LAKE SERENE

REPORT DESCRIPTION

This report is an update on the health of Lake Serene based on water quality data collected from 1992 through 2016 by local volunteers and Snohomish County Surface Water Management (SWM) staff. For additional background on the information provided here or to find out more about Lake Serene, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Serene is located just west of Highway 99, between Lynnwood and Mukilteo. The surface area of Lake Serene covers 45 acres. The lake is quite shallow, with a maximum depth of 6.7 meters (22 feet). The Lake Serene watershed, which is the land area that drains to the lake, is relatively small, only 5.3 times the size of the lake, but it is densely developed with residential uses. New developments proposed or in progress in the watershed and on the lake shore have the potential to adversely affect water quality unless measures are implemented to control nutrients.

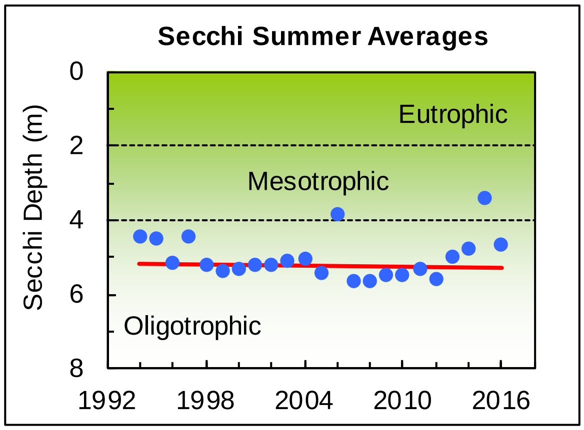
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Serene. 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. 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 Lake Serene is moderately high, with a 1992 – 2016 long-term summer average of 5.0 meters (16.4 feet). Water clarity has shown periods of slight improvement over time in spite of some abnormally low averages (3.9 meters in 2006 and 3.4 meters in 2015). The 2006 decrease in clarity corresponded with an increase in phosphorus levels in 2006 that followed the herbicide treatment to control milfoil plants in the lake. The 2015 decrease can be associated with slightly elevated levels of chlorophyll a, an indicator of algae. Overall, water clarity was at its best from 2007-2012, and between 1992 and 2014, there was a weak, but statistically significant trend towards improved water clarity. However, this improving trend disappeared in 2015. Water clarity improved slightly in 2016 (4.6 meters), although it is still lower than the average.



Water Color

The color of lake water affects water clarity and the depths at which algae and plants can grow. In many lakes, the water is naturally brown, orange, or yellow. This darker color comes from dissolved humic compounds from surrounding wetlands and does not harm water quality. Measurements of true water color provide clues to changes in water clarity. True water color is only the color from dissolved materials and not of the color of algae or sediment suspended in the water.

The water color of Lake Serene averaged 12 pcu (platinum-cobalt color units) in 2010 – 2011, which indicates a slight amount of color in the lake water. This is a small decrease from the 1994 – 1995 average of 15 pcu. This reduction in the color of the water in

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Lake Serene could be a factor in the trend of increasing water clarity over the same time period.

Temperature

The temperature of lake water changes with the seasons and varies with depth. During spring and summer, the sun 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, and these layers do not mix easily. This process is called stratification and occurs during the warm months. 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 2015, the most recent data available, temperature data were collected at each meter throughout the Lake Serene water column (see graph). Temperature profiles for 2015 show that throughout the sampling season the lake was not thermally stratified. This means that the lake remained mixed and there was little to no difference in temperature between the upper waters and the bottom waters. In May the lake waters measured about 61˚F (16°C) in temperature, and by August had reached their peak at 75°F (24°C). Each fall the waters will continue to cool. Lake Serene tends to stay mixed throughout the year with only short periods of stratification.

Dissolved Oxygen

Oxygen dissolved in the water is essential for life in a lake. Most of the 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 the separation between water layers. Meanwhile, bacteria in the lake bottom are consuming 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.

Dissolved oxygen was also measured at every meter throughout the Lake Serene water column from May to September in 2015 (see graph). Oxygen levels remained relatively high in the upper waters throughout the summer, although the levels were slightly lower in the hottest months because warm water cannot hold as much dissolved oxygen as colder water. Meanwhile, the bottom waters contained less dissolved oxygen. During the summer period, oxygen in the lower waters is consumed by the decomposition of organic material within the lake. Lower oxygen levels will remain in the bottom of the lake until the water cools (typically in late October/early November). The lake remains completely mixed through the winter until springtime when the upper waters begin to warm and dissolved oxygen begins to decline in the bottom.

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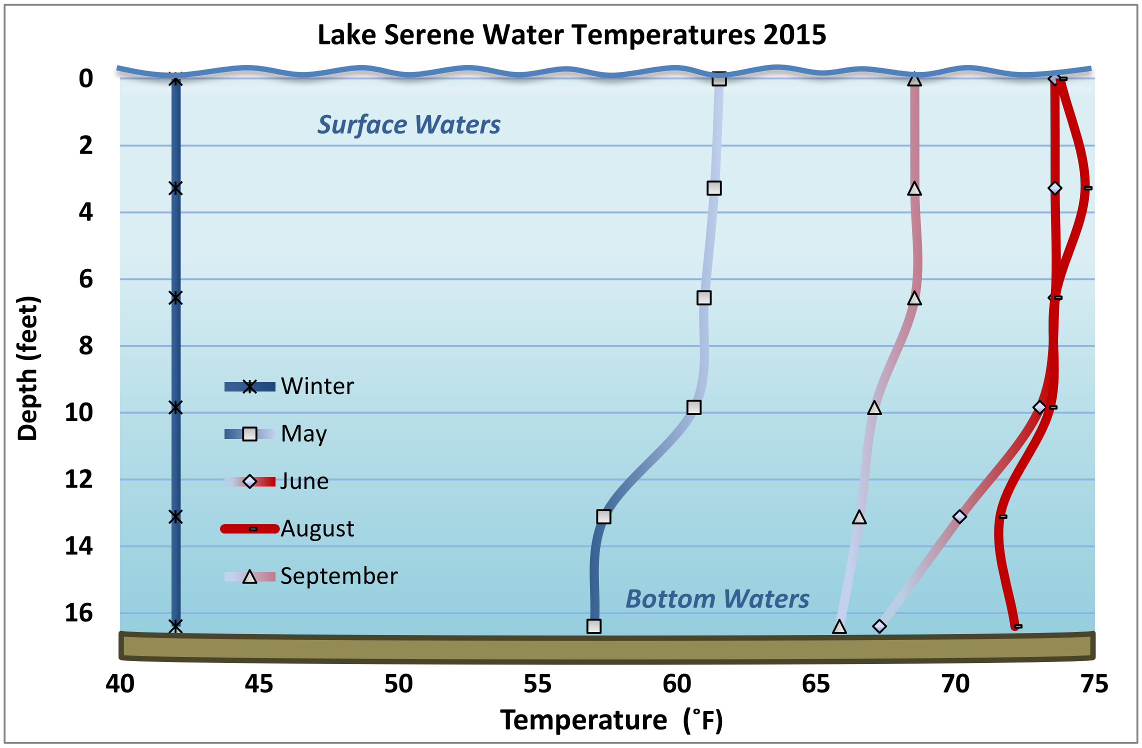
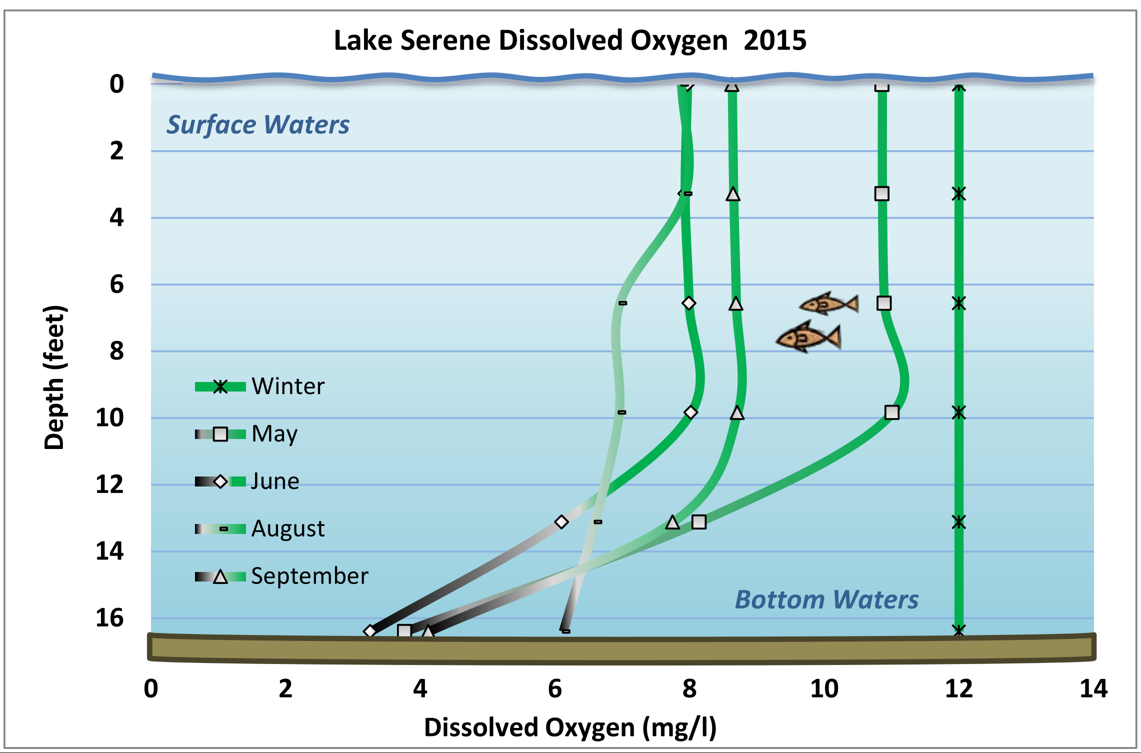

Lake Serene Water Temperatures 2015
Surface Waters
Bottom Waters
Winter
May
June
August
September
Depth (feet)
0
2
4
6
8
10
12
14
16
40
45
50
55
60
65
70
75
Temperature (˚F)


Lake Serene Dissolved Oxygen 2015
Surface Waters
Bottom Waters
Winter
May
June
August
September
Depth (feet)
0
2
4
6
8
10
12
14
16
0
2
4
6
8
10
12
14
Dissolved Oxygen (mg/l)

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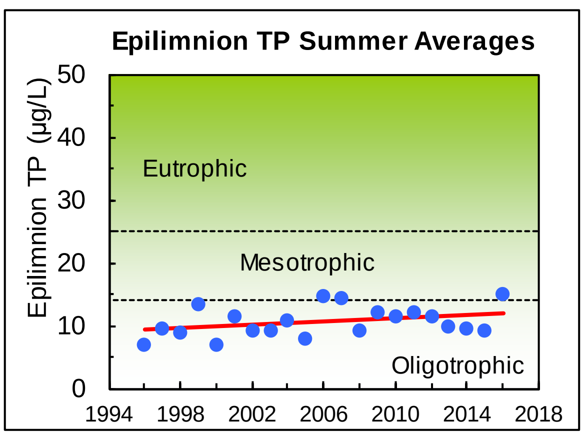
Phosphorus (key nutrient for algae)

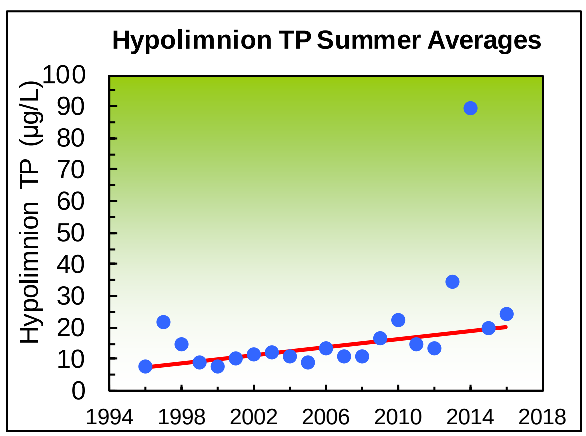
Nutrients are essential for the growth of algae, fish, and aquatic plants in a lake. However, too many nutrients, especially phosphorus, can pollute a lake and lead to unpleasant algae growth. Nutrients enter the lake through stormwater runoff or from streams flowing into the lake. Sources of nutrients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

Total phosphorus (TP) concentrations in Lake Serene are moderately low. The 1996 – 2016 long-term summer average for the epilimnion (upper waters) is only 11 µg/L (micrograms per liter, which is equivalent to parts per billion). Between 1996 and 2016, there has been no trend in phosphorus concentrations in the upper waters. The 2016 summer average in the epilimnion is the highest on record at 15 µg/L. Overall, the amount of phosphorus in the upper waters has been stable over time, but any increases in phosphorus can lead to more algae growing in the lake.



Phosphorus levels in the hypolimnion (bottom waters) are also relatively low. The 1996 – 2016 long-term summer phosphorus average in the bottom waters is only 18 µg/L. However, there has been a statistically significant trend toward increasing phosphorus levels in the hypolimnion ($p=0.00$) between 1996 and 2016. The 2013 and 2014 summer averages, 34 µg/L and 90 µg/L respectively, were the highest on record. The 2015 summer average was closer to the long term average at 20 µg/L, and the 2016 summer average increased slightly to 24 µg/L.

Increasing phosphorus levels in the hypolimnion can result from the release of nutrients from the lake sediments and can be a sign of accelerating eutrophication. However, Lake Serene has a small hypolimnion because the lake is shallow and stratifies very weakly into epilimnion and hypolimnion layers. Also, wind action mixes the lake at times during the summer. This is why phosphorus concentrations in the hypolimnion are often similar to those in the epilimnion and why there is less opportunity for phosphorus that is released from the sediments during periods of low dissolved oxygen to build up in the hypolimnion compared to other lakes. The very high values in 2013 and 2014 may have occurred because of prolonged periods without wind storms and lake mixing that otherwise would have spread the phosphorus throughout the entire lake.



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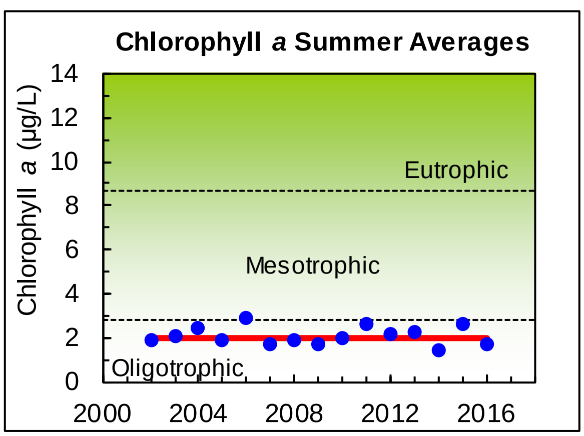
Chlorophyll a (Algae)

Algae are tiny plant-like organisms that are essential for a healthy lake. Fish and other lake 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* measurements are one method for tracking the amount of algae in a lake.

Chlorophyll *a* values in Lake Serene have been relatively low and consistent from 2002 through 2015. The long-term summer average is 2.1 µg/L, indicating low levels of free-floating algae in the lake. Algae levels are low partly because the lake supports dense aquatic plants that compete with algae for nutrients. Also, in some years, there have been widespread clumps or mats of filamentous algae which compete with free-floating algae for nutrients. However, there have been a few reports of occasional nuisance algae blooms during the winter and spring at the lake.



Nitrogen (another essential nutrient for algae)

Nitrogen is another important nutrient for plant and algae growth. Similar to phosphorus, lakes with high levels of nitrogen typically have more aquatic plants and algae. From 2014 to 2016, Lake Serene had relatively low levels of total nitrogen (summer average of 357 µg/L). This is consistent with the low chlorophyll *a* concentrations measured in the lake.

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 the lake bottom sediments are contributing most of the nutrients to the lake.

In contrast, when lakes have higher N:P ratios (greater than 20), algae growth will be limited by the amount of phosphorus available, and blue-green algae are usually less of a problem. Lake Serene had an average N:P ratio of 31, and blue green algae blooms were not observed in 2016.

Aquatic Plants

Aquatic plants are also important in a lake ecosystem. Plants provide food and shelter for fish and other aquatic animals, stabilize the shoreline and bottom sediments, and in some cases increase water clarity by out-competing algae for nutrients. Some plants grow entirely submersed under the water (like elodea), some have leaves that float on the surface (like lilies), and others have roots under the water with most of the plant standing above the water (like cattails).

Although aquatic plants are essential for lake health, excess growth of aquatic plants can interfere with swimming, boating, fishing, and wildlife habitat. In addition, invasion by non-native plant species can seriously damage a lake ecosystem. Non-native aquatic plants choke out native plants and form dense stands that are a nuisance to humans and wildlife.

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An invasion of Eurasian watermilfoil plants was discovered in Lake Serene in August 2004. Milfoil is a threat to the use and enjoyment of the lake. With help from a grant from the Washington State Department of Ecology, SWM worked with local residents to control the milfoil. An herbicide treatment was performed in 2005, and divers removed scattered plants by hand-pulling. The initial results of these actions were promising. In 2006 and 2007, divers found no living Eurasian watermilfoil plants in the lake. However, in later years, several milfoil hot spots appeared and seemed to be spreading. In some cases, this may have been the result of citizens trying to remove the plants by raking them out and unintentionally spreading the plant fragments. Divers were able to successfully hand-pull these plants. Fortunately, no milfoil plants have been found in the lake since 2012.

Snohomish County has a State permit to allow the use of herbicides as another option for controlling milfoil. Herbicides will not be used in Lake Serene unless the milfoil returns and spreads into large patches. SWM will continue to conduct milfoil surveys in the future. SWM will also be working with the Lake Serene community to address funding for future work.

SHORELINE CONDITION

The lake shoreline condition is important in understanding overall lake health. Frequently, lake shorelines are modified through removal of natural vegetation, the installation of bulkheads or other hardening structures, and/or removal of partially submerged logs and branches. These types of alterations can be harmful to the lake ecosystem as natural shorelines protect the lake from harmful pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

Lake Serene has one of the most densely developed shorelines in Snohomish County. There were 94 homes in the mid-1990s, with a few more added in recent years. There are also 80 docks present on the lake, covering about a half of an acre. Development around the lake has resulted in significant shoreline modifications. Seventy-two percent of the 1.4 mile shoreline has some form of shoreline armoring. The primary types of armoring are bulkheads (39%), wood revetments (27%) and fill (6%). The zone of vegetation immediately adjacent to the shoreline has also been greatly altered. Only 6% of the shoreline now supports intact native vegetation. Furthermore, the amount of large wood remaining in the lake is also low (about 9 pieces). These old logs and branches are valuable for fish and wildlife habitat. The high level of shoreline modification at Lake Serene leaves the lake susceptible to pollution from the watershed, eliminates the buffer of native vegetation that can filter out pollution, and limits the amount of habitat available for fish and wildlife. The loss of native vegetation along the shoreline could also lead to shoreline erosion.

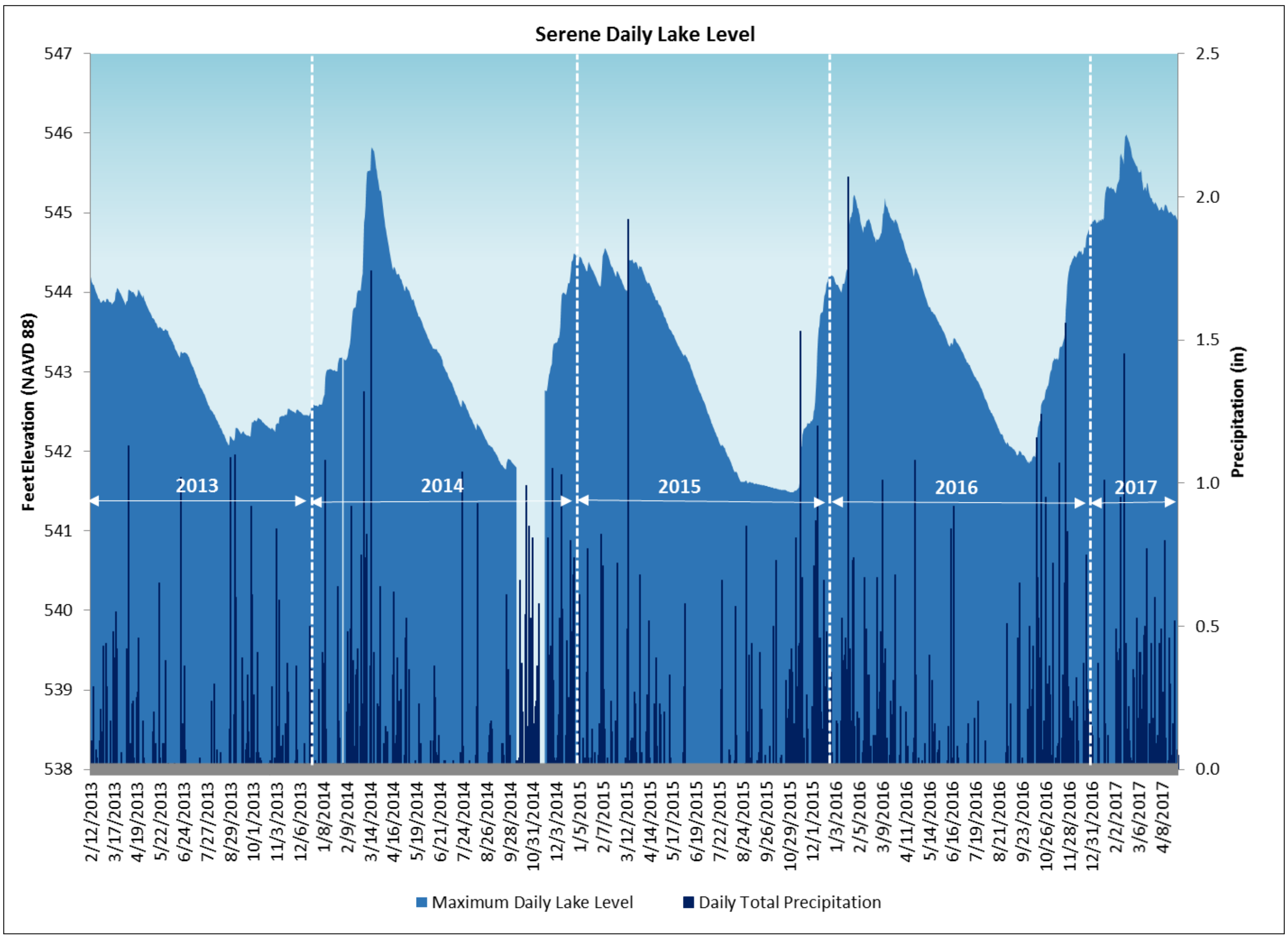
LAKE LEVELS AND FLOODING

Lake level data tracks the amount of water in the lake and the balance between water coming in by streams, precipitation, groundwater and water leaving by evaporation or outflow. Lake levels in our region are highest in early spring and lowest in late summer and fall. The importance of lake level is to indicate the seasonal effects of the water balance in the lake. In addition to rainfall, lake levels can be affected by sedimentation, surrounding topography, beaver activity, plugged outlets, and the ratio of developed to undeveloped land in the watershed. Paved or impervious surfaces will create faster runoff and quickly rising lake levels during large rain events, while forests, wetlands, and pastures will slow down runoff and limit large rises in lake level.

Lake Serene has a history of high water levels during periods of heavy, sustained rainfall. When water levels get very high, many yards and docks are affected, and a number of the lowest properties experience water in basements or crawl spaces.

Drainage investigations found the current private outlet system in a state of disrepair. In February 2017, Snohomish County Executive Dave Somers authorized an emergency action to begin building a temporary drain at Lake Serene. The temporary drain was completed March 14, 2017 and was designed to prevent water from rising to a level that would flood county roads. The County and local residents worked together to find a long term solution. With a cost share program, the County will construct and maintain an outfall system in the public right of way and improve portions of the downstream drainage system along Beverly Park Road. More information about the Lake Serene project can be found in the Snohomish County website (www.Snoco.org, search for "Lake Serene").

SWM installed a continuous gage at Lake Serene in early 2013 to monitor lake levels year round. Lake data is recorded hourly as elevation in feet. The graph below shows the daily average lake level and daily total rainfall for Lake Serene from the time of installation through April 2017. The precipitation data used for the graph was recorded at the Fire Station west of the lake. Lake levels fluctuate 3 – 4 feet in the winter months. Heavy rains in the fall and winter resulted in a rise of 4.1 feet in lake level in early 2017.



LAKE SERENE

SUMMARY

Trophic State

All lakes go through a process of enrichment by nutrients and sediment. In this process, known as eutrophication, nutrients and sediment contribute to the ever-increasing growth of algae and aquatic plants. Over thousands of years, lakes will gradually fill up with organic matter and sediments.

Lakes can be classified by their degree of eutrophication, also known as their trophic state. There are three primary trophic states for lakes—oligotrophic, mesotrophic, and eutrophic—as well as intermediate states. Oligotrophic lakes are usually deep, with clear water, low nutrient concentrations, and few aquatic plants and algae. Mesotrophic lakes are richer in nutrients and produce more algae and aquatic plants. Eutrophic lakes are often shallow and characterized by abundant algae and plants, high nutrient concentrations, limited water clarity, and low dissolved oxygen in the bottom waters.

The trophic state classification of a lake does not necessarily indicate good or bad water quality because eutrophication is a natural process. However, human activities that contribute sediment and excess nutrients to a lake can dramatically accelerate the eutrophication process and result in declining water quality.

Based on long-term monitoring data, Lake Serene may be classified as mesotrophic based on high water clarity, low phosphorus and algae concentrations, but dense aquatic plants. Lake Serene is a typical clear-water, plant-dominated lake.

Condition and Trends

The water quality targets for Lake Serene are to maintain clear water and low phosphorus levels. Water clarity is meeting this target over the long term, although clarity has decreased in the last few years. Phosphorus levels are not meeting the targets. There has been a statistically significant trend toward increasing summer phosphorus averages in the lower waters. Any increases in phosphorus are a concern and may be a sign of nutrient enrichment in the lake.

Overall, Lake Serene is in excellent condition, especially given the high level of development in the watershed and around the lake shore. However, phosphorus levels in the lake should be watched closely for continued increases, which could lead to future algae problems. Improvements, primarily restoration of buffers of native vegetation, could be made to the shoreline to protect the water quality and improve fish and wildlife habitat. In addition, measures to control nutrients in the watershed should be taken to maintain the current water quality.

The primary threat to lake water quality is any increase of phosphorus entering the lake from new development and from human activities in the watershed. To find tips to protect lake water quality and to read more information on the impacts of lake nutrient levels please visit www.lakes.surfacewater.info.

DATA SUMMARY FOR LAKE SERENE						
		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	**7/25/73**	2.1	20	35	-	-
Sumioka and Dion, 1985	**7/1/81**	4.6	10	10	-	0.9
Volunteer	**1992**	3.9 - 5.7 (4.8) *n = 7*	-	-	-	-
Cooke, 1994 or Volunteer	**1993**	3.6 - 5.7 (5.1) *n = 21*	-	-	-	-
SWM Staff or Volunteer	**1994**	3.5 - 5.2 (4.5) *n = 6*	-	-	-	1.2 - 3.0 (2.1) *n = 2*
SWM Staff or Volunteer	**1995**	3.7 - 5.4 (4.5) *n = 6*	-	-	-	5.6
SWM Staff or Volunteer	**1996**	4.4 - 5.8 (5.2) *n = 5*	6 - 8 (7) *n = 2*	6 - 10 (8) *n = 2*	-	-
SWM Staff or Volunteer	**1997**	3.4 - 5.2 (4.4) *n = 8*	9 - 10 (10) *n = 2*	22	-	-
Volunteer	**1998**	4.6 - 5.6 (5.2) *n = 4*	6 - 10 (9) *n = 4*	9 - 23 (15) *n = 4*	-	-
SWM Staff or Volunteer	**1999**	4.9 - 6.3 (5.4) *n = 7*	6 - 28 (14) *n = 4*	6 - 11 (9) *n = 3*	-	-
SWM Staff or Volunteer	**2000**	4.7 - 6.0 (5.3) *n = 7*	4 - 9 (7) *n = 4*	4 - 11 (8) *n = 4*	-	-
SWM Staff or Volunteer	**2001**	3.5 - 5.8 (5.2) *n = 7*	8 - 16 (12) *n = 4*	9 - 13 (10) *n = 4*	-	-
Volunteer	**2002**	3.6 - 6.2 (5.2) *n = 8*	7 - 11 (9) *n = 4*	8 - 14 (12) *n = 4*	-	0.5 - 2.9 (1.9) *n = 4*
Volunteer	**2003**	4.4 - 5.8 (5.1) *n = 6*	8 - 10 (9) *n = 4*	8 - 22 (13) *n = 4*	-	1.1 - 3.2 (2.1) *n = 4*
Volunteer	**2004**	4.5 - 5.3 (5.0) *n = 6*	8 - 12 (11) *n = 4*	8 - 14 (11) *n = 4*	-	1.1 - 3.5 (2.4) *n = 4*
Volunteer	**2005**	4.7 - 5.9 (5.4) *n = 9*	6 - 10 (8) *n = 4*	8 - 11 (9) *n = 3*	-	1.3 - 2.4 (1.9) *n = 3*

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DATA SUMMARY FOR LAKE SERENE						
Source	Date	Water Clarity (Secchi depth in meters)	Total Phosphorus (µg/L) Surface	Total Phosphorus (µg/L) Bottom	Total Nitrogen (µg/L) Surface	Chlorophyll *a* (µg/L) Surface
Volunteer	**2006**	3.5 - 4.6 (3.9) *n = 5*	10 - 21 (15) *n = 4*	12 - 16 (13) *n = 4*	-	1.6 - 4.3 (2.9) *n = 4*
Volunteer	**2007**	5.3 - 6.0 (5.7) *n = 5*	8 - 28 (14) *n = 4*	9 - 13 (11) *n = 4*	-	1.1 - 2.7 (1.7) *n = 4*
Volunteer	**2008**	5.2 - 6.3 (5.6) *n = 5*	6 - 13 (9) *n = 4*	7 - 16 (11) *n = 4*	-	1.6 - 2.1 (1.9) *n = 4*
Volunteer	**2009**	5.1 - 6.2 (5.5) *n = 6*	8 - 16 (12) *n = 3*	10 - 21 (17) *n = 4*	-	1.3 - 2.1 (1.7) *n = 4*
Volunteer	**2010**	5.2 - 6.2 (5.5) *n = 5*	10 - 13 (12) *n = 4*	12 - 46 (22) *n = 4*	-	1.6 - 2.7 (2.0) *n = 4*
Volunteer	**2011**	4.6 - 5.9 (5.3) *n = 4*	8 - 17 (12) *n = 4*	8 - 26 (15) *n = 3*	-	1.3 - 4.0 (2.6) *n = 4*
Volunteer	**2012**	5.3 - 5.9 (5.6) *n = 4*	8 - 14 (12) *n = 4*	12 - 17 (13) *n = 4*	-	1.1 - 4.3 (2.2) *n = 4*
Volunteer	**2013**	4.8 - 5.4 (5.0) *n = 6*	9 - 12 (10) *n = 4*	12 - 64 (34) *n = 4*	-	0.5 - 3.2 (2.3) *n = 4*
Volunteer	**2014**	4.4 - 5.1 (4.7) *n = 5*	7 - 12 (10) *n = 4*	18 - 179 (90) *n = 3*	335 - 375 (357) *n = 4*	0.50 - 2.7 (1.4) *n = 4*
Volunteer	**2015**	*2.5 - 4.8* *(3.4)* *n = 6*	*6 - 12* *(9)* *n = 4*	*14 - 29* *(20)* *n = 4*	*277 - 395* *(319)* *n = 4*	*1.5 - 4.3* *(2.7)* *n = 4*
Volunteer	**2016**	3.9 - 5.1 (4.6) *n = 5*	9 - 19 (15) *n = 4*	8 - 53 (24) *n = 4*	319 - 436 (394) *n = 4*	1.1 - 2.4 (1.7) *n = 4*
Long Term Avg		**5.0** **(1992-2016)**	**11** **(1996-2016)**	**18** **(1996-2016)**	**357** **(2014-2016)**	**2.1** **(2002-2016)**
TRENDS		**None**	**None**	**Increasing**	**NA**	**None**

NOTES

- Table includes summer (May-Oct) data only.
- 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.