LAKE CRABAPPLE

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 2010. An additional expanded monitoring study report is also available for Lake Crabapple. For background on the information provided here or to find out more about Lake Crabapple visit www.lakes.surfacewater.info or call Snohomish County Surface Water Management (SWM) at 425-388-3464.

LAKE DESCRIPTION

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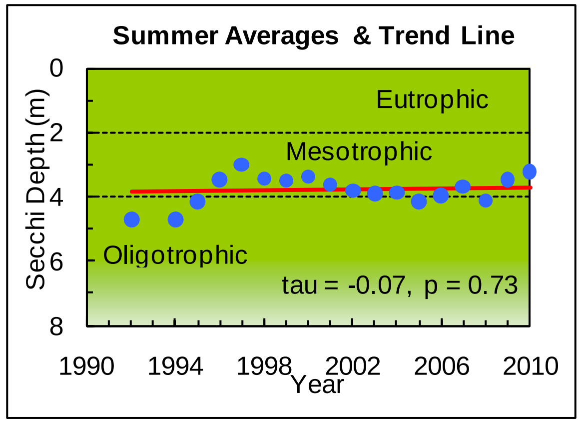
Lake Crabapple is a 37-acre lake located north of the Tulalip Reservation in the Seven Lakes area. It is the second in a four-lake chain that begins at Lake Loma and ultimately drains into Tulalip Bay. Lake Crabapple has a maximum depth of 14.9 meters (49 feet) and a mean depth of 5.5 meters (18 feet). There is only one identifiable inlet stream flowing into Lake Crabapple, which is located on the eastern shore of the lake. The overall lake watershed covers 754 acres, including the watershed of Lake Loma. The watershed contains primarily low to moderate density residential, large rural parcels, and forest. Much of the lake shore is developed with single family homes.

LAKE CONDITIONS

The following small graphs illustrate the summer averages and trend lines (in red) for water clarity, total phosphorus, and chlorophyll *a* for Lake Crabapple. The larger graphs show the most recent measurements of temperature and dissolved oxygen throughout the lake water column. Please refer to the table at the end of the report for long-term averages and averages and ranges for individual years.

Water Clarity

Water clarity in Lake Crabapple is moderate, with a long-term 1992 - 2010 summer average of 3.8 meters. Although there was a period between 1994 and 1997 when summer water clarity was steadily declining, in recent years the clarity has been relatively stable. The summer averages in 2009 and 2010 were the lowest since the late 1990s, however. Overall, there has been no statistically significant change in summertime water clarity in Lake Crabapple.



Temperature

The most recent temperature profile measurements (taken during 2009) showed that the upper waters of the lake were around 4 °C (37°F) during the winter months and began to warm up during March (figure on page 2). By May the lake was strongly thermally stratified, meaning there was warmer water at the surface and cooler water closer to the bottom. When a lake is thermally stratified, there is no mixing of water between the upper and lower waters. The lake remained stratified until the upper waters began to cool in October. Sometime in late fall the temperature differences between the top and bottom will become so small that the entire lake will mix or turn over.

Dissolved Oxygen

Dissolved oxygen patterns in the lake are closely related to temperature levels. When a lake is well mixed, oxygen should be high throughout the lake because it is constantly being replenished at the surface from the atmosphere. However, when a lake is stratified, the bottom waters no longer mix with the surface waters. Subsequently, oxygen cannot be replenished in the lower part of the lake. The oxygen is quickly depleted by bacteria and other organisms that decompose organic material (dying algae, aquatic plants, and other organic matter).

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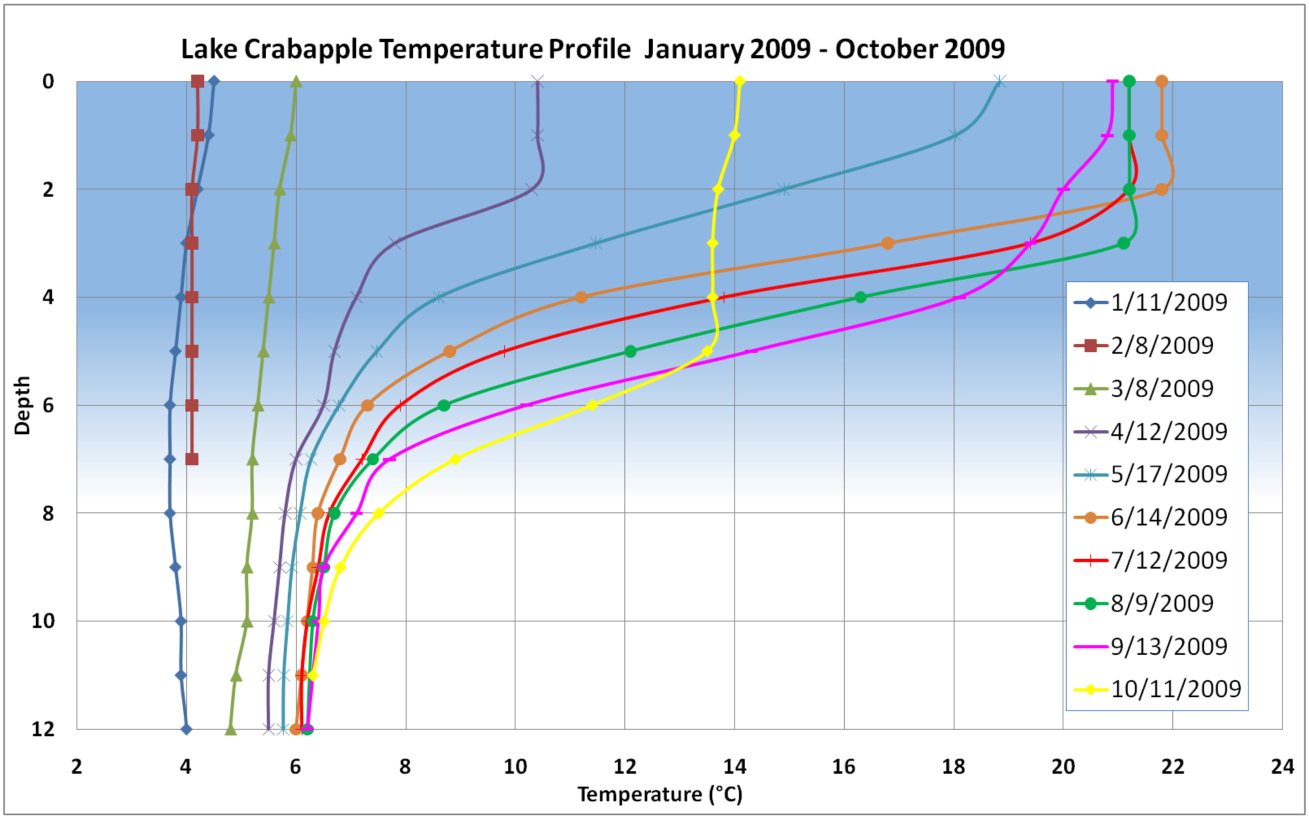

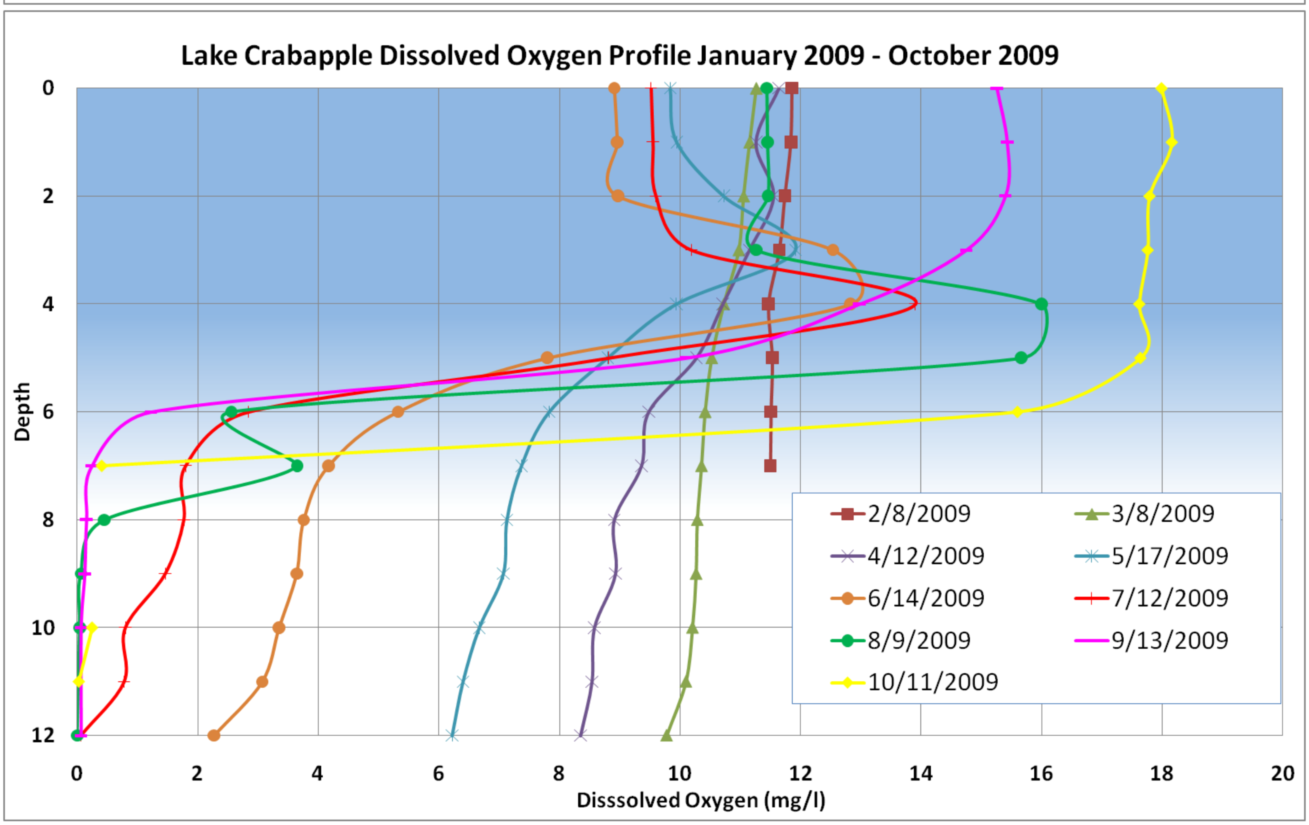

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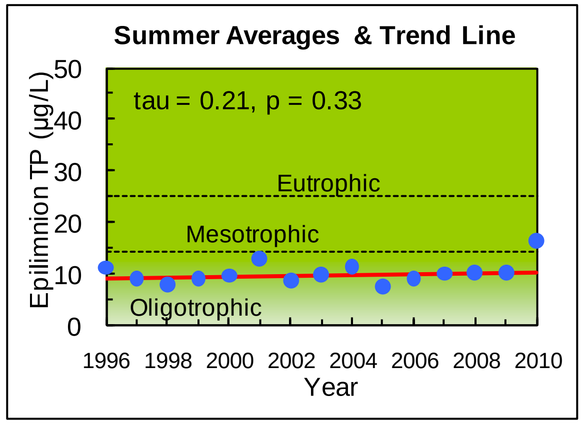
As expected, the dissolved oxygen profiles measured at Lake Crabapple during 2009 were affected by the lake stratification (see figure on page 2). Oxygen levels were high throughout the lake in January through April when the lake was mixed. As temperatures in the lake became stratified in May, dissolved oxygen levels began to drop in the lower waters. The zone of low or no oxygen expanded throughout the summer, and by July there was very little oxygen in the water at 6 meters (20 feet) and below. Even near the surface, dissolved oxygen levels declined somewhat through the summer. Low oxygen in the bottom waters will persist until the lake mixes in late fall, at which time the oxygen will be replenished throughout the lake.

When oxygen levels fall to near zero in the lake bottom, a chemical reaction occurs that releases phosphorus from the lake sediments. This phosphorus can become available to fuel excess algal growth in the lake. However, the strong thermal stratification in Lake Crabapple helps prevent the phosphorus that is released from the bottom sediments from moving to the upper waters to feed algae, at least until the lake mixes in the fall. A detailed modeling study of Lake Crabapple indicates that this internal loading of phosphorus accounts for over 40% of phosphorus entering the lake each year.

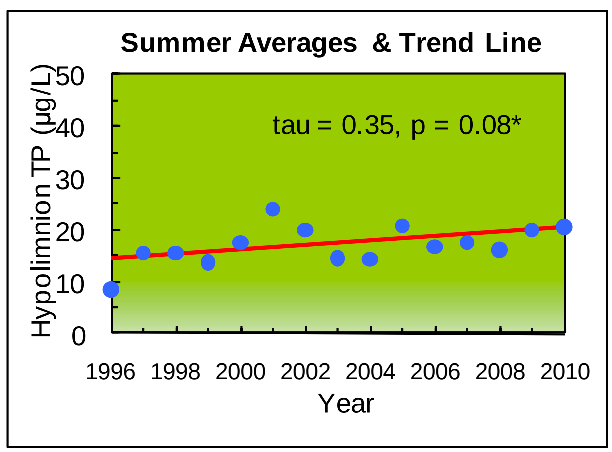
One interesting finding revealed in the dissolved oxygen profiles is the presence of a spike in oxygen levels between 3 and 5 meters (10 to 16 feet) deep during much of the summer. This is likely due to vigorous algal growth at the interface between the upper and lower waters. Algae often thrive in this zone because there is enough light in the upper waters and higher nutrients available in the lower waters. The higher chlorophyll *a* values measured during this time period supports this explanation.

Total Phosphorus (key nutrient for algae)

Total phosphorus concentrations in Lake Crabapple are low to moderate. The 1996 – 2010 long-term summer average for the epilimnion (upper waters) is 10 µg/l. There has been little variation year-to-year. However, the 2010 summer average of 16 µg/l is the highest on record. Overall, there has been no significant trend in phosphorus concentrations in the upper waters between 1996 and 2010.



The long-term summer phosphorus average in the hypolimnion (bottom waters) is 17 µg/l. Phosphorus levels in the hypolimnion have been increasing since 1996. Between 1996 and 2010, there has been a statistically significant trend toward higher phosphorus levels in the bottom waters. More phosphorus in the bottom waters may eventually lead to more algae in the lake.



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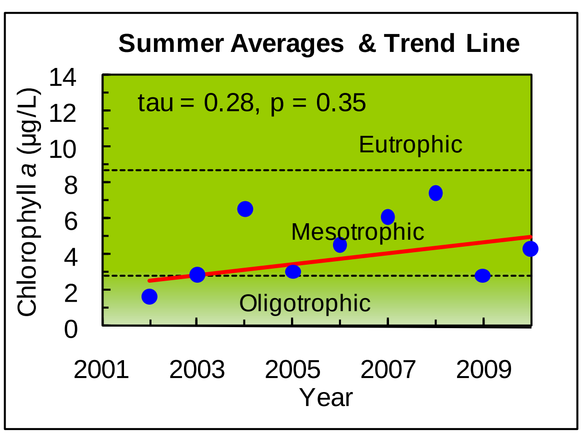
Chlorophyll a (Algae)

Chlorophyll *a* is a measure of the amount of algae in the lake water. Chlorophyll *a* values in Lake Crabapple show moderate algae levels. The 2002 – 2010 long term summer average is 4.4 µg/l. Through 2008 there appeared to be a statistically significant increase in chlorophyll *a* over time. However, the 2009 and 2010 averages were lower, so there is no longer strong evidence of an upward trend. The high degree of variability in chlorophyll *a* readings between months and from year to year makes discerning trends difficult.

Lake Crabapple occasionally has periods of high algal growth called blooms. In the spring of 2005, a severe algal bloom turned the lake brown and drastically reduced water clarity. The bloom was *Uroglenopsis*, a type of golden-brown algae that was reported to be blooming at several other lakes in the region. This type of bloom is particularly notable because the algae release a chemical that smells like dead fish as the bloom dissipates. A similar brown algal bloom occurred in the spring and early summer of 2008.

Lake Crabapple frequently experiences spikes in algal growth each spring and sometimes in early summer, mostly from diatoms and green algae. The consistent blooms in early spring, coupled with occasionally higher summer chlorophyll *a* readings, could indicate that excess algae may become a future concern in Lake Crabapple. Algal growth may occur in response to the nutrient-rich bottom waters being mixed with the upper waters after the lake turns over.



SHORELINE CONDITION

The Lake Crabapple shoreline was surveyed in 2009 (see map on page 8). The condition of the lake shoreline is important to understanding overall lake health. Frequently, lake shorelines are modified through removal of natural vegetation, the installation of bulkheads or other hardening structures, and/or removal of partially submerged logs and branches. These types of alterations can be harmful to the lake ecosystem because natural shorelines protect the lake from pollution, prevent bank erosion, and provide important habitat for fish and wildlife.

Lake Crabapple has a lower level of shoreline development than many other lakes in the county. Surveys conducted in the mid-90s identified 41 homes bordering the lake. Although homes were not counted in 2009, 49 docks were present, covering about 1% of the lake. About 20% of the 1.2 mile shoreline has been armored, mainly in the form of bulkheads (63%) and wood or rock revetments (27%). The zone of vegetation immediately adjacent to the shoreline has been altered even more—only 50% of the native vegetation along the shoreline remains intact. However, there is still a substantial amount of large wood (about 156 pieces) remaining in the lake. These old logs and branches are valuable for fish and wildlife habitat.

The shoreline modifications that have taken place around Lake Crabapple make the lake more susceptible to pollution from the watershed, eliminate the buffer of native vegetation that can filter out pollution, and limit the amount of aquatic habitat available to fish and wildlife. The loss of native vegetation along the shoreline can also lead to shoreline erosion.

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SUMMARY

Trophic State

Lake Crabapple may be classified as mesotrophic, with moderate water clarity, relatively low phosphorus concentrations, and low to moderate productivity of plants and algae.

Condition and Trends

Overall, Lake Crabapple is in relatively satisfactory condition. The lake is meeting the water quality targets set forth in the 2003 State of the Lakes Report, which call for maintaining stable water clarity and total phosphorus levels in the upper waters. There have been no statistical trends in water clarity or in total phosphorus in the upper waters. However, the lake is not meeting the target of maintaining stable phosphorus in the hypolimnion, or bottom waters. In fact, there has been a long-term trend toward increasing phosphorus levels in the bottom waters since 1996. For this reason, the lake may be at risk of future water quality problems if higher phosphorus in the bottom waters leads to more algal growth.

In order to protect the water quality of Lake Crabapple, measures to control nutrients in the watershed should be taken. Nutrients enter the lake through stormwater runoff directly to the lake or from inflowing streams. Sources of nutrients include fertilizers, pet wastes, runoff from roofs and driveways, and erosion from construction and land clearing. Nutrients may also directly enter the lake through poorly maintained septic systems. To find out more about the causes and problems of elevated lake nutrient levels and tips to improve lake water quality please visit www.lakes.surfacewater.info.

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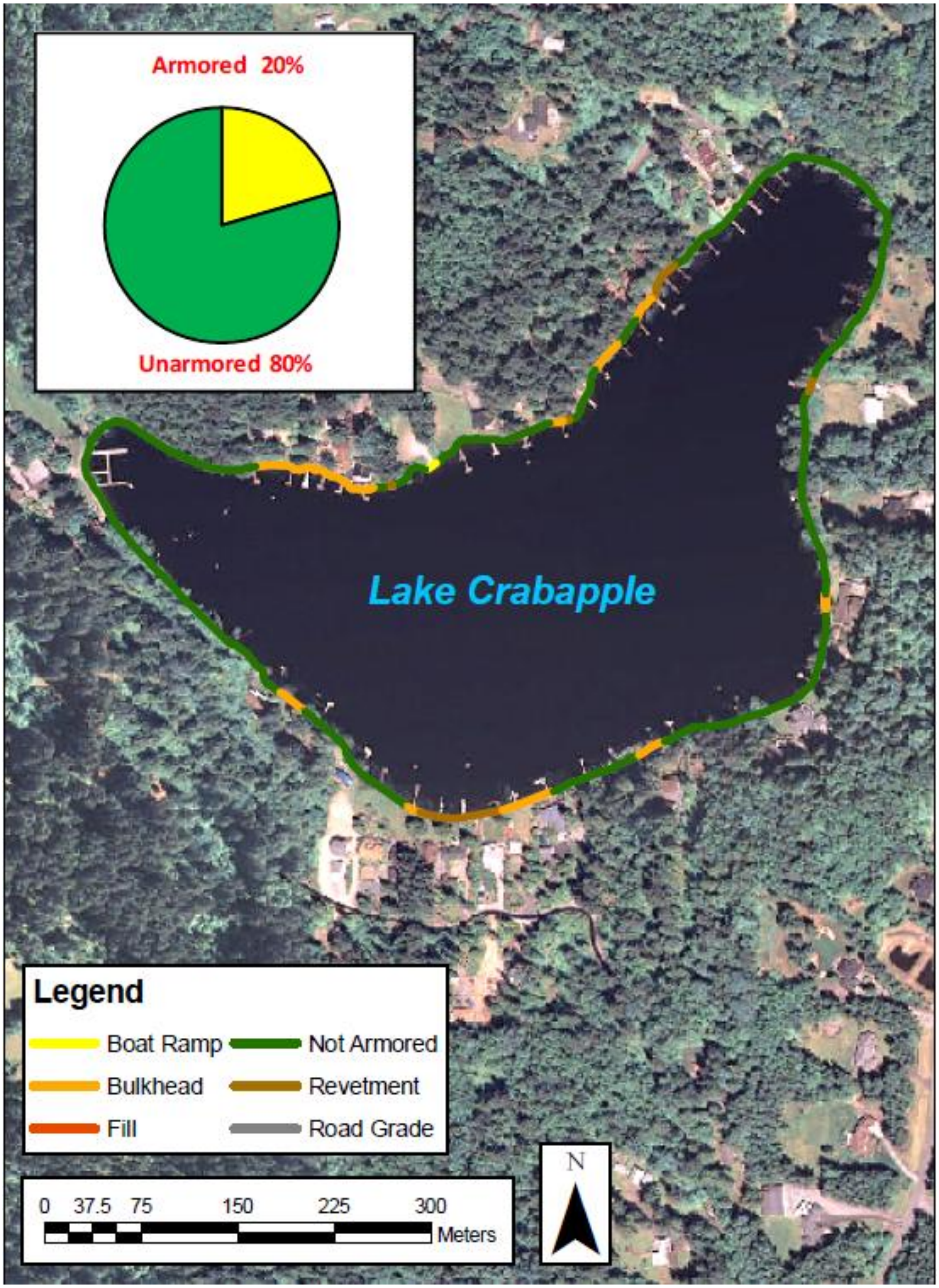
2009 SHORELINE SURVEY RESULTS



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DATA SUMMARY FOR LAKE CRABAPPLE					
		Water Clarity (Secchi depth	**Total Phosphorus (*ug/l*)**		**Chlorophyll *a* (*ug/l*)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
McConnell, et al, 1976	Summer **1973**	2.3 - 5.5 (3.6) *n = 3*	10 - 18 (14) *n = 3*	14 - 15 (15) *n = 3*	1.4 - 2.0 (1.7) *n = 3*
Entranco, 1986	**1983**	2.9 - 4.4 (3.7) *n = 4*	<5 - 7 (6) *n = 5*	8 - 33 (15) *n = 5*	1.8 - 4.6 (3.1) *n = 5*
Volunteer	**1992**	4.6 - 4.9 (4.7) *n = 2*	-	-	-
SWM Staff or Volunteer	**1994**	3.8 - 6.0 (4.7) *n = 12*	-	-	1.8 - 3.8 (2.8) *n = 2*
SWM Staff or Volunteer	**1995**	3.3 - 5.0 (4.2) *n = 9*	-	-	8.1
Volunteer	**1996**	2.7 - 4.1 (3.5) *n = 10*	9 - 13 (11) *n = 2*	8 - 9 (9) *n = 2*	-
SWM Staff or Volunteer	**1997**	2.5 - 3.5 (3.0) *n = 9*	6 - 12 (9) *n = 2*	14 - 17 (16) *n = 2*	-
Volunteer	**1998**	3.0 - 4.5 (3.4) *n = 10*	6 - 10 (8) *n = 4*	15 - 16 (16) *n = 4*	-
Volunteer	**1999**	2.7 - 4.0 (3.5) *n = 10*	8 - 11 (9) *n = 4*	12 - 16 (14) *n = 4*	-
SWM Staff or Volunteer	**2000**	2.8 - 4.1 (3.4) *n = 10*	7 - 12 (10) *n = 4*	16 - 19 (18) *n = 4*	-
SWM Staff or Volunteer	**2001**	2.6 - 4.8 (3.6) *n = 10*	12 - 14 (13) *n = 4*	18 - 29 (24) *n = 4*	
SWM Staff or Volunteer	**2002**	2.6 - 5.0 (3.8) *n = 10*	7 - 11 (9) *n = 4*	15 - 29 (20) *n = 4*	1.1 - 2.7 (1.7) *n = 4*
SWM Staff or Volunteer	**2003**	2.6 - 5.5 (3.9) *n = 13*	7 - 12 (10) *n = 4*	14 - 15 (15) *n = 4*	1.6 - 6.4 (2.9) *n = 4*
SWM Staff or Volunteer	**2004**	1.8 - 5.4 (3.9) *n = 12*	6 - 19 (11) *n = 4*	13 - 16 (14) *n = 4*	1.1 - 21 (6.5) *n = 4*
SWM Staff or Volunteer	**2005**	2.4 - 4.9 (4.1) *n = 12*	5 - 10 (7) *n = 5*	14 - 33 (21) *n = 5*	2.1 - 4.8 (3.0) *n = 5*
SWM Staff or Volunteer	**2006**	2.8 - 5.0 (4.0) *n = 12*	6 - 11 (9) *n = 12*	11 - 24 (17) *n = 12*	1.1 - 7.2 (4.5) *n = 6*

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DATA SUMMARY FOR LAKE CRABAPPLE					
		Water Clarity (Secchi depth	**Total Phosphorus (*ug*/l)**		**Chlorophyll *a* (*ug*/l)**
Source	**Date**	**in meters)**	**Surface**	**Bottom**	**Epilimnion**
SWM Staff or Volunteer	**2007**	2.7 - 4.9 (3.7) *n = 12*	5 - 19 (10) *n = 11*	14 - 22 (18) *n = 11*	3.2 - 13 (6.1) *n = 5*
Volunteer	**2008**	2.9 - 5.3 (4.1) *n =12*	6 - 13 (10) *n = 6*	13 - 19 (16) *n = 6*	1.9 - 20 (7.5) *n = 5*
SWM Staff or Volunteer	**2009**	3.1 - 4.4 (3.5) *n = 10*	8 - 15 (10) *n = 5*	12 - 24 (20) *n = 5*	2.1 - 4.3 (2.8) *n = 5*
SWM Staff or Volunteer	**2010**	2.4 - 3.9 (3.2) *n = 11*	7 - 35 (16) *n = 4*	19 - 24 (21) *n = 3*	2.4 - 5.9 (4.3) *n = 4*
Long Term Avg		**3.8** **(1992-2010)**	**10** **(1996-2010)**	**17** **(1996-2010)**	**4.4** **(2002-2010)**
TRENDS		**None**	**None**	**Increasing**	**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.