HEALTH REPORT

LAKE STEVENS

REPORT DESCRIPTION

This report is an update on the health of Lake Stevens based on water quality data collected from 1990 through 2015 by local volunteers, Drainage Improvement District #8, or Snohomish County Surface Water Management (SWM) staff. For additional background on the information provided here or to find out more about Lake Stevens, please visit www.lakes.surfacewater.info or call SWM at 425-388-3464. You can also call the City of Lake Stevens at 425-377-3235 or visit the City's lake management web page.

LAKE DESCRIPTION

Lake Stevens is the largest natural lake in Snohomish County. Approximately 80% of the lake shore lies within the city limits of the City of Lake Stevens; only the southeastern shore is located in unincorporated Snohomish County. The lake covers 1013 acres, has a maximum depth of 150 feet (46 meters), and has an average depth of 62 feet (19 meters).

Lake Stevens is fed by Stevens, Lundeen, Kokanee, and Stitch creeks and drains to Catherine Creek and the Pilchuck River. The watershed, which is the land area that drains to the lake, covers 3,485 acres, which is large compared to other Snohomish County lake watersheds but relatively small compared to the size of Lake Stevens. The shoreline of Lake Stevens is one of the most densely developed in the county, and residential and commercial development throughout the watershed continues to expand. The large watershed size and dense development increase the potential for water quality impacts from pollution coming from the lands surrounding the lake.

WATER QUALITY BACKGROUND

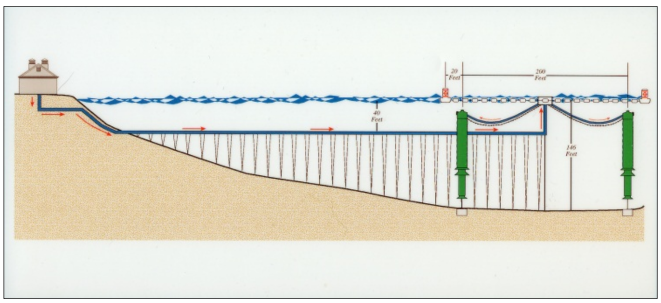
From the 1950s through the 1980s, Lake Stevens experienced declining water quality, with occasional poor water clarity and frequent and severe blooms of algae. Nutrient pollution, particularly phosphorus, was the primary cause of the poor water quality. Historically, phosphorus entered the lake through runoff from forestry and agriculture and later from the rapid residential development of the watershed. Over time, phosphorus built up in the sediments at the bottom of the lake, which then became a significant pollution source. Detailed studies were conducted in 1982 and 1986 to determine the primary sources of phosphorus. The 1986 study concluded that restoration of the lake would require control of both watershed (external) and sediment (internal) phosphorus sources.

The City and County have been working to control in-lake sources of phosphorus. However, because of continued residential development, pollution from the watershed has increased over 50% since the 1980s, and on-going efforts are needed by all property owners in the watershed to protect Lake Stevens.

Aeration System

To help control the phosphorus being released from the lake sediments, a hypolimnetic aeration system was installed in the center of the lake in 1994 (Figure 1). The aeration system was designed to provide oxygen to the bottom waters of the lake, known as the hypolimnion. During the warmer months of the year, the water near the lake surface heats up, but the hypolimnion remains cold. The temperature difference becomes so great that the cold bottom waters stop mixing with the warmer upper waters. Oxygen in the lower waters becomes depleted over time as it is consumed by decomposing algae and organic matter. When the dissolved oxygen in the hypolimnion is exhausted, a chemical reaction releases phosphorus that is normally bound with iron in the lake sediments. This internal cycling of phosphorus contributes to nuisance algae growth in the lake. By oxygenating the lower waters during the warm summer and early fall months, the aeration system allowed the phosphorus in the sediments to stay bound to iron in the sediments. This helped control phosphorus release and improved the water quality of Lake Stevens for nearly 20 years.

Figure 1 – Schematic Drawing of Aeration System



However, in recent years, the lake water quality data showed that the aerators were no longer as effective at maintaining low phosphorus levels in the lake. SWM and the City of Lake Stevens contracted with Tetra Tech, Inc. in 2009 to investigate the sediments in Lake Stevens. The purpose of the investigation was to measure sediment changes since the early 1980s in order to evaluate the effectiveness of the aeration system.

The investigation revealed that the amount of phosphorus in the sediments of Lake Stevens was significantly less than measured in 1982, but still higher than most other lakes in the region. The investigation also revealed that, even with adequate dissolved oxygen provided by the aerators, there was no longer enough iron in the sediments to bind all the phosphorus in the sediments as well as the phosphorus coming from the watershed each year.

Based on this finding, plus the high costs of operating and maintaining the aeration system (approximately $100,000 per year), and the need for expensive structural repairs, the City of Lake Stevens and the County decided to retire the aeration system in 2012.

As an alternative to relying on the aerators to control phosphorus pollution from the lake sediments, the City and County decided to conduct small, annual aluminum sulfate (alum) treatments.

Alum Treatments

Alum is a widely-used chemical for removing impurities, such as phosphorus, from water. The aluminum in alum strips phosphorus out of the lake water and sinks to the lake sediments where it permanently binds phosphorus, making it unavailable for algae growth during periods of low oxygen.

Figure 2 – Aerial View of 2013 Alum Treatment

The long-term plan adopted by the City and the County for managing the phosphorus that is already in Lake Stevens calls for annual small alum treatments over the next ten or more years. The alum treatments will help to alleviate the added phosphorus that washes into the lake from the surrounding watershed each year, as well as treat a small fraction of the phosphorus in the lake sediments. This incremental approach was chosen over a single large-scale treatment because the cost of treating all of the lake sediments is approximately $2 million. Instead, the small annual treatments can be implemented using the previous operating budget needed for the aeration system. In the long run, the repeated alum treatments can be just as effective, or more effective, than operation of the aeration system. The small annual alum treatments began in June 2013. There were also alum treatments in May 2014 and March 2015.

CURRENT LAKE CONDITIONS

Lake Quality Data

Summer averages of water clarity, total phosphorus (both upper and bottom waters), and chlorophyll *a* (algae) are summarized in the table at the end of this report. Detailed data for these parameters and other measurements, such as temperature and dissolved oxygen, may be found on the County's web site at www.data.surfacewater.info.

The following discussion begins with temperature and dissolved oxygen conditions in the lake because these affect the amount of phosphorus in the water. Next, the discussion focuses on phosphorus concentrations, which directly affect the amount of algae in the lake. Third, the discussion highlights chlorophyll *a*, a measure of the amount of algae in the water. Finally, this report describes lake water clarity, perhaps the most important concern of lake users. Water clarity is directly related to the amount of algae in the water, as well as any sediment in the water.

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 (see Figure 3). 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.

Every month each year, Snohomish County staff collect temperature data at multiple depths in the Lake Stevens water column. Figure 4 shows temperature profiles from the surface of the lake down to the lake bottom during 2014. However, only profiles for every other month are shown for clarity.

Figure 3 – Lake Stratification

(Minnesota Pollution Control Agency)

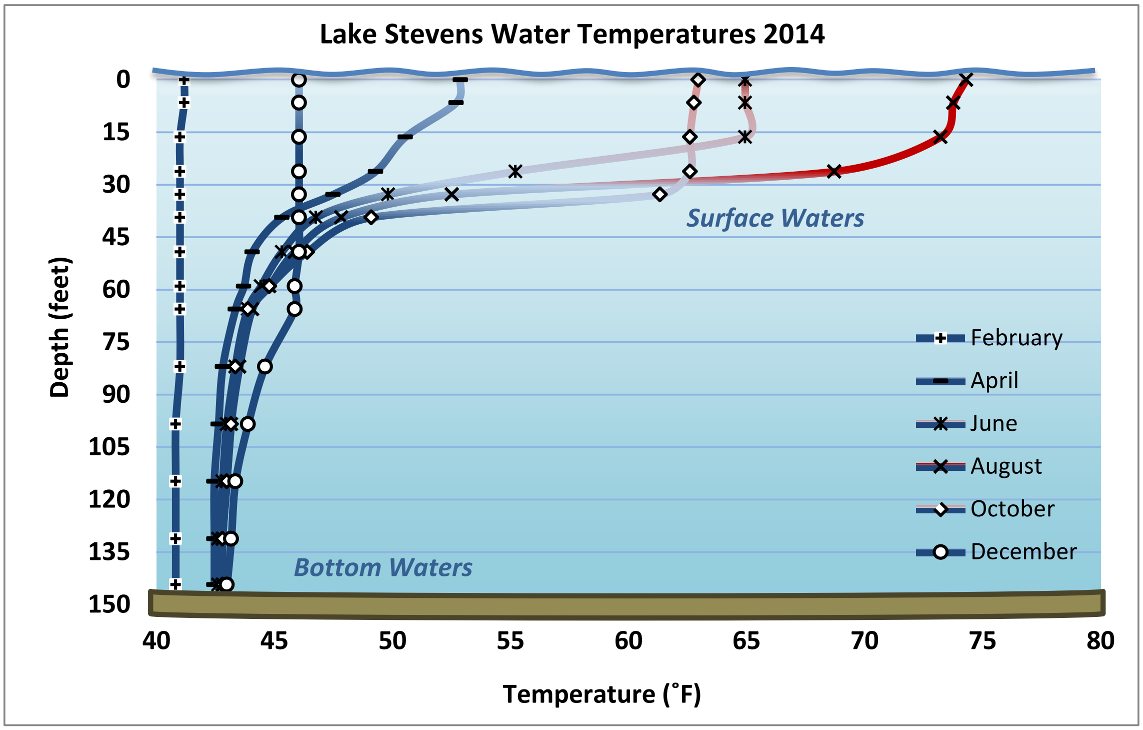
The profiles show that the temperature of the water was nearly the same from the surface to the lake bottom during the winter. The surface waters began warming up in April and continued warming up through May and June. By June, the surface waters had reached a peak of 75°F (23.9°C). At the same time, temperatures of the bottom waters changed only a little, remaining around 43°F (6.1°C). There was a zone between about 20 feet and 60 feet deep where the temperature dropped dramatically. This large temperature difference between the surface waters and the bottom waters means that the lake was strongly stratified, and mixing did not occur.

Then, from August through November, the surface waters slowly cooled. By December, the surface waters were nearly as cold as the bottom waters. When the temperatures become equal from top to bottom (usually in December or January), the entire lake will turn over (or mix). The lake will stay mixed during the winter until the next spring, when the surface 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 bottom 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 of

Figure 4



the lake allows for the release of phosphorus from the lake sediments.

Prior to the installation of the aeration system, the dissolved oxygen concentrations in the bottom waters of the lake dropped to zero during the summer months. This allowed phosphorus to be released from the sediments, which contributed to the growth of nuisance algae in the lake.

However, operation of the aeration system added dissolved oxygen to the bottom waters of the lake and helped prevent the release of phosphorus. From 1994 through part of 2012, the aeration system kept dissolved oxygen at acceptable levels in the bottom waters during the summer/fall period when phosphorus release from the sediments was a threat.

Figure 5 shows selected profiles of dissolved oxygen during 2008. The aerators were in operation from late July through mid-November that year. Oxygen levels were relatively high from the lake surface down to near the lake bottom in all months. Only at the very bottom of the lake did dissolved oxygen concentrations begin to drop, and they never approached zero. In fact, from August through December, although dissolved oxygen began to drop at around 30 to 60 feet deep, it increased between about 80 to 135 feet deep because the aerators were adding oxygen to that deeper portion of the lake. Without the aeration system, the dissolved oxygen concentrations would have continued dropping below 80 feet deep.

Since the aeration system was turned off in 2012, dissolved oxygen has slowly begun to return to the same pattern as before aeration. The oxygen levels gradually decline in the bottom waters from June through the end of the year, although not as quickly as before 1994. Figure 6 on the following page shows selected dissolved oxygen profiles from 2014.

As noted above, very low dissolved oxygen levels in the bottom waters can lead to a release of phosphorus from the lake sediments that contributes to increased algae growth in the lake. The annual spring alum treatments will remove the phosphorus released from the lake sediments as well as strip out phosphorus that has washed into the lake over the winter.

Figure 5

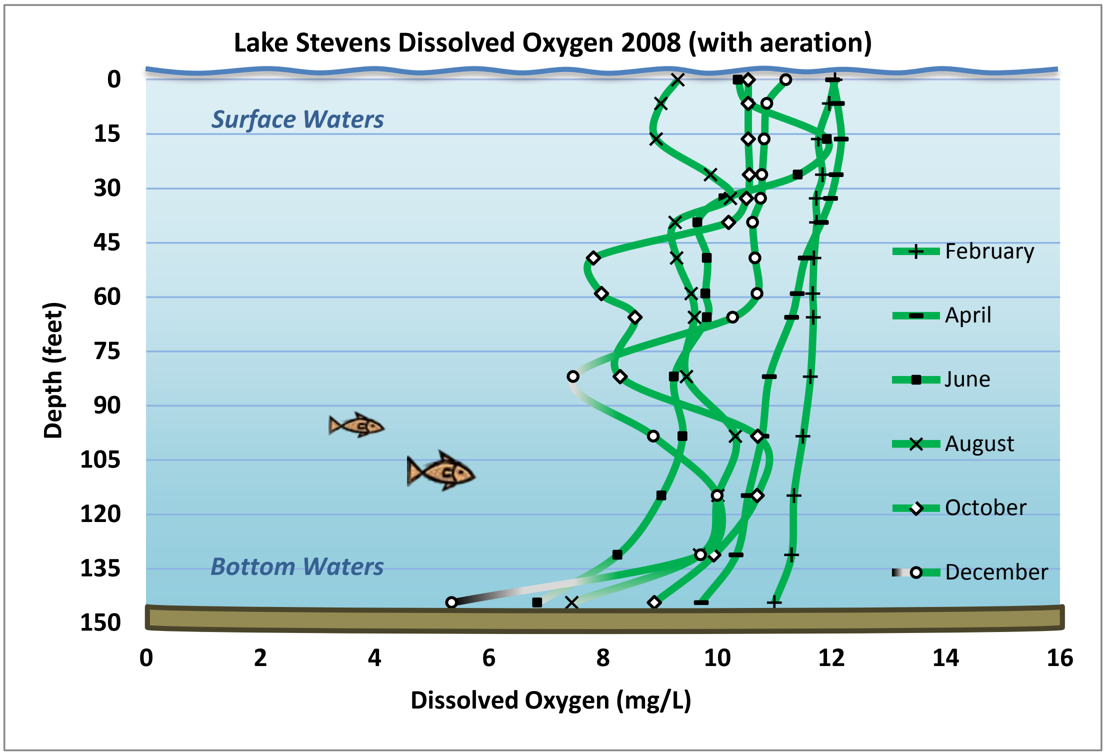
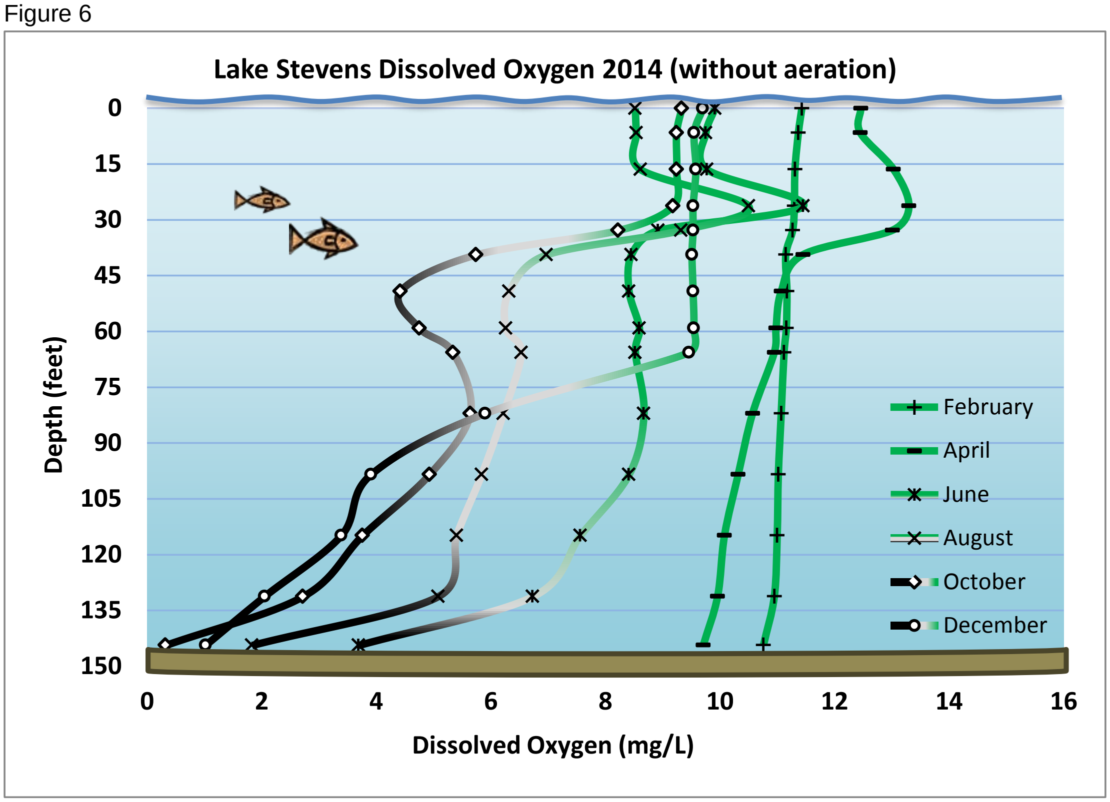


Figure 6



Phosphorus (key nutrient for algae)

Nutrients are essential for the growth of algae, fish, and aquatic plants in a lake. However, as described above, too many nutrients, especially phosphorus, can pollute a lake and lead to unpleasant algae growth. Phosphorus enters the lake through stormwater runoff or from streams flowing into the lake. Sources of phosphorus 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 lake health.

Total phosphorus (TP) concentrations in the epilimnion (upper waters) of Lake Stevens are low to moderate. Figure 7 shows the summer (May–October) phosphorus averages for each year from 1997 through 2015 for samples taken at 1 meter deep in the lake. The long-term 1997 – 2015 summer average is 10 µg/L (micrograms per liter which is equivalent to parts per billion). Between 1997 and 2012, the summer phosphorus averages in the upper waters were gradually increasing, with a large spike in phosphorus in 2006. This increase in phosphorus may have been the result of declining efficiency of the aeration system. The increase may also have been in response to increasing pollution washing into the lake from surrounding properties during storms.

Fortunately, the summer averages since 2013 (when the alum treatments began) have been lower, around 8 µg/L. In fact, compared to the May-October averages during the last six years of aeration (2007-2012) when the aeration system was losing effectiveness, total phosphorus concentrations in the upper waters during the years with alum treatments (2013-2015) have declined by 43%. While many other lakes have also seen lower phosphorus during the last three years, possibly because of warm, dry summers, the other lakes had average decreases of only 25%. So, the improvements at Lake Stevens have been more significant.

Figure 7

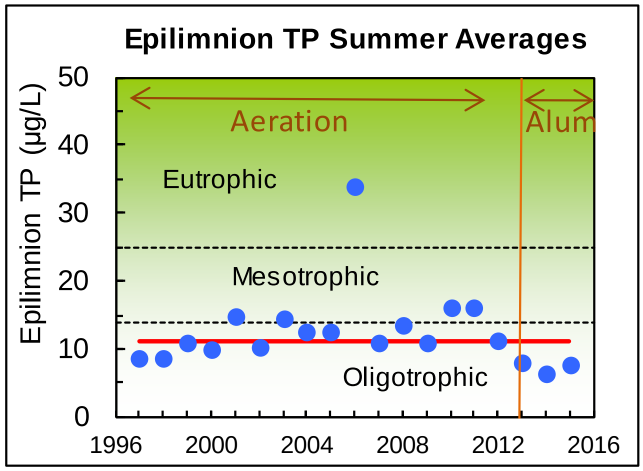


Figure 8 shows the total phosphorus concentrations in the upper waters for every sampling date between January 2007 and October 2015. The values are averages of samples taken at 1 meter, 5 meters, and 10 meters. There are spikes of higher phosphorus levels each year in late winter/early spring. These are the result of winter storm runoff into the lake, as well as phosphorus released from the bottom sediments the previous fall that spreads into the upper waters when the lake mixes.

However, since the beginning of the alum treatments in 2013, the winter phosphorus spikes have been smaller. The whole-lake total phosphorus concentrations from December through April (the period when the lake is mostly mixed) declined 48% during the winters after the alum treatments. This means that the alum treatments are having a positive impact, and there is less phosphorus carried over from the previous year to be available for spring and early summer algae blooms.

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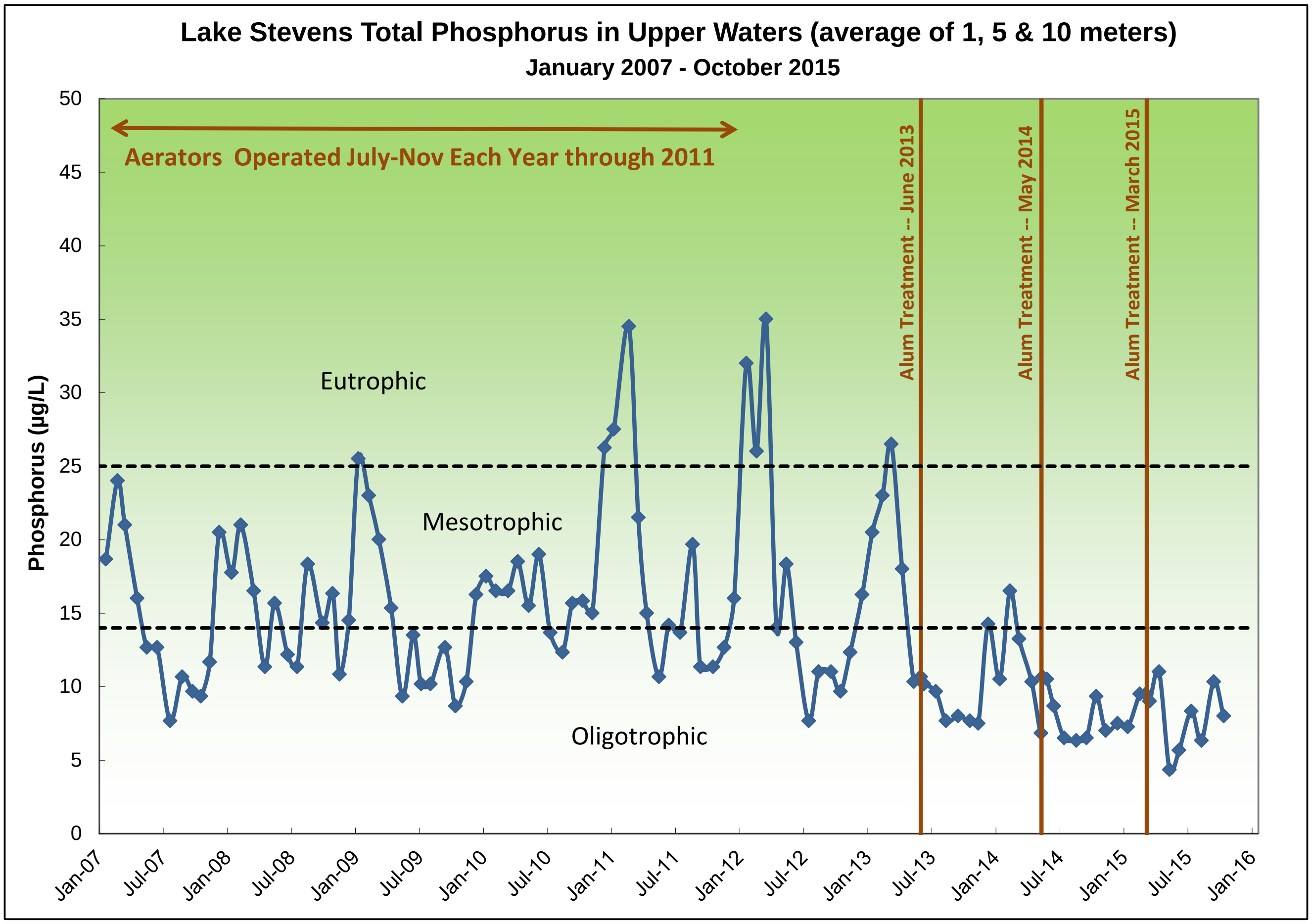
Figure 8



Phosphorus levels in the bottom waters (hypolimnion) are higher than in the upper waters. The long-term 1997-2015 summer average is 26 µg/L. Just like in the upper waters, total phosphorus in the bottom waters (at 40 meters deep) was steadily increasing since 1999 (see Figure 9). This reflects the declining effectiveness of the aeration system and possible release of phosphorus from the lake sediments, as well as increasing pollution from the surrounding watershed. There was no change evident in 2013 after the first alum treatment. However, the May-October total phosphorus averages for 2014 and 2015 dropped to 24 µg/L and 12 µg/L, respectively. Compared to the last six years of aeration, the 2013-2015 phosphorus averages for the bottom waters declined 41%. Again, this is different from other lakes in the county which, on average, showed increases in phosphorus in the bottom waters.

Figure 9

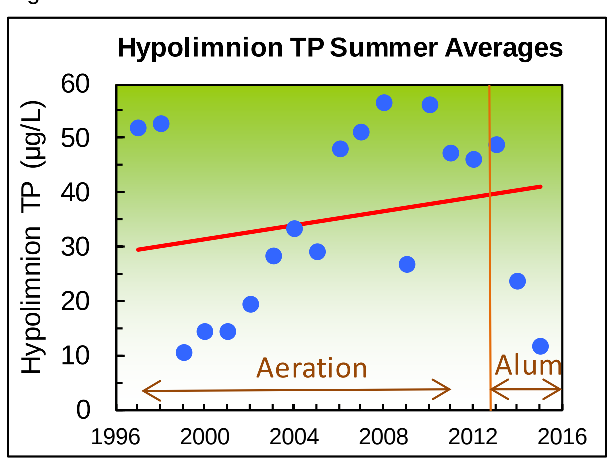


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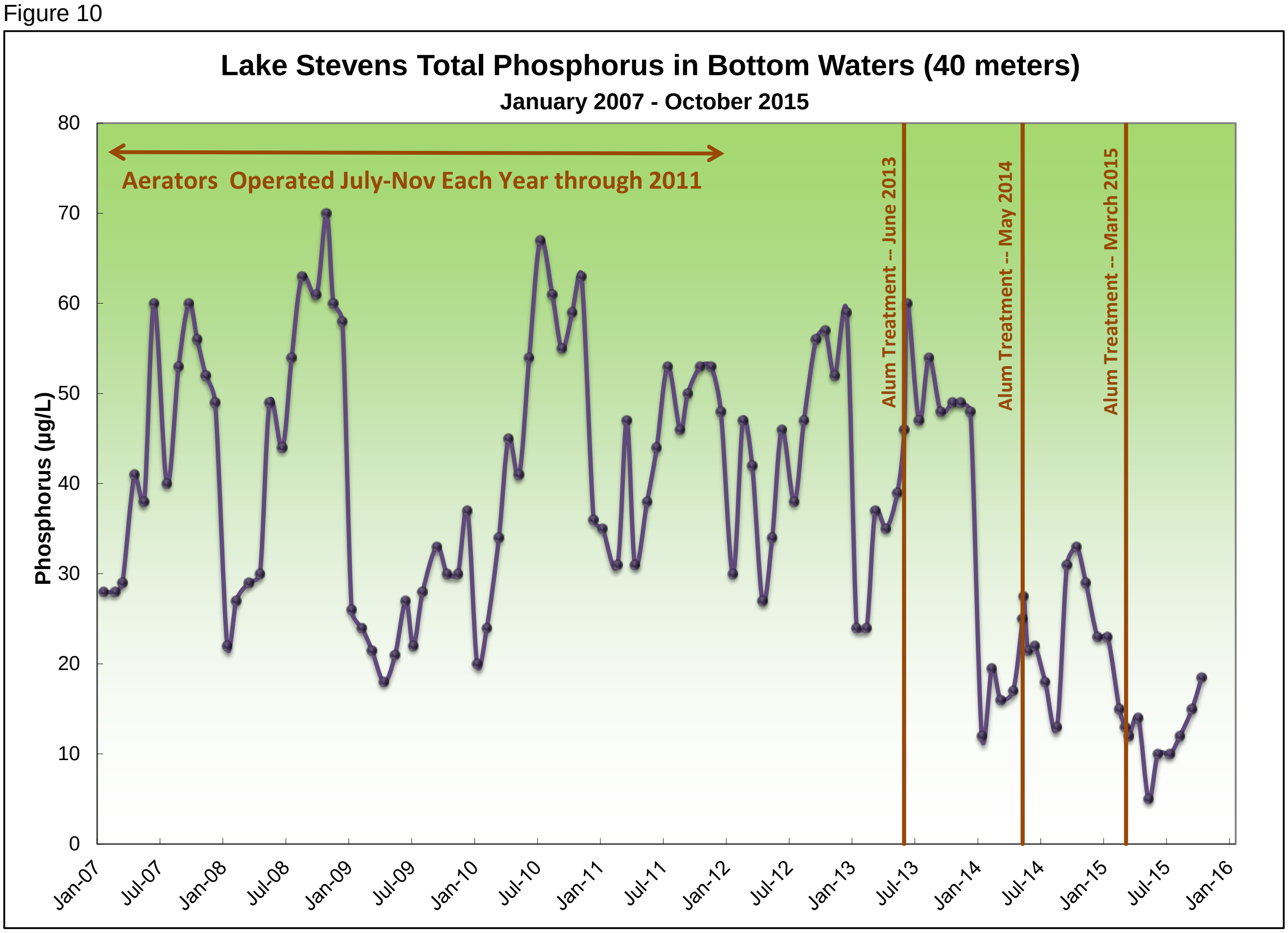
Figure 10 shows the total phosphorus concentrations in the bottom waters (40 meters deep) for every sampling date between January 2007 and October 2015. For most years, phosphorus levels climbed in late summer and early fall. This indicates that phosphorus released from the lake sediments was building up in the bottom waters even with the aeration system working. Although the levels of phosphorus are not high compared to many lakes, phosphorus is abundant enough to contribute to nuisance algae blooms during the winter and following spring.

After each of the alum treatments, total phosphorus concentrations in the bottom waters have sharply declined, then gradually risen in the late summer/fall. This shows that removal of phosphorus from the water column by alum treatments had more effect on phosphorus levels in the lake than did the binding of phosphorus in the sediments. Fortunately, with the alum treatments, the fall peaks of phosphorus have been lower than in previous years, especially in 2014 and 2015.

Another way to evaluate the impacts of the alum treatments is to examine the rate of phosphorus build-up in the bottom waters during the stratified summer/fall period (referred to as the sediment release rate). Compared to the last six years of aeration, the rate of phosphorus increase below 40 meters declined by 99%. The declines were particularly dramatic in 2013 and 2014 when the alum treatments occurred in June and May. The March 2015 alum treatment had less effect on the rate of phosphorus increase, perhaps because it was much earlier in the year.

Figure 10



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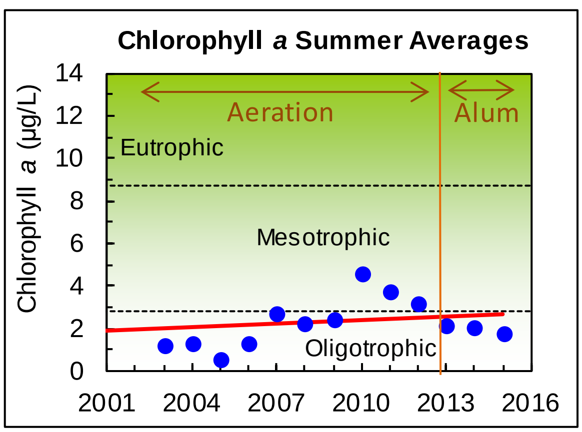
Chlorophyll a (Algae)

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, particularly 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.

Chlorophyll *a* values in Lake Stevens since 2003 have been relatively low. The 2003-2015 long-term summer average is only 2.3 µg/L, which places the lake in the oligotrophic range with low amounts of algae. However, from 2003 to 2012, the summer averages were increasing (see Figure 11). The 2010 average was 4.6 µg/L, the highest since 1990. Since the beginning of the alum treatments, however, there has been less algae in the water. Compared to the chlorophyll *a* averages during the last six years of aeration (2007-2012), the May-October averages during the first three years of alum treatments (2013-2015) have declined 36%.

Figure 11



Lake Stevens does still experience occasional nuisance blue-green algae blooms, especially in the late winter and early spring. These appear to be in response to phosphorus from the sediments mixed throughout the lake after turnover, even with the alum treatments, and phosphorus flushed into the lake during rain storms.

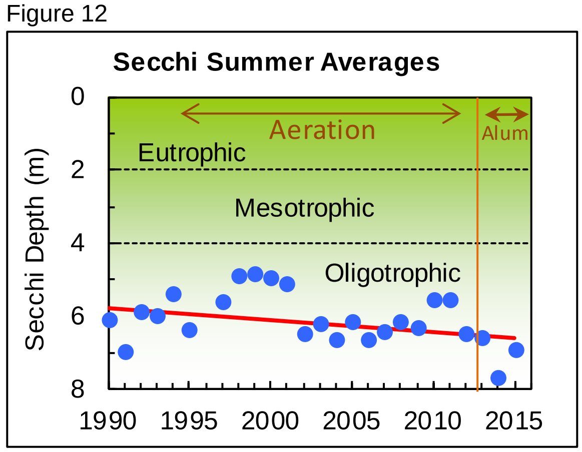
Also, on at least one occasion during the winters of 2011, 2013, and 2015, the algae blooms have been toxic. Each time the toxin was microcystin, a liver toxin that can harm people or pets swimming in or drinking the water. Fortunately, few people are swimming in the lake at that time of year, but the toxins could still affect pets that drink the lake water during harmful winter algae blooms.

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 in the lake, as well as by sediment and 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 Stevens is high, with a long-term 1990–2015 summer average of 6.1 meters (20 feet). Figure 12 shows the summer average for each year. There was a period from 1998 through 2001 when the water clarity was markedly worse. Then, between 2002 and 2009, water clarity was higher. But, clarity dropped again in 2010 and 2011. Since the beginning of the alum treatments in 2013, water clarity has been very good, especially in 2014 when the summer average was 7.7 meters. In fact, compared to the last six years of aeration (2007-2012), water clarity has improved by 16% with the alum treatments. Overall, between 1990 and 2014, there has been a statistically significant trend toward better water clarity ($p=0.05$).

Figure 12



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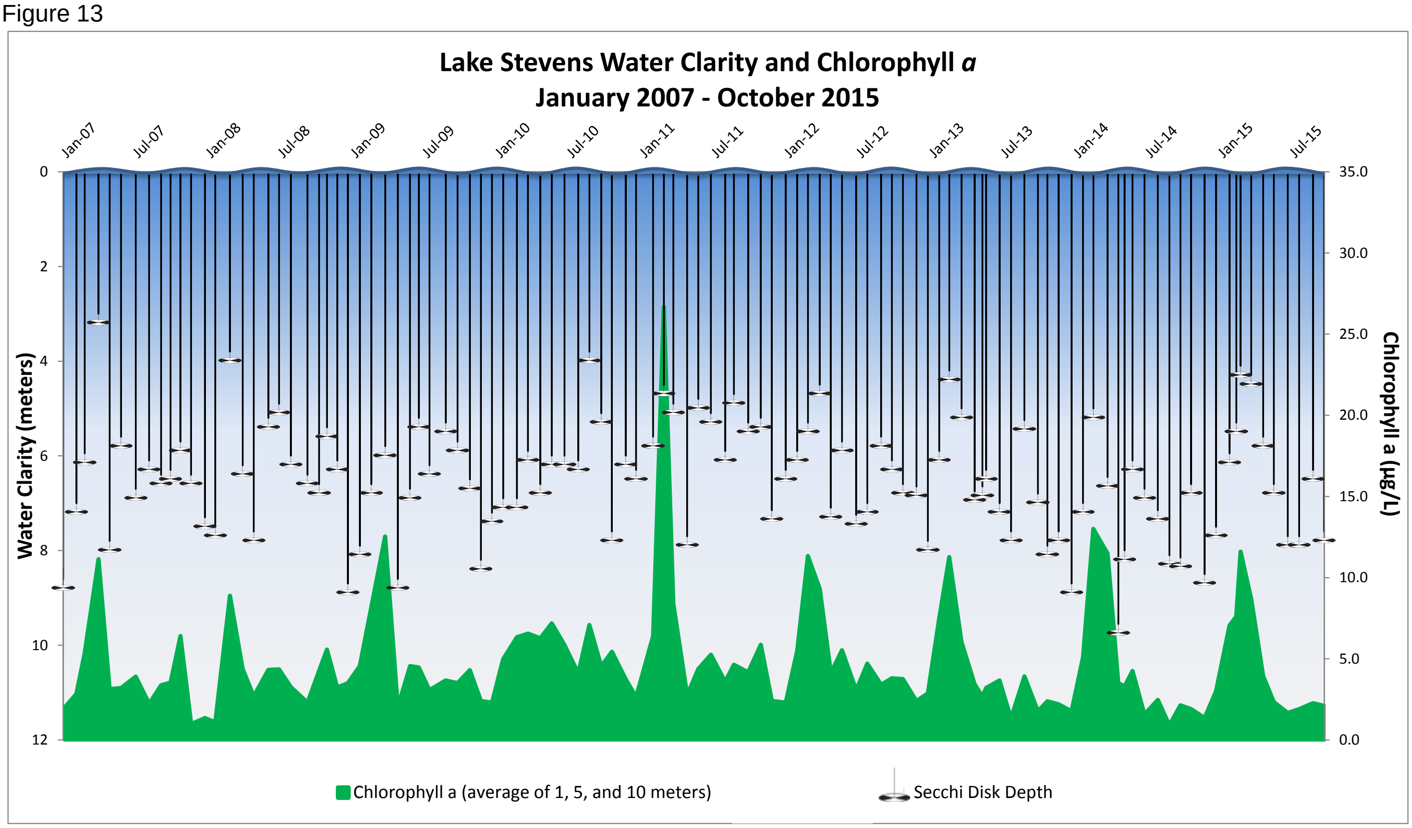
As noted above, water clarity is strongly influenced by the amount of algae in the water. Figure 13 shows the total amount of algae in Lake Stevens from January 2007 through October 2015 based on chlorophyll *a* measurements. Figure 13 also shows the corresponding water clarity (Secchi disk depth) on each date. The pattern is consistent that water clarity declines (one cannot see into the water as far down) every time there is an algae bloom (represented by the peaks in chlorophyll *a*). This confirms that water clarity is closely tied to algae levels in Lake Stevens.

Water Color

The color of lake water also 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 the color of algae or sediment suspended in the water.

Lake Stevens has very little natural color, indicating it does not have significant humic inputs. During 2010-2011, the water color of the lake averaged 6 pcu (platinum-cobalt color units), the second lowest reading in Snohomish County. This means that water color does not play an important role in the water clarity at Lake Stevens.

Figure 13



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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).

Lake Stevens supports moderate levels of aquatic plants. Although some areas with steep shores support only a few plants, in most shallow areas, plants grow prolifically.

However, Lake Stevens has had a serious problem with Eurasian watermilfoil, an invasive, non-native plant. Invasive aquatic plants such as milfoil can choke out native plants and form dense stands that are a nuisance to humans and wildlife. Milfoil was present in low numbers in Lake Stevens in the 1980s, but in the late 2000s, Eurasian watermilfoil grew into a major problem. The thick mats of milfoil were so dense that they interfered with swimming and boating in portions of the lake. By 2010, dense patches of milfoil covered 46 acres of the lake, mainly in the northwest corner and along the eastern shore. Another 90 acres had sparse to moderate concentrations of milfoil.

The City of Lake Stevens, in cooperation with Snohomish County SWM, developed a plan in 2010 to control the Eurasian watermilfoil infestation. The City conducted a herbicide treatment in 2011 to kill milfoil plants in the densest areas. The 2011 treatment was successful in eliminating a high percentage of the milfoil plants in the lake. The City has continued working to control milfoil each year since then using spot herbicide treatments and diver hand removal.

Residents and recreational users of the lake should be sure to check their boats and trailers and remove any Eurasian watermilfoil fragments to prevent the spread of this plant within Lake Stevens and to other lakes.

SHORELINE CONDITION

The condition of the lake shoreline is important to understanding overall lake health. As development near the lake increases, the shoreline is typically modified either through removal of natural vegetation, the installation of bulkheads or other hardening structures, and/or the removal of large logs and branches. This type of alteration can be harmful to the lake ecosystem because natural shorelines protect the lake from harmful pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

Lake Stevens has the most densely developed shorelines in Snohomish County There are approximately 425 developed parcels containing 370 homes bordering the lake, giving an average of 9.6 homes per 1000 feet of shoreline. There are also over 400 docks. A survey in 2008 showed that 78% of the 7.3-mile shoreline had been modified. Bulkheads comprised the majority of the modifications (57%), followed by rock revetments (20%). The vegetation immediately adjacent to the shoreline has also been significantly altered, with only 16% being classified as intact in 2008. Nearly all the large wood has been removed from the lake. Only four large wood pieces were identified in 2008. These old logs and branches are valuable for fish and wildlife habitat.

The high level of shoreline modification significantly limits the amount of aquatic habitat available to fish and wildlife. It also leaves the lake more susceptible to pollution from activities immediately surrounding the lake, such as the use of fertilizers and driveway/roof runoff. Shoreline modification also eliminates the buffer of native vegetation that can trap and filter out pollution. The loss of native vegetation along the shoreline could also lead to shoreline erosion.

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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 Stevens may be classified as oligo-mesotrophic, with high water clarity, low to moderate phosphorus levels, low to moderate chlorophyll *a* values, but occasional blue-green algae blooms,. This means that the lake has low to moderate productivity of plants and algae.

Condition and Trends

Overall, Lake Stevens is in good condition. However, the lake is at risk of future water quality declines unless phosphorus pollution is controlled.

Over the last few years of operating the aeration system, phosphorus concentrations and chlorophyll *a* (algae) levels in the lake were increasing. This was likely because of continuing pollution coming from the surrounding homes, businesses, and roads in the watershed and because the aeration system was losing effectiveness at binding the phosphorus in the lake sediments.

However, the small, annual alum treatments that the City is now performing have helped reduce phosphorus and chlorophyll *a* concentrations in recent years. Phosphorus concentrations have dropped over 40% and chlorophyll *a* levels have declined 36% since the beginning of the alum treatments.

The annual alum treatments should be continued in order to remove phosphorus from the water column and over time inactivate phosphorus in the lake sediments. However, the alum treatments cannot completely offset the impacts of pollution coming from properties in the watershed. Any future increases in phosphorus pollution flowing into the lake may lead to nuisance algae growth. This would affect public use and enjoyment of the lake.

Residents around the lake can make a difference by making simple changes around their properties that reduce phosphorus pollution. These actions include picking up pet wastes, avoiding fertilizers or using phosphorus-free fertilizers, diverting water from roofs and driveways into stable vegetated areas rather than piping it to the lake, covering bare soils, and planting more native shrubs and trees near the water. More ideas can be found at www.ilovelake.org or at www.lakes.surfacewater.info.

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DATA SUMMARY FOR LAKE STEVENS					
		Water Clarity (Secchi depth	**Total Phosphorus (µg/L)**		**Chlorophyll *a* (µg/L)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
Bortleson, et al, 1976	**7/27/72**	5.2	5	56	-
Reid, Middleton & Associates, 1983	**1982**	3.6 - 9.0 (6.0) *n = 5*	5 - 23 (12) *n = 6*	20 - 35 (30) *n = 6*	7 - 17 (9.8) *n = 6*
KCM, 1987	**1986**	5.2 - 8.8 (6.6) *n = 7*	<1 - 14 (5) *n = 7*	56 - 109 (69) *n = 7*	<0.1 - 22 (4.6) *n = 7*
LS Volunteer or DOE	**1990**	4.0 - 8.8 (6.1) *n = 35*	-	-	3.7 - 6.0 (4.8) *n = 2*
LS Volunteer or DOE	**1991**	4.7 - 10.1 (7.0) *n = 39*	-	-	2.0 - 3.0 (2.5) *n = 2*
LS Volunteer or DOE	**1992**	3.8 - 7.8 (5.9) *n = 34*	-	-	2.2 - 5.1 (3.1) *n = 4*
LS Volunteer KCM or DOE	**1993**	3.9 - 8.2 (6.0) *n = 21*	4 - 12 (8) *n = 6*	33 - 85 (48) *n = 6*	1.3 - 4.0 (2.8) *n = 11*
DOE	**1994**	3.8 - 9.5 (5.4) *n = 12*	-	-	1.6 - 3.0 (2.3) *n = 2*
DOE	**1995**	4.6 - 9.9 (6.3) *n = 13*	-	-	1.0 - 4.4 (2.7) *n = 2*
DD#8	**1997**	4.0 - 7.7 (5.6) *n = 6*	<5 - 12 (9) *n = 9*	40 - 66 (52) *n = 8*	1.4 - 9.6 (3.5) *n = 9*
DD#8	**1998**	3.8 - 5.6 (4.9) *n = 8*	6 - 15 (9) *n = 6*	36 - 118 (53) *n = 6*	1.5 - 3.9 (2.6) *n = 6*
DD#8	**1999**	3.6 - 7.3 (4.8) *n = 10*	8 - 15 (11) *n = 6*	6.3 - 17 (11) *n = 5*	0.5 - 3.2 (1.9) *n = 6*
DD#8	**2000**	4.2 - 5.9 (4.9) *n = 9*	7 - 14 (10) *n = 5*	9.2 - 23 (15) *n = 5*	[a]
DD#8	**2001**	3.6 - 6.6 (5.1) *n = 11*	11 - 18 (15) *n = 6*	11 - 21 (14) *n = 6*	[a]
DD#8	**2002**	4.8 - 10 (6.4) *n = 12*	7 - 17 (10) *n = 6*	5 - 45 (20) *n = 6*	[a]
DD#8	**2003**	5.1 - 7.5 (6.2) *n = 10*	7 - 28 (15) *n = 6*	8 - 46 (29) *n = 6*	0.1 - 3.2 (1.2) n = 6
DD#8	**2004**	4.0 - 8.3 (6.6) *n = 10*	5 - 34 (13) *n = 6*	21 - 53 (34) *n = 6*	0.2 - 2.4 (1.4) *n = 6*

DATA SUMMARY FOR LAKE STEVENS					
		Water Clarity (Secchi depth	Total Phosphorus (µg/L)		Chlorophyll *a* (µg/L)
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
DD#8	**2005**	5.2 - 7.7 (6.1) *n = 11*	5 - 9 (7) *n = 5*	19 - 39 (29) *n = 6*	0.2 - 1.6 (0.5) *n = 6*
SWM Staff or DD#8	**2006**	5.9 - 7.7 (6.6) *n = 10*	17 - 53 (35) *n = 6*	27 - 63 (48) *n = 6*	0.2 - 4.0 (1.4) *n = 5*
SWM Staff	**2007**	5.4 - 7.8 (6.4) *n = 10*	8 - 13 (11) *n = 6*	38 - 60 (51) *n = 6*	1.6 - 3.2 (2.8) *n = 6*
SWM Staff	**2008**	4.9 - 7.6 (6.1) *n = 6*	9 - 26 (14) *n = 6*	44 - 70 (57) *n = 6*	1.4 - 3.9 (2.3) *n = 6*
SWM Staff	**2009**	5.2 - 8.6 (6.3) *n = 6*	9 - 15 (11) *n = 6*	21 - 33 (27) *n = 6*	1.6 - 3.4 (2.5) *n = 6*
SWM Staff	**2010**	3.8 - 6.6 (5.5) *n = 5*	12 - 24 (16) *n = 6*	41 - 67 (56) *n = 6*	1.6 - 8.5 (4.6) *n = 6*
SWM Staff	**2011**	4.7 - 7.7 (5.5) *n = 7*	12 - 27 (16) *n = 6*	38 - 53 (47) *n = 6*	2.4 - 4.8 (3.7) *n = 6*
SWM Staff	**2012**	5.6 - 7.3 (6.5) *n = 6*	7 - 16 (11) *n = 6*	34 - 57 (46) *n = 6*	1.6 - 5.6 (3.2) *n = 6*
SWM Staff	**2013**	5.3 - 7.6 (6.6) *n = 8*	6 - 10 (8) *n = 7*	39 - 60 (49) *n = 7*	0.8 - 3.4 (2.2) *n = 7*
SWM Staff	**2014**	6.1 - 9.6 (7.7) *n = 7*	5 - 9 (7) *n = 8*	13 - 33 (24) *n = 8*	0.5 - 4.6 (2.1) *n = 7*
SWM Staff	**2015**	5.6 - 7.7 (6.9) *n = 6*	3 - 20 (8) *n = 6*	5 - 19 (12) *n = 6*	1.2 - 2.7 (1.8) *n = 6*
Long Term Avg		**6.1** **(1990-2015)**	**10** **(1997-2015)**	**26** **(1997-2015)**	**2.3** **(2003-2015)**
TRENDS		**Increasing**	**None**	**None**	**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
- LS Volunteer = citizen volunteer monitors involved in the Lake Stevens Restoration Program
- DD#8 = Lake Stevens Drainage Improvement District #8
- "Surface" samples are from 1 meter depth and "bottom" samples are from 40 meters deep.

[a] Chlorophyll a data for 2000-2002 not included because of quality control issues