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2020 Lower Long 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 Lower Long Lake. Water samples were taken at four different locations and tested for 14 parameters. Tests were conducted on a monthly basis from April through August. Tests were conducted with a Hanna Multiparameter Water Quality Meter or LaMotte SMART2 Colorimeter.

Test results were compared to historical data from the report "2019 Lower Long Lake Water Quality Review" 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 added annual averages for our data and trendlines on the graphs. The trend lines allow us to see the direction each water quality parameter is moving.

Results

Parameter	2020 Season Average	Target Range	Status
Temperature	70.3 ˚F	Less Than 75 ˚F	● Healthy
Dissolved Oxygen	8.2 mg/L	4.0 – 12.0 mg/L	● Healthy
Total Phosphorus	98 ppb	0 – 100 ppb	● Healthy
Phosphate	50 ppb	0 – 100 ppb	● Healthy
Nitrate	59 ppb	0 – 200 ppb	● Healthy
Chlorophyll-a	3.9 ppb	0 – 7.3 ppb	● Healthy
Transparency	16.0 feet	More than 6.5 feet	● Healthy
pH	7.4 S.U.	7.0 – 9.0 S.U.	● Healthy
Total Dissolved Solids	376 ppm	0 – 1,000 ppm	● Healthy
Conductivity	756 ppm	0 – 1,500 ppm	● Healthy
Alkalinity	119 ppm	100 – 250 ppm	● Healthy
Sulfate	12.5 ppm	3 – 30 ppm	● Healthy
Fluoride	0.10 ppm	0.01 – 0.30 ppm	● Healthy
Chloride	139 ppm	0 – 230 ppm	● Healthy

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Parameter	July 2020 Result	Target Range	Status
Cadmium	Non-Detect	0 – 0.005 ppm	● Healthy
Chromium	Non-Detect	0 – 0.1 ppm	● Healthy
Copper	Non-Detect	0 – 1.3 ppm	● Healthy
Lead	Non-Detect	0 – 0.015 ppm	● Healthy
Nickel	Non-Detect	0 – 0.1 ppm	● Healthy
Zinc	Non-Detect	0 – 5.0 ppm	● Healthy
Mercury	Non-Detect	0 – 0.002 ppm	● Healthy
Cyanide	Non-Detect	0 – 0.2 ppm	● Healthy
Arsenic	Non-Detect	0 – 0.01 ppm	● Healthy

Preface

2020 was LakePro's tenth year testing water quality on Lower Long Lake. The historical data reveals trends over the testing history. The trend lines on the following graphs show the change from 2002 to 2019. Each successive year of testing will provide more insight into how the lake changed.

Each test represents a snapshot of the water quality when the sample was pulled. Water quality parameters can change from morning to night, day to day, or year to year. The discussion below will focus on the results listed above. We drew conclusions from the data, timing, and weather, but it is important to understand that each successive year of testing will help support trends and averages and improve our discussion.

This year's weather was marked by minimal rainfall in May and June, followed by above average precipitation in July and August. The precipitation can have two effects: dilute and flush what is in the lake and deliver new substances with runoff. The discussion below describes how these processes may have affected the water quality results.

Discussion

The results of this year's testing indicate that the water of Lower Long Lake remained outstanding throughout the summer. The results show that the aquatic environment was very suitable to support natural wildlife. Also, the lake was safe for recreational uses, such as swimming, boating, fishing, etc., as there are no signs of pollution.

The **Temperature** of the surface water was cool to start the season, then increased sharply in July. Colder water can hold more oxygen, so the higher temperatures created a small concern about dissolved oxygen in the lake, especially during the heat of summer. Despite the higher temperatures, the **Dissolved Oxygen** in the lake remained excellent throughout the summer. Furthermore, the sufficient oxygen concentration was a positive attribute headed into winter when ice seals the lake off from atmospheric oxygen.

The concentrations of **Total Phosphorus** were fluctuated in and out of the target range throughout the summer. **Phosphate**, the usable form of phosphorus, was in the target range during all testing events. Lakes naturally accumulate more nutrients over time, so these slightly higher concentrations may be indications the nutrients are loading in the lake.

The **Nitrate** concentrations remained comfortably within the target range throughout the entire summer. Although concentrations are still in the target range, it is important that residents take measures to ensure their property is not contributing excess fertilizers to the lake.

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We tested water samples for **Chlorophyll** as a direct indicator of plant production. The chlorophyll concentrations responded strongly to the water temperatures, increasing over the course of the summer. During all tests the plant pigment was within the target range at all four sites.

The **Transparency** was excellent during every test, measuring deeper than most other lakes that we tested. Transparency can be affected by many different factors, including suspended solids, dissolved solids, acids, and algae growth. The clear water is generally a positive attribute, but it also allows more sunlight to reach the lake bottom to fuel plant growth.

The **pH** was within the target during all testing events.

The **Total Dissolved Solids** and **Conductivity** were within their target ranges for all tests. These parameters ticked upward later in summer, as more rainfall created additional runoff to deliver foreign substances to the lake. Both parameters decreased in August as the outflow caught up and flushed excess molecules from the lake.

The **Alkalinity** was within the target range all summer, but decreased throughout the summer. The major reason for the decrease in the late summer was productivity. As lake organisms become more active in the summer time, they produce more carbon dioxide. As this gas dissolves, it needs to be buffered, using up the carbonate ions. Rainfall in July infiltrated the ground and reached limestone bedrock. As this additional water reached the lake, it replenished the alkalinity in August.

The **Sulfate, Fluoride,** and **Chloride** were all within their target ranges for the entire summer.

The late summer test for **Heavy Metals** was consistent with previous years. All the heavy metal parameters were non-detectable in the water.

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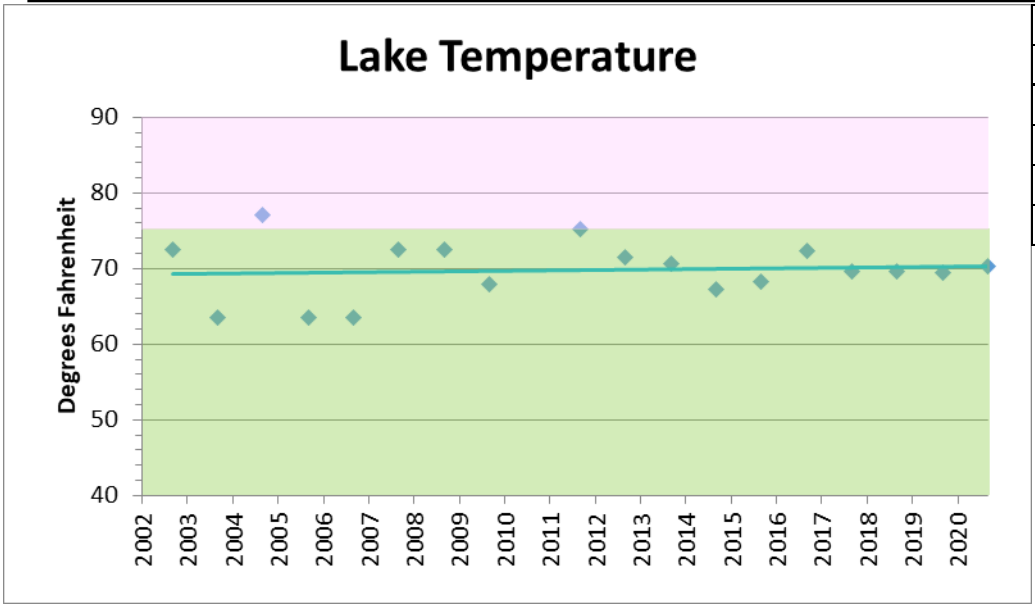
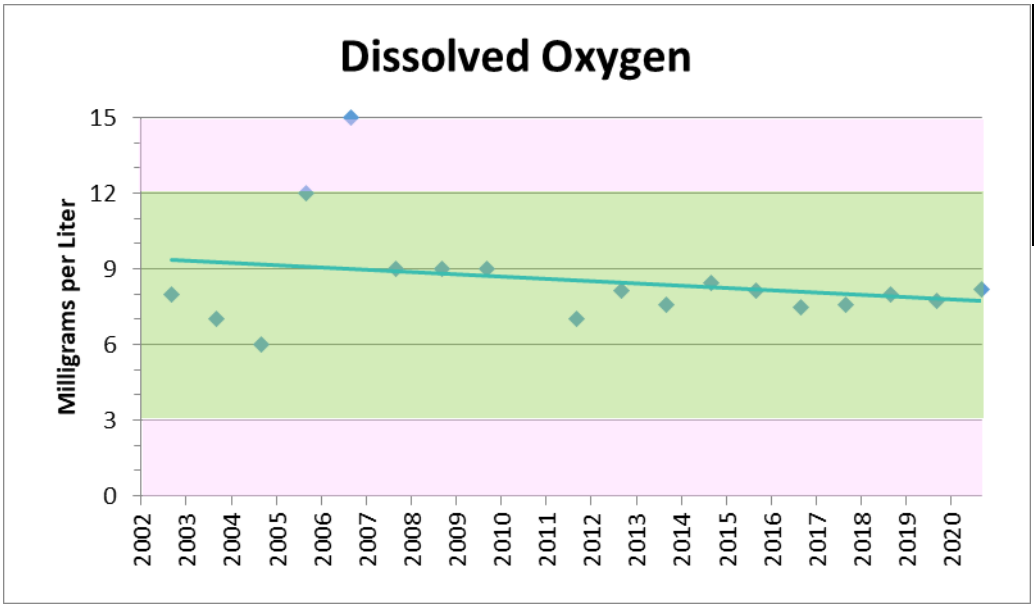
Historical Trends



Temperature (°F)					
	April	May	June	July	August
Site 1	51.1	68.5	72.9	79.5	77.9
Site 2	48.4	69.7	73.6	79.5	78.2
Site 3	49.8	69.9	75.3	79.5	78.3
Site 4	50.6	70.2	74.8	79.6	78.4
				Season Average	70.3

Target Range: < 75˚F

The historical trend for temperature increased marginally. The temperature was affected by the dates selected for testing and the weather each year. As we collect data in subsequent years, the trend line should become a more accurate indicator of the changes in the lake.



Dissolved Oxygen (mg/L)					
	April	May	June	July	August
Site 1	9.5	8.2	7.7	8.7	6.7
Site 2	9.0	8.5	7.7	8.7	7.6
Site 3	9.2	8.2	7.3	8.3	6.9
Site 4	9.1	8.0	7.8	9.1	7.3
				Season Average	8.2

Target Range: 4.0 – 12.0 mg/L

The dissolved oxygen trend showed a slight decrease over the testing history. Oxygen concentrations remained very healthy, showing the lake carries a healthy oxygen concentration despite changes in temperature. We will continue to watch this trend and recommend further actions if the decrease steepens.

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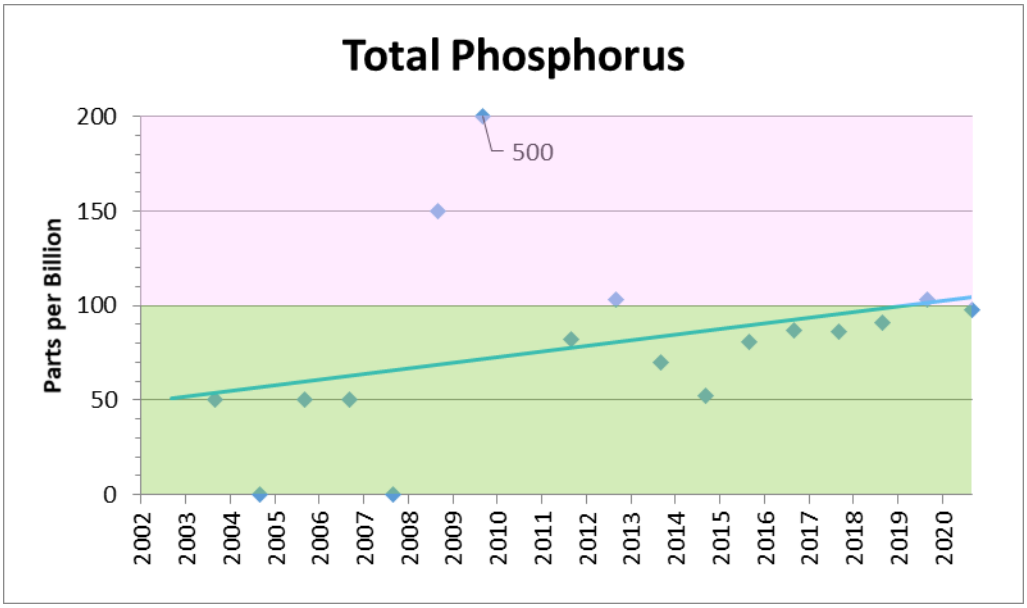
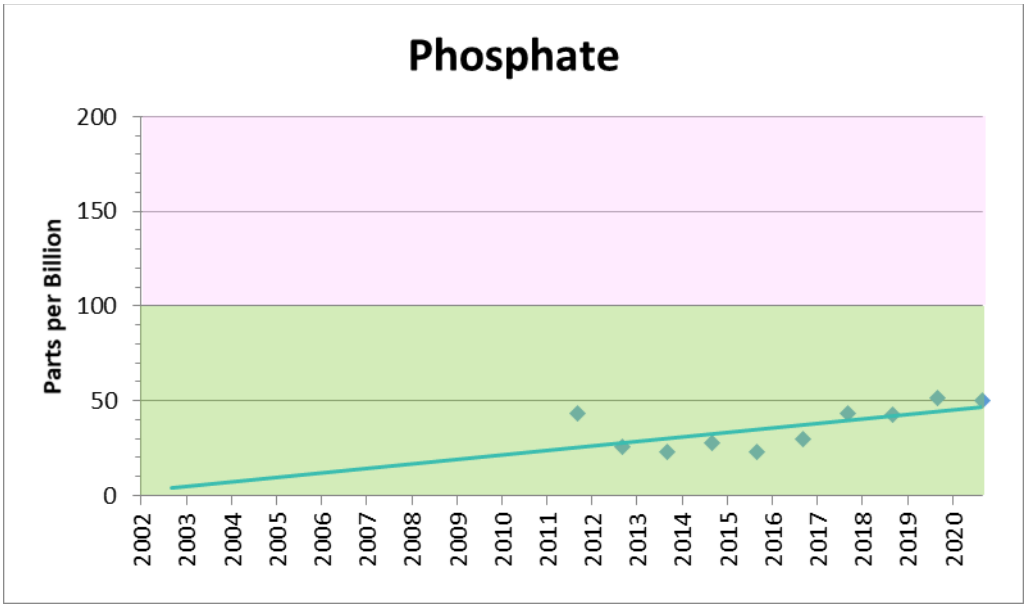


Total Phoshporus (ppb)					
	April	May	June	July	August
Site 1	110	120	100	110	80
Site 2	80	80	90	110	90
Site 3	130	90	100	130	60
Site 4	90	100	100	120	70
			Season Average		98

Target Range: 0 – 100 ppb

The total phosphorus annual averages showed a steady increase over the testing history. Lakes generally accumulate substances, including nutrients, in the process of eutrophication. The state law banning phosphorus fertilizers and active plant management will help decrease the phosphorus in the future. The phosphorus concentrations were very good for a large, heavily developed watershed.



Phosphate (ppb)					
	April	May	June	July	August
Site 1	60	60	50	60	40
Site 2	50	40	40	60	40
Site 3	60	40	50	80	30
Site 4	40	50	50	70	30
			Season Average		50

Target Range: 0 – 100 ppb

Phosphate is the form of phosphorus that is usable to aquatic plants. The phosphate data also showed a slightly upward trend since we began testing this parameter in 2011. Despite the increase, the phosphate remained within the target range and helped to limit plant and algae growth in the lake.

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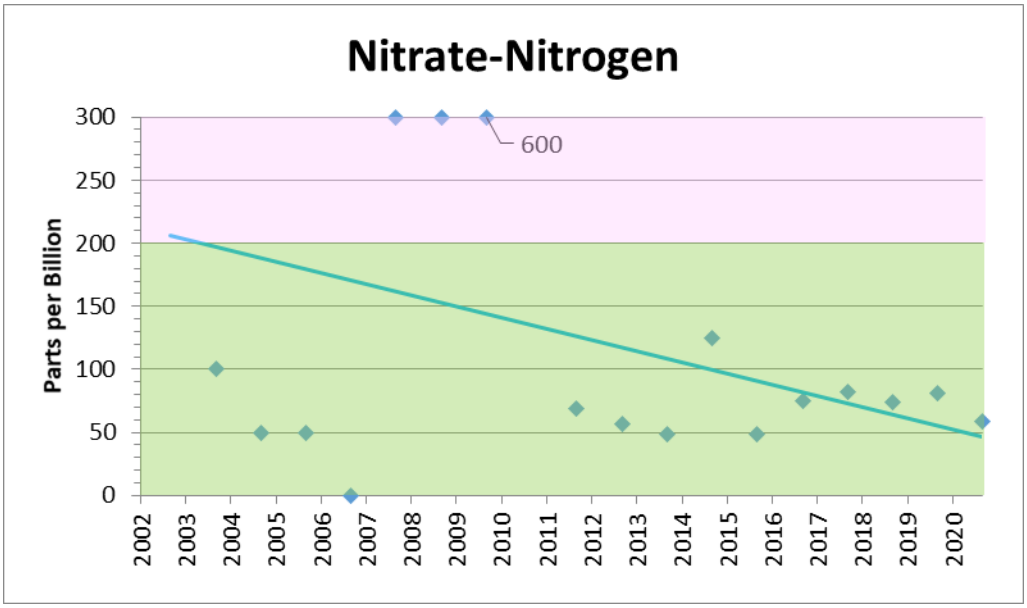
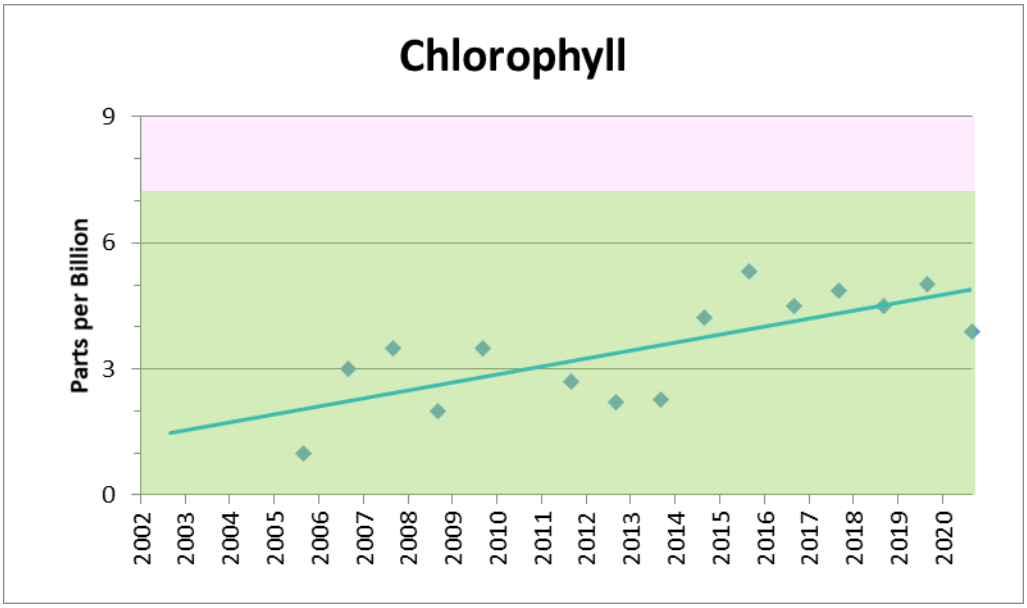


Nitrate-Nitrogen (ppb)					
	April	May	June	July	August
Site 1	110	50	50	30	20
Site 2	90	80	70	40	20
Site 3	120	110	40	10	20
Site 4	120	90	60	30	20
			Season Average		59

Target Range: 0 – 200 ppb

Nitrate is another vital nutrient for the growth of aquatic plants. Water Quality Investigators obtained high results early in the testing history, so the recent data resulted in a downward historical trend. It is important residents continue to be conscience of their property and practices to ensure more nutrients do not enter the lake.



Chlorophyll (ppb)					
	April	May	June	July	August
Site 1	1.9	3.4	3.8	5.2	6.2
Site 2	1.6	3.1	3.4	5.0	6.0
Site 3	1.9	2.5	3.2	3.7	5.7
Site 4	1.3	3.7	4.4	4.9	6.7
			Season Average		3.9

Target Range: 0 – 7.2 ppb

Chlorophyll concentrations were tested as an indicator of plant production, primarily algae in the water column. Over the testing history, the results increased steadily, which matched the increase in total phosphorus. This is also common with invasive plants in the lake, such as Eurasian Milfoil. This reinforces the urgency for responsible land management in the watershed to prevent additional phosphorus from entering the lake.

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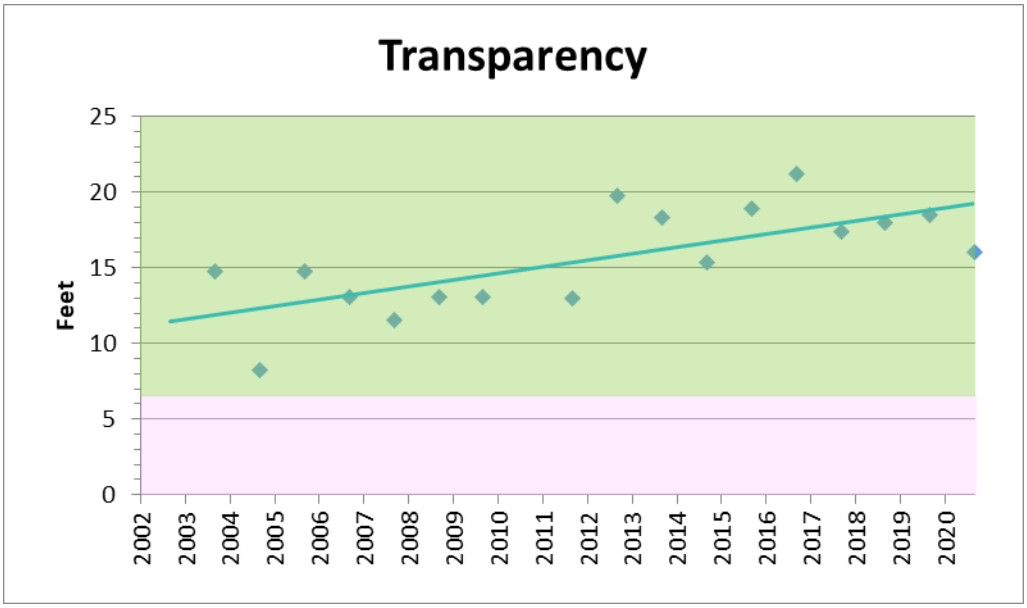
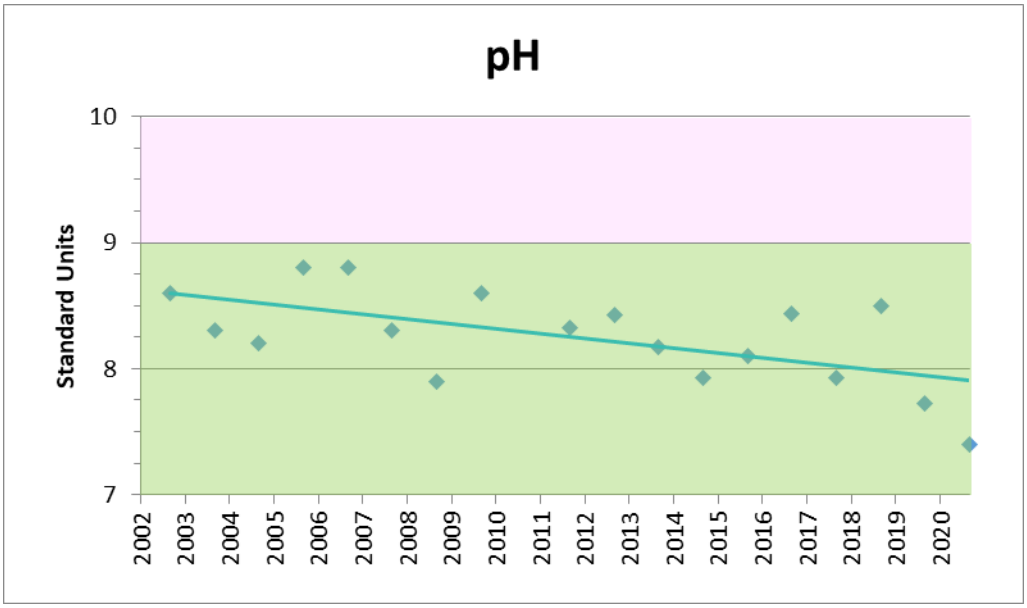


Transparency (feet)					
	April	May	June	July	August
Site 1	15.1	15.6	16.7	14.5	18.4
Site 2	16.6	18.8	16.2	14.2	13.8
Site 3	15.9	18.9	15.1	16.5	14.6
Site 4	15.3	16.7	14.9	18.4	14.2
			Season Average		16.0

Target Range: > 6.5 feet

Transparency was affected by different factors including total dissolved solids, total suspended solids, algae growth, and rain frequency and amount. Overall, the transparency of the lake increased over the testing history.



pH (Standard Units)					
	April	May	June	July	August
Site 1	8.1	7.3	7.1	7.2	7.1
Site 2	7.6	7.2	7.1	7.2	7.3
Site 3	8.2	7.2	7.3	7.1	7.5
Site 4	8.1	7.4	7.2	7.2	7.5
			Season Average		7.4

Target Range: 7.0 – 9.0 S.U.

There was a slight decrease in pH over the testing history, but it stayed in the target range of 7 to 9. We will look for the pH to remain level in future years. If the pH ever drops drastically, we will look for the cause of that change in order to mitigate the trend.

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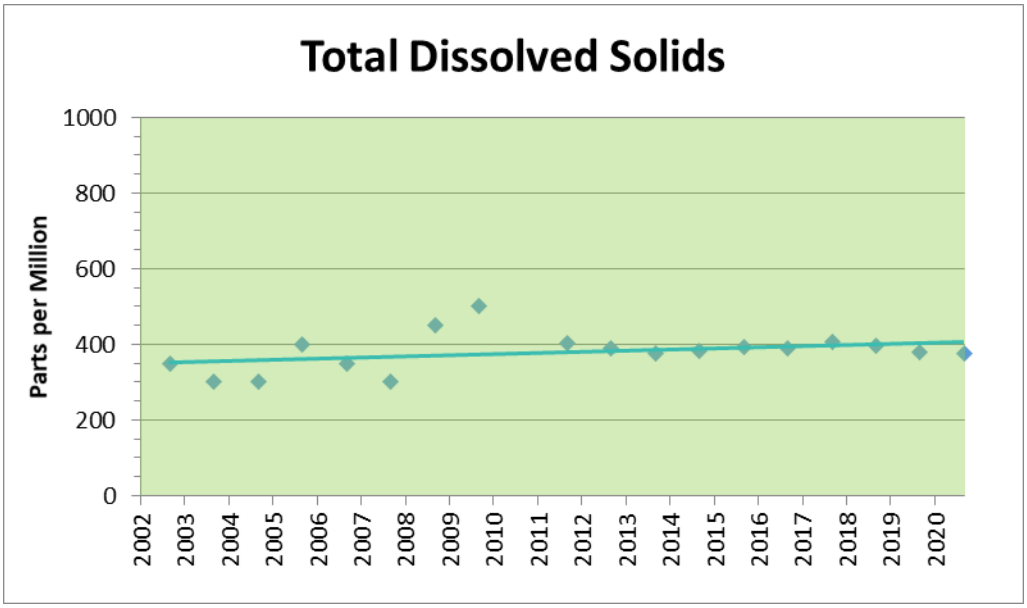
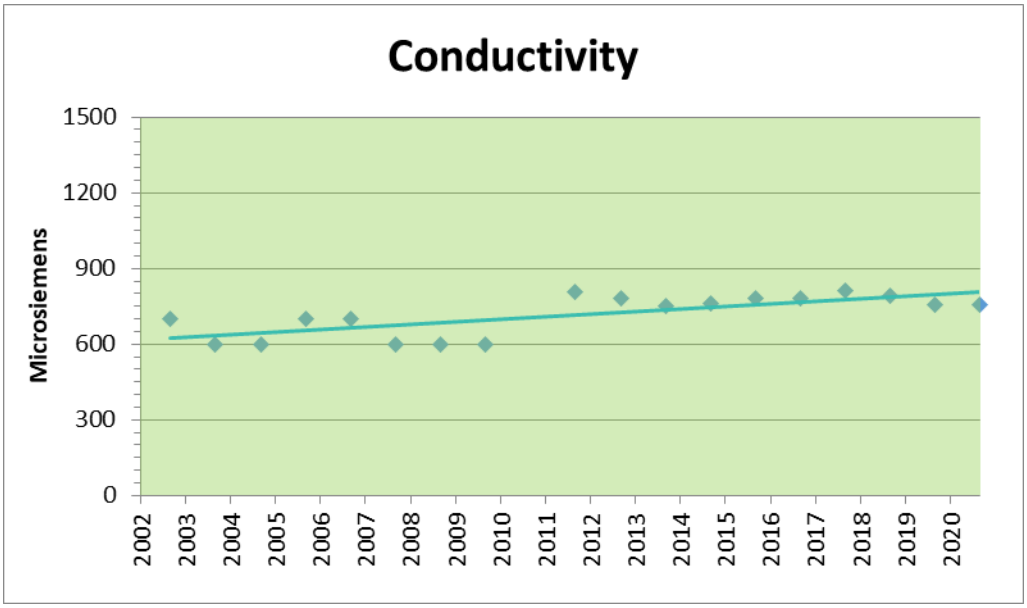


Total Dissolved Solids (ppm)					
	April	May	June	July	August
Site 1	378	367	374	382	371
Site 2	361	376	374	403	375
Site 3	370	379	370	392	375
Site 4	376	377	372	380	375
				Season Average	376

Target Range: 0 – 1,000 ppm

The Total Dissolved Solids showed a slight upward trend over the testing history. This is a common trend for inland lakes as they accumulate more substances from their watershed and the atmosphere.



Conductivity (µS)					
	April	May	June	July	August
Site 1	756	734	748	765	741
Site 2	722	752	747	810	750
Site 3	740	757	740	809	750
Site 4	751	753	744	795	750
				Season Average	756

Target Range: 0 – 1,500 µS

Like the TDS, Conductivity showed a slight upward trend. Conductivity is an extension of TDS and measures the number of ionic molecules in the water (which conduct electricity, usually salts).

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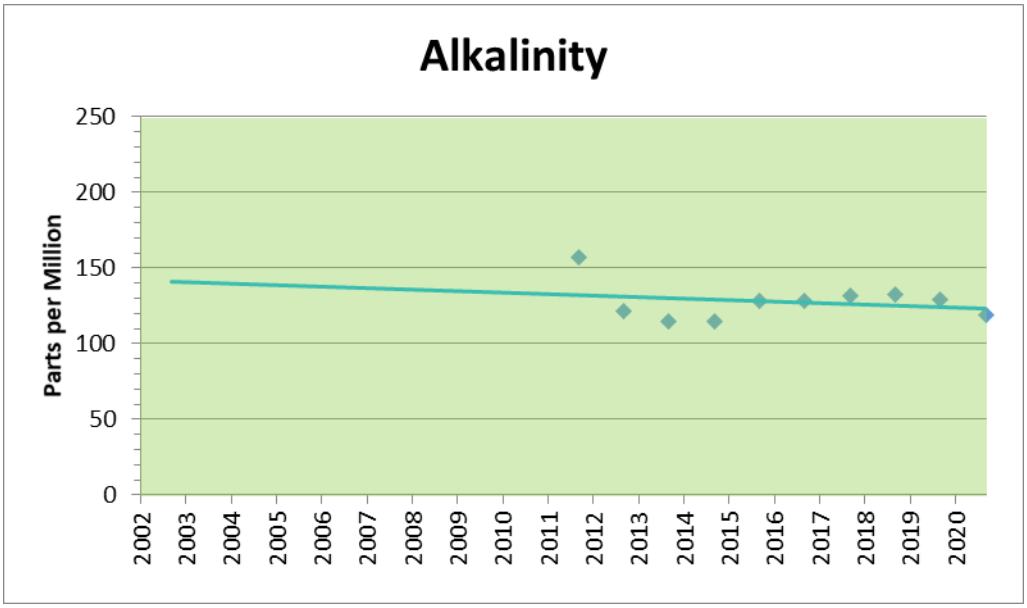
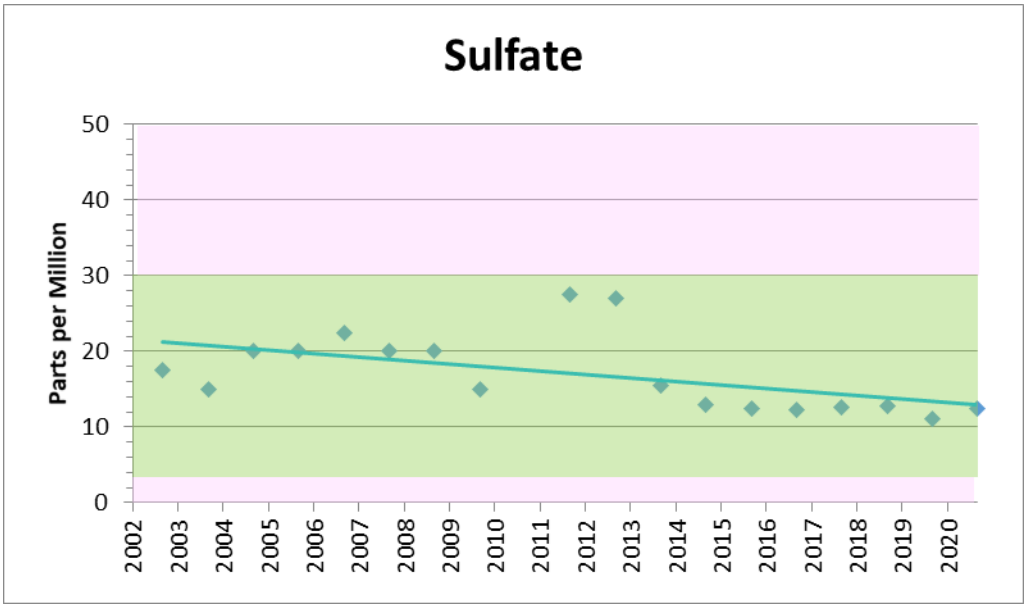


Alkalinity (ppm)					
	April	May	June	July	August
Site 1	130	127	119	94	131
Site 2	132	126	115	96	126
Site 3	125	122	104	90	138
Site 4	128	129	113	100	129
			Season Average		119

Target Range: 0 – 250 ppm

LakePro started testing this parameter in 2011. Since then, the alkalinity decreased slightly. Alkalinity works as a buffer to stabilize the pH when foreign substances enter the lake, so it is important this parameter stay at a healthy level to protect the lake from other changes.



Sulfate (ppm)					
	April	May	June	July	August
Site 1	10.0	14.0	11.0	12.0	11.0
Site 2	11.0	13.0	13.0	12.0	13.0
Site 3	11.0	14.0	14.0	12.0	13.0
Site 4	11.0	14.0	14.0	12.0	14.0
			Season Average		12.5

Target Range: 3 – 30 ppm

Calcium sulfate and magnesium sulfate are common minerals in surface water, so some sulfate should be present. Elevated levels of sulfate can indicate pollution. Over the testing history, sulfate remained within the target range and decreased toward the bottom of the target range.

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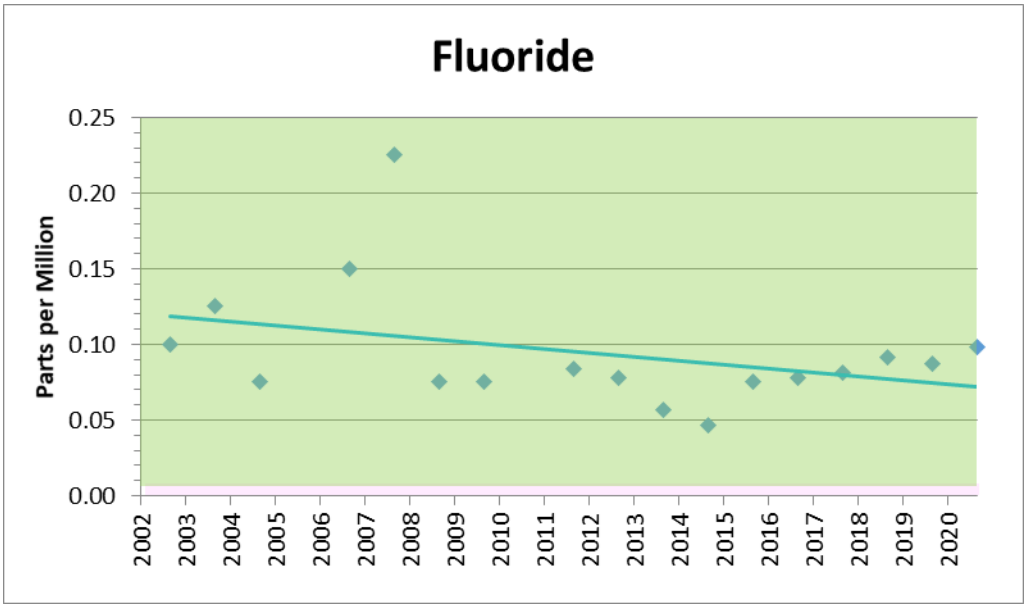
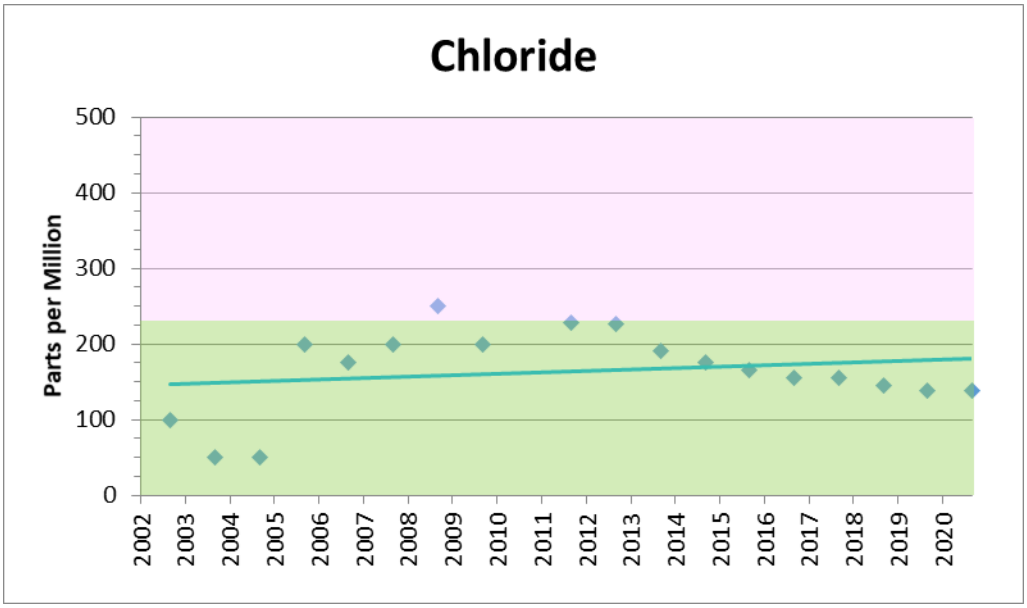


Fluoride (ppm)					
	April	May	June	July	August
Site 1	0.08	0.10	0.09	0.12	0.12
Site 2	0.09	0.08	0.09	0.09	0.11
Site 3	0.09	0.11	0.08	0.08	0.12
Site 4	0.10	0.09	0.09	0.11	0.12
				Season Average	**0.10**

Target Range: 0.01 – 0.30 ppm

Fluoride occurs naturally in ground water, so some may be present in the lake surface water. Elevated levels can indicate pollution, but are not physiologically harmful. Over the testing history, fluoride remained comfortably within the target range.



Chloride (ppm)					
	April	May	June	July	August
Site 1	142	134	139	139	137
Site 2	139	134	140	142	135
Site 3	142	137	136	146	132
Site 4	141	137	137	149	132
				Season Average	**139**

Target Range: 0 – 230 ppm

Chloride is a major anion found in water. This substance may be due to the natural process of water passing through salt formations in the earth or may be evidence of the intrusion of pollution from industrial processes or road salting. The trend was slightly upward due to high concentrations from 2005 to 2012. Since then, there has been a steady downward trend.

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Conclusion

Overall, the water quality of Lower Long Lake was excellent again this year. Only one parameter, Total Phosphorus, tested out of its target range, but the season average was within it. All other parameters remained within their target ranges and some were the best we saw across the state. Our only concerns at this time were the historical increases of phosphorus and chlorophyll. It is vital that everyone within the watershed take steps to limit their nutrient input to the lake.

Despite a heavily developed watershed and homes surrounding the lake, Lower Long Lake is an exemplary water resource with great water quality. There will always be areas that the quality of the water could improve, but the lake remains among the best that we test. You should take pride in this lake and continue your hard work in improving it.

Thanks for choosing LakePro,

Peter Filpansick
Director of Lake Management
Aquatic Biologist

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Analysis Information

Temperature:	The water temperature directly affects the amount of oxygen that can dissolve into the water. The temperature of surface waters is not indicative of the entire water column.
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. Therefore the alkalinity is expressed as "ppm as $CaCO_3$". However, other basic molecules in the water can also contribute to alkalinity.
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.
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.

Fecal Coliforms: Non-fecal coliforms are naturally found as soil organisms. Fecal Coliforms, such as *E. coli*, are coliforms found in the intestines of warm-blooded animals and humans. The presence of fecal coliforms indicates contamination from either animals or humans.

Trophic States

Oligotrophic: Water is very clear. Nutrient levels are generally low. Plant and algae productivity are 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 are 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: