LAKE BEECHER

REPORT DESCRIPTION

This report is an update on the health of Lake Beecher based on water quality data collected from 1997 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 Beecher, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464.

LAKE DESCRIPTION

Lake Beecher is a small, shallow, oxbow lake located about 4 miles south of the City of Snohomish and just west of the Snohomish River. The lake covers 17 acres and has a maximum depth of only 3 meters (9.8 feet). The surrounding watershed, which is the land area that drains to the lake, is very large (over 260 times the size of the lake). Development within the watershed continues to increase, with more homes and businesses every year.

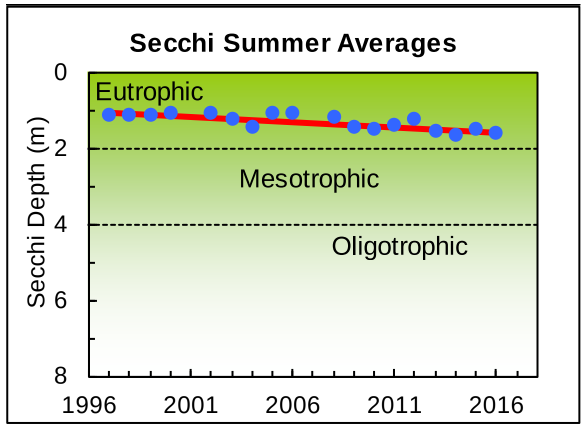
LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (shown in red) for water clarity and total phosphorus for Lake Beecher. 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 Beecher is low because of algae growth and the slight color of the water. The long-term average water clarity is 1.3 meters (4.3 feet), with little year to year variability. Overall, there has been a small, but statistically significant, trend toward improved water clarity in Lake Beecher (p=0.00).



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 true water color of Lake Beecher averaged 18 pcu (platinum-cobalt color units) in 2010 - 2011, which indicates a slight to moderate amount of color in the lake. This amount of color could have a small effect on the amount of algae that grows in the lake. No previous water color measurements have been taken at Lake Beecher to see if the water color has changed over time.

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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.

From May through October 2015 (the most recent data available), temperature was measured at each meter throughout the Lake Beecher water column (see graph). Temperature profiles for 2015 show that the lake was thermally stratified from May through September. This means that there was a temperature difference between the warm upper waters and the cool bottom waters, and mixing between these layers was limited. In May, the upper waters measured about 74°F (23.5°C) in temperature. Through the early summer, the upper waters continued to warm, and by July had reached their peak at 75°F (24°C). At the same time, bottom water temperatures remained cooler, warming up from ~55°F to ~67°F (13 to 19.5°C).The stratification at Lake Beecher is not as strong as in some other local lakes because the lake is relatively shallow.

By October, the surface waters began to cool as air temperatures cooled. As stratification weakens, the lake water will turn over (or mix) where the upper waters and bottom waters are the same temperature. 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.

Dissolved oxygen was also measured at every meter throughout the Lake Beecher water column from May through October 2015 (see graph). Oxygen levels were high in the upper waters for the entire summer. During the same time, there was a slight increase in dissolved oxygen levels around 4 feet deep. This indicates vigorous algae growth at that depth which added oxygen to the water.

In early summer, the water at the very bottom of the lake also contained high levels of dissolved oxygen. Oxygen levels declined in the bottom waters in July and August. During the summer period, oxygen in the lower waters 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.

By July, even the upper waters declined in dissolved oxygen. This was partly because warmer water cannot hold as much oxygen as colder water, but also because of the large biological oxygen demand in the lake. This pattern continued into August. By September, the zone of low oxygen was beginning to shrink. October, there was lower oxygen throughout the water column, suggesting that the lake had begun the fall mixing and there was still a large biological oxygen demand in the lake. Low dissolved oxygen can result in phosphorus being released from the bottom sediments and contributing to future algae growth in the lake. Fall turnover brings more dissolved oxygen from the atmosphere back into the lake. The lake will remain mixed through winter until springtime when the upper waters begin to warm and dissolved oxygen again declines in the bottom.

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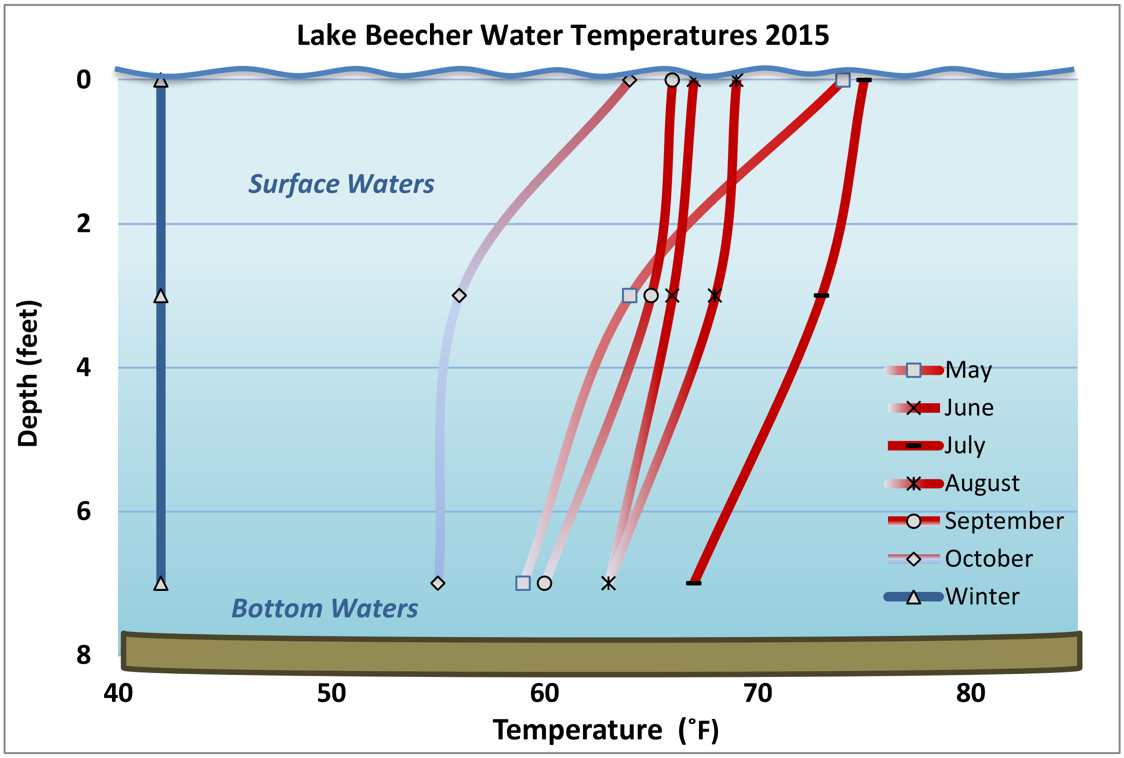

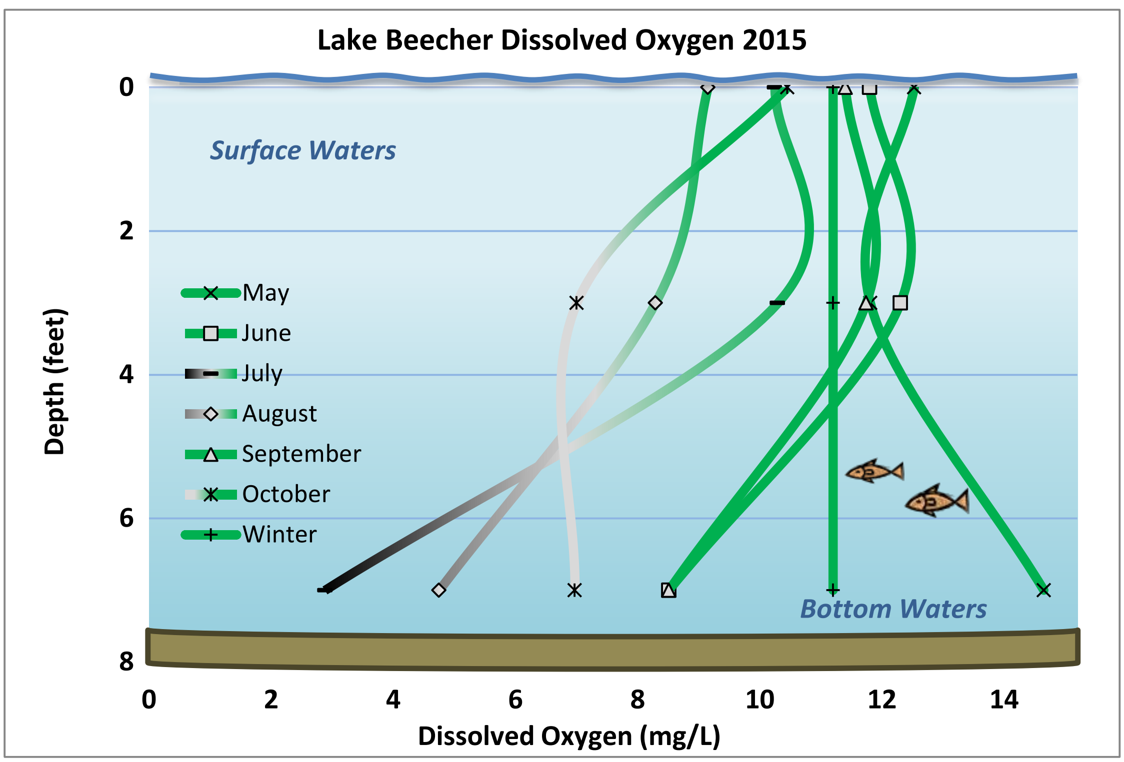

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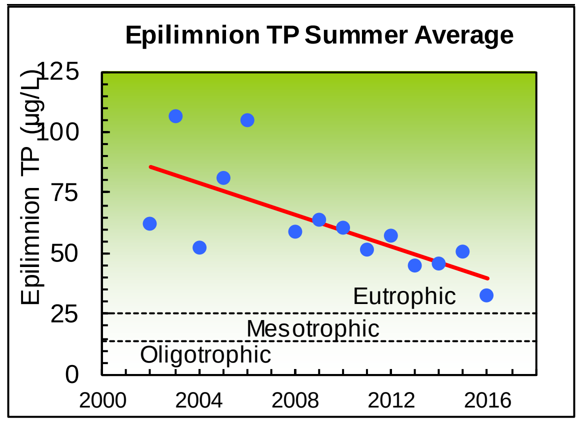
Phosphorus (key nutrient for algae)

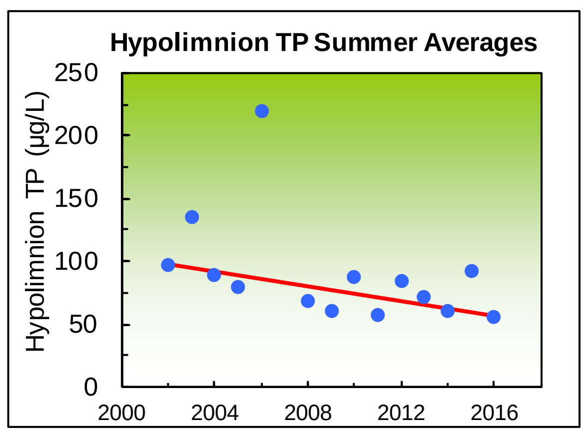
Nutrients are essential for the growth of algae, fish, and aquatic plants in a lake. However, too many nutrients, especially phosphorus, can pollute a lake and lead to unpleasant algae growth. Nutrients enter the lake through stormwater runoff or from streams flowing into the lake. Sources of nutrients 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 concentrations in the epilimnion (upper waters) are high (in the eutrophic range) and quite variable. For this reason, Lake Beecher is listed as "impaired" in Washington State's official 2012 water quality assessment.

The long-term 2002 to 2016 total phosphorus summer average is 62 µg/L (micrograms per liter, which is equivalent to parts per billion) in the upper waters. Individual phosphorus measurements have varied considerably in past years, from as low as 15 µg/L in 2016 to a high of 234 µg/L in 2003. Overall, there has been a statistically significant trend toward lower phosphorus levels in the upper waters (p=0.00), which is especially evident in recent years. The high phosphorus values in the epilimnion are a result of nutrients washing in from the large watershed surrounding Lake Beecher and from the periodic Snohomish River floods that inundate the lake. It has been a number of years since large river flooding has fully inundated Lake Beecher, so declining phosphorus levels may be partly the result of stabilizing conditions in the lake. There was significant flooding in November 2015, but occurred after the sampling season. Weather patterns can also contribute to the variability in phosphorus because there may be more or less mixing between the upper waters and nutrient-rich bottom waters from year to year.



Total phosphorus averages in the hypolimnion (bottom waters) are also high, with a long-term 2002 - 2016 summer average of 90 µg/L. There is a statistically significant trend towards lower phosphorus levels in the hypolimnion (p=0.04). The summer average in 2006 was abnormally high at 220 µg/L. The trend towards lover levels may indicate improvements in water quality, but may also be a sign of mixing between lake water layers and/or stabilizing conditions from past river inundations in this oxbow 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, 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.

Sampling in 2015 and 2016 show that chlorophyll *a* values are moderate to high and are also quite variable. The 2016 summer average is 10 µg/L while the 2015 summer average is 22 µg/L. There are no historic chlorophyll *a* measurements for Lake Beecher to compare to. However, SWM staff and volunteers have observed regular algae blooms in the lake. A significant bloom of cyanobacteria, or blue-green algae, was documented in Lake Beecher in July and August of 2008.

Heavy algae in the water column were also observed intermittently in the summer of 2009, 2014 and 2015. During a bloom, the water turns bright green or blue, and the algae may look like paint floating on the water's surface. This type of bloom has the potential to be toxic and could cause serious illness in humans who drink or play in the affected waters**.** Therefore, lake users should avoid contact with the water and keep pets away from the lake when it is experiencing a blue-green algae bloom.

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. The 2014 - 2016 summer average of total nitrogen is 443 µg/L. In 2016, Lake Beecher had moderate levels of total nitrogen (summer average of 385 µg/L), although the lowest levels in the three years of monitoring. This is consistent with the frequency of algae blooms 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.

Lake Beecher had a very low average N:P ratio of 10. This is because of the high phosphorus levels combined with only moderate nitrogen levels in the lake. Blue green algae blooms are sometimes a problem in Lake Beecher.

When lakes have high 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.

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 Beecher may be classified as eutrophic because of low water clarity and high phosphorus and algae concentrations. The lake is highly productive for both plants and algae. The eutrophic condition is likely the natural state for a shallow oxbow lake.

Condition and Trends

The water quality targets for Lake Beecher are to maintain stable water clarity and to avoid any increases in phosphorus levels. Water clarity has shown a small, but statistically significant, trend toward improvement, so this meets the target. Total phosphorus levels have also shown statistically significant decreasing trends in both the epilimnion and the hypolimnion. However, phosphorus levels are still higher than the criterion set by Washington State for lakes in the Puget Sound basin.

Overall, Lake Beecher is in fair condition, but the lake is at risk of declining water quality because of potential impacts from development in its very large watershed. Land clearing and development increase the amount of nutrients that wash into the lake during rain events. To find out more about ways to protect lake water quality and for information on the causes and problems of elevated lake nutrient levels please visit www.lakes.surfacewater.info.

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DATA SUMMARY FOR LAKE BEECHER						
		Water Clarity (Secchi depth in meters)	**Total Phosphorus (µg/L)**		**Total Nitrogen (µg/L)**	**Chlorophyll *a* (µg/L)**
Source	**Date**		**Surface**	**Bottom**	**Surface**	**Surface**
Sumioka and Dion,1985	**7/6/81**	1.2	60	90	-	-
SWM Staff or Volunteer	**1997**	1.0 - 1.3 (1.1) *n = 10*	126*	58*	-	-
Volunteer	**1998**	1.0 - 1.4 (1.1) *n = 4*	-	-	-	-
Volunteer	**1999**	1.1	-	-	-	-
Volunteer	**2000**	0.8 - 1.3 (1.0) *n = 3*	-	-	-	-
SWM Staff or Volunteer	**2002**	0.8 - 1.3 (1.1) *n = 4*	46 - 71 (62) *n = 4*	67 - 127 (98) *n = 4*	-	-
Volunteer	**2003**	1.1 - 1.3 (1.2) *n = 4*	49 - 234 (107) *n = 4*	50 - 266 (136) *n = 4*	-	-
Volunteer	**2004**	1.2 - 1.8 (1.4) *n = 3*	27 - 90 (53) *n = 3*	40 - 151 (90) *n = 3*	-	-
Volunteer	**2005**	0.8 - 1.3 (1.1) *n = 2*	73 - 89 (81) *n = 2*	79	-	-
Volunteer	**2006**	1.0 - 1.1 (1.1) *n = 2*	53 - 156 (105) *n = 2*	189 - 250 (220) *n = 2*	-	-
Volunteer	**2008**	1.0 - 1.7 (1.2) *n = 9*	42 - 74 (59) *n = 3*	60 - 77 (69) *n = 2*	-	-
Volunteer	**2009**	1.3 - 1.7 (1.4) *n = 8*	34 - 111 (64) *n = 4*	47 - 70 (60) *n = 4*	-	-
Volunteer	**2010**	1.1 - 1.9 (1.5) *n = 12*	52 - 77 (61) *n = 4*	53 - 153 (88) *n = 3*	-	-
Volunteer	**2011**	1.0 - 2.0 (1.4) *n = 12*	47 - 53 (52) *n = 4*	49 - 63 (57) *n = 4*	-	-
Volunteer	**2012**	0.9 - 1.5 (1.2) *n = 12*	44 - 66 (58) *n = 4*	76 - 100 (84) *n = 4*	-	-
Volunteer	**2013**	1.1 - 2.1 (1.6) *n = 13*	42 - 45 (44) *n = 3*	50 - 64 (56) *n = 3*	-	-
Volunteer	**2014**	*1.3 - 2.3 (1.6) n = 11*	*35 - 53 (46) n = 4*	*46 - 78 (61) n = 4*	*393 - 605 (447) n = 4*	-

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DATA SUMMARY FOR LAKE BEECHER						
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	**2015**	*1.0 - 2.0* *(1.5)* *n = 13*	*33 - 64* *(51)* *n = 4*	*53 - 119* *(92)* *n = 4*	*334 - 526* *(432)* *n = 4*	*8.5 - 54* *(22.4)* *n = 4*
Volunteer	**2016**	*0.7 - 2.2* *(1.6)* *n = 11*	*15 - 55* *(33)* *n = 4*	*44 - 69* *(56)* *n = 4*	*240 - 477* *(385)* *n = 4*	*9.9* *(9.9)* *n = 1*
Long Term Avg		**1.3** **(1997-2016)**	**62** **(2002-2016)**	**90** **(2002-2016)**	**443** **(2014-2016)**	**18.1** **(2015-2016)**
TRENDS		**Increasing**	**Decreasing**	**Decreasing**	**NA**	**NA**

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.

* Data not included in long-term trends - flood occurred just prior to sampling, inverting lake stratification.