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2024 Forest Lake Water Quality Review

Introduction

The goals of this testing protocol were to monitor various water quality parameters of the lake, compare results to historical data, and identify any potential risks to the health of Forest Lake. Water samples were taken at two different locations and tested for 14 parameters. Tests were conducted throughout the spring and summer. Tests were conducted with a YSI ProDSS Multiparameter Water Quality Meter, HANNA Nutrient Specific Calorimeters or LaMotte SMART2 Colorimeter.

Test results were compared to historical data from the report "Forest Lake 2023 WQ Report" by LakePro, Inc.

In this report, we included historical data from Water Quality Investigators. Their report provided annual averages for many of the parameters from 2002 to 2009. Including this data allows us to see more accurate trends in the water quality data. In order to make the analysis easier, we displayed annual averages and trendlines on the graphs. The trend lines revealed which direction each water quality parameter moved over the past fifteen years.

Results

Parameter	2024 Season Average	Target Range	Status
Temperature	70.1 ˚F	Less Than 75 ˚F	Healthy
Dissolved Oxygen	8.4 mg/L	4.0 – 12.0 mg/L	Healthy
Total Phosphorus	80 ppb	0 – 100 ppb	Healthy
Phosphate	33 ppb	0 – 100 ppb	Healthy
Nitrate-Nitrogen	60 ppb	0 – 200 ppb	Healthy
Chlorophyll-a	2.3 ppb	0 – 7.3 ppb	Healthy
Transparency	13.9 feet	More than 6.5 feet	Healthy
pH	8.0 S.U.	7.0 – 9.0 S.U.	Healthy
Total Dissolved Solids	547 ppm	0 – 1,000 ppm	Healthy
Conductivity	782 ppm	0 – 1,500 ppm	Healthy
Alkalinity	135 ppm	100 – 250 ppm	Healthy
Sulfate	14.6 ppm	3 – 30 ppm	Healthy
Fluoride	0.07 ppm	0.01 – 0.30 ppm	Healthy
Chloride	303 ppm	0 – 230 ppm	High

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Year-End Discussion

Forest Lake's water quality was very good throughout 2024. The season-average for most parameters were within the target ranges. Total phosphorus was near the top end of the target range, howevr has decreased since 2023. Chloride was high, but remained consistent as discussed below.

Temperature and Dissolved Oxygen

The average surface water temperature this year was higher on average compared to previous years. Most Michigan lakes had significantly less ice and snow cover over the previous winter. This led to atypical water temperatures in the spring, setting up most waterbodies in the state to be higher in temperature across the board. The summer precipitation led to slightly higher water levels and more of a chance for foreign particles to be introduced and/or prefferably flushed. Higher water can hold less oxygen, however this did not present a great issue.

We also measured temperature at different depths to create a profile. This data shows how the temperature changed with depth and whether or not a thermocline was present in the lake. During the spring test, there was not a defined thermocline. By the summer sampling, the water was stratified and water temperatures decreased sharply from 15 to 18 feet. The thermocline was near 16.5 feet.

There is a limit on how much dissolved oxygen can be in the water, which depends upon water temperature. Despite the warmer temperatures in late summer, Forest Lake had excellent dissolved oxygen concentrations throughout the summer. Dissolved oxygen is vital for a healthy aquatic ecosystem, so this year's concentrations were a positive for lake.

The depth profile protocol was followed and measurements were taken for dissolved oxygen. The data showed how the oxygen concentration changed throughout the water column. A concentration of 3.0 milligrams per liter is a general requirement for fish, so this graph shows there was enough oxygen to support fishes in the water down about 25 feet, which was an similar to last three years.

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Nutrients, Plant Production, and Transparency

Nutrients in the water are the fuel for plant growth. Nutrient concentrations can be interpretted as the potential for nuisance plant growth. Phosphorus is a main nutrient necessary for aquatic plant growth, so it is important that this nutrient remains low in the lake. The total phosphorus started the summer near the limit of the target range, but decreased more comfortably into the target range by August. The season average was lower than 2023, showing there was a slight decrease since last year as well as the year before. Phosphate, the active form of phosphorus, was within the target range for all tests this year.

Nitrate is another major nutrient for aquatic plant growth. The nitrate concentrations remained within the target range across all tests. It is important that residents fertilize and use their land responsibly to prevent additional nutrients from entering the lake.

We also measured chlorophyll concentrations because it is a direct indicator of plant production. The target for chlorophyll is below 7.2 parts per billion. In May and August, the concentrations were within the target range along with the annual average.

One of the most important effects of plant growth on the lake is the reduction of water clarity. Before algae forms the green mats of "scum" on the surface, it is suspended in the water column. Algae floating in the water can decrease water clarity, even before you see a tint of green. Despite the higher chlorophyll concentrations recorded in August, the water clarity averaged surged to just under 15 feet this year.

In order to better understand the relationship between nutrients, plant production, and clarity, limnologists use Trophic State Indices (TSI) to score each category and examine the relationship between them. In general, lower scores indicate a less productive lake. The TSIs for Forest Lake this year were:

Category	Water Quality Parameter	Trophic State Index (season average)	Classifciation
Nutrients	Total Phosphorus	67	Eutrophic
Plant Production	Chlorophyll	38	Mesotrophic
Clarity	Transparency	39	Mesotrophic

The TSI for Total Phosphorus classified the lake as eutrophic, or very productive. This is based on the availability of nutrients to fuel plant productivity. The TSI for Chlorophyll, however, is lower than the nutrient score. This suggests that despite the availability of nutrients, the plants did not grow to the levels supported by the nutrients. Another factor is that the aggressive plant management helped control the nuisance plant and algae growth. The TSI for Transparency was even lower, classifying the lake as mesotrophic. This shows that the water clarity was better than expected from the chlorohpyll.

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Water Chemistry Parameters

It is important to monitor the basic water chemistry of the lake water. Shifts in these parameters indicate major changes to the lake that may need to be further investigated.

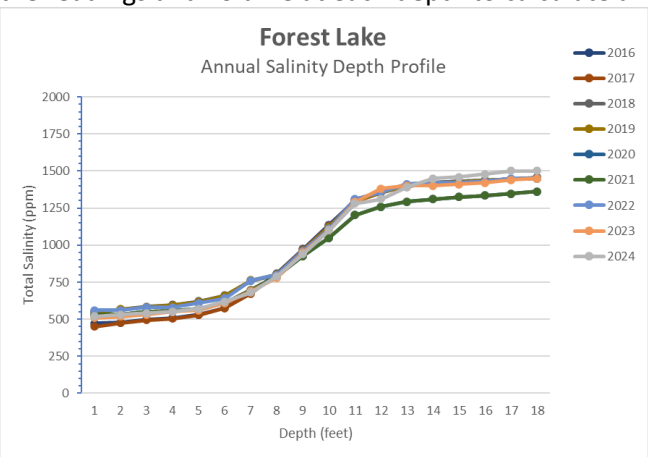
The pH of the lake remained within the target range for the entire summer. The Total Dissolved Solids (TDS) showed there were average amounts of dissolved substances in the water. This parameter includes nutrients, salts, and other substances, so it is a positive that this parameter has remained within the target range. Conductivity, which measures ionic molecules in the water, usually follows the TDS. This parameter measures the ability of molecules in the water to conduct electricity. Thus, it is particularly sensitive to salts, which are excellent conductors. The conductivity was in the middle of the target range this year. We did see a fall in this parameter and we will watch for aditional changes going forward.

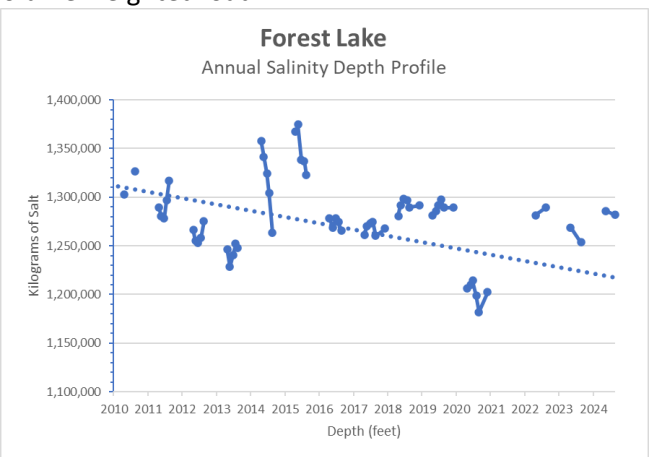
Alkalinity measures the concentration of one salt, Calcium Carbonate, which is beneficial to the aquatic ecosystem. The carbonate ions are able to accept protons from acids, making it a natural buffer. This means that as acidic substances enter the lake, the carbonate is able to buffer against severe changes in pH that could pose a threat to the ecosystem. This year the Alkalinity was at a healthy level for all tests.

Pollutants

Finally, the lake is tested for Sulfate, Fluoride, and Chloride as indicators of pollution. These molecules should be present in the water naturally, but elevated levels can indicate pollution from within the watershed and may pose a risk to the ecosystem. Throughout the year, the sulfate and fluoride concentrations were within their target ranges. Chloride was above the target range for the whole summer, but improved over the course of the year.

Chloride is a major constituent of total salinity. The depth profile protocol was followed and measurements were taken for salinity. This allowed us to see how this parameter changed throughout the water column. We also used the readings and volume at each depth to calculate a volume weighted load.





The first graph shows the average annual salinity at 3-foot depth intervals. This graph shows the salinity increases with depth and ranges from about 500 parts per million at the surface to about 1,500 parts per million in the deepest portion of the lake. This year, there wasn't a stark increase in the salinity in the deeper water, compared to previous years.

Based on the amount of water at each depth interval and the concentration of salts, we calculated a total salt load for the lake. The second graph shows those calculated loads during each testing event. The salinity fluctuated throughout the summer, but this year showed a slight increase in the salinity load, however not impacting the downward trend over the testing history.

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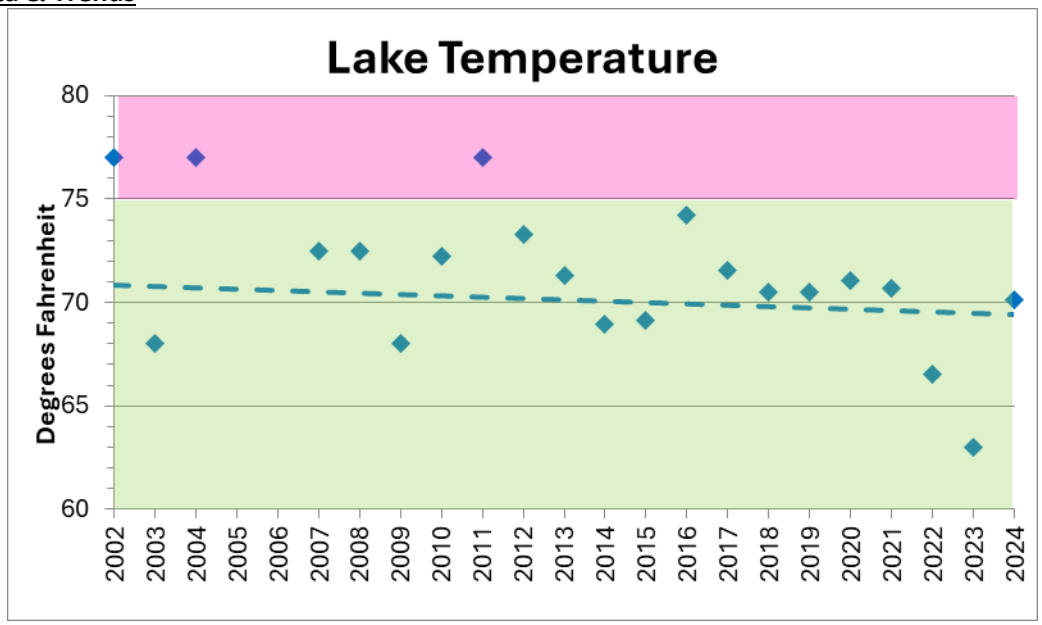
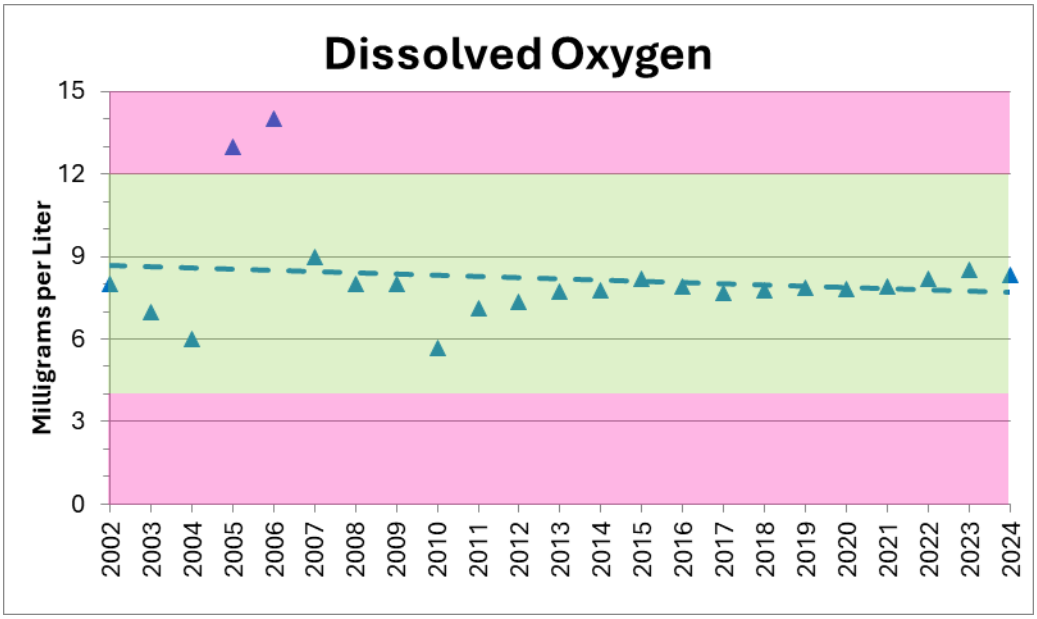
Historical Data & Trends



Discussion

The long term trend for water temperature is slightly downward. The previous four years' averages were below the trend, which helped to flatten it, and now decrease the trend. This year's average was much higher than 2023, which in turn slightly lowered dissolved oxygen levels. Water temperature depends upon air temperatures and the dates selected for testing. For that reason, LakePro tries to select similar dates for testing each year. Cooler water is able to hold more oxygen, so lower temperatures are better for the ecosystem.



Discussion

As expected with increasing temperatures, the dissolved oxygen trend is slightly downward. As water temperature increased, the oxygen solubility decreased. This has been a negative change for the lake, but oxygen concentrations remained adequate to support a healthy ecosystem. The 2022 through 2024 average was above the trend line, which helped to flatten it and we will look for the trend to stabilize in the future.

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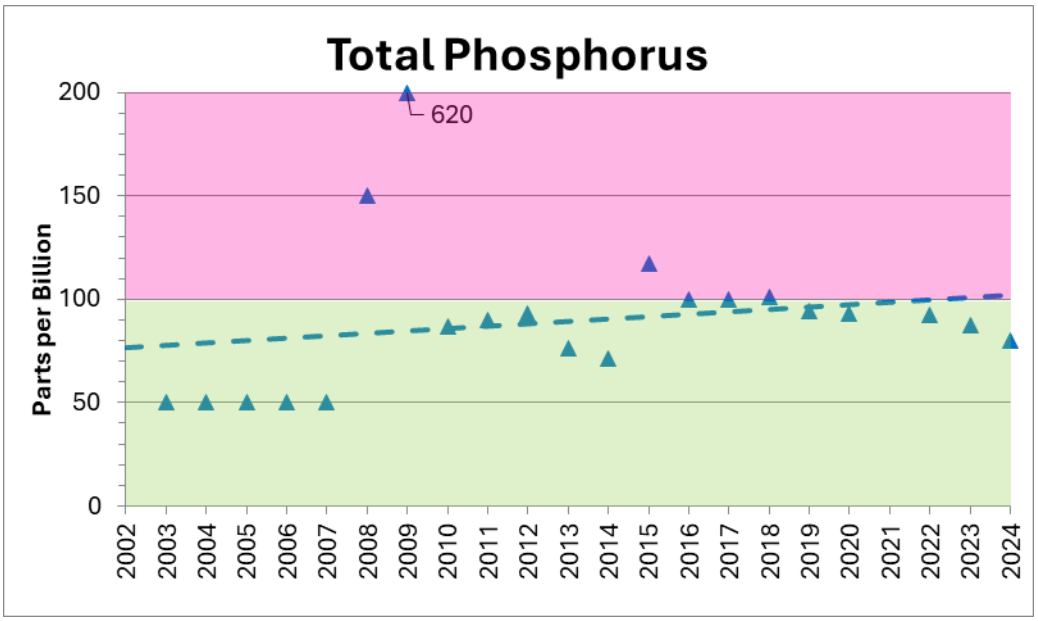
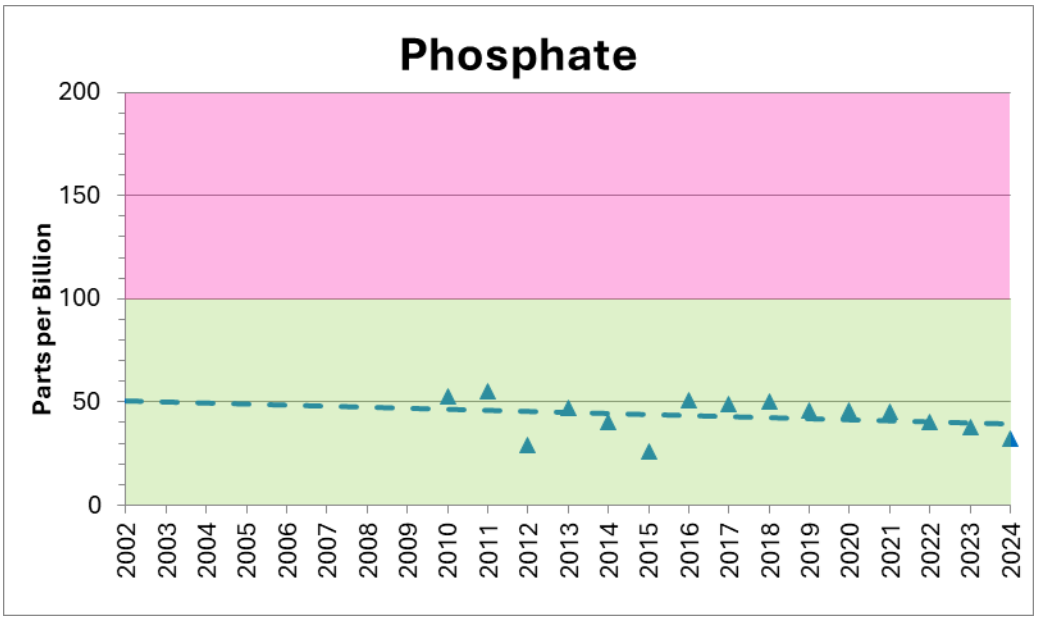


Discussion

Generally, lakes tend to accumulate the substances that flow into it. Since testing began in 2003, the trend for total phosphorus slowly climbed. The 2008 and 2009 concentrations were much higher than all other years of testing, worsening the trend. Since 2020, the data has been below the trend which indicates less amounts of phosphorus entering the water body. There are ways to remove phosphorus, such as mechanical harvesting and heavy rain events that create excess flow. However, it is much easier to prevent excess nutrients from entering the lake. For this reason, it is vital that residents around the lake fertilize and use their land responsibly to prevent phosphorus from reaching the lake.



Discussion

Phosphate is the form of phosphorus that is most usable by plants and algae. As the total phosphorus accumulates, phosphate usually follows. There is no historical data available for phosphates, so the trendline reflected the changes only during the years of LakePro's testing. The trend has started to display a slight decrease in annual phosphate concentrations, while staying within range.

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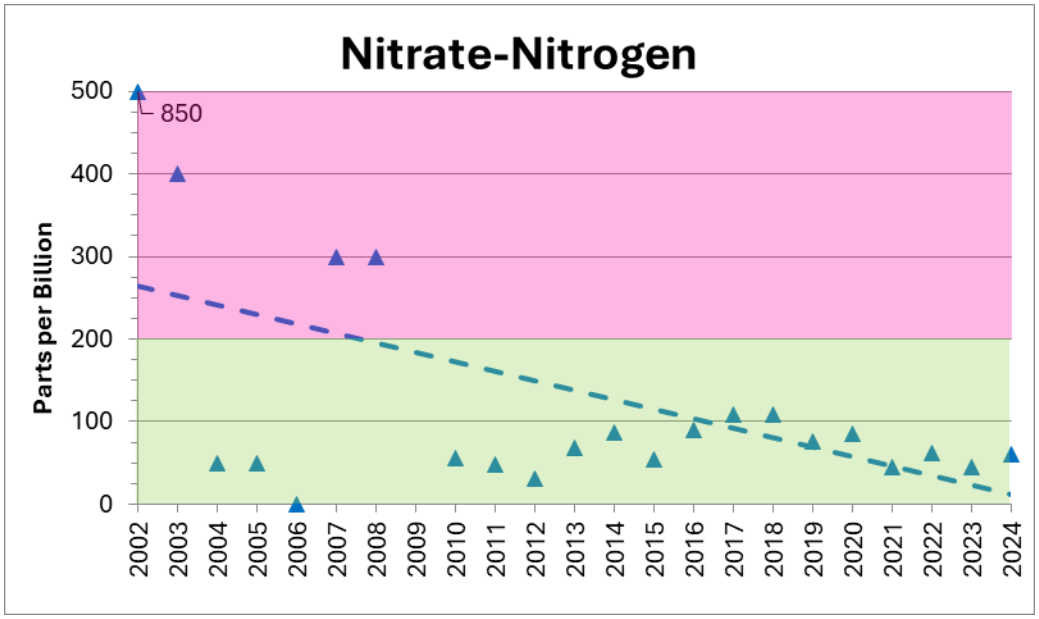
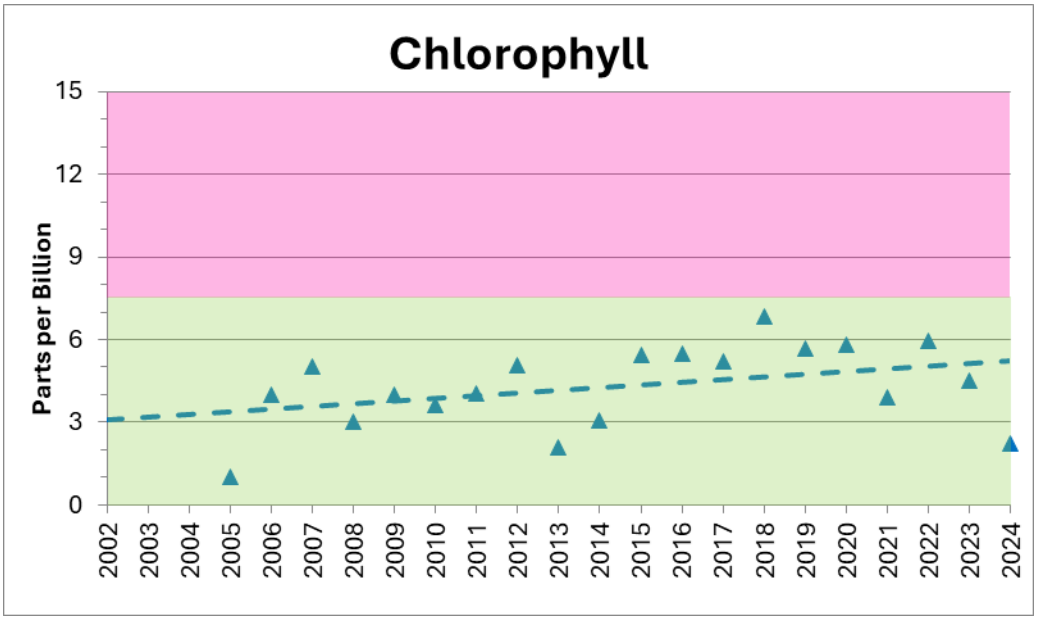


Discussion

The nitrate season averages fluctuated widely over the early testing history. The historical trend is downward. There was a slight upward climb since 2010, but concentrations remained within the target range. It is important that residents around the lake fertilize and use their land responsibly to prevent additional nitrate from reaching the lake.



Discussion

Chlorophyll trended upward over the testing history and shown to be slightly lower each year since 2022. This was most likely a product of decreasing phosphorus concentrations and sufficient nitrates. For now, the annual chlorophyll averages remained within the target range. Continuing to mechanically harvest will remove plant biomass and the nutrients within it. Responsible land management by residents around the lake will help stifle the source of excess nutrients, preventing further worsening of the plant growth.

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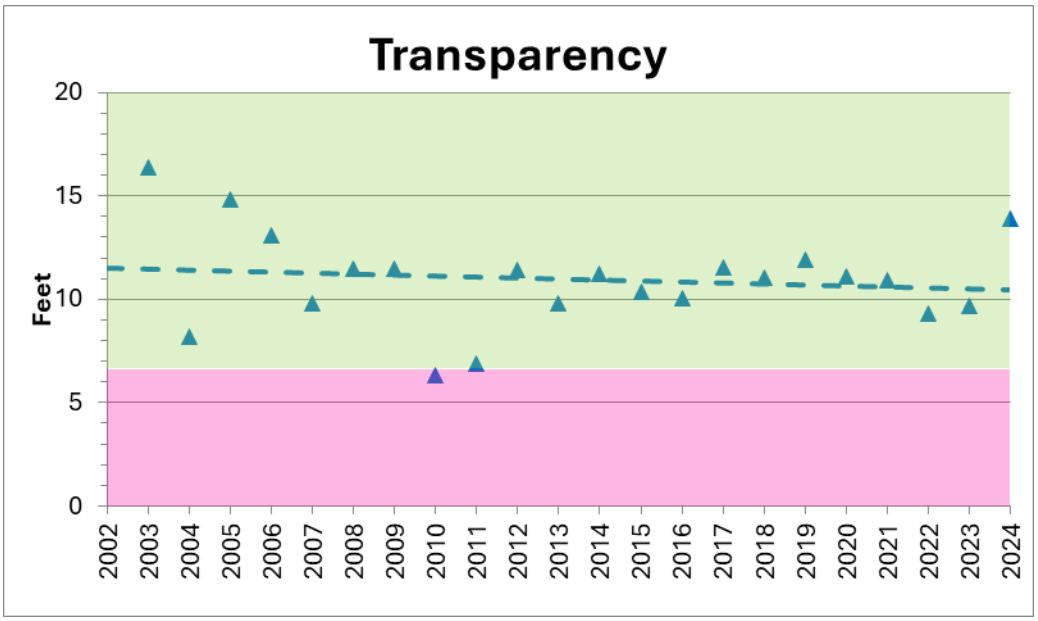
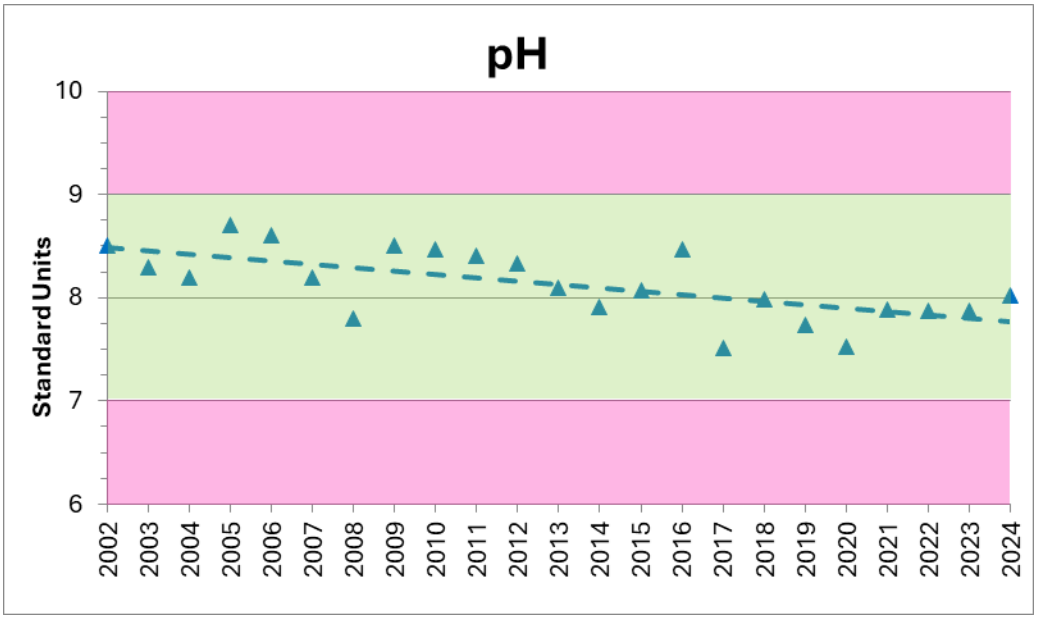


Discussion

Chlorophyll is used as an indicator of plant growth, including algae that clouds the water. Therefore, the increasing chlorophyll concentrations lead to lower transparency over the testing history. The decreasing water clarity could also be due to higher dissolved solids or higher suspended solids (e.g. sediment). Although the clarity trended downward, it was still above the target depth this summer and increased to the lake's highest levels since 2005.



Discussion

The pH decreased slightly over the testing history. The shift moved annual values closer to 8, the middle of the target range. This change has not had a major impact on the lake but changes out of the target range may need to be quickly investigated. Over the past few years, the trend is leveling off around 8 S.U.

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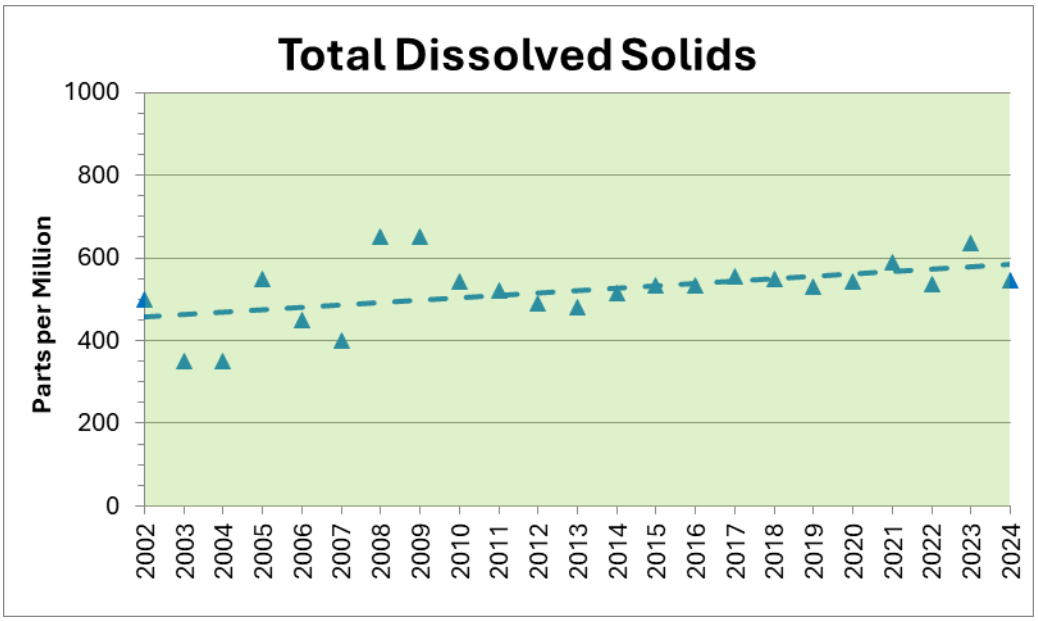
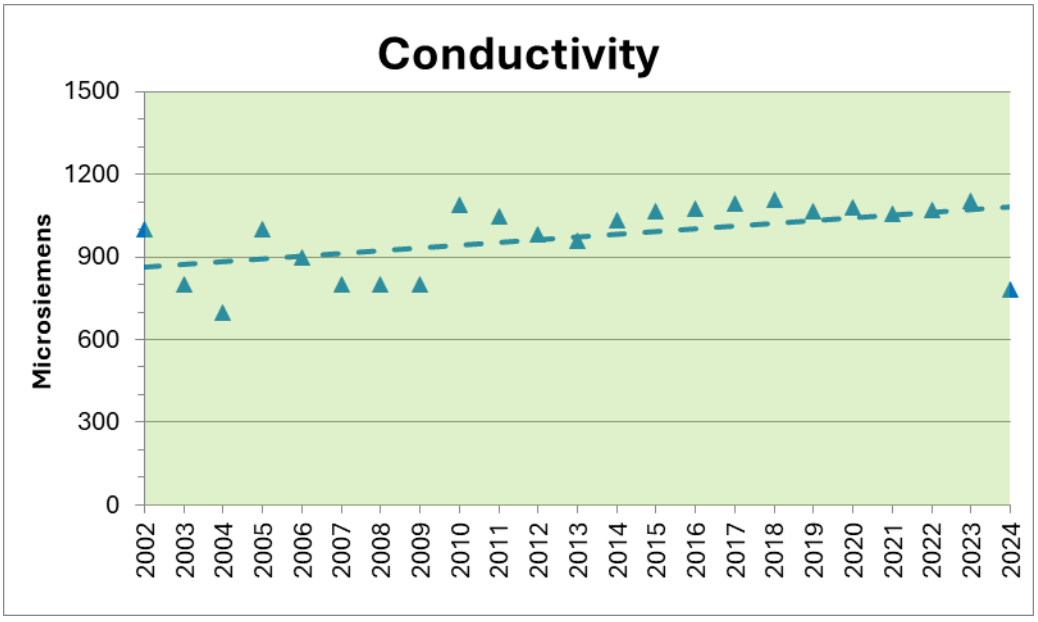


Discussion

The total dissolved solids increased over the testing history, showing that the lake is accumulating more substances. The increase was slow and the averages remained within the target range. Recent years were flat, possibly due to increased precipitation. We saw a slight decrease in TDS this year.



Discussion

Like the TDS, conductivity increased over the testing history. Conductivity is an extension of TDS and measures the amount of ionic molecules in the water (which conduct electricity, usually salts). This year we saw a large decrease in conductivity, possibly due to less snow melt and runoff from a very mild winter. We will look for this trend to slow in future years of testing.

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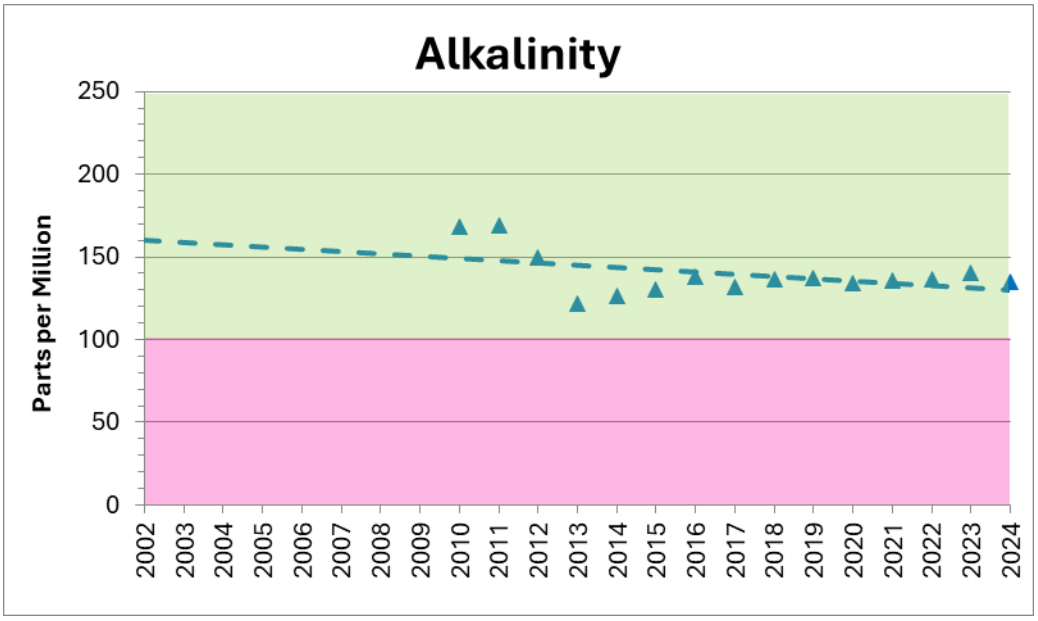
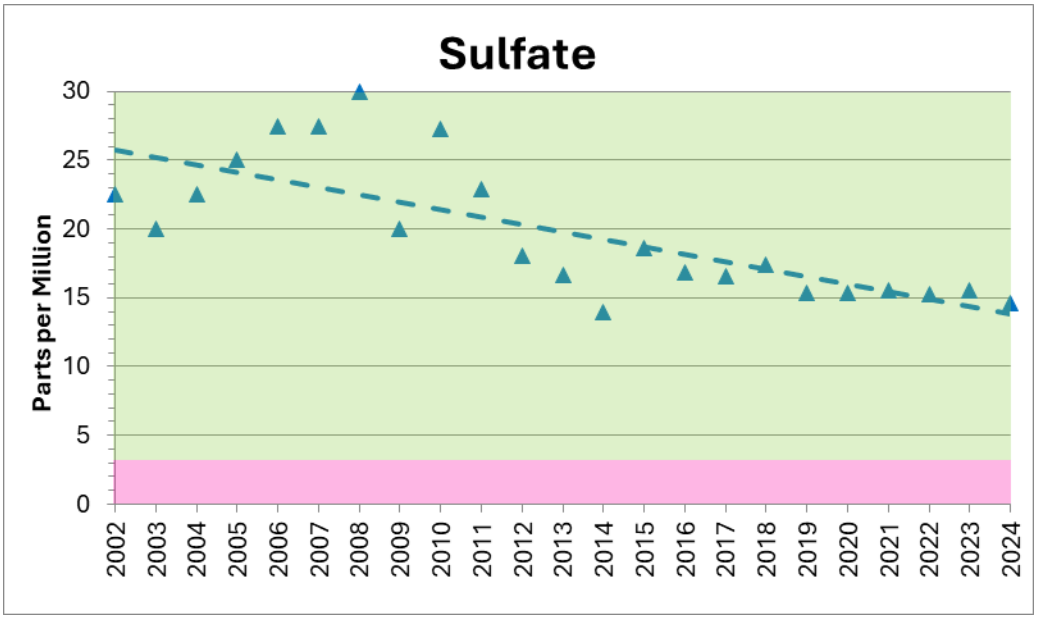


Discussion

Alkalinity was first included in the testing in 2010, so the historical data is abbreviated. Alkalinity decreased since 2011, but remained within the target range and showed slight recovery since 2013.



Discussion

Sulfate fluctuated over the course of testing but the overall trend was downward. It is important that this parameter stay within the target range. Any sharp increases could indicate pollution that would need to be quickly investigated.

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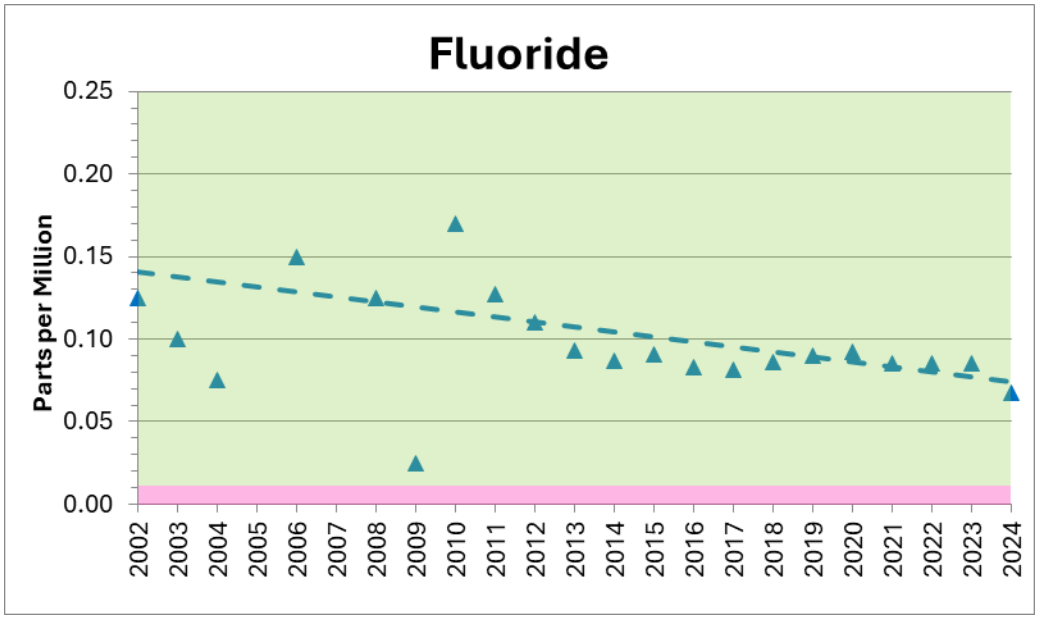
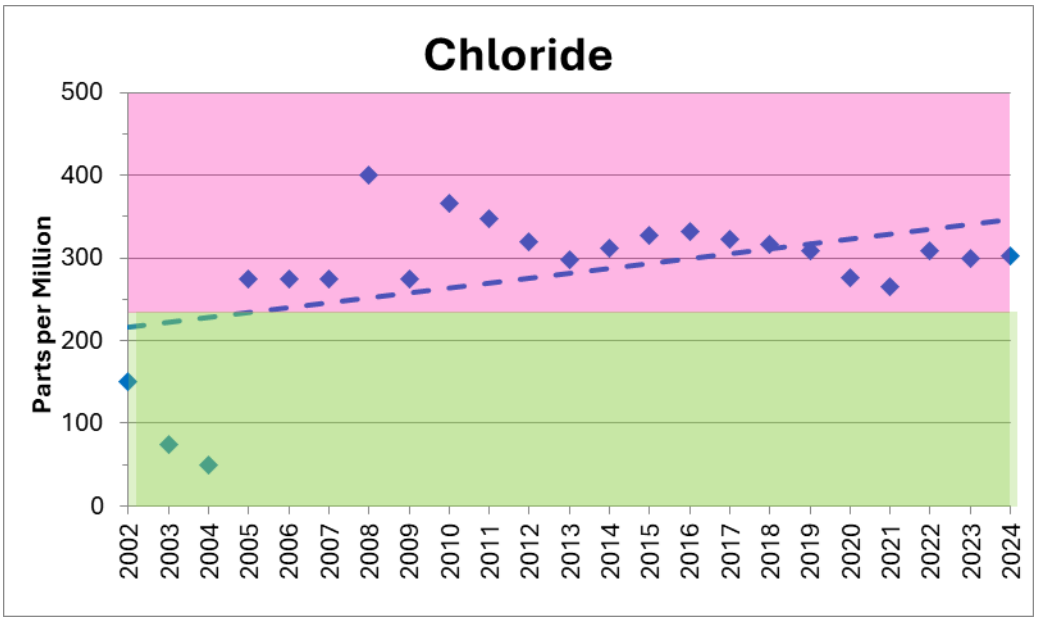


Discussion

Fluoride has fluctuated over the testing history but showed an overall decline. It is important that this parameter stay within the target range and any sharp increases are quickly investigated.



Discussion

The trend line for Chloride is upward. The data shows a large increase in 2005, which put concentrations over the target limit. Since 2008, the overall trend was slightly downward, showing the amount of chlorides slowly decreased. In the past three years, Chloride has started to stabilize around 300 PPM. This change is a good sign and does not show a need for immediate response. We will closely observe this data in the future to make sure an upward trend does not continue.

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Summary & Discussion

Forest Lake displays excellent water quality routinely, and this year was no different. A mild winter led to higher than average temperatures, and a coinciding decrease in snowmelt and run-off. These circumstances contextualize the drops we see in parameters like Total Phosphorus, Salinity, and Total Dissolved Solids, as there was less opportunity for accumulated pollutants to enter the water via run-off from snow melting.

The lowered nutrient levels reflect the care taken by Riparian's to responsibly maintain their properties and prevent fertilizers from entering the waterbody. This practice should be continued to prevent future problems from arising due to excess nutrient influx, which could cause problematic algal blooms.

The historical averages for all of the above parameters and metrics will be monitored over time, and taken into consideration for any future interventions.

Thank you for choosing LakePro,

Michael Smith

Lake Manager
Environmental Science

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Analysis Information

Temperature:	The water temperature directly affects the amount of oxygen that is able to dissolve into the water. The temperature of surface waters is not indicative of the entire water column.
Dissolved Oxygen:	D.O. is a measure of the amount of oxygen dissolved in the water. This oxygen is available to fish and other animals for respiration. Vegetation generally increases DO, particularly during the day and early evening. Animals and other respiring organisms consume the oxygen, mostly during the day. Oxygen is also added to the lake through wave action, rain, fountains and aerators.
Total Phosphorus:	Phosphorus is an essential nutrient for plant growth. However, concentrations exceeding 100 ppb can impair the water and results in nuisance vegetation growth.
Phosphates:	Phosphate is the form of phosphorous that is most readily available to plants and algae.
Nitrate:	Nitrogen is also essential for plant growth. Nitrate is the predominant form of nitrogen in water. Excessive nitrate concentrations may also result in pollution and increased vegetation.
Chlorophyll-a:	Chlorophyll-a is a direct measurement of the amount of green pigment produced by plants and phytoplankton. This indicates the amount of plant growth and is used to calculate a Trophic State Index.
Transparency:	The ability of light to penetrate the water column is determined by the amount of dissolved and suspended particles in the water. Although aesthetically desirable, transparent water allows increased light to reach the lake bed and may result in vegetation growth.
pH:	pH is a measure of acidity or alkalinity. pH is a general measure of lake health and can roughly indicate the range of other measurements such as alkalinity and hardness.
TDS:	Total Dissolved Solids is the amount of all organic and inorganic substances in the water in a molecular or ionized state. Higher values generally indicate richer and more productive water. Lower values usually indicate cleaner and less productive water.
Conductivity:	Conductivity is a measure of the ability of water to conduct electricity. Dissolved ions in the water increase conductivity, thus TDS and Conductivity are closely related.
Alkalinity:	Alkalinity refers to the ability of the water to neutralize acids, mainly through the hydrogenation of carbonate ions. This is why the alkalinity is expressed as "ppm as $CaCO_3$". However, other basic molecules in the water can also contribute to alkalinity.
Sulfate:	Sulfate occurs naturally as minerals, such as calcium sulfate and magnesium sulfate. In fresh water, sulfate is usually the second or third most abundant anion. Other sources of sulfate include water material from pulp mills, steel mills, food processing operations, and municipal wastes. Under low oxygen conditions, sulfate can by reduced to hydrogen sulfide gas, which smells like rotten eggs.
Fluoride:	Fluoride may occur naturally or be added to public drinking water supplies.
Chloride:	Chloride is one of the major anions found in water and sewage. The presence of chlorides may be due to water passing through salt formations in the earth or pollution from industrial processes, domestic wastes, or road salt. The salt content of water affects the distribution of plant and animal life in an aquatic system, based on the amount of slat they can tolerate.

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Trophic States

Oligotrophic: Water is very clear. Nutrient levels are generally low. Plant and algae productivity is also low. Sufficient dissolved oxygen in the bottom, cooler waters allows cold-water fish to survive, such as salmon and trout.

Mesotrophic: Water is moderately clear. Nutrient levels are slightly elevated. Plant and algae productivity is present, but generally not a nuisance. Oxygen and temperature in the lower portion of the lake allow walleye and perch to survive.

Eutrophic: Water is not clear due to high nutrients levels, increased turbidity, and excessive algal growth. There is no oxygen in the bottom, cooler waters, restricting the lake to warm water species, such as bass and bluegill.

Hypereutrophic: Nutrient levels are extremely high, promoting very high algae productivity. Blue-green algae blooms are likely. High turbidity and algae growth make the water opaque. Little plant growth is restricted to invasive plants. The only fish that can survive this environment are rough fish, such as carp, catfish, and mudminnows.

Sample Sites: