2012 Water Quality Monitoring and TMDL Implementation Status Report

Wenck File #0002-188

Prepared for:

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Acronyms

BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
cfs	cubic feet per second
CFU/100 mL	colony forming units per 100 milliliters
Chlor-*a*	Chlorophyll-*a*
CRWD	Clearwater River Watershed District
District	Clearwater River Watershed District
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
lbs	Pounds
MDNR	Minnesota Department of Natural Resources
µg/L	micrograms per liter
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency
NCHF	North Central Hardwood Forest
Ortho-P	Ortho-Phosphorus
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids

Executive Summary

This report was prepared by Wenck Associates, Inc. (Wenck) for the Clearwater River Watershed District (CRWD) to provide a description of the District's monitoring program, summarize and analyze 2012 monitoring data, and provide a progress report of TMDL Implementation activities in the District.

Significant findings in this report include the following:

1. Annual precipitation was near normal overall at monitored locations for the year in 2012, with the exception of May and June, which were far above normal, and August through November, which were far below normal.

2. Runoff over the District was near normal overall, but started the year lower than normal following a winter with very little snowfall. Runoff was higher than normal during a period following well above average precipitation in May and June. Runoff was below normal from August through November, when very little precipitation fell and many stream channels stopped flowing or dried up entirely.

3. Phosphorus loads from the Clearwater River were lower than those observed in recent years due to decreased runoff in 2012. The phosphorus load from the Clearwater River was estimated at 3,009 lbs at CR 10.5 (Grass Lake Dam). The upper watershed load measured at CR28.2 was 13,440 lbs. While this was a reduction from previous year's loads, it was still much higher than the goal established for downstream Lake Betsy (2,280 lbs) and Clearwater Lake (4,000 lbs).

4. Flow-weighted average phosphorus concentrations were 24 µg/L and 335 µg/L at CR 10.5 and CR28.2, respectively. The concentration at CR10.5 was similar to concentrations seen in recent years, which demonstrates the good water quality in Clearwater Lake. The concentration observed at CR28.2 was higher than recent years and indicates the potential export of phosphorus from the Kingston Wetland during low flow conditions.

5. Phosphorus loading at Warner Creek station WR0.2 was 818 lbs in 2012, which was far lower than recent phosphorus loads at the site, which had been increasing since 2009. Expanded monitoring was performed at two upstream locations on Warner Creek in 2012 to determine potential sources of phosphorus in the watershed.

6. Soluble phosphorus made up a large percentage of total phosphorus at monitoring stations downstream of wetland complexes in 2012, except at Warner Creek. This indicates that the export of soluble phosphorus from the wetlands contributes a significant portion of the phosphorus load at these locations during periods of normal or

lower than normal runoff, as experienced in 2012. Projects implemented to reduce phosphorus in the District should include components to reduce soluble phosphorus, as did the Clear Lake project constructed in 2012.

7. With the exception of the 11 lakes that are impaired in the District, the water quality of CRWD lakes is generally good. Water quality has generally improved or remained stable in the majority of the lakes in the District in recent years. The exception is Scott Lake, Lake Louisa, Lake Marie, and Lake Caroline where an increasing phosphorus trend has been observed over the last four years. The increased phosphorus concentrations are likely due to increased loads in the Clearwater River due to a combination of higher runoff and higher phosphorus concentrations in most recent years. Due to their flow - through nature, water quality in these lakes is driven by the hydrology of the Clearwater River. During wet years , phosphorus concentrations approach concentrations observed in the Clearwater River. During dry years, phosphorus concentrations are impacted more heavily by internal loading in the lakes.

8. Lake monitoring efforts conducted in 2012 confirm the impact of internal loading of nutrients in some District lakes, as evidenced by monitoring data showing high bottom phosphorus concentrations that typically increase steadily throughout the summer, and periods of anoxia (dissolved oxygen concentrations < 2.0 mg/L) in some lakes. Monitoring data indicates that lakes especially susceptible to internal nutrient loading include Albion, Swartout, Henshaw, Augusta, Caroline, Louisa, Marie, Betsy, Scott, and Union. CRWD will continue to evaluate potential actions identified in the Watershed Restoration and Protection Plan (TMDL Implementation Plan) that address internal loading in future years.

9. Dissolved oxygen (DO) monitoring conducted in the District identified and confirmed sites with DO impairments. As observed in past years, most DO impairments were observed at sites downstream of large wetland complexes. This confirms conclusions drawn in previous years, that wetland sediment oxygen demand is the cause of low DO at these locations.

10. Continued diagnostic and effectiveness monitoring as part of Cedar Lake Project #06-1 showed that the watershed phosphorus load in 2012 to Cedar Lake of approximately 2,543 lbs remains above the project goal of 1,000 lbs. The majority of the load to Cedar Lake was received during a period of high flow in early June caused by a combination of heavy precipitation and the removal of stoplogs in the Swartout Lake outlet by vandals which allowed a pulse of high-phosphorus water out of Swartout and into Cedar Lake. Summer average phosphorus and chlorophyll-*a* concentrations in Cedar Lake decreased in 2012 and are meeting minimum water quality standards established by the Minnesota Pollution Control Agency (MPCA). However, summer average phosphorus concentrations remain above the goal of 20 µg/L established through Project #06-01, indicating that additional load reductions, additional actions, and time are necessary to

meet lake water quality goals. Water clarity was similar to previous years in 2012 and was good overall except for a period in June following an algae bloom.

11. The CRWD conducted rough fish removal in Segner Pond in 2012, removing approximately 12,000 lbs of carp in May. Rough fish removal efforts will continue in the District in 2013. No winter seining was conducted in 2012 due to poor ice conditions. In past years, winter seining has yielded significant reductions in carp populations. Field observations made in 2012 indicate that the fish population in Henshaw Lake is once again dominated by rough fish of multiple year classes indicating that seining would benefit the lake.

12. The fish trap upstream of Lake Louisa was not operated in 2012. Winter seining in the upper watershed has typically yielded far higher removal rates for rough fish than operation of the fish trap. High rough fish populations have been documented in the Upper Clearwater River and Upper Lakes. For example, 80,000 lbs of rough fish were removed from Lake Betsy in 2011. The area between Kingston Wetland and Lake Louisa provides some habitat that is potentially ideal for rough fish spawning.

13. The results of water quality monitoring and aquatic vegetation surveys conducted in Swartout, Albion, and Henshaw Lakes in 2012 continue to support the connection of lake water quality to the status of fish communities in these lakes. The aggressive management of rough fish leads to clear state shallow lakes in this system, as observed in Swartout Lake in recent years. Shallow lakes in the clear state foster rooted aquatic plant growth which, coupled with lower rough fish populations, stabilize bottom sediments which can reduce internal loading and improve in lake water quality and reduce nutrient export to downstream lakes.

14. In 2012, the CRWD made progress towards water quality goals established in the Watershed Restoration and Protection Plan (WRPP/ TMDL Implementation Plan) by:
    - implementing additional monitoring tasks to fill data gaps identified in the TMDL. Collection of these data assist in achieving grants, final design of capital improvement projects and improved targeting of BMPs;
    - applying for and securing grant dollars for two projects to protect and improve water quality in the Cedar Lake sub-watershed;
    - completing design and permitting for Kingston Wetland Restoration project;
    - construction of a notched weir and iron-sand filter water quality improvement project on a tributary stream south of Clear Lake targeting particulate and soluble phosphorus load reductions in Clear Lake.
    - continuing work on three projects implemented in 2010 and 2011, including:
        - completing seeding and planting on a stormwater reclamation and reuse project in the City of Kimball,

  - executing the contract for the targeted fertilizer application reduction project in the upper watershed and enrolling participants in the program which is funded in part by a federal 319 grant,
  - conducting streambank restoration and stabilization project on the Clearwater River with the Minnesota Conservation Corps
- continuing project development towards securing grant funding to implement projects identified in the WRPP:
  - Watkins impoundment, and
  - Lake Betsy hypolimnetic withdrawal

15. In 2013, the CRWD plans to continue progress towards TMDL goals by:
    - continuing monitoring water quality, hydrology and hydraulics to track water quality trends, project effectiveness and improve efficiencies of implementation projects,
    - conducting rough fish removal and migration mangement
    - continuing to implement the Soil Testing and GPS Fertilizer Application Project by enrolling landowners and conducting follow-up monitoring
    - constructing the Kingston Wetland Restoration Project,
    - finalizing a design for the Kimball Phase II project at let bids,
    - continued development of the Cedar Lake Improvement Project,
    - identifying additional projects and continuing to apply for grant dollars to fund other CRWD projects, and
    - continuing education and outreach efforts, focusing on social media and schools

1.0 Introduction

The Clearwater River Watershed District (CRWD) has conducted a stream, precipitation, and lake monitoring program since 1980 (Appendix A). Ongoing monitoring is critical to establish baseline water quality and hydrologic data and to assess long-term water quality trends within the CRWD.

1.1 PURPOSE

The objectives of the monitoring program are:

1. Track progress towards water quality goals for impaired waters,
2. Fill data gaps identified in the TMDLs, and evaluate water quality through annual monitoring program,
3. Continue to provide baseline water quality data and calibration data sets to refine TMDL load reductions, and
4. Track long-term trends in all CRWD waters monitored ensuring early detection of declining trends.

Data collected through the monitoring program has documented dramatic improvements in lake water quality since the early 1980s, as well as significant reductions in stream nutrient and sediment loads (Appendix B and C). These improvements were largely the result of the CRWD's 1980 Chain of Lakes Restoration Project and other District initiatives. However, some water bodies do not meet state water quality standards for designated uses (aquatic habitat or recreation for example).

1.2 TMDL'S

The CRWD, in partnership with the Minnesota Pollution Control Agency (MPCA), began a Total Maximum Daily Load (TMDL) study in 2003 to address the District's impaired waters. The TMDL process establishes the amount of a given pollutant that the water body can assimilate while still meeting its designated uses. The TMDL studies were finalized in 2008 and the required nutrient, bacteria and oxygen demand load reductions have been quantified.

The status of TMDLs in the District is shown in Table 1.1. Many are complete and were approved by the MPCA, EPA and the public via a public comment period.

Through the TMDL process, the CRWD identified a suite of implementation strategies in the watershed needed to meet water quality goals for impaired waters and to protect water quality of all CRWD waters. These are documented in the Watershed Restoration and Protection Plan for the CRWD (TMDL Implementation Plan) which was approved by the MPCA in May of 2009.

Following the completion of the TMDLs, the CRWD undertook a revision of its Watershed Management Plan to reflect the recommendations in the TMDL and expand on them. The revised Watershed Management Plan was completed and approved by BWSR in 2011. TMDL reports can be found at the MPCA website at http://www.pca.state.mn.us/water/tmdl. The Watershed Management Plan is available at the CWRD web site www.crwd.org.

Another TMDL effort is underway for the larger 8-digit hydrologic unit code (HUC) 07010203, which includes CRWD as well as the Sauk and Elk River watersheds (Figure 1.1). This process began in 2009 under the MPCA's new approach to TMDLs called the watershed approach. The watershed approach is a 10-year rotation for assessing waters of the state on the level of Minnesota's major watersheds (8-digit HUCs). This process is scheduled to be completed in 2013, is being led by the Elk River Watershed Association (ERWSA) and Sherburne County Soil and Water Conservation District. Data collected through this project has resulted in the identification of new impairments and TMDLs needed within the CRWD based on indices of biotic integrity. These impairments are also listed in Table 1.1. Future funding for TMDL related efforts will also largely be controlled by this process; as such it is important for CRWD to remain strongly involved in this process.

Table 1.1 Impaired Waters in CRWD

Water	Impairment and Impaired Use	TMDL Status	Listing Date
Clear Lake (47-0095)	Nutrients, aquatic life and recreation	EPA Approved.	2008
Lake Betsy (47-0042)			2008
Union Lake (86-0298)			2008
Scott Lake (86-0297)			2008
Lake Louisa (86-0282)			2004
Lake Marie (73-0014)			2008
The Clearwater River, Clear Lake to Lake Betsy	Dissolved oxygen and bacteria, aquatic life & recreation		2004
Lake Caroline (86-0281)	Nutrients, aquatic life and recreation	EPA Approved.	2010
Lake Augusta (86-0284)			2010
Swartout Lake (86-0208)			2010
Lake Albion (86-0212)			2010
Henshaw Lake (86-0213)			2010

Water	Impairment and Impaired Use	TMDL Status	Listing Date
The Clearwater River, Grass Lake to the Mississippi	Dissolved oxygen, aquatic life and recreation	This listing was under consideration at MPCA as data collected during the 2007 TMDL study did not support the presence of an impairment, however, data collected in 2011 have indicated an impairment may exist under some high flow conditions. Currently this listing is slated to be addressed during the Mississippi St. Cloud Watershed TMDL.	2008
Clearwater River (Scott Lake to Lake Louisa)	Aquatic Life (Aquatic macroinvertebrates, fish)	Proposed to be listed in 2012.	--
Clearwater River (Clearwater Lake to Mississippi River)	Aquatic Life (Fish)	Proposed to be listed in 2012.	--
Fairhaven Creek (Headwaters to Lake Louisa)	*E. coli* bacteria	Proposed to be listed in 2012.	--

Figure 1.1 Geographic Coverage of 8-Digit HUC Watershed TMDL Currently Underway

1.3 CURRENT PROJECTS

To meet lake water quality goals, nutrient loads must be managed from both watershed sources and internal nutrient cycling sources. Several of the watershed management strategies identified for lakes will also assist with meeting bacteria and dissolved oxygen goals for the Clearwater River. Projects and programs to achieve water quality goals were identified in the CRWD's Watershed Restoration and Protection Plan and are expanded upon in the CRWD's Watershed Management Plan which has been formally approved by BWSR.

The CRWD has also applied for grants since 2009 to fund several of the projects/ programs identified through the TMDL process and subsequent studies. Projects and their status are described in detail in Section 5 of this report. In 2012, the CRWD conducted work on the following grant funded projects:

- Streambank restoration of the Clearwater River in the upper watershed,
- Phase II of a municipal stormwater project to retrofit the city of Kimball, MN and provide stormwater treatment for its surrounding watersheds.
- A stream channel/ wetland restoration of the Kingston Wetland.
- The CRWD also applied for and received a BWSR Clean Water Legacy grant for the following project in 2012: Cedar Lake Watershed Protection and Improvement Project. The project abstract follows: In 2002 citizens began to notice severe algal blooms in Cedar Lake, a high value recreational lake with exceptional clarity and fisheries habitat. Those observations, coupled with a sharp rise in average summer phosphorus and chlorophyll-a raised a red flag over the future of the lake. Clearwater River Watershed District began an intensive monitoring program in 2003 to identify nutrient sources and protect Cedar Lake. Through intensive lake and watershed monitoring, CRWD identified the major source of nutrients to the lake: three nutrient impaired shallow lakes (Swartout, Albion and Henshaw Lakes) in the upper watershed and impaired wetlands discharged excess amounts of soluble phosphorus. CRWD also identified a suite of in-lake and watershed BMPs to improve water quality in the impaired shallow lakes to protect Cedar Lake. Implementation of these projects began in 2007. A TMDL for the three upstream lakes was approved by EPA in 2009 and MPCA approved a Watershed Wide Implementation plan also in 2009. Since 2007, CRWD has implemented as many capital and programmatic BMPs as possible with current funding and landowner participation, but additional load reductions are needed to meet water quality goals in all the lakes. The project targets reductions to the largest watershed sources of nutrient to Cedar and Swartout Lakes by installing iron sand filters to remove soluble phosphorus currently exported from degraded wetlands and lakes. The target is to size sand filters to treat baseflow and the 1.25-inch event to provide the maximum cost/ benefit while preserving upstream hydrology. The projects target reductions from the largest watershed sources of nutrients to each lake providing 80% of the necessary watershed load reductions to Swartout Lake (800 lbs/yr), and 40% of the necessary watershed load reductions to Cedar Lake (480 lbs/ yr).

1.4 CURRENT MONITORING

The 2012 CRWD monitoring plan is found in Appendix A, and summarized below. Figure 1.2 shows locations that were monitored in 2012. Figure 1.3 shows locations of impaired water bodies in the CRWD.

- Thirteen lakes were monitored in 2012 to track long-term trends. The lakes monitored by CRWD in 2012 included Clearwater Lake West, Lake Augusta, Lake Louisa, Lake Caroline, Scott Lake, Marie Lake, Lake Betsy, Pleasant Lake, Clear Lake, Otter Lake, Union Lake, Wiegand Lake, and Little Mud Lake.

- Long-term Clearwater River monitoring stations CR-28.2, located upstream of Lake Betsy, and CR 10.5, located at the Grass Lake Dam, were sampled in 2012. The long-term monitoring station on Warner Creek near its inflow to Clearwater Lake at WR 0.2 was also sampled in 2012.
- Citizen Precipitation Recorders (CPRs) maintained precipitation records in Watkins, Kimball, and Annandale. Additional monitoring was conducted on tributary streams to Clear Lake, and on Willow Creek and Warner Creek in 2012. Water quality and flow were monitored at two additional stations on Warner Creek (WR 1.4 and WR 2.7) near Annandale, two additional stations on Willow Creek (WC 2.5 and WC 3.0) in Kimball, and two tributary streams to Clear Lake.
- Continuous Clearwater River water levels were monitored upstream and downstream of the Kingston Wetland and at the Grass Lake Dam in 2012.
- Monitoring continued in the Cedar Lake sub-watershed in 2012 to track progress on the Cedar Chain of Lakes Improvement Project #06-1. Samples were collected from Albion Lake, Cedar Lake, Henshaw Lake, and Swartout Lake as well as from four tributary streams in the sub-watershed and the outlet of Cedar Lake. Vegetation surveys were also conducted on Swartout, Albion, and Henshaw Lakes.

Figure 1.2 2012 Monitoring Locations

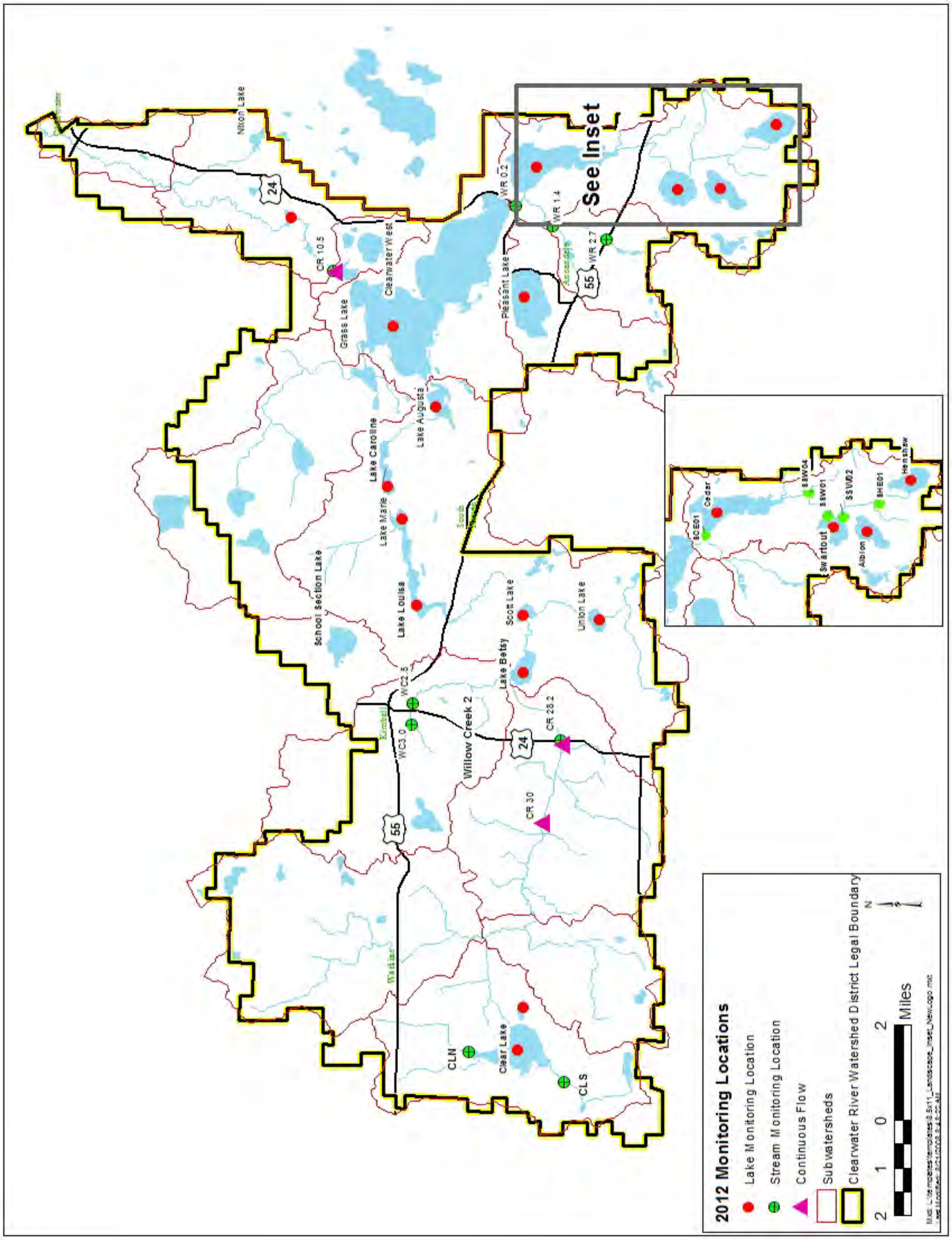
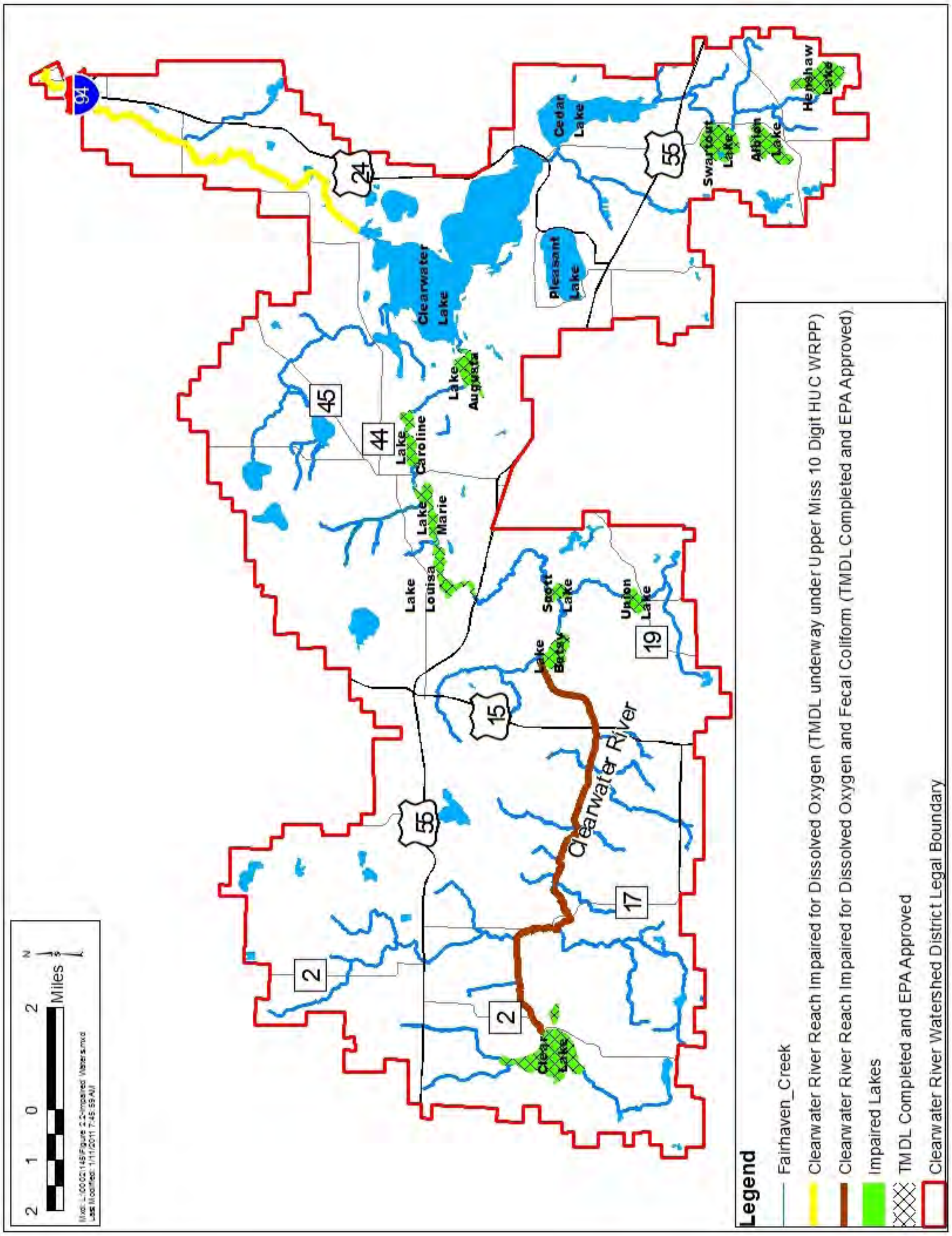


Figure 1.3 Impaired Water Bodies in CRWD



2.0 Hydrology

2.1 PRECIPITATION

Total annual precipitation measured in 2012 was below normal for the year at all five locations across the District. Precipitation was below or near normal during January to April at most stations. Precipitation was well above normal in May at all stations and above or near normal in June and July at most stations. Precipitation levels were well below normal in August through November across the District. Table 2.1 summarizes 2012 precipitation levels and Appendix D contains summary charts for each station and the precipitation records for the CRWD.

Table 2.1 Clearwater River Watershed District 2012 Precipitation Records and Normals (inches)

	2012 St. Cloud (Saint Cloud WSO Airport)	1971-2000 Normal (St. Cloud)	2012 Watkins (Meeker)	2012 Watkins2 (Meeker)	2012 Kimball (Meeker)	1971-2000 Normal (Litchfield)	2012 Annandale/ Corinna (Wright)	1971-2000 Normal (Cokato)
January	0.57	0.76	0.41	0.02	0.76	0.79	0.78	0.93
February	1.23	0.59	1.26	0.61	1.14	0.67	2.00	0.70
March	1.15	1.50	1.23	1.35	4.17	1.55	1.26	1.69
April	2.6	2.13	1.85	2.38	2.34	2.35	2.59	2.33
May	8.76	2.97	9.36	7.95	7.93	3.37	8.26	3.30
June	2.36	4.51	5.25	5.32	3.94	4.89	5.12	4.62
July	3.59	3.34	3.74	3.73	2.88	4.02	4.08	4.04
August	1.22	3.93	1.21	1.34	1.27	3.67	1.36	4.00
September	0.24	2.93	0.09	0.19	0.00	2.92	0.18	2.78
October	0.73	2.24	0.98	0.84	0.76	2.15	0.65	2.23
November	1.18	1.54	1.21	0.97	0.75	1.50	0.85	1.73
December	1.5	0.69	1.58	0.43	1.56	0.68	1.37	0.71
Total	**25.13**	**27.13**	**28.17**	**25.13**	**27.50**	**28.56**	**28.50**	**29.06**

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Below Normal Precipitation

Above Normal Precipitation

2.2 RUNOFF AND DISCHARGE

Dry conditions in late 2011 and very little snowfall in early 2012 lead to low runoff across the District in early spring 2012. The heaviest runoff occurred during a period in early summer following significant precipitation events in May and June. Below normal precipitation for most of the remainder of summer and fall contributed to slightly below average runoff overall for the year. Photographs that were taken at the Grass Lake Dam in June and August demonstrate the different runoff conditions observed in 2012 (see below). Runoff over the upper watershed was 5.2 inches upstream of Lake Betsy at CR 28.2 and 5.6 inches at the outlet of Clearwater Lake (CR10.5), which was lower than the long-term average runoff at CR 10.5 of 8.1 inches and similar to other years with similar precipitation.

Average flows in the Clearwater River were near the long-term average at CR 28.2 and CR10.5; at 35.72 cfs and 91.37 cfs, respectively. Table 2.2 summarizes the runoff volumes and average flows for the monitoring stations. Table B-1 in Appendix B compares the long-term precipitation to runoff for the CRWD as recorded at CR 10.5. Figure B-1 in Appendix B compares historic annual runoff and precipitation in the CRWD. Total runoff over the District is shown in Table B-2 in Appendix B.

Grass Lake Dam June 22, 2012

Grass Lake Dam August 31, 2012

Table 2.2 2012 Runoff Volume and Average Flow

Station	Tributary Sub-watershed Area (acres)	Runoff Volume (ac-ft)	Runoff Over Watershed (inches)	Average Flow in 2012 (cfs)
CR 10.5	99,200	46,030	5.6	91.37
CR 28.2	33,977	14,738	5.2	35.72
WR0.2	16,992	6,199	4.4	17.08

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Continuous Flow Monitoring Sites

In 2012, stream levels were monitored continuously at three sites on the Clearwater River to develop a continuous flow record at the sites, which allows for better quantification of seasonal runoff. Pressure transducers recorded the stream surface elevation at 15 minute intervals upstream of the Kingston Wetland at CR30 and downstream of the Kingston Wetland at CR28.2 while the Clearwater River was flowing from March to October. A pressure transducer was installed at the Grass Lake Dam at the end of July and recorded data through October (site locations shown on Figure 1.2). Data will continue to be collected at this site in future years to maintain a continuous flow record at CR 10.5.

Continuous water elevations at the stations near the Kingston Wetland are shown in Figure 2.1. 2012 continuous flow at CR28.2 is shown in Figure 2.2.

Figure 2.1 2012 Clearwater River Continuous Water Level Elevations (Kingston Wetland)

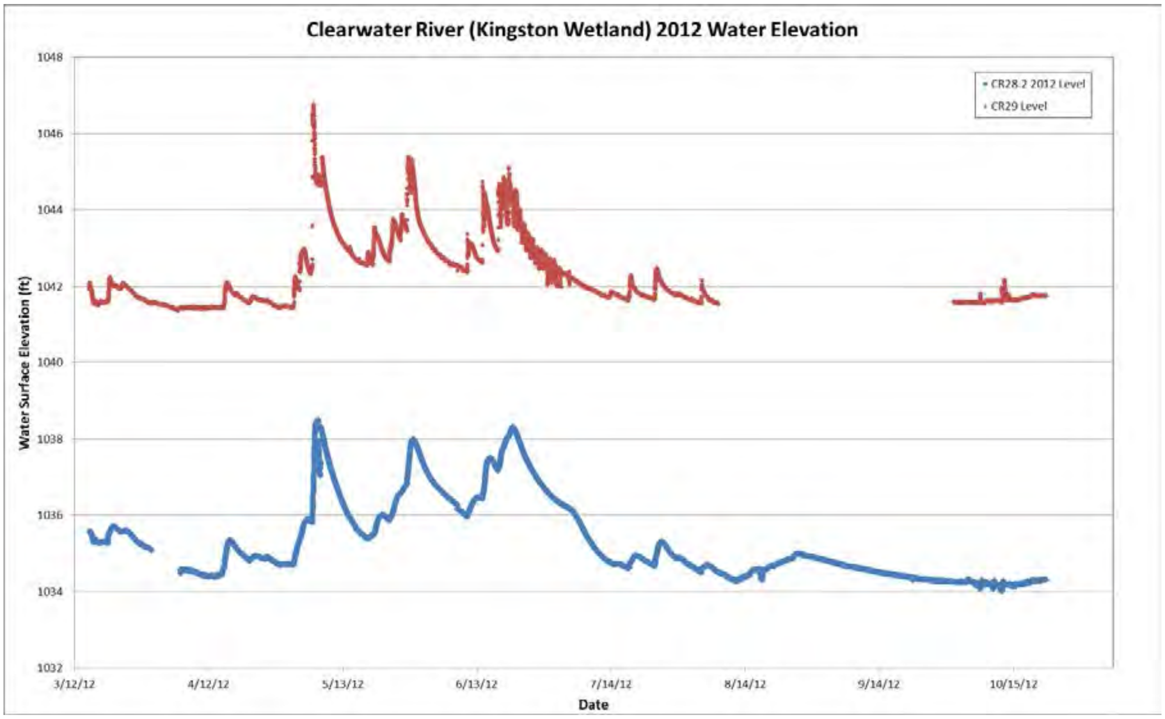
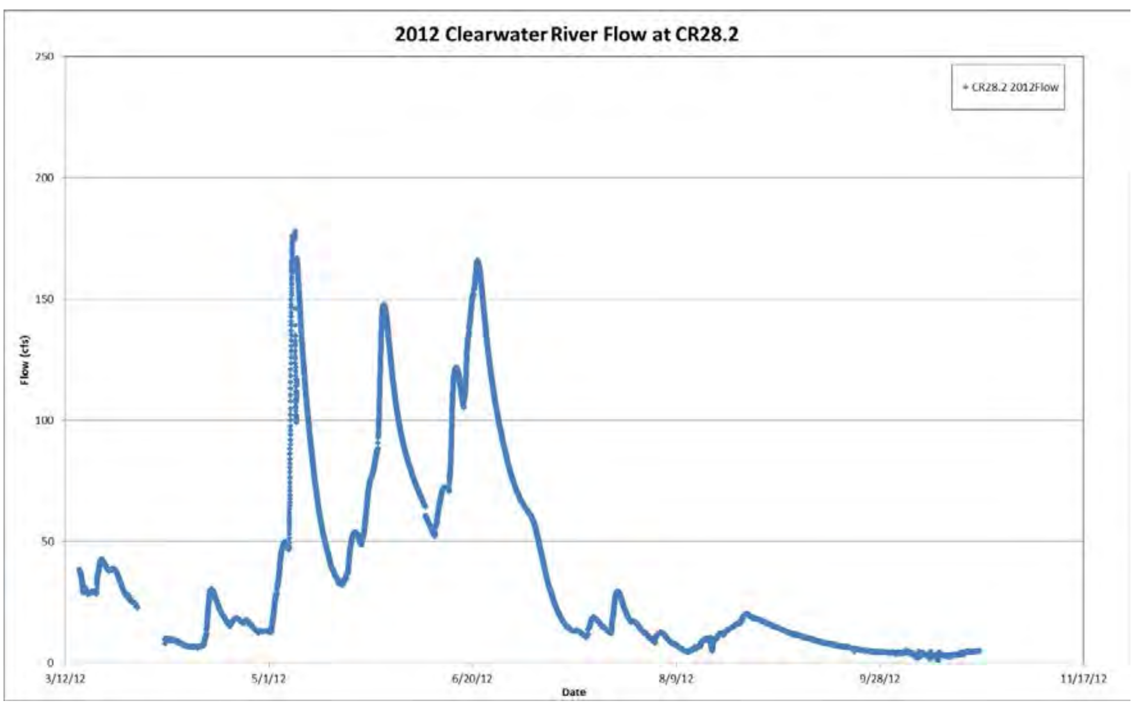


Figure 2.2 2012 Clearwater River Continuous Flow at CR28.2



3.0 Water Quality

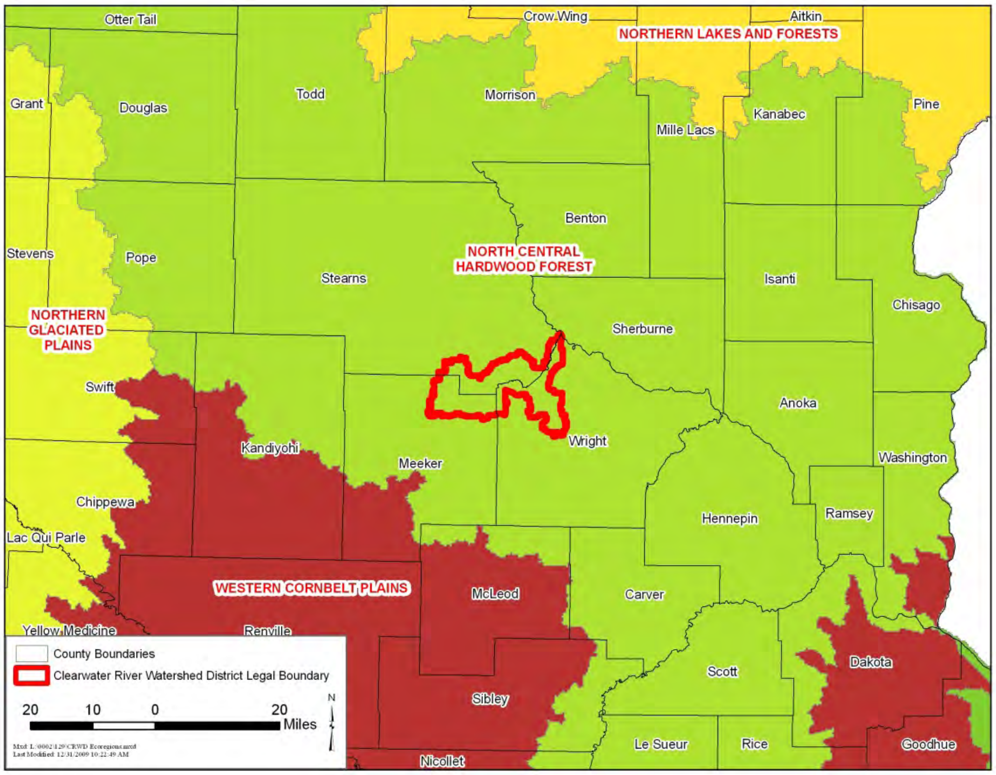
3.1 STREAM WATER QUALITY

Stream water quality was monitored at two long-term stations on the Clearwater River and one long-term station on Warner Creek in 2012. Stream water quality was also monitored at additional stations on Warner Creek, Willow Creek, and upstream and downstream of Clear Lake. Water quality samples were collected monthly or bi-monthly while the streams were flowing from March to October. The water quality samples were analyzed for total phosphorus, ortho-phosphorus, and total suspended solids concentrations. Field data collected during monitoring visits included water temperature, dissolved oxygen, water level elevation, and flow.

CRWD Staff Conducting Monitoring in the Clearwater River

Annual mean concentrations were calculated for comparison to typical concentration ranges and state water quality impairment standards, which are organized by ecoregion across the state. CRWD lies in the North Central Hardwoods Forest NCHF Ecoregion but is close to the border with the Western Corn Belt Plains (WCBP) Ecoregion as demonstrated in Figure 3.1. The watershed's tributary to stations and CR28.2 have characteristics similar to the nearby WCBP ecoregion. For this reason, typical concentrations from both ecoregions are provided for comparison to mean concentrations at CRWD stream monitoring stations.

Figure 3.1 Clearwater River Watershed District Ecoregions



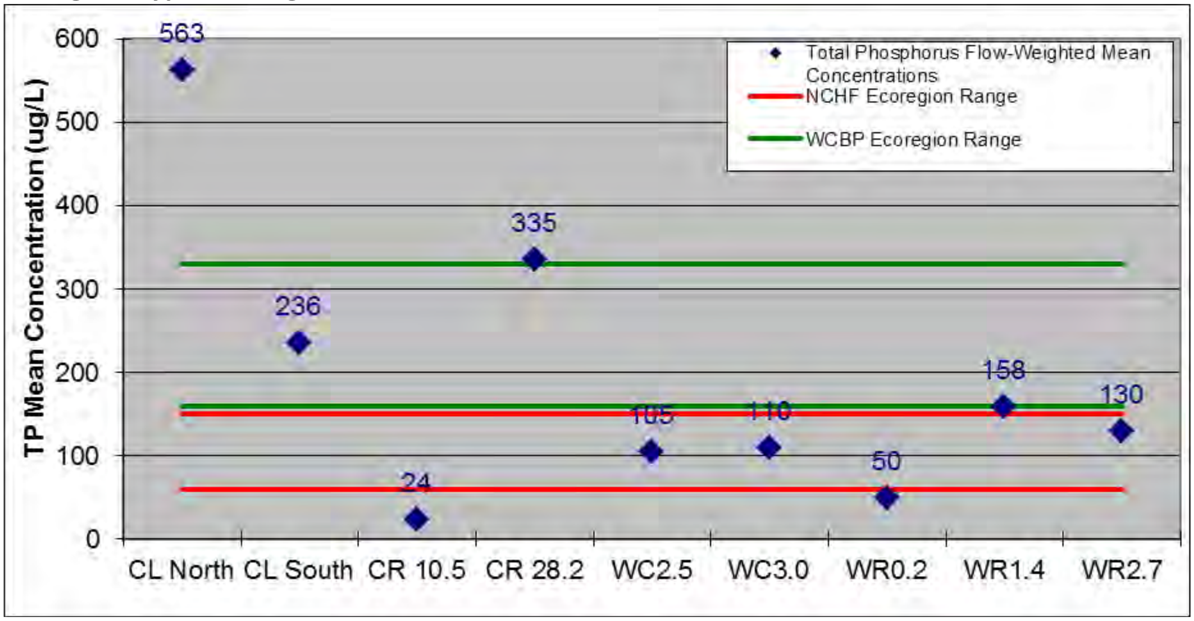
3.1.1 Phosphorus Concentrations and Phosphorus Loads

Stream loads and mean phosphorus concentrations were calculated at each monitoring station on the Clearwater River, Warner Creek, Willow Creek, and Clear Lake tributary streams in 2012 to track the health and integrity of the streams with respect to state standards and to monitor loads to the lakes which drive water quality. Tributary streams were also monitored in the Cedar Lake sub-watershed and are discussed in Section 6.0.

Mean phosphorus concentrations were also calculated for each site and are compared to previous year's concentrations as well as a range of typical concentrations in the NCHF and WCBP ecoregions in Figure 3.2. At the long-term monitoring stations, flow-weighted mean phosphorus concentrations at WR0.2 and CR 10.5 were close to, or within, the typical range for the NCHF Ecoregion. Mean concentrations at CR28.2 were within the range of the WCBP Ecoregion.

Phosphorus concentrations measured in Willow Creek and Warner Creek were within the typical range for the NCHF Ecoregion. Phosphorus concentrations at Clear Lake South were within the WCBP Ecoregion, but concentrations at Clear Lake North were well higher than the Ecoregion ranges.

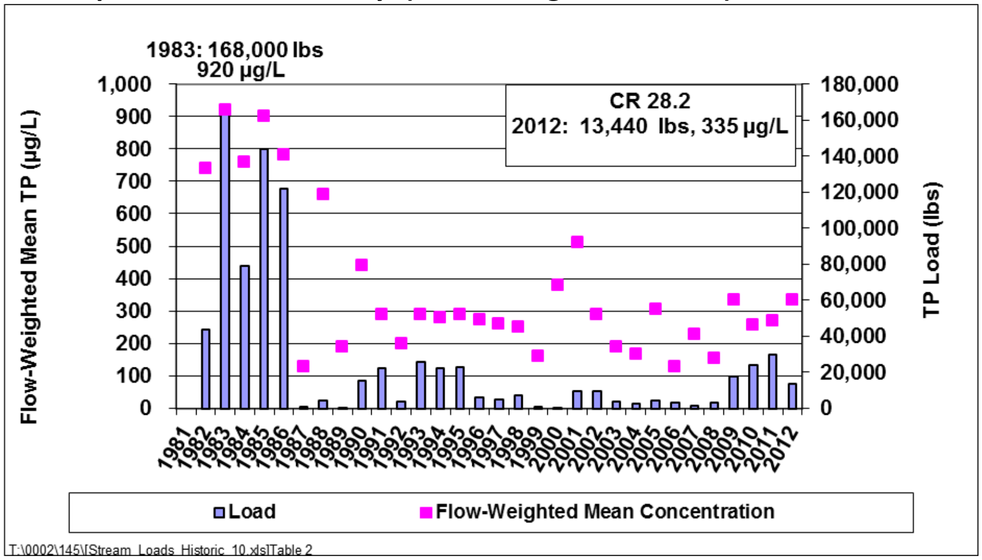
Figure 3.2 Clearwater River Watershed District Mean Phosphorus Concentrations and Ecoregion Typical Range



Baseline total phosphorus (TP) concentrations in the Clearwater River remain low as compared with conditions monitored in the early 1980s. Flow-weighted mean total phosphorus concentrations at CR 28.2, just upstream of Lake Betsy, ranged from 740 to 920 µg/L in the early 1980s. The 2012 concentration was 335 µg/L, which was slightly higher than concentrations observed in recent years but lower than concentrations seen in the early 1980s. The high phosphorus concentration observed at this station in 2012 was driven by two samples with unusually high proportions of particulate phosphorus in late summer. This can sometimes occur when the river bed is agitated prior to sampling, which is especially difficult to prevent in the dry conditions observed in 2012. For this reason, this year's results likely reflect a higher concentration of particulate phosphorus and TSS than actual conditions. Sample protocol during low flow will be adjusted to correct for this in the future.

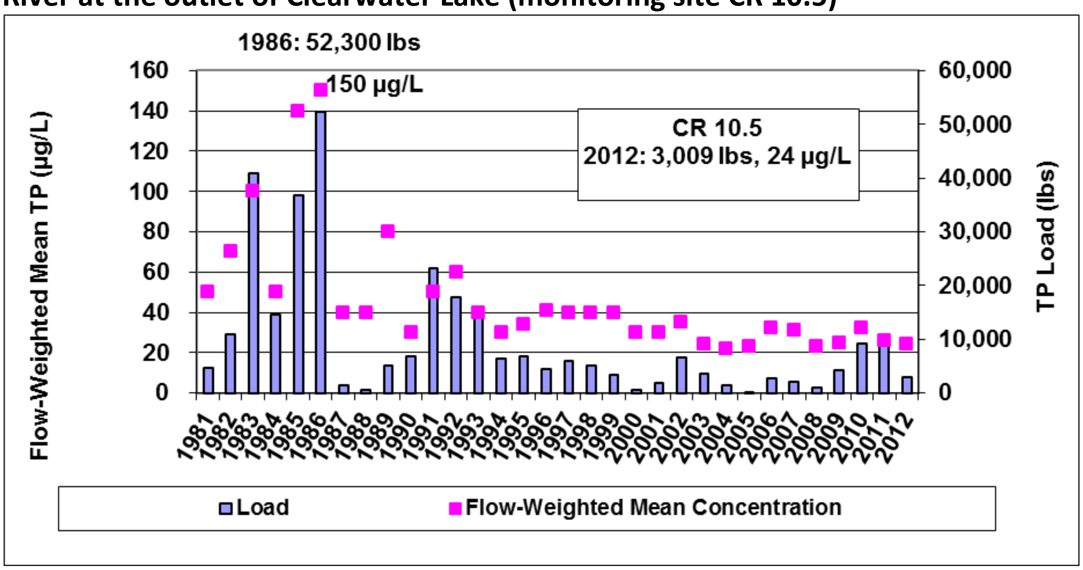
The TP load at CR 28.2 in 2012 was 13,440 lbs, which is lower than loads observed in recent years and slightly higher than loads during other recent years with similar precipitation. Phosphorus loads at CR28.2 are still far below the high TP loads observed in the early 1980s, but remain higher than necessary to meet state water quality standards. Figure 3.3 shows the historical phosphorus load and flow-weighted mean concentration at CR 28.2.

Figure 3.3 Historical Total Phosphorus Loading and Mean Concentration in the Clearwater River upstream of Lake Betsy (monitoring site CR 28.2)



Flow-weighted mean TP concentrations and phosphorus loads at CR 10.5 were calculated using flows over the dam that were calculated using stage measurements taken at the Grass Lake Dam. The estimated mean phosphorus concentration at CR 10.5 in 2012 was 24 µg/L, which was much lower than concentrations measured in the later 1980s and comparable to most recent years. Mean phosphorus concentrations at this station appear to be exhibiting a stable and decreasing trend, which is reflective of improving water quality in Clearwater Lake. The estimated total phosphorus load was 3,009 lbs (Figure 3.4), which is lower than loads observed in recent years and comparable to other years with similar runoff.

Figure 3.4 Historical Total Phosphorus Loading and Mean Concentration in the Clearwater River at the outlet of Clearwater Lake (monitoring site CR 10.5)



Warner Creek was monitored in three locations in 2012, at long-term monitoring station WR0.2, and at two additional stations WR1.4, and WR2.7 (Figure 3.5). The additional monitoring was conducted in response to increasing TP concentrations at WR0.2 in recent years. Phosphorus loads and mean phosphorus concentrations at each monitoring station are shown below in Table 3.1. Mean concentrations and phosphorus loading rates are highest from the upper watersheds of Warner Creek, which drain land in agricultural use and portions of the City of Annandale.

Figure 3.5 Warner Creek 2012 Monitoring Locations

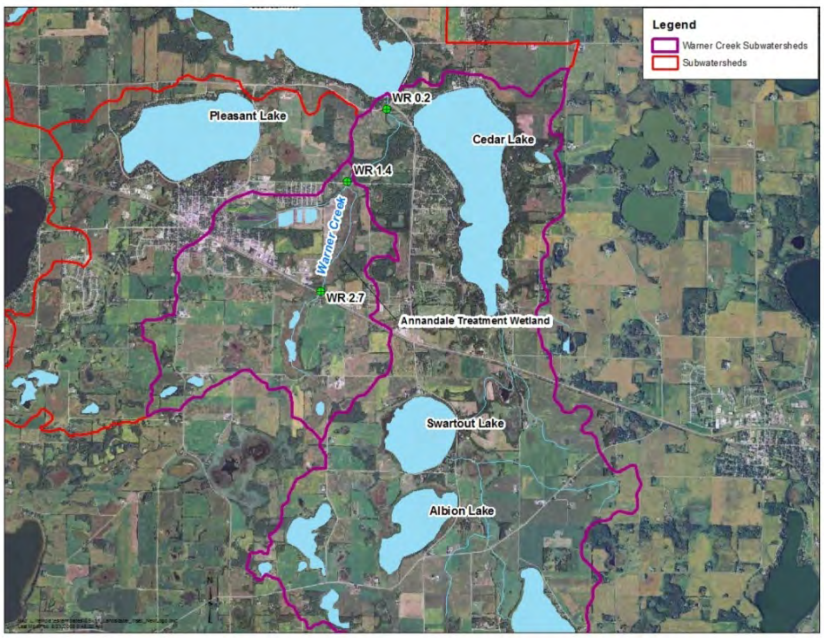
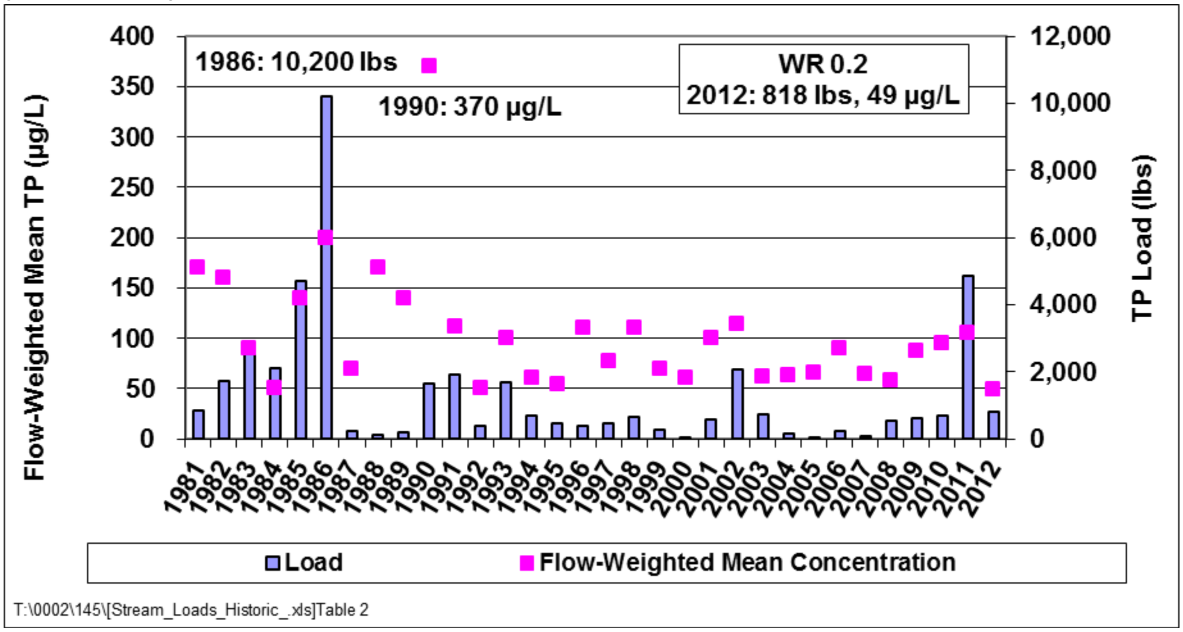


Table 3.1 Warner Creek Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)	Mean TP Concentration (μg/L)
WR0.2	818	49
WR1.4	400	227
WR2.7	218	143

Figure 3.6 compares historical total phosphorus loads and mean phosphorus concentrations in Warner Creek as observed at monitoring station WR0.2. The flow-weighted mean TP concentration at Warner Creek in 2012 was 49 μg/L, which was much lower than concentrations observed in recent years and ended the trend of increasing concentrations observed at this site since 2008. The total phosphorus load in 2012 was 818 lbs, much lower than the load of 4,854 lbs observed in 2011 and similar to loads observed in other recent years with similar runoff.

Figure 3.6 Historical Total Phosphorus Loading and Mean Concentration at Warner Creek (Site WR-0.2)



Willow Creek was monitored at two locations upstream and downstream of the City of Kimball in 2012 in order to monitor the effectiveness of the sedimentation pond constructed as part of the Kimball Phase I Stormwater Project. As shown in Table 3.2, TP loads and concentrations were similar upstream to downstream; concentrations fell from upstream to downstream, but loads are slightly higher reflecting a larger water yield off the impervious areas of Kimball. Planned grant projects will further reduce hydraulic and nutrient loads to Willow Creek and downstream lakes.

Table 3.2 Willow Creek Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)	Mean TP Concentration
WC2.5 (Downstream)	713	90
WC3.0 (Upstream)	619	126

Two tributaries to Clear Lake were also monitored in 2012. Mean phosphorus concentrations and phosphorus loads at Clear Lake North were high in 2012, with a large portion of the load occurring during a period of high runoff accompanied by high phosphorus concentrations in late June. As demonstrated in Table 3.3, TP concentrations and loads were lower at Clear Lake South, but likely still represent a significant portion of the load to Clear Lake.

Table 3.3 Clear Lake Tributaries Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)	Avg TP
Clear Lake North	1,796	512
Clear Lake South	1,013	221

As demonstrated in Table 3.4, phosphorus loading rates varied throughout the District in 2012. Phosphorus loading rates were lowest at sites in the lower watershed, 0.03 lbs/acre at CR 10.5 and 0.05 lbs/acre at WR0.2. Loading rates at upper watershed stations were significantly higher as the loading rate was 0.40 lbs/acre at CR28.2, and 0.72 lbs/acre and 1.70 lbs/acre at Clear Lake South and Clear Lake North, respectively. Loading rates for the upper most portion of the District likely are the truest measurement of watershed phosphorus export as loading data collected downstream reflects the sedimentation of phosphorus in District Lakes.

Table 3.4 2012 Phosphorus Loading Rates by Tributary Watershed

Site	Watershed Area (acres)	Phosphorus Load (lbs)	Phosphorus Loading Rate (lbs/acre)
CR10.5	99,200	3,009	0.03
WR0.2	16,992	818	0.05
WC2.5	6,838	713	0.10
WC3.0	5,926	619	0.10
WR1.4	2,949	400	0.14
WR2.7	1,540	218	0.14
CR28.2	33,977	13,440	0.40
Clear Lake South	1,404	1,013	0.72
Clear Lake North	1,055	1,796	1.70

Ortho-phosphorus (OP) is measured in streams because it is the dissolved form of phosphorus which is more readily used by algae. Relative fractions of ortho-phosphorus to total phosphorus provide valuable insight into the sources of nutrients in the District and potential solutions. Table 3.5 shows the ratio of the flow-weighted means of ortho-phosphorus to total phosphorus (TP) as a percentage at each monitoring site.

Table 3.5 Comparison of Ortho-Phosphorus to Total Phosphorus Concentrations

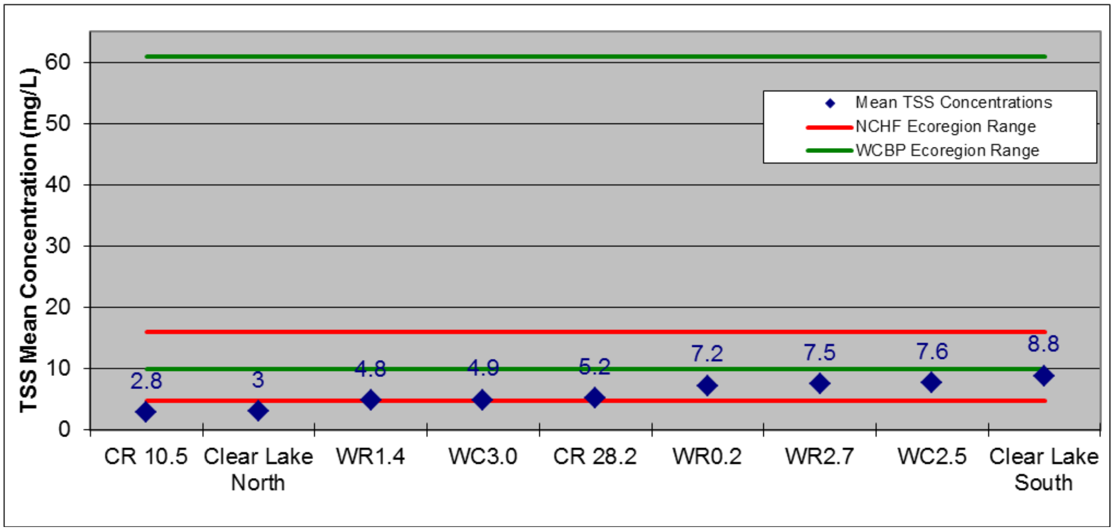
Site	%TP as Ortho-P
WR2.7	10%
WR1.4	11%
WR0.2	16%
CR10.5	20%
WC3.0	28%
WC2.5	30%
Clear Lake South	32%
CR28.2	37%
Clear Lake North	66%

As expected, ortho-phosphorus made up a high percentage of TP in some monitoring stations in 2012, especially those downstream of large wetland complexes, as anoxic conditions developed in these basins during periods of low flow and ortho-phosphorus was released from wetland sediments. Specifically, this was observed at Clear Lake North, CR28.2, and Clear Lake South. Ortho-phosphorus typically makes up a larger percentage of the total phosphorus during years with extended periods of low flows as was experienced in much of 2012. The exception to this trend was observed at Warner Creek at monitoring station WR1.4, which is downstream of the Annandale Wetland Treatment System. At this location, ortho-phosphorus made up a very small percentage of the total phosphorus, indicating that this wetland did not export a significant amount of ortho-phosphorus in 2012.

3.1.2 Total Suspended Solids

Samples were also analyzed for total suspended solids (TSS) in 2012. Mean concentrations of TSS are compared to typical Ecoregion concentrations in Figure 3.7. Mean concentrations were near or the below typical concentrations in the NCHF Ecoregion at all sites. Low TSS and good water clarity at these sites is typical during most conditions in these streams.

Figure 3.7 2012 Total Suspended Solids Mean Concentrations in the District

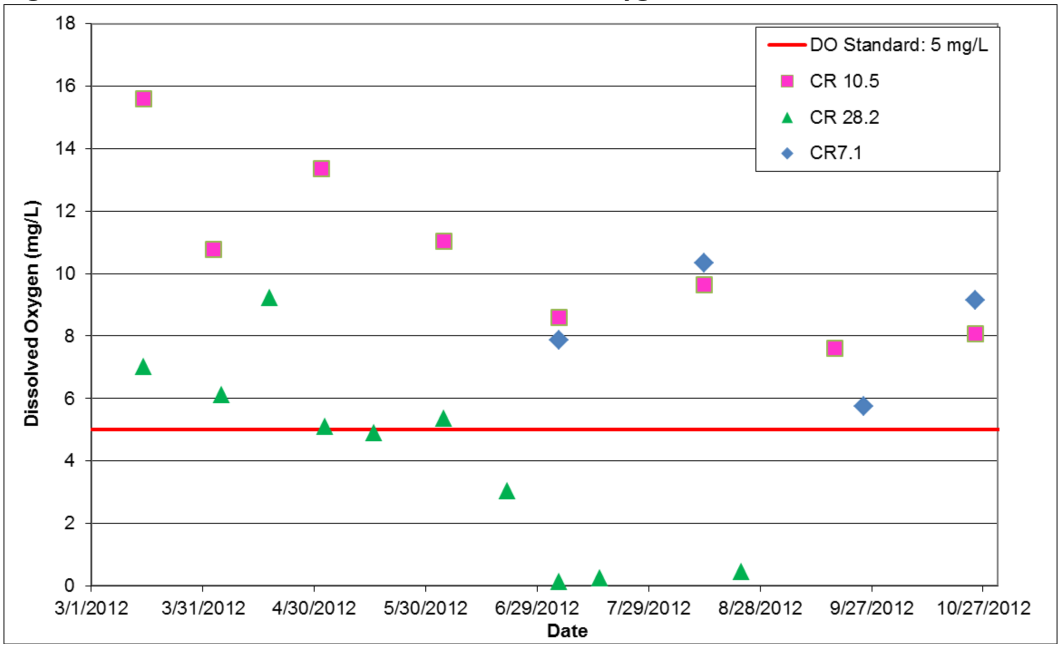


3.1.3 Dissolved Oxygen

Dissolved oxygen (DO) was also measured at each stream monitoring location because DO is essential to the survival of in-stream biota like fish and macroinvertebrates and the concentrations of DO are an indicator of the presence of suitable habitat. DO is also measured to track progress towards achieving the DO TMDL for the Clearwater River and to ensure that other streams in the CRWD meet the MPCA's water quality standard for DO of 5 mg/L or higher. Measured DO concentrations are compared to the MPCA standard for impairment of 5 mg/L in Figure 3.8 and Figure 3.9.

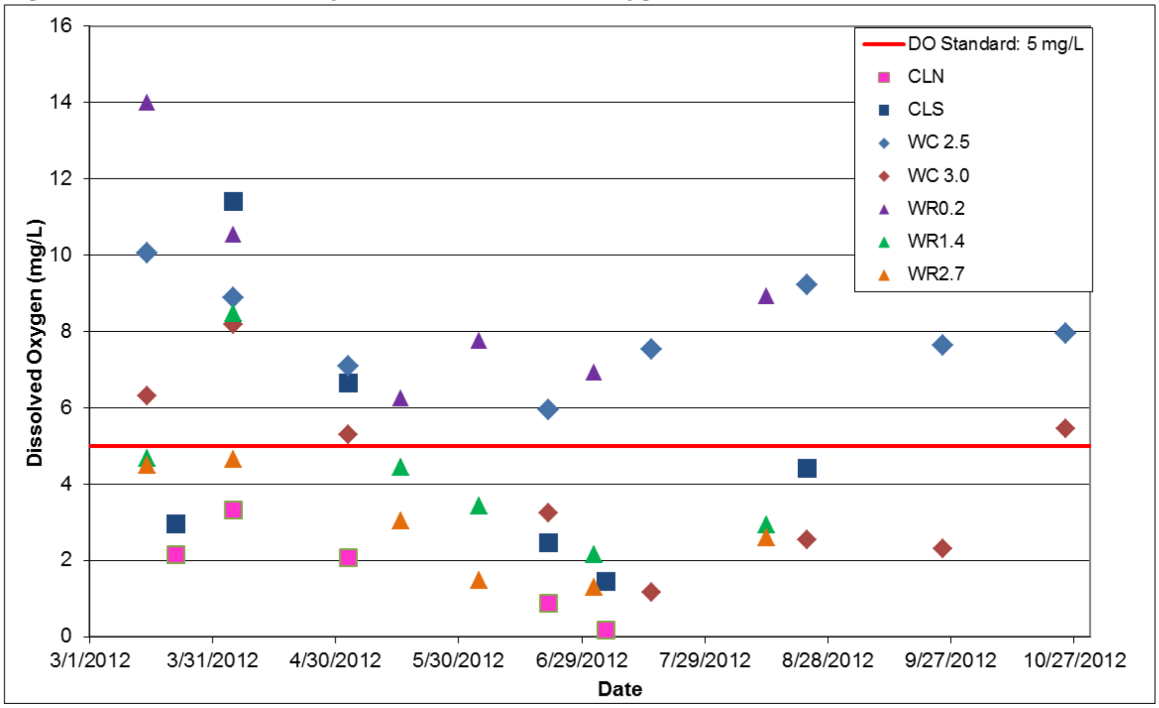
Figure 3.8 presents DO concentrations observed in the Clearwater River in 2012. The data collected at CR28.2 reflect the conclusions drawn in the TMDL, that low-flow DO violations occur downstream of Kingston Wetland and are driven primarily by wetland sediment oxygen demand (SOD).

Figure 3.8 2012 Clearwater River Dissolved Oxygen Concentrations



Dissolved oxygen data collected at tributary stream monitoring sites in 2012 is shown in Figure 3.9. DO concentrations were below the impairment standard during all monitoring events at Clear Lake North and WR2.7. DO concentrations were also near or below the impairment standard during midsummer at Clear Lake South, WR1.4, and WC3.0. The low DO concentrations at these stations are likely a result of anoxic conditions in wetlands upstream of these monitoring sites.

Figure 3.9 2012 Tributary Stream Dissolved Oxygen Concentrations



Additional stream water quality data is found in Appendix B, including summaries of historical phosphorus loads, stream flows, and flow-weighted mean concentrations. Appendix H shows phosphorus concentrations at each site monitored in 2012.

3.2 LAKE WATER QUALITY

The CRWD measures lake water quality to track progress towards meeting state standards, track long-term trends and identify potential areas where water quality is declining. To that end, The CRWDs 21 lakes are sampled on a rotating basis identified in the District's monitoring plan.

CRWD sampled seventeen lakes in 2012. Parameters analyzed in 2012 included surface total phosphorus, ortho-phosphorus, chlorophyll-*a*, and a field reading of Secchi depth. Surface samples characterize lake water quality. Samples for total phosphorus, soluble reactive phosphorus, and total iron were also collected near the lake bottom. Water temperature and dissolved oxygen profile data was also collected at each lake to better characterize lake stratification and the period of anoxia which aids in quantifying internal loading.

CRWD Staff Collecting Lake Water Samples

3.2.1 2012 Monitoring Results

Summer average (June 1 to September 30) values were compared with the MCPA eutrophication standards for phosphorus, chlorophyll-*a*, and Secchi disk depth, based on Ecoregion and lake type. The MPCA uses separate standards for shallow (less than 15 foot maximum depth or 80% of lake area less than 15 feet deep) and deep lakes (greater than 15 foot maximum depth). The appropriate standards for lakes monitored in the CRWD, which is in the North Central Hardwood Forest Ecoregion, are shown in Table 3.6. The MPCA standards are also used as the TMDL goals for summer average concentrations and Secchi depth in District lakes.

Table 3.6 MPCA Standards for Lakes in the North Central Hardwood Forest Ecoregion

	Total Phosphorus	Chlorophyll-*a*	Secchi Depth
Lake Category	**µg/L**	**µg/L**	**meters (not less than)**
Shallow Lakes	60	20	1
Deep Lakes	40	14	1.4
Source: Minnesota Pollution Control Agency			

Figures 3.10 and 3.11 compare the average total phosphorus concentrations in lakes sampled in 2012 to the TMDL goal.

Figure 3.10 2012 Summer Average Total In-Lake Phosphorus Concentrations (Deep Lakes)

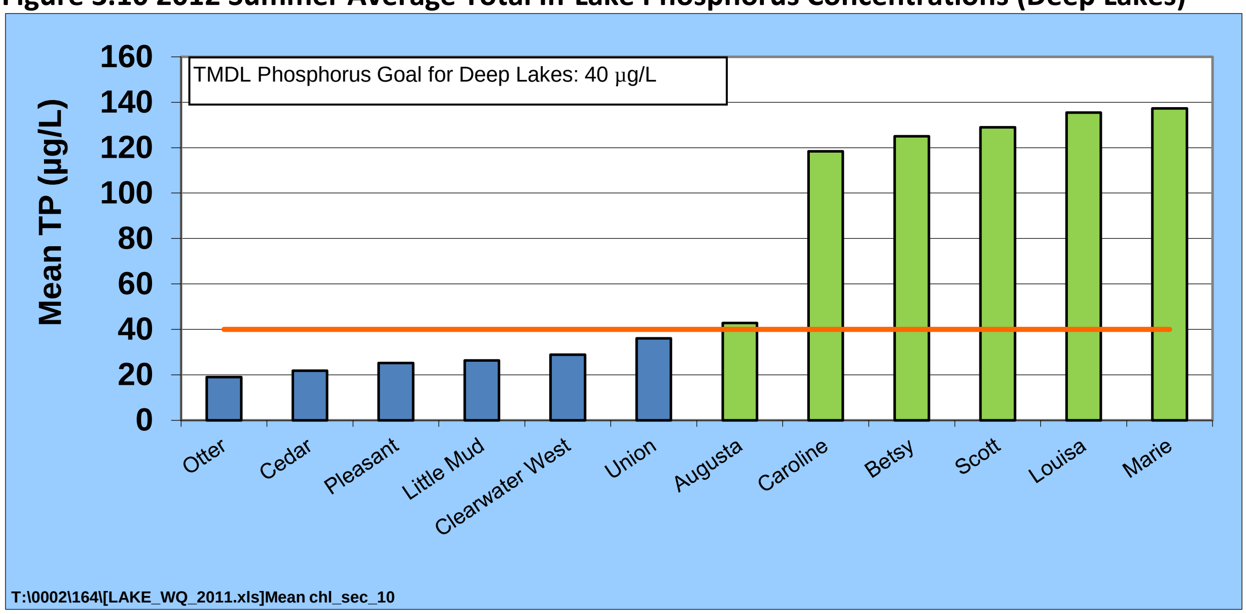
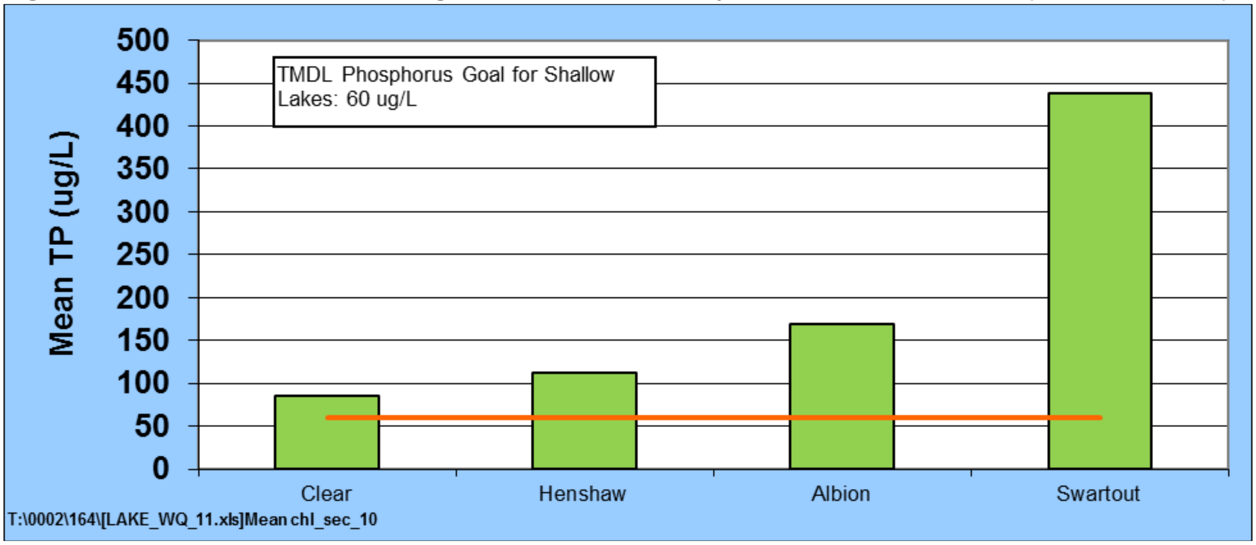


Figure 3.11 2012 Summer Average Total In-Lake Phosphorus Concentrations (Shallow Lakes)



In general, phosphorus concentrations were lower in most lakes in 2012 in comparison to recent years due to decreased runoff and loading from the watershed, with a few exceptions. Based on the 2012 monitoring data for each lake, Augusta, Caroline, Betsy, Louisa, Scott, Marie, Henshaw, Clear, Albion, and Swartout were above the TMDL goal for total phosphorus. Summer average phosphorus concentrations continued a steadily increasing trend in Marie, Louisa, and Caroline Lakes. Phosphorus concentrations were notably improved in 2012 in Clear, Union, Betsy, and Augusta Lakes.

Figures 3.12 and 3.13 compare the most recent summer average chlorophyll-a concentrations for sixteen CRWD lakes to the appropriate chlorophyll-*a* TMDL goal. In 2012, Augusta, Union, Betsy, Caroline, Marie, Louisa, Swartout, Clear, Henshaw, and Albionwere above the TMDL goal for chlorophyll-*a*.

Figure 3.12 2012 Summer Average Chlorophyll-*a* Concentrations (Deep Lakes)

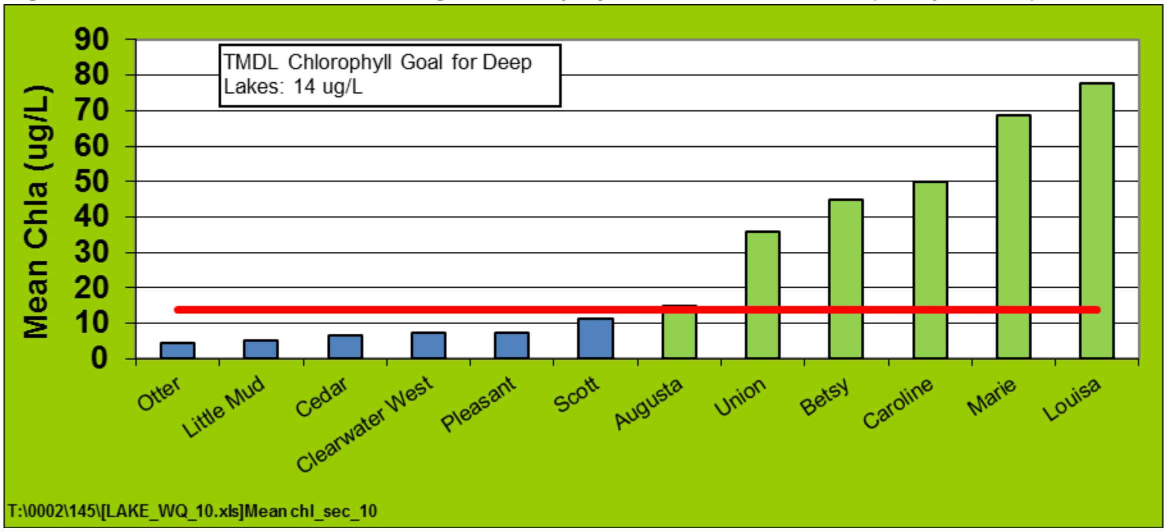
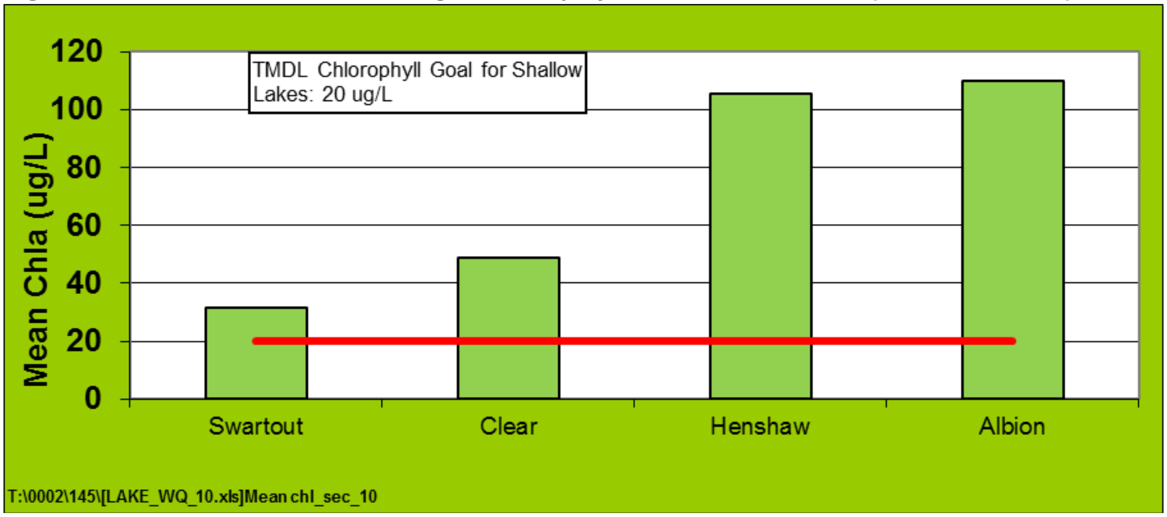


Figure 3.13 2012 Summer Average Chlorophyll-*a* Concentrations (Shallow Lakes)



Figures 3.14 and 3.15 compare the 2011 Secchi disk depth for sixteen CRWD lakes to the appropriate Secchi TMDL goal. 2012 average Secchi depths did not meet the TMDL goal in Louisa, Marie, Caroline, Scott, Albion, Henshaw, and Clear Lakes in 2012. Summer average Secchi depths followed the trend of chlorophyll-*a* and water clarity was reduced in most lakes due to increased algal production from warmer than normal water temperatures and a lack of runoff to flush phosphorus through the lakes.

Figure 3.14 2012 Summer Average In-Lake Secchi Depth (Deep Lakes)

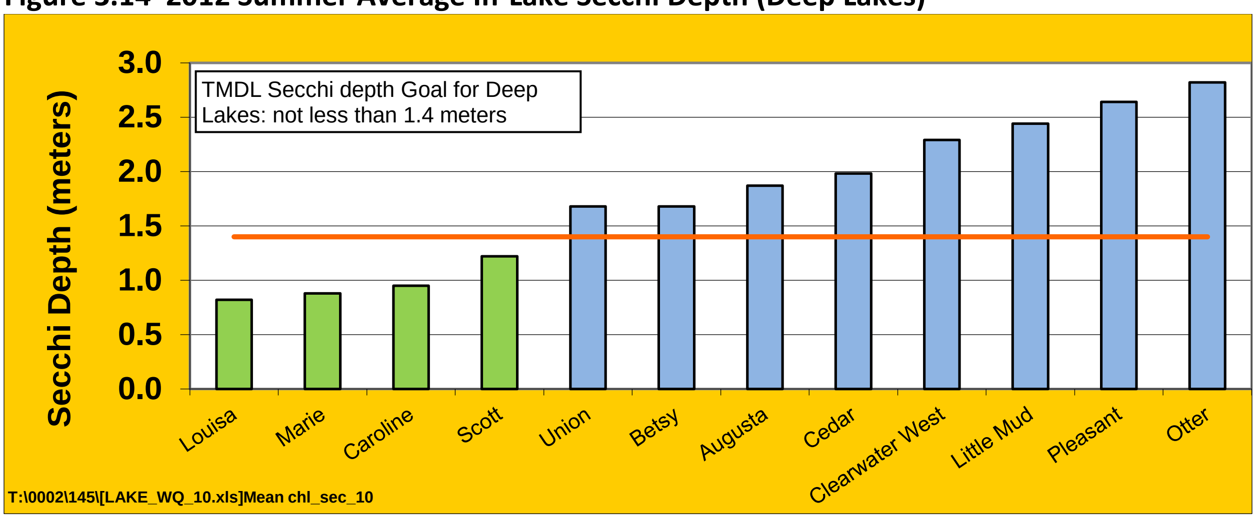
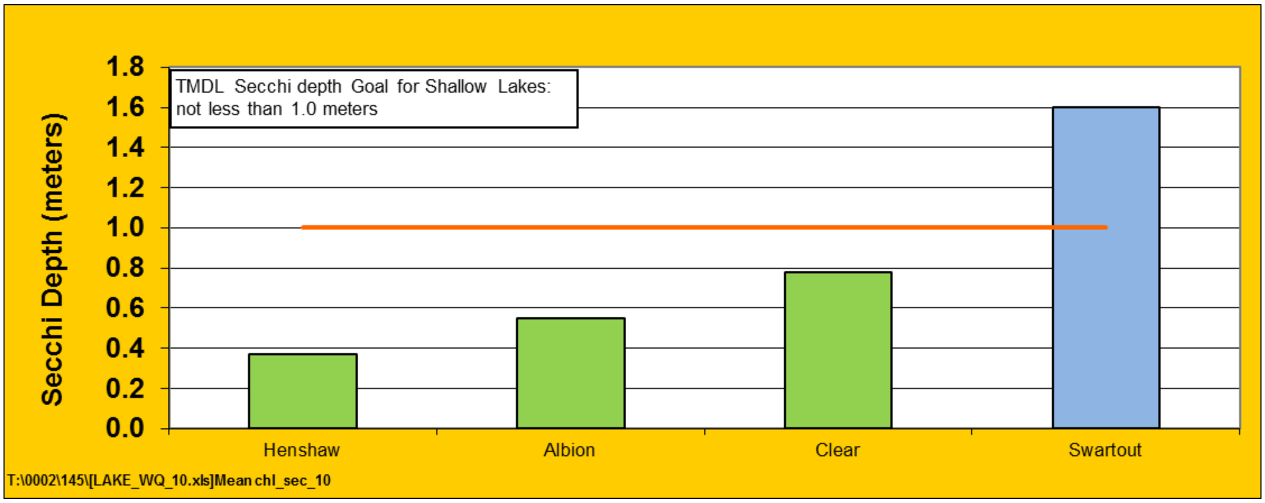


Figure 3.15 2012 Summer Average In-Lake Secchi Depth (Shallow Lakes)



As demonstrated in Table 3.7, phosphorus concentrations were near the low end of historic ranges in most lakes in 2012. Chlorophyll-*a* concentrations were near the middle or high end of historic ranges in most lakes in2012. Secchi disk depths were within or near the low end of historic ranges in most lakes in 2012.

Table 3.7 2012 Mean In-Lake Total Phosphorus, Chlorophyll-*a*, and Secchi Depth, and Historical Ranges

	Total Phosphorus µg/l		Chlorophyll-a µg/L		Secchi Depth (meters)	
Lake	2012 Mean	Historical Range Mean	2012 Mean	Historical Range Mean	2012 Mean	Historical Range Mean
Albion	169	130-296	110	60-204	0.6	0.5-1.2
Augusta	43	28-300	15	4-73	1.9	1.1-1.9
Betsy	125	120-700	45	4-170	1.7	0.5-2.4
Caroline	118	36-300	50	3-55	1.0	0.8-1.9
Cedar	22	19-58	7	3-20	2.0	1.1-3.0
Clear	86	80-307	49	17-134	0.8	0.3-1.2
Clearwater West	29	25-160	7	4-77	2.3	1.4-2.6
Henshaw	112	90-390	105	25-178	0.4	0.2-0.9
Louisa	136	33-440	78	4-101	0.8	0.6-1.5
Marie	137	69-360	69	4-153	0.9	0.6-2.3
Otter	19	13-34	4	1-8	2.8	2.0-3.0
Pleasant	25	15-51	7	4-12	2.6	2.0-3.0
Scott	129	82-660	11	3-223	1.2	0.5-1.9
Swartout	438	200-421	32	23-832	1.6	0.2-1.0
Union	36	25-88	36	7-39	1.7	1.0-2.3

Above TMDL Goal

T:\0002\188\Water Quality\[Lake WQ 2012 v1.xlsx]Historical Table

Table 3.8 compares CRWD lakes to MPCA impairment standards and identifies phosphorus concentration trends in each lake. Water quality does not meet TMDL goals in 11 lakes. Overall, based on the most recent monitoring data for all lakes within CRWD, water quality in most lakes is generally good and appears to be remaining stable or improving. However, a recent increasing phosphorus trend has been observed during the last three years in the Clearwater Chain of Lakes including Louisa, Marie, Caroline, and Augusta. The increasing phosphorus concentrations over the last three years correspond to increased phosphorus loads in the Clearwater River in the upper watershed during that same time period. Due to the flow-through nature of these lakes, the water quality is driven by the hydrology of the Clearwater River. During years with high runoff, phosphorus concentrations in the lake approach concentrations observed in the Clearwater River. During dry years, internal loading contributes a larger portion of the phosphorus load to the lakes.

Table 3.8 Lake Trend and Impairment Summary

Lake	Last Monitored	Phosphorus Trend	Use
Albion*	2012	Stable Trend	Impaired
Augusta*	2012	Recent Decreasing Trend	Impaired
Bass	2009	Stable Trend	Full Use
Betsy*	2012	Recent Stable Trend	Impaired
Caroline*	2012	Recent Increasing Trend	Impaired
Cedar	2012	Recent Decreasing Trend	Full Use
Clear*	2012	Stable to Decreasing Trend	Impaired
Clearwater East	2011	Recent Stable Trend	Full Use
Clearwater West	2012	Recent Stable Trend	Full Use
Grass	2011	Decreasing Trend	Full Use
Henshaw*	2012	Recent Stable Trend	Impaired
Little Mud	2012	Decreasing Trend	Full Use
Louisa*	2012	Recent Increasing Trend	Impaired
Marie*	2012	Recent Increasing Trend	Impaired
Nixon	2011	Recent Stable Trend	Full Use
Otter	2012	Stable Trend	Full Use
Pleasant	2012	Stable Trend	Full Use
School Section	2011	Stable Trend	Full Use
Scott*	2012	Recent Stable Trend	Impaired
Swartout*	2012	Recent Increasing Trend	Impaired
Union*	2012	Recent Decreasing Trend	Impaired
Wiegand	2012	Stable Trend	Full Use

T:\0002\164\[Lake WQ 2011.xlsx]Summary

*TMDL Impaired

Although samples were not collected in Wiegand Lake due to a lack of access in 2012, samples were collected in the Clearwater River just downstream of the outlet of Wiegand Lake. Summer average phosphorus and chlorophyll –a concentrations from these samples were observed to be at the low end of the ranges for Wiegand Lake and water quality continues to be good in the lake.

Additional lake monitoring efforts that were conducted in 2012 are summarized in Section 5.0. Lake report cards provide a more detailed summary of present and historic water quality for each lake and are included in Appendix C. Water quality lab reports are in Appendix E, and field notes are in Appendix F.

4.0 Cedar Lake Project #06-1

4.1 INTRODUCTION

The Cedar Chain of Lakes Restoration Project #06-1 began in 2007 as a response to a petition by lakeshore residents to address the declining water quality and severe algae blooms in Cedar Lake. The goal of the project was to reduce the annual phosphorus load to Cedar Lake to 1,000 lbs which translates into an in-lake summer average phosphorus concentration in Cedar Lake of 20 µg/L. An additional goal of the project was to further reduce phosphorus loading from upstream lakes by reducing the carp population of the lakes.

Segner Pond Limestone Berm Following Repairs

Several projects were implemented between 2007-2012 to reduce in lake phosphorus concentrations in Swartout, Albion, Henshaw, and Cedar Lakes. Projects that have been implemented include rough fish management efforts, including the construction of five fish barriers (See photos below and Figure 4.3 for location) and rough fish removal. Other projects include the construction of the Segner Pond treatment wetland, and watershed BMPs such as tile inlet buffers and buffer strips.

Activities conducted in 2012 included ongoing maintenance of fish barriers, Segner Pond limestone berm repair, and rough fish removal (12,000 lbs of carp removed from Segner Pond in June).

Carp Removal at Segner Pond

Carp Removal at Segner Pond

Fish Barrier at Segner Pond

Fish Barrier at Swartout Lake Outlet

Fish Barrier at Illsley Ave.

Swartout Lake Inlet Fish Barrier

Fish Barrier at Henshaw Lake Outlet

4.2 MONITORING

Cedar Lake, Swartout Lake, Albion Lake, and Henshaw Lake were monitored four times from June to September in 2012. Streams tributary to the lakes were also monitored while they were flowing at five locations in 2012. Tributary streams are monitored to track annual loading to the lakes, which assists in determining progress towards meeting loading goals in addition with tracking the health of the streams.

4.2.1 Lake Monitoring

Cedar Lake

As shown on the Cedar Lake Report Card in Appendix C, the 2012 summer average total phosphorus concentration of 22 µg/L was below the minimum standard for impairment and approaches the Project goal of 20 µg/L. Since Cedar Lake is a high value lake with water quality far better than the minimum standards for impairment, the project goal of 20 µg/L was set to protect water quality from decline. Chlorophyll-*a* concentrations were lower than in recent years and were below impairment standards in 2012. Secchi depth was in the range observed in recent years in 2012 and was better than the minimum standards for impairment.

Overall water quality appears to have stabilized or be slightly improving in Cedar Lake in recent years. However, episodic algal blooms remain a common occurrence in the lake, especially early in the growing season. A sample of the algae was collected on June 1, 2012 and sent to a lab for analysis. The analysis determined that the algae to be a species of blue-green algae that can potentially produce odors and toxins. As observed in previous years, the algal blooms in Cedar Lake were limited to early summer in 2012. A likely cause of these blooms is a pulse of nutrients to the lake that are incorporated by the algae. The pulse of nutrients in 2012 may have been from watershed runoff to the lake, as runoff was especially high to the lake in early June following significant precipitation events during that time period. Another possibility is that the source of the nutrient pulse is from the senescence of curly-leaf pondweed, which is present in portions of the lake.

Although internal loading of phosphorus is not suspected to make up a significant portion of the phosphorus load in Cedar Lake, it is likely that there is some internal loading of phosphorus in the lake. Elevated concentrations of phosphorus near the lake bottom as shown in Appendix C and Appendix H indicate potential for internal loading. Temperature and dissolved oxygen profile data indicate that the lake is strongly stratified during most of the time period from June to November.

It is suspected that curly leaf pondweed may also contribute to internal loading in the lake by making phosphorus from buried lake sediment available in the water column during the growing season. Small areas of the lake containing curly leaf pondweed have been treated periodically with herbicides in recent years in an attempt to control the spread of the plant in the lake. In 2012, 5.6 acres of the lake were treated for curly leaf pondweed. An additional 22 acres were treated for Eurasian water milfoil.

Swartout Lake
Swartout Lake water quality is summarized on the report card for the lake in Appendix C.

Summer average phosphorus concentrations were among the highest observed in the lake since monitoring began and were well above TMDL goals in Swartout Lake in 2012. Chlorophyll-*a* concentrations continued to be well below the long-term range of chlorophyll-*a* concentrations measured in the lake and were near the TMDL goal, a trend that has been observed in the lake since 2010. As in 2010 and 2011, water clarity was extremely high in 2012 relative to historical levels as the summer average Secchi disk depth met the TMDL goal.

Historically low chlorophyll-a concentrations were likely the result of available light limiting the growth of algae. The lake had been very turbid due to the complete absence of rooted aquatic plants and the domination of the fishery by rough fish.
Clarity has increased dramatically in recent years due to a major reduction in the carp due to harvesting, migration management and extensive fish kill occurred in the late winter of 2010 The reduced carp and rough fish population allow for less disturbance to bottom sediments and resulting turbidity which allowed submergent vegetation growth in the lake in 2012 which anchor the sediments and provide habitat for other species.

However, as water clarity has increased, expected corresponding algal blooms have not been documented. While a small number of carp were observed in the lake in early 2012, it does not appear that the population has increased dramatically in the lake.

Dense Sago Pondweed in Swartout Lake

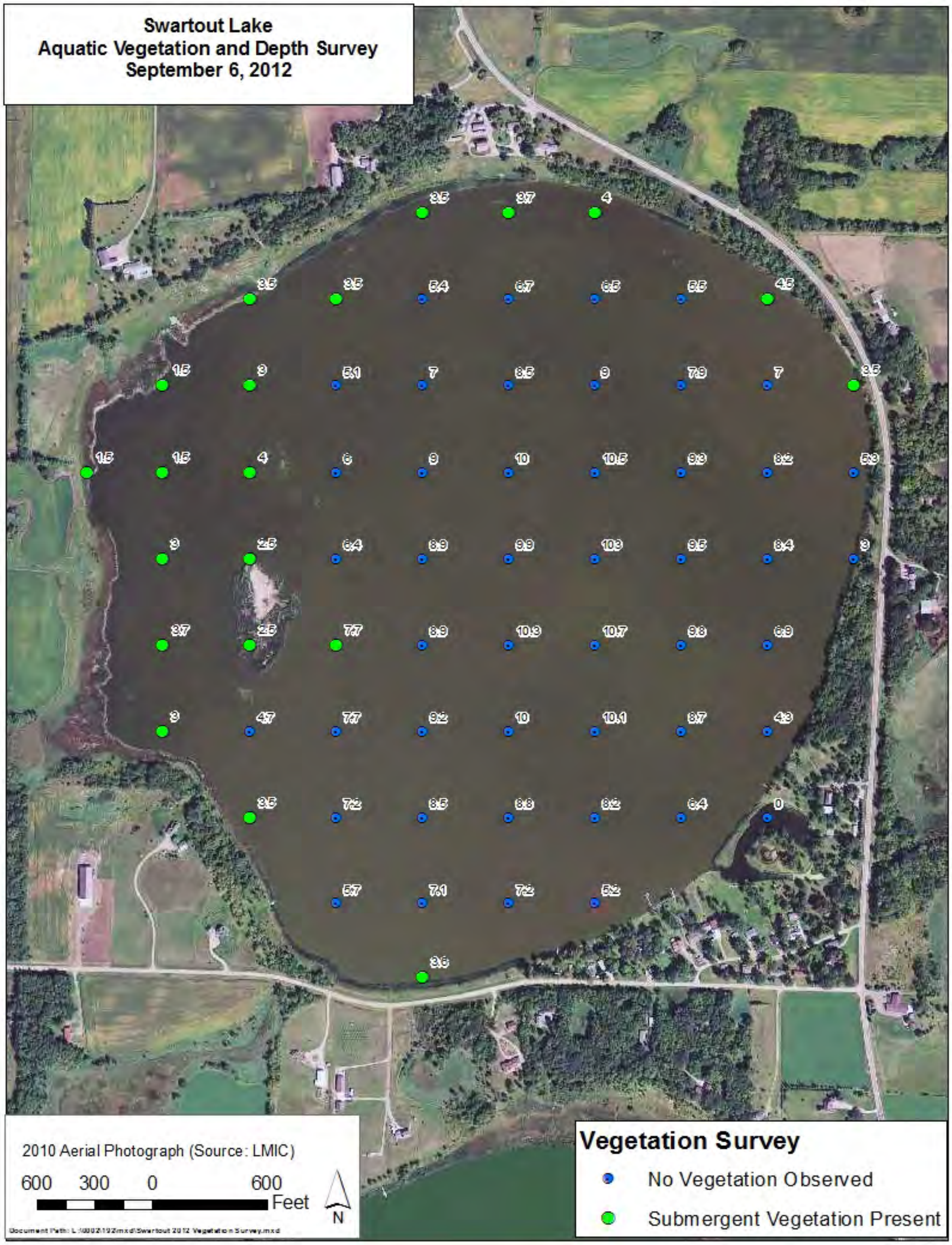
In 2005, a vegetation survey in the lake found almost no rooted aquatic plants. A vegetation survey conducted in early September 2012 found submergent vegetation growing at 18 of 65 sample points across the lake. Figure 4.1 shows the water depth and submergent vegetation coverage as inventoried in 2012. The 2012 vegetation survey found submergent vegetation at most sample points that were less than five feet deep. The submergent vegetation included nine species with native species including sago pondweed, narrow leaf pondweed, and leafy pondweed being the most common species observed. Vegetation density increased from previous years, especially in the western bay of the lake near the island, where dense beds of sago pondweed growing to the surface were observed.

The current clear water condition of Swartout Lake represents the stable and healthy condition of a shallow lake. Clear water allows for abundant submergent vegetation growth, which stabilizes bottom sediments and provides food and cover for invertebrates, fish, and other aquatic animals. The abundant sago pondweed in the lake is also a preferred food source of many species of migratory waterfowl.

Aquatic Vegetation in Swartout Lake

The continued dramatic improvement in water clarity and submergent vegetation growth due to decreased rough fish populations over the last two years following an extensive winterkill of carp in the lake are an indication of the role that rough fish play in decreasing water quality in shallow lakes, especially in Swartout Lake. The reduction in the carp population in Swartout Lake in 2010 allowed for a drastic improvement to the ecological health of the lake.

Figure 4.1 Swartout Lake 2012 Aquatic Vegetation and Depth Survey



Albion Lake

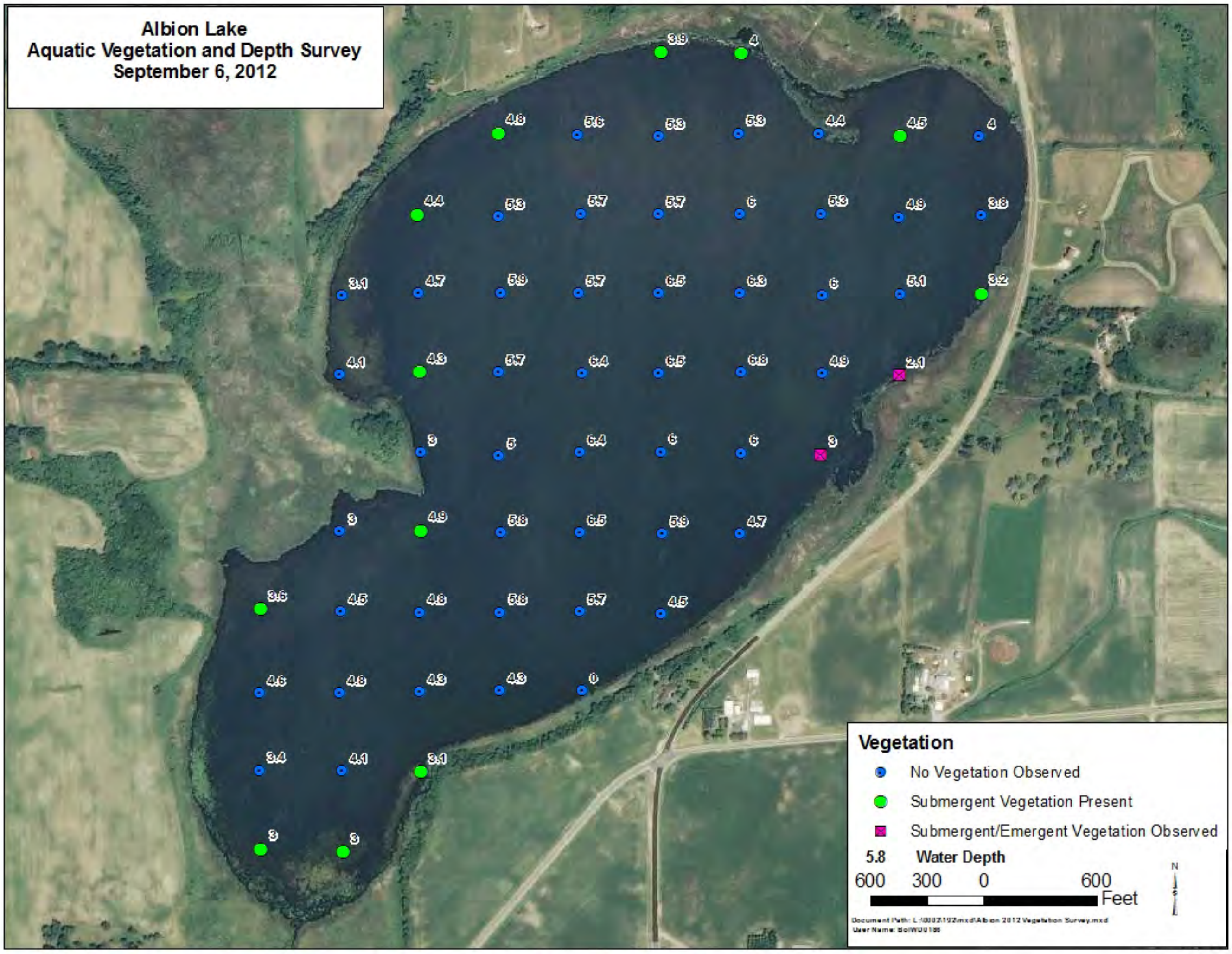
As shown on the Albion Lake report card in Appendix C, summer average phosphorus and chlorophyll- *a* concentrations increased in Albion Lake in 2012 and remained above TMDL goals. Water clarity was poor in the lake as the Secchi depth was below TMDL goals. A review of water quality data indicates that phosphorus and chlorophyll-a concentrations increased dramatically after the June monitoring event and water clarity decreased during that same time period.

An aquatic vegetation survey conducted in September 2012 found aquatic vegetation at 23 of 62 survey points, as shown in Figure 4.2. Curly-leaf pondweed, flatstem pondweed, and elodea were the most common species of submergent vegetation observed in the lake. A fringe of emergent vegetation dominated by hardstem bulrush was also observed in portions of the lake. Curly leaf pondweed was especially prevalent in the lake as turions and young plants were collected at several monitoring points and observed floating in many other areas of the lake.

Emergent Vegetation in Albion Lake

Young Curly Leaf Pondweed Plant Observed in Albion Lake

Figure 4.2 Albion Lake 2012 Aquatic Vegetation and Depth Survey



Henshaw Lake

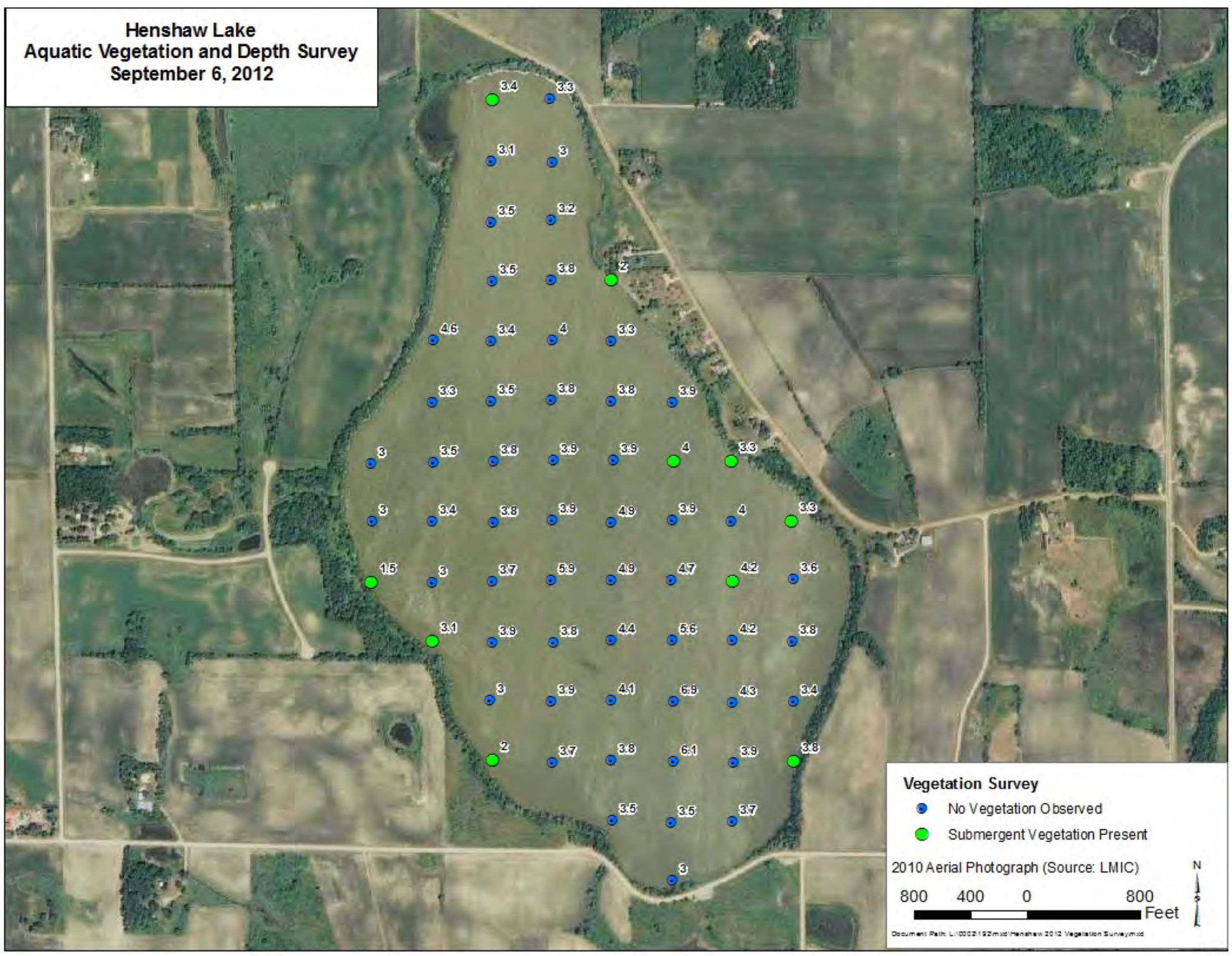
As summarized on the Henshaw Lake report card in Appendix C, summer average phosphorus concentrations in 2012 were above the TMDL goal in Henshaw Lake and have been stable since 2009. Summer average chlorophyll-*a* concentrations in 2012 were similar to recent years and were above the TMDL goal. Water clarity remained poor in the lake in 2012 with a summer average Secchi depth of less than 0.5 meters. The turbidity is due to re-suspension of sediments and poor vegetation growth in Henshaw Lake.

A review of seasonal phosphorus concentrations in 2012 indicates that total phosphorus throughout the summer was comprised almost entirely of particulate phosphorus with very little ortho-phosphorus. This was likely due to the re-suspension of bottom sediments in the lake from rough fish and wind, as well as algal uptake of ortho-phosphorous in the water column.

A fish survey performed on the lake in April 2011 by the MN DNR and observations made by District staff during 2012 monitoring visits indicate that a large rough fish population comprised of multiple year classes of carp and black bullheads is present in the lake.

A vegetation survey conducted on the lake in 2012 found submerged vegetation limited to 3 species found at only 10 of 63 monitoring stations (Figure 4.3). The vegetation survey compares similarly to a vegetation survey conducted on the lake in 2010, a year with similar water clarity. Vegetation surveys conducted on Henshaw Lake demonstrate that the current turbid water state of the lake is not conducive to the growth of aquatic vegetation.

Figure 4.3 Henshaw Lake 2012 Aquatic Vegetation and Depth Survey



4.2.2 Stream Monitoring

Five tributary streams in the Cedar Lake sub-watershed were also monitored in 2012. Locations of the monitored tributary streams are shown on Figure 4.4. Overall, runoff in these tributaries was higher, although the streams flowed for a shorter period in 2012 than in recent years due to a lack of runoff from snowmelt and below normal precipitation in late summer. Annual runoff at each monitoring site from 2007 to 2012 is shown in Table 4.1 below. The calculated phosphorus loads from 2007 to 2012 are shown in Table 4.2 below. Phosphorus loading rates at each monitoring location are shown on Figure 4.4.

Table 4.1 Tributary Stream Flow Data 2007-2012

	Runoff (in)					
Site	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
SCE01	1.6	3.6	2	2.47	12.26	6.49
SHE01	1.2	4.5	1.3	5.27	14.17	5.85
SSW01	0.7	7	3.5	5.95	14.78	3.68
SSW02	0.5	4.7	3.5	3.83	7.41	6.13
SSW04	1.2	4	1.5	3.66	10.76	5.49

Table 4.2 Tributary Stream Total Phosphorus Data 2007-2012

	TP Load (lbs)						
Site	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**TP Load Goal**
SCE01	121	199	136	160	791	395	
SHE01	81	247	61	198	424	272	
SSW01	98	698	602	839	4164	1121	
SSW02	292	858	739	624	2358	1342	
SSW04	870	1011	512	1149	3866	2543	1000

Runoff was higher downstream of Swartout Lake in 2012 due to vandals removing stoplogs at the Swartout Lake outlet control structure in early June which lead to a large flush of water out of Swartout and down into Cedar Lake. Phosphorus loads were larger than normal as a result of high phosphorus concentrations and the period of high flow in early June.

As demonstrated in Table 4.3, ortho-phosphorus made up a large proportion ofthe total phosphorus at SSW04, SSW02, and SSW01 in 2012. This is an indication that the export of soluble phosphorus from wetlands and lakes in the sub-watersheds upstream of Cedar Lake is a significant contributor to the phosphorus load to Cedar Lake.

Table 4.3 Mean Phosphorus Concentrations and %TP as Ortho-P in Cedar Lake Sub-watershed

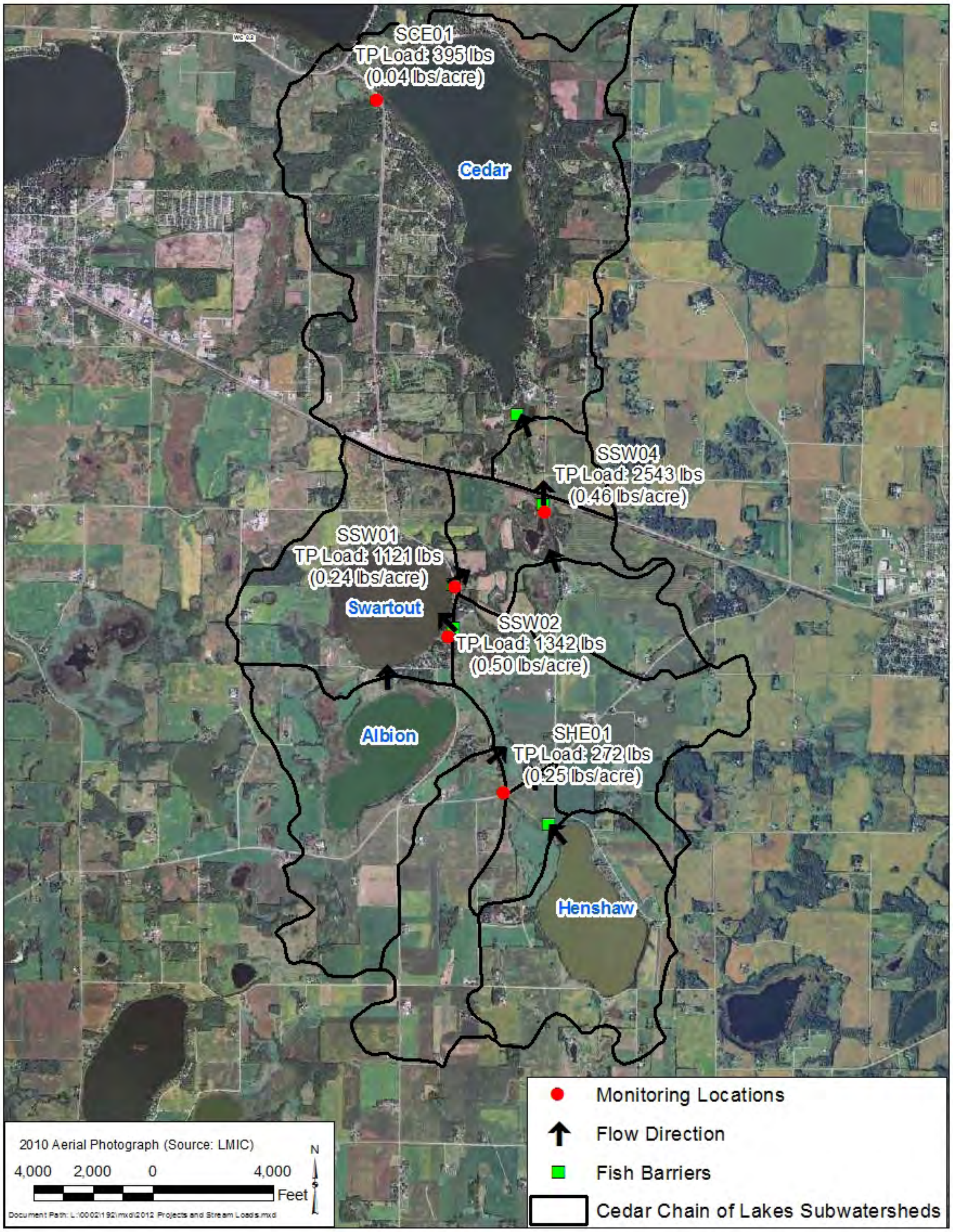
Site	Mean TP Concentration (µg/L)	Mean Ortho-P Concentration (µg/L)	%TP as Ortho-P
SHE01	174	8	4%
SCE01	28	5	18%
SSW04	420	227	54%
SSW02	334	190	57%
SSW01	277	162	58%

Phosphorus loading rates for the sub-watershed draining to each monitoring location are shown in Table 4.4. This table demonstrates that the sub-watershed of the wetland draining into Swartout Lake at SSW02 and the sub-watershed upstream of monitoring station SSW04 contributed the most phosphorus to the inflow to Cedar Lake in 2012.

Table 4.4 Phosphorus Loading Rates in Cedar Lake Sub-watershed

Site	Watershed Area (acres)	Phosphorus Load (lbs)	Phosphorus Loading Rate (lbs/acre)
SCE01	8,930	395	0.04
SSW01	4,768	1,121	0.24
SHE01	1,082	272	0.25
SSW04	5,532	2,543	0.46
SSW02	2,690	1,342	0.50

Figure 4.4 Stream Monitoring, Locations, Fish Barrier Locations, and Total Phosphorus Loads



4.2.3 Conclusions

A review of the phosphorus loading data in 2012 indicates that a large proportion of the phosphorus load to Cedar Lake is from the sub-watershed southeast of Swartout Lake and the sub-watershed directly downstream of Swartout Lake. Efforts to reduce phosphorus loading from these sub-watersheds, such as agricultural BMPs and wetland restoration, would improve water quality in Swartout Lake and reduce the exported phosphorus load to Cedar Lake downstream.

The overall external phosphorus load to Cedar Lake, as measured at monitoring site SSW04, was 2,543 lbs in 2012, which is well above the project goal of 1,000 lbs. Nearly 80% of the phosphorus load that passed through SSW04 in 2012 occurred during a short period of time in June following the increased flow due to the alteration of the Swartout Lake outlet. During this time period, high flows flushed water with high phosphorus concentrations out of the wetland upstream of the monitoring site and towards Cedar Lake. This likely contributed to the algal bloom observed in Cedar Lake in June 2012.

Even with the higher external phosphorus load from the upper watershed in 2012, summer average phosphorus and chlorophyll-*a* concentrations in Cedar Lake improved in 2012, and water quality was good throughout most of the summer. This is an indication that a proportion of the phosphorus load to Cedar Lake is removed as the water is diverted into Segner Pond before entering the lake. Therefore, it appears that the Project has been effective in recent years in reducing the external load of phosphorus to Cedar Lake during normal years and reducing the impacts on water quality of Cedar Lake during periods of high runoff. Additional efforts will be necessary to reach the in lake phosphorus goal of 20 μg/L.

The monitoring results for this project over the last several years highlight the connection of lake water quality to the status of fish and plant communities in Swartout, Albion, and Henshaw Lakes. This project has demonstrated that when addressing impairments in shallow lakes it is necessary to address the health of the biological communities in the lake. To improve the quality of shallow lakes, it is beneficial to restore the health of biological communities in the lake, including fish, plants, and zooplankton. Ideally, shallow lake management plans incorporating water level management to promote vegetation growth, and more intensive fish community management strategies, such as lake drawdowns or the application of Rotenone to promote rough fish kills, would be implemented. Efforts to implement some of these strategies have been met with some resistance on the part of land owners so the implementation strategies have been limited thus far to use of rough fish migration barriers and harvesting, and limited watershed BMPs.

The District received a grant in 2012 to construct iron sand filters at two locations in the watershed upstream of Cedar Lake to remove ortho-phosphorus from the flow to Cedar Lake. The goal of the project is to further reduce TP loads and address the high percentage of ortho-phosphorus observed in monitoring data in the watershed in 2012.

The outlet of Swartout Lake was modified by the MN DNR in 2012 so that the new runout elevation of the lake is approximately 1.5 feet lower than the previous elevation after learning that the elevation of the stoplogs in the structure were erroneously higher than intended for the lake. This will in effect lower the level of Swartout Lake, which will likely improve conditions for submergent and emergent vegetation growth in the lake. An improvement in vegetation coverage in the lake will likely prevent the re-suspension of lake-bottom sediments and decrease internal loading in the lake. The lower water levels may also promote more frequent winterkills of rough fish in the lake.

5.0 Progress towards TMDL Water Quality Goals

The CRWD TMDL addresses water quality impairments in lakes and streams and identifies load reduction goals necessary to meet water quality standards. The CRWD Watershed Restoration and Protection Plan (WRPP/ TMDL Implementation Plan) was developed and approved by the MPCA in May of 2009. The 10-year plan identifies strategies and sets priorities to meet water quality goals in impaired waters.

The plan identifies the upper watershed (upstream of Lake Betsy) as the highest priority for implementing both capital projects and programmatic BMPs. Because of the flow-through nature of the Clearwater Chain of Lakes, the water quality in upper watershed lakes like Clear Lake and Lake Betsy are primary drivers of water quality in downstream lakes like Clearwater Lake. The loads from these upper watershed lakes and their tributary watersheds drive impairments in lakes further downstream. Clear Lake, Lake Betsy, and the tributary watersheds are targeted for intensive BMPs to not only improve water quality in those lakes, but to also reduce the load to downstream water bodies. All lakes will eventually be targeted, but the greatest impact will be made by initially focusing the efforts on improvements in the upstream end of the District and working downstream.

The following section summarizes implementation strategies undertaken since the plan was adopted year by year:

2009

- Identified 5 priority projects
- Applied for 5 grants
- Implemented BMPs identified in the TMDL Implementation Plan
- Conducted additional monitoring, including collection of lake bottom samples and sediment phosphorus release analysis in Clear and Betsy Lakes
- Education

2010

- Identified an additional 3 priority projects
- Applied for 3 grants
- Secured funding for 3 grants
- Implemented BMPs identified in the TMDL Implementation Plan
- Conducted additional monitoring to fill in data gaps and continue to assess internal loading in District lakes
- Education

2011:

- Identified 1 additional priority project
- Applied for 3 grants
- Secured funding for 1 grant
- Implemented BMPs identified in the TMDL Implementation Plan
- Conducted supplemental water quality and hydrologic monitoring in accordance with recommendations of the implementation plan throughout the District to track progress and focus implementation efforts.
- Education

2012:

- Identified 1 additional priority project
- Applied for 3 grants
- Secured funding for 1 grant
- Implemented BMPs identified in the TMDL Implementation Plan
- Conducted supplemental water quality and hydrologic monitoring in accordance with recommendations of the implementation plan throughout the District to monitor project performance and better focus implementation efforts.
- Education

Specific BMPs implemented in the District in 2012 included a project conducted in partnership with Meeker SWCD to control field erosion on agricultural land adjacent to the Clearwater River upstream of Lake Betsy.

An erosion control project was also completed by the township adjacent to Clear Lake South project. This project included ditch cleaning and culvert improvements to allow for better treatment of stormwater runoff prior to it entering Clear Lake.

Field Erosion Project

Erosion Control Project

5.1 TMDL IMPLEMENTATION PROJECTS AND PROGRAMS

Through the process of implementation, priority projects and programs are identified and implemented. In 2009, five priority projects were developed to the concept stage in order to apply for grants. Three additional projects were developed in 2010 and 1 additional project was developed in 2011 and 2012. Table 5.1 provides summary information for these projects and selected projects are described in more detail below.

To date, the CRWD has won grants for several major projects including:

- Kimball Stormwater Management Phase I & II
- Kingston Wetland and Clearwater River Feasibility Study and Wetland Restoration
- Protection and restoration of several stretches of the Clearwater River through MCC
- Gridded soil testing and GPS aided fertilizer applications for 16,000 acres in CRWD
- Cedar Lake Watershed Protection and Improvement Project

Table 5.1 Priority Implementation Projects

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
Watkins Impoundment	796	$645,882	Hold for grant funds: Land was acquired for this project. An initial grant application for $351,906 scored highly but was not selected due to amount requested. Conducted additional feasibility work and completed another grant application which was not awarded. Will continue to seek grant funding for implementation.
City of Kimball Stormwater Management (Phase I)	244	$189,550	Secured grant funds and partner contribution from the City of Kimball. Construction of the project was substantially completed November 2010. Final grading, planting, and stabilization were completed in 2011. Follow up monitoring was conducted in 2012.
City of Kimball Stormwater Reclamation and Reuse (Phase II)	118	$738,000	Secured grant funds in 2011. Began design in 2012.
GPS Fertilizer Application	3,200	$871,000	Implemented field trial in 2010 on approximately 1,400 acres using District funds. Completed analysis of data gathered in 2010. Implemented on an additional 567 acres in 2011. Grant funding secured in 2011 for project to be conducted on 16,000 acres in the District. Contract was executed in 2012 and approximately 4,000 acres were enrolled in the project. Monitoring will be conducted in 2013.
Lake Betsy Hypolimnetic Withdrawal	480	$315,000	Grant application was denied in 2011. Future grant applications are scheduled, as well as discussions with the department of agriculture.

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
Clear Lake Notched Weir	588	$75,000	Easement was secured for project in 2011. Permit applications were completed and submitted in December 2011. Project was constructed in 2012
Kingston Wetland Feasibility Study and Wetland Restoration	1,970	$739,000	A $404,300 grant was secured for this project. Stream monitoring and other data collection tasks began in Spring 2011. Data collection and modeling will continue in 2012.
Conservation Corps Streambank Restoration	TP load reduction associated with sediment load reduction	$65,275	Originally implemented in 2010 when work was conducted along 2,800 linear feet of streambank. CRWD secured a $28,875 grant for the project from Conservation Corps Minnesota. Additional grant funding was secured in 2011 and work on 6,700 linear feet of stream channel was completed in 2011.
Cedar Lake Watershed Protection and Improvement Projects	1,280	$554,200	The project targets reductions to the largest watershed sources of nutrient to Cedar and Swartout Lakes by installing iron sand filters to remove soluble phosphorus currently exported from degraded wetlands and lakes. The target is to size sand filters to treat baseflow and the 1.25-inch event to provide the maximum cost/ benefit while preserving upstream hydrology. The projects target reductions from the largest watershed sources of nutrients to each lake providing 80% of the necessary watershed load reductions to Swartout Lake (800 lbs/yr), and 40% of the necessary watershed load reductions to Cedar Lake (480 lbs/ yr).

5.1.1 Watkins Impoundment

The proposed project is the construction of an impoundment on a 20-acre CRWD-owned parcel of land northeast of the city to treat runoff discharged from the city's storm drainage system. The impoundment would be created by constructing an earthen dike across the creek that runs west to east across the parcel. Two sub-watersheds totalling 740 acres of urban and agricultural land drains through this creek to a nearby ditch. A sheet pile weir with a V-notch outlet point would control discharge from the impoundment. The impoundment is sized to store runoff from the 0.5 inch event, which would provide an annual nutrient removal efficiency of 25%. The impoundment would also potentially provide some removal of bacterial load from the agricultural land and biological oxygen demand currently stressing the Clearwater River.

The filter consists of 3/4 inch to 3 inch diameter limestone wrapped in geotextile fabric and staked in place at the outlet of the structure. As the water passes through the filter, the phosphorus comes in contact with and binds to the calcium in the limestone, and is removed from the water.

No grant funds have been awarded for this project. CRWD will continue to seek grant funding for this project.

5.1.2 City of Kimball Stormwater (Phase I)

This project targets phosphorus removal for Lake Betsy and protection of the Willow Creek trout habitat by collecting and infiltrating/ reusing stormwater runoff from 428 acres in and around the City of Kimball. Stormwater runoff from the City of Kimball drains untreated into Willow Creek, a trout stream. Willow Creek is tributary to Lake Betsy, which is impaired by excess nutrients.

It is estimated that this project will reduce phosphorus discharged to Willow Creek and Lake Betsy by 244 pounds annually, or about 3 percent of the 8,300 pound annual load reduction required for Lake Betsy. Kimball is one of two urban areas tributary to Lake Betsy, making it a targeted area for load reduction in the TMDL.

Completed Basin

A grant was awarded for this project in 2009 and construction began on the project in 2010, with substantial completion of construction that year. Final grading, planting, and stabilization of the basin and raingarden was completed in 2011. The project consists of a shallow basin to collect stormwater for irrigation of a near-by baseball field and infiltration to recharge shallow groundwater. The project also includes a rain garden with native plantings. Education and outreach curriculum centered on the project will be developed and implemented by the school district with support of CRWD staff.

5.1.3 City of Kimball Stormwater (Phase II)

This project is Phase II of the CRWD's plan to manage stormwater from the City of Kimball and reduce nutrient loading to impaired downstream waters. The project proposes to construct shallow enhanced sand filtration/infiltration basins to treat previously untreated stormwater from the City of Kimball and drainage from surrounding agricultural areas before it flows into Willow Creek. The basins will also recharge shallow groundwater and more closely mimic the area's natural hydrology, and will improve water quality and temperature in Willow Creek and reduce nutrient loadings to downstream lakes.

Phase I treated a portion of the City of Kimball's runoff. Phase II provides treatment for the 1.25 inch event for the remainder of the drainage areas from the City of Kimball to Willow

Creek. It is estimated that this project will remove 118 lbs of phosphorus per year over a 35 year life cycle of the project. This project will also enhance the function of Phase I by allowing it to treat a higher volume from a smaller drainage area. The project will also restore previously filled wetlands to enhance the hydrology and habitat in the area and will convert upland areas to wetland to provide retention, filtration, and infiltration.

A grant was awarded for this project in December 2011. A conceptual project design was put together in 2012. Discussions with project partners also began in 2012.

5.1.4 GPS Fertilizer Application

A field trial was conducted in 2010 on approximately 1,400 acres of priority cropland in the western portion of the District tributary to Clear Lake and Lake Betsy. The priority cropland was identified by CRWD based on the proximity to water bodies, slope, and soil type.

The field trial, which was funded by CRWD and conducted in cooperation with the Litchfield Consumers Co-op and other partners, included systematic soil tests to determine the proper amount of fertilizer to be applied to each field. The applicator used GPS to apply the correct amount of fertilizer in each grid of the fields based on the results of the soil tests.

This field trial demonstrated the feasibility and utility of systematic soil testing in reducing fertilizer application and thus phosphorus load in agricultural runoff. The goal of the program is a 10% reduction in fertilizer application rates on selected priority cropland in the District. It is estimated that the program could potentially translate into a 10% to 50% reduction in phosphorus runoff from the watershed.

In 2011, the CRWD secured grant funding to implement this project on a larger scale in the District. Using grant funds, this project will be expanded on up to 16,000 acres in the District. The project targets a 10% reduction in fertilizer application rates resulting in a 3,200 lb annual phosphorus load reduction in the watershed tributary to Lake Betsy.

Water quality monitoring will be conducted in 2013 at drain tile outlets from selected fields. Samples will also be collected from two tile outlets in fields that are not a part of the implementation area to be used as background data for comparison. Crop yields and application rates will also be monitored. The CRWD will also continue to monitor in-lake water quality and watershed loads in the Clearwater River to further track the success of the project. The results will be publicized to encourage wider application of this technique.

A workplan was approved and a contract was executed for the grant in 2012.. The CRWD has begun enrolling landowners in the program in 2012. Soil testing and fertilizer application was conducted in Fall of 2012. Water quality monitoring to document results of the project as described in the workplan is proposed to begin in 2013.

5.1.5 Lake Betsy Hypolimnetic Withdrawal

This proposed project would pump nutrient-rich water from the lake hypolimnion and use it to irrigate a nearby farm field. A field trial including intensive monitoring is proposed to be completed to evaluate the effectiveness of the BMP in reducing internal load. Lake inflows and outflows will be monitored for flow and quality, while weekly temperature and dissolved oxygen profiles and bi weekly nutrient profiles will be taken to evaluate impact on lake water quality. Volume and timing of withdrawals will be tracked to estimate load reduction.
The proposed project will assess the cost-effectiveness of lake hypolimnetic withdrawal and irrigation as an internal phosphorus load management BMP, and evaluate its transferability to lakes in the Clearwater River Watershed District and elsewhere.

This project has not received grant funding. The CRWD continued to conduct monitoring on Lake Betsy to better quantify internal nutrient loading in the lake in 2012. This project will be re-evaluated for implementation in 2013 and grant applications will continue to be submitted.

5.1.6 Clear Lake Notched Weir

The proposed project will temporarily detain water by installing a notched weir on a Clear Lake tributary stream south of the lake. This will allow particulate phosphorus to settle out of agricultural runoff before discharging to Clear Lake. Since monitoring data indicated that a large proportion of the total phosphorus consists of soluble phosphorus, it was recommended that a soluble phorphorus filter be included with the project. As a result of this recommendation, a sand-iron filter was included in the project design to remove soluble phosphorus from the tributary inflow. The targeted load reduction for this project is 588 pounds of phosphorus annually. The phosphorus load removed through the proposed project represents a significant component of the required load reduction from watershed sources to Clear Lake. The imoundment will temporarily detain water from smaller runoff events while allowing controlled overflow of stormwater during larger storm events.

The District secured an easement on the property in 2011. The District also completed the design and permit applications were approved by local, state, and federal regulatory agencies in January 2012. The project was constructed in December 2012.

Constructed Notched Weir and Sand-Iron Filter

5.1.7 Kingston Wetland Feasibility Study and Restoration

The goal of the Kingston Wetland Feasibility Study and Restoration Project is to design and implement a restoration of the dissolved oxygen impaired Clearwater River and its 460 acre riparian Kingston Wetland to improve main channel dissolved oxygen concentrations in a DO impaired reach of the Clearwater River, reduce the seasonal export of soluble phosphorus to impaired lakes while maintaining particulate phosphorus sequestering capacity, and improve stream and wetland habitat.

Improvements in DO will be achieved by mitigating sediment oxygen demand in the wetland complex. The project also targets a 1,970 lb/year phosphorus reduction to downstream lakes by preventing soluble phosphorus export from the riparian wetland.

Macroinvertebrate samples and sediment cores were collected in 2012 as shown in Figure 5.1.

Figure 5.1 Kingston Wetland Sediment and Macroinvertebrate Sample Locations

Macroinvertebrate samples were collected from the Clearwater River just downstream of the Kingston Wetland in September 2012. Analysis of the sample indicated that approximately 40 different taxon of macroinvertebrates were documented in this portion of the river. The macroinvertebrates observed in this portion of the river were all tolerant or very tolerant of sedimentation and pollution. There were no sensitive species observed in the sample. This is an indication that this reach of the Clearwater River and Kingston Wetland in their current condition do not provide quality habitat for macroinvertebrates. This sample will be used as a baseline to compare to the macroinvertebrate community after the project is constructed.

Sediment core samples were collected in the Kingston wetland at two locations in April 2012 as shown in Table 5.2. Site 1 was located in the interior of the wetland outside of the channel. Sediments in this area consisted of a very deep layer of organic soils comprised of muck and decomposed organic matter. Site 2 was located in the center of the channel near the downstream end of the Kingston Wetland. Sediments at site 2 consisted of a thin layer of organic material over sand and clay. The core samples were analyzed for Sediment Oxygen Demand (SOD) and phosphorus release. Results of the analysis are shown in Table 5.3. The analysis demonstrated that SOD was very similar at both locations and was high as expected. Phosphorus release from the sediments was also very high and was nearly twice as high at Site 2.

Table 5.2 Kingston Wetland Sediment Sampling Results

Site	SOD (g/m2/day)	Phosphorus Release Rate (mg/m2/day)
Site 1	1.09	18.5
Site 2	1.08	34.6

A feasibility study was prepared in June of 2012 and permit applications were prepared and submitted to local, state, and federal agencies. All permits will be obtained prior to the start of construction of the project.

Construction is scheduled to begin in late January 2013 and be substantially complete prior to spring of 2013. Followup monitoring will be conducted as soon as the project is on line.

5.1.8 Clearwater River Channel Stabilization

The purpose of this project, which began in 2010, is to stabilize the channel and banksof the Clearwater River. The CRWD has prioritized areas for restoration with extensive tree canopy which does not allow for the growth of stabilizing ground vegetatation.These areas are subject to sloughing and incision of the channel banks. The outcomes of the project are to stop soil loss from the bank area by restoring vegetation, stop soil loss from the channel by installing bank toe protection and grade control, and installing grade control structures that will aerate water.

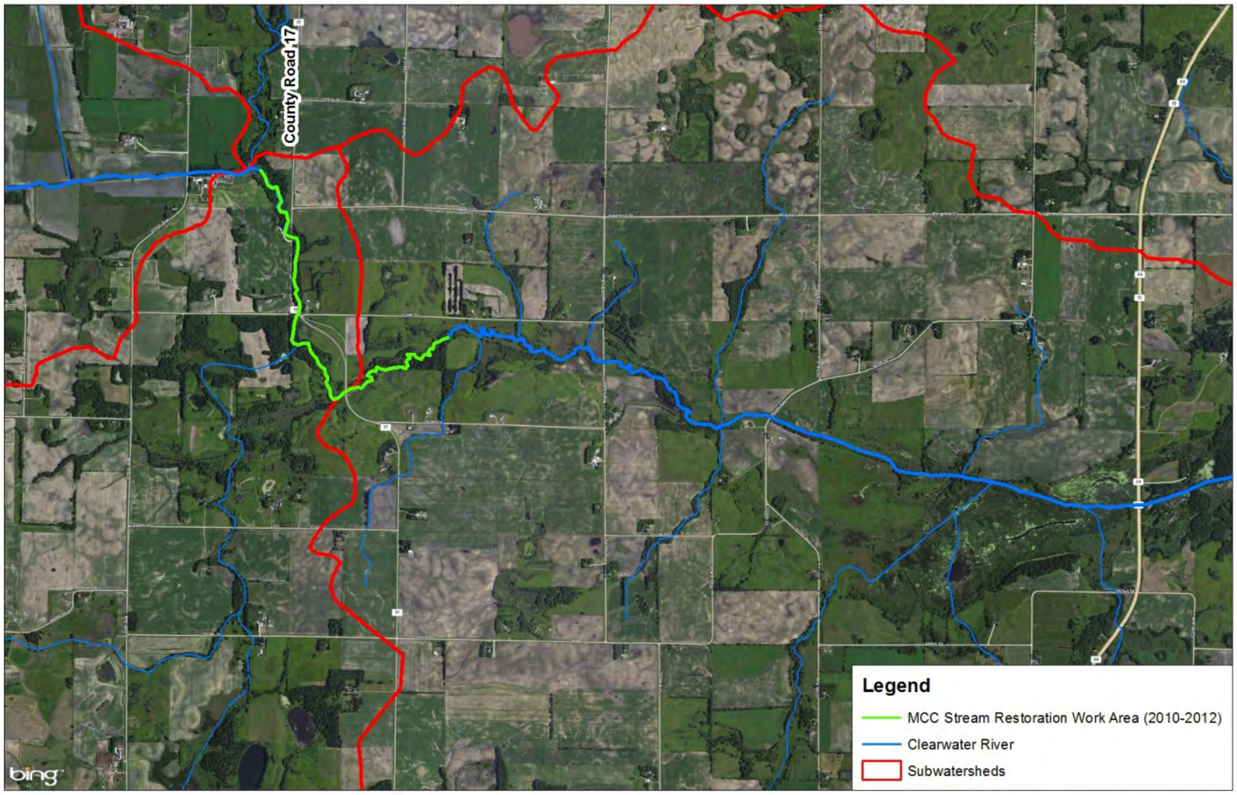
The Conservation Corps crews began work in 2010 and were responsible for thinning trees, building and installing brush bundles, fabricating grade control structures from felled logs, live stake harvesting and installation, seeding slopes, and installing erosion control fabric along approximately 2,800 linear feet in the project area. The CRWD conducted similar work in 2011 on an additional 6,700 linear feet of stream channel of the Clearwater River. In 2012, the CRWD continued working in the same general area by working on an additional 1,800 linear feet of channel and repairing damaged areas within the reaches worked on in previous years. Figure 5.2 shows the 2010, 2011, and 2012 project area. Reference photos showing a representative of the streambank before and after the work was completed were taken and are shown below.

Photos Documenting Work Completed in 2012

The project has given the CRWD the opportunity to work with willing landowners along the Clearwater River. CRWD plans to continue finding additional landowners to continue this project with the CCM in future years.

PostConstruction Photos After One Year of Regrowth in Areas of Work Completed in 2011

Figure 5.2 CCM Channel Stabilization Project Area



5.1.9 Expanded Lake Water Quality Monitoring

Samples were collected near the bottom at each of the monitored lakes and analyzed for total phosphorus, ortho-phosphorus, and total iron. A summary of surface and bottom phosphorus concentrations, bottom iron concentrations, and a DO/temperature profile at each lake for each monitoring date is found in Appendix G. A summary of bottom phosphorus data collected at each lake since 2009 is found in Appendix I. A summary of current and historical lake data is also found on the lake report cards in Appendix C.

Analysis of these parameters in bottom samples is helpful in estimating internal nutrient cycling in lakes. In-lake nutrient cycling is an important component of the whole lake nutrient budget. Phosphorus builds up in lake-bottom sediments due to increases in phosphorus load export from the tributary watershed.

Lake profile data, in which temperature and dissolved oxygen were recorded at 1 meter increments in each lake helps to identify the period of stratification in lakes. This data also allows quantification of the period of anoxia, defined as dissolved oxygen levels less than 2 mg/L, in each lake. Internal loading can be a result of sediment anoxia, where weakly bound phosphorus is released into the water column in a form readily available for phytoplankton production.

Review of the lake profile data collected in 2012 demonstrates that high summer water temperatures observed in late June and July caused by a series of days with high temperatures with little wind caused strong stratification in some lakes at shallower than normal depths through July.

Table 5.3 provides a summary of conditions in CRWD lakes which can be used to determine the potential for in-lake nutrient cycling in each lake sampled in 2012. Generally, lakes which have high bottom phosphorus concentrations and periods of anoxia from stratification are susceptible to internal nutrient cycling. Lake stratification patterns identified in Table 5.2 vary between water bodies. Lake stratification can drive anoxia, which can drive internal loading in deeper lakes. Identifying the stratification and anoxic period can guide design of efforts to reduce internal loading.

Table 5.3 2012 Summer Average Concentrations and Lake Stratification Patterns

Lake Name	Surface Summer Average TP (µg/L)	Surface Summer Average OP (µg/L)	Bottom Summer Average TP (µg/L)	Bottom Summer Average OP (µg/L)	Lake Stratification Pattern
Albion	169	8	Not Sampled	Not Sampled	Mixed
Augusta	43	8	728	553	Strongly Stratifies
Betsy	125	54	1969	595	Weakly Stratifies
Caroline	118	31	2790	2325	Strongly Stratifies
Cedar	22	8	206	161	Strongly Stratifies
Clear	86	8	129	20	Polymictic
Clearwater West	29	7	143	99	Strongly Stratifies
Henshaw	112	7	Not Sampled	Not Sampled	Mixed
Little Mud	26	6	1020	10	Stratifies
Louisa	136	24	2020	1730	Strongly Stratifies
Marie	137	24	1510	1098	Stratifies
Otter	19	8	541	143	Stratifies
Pleasant	25	8	222	73	Stratifies
Scott	129	31	270	167	Polymictic
Swartout	438	274	484	175	Polymictic
Union	36	9	928	196	Stratifies

Mixed and Polymictic: In mixed water bodies, water temperature is fairly uniform from top to bottom in the lake. As a result, oxygen enriched water from near the surface is able to mix throughout the water column, and anoxia is typically not present. Polymictic lakes are lakes that develop a weak stratification and mix periodically throughout the growing season. As a result of the frequent mixing, anoxic conditions would likely occur infrequently.

Stratified: In stratified lakes a warm surface layer forms during summer months and the lake maintains a cooler lower layer in the lake and prevents mixing between the two layers. This does not allow oxygen enriched water to reach the bottom layer and anoxia can develop below the thermocline.

Lakes with high bottom phosphorus concentrations that experience anoxic conditions during periods when the lake is stratified have a high potential for internal loading. Lakes with the highest bottom concentrations of phosphorus in 2012 include Betsy, Caroline, Louisa, Marie, Scott, and Union. Based on the presence of high bottom phosphorus concentrations, lake stratification patterns and associated periods of anoxia during a given year, these lakes have a high potential for internal loading. Shallow lakes such as Henshaw, Albion,Swartout, can load internally throughout the season based on disturbance of bottom sediments from wind and rough fish.

As shown on the Lake Report Cards in Appendix C and in Lake Phosphorus and Profile Data in Appendix G, the bottom phosphorus concentrations in most lakes generally increased throughout the summer in 2012 as anoxic conditions developed in these lakes in early summer. This is especially evident in Betsy, Augusta, Louisa, Marie, and Union Lakes. An exception to this pattern was observed in Lake Caroline in 2012 as bottom phosphorus concentrations were high in the beginning of the summer and remained high through the end of the monitoring season. The bottom phosphorus concentrations in these lakes typically decrease after mixing with the entire water column during fall turnover. This was evident in lakes that were sampled following fall turnover in 2012, including Clearwater and Union.

This pattern of increasing phosphorus concentrations is evident in most years as shown in Appendix I, which compares bottom phosphorus concentrations in District Lakes since 2009. Appendix I demonstrates that surface phosphorus concentrations were higher than in past years in several lakes in 2012, especially lakes on the Clearwater Chain, including Caroline, Louisa, and Marie.

Appendix A

2012 Water Quality Monitoring Program

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1800 Pioneer Creek Ctr.
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Maple Plain, MN 55359-0249

(763) 479-4200
Fax (763) 479-4242
E-mail: wenckmp@wenck.com

MEMORANDUM

TO: **Clearwater River Watershed District Board of Managers**

FROM: **Norman C. Wenck**
Engineer for the District

DATE: **January 11, 2012**

RE: **Proposed 2012 Water Quality Monitoring Program**

Introduction

The Clearwater River Watershed District conducts its annual water quality monitoring at selected lakes and locations on streams. The proposed 2012 program is intended to assess District progress towards water quality goals and to track long-term water quality trends.

The 2012 proposed lake monitoring follows the long-term plan as shown in Table 1 and Figure 1. The proposed stream monitoring sites together with laboratory and field parameters are shown in Table 2.

Lake Monitoring

It is recommended that the District's 2012 lake monitoring include the 13 lakes shown on Table 1, including Clearwater West, Augusta, Louisa, Caroline, Scott, Marie, Betsy, Pleasant, Clear, Otter, Union, Wiegand, and Little Mud. Surface and bottom water samples should be collected at all of the sampled lakes to continue to track internal loading.

The proposed stations and the parameters to be monitored are shown on Table 2. Citizens also monitor approximately 10 lakes for Secchi depth.

Stream Monitoring

The Clearwater River will be monitored twice a month from March-July and once a month from August-October at station CR28.2. The Clearwater River will also be monitored once a month from March-October at station CR 10.5 at the Grass Lake Dam. Warner Creek will be monitored once a month from March-October at WR 0.2.

These stations will be monitored for water quality and flow. Water quality parameters are total phosphorus, ortho-phosphorus, and total suspended solids. CR 28.2 will also be monitored for *E. coli* bacteria.

Cedar Lake Subwatershed Monitoring

Monitoring conducted in the Cedar Lake Subwatershed will continue in 2012. Cedar, Albion, Henshaw, and Swartout Lakes will be monitored in 2012. Tributary streams in the Cedar Lake subwatershed will also be monitored in five locations while they are flowing from March to October.

Estimated Cost

The proposed basic monitoring program is estimated to cost $24,500 plus an estimated additional 300 hours of CRWD staff time. The Cedar Lake Subwatershed monitoring is estimated to cost $4,200 plus an estimated 80 hours of CRWD staff time.

Recommended Supplemental Monitoring

In addition to the basic program, it is recommended that supplemental monitoring efforts be considered in 2012. The proposed supplemental monitoring efforts would allow the District to track the success of individual projects or to investigate specific water quality concerns.

Supplemental Monitoring Task 1: Maintain continuous level measurement station at Grass Lake Dam.

Pressure transducers were previously purchased by CRWD to measure continuous water level elevations in the watershed. It is recommended that the District continue these measurements by installing one of the previously purchased pressure transducers at the Grass Lake Dam. The collection of this data will enable the calculation of continuous flows over the dam and allow for better characterization of runoff in the watershed. The approximate cost of this task which includes installation of the equipment and data management is $1,000 plus 8 to 12 hours of CRWD staff time.

Supplemental Monitoring Task 2: Additional monitoring at Willow Creek.

It is recommended that the District collect samples and monitor flow in Willow Creek at two locations, one upstream and one downstream of the City of Kimball. This monitoring will allow the quantification of the water quality benefits of Phase I and Phase II of the City of Kimball stormwater projects. The sites should be monitored monthly from March-October with an additional 2 events during storms. The cost of this task is approximately $1,200 plus an additional 20-24 hours of CRWD staff time.

Supplemental Monitoring Task 3: Additional monitoring in Warner Creek.

It is recommended that the District add two stream monitoring sites on Warner Creek, one at Highway 55 upstream of the Annandale wetland and one directly downstream of the Annandale wetland, to help determine possible causes of increasing phosphorus concentrations observed in Warner Creek in recent monitoring years. It is recommended that the District should monitor these additional sites for water quality and flow one time per month from March-October with up to an additional 2 monitoring trips during storm events. The cost of this task is approximately $1,200 plus an additional 20-24 hours of CRWD staff time.

Supplemental Monitoring Task 4: Clear Lake tributary stream monitoring.

It is recommended that the District add stream monitoring sites on tributary streams to Clear Lake on the north and south side of the lake. The data from these sites would be used to assess the progress of projects that are being implemented in the Clear Lake subwatershed. It is recommended that the District should monitor these additional sites for water quality and flow one time per month from March-October with up to an additional 2 monitoring trips during storm events. The cost of this task is approximately $1,200 plus an additional 20-24 hours of CRWD staff time.

Supplemental Monitoring Task 5: Contingency stream monitoring.

This supplemental monitoring task would involve collecting up to 2 additional samples from routine monitoring stations CR 28.2, CR 10.5, and WR 0.2 during high runoff periods following significant precipitation events. Flows would also be monitored during these events. This task also includes the budget to collect up to 4 additional samples in the watershed to document unique events observed by CRWD staff, such as runoff from feedlots or other discharges to water bodies that have previously gone unmonitored. The approximate cost of this task would be $750 plus 18-24 hours of CRWD staff time.

Supplemental Monitoring Task 6: Provide assistance for on-going Mississippi TMDL.

The MPCA may request District staff to assist them with monitoring for the ongoing Mississippi River Watershed TMDL in 2012. This effort would involve some CRWD staff time, but would not incur any other additional cost to the District.

Summary

The proposed monitoring program continues the program in place since 1981, coordinates with other programs, and reflects input from the Board and citizens. Please feel free to call me at 763-479-4201 or Rebecca Kluckhohn at 763-479-4224 with any questions or comments that you may have.

TABLE 1
PROPOSED LONG-TERM WATER QUALITY MONITORING PLAN FOR CRWD LAKES

LAKE STATIONS	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Clearwater Lake:										
Clearwater East	DNR		X		X		X		X	
Clearwater West	DNR	X		X	X	X		X		X
Main Stem Lakes:										
Augusta	DNR		X		X	X*	X	X	X	X
Louisa	TMDL/ DNR	TMDL*	X		X	X	X	X	X	X
Caroline	DNR	X		X	X	X	X	X	X	X
Scott		X		X	X	X*	X	X	X	X
Marie	DNR	X*		X	X	X	X	X	X	X
Betsy	X		X		X*	X	X	X	X	X
Other Lakes:										
Cedar	X	X		X(2)	X(2)	X(2)	X(2)	X	X	X
Pleasant	MPCA		X	X(3)	X	X		X		X
School Section			X		X		X		X	
Nixon			X	X	X		X		X	
Otter			X		X			X		
Bass	MPCA/ DNR	X		X(3)	X		X		X	
Clear	X			X	X*	X	X	X	X	X
Union	MPCA			X	X	X	X	X	X	X
Henshaw	X		X	X(2)	X(2)	X(2)	X(2)	X	X	X
Little Mud		X			X			X		
Wiegand	X				X			X		X
Swartout	X	X		X(2)	X(2)	X(2)	X(2)	X	X	X
Albion	X	X		X(2)	X(2)	X(2)	X(2)	X	X	X
Grass	DNR			X	X		X		X	X
Number of Lakes Monitored W/ CRWD Funding	17	10	9	14	22	14	17	17	17	16

Note:

(2) Part of Project #06-1

(3) Added to assess trends

* Lake bottom sediment cores collected and analyzed

T:\0002\188\2012 Monitoring Plan\CRWDSAMP_2012

TABLE 2
Proposed 2012 CRWD Monitoring Plan Summary

Category	2012 Schedule	Station	Parameters
Lakes:	June 1-5, July 6-10, August 3-7, September 7-11 (Additional DO and Temperature profile data to be collected in May and September in Clear, Betsy, Scott, Louisa, Marie, and Union Lakes.) Note: (Lake sampling to be completed by September 15)	The CRWD will monitor Clearwater (West), Augusta, Louisa, Caroline, Scott, Marie, Betsy, Pleasant, Clear, Otter, Union, Wiegand, and Little Mud Lakes.	Field: Secchi depth, DO and temperature profiles.
		Cedar, Albion, Swartout, and Hensaw Lakes will be monitored as well.	Lab: surface samples for total phosphorus, ortho phosphorus, and chlorophyll-a Bottom samples for total phosphorus, ortho phosphorus, and total iron.
			Citizen Secchi: 10 sites not listed here
Streams:	Twice monthly March-July, monthly August-October	CR 28.2	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids, E. coli
	Monthly March-October	CR 10.5	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids,
	Monthly March-October	WR0.2	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids,
	Weekly	River Stage at CR10.5	
Precipitation:	Daily	Corinna, Kimball, Watkins	
Cedar Lake Tributaries	Monthly while streams are flowing from March-October	The CRWD will monitor stream tributary sites SSW01, SSW02, SSW04, SCE01, and SHE01	Tributaries Field: DO, temperature, conductivity, pH ; Lab: total phosphorus, ortho phosphorus, TSS
		Flows will also be gauged at lake outlet sites (SSW01, SHE01, and SCE01) on days when lake samples are collected in Swartout, Henshaw, and Cedar Lakes.	Lakes Field: Secchi, DO, temperature profiles Lab: surface: total phosphorus, ortho phosphorus, chlorophyll-a bottom: total phosphorus, ortho phosphorus, total iron

Appendix B

Historical Mean Flow and Phosphorus Loading

APPENDIX B Table B-1
Historical Mean Flow and Phosphorus Loading

Clearwater River Watershed District

2012 Annual Report

Station Main Stem:	Year	Average Stream Flow (cu m/sec)	(cfs)	Flow-Weighted Average Total Phosphorus Concentration (mg/L)	Total Phosphorus Load (kg)	(lb)	µg/L
CR 28.2	1981 (1)	--	--	1.400	--	--	1,400
	1981						
(Actual River	1982 (1)	0.93	32.8	0.740	19,700	43,500	740
Mile 27.2)	1983	2.62	92.6	0.920	76,000	168,000	920
	1984	1.49	52.6	0.760	35,700	78,800	760
	1985	2.32	81.9	0.900	65,500	144,000	900
	1986	3.20	113	0.780	55,200	122,000	780
	1987	0.11	3.90	0.130	460	1,020	130
	1988	0.09	3.12	0.660	1,850	4,080	660
	1989	0.02	0.72	0.190	120	260	190
	1990	0.51	18.0	0.440	7,040	15,500	440
	1991	1.11	39.1	0.290	10,200	22,500	290
	1992	0.26	9.30	0.200	1,660	3,650	200
	1993	1.28	45.2	0.290	11,600	25,600	290
	1994	1.17	41.2	0.280	10,100	22,300	280
	1995	1.15	40.4	0.288	10,400	22,900	288
	1996	0.33	11.7	0.274	2,860	6,300	274
	1997	0.27	9.36	0.260	2,170	4,790	260
	1998	0.41	14.4	0.250	3,190	7,020	250
	1999	0.08	2.78	0.160	400	870	160
	2000	0.02	0.72	0.380	240	530	380
	2001 (4),(5)	0.27	9.46	0.510	4,309	9,500	510
	2002	0.47	16.50	0.291	4,290	9,460	291
	2003	0.28	9.92	0.190	1,710	3,770	190
	2004	0.48	17.04	0.166	1,248	2,751	166
	2005 (6)	1.11	39.28	0.306	1,862	4,105	306
	2006	0.31	11.10	0.130	1,328	2,928	130
	2007	0.14	5.02	0.228	767	1,692	228
	2008	0.64	22.53	0.155	1,333	2,938	155
	2009	1.15	40.60	0.333	7,982	17,597	333
	2010	1.55	54.60	0.258	10,866	23,955	258
	2011	2.62	92.66	0.269	13,593	29,967	269
	2012	1.01	35.72	0.335	6,096	13,440	335
CR 10.5	1981 (1)	1.15	40.6	0.050	2,060	4,550	50
	1982 (1)	2.20	77.8	0.070	4,990	11,000	70
	1983	5.64	199	0.100	18,500	40,800	100
	1984	4.28	151	0.050	6,620	14,600	50
	1985	3.88	137	0.140	16,700	36,800	140
	1986	5.52	195	0.150	23,700	52,300	150
	1987	0.46	16.2	0.040	600	1,320	40
	1988	0.23	7.95	0.040	260	580	40
	1989	0.97	34.2	0.080	2,340	5,150	80
	1990	3.77	133	0.030	3,060	6,750	30
	1991	6.68	236	0.050	10,500	23,200	50
	1992	4.16	147	0.060	8,090	17,800	60
	1993	5.01	177	0.040	6,330	14,000	40
	1994	2.92	103	0.030	2,850	6,290	30
	1995	2.83	100	0.034	3,040	6,710	34
	1996	1.53	54.2	0.041	1,970	4,350	41
	1997	2.06	72.8	0.040	2,690	5,940	40
	1998	1.78	63.0	0.040	2,330	5,120	40
	1999	1.25	44.1	0.040	1,520	3,350	40
	2000	0.31	10.8	0.030	280	610	30
	2001 (4),(5)	0.90	31.7	0.030	850	1,873	30
	2002	2.46	87.0	0.035	2,950	6,500	35
	2003	2.11	74.6	0.024	1,590	3,500	24
	2004	1.66	58.8	0.022	639	1,409	22
	2005 (6)	3.05	107.6	0.023	59	130	23
	2006 (6)	1.76	62.2	0.032	1,263	2,785	32
	2007	0.97	34.1	0.031	933	2,057	31
	2008	1.27	44.8	0.023	452	997	23
	2009	3.99	141.0	0.025	1,949	4,297	25
	2010	6.16	217.5	0.032	4,150	9,149	32
	2011	9.20	325.1	0.026	4,645	10,240	26
	2012	2.59	91.37	0.024	1,365	3,009	24

APPENDIX B Table B-1
Historical Mean Flow and Phosphorus Loading

Clearwater River Watershed District

2012 Annual Report

Station Main Stem: Tributaries:	Year	Average Stream Flow (cu m/sec)	(cfs)	Flow-Weighted Average Total Phosphorus Concentration (mg/L)	Total Phosphorus Load (kg)	(lb)	µg/L
WR 0.2 (2)	1981 (1)	0.07	2.60	0.170	390	860	170
	1982 (1)	0.23	8.20	0.160	780	1,720	160
	1983	0.47	16.50	0.090	1,270	2,800	90
	1984	0.60	21.20	0.050	950	2,100	50
	1985	0.48	17.10	0.140	2,130	4,700	140
	1986	0.86	30.40	0.200	4,630	10,200	200
	1987	0.04	1.50	0.070	100	230	70
	1988	0.01	0.40	0.170	60	130	170
	1989	0.03	1.19	0.140	80	180	140
	1990	0.06	2.28	0.370	750	1,660	370
	1991	0.26	9.22	0.111	860	1,900	111
	1992	0.11	4.02	0.050	170	370	50
	1993	0.24	8.59	0.100	760	1,670	100
	1994	0.18	6.34	0.060	320	700	60
	1995	0.12	4.27	0.054	210	460	54
	1996	0.05	1.78	0.110	180	380	110
	1997	0.09	3.15	0.077	220	480	77
	1998	0.09	3.11	0.110	290	650	110
	1999	0.06	2.03	0.070	130	280	70
	2000 (3)	0.01	0.44	0.060	25	56	60
	2001 (4),(5)	0.08	2.88	0.100	257	567	100
	2002	0.26	9.17	0.114	930	2,060	114
	2003	0.16	5.79	0.062	320	710	62
	2004	0.07	2.6	0.063	78	172	63
	2005	0.58	20.6	0.066	22	48	66
	2006	0.06	2.1	0.090	102	224	90
	2007	0.03	0.9	0.064	34	76	64
	2008	0.31	11.1	0.058	246	542	58
	2009	0.15	5.3	0.087	273	602	87
	2010	0.16	5.6	0.095	311	685	95
	2011	1.12	39.47	0.105	2,202	4,854	105
	2012	0.48	17.08	0.049	371	818	49

NOTES:

Flow values are time-weighted averages unless otherwise noted.
Total phosphorus values are flow- and time-weighted averages unless otherwise noted.

(1) Values in 1981 and 1982 are arithmetic means
(2) Station WR 0.2 was designated Station WC 0.2 in 1981-1983
(3) Phosphorus values in 2000 are flow-weighted and adjusted per log-log regression on flow so as to correspond to annual mean flows.
(4) 2001 Flow and total phosphorus values are arithmetic averages.
(5) 2001 total phosphorus loads estimated from arithmetic averages of flow and total phosphorus values.
(6) Values in 2005 and 2006 were calculated using supplemental flow data from CSAH 40 near Clearwater

T:\0002\188\Water Quality\[Stream_Loads_Historic_12.xls]Table 2

Appendix B-TABLE B-2

YEARLY PRECIPITATION AND RUNOFF TOTALS

Clearwater River Watershed District

	Precipitation (inches of water)					
YEAR	Watkins	Kingston	Maine Prairie	Corinna	Area-Weighted Precipitation Average	Runoff (inches)
1981	--	--	--	--	19.76	(1) 3.6
1982	--	--	--	--	24.58	(1) 6.8
1983	46.54	--	42.32	35.02	41.78	17.4
1984	32.23	30.13	32.37	36.07	32.95	13.3
1985	40.72	39.49	45.28	--	42.22	12.0
1986	40.02	35.63	39.68	33.40	37.26	16.0
1987	18.97	15.40	19.41	16.16	17.52	1.4
1988	16.57	18.98	15.96	15.01	16.48	0.7
1989	22.13	22.68	21.80	16.96	20.68	3.0
1990	40.35	39.18	41.36	32.18	37.94	11.7
1991	41.30	45.11	43.41	36.28	41.01	20.7
1992	23.06	18.41	20.47	24.35	22.01	12.9
1993	40.17	35.27 (2)	37.54 (2)	33.33	36.71	15.5
1994	34.77	--	30.13	30.26	31.98	9.0
1995	33.80	--	33.65	28.66	32.21	8.8
1996	31.31	--	24.32 (2)	26.13 (2)	27.59	4.8
1997	24.18	--	21.90	27.37	24.43	6.3
1998	30.03	--	29.39	27.43 (2)	29.05	5.5
1999	22.08	--	22.31 (2)	27.71	23.84	3.9
2000	23.83	--	20.56	19.91	21.22	1.0
2001	31.00	--	33.56	29.57	31.28	2.8
2002	37.50	--	40.27	44.72	40.57	7.6
2003	22.63	--	21.34	26.77 (2)	23.02	6.5
2004	33.58	--	33.58	31.67	33.10	2.8
2005	32.30 (2)	--	--	41.47	36.89	8.6
2006	20.95	--	--	23.38	22.17	4.2
2007	26.58	--	--	27.82	27.20	3.0
2008	26.19	--	--	25.00	25.58	2.0
2009	28.86	28.06*	--	27.65	28.26	7.6
2010	34.36	36.56*		32.94	33.65	13.1
2011	30.87	33.61*		30.61	30.74	18.8
2012	27.42	27.50		28.50	27.81	5.6
				Mean	29.42	8.0
				Std. Dev.	7.6	5.6

NOTES:

Whole watershed runoff is based on time-weighted average flow at Clearwater Lake outlet (station CR 10.5), and total drainage area of 155 square miles.

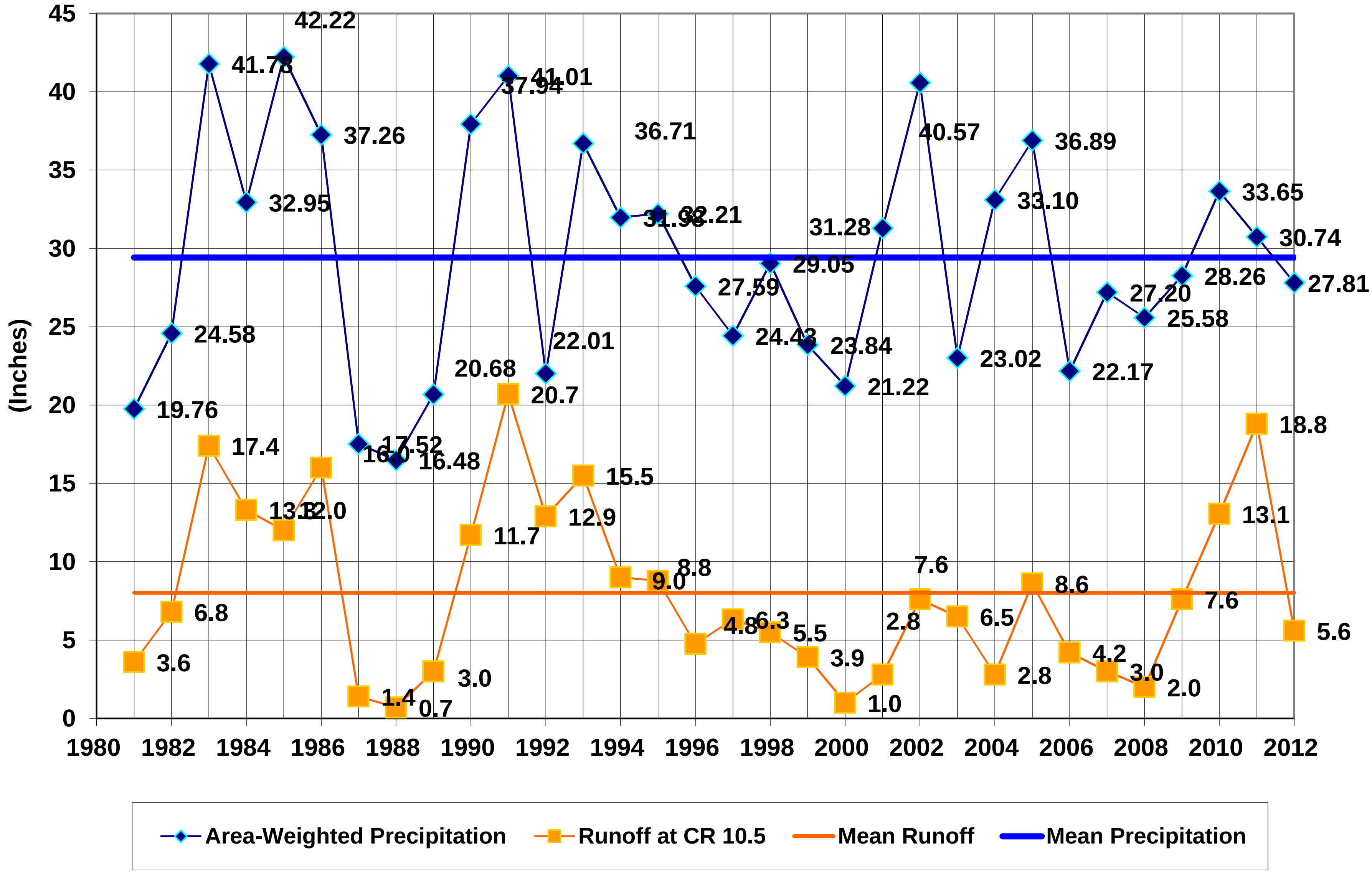
(1) Data for single gauge in east-central part of watershed (Camp Heritage on Lake Caroline).

(2) Average values of other stations in District were used to fill in missing data.

* Value from Kimball Station

T:\0002\188\Water Quality\[Stream_Loads_Historic_12.xls]Precip_Runoff Data

Appendix B Figure B- 1
Clearwater River Watershed District
2012 Annual Report

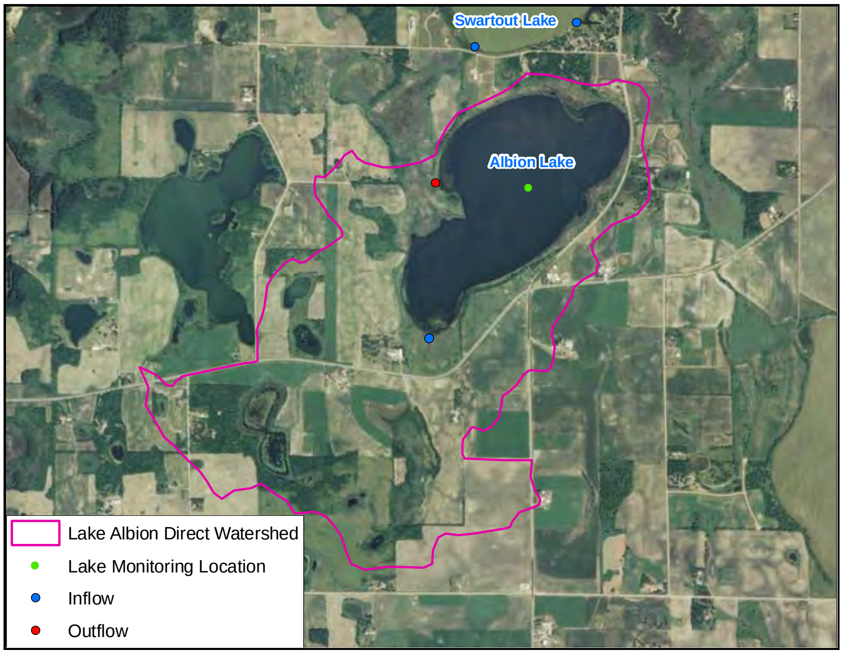


T:\0002\188\Water Quality\Stream_Loads_Historic_12Precip_Runoff_Graph_07

Appendix C

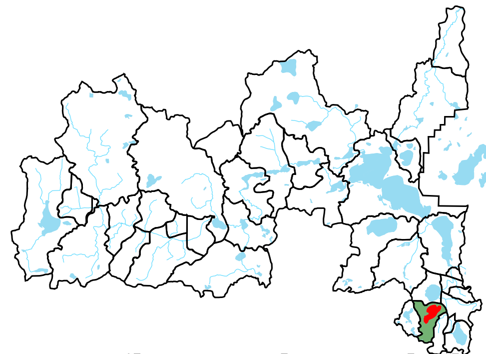
2012 Lake Report Cards

2012 Albion Lake Report Card

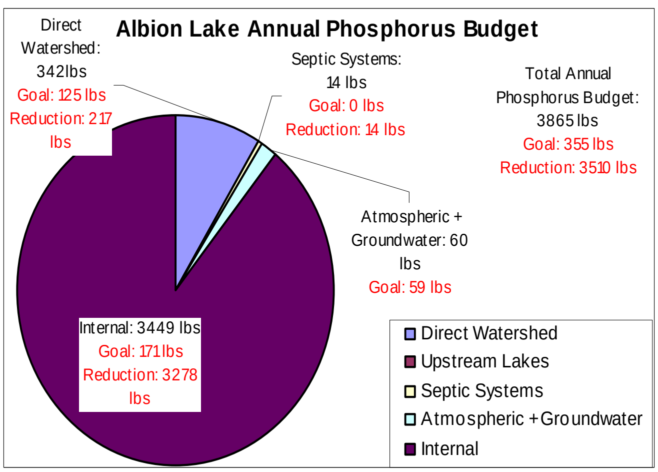


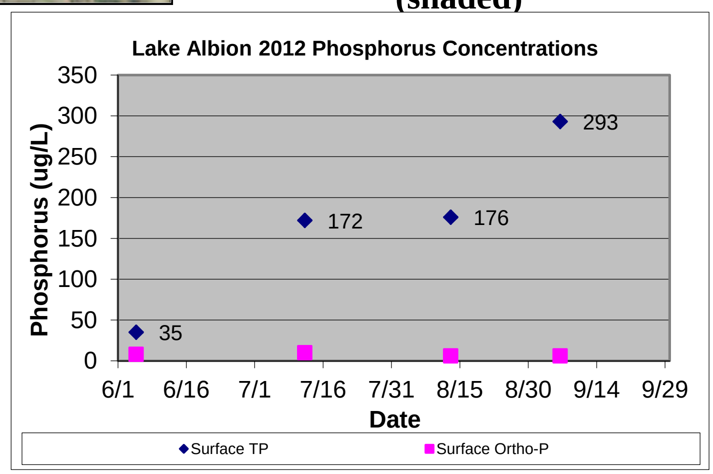
Lake Data

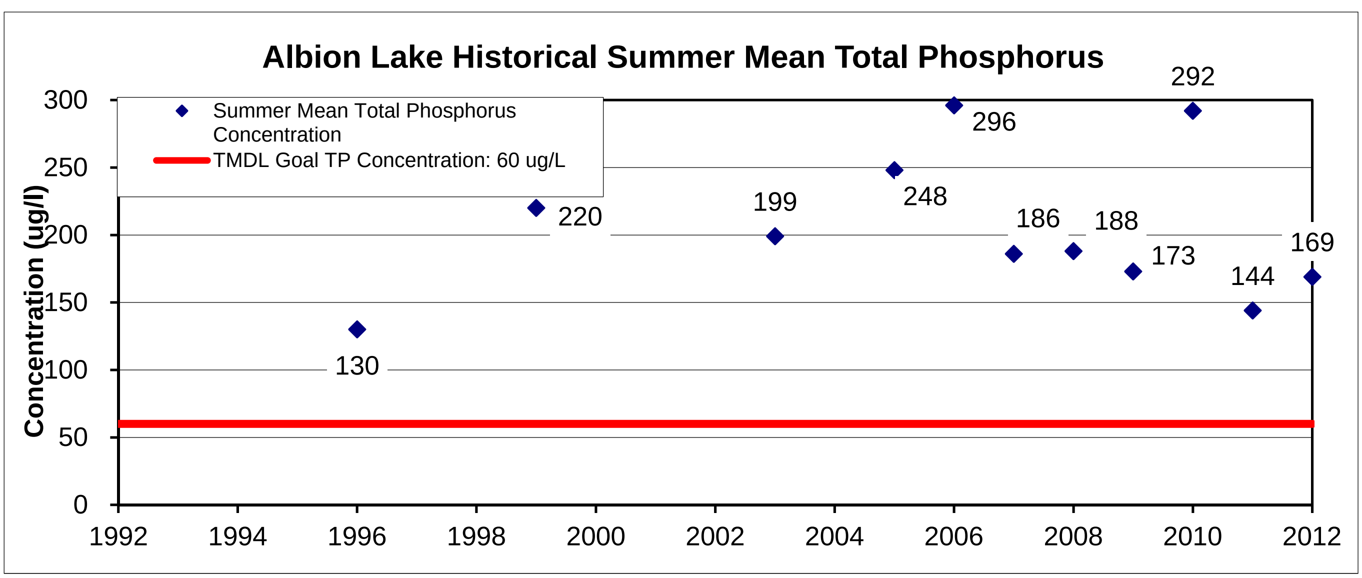
Surface Area:	251 Acres
Maximum Depth:	9 Feet
Contributing Subwatershed Area:	1,094 acres



Tributary Sub watershed (shaded)



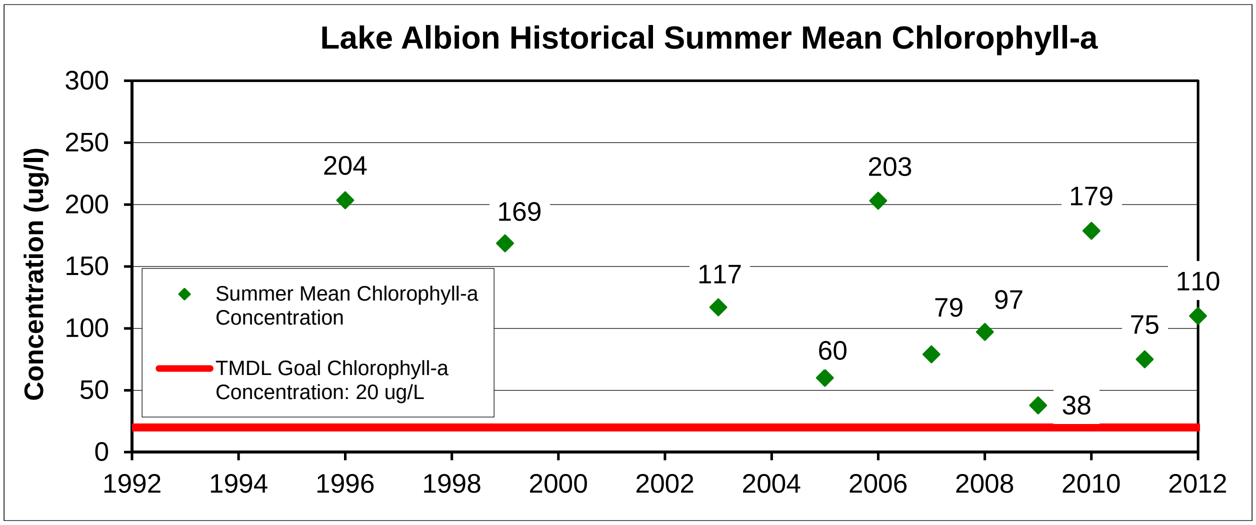


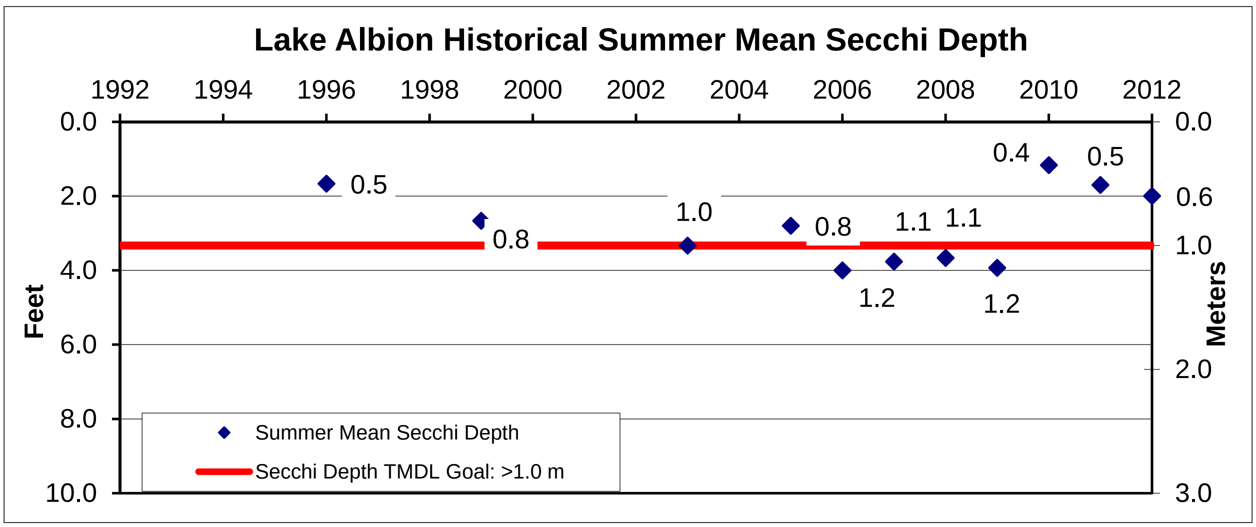


Albion Lake

2012 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





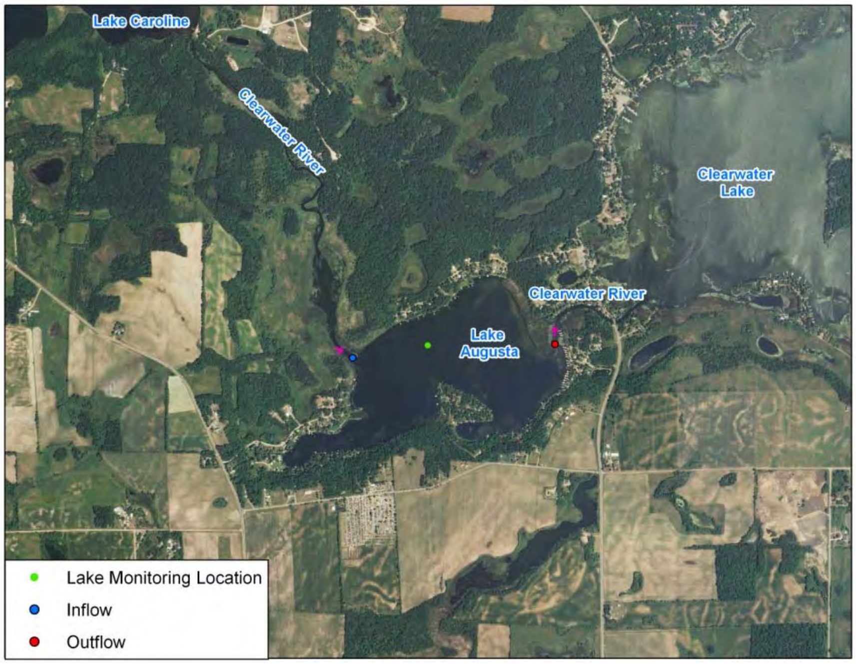
Summary

- TP and Chlorophyll-a concentrations were slightly higher than in 2011 and remained above TMDLwater quality goals.
- Water clarity has increased slightly since 2010, but remained lower than the TMDL goal as well as water clarity observed in the mid 2000s.
- Carp were observed to be abundant in the lake in 2012, which is likely contributing to poor water clarity and increased phosphorus concentrations due to resuspension of sediments and internal nutrient loading.
- An aquatic vegetation survey conducted in 2012 found submerged vegetation at 23% of sampled points, compared to 48% in 2011 and 28% in 2005. Curly leaf pondweed turions were found in abundance during the survey.

TMDL Activities

- Due to Lake Albion's small tributary watershed, the reduction of watershed loads alone will not be sufficient to achieve water quality goals for the lake.A significant reduction in the internal nutrient source will be required to meet water quality targets in the lake.
- The extent of curly leaf pondweed should be monitored in the lake in 2013.
- Management strategies including rough fish management should be implemented carefully in order to establish a state of high ecological integrity in the lake.
- Nutrient reduction strategies implemented as part of the Cedar Lake Improvement Project have included watershed BMPs and rough fish management.
- A shallow lake management plan should be developed for the lake in the future.

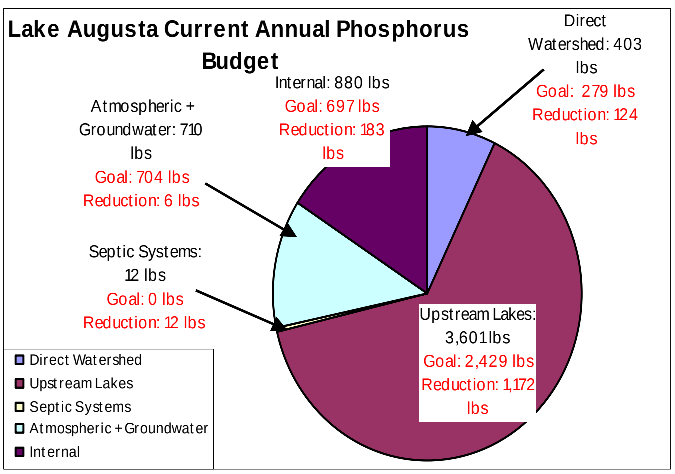
2012 Lake Augusta Report Card

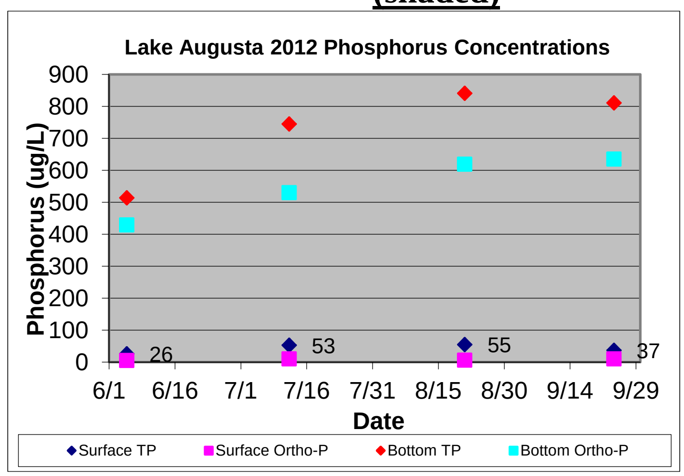


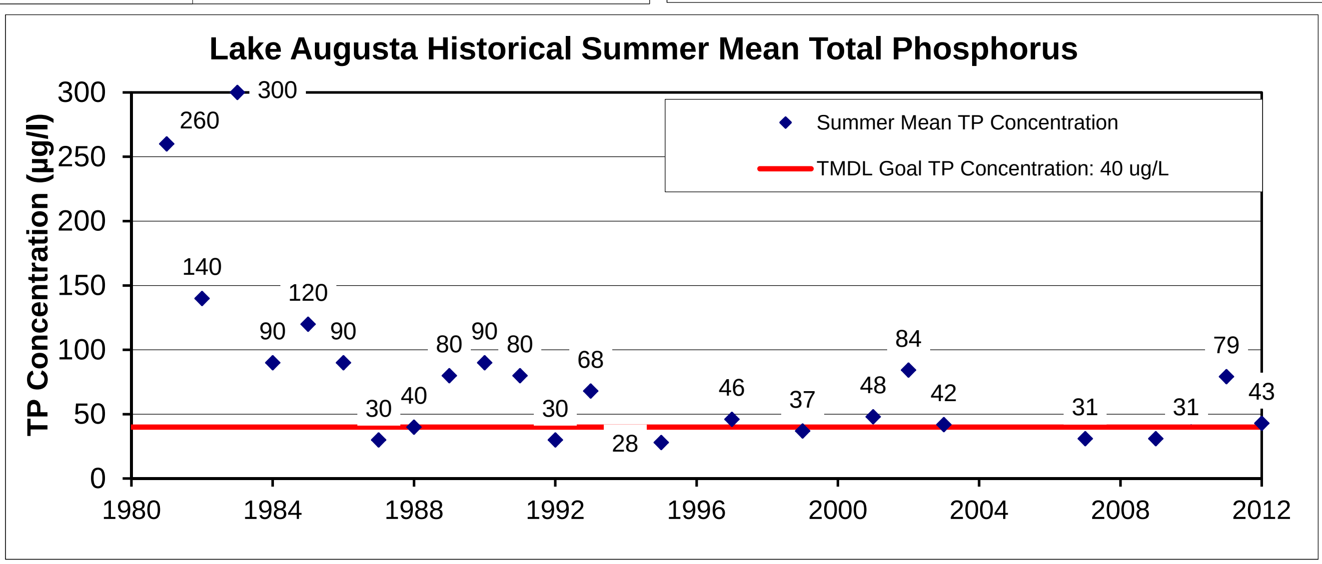
Lake Data

Surface Area: 177 Acres
Maximum Depth: 82 Feet
Subwatershed Area: 62,936 acres

Tributary Sub watershed (shaded)





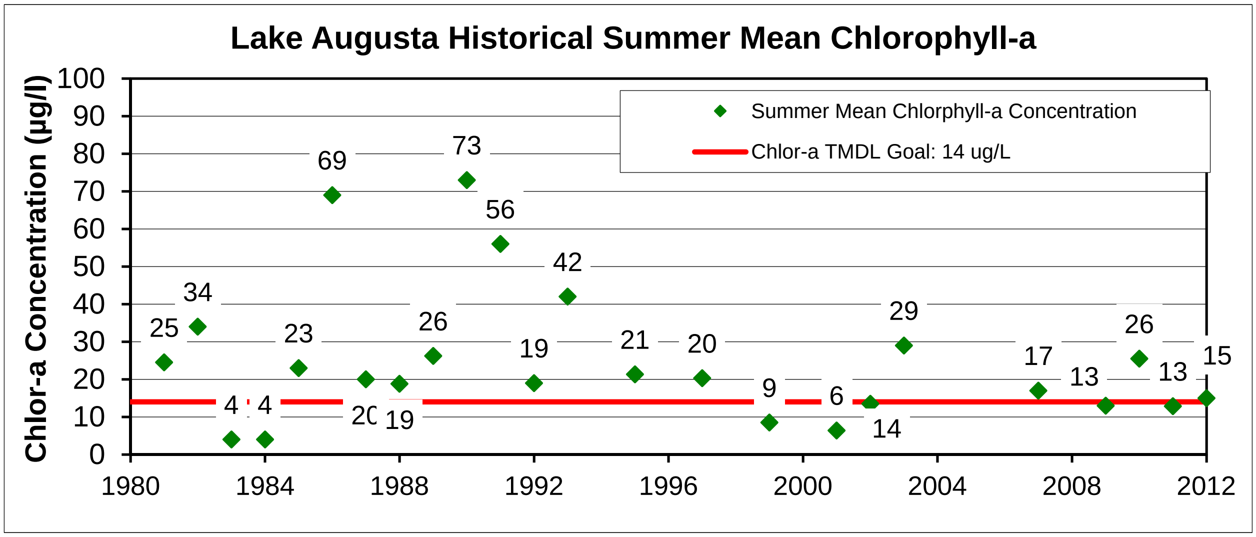


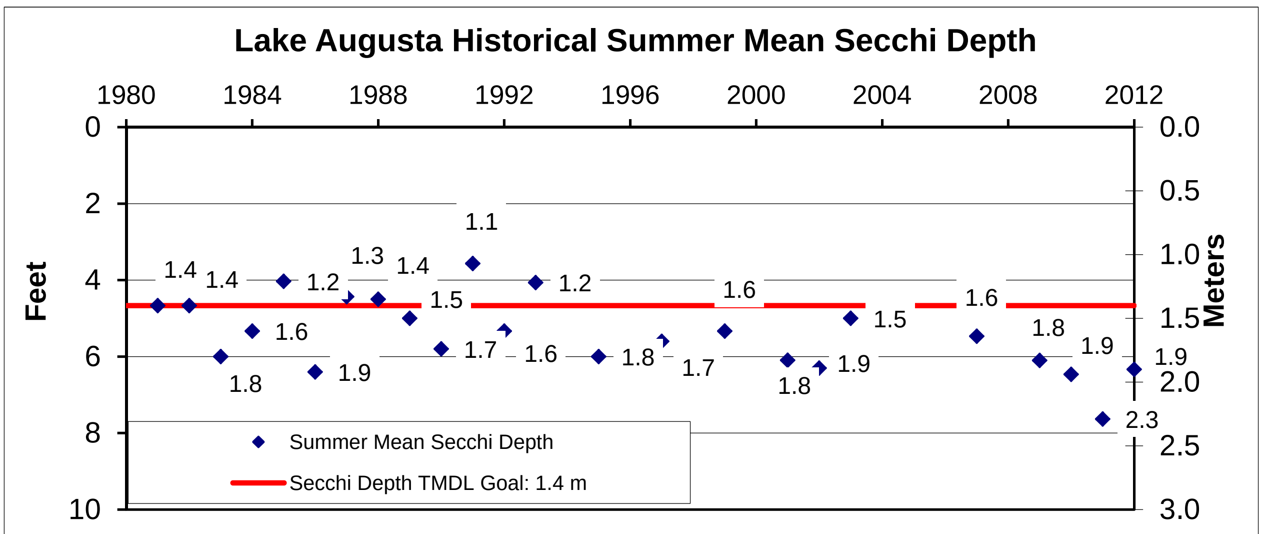
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
Lake Augusta		Appendix C

Lake Augusta

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





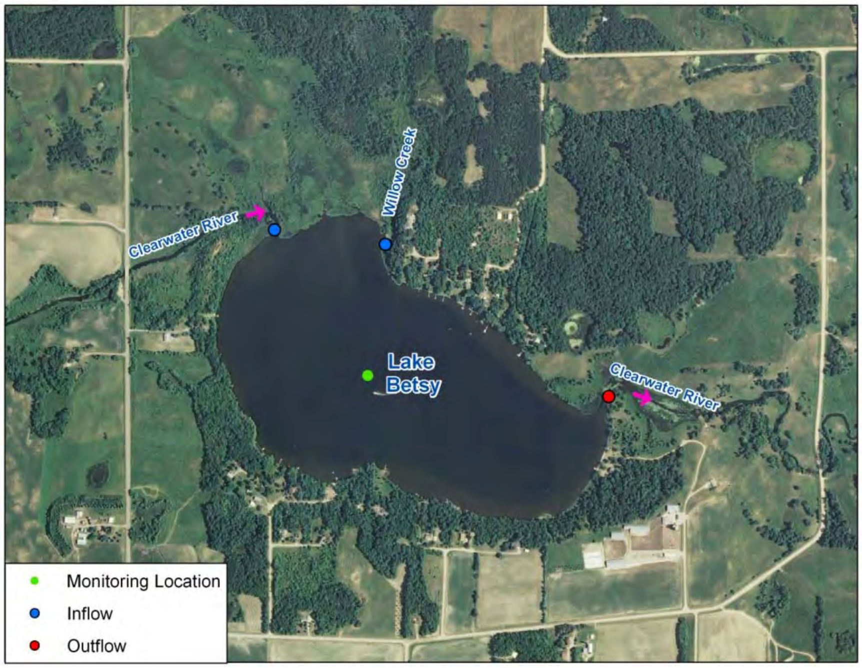
2012 Summary

- Phosphorus concentrations decreased in 2012 and were above TMDL goals.
- Chlorophyll-a concentrations were similar to recent years and were near TMDL goals.
- Secchi disk depth was similar to recent years and met TMDL goals in 2012.
- Water quality is dominated by loads from the Clearwater River and is buffered by upstream lakes.
- Monitoring data indicates a potential for high internal loads as bottom phosphorus concentrations were very high in 2012.

TMDL Activities

- TMDL calls for a combination of watershed load reductions and internal load reductions in order to meet water quality goals.
- Activities implemented in the upstream watersheds (Clear Lake and Lake Betsy) will have a cumulative impact on downstream lakes.
- Phosphorus reduction activities identified for implementation by the TMDL Implementation Plan in the watersheds tributary to Lake Betsy and Clear Lake include BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds.

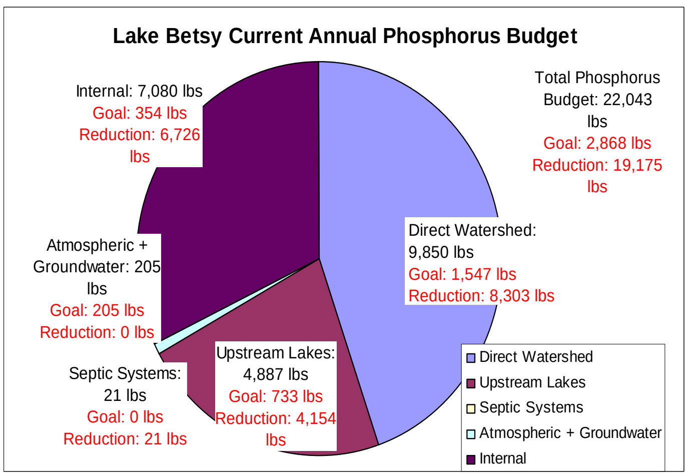
2012 Lake Betsy Report Card

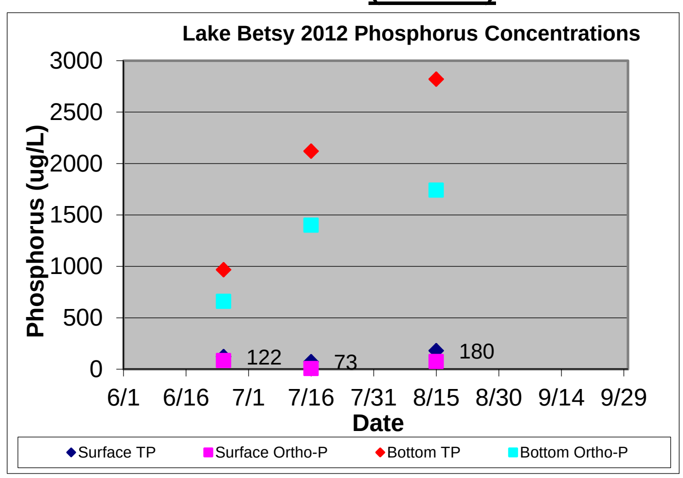


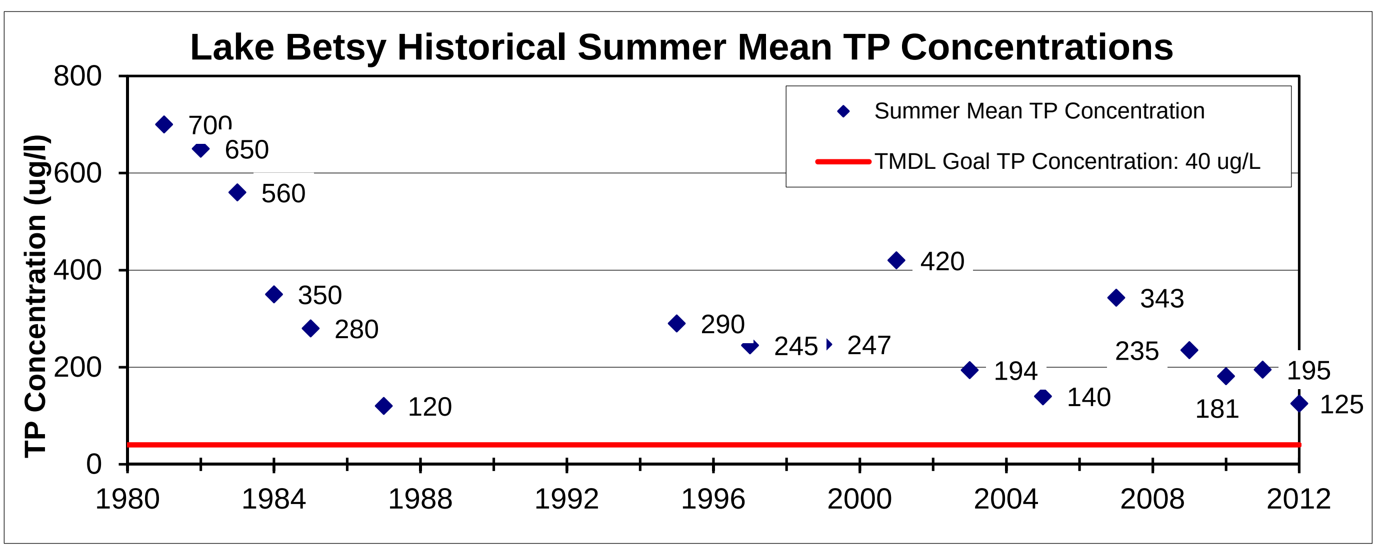
Lake Data

Surface Area:	153 Acres
Maximum Depth:	23 Feet
Subwatershed Area:	43,789 acres
Mean Depth:	10 Feet

Tributary Sub watershed (shaded)







Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
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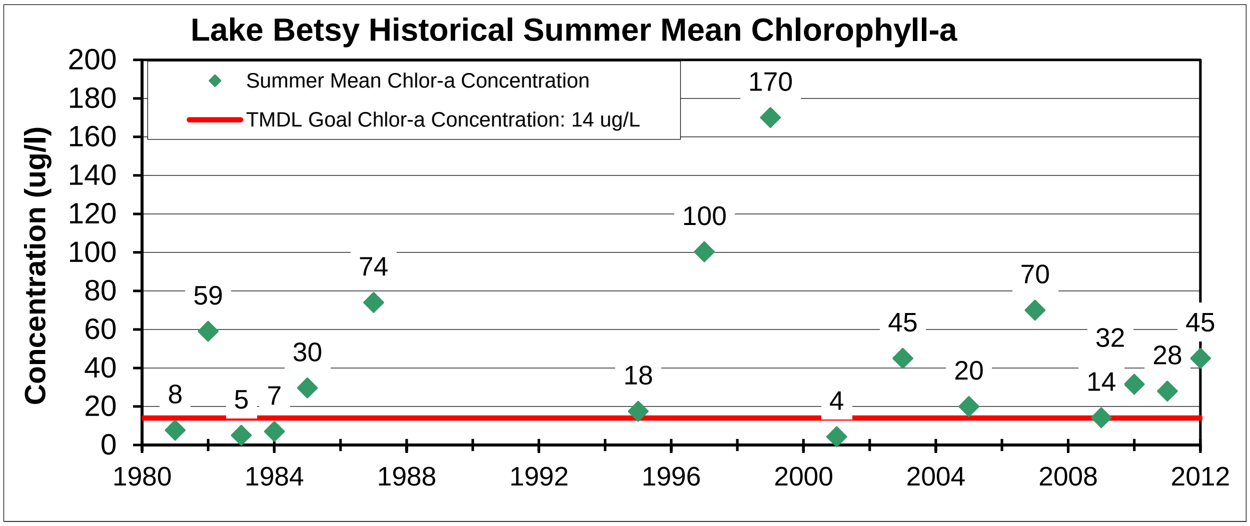
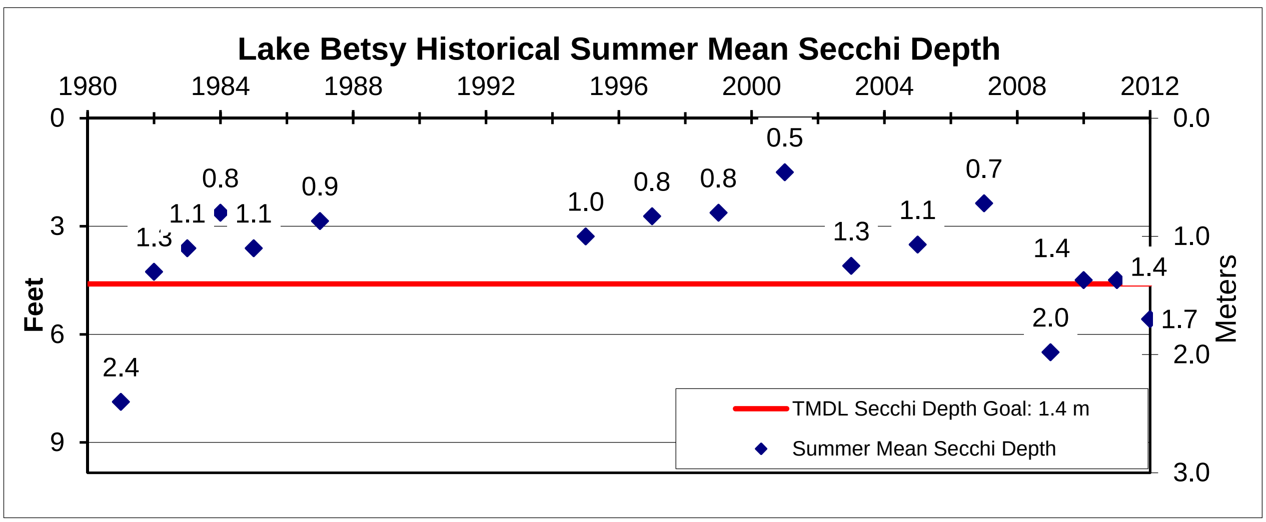
Lake Betsy

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2012 Summary

- Recent TP concentrations have been stable and remain below that of the early 1980's but are still well above the TMDL goals.
- Water clarity has improved recently as Secchi depth has met TMDL goals in recent years.
- Water quality is dominated by loads from the Clearwater River.
- 80,000 lbs of carp were removed from the lake in Summer 2011.
- Phosphorus release rates from sediment were measured in 2009 and internal loading of phosphorus was found to be well above the TMDL allocation for the lake.
- Bottom phosphorus concentrations were extremely high in 2012, which is a further indication of high potential for internal loading.

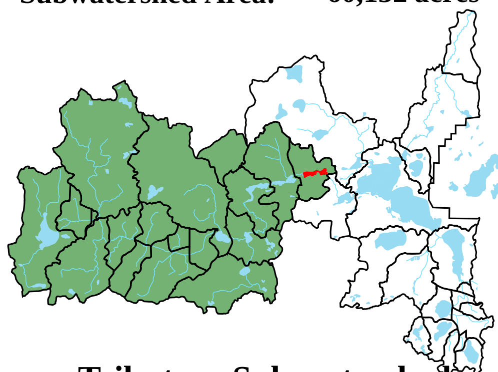
TMDL Activities

- TMDL calls for significant phosphorus reductions in watershed runoff and internal loading in order for Lake Betsy to meet state standards.
- The TMDL Implementation Plan identifies activities to be implemented in the watershed tributary to Lake Betsy, including BMPs, hypolimnetic withdrawal (potential 480 lb reduction), Kingston Wetland restoration (potential 1,970 lb reduction) and targeted soil testing and GPS fertilizer application (potential 600 lb reduction).
- Implementation activities in the watershed in 2012 included streambank restoration and GPS fertilizer application and testing.

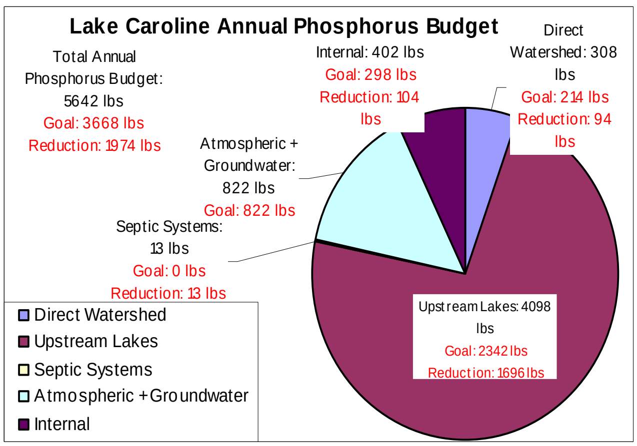
2012 Lake Caroline Report Card

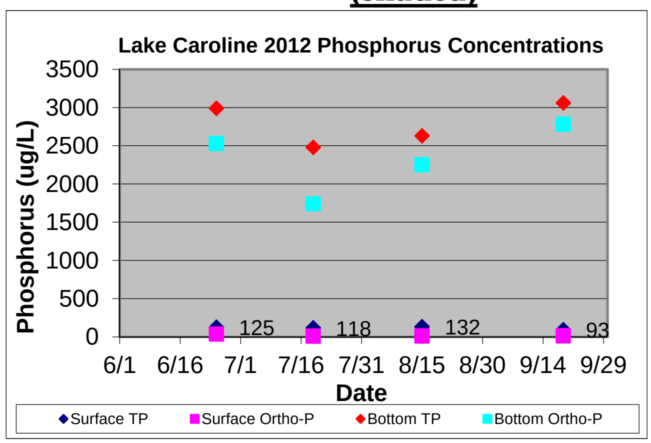
Lake Data

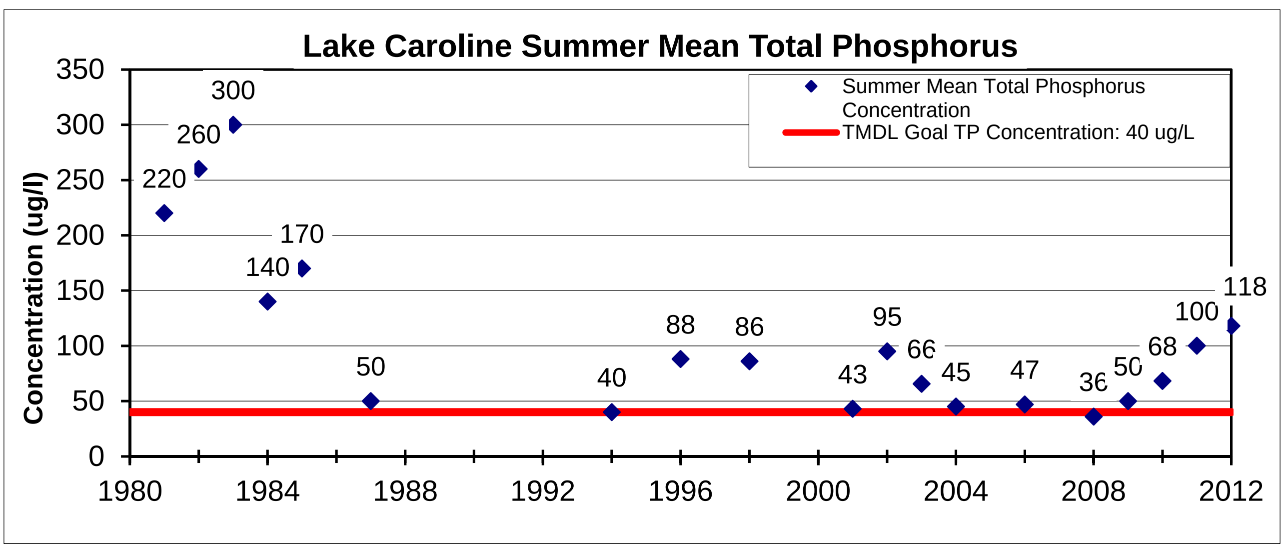
Surface Area: 126 Acres
Maximum Depth: 45 Feet
Subwatershed Area: 60,132 acres



Tributary Sub watershed (shaded)







Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
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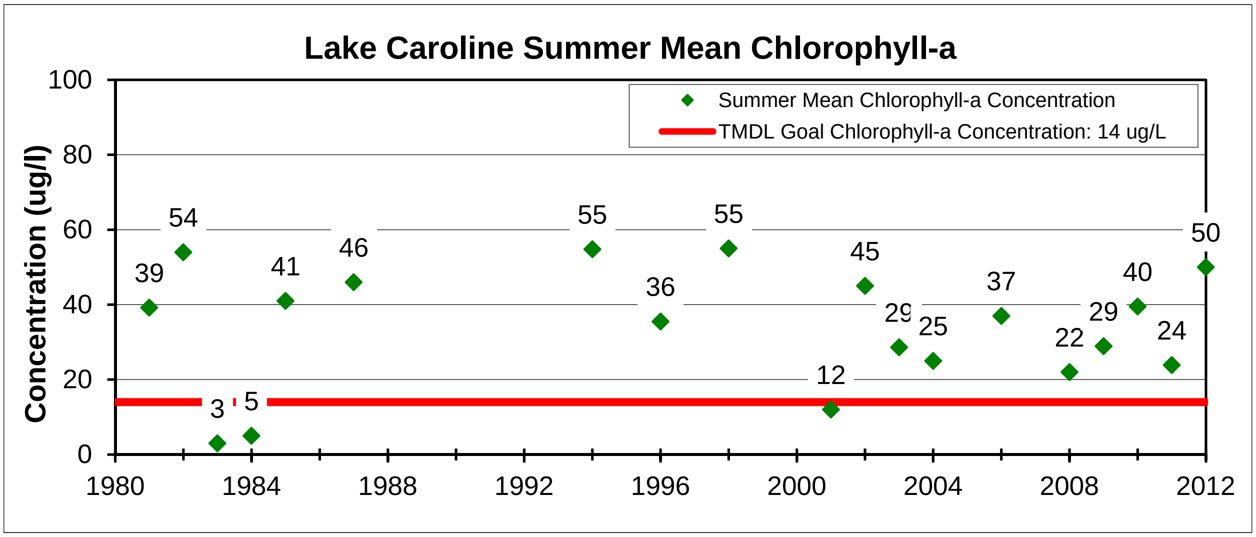
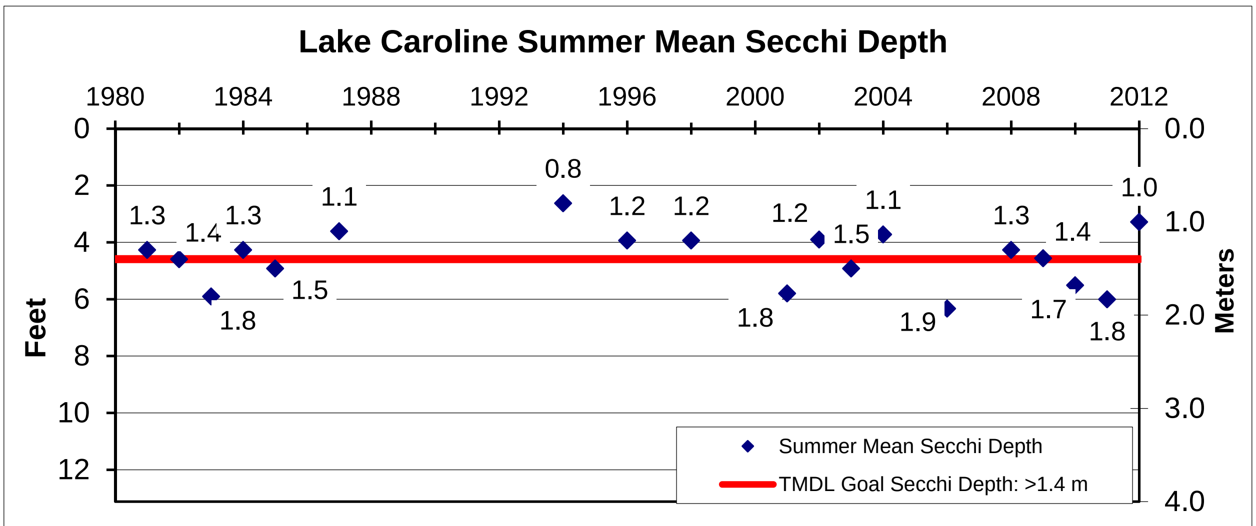
Lake Caroline

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2012 Summary

- TP concentrations have increased steadily since 2008 and are above TMDL goals.
- Chlorophyll –a concentrations and Secchi depth do not meet TMDL goals.
- Water quality is dominated by loads from the Clearwater River and Lake Marie.
- High bottom phosphorus concentrations and periods of stratification in the summer months observed in 2012 indicate that internal loading may contribute significant phosphorus to the lake during years with low runoff.

TMDL Activities

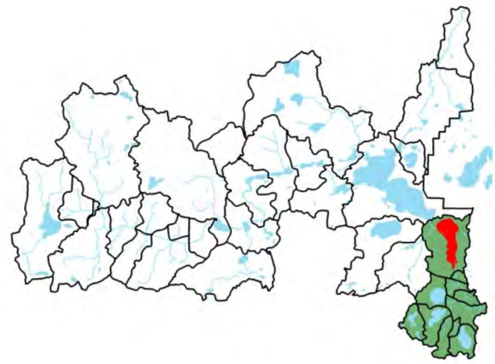
- Measures recommended by the TMDL Implementation Plan for the upper watershed will help decrease the load of phosphorus to Lake Caroline.
- Water quality goals can be met through a combination of watershed management and internal load reductions.

Wenck
Wenck Associates, Inc. Environmental Engineers
1800 Pioneer Creek Center Maple Plain, MN 55359

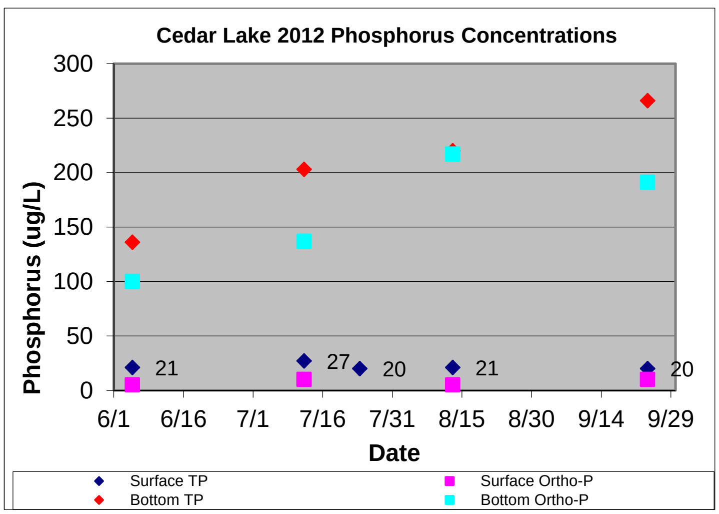
2012 Cedar Lake Report Card

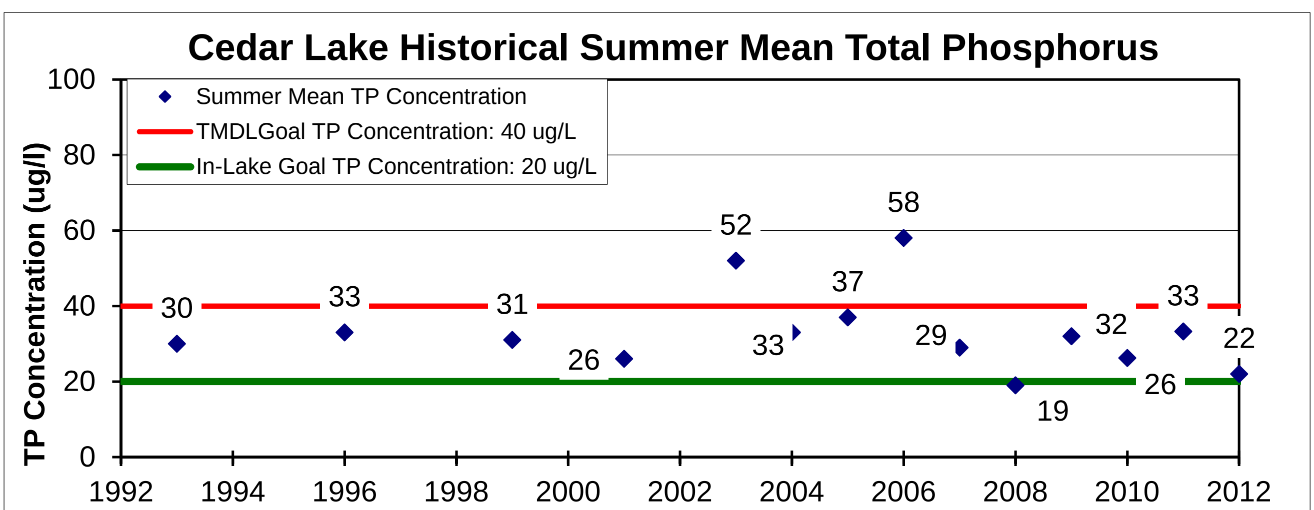
Lake Data

Surface Area: 783 Acres
Maximum Depth: 108 Feet
Subwatershed Area: 9,715 acres



Tributary Sub watershed (shaded)



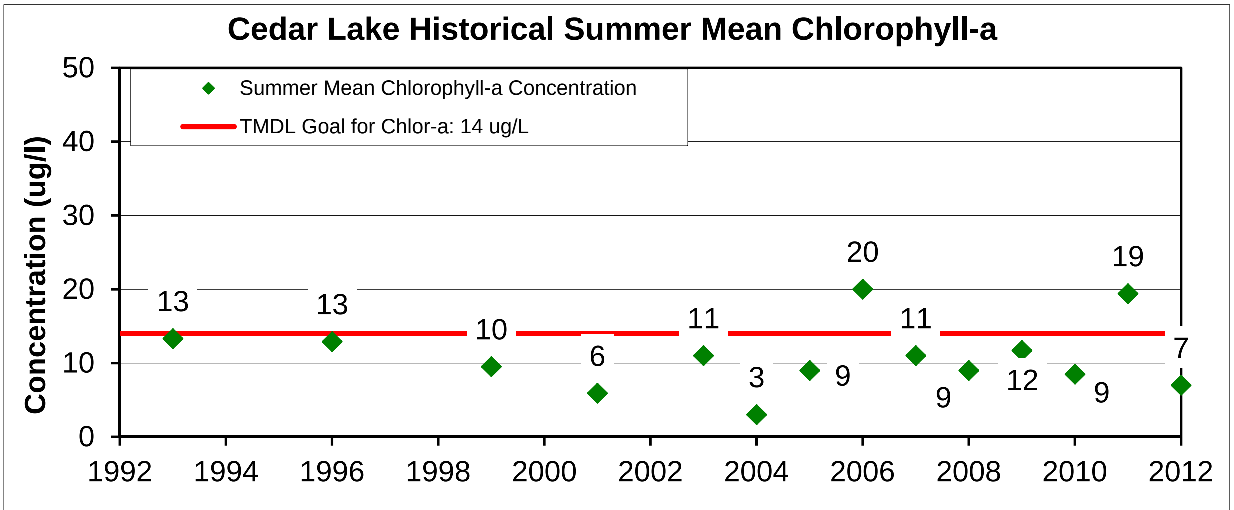


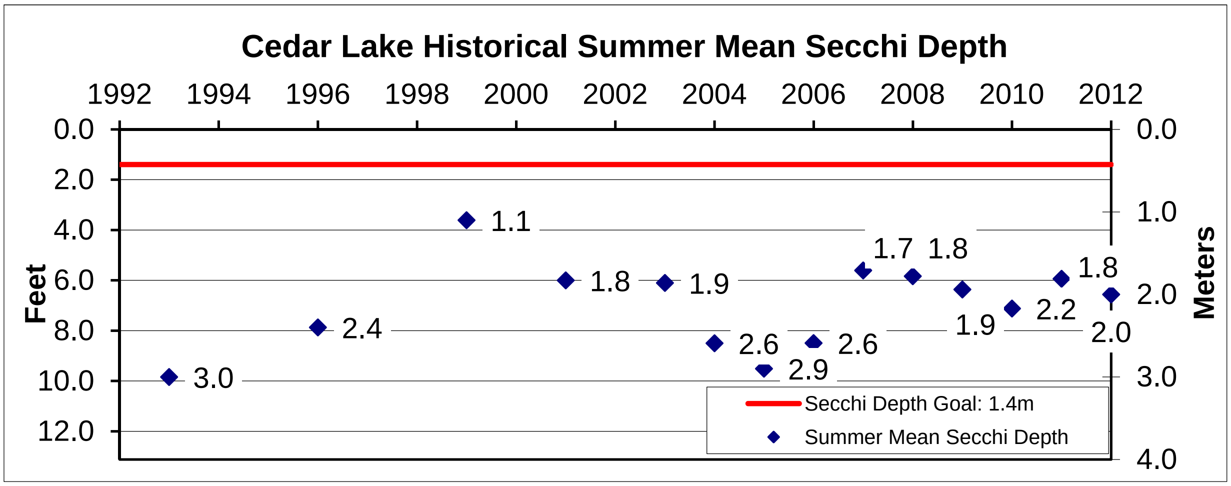
Clearwater River Watershed District	Wenck	January 2013
Cedar Lake	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	Appendix C

Cedar Lake

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2012 Summary

- Phosphorus concentrations were below TMDL goals and near the goals established for the lake at the start of Project #06-1 in 2007.
- Chlorophyll-a concentrations decreased from recent years and were below the impairment standard in 2012.
- Although periodic algal blooms have been common early in the summer in recent years, overall water clarity remains good in the lake, as Secchi depth is better than the TMDL goal.
- The primary source of phosphorus is from the upper watersheds and Swartout, Albion, and Henshaw Lakes.

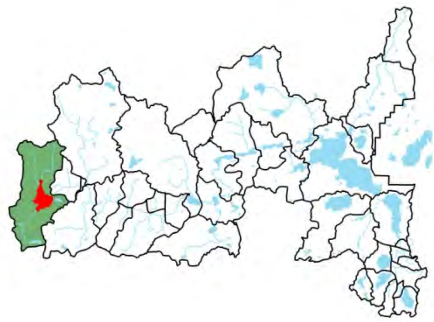
TMDL Activities

- Since 2007, the Cedar Lake Restoration Project has implemented fish barriers, buffers, tile inlet replacement, and the construction of Segner Pond, a wetland treatment basin.
- The goal of the project is to reduce the phosphorus load to Cedar Lake from the upper watershed.
- Measures recommended by the TMDL Implementation Plan for the impaired Swartout, Albion, and Henshaw Lakes will serve to improve water quality in Cedar Lake.
- Curly leaf pondweed was treated in 5.6 acres in 2012 (compared to 11 acres of the lake in 2011.)
- Eurasian water milfoil was treated in 22 acres of the lake in 2012 compared to 9 acres in 2011.

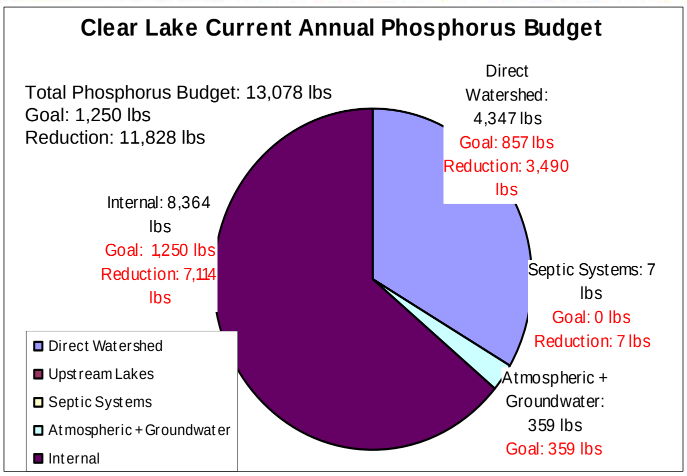
2012 Clear Lake Report Card

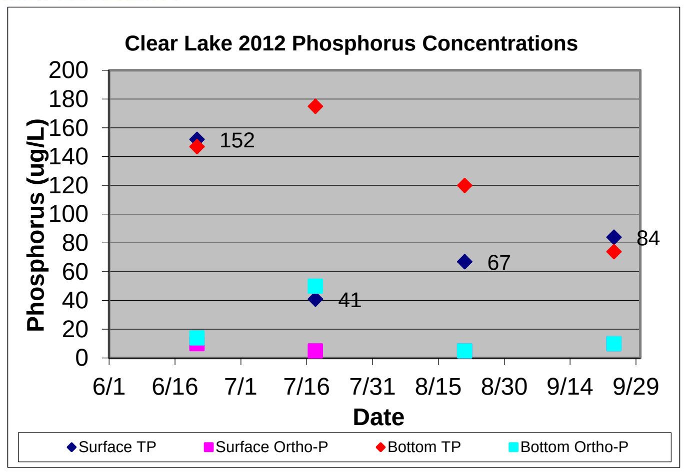
Lake Data

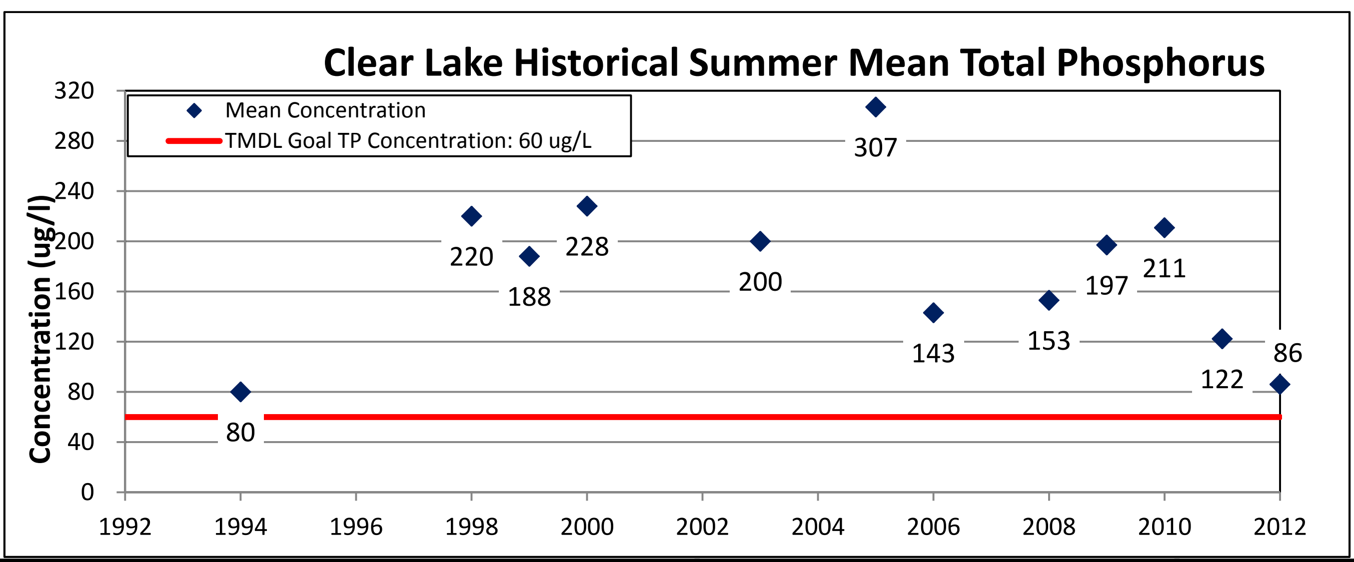
Surface Area:	**515 Acres**
Maximum Depth:	**17 Feet**
Subwatershed Area:	**6,801 acres**
Mean Depth:	**9 Feet**



Tributary Sub watershed (shaded)



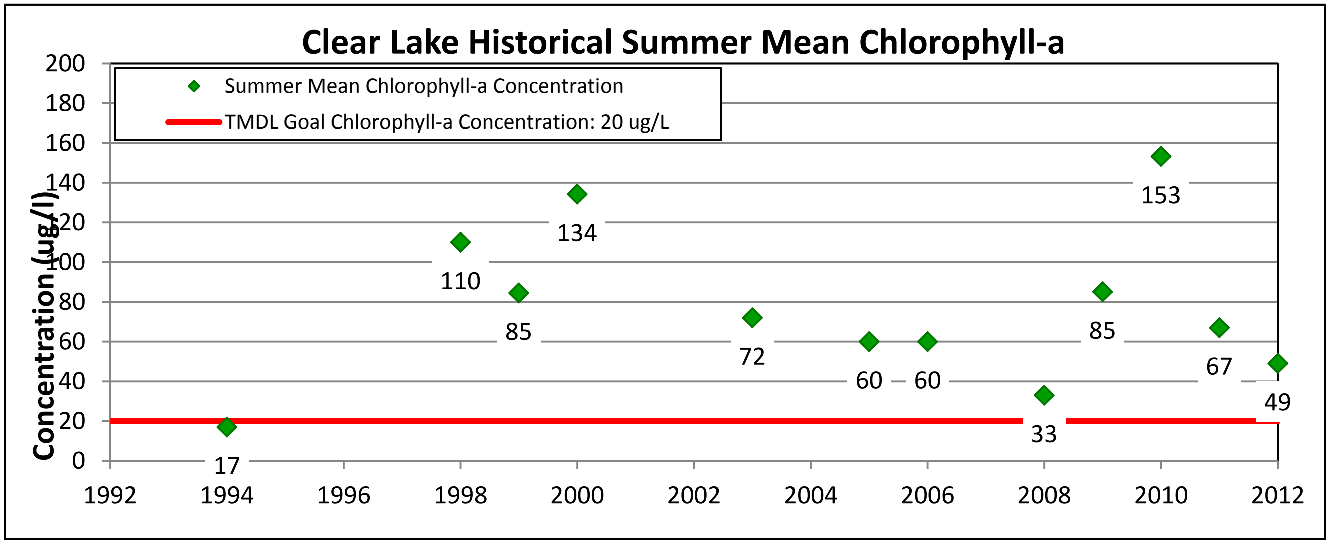


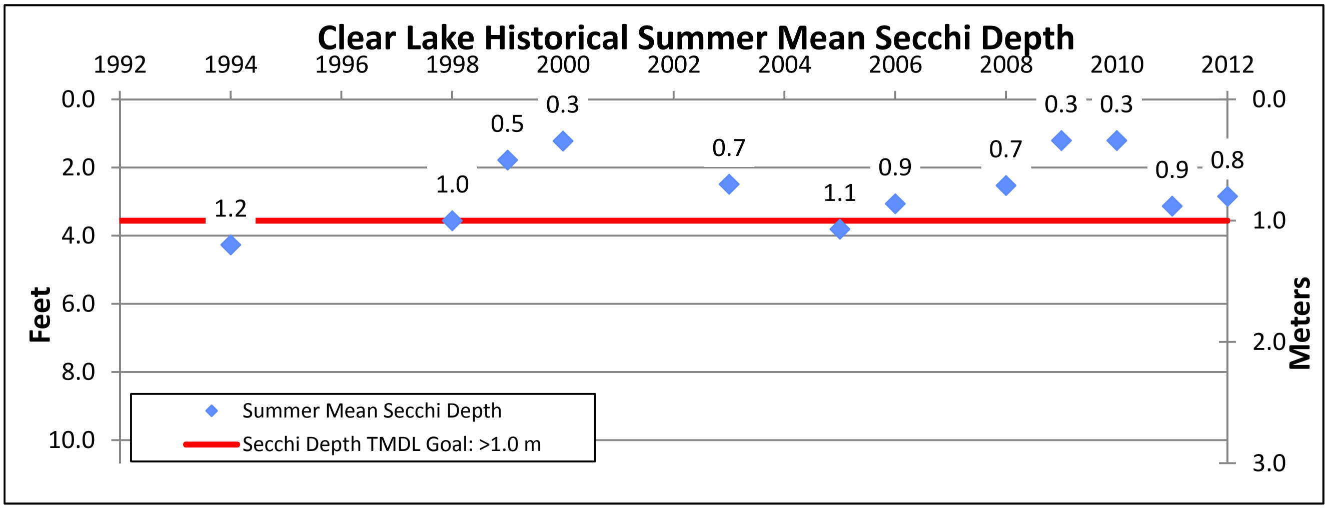


Clear Lake

2012 Lake Report Card

MPCA Shallow Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





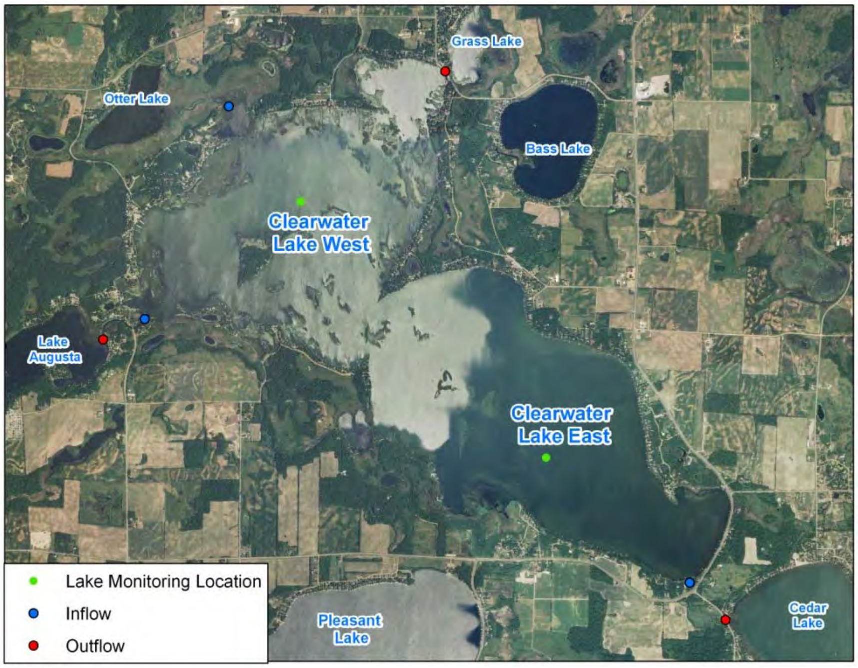
2012 Summary

- Clear Lake is located at the headwaters of the Clearwater River.
- Phosphorus concentrations remained above TMDL goals in 2012, but decreased from recent years and were among the lowest observed in the lake since monitoring began.
- Secchi depth and chlorophyll-a concentrations were above TMDL goals but were improved from recent years.
- Periodic poor water quality and nuisance algal blooms have been common in Clear Lake.
- High bottom phosphorus concentrations along with the lake's nature of becoming stratified and mixing throughout the summer indicates that internal loading of phosphorus from the lake's bottom sediments occurs throughout the year.

TMDL Activities

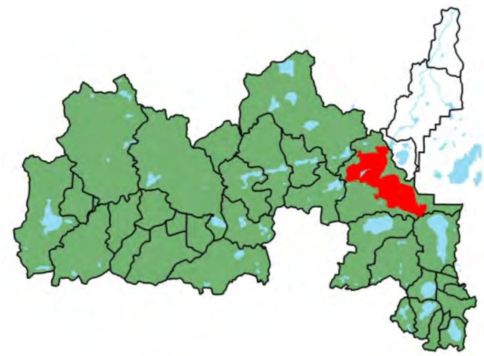
- The TMDL Implementation Plan calls for significant reductions in phosphorus from direct watershed runoff and internal loading in order for Clear Lake to meet state standards
- All but 7 of the ISTSs on the lake have been routed to the City of Watkins WWTP, resulting in approximately 100 lbs. of TP reduction to the lake.
- Sedimentation ponds were installed at two inlets to the lake.
- Clear Lake Association has implemented curly leaf pondweed treatment and rough fish removal.
- GPS Fertilizer application project was implemented in the Clear Lake Subwatershed in 2011 and continued in 2012.
- Additional sedimentation ponds and watershed BMPs have been recommended as potential TP reduction strategies.
- The CRWD constructed a notched weir on a tributary stream south of the lake in 2012 to address phosphorus loads from the subwatershed.

2012 Clearwater Lake Report Card

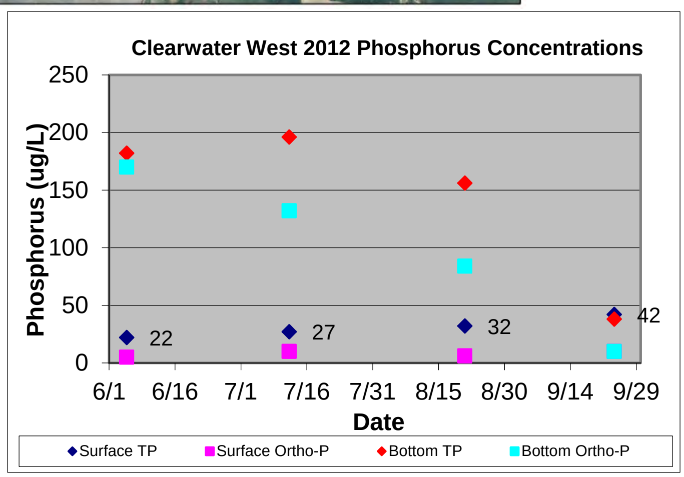


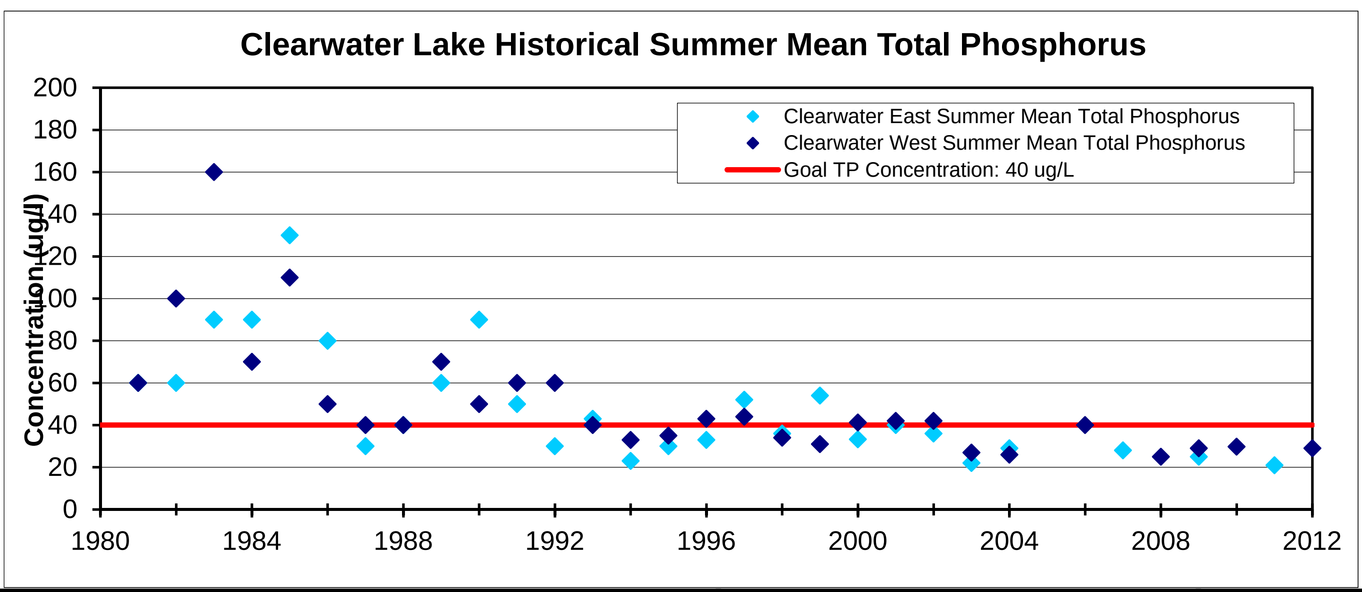
Lake Data

Surface Area: 3,158 Acres
Maximum Depth: 73 Feet
Subwatershed Area: 100,232 acres



Tributary Sub watershed (shaded)





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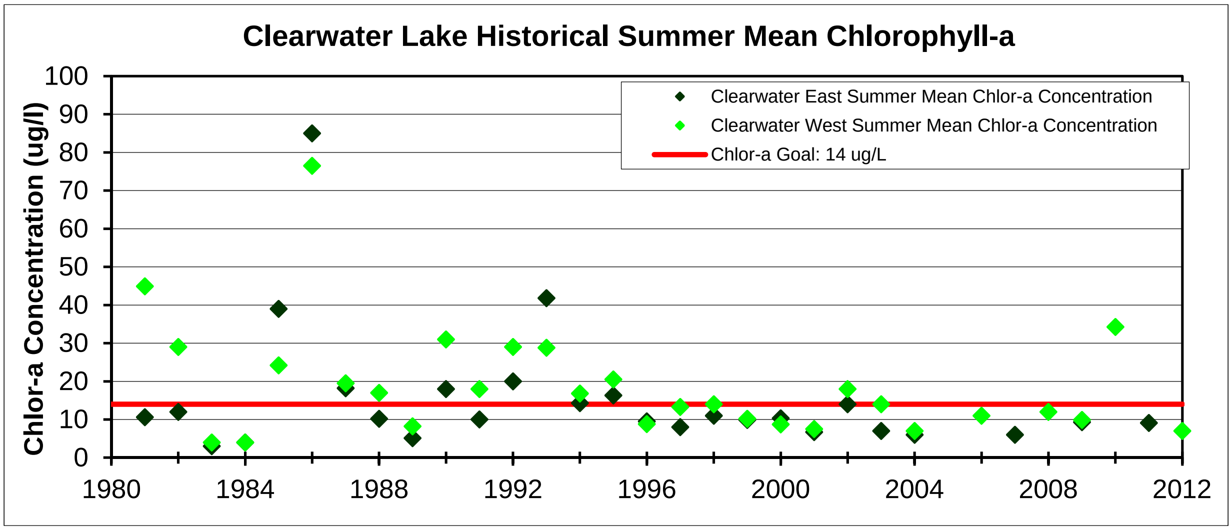
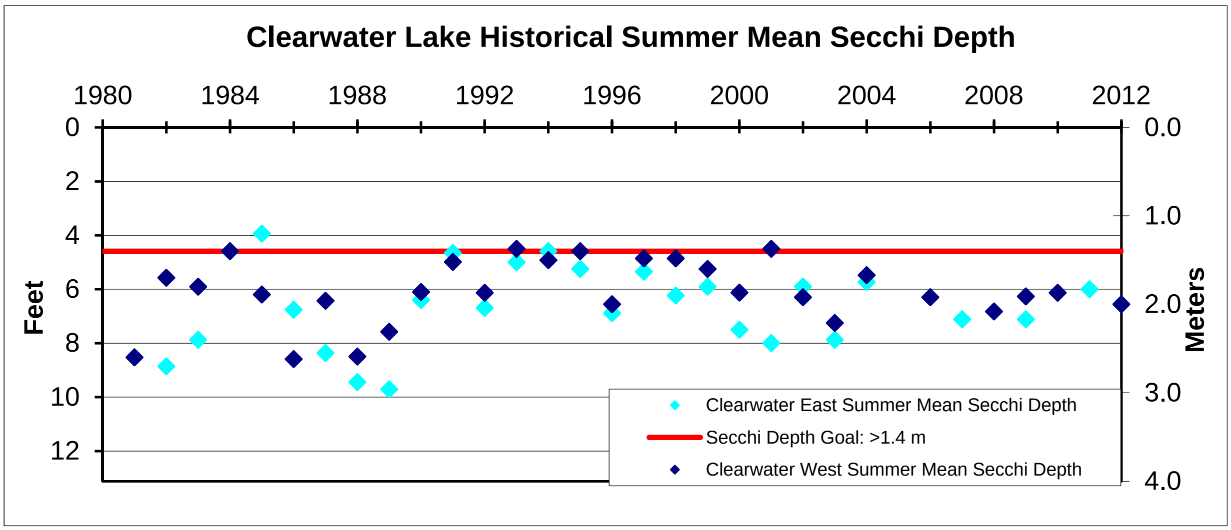
Clearwater Lake

2012 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2012 Summary

- Water quality has improved significantly in Clearwater Lake since the early 1990s, as summer mean phosphorus and chlorophyll-a concentrations have decreased significantly and the lake meets recreational water quality goals.
- Water quality measurements have been stable over recent years and meet TMDL goals.
- The majority of the phosphorus load to Clearwater Lake comes from the upstream watersheds.

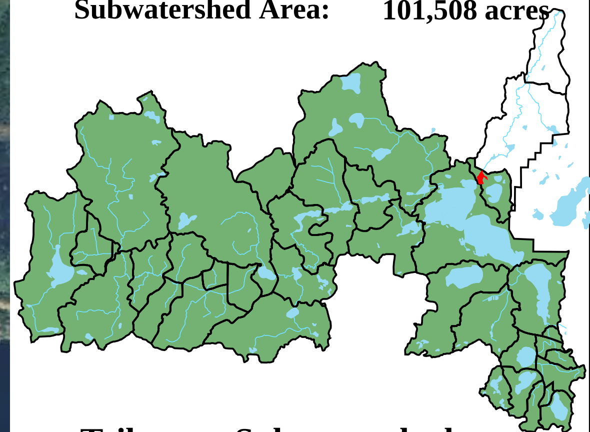
Lake Management Activities

- Watershed loads to Clearwater Lake have been below the established phosphorus loading goals of 5,000 lbs. in most recent years.
- Measures that are put in place in the upper watershed as part of the TMDL Implementation Plan will also help to maintain or improve water quality in Clearwater Lake in the future. Specifically, BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified for implementation in the upstream watersheds.

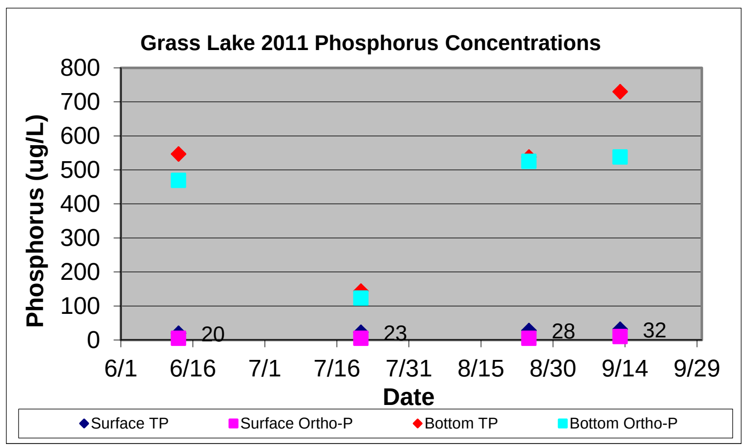
2011 Grass Lake Report Card

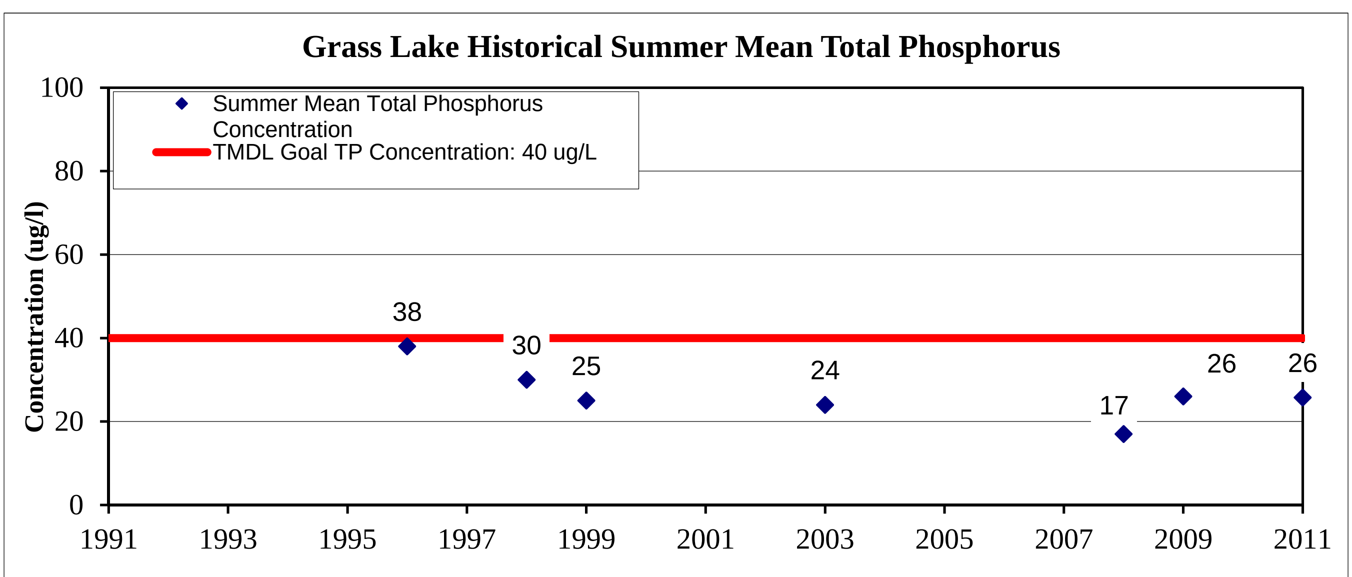
Lake Data

Surface Area: 92 Acres
Maximum Depth: 35 Feet
Subwatershed Area: 101,508 acres



Tributary Sub watershed (shaded)





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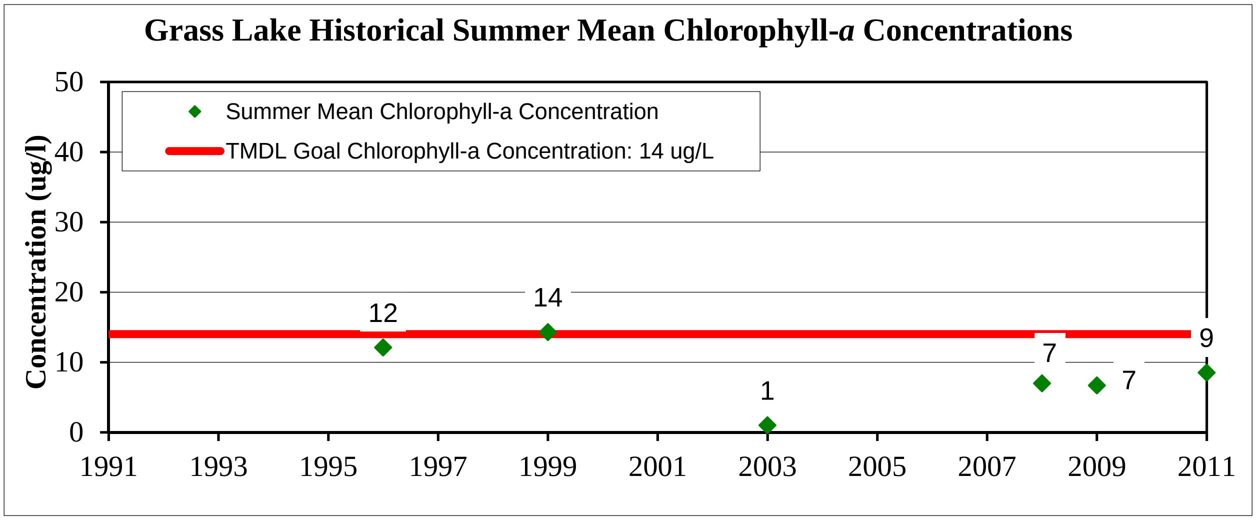
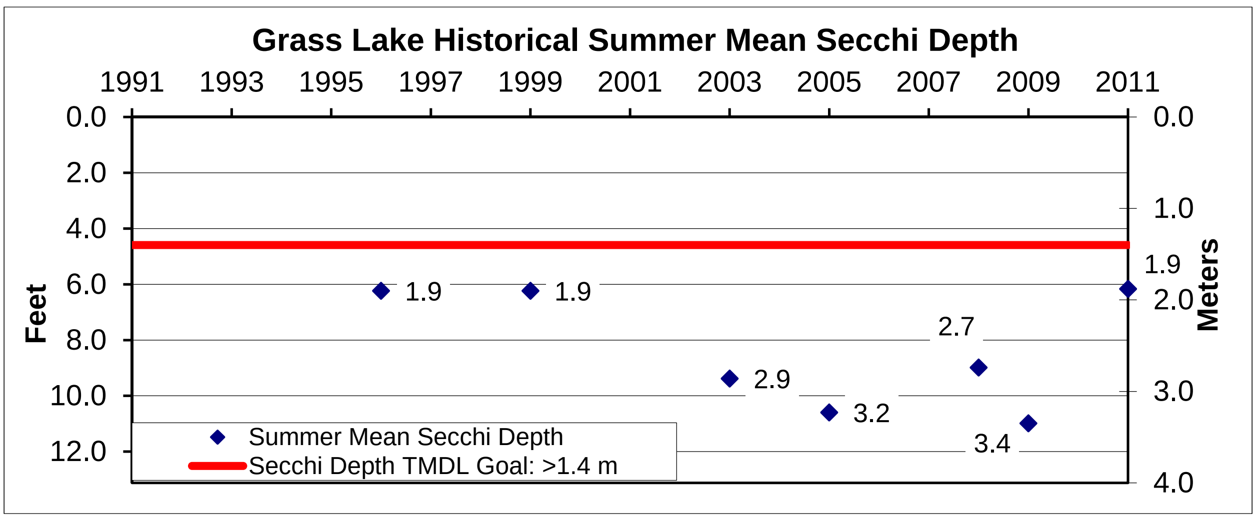
Grass Lake

2011 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





Summary

- Current water quality is good in Grass Lake as phosphorus concentrations, chlorophyll-a, and Secchi depth have met TMDL Goals since monitoring of the lake began in 1994.
- Water levels in Grass Lake were extremely high in July and August of 2011.

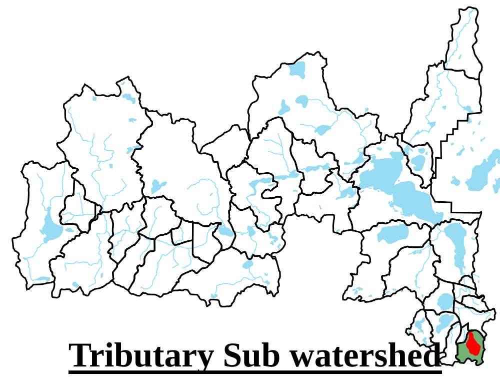
Water Quality Improvement Activiities

- Good land management practices along the lakeshore and in the upstream watershed that are implemented to improve the water quality in upstream lakes and the Clearwater River will also help to maintain the good water quality in Grass Lake.

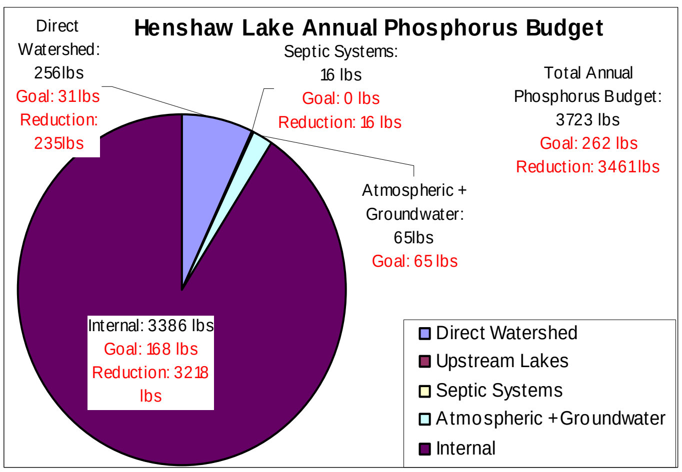
2012 Henshaw Lake Report Card

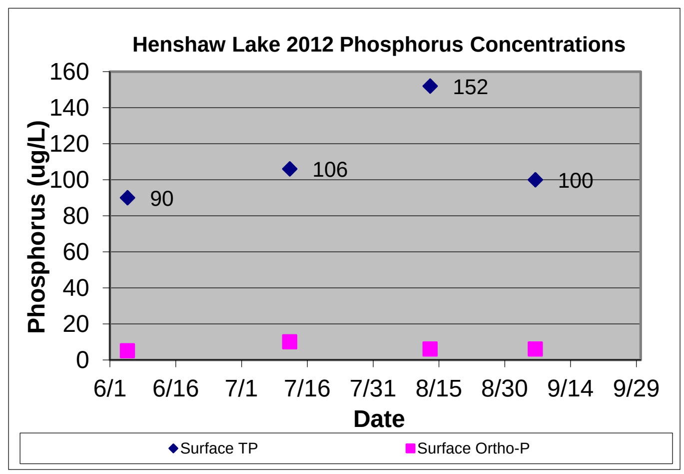
Lake Data

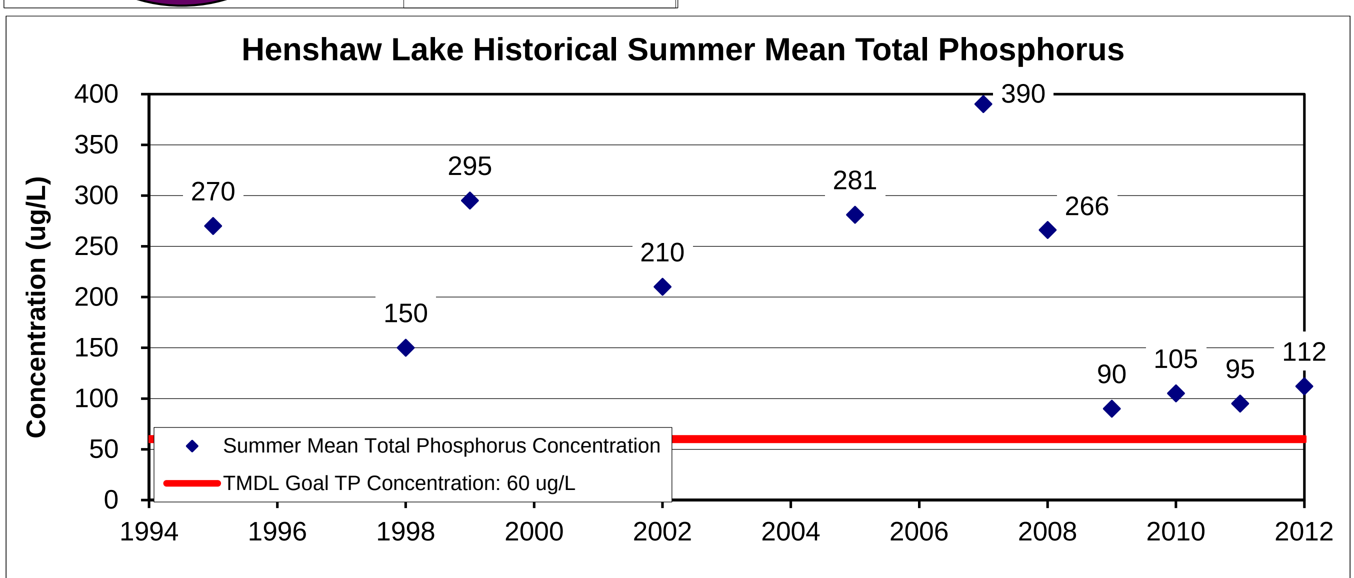
Surface Area:	**271 Acres**
Maximum Depth:	**8 Feet**
Contributing Subwatershed Area:	**903 acres**



Tributary Sub watershed (shaded)



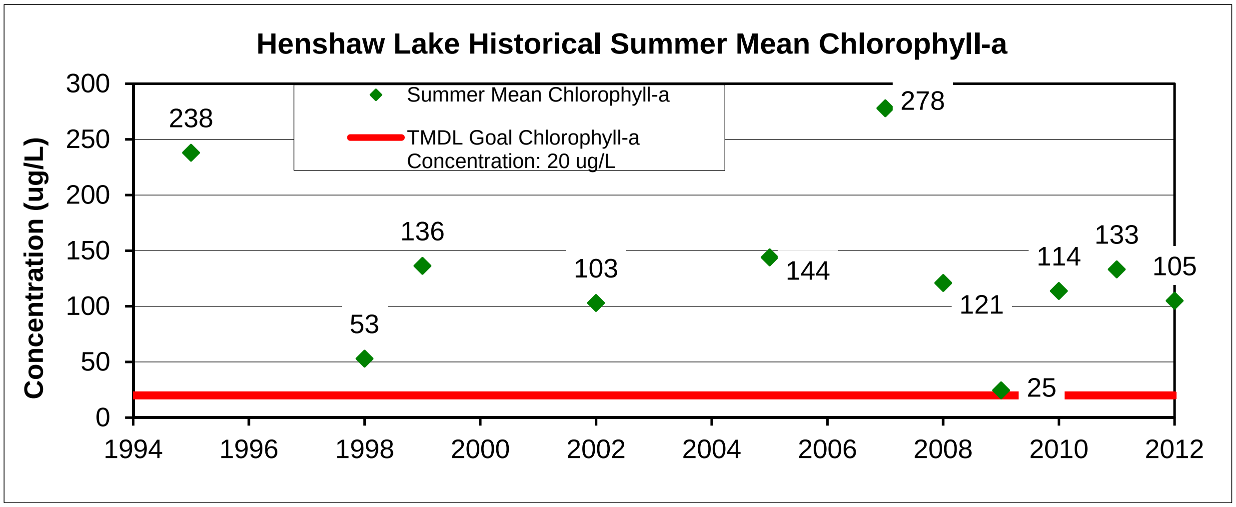


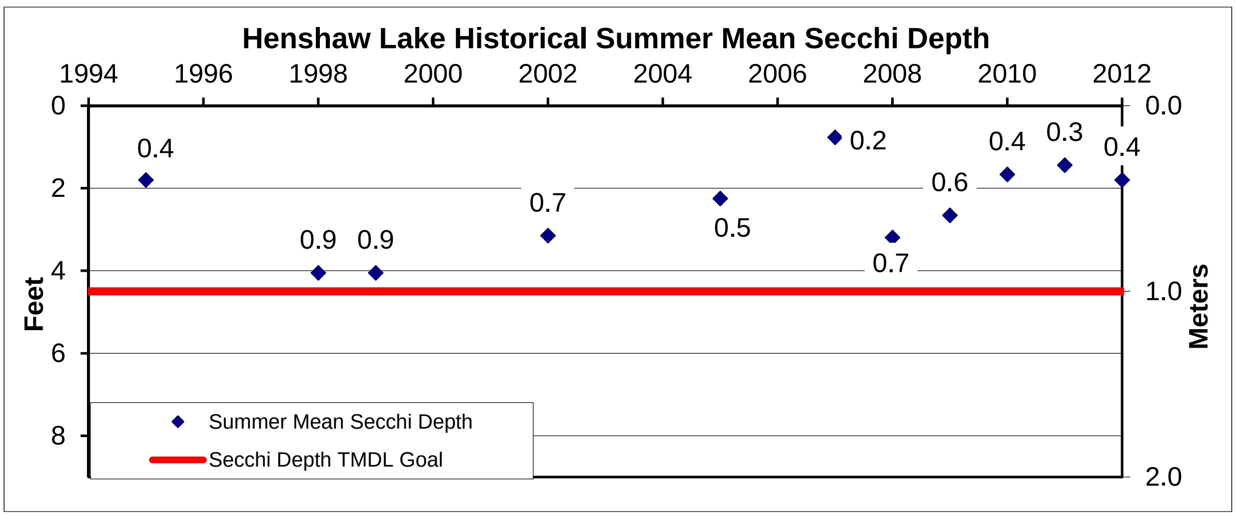


Henshaw Lake

2012 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





2012 Summary

- In-lake phosphorus concentrations exceeded TMDL goals in 2012 but were similar to concentratons observed in the lake since 2008, in spite of reestablished rough fish populations.
- Water clarity remains poor in the lake, as Secchi depths are below TMDL goals, primarily due to resuspension of loose bottom sediments.
- A vegetation survey conducted in September 2012 found that growth of aquatic vegetation in the lake is limited by poor water clarity to shallow water near shore.
- Internal loads are the major nutrient source to the lake.
- A fish survey conducted in April 2011 and observations made in 2012 indicate that a large population of carp and black bullheads has reestablished in the lake.

TMDL Activities

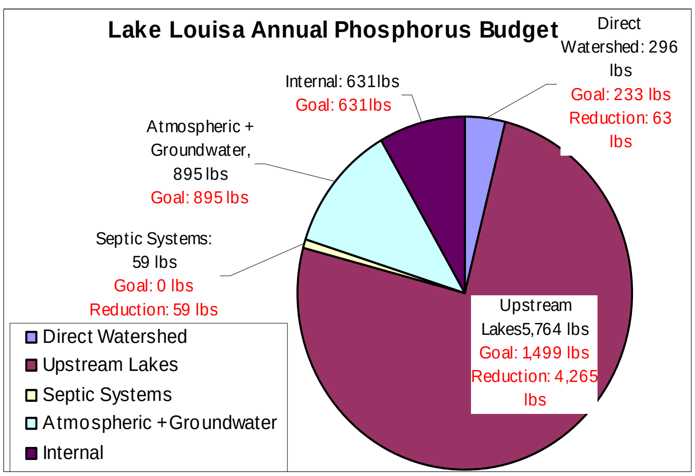
- Due to it's small tributary watershed, the reduction of watershed loads alone will not be sufficient to achieve water quality goals. A significant reduction in the internal nutrient source will be required to improve water quality in the lake.
- Hydrologic and ecological restorations, especially managing rough fish populations which are currently high in the lake, will be required to improve water quality in the lake.
- Nutrient reduction strategies implemented as part of the Cedar Lake Improvement Project as well as activities recommended by the TMDL Implementation Plan will help improve water quality in Henshaw Lake.

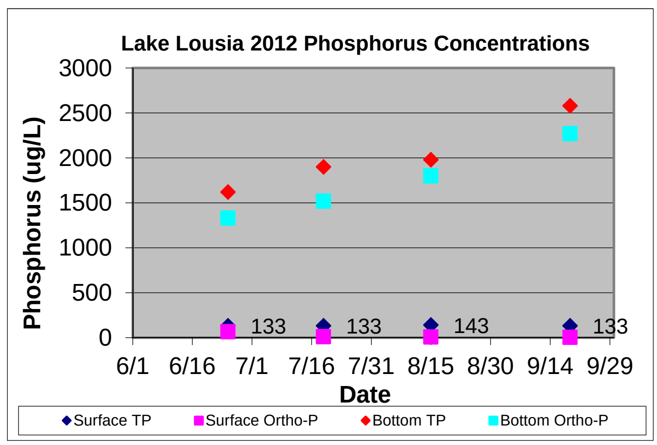
2012 Lake Louisa Report Card

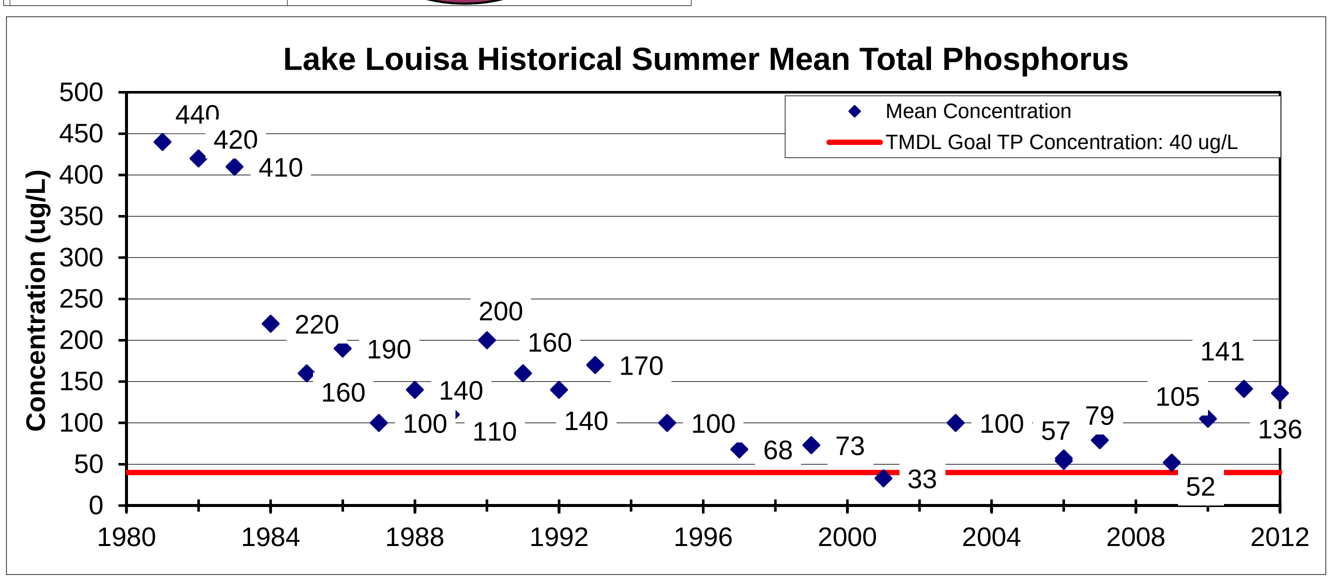
Lake Data

Surface Area: 193 Acres
Maximum Depth: 44 Feet
Subwatershed Area: 53,881 acres

Tributary Sub watershed (shaded)







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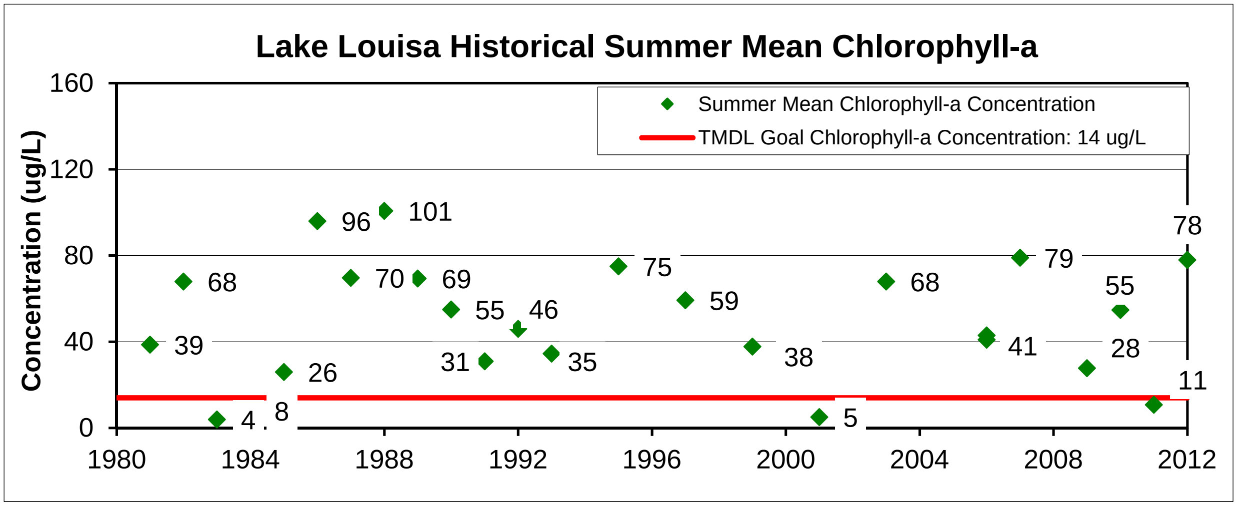
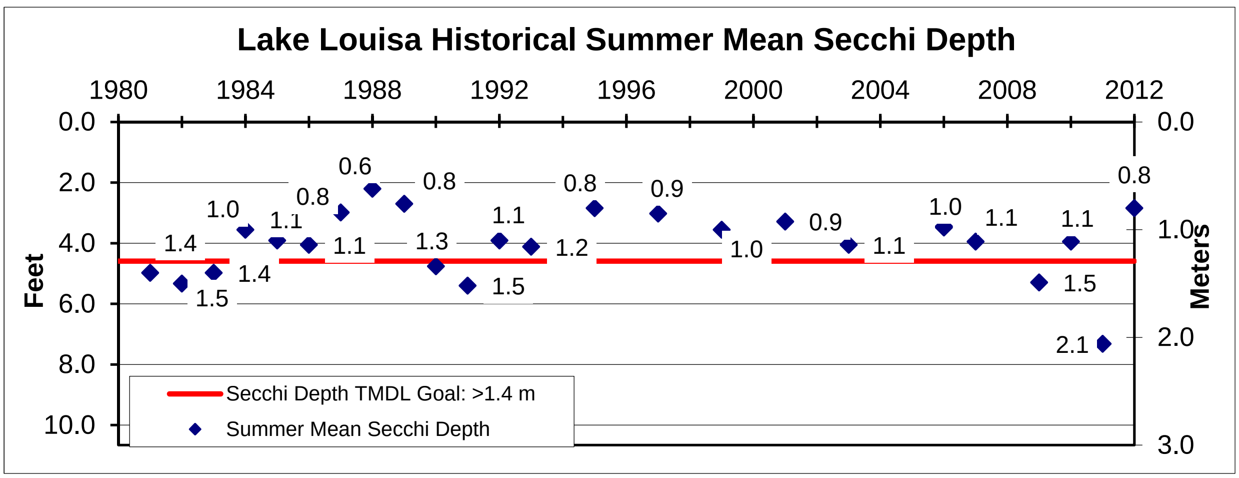
Lake Louisa

2012 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2012 Summary

- Summer average phosphorus concentrations have increased since 2009 and are above TMDL goals. Phosphorus concentrations were likely elevated in 2012 due to a high phosphorus load from the Clearwater River and upstream lakes during the previous years.
- Chlorophyll-a and Secchi depth did not meet TMDL goals in 2012. These parameters were poorer than in 2011 due most likely to low runoff that did not allow the lake to flush, which allowed algae to uptake phosphorus and decrease water clarity.
- Monitoring data indicates the potential for high internal loads in the lake as bottom phosphorus concentrations were extremely high and periods of anoxia were observed in 2012.

TMDL Activities

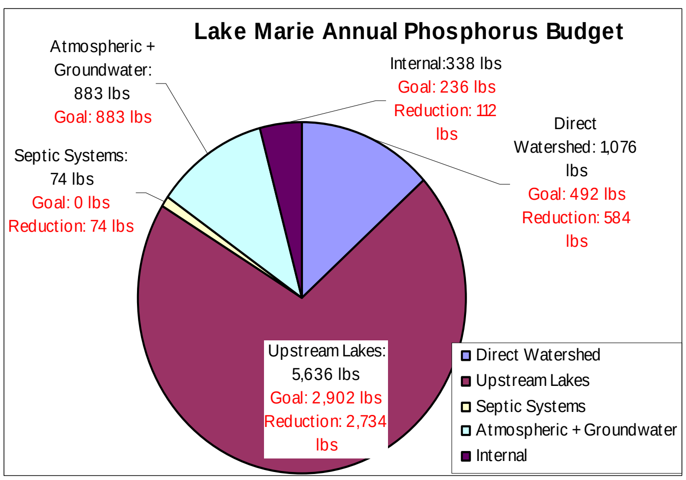
- Reducing phosphorus loads from upstream lakes and the direct tributary watershed will have the greatest impact on improving water quality in Lake Louisa.
- Phosphorus reduction strategies including BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified by the TMDL Implementation Plan for the upstream watersheds
- Lake management strategies have included rough fish removal since 1984 and aerators from 1985 to 1995.

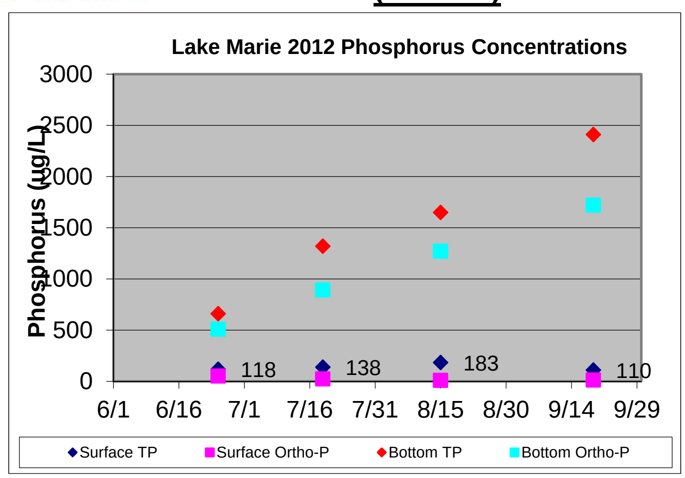
2012 Lake Marie Report Card

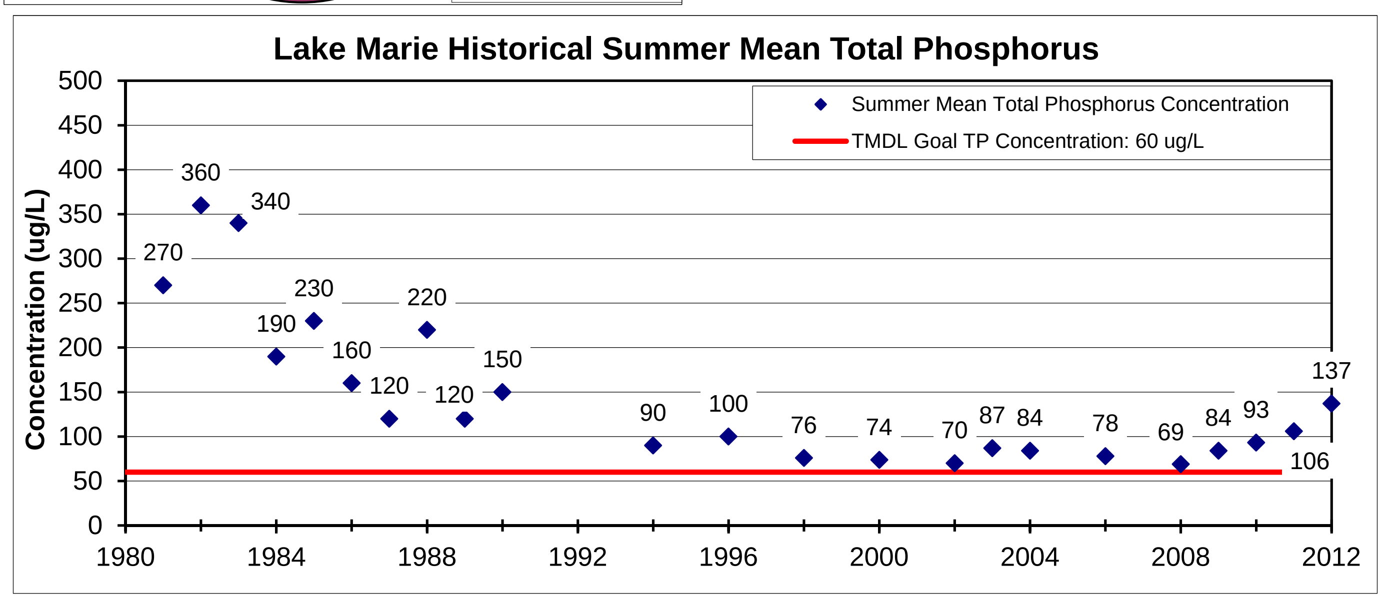
Lake Data

Surface Area:	**140 Acres**
Maximum Depth:	**36 Feet**
Subwatershed Area:	**59,837 acres**

Tributary Sub watershed (shaded)





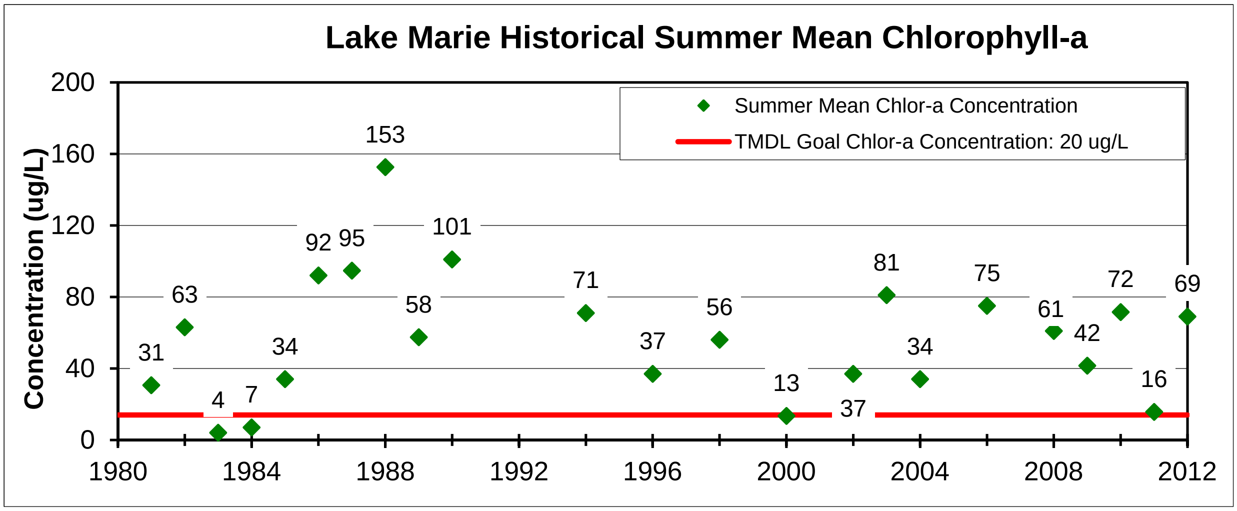


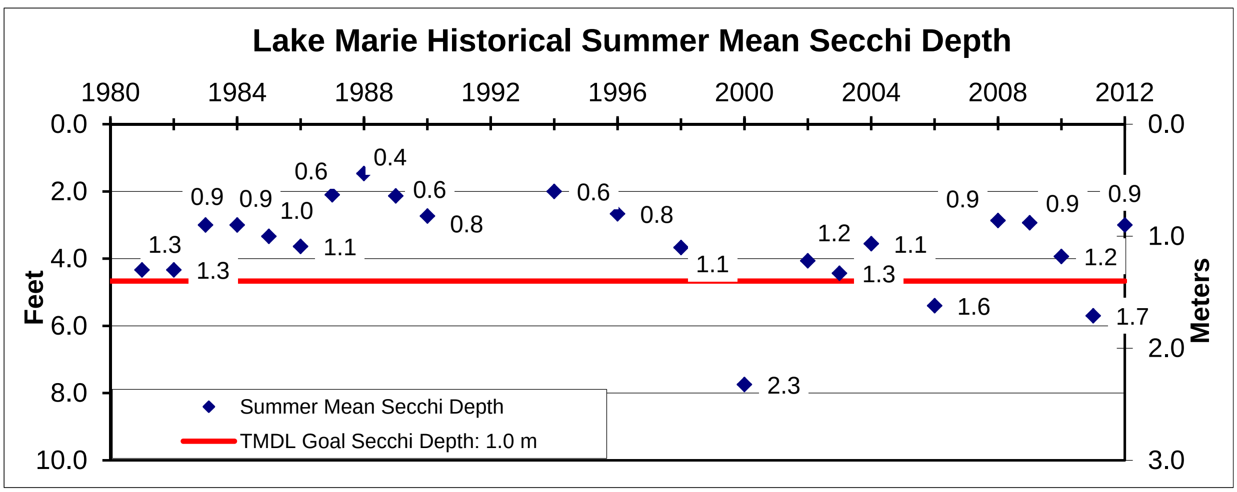
Clearwater River Watershed District	**Wenck**	January 2013
Lake Marie	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	Appendix C

Lake Marie

2012 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2011 Summary

- Although water quality has improved significantly since the early 1990s, phosphorus concentrations are above TMDL goals and have increased steadily since 2008.
- Chlorophyll-a concentrations increased compared to 2011, but were similar to other recent years.
- Secchi depth decreased compared to 2011 but were similar to most recent years.
- Monitoring data demonstrated extremely high bottom phosphorus concentrations throughout the season in the lake in 2012.
- High bottom phosphorus concentrations and periods of anoxia demonstrates the potential for high internal loads in the lake.

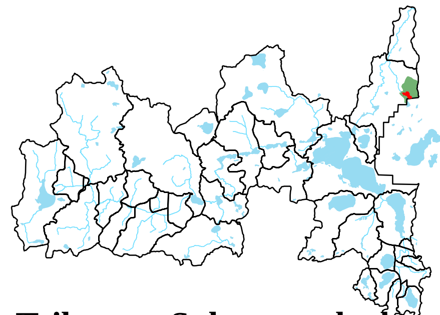
TMDL Activities

- The reduction of phosphorus loads from upstream lakes and the direct tributary watershed will have the greatest impact on improving lake water quality.
- Lake management strategies have included rough fish removal since 1984 and aeration from 1985 to 1995.
- Phosphorus reduction activities identified for implementation by the TMDL Implementation Plan in the upstream watersheds tributary to Lake Betsy and Clear Lake include BMP's, hypolimnetic withdrawal, Kingston Wetland restoration, soil testing and GPS fertilizer application, and the construction of sedimentation ponds.

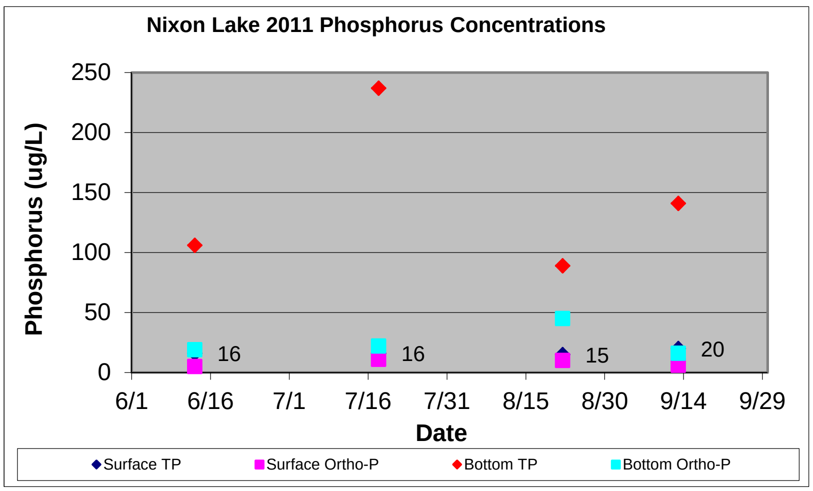
2011 Nixon Lake Report Card

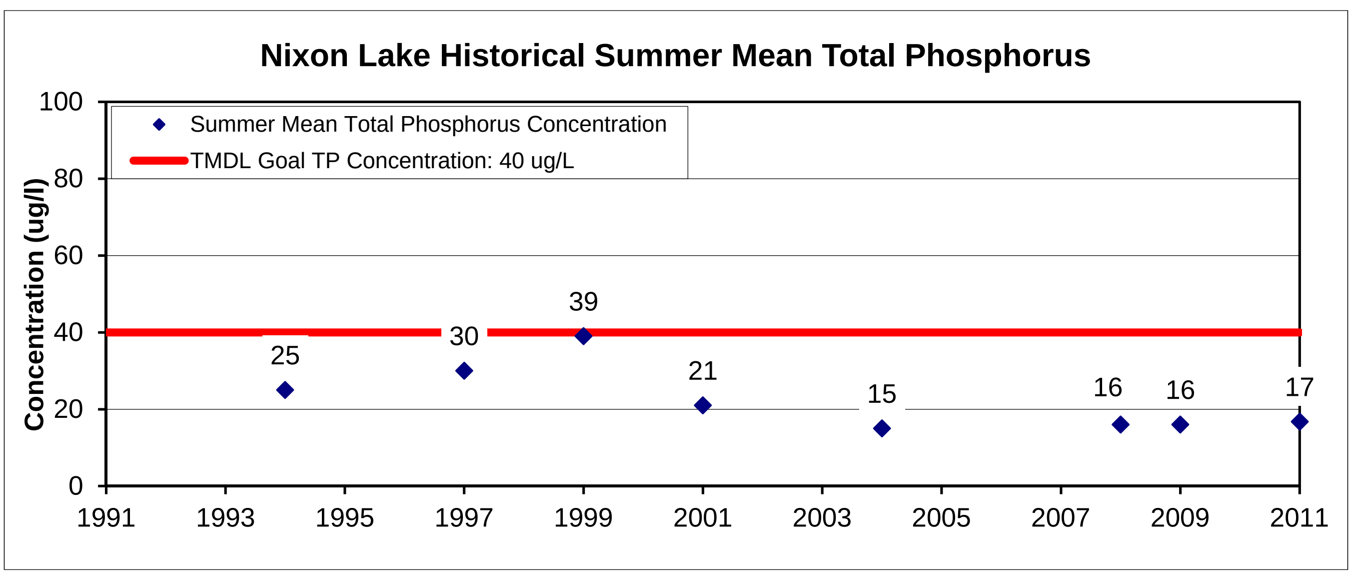
Lake Data

Surface Area: 56 Acres
Maximum Depth: 67 Feet
Subwatershed Area: 570 acres



Tributary Sub watershed (shaded)





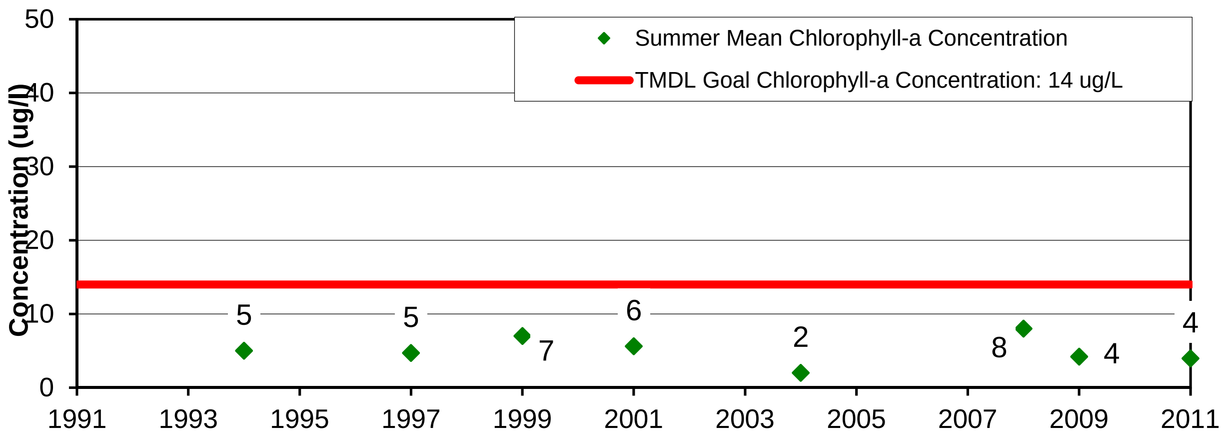
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2012
Nixon Lake		Appendix C

Nixon Lake

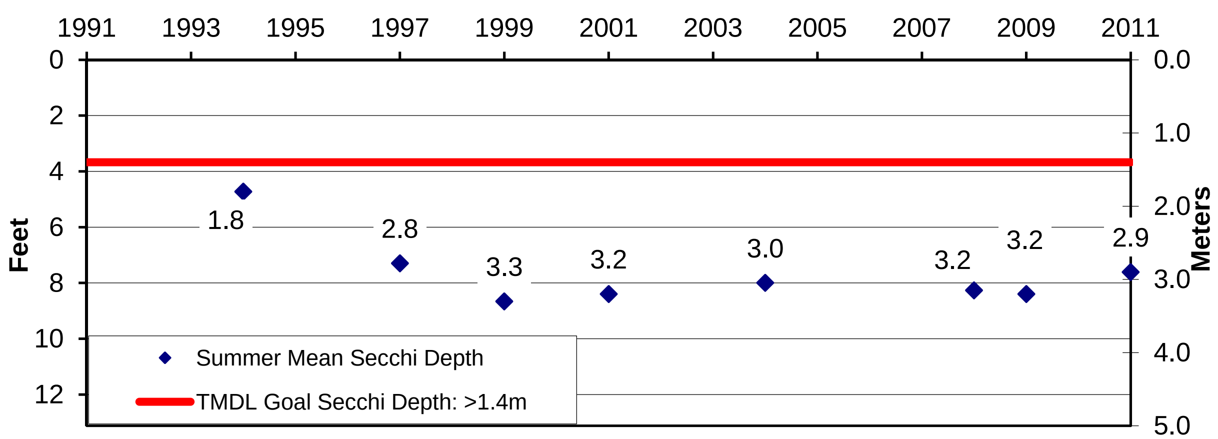
2011 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter

Nixon Lake Historical Summer Mean Chlorophyll-a



Nixon Lake Historical Summer Mean Secchi Depth



2011 Summary

- Current water quality is good in Nixon Lake as phosphorus concentrations, chlorophyll-a, and Secchi depth have met MPCA standards since monitoring of the lake began in 1994.
- A small watershed with limited development contribute to good water quality in the lake.
- Nixon Lake has a diverse aquatic plant community and wetlands and cattail fringe surround most of the lake.

TMDL Activities

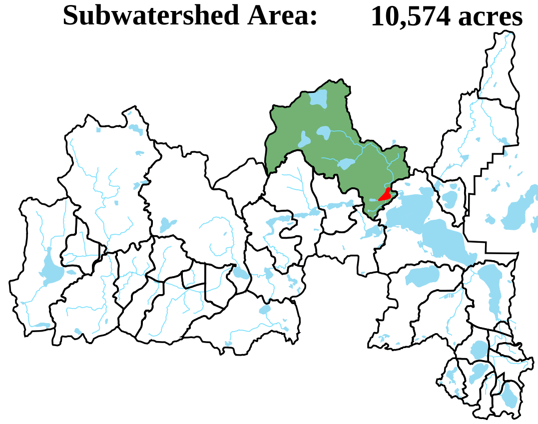
- Good land management practices along the lakeshore and in the lake's small watershed will help to maintain the good water quality in Nixon Lake.

Wenck
Wenck Associates, Inc. Environmental Engineers
1800 Pioneer Creek Center Maple Plain, MN 55359

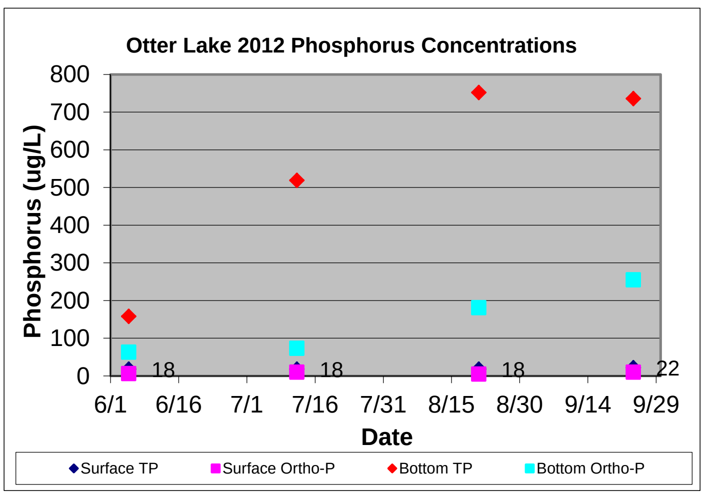
2012 Otter Lake Report Card

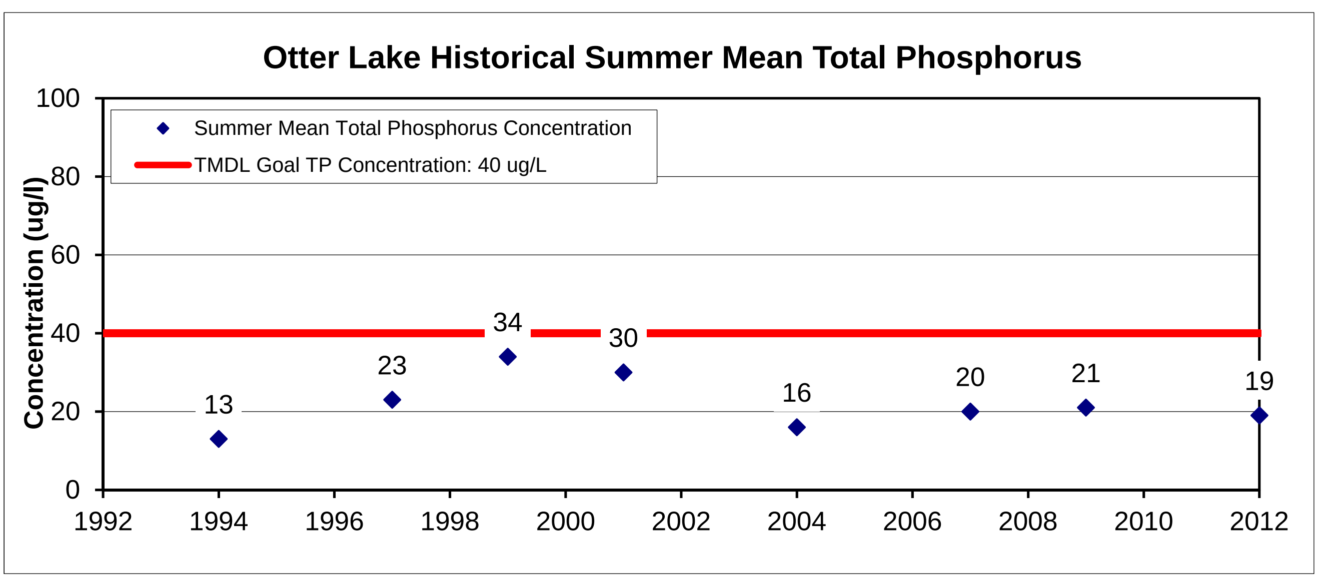
Lake Data

Surface Area: 96 Acres
Maximum Depth: 51 Feet
Subwatershed Area: 10,574 acres



Tributary Sub watershed (shaded)



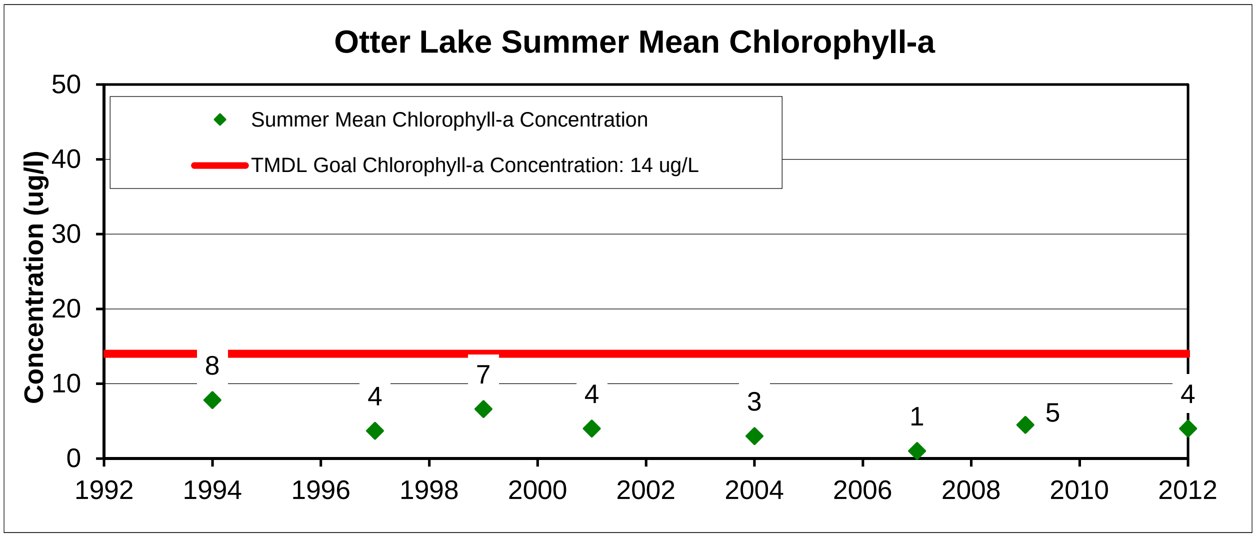


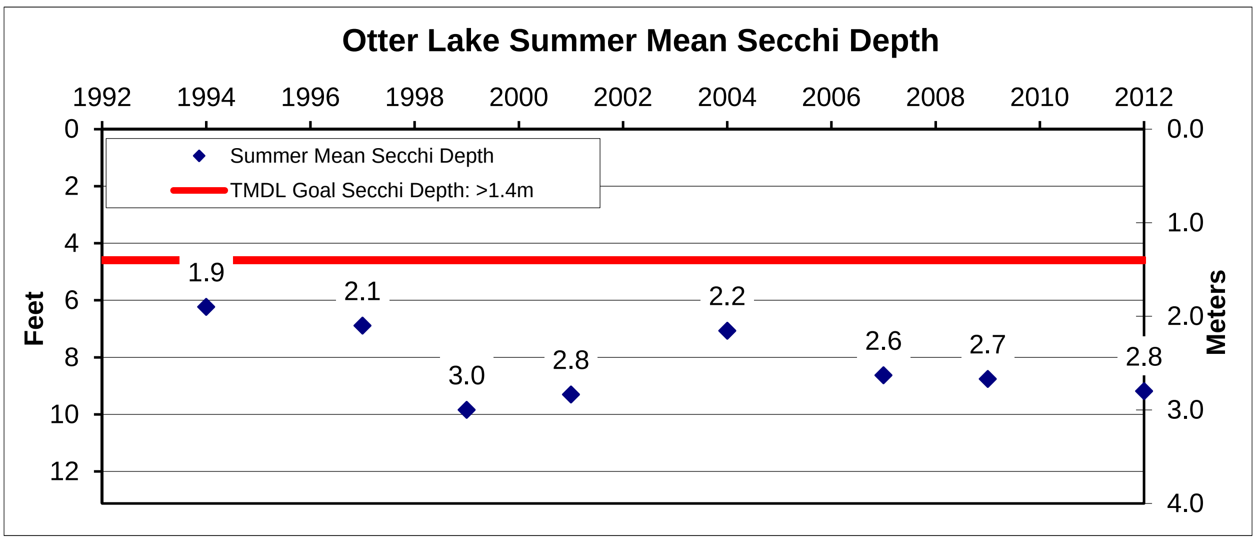
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
Otter Lake		Appendix C

Otter Lake

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





Summary

- Overall water quality is good in Otter Lake as phosphorus and chlorophyll-a concentrations, and Secchi depth have met TMDL goals since monitoring of the lake began in 1994.
- A small direct contributing watershed with limited development contributes to good water quality in Otter Lake.
- Otter Lake is connected to Clearwater Lake by a channel, and a high quality fishery exists for both northern pike and walleye in the lake.*

Water Quality Improvement Activities

- Good land management practices adjacent to the lakeshore and thorughout the lake's watershed will help to maintain the good water quality in Otter Lake.
- A small direct contributing watershed with limited development contributes to good water quality in Otter Lake

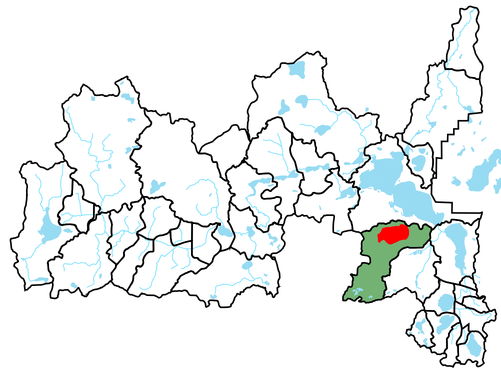
*Source: MN DNR Lake Finder

Wenck
Wenck Associates, Inc. Environmental Engineers
1800 Pioneer Creek Center Maple Plain, MN 55359

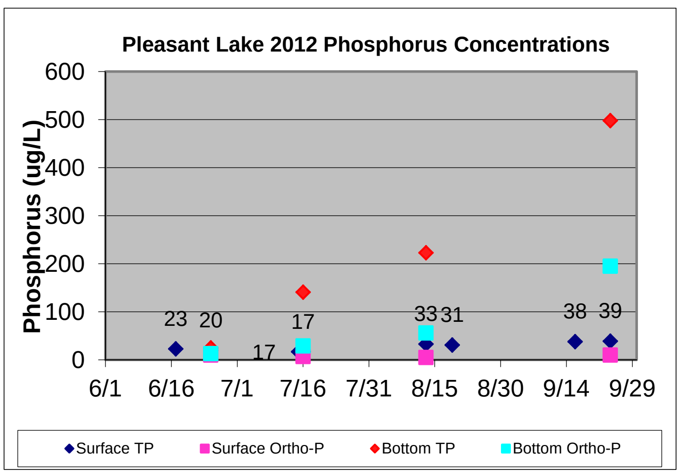
2012 Pleasant Lake Report Card

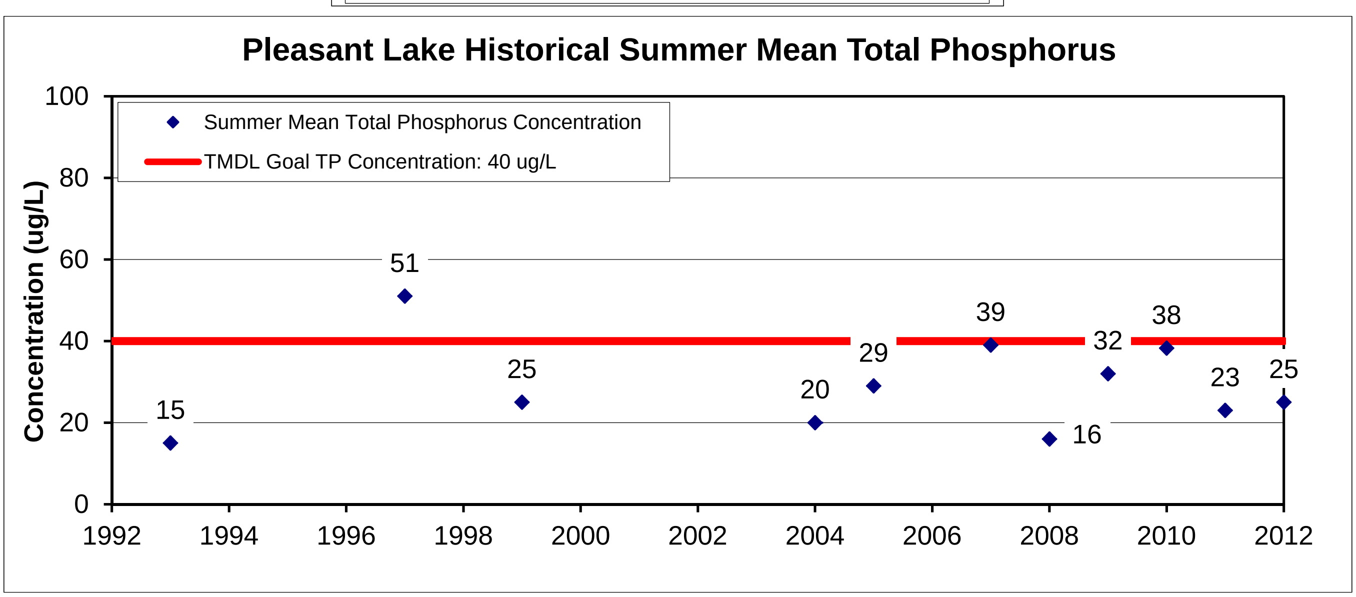
Lake Data

Surface Area:	**571 Acres**
Maximum Depth:	**74 Feet**
Subwatershed Area:	**4,325 acres**



Tributary Sub watershed (shaded)



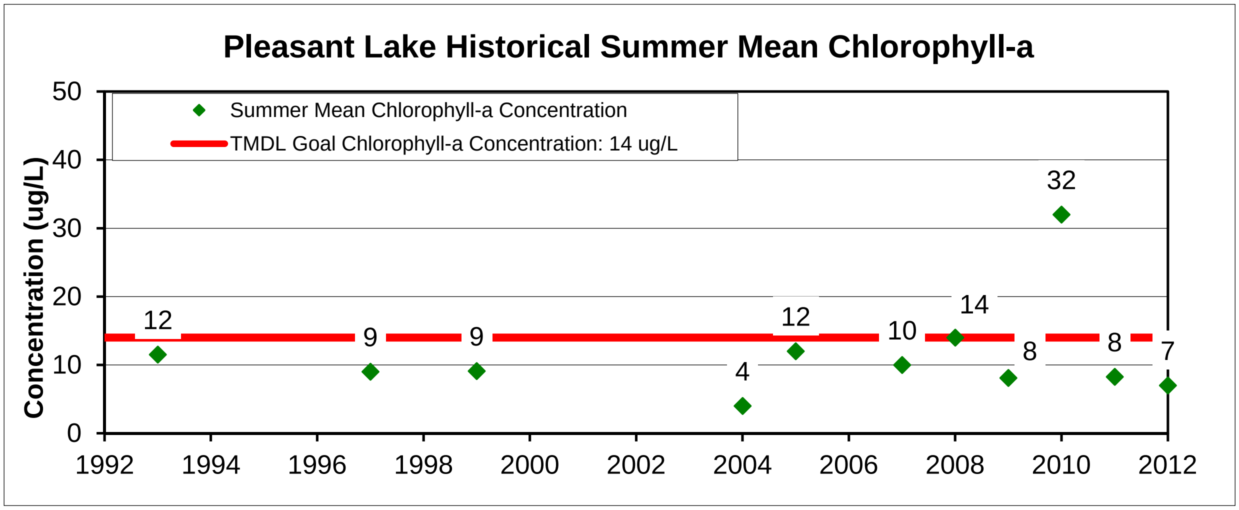


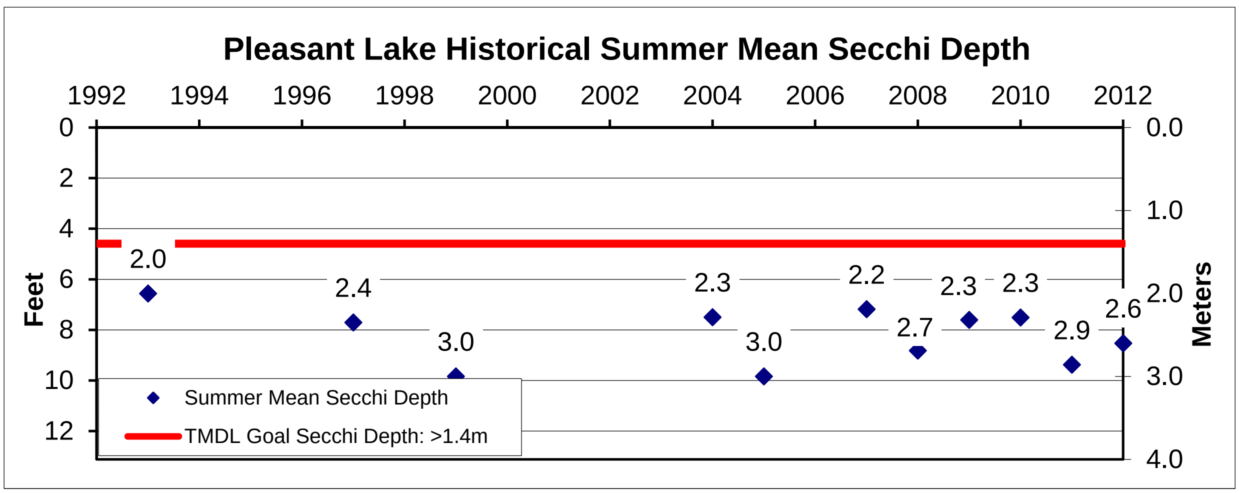
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
Pleasant Lake		Appendix C

Pleasant Lake

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





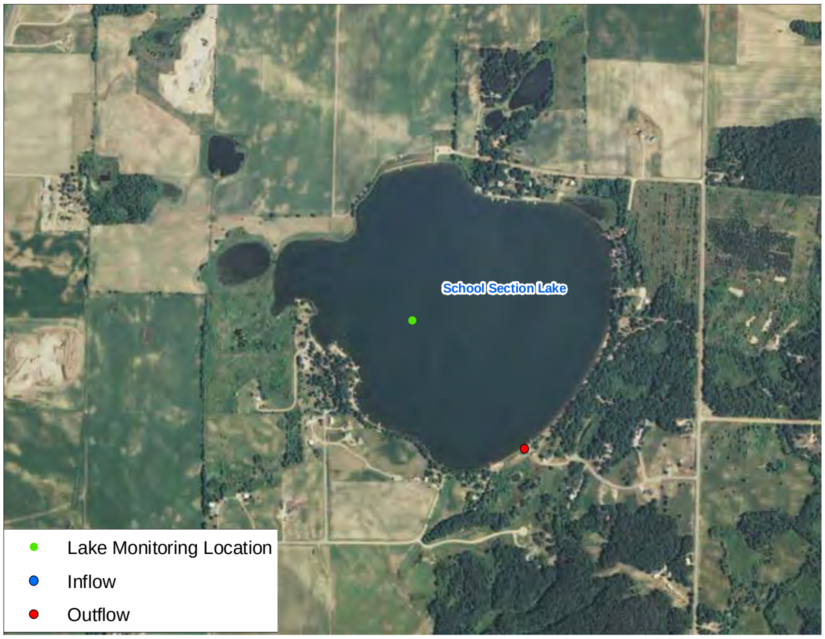
2012 Summary

- Current water quality is good in Pleasant Lake as phosphorus concentrations, chlorophyll-a, and Secchi depths have met TMDL goals since 1993.
- Summer average phosphorus and chlorophyll-a concentrations as well as Secchi depths were similar to 2011.

Water Quality Improvement Activities

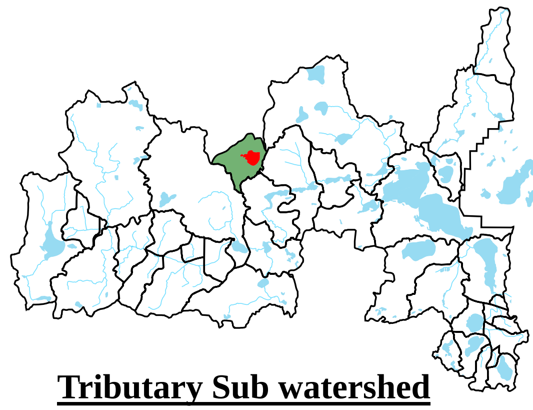
- Good land management practices adjacent to the lakeshore, the upstream watershed, and in the City of Annandale will help to maintain the good water quality in Pleasant Lake.
- Treatment of expanding curly leaf pondweed may be necessary if water quality monitoring results indicate that it is negatively impacting water quality in the lake.

2011 School Section Lake Report Card

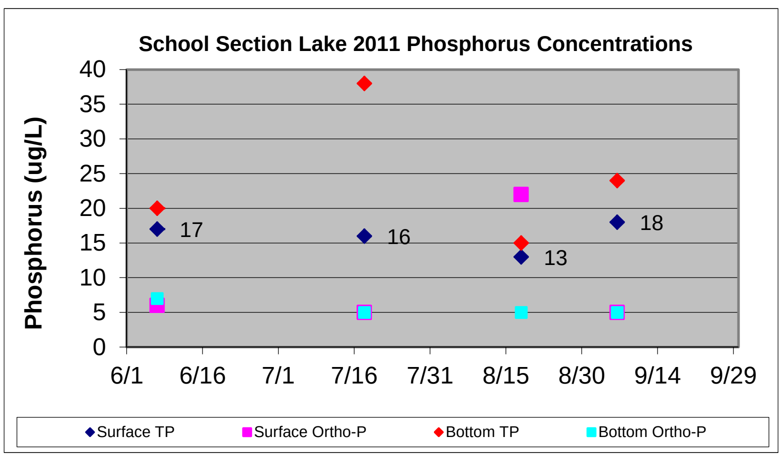


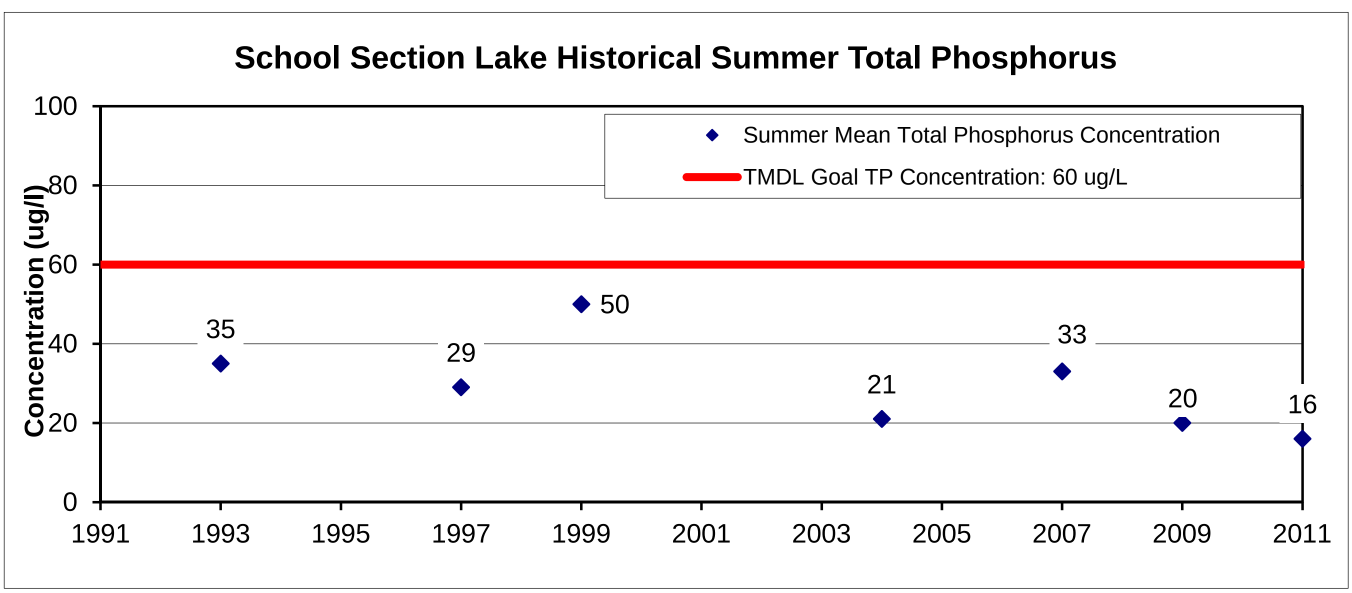
Lake Data

Surface Area:	**192 Acres**
Maximum Depth:	**12 Feet**
Subwatershed Area:	**1,843 acres**



<u>Tributary Sub watershed (shaded)</u>

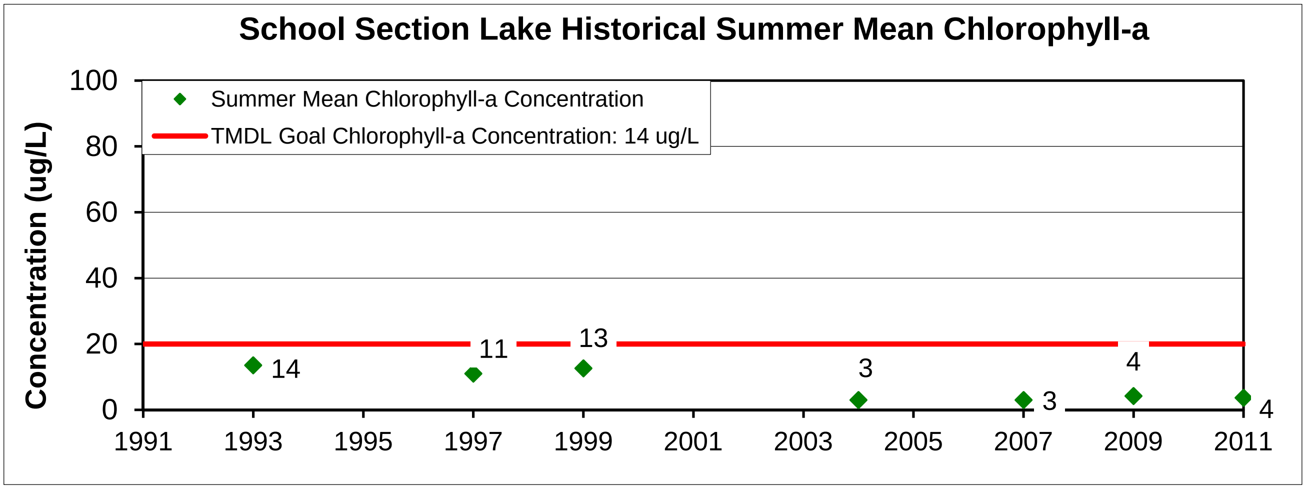


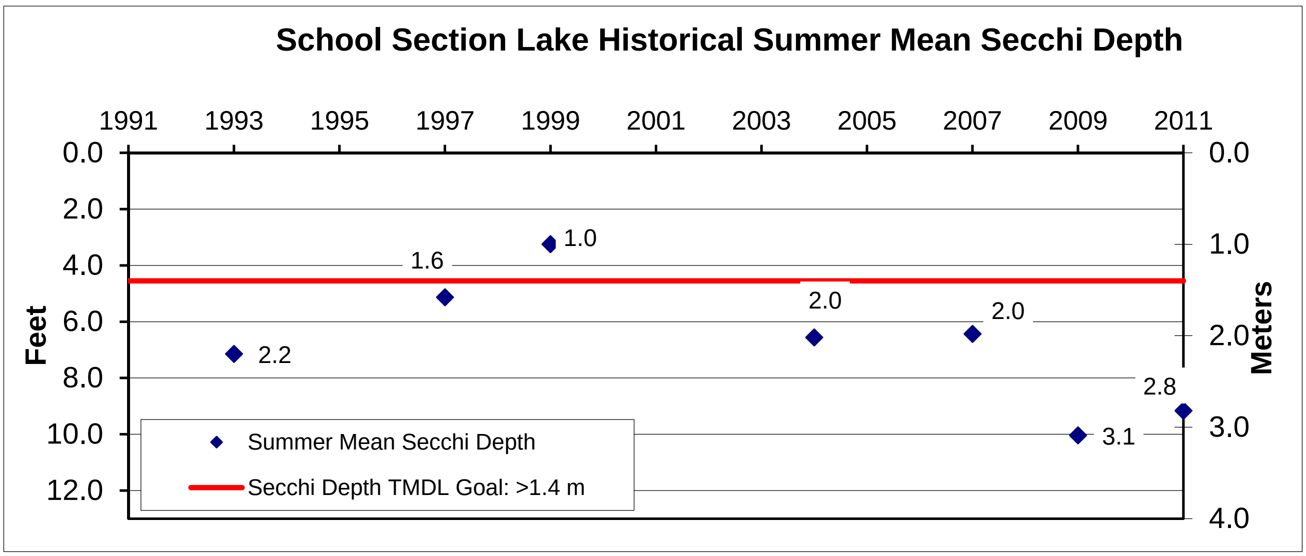


School Section Lake

2011 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





2011 Summary

- Current water quality is good in School Section Lake as phosphorus concentrations, chlorophyll-a concentrations, and Secchi depth have met MPCA standards since monitoring of the lake began in 1993
- School Section Lake is a shallow natural environment lake with a diverse aquatic plant community comprised primarily of native species. Invasive curly leaf pondweed was abundant in 1990 but was rare in 2008, covering less than one tenth of an acre over the lake.*
- Water levels were higher than normal during most of 2011. An outlet structure is maintained and operated by the CRWD to control lake water elevations.

Water Quality Improvement Activities

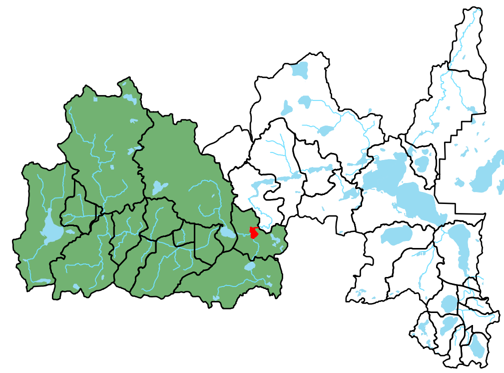
- Good land management practices along the lakeshore and in the watershed will help to maintain the good water quality in School Section Lake.

*Source: MN DNR Lake Finder

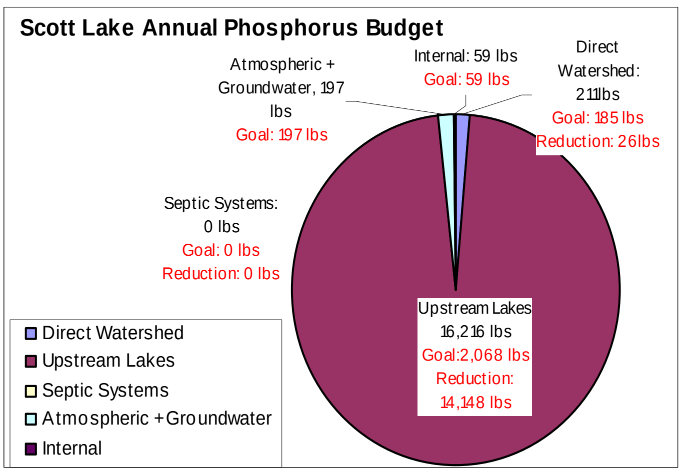
2012 Scott Lake Report Card

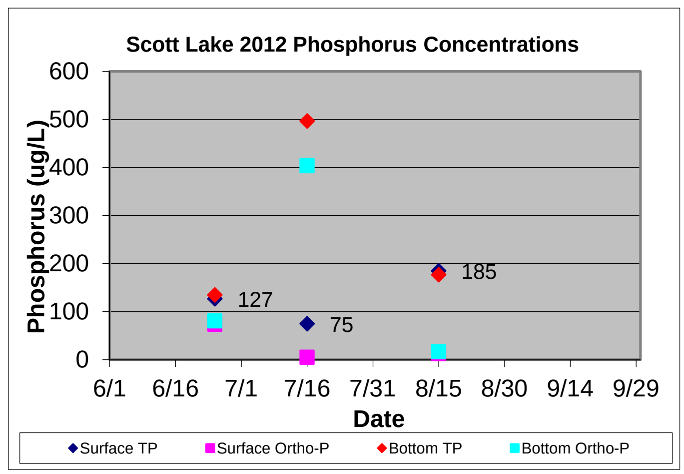
Lake Data

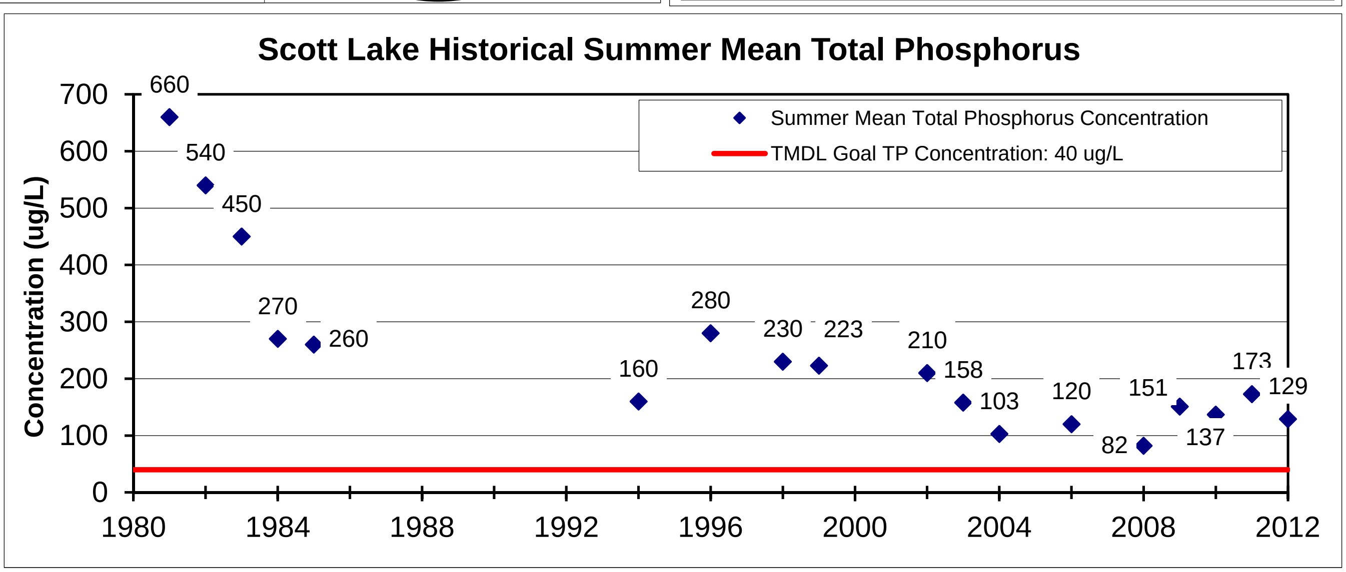
Surface Area:	**80 Acres**
Maximum Depth:	**23 Feet**
Subwatershed Area:	**51,000 acres**



Tributary Sub watershed (shaded)



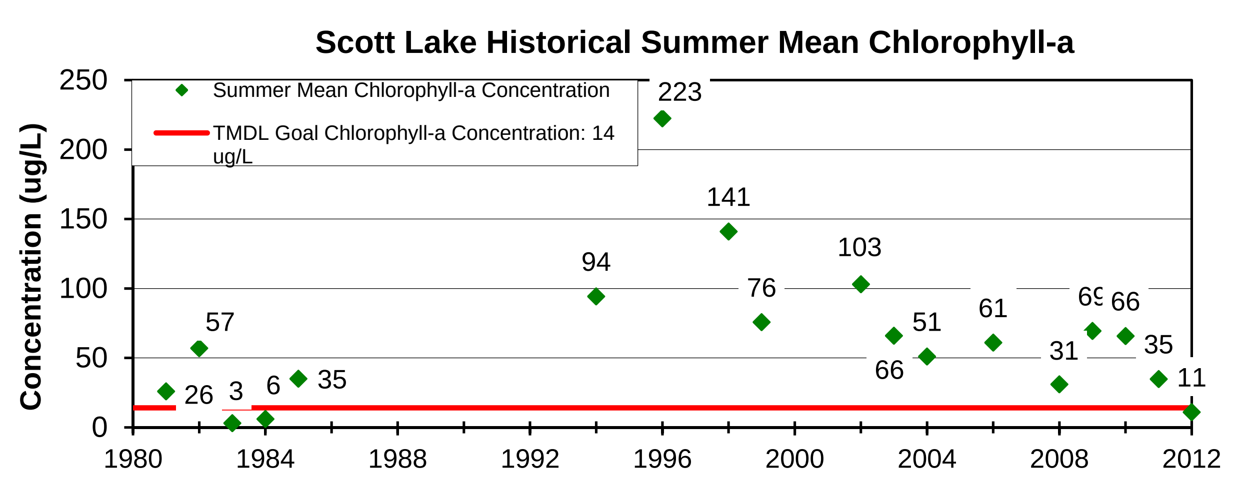


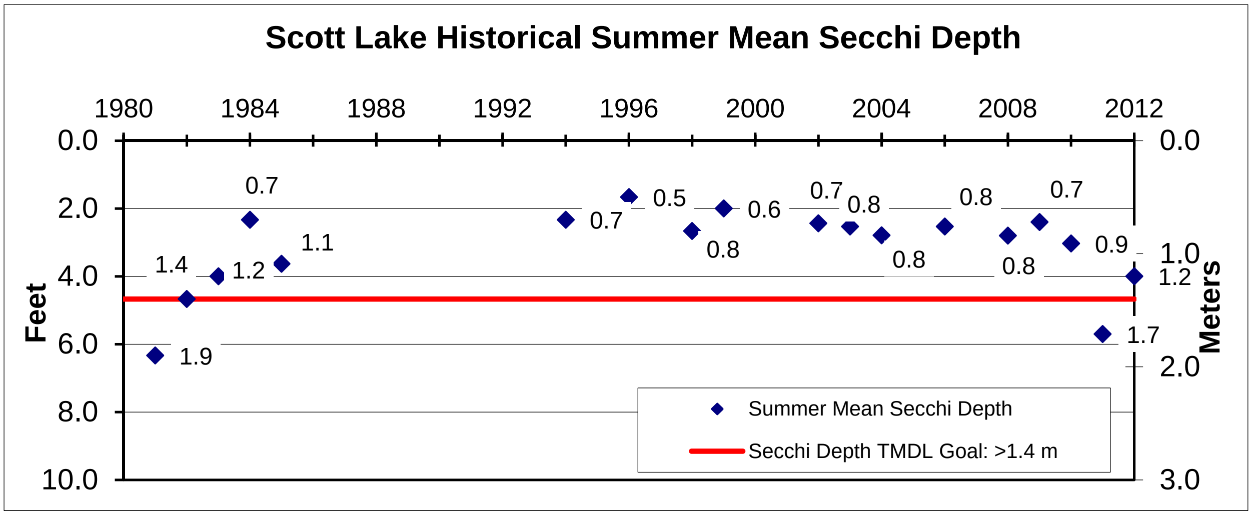


Scott Lake

2012 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





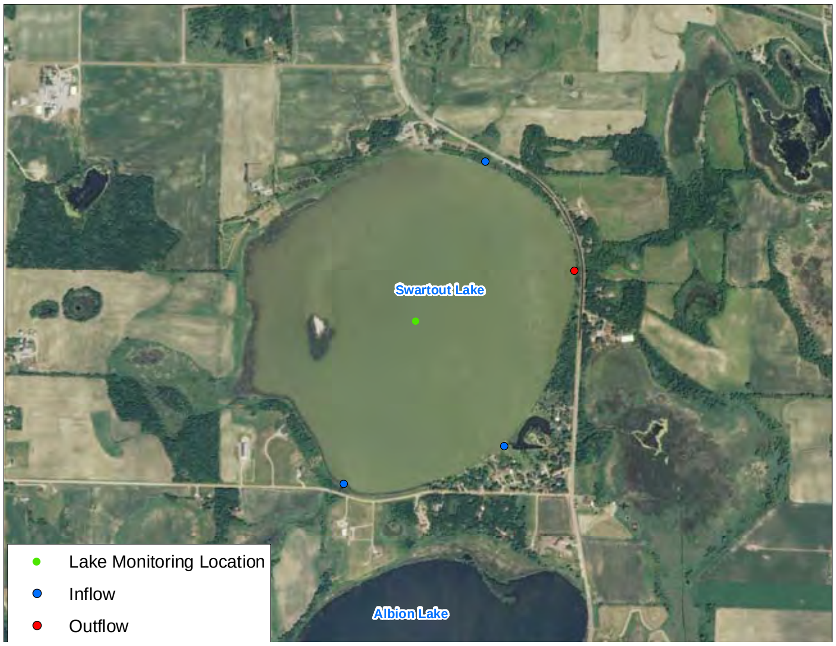
Summary

- While water quality has improved since the 1980s in Scott Lake, phosphorus concentrations have increased in recent years since 2008.
- TP concentrations and Secchi depths did not meet TMDL goals in 2012 and were similar to values seen in recent years.
- Chlorophyll-a met TMDL goals in 2012 continues a downward trend observed in recent years.
- Water quality in Scott Lake is dominated by the inflow from Lake Betsy. However, 20121 monitoring results and sediment phosphorus release analysis performed in 2010 indicate that Internal loading may represent a significant source of phosphorus to the lake as well.

TMDL Activities

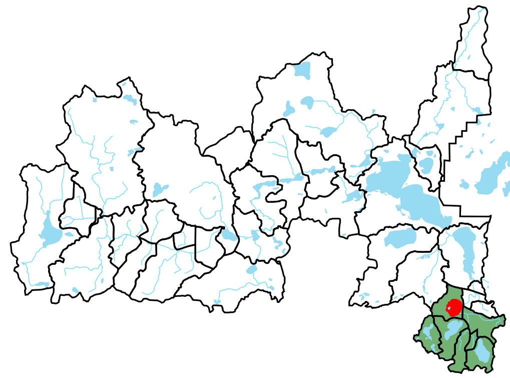
- Reducing phosphorus loads from upstream lakes and the direct tributary watershed will have the greatest impact on improving water quality in Scott Lake. Controlling loads in Lake Betsy is the key to improving water quality in Scott Lake
- Phosphorus reduction strategies including BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified by the TMDL Implementation Plan for implementation in upstream watersheds.

2012 Swartout Lake Report Card

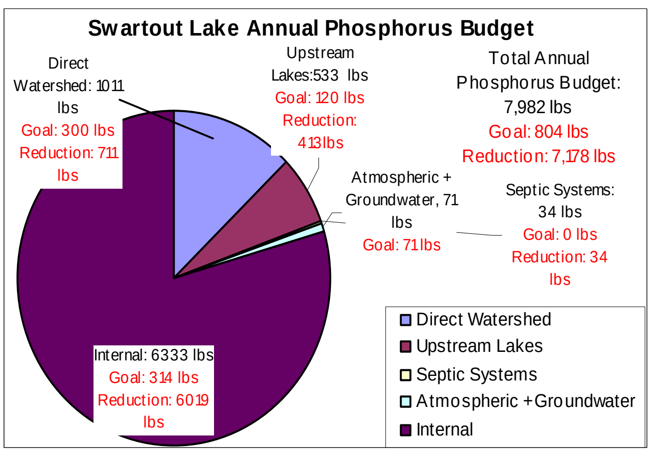


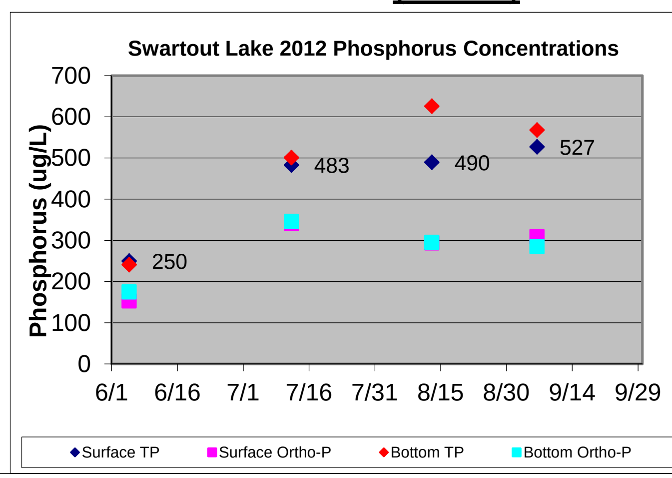
Lake Data

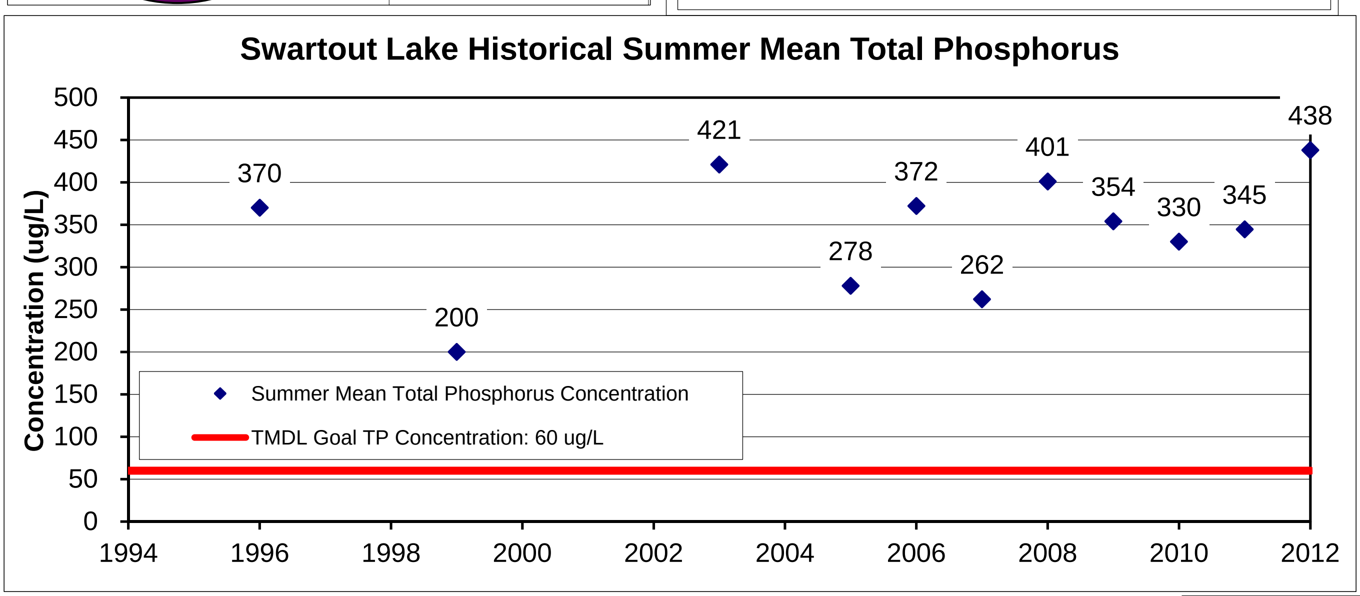
Surface Area:	**296 Acres**
Maximum Depth:	**12 Feet**
Subwatershed Area:	**5,551 acres**



Tributary Sub watershed (shaded)



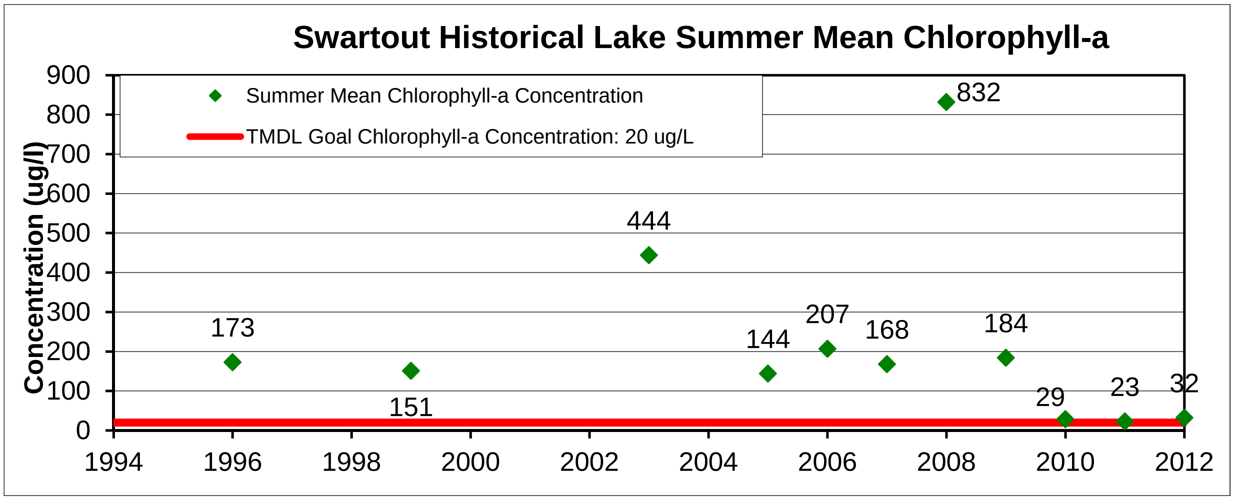


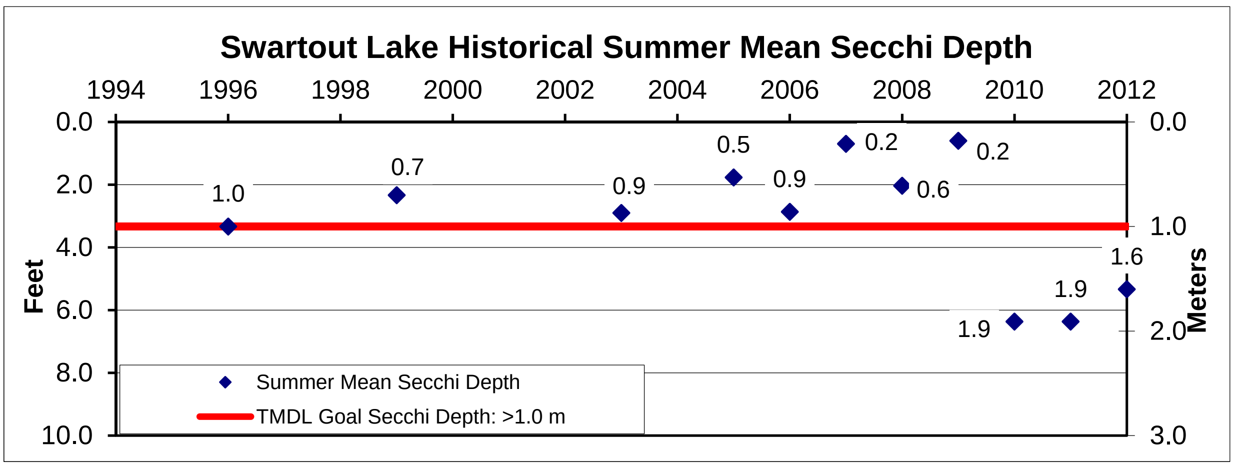


Swartout Lake

2012 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





Summary

- Phosphorus concentrations in 2012 were similar to recent years and remained well above TMDL goals.
- Chlorophyll-a concentrations do not meet TMDL goals, but have remained near the TMDL goal since 2010.
- Secchi depth met the TMDL goal and water clarity continued to be very good in 2012 due to the lack of rough fish in the lake since an extensive winter fish kill in 2010.
- An aquatic vegetation inventory conducted in September 2012 found dense beds of submergent vegetation growing at one third of the sample points around the lake. The vegetation community was comprised primarily of native species. For comparison, in 2005 a survey found no vegetation growing at any of the sample points.
- Internal loads are the major source of nutrients to the lake.

TMDL Activities

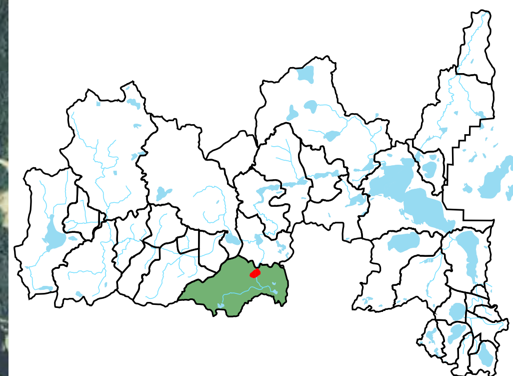
- Swartout Lake receives significant nutrient loads from upstream lakes Albion and Henshaw. A reduction in these external loads as well as a significant reduction in internal nutrient cycling will be required to meet TMDL goals in Swartout Lake.

- Rough fish migration control and removal is an important element of lake management. Fish barriers have been installed on tributary streams to inhibit carp from reaching spawning wetlands. Rough fish harvest has been conducted during the winter as well.

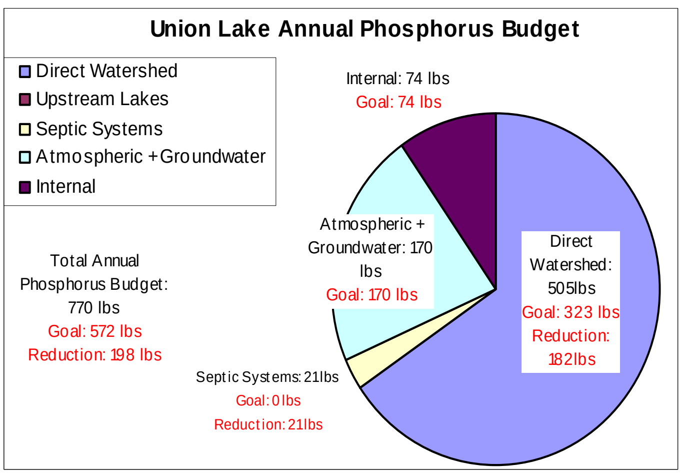
2012 Union Lake Report Card

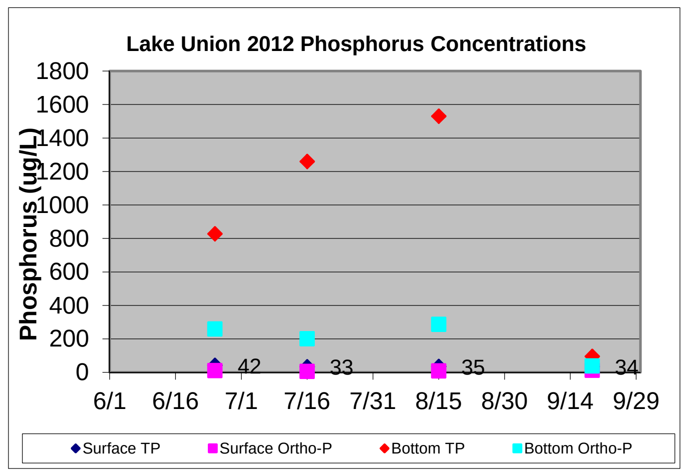
Lake Data

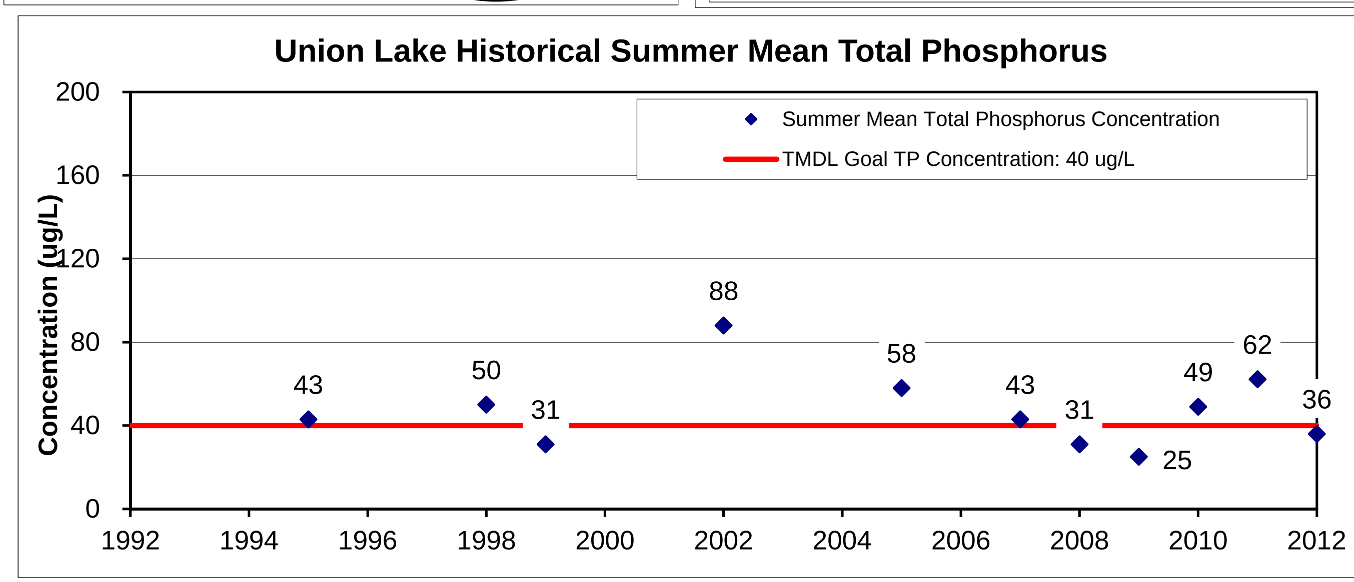
Surface Area: 93 Acres
Maximum Depth: 35 Feet
Subwatershed Area: 4,741 acres



Tributary Sub watershed (shaded)





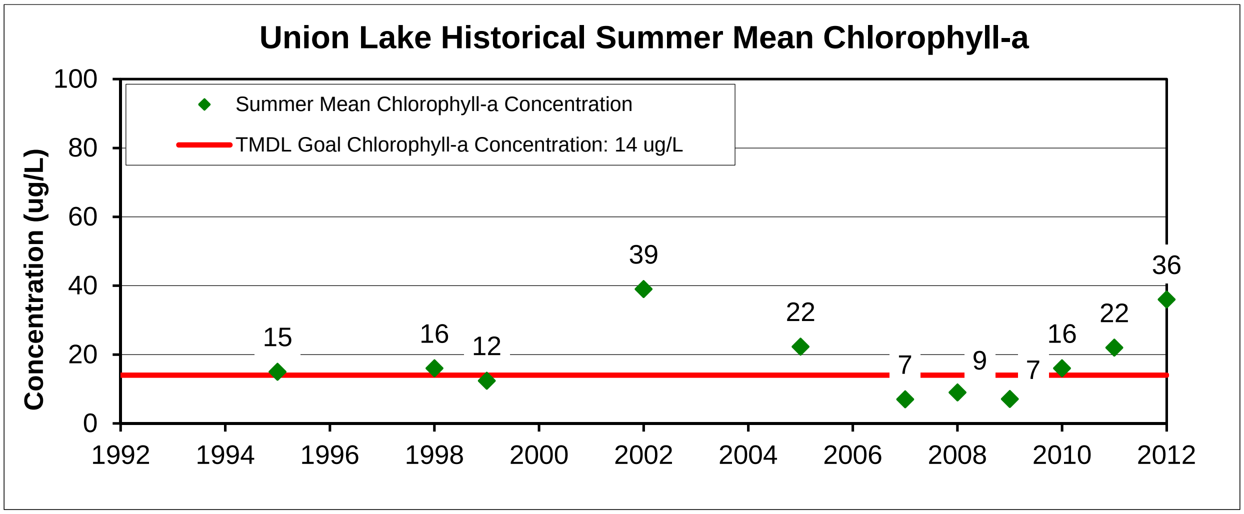


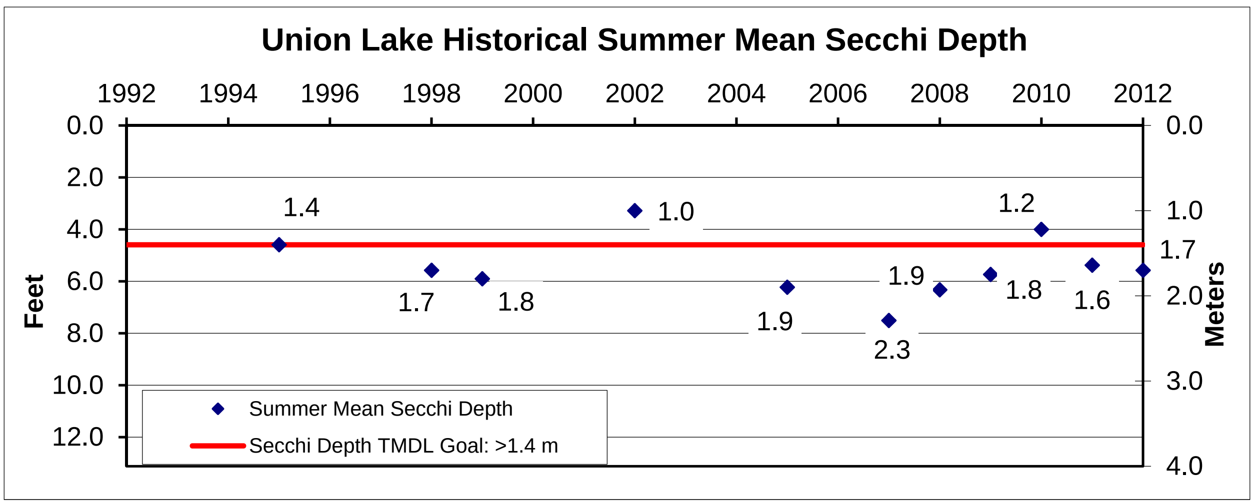
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
Union Lake		Appendix C

Union Lake

2012 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): $\leq$ 40 ug/L
Chlorophyll-a: $\leq$ 14 ug/L
Secchi Depth: $\geq$ 1.4 meter





2012 Summary

- Total phosphorus concentrations were lower than in 2010 and 2011 and met TMDL goals in 2012.
- Chlorophyll-a concentrations have increased in recent years and have not met TMDL goals since 2009.
- Secchi disk depth met TMDL goals in 2012.

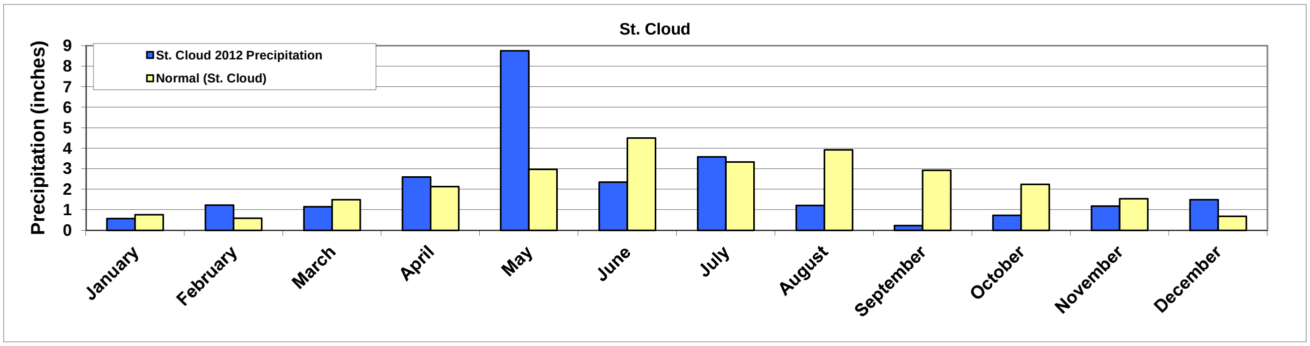
TMDL Activities

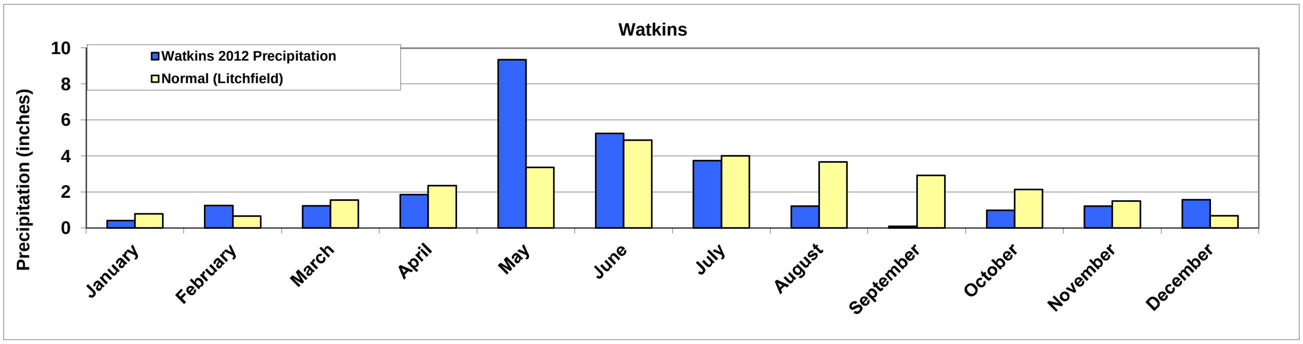
- Watershed loads appear to be the only reduction necessary for Union Lake to meet its water quality goals.
- Reducing phosphorus loads from the lake's direct tributary watershed will have the greatest impact on improving water quality in Union Lake.
- Phosphorus reduction strategies including BMPs, hypolimnetic withdrawal, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified by the TMDL Implementation Plan for implementation in upstream watersheds.

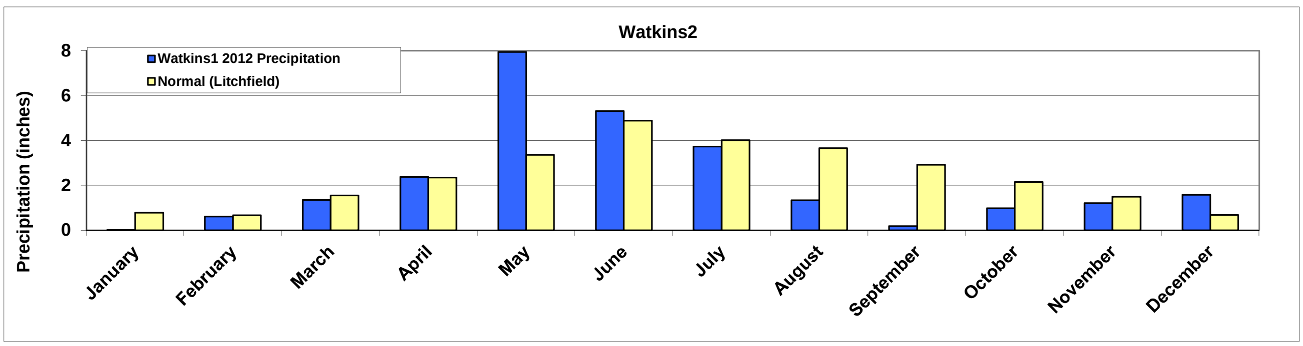
Appendix D

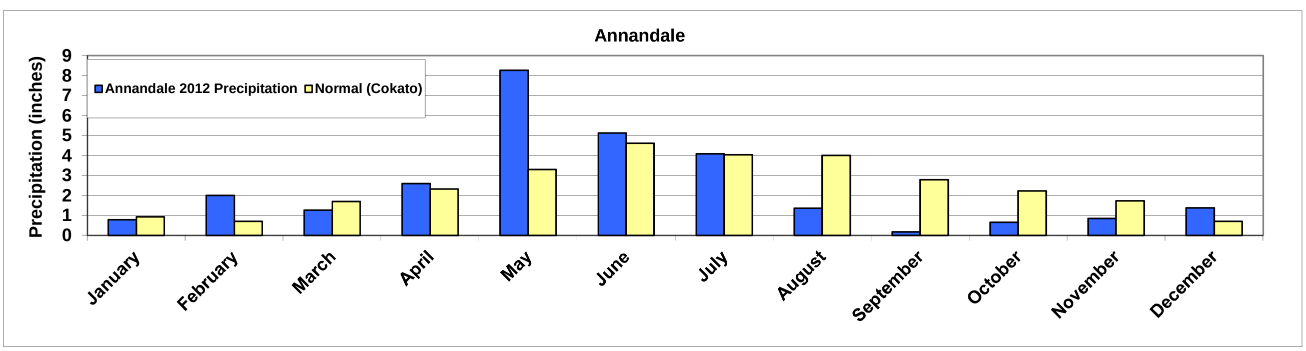
Citizen Precipitation Records

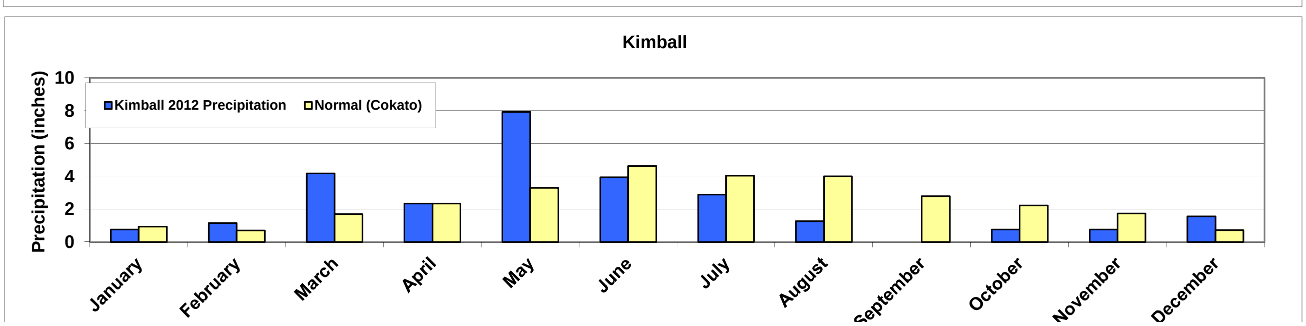
Appendix D
Figure 1
Clearwater River Watershed District
2012 Annual Report











Appendix E

2012 Water Quality Laboratory Reports and Data (On Enclosed CD Only)

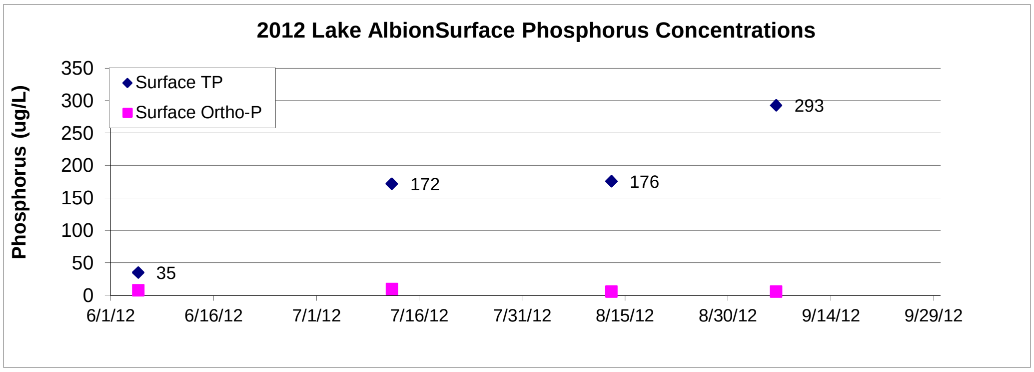
Appendix F

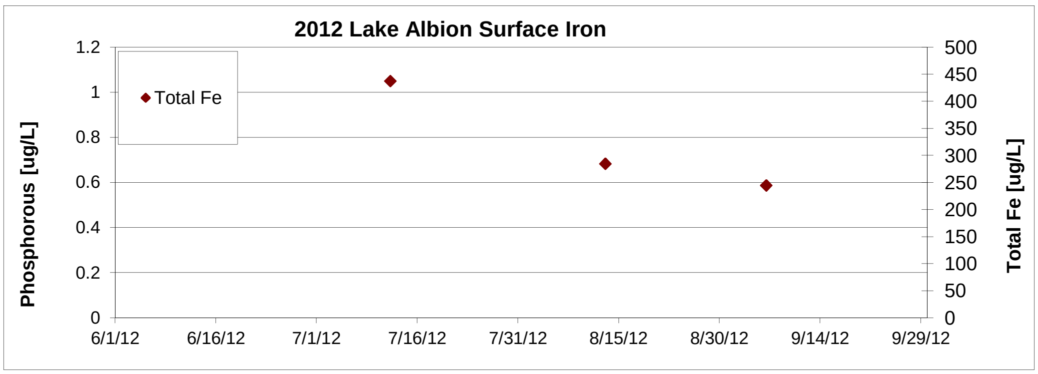
2012 Field Notes and Measurements (On Enclosed CD Only)

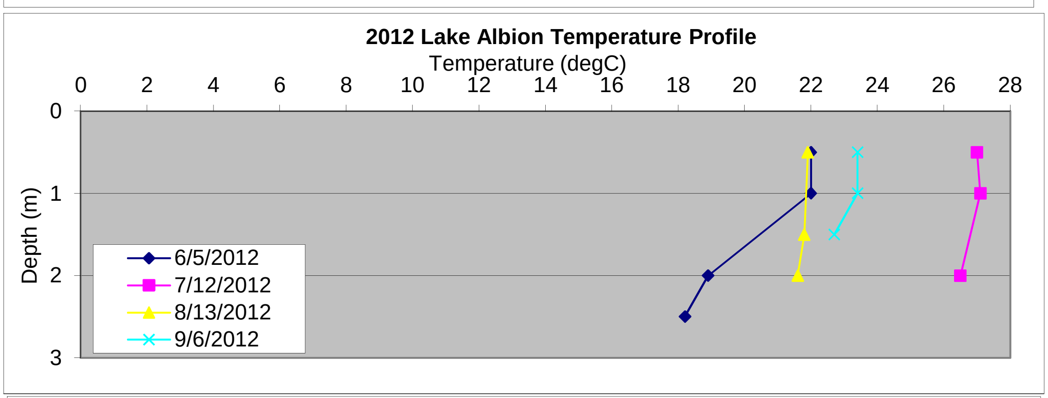
Appendix G

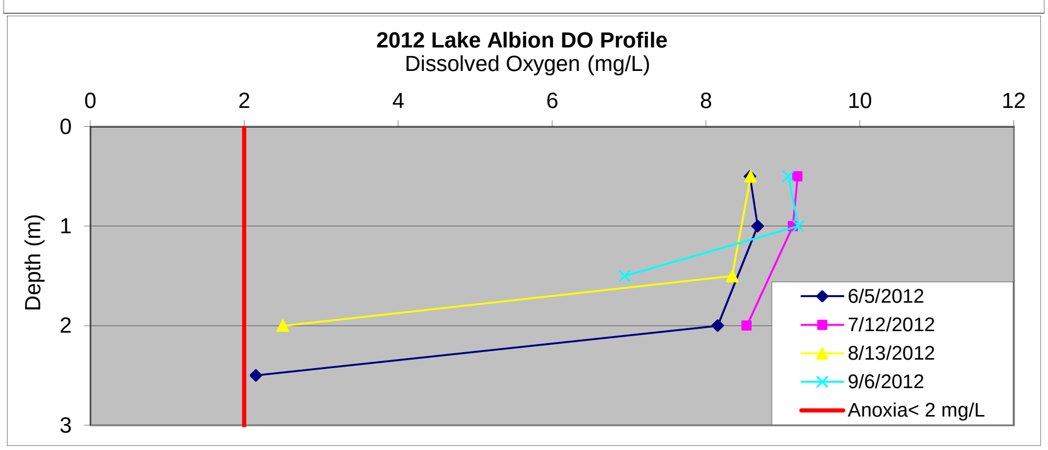
Lake Phosphorus and Profile Data

CRWD 2012 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data









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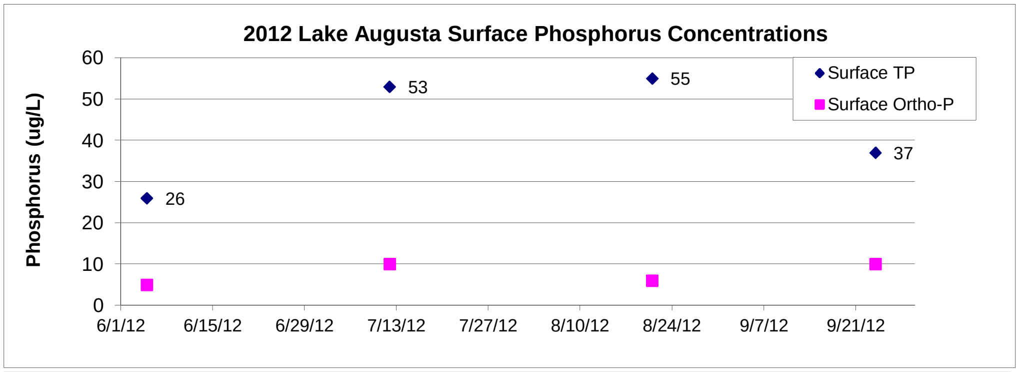
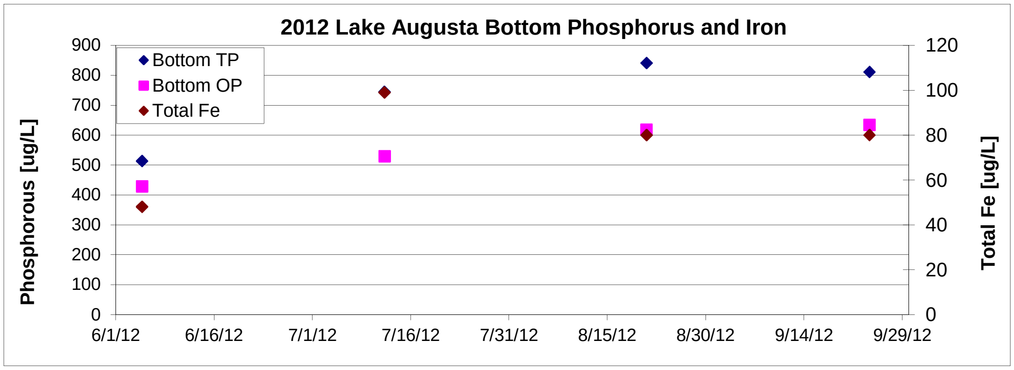
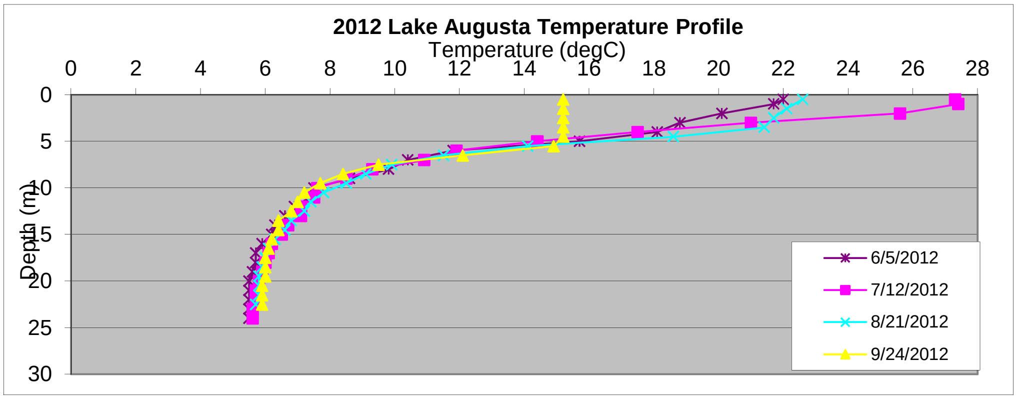
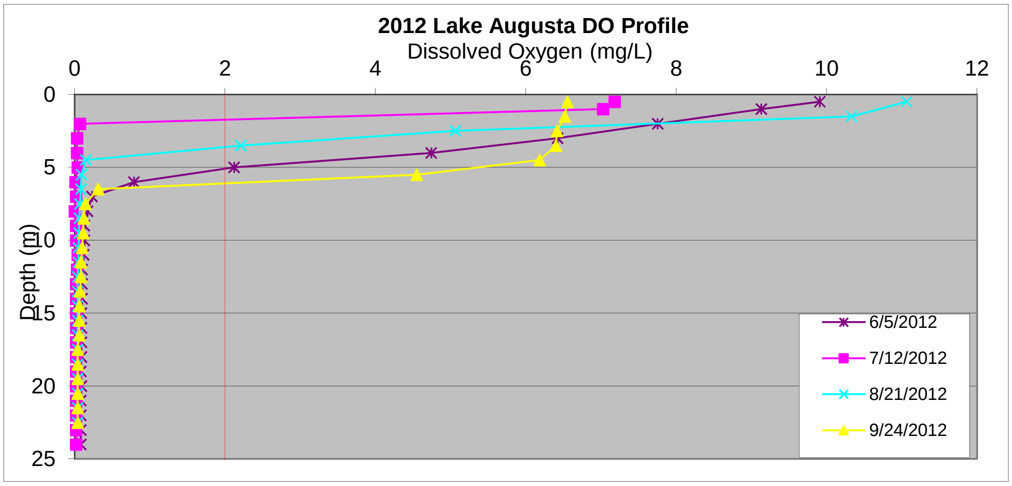
Appendix G-Lake Phosphorus
and Profile Data









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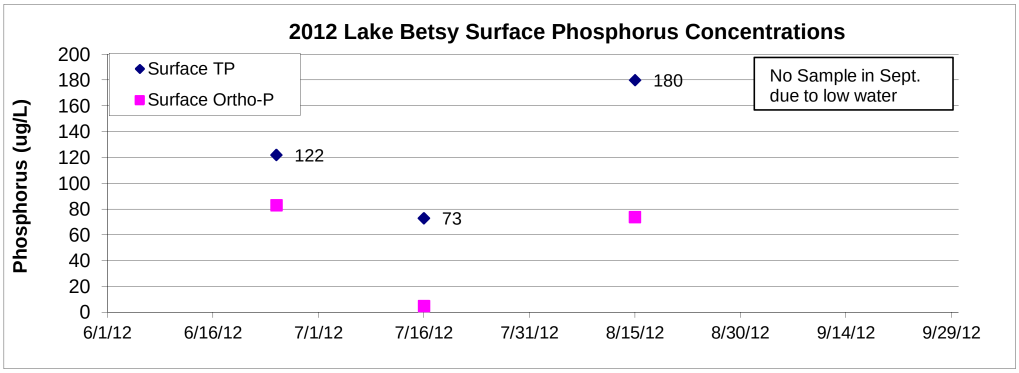
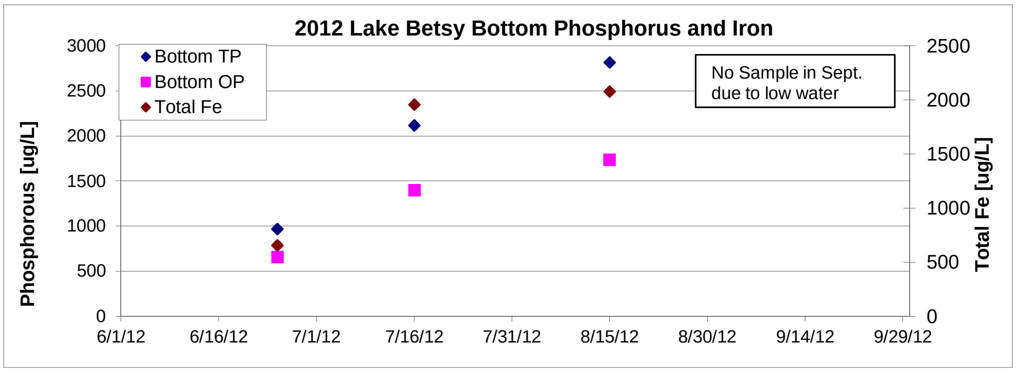
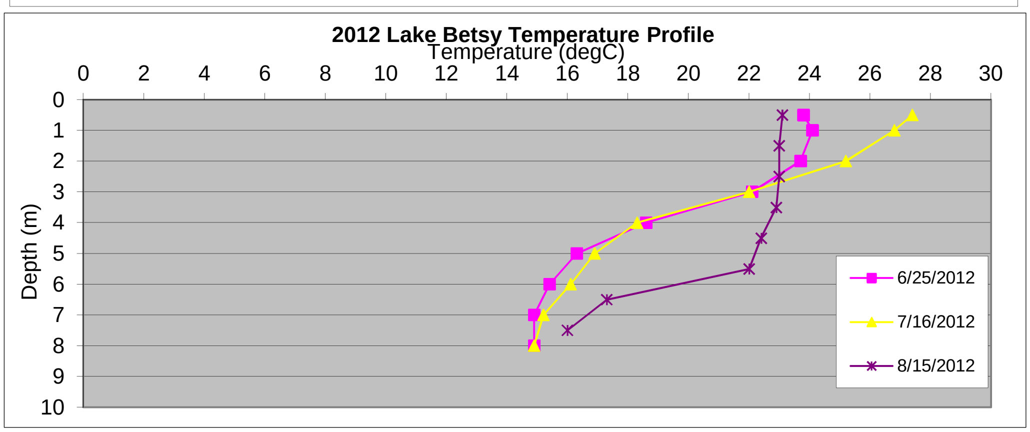
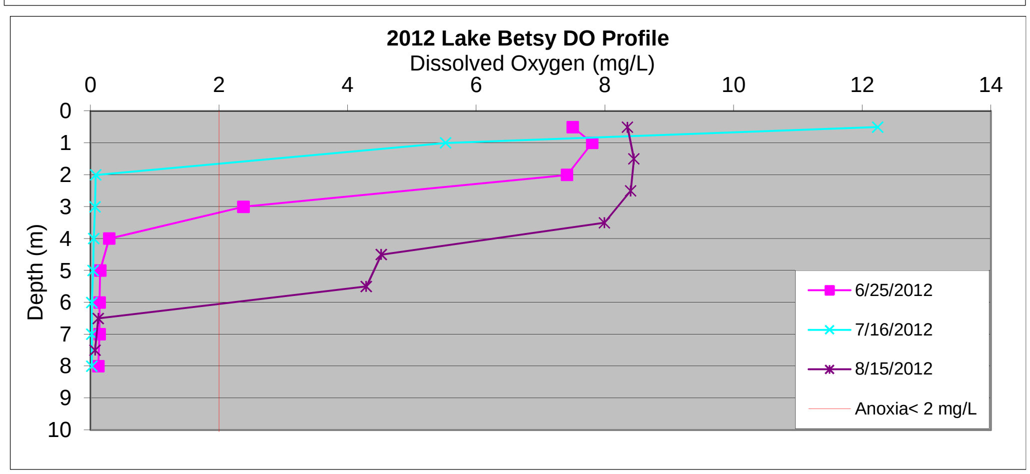
Appendix G-Lake Phosphorus and Profile Data









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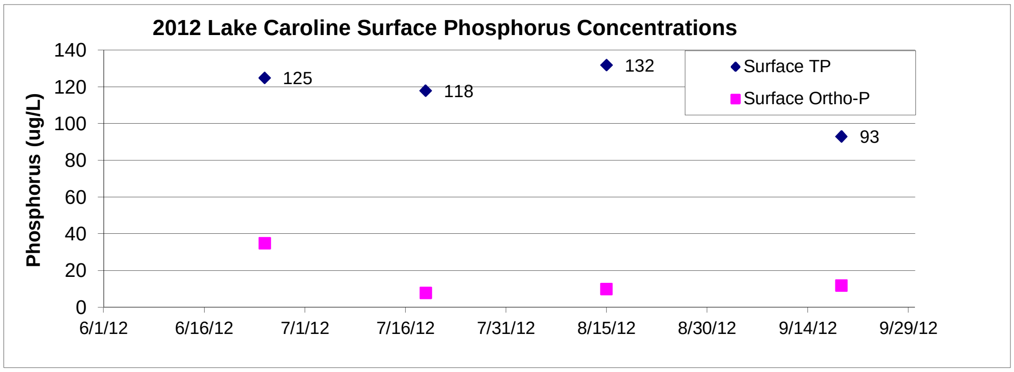
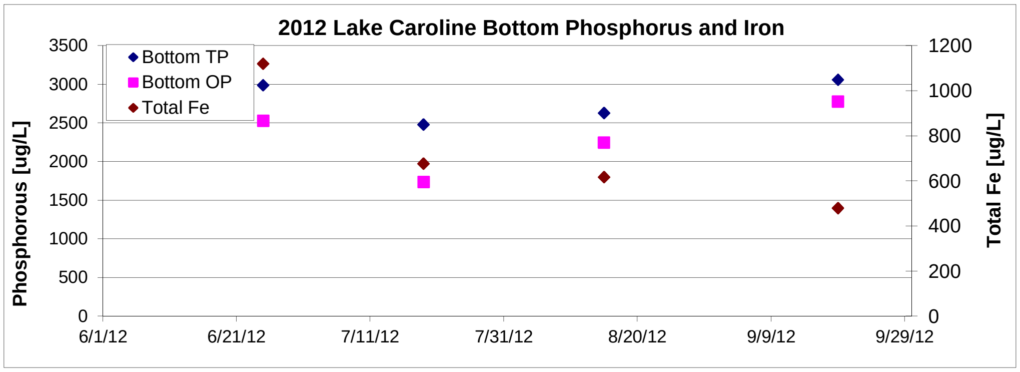
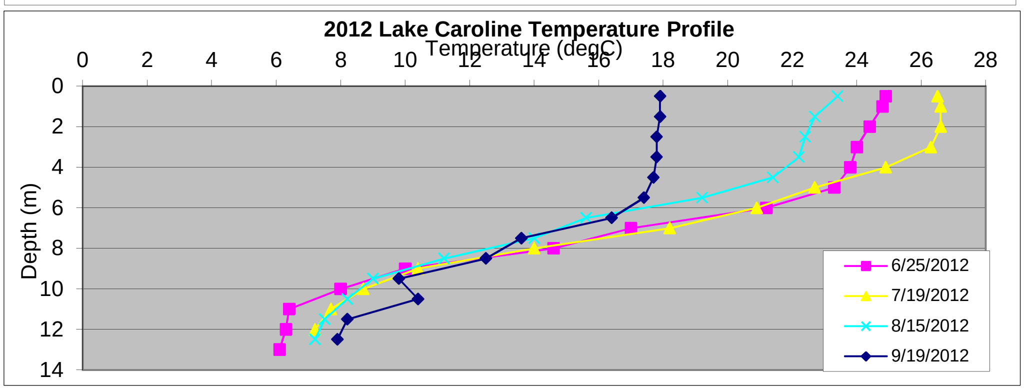
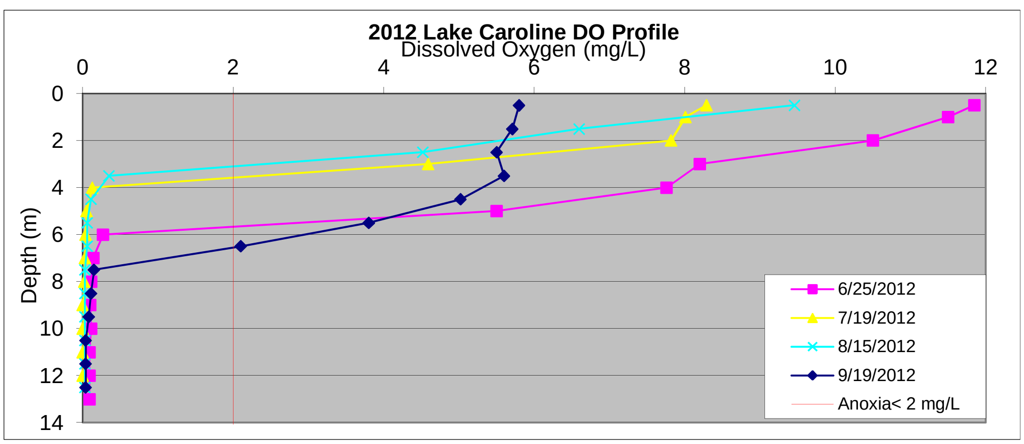
Appendix G-Lake Phosphorus
and Profile Data









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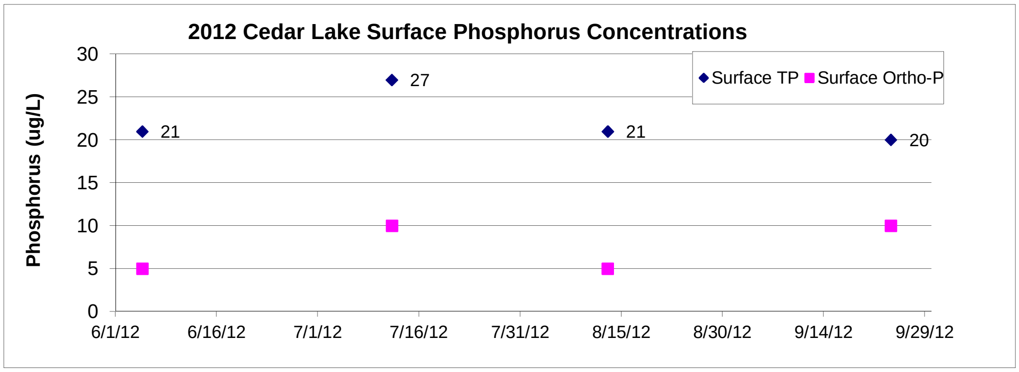
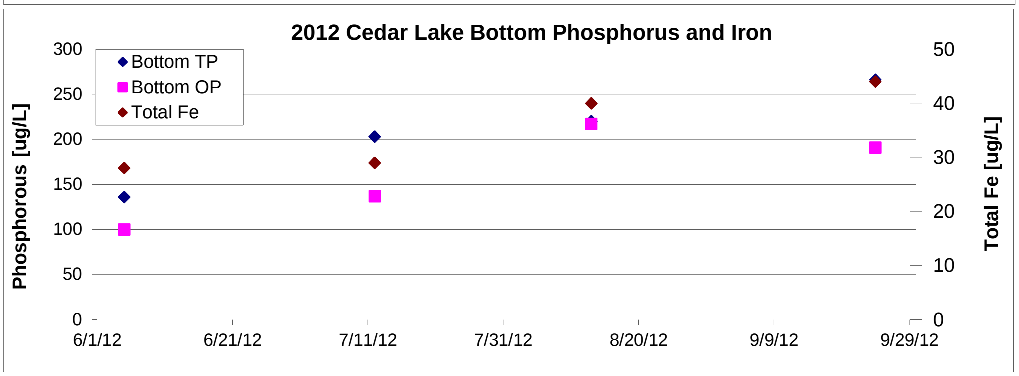
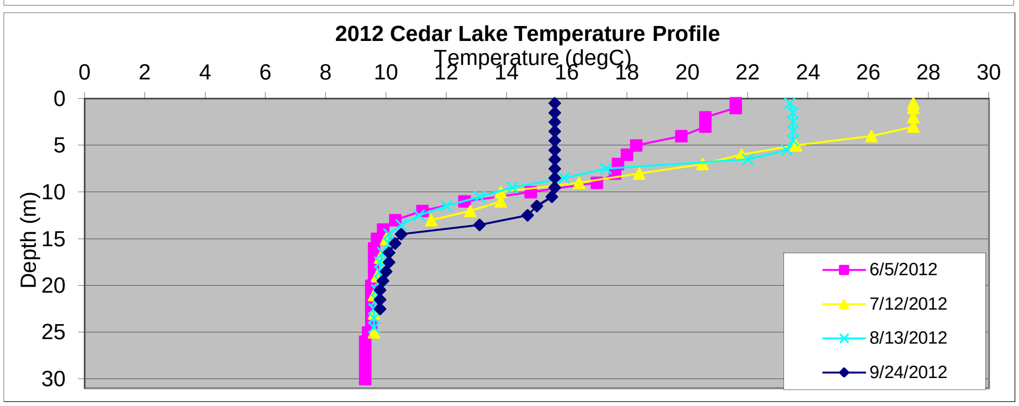
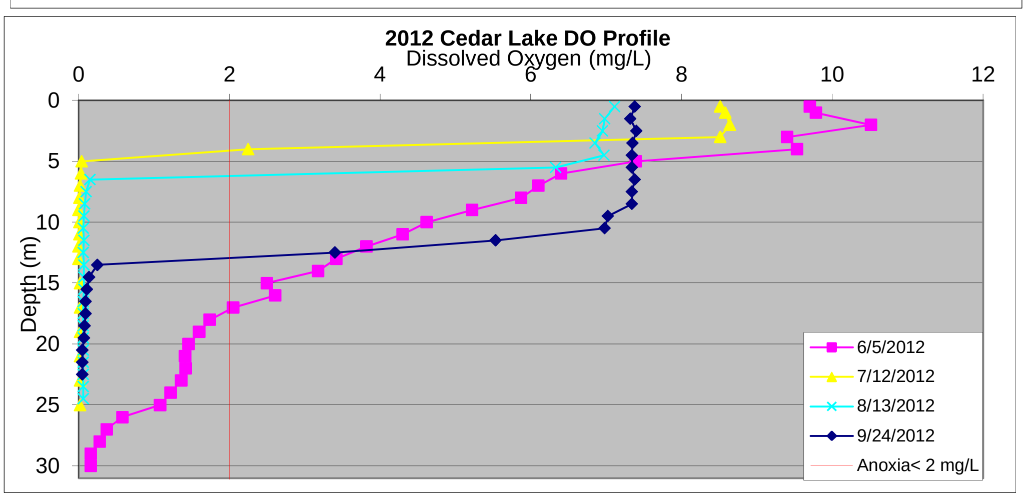
Appendix G-Lake Phosphorus
and Profile Data









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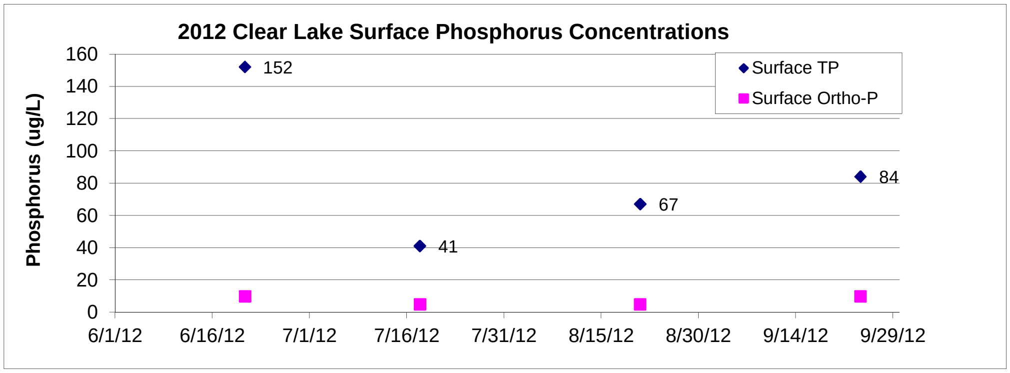
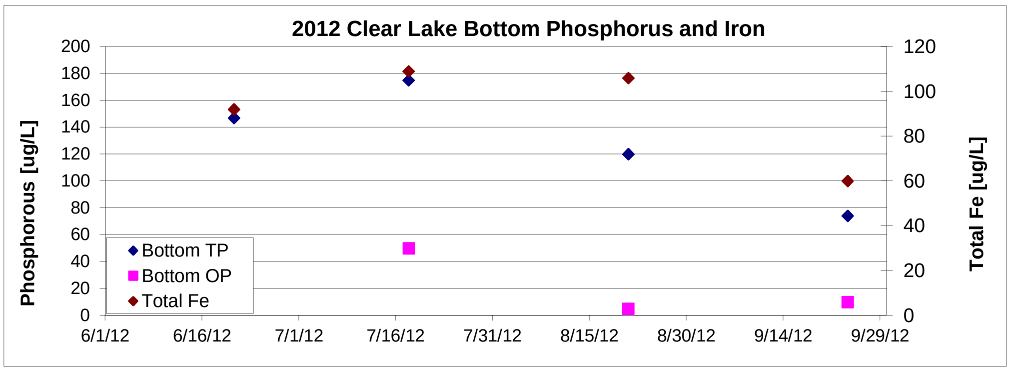
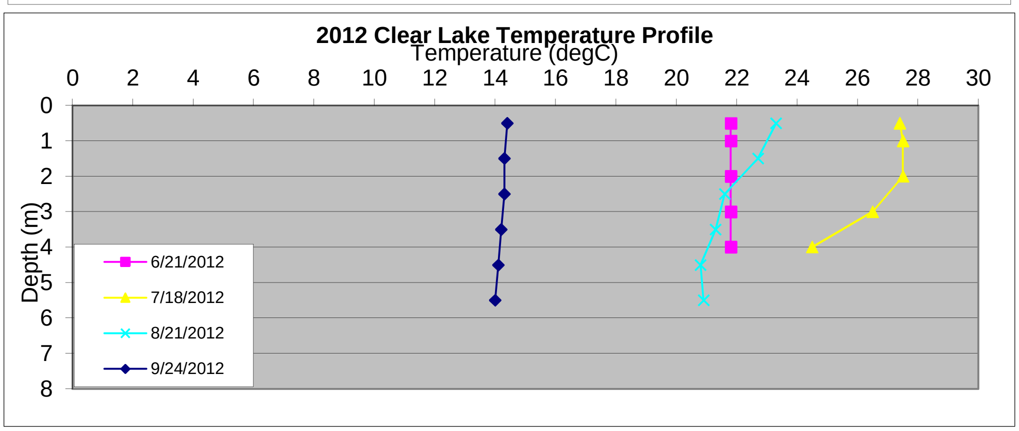
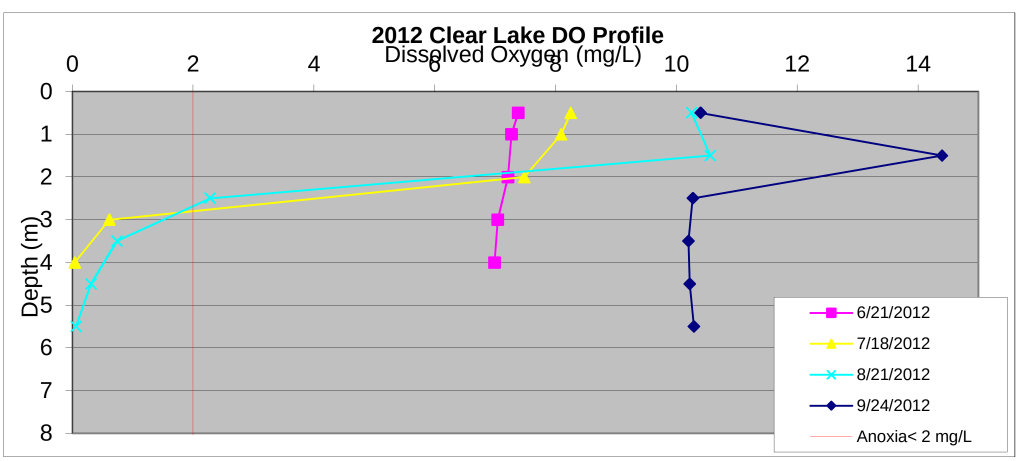
Appendix G-Lake Phosphorus
and Profile Data









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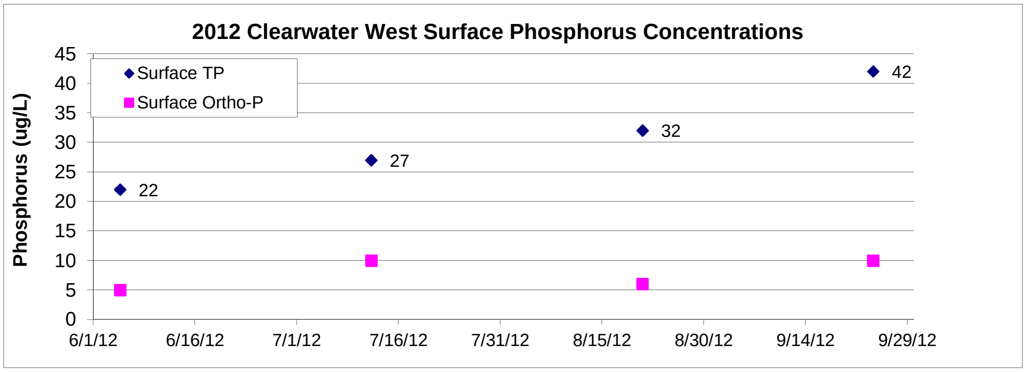
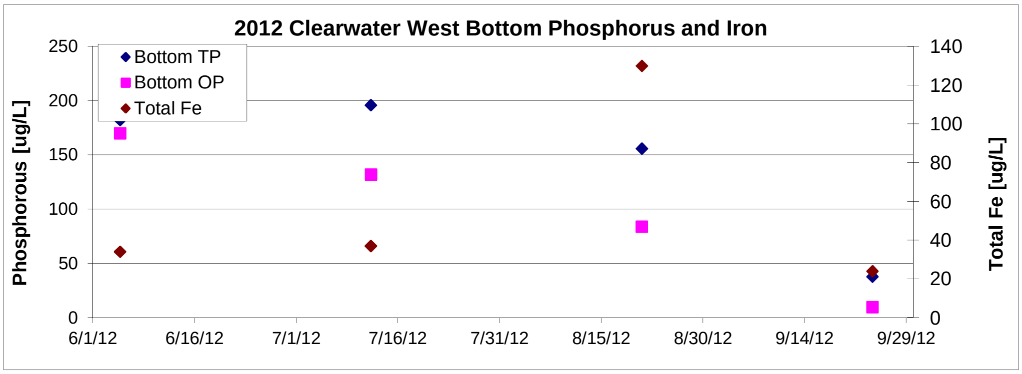
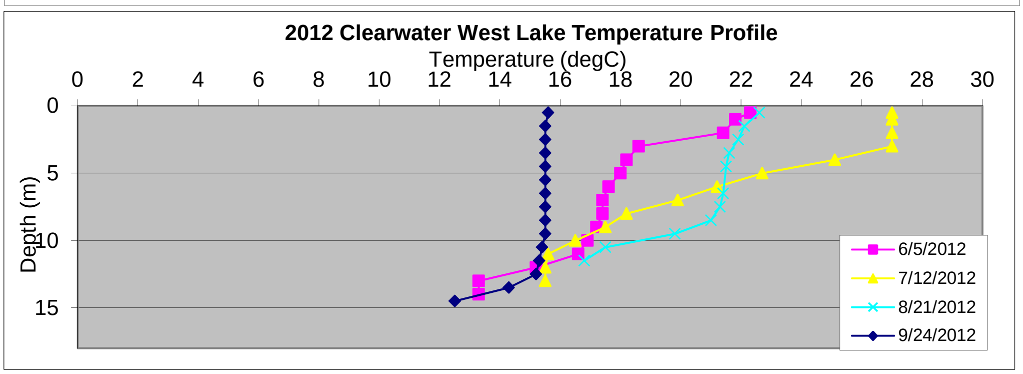
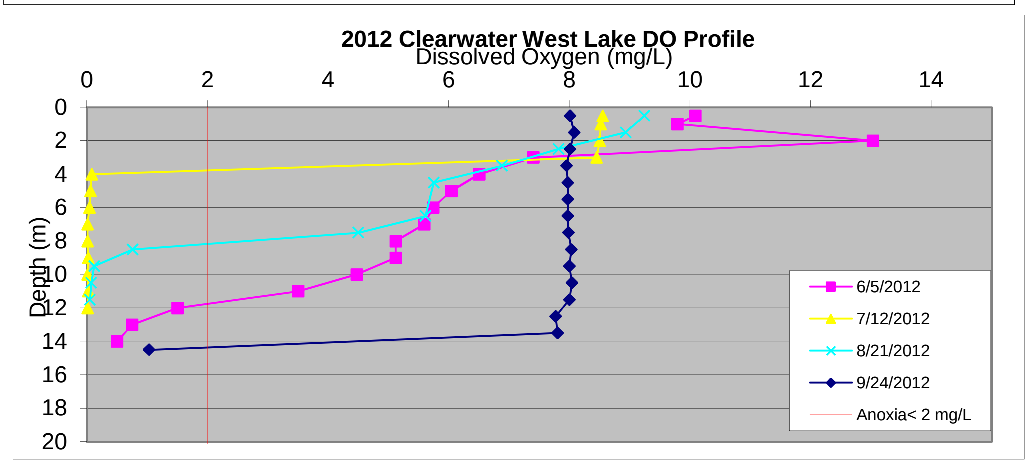
and Profile Data









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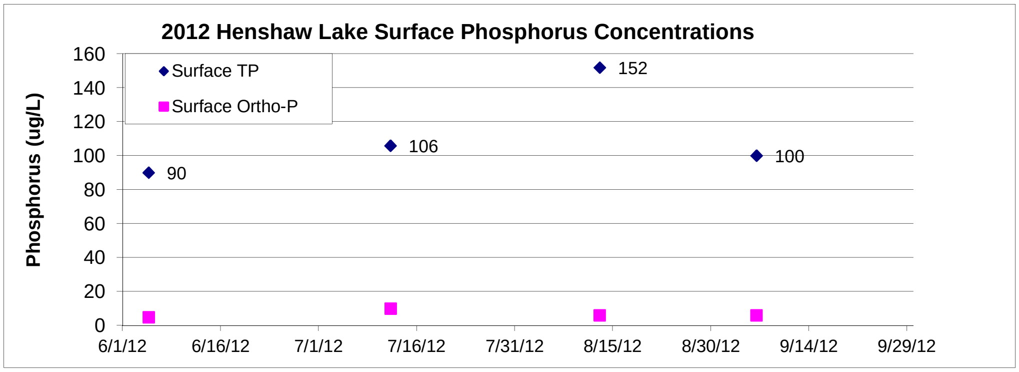
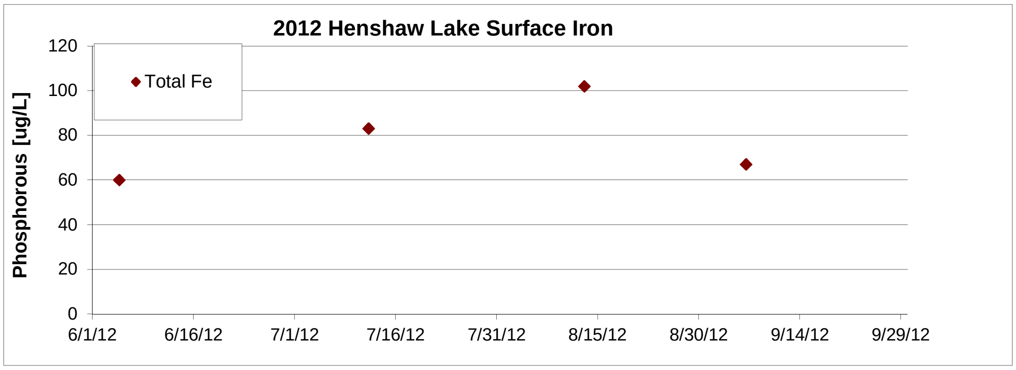
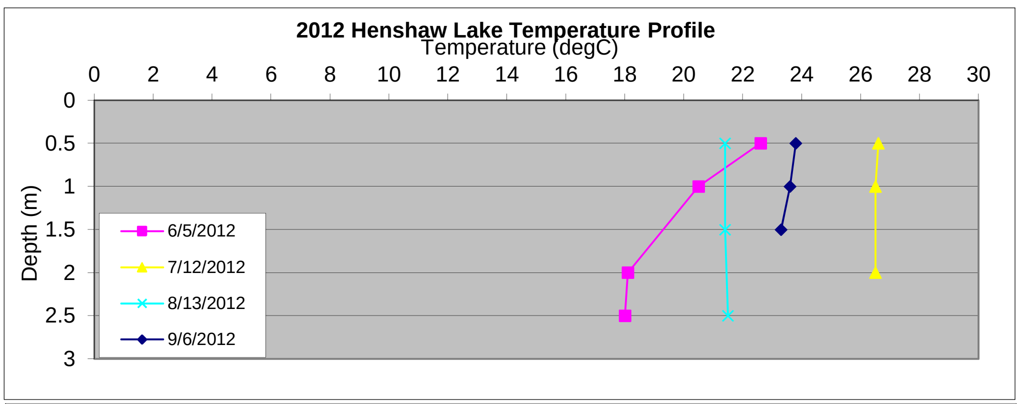
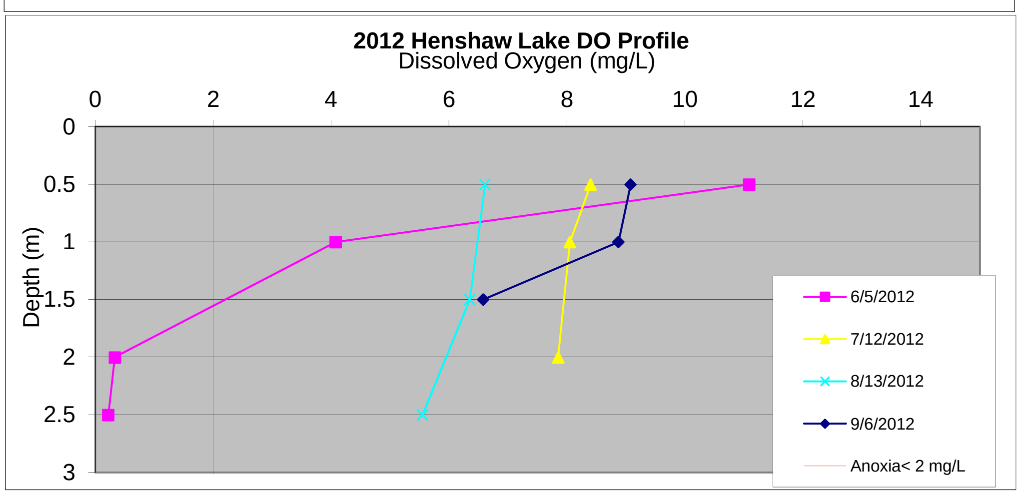
Appendix G-Lake Phosphorus
and Profile Data









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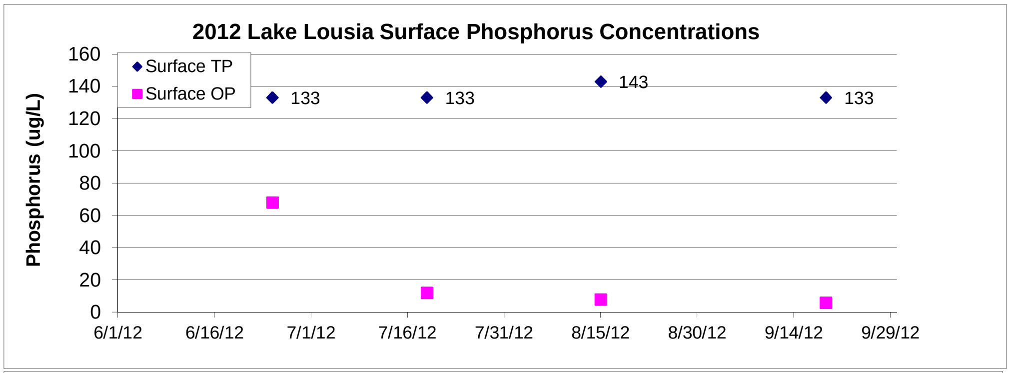
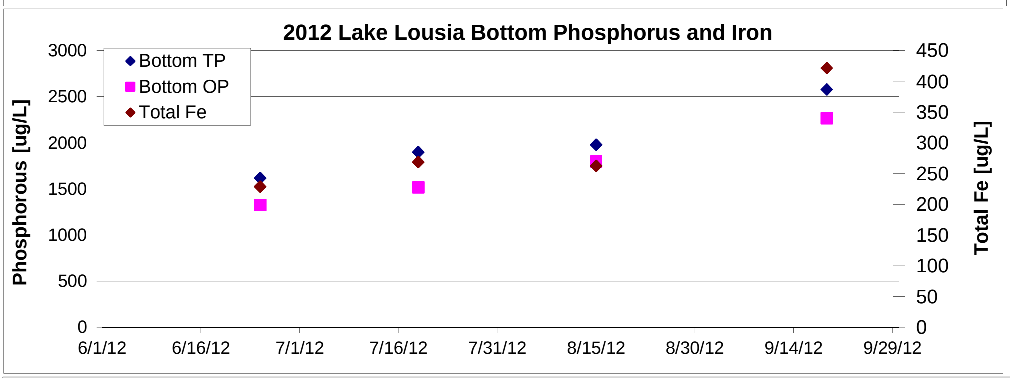
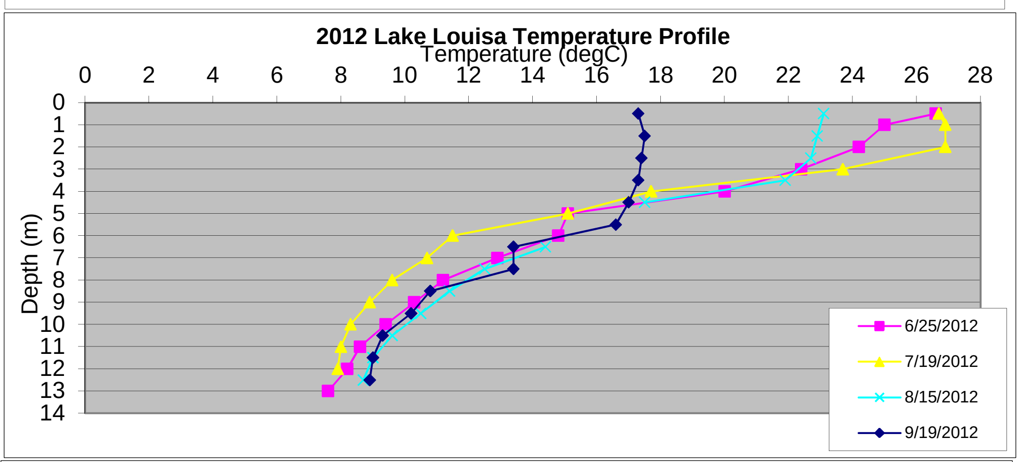
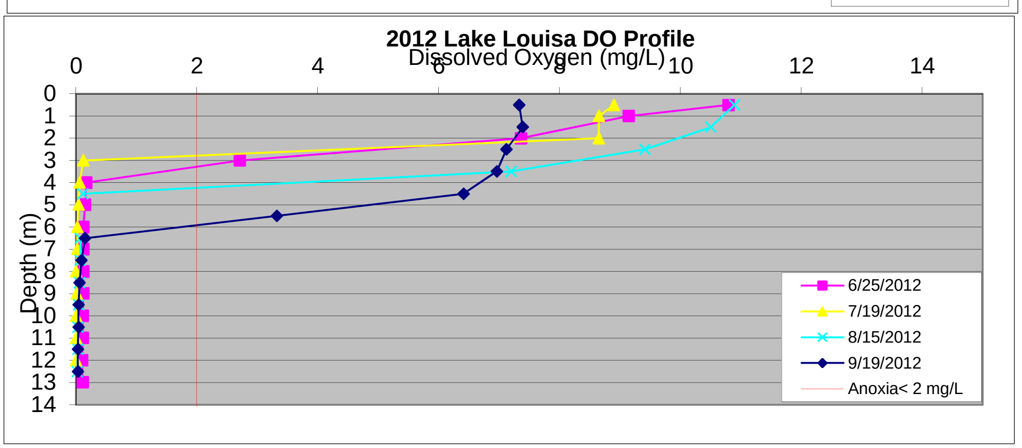
Appendix G-Lake Phosphorus
and Profile Data









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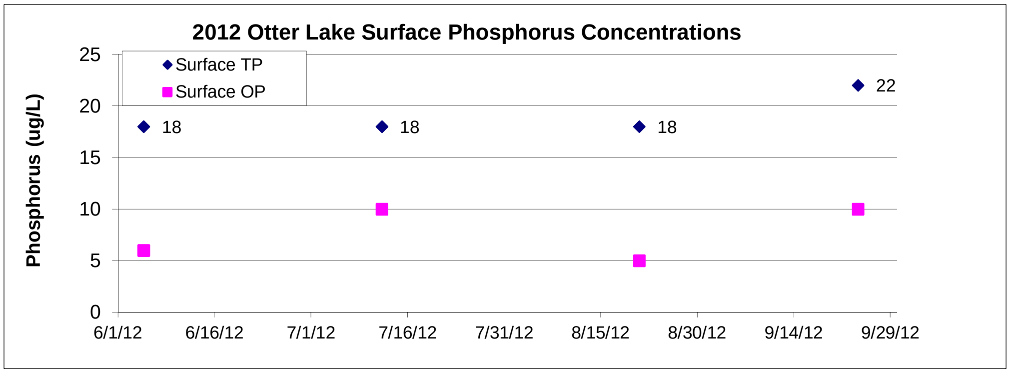
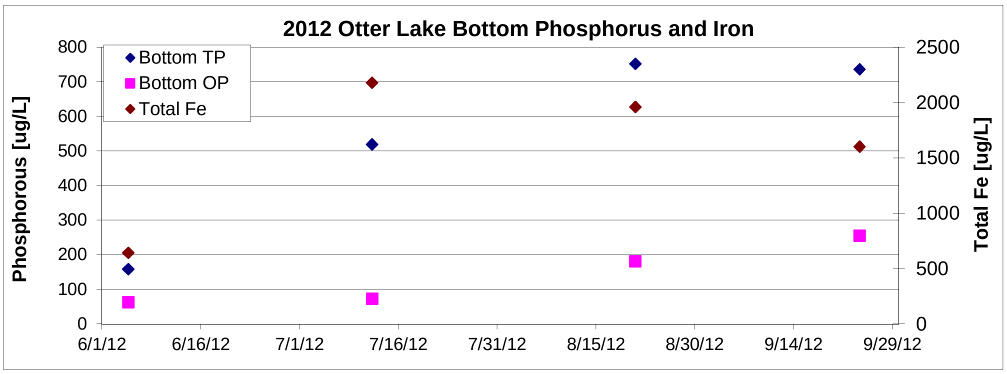
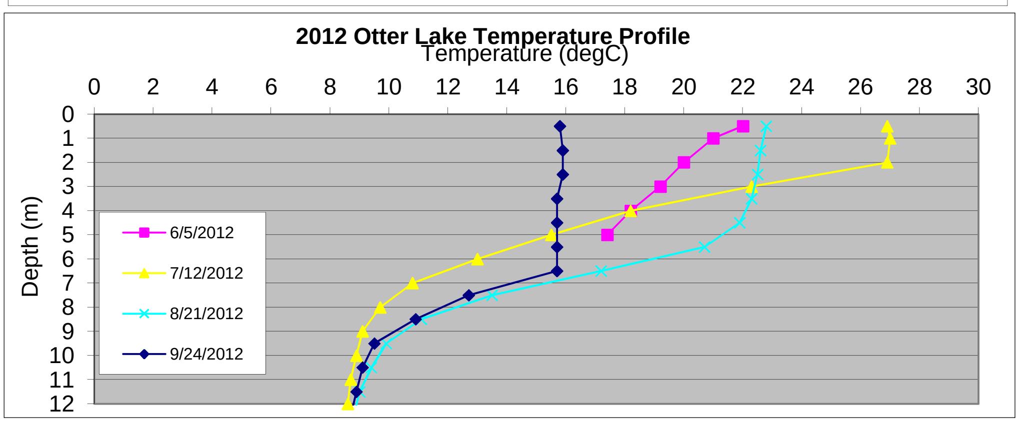
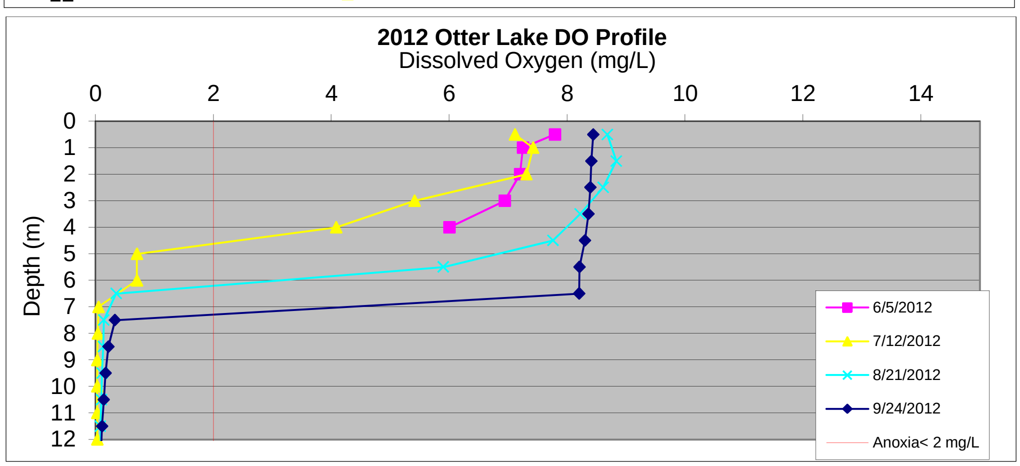
and Profile Data









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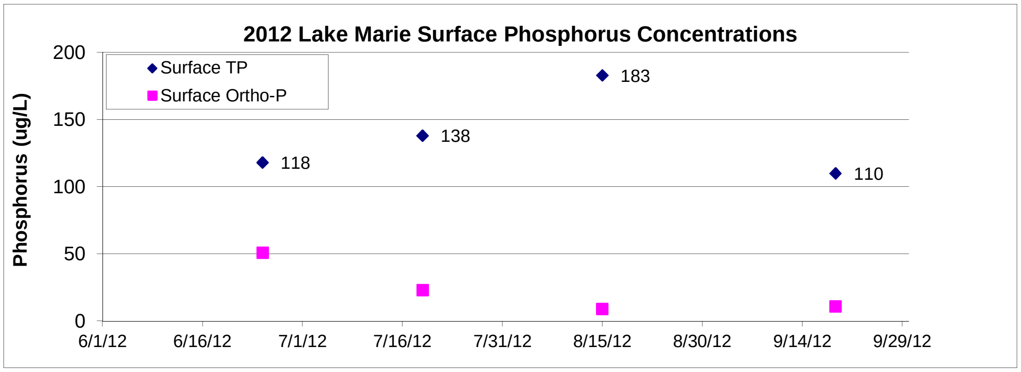
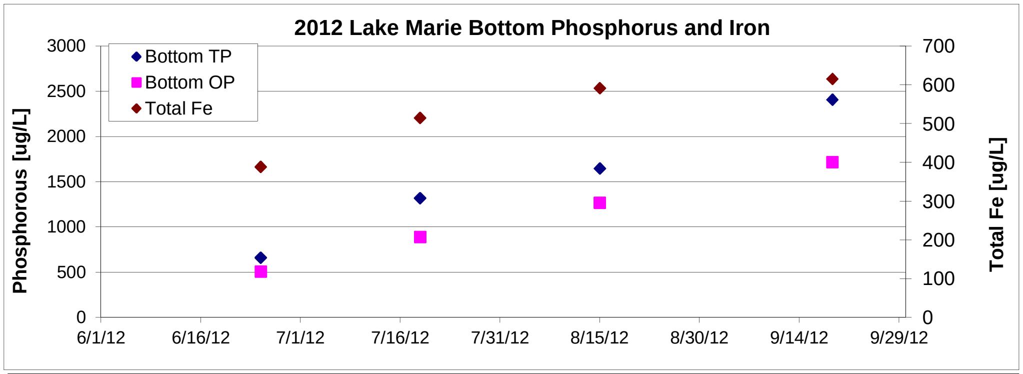
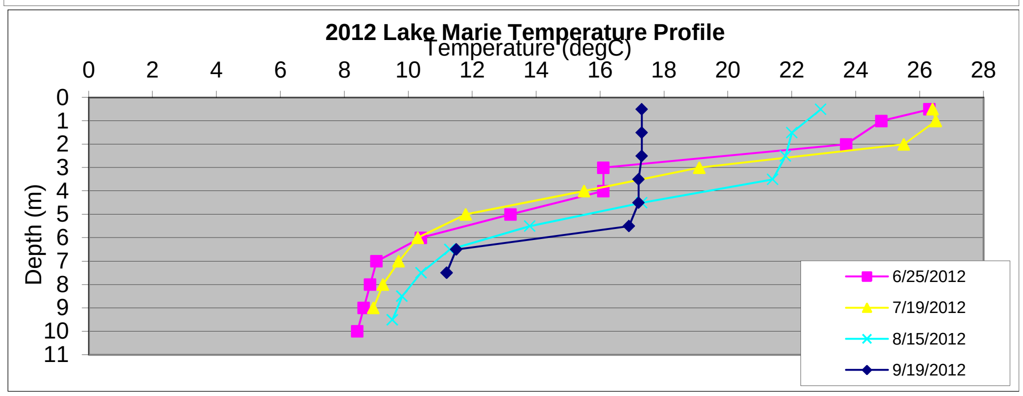
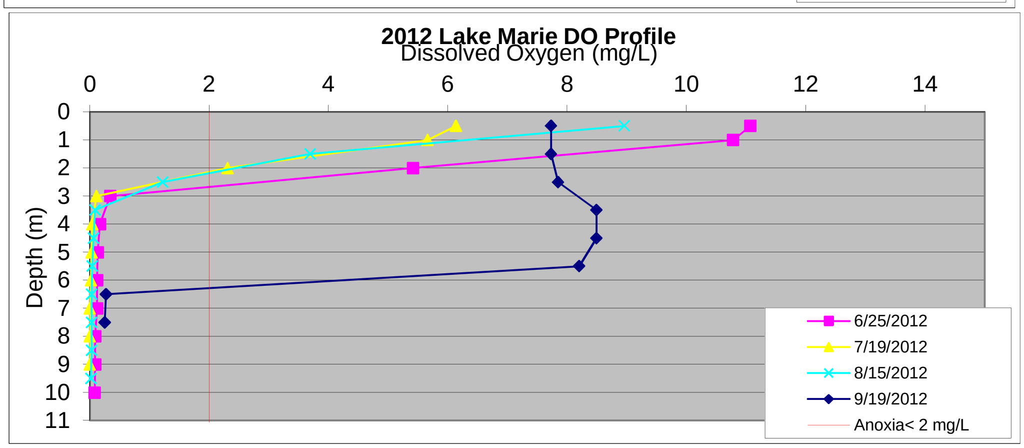
and Profile Data









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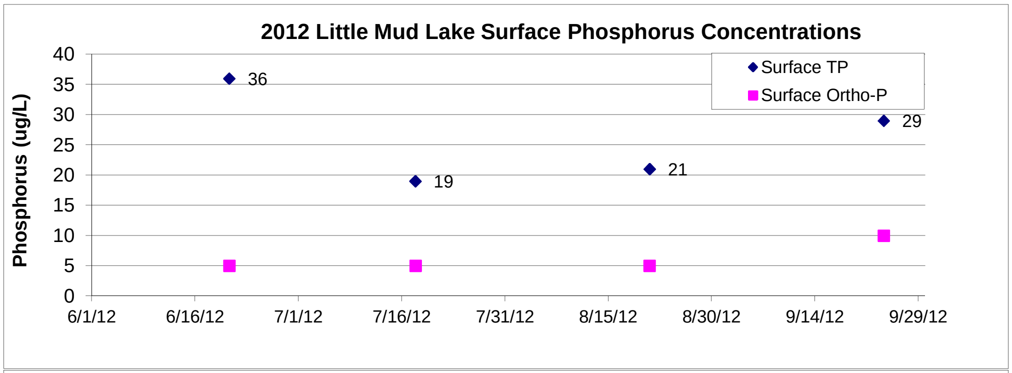
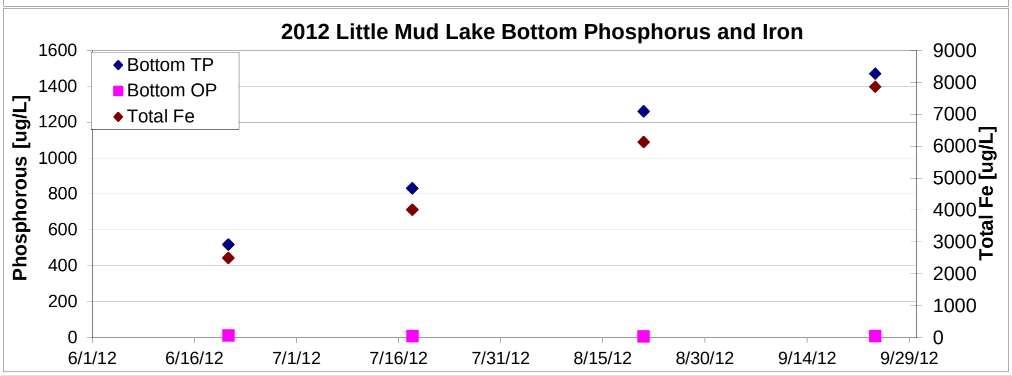
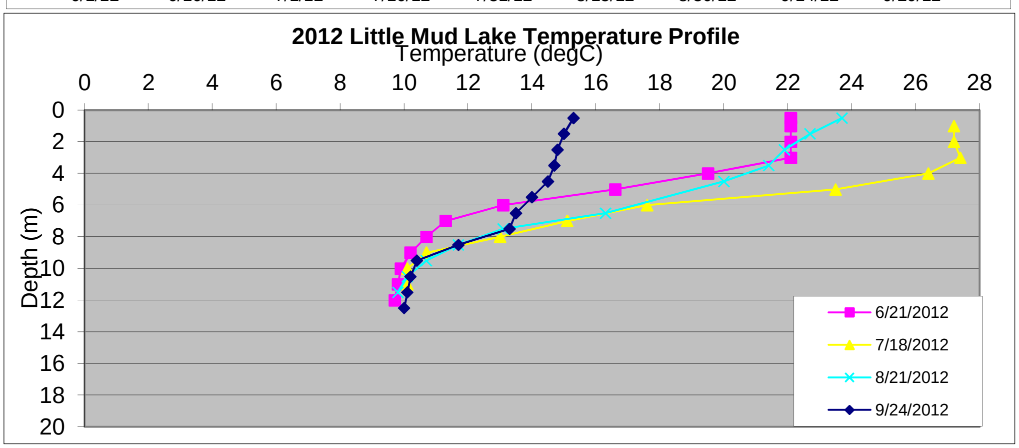
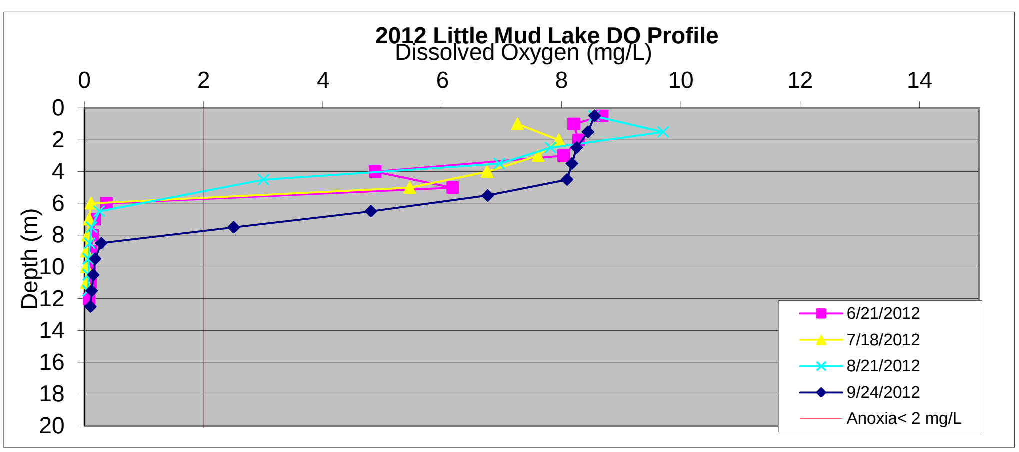
Appendix G-Lake Phosphorus
and Profile Data









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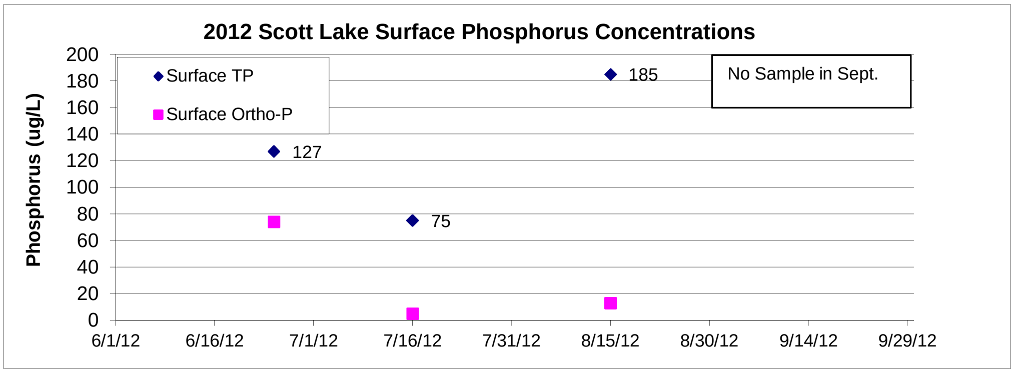
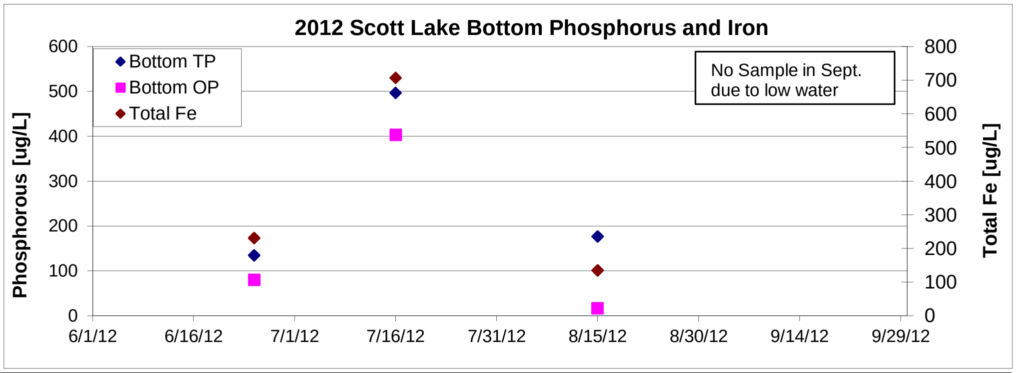
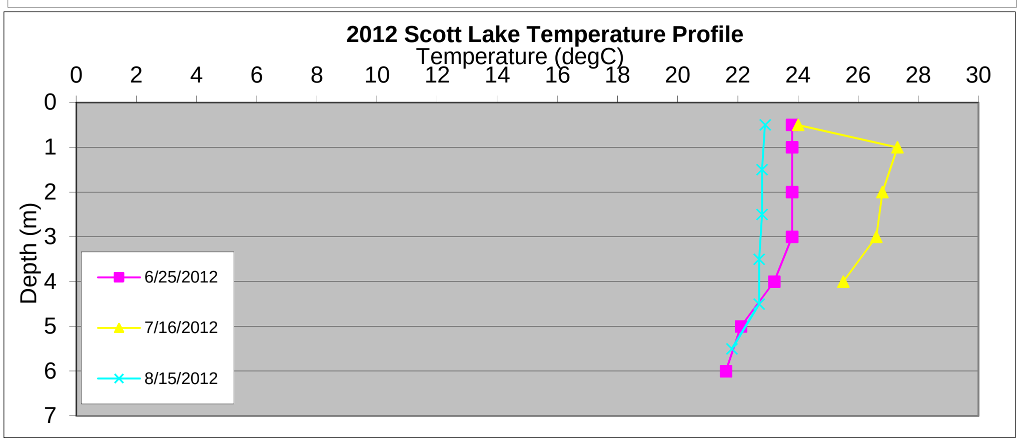
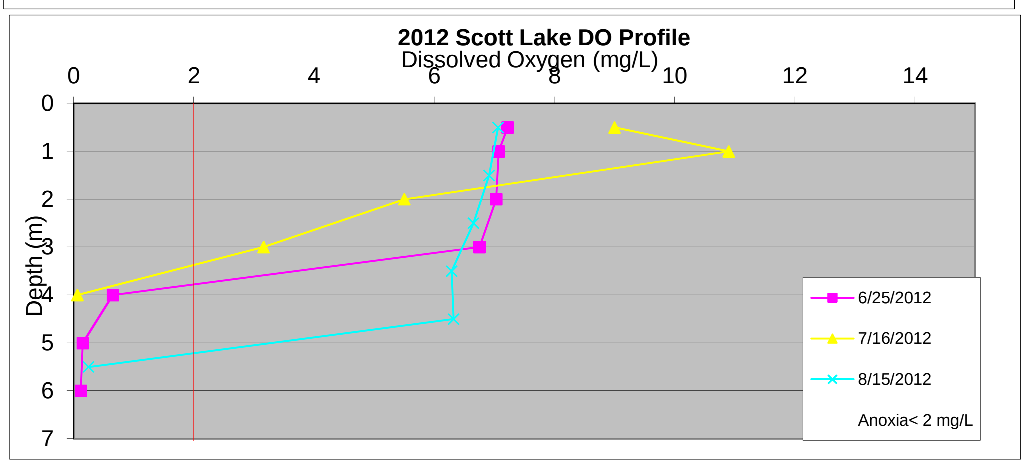
Appendix G-Lake Phosphorus
and Profile Data









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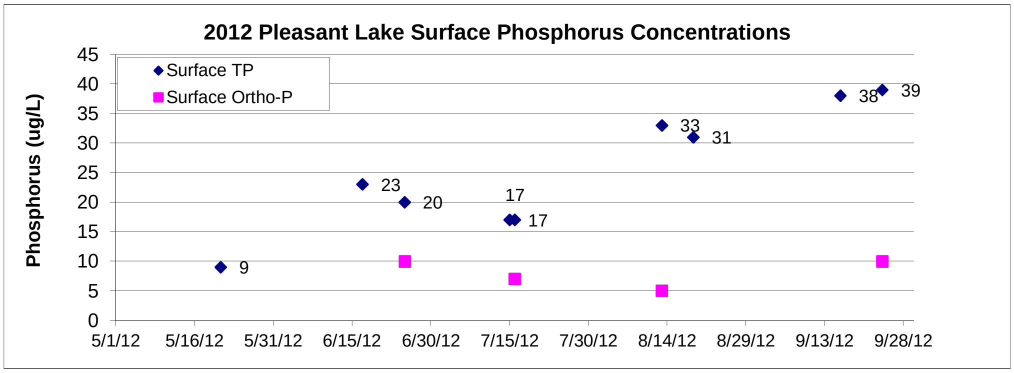
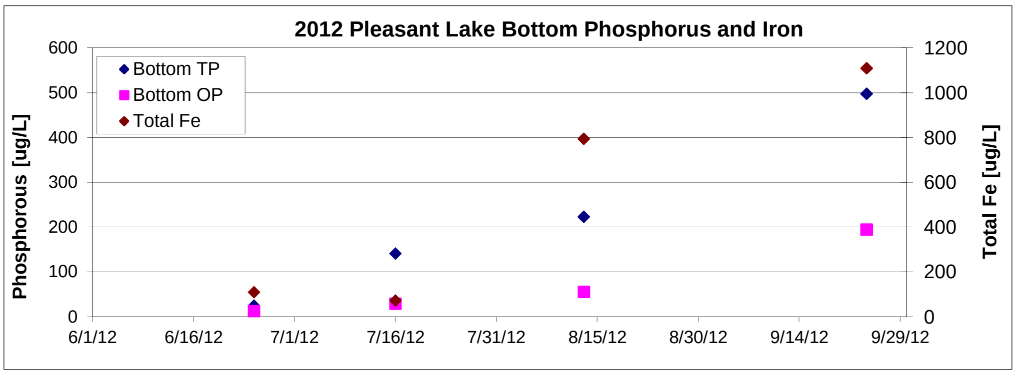
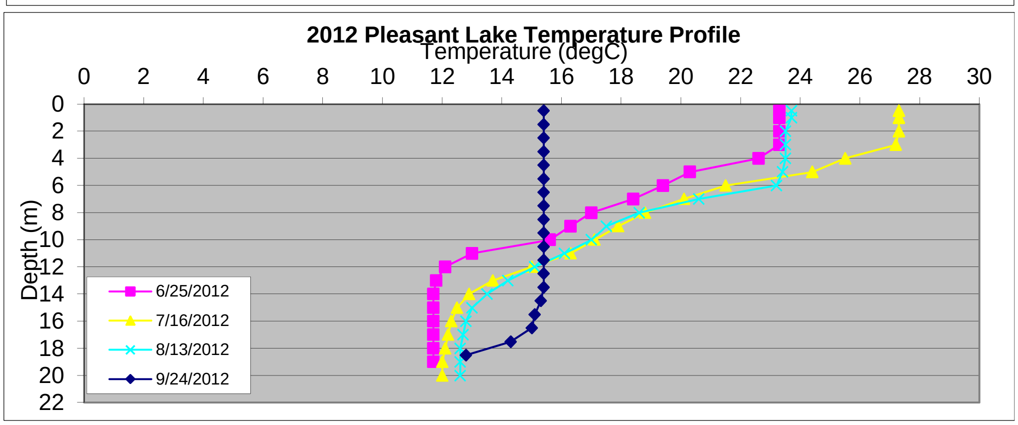
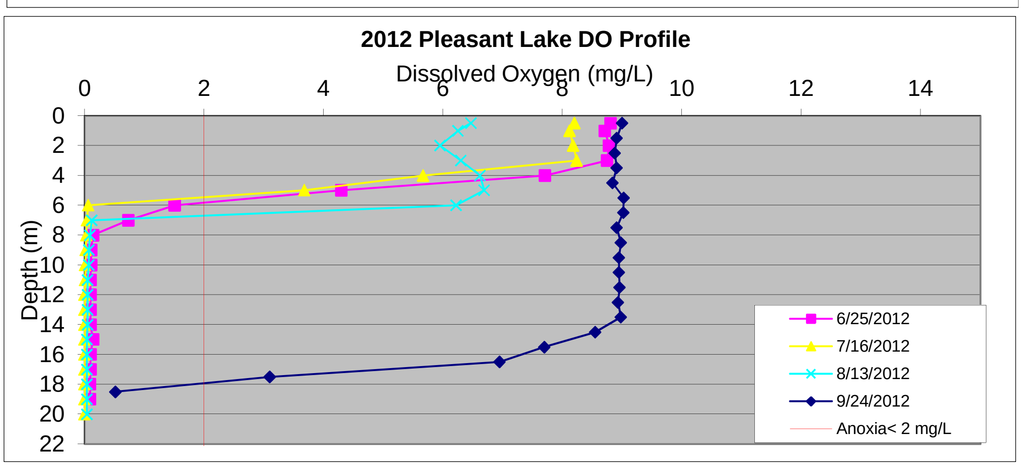
Appendix G-Lake Phosphorus
and Profile Data









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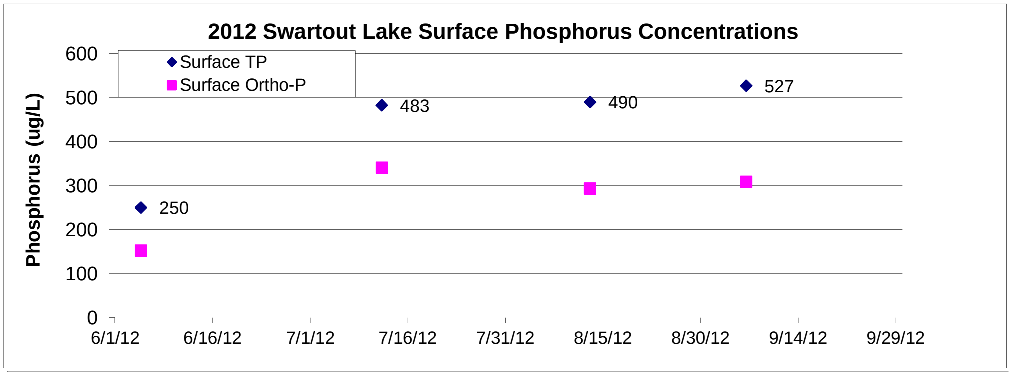
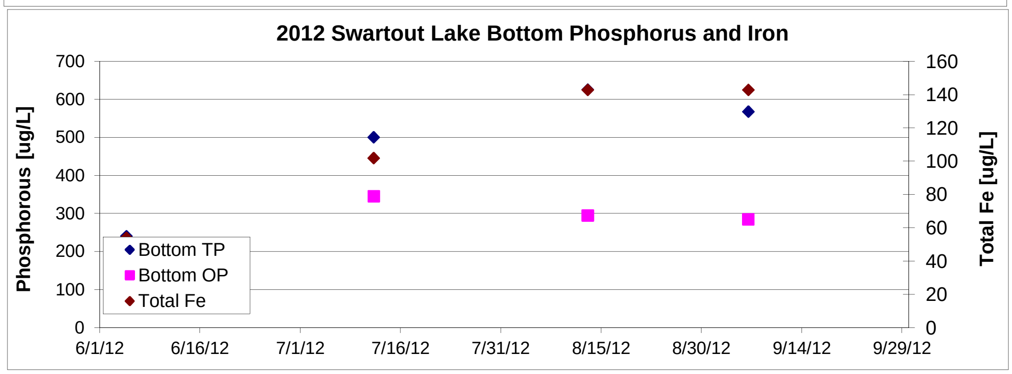
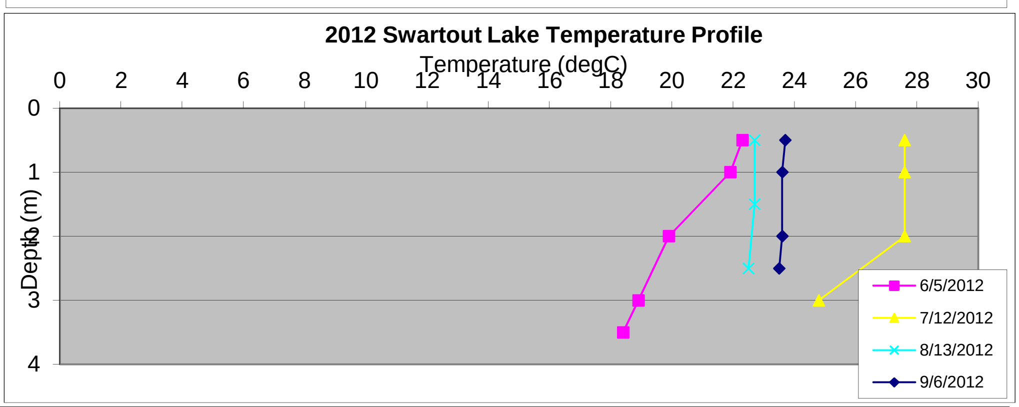
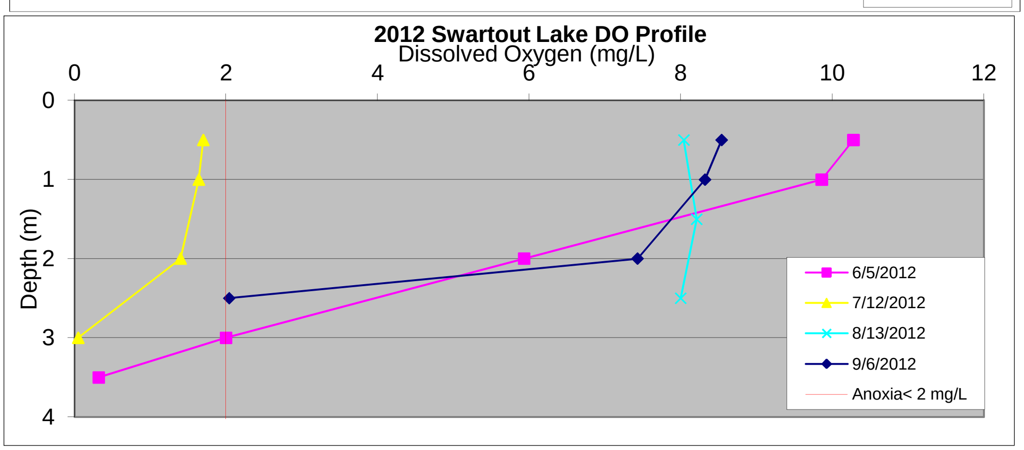
Appendix G-Lake Phosphorus and Profile Data









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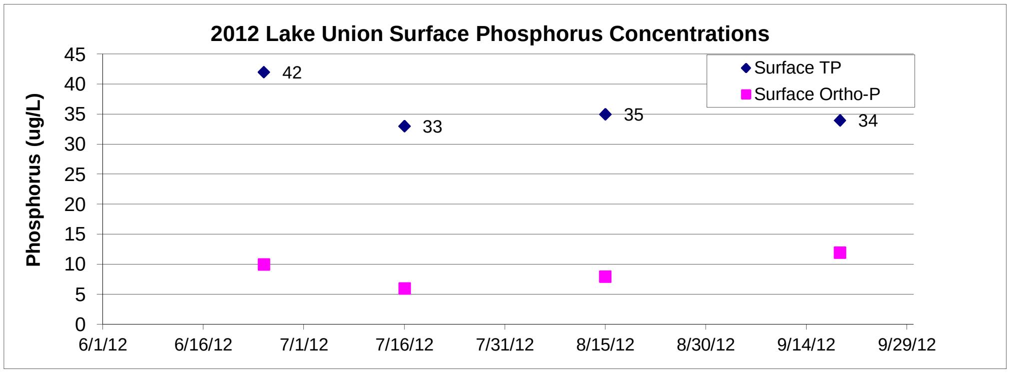
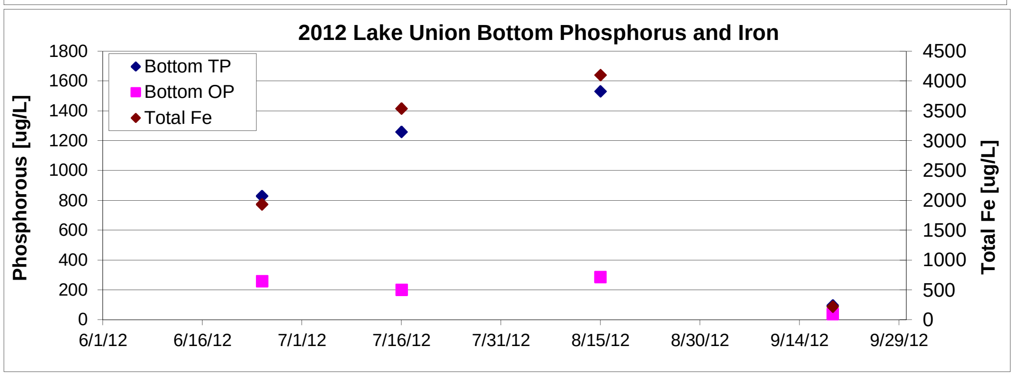
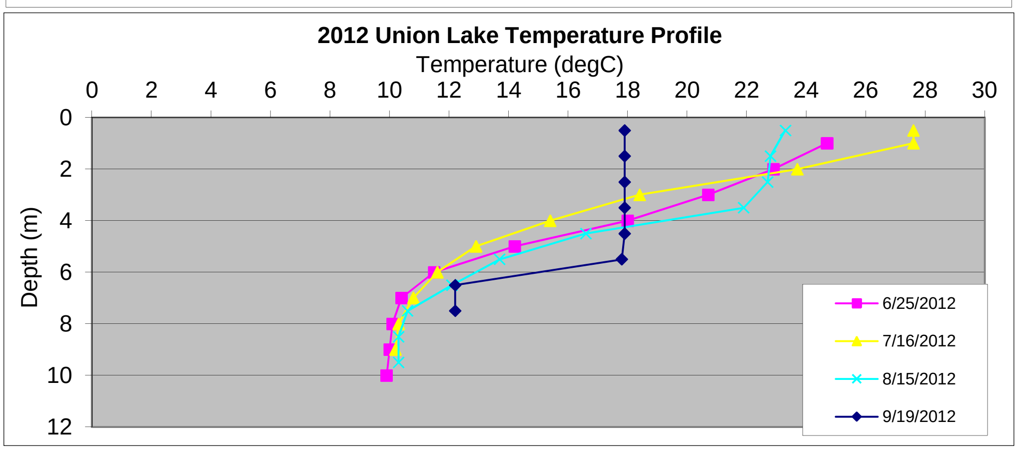
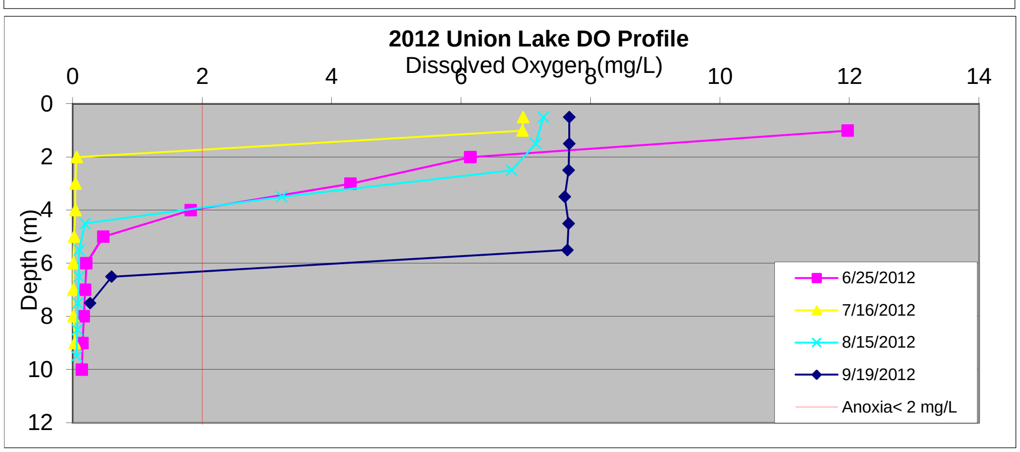
Appendix G-Lake Phosphorus
and Profile Data









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Appendix H

2012 Stream Phosphorus Concentrations

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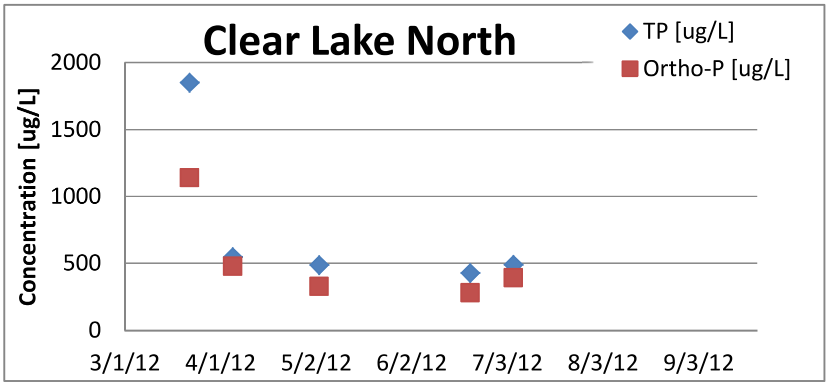

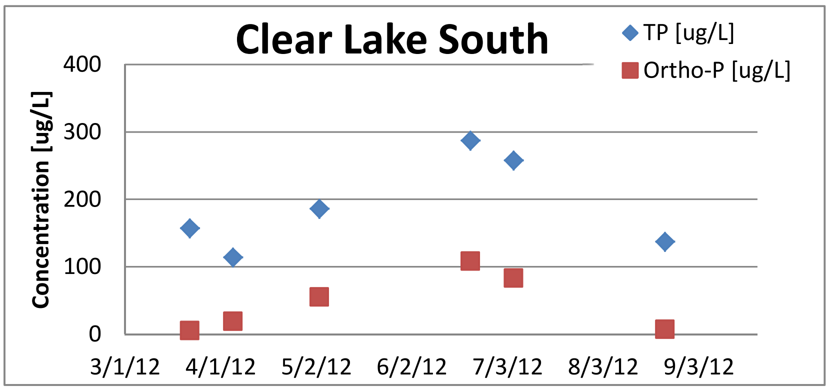

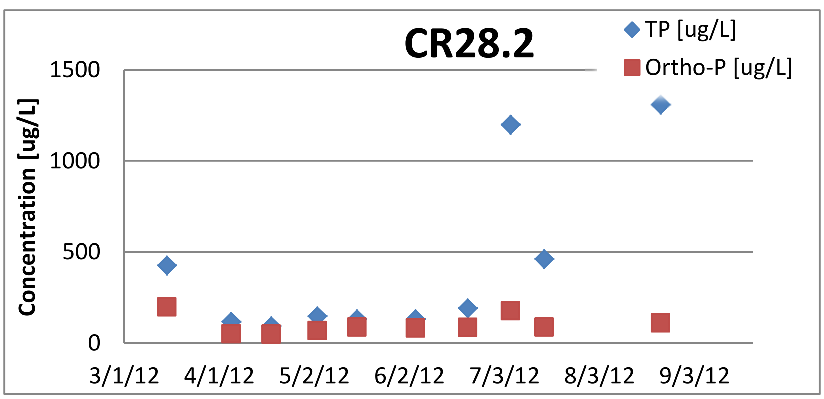

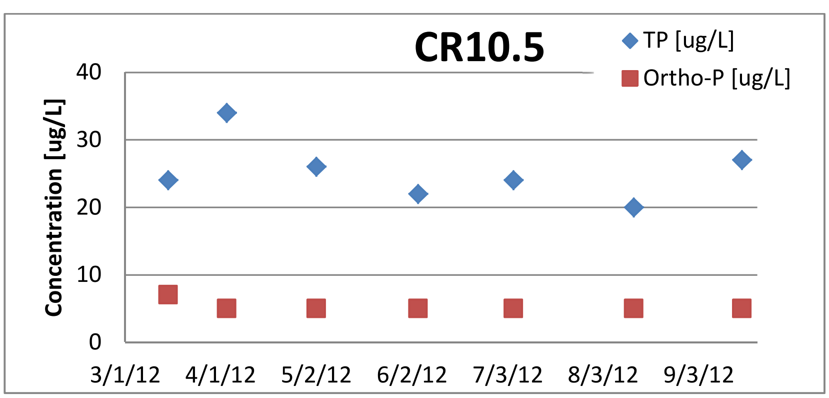

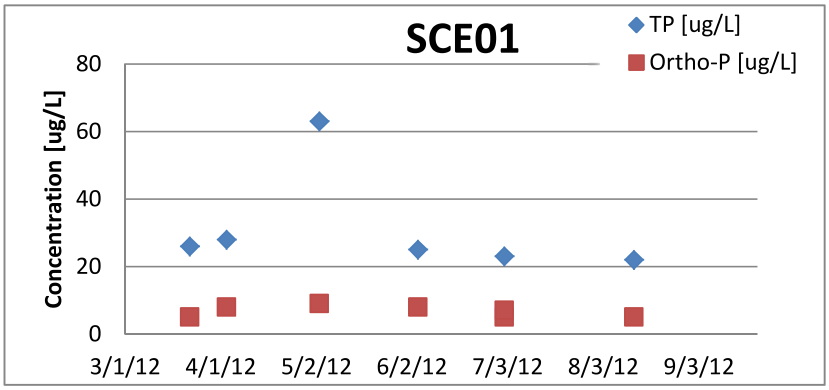
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Ortho-P [ug/L]
Concentration [ug/L]
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60
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7/3/12
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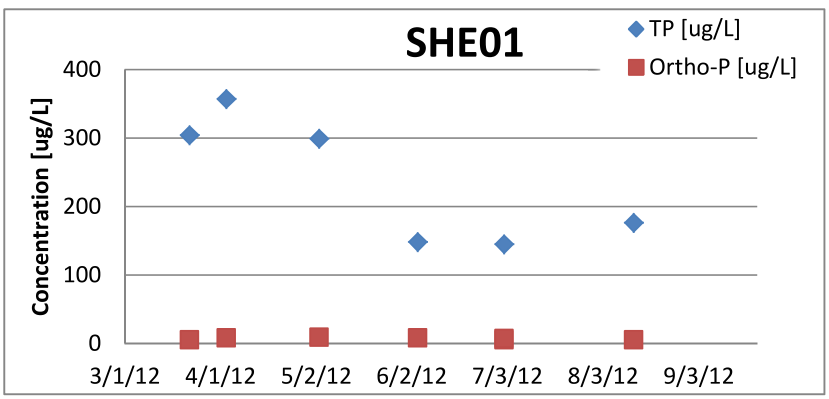
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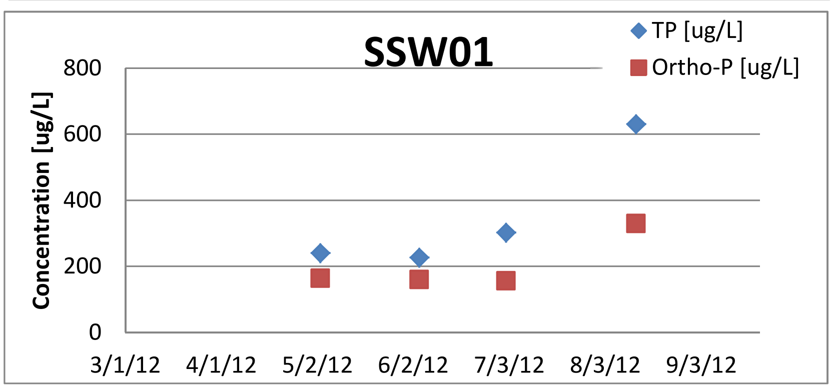
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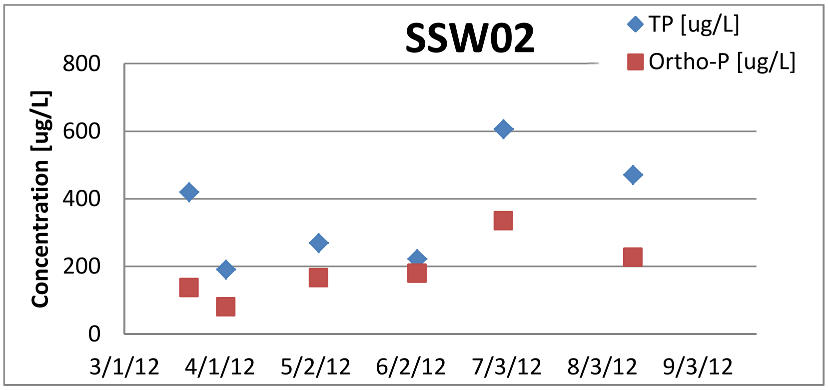
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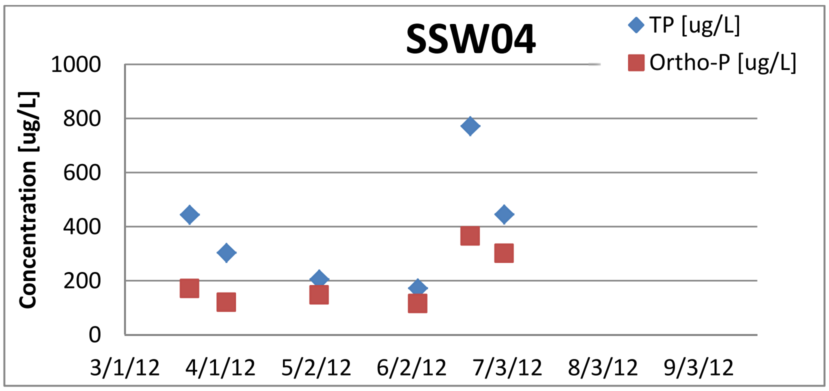
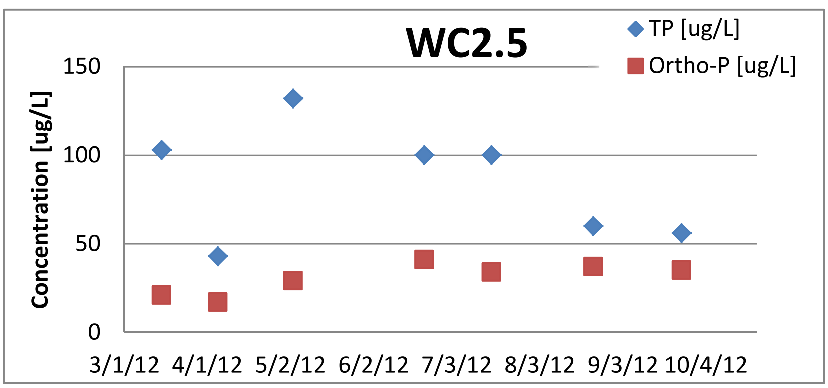
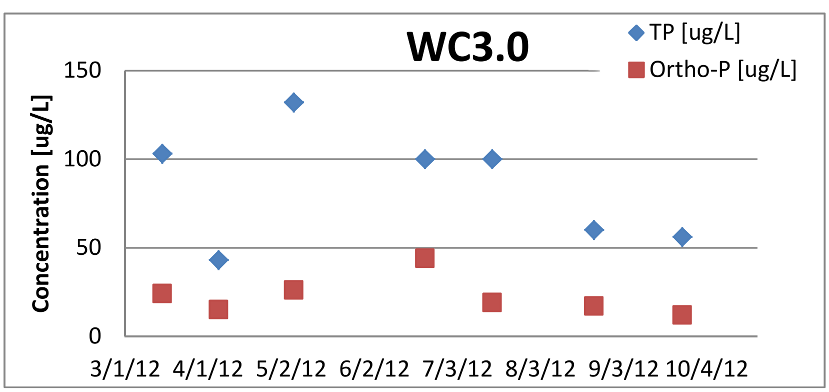
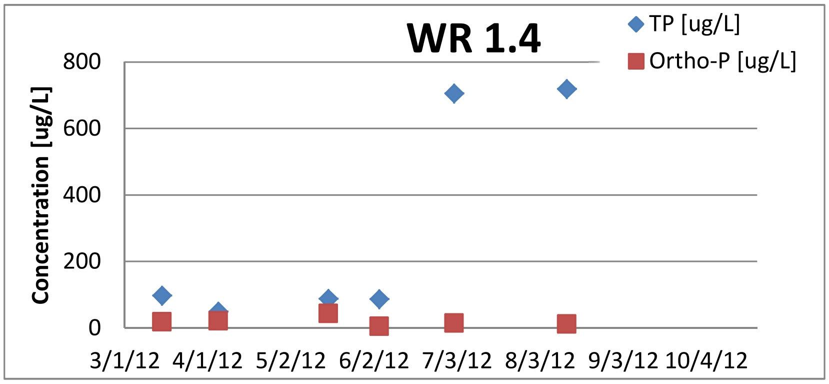
TP [ug/L]
Ortho-P [ug/L]
Concentration [ug/L]
800
600
400
200
0
3/1/12
4/1/12
5/2/12
6/2/12
7/3/12
8/3/12
9/3/12

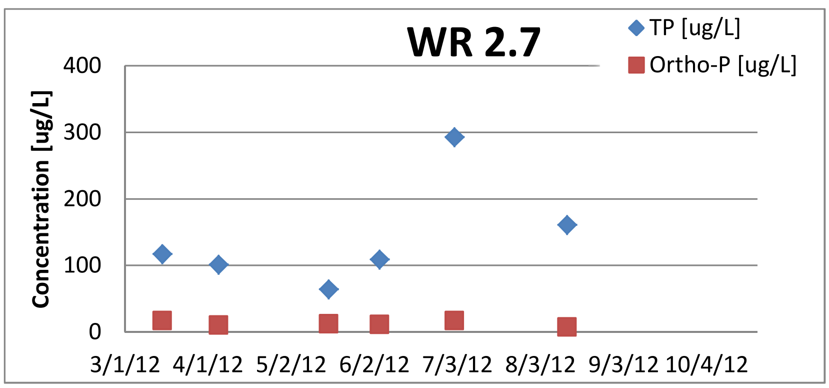

SSW04
TP [ug/L]
Ortho-P [ug/L]
Concentration [ug/L]
1000
800
600
400
200
0
3/1/12
4/1/12
5/2/12
6/2/12
7/3/12
8/3/12
9/3/12

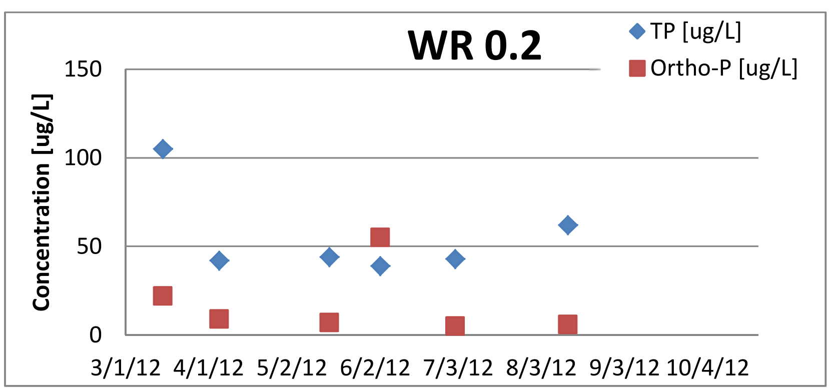

WC2.5
TP [ug/L]
Ortho-P [ug/L]
Concentration [ug/L]
150
100
50
0
3/1/12
4/1/12
5/2/12
6/2/12
7/3/12
8/3/12
9/3/12
10/4/12


WC3.0
TP [ug/L]
Ortho-P [ug/L]
Concentration [ug/L]
150
100
50
0
3/1/12
4/1/12
5/2/12
6/2/12
7/3/12
8/3/12
9/3/12
10/4/12

Clearwater River Watershed District
2012 Annual Report
Appendix H

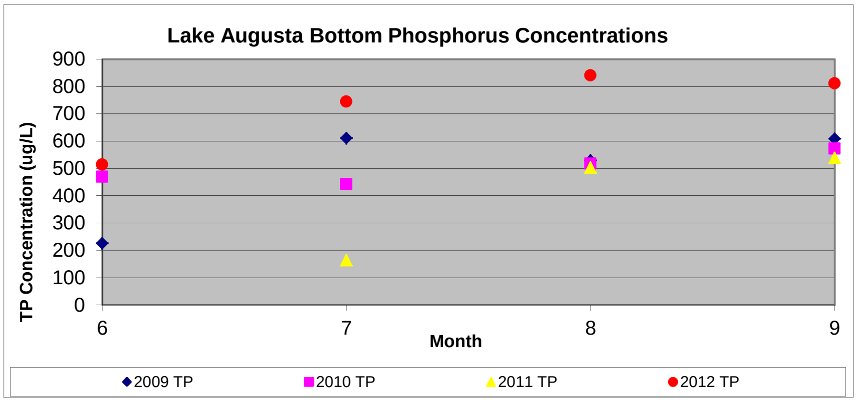


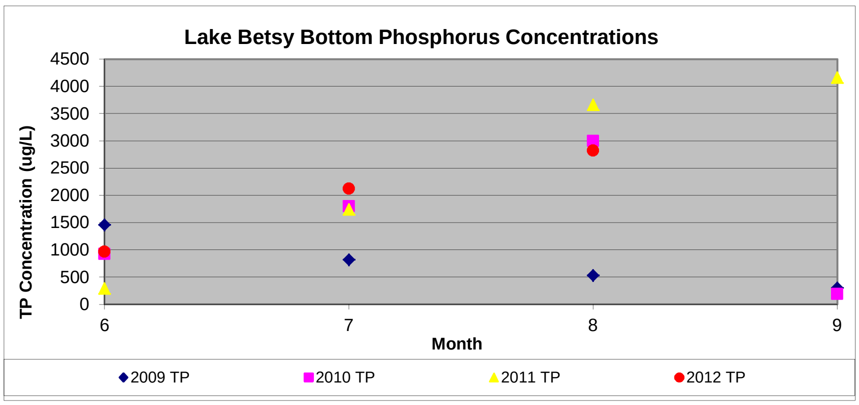


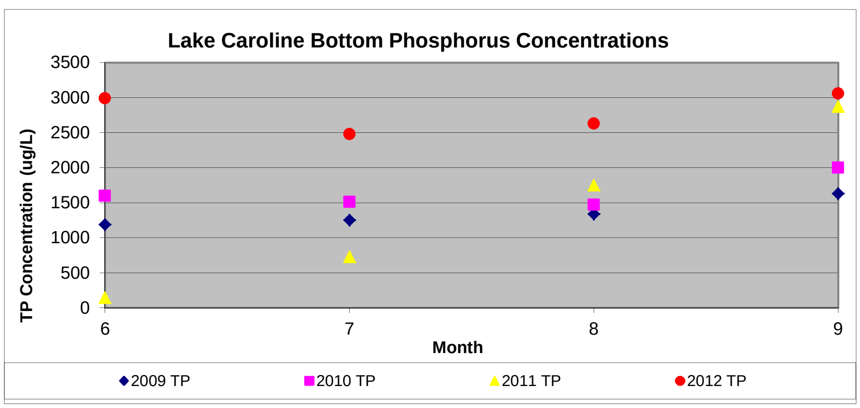


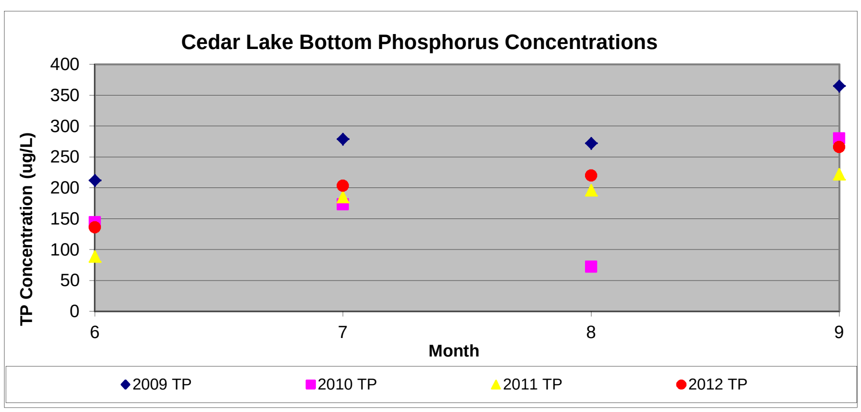
Appendix I

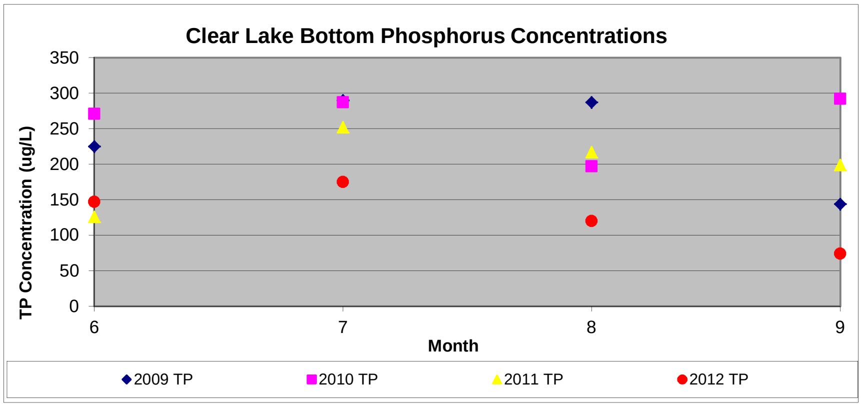
Lake Bottom Phosphorus Concentrations (2009-2012)

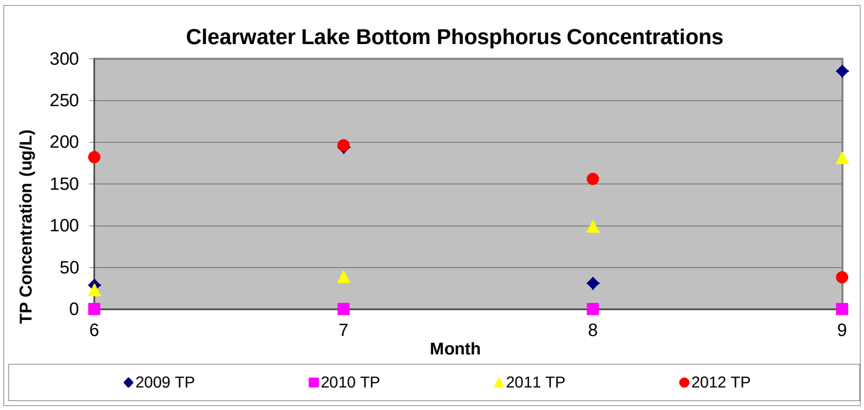

Lake Augusta Bottom Phosphorus Concentrations
TP Concentration (ug/L)
900
800
700
600
500
400
300
200
100
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

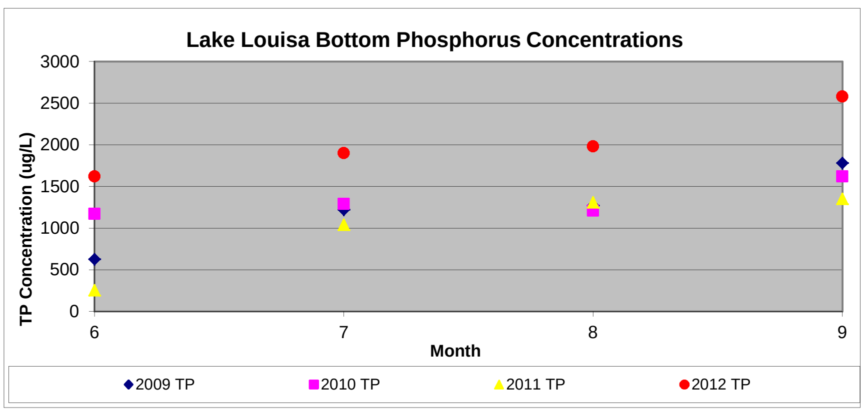

Lake Betsy Bottom Phosphorus Concentrations
TP Concentration (ug/L)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

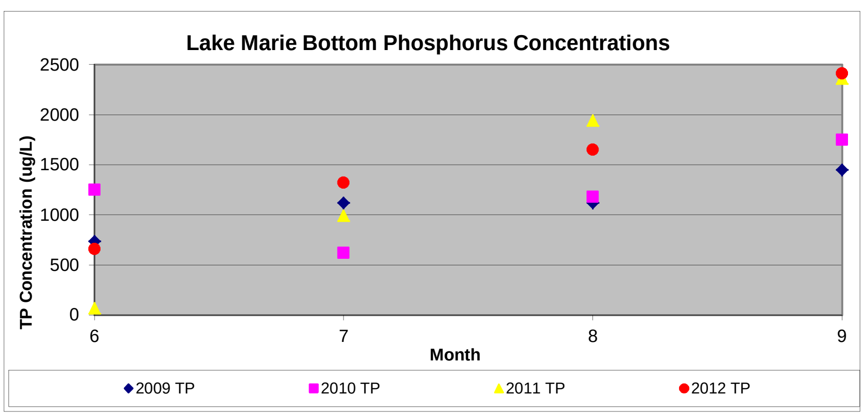

Lake Caroline Bottom Phosphorus Concentrations
TP Concentration (ug/L)
3500
3000
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

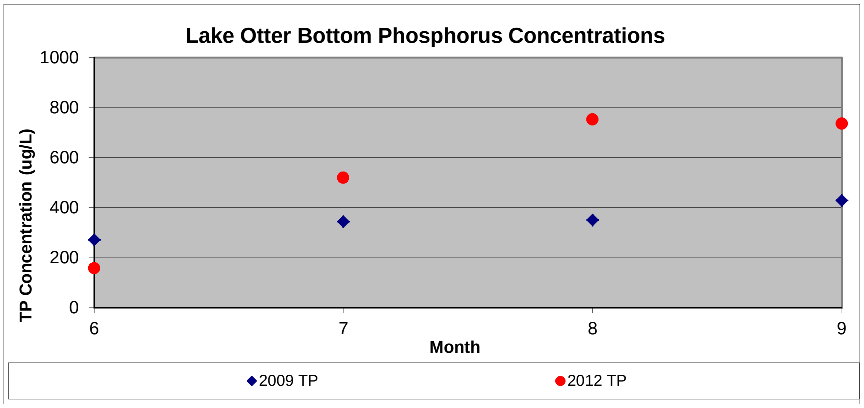

Cedar Lake Bottom Phosphorus Concentrations
TP Concentration (ug/L)
400
350
300
250
200
150
100
50
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

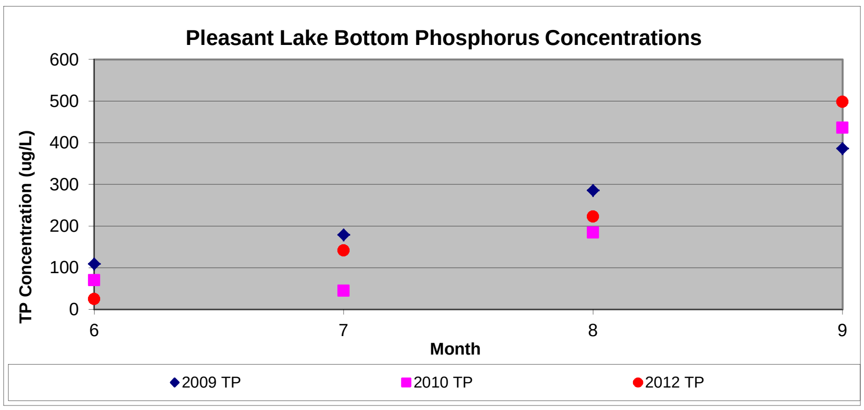

Clear Lake Bottom Phosphorus Concentrations
TP Concentration (ug/L)
350
300
250
200
150
100
50
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

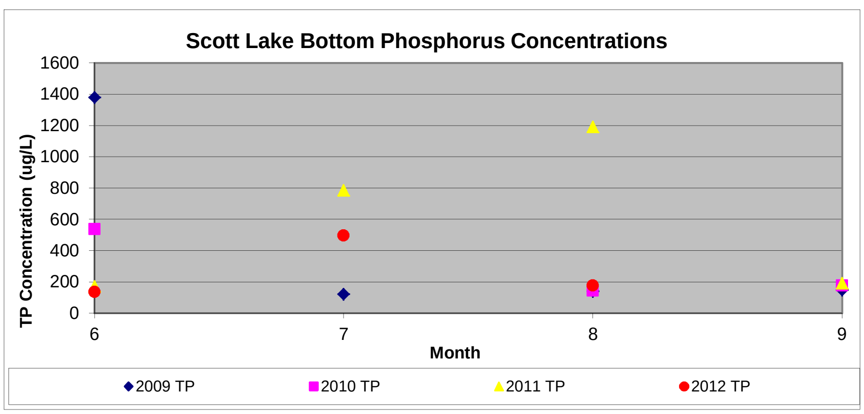

Clearwater Lake Bottom Phosphorus Concentrations
TP Concentration (ug/L)
300
250
200
150
100
50
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

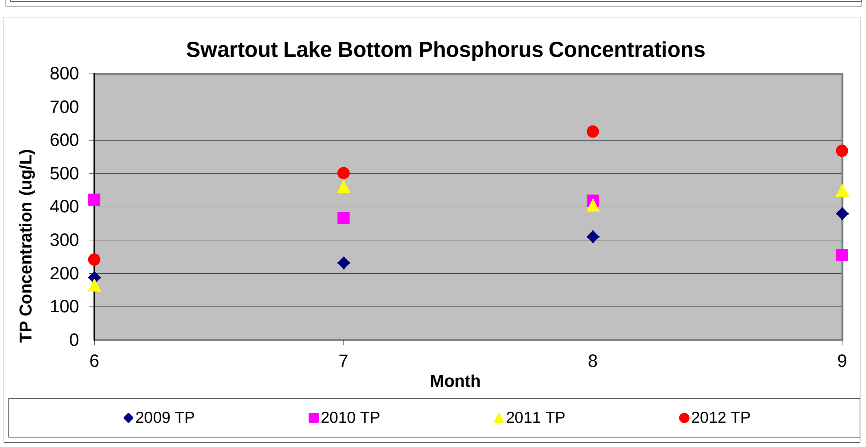

Lake Louisa Bottom Phosphorus Concentrations
TP Concentration (ug/L)
3000
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP

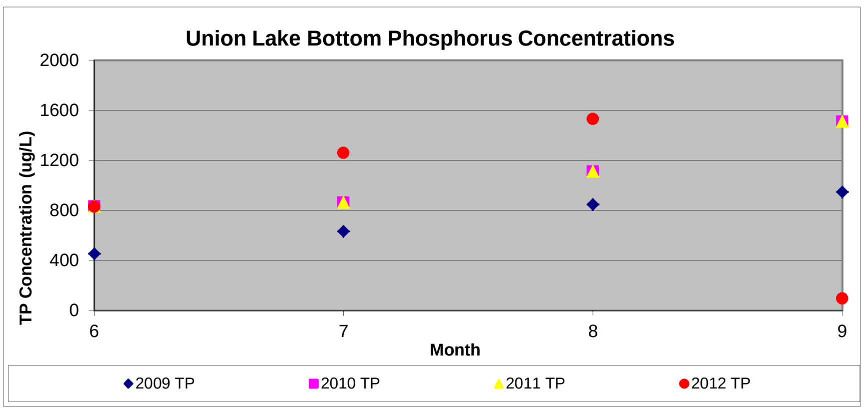

Lake Marie Bottom Phosphorus Concentrations
TP Concentration (ug/L)
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP


Lake Otter Bottom Phosphorus Concentrations
1000
800
600
400
200
0
TP Concentration (ug/L)
6
7
8
9
Month
2009 TP
2012 TP


Pleasant Lake Bottom Phosphorus Concentrations
600
500
400
300
200
100
0
TP Concentration (ug/L)
6
7
8
9
Month
2009 TP
2010 TP
2012 TP


Scott Lake Bottom Phosphorus Concentrations
1600
1400
1200
1000
800
600
400
200
0
TP Concentration (ug/L)
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP


Swartout Lake Bottom Phosphorus Concentrations
800
700
600
500
400
300
200
100
0
TP Concentration (ug/L)
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP


Union Lake Bottom Phosphorus Concentrations
2000
1600
1200
800
400
0
TP Concentration (ug/L)
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP