Pioneer and Sarah Creek Watershed Management Commission
Lake Water Quality Summaries
2013

Introduction

The Pioneer- Sarah Creek Watershed Commission contracted with Three Rivers Park District (TRPD) to monitor the trophic condition for several lakes in 2013. TRPD monitored the water quality in Lake Independence, Spurzem Lake, Half Moon Lake, Lake Sarah and Whaletail Lake (west and east basins). These lakes were sampled biweekly from April through 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). It should be noted that 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.

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.*

Lake Independence

Lake Independence has exceeded the MPCA "deep lake" phosphorus standards since 2001. There has not been any significant improvement in water quality since the completion of the TMDL (2006) and implementation plan (2007). The changes in total phosphorus concentration appeared cyclic with gradual decreases and increases in total phosphorus since 1995 (Figure 1). The average phosphorus concentration in Lake Independencewas 58 µg/L in 2013 (Figure 1). Total phosphorus concentration in 2013 ranged from 32.8to 77.4 µg/L (Figure 2). The fluctuations in phosphorus concentration for Lake Independence have often been attributed to the watershed and internal loading processes. The watershed is primarily agricultural land use that potentially contributes a significant amount of phosphorus loading to Lake Independence. The lake also has the potential provide a significant amount of phosphorus loading through internal loading processes. After the onset of stratification, phosphorus concentrations build up in the hypolimnion during the summer. Lake Independence hypolimnetic phosphorus concentrations near the bottom reached 1349.7 µg/L (Figure 3). The seasonal changes in lake stratification have the potential to entrain some of this hypolimnetic phosphorus to the surface through partial mixing events and complete fall turnover. The excessive watershed and internal phosphorus load is significant enough to be conducive for the development of severe algal blooms.

The high phosphorus concentrations resulted in severe algal blooms that reduced water clarity in 2013. The lake typically has a clear water phase in early spring that is followed by severe algal blooms that persist throughout the summer. Zooplankton feeding on algae resulted in a clear water phase for Lake Independence that

occurred from May 20th through July 1stin 2013. During the clear water phase, chlorophyll-a concentration ranged from 1.2 to 22.8 µg/L with secchi depth measurements exceeding 3.5 m and reaching a maximum depth of 8.1 m (Figure 5). The lake had severe algal blooms following the July 1st sampling period. The chlorophyll-a concentrationsranged from 42.1 to 84.3 µg/L with water clarity often below 1 m in depth (Figure 5). The summer chlorophyll-a concentrations and secchi depth measurements during the summer were considered impaired with regards to the respective state standards. Thesevere algae blooms resulted in an averagechlorophyll-a concentration of 32.7 µg/L that was considerably higher than the water quality standard (Figure 4).Despite the periods with severe algal blooms, the average secchi depth transparency of 2.74 m met the state standard in 2013 (Figure 6). An average secchi depth that met state standards despite the impaired chlorophyll-a concentrations was attributed to the excellent water clarity that occurred during the clear water phase in the spring.

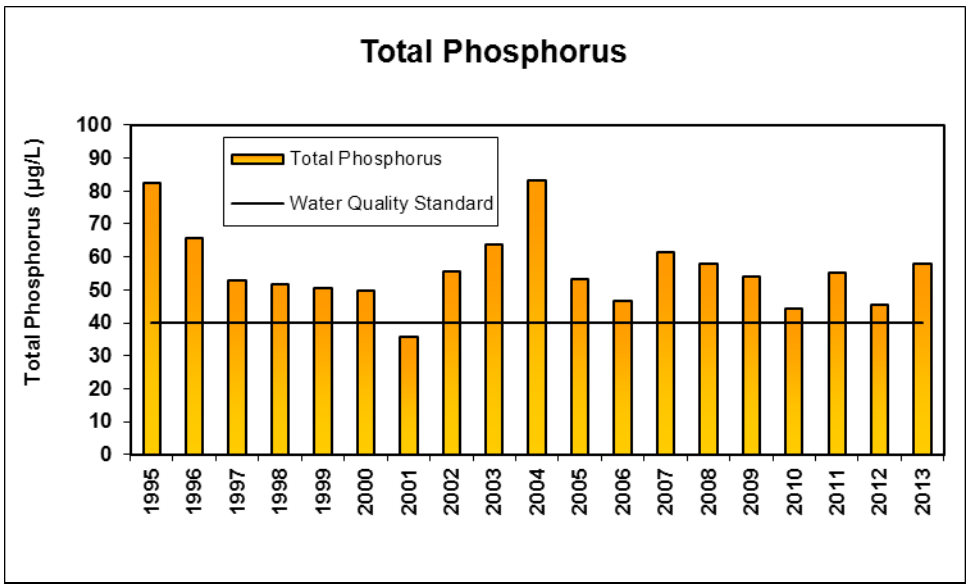

Figure 1.Lake Independence annual changes in average phosphorus concentration from 1995-2013.

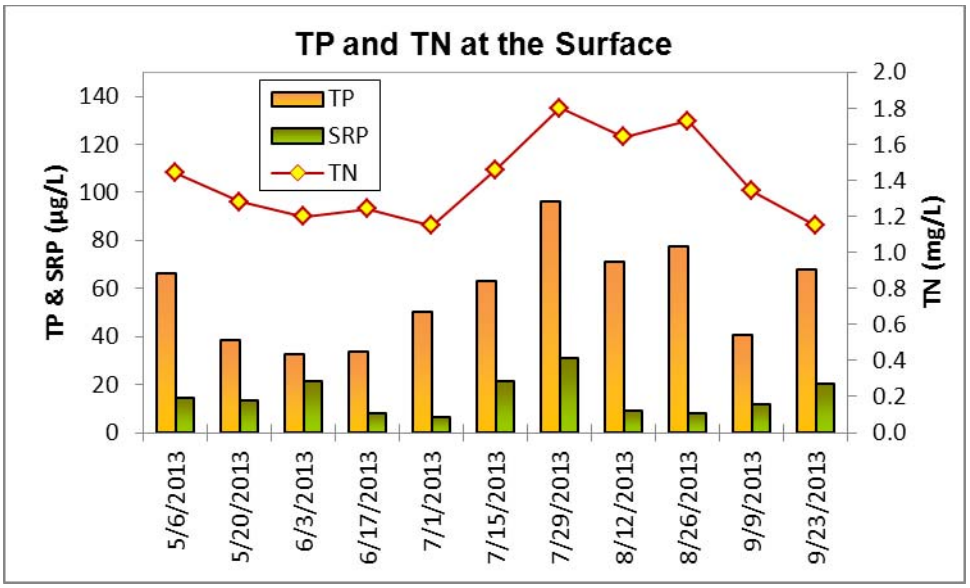

Figure 2. Lake Independence seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2013.

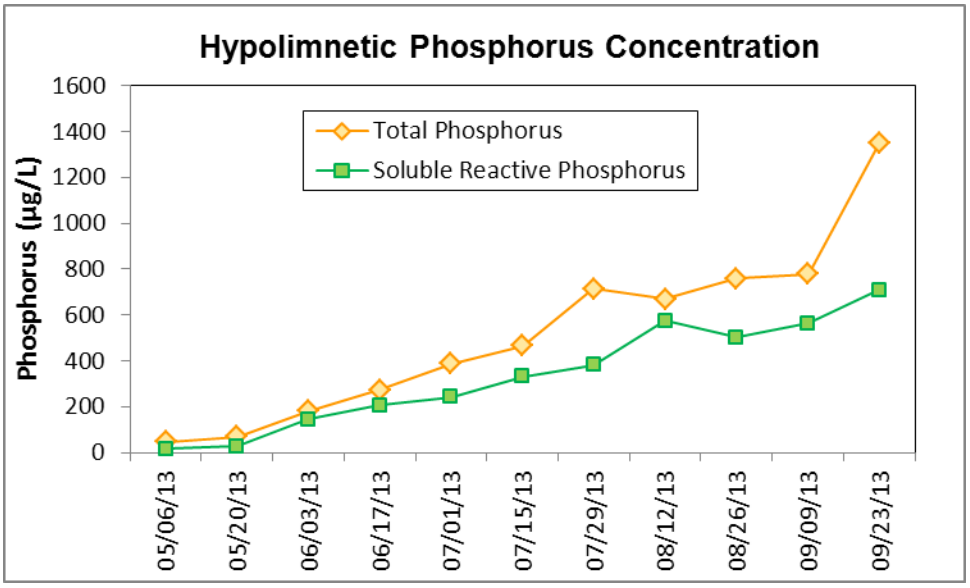

Figure 3.Lake Independence seasonal changes in hypolimnetic phosphorus concentration in 2013.

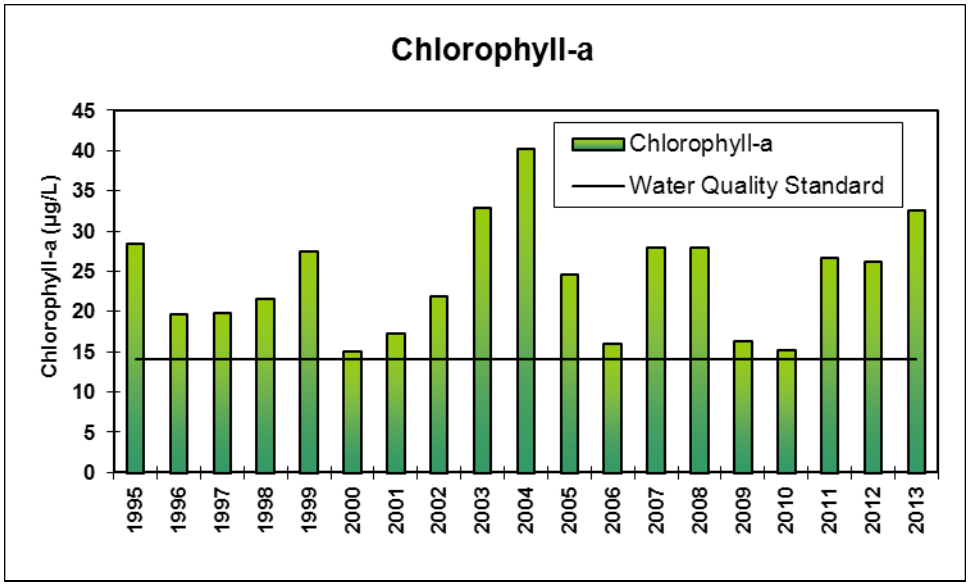

Figure 4.Lake Independence annual changes in average chlorophyll-a concentration from 1995-2013.

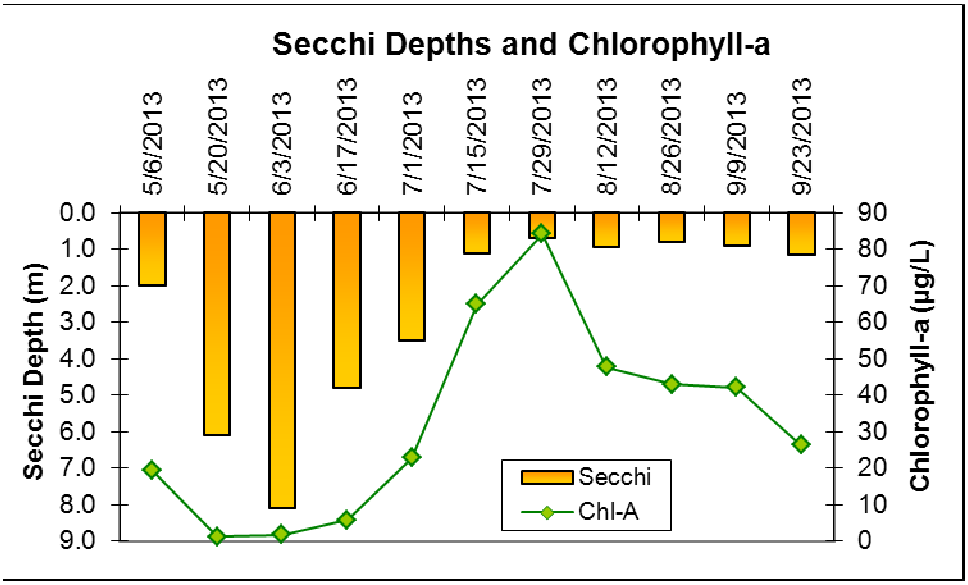

Figure 5.Lake Independence seasonal changes in Secchi depth and chlorophyll-a concentration in 2013.

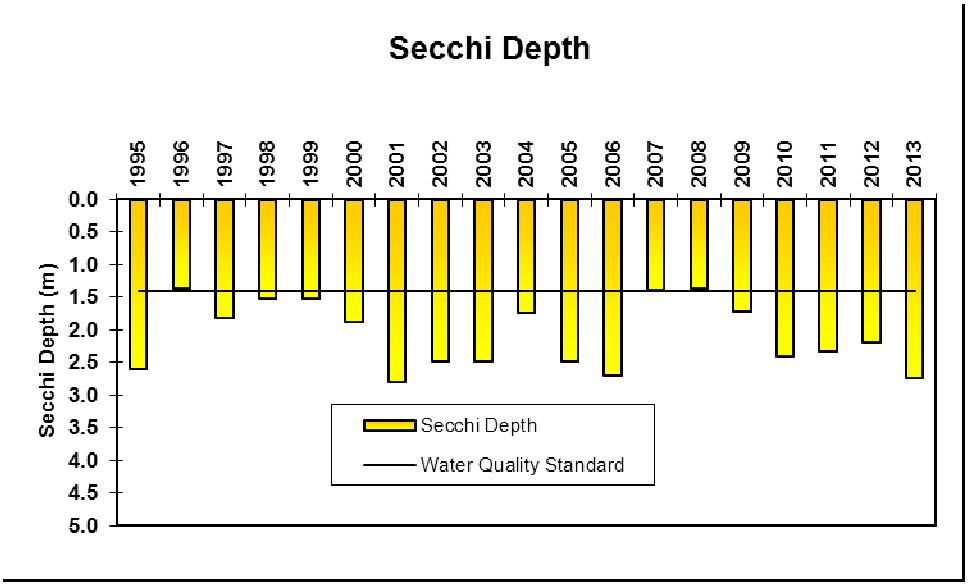

Figure 6.Lake Independence annual changes in average Secchi depth from 1995-2013.

Spurzem Lake

Spurzem Lake continues to exceed the impaired water criteria for the MPCA "deep lake" eutrophication standards. The total phosphorus concentration standard to support direct contact recreational use for Spurzem Lake is 40 µg/L. The average total phosphorus concentration in 2013 was 202.1 µg/L with values ranging between 73.0and 389.0 µg/L (Figures 7&8).These phosphorus concentrations are the highest reported since monitoring in 1995. Typically, the high phosphorus concentrations are attributed to significant sources of external and internal loading. In September of 2013, phosphorus concentrations collected 1-m from the bottom prior to lake turnover were 2938.1 µg/L and 3756.1 µg/L, which suggests that internal loading most likely provided a significant source of the entire loading to the lake. These extremely high phosphorus concentrations are considered hypereutrophic with respect to other lakes within the ecoregion.

The excess phosphorus concentrations in Spurzem Lake resulted in severe algal blooms with decreased water clarity. The average chlorophyll-a concentration in 2013was 80.2µg/L (Figure 9), which is considerably higher than the state standard of 14 µg/L. There was an increase in chlorophyll-a concentration that corresponded with an increase in water temperatures at the end of June and the beginning of July (Figure 10). Despite these high chlorophyll-a concentrations, there were periods during the 2013 season with excellent water clarity conditions. There was a clear water phase in June that had chlorophyll-a concentrations ranging between 2.1 and 21.7 µg/L; and secchi depth transparencies ranging between 2.1 to 4.9 m (Figure 10). The clear water period with excellent water clarity resulted in an average Secchi depth transparency of1.56 m (Figure 11). This is the second consecutive year in which water transparency met the water quality standard despite the severe algal blooms during the summer.

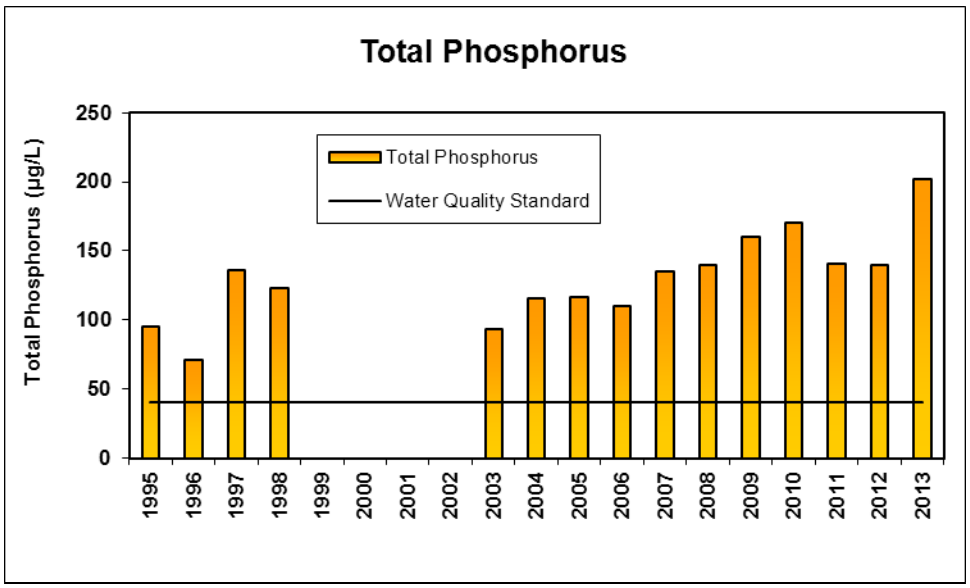

Figure 7.Spurzem Lake annual changes in average phosphorus concentration from 1995-2013.

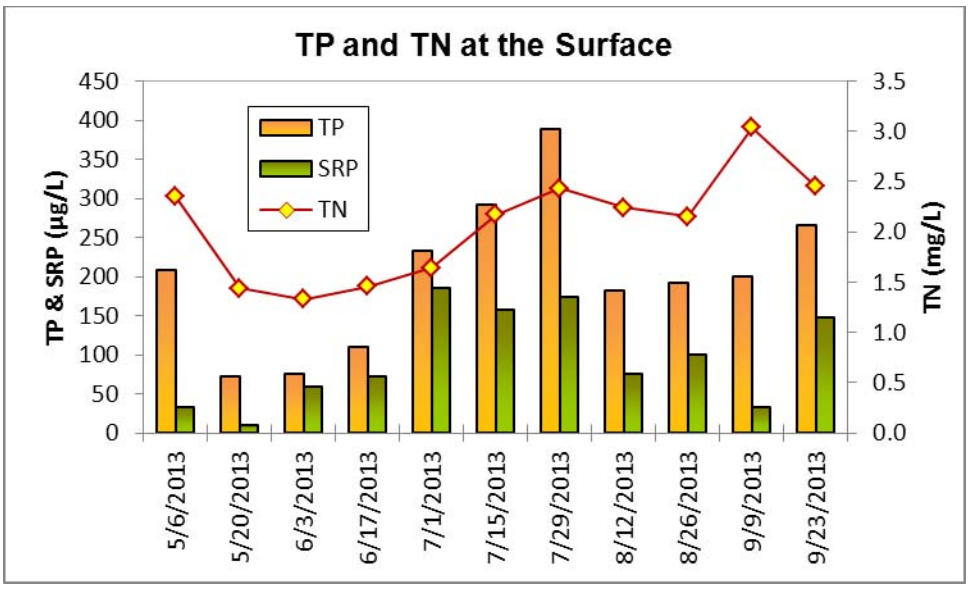

Figure 8.Spurzem Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2013.

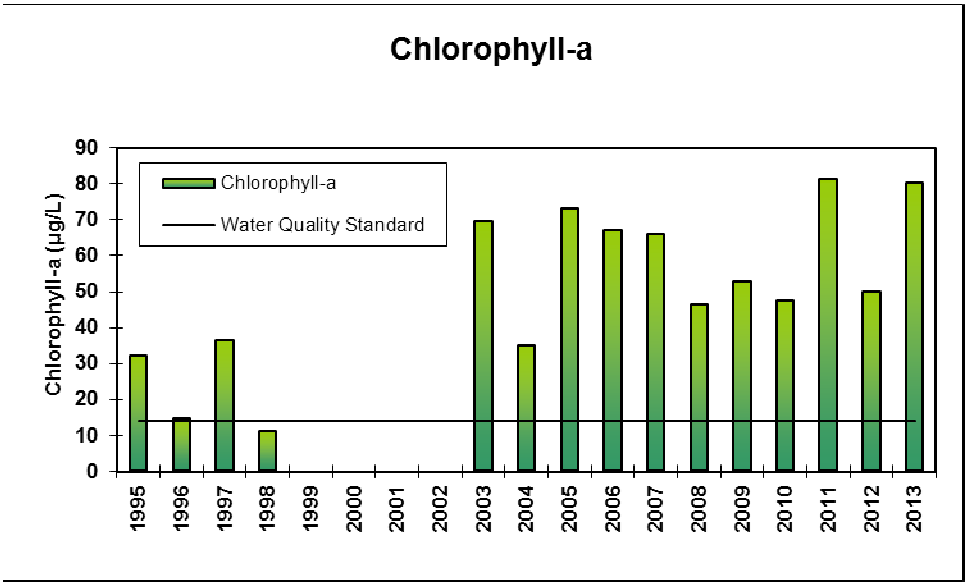

Figure 9.Spurzem Lake annual changes in average chlorophyll-a concentration from 1995-2013.

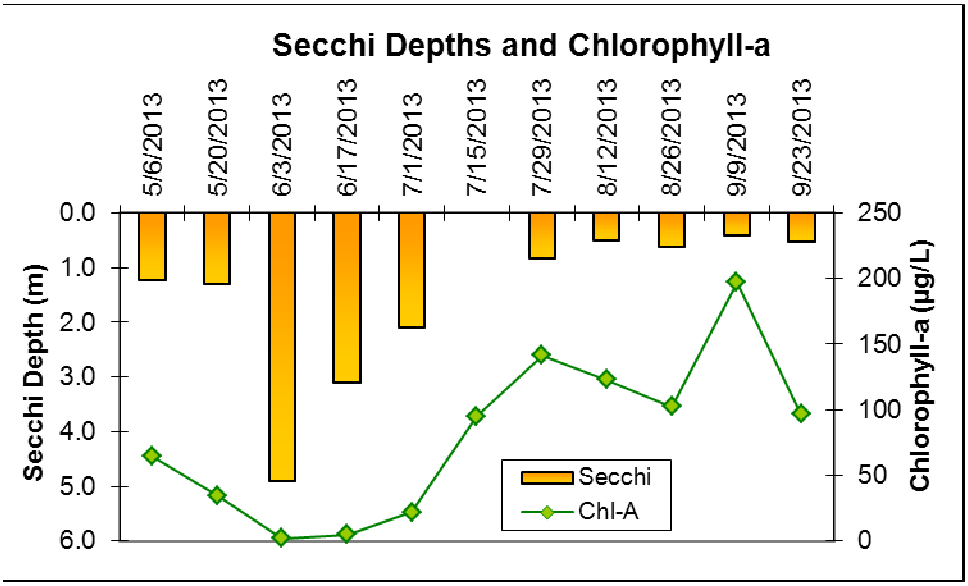

Figure 10.Spurzem Lake seasonal changes in Secchi depth and chlorophyll-a concentration in 2013.

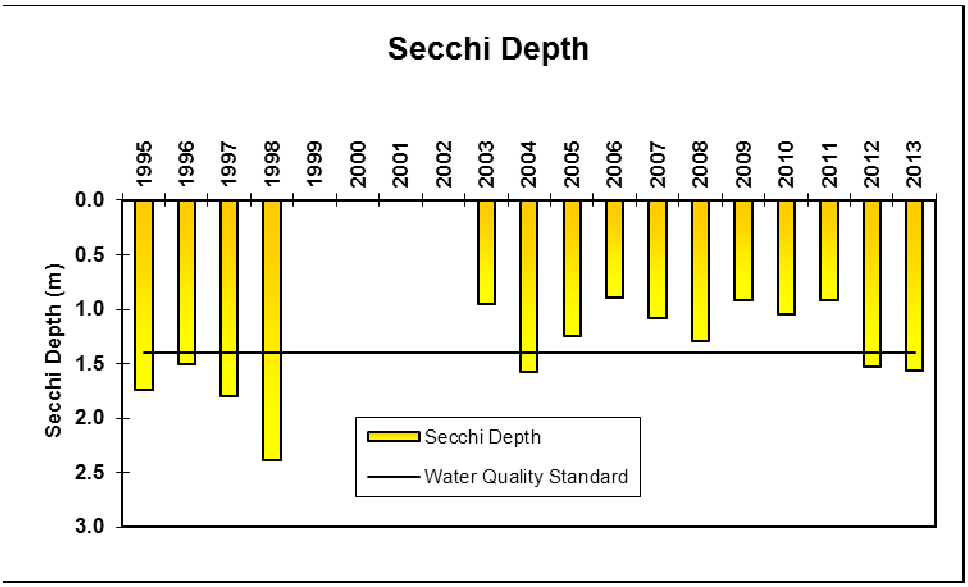

Figure 11.Spurzem Lake annual changes in average Secchi depth from 1995-2013.

Half Moon Lake

Half Moon Lake continues to exhibit degraded water quality conditions. Half Moon had an average phosphorus concentration of 126.5 µg/L with values ranging from 78.6 to 196.5 µg/L in 2013 (Figures 12&13).There has not been any improvement in phosphorus concentrations relative to the previous years that have been monitored. The average total phosphorus concentrations have been substantially higher than the MPCA "deep lake" standard of 40 µg/L to support aquatic recreational use. The high phosphorus concentrations were attributed to significant sources of watershed and internal loading. Half Moon Lake is the downstream receiving water body from Spurzem Lake. The high phosphorus concentration from Spurzem Lake most likely contributes a major source of the watershed loading to Half Moon Lake. In addition, Half Moon Lake bottom (1-m from bottom) phosphorus concentrations were 1191 µg/L and 1887.8 µg/L in September prior to lake-turnover, which suggests that internal loading most likely accounts for a significant portion of the entire phosphorus mass balance.

The excessive phosphorus concentrations are conducive for the development of severe algal blooms that occurred during the middle of the summer. The average chlorophyll-a concentration in 2013 was 50.0 µg/L (Figure 14)with values ranging from 23.7 to 89.4 µg/L (Figures15). These concentrations are similar to those years previously sampled since 2009. The severe algal blooms in Half Moon resulted in poor water clarity conditions that produced an average secchi depth transparency of 1.17 m (Figure 16). The average secchi depth transparency does not meet the state standard of 1.4 m. Despite the severe algal blooms, there was a clear water phase that was most likely attributed to an increase in zooplankton abundance that persisted throughout June. Water clarity gradually decreased in response to the development of algal blooms as water temperatures increased throughout the summer.

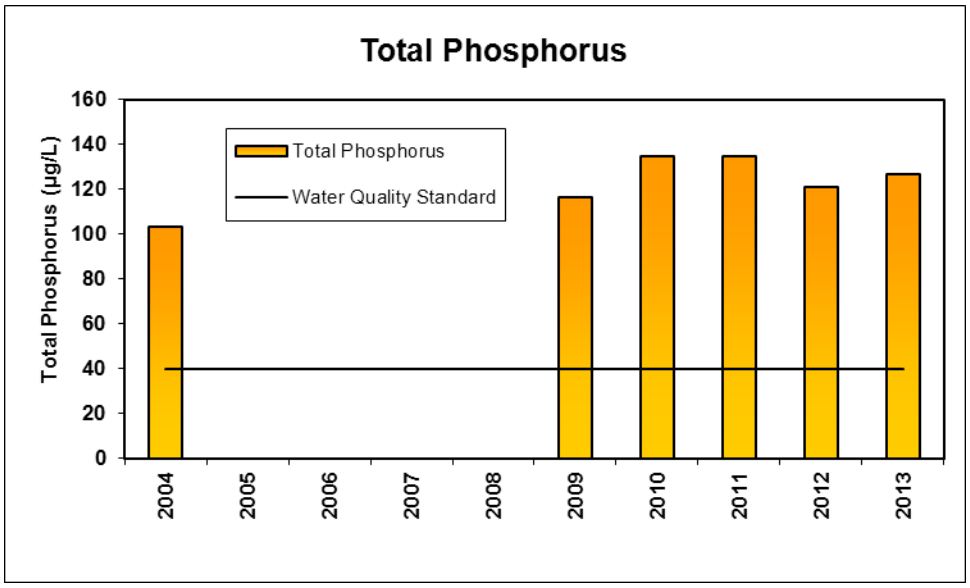

Figure 12.Half Moon Lake annual changes in average phosphorus concentration from 2004-2013.

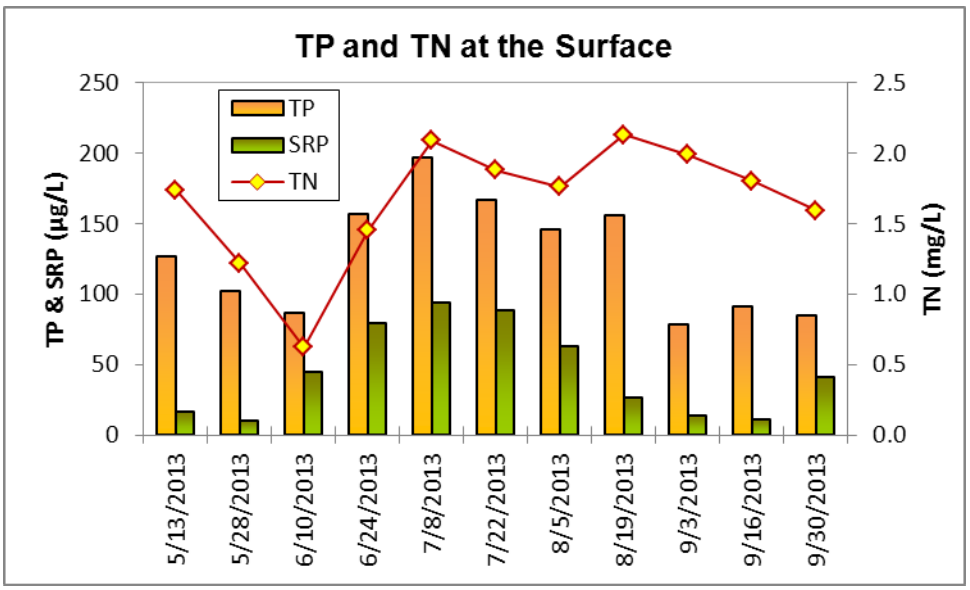

Figure 13.Half Moon Lake seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2013.

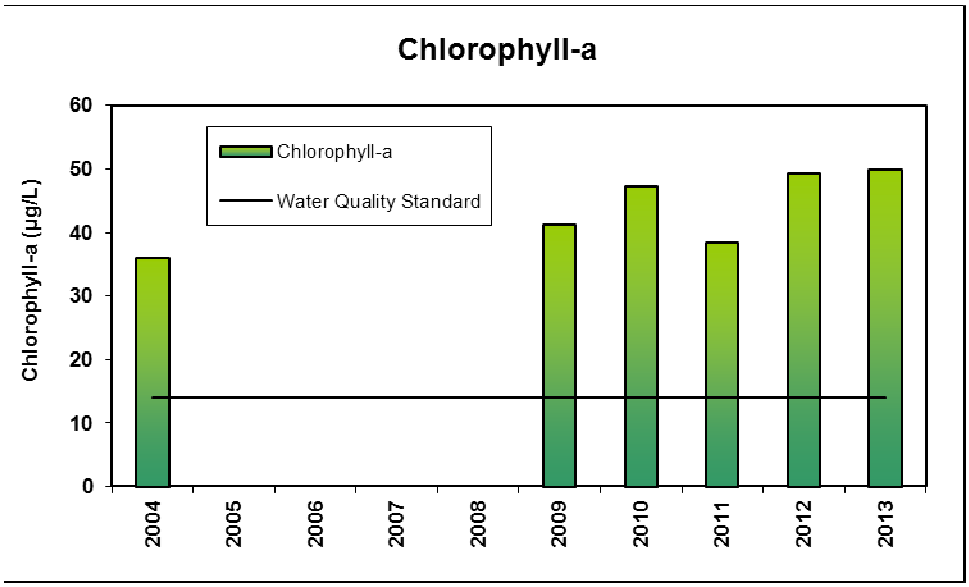

Figure 14.Half Moon Lake annual changes in average chlorophyll-a concentration from 2004-2013.

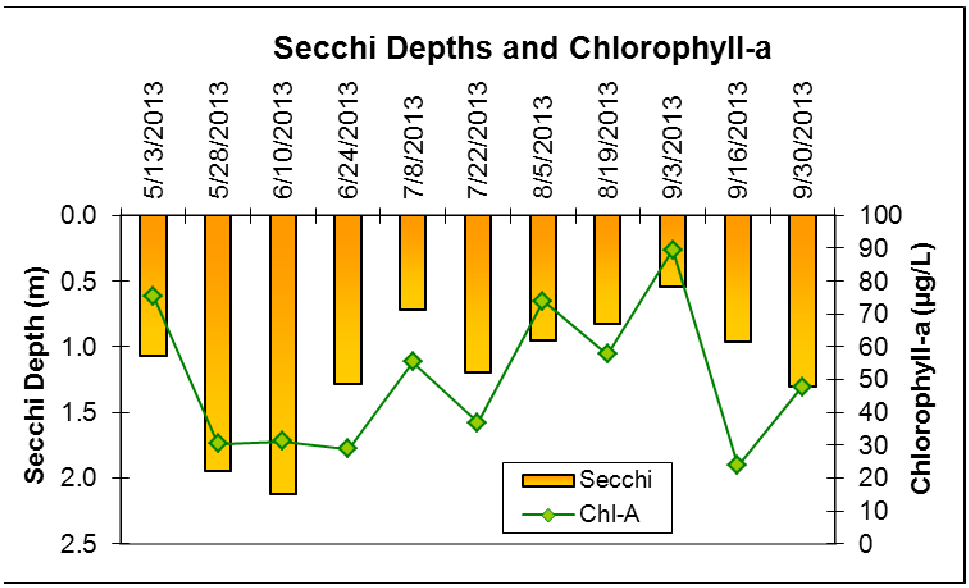

Figure 15.Half Moon Lake seasonal changes in Secchi depth and chlorophyll-a concentration in 2013.

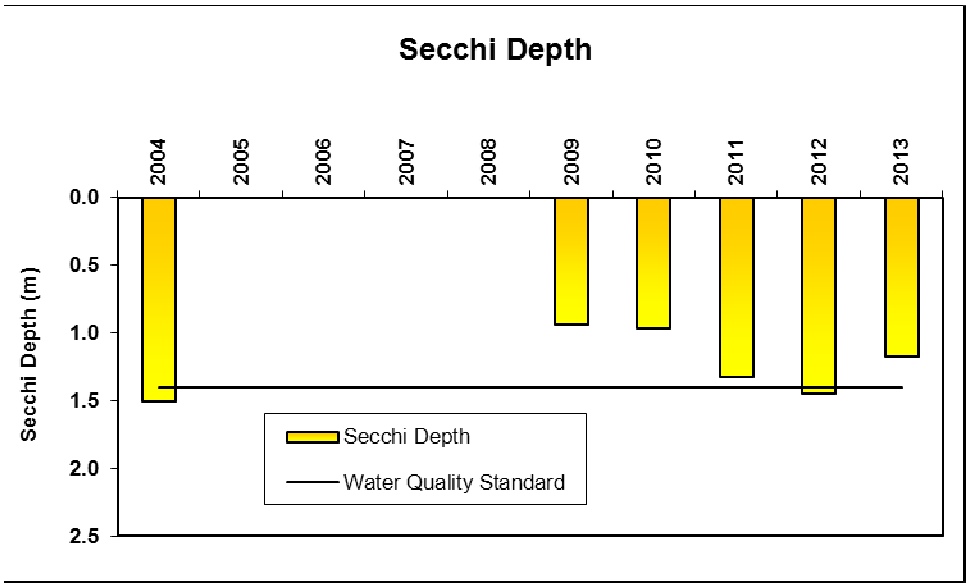

Figure 16.Half Moon Lake annual changes in average Secchi depth from 2004-2013.

Lake Sarah

Lake Sarah has exceeded MPCA "deep lake" standards for total phosphorus since 1996 (Figure 17). The average phosphorus concentration in 2013 was96.3µg/L(Figure 17)with values ranging from 53.6 µg/L to 174.1 µg/L (Figures 18). The high phosphorus concentrations are attributed to sources of watershed and internal loading. Lake Sarah watershed is 4,454 acres (8:1 watershed to lake area ratio) that potentially results in a significant amount of nutrient loading to the lake. In addition, the lake has two sources of internal load that may potentially further degrade water quality. The lake had a bottom phosphorus concentration of 1243.6 µg/L in September prior to lake turn-over in 2013 (Figure 19), which suggests that internal phosphorus load released from the sediments during anoxic conditions is significant. The lake also has nuisance growth of curlyleaf pondweed that dies-off at the end of June and provides a source of internal loading to the lake.A five year lake-wide management project to control curlyleaf pondweed began in 2013. Since this was the first year of the project, there have been no significant changes in phosphorus concentrations or water quality conditions.

The high phosphorus concentrations have been conducive for the development of algal blooms.Lake Sarah annual average chlorophyll-a concentration was52.4 µg/L in 2013 (Figure 20) which exceeds the MPCA "deep lake" standard for impairment.The average chlorophyll-a concentrations has significantly increased since 2009 (Figure 20). Despite an increase in chlorphyll-a concentrations, the average secchi depth transparency met the state standards the past three years (Figure 22). The state standard has been met the past three years due to a clear water phase in the spring of each year. Lake Sarah exhibited a clear-water phase from mid-May through early-June in 2013 that produced a secchi depth transparency ranging from 3.52 meters to 4.06 meters(Figure 21).Water clarity gradually decreased in response to the development of algal blooms as water temperatures increased throughout the summer. The decrease in water clarity due to severe algal blooms persisted throughout the remaining portion of the summer.

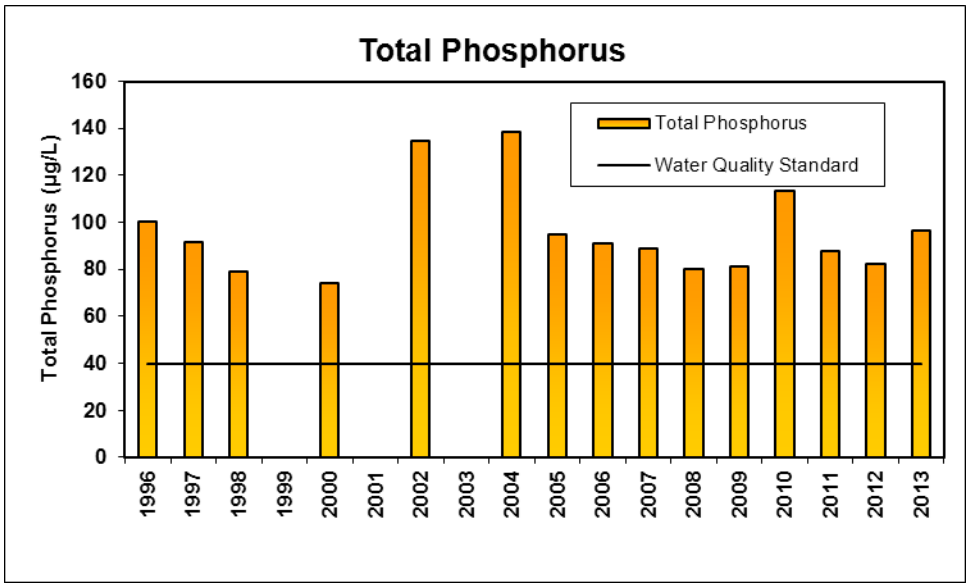

Figure 17.Lake Sarahannual changes in average phosphorus concentration from 1996-2013.

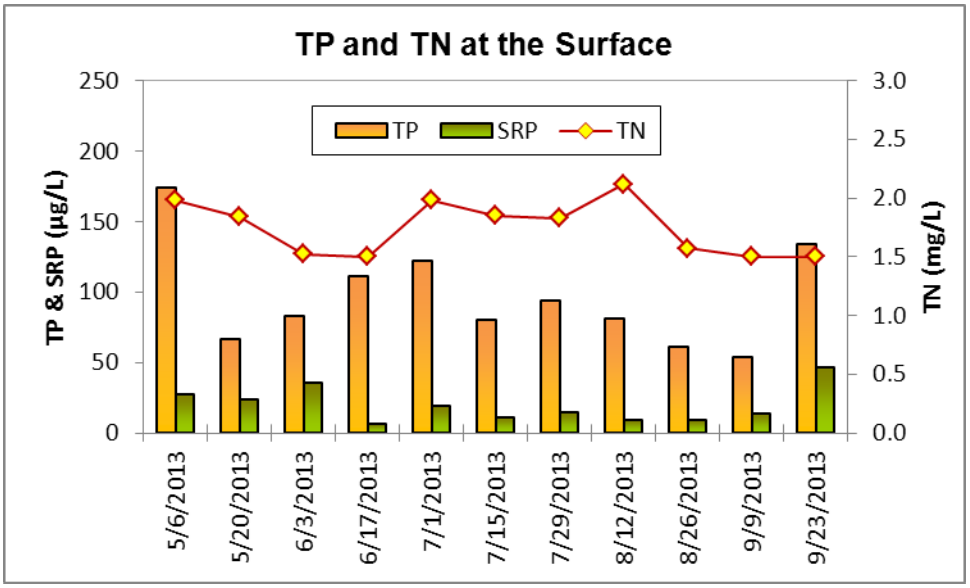

Figure 18.Lake Sarah seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2013.

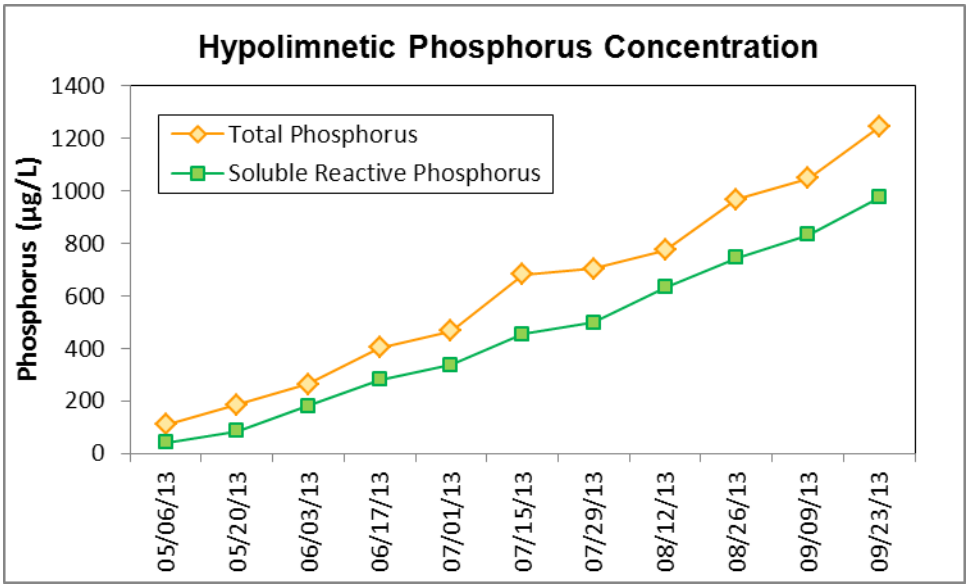

Figure 19.Lake Sarah seasonal changes in hypolimnetic phosphorus concentration in 2013.

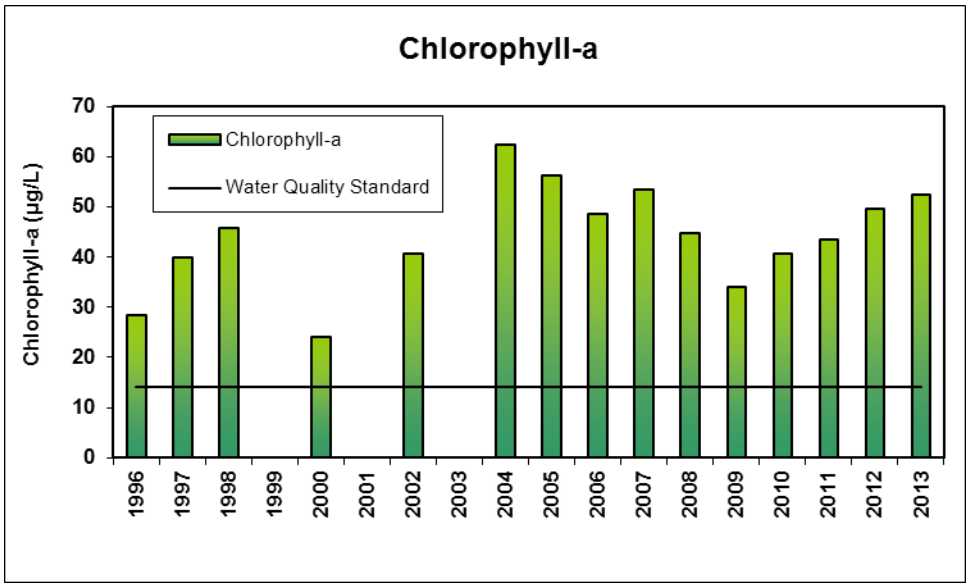

Figure 20.Lake Sarah annual changes in average chlorophyll-a concentration from 1996-2013.

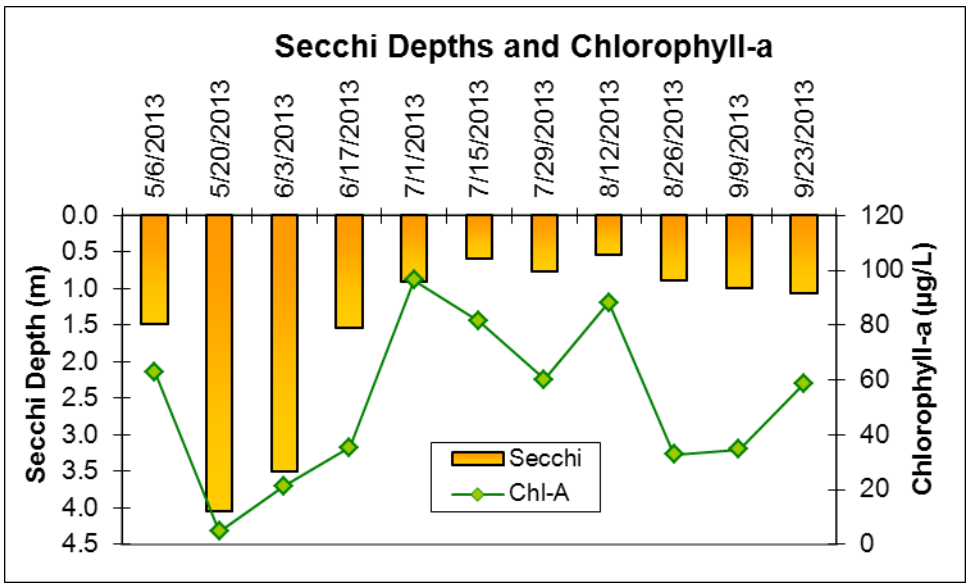

Figure 21.Lake Sarah seasonal changes in Secchi depth and chlorophyll-a concentration in 2013.

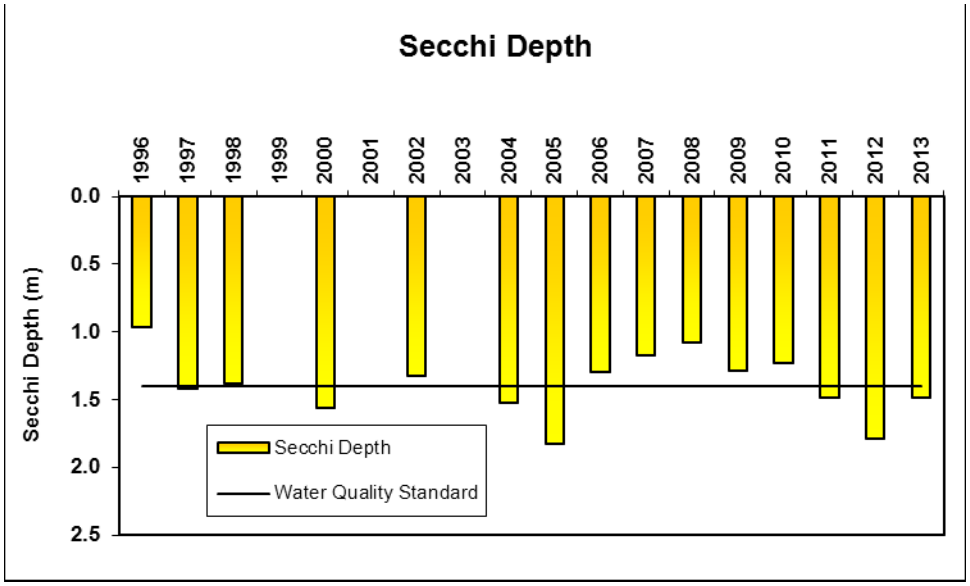

Figure 22.Lake Sarah annual changes in average Secchi depth from 1996-2013.

Whaletail Lake

Whaletail Lake has two distinct basins that have been monitored to assess water quality conditions.The west basin of Whaletail Lake has characteristics that are similar to a shallow lake, and the east basin has characteristics that are similar to a deep lake. The distinct differences in morphology have contributed to variations in water quality trophic conditions between the two basins. The water quality conditions were compared to the shallow lake and deep lake water nutrient criteria that are representative for each basin.

Whaletail-West Basin

The West Basin frequently has impaired water quality conditions that do not meet the “shallow lake” standards to support recreational use.There has been the occasional exception in which some of the water quality parameters have met the state standard. In 2013, it appears that the average total phosphorus concentration met the state standardof 60 µg/L (Figure 23). The seasonal changes in phosphorus concentrations were relatively low throughout the year in which the state standard was exceeded twice in July (7/1/2013 = 71 µg/L; 7/29/2013 = 114.3 µg/L) and only once in August (8/26/2013 = 62.1 µg/L) (Figure 24). Despite phosphorus meeting the state standard, the chlorophyll-a andsecchi depth response variables did not meet state standards in 2013. The average chlorophyll-a concentration was 30.7 µg/L (Figure 25); and the average secchi depth transparency was 0.75 m (Figure 27). There was considerable variation in seasonal chlorophyll-a concentrations and water clarity (Figure 26). The west basins shallow morphology is conducive for re-suspension of sediments and nutrients due to wind mixing that potentially can result in elevated phosphorus concentrations. However, there was a significant amount of plant growth on major portions of the lake in 2013 that stabilized in-lake sediments and nutrients resulting in lower phosphorus concentrations. It appears that the West Basin for Whaletail periodically meets the state standards for some of the water quality parameters when the lake is in the plant-dominated condition. Unfortunately, these lower phosphorus concentrations did not translate into improvements in water clarity for the lake. The in-lake phosphorus concentrations as well as other environmental conditionsmust have been conducive enough to support nuisance algal growth that further reduced water clarity.

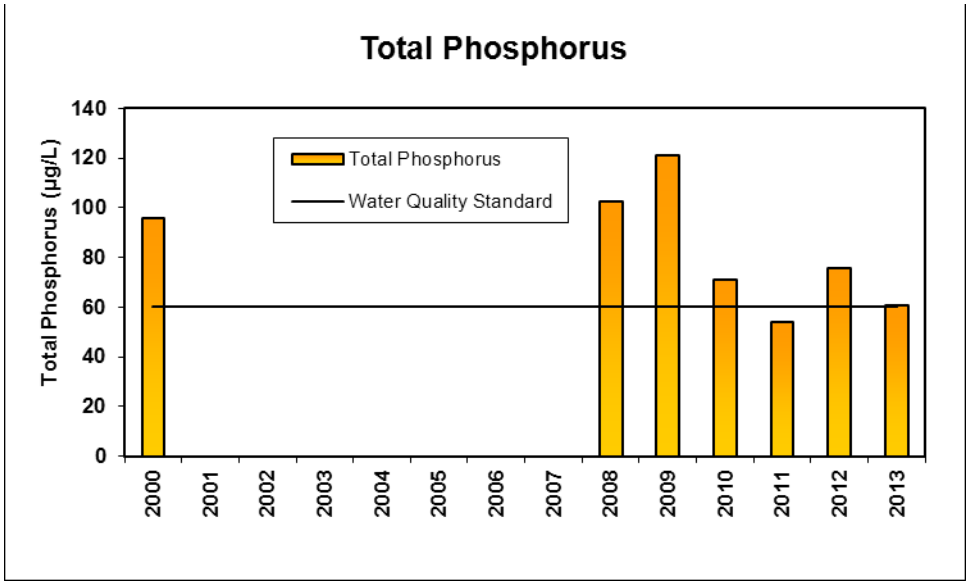

Figure 23.Whaletail-West Basin annual changes in average phosphorus concentration from 2000-2013.

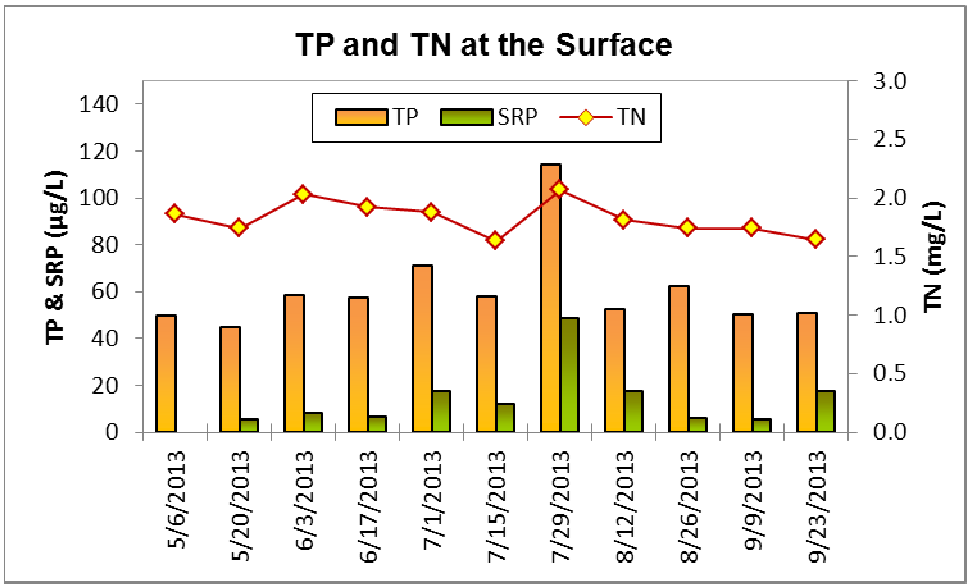

Figure 24.Whaletail-West Basin seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2013.

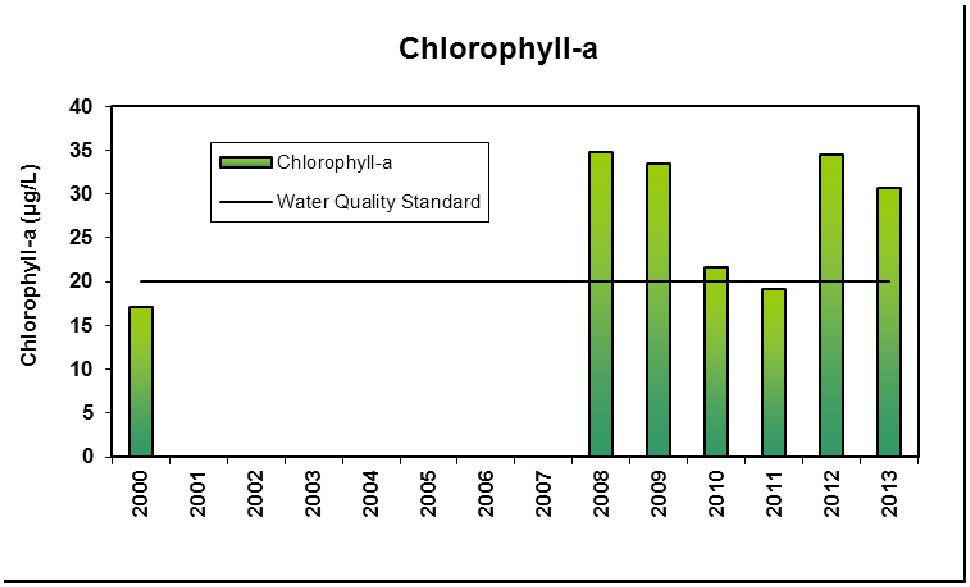

Figure 25.Whaletail-West Basin annual changes in average chlorophyll-a concentration from 2000-2013.

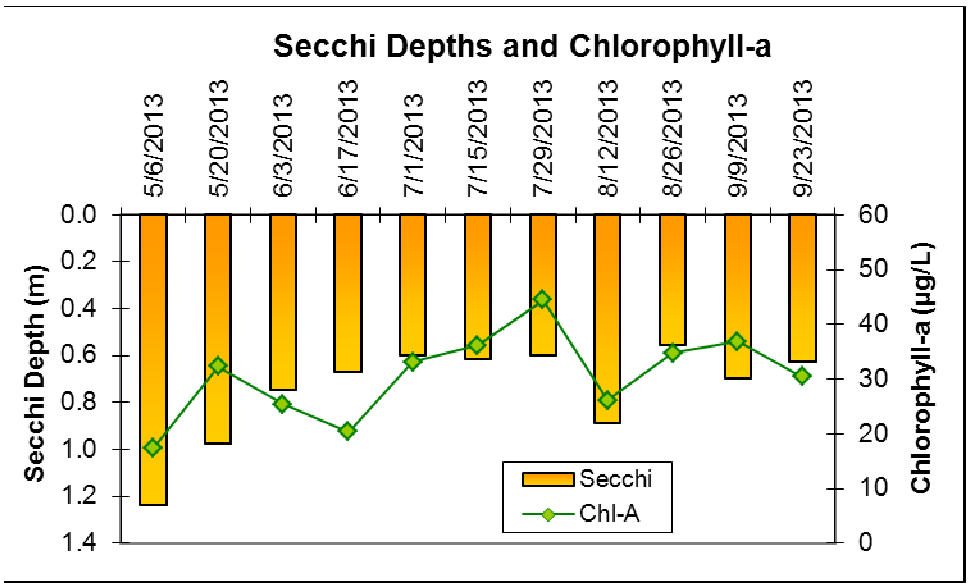

Figure 26.Whaletail-West Basin seasonal changes in Secchi depth and chlorophyll-a concentration in 2013.

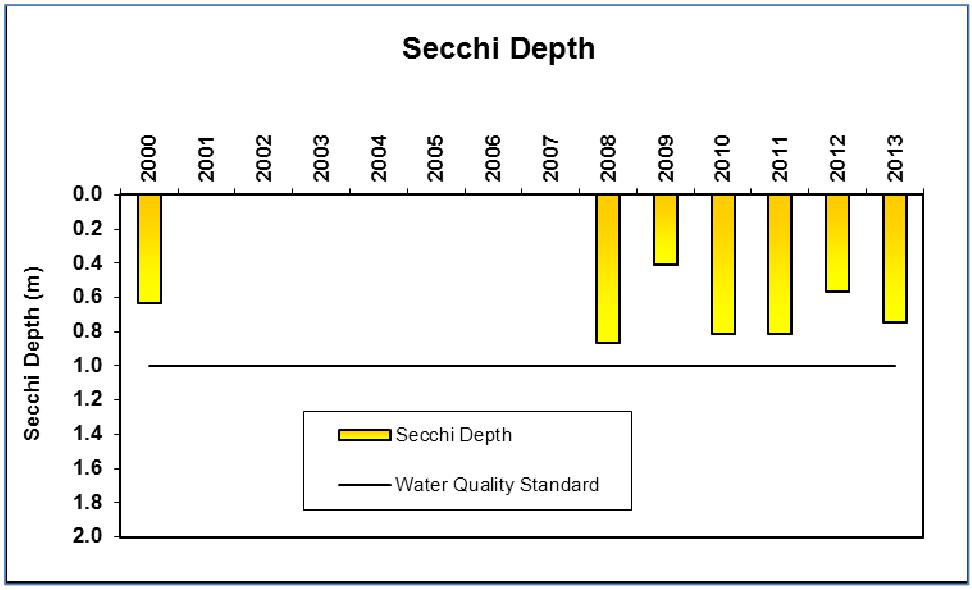

Figure 27.Whaletail-West Basin annual changes in average Secchi depth from 2000-2013.

Whaletail-East Basin

The east basin of Whaletail Lake typically has had better water quality in comparison to the west basin. The east basin has a maximum depth of 8 m that allows for the development of in-lake stratification during the summer. Stratification within the east basin typically persists throughout the summer (June-September) which confines the nutrients from sediment release within the hypolimnion. The west basins shallow morphology is more conducive for re-suspension of sediments and nutrients due to wind mixing. Based on the east basin water quality, the re-suspension of nutrients and sediments does not appear to occur as frequently as the west basin.

Although the east basin typically has better water quality, the water quality parameters typically do not meet MPCA standards. The average annual phosphorus concentrations within the east basin ranged between 44.6 µg/L to 55.0µg/L from 2000 to 2008 (Figure 28). The phosphorus concentrations substantially increased to 71.9 µg/L in 2009 (Figure 28). Since 2009, the annual average phosphorus concentration gradually decreased each consecutive year (Figure 28). In 2012, the average annual phosphorus concentration of 39.7 µg/Lactually met the state phosphorus standard (Figure 28). This was the first year in which phosphorus concentrations have met the MPCA standard since monitoring began in 2000. Unfortunately, the average phosphorus concentration increased to 45.1 µg/L (Figure 28) with values ranging between 34.6 µg/L to 65.2 µg/L in 2013 (Figure 29). The average phosphorus concentration in 2013 exceeded the state standard, but is still relatively lower in comparison to previous years monitored. The specific reason for the recent lower phosphorus concentrations in 2012 and 2013 are currently unknown. There doesn't appear to be any significant changes in the watershed that would account for reductions in watershed loading. Consequently, the decrease in phosphorus concentrations may be more attributed to changes in internal loading.

Despite the recent noticeable improvements in phosphorus concentrations, the water clarity conditions have slightly degraded in the past several years. The annual average chlorophyll-a concentration increased from 17.4 µg/L in 2010 to 24.5 µg/L in 2013 (Figure 30); and secchi depth transparency has decreased from 1.61 m in 2010 to 1.36 m in 2013 (Figure 32). The chlorophyll-a concentrations have never met the MPCA standards since monitoring began in 2000 (Figure 30). However, water clarity transparency occasionally meets the secchi depth state standard. The most recent annual period in which secchi depth met the state standard was in 2010 and 2011 (Figure 32). Unfortunately, secchi depth transparency did not meet MPCA standards in 2012 and 2013 (Figure 32). The past several years there doesn't seem to be a relationship between changes in the annual average phosphorus concentrations and water clarity. The changes in water clarity are most likely attributed to annual variations in zooplankton community.

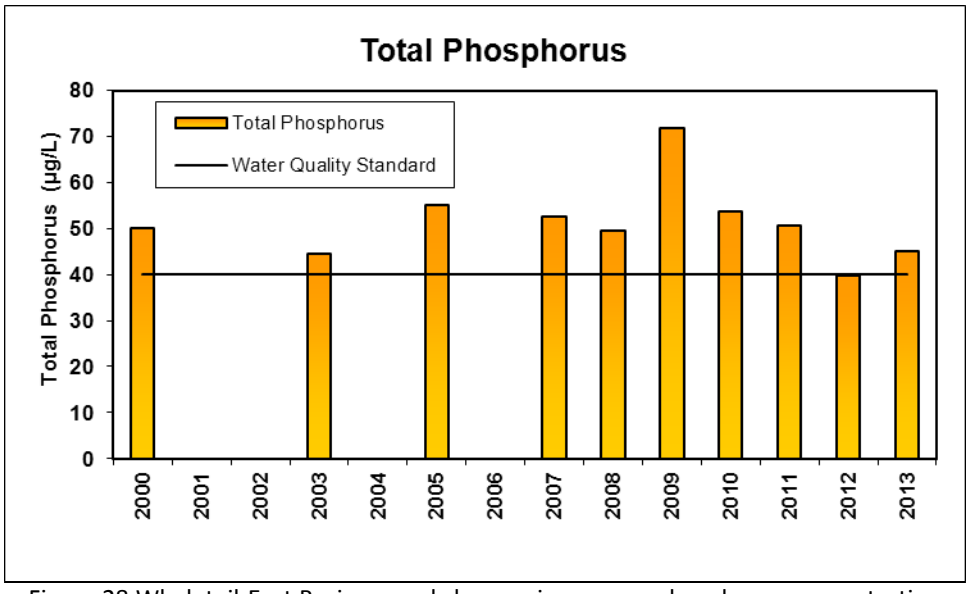

Figure 28.Whaletail-East Basin annual changes in average phosphorus concentration from 2000-2013.

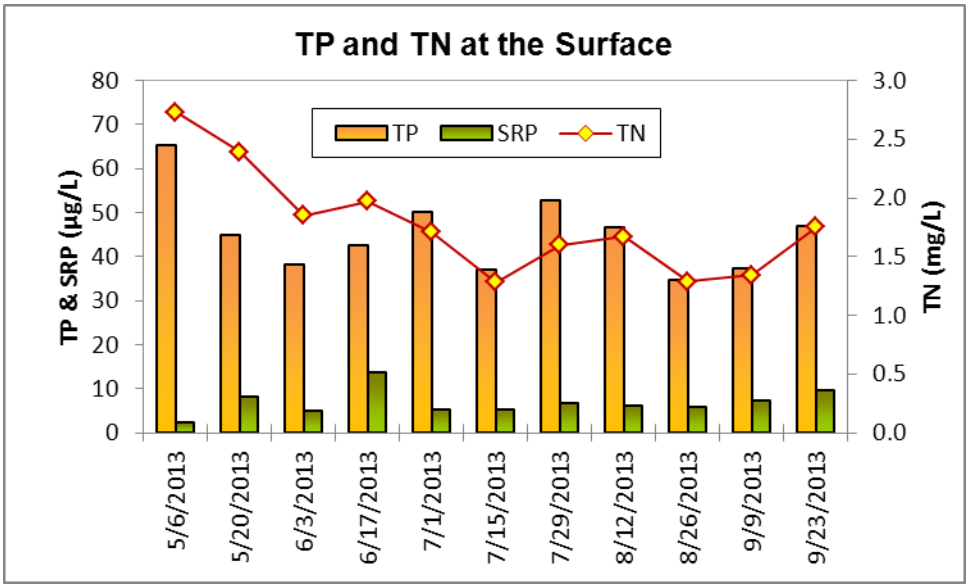

Figure 29.Whaletail-East Basin seasonal changes in total phosphorus, soluble reactive phosphorus, and total nitrogen concentrations in 2013.

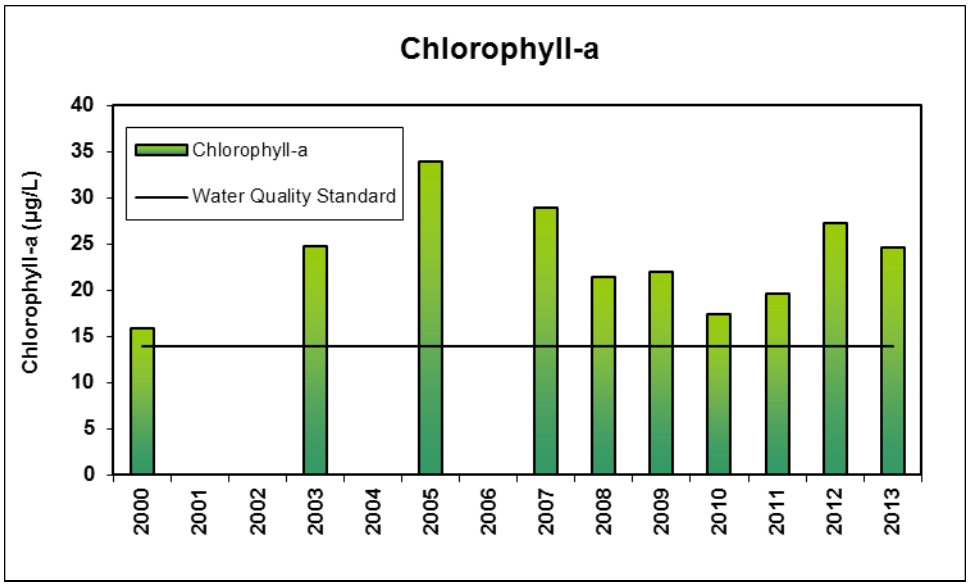

Figure 30.Whaletail-East Basin annual changes in average chlorophyll-a concentration from 2000-2013.

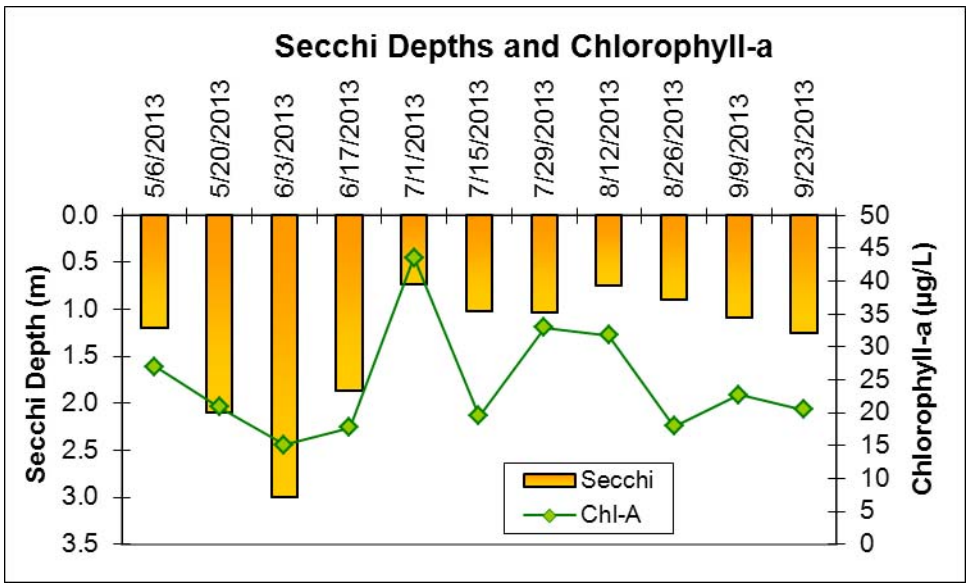

Figure 31.Whaletail-East Basin seasonal changes in Secchi depth and chlorophyll-a concentration in 2013.

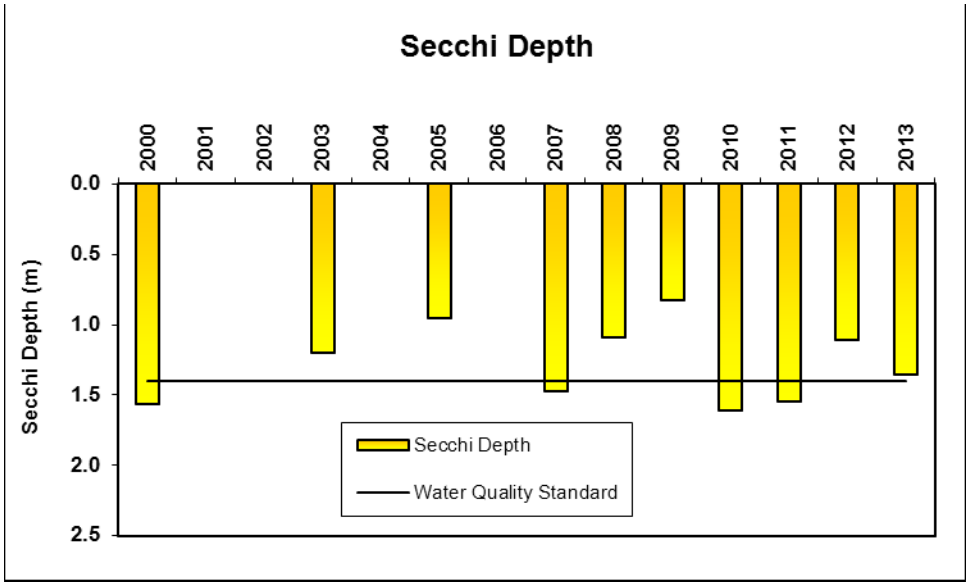

Figure 32.Whaletail-East Basin annual changes in average Secchi depth from 2000-2013.

2013 Lake Monitoring - CAMP

Hafften Lake was monitored through the 2013 Citizens Assisted Monitoring Program (CAMP). The 2013 annual CAMP report will be available in summer 2014.

CAMP was initiated by the Metropolitan Council to supplement the water quality monitoring performed by Met Council staff and to increase the knowledge of water quality of area lakes. Volunteers monitor the lakes semi-monthly from mid-April to mid-October. They note natural and cultural observations and general perceptions of the lakes' condition and suitability for recreation. They take a water transparency reading using a Secchi disk, measure surface water temperature, and collect surface water samples that are analyzed for total phosphorous, total Kjeldahl nitrogen, and chlorophyll-a.

Data from each lake's sampling forms and lab analyses are entered into a data management and statistical analysis program called Statistical Analysis System (SAS). Various quality control methods are used throughout the program to ensure that proper sampling and data analysis techniques were used. Suspect data are excluded from the databases or conclusions.

After some delay, Met Council's **2012 Annual Lake Report** is now available. The report is a product of a project to convert the Annual Lake report to an electronic and automated process, which delayed its publication. The report is in a similar format as before, except that the individual lake reports now have room for expanding data sets. The report is located on Met Council's EIMS document repository: http://es.metc.state. mn.us/eims related_documents/view_documents.asp.

Appendix 3

Pioneer-Sarah Creek Watershed Management Commission
Lake Monitoring History

Lake City	Ardmore Loretto	Hafften Greenfield	Half Moon Independence	Haughey Independence	Independence Independence Medina	Little Long Minnetrista	Peter Medina	Rattail Independence	Rebecca Greenfield Independence	Robbina Independence	Sarah Greenfield Independence	Schendel Greenfield	Schwauppauff Greenfield	Spurzem Medina	Whaletail Minnetrista	Winterhalter Medina
2013		C	T		T						T			T	T	
2012			T		T	M		S		S	T		S	T	T	
2011			T		T		C	T	T	T			T	T	T	
2010		T	T	x	T	x	x		x	x	T	x		T	T	x
2009	C	T			T	C	C				T			T	T	
2008	C				T						T			T		
2007	C				T	C					T			T		
2006		C			T	C			T		T			T		
2005		C			T						T			T	M	
2004		M			T	T					T			T	M	
2003						M								T	T	
2002				C	T	T			T		T					
2001		M				M									M	
2000		M									T				T	
1999						T	T					T				
1998		T				M				T	T				M	
1997																
1996		T					T								T	
1995																
1994					C		T				T					
1993					C	T									T	
1992							T				T					
1991	T					T										
1990							T								T	
1989						T					T			T		
1988					T		T				T					T

T = Monitored by Three Rivers Park District/Hennepin Parks
C = Monitored through the CAMP Program
M = Monitored by Metropolitan Council
S = Monitored as part of SWAG IN 2012. Irene Mud and Rice lakes were also monitored.

Lake Rebecca – a small lake with big improvements

August 2013 Snapshots

Post-alum treatment picture of Lake Rebecca. According to Three Rivers Park District, more than 187,000 people visit the park annually.

It took more than ten years to accomplish, but 254-acre Lake Rebecca in Hennepin County is finally cleaned up.

First listed on the state's impaired water's list in 1998 for excessive mercury, Lake Rebecca was also listed in 2008 for excess nutrients, limiting recreation on the popular west-metro lake. At one point, the excess nutrients (phosphorus) caused so much algae that the swimming beach had to be curtained off to allow for summer fun.

Richard Brasch, senior water resources manager at Three Rivers Park District, said that a substantial part of the pollution affecting Lake Rebecca can be considered "legacy" impacts of poor land use management practices that probably severely affected the lake even prior to the time the park district purchased the land in the 1960s.

"Foremost among these was probably the wintering of cattle on the ice of Lake Rebecca, which may be single biggest causal factor in the high internal loading rates in the lake," Brasch said.

Managed by Three Rivers Park District and Hennepin County Environmental Services, staff worked for years to target sources of pollution and install a series of best management practices (BMPs) that would decrease nutrient loading.

One of the bigger partnerships staff developed to address lake pollution was with the Zuhrah Shriners, who own a nearby ranch. Pinpointing runoff issues, staff worked tirelessly with the Shriners to identify solutions and install feedlot and manure best management practices. Additional projects on the property included exclusion fencing, easement acquisition, buffers, waterways, clean water diversions, runoff ponding areas, and a manure containment stacking slab.

Hennepin County Environmental Services Senior Scientist Jim Kujawa said the Shriners take serious pride in personal responsibility and therefore have been receptive to changes in their operation. "We have assisted them for more than fifteen years and they really like the projects," Kujawa said.

More work was needed to clean up the lake. Three Rivers Park District installed stormwater BMPs in the park such as pervious pavement and shoreline improvements as part of park upgrade projects. Finally, the Three Rivers Park Board treated the invasive curly-leaf pondweed for three consecutive years, funded by a DNR Aquatic Plant Management grant. The third year's treatment also included an alum treatment which binds the in-lake phosphorus to the bottom. Outdoor Heritage Funds (from the Clean Water, Land and Legacy Amendment) partially funded the in-lake treatments.

Other funding sources included Hennepin County, Hennepin Conservation District, and Pioneer - Sarah Creek Watershed Management Organization, which paid for Hennepin County staff to remain persistent working with the Zuhrah Shriner's. Construction costs for the runoff control and feedlot projects were split between Hennepin County's Natural Resource Incentives for Critical Habitat (NRICH) cost-share program, federal NRCS funds, and the State Cost Share Program (Board of Water and Soil Resources).

Brasch said visitors to the park have responded positively to the changes in the lake. "Most gratifying is that a 2012 survey of repeat beach users indicated that almost 2/3 of those surveyed indicated a noticeable improvement in water quality in the lake and 3/4 of all of those surveyed gave water quality in the lake a school grade of 'B' or 'A'," Brasch said.