LAKE ARMSTRONG

REPORT DESCRIPTION

This report is an annual update to the 2003 State of the Lakes Report and includes water quality data collected from 2003 through 2009. For additional background on the information provided here or to find out more about Lake Armstrong visit www.lakes.surfacewater.info or call Snohomish County Surface Water Management at 425-388-3464.

LAKE DESCRIPTION

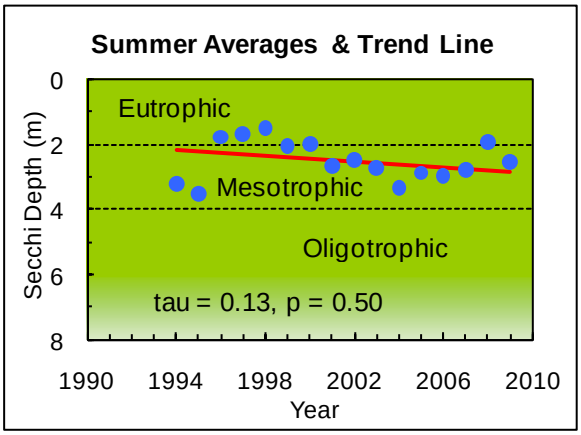
Lake Armstrong is a 31-acre lake located north of the City of Arlington. The maximum depth is 8.7 meters and the average depth is over 4.6 meters. The watershed of the lake is mostly undeveloped, except for about a dozen homes around the lake shore.

LAKE CONDITIONS

The following graphs illustrate the summer averages and trend lines (in red) for water clarity, total phosphorus, and chlorophyll for Lake Armstrong. 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 in Lake Armstrong is low to moderate, with a long-term summer average of 2.5 meters. Beginning in 1996, water clarity was substantially worse than it had been in 1994 and 1995. There were slow improvements over the years, and by 2004, the water clarity had again reached the level of 1994 and 1995. However, in 2008 the water clarity was again relatively poor, only 1.9 meters. One possible explanation for the poor water clarity in some years is watershed activities (such as land clearing or timber harvest) that result in more nutrients washing into the lake and fueling increased algal blooms. Another possibility is that the water color is darker in wetter years, which reduces the water clarity. In 2009 the clarity was very close to the long-term average.



Temperature

From June through October 2009, temperature data were collected at each meter throughout the Lake Armstrong water column. The temperature data show that the lake was strongly thermally stratified during the entire June through October period (see graph on page 3). This means that there is a strong temperature difference between the warm upper waters and the cool bottom waters, and mixing does not occur between these layers. By June the upper waters are significantly warmer than the lower waters with a 16°C (28°F) temperature difference. The upper waters reached their peak in temperature in June at 22 °C (71° F) and then cooled down until October. At the same time, bottom water temperatures changed only a little and remained around 6° C (43°F). In November and December, the surface waters will continue 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

The depth profiles of dissolved oxygen measured in 2009 largely correspond to the temperature profiles seen during that time period (see graph on page 3). There was little or no oxygen in the water at 3 meters and below by

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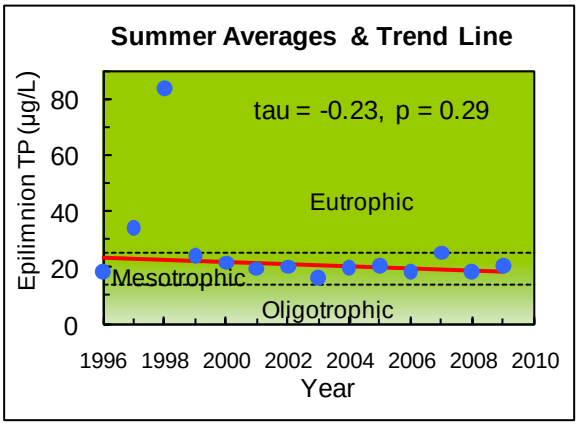
July. During the stratified summer period, oxygen in the lower waters is consumed by the decomposition of organic material within the lake. Since the lake is strongly stratified, the oxygen is not replenished by the overlying oxygen-rich upper waters or by the atmosphere. Even in October, when the upper waters began to cool, the dissolved oxygen was still near zero below approximately 4 meters, meaning that the lake had not completely mixed. During the winter the lake will mix and dissolved oxygen will be replenished throughout the lake.

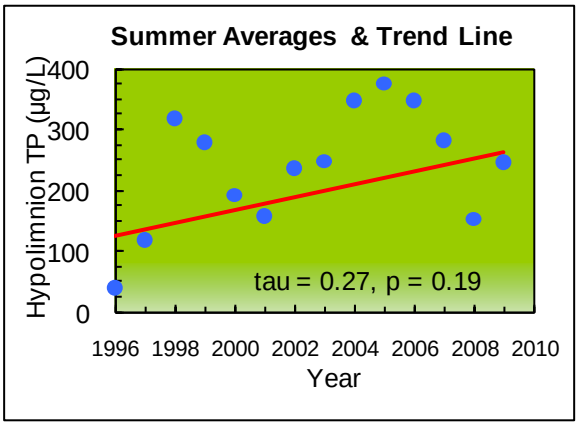
In June dissolved oxygen levels at 2 meters increased sharply. This is likely due to vigorous algal growth at the interface between the upper and lower waters. Algae often thrive in this zone because there is available light in the upper waters and higher nutrients available in the lower waters. During this period the water clarity was also reduced, which indicates that algae were likely present and affecting the clarity.

Total Phosphorus (key nutrient for algae)

Total phosphorus concentrations in the epilimnion (upper waters) are relatively high, with a long-term average of 26 µg/l. There were very high phosphorus averages in 1997 and 1998. These two years correspond with the worst years of water clarity and could be related to watershed activities. In contrast, from 1999 through 2009, phosphorus values have been lower and stable, ranging between 16 and 25 µg/l. As a result, there are no statistically significant trends in phosphorus levels in the epilimnion. However, long-term phosphorus levels in upper waters remain high, which is why Lake Armstrong is listed as "impaired" in Washington State's official 2008 water quality assessment.



Phosphorus averages in the hypolimnion (bottom waters) are much higher than in the epilimnion, with a long-term 1996-2009 average of 239 µg/l. There appears to be a trend toward increasing concentrations; however, the trend is not yet statistically significant. The concentrations were especially high in 1998-1989 and 2002-2006. High and increasing phosphorus levels point to the on-going build-up of nutrients in the bottom sediments which are released during periods of oxygen depletion in the summer months. This is a sign of accelerated eutrophication.



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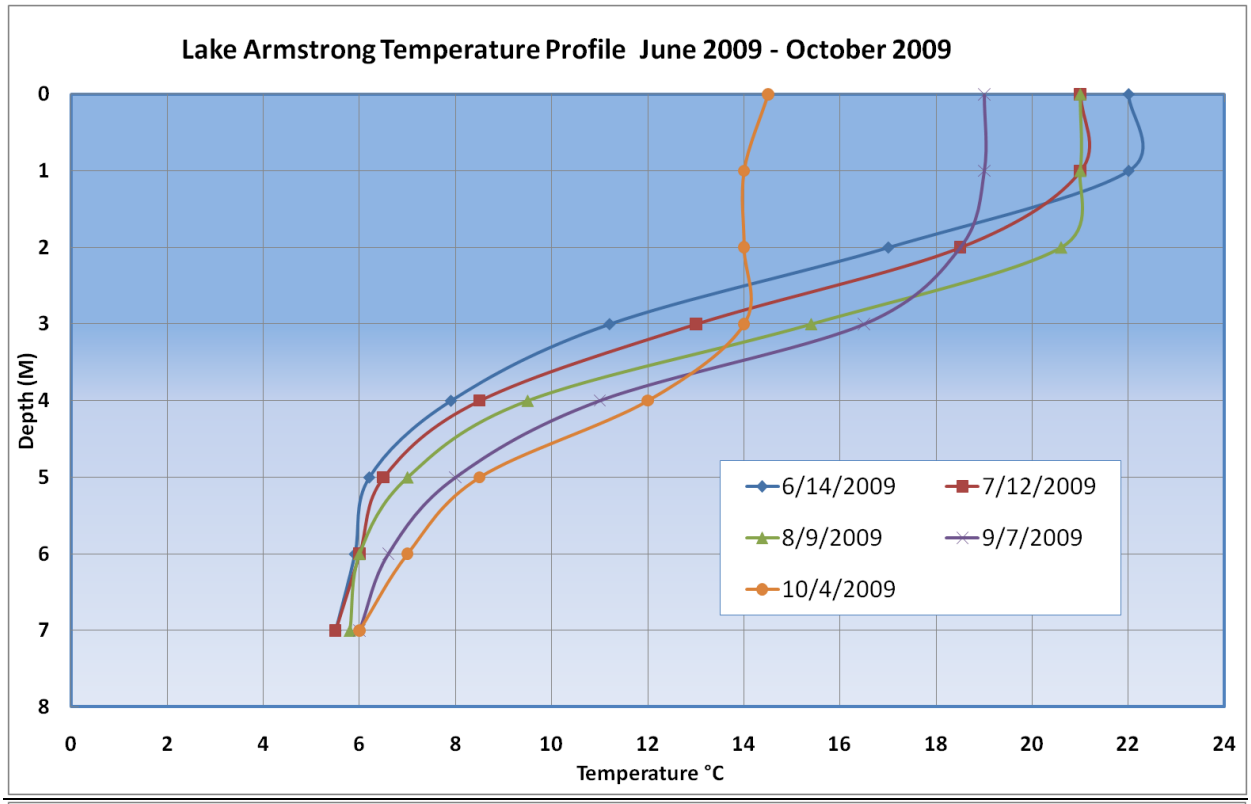

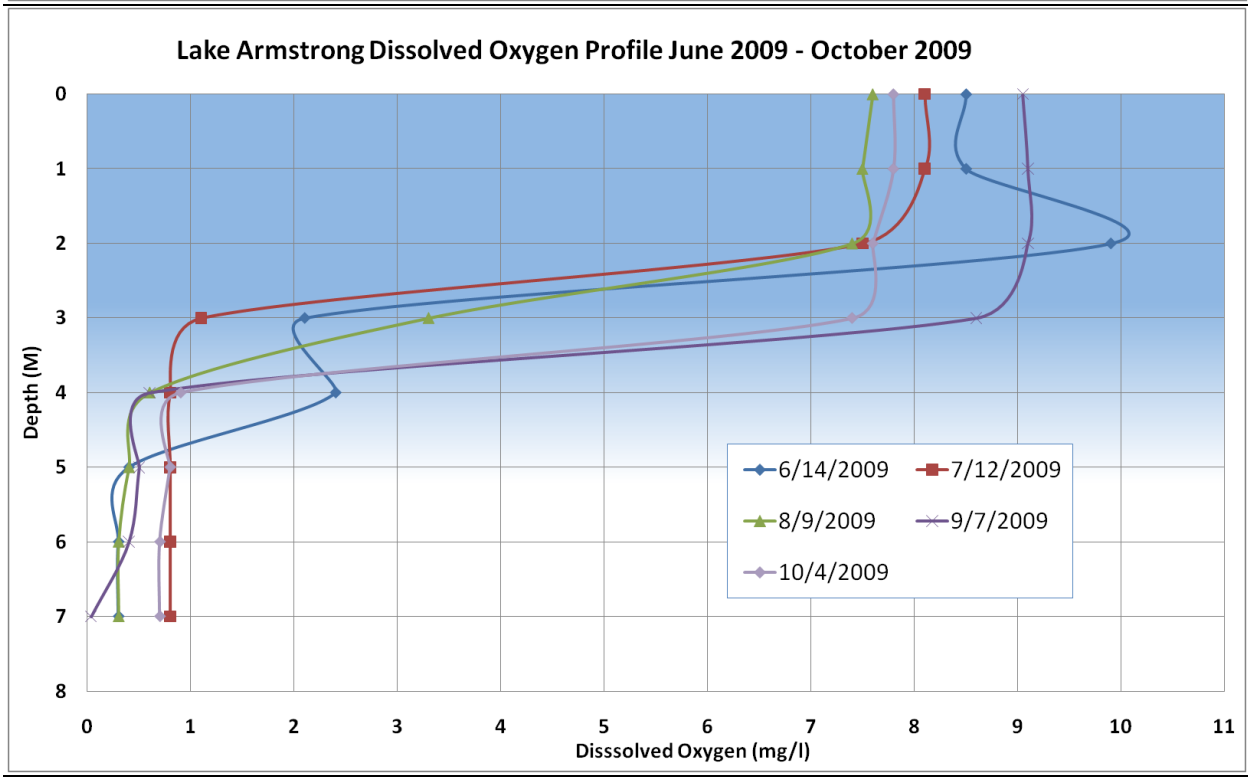

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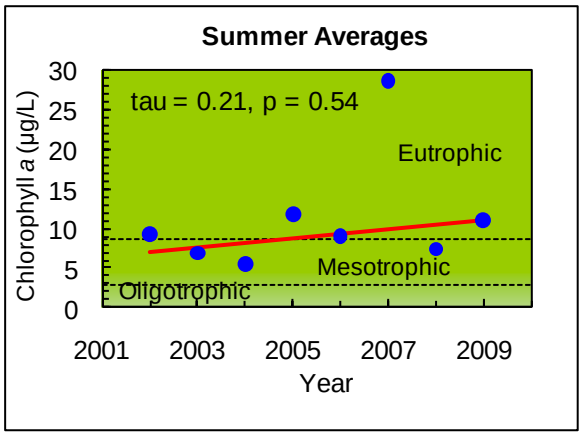
Chlorophyll a (Algae)

Sampling between 2002 and 2009 shows that chlorophyll *a* values are moderate to high and are also variable. The long term average is 11 µg/l. In 2007, the summer average was exceptionally high at 29 µg/l. The higher average was caused by one value of 96 µg/l measured in October, which corresponded with an algal bloom. Observations at Lake Armstrong indicate that the lake does experience regular nuisance blue-green algal blooms. A longer term data set is needed to identify trends in chlorophyll *a* in Lake Armstrong, particularly with the high variability in the data.



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 algal bloom. If a bloom has been identified as toxic, the lake will have postings at public access sites.

Since 2005, volunteers and SWM staff have screened algae at Lake Armstrong for potential toxic blooms. Beginning in 2009, routine toxin testing also began as part of a larger project coordinated by the Washington State Department of Health. The project is funded by a grant from the U.S. Centers for Disease Control (CDC) and includes monitoring of thirty lakes in Snohomish, King, and Pierce Counties. The CDC project is being conducted to identify algal blooms that could pose a potential health threat and to alert the public about toxic algae. Water samples are tested for two types of toxins: microcystin (a liver toxin) and anatoxin-a (a neurotoxin).

In 2009, Lake Armstrong did not have noticeable surface accumulations or scums of blue-green algae. However, one water sample taken in September did test positive for microcystin. The concentration was very low, (0.066 ug/l), which is below the recreational Washington State Department of Health standard of 6 ug/l. Anatoxin-a was not detected in any of the samples collected. The project will continue in 2010 and 2011 and will help to determine if 2009 was a typical year for algal blooms and associated toxins at Lake Armstrong.

SHORELINE CONDITION

The Lake Armstrong shoreline was surveyed in 2008. The condition of the lake shoreline is important to understanding the overall lake health. Frequently, lake shorelines are modified through removal of natural vegetation, the installation of bulkheads or other hardening structures, and/or removal of partially submerged logs and branches. These types of alterations can be harmful to the lake ecosystem because natural shorelines protect the lake from harmful pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

Lake Armstrong has one of the least developed shorelines in the county (see map on page 6). Less than one percent of the 1.8 km (1.1 miles) shoreline has been modified. The vegetation immediately adjacent to the shoreline is also

intact, with 96% remaining in native grasses, trees, and shrubs. The amount of old logs and branches remaining in the lake is also high (about 178 pieces), which is valuable for fish and wildlife habitat. In addition, there are only six docks on the entire lake. The development around the lake appears to have changed little over the past few decades. Previous shoreline surveys showed there were only 8 homes along the shoreline in 1973 and 11 by the mid-90s. The natural state of the shoreline plays an important role in protecting the lake and providing quality aquatic habitat for fish and wildlife.

SUMMARY

Trophic State

Lake Armstrong may be classified as meso-eutrophic based on low to moderate water clarity and moderate to high phosphorus and chlorophyll *a* concentrations.

Condition and Trends

The 2003 State of the Lakes Report set targets for Lake Armstrong of improving water clarity and reducing phosphorus levels. The results for Lake Armstrong are mixed. Water clarity no longer appears to be improving. Therefore, the water clarity target is not being met. However, both water clarity and epilimnetic phosphorus levels appear to have stabilized after several years of poor readings in the mid 1990s. On the other hand, phosphorus levels in the bottom waters appear to be increasing, although the increase is not yet statistically significant. A steady increase in phosphorus may lead to problems such as more nuisance algal blooms in the future.

Overall, Lake Armstrong is at risk of future water quality declines because of increasing phosphorus in the bottom waters. The primary threat to the lake is future modifications to the shoreline that may come with increased development. The current natural shoreline provides protection for the lake.

The lake may also be susceptible to activities in the watershed, such as land clearing, as exhibited by the high nutrient values seen in the 1990s that were likely the results of watershed activities. Land clearing and development increase the amount of nutrients entering the lake through stormwater runoff. Sources of nutrients include: fertilizers, pet wastes, and erosion from construction and land clearing. Nutrients may also directly enter the lake through poorly maintained septic systems. Measures to control nutrients in the watershed should be taken now to prevent any 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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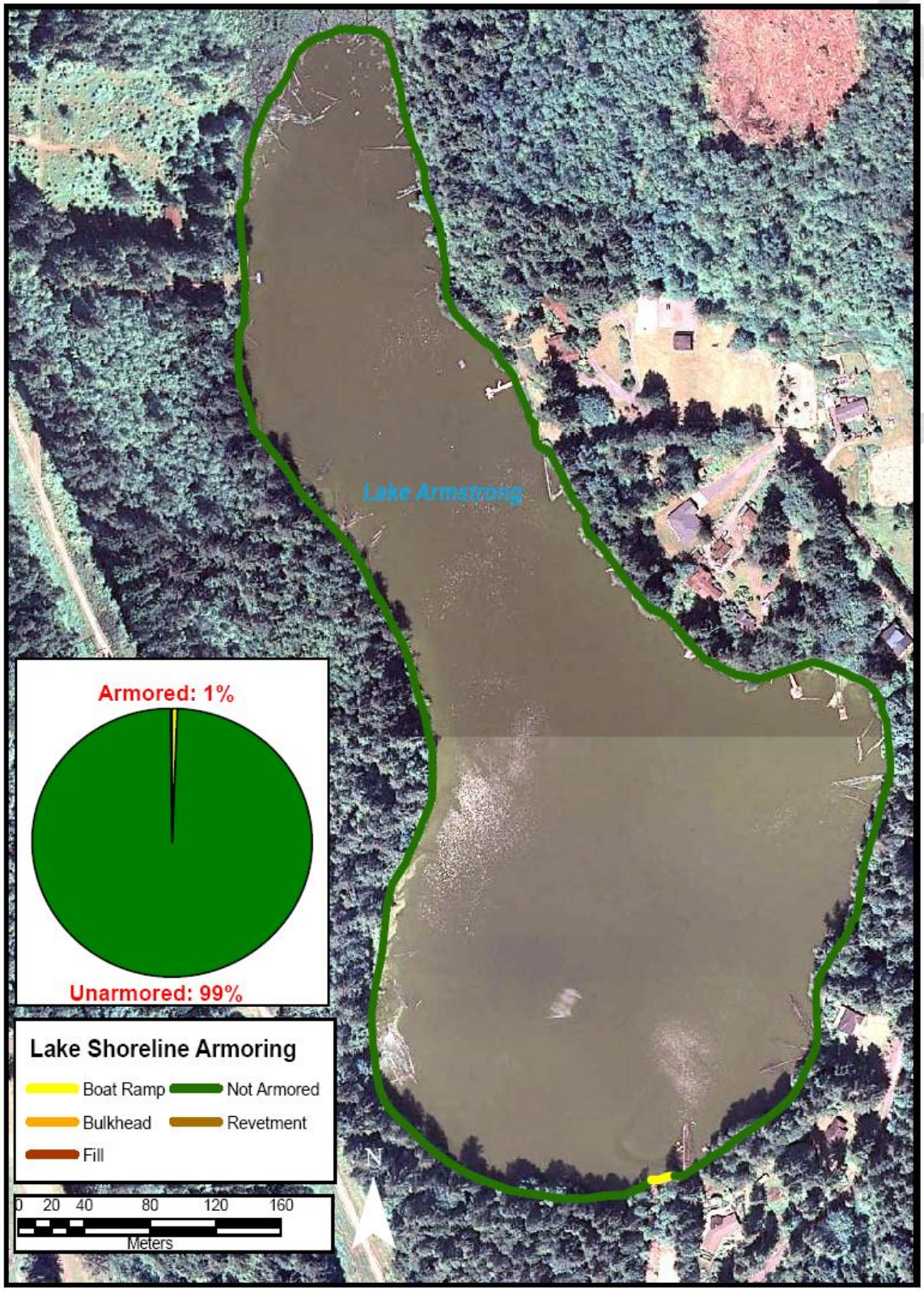

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DATA SUMMARY FOR LAKE ARMSTRONG					
Source	**Date**	**Water Clarity (Secchi depth in meters)**	**Total Phosphorus (*ug*/l)**		**Chlorophyll *a* (*ug*/l)**
			Surface	**Bottom**	**Epilimnion**
Bortleson, et al, 1976	**8/13/73**	2.7	18	400	-
SWM Staff	**1994**	3.0 - 3.4 (3.2) *n = 3*	-	-	1.2 - 4.7 (3.0) *n = 2*
SWM Staff or Volunteer	**1995**	3.0 - 3.9 (3.5) *n = 3*	-	-	6.6
SWM Staff or Volunteer	**1996**	1.6 - 2.1 (1.8) *n = 6*	10 - 27 (19) *n = 2*	29 - 51 (40) *n = 2*	-
SWM Staff or Volunteer	**1997**	1.0 - 2.9 (1.7) *n = 4*	15 - 53 (34) *n = 2*	100 - 136 (118) *n = 2*	-
SWM Staff or Volunteer	**1998**	0.7 - 2.1 (1.5) *n = 6*	15 - 275 (84)[a] *n = 4*	46 - 575 (319) *n = 4*	-
SWM Staff or Volunteer	**1999**	1.8 - 2.2 (2.0) *n = 4*	20 - 29 (24) *n = 4*	142 - 524 (278) *n = 4*	-
SWM Staff or Volunteer	**2000**	1.4 - 2.6 (2.0) *n = 4*	18 - 30 (22) *n = 4*	102 - 294 (192) *n = 4*	-
SWM Staff or Volunteer	**2001**	2.3 - 3.1 (2.7) *n = 4*	15 - 26 (20) *n = 4*	105 - 283 (157) *n = 4*	-
SWM Staff or Volunteer	**2002**	2.3 - 2.7 (2.5) *n = 4*	17 - 25 (20) *n = 4*	74 - 439 (237) *n = 4*	2.1 - 19 (9.2) *n = 4*
SWM Staff	**2003**	1.2 - 3.5 (2.7) *n = 6*	11 - 20 (16) *n = 4*	130 - 438 (248) *n = 4*	3.2 - 12 (6.9) *n = 4*
SWM Staff	**2004**	3.0 - 3.9 (3.3) *n = 4*	14 - 27 (20) *n = 4*	46 - 816 (349) *n = 4*	2.8 - 8.3 (5.6) *n = 4*
SWM Staff	**2005**	2.5 - 3.0 (2.9) *n = 4*	18 - 24 (21) *n = 4*	120 - 776 (376) *n = 4*	3.7 - 22 (12) *n = 4*
SWM Staff	**2006**	1.9 - 3.9 (3.0) *n = 4*	13 - 24 (18) *n = 4*	136 - 505 (347) *n = 4*	2.9 - 15 (9.0) *n = 4*
SWM Staff	**2007**	2.8 - 3.1 (2.8) *n = 4*	16 - 34 (25) *n = 4*	115 - 403 (283) *n = 4*	4.5 - 96 (29)[a] *n = 4*
SWM Staff or Volunteer	**2008**	1.7 - 2.6 (1.9) *n = 8*	15 - 22 (19) *n = 4*	60 - 278 (153) *n = 4*	5.6 - 10 (7.4) *n = 4*

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DATA SUMMARY FOR LAKE ARMSTRONG					
		Water Clarity (Secchi depth	**Total Phosphorus (*ug*/l)**		**Chlorophyll *a* (*ug*/l)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
SWM Staff or Volunteer	**2009**	2.2 - 3.1 (2.6) *n = 5*	17 - 24 (21) *n = 4*	82 - 451 (245) *n = 4*	4.8 - 16 (11) *n = 4*
Long Term Avg		**2.5 (1994-2009)**	**26 (1996-2009)**	**239 (1996-2009)**	**11 (2002-2009)**
TRENDS		**None**	**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.
- "Surface" samples are from 1 meter depth and "bottom" samples are from 1-2 meters above the bottom.

[a] Average is influenced by one high value.