2023 STATE OF THE LAKES UPDATE

SUNDAY LAKE

REPORT DESCRIPTION

This report is an update on the health of Sunday Lake based on water quality data collected from 1990 through 2021 by community volunteers and Snohomish County Surface Water Management (SWM) staff. For additional background on the information provided here or to find out more about Sunday Lake, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Sunday Lake is a 49-acre lake located west of Interstate 5 and east of Stanwood. The lake is shallow, with a maximum depth of 5.8 meters (19 feet). One main stream (sometimes called Jackson Gulch) enters at the west end of the lake. The lake outlet flows east and then south to the Stillaguamish River. The development pattern around the lake shore is irregular, with some areas of dense homes and other areas of large, undeveloped lots. There are about 30 homes directly on the shoreline. The lake watershed, which is the land area that drains to the lake, is relatively large—about 13 times the size of the lake. A lake with a large watershed is more susceptible to pollution from the surrounding area than a lake with a small watershed.

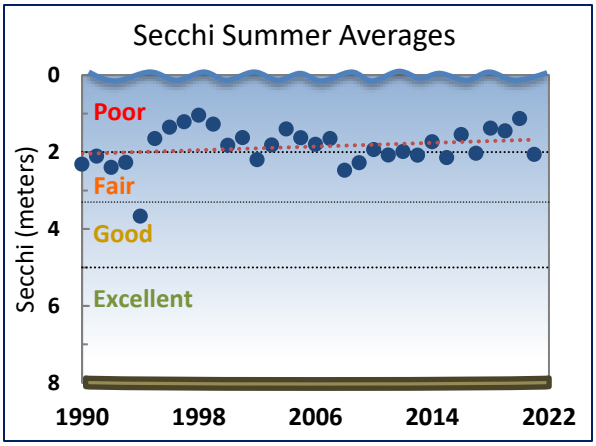
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, chlorophyll *a*, and total persulfate nitrogen for Sunday Lake. Please refer to the table at the end of the report for long-term averages and for averages and ranges for individual years.

Water Clarity

The water clarity of a lake, measured with a Secchi disk, is a reading of how far one can see into the water. Water clarity is affected by the amount of algae and sediment in the lake, as well as by water color (see below). Lakes with high water clarity usually have low amounts of algae, while lakes with poor water clarity often have excessive amounts of algae.

Water clarity in Sunday Lake is low, with a long-term 1990 - 2021 summer average of 1.9 meters (6 feet). In 2008 and 2009, water clarity was slightly improved, averaging 2.5 and 2.3 meters, respectively. However, the summer averages from 2010 through 2021 have been close to the long-term average. Overall, between 1990 and 2021 there was no trend in changing water clarity.



Water Color

The color of lake water affects the depths at which algae and plants can grow, and measurements of true water color provide clues to changes in water clarity. In many lakes, the water is naturally brown, orange, or yellow. This true color is a result of dissolved humic compounds entering the lake from surrounding wetlands, rather than algae or sediment suspended in the water, and does not harm water quality.

The water color of Sunday Lake averaged 37 pcu (platinum-cobalt color units) in 2010 - 2011, which indicates a moderate amount of color in the lake water. The natural brown color of the lake

SUNDAY LAKE

water is part of the reason why Sunday Lake has low water clarity.

Water color data will be taken again in the summers of 2021 and 2022. After two years of data collection, the results can be compared to previous measurements and assessed for changes.

Temperature

The temperature of lake water changes with the seasons and varies with depth. During spring and summer, sunlight warms the upper waters. Because warmer water is less dense, it floats above the cooler, denser water below. The temperature and density differences create distinct layers of water in the lake during warmer months, and these layers do not mix easily. This process is called stratification. The warm, upper water layer is called the epilimnion. The colder, darker bottom zone is called the hypolimnion. These layers will stay separated until the fall when the upper waters cool, the temperature differences decrease, and the entire lake mixes, or turns over.

From May through September 2021, the most recent available data, temperature was measured at each meter throughout the Sunday Lake water column (see graph). Temperature profiles show that from June through August, the lake was strongly thermally stratified. This means that there was a large temperature difference between the warm upper waters and the cool bottom waters, and mixing did not occur between these layers. Upper waters reached a peak of 81°F (27.2°C) in June, while bottom water temperatures remained in the mid 50's.

By September, the upper waters were beginning to cool, and they continued cooling through the fall. As stratification weakened, the lake water turned over, or mixed. The lake will stay mixed during the winter until springtime when the upper waters begin to warm again.

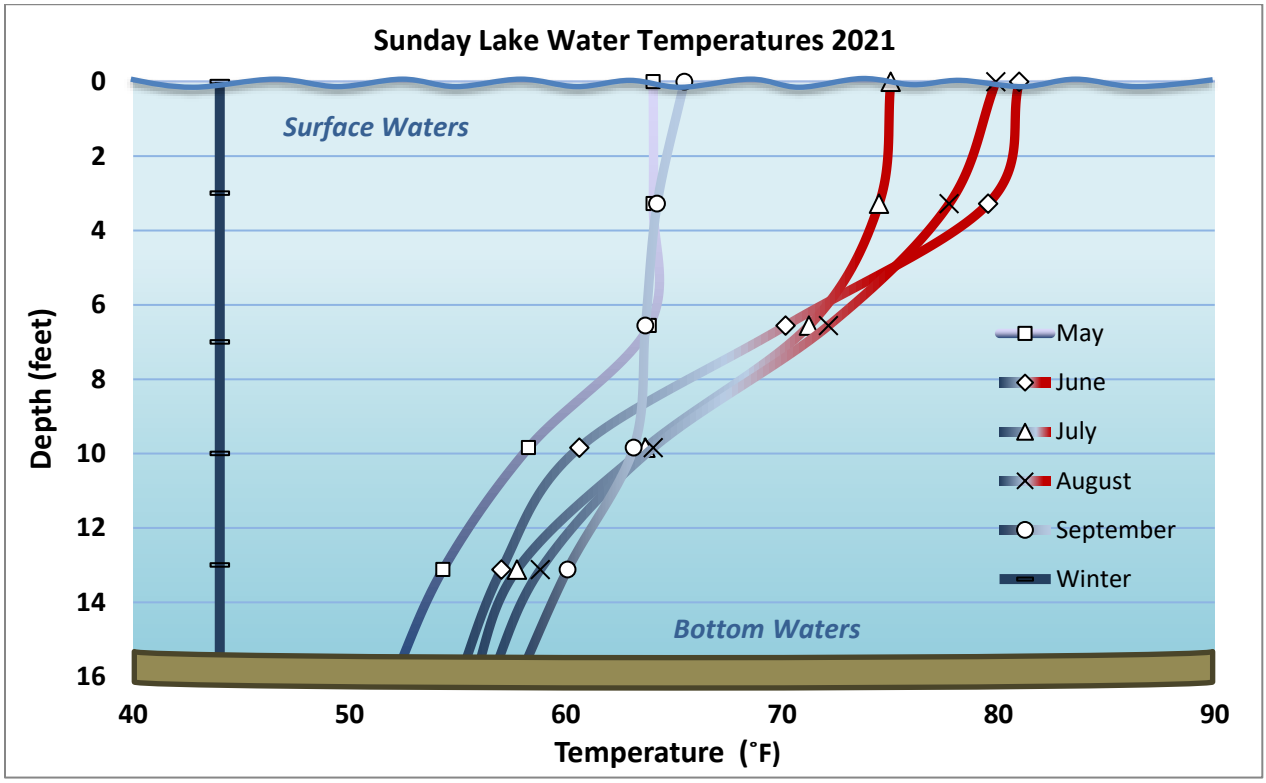
Dissolved Oxygen

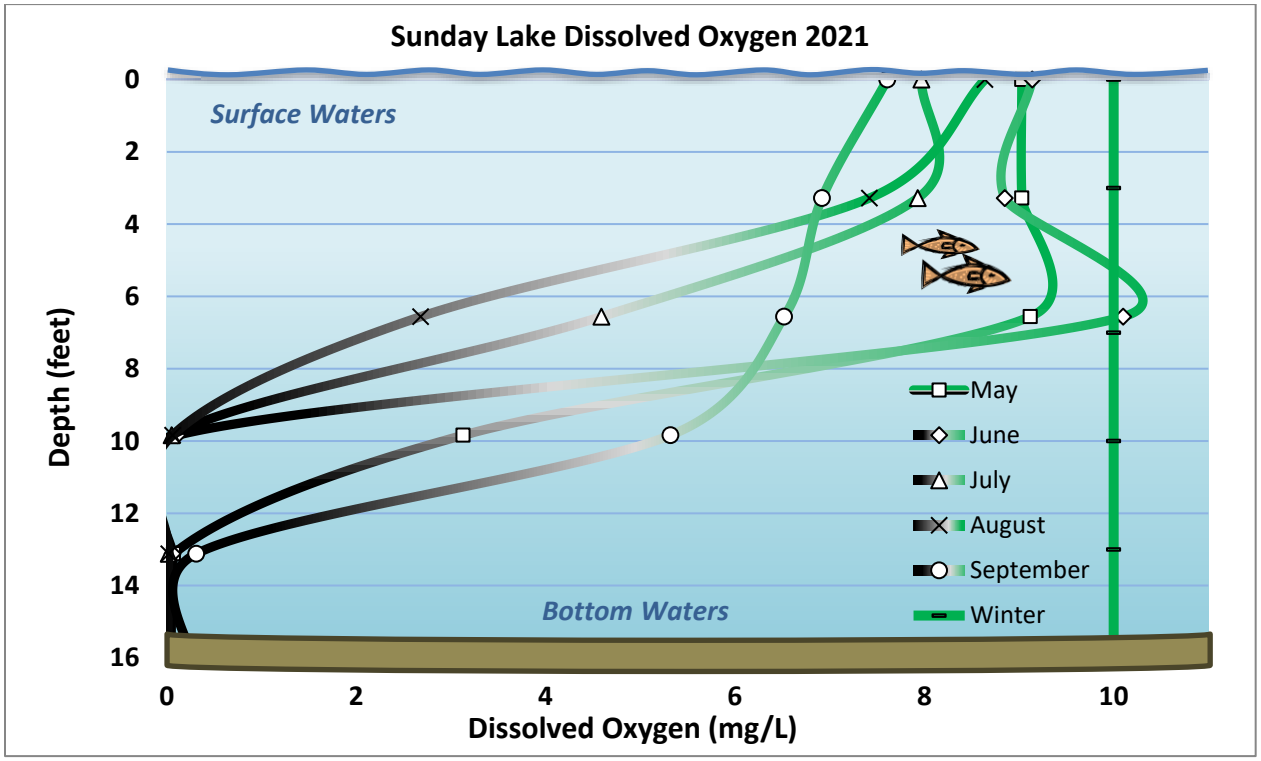
Oxygen dissolved in the water is essential for life in a lake. Most dissolved oxygen comes from the atmosphere. Like temperature, dissolved oxygen levels vary over time and with depth. During the warm months, the upper waters receive oxygen from the atmosphere, but the lower waters cannot be replenished with oxygen because of stratification. Meanwhile, bacteria in the lake bottom consume oxygen as they decompose organic matter. Eventually, oxygen is depleted in the bottom waters. Low dissolved oxygen in the bottom waters can lead to a release of nutrients from the lake sediments. The bottom of the lake remains devoid of oxygen until the lake mixes in late fall.

Dissolved oxygen has also been measured some years at every meter throughout the Sunday Lake water column, most recently in 2021 (see graph). Oxygen levels were relatively high in the upper waters from May through September, while the bottom waters contained much less dissolved oxygen. In June, there was a sharp increase in dissolved oxygen at around 6 feet deep. This indicates vigorous algae growth at that depth which added oxygen to the water.

Aside from these spikes, the lower waters of the lake contained little to no oxygen until fall turn over. By winter, the lake was fully mixed, and oxygen from the atmosphere replenished the dissolved oxygen levels within the bottom waters.

SUNDAY LAKE


Sunday Lake Water Temperatures 2021
Surface Waters
Bottom Waters
Depth (feet)
0
2
4
6
8
10
12
14
16
40
50
60
70
80
90
Temperature (˚F)
May
June
July
August
September
Winter


Sunday Lake Dissolved Oxygen 2021
Surface Waters
Bottom Waters
Depth (feet)
0
2
4
6
8
10
12
14
16
0
2
4
6
8
10
Dissolved Oxygen (mg/L)
May
June
July
August
September
Winter

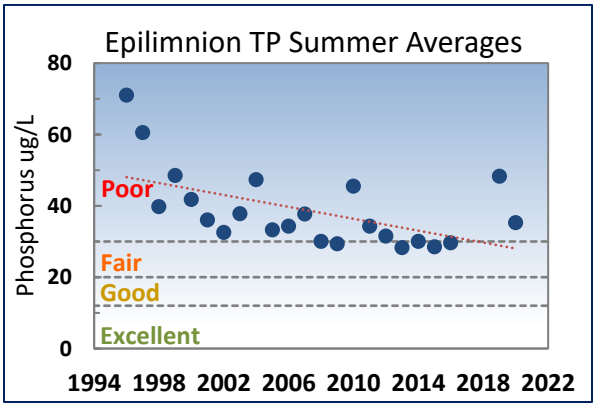
SUNDAY LAKE

Phosphorus (key nutrient for algae)

Nutrients are essential for the growth of algae, fish, and aquatic plants in a lake. However, too many nutrients, especially phosphorus, can pollute a lake and lead to unpleasant algae growth. Nutrients enter the lake through stormwater runoff or from streams flowing into the lake. Sources of nutrients include fertilizers, pet and animal wastes, poorly maintained septic systems, and erosion from land clearing and construction. Monitoring phosphorus levels over time helps to identify changes in nutrient pollution.

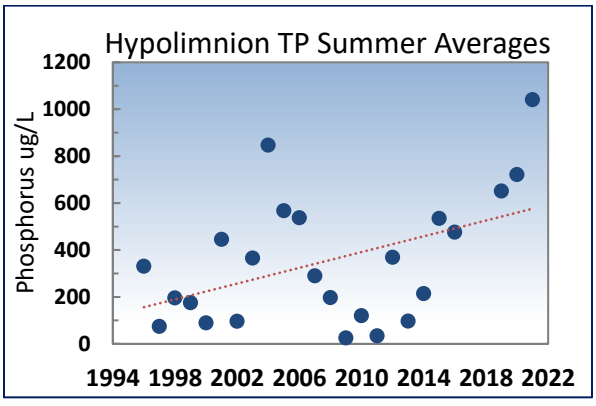
Total phosphorus (TP) levels in Sunday Lake are high. For this reason, Sunday Lake was listed as "impaired" in the 2018 Washington State Water Quality Assessment.

The long-term 1996 - 2021 summer average for total phosphorus in the epilimnion (upper waters) was 39 µg/L (micrograms per liter which is equivalent to parts per billion). Between 1996 and 2021, there was a statistically significant decrease in phosphorus levels in the upper waters (p=0.00). This is good news. However, phosphorus levels continue to be a concern in Sunday Lake because they are high enough to lead to increased algae growth.



Monitoring of the stream entering Sunday Lake during the winters of 2003 - 2004 and 2009 - 2010 showed that relatively high levels of phosphorus are flowing in from the watershed. Where the stream crosses 25th Avenue NW, the water had average total phosphorus concentrations between 53 - 60 µg/L, which are high enough to contribute additional phosphorus to the lake and increase the growth of algae and aquatic plants.

Summertime phosphorus levels in the hypolimnion (bottom waters) are very high and more variable than in the upper waters. The long-term 1996 - 2021 summer average was 354 µg/L, with a record of 1040 µg/L in 2021. Overall, between 1996 and 2016, there was a statistically significant increasing trend in hypolimnion phosphorous concentrations (p=0.05). The variability in phosphorus levels in the bottom waters may be affected by several factors. These include the amount of nutrients coming from the watershed, partial mixing of the lake during wind storms, the degree of oxygen depletion from decaying matter in the lake bottom, the depth of sample collection, and the rise and fall of lake levels because of weather conditions and beaver activity.

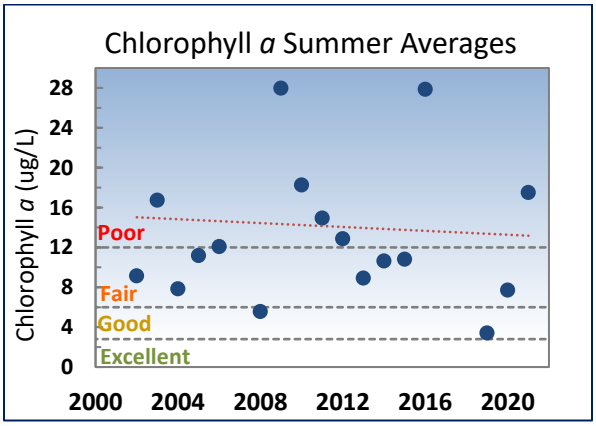


SUNDAY LAKE

Chlorophyll a (Algae)

Algae are tiny plant-like organisms that are essential for lake health. Fish and other aquatic life depend on algae as the basis for their food supply. However, excessive growths of algae, called algae blooms, can cloud the water, form unsightly scums, and sometimes release toxins. Excess nutrients, such as phosphorus and nitrogen, are the main cause of nuisance algae growth in a lake. Chlorophyll *a* (chl) measurements are one method for tracking the amount of algae in a lake.

Chlorophyll *a* values in Sunday Lake are also high, with a long-term 2002 - 2021 summer average of 14.2 µg/L. The averages in 2007 and 2016 were particularly high and indicate abundant algae production in the lake. Overall, there was no evidence of a statistically significant trend in changing chlorophyll *a* levels between 2002 and 2021.



Toxic Blue-Green Algae (Cyanobacteria)

Blue-green algae, also called cyanobacteria, are a group of algae capable of producing toxins during periods of high growth, known as blooms. The toxins can cause serious illness in people and pets that encounter affected water. Blooms often look like blue or green paint floating on the water's surface. Lake users should avoid contact with the water and keep pets away from the lake when it is experiencing a blue-green algae bloom. If a bloom has been identified as toxic, the lake will have postings at public access sites.

Since 2005, volunteers and SWM staff have screened algae at Sunday Lake for potentially toxic blooms. During 2010, Sunday Lake tested positive for anatoxin (a nerve toxin) and for cylindrospermopsin (a liver toxin), although detected levels were very low. In 2011, Sunday Lake tested positive for both microcystin (another liver toxin) and anatoxin. The microcystin concentrations exceeded the State guideline of 8 µg/L. In November 2012, microcystin was measured at 4.8 µg/L during an algae bloom. No blue-green algae blooms were reported from 2013 to 2021.

Screening for toxic algae will continue in future years as part of the Snohomish County Lake Monitoring Program. Continued monitoring will help alert the public to potential health risks as well as determine the frequency and severity of toxic algae blooms at Sunday Lake.

Learn more at https://snohomishcountywa.gov/1959/Algae-Toxic-Algae and sign up for alerts at https://snohomishcountywa.gov/5396/Sunday.

Algae Bloom Toxin Levels at Sunday Lake

Year	Weeks Posted	Microcystin Range (µg/L)	Anatoxin Range (µg/L)	Cylindrospermopsin Range (µg/L)	Saxitoxin Range (µg/L)
2009	-	<MDL	<MDL	-	-
2010	-	<MDL	0.02-0.19	-	-
2011	11	0.08-67.6	0.02-0.03	<MDL	<MDL
2012	8	<1-4.8	<MDL	-	-

Washington State Department of Health recreational guidelines are 8 µg/L for Microcystin, 1 µg/L for Anatoxin, 15 µg/L for Cylindrospermopsin, 75 µg/L for Saxitoxin. Blooms are not sampled for toxins in the winter months.

Nitrogen (another essential nutrient for algae)

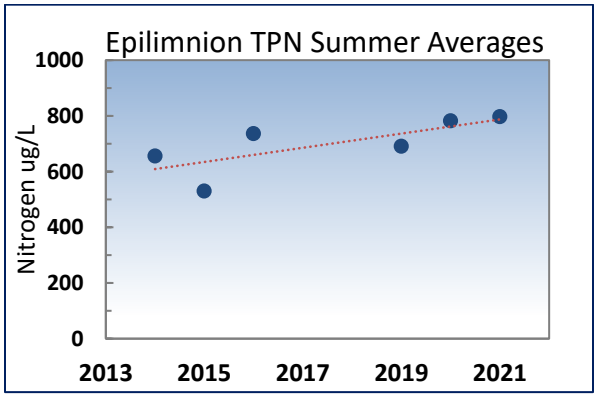
Nitrogen is another important nutrient for plant and algae growth. Lakes with high levels of

SUNDAY LAKE

nitrogen typically have more aquatic plants and algae. The long-term 2012 - 2021 total persulfate nitrogen (TPN) epilimnion summer average for Sunday Lake was high at 698 µg/L. For this reason (in addition to the high levels of phosphorous) Sunday Lake was listed as "impaired" in the 2018 Washington State Water Quality Assessment. Overall, there was a trend toward increasing nitrogen concentrations during this period (p=0.04).

The relative abundance of nitrogen and phosphorus can also be a useful indicator of lake conditions. This is referred to as the nitrogen to phosphorus ratio, or N:P ratio. When lakes have low N:P ratios (typically less than 20), algae growth is often high, and harmful blue-green algae blooms may be a problem. Low N:P ratios may also indicate that fertilizers, septic systems, polluted runoff from developed areas, and release of phosphorus from bottom sediments are contributing most of the nutrients to the lake.

In contrast, when lakes have higher N:P ratios (substantially greater than 20), algae growth will be limited by the amount of phosphorus available, and blue-green algae blooms are usually less of a problem. Sunday Lake had a low N:P ratio of 19.



SHORELINE CONDITION

The condition of the lake shoreline is important for understanding overall lake health. Frequently, lake shorelines are modified through the removal of natural vegetation, installation of bulkheads or other hardening structures, and/or removal of partially submerged logs and branches. These alterations leave the lake ecosystem susceptible to pollution from the watershed, eliminate the buffer of native vegetation that can filter out excess nutrients, and limit the amount of habitat available for fish and wildlife. The loss of native vegetation along the lake shore could also lead to shoreline erosion.

Surveys conducted in the mid-90s showed 31 homes bordering Sunday Lake. There are also 17 docks around the lake. Given the level of residential development on the south and west shores, the overall physical shoreline is still relatively intact. Only 22% of the 1.4-mile shoreline has been armored with bulkheads or fills. The zone of native vegetation immediately adjacent to the shoreline has experienced more modification. About 62% of the native shoreline vegetation has been significantly altered. Also, there is a low amount of large wood left in the lake (about 34 pieces). Any remaining old logs or branches are valuable habitat for aquatic life.

Shoreline condition data will be taken in the summers of 2021 and 2022 and will be compared to previous survey data.

SUMMARY

Lake Health Classifications

Snohomish County lakes vary greatly in their natural condition. The size and depth of a lake are major factors in determining the lake's characteristics. Lakes also vary based on their state of eutrophication. Eutrophication is a process of lake enrichment in which, over time, nutrient inputs cause an ever-increasing growth of algae and aquatic plants. As plants decay, organic matter, or sediment, builds up on the lake bottom. In some cases, lakes gradually fill up and become wetlands. Eutrophication is a slow,

SUNDAY LAKE

natural process that takes hundreds of years, but it can be accelerated by human activities that add nutrients to the system.

Snohomish County used the natural variation in lake characteristics to develop four lake health classifications as follows:

- **Excellent** – often deep, with clear water, low nutrient concentrations, few aquatic plants, and low levels of algae.
- **Good** – can be deep or shallow with moderate levels of nutrients, algae, and aquatic plants.
- **Fair** – often shallow with high nutrient concentrations, abundant plants, high levels of algae, occasional toxic blooms, and limited water clarity.
- **Poor** – very high nutrient concentrations, abundant plant growth, very high levels of algae (often with toxic blooms), very limited water clarity, and very low dissolved oxygen in the bottom waters.

Lakes classified as "excellent", "good" and "fair" are all potentially natural states of area lakes. However, lakes should remain in the same category over decades. A shift in a lake health rating is a sign of deteriorating water quality or shoreline conditions that require action. Similarly, lakes classified as "poor" have had excessive nutrient pollution or severe shoreline degradation, leading to unhealthy conditions. These lakes will likely require restoration.

Health Summary

Based on the long-term monitoring data, Sunday Lake may be classified as poor overall, with low water clarity, high and variable phosphorus concentrations, high levels of nitrogen, and high and variable algae levels.

Total phosphorus levels in the epilimnion (upper waters) are declining, which is good for the lake. In contrast, phosphorus in the bottom waters and chlorophyll *a* levels remain high, with no improving trends, and the main stream flowing into the lake exacerbates phosphorous loading. Further, nitrogen concentrations appear to be increasing in the lake overall. Taken together, these conditions indicate that the lake is capable of producing excess aquatic plants and algae, including occasionally toxic algae blooms, which can impair lake health and usability.

Residents around the lake can help Sunday Lake. Some of the most important actions to reduce harmful phosphorus pollution include picking up pet waste, practicing natural lawn care, preventing soil erosion, infiltrating roof and driveway runoff, and maintaining a leak-free septic system. Shoreline landowners can also create a Healthy Shoreline by replacing some shoreline lawns with trees and shrubs. Snohomish County's LakeWise program is here to help by providing free educational site visits and resources to help you complete these actions. Visit www.lakewise.org to learn more.

To find out more about ways to protect lake water quality and obtain information on the causes and problems of elevated lake nutrient levels, visit www.lakes.surfacewater.info.

SUNDAY LAKE

DATA SUMMARY FOR SUNDAY LAKE						
		Water Clarity (Secchi depth	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll *a* (µg/L)
Source	**Date**	in meters)	**Surface**	**Bottom**	**Surface**	**Surface**
Bortleson, et al, 1976	**7/26/73**	3.0	18	21	-	-
DOE	**1990**	0.7 - 3.4 (2.3) *n = 9*	-	-	-	-
DOE	**1991**	0.6 - 2.9 (2.1) *n = 8*	-	-	-	-
DOE	**1992**	0.5 - 2.9 (2.4) *n = 8*	-	-	-	4.3 - 7.8 (6.1) *n = 2*
DOE	**1993**	0.6 - 2.9 (2.3) *n = 11*	-	-	-	4.8 - 57 (31) *n = 2*
SWM Staff or DOE	**1994**	2.8 - 4.3 (3.7) *n = 3*	-	-	-	2.6 - 120 (34) *n = 4*
SWM Staff	**1995**	1.6 *n = 1*	-	-	-	33
SWM Staff or Volunteer	**1996**	0.9 - 1.7 (1.4) *n = 5*	54 - 88 (71) *n = 2*	241 - 420 (331) *n = 2*	-	-
SWM Staff or Volunteer	**1997**	0.8 - 1.7 (1.2) *n = 10*	55 - 66 (61) *n = 2*	56 - 92 (74) *n = 2*	-	-
SWM Staff or Volunteer	**1998**	0.6 - 1.5 (1.0) *n = 8*	31 - 61 (40) *n = 4*	117 - 352 (195) *n = 4*	-	-
SWM Staff	**1999**	0.8 - 1.7 (1.3) *n = 4*	38 - 66 (49) *n = 4*	118 - 306 (175) *n = 4*	-	-
SWM Staff	**2000**	1.6 - 2.0 (1.8) *n = 4*	17 - 89 (42) *n = 4*	35 - 194 (89) *n = 4*	-	-
Volunteer	**2001**	1.2 - 2.0 (1.6) *n = 4*	24 - 58 (36) *n = 4*	77 - 842 (445) *n = 4*	-	-
SWM Staff or Volunteer	**2002**	1.6 - 2.5 (2.2) *n = 4*	24 - 51 (33) *n = 4*	37 - 137 (96) *n = 4*	-	2.7 - 22 (9.1) *n = 4*
Volunteer	**2003**	1.2 - 2.5 (1.8) *n = 9*	27 - 52 (38) *n = 4*	175 - 596 (365) *n = 4*	-	8.3 - 71 (24) *n = 6*
Volunteer	**2004**	1.0 - 1.6 (1.4) *n = 3*	26 - 81 (47) *n = 3*	356 - 1388 (847) *n = 3*	-	2.1 - 15 (7.8) *n = 3*

SUNDAY LAKE

DATA SUMMARY FOR SUNDAY LAKE						
		Water Clarity (Secchi depth	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll *a* (µg/L)
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Surface**	**Surface**
Volunteer	**2005**	1.1 - 2.5 (1.6) *n = 5*	29 - 37 (33) *n = 4*	116 - 1010 (567) *n = 4*	-	3.2 - 31 (11) *n = 4*
Volunteer	**2006**	1.5 - 2.1 (1.8) *n = 4*	24 - 53 (34) *n = 4*	147 - 791 (537) *n = 4*	-	4.8 - 25 (12) *n = 4*
SWM Staff	**2007**	0.8 - 2.2 (1.7) *n = 4*	31 - 42 (38) *n = 4*	35 - 745 (290) *n = 3*	-	6.1 - 73 (35) *n = 4*
SWM Staff	**2008**	2.2 - 2.6 (2.5) *n = 4*	23 - 41 (30) *n = 3*	50 - 484 (197) *n = 4*	-	2.7 - 11 (5.6) *n = 4*
Volunteer	**2009**	1.3 - 3.2 (2.3) *n = 12*	25 - 33 (29) *n = 3*	25	-	9.9 - 37 (28) *n = 3*
Volunteer	**2010**	1.7 - 2.0 (1.9) *n = 4*	38 - 55 (46) *n = 4*	42 - 226 (120) *n = 4*	-	14 - 23 (18) *n = 4*
Volunteer	**2011**	1.1 - 3.2 (2.1) *n = 7*	30 - 40 (34) *n = 4*	26 - 41 (34) *n = 2*	-	9.1 - 27 (15) *n = 4*
Volunteer	**2012**	1.3 - 2.7 (2.0) *n = 6*	25 - 41 (32) *n = 4*	117 - 620 (369) *n = 2*	-	6.4 - 19 (13) *n = 4*
Volunteer	**2013**	1.4 - 2.3 (2.1) *n = 5*	24 - 32 (28) *n = 4*	51 - 160 (97) *n = 4*	-	1.6 - 27 (8.9) *n = 4*
Volunteer	**2014**	1.4 - 2.2 (1.7) *n = 3*	25 - 36 (30) *n = 3*	25 - 538 (214) *n = 3*	638 - 673 (656) *n = 2*	6.4 - 18 (11) *n = 3*
SWM Staff	**2015**	1.6 - 2.5 (2.1) *n = 4*	19 - 37 (29) *n = 4*	314 - 827 (534) *n = 4*	488 - 573 (529) *n = 4*	6.9 - 20 (11) *n = 4*
SWM Staff	**2016**	1.1 - 1.8 (1.5) *n = 4*	18 - 50 (30) *n = 4*	174 - 681 (475) *n = 4*	542 - 932 (737) *n = 4*	2.4 - 87 (28) *n = 4*
SWM Staff	**2017**	1.1 - 3.8 (2.0) *n = 11*	-	-	-	-
SWM Staff	**2018**	0.9 - 2.7 (1.4) *n = 12*	-	-	-	-
SWM Staff	**2019**	0.6 - 3.6 (1.5) *n = 15*	33 - 82 (48) *n = 4*	409 - 875 (651) *n = 4*	608 - 790 (690) *n = 4*	0.9 - 6.9 (3.4) *n = 4*
SWM Staff	**2020**	0.7 - 2.0 (1.1) *n = 11*	28 - 49 (35) *n = 4*	416 - 958 (721) *n = 4*	746 - 838 (782) *n = 4*	1.5 - 22 (7.7) *n = 4*

SUNDAY LAKE

DATA SUMMARY FOR SUNDAY LAKE						
		Water Clarity (Secchi depth	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll *a* (µg/L)
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Surface**	**Surface**
SWM Staff	**2021**	1.5 - 2.7 (2.1) *n = 8*	35 - 65 (44) *n = 4*	688 - 1,680 (1,040) *n = 4*	700 - 949 (797) *n = 4*	15 - 21 (18) *n = 4*
Long Term Avg		**1.9 (1990-2021)**	**39 (1996-2021)**	**354 (1996-2021)**	**698 (2014-2021)**	**14 (2002-2021)**
TRENDS		**None**	**Decreasing**	**Increasing**	**Increasing**	**None**

NOTES

- DOE = Washington Department of Ecology.
- Table includes summer data only, Secchi (May-Oct) and TP, TPN and chl (Jun-Sep).
- Each box shows the range on top, followed by summer average in ( ) and number of samples (n).
- Total phosphorus data are from samples taken at discrete depths only.
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.
- No water sampling in 2017.
- TP, TPN, chl data rejected in 2018.