2018 Hicks Lake Water Quality Report

Prepared by Thurston County Environmental Health Division

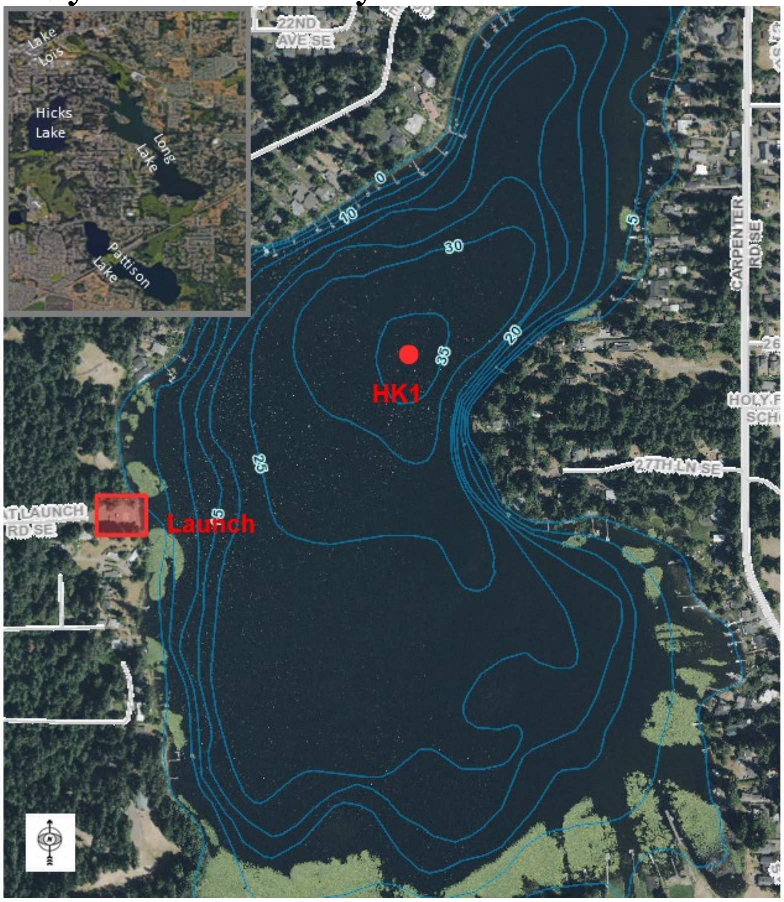

Figure 1. Hicks Lake map showing location of sample site HK1.

HENDERSON INLET WATERSHED

- **SHORELINE LENGTH**: 2.4 miles
- **LAKE SIZE**: 0.25 square miles
- **BASIN SIZE**: 1.8 square miles
- **MEAN DEPTH**: 18 feet (5.5 meters)
- **MAXIMUM DEPTH**: 35 feet (10.7 meters)
- **VOLUME**: 2,700 acre-feet

PRIMARY LAND USES:
The watershed is primarily urban and sub-urban residential with a small percentage in undeveloped forest cover.

PRIMARY LAKE USES:
Fishing, boating, water sports, and swimming.

PUBLIC ACCESS:
Washington Department of Fish and Wildlife public boat launch and City of Lacey Wanschers Park.

GENERAL TOPOGRAPHY:
Approximate altitude of the lake is 162 feet. The watershed is relatively flat with extensive wetlands between lakes including one south of Hicks Lake.

GENERAL WATER QUALITY:
(Excellent, Good, Fair, and Poor)

Good –Water quality is generally considered good and supports the beneficial uses of the lake. The average 2018 TSI is within the mesotrophic range. Annual average phosphorus levels are within the state regulatory standards for the period of record.

DESCRIPTION

Hicks Lake is the first lake in a chain of four hydraulically-connected lakes (Hicks, Pattison, Long, and Lois Lakes) that eventually discharge to Henderson Inlet via Woodland Creek. Hicks Lake is a relatively small lake, popular for fishing, boating, and swimming. The City of Lacey owns Wanschers Park, an undeveloped public park on the west side of the lake.

METHODS

In 2018, Thurston County Environmental Health (TCEH) conducted monthly monitoring (Table 1) at Hicks Lake from May to October. Figure 1 shows the sample site, located in the deepest basin of the lake.

Table 1. List of parameters, units, method, and sampling locations.

Parameter	Units	Method	Sampling Location
Transparency	meters	Secchi Disk	Depth where disk is no longer visible
Color	#1 to #11	Custer Color Strip	Color of water on white portion of Secchi Desk
Vertical Water Quality Profile	• Water Temperature (°C) • Dissolved Oxygen (mg/L) • pH (standard units) • Specific Conductivity (µS/cm)	YSI EXO1 Multi-parameter Sonde	~ 0.5 meter below the water surface to ~ 0.5 meter above the bottom sediments
Total Phosphorus	mg/L	Grab Samples with Kemmerer	Surface Sample: ~ 0.5 meter below the surface Bottom Sample: ~ 0.5 meter above the benthos
Total Nitrogen	mg/L	Grab Samples with Kemmerer	Surface Sample: ~ 0.5 meter below the surface Bottom Sample: ~ 0.5 meter above the benthos
Chlorohyll-a	µg/L	Composite of Multiple Grab Samples	Photic Zone
Phaeo-a	µg/L	Composite of Multiple Grab Samples	Photic Zone
Algae Identification*	Genera, Present, Dominant, Subdominant	Composite of Multiple Grab Samples	Photic Zone

*July 2018 sample was lost in shipping

TCEH observed the water color against the white background of the secchi disk and compared it to the Custer Color Strip (Figure 2).

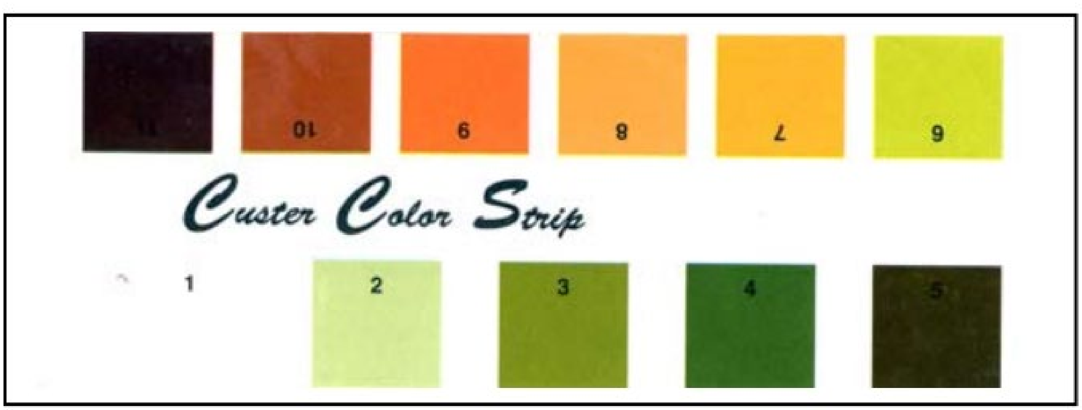

Figure 2. TCEH compared the water color to the Custer Color Strip.

Quality Assurance and Quality Control (QA/QC)

Each day TCEH collected 10% replicate samples and trip blanks to assess total variation for laboratory samples (TCEH samples 3-4 lakes per day). The calibration of the Yellow Springs Instrument (YSI) EXO 1 was verified before and after each sampling day. See Appendix C for QA/QC data.

RESULTS

Weather Conditions

Weather conditions during the 2018 sample season are provided in Table 2.

Table 2. Weather on sample days and the average, minimum, and maximum air temperatures for each month.

Month	Weather on Sample Day	Temperature (° C) Monthly Average (Low/High)
May	Clear and Sunny (18° C); 0-3 mph SE wind	31 (14/23)
June	Mostly cloudy (20° C); 0-3 mph S wind	31 (16/22)
July	Clear, (23° C); 5-10 mph S wind	34 (21/28)
August	Hazy from wildfire smoke, (22° C); 0-3 mph NNE wind	26 (18/36)
September	Sunny (19° C); 0-10 mph NNE wind	22 (17/29)
October	Fog (48° F); 0-5 mph S to SSW wind	16 (12/22)

Vertical Water Quality Profiles

The vertical water quality profiles (Figures 3 and 4) illustrate how the water column at Hicks Lake was thermally stratified into 3 distinct regions from May to August, with early signs of mixing in September. The water column mixed to almost 75% of the total depth in October.

Solar radiation heated the upper layer of lake water, the epilimnion. The heat was retained from May to August because air temperature remained high. Exposed to the wind, this upper stratum circulated, but resisted mixing with the lower layers due to the difference in water density. The warm epilimnion essentially floated on the cold, deeper water.

The hypolimnion, a layer of relatively undisturbed, cold water extended from a depth of 7 to 8 meters to the benthos from May to August.

Separating the warm epilimnion and the hypolimnion is the metalimnion or thermocline. As the graphs show, the metalimnion exhibits a steep thermal gradient, where temperature showed a marked thermal discontinuity.

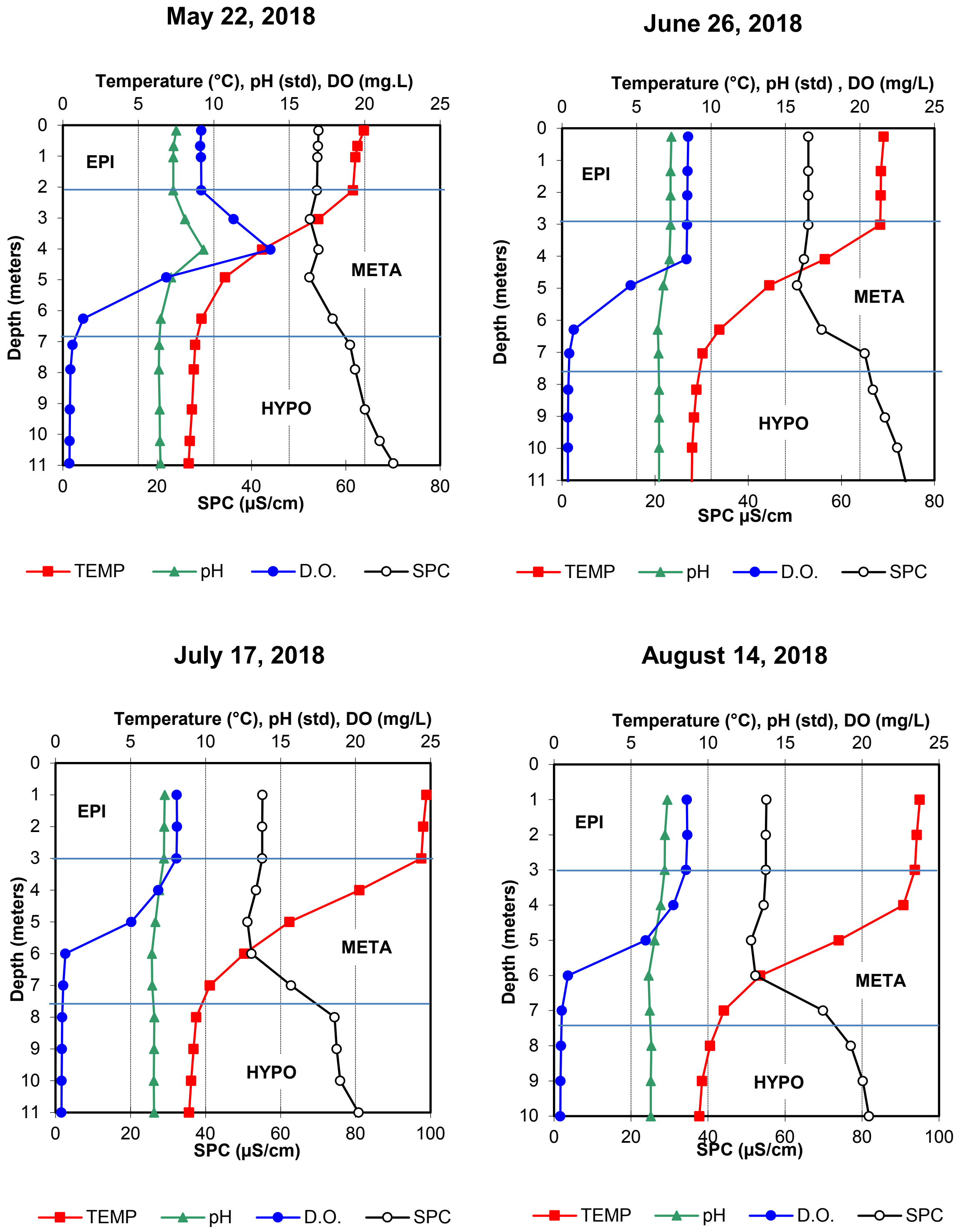

Figure 3. Vertical water quality profiles for May to August, 2018.

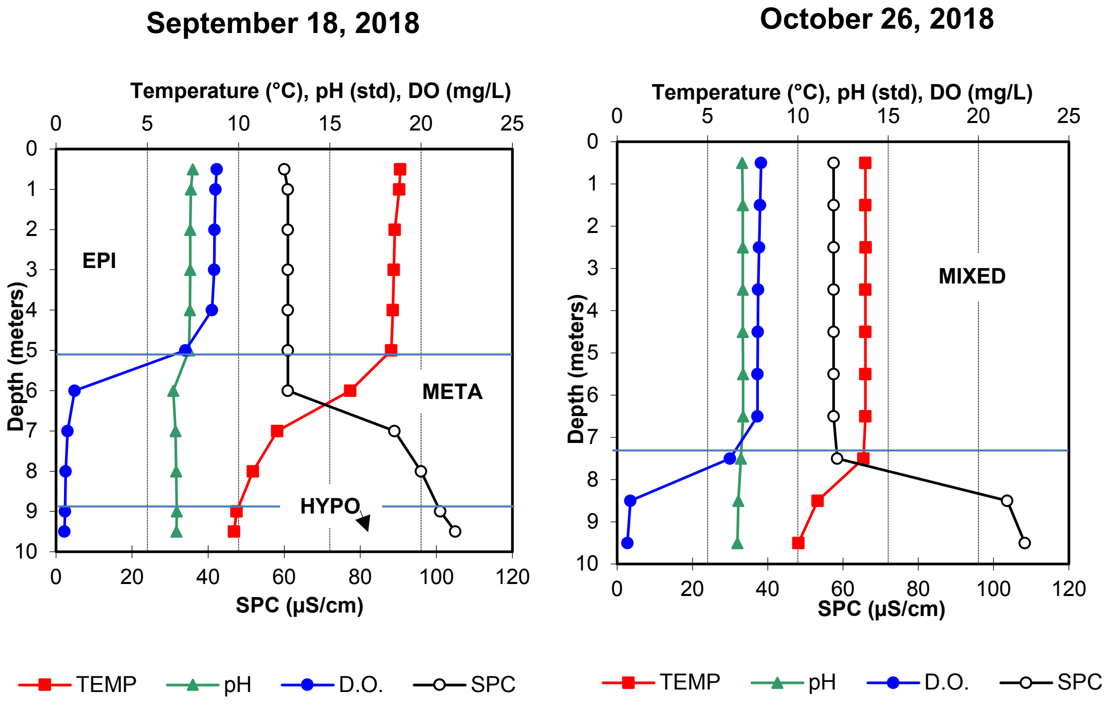

Figure 4. Vertical water quality profiles for September and October, 2018.

In September and October, average air temperatures declined. Hicks Lake lost more heat than it gained through solar radiation, especially at night. The surface water cooled, increased in density and sank. Convection currents and wind induced epilimnetic circulation. In September, surface water penetrated the metalimnion, warming the lake to a depth of 5 meters (Figure 4). By October the upper two-thirds of Hicks Lake had mixed. The mixing process, where the top layer mixes with the bottom layer is called turnover.

The dissolved oxygen curve changed with thermal stratification, from positive heterograde curve in May, to clinograde oxygen until October. In May, a positive heterograde oxygen curve was created when a zone of excess oxygen formed in the thermocline. By June, excess oxygen consuming processes (redox processes) in the hypolimnion resulted in a clinograde oxygen curve. The epilimnion, in contact with the atmosphere, was near saturation. The hypolimnion, cut-off from the atmosphere after stratification, lost oxygen to redox processes.

Water Clarity

Color can reveal information about a lake's nutrient load, algal growth, water quality and surrounding landscape. The water color (not apparent color) observed each month is provided in Appendix A and Figure 5. High concentrations of algae cause the water color to appear green, golden, or red. Weather, rocks and soil, land use practices, and types of trees and plants influence dissolved and suspended materials in the lake. Tannins and lignins, naturally occurring organic compounds from decomposition, can color the water yellow to brown.

Transparency of water to light has been used to approximate turbidity and phytoplankton populations. Secchi depth is closely correlated with the percentage of light transmission through water. The depth at which the secchi disk is no longer visible approximates 10% of surface light, however suspended particles in the water affect accuracy. In 2018, average transparency was 3.16 meters, ranging from a low of 2.2 meters in September to a high of 3.9 meters in July (Figure 5). The lake water was transparent in May (3.8 meters secchi depth), which permitted photosynthesis in the metalimnion. May was the most productive month for phytoplankton.

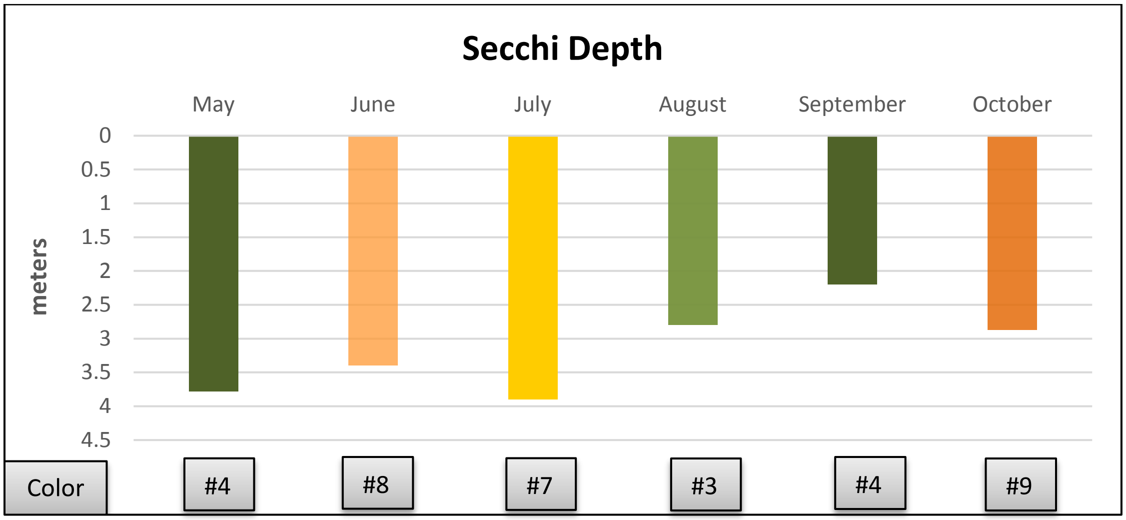

Figure 5. Water color (number and bar color in graph) and average secchi depths for 2018.

Figure 6 shows the transparency annual average compared to the long-term average. Positive values reflect transparency better than the long-term average. The data show a cyclical pattern, often in 2 to 3 year periods, with transparency 0.8 below or 0.9 above the long-term average.

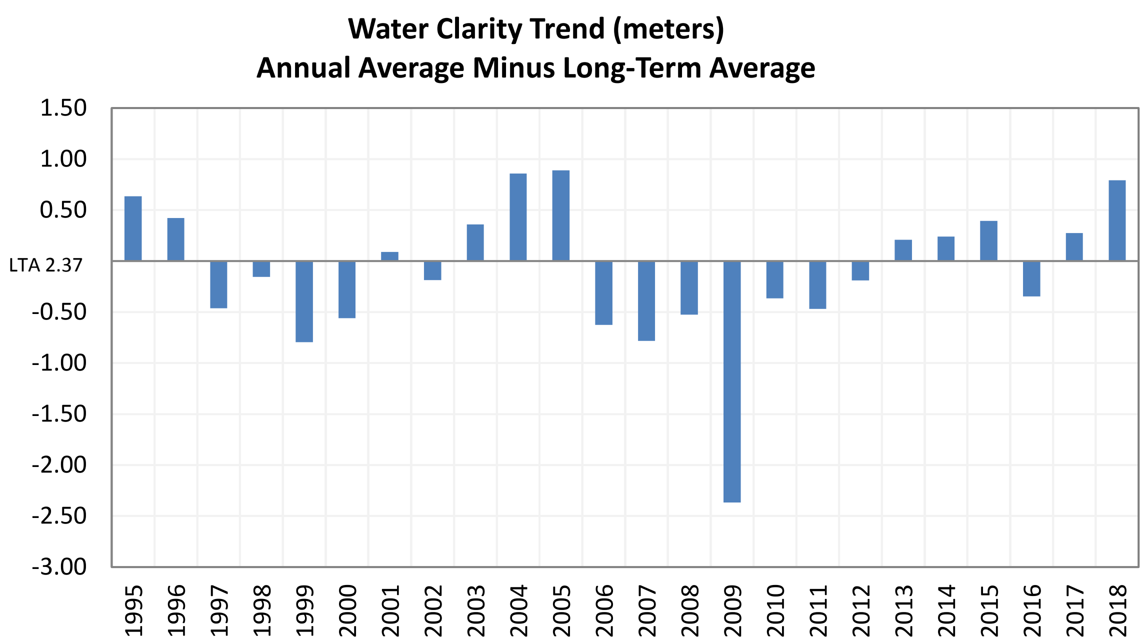

Figure 6. Transparency compared to the long-term average (LTA).

Productivity

Pigments

Chlorophyll-a pigment is present in all algae and is widely used to assess the abundance of algae in suspension. Phaeophytin is also a pigment, but it is not active in photosynthesis. It is a breakdown product of chlorophyll and is present in dead suspended material (Moss, 1967). Phaeophytin absorbs light in the same region of the spectrum as chlorophyll-a, and, if present can interfere with acquiring an accurate chlorophyll-a value. The ratio of chlorophyll-a to phaeophytin-a has been used as an indicator of the physiological condition of phytoplankton in the sample.

2018 Productivity Data

Figure 7 shows that the highest concentration of chlorophyll-a occurred in May (23 µg/L). The concentration declined in June and July. Productivity increased each month from June to September, but the chlorophyll-a concentration reached only half that of May. The ratio of chlorophyll-a to phaeophytin-a was highest in August, indicating a breakdown in chlorophyll-a.

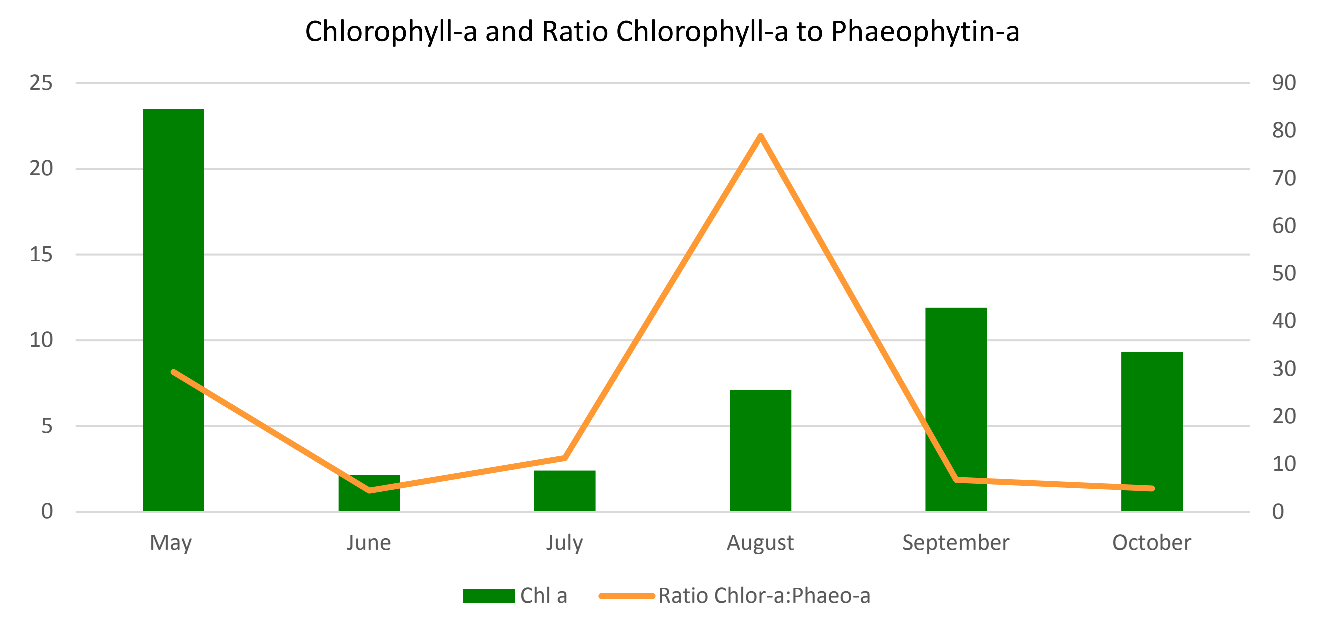

Figure 7. Chlorophyll-a and phaeophytin-a pigments concentration in samples.

The Seasonal Kendall Test

TCEH used the Seasonal Kendall test, a highly robust, non-parametric test, to identify trends in the data. This test compares the relationship between points at separate time periods and determines if there is a trend. The seasonal Kendall test statistic was computed by performing a Mann-Kendall calculation for each month from 2007 to 2018. TCEH summed the monthly statistics and calculated a Z statistic and Sen slope. The Sen slope estimates the slope of the trend over time. The seasonal Kendall test statistic for chlorophyll-a concentration indicates a significant ($p < 0.05$) decreasing trend in chlorophyll-a concentration (Appendix D) from 2007 to 2018.

Algae and Cyanobacteria Identification

Hick Lake supported 7 different types of algae in 2018:

Blue-Green Algae/Cyanobacteria (BG)
Cryptophyta (CP)
Dinoflagellate (DF)
Diatoms (DT)
Euglenophyta (EU)
Chlorophyta/Green Algae (GR)
Chrysophyta (YL) Golden Algae

Out of the 7 types of algae listed above, 48 genera were identified to genus. Also, the lab noted an undetermined type of diatom and Dinophyceae. Figure 8 shows the diversity of the community by comparing the number of genera for each the 7 types to the total number of genera in the sample.

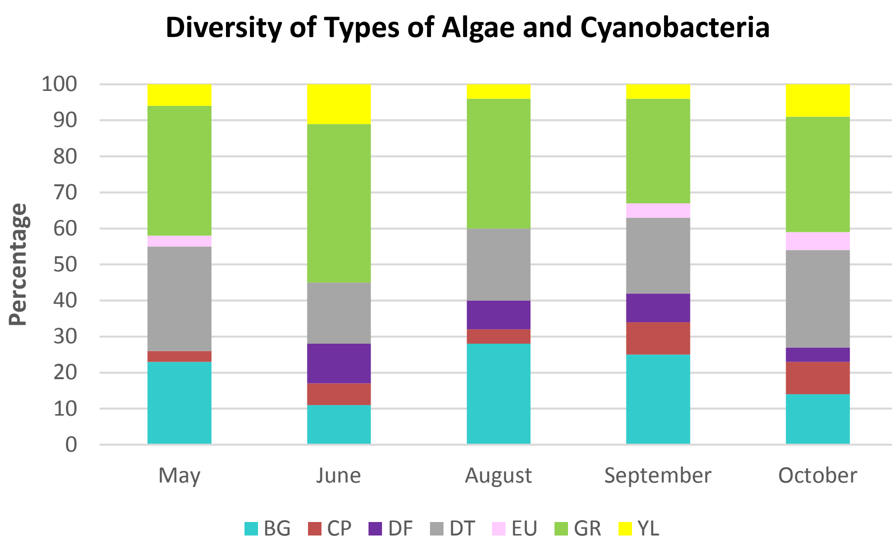

Figure 8. Percentage of genera of algae and cyanobacteria in the sample.

Figure 8 illustrates how the phytoplankton community changed from May to October. The chlorophyll-a data shows that the populations fluctuated (high in May and moderate in September) due to a number of factors, including seasonal changes and nutrient availability (Wetzel, 1983). Two genera of cyanobacteria dominated the community: in May *Aphanizomenon;* in September and October *Dolichospermum*. In June, *Dinobryon*, a genus of Chrysophyta (golden algae) dominated the photic zone.

Nutrients

Inorganic nutrients, particularly the elements phosphorus and nitrogen, are vital for algal nutrition and cellular constituents.

Total Phosphorus

Compared to the rich supply of other elements required for nutrition or structure, phosphorus is the least abundant and most commonly limits biological productivity. Lakes in this region experience undesirable algae growth when the annual average surface phosphorus level reaches 0.030 mg/L (Gilliom, 1983). The 2018 seasonal average surface total phosphorus concentration in Hicks Lake was 0.014 mg/L (Figure 9 depict concentrations from May to October). The action level is 0.020 mg/L (WAC, 2019).

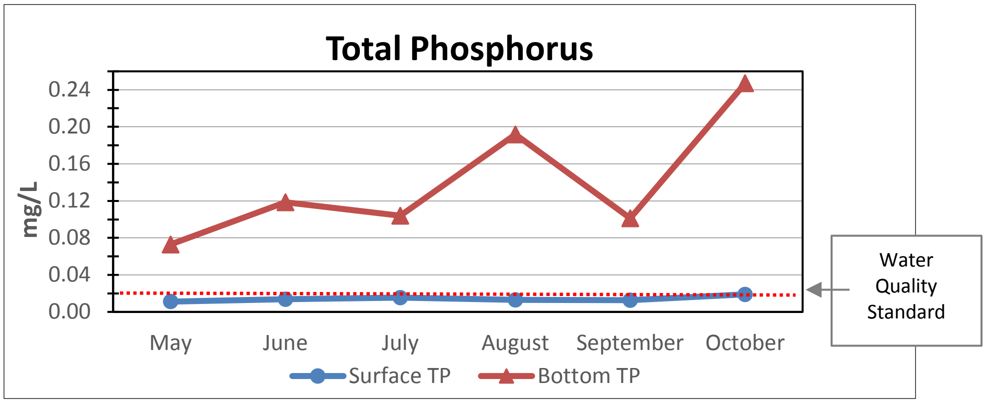

Figure 9. Concentration of Total Phosphorus at the surface and bottom of the lake in 2018.

The vertical profile graphs show that Hicks Lake exhibited a clinograde oxygen curve, especially in the later phases of thermal stratification. The hypolimnion was not mixing with the oxygenated water above. Meanwhile, oxygen in the hypolimnion was consumed by redox processes like decomposition. Dissolved oxygen concentration remained between 0.4 to 0.5 mg/L in the hypolimnion from May to October. Due to the lack of oxygen, phosphorus stored in the sediments was released into the water column and accumulated in the hypolimnion.

Nitrogen

Nitrogen is also limiting to lake productivity, but supplies are more readily augmented by inputs from external sources. The State of Washington does not have established action or cleanup levels for surface total nitrogen. The average total surface nitrogen concentration was 0.472 mg/L.

In anoxic conditions, ammonia-nitrogen is released from the bottom sediments and accumulates in the hypolimnion, as seen in Figure 10. This figure also shows a pulse of higher nitrogen at the surface in July.

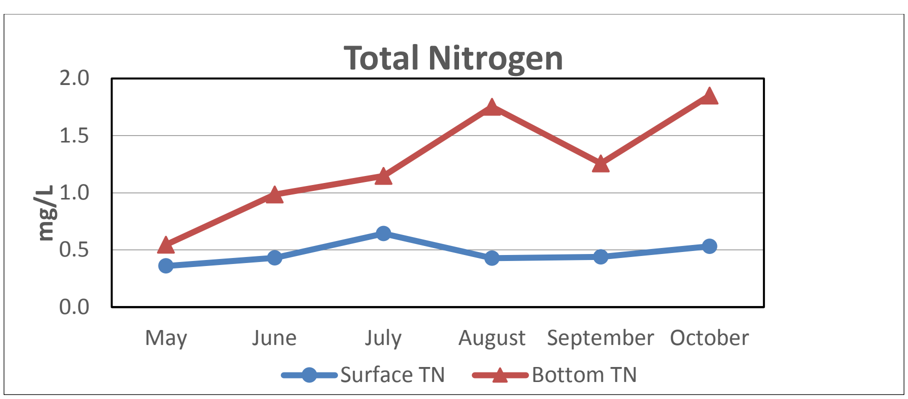

Figure 10. Concentration of Total Nitrogen at the surface and bottom in 2018.

Figures 11 and 12 display the average annual concentrations for total phosphorus and total nitrogen from 1995 to 2018. The surface samples for total phosphorus have remained below the state action level of 0.020 mg/L over the entire period of record.

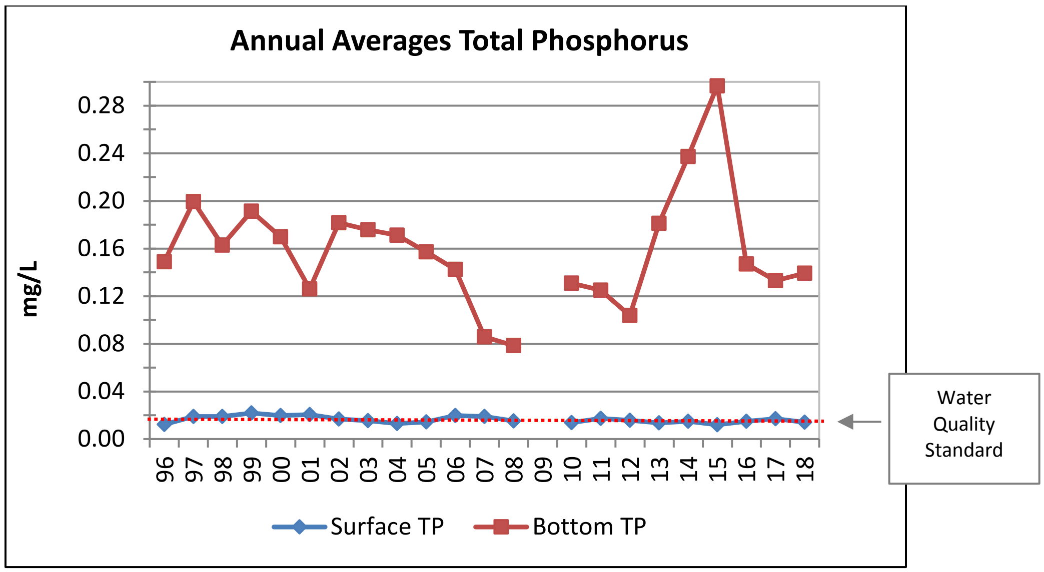

Figure 11. Average Annual Total Phosphorus from 1995 to 2018.

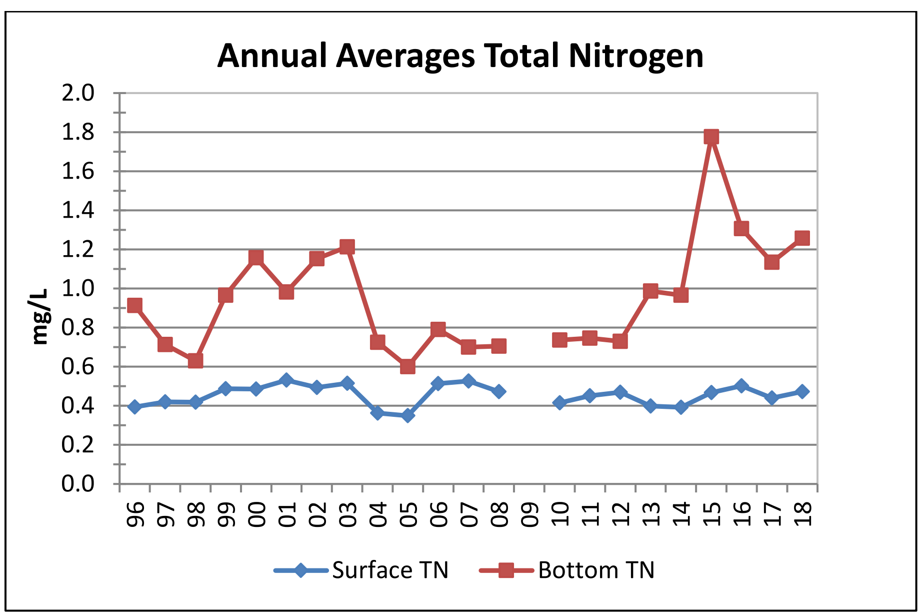

Figure 12. Average Annual Total Nitrogen from 1995 to 2018.

The seasonal Kendall test shows a significant ($p < 0.05$) downward trend of both surface TP and surface TN concentrations from 2007 to 2018 (Appendix D).

Trophic State Indices (TSI)

The most commonly used method to classify lakes is called the Carlson's Trophic State Index (Carlson, 1977). Based on the productivity, this method uses three index variables: transparency (secchi disk depth), chlorophyll-a, and phosphorus concentrations. Table 3 provides the index values for each trophic classification.

Table 3. Trophic State Index variables.

TSI Value	Trophic State	Productivity
0 to 40	oligotrophic	Low
41 to 50	mesotrophic	Medium
> 50	eutrophic	High

The TSI calculated from the 2018 results are:

Secchi Disk: 43 mesotrophic
Chlorophyll-a: 53 eutrophic
Total Phosphorus: 42 mesotrophic

The average of the three TSI variables is 43, which categorizes Hicks Lake as mesotrophic in 2018, which is how it was classified in 1981 by the USGS. Based on the concentration of chlorophyll-a, Hicks Lake was classified as eutrophic 17 out of 23 (74%) sample seasons since 1995 (Figure 13).

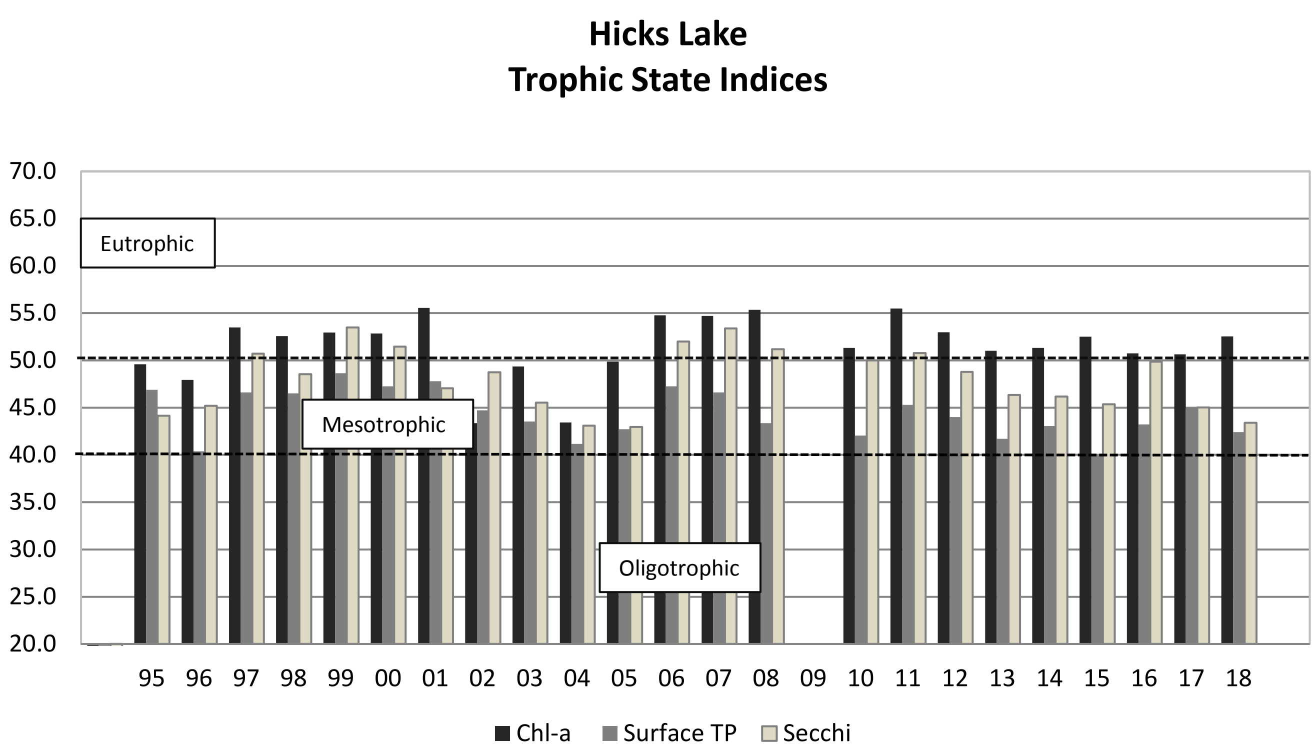

Figure 13. Trophic State Index from 1995 to 2018.

SUMMARY

Thermal Stratification
In 2018, the water column at Hicks Lake was thermally stratified into 3 distinct layers from May to September, which partially mixed in October.

Higher than Average Clarity
In 2018, average transparency (2.87 meters) was higher than the long-term average (2.37 meters). Secchi depths ranged from a low of 2.2 meters in September to a high of 3.9 meters in July.

Productivity High Early Summer
Based on the chlorophyll-a concentration, productivity was highest in May (23 µg/L), when *Aphanizomenon* sp., a type of cyanobacteria, dominated the surface community. The concentration fell to 2.1 to 2.4 µg/L in June and July. *Dinobryon*, a type of golden-algae, was the dominant species in July. The concentration of phaeophytin-a peaked in August, which indicates poor physiological condition of phytoplankton. Chlorophyll-a concentration increased again in September and October, when the cyanobacteria *Dolichospermum* sp. dominated the surface community.

Chlorophyll-a Concentration Decreasing 2007 to 2018
The seasonal Kendall test indicates that the chlorophyll-a concentration had a significant ($p < 0.05$) decreasing trend from 2007 to 2018.

Surface TP and Surface TN Concentrations Decreasing 2007 to 2018
The seasonal Kendall test reveals a significant ($p < 0.05$) trend of decreasing surface TP and TN concentrations from 2007 to 2018. The 2018 seasonal average surface total phosphorus concentration was 0.014 mg/L, which is below the water quality standard 0.020 mg/L. The average total surface nitrogen was 0.472 mg/L.

Classified as Mesotrophic
Hicks Lake was classified as mesotrophic in 2018 based on an average of the 3 TSI variables.

DATA SOURCES:

Thurston County Community Planning and Economic Development
(360) 786-5549 or
https://www.thurstoncountywa.gov/planning/Pages/water-gateway.aspx

Thurston County Environmental Health
(360) 867-2626 or
https://www.co.thurston.wa.us/health/ehrp/annualreport.html

FUNDING SOURCE:

City of Lacey funded monitoring in 2018.

LITERATURE CITED

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Gillion, R.J. 1983. Estimation of nonpoint source loadings of phosphorus for lakes in the Puget Sound region, Washington. USGS Water Supply Paper 2240.

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Moss, Brian. 1967. Studies on the degradation of chlorophyll-a and carotenoids in freshwaters. New Phytol. 67: 49-59.

WAC. 2019. Chapter 173-201A, "*Water Quality Standards for Surface Water of the State of Washington*." https://apps.leg.wa.gov/wac/default.aspx?cite=173-201a

Appendices

Appendix A. Raw data

Date	Time	Bottom Depth (meters)	Bottom Sample Depth (meters)	Surface TP (mg/L)	Bottom TP (mg/L)	Surface TN (mg/L)	Bottom TN (mg/L)	Secchi (meters)	Chl a (µg/L)	Phae a (µg/L)	Water Color
5/22/2018	10:45	10.5	10	0.011	0.073	0.360	0.546	3.8	23.496	0.801	#4
6/26/2018	9:10	11.4	10.8	0.014	0.119	0.431	0.986	3.4	2.136	0.481	#8
7/17/2018	10:04	11.3	10.7	0.016	0.104	0.643	1.148	3.9	2.403	0.214	#7
8/14/2018	10:44	10.7	10.2	0.013	0.192	0.429	1.754	2.8	7.100	<0.1	#3
9/18/2018	12:19	9.9	9	0.013	0.101	0.439	1.257	2.2	11.901	1.770	#4
10/23/2018	10:55	10.28	9.5	0.019	0.247	0.532	1.850	2.9	9.300	1.900	#9
Mean Values		*10.68*	*10.03*	*0.014*	*0.139*	*0.472*	*1.257*	*3.2*	*9.389*	*0.876*	

Appendix B. Algae and Cyanobacteria Identification

Date/Time	Type	Species	Composite Qualifier	Surface Qualifier	Comments
5/22/18 10:48	BG	Aphanocapsa sp.	P	P	
5/22/18 10:48	BG	Chroococcus sp.	P		
5/22/18 10:48	BG	Dolichospermum sp. - irregularly twisted		P	formerly Anabaena sp.
5/22/18 10:48	BG	Dolichospermum sp. - straight	P		formerly Anabaena sp.
5/22/18 10:48	BG	Merismopedia sp.		P	
5/22/18 10:48	BG	Woronichinia sp.	P		
5/22/18 10:48	CP	Cryptomonas sp.	P	P	
5/22/18 10:48	DT	Asterionella sp.	P	P	
5/22/18 10:48	DT	Aulacoseira sp.		P	
5/22/18 10:48	DT	Cocconeis sp.		P	
5/22/18 10:48	DT	Cyclotella sp.		P	
5/22/18 10:48	DT	Fragilaria sp.		P	
5/22/18 10:48	DT	Nitzschia sp.		P	
5/22/18 10:48	DT	Stephanodiscus sp.	P	P	
5/22/18 10:48	DT	Tabellaria sp.	S	S	
5/22/18 10:48	DT	Undetermined Diatom: Pennate	P		
5/22/18 10:48	EU	Trachelomonas sp.	P		
5/22/18 10:48	GR	Closterium sp.	P		
5/22/18 10:48	GR	Cosmarium sp.	P	P	
5/22/18 10:48	GR	Elakatothrix sp.	P	P	
5/22/18 10:48	GR	Eudorina sp.		P	
5/22/18 10:48	GR	Oocystis sp.	P	P	
5/22/18 10:48	GR	Scenedesmus sp.	P		
5/22/18 10:48	GR	Sphaerocystis sp.	P	P	
5/22/18 10:48	GR	Spondylosium sp.	P	P	
5/22/18 10:48	GR	Staurastrum sp.	P	P	
5/22/18 10:48	GR	Staurodesmus sp.	P	P	
5/22/18 10:48	YL	Dinobryon sp.	P	D	
5/22/18 10:48	YL	Mallomonas sp.		P	
5/22/18 10:48	BG	Aphanizomenon sp.	D	P	
5/22/18 10:48	GR	Ankistrodesmus sp.		P	

Type of Algae	Qualifier
BG = Blue green	D = Dominant
CP = Cryptophyte	P = Present
DF = Dinoflagellate	S = Subdominant
DT = Diatom	N/A = Not Applicable
EU = Euglenophyte	
GR = Green	
YL = Yellow	

Date/Time	Type	Species	Composite Qualifier	Comments
6/26/18 10:00	BG	Chroococcus sp.	P	
6/26/18 10:00	BG	Snowella sp.	P	
6/26/18 10:00	CP	Cryptomonas sp.	P	
6/26/18 10:00	DF	Ceratium sp.	P	
6/26/18 10:00	DF	Peridinium sp.	P	
6/26/18 10:00	DT	Asterionella sp.	S	
6/26/18 10:00	DT	Cyclotella sp.	P	
6/26/18 10:00	DT	Tabellaria sp.	P	
6/26/18 10:00	GR	Cosmarium sp.	P	
6/26/18 10:00	GR	Elakatothrix sp.	P	
6/26/18 10:00	GR	Oocystis sp.	P	
6/26/18 10:00	GR	Quadrigula sp.	P	
6/26/18 10:00	GR	Scenedesmus sp.	P	
6/26/18 10:00	GR	Staurastrum sp.	P	
6/26/18 10:00	YL	Dinobryon sp.	D	
6/26/18 10:00	YL	Mallomonas sp.	P	
6/26/18 10:00	GR	Ankistrodesmus sp.	P	
6/26/18 10:00	GR	Ankyra sp.	P	

Type of Algae	Qualifier
BG = Blue green	D = Dominant
CP = Cryptophyte	P = Present
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EU = Euglenophyte	
GR = Green	
YL = Yellow	

Date/Time	Type	Species	Composite Qualifier	Comments
8/14/18 10:40	BG	Aphanizomenon sp.	D	
8/14/18 10:40	BG	Aphanocapsa sp.	S	
8/14/18 10:40	BG	Chroococcus sp.	P	
8/14/18 10:40	BG	Dolichospermum sp. - irregularly twisted	P	formerly Anabaena sp.
8/14/18 10:40	BG	Dolichospermum sp. - straight	P	formerly Anabaena sp.
8/14/18 10:40	BG	Pseudanabaena sp.	P	
8/14/18 10:40	BG	Woronichinia sp.	P	
8/14/18 10:40	CP	Rhodomonas sp.	P	
8/14/18 10:40	DF	Ceratium sp.	P	
8/14/18 10:40	DF	Peridinium sp.	P	
8/14/18 10:40	DT	Cyclotella sp.	P	
8/14/18 10:40	DT	Fragilaria sp.	P	
8/14/18 10:40	DT	Navicula sp.	P	
8/14/18 10:40	DT	Tabellaria sp.	P	
8/14/18 10:40	GR	Ankistrodesmus sp.	P	
8/14/18 10:40	GR	Cosmarium sp.	P	
8/14/18 10:40	GR	Dictyosphaerium sp.	P	
8/14/18 10:40	GR	Elakatothrix sp.	P	
8/14/18 10:40	GR	Planktosphaeria sp.	P	
8/14/18 10:40	GR	Quadrigula sp.	P	
8/14/18 10:40	GR	Schroederia sp.	P	
8/14/18 10:40	GR	Staurastrum sp.	P	
8/14/18 10:40	Gr	Staurodesmus sp.	P	
8/14/18 10:40	YL	Mallomonas sp.	P	
8/14/18 10:40		Encyonema sp.	P	

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BG = Blue green	D = Dominant
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9/18/18 12:29	BG	Aphanizomenon sp.	P	
9/18/18 12:29	BG	Aphanocapsa sp.	P	
9/18/18 12:29	BG	Chroococcus sp.	P	
9/18/18 12:29	BG	Dolichospermum sp. - straight,	D	formerly Anabaena sp.
9/18/18 12:29	BG	Gomphonema sp.	P	
9/18/18 12:29	BG	Snowella sp.	P	
9/18/18 12:29	CP	Cryptomonas sp.	P	
9/18/18 12:29	CP	Rhodomonas sp.	P	
9/18/18 12:29	DF	Ceratium sp.	P	
9/18/18 12:29	DF	Undetermined Dinophyceae	P	
9/18/18 12:29	DT	Asterionella sp.	P	
9/18/18 12:29	DT	Aulacoseira sp.	P	
9/18/18 12:29	DT	Cyclotella sp.	P	
9/18/18 12:29	DT	Synedra sp.	P	
9/18/18 12:29	DT	Tabellaria sp.	P	
9/18/18 12:29	EU	Trachelomonas sp.	S	
9/18/18 12:29	GR	Ankistrodesmus sp.	P	
9/18/18 12:29	GR	Closterium sp.	P	
9/18/18 12:29	GR	Cosmarium sp.	P	
9/18/18 12:29	GR	Crucigenia sp.	P	
9/18/18 12:29	GR	Elakatothrix sp.	P	
9/18/18 12:29	GR	Quadrigula sp.	P	
9/18/18 12:29	GR	Xanthidium sp.	P	
9/18/18 12:29	YL	Dinobryon sp.	P	formerly Anabaena sp.

Type of Algae	Qualifier
BG = Blue green	D = Dominant
CP = Cryptophyte	P = Present
DF = Dinoflagellate	S = Subdominant
DT = Diatom	N/A = Not Applicable
EU = Euglenophyte	
GR = Green	
YL = Yellow	

Date/Time	Type	Species	Composite Qualifier	Comments
10/23/18 11:10	BG	Aphanocapsa sp.	P	
10/23/18 11:10	BG	Chroococcus sp.	P	
10/23/18 11:10	BG	Dolichospermum sp. - straight	D	formerly Anabaena sp.
10/23/18 11:10	CP	Cryptomonas sp.	P	
10/23/18 11:10	CP	Rhodomonas sp.	P	
10/23/18 11:10	DF	Undetermined Dinophyceae	P	
10/23/18 11:10	DT	Asterionella sp.	P	
10/23/18 11:10	DT	Cocconeis sp.	P	
10/23/18 11:10	DT	Nitzschia sp.	P	
10/23/18 11:10	DT	Pinnularia sp.	P	
10/23/18 11:10	DT	Tabellaria sp.	P	
10/23/18 11:10	DT	Undetermined Diatom: Pennate	P	
10/23/18 11:10	EU	Trachelomonas sp.	S	
10/23/18 11:10	GR	Ankistrodesmus sp.	P	
10/23/18 11:10	GR	Cosmarium sp.	P	
10/23/18 11:10	GR	Dictyosphaerium sp.	P	
10/23/18 11:10	GR	Elakatothrix sp.	P	
10/23/18 11:10	GR	Quadrigula sp.	P	
10/23/18 11:10	GR	Scenedesmus sp.	P	
10/23/18 11:10	GR	Staurastrum sp.	P	
10/23/18 11:10	YL	Dinobryon sp.	P	
10/23/18 11:10	YL	Mallomonas sp.	P	

Type of Algae	Qualifier
BG = Blue green	D = Dominant
CP = Cryptophyte	P = Present
DF = Dinoflagellate	S = Subdominant
DT = Diatom	N/A = Not Applicable
EU = Euglenophyte	
GR = Green	
YL = Yellow	

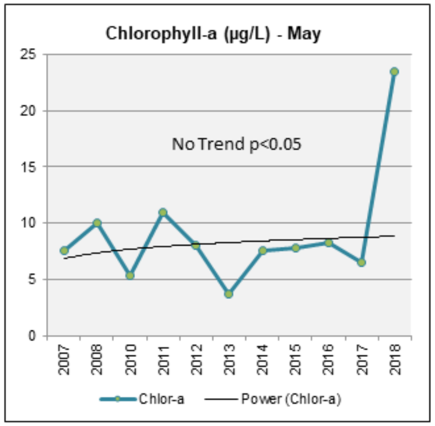
Appendix C. Quality Assurance/Quality Control

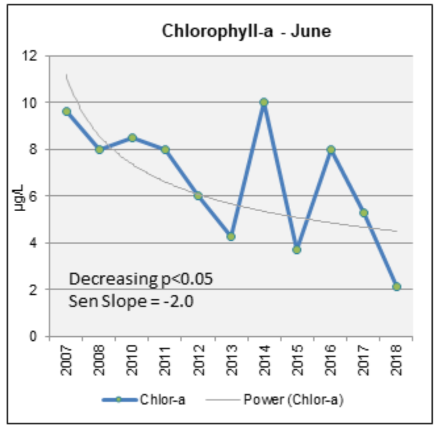
This table provides the amount of instrument drift for specific conductivity, dissolved oxygen (collected with optical sensor), and pH for the post-checks after sampling at Hicks Lake. The temperature thermistor was checked against a NIST thermometer on May 31, 2018 and difference was 0.04° C.

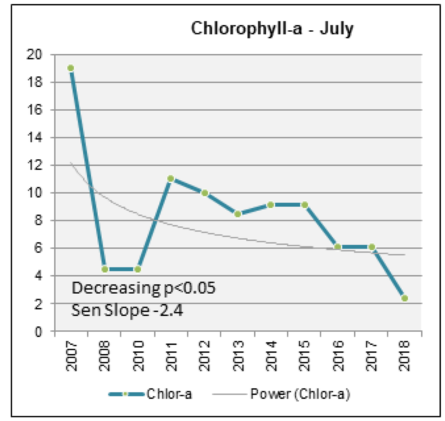
Date/Time	Specific Conductivity (µS/cm)	Dissolved Oxygen (Percent Saturation)	pH (standard units)
5/23/18 7:34	0.00	-0.13	0.02
6/27/18 7:28	-3.30	-0.85	0.07
7/18/18 7:45	2.20	-0.82	0.11
8/15/18 15:40	1.50	-0.01	0.17
9/19/18 8:20	0.10	-0.29	-0.05
10/24/18 7:40	-0.10	-0.03	0.01

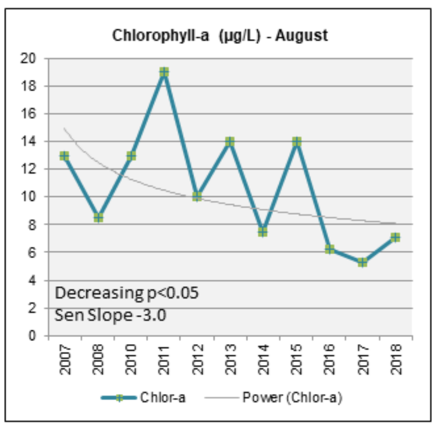
TCEH collected 10% field replicates and one blank lab sample each day. For the dates that Hicks Lake was sampled, TCEH collected these samples at other lakes (3 to 4 lakes sampled each day).

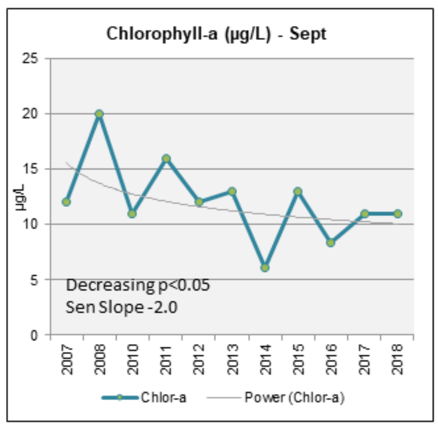
Appendix D. Seasonal Kendall Tests

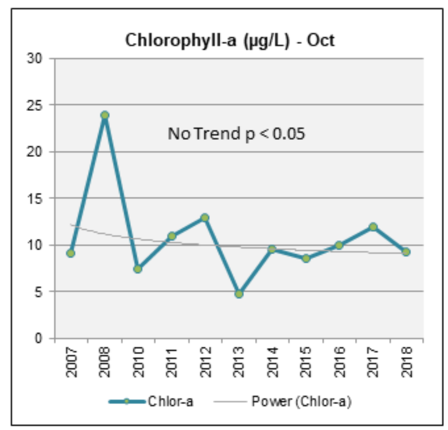


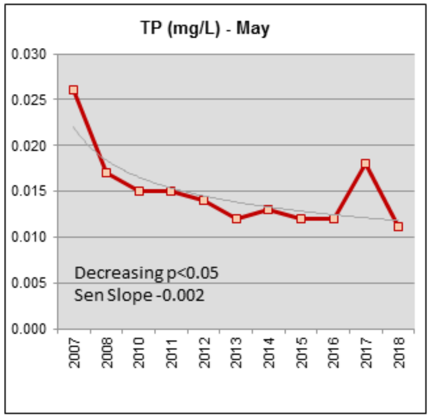


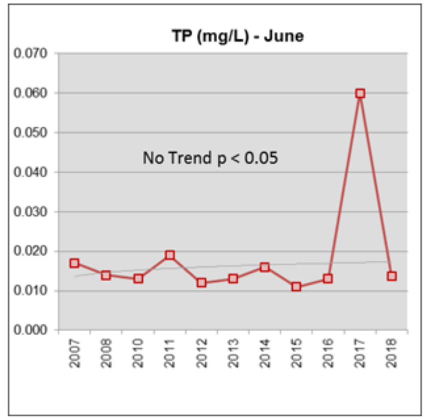


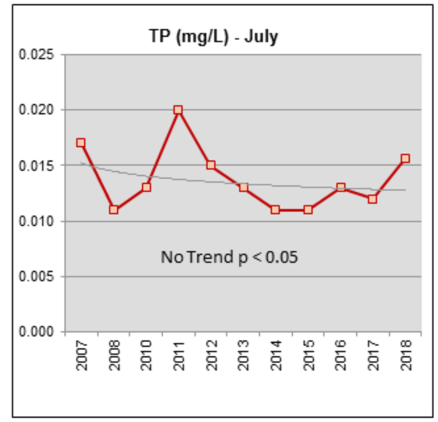


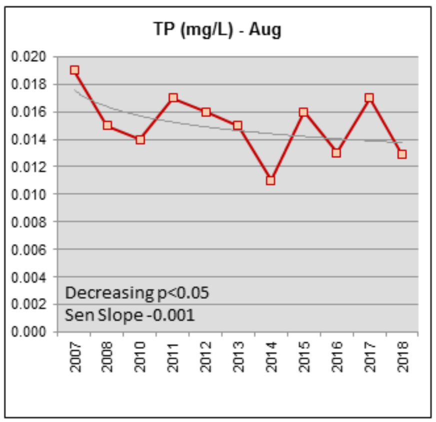


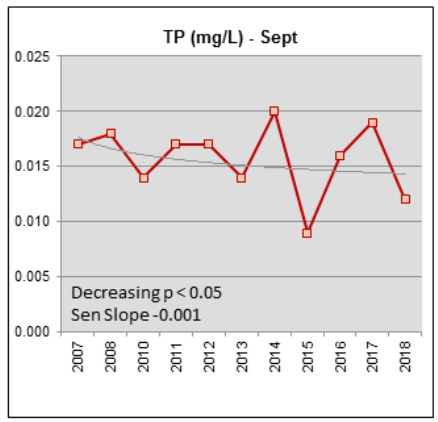


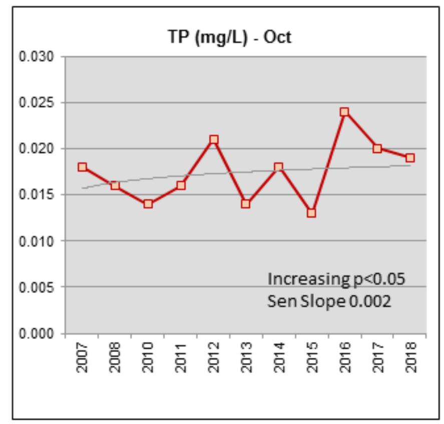

TP (mg/L) - May
Decreasing p<0.05
Sen Slope -0.002

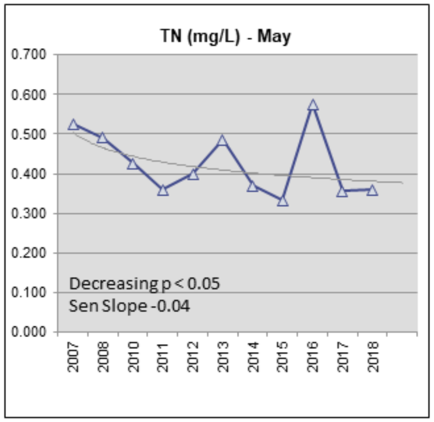

TP (mg/L) - June
No Trend p < 0.05

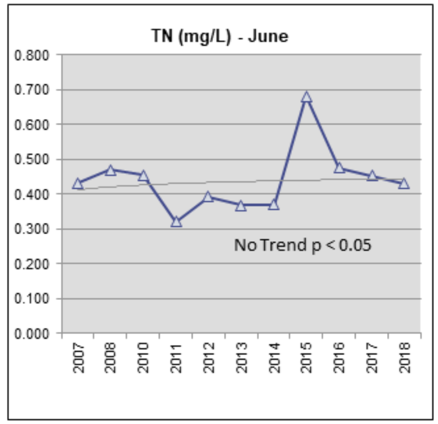

TP (mg/L) - July
No Trend p < 0.05

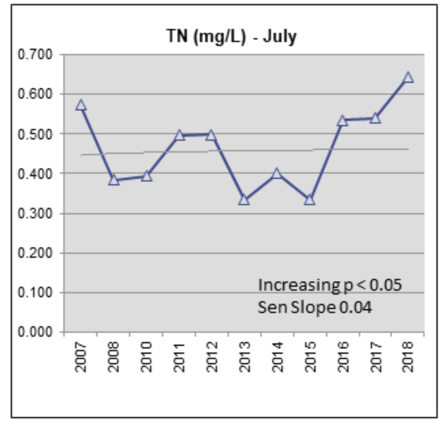

TP (mg/L) - Aug
Decreasing p<0.05
Sen Slope -0.001

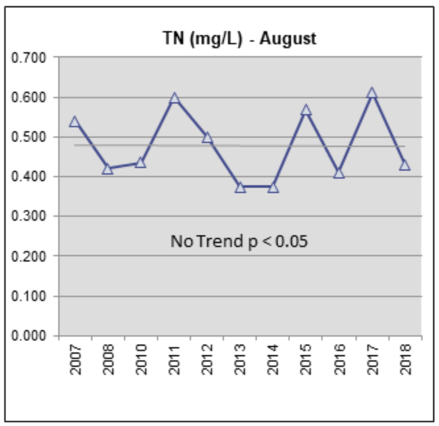

TP (mg/L) - Sept
Decreasing p < 0.05
Sen Slope -0.001

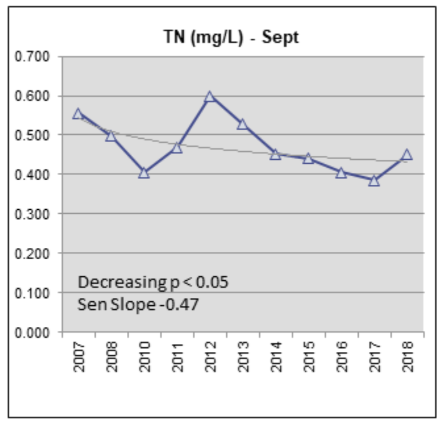

TP (mg/L) - Oct
Increasing p<0.05
Sen Slope 0.002

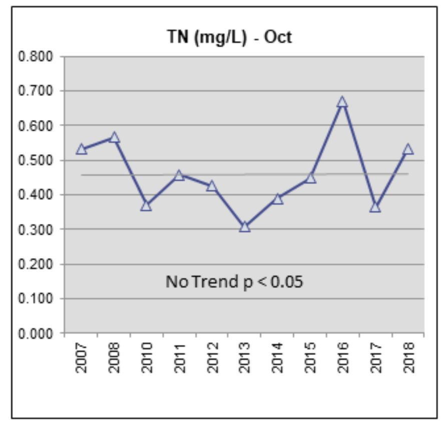

TN (mg/L) - May
Decreasing p < 0.05
Sen Slope -0.04


TN (mg/L) - June
No Trend p < 0.05


TN (mg/L) - July
Increasing p < 0.05
Sen Slope 0.04


TN (mg/L) - August
No Trend p < 0.05


TN (mg/L) - Sept
Decreasing p < 0.05
Sen Slope -0.47


TN (mg/L) - Oct
No Trend p < 0.05