FLOWING LAKE

REPORT DESCRIPTION

This report is an update on the health of Flowing Lake based on water quality data collected from 1989 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 Flowing Lake, please visit www.lakes.surfacewater.info or call 425-388-3464.

LAKE DESCRIPTION

Flowing Lake is located five miles northeast of Snohomish. Fed by Storm Lake, it drains to Panther Lake and eventually to the Pilchuck River. Flowing Lake is one of the largest and deepest lakes in the County at 133 acres in area and a maximum depth of 21 meters (69 feet). The lake watershed, which is the land area that drains to the lake, is quite small—only 5.7 times the size of the lake (including the Storm Lake watershed). A small watershed means that there should be less potential for pollution from the watershed than at a lake with a large watershed. However, the lake shore is densely developed with single family homes.

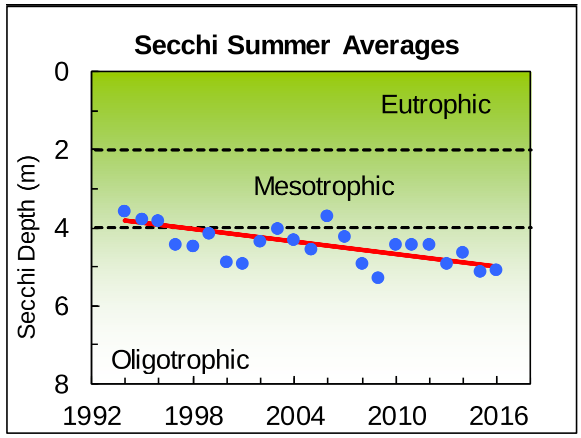
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Flowing 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. Lakes with high water clarity usually have low amounts of algae, while lakes with poor water clarity often have excessive amounts of algae.

The water clarity in Flowing Lake is moderate to high, with a long-term summer average of 4.3 meters (14.1 feet). Between 1989 and 2016, there has been a statistically significant trend toward improving water clarity (p=0.00). Water clarity was especially good in 2008 and 2009. This improving trend is clear despite the considerable variability in water clarity from year to year. However, improvement in water clarity is at odds with the trend toward more phosphorus in the lower lake waters, as described below. The amount of algae has not declined over time, so changes in the types of algae may be affecting water clarity.



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 Flowing Lake averaged 14 pcu (platinum-cobalt color units) in 2010 - 2011, which indicates a small amount of color in the lake water. The color of the lake is not enough to have a significant effect on water clarity or algae growth. Also, the water color has not changed significantly from the 1994 – 1995 average of 15 pcu.

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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.

Temperature data have been collected at each meter throughout the Flowing Lake water column in some years (the graph on the following page shows a typical year). Temperature profiles show that from May through October 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. From May through July, the upper waters gradually warmed up, reaching a peak of 72°F (22°C). At the same time, bottom water temperatures remained around 42°F (5.5°C). Then, from August through October, the surface waters gradually cooled off. Eventually, the temperatures will become almost equal from top to bottom. As stratification weakens, the lake water will turn over (or mix). 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 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 has also been measured some years at every meter throughout the Flowing Lake water column (see graph). Oxygen levels were relatively high in the upper waters from May through October, while the bottom waters contained much less dissolved oxygen. In May and July, there was a sharp increase in dissolved oxygen at 10 to 15 feet deep. This indicates vigorous algae growth at that depth which added oxygen to the water.

During the summer period, oxygen in the lower waters is consumed by the decomposition of organic material near the lake bottom. Also, when the lake is stratified, the oxygen in the bottom waters is not replenished by the overlying oxygen-rich upper waters or the atmosphere. Therefore, throughout the summer, the dissolved oxygen levels continue to drop in the bottom waters. By September and October, there was essentially no oxygen below about 25 feet deep. Very low dissolved oxygen levels in the bottom waters can lead to a release of phosphorus from the lake sediments that can result in increased algae growth in late summer and fall or the next spring. The bottom of the lake will remain devoid of oxygen until the lake mixes (typically in late October/early November). The lake then remains mixed until springtime when the upper waters begin to warm and dissolved oxygen begins to decline in the bottom.

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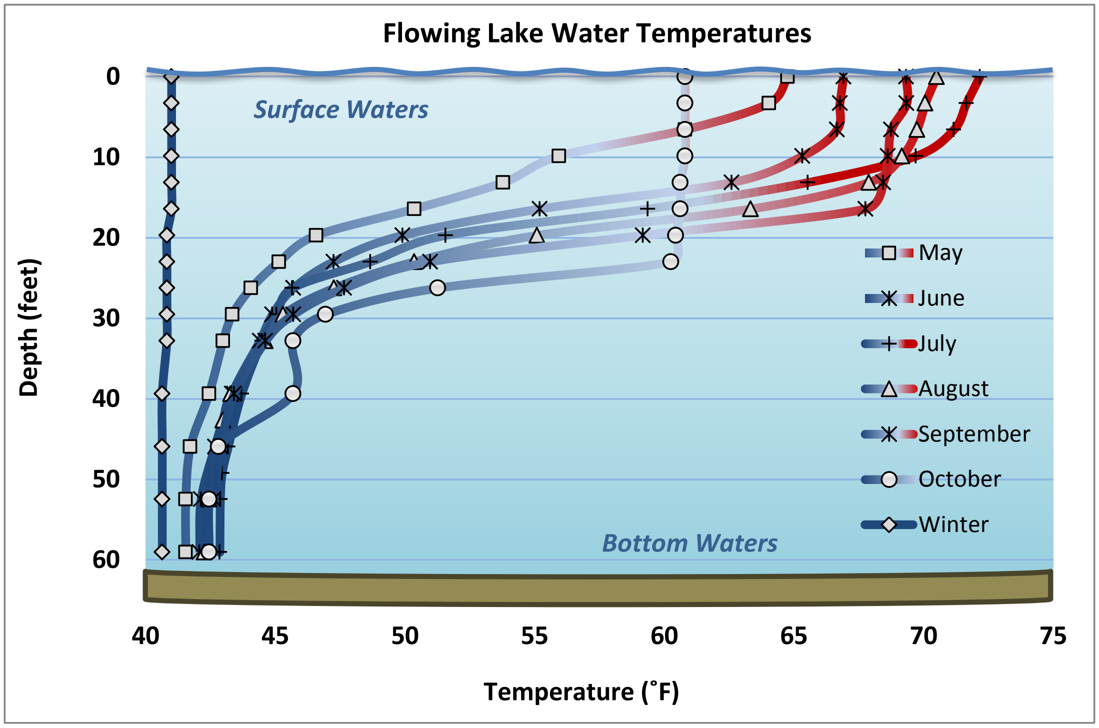

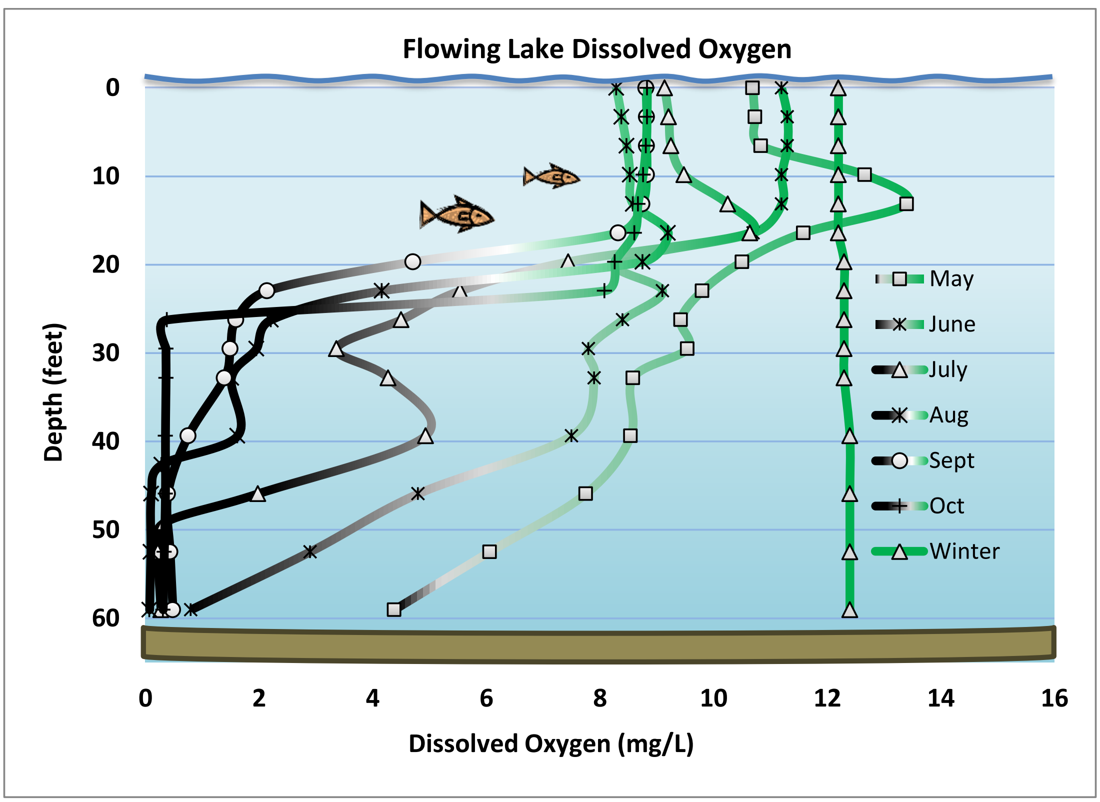

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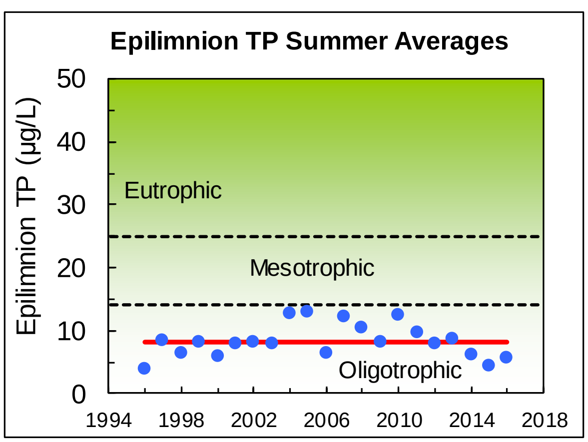
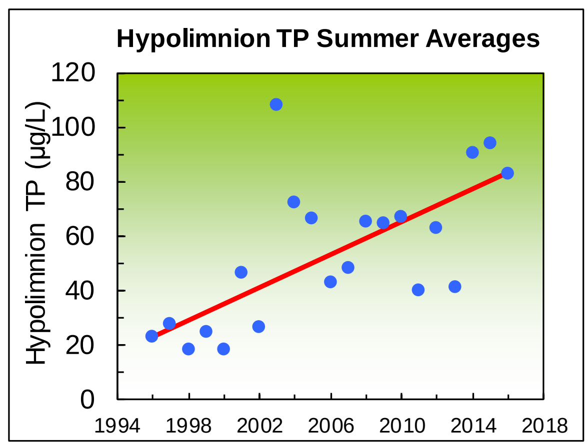
Phosphorus (key nutrient for algae)

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 the epilimnion (upper waters) are generally low, with a long-term summer average of 8 µg/L (micrograms per liter, which is equivalent to parts per billion). However, phosphorus levels have been higher in some years, approaching the mid or mesotrophic range where greater production of algae is likely. In spite of the years with more phosphorus, there has not been a statistically significant trend toward increasing phosphorus levels in the upper waters between 1996 and 2016. The primary concern about increasing phosphorus levels is that it may result in more algae that can eventually affect the use and enjoyment of the lake.



Phosphorus values in the hypolimnion (bottom waters) are higher and more variable than in the epilimnion. The 1996 to 2016 long-term summer average is 54 µg/L. Even with high variability from year to year, there has been a statistically significant trend toward increasing phosphorus concentrations in the hypolimnion over these years ($p=0.00$). The summer averages for 2014 and 2015 were particularly high at 90 µg/L and 94 µg/L respectively. Higher phosphorus levels may indicate a build-up of nutrients in the bottom sediments which are released into the lake during times of low dissolved oxygen in the summer. The phosphorus is then available for algae growth in late fall or in the following spring and summer. This build-up of phosphorus in the bottom waters is likely a sign of accelerating eutrophication.



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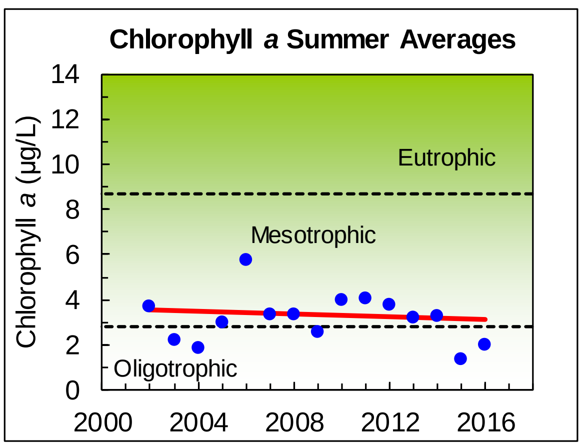
Chlorophyll a (Algae)

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 have been low to moderate in the summers of 2002 through 2016. The long-term average is 3.2 µg/L. In 2015, the summer chlorophyll *a* average was the lowest observed at 1.4 µg/L. Overall, between 2002 and 2016, there has been no trend toward increasing chlorophyll *a* concentrations in spite of higher phosphorus levels in the lake.



While algae blooms have been noted on occasion in Flowing Lake, they have not usually created serious impacts for lake users. In June 2006, there was a notable algae bloom, and chlorophyll *a* concentrations rose as high as 13 µg/L. In February and March 2015, there was a persistent bloom of blue-green algae with scum that covered some portions of the lake. The bloom may have been a result of the high phosphorus concentration in the bottom waters during 2014 that spread throughout the lake and was available for algae growth during the unusually warm winter.

Blue-green algae, also called cyanobacteria, are a group of algae capable of producing toxins during periods of high growth. The toxins can cause serious illness in people and pets that come into contact with affected water. Blooms often look like blue or green paint floating on the surface. Fortunately, the bloom in Flowing Lake in early 2015 was not toxic. Lake users should avoid contact with the water and keep pets away from the lake when it is experiencing a blue-green algae bloom. No blooms were reported in 2016, and SWM will continue to screen for potentially toxic algae blooms in 2017.

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, Flowing Lake had relatively low levels of total nitrogen (summer average of 256 µg/L). This is consistent with the low to moderate 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. Flowing Lake had a high average N:P ratio of 45, and no blooms were reported in 2016.

FLOWING LAKE

SHORELINE CONDITION

The condition of the lake shoreline 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. This type of alteration can be harmful to the lake ecosystem because natural shorelines protect the lake from pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

Flowing Lake has a high level of shoreline development compared to other lakes in the County. Surveys conducted in the mid-90s identified 104 homes bordering the lake with an average of 9.0 homes per 1000 feet of shoreline. There are also 116 docks are now present, covering over 1 acre of the lake. Over half (51%) of the 2.6 miles of shoreline has been armored. The armoring is mainly in the form of bulkheads (44%) and wood or rock revetments (42%). The native vegetation immediately adjacent to the shoreline has also been significantly altered, with only 36% being classified as remaining intact. The shoreline alterations make the lake susceptible to pollution inputs from the watershed and limit the amount of aquatic habitat available to fish and wildlife. The loss of native vegetation along the shoreline eliminates a buffer to filter pollution and could also lead to shoreline erosion. There is still a moderate amount of large wood (about 82 pieces) remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat.

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, Flowing Lake may be classified as oligo-mesotrophic, with moderate to high water clarity and low to moderate phosphorus and chlorophyll *a* concentrations. This means that the lake has low to moderate production of algae and aquatic plants.

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Condition and Trends

The monitoring data reveal mixed results for Flowing Lake. The lake is meeting the water quality target of maintaining good water clarity. In fact, there has been a significant trend toward improving water clarity between 1989 and 2016.

However, the lake is not meeting its target of maintaining stable long-term phosphorus levels. The long-term summer phosphorus average in the upper waters has risen slightly through the years, and there has been a statistically significant trend toward increasing phosphorus in the bottom waters. These higher nutrient levels are likely a sign of accelerating eutrophication in the lake.

Overall, Flowing Lake is in good condition. However, the lake may be at risk of future water quality problems. The increasing phosphorus levels may lead to more algae growth and reduced water clarity in the future. The primary threat to lake water quality is the potential influx of nutrients entering the lake because of new development and from human activities in the watershed. Measures to control nutrients in the watershed should be taken now to prevent future negative impacts to the lake. To find out more about ways to protect lake water quality and information on the causes and problems of elevated lake nutrient levels visit www.lakes.surfacewater.info.

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DATA SUMMARY FOR FLOWING 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	**7/23/73**	2.7 -	7	34	-	-
DOE	**1989**	2.9 - 3.8 (3.4) *n = 12*	-	-	-	-
DOE	**1990**	1.8 - 3.8 (3.0) *n = 14*	-	-	-	-
DOE	**1991**	2.7 - 3.8 (3.3) *n =12*	-	-	-	-
Volunteer	**1992**	4.0 - 4.6 (4.2) *n = 4*	-	-	-	-
DOE	**1993**	3.7 - 5.3 (4.4) *n = 8*	-	-	-	-
SWM Staff or Volunteer	**1994**	2.7 - 4.8 (3.6) *n = 7*	-	-	-	2.4 - 2.9 (2.7) *n = 2*
SWM Staff or Volunteer	**1995**	3.0 - 4.4 (3.8) *n = 11*	-	-	-	-
SWM Staff, Volunteer or DOE	**1996**	3.0 - 5.0 (3.8) *n = 10*	<2 - 6 (4) *n = 2*	16 - 30 (23) *n = 2*	-	-
SWM Staff or Volunteer	**1997**	3.5 - 5.9 (4.4) *n = 9*	5 - 12 (9) *n = 2*	23 - 32 (28) *n = 2*	-	-
SWM Staff or Volunteer	**1998**	3.3 - 5.8 (4.5) *n = 13*	4 - 8 (7) *n = 4*	6 - 37 (18) *n = 4*	-	-
Volunteer	**1999**	3.8 - 5.0 (4.2) *n = 10*	6 - 10 (8) *n = 4*	11 - 37 (24) *n = 4*	-	-
SWM Staff or Volunteer	**2000**	3.6 - 5.9 (4.9) *n = 10*	3 - 8 (6) *n = 3*	2 - 33 (18) *n = 4*	-	-
SWM Staff	**2001**	4.6 - 5.3 (5.0) *n = 4*	6 - 9 (8) *n = 4*	22 - 71 (47) *n = 4*	-	-
SWM Staff	**2002**	3.2 - 5.4 (4.4) *n = 4*	6 - 10 (8) *n = 4*	11 - 43 (26) *n = 4*	-	2.7 - 5.6 (3.7) *n = 4*
Volunteer	**2003**	2.7 - 5.3 (4.1) *n = 11*	5 - 12 (8) *n = 4*	48 - 156 (108) *n = 4*	-	1.3 - 3.2 (2.2) *n = 4*

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DATA SUMMARY FOR FLOWING LAKE

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
SWM Staff	**2004**	4.0 - 4.6 (4.4) *n = 4*	9 - 19 (13) *n = 4*	36 - 118 (72) *n = 4*	-	1.3 - 2.7 (1.9) *n = 4*
SWM Staff	**2005**	4.1 - 5.1 (4.6) *n = 4*	11 - 14 (13) *n = 4*	30 - 98 (66) *n = 4*	-	2.7 - 3.2 (3.0) *n = 4*
SWM Staff	**2006**	2.7 - 5.0 (3.7) *n = 10*	5 - 8 (7) *n = 4*	22 - 62 (43) *n = 4*	-	3.0 - 13 (5.7) *n = 4*
SWM Staff	**2007**	3.0 - 5.0 (4.3) *n = 5*	8 - 16 (12) *n = 4*	12 - 74 (48) *n = 4*	-	1.9 - 4.3 (3.3) *n = 3*
SWM Staff	**2008**	4.8 - 5.1 (5.0) *n = 3*	8 - 16 (11) *n = 3*	27 - 90 (65) *n = 3*	-	1.9 - 5.1 (3.4) *n = 3*
Volunteer	**2009**	4.7 - 5.9 (5.3) *n = 9*	6 - 11 (8) *n = 4*	31 - 99 (65) *n = 4*	-	1.9 - 4.0 (2.5) *n = 4*
Volunteer	**2010**	4.0 - 5.0 (4.5) *n = 8*	8 - 24 (13) *n = 4*	21 - 145 (67) *n = 4*	-	2.1 - 7.5 (4.0) *n = 4*
Volunteer	**2011**	3.4 - 6.1 (4.5) *n = 9*	8 - 11 (10) *n = 4*	18 - 70 (40) *n = 4*	-	1.9 - 5.8 (4.1) *n = 4*
Volunteer	**2012**	3.6 - 5.1 (4.5) *n = 8*	6 - 11 (8) *n = 4*	28 - 86 (63) *n = 4*	-	1.9 - 7.5 (3.8) *n = 4*
Volunteer	**2013**	4.2 - 5.8 (4.9) *n = 9*	6 - 12 (9) *n = 4*	13 - 64 (41) *n = 4*	-	1.6 - 6.4 (3.2) *n = 4*
Volunteer	**2014**	*3.6 - 6.2* *(4.7)* *n = 13*	*5 - 8* *(6)* *n = 5*	*29 - 159* *(90)* *n = 4*	*253 - 307* *(287)* *n = 4*	*1.1 - 6.1* *(3.3)* *n = 4*
Volunteer	**2015**	*4.7 - 5.7* *(5.1)* *n = 8*	*3 - 6* *(5)* *n = 4*	*45 - 156* *(94)* *n = 4*	*207 - 237* *(222)* *n = 2*	*0.80 - 2.1* *(1.4)* *n = 4*
Volunteer	**2016**	4.4 - 5.6 (5.1) *n = 10*	5 - 7 (6) *n = 4*	33 - 134 (83) *n = 4*	155 - 346 (260) *n = 4*	1.6 - 2.7 (2.0) *n = 4*
Long Term Avg		**4.3** **(1989-2016)**	**8** **(1996-2016)**	**54** **(1996-2016)**	**263** **(2014-2016)**	**3.2** **(2002-2016)**
TRENDS		**Increasing**	**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.
- DOE = Washington Department of Ecology
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.