# SHADOW LAKE 2017

## Lake Stewardship Monitoring Report

King County Water & Land Resources Division
Science & Technical Support Section
www.kingcounty.gov/EnvironmentalScience

# Summary & Recommendations

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

**The key takeaways from the 2017 monitoring season are:**

- Shadow Lake continued to have fairly clear water, with moderate nutrient concentrations and algal growth.
- Algal growth has been increasing over time, as indicated by a long-term trend of increasing chlorophyll concentrations. Secchi depths have also been getting shallower over time, likely as a result of more algal growth.
- No algal blooms were reported for toxin testing in 2017.

**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 Shadow Lake through the Lake Stewardship Program.

## *In this report:*

# What We Measure & Why

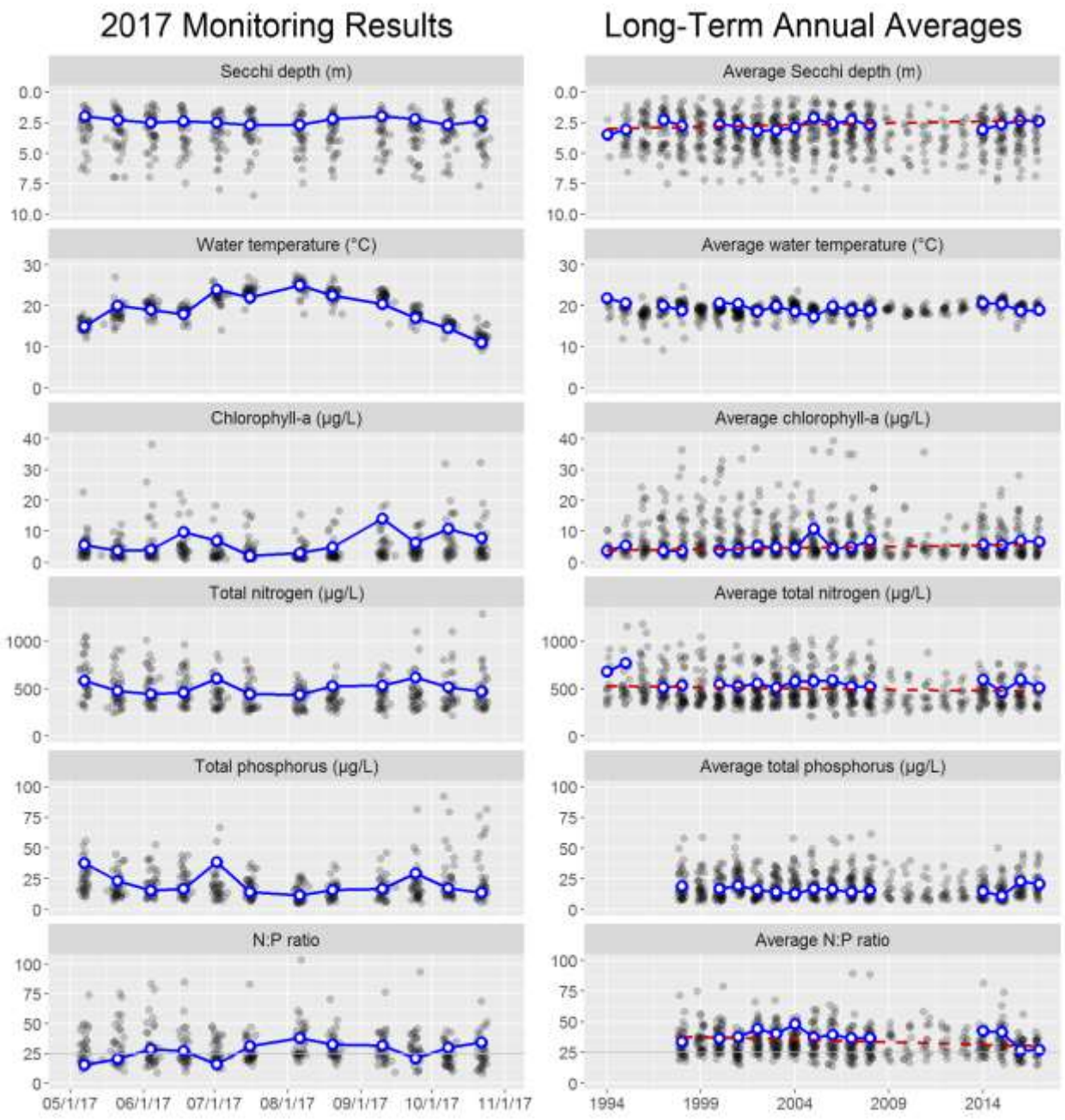
- **Secchi depth** is a measure of water clarity or transparency. Secchi depth is shallower when there are more suspended particles in the lake, such as sediment or algae. Secchi depth is also affected by water color, often from tannins or other naturally occurring organic molecules.
- **Water temperature** 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.
- **Chlorophyll-a** is a measure of the amount of algae in a lake. Chlorophyll-a is a pigment necessary for algae to photosynthesize and store energy.
- **Phosphorus** and **nitrogen** are naturally occurring nutrients necessary for growth and reproduction in both plants and animals. Increases in nutrients (especially phosphorus) can lead to more frequent and dense algal blooms.
- The **ratio of total nitrogen to total phosphorus (N:P)** indicates whether nutrient conditions favor the growth of cyanobacteria (blue-green algae). When N:P ratios are near or below 25, cyanobacteria can dominate the algal community. This is important because cyanobacteria have the ability to produce toxins.

# Water Quality Results & Trends

The following 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 *Supplemental Data*). The left column of graphs shows results for each sampling date in 2017, and the right column shows average values for each year (May-October averages).

Data for Shadow Lake are the blue circles (with white centers) 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 long-term trends in Shadow Lake are drawn with a dashed red line and described further after the graphs. Statistical trend analyses used a seasonal (monthly) Kendall test ($p<0.05$).




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 | -0.3 m | (-10%) |
| Chlorophyll-a | 0.9 µg/L | (24%) |
| Total nitrogen | -24 µg/L | (-4.6%) |
| N:P ratio | -4 | (-10%) |

Algal growth has been increasing over time, as indicated by a long-term trend of increasing chlorophyll concentrations. Secchi depths have also been getting shallower over time, likely as a result of increasing algal growth. The cause of the increasing algal growth is not clear, since nitrogen concentrations have decreased over time and there is no clear trend in phosphorus concentrations.

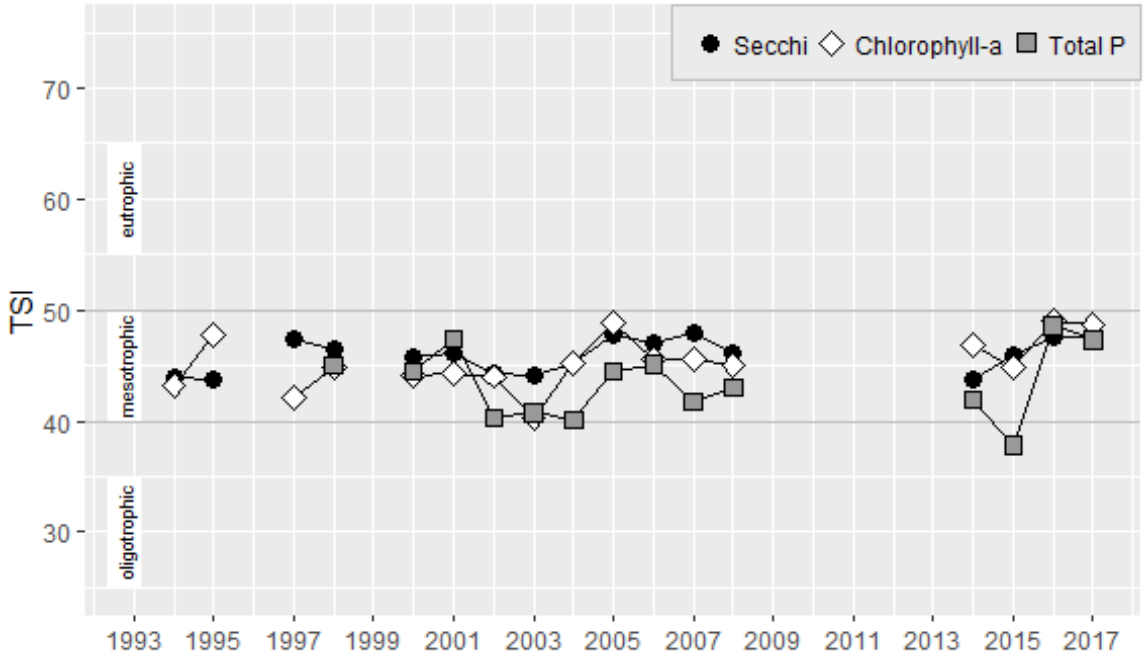
# Trophic State

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 previous Lake Stewardship reports (through 2016) included May and October data as well. The TSI values presented below, for all years, have been recalculated using only June-September data.

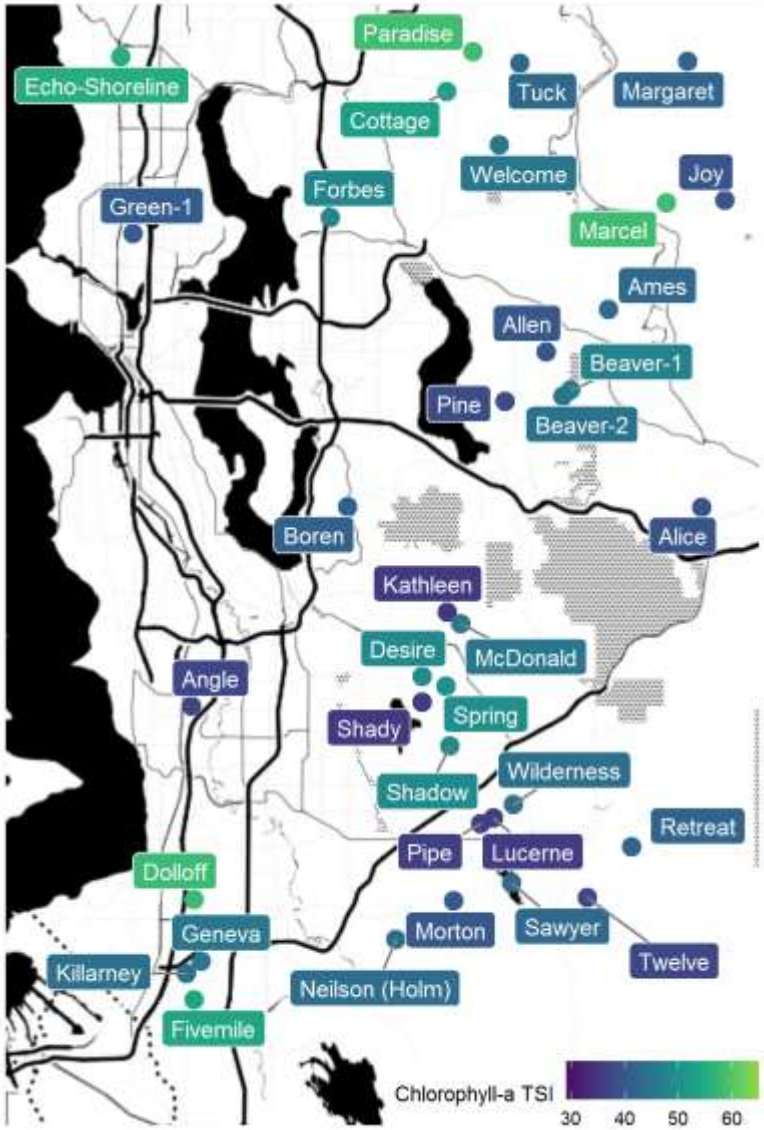
*Oligotrophic* lakes (TSI <40) are very clear, with low nutrient concentrations and low algal growth. *Eutrophic* lakes (TSI >50) have less-clear water, with high nutrient concentrations and high algal growth. Eutrophic lakes are more likely to have frequent algal blooms. *Mesotrophic* lakes (TSI 40-50) 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).

## Trophic state indices



# Comparison map

For a comparison with other lakes, this map shows the trophic state for each lake in the King County Lake Stewardship program in 2017. The color of each circle indicates the lake's average chlorophyll-a TSI value for the year.



# Supplemental Data

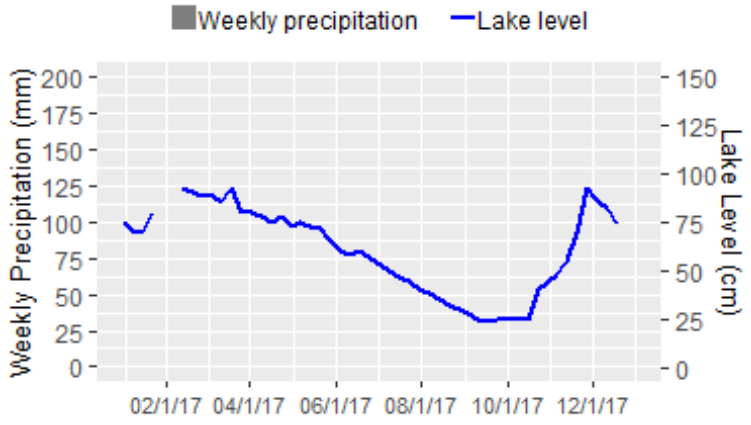
## Summary statistics

This table summarizes data from 2017 (1 m depth only), giving the minimum, mean (average), and maximum values for each parameter. This includes summary statistics for the full 2017 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) | 1.3 | 2.2 | 2.9 |
| Water temperature (°C) | 2.5 | 13.0 | 26.0 |
| **May-October statistics** | | | |
| Secchi depth (m) | 2.0 | 2.4 | 2.9 |
| Water temperature (°C) | 11.0 | 19.5 | 26.0 |
| Chlorophyll-a (µg/L) | 1.9 | 6.5 | 14.0 |
| Total nitrogen (µg/L) | 438.0 | 510.4 | 619.0 |
| Total phosphorus (µg/L) | 11.5 | 21.0 | 38.8 |
| N:P ratio | 15.4 | 27.1 | 38.1 |

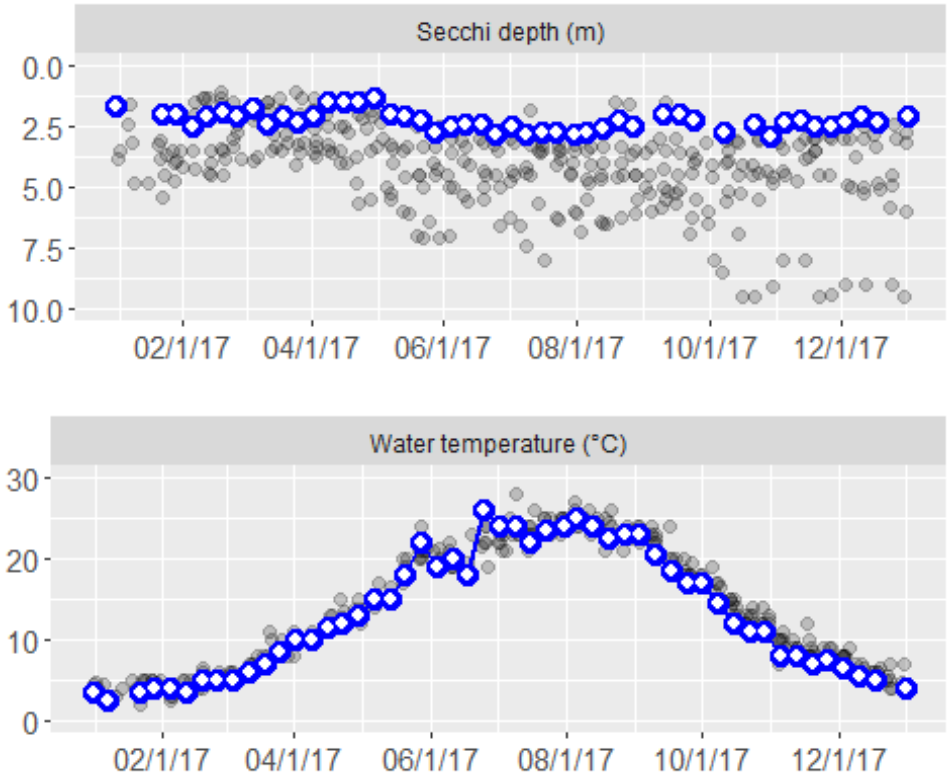
## Hydrology: Lake level and precipitation

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



# Year-round Secchi depth and water temperature

Secchi depth and water temperature (at 1 m depth) were measured weekly in 2017. The blue circles (with white centers) and blue 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.



# 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.

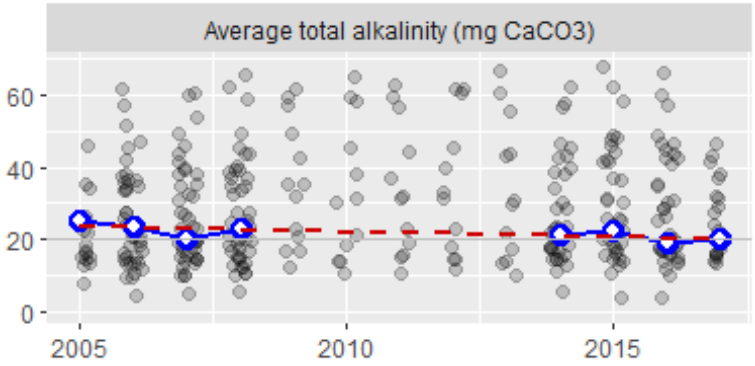
| Date | Depth | Temp | Chlor | Pheo | TN | NH3 | NO2/3 | TP | OPO4 |
|---|---|---|---|---|---|---|---|---|---|
| **5/21/2017** | 1 | 20.0 | 3.6 | (1.0) | 479 | 5.5 | (10.0) | 23.4 | 2.1 |
| | 4 | 18.0 | 17.2 | 2.7 | 998 | – | – | 28.5 | – |
| | 8 | 17.0 | – | – | 899 | 3.1 | 491.0 | 42.4 | 14.7 |
| **8/20/2017** | 1 | 22.5 | 4.8 | 2.3 | 528 | 9.2 | (10.0) | 16.2 | 0.9 |
| | 4 | 12.0 | 58.1 | 24.6 | 539 | – | – | 46.8 | – |
| | 8 | 6.0 | – | – | 788 | 163.0 | 216.0 | 57.8 | 9.7 |

* 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.

# Total alkalinity

A lake's ability to resist acidification, also called its buffering capacity, is measured as "total alkalinity." Lakes with total alkalinity less than 20 mg $CaCO_3$ are considered sensitive to acidification. We measured total alkalinity in May and August (on profile-sampling days) at 1 m depth. In 2017, the average total alkalinity of these two samples was 19.9 mg $CaCO_3$.

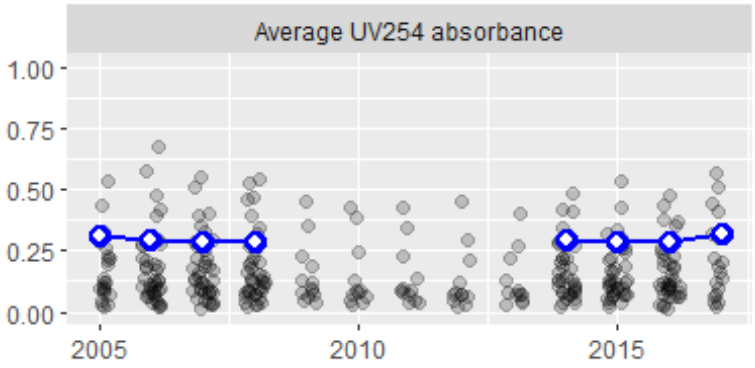
The blue circles (with white centers) and blue line are annual average alkalinity values for Shadow Lake. Grey points in the background are results for all other lakes in the Lake Stewardship program. The dashed red line shows the long-term trend in alkalinity, with an average change of -2.5 mg $CaCO_3$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



# Water color

Water color affects a lake's water clarity (and Secchi depth). Water color is measured by shining a specific wavelength of ultraviolet light (254 nm) through a filtered water sample and measuring the percent that was absorbed. We measured UV254 absorbance in May and August (on profile-sampling days) at 1 m depth. In 2017, the average UV254 absorbance of these two samples was 0.32, on a scale where 0 is no absorbance (perfectly clear) and 1 is complete absorbance (perfectly opaque).

The blue circles (with white centers) and blue 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.

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