

LAKE HOWARD

REPORT DESCRIPTION

This report is an update on the health of Lake Howard based on water quality data collected from 1993 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 Howard, visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Howard is a 28 acre lake located in the Seven Lakes area north of the Tulalip Reservation. The lake is relatively deep, with a maximum depth of 15.2 meters (50 feet) and an average depth of 8.8 meters (29 feet). The lake is situated in a protected bowl surrounded by hills. Much of the watershed, which is the land area that drains to the lake, is undeveloped. However, there are numerous homes around much of the lake shore, and more growth is planned in the area, which may have impacts to the lake.

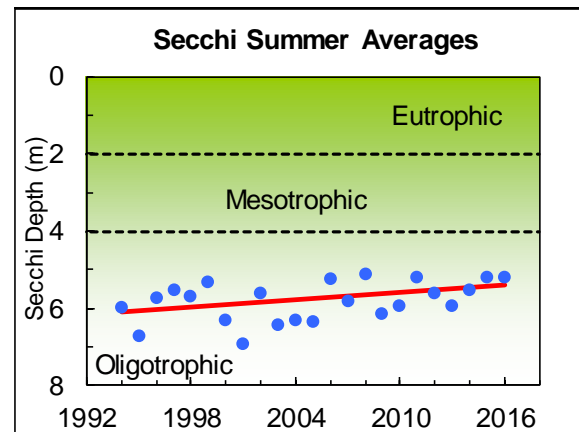
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Howard. 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 is generally high at Lake Howard, with a 1993 – 2016 long-term summer average of 5.9 meters (19 feet). Water clarity averages vary considerably from year to year, from a high of 6.9 meters in 2001 to a low of 5.2 meters in 2008, 2011, 2015, and 2016. The water clarity may vary because higher nutrient levels in some years lead to more algae growth. Overall, between 1993 and 2016, there is a statistically significant trend in declining water clarity ($p=0.04$).



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 Howard averaged 13 pcu (platinum-cobalt color units) in 2010 – 2011, which indicates a slight amount of color in the lake water. This is not much change from the 1994 – 1995 average of 10 pcu. This slight amount of color in the lake water should not have much of an effect on water clarity or algae growth within the lake.

LAKE HOWARD

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.

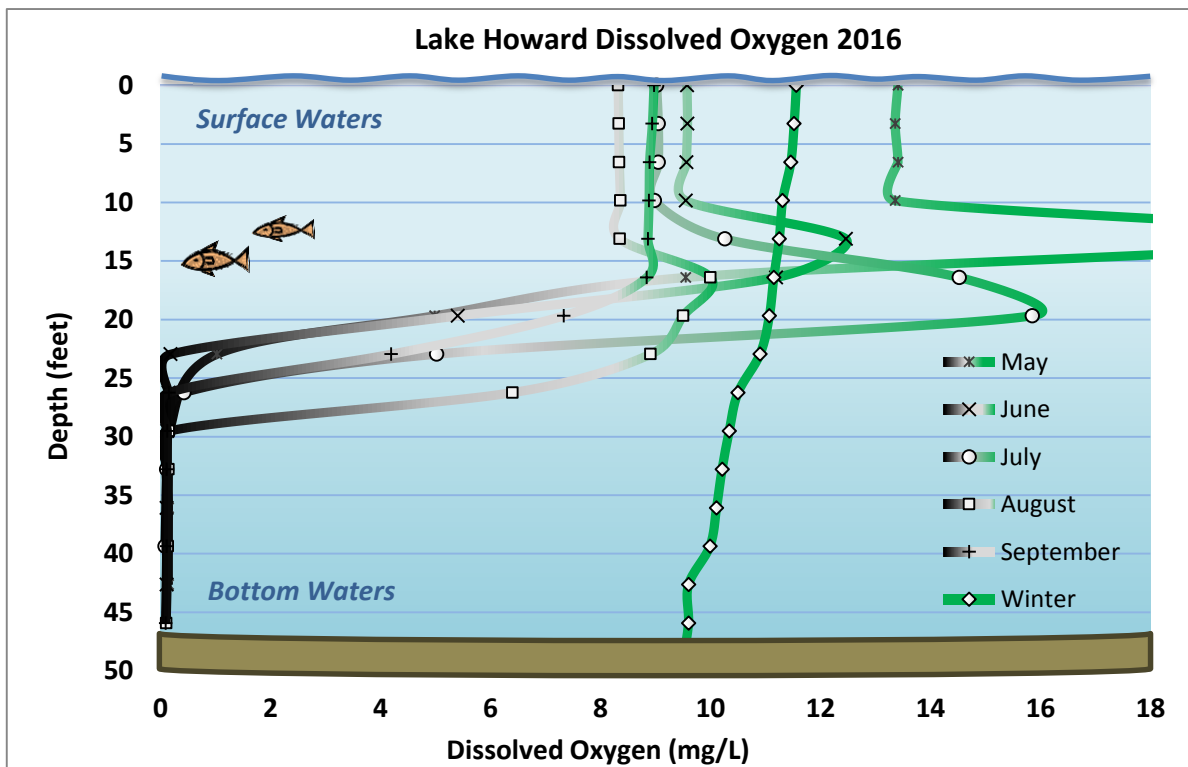
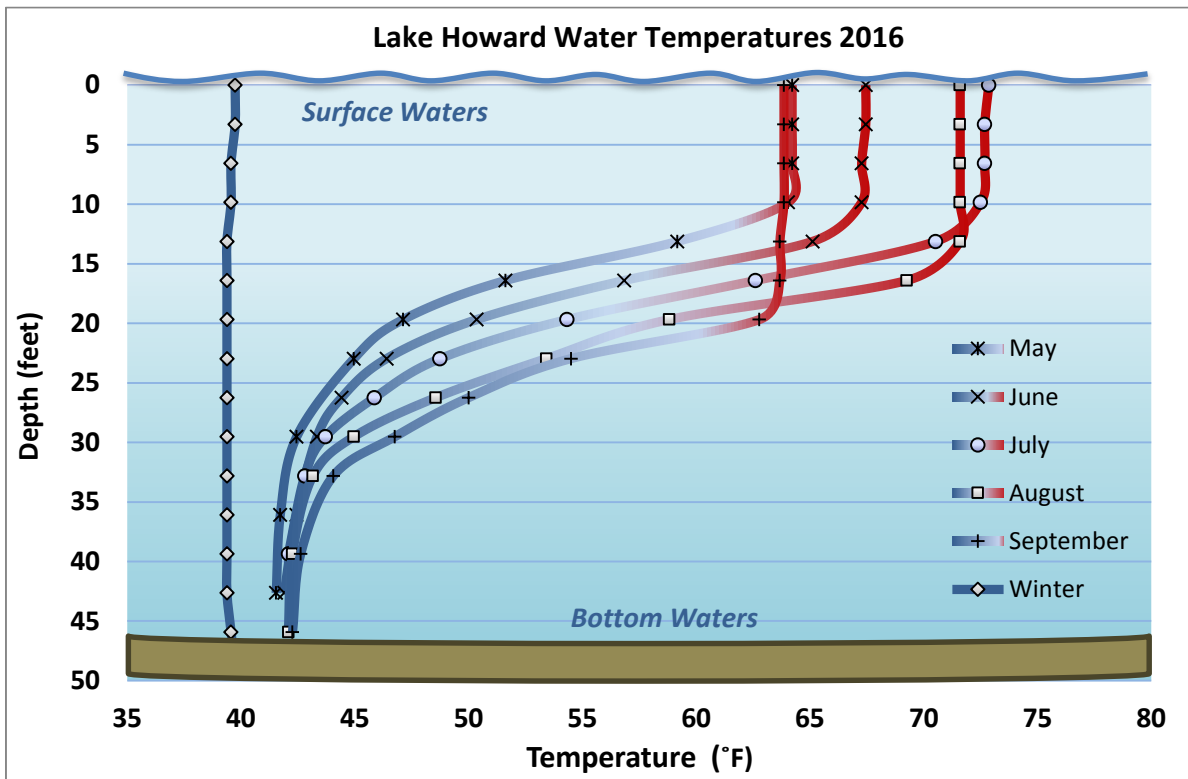
From May through September 2016 temperature measurements were taken at each meter throughout the Lake Howard water column. Temperature profiles for 2016 (see graph) show that throughout the summer season the lake was strongly thermally stratified. This means that there was a large temperature difference between the warm upper waters and the cool bottom waters, and mixing did not occur between these layers. In May the upper waters measured about 64° F (19°C) in temperature, and by August had reached their peak at 73° F (23°C). At the same time, bottom water temperatures changed only a little and remained between 42-43 °F (4-6°C). Each fall the surface waters will begin to cool until the temperatures are 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 began 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.

The depth profiles of dissolved oxygen measured in 2016 generally correspond with the temperature profiles seen during that time period (see graph). Oxygen levels were relatively high in the upper waters from May through September, while the bottom waters contained much less oxygen. Between May and September, there was little or no oxygen in the water at 20 feet and below. From May through August, there was actually an increase in dissolved oxygen levels between about 10 and 20 feet deep. This indicates vigorous algae growth at that depth which added oxygen to the water. During the stratified summer period, oxygen in the lower waters (below 20 feet) is consumed by the decomposition of organic material within the lake. When the lake is stratified, the oxygen is not replenished by the overlying oxygen-rich upper waters or the atmosphere. 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 again in the bottom.

LAKE HOWARD



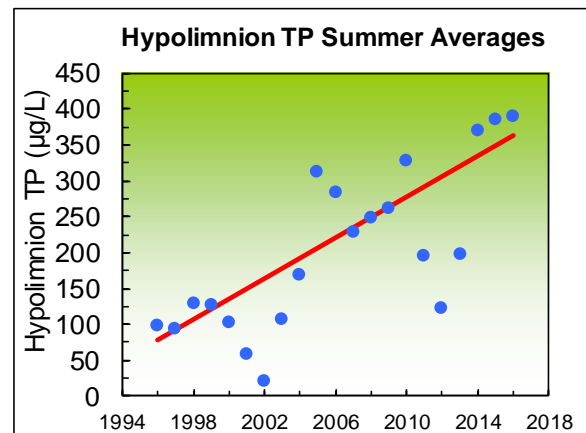
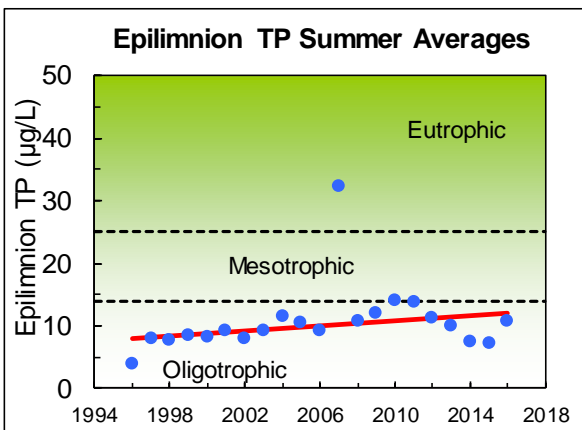
LAKE HOWARD

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 concentrations in the epilimnion (upper waters) are low, with a 1996 – 2016 long-term summer average of 11 µg/L (micrograms per liter which is equivalent to parts per billion). However, between 1996 and 2016, there has been a gradual, and statistically significant, trend toward higher phosphorus concentrations in the upper waters of Lake Howard (p=0.04). Summer averages in 2010 and 2011 reached the mesotrophic range (the lower threshold value of mesotrophic is 14 µg/L). Fortunately, the summer averages declined in 2012 through 2015, although there was a slight increase in 2016. The gradual increase in phosphorus levels over time, combined with the extremely high summer average in 2007 (32 µg/L), indicate that more phosphorus pollution is coming from the watershed and from the release of phosphorus from lake bottom sediments. Higher phosphorus levels will likely result in more nuisance algae in the lake.

The summertime phosphorus averages in the hypolimnion (bottom waters) are much higher than the upper waters and are quite variable. The long term summer average (1996 – 2016) is now 201 µg/L. Although there were very low phosphorus values in 2001 and 2002, the averages steadily increased until 2010. Summer averages decreased from 2011 through 2013, but the 2014, 2015, and 2016 summer averages were the highest on record, at 370 µg/L, 385 µg/L, and 390 µg/L respectively. Overall, between 1996 and 2016, there has been a strong statistically significant increasing trend in phosphorus concentrations in the bottom waters (p=0.00). This build-up of phosphorus in the bottom of the lake, coupled with the rising phosphorus levels in the upper waters, is a strong indicator of accelerating eutrophication and a warning of poorer water quality in the future.



LAKE HOWARD

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.

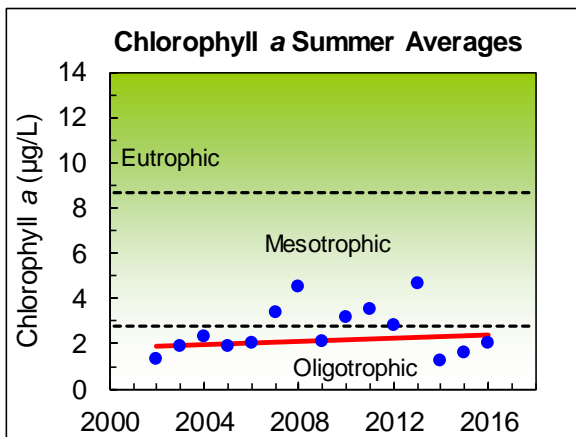
Chlorophyll a values showed low to moderate levels of algae in the summers of 2002 – 2016, with a long-term summer average of 2.6 µg/L. From 2002 to 2016 there has been a statistically significant increasing trend in chlorophyll a (algae) levels in Lake Howard (p=0.07). There are also often high dissolved oxygen and pH levels several meters below the surface of the lake, which indicate vigorous algae growth at that depth. The chlorophyll a samples, which are taken at 1 meter deep, may be missing this zone of algae growth, so in actuality the algae levels may be even higher than shown by the chlorophyll a measurements. The lake does experience algae blooms from time to time, particularly in the spring and early summer.

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 come into contact with affected water. Blooms often look like blue or green paint floating on the 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 be posted at public access sites.

In 2010 Lake Howard experienced periods of intense blue-green algae growth known as blooms. In response, water samples were taken regularly to test for two types of algae toxins, microcystin (a liver toxin) and anatoxin-a (a neurotoxin) from 2011 through 2013. Most samples showed low levels of microcystin. However, samples taken in the late summer to early fall of 2011 through 2013 had higher levels, well above the Washington State Department of Health’s recreational guideline of 6 µg/L for microcystin (see table below). There were no reported algae blooms in 2014. In 2015, Lake Howard experienced algae blooms in the early spring and again in August. Sample results for 2015 show that microcystin was present but below the State recreational standard. Blooms reported in 2016 had microcystin ranges from 0.9 to over 6 µg/L (over the recreational guideline), and anatoxin-a concentrations of 0.112 to 0.922 µg/L (below the recreational guideline).

Testing for toxic algae will continue in 2017 as part of the SWM lake monitoring program. Continued monitoring will help to alert the public to potential health risks as well as determine the frequency and severity of the toxic algae blooms at Lake Howard.



LAKE HOWARD

Lake Howard Toxic Algae Testing Results

Year	# Weeks Sampled	# Weeks Toxic*	Microcystin Range (µg/L)	Anatoxin Range (µg/L)
2011	10	2	<1 to 56.3	-
2012	14	5	<1 to 2,700	-
2013	4	1	1 to 20.6	-
2015	5	0	0.2 to <6	-
2016	10	2	0.9 to > 6	0.112 to 0.922

*Number of weeks above the State recreational guideline of 6 µg/L for microcystin and 1 µg/L for Anatoxin

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 Howard had low to moderate levels of total nitrogen (summer average of 400 µg/L). This is consistent with the low to moderate chlorophyll *a* concentrations measured in the lake and occasional dense algae blooms.

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 Howard had a moderately high average N:P ratio of 46 in 2016, although persistent blue green algae blooms were observed.

SHORELINE CONDITION

The lake shoreline condition is important for understanding the overall lake health. Frequently, lake shorelines are modified either through removal of natural vegetation and/or the installation of bulkheads or other hardening structures. This type of alteration 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 Howard has a moderately developed shoreline. Surveys conducted in the mid-90s showed 32 homes bordering the lake. There are also 35 docks present on the lake covering a quarter of an acre of the lake's surface. Armoring of the shoreline was found along 28% of the 0.9 mile long lakefront. Most of the armoring is rock or log revetments (20% of the shoreline) in addition to a small number of bulkheads. The natural vegetation immediately adjacent to the shoreline has been significantly altered, with only 41% of the shoreline still supporting native grasses, shrubs, or trees. There is still a moderate amount of large wood (about 51 pieces) remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat.

The overall amount of shoreline modification 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.

LAKE HOWARD

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 the long-term monitoring data, Lake Howard may be classified as mesotrophic, based on elevated and increasing phosphorus in both the upper and bottom waters, increasing algae levels, low dissolved oxygen in the bottom waters, and moderate levels of aquatic plants.

Condition and Trends

With a long-term water clarity average of 5.9 meters, Lake Howard is still very close to meeting the water clarity target of maintaining stable water clarity of 6.0 meters. However, there is a statistically significant trend of declining water quality from 1996-2016.

The lake is not meeting the target of reducing phosphorus levels. In fact, phosphorus concentrations in both the upper and lower waters are increasing, with a statistically significant trend of increasing phosphorus levels in the bottom waters. In addition, chlorophyll *a* levels also show a statistically significant increasing trend.

In spite of these trends, overall Lake Howard is still in good condition. But, the lake appears to be at risk for future water quality declines. The increasing phosphorus in the upper and lower waters, combined with periodic algae blooms that are sometimes toxic and increasing chlorophyll *a* levels, are warning signs that accelerated eutrophication is occurring in the lake. The primary threat to Lake Howard is the inflow of nutrients into the lake from human activities and new development in the watershed. Measures to control nutrients in the watershed should be taken now to reverse the trends of increasing phosphorus and prevent any future negative impacts to the lake.

In addition, it is very likely that the release of phosphorus from the lake bottom sediments during the period of low dissolved oxygen in the late summer is contributing more and more phosphorus to the lake. This internal phosphorus release can only be addressed with a chemical treatment of the sediments or other restoration alternatives.

In 2012, Snohomish County SWM launched a new educational outreach campaign, LakeWise, to help citizens take actions to reduce phosphorus pollution into the lake. Many property owners around Lake Howard are participating. 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.

LAKE HOWARD

DATA SUMMARY FOR LAKE HOWARD						
Source	Date	Water Clarity (Secchi depth in meters)	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll a (µg/L)
			Surface	Bottom	Surface	Surface
McConnell, et al, 1976	Summer 1973	2.3 - 2.7 (2.5) n = 3	14 - 60 (32) n = 3	110 - 190 (150) n = 3	-	1.8 - 2.0 (1.9) n = 3
Sumioka and Dion, 1985	6/30/1981	6.4	20	310	-	2.3
Entranco, 1986	1983	3.8 - 5.0 (4.5) n = 5	<5 - 17 (10) n = 5	70 - 359 (157) n = 5	-	1.0 - 9.9 (3.9) n = 5
DOE	1993	5.0 - 7.3 (5.8) n = 12	-	-	-	-
SWM Staff or DOE	1994	5.3 - 6.9 (6.0) n = 7	-	-	-	0.1 - 3.2 (1.7) n = 4
SWM Staff	1995	6.8	-	-	-	2.4
SWM Staff or Volunteer	1996	4.6 - 6.8 (5.8) n = 6	3 - 5 (4) n = 2	76 - 122 (99) n = 2	-	-
SWM Staff or Volunteer	1997	5.1 - 6.1 (5.6) n = 2	5 - 11 (8) n = 2	82 - 106 (94) n = 2	-	-
SWM Staff or Volunteer	1998	4.0 - 6.9 (5.7) n = 10	6 - 10 (8) n = 4	89 - 150 (129) n = 4	-	-
SWM Staff or Volunteer	1999	3.7 - 7.4 (5.4) n = 12	7 - 10 (9) n = 4	74 - 150 (126) n = 4	-	-
SWM Staff or Volunteer	2000	5.1 - 7.3 (6.3) n = 7	3 - 11 (8) n = 4	58 - 175 (104) n = 4	-	-
Volunteer	2001	6.0 - 8.0 (6.9) n = 5	7 - 13 (9) n = 4	27 - 88 (57) n = 4	-	-
Volunteer	2002	3.7 - 7.3 (5.7) n = 8	7 - 9 (8) n = 4	9 - 30 (21) n = 4	-	0.8 - 2.1 (1.3) n = 4
SWM Staff	2003	5.7 - 7.1 (6.5) n = 4	8 - 11 (9) n = 4	46 - 188 (107) n = 4	-	0.8 - 2.7 (1.9) n = 4
SWM Staff	2004	5.4 - 7.5 (6.3) n = 4	9 - 15 (12) n = 4	61 - 270 (170) n = 4	-	1.1 - 3.7 (2.3) n = 4
SWM Staff	2005	5.5 - 7.6 (6.4) n = 4	8 - 13 (11) n = 4	256 - 350 (312) n = 4	-	1.6 - 2.0 (1.9) n = 4

LAKE HOWARD

DATA SUMMARY FOR LAKE HOWARD						
Source	Date	Water Clarity (Secchi depth in meters)	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)	Chlorophyll a (µg/L)
			Surface	Bottom	Surface	Surface
Volunteer	2006	4.4 - 7.0 (5.3) n = 7	6 - 13 (9) n = 4	222 - 360 (285) n = 4	-	1.6 - 2.9 (2.0) n = 4
Volunteer	2007	5.1 - 6.7 (5.9) n = 6	11 - 55 (32) n = 4	160 - 314 (228) n = 4	-	2.1 - 5.3 (3.4) n = 4
Volunteer	2008	3.9 - 6.1 (5.2) n = 10	9 - 12 (11) n = 3	174 - 372 (248) n = 3	-	1.6 - 10 (4.5) n = 3
Volunteer	2009	4.5 - 7.4 (6.2) n = 11	11 - 14 (12) n = 4	146 - 462 (261) n = 4	-	1.9 - 2.4 (2.1) n = 4
Volunteer	2010	4.0 - 7.2 (6.0) n = 11	10 - 19 (14) n = 4	188 - 524 (327) n = 4	-	1.6 - 6.9 (3.2) n = 4
Volunteer	2011	4.0 - 6.3 (5.2) n = 12	11 - 15 (14) n = 4	93 - 358 (196) n = 4	-	2.7 - 4.1 (3.5) n = 4
Volunteer	2012	4.8 - 7.0 (5.6) n = 11	7 - 13 (11) n = 6	46 - 212 (123) n = 6	-	1.3 - 5.1 (2.8) n = 6
Volunteer	2013	4.5 - 7.2 (6.0) n = 11	6 - 17 (10) n = 6	61 - 301 (197) n = 6	-	0.5 - 19 (4.7) n = 6
Volunteer	2014	3.9 - 7.2 (5.6) n = 12	6 - 10 (8) n = 4	246 - 492 (370) n = 4	317 - 486 (397) n = 4	0.50 - 2.7 (1.3) n = 4
Volunteer	2015	2.0 - 7.1 (5.2) n = 11	6 - 9 (7) n = 4	183 - 489 (385) n = 4	310 - 436 (367) n = 4	1.5 - 1.8 (1.6) n = 4
Volunteer	2016	3.2 - 7.1 (5.2) n = 10	9 - 13 (11) n = 4	355 - 428 (390) n = 4	294 - 589 (437) n = 4	0.95 - 3.5 (2.1) n = 4
Long Term Avg		5.9 (1993-2016)	7 (1996-2016)	201 (1996-2016)	400 (2014-2016)	2.6 (2002-2016)
TRENDS		Decreasing	None	Increasing	NA	Increasing

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.