King County
Lake Stewardship Program
2018 Monitoring Report

February 2019

King County

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1.0 LAKE STEWARDSHIP PROGRAM

Since 1994, the Lake Stewardship Program has been working with dedicated volunteers to monitor small lakes throughout King County. In 2018, 36 lakes were monitored, in both incorporated cities (through interlocal agreements) and unincorporated King County.

Specific objectives of the Lake Stewardship Program include:

- gathering baseline data to assess long-term trends
- defining seasonal and water-column variability
- identifying potential concerns, and proposing possible management solutions when feasible
- educating lake residents, lake users, and policy makers about lake water quality
- understanding the nature and character of the smaller lakes in King County.

From May through October, all lakes in the program were monitored twice per month to measure nutrient and algal concentrations. At the mid-lake sampling station, volunteers collected water samples from 1 m depth for chlorophyll, nutrients, and other chemical analyses, and measured water temperature and Secchi depth. Water samples were picked up by Lake Stewardship staff and delivered to the King County Environmental Laboratory.

Some lakes were monitored year-round to observe the hydrological balance between the lake and its watershed, as well as to characterize lake fluctuations throughout the entire year. Volunteers measured lake level and precipitation data each day at lake-side docks. They also made weekly measurements of water temperature and Secchi depth at the mid-lake sampling station.

Data were analyzed and uploaded to the Small Lakes Data and Information webpage (http://green2.kingcounty.gov/SmallLakes).

Both May–October and year-round volunteers routinely recorded their observations of recreational lake use, algal blooms, and weather conditions that may have had an effect on measurements. Volunteers were provided with training, equipment, and ongoing technical assistance. They were also invited to attend the annual Lake Stewardship Program training workshops held each year in late April.

2.0 WHAT WE MEASURE AND WHY

2.1 Types of Monitoring

Year-round monitoring measures a few key parameters throughout the year. **Precipitation** and **lake level** are measured daily at lake-side docks. **Water temperature** (at 1 m depth) and **Secchi depth** are measured weekly at a mid-lake sampling station located over the deepest part of the lake.

May–October monitoring is conducted twice-monthly from May through October, at a mid-lake sampling station located over the deepest part of the lake. In addition to **water temperature** (at 1 m depth) and **Secchi depth**, water samples are also collected from 1 m depth and analyzed for:

- **Chlorophyll-*a***
- **Pheophytin**
- **Total nitrogen**
- **Total phosphorus**

Twice a year, in May and August, the May–October monitoring includes a **water column profile** that collects temperature measurements and water samples from 1 m depth, mid-column, and 1 m above the lake bottom. These samples are analyzed for the usual May-October parameters plus:

- Inorganic nitrogen, as **ammonia** (NH_3) and **nitrate/nitrite** (NO_2/NO_3)
- Inorganic phosphorus, as **orthophosphate** (OPO_4)
- **Alkalinity**
- **Water color** (UV254)

2.2 Parameters

Physical parameters

Precipitation and **lake level** help us understand a lake's hydrological balance and track seasonal trends and long-term changes. Relationships between precipitation and lake level reflect watershed characteristics and groundwater inputs. Precipitation is measured with a plastic volumetric rain gauge mounted in an open area. Lake level is measured using a staff plate mounted to a fixed structure such as a dock.

Secchi depth is a measure of water clarity or transparency. A 20-cm (8-in) black-and-white Secchi disk is lowered into the lake until it disappears from view. Secchi depth is shallower when there are more suspended particles, such as sediment or algae, in the lake,.

Water temperature can affect the growth rates of plants and algae. In addition, cooler or warmer water temperatures favor different species of fish and other aquatic organisms. Temperature measurements in a water column profile also show the extent of lake

stratification. In a stratified lake, surface waters are warmer than deeper, cooler waters, which reduces mixing between the two layers.

Nutrients

Phosphorus and **nitrogen** are naturally occurring elements necessary for growth and reproduction in both plants and animals. Fertilizer, pet waste, wastewater, and other human activities can increase the concentration of these nutrients in a lake. In lakes of the Puget Sound lowlands, biological productivity is most often limited by the amount of available phosphorus in the water. Increases in phosphorus can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential health threat if blooms become dominated by cyanobacteria (blue-green algae) that can produce toxins.

The **ratio of total nitrogen to total phosphorus (N:P)** indicates whether nutrient conditions may favor the growth of cyanobacteria (blue-green algae). When N:P ratios are near or below 25, nitrogen is as likely to be the limiting nutrient as phosphorus. Certain cyanobacteria species can "fix" nitrogen (convert inert atmospheric N_2 into ammonia, which is biologically available), which gives them a competitive advantage over other algae when nitrogen is limiting.

Nutrients in a lake can be part of either organic or inorganic molecules. Inorganic forms of nitrogen are **ammonia** (NH_3) and **nitrate/nitrite** (NO_2/NO_3); the inorganic form of phosphorus is **orthophosphate** (PO_4). In deeper waters when dissolved oxygen concentrations are low, nutrients are found primarily in inorganic forms.

Algal pigments

Chlorophyll-*a* concentration is an indicator of the abundance of phytoplankton (algae) in a lake. Chlorophyll-*a* is a pigment necessary for algae to photosynthesize and store energy. While all algal cells contain some chlorophyll-*a*, the amount varies depending on the species. For example, some cyanobacteria have other light-catching pigments, and little chlorophyll-*a* compared to other algal types (e.g., diatoms and chlorophytes), so chlorophyll-*a* concentrations may not always correlate with the abundance of cyanobacteria.

Pheophytin is a product of chlorophyll decomposition and is generally measured along with chlorophyll-*a* as an indicator of how fresh or viable the phytoplankton in the sample are. Bottom sediments will contain a large amounts of pheophytin compared to chlorophyll-*a*, while actively-growing algae from the water column will have very little pheophytin present.

Other parameters

Lake Stewardship volunteers also look for potentially toxic algal blooms, and sample visible blooms for algal toxin testing. **Microcystin** and **anatoxin-*a*** are toxins produced by some species of cyanobacteria (blue-green algae). Microcystin is a liver toxin, and anatoxin-*a* is a neurotoxin. These toxins can cause illnesses in people and animals, with symptoms such as

nausea and vomiting or numbness and tingling. High concentrations of cyanobacterial toxins are potentially lethal.

Alkalinity measures the buffering capacity of a lake, or the ability to resist changes in pH.

Water color is an index of the concentration of dissolved organic compounds in the water. It is measured as the absorbance of a specific wavelength of light (ultraviolet light at 254 nm) that is absorbed by many dissolved organic compounds.

Trophic State Index

The **Trophic State Index (TSI)** is a common index of a lake's overall biological productivity. TSI values are calculated from Secchi depth, chlorophyll-a concentrations, and total phosphorus concentrations. These three TSI estimates are all scaled between 0 and 100.

TSI calculations use average values from June–September, focusing on fairly consistent "summer" conditions. Note that older Lake Stewardship reports (through 2016) included May and October data as well. The TSI values presented in this report, for all years, have been recalculated using only June–September data.

Oligotrophic lakes (TSI <40) are very clear, with low nutrient concentrations and low algal growth. *Eutrophic* lakes (TSI >50) have less-clear water, with high nutrient concentrations and high algal growth. Eutrophic lakes are more likely to have frequent algal blooms. *Mesotrophic* lakes (TSI 40–50) are in the middle, with fairly clear water, and moderate nutrient concentrations and algal growth. Lakes in lowland King County have a range of different natural trophic states, and human activities may also alter a lake's trophic state (usually by changing nutrient inputs).

The three parameters used to estimate TSI are interrelated: Higher phosphorus concentrations feed more algal growth (higher chlorophyll concentrations), and more algal particles causes shallower Secchi depths. In an idealized "typical" lake, the three TSI estimates are equal. Real lakes usually have small differences among the three TSI estimates, though substantial divergence warrants further investigation. Divergence may be due to data errors, or to special conditions in the lake that alter the usual relationships among nutrients, chlorophyll, and water clarity. For example, high concentrations of humic compounds (dissolved organic molecules from decomposing plant material) will cause a dark water color that also reduces water clarity, independent of algal productivity.

Long-term trends

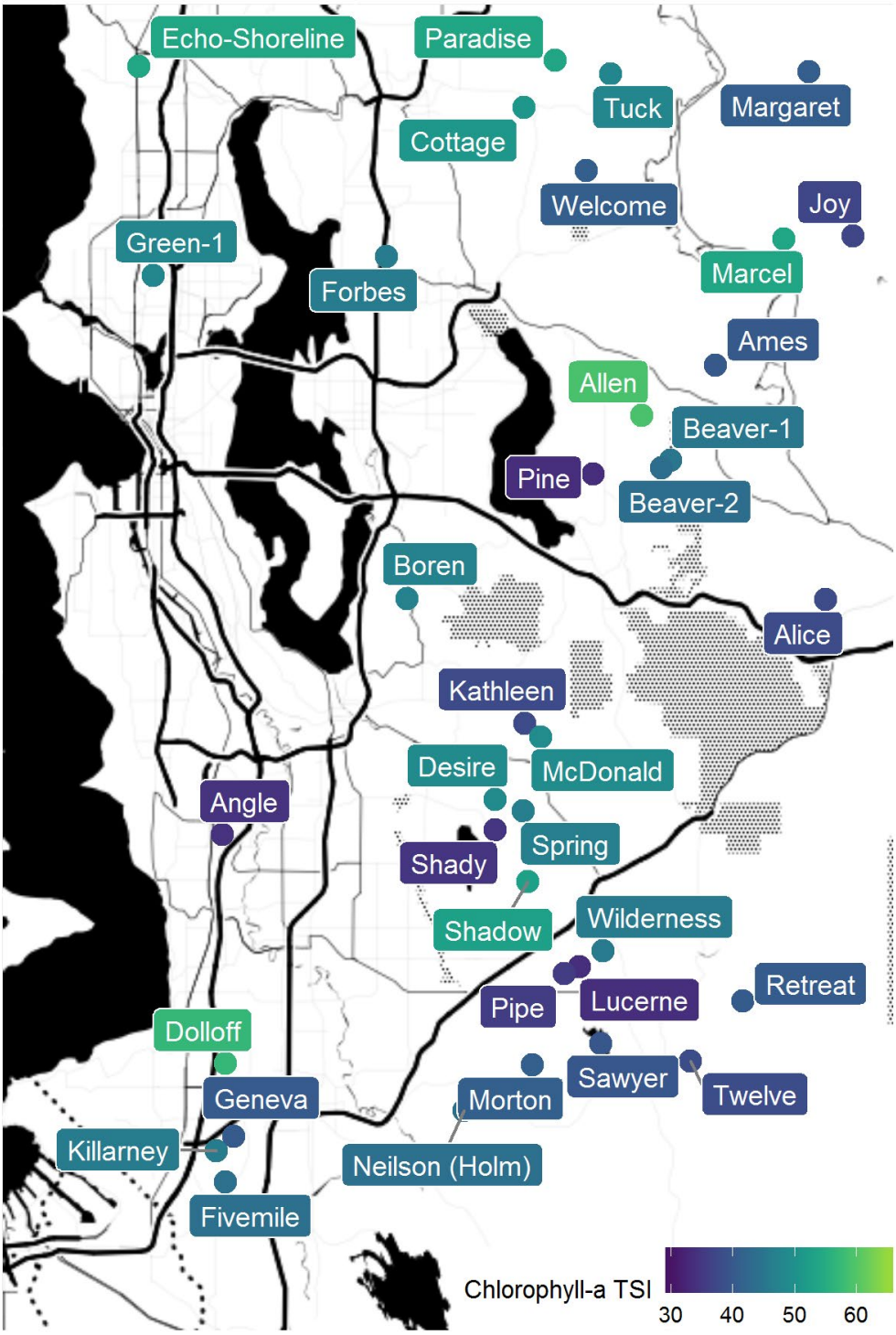
For each lake, we tested for long-term trends using May–October data from 1 m depth. We used a seasonal Kendall test, with monthly "seasons" and a p-value threshold of $p<0.05$. This is a non-parametric statistical test that can detect trends whether or not they are linear. For each year, data are averaged together within each calendar month. The seasonal Kendall test then tests for trends across years within each month; for example, it looks for

trends in May data separately from trends in June data. The test statistic from the monthly tests are combined to give an overall trend test.

To estimate the magnitude of the overall trends, we used the Thiel-Sen method (a common pairing with Kendall tests). This method assumes a constant linear trend, and can be a poor fit to the data if the trend is non-linear (such as a fairly sudden change in between relatively stable periods). Trend lines are drawn on water-quality graphs of annual means, and trend magnitudes are quantified in a table for each lake. Magnitudes are stated as absolute amounts of change per decade, as well as percent change per decade (calculated relative to the estimated value in the year when monitoring started).

3.0 LAKE TROPHIC STATES

As an overall comparison among lakes, this map shows the trophic state for each lake in the King County Lake Stewardship program in 2018. The color of each circle indicates the lake's average chlorophyll-a TSI value for the year.



4.0 LAKE ALICE: 2018

Thank you to Gerald Brewster, Stephen Dennis, and Bill Wheeler, the volunteer monitors for Lake Alice.

The key takeaways from the 2018 monitoring season are:

- Lake Alice continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Long-term trends suggest that water quality in Lake Alice has been declining over time, with increasing nitrogen and phosphorus concentrations, and shallower Secchi depths.
- An algal bloom was sampled for toxin testing in May. No algal toxins were detected in this sample.

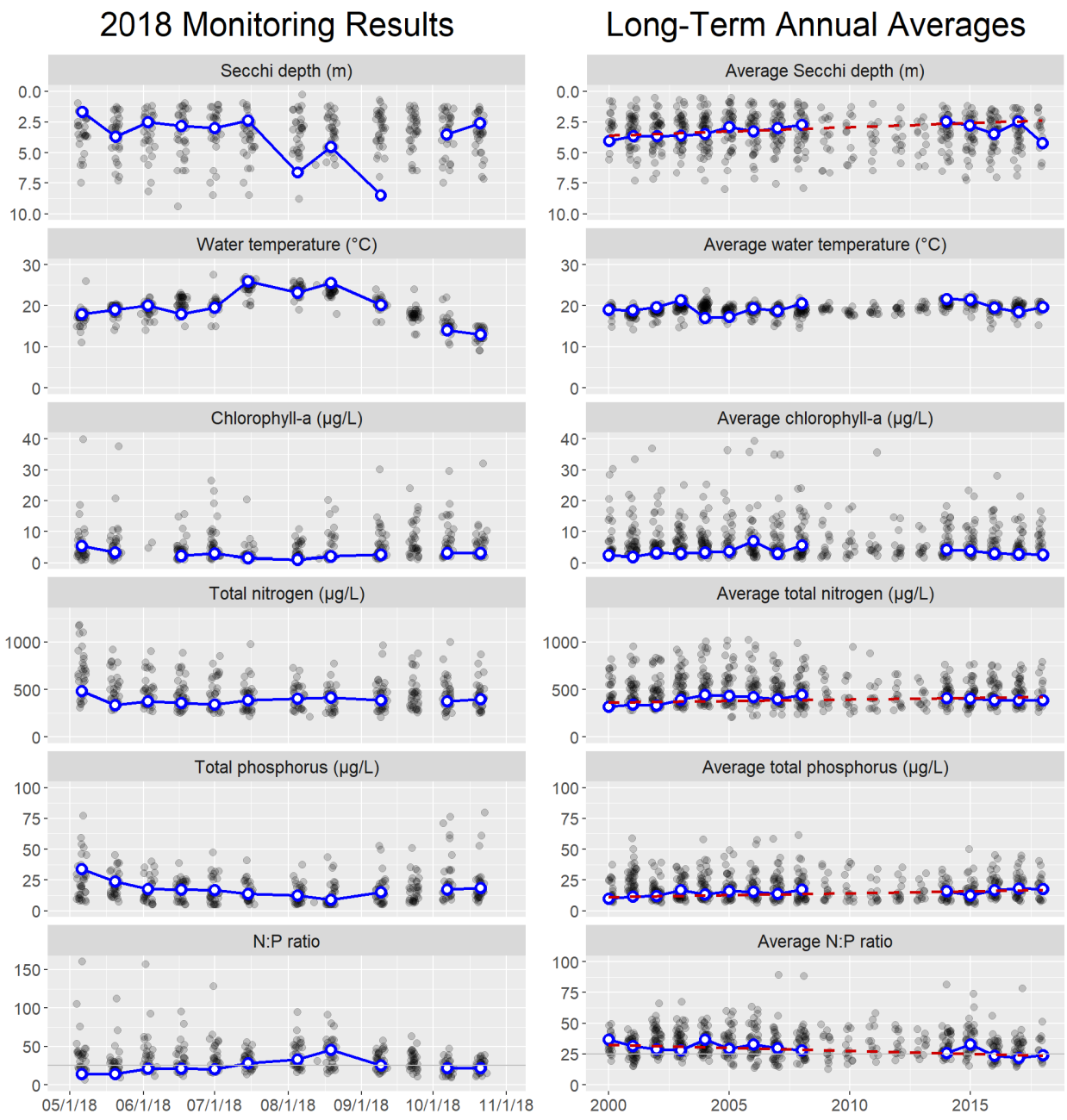
The Lake Stewardship Program recommends:

- Explore why nutrient concentrations have been increasing over time. If this increase continues, it could lead to more algal blooms in the future.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Alice through the Lake Stewardship Program.

4.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Alice are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



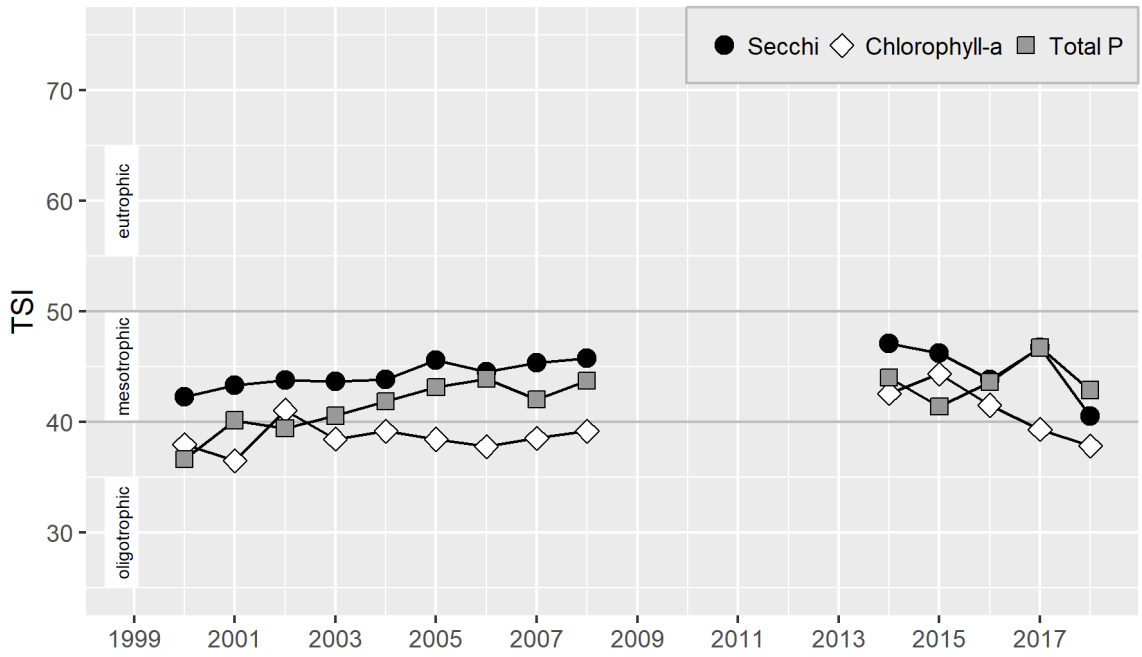
Secchi depths were noticeably deeper in summer. In contrast, nutrient and chlorophyll concentrations were fairly consistent throughout the sampling season, without strong seasonal patterns. Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2000, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-0.67 m	(-19%)
Total nitrogen	33 µg/L	(9%)
Total phosphorus	3 µg/L	(27%)
N:P ratio	-5.1	(-16%)

Long-term trends suggest that water quality in Lake Alice has been declining over time, with increasing nitrogen and phosphorus concentrations, and shallower Secchi depths.

4.2 Trophic state



In 2018, the three TSI values were around the mesotrophic-oligotrophic boundary.

4.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.7	4.2	8.5
Water temperature (°C)	13.0	19.7	26.0
Chlorophyll-a (µg/L)	0.9	2.6	5.3
Total nitrogen (µg/L)	336.0	386.8	483.0
Total phosphorus (µg/L)	9.1	17.6	34.1
N:P ratio	14.1	24.2	45.4

4.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

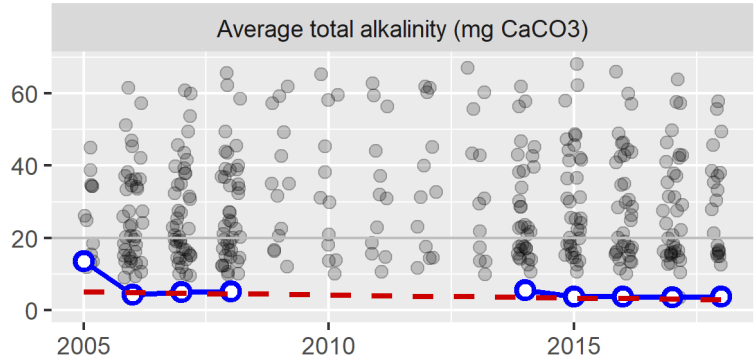
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	19.0	3.3	(2.0)	336	2.9	(10.0)	23.9	0.5
	4.0	11.5	3.6	2.3	284	–	–	19.4	–
	7.5	8.5	–	–	3180	64.4	37.0	419.0	4.0
8/19/2018	1.0	25.5	2.0	(1.4)	413	3.4	(10.0)	9.1	0.8
	4.0	22.0	4.9	2.5	254	–	–	16.8	–
	7.5	12.0	–	–	882	(2.0)	(10.0)	98.7	1.3

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

4.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 3.8 mg $CaCO_3$.

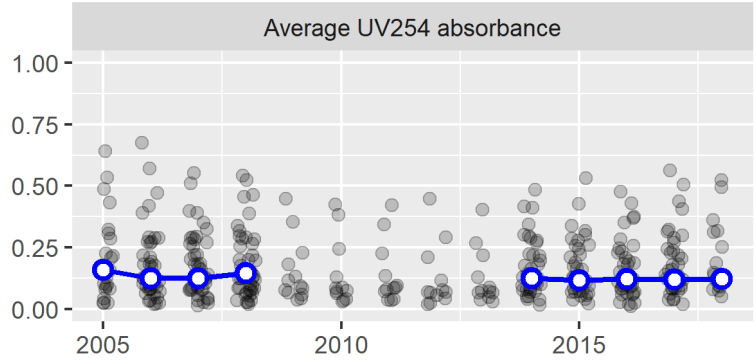
The blue points and line are annual average alkalinity values for Lake Alice. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -1.7 mg $CaCO_3$ (-33%) per decade.



4.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.12, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Alice. Grey points in the background are results for all other lakes in the Lake Stewardship program.



5.0 ALLEN LAKE: 2018

Thank you to David Burton, the volunteer monitor for Allen Lake.

The key takeaways from the 2018 monitoring season are:

- Allen Lake had fairly high nutrient concentrations, moderate algal growth, and less-clear water.
- Long-term trends suggest that water quality in Allen Lake has generally been improving over time, though there has been considerable variation from year to year. Overall, nitrogen, phosphorus, and chlorophyll concentrations have decreased, and Secchi depths have gotten deeper.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 throughout the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- No algal blooms were reported for toxin testing in 2018.

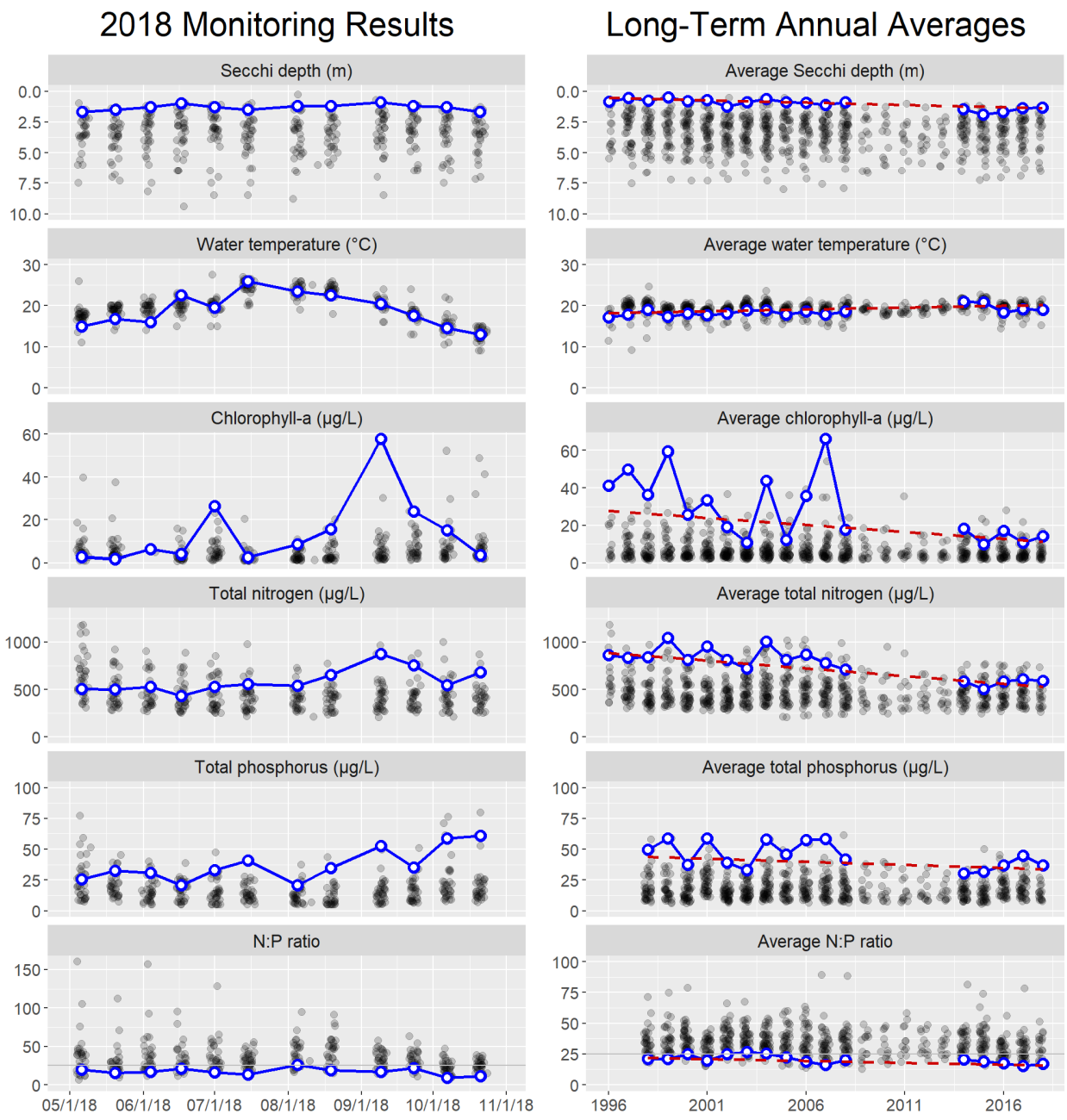
The Lake Stewardship Program recommends:

- Stay alert for toxic algal blooms in Allen Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore what has helped to decrease nutrient concentrations in Allen Lake – and encourage those trends to continue. Understanding the sources of year-to-year variability may provide some useful insights, as well.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Allen Lake through the Lake Stewardship Program.

5.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Allen Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



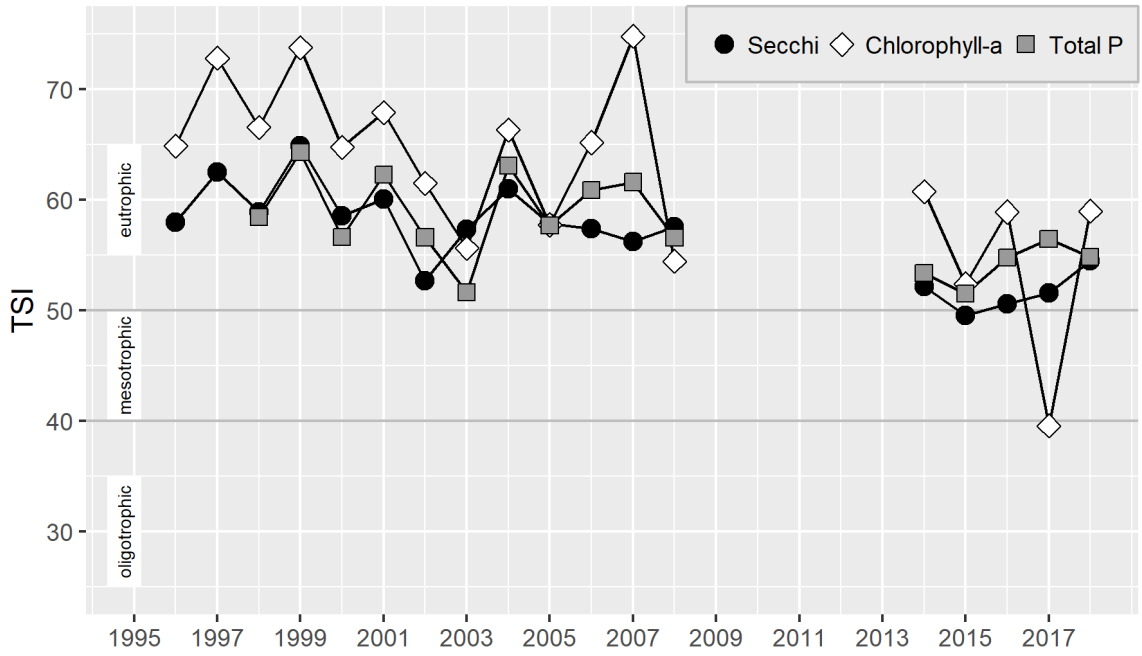
Nitrogen-to-phosphorus (N:P) ratios were below 25 throughout the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.38 m	(68%)
Water temperature	0.88 °C	(4.8%)
Chlorophyll-a	-7.6 µg/L	(-27%)
Total nitrogen	-160 µg/L	(-18%)
Total phosphorus	-5.2 µg/L	(-11%)
N:P ratio	-3	(-13%)

Long-term trends suggest that water quality in Allen Lake has generally been improving over time, though there has been considerable variation from year to year. Overall, nitrogen, phosphorus, and chlorophyll concentrations have decreased, and Secchi depths have gotten deeper.

5.2 Trophic state



Looking at the TSI values over time highlights that water quality in Allen Lake has varied considerably from year to year. In 2018, the three TSI values were in the eutrophic range.

5.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	0.9	1.3	1.7
Water temperature (°C)	13.0	18.9	26.0
Chlorophyll-a (µg/L)	1.6	14.0	57.9
Total nitrogen (µg/L)	434.0	590.9	872.0
Total phosphorus (µg/L)	20.8	37.2	60.8
N:P ratio	9.3	17.2	26.0

5.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

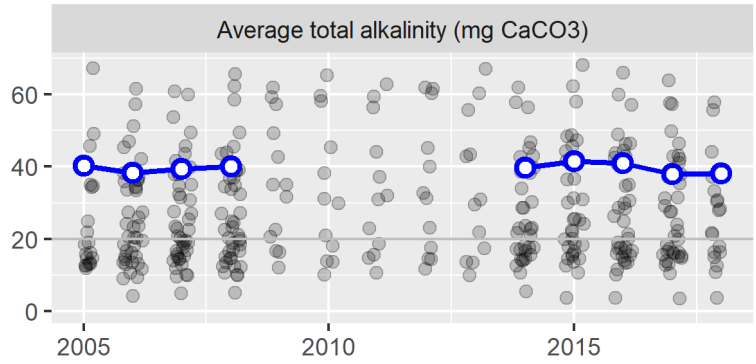
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	16.8	1.6	(1.5)	499	26.9	17.0	32.5	2.7
	2.0	11.0	0.9	(1.4)	485	–	–	38.4	–
	3.5	7.5	1.2	2.1	472	55.2	57.6	39.4	14.6
8/19/2018	1.0	22.5	15.6	4.0	651	2.7	(10.0)	34.6	1.5
	2.0	22.0	89.9	8.5	792	–	–	38.7	–
	3.5	13.5	131.0	–	1200	8.8	(10.0)	553.0	39.2

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

5.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 38.2 mg $CaCO_3$.

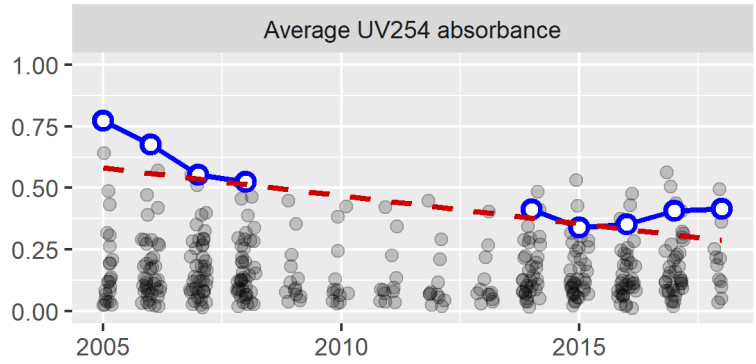
The blue points and line are annual average alkalinity values for Allen Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



5.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.42, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Allen Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.23 absorbance units (-39%) per decade.



6.0 AMES LAKE: 2018

Thank you to Nate Johnson and Kim Ross, the volunteer monitors for Ames Lake.

The key takeaways from the 2018 monitoring season are:

- Ames Lake continued to have fairly clear water and moderate algal growth. Nutrient concentrations in 2018 were noticeably lower than in 2016-2017.
- No algal blooms were reported for toxin testing in 2018.

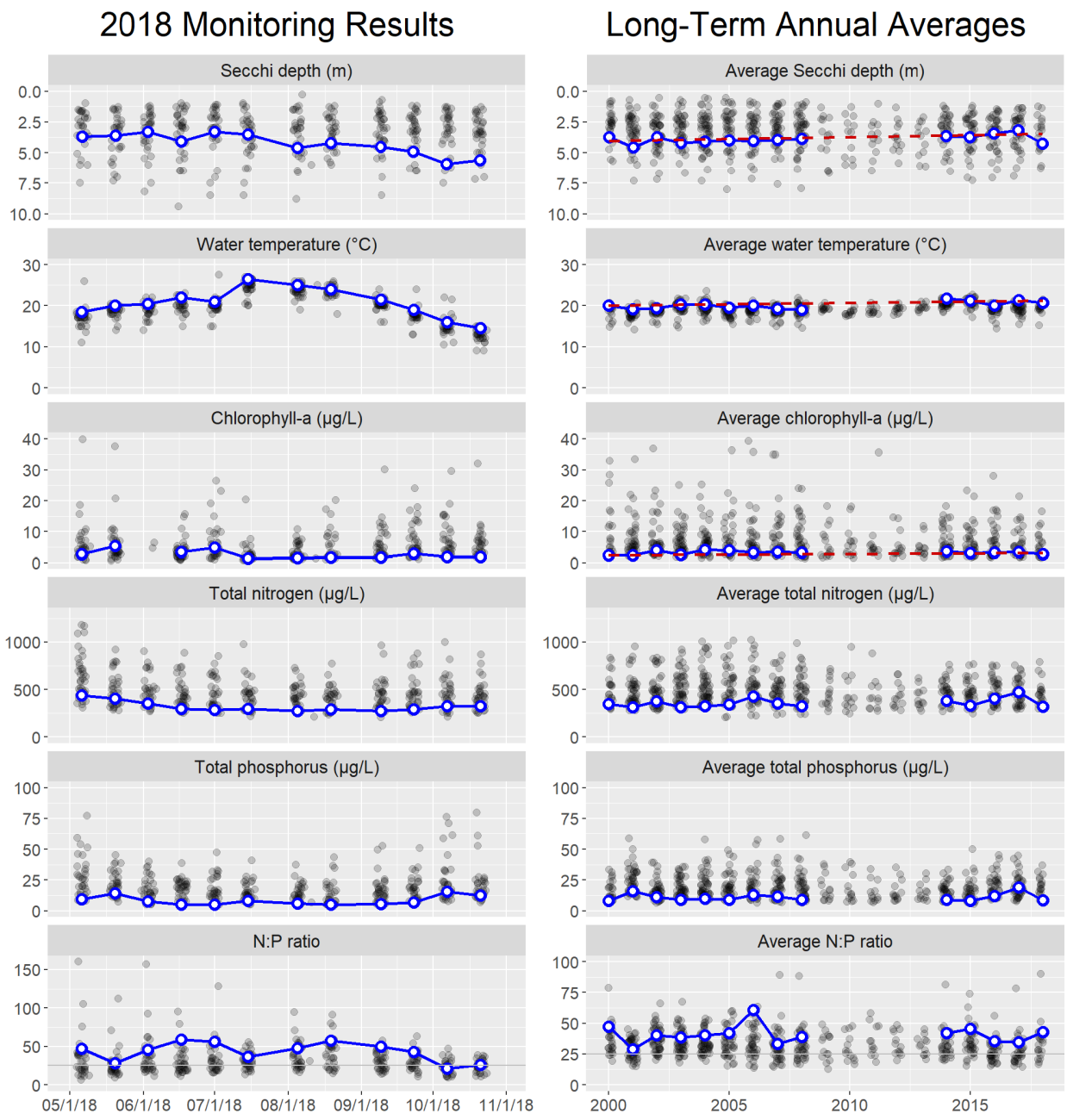
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Ames Lake through the Lake Stewardship Program.

6.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Ames Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

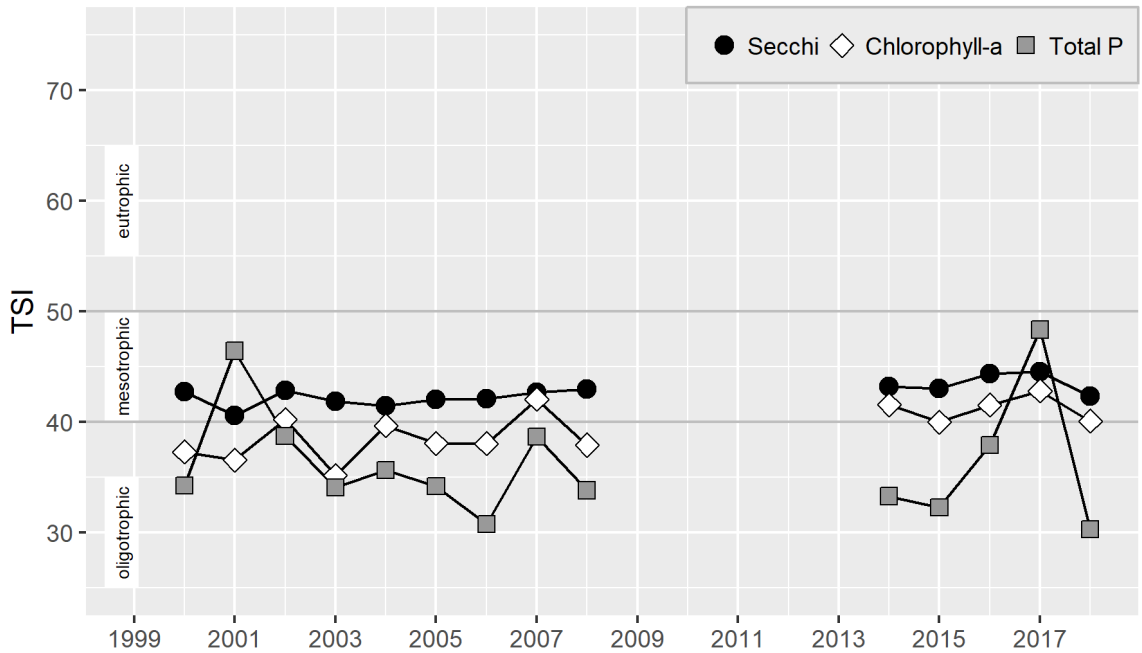


Nitrogen-to-phosphorus (N:P) ratios were above 25 for most of the monitoring season. This indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2000, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-0.31 m	(-7.7%)
Water temperature	0.65 °C	(3.2%)
Chlorophyll-a	0.41 µg/L	(18%)

6.2 Trophic state



In 2018, the TSI values ranged from the oligotrophic to the mesotrophic. From 2014-2018, the total-phosphorus TSI value has varied considerably while the Secchi and chlorophyll TSI values have not shown similar changes. This suggests that phosphorus may not be the primary driver of algal growth in Ames Lake.

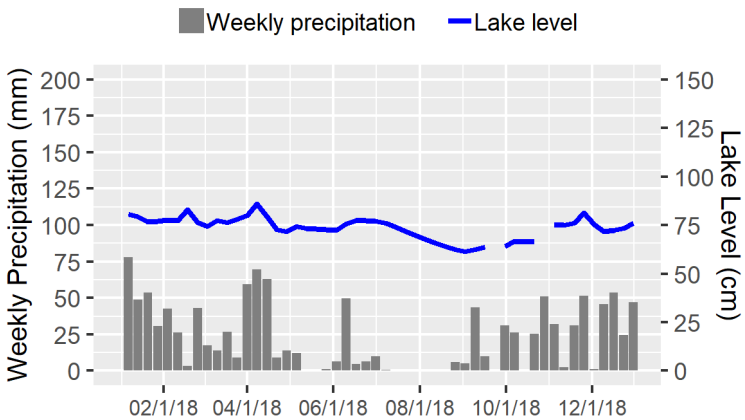
6.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	1.8	3.5	5.9
Water temperature (°C)	4.5	13.7	26.5
May-October statistics			
Secchi depth (m)	2.3	3.9	5.9
Water temperature (°C)	14.0	19.9	26.5
Chlorophyll-a (µg/L)	1.3	2.7	5.4
Total nitrogen (µg/L)	275.0	320.1	435.0
Total phosphorus (µg/L)	5.0	8.4	15.4
N:P ratio	21.0	43.1	58.6

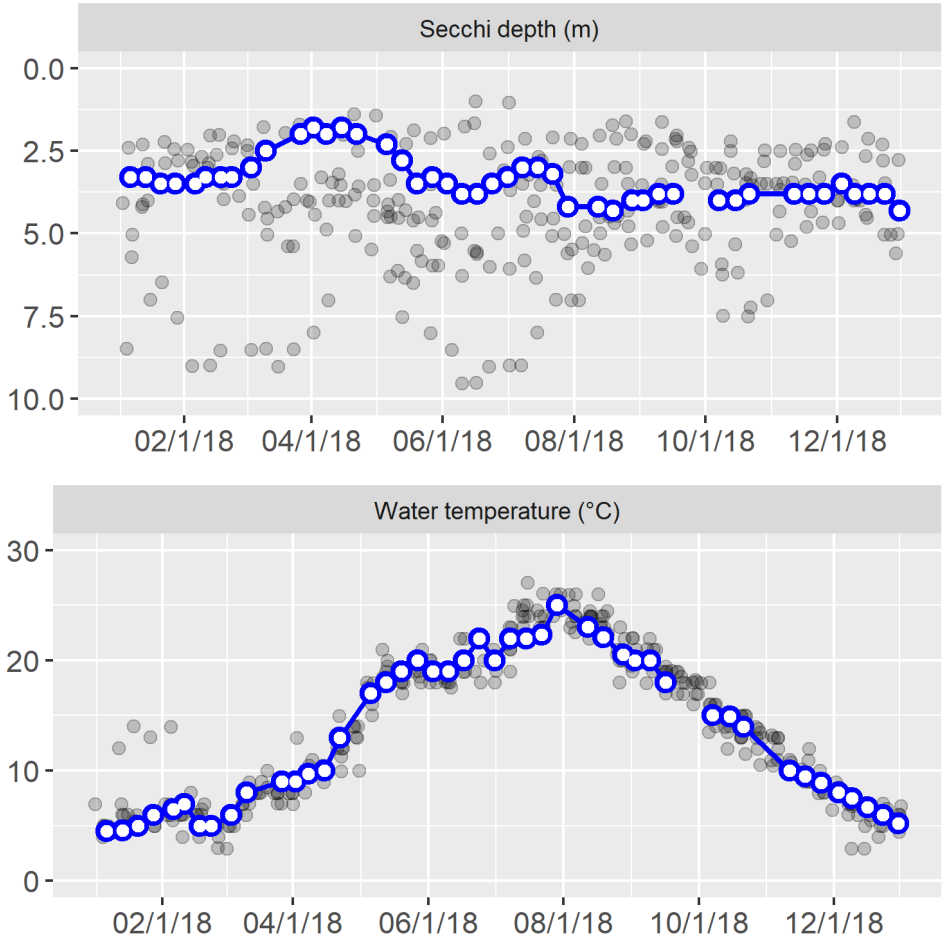
6.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



6.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Ames Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



6.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

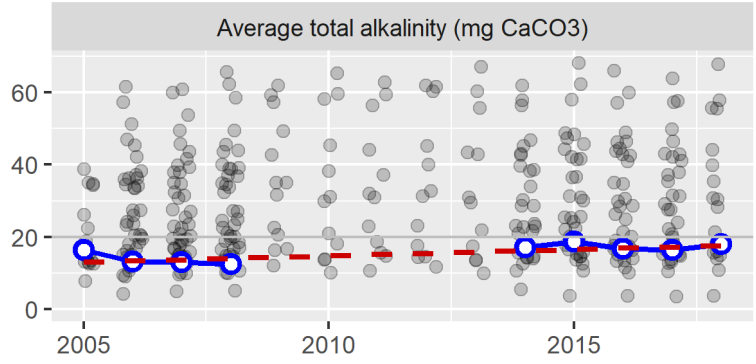
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	5.4	(1.0)	403	19.9	94.9	14.4	0.6
	4	10.5	10.2	1.5	475	–	–	14.0	–
	7	8.5	15.0	(1.0)	800	418.0	(10.0)	56.4	2.1
8/19/2018	1	24.0	1.7	(2.9)	289	(2.0)	(10.0)	(5.0)	0.9
	4	21.5	2.4	(2.0)	286	–	–	6.5	–
	7	10.5	169.0	–	1170	4.6	(10.0)	162.0	1.1

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

6.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 17.9 mg $CaCO_3$.

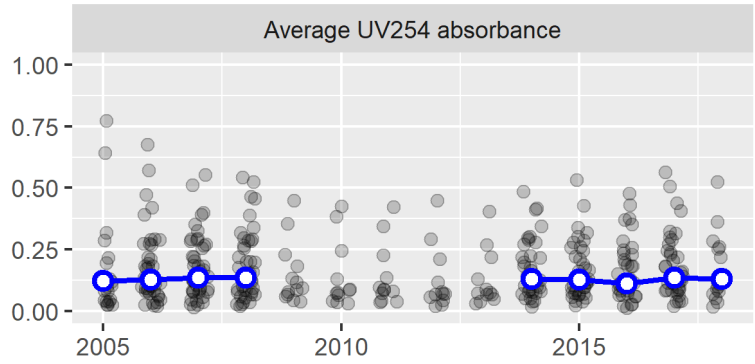
The blue points and line are annual average alkalinity values for Ames Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of 3.5 mg $CaCO_3$ (27%) per decade.



6.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.13, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Ames Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



7.0 ANGLE LAKE: 2018

Thank you to Diane & Buff Chace, and Bruce & Sandy Goulet, the volunteer monitors for Angle Lake.

The key takeaways from the 2018 monitoring season are:

- Angle Lake continued to have clear water, with low nutrient concentrations and low algal growth.
- Angle Lake has been one of the clearest lakes in the Lake Stewardship Program.
- No algal blooms were reported for toxin testing in 2018.

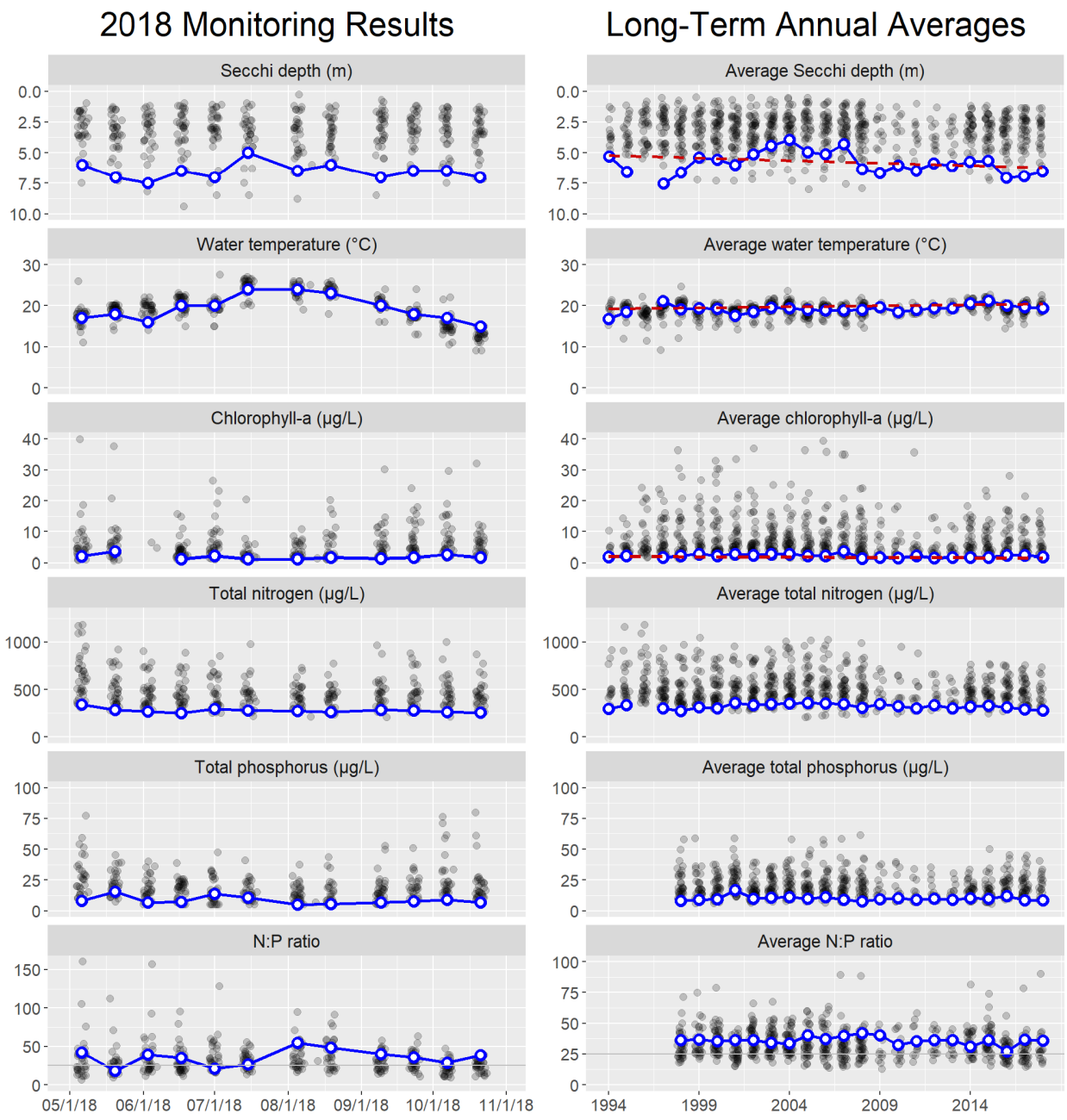
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Angle Lake through the Lake Stewardship Program.

7.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Angle Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



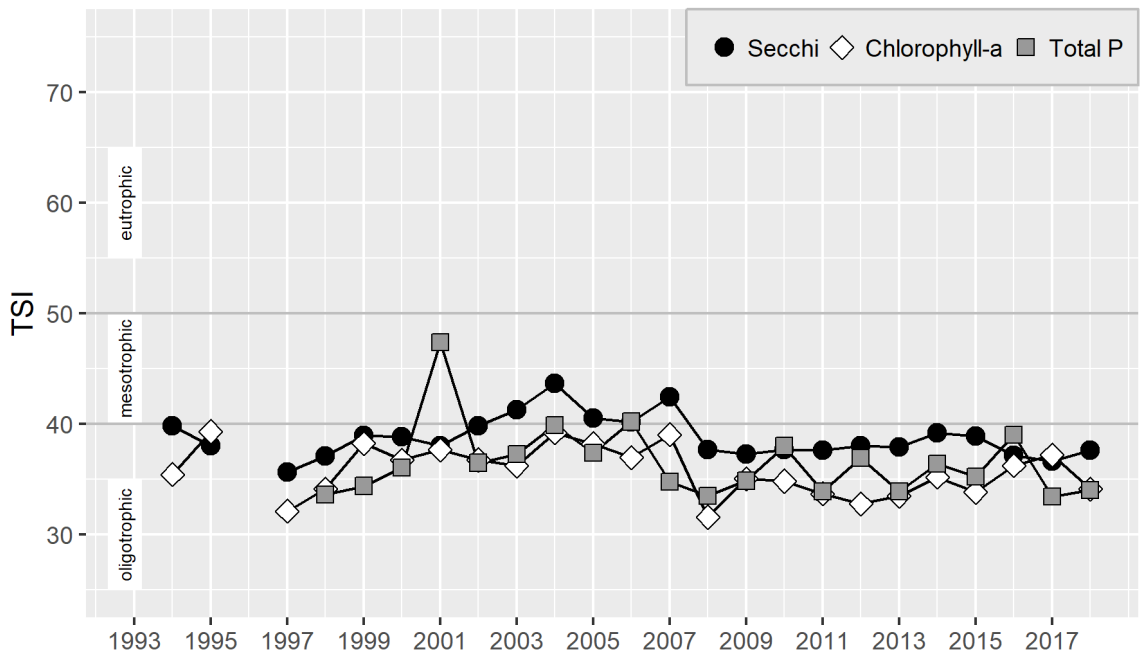
Nutrient and chlorophyll concentrations remained low and fairly stable throughout the monitoring season.

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.42 m	(8%)
Water temperature	0.5 °C	(2.6%)
Chlorophyll-a	-0.22 µg/L	(-10%)

Chlorophyll concentrations have decreased over time in Angle Lake, and Secchi depths have gotten deeper, suggesting that water quality has been improving slightly. Although the 0.22 µg/L decrease per decade would be insignificant in many lakes, it is several percent of Angle Lake's average chlorophyll concentration.

7.2 Trophic state



In 2018, all three TSI values were in the oligotrophic range.

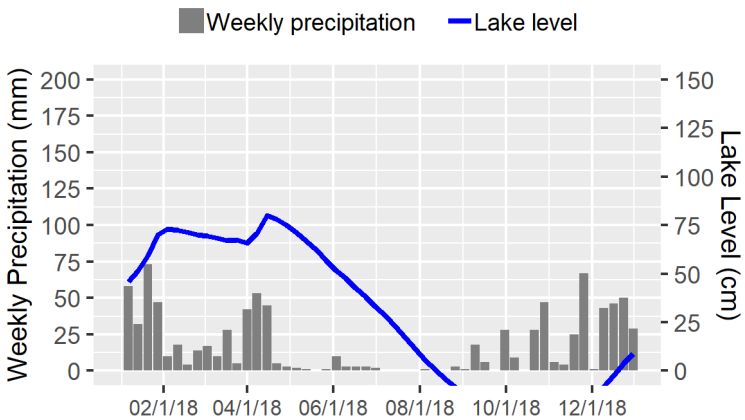
7.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.9	5.2	7.5
Water temperature (°C)	5.0	13.9	25.0
May-October statistics			
Secchi depth (m)	4.3	6.0	7.5
Water temperature (°C)	14.0	19.7	25.0
Chlorophyll-a (µg/L)	1.1	1.8	3.6
Total nitrogen (µg/L)	251.0	277.1	339.0
Total phosphorus (µg/L)	5.0	8.6	15.5
N:P ratio	18.3	35.8	54.8

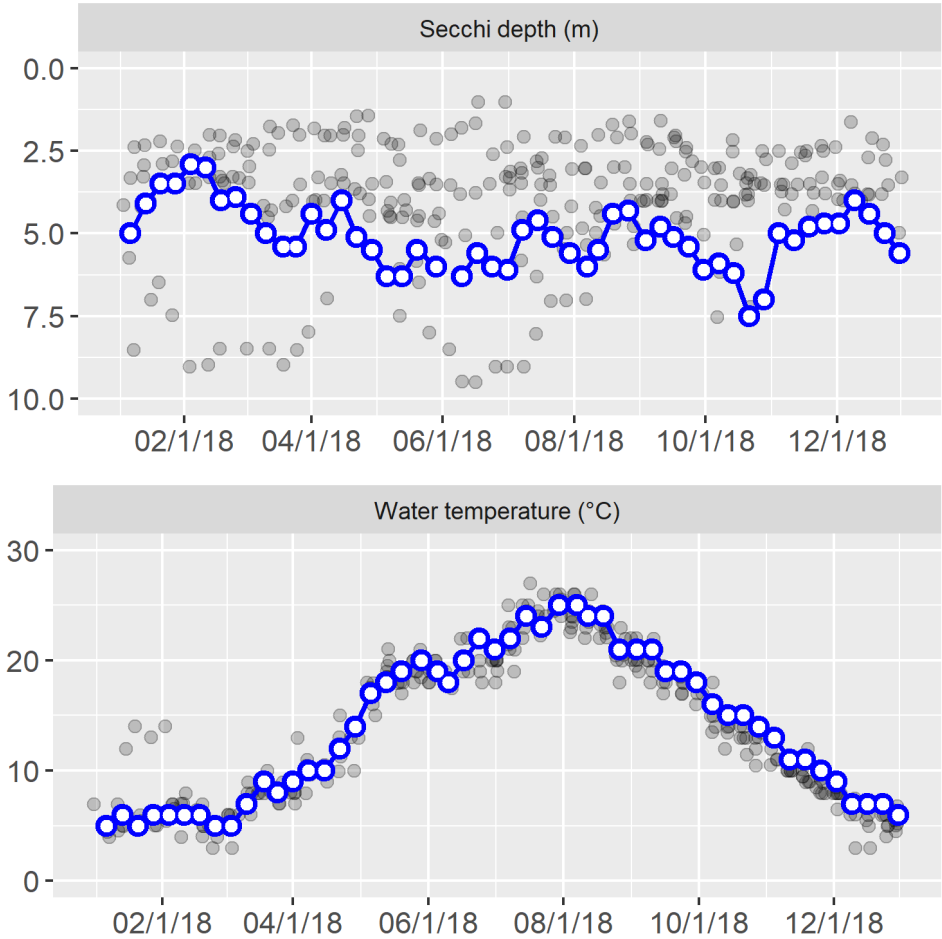
7.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



7.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Angle Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



7.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

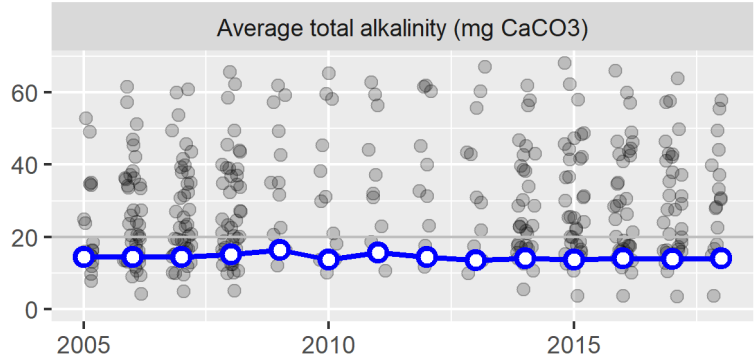
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	18.0	3.6	(1.0)	283	11.3	15.0	15.5	(0.5)
	7	11.0	6.2	1.2	395	–	–	31.7	–
	14	3.0	–	–	554	185.0	35.0	39.4	4.9
8/19/2018	1	23.0	1.6	(1.7)	262	(2.0)	(10.0)	5.4	(0.5)
	7	22.0	2.1	(2.5)	277	–	–	7.0	–
	14	8.0	–	–	317	(2.0)	(10.0)	22.4	0.7

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

7.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 14.1 mg $CaCO_3$.

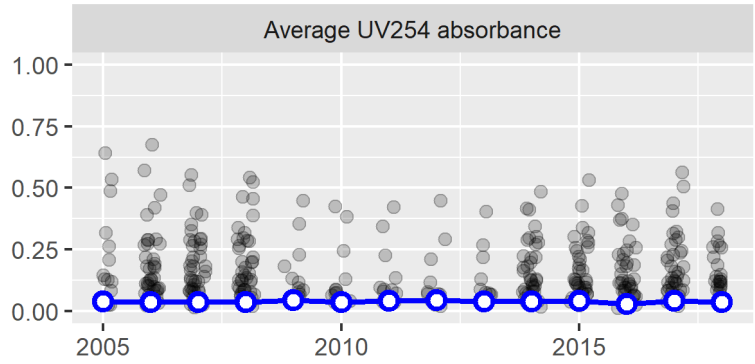
The blue points and line are annual average alkalinity values for Angle Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -1 mg $CaCO_3$ (-6.7%) per decade.



7.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.04, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Angle Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



8.0 BEAVER LAKE 1: 2018

Thank you to Donna Carlson and Mariana Varotto, the volunteer monitors for Beaver-1.

The key takeaways from the 2018 monitoring season are:

- Chlorophyll concentrations in 2018 and 2017 were noticeably lower than usual for Beaver-1.
- Although chlorophyll was relatively low, Beaver-1 continued to have high nutrient concentrations and some of the shallowest Secchi depths of any lake in the Lake Stewardship Program.
- Beaver-1's high nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios below 25 both indicate that Beaver-1 is likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in July. No algal toxins were detected in this sample.

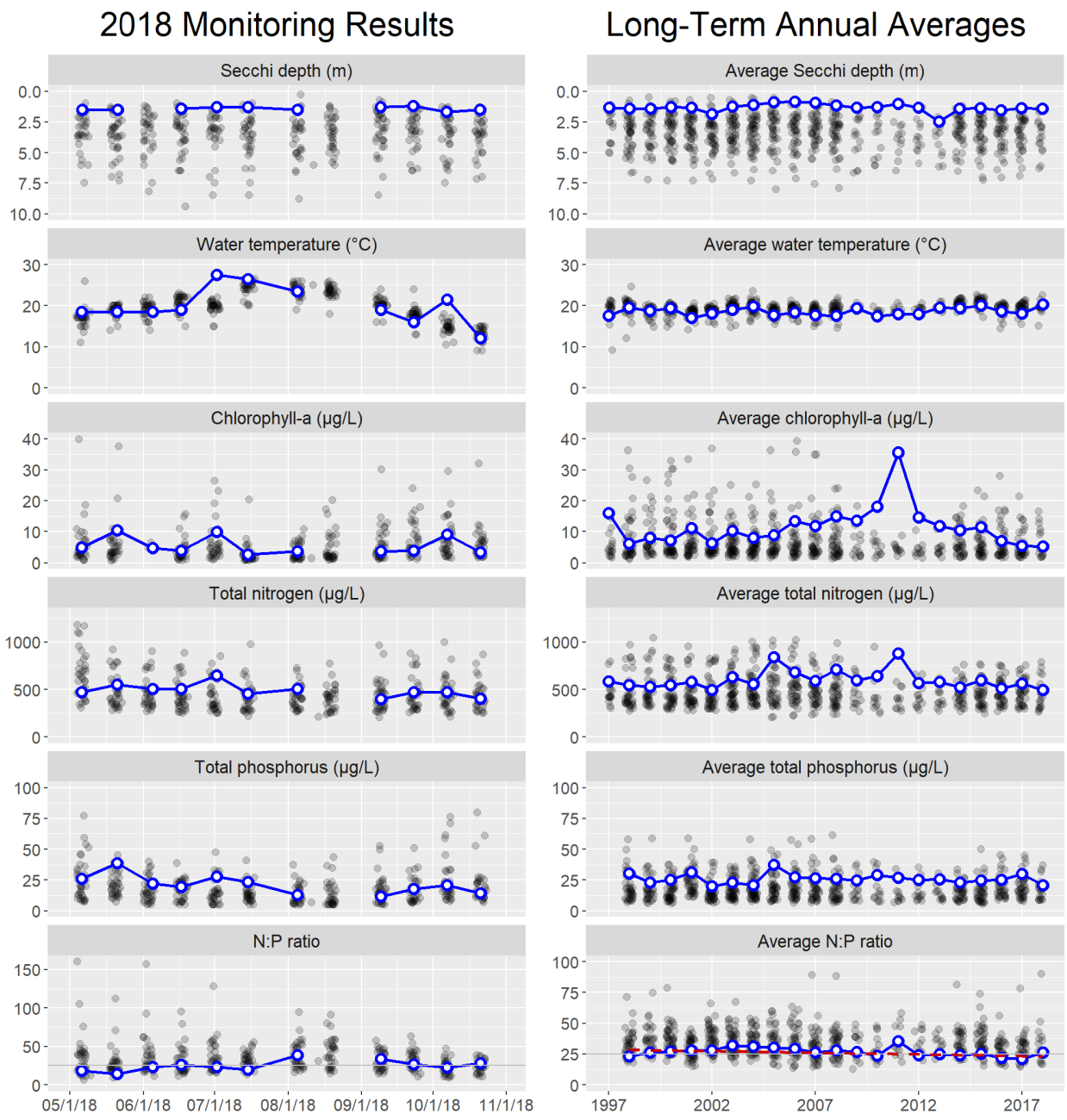
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Beaver-1 – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Beaver Lake through the Lake Stewardship Program.

8.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Beaver Lake 1 are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

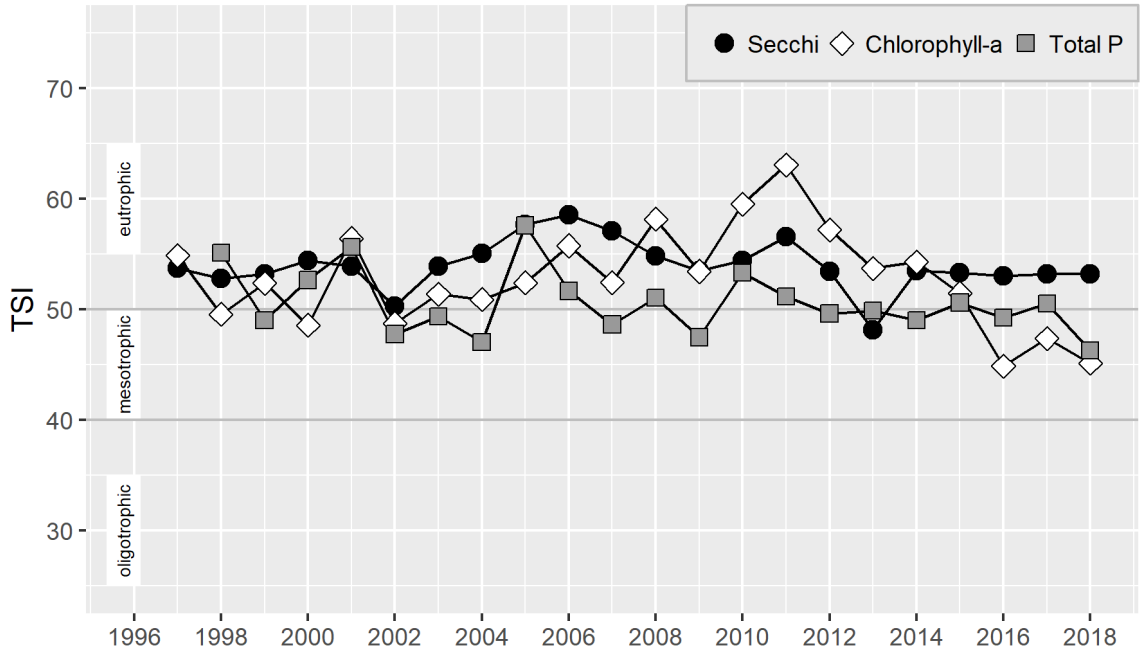
To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1997, when monitoring started.

Parameter	Change per Decade	(%)
N:P ratio	-2.8	(-9.6%)

8.2 Trophic state



In 2018, the chlorophyll and total-phosphorus TSI values were in the mesotrophic range, while the Secchi TSI was in the eutrophic range. Some of this difference is likely due to Beaver Lake's naturally tea-colored water (caused by dissolved organic compounds from the bog). This water color can contribute to shallower Secchi depths than would be expected for the nutrient and chlorophyll concentrations.

8.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.2	1.4	1.7
Water temperature (°C)	12.0	20.3	27.5
Chlorophyll-a (µg/L)	2.5	5.2	10.4
Total nitrogen (µg/L)	396.0	491.6	645.0
Total phosphorus (µg/L)	11.7	20.7	38.8
N:P ratio	14.3	26.1	38.7

8.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

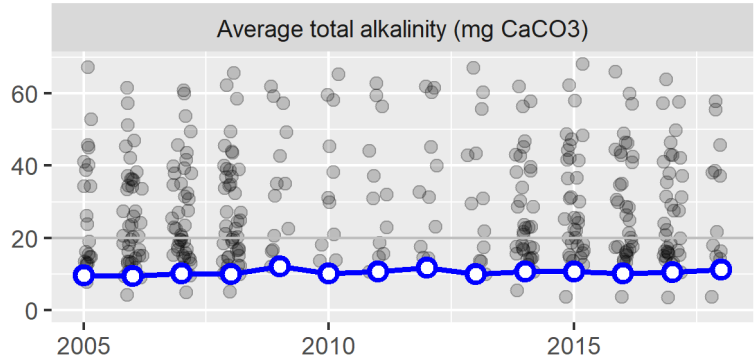
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/21/2018	1	18.5	10.4	(2.0)	553	3.8	(10.0)	38.8	0.9
	7	5.5	(0.9)	(1.8)	468	–	–	32.2	–
	14	4.0	–	–	566	60.1	138.0	69.2	28.3
9/9/2018	1	19.0	3.6	(1.3)	396	9.1	(10.0)	11.7	0.8
	7	15.0	1.5	–	478	–	–	23.8	–
	13	14.0	–	–	929	420.0	(10.0)	226.0	88.1

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

8.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 11.2 mg $CaCO_3$.

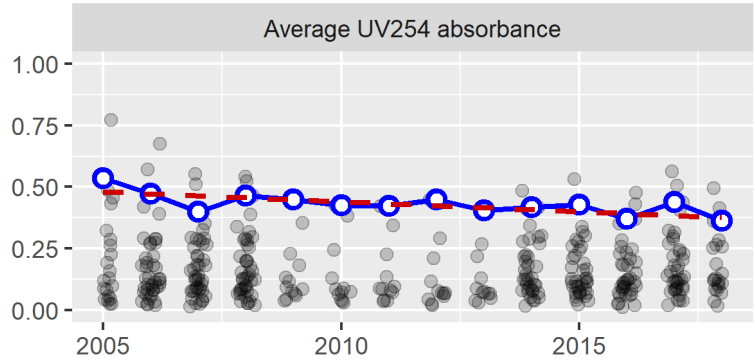
The blue points and line are annual average alkalinity values for Beaver Lake 1. Grey points in the background are results for all other lakes in the Lake Stewardship program.



8.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.36, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Beaver Lake 1. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.08 absorbance units (-17%) per decade.



9.0 BEAVER LAKE 2: 2018

Thank you to Bassem Bejjani, Donna Carlson, and Robb Wolfe, the volunteer monitors for Beaver-2.

The key takeaways from the 2018 monitoring season are:

- Beaver-2 continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).
- Algal blooms were sampled for toxin testing in May, August, and September. Toxin testing found very low concentrations of algal toxins, well below the Washington State Recreational Guidelines.

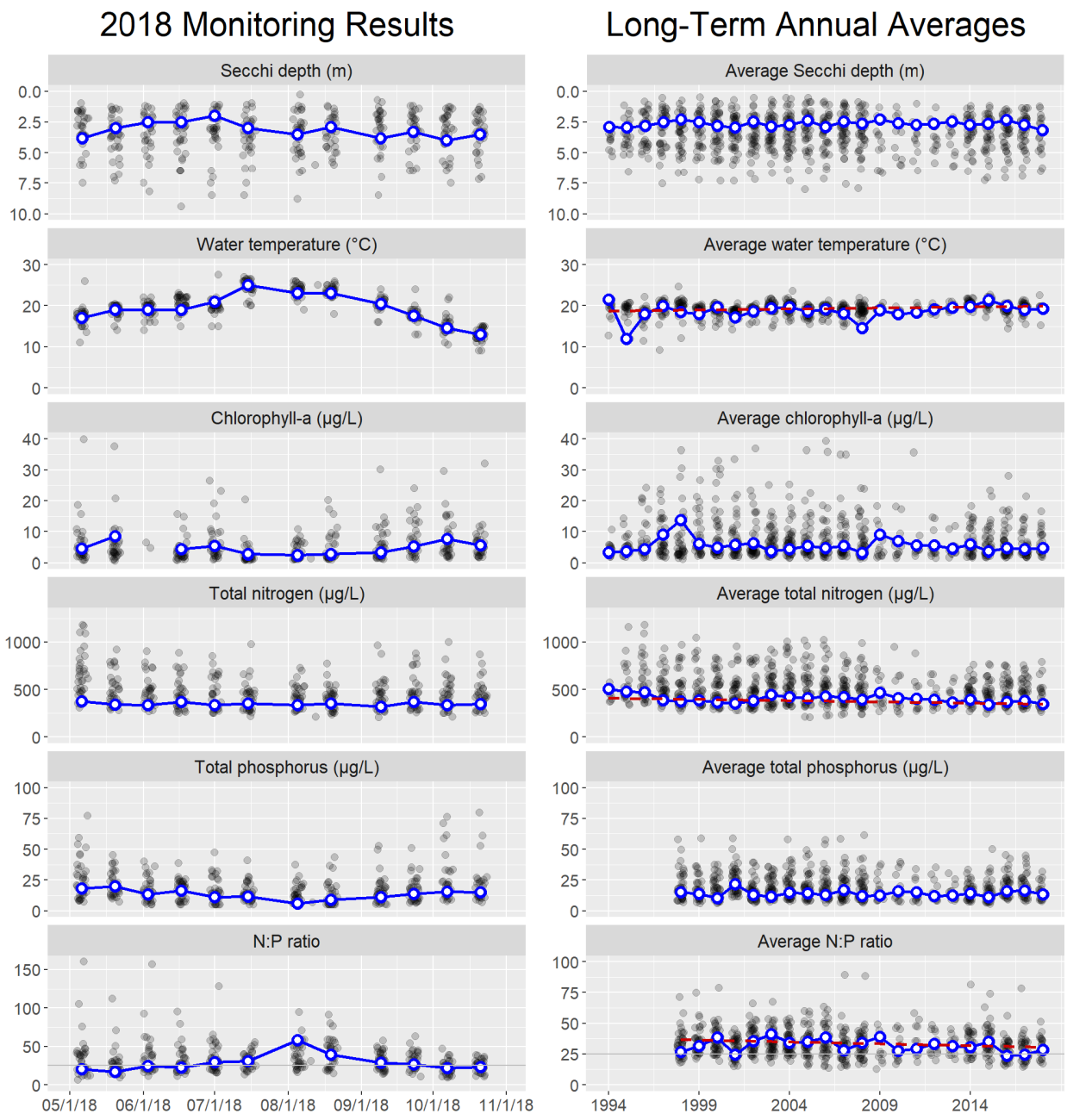
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Beaver-2 – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Beaver Lake through the Lake Stewardship Program.

9.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Beaver Lake 2 are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

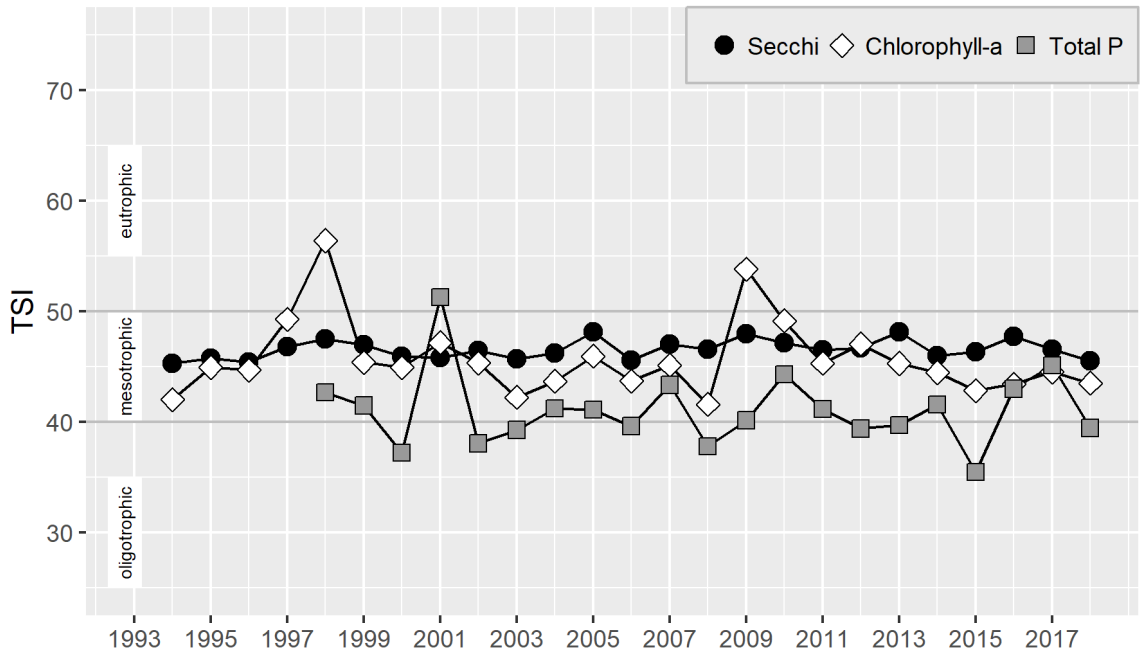


Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Water temperature	0.5 °C	(2.7%)
Total nitrogen	-25 µg/L	(-6.1%)
N:P ratio	-3.1	(-8.1%)

9.2 Trophic state



In 2018, the TSI values were in or near the mesotrophic range.

9.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	2.0	3.1	4.0
Water temperature (°C)	13.0	19.3	25.0
Chlorophyll-a (µg/L)	2.4	4.7	8.6
Total nitrogen (µg/L)	321.0	347.4	377.0
Total phosphorus (µg/L)	5.8	13.4	19.9
N:P ratio	17.0	28.6	58.1

9.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

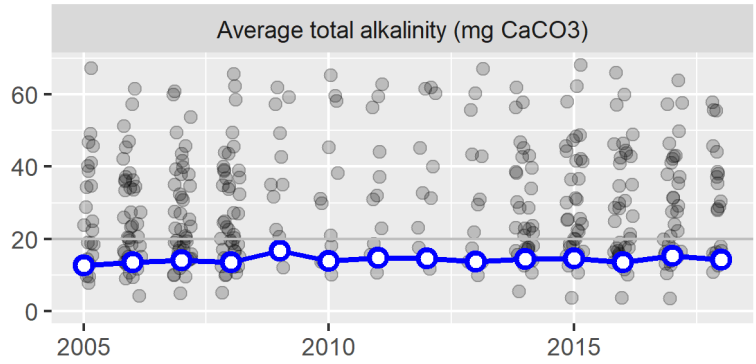
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	19.0	8.6	(2.0)	339	3.6	(10.0)	19.9	0.8
	7	7.5	1.9	(2.2)	533	–	–	25.4	–
	14	6.0	–	–	526	59.4	195.0	33.2	2.7
8/19/2018	1	23.0	2.7	(1.2)	353	2.2	(10.0)	9.0	0.9
	7	8.0	(0.7)	(1.3)	371	–	–	39.6	–
	14	7.0	–	–	487	177.0	(10.0)	112.0	6.8

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

9.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 14.2 mg $CaCO_3$.

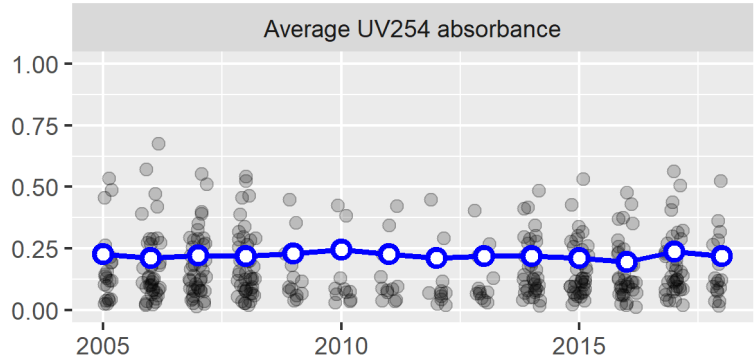
The blue points and line are annual average alkalinity values for Beaver Lake 2. Grey points in the background are results for all other lakes in the Lake Stewardship program.



9.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.22, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Beaver Lake 2. Grey points in the background are results for all other lakes in the Lake Stewardship program.



10.0 LAKE BOREN: 2018

Thank you to the City of Newcastle staff who monitored Lake Boren.

The key takeaways from the 2018 monitoring season are:

- Lake Boren continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- No algal blooms were reported for toxin testing in 2018.

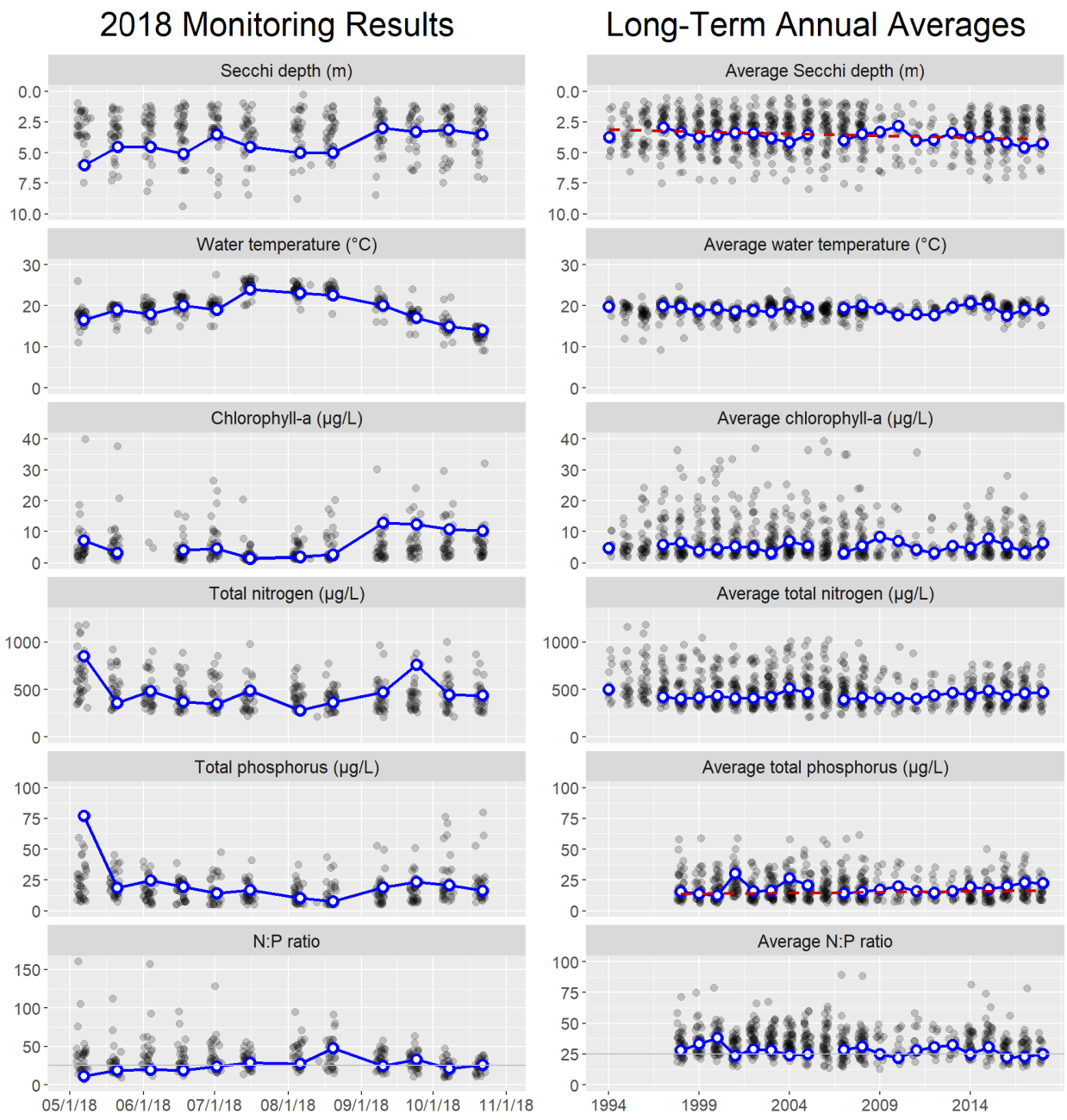
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Boren – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Boren through the Lake Stewardship Program.

10.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Boren are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

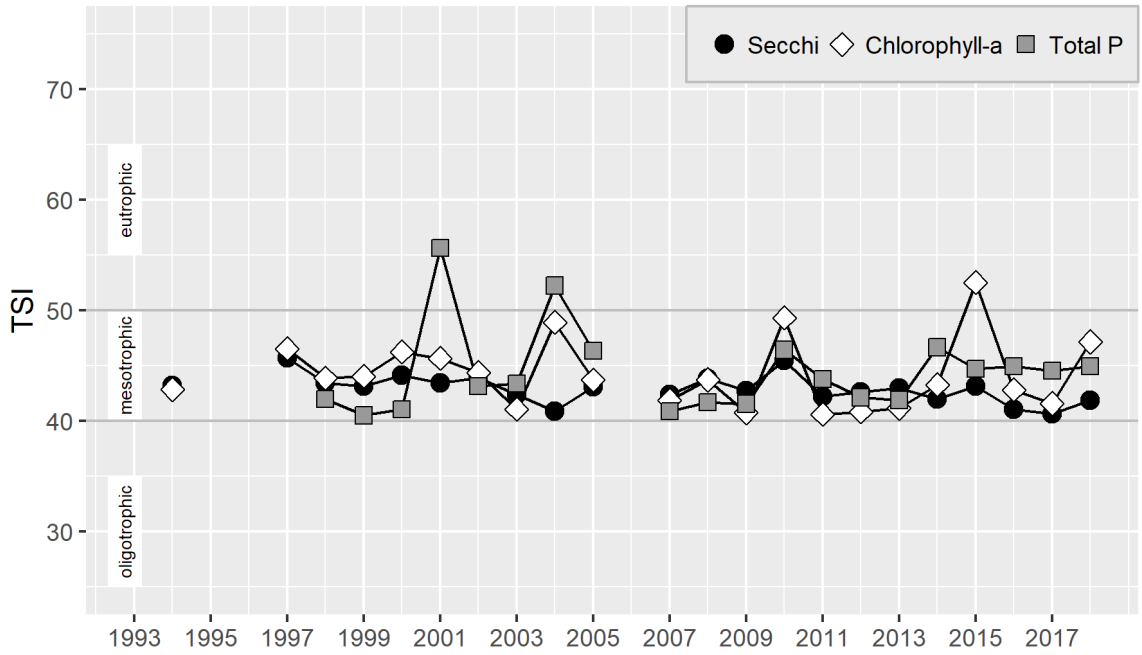


Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.33 m	(11%)
Total phosphorus	1.4 µg/L	(10%)

10.2 Trophic state



In 2018, the TSI values were in the mesotrophic range.

10.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	3.0	4.2	6.0
Water temperature (°C)	14.0	19.0	24.0
Chlorophyll-a (µg/L)	1.4	6.2	12.8
Total nitrogen (µg/L)	278.0	470.8	854.0
Total phosphorus (µg/L)	7.7	22.4	77.2
N:P ratio	11.1	25.1	47.4

10.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

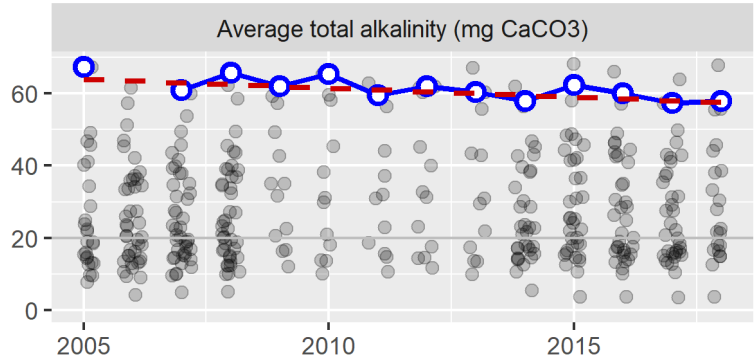
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/21/2018	1	19.0	3.1	(1.3)	357	23.8	(10.0)	18.6	1.5
	5	8.0	12.2	(2.0)	623	–	–	28.1	–
	9	5.5	(0.7)	8.4	756	105.0	341.0	54.6	4.9
8/20/2018	1	22.5	2.6	(2.0)	365	4.4	(10.0)	7.7	0.6
	5	15.0	13.1	(4.0)	500	–	–	26.4	–
	9	6.0	8.8	–	929	740.0	(10.0)	129.0	4.3

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

10.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 57.8 mg $CaCO_3$.

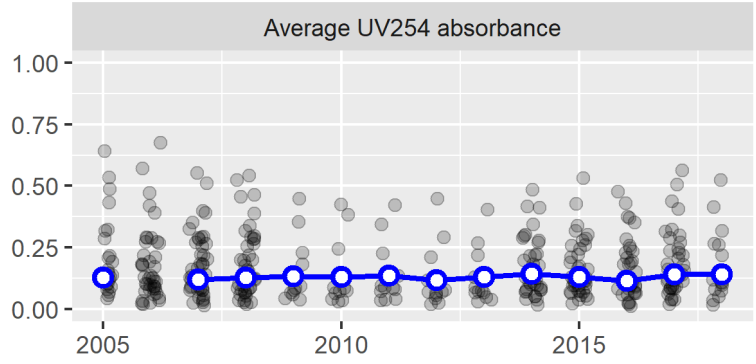
The blue points and line are annual average alkalinity values for Lake Boren. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -5 mg $CaCO_3$ (-7.6%) per decade.



10.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.14, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Boren. Grey points in the background are results for all other lakes in the Lake Stewardship program.



11.0 COTTAGE LAKE: 2018

Thank you to Jonathan Morrison, the volunteer monitor for Cottage Lake.

The key takeaways from the 2018 monitoring season are:

- Cottage continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- In 2018, Cottage Lake had algal blooms from August through October, and again during a warm spell in late November. Toxin testing found elevated microcystin concentrations in late August (9.2 µg/L) and late September (6.9 µg/L), above the Washington State Recreational Guideline of 6.0µg/L.

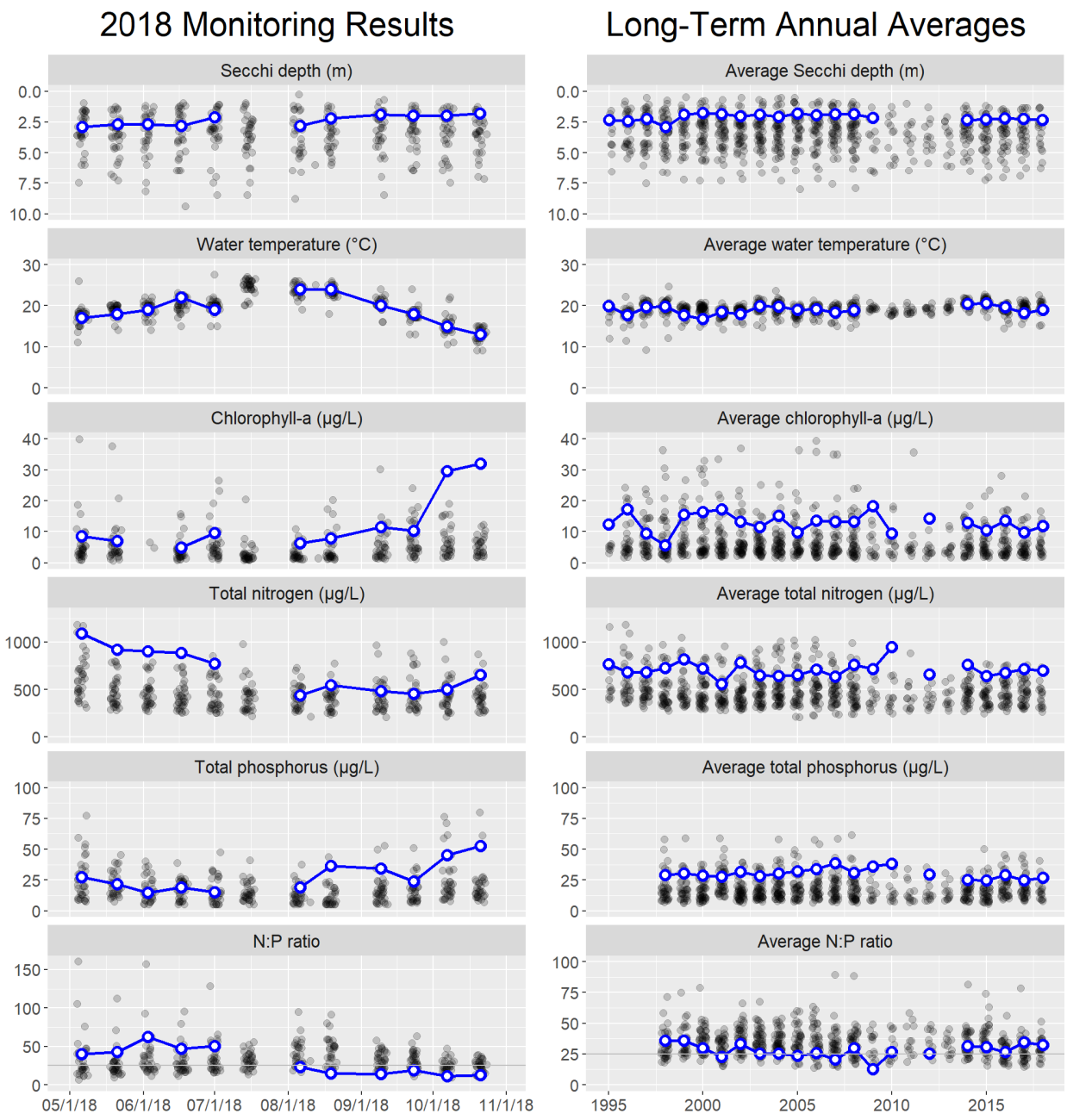
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Cottage Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore options to reduce the frequent, prolonged toxic algae blooms in Cottage Lake. Quantifying the sources of phosphorus to Cottage Lake is likely to be an important first step towards reducing phosphorus concentrations and algal blooms in the lake.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Cottage Lake through the Lake Stewardship Program.

11.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Cottage Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

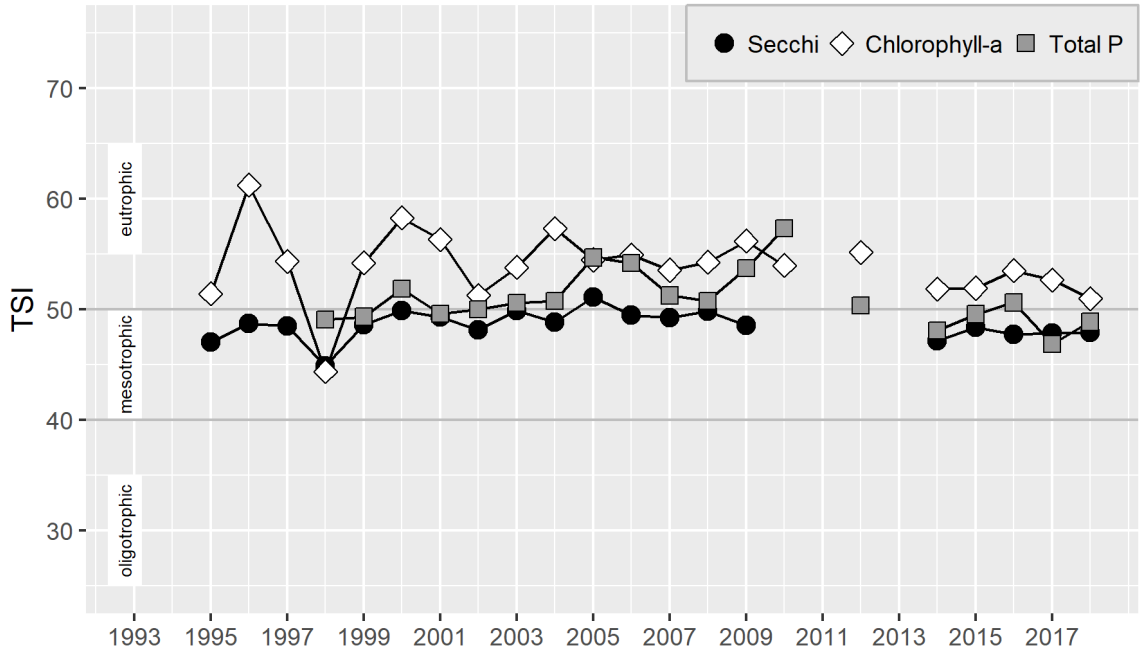
To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Nitrogen and phosphorus concentrations showed opposite seasonal patterns – nitrogen decreased through much of the sampling season, while phosphorus increased. As a result, N:P ratios decreased through the sampling season, and were below 25 from August onwards. This indicates the potential for algal blooms during late summer and fall to be dominated by cyanobacteria (which have the ability to produce toxins), such as the August-October toxic bloom.

Cottage Lake does not have any long-term trends.

11.2 Trophic state



In 2018, the TSI values were near the mesotrophic-eutrophic boundary.

11.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.8	2.3	2.9
Water temperature (°C)	13.0	19.0	24.0
Chlorophyll-a (µg/L)	4.8	11.8	32.0
Total nitrogen (µg/L)	435.0	700.8	1090.0
Total phosphorus (µg/L)	14.5	27.0	52.6
N:P ratio	11.0	32.2	62.2

11.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

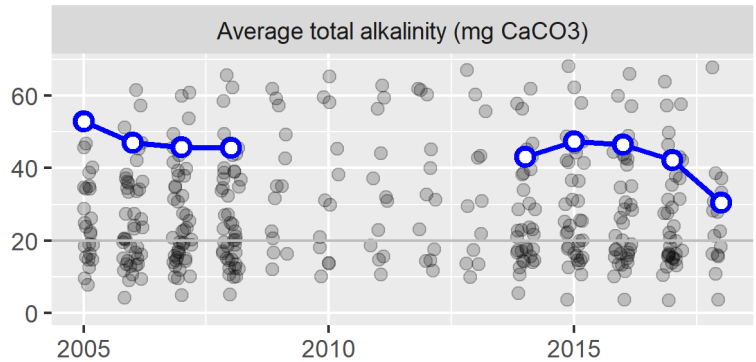
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/21/2018	1.0	18.0	6.9	1.4	922	38.9	549.0	21.6	1.0
	3.0	12.5	13.1	3.7	827	–	–	30.5	–
	6.5	8.0	20.5	(1.0)	723	367.0	11.0	233.0	69.1
8/19/2018	1.0	24.0	7.7	(2.0)	543	2.2	(10.0)	36.4	1.3
	3.0	22.0	6.3	(2.0)	470	–	–	24.6	–
	6.5	10.0	88.5	–	1290	710.0	(10.0)	535.0	44.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

11.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 30.4 mg $CaCO_3$.

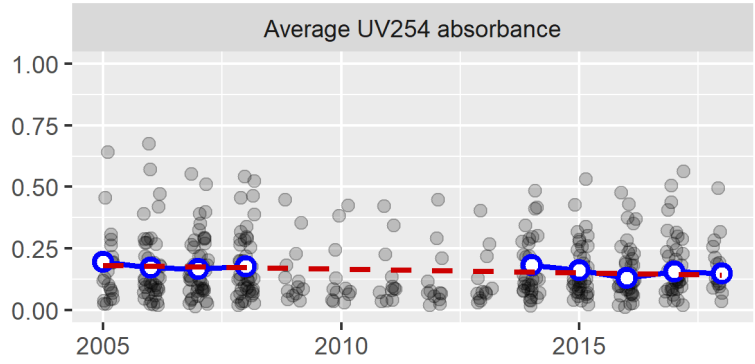
The blue points and line are annual average alkalinity values for Cottage Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



11.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.15, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Cottage Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.031 absorbance units (-17%) per decade.



12.0 LAKE DESIRE: 2018

Thank you to Chuck Linders, the volunteer monitor for Lake Desire.

The key takeaways from the 2018 monitoring season are:

- Lake Desire continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in late September. No algal toxins were detected in this sample.

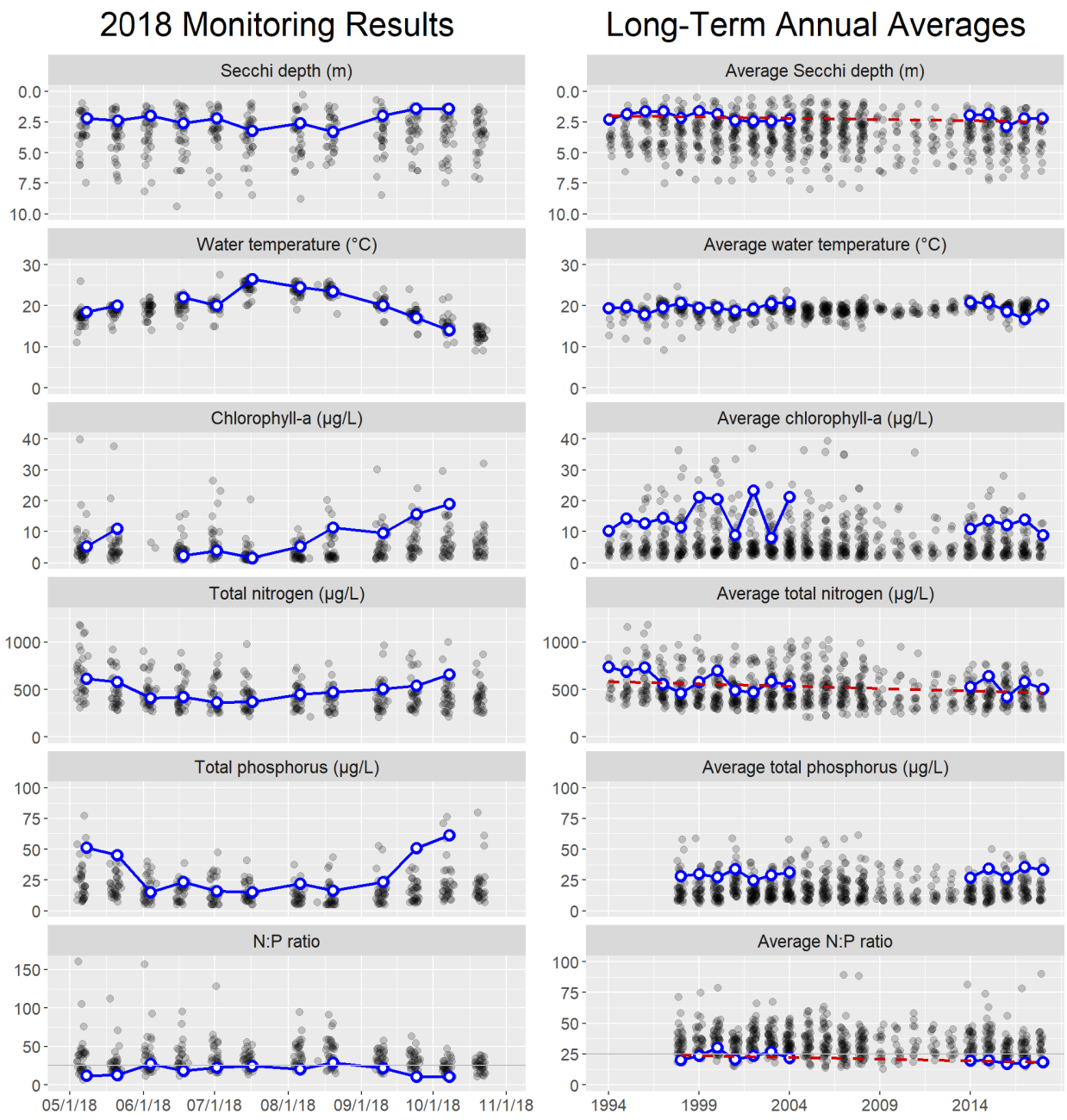
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Desire – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Desire through the Lake Stewardship Program.

12.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Desire are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

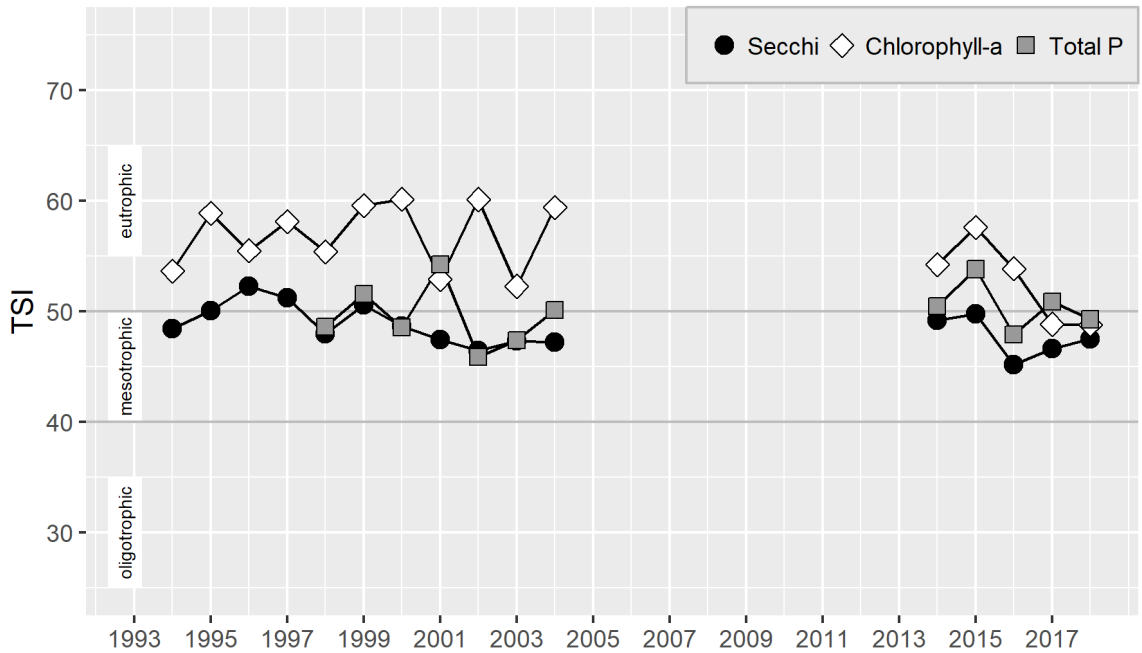


Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.21 m	(11%)
Total nitrogen	-52 µg/L	(-8.8%)
N:P ratio	-2.8	(-11%)

12.2 Trophic state



In 2018, the TSI values were in the upper mesotrophic range.

12.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.4	2.2	3.3
Water temperature (°C)	14.0	20.2	26.5
Chlorophyll-a (µg/L)	1.5	8.8	19.0
Total nitrogen (µg/L)	366.0	503.7	660.0
Total phosphorus (µg/L)	14.9	33.5	61.4
N:P ratio	10.5	18.3	28.4

12.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

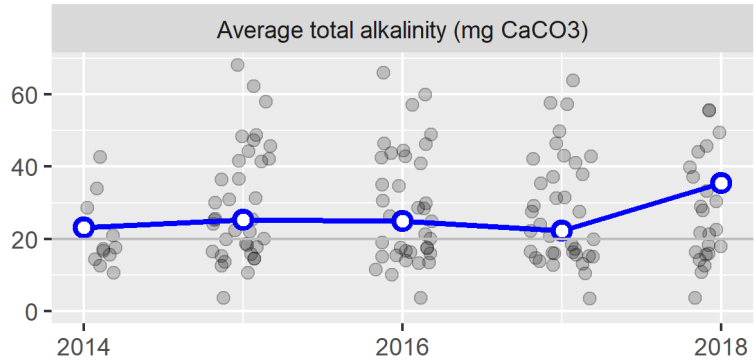
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/21/2018	1	20.0	10.9	(1.4)	581	5.0	(10.0)	45.2	5.5
	3	13.5	18.8	2.7	500	–	–	21.8	–
	5	10.0	1.1	2.1	490	63.2	66.8	53.1	5.3
8/20/2018	1	23.5	11.3	(2.0)	472	3.0	(10.0)	16.6	1.1
	3	22.5	68.2	(6.3)	555	–	–	42.6	–
	5	13.5	57.0	–	603	3.0	(10.0)	229.0	7.8

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

12.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 35.5 mg $CaCO_3$.

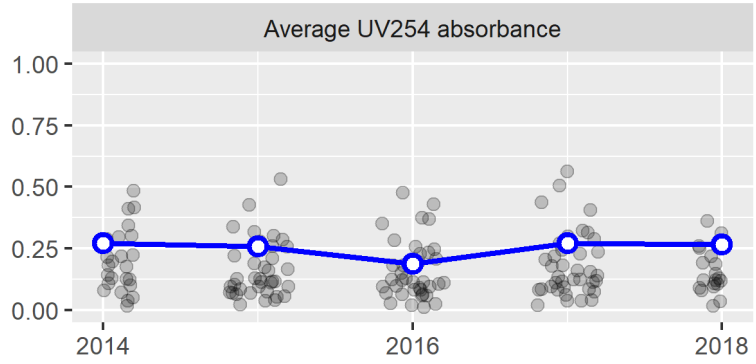
The blue points and line are annual average alkalinity values for Lake Desire. Grey points in the background are results for all other lakes in the Lake Stewardship program.



12.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.27, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Desire. Grey points in the background are results for all other lakes in the Lake Stewardship program.



13.0 LAKE DOLLOFF: 2018

Thank you to Jeff Horne and Taylor Evans-Race, the volunteer monitors for Lake Dolloff.

The key takeaways from the 2018 monitoring season are:

- Lake Dolloff continued to have fairly high nutrient concentrations and algal growth, and less-clear water.
- Lake Dolloff's high nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios below 25 both indicate that Lake Dolloff is likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in early August. No algal toxins were detected in this sample.

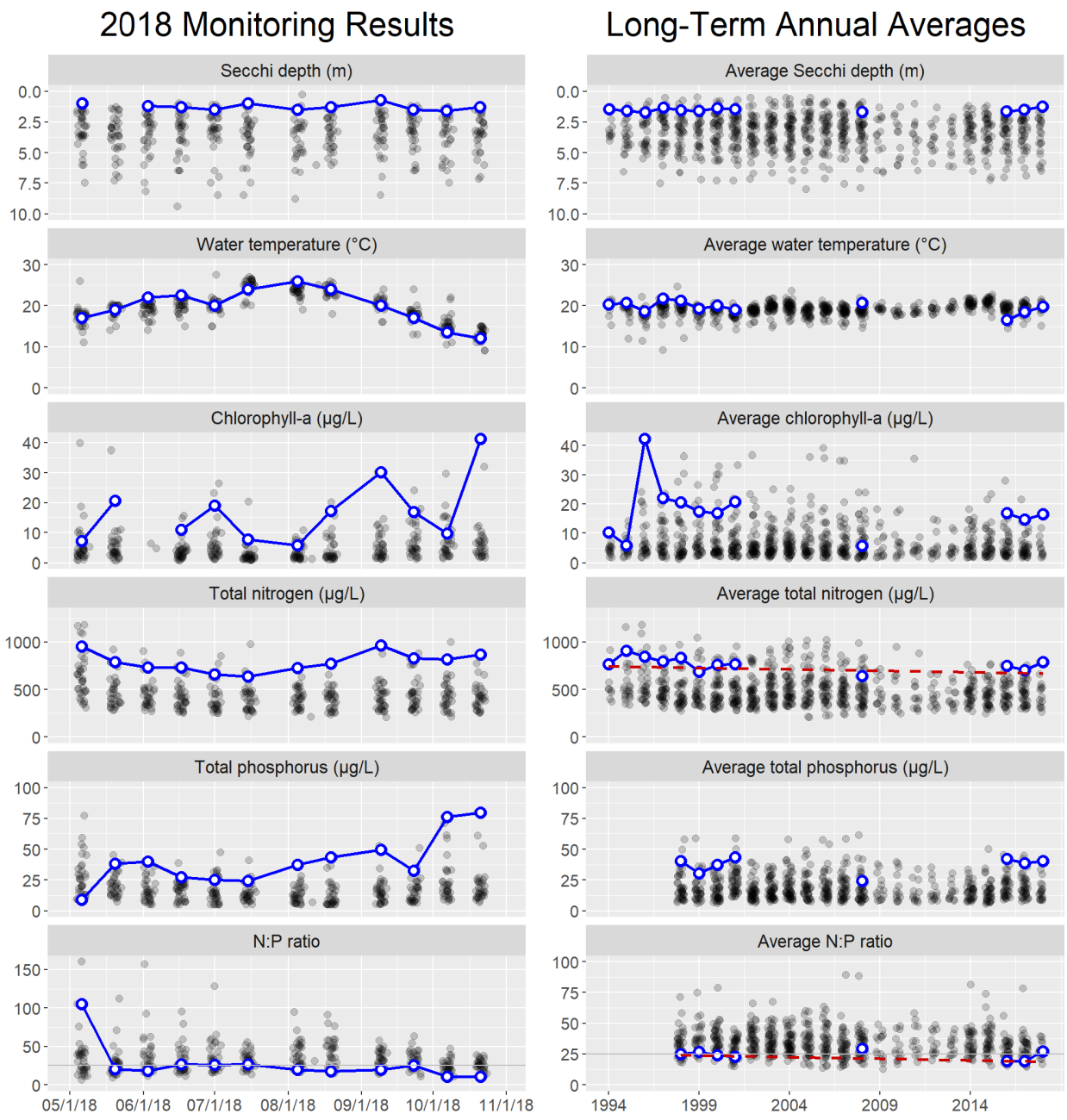
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Dolloff – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Dolloff through the Lake Stewardship Program.

13.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Dolloff are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

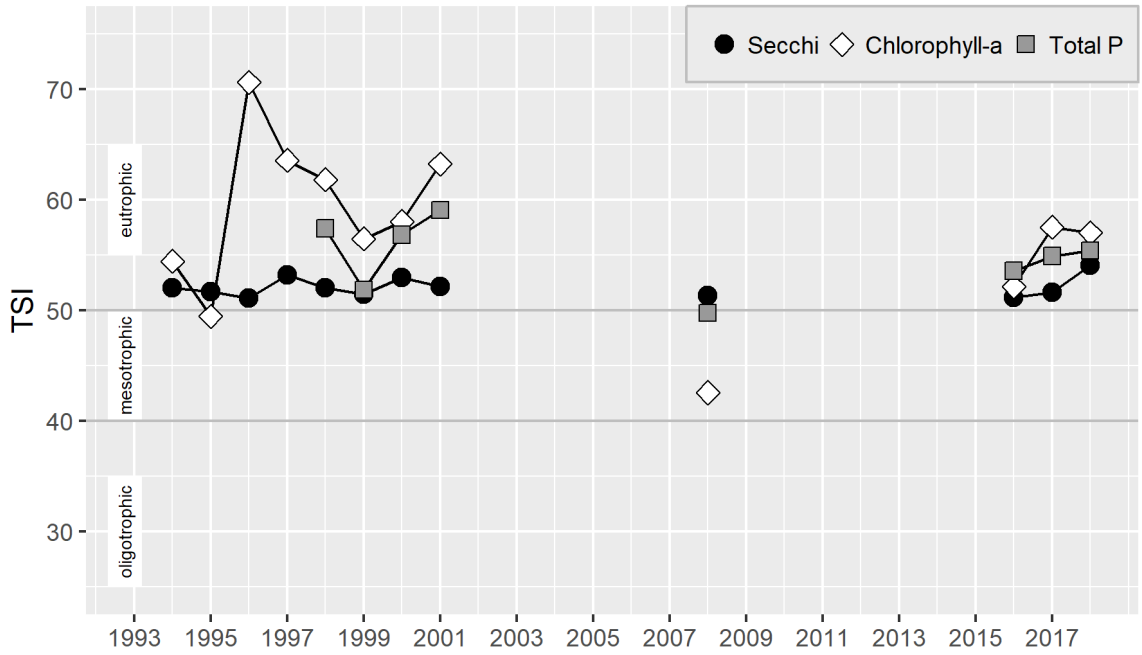


Lake Dolloff's high nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios below 25 both indicate that Lake Dolloff is likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Total nitrogen	-32 µg/L	(-4.3%)
N:P ratio	-2.6	(-11%)

13.2 Trophic state



13.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	0.7	1.2	1.6
Water temperature (°C)	12.0	19.8	26.0
Chlorophyll-a (µg/L)	5.8	16.5	41.3
Total nitrogen (µg/L)	638.0	790.9	966.0
Total phosphorus (µg/L)	9.1	40.3	79.9
N:P ratio	10.7	27.3	104.9

13.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

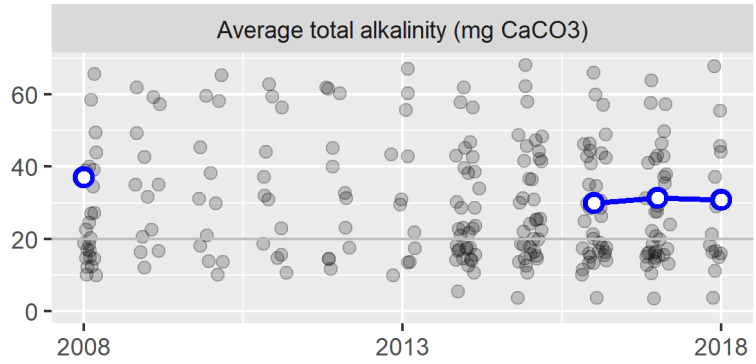
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	19.0	20.7	3.6	789	5.4	(10.0)	38.4	2.2
	2.5	16.0	2.5	1.2	711	–	–	32.0	–
	4.0	10.0	12.7	(1.0)	770	163.0	53.8	68.7	11.6
8/19/2018	1.0	24.0	17.3	(2.0)	774	3.0	(10.0)	43.3	2.5
	2.5	19.0	6.5	3.6	742	–	–	68.1	–
	4.0	11.0	142.0	–	2400	1350.0	(10.0)	629.0	19.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

13.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 30.8 mg $CaCO_3$.

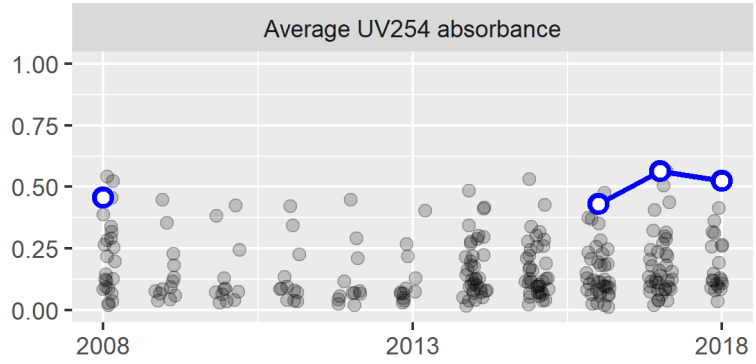
The blue points and line are annual average alkalinity values for Lake Dolloff. Grey points in the background are results for all other lakes in the Lake Stewardship program.



13.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.52, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Dolloff. Grey points in the background are results for all other lakes in the Lake Stewardship program.



14.0 ECHO LAKE: 2018

Thank you to Saul Malamud and the City of Shoreline staff for monitoring Echo Lake.

The key takeaways from the 2018 monitoring season are:

- Nitrogen, phosphorus, and chlorophyll concentrations continued to decline from peaks in 2015.
- Even with the recent declines, Echo Lake's nutrient concentrations and algal growth were still fairly high, and the water was less clear.
- Echo Lake's high nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios below 25 both indicate that Echo Lake is likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in late October. Toxin testing found microcystin present at 5.0 µg/L, below the Washington State Recreational Guideline of 6.0 µg/L.

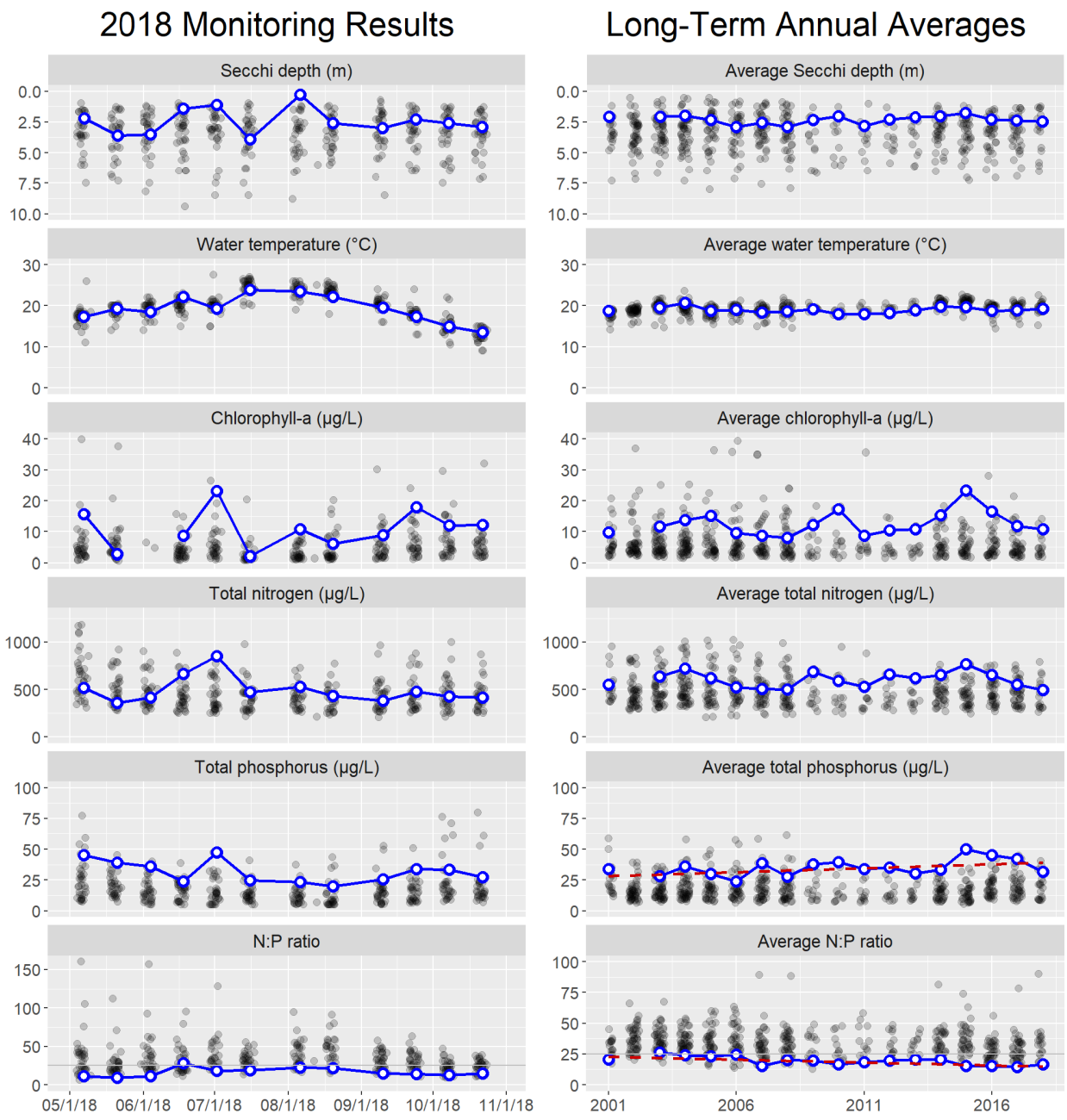
The Lake Stewardship Program recommends:

- Explore what has helped to decrease nutrient concentrations in Echo Lake since 2015 – and encourage those trends to continue. Reducing nutrient concentrations will likely help to reduce algal blooms.
- Stay alert for toxic algae blooms in Echo Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Echo Lake through the Lake Stewardship Program.

14.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Echo Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

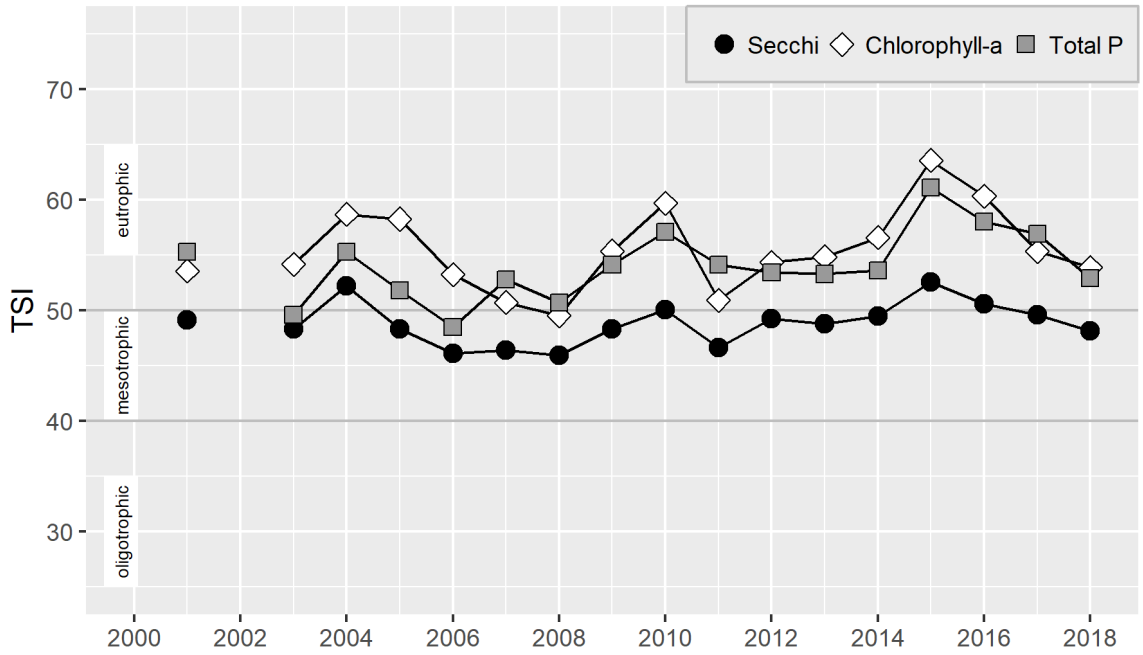


Echo Lake's high nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios below 25 both indicate that Echo Lake is likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2001, when monitoring started.

Parameter	Change per Decade	(%)
Total phosphorus	6.5 µg/L	(23%)
N:P ratio	-4.6	(-20%)

14.2 Trophic state



In 2018, the TSI values were in the eutrophic or upper mesotrophic range.

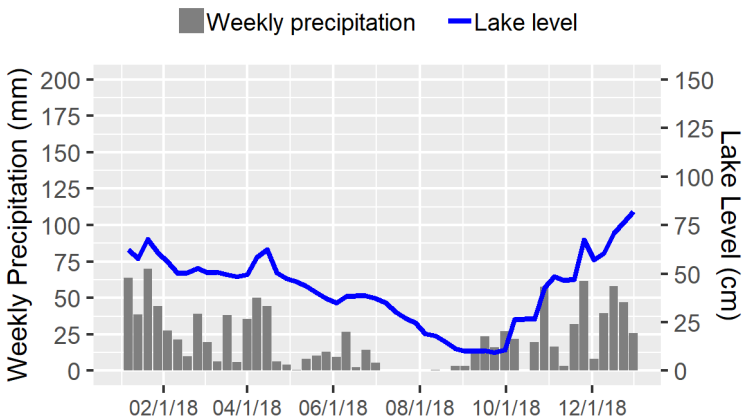
14.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	0.3	2.3	3.9
Water temperature (°C)	5.0	13.3	24.0
May-October statistics			
Secchi depth (m)	0.3	2.3	3.9
Water temperature (°C)	12.0	18.8	24.0
Chlorophyll-a (µg/L)	2.0	10.7	23.2
Total nitrogen (µg/L)	360.0	495.4	850.0
Total phosphorus (µg/L)	19.9	31.7	47.3
N:P ratio	9.2	16.5	27.9

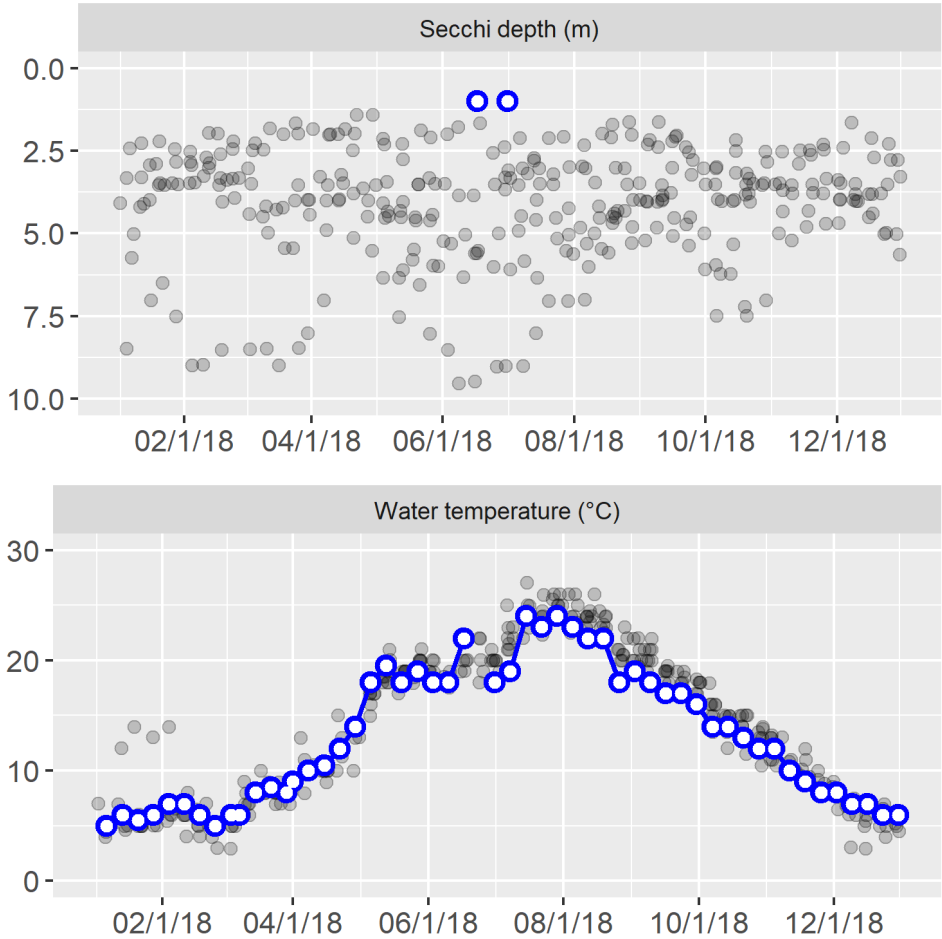
14.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



14.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Echo Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



Note that Echo Lake's year-round measurements were taken from a dock where the water was about 1.5 m deep. Only Secchi depths shallower than 1.5 m could be measured from this location.

14.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

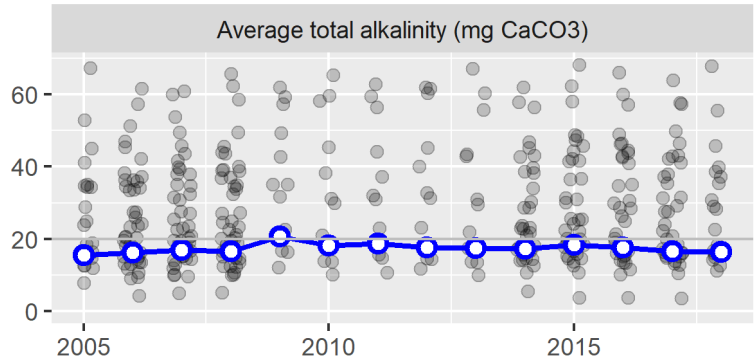
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/21/2018	1.0	19.2	2.7	(1.3)	360	33.2	12.0	39.1	7.4
	3.5	14.7	1.3	(1.4)	496	–	–	62.4	–
	7.0	7.9	1.9	5.5	922	394.0	236.0	171.0	105.0
8/20/2018	1.0	22.1	6.1	1.3	434	2.4	(10.0)	19.9	1.2
	3.5	22.0	7.4	1.6	436	–	–	20.2	–
	7.0	9.3	150.0	–	1470	540.0	(10.0)	336.0	37.1

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

14.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 16.4 mg $CaCO_3$.

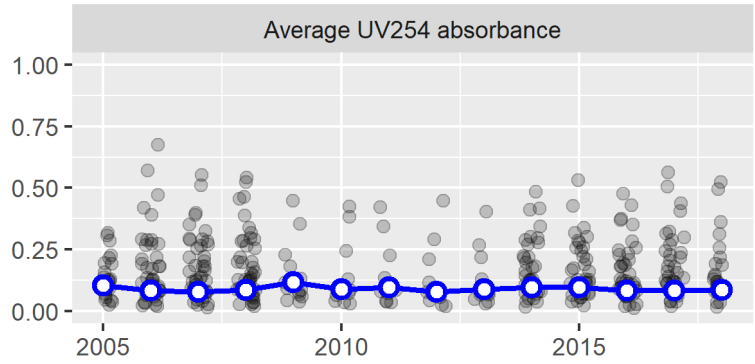
The blue points and line are annual average alkalinity values for Echo Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



14.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.09, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Echo Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



15.0 FIVEMILE LAKE: 2018

Thank you to Brent Nordyke, the volunteer monitor for Fivemile Lake.

The key takeaways from the 2018 monitoring season are:

- Fivemile Lake had moderate nutrient concentrations and algal growth, and less-clear water. Fivemile Lake had some of the shallowest Secchi depths of any lake in the Lake Stewardship Program.
- An algal bloom was sampled for toxin testing in early October. Toxin testing found very low concentrations of algal toxins, well below the Washington State Recreational Guidelines.

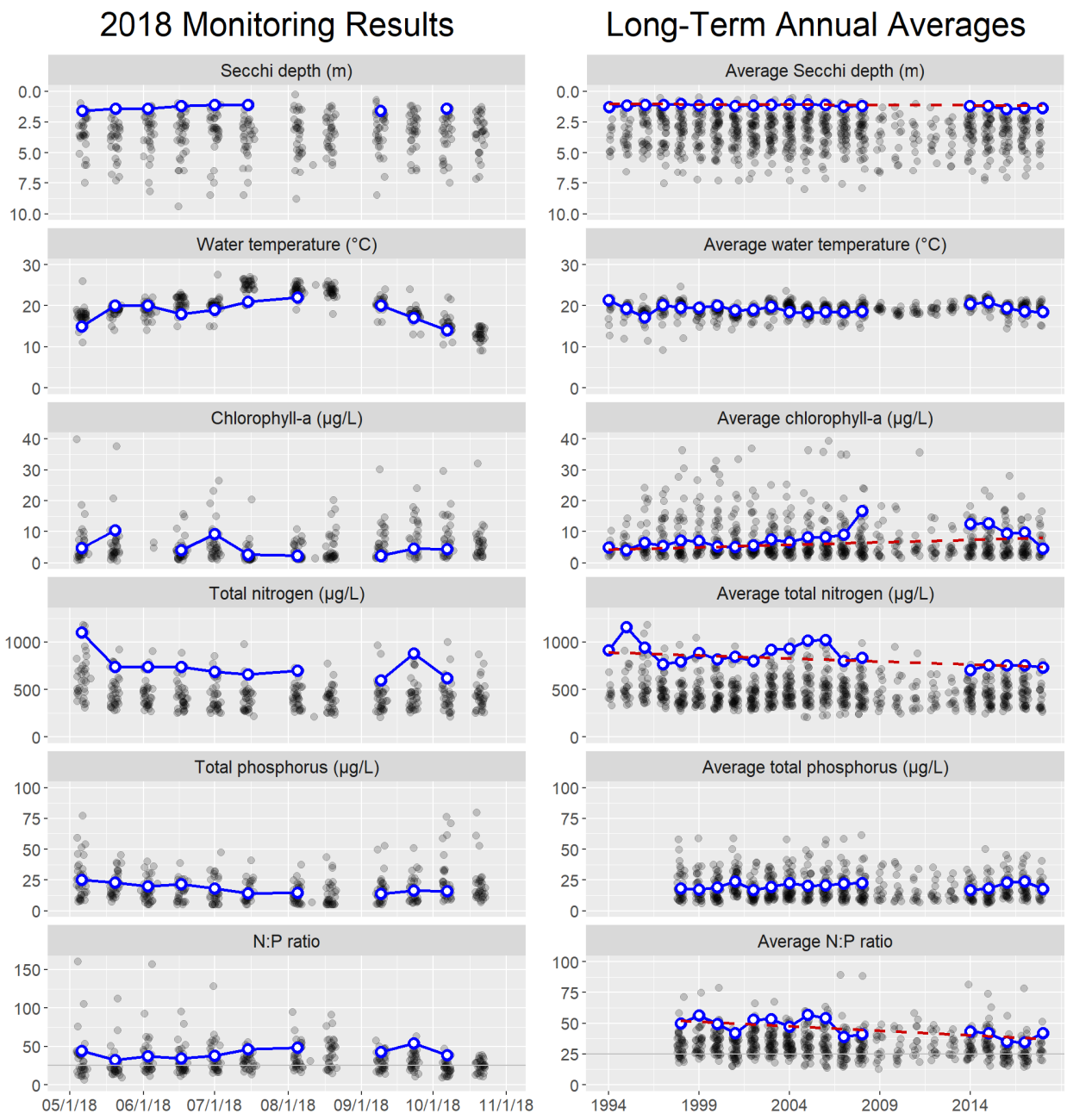
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Fivemile Lake through the Lake Stewardship Program.

15.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Fivemile Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Nitrogen-to-phosphorus (N:P) ratios were above 25 for most of the monitoring season. This indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

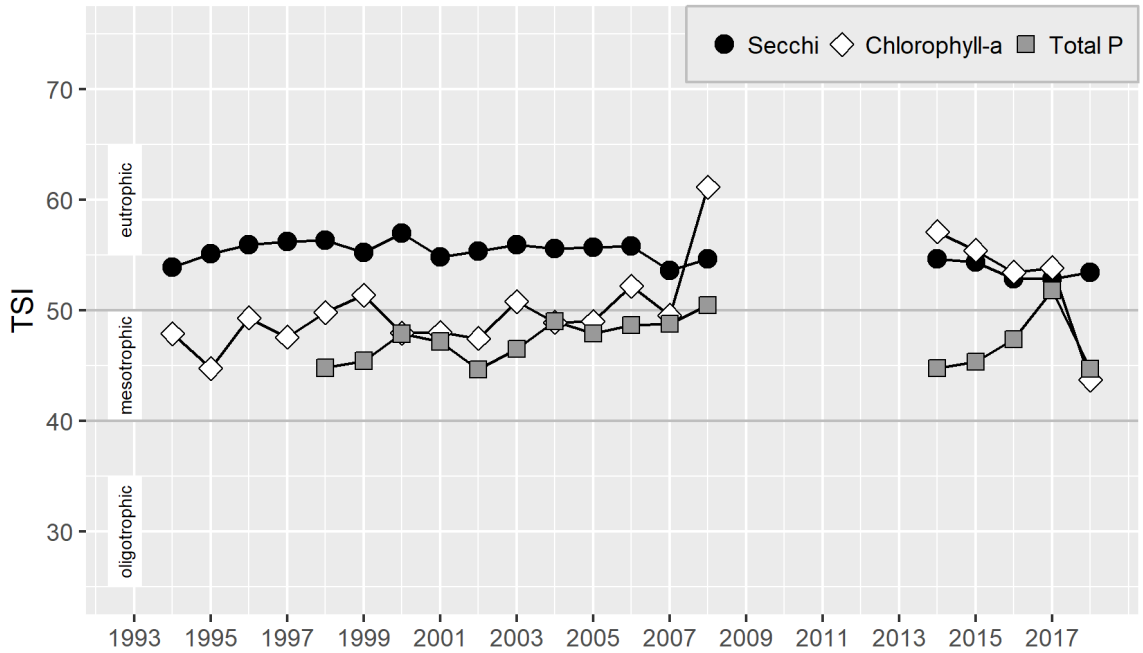
The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.056 m	(5.4%)
Chlorophyll-a	1.6 µg/L	(39%)
Total nitrogen	-65 µg/L	(-7.2%)
N:P ratio	-7.6	(-14%)

Chlorophyll concentrations have increased over time, which is often due to increasing nutrients. However, nitrogen concentrations have decreased and there has been no evident trend in phosphorus concentrations. Changes in other factors besides nutrients may be affecting algal growth.

The trend in Secchi depths is too small to be considered ecologically significant. In addition, a small Secchi trend might be due to factors such as the time of day or the individual observer, rather than any actual changes in water clarity.

15.2 Trophic state



In 2018, the chlorophyll and total-phosphorus TSI values were in the mesotrophic range, and the Secchi TSI value was in the eutrophic range.

15.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.1	1.4	1.6
Water temperature (°C)	14.0	18.5	22.0
Chlorophyll-a (µg/L)	2.2	4.5	10.4
Total nitrogen (µg/L)	597.0	731.6	1100.0
Total phosphorus (µg/L)	14.0	17.8	25.0
N:P ratio	32.1	41.8	53.9

15.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

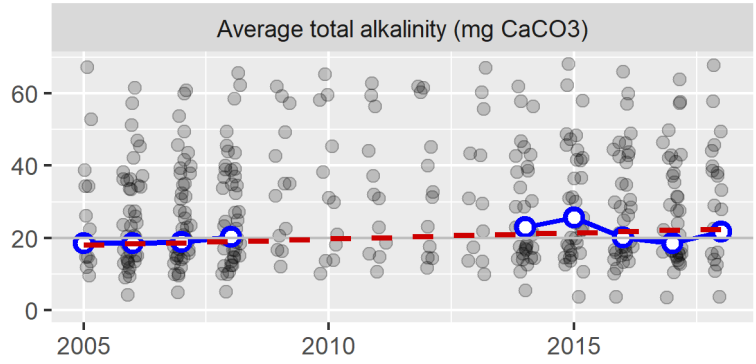
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	10.4	3.2	739	12.0	53.1	23.0	1.1
	5	8.0	1.1	1.2	782	–	–	17.7	–
	9	5.0	–	–	861	91.3	165.0	55.7	10.6
9/9/2018	1	20.0	2.2	(1.4)	597	15.4	(10.0)	14.0	1.1
	5	10.0	7.1	–	503	–	–	36.4	–
	9	6.0	–	–	1210	699.0	(10.0)	187.0	35.2

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

15.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 21.8 mg $CaCO_3$.

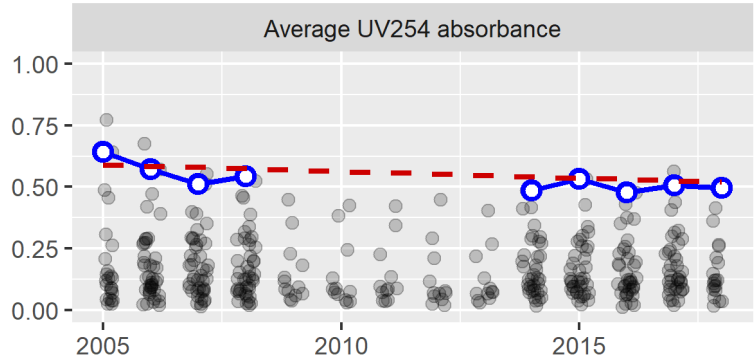
The blue points and line are annual average alkalinity values for Fivemile Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of 3.3 mg $CaCO_3$ (18%) per decade.



15.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.5, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Fivemile Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.053 absorbance units (-9.1%) per decade.



16.0 FORBES LAKE: 2018

Thank you to Caroll & Elena Ferry, and Bud & Corrine Gessell, the volunteer monitors for Forbes Lake.

The key takeaways from the 2018 monitoring season are:

- Forbes Lake continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Long-term trends suggest that water quality in Forbes Lake has been improving over time, with decreasing nitrogen and phosphorus concentrations, and deeper Secchi depths.
- No algal blooms were reported for toxin testing in 2018.

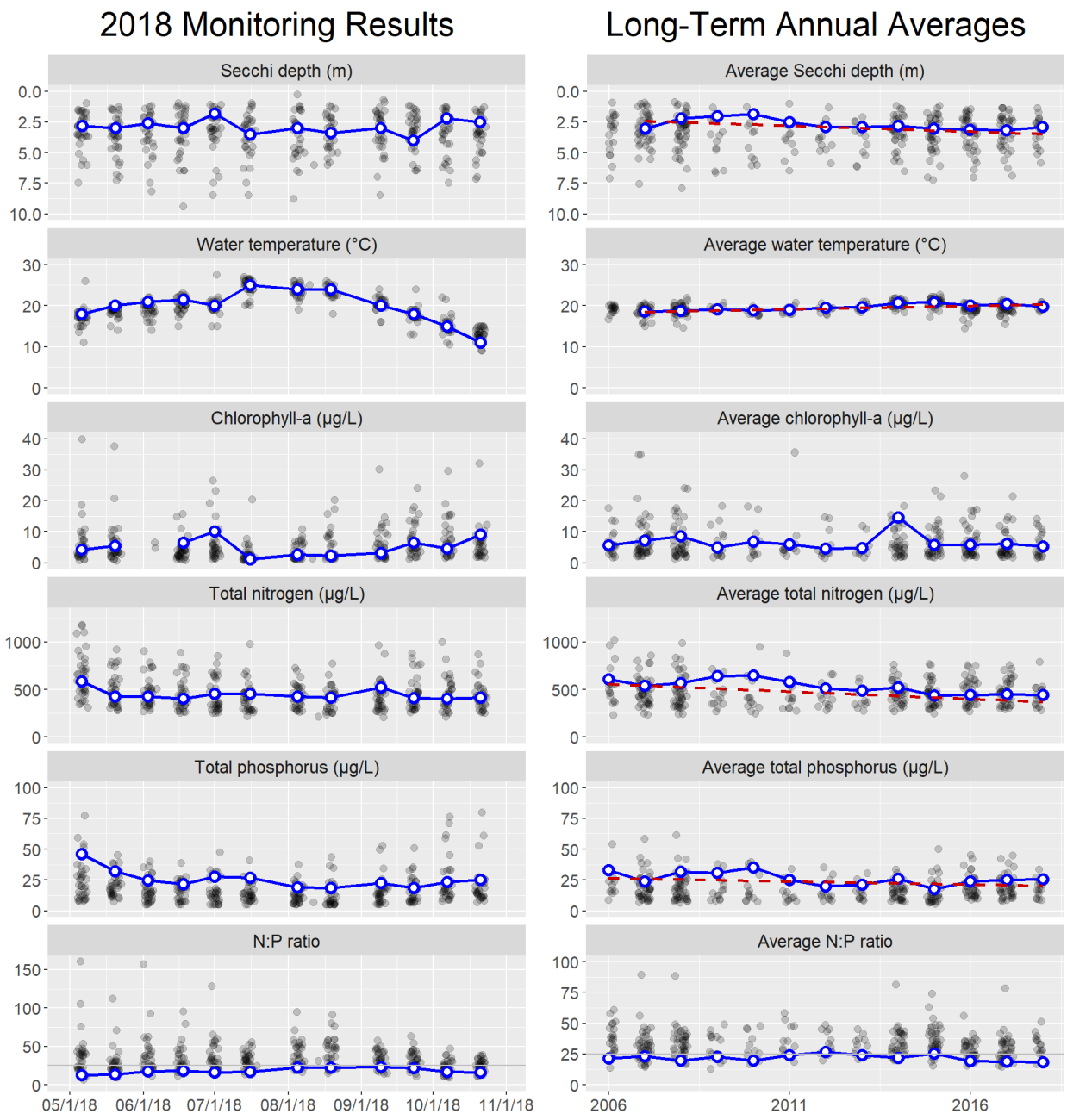
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Forbes Lake through the Lake Stewardship Program.

16.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Forbes Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



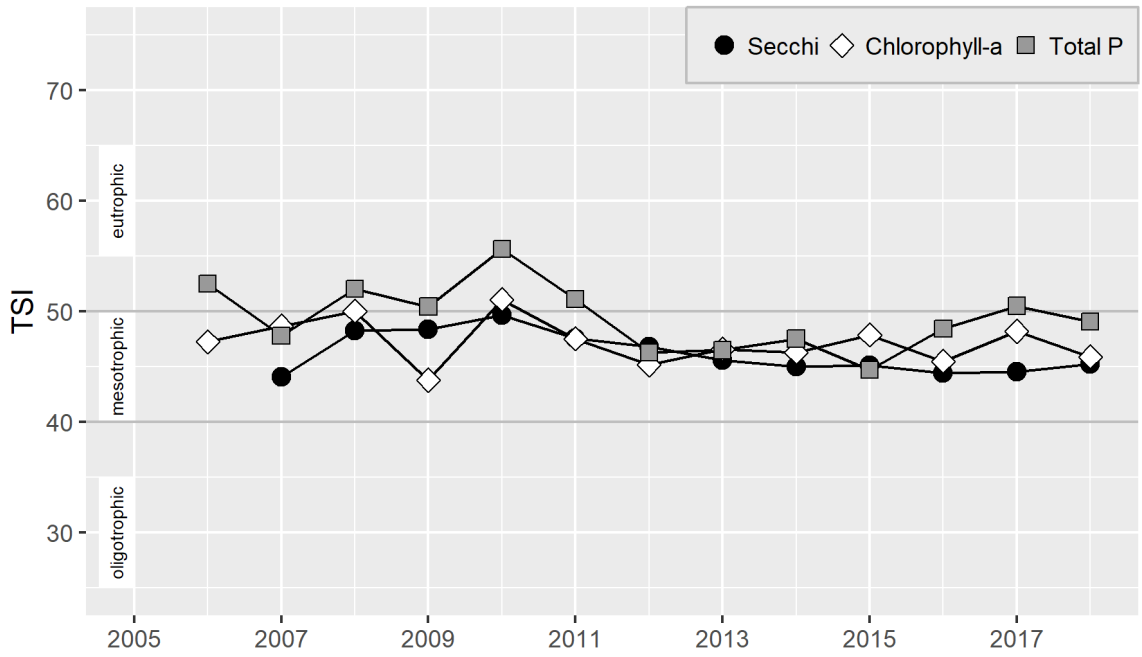
Nitrogen-to-phosphorus (N:P) ratios were below 25 throughout the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2006, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.98 m	(42%)
Water temperature	1.7 °C	(9.1%)
Total nitrogen	-150 µg/L	(-28%)
Total phosphorus	-5.3 µg/L	(-20%)

Long-term trends suggest that water quality in Forbes Lake has been improving over time, with decreasing nitrogen and phosphorus concentrations, and deeper Secchi depths.

16.2 Trophic state



In 2018, the TSI values were in the mesotrophic range.

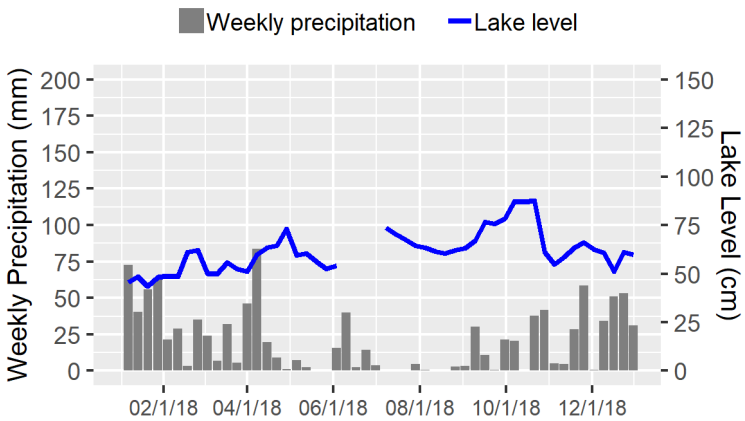
16.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.8	2.9	4.0
Water temperature (°C)	11.0	19.8	25.0
Chlorophyll-a (µg/L)	1.1	5.1	10.0
Total nitrogen (µg/L)	401.0	445.2	586.0
Total phosphorus (µg/L)	18.5	25.6	46.0
N:P ratio	12.7	18.2	23.2

16.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



16.5 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

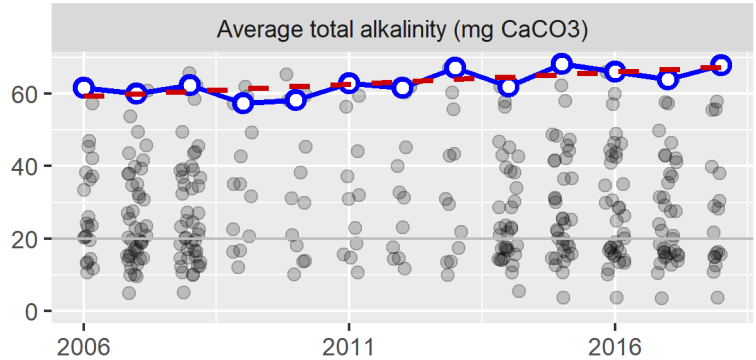
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	5.3	(1.3)	428	33.1	(10.0)	32.3	3.1
	4	10.0	9.1	4.1	435	–	–	45.9	–
	8	5.5	6.9	(1.0)	740	433.0	10.0	86.5	12.9
8/19/2018	1	24.0	2.2	(1.4)	417	5.1	(10.0)	18.5	1.3
	4	–	31.7	(2.9)	–	–	–	–	–

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

16.6 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 67.8 mg $CaCO_3$.

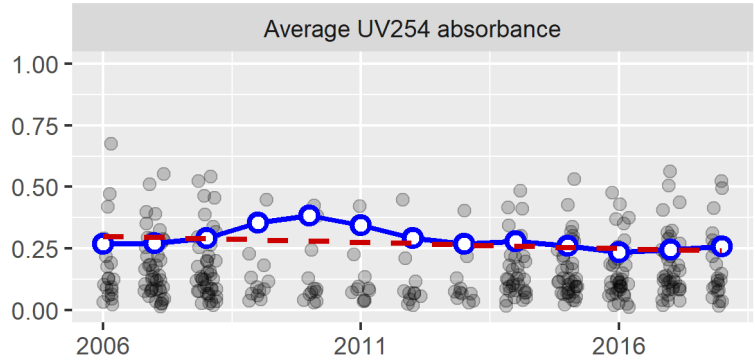
The blue points and line are annual average alkalinity values for Forbes Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of 6.7 mg $CaCO_3$ (11%) per decade.



16.7 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.26, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Forbes Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.05 absorbance units (-17%) per decade.



17.0 LAKE GENEVA: 2018

Thank you to David Ellison and Jerry & Tracey Galland, the volunteer monitors for Lake Geneva.

The key takeaways from the 2018 monitoring season are:

- Lake Geneva continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Water quality in Lake Geneva was better in 2018 than in recent years. Nutrient and chlorophyll concentrations had high peaks in 2016, and decreased in 2017 and 2018.
- In contrast, long-term trends suggest that water quality in Lake Geneva has been declining over time, with increasing nitrogen and chlorophyll concentrations, and shallower Secchi depths.
- An algal bloom was sampled for toxin testing in late October. Toxin testing found microcystin present, at concentrations below the Washington State Recreational Guidelines.

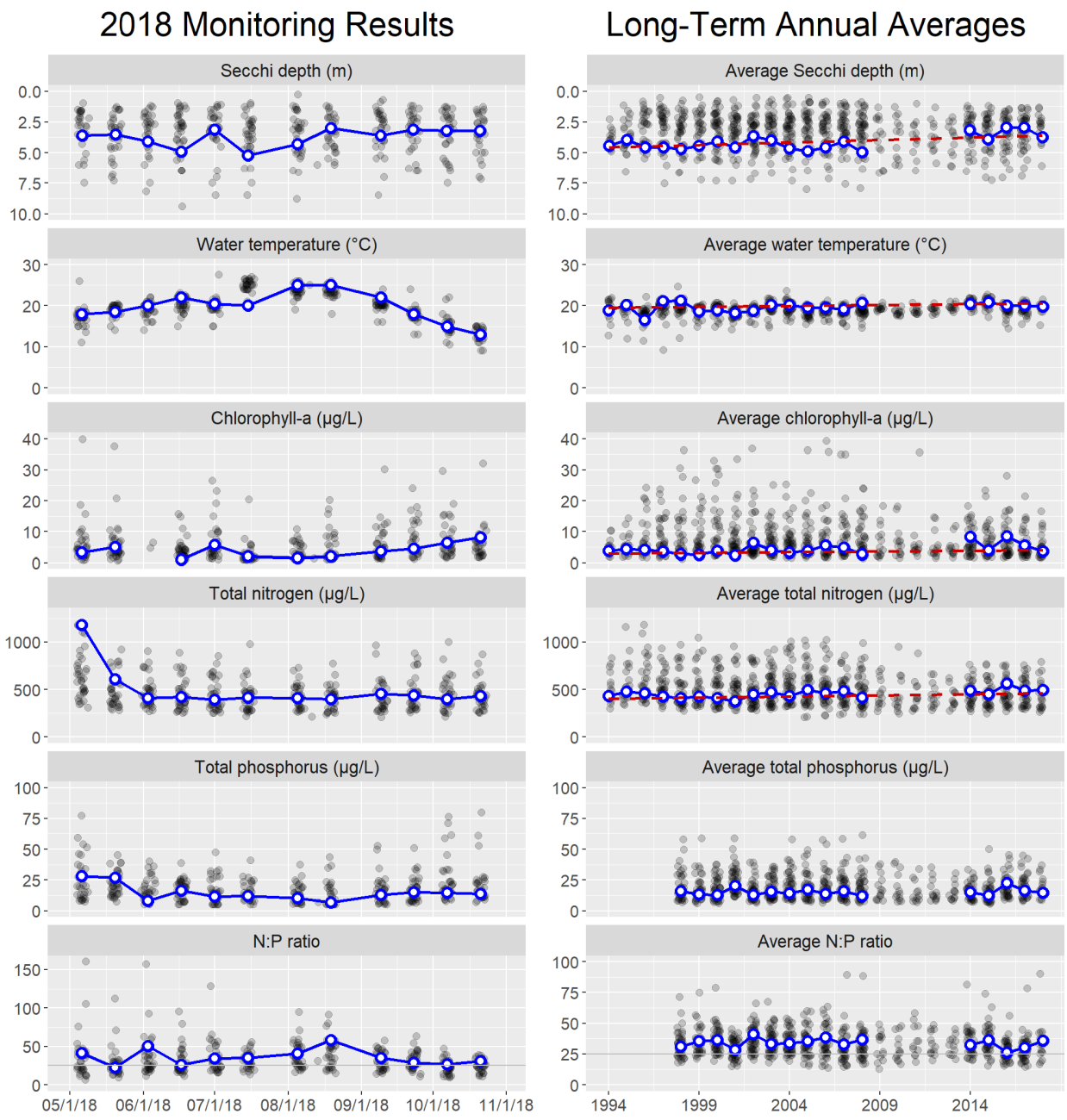
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Geneva – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore what has been affecting nutrient concentrations in Lake Geneva, both the short-term decreases and the long-term increases. These may offer insights for how to reduce nutrient concentrations, which will likely help reduce algal blooms.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Geneva through the Lake Stewardship Program.

17.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Geneva are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



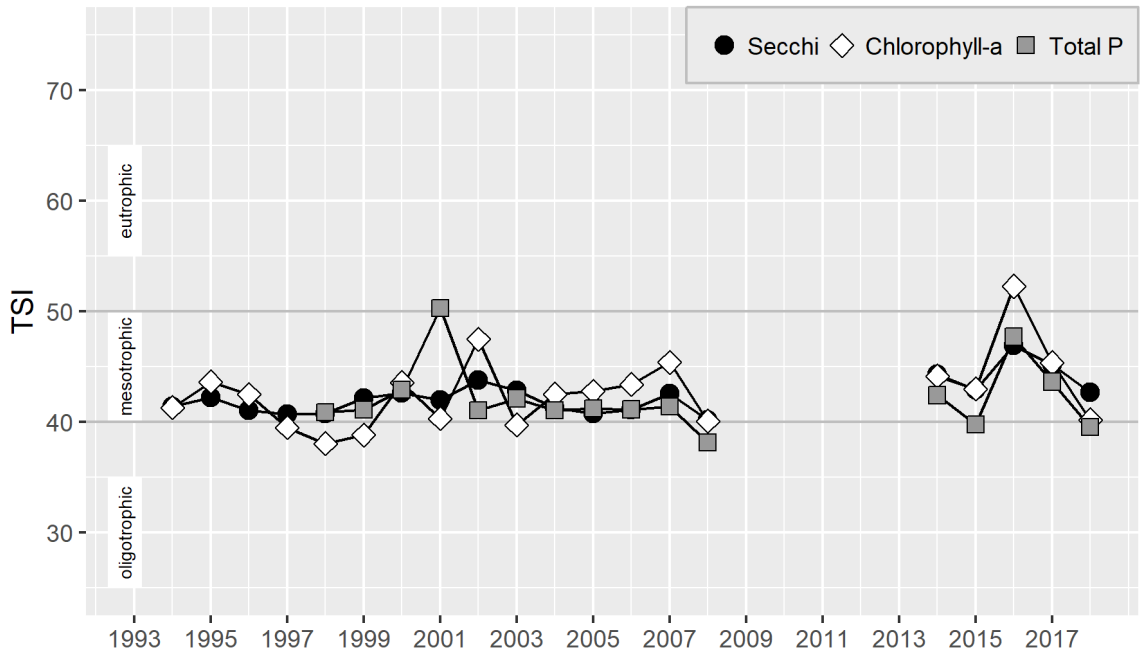
Nitrogen-to-phosphorus (N:P) ratios were occasionally below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-0.41 m	(-8.9%)
Water temperature	0.45 °C	(2.3%)
Chlorophyll-a	0.43 µg/L	(15%)
Total nitrogen	22 µg/L	(5.4%)

Long-term trends suggest that water quality in Lake Geneva has been declining over time, with increasing nitrogen and chlorophyll concentrations, and shallower Secchi depths.

17.2 Trophic state



In 2018, the TSI values were around the mesotrophic-oligotrophic boundary.

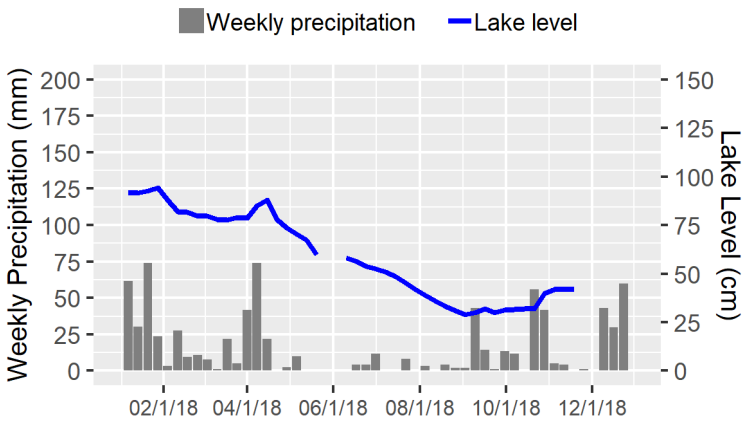
17.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	3.0	3.7	5.2
Water temperature (°C)	13.0	19.8	25.0
Chlorophyll-a (µg/L)	1.0	3.7	8.1
Total nitrogen (µg/L)	394.0	497.0	1180.0
Total phosphorus (µg/L)	6.9	14.8	28.3
N:P ratio	22.6	35.8	58.0

17.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



17.5 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

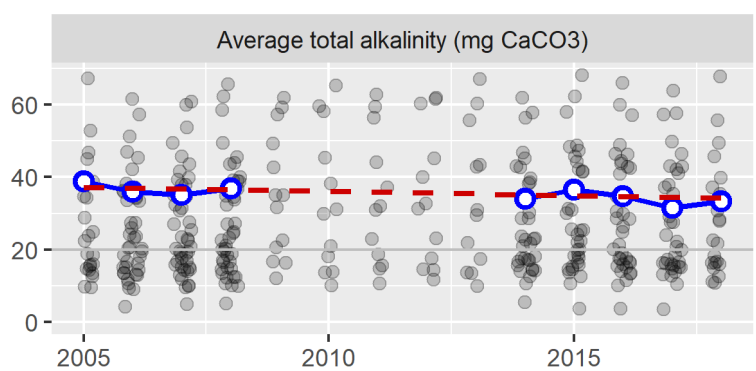
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	18.5	4.9	(1.0)	609	43.2	70.9	27.0	(0.5)
	7	6.5	7.1	(2.0)	737	–	–	40.8	–
	12	5.5	–	–	1030	660.0	14.0	226.0	78.9
8/19/2018	1	25.0	2.1	(1.2)	400	(2.0)	(10.0)	6.9	0.7
	7	15.0	10.2	3.0	498	–	–	27.7	–
	13	10.0	–	–	1060	670.0	(10.0)	256.0	32.8

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

17.6 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 33.2 mg $CaCO_3$.

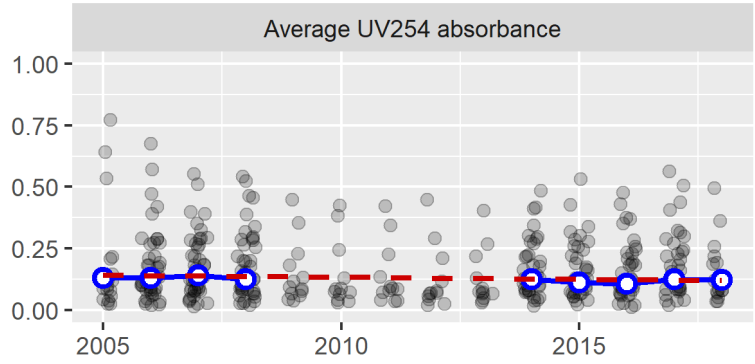
The blue points and line are annual average alkalinity values for Lake Geneva. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -2.4 mg $CaCO_3$ (-6.5%) per decade.



17.7 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.12, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Geneva. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.016 absorbance units (-11%) per decade.



18.0 GREEN LAKE: 2018

Thank you to Sally & Ted Abella, Jeff Howard, Jeff Huguenor, and Garet Munger, the volunteer monitors for Green Lake.

The key takeaways from the 2018 monitoring season are:

- Green Lake continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Average 2018 phosphorus and chlorophyll concentrations, as well as Secchi depths, were noticeably higher than values observed in 2016 following the alum treatment in spring 2016. They were similar to values observed in 2013-2015, before the alum treatment.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 throughout the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in October. Toxin testing found low concentrations of algal toxins, well below the Washington State Recreational Guidelines.

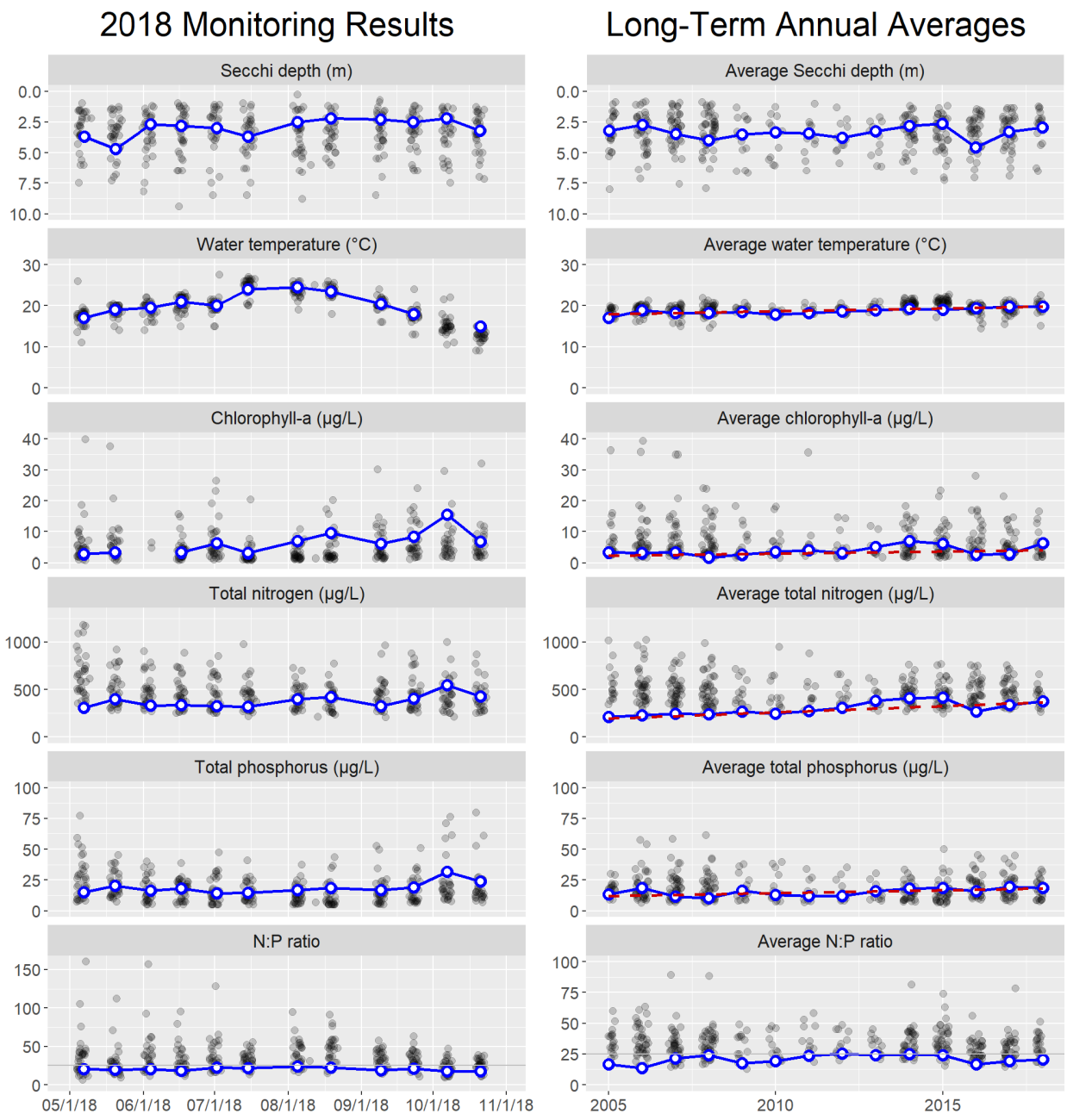
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Green Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Green Lake through the Lake Stewardship Program.

18.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Green Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



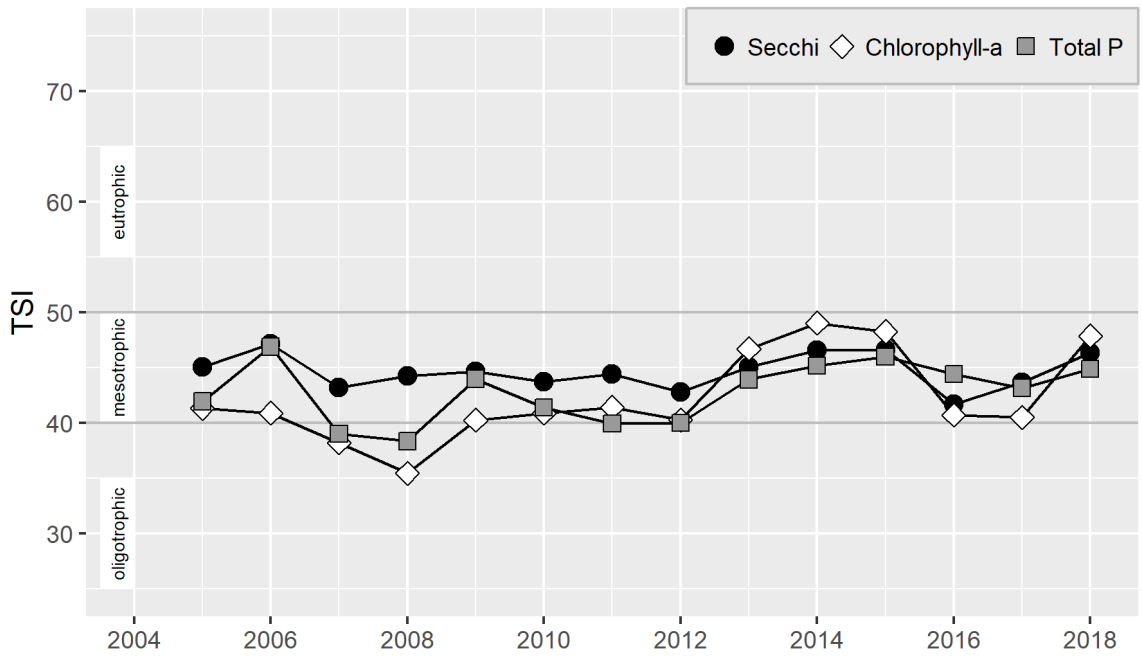
Nitrogen-to-phosphorus (N:P) ratios were below 25 throughout the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2005, when monitoring started.

Parameter	Change per Decade	(%)
Water temperature	1.4 °C	(8%)
Chlorophyll-a	1.2 µg/L	(55%)
Total nitrogen	130 µg/L	(66%)
Total phosphorus	4.5 µg/L	(37%)

The increasing trends in chlorophyll, nitrogen, and phosphorus primarily reflect the timing of monitoring and alum treatments. Monitoring started in 2005, and the early years had low nutrient and chlorophyll concentrations due to an alum treatment in 2004.

18.2 Trophic state



In 2018, the TSI values were in the mesotrophic range.

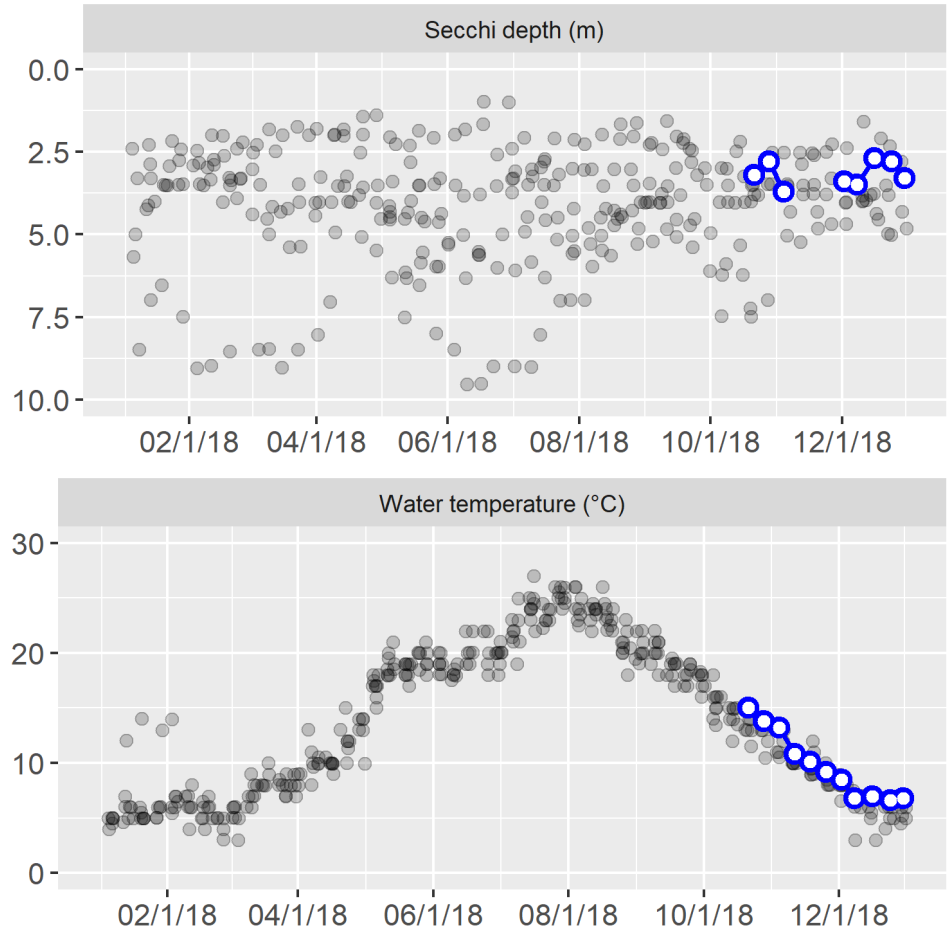
18.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.2	3.1	4.7
Water temperature (°C)	6.6	17.0	24.5
May-October statistics			
Secchi depth (m)	2.2	3.0	4.7
Water temperature (°C)	13.8	19.7	24.5
Chlorophyll-a (µg/L)	2.7	6.2	15.5
Total nitrogen (µg/L)	306.0	377.7	546.0
Total phosphorus (µg/L)	14.2	18.8	31.5
N:P ratio	17.3	20.4	23.7

18.4 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Green Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



Year-round monitoring for Green Lake began in October 2018.

18.5 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

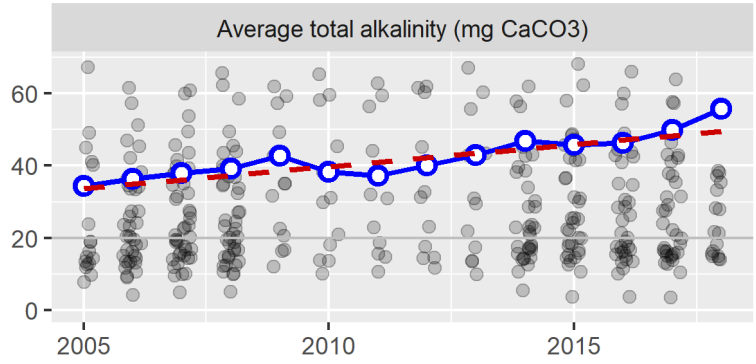
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	19.0	3.3	(2.8)	398	15.2	(10.0)	20.5	1.9
	3.0	18.0	3.1	(1.3)	314	–	–	19.6	–
	6.0	18.0	2.9	(1.1)	303	9.4	(10.0)	16.3	1.3
8/19/2018	1.0	23.5	9.6	(2.0)	420	2.2	(10.0)	18.5	0.6
	3.0	23.0	8.1	(2.0)	378	–	–	15.6	–
	5.5	23.0	9.4	(2.5)	381	5.7	(10.0)	23.5	0.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

18.6 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 55.8 mg $CaCO_3$.

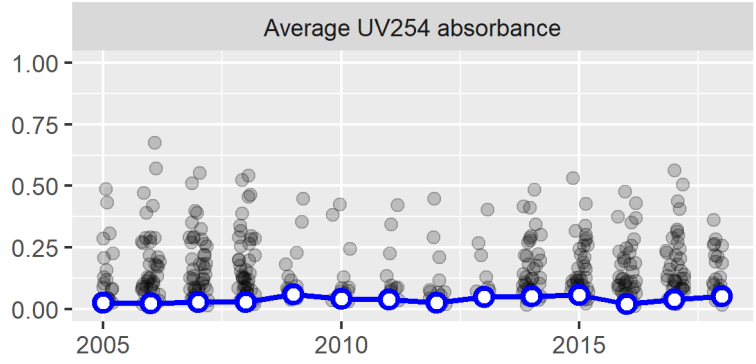
The blue points and line are annual average alkalinity values for Green Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of 12 mg $CaCO_3$ (37%) per decade.



18.7 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.05, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Green Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



19.0 LAKE JOY: 2018

Thank you to Bob & Sam Charles, Janah & Mike Pierce, and Sharon Ramires, the volunteer monitors for Lake Joy.

The key takeaways from the 2018 monitoring season are:

- Lake Joy continued to have fairly clear water, with low nutrient concentrations and low algal growth.
- Long-term trends suggest that water quality in Lake Joy has been improving over time, with decreasing nitrogen, phosphorus, and chlorophyll concentrations.
- No algal blooms were reported for toxin testing in 2018.

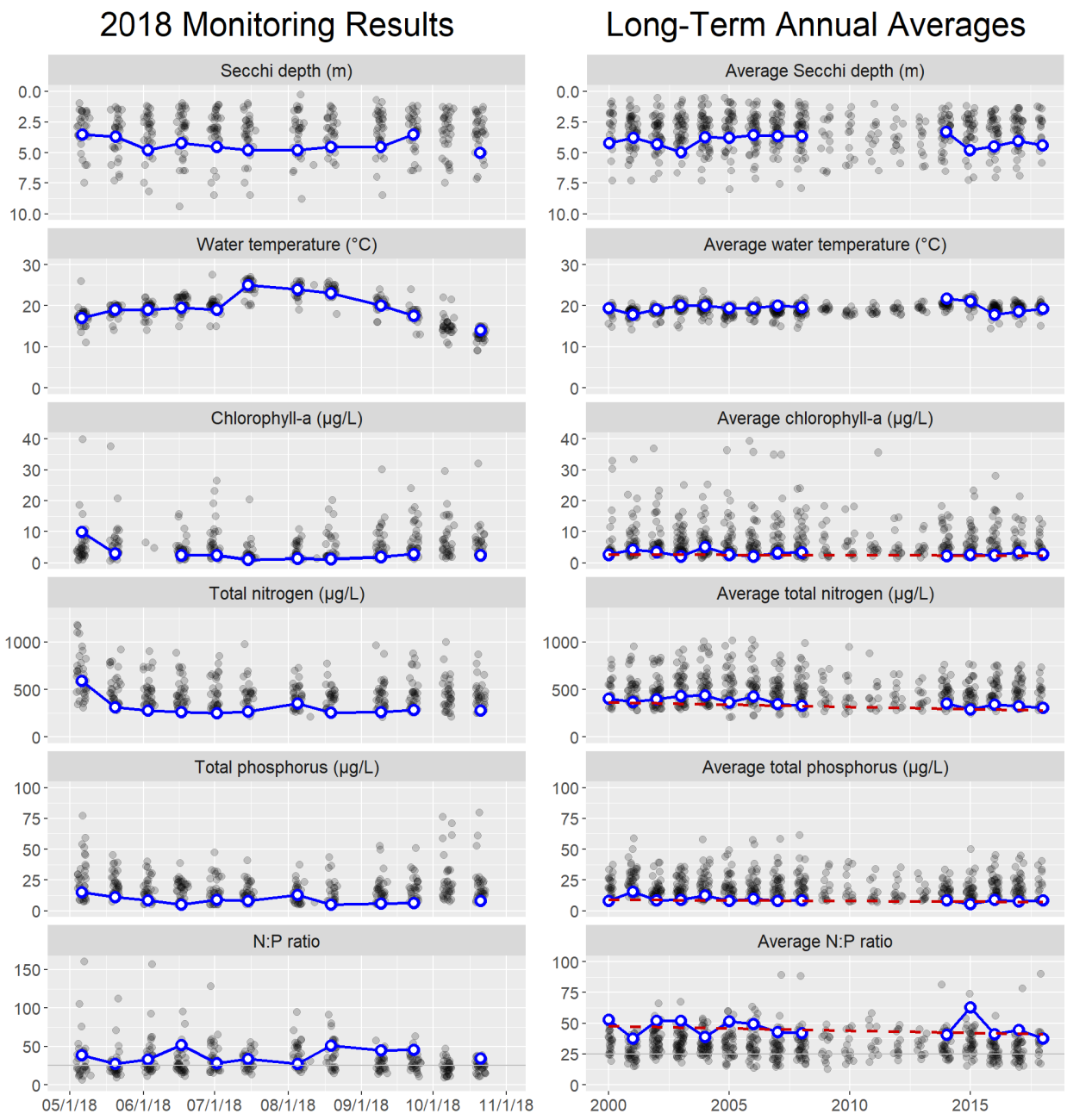
The Lake Stewardship Program recommends:

- Explore what has helped to decrease nutrient concentrations in Lake Joy – and encourage those trends to continue. Reducing nutrient concentrations will likely help to reduce algal blooms.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Joy through the Lake Stewardship Program.

19.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Joy are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



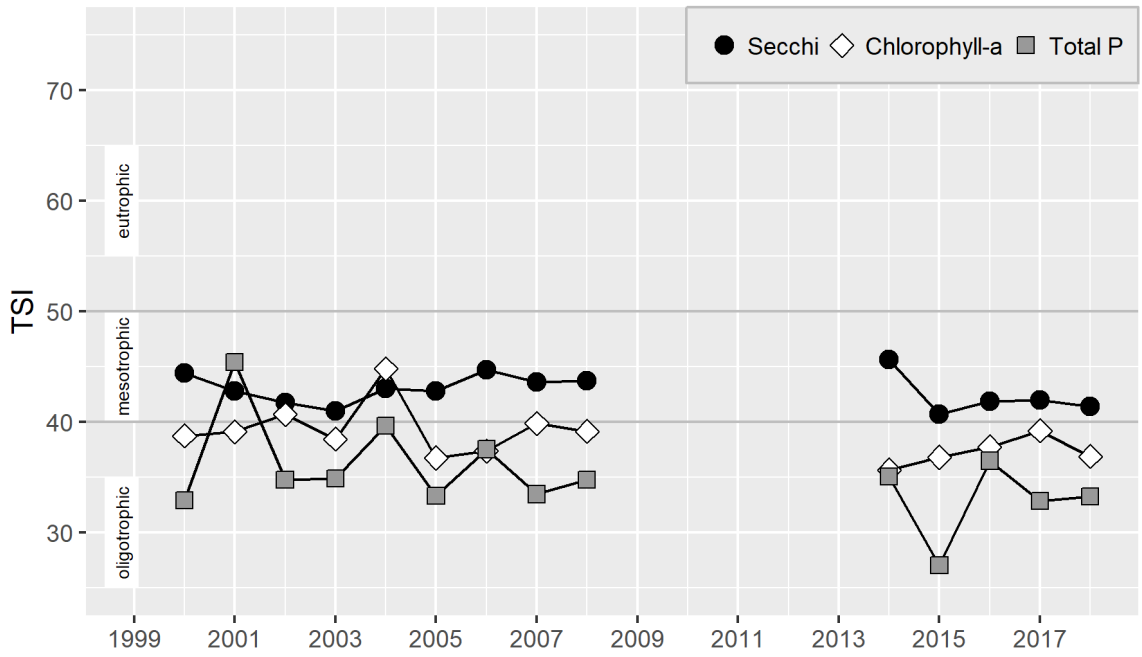
Nitrogen-to-phosphorus (N:P) ratios were above 25 during the monitoring season. This indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2000, when monitoring started.

Parameter	Change per Decade	(%)
Chlorophyll-a	-0.25 µg/L	(-9.7%)
Total nitrogen	-46 µg/L	(-13%)
Total phosphorus	-0.91 µg/L	(-10%)
N:P ratio	-3.6	(-7.6%)

Long-term trends suggest that water quality in Lake Joy has been improving over time, with decreasing nitrogen, phosphorus, and chlorophyll concentrations.

19.2 Trophic state



In 2018, the TSI values were in the oligotrophic

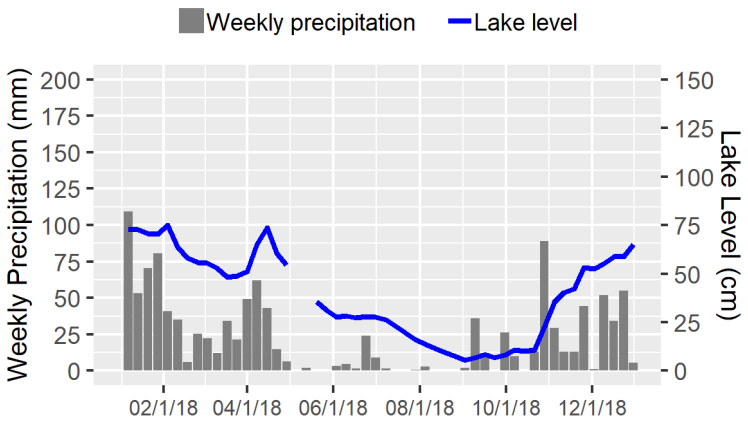
19.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	3.5	4.4	5.0
Water temperature (°C)	14.0	19.2	25.0
Chlorophyll-a (µg/L)	0.9	2.7	9.9
Total nitrogen (µg/L)	249.0	306.4	593.0
Total phosphorus (µg/L)	5.0	8.6	15.3
N:P ratio	27.1	37.6	52.0

19.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



19.5 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

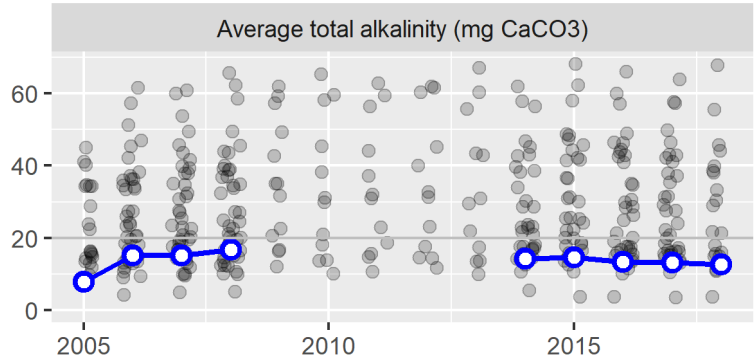
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	19.0	2.9	1.3	312	12.9	35.0	11.4	1.2
	5.5	7.5	8.9	3.0	523	–	–	15.0	–
	11.0	5.0	–	–	669	37.1	289.0	39.2	4.7
8/19/2018	1.0	23.0	1.2	(2.0)	255	5.7	(10.0)	(5.0)	1.0
	5.5	10.0	22.3	5.5	316	–	–	12.1	–
	11.0	5.0	–	–	1390	974.0	(10.0)	124.0	6.9

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

19.6 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 12.6 mg $CaCO_3$.

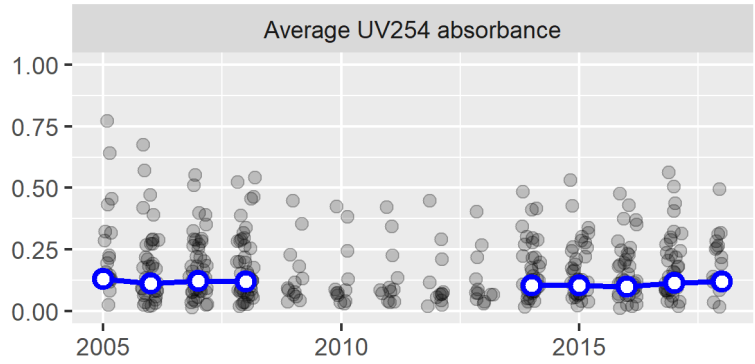
The blue points and line are annual average alkalinity values for Lake Joy. Grey points in the background are results for all other lakes in the Lake Stewardship program.



19.7 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.12, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Joy. Grey points in the background are results for all other lakes in the Lake Stewardship program.



20.0 LAKE KATHLEEN: 2018

Thank you to Keith Lanan and Kurt Tokita, the volunteer monitors for Lake Kathleen.

The key takeaways from the 2018 monitoring season are:

- Lake Kathleen had fairly clear water, with moderate nutrient concentrations and fairly low algal growth.
- Long-term trends suggest that water quality in Lake Kathleen has been improving over time, with decreasing phosphorus and chlorophyll concentrations, and deeper Secchi depths.
- Algal blooms were sampled for toxin testing in June. Toxin testing found low concentrations of algal toxins, well below the Washington State Recreational Guidelines.

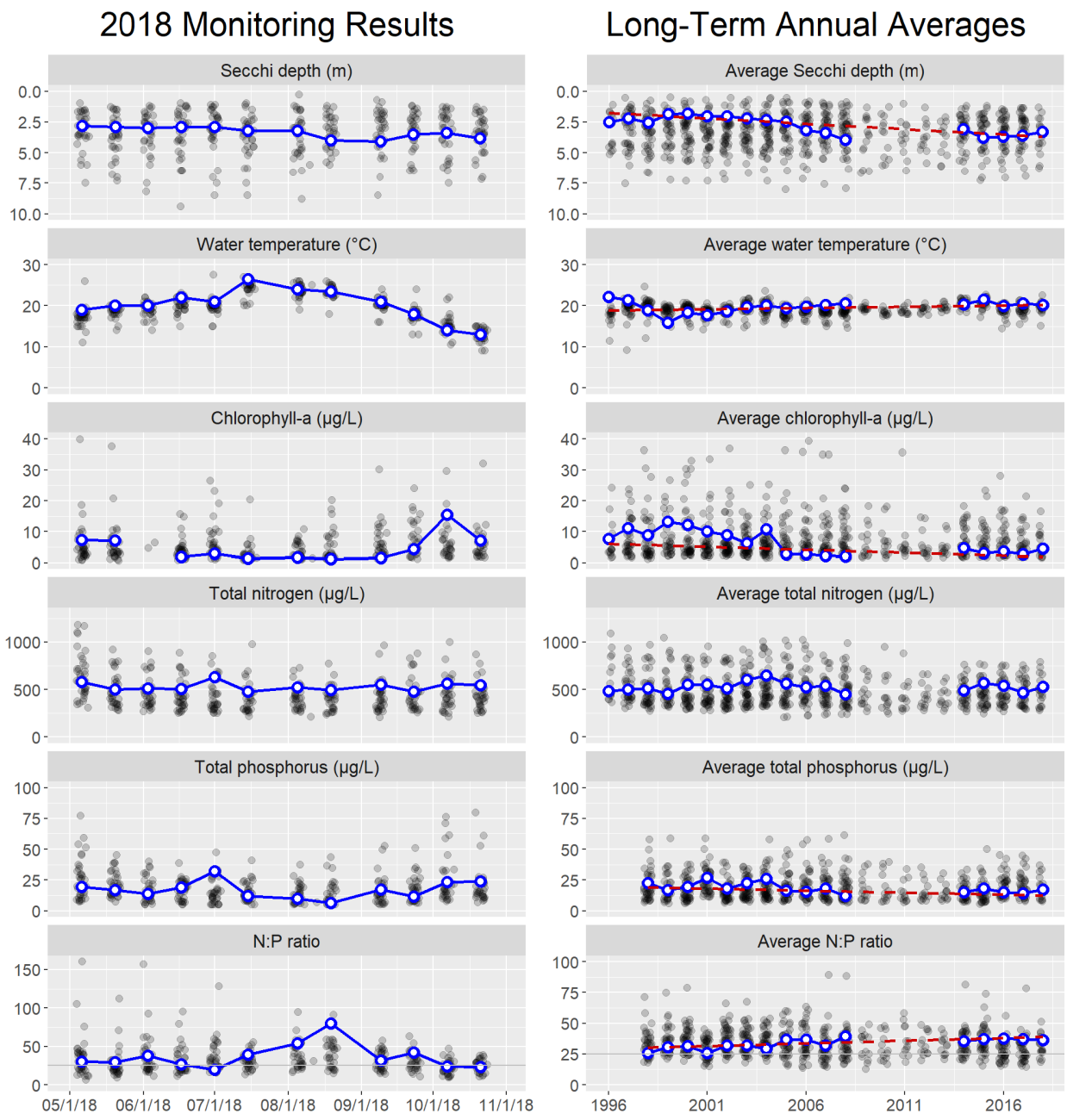
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Kathleen – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore what has helped to decrease phosphorus concentrations in Lake Kathleen – and encourage those trends to continue. Reducing nutrient concentrations will likely help to reduce algal blooms.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Kathleen through the Lake Stewardship Program.

20.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Kathleen are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



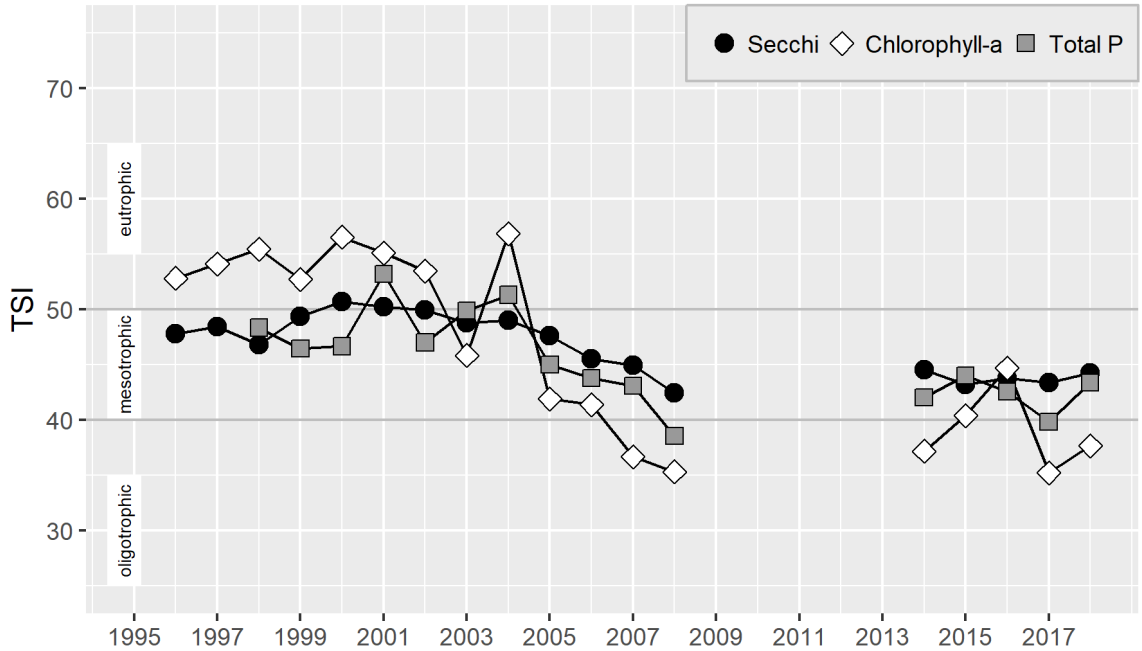
Nitrogen-to-phosphorus (N:P) ratios were above 25 for most of the monitoring season. This typically indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins). Contrary to this expectation, however, the June algal bloom samples did contain toxin-producing cyanobacteria.

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.87 m	(50%)
Water temperature	0.56 °C	(2.9%)
Chlorophyll-a	-2 µg/L	(-32%)
Total phosphorus	-3.1 µg/L	(-16%)
N:P ratio	4.4	(15%)

Long-term trends suggest that water quality in Lake Kathleen has been improving over time, with decreasing phosphorus and chlorophyll concentrations, and deeper Secchi depths.

20.2 Trophic state



In 2018, the TSI values were in the mesotrophic or upper oligotrophic range.

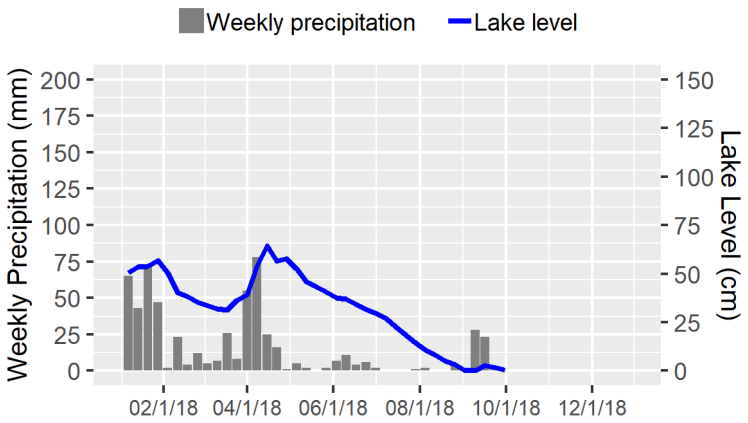
20.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	2.8	3.3	4.1
Water temperature (°C)	13.0	20.2	26.5
Chlorophyll-a (µg/L)	1.2	4.4	15.4
Total nitrogen (µg/L)	476.0	529.8	628.0
Total phosphorus (µg/L)	6.2	17.1	32.0
N:P ratio	19.6	36.4	79.5

20.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



20.5 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

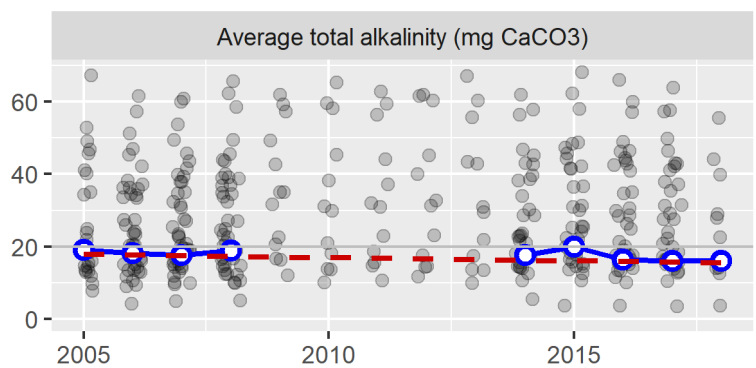
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	7.1	2.8	498	2.5	(10.0)	17.0	1.2
	3	13.0	26.2	4.8	427	–	–	21.1	–
	5	9.0	53.4	(1.0)	550	2.2	(10.0)	45.9	0.7
8/19/2018	1	23.5	1.2	(1.1)	493	5.5	(10.0)	6.2	0.8
	3	22.0	4.7	2.2	480	–	–	35.5	–
	5	14.0	212.0	–	843	4.6	(10.0)	169.0	0.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

20.6 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 16.1 mg $CaCO_3$.

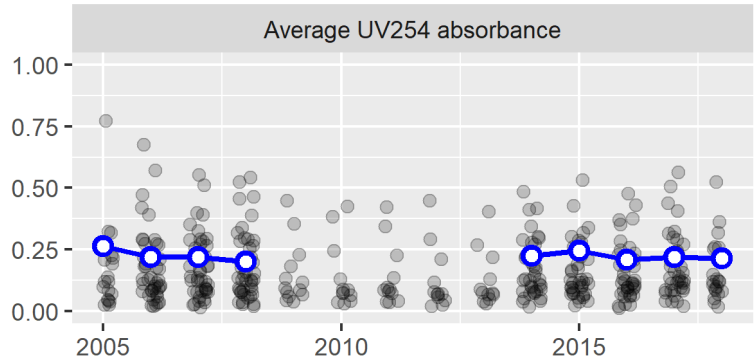
The blue points and line are annual average alkalinity values for Lake Kathleen. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -1.9 mg $CaCO_3$ (-11%) per decade.



20.7 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.22, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Kathleen. Grey points in the background are results for all other lakes in the Lake Stewardship program.



21.0 LAKE KILLARNEY: 2018

Thank you to Jimmy Hsieh and Craig Rice, the volunteer monitors for Lake Killarney.

The key takeaways from the 2018 monitoring season are:

- Lake Killarney continued to have fairly clear water, with moderate algal growth and fairly high nutrient concentrations.
- Long-term trends suggest that water quality in Lake Killarney has been improving over time, with decreasing nitrogen and phosphorus concentrations.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in 2018. Toxin testing found microcystin present, at concentrations below the Washington State Recreational Guidelines.

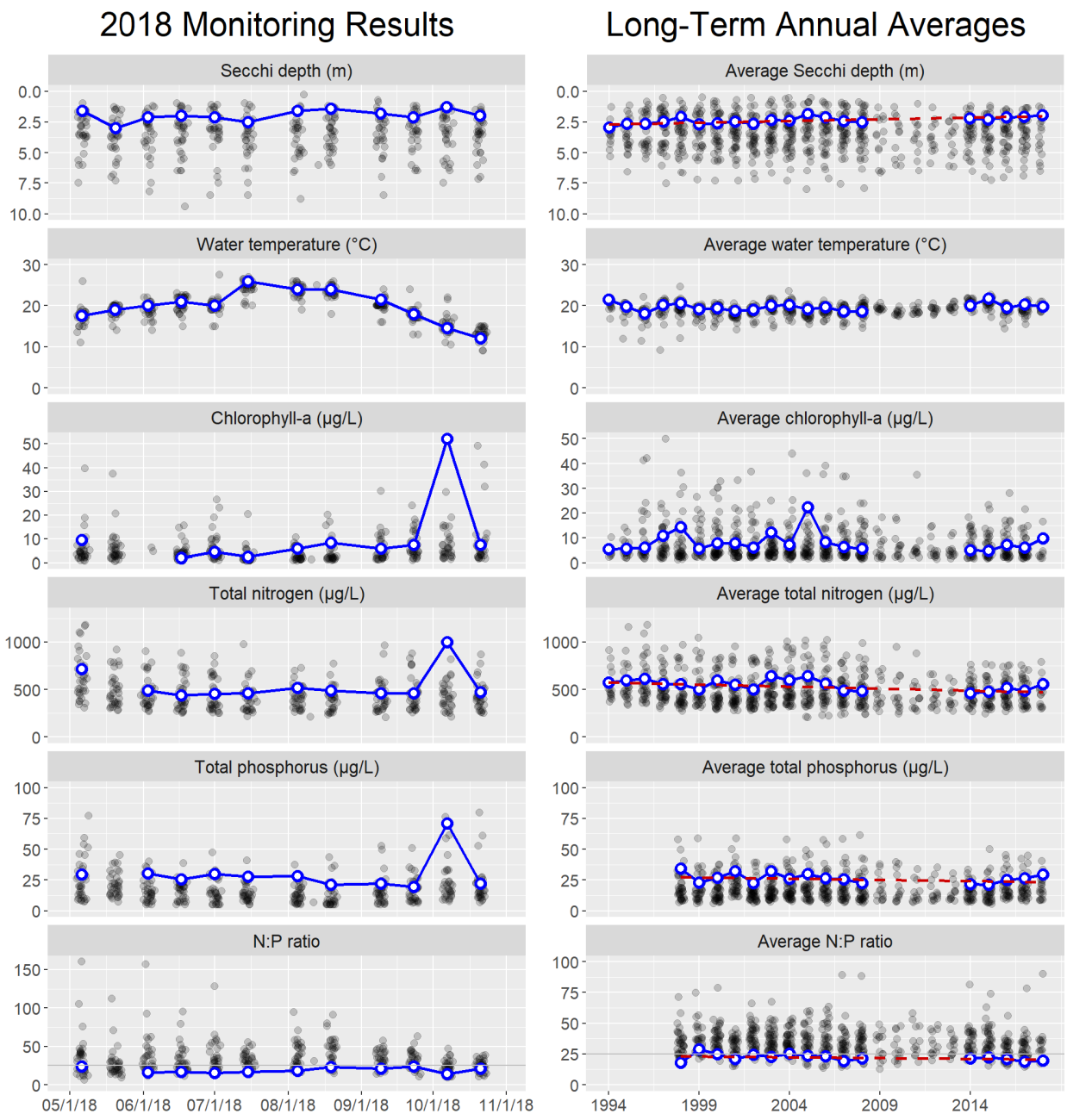
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Killarney – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore what has helped to decrease nutrient concentrations in Lake Killarney – and encourage those trends to continue. Reducing nutrient concentrations will likely help to reduce algal blooms.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Killarney through the Lake Stewardship Program.

21.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Killarney are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

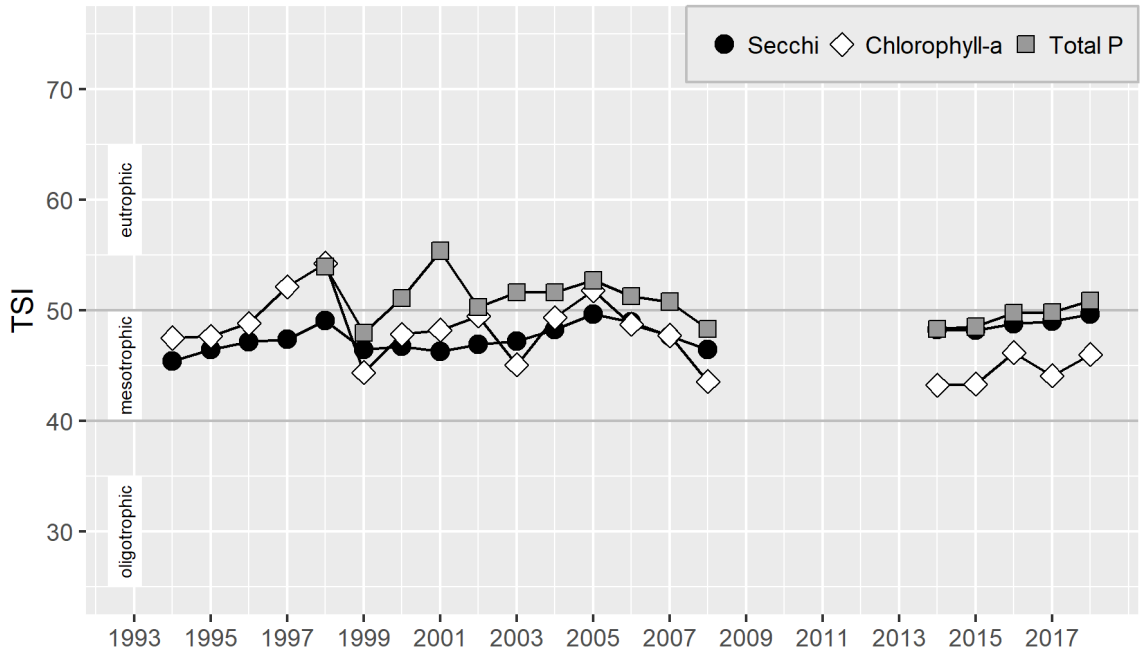
High chlorophyll concentrations in early October indicate an algal bloom, fed by high nitrogen and phosphorus concentrations at this time. Fall algal blooms are common in local lakes. Early rains wash in nutrients that have accumulated on land during dry weather, and there is still enough warmth and light to favor algal growth.

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-0.27 m	(-10%)
Total nitrogen	-42 µg/L	(-7.3%)
Total phosphorus	-1.9 µg/L	(-6.8%)
N:P ratio	-1.3	(-5.4%)

Long-term trends suggest that water quality in Lake Killarney has been improving over time, with decreasing nitrogen and phosphorus concentrations. Secchi depth has gotten shallower over time, although decreasing nutrient concentrations would be expected to lead to deeper Secchi depths instead. Secchi depth readings can vary considerably depending on the weather, time of day, or the individual observer. Further analysis is needed to determine if the observed trend is due to these factors, or if water clarity has actually decreased over time.

21.2 Trophic state



In 2018, the TSI values were near the mesotrophic-eutrophic boundary.

21.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.3	2.0	3.0
Water temperature (°C)	12.0	19.8	26.0
Chlorophyll-a (µg/L)	2.0	9.8	52.1
Total nitrogen (µg/L)	435.0	555.4	999.0
Total phosphorus (µg/L)	19.4	29.7	70.8
N:P ratio	14.1	19.5	24.1

21.4 Water column profile

In June and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

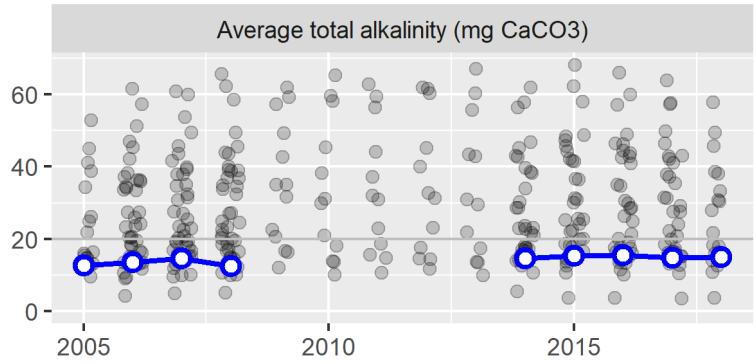
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
6/3/2018	1.0	20.0	–	–	488	3.4	(10.0)	30.4	1.6
	2.5	19.0	–	–	484	3.7	(10.0)	32.5	2.2
8/19/2018	1.0	24.0	8.4	(2.0)	487	(2.0)	(10.0)	21.2	1.6
	2.5	22.3	10.3	(4.0)	501	3.0	(10.0)	27.6	1.5

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

21.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 14.9 mg $CaCO_3$.

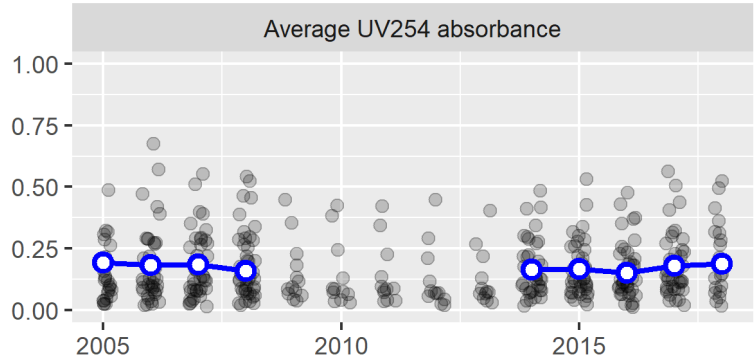
The blue points and line are annual average alkalinity values for Lake Killarney. Grey points in the background are results for all other lakes in the Lake Stewardship program.



21.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.19, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Killarney. Grey points in the background are results for all other lakes in the Lake Stewardship program.



22.0 LAKE LUCERNE: 2018

Thank you to Jay Adams, the volunteer monitor for Lake Lucerne.

The key takeaways from the 2018 monitoring season are:

- Lake Lucerne continued to have clear water, with low nutrient concentrations and low algal growth.
- Secchi depths in Lake Lucerne have gotten deeper (clearer water) over time.
- Algal blooms were sampled for toxin testing in May. Toxin testing found microcystin and anatoxin present, at concentrations below the Washington State Recreational Guidelines.

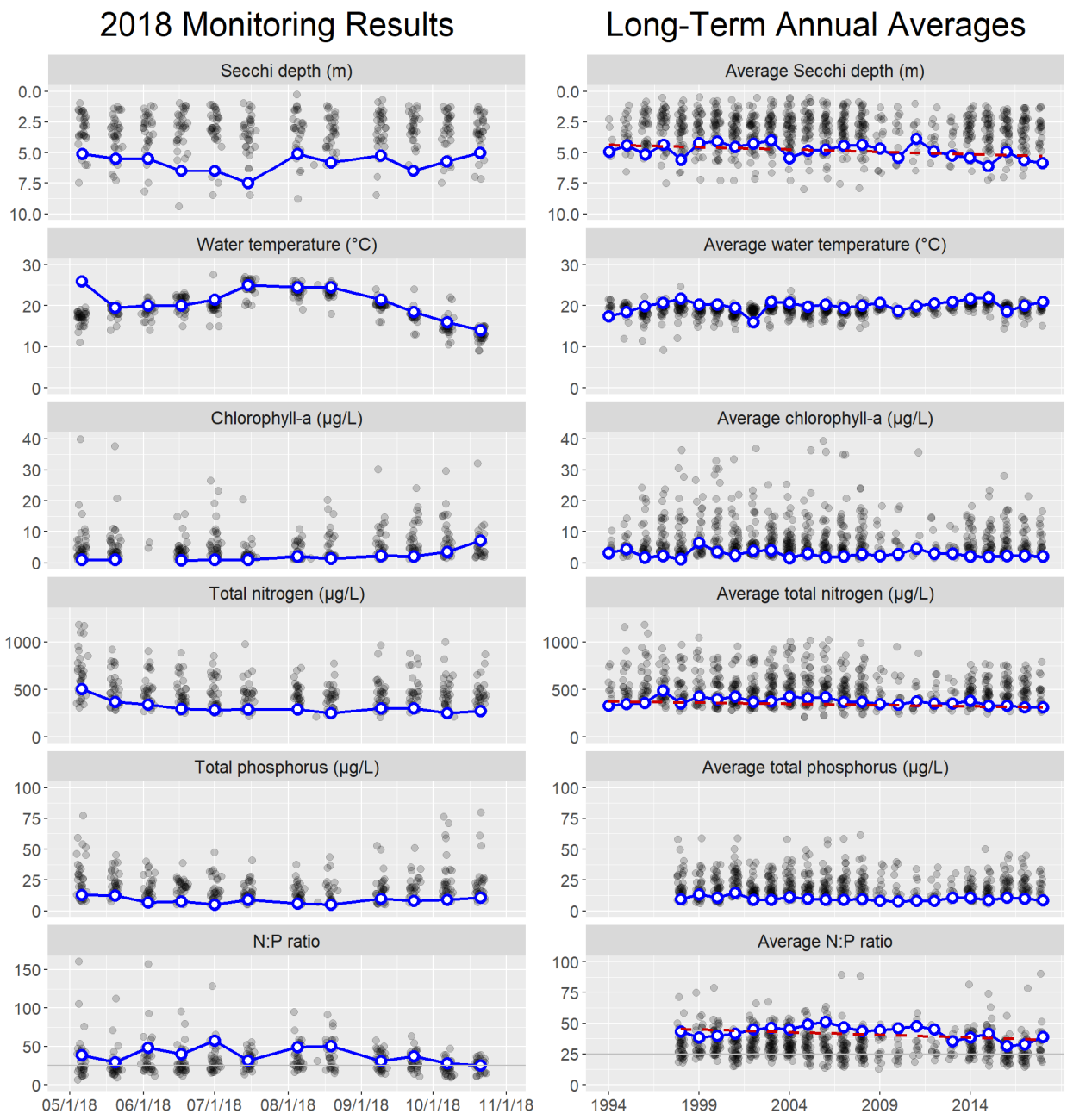
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Lucerne – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Lucerne through the Lake Stewardship Program.

22.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Lucerne are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



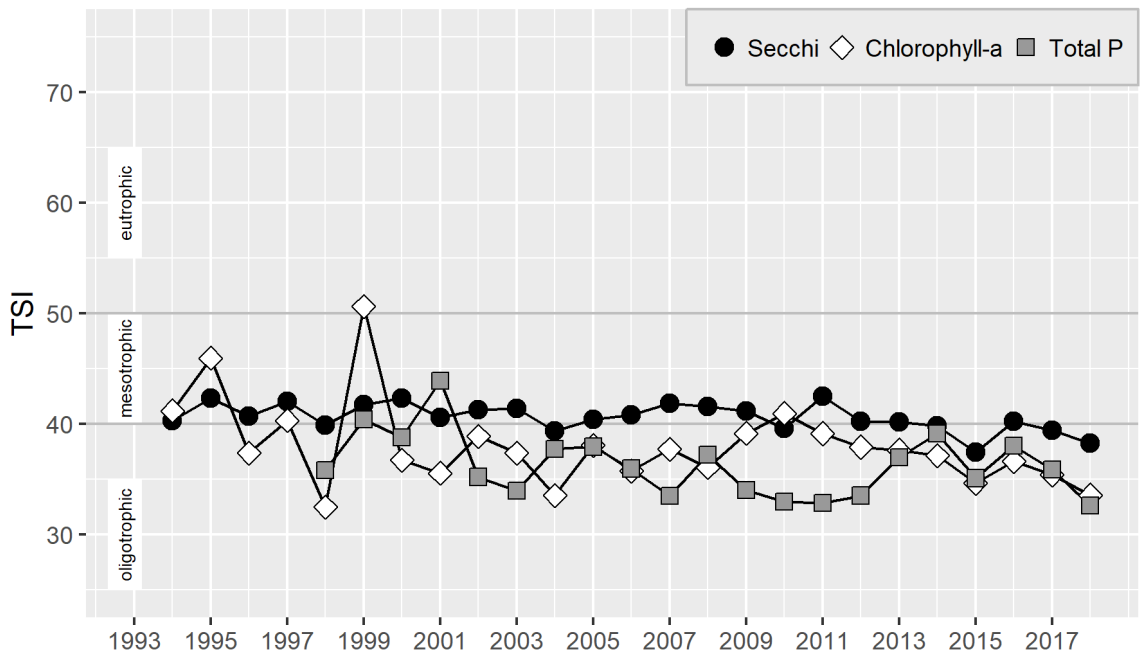
Lake Lucerne's low nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios above 25 both typically indicate that Lake Lucerne is not likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins). Contrary to this expectation, however, there was a toxin-producing algal bloom in May.

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.39 m	(8.9%)
Total nitrogen	-28 µg/L	(-7.4%)
N:P ratio	-4.3	(-9.1%)

Secchi depths in Lake Lucerne have gotten deeper (clearer water) over time. Nitrogen concentrations have also decreased, though it is not clear whether this is causing the deeper Secchi depths.

22.2 Trophic state



In 2018, the TSI values were in the oligotrophic range.

22.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	5.0	5.8	7.5
Water temperature (°C)	14.0	20.9	26.0
Chlorophyll-a (µg/L)	0.7	1.9	7.1
Total nitrogen (µg/L)	253.0	313.7	504.0
Total phosphorus (µg/L)	5.0	8.6	13.1
N:P ratio	25.2	38.8	57.2

22.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

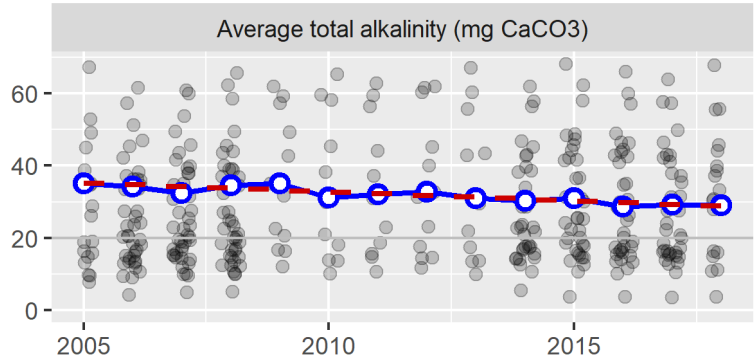
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	19.5	1.0	(1.2)	371	33.7	113.0	12.6	0.6
	5.0	10.0	23.7	(2.2)	527	–	–	41.6	–
	10.0	7.2	–	–	428	28.3	111.0	50.1	3.4
8/19/2018	1.0	24.5	1.4	(2.5)	253	3.5	(10.0)	(5.0)	(0.5)
	5.0	20.0	5.5	(2.5)	249	–	–	8.3	–
	8.8	8.0	–	–	346	(2.0)	(10.0)	82.2	1.3

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

22.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 29 mg $CaCO_3$.

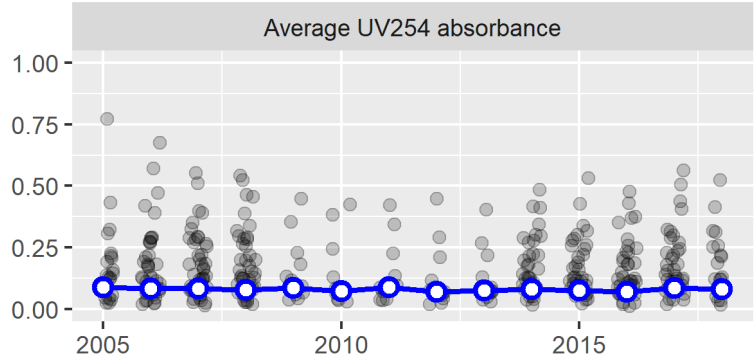
The blue points and line are annual average alkalinity values for Lake Lucerne. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -5.5 mg $CaCO_3$ (-15%) per decade.



22.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.08, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Lucerne. Grey points in the background are results for all other lakes in the Lake Stewardship program.



23.0 LAKE MARCEL: 2018

Thank you to Allan & Lee Culverwell, Peter Templin, and Andrew Wones, the volunteer monitors for Lake Marcel.

The key takeaways from the 2018 monitoring season are:

- Lake Marcel continued to have fairly clear water, with moderate nutrient concentrations and fairly high algal growth.
- Lake Marcel had a prolonged algal bloom in August through October. Toxin testing found elevated microcystin concentrations as high as 124 µg/L at times, above the Washington State Recreational Guideline of 6 µg/L.

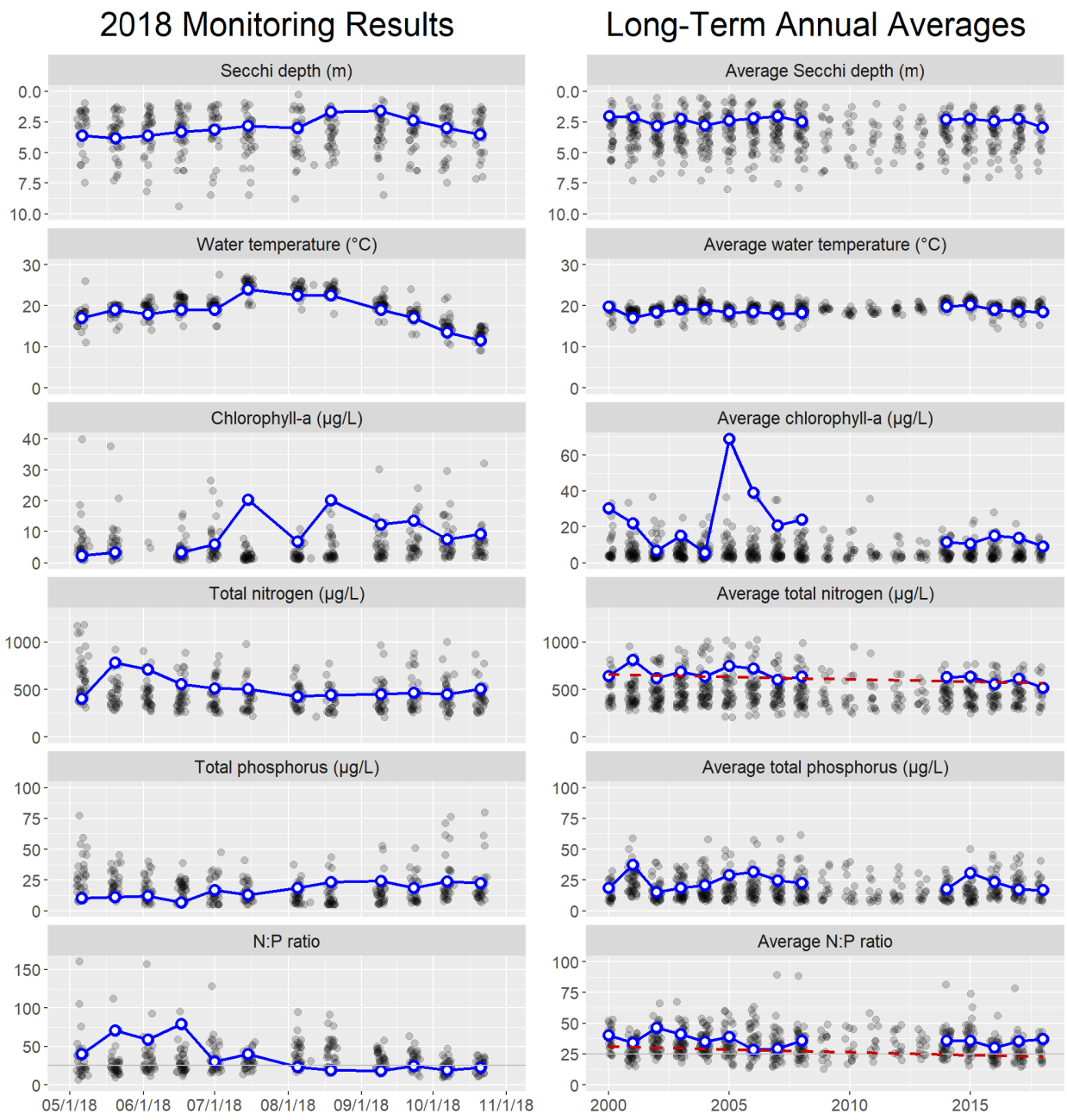
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Marcel – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Marcel through the Lake Stewardship Program.

23.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Marcel are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

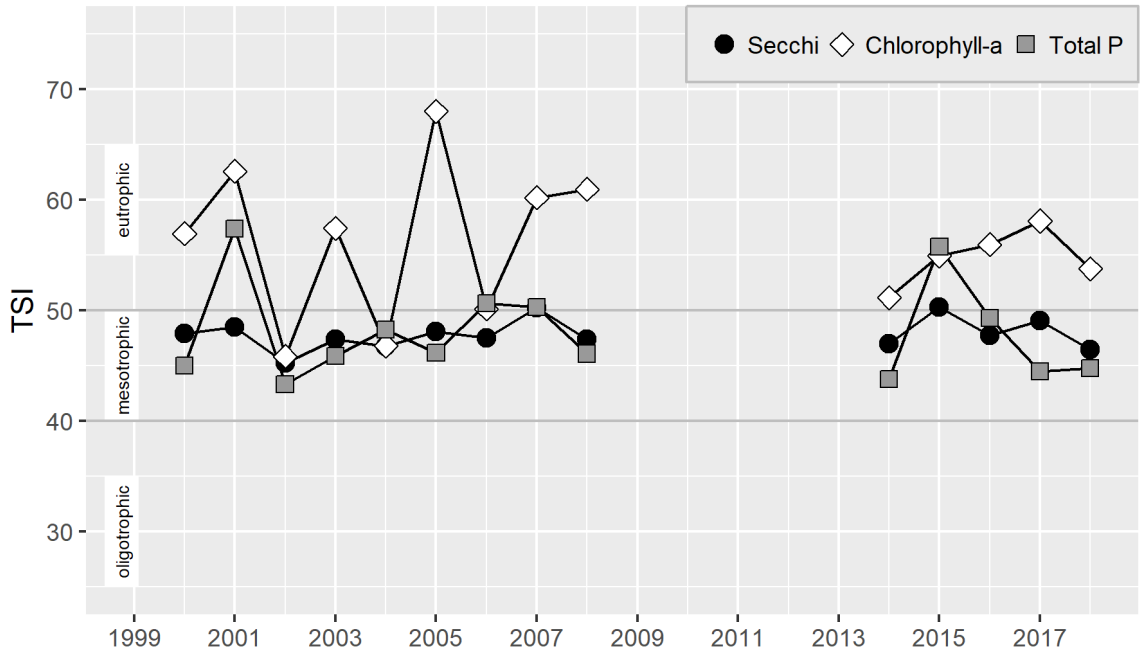


Nitrogen-to-phosphorus (N:P) ratios were below 25 from August through October, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins). This corresponds with the observed toxin-producing algal bloom. Higher chlorophyll concentrations were also observed during those months.

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2000, when monitoring started.

Parameter	Change per Decade	(%)
Total nitrogen	-52 µg/L	(-7.8%)
N:P ratio	-4.4	(-14%)

23.2 Trophic state



In 2018, the total-phosphorus and Secchi TSI values were in the mesotrophic range, while the chlorophyll TSI value was in the eutrophic range.

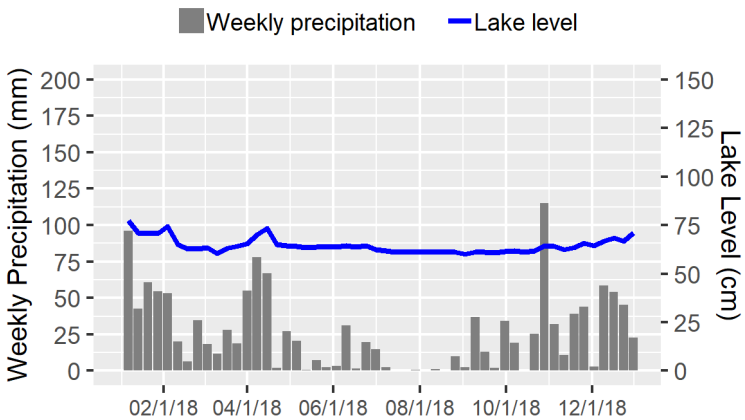
23.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	1.6	3.0	3.8
Water temperature (°C)	3.0	15.9	26.0
May-October statistics			
Secchi depth (m)	1.6	2.9	3.8
Water temperature (°C)	10.5	18.8	26.0
Chlorophyll-a (µg/L)	2.1	8.9	20.3
Total nitrogen (µg/L)	406.0	517.9	782.0
Total phosphorus (µg/L)	7.0	16.8	24.3
N:P ratio	18.6	37.2	79.3

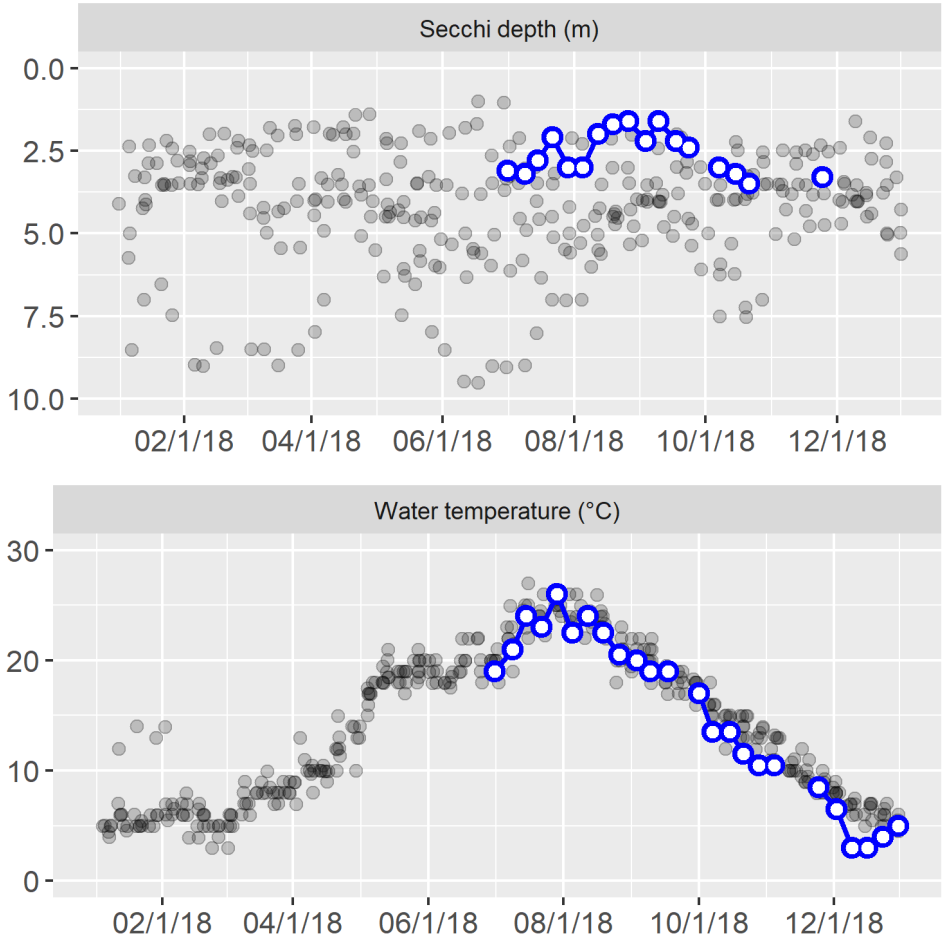
23.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



23.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Lake Marcel. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



23.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

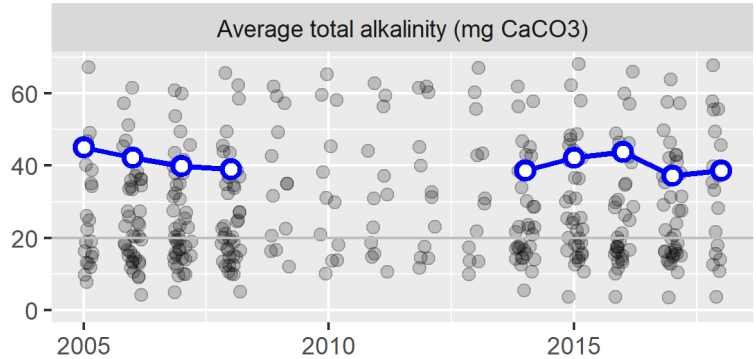
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	19.0	3.3	(2.0)	782	21.5	584.0	11.0	0.6
	3	–	6.0	1.3	797	20.2	571.0	16.6	(0.5)
8/19/2018	1	22.5	20.2	(2.0)	443	4.7	21.0	23.4	0.7
	3	22.0	16.5	3.7	448	32.6	24.0	29.6	0.7

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

23.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 38.7 mg $CaCO_3$.

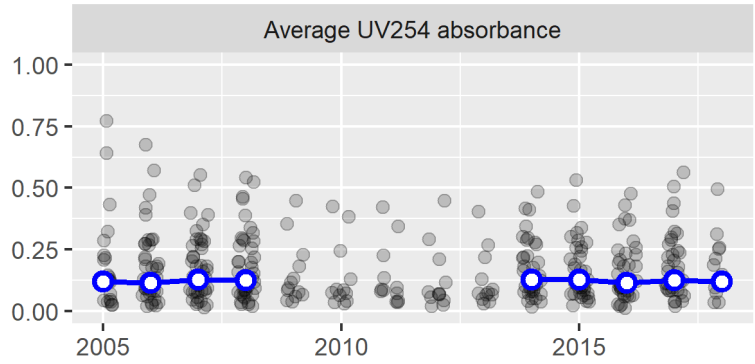
The blue points and line are annual average alkalinity values for Lake Marcel. Grey points in the background are results for all other lakes in the Lake Stewardship program.



23.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.12, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Marcel. Grey points in the background are results for all other lakes in the Lake Stewardship program.



24.0 LAKE MARGARET: 2018

Thank you to Jason Perez, the volunteer monitor for Lake Margaret.

The key takeaways from the 2018 monitoring season are:

- Lake Margaret had fairly low nutrient concentrations and moderate algal growth.
- An algal bloom was sampled for toxin testing in early May. No algal toxins were detected in this sample.

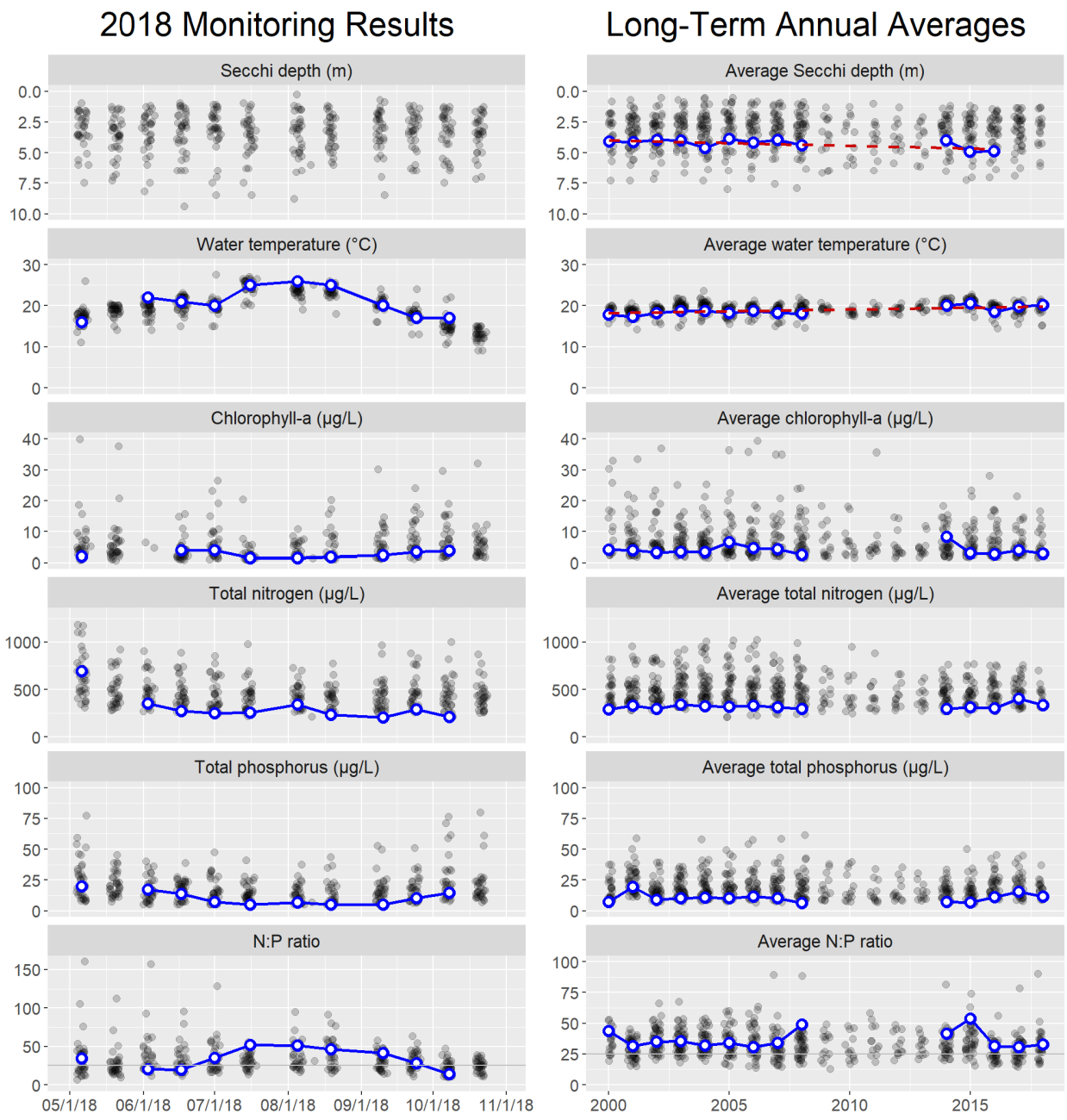
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Margaret – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Margaret through the Lake Stewardship Program.

24.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Margaret are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

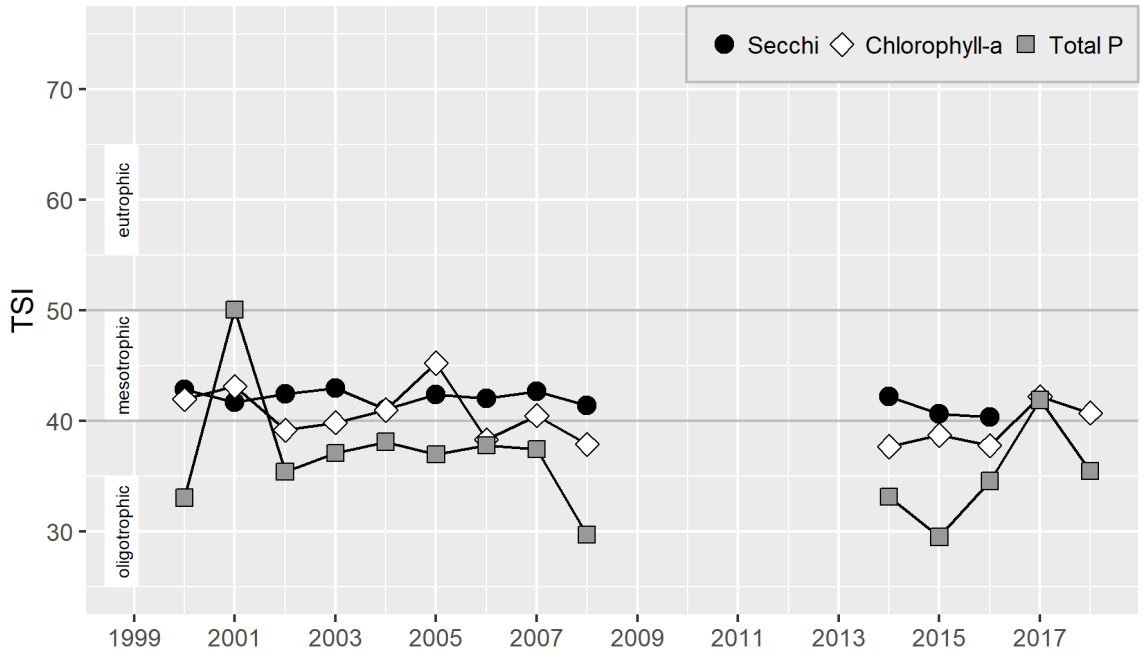


Secchi depth was not measured on Lake Margaret in 2017 or 2018. Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2000, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.42 m	(10%)
Water temperature	0.89 °C	(4.9%)

24.2 Trophic state



In 2018, the TSI values were in the oligotrophic range or near the oligotrophic-mesotrophic boundary. Note that the Secchi TSI was not calculated for 2017-2018, as Secchi depth was not measured those years.

24.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	–	–	–
Water temperature (°C)	16.0	20.2	26.0
Chlorophyll-a (µg/L)	1.5	2.8	4.0
Total nitrogen (µg/L)	207.0	334.1	691.0
Total phosphorus (µg/L)	5.0	11.7	20.1
N:P ratio	14.4	32.7	51.6

24.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

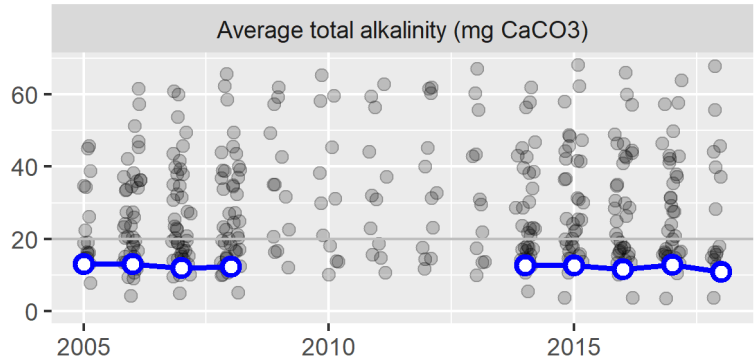
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	–	–	–	–	–	–	–	–
	5.5	–	–	–	–	–	–	–	–
	11.0	–	–	–	–	–	–	–	–
8/19/2018	1.0	25.0	1.8	(1.3)	233	2.2	(10.0)	(5.0)	0.6
	5.5	22.0	1.9	(1.3)	236	–	–	5.4	–
	10.0	8.0	–	–	1080	60.2	(10.0)	163.0	0.7

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

24.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 10.9 mg $CaCO_3$.

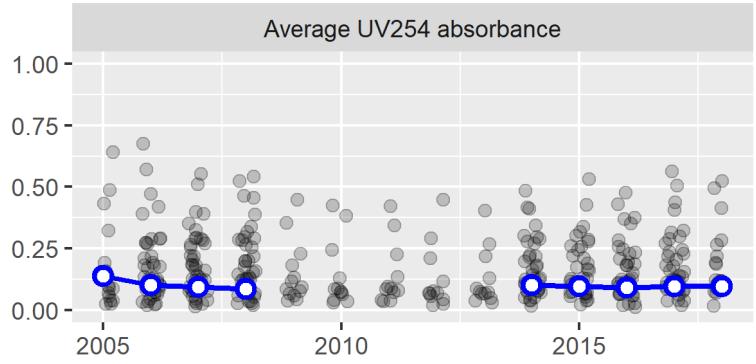
The blue points and line are annual average alkalinity values for Lake Margaret. Grey points in the background are results for all other lakes in the Lake Stewardship program.



24.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.1, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Margaret. Grey points in the background are results for all other lakes in the Lake Stewardship program.



25.0 LAKE MCDONALD: 2018

Thank you to Emily & David Treece, the volunteer monitors for Lake McDonald.

The key takeaways from the 2018 monitoring season are:

- Lake McDonald continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Long-term trends suggest that water quality in Lake McDonald has been improving over time, with decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths.
- An algal bloom was sampled for toxin testing in early June. No algal toxins were detected in this sample.

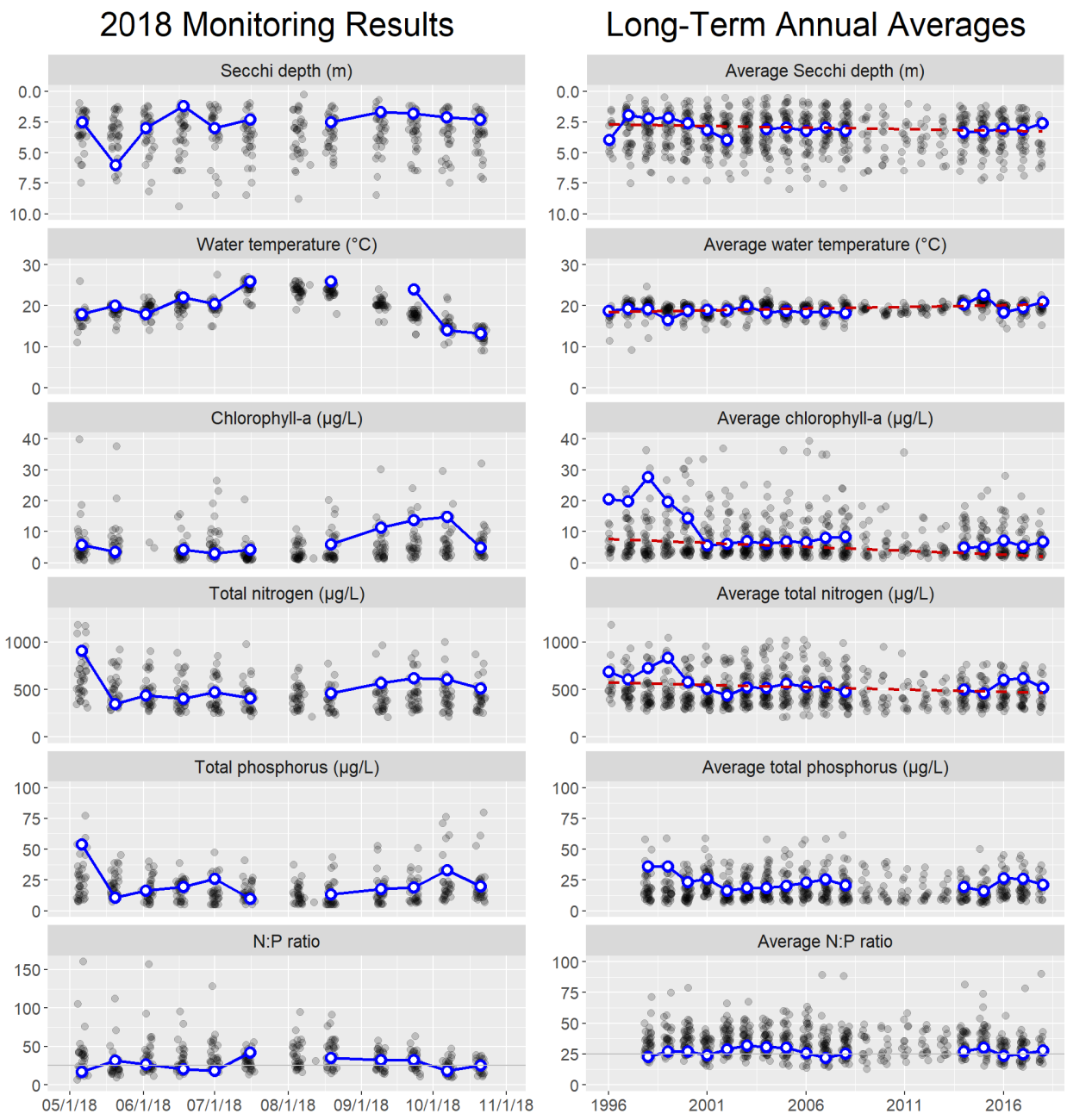
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake McDonald – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake McDonald through the Lake Stewardship Program.

25.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Mcdonald are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

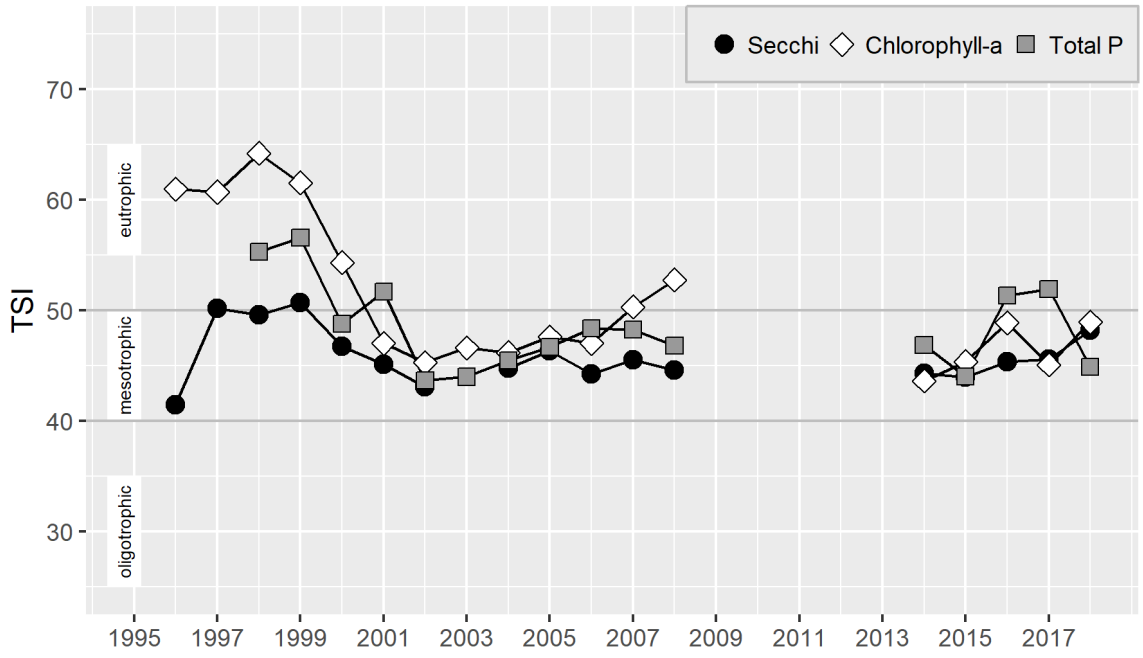
The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.26 m	(9.8%)
Water temperature	0.83 °C	(4.5%)
Total nitrogen	-49 µg/L	(-8.5%)

Long-term trends suggest that water quality in Lake McDonald has been improving over time, with decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths.

Chlorophyll concentrations in 1996-2000 were substantially higher than those observed from 2001 onwards. This trend is not described in the table above, since the estimates for the amount and percent of change assume a constant, linear trend – but the chlorophyll trend is distinctly non-linear. In the water-quality plots above, note that the red dashed trend line (the estimate of constant, linear change) is a poor fit for the actual data.

25.2 Trophic state



In 2018, the TSI values were in the mesotrophic range.

25.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.2	2.6	6.0
Water temperature (°C)	13.2	21.0	26.0
Chlorophyll-a (µg/L)	2.9	6.7	14.7
Total nitrogen (µg/L)	346.0	516.7	909.0
Total phosphorus (µg/L)	9.7	21.1	53.8
N:P ratio	16.9	27.9	42.1

25.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

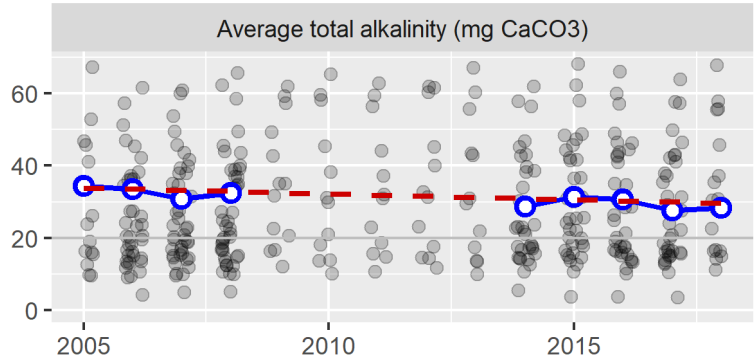
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	3.4	(1.0)	346	11.5	13.0	10.9	0.7
	7	6.0	10.6	(2.0)	717	–	–	39.3	–
	11	5.0	–	–	716	52.4	291.0	84.2	5.9
8/19/2018	1	26.0	5.9	(2.5)	460	5.8	(10.0)	13.2	1.1
	7	–	11.7	(4.0)	432	–	–	58.4	–
	10	–	–	–	–	–	–	–	–

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

25.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 28.2 mg $CaCO_3$.

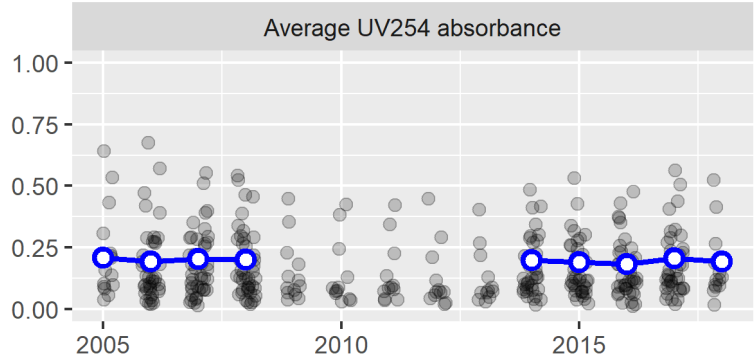
The blue points and line are annual average alkalinity values for Lake Mcdonald. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -3.3 mg $CaCO_3$ (-9.8%) per decade.



25.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.19, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Mcdonald. Grey points in the background are results for all other lakes in the Lake Stewardship program.



26.0 LAKE MORTON: 2018

Thank you to Chip deWitt and Paul Mueller, the volunteer monitors for Lake Morton.

The key takeaways from the 2018 monitoring season are:

- Lake Morton had fairly clear water, with low nutrient concentrations and moderately low algal growth.
- No algal blooms were reported for toxin testing in 2018.

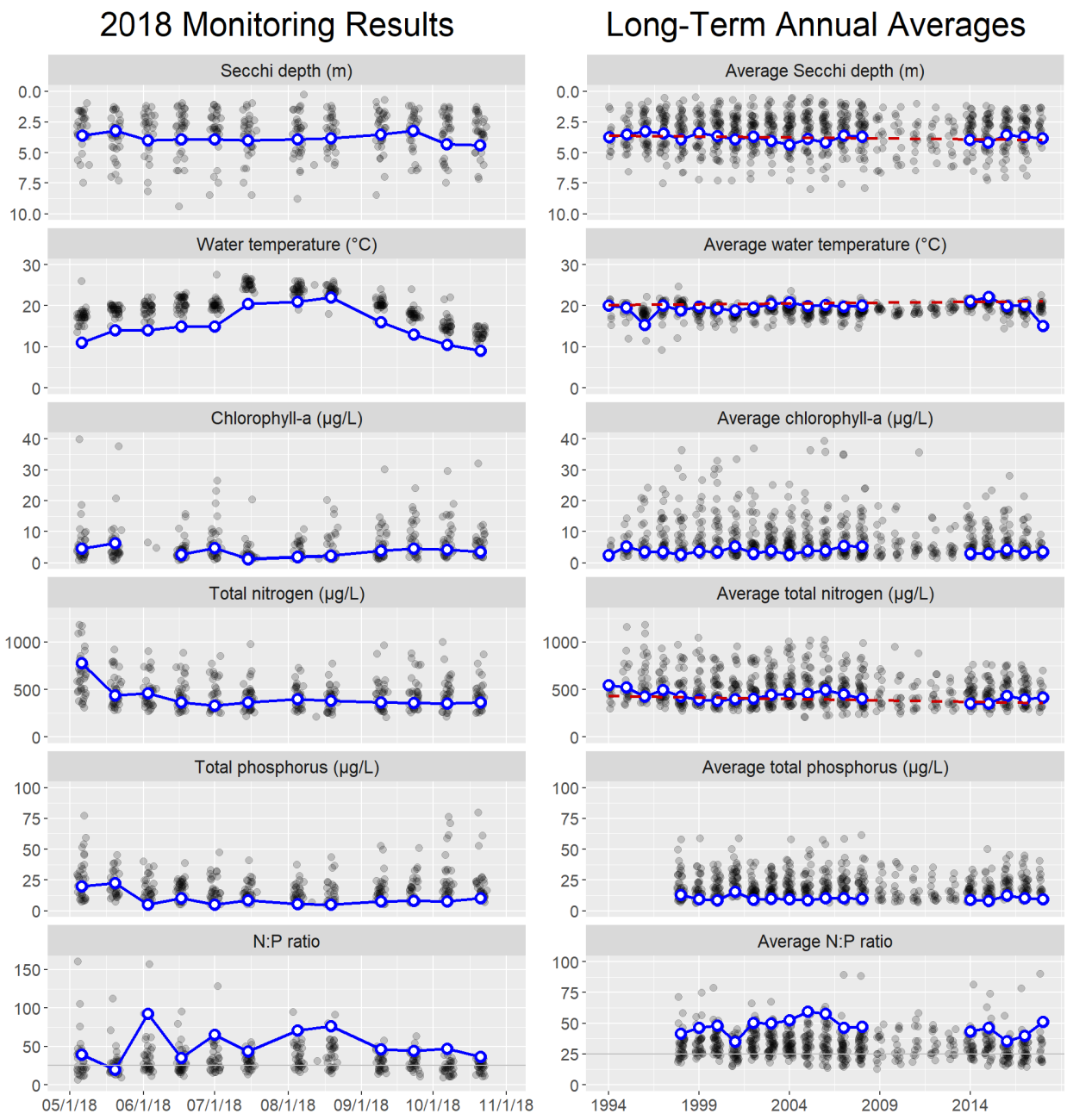
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Morton through the Lake Stewardship Program.

26.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Morton are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

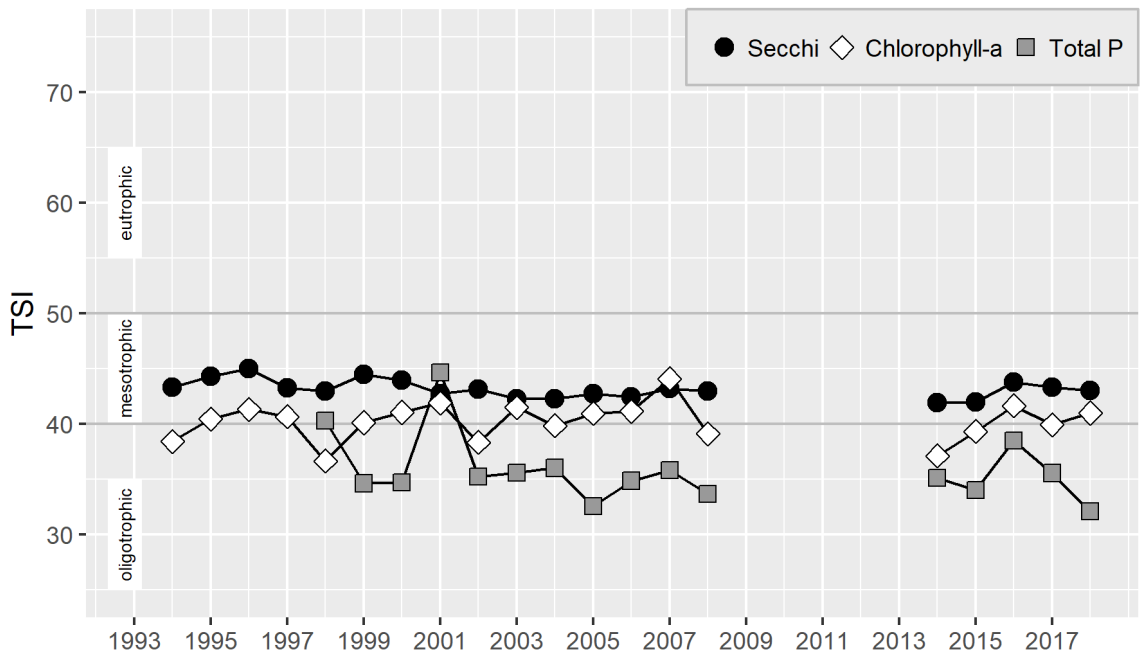


Nitrogen-to-phosphorus (N:P) ratios were above 25 for most of the monitoring season. This indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.15 m	(4.2%)
Water temperature	0.42 °C	(2.1%)
Total nitrogen	-30 µg/L	(-7.1%)

26.2 Trophic state



In 2018, the total-phosphorus TSI value was in the oligotrophic range, and the chlorophyll and Secchi TSI values were in the mesotrophic range.

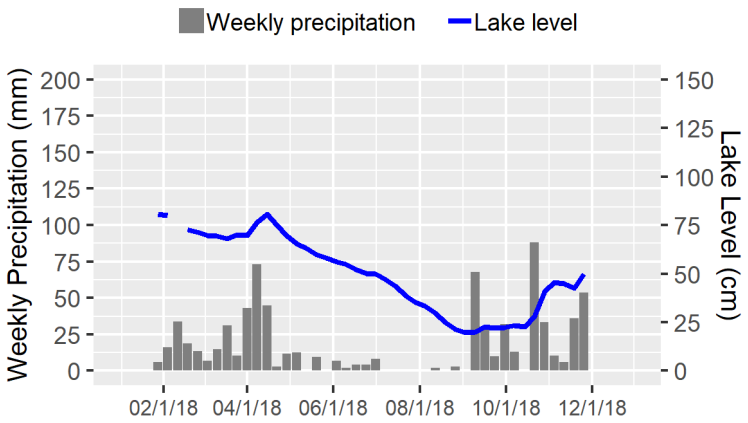
26.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	3.2	3.8	4.4
Water temperature (°C)	9.0	15.1	22.0
Chlorophyll-a (µg/L)	1.1	3.5	6.2
Total nitrogen (µg/L)	327.0	413.1	780.0
Total phosphorus (µg/L)	5.0	9.6	22.5
N:P ratio	19.5	51.3	92.6

26.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



26.5 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

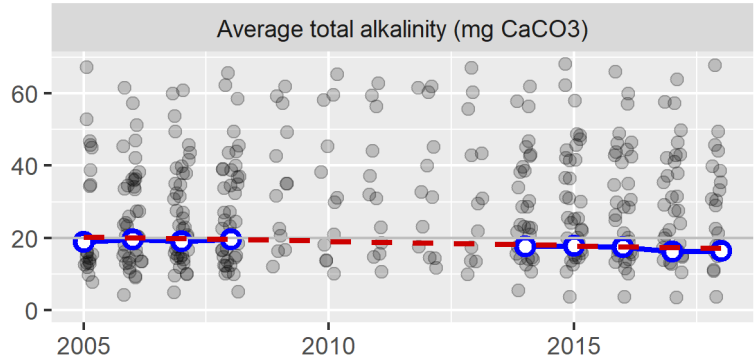
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	14.0	6.2	(2.0)	438	17.9	80.5	22.5	0.8
	2.5	13.0	8.4	(1.0)	458	–	–	15.4	–
	4.0	9.0	15.1	(2.0)	553	44.0	83.9	20.2	0.6
8/19/2018	1.0	22.0	2.1	(1.7)	381	2.6	(10.0)	(5.0)	(0.5)
	2.5	20.0	2.4	(2.5)	386	–	–	(5.0)	–
	4.0	20.0	2.0	(1.0)	371	6.2	(10.0)	(5.0)	0.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

26.6 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 16.3 mg $CaCO_3$.

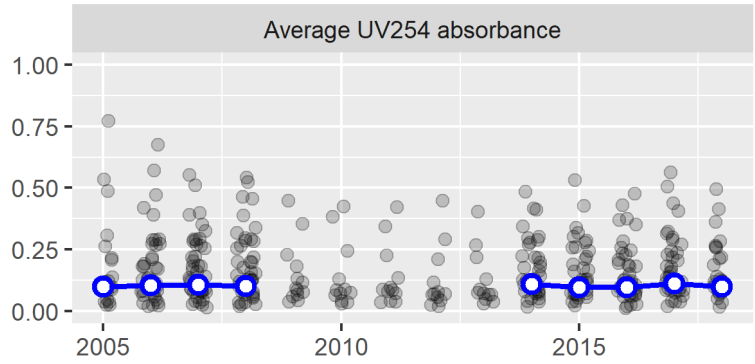
The blue points and line are annual average alkalinity values for Lake Morton. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -2.5 mg $CaCO_3$ (-12%) per decade.



26.7 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.1, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Morton. Grey points in the background are results for all other lakes in the Lake Stewardship program.



27.0 NEILSON LAKE: 2018

Thank you to Mark and Wendy Nygren, the volunteer monitors for Neilson Lake.

The key takeaways from the 2018 monitoring season are:

- Neilson Lake continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- No algal blooms were reported for toxin testing in 2018.

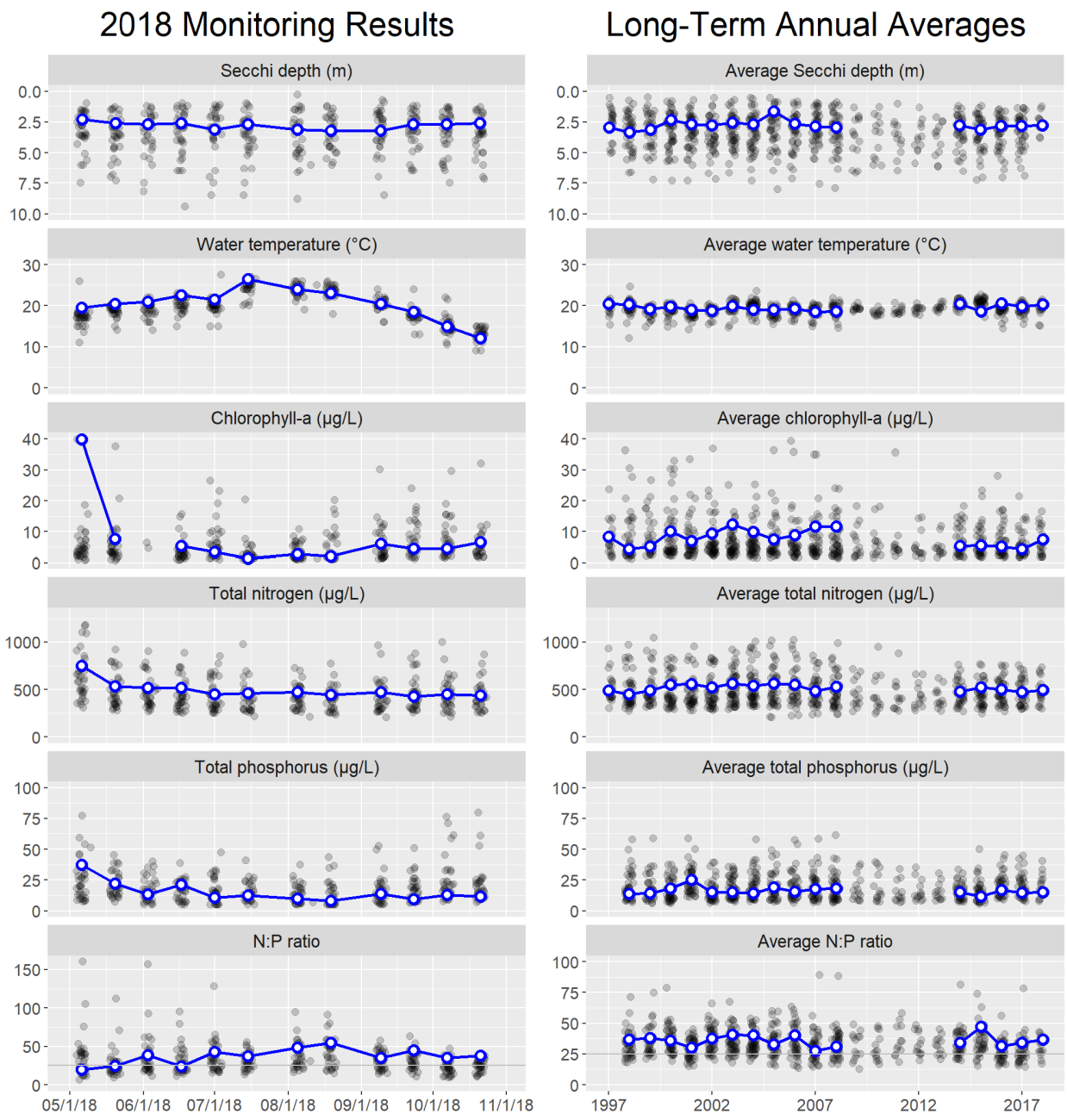
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Neilson Lake through the Lake Stewardship Program.

27.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Neilson Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

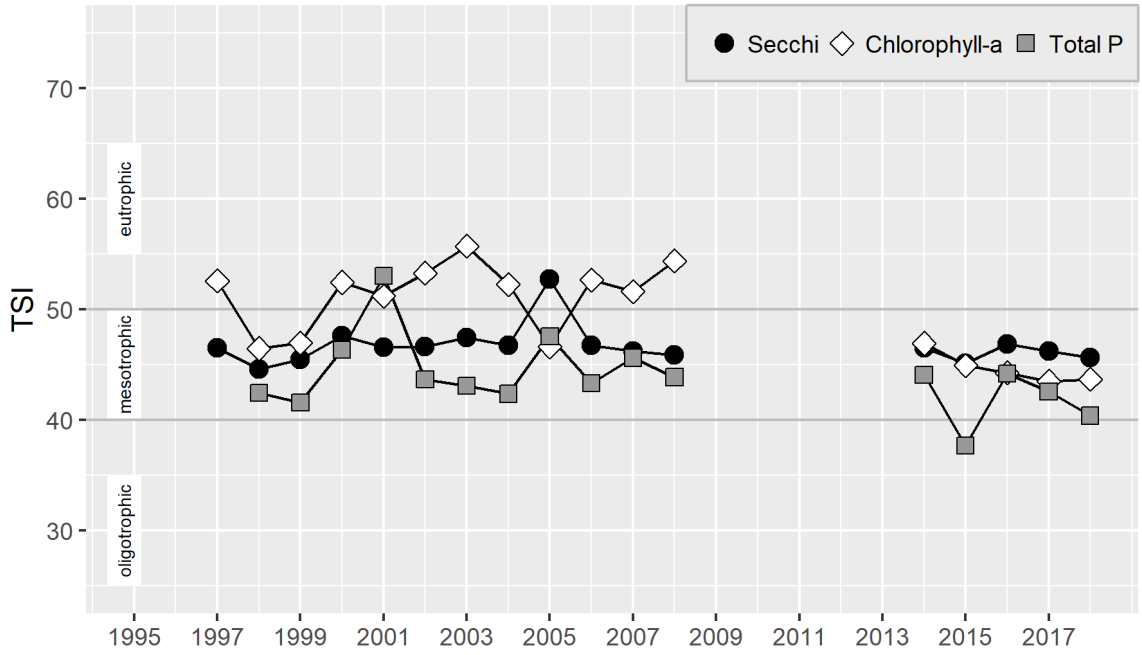
To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Nitrogen-to-phosphorus (N:P) ratios were occasionally below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

Neilson Lake does not have any long-term trends.

27.2 Trophic state



In 2018, the TSI values were in the mesotrophic range.

27.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	2.3	2.8	3.2
Water temperature (°C)	12.0	20.4	26.5
Chlorophyll-a (µg/L)	1.4	7.4	39.8
Total nitrogen (µg/L)	428.0	494.5	748.0
Total phosphorus (µg/L)	8.1	15.2	37.4
N:P ratio	20.0	36.9	54.6

27.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

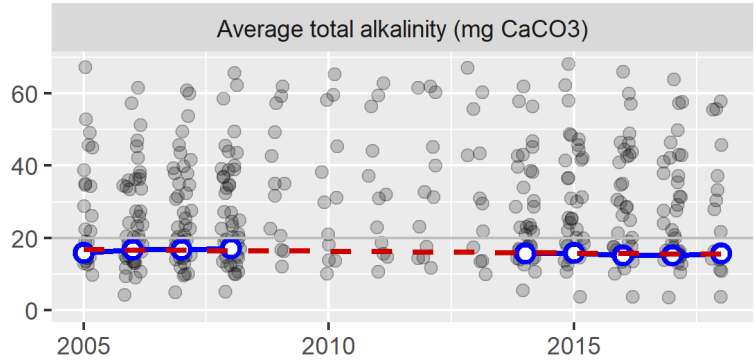
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.5	7.6	(2.0)	536	10.0	(10.0)	21.9	0.8
	4	13.0	7.6	1.2	466	–	–	21.7	–
	8	10.0	–	–	567	68.4	94.1	47.6	5.6
8/19/2018	1	23.0	2.0	(1.0)	442	3.7	(10.0)	8.1	0.8
	4	15.0	7.5	3.4	440	–	–	11.7	–
	8	10.0	–	–	1170	641.0	(10.0)	181.0	19.8

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

27.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 15.8 mg $CaCO_3$.

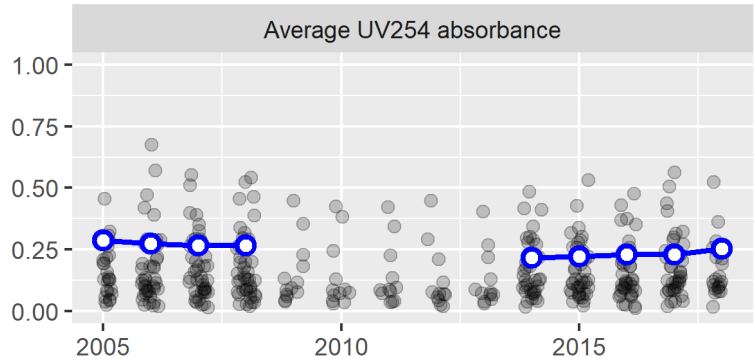
The blue points and line are annual average alkalinity values for Neilson Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -1 mg $CaCO_3$ (-6%) per decade.



27.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.25, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Neilson Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



28.0 PARADISE LAKE: 2018

Thank you to Shirley Doolittle, the volunteer monitor for Paradise Lake.

The key takeaways from the 2018 monitoring season are:

- Paradise Lake had fairly clear water, with moderate nutrient concentrations and fairly high algal growth.
- No algal blooms were reported for toxin testing in 2018.

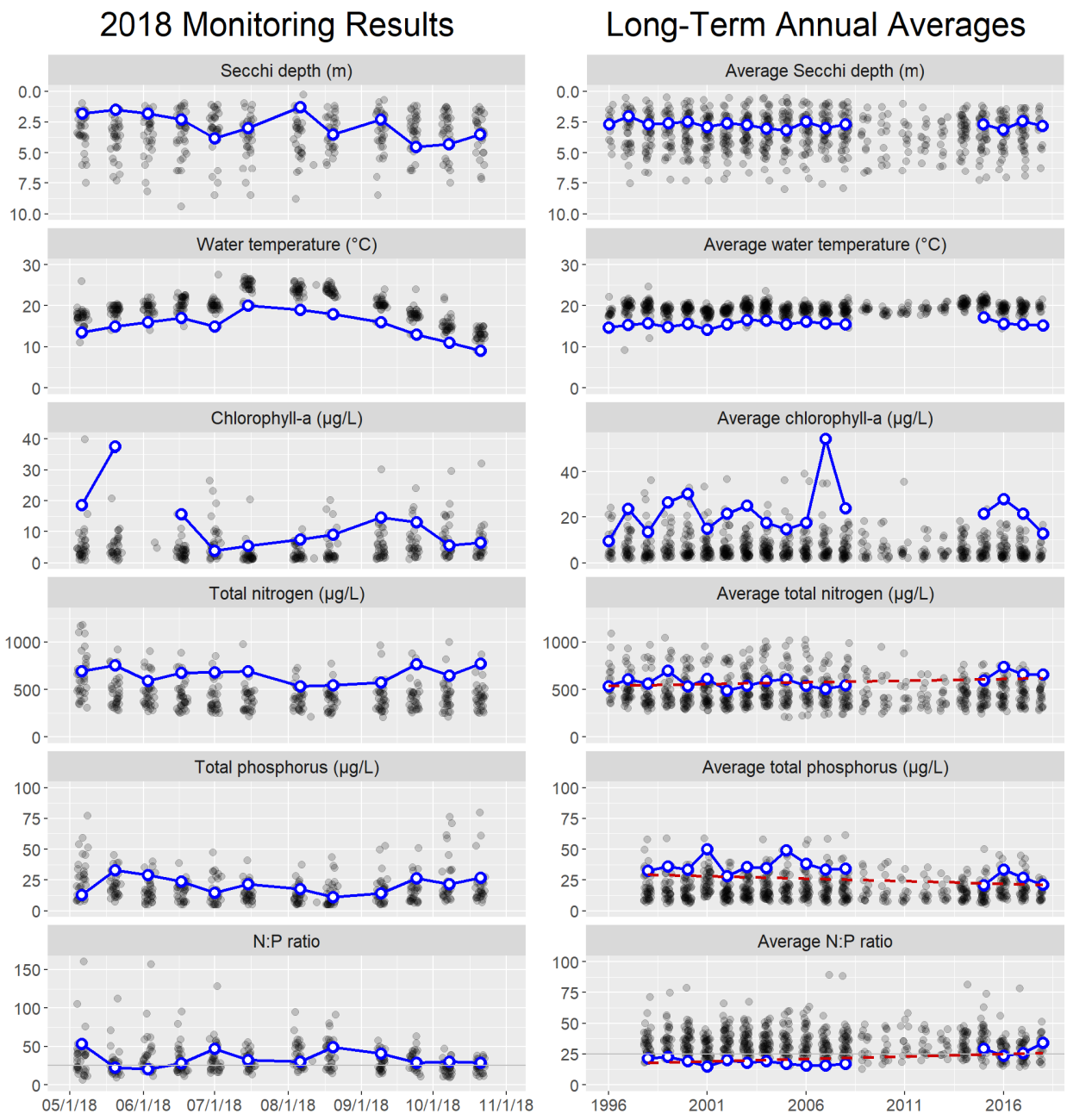
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Paradise Lake through the Lake Stewardship Program.

28.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Paradise Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



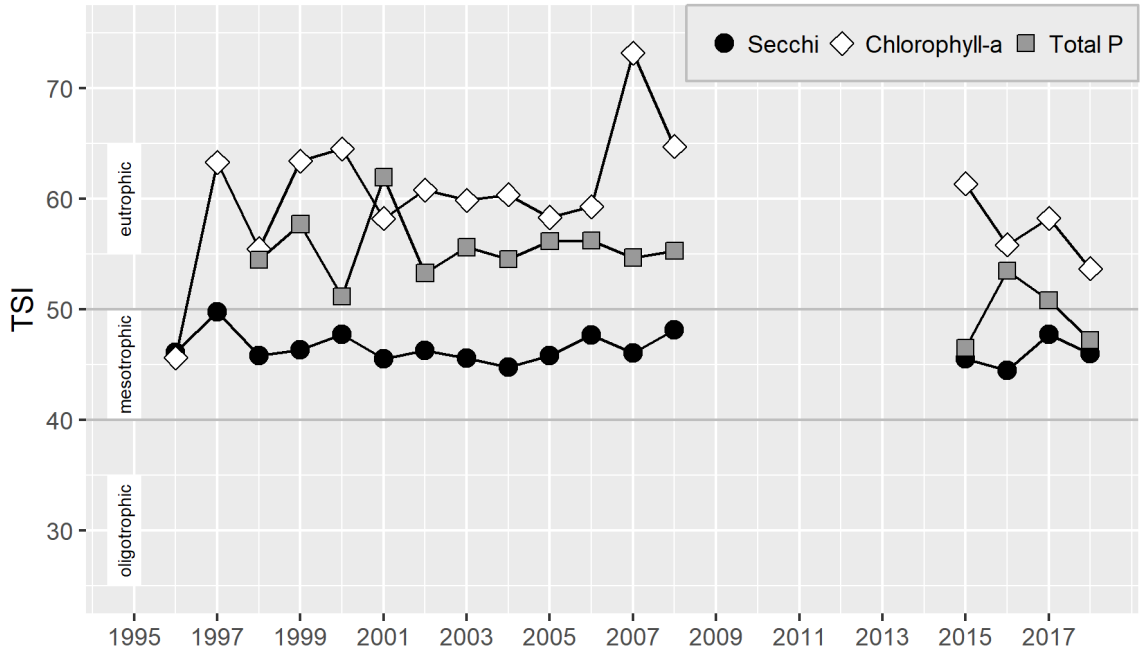
Nitrogen-to-phosphorus (N:P) ratios were occasionally below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Total nitrogen	37 µg/L	(6.8%)
Total phosphorus	-4 µg/L	(-13%)
N:P ratio	3.9	(22%)

Paradise Lake has contrasting trends in nitrogen and phosphorus concentrations, which is not common. Nitrogen concentrations have increased over time, while phosphorus concentrations have decreased.

28.2 Trophic state



In 2018, the total-phosphorus and Secchi TSI values were in the mesotrophic range, and the chlorophyll TSI value was in the eutrophic range.

28.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.3	2.8	4.5
Water temperature (°C)	9.0	15.2	20.0
Chlorophyll-a (µg/L)	3.8	12.7	37.5
Total nitrogen (µg/L)	534.0	661.1	773.0
Total phosphorus (µg/L)	11.1	21.1	33.2
N:P ratio	20.3	34.3	53.2

28.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

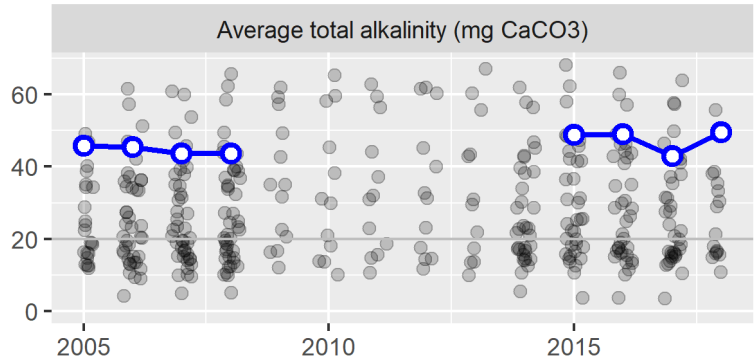
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	15.0	37.5	4.5	758	2.7	332.0	33.2	2.2
	4	7.0	13.1	15.6	693	–	–	22.1	–
	7	6.0	–	–	694	42.8	416.0	33.3	3.2
8/20/2018	1	18.0	9.0	(1.2)	547	27.0	259.0	11.1	0.6
	4	14.0	5.8	(1.3)	607	–	–	24.2	–
	7	6.0	–	–	1190	866.0	(10.0)	216.0	45.3

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

28.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 49.5 mg $CaCO_3$.

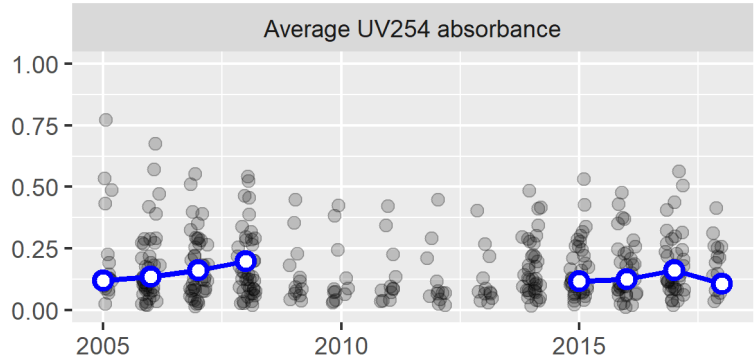
The blue points and line are annual average alkalinity values for Paradise Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



28.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.11, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Paradise Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



29.0 PINE LAKE: 2018

Thank you to Kate Bradley and Peter Breining, the volunteer monitors for Pine Lake.

The key takeaways from the 2018 monitoring season are:

- Pine Lake continued to have clear water, with low nutrient concentrations and low algal growth.
- Long-term trends suggest that water quality in Pine Lake has been improving over time, with decreasing nitrogen and chlorophyll concentrations.
- No algal blooms were reported for toxin testing in 2018.

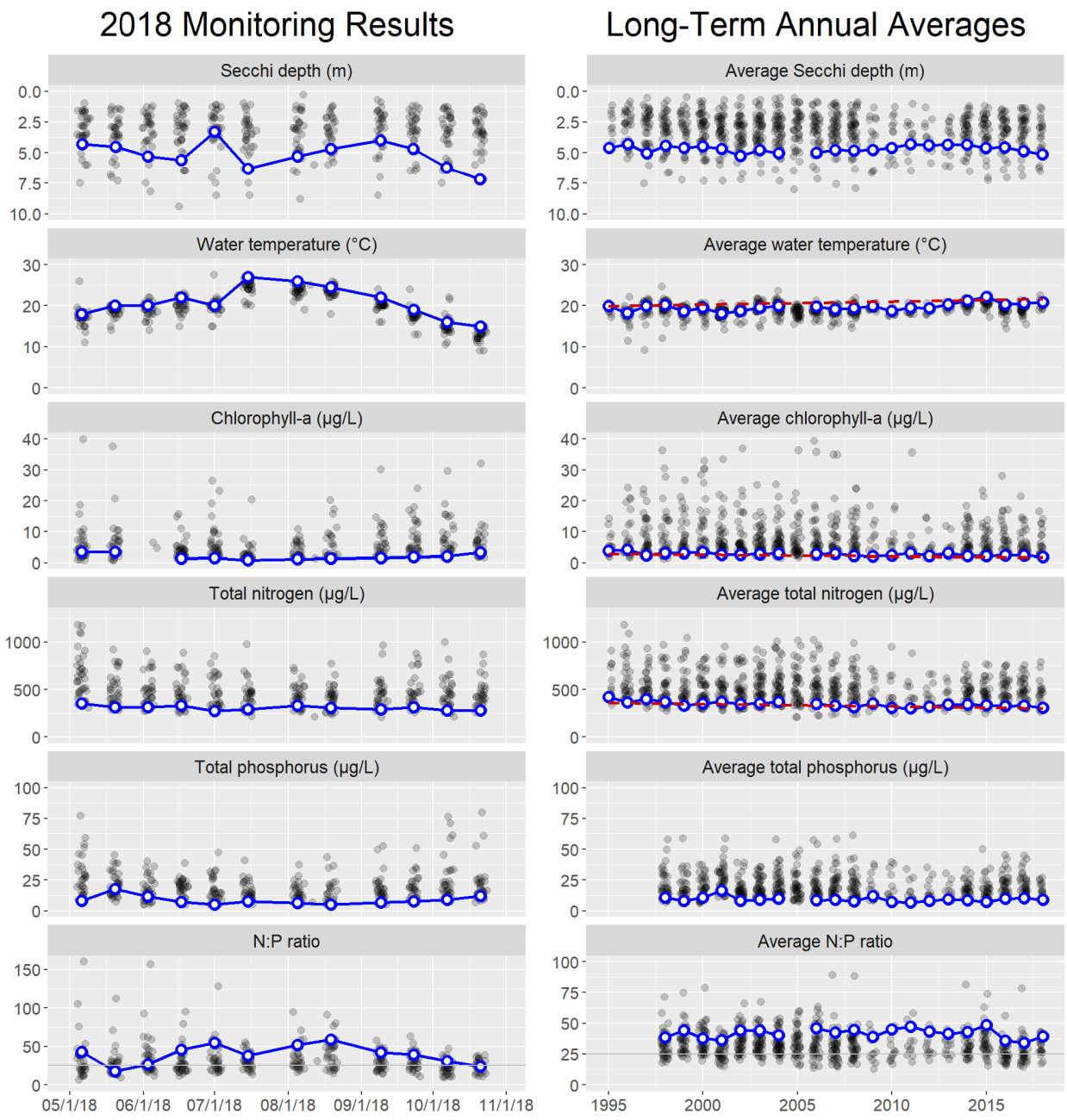
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Pine Lake through the Lake Stewardship Program.

29.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Pine Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



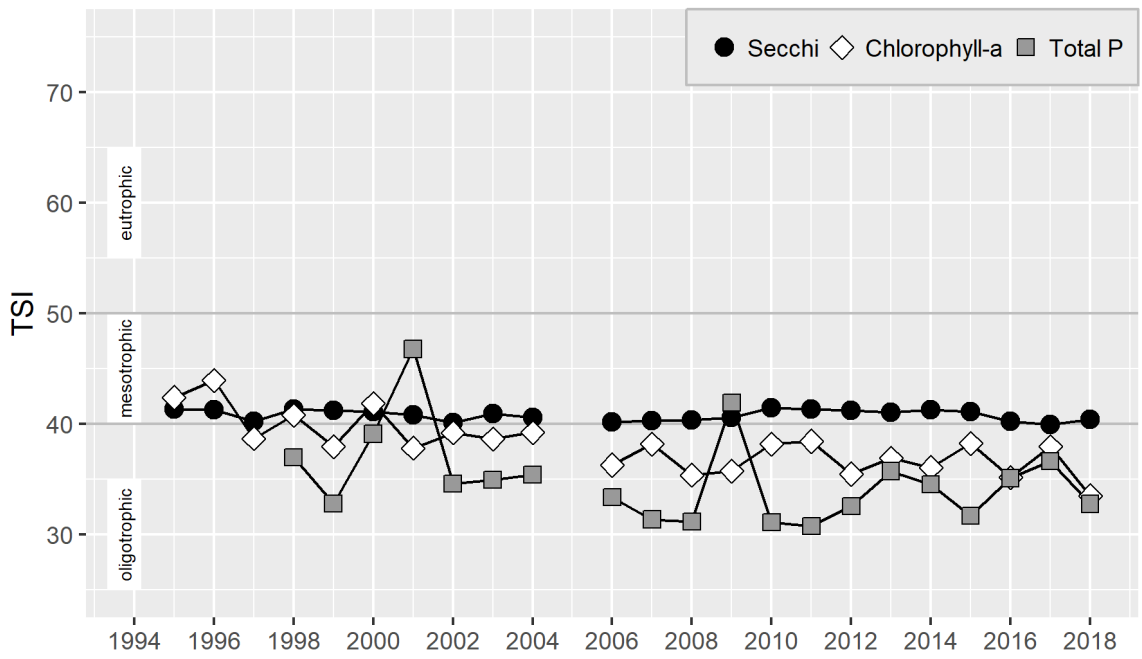
Nitrogen-to-phosphorus (N:P) ratios were above 25 for most of the monitoring season. This indicates a low likelihood for the algal community to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1995, when monitoring started.

Parameter	Change per Decade	(%)
Water temperature	0.74 °C	(3.7%)
Chlorophyll-a	-0.47 µg/L	(-17%)
Total nitrogen	-26 µg/L	(-7.3%)

Long-term trends suggest that water quality in Pine Lake has been improving over time, with decreasing nitrogen and chlorophyll concentrations. The data suggest that phosphorus concentrations may also have a decreasing trend, but the trend is not statistically robust (p=0.15).

29.2 Trophic state



In 2018, the TSI values were in or near the oligotrophic range.

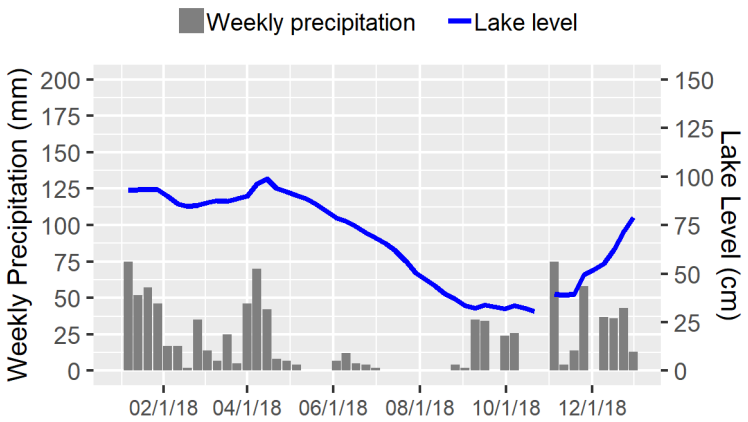
29.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.9	4.6	7.2
Water temperature (°C)	7.0	15.9	27.0
May-October statistics			
Secchi depth (m)	3.3	5.2	7.2
Water temperature (°C)	15.0	20.8	27.0
Chlorophyll-a (µg/L)	0.9	1.9	3.4
Total nitrogen (µg/L)	275.0	306.2	353.0
Total phosphorus (µg/L)	5.0	8.8	17.9
N:P ratio	17.5	39.2	58.8

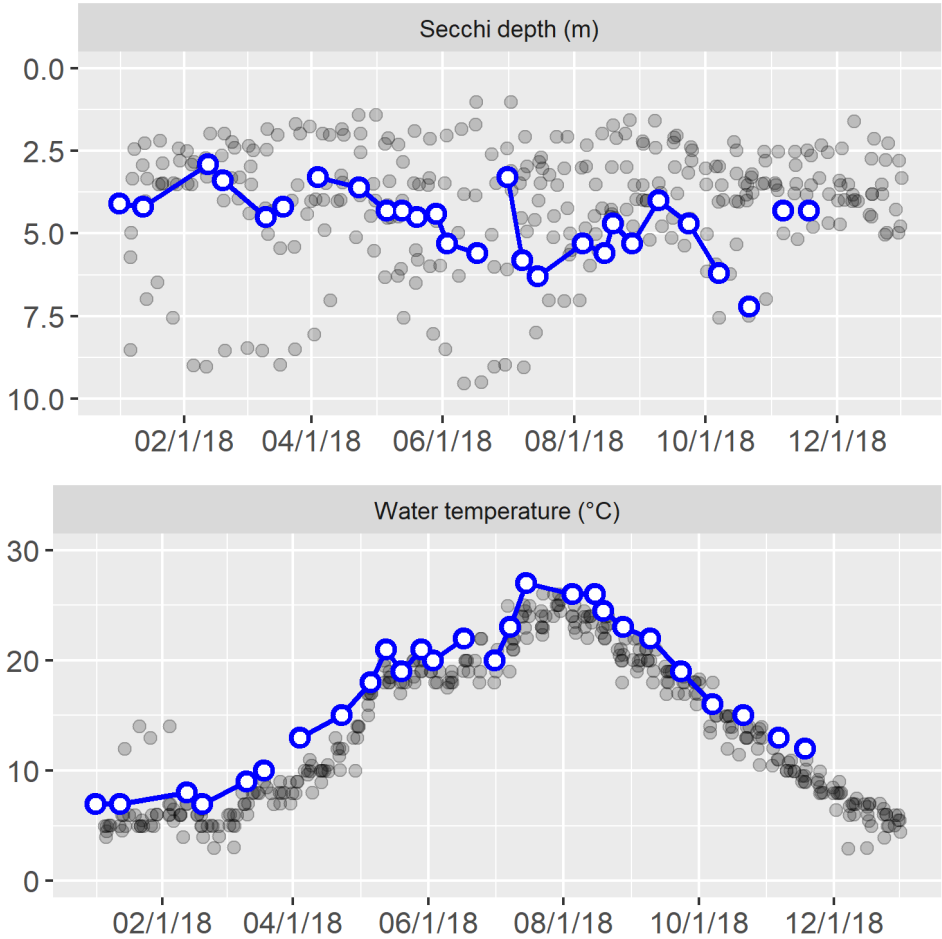
29.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



29.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Pine Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



29.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

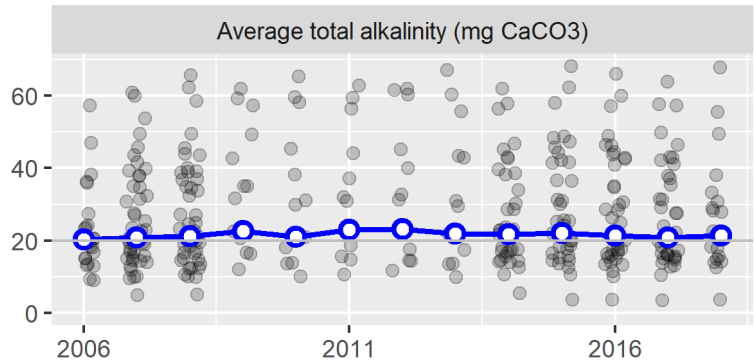
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	20.0	3.4	(1.4)	314	6.1	(10.0)	17.9	1.0
	4.5	19.0	10.0	(2.0)	326	–	–	15.0	–
	9.0	8.0	–	–	406	76.7	75.4	19.9	1.7
8/19/2018	1.0	24.5	1.3	(1.2)	306	3.1	(10.0)	5.2	0.6
	4.5	24.0	2.0	(1.3)	317	–	–	5.6	–
	9.0	10.0	–	–	350	2.0	(10.0)	54.0	3.7

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

29.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 21.3 mg $CaCO_3$.

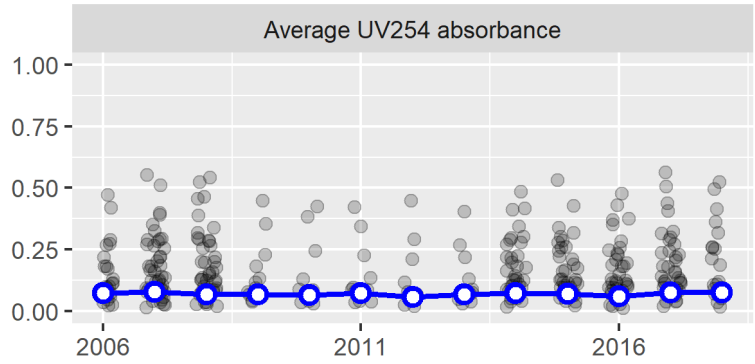
The blue points and line are annual average alkalinity values for Pine Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



29.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.08, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Pine Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



30.0 PIPE LAKE: 2018

Thank you to Tom Sullivan, the volunteer monitor for Pipe Lake.

The key takeaways from the 2018 monitoring season are:

- Pipe Lake continued to have clear water, low nutrient concentrations, and low algal growth.
- Pipe Lake has one of the deepest Secchi depths (clearest water) of any lake in the Lake Stewardship program. Secchi depths have been getting even deeper over time.
- Long-term trends suggest that water quality in Pipe Lake has been improving over time, with decreasing nitrogen, phosphorus, and chlorophyll concentrations in addition to the deeper Secchi depths.
- An algal bloom was sampled for toxin testing in early May. Toxin testing found very low concentrations of algal toxins, well below the Washington State Recreational Guidelines.

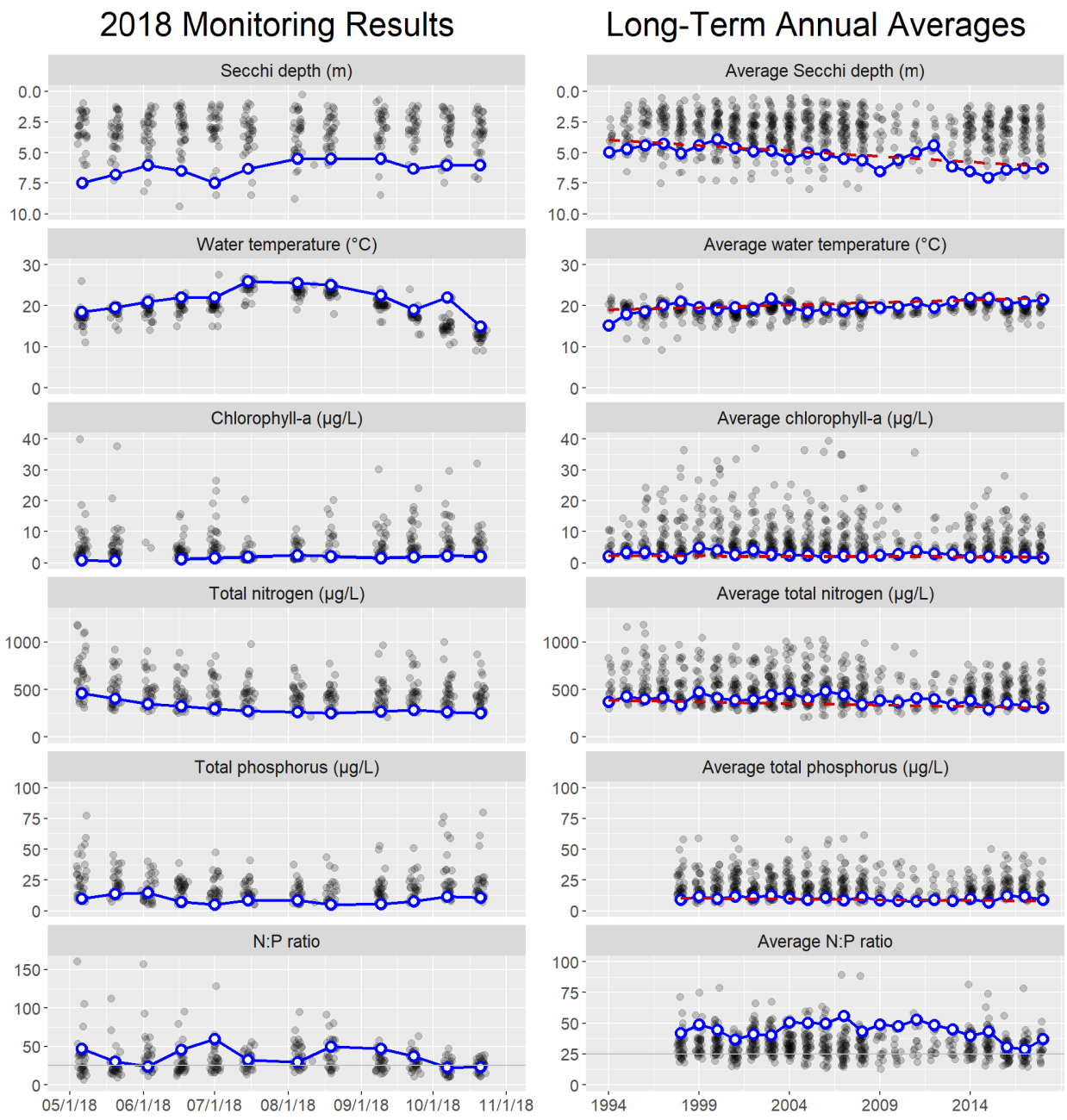
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Pipe Lake through the Lake Stewardship Program.

30.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Pipe Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



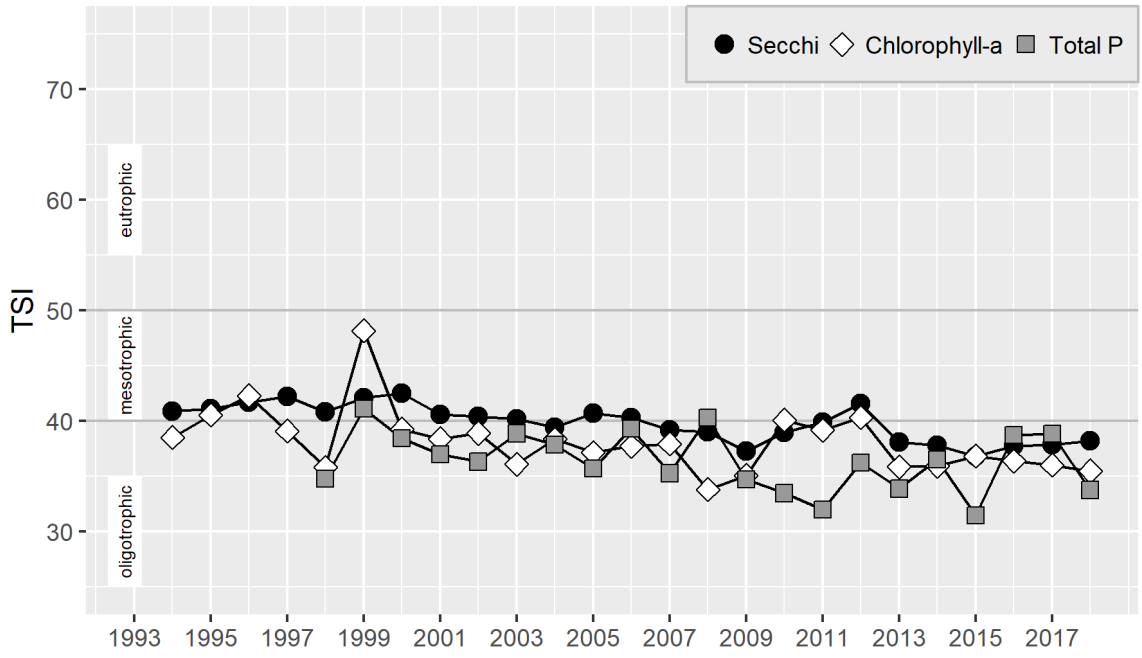
Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.88 m	(22%)
Water temperature	1.2 °C	(6.1%)
Chlorophyll-a	-0.2 µg/L	(-8.8%)
Total nitrogen	-33 µg/L	(-8.6%)
Total phosphorus	-1.1 µg/L	(-10%)

Long-term trends suggest that water quality in Pipe Lake has been improving over time, with decreasing nitrogen, phosphorus, and chlorophyll concentrations, and deeper Secchi depths. The trend of deeper Secchi depths (clearer water) in Pipe Lake is especially noticeable. On average, Secchi depths in recent years have been about 1.5 m deeper than they were in the mid-1990s when monitoring began.

30.2 Trophic state



In 2018, the TSI values were in the oligotrophic range.

30.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	5.5	6.3	7.5
Water temperature (°C)	15.0	21.5	26.0
Chlorophyll-a (µg/L)	0.7	1.6	2.3
Total nitrogen (µg/L)	248.0	306.2	458.0
Total phosphorus (µg/L)	5.0	9.0	14.7
N:P ratio	22.6	37.3	59.4

30.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

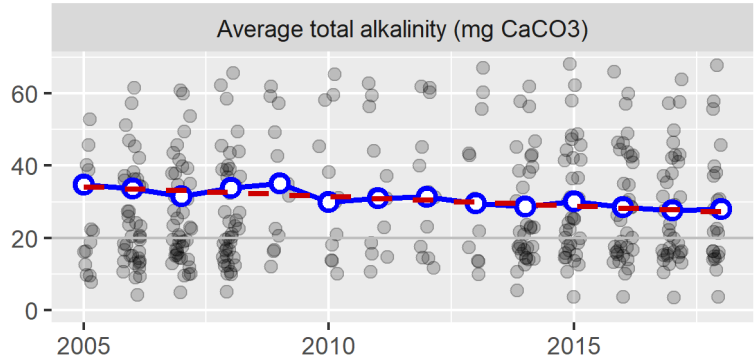
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	19.5	0.7	(1.3)	406	32.6	136.0	13.6	0.8
	10	9.5	(0.6)	(1.3)	500	–	–	11.1	–
	19	7.0	–	–	582	31.8	342.0	41.1	9.2
8/19/2018	1	25.0	2.0	(1.4)	248	2.3	(10.0)	(5.0)	(0.5)
	10	8.5	1.2	1.7	453	–	–	8.0	–
	19	7.0	–	–	585	383.0	(10.0)	115.0	4.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

30.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 27.9 mg $CaCO_3$.

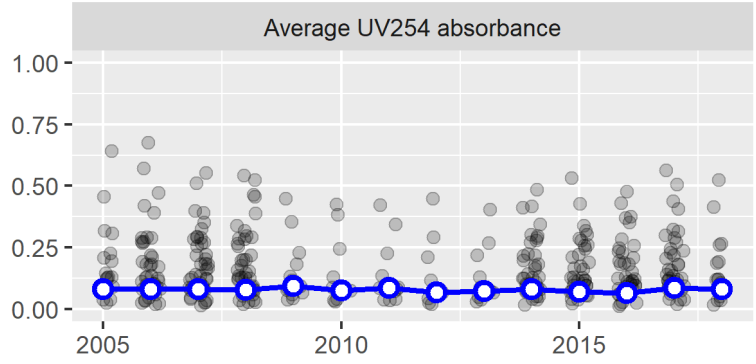
The blue points and line are annual average alkalinity values for Pipe Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -5.3 mg $CaCO_3$ (-15%) per decade.



30.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.08, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Pipe Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



31.0 LAKE RETREAT: 2018

Thank you to Todd & Janice Hammerstrom, and Tony, Gretchen, Adam, Anya, & Jillian Wulfing, the volunteer monitors for Lake Retreat.

The key takeaways from the 2018 monitoring season are:

- Lake Retreat had two distinct phases in 2018. Before mid-August, it had very clear water with low algal growth. After mid-August, it had moderately clear water and moderate algal growth.
- Lake Retreat had fairly low phosphorus concentrations, but fairly high nitrogen concentrations.
- Long-term trends suggest that water quality in Lake Retreat has been declining over time, with increasing nitrogen and phosphorus concentrations, and shallower Secchi depths.
- No algal blooms were reported for toxin testing in 2018.

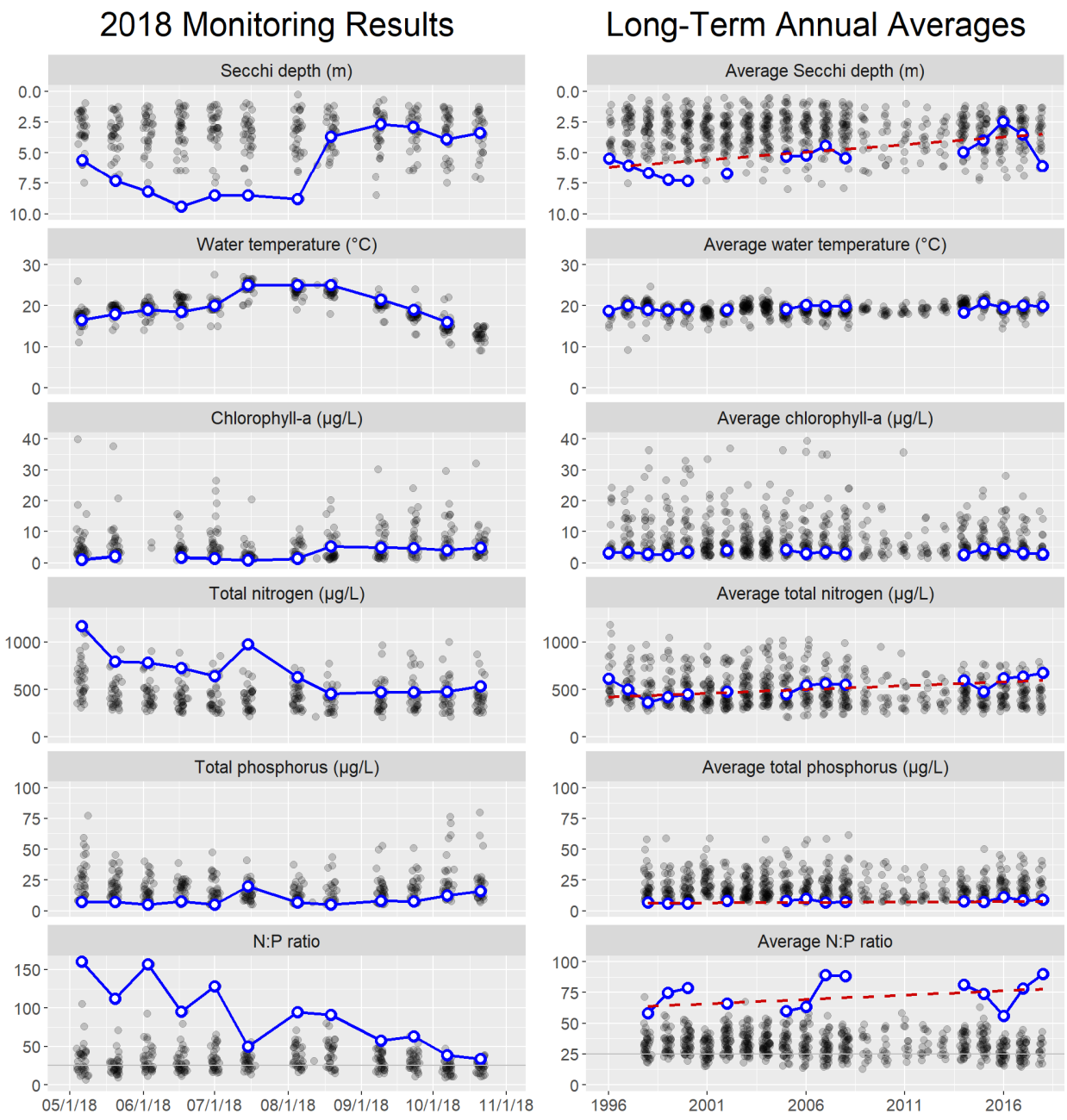
The Lake Stewardship Program recommends:

- Explore why nutrient concentrations have been increasing over time. If this increase continues, it could lead to more algal blooms in the future.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Retreat through the Lake Stewardship Program.

31.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Retreat are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



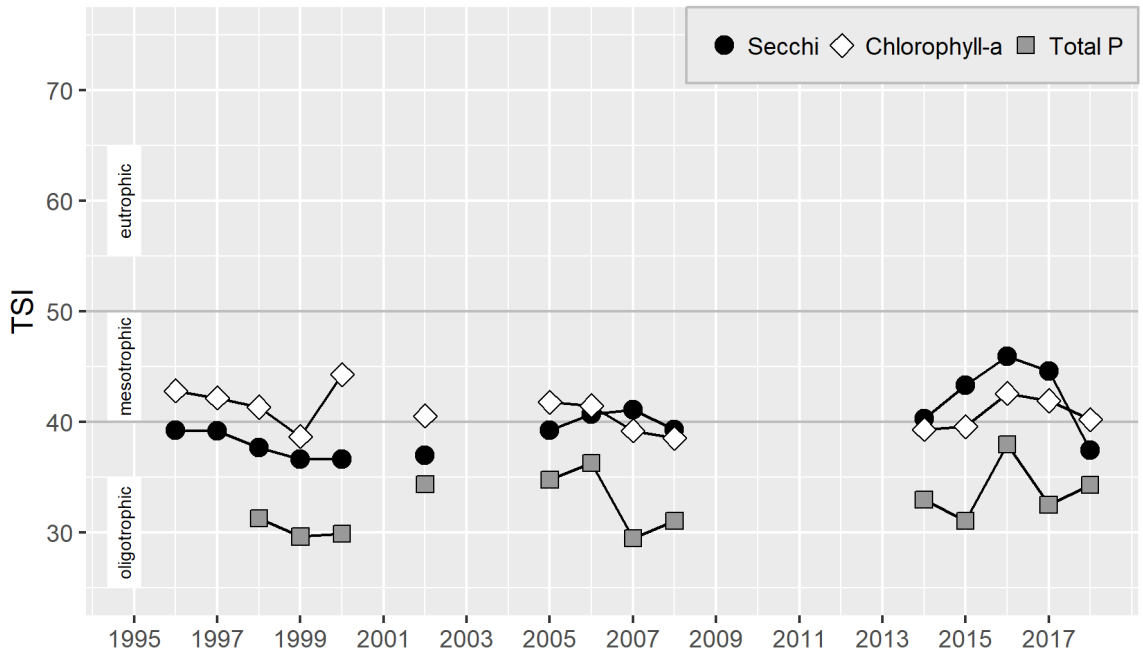
Lake Retreat had a noticeable shift in mid-August. Before that time, it had very deep Secchi depths (clear water), and low chlorophyll concentrations (<1 µg/L). After mid-August, it had much shallower Secchi depths, and chlorophyll concentrations were over four times higher (4 to 5 µg/L).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-1.2 m	(-20%)
Total nitrogen	81 µg/L	(19%)
Total phosphorus	0.73 µg/L	(12%)
N:P ratio	6.8	(11%)

Long-term trends suggest that water quality in Lake Retreat has been declining over time, with increasing nitrogen and phosphorus concentrations, and shallower Secchi depths.

31.2 Trophic state



Note that these TSI values are June-September averages, which obscure the changes in mid-August. Lake Retreat was in an oligotrophic state in June and July, and a mesotrophic state in August and September.

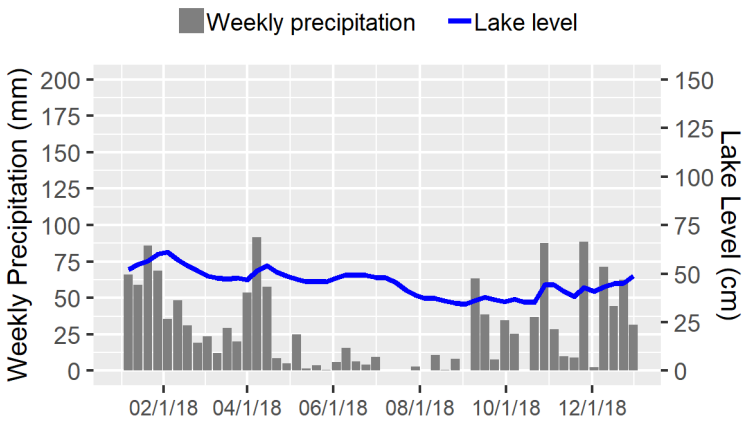
31.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.5	6.2	9.5
Water temperature (°C)	4.5	13.4	25.0
May-October statistics			
Secchi depth (m)	2.5	6.0	9.5
Water temperature (°C)	13.0	19.5	25.0
Chlorophyll-a (µg/L)	0.8	2.8	5.1
Total nitrogen (µg/L)	454.0	678.2	1170.0
Total phosphorus (µg/L)	5.0	9.0	19.7
N:P ratio	33.5	90.0	160.3

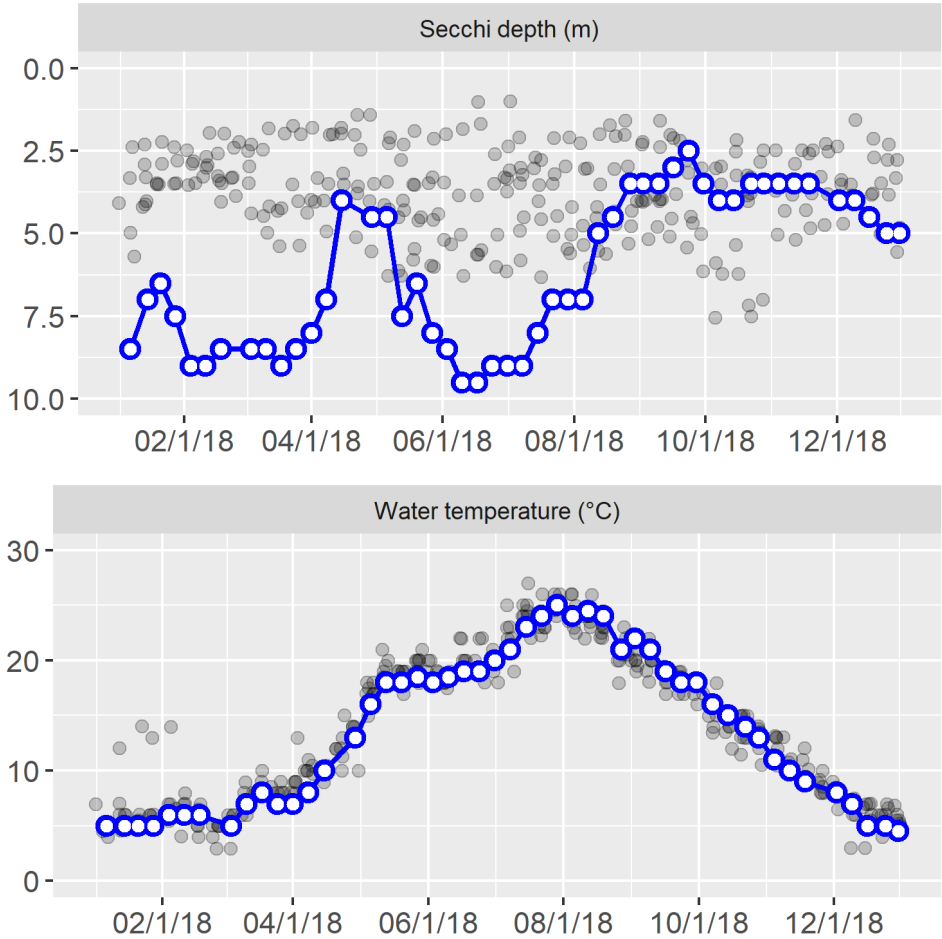
31.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



31.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Lake Retreat. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



31.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

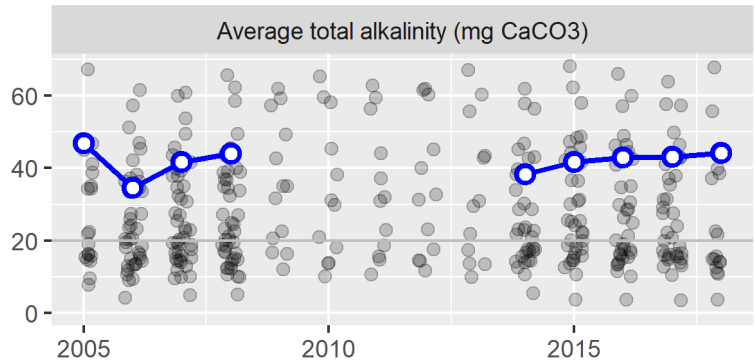
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	18.0	2.0	(1.0)	797	12.6	643.0	7.1	(0.5)
	7.0	16.5	3.5	1.2	870	–	–	7.0	–
	11.5	10.0	–	–	725	169.0	251.0	25.7	0.8
8/19/2018	1.0	25.0	5.1	(2.0)	454	9.6	244.0	(5.0)	1.3
	7.0	23.0	11.0	2.5	493	–	–	(5.0)	–
	11.5	15.0	–	–	949	500.0	16.0	52.9	0.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

31.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 44.1 mg $CaCO_3$.

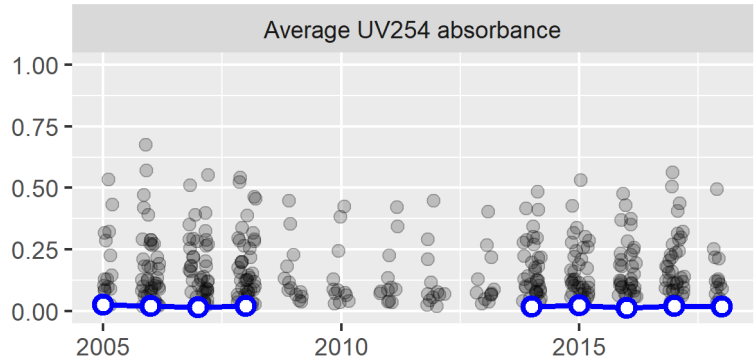
The blue points and line are annual average alkalinity values for Lake Retreat. Grey points in the background are results for all other lakes in the Lake Stewardship program.



31.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.02, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Retreat. Grey points in the background are results for all other lakes in the Lake Stewardship program.



32.0 LAKE SAWYER: 2018

Thank you to Kenneth Docktor, the volunteer monitor for Lake Sawyer.

The key takeaways from the 2018 monitoring season are:

- Lake Sawyer continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Long-term trends suggest that water quality in Lake Sawyer has been improving over time, with decreasing nitrogen and chlorophyll concentrations.
- No algal blooms were reported for toxin testing in 2018.

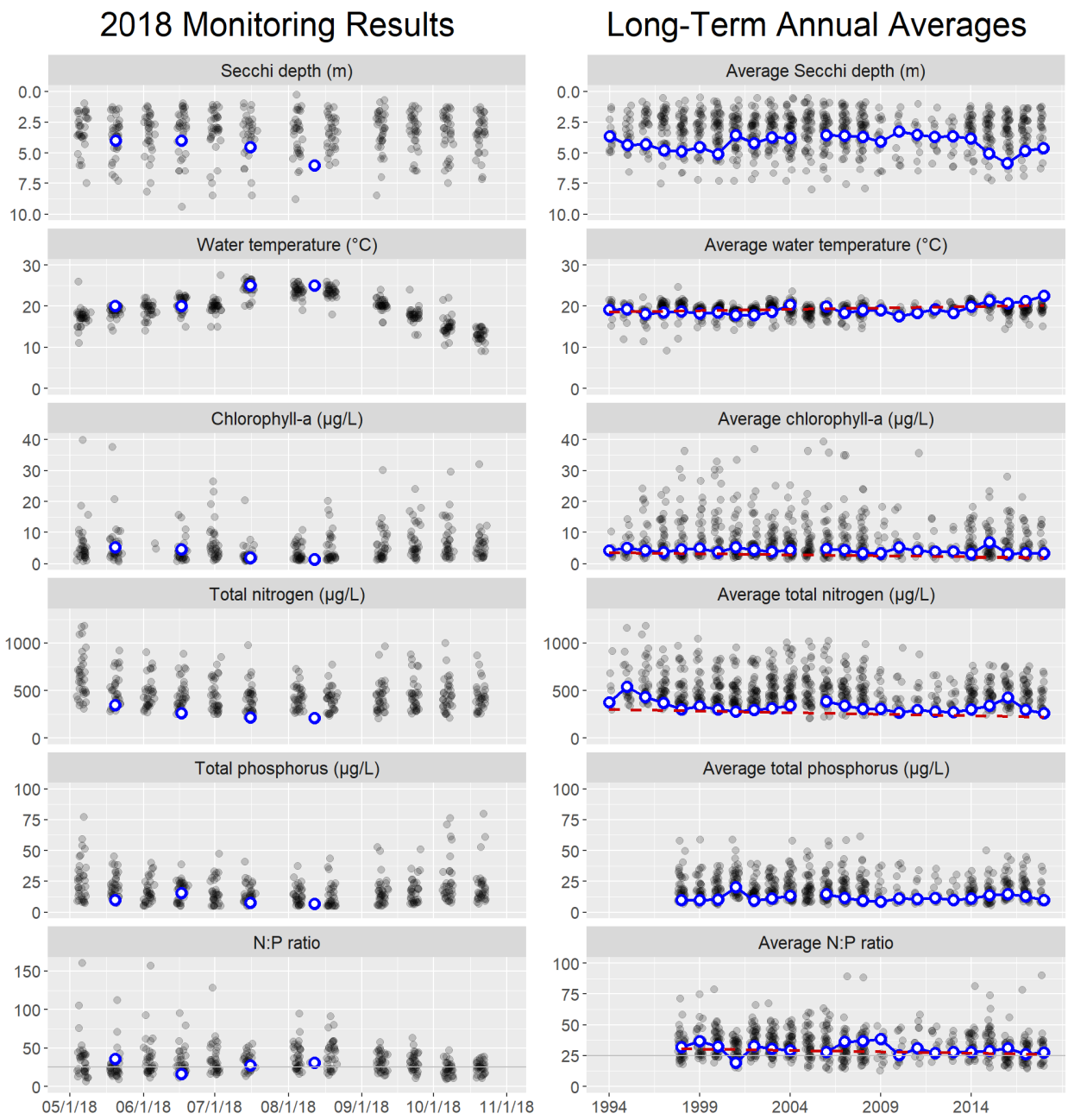
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Sawyer through the Lake Stewardship Program.

32.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Sawyer are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Lake Sawyer was only sampled once per month (the typical Lake Stewardship sampling frequency is twice per month), as specified in the current monitoring agreement with the City of Black Diamond. No samples were collected in September or October because low lake levels prevented the volunteer monitor from launching his boat.

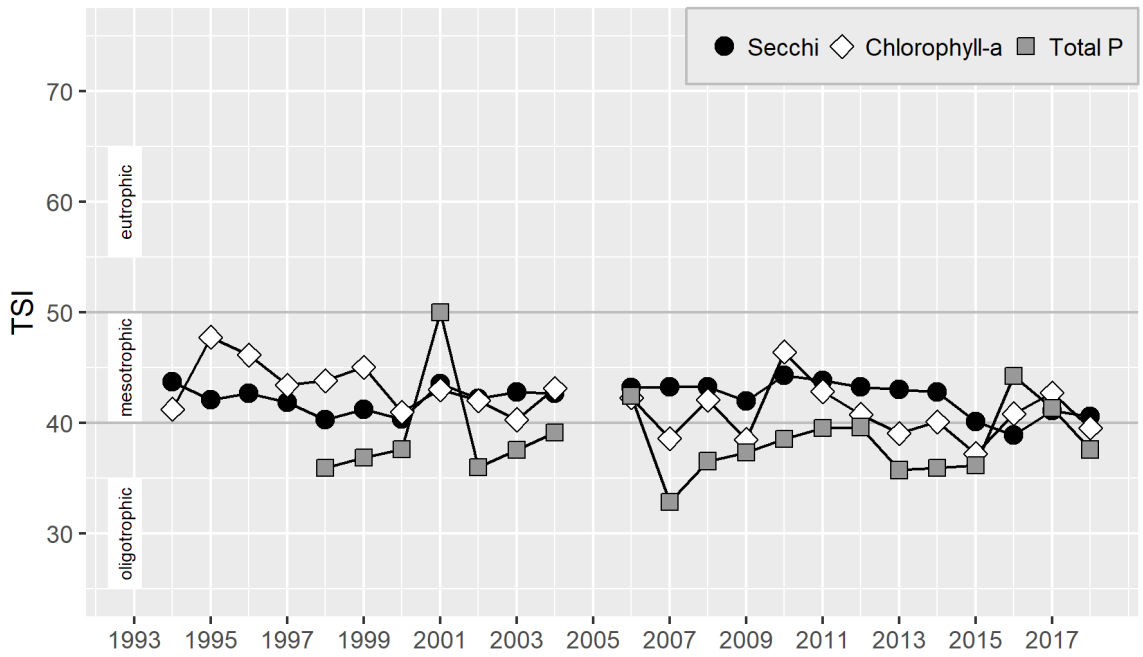
Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Water temperature	0.62 °C	(3.3%)
Chlorophyll-a	-0.62 µg/L	(-19%)
Total nitrogen	-33 µg/L	(-11%)
N:P ratio	-2.2	(-6.9%)

Long-term trends suggest that water quality in Lake Sawyer has been improving over time, with decreasing nitrogen and chlorophyll concentrations. There is no evidence of a trend in phosphorus concentrations over time.

32.2 Trophic state



In 2018, the TSI values were around the mesotrophic-oligotrophic boundary.

32.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	4.0	4.6	6.0
Water temperature (°C)	20.0	22.5	25.0
Chlorophyll-a (µg/L)	1.3	3.2	5.2
Total nitrogen (µg/L)	213.0	259.5	348.0
Total phosphorus (µg/L)	6.9	10.1	15.7
N:P ratio	16.5	27.6	35.5

32.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

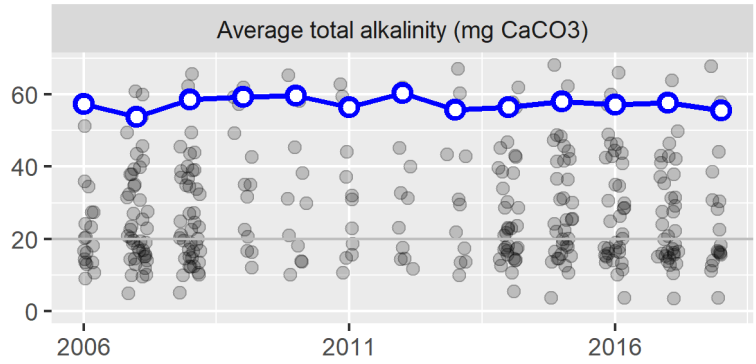
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	5.2	(2.0)	348	17.5	134.0	9.8	(0.5)
	8	9.0	2.4	(2.0)	437	–	–	6.1	–
	15	7.0	–	–	463	2.7	303.0	15.4	1.9
8/12/2018	1	25.0	1.3	(1.1)	213	(2.0)	(10.0)	6.9	0.9
	8	7.0	7.3	3.2	474	–	–	42.3	–
	15	10.0	–	–	396	185.0	(10.0)	99.8	8.2

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

32.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 55.6 mg $CaCO_3$.

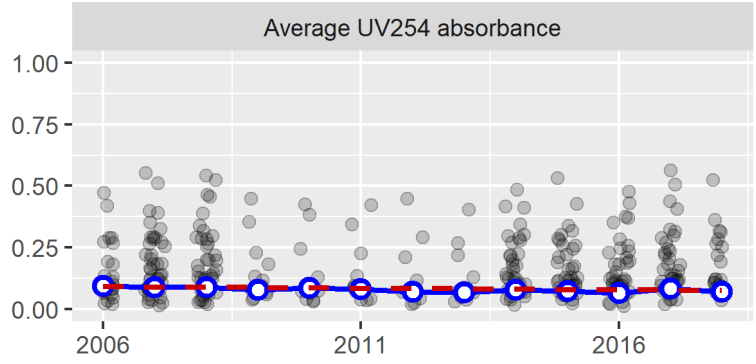
The blue points and line are annual average alkalinity values for Lake Sawyer. Grey points in the background are results for all other lakes in the Lake Stewardship program.



32.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.07, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Sawyer. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in UV absorbance, with an average change of -0.013 absorbance units (-14%) per decade.



33.0 SHADOW LAKE: 2018

Thank you to Joanne & Evan Bradley, the volunteer monitors for Shadow Lake.

The key takeaways from the 2018 monitoring season are:

- Shadow Lake had fairly clear water, with moderate nutrient concentrations and fairly high algal growth.
- Long-term trends suggest that water quality in Shadow Lake has been declining over time, with increasing phosphorus and chlorophyll concentrations, and shallower Secchi depths.
- An algal bloom was sampled for toxin testing in mid-June. Toxin testing found very low concentrations of algal toxins, well below the Washington State Recreational Guidelines.

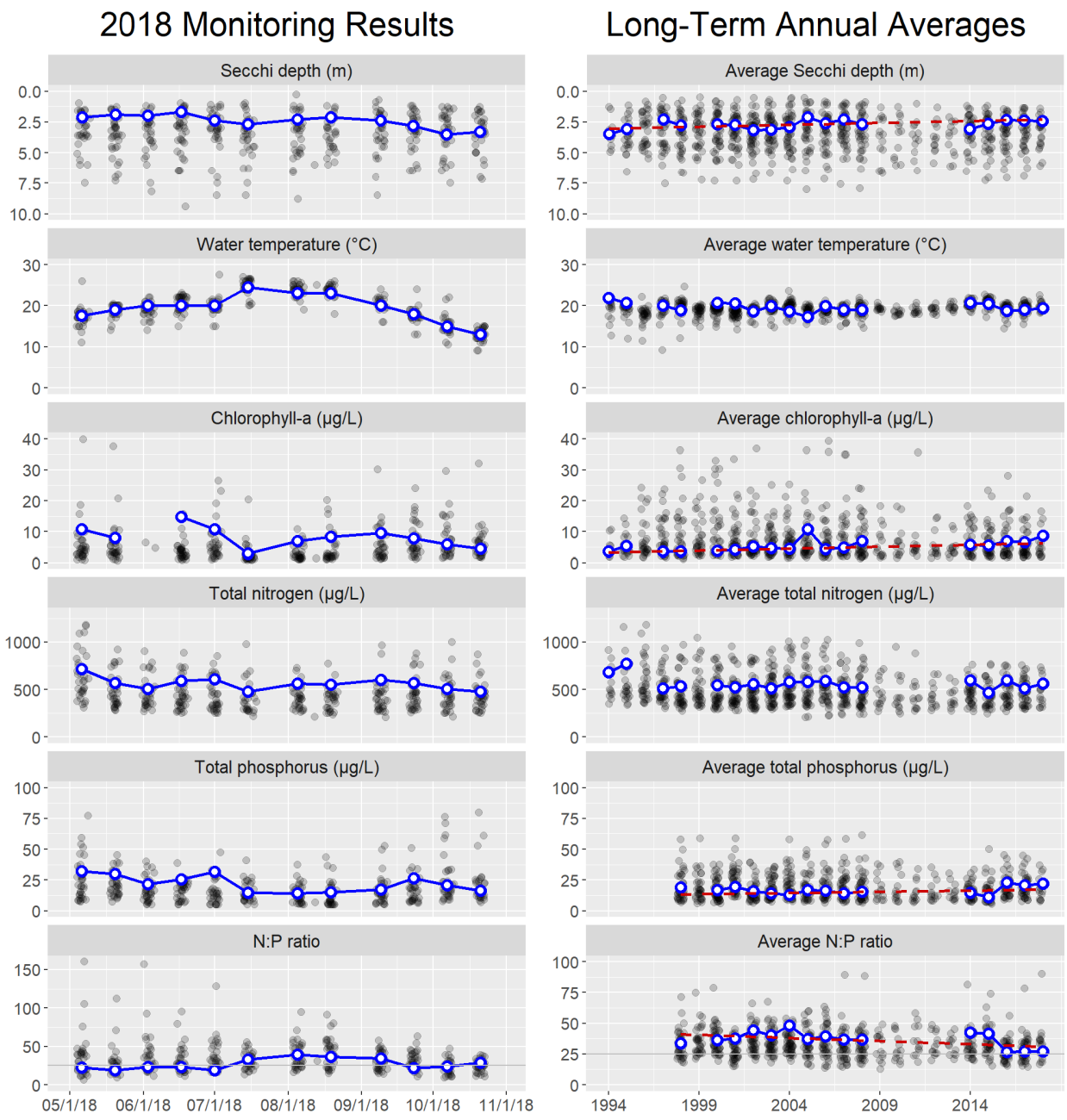
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Shadow Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore why phosphorus concentrations have been increasing over time. If this increase continues, it could lead to more algal blooms in the future.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Shadow Lake through the Lake Stewardship Program.

33.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Shadow Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



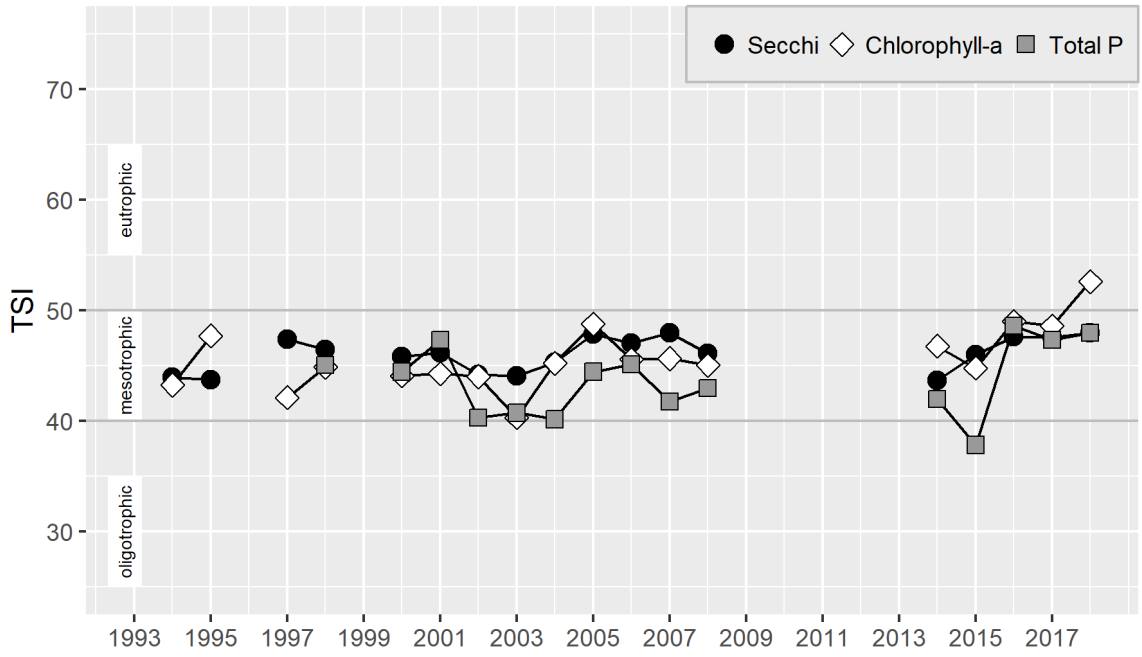
Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-0.3 m	(-9.9%)
Chlorophyll-a	1.2 µg/L	(36%)
Total phosphorus	1.9 µg/L	(15%)
N:P ratio	-5	(-12%)

Long-term trends suggest that water quality in Shadow Lake has been declining over time, with increasing phosphorus and chlorophyll concentrations, and shallower Secchi depths. The data suggest that nitrogen concentrations may have a decreasing trend, by contrast, but the trend is slightly above our statistical threshold (p=0.09).

33.2 Trophic state



In 2018, the TSI values were in the mesotrophic range or around the mesotrophic-eutrophic boundary.

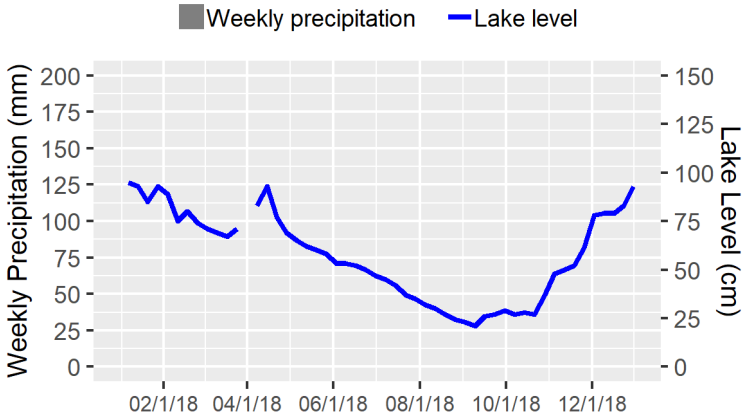
33.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	1.4	2.3	3.5
Water temperature (°C)	4.0	13.5	26.0
May-October statistics			
Secchi depth (m)	1.7	2.4	3.5
Water temperature (°C)	13.0	19.6	26.0
Chlorophyll-a (µg/L)	2.9	8.7	14.7
Total nitrogen (µg/L)	477.0	561.0	716.0
Total phosphorus (µg/L)	14.4	22.2	32.0
N:P ratio	18.8	27.0	39.0

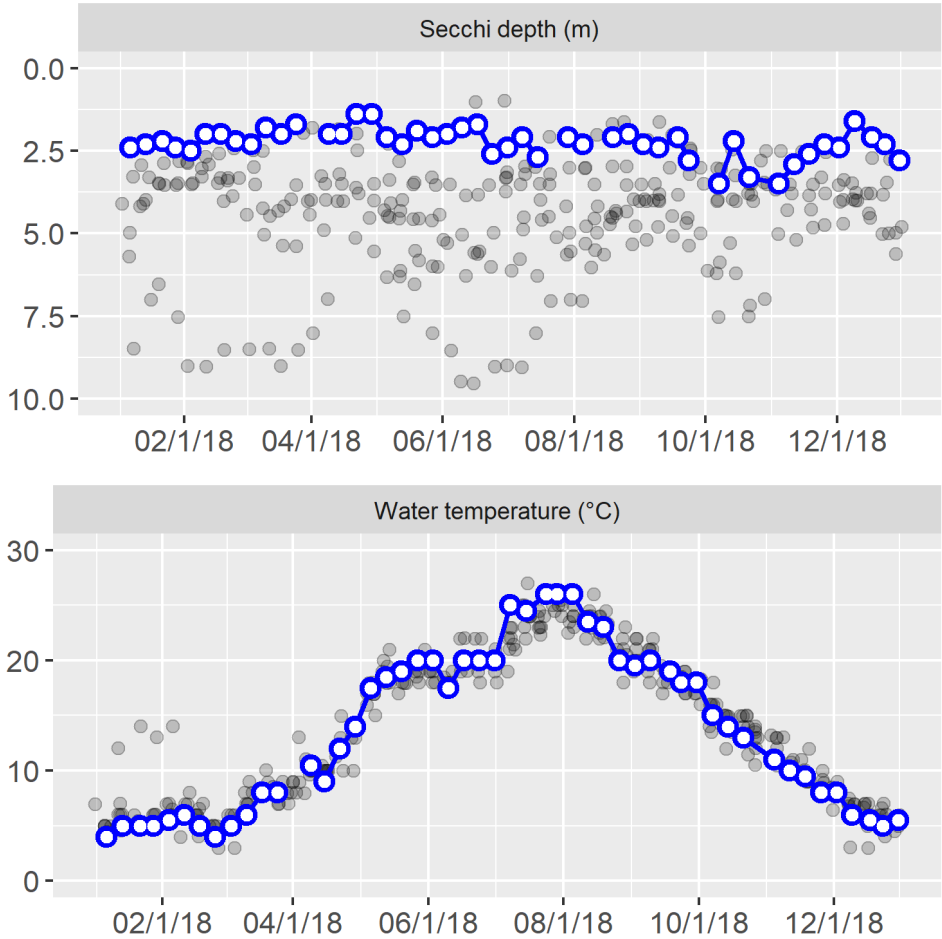
33.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



33.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Shadow Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



33.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

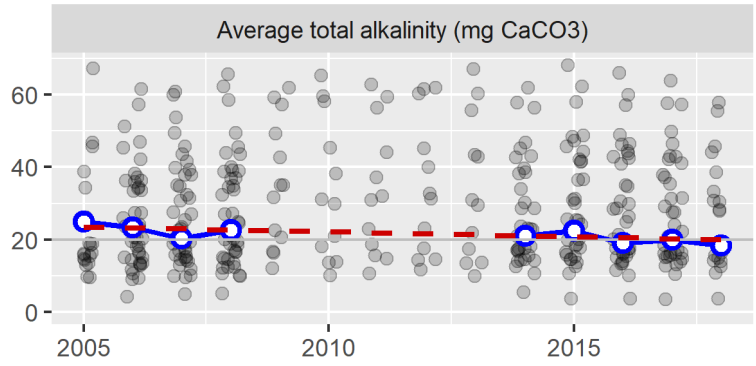
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	19.0	7.9	(1.0)	567	6.4	(10.0)	30.1	2.0
	4	8.0	3.5	3.6	779	–	–	25.7	–
	8	5.0	–	–	832	7.5	427.0	34.3	8.3
8/19/2018	1	23.0	8.4	(2.0)	549	2.2	(10.0)	15.1	1.9
	4	10.0	9.6	–	507	–	–	31.1	–
	8	6.0	–	–	767	42.4	263.0	68.1	11.8

* Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

33.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 18.4 mg $CaCO_3$.

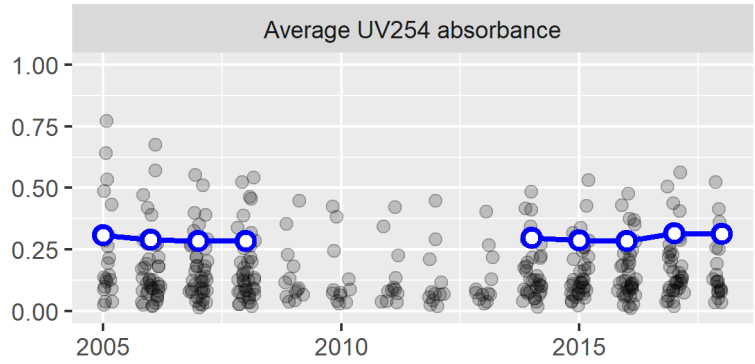
The blue points and line are annual average alkalinity values for Shadow Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -2.7 mg $CaCO_3$ (-12%) per decade.



33.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.31, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Shadow Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



34.0 SHADY LAKE: 2018

Thank you to Ray Konecke and Mark Reeves, the volunteer monitors for Shady Lake.

The key takeaways from the 2018 monitoring season are:

- Shady Lake continued to have fairly clear water, with low nutrient concentrations and low algal growth.
- Long-term trends suggest that water quality in Shady Lake has been improving over time, with decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths.
- No algal blooms were reported for toxin testing in 2018.

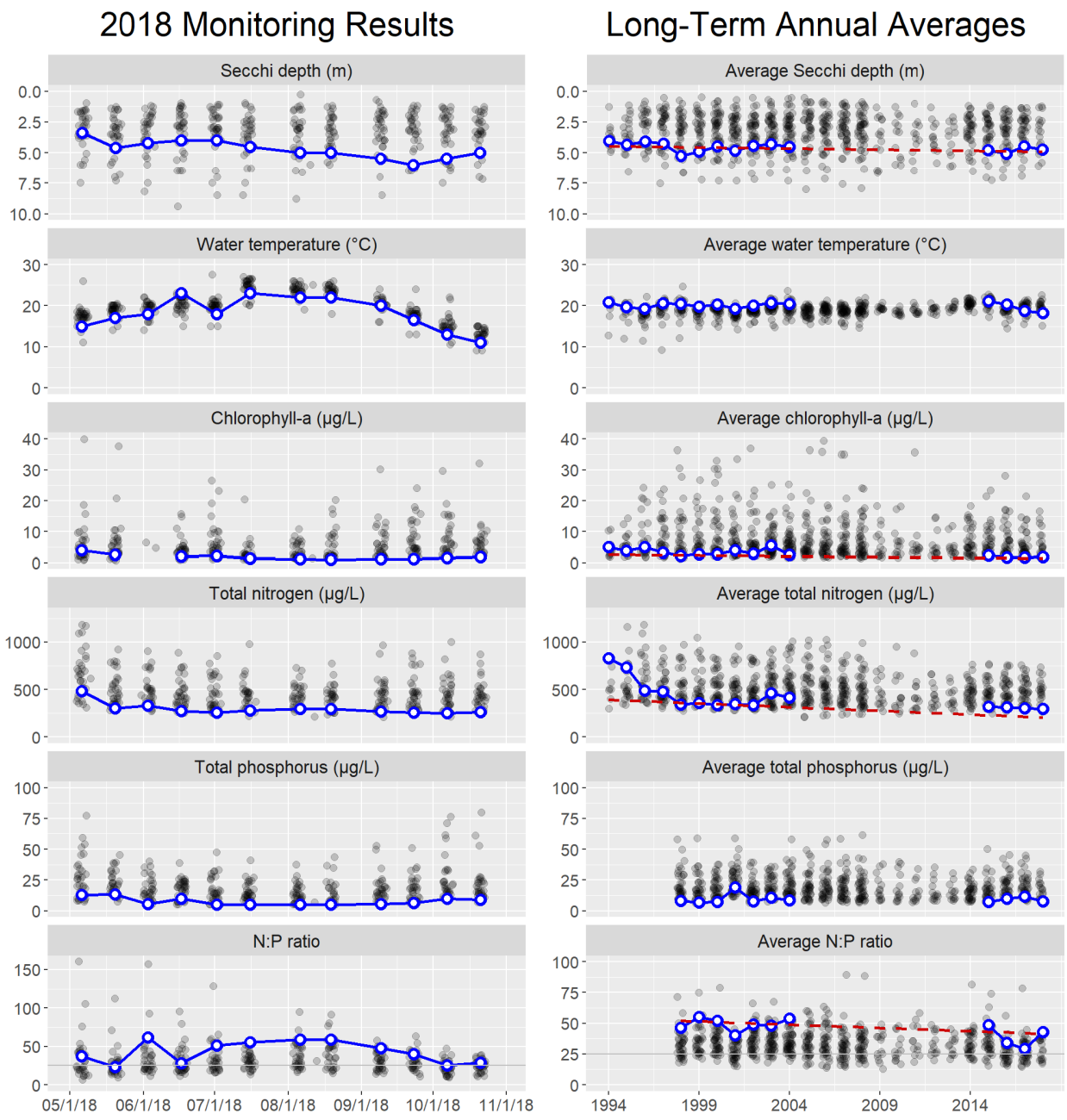
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Shady Lake through the Lake Stewardship Program.

34.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Shady Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



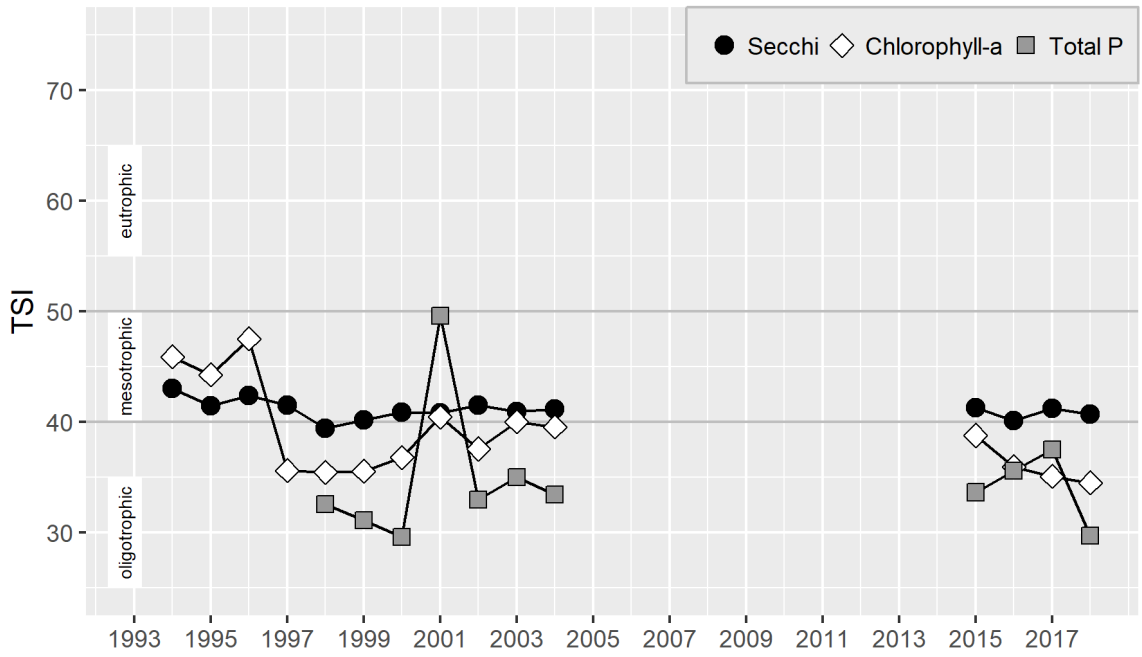
Shady Lake's low nutrient concentrations and nitrogen-to-phosphorus (N:P) ratios above 25 both indicate that Shady Lake is not likely to have algal blooms dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.19 m	(4.3%)
Chlorophyll-a	-0.5 µg/L	(-19%)
Total nitrogen	-78 µg/L	(-20%)
N:P ratio	-5	(-9.4%)

Long-term trends suggest that water quality in Shady Lake has been improving over time, with decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths.

34.2 Trophic state



In 2018, the TSI values were in or near the oligotrophic range.

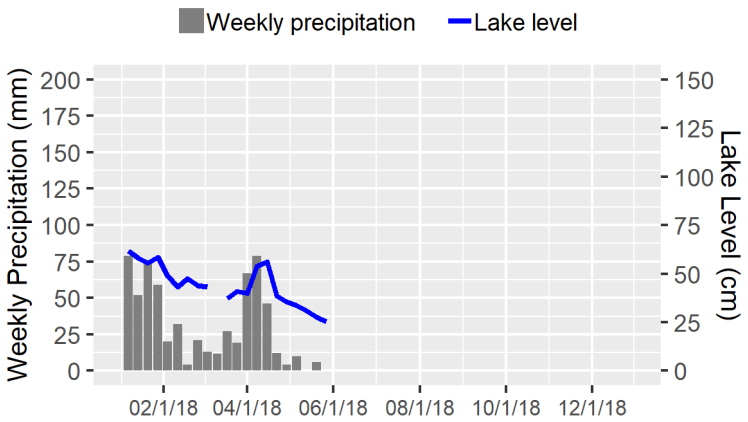
34.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.4	4.1	6.0
Water temperature (°C)	3.0	14.4	23.0
May-October statistics			
Secchi depth (m)	3.4	4.7	6.0
Water temperature (°C)	11.0	18.4	23.0
Chlorophyll-a (µg/L)	1.0	1.8	3.9
Total nitrogen (µg/L)	250.0	295.3	481.0
Total phosphorus (µg/L)	5.0	7.7	13.2
N:P ratio	23.0	43.0	61.7

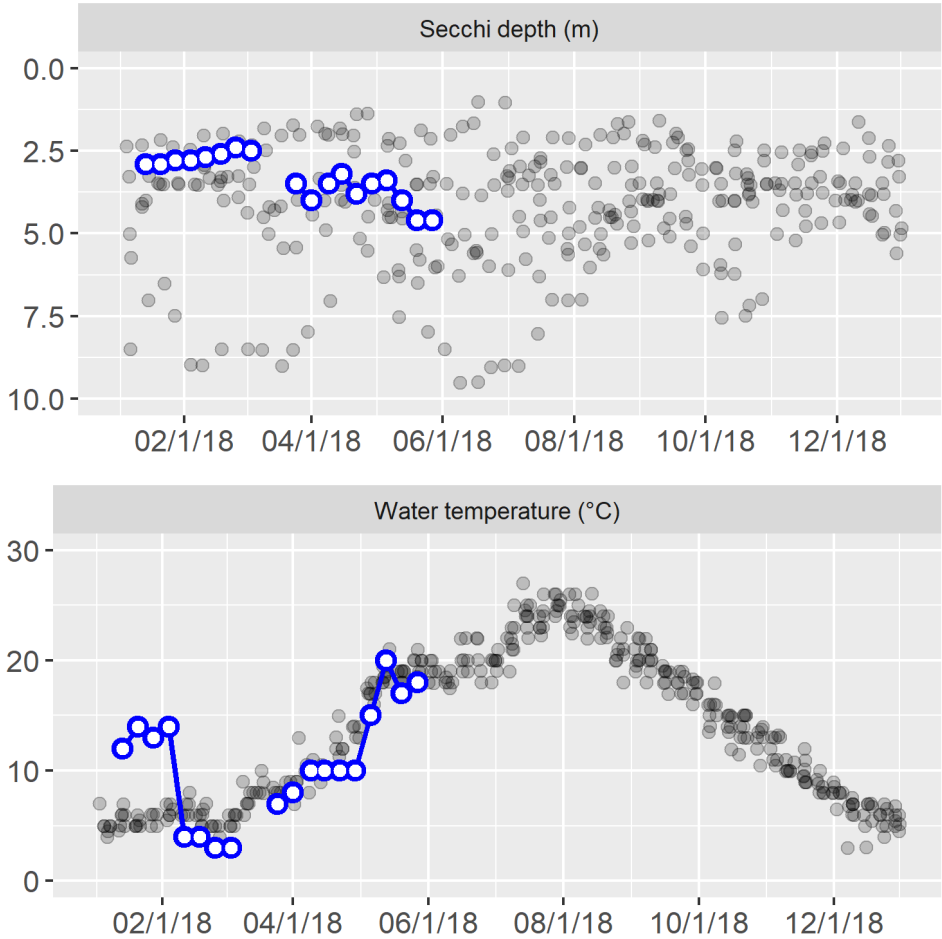
34.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



34.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Shady Lake. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



34.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

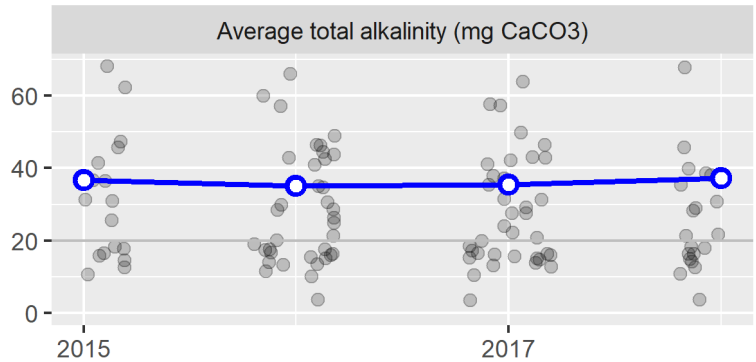
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	17.0	2.5	(1.4)	303	23.1	47.9	13.2	0.6
	6	10.0	7.3	3.1	494	–	–	20.5	–
	11	8.0	8.8	(1.0)	599	127.0	195.0	52.0	3.6
8/19/2018	1	22.0	1.0	(1.4)	295	3.3	(10.0)	(5.0)	0.7
	6	18.0	3.6	(2.0)	322	–	–	11.1	–
	12	8.0	21.9	–	726	284.0	(10.0)	72.4	0.7

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

34.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 37.2 mg $CaCO_3$.

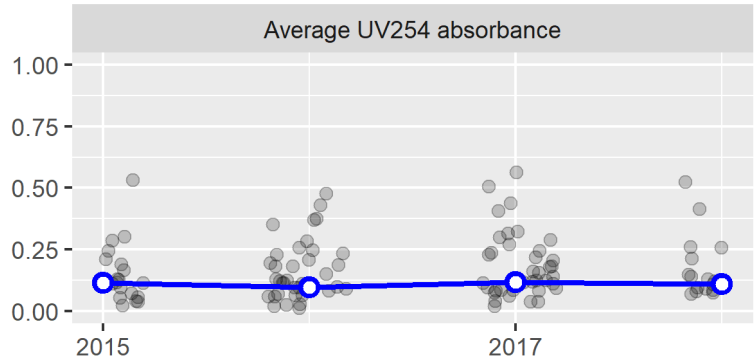
The blue points and line are annual average alkalinity values for Shady Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



34.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.11, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Shady Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



35.0 SPRING LAKE: 2018

Thank you to Caren Adams, the volunteer monitor for Spring Lake.

The key takeaways from the 2018 monitoring season are:

- Spring Lake had less-clear water, with moderate nutrient concentrations and algal growth.
- Spring Lake had long-term trends of increasing phosphorus concentrations and shallower Secchi depths.
- No algal blooms were reported for toxin testing in 2018.

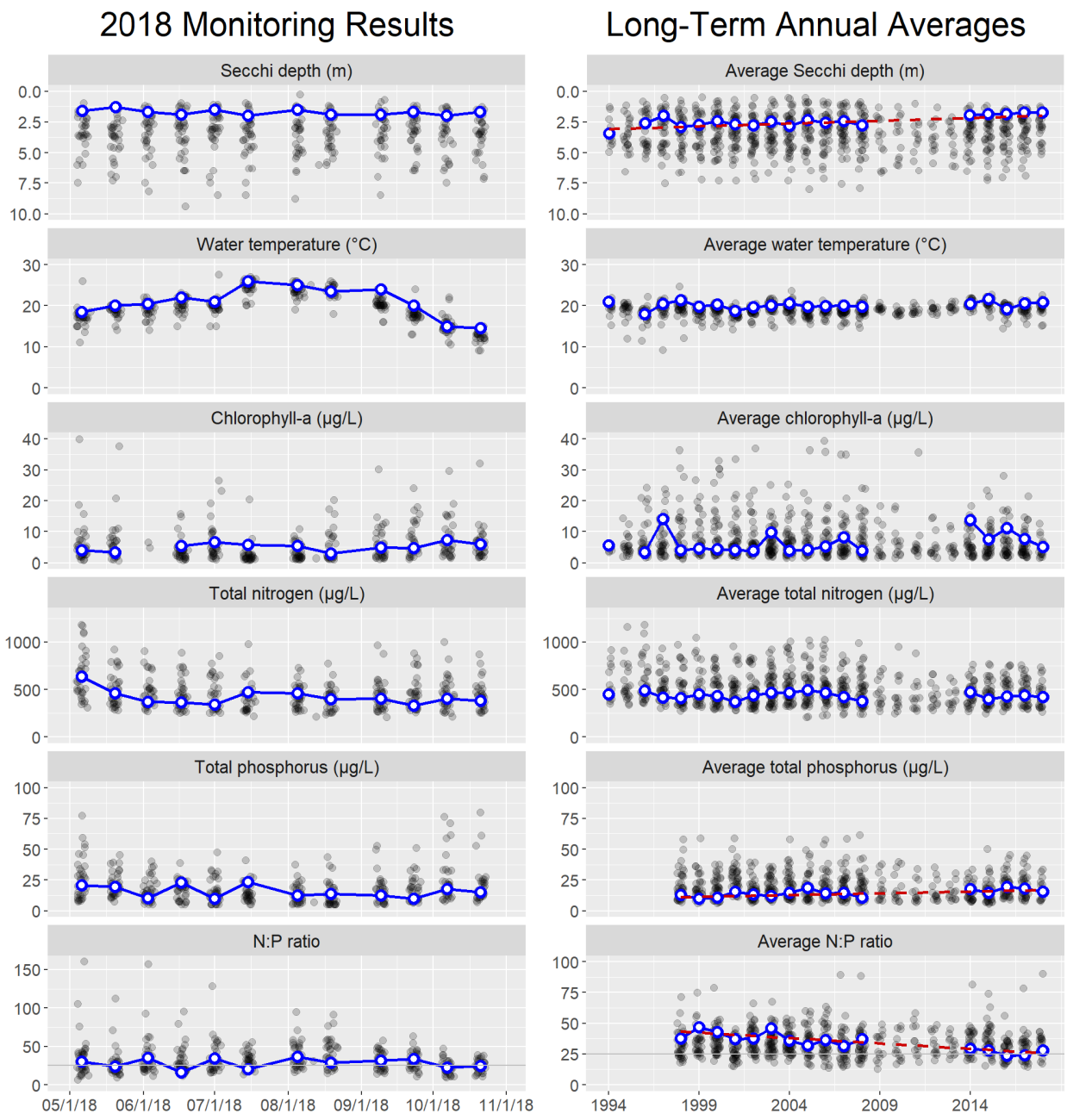
The Lake Stewardship Program recommends:

- Explore why phosphorus concentrations have been increasing over time. If this increase continues, it could lead to more algal blooms in the future.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Spring Lake through the Lake Stewardship Program.

35.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Spring Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.

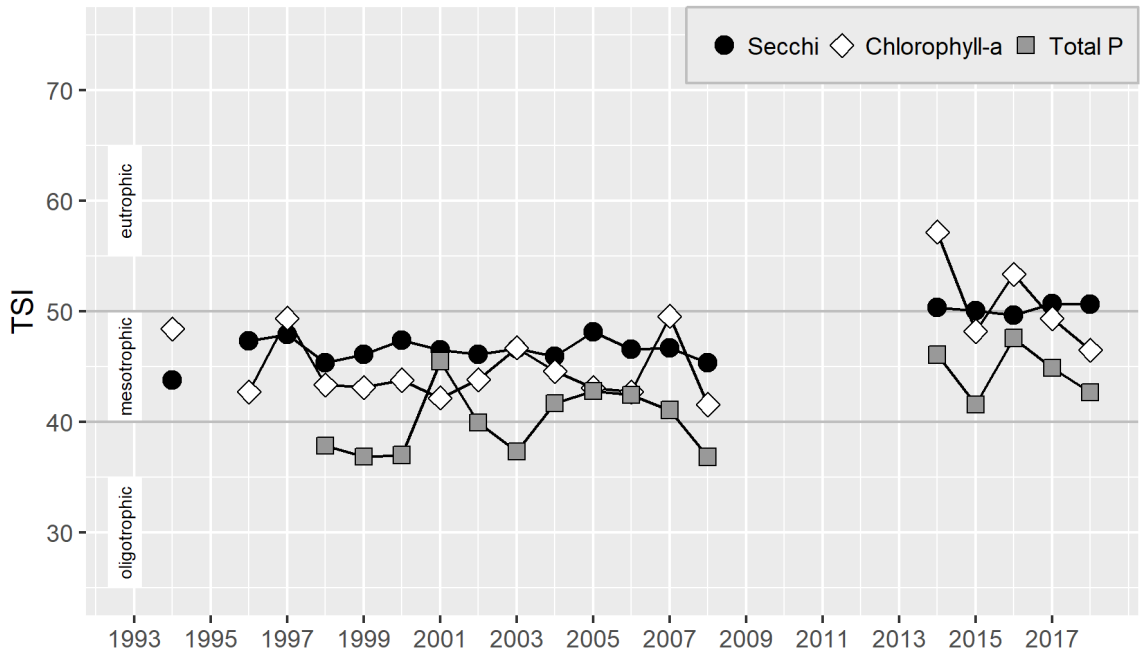


Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	-0.44 m	(-15%)
Total phosphorus	2.9 µg/L	(30%)
N:P ratio	-8.7	(-19%)

35.2 Trophic state



Spring Lake was not monitored in 2009-2013, when budget cuts reduced monitoring for many lakes in unincorporated King County. During that data gap, water quality appears to have changed. All three TSI values were noticeably higher in 2014-2017 than they had been in 1994-2008. The three TSI values in recent years have been around the mesotrophic-eutrophic boundary.

35.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.3	1.7	2.0
Water temperature (°C)	14.5	20.8	26.0
Chlorophyll-a (µg/L)	2.9	5.1	7.2
Total nitrogen (µg/L)	329.0	418.0	634.0
Total phosphorus (µg/L)	9.7	15.8	23.3
N:P ratio	15.8	28.2	36.8

35.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

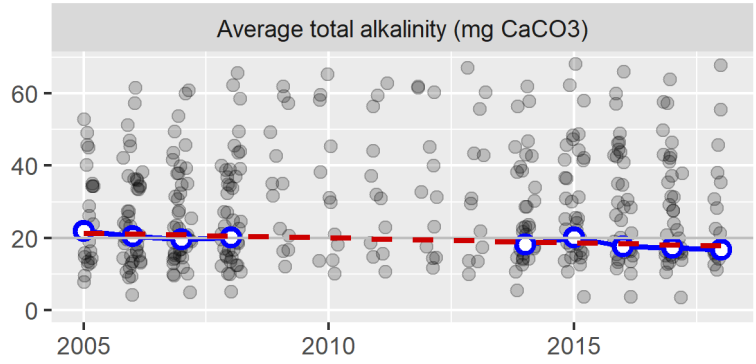
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	20.0	3.2	(1.4)	460	14.3	81.0	19.4	1.2
	4	10.5	7.5	2.2	451	–	–	14.4	–
	8	8.5	–	–	542	21.3	246.0	41.9	5.2
8/19/2018	1	23.5	2.9	(2.0)	398	3.6	(10.0)	13.9	0.7
	4	13.5	9.9	4.6	308	–	–	38.8	–
	8	9.0	–	–	837	495.0	(10.0)	285.0	9.9

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

35.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 16.8 mg $CaCO_3$.

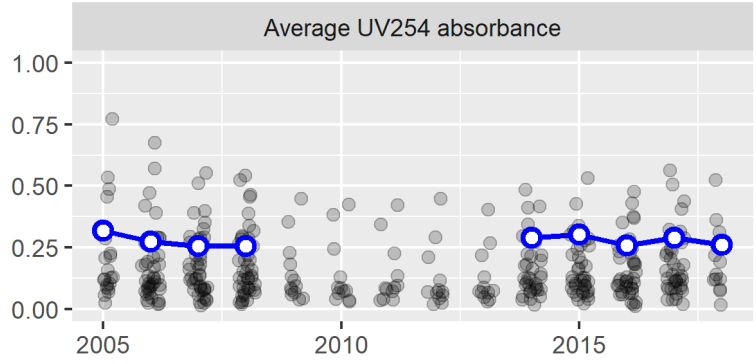
The blue points and line are annual average alkalinity values for Spring Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -2.8 mg $CaCO_3$ (-13%) per decade.



35.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.26, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Spring Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



36.0 TUCK LAKE: 2018

Thank you to Cindy Bowles and Jane Hance, the volunteer monitors for Tuck Lake.

The key takeaways from the 2018 monitoring season are:

- Tuck Lake continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Long-term trends suggest that water quality in Tuck Lake has been improving over time, with decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- An algal bloom was sampled for toxin testing in mid-July. No algal toxins were detected in this sample.

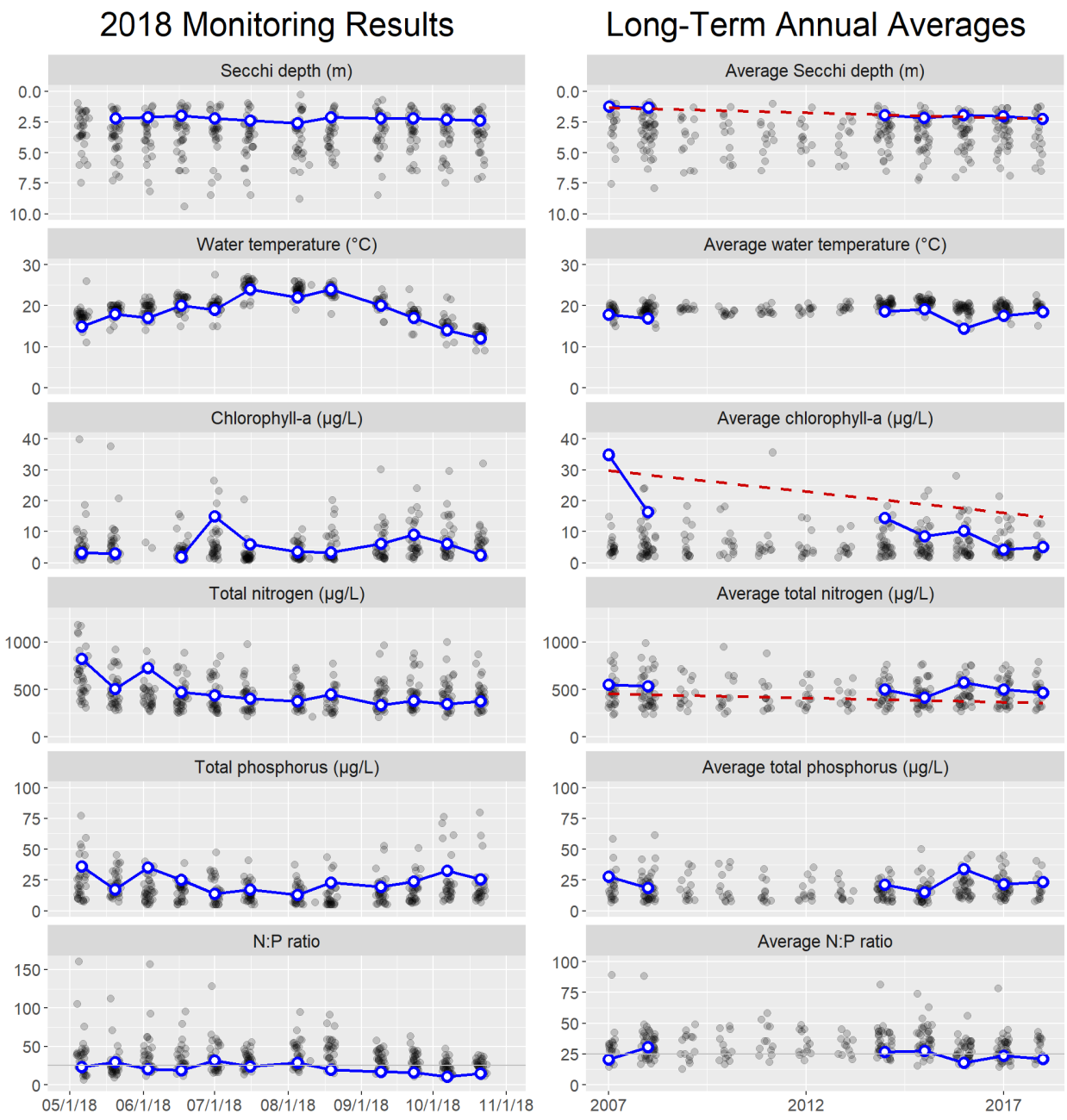
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Tuck Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore what has helped to decrease nitrogen concentrations in Tuck Lake, and look for ways to reduce phosphorus concentrations as well. Reducing nutrient concentrations will likely help to reduce algal blooms.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Tuck Lake through the Lake Stewardship Program.

36.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Tuck Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 2007, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.83 m	(62%)
Chlorophyll-a	-14 µg/L	(-46%)
Total nitrogen	-91 µg/L	(-20%)

Long-term trends suggest that water quality in Tuck Lake has been improving over time, with decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths.

36.2 Trophic state

In 2018, the TSI values were in the mesotrophic range.

36.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	2.0	2.2	2.6
Water temperature (°C)	12.0	18.5	24.0
Chlorophyll-a (µg/L)	1.9	5.1	15.0
Total nitrogen (µg/L)	334.0	468.8	821.0
Total phosphorus (µg/L)	12.9	23.5	35.9
N:P ratio	10.6	21.1	31.7

36.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

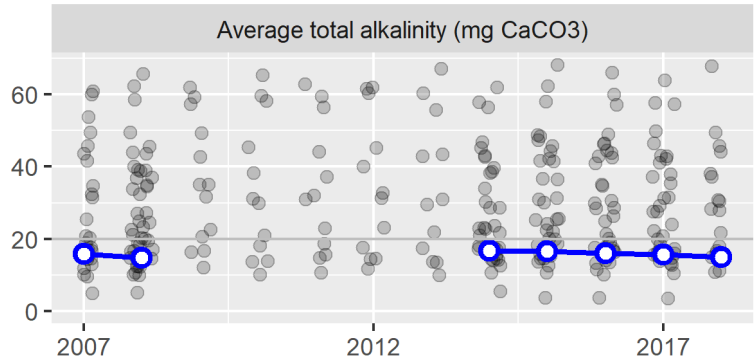
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	18.0	2.8	(2.0)	504	28.7	195.0	17.3	0.8
	2.5	14.0	3.0	(2.0)	512	–	–	16.9	–
	5.0	11.0	–	–	573	31.6	264.0	23.4	1.1
8/19/2018	1.0	24.0	3.3	(1.5)	448	10.0	(10.0)	23.1	1.0
	2.5	20.0	5.2	2.6	351	–	–	23.1	–
	5.0	20.0	–	–	1510	4.1	(10.0)	266.0	2.0

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

36.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 15 mg $CaCO_3$.

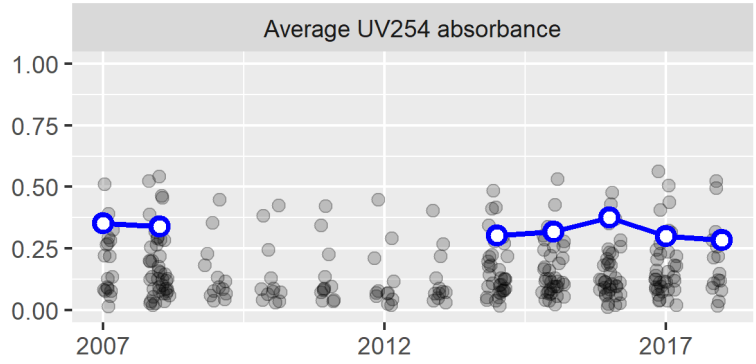
The blue points and line are annual average alkalinity values for Tuck Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



36.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.29, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Tuck Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



37.0 LAKE TWELVE: 2018

Thank you to Jan Delacy and Jill & Ken Eide, the volunteer monitors for Lake Twelve.

The key takeaways from the 2018 monitoring season are:

- Lake Twelve had fairly clear water, with moderate nutrient concentrations and fairly low algal growth.
- An algal bloom was sampled for toxin testing in early September. No algal toxins were detected in this sample.

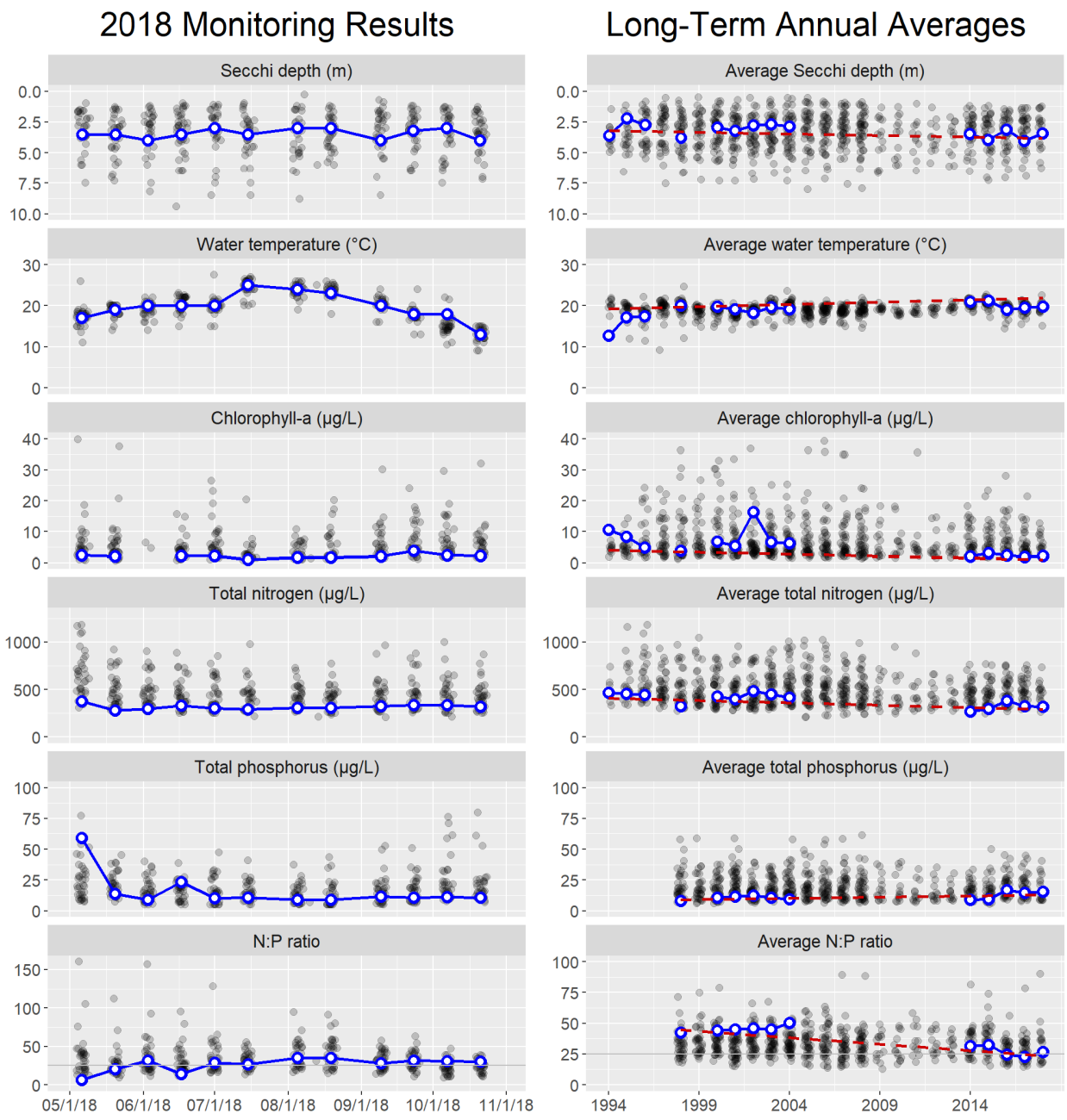
The Lake Stewardship Program recommends:

- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Twelve through the Lake Stewardship Program.

37.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Twelve are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



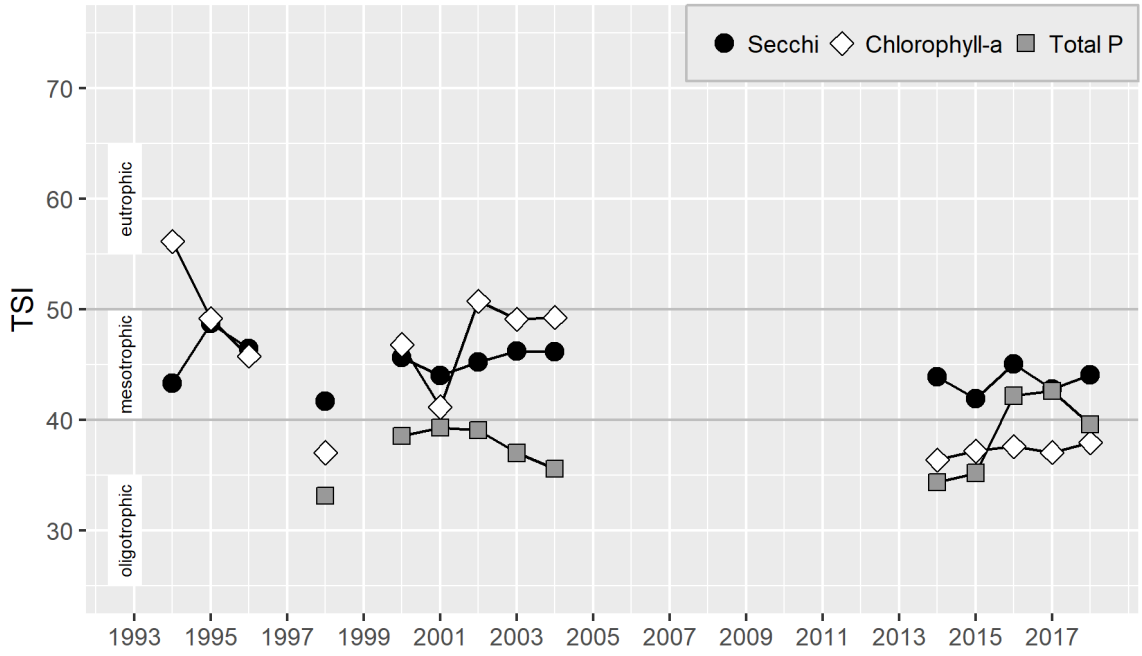
Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Secchi depth	0.26 m	(8.2%)
Water temperature	1.1 °C	(5.7%)
Chlorophyll-a	-1.3 µg/L	(-31%)
Total nitrogen	-49 µg/L	(-12%)
Total phosphorus	2.1 µg/L	(25%)
N:P ratio	-10	(-22%)

The trends in Lake Twelve do not tell a simple story about water quality. The trends of decreasing nitrogen and chlorophyll concentrations, and deeper Secchi depths, all suggest that water quality has been improving. However, there is a trend of increasing phosphorus concentrations. Further analysis (and likely more data) is needed before making any management recommendations based on these trend results.

37.2 Trophic state



In 2018, the three TSI values spanned the mesotrophic-oligotrophic boundary.

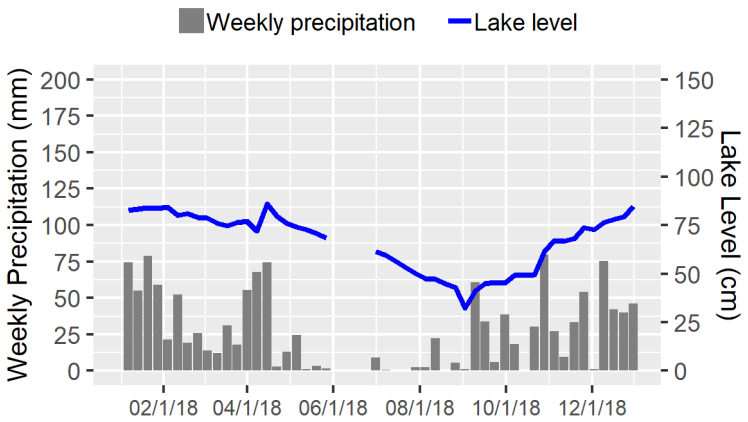
37.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.0	3.5	5.0
Water temperature (°C)	12.0	19.7	25.5
May-October statistics			
Secchi depth (m)	2.0	3.5	5.0
Water temperature (°C)	12.0	19.7	25.5
Chlorophyll-a (µg/L)	1.0	2.2	3.7
Total nitrogen (µg/L)	279.0	315.8	373.0
Total phosphorus (µg/L)	8.8	15.7	59.0
N:P ratio	6.3	26.5	34.9

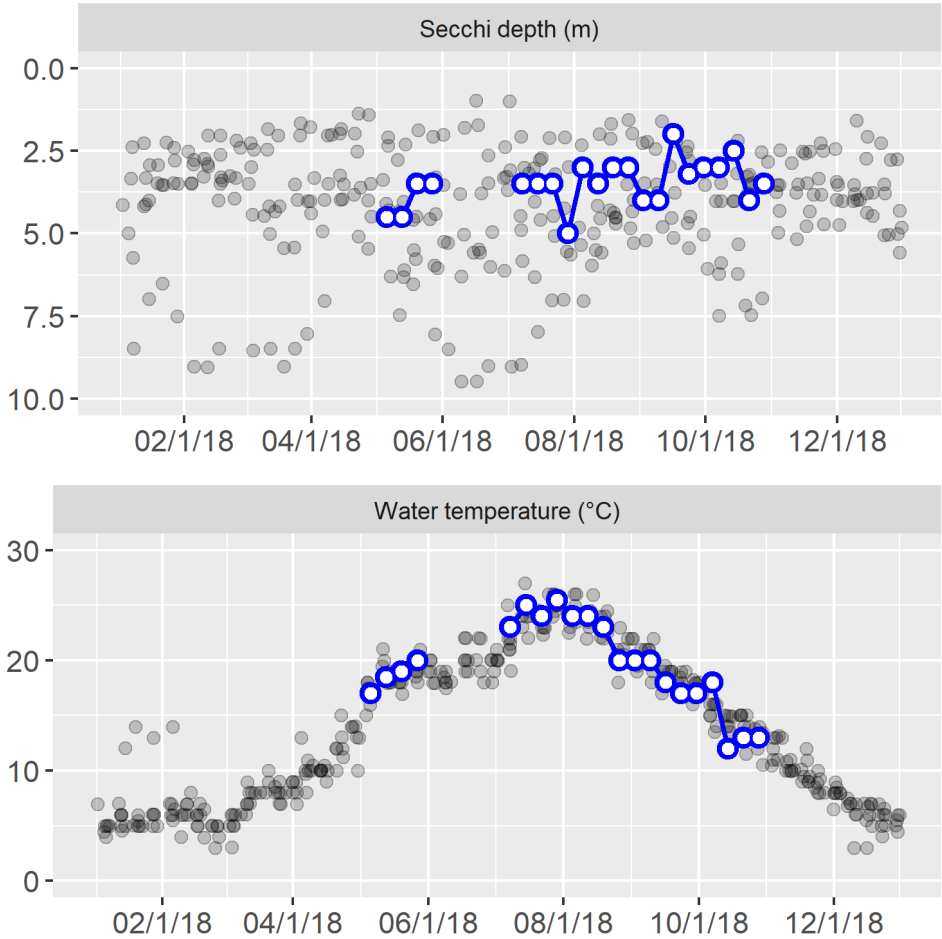
37.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



37.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Lake Twelve. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



37.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

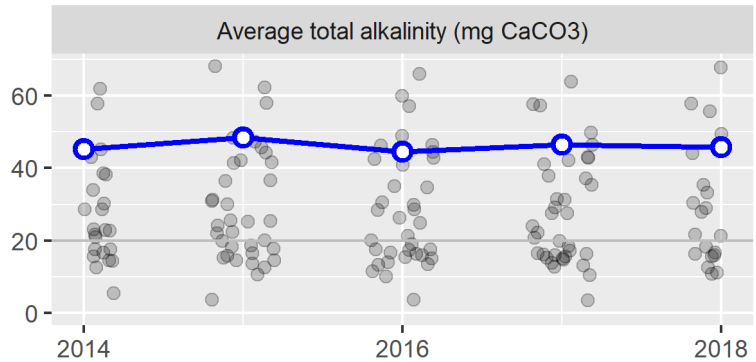
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1	19.0	1.9	(1.0)	279	7.3	(10.0)	13.8	0.5
	4	–	1.9	(2.0)	302	–	–	29.2	–
	6	–	–	–	262	18.8	(10.0)	19.6	(0.5)
8/19/2018	1	23.0	1.7	(1.7)	307	(2.0)	(10.0)	8.8	1.0
	4	–	7.7	(2.0)	421	–	–	19.1	–
	6	–	–	–	367	2.6	(10.0)	19.3	1.0

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

37.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 45.8 mg $CaCO_3$.

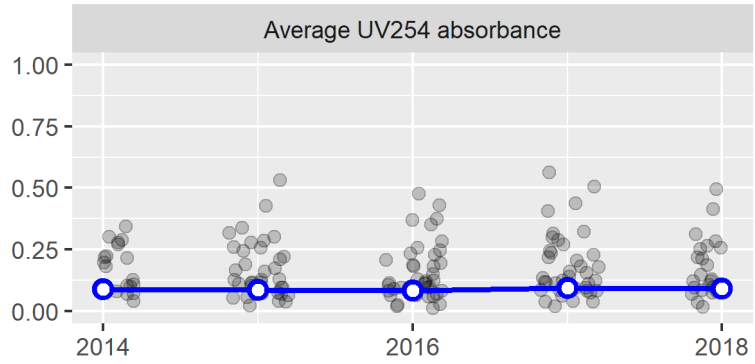
The blue points and line are annual average alkalinity values for Lake Twelve. Grey points in the background are results for all other lakes in the Lake Stewardship program.



37.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.09, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Twelve. Grey points in the background are results for all other lakes in the Lake Stewardship program.



38.0 WELCOME LAKE: 2018

Thank you to Dave Hadley, the volunteer monitor for Welcome Lake.

The key takeaways from the 2018 monitoring season are:

- Welcome Lake had fairly clear water, with moderate algal growth and fairly high nutrient concentrations.
- Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).
- No algal blooms were reported for toxin testing in 2018.

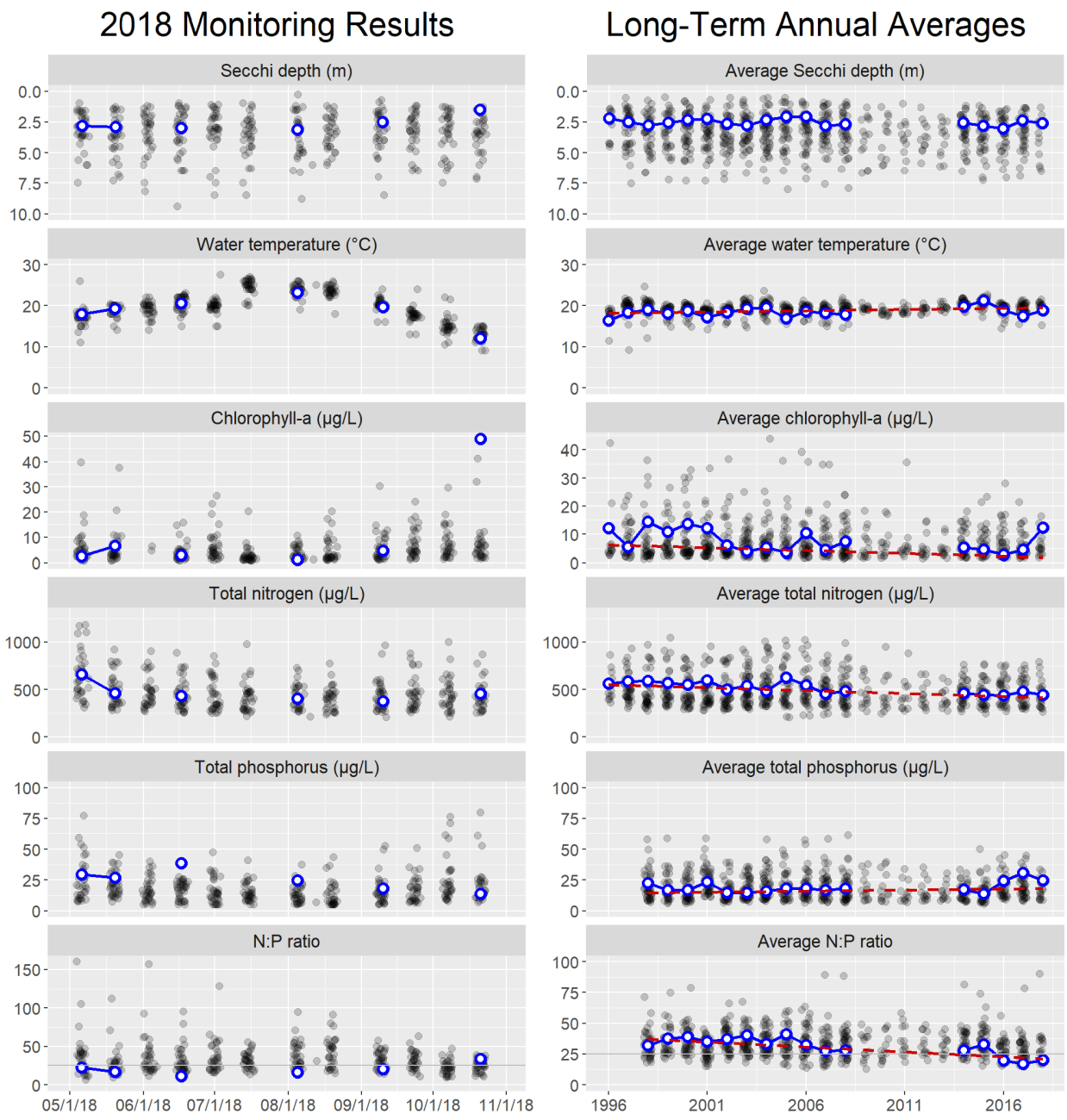
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Welcome Lake – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Welcome Lake through the Lake Stewardship Program.

38.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Welcome Lake are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



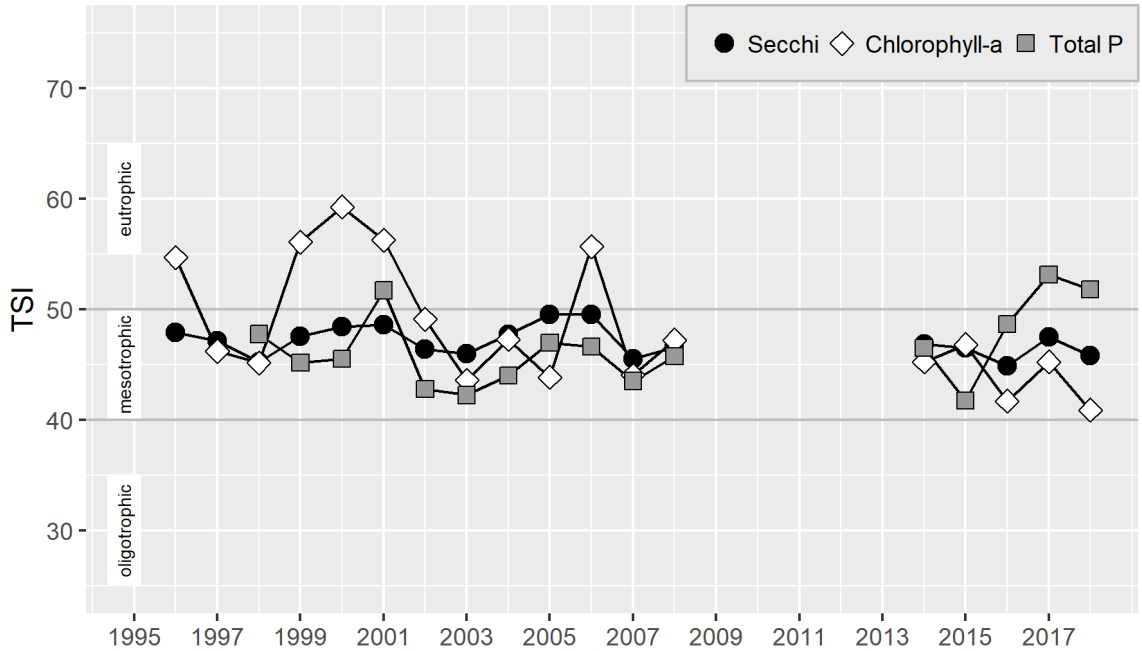
Nitrogen-to-phosphorus (N:P) ratios were below 25 for much of the monitoring season. This indicates the potential for algal blooms to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1996, when monitoring started.

Parameter	Change per Decade	(%)
Water temperature	0.6 °C	(3.3%)
Chlorophyll-a	-2 µg/L	(-32%)
Total nitrogen	-62 µg/L	(-11%)
Total phosphorus	1.8 µg/L	(13%)
N:P ratio	-7.9	(-21%)

The trends in Welcome Lake do not tell a simple story about water quality. The trends of decreasing nitrogen and chlorophyll concentrations suggest that water quality has been improving. Similarly, the data suggest that Secchi depths may also have a trend of getting deeper (clearer water), but the trend is slightly above our statistical threshold (p=0.08). However, there is a trend of increasing phosphorus concentrations. Further analysis (and likely more data) is needed before making any management recommendations based on these trend results.

38.2 Trophic state



In 2018, the three TSI values had a wide span in and near the mesotrophic range. Note that only three samples were collected during June-September, so the accuracy of these TSI values is questionable.

38.3 Data summary

This table summarizes data from May-October 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Secchi depth (m)	1.5	2.6	3.1
Water temperature (°C)	12.0	18.8	23.2
Chlorophyll-a (µg/L)	1.1	12.4	49.0
Total nitrogen (µg/L)	376.0	445.4	657.0
Total phosphorus (µg/L)	13.6	24.7	38.8
N:P ratio	11.2	20.3	33.5

38.4 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

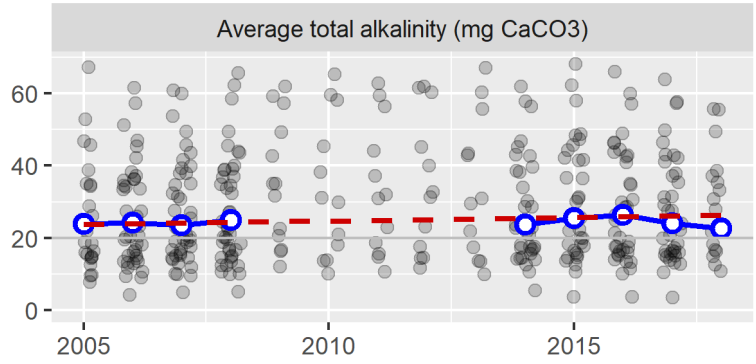
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	19.2	6.5	(2.0)	463	31.0	97.0	26.9	1.3
	2.0	16.8	3.2	1.2	485	–	–	31.0	–
	3.5	11.8	2.4	1.1	504	64.9	134.0	35.0	1.9
8/19/2018	1.0	–	–	–	–	–	–	–	–
	2.0	–	–	–	–	–	–	–	–
	3.5	–	–	–	–	–	–	–	–

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

38.5 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 22.7 mg $CaCO_3$.

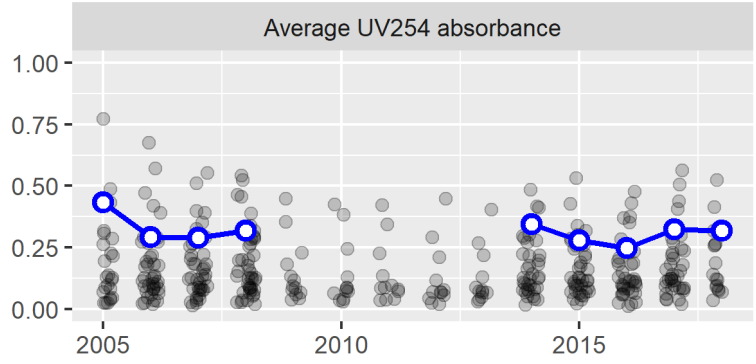
The blue points and line are annual average alkalinity values for Welcome Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of 1.9 mg $CaCO_3$ (8.2%) per decade.



38.6 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.32, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Welcome Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program.



39.0 LAKE WILDERNESS: 2018

Thank you to Renato Santos, Dan Tift, and Paul Wichelmann, the volunteer monitors for Lake Wilderness.

The key takeaways from the 2018 monitoring season are:

- Lake Wilderness continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- An algal bloom was sampled for toxin testing in mid-July. No algal toxins were detected in this sample.

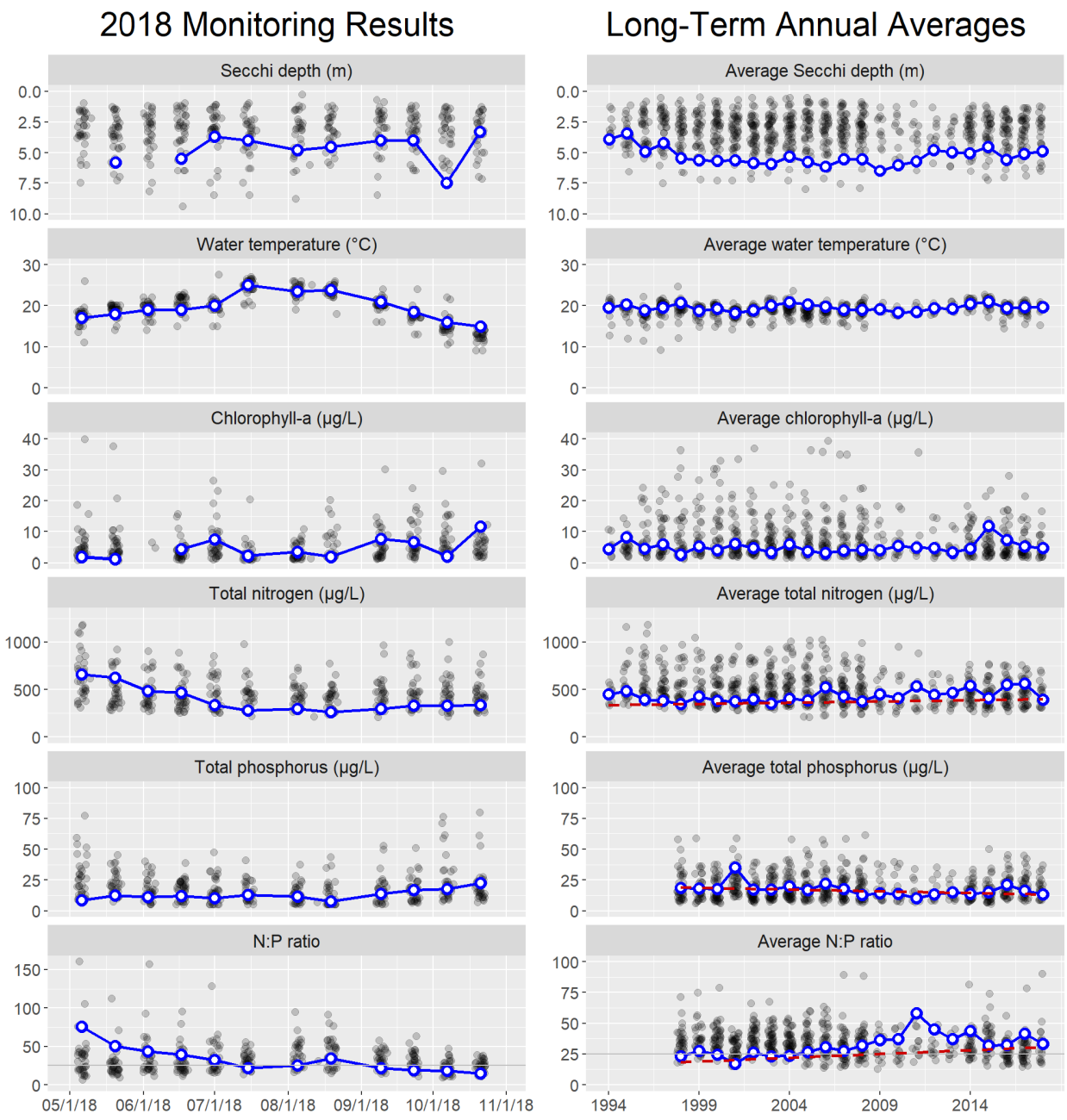
The Lake Stewardship Program recommends:

- Stay alert for toxic algae blooms in Lake Wilderness – increase people's awareness of toxic algae, and their ability to identify which algae are potentially toxic. Any potentially toxic blooms should be reported to the King County Lake Stewardship Program and sampled for toxin analysis.
- Explore why total nitrogen concentrations have been increasing over time. If this increase continues, it could lead to more algal blooms in the future.
- Monitoring is a key part of good lake stewardship, building a valuable long-term dataset to guide lake management and detect any future problems. Continue to monitor Lake Wilderness through the Lake Stewardship Program.

39.1 Water quality results & trends

These graphs show the water-quality parameters that are sampled from May through October, at 1 m depth (additional depths and parameters are measured on profile days; see below). The left column shows results for each sampling date in 2018, and the right column shows average values for each year (May-October averages). Data for Lake Wilderness are the blue points connected by the blue line. Any gaps in the blue line indicate missed samples.

To provide some context for these values, the grey points in the background are results for all other lakes in the Lake Stewardship program. Any statistically discernable long-term trends are drawn with a dashed red line, and described further in the next section.



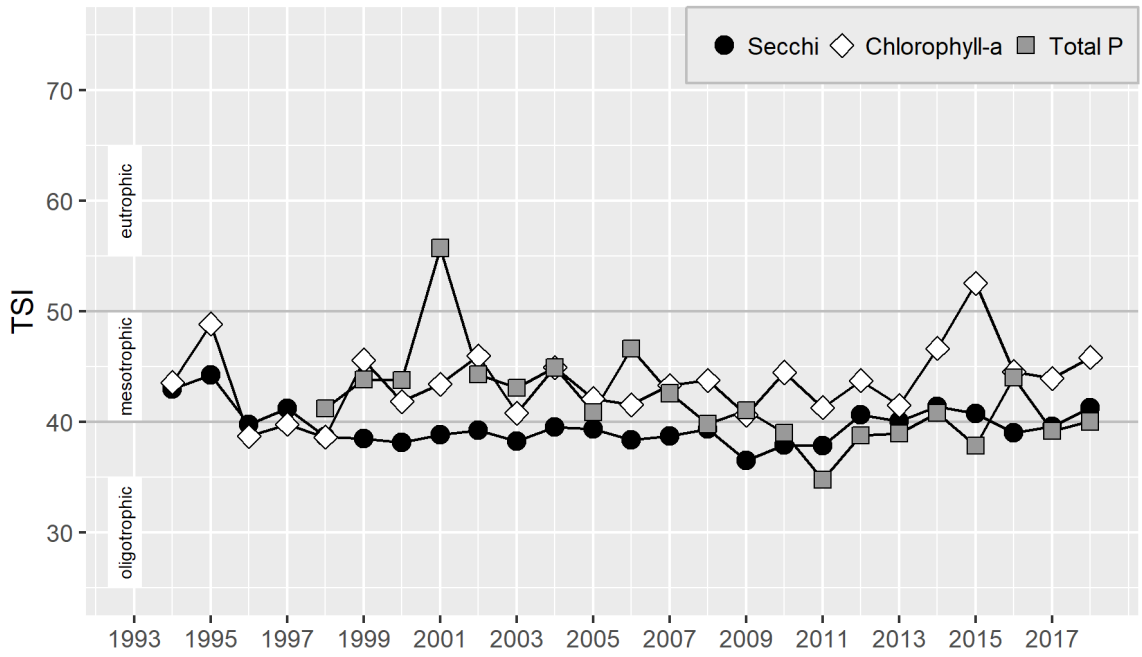
Nitrogen-to-phosphorus (N:P) ratios were periodically below 25, indicating times when the algal community was more likely to be dominated by cyanobacteria (which have the ability to produce toxins).

The table below gives more details about the long-term trends. Results are presented as an average amount and percent of change per decade (the increase or decrease over ten years). Percent change is calculated as the percent of the estimated value in 1994, when monitoring started.

Parameter	Change per Decade	(%)
Total nitrogen	26 µg/L	(7.6%)
Total phosphorus	-2.7 µg/L	(-14%)
N:P ratio	6.1	(38%)

The increasing total nitrogen concentrations and decreasing total phosphorus concentrations have both contributed to an increasing N:P ratio. If the N:P ratio continues to increase, it will become less likely for algal blooms in Lake Wilderness to be dominated by cyanobacteria (which have the ability to produce toxins).

39.2 Trophic state



In 2018, the TSI values were in or near the mesotrophic range.

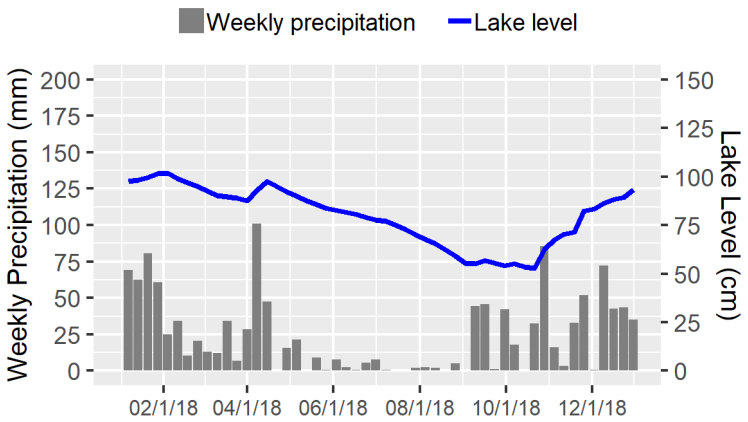
39.3 Data summary

This table summarizes data from 2018 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2018 calendar year for Secchi and temperature, which were measured year-round, and May-October summary statistics for all parameters. To reduce biases from missing data or changes in sampling frequency, monthly means were calculated and then averaged to give an overall mean.

Parameter	Minimum	Mean	Maximum
Full-year statistics			
Secchi depth (m)	2.5	4.2	7.5
Water temperature (°C)	5.0	13.7	25.0
May-October statistics			
Secchi depth (m)	2.5	4.8	7.5
Water temperature (°C)	13.5	19.6	25.0
Chlorophyll-a (µg/L)	1.2	4.6	11.7
Total nitrogen (µg/L)	263.0	391.7	657.0
Total phosphorus (µg/L)	7.6	13.2	22.7
N:P ratio	14.9	33.1	75.5

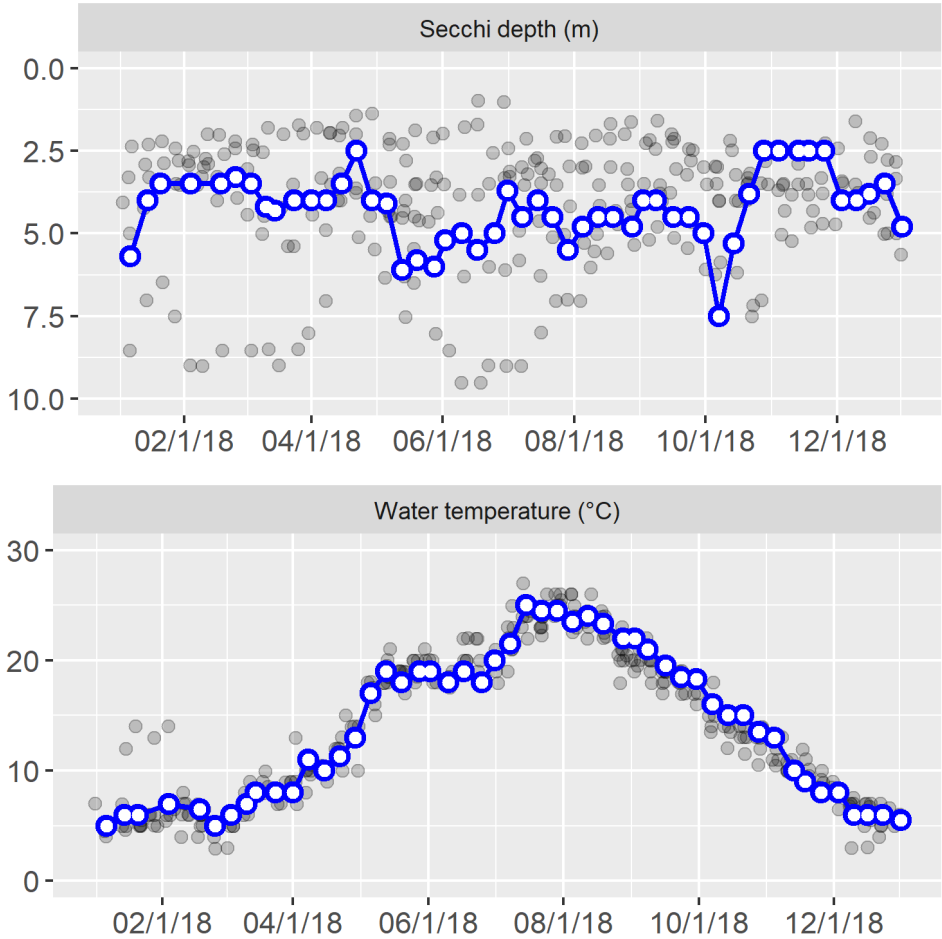
39.4 Hydrology: Lake level and precipitation

Lake level and precipitation were recorded year-round. Bars show total weekly precipitation, and the line shows average weekly lake level.



39.5 Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2018. The blue points and line are data for Lake Wilderness. Gaps in the line indicate missed sampling dates. Grey points in the background are results for all other lakes in the Lake Stewardship program.



39.6 Water column profile

In May and August, water was collected at the mid-lake sampling station from three depths in a water-column profile: 1 m, the middle depth of the water column, and 1 m from the lake bottom.

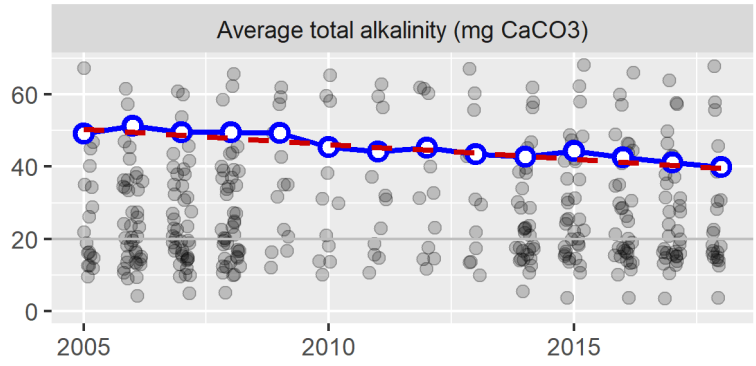
Date	Depth	Temp	Chlor	Pheo	TN	NH3	NO2/3	TP	OPO4
5/20/2018	1.0	18.0	1.2	(1.4)	625	50.1	359.0	12.3	0.7
	4.0	15.3	4.2	(1.3)	659	–	–	14.7	–
	8.5	9.5	25.5	19.9	510	42.2	17.0	83.8	2.9
8/19/2018	1.0	23.8	1.9	(2.0)	263	4.9	(10.0)	7.6	0.6
	4.0	22.5	2.8	(2.0)	287	–	–	6.4	–
	8.5	12.0	349.0	(32.0)	1900	18.5	(10.0)	287.0	7.6

Parameter abbreviations are: chlorophyll-a (Chlor), pheophytin (Pheo), total nitrogen (TN), ammonia (NH3), nitrate/nitrite (NO2/3), total phosphorus (TP), orthophosphate (OPO4). Depth is in m, temperature is in °C, and all other parameters are in µg/L. Dashes indicate parameters that were not analyzed for a given sample. Values below the method detection limit (MDL) are enclosed in parentheses and have the value of the MDL substituted.

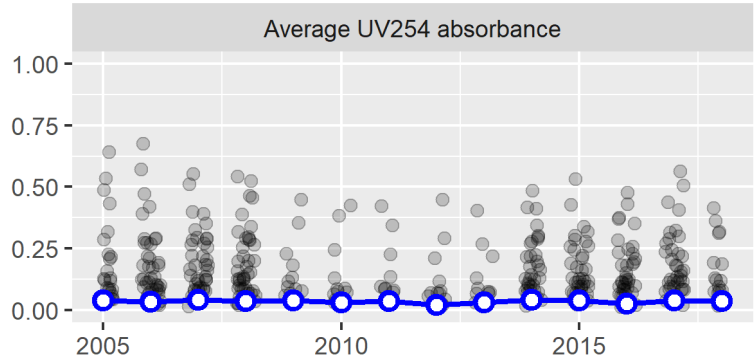
39.7 Total alkalinity

Alkalinity was measured in May and August, on profile-sampling days. In 2018, the average total alkalinity was 40 mg $CaCO_3$.

The blue points and line are annual average alkalinity values for Lake Wilderness. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -9.8 mg $CaCO_3$ (-19%) per decade.



39.8 Water color

Water color was measured in May and August, on profile-sampling days. In 2018, the average UV254 absorbance was 0.04, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue points and line are annual average UV absorbance values for Lake Wilderness. Grey points in the background are results for all other lakes in the Lake Stewardship program.