this was due to the extremely high lake level (9.6 ft. at the time of sampling) following the 3.6-inch rainstorm on 9 July indicating the channel was backwatered. The water depth was similar on 14 August but water was flowing slowly through the culvert; the lake level was lower on 14 August at approximately 9.1 feet. The nearshore area of the lake in Lee's Cove where S-3 discharges was sampled on 5 July. The submerged pipe that S-3 discharges through could not be located but the entire stretch of shoreline was sampled with the water quality meter and no sources of significantly cooler water were located.

It is worth noting that there was a large delta of sediment and/or road grit that had accumulated adjacent to the culvert that S-3 discharges through in August; there is a smaller pipe next to the culvert that drains a portion of the surrounding road. The accumulated sediment was not as visible during the July sampling event and it is possible that this delta expanded as the summer progressed from all of the rain. Photos 2.6 and 2.7 below show the same area around S-3.

Photos 2.6 – 2.7: Culvert at the S-3 stream in July (left) and August (right) with significant sediment accumulation

S-4 was sampled in Great Cove at the exact location where a small tributary discharges into the lake via a pipe. This tributary has a drainage area of 450 acres of mostly forested and residential land. The tributary is piped underground for approximately 500 feet, traveling under Felter Place and Espanong Road before discharging into the lake in Great Cove adjacent to the State Police building. While this tributary would not be able to serve as a direct area of refuge for trout, the lake water was 2.0 °C cooler than the Mid-Lake Station next to the inlet pipe. Of even more importance is the cooling effect that this tributary had in the surrounding nearshore area on 11 July. Nearshore sites 24 and 25, which were 3.3 °C to 4.9 °C cooler than the Mid-Lake station, were located approximately 20 feet and 250 feet, respectively, from S-4; the measured temperature range for these three points is 20.74 °C – 22.31 °C. Temperatures were continuously monitored for a few minutes as the boat traveled further in-lake, but no significant temperature departures were observed much past nearshore station 24. This indicates that the S-4 tributary provided a significant cooling effect in the immediate vicinity of the pipe and a moderate cooling effect approximately 250 feet away, providing a small refuge area for trout during the warm summer months.


Photos 2.8 – 2.9: S-4 (left) and the shoreline adjacent to the pipe in Great Cove

S-5 was sampled immediately downstream of the Lake Shawnee dam on the west side of East Shawnee Trail. Unlike the August 2022 stream sampling, there was water flowing over the spillway at the Lake Shawnee dam during both sampling events in 2023. The water here was 2.4 °C cooler than the Mid-Lake station on 11 July and 0.8 °C cooler in August. However, this inflow has to travel through the very shallow Jefferson Canals before mixing with the main body of the lake north of Brady Bridge. Nearshore sites 37 – 39 are located where the flow from Jefferson Canals mixes with the main body of Lake Hopatcong. These sites were sampled on 17 July and were all over 2.0 °C cooler than the Mid-Lake station below the surface.


Photos 2.10 -2.11: S-5 downstream of Lake Shawnee in July (left) and August (right)

S-6 was sampled at the inlet stream from Lake Winona from the southwestern side of Lorettacong Drive. This inlet flows directly into Bright's Cove at the northeastern end of Lake Hopatcong. Water temperatures were 3.0 °C cooler than the Mid-Lake station on 11 July and 0.8 °C cooler in August. This station had some of the warmest temperatures of all of the streams that were sampled; however, it was still providing a source of cooler water to the northern end of the lake, especially in July. Water temperatures were 6.2 °C cooler than the Mid-Lake station on 16 August 2022 but flow was significantly lower than both 2023 monitoring events. Water that discharges into Lake Winona is heated due to the increased retention time, resulting in warmer water that flows into Lake

Hopatcong. Nearshore sites 52 – 54, located in Bright's Cove, all had negative temperature departures of at least 1.2 °C relative to the Mid-Lake station on 1 August.


Photos 2.12 – 2.13: S-6 facing Bright's Cove in August 2022 (left) and August 2023 (right)

S-7 was sampled just down the road from S-6 in an unnamed tributary that also drains to Bright's Cove. Water temperatures were cooler than S-6 during both events, with negative temperature departures of 4.4 °C in July and 3.2 ° in August. Bright's Cove and the northern end of Lake Hopatcong between the inlet from Bright's Cove and Woodport Bay was identified as a potential area of refuge for brown trout during the warm summer month's during the 2022 study based on the nearshore and stream temperatures during the hot and dry summer. Although the streams were not as cool in 2023, they were still moderately cooler than the Mid-Lake station and there was significantly more flow in both streams during the 2023 summer. In-lake subsurface temperatures at the nearshore stations in proximity to these stream inlets were cooler than the Mid-Lake station during both sampling seasons.


Photos 2.14 – 2.15: S-7 facing Bright's Cove in August 2022 (left) and August 2023 (right)

S-8 was sampled at a small stream on the west side of Brady Road, approximately 350 feet north of where the stream discharges into the lake near Beebe Marina. The stream travels underground just across Brady Road from where it discharges into the lake via a pipe. This pipe also receives road runoff from the immediate area. The water temperature in the stream was 6.3 °C cooler than the Mid-Lake station in July and 5.3 °C cooler in August.

This stream is small relative to many of the other inlets that were sampled but temperatures were cooler during both sampling events in 2023 and there was more flow compared to the August 2022 sampling event.


Photos 2.16 – 2.17: Upstream view of S-8 in August 2022 (left) and July 2023 (right)

S-10 was sampled in a stream that discharges into the southern end of Crescent Cove, just before the stream travels under the Crescent Cove Beach Club parking lot. This is a fairly large stream that generally flows throughout the year and had consistent flow during both sampling events. The water temperature in the stream was 7.8 °C cooler than the Mid-Lake station surface water temperature in July and 6.0 °C cooler in August. The stream discharges into the southern end of Crescent Cove via a pipe. Unfortunately, although the water temperature was significantly cooler than the Mid-Lake station in July and August, this stream should be considered low priority due to the location of where it discharges into Lake Hopatcong. Crescent Cove is a very secluded, shallow, and narrow cove that has little shade coverage and poor circulation. Thus, water temperatures in the cove are usually significantly warmer than the main body of the lake during the warm summer months. Still, this stream is important to the overall resiliency of the lake and provides a source of cool water to the secluded Crescent Cove.


Photos 2.18 – 2.19: Upstream view of S-10 in July (left) and August (right) 2023

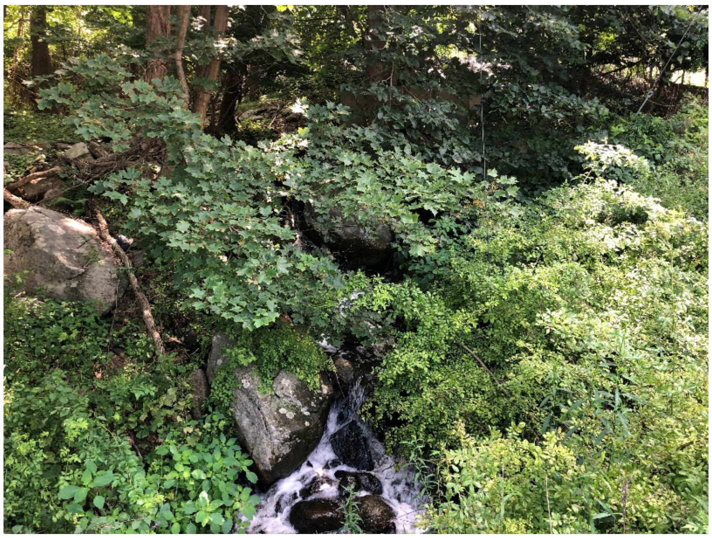
S-11 was sampled in a small tributary that discharges into Lake Hopatcong in a small, secluded cove just south of Brady Bridge. The stream flows around the perimeter of East Shore Park before discharging into a culvert under East Shore Road and directly into Lake Hopatcong. Water temperatures were 6.7 °C cooler than the Mid-Lake station surface water temperature in July and 5.4 °C cooler in August. This tributary is small relative to most of the other streams that were sampled, but the water was significantly cooler than the limnetic portion of the lake. Nearshore station 35 is located just south of Brady Bridge, where the small cove that receives flow from this tributary mixes with the main body of Lake Hopatcong. Surface temperatures were warmer than the Mid-Lake station surface temperatures on 17 July but the temperature at a depth of 1.60 m was 2.6 °C cooler. Thus, this tributary may be providing a minor subsurface cooling effect to this section of the lake.


Photos 2.20 – 2.21: Downstream (left) and upstream (right) views of S-11 in August 2023

S-12 was sampled in an unnamed tributary that discharges into the southern end of Byram Cove. The stream flows through a culvert under Maxim Drive and back into a small stream segment before discharging into the lake. Water temperatures were 4.9 °C cooler than the Mid-Lake station surface water temperature in July and 4.8 °C cooler in August. There were no significant negative temperature departures when the southern end of Byram Cove was sampled on 14 August 2023.


Photos 2.22 – 2.23: Upstream view of S-11 in July (left) and August (right) 2023

S-13 was sampled in a stream located approximately 100 feet from S-10, just across the street on the south side of Crescent Road. Similar to S-10, the stream discharges into a pipe that travels under the Crescent Cove Beach Club parking lot. This stream also usually maintains flow throughout the year and had consistent flow during both sampling events; the stream was not sampled in August due to access and safety concerns relative to the location along the relatively busy Crescent Road. The water temperature was 4.7 °C cooler than the Mid-Lake station surface water temperature in July. Unfortunately, similar to S-10, this stream is also considered low priority relative to in-lake trout habitat due to its location in the shallow, secluded Crescent Cove that is typically very warm during the summer.




Photos 2.24 – 2.25: Upstream view of S-13 in July

2.5.4 DISCUSSION OF NEARSHORE AND STREAM MONITORING RESULTS

The nearshore sampling results did identify a number of locations that were moderately to significantly cooler than the respective temperatures at the Mid-Lake station during the same day of sampling. More nearshore locations were identified in 2023 than in 2022 and the negative temperature departures were also greater in 2023, resulting in improved conditions for potential trout refuge. Of the 116 nearshore sites sampled in 2022, only two had temperatures that were more than 1.0 °C cooler than the Mid-Lake station on that same day; this represents 1.7% of all nearshore sites. In 2023, 16 of the 110 nearshore sites had negative temperatures that were more than 1.0 °C cooler than the Mid-Lake station, representing 14.5 % of all nearshore sites.

In addition to the higher frequency of negative temperature departures at the nearshore stations in 2023, overall carryover trout habitat conditions were improved at the nearshore stations in 2023. Only 37 of the 116 nearshore sampling sites had temperature and DO conditions that supported carryover trout habitat in 2022, representing 37% of all sites. In 2023, 80 of the 110 nearshore sites had temperature and DO conditions that supported carryover trout habitat, representing 73% of all sites. More attention was given in 2023 to the areas that showed the best potential for carryover habitat in 2022, but the entire shoreline, with the exception of Crescent Cove, was sampled again in 2023. As discussed in the weather analysis section, 2022 was a historically hot and dry summer while 2023 was cooler and significantly wetter. Thus, these improved nearshore trout habitat conditions in 2023 are the result of more favorable weather conditions.

All of the stream sites had significantly more flow in 2023 relative to 2022 while still providing water that was significantly cooler than the lentic water in the lake. Most of the nearshore sites that had negative temperature departures greater than 1.0 °C were located in proximity to the inlet streams that were sampled. The increased tributary flow in the streams from the above average precipitation in July and August had a positive effect on nearshore trout habitat in Lake Hopatcong in 2023.

While these improved conditions were an extremely positive sign in 2023, it is still not known how much of an effect it actually has in providing refuge for brown trout during the critical summer period. However, there is increased expectation that carryover trout may be observed in 2024. Summer conditions were likely too extreme in 2022 for many brown trout to survive into 2023, although it is certainly possible that some of the bigger fish were able to survive. The more favorable conditions in 2023 significantly increase the chances that carryover trout are captured in the spring of 2024. There likely was not much fishing during the fall of 2023 because the lowering of the lake level for the five-year, five-foot drawdown began in late September.

Princeton Hydro supports a third consecutive season of a similar water quality and habitat sampling study to further refine the results from the first two years of the study. The trout tagging will be conducted for three consecutive years. Although it is impossible to predict what the weather conditions in the summer of 2024 will be, weather conditions, and particularly precipitation, closer to the long-term average would provide useful information. Regardless, collecting water quality data in conjunction with weather data for three consecutive years will provide a robust database. Thus, conducting a similar sampling plan under varying weather conditions will offer additional insight into potential trout carryover habitat in and around Lake Hopatcong.

3.0 FISHERIES DATA ANALYSIS

This section of the report will analyze the fisheries data generated as part of this study. 2023 marked the second year of the trout tagging study commencing with the stocking of 1,000 jaw-tagged brown trout in March 2023 replicating the efforts of the previous spring. Tagging studies allow for an exploration of population dynamics over time and will help to determine the potential of the lake to sustain carryover trout populations. This study has helped to refine the understanding of coldwater fisheries habitat in Lake Hopatcong as controlled by water temperatures and DO concentrations.

Coldwater fishes, such as trout, have a higher oxygen demand and lower temperature requirements than warmwater species, like largemouth bass and bluegill, that comprise the majority of the fishery biomass in Lake Hopatcong. These habitat requirements, as well as the in-lake regimes, have been described at length in the preceding sections of this document. In short, available trout habitat in the water column becomes maximally compressed in Lake Hopatcong in July and August. The upper habitat bound, near the surface, moves downward through the water column reaching its maximum depth in mid to late summer as the epilimnion warms, while the lower bound moves up through the water column, away from the lake bed, as oxygen concentrations fall due to thermal stratification and the exhaustion of available oxygen by microbial respiration.

A recent analysis of a 30+ year water quality database of conditions at Lake Hopatcong showed that the lake is warming and that the extent and duration of anoxia in the hypolimnion has increased over this period suggesting declining suitability for trout, particularly during that critical July to August period. 2022 was a particularly harsh year with very hot and dry conditions and as a result there were periods where no suitable trout habitat was recorded in the limnetic portions of the lake. 2023 showed better habitat suitability; while conditions were largely warmer than long-term climate averages, the departure was lower than it was in 2022, and the growing season from June onward was historically wet. While habitat compression was observed, at no point was suitable trout habitat absent. This study has also demonstrated that habitat conditions can change very rapidly and the arrival of a cold front or a significant storm event can rapidly cool the water and increase habitat availability.

This analysis will explore in part how these water quality conditions affect trout. This was accomplished by examining the water quality data in conjunction with trout tagging data. The trout tagging study essentially consists of two parts: the spring stocking of tagged trout and an angler creel survey, a good example of a citizens science program. Anglers catching tagged trout were able to self-report their catch through a website at LHCTROUT.com (https://lakehopatcongcommission.org/index.php/lake-hopatcong-trout-habitat-study/) or on paper forms available at Dow's Boat Rental and Lake's End Marina. The forms were able to capture a variety of crucial data including the following:

- Date caught
- Location
- Tag color (indicating stocking cohort, blue for 2022 and silver for 2023)
- Total length
- If the fish was released
- General comments including the depth at which the fish was caught, water temperature, conditions, and other relevant information

These data formed the basis of the analysis and were used to assess holdover trout, angling interest, disposition of fish after capture, and other related metrics. Comparisons to the previous year's data, weather, *in-situ* water and quality will also be made where appropriate.

3.1 GENERAL CAPTURE SUMMARY

In total, 55 trout were reported in 2023. This is a major improvement over the 2022 season when only 14 fish were reported. The difference is related to efforts of the Trout Committee to expand marketing to promote the study and increase awareness among the angling public, a decision that has yielded dividends. Additionally, spring fishing conditions were better overall with more pleasant weather which likely increased overall participation in fishing. This represents an initial capture of 5.5% of the tagged fish. While lower than hoped for, this represents a fair return considering the number of fish stocked and the size of the lake. Unfortunately, all of the reported fish were from the 2023 stocking cohort and there was no carryover fish stocked in 2022. Of the 55 fish, the vast majority were reported as bearing silver tags, consistent with the tag color for 2023, with several close variants like grey. Two were reported as gold; the pictures of these fish were reviewed and the tags indeed had a slight golden tinge but otherwise the stampings were consistent with the 2023 tags. The coloration could reflect some low-level oxidation, loss of plating, or even reflection off the fish which often exhibit a namesake golden-brown coloration.

It is not clear if the final fish reported was tagged but it was included in this dataset. In any case, none of the captured trout bore a 2022 tag. On the limited basis of this study, there has been no evidence of carryover of stocked trout. This is not to say that it has not occurred, but it has not been validated by this study. Certainly, conditions in 2022 were very harsh and the fish likely experienced above-average mortality due to water quality conditions. Better conditions in 2023 will hopefully manifest in improved survival and positive detection of fish in 2024 and potentially beyond; while the term of this study is set for three years, it is encouraged that the creel study be maintained into 2025 to examine the potential of survival of those fish stocked in 2024 as well as the previous two years. A table of summary statistics for the 2023 creel survey is provided below (Table 3.1).

Table 3.1: 2023 Summary Creel Survey Statistics

2023 Summary Creel Survey Statistics	
Fish Reported	54
Percent Captured	5.4%
Capture Date Range	3/31/2023 - 7/7/2023
Reported Size Range	10" - 18"
Anglers Reporting	39
Most Reports Single Angler	6
Fish Released	44
Percent Fish Released	80%
Percent Mortality of Captured Fish	27%
Fish Reported with 2022 Tag	0

In the table above, several of these metrics, namely fish reported, percent captured, and capture of 2022 tagged fish, have been discussed above, while captured date range and reported size range will be explored in subsequent sections. In total, 39 anglers reported catches in 2023, representing nearly a threefold increase relative to the 14 in 2022. Five anglers reported fish in both years. The highest number of reports by a single angler was seven, indicating both a high level of skill and effort spent on the water. In alignment with modern conservation practices adopted by many anglers, 80% of the fish were released. At least 27% of the fish that were not released were done so due to injury to the fish based on self-reporting, but the number is likely higher as this explanation was independently offered in the comments and was not a formal field in the survey. This shows an overwhelming intention to release any captured fish which limits overall recreational mortality.

The hometown for each angler was provided with their tag report. In total, anglers from ten different counties in New Jersey and one angler from New York reported a tagged trout. The New Jersey counties include Morris, Sussex, Warren, Essex, Bergen, Hunterdon, Camden, Passaic, and Somerset. This shows that anglers are traveling from throughout the state to fish for trout in Lake Hopatcong. Thus, the trout fishery certainly has a positive economic impact on Lake Hopatcong and the surrounding communities.

3.2 CAPTURE TIMING

This section will explore some of the aspects regarding the timeline of events and when reported fish were captured. The stocking of 1,000 brown trout, sourced from Musky Trout Hatchery in Warren County, New Jersey was conducted on 26 March 2023. The first report was received just five days later on 31 March 2023. According to the NJDEP New Jersey Freshwater Fishing Digest 2023, Lake Hopatcong has no closed trout season, and remained open to fishing from 20 March through 8 April, the opening day of the season, although all fish caught in that window must be immediately released. As such, the first week post-stocking showed low returns (Figure 3.1).

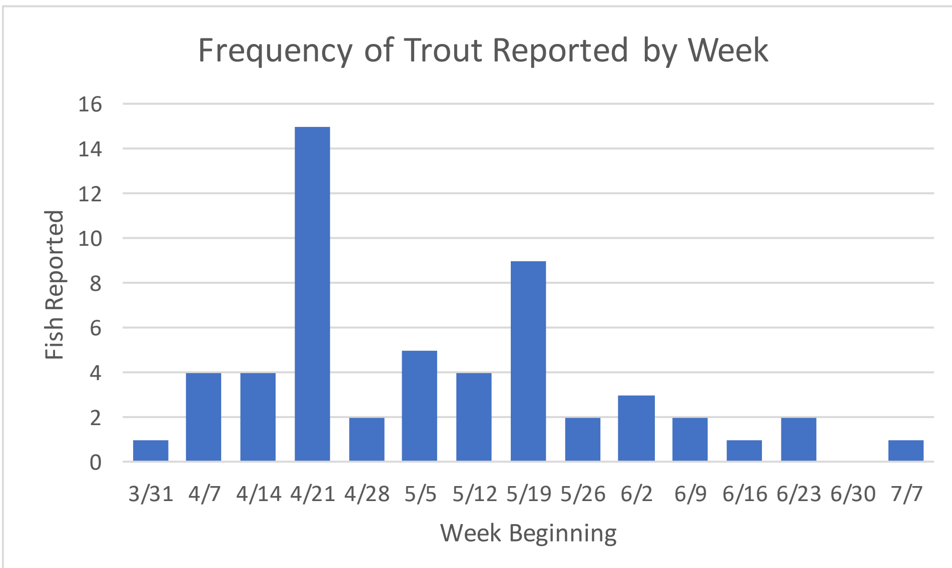


Figure 3.1: Frequency of Trout Reported by Week

Reports increased starting the week of 7 April including opening day on Saturday 8 April. The week of 21 April showed the highest reporting throughout the study with 15 fish. This coincided with the Knee Deep Trout Contest, a popular event, held on Sunday, 23 April. Besides the higher number of anglers specifically targeting trout, seasonality is likely a factor. Trout are coldwater fishes and need lower water temperatures than many fish common to lakes in the region, but like all ectothermic (cold-blooded) organisms, activity levels tend to rise with temperature to an inflection point before starting to wane. As such, warming temperatures likely increased trout activity and feeding. Creel survey reporting shows that water temperatures were at or below 50°F around opening day but had increased to between 55°F and 58°F during the week of 21 April, much nearer to optimum temperatures.

Following this seasonal maximum, catch rates decreased. This is likely due to decreased participation following the contest and rainy conditions extending into early May. Once weather stabilized, catches increased, including 9 fish reported the week of 19 May. This may reflect increased angling pressure coincident with the Knee Deep Club Panfish Challenge held 21 May.

Catch rates declined remarkedly after this and no more than 3 fish were captured in any week subsequent. The final fish was captured on 7 July. A number of factors likely worked in conjunction to cause catch rates to fall off. First, environmental conditions are likely a significant factor. At the Mid-Lake station, the surface temperature on 11 May was 16.8 °C (62.3°F) and had risen to 20.0 °C (68.0°C) by 13 June. While this temperature is well within the range to support trout it also marks a point where activity levels are starting to wane. By July, the surface temperature at the Mid-Lake station had soared to 26.5 °C (79.7°F) on 24 July and some level of mortality was likely experienced. Second, while reported catch rates were low, undoubtedly there is a higher proportion of fish that went unreported and were removed. Combined with other mortalities, like predation by birds and fish, the overall population was likely shrinking. Finally, many trout were likely actively seeking refuge habitat, be it a compressed layer in the water column, moving to cooler and more oxygenated waters in shoreline refugia or in tributaries, or passing downstream into the Musconetcong River

3.3 LENGTH METRICS

One of the central questions of the study was whether the stocking of larger trout would result in better survivability and improved holdover populations. There are a number of reasons why larger trout are better suited to withstand harsh environmental conditions. One of the primary ones involves body mass and energy storage. As temperatures increase feeding activity is often suspended and fish go into a state of catabolism where energy is produced by the breakdown of body tissues including fat stores rather than gained externally through feeding. Larger fish have both more body mass and higher lipid content that enable them to survive this stressor for a longer time relative to smaller fish. For this reason, and others, it is instructive to analyze total length.

As noted in Table 3.1, reported lengths ranged from 10 in to 18 in. The raw data was corrected mostly to convert the text strings with unusual characters into numeric values. Fish lacking values were estimated based on provided pictures where appropriate. The most significant change was the downsizing of the 18 in. fish to 14 in. The report noted that it was not an exact measurement; examination of the accompanying photograph showed the fish was similar in size to the other trout captured which were known to be largely between 12 in and 14 in, and thus was set at 14 in. In general, the length reports matched closely with the specified stocking range although approximately 15% of the fish were below 12 in.

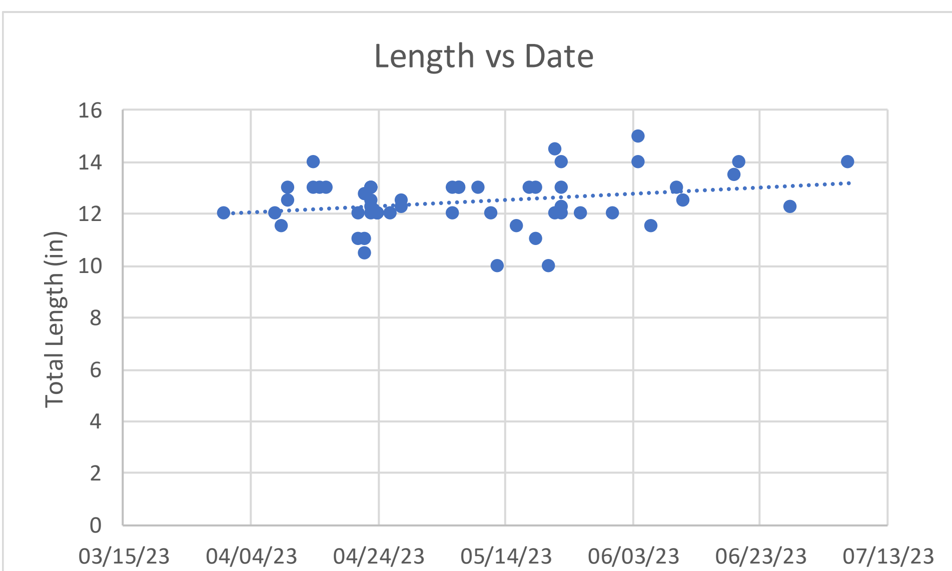


Figure 3.2: Length vs Date Caught

The length of each fish was plotted against the day on which it was caught (Figure 3.2). Overall, there is a weak but distinct trend that emerges. A linear regression of the data showed the total length of reported fish increased throughout the period of record. There are two possible explanations for this trend. First, the increase in size is likely related to normal growth of the fish; as a eutrophic waterbody, Lake Hopatcong has a high biomass of forage items including baitfish like alewife and golden shiner as well as insects like midges which could sustain rapid trout growth. Growth would be expected to be highest in the spring and fall periods when activity and feeding levels are high. During the summer, high temperatures and low DO would be expected to decrease foraging as would cold temperatures during the winter months. The second explanation is the preferential survival of larger fish during the period when high temperatures and low DO levels would begin to increase mortality in trout, particularly in smaller fish, as expressed along a length spectrum. The effect is subtle and both explanations are likely working in tandem. While the sample size is insufficient to definitively state the validity of the increasing size trend, the effect is likely real.

3.4 DEPTH ANALYSIS

Many of the respondents included depth information in their reports; in total 25 reports, 46% of the dataset, included depth information. In some cases, the total depth of the water column was reported, in others the depth at which the fish was hooked is identified, and some included both. Several stations included location information from which the depth of the site could be inferred based on the bathymetry of the lake. As such, this is somewhat of a mixed dataset and includes some assumptions with a bias towards an estimated depth at which the fish was hooked, nonetheless, some interesting results were produced.

Figure 3.3 plots the depth data against the date at which the fish was caught. During the early part of the study, primarily April, fish were found throughout water column, from 3 ft to 35 ft. By May, the utilized range began to compress and fish were found in 8 ft to 28 ft. By June the band was narrower, extending from 12 ft to 20 ft. The last reported fish, caught 7 July, was reported at 12 ft. This very neatly meshes with trout habitat boundaries as depicted above in Figure 2.15 Trout Habitat Boundaries, Figure 2.16 Trout Habitat Extent, and Figure 2.17 Trout Habitat Availability Isopleth. All fish were captured well inside these projected boundaries and shows that fish move deeper to avoid warm waters near the surface and move upward from the hypolimnion to avoid hypoxia.

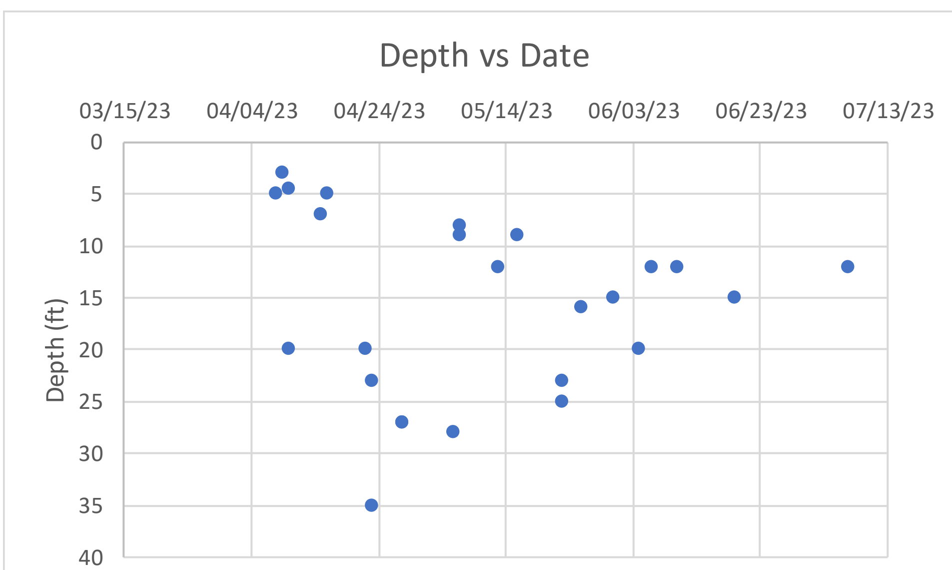


Figure 3.3: Depth vs Date Caught

This plot also includes an added element, a time shift in which trout moved within the defined bounds up to several weeks in advance of the designation of habitat boundaries as based on measured water quality. The defined habitat bounds are marginal and represent extremes outside of which the risk of mortality increases with chronic departure from those boundaries, either with higher temperatures or lower dissolved oxygen. As such, preferred or core habitat nearer to life history requirements of greater suitability are preferentially utilized; stated differently, trout will avoid those extreme boundary conditions where possible in seeking suitable habitat. These data validate the models of carryover habitat utilized for this project. It demonstrates that there is a real effect in habitat utilization of trout seeking and occupying cool waters with adequate oxygenation. It also suggests that extreme compression of available habitat in the summer is an issue that likely impacts long-term survival.

3.5 SUMMARY

Overall, the results of the stocking program and paired creel survey in 2023 were considerably better than 2022. Efforts to publicize the study and more favorable angling conditions resulted in increased participation and reporting. In total, 55 fish were reported, all stocked in 2023. While this is a favorable capture of fish, no carryover trout stocked in 2022 were reported. At a minimum, this suggests that carryover of trout, even larger brown trout used in this study, is limited. Environmental conditions are obviously a major factor in this result, likely the controlling factor, but loss to predation, recreational take, and movement around the lake and potentially passage out of the lake into tributaries or downstream loss to the Musconetcong River must also be considered as complicating factors. The five-year, five foot drawdown occurred beginning in September 2023, and it is possible that stocked trout moved downstream during this event, although the effects would not be reflected in the 2023 data.

This larger dataset, including more complete answering of survey questions, produced sufficient data to promote a deeper analysis of this project. 39 different anglers reported fish and 80% of captured trout were released. Reporting remained low in the first two weeks after stocking but reports quickly peaked due to increased foraging levels as a result of warming temperatures and rates of participation in the trout contest. A secondary peak was observed in mid-May after which reporting rapidly fell correlating to decreasing water quality conditions as it relates to the needs of trout and their ability to actively forage.

An analysis of length indicated that the size of fish increased moving through the study. Because reports were limited to a period of little more than three months the trend is slight, but likely indicates both the growth of stocked fish and improved survivability among the larger individuals.

Lastly, depth data indicate that trout remain within the habitat bounds defined by this project. As a result, when water quality conditions were good in the early part of the growing season with low water temperatures and high DO concentrations, trout were found throughout most of the water column from the surface to at least 35 ft. As the season progressed and water temperatures warmed at the surface and the hypolimnion began to go anoxic the trout appeared to move to a narrower band with suitable conditions. This band continued to shrink vertically from both the lower and upper bounds through the end of the reporting period reaching its minimal thickness during the last report. The trout all appeared to stay within the defined bounds and also avoided the bounds when possible, moving toward higher suitability core habitats in the water column.

To date, no carryover trout have been identified in this study. There is however an increased expectation that carryover trout will be observed in 2024, and in 2025 if recommendations to extend the creel survey element of the study are adopted, due to improved water quality conditions in 2023. While compression of available trout habitat was observed in 2023, this habitat persisted throughout the summer and likely provided sufficient refuge to limit heat and oxygen stress related mortality. This was not the case in 2022 in which there were periods when no suitable trout habitat was documented and likely led to higher rates of summer mortality. Combined with higher levels of participation, the chance of carryover trout is much higher. With this hopeful prediction, it must also be recognized that water quality conditions can be harsh and year-to-year rates of survival are likely strongly correlated to the climatic conditions of the preceding summer. The continued warming of the lake and expansion of the anoxic zone in volume and duration also suggests that efforts to address suitability for trout focus on controlling temperature and improving deepwater oxygen concentrations. The identification of more refuge habitat, including at the tributary mouths and some nearshore areas in 2023 when the streams were flowing, is also a positive sign and identifies a target at those sites for protection and restoration.

4.0 PRIORITIZATION OF WATERSHED LOCATIONS TO PRESERVE VITAL TROUT HABITAT

One of the major goals of this study is the identification of potential locations in the watershed that can be preserved and/or enhanced to protect near-shore and stream habitat that may be providing refuge to brown trout during the critical summer period. Unfortunately, much of the Lake Hopatcong shoreline is either private residential or commercial land and/or bulkhead rather than naturalized shoreline. However, given the extensive length of the shoreline, there are still a number of locations in the immediate watershed that can be preserved or enhanced.

A revised Watershed Implementation Plan (WIP) for the Upper Musconetcong River Watershed, which includes Lake Hopatcong, was recently updated. This document outlines 52 sites throughout the watershed that can be enhanced to improve water quality conditions in Lake Hopatcong. These sites include areas that can accommodate stormwater best management practices (BMPs), in addition to shoreline sites directly on Lake Hopatcong, as well as stream and riparian sites. This section will provide an overview of a few select sites as they are related to preserving or enhancing some of the near-shore and stream sites that were sampled in 2022 and 2023 and deemed as potential trout refuge habitat. Additional sites will be listed if applicable. Finally, a few general stormwater management recommendations will be included at the end.

Any stormwater related sites included for enhancement will be mostly focused on green infrastructure. Green infrastructure refers to natural and engineered ecological systems that treat stormwater in a way that mimics natural processes; e.g. bioretention systems or rain gardens that receive stormwater and sequester nutrients. Thermal pollution is the primary threat to carryover trout habitat in the epilimnion of Lake Hopatcong. Associated with increased temperatures is a decrease in DO concentration, as warmer water has reduced capacity to store oxygen. Metabolic rates also increase with warmer temperatures, resulting in an increased biological oxygen demand (BOD). Thus, implementing green infrastructure practices such as bioretention systems, wetlands, filter strips, riparian and shoreline buffers, and native plantings in general will help alleviate the thermal pollution that's occurring as a result the warming ambient temperatures in conjunction with an increase in impervious surface throughout the watershed.

4.1 WATERSHED, STREAM, AND SHORELINE LOCATIONS FOR ENHANCEMENT

4.1.1 SITE ONE: MEMORIAL POND

Memorial Pond is located at the southern end of Memorial Park, at the corner of N. Glen Avenue and Mountainview Avenue. The pond is located between stream sampling stations S-1 and S-2. This pond receives stormwater runoff, both surface and subsurface, from the entire sub-watershed upgradient of the pond before discharging into Glen Brook. From the outlet of the pond, Glen Brook runs through Memorial Park, under Altenbrand Avenue, and continues along before discharging into the swim area through an outfall.

The water temperature at S-1 was measured to be 5.6 °C cooler than the Mid-Lake station in July and 5.0 °C cooler in August. The water temperature at S-2, located further downstream, just before Glen Brook discharges into Lake Hopatcong, was measured to be 4.9 °C cooler than the Mid-Lake station in July and 4.8 °C cooler in August. Thus, although the water remains significantly cooler than the Mid-Lake station downstream, the water does warm slightly. Memorial Pond acts as a settling pond, removing sediment and nutrients before discharging downstream. While this is an important service for the overall management of Lake Hopatcong, the increased retention time in the pond increases the temperature of the water.

This site was previously identified in the 2022 Restoration Plan for the Mount Arlington Municipal Beach as lacking a sufficient shoreline buffer. Of particular emphasis was the steep bank along the southwest shoreline that lacked vegetation and was exhibiting signs of erosion. Following the Restoration Plan, the LHC received an NJDEP 319 grant to address the southwest shoreline. Approximately 2,800 square feet of shoreline and adjacent bank was planted with native herbaceous and woody plant material in July 2023. The use of native plants enhances the ecological value of the site, reduces vulnerability of the shoreline to future erosion and invasive species establishment, and will provide shade over a portion of the pond. Thus, this project will help to keep the pond cooler in the future.

Memorial Pond was also identified as an ideal candidate for the installation of floating wetland islands (FWIs). FWIs provide a natural method of removing nutrients from the water column, improving water quality downstream. These ponds would also provide additional shading in Memorial Pond, potentially reducing water temperatures that are discharged into Glen Brook and eventually Lake Hopatcong. FWIs were recently installed in Landing Channel and Ashley Cove, two locations in Lake Hopatcong, with funds from various NJDEP grants.

Photos 4.1 – 4.2: Memorial Pond shoreline at the end of the planting day in July 2023 (left) and a mature floating wetland island (right)

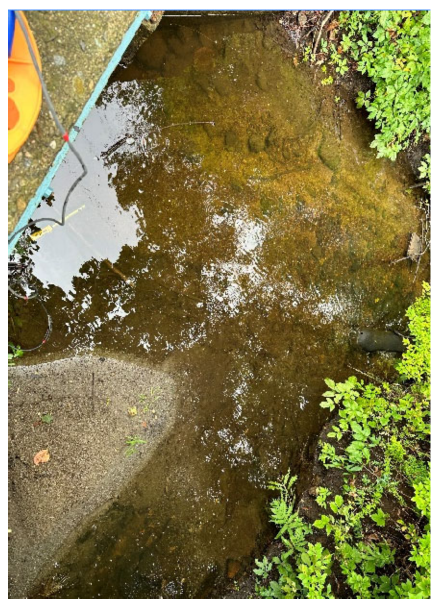
4.1.2 SITE TWO: HOWARD BLVD CULVERT (S-3)

S-3 was sampled in an unnamed tributary in front of Edith M. Decker Elementary School and the water temperatures were 6.9 °C cooler than the Mid-Lake station in July and 5.3 °C cooler in August. Water just upstream of the culvert was observed to be stagnant in July and had minimal flow in August despite the wet summer and rain prior to each sampling event. It is possible that the stagnant water was due to the extremely high lake level (9.6 feet at the time of sampling) following the 3.6-inch rainstorm on 9 July. The water depth was similar on 14 August but water was flowing slowly through the culvert; the lake level was lower on 14 August and was approximately 9.1 feet. The nearshore area of the lake in Lee's Cove where S-3 discharges was sampled on 5 July. The submerged pipe that flow from S-3 discharges through could not be located but the entire stretch of shoreline was monitored with the water quality meter and no sources of significantly cooler water were located.

Additionally, a large delta of sediment and/or road grit had accumulated adjacent to the culvert in August. The source of the sediment accumulation is a smaller pipe next to the culvert that drains a portion of the surrounding road. The accumulated sediment was not as visible during the July sampling event and it is possible that this delta grew as the summer progressed from all of the rain.

Based on the sediment accumulation observed in August and the lack of sediment accumulation following the 3.6 inch rainstorm on 9 July, it is possible that the July storm washed any accumulated sediment downstream through the culvert. Sediment accumulation within the pipe, or near the outlet to Lake Hopatcong, could explain why there was barely any flow in July and a low flow in August. It is also possible that the outlet in Lee's Cove was not identified during the nearshore sampling because of potential sediment accumulation.

Moving forward, it is important that the section of the tributary just upstream of the culvert, as well as any catch basins that drain to this culvert, are periodically inspected and cleaned out to prevent additional sediment accumulation. Additionally, it is recommended that the pipe downstream of the culvert be inspected to determine if sediment has accumulated in the pipe and is preventing the normal water flow. This tributary has been identified over the past two years as a source of significantly cooler water that could benefit carryover trout habitat in the nearshore area around Lee's Cove but flow must be maintained.



Photos 4.3 – 4.4: Culvert at the S-3 stream in July (left) and August (right) with significant sediment accumulation

4.1.3 SITE THREE: EAST SHORE PARK STREAM (S-11)

A small un-named stream passes through East Shore Park before traveling through a culvert under East Shore Road and into Lake Hopatcong. During the initial site visit in 2019 during the preparation of the WIP, the entire left bank located on the park side lacked a vegetated buffer (Photo 4.5). The stream had low flow during the site visit but there was an excessive amount of sedimentation occurring just upstream of the culvert. The sediment accumulation was sufficient in the center of the stream to support the growth of phragmites (*Phragmites australis*). There was a 30-foot stretch along the lower right bank that was eroding and was the likely source of sedimentation; the sediment was loose there and lacked any vegetation or toe protection.

During the July and August stream sampling events in 2023, the phragmites growth had increased significantly. While the phragmites was providing shade over the stream, it appeared to grow mostly out of the streambed and was extremely dense in areas. The stream would likely benefit from the removal of the phragmites from the streambed and the establishment of a vegetated buffer with native plant species that will not grow as aggressively.

Nearshore station 35 is located just south of Brady Bridge where the small cove that receives flow from this tributary mixes with the main body of Lake Hopatcong. Surface temperatures were warmer than the Mid-Lake station surface temperatures on 17 July but the temperature at a depth of 1.60 m was 2.6 °C cooler. Thus, this tributary may be providing a minor subsurface cooling effect to this section of the lake and should be maintained and/or enhanced.


Photos 4.5 – 4.6: Downstream view of the S-11 tributary in August 2019 (left) and July 2023 (right)

4.1.4 SITE FOUR: LAKESIDE FIELDS PARKING LOT

The parking lot at Lakeside Fields has multiple catch basins and curbside storm drains that capture the runoff from the parking lot. Currently, runoff from the impervious parking lot flows into a small creek which then flows directly into Lake Hopatcong in proximity to the Jefferson Canals. This project site has been identified as a priority for implementation in the Upper Musconetcong River WIP.

Nearshore sites 37 – 39 are located where the flow from this inlet stream and the Jefferson Canals mixes with the main body of Lake Hopatcong. These sites were sampled on 17 July and were all over 2.0 °C cooler than the Mid-Lake station below the surface. Stormwater that falls on the impervious Lakeside Fields parking lots will be heated before draining to the creek. The area of Lake Hopatcong in proximity to nearshore sites 37 – 39 has proven to be slightly cooler than the limnetic portion of the lake, and addressing the impervious surface at the Lakeside Fields sports complex will serve to preserve or enhance the cooler water in the northern end of Lake Hopatcong.

The proposed recommendation at this site is the installation of a biofiltration basin in the large parking lot at Lakeside Fields (drainage area of 215,582 sq ft). This project is estimated to remove 3 lbs of TP per year, which has the potential to prevent the production of over 3,330 lbs of wet algae biomass and will also remove approximately 315 lbs of TSS per year. In addition to removing pollutants, the biofiltration basin will promote groundwater recharge and reduce the volume of warmer stormwater entering Lake Hopatcong.

The LHF was awarded funds under the 2022 NJDEP Stormwater Management Grant to implement this project.

Photos 4.7 – 4.8: Lakeside Fields parking lots that drain to Lake Hopatcong

4.1.5 SITE FIVE: WITTEN PARK DRAINAGE STREAM

There is a drainage stream located in Witten Park that receives runoff from the surrounding neighborhood through four outfall pipes before discharging into Byram Bay. This project site has been identified as a priority for implementation in the Upper Musconetcong River WIP. Following the completion of the WIP, this site was awarded funds from a 2021 National Fish and Wildlife Foundation (NFWF) – Delaware Watershed Conservation Fund Grant for the design of a regenerative stormwater conveyance system (RSCS); all permitting efforts were also included under this grant. The first phase of the project is almost complete, and the LHC will be applying for additional funds through a 2024 NFWF – Delaware Watershed Conservation Fund Grant for the implementation of the RSCS.

This site was identified as a high priority due to the extensive erosion that was observed along both banks during the initial site visit in 2019, including bank scouring and severe undercutting. Both streambanks were void of any vegetation along the entire reach, and the entire park was comprised of mostly loose dirt and gravel. Tree roots were visible along both banks down the entire stream reach, and there was sediment accumulating in multiple locations. The two main outfall pipes are located at a higher elevation than the stream, and the water travels down scattered rocks before entering the main channel. This stream typically maintains low flow throughout the year but is subject to extremely high flow during and following rain events.

In its current state, the drainage stream is a significant source of sediment loading to Lake Hopatcong due to the lack of riparian vegetation and the steep grade from the outfall pipes to the lake. However, the proposed RSCS will be designed with a series of riffles, pools, native vegetation, and underlying sand and woodchip media. The RSCS will be hydraulically linked to an adjacent wetland area and would be designed to treat, detain, and convey stormwater in a more controlled manner. In addition, riffles, pools, and native vegetation will provide habitat for a variety of macroinvertebrates and small fish. Incorporating all of these features will provide more shade to the stream and reduce the amount of erosion entering Lake Hopatcong, which could result in cooler water temperatures. Increased turbidity, which occurs from the streambank erosion, results in increased heat adsorption.


Photos 4.9 – 4.10: Upstream view of the main outfall pipe (left) and downstream view of the drainage stream (right) in Witten Park

4.1.6 SITE SIX: LAKE HOPATCONG SHORELINE ALONG SIERRA ROAD

This stretch of shoreline runs parallel to Sierra Road, and the lake is only separated from the road by a small gravel parking lot. The shoreline here lacks any type of vegetative buffer that would filter stormwater runoff from Sierra Road. The parking lot between Sierra Road and the lake slopes down towards the lake, likely increasing the rate of stormwater flow from Sierra Road. The installation of a native shoreline buffer here would help to absorb stormwater flow, resulting in increased infiltration and filtration of pollutants, including thermal pollution.

Photos 4.11 – 4.12: Lack of shoreline buffer along Sierra Road in proximity to nearshore site 38

4.2 GENERAL STORMWATER MANAGEMENT RECOMMENDATIONS

This section outlines general stormwater management measures that can be implemented throughout the watershed. Some of these general recommendations can be implemented as small-scale efforts on residential property. Although these are mostly small scale measures, they all reduce the volume of stormwater runoff entering Lake Hopatcong and have the potential to promote groundwater recharge thus providing a cooling effect to the water entering the lake.

4.2.1 DOWNSPOUT DISCONNECTION

Downspout disconnection is a simple practice that involves the rerouting of rooftop drainage pipes (gutter downspouts) from draining to an impervious surface that drains directly to the stormwater sewer, to draining rainwater into rain barrels, cisterns, or other permeable areas such as grassy or vegetated areas. It is important to divert the rainwater away from the foundation of a house, especially if there is a basement or crawlspace.

Photo 4.13: Downspout Disconnection, Source: USEPA

4.2.2 RAINWATER HARVESTING

Rainwater harvesting is one of the easiest and cheapest methods of managing stormwater runoff from impervious roofs. Rainwater harvesting simply involves capturing runoff from the gutter downspout of a roof and temporarily storing it in a container. Harvesting stormwater from the gutter downspout reduces the erosive force that occurs when the downspout drains directly to the ground. The rain barrel overflow can be directed to vegetated areas to allow for infiltration into the soil rather than draining directly to an impervious surface. The harvested rainwater is also an ideal source of irrigation for gardening or lawn maintenance.

For a small roof such as a house, a rain barrel is the ideal container for rainwater harvesting. Rain barrels are typically 55-gallon drums but can be purchased or built to accommodate larger volumes. Additionally, multiple rain barrels can be connected with hoses for increased storage capacity. There are countless resources on how to build and install a rain barrel at home and can cost from around $30 - $300 or more, depending on availability of the materials. Rutgers has a number of websites dedicated to rain barrels, including on how to build one (E329: Rain Barrels Part I: How to Build a Rain Barrel (Rutgers NJAES)).

For commercial rooftops or any rooftop with a large surface area, cisterns and dry wells are superior to rain barrels for rainwater harvesting. Cisterns are used for larger rooftops and can capture and store between 100 and 10,000 gallons of runoff. Drywells are small, subsurface detention basins that collect stormwater runoff from smaller drainage areas. Water collected by drywells slowly infiltrates into the ground to contribute to recharge. Generally, the costs for cisterns and dry wells can range anywhere from $150 - $700+ for units <500 gallons to $500 - $3000+ for units >500 gallons ($3000+ for a sub-surface, 800 gallon two-tank unit). Costs will vary greatly depending on size, number of downspouts, above ground or below ground, etc. and do not include design and installation.


Photos 4.14 – 4.15: Rain barrel (left) and cistern (right), Sources: CT DEEP (left) and USEPA (right)

DOWNSPOUT PLANTERS

Downspout planters or planter boxes are small structures that contain an engineered soil/gravel mix and native vegetation that enhance stormwater infiltration and nutrient removal. They are essentially small-scale rain gardens and can create the visual appeal of standard landscape planters with an enhanced ability for infiltration and nutrient removal. These systems are placed directly adjacent to a building, similar to a rain-barrel, where rainwater from the roof of a structure flows into the structure through the gutter downspout. Similar to a rain garden, these systems can be designed with an underdrain pipe or they can be designed to infiltrate into the subsoil.

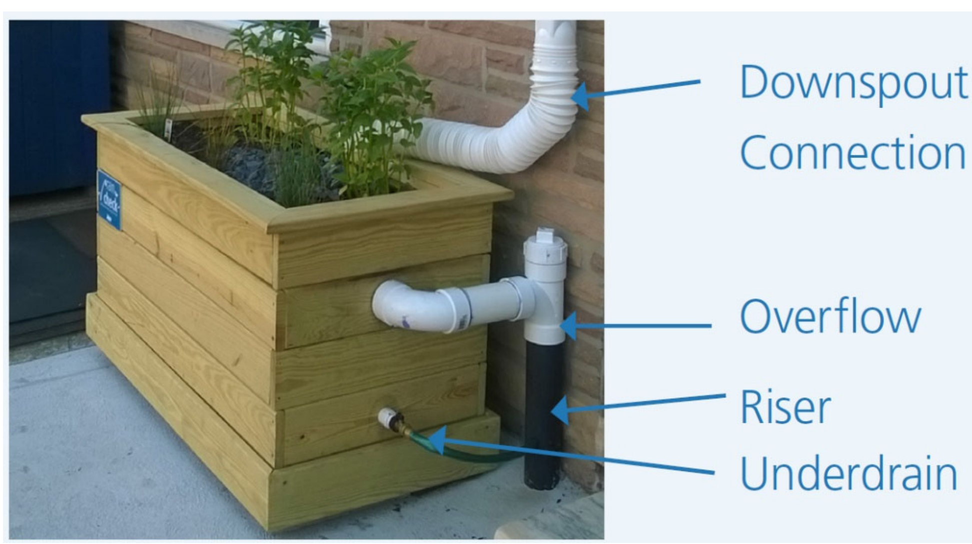


Photo 4.16: Downspout planter, Source: Phillywatersheds.org

GREEN ROOF

Green roofs are roofing surfaces that are partly or completely covered with vegetation. Green roofs provide stormwater management by slowing down rainfall and by allowing a portion of the precipitation to be returned to the atmosphere through evapotranspiration. Green roofs have been shown to hold a significant amount of the rainfall that reaches their surface in the summer. Green roofs decrease stress on storm sewer systems by retaining and delaying the release of stormwater.

A professional company can install a green roof, typically for approximately $10 to $40 per square foot. Note, site specific issues or constraints may result in additional costs in the installation; considerations include roof loading, accessibility for maintenance, the height and the pitch of the roof, and maintenance budgets. Such considerations often necessitate the need for professional installation. An extensive green rooftop is one that is limited to grasses and mosses and has a shallow substrate (< 4”).

Photo 4.17: Green Roof, Source: New Jersey Future

CURB BUMPOUT

Curb bumpouts are relatively small extensions of the curb that extend into the roadway. These areas are designed in a similar fashion to rain gardens, with a bottom layer of gravel or stone, followed by soil and native plants. They are designed with inlets and/or curb-cuts along the street and/or sidewalk that directs stormwater runoff into the system. In addition to improving stormwater management in the community through enhanced infiltration and filtration of nutrients and other pollutants, they improve the appearance of the community. They can also be strategically placed at intersections to help slow traffic and improve pedestrian safety.

Photo 4.18: Curb bumpout, Source: Phillywatersheds.org

STORMWATER PLANTER

Stormwater planters are a type of linear bioretention system often used in urban areas. However, they can also be used in residential neighborhoods when space is limited for larger green infrastructure practices, such as bioswales. Stormwater planters are rectangular structures, usually with four concrete curbs around the perimeter. They are vegetated structures that are often installed within an existing sidewalk, between the walkway and the road. They are designed to receive stormwater runoff from both the road and the sidewalk through curb cuts and drains. They are similar to curb bumpouts and other bioretention systems in that they incorporate gravel or stone, soil, and native plants to enhance stormwater infiltration and nutrient filtration. Wherever possible, these systems are designed to infiltrate water into the subsoil; however, they can also be designed with an outlet structure that conveys the stormwater back to the existing subsurface stormwater system. The latter type of system is only recommended when the soil is not suitable for proper infiltration.

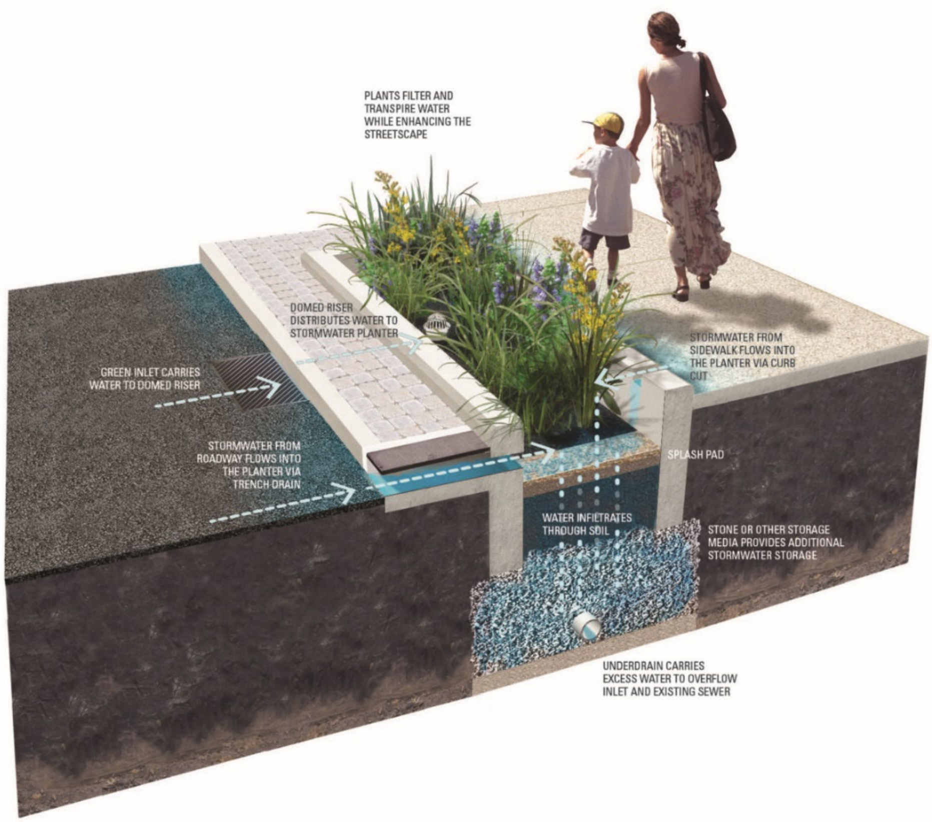


Photo 4.19: Stormwater Planter, Source: Philadelphia Water Department

TREE BOXES

Tree boxes are manufactured treatment devices that incorporate soil and vegetation, classifying them as a form of green infrastructure. These devices are large concrete boxes that incorporate a specialized soil media and a tree. They are often installed along a curb, similar to a curbside catch basin, and allow for high volume/flow treatment in a compact system. Unlike a standard bioretention system, they do not result in volume reduction; however, they do provide pollutant removal. There are a number of tree boxes that have been installed throughout the Lake Hopatcong watershed.

Photo 4.20: Tree Box, Source: Contech

APPENDIX I: MAPS

APPENDIX II: LIMNETIC *IN-SITU* DATA

Lake Hopatcong *In-Situ* Monitoring Data 2023.05.11

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
STA-1	2.30	1.80	0.1	18.49	426.0	11.27	123.8	8.58
			1.0	18.33	428.0	11.55	126.1	8.51
			2.0	17.31	429.0	10.87	115.5	7.99
STA-2	14.20	1.50	0.1	16.81	441.0	11.99	126.7	8.79
			1.0	16.83	441.0	12.10	127.8	8.78
			2.0	16.16	437.0	12.00	124.4	8.72
			3.0	15.29	440.0	11.30	115.5	8.39
			4.0	14.47	449.0	10.68	107.0	8.12
			5.0	13.58	446.0	9.97	98.1	7.87
			6.0	12.13	455.0	8.72	82.8	7.56
			7.0	11.83	458.0	8.29	78.5	7.36
			8.0	11.58	459.0	7.86	74.0	7.23
			9.0	11.20	458.0	6.94	64.5	7.10
			10.0	10.61	460.0	5.91	54.4	6.98
			11.0	9.94	462.0	4.66	42.2	6.85
			12.0	9.45	462.0	4.36	39.0	6.80
			13.0	9.14	464.0	3.65	32.4	6.74
			14.0	8.84	467.0	2.41	20.9	6.65
STA-3	2.30	1.70	0.1	17.89	761.0	13.81	149.6	9.13
			1.0	17.24	740.0	13.81	147.4	9.06
			2.0	16.80	755.0	13.54	143.0	8.98
STA-4	3.20	1.10	0.1	17.72	448.0	13.32	143.4	9.32
			1.0	17.70	447.0	13.39	144.1	9.33
			2.0	16.26	444.0	12.67	132.2	9.04
			3.0	13.05	467.0	3.36	32.7	7.66
STA-5	2.60	1.50	0.1	17.72	450.0	13.92	140.6	9.61
			1.0	17.27	447.0	14.44	153.9	9.67
			2.0	13.89	458.0	10.31	102.3	8.29
STA-6	3.00	1.90	0.1	16.47	438.0	11.35	119.3	8.35
			1.0	15.72	440.0	11.44	117.8	8.09
			2.0	15.30	442.0	11.44	117.3	8.02
			2.5	14.86	445.0	10.75	109.2	7.81
STA-7	1.80	1.60	0.1	18.69	151.0	8.83	97.1	7.81
			1.0	18.23	184.0	8.69	94.4	7.61
			1.5	17.73	183.0	8.49	91.3	7.47
STA-8	5.50	1.50	0.1	16.89	431.0	11.38	120.7	8.60
			1.0	16.56	433.0	11.54	121.2	8.54
			2.0	16.31	431.0	11.56	120.9	8.53
			3.0	16.24	432.0	11.51	120.0	8.43
			4.0	15.97	433.0	11.25	116.8	8.25
			5.0	15.18	437.0	10.68	109.0	8.00
STA-9	8.00	1.40	0.1	16.84	447.0	11.39	120.5	8.95
			1.0	15.55	447.0	11.67	120.1	8.08
			2.0	14.83	447.0	11.49	116.3	7.93
			3.0	14.41	448.0	11.27	113.9	7.74
			4.0	14.05	448.0	10.85	108.2	7.58
			5.0	13.81	451.0	10.43	103.2	7.45
			6.0	13.54	454.0	10.04	99.0	7.35
			7.0	12.44	453.0	8.67	83.3	7.13
			7.5	11.64	461.0	5.00	47.4	6.96
STA-10	1.30	1.30	0.1	18.11	475.0	14.51	158.6	8.88
			1.0	17.39	477.0	18.88	201.6	9.14
STA-11	1.20	1.20	0.1	18.22	147.0	8.88	96.5	7.51
			1.0	17.42	152.0	8.67	92.8	7.38
STA-12	2.00	1.40	0.1	18.67	469.0	11.76	129.2	9.36
			1.0	18.53	469.0	11.58	126.7	9.34
			1.5	18.41	469.0	11.44	125.0	9.34

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.06.13

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
STA-1	2.30	1.10	0.1	21.02	440.0	8.78	102.4	7.58
			1.0	20.86	441.0	8.69	101.2	7.65
			1.5	20.72	442.0	8.58	99.6	7.88
STA-2	14.20	1.20	0.1	19.99	464.0	9.25	105.9	8.01
			1.0	19.97	463.0	9.24	105.8	8.04
			2.0	19.90	464.0	9.21	105.1	8.03
			3.0	19.77	465.0	9.07	103.8	7.96
			4.0	19.69	465.0	8.80	99.9	7.89
			5.0	19.65	465.0	8.62	98.0	7.82
			6.0	19.11	465.0	7.79	87.6	7.66
			7.0	17.40	459.0	4.93	53.6	7.36
			8.0	15.85	453.0	2.63	27.0	7.18
			9.0	12.97	457.0	0.63	6.2	7.03
			10.0	12.14	459.0	0.24	2.2	6.85
			11.0	11.38	464.0	0.06	0.5	6.68
			12.0	10.55	472.0	0.01	0.0	6.61
			13.0	9.95	480.0	0.00	0.0	6.55
			13.5	9.94	488.0	0.00	0.0	6.84
STA-3	2.30	1.00	0.1	21.80	714.0	8.46	99.2	7.52
			1.0	21.20	714.0	8.10	95.0	7.61
			2.0	20.98	672.0	7.71	90.0	7.60
STA-4	3.20	0.80	0.1	20.32	477.0	8.16	94.0	7.36
			1.0	20.40	475.0	7.92	91.4	7.40
			2.0	30.36	475.0	7.78	89.7	7.44
			2.5	20.30	476.0	7.32	84.3	7.37
STA-5	3.20	0.75	0.1	21.53	497.0	8.65	101.2	7.28
			1.0	21.30	496.0	8.25	96.1	7.38
			2.0	21.12	496.0	7.50	87.7	7.41
			3.0	20.85	499.0	6.03	70.1	7.32
STA-6	3.20	1.20	0.1	20.96	463.0	8.89	103.7	7.47
			1.0	20.70	461.0	8.92	103.5	7.60
			2.0	20.26	462.0	8.44	97.1	7.63
			3.0	18.98	460.0	7.15	79.5	7.51
STA-7	1.80	1.50	0.1	21.48	397.0	7.50	88.4	7.49
			1.0	21.47	396.0	6.91	81.2	7.42
			1.5	21.31	396.0	6.52	76.6	7.39
STA-8	5.50	1.30	0.1	19.93	463.0	9.25	105.6	8.00
			1.0	19.92	463.0	9.24	105.5	8.02
			2.0	19.90	463.0	9.21	105.1	8.04
			3.0	19.89	463.0	9.17	104.7	8.04
			4.0	19.89	463.0	9.15	104.4	8.04
			5.0	19.78	463.0	9.10	103.7	8.01
STA-9	8.00	1.30	0.1	20.44	464.0	9.75	112.7	8.12
			1.0	20.44	464.0	9.81	113.4	8.21
			2.0	20.40	463.0	9.79	112.9	8.19
			3.0	20.20	462.0	9.28	106.1	8.03
			4.0	18.50	458.0	6.89	76.4	7.76
			5.0	16.38	457.0	2.79	29.6	7.35
			6.0	14.25	459.0	0.85	8.6	7.14
			7.0	13.16	464.0	0.33	3.0	7.01
			7.5	12.30	471.0	0.13	1.2	6.85
STA-10	1.30	0.70	0.1	21.46	509.0	7.45	87.2	7.60
			1.0	21.17	499.0	7.90	92.5	7.85
STA-11	1.20	1.10	0.1	20.83	318.0	7.41	84.9	7.50
			1.0	20.37	331.0	6.68	76.6	7.31
STA-12	2.00	0.75	0.1	20.52	502.0	6.93	80.2	7.30
			1.0	20.47	498.0	6.93	80.2	7.32
			1.5	20.50	500.0	6.67	77.1	7.30

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.07.05

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.5	1.4	0.2	26.89	447.9	8.87	114.5	7.92
			1.0	26.18	447.6	9.07	115.6	7.98
			1.3	25.90	447.6	9.15	115.9	7.98
			2.0	25.47	448.1	9.18	115.6	7.98
			3.0	25.27	451.3	8.43	105.6	7.66
			4.0	22.76	456.9	5.68	67.9	7.38
			4.3	22.33	458.7	5.32	62.4	7.21
			4.6	21.84	460.9	4.16	48.8	7.14
			5.0	21.84	459.4	4.69	54.9	7.12
			6.0	19.72	464.2	1.88	21.2	6.99
			7.0	18.14	464.0	0.00	0.0	6.90
			8.0	15.27	465.7	0.00	0.0	6.92
			9.0	12.52	471.9	0.00	0.0	6.99
			10.0	11.38	473.9	0.00	0.0	7.06
Halsey Island	10.3	1.4	0.1	26.36	442.4	9.02	115.2	8.02
			0.4	26.30	442.6	9.04	115.1	8.02
			0.7	26.17	443.4	9.08	115.8	8.02
			1.0	25.95	444.3	9.13	115.9	8.03
			2.0	25.30	451.3	9.06	113.5	7.97
			3.0	24.68	457.1	8.71	108.2	7.86
			4.0	23.96	457.4	7.86	96.2	7.69
			5.0	22.60	460.1	6.36	75.9	7.41
			5.3	21.41	461.9	4.57	52.9	7.24
			6.0	19.43	463.1	1.61	18.0	7.03
			7.0	18.04	461.7	0.00	0.0	6.94
			8.0	15.09	466.3	0.00	0.0	6.94
			9.0	13.37	470.3	0.00	0.0	7.01
			10.0	12.42	470.3	0.00	0.0	7.04
Mid-Lake	14.5	1.6	0.2	26.11	432.1	9.10	115.8	8.10
			0.5	25.67	433.7	9.09	114.8	8.06
			1.0	25.63	434.2	9.09	114.9	8.05
			2.0	25.31	436.1	9.03	113.3	7.99
			3.0	25.11	439.8	8.84	110.3	7.97
			4.0	23.57	456.3	7.67	93.1	7.60
			5.0	22.27	458.1	6.01	71.9	7.37
			5.3	21.54	459.9	5.00	57.8	7.20
			6.0	19.14	462.9	1.43	15.3	6.96
			7.0	17.91	463.7	0.00	0.0	6.87
			8.0	16.45	464.0	0.00	0.0	6.89
			9.0	14.30	463.0	0.00	0.0	6.92
			10.0	12.43	467.3	0.00	0.0	6.96
			11.0	11.52	471.7	0.00	0.0	7.03
			12.0	10.96	477.4	0.00	0.0	7.07
			13.0	10.70	479.8	0.00	0.0	7.11
			14.0	10.28	485.2	0.00	0.0	7.15
Great Cove	7.3	1.7	0.1	26.26	455.0	9.24	118.2	8.35
			0.4	26.26	455.2	9.27	118.3	8.35
			0.7	26.29	455.1	9.25	118.2	8.35
			1.0	25.85	454.7	9.27	117.7	8.34
			2.0	25.51	452.7	9.36	117.8	8.29
			3.0	25.27	453.5	8.66	108.5	7.98
			4.0	23.75	457.6	7.53	91.8	7.65
			5.0	21.99	460.7	5.24	61.7	7.33
			6.0	20.44	463.7	3.35	38.3	7.15
			7.0	17.40	461.7	0.00	0.0	6.98
King's Cove	3.2	1.2	0.2	26.19	459.9	8.70	111.1	7.97
			1.0	25.74	459.3	8.93	113.1	8.03
			2.0	25.24	457.9	8.58	107.6	7.80
			2.3	24.94	459.6	8.08	100.8	7.55
			2.6	24.00	460.6	4.93	60.1	7.15
			3.0	23.34	463.1	2.52	30.5	7.01

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.07.11

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.5	1.6	0.2	26.22	416.6	9.34	119.5	8.55
			1.0	26.05	418.7	9.37	119.6	8.54
			1.3	25.77	419.6	9.36	118.9	8.51
			2.0	25.55	421.9	8.79	111.2	8.24
			3.0	25.38	422.7	7.92	99.8	7.85
			4.0	24.88	430.2	6.28	75.7	7.43
			4.3	23.86	436.8	3.45	43.2	7.20
			5.0	22.88	440.2	2.36	28.9	7.06
			6.0	21.38	441.9	0.00	0.0	6.97
			7.0	19.10	446.3	0.00	0.0	6.93
			8.0	15.95	447.0	0.00	0.0	6.97
			9.0	12.98	455.5	0.00	0.0	7.05
			10.0	11.83	462.3	0.00	0.0	7.12
Halsey Island	10.3	1.6	0.1	25.99	423.8	9.19	117.2	8.49
			1.0	25.77	423.4	9.26	117.8	8.48
			2.0	25.48	422.9	8.53	107.7	8.22
			3.0	25.42	409.0	7.92	99.5	7.86
			4.0	25.36	409.6	7.71	97.2	7.75
			4.6	25.28	408.9	7.48	94.1	7.61
			5.0	24.35	426.6	4.52	55.6	7.30
			6.0	19.56	446.7	0.00	0.0	6.92
			7.0	17.85	448.0	0.00	0.0	6.95
			8.0	15.89	449.6	0.00	0.0	6.98
			9.0	14.89	451.8	0.00	0.0	7.02
			10.0	12.12	457.4	0.00	0.0	7.09
Mid-Lake	14.5	1.6	0.2	25.61	440.9	8.74	110.6	8.28
			1.0	25.63	441.2	8.79	111.3	8.30
			2.0	25.57	440.8	8.72	110.2	8.23
			3.0	25.51	440.3	8.57	108.1	8.15
			4.0	25.47	439.1	8.39	105.4	8.08
			4.3	25.49	439.4	8.25	104.1	7.95
			4.6	25.29	438.9	7.94	100.2	7.86
			5.0	22.65	452.7	2.20	26.2	7.15
			6.0	19.46	456.1	0.00	0.0	6.96
			7.0	17.48	457.1	0.00	0.0	6.97
			8.0	16.10	459.2	0.00	0.0	7.00
			9.0	14.83	259.4	0.00	0.0	7.03
			10.0	13.20	257.9	0.00	0.0	7.06
			11.0	12.05	263.5	0.00	0.0	7.09
			12.0	10.85	470.8	0.00	0.0	7.17
			13.0	10.58	474.9	0.00	0.0	7.22
			14.0	10.27	480.5	0.00	0.0	7.25
Great Cove	7.3	1.5	0.1	25.77	479.3	8.14	103.2	8.00
			1.0	25.64	429.8	8.10	102.5	7.95
			2.0	25.51	428.0	7.85	99.1	7.84
			3.0	25.48	427.8	7.61	96.0	7.73
			4.0	25.44	433.9	7.41	93.3	7.68
			4.3	25.44	434.9	7.42	93.6	7.67
			4.6	25.39	435.2	7.29	91.8	7.64
			5.0	25.23	439.3	6.98	87.6	7.59
			5.3	23.98	437.8	4.05	57.1	7.18
			5.6	21.76	452.5	0.00	0.0	7.00
			6.0	20.60	454.8	0.00	0.0	6.89
			7.0	17.68	459.7	0.00	0.0	6.94
King's Cove	3.2	1.4	0.2	25.51	443.2	8.56	108.1	8.20
			1.0	25.47	442.7	8.47	106.1	8.14
			2.0	25.40	442.5	8.29	104.6	8.01
			3.0	25.04	442.5	7.18	89.8	7.73

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.07.17

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
Byram Bay	10.5	1.5	0.2	27.78	438.2	9.39	123.2	8.65
			1.0	27.19	435.6	9.75	126.6	8.77
			2.0	26.66	431.9	9.08	116.9	8.50
			3.0	26.56	432.2	8.90	114.0	8.44
			3.6	26.47	429.5	8.48	108.8	8.25
			4.0	26.43	431.5	8.07	103.1	8.05
			4.3	26.10	449.6	6.99	89.5	7.62
			4.6	24.46	434.1	3.28	40.6	7.36
			5.0	23.11	453.1	0.00	0.0	7.14
			6.0	20.80	465.7	0.00	0.0	6.96
			7.0	19.15	468.8	0.00	0.0	6.91
			8.0	17.13	471.1	0.00	0.0	6.84
			9.0	15.43	470.4	0.00	0.0	6.82
			10.0	13.38	475.8	0.00	0.0	6.83
Halsey Island	10.3	1.3	0.2	27.25	431.5	8.57	111.6	8.19
			1.0	26.91	429.5	8.54	110.9	8.17
			2.0	26.41	434.9	8.01	102.7	8.01
			3.0	26.26	438.1	7.84	100.1	7.90
			3.3	26.14	441.6	7.58	96.9	7.85
			3.6	25.82	447.0	6.43	81.5	7.60
			4.0	25.71	441.9	5.98	75.9	7.46
			4.3	25.33	450.7	4.55	57.2	7.33
			5.0	24.37	431.9	3.54	43.7	7.16
			6.0	20.69	468.5	0.00	0.0	6.98
			7.0	18.92	469.2	0.00	0.0	6.90
			8.0	16.72	471.6	0.00	0.0	6.83
			9.0	13.74	472.2	0.00	0.0	6.82
			10.0	12.57	475.8	0.00	0.0	6.84
Mid-Lake	14.5	1.5	0.2	26.76	441.9	8.52	109.9	8.20
			1.0	26.16	441.7	8.84	112.6	8.36
			1.3	26.12	442.9	8.41	107.3	8.17
			1.6	26.07	443.2	8.26	105.1	8.10
			2.0	26.02	443.4	8.11	103.1	8.01
			2.3	25.99	443.4	8.00	101.7	7.97
			3.0	25.97	443.7	7.93	100.9	7.93
			4.0	25.85	444.1	7.42	93.3	7.81
			4.3	25.36	441.3	5.21	65.3	7.41
			4.6	25.07	448.8	3.80	47.6	7.29
			5.0	24.41	456.1	2.27	28.3	7.08
			6.0	21.39	463.2	0.00	0.0	6.92
			7.0	17.50	467.9	0.00	0.0	6.88
			8.0	15.51	468.6	0.00	0.0	6.78
			9.0	13.72	471.4	0.00	0.0	6.79
			10.0	12.59	472.8	0.00	0.0	6.79
			11.0	11.80	476.9	0.00	0.0	6.80
			12.0	10.97	484.2	0.00	0.0	6.81
			13.0	10.69	487.0	0.00	0.0	6.84
			14.0	10.27	492.7	0.00	0.0	6.84
Great Cove	7.3	1.5	0.2	27.15	429.1	8.81	114.3	8.40
			1.0	26.29	437.5	8.87	113.5	8.45
			2.0	26.20	437.8	8.57	109.5	8.33
			2.3	26.17	437.7	8.40	107.2	8.26
			2.6	26.13	437.0	8.15	103.9	8.14
			3.0	26.12	436.7	8.04	102.5	8.07
			3.3	26.09	436.9	7.96	101.4	8.02
			3.6	26.08	437.5	7.93	101.1	8.00
			4.0	25.50	434.0	5.80	73.1	7.62
			4.3	24.93	447.8	3.76	46.8	7.57
			5.0	24.22	452.2	2.19	26.7	7.22
			6.0	22.80	458.7	0.00	0.0	6.99
			7.0	18.02	467.0	0.00	0.0	6.98
King's Cove	2.8	1.3	0.2	26.69	455.3	8.04	104.3	7.92
			1.0	26.00	444.8	8.01	101.8	7.89
			1.3	25.79	444.8	7.84	99.3	7.78
			2.0	25.66	444.8	7.27	91.8	7.69
			2.5	25.56	445.9	6.23	78.3	7.49

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.07.24

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
STA-1	2.30	0.70	0.1	26.64	316.0	7.96	101.8	7.47
			1.0	26.64	351.0	7.91	101.2	7.45
			1.5	26.51	352.0	7.31	93.3	7.38
STA-2	14.20	1.10	0.1	26.50	432.0	8.82	112.7	8.30
			1.0	26.51	431.0	8.82	112.7	8.31
			2.0	26.46	432.0	8.76	111.7	8.25
			3.0	26.30	430.0	8.45	107.6	8.11
			4.0	26.06	430.0	7.83	99.0	7.86
			4.3	25.25	435.0	5.06	63.9	7.45
			4.6	24.95	443.0	4.55	56.5	7.36
			5.0	23.94	445.0	1.95	23.2	7.14
			6.0	22.08	456.0	0.00	0.0	6.98
			7.0	19.06	469.0	0.00	0.0	6.93
			8.0	15.31	469.0	0.00	0.0	6.88
			9.0	13.84	472.0	0.00	0.0	6.90
			10.0	12.90	470.0	0.00	0.0	6.90
			11.0	12.09	475.0	0.00	0.0	6.89
			12.0	11.48	477.0	0.00	0.0	6.89
			13.0	10.85	484.0	0.00	0.0	6.84
			14.0	10.51	488.0	0.00	0.0	6.89
STA-3	2.30	0.60	0.1	27.14	576.0	10.45	135.1	8.49
			1.0	27.07	578.0	10.40	134.1	8.51
			2.0	26.39	601.0	9.00	114.6	8.12
STA-4	2.80	1.00	0.1	26.93	376.0	8.60	110.8	8.03
			1.0	26.74	418.0	8.51	109.3	8.00
			2.0	25.86	411.0	6.80	86.0	7.67
			2.5	25.50	411.0	5.54	69.1	7.49
STA-5	2.80	0.80	0.1	27.55	500.0	9.15	118.8	8.13
			1.0	26.86	417.0	9.24	118.5	8.18
			2.0	26.32	426.0	7.42	92.5	7.76
			2.5	26.22	427.0	6.35	80.5	7.54
STA-6	2.90	1.00	0.1	26.94	361.0	8.10	104.2	7.22
			1.0	26.77	373.0	8.00	102.6	7.37
			2.0	26.56	378.0	7.39	94.7	7.38
			2.7	26.29	381.0	6.48	81.0	7.27
STA-7	1.80	0.90	0.1	26.26	132.0	7.04	89.5	7.22
			1.0	25.84	190.0	6.24	77.8	7.09
			1.5	24.74	159.0	4.85	59.9	6.90
STA-8	5.50		0.1	27.07	382.0	9.05	116.5	8.29
			1.0	27.01	414.0	9.04	116.5	8.31
			2.0	26.93	415.0	9.01	116.0	8.29
			3.0	26.85	416.0	8.82	113.1	8.19
			4.0	26.64	420.0	8.03	102.8	7.90
			5.0	26.01	421.0	6.41	80.8	7.54
			5.3	24.77	425.0	3.86	47.8	7.33
			6.0	22.18	448.0	0.00	0.0	7.11
			7.0	19.10	463.0	0.00	0.0	7.01
STA-9	8.20	1.10	0.1	26.78	427.0	8.88	113.9	7.92
			1.0	26.72	424.0	8.89	114.0	7.97
			2.0	26.26	427.0	8.49	107.9	7.86
			3.0	26.04	427.0	7.43	94.6	7.64
			4.0	25.74	432.0	6.41	80.7	7.47
			5.0	25.33	439.0	4.64	57.9	7.26
			6.0	21.67	462.0	0.00	0.0	7.08
			7.0	17.83	470.0	0.00	0.0	6.89
			8.0	15.92	474.0	0.00	0.0	6.85
STA-10	1.30	0.60	0.1	26.53	363.0	9.27	118.4	7.78
			1.0	24.88	402.0	8.66	107.3	7.74
STA-11	1.30	1.30+	0.1	24.79	132.0	4.21	52.1	6.72
			1.0	24.13	177.0	3.62	43.7	6.63
STA-12	2.00	0.60	0.1	27.69	412.0	9.08	118.4	7.93
			1.0	27.29	421.0	8.84	114.1	7.85
			1.8	26.74	423.0	7.24	92.2	7.65

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.08.01

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.5	1.2	0.2	25.84	420.3	7.94	99.9	7.80
			1.0	25.82	420.6	7.92	99.9	7.80
			2.0	25.81	420.2	7.92	99.6	7.75
			3.0	25.54	420.7	7.61	95.3	7.65
			4.0	25.48	421.7	7.25	90.7	7.58
			5.0	25.42	422.7	7.03	87.9	7.55
			5.3	25.22	423.3	5.81	72.4	7.32
			5.6	23.19	428.1	0.00	0.0	6.75
			6.0	21.84	445.2	0.00	0.0	6.79
			7.0	18.58	470.2	0.00	0.0	6.99
			8.0	15.73	469.9	0.00	0.0	7.13
			9.0	14.04	478.8	0.00	0.0	7.18
			10.0	12.93	476.2	0.00	0.0	7.23
Halsey Island	10.3	1.1	0.2	25.91	425.8	8.08	101.9	7.91
			1.0	25.87	425.5	8.10	102.1	7.91
			2.0	25.75	425.6	7.90	99.2	7.78
			3.0	25.68	422.2	7.45	93.0	7.67
			4.0	25.65	419.8	7.41	93.0	7.63
			5.0	25.53	416.6	7.08	88.6	7.60
			5.3	24.18	434.0	2.42	29.7	7.12
			6.0	21.58	450.4	0.00	0.0	6.99
			7.0	19.13	470.1	0.00	0.0	7.13
			8.0	16.62	468.2	0.00	0.0	7.16
			9.0	13.36	470.5	0.00	0.0	7.19
			10.0	11.79	476.4	0.00	0.0	7.23
Mid-Lake	14.5	1.2	0.2	25.72	422.3	7.86	99.0	7.81
			1.0	25.68	422.3	7.82	98.3	7.75
			2.0	25.73	422.3	7.87	98.6	7.72
			3.0	25.67	421.8	7.72	97.0	7.70
			4.0	25.63	421.3	7.61	95.5	7.68
			4.3	25.63	421.4	7.62	95.6	7.69
			4.6	25.62	421.5	7.63	95.8	7.70
			5.0	25.60	421.5	7.60	95.4	7.71
			5.3	25.60	421.6	7.60	95.4	7.73
			5.6	25.56	422.1	7.47	93.0	7.73
			6.0	24.66	435.9	3.34	41.2	7.21
			7.0	19.58	468.9	0.00	0.0	7.15
			8.0	15.67	468.7	0.00	0.0	7.18
			9.0	13.72	470.4	0.00	0.0	7.21
			10.0	12.85	470.5	0.00	0.0	7.23
			11.0	12.10	473.8	0.00	0.0	7.23
			12.0	11.62	477.6	0.00	0.0	7.23
			13.0	11.10	481.3	0.00	0.0	7.22
			14.0	10.81	483.3	0.00	0.0	7.23
Great Cove	7.3	1.3	0.2	26.27	423.4	8.04	102.2	7.90
			1.0	26.17	423.1	8.05	102.1	7.93
			2.0	26.04	423.5	8.02	101.4	7.87
			2.3	25.85	424.3	7.81	98.4	7.77
			3.0	25.73	423.1	7.51	94.5	7.69
			4.0	25.71	422.6	7.44	94.3	7.66
			5.0	25.12	428.5	5.01	62.9	7.32
			6.0	23.37	433.8	0.00	0.0	6.96
			7.0	19.09	464.7	0.00	0.0	6.96
King's Cove	2.8	0.7	0.2	25.51	440.0	7.33	91.3	7.66
			1.0	25.50	440.0	7.30	91.4	7.63
			2.0	25.44	439.7	6.62	82.7	7.49
			2.5	25.37	439.9	6.33	79.0	7.38

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.08.07

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
Byram Bay	10.5	1.1	0.2	24.73	N.D.	8.09	100.9	7.64
			1.0	24.74	N.D.	8.09	100.9	7.65
			2.0	24.75	N.D.	8.05	100.4	7.63
			3.0	24.65	N.D.	7.89	98.2	7.52
			4.0	24.60	N.D.	7.77	96.7	7.52
			5.0	24.54	N.D.	7.69	95.6	7.53
			6.0	23.96	N.D.	5.56	68.3	7.43
			7.0	22.78	N.D.	2.40	28.8	7.23
			8.0	16.06	N.D.	0.00	0.0	7.16
			9.0	13.74	N.D.	0.00	0.0	7.22
			10.0	12.94	N.D.	0.00	0.0	7.24
Halsey Island	10.3	1.1	0.2	24.79	N.D.	7.63	95.3	7.56
			1.0	24.74	N.D.	7.66	95.5	7.56
			2.0	24.73	N.D.	7.61	94.9	7.47
			3.0	24.73	N.D.	7.63	95.1	7.47
			4.0	24.72	N.D.	7.61	94.9	7.50
			5.0	24.70	N.D.	7.52	93.7	7.53
			6.0	24.48	N.D.	6.82	84.6	7.54
			7.0	18.40	N.D.	0.00	0.0	7.37
			8.0	16.07	N.D.	0.00	0.0	7.30
			9.0	14.70	N.D.	0.00	0.0	7.29
			10.0	13.50	N.D.	0.00	0.0	7.28
Mid-Lake	14.5	1.1	0.2	24.95	N.D.	8.08	101.2	7.17
			1.0	24.97	N.D.	8.04	100.7	7.63
			2.0	24.81	N.D.	7.90	98.7	7.57
			3.0	24.74	N.D.	7.90	98.5	7.59
			4.0	24.40	N.D.	7.16	88.7	7.56
			5.0	23.57	N.D.	4.57	55.8	7.30
			6.0	22.09	N.D.	0.73	8.7	6.98
			7.0	20.03	N.D.	0.00	0.0	7.01
			8.0	16.60	N.D.	0.00	0.0	7.18
			9.0	14.42	N.D.	0.00	0.0	7.39
			10.0	13.12	N.D.	0.00	0.0	7.48
			11.0	12.27	N.D.	0.00	0.0	7.50
			12.0	11.66	N.D.	0.00	0.0	7.47
			13.0	11.13	N.D.	0.00	0.0	7.43
			14.0	10.70	N.D.	0.00	0.0	7.34
Great Cove	7.3	1.0	0.2	25.18	N.D.	8.29	105.4	7.80
			1.0	25.09	N.D.	8.37	105.1	7.79
			2.0	15.15	N.D.	8.32	104.5	7.75
			3.0	15.12	N.D.	8.32	104.5	7.66
			4.0	24.96	N.D.	7.92	99.2	7.65
			5.0	24.60	N.D.	7.31	90.9	7.58
			6.0	22.55	N.D.	2.43	29.1	7.25
			7.0	19.83	N.D.	0.00	0.0	7.13
King's Cove	2.8	0.8	0.2	24.61	N.D.	7.25	90.2	7.31
			1.0	24.70	N.D.	7.17	89.3	7.30
			2.0	24.70	N.D.	7.09	88.4	7.29
			2.7	24.64	N.D.	7.00	87.1	7.30

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)
N.D. indicated no data due to a mulfunction with the specific conductivity probe

Lake Hopatcong *In-Situ* Monitoring Data 2023.08.14

Station	Depth (m) Total	Secchi	Sample	Temperature °C	Specific Conductance µS/cm	Dissolved Oxygen Conc. (mg/L)	Sat. (%)	pH s.u.
Byram Bay	10.5	1.0	0.2	24.78	428.5	8.65	107.4	7.82
			1.0	24.60	428.2	8.34	103.3	7.78
			2.0	24.52	428.5	8.19	101.2	7.65
			3.0	24.49	428.8	8.18	100.9	7.62
			4.0	24.43	429.0	8.06	99.5	7.62
			5.0	23.98	429.2	6.68	81.7	7.51
			5.3	23.64	429.6	6.37	77.5	7.37
			5.6	23.47	430.1	5.72	69.3	7.30
			6.0	22.75	431.6	3.95	46.9	7.12
			7.0	21.41	431.6	0.00	0.0	6.92
			8.0	18.31	481.7	0.00	0.0	7.04
			9.0	14.64	482.9	0.00	0.0	7.17
			10.0	13.72	484.4	0.00	0.0	7.22
Halsey Island	10.3	0.9	0.2	24.82	425.5	8.53	106.0	7.73
			1.0	24.70	427.7	8.59	106.5	7.76
			2.0	24.61	428.5	8.26	102.0	7.64
			3.0	24.54	428.9	8.22	101.6	7.61
			4.0	24.47	430.8	7.99	98.6	7.61
			5.0	23.87	432.2	6.87	84.1	7.45
			5.3	23.66	433.9	4.57	54.9	7.18
			5.6	22.85	435.0	4.06	46.7	7.12
			6.0	22.65	435.1	3.59	43.0	7.08
			7.0	21.75	436.9	1.38	16.1	6.98
			8.0	17.57	489.8	0.00	0.0	7.15
			9.0	15.16	482.1	0.00	0.0	7.25
			10.0	12.83	484.2	0.00	0.0	7.21
Mid-Lake	14.5	1.3	0.2	24.65	435.2	8.52	105.6	7.86
			1.0	24.62	435.2	8.55	105.8	7.82
			2.0	24.54	433.9	8.30	102.5	7.76
			3.0	24.43	433.5	8.14	100.4	7.69
			4.0	24.36	435.6	8.08	99.5	7.68
			5.0	23.84	435.4	6.33	77.2	7.48
			5.3	23.66	435.6	5.83	71.1	7.42
			5.6	23.42	435.8	5.27	63.6	7.35
			6.0	23.24	434.2	5.03	60.7	7.31
			6.3	23.01	435.4	4.31	51.8	7.23
			6.6	22.64	436.7	3.07	36.5	7.08
			7.0	21.62	438.2	1.46	17.0	7.62
			8.0	16.39	491.2	0.00	0.0	7.24
			9.0	13.94	482.0	0.00	0.0	7.17
			10.0	13.06	479.8	0.00	0.0	7.18
			11.0	12.16	480.6	0.00	0.0	7.18
			12.0	11.48	484.2	0.00	0.0	7.18
			13.0	11.16	488.8	0.00	0.0	7.17
			14.0	10.82	493.1	0.00	0.0	7.16
Great Cove	7.3	1.1	0.2	24.93	432.9	8.74	108.8	8.00
			1.0	24.84	432.7	8.77	109.1	8.03
			2.0	24.71	432.3	8.54	105.8	7.87
			3.0	24.62	432.4	8.38	103.7	7.78
			4.0	24.52	432.6	7.95	98.3	7.65
			5.0	23.69	433.9	5.44	66.2	7.40
			5.3	23.42	433.5	5.16	62.5	7.29
			5.6	23.23	433.1	4.98	60.1	7.23
			6.0	22.84	434.8	3.82	45.8	7.15
			7.0	22.63	435.8	2.05	24.1	7.05
King's Cove	2.8	0.9	0.2	24.70	440.9	7.57	93.9	7.59
			1.0	24.70	440.9	7.55	93.5	7.55
			2.0	24.61	440.2	7.35	91.0	7.45
			2.6	24.50	439.8	7.21	88.2	7.41

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

Lake Hopatcong *In-Situ* Monitoring Data 2023.08.21

Station	Depth (m)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
STA-1	2.30	0.70	0.1	25.79	343.0	8.94	112.9	7.56
			1.0	25.34	347.0	8.54	107.2	7.53
			1.5	24.80	348.0	7.46	92.1	7.44
STA-2	14.20	1.50	0.1	24.49	427.0	8.57	105.9	7.79
			1.0	24.48	427.0	8.55	105.4	7.74
			2.0	24.39	427.0	8.44	103.9	7.71
			3.0	24.03	427.0	7.70	94.1	7.60
			4.0	23.96	428.0	7.80	95.1	7.63
			5.0	23.90	427.0	7.34	89.5	7.63
			5.3	23.82	427.0	6.80	82.8	7.45
			5.6	23.44	425.0	5.13	61.9	7.29
			6.0	23.33	426.0	4.77	57.6	7.22
			7.0	21.79	417.0	0.00	0.0	6.80
			8.0	17.69	486.0	0.00	0.0	7.16
			9.0	15.06	475.0	0.00	0.0	7.24
			10.0	12.80	473.0	0.00	0.0	7.19
			11.0	12.20	477.0	0.00	0.0	7.17
			12.0	11.65	479.0	0.00	0.0	7.21
			13.0	11.14	483.0	0.00	0.0	7.21
			14.0	10.91	486.0	0.00	0.0	7.21
STA-3	2.30	0.70	0.1	24.80	532.0	8.37	103.2	7.92
			1.0	24.58	533.0	7.90	98.1	7.74
			2.0	24.42	531.0	7.36	90.4	7.66
STA-4	2.80	1.00	0.1	24.39	433.0	8.39	103.3	7.74
			1.0	24.35	433.0	8.37	102.9	7.69
			2.0	24.15	433.0	7.54	92.2	7.58
			2.7	24.06	432.0	6.48	79.8	7.44
STA-5	2.80	0.90	0.1	24.58	434.0	8.56	105.7	7.88
			1.0	24.25	434.0	7.91	96.9	7.78
			2.0	24.09	434.0	7.67	93.9	7.59
			2.5	24.02	434.0	7.28	88.7	7.54
STA-6	2.90	1.20	0.1	25.60	419.0	8.40	112.9	7.84
			1.0	25.17	419.0	8.77	109.8	7.73
			2.0	24.42	420.0	8.15	100.5	7.60
			2.7	24.25	421.0	6.59	80.4	7.49
STA-7	2.00	0.90	0.1	25.10	252.0	7.75	96.6	7.31
			1.0	24.38	257.0	6.82	82.8	7.17
			1.8	23.62	249.0	6.04	73.1	7.64
STA-8	7.30	1.40	0.1	24.91	421.0	8.80	109.1	7.95
			1.0	24.59	422.0	8.87	109.5	7.90
			2.0	24.38	424.0	8.56	105.3	7.74
			3.0	24.31	424.0	8.05	98.8	7.69
			4.0	24.24	423.0	8.02	98.4	7.68
			5.0	23.98	433.0	7.35	89.7	7.66
			6.0	23.29	423.0	5.00	60.2	7.45
			7.0	22.00	413.0	0.00	0.0	7.04
STA-9	8.20	1.30	0.1	25.17	426.0	9.03	112.7	7.97
			1.0	24.52	425.0	9.02	111.0	7.97
			2.0	24.30	425.0	8.80	108.3	7.92
			3.0	24.16	426.0	7.99	98.0	7.77
			4.0	24.05	426.0	7.63	93.0	7.71
			5.0	23.76	431.0	6.72	81.5	7.64
			6.0	22.96	427.0	2.66	31.9	7.32
			7.0	20.49	441.0	0.00	0.0	7.17
			8.0	17.27	491.0	0.00	0.0	7.31
STA-10	1.30	0.60	0.1	25.84	361.0	9.59	120.7	8.04
			1.0	24.83	368.0	9.26	114.9	7.89
STA-11	1.30	1.30+	0.1	24.61	191.0	5.48	67.9	6.99
			1.0	23.52	189.0	4.95	59.8	6.76
STA-12	1.80	0.90	0.1	24.66	438.0	8.09	99.9	7.70
			1.0	24.65	438.0	7.97	98.5	7.66
			1.5	24.44	442.0	6.85	84.3	7.49

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

***In-Situ* Monitoring for Lake Hopatcong 9/18/2023**

Station	Depth (meters)			Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Secchi	Sample	°C	mS/cm	mg/L	% Sat.	S.U.
STA-1	2.80	0.80	0.1	21.37	0.348	8.40	99.6	7.44
			1.0	21.48	0.348	8.45	99.3	7.50
			2.0	21.42	0.346	8.39	98.5	7.54
			2.5	21.32	0.343	7.92	92.4	7.54
STA-2	14.20	1.20	0.1	22.21	0.428	7.44	88.9	7.58
			1.0	22.34	0.427	7.42	88.8	7.50
			2.0	22.35	0.427	7.40	88.5	7.51
			3.0	22.35	0.427	7.44	89.0	7.52
			4.0	22.32	0.427	7.40	88.4	7.55
			5.0	22.35	0.427	7.39	88.3	7.59
			6.0	22.21	0.429	6.43	76.6	7.55
			7.0	21.41	0.434	3.31	38.9	7.30
			8.0	19.63	0.468	0.00	0.0	7.27
			9.0	16.60	0.503	0.00	0.0	7.51
			10.0	14.40	0.496	0.00	0.0	7.50
			11.0	13.10	0.490	0.00	0.0	7.33
			12.0	11.92	0.487	0.00	0.0	7.22
			13.0	11.47	0.491	0.00	0.0	7.17
			14.0	10.82	0.496	0.00	0.0	7.09
STA-3	2.30	0.60	0.1	21.42	0.486	7.69	90.3	7.64
			1.0	21.43	0.485	7.68	90.3	7.60
			1.9	21.46	0.482	7.61	89.5	7.57
STA-4	3.10	1.20	0.1	21.94	0.436	8.27	98.2	7.73
			1.0	22.02	0.427	8.24	97.9	7.65
			2.0	21.87	0.430	8.13	96.3	7.66
			2.9	21.70	0.433	6.80	80.4	7.54
STA-5	3.20	0.90	0.1	21.40	0.430	8.22	96.5	7.83
			1.0	21.37	0.431	7.85	92.0	7.73
			2.0	21.37	0.431	7.68	90.1	7.60
			3.0	21.37	0.431	7.57	88.8	7.57
STA-6	3.20	1.30	0.1	21.64	0.420	6.55	77.3	7.31
			1.0	21.77	0.419	6.48	76.6	7.20
			2.0	21.80	0.419	6.47	78.7	7.19
			2.9	21.68	0.418	6.39	75.8	7.17
STA-7	1.80	1.50	0.1	20.33	0.248	7.38	84.9	7.35
			1.0	20.44	0.246	7.26	83.4	7.14
			1.5	20.13	0.223	6.40	73.2	7.10
STA-8	7.30	1.20	0.1	22.28	0.425	7.64	91.4	7.56
			1.0	22.30	0.426	7.64	91.3	7.51
			2.0	22.30	0.426	7.62	91.0	7.51
			3.0	22.35	0.425	7.59	90.8	7.52
			4.0	22.32	0.425	7.56	90.4	7.54
			5.0	22.29	0.425	7.53	89.9	7.56
			6.0	22.27	0.424	7.33	87.4	7.59
			7.0	22.21	0.425	7.12	84.4	7.61
STA-9	8.20	1.10	0.1	21.45	0.422	6.53	77.6	7.22
			1.0	22.03	0.422	6.47	76.7	7.13
			2.0	22.01	0.422	6.49	77.3	7.13
			3.0	22.02	0.422	6.48	77.2	7.15
			4.0	22.02	0.422	6.23	73.9	7.17
			5.0	21.99	0.422	6.19	73.5	7.20
			6.0	21.98	0.422	6.01	71.3	7.24
			7.0	21.90	0.423	4.49	52.3	7.22
			8.0	21.70	0.432	3.54	41.2	7.15
STA-10	1.30	0.70	0.1	20.96	0.355	8.41	98.2	7.68
			1.0	20.94	0.367	8.25	96.0	7.61
STA-11	1.30	1.30+	0.1	19.91	0.222	5.90	67.3	7.00
			1.0	19.96	0.202	5.89	66.7	6.79
STA-12	1.80	0.80	0.1	21.07	0.433	7.97	92.9	7.72
			1.0	21.12	0.433	7.84	91.5	7.60
			1.5	21.09	0.440	7.53	87.7	7.52

Trout Habitat Highlighted in Pale Blue (5 mg/L) and Gray (4 mg/L)

APPENDIX III: NEARSHORE *IN-SITU* DATA

Nearshore *In-Situ* Monitoring for Lake Hopatcong 7/5/2023

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
1	0.2	27.92	454.8	8.71	114.2	8.01
	1.0	27.34	459.1	8.60	111.8	7.98
2	0.2	28.84	459.4	7.70	102.9	7.61
	1.0	26.61	455.2	7.38	94.7	7.50
3	0.2	28.73	451.1	8.15	108.1	7.67
	1.0	27.10	447.9	8.30	107.3	7.72
	2.0	25.55	450.4	2.61	32.7	7.13
4	0.2	27.98	462.3	8.66	114.1	7.86
	1.0	26.80	459.2	8.80	113.3	7.91
5	0.2	27.80	460.9	8.53	111.9	7.94
	1.0	26.27	458.8	8.59	109.8	7.91
	1.5	25.81	460.7	7.85	99.4	7.60
6	0.2	28.21	463.9	8.54	112.0	7.95
	1.0	25.75	458.3	8.04	101.6	7.86
	1.5	25.48	460.9	7.55	95.7	7.71
7	0.2	28.53	464.6	8.62	114.9	7.99
	1.0	26.59	462.3	7.71	98.9	7.67
8	0.2	27.96	462.7	8.55	112.5	7.92
	1.0	26.53	461.5	8.84	113.4	7.92
	1.5	25.78	464.9	6.20	78.0	7.46
9	0.2	28.16	461.9	8.50	112.3	8.03
	1.0	25.99	458.2	8.49	107.6	7.93
	1.8	25.56	460.1	8.21	103.6	7.78
10	0.2	27.00	460.9	9.27	120.7	8.34
	1.0	26.40	50.9	9.56	122.2	8.42
	2.0	25.43	457.6	9.87	124.2	8.45
	2.8	25.22	459.9	8.81	109.9	8.08
11	0.2	27.71	458.2	9.22	120.9	8.31
	1.0	27.38	457.9	9.36	121.9	8.34
	2.0	25.74	457.4	9.67	122.3	8.40
	3.0	25.33	451.9	9.71	121.8	8.44
	4.0	25.18	458.7	9.60	114.6	8.34
	5.0	21.57	460.6	3.66	42.8	7.46
12	0.2	28.05	458.9	9.14	120.7	8.29
	1.0	27.20	457.0	9.34	121.4	8.36
	2.0	26.06	458.2	11.66	148.5	9.01
13	0.2	28.54	459.1	9.06	120.1	8.33
	1.0	27.89	457.9	9.21	121.2	8.33
	2.0	26.30	456.9	9.31	119.2	8.33
14	0.2	27.32	459.8	8.82	114.8	8.18
	1.0	26.29	459.3	8.87	113.7	8.14
15	0.2	27.84	459.3	8.93	116.5	8.24
	1.0	25.92	456.6	9.48	119.8	8.37
16	0.2	27.10	459.2	9.13	118.7	8.28
	1.0	26.10	457.9	9.41	120.2	8.32
	2.0	25.60	456.3	9.34	117.8	8.27
17	0.2	27.58	459.9	8.52	111.1	8.12
	0.8	27.07	459.3	9.01	110.9	8.17
18	0.2	27.48	454.2	9.57	125.1	8.52
	1.0	26.21	451.5	10.54	134.9	8.77
	1.5	25.75	452.8	10.89	137.5	8.83
19	0.2	26.72	454.2	9.56	122.4	8.45
	1.0	26.55	453.3	9.76	124.6	8.44
	1.8	25.52	454.3	9.52	119.1	8.24
20	0.2	27.56	455.3	9.20	120.2	8.29
	1.0	26.67	456.1	9.45	122.2	8.33
21	0.2	28.05	459.8	9.06	119.8	8.29
	1.0	26.76	453.1	9.68	125.2	8.49
	1.5	26.06	456.5	9.91	125.7	8.59
23	0.2	28.38	463.7	9.12	120.9	8.35
	1.0	26.27	508.5	7.72	98.4	7.76
	1.5	24.19	626.7	8.61	105.9	7.64
22	0.2	27.90	462.9	9.17	120.6	8.34
	1.0	26.94	478.9	9.27	119.8	8.22
	2.0	25.67	511.5	11.61	149.1	8.70

Trout Habitat Highlighted in Pale Blue

Nearshore *In-Situ* Monitoring for Lake Hopatcong 7/11/2023						
Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
24	0.2	24.97	459.5	8.83	110.3	8.26
	1.0	21.23	451.9	8.57	99.7	7.65
	1.5	20.74	453.6	8.55	98.8	7.55
25	0.2	25.42	438.9	9.11	114.7	8.42
	1.0	24.47	440.4	9.17	114.9	8.27
	1.5	22.31	438.6	9.48	112.6	8.01

Trout Habitat Highlighted in Pale Blue

Nearshore *In-Situ* Monitoring for Lake Hopatcong 7/17/2023

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
26	0.2	27.04	420.9	8.27	106.5	8.36
	1.0	26.59	435.9	9.06	110.9	8.51
	1.5	25.84	460.6	10.28	103.7	8.40
27	0.2	26.49	433.2	9.06	116.6	8.48
	1.0	26.46	432.9	9.05	115.9	8.47
	1.5	26.18	436.4	10.12	131.6	8.64
28	0.2	26.99	451.7	8.60	110.9	8.24
	1.0	26.70	458.2	8.51	109.7	8.10
	1.4	26.24	477.9	9.26	110.5	8.31
29	0.2	27.65	414.8	8.33	107.9	8.12
	1.0	26.93	415.8	8.18	105.5	8.04
	2.0	26.27	413.5	7.56	95.9	7.93
	2.9	26.18	422.7	7.13	91.0	7.76
30	0.2	28.61	281.2	7.97	106.2	7.53
	1.0	27.46	293.2	7.95	104.3	7.54
31	0.2	28.60	296.8	7.96	106.6	7.60
	1.0	27.22	325.1	7.99	103.6	7.67
	1.3	26.20	348.3	7.33	93.4	7.46
32	0.2	28.60	241.6	7.65	104.7	7.32
	1.0	27.55	272.6	7.59	97.9	7.46
33	0.2	28.43	252.2	7.99	106.3	7.39
	1.0	27.55	286.2	8.26	108.2	7.46
34	0.2	28.00	252.8	8.12	108.1	7.48
	1.0	27.63	251.3	7.95	103.4	7.41
	1.5	27.53	248.4	7.51	93.5	7.34
35	0.2	27.57	254.1	8.44	110.6	7.46
	1.0	27.52	254.1	8.46	110.7	7.44
	1.6	24.13	314.7	6.47	79.0	7.17
36	0.2	27.30	307.3	8.72	113.8	7.51
	1.0	25.81	269.1	7.77	97.4	7.37
	1.5	23.87	140.9	4.31	52.6	6.97
37	0.2	27.87	294.9	9.21	122.2	7.65
	1.0	24.70	175.0	5.15	64.0	6.97
38	0.2	27.15	230.9	7.56	97.9	7.12
	1.0	24.54	129.5	5.68	70.1	6.77
	1.5	24.39	119.0	5.43	66.5	6.64
39	0.2	27.78	329.2	8.64	113.5	7.51
	1.0	25.39	201.8	6.57	823.0	7.08
	1.4	24.26	125.0	5.61	69.0	6.88
40	0.2	28.10	343.6	8.58	113.4	7.63
	0.8	27.24	351.8	10.65	130.7	8.45
41	0.2	28.97	369.1	9.19	123.2	8.40
	1.0	26.44	365.4	10.33	132.1	8.28

Trout Habitat Highlighted in Pale Blue

Nearshore *In-Situ* Monitoring for Lake Hopatcong 8/1/2023						
Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
42	0.2	25.44	255.1	9.13	114.3	8.32
	0.7	25.35	344.4	8.85	100.1	8.25
43	0.2	25.62	358.0	9.72	121.9	8.52
	1.0	25.87	359.6	9.24	121.5	8.47
44	0.2	26.19	360.1	9.18	115.9	8.37
	1.0	25.44	361.7	9.12	114.2	8.22
45	0.2	26.12	352.8	9.10	115.3	8.23
	1.0	25.86	354.3	8.54	107.0	7.97
46	0.2	26.08	351.8	9.02	114.1	8.12
	1.0	26.08	350.7	8.99	113.1	8.05
	1.9	25.83	351.6	8.05	109.2	7.69
47	0.2	26.06	359.1	8.94	113.2	8.09
	1.0	26.08	353.7	8.73	110.3	7.96
	2.0	25.85	352.0	7.84	98.6	7.77
48	0.2	26.18	353.7	8.05	112.2	8.06
	1.0	26.14	356.9	9.02	114.6	8.05
49	0.2	25.45	357.4	9.90	118.9	8.45
	1.0	25.56	357.6	9.44	118.4	8.32
	1.5	25.47	357.4	8.87	111.9	8.15
50	0.2	26.02	324.4	9.30	117.8	8.28
	1.0	25.34	358.6	8.12	101.4	7.90
51	0.2	25.41	313.5	9.03	113.1	8.03
	1.0	24.75	331.4	7.52	92.8	7.58
	2.0	24.59	330.1	6.61	81.0	7.46
	3.0	24.35	323.8	6.60	80.9	7.42
52	0.2	25.47	310.2	9.98	125.0	8.17
	1.0	25.18	306.2	9.93	123.6	8.15
	1.8	23.84	308.3	5.12	62.3	7.46
53	0.2	25.43	302.7	9.22	115.9	7.79
	1.0	24.30	306.9	8.89	108.8	7.73
	2.0	23.15	281.9	4.41	52.0	7.34
54	0.2	25.07	315.5	9.99	111.0	8.12
	1.0	24.48	328.1	9.06	112.2	7.78
55	0.2	25.78	348.9	9.90	122.9	8.24
	1.0	24.81	382.9	10.92	134.6	8.65
56	0.2	25.35	390.9	12.11	151.3	8.95
	1.0	23.81	411.3	10.43	120.7	8.49
57	0.2	25.38	384.8	11.77	147.4	8.92
	1.0	23.88	389.7	10.75	130.7	8.54
58	0.2	26.03	358.5	9.93	125.0	8.53
	1.0	25.32	355.2	7.95	99.2	8.08
59	0.2	26.19	356.2	9.16	116.4	8.18
	1.0	26.15	354.9	9.08	115.0	8.11
	2.0	25.82	353.7	7.92	99.9	7.76
60	0.2	26.28	356.5	9.58	122.0	8.38
	1.0	26.28	354.9	9.42	119.7	8.30
	1.6	26.07	354.7	8.70	111.8	8.08
61	0.2	26.48	353.6	9.20	117.5	8.22
	1.0	26.37	354.2	8.92	112.2	8.10
62	0.2	26.54	355.1	9.63	122.1	8.45
	1.0	26.28	353.2	9.37	118.7	8.27
	1.5	26.12	353.4	8.72	110.5	7.90
63	0.2	26.42	341.2	10.40	133.0	9.02
	1.0	25.14	330.5	10.84	133.5	8.93
64	0.2	26.40	328.2	10.36	131.9	8.88
	1.0	25.73	335.7	12.22	152.2	9.17
65	0.2	26.89	338.9	11.17	146.4	8.99
	1.0	25.79	336.6	11.79	148.9	8.92
66	0.2	27.03	313.1	9.23	118.5	8.11
	1.0	26.49	309.2	9.12	112.4	7.93
67	0.2	27.56	298.4	10.06	130.9	8.25
	1.0	24.77	311.9	12.92	101.8	8.38
68	0.2	26.93	292.5	9.26	119.1	8.09
	1.0	25.53	292.6	9.08	129.2	7.07
	1.5	24.87	301.8	5.88	72.8	7.55
69	0.2	27.41	314.6	9.76	116.9	8.15
	1.0	26.25	325.8	10.37	131.9	8.32
70	0.2	26.49	377.6	9.46	120.8	8.20
	1.0	26.20	385.3	9.14	119.7	8.13
	1.5	25.77	402.1	8.30	104.6	7.85
71	0.2	26.18	417.5	8.68	110.0	7.92
	1.0	26.02	411.2	10.38	131.0	8.48
72	0.2	26.15	389.6	8.10	103.8	7.90
	1.0	26.35	415.4	8.10	103.2	7.76
	1.5	26.00	415.8	8.00	101.7	7.71
73	0.2	26.63	421.2	8.10	105.7	7.71
	1.0	26.43	424.5	8.00	109.7	7.06

Trout Habitat Highlighted in Pale Blue

Neasrhore *In-Situ* Monitoring for Lake Hopatcong 8/14/2023

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
74	0.2	24.89	425.6	8.19	101.4	7.63
	1.0	24.96	424.9	7.92	98.6	7.59
75	0.2	24.94	419.8	7.73	96.0	7.56
	1.0	24.82	419.5	7.55	93.4	7.51
	1.5	24.46	425.8	4.94	60.9	7.25
76	0.2	25.02	426.5	8.54	106.5	7.78
	1.0	24.87	426.5	8.30	104.0	7.75
	1.5	24.67	426.9	7.51	94.0	7.61
77	0.2	25.36	426.5	8.28	103.9	7.68
	1.0	25.05	426.3	7.74	96.4	7.56
78	0.2	25.54	425.6	8.24	103.9	7.69
	0.5	25.26	425.4	8.01	100.4	7.55
79	0.2	25.29	426.7	8.31	104.2	7.69
	1.0	25.07	427.7	7.94	94.1	7.55
80	0.2	25.21	398.4	8.76	109.8	7.78
	1.0	24.97	399.7	8.65	107.7	7.75
	1.9	24.65	424.8	7.88	97.5	7.64
81	0.2	25.09	426.1	8.87	110.6	7.81
	1.0	24.76	422.9	8.40	104.2	7.74
	1.5	23.31	415.2	3.32	40.0	7.23
82	0.2	25.21	427.4	8.69	108.7	7.70
	1.0	24.89	427.6	8.39	104.7	7.73
83	0.2	25.11	428.2	8.76	109.6	7.90
	1.0	24.65	428.6	8.05	99.3	7.77
	2.0	24.57	427.5	8.07	99.8	7.65
	3.0	24.52	427.9	7.77	95.0	7.63
84	0.2	25.30	425.3	8.95	112.3	7.91
	1.0	24.82	425.2	9.07	112.8	7.94
	2.0	24.63	425.9	8.50	105.0	7.90
85	0.2	25.22	419.4	8.85	110.4	7.93
	1.0	24.78	419.9	8.65	107.5	7.85
	2.0	24.57	419.5	8.37	103.5	7.77
	3.0	24.49	428.5	7.66	93.6	7.70
86	0.2	25.30	429.8	8.87	111.3	7.99
	1.0	24.62	429.3	8.47	104.9	7.84
	2.0	24.51	429.5	8.10	99.6	7.75
87	0.2	25.31	428.7	8.51	106.9	7.84
	1.0	24.86	426.3	8.10	106.7	7.74
88	0.2	25.47	429.4	8.88	111.8	8.02
	1.0	25.07	429.7	9.02	112.8	7.98
	2.0	24.67	428.6	8.47	104.8	7.86
	3.0	24.45	429.5	7.55	93.1	7.73
89	0.2	25.71	436.5	8.87	112.0	7.97
	1.0	25.40	433.4	9.01	113.7	8.01
	2.0	24.67	436.2	9.05	112.2	8.00
90	0.2	25.34	430.6	9.18	115.1	8.17
	1.0	24.95	437.3	9.15	114.2	8.14
	1.3	24.63	455.4	8.85	109.8	7.94
91	0.2	25.52	414.3	9.06	114.1	8.12
	1.0	25.03	428.2	9.04	112.4	8.06
92	0.2	25.35	431.4	8.09	109.1	8.03
	1.0	24.98	429.4	9.26	114.7	8.23
93	1.0	25.59	429.8	9.00	113.5	8.09
	1.0	25.20	428.9	9.02	112.9	8.04
	1.9	24.70	429.9	8.15	101.0	7.86
94	0.2	25.93	427.2	8.87	112.5	7.97
	1.0	25.35	471.9	9.74	122.1	8.11
95	0.2	25.74	430.3	8.97	112.5	8.04
	1.0	25.25	429.6	9.26	116.0	8.02
	2.0	24.55	448.6	8.42	104.5	7.80
96	0.2	25.88	431.2	8.86	112.3	8.01
	1.0	25.70	432.6	8.96	113.1	7.97
97	0.2	25.56	439.9	8.95	112.6	8.06
	1.0	25.05	439.4	8.98	112.6	8.00
	2.0	24.82	439.0	9.22	114.7	8.04
98	0.2	25.91	430.9	8.98	114.3	8.00
	1.0	25.44	429.8	9.05	114.2	7.97
	2.0	24.78	428.2	9.14	113.6	7.98
99	0.2	26.01	431.9	8.92	113.2	8.00
	1.0	25.51	432.4	9.04	114.3	8.02
	2.0	24.77	432.2	9.09	113.1	8.04
100	0.2	26.05	434.1	8.80	111.8	8.00
	1.0	25.06	432.5	9.38	118.7	8.06
101	0.2	25.89	435.6	8.74	111.2	8.00
	1.0	25.18	434.0	9.08	113.6	8.03
	2.0	24.83	434.4	8.83	109.9	8.00
102	0.2	26.25	575.4	8.71	111.4	7.99
	1.0	25.47	441.2	8.68	109.2	7.90
103	0.2	26.22	435.9	8.91	113.9	8.15
	1.0	26.03	436.7	8.96	114.1	8.12
	2.0	25.12	435.2	10.11	121.9	8.10
104	0.2	25.65	407.1	8.97	113.5	8.18
	1.0	25.52	439.3	9.00	113.4	8.14
	2.0	24.88	434.0	9.34	116.5	8.16

Trout Habitat Highlighted in Pale Blue

Nearshore *In-Situ* Monitoring for Lake Hopatcong 8/21/2023

Station	Depth	Temperature	Specific Conductance	Dissolved Oxygen		pH
	m	°C	µS/cm	Conc. (mg/L)	Sat. (%)	s.u.
105	0.2	25.64	428.5	8.70	109.2	7.92
	1.0	24.86	427.4	9.00	111.4	7.94
	2.0	24.41	427.4	9.12	112.3	8.00
106	0.2	25.31	440.2	9.15	114.6	8.12
	1.0	24.30	461.2	10.64	130.8	8.50
	1.4	23.91	482.2	10.58	129.4	8.49
107	0.2	25.32	430.0	8.67	108.7	8.00
	1.0	25.31	430.5	8.64	108.9	7.90
	1.5	24.97	430.6	8.69	108.2	7.88
108	0.2	25.19	432.4	9.15	113.3	7.99
	1.0	24.65	432.1	9.28	114.9	7.94
	2.0	24.34	432.7	7.50	92.5	7.84
109	0.2	25.23	431.7	9.77	115.8	8.17
	1.0	24.58	434.9	9.64	120.6	8.13
	2.0	24.29	433.5	8.13	96.4	8.11
110	0.2	24.58	434	8.56	105.7	7.88
	1.0	24.25	434	7.91	96.9	7.78
	2.0	24.09	434	7.67	93.9	7.59
	2.5	24.02	434	7.28	88.7	7.54

Trout Habitat Highlighted in Pale Blue