LAKE LEMON MONITORING PROGRAM

2019 Results Summary

Prepared for:

Lake Lemon Conservancy District

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Lake Lemon 2019 Water Monitoring Overview

The Lake Lemon Conservancy District (LLCD) began contracting Indiana University in 1998 to monitor water quality of the lake and incoming tributaries. Figure 1 shows the sampling locations for Lake Lemon and the tributaries in 2019. IU has provided full sampling methods to the LLCD. Figure 2 displays precipitation during the sampling season with individual sampling events indicated. A storm event sample was collected on June 17, 2019.

Figure 1. Sampling locations for the Lake Lemon Water Monitoring Program.

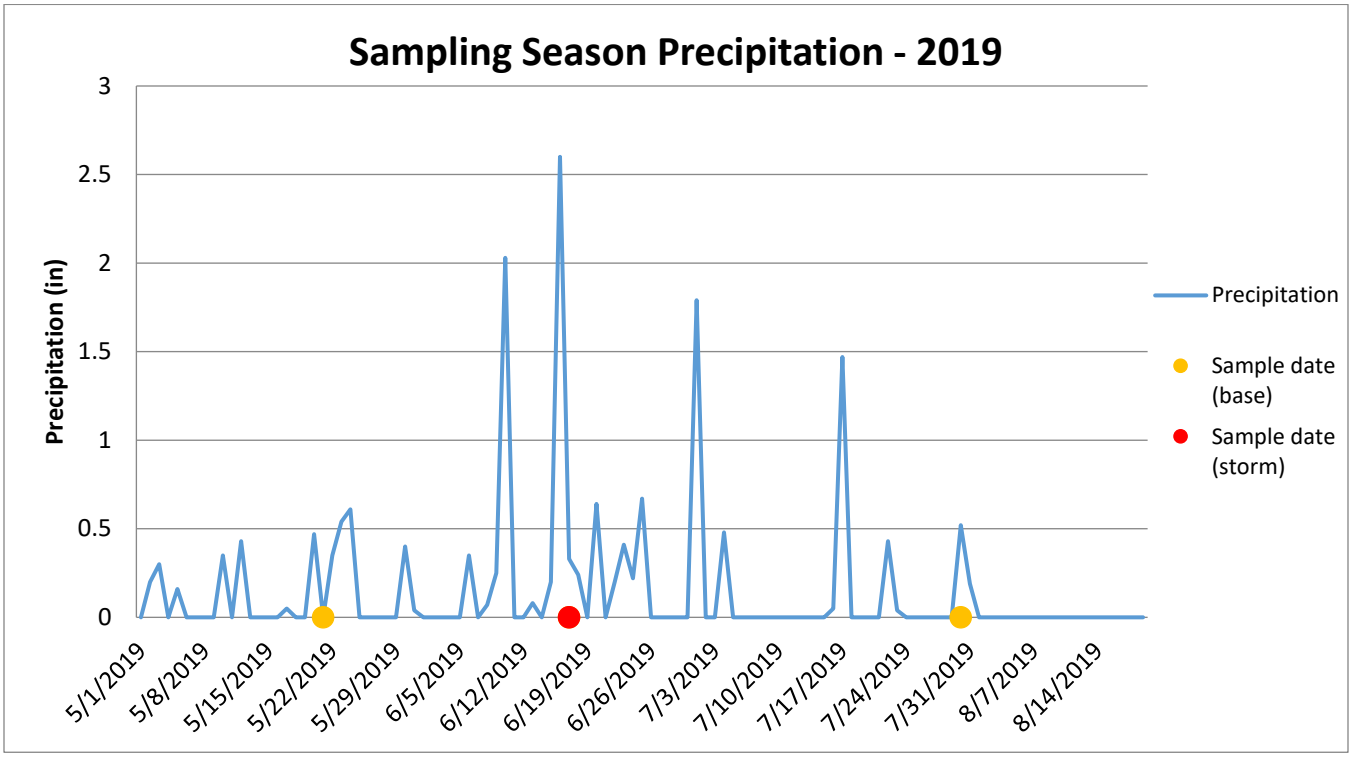

Figure 2. Precipitation amounts during the 2019 sampling season.

Lake Lemon 2019 Summary Results

Temperature and Dissolved Oxygen IU collected a full profile of temperature and dissolved oxygen from one-meter depth increments through the water column at Riddle and Reed Point in Lake Lemon. The temperature profile illustrates the seasonal variation in water temperature and thermal stratification that occurs as the surface water warms. The upper 3 meters of water remained oxygenated during all three sampling events at Riddle Point (Figure 3). The late July dissolved oxygen concentrations averaged 9.15 mg/L in the epilimnion, a slight increase of approximately 0.5mg/L respectively from the sample collected during August of 2018. Anoxic conditions develop below 3 meters depth as organic matter on the lake bottom creates biochemical oxygen demand (BOD) that breaks down the organic matter consuming available oxygen. Stratification of the surface water reduces mixing of oxygen in the deeper water. The shallow depth of Reed Point and lake turbulence keep this area of the lake well mixed and oxygenated (Figure 4).

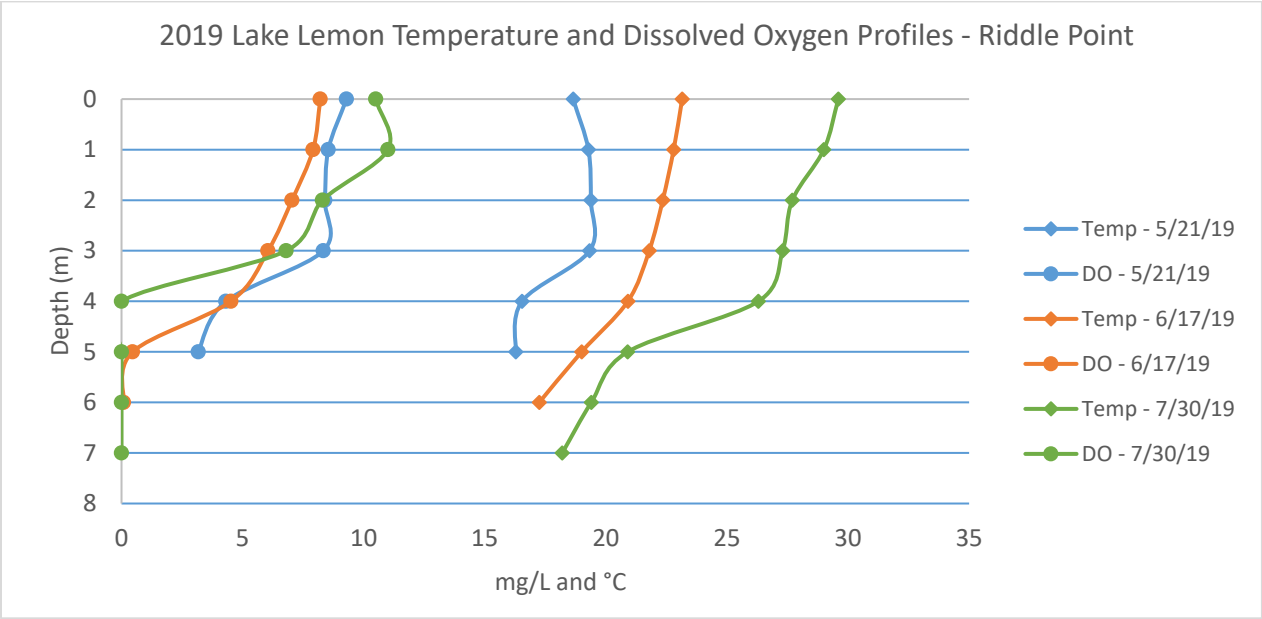

Figure 3. Temperature and dissolved oxygen profiles from all sample dates from Indiana University at Riddle Point in 2019.

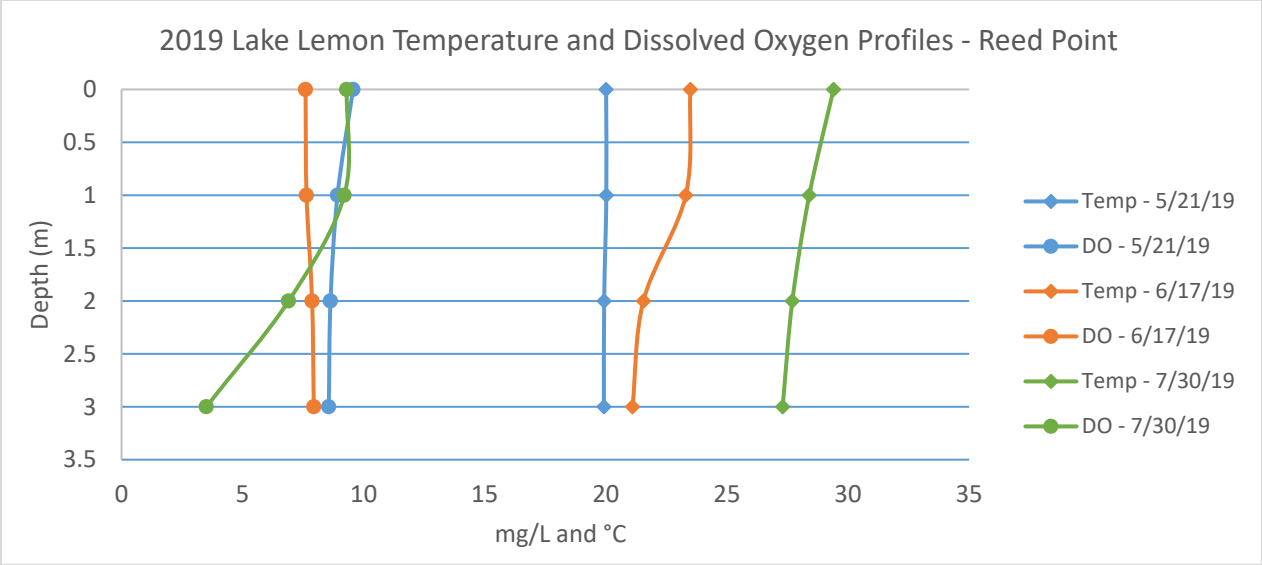

Figure 4. Temperature and dissolved oxygen profiles from all sample dates from Indiana University at Reed Point in 2019.

Water Quality Summary IU collected epilimnion samples from the top 2 meters of the water column and hypolimnion at 6 meters depth (19.7 ft) at Riddle Point. IU collected samples in the epilimnion only at Reed Point.

Table 1. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 5/21/2019.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.8	--	0.6
Light trans @ 3' (%)	53.83	--	42.13
1% Light Level (ft)	7.9	--	5.2
% Water Column Oxic	100	--	100
pH	7.5	6.94	7.49
Conductivity (uS/cm))	100.51	185.61	202.47
Alkalinity (mg/L)	55.8	54.7	66.1
Nitrate (mg/L)	0.024	0.009	0.027
Ammonia (mg/L)	0.149	0.043	< 0.014
Total Nitrogen (mg/L)	0.545	1.659	0.451
Orthophosphate (mg/L)	0.010	0.015	0.019
Total Phosphorus (mg/L)	0.02	0.135	0.024
Chlorophyll-*a* (ug/L)	--	--	--
Plankton (Cells/ml)	1,577	--	2,288
Plankton (#/L)	1,727,279	--	2,717,931
Blue-green dominance NU (%)	55	--	59
Blue-green dominance – cells/ml (%)	56	--	60
***E. coli* (#/100 mls)**	1,190	--	1,170

Table 2. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 6/17/2019.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	1.1	--	0.6
Light trans @ 3' (%)	607.1	--	118.7
1% Light Level (ft)	9.3	--	6.7
% Water Column Oxic	71.4	--	100
pH	7.42	7.1	7.04
Conductivity (uS/cm)	213.8	228.7	2.5
Alkalinity (mg/L)	66.0	71.0	62.0
Nitrate (mg/L)	< 0.008	0.023	0.124
Ammonia (mg/L)	< 0.014	0.181	0.061
Total Nitrogen (mg/L)	0.295	0.539	0.421
Orthophosphate (mg/L)	0.003	0.011	0.005
Total Phosphorus (mg/L)	0.02	0.035	0.023
Chlorophyll-a (ug/L)	13.78	--	11.48
Plankton (Cells/ml)	7,202	--	6,690
Plankton (#/L)	1,933,717	--	1,478,667
Blue-green dominance NU (%)	87	--	87
Blue-green dominance – cells/ml (%)	96	--	96
***E. coli* (#/100 mls)**	400	--	720

Table 3. Water Quality Characteristics of Lake Lemon – Riddle Point and Reed Point, 7/30/2019.

Parameter	Riddle		Reed
	Epilimnion	Hypolimnion	Epilimnion
Secchi (m)	0.8	--	0.4
Light trans @ 3' (%)	288.5	--	63.0
1% Light Level (ft)	6.99	--	4.99
% Water Column Oxic	50	--	100
pH	8.3	6.7	7.7
Conductivity (uS/cm))	190.3	236.3	195
Alkalinity (mg/L)	71.0	101.0	71.0
Nitrate (mg/L)	< 0.008	< 0.008	< 0.008
Ammonia (mg/L)	0.048	1.941	0.018
Total Nitrogen (mg/L)	0.445	0.839	0.815
Orthophosphate (mg/L)	0.002	0.276	0.032
Total Phosphorus (mg/L)	0.045	0.195	0.067
Chlorophyll-a (ug/L)	40.89	--	40.71
Plankton (Cells/ml)	182,959	--	176,131
Plankton (#/L)	38,742,228	--	13,333,666
Blue-green dominance NU (%)	95	--	86
Blue-green dominance – cells/ml (%)	98	--	97
***E. coli* (#/100 mls)**	--	--	--

Chlorophyll-*a*, which is a measure of the primary pigment in algae, is a direct measure of algal productivity. In the integrated samples from the surface to the 2-meter depth, the chlorophyll-*a* concentrations ranged from 11.48 µg/L in June to 40.89 µg/L in late July. Chlorophyll-*a* concentrations >7 µg/L are indicative of eutrophic lake conditions. Overall, we see a seasonal pattern of nutrient increase by late summer as total phosphorous concentrations increase, which is characteristic of Lake Lemon. This pattern is mirrored by increases in chlorophyll-*a* concentrations. This suggests that conditions exist for increasing growth of algae (Figures 5 and 6).

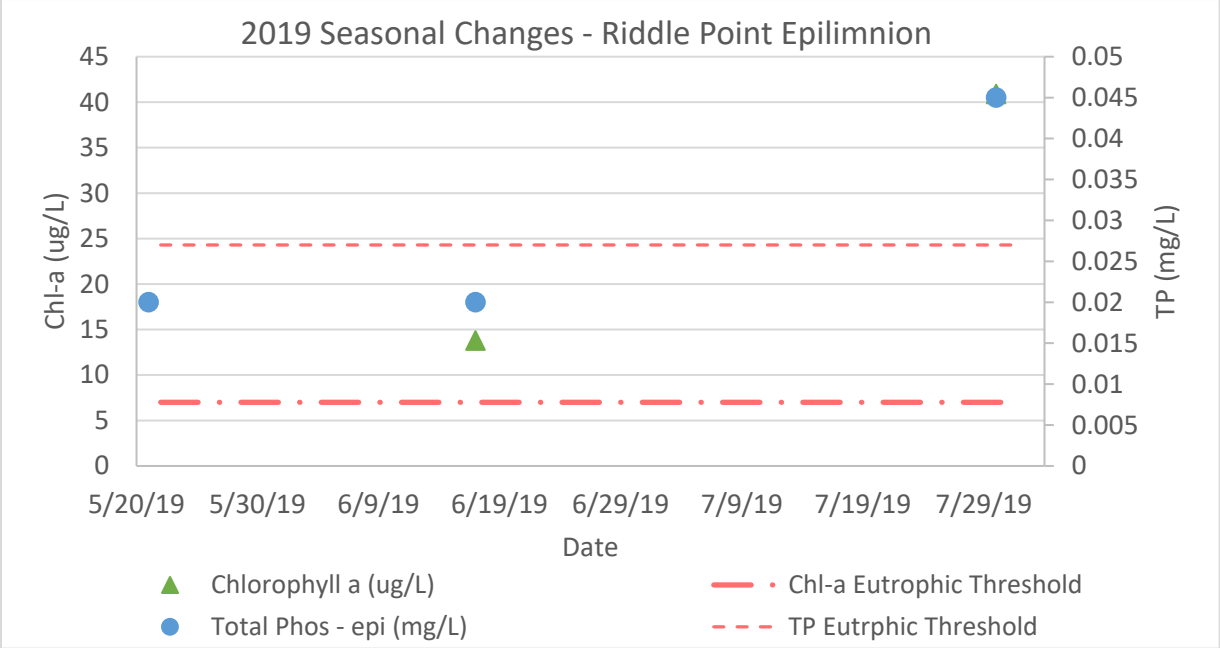

Figure 5. Seasonal changes in total phosphorus and chlorophyll-*a* in the surface waters (epilimnion) at Riddle Point in Lake Lemon in 2019.

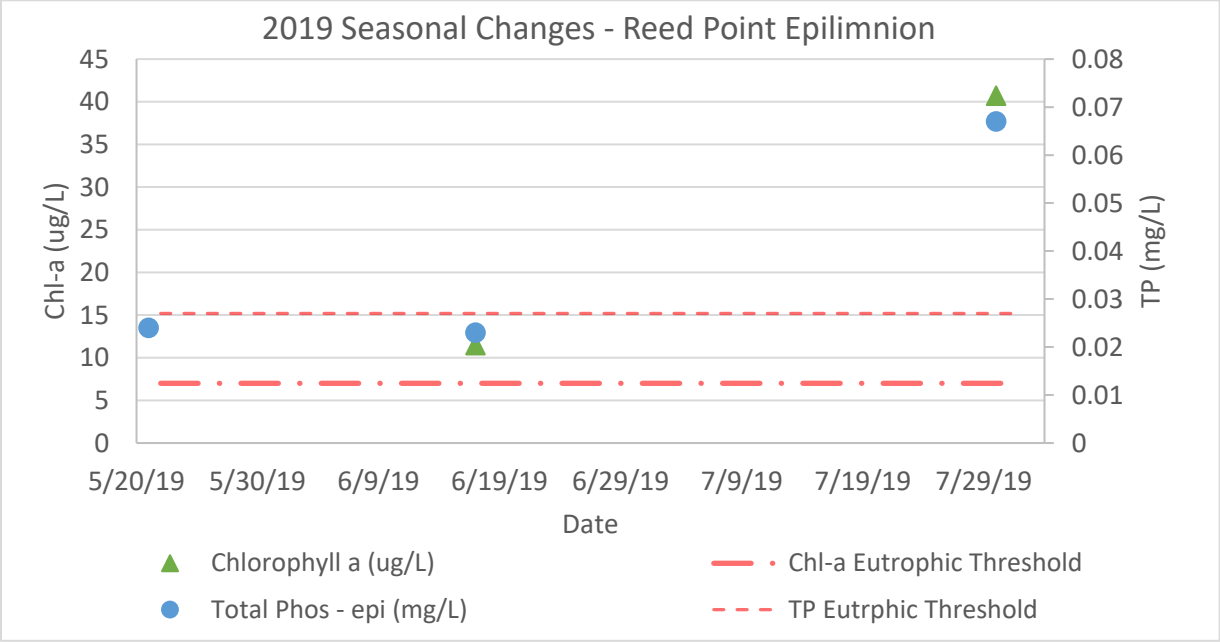

Figure 6. Seasonal changes in total phosphorus and chlorophyll-*a* in the surface waters (epilimnion) at Reed Point in Lake Lemon in 2019.

Beach and Tributary Samples IU collected turbidity and E. coli samples around the Lake Lemon watershed in 2019 (Tables 4 and 5). The state standard for full body contact and recreation is 200 colonies per 100mls.

Table 4. Tributary Turbidity and E. coli for 2019.

	E. coli (#/100 mls)	*E. coli* (#/100 mls)	*E. coli* (#/100 mls)	Turbidity (NTU)	Turbidity (NTU)	Turbidity (NTU)
	5/21/19	**7/1/19**	**7/30/19**	**5/21/19**	**7/1/19**	**7/30/19**
Chitwood #1	--	9,000	270	--	23.3	24.6
Chitwood #2	--	9,200	140	--	18.9	16
Chitwood Channel	--	2,560	540	--	21.1	29.1
Chitwood Stream	--	1,500	TNTC	--	26.4	72.8
Beanblossom Creek	2,500	--	190	--	--	10.2
Bear Creek	3,000	510	400	--	12	6.78
Knobb Creek	13,500	1,640	6,400	--	9.83	17.8
Possom Trot	--	530	150	--	13.7	14.9
Shuffle Creek	--	200	--	--	8.14	--

Table 5. Beach Turbidity and E. coli for 2019.

Lake Lemon Beach	*E. coli* (#/100 mls)	Turbidity (NTU)
7/8/19	80	14.4
7/15/19	180	--
7/22/19	80	--
7/30/19	100	11.5
8/5/19	0	--
8/14/19	2	--
8/23/19	310	--

Trophic State. The trophic state of a lake helps characterize the level of productivity and the expected life that may exist in a lake. The overall classifications of lakes can help with comparison across lakes as well as from year to year. We use Carlson's Trophic State as it was developed based on lakes similar to those in Indiana.

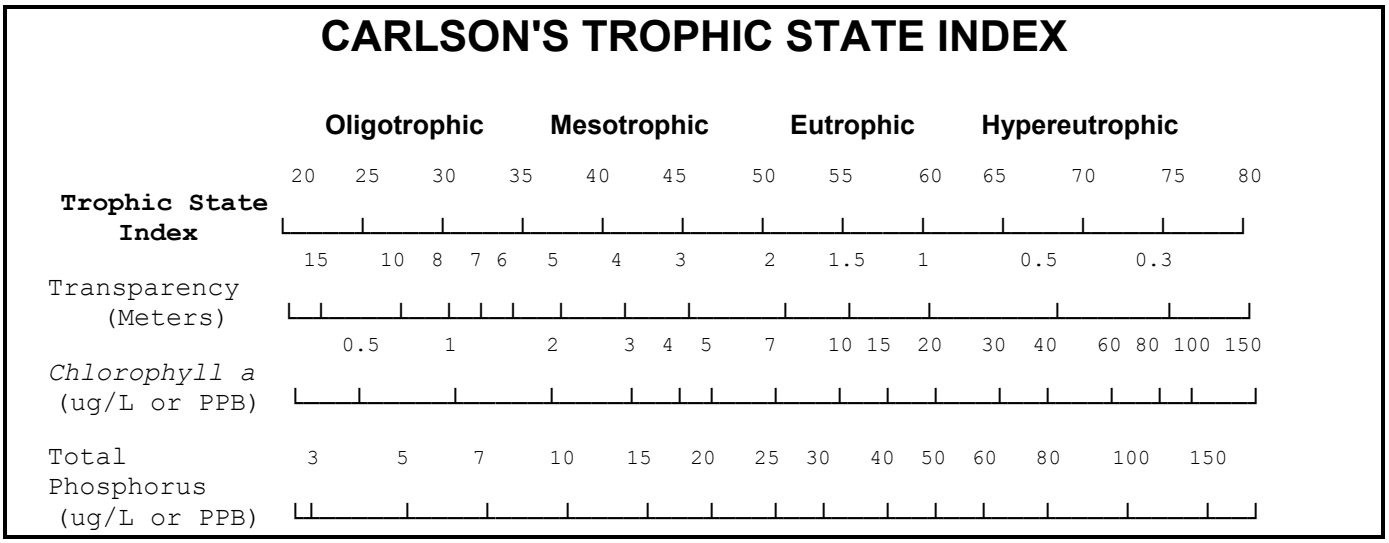

Figure 10. Carlson's trophic state index.

Table 6. Characteristics of trophic state categories.

Classification	Transparency	Nutrients	Algae	D.O.	Fish
Oligotrophic	clear	Low TP < 6 µg/L	few algae	Hypo has D.O.	can support salmonids (trout and salmon)
Mesotrophic	Less clear	Moderate TP 10-30 µg/L	healthy populations of algae	Less D.O. in hypo	lack of salmonids
Eutrophic	transparency <2 meters	High TP > 35 µg/L	abundant algae and weeds	No D.O. in the hypo during the summer	Warmwater fisheries only. Bass may dominate.
Hypereutrophic	transparency <1 meter	extremely high TP > 80 µg/L	thick algal scum Dense weeds	No D.O. in the hypo during the summer	Rough dominate. Summer fish kills possible.

We use Riddle Point Carlson TSI scores to look at the historic trend for Lake Lemon demonstrating that the lake is generally characterized as eutrophic. Figures 11-13 illustrate the Carlson TSI historic trends for Secchi disk, total phosphorus, and chlorophyll-*a*. Overall, Lake Lemon has a pattern of seasonal variation of lower scores (less eutrophic) in the spring and increasing trophic state to eutrophic/hypereutrophic status by late summer.

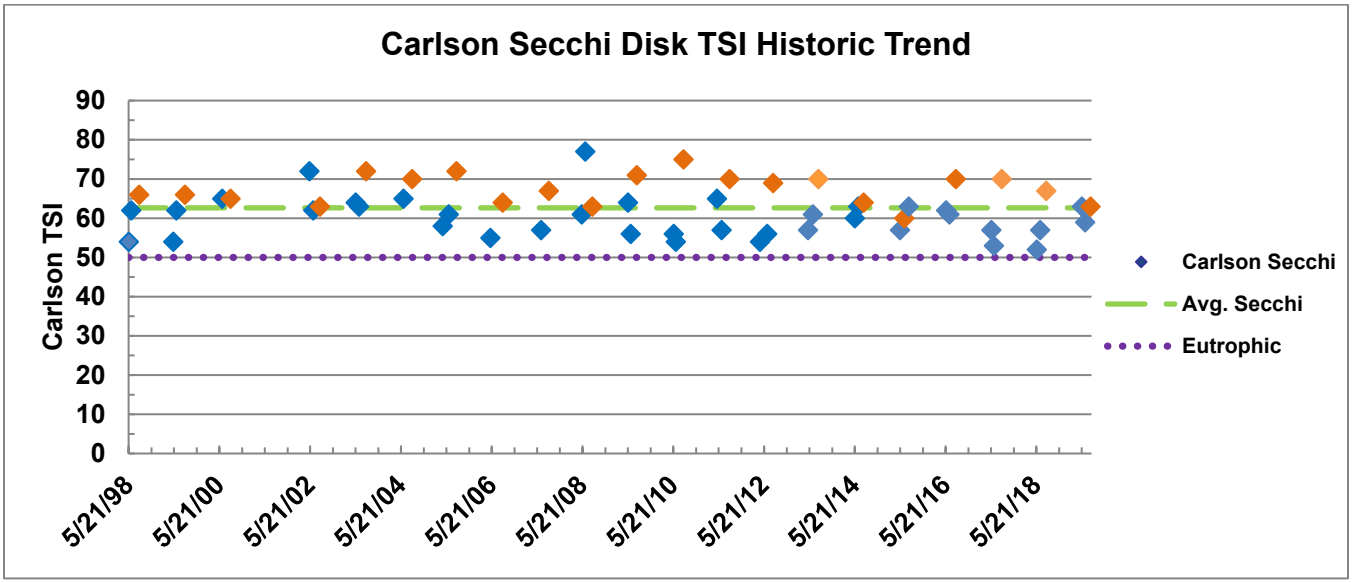

Figure 11. The 21-year historic trend for Carlson Secchi disk TSI scores. Orange represents the August samples. The green dashed line illustrates the 21-year mean. The purple dotted line illustrates eutrophic status for the Carlson TSI.

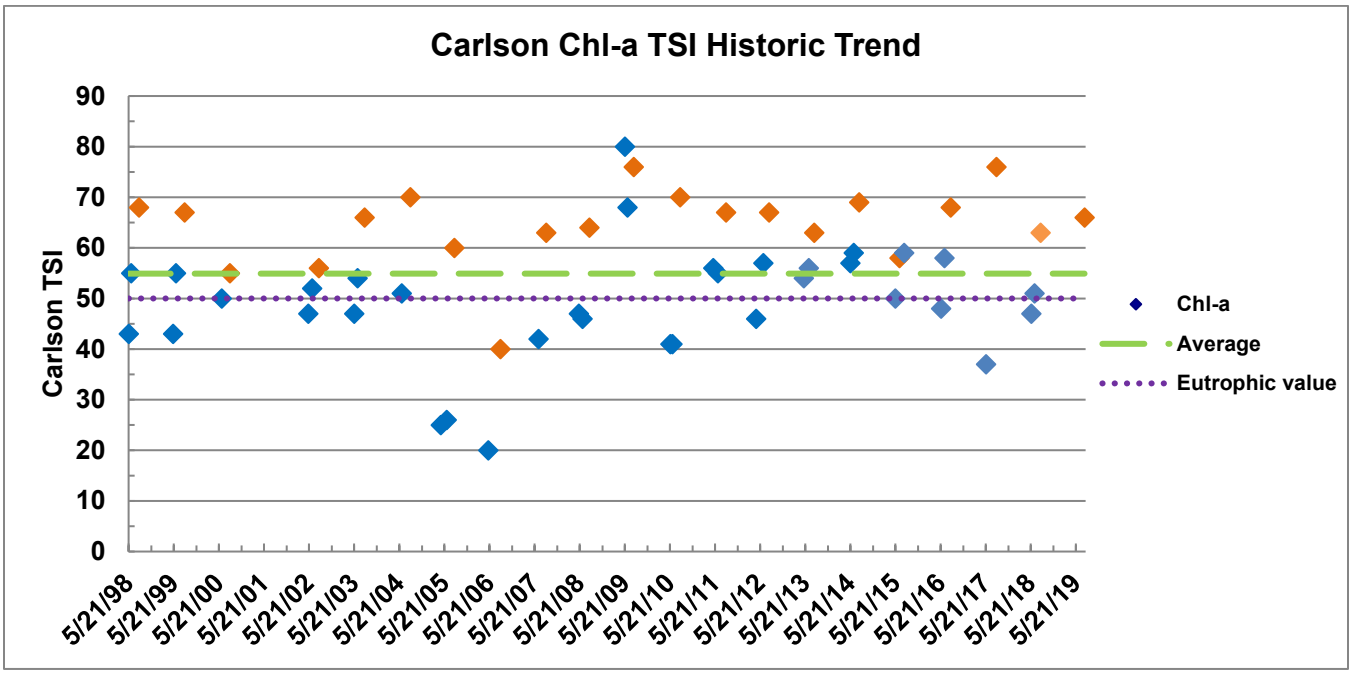

Figure 12. The 21-year historic trend for Carlson chlorophyll-*a* TSI scores. Most August samples, shown in orange, score above the mean for eutrophic status. The 21-year mean is just above the Carlson TSI eutrophic status score of 50 (purple dotted line).

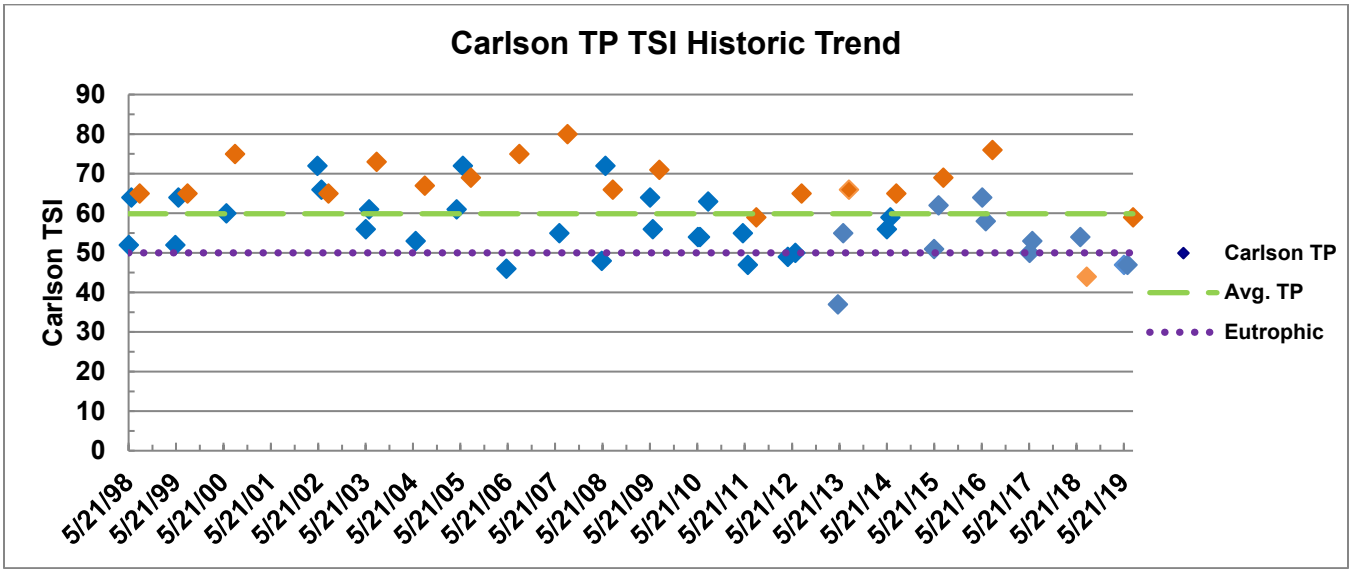

Figure 13. The 21-year historic trend for Carlson total phosphorus TSI scores. All August samples, shown in orange, score above the mean for eutrophic status save for one in 2018. The green dashed line illustrates the 21-year mean. The purple dotted line illustrates eutrophic status for the Carlson TSI.

Continuing the monitoring for toxin producing algae from 2018, the May and June samples still remained below the 100,000 cells/mL threshold for recreation advisories. The late July sample did exceed this threshold at approximately 176,000 cells/mL with over 50% of these cells under the harmful algal bloom (HAB) grouping. We have started contracting Phycotech to analyze phytoplankton for us. We will be sending lake samples to them in 2020. We will send the reports to the Lake Manager post analysis. We hope this will provide a quick turnaround for management decisions.

Lake Lemon Water Monitoring Conclusions and Recommendations

Lake Lemon remains a eutrophic lake. The influx of nutrients from spring rains and warming temperatures as summer reaches its peak lead to higher levels of algal biomass by late summer. In 2019 we contracted out the phytoplankton analysis (sample was analyzed in the spring of 2020) which showed results of warning level HAB populations at Reed and Riddle Point (see appendix for detailed analysis). Warning levels are reached when algal cell counts for HAB's reach 100,000 cells/mL. We are aware that the overflow pond to the south of the causeway typically has high levels of HAB populations. The high levels in this pond are likely caused by high nutrient inputs, stagnate waters, shallow depth, and lack of vegetation leading to an ideal habitat for algal growth. It is important to recognize that when aquatic plants are removed or lacking in any system, those nutrients become available for other primary producers—in lakes this is the algal community.

Bacteria in the lake remain an area of concern. Some areas of the lake are working to mitigate the problem; however, some areas still need to address the concern. We have shared our results with a Monroe County Health Department representative and they are working to obtain more information on particular areas of concern expressed by the LLCD (Knobb Creek). In all sampling events since 2017, when sampling began at this location, Knobb Creek has exceed contact standards.

Recommendations based on the above information and post meeting with the LLCD Include:

1. The LLCD should develop a Harmful Algal Bloom Response Plan. The plan should include:

- warning post processes
- advisory messages
- public communication plan
- signage for beach, boat launch and overflow ponds
- algal toxin testing plan (options include rapid strip test analysis kit or a planned contract to send samples for analysis)

2. To reduce nutrient availability for the algal community the LLCD should increase the aquatic vegetation in the lake, particularly in the overflow pond.

3. LLCD should work with the Monroe and Brown County Health Department to find solutions to the bacteria issues in the lake.

4. Implement a septic system-testing program on a rotational basis.

5. Work with partners in the watershed to consider the weather when doing land application of manure.