Elm Creek Watershed Management Commission
Lake Water Quality Summaries
2011

Introduction

Elm Creek Watershed Commission contracted Three Rivers Park District to monitor the trophic conditions for several lakes in 2011. Three Rivers Park District monitored the water quality in Fish Lake, Weaver Lake, Diamond Lake, French Lake, and Mill Pond. These lakes were sampled biweekly from late April through late October. The seasonal and annual changes in water quality parameters were monitored for total phosphorus, soluble reactive phosphorus, total nitrogen, chlorophyll-a, and Secchi depth transparency. To assess changes in water quality trophic conditions, annual growing season averages were calculated for total phosphorus, chlorophyll-a, and Secchi depth transparency using data collected from May through September. The annual average for each trophic assessment parameter was compared to the MPCA state nutrient standards used for determination of recreational use impairment (Table 1). The MPCA's assessment for waterbody impairments are based on a conservative average that is estimated from data collected from June through September. This report is an assessment of overall trophic condition during the time period of primary recreational use (growing season from May through September) and is compared to MPCA state standards as a reference point. Trophic state indices (TSI) were also calculated using growing season means for total phosphorus, chlorophyll-a, and Secchi depth. The trophic state index (TSI values ranging from 0-100) describes the productivity of a lake from oligrotrophic to hypereutrophic conditions. An average TSI value is calculated from the estimated TSI values derived for total phosphorus, chlorophyll-a, and Secchi depth.

Table 1: Minnesota Pollution Control Agency lake eutrophication standards for aquatic recreational use assessments.

North Central Hardwood Forest Ecoregion			
Classification	TP µg/L	Chl-a µg/L	Secchi m
Aquatic Recreation Use (Class 2b) Deep Lakes	< 40	< 14	> 1.4
Aquatic Recreation Use (Class 2b) Shallow Lakes	< 60	< 20	> 1.0

Note: ***Deep Lakes*** *are enclosed basins filled or partially filled with fresh water that have a maximum depth > 15 feet.*
Shallow Lakes *are enclosed basins filled or partially filled with fresh water that have a maximum depth < 15 feet or a littoral zone (area shallow enough to support emergent and submerged vegetation) that is ≥ 80% of the lake surface area.*

Fish Lake

Fish Lake has consistently had an average phosphorus concentration above the MPCA "deep lake" impaired water eutrophication standard of 40 µg/L. The average phosphorus concentration for Fish Lake in 2011 was 50.2 µg/L (Figure 1). The highest in-lake phosphorus concentrations coincided with the spring and fall turnover cycles. The process of lake turnover re-suspended nutrients throughout the water column and contributed to high total phosphorus concentrations at the end of April (113.2 µg/L) and at the end of October (115.7 µg/L) (Figure 2). The total phosphorus concentrations have fluctuated between 30.1 and 78.0 µg/L throughout the growing season (May-September) (Figure 2). Overall, there have been variations in total phosphorus concentration since 2001. Currently, the average phosphorus concentration has gradually decreased since 2009.

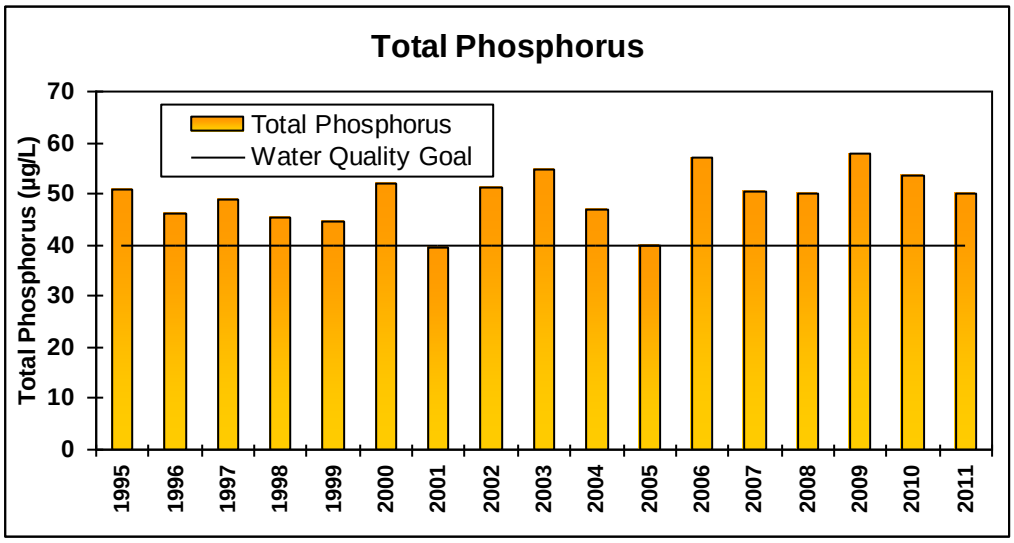

Figure 1. Fish Lake average annual total phosphorus concentrations.

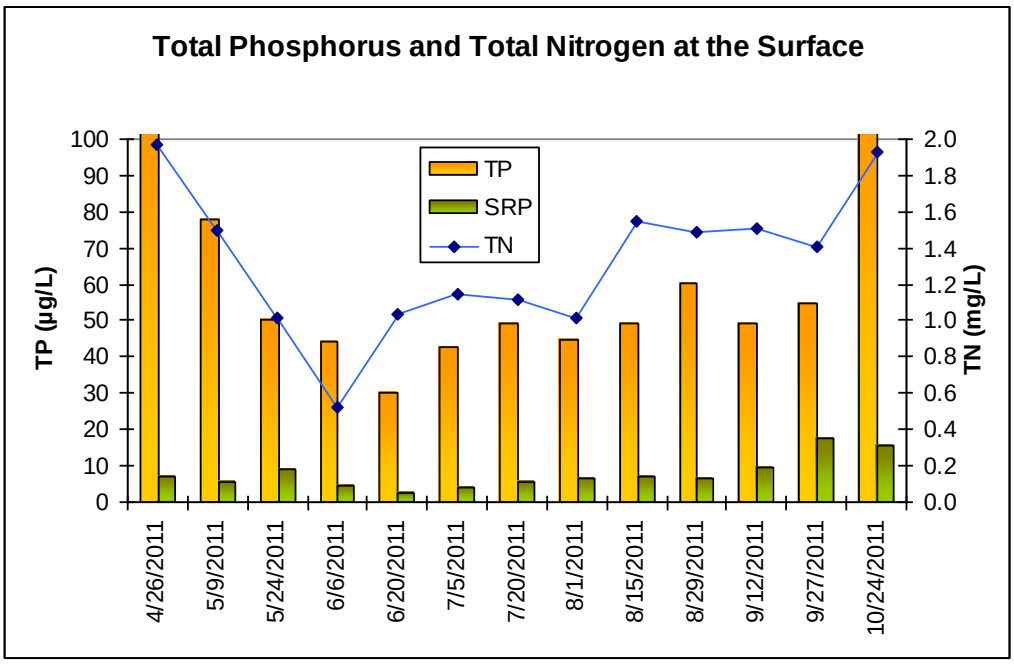

Figure 2. Fish Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2011.

The excessive amount of phosphorus has been conducive for the development of severe algal blooms during the summer. The severity of these algal blooms has often been in response to the changes in phosphorus concentration. Although phosphorus concentrations may influence algal biomass, the impact phosphorus had on the severity of the algal blooms after 2007 does not appear to be as significant. Since 2007, the average chlorophyll-a concentrations have significantly decreased and have been slightly above the MPCA "deep lake" standard of 14 µg/L. In 2011, the average chlorophyll-a concentration was 18.5 µg/L with values ranging from 2.9 to 44.5 µg/L (Figure 3). The decrease in chlorophyll-a concentration has contributed to improved water clarity conditions with secchi depth transparency meeting the MPCA "deep lake" standards. The average Secchi depth transparency in 2011 was 1.88 m (Figure 4) with values ranging from 0.6 m to 4.7 m (Figure 5). The improvements in chlorophyll-a concentrations and Secchi depth transparency has contributed to a trophic state index (58.7) that is at the lower range defining eutrophic conditions. The factors contributing to the improvements in chlorophyll-a concentration and water clarity are currently unknown.

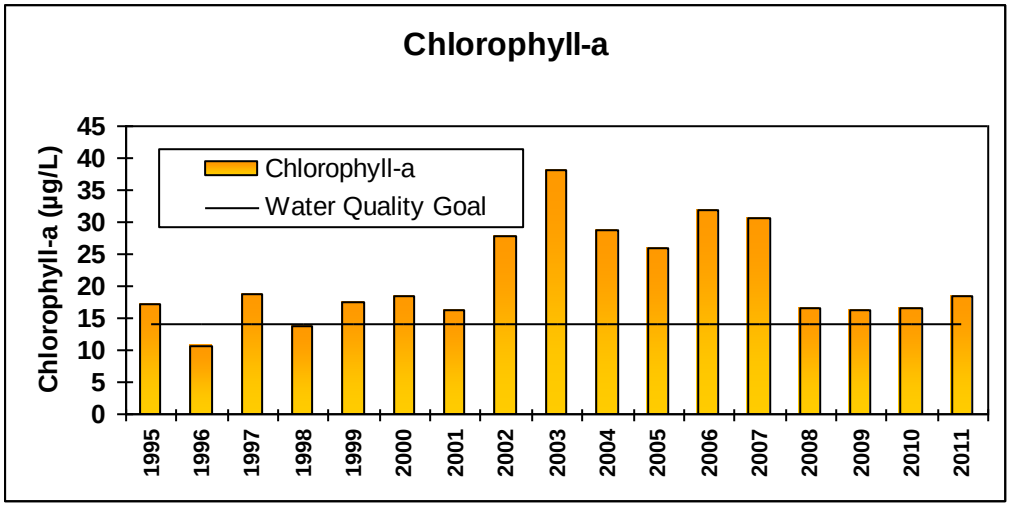

Figure 3. Fish Lake average annual chlorophyll-a concentrations.

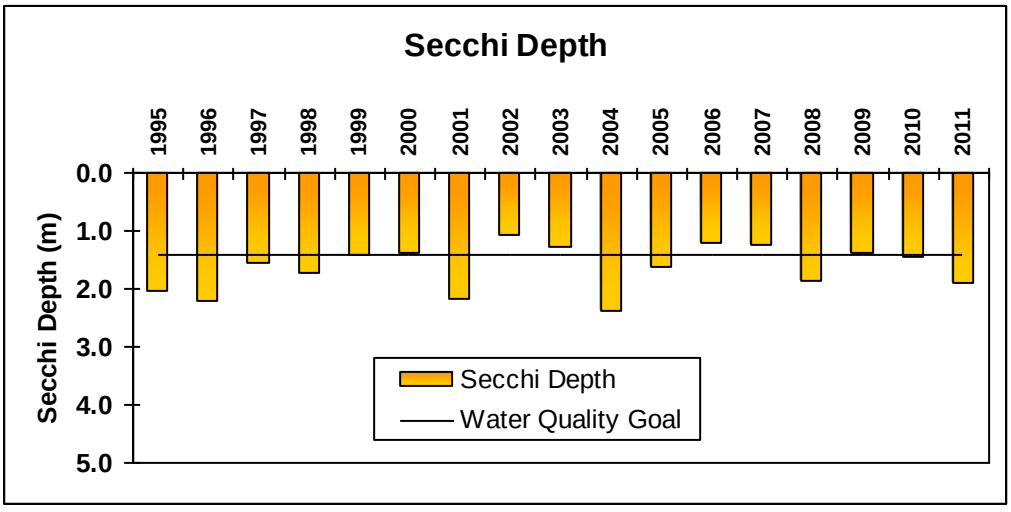

Figure 4. Fish Lake average annual Secchi depth concentrations.

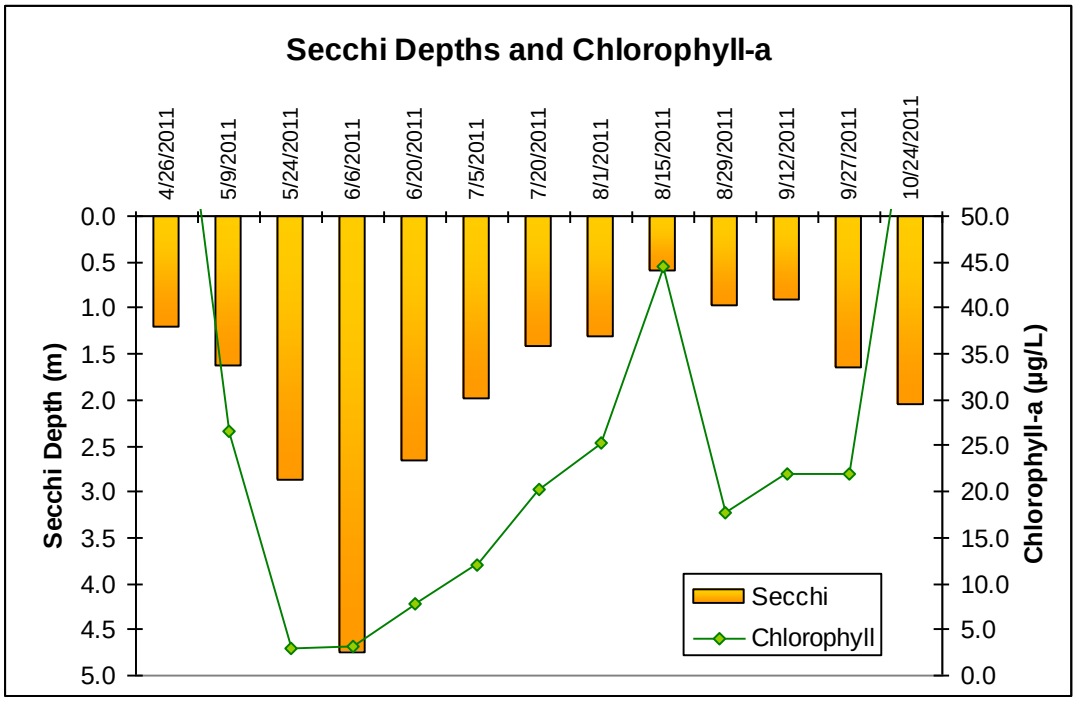

Figure 5. Fish Lake seasonal changes in Secchi depth and chlorophyll-a concentrations in 2011.

Weaver Lake

The Weaver Lake water quality conditions have significantly improved. Prior to 2005, the lake frequently had phosphorus concentrations that were above the MPCA "deep lake" impaired water criteria of 40 µg/L. Since 2005, Weaver Lake has achieved the MPCA "deep lake" standards for total phosphorus. The average phosphorus concentrations from 2005 through 2011 have consistently averaged between 20 to 35 µg/L (Figure 1). The average annual phosphorus concentration in 2011 was 30.4 µg/L (Figure 1) with values ranging from 24.3 to 34.2 µg/L during the 2011 growing season (Figure 2). These concentrations are considerably lower in comparison to other lakes within the ecoregion.

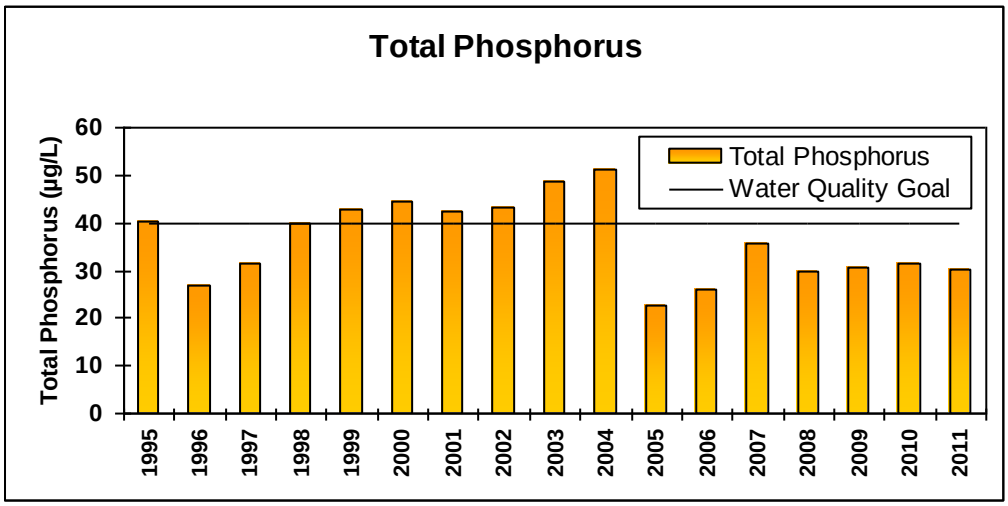

Figure 1. Weaver Lake average annual total phosphorus concentrations.

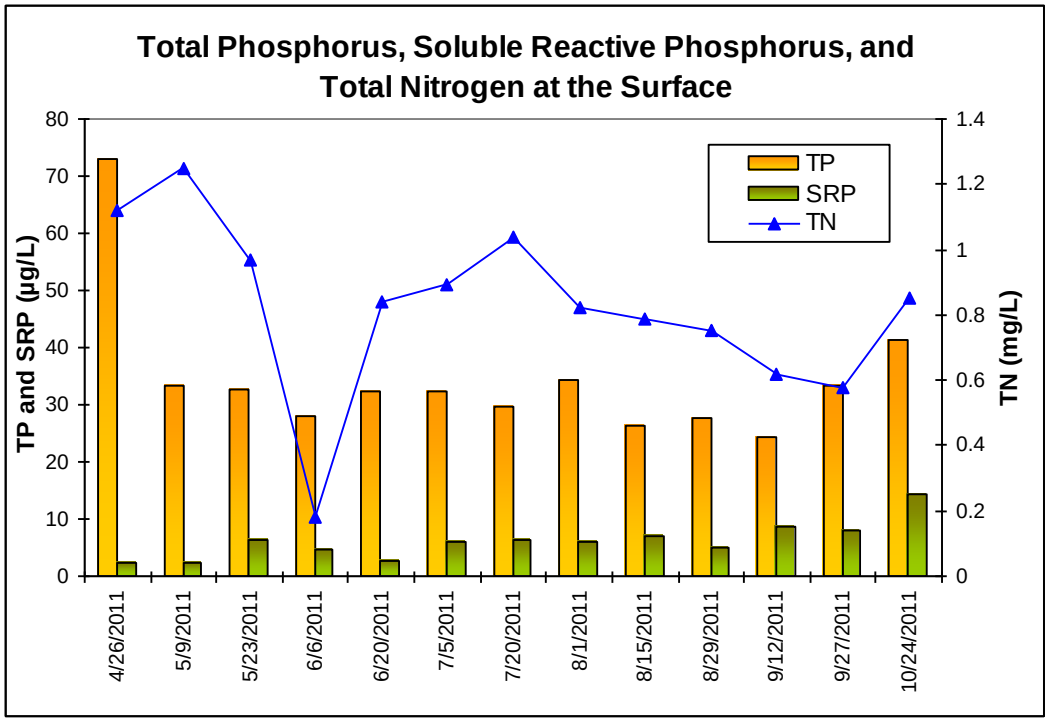

Figure 2. Weaver Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2011.

Weaver Lake has achieved MPCA "deep lake" water quality standards for chlorophyll-a concentration and Secchi depth transparency since 2005. The low phosphorus concentrations have significantly improved water clarity conditions by reducing the frequency of algal blooms. In 2011, the low chlorophyll-a concentrations have corresponded with improvements in water clarity (Secchi depths) (Figures 3 & 4). The average chlorophyll-a concentration was 7.49 µg/L in 2011(Figure 3). Weaver Lake had an average Secchi depth transparency of 2.41 m (Figure 4) with values ranging from 1.49 to 4.29 meters during the growing season (Figure 5). The low chlorophyll-a concentrations and excellent water clarity conditions suggests that Weaver Lake does not appear to have severe algal blooms that inhibit recreational use. The trophic state index of 52.2 indicates that Weaver Lake water quality conditions are at the lower range of defining eutrophic conditions.

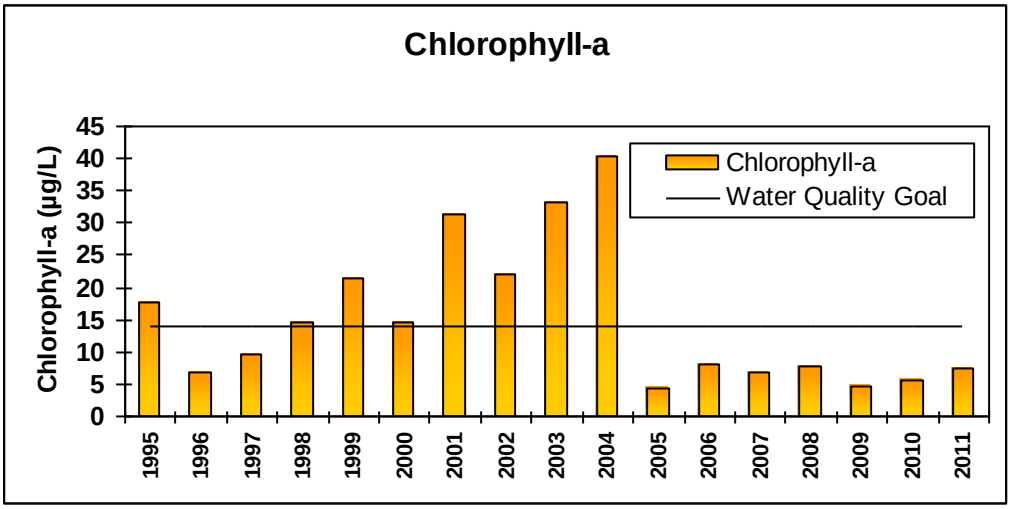

Figure 3. Weaver Lake annual changes in average chlorophyll-a concentrations.

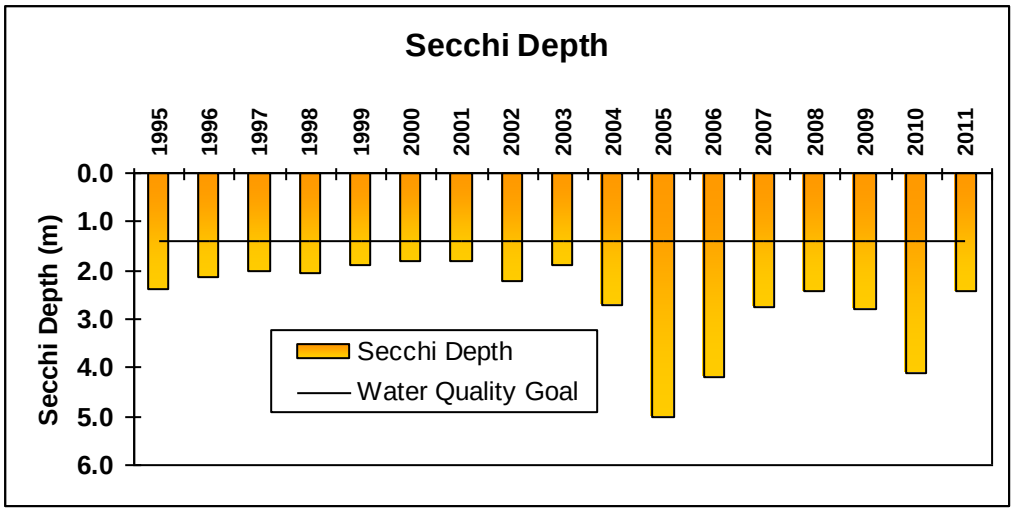

Figure 4. Weaver Lake changes in average annual Secchi depth from 1995 through 2011.

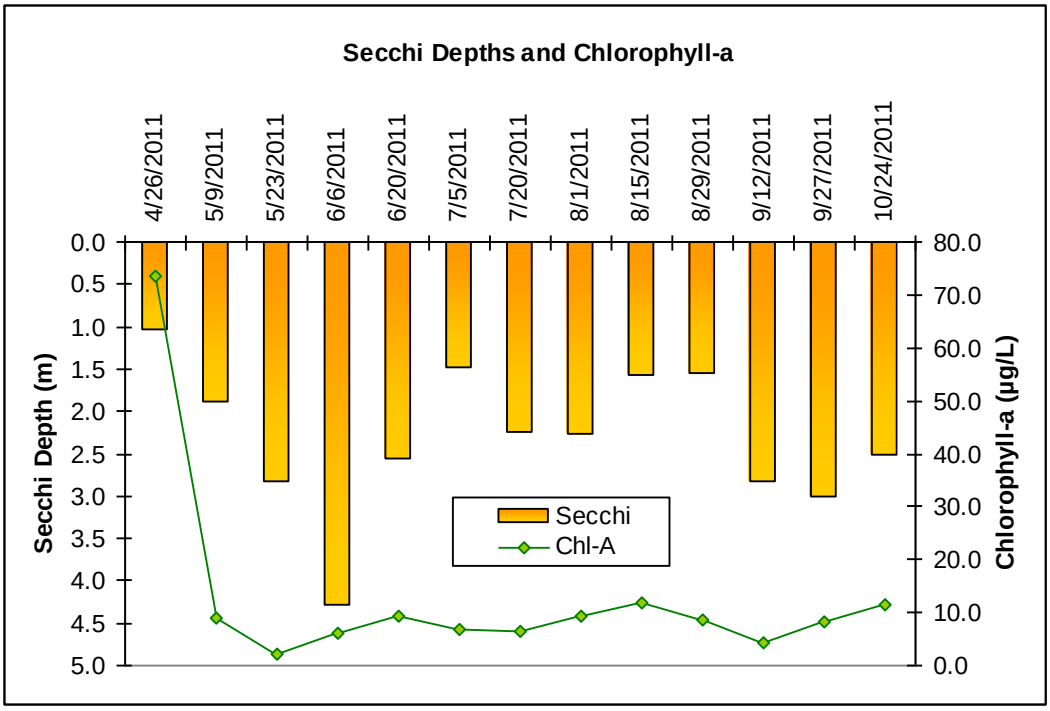

Figure 5. Weaver Lake average annual chlorophyll-a concentrations and Secchi depth transparency.

The improvements in water quality conditions for Weaver Lake correspond with a lake-wide effort to control curlyleaf pondweed. Historically, Weaver Lake has had nuisance growth conditions of curlyleaf pondweed that inhibited recreational use and degraded water quality. Weaver Lake typically developed algal blooms after the senescence of curlyleaf pondweed. In an attempt to control curly leaf pondweed, herbicide applications occurred throughout the littoral area of the lake with fluridone from 2005 through 2007 and with endothall from 2008 and 2009. The herbicide treatments were successful in controlling curlyleaf pondweed in Weaver Lake. There were also noticeable improvements in water quality that corresponded with the first year of treatment in 2005. Management efforts to control curlyleaf pondweed reduced the amount of internal loading associated with senescence.

Diamond Lake

Diamond Lake continues to have impaired water quality conditions for excessive nutrients. Diamond Lake is a "shallow lake" that has a total phosphorus standard of 60 µg/L. The lake has been considered hyper-eutrophic with extremely high phosphorus concentrations ranging from 150 µg/L to 250 µg/L (Figure 1). Despite the excessive phosphorus concentrations, the average total phosphorus concentrations have significantly declined since 2008. The average phosphorus concentration in 2011 was 96.0 µg/L with values ranging between 36.8 µg/L and 191.4 µg/L (Figure 2). These current phosphorus concentrations are similar to other shallow lakes within the ecoretion.

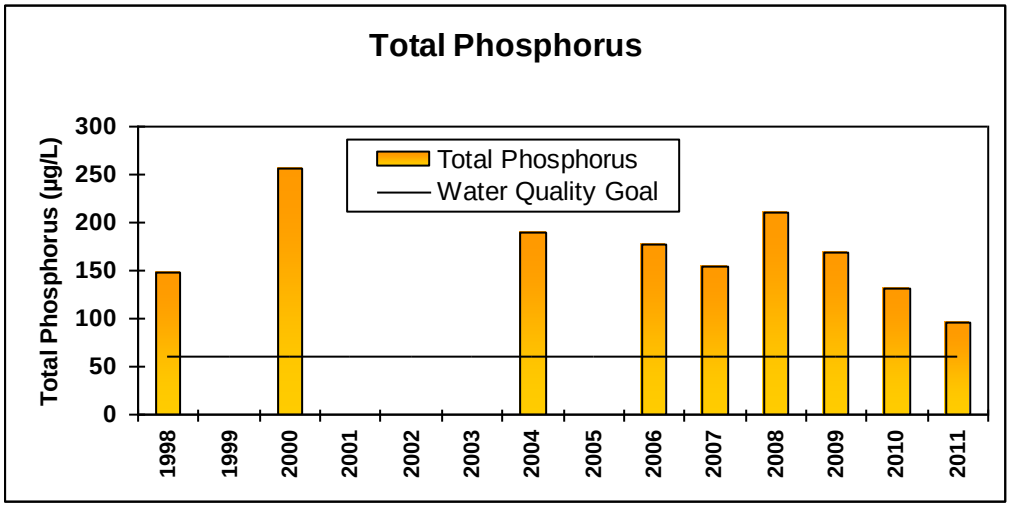

Figure 1. Diamond Lake average annual total phosphorus concentrations from 1998 through 2011.

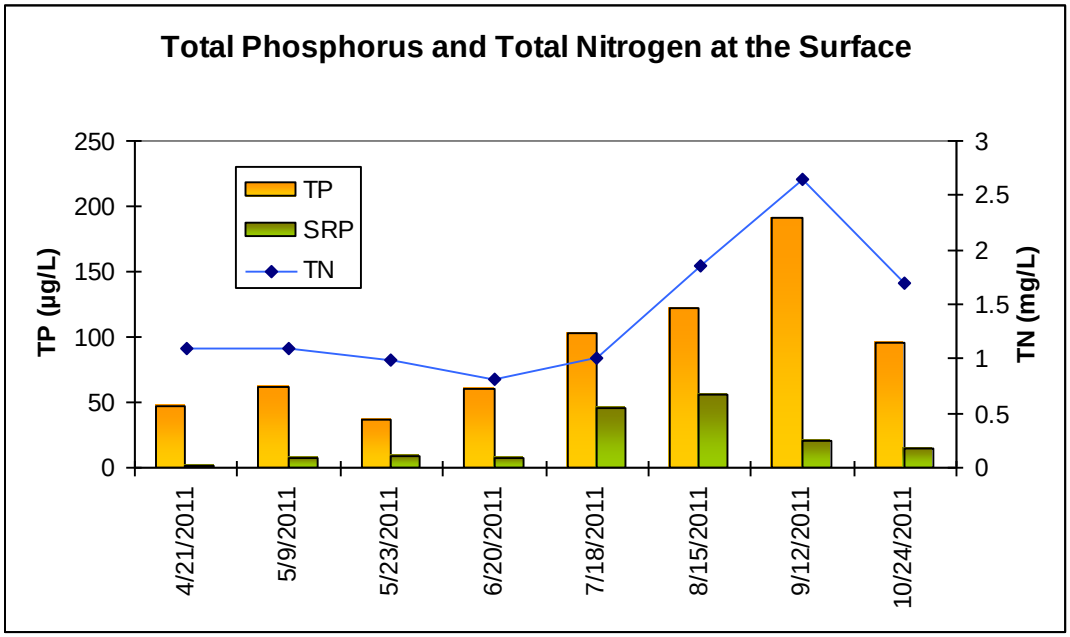

Figure 2. Diamond Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen at the surface in 2011.

The excessive phosphorus concentrations have been conducive for the development of severe algal blooms. Diamond Lake typically has had annual average chlorophyll-a concentrations ranging from 50 to 90 µg/L (Figure 3). Despite the historically high chlorophyll-a concentration, the data suggests that the severity of algal blooms have significantly decreased since 2008. In 2011, the average chlorophyll-a concentration was 16.8 µg/L (Figure 3), which currently meets the MPCA "shallow lake" standard of 20 µg/L. There have been water clarity improvements in response to the decreasing chlorophyll-a concentration. Since 2009, Diamond Lake has met the MPCA "shallow lake" Secchi depth standards (Figure 4). Currently, the average secchi depth for Diamond Lake was 1.7 m in 2011 (Figure 4). There was a slight algal bloom during late summer and early fall that resulted in an increase in chlorophyll-a concentration and a decrease in water clarity (Figure 5).

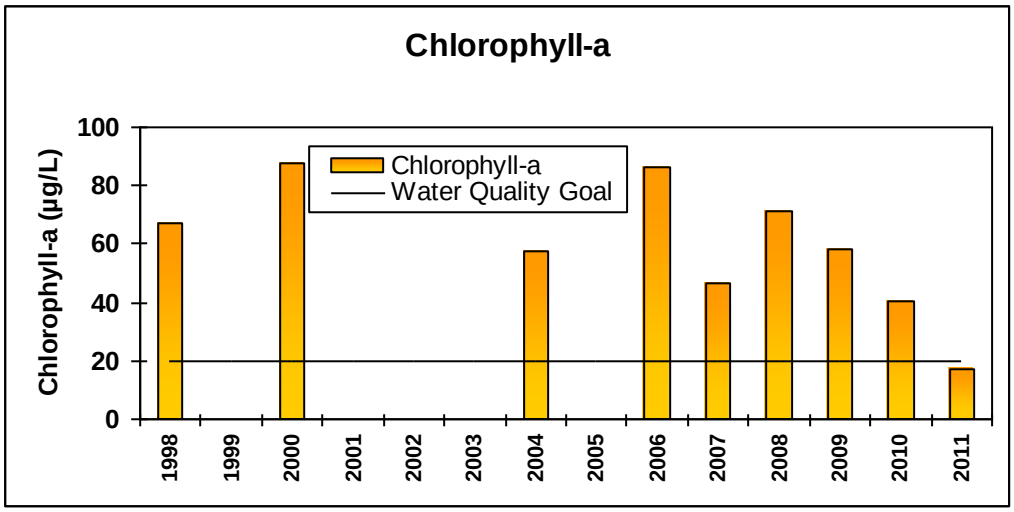

Figure 3. Diamond Lake annual changes in chlorophyll-a concentration from 1998-2011.

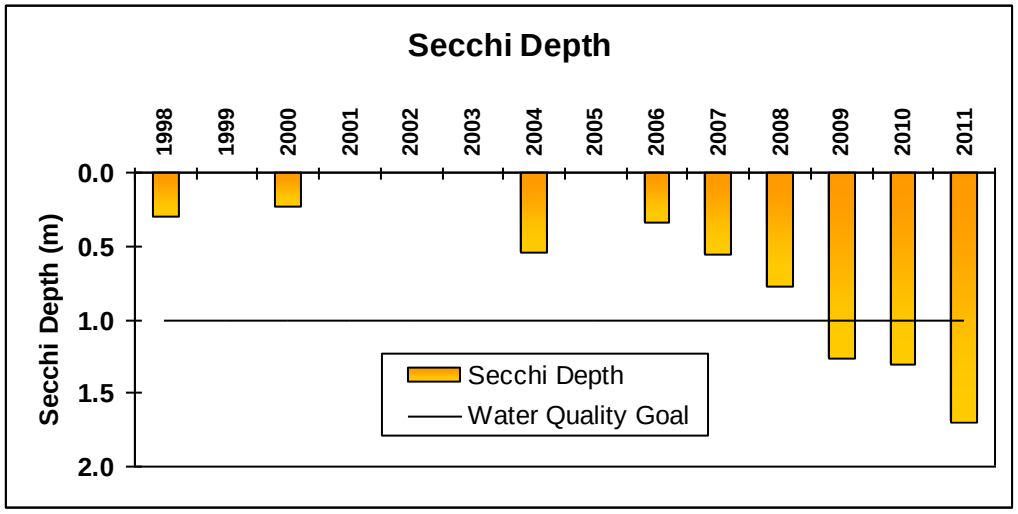

Figure 4. Diamond Lake annual changes in Secchi depth from 1998-2011.

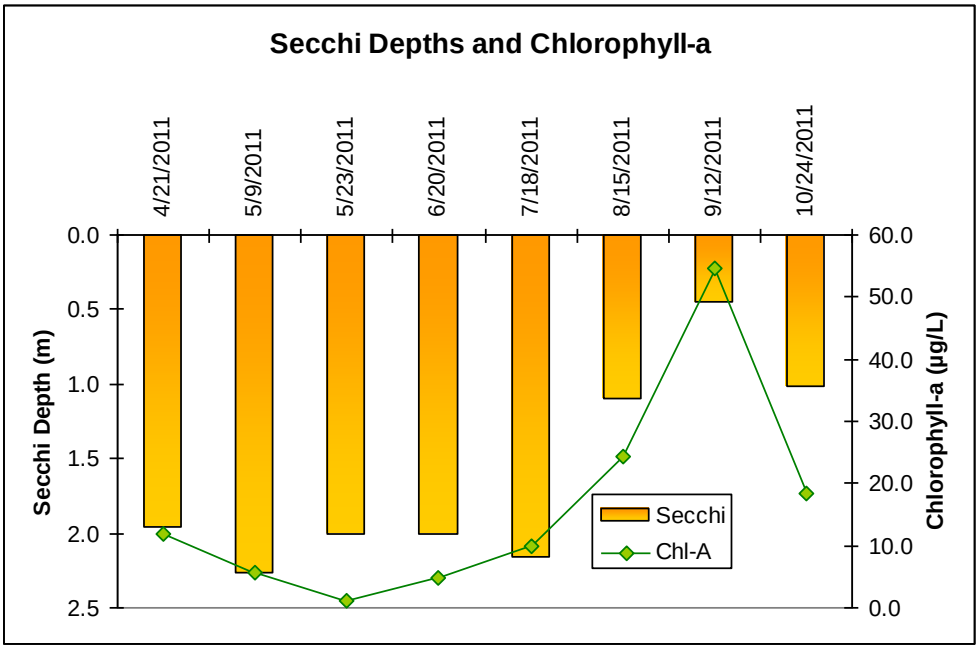

Figure 5. Diamond Lake seasonal changes in chlorophyll-a concentration and Secchi depth in 2011.

There are several factors that contributed to the improvements in water quality conditions. Diamond Lake appears to have shifted from an algal-dominated to a plant-dominated lake. There are several water quality benefits when a shallow lake shifts to the plant-dominated condition. The aquatic plants reduce the potential for nutrient re-suspension by stabilizing in-lake sediments. Consequently, lakes shifting to the plant-dominated condition often have improved water clarity with reduced phosphorus concentrations. An aquatic plant point- intercept survey conducted in the early summer of 2011 indicated an abundant plant community that consisted of coontail (43.8%), small pondweed (52.4%), and elodea (41%). Unfortunately, Diamond Lake also has nuisance growth of curlyleaf pondweed in the spring with a percent frequency of 92.4%. Curlyleaf pondweed senescence has the potential to offset any improvements in water quality. Currently, the native plant community appears to be able to compete with curlyleaf pondweed maintaining the plant-dominated condition. The specific mechanisms causing the shift from the algal-dominated condition to the plant-dominated condition are currently unknown. However, a shift to the plant-dominated condition for similar shallow lakes in the ecoregion has frequently occurred following winter fish kills. Rough fish such as common carp often inhibit the development of an aquatic plant community. There has been winter and summer fish kills observed in Diamond Lake the past several years. This may have provided an opportunity for the native plant community to become established and subsequently improving water quality conditions.

French Lake

French Lake is a shallow lake that has impaired water quality conditions. The lake is extremely eutrophic with phosphorus concentrations above the MPCA "shallow lake" standard of 60 µg/L (Figure 1). The average phosphorus concentration in 2011 was 154.8 µg/L (Figure 1) with values ranging between 62.2 µg/L and 317.5 µg/L (Figure 2). These phosphorus concentrations are conducive for the development of severe algal blooms.

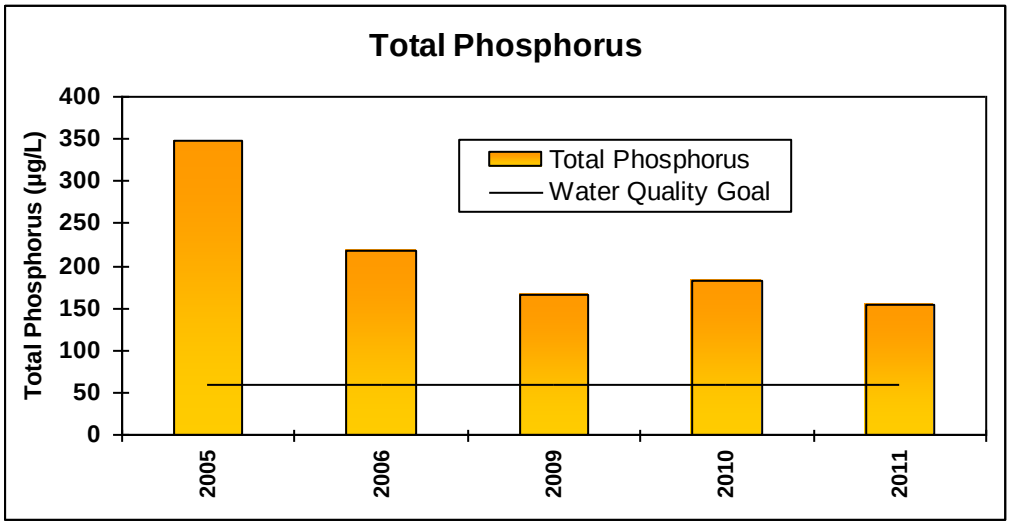

Figure 1. French Lake average annual total phosphorus concentration between 2005- 2011.

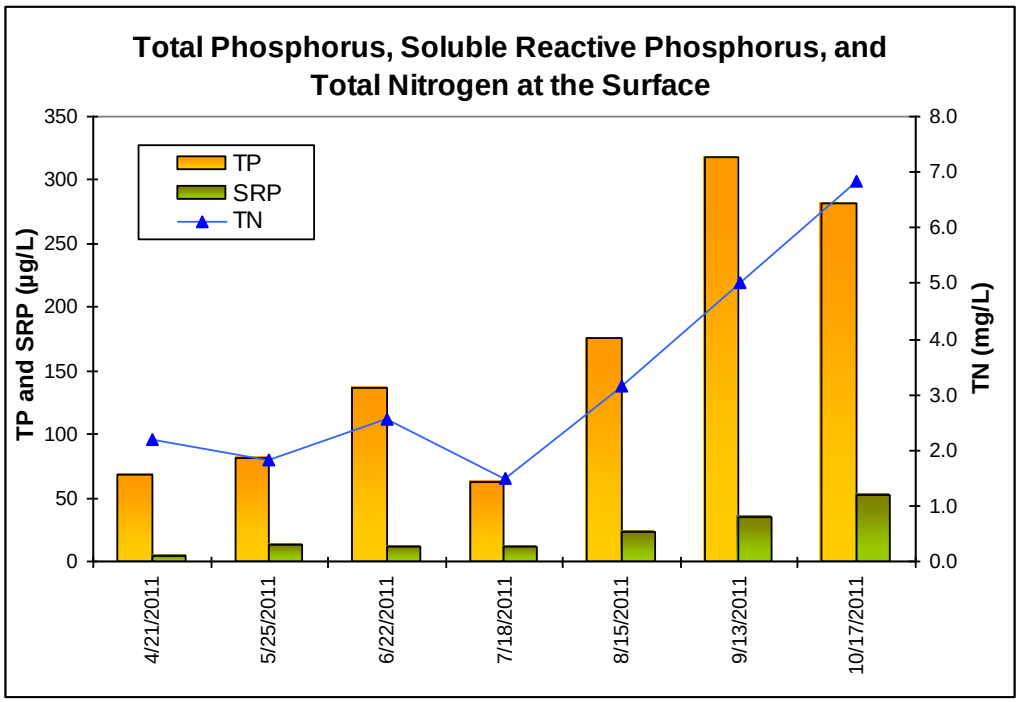

Figure 2. French Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2011.

French Lake has severe algal blooms that reduced water clarity conditions during the summer. In 2011, the average chlorophyll-a concentration was 75.7 µg/L with values ranging from 15 µg/L to 175 µg/L (Figure 3 & 5). These concentrations are considerably lower than chlorophyll-a concentrations observed in 2010 (average of 138.8 µg/L). Despite the lower chlorophyll-a concentration, there were no improvements in water clarity. The average Secchi depth transparency in 2011 was 0.6 m (Figure 4) with values ranging from 0.24 to 1.09 (Figure 5). The chlorophyll-a concentration and Secchi depth did not meet the MPCA "shallow lake" water quality standards (Figures 3 & 4). The trophic state index for French Lake was 74.2, which indicates the lake is in a hyper-eutrophic condition. Lakes classified as hyper-eutrophic have severe algal blooms that persist throughout the summer.

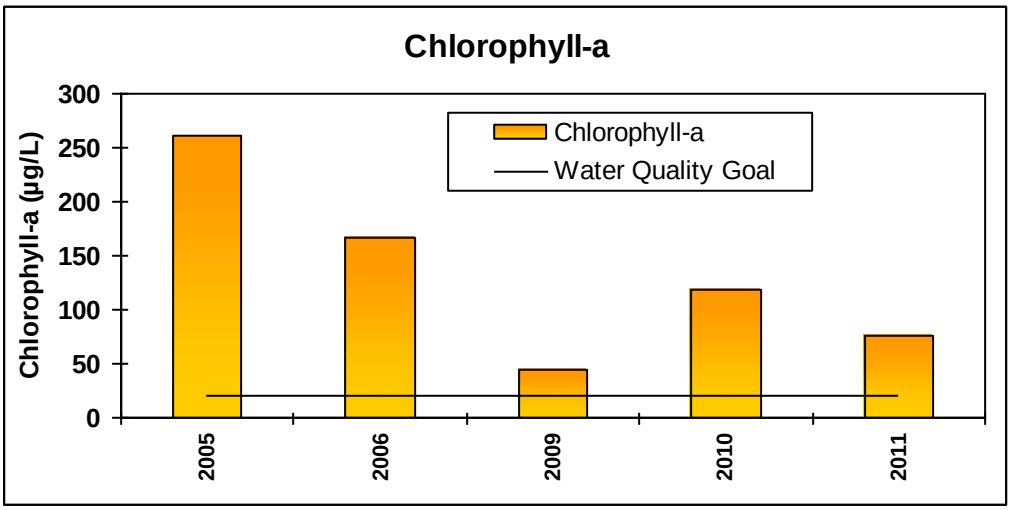

Figure 3. French Lake annual chlorophyll-a concentration from 2005 through 2011.

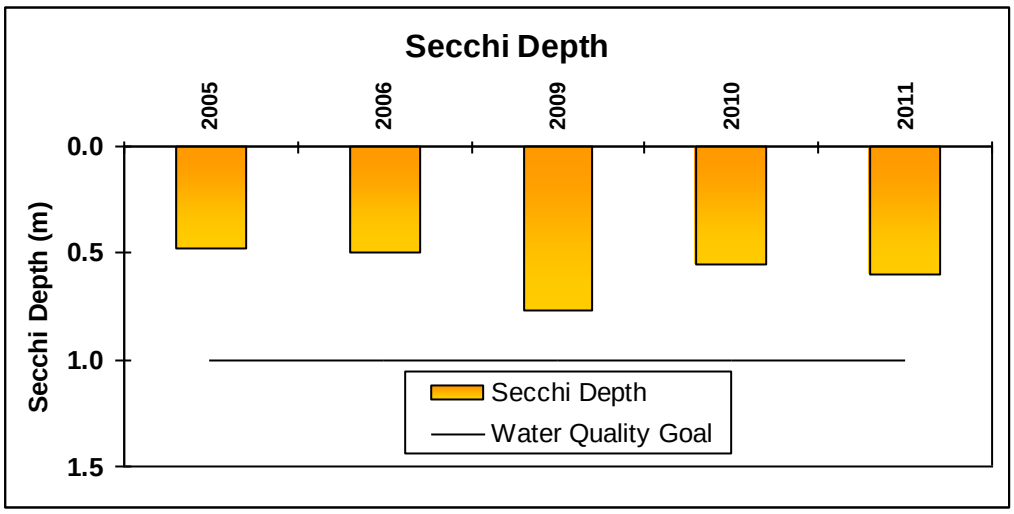

Figure 4. French Lake annual Secchi depths 2005 through 2011.

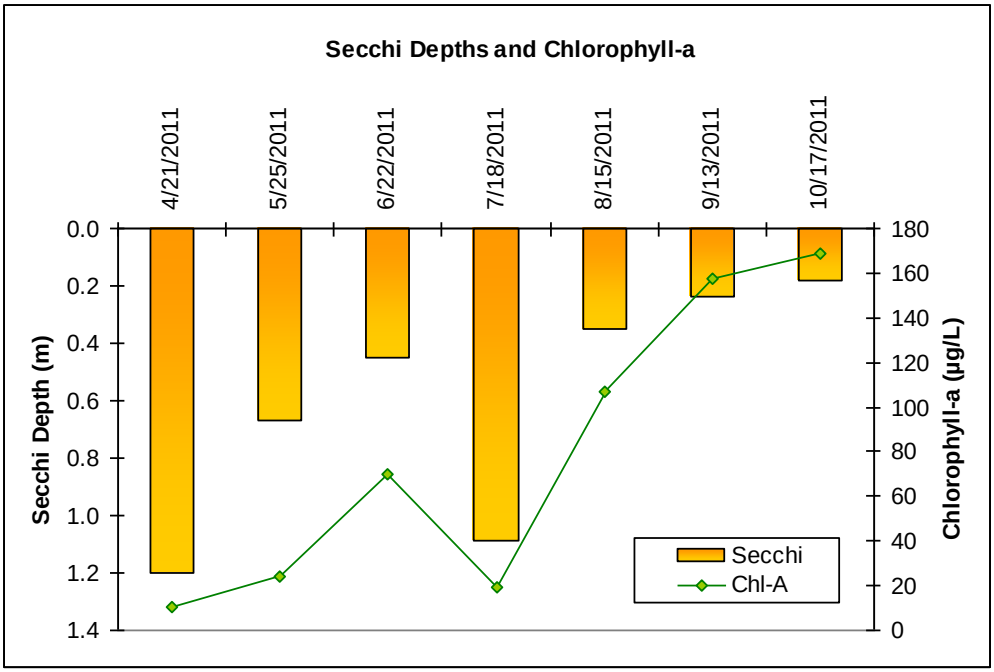

Figure 5. French Lake seasonal changes in chlorophyll-a concentration and Secchi depth from 2005 to 2011.

Mill Pond

Mill Pond is essentially part of the Elm Creek flowage prior to draining to the Mississippi River. Mill Pond is a shallow lake that has hypereutrophic phosphorus concentrations. The average annual phosphorus concentration for Mill Pond was 241.4 µg/L in 2011 with values ranging from 107.4 µg/L to 460.5 µg/L (Figure 1 & 2). These concentrations exceed the MPCA "shallow lake" phosphorus standard of 60 µg/L. These concentrations in Mill Pond are highly indicative of the phosphorus loading exhibited by Elm Creek. Consequently, seasonal changes in phosphorus concentration become dependent upon storm-event run-off volume and loading from Elm Creek.

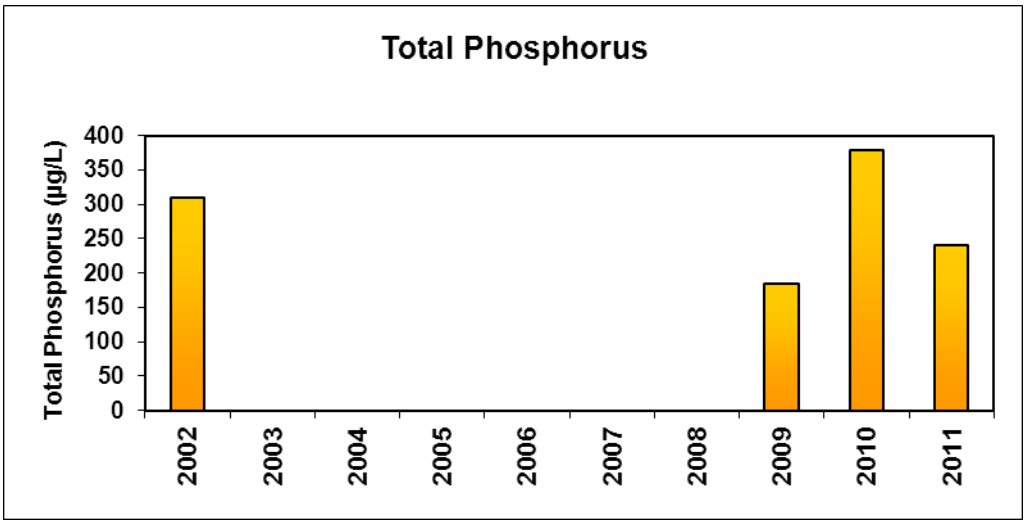

Figure 1: Mill Pond annual changes in total phosphorus concentrations.

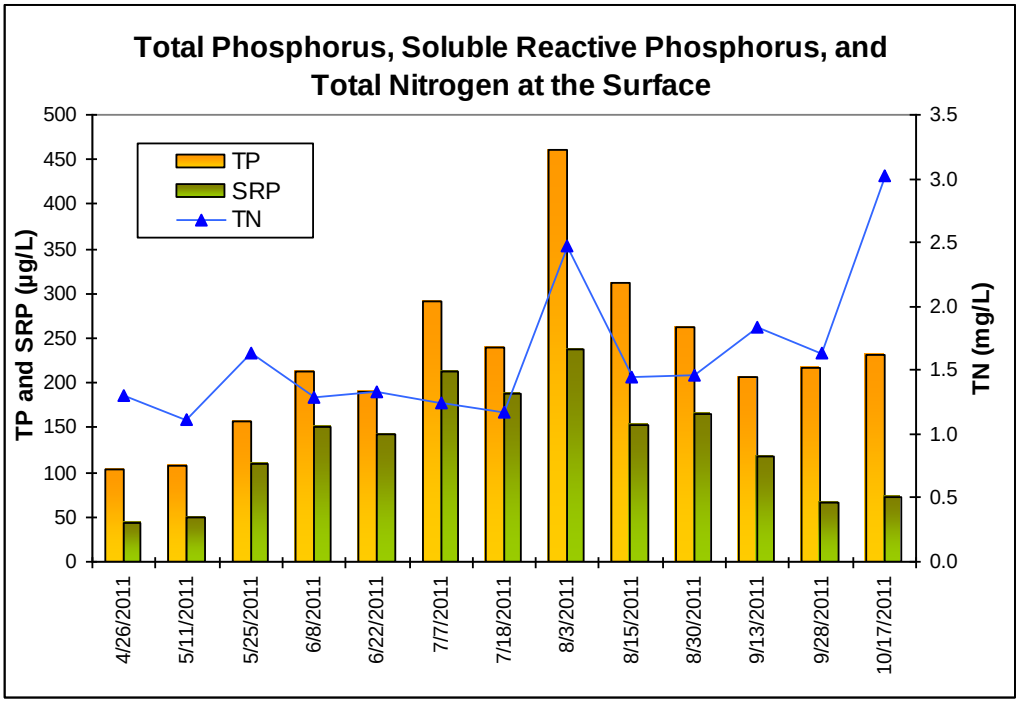

Figure 2. Mill Pond seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen in 2010.

Despite high phosphorus concentrations, Mill Pond does not appear to have severe algal blooms. The average chlorophyll-a concentration was 5.22 µg/L with values ranging from 1.0 µg/L to 26.7 µg/L (Figure 3 & 4). Secchi depth transparency was not measured consistently throughout the summer, but Secchi depth transparency was frequently on the bottom. The residence time within Mill Pond is relatively short since the shallow lake is essentially part of the Elm Creek flowage. Consequently, Mill Pond has chlorophyll-a concentrations that are more indicative of Elm Creek. The reduced residence time is not conducive for the development of algal blooms despite the high phosphorus concentrations. Maximum chlorophyll-a concentration of 26.7 µg/L in late September may is most likely due to low base flow conditions during periods of below average rainfall in the fall of 2011.

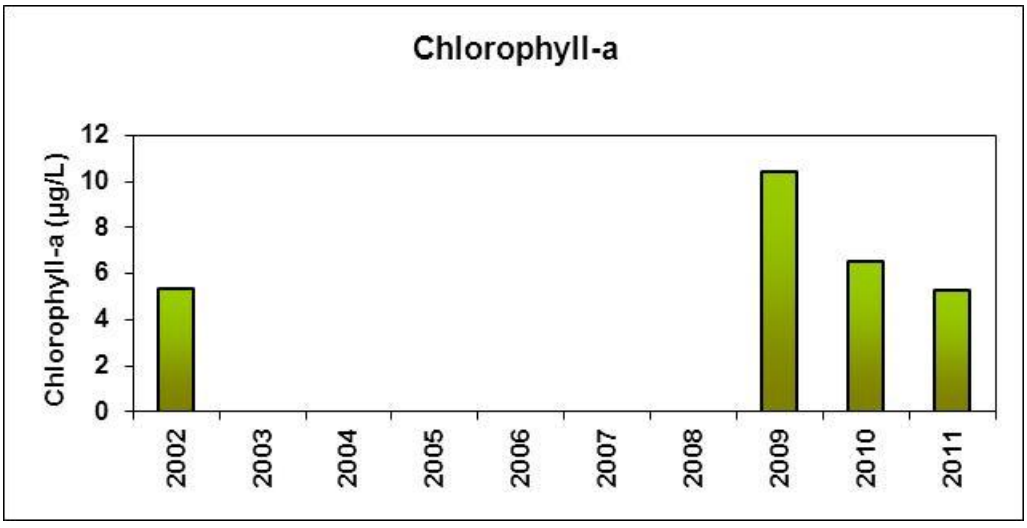

Figure 3: Mill Pond annual changes in chlorophyll-a concentration.

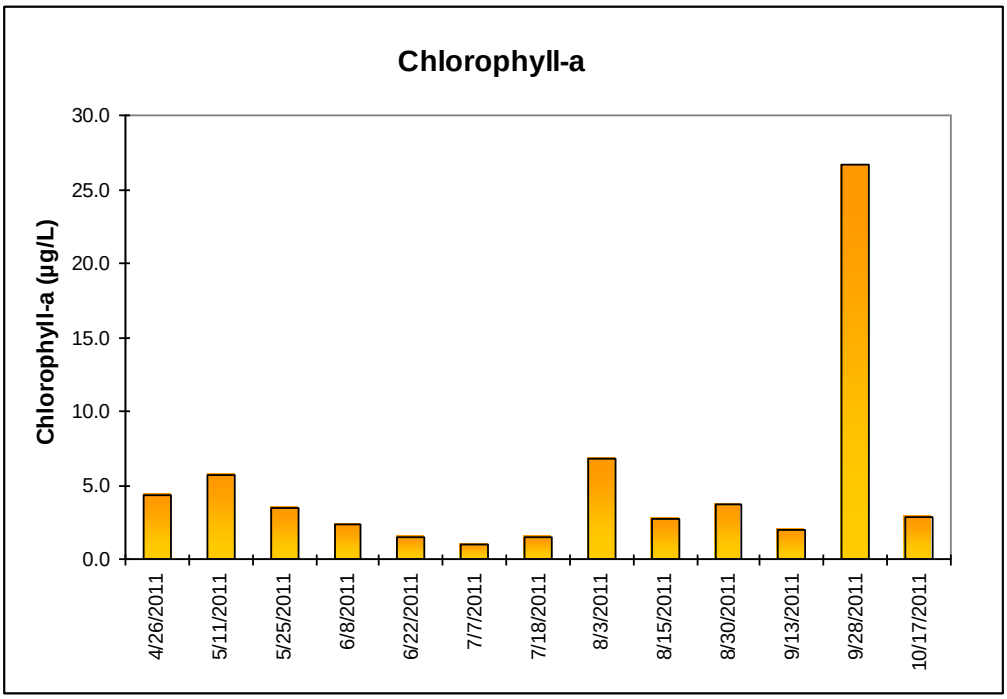

Figure 4. Mill Pond average chlorophyll-a concentrations during 2011.

Lake Monitoring History

	Cook	*Cowley*	*Diamond*	*Dubay*	*Fish*	*French*	*Henry*	*Jubert*	*Mill Pond*	*Mud*	*Rice*	*Sylvan*	*Weaver*
2011			**T**	**C**	**T**	**T**	**C**		**T**		**C**		**T**
2010		**C**	**T**		**T**	**T**	**C**		**T**	**T**	**C/T**		**T**
2009		**C**	**T**		**T**	**T**	**C**		**T**		**C**		**T**
2008			**T**		**T**		**C**				**C**	**C**	**T**
2007		**C**	**T**		**T**		**C**				**C**		**T**
2006		**C**			**T**	**T**	**C**						**T**
2005					**T**	**T**	**C**						**T**
2004			**T**		**T**	**T**							**T**
2003													
2002					**T**	**C**			**T**				**T**
2001	**T**				**T**	**C**							**T**
2000					**T**			**C**					**T**
1999					**T**				**T**				**T**
1998			**T**		**T**								**T**
1997					**T**							**T**	**T**
1996					**T**								**T**
1995					**T**		**C**						**T**
1994			**C**		**T**								**T**
1993					**T**								**T**
1992	**T**		**T**		**T**								**T**
1991					**T**			**T**	**T**				**T**
1990	**T**				**T**	**T**							**T**
1989			**T**	**T**	**T**			**T**					**T**
1988	**T**				**T**				**T**				**T**
1987					**T**			**T**					**T**
1986	**T**		**T**	**T**	**T**					**T**			**T**

T = monitored by Three Rivers Park District **C** = monitored through CAMP program