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2014 Water Quality Monitoring and Watershed Management Plan Implementation Status Report

Clearwater River
WATERSHED DISTRICT

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 progress report of Watershed Management Plan Implementation activities in the District. The report summarizes 2014 hydrologic, hydraulic and water quality monitoring data and provides an analysis of progress towards goals in the context of the District's watershed management activities.

In 2014, the CRWD made progress towards goals established in the Watershed Management Plan by doing the following:

- Completed design and permitting of two projects to protect and improve water quality in the Cedar Lake sub-watershed; the District will construct both projects in early 2015. Both projects are funded through grants and property taxes on benefited property owners.
- Conducted ongoing monitoring of the Kingston Wetland Restoration Project constructed in 2013; this monitoring was planned for and funded through a Federal 319 grant and is required by the DNR permit for the project. Monitoring continues to show the project has improved dissolved oxygen (DO) concentrations so that the river now meets the State of Minnesota DO standard. Data also shows a reduction in the export of soluble reactive phosphorus from Kingston Wetland to lakes downstream. Maintenance of the sediment trap forebay is planned for early 2015. Final reporting will be completed this summer.
- Continued work on previously implemented projects, including:
  - Most of the construction of the Phase II Kimball Stormwater Project was complete in 2014. The remaining construction will be completed in 2015.
  - Enrolled participants, conducted gridded soil testing and GPS aided fertilizer application, and monitored the Targeted Fertilizer Application Project in the upper watershed which is funded in part by a federal 319 grant,
- Continued project development towards securing grant funding to implement projects identified in Districts Comprehensive Plan. CRWD applied for three major grants in 2014:
  - Round 2 of BWSR's Targeted Watershed Demonstration Grant for District-wide implementation.
  - An LCCMR grant for Lake Betsy internal load management.
  - A Clean Water Legacy Grant for the Watkins Area Stormwater Treatment Project.
- Continued targeted implementation of agricultural cost share BMPs- high priority locations for implementation were identified through the TMDL study.
- Continued to implement rough fish management (removal and migration barriers).
- Completed a feasibility study on internal load management in Lake Betsy. The study evaluated the different technologies available and estimated costs. The lowest cost alternative is whole-lake alum treatment, though hypolimnetic withdrawal provides other benefits and a higher level of certainty to reduce internal loads for a longer period of time.
- Participated in completion of the Upper Mississippi TMDL/ WRAPS Project.
- Implemented 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.

Continued Aquatic Invasive Species (AIS) work with lake associations as initiated by the lake associations.

In 2015, the CRWD plans to continue progress towards Watershed Management Plan and TMDL goals by:

Continuing to monitor water quality, hydrology and hydraulics to track water quality trends and the effectiveness of existing management strategies. These actions help to improve efficiencies of implementation projects.

Conducting rough fish removal and migration management as necessary.

Continuing to implement the Targeted Fertilizer Application Project by enrolling landowners and continuing follow-up monitoring.

Continuing to monitor the Kingston Wetland Restoration Project.

Finalizing construction of the Kimball Phase II Project.

Constructing the Cedar Lake Watershed Protection & Improvement Project.

Identifying additional projects and continuing to apply for grant dollars to fund other CRWD projects.

Continuing education and outreach efforts, expanding focus to include social media and schools.

Significant hydrologic, hydraulic and water quality findings in this report include the following:

1. Overall, annual precipitation and runoff was above normal at monitored locations for the year in 2014. Precipitation ranged from 28.48 inches in Annandale to 36.71 inches in St. Cloud. Runoff near the watershed outlet was slightly above average at 8.1 inches (compared to 7.9 inches in an average year).
2. Phosphorus loads from the Clearwater River are stable to declining, but still above water quality target loads: 4,009 lbs at the Grass Lake Dam and 8,227 lbs upstream of Lake Betsy.
3. Lake water quality is stable to improving in all but three CRWD lakes (although Lake Caroline, Clear Lake and Scott Lake have experienced recent increasing trends). Lake Betsy is a bright spot in the watershed. Water quality in this lake (located in the high priority target watershed for implementation) has improved dramatically since implementation activities began in 2009.

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 long term water quality and hydrologic trends. In 2009, the annual report in which these data were published was expanded to include tracking CRWD progress towards water quality goals in terms of program/ project implementation. This allows the CRWD to optimize costs and benefits of protection and restoration of natural resources within the District.

1.1 MONITORING & REPORT OBJECTIVES

The objectives of the Water Quality Monitoring and Watershed Management Plan Implementation Status program are:

1. Track progress towards water quality goals for impaired waters by:
    a) Measuring water quality trends in lakes and streams and pollutant loads
    b) Tracking programs and projects implemented
    c) Evaluating water quality in the context of programs/ projects implemented
2. Fill data gaps identified in the TMDLs
3. Continue to provide baseline water quality data and calibration data sets to refine TMDL load reductions
4. Track long-term trends in all CRWD waters monitored ensuring early detection of declining trends
5. Provide recommendations for ongoing programs, projects and watershed management strategies based on data

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 are largely the result of the CRWD's 1980 Chain of Lakes Restoration Project and other more recent CRWD 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. Through the study, the District also prioritized implementation areas to maximize cost/ benefit. 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 Elk River watershed (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 was scheduled to be completed in 2013, and is nearing final approval. It was 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

Water	Impairment and Impaired Use	TMDL Status	Listing Date
Lake Albion (86-0212)			2010
Henshaw Lake (86-0213)			2010
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)		Listed in 2012.
Clearwater River (Clearwater Lake to Mississippi River)	Aquatic Life (Fish)		Listed in 2012.
Fairhaven Creek (Headwaters to Lake Louisa)	*E. coli* bacteria		Listed in 2012.

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 2 of this report.

1.4 CURRENT MONITORING

The 2014 CRWD monitoring plan is found in Appendix A, and summarized below. Figure 1-2 shows locations that were monitored in 2014. Figure 1-3 shows locations of impaired water bodies in the CRWD.

Figure 1-1: Geographic Coverage of 8-Digit HUC Watershed TMDL Currently Underway

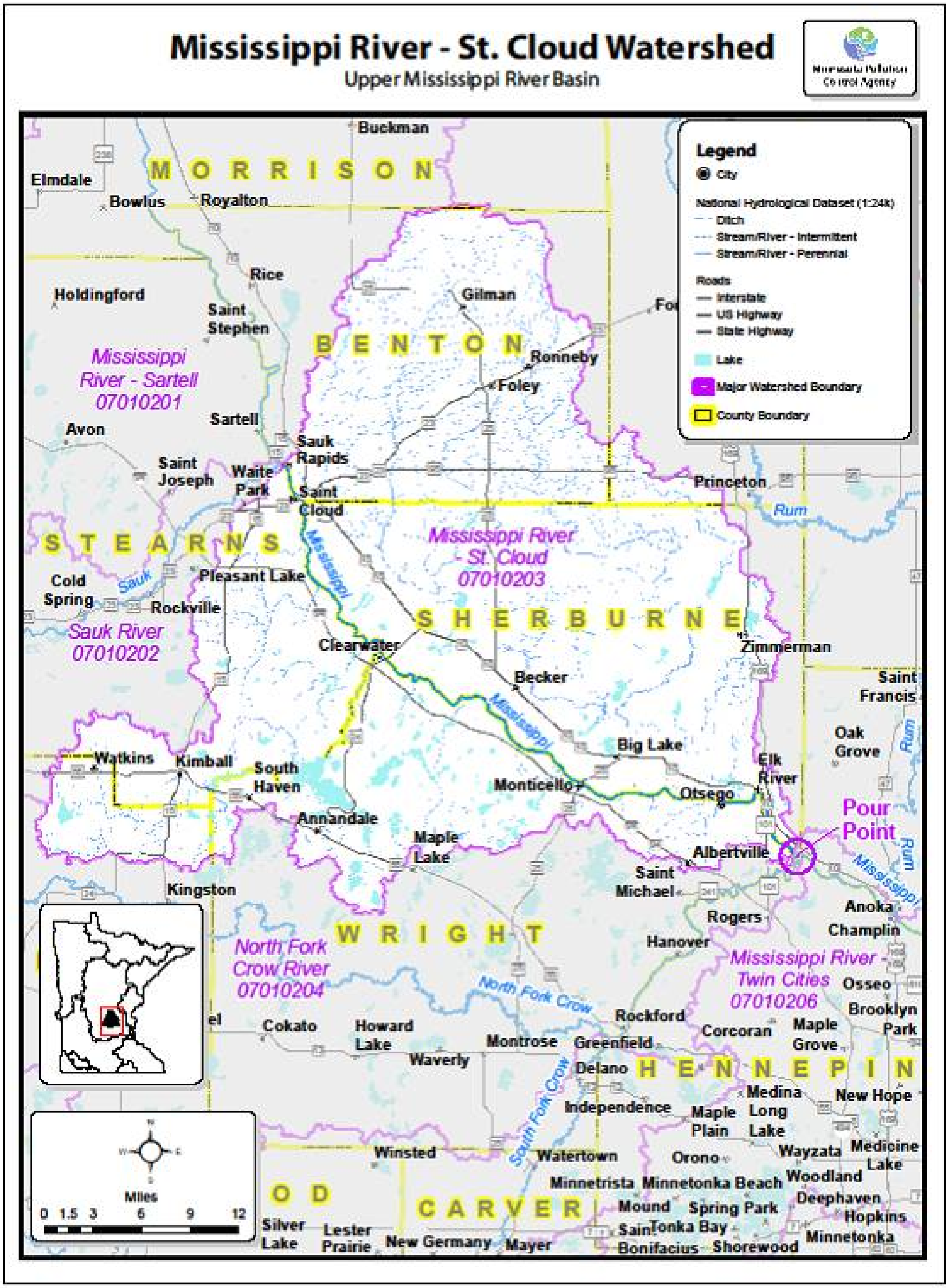


Figure 1-2: 2014 Monitoring Locations

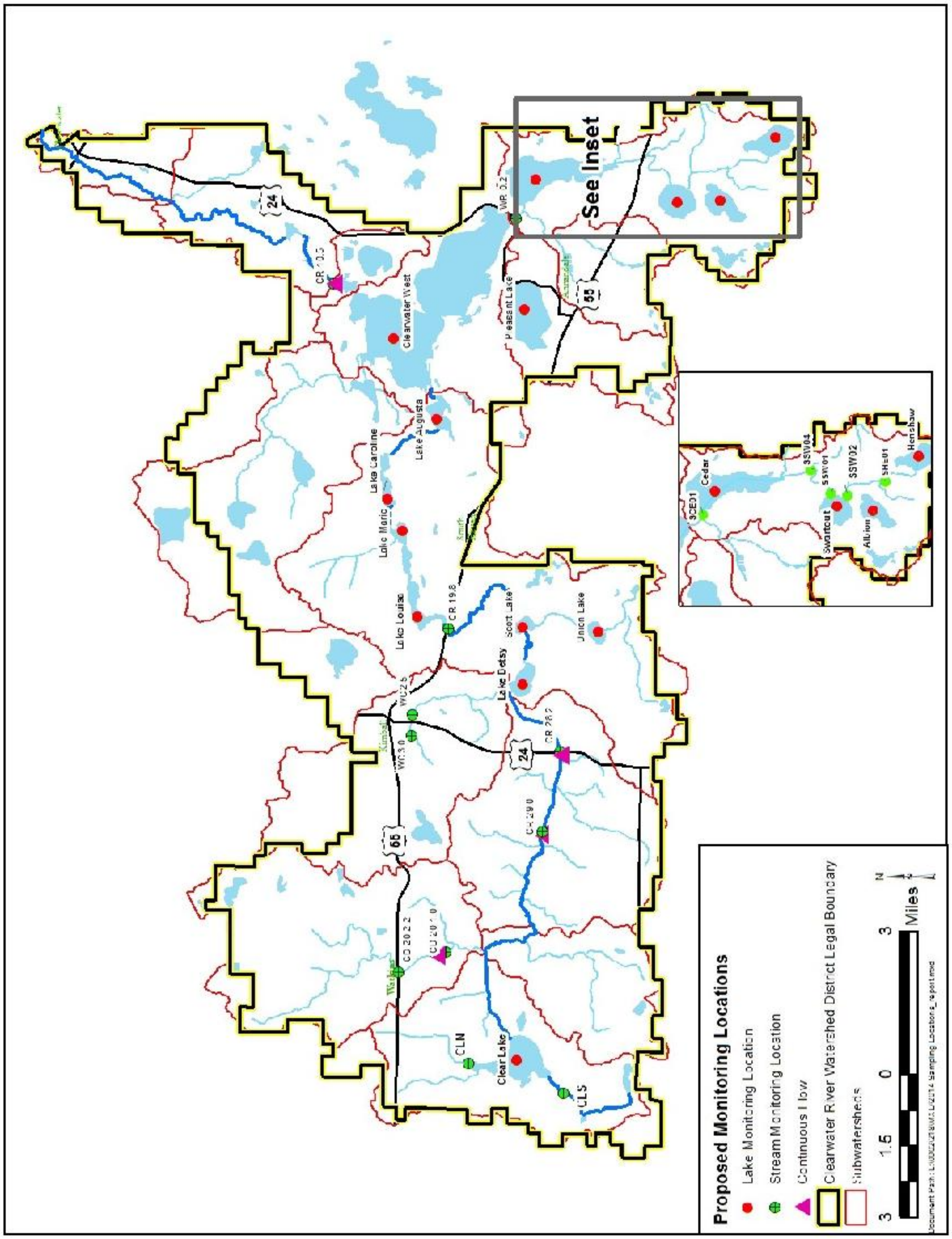
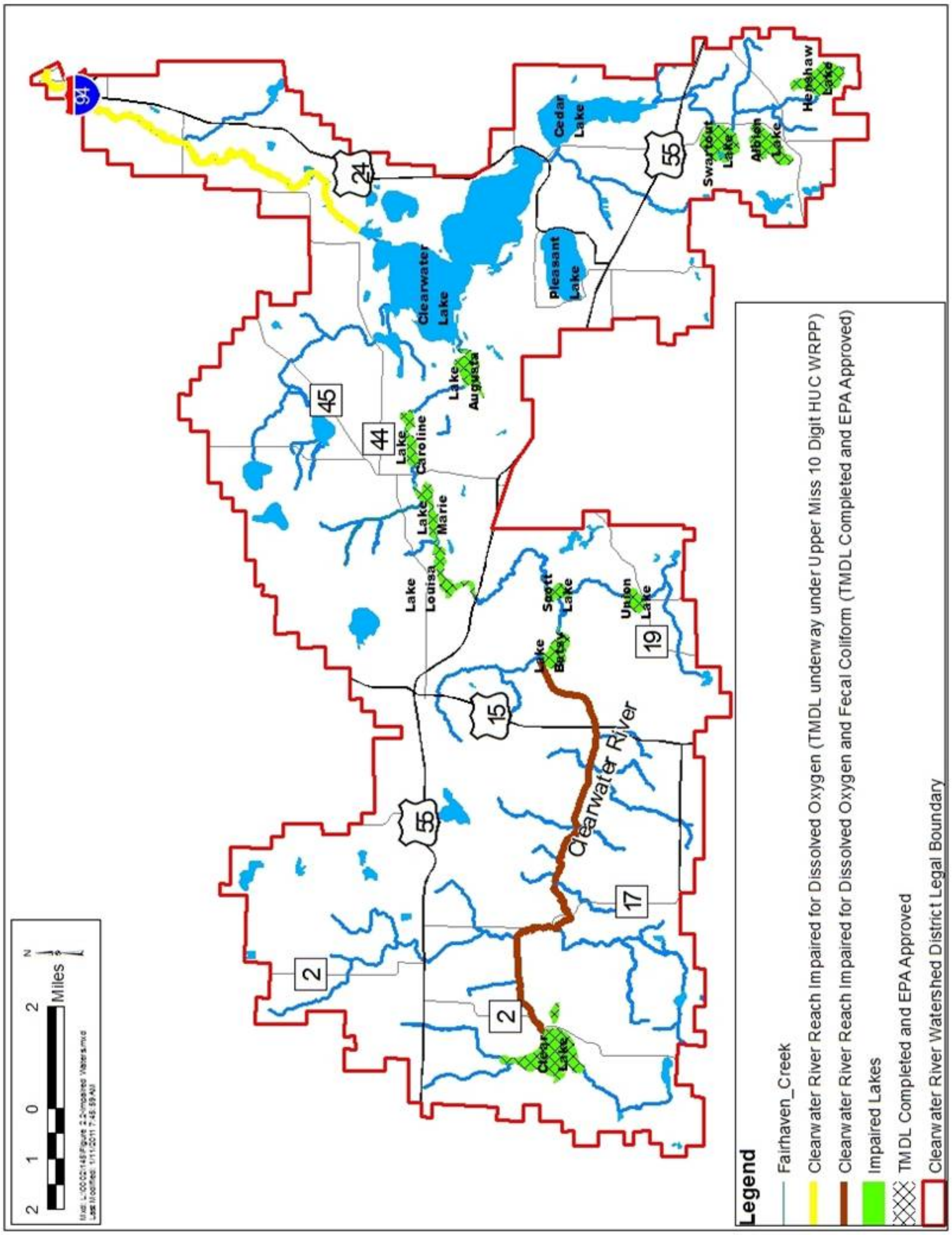


Figure 1-3: Impaired Water Bodies in CRWD



2.0 Progress Towards Water Quality Goals

The CRWD 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, water quality in upper watershed lakes like Clear Lake and Lake Betsy is the primary driver of water quality in downstream lakes like Clearwater Lake. Nutrient loads from 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 achieved for the lowest cost by initially focusing the efforts on improvements in the upstream end of the District and working downstream.

2.1 PROCESS

The CRWD Plan is specific in its focus: implement the identified projects and programs in high priority geographical areas. The District makes annual adjustments to further focus and refine management activities. The Board and staff review this report, and compare findings to the Watershed Management Plan then prioritize projects and programs. They typically select 1-3 projects and programs to focus on in the coming year. The annual planning is based on remaining programs and projects identified in the Plan, water quality monitoring findings as well as other opportunistic projects identified during the year. This on-going strategic planning keeps the CRWD focused and efficient.

2.2 SUMMARY

The following section summarizes year by year strategy as well as programs and projects undertaken since the plan was adopted:

2009

- Prioritized 6 projects from the overall TMDL Implementation Plan
    - City of Kimball Stormwater Retrofit
    - Lake Betsy Internal Load Management
    - Watkins treatment area
    - Targeted Fertilizer Application Project
    - Kingston Wetland Restoration
    - Clear Lake South Sand Filter/ Weir
- Applied for grants for each of prioritized projects, received grant for Kimball stormwater (Kimball Stormwater would eventually be broken into 2 phases, grant for Phase I was received in 2009)
- Implemented agricultural BMPs identified in the TMDL Implementation Plan in upper watershed
- Conducted additional monitoring, including collection of lake bottom samples and sediment phosphorus release analysis in Clear and Betsy Lakes

- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.

2010

- Applied for received grant for Kingston Wetland Restoration and Targeted Fertilizer Application Project
- Applied for Watkins Area Restoration Grant and Lake Betsy Internal Load, grants not funded
- Applied for and received CCM funding for streambank restoration.
- 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
- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- Implemented Fertilizer Field Trial Project

2011

- Constructed Kimball Stormwater Project (now known as Phase I)
- Applied for and secured a grant for Kimball Stormwater Phase II
- Implemented BMPs identified in the TMDL Implementation Plan
- Applied for and received CCM funding for streambank restoration.
- 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.
- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- Implemented Fertilizer Field Trial Project

2012

- Applied for and secured funding for 1 grant for two projects in the Cedar Lake Subwatershed:
  - Highway 55 project
  - Swartout Wetland Project
- Completed Clear Lake South Sand Filter/ Weir
- Implemented BMPs identified in the TMDL Implementation Plan
- Applied for and received CCM funding for streambank restoration.
- 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.
- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- Implemented Targeted Fertilizer Project

2013

- Advanced implementation for priority projects
  - Completed design of Kimball Phase II stormwater retrofit; worked to complete permitting
  - Further developed feasibility for Betsy Lake Internal Load Management
  - Feasibility study of Lake Augusta Internal Load management options

  - Lake Augusta AIS Project
- Applied for and received CCM funding for streambank restoration.
- Secured funding for 20 CCM crew hours for stream bank stabilization for 2014.
- 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.
- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- Began Kingston Wetland Restoration Project
- Implemented Targeted Fertilizer Project

2014

- Advanced implementation for priority projects
  - Completed 90% of construction for Kimball Phase II stormwater retrofit
  - Conducted Feasibility Study Betsy Lake Internal Load Management
  - Completed design and permitting for two Cedar Lake projects, construction to begin early in 2015
  - Continued implementation of Targeted Fertilizer Application Program, early reports from Co-Ops indicate enrollment is approaching goals
- The Targeted Fertilizer Application Program was Awarded
  - Minnesota Association of Watershed District Program of the Year
  - Environmental Initiative Natural Resources Award
- Applied for both rounds of BWSR's Targeted Watershed Implementation Funding to complete the plan implementation, CRWD was not selected for either grant.
- Applied for a Clean Water Legacy (CWL) grant for the Watkins Project
- Applied for 319 funds for the Alternative Tile Intake Demonstration Program
- Measured and recorded positive results of the Kingston Wetland Restoration Project including reduced soluble phosphorus export from the wetland and improved dissolved oxygen concentrations downstream
- 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.
- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.

The CRWD has implemented several major projects to achieve water quality goals; status is shown in Table 2-1.

Table 2-1: Priority Implementation Projects

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
Projects Recently Completed			
Cedar Lake Restoration (06-	1,500 lbs/yr	$295,000	Project completed, currently in project maintenance phase

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
01 Original)			
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 and 2013.
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. Monitoring conducted in 2013.
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 between 2011 and 2013.
Projects In Progress			
Cedar Lake Watershed Protection and Improvement Projects (06-01-Modified)	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/iron 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).
City of Kimball Stormwater Reclamation and Reuse (Phase II)	118	$738,000	Secured grant funds in 2011. Completed design and permitting for project in 2013. Construction 90% complete in 2014. Construction will be completed in 2015. Signage and education and outreach are planned.
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, modeling, and design were completed in 2012. The project was constructed in 2013 and monitoring was conducted to measure the success of the project. Results indicate improvement in indices of biotic integrity (IBI) and water quality throughout the

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
			reach and downstream.
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. 8,841 acres enrolled through 2013. Monitoring was conducted on tile outlets and tributary streams and ditches in the project area. Application of this program is recommended for expansion to the remainder of the watershed.
Planned Projects			
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 in 2009 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 in 2014.
Expand Education Program	NA		Incorporated in grant funded scopes of work are efforts to expand the CRWD's Education/ Outreach programs. The CRWD currently has a strong relationship with Lake Associations and hosts educational events that primarily target adults. The education program will be expanded to include social media outreach as well as school age children in the community.
Lake Betsy Internal Load	1,300 – 6,500 lbs	$250,000-$600,000	Grant applications were most recently denied in 2014. A feasibility study was conducted in 2014 to support project development.

2.3 RESULTS

2.3.1 Projects Completed

2.3.1.1 Cedar Lake Project 06-1 (Original)

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.

The District implemented several projects identified in the Engineer's Report (Wenck 2006) between 2007-2014. The District managed rough fish populations through winter seining and installation of five fish migration barriers to control access to rough fish spawning areas. CRWD constructed the Segner Pond treatment wetland and implemented watershed BMPs like tile inlet buffers and buffer strips in the high priority target areas.

Cedar Lake residents and the active Cedar Lake Conservation Club returned to the CRWD in 2011 to request the District apply for additional grant funding to install more capital projects. The District secured a Clean Water Legacy Grant to construct two additional projects and the original project was modified to include the Highway 55 filtration project and a Swartout Wetland Restoration. These projects are discussed in the following sections. The District project (O6-01) included water quality monitoring to track progress towards water quality goals. The monitoring and results are described in the following sections.

2.3.1.1.1 Monitoring

Cedar Lake, Swartout Lake, Albion Lake, and Henshaw Lake were monitored four times from June to September in 2014. Streams tributary to the lakes were also monitored while they were flowing at five locations in 2014. 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.

The District used Lowrance HDS sonar technology and ciBioBase to evaluate bottom composition, measure biomass, extent of aquatic vegetation and bathymetry in Swartout, Albion, and Henshaw Lakes in 2014. The District also conducted point intercept survey's to assess changes submergent vegetative cover for each lake.

Cedar Lake

Overall water quality appears to have stabilized or be slightly improving in Cedar Lake in recent years (Appendix C). Episodic algal blooms, while decreasing, still occur in the lake, especially early in the growing season. The Cedar Lake Conservation Club continues to track and treat the lakes curly leaf pondweed population.

Swartout Lake

Water quality is improving in Swartout (Appendix C) but remained well above TMDL goals in Swartout Lake in 2014. Chlorophyll-a concentrations continued to improve as the 2014 summer average chlorophyll-a concentrations were the lowest observed in the lake and were below TMDL goals. Water clarity continued to be very good in 2014, relative to historical levels observed prior to 2010, as the summer average Secchi disk depth met the TMDL goal.

Chlorophyll-a concentrations have been low and stable since 2010. This is likely the result of available light promoting aquatic vegetation growth and limiting the growth of algae. Prior to 2010, 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 increased dramatically and has remained good in recent years due to a major reduction in the carp population due to harvesting and migration management following an extensive fish kill that occurred in the late winter of 2010. The reduced carp and rough fish population allows for less disturbance to bottom sediments and less turbidity which allowed submergent vegetation growth in the lake in 2014. Rooted plants anchor the sediments and provide habitat for other species.

However, as water clarity has increased, expected corresponding sustained algal blooms have not been documented. Algal blooms were limited to periodic episodes during mid-summer in 2014. While a small number of carp have been observed in the lake since 2012, it does not appear that the population has increased dramatically in the lake to a level that has an impact on water quality, as observed prior to 2010.

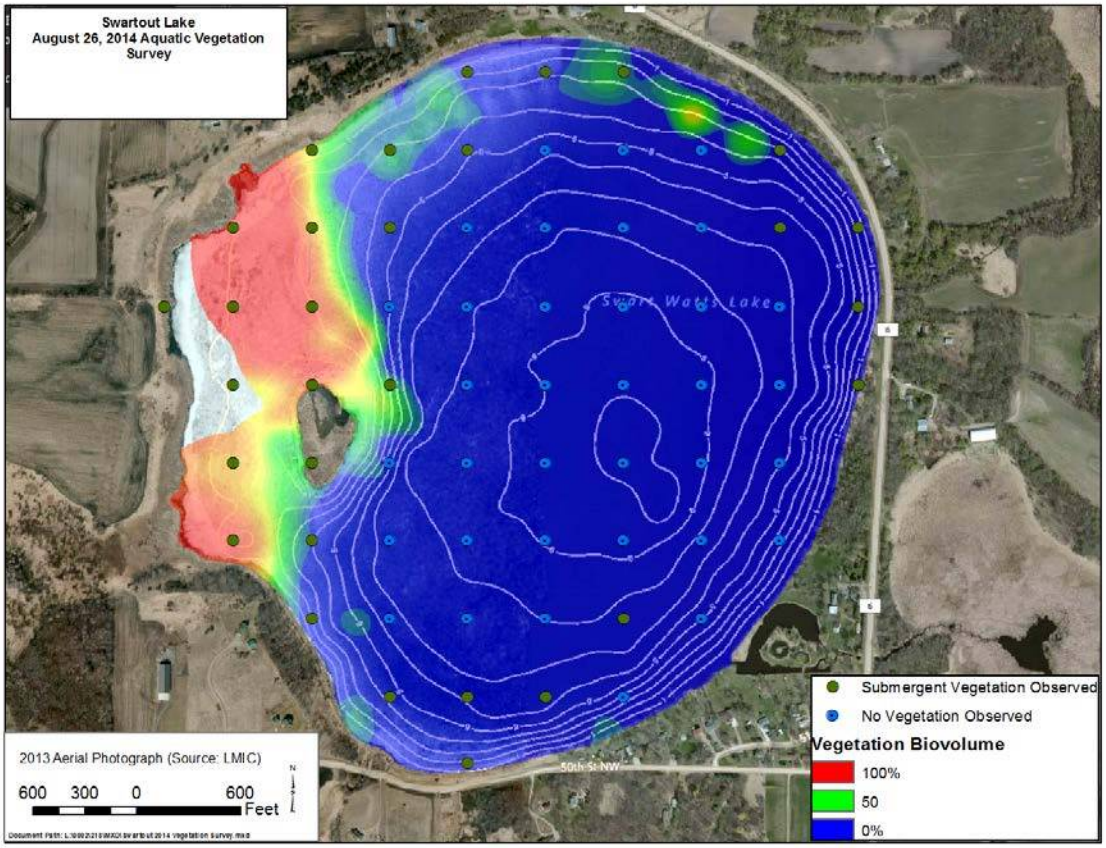
A 2005 vegetation survey in the lake showed the population of rooted aquatic plants growing in the lake was effectively zero. Vegetation surveys conducted in 2010 through 2014 found submergent vegetation growing at approximately 30% of sample points across the lake (Figure 2-1). Figure 2-1 shows the water depth and typical areas of submergent and emergent vegetation coverage as inventoried from 2010 to 2014.

The 2014 late summer vegetation inventory showed vegetation is limited to shallow areas along the western and northern shorelines of the lake despite increased clarity indicating submerged aquatic vegetation growth is limited by bottom substrate and not just water clarity. Areas with mucky bottom sediments are vegetated with dense stands of native species. Many areas of the lake with similar depth with a sand/gravel substrate are not vegetated.

Similar to previous year's surveys, submergent vegetation is observed at most sample points less than five feet deep in the western portion of the lake. The submergent vegetation community was dominated by native species in 2014, with coontail, sago pondweed, narrow leaf pondweed, and Canada waterweed (Elodea) being the most common species observed. Coontail and Canada waterweed were far more common in 2014 than in any other survey. As shown in Figure 2-1 the vegetation biovolume was highest in the western portion of the lake, where dense stands of native pondweeds are typically present. 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 continued dramatic improvement in water clarity and sustained submergent vegetation growth due to decreased rough fish populations over the last five years 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 2-1: Swartout Lake 2013 Aquatic Vegetation and Water Depth



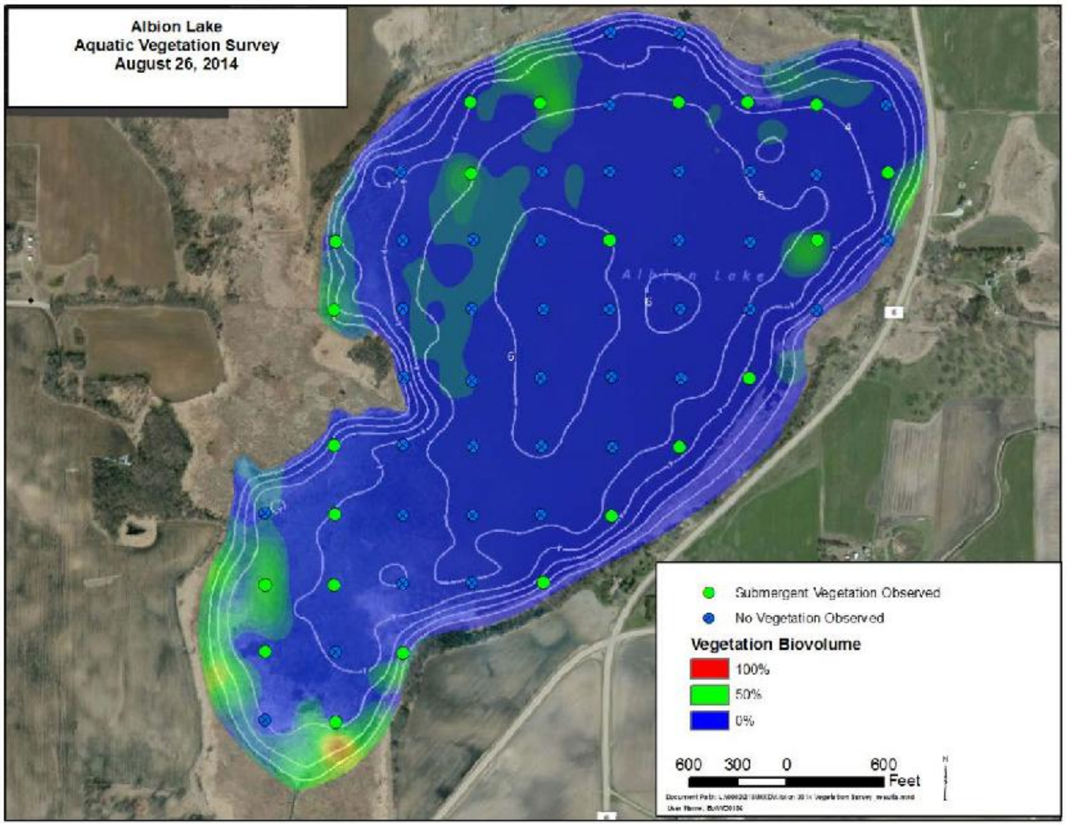
Albion Lake

As shown on the Albion Lake report card in Appendix C, summer average phosphorus and Chlorophyll- a concentrations were among the lowest ever observed in Albion Lake in 2014 but still above TMDL goals. In spite of the reduction in phosphorus and chlorophyll-a concentrations, water clarity continued to be poor and has been since 2010.

A review of seasonal phosphorus concentrations in 2014 demonstrates that total phosphorus throughout the summer was comprised almost entirely of particulate phosphorus with very little ortho-phosphorus. This is 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. The poor water clarity was also likely due to resuspension of sediments in the water column.

An aquatic vegetation survey was conducted during late summer in 2014. Aquatic vegetation was observed at 34% of the survey points, as shown in Figure2-2. Sago pondweed was the only native submerged vegetation species observed in 2014, with young curly leaf pondweed plants also observed. A 2013 survey conducted early in the season found that curly leaf pondweed was very common in the lake. A fringe of emergent vegetation dominated by hardstem bulrush and cattail was also observed in portions of the lake.

Figure 2-2: Albion Lake 2014 Aquatic Vegetation and Depth Survey



Henshaw Lake

Water quality remained improved in Henshaw Lake in 2014 following an extensive fish kill during the winter of 2012-2013. As summarized on the Henshaw Lake report card in Appendix C, summer average phosphorus concentrations in 2014 were similar to recent years and far lower than concentrations observed prior to 2009, but remained above the TMDL goal in the lake. Summer average Chlorophyll-a concentrations in 2014 continued to meet the TMDL goal. Water clarity also remained good as the summer average Secchi depth of 1.2 meters met the TMDL goal. The Secchi disk was visible on the bottom of the lake during most monitoring visits.

The dramatic improvement in water quality following a winterkill during the winter of 2012-2013 demonstrates that the rough fish population is likely the main driver of water quality in Henshaw Lake.

A vegetation survey was conducted in the lake in August 2014 to document the extent of aquatic vegetation in the lake for comparison to previous year's surveys (Figure 2-3). Vegetation was found at 63 of 64 sample stations (98%) during the survey. The vegetation community was dominated by dense stands of sago pondweed, with northern water milfoil and coontail also abundant. The vegetation biovolume was near 100% over the majority of the lake in 2014. For comparison, as demonstrated in Figure 2-4, aquatic vegetation surveys found vegetation at less than 20% of sampled points during surveys conducted in 2010 and 2012. Aquatic vegetation coverage, density, and diversity remained improved in Henshaw in 2014 as the lack of rough fish in the lake allowed for increased water clarity and optimal conditions for submerged vegetation growth. The current state of the aquatic vegetation in Henshaw Lake is reflective of a healthy shallow lake in the clear water state and provides optimal habitat and food for fish, waterfowl, and other wildlife.

Figure 2-3: Henshaw Lake 2014 Aquatic Vegetation and Depth Survey

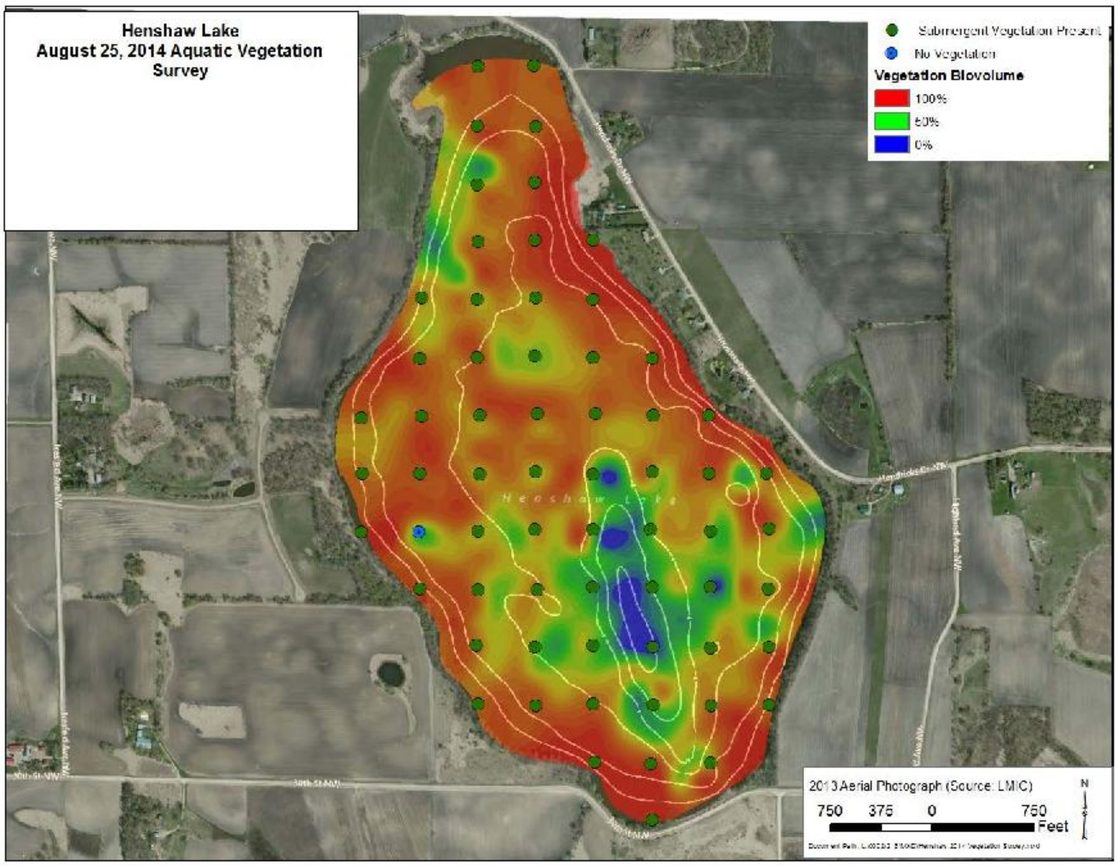
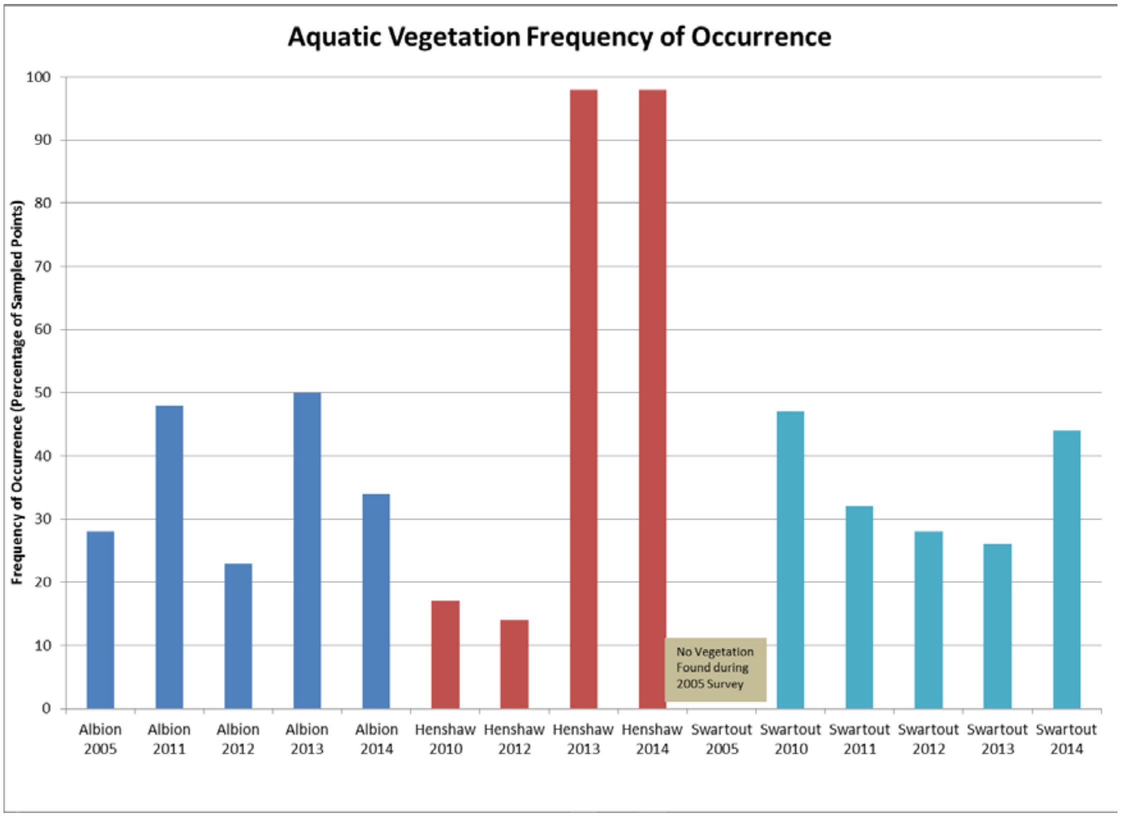


Figure 2-4: Aquatic Vegetation Frequency of Occurrence in Albion, Henshaw, and Swartout Lakes



Stream Monitoring

Five tributary streams in the Cedar Lake subwatershed were monitored in 2014 to quantify nutrient loads to the lakes. Locations of the monitored tributary streams are shown on Figure 2-5. Annual runoff at each monitoring site from 2007 to 2014 is shown in Table 2-2 below. The calculated phosphorus loads from 2007 to 2014 are shown in Table 2-3 below. Mean total phosphorus concentrations are shown in Table 2-4 and phosphorus loading rates at each monitoring location are shown on Figure 2-5.

Table 2-2: Tributary Stream Annual Runoff (inches/year) 2007-2014

Site	2007	2008	2009	2010	2011	2012	2013	2014
SCE01	1.60	3.60	2.00	2.47	21.26	6.49	3.98	6.99
SHE01	1.20	4.50	1.30	5.27	14.17	5.85	1.62	7.86
SSW01	0.70	7.00	3.50	5.95	14.78	3.68	2.10	7.72
SSW02	0.50	4.70	3.50	3.83	7.41	6.13	1.55	4.40
SSW04	1.20	4.00	1.50	3.66	10.76	5.49	2.48	8.62

Table 2-3: Tributary Stream Total Phosphorus Load 2007-2014

	TP Load (lbs)								
Site	2007	2008	2009	2010	2011	2012	2013	2014	TP Load Goal
SCE01	121	199	136	160	791	395	225	408	
SHE01	81	247	61	198	424	272	37	238	
SSW01	98	698	602	839	4,164	1,121	581	1,127	
SSW02	292	858	739	624	2,358	1,342	300	625	
SSW04	870	1,011	512	1,149	3,866	2,543	773	1,081	1000

Table 2-4: Tributary Stream Mean Total Phosphorus Concentrations 2007-2014

	Mean TP Concentration (ug/L)							
Site	2007	2008	2009	2010	2011	2012	2013	2014
SCE01	38	28	34	32	33	31	33	26
SHE01	283	222	195	153	122	189	95	128
SSW01	232	159	276	225	261	282	286	234
SSW02	96	301	345	267	522	359	359	284
SSW04	58	201	265	251	313	369	369	187

Overall, runoff in Cedar/ Swartout tributaries was within the range of those observed in recent years, but on the high side. Mean TP concentrations were similar to those observed in most recent years and were on the low side of normal for all sites. Despite high runoff, phosphorus loads were within what has been observed in previous years and at 1,081 lbs, close to the load goal for Cedar Lake.

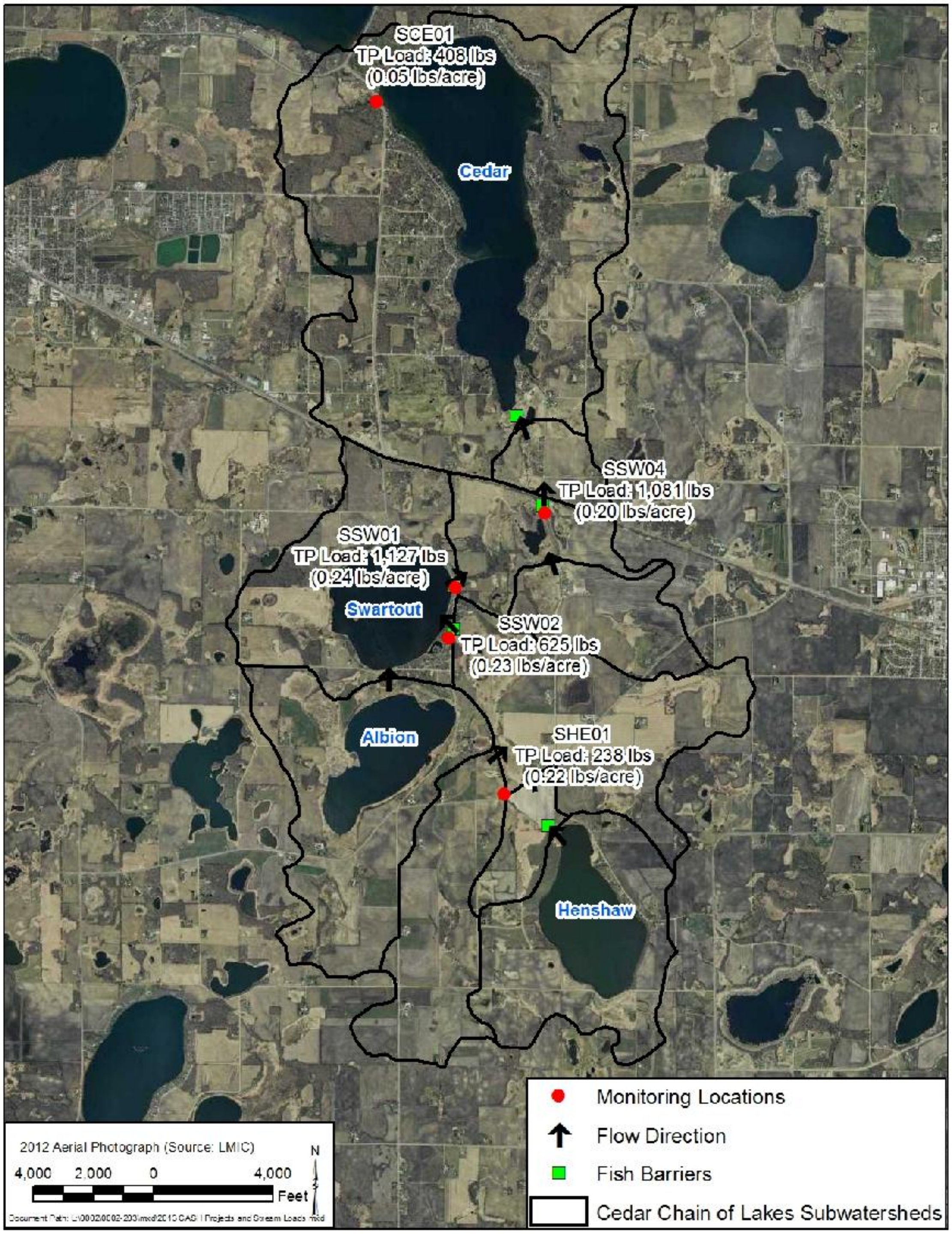
Table 2-5 shows the ortho-phosphorus proportion of total phosphorus at Cedar/ Swartout stations. Values are fairly consistent with those measured in previous years. The export of soluble phosphorus from wetlands and lakes in the sub-watersheds upstream of Cedar Lake is a significant contributor to the phosphorus load to Cedar Lake.

Table 2-5: 2013 Mean Phosphorus Concentrations and %TP as Ortho-P in Cedar Lake Sub-watershed

Site	Mean TP Concentration (ug/L)	Mean Ortho-P Concentration (ug/L)	%TP as Ortho-P
SHE01	128	37	29%
SCE01	26	5	20%
SSW04	187	80	42%
SSW02	284	95	33%
SSW01	234	98	42%

Phosphorus loads and phosphorus loading rates for the sub-watershed draining to each monitoring location are shown in Figure 2-5.

Figure 2-5: 2014 Stream Monitoring, Locations, Fish Barrier Locations, and Total Phosphorus Loads



2.3.1.1.2 Conclusions

The monitoring results for this project over the last several years continue show that projects and programs have effectively reduced in-lake concentrations and loads to the lake. This indicates that the water quality goals for Cedar Lake are appropriate. Results of this project continue to highlight the connection of between Cedar Lake water quality and the status of fish and plant communities in the shallow upstream lakes: Swartout, Albion, and Henshaw. 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. Restoring in-lake biological communities including fish, plants, and zooplankton is critical to achieving healthy, clear-state shallow lakes.

Ideally, shallow lake management plans incorporate 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. Efforts to implement some of these strategies have been met with resistance on the part of land owners. To date, biological management strategies are limited to rough fish migration barriers and harvesting, and limited watershed BMPs.

Though water quality is stable to improving, additional load reductions are necessary to achieve in-lake water quality goals for Cedar, Swartout, Albion and Henshaw. Two additional projects which will be constructed in 2015 and on ongoing biological management of upstream shallow lakes and wetlands will target remaining TP loads in excess of water quality goals.

2.3.1.2 City of Kimball Stormwater (Phase I)

This project targeted phosphorus and sediment 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. Prior to the project, stormwater runoff from the City of Kimball drained untreated into Willow Creek, a trout stream. Willow Creek is tributary to Lake Betsy, which is impaired by excess nutrients.

The project was designed to 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.

The District secured a grant 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 were 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 pretreatment forebay/ rain garden with native plantings. Cleanout of the sedimentation forebay is planned for 2015, as is optimization of the water reuse system.

CRWD staff retained a private consultant to maintain native vegetation in the raingarden on site. Continued vegetation maintenance in the raingarden and basin is planned for 2015, including new plantings.

2.3.1.3 Clear Lake Notched Weir/ Iron Sand Filter

The District installed a notched weir and iron sand filter on a Clear Lake tributary stream south of the lake. The project filters soluble phosphorus and allows particulate phosphorus to settle out of runoff before discharging to Clear Lake. 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 load reduction from watershed sources to Clear Lake needed to meet in lake water quality goals. The weir/ filter temporarily detains water from smaller runoff events allowing it to filter through the sand/ iron bed while allowing controlled overflow of stormwater during larger storm events.

The District secured an easement on the property required to construct the project in 2011. Final design was approved by local, state, and federal regulatory agencies in January 2012. The project was constructed in December 2012.

Monitoring was conducted in the tributary stream downstream of the project in 2014. Results show post-project phosphorus concentrations were lower than pre-project concentrations. Results are shown in the stream monitoring section of this report.

2.3.1.4 Clearwater River Channel Stabilization

The purpose of this project, which began in 2010, is to stabilize the channel and banks of the Clearwater River. The CRWD has prioritized areas with extensive tree canopy for restoration. Overly dense tree canopy does not allow for the growth of stabilizing ground vegetation. These areas are subject to sloughing and incision of the channel banks. Thinning the tree canopy allows ground cover to re-establish which slows soil loss from the bank. Bank toe protection and grade control armor the channel, redirect flows and aerate the river.

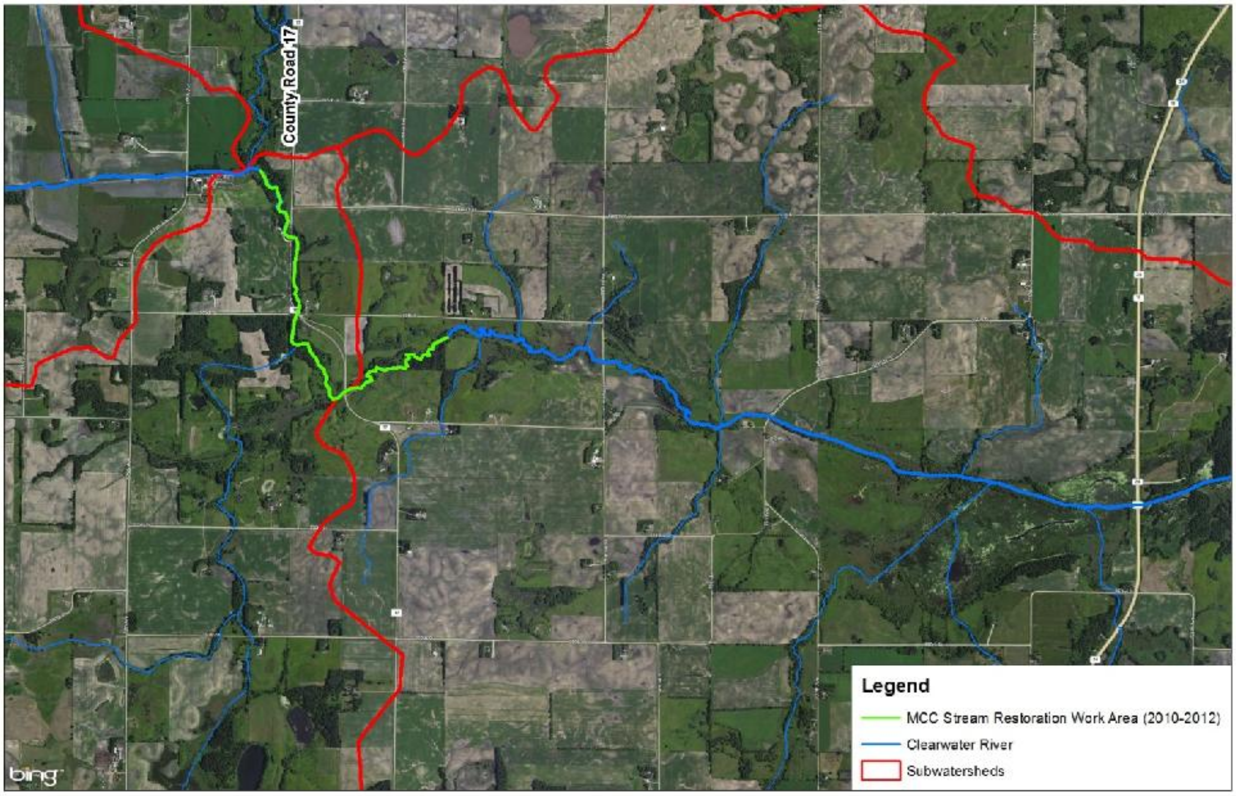
The Conservation Corps crews began work in 2010. Crews

- thinned trees,
- assembled and installed brush bundles for toe protection,
- fabricated grade control structures from felled logs,
- harvested and installed live stakes
- seeded slopes, and
- installed erosion control fabric

CRWD restored 2,800 linear feet of streambank in 2010, 6,700 linear feet in 2011 and 1,800 lineal feet in 2012. Additional stabilization was conducted in 2013. Figure 2-6 shows the channel stabilization project area since 2010. Reference photos showing a representative of the streambank before and after the work was completed were taken and are shown below.

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. The District did not receive funding to continue this project in 2014.

Figure 2-6: Extent of Clearwater River Stream Stabilization Projects



2.3.2 Projects/Programs in Progress

2.3.2.1 Kingston Wetland Feasibility Study and Restoration

The Kingston Wetland Feasibility Study and Restoration Project was designed to restore main channel dissolved oxygen concentrations in the Clearwater River and reduce the seasonal export of soluble phosphorus to impaired lakes while maintaining particulate phosphorus sequestering capacity, and improve stream and wetland habitat and ecology.

Data collected in the 2 years following construction show improvements in DO were achieved by mitigating sediment oxygen demand in the wetland complex. The project also targets a 1,970 lbs/year phosphorus reduction to downstream lakes by preventing soluble phosphorus export from the riparian wetland. Soluble reactive phosphorus concentrations downstream of the wetland are generally lower than pre-project compared with upstream concentrations. This indicates that the load reduction goal for this project was appropriate. Final results will be published in the end of project report required by the grant.

Following the completion of a feasibility study and permitting for the project, construction began on the project in late January 2013 and was completed in March 2013. Wenck and

District staff observed the construction and documented that the construction was completed according to plans.

Photographs of the project area in the second year after construction (2014) are found in Appendix I. As documented in the field and shown in the photographs, the meandering constructed stream channel has been successfully restored and is fully functioning. Vegetation cover has been successfully established within the entire reach of the project area.

Water quality monitoring was conducted upstream of the project area at monitoring site CR29 and downstream of the project area at monitoring site CR28.2 in 2014. The monitoring results were compared to monitoring results from 2006 and 2011 at CR29 and 2006, 2011, and 2012 at CR28.2. A summary of monitoring data for comparison is found in Appendix I.

Monitoring data was evaluated to measure the success of the goal of the project of reducing the export of soluble phosphorus from the wetland and improving dissolved oxygen concentrations in the Clearwater River. In general, TP concentrations at the downstream monitoring location were lower in 2013 than in most previous years with similar flows. TP concentrations and the proportion of TP comprised of ortho-phosphorus were similar from upstream of the wetland to downstream, indicating a reduction in phosphorus export from the Kingston wetland to the Clearwater River in comparison to previous years.

Dissolved oxygen concentrations were improved in the Clearwater River downstream of the Kingston Wetland in 2013, as DO concentrations remained above the impairment standard for most of the year, with the exception of late summer, when zero flow conditions and warm water contributed to a sag in DO concentrations. This is in comparison to 2011 and 2012, when DO concentrations were below the impairment standard for the entire period from June to October across ranges of high and low flows.

Macroinvertebrate samples were collected in September 2014 and analyzed for comparison to samples that were collected in September 2012 prior to the restoration project. In 2012, samples were collected in the reach of the Clearwater River from downstream of the Kingston Wetland to State Highway 15. In 2014, samples were collected from the entire reach of the Clearwater River from State Highway 15 to upstream of the Kingston Wetland.

The 2012 macroinvertebrate sampling demonstrated that the macroinvertebrate community in the Clearwater River downstream of the Kingston Wetland was dominated by species tolerant of organic pollution and sedimentation. Tolerant invertebrate species are often found to thrive in areas with low dissolved oxygen, high turbidity, or heavy siltation. Tolerant species tend to dominate in relative abundance as conditions are degraded.

Selected metrics from the analysis of the macroinvertebrate samples from 2012 and 2014 were used to compare the macroinvertebrate community present prior to the construction of the restoration project to the community present after construction. Table 2-6 compares these selected metrics.

Table 2-6: Selected Macroinvertebrate Metrics

Metric	2012 Value	2014 Value
Hilsenhoff Biotic Index	8.26	6.08
Intolerant Percent	0.00%	1.59%
Pollution Tolerant Percent	35.22%	18.73%
Supertolerant Percent	55.66%	6.03%

The Hilsenhoff Biotic Index (HBI) estimates the overall tolerance of the invertebrate community to organic pollution on a scale of 0 to 10, with a score of 0 indicating little pollution and intolerant species and a score of 10 indicating severe pollution and tolerant species. The HBI in 2012 was 8.26, demonstrating that the invertebrate community was dominated by tolerant species. The HBI in 2014 improved to 6.08, demonstrating a decrease in the overall abundance of tolerant species following the restoration of the stream channel. For comparison, HBI scores from other low gradient streams in Minnesota ranged from 5.8 to 8.8. The best achievable goal for the Clearwater River in this section is 5.8, and the post project result showed 6.08.

Monitoring will continue in future years to continue to track and report the progress of reaching the project goals of improving in-stream DO downstream of Kingston Wetland and reducing the export of soluble reactive phosphorus without sacrificing the particulate trapping capability of the wetland.

2.3.2.2 GPS Fertilizer Application

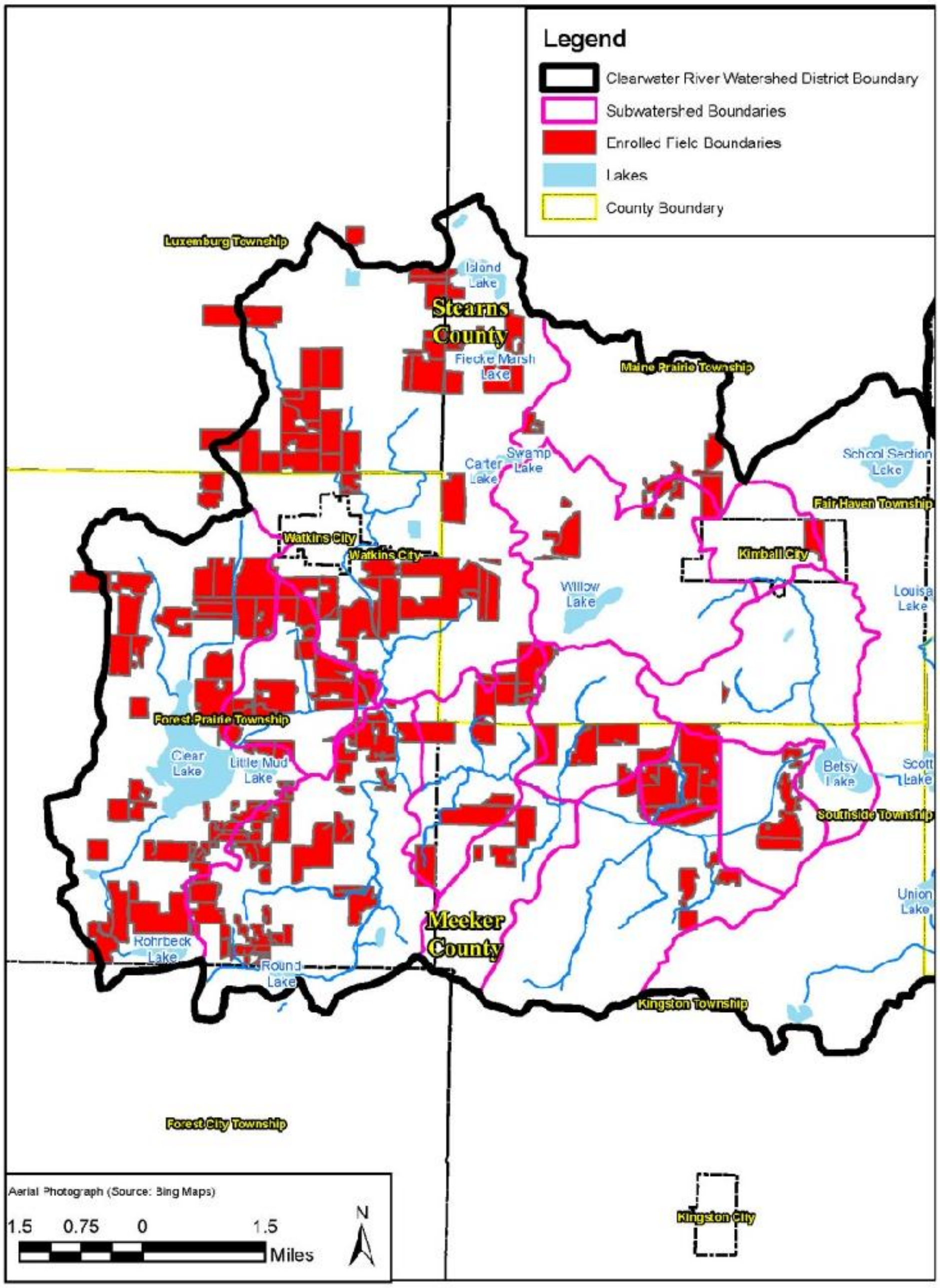
Using grant funds secured in 2011, this project has a goal of enrolling up to 16,000 acres in the target watershed in a gridded soil testing and GPS fertilizer application project. The project includes systematic soil tests to determine nutrient concentrations and the proper amount of fertilizer to be applied in each field. The fertilizer is applied using GPS to apply the correct amount of fertilizer in each grid of the fields based on the results of the soil tests.

Prior to the implementation of the grant project, a field trial was conducted in 2010 in cooperation with the Litchfield Consumers Co-op and other partners 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. This field trial demonstrated the feasibility and utility of systematic soil testing in reducing fertilizer application and thus phosphorus load in agricultural runoff. A workplan was approved and a contract was executed for the grant in 2012. The CRWD began enrolling landowners in the program in 2012 and enrolled more landowners in 2013. Soil testing and fertilizer application was conducted in fall of 2012 and 2013.

The goal of the program is a 10% reduction in fertilizer application rates on selected priority cropland in the District resulting in a potential 3,200 lb annual reduction of phosphorus load in the watershed tributary to Lake Betsy. It is estimated that the program could potentially translate into a 10% to 50% reduction in phosphorus runoff from the watershed.

By 2013 7,414 acres had been enrolled in the program, representing 54% of cropland in the watershed tributary to lake Betsy (see Figure 2-7), early enrollment reports for 2014 indicate that goals have been met though we await the final data. All data will be summarized in an end of project report in 2016.

Figure 2-7: Enrolled Fields through 2013 (2014 Data Not Available)



Responsive partner. Exceptional outcomes.

2.3.2.3 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 enhances water quality treatment and promotes infiltration to recharge shallow groundwater through construction of shallow basins and an off-line filtration ditch to treat previously untreated stormwater from the City of Kimball before it flows into Willow Creek. The project 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 1,175 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 improve the quality of 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. Project concept was completed in 2012, final design and permitting in 2013. Construction began in spring 2014 and was 90% complete by the end of 2014. Final construction will be completed in spring 2015.

2.3.3 Planned Projects

The District's 2015 plans are not final until after the CRWD Board of Managers sets the course in early 2015, however, the following projects have been and continue to be priorities for the District and will likely be pursued in 2015. This section will be updated as needed following the February planning session.

2.3.3.1 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, about 740 acres of urban and agricultural land, drain 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.

The District submitted a Clean Water Legacy grant for this project in 2014, and is waiting to hear if funds will be awarded. Grant efforts to date have been unsuccessful, though the project remains a high priority for the District.

2.3.3.2 Lake Betsy Internal Load Management

The District conducted a feasibility study of internal load management alternatives for Lake Betsy in 2014. The study showed that hypolimnetic withdrawal was feasible and had a high likelihood of successfully removing bottom phosphorus from the lake. Hypolimnetic withdrawal entails pumping nutrient-rich water from the stratified lake bottom and using it to irrigate a nearby pasture. The District may also evaluate a whole-lake alum treatment for Lake Betsy going forward.

Internal load management in Lake Betsy has not received grant funding to date, despite three attempts at grant funding.

3.0 Hydrology

3.1 PRECIPITATION

Total annual precipitation measured in 2014 was above normal for the year at three of the four monitoring locations across the District. Precipitation was well above normal in early summer during most of the period from April to June at all stations. Table 3-1 summarizes 2014 precipitation levels and Appendix D contains summary charts for each station.

Table 3-1: Clearwater River Watershed District 2014 Precipitation Records and Normals (inches)

	2014 St. Cloud (Saint Cloud WSO Airport)	1981-2010 Normal (St. Cloud)	2014 Watkins (Meeker)	2014 Watkins1 (Meeker)	2014 Kimball (Meeker)	1981-2010 Normal (Litchfield)	2014 Annandale/ Corinna (Wright)	1981-2010 Normal (Cokato)
January	1.34	0.65	1.12	0.15	1.33	0.70	1.26	0.77
February	1.17	0.59	1.06	0.13	1.03	0.64	1.08	0.70
March	1.20	1.55	0.98	0.49	1.21	1.46	0.69	1.63
April	5.90	2.57	5.82	3.81	5.07	2.60	3.51	2.97
May	6.74	2.95	6.58	5.27	4.12	3.22	5.67	3.39
June	6.18	4.17	5.91	5.87	5.56	4.99	5.09	4.57
July	1.25	3.31	1.79	1.89	2.08	3.83	2.66	3.70
August	5.59	3.79	5.24	5.22	3.56	3.86	3.13	4.23
September	4.06	3.46	1.37	1.32	2.21	3.39	3.07	3.25
October	0.64	2.49	0.53	0.54	0.66	2.42	0.49	2.50
November	1.89	1.38	1.48	0.50	1.98	1.32	1.21	1.61
December	0.75	0.82	1.00	0.90	0.89	0.87	0.62	0.94
Total	**36.71**	**27.73**	**32.88**	**26.09**	**29.70**	**29.30**	**28.48**	**30.26**

T:\0002\218_2014 Water Quality Monitoring\Water Quality Data\[PRECIP_2014.xls]summary 14

Below Normal Precipitation (blue)
Above Normal Precipitation (red)

3.2 RUNOFF AND DISCHARGE

The above-average 2013-2014 snowpack and extreme summer precipitation in 2014 contributed high runoff in 2014. Late summer drought dried up streams by late August or early September. Runoff over the upper watershed was 5.1 inches upstream of Lake Betsy at CR 28.2 and 8.1 inches at the outlet of Clearwater Lake (CR10.5), which is higher than the long-term average runoff at CR 10.5 of 7.9 inches and similar to other years with similar precipitation.

Average flows in the Clearwater River were below the long-term average at CR 28.2 and CR10.5; at 37 cfs and 161 cfs, respectively. Table 3-2 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.

Table 3-2: 2014 Runoff Volume and Average Flow

Station	Tributary Sub-watershed Area (acres)	Runoff Volume (ac-ft)	Runoff Over Watershed (inches)	Average Flow (cfs)
CR 10.5	99,200	67,189	8.1	161.31
CR 28.2	33,977	14,390	5.1	36.83
WR0.2	16,992	4,888	3.5	13.47

Continuous Flow Monitoring Sites

In 2014, 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 and annual phosphorus loads. Pressure transducers were also installed at the Fairhaven Dam, County Ditch 20 at River Mile 1.0 (CD20 1.0), and at Cedar Lake monitoring station SSW04. Pressure transducers recorded the stream surface elevation at 15 minute intervals upstream of the Kingston Wetland at CR29.0 and downstream of the Kingston Wetland at CR28.2 while the Clearwater River was flowing from April to October. A pressure transducer was also installed at the Grass Lake Dam from April to October in 2014 (site locations shown on Figure 1-2).

Continuous water elevations at the stations near the Kingston Wetland are shown in Figure 3-1. 2014 continuous flows at CR28.2 and CR10.5 are shown in Figure 3-2 and Figure 3-3, respectively. The figures demonstrate that flows at all three sites peaked in early July and declined for the rest of the summer, before recovering slightly following a precipitation event in October.

Figure 3-1: 2013 Clearwater River Continuous Water Level Elevations (Kingston Wetland)

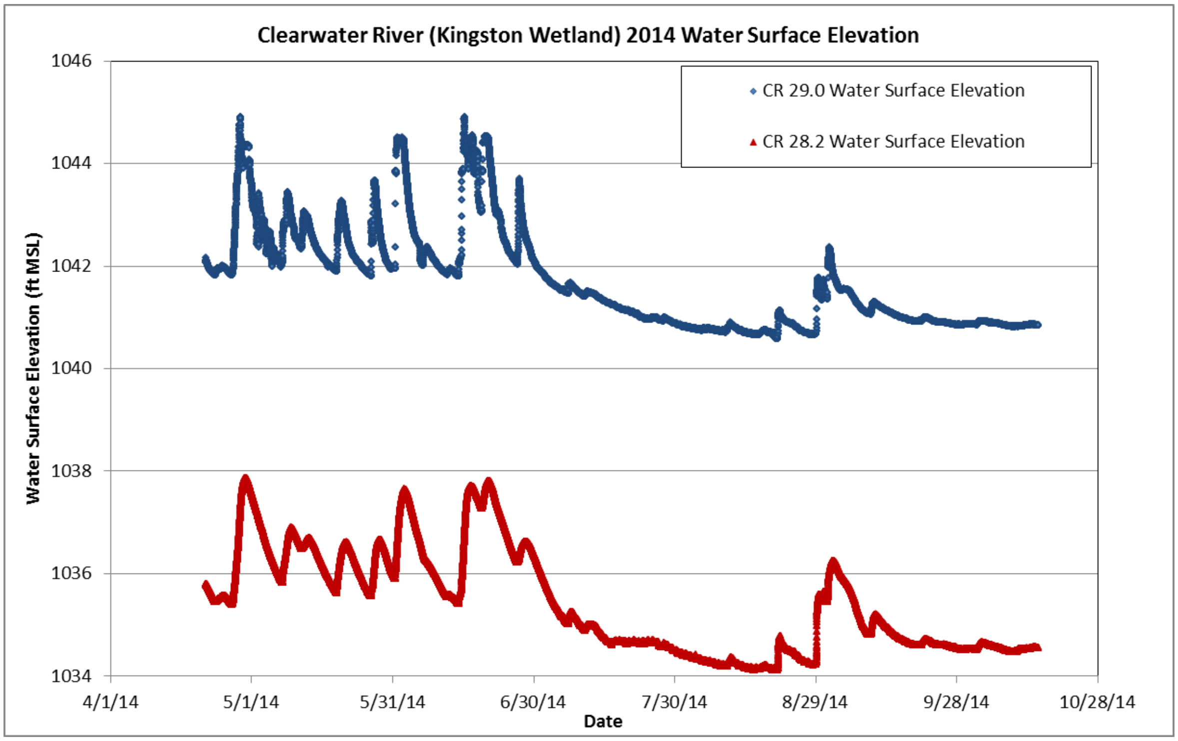


Figure 3-2: 2014 Clearwater River Continuous Flow at Kingston Wetland

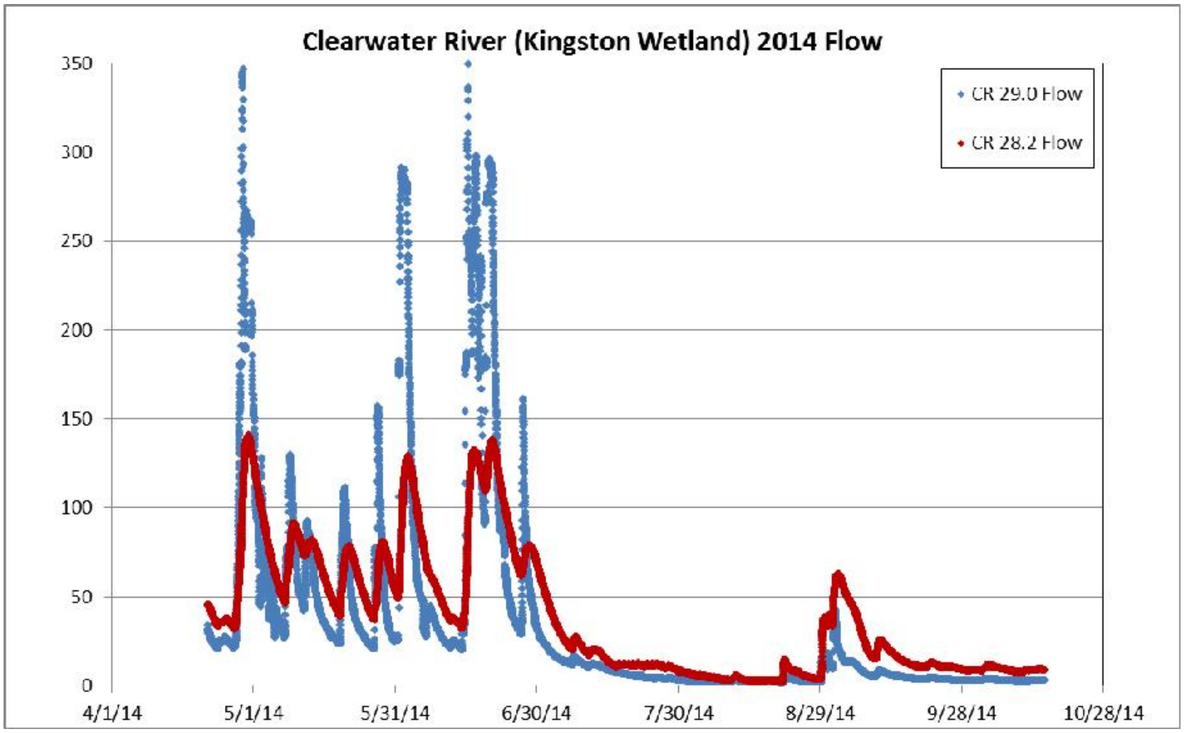
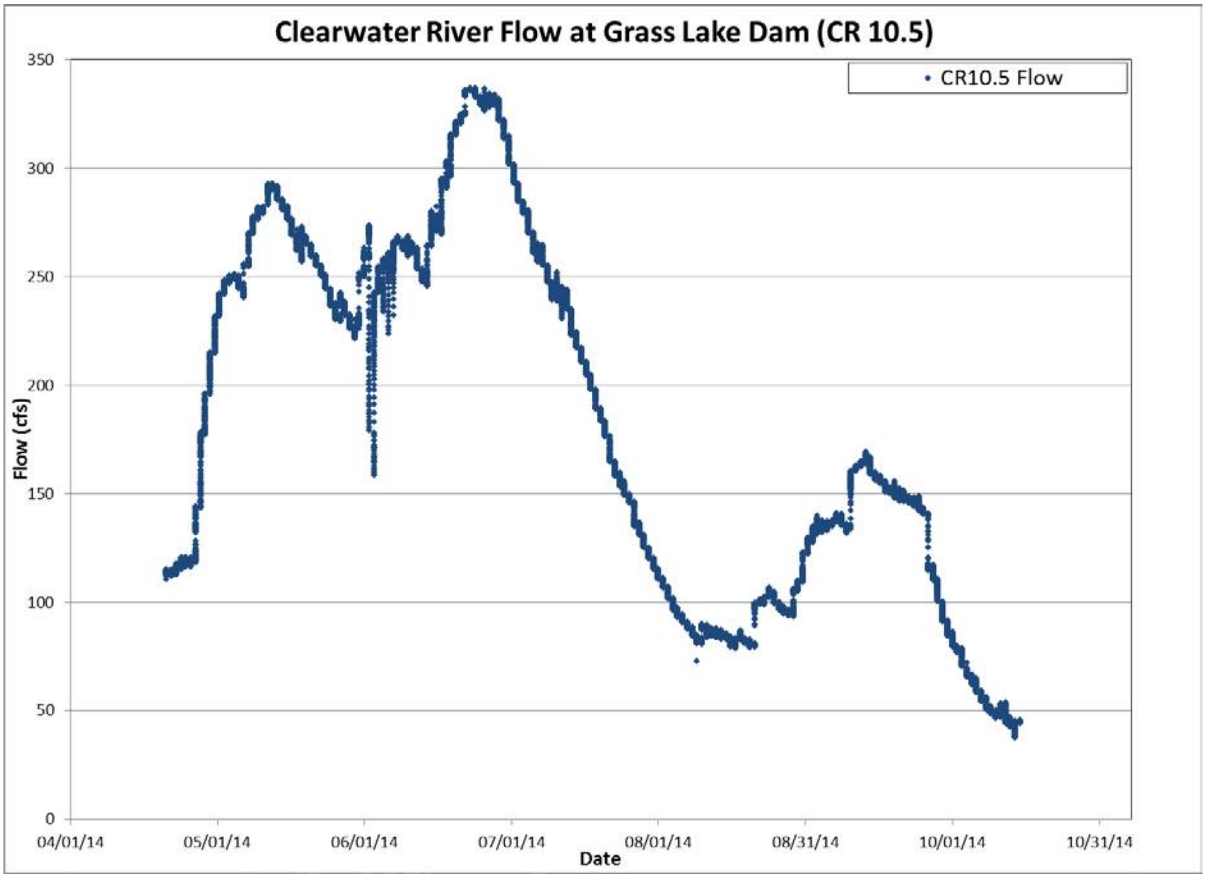


Figure 3-3: 2014 Clearwater River Continuous Flow at CR10.5



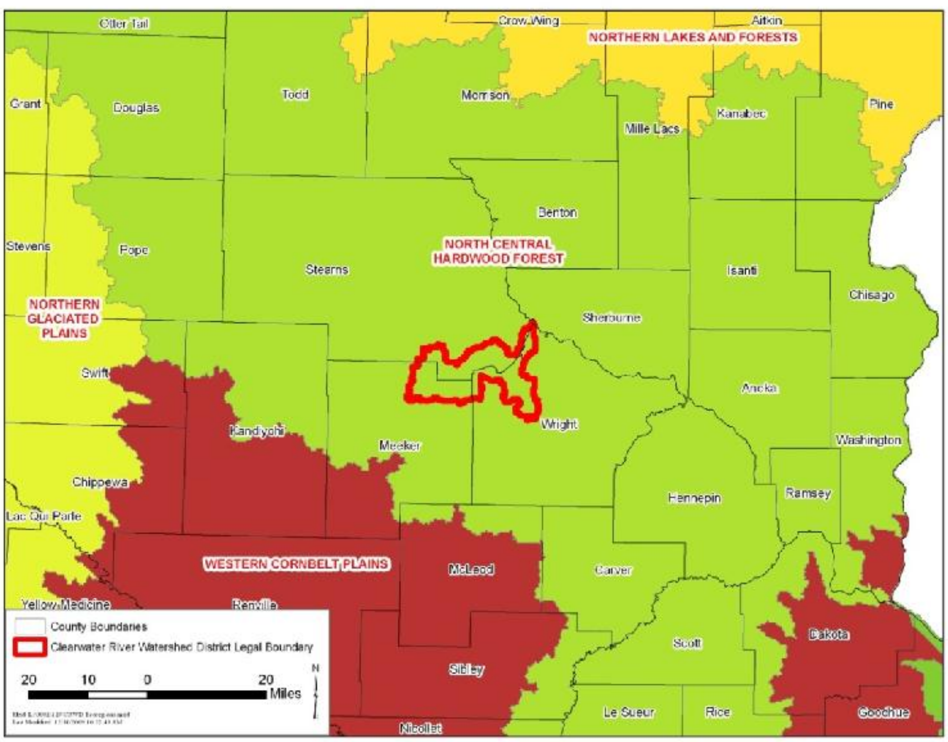
4.0 Water Quality

4.1 STREAM WATER QUALITY

Stream water quality was monitored at several locations in the CRWD. Two long-term stations on the Clearwater River and one long-term station on Warner Creek in 2014. Stream water quality was also monitored at additional stations on the main north and south tributaries to Clear Lake, and on County Ditch 20 near Watkins. Water quality samples were collected monthly or bi-monthly while the streams were flowing from April 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, and flow.

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 entirely 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 4-1. The watershed tributary to station CR28.2 has 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 4-1: Clearwater River Watershed District Ecoregions



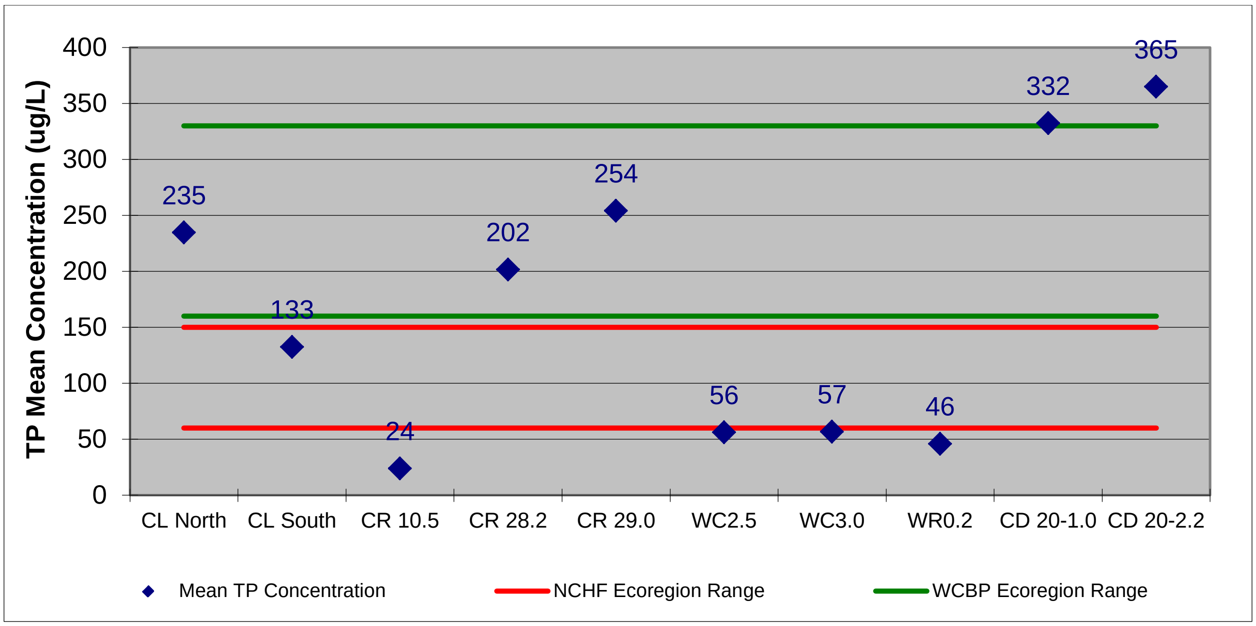
4.1.1 Phosphorus Concentrations and Phosphorus Loads

Stream loads and mean phosphorus concentrations were calculated at each monitoring station on the Clearwater River, Warner Creek, Willow Creek, Clear Lake tributary streams, and County Ditch 20 in 2014 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 were discussed in Section 2.0.

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 4-2. At the long-term monitoring stations, flow-weighted mean phosphorus concentrations at WR0.2 and CR 10.5 were below 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 were slightly below the typical range for the NCHF Ecoregion. Phosphorus concentrations at Clear Lake South were at the high end of the NCHF Ecoregion, but concentrations at CD 20.2.2 were well above than the Ecoregion ranges.

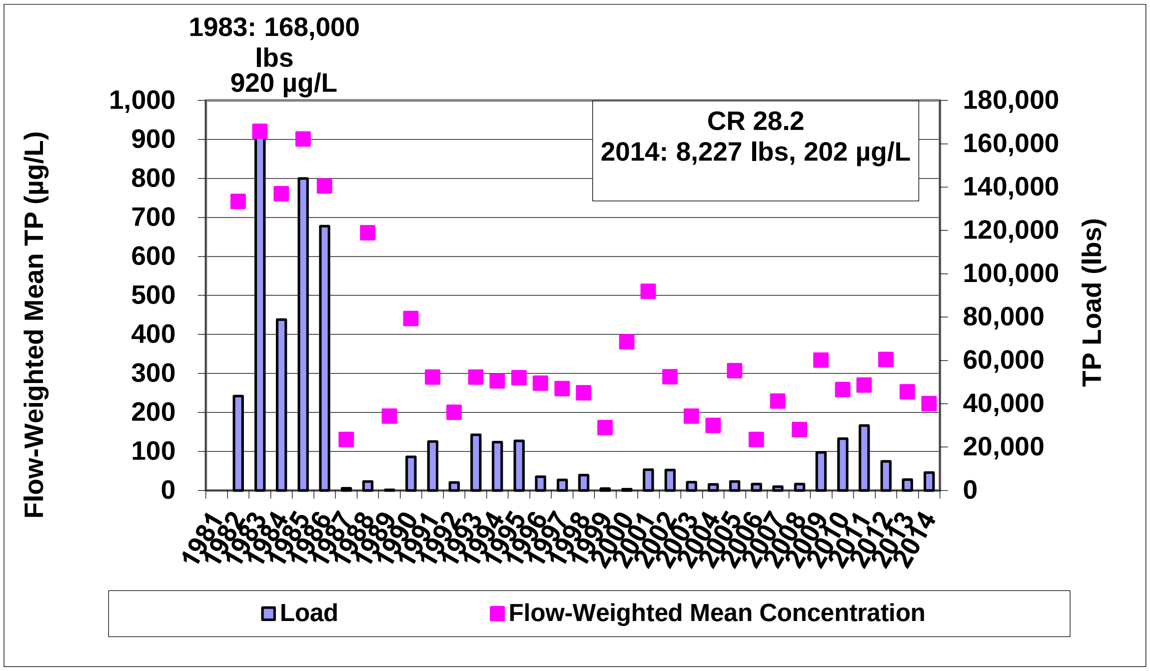
Figure 4-2: Clearwater River Watershed District 2014 Mean Phosphorus Concentrations in Runoff and Ecoregion Typical Range



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 2014 concentration was 202 µg/L, which was lower than 2013 and within the range of concentrations observed in recent years and far lower than concentrations seen in the early 1980s.

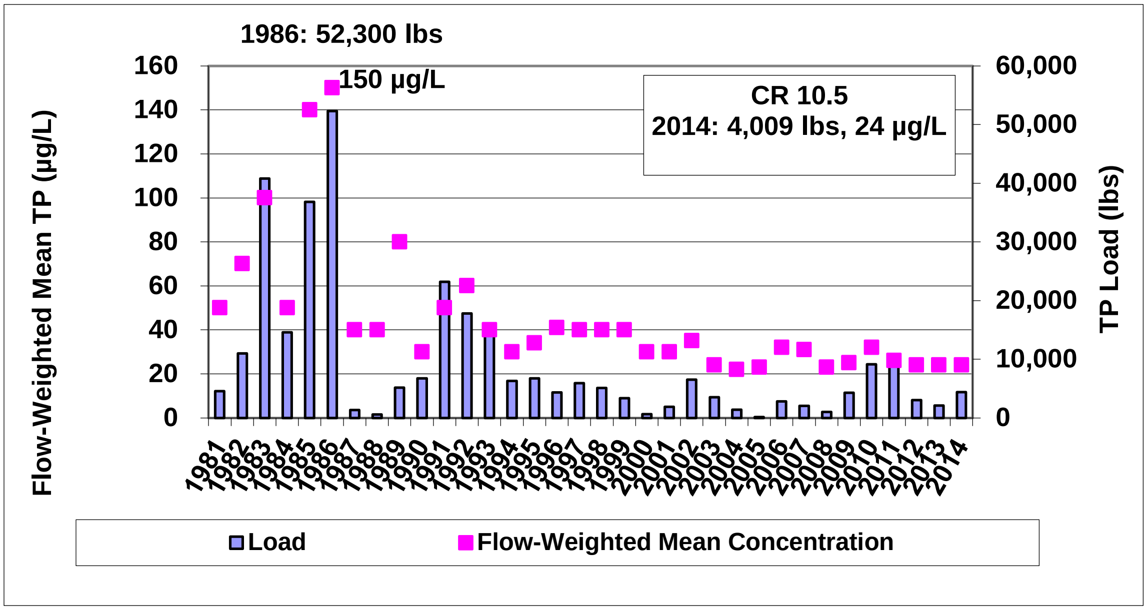
The TP load at CR28.2 was calculated using the continuous flow record data collected at CR28.2. Lower TP concentrations were offset by higher flows in 2014: TP load at CR 28.2 in 2014 was almost double the 2013 value at 8, 227 lbs. However, the load was comparable to years with similar precipitation and runoff. Phosphorus loads at CR28.2 are still far below the high TP loads observed in the early 1980s, but remain higher than loads necessary to meet state water quality standards. Figure 4-3 shows the historical phosphorus load and flow-weighted mean concentration at CR 28.2.

Figure 4-3: Historical Total Phosphorus Loading and Mean Concentration in the Clearwater River upstream of Lake Betsy (monitoring site CR 28.2)



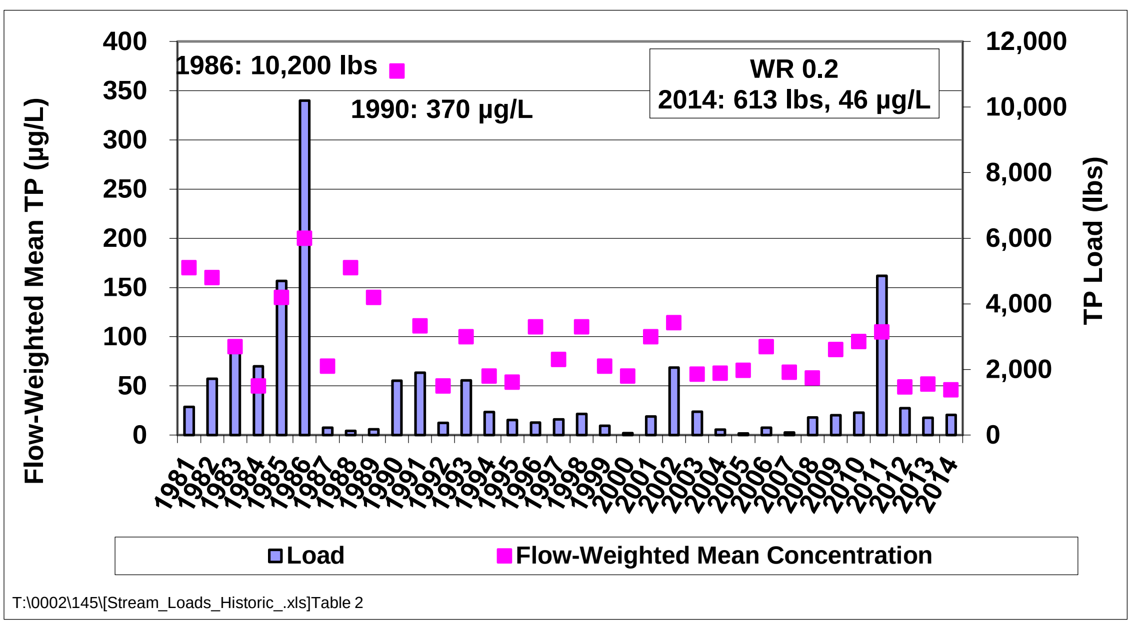
Flow-weighted mean TP concentrations and phosphorus loads at CR 10.5 were calculated using flows over the dam that were calculated using continuous level data collected upstream of the Grass Lake Dam. The estimated mean phosphorus concentration at CR 10.5 in 2014 was 24 µg/L, which was much lower than concentrations measured in the later 1980s and similar to most recent years. Mean phosphorus concentrations at this station appear to be exhibiting a stable and decreasing trend, which is reflective of stable water quality in Clearwater Lake. The 2014 total phosphorus load was 4,009 lbs (Figure 4-4), which is lower than loads observed in recent years and comparable to other years with similar runoff.

Figure 4-4: Historical Total Phosphorus Loading and Mean Concentration in the Clearwater River at the outlet of Clearwater Lake (monitoring site CR 10.5)



Phosphorus loads and mean phosphorus concentrations in Figure 4-5 compare historical total phosphorus loads and mean phosphorus concentrations in Warner Creek at monitoring station WR0.2. The flow-weighted mean TP concentration at Warner Creek in 2014 was 46 µg/L, which was similar to 2013 and much lower than concentrations observed at this site during the time period from 2008 to 2011. The total phosphorus load in 2014 was 613 lbs, similar to 2013 and to loads observed in other recent years with similar runoff.

Figure 4-5: Historical Total Phosphorus Loading and Mean Concentration at Warner Creek (Site WR-0.2)



Willow Creek has been monitored at two locations upstream and downstream of the City of Kimball since 2012 in order to monitor the effectiveness of projects constructed in the City. As shown in Table 4-1, concentrations decreased slightly from upstream to downstream, while loads increased slightly from upstream to downstream proportionately with the increase in flow. Phase II of the Kimball Stormwater Project was under construction in 2014, once complete it should further reduce hydraulic and nutrient loads to Willow Creek and downstream lakes. Monitoring will continue at these sites on Willow Creek to continue to track the effectiveness of these projects.

Table 4-1: Willow Creek Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)			Mean TP Concentration (ug/L)			Runoff (in)		
	2012	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
WC2.5	713	452	355	90	101	55	5.11	2.89	4.19
WC3.0	619	415	299	126	119	59	3.65	2.59	3.75

Two tributaries to Clear Lake were also monitored in 2014 (Table 4-2). Monitoring will continue at these two locations in future years to track the progress of District projects implemented in the subwatershed tributary to Clear Lake.

Table 4-2: Clear Lake Tributaries Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)			Mean TP Concentration (ug/L)			Runoff (in)		
	2012	**2013**	**2014**	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
CLN	1,796	475	981	512	495	296	14.73	4.01	13.87
CLS	1,013	123	367	221	190	145	14.42	2.04	7.97

As shown in Figure 4-6, County Ditch 20 was also monitored in 2014 at two locations upstream and downstream of the Watkins wetland. As shown in Table 4-3, total phosphorus concentrations were similar and high at both sites with slightly higher concentrations observed at downstream station CD 20-1.0. The phosphorus load was over twice as high at the downstream monitoring location. The proportion of total phosphorus comprised of soluble phosphorus was very high at both sites, indicating potential export of soluble phosphorus from wetlands in this subwatershed as a significant source of phosphorus.

Figure 4-6: County Ditch 20 Monitoring Locations

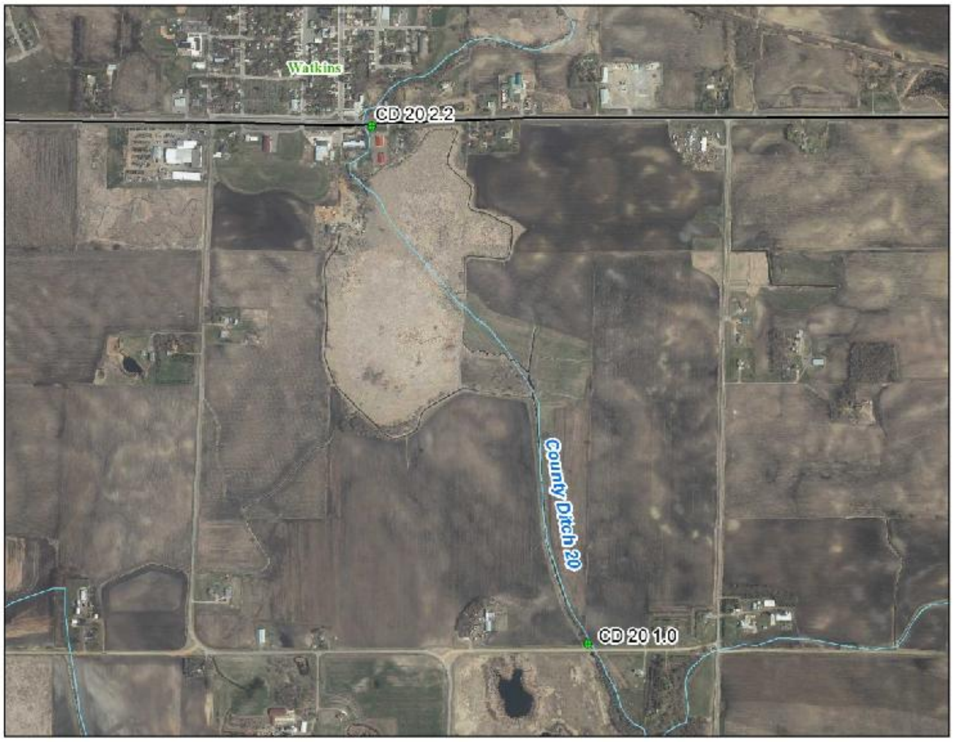


Table 4-3: 2013-2014 County Ditch 20 Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)		Mean TP Concentration (ug/L)		Runoff (in)	
	2013	2014	2013	2014	2013	2014
CD20-1.0	1,477	3,185	376	403	2.10	4.23
CD20-2.2	633	1,384	341	144	1.15	2.26

Table 4-4 shows areal phosphorus loading rates throughout the District in 2014. Phosphorus loading rates were lowest at sites in the lower watershed, 0.04 lbs/acre at CR 10.5 WR0.2. Loading rates at upper watershed stations were generally higher as the loading rate was 0.22 lbs/acre at CR28.2, and 0.39 lbs/acre at CD20-1.0 and 0.93 lbs/acre at Clear Lake South.

It is notable that the loading rate at CR28.2 was less than the loading rate at CR29.0 upstream of the Kingston Wetland, demonstrating a decrease of phosphorus export from the Kingston Wetland. This occurred in 2013 and in 2014 following the construction of the Kingston Wetland Restoration project. 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 4-4: 2014 Phosphorus Loading Rates by Tributary Watershed

Site	Watershed Area (acres)	Phosphorus Load (lbs)	Phosphorus Loading Rate (lbs/acre)
CR10.5	99,200	4,409	0.04
WR0.2	16,992	613	0.04
WC2.5	6,838	355	0.05
WC3.0	5,926	299	0.05
Clear Lake South	1,055	981	0.93
CD20-2.2	7,152	1,384	0.19
CR28.2	33,977	7,404	0.22
CR29.0	27,695	8,782	0.32
CD20-1.0	8,247	3,185	0.39
Clear Lake North	1,404	367	0.26

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 4-5 shows the ratio of the flow-weighted means of OP to total phosphorus (TP) as a percentage at each monitoring site.

OP continues to make up a high percentage of TP in some monitoring stations in 2014. This is especially true of monitoring locations downstream of large wetland complexes, as anoxic conditions developed in these basins during periods of low flow and OP was released from wetland sediments. Specifically, this was observed at the monitoring sites on County Ditch 20 and Clear Lake North. Results from tile monitoring conducted as part of the GPS Fertilizer Application Project demonstrate a high proportion of OP in water draining from subsurface tiles, which may be contributing to elevated fractions of OP at some monitoring sites.

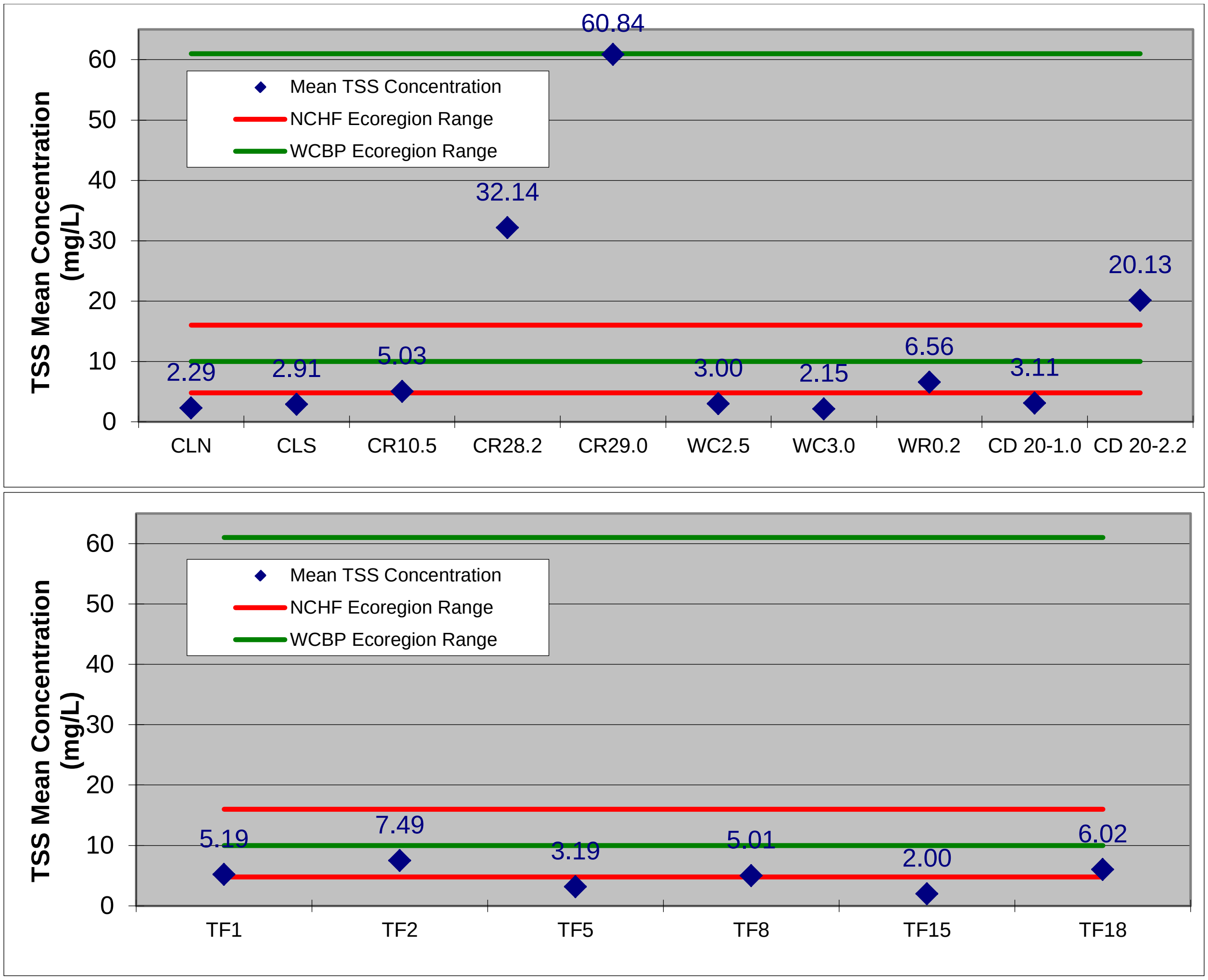
Table 4-5: Comparison of Ortho-Phosphorus to Total Phosphorus Concentrations in 2014

Site	%TP as Ortho-P
WC3.0	35%
WR0.2	19%
CR10.5	28%
WC2.5	57%
Clear Lake South	38%
CR28.2	53%
CR29.0	46%
CD20-2.2	70%
Clear Lake North	77%
CD20-1.0	81%

4.1.2 Total Suspended Solids

Samples were also analyzed for total suspended solids (TSS) in 2014. Mean concentrations of TSS are compared to typical Ecoregion concentrations in Figure 4-7.

Figure 4-7: 2014 Total Suspended Solids Mean Concentrations in the District



4.1.3 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 4-8 and Figure 4-9.

Figure 4-8 presents DO concentrations observed in the Clearwater River in 2014. Prior to the construction of the Kingston Wetland restoration project, data collected at CR28.2 demonstrated that low-flow DO violations occur downstream of Kingston Wetland for most of the year and were driven primarily by wetland sediment oxygen demand (SOD). The Kingston Wetland restoration project rerouted most of the flow of the Clearwater River through a restored meandering stream channel instead of through the Kingston Wetland in early 2013. The DO concentrations observed in summer 2013 and again in 2014 demonstrate that DO concentrations did not decrease significantly from those observed upstream of the Kingston Wetland, and the period during which DO concentrations are in violation of the DO standard was reduced to extreme low flow conditions (flows less than 2 cfs) in late summer.

Figure 4-8: 2014 Clearwater River Dissolved Oxygen Concentrations

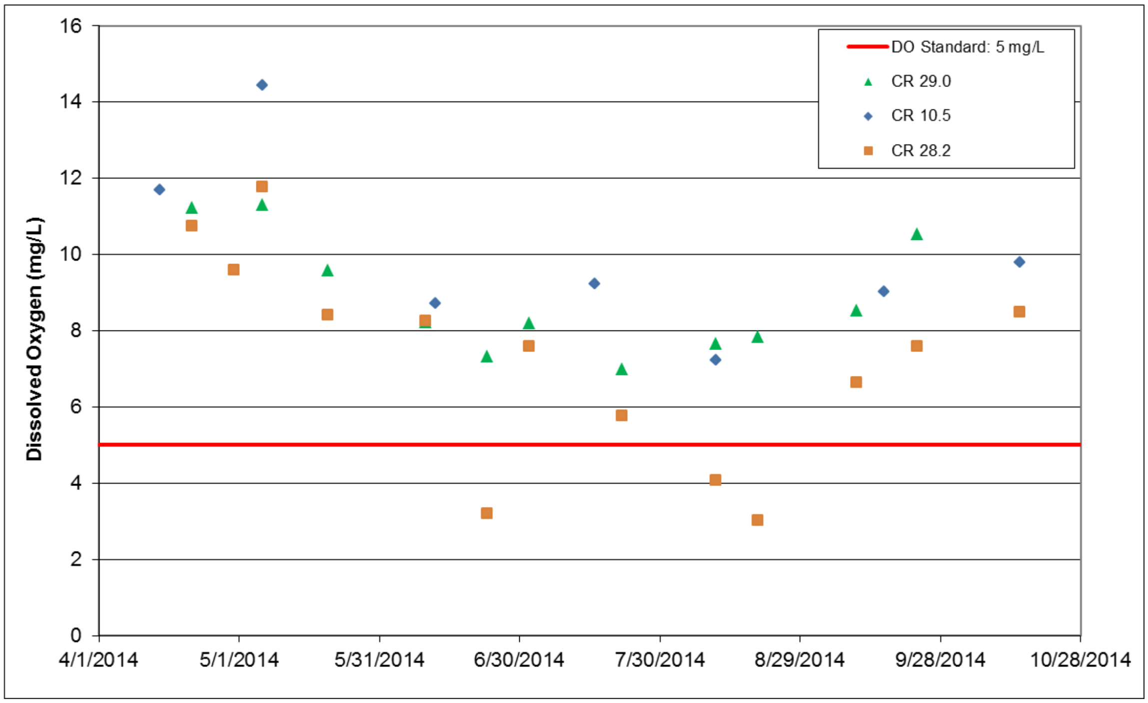
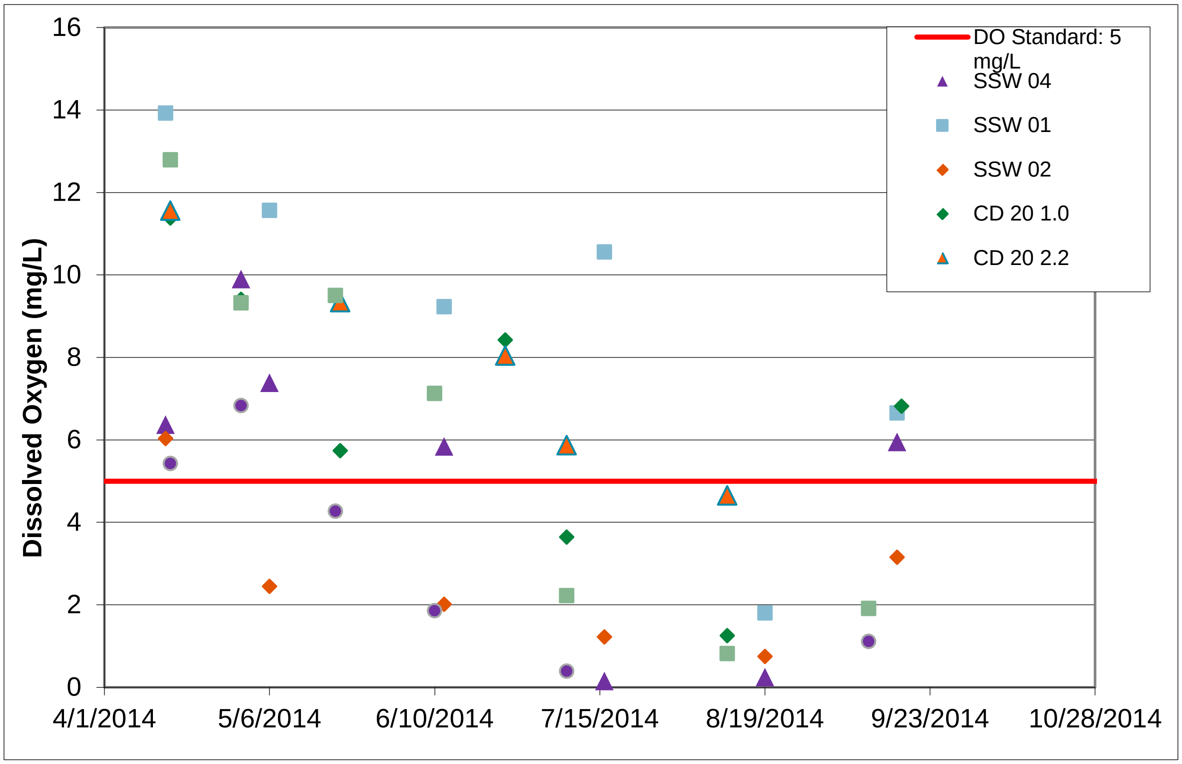


Figure 4-9 shows dissolved oxygen data collected at tributary stream monitoring sites in 2014. DO concentrations fell below the impairment standard at each tributary monitored. In some cases, low DO is the result of oxygen demand in upstream wetlands. In others low summer flow and increased temperatures contributes to low DO.

Figure 4-9: 2014 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 2013.

4.1.4 *E. Coli* Bacteria

Bacteria is measured in the CRWD to track progress towards meeting the CRWDs bacteria TMDL in the Clearwater River between Clear Lake and Lake Betsy, ensure that other areas within the District meet the state standards, and to track sources of non-point source pollution in the District.

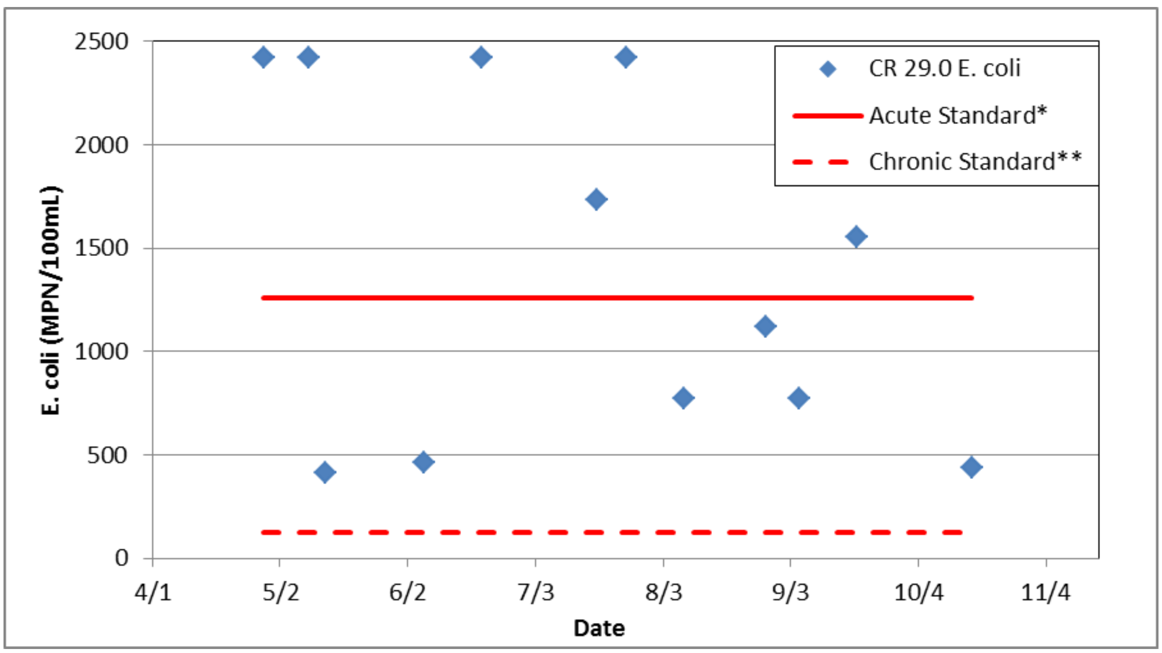
Measurements of most probable number (MPN) of colony forming units (CFU) per 100 mL of *E. coli* were taken at one location on the Clearwater River (CR29.0). Data collected at this site tracks TMDL implementation progress. Table 4-6 shows the monthly geometric means of *E. coli* at stations CR0.1 and CR28.2.

Table 4-6: E. coli Monthly Geometric Means in the Clearwater River

Month	*E. Coli* Geometric Mean (MPN/100mL)	# of Measurements
April	2,420	1
May	997	2
June	1,056	2
July	2,048	2
August	929	2
September	1,094	2
October	435	1

All samples collected at CR29.0 exceeded the chronic standard in 2014. Half the samples exceeded the acute standard. Figure 4-10 shows the *E. coli* measurements during 2014. Depending on the sources of bacteria in the watershed, this may indicate the need for additional projects to target and control bacteria concentrations. Such projects may include controlled access to the River and tributaries for livestock.

Figure 4-10: 2014 E. coli Measurements in the Clearwater River



*Acute Standard: Not to be exceeded by the monthly geometric mean

**Chronic Standard: Maximum not to be exceeded by 10% of samples taken in a calendar month

4.2 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 fourteen lakes in 2014. Parameters analyzed in 2014 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, ortho-phosphorus, and total iron were also collected near the lake bottom for selected lakes. 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.

4.2.1 2014 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 4-7. The MPCA standards are also used as the TMDL goals for summer average concentrations and Secchi depth in District lakes.

Table 4-7: 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 4-11 and 4-12 compare the average total phosphorus concentrations in lakes sampled in 2013 to the TMDL goal.

Figure 4-11: 2014 Summer Average Total In-Lake Phosphorus Concentrations (Deep Lakes)

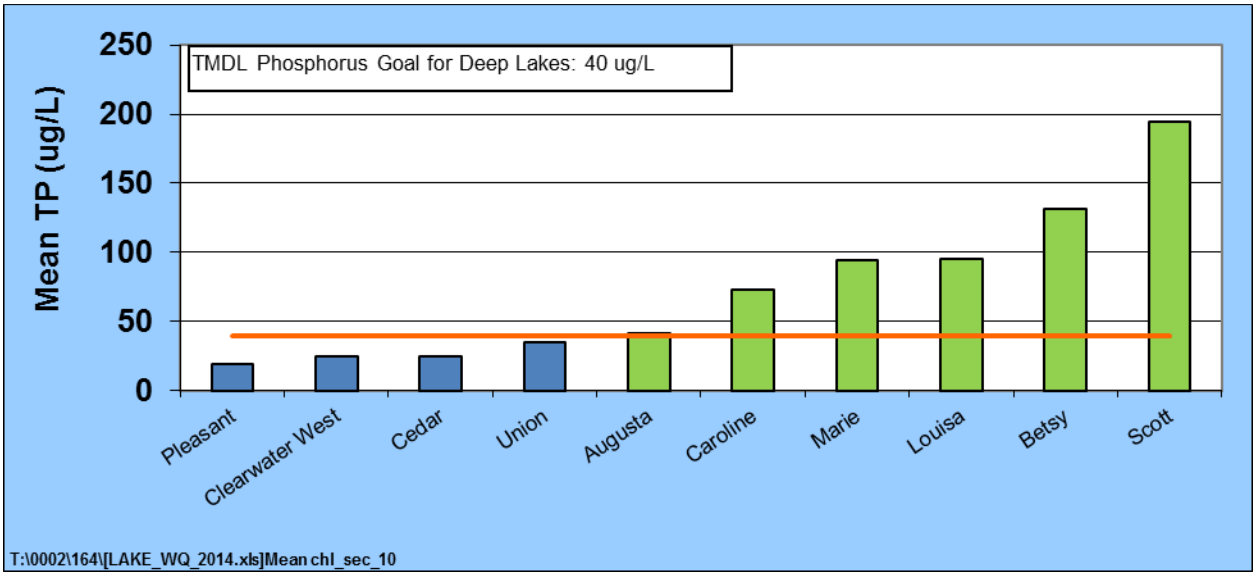
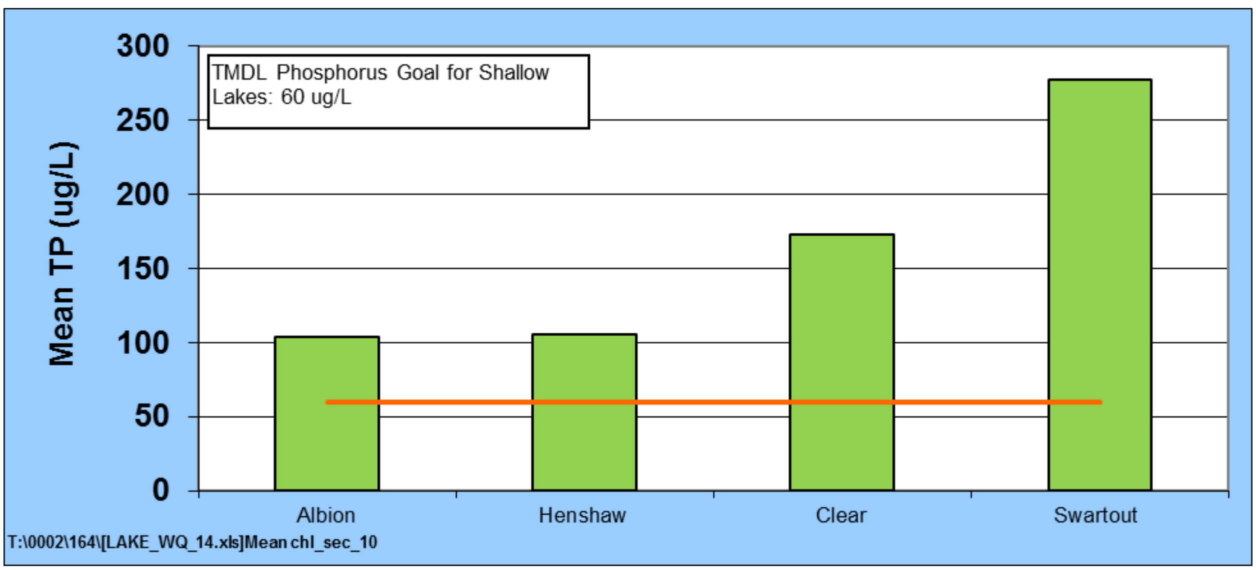


Figure 4-12: 2014 Summer Average Total In-Lake Phosphorus Concentrations (Shallow Lakes)



In general, phosphorus concentrations were slightly higher in most lakes in 2014 in comparison to recent years due to increased runoff and loading from the watershed, but were lower than concentrations observed in recent years with similar runoff. Particulate phosphorus concentrations appeared to make up a larger proportion of the total phosphorus in 2014. Based on the 2014 monitoring data for each lake Augusta, Caroline, Marie, Louisa, Betsy, Scott, Henshaw, Clear, Albion, and Swartout were above the TMDL goal for total phosphorus. Although phosphorus concentrations did not meet TMDL goals in these lakes, concentrations were dramatically improved in Albion, Betsy, and Swartout Lakes. Phosphorus concentrations increased significantly in Clear, Louisa, and Scott in 2014.

Figures 4-13 and 4-14 compare the most recent summer average chlorophyll-a concentrations for fourteen CRWD lakes to the appropriate chlorophyll-a TMDL goal. In 2014, Caroline, Marie, Louisa, Scott, Clear, and Albion were above the TMDL goal for chlorophyll-a. A recent trend of decreasing chlorophyll-a concentrations continued in 2014 in Albion, Betsy, Henshaw, Louisa, Swartout, and Union Lakes.

Figure 4-13: 2013 Summer Average Chlorophyll-a Concentrations (Deep Lakes)

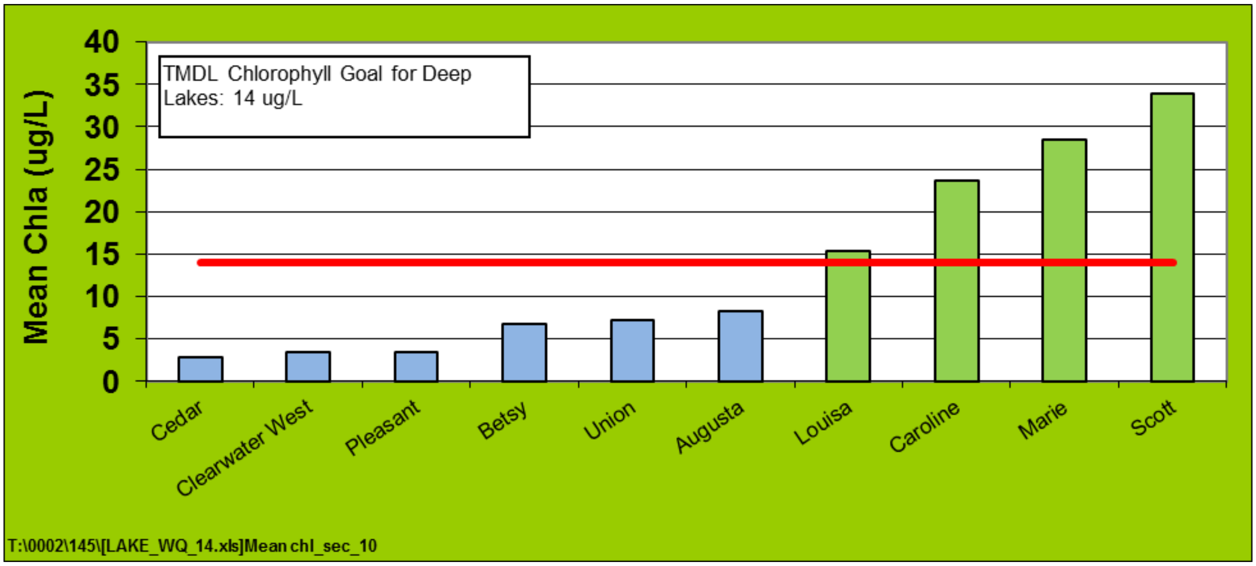
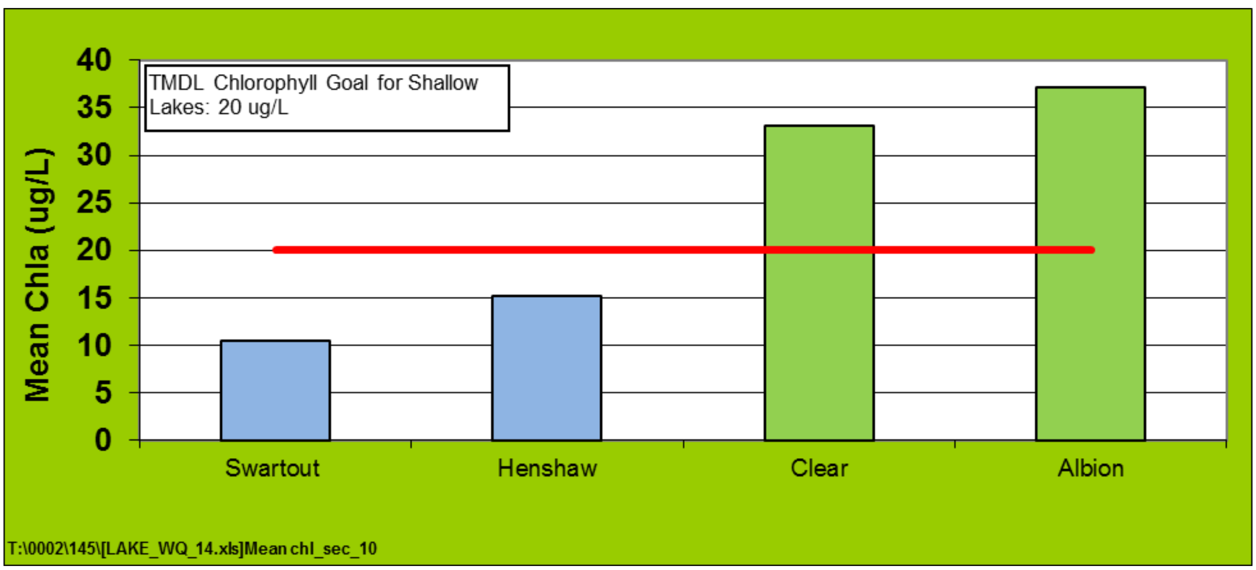


Figure 4-14: 2013 Summer Average Chlorophyll-a Concentrations (Shallow Lakes)



Figures 4-15 and 4-16 compare the 2014 Secchi disk depth for CRWD lakes to the appropriate Secchi TMDL goal. Water clarity generally decreased in many District lakes in 2014 due to increased runoff in the lakes in early summer. The TMDL goal was met for all lakes except Marie, Caroline, Louisa, Albion, and Clear.

Figure 4-15: 2014 Summer Average In Lake Secchi Depth (Deep Lakes)

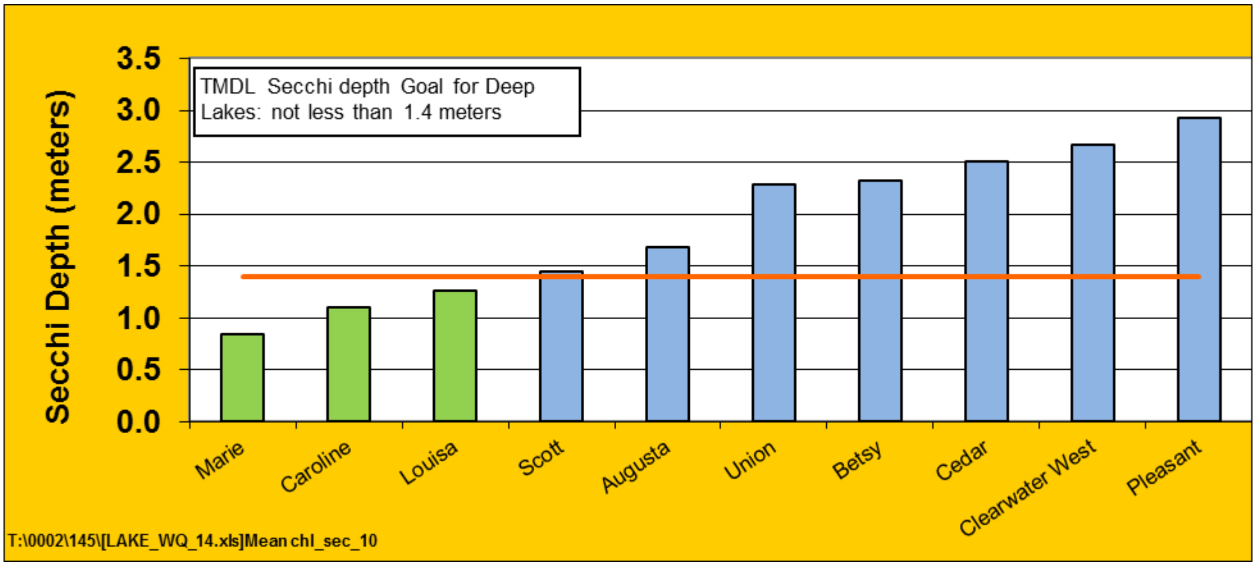
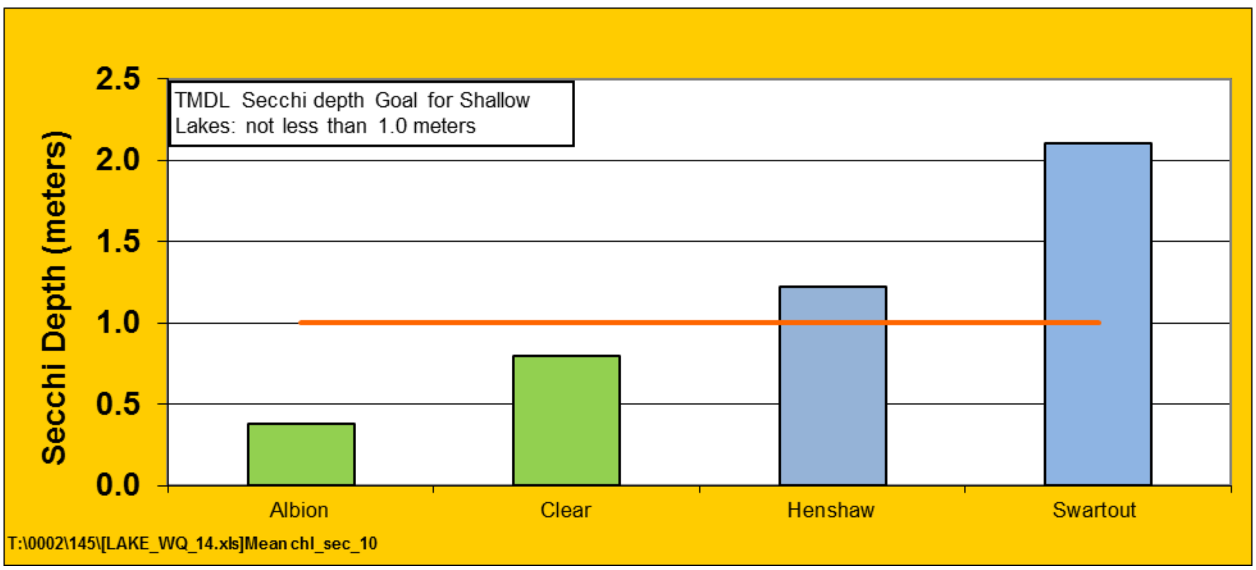


Figure 4-16: 2014 Summer Average In-Lake Secchi Depth (Shallow Lakes)



As demonstrated in Table 4-8, phosphorus and Chlorophyll-a concentrations were near the low end of historic ranges in most lakes in 2014. Phosphorus concentrations in Albion and Clearwater Lakes and Chlorophyll-a concentrations in Albion, Cedar, Clearwater, Pleasant, Swartout and Union were the lowest ever observed in these lakes. Secchi disk depths were near the midpoint of historic ranges in most lakes in 2014, with the highest Secchi readings ever observed at each lake being recorded in Clearwater and Swartout Lakes. Secchi depth was near the low end of the historic range in Albion, Caroline, and Marie Lakes in 2014.

Table 4-8: 2014 Mean In-Lake Total Phosphorus, Chlorophyll-a, and Secchi Depth, and Historical Ranges

	Total Phosphorus ug/l		Chlorophyll-a ug/L		Secchi Depth (meters)	
Lake	2014 Mean	Historical Range Mean	2014 Mean	Historical Range Mean	2014 Mean	Historical Range Mean
Albion	104	130-296	37	38-204	0.4	0.3-1.2
Augusta	42	28-300	8	4-73	1.7	1.1-2.3
Betsy	131	120-700	7	4-170	2.3	0.5-2.4
Caroline	73	36-300	24	3-55	1.1	0.8-2.1
Cedar	25	19-58	3	3-20	2.5	1.1-3.0
Clear	173	80-307	33	17-153	0.8	0.3-1.2
Clearwater West	25	25-160	3	4-77	2.7	1.4-2.6
Henshaw	105	81-390	15	7-178	1.2	0.2-1.7
Louisa	96	33-440	15	4-101	1.3	0.6-2.1
Marie	473	69-360	28	4-153	0.8	0.4-2.3
Pleasant	20	15-51	3	4-32	2.9	2.0-3.0
Scott	194	82-660	34	3-223	1.5	0.5-1.9
Swartout	277	200-421	11	23-832	2.1	0.2-1.9
Union	35	25-88	7	7-39	2.3	1.0-2.6
Above TMDL Goal						
T:\0002\218_2014 Water Quality Monitoring\Water Quality Data\[Lake WQ 2014.xlsx]Historical Table						

Table 4-9 compares CRWD lakes to MPCA impairment standards and identifies phosphorus concentration trends in each lake. Water quality does not meet TMDL goals in 10 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. 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 4-9: Lake Trend and Impairment Summary

Lake	Last Monitored	Phosphorus Trend	Use
Albion*	2014	Recent Decreasing Trend	Impaired
Augusta*	2014	Stable Trend	Full Use
Bass	2013	Stable Trend	Full Use
Betsy*	2014	Recent Stable Trend	Impaired
Caroline*	2014	Recent Increasing Trend	Impaired
Cedar	2014	Stable Trend	Full Use
Clear*	2014	Recent Increasing Trend	Impaired
Clearwater East	2013	Recent Stable Trend	Full Use
Clearwater West	2014	Recent Stable Trend	Full Use
Grass	2013	Decreasing Trend	Full Use
Henshaw*	2014	Stable Trend	Impaired
Little Mud	2012	Decreasing Trend	Full Use
Louisa*	2014	Recent Stable Trend	Impaired
Marie*	2014	Recent Stable Trend	Impaired
Nixon	2013	Recent Stable Trend	Full Use
Otter	2012	Stable Trend	Full Use
Pleasant^	2014	Stable Trend	Full Use
School Section	2013	Stable Trend	Full Use
Scott*	2014	Recent Increasing Trend	Impaired
Swartout*	2014	Recent Stable Trend	Impaired
Union*	2014	Recent Stable Trend	Impaired
Wiegand	2009	Decreasing Trend	Full Use

T:\0002\218_2014 Water Quality Monitoring\Water Quality Data\[Lake WQ 2014.xlsx]Summary

*TMDL Impaired

^ Also monitored by lake association in 2014

4.2.2 Additional Monitoring Efforts

Samples were collected near the bottom at Augusta, Caroline, Louisa, Marie, Scott, and Union Lakes in 2013 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 J. 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 2014 demonstrates that most lakes that typically stratify were stratified in early June and remained stratified through September.

Table 4-10 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 2014. 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 4-10 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 4-10: 2014 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	104	8	Not Sampled		Mixed
Augusta	42	8	554	415	Strongly Stratifies
Betsy	131	70	1246	771	Weakly Stratifies
Caroline	73	10	1450	1168	Strongly Stratifies
Cedar	25	8	Not Sampled		Strongly Stratifies
Clear	173	52	155	56	Polymictic
Clearwater West	25	11	Not Sampled		Strongly Stratifies
Henshaw	105	11	Not Sampled		Mixed
Louisa	96	27	882	740	Strongly Stratifies
Marie	95	10	1010	784	Strongly Stratifies
Pleasant	20	4	Not Sampled		Strongly Stratifies
Scott	194	86	282	185	Polymictic
Swartout	277	142	Not Sampled		Mixed
Union	35	36	860	634	Strongly 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 2014 include Betsy, Caroline, Louisa, Marie, 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, and Clear 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 2014 as anoxic conditions developed in these lakes in early summer. This is especially evident in Augusta, Louisa, Marie, and Union Lakes. The bottom phosphorus concentrations in these lakes typically decrease after mixing with the entire water column during fall turnover. This pattern of seasonal increase in bottom phosphorus concentrations is evident in most years as shown in Appendix J, which compares bottom phosphorus concentrations in District Lakes since 2009.

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.

Appendix A

2014 Water Quality Monitoring Plan

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TECHNICAL MEMORANDUM

TO: Clearwater River Watershed District Board of Managers

FROM: Norman C. Wenck, Engineer for the District

DATE: February 12, 2014

SUBJECT: Proposed 2014 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 2014 program is intended to assess District progress towards water quality goals and to track long-term water quality trends. The monitoring program also tracks the performance of water quality improvement projects implemented by the District.

Please note that additional sites will continue to be monitored in the upper watershed in 2014 as part of the GPS Fertilizer Application Project and Kingston Wetland post-construction monitoring.

The 2014 proposed monitoring stations are shown on Figure 1. The 2014 proposed lake monitoring follows the long-term plan as shown in Table 1. The proposed monitoring sites together with a proposed schedule and laboratory and field parameters are shown in Table 2.

Lake Monitoring

It is recommended that the District's 2014 lake monitoring include the lakes shown on Table 1, including Clearwater West, Augusta, Louisa, Caroline, Scott, Marie, Pleasant, and Union Lakes. Clear Lake and Lake Betsy will be monitored from May to September as part of the Fertilizer Application Project. Surface water samples and profiles of field parameters should be collected at all of the sampled lakes. Bottom samples should be collected in Betsy, Clear, Augusta, Louisa, Marie, Caroline, Scott, and Union Lakes to track internal loading in these lakes.

The proposed stations and the parameters to be monitored are shown on Table 2.

Stream Monitoring

The Clearwater River will be monitored once a month from March-October at long –term monitoring station CR 10.5 at the Grass Lake Dam. Warner Creek will be monitored once a month at long-term monitoring station WR 0.2 from March-October. Willow Creek will be monitored at two locations (WC2.5 & WC 3.0) to track the progress of projects implemented in the City of Kimball.

These stations will be monitored for water quality and flow. Water quality parameters are total phosphorus, ortho-phosphorus, and total suspended solids.

The Clearwater River will be monitored twice a month from March-October at long-term monitoring station CR28.2 and CR 29.0 as part of the Kingston Wetland Restoration Project. Water quality parameters at these stations are total phosphorus, ortho-phosphorus, total suspended solids, and total nitrogen. Samples will be collected to be analyzed for *E. coli* at CR29.0. Continuous water level will also be recorded at both stations.

As shown in Figure 1, several other stream locations in the upper watershed will be monitored as part of the Fertilizer Application Project in 2014.

Cedar Lake Subwatershed Monitoring

Monitoring conducted in the Cedar Lake Subwatershed will continue in 2014. Surface water quality samples and temperature/dissolved oxygen profile data should be collected from Cedar, Albion, Henshaw, and Swartout Lakes in 2014. Tributary streams in the Cedar Lake subwatershed will also be monitored in five locations while they are flowing from March to October.

It is also recommended that the District continue to conduct aquatic vegetation surveys in Albion, Henshaw, and Swartout Lakes in 2014. The vegetation surveys should be conducted in late summer to track the overall vegetation coverage and species in each lake to compare to surveys conducted in previous years. The lakes would also be mapped using sonar equipment during the survey to provide aquatic vegetation biomass, lake contours, lake volume, and bottom hardness data.

It is also recommended that the District develop a continuous water level measurement station in the Cedar Lake subwatershed by installing equipment that the District already owns at a site in the watershed.

Estimated Cost

The proposed basic monitoring program is estimated to be funded by an estimated $12,000 from the 1980 Project and $9,000 from the Data Acquisition Fund. An estimated 280 hours of CRWD staff time will be required to complete these monitoring tasks. The Cedar Lake Subwatershed monitoring is estimated to cost $5,500 plus an estimated 120 hours of CRWD staff time.

Recommended Supplemental Monitoring

In addition to the basic program, it is recommended that supplemental monitoring efforts be considered in 2014. 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: 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 2: Purchase and install additional continuous water level transducer to develop and maintain continuous flow records at additional sites in the watershed.

This supplemental monitoring task would involve purchasing and installing additional pressure transducers at locations in the watershed. The transducers would be used to collect continuous water level data and develop a continuous flow record which would help the District to more accurately estimate runoff and phosphorus loading in the watershed. The estimated cost of this supplemental task would be $1,500 for the purchase of equipment per site and installation materials and 20 hours of District time for installation and maintenance per site. Potential locations would be on County Ditch 20 south of Watkins or the Fairhaven Dam.

Supplemental Monitoring Task 3: Lake mapping with sonar equipment.

This supplemental monitoring task would involve Wenck and District staff mapping selected lakes with sonar equipment that allows for the quantification of aquatic vegetation biomass, lake contours, lake volume, and bottom hardness. This information, in combination with water quality data collected on the lakes, would assist the District in planning future potential projects or evaluating past projects on District lakes. The estimated cost for this supplemental task would be $1,150 per lake for field data collection and processing of the data. Recommended lakes for this data collection and analysis in 2014 are Betsy, Clear, and Augusta. This information would also be collected while conducting vegetation surveys in Swartout, Albion, and Henshaw Lakes.

Supplemental Monitoring Task 4: Additional water quality monitoring on the Clearwater River at monitoring site CR19.8 at Highway 55 upstream of Lake Louisa

This supplemental monitoring task would involve monitoring water quality and flow at the Clearwater River at site CR19.8 upstream of Lake Louisa. The monitoring is proposed to be conducted once a month from March to October. Water quality parameters would include total phosphorus, ortho-phosphorus, and total suspended solids. Flow would be gauged when possible at this site. Water level readings at the Fairhaven Dam could also be used to measure flow at this station. The estimated cost for this supplemental task would be $400 plus 16 hours of District time.

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	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Clearwater Lake:										
Clearwater East		X		X		X		X		X
Clearwater West	X		X	X	X		X		X	
Main Stem Lakes:										
Augusta		X		X	X*	X	X	X	X	X
Louisa	TMDL*	X		X	X	X	X	X	X	X
Caroline	X		X	X	X	X	X	X	X	X
Scott	X		X	X	X*	X	X	X	X	X
Marie	X*		X	X	X	X	X	X	X	X
Betsy		X		X*	X	X	X	X	X	X
Other Lakes:										
Cedar	X		X(2)	X(2)	X(2)	X(2)	X	X	X	X
Pleasant		X	X(3)	X	X		X		X	
School Section		X		X		X		X		X
Nixon		X	X	X		X		X		
Otter		X		X			X			X
Bass	X		X(3)	X		X		X		
Clear			X	X*	X	X	X	X	X	X
Union			X	X	X	X	X	X	X	X
Henshaw		X	X(2)	X(2)	X(2)	X(2)	X	X	X	X
Little Mud	X			X			X			X
Wiegand				X			X			X
Swartout	X		X(2)	X(2)	X(2)	X(2)	X	X	X	X
Albion	X		X(2)	X(2)	X(2)	X(2)	X	X	X	X
Grass			X	X		X		X		X
Number of Lakes Monitored W/ CRWD Funding	10	9	14	22	14	17	17	17	14	18

Note:

(2) Part of Project #06-1

(3) Added to assess trends

* Lake bottom sediment cores collected and analyzed

TABLE 2
Proposed 2014 CRWD Monitoring Plan Summary

Category	2014 Schedule	Station	Parameters
Lakes:	June 3-7, July 8-12, August 5-9, September 2-6 Note: (Lake sampling to be completed by September 15)	The CRWD will monitor Clearwater (West), Augusta, Louisa, Caroline, Scott, Marie, Pleasant, and Union Lakes. Cedar, Albion, Swartout, and Hensaw Lakes will be monitored under Project #06-1. Clear and Betsy will be monitored under the Fertilizer Application Project.	Field: Secchi depth, DO and temperature profiles.
			Lab: surface samples for total phosphorus, ortho phosphorus, and chlorophyll-a Bottom samples for total phosphorus, ortho phosphorus, and total iron in Augusta, Louisa, Caroline, Scott, Marie, Union, Clear, and Betsy.
Streams:	Twice monthly March-October	CR 28.2 and CR29.0 (monitored under Kingston Wetland Project)	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	Warner Creek at WR0.2; Willow Creek at WC 2.5 and WC 3.0	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids,
	Monthly March-October	Clear Lake North, Clear Lake South, CD 20-1.0, CD20-2.2(monitored under Fertilizer Application Project)	
	Continuous Water Level	River Stage at CR10.5, CR28.2, and CR29.0	
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.	

Appendix B

Historical Mean Flow and Phosphorus Loading

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

Clearwater River Watershed District

2014 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
	2013	0.55	19.38	0.252	2,261	4,984	252
	2014	1.04	36.83	0.222	3,358	7,404	222
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
	2013	2.16	76.50	0.024	959	2,115	24
	2014	4.57	161.31	0.024	2,000	4,409	24

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

Clearwater River Watershed District

2014 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
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
	2013	0.49	17.37	0.052	240	529	52
	2014	0.38	13.47	0.046	278	613	46

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\218_2014 Water Quality Monitoring\Water Quality Data\[Stream_Loads_Historic_14.xls]Table 2

Appendix B-TABLE B-2

YEARLY PRECIPITATION AND RUNOFF TOTALS

Clearwater River Watershed District

2014 Annual Report

	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
2013	28.30	24.35		28.87	27.17	3.9
2014	29.49	29.70		28.48	29.22	8.1
				Mean	29.35	7.9
				Std. Dev.	7.6	5.4

NOTES:

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

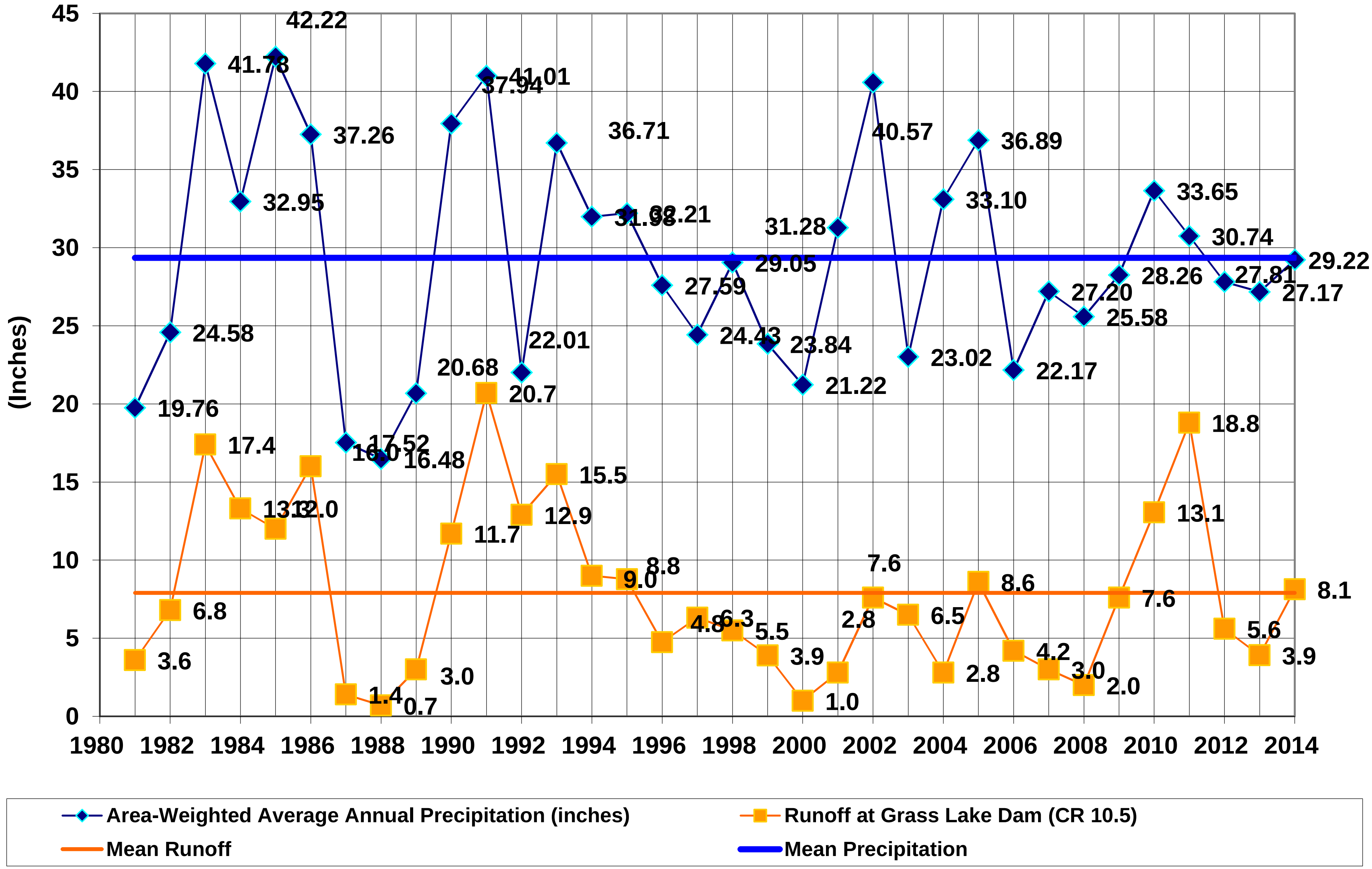
(1) Data for single gauge in east-central part of watershed (Camp Heritage on Lake Caroline).

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

* Value from Kimball Station

T:\0002\218_2014 Water Quality Monitoring\Water Quality Data\[Stream_Loads_Historic_14.xls]Precip_Runoff Data

Appendix B Figure B- 1
Clearwater River Watershed District
2014 Annual Report



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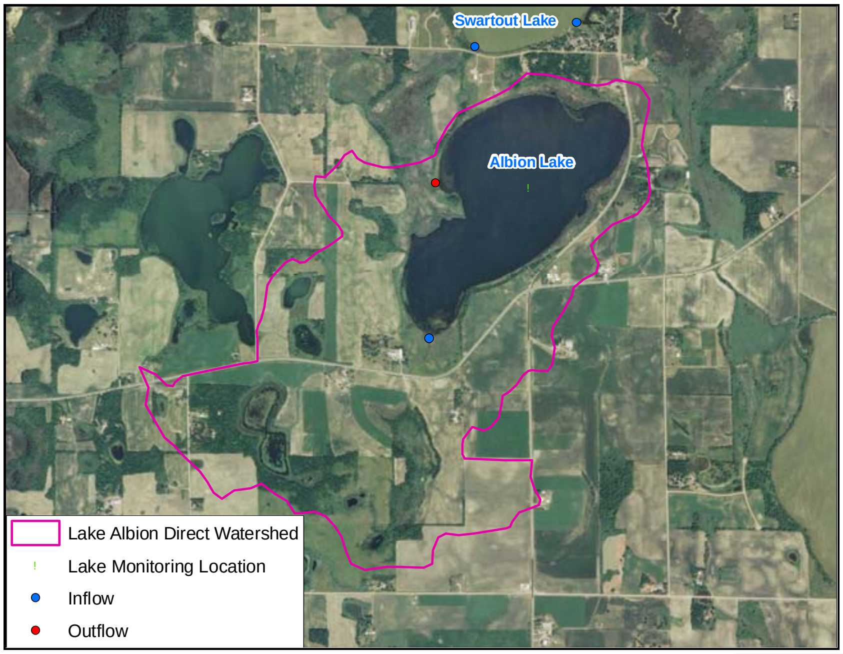
Appendix C

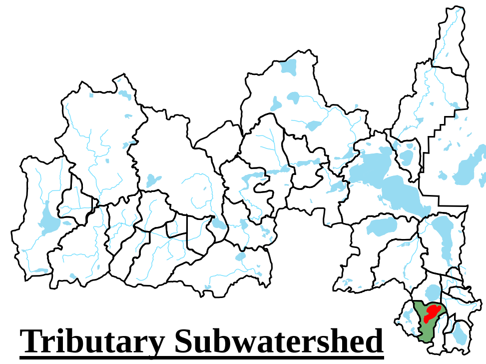
Lake Report Cards

2014 Albion Lake Report Card

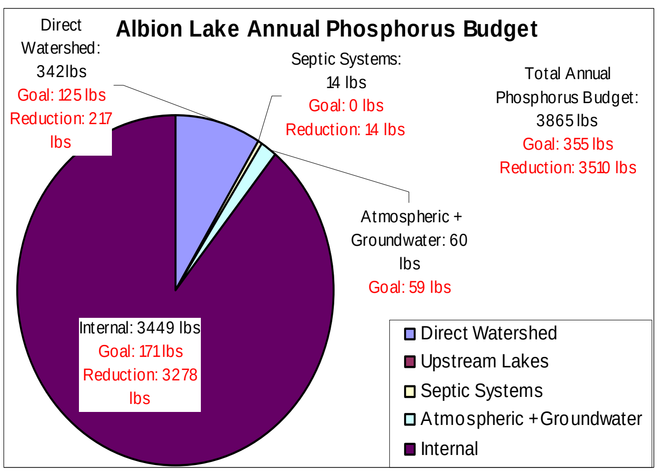


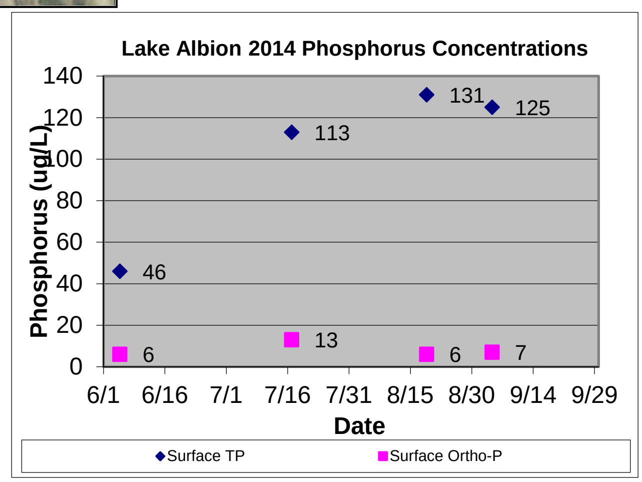
Lake Data

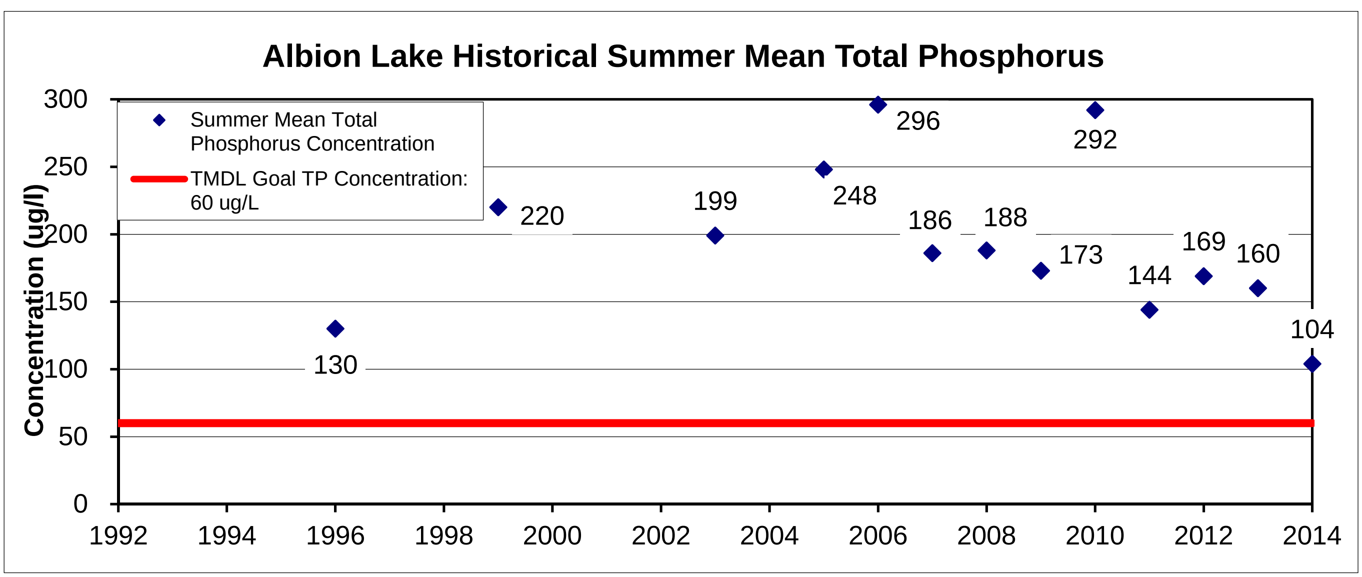
Surface Area:	251 Acres
Maximum Depth:	9 Feet
Contributing Subwatershed Area:	1,094 acres



Tributary Subwatershed (shaded)

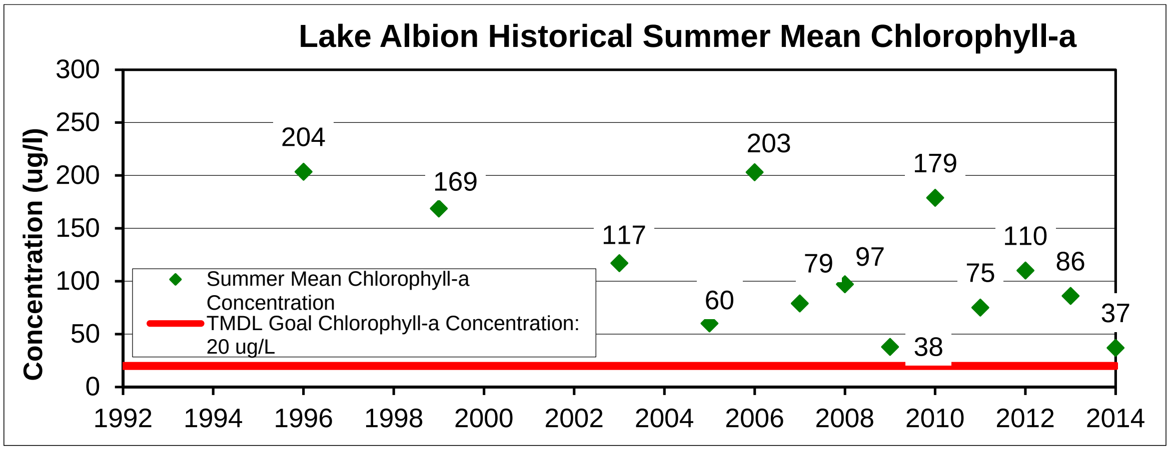


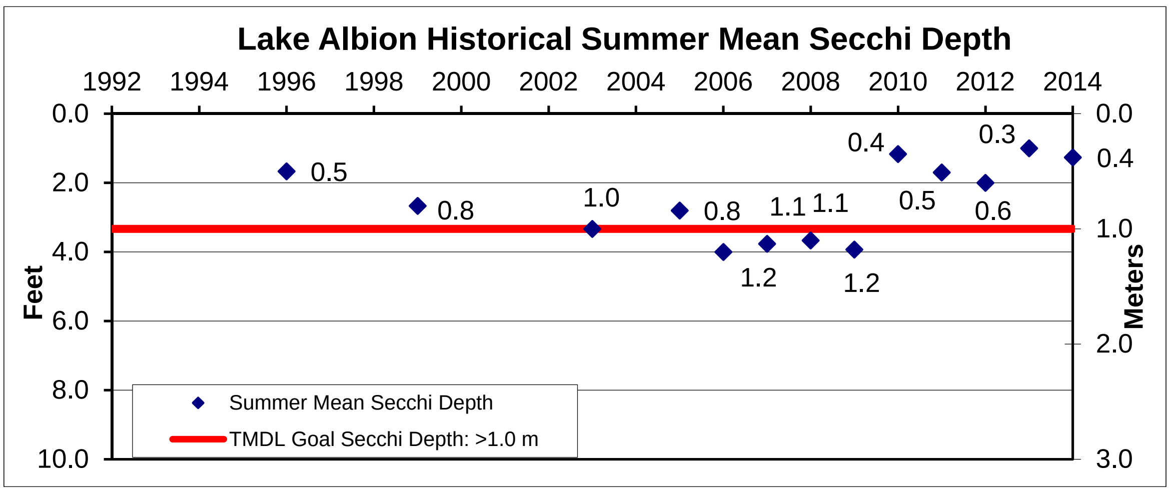




Albion Lake
2014 Lake Report Card

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





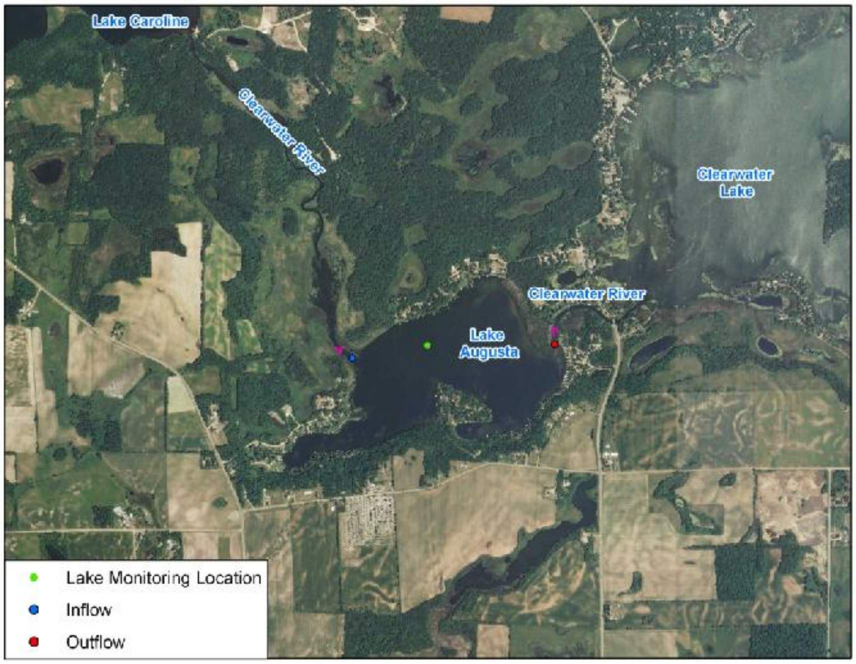
Summary

- TP and Chlorophyll-a concentrations were lower than observed in previous years and were close to the lowest observed in the lake but still remained above TMDL water quality goals.
- Water clarity remained poor in 2014 and was lower than the TMDL goal. Resuspension of bottom sediments are the likely cause of poor water clarity in the lake in 2014.
- An aquatic vegetation survey conducted in 2014 found submerged vegetation at 36% of sampled points. Sago pondweed was the most common vegetation species observed during the 2014 survey, as it was observed at 28% of sampled points.
- Curly leaf pondweed, a non-native aquatic plant that can be detrimental to water quality, was observed in the lake in 2013 and 2014.

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 lake was surveyed for curly leaf pondweed in June 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.

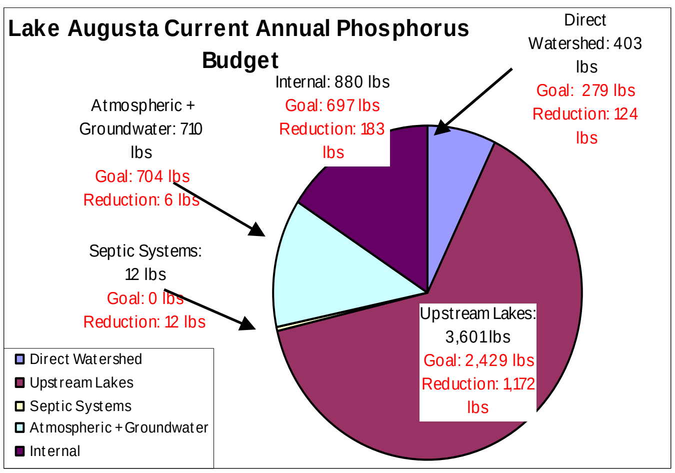
2014 Lake Augusta Report Card

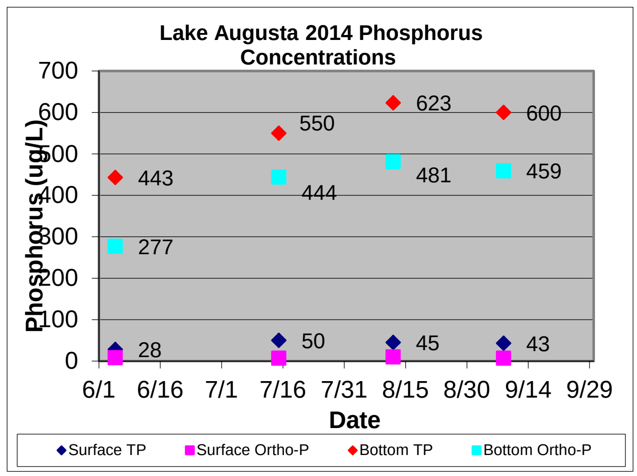


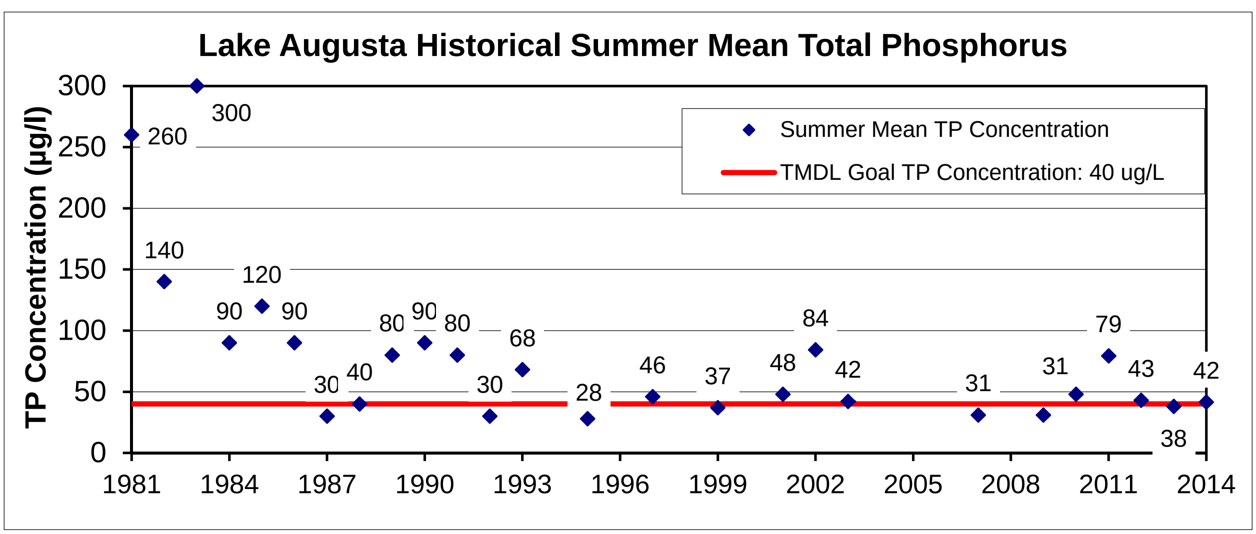
Lake Data

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

Tributary Subwatershed (shaded)



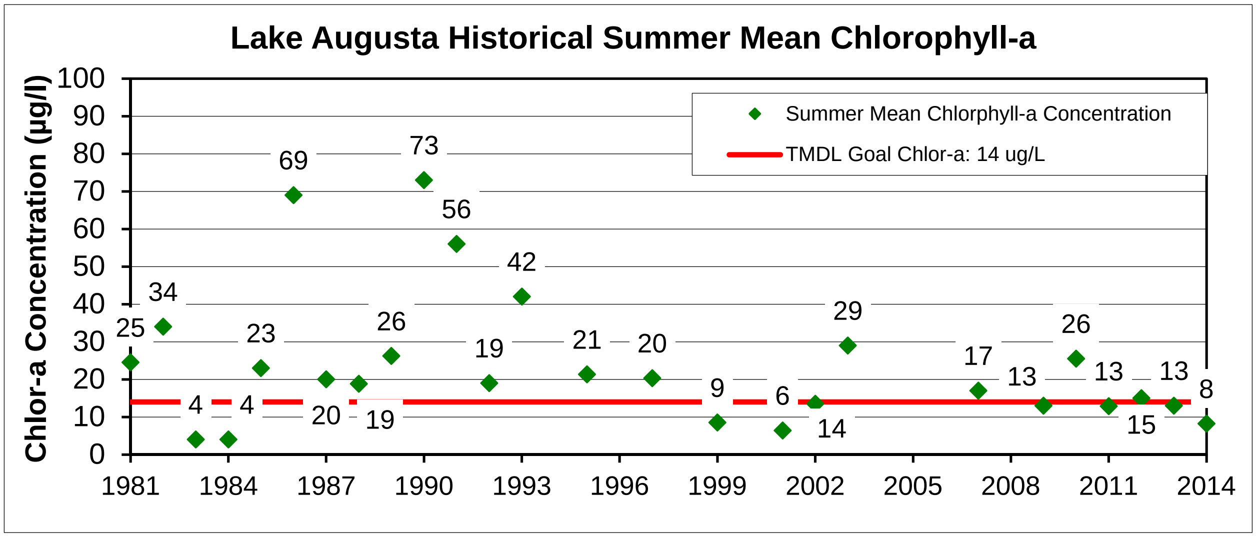


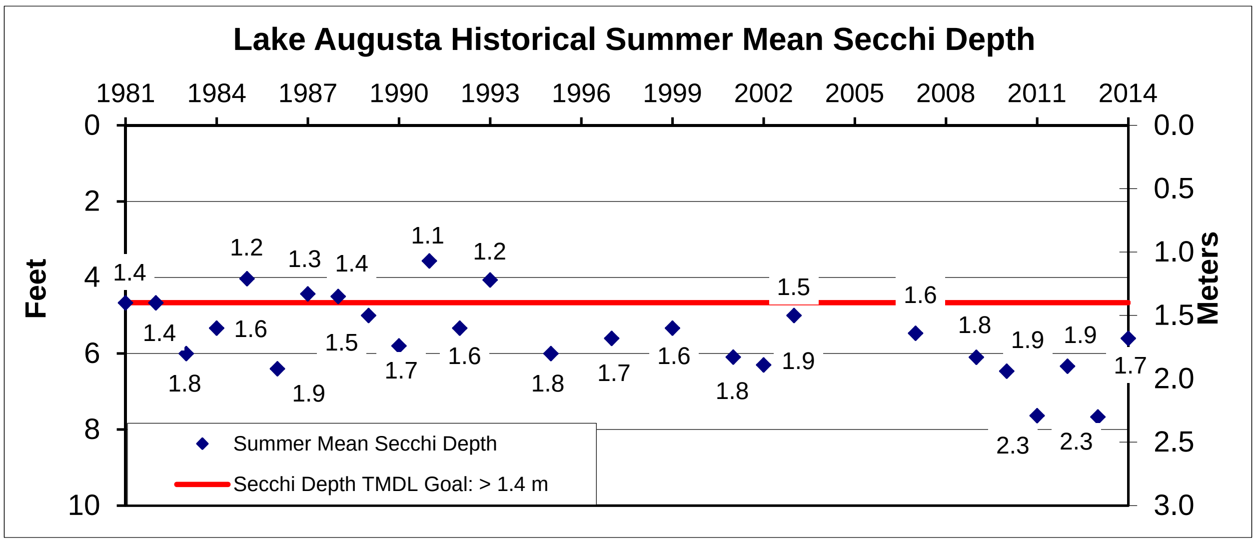


Clearwater River Watershed District	WENCK Responsive partner. Exceptional outcomes. 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2015
Lake Augusta		Appendix C

Lake Augusta
2014 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





2014 Summary

- Phosphorus concentrations were similar to recent years and were near TMDL goals in 2014.
- Chlorophyll-a concentrations were lower than recent years and were below TMDL goals.
- Water clarity decreased slightly in 2014 as Secchi depth was slightly lower but similar to values observed in most recent years and met TMDL goals.
- 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 in the lake as bottom phosphorus concentrations are high in the lake.

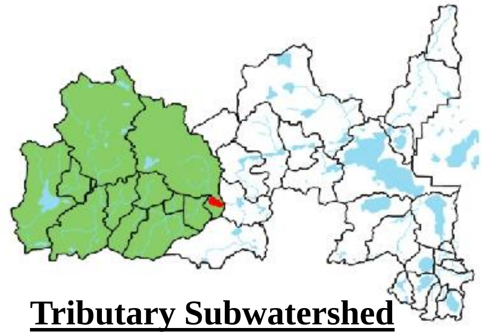
TMDL Activities

- 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 or implemented 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.

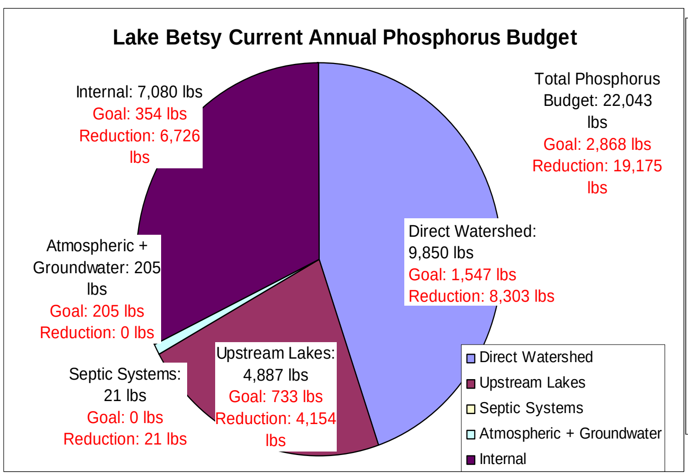
2014 Lake Betsy Report Card

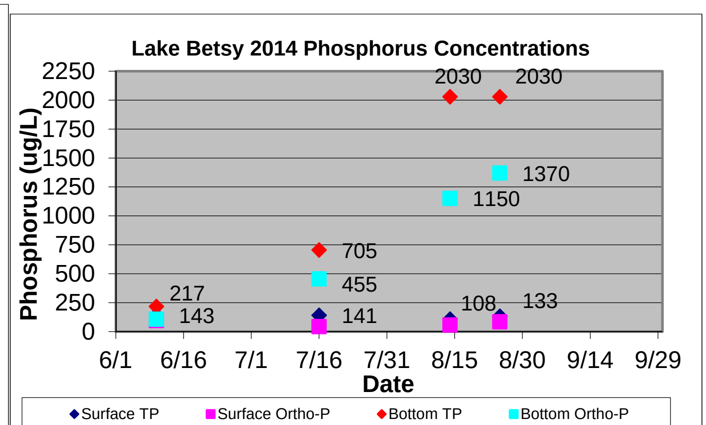
Lake Data

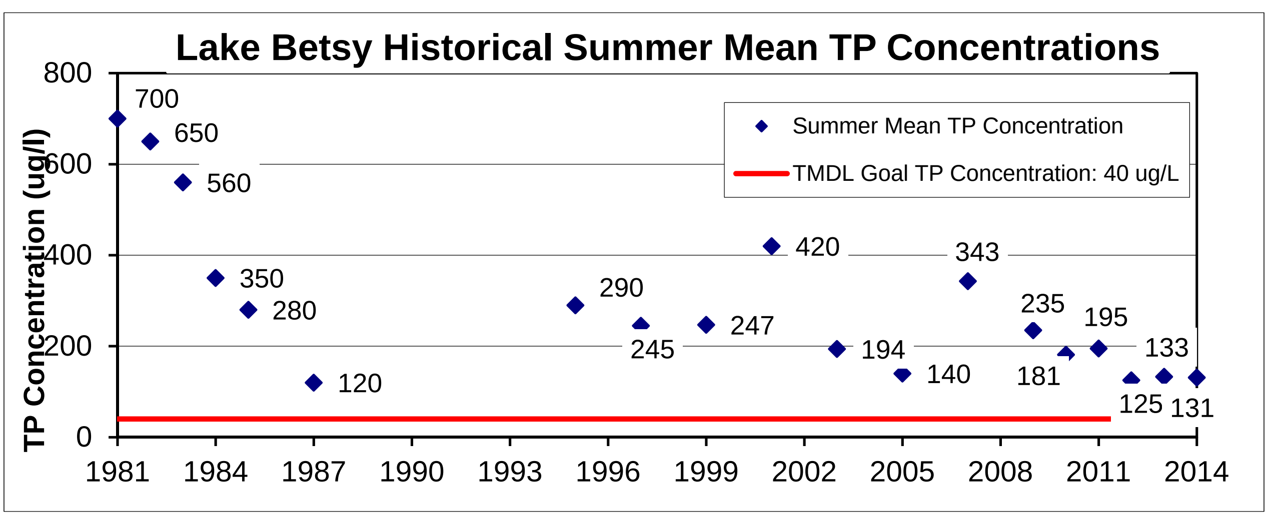
Surface Area:	**153 Acres**
Maximum Depth:	**23 Feet**
Subwatershed Area:	**43,789 acres**
Mean Depth:	**10 Feet**



Tributary Subwatershed (shaded)



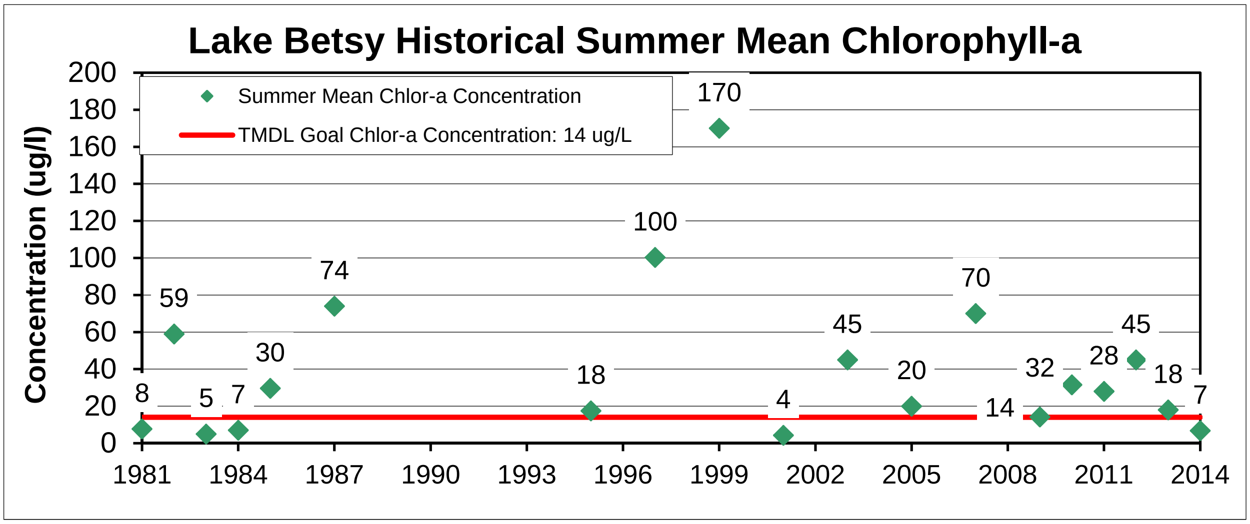


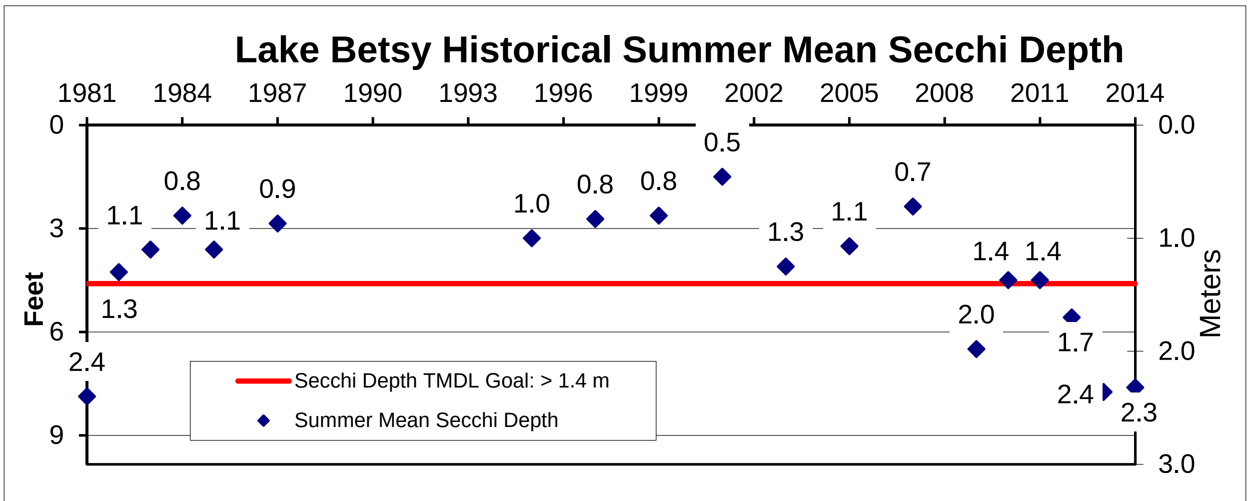


Clearwater River Watershed District	WENCK Responsive partner. Exceptional outcomes. 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2015
Lake Betsy		Appendix C

Lake Betsy
2014 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





2014 Summary

- Recent TP concentrations have been stable and generally decreasing since 2007. TP concentrations remain below those of the early 1980's but are still well above the TMDL goals.
- Water clarity has improved recently as Secchi depth continued to increase in 2014 and has met TMDL goals in recent years.
- Chlorophyll-a concentrations continued to decrease and met TMDL goals in 2014.
- Water quality is dominated by loads from the Clearwater River.
- Sediment phosphorus release rates were measured in 2009 and internal loading of phosphorus was found to be well above the TMDL allocation for the lake.
- Bottom phosphorus concentrations are extremely high in the lake, which is a further indication of high potential for internal loading.

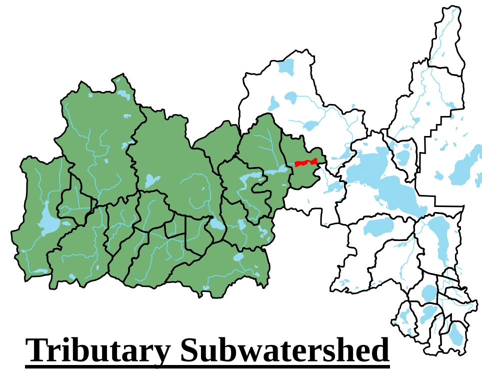
TMDL Activities

- 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 completed in the watershed in recent years appear to have contributed to improved water quality in Lake Betsy.

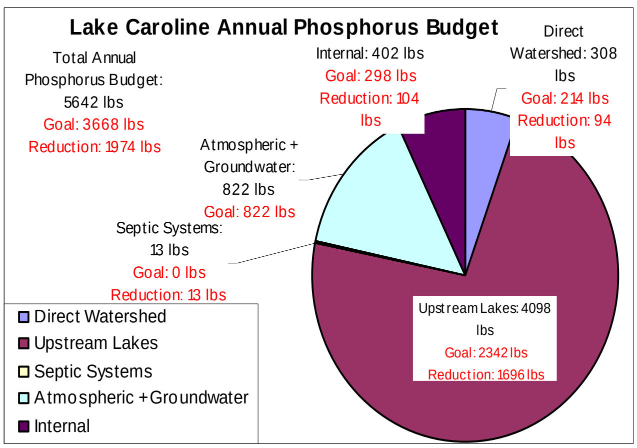
2014 Lake Caroline Report Card

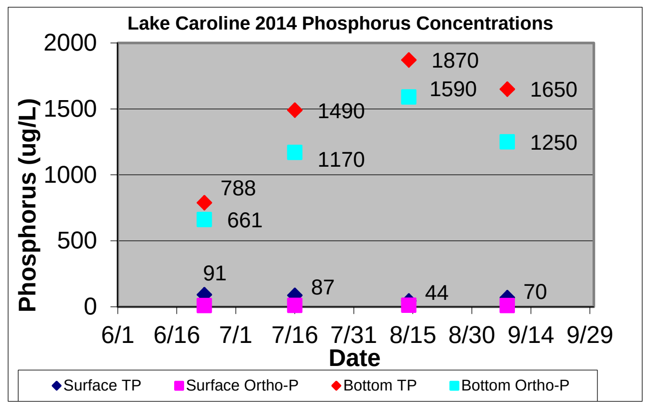
Lake Data

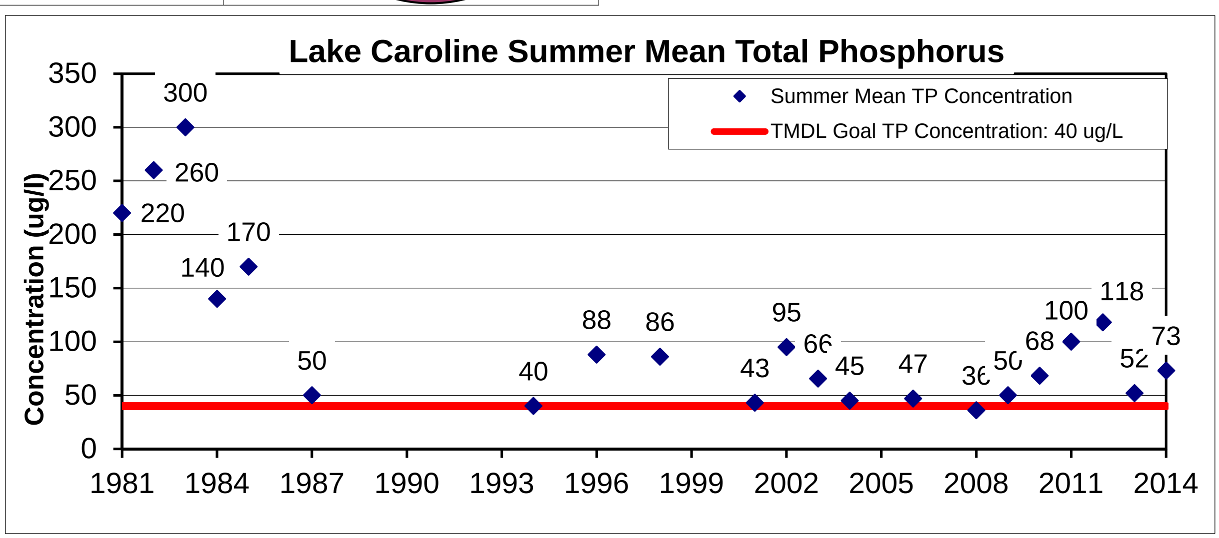
Surface Area: 126 Acres
Maximum Depth: 45 Feet
Subwatershed Area: 60,132 acres



Tributary Subwatershed (shaded)

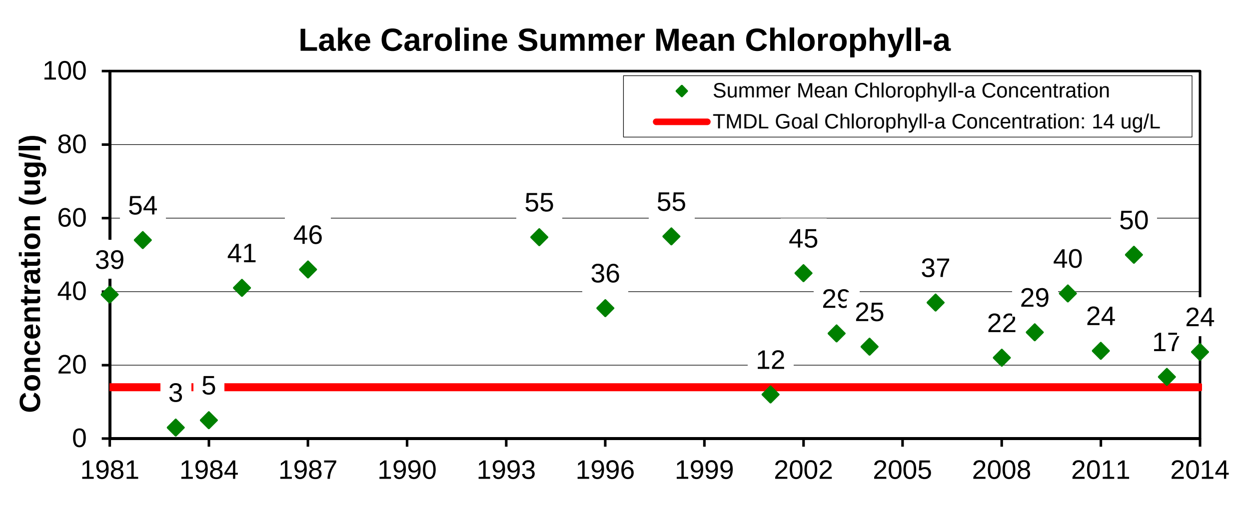


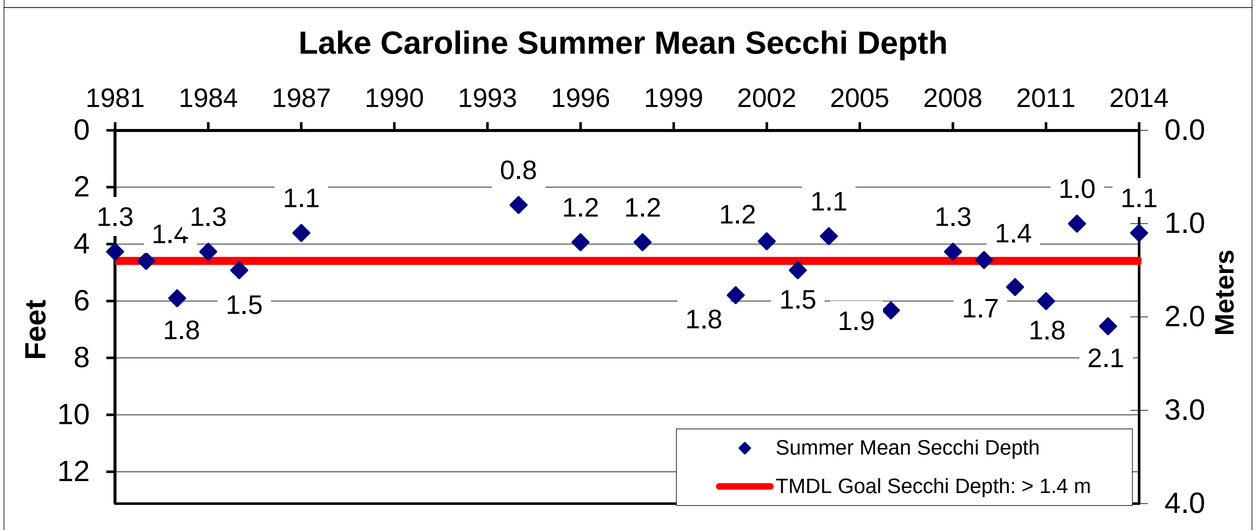




Lake Caroline
2014 Lake Report Card

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





2014 Summary

- TP concentrations were slightly higher than 2013 but remained lower than concentrations observed in most recent years.
- Chlorophyll –a concentrations were similar to most recent years and were above TMDL goals.
- Water clarity decreased in 2014 and the summer mean Secchi depth did not meet TMDL goals.
- Water quality is dominated by loads from the Clearwater River and Lake Marie.
- Bottom phosphorus concentrations observed in 2014 remained high and indicate that internal loading may contribute significant phosphorus to the lake during years with low runoff.

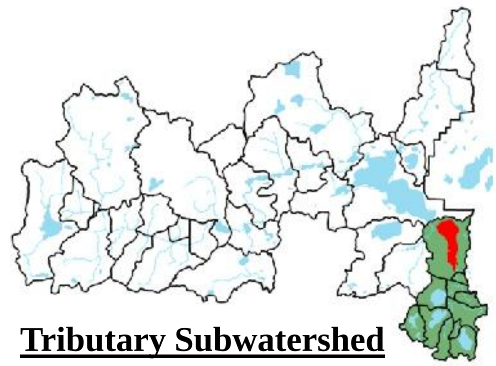
TMDL Activities

- 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.

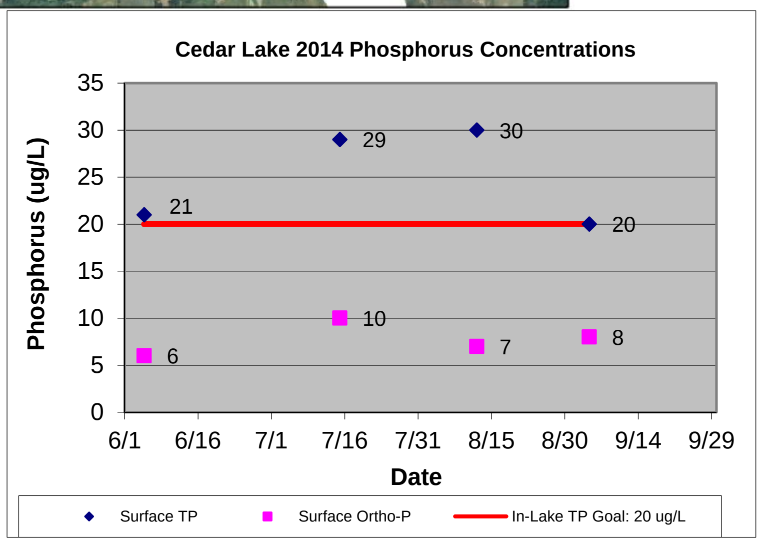
2014 Cedar Lake Report Card

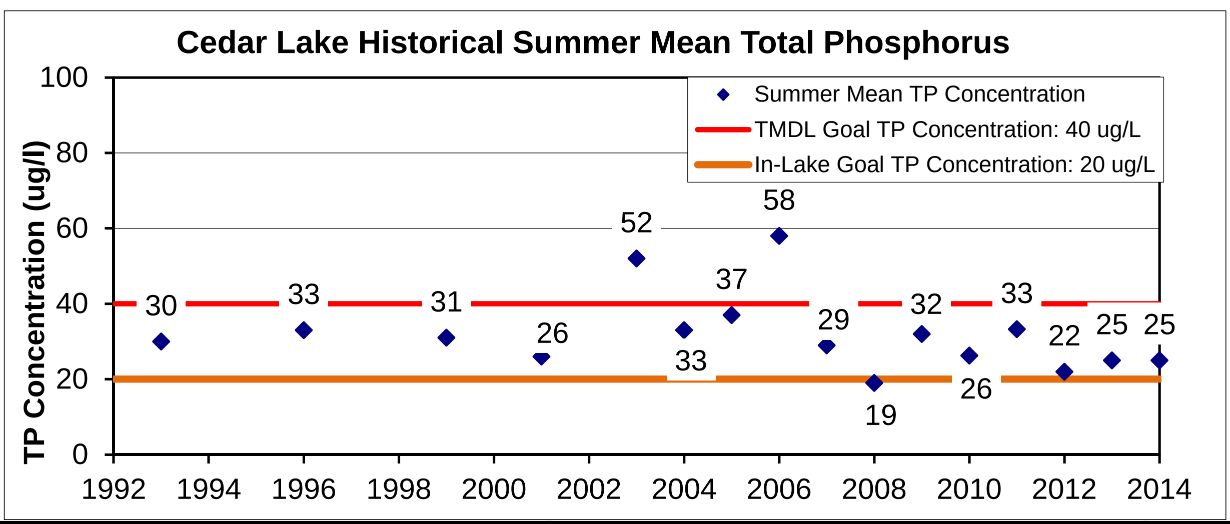
Lake Data

Surface Area:	**783 Acres**
Maximum Depth:	**108 Feet**
Subwatershed Area:	**9.715 acres**



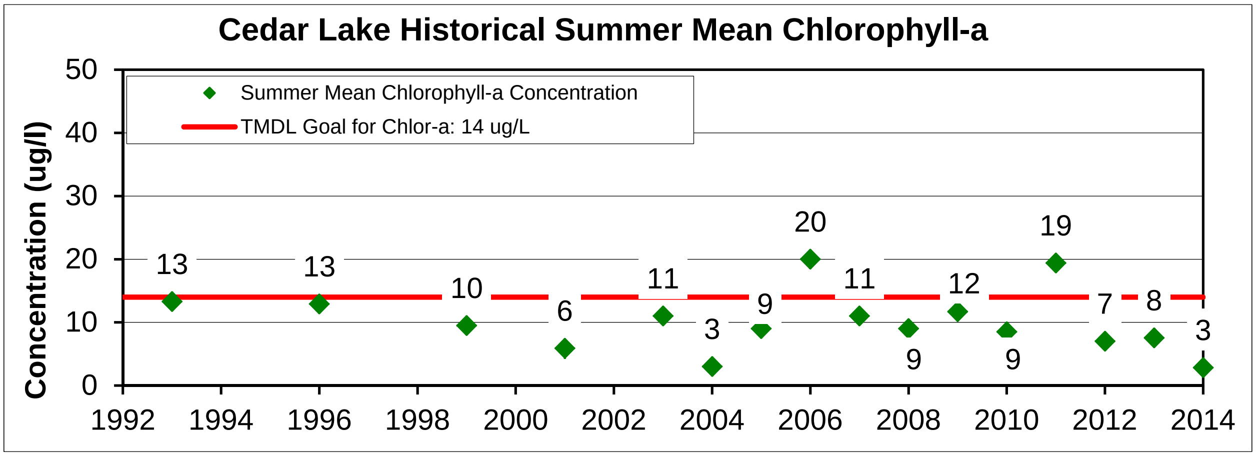
Tributary Subwatershed (shaded)

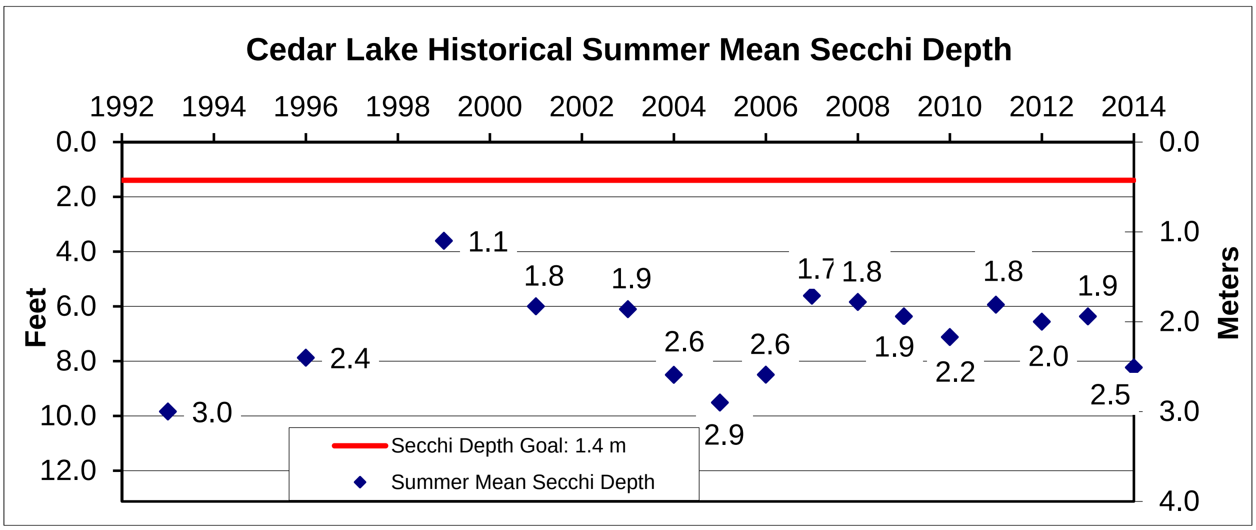




Cedar Lake
2014 Lake Report Card

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





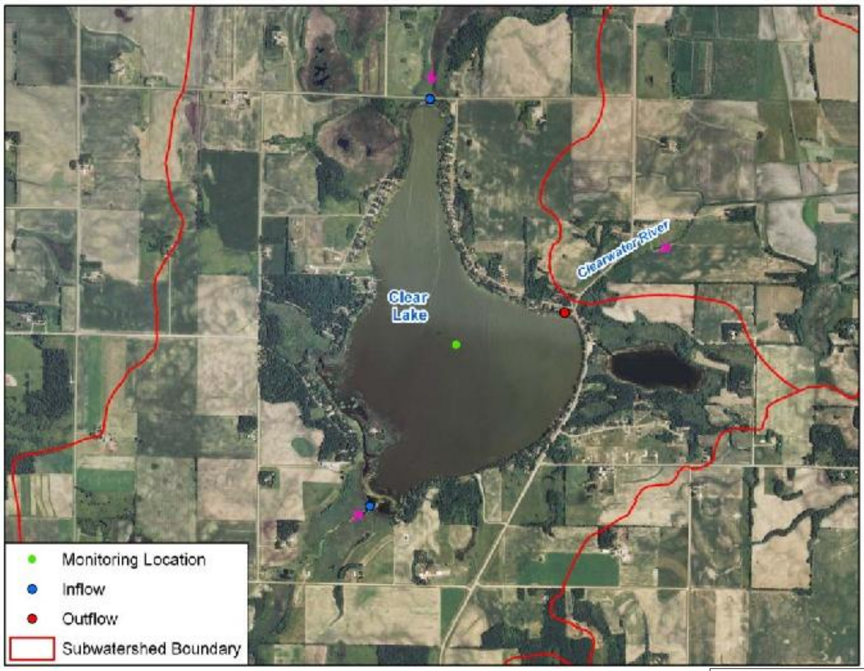
2014 Summary

- 2014 average phosphorus concentrations were identical to 2013 concentrations, were below TMDL goals and near the goals established for the lake at the start of Project #06-1 in 2007.
- 2014 average chlorophyll-a concentrations were the lowest observed in the lake and were below the impairment standard.
- 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 and increased in 2014.
- The primary source of phosphorus is from the upper watersheds and Swartout, Albion, and Henshaw Lakes.

TMDL Activities

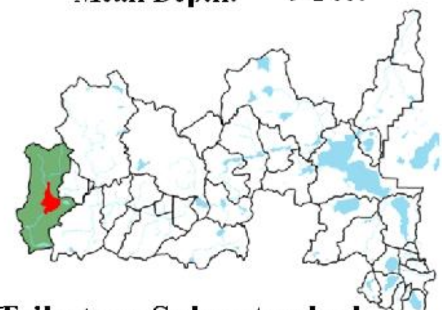
- Since 2007, the Cedar Lake Restoration Project has implemented fish barriers, buffers, tile inlet replacement, and the construction of Segner Pond, a wetland treatment basin. The goal of the project is to reduce the phosphorus load to Cedar Lake from the upper watershed.
- Additional projects geared towards reducing phosphorus are proposed to be implemented in 2014 and future years on the inflow to Cedar Lake upstream of Segner Pond and in the outflow from the tributary wetland upstream of Swartout Lake.
- Measures recommended by the TMDL Implementation Plan for the impaired Swartout, Albion, and Henshaw Lakes will serve to improve water quality in Cedar Lake.

2014 Clear Lake Report Card

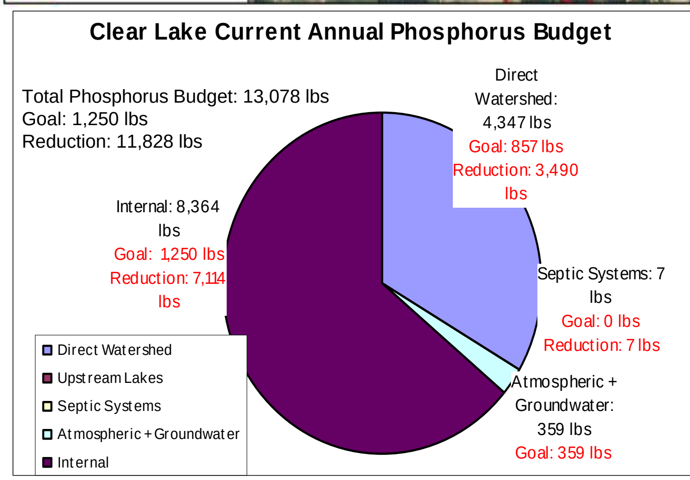


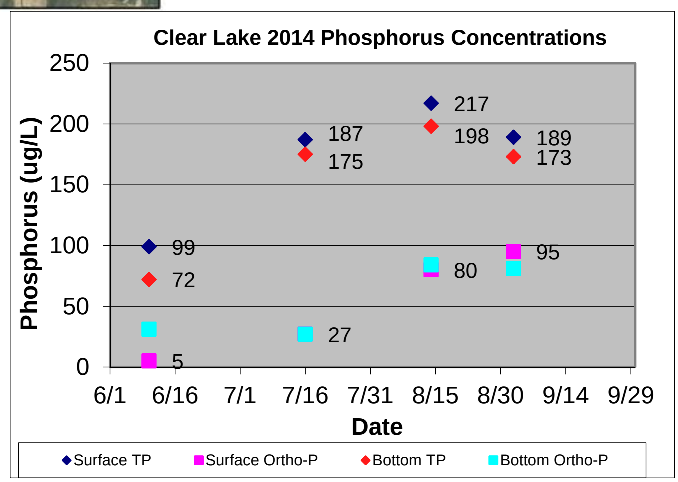
Lake Data

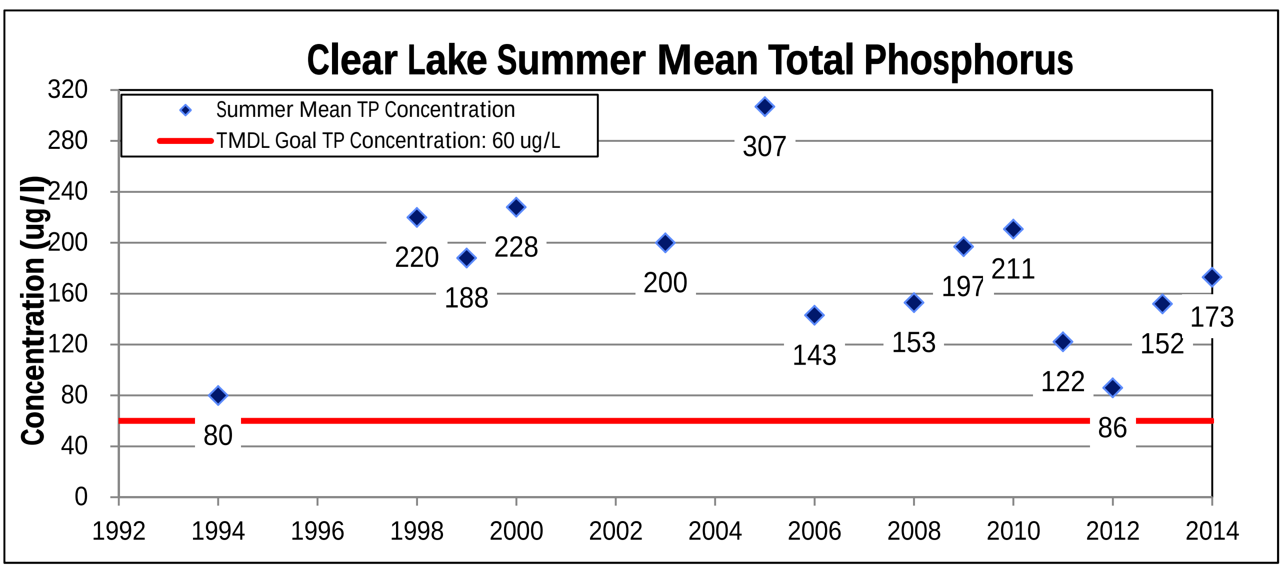
Surface Area: 515 Acres
Maximum Depth: 17 Feet
Subwatershed Area: 6,801 acres
Mean Depth: 9 Feet



Tributary Subwatershed (shaded)

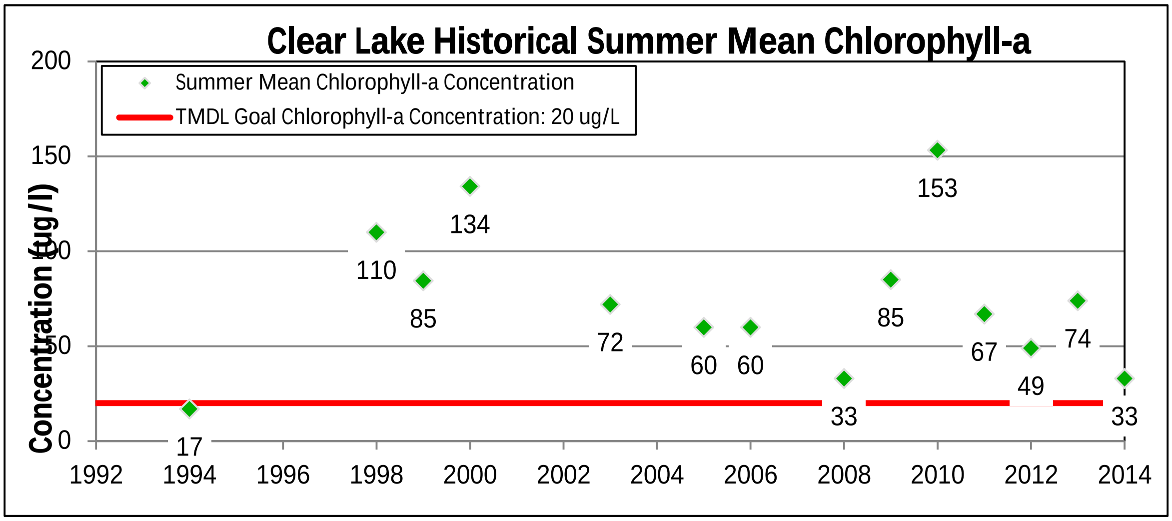


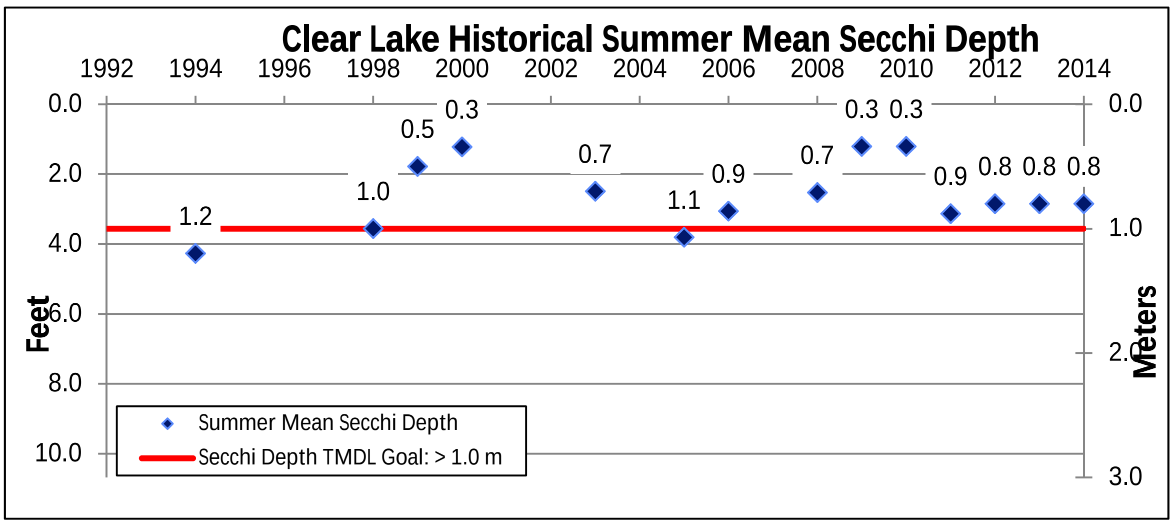




Clear Lake
2014 Lake Report Card

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





2014 Summary

- Clear Lake is located at the headwaters of the Clearwater River.
- Phosphorus concentrations remained above TMDL goals in 2014 and show an increasing trend in recent years. Chlorophyll-a concentrations decreased in 2014 but remain above TMDL goals.
- Secchi depth did not meet the TMDL goal but remained similar to 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.

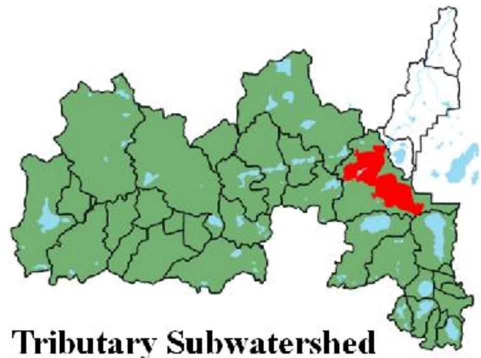
TMDL Activities

- 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 2013.
- Additional sedimentation ponds and watershed BMPs have been recommended as potential TP reduction strategies.
- The CRWD constructed a notched weir and treatment filter on a tributary stream south of the lake in 2012 to address phosphorus loads from the subwatershed.

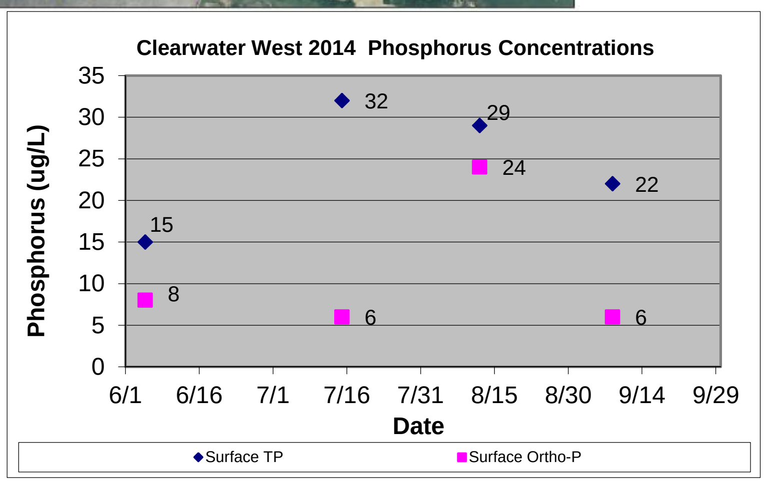
2014 Clearwater Lake Report Card

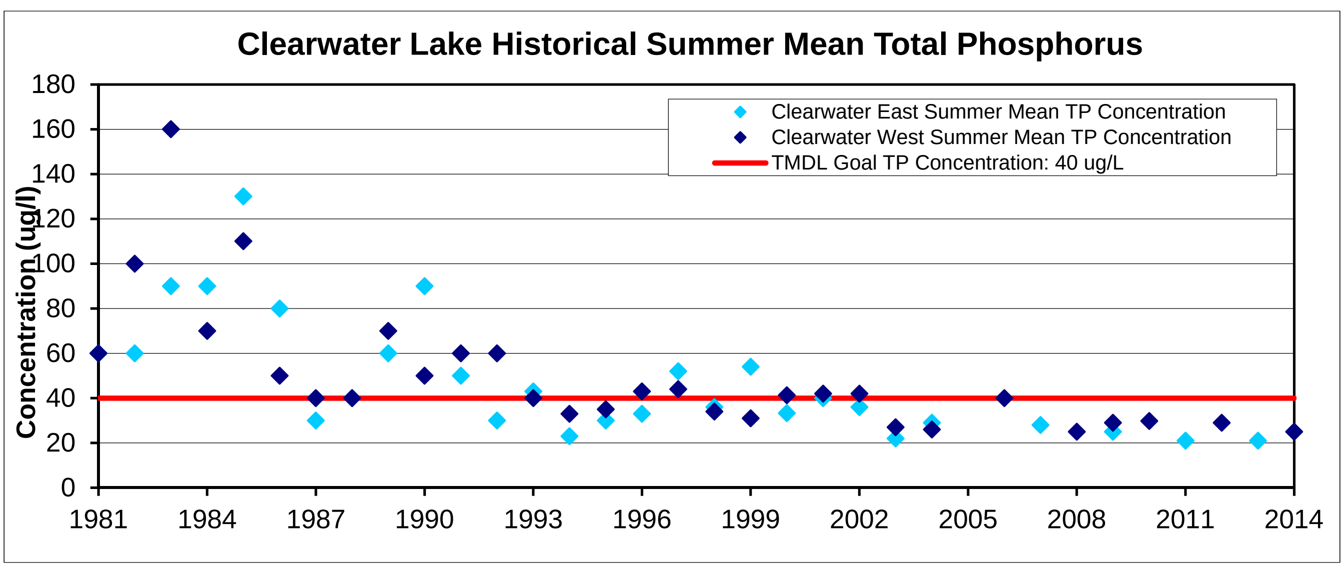
Lake Data

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



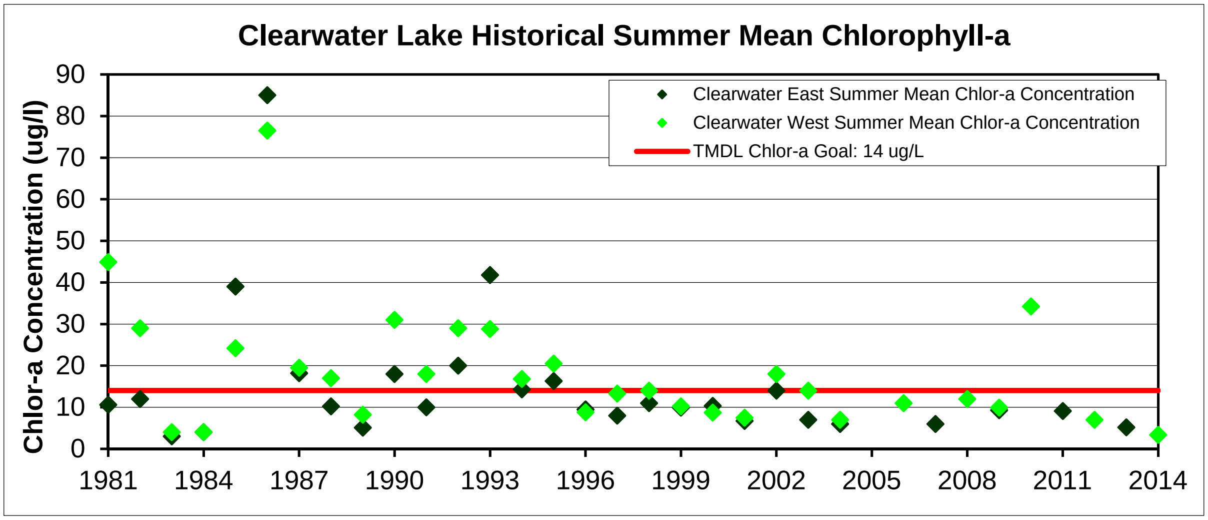
Tributary Subwatershed (shaded)

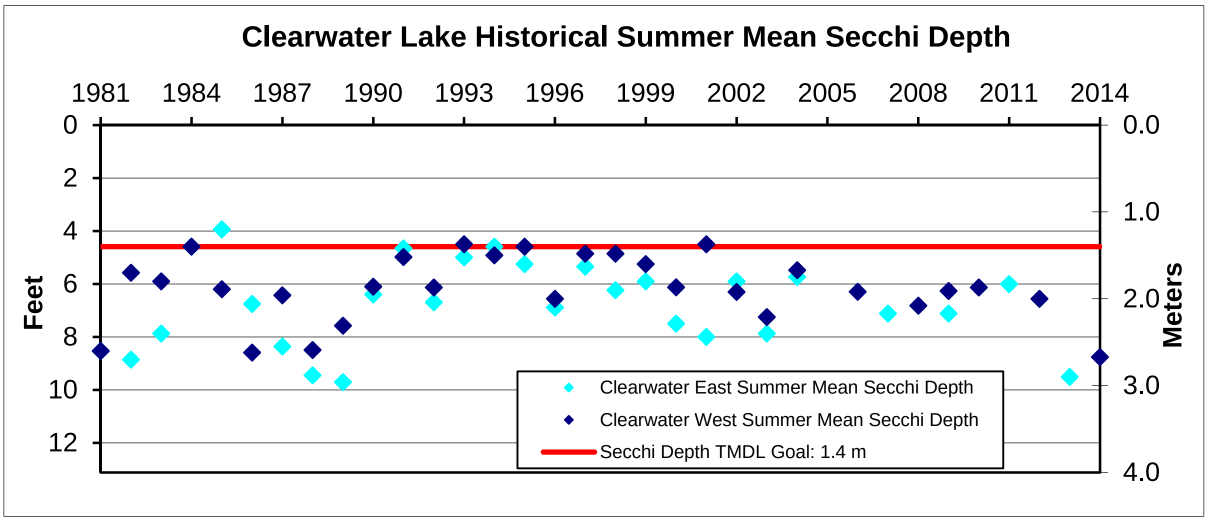




Clearwater Lake
2014 Lake Report Card

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





2014 Summary

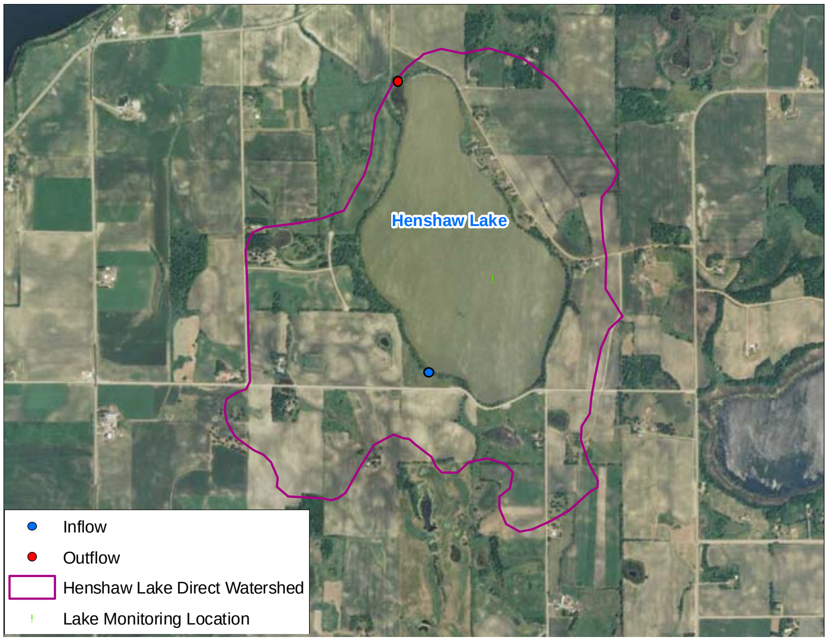
- Water quality has improved significantly in Clearwater Lake since the early 1990s, as summer mean phosphorus and chlorophyll-a concentrations have decreased significantly and the lake meets recreational water quality goals.
- Water quality measurements have been stable over recent years and meet TMDL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

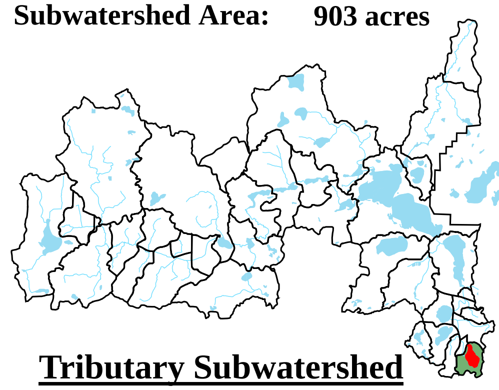
WENCK
Responsive partner. Exceptional outcomes.
1800 Pioneer Creek Center
Maple Plain, MN 55359

2014 Henshaw Lake Report Card

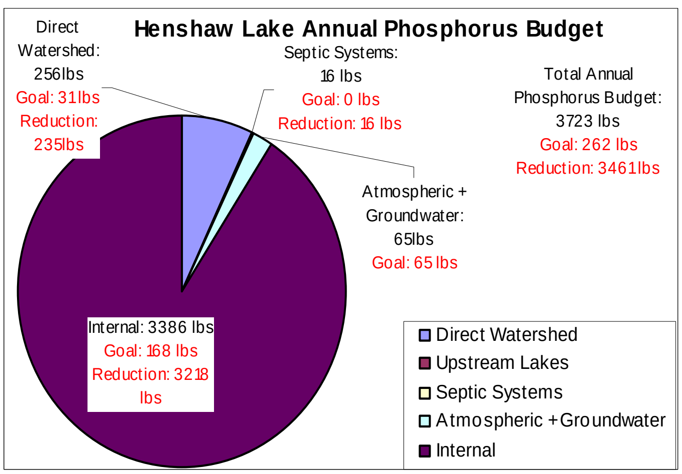


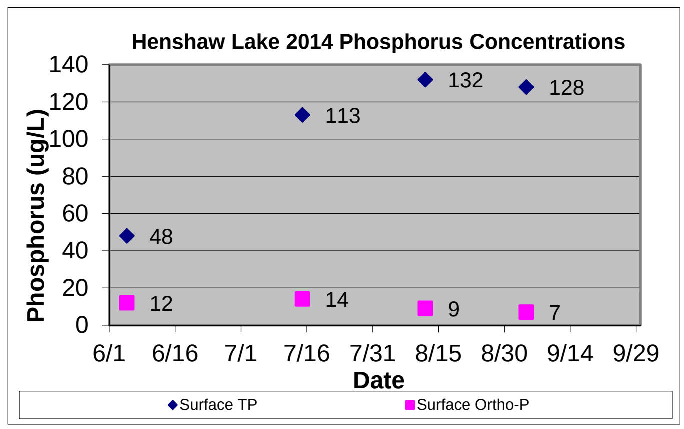
Lake Data

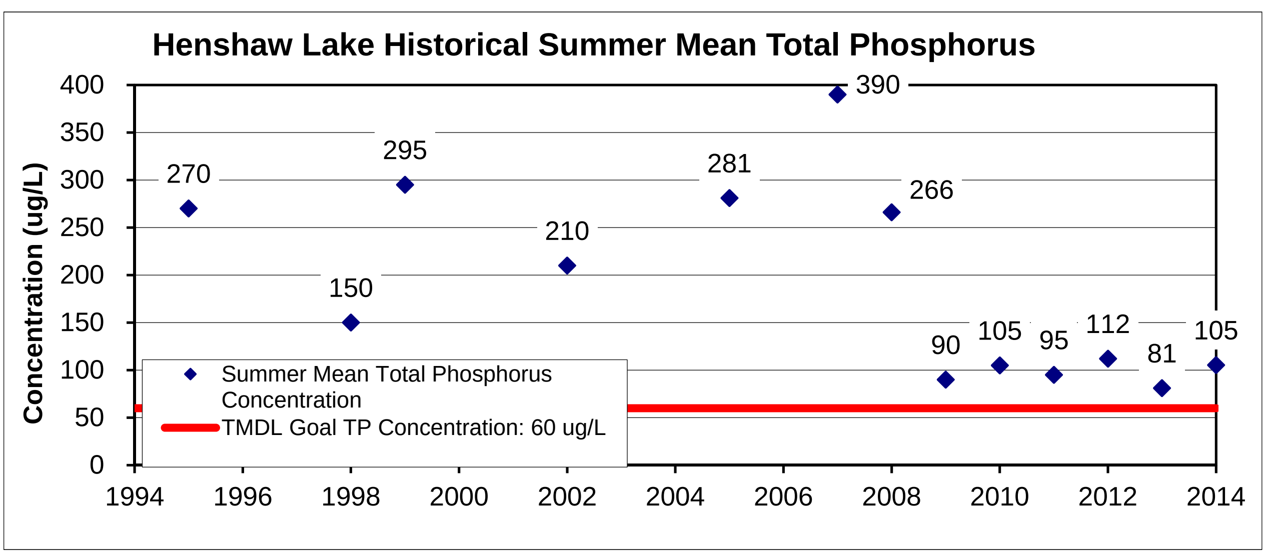
Surface Area: 271 Acres
Maximum Depth: 8 Feet
Contributing Subwatershed Area: 903 acres



Tributary Subwatershed (shaded)

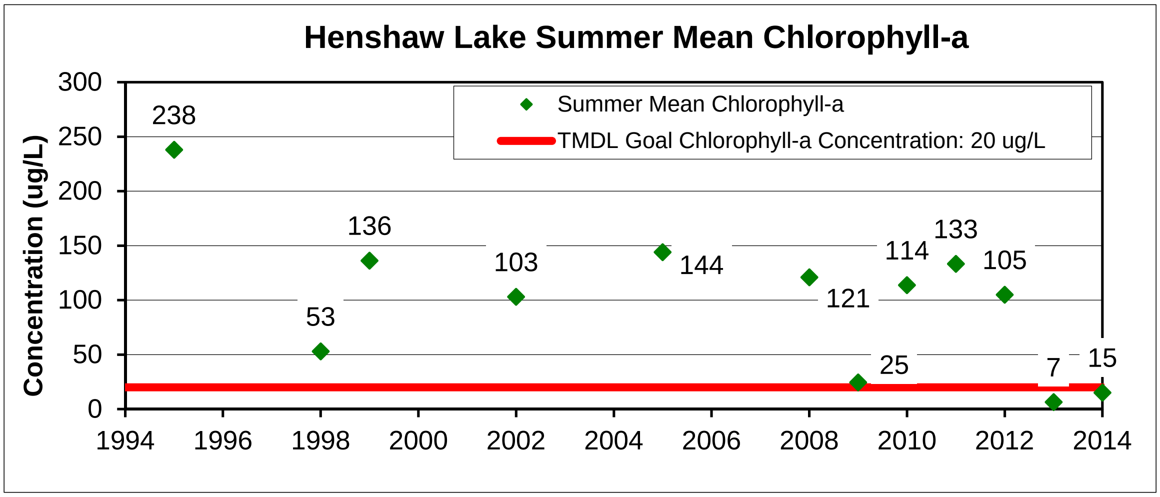


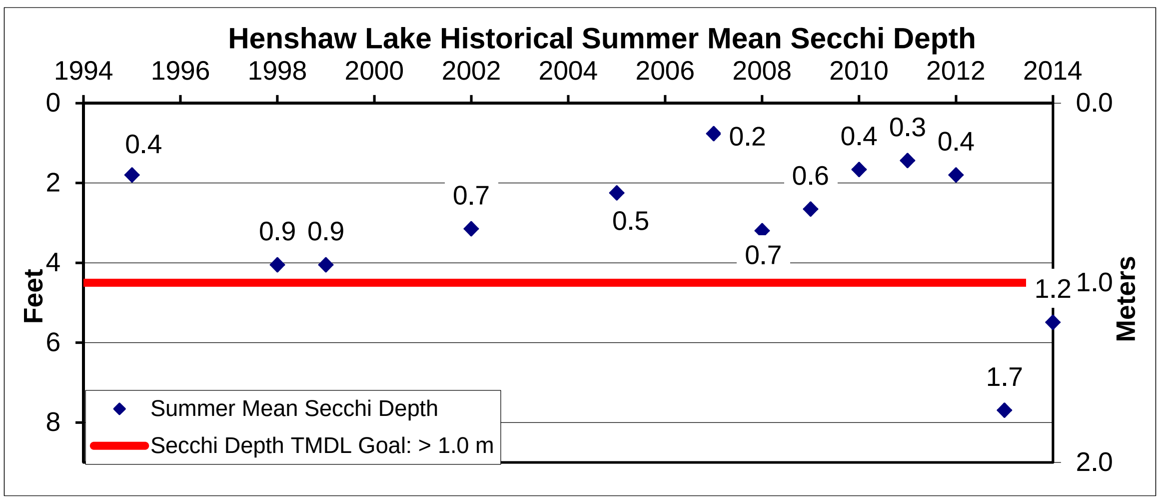




Henshaw Lake
2014 Lake Report Card

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





2014 Summary

- In-lake phosphorus concentrations exceeded TMDL goals in 2014 but remained similar to recent years and lower than historical concentrations.
- Water clarity was good in 2014, as Secchi depths met TMDL goals.
- A vegetation survey conducted in August 2014 found aquatic vegetation at nearly every sample point compared to less than 20% coverage in surveys conducted prior to 2013. Sago pondweed was the dominant native species observed in the lake with coontail and northern milfoil also common.
- The improved water clarity and vegetation community is attributed to an extensive winterkill of rough fish in early 2013, demonstrating the impact that rough fish have on the water quality in the lake.

TMDL Activities

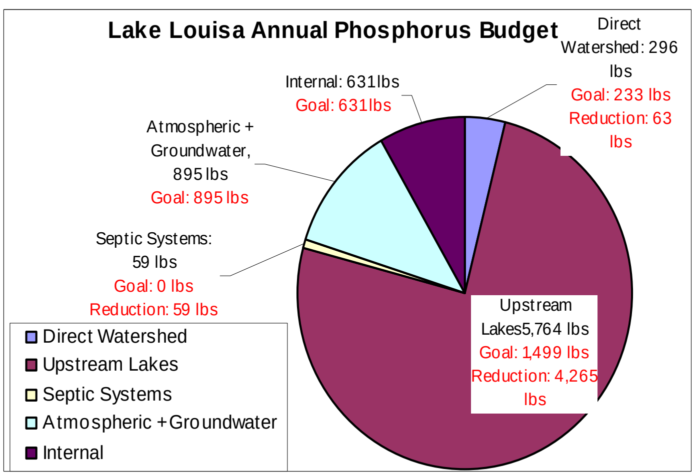
- Due to its small tributary watershed, the reduction of watershed loads alone will not be sufficient to achieve water quality goals. A significant reduction in the internal nutrient source will be required to improve water quality in the lake.
- Hydrologic and ecological restorations, especially the permanent management of rough fish populations, will be required to improve water quality in the lake. The lakes rapid rebound to a clear water state in the absence of rough fish is a demonstration of the important role that rough fish populations play in the water quality and ecological integrity of 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.

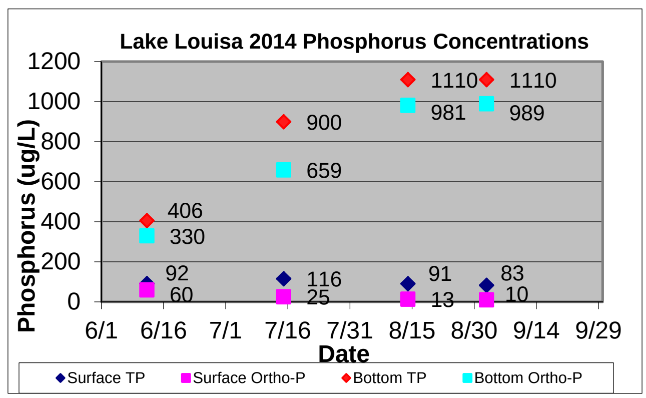
2014 Lake Louisa Report Card

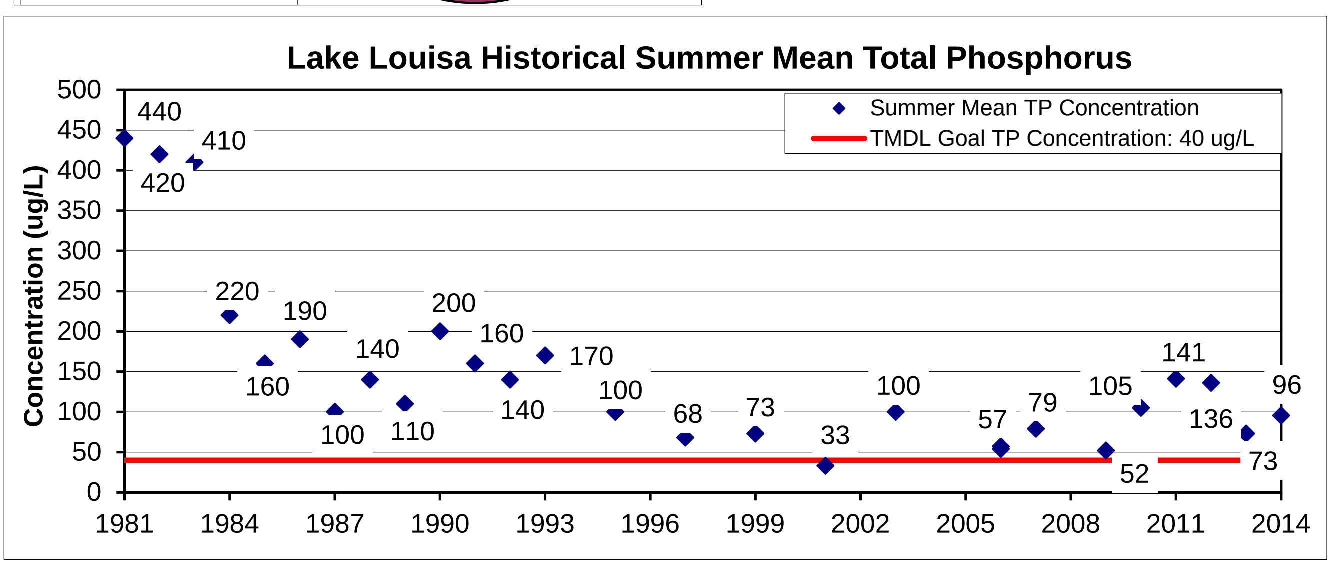
Lake Data

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

Tributary Subwatershed (shaded)



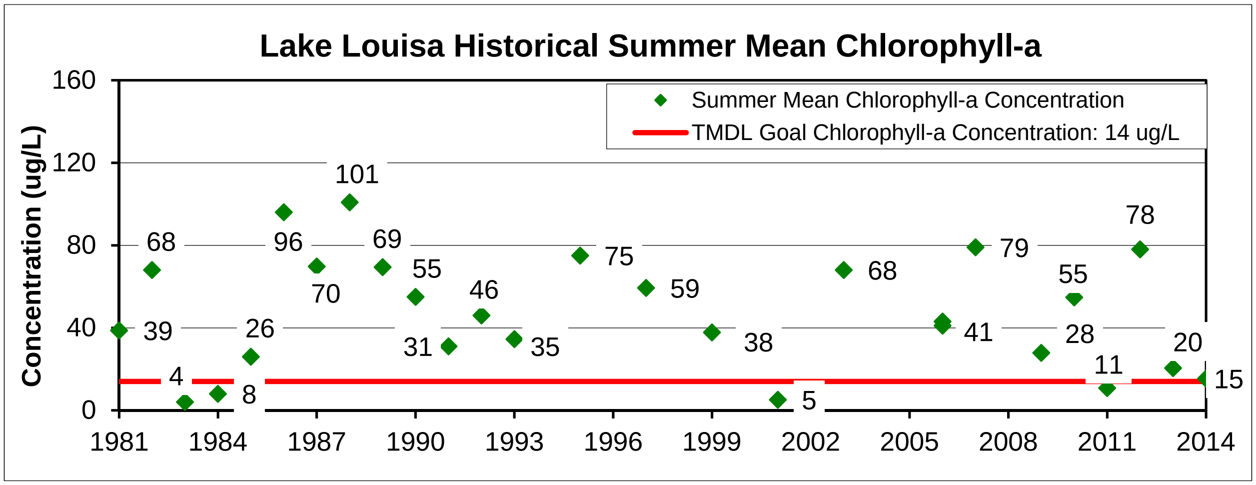


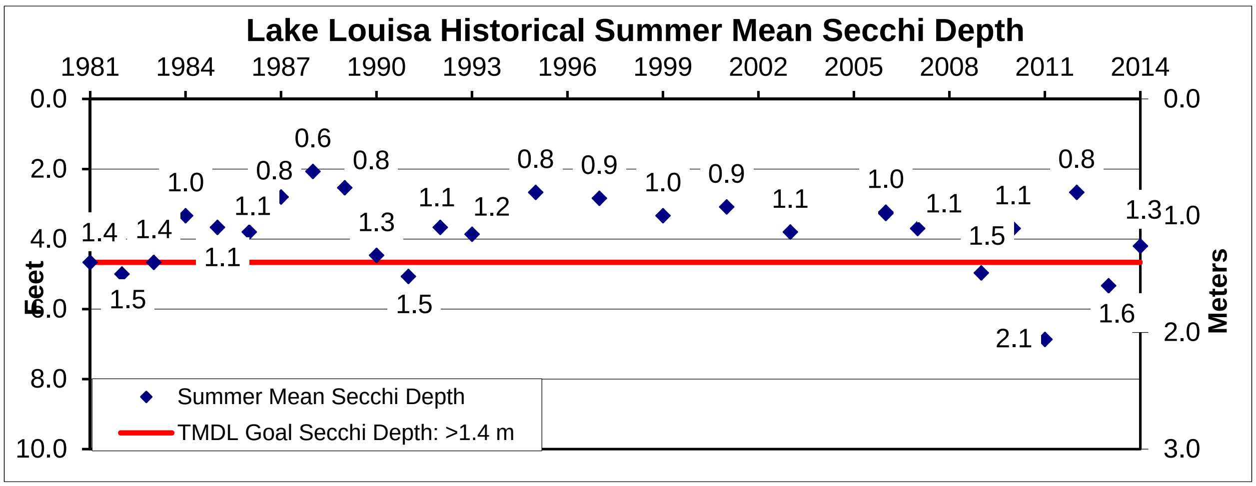


Clearwater River Watershed District	WENCK Responsive partner. Exceptional outcomes. 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2015
Lake Louisa		Appendix C

Lake Louisa
2014 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





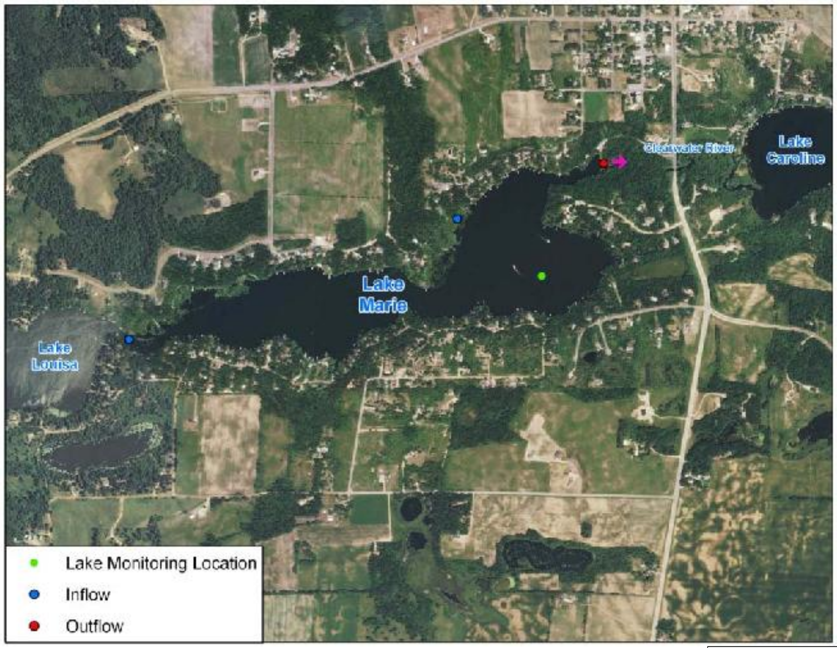
2014 Summary

- Summer average phosphorus concentrations are above TMDL goals and increased slightly in 2014 but were below elevated concetrations observed in other recent years. Phosphorus concentrations in the lake are driven primarily by phosphorus loads from the Clearwater River and upstream lakes.
- 2014 chlorophyll-a concentrations decreased from previous years and were near TMDL goals.
- Secchi depth decreased in 2014 and did not meet TMDL goals.
- Monitoring data indicates the potential for high internal loads in the lake as periods with high bottom phosphorus concentrations coupled with extended periods of bottom anoxia are observed in late summer and early fall. 2014 bottom phosphorus concentrations were the highest observed in the lake.

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.

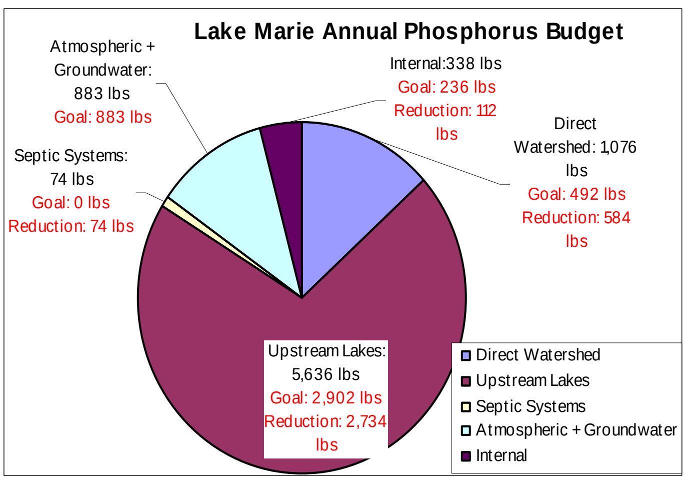
2014 Lake Marie Report Card

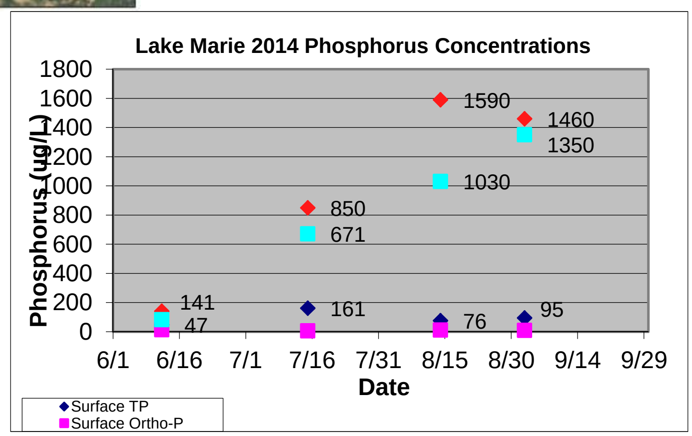


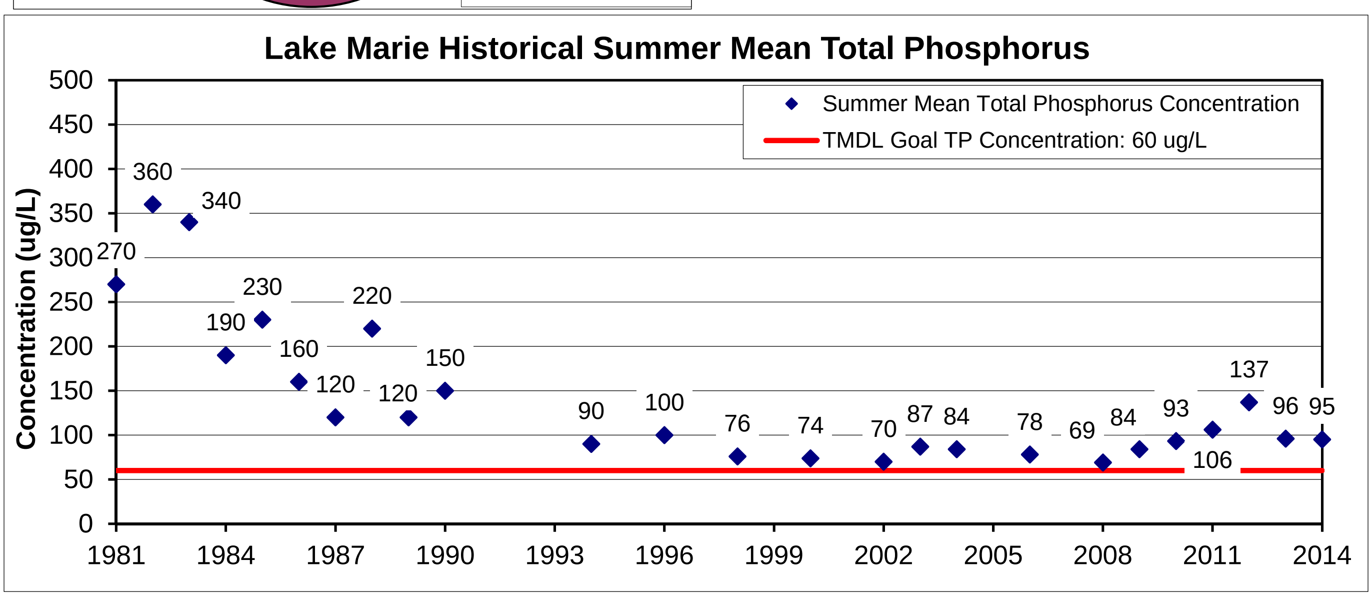
Lake Data

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

Tributary Subwatershed (shaded)



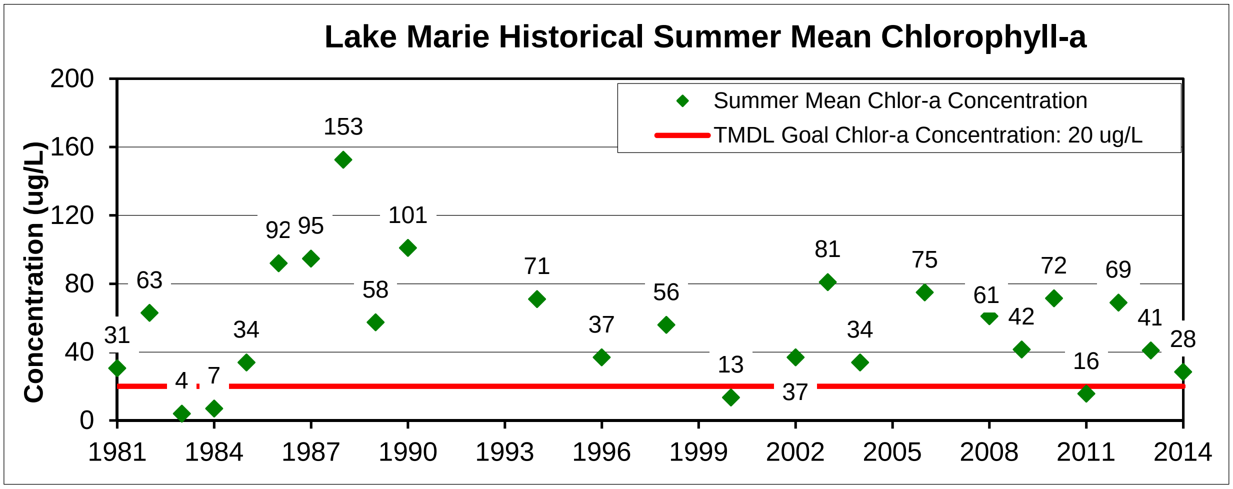


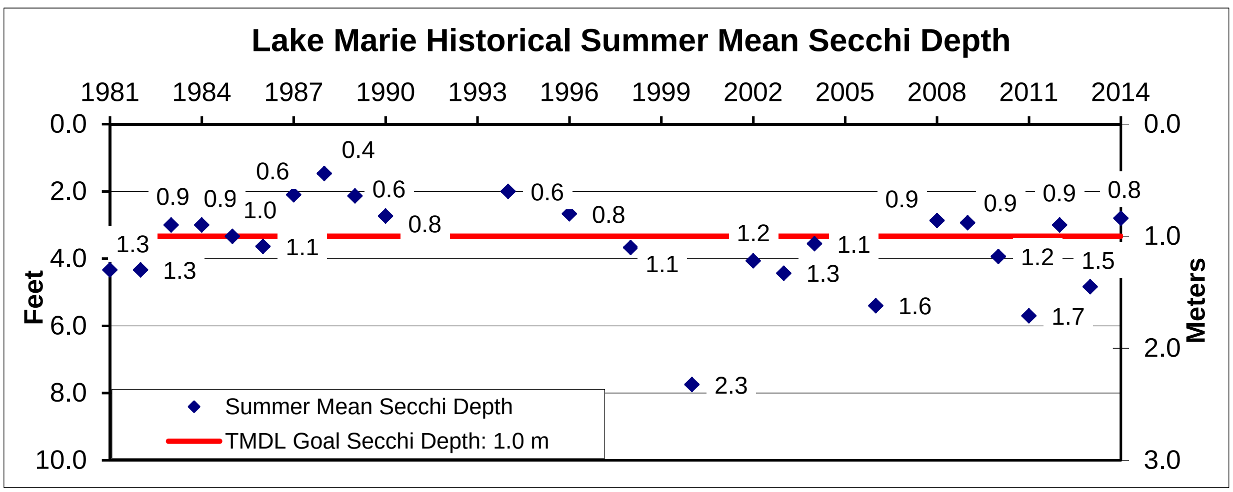


Clearwater River Watershed District	WENCK 1800 Pioneer Creek Center Maple Plain, MN 55359 Responsive partner. Exceptional outcomes.	January 2015
Lake Marie		Appendix C

Lake Marie
2014 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





2014 Summary

- Phosphorus concentrations remained stable in 2014 after increasing steadily since 2008. Although water quality has improved significantly since the early 1990s, phosphorus concentrations remain above TMDL goals.
- Chlorophyll-a concentrations continued to decrease compared to recent years but were above TMDL goals.
- Water clarity decreased as Secchi depth decreased compared to most recent years and exceeded the TMDL goal.
- Monitoring data continued to demonstrate extremely high bottom phosphorus concentrations throughout the season in the lake in 2014.
- High bottom phosphorus concentrations and extended periods of anoxia demonstrates the potential for high internal loads in the lake.

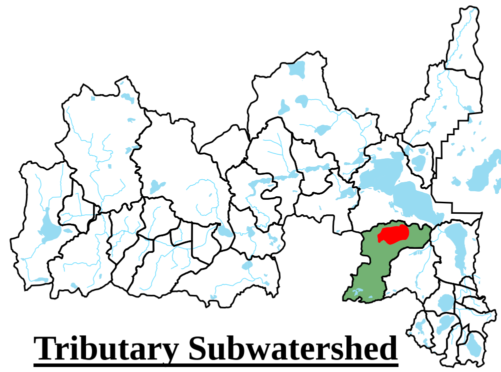
TMDL Activities

- 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.

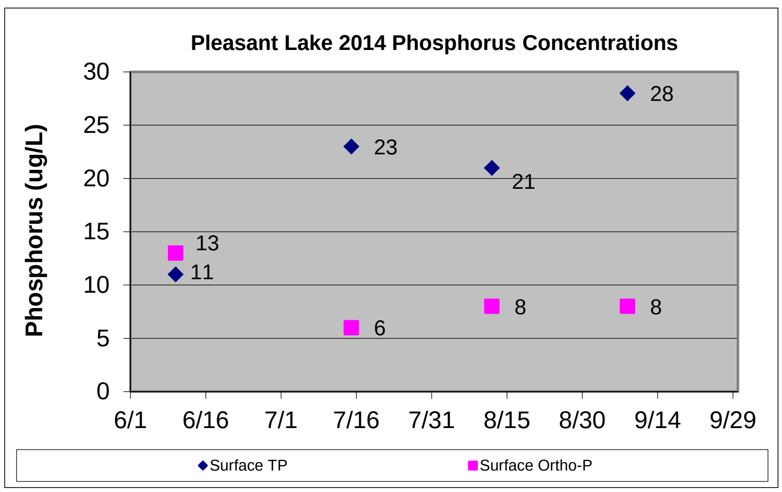
2014 Pleasant Lake Report Card

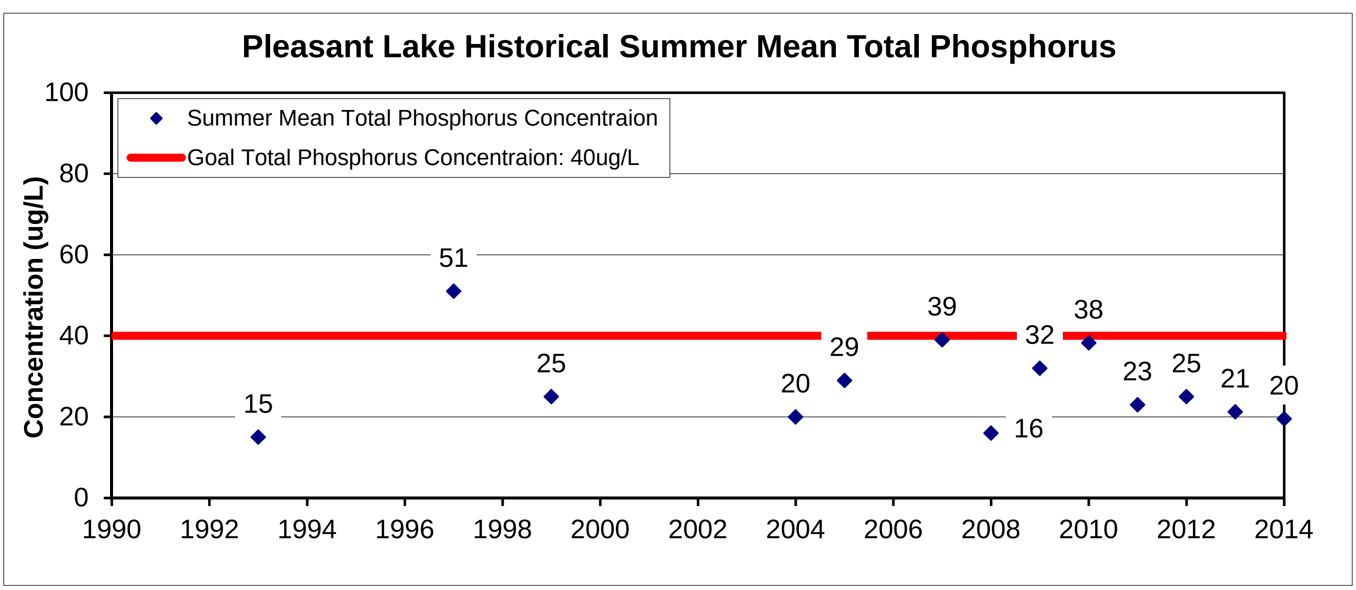
Lake Data

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



Tributary Subwatershed (shaded)

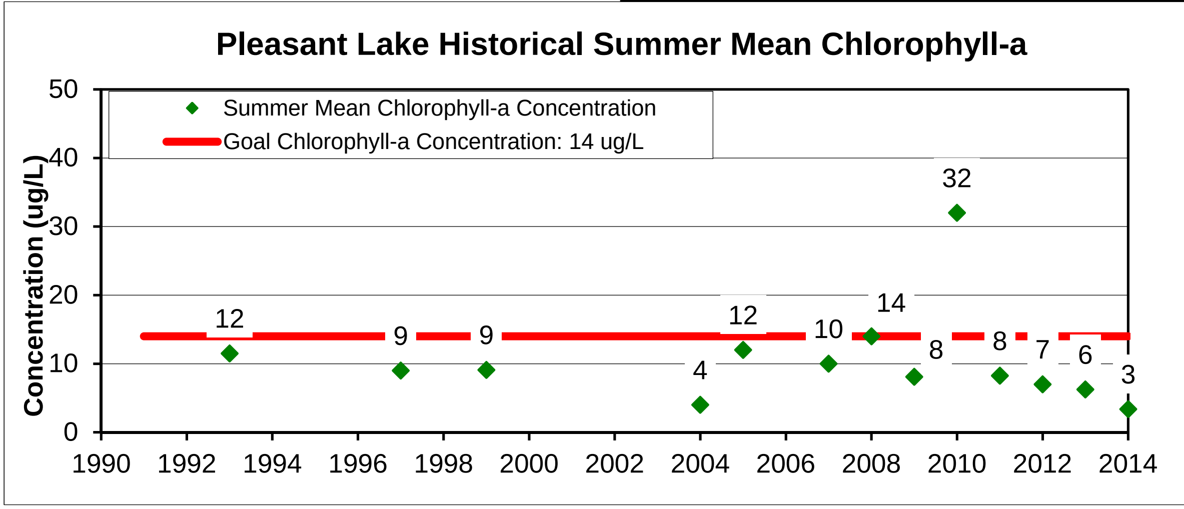


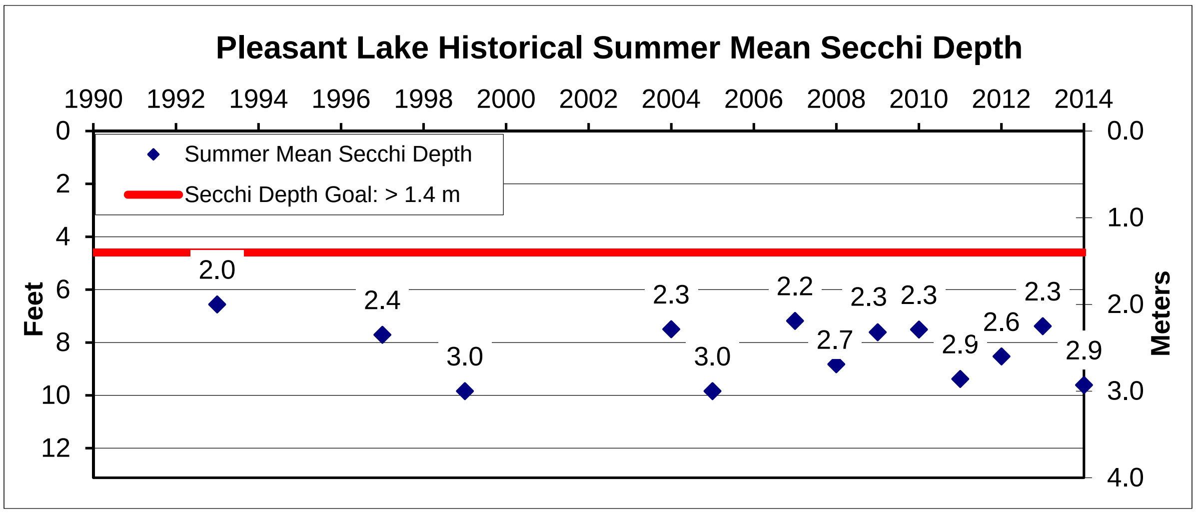


Clearwater River Watershed District	WENCK Responsive partner. Exceptional outcomes. 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2015
Pleasant Lake		Appendix C

Pleasant Lake
2014 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





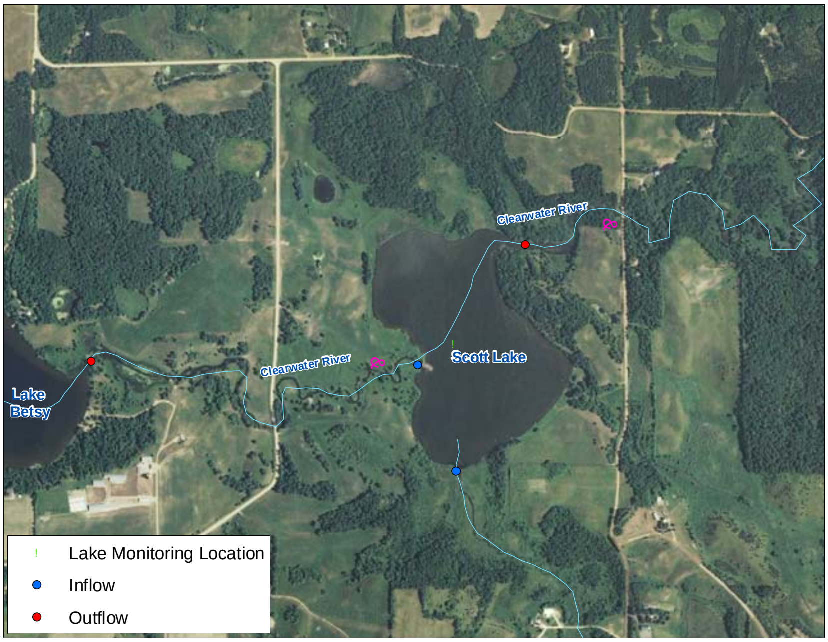
2014 Summary

- Current water quality is good in Pleasant Lake as phosphorus concentrations, chlorophyll-a, and Secchi depths have met TMDL goals since 1993.
- Phosphorus concentrations have continued to decrease since slightly higher concentrations were observed in 2009 and 2010.
- Summer average chlorophyll-a concentrations as well as Secchi depths were similar or slightly improved when compared to 2013.

Water Quality Improvement Activities

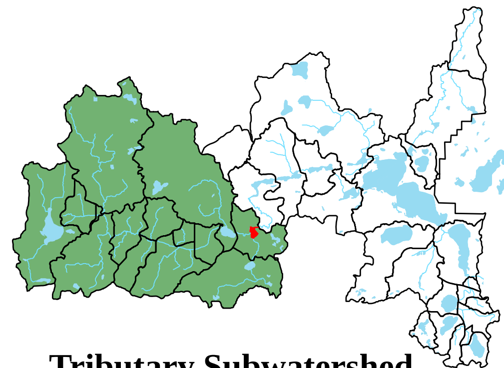
- Good land management practices adjacent to the lakeshore, the upstream watershed, and in the City of Annandale will help to maintain the good water quality in Pleasant Lake.
- The expansion of curly leaf pondweed in the lake in recent years does not seem to have negatively impacted water quality.

2014 Scott Lake Report Card

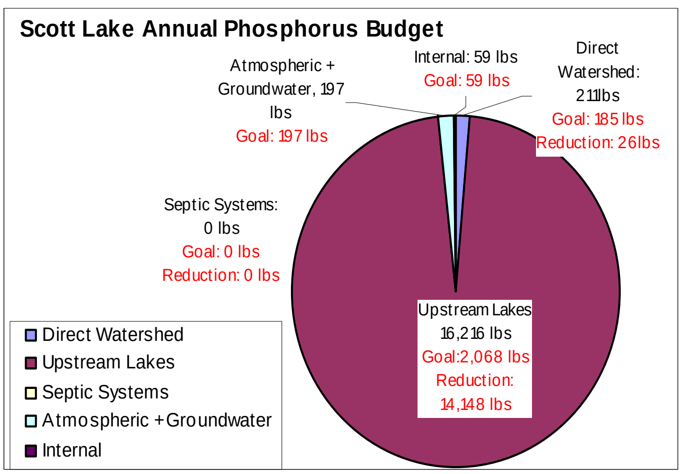


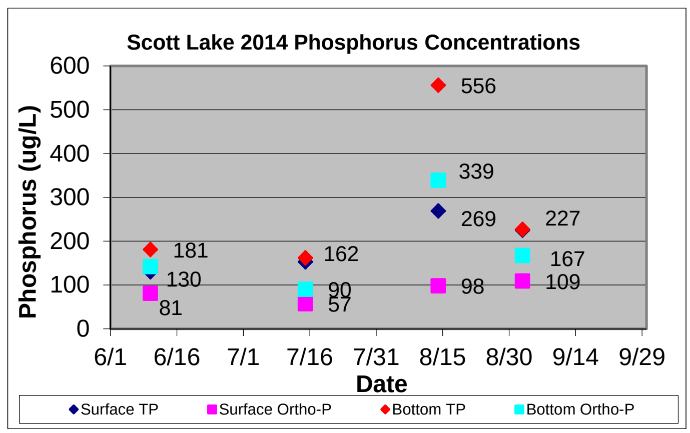
Lake Data

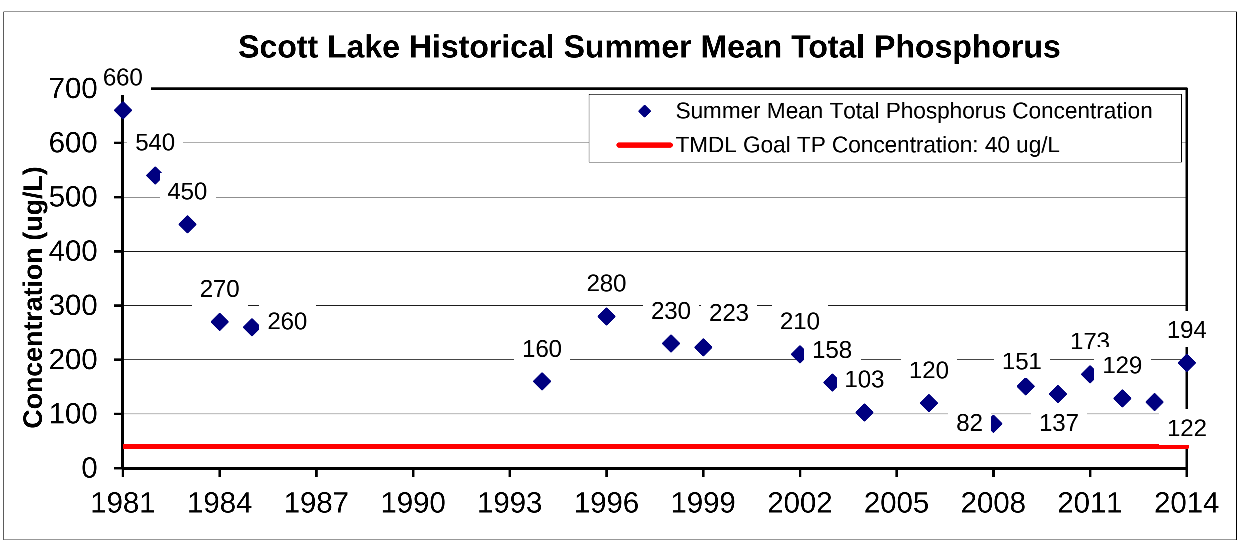
Surface Area:	**80 Acres**
Maximum Depth:	**23 Feet**
Subwatershed Area:	**51,000 acres**



Tributary Subwatershed (shaded)

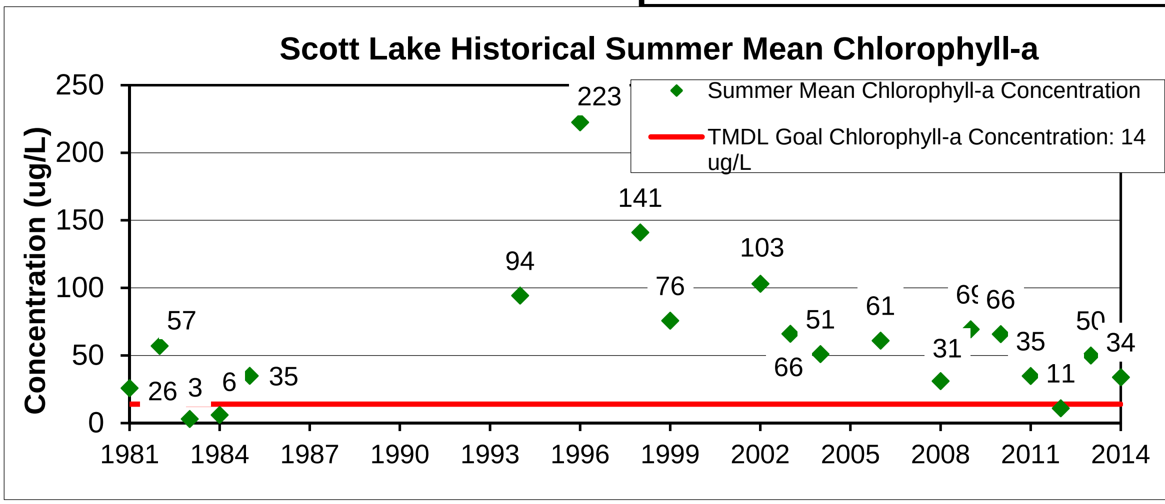


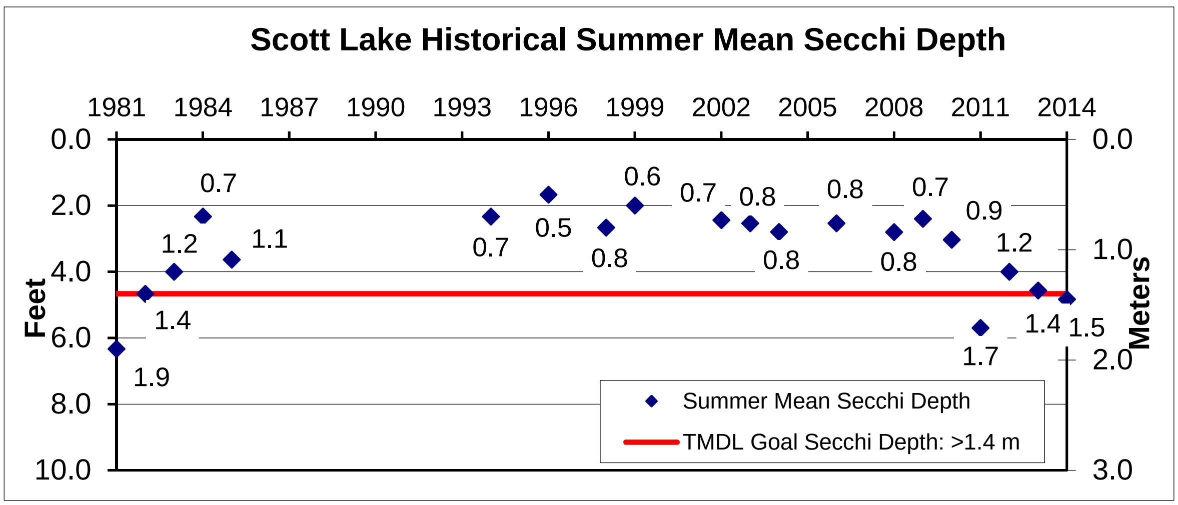




Scott Lake
2014 Lake Report Card

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





2014 Summary

- Phosphorus concentrations increased in 2014, following a decreasing trend observed since 2011. TP concentrations are higher than values seen in recent years and remain above TMDL goals.
- Secchi depth has increased in recent years and met the TMDL goal in 2014. Overall, Secchi depth has improved since the early 1990s.
- Chlorophyll-a concentrations decreased from 2013 and did not meet TMDL goals, but was simlar to values seen in most recent years.
- Water quality in Scott Lake is dominated by the inflow from Lake Betsy. Recent bottom phosphorus concentration analysis and sediment phosphorus release analysis performed in 2010 indicate that Internal loading may represent a significant source of phosphorus to the lake during some years 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.

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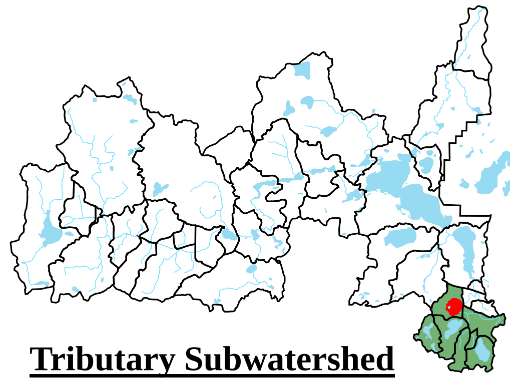
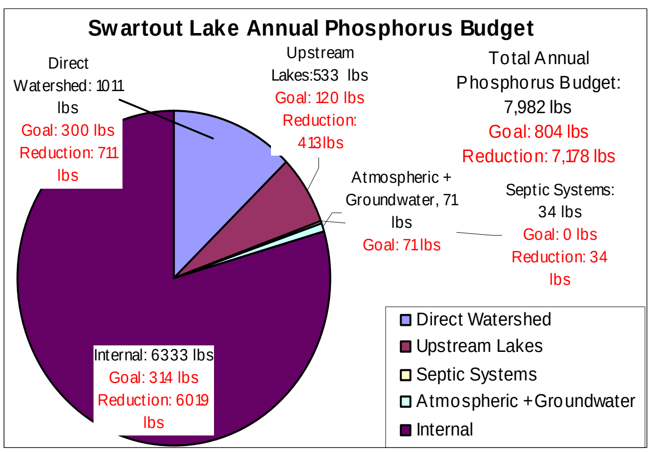
2014 Swartout Lake Report Card

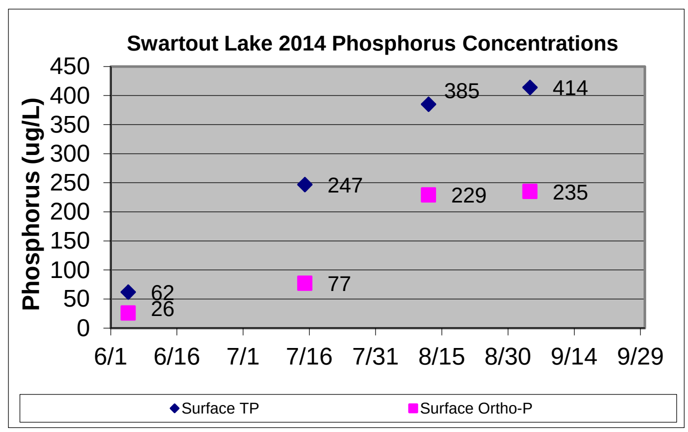
Lake Data

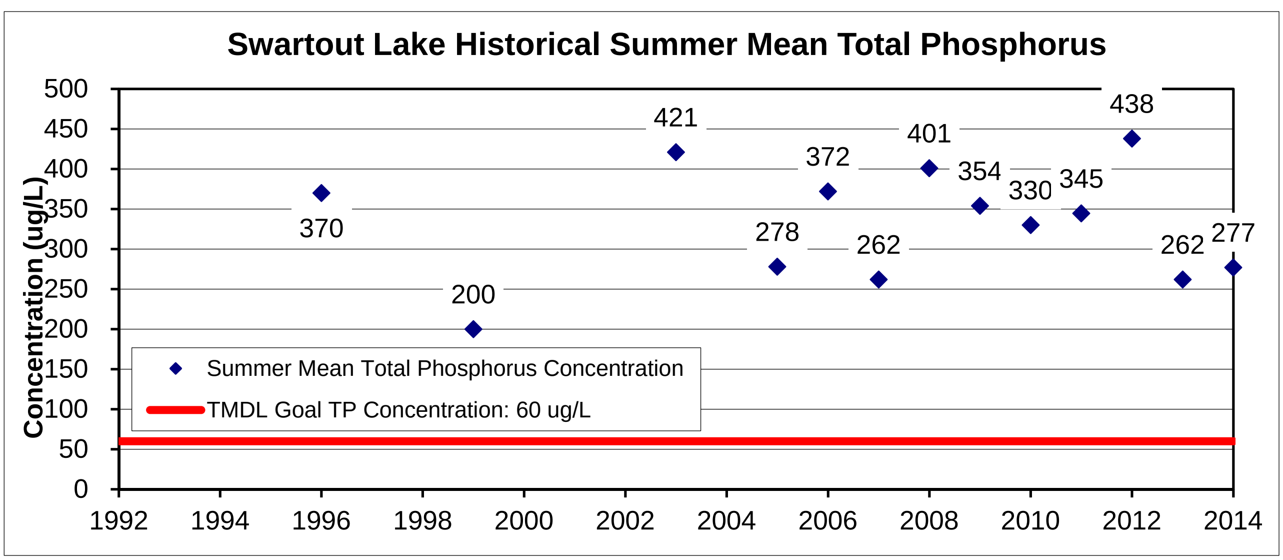
Surface Area:	**296 Acres**
Maximum Depth:	**12 Feet**
Subwatershed Area:	**5,551 acres**



Tributary Subwatershed (shaded)

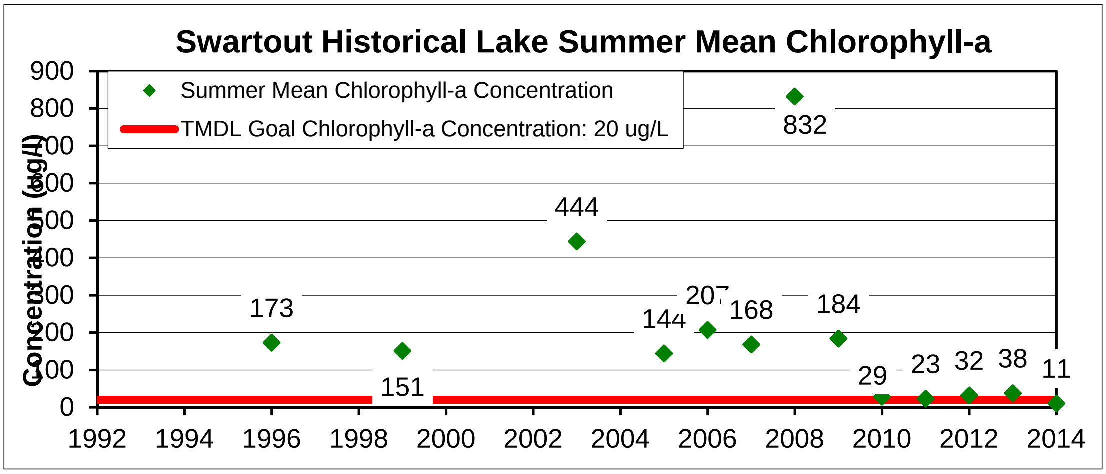


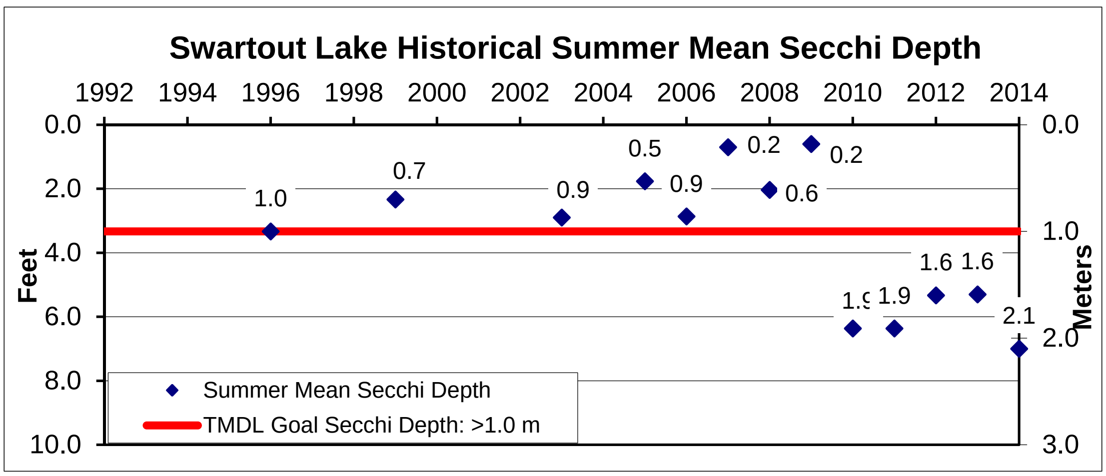




Swartout Lake
2014 Lake Report Card

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





2014 Summary

- Phosphorus concentrations remained well above TMDL goals but are significantly lower than most past values observed. Phosphorus concentrations increased in late summer in 2014.
- Chlorophyll-a concentrations were the lowest observed in the lake and met the TMDL goal in 2014.
- Secchi depth was the highest observed in the lake and met the TMDL goal in 2014. The increased water clarity is due to decreased numbers of rough fish in the lake since an extensive winter fish kill in 2010.
- An aquatic vegetation inventory conducted in June 2014 found similar results to vegetation surveys performed since 2010. Dense beds of native species of submergent vegetation were observed in shallow portions of the lake with a suitable substrate for aquatic vegetation growth.
- Internal loads are the major source of nutrients to the lake.

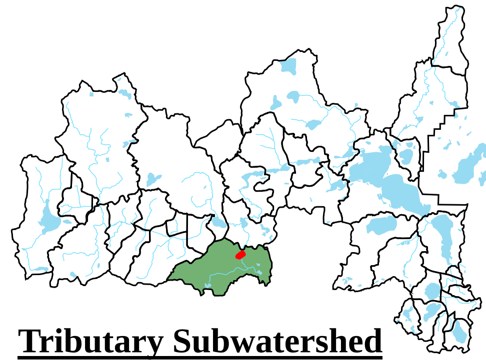
TMDL Activities

- 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.
- A nutrient reduction project at the inlet to the lake from Swartout WMA is planned for 2015. This project will address the largest source of exported phosphorus to the lake.

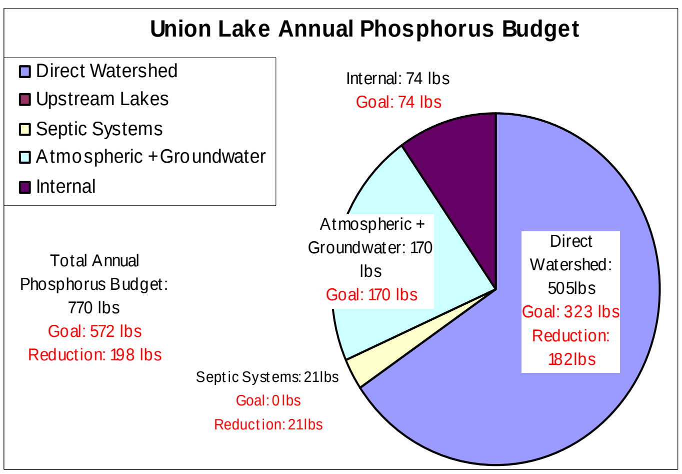
2014 Union Lake Report Card

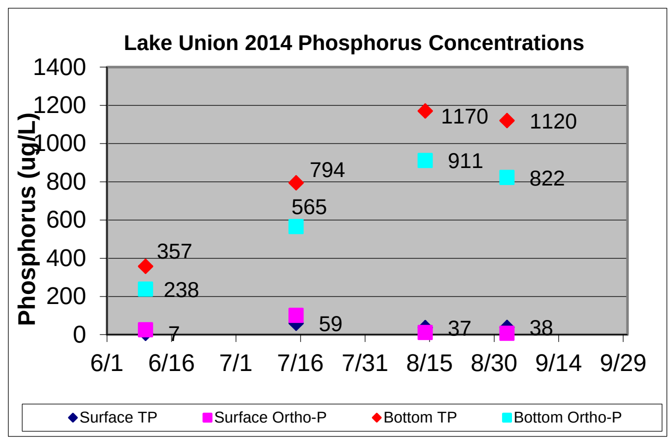
Lake Data

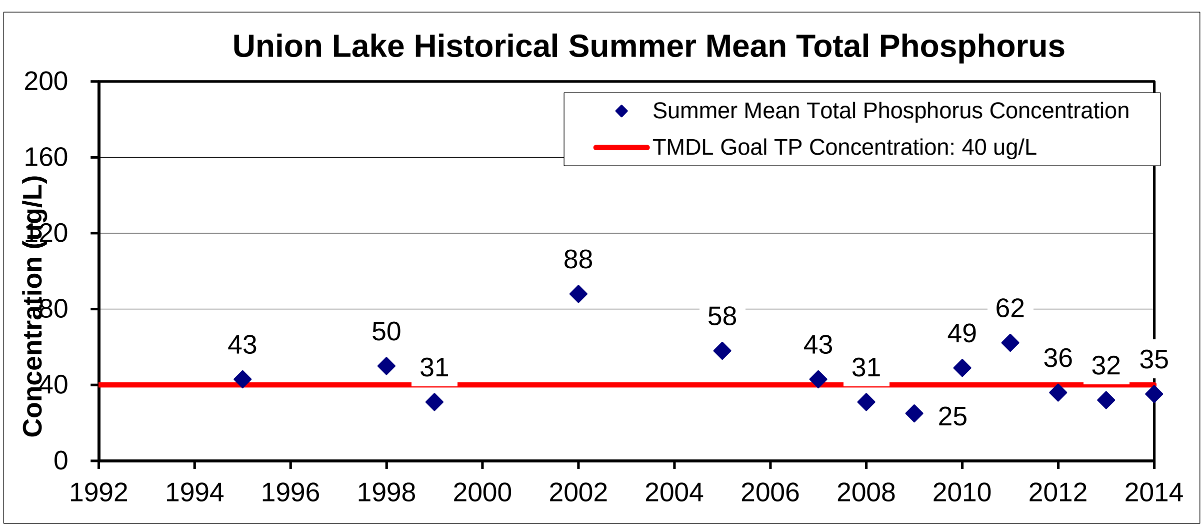
Surface Area: 93 Acres
Maximum Depth: 35 Feet
Subwatershed Area: 4,741 acres



Tributary Subwatershed (shaded)



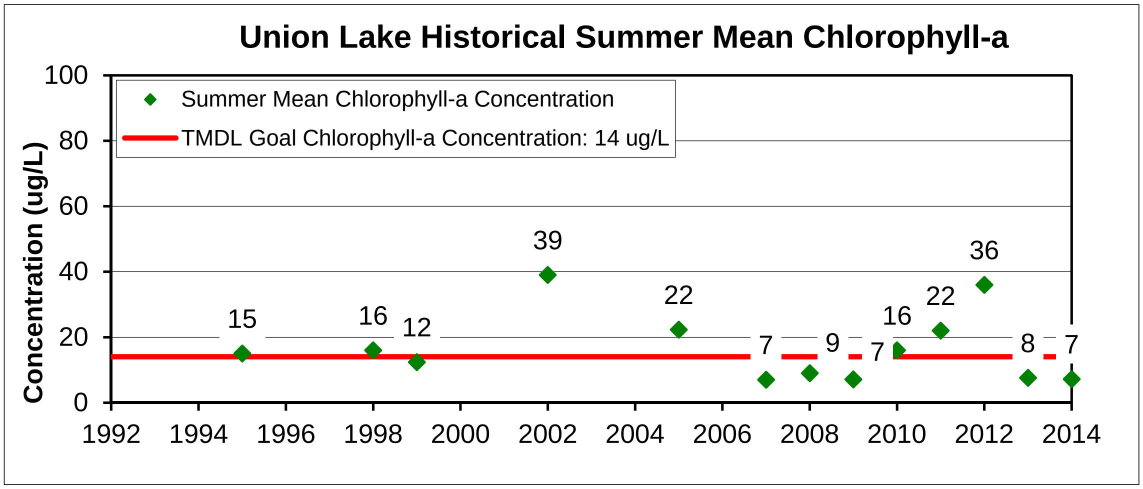


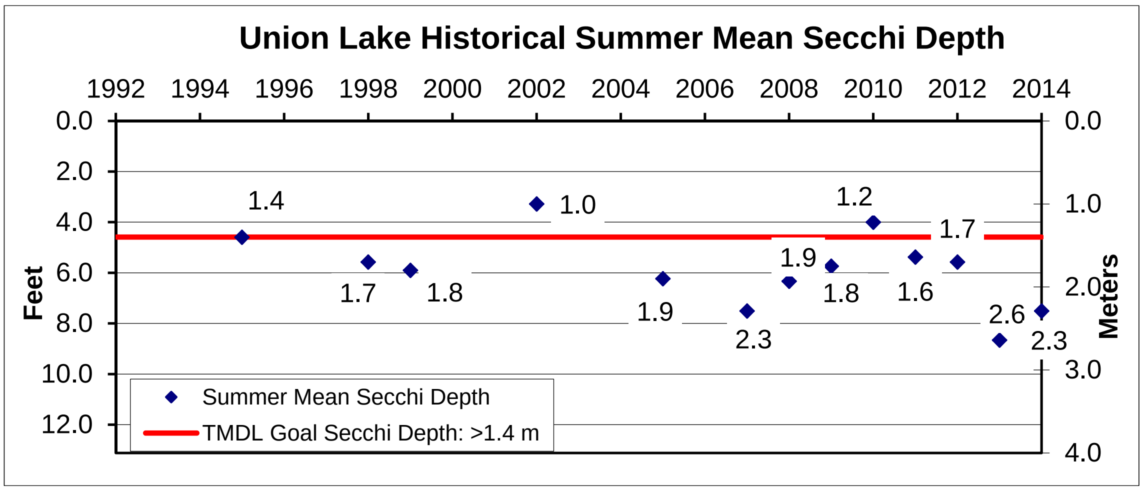


Clearwater River Watershed District	WENCK	1800 Pioneer Creek Center Maple Plain, MN 55359	January 2015
Union Lake	Responsive partner. Exceptional outcomes.		Appendix C

Union Lake
2014 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





2014 Summary

- Total phosphorus concentrations have been stable since 2011 and met TMDL goals in 2014.
- Chlorophyll-a concentrations remained low in 2014 and met TMDL goals.
- Water clarity remained good in 2014, as the Secchi disk depth met TMDL goals in 2013.
- Bottom phosphorus concentrations, which can be an indicator for the potential for internal loading, were similar to recent years.

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.

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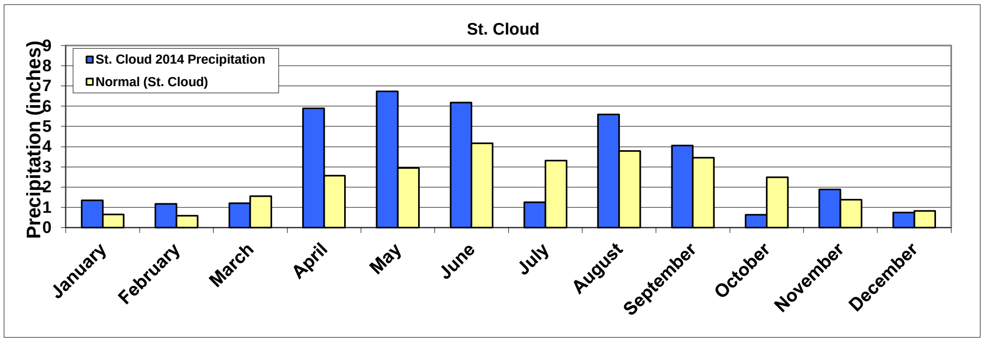
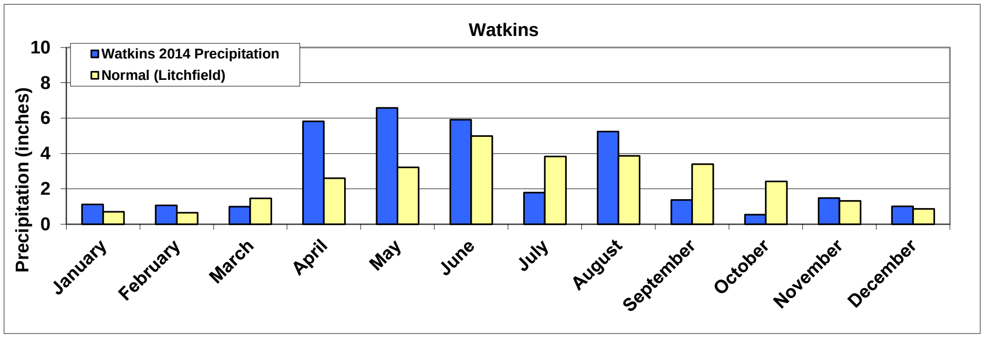
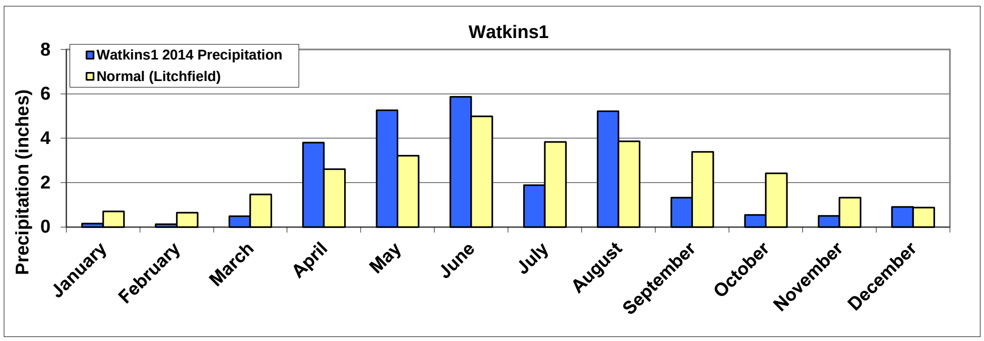
Appendix D

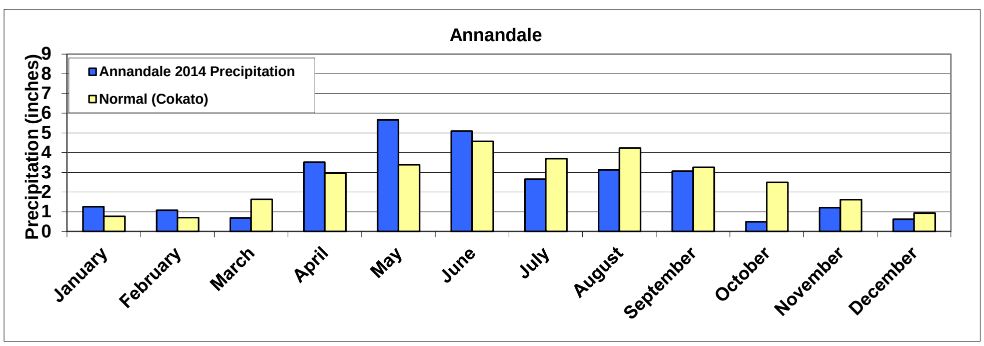
Precipitation

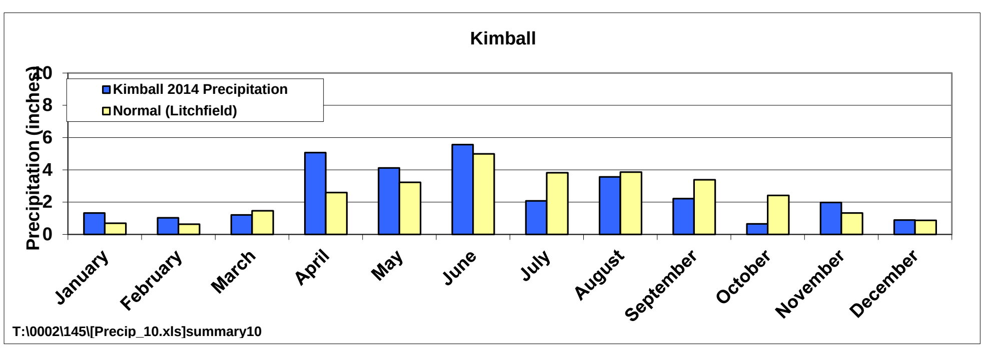
Appendix D
Figure 1
Clearwater River Watershed District 2014
Annual Report







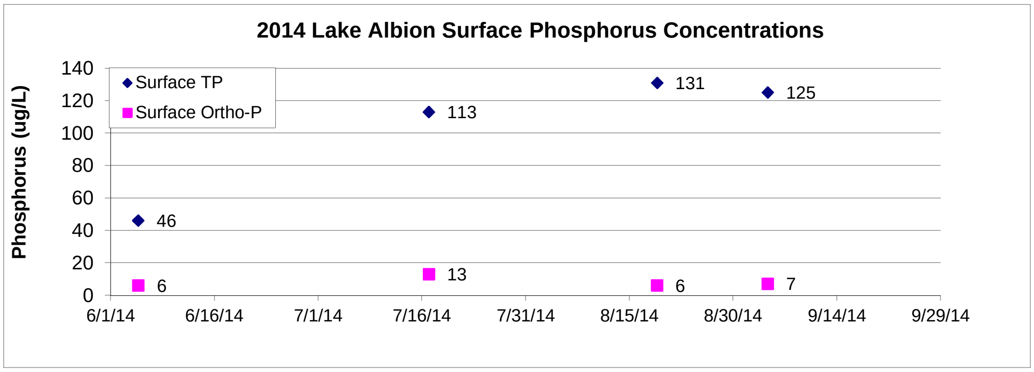


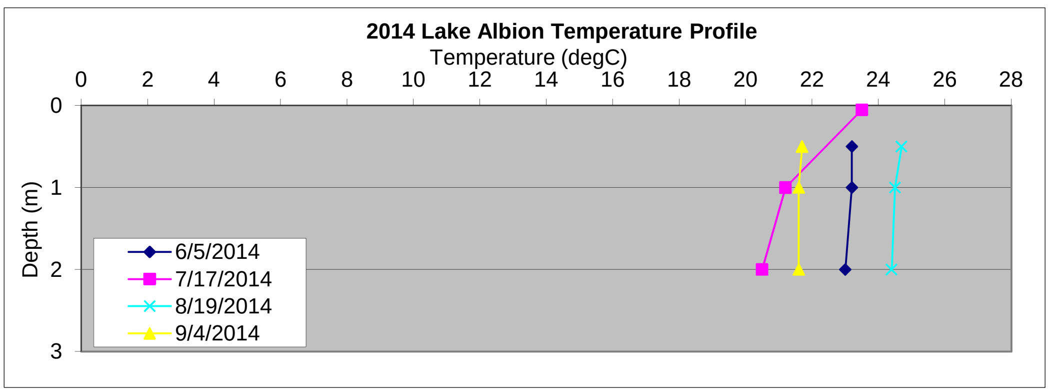


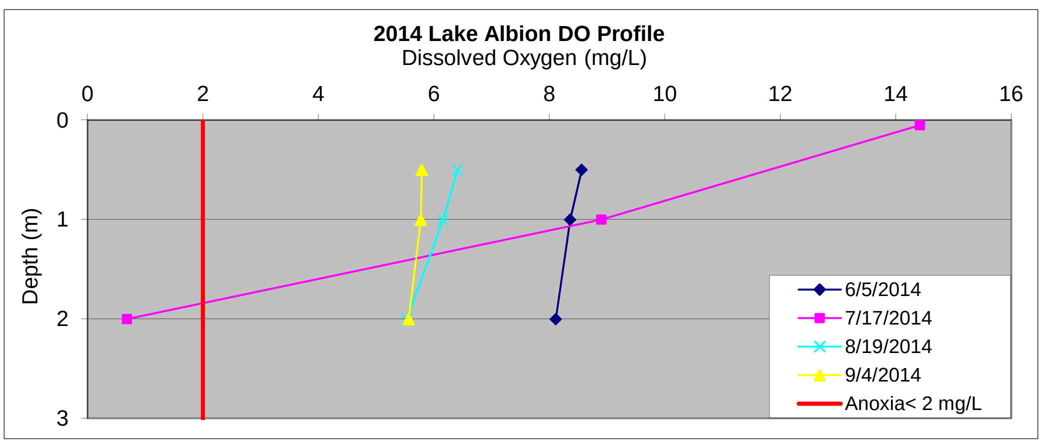
Appendix G

Lake Profile Data

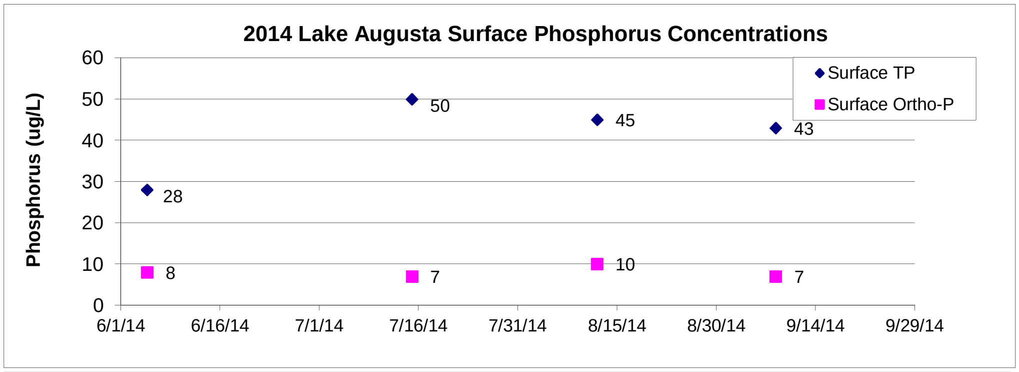
CRWD 2014 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data

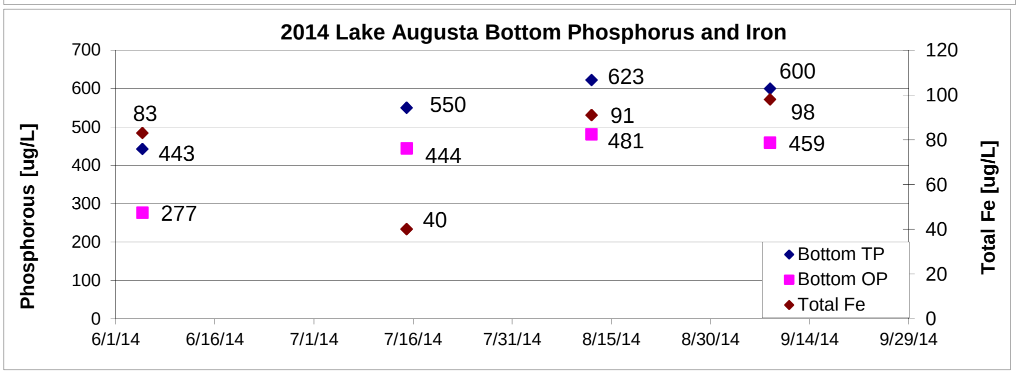


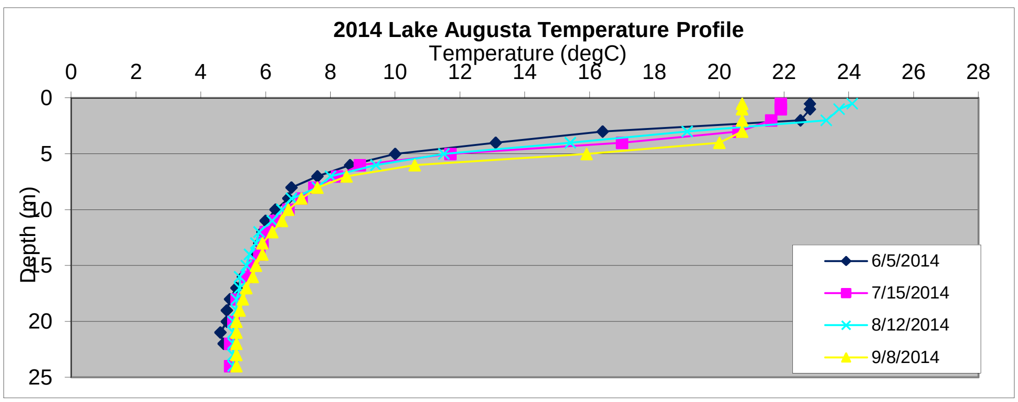


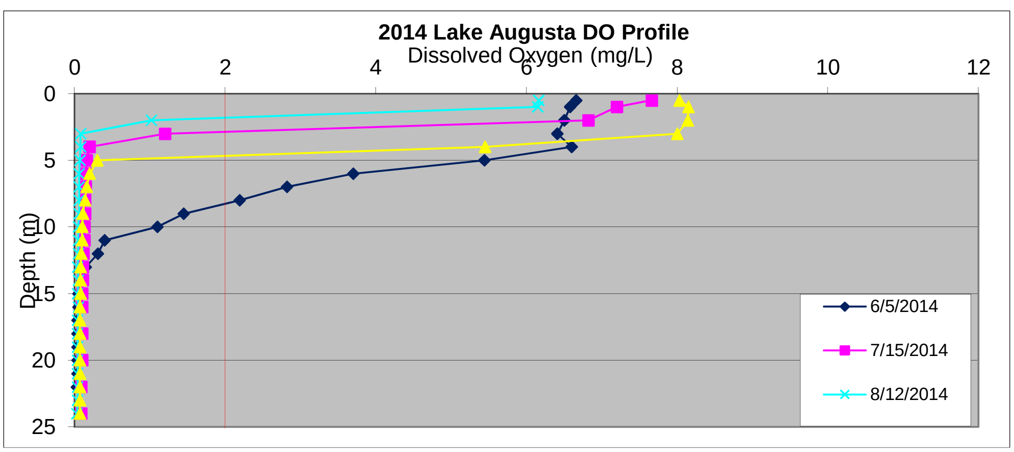


CRWD 2014 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data









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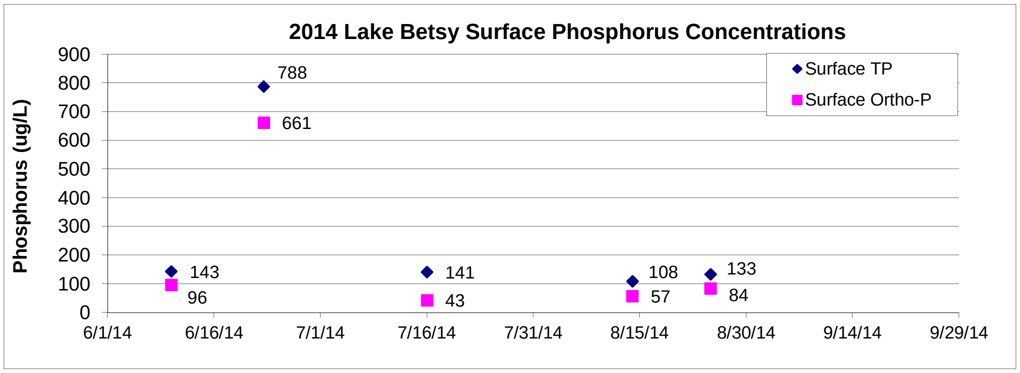
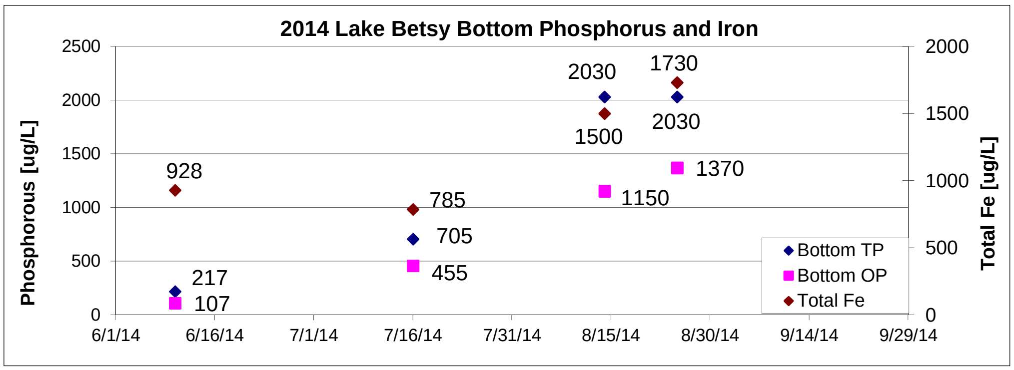
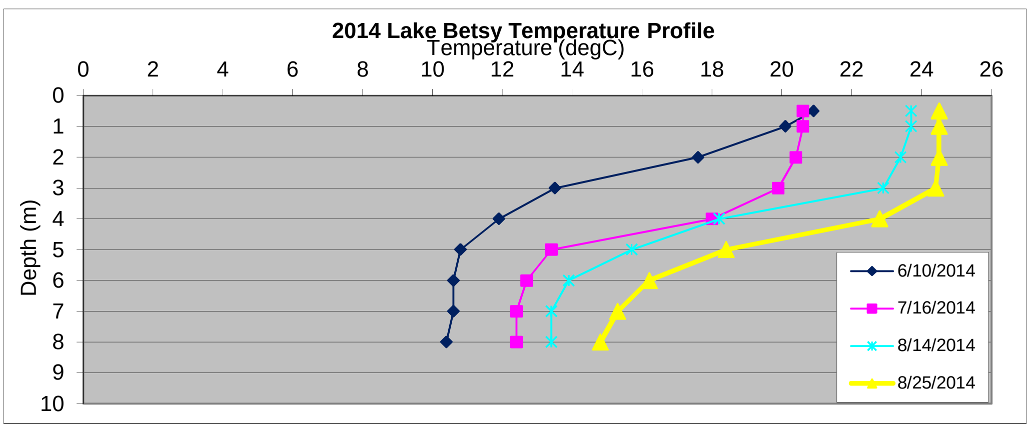
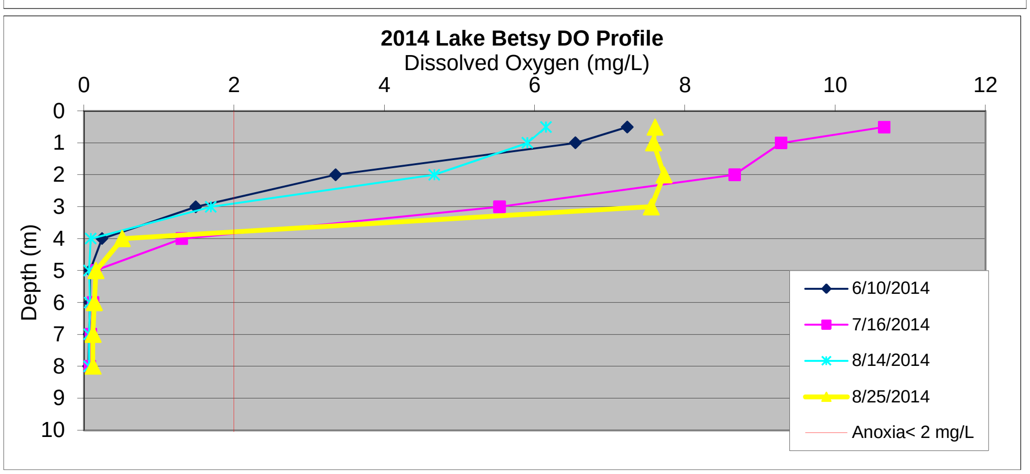
CRWD 2014 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data









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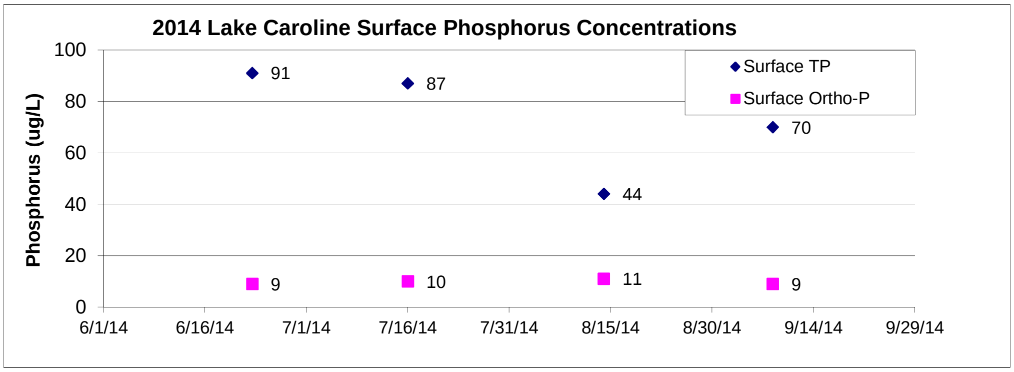
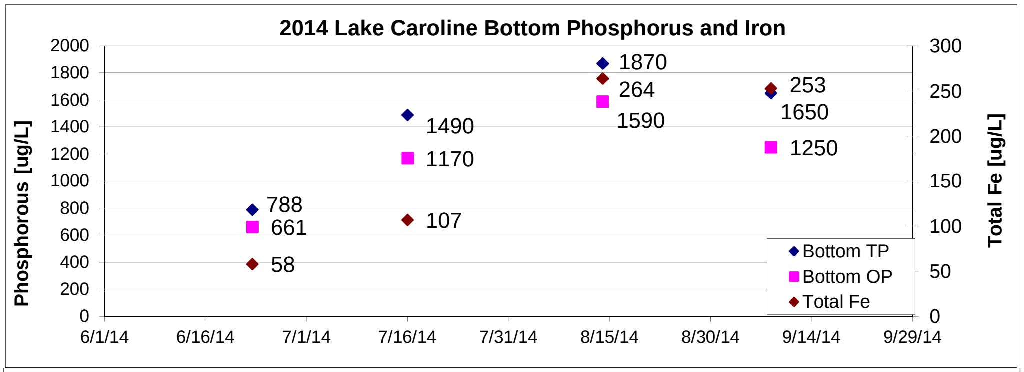
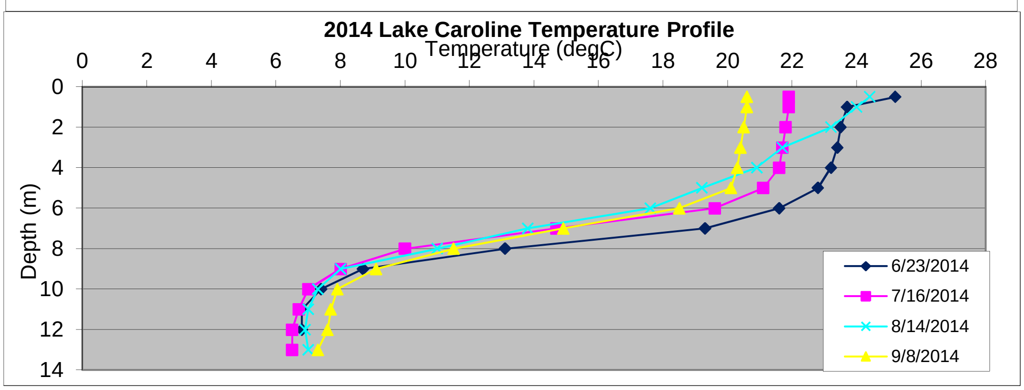
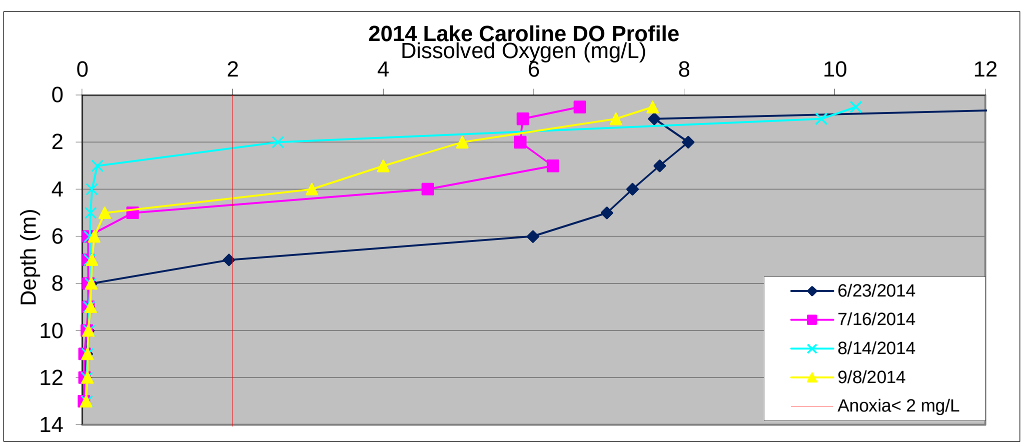
Appendix G-Lake Phosphorus
and Profile Data









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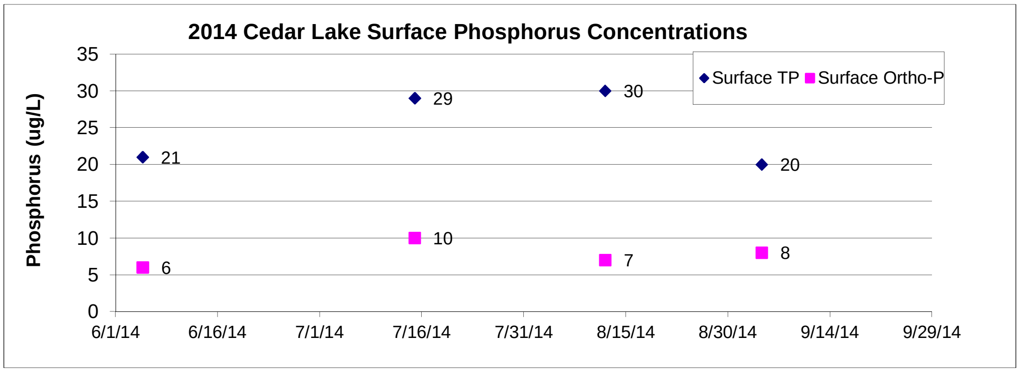
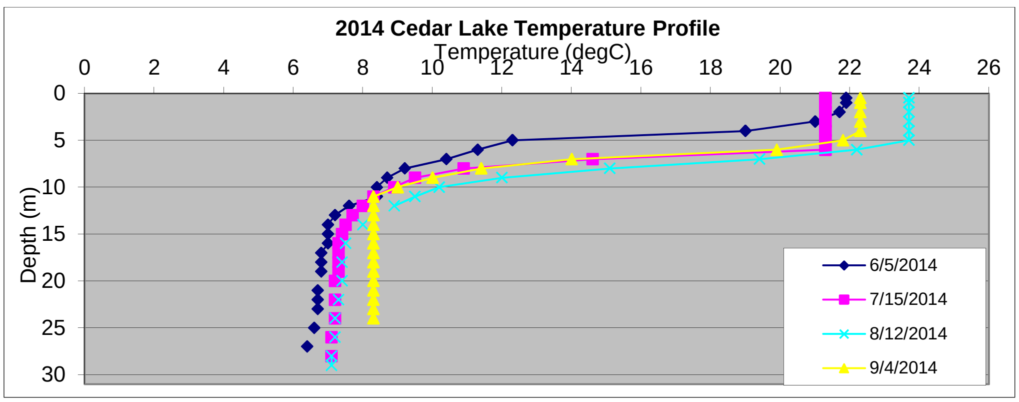
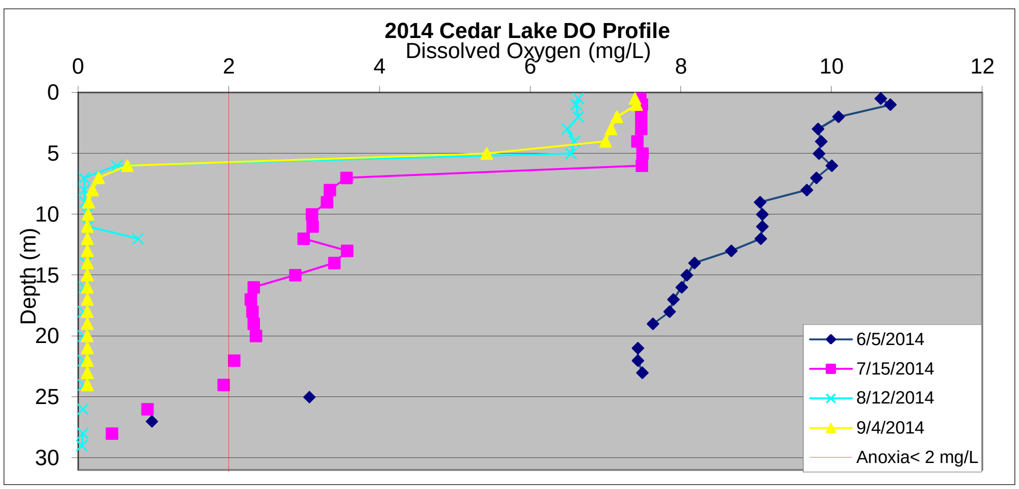
Appendix G-Lake Phosphorus
and Profile Data







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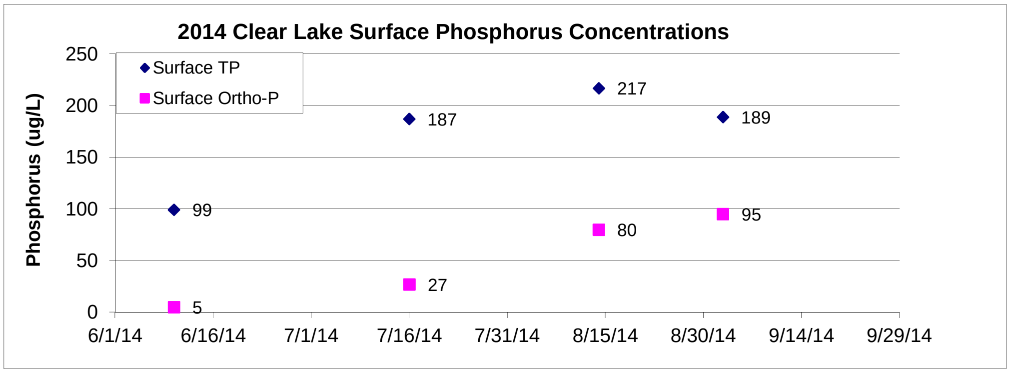
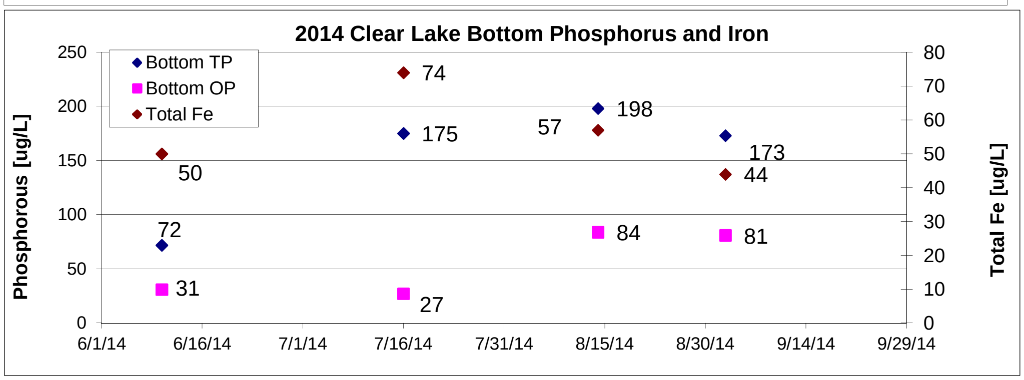
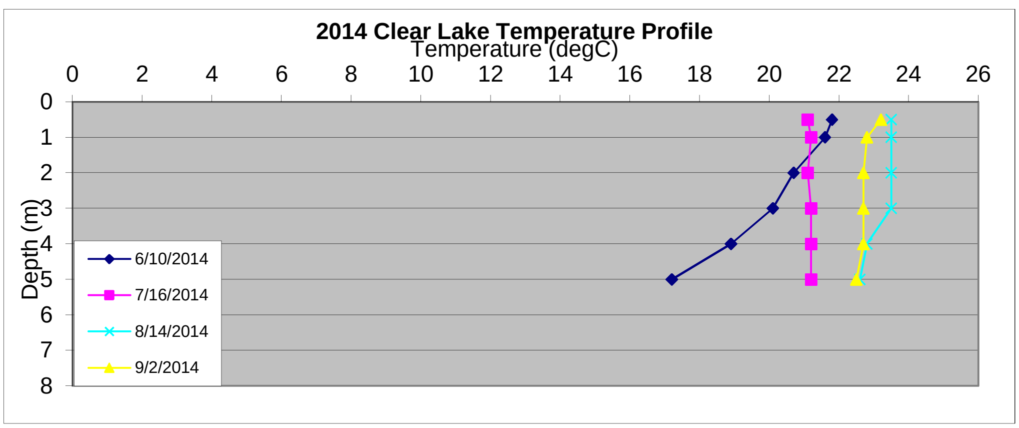
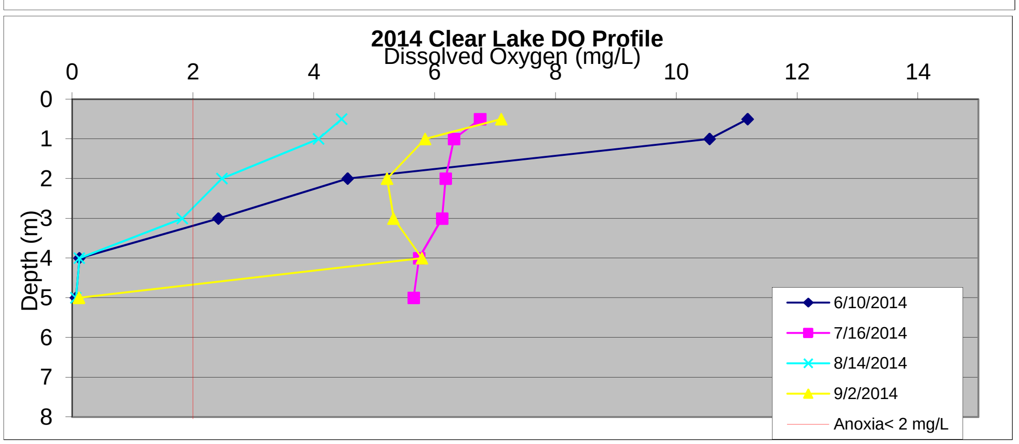
Appendix G-Lake Phosphorus
and Profile Data









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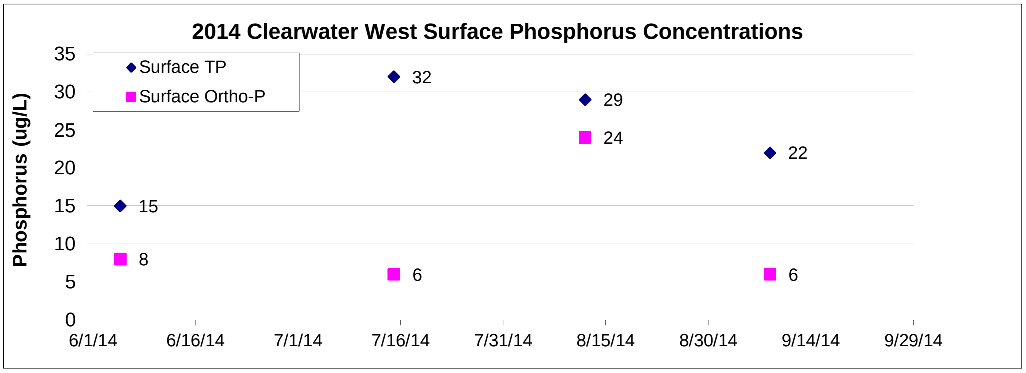
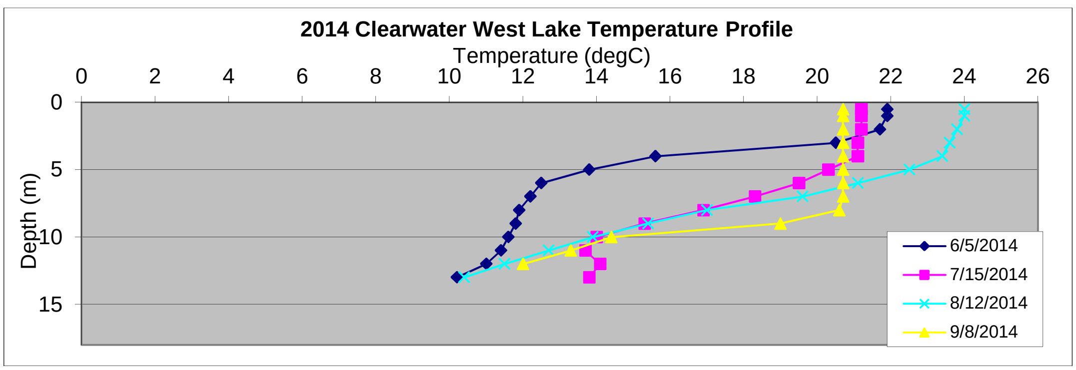
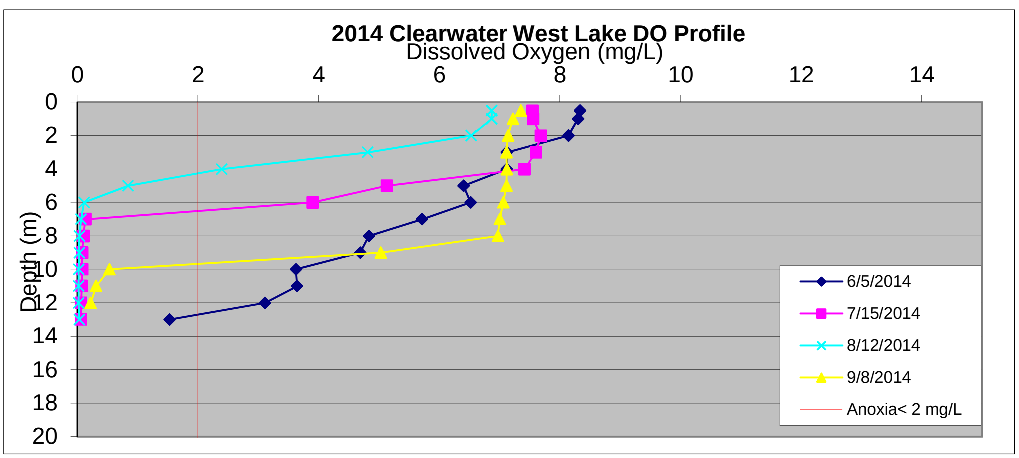
Appendix G-Lake Phosphorus
and Profile Data







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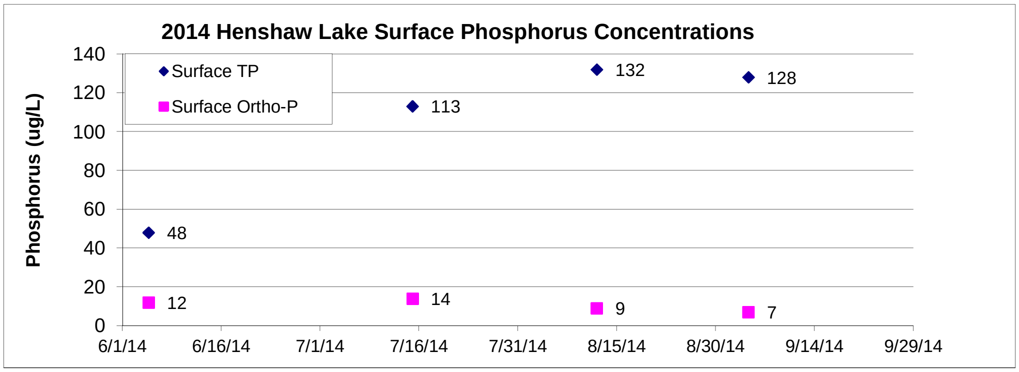
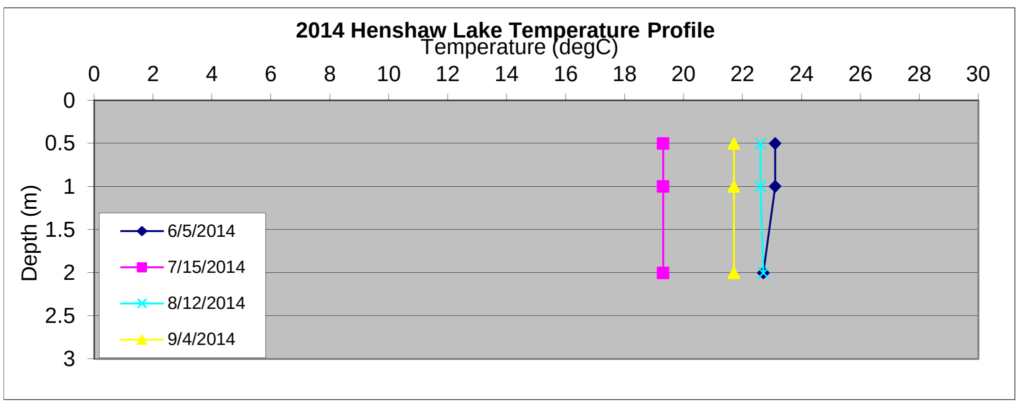
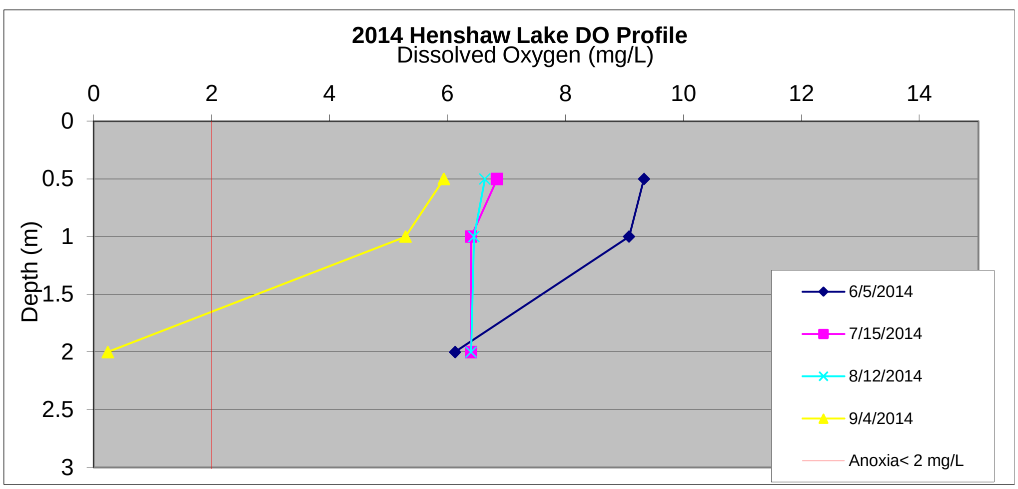
Appendix G-Lake Phosphorus
and Profile Data







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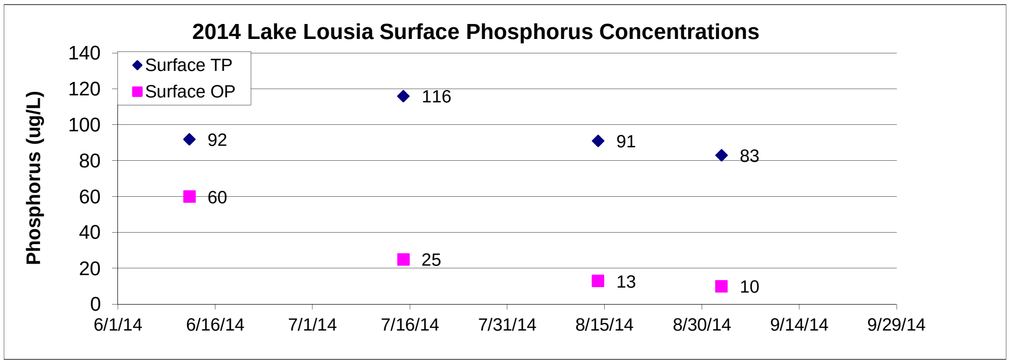
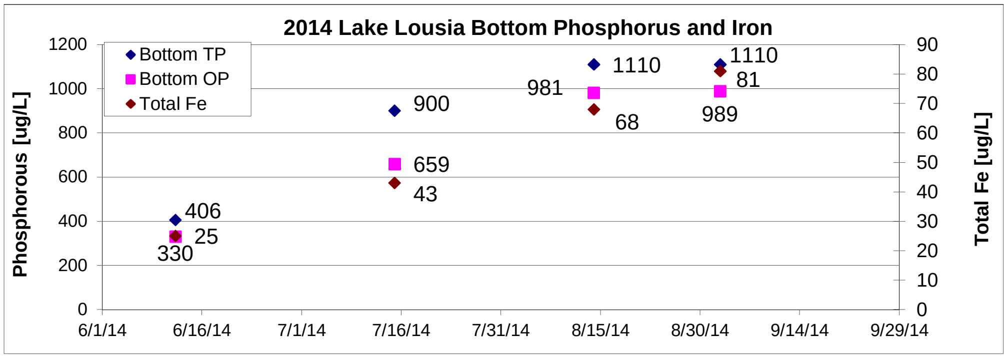
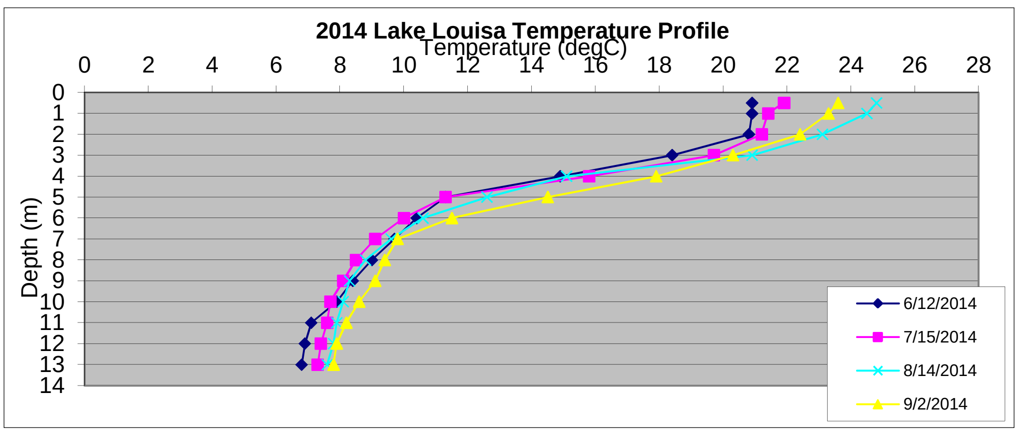
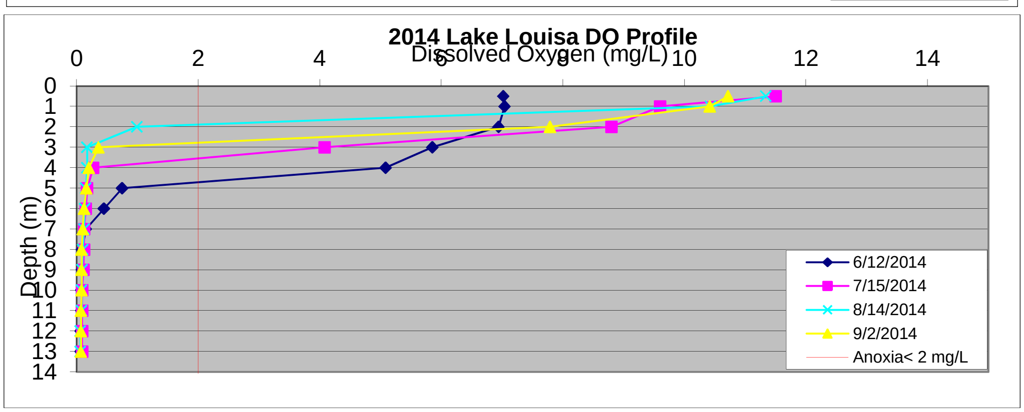
Appendix G-Lake Phosphorus
and Profile Data









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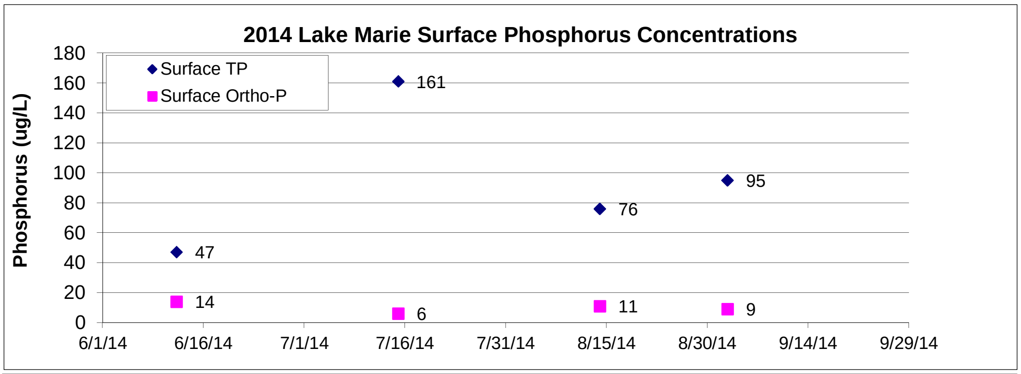
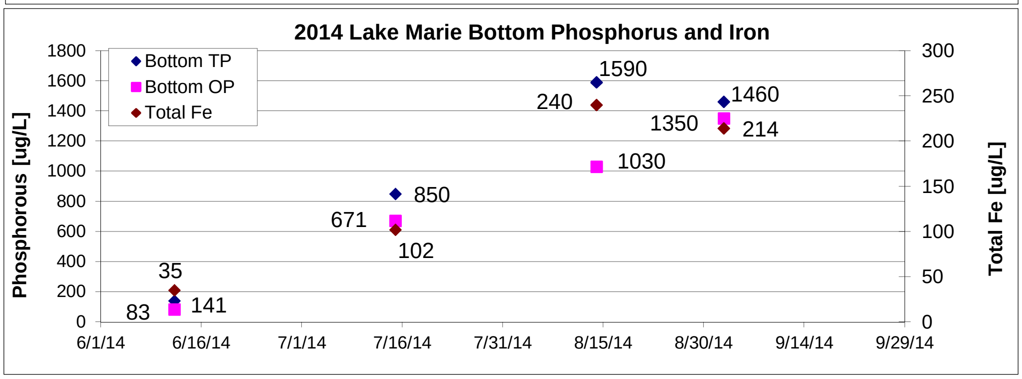
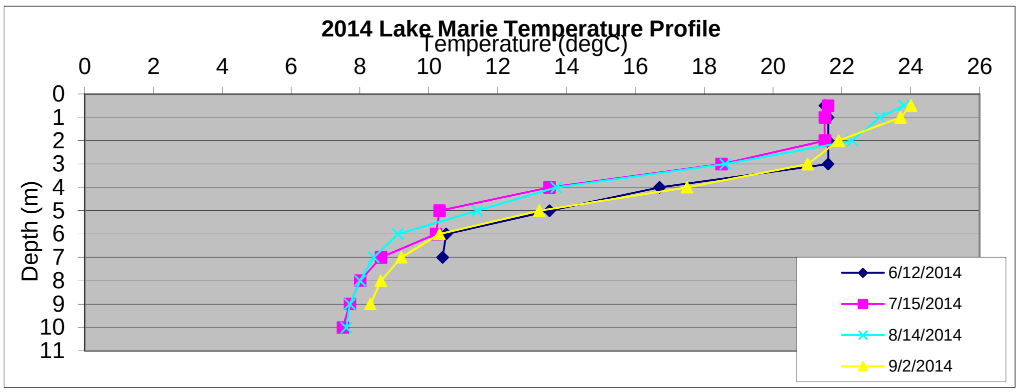
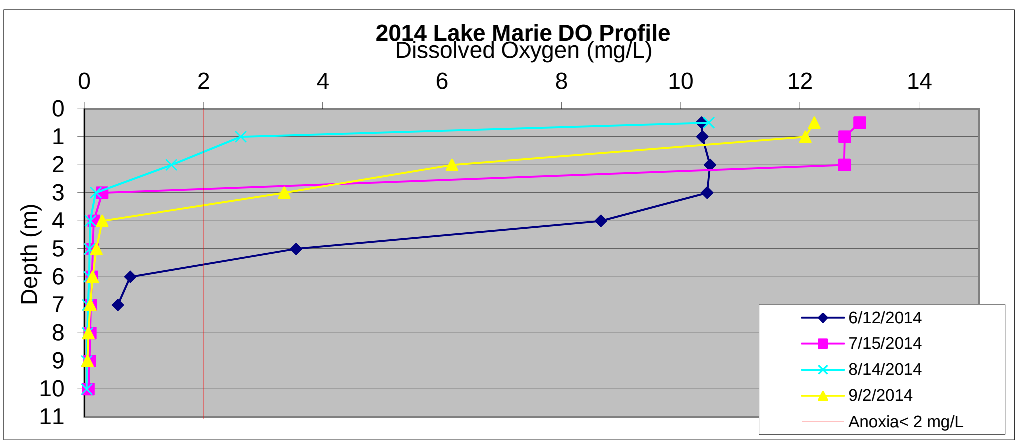
Appendix G-Lake Phosphorus
and Profile Data









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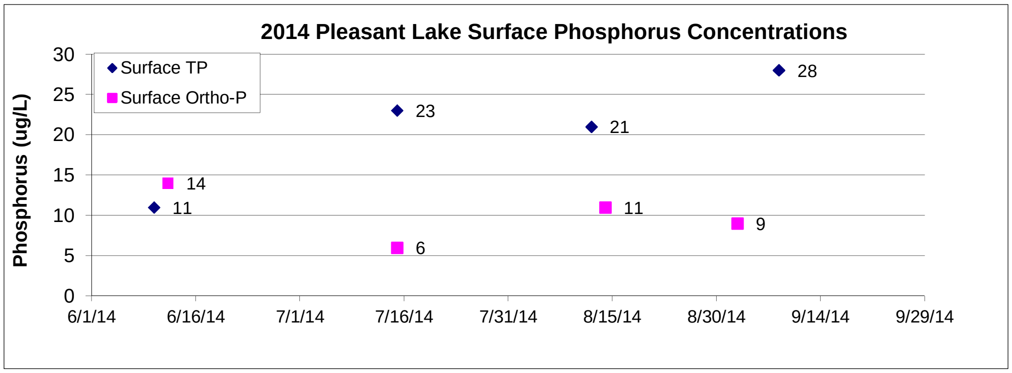
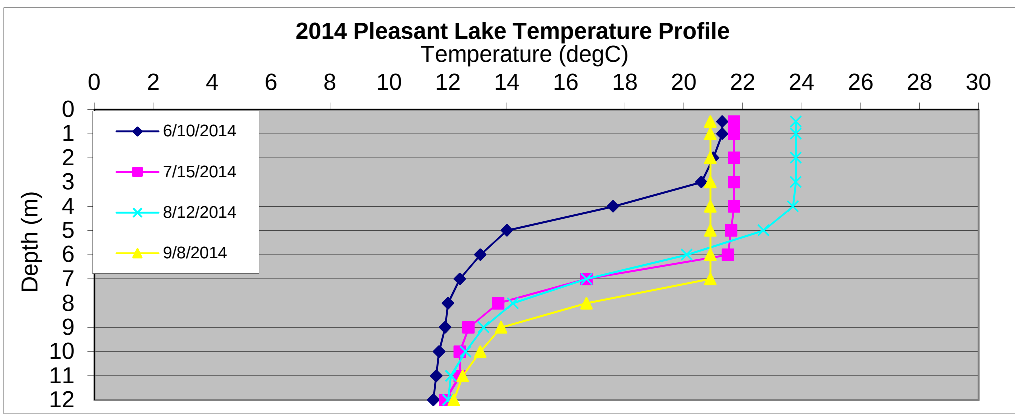
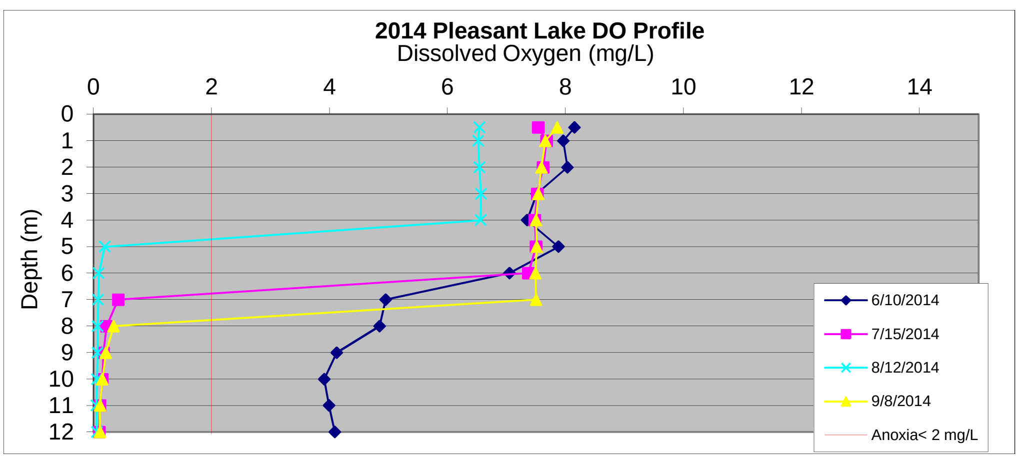
Appendix G-Lake Phosphorus
and Profile Data







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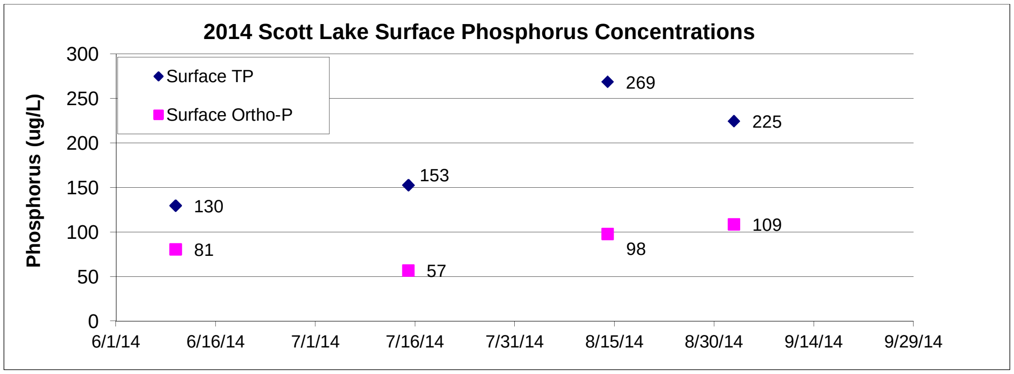
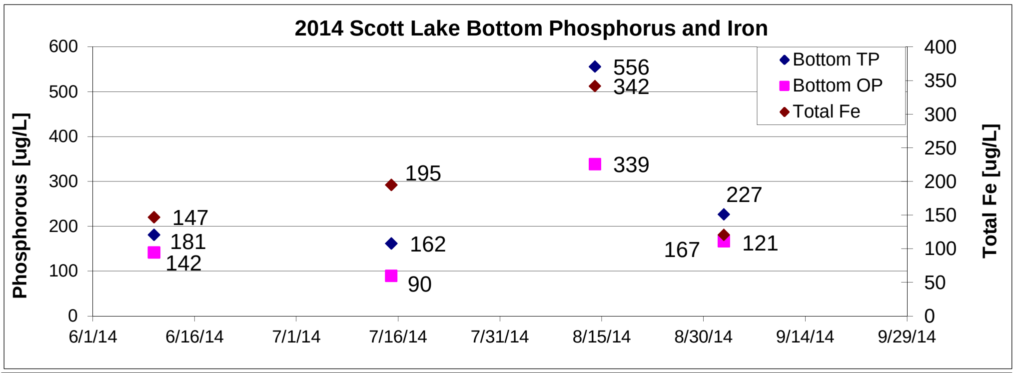
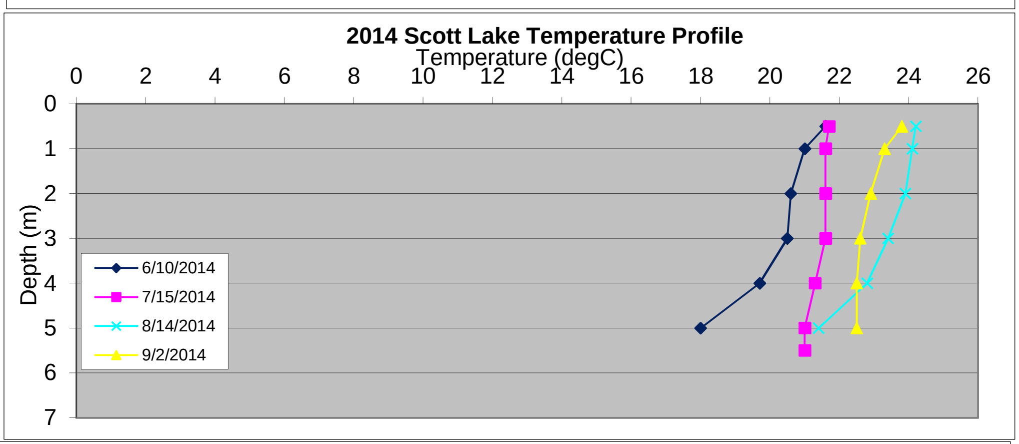
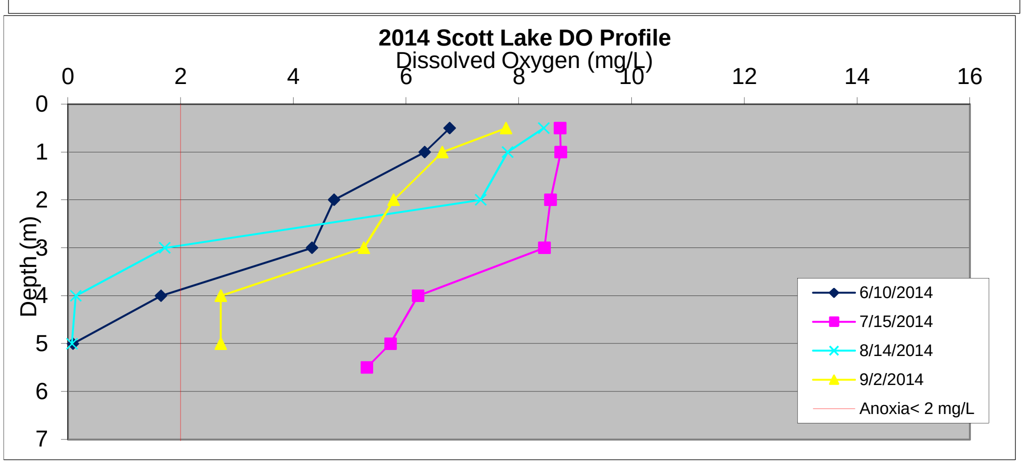
Appendix G-Lake Phosphorus
and Profile Data









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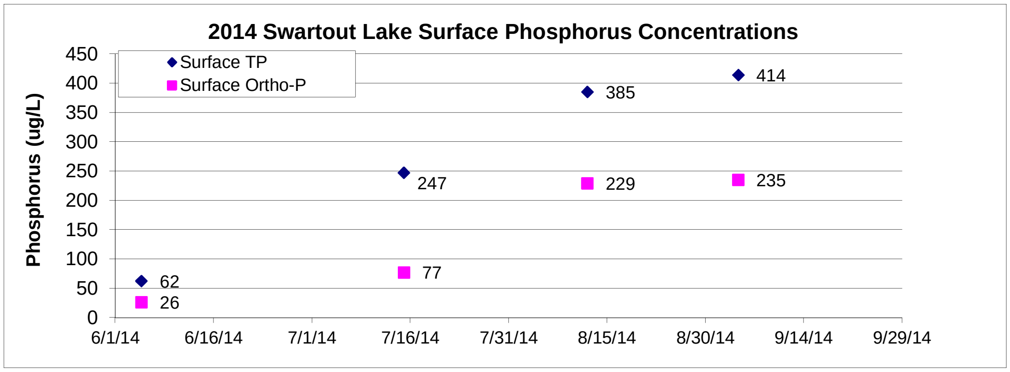
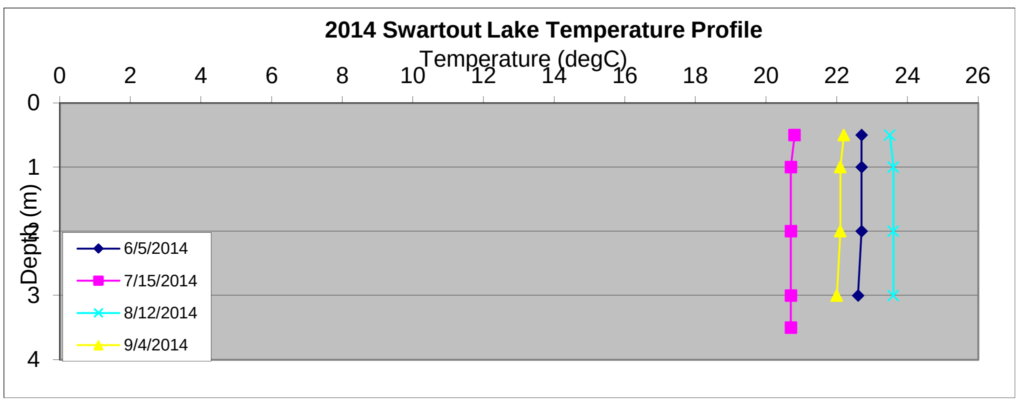
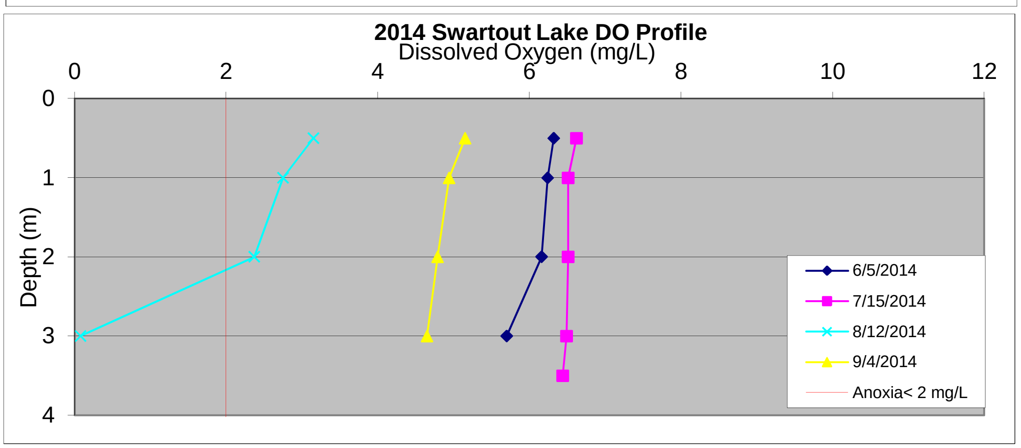
Appendix G-Lake Phosphorus
and Profile Data







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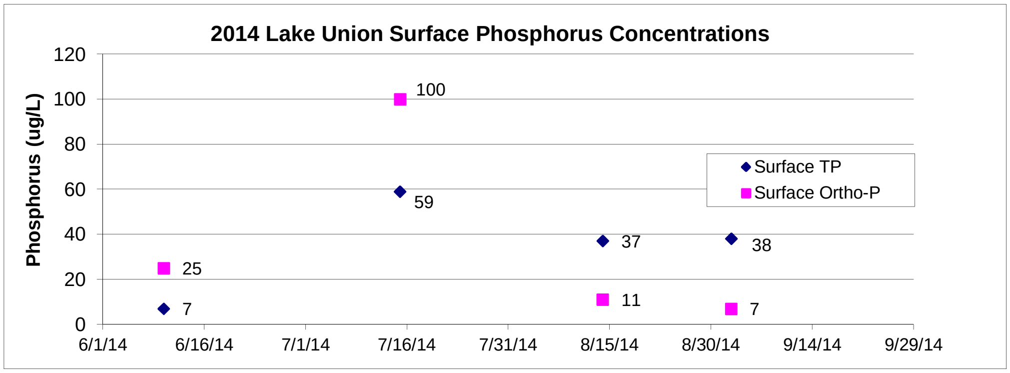
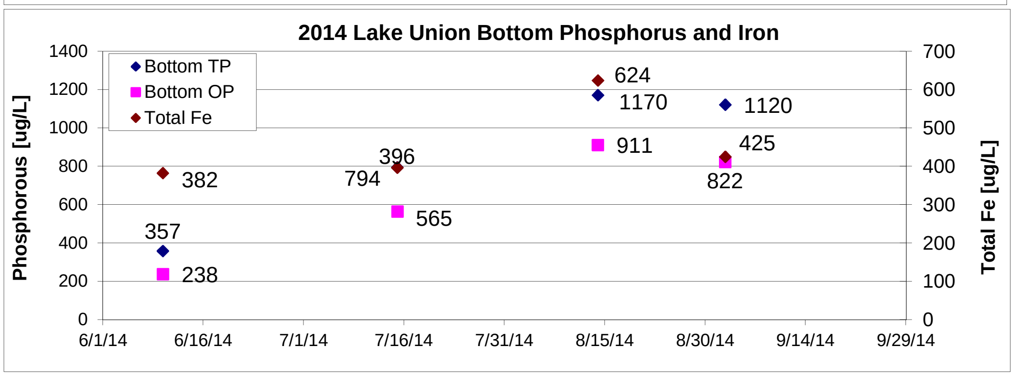
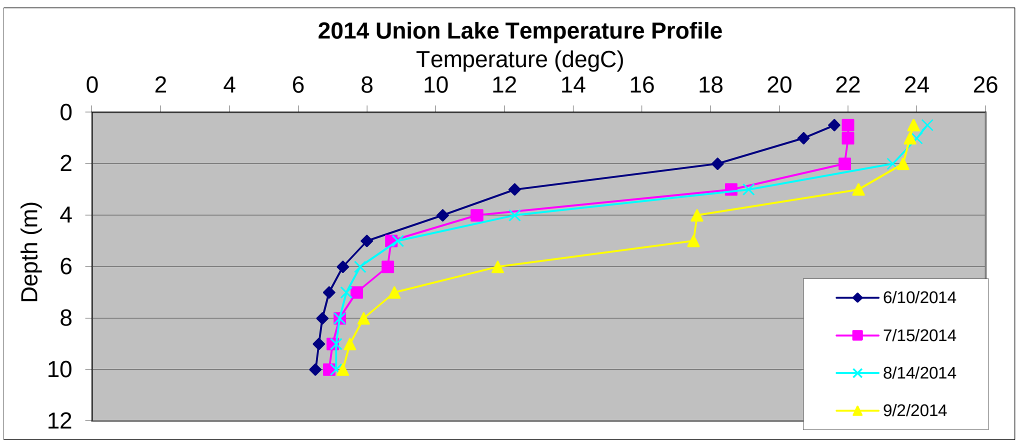
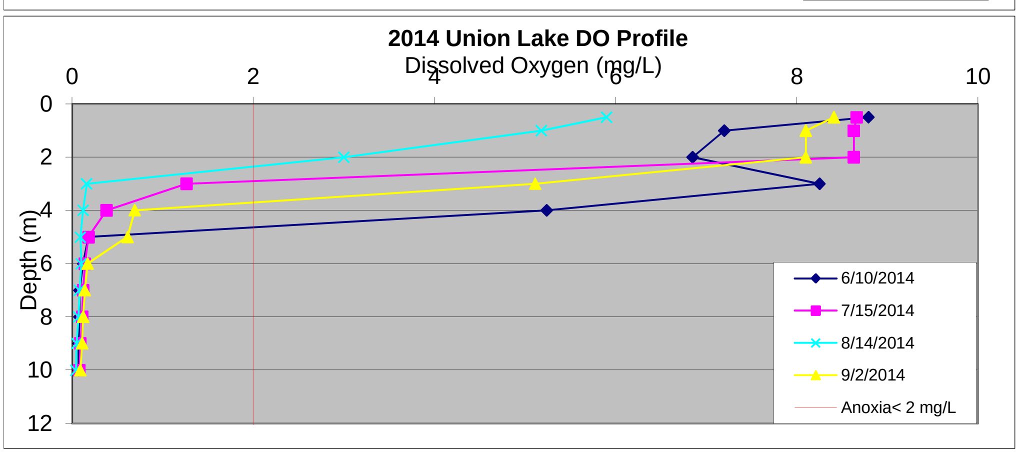
Appendix G-Lake Phosphorus
and Profile Data









Appendix H

2014 Stream Phosphorus Concentrations

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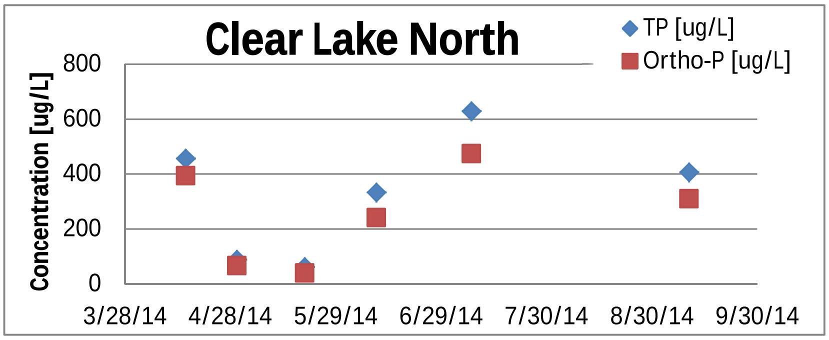

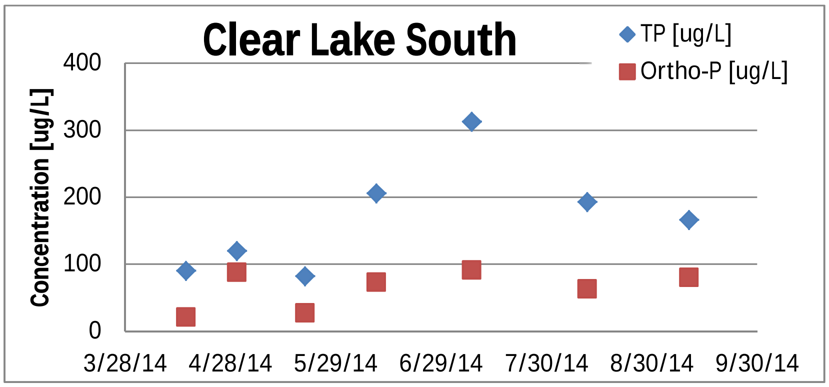

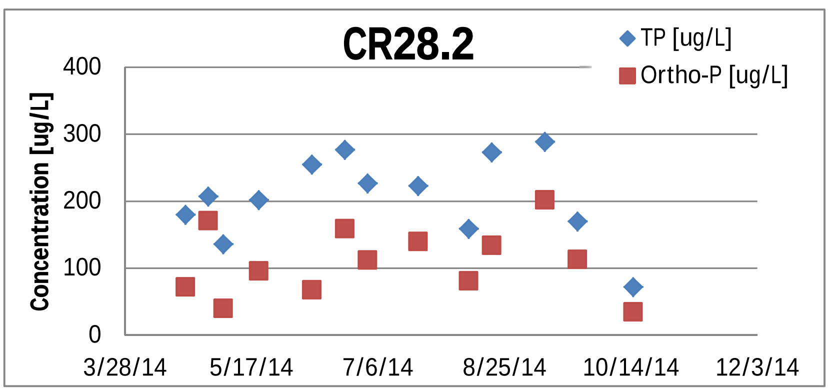

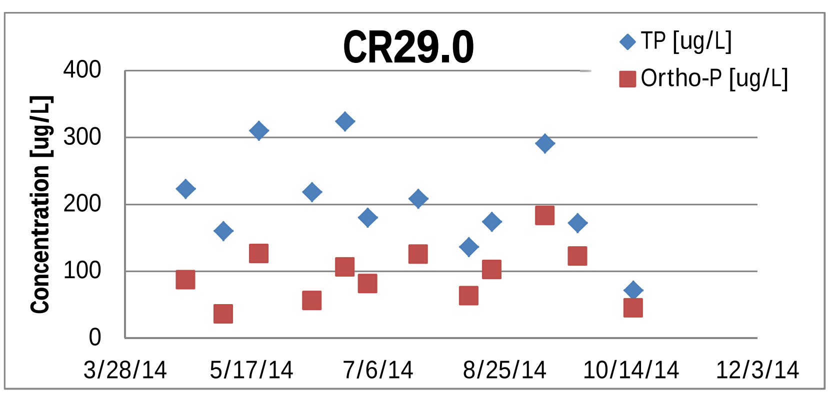

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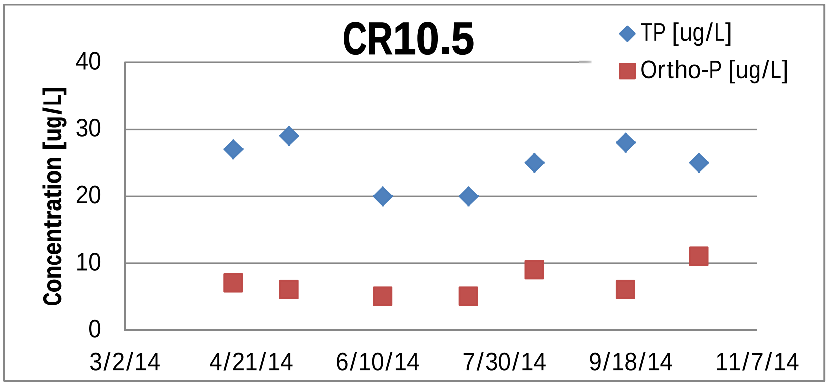

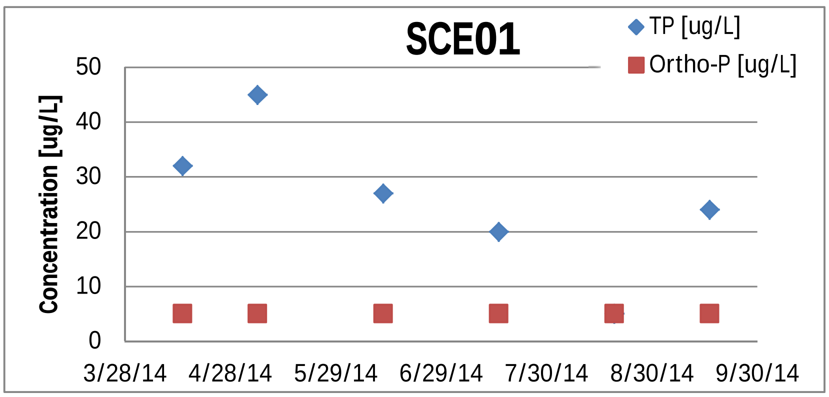

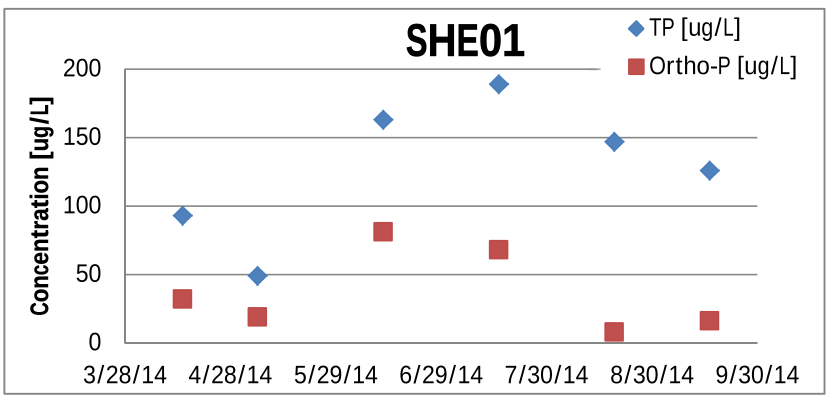

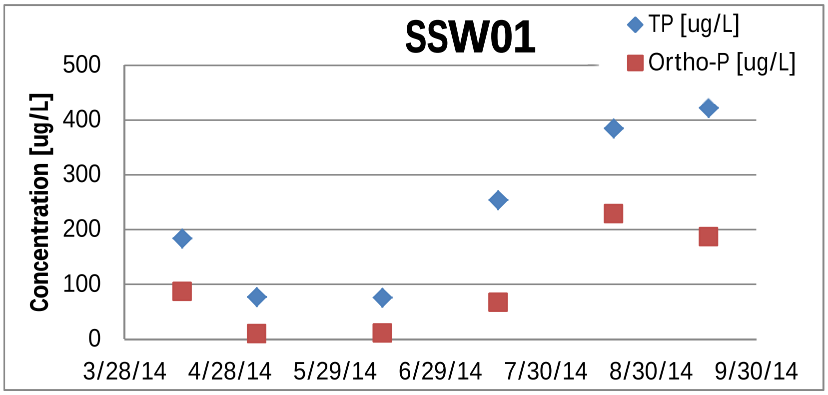
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Concentration [ug/L]
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300
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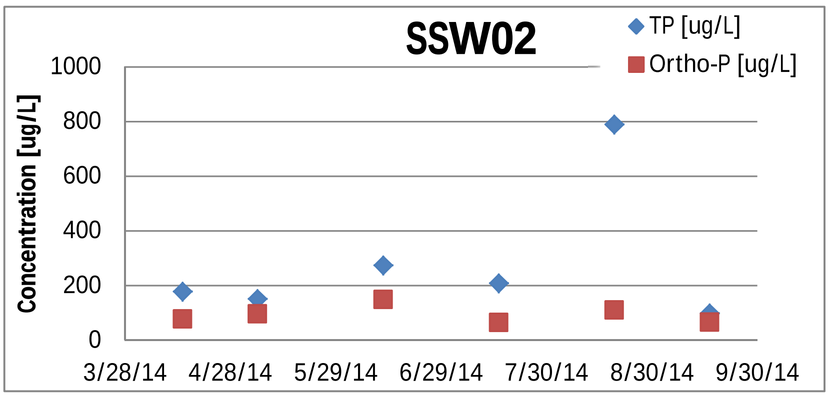
8/30/14
9/30/14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Ortho-P [ug/L]
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800
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400
200
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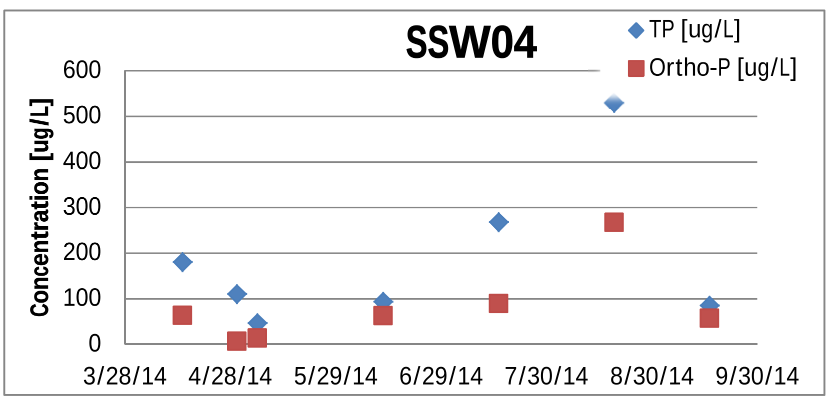
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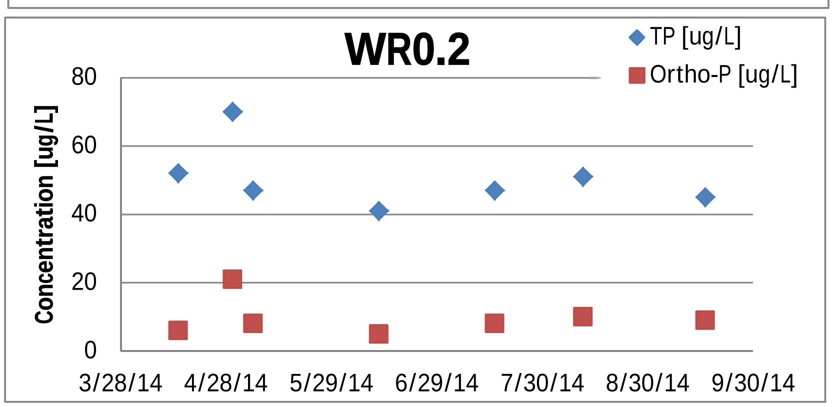
8/30/14
9/30/14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Ortho-P [ug/L]
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20
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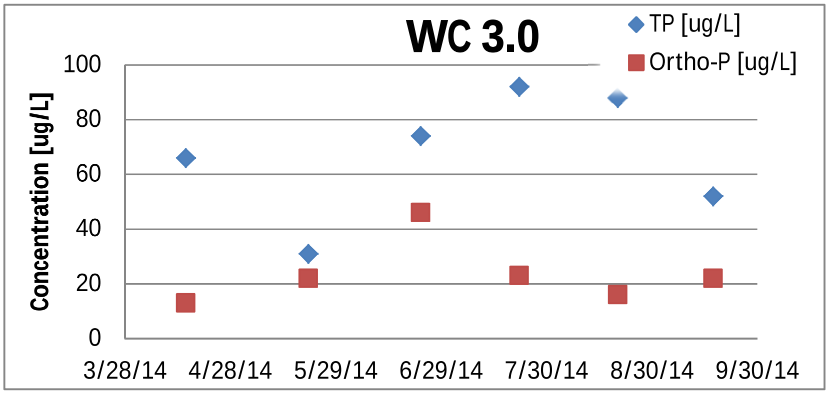

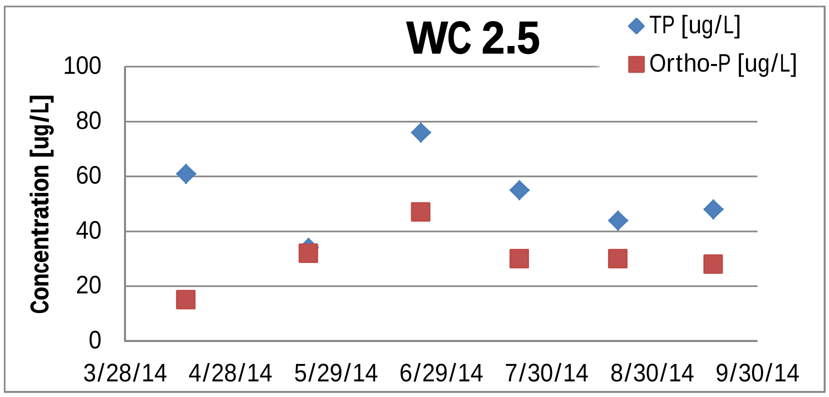

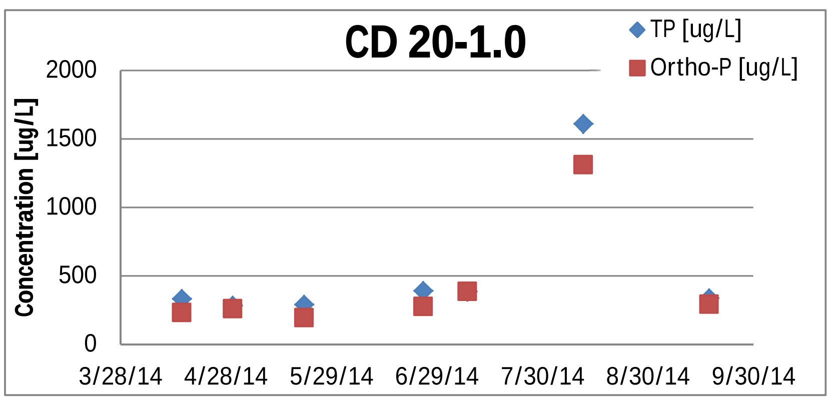

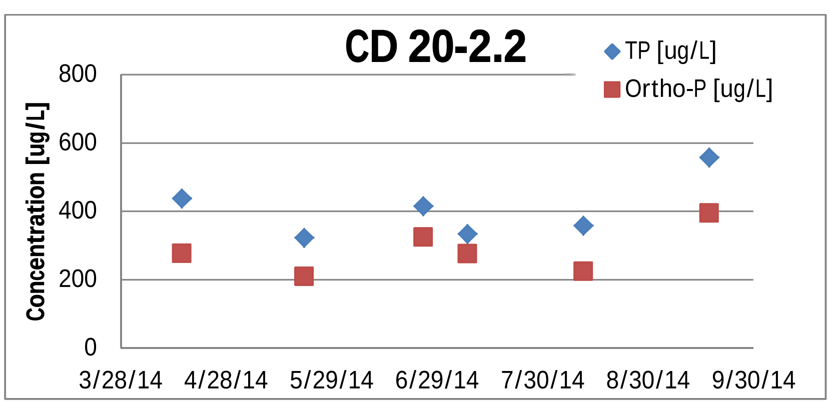

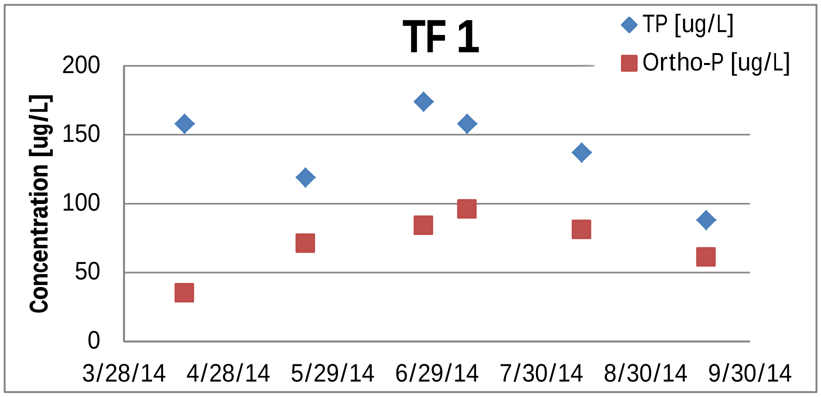
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TP [ug/L]
Ortho-P [ug/L]
Concentration [ug/L]
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150
100
50
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3/28/14
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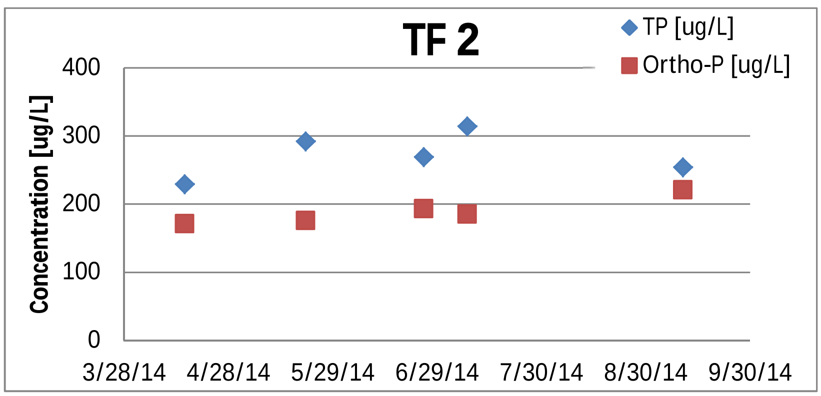
9/30/14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Ortho-P [ug/L]
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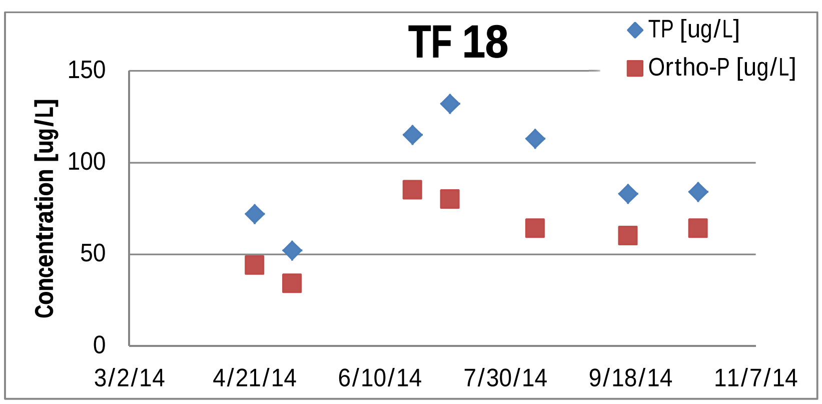
9/30/14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Concentration [ug/L]
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Appendix I

Kingston Wetland Monitoring Data

Appendix I-Kingston Wetland Monitoring Data

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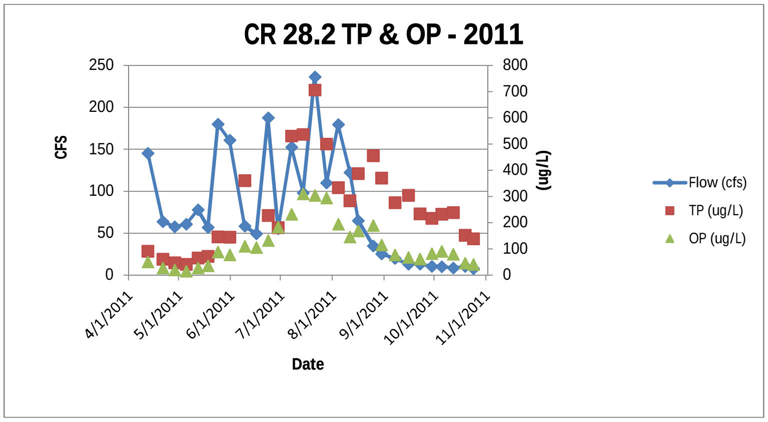

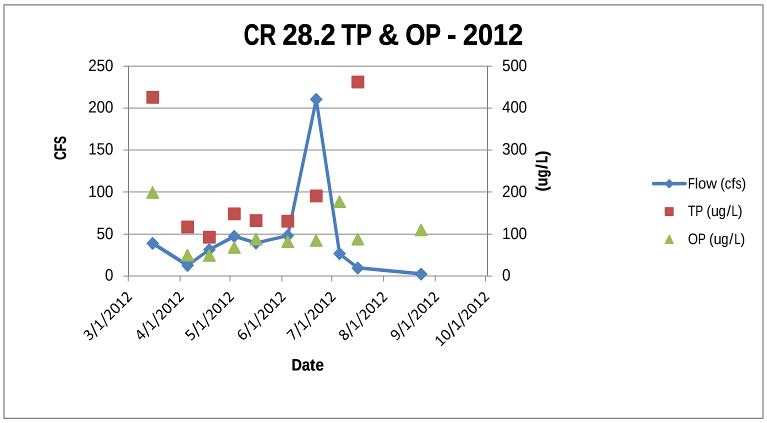

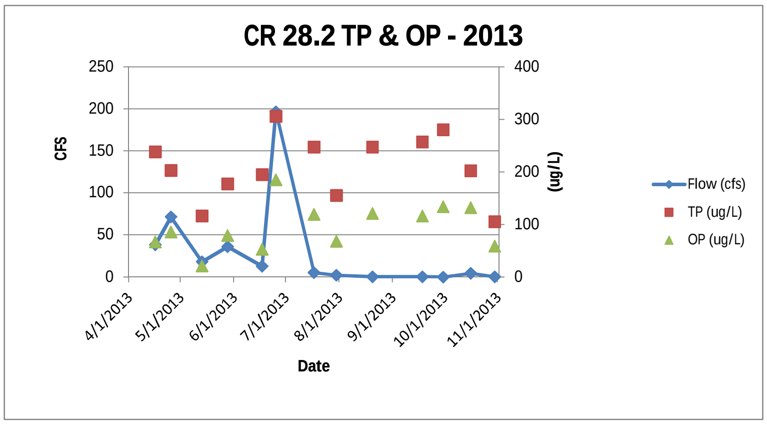

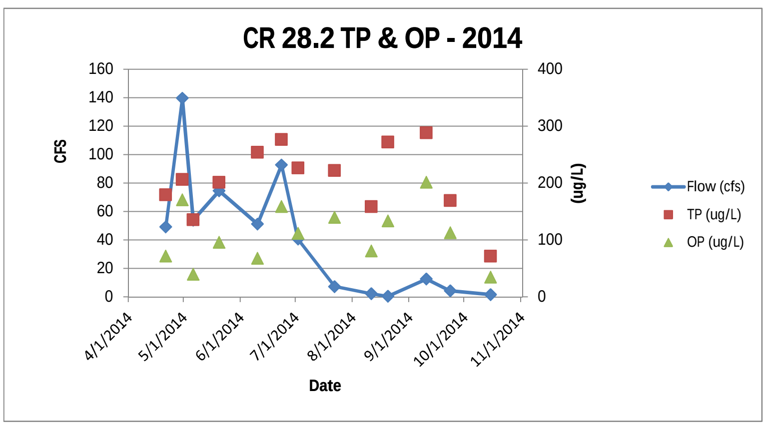

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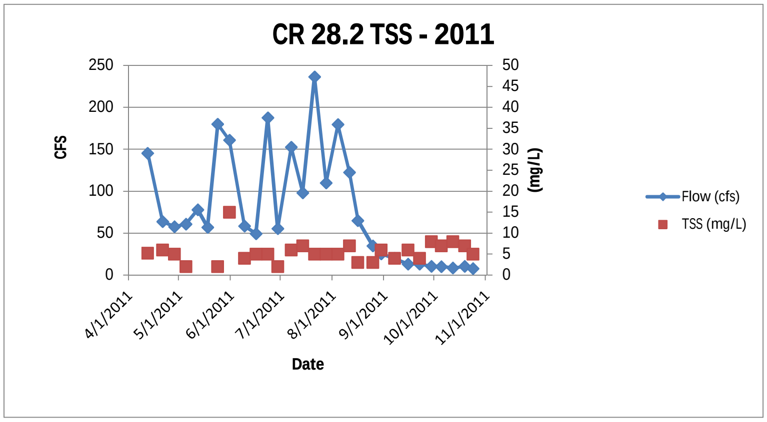
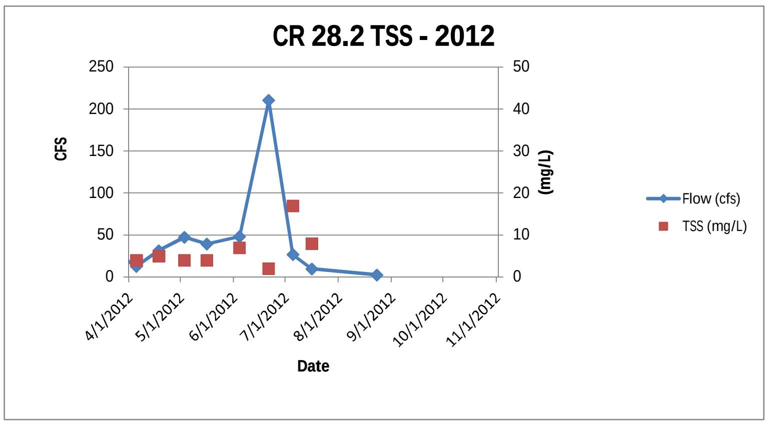
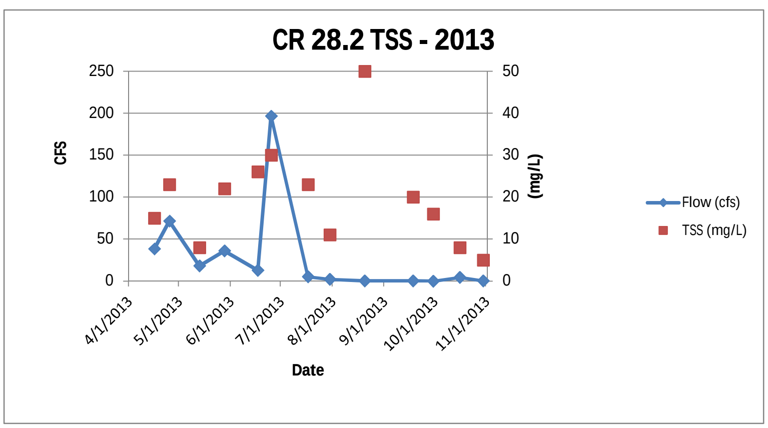
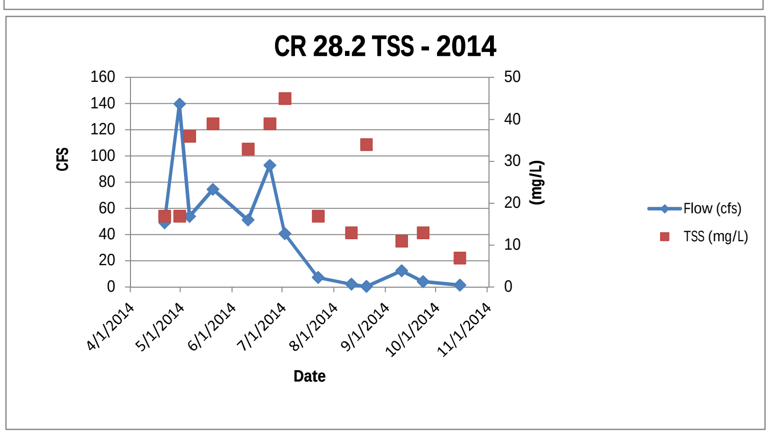
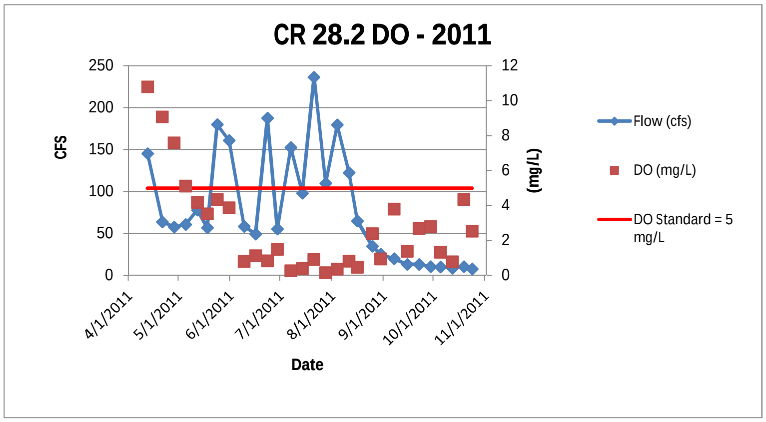
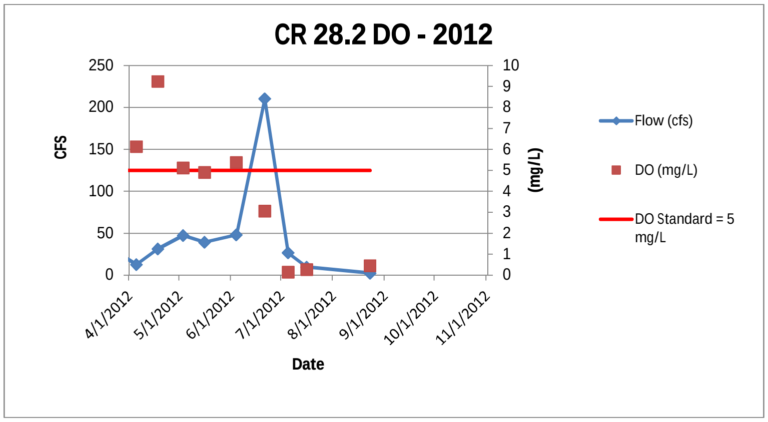


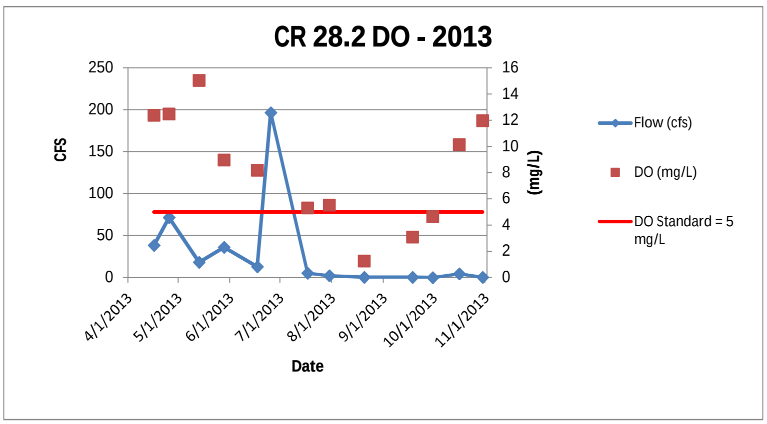


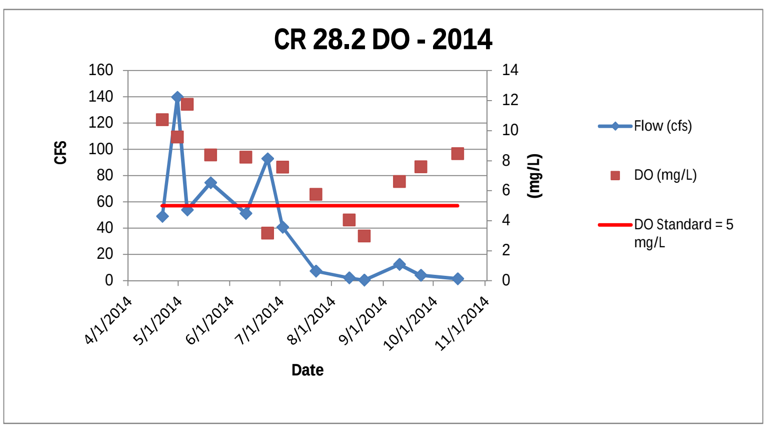





CR 28.2 DO - 2011
CFS
(mg/L)
Date
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L
4/1/2011
5/1/2011
6/1/2011
7/1/2011
8/1/2011
9/1/2011
10/1/2011
11/1/2011

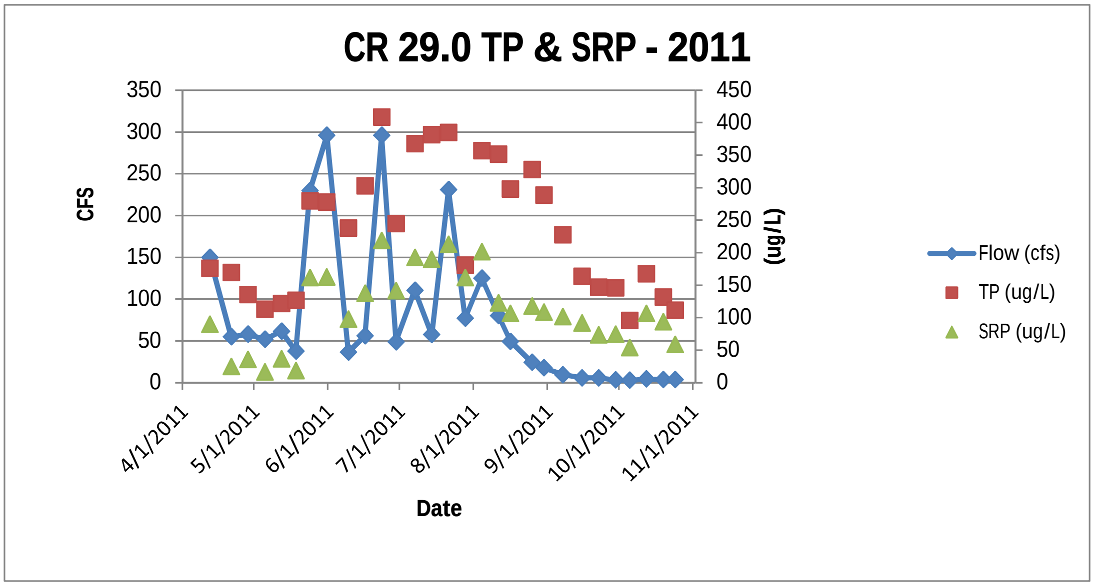

CR 28.2 DO - 2012
CFS
(mg/L)
Date
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L
4/1/2012
5/1/2012
6/1/2012
7/1/2012
8/1/2012
9/1/2012
10/1/2012
11/1/2012

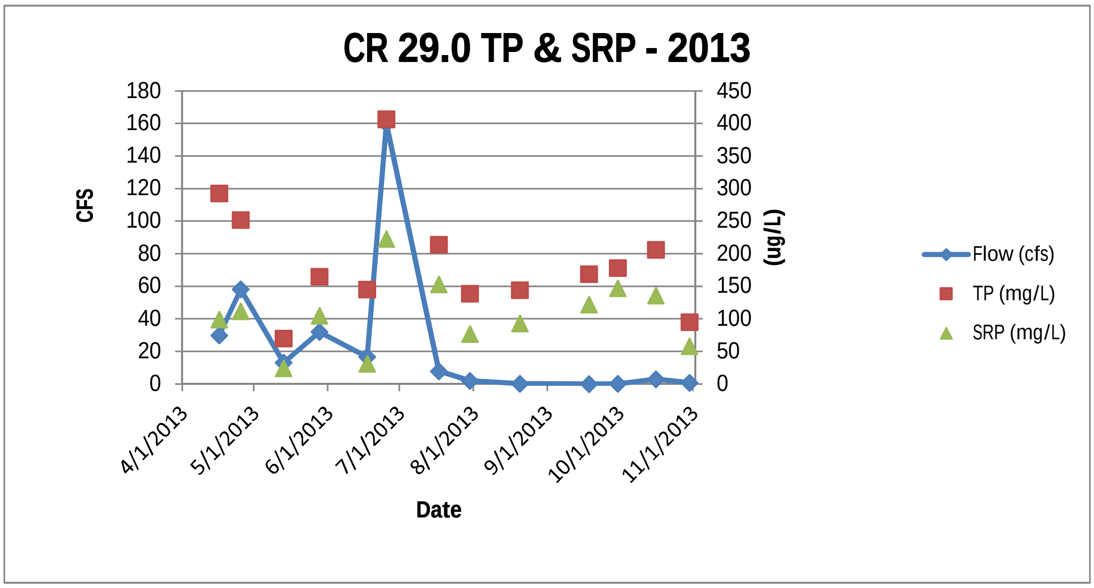

CR 28.2 DO - 2013
CFS
(mg/L)
Date
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013
11/1/2013

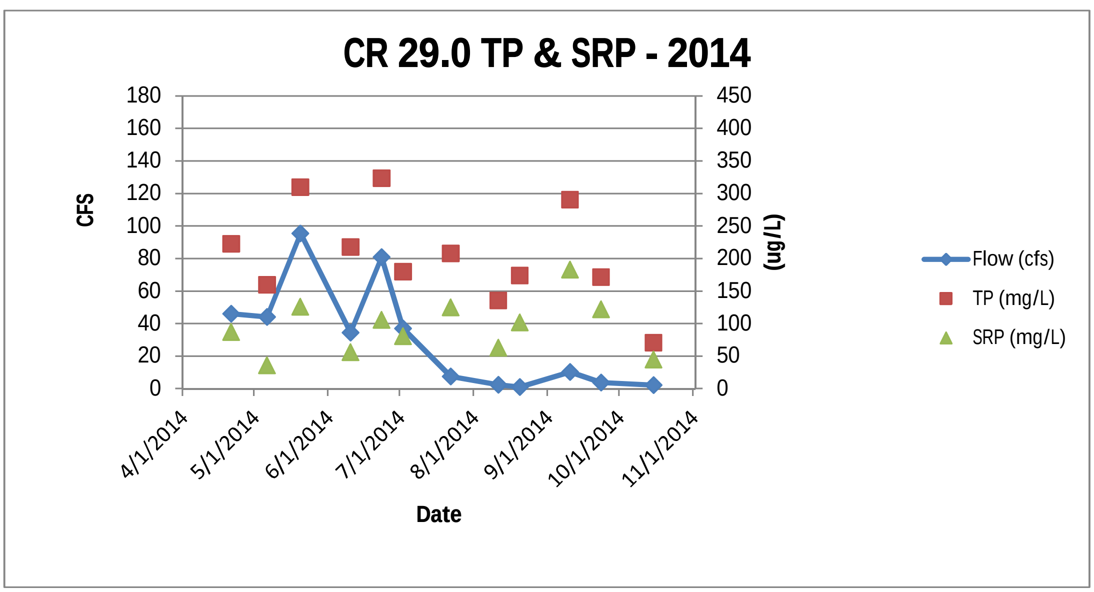

CR 28.2 DO - 2014
CFS
(mg/L)
Date
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L
4/1/2014
5/1/2014
6/1/2014
7/1/2014
8/1/2014
9/1/2014
10/1/2014
11/1/2014

Appendix I-Kingston Wetland Monitoring Data

2014 CRWD Water Quality Report

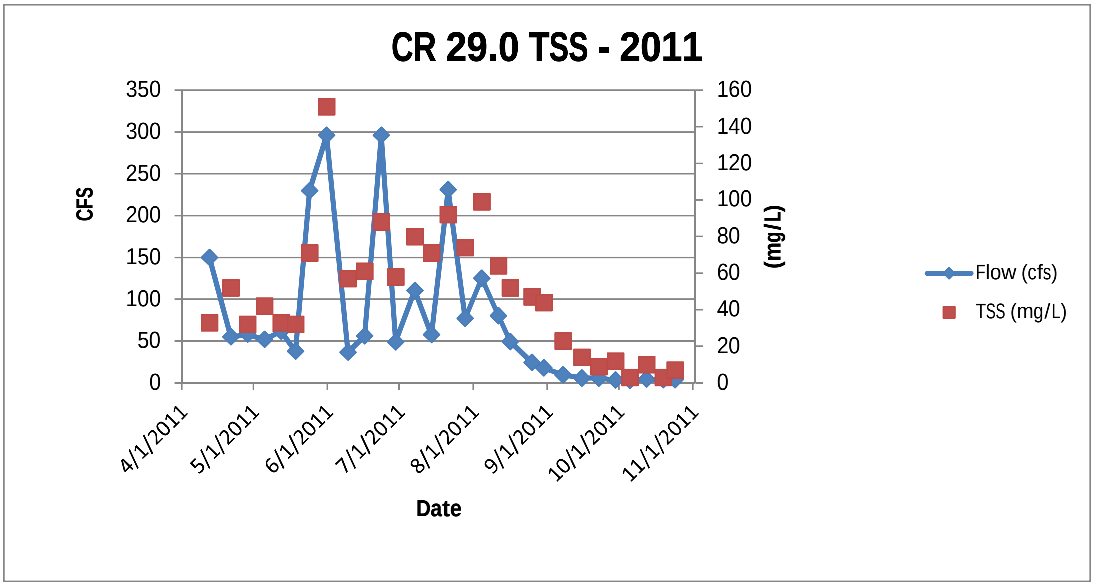


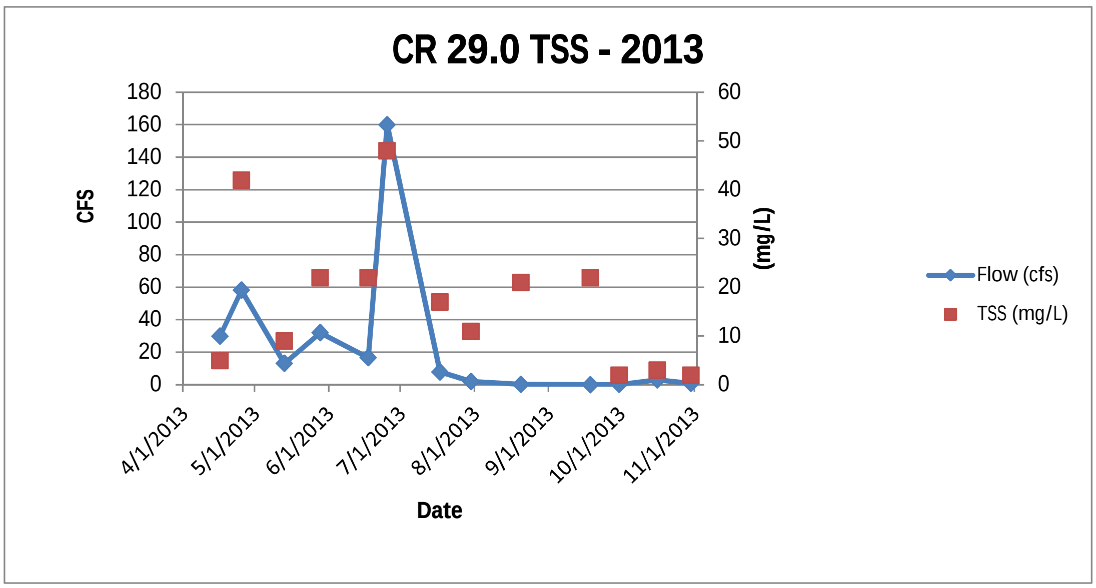


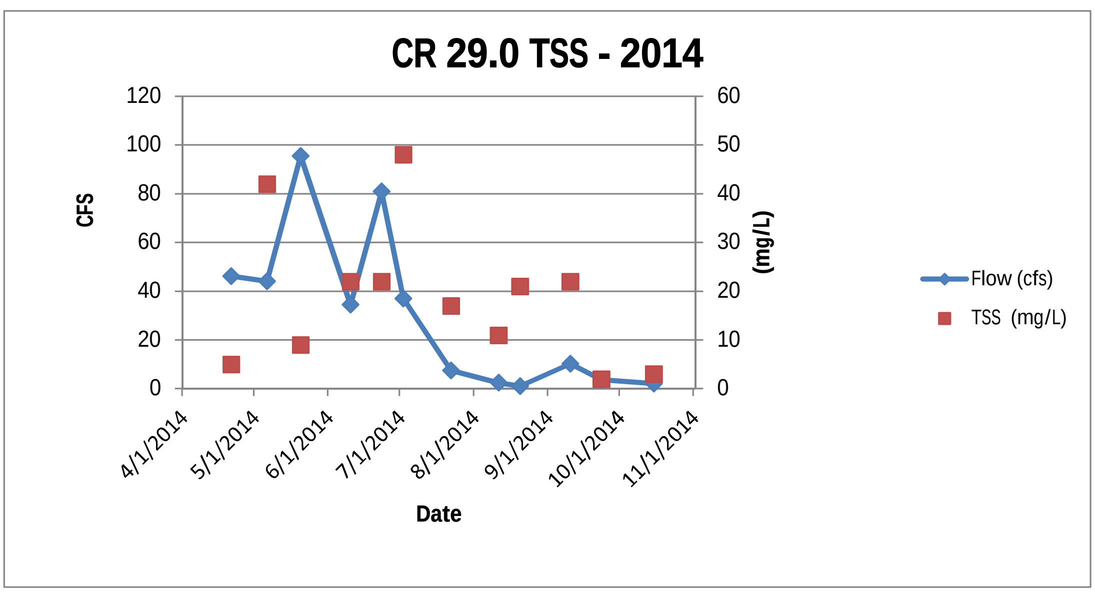


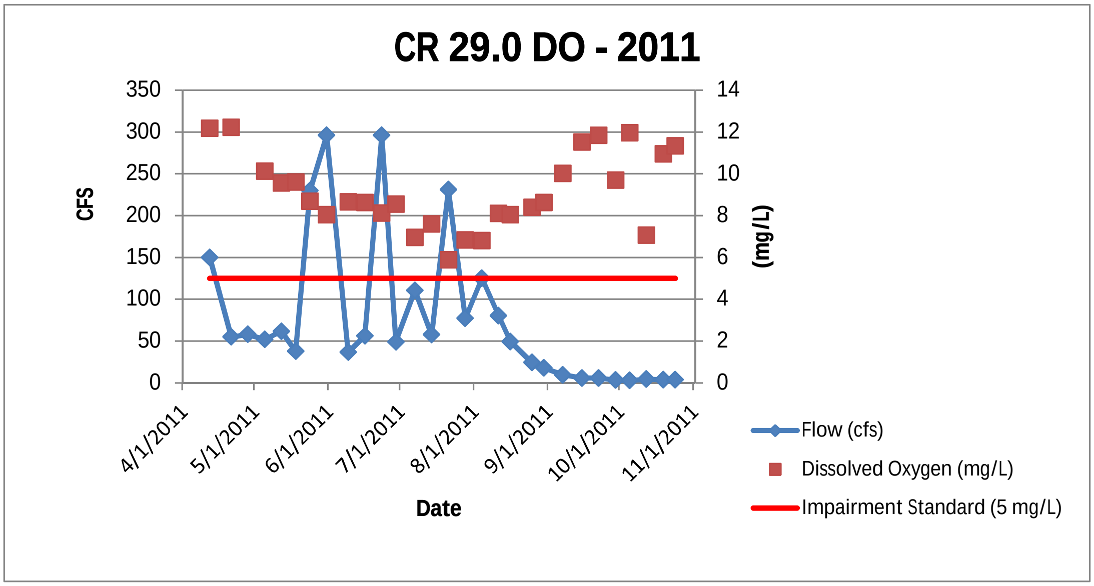
Appendix I-Kingston Wetland Monitoring Data

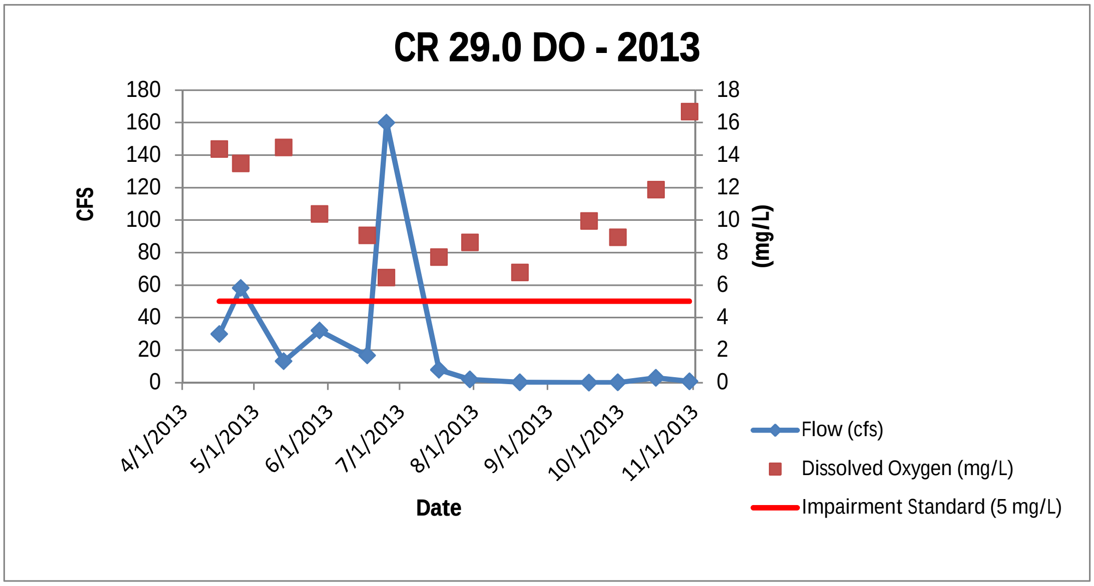
2014 CRWD Water Quality Report

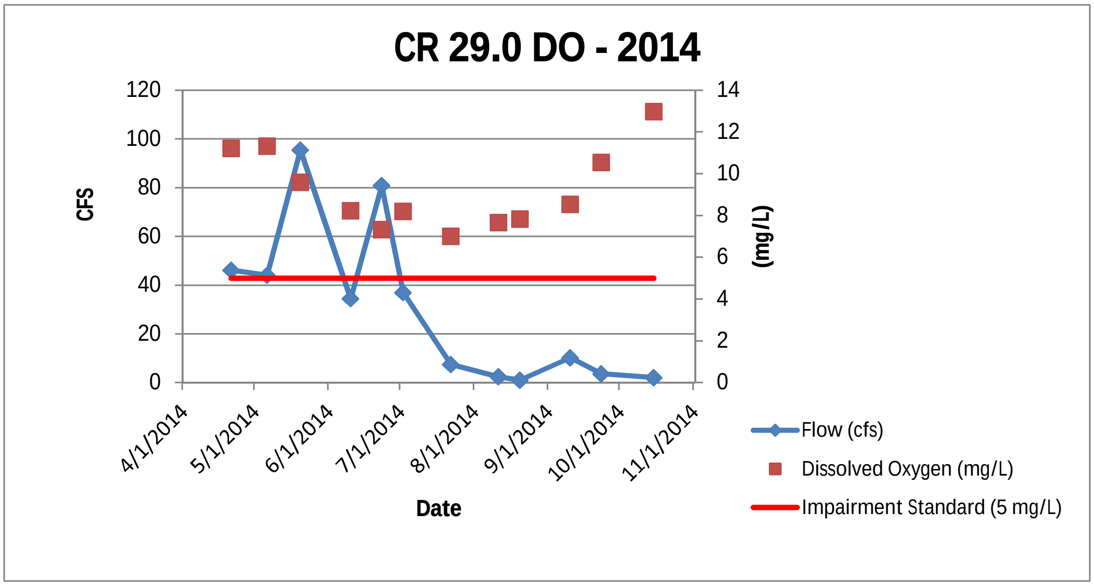






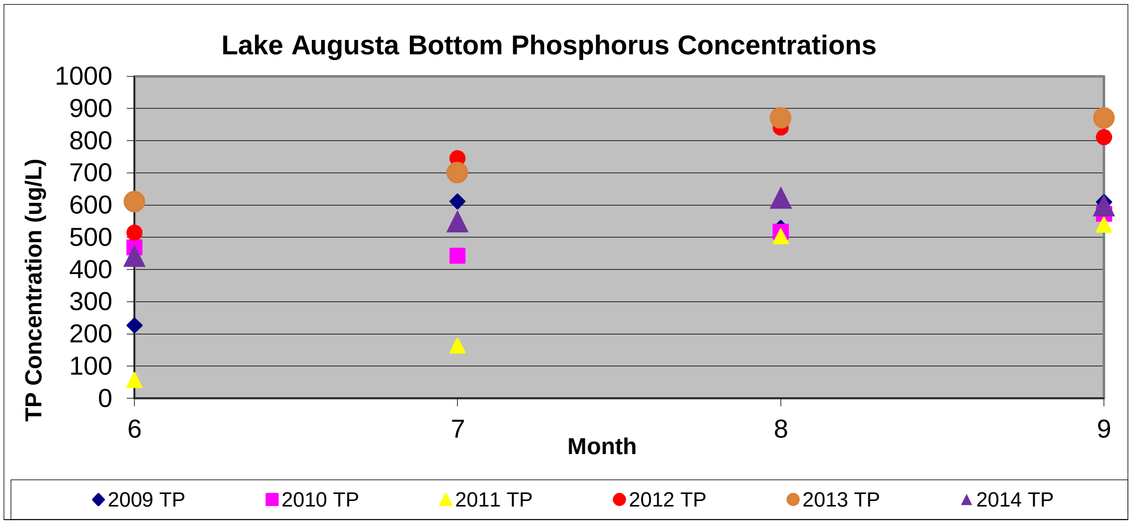

CR 29.0 DO - 2011
CFS
(mg/L)
350
300
250
200
150
100
50
0
14
12
10
8
6
4
2
0
4/1/2011
5/1/2011
6/1/2011
7/1/2011
8/1/2011
9/1/2011
10/1/2011
11/1/2011
Date
Flow (cfs)
Dissolved Oxygen (mg/L)
Impairment Standard (5 mg/L)

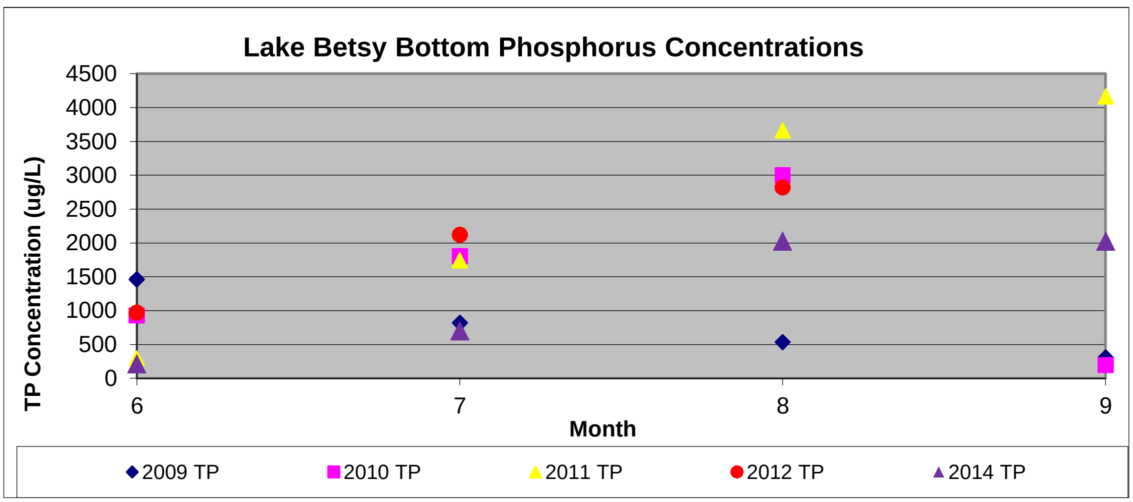

CR 29.0 DO - 2013
CFS
(mg/L)
180
160
140
120
100
80
60
40
20
0
18
16
14
12
10
8
6
4
2
0
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013
11/1/2013
Date
Flow (cfs)
Dissolved Oxygen (mg/L)
Impairment Standard (5 mg/L)

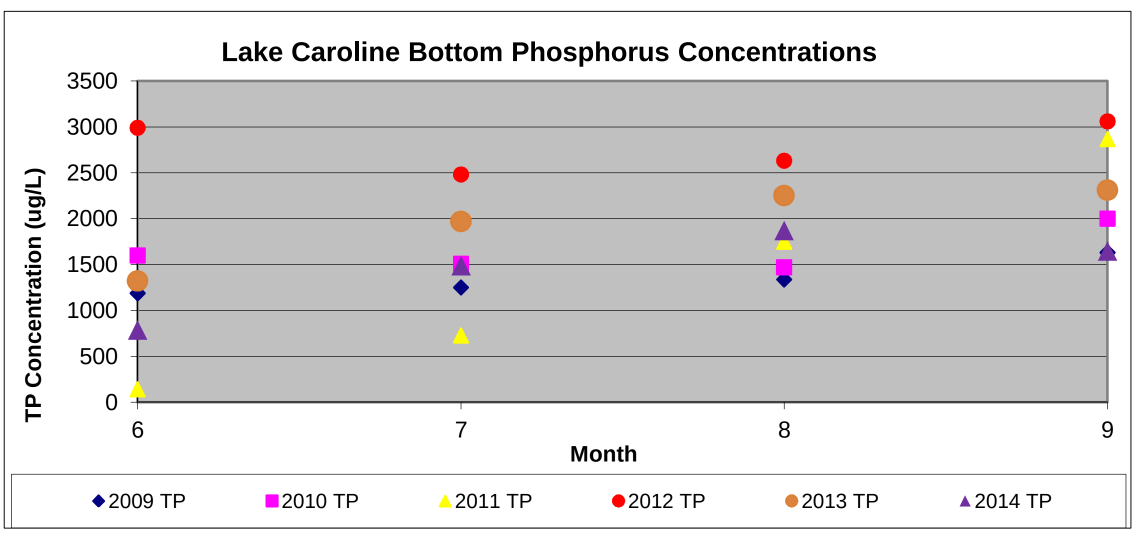

CR 29.0 DO - 2014
CFS
(mg/L)
120
100
80
60
40
20
0
14
12
10
8
6
4
2
0
4/1/2014
5/1/2014
6/1/2014
7/1/2014
8/1/2014
9/1/2014
10/1/2014
11/1/2014
Date
Flow (cfs)
Dissolved Oxygen (mg/L)
Impairment Standard (5 mg/L)

Appendix J

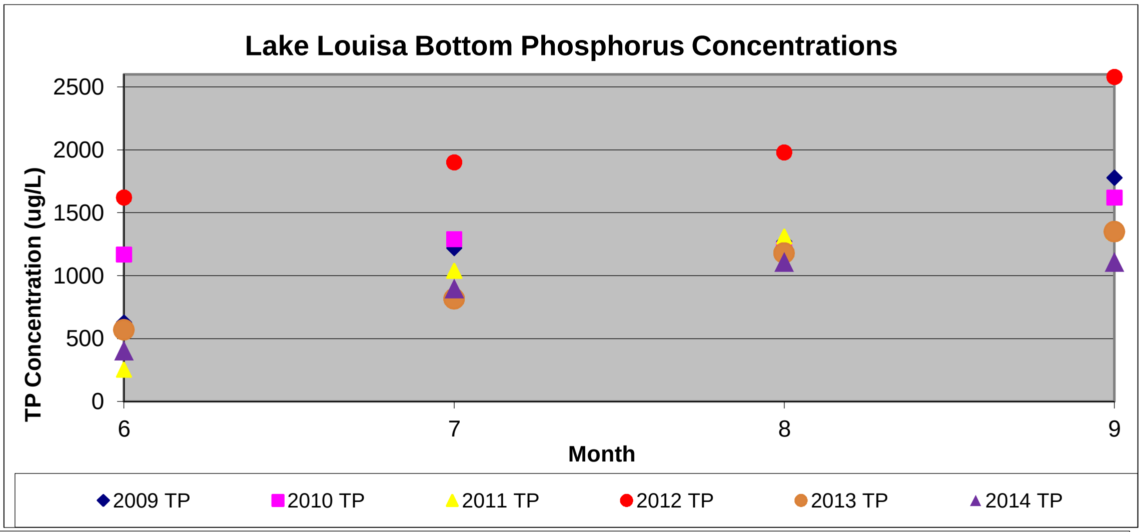
Historical Lake Bottom Data

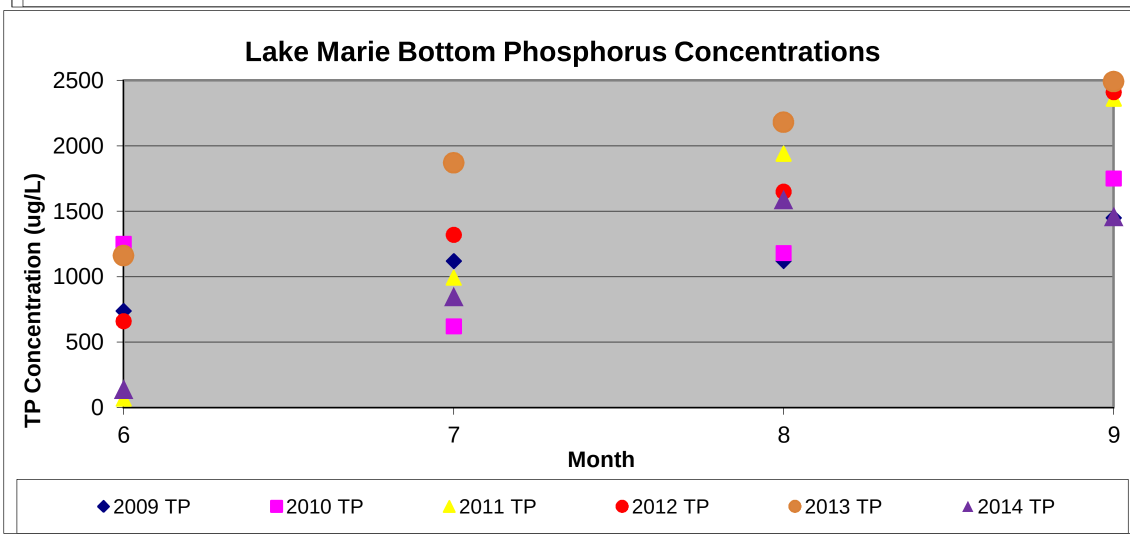

Lake Augusta Bottom Phosphorus Concentrations
TP Concentration (ug/L)
1000
900
800
700
600
500
400
300
200
100
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2013 TP
2014 TP

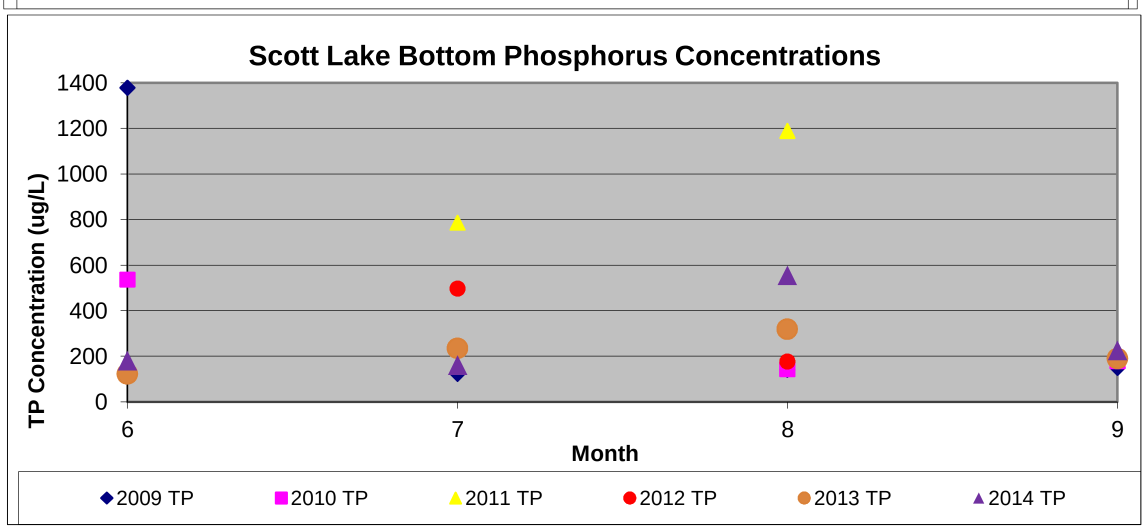

Lake Betsy Bottom Phosphorus Concentrations
TP Concentration (ug/L)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2014 TP

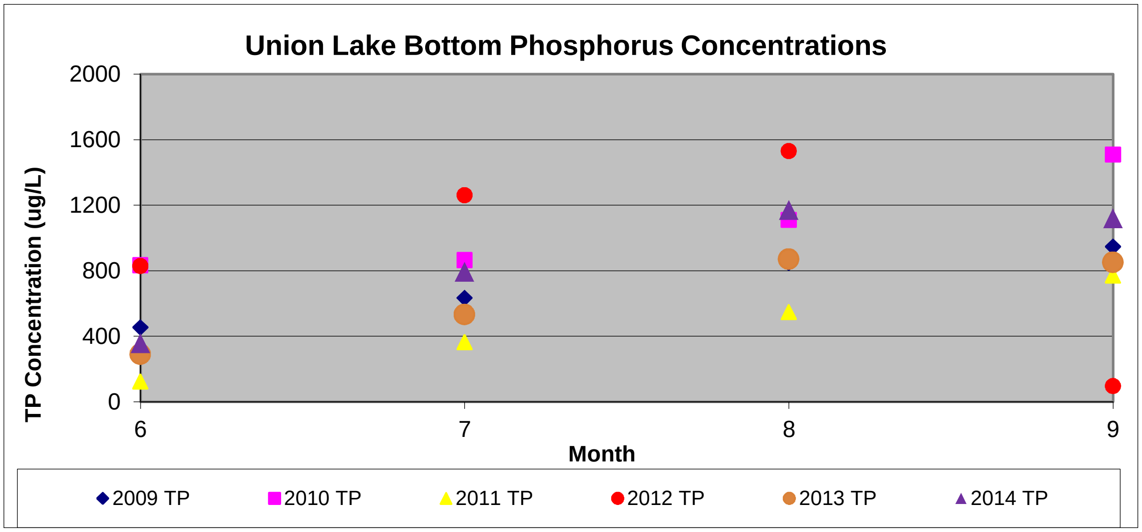

Lake Caroline Bottom Phosphorus Concentrations
TP Concentration (ug/L)
3500
3000
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2013 TP
2014 TP

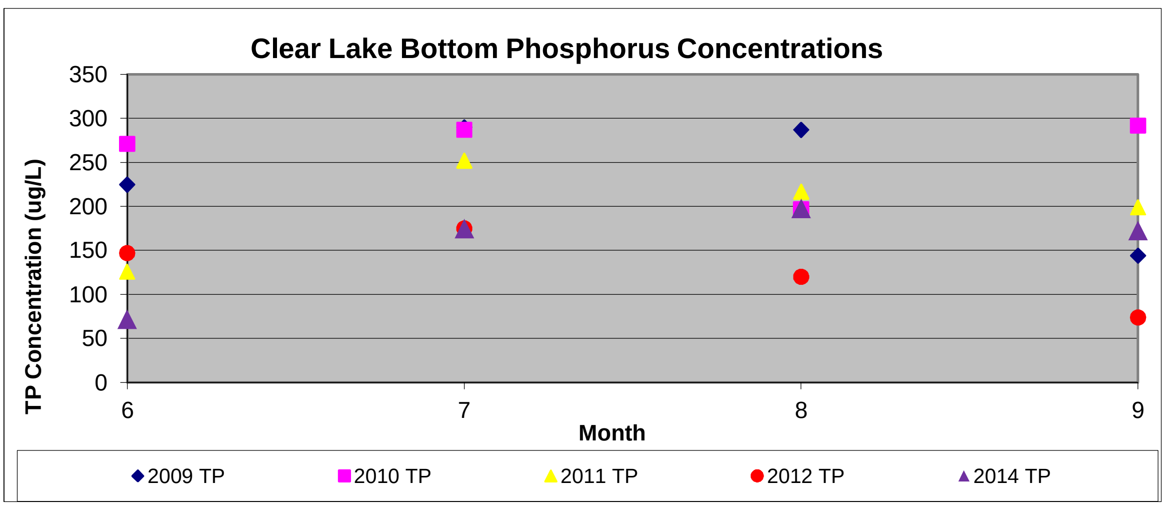
Clearwater River Watershed District
2014 Annual Monitoring Report
Appendix J








Union Lake Bottom Phosphorus Concentrations
TP Concentration (ug/L)
2000
1600
1200
800
400
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2013 TP
2014 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
2014 TP

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