Apple River Flowage
Lake Management Plan

Polk County, Wisconsin
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Purpose of the Study

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Due to this fact, lakes situated within feet of others can differ profoundly in the uses they support.

Factors such as lake size, lake depth, water sources to a lake, and geology all cause inherent differences in lake quality.

Additionally, humans, by changing the landscape, can bring about changes in a lake. This arises because rain and melting snow may eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a lake is not inherently problematic. However, water has the ability to carry nutrients, bacteria, sediments, and chemicals into a lake. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

The landscape can be divided into watersheds and subwatersheds, which define the land area that drains into a particular lake, flowage, stream, or river. Watersheds that preserve native vegetation and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to cause negative impacts on lakes, rivers, and streams.

Lake studies often examine the underlying factors that impact a lake's health, such as lake size, depth, water sources, and the land use in a lake's watershed. Many forms of data can be collected and analyzed to gauge a lake's health including: physical data (oxygen, temperature, etc.), chemical data (including nutrients such a phosphorus and nitrogen), biological data (algae and zooplankton), and land use within a lake's watershed.

Lakes can be classified based on their nutrient status and clarity levels. Three categories commonly used are: oligotrophic, mesotrophic, and eutrophic.

- ✓ Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms.

- ✓ Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

- ✓ Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms. Lakes can also be hypereutrophic. Hypereutrophic lakes are characterized by dense algae and plant communities and can experience heavy algal blooms throughout the summer.

Lake studies often identify strengths, opportunities, challenges, and threats to a lake's health. These studies can identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake's ecosystem. Additionally, these studies often quantify practices or areas on the landscape that have the potential to negatively impact the health of a lake.

The end product of a lake study is a Lake Management Plan which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistic based on inherent lake characteristics (lake size, depth, etc.) and should align with watershed residents' goals.

Included in this document are the data and conclusions drawn from a 2012 lake study completed by the Polk County Land and Water Resources Department. This study collected and analyzed the following data to aid in the creation of a Lake Management Plan for the Apple River Flowage:

- ✓ Lake resident opinions
- ✓ Lake level and precipitation data
- ✓ In lake physical and chemical data
- ✓ Algae and zooplankton data
- ✓ Lake sediment chemistry
- ✓ Shoreline land use results
- ✓ Tributary monitoring results
- ✓ Watershed and subwatershed land use

This study also included a number of educational opportunities for members of the Apple River Flowage District including:

- ✓ A pontoon classroom
- ✓ A shoreline restoration workshop
- ✓ A series of five meetings to review the data collected and develop a Lake Management Plan

Whenever possible, past lake studies completed on the Apple River Flowage are used as a baseline comparison for this study. A summary of previous lake studies can be found on page 21.

Executive Summary

Lake information

The Apple River Flowage is located in southeastern Polk County, Wisconsin in the Town of Lincoln and within the Amery city limits. The Apple River Flowage is a 604 acre impoundment with a mean depth of six feet and a maximum depth of eighteen feet.

There are two inflows to the Apple River Flowage: the Beaver Brook Inlet and the Apple River Inlet. The Beaver Brook Inlet originates in Barron County and flows through the Joel Flowage to the Apple River Flowage; and the Apple River Inlet originates from Staples Lake and flows through White Ash Lake to the Apple River Flowage. The Apple River Flowage has one outlet which is located at the Amery Dam and flows to the Black Brook Flowage.

The Apple River Flowage and many of its tributaries (Beaver Brook Inlet originating at the Joel Flowage, Apple River Inlet, and the Apple River Outlet) are designated as Areas of Special Natural Resource Interest through their identification as Natural Heritage Inventory Waters.

The drainage basin: lake area ratio (DB: LA) compares the size of a lake's watershed to the size of a lake. If a lake has a relatively large DB: LA then surface water inflow (containing nutrients and sediments) occurs from a large area of land relative to the area of the lake. The DB: LA ratio for the Apple River Flowage is approximately 175:1, which is quite large.

The total phosphorus criterion for the Apple River Flowage (classified as a drainage lake that does not stratify) is 0.040 mg/L. In 2011, the Apple River Flowage was proposed for the 303(d) list of Impaired Waters for the pollutant total phosphorus and the resulting impairment of excess algae growth. As of January 2013, the Flowage had not yet been formally listed.

Survey results

Ninety-two members of the Apple River Flowage Protection and Rehabilitation District completed a survey regarding the flowage (41% response rate). In this survey concerns for the flowage were ranked. Invasive species ranked as the 1st concern for the flowage, followed by aquatic plants in 2nd, and algae blooms in 3rd.

Around a quarter of respondents described the water quality of the Apple River Flowage as either poor (36%) or fair (32%). Fewer respondents described the water quality as good (14%) and zero respondents described it as excellent. The majority of respondents felt that in the time since they have owned their property, the water quality has degraded. Zero respondents perceived that water quality has improved.

In general, more respondents felt that algae often or always negatively impact their enjoyment of the flowage as compared to never or rarely.

A third of respondents described the current amount of shoreline vegetation on the Apple River Flowage as just right (33%). Generally, more respondents felt there was too much shoreline vegetation as compared to not enough.

Although a combined 74% of respondents felt that shoreline buffers, rain gardens, and native plants are very important or somewhat important to water quality; nearly half (47%) of respondents are not interested in installing a shoreline buffer or rain garden on their property.

Respondents are making educated decisions when applying fertilizer to their property. Two thirds of respondents do not use fertilizer on their property (64%) and one third use zero phosphorus fertilizer (33%). Very few respondents use fertilizer but are unsure of its phosphorus content (5%), and zero respondents use fertilizer on their property that contains phosphorus.

Survey respondents were asked to choose all of the management practices they felt should be used to maintain or improve the water quality of the Apple River Flowage from a list of options. Over half of respondents felt that enhanced efforts to monitor for new populations of aquatic invasive species should be used to maintain or improve the water quality of the flowage (60%). Other management practices supported by many respondents include information and education opportunities (46%) and cost-sharing assistance for the installation of farmland conservation practices (41%).

Lake level and precipitation data

Seasonal precipitation totaled eighteen inches north of the 46 bridge and thirteen inches south of the 46 bridge. Shortly following precipitation events, water levels did increase in the flowage. The flowage is created by a dam within the city limits of Amery. Currently, the dam is used to maintain water levels on the flowage. Overall, water levels remained fairly constant over the sampling season.

Sampling procedure

Physical and chemical data were collected in-lake at two sites (Site 1, north and Site 2, south) on the Apple River Flowage from May 8th, 2012 through September 17th, 2012. Spring turnover samples were taken on April 3rd, 2012. Fall turnover samples were taken on October 15th, 2012.

Turnover

Turnover events in lakes occur two times a year in Wisconsin. At spring and fall turnover, the temperature and density of the water is constant from the top to the bottom. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. The Apple River Flowage, with a maximum depth of eighteen feet, remained well mixed over the sampling season.

In stratified lakes, warmer surface waters are prevented from mixing with cooler bottom waters. As a result, nutrients can actually become trapped in the bottom waters of a lake that stratifies. Additionally, because mixing is one of the main ways oxygen is distributed throughout a lake, lakes that stratify have the potential to have very low levels of oxygen in the bottom waters. The Apple River Flowage did not stratify in 2012.

Chemical data

The total phosphorus criterion for the Apple River Flowage is 0.040 mg/L. In 2012, the summer index period (July 15th – September 15th) average total phosphorus was 0.0895 mg/L at site one (north) and 0.0680 mg/L at site two (south). The total phosphorus criterion was exceeded at site one in 2012.

Nitrate/nitrite and ammonium are all inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/L can support summer algae blooms in lakes. Average growing season (excludes turnover) inorganic nitrogen was 0.02 mg/L at site one (north) and 0.03 mg/L at site two (south). Inorganic nitrogen concentrations at both sites were well below the healthy limit.

The total nitrogen to total phosphorus ratio (TN: TP) is a calculation that depicts which nutrients limit algae growth in a lake. The total nitrogen to total phosphorus ratio for both sites (north and south) indicate a nitrogen limited state during the growing season, which is fairly uncommon in Wisconsin.

Physical data

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. Oxygen levels remained above 5 mg/L near the surface but dropped below this threshold in the bottom waters.

Secchi depth serves as a general indicator of water quality. The average growing season secchi depth was 5.5 feet at site one (north) and 4.5 feet at site two (south).

Chlorophyll a (an indicator of algae) seems to have the greatest impact on water clarity when levels exceed 0.03 mg/L. Lakes which appear clear generally have chlorophyll a levels less than 0.015 mg/L. With the exception of site two (south) on August 7th, 2012, chlorophyll a levels on the flowage were below 0.015 mg/L.

Trophic state index

Trophic State Index (TSI) data indicates that in 2012 the Apple River Flowage was mildly eutrophic to eutrophic. Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms.

Phytoplankton or Algae

At both sites the dominant algae division in May and June was Cryptophyta, or cryptomonads. By July, the algae community at both sites was dominated nearly equally by cryptomonads and Chlorophyta, or green algae. In August, the algae community at site one was dominated by cryptomonads and the algae community at site two was dominated by Cyanophyta, or blue green algae. In September, the algae community at site one shifted back to being green algae dominated and the algae community at site two shifted back to being dominated by cryptomonads.

Blue green algae were only present in August at site one and only present in August and September at site two. Their concentrations at these sampling dates were very low and well below the risk threshold for toxin production.

Zooplankton

The Apple River Flowage zooplankton were dominated by rotifers, which is characteristic of flowing waters. Some cladocera are present but almost no copepods, which is somewhat unusual even for a flowing system. Abundance appears to fluctuate with the likely drivers being water retention time (higher flows reducing populations) and temperature (increasing productivity).

Shoreline survey

The shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (93%), followed by rip rap (5%), and lawn (2%). A characterization of the shoreline buffer composition (area upland thirty-five feet from the ordinary high water mark) shows that the greatest land use is natural (82%), followed by lawn (17%), and hard surfaces (1%).

Tributary monitoring

The Apple River Inlet is contributing the greatest amount of phosphorus to the Apple River Flowage (8,442 pounds on an annual basis). The Beaver Brook Inlet is contributing 2,580 pounds of phosphorus on an annual basis. Total phosphorus concentrations were elevated on the East branch of the Beaver Brook Inlet (0.2472 mg/L).

Site	Total Phosphorus (mg/L)	Discharge (L/s)	Instantaneous Load (mg/s)	Annual Load (lb/yr)
Fox Creek	0.0518	974.610	50.485	3,512.284
Apple River Inlet	0.0648	1,872.570	121.343	8,441.935
Apple River Outlet	0.0636	3,652.740	232.314	16,162.362
Beaver Brook Inlet	0.0836	443.520	37.078	2,579.577
Beaver Brook West	0.0586	125.496	7.354	511.631
Beaver Brook East	0.2472	60.048	14.844	1,032.704

Watershed land use and phosphorus loading

The area of land that drains towards a lake is called a watershed. Since the Apple River Flowage Watershed is so extensive in size and drains from many area lakes and rivers, a management area was established for the Apple River Flowage. Areas of land already included in lake management areas for other Polk County lakes (ie. Bone Lake, Balsam Lake, Blake Lake, White Ash Lake, etc.) were excluded from the management area.

The resulting management area is 37,125 acres in size. The largest land uses in the management area are row crop (32%) and forest (31%), with row crop contributing the greatest phosphorus load to the Flowage (74%).

Implementation plan

The following goals of the Implementation Plan for the Apple River Flowage were created through collaborative efforts and take into account current and past water quality data, a 2012 sociological survey regarding the needs of the Apple River Flowage Protection and Rehabilitation District members, and a series of four meetings by the Apple River Flowage Water Quality Committee.

Goal 1: Reduce excessive watershed nutrient inputs to the flowage to improve water quality

Goal 2: Minimize the release of nutrients from within the Apple River Flowage to improve water quality

Goal 3: Protect, maintain, and enhance fish and wildlife habitat

Goal:4 Maintain and enhance the natural beauty of the Apple River Flowage

Goal 5: Evaluate the progress of lake management efforts through monitoring and data collection

Goal 6: Provide information and education opportunities to residents and users

Goal 7: Develop partnerships with a diversity of people and organizations

Goal 8: Implement the Aquatic Plant Management Plan

Introduction to the Flowage

The Apple River Flowage (WBIC 2624200) is located in southeastern Polk County, Wisconsin in the Town of Lincoln and within the Amery city limits (Polk/T.33N.-R.16W./Sec.21,22,28,33 & T.33N.R.16W./Sec 9,10,15,16,22 & T.33, 34N.-R.16W./Sec 3,4,5,9,32,33).

The Apple River Flowage is located in the Upper Apple River Watershed which is part of the St. Croix River Basin. The Upper Apple River Watershed drains to the Apple River Flowage, which ultimately drains to the St. Croix River.

The Upper Apple River Watershed is the largest watershed in Polk County, totaling approximately 125,074 acres in size. Close to half of the watershed land use is forest and nearly a third is agriculture.

There are two inflows to the Apple River Flowage, the Beaver Brook Inlet and the Apple River Inlet. The Beaver Brook Inlet originates in Barron County and flows through the Joel Flowage to the Apple River Flowage; and the Apple River Inlet originates from Staples Lake and flows through White Ash Lake to the Apple River Flowage. The Apple River Flowage has one outlet which is located at the Amery Dam and flows to the Black Brook Flowage.

Although the soils of the Apple River watershed are mixed, the majority of the soils are Type B, or loamy to sandy soils.

There are two ramp public access sites and one carry in public access site on the flowage. One ramp site is located within the city of Amery on Birch Street and the second ramp site is located north of Amery at the end of River Shore Lane. The carry in site is adjacent to North Park, the city park. North Park and Michael Park/Riverfront Park (also known as Bobber Park) are both situated on the Apple River, providing public access and use opportunities. Both parks have public fishing piers and picnic table areas.

Harvesting for aquatic plants began on the flowage in early August 2012.

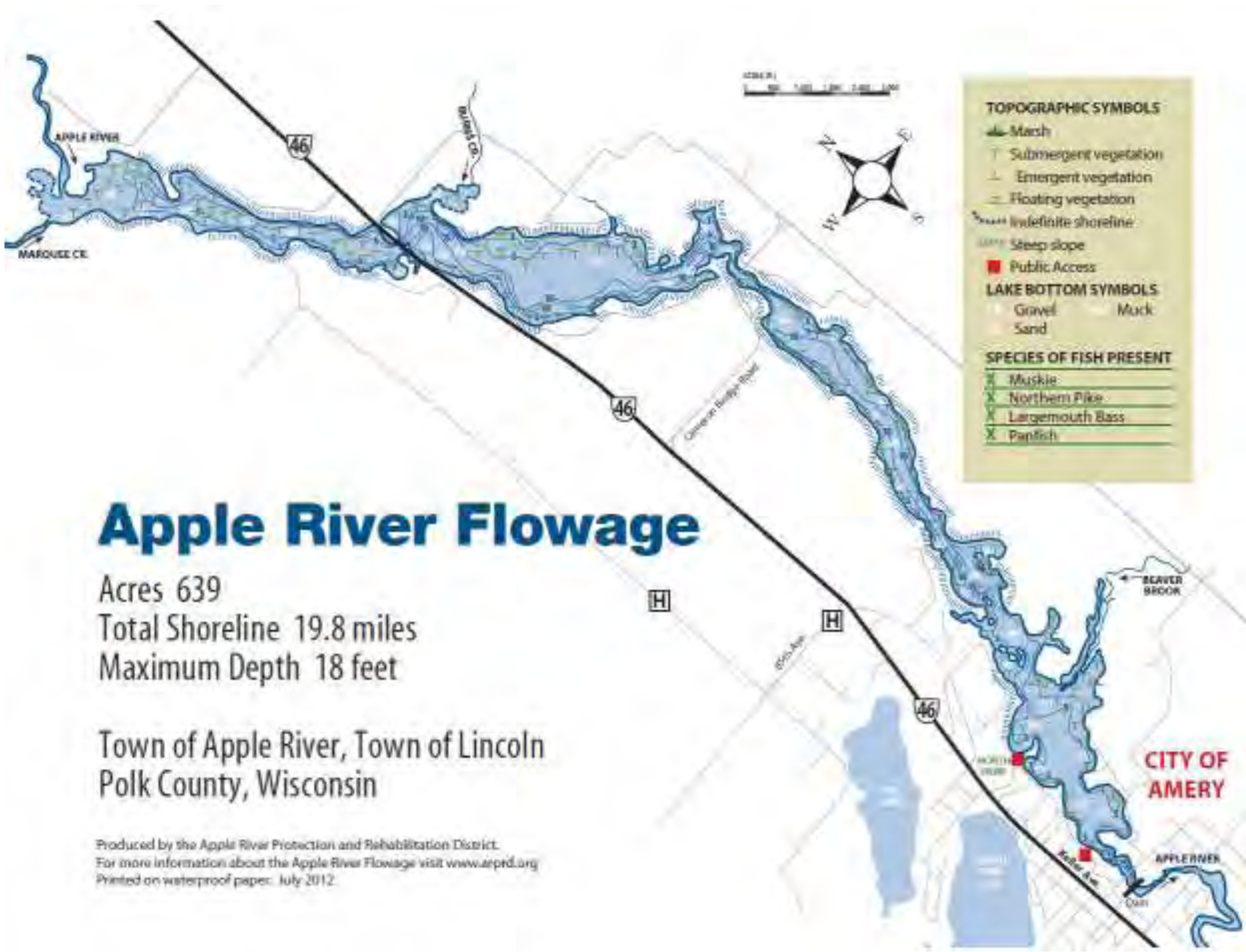
Flowage Characteristics

Information from: (Wisconsin Department of Natural Resources, 2012).

Apple River Flowage (WBIC: 2616100)

Area: 604 Acres
Maximum depth: 18 feet
Mean depth: 6 feet
Bottom: 40% sand, 10% gravel, 0% rock, and 50% muck
Hydrologic lake type: drainage
Total shoreline: 19.8 miles
Invasive species: Curly leaf pondweed

Self Help Monitoring Data has been collected on the Apple River Flowage at the deep hole annually since 1986. Secchi depth has been recorded since 1986 and chlorophyll *a* and total phosphorus have been recorded since 1994. The Self Help Monitoring Data show that the Apple River Flowage is eutrophic.

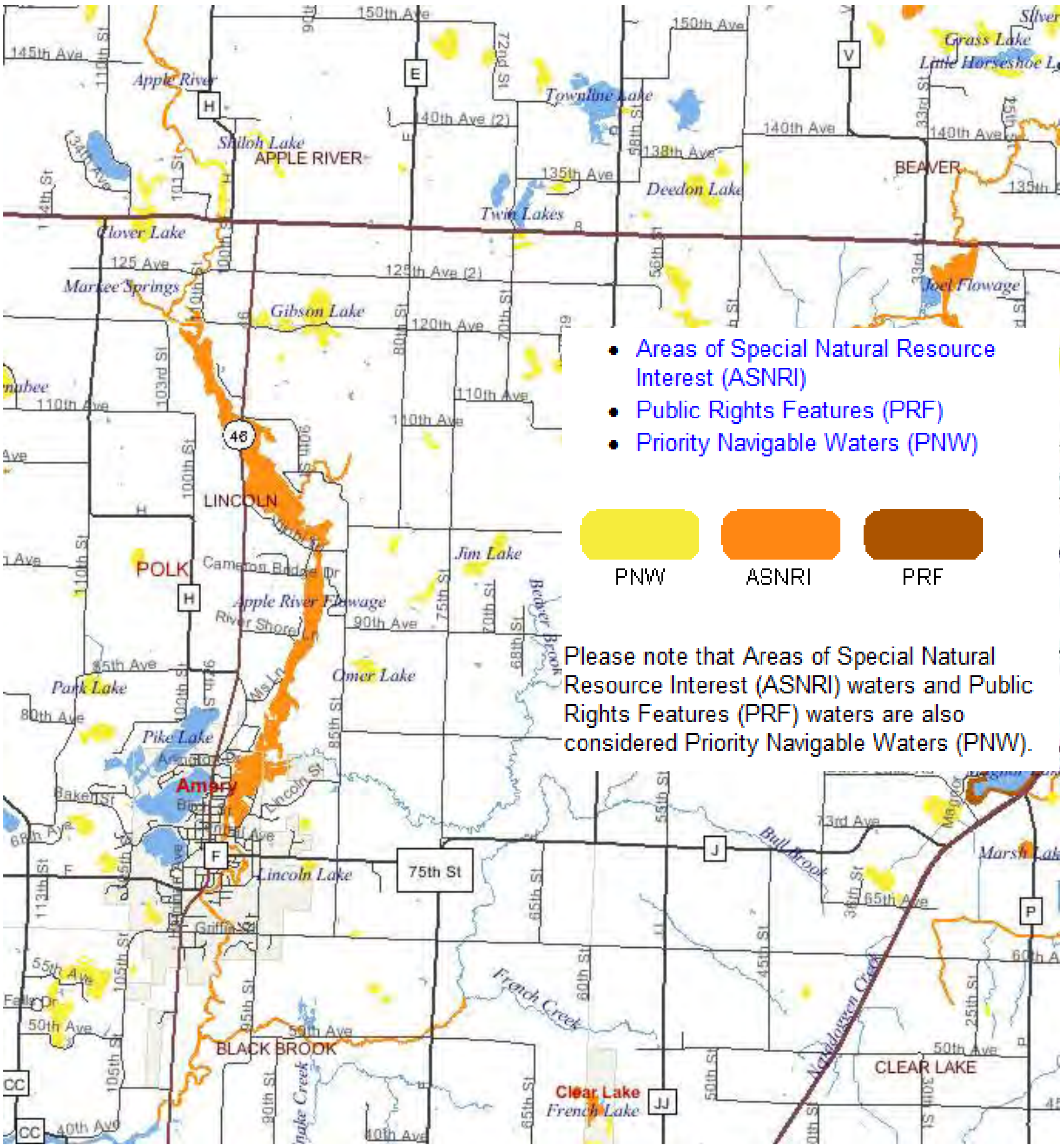


Designated Waters

Information from: (Wisconsin Department of Natural Resources, 2012).

A designated water is a waterbody with special designations that affect permit requirements.

The Apple River Flowage and many of its tributaries (Beaver Brook inlet originating at the Joel Flowage, the Apple River inlet, and the Apple River Outlet) are designated as Areas of Special Natural Resource Interest through their identification as Natural Heritage Inventory Waters. The Natural Heritage Inventory Program identifies waters or portions of waters inhabited by any endangered, threatened, special concern species, or unique ecological community indentified in the Natural heritage Inventory.



Habitat Areas

Information directly from: (Harmony Environmental and Endangered Resource Services, LLC, September 2011).

Naturally occurring native plants are extremely beneficial to the Apple River Flowage. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of nutrient-rich bottom sediments. In the flowage, this is particularly important.

Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline. The rush, reed, and rice populations around the flowage are particularly important for reducing erosion along the shoreline, but these populations are also vulnerable to nutrient loading and resultant algae growth. Dense wild rice is found near the Apple River Inlet north and west of the State Highway 46 Bridge, and scattered growth occurs in other areas.

Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish, such as bluegills, graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species.

Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.

A draft sensitive area study was completed by the Department of Natural Resources in the late 1990's/early 2000's and is included in the 2003 DNR/Polk County *Apple River Flowage Aquatic Plant Survey Report*. The sensitive area study is not included in DNR records, and it is not clear if results will be used for permitting in the flowage.

The Natural Heritage Inventory map of Polk County indicates occurrences of aquatic listed species in the sections where the flowage is located. A species list is available to the public only by town and range. The Apple River Flowage is located in the town of Lincoln (T33N, R16W). The Natural Heritage Inventory indicated two species of special concern in the Town of Lincoln: banded killifish (SC/N; no laws regulating use, possession, or harvesting) and bald eagle (SC/P; fully protected).

Fishery

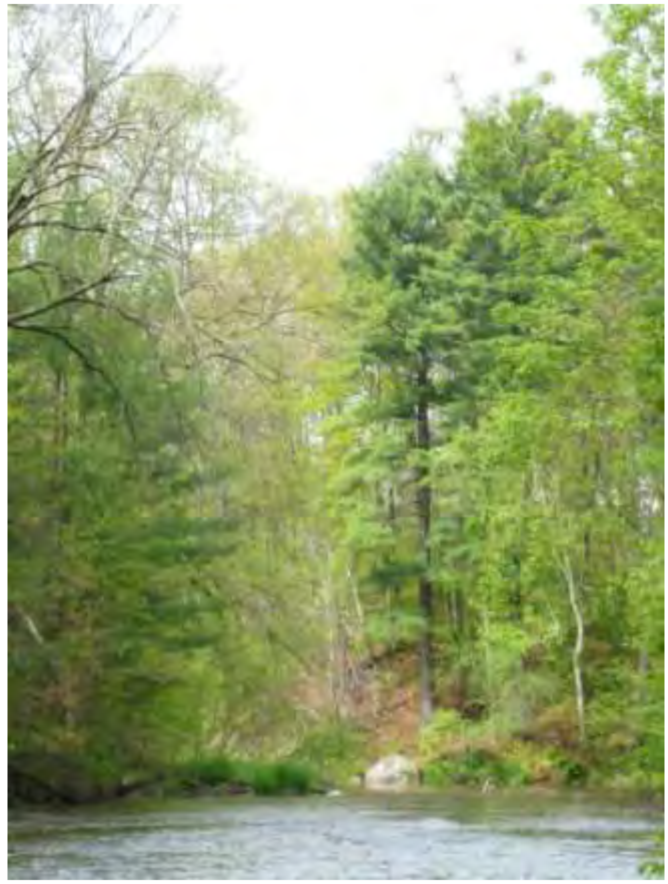
The Apple River Flowage fishery is comprised of muskie, northern pike, largemouth and smallmouth bass, and pan fish. Pan fish include blue gills, crappies, pumpkin seeds, and yellow perch. Muskies are in small numbers, but good sized muskies are harvested from the flowage. The flowage is an excellent largemouth bass fishery with quality fish harvested in good numbers (Harmony Environmental and Endangered Resource Services, LLC, September 2011).

The most recent fish survey on the Apple River Flowage occurred in May 2011. A shocking survey was completed in mid May targeting pan fish such as bass, blue gills, and crappie and a netting survey was completed in late May targeting muskie and walleye (Aaron Cole, Northern Region Fisheries Biologist, personal communication, 2013).

Lake Classification

Lake classification in Polk County is a relatively simple model that considers:

- ✓ lake surface area
- ✓ maximum depth
- ✓ lake type
- ✓ watershed area
- ✓ shoreline irregularity
- ✓ existing level of shoreline development



These parameters are then used to classify lakes as class one, class two, or class three lakes.

Class one lakes are large and highly developed.
Class two lakes are less developed and more sensitive to development pressure.
Class three lakes are usually small, have little or no development, and are very sensitive to development pressure.

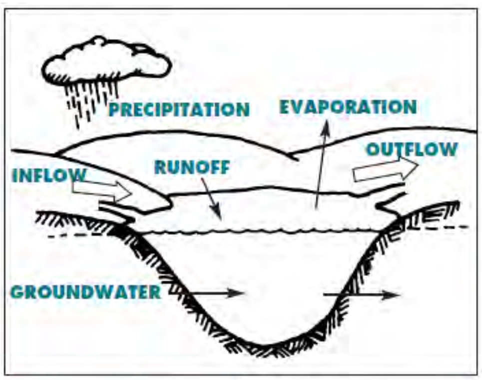
(Polk County Shoreland Protection Zoning Ordinance, Effective April 1, 2010).

The Apple River Flowage is classified as a class one lake (Polk County, Wisconsin Shoreland Property Owner Handbook A Guide to the Polk County Shoreland Protection Zoning Ordinance in Developing and Caring for Waterfront Property, October 2002).

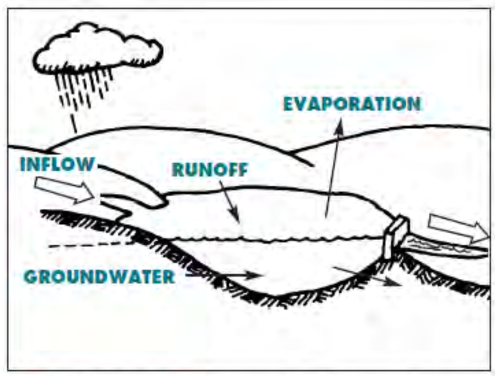
Lake Types

Lakes are commonly classified into four main types based on water source and type of outflow: seepage lakes, groundwater drainage lakes, drainage lakes, and impoundments.

The Apple River Flowage is a six mile impoundment that was created in 1888 by a dam located in the City of Amery (Office of Inland Lake Renewal Wisconsin Department of Natural Resources, 1979). An impoundment is a man-made lake that is formed when the flow of a stream or river is impeded. The restriction on the natural flow of water often results in the collection of soil and nutrients in impoundments. By definition all impoundments have outlet flows and are thus categorized as drainage lakes. The Wisconsin DNR has classified the Apple River Flowage as a drainage lake.



3. DRAINAGE LAKE—a lake fed by streams, groundwater, precipitation and runoff and drained by a stream.



4. IMPOUNDMENT—a manmade lake created by damming a stream. An impoundment is also drained by a stream.

Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004)

The drainage basin: lake area ratio (DB: LA) compares the size of a lake's watershed to the size of a lake. If a lake has a relatively large DB: LA then surface water inflow (containing nutrients and sediments) occurs from a large area of land relative to the area of the lake (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

The DB: LA for the Apple River Flowage is approximately 175:1, which can be compared with a ratio of 2.5:1 for Pike Lake and a ratio of 1.3:1 for North Twin Lake (Harmony Environmental and Endangered Resource Services, LLC, September 2011). The DB: LA ratio for the Apple River Flowage is quite large, which indicates that the flowage receives nutrients and sediments from an extensive land base. Additionally, since the flowage is fairly shallow, the effects of nutrients and sediments are intensified.

The residence time is the average amount of time water remains in a body of water. In general, impoundments are characterized by short residence times. The residence time for the Apple River Flowage is estimated at around twelve days (Harmony Environmental and Endangered Resource Services, LLC, September 2011). However, 2012 flow data was used to determine an outlet discharge of 255.87 acre feet/day, which divided into the acre feet of water for the Flowage (3624 acre feet) gives a residence time of 14.2 days.

Impaired Waters

Wisconsin lakes, rivers, and streams are managed to determine if their conditions are meeting state and federal water quality standards. Water samples are collected through monitoring studies and results are compared to guidelines designed to evaluate conditions as compared to set standards. General assessments can place waters in four different categories: poor, fair, good, and excellent. The results of assessments can be used to determine which actions will ensure that water quality standards are being met (anti-degradation, maintenance, or restoration).

If a waterbody does not meet water quality standards it is placed on Wisconsin's Impaired Waters List under the Federal Clean Water Act, Section 303(d). Every two years the State of Wisconsin is required to submit list updates to the United States Environmental Protection Agency for approval.

Waterbodies can be listed as impaired based on pollutants such as total phosphorus, total suspended solids, and metals.

In 2011, the Apple River Flowage was proposed for the 303(d) list of Impaired Waters for the pollutant total phosphorus and the resulting impairment of excess algae growth. As of November 2013, the Flowage had not yet been formally listed.

The total phosphorus criterion for a body of water varies depending on lake type and whether or not a body of water stratifies. Currently, the Apple River Flowage is classified as a drainage lake which does not stratify, with a total phosphorus criterion of 0.040 mg/L.

However, if the Apple River Flowage is classified as a stream based on a residence time of less than fourteen days the total phosphorus criteria would be 0.075 mg/L.

Water Quality in Impoundments

Impoundments are distinct from naturally formed lakes in terms of water quality. As a result, impoundments should not be expected to have the water quality of nearby lakes.

In general as compared to natural lakes, impoundments are characterized as having:

- ✓ higher nutrient concentrations
- ✓ lower water clarity
- ✓ poorer water quality

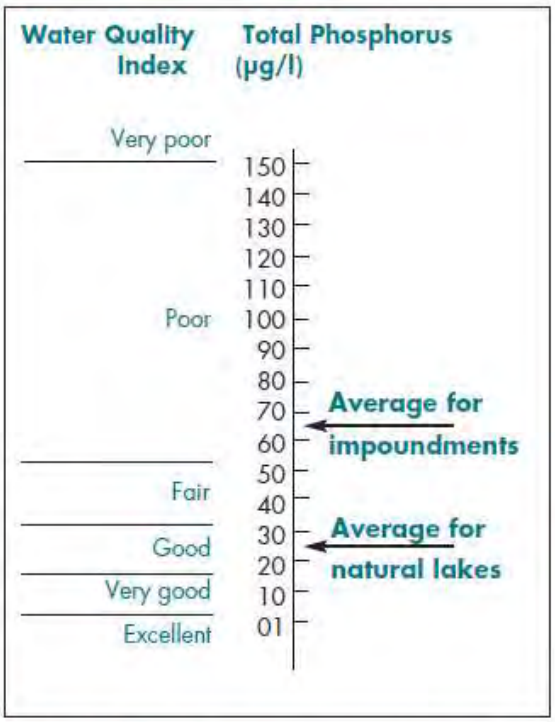


FIGURE 4. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments. (*Adapted from Lillie and Mason, 1983.*)

Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004)

Previous Lake Studies

Past studies that include the Apple River Flowage are:

- ✓ Office of Inland Lake Renewal Feasibility Study and Management Alternatives (1979)
- ✓ Polk County Land and Water Resources Department Apple River Association Development and I&E Project (2003)
- ✓ Harmony Environmental and Endangered Resources Services Aquatic Plant Management Plan (2011)

Office of Inland Lake Renewal Feasibility Study and Management Alternatives

The most recent water quality study completed for the Apple River Flowage was conducted by the Office of Inland Lake Renewal in 1979.

This study included surveys of:

- ✓ Soil loss
- ✓ Barnyard and feedlot locations
- ✓ In-lake sediment volume and accumulation rates
- ✓ Flow, nutrient, and sediment data at the Beaver Brook Inlet, Apple River Inlet, and Amery Dam Outlet
- ✓ In-lake physical and chemical data
- ✓ In-lake aquatic plant species and abundance

This study suggested that although high flow precipitation events may produce sediment erosion in the Beaver Brook basin, the problems are not serious. Additionally, the study suggested that feedlot runoff is not a major problem. The study suggested that considerable sediment has accumulated in the flowage since 1954. Sediment accumulation over the 1954-1977 timeframe has ranged from 16-25 inches across four sample sites.

Nutrients levels were found to be relatively low for an impoundment, although they were sufficient to fuel aquatic plant and algae growth. However, chlorophyll a values indicated that no algae blooms occurred.

Aquatic vegetation was found at 94% of the points sampled in June and 96% of the points sampled in August. The study also concluded that in recent years coontail and northern water milfoil have replaced more desirable species.

The management alternatives for the flowage suggested by this study include:

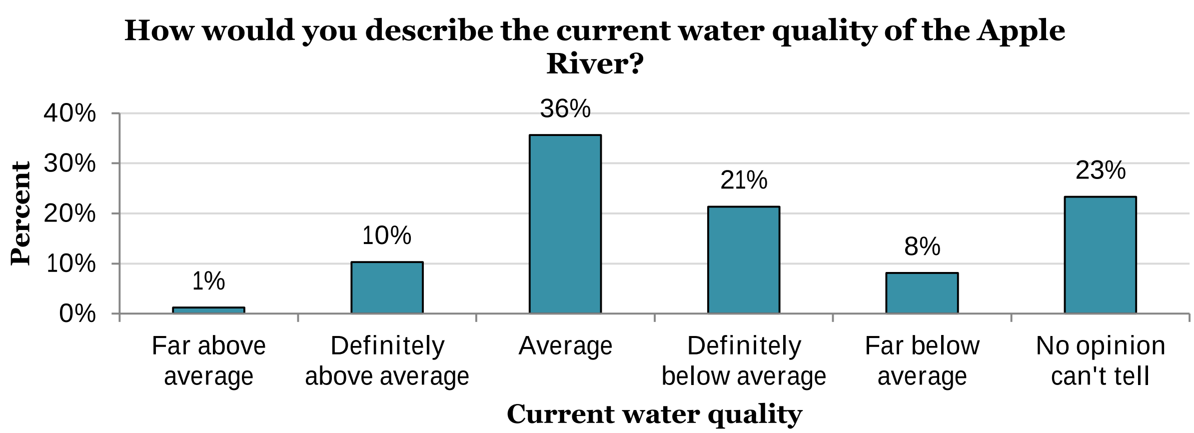
1. Sediment removal through dredging
2. Aquatic plant control through herbicides or harvesting
3. No action

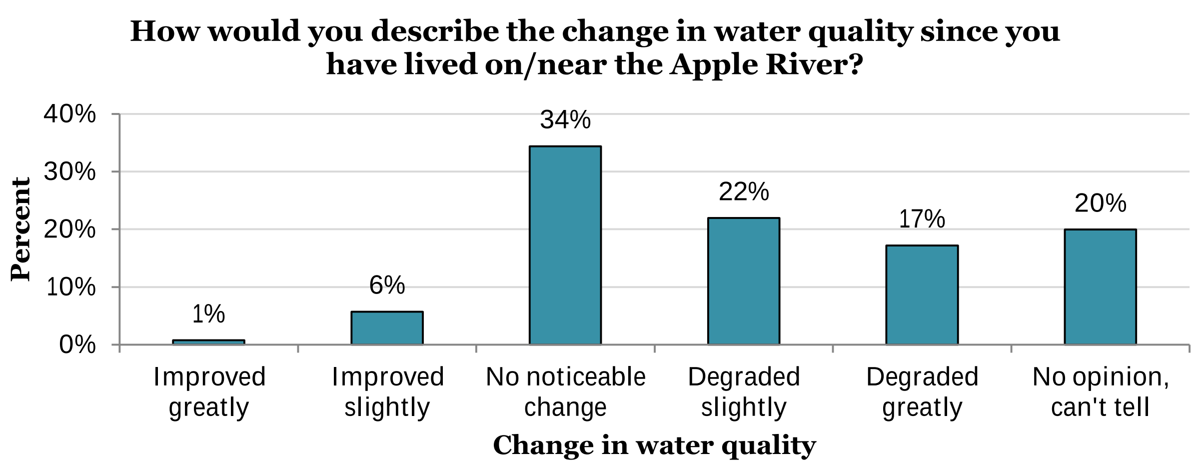
Polk County Land and Water Resources Department Apple River Association Development and I&E Project

The primary focus of this project was to increase public education and protect the water quality of the Apple River by creating the Apple River Association. The Association was established in 2001. This project also sponsored the mailing of a sociological survey in 2001 which was mailed to 1,958 landowners in the Apple River Watershed. Four hundred four surveys were returned for a response rate of 21%.

The top three concerns for the Apple River that emerged from this survey were pollution, development, and aquatic plants.

Over a third of respondents described the current water quality of the Apple River as average (36%). Combined more respondents described the current water quality of the Apple River as below average (29%) as compared to above average (11%). Survey participants were also asked to describe the change in water quality since they have lived on or near the river. Approximately a third of respondents described no noticeable change (34%). Combined, more respondents described a degradation in water quality (39%) as compared to an improvement (10%).





Harmony Environmental and Endangered Resources Services Aquatic Plant Management Plan

The most recent Aquatic Plant Management Plan for the Apple River Flowage was completed in 2011 by Harmony Environmental and Ecological Integrity Services.

In July 2010, an aquatic plant inventory was completed for the Apple River Flowage by Endangered Resource Services. This survey documented aquatic vegetation at 88% of the points sampled.

In June 2010, a bed mapping survey for curly leaf pondweed was completed by Endangered Resource Services. This survey documented curly leaf pondweed at 69% of the sample locations. Additionally, this survey classified areas of curly leaf pondweed by beds and areas of high density. The survey mapped thirteen beds totaling 345 acres and an additional 27 acres that were considered areas of high density.

To be considered a curly leaf bed two criteria had to be met: greater than 50% of the plants in an area had to be curly leaf pondweed and the curly leaf pondweed needed to have canopied at the surface or close enough to the surface to likely cause interference with normal boating traffic. Areas with high amounts of curly leaf pondweed that did not meet the density requirements, or were not canopied out, were considered high density curly leaf pondweed areas. These high density areas have the potential to form beds in the future.

The goals developed for the Apple River Flowage Aquatic Plant Management Plan include:

- ✓ Improve water quality on the Apple River Flowage and downstream on the Apple River
- ✓ Prevent the introduction of aquatic invasive species
- ✓ Maintain navigation for fishing, boating, and access to lake residences
- ✓ Maintain native aquatic plant functions
- ✓ Minimize environmental impacts of aquatic plant management

Lake District Resident Survey

A Wisconsin Department of Natural Resources approved sociological survey was mailed to two hundred twenty five residences of the Apple River Flowage Protection and Rehabilitation District in late June 2012. The survey was designed to gather information from residents concerning property ownership and use, land use, flowage use, concerns for the flowage, water quality, algae, shoreline vegetation, management practices for improvement of the flowage, wetlands, and website use.

Ninety two surveys were returned (41% response rate) and data was entered and analyzed. Ninety one percent of respondents own shoreline property on the Apple River Flowage; whereas the remaining 9% do not (n = 92). Respondents who did not own waterfront property were directed to skip questions to quantify shoreline habitat.

Property Ownership and Use

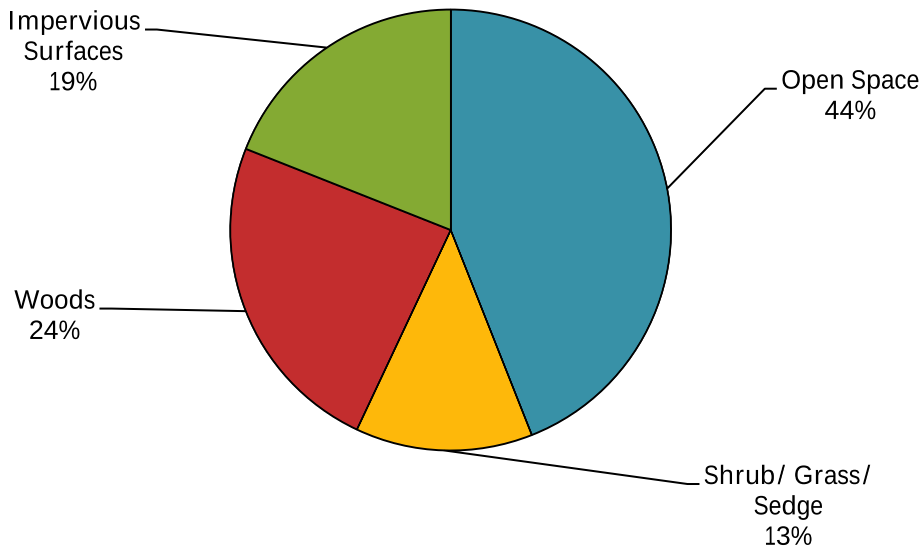
Respondents have owned property on or near the flowage for an average of 19 years (97%). The majority of residents use their property as a year round residence (59%) and close to a quarter of respondents use their property as a weekend, vacation, and/or holiday residence (21%). Fewer respondents use their property as a seasonal residents (continued occupancy for months at a time) (5%) and as a rental property (3%). Survey participants were also given the opportunity to specify how their property is used. A number of respondents own lots that do not currently have buildings (8%).

On average, respondents occupy their property for 237 days per year. At any given time an average of three people occupy each property.

Land Use

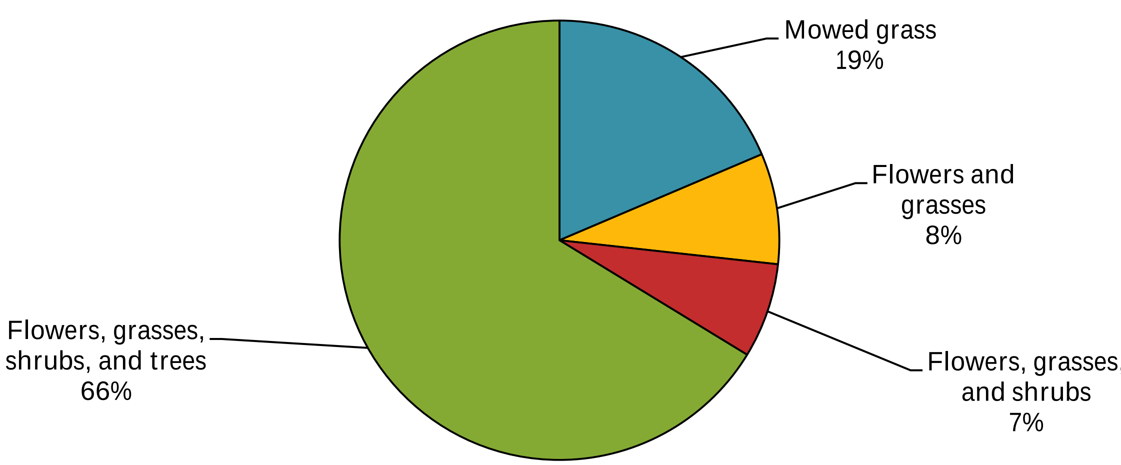
Survey respondents were asked to classify the amount of open space (lawns or mowed areas), shrub/grass/sedge community, woods, and impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways) on their property to gauge land use in the area directly surrounding the Apple River Flowage. According to respondent classification an average of 44% of properties are occupied by open space, 24% by woods, 19% by impervious surfaces, and 13% by the shrub/grass/sedge community.

Please use estimated percentages to describe the amount of each land use on your property.



Respondents owning waterfront property were also asked to describe the first 35 feet of their shoreline (the area located directly adjacent to the flowage). The majority (66%) classified the first 35 feet of their shoreline as a mix of native flowers, grasses, shrubs, and trees. Nineteen percent classified the first 35 feet of their shoreline as mostly mowed grass, 8% as mostly native flowers and grasses, and 7% as a mix of native flowers, grasses, and shrubs.

Which best describes the first 35 feet of your shoreline (the area located directly adjacent to the lake)?



Flowage Use

Survey participants use the Apple River Flowage for a variety of recreational activities. Seventy one percent of respondents partake in fishing (any season); 52% partake in motorized water activities (PWC, boating, water skiing, tubing, jet skiing); 39% partake in non-motorized water activities (birding, canoeing, hiking, running); and 22% partake in swimming. Winter specific recreational activities were less frequent on the flowage. Eighteen percent of respondents partake in non-motorized winter activities (skiing, snowshoeing, ice skating) and 10% partake in motorized winter activities (ATV, snowmobile). Eight percent of survey participants do not participate in any of the activities described in the survey.

Respondents keep a total of 32 paddleboats/rowboats, 37 canoes/kayaks, 2 sailboats, 2 jet skis, 21 motorboats/pontoons (1-20 HP), 34 motorboats/pontoons (21-50HP), and 10 motorboats/pontoons (50+ HP).

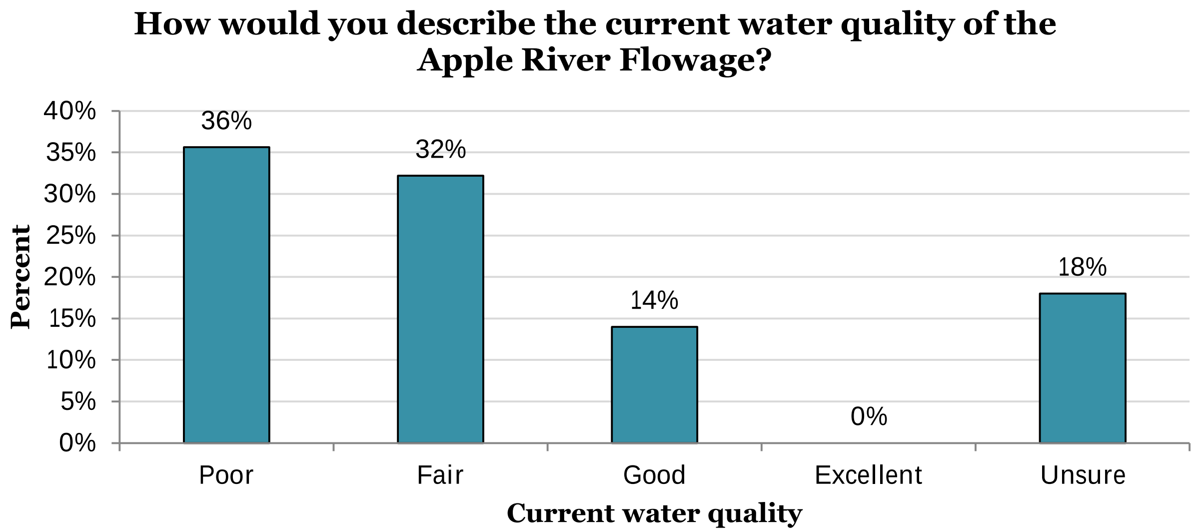
Concerns for the Apple River Flowage

Survey respondents were asked to rank their top three concerns for the Apple River Flowage. To analyze this data each concern that was ranked first received 3 points, each concern that was ranked second received 2 points, and each concern that was ranked third received 1 point. Total points were then added to determine the ranking of concerns for the flowage. Invasive species ranked as the 1st concern, followed by aquatic plants, and algae blooms.

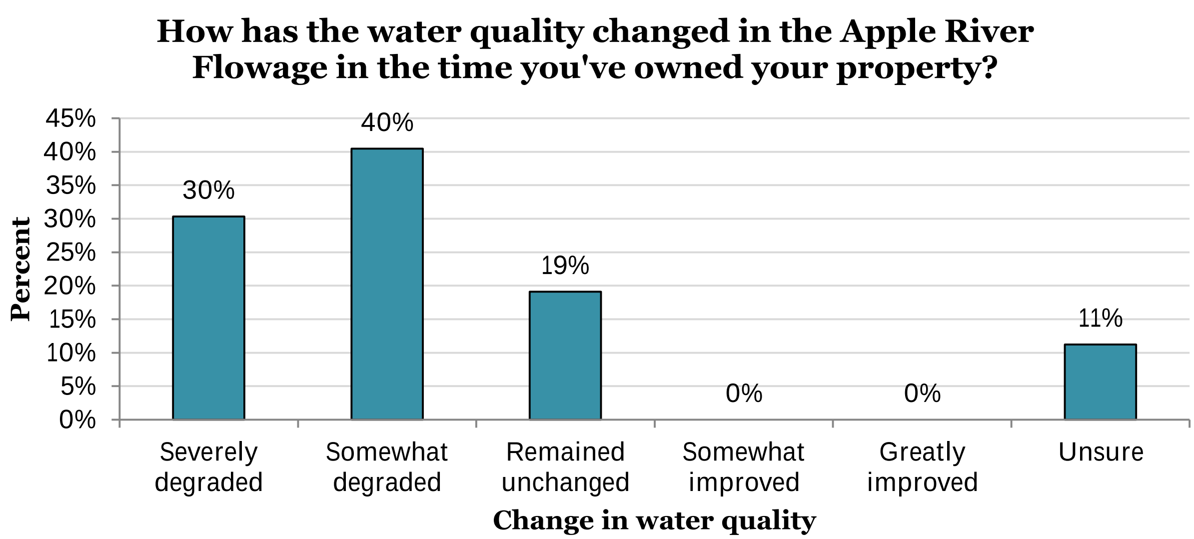
Concerns for the Apple River Flowage	Rank	Points
Invasive species (Eurasian water milfoil, zebra mussels, curly leaf, purple loosestrife)	1st	113
Aquatic plants (not including algae)	2nd	87
Algae blooms	3rd	63
Pollution (chemical inputs, septic systems, agriculture, erosion, storm water runoff)	4th	60
Property values and/or taxes	5th	50
Water clarity (visibility)	6th	39
Quality of fisheries	7th	29
Quality of life	8th	28
Water levels (loss of lake volume)	9th	24
Development (population density, loss of wildlife habitat)	10th	13
Water recreation safety (boat traffic, no wake zone)	11th	10
Other, please describe (geese, muskrats, sediment buildup, navigation)		10

Water Quality

Around a quarter of respondents described the water quality of the Apple River Flowage as either poor (36%) or fair (32%). Fewer respondents described the water quality as good (14%) and zero respondents described it as excellent. The remaining respondents were unsure how to describe the water quality of the flowage (18%).

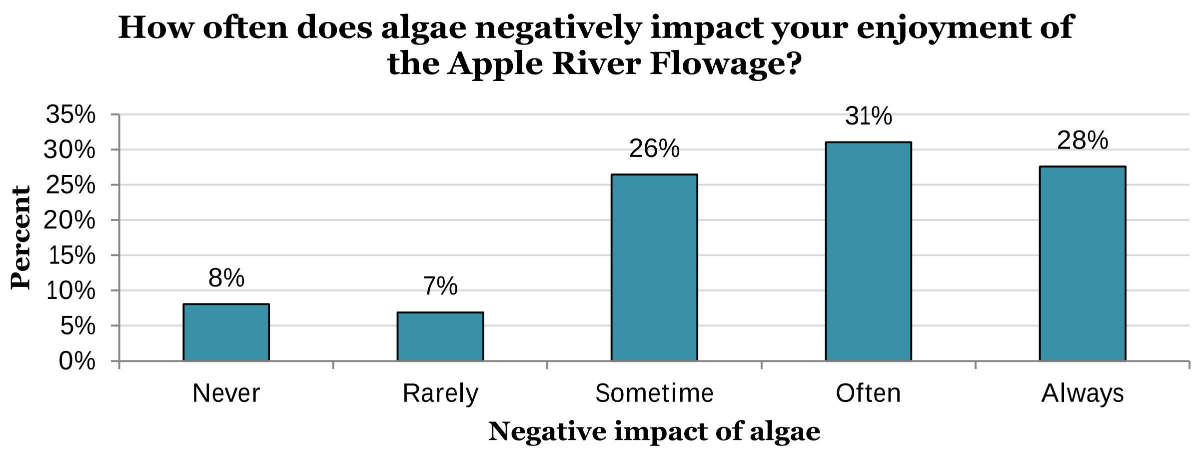


Survey participants were asked how the water quality has changed in the flowage in the time they have owned their property. Forty percent of respondents perceive that water quality has somewhat degraded and 30% perceive that water quality has severely degraded. Zero respondents perceive that water quality has either somewhat improved or greatly improved. Nineteen percent of respondents perceive that water quality has remained unchanged and 11% are unsure how water quality has changed.



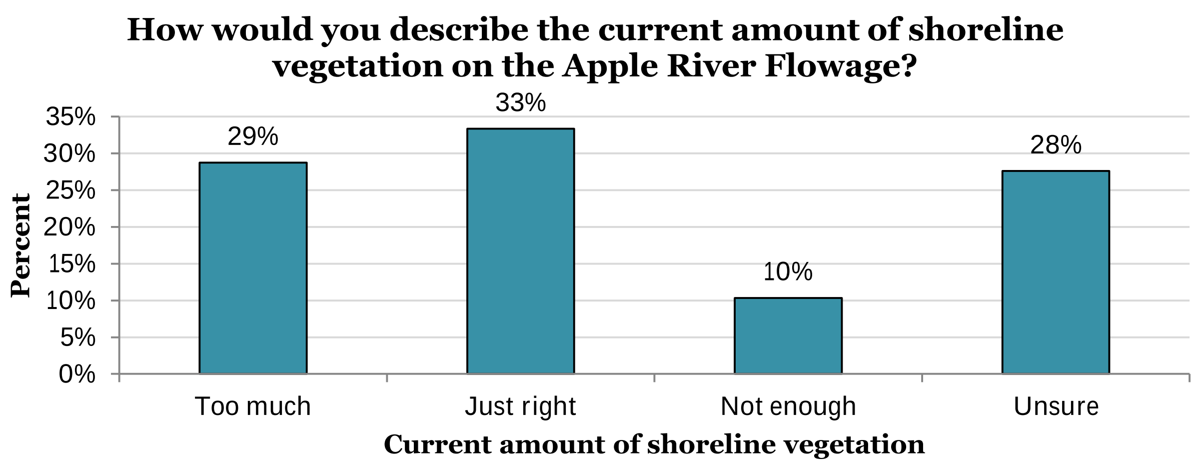
Algae

Over a quarter of respondents feel that algae always negatively impacts their enjoyment of the flowage (28%) and nearly a third of respondents feel that algae often negatively impacts their enjoyment of the flowage (31%). Approximately a quarter of respondents feel that algae sometimes negatively impact their enjoyment of the flowage (26%). Fewer respondents feel that algae rarely (7%) or never (8%) negatively impacts their enjoyment of the flowage.



Shoreline Vegetation

Survey participants were asked how they would describe the current amount of shoreline vegetation on the Apple River Flowage. Around a third of respondents described the amount of shoreline vegetation as either too much (29%) or just right (33%). A mere 10% of respondents described the amount of shoreline vegetation as not enough. The remaining 28% of respondents were unsure how to describe the current amount of shoreline vegetation.



Overall respondents recognize the importance of shoreline buffers, rain gardens, and native plants to the water quality of the flowage. Nearly half of respondents described shoreline buffers, rain gardens, and native plants as very important to the water quality of the flowage (47%) and over a quarter described shoreline buffers, rain gardens, and native plants as somewhat important to the water quality of the flowage (27%). Very few respondents described shoreline buffers, rain gardens, and native plants as not at all important (2%) and not too important (6%). The remaining 18% of respondents were unsure how to describe the importance of shoreline buffers, rain gardens, and native plants.

The results from this question suggest a possible educational need regarding the importance of shoreline buffers, rain gardens, and native plants to water quality.

Although a combined 74% of respondents felt that shoreline buffers, rain gardens, and native plants are very important or somewhat important to water quality, nearly half (47%) of respondents are not interested in installing a shoreline buffer or rain garden on their property. In contrast, 28% of respondents have already installed a shoreline buffer or rain garden and 12% are interested in installing a shoreline buffer or rain garden. The remainder of respondents (15%) were unsure of their interest in installing a shoreline buffer or rain garden.

Respondents are making educated decisions when applying fertilizer to their property. Nearly two thirds of respondents do not use fertilizer on their property (64%) and one third use zero phosphorus fertilizer (33%). Very few respondents use fertilizer but are unsure of its phosphorus content (5%), and zero respondents use fertilizer on their property that contains phosphorus.

Management Practices for Improvement

Survey respondents were asked to choose all of the management practices they felt should be used to maintain or improve the water quality of the Apple River Flowage from a list of seven options. Over half of respondents felt that enhanced efforts to monitor for new populations of aquatic invasive species should be used to maintain or improve the water quality of the flowage (60%).

Other management practices supported by many respondents include information and education opportunities (46%) and cost-sharing assistance for the installation of farmland conservation practices (41%).

Management practices to improve water quality	Percent
Enhanced efforts to monitor for new populations of aquatic invasive species	60%
Information and education opportunities	46%
Cost-sharing assistance for the installation of farmland conservation practices (nutrient management plans, contour strips, conservation tillage)	41%
Collection of sediment cores to provide information concerning historical lake conditions	38%
Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat	35%
Cost-sharing assistance for the installation of shoreline buffers and rain gardens	27%

Wetlands

Overall survey participants feel wetlands in the Apple River Flowage Watershed are important to the water quality of the flowage. Very few respondents described wetlands as not at all important (3%) or not too important (1%). Over half of respondents described wetlands as very important to the water quality of the flowage (52%) and close to a quarter described wetlands as somewhat important (21%). The remaining 22% of respondents were unsure how to describe the importance of wetlands to water quality on the flowage (n = 89). The results from this question suggest a possible educational need regarding the importance of wetlands to water quality.

Website Use

The Apple River Flowage Protection and Rehabilitation District maintains a website available at http://arprd.org. Over half of respondents never visit the website (59%) and an additional 20% of respondents rarely visit the website. Seventeen percent of respondents sometimes visit the website and 3% of respondents often visit the website.

Comparison of results to the 2001 survey

Although the 2001 survey was mailed to a much larger sample size (Apple River Watershed residents) as compared to the 2012 survey (Apple River Flowage Protection and Rehabilitation members) and was used to assess the Apple River rather than the Apple River Flowage, it may still be useful to analyze sharp differences or similarities across the two surveys.

On both the Apple River survey in 2001 and the Apple River Flowage survey in 2012, survey responses for current water quality were clustered towards average and below average, or poor and fair. Additionally, changes in water quality for both surveys indicate responses that are clustered towards degradation as opposed to improvement.

Concerns cited by survey respondents for the Apple River in 2001 differ substantially from concerns for the Apple River Flowage in 2012. Top concerns in the 2001 survey were pollution followed by development and aquatic plants (weeds)[1]. In the 2012 survey for the Apple River Flowage the top concerns were invasive species, followed by aquatic plants, and algae.

Although aquatic plants rank high as concerns in both surveys, pollution and development were of greater concern for the Apple River in 2001, and invasive species and algae were of greater concern for the Apple River Flowage in 2012.

[1] Responses for the 2001 survey were re-ranked such that each concern that was ranked first received 3 points, each concern that was ranked 2nd received 2 points, and each concern that was ranked third received 1 point. Total points were then added to determine the ranking of concerns. Points for pollution totaled 688, points for development totaled 475, and points for aquatic plants (weeds) totaled 458.

Lake Level and Precipitation Monitoring

Lake water-level fluctuations are important to lake managers, lakeshore property owners, developers, and persons using lakes for recreation. Lake level fluctuations can have significant effects on lake water quality and usability. Although lake levels naturally change from year to year, extreme high or low levels can present problems such as restricted water access, flooding, shoreline and structure damage, and changes in riparian (near shore) vegetation.

Records of lake water elevations can be very useful in understanding changes that may occur in lakes. While some lakes respond almost immediately to precipitation, other lakes do not reflect changes in precipitation until months later.

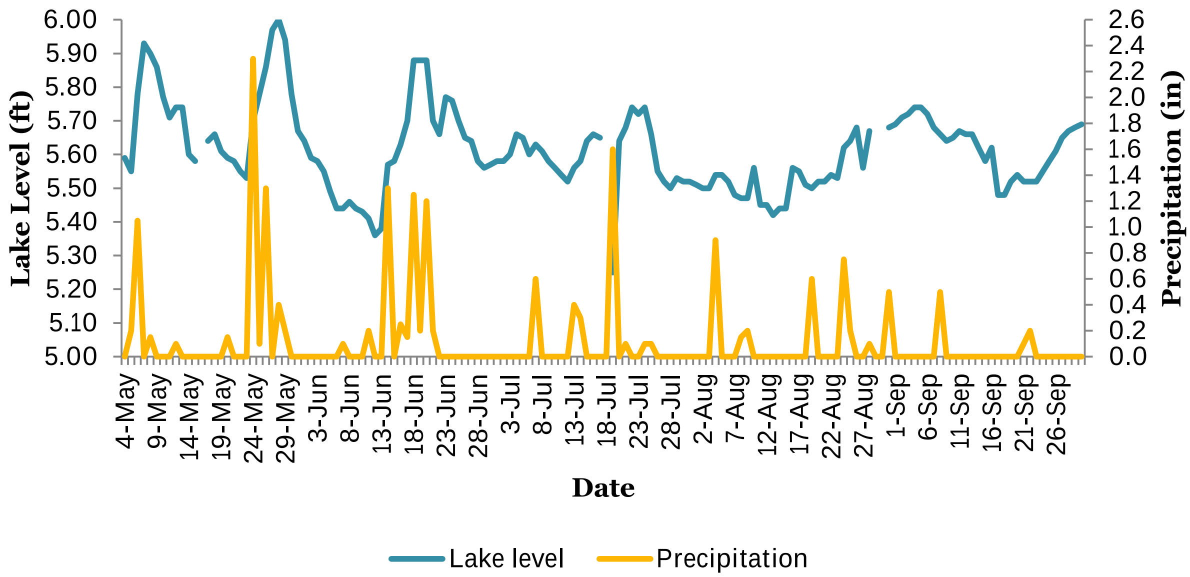
Volunteers monitored lake level and precipitation data for the Apple River Flowage in two locations: north and south of the 46 bridge. LWRD provided training to volunteers regarding data collection and installed staff and rain gauges at both sites. Staff gauges were set at an arbitrary height; therefore, lake levels are not comparable across the two sites at a specific point in time. However, the relative changes in lake level across the two sites are comparable.

Monitoring north of the 46 bridge began on May 4th, 2012 and monitoring south of the 46 bridge began on May 6th, 2012. Both sites were monitored through September 30th, 2012.

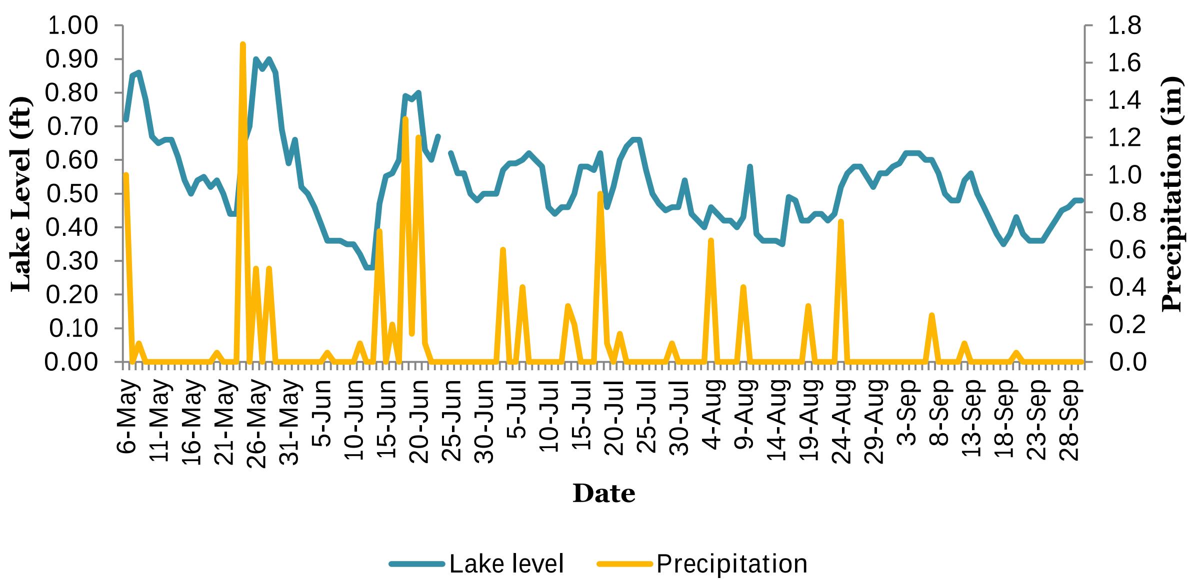
Seasonal precipitation totaled 18 inches north of the 46 bridge and 13 inches south of the 46 bridge. Shortly following precipitation events, water levels did increase in the flowage.

The flowage is created by a dam within the city limits of Amery. Currently, the dam is used to maintain water levels on the flowage. Water levels in the flowage changed by sixty-four-tenths of a foot north of the 46 bridge and sixty-two-tenths of a foot south of the bridge. Largely these changes are due to increased water levels after rainfall events. Overall, water levels remained fairly constant over the sampling season.

Lake Level and Precipitation North of 46 Bridge



Lake Level and Precipitation South of 46 Bridge



Chemical and Physical Data: Sampling Procedure

Chemical and physical data were collected in-lake at two sites (Site 1, North and Site 2, South) on the Apple River Flowage from May 8th, 2012 through September 17th, 2012. Spring turnover samples were taken on April 3rd, 2012. Fall turnover samples were taken on October 15th, 2012.

Two meter integrated samples were collected from the water column once a month during the growing season and at spring and fall turnover. Samples were analyzed at the Water and Environmental Analysis Lab (WEAL) at UW-Stevens Point for two types of phosphorus (total phosphorus and soluble reactive phosphorus), three types of nitrogen (nitrate/nitrite, ammonium, and total Kjeldahl nitrogen), chlorophyll *a*, chloride, and total suspended solids. Metals were analyzed for growing season samples and included: arsenic, calcium, copper, iron, potassium, magnesium, manganese, sodium, phosphorus, lead, zinc, and sulfate. In addition to these parameters, total hardness, calcium, sulfate, and sodium were analyzed at both turnover events.

Lake profile monitoring—which included dissolved oxygen, temperature, conductivity, pH, and secchi depth—was conducted bi-monthly during the growing season. Dissolved oxygen, temperature, and conductivity readings were recorded at every meter within the water column using a YSI 85 multi-parameter probe. pH readings were recorded at every meter within the water column using a YSI 60 pH meter. During the second sampling set in July, both YSI meters stopped working. Beginning with the August 6th sample, lake profile monitoring data was collected using an HI 9828 multi-parameter probe.

Secchi depth was recorded using a secchi disk, which is an eight inch diameter round disk with alternating black and white quadrants. To record secchi depth, the secchi disk was lowered into the flowage on the shady side of a boat until it just disappeared from sight. This depth was measured in feet and recorded as the secchi depth.

In most instances in this report, data is presented as an average over the **growing season**, which refers to data collected from May through September and excludes April and October turnover data. In some instances, data is averaged over the **summer index period**, which refers to data collected from July 15th through September 15th.

Lake Mixing and Stratification: Background Information

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Water quality is greatly affected by the degree to which the water in a lake mixes. Within a lake, mixing is most directly impacted by the temperature-density relationship of water. When comparing why certain lakes mix differently than others, lake area, depth, shape, and position in the landscape become important factors to consider.

Water reaches its greatest density at 3.9^{o}C (39^{o}F) and becomes less dense as temperatures increase and decrease. Compared to other liquids, the temperature-density relationship of water is unusual: liquid water is denser than water in its solid form (ice). As a result, ice floats on liquid water.

When ice melts in the early spring, the temperature and density of the water will be constant from the top to the bottom of the lake. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments. This event is termed **spring turnover**.

In spring 2012, ice out on the Apple River Flowage occurred approximately one month earlier than what is typical in Polk County. Since the grant start date was April 1st, spring turnover samples were not taken until April 3rd. However, due to early ice out, the spring turnover samples were likely taken after spring turnover occurred.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. Generally, in a shallow lake, the water may remain mixed all summer. However, a deeper lake usually experiences layering called **stratification**.

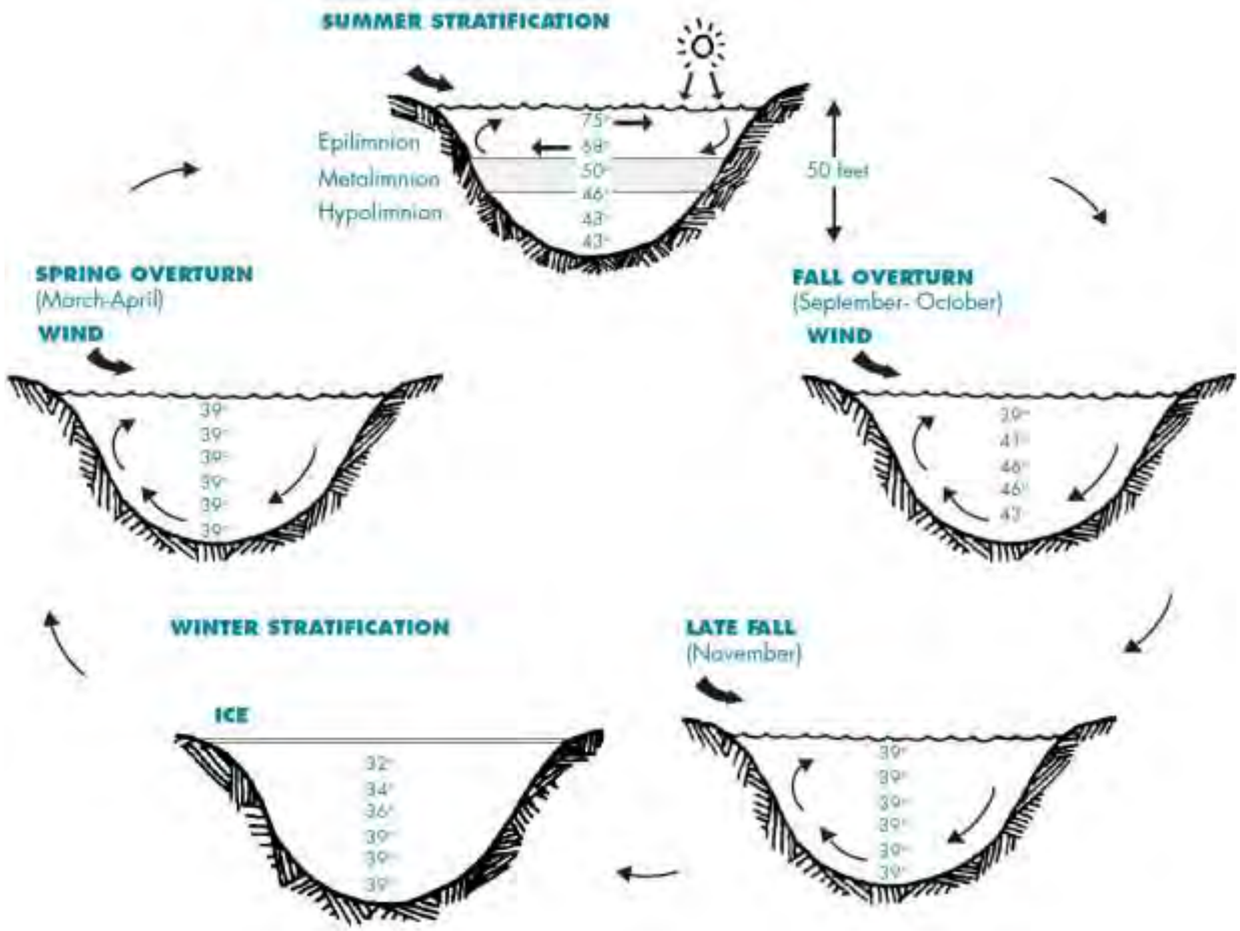
During the summer, lakes have the potential to divide into three distinct zones: the **epilimnion**, **thermocline** or **metalimnion**, and the **hypolimnion**. The epilimnion describes the warmer surface layer of a lake; whereas the hypolimnion describes the cooler bottom area of a lake. The thermocline, or metalimnion, describes the transition area between the warmer surface layer and the cooler bottom layer.

As surface waters cool in the fall, they become more dense and sink until the water temperature evens out from top to bottom. This process is called **fall turnover** and allows for a second mixing event to occur. Occasionally, algae blooms can occur at fall overturn when nutrients from the hypolimnion are made available throughout the water column.

The variations in density arising from different water temperatures can prevent warmer water from mixing with cooler water. As a result, nutrients released from the sediments can become trapped in the hypolimnion of a lake that stratifies. Additionally, because mixing is one of the main ways oxygen is distributed throughout a lake, lakes that don't mix have the potential to have very low levels of oxygen in the hypolimnion.

The absence of oxygen in the hypolimnion can have adverse effects on fisheries. Species of cold water fishes, such as trout, require the cooler waters that result from stratification. Cold water holds more oxygen as compared to warm water. As a result, the cooler waters of the hypolimnion can provide a refuge for cold water fisheries in the summer as long as oxygen is present. Respiration by plants, animals, and bacteria is the primary means by which oxygen is removed from the hypolimnion. A large algae bloom can cause oxygen depletion in the hypolimnion as algae die, sink, and decay.

In the winter, stratification remains constant because ice cover prevents mixing by wind action.



Phosphorus

Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil, rocks, and the atmosphere and can make its way into lakes through groundwater and soil erosion induced from construction site runoff or other human induced disturbances. Additional sources of phosphorus input into a lake can include fertilizer runoff from urban and agricultural settings and manure.

Phosphorus does not readily dissolve in water, instead it forms insoluble precipitates (particles) with calcium, iron, and aluminum. If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve in the water. Strong wind action or turnover events can then re-distribute phosphorus throughout the water column.

While phosphorus is necessary for plant and animal growth, excessive amounts lead to an overabundance of growth which can decrease water clarity and lead to nutrient pollution in lakes. Phosphorus is present in lakes in several forms. This study measured two forms of phosphorus: total phosphorus and soluble reactive phosphorus.

Total phosphorus (TP) is a measure of all the phosphorus in a sample of water. In many cases total phosphorus is the preferred indicator of a lake's nutrient status because it remains more stable than other forms over an annual cycle.

Soluble reactive phosphorus (SRP) includes forms of phosphorus that are dissolved in the water and are readily available for uptake by algae and aquatic macrophytes (plants).

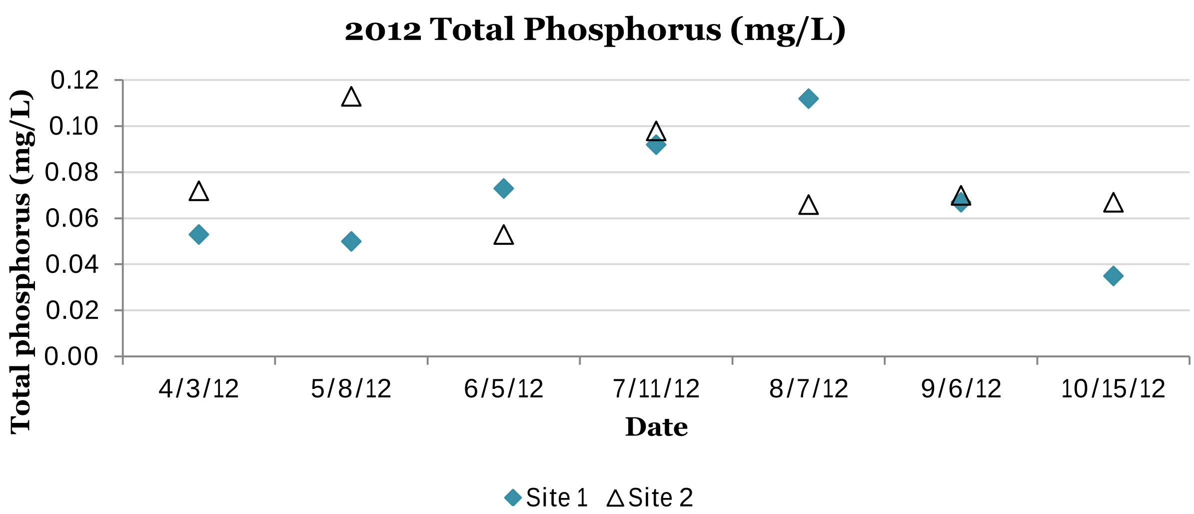
In lakes, a "healthy" limit of phosphorus is set at 0.02 mg/L total phosphorus and 0.01 mg/L soluble reactive phosphorus to prevent nuisance algae blooms. If a value is above the healthy limit it is more likely that a lake could support nuisance algae blooms. In impoundments, the limit is set at 0.03 mg/L total phosphorus. If a value is above the healthy limit it is more likely that a lake could support nuisance algae blooms.

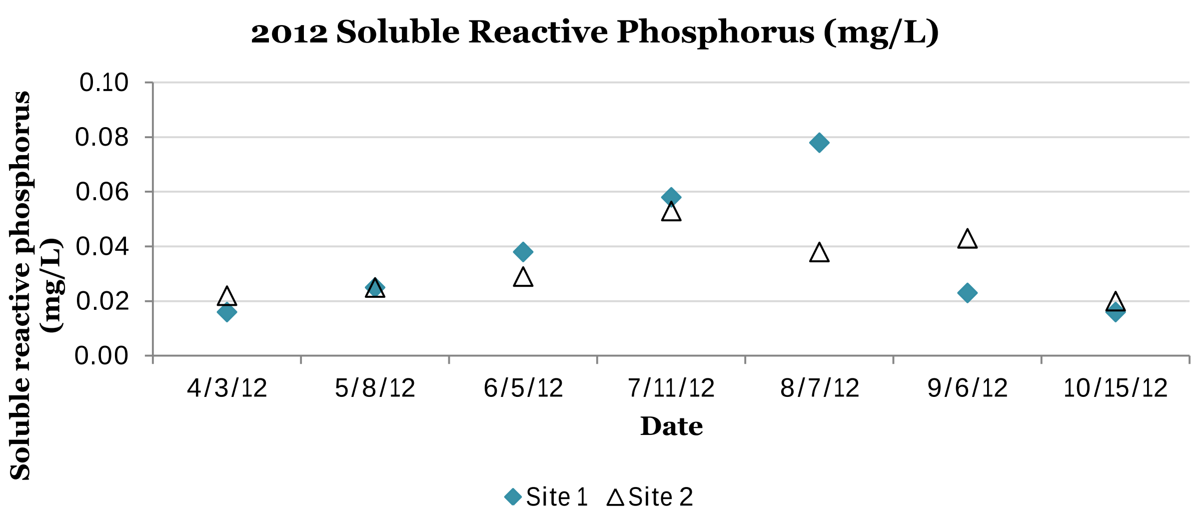
Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

The growing season average total phosphorus was 0.0788 mg/L at site one and 0.0800 mg/L at site two.

The summer index period average total phosphorus was 0.0895 mg/L at site one and 0.0680 mg/L at site two. The total phosphorus criterion was exceeded at site one in 2012.

The growing season average (excludes turnover) soluble reactive phosphorus was 0.0444 mg/L at site one 0.0376 mg/L at site two.





Nitrogen

Nitrogen, like phosphorus, is an element necessary for plant growth. Nitrogen sources in a lake can vary widely. Although nitrogen does not occur naturally in soil minerals, it is a major component of all plant and animal matter. The decomposition of plant and animal matter releases ammonia, which is converted to nitrate in the presence of oxygen. This reaction accelerates when water temperatures increase. Nitrogen can also be introduced to a lake through rainfall, in the form of nitrate and ammonium, and through groundwater in the form of nitrate.

In most instances, the amount of nitrogen in a lake corresponds to land use. Nitrogen can enter a lake from surface runoff or groundwater sources as a result of fertilization of lawns and agricultural fields, animal waste, or human waste from septic systems or sewage treatment plants. During spring and fall turnover events, nitrogen is recycled back into the water column, which can cause spikes in ammonia levels. Under low oxygen circumstances, nitrogen can be lost from a lake system through a process called denitrification. Under these conditions nitrate is converted to nitrogen gas. Additionally, nitrogen can be lost through permanent sedimentation.

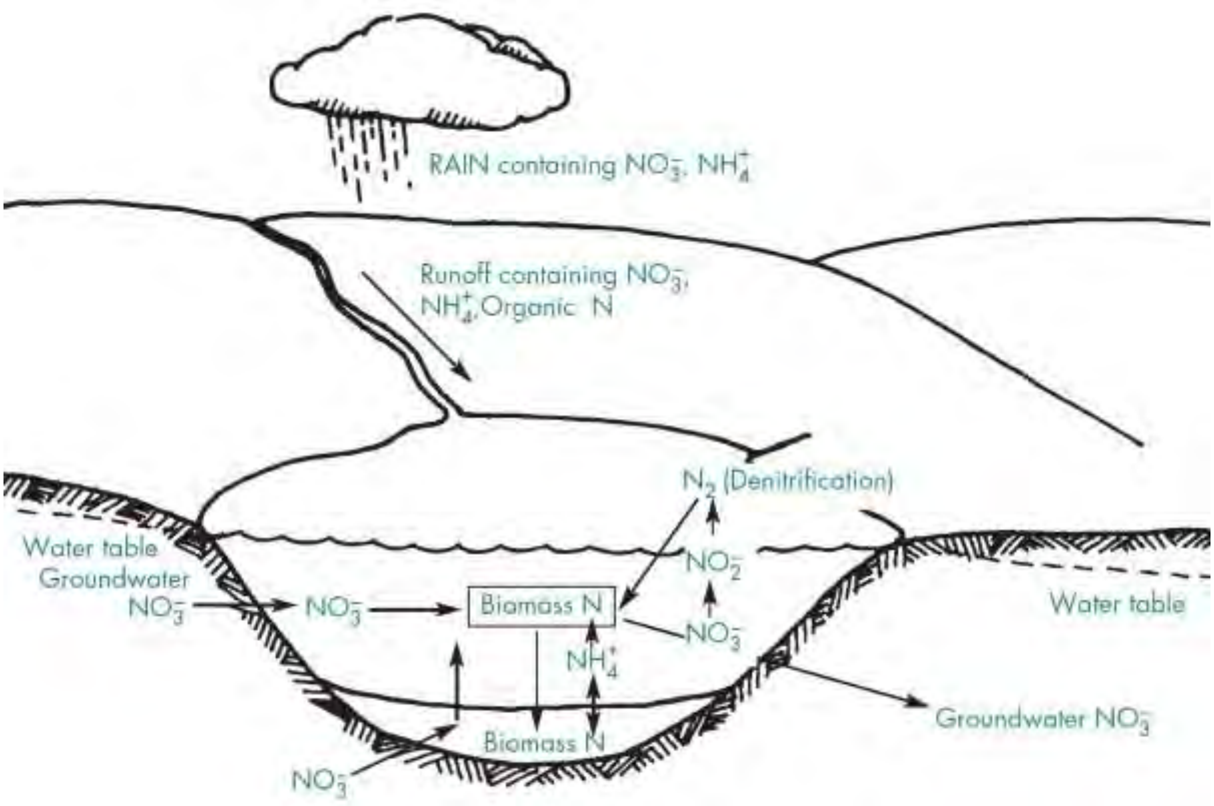


Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Nitrogen comprises the majority (78%) of the gases in the Earth's atmosphere. As with other gases, nitrogen is more soluble in cooler water as compared to warmer water. Nitrogen gas is not readily available to most aquatic plants, with the exception of blue green algae.

Similar to phosphorus, nitrogen is divided into many components. In this study nitrate/nitrite (NO_3 and NO_2), ammonium (NH_4), and total Kjeldahl nitrogen (TKN) were analyzed.

Nitrate/nitrite and ammonium are all inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/L can support summer algae blooms in lakes.

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. By subtracting the ammonium concentration from TKN, the organic nitrogen concentration found in plants and algal material can be found.

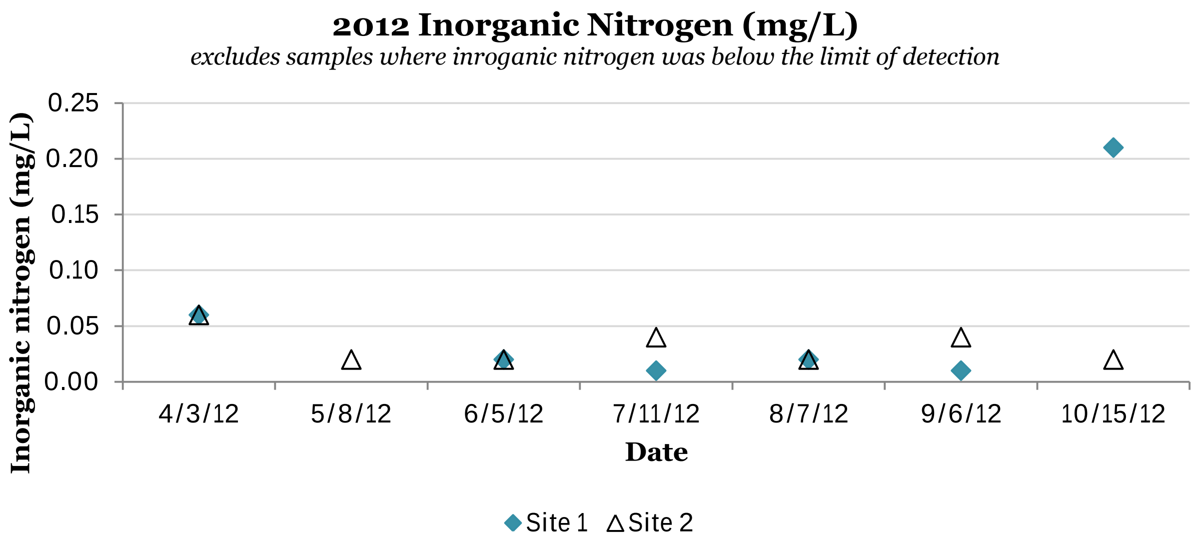
Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

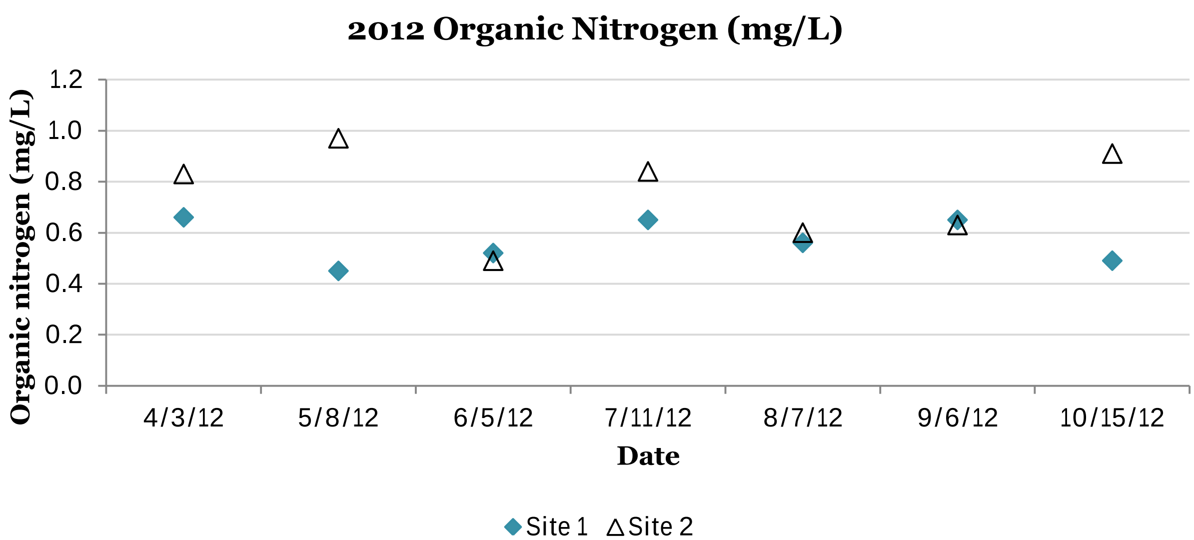
Average growing season (excludes turnover) inorganic nitrogen was 0.02 mg/L at site one and 0.03 mg/L at site two. Inorganic nitrogen concentrations at both sites were below the healthy limit which can support summer algae blooms in lakes. However, these healthy limit values are based on lakes versus impoundments.

Average growing season (excludes turnover) organic nitrogen was 0.566 mg/L at site one and 0.706 mg/L at site two.

At site one, nitrate/nitrite concentrations were below the limit of detection (0.1 mg/L) at all samples dates with the exception of spring and fall turnover. Additionally, at site one ammonium concentrations were below the limit of detection (0.01 mg/L) on May 8th. As a result, inorganic nitrogen concentrations were below the limit of detection on May 8th at site one.

At site two, nitrate/nitrite concentrations were below the limit of detection at all sample dates with the exception of spring turnover.


2012 Inorganic Nitrogen (mg/L)
excludes samples where inroganic nitrogen was below the limit of detection
Inorganic nitrogen (mg/L)
0.25
0.20
0.15
0.10
0.05
0.00
4/3/12
5/8/12
6/5/12
7/11/12
8/7/12
9/6/12
10/15/12
Date
Site 1
Site 2


2012 Organic Nitrogen (mg/L)
Organic nitrogen (mg/L)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
4/3/12
5/8/12
6/5/12
7/11/12
8/7/12
9/6/12
10/15/12
Date
Site 1
Site 2

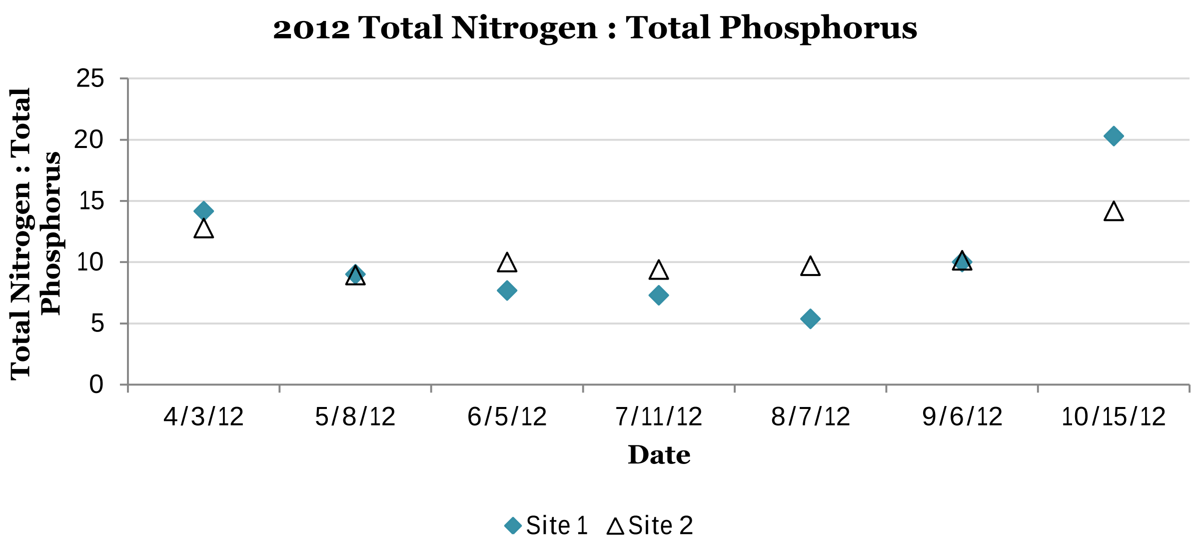
Total Nitrogen to Total Phosphorus Ratio

The total nitrogen to total phosphorus ratio (TN: TP) is a calculation that depicts which nutrient limits algae growth in a lake.

Lakes are considered nitrogen limited, or sensitive to the amount of nitrogen inputs, when TN: TP ratios are less than 10. Only about 10% of Wisconsin lakes are limited by nitrogen. In contrast, lakes are considered phosphorus limited, or sensitive to the amount of phosphorus inputs into a lake, when the TN: TP ratio is above 15. Lakes with values between 10 and 15 are considered transitional. In transitional lakes it is impossible to determine which nutrient, either nitrogen or phosphorus, is limiting algae growth.

Total nitrogen is found by adding NO_3+NO_2+TKN. As previously mentioned, nitrate/nitrite concentrations were below the limit of detection on all sample dates at site one, with the exception of spring and fall turnover, and on all sample dates at site two with the exception of spring turnover. As a result, total nitrogen is largely reflective of TKN.

The total nitrogen to total phosphorus ratio for both sites indicate a nitrogen limited state during the growing season. During spring turnover at both sites and during fall turnover at site two, the ratio indicates a transitional state. During fall turnover at site one, the ratio indicates a phosphorus limited state.



Chloride

Although chloride does not directly negatively impact plants, algae, or aquatic organisms, elevated levels of chloride in a lake can indicate possible water pollution.

With the exception of limestone deposits, chloride is uncommon in Wisconsin soils, rocks, and minerals. Background levels of chloride are generally found in small quantities in nearly every Wisconsin lake and can be introduced to waterways through rainwater.

The watershed for the Apple River Flowage is located in an area where chloride concentrations can be expected to range from greater than three up to ten mg/L.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

FIGURE 7. Generalized distribution gradients of chloride in the surface waters of Wisconsin lakes. *(Adapted from Lillie and Mason, 1983.)*

Chloride concentrations range from 4.2 mg/L up to 6.7 mg/L at site one and from 4.3 mg/L up to 7.3 mg/L at site two. Average growing season (excludes turnover) chloride concentrations were 5.1 mg/L at site one and 5.2 mg/L at site two.

Sulfate

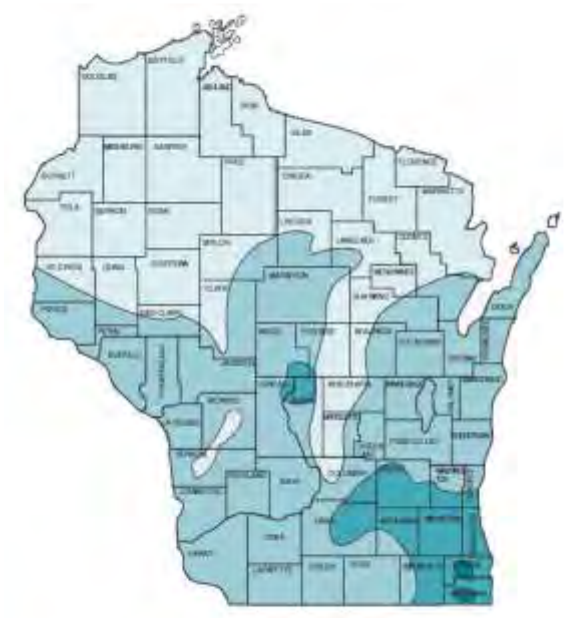
Sulfate concentrations in lakes are most directly related to the types of minerals found in the watershed and to acid rain. Sulfur compounds released into the atmosphere by coal burning facilities can enter lakes via rainfall. In general, sulfate concentrations are higher in the southeastern portion of the state where mineral sources of sulfate and acid rain are more common.

In Polk County, sulfate concentrations are generally less than 10 mg/L.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

Sulfate concentrations ranged from 2.6 mg/L up to 6.4 mg/L at site one and from 2.6 mg/L up to 7.5 mg/L at site two

Average growing season sulfate concentrations were 5.0 mg/L at site one and 5.5 mg/L at site two.



SULFATE CONCENTRATIONS (mg/l)

>40 | 20 - 40 | 10 - 20 | <10

FIGURE 8. Generalized distribution gradients of sulfate in the surface waters of Wisconsin lakes. *(Adapted from Lillie and Mason, 1983.)*

Calcium and Magnesium

Calcium and magnesium concentrations in Wisconsin lakes are closely related to the bedrock geology of the landscape, with highest concentrations found in areas with limestone and dolomite deposits. In Polk County, calcium concentrations typically range from 10-20 mg/L and magnesium concentrations are typically less than 10 mg/L (Lillie, 1983). Calcium concentrations were elevated as compared to the average for Polk County lakes and magnesium concentrations were at the maximum range for Polk County lakes.

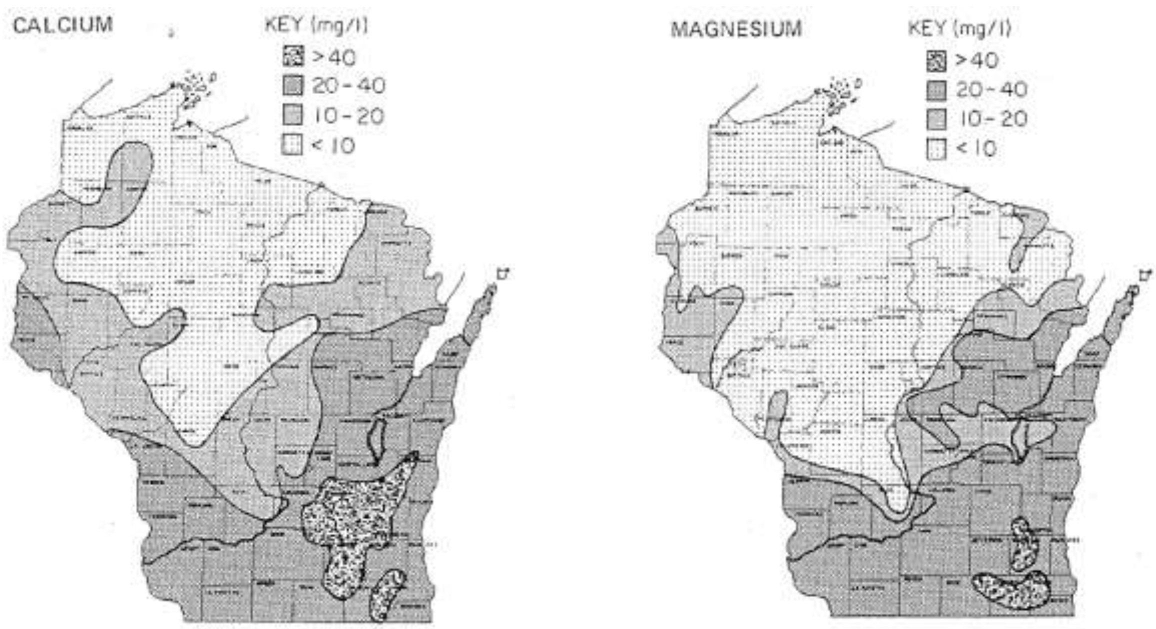


Figure from: (Lillie, 1983).

	Site 1	Site 2
Average Calcium (mg/L)	**30.7**	**29.9**
Minimum Calcium (mg/L)	26.6	24.0
Maximum Calcium (mg/L)	34.4	34.4

	Site 1	Site 2
Average Magnesium (mg/L)	**10.9**	**11.1**
Minimum Magnesium (mg/L)	8.6	8.7
Maximum Magnesium (mg/L)	12.9	12.6

Total Suspended Solids

Total suspended solids (TSS) quantify the amount of inorganic matter that is floating in the water column. Wind, waves, boats, and even some fish species can stir up sediments from the lake bottom re-suspending them in the water column. Fine sediments, especially clay, can remain suspended in the water column for weeks. These particles scatter light and decrease water transparency.

Total suspended solids were below the limit of detection (2 mg/L) at site one on June 5th and September 6th.

Dissolved Oxygen

Oxygen is required by all aquatic organisms for survival. The amount of oxygen dissolved in water depends on water temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake.

In a process called photosynthesis, plants use carbon dioxide, water, and the sun's energy to produce simple sugars and oxygen. Chlorophyll, the pigment in plants that captures the light energy necessary for photosynthesis, is the site where oxygen is produced. Since photosynthesis requires light, the oxygen producing process only occurs during the daylight hours and only at depths where sunlight can penetrate.

Plants and animals also use oxygen in a process called respiration. During respiration, sugar and oxygen are used by plants and animals to produce carbon dioxide and water.

Temperature °C	Temperature °F	Oxygen solubility (mg/L)
0	32	15
5	41	13
10	50	11
15	59	10
20	68	9
25	77	8

Cold water is able to hold more oxygen as compared to warm water. However, although temperatures are coolest in the deepest part of a lake, these waters often do not contain the most oxygen. This arises because in the deepest parts of lakes, oxygen producing photosynthesis is not occurring, mixing is unable to introduce oxygen, and the only reaction occurring is oxygen consuming respiration. Therefore, it is not uncommon for oxygen depletion to occur in the hypolimnion.

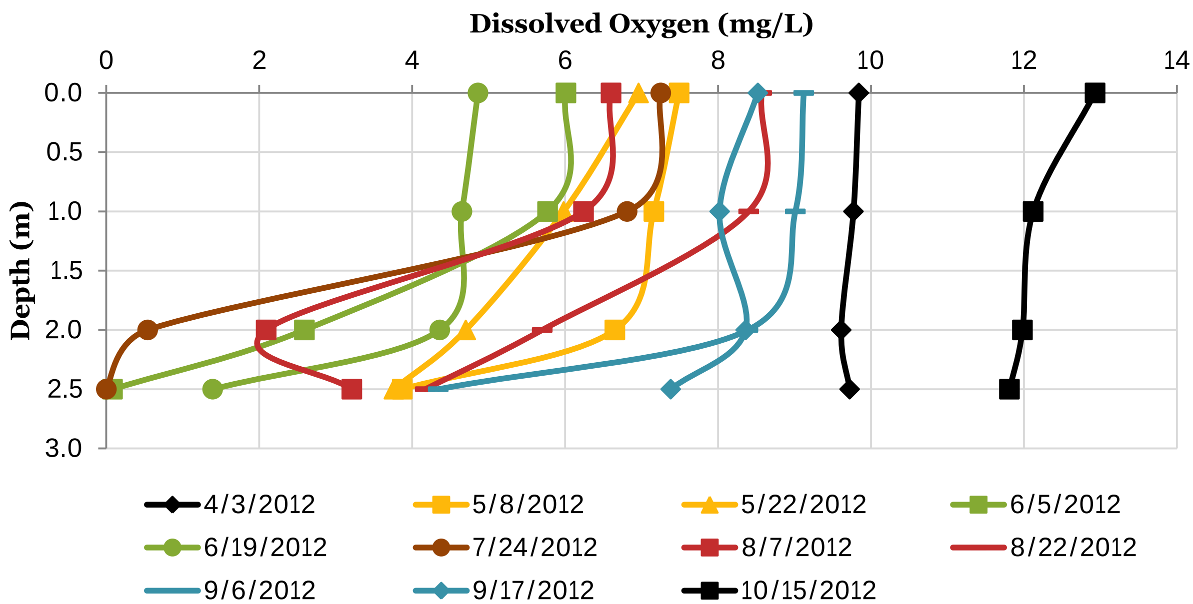
During the sunlight hours, when photosynthesis is occurring, dissolved oxygen levels at a lake's surface may exceed the oxygen solubility values. Conversely, at night or early in the morning (when photosynthesis is not occurring), the dissolved oxygen values can be expected to be lower.

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. For cold water lakes supporting trout, the standard is set even higher at 7 mg/L.

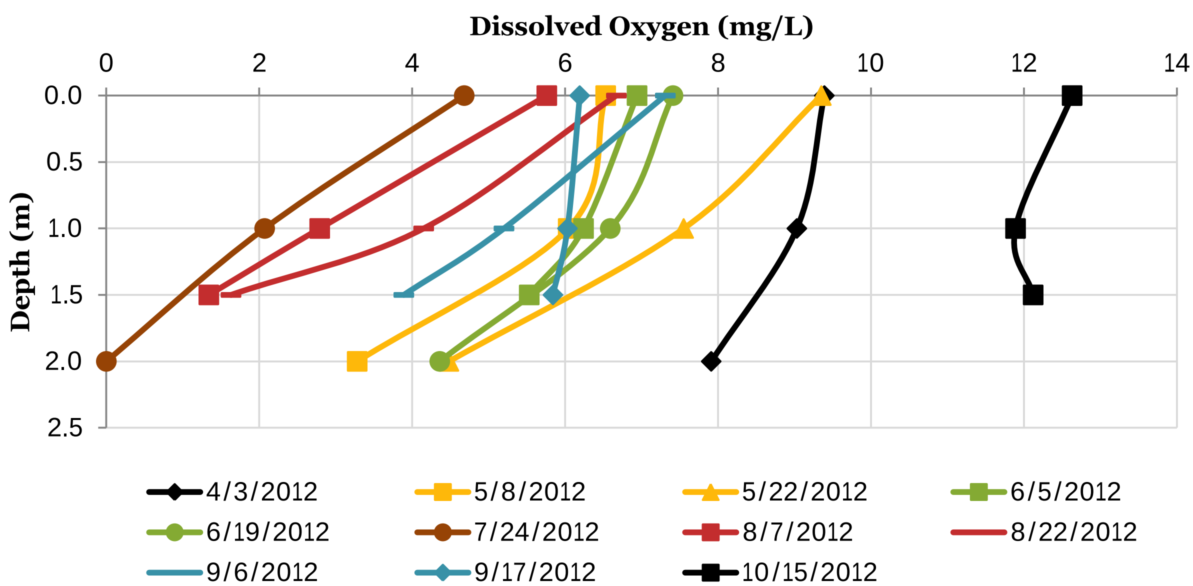
Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

The upper waters of the Apple River Flowage remained well oxygenated throughout the majority of the summer. Near bottom, dissolved oxygen levels were lowest in June and July at site one and lowest in July and August at site 2. At site one, where water depths were 2.5 meters, the first meter of the water column remained well oxygenated. At site two, where water depths were 2 meters, oxygen levels dropped substantially by the first meter. This likely arose from the increased abundance of plants at this site.

2012 Site 1 Dissolved Oxygen (mg/L)

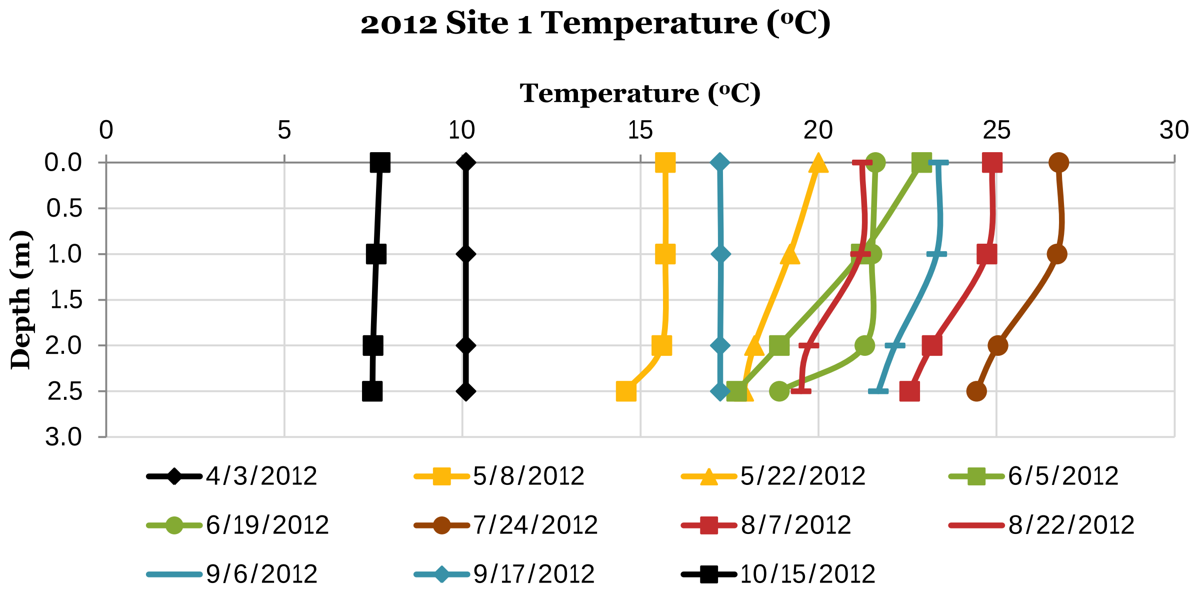


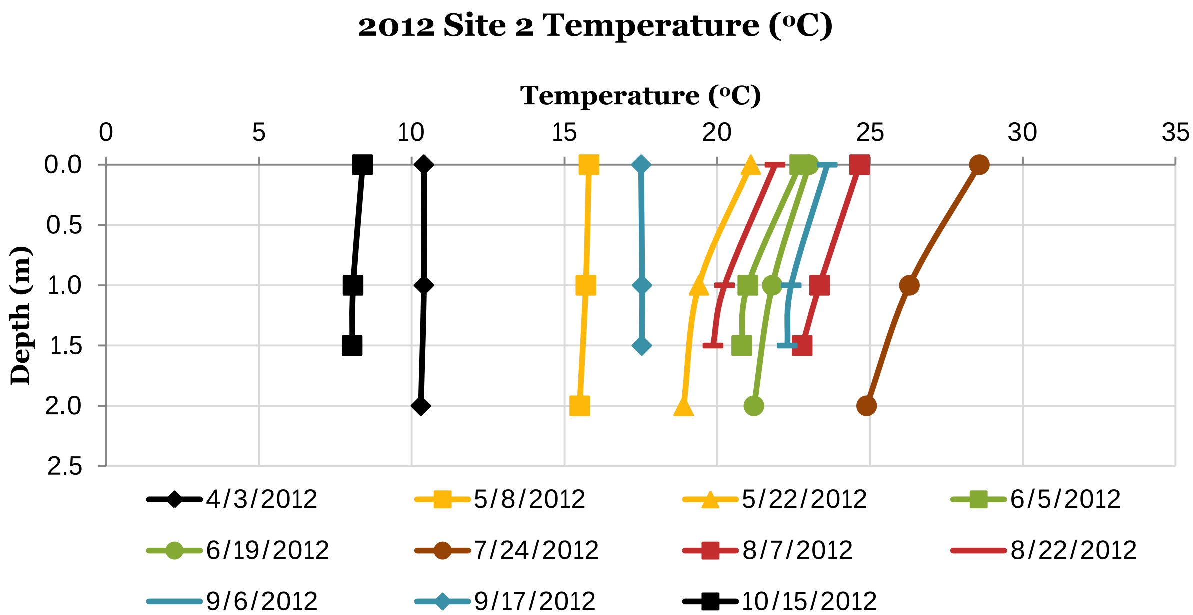
2012 Site 2 Dissolved Oxygen (mg/L)



Temperature

The Apple River Flowage reached its warmest surface temperature (26.8 ºC at site one and 28.6 ºC at site two) on July 24th. By examining the temperature profile it is clear that in 2012 the Apple River Flowage did not stratify, or develop density dependent differences that create distinct layers in the water column.





Conductivity (Specific Conductance)

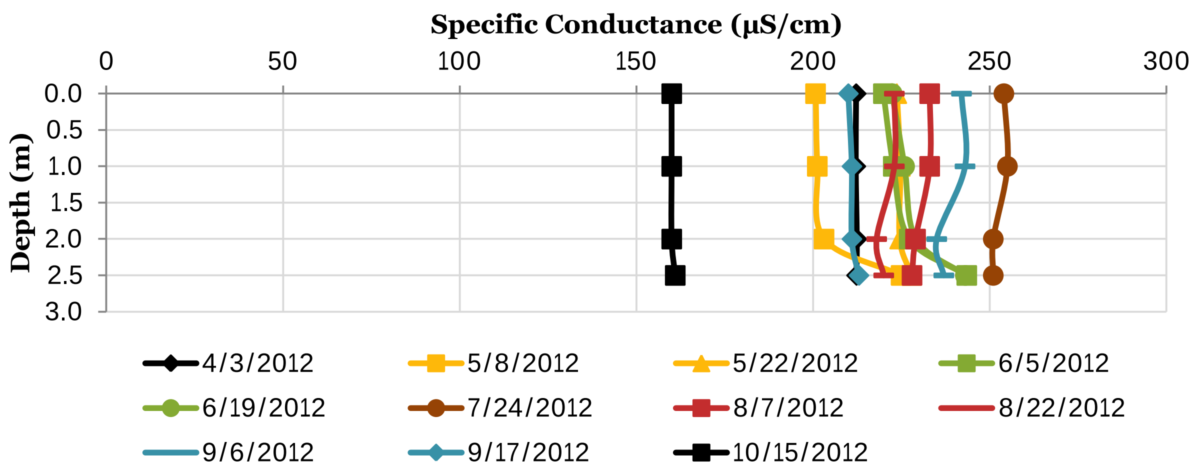
Conductivity is the measure of the ability of water to conduct an electrical current and serves as an indicator of the concentration of total dissolved inorganic chemicals in the water. Since conductivity is temperature related, reported values are normalized at 25°C and termed specific conductance. Specific conductance increases as the concentration of dissolved minerals in a lake increase.

Specific conductance values are typically two times the water hardness. Hardness is the quantity of cations with more than one positive charge, primarily calcium and magnesium. Soluble minerals, especially limestone, in a lakes watershed impact the value for hardness. A categorization of hardness indicates that the Apple River Flowage is moderately hard (between 61-120 mg/L).

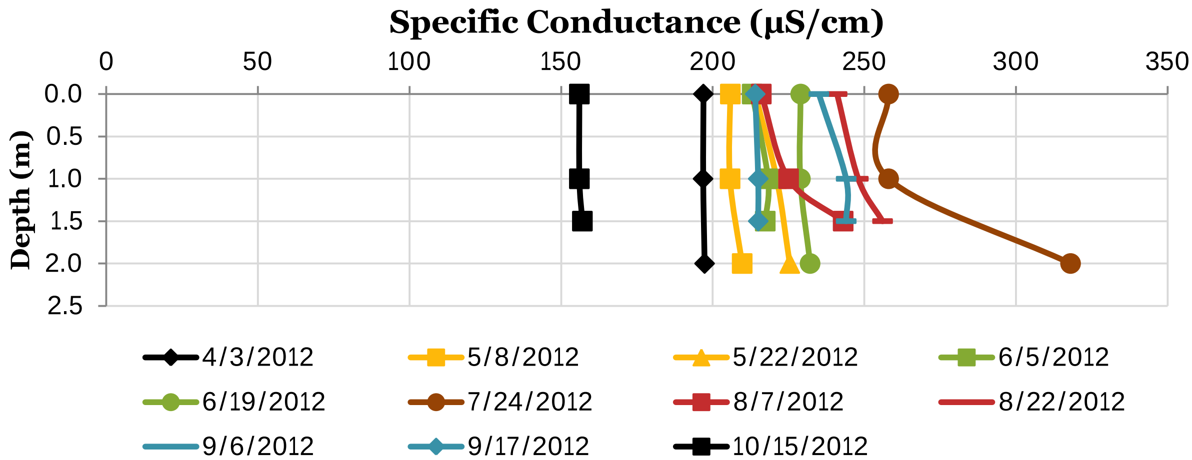
Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

In general, conductivity values fell between 200-250 µS/cm at both sites on the Apple River Flowage. Conductivity values were the highest on July 24th, 2012 and the lowest at fall turnover (October 15th, 2012).

2012 Site 1 Specific Conductance (µS/cm)



2012 Site 2 Specific Conductance (µS/cm)



pH

An indicator of acidity, pH is the negative logarithm of the hydrogen ion (H+) concentration. Lower pH waters have more hydrogen ions and are more acidic, and high pH waters have less hydrogen ions and are less acidic.

A pH value of seven is considered neutral. Values less than seven indicate acidic conditions; whereas, values greater than seven indicate alkaline conditions. A single pH unit change represents a tenfold change in the concentration of hydrogen ions. As a result, a lake with a pH value of eight is ten times less acidic than a lake with a pH value of seven.

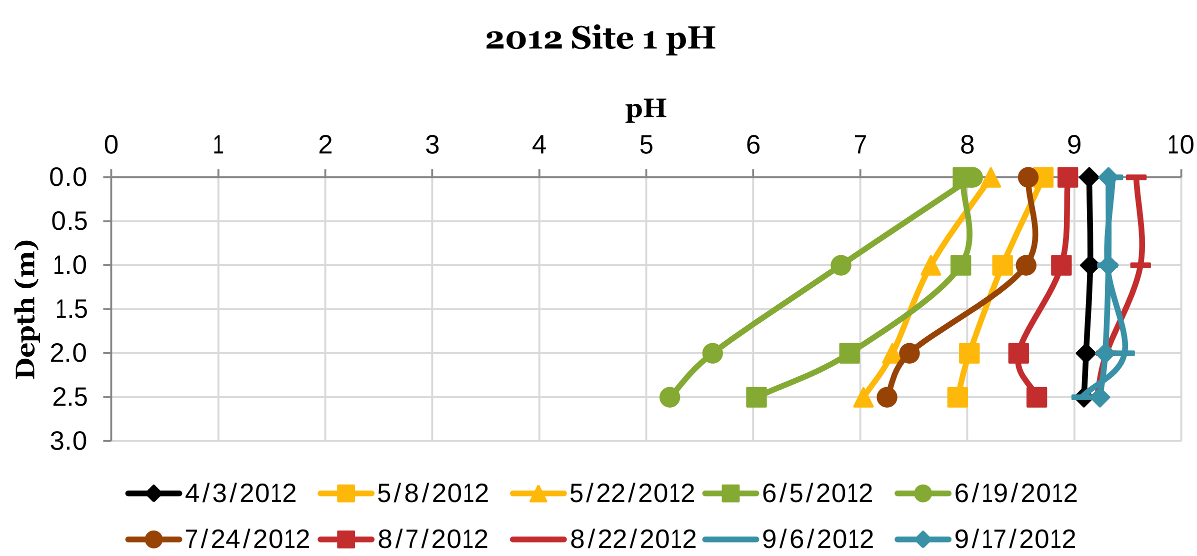
Across Wisconsin lakes, pH values can range from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes).

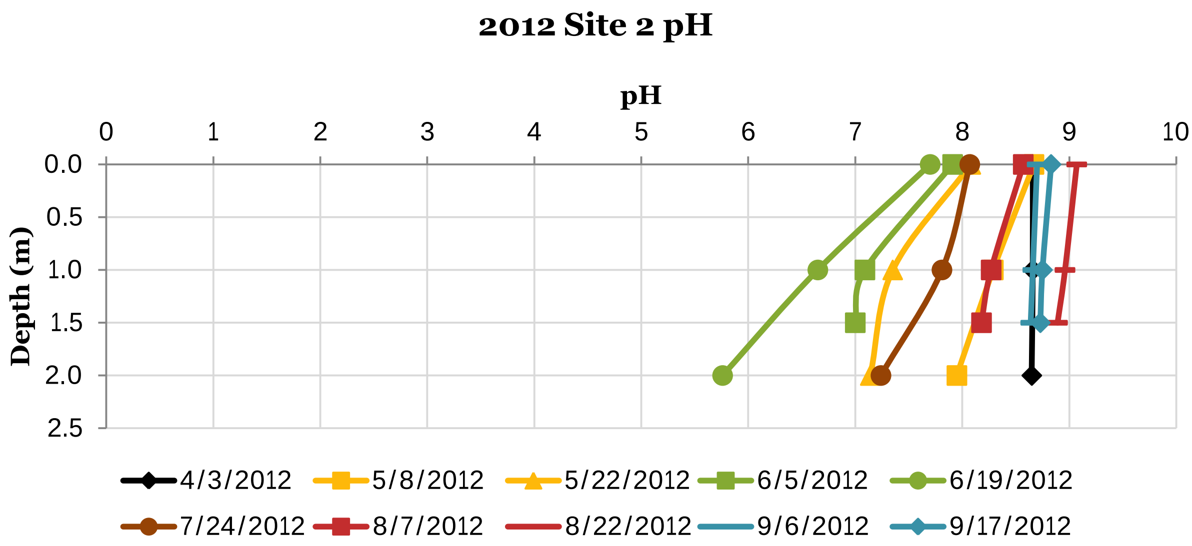
Through the removal of CO_2 from the water column, photosynthesis has the effect of increasing pH. As a result, pH generally increases during the day and decreases at night. Under conditions such as high temperature, high nutrients, and dense algae blooms, pH levels can increase.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

April, May, and June data were collected using a YSI 60 pH meter; whereas, July, August, and September data were collected with a HI 9828 multi-parameter probe.

In general, at any given sampling date, the pH was greater at the surface of the flowage as compared to the bottom of the flowage. In general, pH was the lowest in May and June and the greatest in August and September.




2012 Site 2 pH
pH
0
1
2
3
4
5
6
7
8
9
10
Depth (m)
0.0
0.5
1.0
1.5
2.0
2.5
4/3/2012
5/8/2012
5/22/2012
6/5/2012
6/19/2012
7/24/2012
8/7/2012
8/22/2012
9/6/2012
9/17/2012

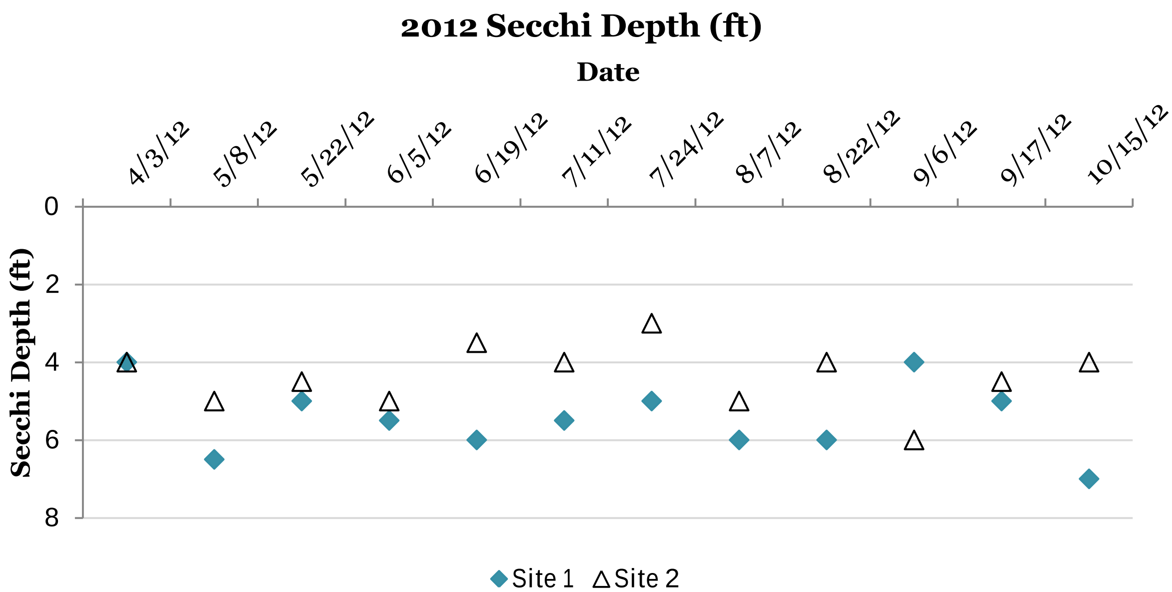
Secchi Depth

The depth to which light can penetrate into lakes is affected by suspended particles, dissolved pigments, and absorbance by water. Often, the ability of light to penetrate the water column is determined by the abundance of algae or other photosynthetic organisms in a lake.

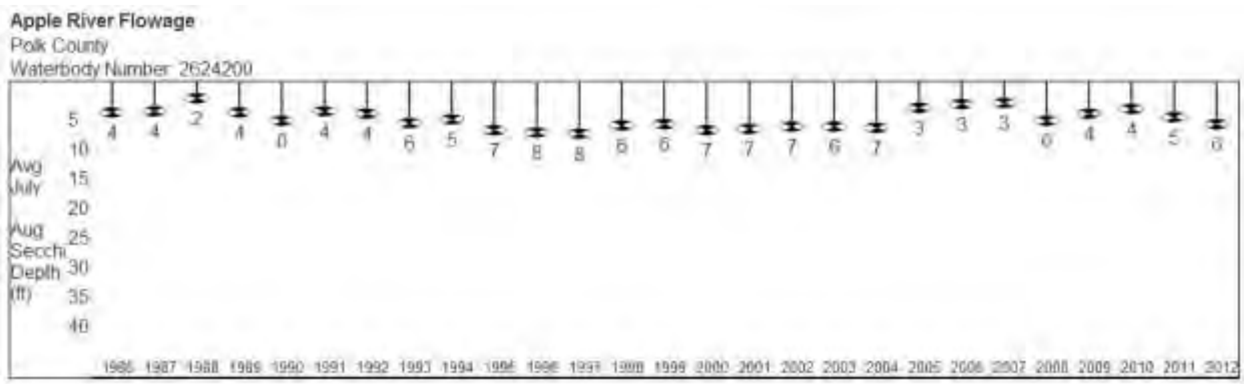
One method of measuring light penetration is with a secchi disk. A secchi disk is an eight inch diameter round disk with alternating black and white quadrants that is used to provide a rough estimate of water clarity. The depth at which the secchi disk is just visible is defined as the secchi depth. A greater secchi depth indicates greater water clarity.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

The average growing season secchi depth was greater at site one (5.5 feet) as compared to site two (4.5 feet). A similar trend is evident when averaging the secchi depths over the summer index period. Average summer index period secchi depth was greater at site one (5.3 feet) as compared to site two (4.5 feet). Water depth at site one was approximately two feet greater that water depth at site two. Additionally, plants were much more abundant at site two. The plant community at site two was dominated by curly leaf pondweed in the spring and coon tail in the summer. In many instances, secchi depth at site two was limited by the plant canopy versus the clarity of the water.



The Wisconsin Department of Natural Resources provides historic secchi depth averages for the months of July and August only. This data exists for the Apple River Flowage deep hole from 1986 through the present year. Site one north and site two south are distinct from the deep hole site.



Past secchi averages in feet (July and August only)

Chlorophyll *a*

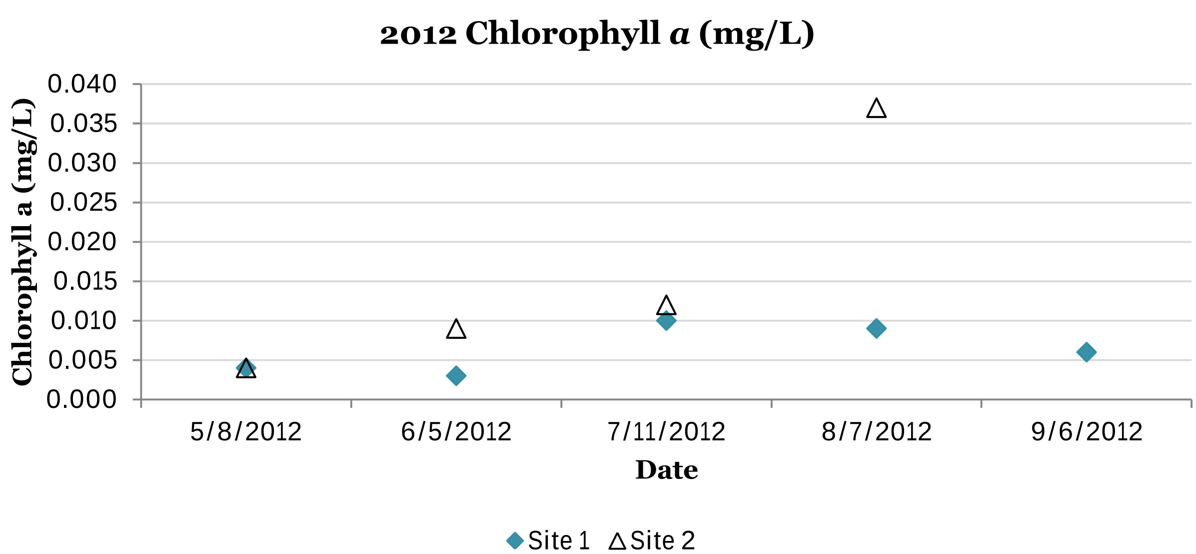
Chlorophyll *a* is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. Chlorophyll *a* gives a general indication of the amount of algae growth in a lake, with greater values for chlorophyll *a* indicating greater amounts of algae. However, since chlorophyll *a* is present in sources other than algae— such as decaying plants— it does not serve as a direct indicator of algae biomass.

Chlorophyll *a* seems to have the greatest impact on water clarity when levels exceed 0.03 mg/L. Lakes which appear clear generally have chlorophyll *a* levels less than 0.015 mg/L.

Information summarized from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

With the exception of site two on August 7th, 2012, chlorophyll *a* levels on the flowage were below 0.015 mg/L.

The growing season average chlorophyll *a* was 0.0064 mg/L at site one and 0.0155 mg/L at site two. The summer index average chlorophyll *a* was 0.0075 mg/L at site one and 0.037 mg/L at site two. However, since the September chlorophyll *a* sample for site two was dropped at the lab, the summer index average at site two represents only one sample date.



Trophic State Index

Lakes are divided into three categories based on their trophic states: oligotrophic, eutrophic, and mesotrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity.

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often poor in nutrients and are therefore unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish.

Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations, but are susceptible to oxygen depletion.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

All lakes experience a natural aging process which causes a change from an oligotrophic to a eutrophic state. Human influences which introduce nutrients into a lake (agriculture, lawn fertilizers, and septic systems) can accelerate the process by which lakes age and become eutrophic.

Figure from: (Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004).

A common method of determining a lake's trophic state is to compare total phosphorus concentration (important for algae growth), chlorophyll *a* concentration (an indicator of the amount of algae present), and secchi disk readings (an indicator of water clarity). Although many factors influence these relationships, the link between phosphorus concentration, chlorophyll *a* concentration, and secchi disk readings is the basis of comparison for the Trophic State Index (TSI).

TSI is determined using a mathematic formula and ranges from 0 to 110. Lakes with the lowest numbers are oligotrophic and lakes with the highest values are eutrophic.

Three equations for summer index period TSI were examined for site one and site two on the Apple River Flowage. Phosphorus and chlorophyll *a* data were averaged from August 7th and September 6th. On September 6th, the sample for chlorophyll *a* was dropped by the Water and Environmental Analysis Lab. As a result, TSI chlorophyll is calculated using the single sample collected on August 7th. Secchi depth data were averaged from July 24th, August 7th, August 22nd, and September 6th.

TSI (P) = 14.42 * Ln [TP] + 4.15 (where TP is in µg/L)
TSI (C) = 30.6 + 9.81 Ln [Chlor-a] (where the chlorophyll *a* is in µg/L)
TSI (S) = 60-14.41 * Ln [Secchi] (where the secchi depth is in meters)

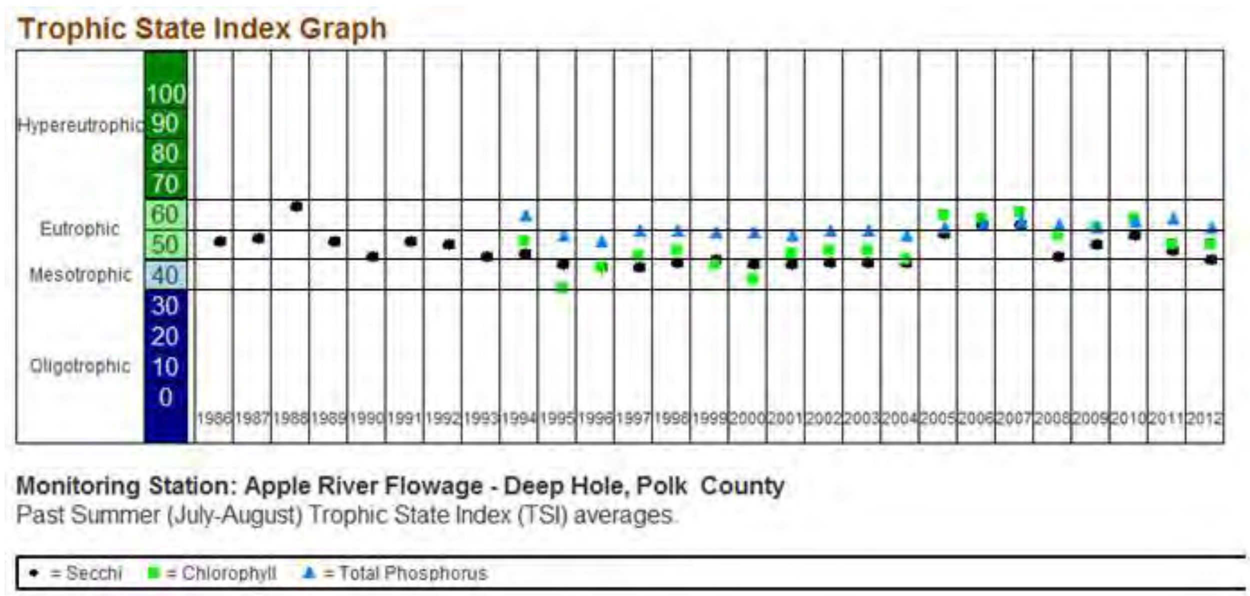
Apple River Flowage Site 1
Average summer index period TSI (total phosphorus) = 68.96
Average summer index period TSI (chlorophyll *a*) = 50.37
Average summer index period TSI (secchi depth) = 53.09
Average summer index period TSI = 57.47 = mildly eutrophic

Apple River Flowage Site 2
Average summer index period TSI (total phosphorus) = 65.00
Average summer index period TSI (chlorophyll *a*) = 66.02
Average summer index period TSI (secchi depth) = 55.45
Average summer index period TSI = 62.16 = eutrophic

TSI	General Description
<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem; warm-water fisheries only
60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth. Full body recreation may be decreased
70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Monitoring the TSI of a lake gives stakeholders a method by which to gauge lake productivity over time. Fortunately, complete TSI secchi data exists for the Apple River Flowage Deep Hole from 1986 through 2012. Additionally, complete TSI phosphorus and chlorophyll *a* data exists for the Apple River Flowage Deep Hole from 1994-2012.

The majority of the historic TSI data for chlorophyll *a* and total phosphorus fall between 50 and 70; whereas, the majority of TSI data for secchi fall between 40 and 60.



Phytoplankton

Algae, also called phytoplankton, are microscopic plants that convert sunlight and nutrients into biomass. They can live on bottom sediments and substrate, in the water column, and on plants and leaves. Algae are the primary producers in an aquatic ecosystem and can vary in form (filamentous, colonial, unicellular, etc). Zooplankton, are small aquatic organisms that feed on algae. The size and shape of algae determine which types of zooplankton—if any—can consume them.

Algae have short life cycles. As a result, changes in water quality are often reflected by changes in the algal community within a few days or weeks. The number and types of algae in a waterbody can provide useful information for environmental monitoring programs, impairment assessments, and the identification of best management strategies.

The types of algae in a lake will change over the course of a year. Typically, there is less algae in winter and spring because of ice cover and cold temperatures. As a lake warms up and sunlight increases, algae communities begin to increase. Their short life span quickly cycles the nutrients in a lake and affects nutrient dynamics.

The types of algae present in a lake are influenced by environmental factors like climate, phosphorus, nitrogen, silica and other nutrient content, carbon dioxide, grazing, substrate, and other factors in the lake. When high levels of nutrients are available, blue green algae often become predominant.

Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis. Chlorophyll a gives a general indication of the amount of algae growth in the water column; however, it is not directly correlated with algae biomass. To obtain accurate algae data, composite samples from a two meter water column were collected monthly, preserved with glutaraldehyde, placed on ice, and sent to the State Lab of Hygiene for identification and enumeration of algae species.

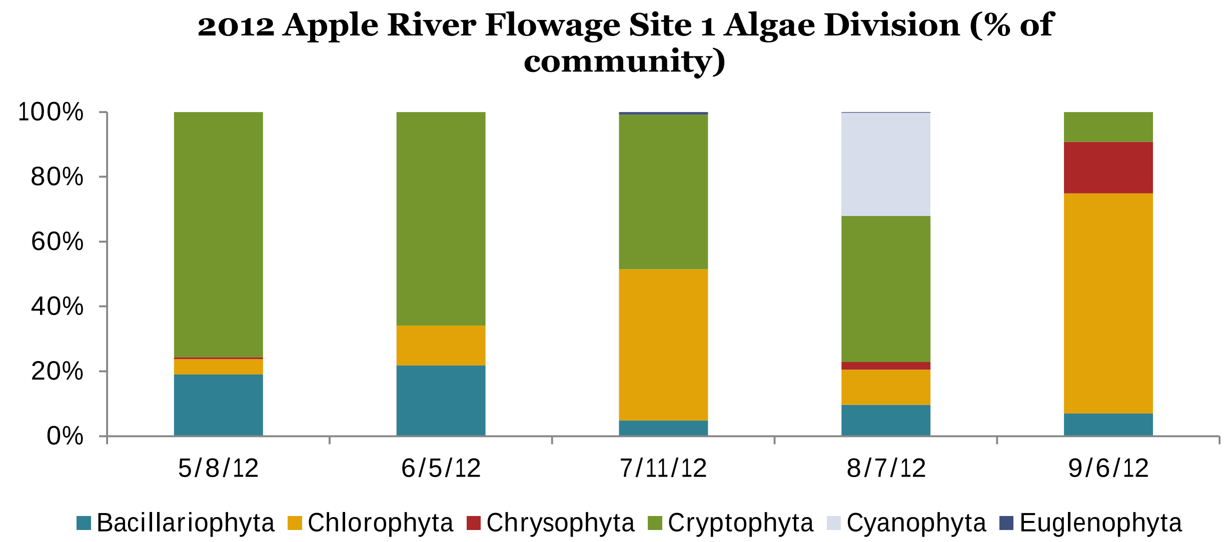
Algae were identified to genus, and a relative concentration and natural unit count was made to describe the algae community throughout the growing season. This method of sampling also allows the identification of any species of concern which might be present.

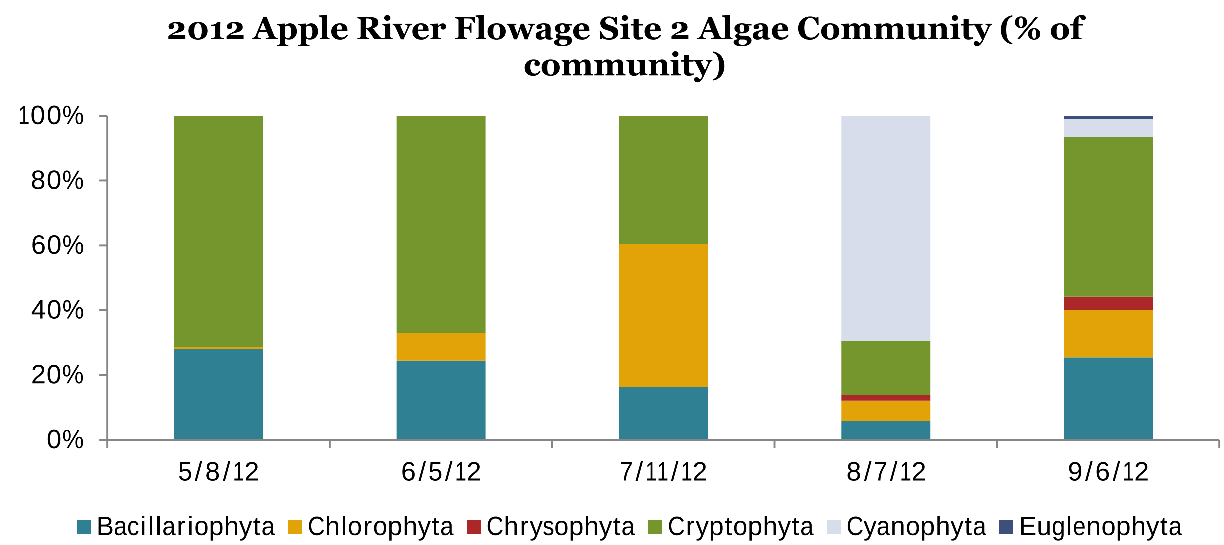
There are 12 divisions of algae found in typical lakes of Wisconsin. Six divisions were found in the Apple River Flowage.

Algal Division	Common Name	Characteristics
Bacillariophyta	Diatoms	Have a siliceous frustule that makes up the external covering. Sensitive to chloride, pH, color, and total phosphorus (TP) in water. As TP increases, see a decrease in diatoms. Generally larger in size. Tend to be highly present in spring and late spring. Can be benthic or planktonic.
Chlorophyta	Green algae	Have a true starch and provide high nutritional value to consumers. Can be filamentous and intermingle with macrophytes.
Chrysophyta	Golden brown algae	Organisms which bear two unequal flagella. A genus of single-celled algae in which the cells are ovoid. Contain chlorophyll a, c_1 and c_2, generally masked by abundant accessory pigment, fucoxanthin, imparting distinctive golden color to cells.
Cryptophyta	Cryptomonads	Have a true starch. Planktonic. Bloom forming, are not known to produce any toxins and are used to feed small zooplankton. Cryptomonads frequently dominate the phytoplankton assemblages of the Great Lakes.
Cyanophyta	Blue green algae	Prevail in nutrient-rich standing waters. Blooms can be toxic to zooplankton, fish, livestock, and humans. Can be unicellular, colonial, planktonic, or filamentous. Can live on almost any substrate. More prevalent in late to mid-summer.
Euglenophyta	Euglenoids	One of the best-know groups of flagellates, commonly found in freshwater that is rich in organic materials. Most are unicellular.

At both sites the dominant algae division in May and June was Cryptophyta, or cryptomonads. By July, the algae community at both sites was dominated nearly equally by cryptomonads and Chlorophyta, or green algae. In August, the algae community at site one was dominated by cryptomonads and the algae community at site two was dominated by Cyanophyta, or blue green algae. In September, the algae community at site one shifted back to being green algae dominated and the algae community at site two shifted back to being dominated by cryptomonads.

Across the entire sampling season Euglenophyta, or euglenoids, made up less than 1% of the algae community at both sites.





Blue green algae have been around for billions of years and typically bloom during the summer months. However, blue-green algae blooms become more frequent as a result of increased nutrient concentrations.

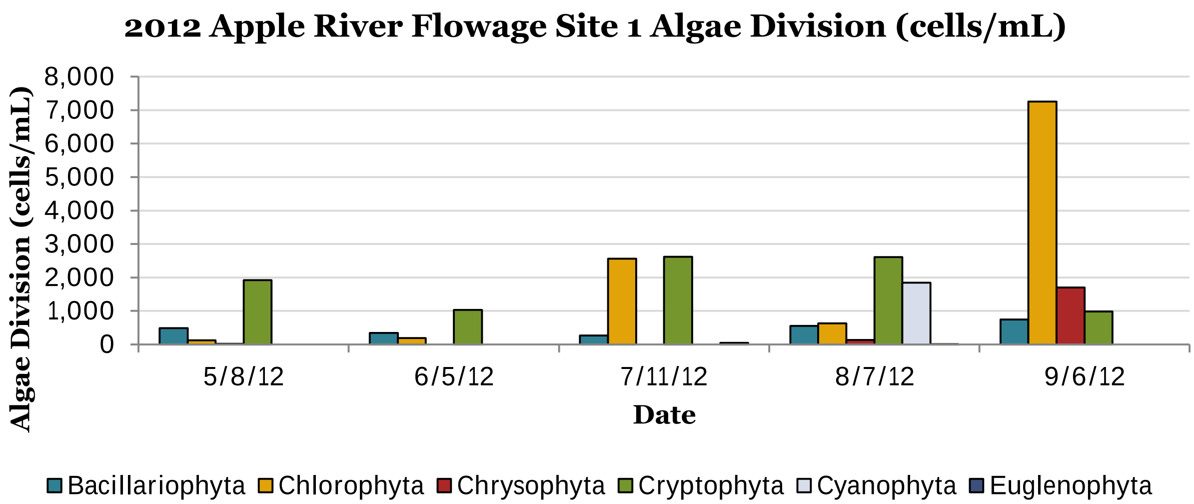
In addition to the negative aesthetics posed by algae, blue green algae are of specific concern because of their ability to produce toxins, that when ingested or inhaled, can cause short and long term health effects. Effects range from tingling, burning, numbness, drowsiness, and dermatitis to liver or respiratory failure possibly leading to death.

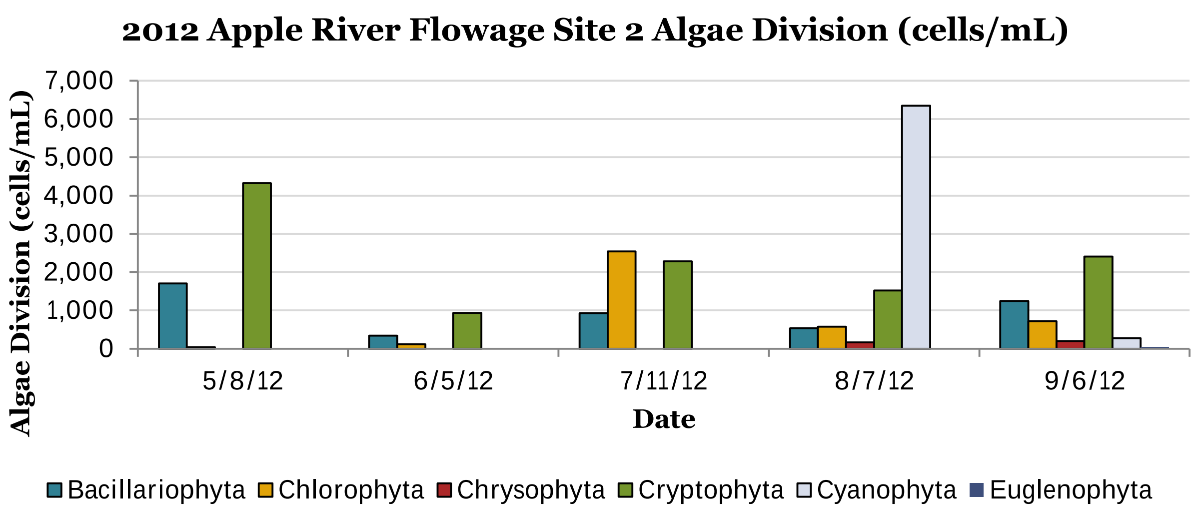
It is not know which environmental conditions cause the production of cyanotoxins, but scientists have found that when blue green algae is present at concentrations over 100,000 cells/mL toxin production is more likely to occur.

Federal guidelines for cyanobacterial cell densities and chlorophyll *a* concentrations do not exist. The Wisconsin Harmful Algal Bloom (HAB) Surveillance Program uses guidelines of the World Health Organization to determine risks from cyanobacteria:

Cyanobacterial cell density (cells/mL)	Chlorophyll *a* (mg/L)	Risk
Less than 20,000	Less than 0.01	Low
20,000 to 100,000	0.01 to 0.05	Moderate
Greater than 100,000	Greater than 0.05	High

Blue green algae were only present in August at site one and only present in August and September at site two. Their concentrations at these sampling dates were very low and well below the risk threshold for toxin production.





Zooplankton

Zooplankton are small aquatic animals that feed on algae and are eaten by fish. They are divided into three main components: rotifers, copepods, and cladocerans.

Rotifers eat algae, other zooplankton, and sometimes each other. Due to their small size, rotifers are not capable of significantly reducing algal biomass although they are able to shift the algae community to favor larger species.

Copepods feed on algae and other plankton. They are eaten by larger plankton and are preyed heavily upon by pan fish, minnows, and the fry of larger fish.

Cladocerans are filter feeders that play an important part in the food web. Species of cladocerans (particularly Daphnia) are well known for their ability to reduce algal biomass and help maintain clear water in lake ecosystems.

Zooplankton are often overlooked as a component of aquatic systems, but their role in a lake is extremely important. Lake systems are valued primarily for water clarity, fishing, or other recreation, all of which are strongly linked to water quality and ecosystem health. Zooplankton are the primary link between the "bottom up" processes and "top down" processes of the lake ecosystem.

"Bottom up" processes include factors such as increased nutrients, which can cause noxious algal blooms. Zooplankton have the ability to mediate algae blooms by heavy grazing. Conversely, shifts in algal composition, which can be caused by increased nutrients, can change the composition of the zooplankton community. If the composition shifts to favor smaller species of zooplankton, for example, algal blooms can be intensified, planktivorous fish can become stressed, and the development of fry can be negatively impacted.

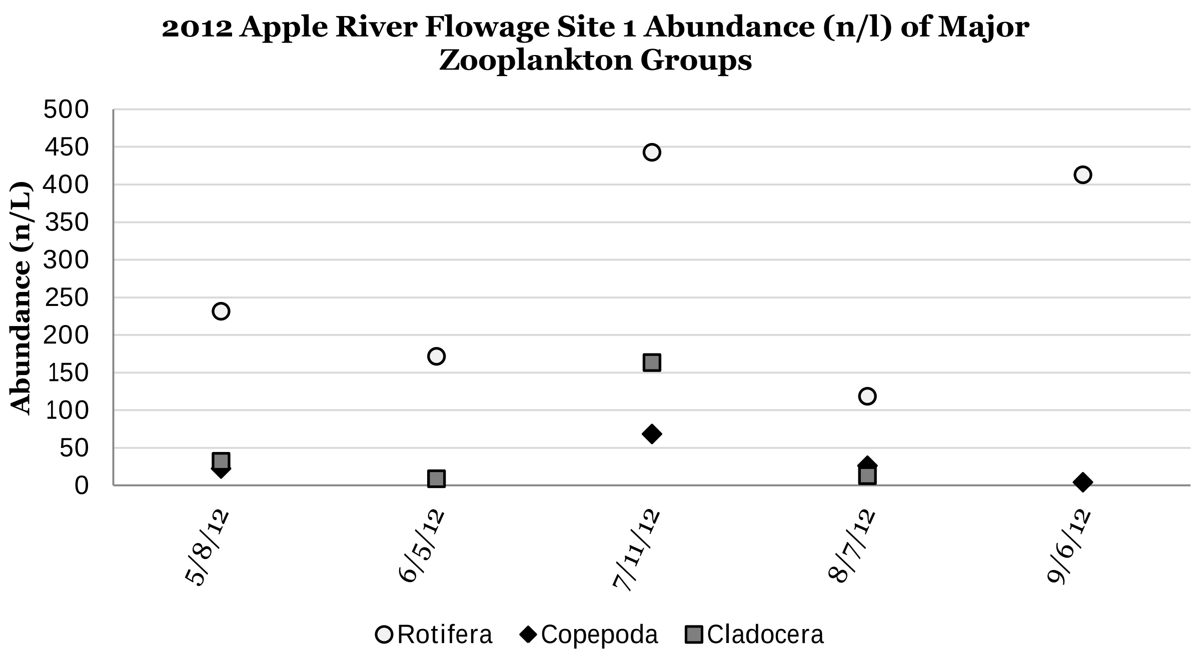
"Top down" processes include factors such as increased fish predation. Increases in planktivorous fishes (pan fish) can dramatically reduce zooplankton populations and lead to algal blooms. In some lakes, biomanipulation is utilized to manage this effect and improve water clarity. Piscivorous fish (fish that eat other fish) are used to reduce planktivorous fish. This in turn increases zooplankton populations and ultimately reduces algae populations.

Changes in the aquatic plant community and shoreland habitat can impact zooplankton populations. This occurs especially in shallow lakes where zooplankton are more likely to have the ability to migrate horizontally to avoid predation from fish and other invertebrates. In general, a diverse shoreland habitat (substrate, plant species, and woody debris) will support a diverse zooplankton community.

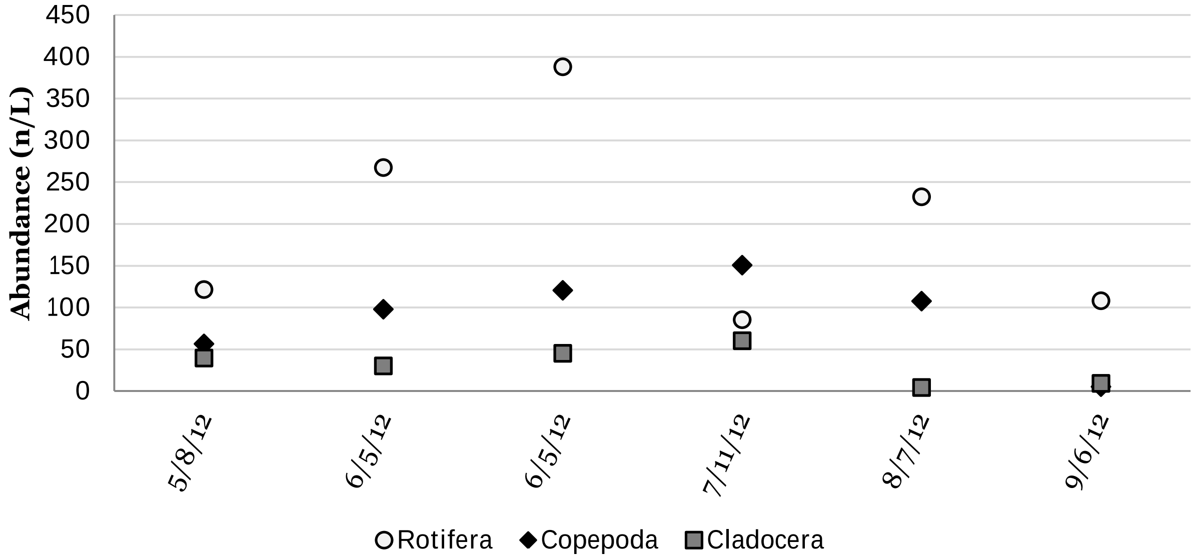
Composite samples from a two meter water column were collected monthly, preserved with denatured ethanol, placed on ice, and sent to the Northland College for identification and enumeration of zooplankton species. This analysis shows the abundance of the major zooplankton groups—cladocera, copepoda, and rotifer—in the Apple River Flowage.

Composite samples from a two meter water column were collected monthly, preserved with denatured ethanol, placed on ice, and sent to the Northland College for identification and enumeration of zooplankton species. This analysis shows the abundance of the major zooplankton groups: cladocera, copepoda, and rotifer in the Apple River Flowage.

The Apple River Flowage zooplankton were dominated by rotifers, which is characteristic of flowing waters. Some cladocera are present but almost no copepods, which is somewhat unusual even for a flowing system. Abundance appears to fluctuate with the likely drivers being water retention time (higher flows reducing populations) and temperature (increasing productivity) (Lafroncois, 2013).



2012 Apple River Flowage Site 2 Abundance (n/l) of Major Zooplankton Groups



Lake Sediments

On August 22nd, 2012 a Petite Ponar® Grab Sampler was used to sample the surface sediments at site one and site two on the Apple River Flowage. Samples were analyzed by the University of Wisconsin-Madison Soil Testing Laboratories for total nitrogen, phosphorus, potassium, calcium magnesium, sulfur, zinc, boron, manganese, iron, copper, aluminum, and sodium.

In shallow lakes and reservoirs there is intense interaction of the water sediment interface; understanding the sediment water-interactions is therefore crucial to understanding the nutrient dynamics of shallow lakes such as the Apple River Flowage (Scheffer, 1998). This is the reason for the following analysis, which could have many implications for management actions.

	Total Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Sulfur
Site 1 N	8,600	1,500	1,400	16,200	3,300	4,100
Site 2 S	8,300	1,800	1,300	20,500	2,900	6,000

	Zinc	Boron	Manganese	Iron	Copper	Aluminum	Sodium
Site 1 N	54.44	8.12	769.57	53,359.20	21.12	11,092.40	127.20
Site 2 S	49.31	6.83	1,310.96	32,024.30	21.78	11,899.20	157.90

Copper is an essential trace element that tends to accumulate in sediments and can be toxic to aquatic life at elevated concentrations (United States Environmental Protection Agency, June 2008).

A study completed by MacDonald et al. (2000) developed consensus based numerical sediment quality guidelines for metals in freshwater ecosystems. This study provides guidelines for metals in freshwater ecosystems that reflect threshold effect concentrations (TECs, i.e., below which harmful effects are unlikely to be observed) and probable effect concentrations (PECs, i.e., above which harmful effects are likely to be observed). The consensus based TEC for copper is 31.6 mg/kg and the consensus based PEC for copper is 149 mg/kg.

Sediment copper concentrations were 21.12 mg/kg at site one and 21.78 mg/kg at site two. These concentrations are well below the consensus based TEC for copper, or the concentration below which harmful effects are unlikely to be observed.

Zinc is an additional essential trace element that can be toxic to aquatic life at elevated concentrations. The consensus based TEC for zinc is 121 mg/kg and the consensus based probable effect concentration for zinc is 315 mg/kg.

Sediment zinc concentrations were 54.44 mg/kg at site one and 49.31 mg/kg at site two. These concentrations are well below the consensus based TEC for zinc, or the concentration below which harmful effects are unlikely to be observed.

Nitrogen occurs in lakes and reservoirs in many different forms: dissolved nitrogen (N_2), a large number of organic compounds, ammonia (NH_4^+), nitrite (NO_2^-), and nitrate (NO_3^-). Sources of nitrogen include precipitation, nitrogen fixation in the water and sediment (in eutrophic lakes and reservoirs this can account for >80% of the N input), and inputs from the watershed. Losses occur by outflow, reduction of nitrate to nitrogen gas (which escapes to the atmosphere), and permanent sedimentation loss of organic and inorganic nitrogen compounds (Wetzel, 2001).

Ammonia is a common end product of the decomposition of organic matter. In the sediment of healthy lakes, a large portion of NH_4^+ is adsorbed on sediment particles. However, as the lake or reservoir becomes anoxic the ability of sediment to adsorb ammonia is greatly reduced. In this situation a large release of NH_4^+ occurs. Nitrate (NO_3^-) is also reduced to nitrite (NO_2^-) in the anaerobic sediments of eutrophic lakes and reservoirs.

However, rooted aquatic macrophytes are capable of absorbing large amounts of nitrogen from the sediment and can immobilize it by storing it in their root and foliage, in some cases to the point of reducing NO_3-N below detectable limits (Wetzel, 2001). This illustrates the importance of a healthy aquatic plant community. Healthy aquatic plant communities can be a primary storage site for nitrogen and their senescing tissues become a very important component of nutrient burial and assimilation into the sediment. The total nitrogen content was analyzed on the Apple River Flowage, so the different nitrogen species, are not known.

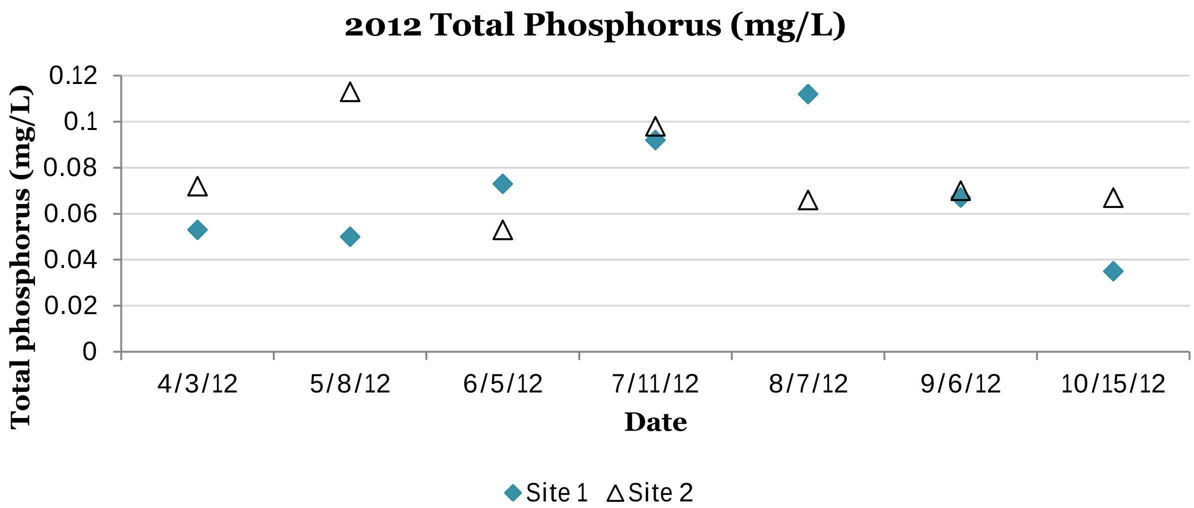
In contrast to nitrogen, which has many forms in lakes, the most significant form of inorganic phosphorus is orthophosphate (PO_4^{3-}). Because of the fundamental importance of phosphorus as a nutrient, a lot of emphasis has been placed on its evaluation in lake and reservoir systems. Four operational categories are commonly evaluated: (1) soluble reactive phosphorus, (2) soluble unreactive phosphorus, (3) particulate reactive phosphorus, and (4) particulate unreactive phosphorus (Wetzel, 2001). Often times, analysis is done for total phosphorus (TP).

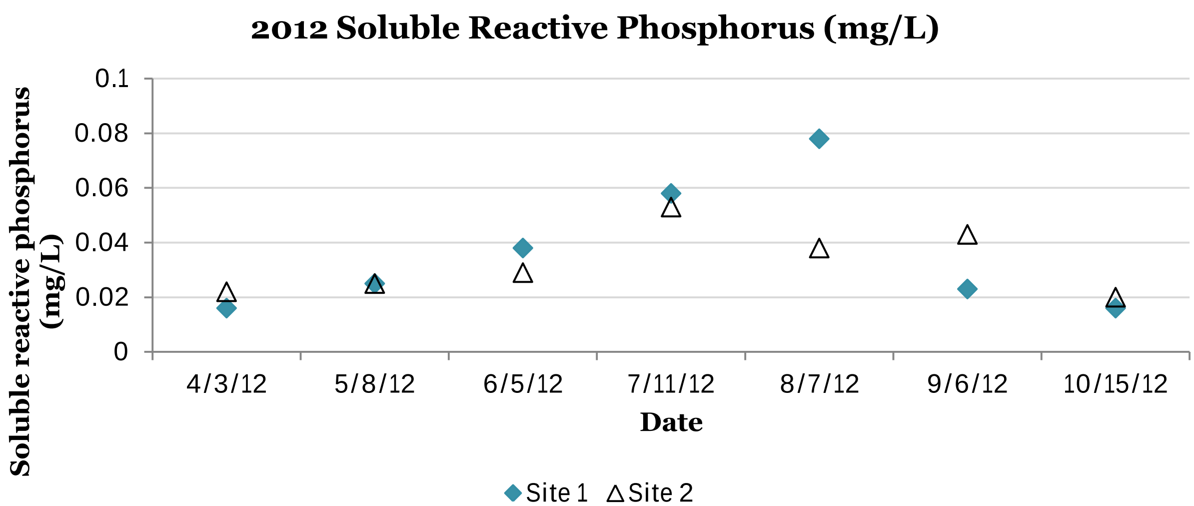
A substantial part of the available phosphorus in shallow lakes and reservoirs, such as the Apple River Flowage, is in the sediment. Release of phosphorus from the sediment into the water depends on the composition of the sediment and the concentration of the phosphorus in the water column; but varies strongly on the conditions at the sediment water interface (Scheffer, 1998) (Kaiserli, A., Voutsa, D., and Samara, C., 2002) (Gonsiorczyk, T., Casper, P., and Koschel, R., 1998).

Phosphorus in the sediments of lakes is often phosphorus precipitated with clays, aluminum, and iron compounds. Work on Wisconsin lake sediments and the Great Lakes, indicate that phosphorus in the sediments was predominately apatites (phosphate minerals), organic phosphorus, and orthophosphate bonded to iron compounds. However, as the oxygen content near the sediment declines there is a release of phosphorus, iron, and manganese to the water column (Wetzel, 2001).

The concentrations of phosphorus in the water tend to correlate well with the ratio between phosphorus and iron concentrations (P:Fe) in the sediment. It has been found where the P:Fe ratio is lower than 1: 10, the correlation with lake water becomes weak (Scheffer, 1998). The ratio in the north basin is approximately 1:36 while the ratio in the south basin is 1:18 indicating a strong correlation between the sediment phosphorus pool and the water column phosphorus concentration. The mobilization of recently deposited phosphorus seems to be the driving force of phosphorus release in eutrophic lakes and reservoirs (Gonsiorczyk, T., Casper, P., and Koschel, R., 1998). However, there is a limited amount of knowledge of the mechanisms behind internal loading in shallow waters (Sondergaard, M., Jensen, J.P., Jeppesen, E., 2001).

Water samples analyzed from the water column interface do indeed show an increase in phosphorus during the open water season (especially the north basin), indicating an internal release of phosphorus (sites were shallow enough that the entire water column was able to be sampled with a composite sampler).





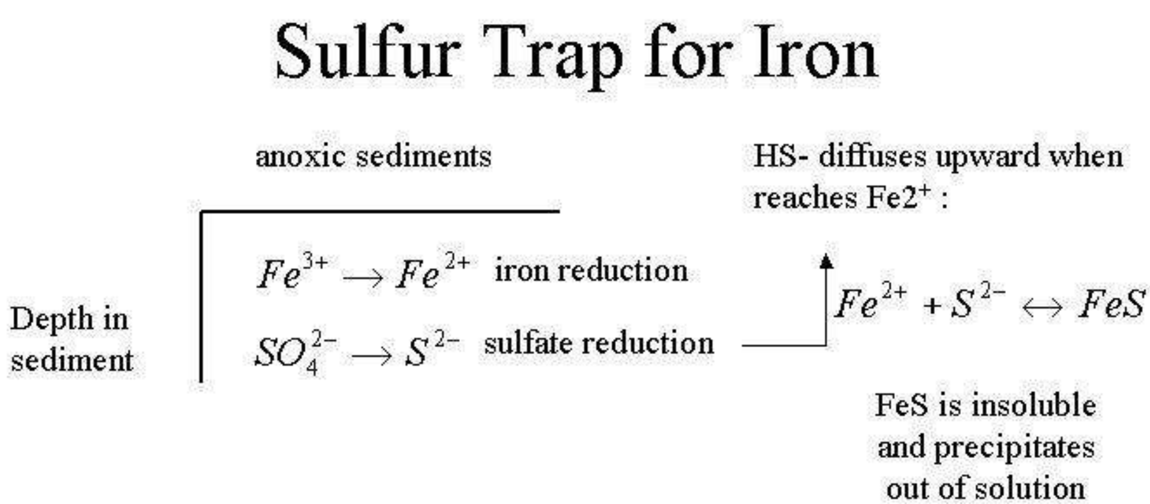
This internal phosphorus loading may delay the recovery of a lake once the external phosphorus loading sources are reduced; therefore it is important that the fraction of available phosphorus (iron and manganese bound) is evaluated for predicting internal phosphorus loading. The major factors controlling phosphorus release are dissolved oxygen, nitrates, sulfates, and pH (Kaiserli, A., Voutsa, D., and Samara, C., 2002). The University of Wisconsin Soil and Plant Analysis Lab uses the Bray-Kurtz method which analyzes plant available phosphorus, this fraction is considered to be the potentially mobile pool of phosphorus and is available to algae. However the residence time of the water in the Apple River Flowage is so short this should become less of a factor especially as native rooted aquatic macrophytes become more prevalent in the Apple River Flowage.

Concentrations of nutrient binding elements, such as iron, depend greatly on the redox potential of the sediment. A redox reaction is the flow of electrons between an oxidized and reduced state (for example iron moving from Fe^{3+} to Fe^{2+} and vice versa) the state of these elements is very important for the ability to bind to nutrients, particularly phosphorus.

There are many similarities in the behavior of iron and manganese, so they can be discussed together, although much more is known about the cycling of iron. There is also a very strong interaction between iron and sulfur. The fluxes of iron and magnesium reflect the variations in physical chemistry at the sediment water interface (Wetzel, 2001).

Iron is a very important micronutrient in aquatic systems. It is essential for aquatic organisms in many ways including: electron transport in oxidation-reduction systems of photosynthesis and respiration, it can be responsible for enzyme activation, and an oxygen carrier in nitrogen fixation.

Iron exists in solution in two different forms; either ferrous (Fe^{2+}) or ferric (Fe^{3+}). The amounts of iron in solution in lakes and the rate of oxidation of Fe^{2+} to Fe^{3+} in oxygenated water are dependent on pH, reduction potential, and temperature. Ferrous iron tends to be more soluble than ferric. Under anaerobic conditions with low redox potential, in productive lakes and reservoirs such as the flowage, bacteria often reduce sulfate to sulfide which decreases the concentration of Fe^{2+} through the formation of insoluble FeS (iron sulfide). This, iron sulfide formation can reduce the abundance of Fe compounds that can complex to phosphorus and promote release of phosphorus from the sediment (Wetzel, 2001). If enough FeS precipitates you can remove enough iron to get iron poor water making phosphorus more available for algae uptake. This is sometimes called the Sulfur Trap.



Iron bonds (complexes) with many organic compounds (e.g. detritus), which greatly alters its solubility and availability to organisms. Under anoxic conditions in the surface sediment and overlying water these complexes are reduced and phosphorus is released, with the release rate from sediments doubling g if the sediments are disturbed (though activities such as power boating for example) (Wetzel). Aquatic plants become especially important in productive waters such as the Apple River Flowage. Oxygen loss from the roots oxidized iron and the iron deposition can result in appreciable retention of iron and consequently phosphorus in the vegetated sediments (Wetzel, 2001) (Sondergaard, M., Jensen, J.P., Jeppesen, E., 2001).

Manganese is responsible for many cellular activities in organisms (i.e. electron transport reactions) and enzyme activation. Manganese (Mn) occurs in several states. Mn^{3+} is unstable under normal conditions in water and Mn^{4+} is insoluble at most pH values that would be found in natural lakes. As with ferrous iron, Mn^{2+} occurs at low redox potentials and pH. Manganese also reacts relatively rapidly with other anions and precipitates to the sediment. Unlike iron, whose concentrations can be controlled by precipitation of FeS, manganese is usually under-saturated so MnS (manganous sulfide) is usually not precipitated. Even so, MnS is much more soluble and formation of MnS has little effect on the Mn^{2+} concentrations (Wetzel, 2001).

Sulfur is utilized by all living organisms in both inorganic and organic forms. Sources of sulfur compounds to natural waters include solubilization from rock, fertilizers, precipitation, and dry deposition. Most (about 90%) of the total sulfur content in lake basins is found in the organic matter of mineral soil. Therefore much of the loading of sulfur compounds to lakes and reservoirs is in the form of sulfate and soluble organic sulfur compounds (Wetzel, 2001).

The cycling of sulfur entails the different sulfur chemical species under various conditions, the biotic influences, and sulfur transport within the lake or reservoir. The predominant form of sulfur in water is sulfate; nearly all assimilation of sulfur is as sulfate.

Sulfur that reacts with metals to form metal sulfides are extremely insoluble, so when Fe^{+2} is released from the sediment, it reacts vigorously with S to form FeS. Because the FeS is so insoluble the iron is not available to bind with phosphorus (Wetzel, 2001).

All data collected and modeling indicates that the internal loading component of the nutrient budget is present and could be significant. The senescence (dying back) of *Potamogeton crispus* (CLP) contributes, but likely the main release mechanism is the release of phosphorus bound to iron because of changes in redox potential at the sediment water interface due to shading by *Ceratophyllum demersum* (coontail) and a variety of duckweeds and sediment re-suspension.

Establishment of a robust, rooted aquatic macrophyte community could reduce the internal load if the macrophyte community extended deep enough. Radial oxygen loss from plant root tissues can maintain iron-bound phosphorus in the surrounding sediment. The epiphytic and epipelic algae associated within macrophyte stands utilize phosphorus from the water column, released from the sediment, and excreted by the macrophytes themselves. In addition, plants and algae that can use bicarbonate as a carbon source for photosynthesis can create free calcium ions (Ca) that can co-precipitate phosphorus with calcite. This can be an important self-cleaning mechanism in eutrophic lakes and reservoirs that can lead to the permanent burial of P within the sediments (Gonsiorczyk, T., Casper, P., and Koschel, R., 1998).

Because of the importance of the sediment phosphorus pool in almost all lakes and reservoirs further study of sediment release is warranted. *In situ* sediment release rates could be measured with benthic flux chambers over a series of years in several locations to accurately calculate actual phosphorus release from the sediment, this process can also be done in a lab using sediment cores. In addition, sediment cores should be considered. Species of phosphorus can be fractioned using sequential extractions (Engstrom, D.R., and Wright, H.E., 1984), and water column phosphorus can be reconstructed along with aquatic macrophyte community, soft algae (pigments), and chironomid (dissolved oxygen) reconstructions.

Land Use and Water Quality

Information summarized from: (D.D. MacDonald, C.G. Ingersoll, and T.A. Berger, 2000) and (Lynn Markham and Ross Dudzik, 2012).

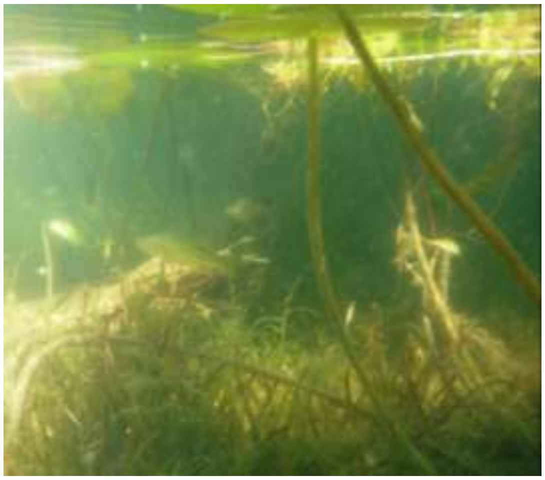
The health of our water resources depends largely on the decisions that landowners make on their properties. When waterfront lots are developed, a shift from native plants and trees to impervious surfaces and lawn often occurs. Impervious surfaces are defined as hard, man-made surfaces that make it impossible for rain to infiltrate into the ground. Examples of impervious surfaces include rooftops, paved driveways, and concrete patios.

By making it impossible for rainwater to infiltrate into the soil, impervious surfaces increase the amount of rainwater that washes over the soil surface and feeds directly into lakes and streams. This rainwater runoff can carry pollutants such as sediment, lawn fertilizers, and car oils directly into a lake. Native vegetation can slow the speed of rainwater, giving it time to soak into the soil where it is filtered by soil microbes. Median surface runoff estimates from wooded areas are an order of magnitude less than those from lawn areas.

In extreme precipitation events erosion and gullies can result, causing loss of property as soil is carried to the lake. The signs of erosion are unattractive and can cause decreases in property values. Additionally, sediment can have negative impacts on aquatic life. For example, fish eggs will die when covered with sediment, and sediment influxes to a lake can cause decreases in water clarity making it difficult for predator fish species to locate food.

Increases in impervious surfaces can also cause other negative impacts to fisheries. A study of 164 Wisconsin lakes conducted in 2008 found that the amount of impervious surfaces surrounding lakes can cause shifts in fisheries species assemblages. Certain species such as smallmouth and rock bass, blackchin and blacknose shiners, and mottled sculpin become less common with increasing amounts of impervious surfaces. Many of the smaller species affected are an essential food source for common game fish species such as walleye, northern pike, and smallmouth bass.

Increases in impervious surfaces and lawns cause a loss of habitat for birds and other wildlife. Over ninety percent of all lake life is born, raised, and fed in the area where land and water meet. Overdeveloped shorelines remove critical habitat which species such as loons, frogs, songbirds, ducks, otters, and mink depend on. Impervious surfaces and lawns can be thought of as biological desserts which lack food and shelter for birds and wildlife. Additionally, nuisance species such as Canada geese favor lawns over taller native grasses and flowers. Lawns provide geese with a ready food source (grass) and a sense of security from predators (open views).



Additionally, fish species depend on the area where land and water meet for spawning. The removal of coarse woody habitat, or trees and braches that fall into a lake, causes decreases in fisheries habitat.

Lawns in and of themselves are not particularly harmful and can provide an area for families to recreate. However, problems arise when lawns are not properly maintained, over-fertilized, located in areas important to wildlife habitat, or located on steep slopes.

Common lawn species, such as Kentucky bluegrass, are often dependent on chemical fertilizers and require mowing. Excess chemical fertilizers are washed directly into the adjacent water during precipitation events. The phosphorus and other nutrients in fertilizers, which produce lush vegetative growth on land, are the same nutrients which fuel algae blooms and decrease water clarity in a lake. Additionally, since common lawn species have very shallow root systems, when lawns are located on steep slopes, the impacts of erosion can be intensified.

Avoiding establishing lawns on steep slopes and at the water land-interface can provide direct positive impacts on lake water quality. The creation of a buffer zone of native grasses, wildflowers, shrubs, and trees where the land meets the water can provide numerous benefits for water quality and restore valuable bird and wildlife habitat.

In Polk County, all new constructions on lakeshore properties require that a shoreland protection area be in place. A shoreland protection area is required to be 35 feet in depth as measured from the ordinary high water mark, which is defined as the point on the bank or shore up to which the water leaves a distinct mark (erosion, change in vegetation, etc.).

These rules are in place largely to protect water quality and also provide benefits in terms of natural beauty, and bird and wildlife viewing opportunities. Additionally, shoreline protection areas allow for a 30 foot maximum viewing corridor (or 30% of the width of the lot, whichever is less), which can be established as lawn (Polk County, Wisconsin Shoreland Property Owner Handbook A Guide to the Polk County Shoreland Protection Zoning Ordinance in Developing and Caring for Waterfront Property, October 2002) and (Polk County Shoreland Protection Zoning Ordinance, Effective April 1, 2010).

Shoreline Inventory

On Monday, September 10th five resident volunteers were trained by Polk County Land and Water Resources Department staff to conduct a shoreline inventory for the Apple River Flowage. The shoreline inventory followed the protocol first developed for Bone Lake by Harmony Environmental (Harmony Environmental, Polk County Land and Water Resources Department, and Ecological Integrity Services, 2009).

Prior to the inventory, the linear feet of shoreline and the area of the shoreline buffer at each parcel were estimated using the Polk County Interactive GIS Map available online at: http://polkcowi.wgxtreme.com/.

Land use for each parcel was categorized for the shoreline (linear feet at the ordinary high water mark) and for the shoreline buffer area (area upland thirty-five feet from the ordinary high water mark). Additionally, the presence or absence of coarse woody habitat was determined at each parcel.

The shoreline (linear feet) was categorized as:

- ✓ Rip rap
- ✓ Structure
- ✓ Lawn
- ✓ Sand
- ✓ Natural

The shoreline buffer area (square feet) was categorized as:

- ✓ Hard surface
- ✓ Landscaping
- ✓ Lawn
- ✓ Bare soil
- ✓ Natural

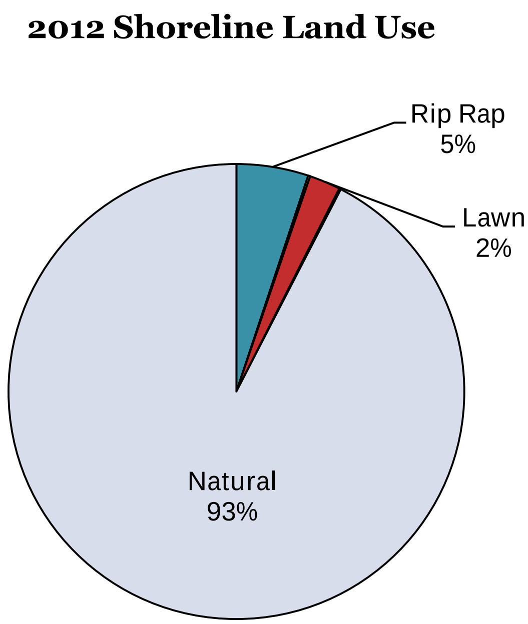
A total of 19.42 linear miles of shoreline and 0.13 square miles of buffer areas were categorized by volunteers beginning on September 10th through September 21st, 2012.

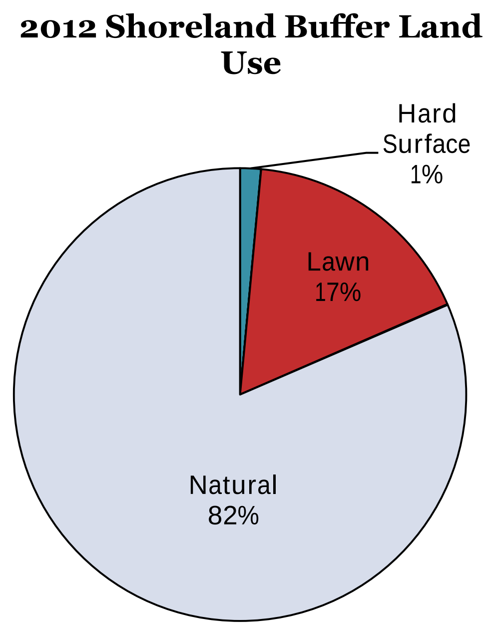
A characterization of the Apple River Flowage shoreline (linear area directly adjacent to the water) shows that the greatest land use is natural (93%), followed by rip rap (5%), lawn (2%), structure (0.15%), and sand (0.12%).

A characterization of the Apple River Flowage shoreline buffer area (area 35 feet upwards from the water) shows that the greatest land use is natural (82%), followed by lawn (17%), hard surface (1%), bare soil (0.05%) and landscaping (0.01%).

In comparison to the shoreline inventory, the shoreline buffer inventory showed a greater proportion of lawn. The large amount of natural area preserved along the shoreline and within the buffer area should be maintained for the extensive water quality benefits these areas provide.

Coarse woody habitat was present at 107 parcels on the Apple River Flowage.


2012 Shoreline Land Use
Rip Rap
5%
Lawn
2%
Natural
93%


2012 Shoreland Buffer Land Use
Hard Surface
1%
Lawn
17%
Natural
82%

Tributaries

Data was collected on six of the tributaries of the Apple River Flowage: Beaver Brook (two sites, east and west), Beaver Brook Inlet, Fox Creek, Apple River Inlet, and Apple River Outlet. Fox Creek ultimately enters the flowage through the Apple River Inlet; and Beaver Brook east and west ultimately enter the flowage through the Beaver Brook Inlet.

Flow data was collected bi-weekly at each tributary with a March McBirney Flo-Mate ™ velocity flowmeter. At each foot interval across each of the tributaries, depth (ft) and velocity (m/s) were measured. Grab samples were collected once monthly on each tributary. Samples were analyzed at WEAL for total suspended solids, nitrate/nitrite, ammonium, total Kjeldahl nitrogen, total phosphorus, soluble reactive phosphorus, and chloride.

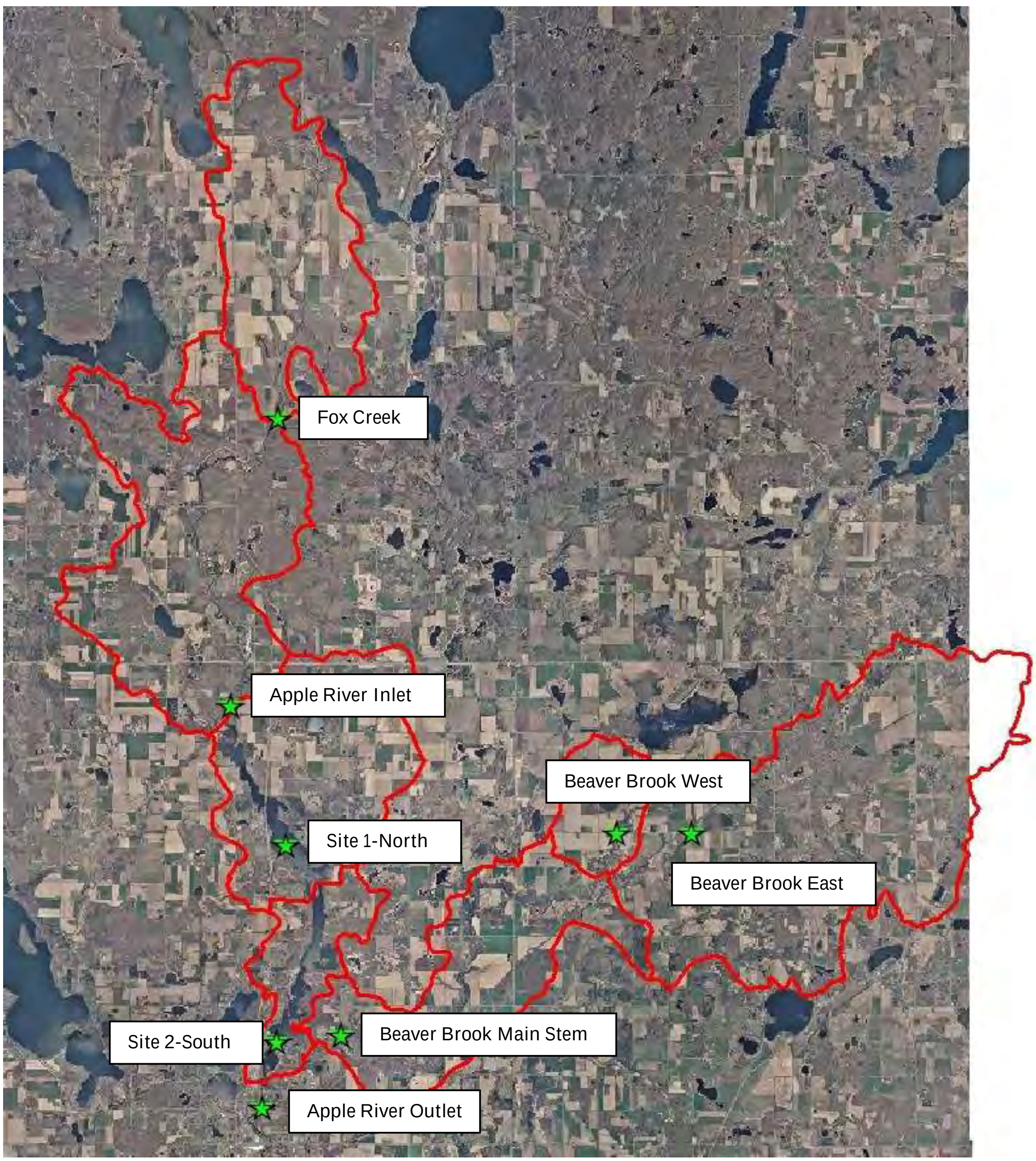
The phosphorus data collected is specific to date and location and can be used to theoretically determine how much phosphorus is entering the flowage through tributaries. Values for phosphorus influxes are established by multiplying the phosphorus concentration at a specific location by the volume of water that moves through a specific location, or the discharge in cubic feet per second. To determine the average instantaneous load of phosphorus (in mg/s), the average phosphorus concentration is multiplied by the average seasonal discharge. Units are then converted and expressed as lb/yr.

The analysis of this data allows for areas of highest phosphorus loading to be identified. Once areas of highest phosphorus loading are identified, the land use and geology of these areas can be investigated for their total phosphorus contribution and best management recommendations can be made.

The Apple River Inlet is contributing the greatest amount of phosphorus to the Apple River Flowage (8,442 pounds on an annual basis). The Beaver Brook Inlet is contributing 2,580 pounds of phosphorus on an annual basis. Phosphorus leaving the Apple River Flowage via the Outlet totals 16,162 pounds on an annual basis.

Total phosphorus concentrations were elevated on the East branch of the Beaver Brook Inlet (0.2472 mg/L).

Site	Total Phosphorus (mg/L)	Discharge (L/s)	Instantaneous Load (mg/s)	Annual Load (lb/yr)
Fox Creek	0.0518	974.610	50.485	3,512.284
Apple River Inlet	0.0648	1,872.570	121.343	8,441.935
Apple River Outlet	0.0636	3,652.740	232.314	16,162.362
Beaver Brook Main Stem	0.0836	443.520	37.078	2,579.577
Beaver Brook West	0.0586	125.496	7.354	511.631
Beaver Brook East	0.2472	60.048	14.844	1,032.704



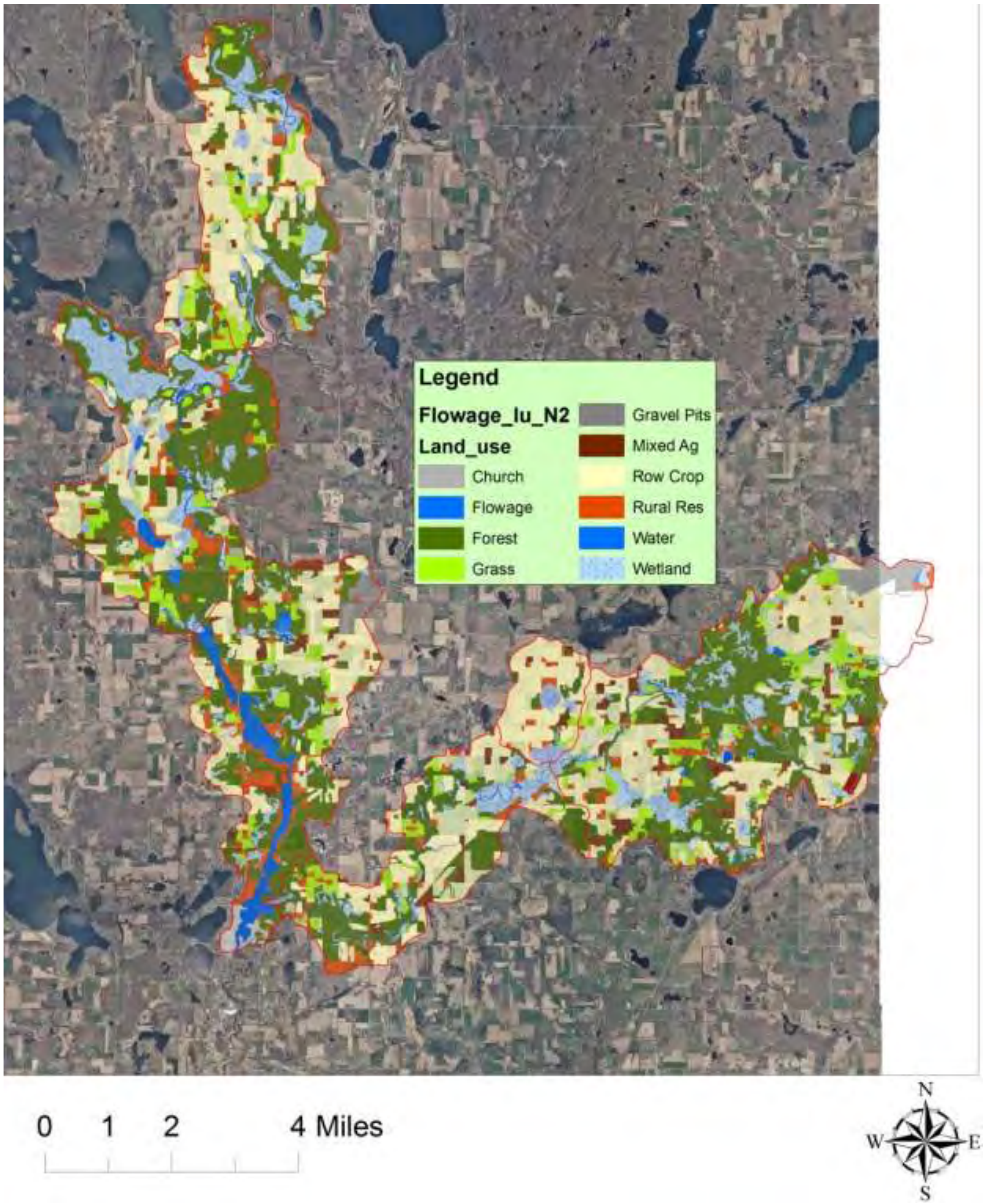
Land Use and Nutrient Loading in the Apple River Flowage Watershed

The area of land that drains towards a lake is called a watershed. Since the Apple River Flowage Watershed is so extensive in size and drains from many area lakes and rivers, a management area was established for the Apple River Flowage. Areas of land already included in lake management areas for other Polk County lakes (ie. Bone Lake, Balsam Lake, Blake Lake, White Ash Lake, etc.) were excluded from the management area.

The resulting management area is 37,125 acres in size. The largest land uses in the management area are row crop (32%) and forest (31%), with row crop contributing the greatest phosphorus load to the Flowage (74%).

The Wisconsin Lakes Modeling Suite (WiLMS) was used to model current conditions for the Apple River Flowage, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algae growth in most waterbodies.

Land Use	Total Acres	Percent Acres	Total Load (lb P/year)	Percent Load (lb P/year)
Flowage	633	2%	169	1%
Forest	11594	31%	926	7%
Grass	1182	3%	315	2%
Gravel Pits	242	1%	0	0%
Mixed Ag	1139	3%	810	6%
Pasture/Grass	1766	5%	471	3%
Row Crop	11718	32%	10430	74%
Rural Residential	2472	7%	220	2%
Wastewater treatment	37	0%	15	0%
Water	502	1%	121	1%
Wetland	4802	13%	429	3%
Unmapped	503	1%	0	0%
City/Village	494	1%	260	2%
Miscellaneous	40	0%	18	0%


Legend
Flowage_lu_N2
Land_use
Church
Flowage
Forest
Grass
Gravel Pits
Mixed Ag
Row Crop
Rural Res
Water
Wetland
0 1 2 4 Miles
N
W
E
S

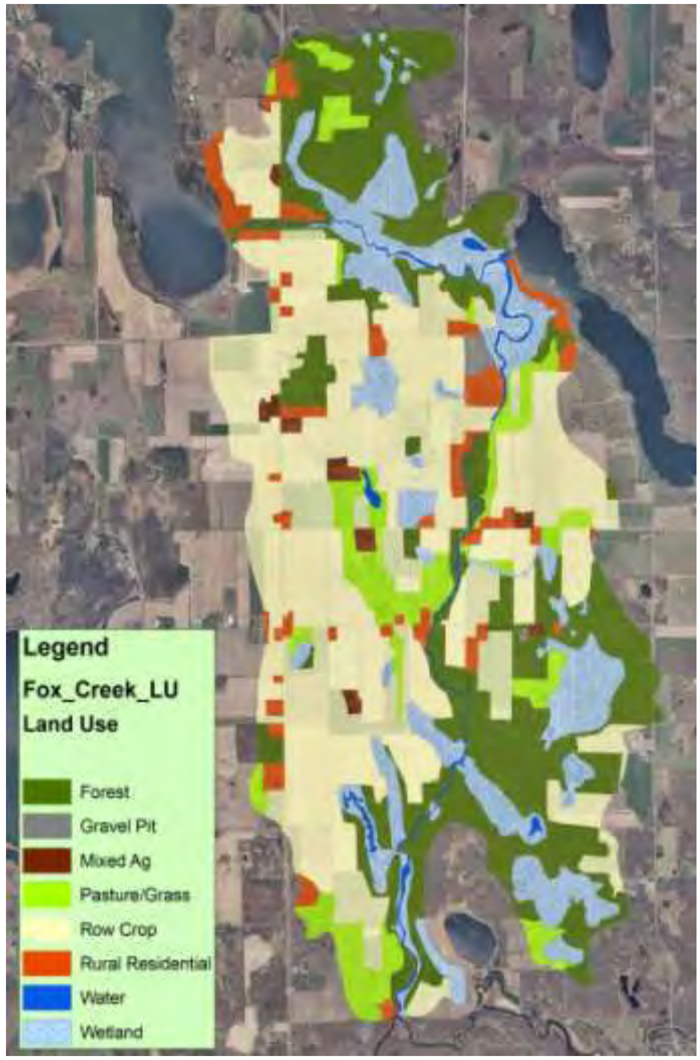
Land Use and Nutrient Loading in the Apple River Flowage Subwatersheds

Fox Creek Subwatershed

The Fox Creek Subwatershed is 5,136 acres in size.

The largest land use in the Fox Creek Watershed is row crop (42%) followed by forest (26%).

The largest contributor of phosphorus is row crop (84%).



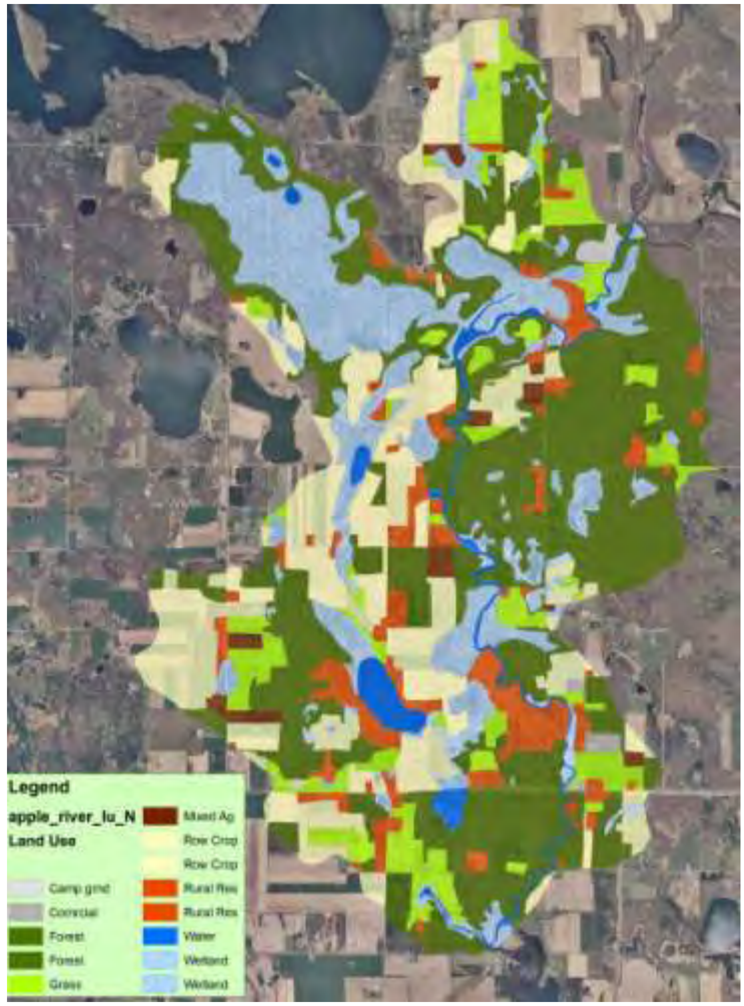
Land Use	Total Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
Forest	1356	26%	108	5%
Gravel Pit	17	0%	0	0%
Mixed Ag	54	1%	37	2%
Pasture/Grass	425	8%	114	5%
Row Crop	2175	42%	1936	84%
Rural Residential	270	5%	24	1%
Water	66	1%	18	1%
Wetland	773	15%	68	3%

Apple River Flowage Inlet Subwatershed

The Apple River Flowage Inlet Watershed is 7,965 acres in size.

The largest land use in the Apple River Flowage Inlet Subwatershed is forest (40%), followed by row crop (20%), and wetland (19%).

The largest contributor of phosphorus is row crop (63%).



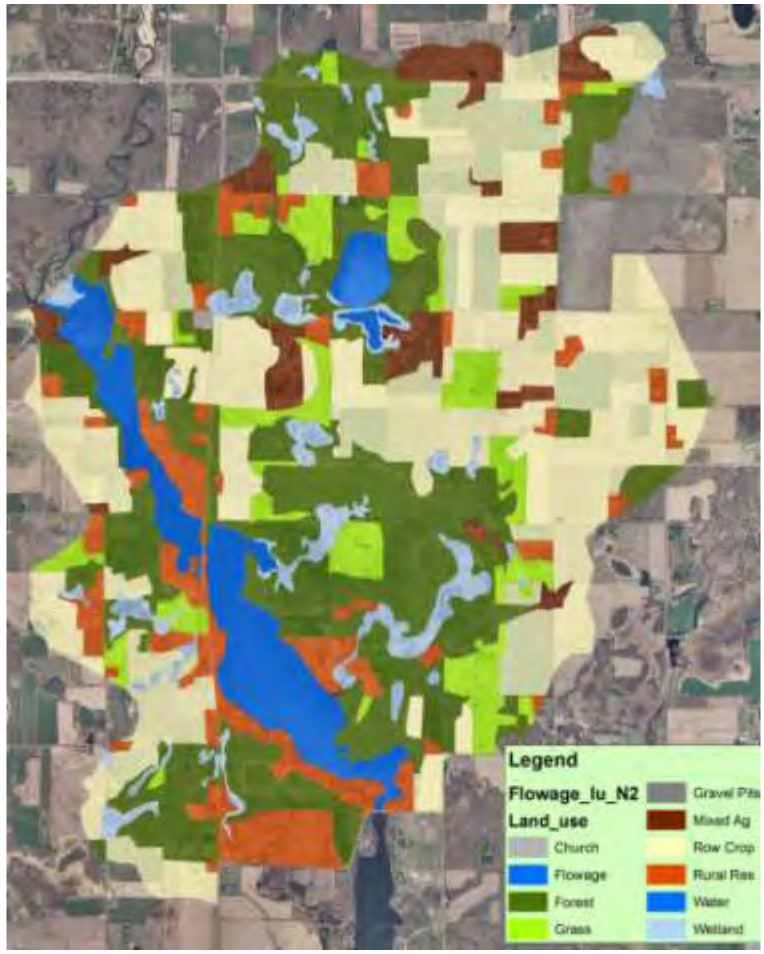
Land Use	Total Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
Campground	26	0%	11	0%
Commercial	27	0%	37	2%
Forest	3175	40%	255	11%
Grass	725	9%	194	9%
Mixed Ag	110	1%	79	4%
Row Crop	1584	20%	1410	63%
Rural Residential	595	7%	53	2%
Water	215	3%	57	3%
Wetland	1508	19%	134	6%

Site 1 North Subwatershed

The Site 1 North Subwatershed is 5130 acres in size.

The largest land use in the Site 1 North Subwatershed is row crop (33%), followed by forest (28%).

The largest contributor of phosphorus is row crop (74%).



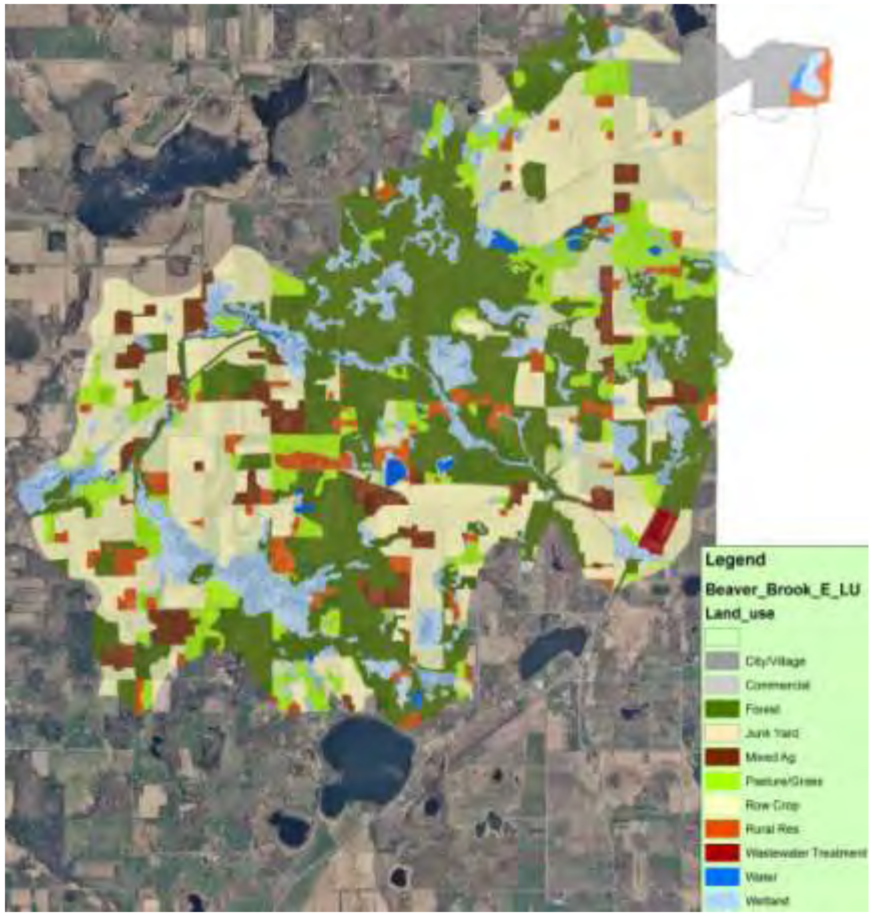
Land Use	Total Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
Church	4	0%	2	0%
Flowage	334	7%	90	4%
Forest	1439	28%	114	6%
Grass	364	7%	97	5%
Gravel Pits	225	4%	0	0%
Mixed Ag	254	5%	180	9%
Row Crop	1718	33%	1529	74%
Rural Residential	476	9%	42	2%
Water	53	1%	0	0%
Wetland	261	5%	24	1%

Beaver Brook East Subwatershed

The Beaver Brook East Subwatershed is 11,134 acres in size.

The largest land uses in the Beaver Brook East Subwatershed are forest (30%) and row crop (30%).

The largest contributor of phosphorus is row crop (70%).



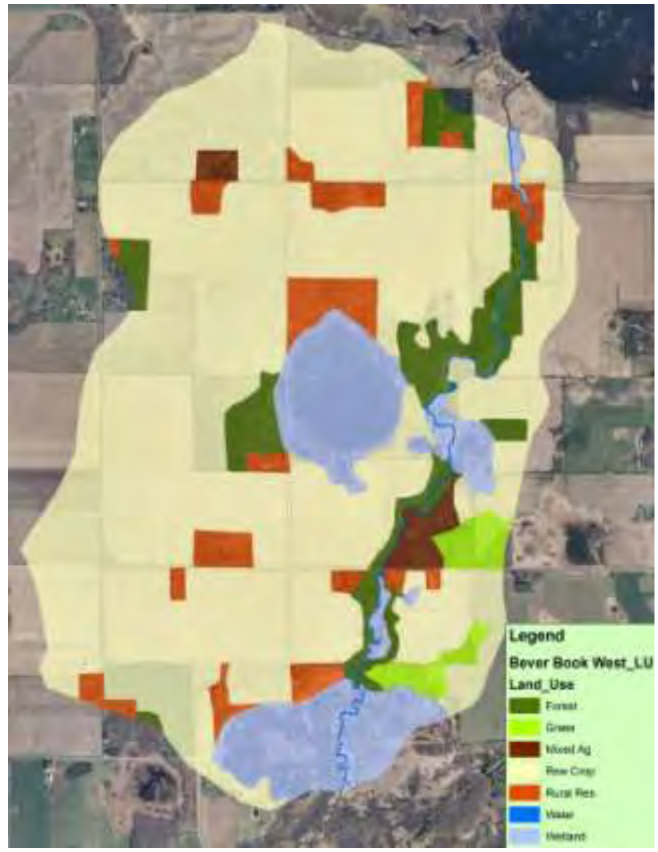
Land Use	Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
Unmapped	503	5%	0	0%
City/Village	308	3%	136	3%
Commercial	15	0%	20	0%
Forest	3351	30%	268	6%
Junk Yard	6	0%	2	0%
Mixed Ag	526	5%	374	9%
Pasture/Grass	1016	9%	271	6%
Row Crop	3395	30%	3023	70%
Rural Residential	453	4%	40	1%
Wastewater Treatment	37	0%	15	0%
Water	98	1%	26	1%
Wetland	1427	13%	128	3%

Beaver Brook West Subwatershed

The Beaver Brook West Subwatershed is 1,345 acres in size.

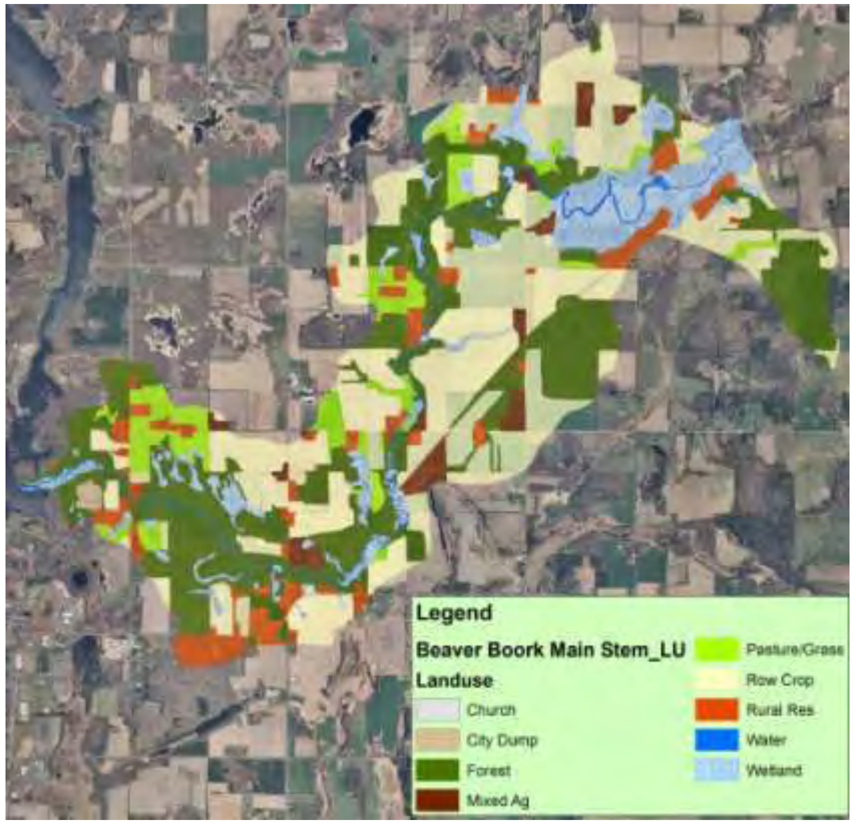
The largest land use in the Beaver Brook West Subwatershed is row crop (70%).

The largest contributor of phosphorus is row crop (94%).



Land Use	Total Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
Forest	93	7%	7	1%
Grass	28	2%	7	1%
Mixed Ag	21	2%	15	2%
Row Crop	936	70%	834	94%
Rural Res	89	7%	9	1%
Water	8	1%	2	0%
Wetland	171	13%	15	2%

Beaver Brook Main Stem Subwatershed



The Beaver Brook Main Stem Subwatershed is 4,630 acres in size.

The largest land use in the Beaver Brook Main Stem Subwatershed is row crop (37%), followed by forest (32%).

The largest contributor of phosphorus is row crop (79%).

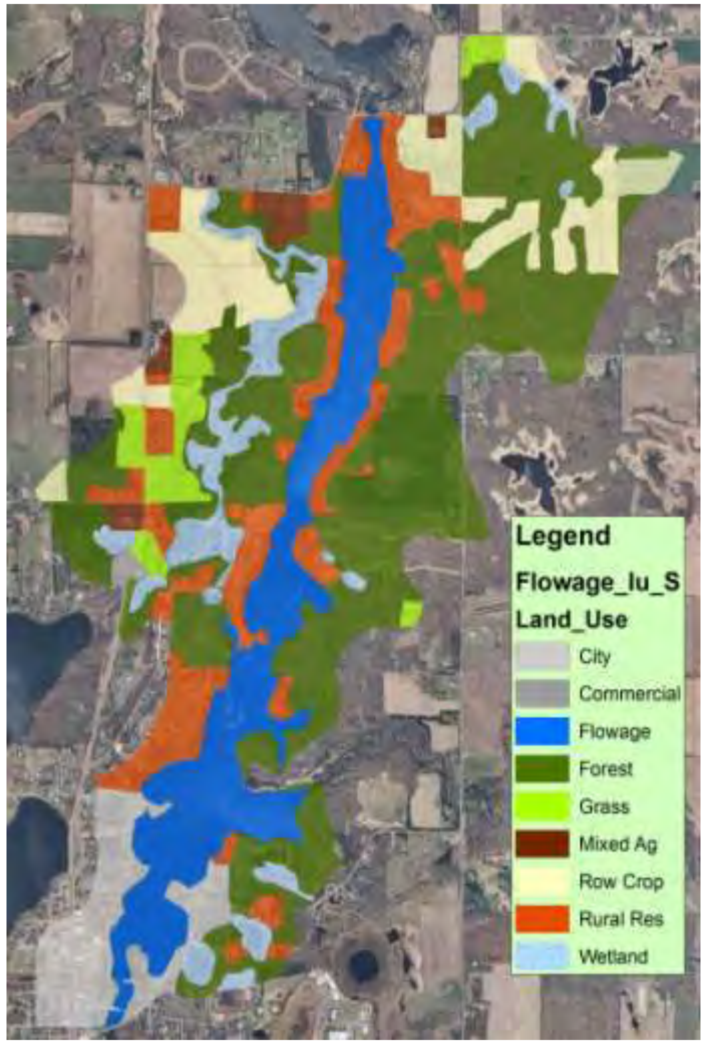
Land Use	Total Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
Church	4	0%	2	0%
City Dump	16	0%	2	0%
Forest	1461	32%	117	6%
Mixed Ag	145	3%	103	5%
Pasture/Grass	325	7%	86	4%
Row Crop	1730	37%	1540	79%
Rural Residential	348	8%	31	2%
Water	62	1%	18	1%
Wetland	538	12%	48	2%

Site 2 South Subwatershed

The Site 2 South Subwatershed is 1,785 acres in size.

The largest land use in the Site 2 South Subwatershed is forest (40%), followed by the flowage itself (17%), and rural residential (14%).

The largest contributor of phosphorus is row crop (37%), followed by the flowage itself (18%), the city of Amery (13%), and forest (13%).

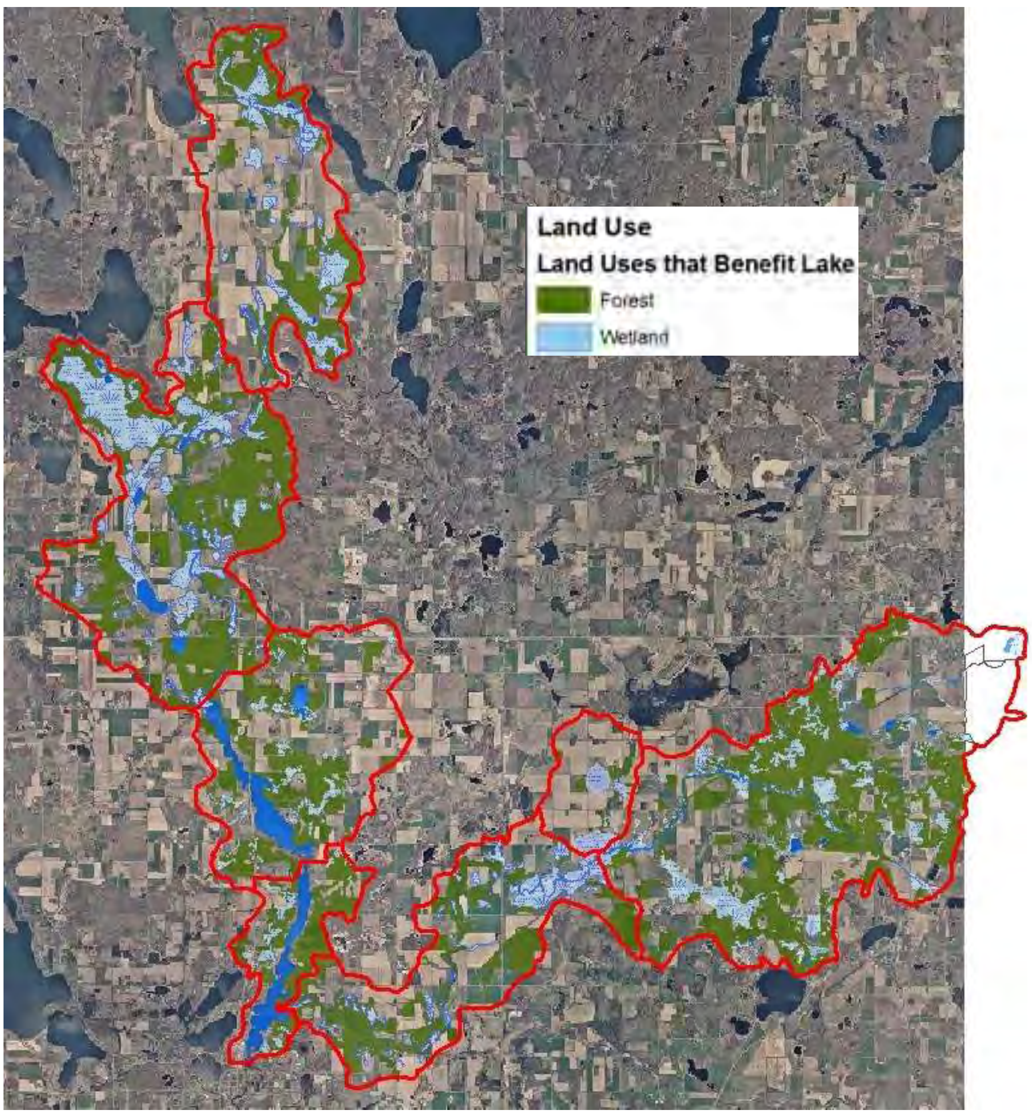


Land Use	Total Acres	Percent Acres	Total loading (lb P/year)	Percent Loading (lb P/year)
City	122	7%	55	13%
Commercial	6	0%	9	2%
Flowage	299	17%	79	18%
Forest	719	40%	57	13%
Grass	65	4%	18	4%
Mixed Ag	29	2%	20	5%
Row Crop	178	10%	158	37%
Rural Residential	242	14%	22	5%
Wetland	124	7%	11	3%

Areas Providing Water Quality Benefits to the Apple River Flowage

Natural areas such as forests and wetlands allow for more infiltration of precipitation when compared with row cropped fields and developed residential sites containing lawns, rooftops, sidewalks, and driveways. This occurs because dense vegetation lessens the impact of raindrops on the soil surface, thereby reducing erosion and allowing for greater infiltration of water. Additionally, wetlands provide extensive benefits through their ability to filter nutrients and allow sediments to settle out before reaching lakes and rivers.

Forests make up the second largest land use in the Apple River Flowage Watershed Management Area (31%) and wetlands make up the third largest land use (13%). The wetlands and forests of the Apple River Flowage Watershed Management Area should be considered sensitive areas and preserved for the benefits they provide to the flowage.



Watershed and Reservoir Modeling

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions and nutrient reductions for the north and south basins of the Apple River Flowage, verify monitoring, and estimate in-lake nutrient loading. Phosphorous is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes and reservoirs.

Based on average evaporation, precipitation, and runoff coefficients for Polk County soils and land use, the annual non-point source load was calculated to be 5,443.6 pounds of phosphorous for north basin. The measured load from Fox Creek and the Apple River entering the north basin was 8441.9 pounds of phosphorus or 80.1% of the external load. For the south basin the non-point source load was calculated to be 821.0 pounds of phosphorus per year and the outflow of the north basin into the south basin was calculated to be 7,712 pounds of phosphorus or 71.9% of the load. The measured load from Beaver Brook entering the south basin was 2,574.0 pounds of phosphorus per year.

Sub-watersheds were also modeled to estimate the total loading per acre as was reported in the Land Use and Nutrient Loading in the Apple River Flowage Subwatersheds section of this report.

Because the Apple River Flowage is a large, flowing system methods employed to model the internal loading from bottom sediments did not prove useful. The areal phosphorus loading was manipulated to come close to an actual number for the impact internal loading has on the Apple River Flowage. Areal loading is the amount of phosphorus entering the lake in milligrams per meter squared of lake surface area per year. Doing this, the north basin was calculated to have an internal load of 2,637 pounds of phosphorus per year; while the south basin was calculated to have an internal load of 2,690 pounds of phosphorus per year. Both of those calculations amount to about 25% of the total load which is reasonable for a system such as the flowage. Consideration of additional studies quantifying internal loading from bottom sediment is strongly encouraged.

The Nurnberg total phosphorus model takes internal loading into account:

$$\left(P = \frac{L_{Ext}}{q_s}(1-R) + \frac{L_{Int}}{q_s};\ \text{where } R = \frac{15}{18+q_s}\right)$$ [2]

This model predicts that the mixed lake total phosphorus concentration would be 59 µg/l in the north basin and 52 µg/l in the south basin. These estimates are low compared to the actual measured total phosphorus in both basins. There are obvious ecological and biogeochemical processes that affect measurable nutrient levels in lakes (such as sediment

[2] P is the predicted mixed lake total phosphorus concentration, L_{ext} is external areal loading, L_{int} is areal internal loading, qs is areal water loading or surface overflow rate, z is the lakes mean depth, and R is the Fraction of inflow total phosphorus retained in the lake.

REDOX potential) that simply can't be modeled and need to be measured and studied before assumptions can be made about the impact of sediments and internal loading on the nutrient cycle.

The model that was used to more accurately estimate the mixed lake water column total phosphorus concentration was the Canfield-Bachmann 1981 Artificial Lake Model which is calculated by:

$$P = \frac{0.8L}{z(0.0942L/z)^{0.639}+p}.$$ [3]

The model was calibrated with available data for both the north and south basins.

The model estimated the north basin water column total phosphorus concentration as 74.74 µg/l, which was close to the actual annual measured average of 78.8 µg/l. A 15% reduction in the external areal load to the basin reduces phosphorus to 68.26 µg/l, a 25% reduction reduces phosphorus to 63.72 µg/l, a 32% reduction reduces phosphorus to 60.42 µg/l, and a 40% reduction reduces phosphorus to 56.54 µg/l.

The model also estimated the south basin water column total phosphorus concentration to be 74.74 µg/l, which also close to the actual annual measured average of 80.0 µg/l. A 15% reduction in the external areal load to the lake reduces phosphorus to 68.60 µg/l, a 25%% reduction reduces phosphorus to 64.72 µg/l, a 32% reduction reduces phosphorus to 61.77 µg/l, and a 40% reduction reduces phosphorus to 58.31 µg/l.

Using the available in situ and modeled data it is possible to predict reductions in chlorophyll a concentrations and total primary productivity within the water column by using the equation

$$\left[\overline{chl.a}\right] = 0.55\{[P]_i/(1+\sqrt{T_w}\}^{0.76}$$

for estimating the annual average chlorophyll a concentrations and

$$\sum C(gm^{-2}yr^{-1}) = \left[\frac{\{[P]_i/(1+\sqrt{T_w}\}^{0.76}}{0.3+0.011\{[P]_i/(1+\sqrt{T_w}\}^{0.76}}\right]$$ [4]

to correlate the relationship of total primary productivity with chlorophyll a. This equation is based on average chlorophyll concentrations and light extinction resulting from turbidity and dissolved organic substances (Wetzel, 2001).

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[3] P is the predicted mixed lake total phosphorus concentration, L is areal loading, z is the lakes mean depth, and p is the lakes flushing rate.

[4] $\left[\overline{chl.a}\right]$ is the average annual concentration of chlorophyll a, $[P]_i$ is the average inflow concentration of total phosphorus, T_w is the lake hydraulic retention time, and $\sum C(gm^{-2}yr^{-1})$ is the sum of grams of carbon per meter squared of lake area per year produced during photosynthesis.

Using these equations it was predicted that the north basin would have an annual chlorophyll *a* concentration of 46.24 µg/l under current conditions, 40.87 µg/l with a 15% external load reduction, 37.16 µg/l with a 25% reduction, 34.49 µg/l with a 32% reduction, and 31.36 µg/l with a 40% reduction. All numbers are much higher than the 6.4 µg/l average measured in 2012; however, the model does predict a decline in chlorophyll *a* at all levels watershed nutrient reduction.

Similar results were found in primary productivity with the model predicting 462.91 C ($gm^{-2}yr^{-1}$) under current conditions, 446.99 C ($gm^{-2}yr^{-1}$) with a 15% reduction, 434.11 C ($gm^{-2}yr^{-1}$) with a 25% reduction, 423.69 C ($gm^{-2}yr^{-1}$) with a 32% reduction and 410.02 C ($gm^{-2}yr^{-1}$) with a 40% reduction in phosphorus.

The same equations showed that under current conditions the south basin would have an annual chlorophyll a concentration of 56.13 µg/l under current conditions. With a 15% external load reduction the south basin would have a chlorophyll concentration of 49.61 µg/l, 45.11 µg/l with a 25% external load reduction, 41.87 µg/l with a 32% reduction, and 38.07 µg/l with a 40% reduction. These values are still higher than the 15.5 µg/l measured in 2012, but still show a 12% reduction in chlorophyll *a* even at the lowest reduction level.

Total primary productivity went from 486.35 C ($gm^{-2}yr^{-1}$) under current conditions to 471.73 C ($gm^{-2}yr^{-1}$) with a 15% reduction, 459.85 C ($gm^{-2}yr^{-1}$) with a 25% reduction, 450.20 C ($gm^{-2}yr^{-1}$) with a 32% reduction and 437.43 C ($gm^{-2}yr^{-1}$) with a 40% reduction in phosphorus.

Models are generally an over simplification of natural phenomenon; however, they can be useful to guide lake and reservoir management because they can be used to predict many different scenarios. The models employed do show reductions in water column total phosphorus concentrations, chlorophyll *a* concentrations, and total primary productivity.

However, to enhance current understanding of these lakes' ecosystems and guide future management decisions a clear understanding of the Apple River Flowage current and past ecosystem functions needs to be achieved. Current aquatic macrophyte surveys should be coupled with continuous water column monitoring. Additionally, a detailed study of in situ sediment nutrient release and REDOX conditions should be seriously considered to adequately quantify internal loading and paleolimnological techniques should be employed to understand past water quality and ecosystem change and refine goals as needed.

Nutrient Budget Summary: Apple River North Basin

Modeling was used to estimate an annual phosphorus budget for both the North and South Basins of the Apple River Flowage for external (watershed) and internal (in-lake) sources of phosphorus.

Non-point source load estimated from WiLMS: 6,614 pounds phosphorus/year

Divided by land use:

- ✓ Row crop: 4,875 pounds
- ✓ Forest: 477 pounds
- ✓ Mixed agriculture: 297 pounds
- ✓ Grass: 290 pounds
- ✓ Wetland: 227 pounds
- ✓ Rural residential: 119 pounds
- ✓ Pasture/grass: 114 pounds
- ✓ Precipitation to flowage surface: 90 pounds
- ✓ Water: 75 pounds
- ✓ Commercial: 37 pounds
- ✓ Campground: 11 pounds
- ✓ Church: 2 pounds

Tributary load calculated using field collected phosphorus data: 8,442 pounds phosphorus/year

- ✓ Fox Creek: 3,512 pounds
- ✓ Apple River Inlet: 8,442 pounds

Internal load (load from sediments/dead or decaying matter): 2,637 pounds phosphorus/year

Modeling was used to predict changes in water quality that would result from a 15%, 25%, 32%, and 40% reduction in external sources of phosphorus to the North Basin.

Modeling predicts that current water column phosphorus (with no reductions in internal or external loading) would be 0.07474 mg/L with a TSI(Phosphorus) of 66.3, which is close to the actual measured growing season average of 0.07888 mg/L with a TSI(Phosphorus) of 67.1.

Water column and TSI Phosphorus were estimated for each reduction.

Reduction	Water column phosphorus (mg/L)	TSI (Phosphorus)
15%	0.06826	65.0
25%	0.06372	64.0
32%	0.06042	63.3
40%	0.05654	62.3
80%	0.03990	57.3

Nutrient Budget Summary: Apple River South Basin

Modeling was used to estimate an annual phosphorus budget for both the North and South Basins of the Apple River Flowage for external (watershed) and internal (in-lake) sources of phosphorus.

Non-point source load estimated from WiLMS: <u>7,567 pounds phosphorus/year</u>

Divided by land use:

- ✓ Row crop: 5,555 pounds
- ✓ Mixed agriculture: 513 pounds
- ✓ Forest: 449 pounds
- ✓ Pasture/grass: 356 pounds
- ✓ Wetland: 202 pounds
- ✓ City/Village: 193 pounds
- ✓ Rural residential: 101 pounds
- ✓ Precipitation to flowage surface: 79 pounds
- ✓ Water: 46 pounds
- ✓ Commercial: 29 pounds
- ✓ Grass: 24 pounds
- ✓ Wastewater: 15 pounds
- ✓ Church: 2 pounds
- ✓ Junk yard: 2 pounds

Tributary load calculated using field collected phosphorus data: <u>2,580 pounds phosphorus/year</u>

- ✓ Beaver Brook Main Stem: 2,580 pounds
- ✓ Beaver Brook West: 512 pounds
- ✓ Beaver Brook East: 1,033 pounds

Internal load (load from sediments/dead or decaying matter): <u>2,690 pounds phosphorus/year</u>

Point source load from North Basin: <u>7,712 pounds phosphorus/year</u>

Tributary load leaving the South Basin using field collected phosphorus data: <u>16,162 pounds phosphorus/year</u>

Modeling was used to predict changes in water quality that would result from a 15%, 25%, 32%, and 40% reduction in external sources of phosphorus to the South Basin.

Modeling predicts that current water column phosphorus (with no reductions in internal or external loading) would be 0.07474 mg/L with a TSI(Phosphorus) of 66.3, which is close to the actual measured growing season average of 0.0800 mg/L with a TSI(Phosphorus) of 67.3.

Water column and TSI Phosphorus were estimated for each reduction.

Reduction	Water column phosphorus (mg/L)	TSI (Phosphorus)
15%	0.06860	65.1
25%	0.06472	64.2
32%	0.06177	63.6
40%	0.05831	62.7
75%	0.03988	57.3

Pontoon Classrooms

On September 12th, 2012 a pontoon classroom was held for members of the Apple River Flowage Protection and Rehabilitation District. The classroom was attended by five members.

At the pontoon classrooms, participants were given the chance to collect physical and chemical data, zooplankton samples, and algae samples. Data was explained and participants had the opportunity to see zooplankton and filter chlorophyll *a* samples. Plants were collected with a rake and shown to participants during a conversation regarding the benefits of aquatic plants and how to identify invasive species. Participants were given the chance to ask any questions they had regarding water quality. Tributary sampling was also discussed.

The pontoon classroom was promoted through the District newsletter and District Annual Meeting.

Shoreline Restoration Workshop

On October 10th, 2013 a shoreline restoration workshop was held for members of the Apple River Flowage Protection and Rehabilitation District at the Amery Public Library. The workshop began at 1 pm and lasted until 2:30 pm. Eight attendees gained valuable information regarding shoreline restoration, rain gardens, and additional options for managing erosion. Attendees were also offered numerous educational handouts including native plant lists for Polk County, rain garden designs, and grids to design their own project. Four additional residents were unable to attend the workshop. Materials were sent to these residents through email. Additionally, one resident requested a site visit which was provided by LWRD staff.

The workshop was promoted at the District Annual Meeting and through the sociological survey. Those expressing interest were sent an event postcard prior to the workshop.

Polk County Ordinances

Comprehensive Land Use Planning

The Polk County Comprehensive Land Use Plan was adopted in 2009. The plan includes an analysis of population, economy, housing, transportation, recreation, and land use trends. It also reports the physical features of Polk County. The purpose of the land use plan is to provide general guidance to achieve the desired future development of the county and direction for development decisions. The lakes classification outlines restriction on development according to lake features. Plan information is available online at http://www.co.polk.wi.us/landinfo/PlanningCompPlan.asp

Town, City and Village Comprehensive Plans are available at: http://www.co.polk.wi.us/landinfo/PlanningCompPlans.asp

Smart growth is a state mandated planning requirement to guide land use decisions and facilitate communication between municipalities. Wisconsin's Comprehensive Planning Law (Statute 66.1001, Wis. Stats.) was passed as part of the 1999 Budget Act. The law requires that if a local government engages in zoning, subdivision regulations, or official mapping, those local land use regulations must be consistent with that unit of local government's comprehensive plan beginning on January 1, 2010. The law defines a comprehensive plan as having at least the following nine elements:

- ✓ Issues and opportunities
- ✓ Housing
- ✓ Transportation
- ✓ Utilities and community facilities
- ✓ Agricultural, natural, and cultural resources
- ✓ Economic development
- ✓ Intergovernmental cooperation
- ✓ Land use
- ✓ Implementation
- ✓ Polk County added "Energy and Sustainability"

Polk County Comprehensive Land Use Ordinance

The Polk County Comprehensive Land Use Ordinance, more commonly known as the Zoning Ordinance, is currently being updated due to the passage of the Comprehensive Plan. 17 of Polk County's 24 Towns have adopted county zoning, including: the Towns of Alden, Apple River, Beaver, Black Brook, Clam Falls, Clayton, Clear Lake, Eureka, Georgetown, Johnstown, Lincoln, Lorain, Luck, McKinley, Milltown, Osceola, and West Sweden. The Towns of Farmington, Garfield, and St Croix Falls have adopted Town Zoning and the Towns of Balsam Lake, Bone Lake, Laketown, and Sterling have no town or county zoning other than the state-mandated shoreland zoning. Land use regulations in the zoning ordinance include building height requirements, lot sizes, permitted uses, and setbacks among other provisions. The current Comprehensive Zoning Ordinance is available at: http://www.co.polk.wi.us/landinfo/pdfs/Ordinances/ComprehensiveLandUse.pdf

Shoreland Protection Zoning Ordinance

The State of Wisconsin's Administrative Rule NR115 dictates that counties must regulate lands within 1,000 feet of a lake, pond or flowage and 300 feet of a river or stream. The Shoreland Protection Zoning Ordinance is also currently being rewritten due to the Comprehensive Plan and the State of Wisconsin passing a new version of NR 115 in 2010. Polk County passed an update of the current Shoreland Ordinance in 2002 and again in 2008. These updates put in place standards for impervious surfaces, a phosphorus fertilizer ban for shoreland property, and lakes classification and setback standards. The current ordinance is available online at:
http://www.co.polk.wi.us/landinfo/pdfs/Ordinances/ShorelandOrdinance.pdf

Updates to the Shoreland Protection Ordinance and the Comprehensive Land Use Ordinance will be completed in 2013. The old and new version of the ordinances will be available at: http://www.co.polk.wi.us/landinfo/ordinances.asp

Subdivision Ordinance

The subdivision ordinance, adopted in 1996 and updated in 2005, requires a recorded certified survey map for any parcel less than 19 acres. The ordinance requires most new plats to incorporate storm water management practices with no net increase in runoff from development. The ordinance is available online at:
http://www.co.polk.wi.us/landinfo/PDFs/Ordinances/Subdivision%20Ordinance%202005-07-01.pdf

Animal Waste

The Polk County Manure and Water Quality Management Ordinance was revised in January 2000. A policy manual established minimum standards and specifications for animal waste storage facilities, feedlots, degraded pastures, and active livestock operations greater than 300 animal units for livestock producers regulated by the ordinances. The Land and Water Resource Department's objective was to have countywide compliance with the ordinance by 2006. The ordinance is available online at:
http://www.co.polk.wi.us/landwater/MANUR21A.htm.

Storm Water and Erosion Control

The ordinance, passed in December 2005, establishes planning and permitting requirements for erosion control on disturbed sites greater than 3,000 square feet, where more than 400 cubic yards of material is cut or filled, or where channels are used for 300 feet more of utility installation (with some exceptions). Storm water plans and implementation of best management practices are required for subdivisions, survey plats, and roads where more than ½ acre of impervious surface will result. The Polk County Land and Water Resources Department administers the ordinance. The ordinance is a local mechanism to implement the Wisconsin Non-agricultural Runoff Performance Standards found in NR 151.

WI Non-Agricultural Performance Standards (NR 151)

Construction Sites >1 acre – must control 80% of sediment load from sites

Storm water management plans (>1 acre)
- Total Suspended Solids
- Peak Discharge Rate
- Infiltration
- Buffers around water

Developed urban areas (>1000 persons/square mile)
- Public education
- Yard waste management
- Nutrient management
- Reduction of suspended solids

Amended Illegal Transport of Aquatic Plants and Invasive Animals

The purpose of this ordinance, passed in June 2011, is to prevent the spread of aquatic invasive species in Polk County and surrounding water bodies by prohibiting the transport of boats, trailer, personal watercraft, and equipment if aquatic invasive plants or invasive animals are attached.

Polk County Land and Water Resources Management Plan

The Polk County Land and Water Resources Management Plan describes the strategy the Land and Water Resources Department (LWRD) will employ from 2010-2018 to address agriculture and non-agriculture runoff management, stormwater discharge, shoreline management, soil conservation, invasive species and other environmental degradation that affects the natural resources of Polk County. The plan specifies how the LWRD will implement NR 151 (Runoff Management). It involves identifying critical sites, offering cost-share and other programs, identifying BMP's monitoring and evaluating projects for compliance, conducting enforcement activities, tracking progress, and providing information and education.

Polk County has local shoreland protection, zoning, subdivision, animal waste, and non-metallic mining ordinances. Enforcing these rules and assisting other agencies with programs are part of LWRD's ongoing activities. Other activities to implement the NR 151 Standards include information and education strategies, write nutrient management plans, provide technical assistance to landowners and lakeshore owners, perform lake studies, collaborate with other agencies, work on a rivers classification system, set up demonstration sites of proper BMP's, control invasive species, and revise ordinances to offer better protection of resources.

WI Agricultural Performance Standards (NR 151)

For farmers who grow agricultural crops
- ✓ Meet "T" on cropped fields
- ✓ Starting in 2005 for high priority areas such as impaired or exceptional waters, and 2008 for all other areas, follow a nutrient management plan designed to limit entry of nutrients into waters of the state

For farmers who raise, feed, or house livestock
- ✓ No direct runoff from feedlots or stored manure into state waters
- ✓ No unlimited livestock access to waters of the state where high concentrations of animals prevent the maintenance of adequate or self sustaining sod cover
- ✓ Starting in 2005 for high priority areas, and 2008 for all other areas, follow a nutrient management plan when applying or contracting to apply manure to limit entry of nutrients into waters of the state

For farmers who have or plan to build a manure storage structure
- ✓ Maintain a structure to prevent overflow, leakage, and structural failure
- ✓ Repair or upgrade a failing or leaking structure that poses an imminent health threat or violates groundwater standards
- ✓ Close a structure according to accepted standards
- ✓ Meet technical standards for a newly constructed or substantially-altered structure

For farmers with land in a water quality management area (defined as 300 feet from a stream, or 1,000 feet from a lake or areas susceptible to groundwater contamination)
- ✓ Do not stack manure in unconfined piles
- ✓ Divert clean water away from feedlots, manure storage areas, and barnyards located within this area

Lake Management Plan

Lake Management Plans help protect water bodies by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. Lake Management Plans identify concerns of importance and set realistic goals, objectives, and action items to address identified concerns. Additionally, Lake Management Plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake Management Plans are living documents that are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitments, and the needs of lake stakeholders.

The implementation plan presented below was created through collaborative efforts and takes current and past water quality data, a 2012 sociological survey regarding the needs of The Apple River Flowage Protection and Rehabilitation members, and a series of four meetings by the Apple River Flowage Water Quality Committee.

Vision

We envision the Apple River Flowage as a healthy body of water with appropriate nutrient levels which supports human recreational uses and a diverse population of fish, wildlife, and native plants.

Guiding Principles

Lake management decisions are driven by what is best for the resource based on information that includes the ever evolving nature of lake management.

Communication regarding lake management needs to be easy to understand, concise, and frequent.

<u>Goal 1:</u> Reduce excessive watershed nutrient inputs to the flowage to improve water quality

Watershed nutrient inputs come from the land mass that drains to the Apple River Flowage. The watershed for the Apple River Flowage is 175 times larger than the flowage itself. As a comparison, the watershed for Pike Lake is 2.5 times larger than the lake itself and the watershed for North Twin Lake is 1.3 times larger than the lake itself.

The watershed management area for this study is 37,125 acres in size and spans from Balsam Lake, to Turtle Lake, Clayton, and Amery.

Means to accomplish this goal:

1. Reduce phosphorus loading from watershed sources by at least 15% (2,128 pounds)
*A 15% reduction in phosphorus loading would remove the Apple River Flowage from the federal 303(d) list of Impaired Waters if it was classified as a stream

The long term goal will be to meet the State of Wisconsin standard for total phosphorus for nonstratified drainage lakes of 0.040 mg/L . To meet this goal, phosphorus loading from watershed sources would have to be reduced by 80% in the north basin and 75% in the south basin. The progress towards achieving this goal will be assessed following full plan implementation.

Priority projects: installation of agricultural best management practices in the Beaver Brook East and Fox Creek Subwatersheds; installation of shoreline buffers and rain gardens on more urbanized shoreline properties; and installation of stormwater practices in the City of Amery

2. Engage watershed residents and users in reducing nutrients and sediments to improve water quality

- Identify and contact residents and users to explain options for reducing nutrients and sediments
- Recognize residents and users that have taken steps to reduce watershed nutrient inputs and improve nutrient management
- Partner with the City of Amery to install stormwater practices

3. Support installation of best management practices, or practices which reduce runoff to the flowage

- Provide technical assistance and cost sharing (incentives) for the installation of best management practices including but not limited to:
    - Shoreline buffers
    - Rain gardens

  - Nutrient management
  - Soil testing on farm fields
  - Evaluation of septic systems
  - Water diversions
  - Sediment ponds
  - Stormwater practices
  - Stream and creek buffers
  - Shoreline erosion practices

- Consider purchase of highly erodible/ecologically sensitive land if option arises, with priority given to willing landowners owning shoreline on the Apple River Flowage and its tributaries (Apple River, Fox Creek, and Beaver Brook)

Goal 2: Minimize the release of nutrients from within the Apple River Flowage to improve water quality

Nutrients are trapped in lake sediments and plants. If these nutrients are released back into the water column (through sediment disturbance or plant die back) they are made available to further increase plant or algae growth. This process is called internal loading.

Means to accomplish this goal:

1. Engage watershed residents and users in reducing internal loading

- Identify and contact residents and users to explain options for reducing internal loading

2. Support practices that reduce internal loading

- Support harvesting of curly-leaf pondweed, which removes nutrients from the flowage
- Educate the public on the importance of slow-no-wake zones using kiosks, signs, and newsletters
- Determine costs and permits necessary to install aerators in stagnant bays
- Work with the County to develop a plan to install culverts on the 46 bridge when the bridge is redone

Goal 3: Protect, maintain, and enhance fish and wildlife habitat

Means to accomplish this goal:

1. Maintain desirable levels of game fish in the flowage

- Work with fish biologist to determine locations for fish sticks and other habitat improvements
- Communicate with WDNR and Tribes to make informed decisions and encourage assessment and management of fish
- Continue work to maintain desirable levels of game fish
- Install five fish structures to increase woody habitat based on expert recommendations
- Consider monetarily supporting fish stocking based on expert recommendations
- Develop a plan to take into account the potential for higher boat traffic associated with increased game fish (ie. boat wash, increased slow-no-wake)

2. Increase understanding of options for attracting desirable birds, waterfowl, and wildlife to property

- Identify and contact residents and users with educational information

3. Enhance wildlife habitat

- Provide technical assistance and incentives to encourage restoration of at least 25 shoreline buffer zones, prioritizing properties in urbanized areas

Goal:4 Maintain and enhance the natural beauty of the Apple River Flowage

Means to accomplish this goal:

1. Promote the preservation and restoration of natural vegetation along the Apple River Flowage shoreline

- Provide technical assistance and incentives to encourage restoration of at least 25 shoreline buffer zones, prioritizing properties in urbanized areas

2. Maintain undeveloped natural areas where feasible

- Consider conservation easements to preserve undeveloped lands
- Consider property acquisition to preserve undeveloped, priority, or degraded lands

3. Enhance natural beauty of developed areas

- Organize an annual clean-up date to remove old docks and garbage

4. Create areas for public use

- Research costs, necessary permits, and locations for the installation of a public fishing pier
- Research costs, necessary permits, and locations for the creation of public parks with walking trails

Goal 5: Evaluate the progress of lake management efforts through monitoring and data collection

Means to accomplish this goal:

1. Continue current data collection efforts

- Ensure that a Citizen Lake Monitoring volunteer system is in place for each year

2. Expand data collection efforts

- Implement tributary sampling to track reductions in watershed nutrients
- Consider sediment cores to gather historical data (100-200 years)
- Implement a study to assess the impacts of harvesting
- Consider a study to determine phosphorus release from curly-leaf pondweed die off
- Determine feasibility of dredging and drawdown to address sediments
  *Note a drawdown typically reduces sediment by 1/3
- Work with the City to develop a plan if the dam fails or requires maintenance
  *If a drawdown needs to occur it could be used as an opportunity to reduce sediment or manage aquatic invasive species
- Work with the City to implement monitoring strategies to reassess the residence time for the Apple River Flowage
- Repeat the 2012 water quality study in five years

<u>Goal 6:</u> Provide information and education opportunities to residents and users

Means to accomplish this goal:

1. Utilize various methods of communication:

- Website
- Social media such as Facebook and QR codes
- Emails
- Geo-caching
- Newsletters
- Press releases
- Regularly scheduled workshops
- Demonstration sites for best management practices

2. Topics to communicate:

- Water quality
- Opportunities for technical assistance and cost sharing of projects
- District projects
- District events
- Recognition of partners

Goal 7: Develop partnerships with a diversity of people and organizations

Means to accomplish this goal:

1. Develop a relationship with a diversity of groups

- City of Amery
- Apple River Association
- WDNR
- Tribe
- Polk County LWRD
- Polk County Association of Lakes and Rivers
- Lake Districts and organizations within the Upper Apple River Watershed
- Watershed residents
- Amery School District
- Youth groups
- Sportsman's Clubs
- Polk County Parks Department
- St. Croix Basin Team

2. Attend 3 area meetings held by partners

3. Invite partners to Apple River Flowage District Meetings

4. Consider the formation of a Watershed Council

5. Create and maintain a directory of key contacts

6. Partner with the St. Croix Basin Team to advance the goals of the St. Croix TMDL Implementation Plan

Goal 8: Implement the Aquatic Plant Management Plan

Means to accomplish this goal:

1. Improve water quality on the Apple River Flowage and downstream on the Apple River
2. Prevent the introduction of aquatic invasive species
3. Maintain navigation for fishing, boating, and access to lake residences
4. Maintain native aquatic plant functions
5. Minimize environmental impacts of aquatic plant management

Goal 1: Reduce excessive watershed nutrient inputs to the flowage to improve water quality

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Identify and contact residents and users to explain options for reducing nutrients and sediments	2013, ongoing			ARPRD Board LWRD	
Recognize residents and users that have taken steps to reduce watershed nutrient inputs and improve nutrient management	As projects are implemented			ARPRD Board	
Partner with the City of Amery to install stormwater practices	3-5 years			ARPRD Board City of Amery	WDNR Urban Nonpoint Source and Stormwater Management Grant
Provide technical assistance and cost sharing (incentives) for the installation of best management practices including but not limited to: shoreline buffers, rain gardens, nutrient management, soil testing on farm fields, evaluation of septic systems, water diversions, sediment ponds, stormwater practices, stream and creek buffers, and shoreline erosion practices	2015 or if funding available			ARPRD Board LWRD Consultant	WDNR Lake Protection Grant*
Consider purchase of highly erodible/ecologically sensitive land if option arises	If available funding			ARPRD Board	WDNR Lake Protection Grant*

* Covenants and Operation and Maintenance Plans are required for activities implemented with WDNR Lake Protection Grants.

Goal 2: Minimize the release of nutrients from within the Apple River Flowage to improve water quality

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Identify and contact residents and users to explain options for reducing internal loading	2013, ongoing			ARPRD Board	
Support harvesting of curly-leaf pondweed, which removes nutrients from the flowage	Ongoing			ARPRD Board	
Educate the public on the importance of slow-no-wake zones using kiosks, signs, and newsletters	As needed			ARPRD Board	
Determine costs and permits necessary to install aerators in stagnant bays	2013			ARPRD Board Amery Economic Development	
Work with the County to develop a plan to install culverts on the 46 bridge when the bridge is redone	Ongoing			ARPRD Board Polk County	

Goal 3: Protect, maintain, and enhance fish and wildlife habitat

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Work with fish biologist to determine locations for fish sticks and other habitat improvements	Ongoing			WDNR Tribe	
Communicate with WDNR and Tribes to make informed decisions and encourage assessment and management of fish	Ongoing			ARPRD Board WDNR Tribe	
Continue work to maintain desirable levels of game fish	Ongoing			ARPRD Board	
Install five fish structures to increase woody habitat based on expert recommendations	TBD			ARPRD Board WDNR	
Consider monetarily supporting fish stocking based on expert recommendations	TBD			ARPRD Board	
Develop a plan to take into account the potential for higher boat traffic associated with increased game fish (ie. boat wash, increased slow-no-wake)	As needed			ARPRD Board	
Identify and contact residents and users with educational information	2013, ongoing			ARPRD Board	
Provide technical assistance and incentives to encourage restoration of at least 25 shoreline buffer zones, prioritizing properties in urbanized areas	2015			ARPRD Board LWRD Consultant	WDNR Lake Protection Grant*

* Covenants and Operation and Maintenance Plans are required for activities implemented with WDNR Lake Protection Grants.

Goal 4: Maintain and enhance the natural beauty of the Apple River Flowage

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Provide technical assistance and incentives to encourage restoration of at least 25 shoreline buffer zones, prioritizing properties in urbanized areas	2015 or if funding available			ARPRD Board LWRD Consultant	WDNR Lake Protection Grant*
Consider conservation easements to preserve undeveloped lands	If available funding			ARPRD Board	WDNR Lake Protection Grant*
Consider property acquisition to preserve undeveloped, priority, or degraded lands	If available funding			ARPRD Board	WDNR Lake Protection Grant*
Organize an annual clean-up date to remove old docks and garbage	2013, ongoing			ARPRD Board Apple River Association	
Research costs, necessary permits, and locations for the installation of a public fishing pier	TBD			ARPRD Board City of Amery	
Research costs, necessary permits, and locations for the creation of public parks with walking trails	TBD			ARPRD Board City of Amery Town of Lincoln	

* Covenants and Operation and Maintenance Plans are required for activities implemented with WDNR Lake Protection Grants.

Goal 5: Evaluate the progress of lake management efforts through monitoring and data collection

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Ensure that a Citizen Lake Monitoring volunteer system is in place for each year	2013, ongoing	$100/year	20-40	ARPRD Board Volunteer	WDNR Citizen Lake Monitoring Network
Implement tributary sampling to track reductions in watershed nutrients	Inlet/outlet every year or as practices implemented	$81/sample		ARPRD Board Volunteer LWRD Consultant Tribe	WDNR Lake Planning Grant or Protection Grant * WAV program
Consider sediment cores to gather historical data (100-200 years)	5-10 years	$12-30,000		ARPRD Board LWRD Consultant	WDNR Lake Planning Grant
Implement a study to assess the impacts of harvesting	2014			ARPRD Board LWRD Consultant Tribe	WDNR AIS Grant or Planning Grant
Consider a study to determine phosphorus release from curly-leaf pondweed die off	2014			ARPRD Board LWRD Consultant Tribe	WDNR AIS Grant or Planning Grant
Determine feasibility of dredging and drawdown to address sediments	5-10 years			ARPRD Board LWRD Consultant	
Work with the City to develop a plan if the dam fails or requires maintenance	Ongoing			ARPRD Board City of Amery	
Repeat the 2012 water quality study in five years	5 years			ARPRD Board LWRD Consultant	WDNR Lake Planning Grant

* Covenants and Operation and Maintenance Plans are required for activities implemented with WDNR Lake Protection Grants.

Goal 6: **Provide information and education opportunities to residents and users**

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Website	Ongoing			ARPD Board	
Social media such as Facebook and QR codes	2014, ongoing			Task Force	
Emails	Ongoing			ARPD Board	
Geo-caching	3-5 years			Task Force	
Newsletters	Ongoing			ARPD Board LWRD	
Press releases	Ongoing			ARPD Board LWRD	
Regularly scheduled workshops	3-5 years			ARPD Board LWRD Area partners	
Demonstration sites for best management practices	Ongoing			ARPD Board LWRD Area partners	

Goal 7: Develop partnerships with a diversity of people and organizations

Action	Timeline	$ Estimate	Volunteer Hours	Partners	Funding Sources
Develop a relationship with a diversity of groups	Ongoing	$25 PCALR membership		ARPD Board Area partners	
Attend 3 area meetings held by partners	Ongoing			ARPD Board Area partners	
Invite partners to Apple River Flowage District Meetings	2013, ongoing			ARPD Board Area partners	
Consider the formation of a Watershed Council	3-5 years			ARPD Board Area partners	McKnight Joyce Foundation WDNR
Create and maintain a directory of key contacts	2013, ongoing			ARPD Board	
Partner with the St. Croix Basin Team to advance the goals of the St. Croix TMDL Implementation Plan	Ongoing			ARPD Board	

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Appendix A

Lake District Resident Survey and Results

2012 Apple River Flowage Watershed Survey

The Land and Water Resources Department (LWRD) and the Apple River Flowage P&R District received a WDNR lake planning grant to conduct a water quality and biological assessment on Apple River Flowage in 2012. Following is a survey designed to gather information about the flowage and its intended use to direct future water quality management decisions. The survey should take approximately 5-10 minutes to complete. Your responses will remain confidential. Final results will be compiled and made available to the public. If you have questions, feel free to contact Katelin Holm, Information and Education Coordinator/Water Quality Specialist at LWRD, 485-8637, katelin.holm@co.polk.wi.us. Surveys should be returned by July 15th, 2012 to:

LWRD
100 Polk County Plaza- Suite 120
Balsam Lake, WI 54810

The results of this survey will help guide lake management decisions. Thank you again for your participation!

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1. How many years have you owned property on or near the Apple River Flowage? *Note: If you own more than one property, please answer all questions for the property you have owned the longest.*
   ________ years

2. Which of the following best describes how you use your property? Please check one.
   ____Year-round residence
   ____Seasonal residence—continued occupancy for months at a time
   ____Weekend, vacation, and/or holiday residence
   ____Rental property
   ____Other (please specify) ____________________

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.
   ________ days per year

4. On the average day that your property is occupied, how many people occupy the property?
   ________ people

5. Land use generally falls into one of the following four categories: open space, shrub/grass/sedge community, woods, and impervious (hard) surfaces. Please use **estimated percentages** to describe the amount of each land use on your property. (The total should equal 100%.) We realize this may be challenging but please just provide your best estimate.
   ____% Open space (lawns or mowed areas)
   ____% Shrub/grass/sedge community
   ____% Woods
   ____% Impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways)

6. Do you own shoreline property on the Apple River Flowage?
   ____No, **please skip to question 8**
   ____Yes

7. From the list below, which best describes the first 35 feet of your shoreline (the area located directly adjacent to the lake)? **If you do not own shoreline property, please skip this question.**
____Mostly mowed grass
____Mostly native flowers and grasses
____A mix of native flowers, grasses, *and shrubs*
____A mix of native flowers, grasses, *shrubs, and trees*

8. On an average year, which activities do you and/or your family participate in on the Apple River Flowage? Please check all that apply.
____Fishing (any season)
____Swimming, snorkeling, or scuba diving
____Non-motorized water activities (birding, canoeing, hiking, running)
____Motorized water activities (PWC, boating, water skiing, tubing, jet skiing)
____Non-motorized winter activities (skiing, snowshoeing, ice skating)
____Motorized winter activities (ATV, snowmobile)
____Other, please describe____________________________

9. How many of the following watercraft are kept on your property for use on the Apple River Flowage? If none, please write 0.
____ Jet skis
____ Motorboats/pontoons between 1-20 HP
____ Motorboats/pontoons between 21-50 HP
____ Motorboats/pontoons more than 50 HP
____ Canoes and kayaks
____ Paddleboats/rowboats
____ Other, please describe______________________

10. From the list below, please rank your top three concerns for the Apple River Flowage. (Please list your top three concerns in order of importance, with 1st being most important).

1st ___
2nd ___
3rd ___

A. **Pollution** (chemical inputs, septic systems, agriculture, erosion, storm water runoff)
B. **Development** (population density, loss of wildlife habitat)
C. **Quality of life**
D. **Property values and/or taxes**
E. **Water recreation safety** (boat traffic, no wake zone)
F. **Water clarity** (visibility)
G. **Aquatic plants** (not including algae)
H. **Algae blooms**
I. **Invasive species** (Eurasian water milfoil, zebra mussels, curly leaf pondweed, purple loosestrife)
J. **Quality of fisheries**
K. **Water levels** (loss of lake volume)
L. **Other**, please describe____________________________

11. How would you describe the current water quality of the Apple River Flowage?

____Poor
____Fair
____Unsure
____Good
____Excellent

12. How has the water quality changed in the Apple River Flowage in the time you've owned your property?

____Severely degraded
____Somewhat degraded
____Remained unchanged
____Somewhat improved
____Greatly improved
____Unsure

13. How often does algae negatively impact your enjoyment of the Apple River Flowage?

____Never
____Rarely
____Sometimes
____Often
____Always

14. How would you describe the current amount of shoreline vegetation on the Apple River Flowage?

____Too much
____Just right
____Not enough
____Unsure

15. How would you describe the importance of wetlands in the Apple River Flowage watershed to the water quality of the Apple River Flowage? Note: A watershed is the land area that drains to a particular lake or river.

____Not at all important
____Not too important
____Unsure
____Somewhat important
____Very important

16. How would you describe the importance of shoreline buffers, rain gardens, and native plants to the water quality of the Apple River Flowage?

____Not at all important
____Not too important
____Unsure
____Somewhat important
____Very important

17. How would you describe your current use of fertilizer on your property?

____I do not use any fertilizer on my property
____I use zero phosphorus fertilizer on my property
____I use fertilizer on my property but I'm unsure of its phosphorus content
____I use fertilizer on my property that contains phosphorus

18. From the list below, please check all of the management practices you feel should be used to maintain or improve the water quality of the Apple River Flowage. Note: Cost sharing assistance refers to a process where the landowner is responsible for a portion of the cost of a particular project and their contribution is matched by another source (state dollars, grant dollars, district dollars).

____ Cost-sharing assistance for the installation of shoreline buffers and rain gardens
____ Cost-sharing assistance for the installation of farmland conservation practices (for example nutrient management plans, contour strips, conservation tillage, etc)
____ Information and education opportunities
____ Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat
____ Practices to enhance fisheries, such as the introduction of coarse woody habitat
____ Collection of sediment cores to provide information concerning historical changes in lake condition
____ Enhanced efforts to monitor for new populations of aquatic invasive species
____ Other, please describe____

19. How often do you visit the Apple River Flowage P&R District website (http://arprd.org/)?

____Never ____Sometimes
____Rarely ____Often

20. Are you interested in installing a shoreline buffer or rain garden on your property?

____No
____Already installed
____Unsure, please contact me with additional information
____Yes

If you answered yes or unsure and would like more information about this opportunity please list your contact information below. This information will be kept separate from your responses to ensure confidentiality.

____

21. Please provide your age. I am ________ years old.

Thank you for your participation in this survey! Please feel free to use the space below for comments.

2012 Apple River Flowage Watershed Survey Results

Surveys mailed: 225
Surveys returned: 92
Response rate: 41%

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1. How many years have you owned property on or near the Apple River Flowage? *Note: If you own more than one property, please answer all questions for the property you have owned the longest.*
   89 respondents, 97% **Average years: 19**

2. Which of the following best describes how you use your property? Please check one.
   92 respondents, 100%
   ____Year-round residence **54 respondents, 59%**
   ____Seasonal residence—continued occupancy for months at a time **5 respondents, 5%**
   ____Weekend, vacation, and/or holiday residence **19 respondents, 21%**
   ____Rental property **3 respondents, 3%**
   ____Other (please specify) ____________________ **11 respondents, 12%**

   Bought land for investment
   Family visits year round
   Hunting land - no residence. I visit approximately once per month.
   Land, build in future
   Land, no building yet
   Lot owned
   No use, no livable buildings. Property for sale.
   Only go up 1-2 times a year
   Recreational lot
   Resort
   Year round non residence

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.
   90 respondents, 98% **Average days per year: 237**

4. On the average day that your property is occupied, how many people occupy the property?
   92 respondents, 100% **Average people: 3**

5. Land use generally falls into one of the following four categories: open space, shrub/grass/sedge community, woods, and impervious (hard) surfaces. Please use **estimated percentages** to describe the amount of each land use on your property. (The total should equal 100%.) We realize this may be challenging but please just provide your best estimate.
   87 respondents, 95%
   ____% Open space (lawns or mowed areas) **Average: 44%**
   ____% Shrub/grass/sedge community **Average: 13%**
   ____% Woods **Average: 24%**
   ____% Impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways)
   Average: 19%

6. Do you own shoreline property on the Apple River Flowage?
   92 respondents, 100%
   ____No, please skip to question 8 **8 respondents, 9%**
   ____Yes **84 respondents, 91%**

7. From the list below, which best describes the first 35 feet of your shoreline (the area located directly adjacent to the lake)? **If you do not own shoreline property, please skip this question.**
   82 respondents, 89%
   ____Mostly mowed grass **16 respondents, 20%**
   ____Mostly native flowers and grasses **7 respondents, 9%**
   ____A mix of native flowers, grasses, *and shrubs* **6 respondents, 7%**
   ____A mix of native flowers, grasses, *shrubs, and trees* **57 respondents, 70%**

8. On an average year, which activities do you and/or your family participate in on the Apple River Flowage? Please check all that apply.
   87 respondents, 95%
   ____Fishing (any season) **62 respondents, 71%**
   ____Swimming, snorkeling, or scuba diving **19 respondents, 22%**
   ____Non-motorized water activities (birding, canoeing, hiking, running) **34 respondents, 39%**
   ____Motorized water activities (PWC, boating, water skiing, tubing, jet skiing) **45 respondents, 52%**
   ____Non-motorized winter activities (skiing, snowshoeing, ice skating) **16 respondents, 18%**
   ____Motorized winter activities (ATV, snowmobile) **9 respondents, 10%**
   ____Other, please describe____________________________ **11 respondents, 13%**

   Don't use land
   None
   None
   None
   None of the above, too many weeds
   None, too many cattails
   None, property for sale
   Photography of wild birds and animals
   Simply observing the beauty of the river
   Watching the river
   Watching waterfowl and other natural activity. General beauty of the flowage and shoreline.

9. How many of the following watercraft are kept on your property for use on the Apple River Flowage? If none, please write 0.
87 respondents, 95%

____ Jet skis **2**
____ Motorboats/pontoons between 1-20 HP **21**
____ Motorboats/pontoons between 21-50 HP **34**
____ Motorboats/pontoons more than 50 HP **10**
____ Canoes and kayaks **37**
____ Paddleboats/rowboats **32**
____ Other, please describe______________________ **7**

Achilles hard floor inflatable
Mini pontoon with electric trolling motor
None
None
None
Sail
Sail

10. From the list below, please rank your top three concerns for the Apple River Flowage. (Please list your top three concerns in order of importance, with 1st being most important).
89 respondents, 97%

1st **Invasive species**
2nd **Aquatic plants (not including algae)**
3rd **Algae**

Pollution (chemical inputs, septic systems, agriculture, erosion, storm water runoff) **60 points**
Development (population density, loss of wildlife habitat) **13 points**
Quality of life **28 points**
Property values and/or taxes **50 points**
Water recreation safety (boat traffic, no wake zone) **10 points**
Water clarity (visibility) **39 points**
Aquatic plants (not including algae) **87 points**
Algae blooms **63 points**
Invasive species (Eurasian water milfoil, zebra mussels, curly leaf pondweed, purple loosestrife) **113 points**
Quality of fisheries **29 points**
Water levels (loss of lake volume) **24 points**
Other, please describe____________________________ **10 points**

Rank of 3: Goose poop/damage, muskrat and beaver damage, high nutrient level that cause excessive weed growth
Rank of 3: Too many geese, can't even walk in yard
Rank of 1: Boat navigation without river weeds, on water access to all areas
Rank of 3: Sediment build up

11. How would you describe the current water quality of the Apple River Flowage?
87 respondents, 95%
____Poor **31 respondents, 36%**
____Fair **28 respondents, 32%**
____Unsure **16 respondents, 18%**
____Good **12 respondents, 14%**
____Excellent **0 respondents, 0%**

12. How has the water quality changed in the Apple River Flowage in the time you've owned your property?
89 respondents, 97%
____Severely degraded **27 respondents, 30%**
____Somewhat degraded **36 respondents, 40%**
____Remained unchanged **17 respondents, 19%**
____Somewhat improved **0 respondents, 0%**
____Greatly improved **0 respondents, 0%**
____Unsure **10 respondents, 11%**

13. How often does algae negatively impact your enjoyment of the Apple River Flowage?
87 respondents, 95%
____Never **7 respondents, 8%**
____Rarely **6 respondents, 7%**
____Sometimes **23 respondents, 26%**
____Often **27 respondents, 31%**
____Always **24 respondents, 28%**

14. How would you describe the current amount of shoreline vegetation on the Apple River Flowage?
87 respondents, 95%
____Too much **25 respondents, 29%**
____Just right **29 respondents, 33%**
____Not enough **9 respondents, 10%**
____Unsure **24 respondents, 28%**

15. How would you describe the importance of wetlands in the Apple River Flowage watershed to the water quality of the Apple River Flowage? Note: A watershed is the land area that drains to a particular lake or river.
89 respondents, 97%
____Not at all important **3 respondents, 3%**
____Not too important **1 respondents, 1%**
____Unsure **20 respondents, 22%**
____Somewhat important **19 respondents, 21%**
____Very important **46 respondents, 52%**

16. How would you describe the importance of shoreline buffers, rain gardens, and native plants to the water quality of the Apple River Flowage?
88 respondents, 96%
____Not at all important **2 respondents, 2%**
____Not too important **5 respondents, 6%**
____Unsure **16 respondents, 18%**
____Somewhat important **24 respondents, 27%**
____Very important **41 respondents, 47%**

17. How would you describe your current use of fertilizer on your property?
88 respondents, 96%
____I do not use any fertilizer on my property **56 respondents, 64%**
____I use zero phosphorus fertilizer on my property **29 respondents, 33%**
____I use fertilizer on my property but I'm unsure of its phosphorus content **4 respondents, 5%**
____I use fertilizer on my property that contains phosphorus **0 respondents, 0%**

18. From the list below, please check all of the management practices you feel should be used to maintain or improve the water quality of the Apple River Flowage. Note: Cost sharing assistance refers to a process where the landowner is responsible for a portion of the cost of a particular project and their contribution is matched by another source (state dollars, grant dollars, district dollars).
78 respondents, 85%
____ Cost-sharing assistance for the installation of shoreline buffers and rain gardens
21 respondents, 27%
____ Cost-sharing assistance for the installation of farmland conservation practices (for example nutrient management plans, contour strips, conservation tillage, etc) **32 respondents, 41%**
____ Information and education opportunities **36 respondents, 46%**
____ Establishment of slow-no-wake zones to protect aquatic plants and fisheries habitat
27 respondents, 35%
____ Practices to enhance fisheries, such as the introduction of coarse woody habitat
23 respondents, 29%
____ Collection of sediment cores to provide information concerning historical changes in lake condition **30 respondents, 38%**
____ Enhanced efforts to monitor for new populations of aquatic invasive species **47 respondents, 60%**
____ Other, please describe____ **9 respondents, 12%**
Consider EPA approved nontoxic to human/fish weed killers
Harvesting of weeds
Weed harvester impact study
Weed removal
Weeds need to be removed! Not just cut. Cutting does nothing to stop the spread of weeds.
None of the above
Professional guides and fishing tours should also put monies towards river cleaning efforts not just landowners—perhaps boat launch access fees
Take whatever measures are necessary to eradicate the muskrats. They are destroying the shoreline.
To prevent further shoreline loss

19. How often do you visit the Apple River Flowage P&R District website (http://arprd.org/)?
90 respondents, 98%
____Never **53 respondents, 59%**
____Rarely **18 respondents, 20%**
____Sometimes **15 respondents, 17%**
____Often **3 respondents, 3%**

20. Are you interested in installing a shoreline buffer or rain garden on your property?
89 respondents, 97%
____No **42 respondents, 47%**
____Already installed **25 respondents, 28%**
____Unsure, please contact me with additional information **13 respondents, 15%**
____Yes **11 respondents, 12%**

21. Please provide your age. I am ________ years old.
88 respondents, 96% **Average age: 63 years**

Thank you for your participation in this survey! Please feel free to use the space below for comments.

Area farms on the river need buffers. Farm on 120th Ave (Amery) has had cows standing in the river for years. Chemical treatments worked the best. Why not dredge the channels? Water level too low!

Because of the thick green slime we have not put our dock in or got our runabout out of storage. Also have not bought a fishing license this year for the two of us because of river.

This is a river damed up to crest a shallow flowage offering very good fishing. The weeds are what makes this possible. You are never going to change this. People should be made aware of this before buying and building.

Can we please use the weed harvester beyond just the channel? I believe most people would also be more than happy to pay for this service for their own frontage.

After 37 years on the river, we made progress for the first time 10 years ago with spraying to control the weeds. We need to harvest and spray to stop the phosphorus build up. Also the DNR and the county dropped the ball when removing the country dam - too much silt was allowed to flow down stream and still is.

Flowage should be "quiet" waters - no jet skis or high powered boats.

I want to see good things happen to Apple River, but am selling my property and can't invest.

In the 45 years the Apple River has lost quality. This really was notable after the DNA draw down. Establishment of the Apple River Association helped but it was not effective. Think we may be on the right track - or maybe too late!

Keep up the good work!

Must take action to prevent use of fertilizers.

Review harvesting guidelines with the amount of vegetation in the flowage, it could hardly be over harvested.

The Apple River PRD is a joke. It has not made the river a better body of water but has allowed it to become what it is. When I first moved here, I could fish from shore and catch fish. Now I can't cast past the weeds and that's from a 20' dock!

The river is a mess. We pay for improvement in river quality but fail to see any action.

Appendix B

Chemical Data: In-lake and Tributary

ARF

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: LAKES
Date Sampled: APRIL 3, 2012
Sample Time:
Date Received in Lab: APRIL 4, 2012
Purchase Order #:
WEAL Invoice: 372974

Sampled By: ~~BK~~ KH, JW
Preserved: H2SO4
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		pH (S.U.)	Conductivity	Alkalinity	Total Hardness	Calcium	Reactive Phosphorus	Total Phosphorus	Ammonium (N)	NO2+NO3(N)	Total Kjeldahl Nitrogen	Chloride	Sulfate	Sodium	Potassium	Turbidity (NTU)	Color		
Date Prepared							6-Apr	19-Apr											
Date Analyzed		9-Apr	9-Apr	11-Apr	11-Apr	13-Apr	9-Apr	20-Apr	9-Apr	6-Apr	20-Apr	6-Apr	13-Apr	13-Apr	15-Apr	15-May	14-May		
Method		4500 H B	2510 B	2320B	2340 C	EPA 200.7	4500 P F	4500 P F	4500 NH3 H	4500 NO3 F	4500-NH3 G	4500 Cl E	EPA 200.7	EPA 200.7	EPA 200.7	2130 B	20-Oct		
Lab #	Site																		
124-12-1	APPLE RIVER FLOW IN	8.15	192	108	120	26.6	0.016	0.053	0.03	0.3	0.69	5.2	3.8	3	2.3	3.7	23.4		1 North
124-12-2	APPLE RIVER LOW 25	7.94	183	96	88	24.0	0.022	0.072	0.03	0.3	0.86	4.7	3.6	2	2.7	11.1	25.7		2 South
124-12-3	CHURCH PINE LAKE	7.70	150	76	88	17.3	0.008	0.031	0.02	<0.1	0.56	7.8	2.9	4	1.5	1.1	12.5		
124-12-4	WIND LAKE	7.81	186	92	108	23.7	0.017	0.039	0.06	0.2	0.68	9.1	4.1	4	1.9	2.3	11.4		
124-12-5	BIG LAKE	7.06	214	88	112	26.7	0.028	0.033	0.11	0.4	0.39	9.3	21.3	4	1.8	1.9	8.7		

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: ARF
Date Sampled: MAY 8, 2012
Sample Time: 11:30AM-3:25PM
Date Received in Lab: MAY 9, 2012
Purchase Order #:
WEAL Invoice: 374878

Sampled By: JW & KH
Preserved: H2SO4
Sample Type: SW
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209
DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])										
Date Prepared				10-May			10-May	23-May	6-Jun										
Date Analyzed		11-May	11-May	11-May	30-May	30-May	11-May	24-May	7-Jun										
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H										
Lab #	Site																		
✓ 208-12-1	A. RIVER FLOW SITE 1	<0.1	4.5	<0.01	0.45	0.050	0.025	4	4										
✓ 208-12-2	A. RIVER FLOW SITE 2	<0.1	4.3	0.02	0.99	0.113	0.025	33	4										
✓ 208-12-3	FOX CREEK	0.1	3.3	0.05	0.62	0.055	0.018	10											
✓ 208-12-4	APPLE RIVER INLET	<0.1	2.8	0.02	0.77	0.089	0.034	16											
✓ 208-12-5	APPLE RIVER OUTLET	<0.1	4.1	0.03	0.61	0.062	0.024	4											
✓ 208-12-6	MAIN STEM	0.3	4.9	0.04	0.87	0.125	0.082	14											
✓ 208-12-7	BEAVER BROOK WEST	0.2	5.5	0.05	1.16	0.117	0.056	32											
✓ 208-12-8	BEAVER BROOK EAST	<0.1	4.6	0.03	0.81	0.236	0.199	7											

entered

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: ARF
Date Sampled: JUNE 5, 2012
Sample Time: VARIES
Date Received in Lab: JUNE 6, 2012
Purchase Order #:
WEAL Invoice: 375190

Sampled By: JW/KH
Preserved: H2SO4
Sample Type: SW
Field Filtered: NO
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared					11-Jun	11-Jun		25-Jun	21-Jun
Date Analyzed		8-Jun	8-Jun	7-Jun	13-Jun	13-Jun	7-Jun	26-Jun	22-Jun
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H
Lab #	Site								
262-12-1	FOX CREEK	<0.1	3.9	0.05	0.56	0.060	0.029	8	
262-12-2	APPLE RIVER FLOWAGE INLET	<0.1	4.3	0.04	0.69	0.076	0.050	5	
262-12-3	A. RIVER FLOWAGE OUTLET	<0.1	5.2	0.05	0.55	0.070	0.045	2	
262-12-4	MAIN STEM	0.5	6.1	0.04	0.69	0.103	0.073	9	
262-12-5	BEAVER BROOK WEST	<0.1	5.9	0.04	0.68	0.044	0.025	4	
262-12-6	BEAVER BROOK EAST	0.2	5.2	0.03	0.69	0.366	0.322	4	
262-12-7	A. RIVER FLOWAGE (SITE#1N)	<0.1	4.2	0.02	0.54	0.073	0.038	<2	3
262-12-8	A. RIVER FLOWAGE (SITE#2S)	<0.1	4.4	0.02	0.51	0.053	0.029	3	9

6/5/12 entered

University of Wisconsin-Stevens Point
College of Natural Resources
Center for Watershed Science & Education
Water & Environmental Analysis Lab

Stevens Point WI 54481-3897
715-346-3209
www.uwsp.edu/cnr/etf

Home Owner Package Metals Results All results mg/L

	Sample	As	Ca	Cu	Fe	K	Mg	Mn	Na	P	Pb	SO_4	Zn
IN	262-12-7	0.004	30.6	0.003	0.106	1.4	8.6	0.027	4	0.12	<0.002	5.1	0.047
25	262-12-8	0.015	27.4	0.006	0.119	1.3	8.7	0.064	3	0.06	<0.002	7.5	0.039

entered

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: ARF
Date Sampled: JULY 11, 2012
Sample Time: VARIES
Date Received in Lab: JULY 12, 2012
Purchase Order #:
WEAL Invoice: 376472

Sampled By: KH/JW
Preserved: H2SO4
Sample Type:
Field Filtered: NO
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		Total Suspended Solids	NO2+NO3(N)	Ammonium (N)	Total Kjeldahl Nitrogen	Chloride	Total Phosphorus	Reactive Phosphorus	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared		17-Jul	12-Jul	13-Jul	18-Jul	12-Jul	18-Jul	13-Jul	12-Jul
Date Analyzed		18-Jul	12-Jul	13-Jul	19-Jul	12-Jul	19-Jul	13-Jul	13-Jul
Method		2540 D	4500 NO3 F	4500 NH3 H	4500-NH3 G	4500 Cl E	4500 P F	4500 P F	10200 H
Lab #	Site								
347-12-1	Fox Creek	4	<0.1	0.05	0.60	4.1	0.049	0.032	
347-12-2	Apple River Flowage Inlet	4	<0.1	0.02	0.51	4.3	0.054	0.039	
347-12-3	Apple River Flowage Outlet	<2	<0.1	0.03	0.66	4.1	0.074	0.050	
347-12-4	Main Stem	3	0.5	0.03	0.56	6.7	0.077	0.074	
347-12-5	Beaver Brook East	<2	0.7	0.05	0.69	9.8	0.251	0.233	
347-12-6	Beaver Brook West	<2	0.1	0.03	0.73	5.3	0.046	0.028	
347-12-7	Apple River Flowage #1 N	4	<0.1	0.01	0.66	4.5	0.092	0.058	10
347-12-8	Apple River Flowage #2 S	6	<0.1	0.04	0.88	4.8	0.098	0.053	12

entered

July

University of Wisconsin-Stevens Point
College of Natural Resources
Center for Watershed Science & Education
Water & Environmental Analysis Lab

Stevens Point WI 54481-389
715-346-320
www.uwsp.edu/cnr/e

Home Owner Package Metals Results All results mg/L

Sample	As	Ca	Cu	Fe	K	Mg	Mn	Na	P	Pb	SO_4	Zn
347-12-7	<0.005	28.1	0.003	0.019	0.6	9.7	0.003	3	0.02	<0.002	2.6	0.064
347-12-8	<0.005	28.1	<0.001	0.012	0.6	10.4	0.002	3	0.03	<0.002	2.6	0.026

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWRD
Sample Location: ARF
Date Sampled: AUGUST 7, 2012
Sample Time: VARIES
Date Received in Lab: AUGUST 8, 2012
Purchase Order #:
WEAL Invoice: 377320

Sampled By: KH/JW
Preserved: yes
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209
DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])
Date Prepared		9-Aug	9-Aug	13-Aug	15-Aug	15-Aug	13-Aug	20-Aug	13-Aug
Date Analyzed		9-Aug	9-Aug	14-Aug	22-Aug	22-Aug	14-Aug	21-Aug	15-Aug
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H
Lab #	Site								
414-12-1	Fox Creek	0.3	5.5	0.10	0.63	0.045	0.029	3	
414-12-2	ARF Inlet	<0.1	5.0	0.02	0.47	0.047	0.034	<2	
414-12-3	ARF Outlet	<0.1	6.1	0.05	0.53	0.053	0.039	<2	
414-12-4	Main Stem	1.1	8.0	0.03	0.44	0.061	0.050	<2	
414-12-5	Beaver Brook West	1.0	7.4	0.05	0.73	0.046	0.031	<2	
414-12-6	Beaver Brook East	0.7	13.3	0.03	0.50	0.183	0.165	<2	
414-12-7	ARF Site 1 North	<0.1	5.6	0.02	0.58	0.112	0.078	5	9
414-12-8	ARF Site 2 South	<0.1	6.0	0.02	0.62	0.066	0.038	8	37

8/7/12

X

University of Wisconsin-Stevens Point
College of Natural Resources
Center for Watershed Science & Education
Water & Environmental Analysis Lab

Stevens Point WI 54481-3897
715-346-3209
www.uwsp.edu/cnr/etf

Home Owner Package Metals Results All results mg/L

	Sample	*As	Ca	Cu	Fe	K	Mg	Mn	Na	P	Pb	SO_4	Zn
1 North	414-12-7	0.011	31.6	0.006	0.047	1.0	11.0	0.011	4	0.05	<0.002	5.7	0.009
2 South	414-12-8	0.008	31.3	0.009	0.029	1.4	11.1	0.017	4	0.06	0.002	5.0	0.011

*As was re-analyzed via ICP-ms.

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK COUNTY LWDR
Sample Location: ARF
Date Sampled: September 6, 2012
Sample Time:
Date Received in Lab: September 10, 2012
Purchase Order #:
WEAL Invoice: 137477

Sampled By: JW/KH
Preserved: H2SO4, HNO3
Sample Type: un
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209
DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		NO2+NO3(N)	Chloride	Ammonium (N)	Total Kjeldahl Nitrogen	Total Phosphorus	Reactive Phosphorus	Total Suspended Solids	Chlorophyll-a (mg/M3 [ug/L])	As	Ca	Cu	Fe	K	Mg	Mn	Na	P	Pb	SO_4	Zn
Date Prepared		13-Sep	13-Sep	11-Sep	20-Sep	20-Sep	11-Sep	4-Oct	19-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep
Date Analyzed		14-Sep	14-Sep	12-Sep	21-Sep	21-Sep	12-Sep	9-Oct	21-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep	12-Sep
Method		4500 NO3 F	4500 Cl E	4500 NH3 H	4500-NH3 G	4500 P F	4500 P F	2540 D	10200 H	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7	EPA 200.7
Lab #	Site																				
497-12-1	Fox Creek	0.7	6.6	0.10	0.65	0.050	0.038	4													
497-12-2	Apple RF Inlet	0.1	5.0	0.02	0.48	0.058	0.046	<2													
497-12-3	Apple RF Outlet	<0.1	6.6	0.03	0.56	0.059	0.034	<2													
497-12-4	Main Stem	0.8	9.1	0.02	0.27	0.052	0.045	<2													
497-12-5	Beaver Brk East	1.1	15.4	0.05	0.50	0.200	0.182	10													
497-12-6	Beaver Brk West	1.8	7.9	0.03	0.46	0.040	0.035	3													
497-12-7	ARF Site 1 North	<0.1	6.6	0.01	0.66	0.067	0.023	<2	6	0.015	33.0	0.019	0.022	2.3	12.1	0.017	5	0.03	<0.002	6.4	0.008
497-12-8	ARF Site 2 South	<0.1	6.5	0.04	0.67	0.070	0.043	5		0.016	34.4	0.025	0.066	2.2	12.6	0.138	5	0.05	<0.002	6.9	0.025

Sample dropped at lab

WATER & ENVIRONMENTAL ANALYSIS LAB - DATA REPORT FORM

REPORT IDENTIFICATION: POLK CO LWRD
Sample Location: ARF
Date Sampled: OCTOBER 15, 2012
Sample Time:
Date Received in Lab: OCTOBER 16, 2012
Purchase Order #:
WEAL Invoice: 139866

Sampled By: KH, JW
Preserved: H2SO4, HNO3
Sample Type:
Field Filtered:
Circumstances that may affect results: °

FLAGS
B = Blank Contamination
D = Dilution
HT = Holding Time
J = Between LOD & LOQ (est.)
Q = QC Failure
R = Rejected

UW-STEVENS POINT
CNR, Room 200
Stevens Point, WI 54481
(715) 346-3209

DNR Cert. No. 750040280

ALL DATA mg/l UNLESS NOTED		pH (S.U.)	Conductivity	Alkalinity	Calcium	Magnesium	Reactive Phosphorus	Total Phosphorus	Ammonium (N)	NO2+NO3(N)	Total Kjeldahl Nitrogen	Chloride	Sulfate	Sodium	Potassium	Turbidity (NTU)	Color		
Date Prepared		25-Oct	25-Oct	26-Oct	15-Nov	15-Nov	22-Oct	18-Oct	22-Oct	23-Oct	18-Oct	23-Oct	15-Nov	15-Nov	15-Nov	12-Nov	6-Nov		
Date Analyzed		25-Oct	25-Oct	26-Oct	15-Nov	15-Nov	23-Oct	19-Oct	23-Oct	24-Oct	19-Oct	24-Oct	15-Nov	15-Nov	15-Nov	2-Nov	6-Nov		
Method		4500 H B	2510 B	2320B	EPA 200.7	EPA 200.7	4500 P F	4500 P F	4500-NH3 G	4500 NO3 F	4500-NH3 G	4500 Cl E	EPA 200.7	EPA 200.7	EPA 200.7	2130 B	20-Oct		
Lab #	Site																		
558-12-1	Apple River Flowage																		
	Site 2 South	7.69	264	144	33.927	12.498	0.020	0.067	0.02	<0.1	0.93	7.3	5.74	4.82	1.88	12.0	19.6		
558-12-2	Apple River Flowage																		
	Site 1 North	8.15	251	140	34.405	12.876	0.016	0.035	0.01	0.2	0.50	6.7	5.15	5.94	3.67	2.1	12.7		

Appendix C

Physical Data: In-lake and Tributary

Apple River Flowage: Site 1, 45.21.406, 92.21.053

Date	Depth (m)	DO (mg/l)	Conduct (ms/s)	SpCond (ms/s)	Temp (oC)	Salinity (ppt)	pH	ORP	Secchi (ft)
4/3/2012	0	9.84	152	212	10.10	0.10	9.14		4
	1	9.77	152	212	10.10	0.10	9.15		
	2	9.61	152	212	10.10	0.10	9.11		
	2.5	9.72	152	212	10.10	0.10	9.09		
5/8/2012	0	7.49	165	201	15.70	0.10	8.71		6.5
	1	7.16	166	201	15.70	0.10	8.33		
	2	6.65	167	203	15.60	0.10	8.02		
	2.5	3.87	180	225	14.60	0.10	7.91		
5/22/2012	0	6.96	202	224	20.00	0.10	8.22		5
	1	5.98	200	225	19.20	0.10	7.66		
	2	4.70	195	225	18.20	0.10	7.30		
	2.5	3.76	197	228	17.90	0.10	7.03		
6/5/2012	0	6.01	211	220	22.90	0.10	7.96		5.5
	1	5.77	207	223	21.20	0.10	7.94		
	2	2.59	201	227	18.90	0.10	6.90		
	2.5	0.08	209	244	17.70	0.10	6.03		
6/19/2012	0	4.86	208	222	21.60	0.10	8.05		6
	1	4.65	211	226	21.50	0.10	6.82		
	2	4.36	214	229	21.30	0.10	5.62		
	2.5	1.39	215	243	18.90	0.10	5.22		
7/11/2012									5.5
7/24/2012	0	7.25	246	254	26.75	0.12	8.57	147.0	5
	1	6.81	247	255	26.70	0.12	8.55	146.5	
	2	0.54	251	251	25.04	0.12	7.46	179.7	
	2.5	0.00	254	251	24.44	0.12	7.25	187.2	
8/7/2012	0	6.60	233	233	24.88	0.11	8.94	101.8	6
	1	6.24	235	233	24.73	0.11	8.88	109.8	
	2	2.09	238	229	23.19	0.11	8.48	28.8	
	2.5	3.21	240	228	22.56	0.11	8.65	-75.3	
8/22/2012	0	8.57	240	223	21.23	0.11	9.58	-11.1	6
	1	8.40	240	223	21.18	0.11	9.62	-87.4	
	2	5.70	243	218	19.73	0.12	9.30	-92.8	
	2.5	4.17	246	220	19.51	0.12	9.21	-92.2	
9/6/2012	0	9.12	249	242	23.37	0.12	9.36	-75.6	4
	1	9.01	251	243	23.32	0.12	9.31	-75.1	
	2	8.39	248	235	22.15	0.12	9.47	-69.3	
	2.5	4.34	253	237	21.68	0.12	9.07	-69.1	
9/17/2012	0	8.52	247	210	17.23	0.12	9.32	-62.9	5
	1	8.02	247	211	17.26	0.12	9.32	-68.6	
	2	8.36	248	211	17.24	0.12	9.29	-71.1	
	2.5	7.38	250	213	17.24	0.12	9.24	-81.1	
10/15/2012	0	12.93	238	160	7.69	0.11			7.0
	1	12.12	238	160	7.58	0.11			
	2	11.98	240	160	7.49	0.11			
	2.5	11.81	241	161	7.47	0.12			

Apple River Flowage: Site 2, 45.19.057, 92.21.281

Date	Depth (m)	DO (mg/l)	Conduct (ms/s)	SpCond (ms/s)	Temp (oC)	Salinity (ppt)	pH	ORP	Secchi (ft)
4/3/2012	0	9.39	142	197	10.40	0.10	8.66		4.0
	1	9.03	142	197	10.40	0.10	8.66		
	2	7.91	142	197	10.30	0.10	8.65		
5/8/2012	0	6.53	170	206	15.80	0.10	8.67		5.0
	1	6.04	170	206	15.70	0.10	8.29		
	2	3.28	172	210	15.50	0.10	7.95		
5/22/2012	0	9.35	198	214	21.10	0.10	8.08		4.5
	1	7.55	198	221	19.40	0.10	7.35		
	2	4.48	199	225	18.90	0.10	7.14		
6/5/2012	0	6.94	203	213	22.70	0.10	7.91		5.0
	1	6.24	201	218	21.00	0.10	7.09		
	1.5	5.53	200	217	20.80	0.10	7.00		
6/19/2012	0	7.41	220	229	23.00	0.10	7.70		3.5
	1	6.59	218	229	21.80	0.10	6.65		
	2	4.36	215	232	21.20	0.10	5.76		
7/11/2012									4.0
7/24/2012	0	4.68	251	258	28.58	0.12	8.07	125.4	3.0
	1	2.07	252	258	26.29	0.12	7.81	139.1	
	2	0.00	318	318	24.89	0.15	7.24	-164.9	
8/7/2012	0	5.76	217	216	24.66	0.10	8.57	72.4	5.0
	1	2.79	233	225	23.35	0.11	8.27	94.5	
	1.5	1.34	254	243	22.78	0.12	8.18	-16.2	
8/22/2012	0	6.67	256	241	21.89	0.12	9.07	-148.3	4.0
	1	4.15	273	248	20.24	0.13	8.96	-138.3	
	1.5	1.63	283	256	19.86	0.14	8.89	-157.1	
9/6/2012	0	7.31	242	235	23.60	0.11	8.70	-95.5	6.0
	1	5.20	256	244	22.42	0.12	8.66	-94.6	
	1.5	3.89	258	244	22.29	0.12	8.64	-93.8	
9/17/2012	0	6.19	249	214	17.51	0.12	8.83	-67.9	4.5
	1	6.03	250	215	17.54	0.12	8.75	-72.0	
	1.5	5.84	250	215	17.53	0.12	8.73	-73.5	
10/15/2012	0	12.63	229	156	8.39	0.11			4.0
	1	11.89	229	156	8.08	0.11			
	1.5	12.12	232	157	8.05	0.11			

Fox Creek Inlet

Date	Feet	Depth	Flow
5/8/12	0	0.2	0.01
	1	0.9	0.01
	2	1.0	0.01
	3	0.9	0.14
	4	0.9	0.27
	5	1.1	0.47
	6	1.1	0.36
	7	1.9	0.69
	8	1.7	0.78
	9	2.0	0.66
	10	2.1	0.60
	11	2.1	0.67
	12	2.2	0.48
	13	2.4	0.46
	14	2.4	0.60
	15	2.3	0.56
	16	2.4	0.67
	17	2.4	0.67
	18	2.4	0.75
	19	2.0	0.34
	20	1.8	0.31
	21	1.6	0.36
	22	1.2	0.36
	23	0.7	0.31
	24	0.7	0.19
	25	0.4	0.01
5/22/12	0	0.4	0.00
	1	0.5	0.00
	2	0.9	0.00
	3	1.0	0.17
	4	1.0	0.39
	5	1.1	0.36
	6	1.1	0.64
	7	1.3	0.74
	8	1.3	0.70
	9	1.5	0.66
	10	1.6	0.56
	11	1.7	0.57
	12	1.7	0.64
	13	1.6	0.71
	14	1.8	0.68
	15	1.7	0.78
	16	1.7	0.73
	17	1.4	0.24
	18	1.5	0.05
	19	0.9	0.02
	20	0.2	0.00
6/5/12	0	0.2	0.00
	1	0.5	0.02
	2	1.0	0.03
	3	1.0	0.15
	4	1.5	0.32
	5	1.3	0.35
	6	2.1	0.18
	7	2.1	0.79
	8	2.0	0.79
	9	2.1	0.68
	10	1.9	0.58
	11	1.9	0.74
	12	1.8	0.49
	13	1.9	0.47
	14	1.9	0.67
	15	1.8	0.73
	16	1.6	0.87
	17	1.4	0.82
	18	1.6	0.68
	19	1.4	0.44
	20	1.3	0.39
	21	1.2	0.16
	22	1.1	0.06
	23	0.7	0.00
	24	0.6	0.00
6/19/12	0	0.7	0.24
	1	0.9	0.20
	2	1.3	0.42
	3	1.7	0.42
	4	1.8	0.59
	5	2.1	0.35
	6	2.4	0.52
	7	2.6	0.78
	8	2.6	0.73
	9	2.6	0.69
	10	2.5	0.43
	11	2.4	0.57
	12	2.6	0.53
	13	2.4	0.45
	14	2.4	0.63
	15	2.4	0.68
	16	2.3	0.80
	17	2.0	0.74
	18	2.1	0.72
	19	2.0	0.53
	20	1.9	0.33
	21	1.8	0.45
	22	1.5	0.27
	23	1.3	0.27
	24	1.3	0.15
	25	0.3	0.08
	26	0.0	0.00
7/11/12	0	0.7	0.07
	1	1.0	0.12
	2	1.1	0.18
	3	1.5	0.19
	4	1.8	0.15
	5	2.0	0.20
	6	2.2	0.12
	7	2.5	0.26
	8	2.2	0.20
	9	2.5	0.32
	10	2.5	0.24
	11	2.3	0.29
	12	2.4	0.30
	13	2.4	0.27
	14	2.3	0.28
	15	2.2	0.27
	16	2.2	0.07
	17	2.1	0.23
	18	2.0	0.17
	19	2.0	0.24
	20	1.9	0.23
	21	1.8	0.11
	22	1.7	0.11
	23	1.4	0.16
	24	1.3	0.15
	25	1.0	0.05
	26	0.5	0.05
	27	0.2	0.00
7/24/12	0	0.5	0.04
	1	0.8	0.05
	2	1.1	0.13
	3	1.5	0.14
	4	1.9	0.13
	5	1.9	0.14
	6	2.0	0.16
	7	2.1	0.22
	8	2.2	0.23
	9	2.1	0.17
	10	2.3	0.15
	11	2.4	0.08
	12	2.4	0.12
	13	2.4	0.16
	14	2.4	0.22
	15	2.6	0.31
	16	2.6	0.20
	17	2.7	0.16
	18	2.6	0.22
	19	2.7	0.07
	20	2.7	0.28
	21	2.4	0.21
	22	2.1	0.17
	23	1.7	0.19
	24	1.3	0.18
	25	1.3	0.12
	26	1.0	0.09
8/7/12	0	0.4	0.01
	1	0.4	0.01
	2	0.5	0.01
	3	1.3	0.08
	4	1.7	0.11
	5	1.8	0.08
	6	1.9	0.11
	7	1.9	0.10
	8	2.1	0.04
	9	2.0	0.10
	10	2.2	0.09
	11	2.3	0.05
	12	2.3	0.09
	13	2.4	0.11
	14	2.4	0.12
	15	2.5	0.08
	16	2.4	0.21
	17	2.6	0.10
	18	2.5	0.18
	19	2.6	0.04
	20	2.6	0.01
	21	1.4	0.20
	22	2.1	0.13
	23	1.3	0.17
	24	1.6	0.15
	25	1.2	0.10
	26	0.9	0.11
	27	0.9	0.10
	28	0.6	0.05
8/22/12	0	0.2	0.00
	1	0.4	0.02
	2	1.0	0.05
	3	1.4	0.08
	4	1.4	0.06
	5	1.6	0.05
	6	1.5	0.09
	7	1.7	0.12
	8	1.9	0.08
	9	1.9	0.09
	10	1.9	0.07
	11	2.0	0.07
	12	2.1	0.12
	13	2.2	0.15
	14	1.7	0.17
	15	2.2	0.17
	16	2.1	0.11
	17	2.2	0.21
	18	2.3	0.04
	19	2.4	0.11
	20	1.2	0.19
	21	2.1	0.07
	22	1.2	0.14
	23	1.1	0.12
	24	0.9	0.11
	25	0.5	0.08
	26	0.7	0.05
9/6/12	0	0.2	0.00
	1	0.8	0.01
	2	1.1	0.07
	3	1.2	0.08
	4	1.3	0.11
	5	1.4	0.16
	6	1.4	0.17
	7	1.6	0.16
	8	1.5	0.13
	9	1.7	0.13
	10	1.6	0.18
	11	1.7	0.13
	12	1.7	0.17
	13	1.8	0.25
	14	1.8	0.17
	15	1.9	0.22
	16	1.9	0.14
	17	1.9	0.09
	18	2.0	0.16
	19	0.8	0.15
	20	1.7	0.09
	21	1.0	0.12
	22	0.7	0.09
	23	0.5	0.04
	24	0.3	0.03

Apple River Inlet

Date	Feet	Depth	Flow
5/8/12	0	1.2	0.27
	1	1.7	0.30
	2	2.0	0.30
	3	2.2	0.35
	4	2.5	0.40
	5	2.7	0.49
	6	3.0	0.49
	7	3.4	0.50
	8	3.3	0.52
	9	3.5	0.62
	10	3.6	0.65
	11	3.6	0.60
	12	3.7	0.60
	13	3.6	0.62
	14	3.7	0.63
	15	3.6	0.52
	16	3.4	0.58
	17	3.3	0.58
	18	3.1	0.64
	19	3.1	0.60
	20	3.0	0.64
	21	2.9	0.60
	22	2.8	0.57
	23	2.6	0.52
	24	2.4	0.53
	25	2.3	0.42
	26	2.1	0.43
	27	2.1	0.39
	28	2.2	0.42
	29	2.4	0.38
	30	2.2	0.36
	31	2.0	0.26
	32	2.2	0.15
	33	2.2	0.37
	34	2.0	0.45
	35	1.9	0.57
	36	1.4	0.53
	37	1.3	0.47
	38	1.4	0.52
	39	1.3	0.45
	40	1.1	0.38
	41	1.1	0.38
	42	0.7	0.32
	43	0.9	0.13
	44	0.8	0.17
	45	0.6	0.19
5/22/12	0	0.2	0.04
	1	0.3	0.06
	2	0.5	0.05
	3	0.6	0.22
	4	0.8	0.22
	5	1.0	0.18
	6	1.1	0.26
	7	1.2	0.34
	8	1.2	0.59
	9	1.3	0.65
	10	1.4	0.63
	11	1.4	0.70
	12	1.4	0.88
	13	1.5	0.77
	14	1.6	0.77
	15	1.6	0.93
	16	1.6	1.01
	17	1.5	0.86
	18	1.5	0.71
	19	1.4	0.66
	20	1.5	0.66
	21	1.5	0.59
	22	1.0	0.77
	23	1.0	0.80
	24	1.0	0.75
	25	1.0	0.68
	26	1.6	0.75
	27	1.6	0.68
	28	1.1	0.50
	29	1.1	0.52
	30	1.1	0.44
	31	1.1	0.37
	32	1.1	0.64
	33	1.0	0.30
	34	0.8	0.26
	35	0.8	0.08
	36	0.6	0.00
	37	0.5	0.00
	38	0.4	0.00
	39	0.4	0.00
	40	0.5	0.00
	41	0.5	0.00
	42	0.3	0.00
	43	0.2	0.00
6/5/12	0	0.2	0.01
	1	0.3	0.00
	2	0.4	0.04
	3	0.4	0.01
	4	0.5	0.00
	5	0.4	0.01
	6	0.5	0.02
	7	0.6	0.06
	8	0.6	0.10
	9	0.6	0.17
	10	0.8	0.16
	11	0.8	0.28
	12	0.9	0.30
	13	0.9	0.70
	14	1.0	0.44
	15	1.1	0.49
	16	1.2	0.51
	17	1.3	0.52
	18	1.3	0.59
	19	1.4	0.64
	20	1.4	0.65
	21	1.4	0.68
	22	1.4	0.79
	23	1.5	0.85
	24	1.5	0.71
	25	1.5	0.79
	26	1.6	0.97
	27	1.5	0.76
	28	1.5	0.91
	29	1.7	0.88
	30	1.7	0.92
	31	1.6	0.87
	32	1.7	0.84
	33	1.6	0.80
	34	1.6	0.86
	35	1.6	0.74
	36	1.6	0.66
	37	1.5	0.54
	38	1.4	0.45
	39	1.2	0.47
	40	1.2	0.29
	41	0.9	0.19
	42	0.9	0.13
	43	0.8	0.08
	44	0.5	0.05
	45	0.4	0.01
	46	0.2	0.04
6/19/12	0	0.4	0.00
	1	0.6	0.00
	2	0.6	0.02
	3	0.7	0.02
	4	0.9	0.03
	5	0.9	0.23
	6	0.9	0.53
	7	1.0	0.56
	8	1.0	0.57
	9	1.0	0.60
	10	1.1	0.58
	11	1.1	0.65
	12	1.2	0.66
	13	1.3	0.68
	14	1.4	0.68
	15	1.5	0.71
	16	1.5	0.66
	17	1.6	0.68
	18	1.6	0.73
	19	1.7	0.70
	20	1.7	0.73
	21	1.8	0.82
	22	1.8	0.81
	23	1.9	0.75
	24	1.9	0.78
	25	1.9	0.83
	26	1.9	0.80
	27	2.0	0.87
	28	2.0	0.94
	29	1.9	0.94
	30	2.0	0.94
	31	2.0	0.94
	32	2.1	0.94
	33	1.9	0.90
	34	2.2	0.78
	35	2.1	0.87
	36	2.1	0.72
	37	2.1	0.73
	38	1.9	0.72
	39	1.9	0.62
	40	1.9	0.55
	41	1.8	0.55
	42	1.7	0.42
	43	1.4	0.25
	44	1.3	0.23
	45	1.2	0.12
	46	0.1	0.14
	47	0.7	0.19
	48	0.7	0.23
	49	0.7	0.08
	50	0.7	0.01
	51	0.3	0.01
	52	0.2	0.00
7/11/12	0	0.2	0.00
	1	0.2	0.01
	2	0.3	0.01
	3	0.4	0.01
	4	0.4	0.02
	5	0.4	0.01
	6	0.4	0.00
	7	0.5	0.01
	8	0.5	0.02
	9	0.5	0.03
	10	0.6	0.06
	11	0.6	0.11
	12	0.8	0.17
	13	0.8	0.19
	14	0.9	0.25
	15	1.0	0.25
	16	1.0	0.31
	17	1.1	0.34
	18	1.1	0.39
	19	1.1	0.42
	20	1.4	0.42
	21	1.3	0.55
	22	1.4	0.58
	23	1.4	0.60
	24	1.3	0.53
	25	1.4	0.52
	26	1.4	0.63
	27	1.4	0.46
	28	1.4	0.64
	29	1.5	0.63
	30	1.5	0.62
	31	1.5	0.64
	32	1.5	0.72
	33	1.5	0.62
	34	1.5	0.58
	35	1.5	0.49
	36	1.4	0.45
	37	1.2	0.44
	38	1.3	0.30
	39	1.2	0.25
	40	1.0	0.15
	41	0.9	0.12
	42	0.8	0.10
	43	0.3	0.01
	44	0.3	0.06
	45	0.2	0.01
	46	0.2	0.00
7/24/12	0	0.1	0.00
	1	0.2	0.00
	2	0.3	0.00
	3	0.4	0.03
	4	0.5	0.01
	5	0.5	0.01
	6	0.6	0.04
	7	0.6	0.16
	8	0.6	0.21
	9	0.6	0.23
	10	0.6	0.27
	11	0.8	0.28
	12	0.9	0.28
	13	0.9	0.30
	14	1.0	0.31
	15	1.0	0.29
	16	1.1	0.32
	17	1.2	0.29
	18	1.2	0.34
	19	1.3	0.33
	20	1.4	0.38
	21	1.3	0.29
	22	1.4	0.44
	23	1.4	0.42
	24	1.5	0.45
	25	1.5	0.45
	26	1.5	0.44
	27	1.6	0.46
	28	1.6	0.54
	29	1.6	0.45
	30	1.5	0.52
	31	1.6	0.47
	32	1.6	0.56
	33	1.7	0.44
	34	1.7	0.52
	35	1.7	0.49
	36	1.6	0.50
	37	1.6	0.44
	38	1.4	0.40
	39	1.7	0.33
	40	1.4	0.33
	41	1.3	0.35
	42	1.4	0.25
	43	1.1	0.08
	44	1.0	0.07
	45	0.9	0.05
	46	0.9	0.04
	47	0.6	0.04
	48	0.5	0.01
	49	0.6	0.07
	50	0.5	0.07
	51	0.3	0.01
	52	0.1	0.00
8/7/12	0	0.2	0.00
	1	0.3	0.02
	2	0.4	0.01
	3	0.4	0.01
	4	0.4	0.01
	5	0.5	0.03
	6	0.5	0.08
	7	0.6	0.12
	8	0.6	0.12

	9	0.7	0.12
	10	0.7	0.12
	11	0.7	0.14
	12	0.8	0.17
	13	0.9	0.17
	14	0.9	0.22
	15	1.0	0.17
	16	1.0	0.25
	17	1.1	0.27
	18	1.2	0.31
	19	1.2	0.36
	20	1.2	0.31
	21	1.2	0.37
	22	1.3	0.40
	23	1.4	0.43
	24	1.4	0.40
	25	1.4	0.46
	26	1.5	0.52
	27	1.5	0.50
	28	1.5	0.49
	29	1.5	0.55
	30	1.5	0.49
	31	1.5	0.46
	32	1.6	0.46
	33	1.6	0.44
	34	1.5	0.39
	35	1.5	0.44
	36	1.4	0.38
	37	1.3	0.25
	38	1.2	0.30
	39	1.0	0.35
	40	1.1	0.23
	41	1.0	0.11
	42	0.9	0.09
	43	0.8	0.07
	44	0.7	0.04
	45	0.5	0.00
	46	0.3	0.00
	47	0.3	0.00
	48	0.2	0.00
8/22/12	0	0.1	0.00
	1	0.2	0.00
	2	0.3	0.00
	3	0.3	0.00
	4	0.3	0.00
	5	0.3	0.01
	6	0.5	0.03
	7	0.5	0.06
	8	0.5	0.04
	9	0.6	0.03
	10	0.6	0.08
	11	0.7	0.10
	12	0.8	0.09
	13	0.8	0.14
	14	0.9	0.13
	15	0.9	0.16
	16	1.0	0.24
	17	1.0	0.26
	18	1.1	0.31
	19	1.1	0.34
	20	1.0	0.28
	21	1.1	0.35
	22	1.2	0.42
	23	1.2	0.43
	24	1.3	0.35
	25	1.4	0.46
	26	1.4	0.47
	27	1.4	0.38
	28	1.3	0.50
	29	1.3	0.51
	30	1.2	0.57
	31	1.4	0.51
	32	1.4	0.50
	33	1.4	0.51
	34	1.4	0.45
	35	1.4	0.35
	36	1.1	0.37
	37	1.1	0.24
	38	1.1	0.25
	39	1.0	0.22
	40	1.0	0.14
	41	0.9	0.09
	42	0.8	0.07
	43	0.7	0.04
	44	0.5	0.03
	45	0.3	0.00
	46	0.3	0.00
	47	0.3	0.04
	48	0.2	0.01
9/6/12	0	0.1	0.00
	1	0.2	0.01
	2	0.2	0.00
	3	0.2	0.00
	4	0.2	0.00
	5	0.3	0.01
	6	0.4	0.01
	7	0.4	0.02
	8	0.5	0.00
	9	0.5	0.02
	10	0.6	0.07
	11	0.6	0.08
	12	0.7	0.11
	13	0.7	0.15
	14	0.8	0.23
	15	0.8	0.23
	16	0.9	0.30
	17	1.0	0.27
	18	1.0	0.38
	19	1.0	0.44
	20	1.0	0.26
	21	1.1	0.48
	22	1.1	0.46
	23	1.1	0.38
	24	1.1	0.48
	25	1.2	0.44
	26	1.3	0.38
	27	1.2	0.54
	28	1.3	0.56
	29	1.2	0.59
	30	1.3	0.41
	31	1.4	0.61
	32	1.4	0.47
	33	1.4	0.46
	34	1.4	0.53
	35	1.0	0.43
	36	1.2	0.37
	37	0.9	0.27
	38	0.9	0.34
	39	0.6	0.20
	40	0.8	0.10
	41	0.7	0.08
	42	0.7	0.03
	43	0.5	0.01
	44	0.4	0.00
	45	0.2	0.00
	46	0.2	0.02
	47	0.2	0.01

Apple River Outlet

Date	Feet	Depth	Flow
5/8/12	0	1.1	0.27
	1	1.3	0.55
	2	1.4	0.74
	3	1.5	0.81
	4	1.6	0.74
	5	1.7	0.63
	6	1.9	0.63
	7	2.0	0.61
	8	2.0	0.53
	9	2.1	0.57
	10	2.1	0.67
	11	2.1	0.67
	12	2.2	0.64
	13	2.2	0.64
	14	2.2	0.64
	15	2.2	0.63
	16	2.2	0.64
	17	2.1	0.59
	18	2.0	0.64
	19	2.1	0.54
	20	2.1	0.53
	21	2.2	0.53
	22	2.1	0.55
	23	2.0	0.55
	24	1.9	0.58
	25	1.9	0.57
	26	1.8	0.58
	27	1.7	0.62
	28	1.7	0.59
	29	1.6	0.54
	30	1.5	0.63
	31	1.5	0.60
	32	1.5	0.59
	33	1.5	0.60
	34	1.3	0.55
	35	1.3	0.58
	36	1.3	0.68
	37	1.3	0.62
	38	1.2	0.64
	39	1.2	0.70
	40	1.2	0.66
	41	1.1	0.71
	42	1.0	0.73
	43	1.1	0.77
	44	1.1	0.75
	45	1.0	0.71
	46	1.0	0.69
	47	1.0	0.73
	48	1.0	0.69
	49	0.9	0.78
	50	1.0	0.70
	51	1.0	0.70
	52	1.1	0.82
	53	1.0	0.71
	54	1.0	0.78
	55	1.0	0.73
	56	1.0	0.82
	57	1.0	0.66
	58	1.1	0.76
	59	1.1	0.80
	60	1.2	0.74
	61	1.1	0.83
	62	1.1	0.86
	63	1.0	0.94
	64	1.1	0.93
	65	1.0	0.83
	66	1.1	1.02
	67	1.1	0.96
	68	1.1	0.80
	69	1.1	0.62
	70	1.1	0.81
	71	1.0	0.80
	72	1.1	1.03
	73	1.1	1.02
	74	1.1	0.92
	75	1.1	0.97
	76	1.1	0.95
	77	1.1	0.90
	78	1.1	0.83
	79	1.1	0.87
	80	1.1	0.90
	81	1.1	0.86
	82	1.1	0.87
	83	1.2	0.74
	84	1.1	0.83
	85	1.1	0.88
	86	1.0	0.70
	87	1.1	0.80
	88	0.9	0.86
	89	1.0	0.80
	90	1.0	0.84
	91	1.0	0.91
	92	0.9	0.88
	93	0.8	0.82
	94	0.6	0.12
5/22/12	0	0.7	0.23
	1	0.9	0.29
	2	1.0	0.40
	3	1.1	0.36
	4	1.2	0.33
	5	1.3	0.29
	6	1.3	0.30
	7	1.4	0.28
	8	1.5	0.32
	9	1.5	0.32
	10	1.6	0.45
	11	1.6	0.48
	12	1.6	0.47
	13	1.6	0.47
	14	1.5	0.42
	15	1.6	0.40
	16	1.7	0.46
	17	1.7	0.38
	18	1.5	0.42
	19	1.5	0.42
	20	1.5	0.42
	21	1.5	0.41
	22	1.4	0.37
	23	1.4	0.35
	24	1.4	0.38
	25	1.0	0.45
	26	1.0	0.39
	27	1.0	0.34
	28	1.1	0.30
	29	1.0	0.34
	30	0.9	0.31
	31	0.9	0.34
	32	0.9	0.32
	33	0.9	0.37
	34	0.8	0.37
	35	0.8	0.38
	36	0.7	0.42
	37	0.8	0.39
	38	0.7	0.44
	39	0.6	0.45
	40	0.7	0.45
	41	0.6	0.42
	42	0.6	0.40
	43	0.5	0.50
	44	0.5	0.54
	45	0.6	0.49
	46	0.6	0.49
	47	0.5	0.47
	48	0.5	0.46
	49	0.5	0.48
	50	0.5	0.39
	51	0.6	0.47
	52	0.6	0.57
	53	0.5	0.53
	54	0.5	0.41
	55	0.5	0.50
	56	0.6	0.60
	57	0.6	0.58
	58	0.6	0.70
	59	0.6	0.62
	60	0.6	0.75
	61	0.6	0.74
	62	0.6	0.75
	63	0.7	0.67
	64	0.6	0.71
	65	0.6	0.80
	66	0.7	0.74
	67	0.6	0.74
	68	0.6	0.81
	69	0.7	0.81
	70	0.6	0.66
	71	0.6	0.58
	72	0.6	0.80
	73	0.7	0.68
	74	0.6	0.78
	75	0.6	0.67
	76	0.6	0.67
	77	0.6	0.67
	78	0.6	0.65
	79	0.6	0.63
	80	0.6	0.58
	81	0.6	0.60
	82	0.5	0.62
	83	0.6	0.59
	84	0.5	0.55
	85	0.4	0.65
	86	0.5	0.62
	87	0.6	0.52
	88	0.6	0.48
	89	0.5	0.52
	90	0.5	0.61
	91	0.5	0.57
	92	0.5	0.64
	93	0.5	0.61
	94	0.4	0.40
	95	0.3	0.44
	96	0.3	0.36
6/5/12	0	0.3	0.44
	1	0.5	0.45
	2	0.5	0.48
	3	0.6	0.60
	4	0.6	0.51
	5	0.6	0.59
	6	0.7	0.71
	7	0.6	0.67
	8	0.6	0.64
	9	0.7	0.64
	10	0.7	0.66
	11	0.7	0.65
	12	0.7	0.70
	13	0.7	0.71
	14	0.7	0.64
	15	0.7	0.71
	16	0.6	0.73
	17	0.7	0.74
	18	0.7	0.77
	19	0.6	0.74
	20	0.6	0.74
	21	0.7	0.76
	22	0.7	0.85
	23	0.7	0.87
	24	0.7	0.93
	25	0.7	0.59
	26	0.7	0.66
	27	0.6	0.93
	28	0.7	0.81
	29	0.7	0.87
	30	0.8	0.86
	31	0.7	0.84
	32	0.7	0.88
	33	0.7	0.76
	34	0.7	0.86
	35	0.6	0.79
	36	0.7	0.81
	37	0.6	0.84
	38	0.6	0.78
	39	0.6	0.69
	40	0.6	0.59
	41	0.6	0.59
	42	0.6	0.54
	43	0.6	0.66
	44	0.6	0.66
	45	0.6	0.66
	46	0.6	0.69
	47	0.5	0.56
	48	0.6	0.63
	49	0.6	0.55
	50	0.6	0.70
	51	0.5	0.60
	52	0.6	0.64
	53	0.6	0.59
	54	0.6	0.53
	55	0.7	0.53
	56	0.7	0.55
	57	0.7	0.63
	58	0.7	0.51
	59	0.8	0.53
	60	0.8	0.43
	61	0.8	0.44
	62	0.9	0.40
	63	0.9	0.28
	64	1.0	0.42
	65	1.0	0.35
	66	1.1	0.38
	67	1.1	0.42
	68	1.2	0.41
	69	1.2	0.43
	70	1.3	0.44
	71	1.3	0.41
	72	1.3	0.37
	73	1.4	0.37
	74	1.5	0.37
	75	1.6	0.45
	76	1.6	0.47
	77	1.6	0.45
	78	1.6	0.43
	79	1.6	0.45
	80	1.7	0.51
	81	1.7	0.48
	82	1.6	0.46
	83	1.6	0.53
	84	1.7	0.52
	85	1.7	0.53
	86	1.6	0.45
	87	1.6	0.38
	88	1.6	0.32
	89	1.5	0.31
	90	1.5	0.29
	91	1.5	0.31
	92	1.4	0.41
	93	1.3	0.41
	94	1.2	0.43
	95	0.9	0.35
	96	0.8	0.25
6/19/12	0	0.7	0.49
	1	0.8	0.66
	2	0.8	0.85
	3	0.9	0.79
	4	0.9	0.66
	5	0.9	0.70
	6	0.9	0.57
	7	0.9	0.62
	8	0.7	0.53
	9	1.0	0.63
	10	1.0	0.83
	11	1.0	0.85
	12	1.0	0.86
	13	1.0	0.77
	14	1.0	0.70
	15	1.0	0.83
	16	1.0	0.82
	17	1.0	0.77
	18	1.0	0.74

	19	1.0	0.79
	20	1.0	0.69
	21	1.0	0.78
	22	1.0	0.78
	23	1.0	0.93
	24	1.0	0.95
	25	1.0	0.76
	26	1.0	0.69
	27	1.0	0.82
	28	1.1	0.91
	29	1.0	0.99
	30	1.0	0.95
	31	1.1	0.92
	32	1.1	0.90
	33	1.0	0.90
	34	1.0	0.93
	35	1.0	0.91
	36	1.0	0.78
	37	1.0	0.83
	38	1.0	0.82
	39	0.9	0.82
	40	1.0	0.73
	41	1.0	0.68
	42	1.0	0.83
	43	1.0	0.85
	44	0.9	0.74
	45	0.9	0.71
	46	1.0	0.78
	47	1.0	0.72
	48	1.0	0.74
	49	1.0	0.79
	50	1.0	0.80
	51	1.0	0.62
	52	0.9	0.68
	53	1.0	0.66
	54	1.1	0.61
	55	1.1	0.61
	56	1.1	0.59
	57	1.2	0.68
	58	1.2	0.57
	59	1.2	0.58
	60	1.2	0.58
	61	1.4	0.53
	62	1.5	0.60
	63	1.5	0.63
	64	1.5	0.55
	65	1.6	0.62
	66	1.6	0.58
	67	1.6	0.59
	68	1.7	0.53
	69	1.7	0.55
	70	1.9	0.55
	71	1.9	0.53
	72	1.9	0.51
	73	1.9	0.53
	74	2.0	0.58
	75	2.1	0.58
	76	2.1	0.57
	77	2.1	0.58
	78	2.0	0.56
	79	2.0	0.56
	80	2.0	0.56
	81	2.0	0.52
	82	2.0	0.61
	83	1.9	0.52
	84	1.8	0.51
	85	1.7	0.54
	86	1.6	0.52
	87	1.7	0.48
	88	1.7	0.57
	89	1.6	0.62
	90	1.4	0.54
	91	1.2	0.52
	92	1.1	0.20
7/11/12	0	0.2	0.09
	1	0.3	0.37
	2	0.3	0.38
	3	0.4	0.37
	4	0.4	0.25
	5	0.4	0.23
	6	0.5	0.15
	7	0.5	0.06
	8	0.5	0.11
	9	0.5	0.13
	10	0.5	0.27
	11	0.5	0.15
	12	0.4	0.20
	13	0.4	0.31
	14	0.5	0.24
	15	0.4	0.22
	16	0.4	0.19
	17	0.5	0.36
	18	0.5	0.38
	19	0.5	0.51
	20	0.5	0.48
	21	0.5	0.47
	22	0.5	0.50
	23	0.5	0.48
	24	0.5	0.55
	25	0.5	0.56
	26	0.5	0.46
	27	0.5	0.53
	28	0.5	0.52
	29	0.5	0.51
	30	0.5	0.56
	31	0.5	0.68
	32	0.5	0.60
	33	0.4	0.64
	34	0.4	0.62
	35	0.5	0.58
	36	0.5	0.54
	37	0.5	0.55
	38	0.5	0.53
	39	0.5	0.51
	40	0.4	0.39
	41	0.4	0.40
	42	0.4	0.46
	43	0.4	0.43
	44	0.4	0.41
	45	0.4	0.40
	46	0.4	0.33
	47	0.4	0.38
	48	0.4	0.36
	49	0.4	0.41
	50	0.4	0.36
	51	0.4	0.20
	52	0.4	0.23
	53	0.4	0.34
	54	0.4	0.32
	55	0.5	0.26
	56	0.5	0.28
	57	0.5	0.24
	58	0.6	0.30
	59	0.6	0.22
	60	0.7	0.10
	61	0.7	0.26
	62	0.8	0.20
	63	0.9	0.27
	64	0.9	0.28
	65	0.9	0.28
	66	1.0	0.29
	67	1.0	0.30
	68	1.0	0.31
	69	1.1	0.28
	70	1.2	0.26
	71	1.2	0.20
	72	1.2	0.20
	73	1.2	0.31
	74	1.1	0.36
	75	1.1	0.35
	76	1.3	0.30
	77	1.3	0.32
	78	1.3	0.33
	79	1.4	0.36
	80	1.5	0.36
	81	1.5	0.40
	82	1.4	0.37
	83	1.4	0.38
	84	1.4	0.42
	85	1.4	0.43
	86	1.4	0.30
	87	1.3	0.33
	88	1.3	0.29
	89	1.3	0.27
	90	1.1	0.29
	91	1.0	0.32
	92	1.0	0.27
	93	0.9	0.23
	94	0.8	0.17
	95	0.6	0.27
	96	0.4	0.24
	97	0.2	0.05
7/24/12	0	0.5	0.32
	1	0.6	0.16
	2	0.6	0.14
	3	0.6	0.09
	4	0.6	0.02
	5	0.7	0.05
	6	0.6	0.01
	7	0.7	0.07
	8	0.7	0.02
	9	0.7	0.05
	10	0.7	0.06
	11	0.7	0.05
	12	0.7	0.10
	13	0.8	0.14
	14	0.7	0.18
	15	0.8	0.03
	16	0.7	0.12
	17	0.7	0.25
	18	0.6	0.18
	19	0.6	0.29
	20	0.7	0.30
	21	0.7	0.29
	22	0.6	0.26
	23	0.7	0.20
	24	0.7	0.37
	25	0.8	0.35
	26	0.7	0.29
	27	0.7	0.49
	28	0.7	0.49
	29	0.7	0.51
	30	0.7	0.50
	31	0.7	0.53
	32	0.7	0.50
	33	0.7	0.51
	34	0.7	0.44
	35	0.7	0.44
	36	0.7	0.40
	37	0.7	0.36
	38	0.7	0.42
	39	0.6	0.41
	40	0.6	0.38
	41	0.6	0.34
	42	0.6	0.34
	43	0.6	0.31
	44	0.6	0.34
	45	0.6	0.35
	46	0.6	0.37
	47	0.6	0.39
	48	0.7	0.37
	49	0.7	0.35
	50	0.7	0.35
	51	0.7	0.27
	52	0.7	0.25
	53	0.7	0.25
	54	0.7	0.24
	55	0.7	0.21
	56	0.7	0.17
	57	0.7	0.25
	58	0.7	0.26
	59	0.8	0.23
	60	0.9	0.22
	61	0.9	0.15
	62	1.1	0.14
	63	1.1	0.16
	64	1.1	0.21
	65	1.2	0.16
	66	1.2	0.18
	67	1.2	0.21
	68	1.3	0.24
	69	1.4	0.24
	70	1.4	0.23
	71	1.4	0.25
	72	1.6	0.27
	73	1.5	0.27
	74	1.6	0.30
	75	1.6	0.26
	76	1.6	0.23
	77	1.6	0.21
	78	1.6	0.23
	79	1.7	0.28
	80	1.7	0.31
	81	1.7	0.28
	82	1.7	0.24
	83	1.8	0.23
	84	1.7	0.30
	85	1.7	0.35
	86	1.7	0.37
	87	1.7	0.36
	88	1.7	0.31
	89	1.6	0.30
	90	1.5	0.26
	91	1.5	0.23
	92	1.3	0.29
	93	1.3	0.27
	94	1.1	0.29
	95	1.0	0.27
	96	0.7	0.20
8/7/12	0	0.7	0.22
	1	0.7	0.20
	2	0.8	0.10
	3	0.9	0.10
	4	0.9	0.05
	5	0.9	0.02
	6	0.9	0.09
	7	0.9	0.04
	8	1.0	0.08
	9	0.9	0.06
	10	0.9	0.07
	11	0.9	0.08
	12	0.9	0.01
	13	1.0	0.05
	14	0.9	0.10
	15	0.9	0.18
	16	0.9	0.13
	17	0.9	0.18
	18	0.9	0.15
	19	0.9	0.15
	20	1.0	0.18
	21	1.0	0.15
	22	0.9	0.13
	23	1.0	0.13
	24	1.0	0.22
	25	1.0	0.24
	26	1.0	0.25
	27	1.0	0.33
	28	1.0	0.40
	29	1.0	0.39
	30	1.0	0.32
	31	1.0	0.42
	32	1.0	0.37
	33	0.9	0.34
	34	1.0	0.29
	35	0.9	0.27
	36	0.9	0.21
	37	0.9	0.28
	38	0.9	0.27
	39	0.9	0.21
	40	0.9	0.21
	41	0.9	0.22
	42	0.9	0.19

	43	0.9	0.26
	44	0.9	0.26
	45	0.9	0.23
	46	0.9	0.27
	47	0.9	0.29
	48	0.9	0.24
	49	0.9	0.15
	50	0.9	0.11
	51	0.9	0.10
	52	0.9	0.10
	53	0.9	0.13
	54	1.0	0.16
	55	1.0	0.17
	56	1.0	0.17
	57	1.0	0.16
	58	1.0	0.17
	59	1.0	0.07
	60	1.0	0.07
	61	1.2	0.07
	62	1.2	0.02
	63	1.3	0.11
	64	1.3	0.14
	65	1.3	0.18
	66	1.4	0.15
	67	1.5	0.20
	68	1.5	0.16
	69	1.5	0.15
	70	1.5	0.18
	71	1.6	0.17
	72	1.7	0.14
	73	1.8	0.14
	74	1.8	0.15
	75	1.9	0.14
	76	1.9	0.15
	77	1.9	0.17
	78	2.0	0.23
	79	2.0	0.23
	80	1.9	0.22
	81	1.9	0.29
	82	1.9	0.26
	83	1.9	0.30
	84	1.9	0.33
	85	1.9	0.37
	86	1.9	0.37
	87	1.8	0.36
	88	1.8	0.33
	89	1.8	0.29
	90	1.7	0.29
	91	1.5	0.33
	92	1.5	0.35
	93	1.3	0.38
	94	1.1	0.29
	95	0.9	0.10
8/22/12	0	0.5	0.05
	1	0.6	0.24
	2	0.5	0.22
	3	0.6	0.05
	4	0.7	0.11
	5	0.7	0.08
	6	0.7	0.15
	7	0.7	0.10
	8	0.7	0.10
	9	0.7	0.08
	10	0.7	0.12
	11	0.7	0.10
	12	0.7	0.09
	13	0.7	0.08
	14	0.7	0.12
	15	0.7	0.08
	16	0.7	0.07
	17	0.7	0.07
	18	0.8	0.16
	19	0.8	0.19
	20	0.7	0.23
	21	0.7	0.20
	22	0.8	0.13
	23	0.8	0.15
	24	0.8	0.15
	25	0.8	0.18
	26	0.7	0.22
	27	0.8	0.26
	28	0.7	0.43
	29	0.8	0.45
	30	0.8	0.35
	31	0.8	0.30
	32	0.8	0.43
	33	0.8	0.41
	34	0.8	0.39
	35	0.8	0.31
	36	0.7	0.29
	37	0.7	0.24
	38	0.7	0.20
	39	0.7	0.23
	40	0.7	0.27
	41	0.7	0.24
	42	0.7	0.22
	43	0.7	0.21
	44	0.7	0.23
	45	0.7	0.22
	46	0.7	0.22
	47	0.7	0.20
	48	0.7	0.22
	49	0.7	0.18
	50	0.7	0.18
	51	0.7	0.15
	52	0.6	0.16
	53	0.7	0.13
	54	0.8	0.14
	55	0.7	0.10
	56	0.9	0.10
	57	0.9	0.04
	58	0.9	0.08
	59	1.0	0.07
	60	0.7	0.03
	61	1.1	0.03
	62	1.1	0.03
	63	1.2	0.06
	64	1.2	0.05
	65	1.3	0.07
	66	1.4	0.09
	67	1.4	0.15
	68	1.4	0.13
	69	1.5	0.11
	70	1.5	0.13
	71	1.5	0.13
	72	1.5	0.12
	73	1.5	0.15
	74	1.6	0.16
	75	1.7	0.15
	76	1.7	0.15
	77	1.8	0.17
	78	1.8	0.17
	79	1.9	0.18
	80	1.9	0.22
	81	1.8	0.32
	82	1.8	0.25
	83	1.7	0.30
	84	1.6	0.32
	85	1.6	0.24
	86	1.6	0.24
	87	1.4	0.22
	88	1.3	0.34
	89	1.4	0.35
	90	1.3	0.25
	91	1.2	0.13
	92	1.0	0.24
	93	0.9	0.32
	94	0.7	0.12
	95	0.7	0.04
9/6/12	0	0.2	0.45
	1	0.3	0.43
	2	0.4	0.41
	3	0.4	0.46
	4	0.4	0.52
	5	0.5	0.60
	6	0.5	0.66
	7	0.5	0.53
	8	0.6	0.52
	9	0.5	0.25
	10	0.5	0.50
	11	0.5	0.09
	12	0.5	0.01
	13	0.5	0.08
	14	0.5	0.61
	15	0.5	0.63
	16	0.5	0.67
	17	0.5	0.63
	18	0.5	0.45
	19	0.6	0.57
	20	0.6	0.66
	21	0.6	0.68
	22	0.6	0.59
	23	0.6	0.48
	24	0.5	0.26
	25	0.5	0.40
	26	0.4	0.08
	27	0.5	0.01
	28	0.5	0.00
	29	0.5	0.01
	30	0.5	0.05
	31	0.5	0.46
	32	0.5	0.72
	33	0.5	0.66
	34	0.5	0.76
	35	0.6	0.66
	36	0.5	0.67
	37	0.5	0.65
	38	0.5	0.67
	39	0.5	0.65
	40	0.4	0.66
	41	0.5	0.47
	42	0.5	0.53
	43	0.5	0.53
	44	0.5	0.53
	45	0.5	0.41
	46	0.5	0.36
	47	0.5	0.31
	48	0.5	0.31
	49	0.5	0.33
	50	0.5	0.34
	51	0.5	0.34
	52	0.5	0.32
	53	0.5	0.32
	54	0.5	0.31
	55	0.5	0.30
	56	0.6	0.31
	57	0.6	0.29
	58	0.6	0.26
	59	0.7	0.23
	60	0.8	0.21
	61	0.8	0.29
	62	0.8	0.27
	63	0.9	0.30
	64	0.9	0.29
	65	0.9	0.31
	66	1.0	0.31
	67	1.0	0.29
	68	1.1	0.20
	69	1.2	0.20
	70	1.3	0.20
	71	1.4	0.16
	72	1.4	0.27
	73	1.4	0.25
	74	1.4	0.38
	75	1.5	0.28
	76	1.4	0.22
	77	1.4	0.22
	78	1.4	0.33
	79	1.6	0.24
	80	1.6	0.26
	81	1.5	0.26
	82	1.5	0.32
	83	1.4	0.40
	84	1.4	0.39
	85	1.3	0.27
	86	1.3	0.35
	87	1.3	0.25
	88	1.3	0.27
	89	1.2	0.26
	90	1.0	0.25
	91	1.0	0.26
	92	0.8	0.28
	93	0.6	0.23
	94	0.5	0.17
	95	0.2	0.01

Main Stem

Date	Feet	Depth	Flow
5/8/12	0	0.1	0.00
	1	0.6	0.01
	2	1.1	0.20
	3	1.7	0.39
	4	2.2	0.31
	5	2.6	0.23
	6	2.6	0.28
	7	2.5	0.43
	8	2.4	0.50
	9	2.3	0.42
	10	2.2	0.48
	11	2.2	0.58
	12	2.2	0.63
	13	2.0	0.62
	14	1.9	0.62
	15	1.7	0.58
	16	1.6	0.55
	17	1.7	0.52
	18	1.7	0.49
	19	1.7	0.45
	20	1.6	0.30
	21	1.9	0.21
	22	0.7	0.14
	23	1.2	0.04
5/22/12	0	0.7	0.03
	1	0.6	0.13
	2	1.7	0.11
	3	1.6	0.11
	4	1.9	0.16
	5	1.8	0.17
	6	1.7	0.22
	7	1.6	0.23
	8	1.5	0.26
	9	1.5	0.22
	10	1.5	0.28
	11	1.5	0.30
	12	1.5	0.30
	13	1.6	0.29
	14	1.5	0.29
	15	1.4	0.22
	16	1.2	0.17
	17	1.1	0.14
	18	1.0	0.08
	19	0.5	0.03
6/5/12	0	0.3	0.00
	1	0.4	0.01
	2	1.0	0.09
	3	1.9	0.06
	4	1.9	0.10
	5	1.9	0.10
	6	2.0	0.24
	7	1.8	0.28
	8	1.6	0.27
	9	1.5	0.28
	10	1.6	0.34
	11	1.6	0.35
	12	1.6	0.34
	13	1.6	0.37
	14	1.6	0.33
	15	1.5	0.33
	16	1.4	0.31
	17	1.4	0.26
	18	1.3	0.15
	19	1.3	0.12
	20	0.9	0.01
	21	0.3	0.00
6/19/12	0	0.2	0.00
	1	0.5	0.02
	2	1.0	0.22
	3	2.1	0.25
	4	2.4	0.26
	5	2.4	0.18
	6	2.4	0.26
	7	2.4	0.40
	8	2.4	0.42
	9	2.3	0.44
	10	2.3	0.46
	11	2.3	0.53
	12	2.2	0.49
	13	2.2	0.53
	14	2.1	0.56
	15	2.1	0.45
	16	2.0	0.54
	17	1.9	0.43
	18	1.8	0.36
	19	1.7	0.29
	20	1.7	0.15
	21	1.6	0.12
	22	1.2	0.02
	23	0.7	0.00
7/11/12	0	0.6	0.01
	1	0.3	0.05
	2	0.7	0.05
	3	1.4	0.10
	4	1.5	0.10
	5	1.4	0.08
	6	1.4	0.14
	7	1.4	0.13
	8	1.4	0.14
	9	1.4	0.19
	10	1.3	0.22
	11	1.3	0.22
	12	1.3	0.26
	13	1.2	0.19
	14	1.2	0.21
	15	1.2	0.20
	16	1.1	0.16
	17	0.9	0.12
	18	1.0	0.12
	19	1.0	0.06
	20	0.5	0.03
7/24/12	0	0.5	0.02
	1	0.9	0.03
	2	1.4	0.06
	3	1.5	0.10
	4	1.4	0.09
	5	1.4	0.10
	6	1.4	0.13
	7	1.4	0.13
	8	1.4	0.15
	9	1.3	0.18
	10	1.3	0.21
	11	1.3	0.22
	12	1.2	0.18
	13	1.2	0.17
	14	1.1	0.16
	15	1.0	0.15
	16	0.8	0.14
	17	0.9	0.12
	18	0.7	0.04
	19	0.4	0.01
8/7/12	0	0.5	0.01
	1	0.3	0.02
	2	1.6	0.07
	3	1.6	0.08
	4	1.4	0.08
	5	1.3	0.11
	6	1.3	0.12
	7	1.3	0.11
	8	1.3	0.11
	9	1.3	0.14
	10	1.2	0.13
	11	1.2	0.19
	12	1.2	0.15
	13	1.2	0.15
	14	1.1	0.15
	15	1.1	0.14
	16	0.8	0.12
	17	0.8	0.11
	18	0.7	0.05
	19	0.4	0.01
8/22/12	0	0.5	0.01
	1	0.8	0.02
	2	1.3	0.06
	3	1.4	0.06
	4	1.3	0.07
	5	1.3	0.10
	6	1.3	0.08
	7	1.3	0.11
	8	1.4	0.09
	9	1.2	0.14
	10	1.2	0.16
	11	1.2	0.16
	12	1.2	0.11
	13	1.1	0.14
	14	1.1	0.12
	15	0.9	0.10
	16	0.8	0.10
	17	0.8	0.08
	18	0.7	0.03
	19	0.2	0.00
9/6/12	0	0.5	0.00
	1	0.3	0.04
	2	1.6	0.04
	3	1.5	0.05
	4	1.3	0.06
	5	1.3	0.05
	6	1.3	0.08
	7	1.3	0.09
	8	1.3	0.10
	9	1.2	0.12
	10	1.2	0.13
	11	1.2	0.12
	12	1.2	0.13
	13	1.1	0.13
	14	1.1	0.10
	15	0.9	0.10
	16	0.8	0.08
	17	0.8	0.07
	18	0.7	0.04
	19	0.3	0.01

Beaver Brook West

Date	Feet	Depth	Flow
5/8/12	0	1.1	0.14
	1	1.2	0.26
	2	1.5	0.58
	3	1.4	0.76
	4	1.5	0.75
	5	1.5	0.76
	6	1.6	0.56
	7	1.6	0.48
	8	1.5	0.27
5/22/12	0	0.5	0.17
	1	0.6	0.20
	2	0.9	0.29
	3	0.8	0.34
	4	1.0	0.34
	5	1.0	0.44
	6	1.0	0.36
	7	0.9	0.39
	8	0.6	0.31
	9	0.6	0.18
	10	0.5	0.12
	11	0.5	0.01
6/5/12	0	0.2	0.09
	1	0.3	0.17
	2	0.7	0.11
	3	0.7	0.03
	4	0.8	0.32
	5	0.9	0.42
	6	1.0	0.49
	7	1.1	0.43
	8	1.0	0.48
	9	0.8	0.48
	10	1.0	0.42
	11	1.0	0.28
	12	0.6	0.31
	13	0.7	0.19
	14	0.7	0.11
	15	0.4	0.01
6/19/12	0	0.2	0.12
	1	0.2	0.18
	2	0.8	0.08
	3	0.8	0.30
	4	0.9	0.42
	5	1.0	0.44
	6	1.0	0.38
	7	1.1	0.40
	8	1.0	0.40
	9	1.0	0.35
	10	0.9	0.29
	11	0.8	0.27
	12	0.8	0.23
	13	0.7	0.16
	14	0.7	0.06
	15	0.3	0.01
7/11/12	0	0.2	0.00
	1	0.3	0.03
	2	0.4	0.09
	3	0.3	0.13
	4	0.4	0.13
	5	0.6	0.42
	6	0.7	0.27
	7	0.8	0.32
	8	0.8	0.41
	9	0.8	0.39
	10	0.7	0.24
	11	0.6	0.20
	12	0.2	0.00
	13	0.4	0.00
7/24/12	0	0.1	0.00
	1	0.2	0.00
	2	0.2	0.08
	3	0.5	0.01
	4	0.5	0.09
	5	0.6	0.38
	6	0.6	0.31
	7	0.6	0.28
	8	0.5	0.02
	9	0.3	0.00
	10	0.3	0.00
	11	0.2	0.00
8/7/12	0	0.1	0.01
	1	0.2	0.00
	2	0.3	0.14
	3	0.4	0.06
	4	0.5	0.14
	5	0.4	0.29
	6	0.4	0.21
	7	0.5	0.16
	8	0.3	0.02
	9	0.2	0.03
8/22/12	0	0.1	0.01
	1	0.1	0.05
	2	0.2	0.09
	3	0.3	0.05
	4	0.2	0.15
	5	0.2	0.26
	6	0.3	0.21
	7	0.3	0.01
	8	0.2	0.00
9/6/12	0	0.1	0.01
	1	0.1	0.04
	2	0.2	0.00
	3	0.3	0.06
	4	0.4	0.12
	5	0.4	0.15
	6	0.4	0.10
	7	0.2	0.17
	8	0.2	0.00

Beaver Brook East

Date	Feet	Depth	Flow
5/8/12	0	0.7	0.25
	1	0.8	0.37
	2	0.9	0.38
	3	1.0	0.34
	4	1.0	0.43
	5	1.0	0.39
	6	1.0	0.34
	7	1.0	0.34
	8	1.0	0.35
	9	1.0	0.33
	10	0.8	0.30
	11	0.8	0.28
	12	0.5	0.22
5/22/12	0	0.2	0.01
	1	0.3	0.07
	2	0.5	0.07
	3	0.5	0.11
	4	0.6	0.09
	5	0.6	0.08
	6	0.6	0.07
	7	0.4	0.08
	8	0.4	0.08
	9	0.4	0.08
	10	0.4	0.06
	11	0.3	0.03
6/5/12	0	0.2	0.00
	1	0.5	0.08
	2	0.5	0.14
	3	0.6	0.19
	4	0.5	0.18
	5	0.5	0.19
	6	0.5	0.19
	7	0.4	0.04
	8	0.4	0.06
	9	0.3	0.04
	10	0.3	0.19
	11	0.2	0.13
	12	0.3	0.04
	13	0.2	0.20
6/19/12	0	0.2	0.17
	1	0.4	0.38
	2	1.1	0.14
	3	1.1	0.41
	4	1.1	0.38
	5	0.8	0.42
	6	0.9	0.41
	7	0.9	0.43
	8	0.9	0.32
	9	0.7	0.45
	10	0.8	0.43
	11	0.8	0.47
	12	0.6	0.50
	13	0.5	0.36
	14	0.6	0.13
	15	0.4	0.09
7/11/12	0	0.3	0.01
	1	0.2	0.01
	2	0.4	0.14
	3	0.5	0.13
	4	0.5	0.09
	5	0.4	0.04
	6	0.3	0.04
	7	0.2	0.02
	8	0.2	0.03
	9	0.1	0.00
	10	0.05	0.00
	11	0.0	0.00
	12	0.05	0.02
	13	0.2	0.16
	14	0.1	0.01
	15	0.1	0.01
7/24/12	0	0.2	0.00
	1	0.2	0.01
	2	0.5	0.16
	3	0.6	0.15
	4	0.6	0.13
	5	0.4	0.08
	6	0.5	0.01
	7	0.2	0.02
	8	0.2	0.02
	9	0.1	0.00
	10	0.1	0.00
	11	0.1	0.01
	12	0.2	0.12
	13	0.1	0.29
	14	0.1	0.10
	15	0.2	0.06
	16	0.1	0.02
8/7/12	0	0.3	0.01
	1	0.3	0.06
	2	0.3	0.07
	3	0.5	0.09
	4	0.5	0.05
	5	0.4	0.01
	6	0.3	0.08
	7	0.3	0.06
	8	0.3	0.03
	9	0.3	0.00
	10	0.2	0.01
8/22/12	0	0.3	0.03
	1	0.1	0.04
	2	0.4	0.09
	3	0.5	0.09
	4	0.5	0.12
	5	0.2	0.07
	6	0.3	0.03
	7	0.1	0.00
	8	0.1	0.01
	9	0.1	0.00
	10	0.0	0.00
	11	0.0	0.00
	12	0.1	0.06
	13	0.1	0.04
	14	0.0	0.00
	15	0.1	0.06
	16	0.1	0.03
9/6/12	0	0.3	0.02
	1	0.1	0.00
	2	0.2	0.03
	3	0.5	0.05
	4	0.4	0.12
	5	0.2	0.01
	6	0.0	0.00
	7	0.1	0.01
	8	0.0	0.00
	9	0.1	0.01
	10	0.0	0.00
	11	0.0	0.00
	12	0.1	0.04
	13	0.1	0.03
	14	0.1	0.06
	15	0.0	0.00

Appendix D

Phytoplankton Data

WSLH

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000355

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:

Field #:
Collection Start: 05/08/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12
Sample Location: APPLE RIVER FLOWAGE - SITE 1 NORTH
Sample Description: COMPOSITE SAMPLER

Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Analyses and Results:

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	55.	CELLS/ML	2.2 %
FRAGILARIA SP.	BACILLARIOPHYTA	380.	CELLS/ML	15.0 %
PLACONEIS SP.	BACILLARIOPHYTA	16.	CELLS/ML	0.6 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	24.	CELLS/ML	0.9 %
SYNEDRA SP.	BACILLARIOPHYTA	8.	CELLS/ML	0.3 %
ANKISTRODESMUS SP.	CHLOROPHYTA	24.	CELLS/ML	0.9 %
QUADRIGULA SP.	CHLOROPHYTA	63.	CELLS/ML	2.5 %
SCENEDESMUS SP.	CHLOROPHYTA	32.	CELLS/ML	1.3 %
DINOBRYON SP.	CHRYSOPHYTA	16.	CELLS/ML	0.6 %
CRYPTOMONAS SP.	CRYPTOPHYTA	158.	CELLS/ML	6.2 %
KOMMA CAUDATA	CRYPTOPHYTA	1759.	CELLS/ML	69.4 %

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http://www.slh.wisc.edu

Laboratory Report

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000355

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: ____________ Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9545808

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000357

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Field #:
Collection Start: 05/08/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12;
Sample Location: APPLE RIVER FLOWAGE - SITE 2 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
FRAGILARIA SP.	BACILLARIOPHYTA	1663.	CELLS/ML	27.4 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	20.	CELLS/ML	0.3 %
SYNEDRA SP.	BACILLARIOPHYTA	20.	CELLS/ML	0.3 %
ANKISTRODESMUS SP.	CHLOROPHYTA	40.	CELLS/ML	0.7 %
CRYPTOMONAS SP.	CRYPTOPHYTA	521.	CELLS/ML	8.6 %
KOMMA CAUDATA	CRYPTOPHYTA	3807.	CELLS/ML	62.7 %

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000357

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9545810

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000354

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Field #:
Collection Start: 06/05/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12
Sample Location: APPLE RIVER FLOWAGE - SITE 1 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	98.	CELLS/ML	6.3 %
CAVINULA SP.	BACILLARIOPHYTA	28.	CELLS/ML	1.8 %
FRAGILARIA SP.	BACILLARIOPHYTA	196.	CELLS/ML	12.5 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	19.	CELLS/ML	1.2 %
ANKISTRODESMUS SP.	CHLOROPHYTA	51.	CELLS/ML	3.3 %
CHODATELLA SP.	CHLOROPHYTA	9.	CELLS/ML	0.6 %
CLOSTERIUM SP.	CHLOROPHYTA	19.	CELLS/ML	1.2 %
COELASTRUM SP.	CHLOROPHYTA	84.	CELLS/ML	5.4 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	5.	CELLS/ML	0.3 %
GOLENKINIA SP.	CHLOROPHYTA	5.	CELLS/ML	0.3 %
SCENEDESMUS SP.	CHLOROPHYTA	19.	CELLS/ML	1.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	350.	CELLS/ML	22.4 %
KOMMA CAUDATA	CRYPTOPHYTA	681.	CELLS/ML	43.5 %

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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000354

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9545807

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000358

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/18/2013
Sample Reason:

Field #:
Collection Start: 06/05/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12;
Sample Location: APPLE RIVER FLOWAGE - SITE 2 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	68.	CELLS/ML	4.9 %
CAVINULA SP.	BACILLARIOPHYTA	102.	CELLS/ML	7.3 %
CYCLOTELLA SP.	BACILLARIOPHYTA	9.	CELLS/ML	0.6 %
FRAGILARIA SP.	BACILLARIOPHYTA	106.	CELLS/ML	7.6 %
MERIDION SP.	BACILLARIOPHYTA	26.	CELLS/ML	1.9 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	30.	CELLS/ML	2.2 %
ANKISTRODESMUS SP.	CHLOROPHYTA	47.	CELLS/ML	3.4 %
GOLENKINIA SP.	CHLOROPHYTA	4.	CELLS/ML	0.3 %
PANDORINA SP.	CHLOROPHYTA	51.	CELLS/ML	3.7 %
SCENEDESMUS SP.	CHLOROPHYTA	17.	CELLS/ML	1.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	345.	CELLS/ML	24.8 %
KOMMA CAUDATA	CRYPTOPHYTA	588.	CELLS/ML	42.2 %

Wisconsin State Laboratory of Hygiene
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000358

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546126

Wisconsin State Laboratory of Hygiene
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http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000353

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Field #:
Collection Start: 07/11/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12
Sample Location: APPLE RIVER FLOWAGE - SITE 1 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000353

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	96.	CELLS/ML	1.7 %
FRAGILARIA SP.	BACILLARIOPHYTA	149.	CELLS/ML	2.7 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	21.	CELLS/ML	0.4 %
ANKISTRODESMUS SP.	CHLOROPHYTA	85.	CELLS/ML	1.5 %
CLOSTERIUM SP.	CHLOROPHYTA	21.	CELLS/ML	0.4 %
COELASTRUM SP.	CHLOROPHYTA	1607.	CELLS/ML	29.3 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	202.	CELLS/ML	3.7 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	43.	CELLS/ML	0.8 %
PANDORINA SP.	CHLOROPHYTA	170.	CELLS/ML	3.1 %
PEDIASTRUM SP.	CHLOROPHYTA	11.	CELLS/ML	0.2 %
SCENEDESMUS SP.	CHLOROPHYTA	426.	CELLS/ML	7.8 %
CRYPTOMONAS SP.	CRYPTOPHYTA	1767.	CELLS/ML	32.2 %
KOMMA CAUDATA	CRYPTOPHYTA	852.	CELLS/ML	15.5 %
PHACUS SP.	EUGLENOPHYTA	11.	CELLS/ML	0.2 %
TRACHELOMONAS SP.	EUGLENOPHYTA	32.	CELLS/ML	0.6 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9545806

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000359

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/18/2013
Sample Reason:

Field #:
Collection Start: 07/11/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12;
Sample Location: APPLE RIVER FLOWAGE - SITE 2 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000359

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	39.	CELLS/ML	0.7 %
CAVINULA SP.	BACILLARIOPHYTA	576.	CELLS/ML	10.0 %
FRAGILARIA SP.	BACILLARIOPHYTA	275.	CELLS/ML	4.8 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	26.	CELLS/ML	0.5 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	13.	CELLS/ML	0.2 %
ANKISTRODESMUS SP.	CHLOROPHYTA	210.	CELLS/ML	3.7 %
CLOSTERIUM SP.	CHLOROPHYTA	13.	CELLS/ML	0.2 %
COELASTRUM SP.	CHLOROPHYTA	157.	CELLS/ML	2.7 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	511.	CELLS/ML	8.9 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	197.	CELLS/ML	3.4 %
PANDORINA SP.	CHLOROPHYTA	131.	CELLS/ML	2.3 %
SCENEDESMUS SP.	CHLOROPHYTA	1310.	CELLS/ML	22.8 %
STAURASTRUM SP.	CHLOROPHYTA	13.	CELLS/ML	0.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	1900.	CELLS/ML	33.0 %
KOMMA CAUDATA	CRYPTOPHYTA	380.	CELLS/ML	6.6 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9546127

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000352

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Field #:
Collection Start: 08/07/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12
Sample Location: APPLE RIVER FLOWAGE - SITE 1 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000352

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	170.	CELLS/ML	2.9 %
FRAGILARIA SP.	BACILLARIOPHYTA	375.	CELLS/ML	6.5 %
SYNEDRA SP.	BACILLARIOPHYTA	11.	CELLS/ML	0.2 %
ACTINASTRUM SP.	CHLOROPHYTA	91.	CELLS/ML	1.6 %
ANKISTRODESMUS SP.	CHLOROPHYTA	68.	CELLS/ML	1.2 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	34.	CELLS/ML	0.6 %
GOLENKINIA SP.	CHLOROPHYTA	23.	CELLS/ML	0.4 %
SCENEDESMUS SP.	CHLOROPHYTA	409.	CELLS/ML	7.1 %
DINOBRYON SP.	CHRYSOPHYTA	136.	CELLS/ML	2.4 %
CRYPTOMONAS SP.	CRYPTOPHYTA	1374.	CELLS/ML	23.8 %
KOMMA CAUDATA	CRYPTOPHYTA	1238.	CELLS/ML	21.4 %
APHANIZOMENON ISSATSCHENKOI	CYANOPHYTA	1658.	CELLS/ML	28.7 %
MERISMOPEDIA SP.	CYANOPHYTA	182.	CELLS/ML	3.1 %
PHACUS SP.	EUGLENOPHYTA	11.	CELLS/ML	0.2 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9545805

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000360

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #:   PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/18/2013
Sample Reason:

Field #:
Collection Start: 08/07/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12;
Sample Location: APPLE RIVER FLOWAGE - SITE 2 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FX000360

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	26.	CELLS/ML	0.3 %
CAVINULA SP.	BACILLARIOPHYTA	145.	CELLS/ML	1.6 %
CYCLOTELLA SP.	BACILLARIOPHYTA	17.	CELLS/ML	0.2 %
FRAGILARIA SP.	BACILLARIOPHYTA	324.	CELLS/ML	3.5 %
MERIDION SP.	BACILLARIOPHYTA	9.	CELLS/ML	0.1 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	9.	CELLS/ML	0.1 %
ANKISTRODESMUS SP.	CHLOROPHYTA	77.	CELLS/ML	0.8 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	77.	CELLS/ML	0.8 %
GOLENKINIA SP.	CHLOROPHYTA	17.	CELLS/ML	0.2 %
SCENEDESMUS SP.	CHLOROPHYTA	409.	CELLS/ML	4.5 %
DINOBRYON SP.	CHRYSOPHYTA	162.	CELLS/ML	1.8 %
CRYPTOMONAS SP.	CRYPTOPHYTA	579.	CELLS/ML	6.3 %
KOMMA CAUDATA	CRYPTOPHYTA	945.	CELLS/ML	10.3 %
OSCILLATORIA SP.	CYANOPHYTA	3159.	CELLS/ML	34.5 %
PLANKTOTHRIX SP.	CYANOPHYTA	2419.	CELLS/ML	26.4 %
PSEUDANABAENA SP.	CYANOPHYTA	775.	CELLS/ML	8.5 %

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List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

Report #: 9546128

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000351

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Field #:
Collection Start: 09/06/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: LPL-1474-12
Sample Location: APPLE RIVER FLOWAGE - SITE 1 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
CYCLOTELLA SP.	BACILLARIOPHYTA	102.	CELLS/ML	1.0 %
FRAGILARIA SP.	BACILLARIOPHYTA	613.	CELLS/ML	5.7 %
SYNEDRA SP.	BACILLARIOPHYTA	34.	CELLS/ML	0.3 %
ANKISTRODESMUS SP.	CHLOROPHYTA	409.	CELLS/ML	3.8 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	341.	CELLS/ML	3.2 %
GOLENKINIA SP.	CHLOROPHYTA	6234.	CELLS/ML	58.3 %
SCENEDESMUS SP.	CHLOROPHYTA	273.	CELLS/ML	2.6 %
DINOBRYON SP.	CHRYSOPHYTA	1703.	CELLS/ML	15.9 %
CRYPTOMONAS SP.	CRYPTOPHYTA	409.	CELLS/ML	3.8 %
KOMMA CAUDATA	CRYPTOPHYTA	579.	CELLS/ML	5.4 %

Wisconsin State Laboratory of Hygiene
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Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000351

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

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Report #:   9545804

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000356

POLK COUNTY LAND & WATER RESOU
100 POLK COUNTY PLAZA, SUITE 1
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK COUNTY PLAZA, SUITE 120
BALSAM LAKE WI 54810

ID#:
Waterbody/Outfall ID: 2614000
Point/Well:
Account #: PP001
Project No:
Date Received: 10/02/2012
Date Reported: 03/14/2013
Sample Reason:

Field #:
Collection Start: 09/06/2012
Collection End:
Collected By: J. WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: ; LPL-1474-12
Sample Location: APPLE RIVER FLOWAGE - SITE 2 NORTH
Sample Description: COMPOSITE SAMPLER
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FX000356

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	576.	CELLS/ML	11.8 %
CAVINULA SP.	BACILLARIOPHYTA	26.	CELLS/ML	0.5 %
FRAGILARIA SP.	BACILLARIOPHYTA	354.	CELLS/ML	7.2 %
MERIDION SP.	BACILLARIOPHYTA	39.	CELLS/ML	0.8 %
NAVICULOID DIATOMS	BACILLARIOPHYTA	223.	CELLS/ML	4.6 %
STEPHANODISCUS SP.	BACILLARIOPHYTA	26.	CELLS/ML	0.5 %
ANKISTRODESMUS SP.	CHLOROPHYTA	105.	CELLS/ML	2.1 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	52.	CELLS/ML	1.1 %
GOLENKINIA SP.	CHLOROPHYTA	210.	CELLS/ML	4.3 %
OOCYSTIS SP.	CHLOROPHYTA	39.	CELLS/ML	0.8 %
SCENEDESMUS SP.	CHLOROPHYTA	314.	CELLS/ML	6.4 %
DINOBRYON SP.	CHRYSOPHYTA	197.	CELLS/ML	4.0 %
CRYPTOMONAS SP.	CRYPTOPHYTA	393.	CELLS/ML	8.0 %
KOMMA CAUDATA	CRYPTOPHYTA	2018.	CELLS/ML	41.3 %
PSEUDANABAENA SP.	CYANOPHYTA	275.	CELLS/ML	5.6 %
PHACUS SP.	EUGLENOPHYTA	26.	CELLS/ML	0.5 %
TRACHELOMONAS SP.	EUGLENOPHYTA	13.	CELLS/ML	0.3 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

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Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: [signature] Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9545809

Appendix E

Zooplankton Data

Taxa abundance

Site	Apple North 1	Apple North 1	Apple North 1	Apple North 1	Apple North 1	Apple South 2	Apple South 2	Apple South 2	Apple South 2	Apple South 2	Apple South 2
Date	5-May-12	8-Jun-12	11-Jul-12	7-Aug-12	6-Sep-12	8-May-12	5-Jun-12	5-Jun-12	11-Jul-12	7-Aug-12	6-Sep-12
								Replicate			
Site Code	AppN	AppN	AppN	AppN	AppN	AppS	AppS	AppS	AppS	AppS	AppS
Taxa richness	14	15	18	18	13	15	16	16	14	13	18
#/l -->											
total n (#/l)	289.3041106	203.41692	675.042944	163.486932	421.901828	231.6693073	470.8725759	629.0857613	316.426371	357.3250176	156.894717
Rotifera	231.6693073	171.774288	442.996932	118.65987	413.1122065	121.4851246	267.4556231	387.9990025	85.38489375	232.4765175	108.112326
Copepoda	22.60188364	0	68.559049	26.36886	4.394810708	56.5047091	97.94149578	120.5433794	150.6792243	107.6280173	5.273772
Cladocera	32.20768419	9.040752	163.486963	13.18443	0	39.55329637	30.13584485	45.20376728	60.27168971	4.305120694	9.229101
testate protozoa	2.825235455	20.341692	0	0	4.394810708	14.12617728	75.33961214	75.33961214	0	12.91536208	34.279518
#/l -->											
ROTIFERA											
Anuraeopsis fissa											2.636886
Ascomorpha sp.				2.636886							
Asplanchna herricki			15.821319		61.52734991	25.4271191	11.30094182	45.20376728			
Aplanchna priodonta	39.55329637	13.561128			17.57924283						36.916404
Brachionus quadridentatus											2.636886
Collotheca sp.			5.273773								5.273772
Colurella sp.	2.825235455		5.273773								
Conochilus unicornis	121.4851246				4.394810708		3.766980607	3.766980607			2.636886
Euchlanis sp.		2.260188									
Kellicottia longispina					4.394810708						
Keratella cochlearis cochlearis	31.07759001	36.163008	10.547546	2.636886	79.10659274	25.4271191	18.83490303	33.90282546	35.15848566	30.13584485	2.636886
Keratella cochlearis hispida			295.331288	52.73772							
Keratella cochlearis robusta						42.37853183					
Keratella cochlearis tecta			5.273773	29.005746	136.2391319					68.8819311	21.095088
Keratella earlinae		24.862068									
Lecane luna									5.022640809		
Monostyla bulla									15.06792243		
Monostyla lunaris				2.636886						4.305120694	
Notholca squamula		2.260188									
Notholca acuminata var extensa		6.780564				5.65047091					
Notomata sp.				5.273772							
Polyarthra sp.		18.081504		2.636886							10.547544
Polyarthra dolichoptera	5.65047091	40.683384	10.547546		74.71178204	2.825235455	94.17451517	116.7763988	5.022640809	43.05120694	
Polyarthra major							7.533961214	18.83490303			
Polyarthra remata	28.25235455		94.927914				22.60188364	26.36886425			
Polyarthra vulgaris	2.825235455			5.273772		14.12617728	94.17451517	135.6113018	25.11320405	77.49217248	5.273772
Pompholyx sulcata					17.57924283		3.766980607				
Synchaeta sp.											10.547544
Trichocerca cylindrica				13.18443	8.789621416					4.305120694	
Trichocerca pusilla				2.636886	4.394810708						5.273772
Trichocerca multicrinis					4.394810708						
Trichotria tetractis		2.260188									
Trocosphaera sp.		24.862068									
unidentified rotifer						5.65047091	11.30094182	7.533961214		4.305120694	2.636886
COPEPODA											
cyclopoid nauplius	16.95141273		21.095092	18.458202	4.394810708	48.02900274	86.64055396	109.2424376	95.43017537	94.71265526	5.273772

cyclopoid copepodid	5.65047091		21.095092	2.636886			7.533961214	3.766980607	45.20376728	8.610241387	
calanoid nauplius							3.766980607	3.766980607			
Acanthocyclops sp.			5.273773								
Diacyclops spp.			5.273773			5.65047091		3.766980607	10.04528162	4.305120694	
Microcyclops sp.			15.821319	5.273772							
Paracyclops chiltoni						2.825235455					
CLADOCERA											
Bosmina coregoni				2.636886		5.65047091					
Bosmina leideri			52.73773	2.636886							
Bosmina longirostris	19.77664819	2.260188	26.368865	5.273772		16.95141273	15.06792243	30.13584485			
Ceriodaphnia sp.	5.65047091								10.04528162		
Ceriodaphnia lacustris							3.766980607				
Ceriodaphnia laticaudata							11.30094182	11.30094182			
Ceriodaphnia pulchella			26.368865								
Chydorus sp.		6.780564									
Chydorus faviformis			26.368865						20.09056324		
Chydorus sphaericus						14.12617728		3.766980607		4.305120694	
Diaphanosoma sp.	1.130094182		31.642638	2.636886					5.022640809		
Daphnia ambigua											2.636886
Acroperus harpae									10.04528162		
Camptocercus sp.											5.273772
Paralona pigra	5.65047091					2.825235455					
Sida sp.											1.318443
Simocephalus mirabilis									15.06792243		
OSTRACODA											
Candonidae				5.273772							
Juvenile ostracod		2.260188							20.09056324		
TESTATE PROTIST											
Centropyxis aerophila		4.520376									
Cyclopyxis arcelloides		15.821316									5.273772
Difflugia oblonga	2.825235455									8.610241387	29.005746
Trinema sp.					4.394810708	14.12617728	75.33961214	75.33961214			
unidentifiable protist										4.305120694	

Genera Abundance

Site	Apple North 1	Apple North 1	Apple North 1	Apple North 1	Apple North 1	Apple South 2	Apple South 2	Apple South 2	Apple South 2	Apple South 2	Apple South 2
Date	5-May-12	8-Jun-12	11-Jul-12	7-Aug-12	6-Sep-12	8-May-12	5-Jun-12	5-Jun-12	11-Jul-12	7-Aug-12	6-Sep-12
								Replicate			
Site Code	AppN	AppN	AppN	AppN	AppN	AppS	AppS	AppS	AppS	AppS	AppS
Taxa richness	14	15	18	18	13	15	16	16	14	13	18
total n (#/l)	289.3041106	203.41692	675.042944	163.486932	421.901828	231.6693073	470.8725759	629.0857613	316.426371	357.3250176	156.894717
Rotifera	231.6693073	171.774288	442.996932	118.65987	413.1122065	121.4851246	267.4556231	387.9990025	85.38489375	232.4765175	108.112326
Copepoda	22.60188364		68.559049	26.36886	4.394810708	56.5047091	97.94149578	120.5433794	150.6792243	107.6280173	5.273772
Cladocera	32.20768419	9.040752	163.486963	13.18443		39.55329637	30.13584485	45.20376728	60.27168971	4.305120694	9.229101
testate protozoa	2.825235455	20.341692			4.394810708	14.12617728	75.33961214	75.33961214	0	12.91536208	34.279518
ROTIFERA											
Anuraeopsis											2.636886
Ascomorpha				2.636886							

Asplanchna	39.55329637	13.561128	15.821319	0	79.10659274	25.4271191	11.30094182	45.20376728	0	0	36.916404
Brachionus											2.636886
Collotheca			5.273773								5.273772
Colurella	2.825235455		5.273773								
Conochilus	121.4851246				4.394810708		3.766980607	3.766980607			2.636886
Euchlanis		2.260188									
Kellicottia					4.394810708						
Keratella	31.07759001	61.025076	311.152607	84.380352	215.3457247	67.80565092	18.83490303	33.90282546	35.15848566	99.01777595	23.731974
Lecane									5.022640809		
Monostyla				2.636886					15.06792243	4.305120694	
Notholca		9.040752				5.65047091					
Notomata				5.273772							
Polyarthra	36.72806092	58.764888	105.47546	7.910658	74.71178204	16.95141273	218.4848752	297.5914679	30.13584485	120.5433794	15.821316
Pompholyx					17.57924283		3.766980607				
Synchaeta											10.547544
Trichocerca				15.821316	17.57924283					4.305120694	5.273772
Trichotria		2.260188									
Trocosphaera		24.862068									
unidentified rotifer						5.65047091	11.30094182	7.533961214		4.305120694	2.636886
COPEPODA											
cyclopoid nauplius	16.95141273		21.095092	18.458202	4.394810708	48.02900274	86.64055396	109.2424376	95.43017537	94.71265526	5.273772
cyclopoid copepodid	5.65047091		21.095092	2.636886			7.533961214	3.766980607	45.20376728	8.610241387	
calanoid nauplius							3.766980607	3.766980607			
Acanthocyclops			5.273773								
Diacyclops			5.273773			5.65047091		3.766980607	10.04528162	4.305120694	
Mesocyclops											
Microcyclops			15.821319	5.273772							
Paracyclops						2.825235455					
CLADOCERA											
Acroperus									10.04528162		
Bosmina	19.77664819	2.260188	79.106595	10.547544		22.60188364	15.06792243	30.13584485			
Camptocercus											5.273772
Ceriodaphnia	5.65047091		26.368865				15.06792243	11.30094182	10.04528162		
Chydorus		6.780564	26.368865			14.12617728		3.766980607	20.09056324	4.305120694	
Daphnia											2.636886
Diaphanosoma	1.130094182		31.642638	2.636886					5.022640809		
Paralona	5.65047091					2.825235455					
Sida											1.318443
Simocephalus									15.06792243		
OSTRACODA		2.260188		5.273772					20.09056324		
TESTATE PROTIST											
Centropyxis		4.520376									
Cyclopyxis		15.821316									5.273772
Difflugia	2.825235455									8.610241387	29.005746
Trinema					4.394810708	14.12617728	75.33961214	75.33961214			
unidentifiable protist										4.305120694	

Zooplankton of the Apple River Flowage, Big Lake, Church Pine Lake, Long Lake and Wind Lake of Polk County, WI, 2012.

Toben Lafrançois
Northland College
Dept. Natural Resources
1411 Ellis Avenue #CB126
Ashland, WI 54806

May 2013

***Bosmina coregoni* from Long Lake, Polk Co., WI, 2012. Lateral field of view = 0.75 mm. Photo T. Lafrançois.**

Suggested citation: Lafrançois, T. 2013. Zooplankton of the Apple River Flowage, Big Lake, Church Pine Lake, Long Lake and Wind Lake of Polk County, WI, 2012. Final report to Polk County Land & Water Resources Department, Polk Co. WI.

Thirty five samples from lakes in Polk County were examined for zooplankton species abundances, including Wind Lake, Church Pine Lake, Big Lake, Long Lake, and two sites in the Apple River Flowage. Data and preliminary analyses have been sent with this report as an attachment in Microsoft Excel.

Methods

Laboratory methods used a dual counting technique for different size fractions modified from Chick et al. 2006 and Chick et al. 2010. Samples were processed and counted at the Applied Research and Environmental Laboratory (ARELab) of Northland College, Ashland WI and at the Great Lakes Inventory and Monitoring Network of the National Park Service who generously provided microscope access during construction at the Northland College lab. Zooplankton samples were condensed on a 20 µm filter, transferred to 40 mL centrifuge tubes and diluted to between 20 and 40 ml depending on sample density. This volume was rigorously agitated, sub-sampled with a 1mL Hensen-Stempel pipette, and transferred to a 1mL Sedgwick Rafter counting slide. Organisms of all size fractions were counted on a compound microscope at magnifications of 40x to 100x. Counts were tallied row by row (1/20 ml increments) on the Sedgwick Rafter cell until stable variance in taxa diversity was achieved (Colwell & Coddington 1994). The larger organisms (primarily copepods and cladocerans) were then counted for the entire cell and checked against the entire sample.

Stable variance in taxonomic diversity and total number for these samples was achieved when at least 50 individuals of smaller species were counted (with volume counted between 0.6 and 2 ml out of 20-40 ml). The abundance of larger individuals varied greatly so best professional judgment was used to count based not on number but subsample volume of 1 to 2 ml out of 20-40 ml. Standard identification keys were used from Thorp & Covich (2010) to allow cross study comparison. Zooplankton counts were converted from numbers per subsample to number per liter (n/l). Three replicate samples were counted, randomly chosen from three different lakes (after a sample was randomly chosen, that lake was eliminated from the next random draw). This was done because variance can be different between systems. Lab replicates are shown on Figures 1-8, below simply as additional points. The biggest difference between replicates was in taxonomic diversity of Wind Lake, with three species between lab replicates. None of the replicates show differences in variance greater than differences between groups. Sample counting was constrained by budget but the numbers here are statistically robust but indicate that diversity would be best captured with more intensive counting (adding 1-2 rafter cells per sample).

Results and Discussion

Ninety one taxa were identified from the six sampling sites of the five lakes (Table 1). The majority of this diversity is from phylum Rotifera, followed by the crustacean Cladocera and then Copepoda. Testate protists should be considered an index of protist presence since most of that group is destroyed in ETOH preservative or is too small to be caught in the net. Ostracods are benthic and should be considered incidental catch not definitive of that community. The categories 'unidentifiable X' were specimens individually un-identifiable and are not a single taxa across samples or even within a sample.

No male calanoid copepods were found during counting which presents a problem taxonomically. Calanoids were identifiable to family (Diaptomidae) and sometimes genus or species but without males it is impossible to confirm. Species names in parentheses were assigned only with at least some evidence and should be taken as preliminary estimates of diversity and species presence. Cyclopoid copepod genera *Microcyclops* and *Cryptocyclops* are difficult to distinguish. All of the specimens where full identification was possible keyed to *Microcyclops*, but it is possible that *Cryptocyclops* is present.

Other cyclopoid copepods represent a very difficult problem. Species in brackets indicate species identified with very high certainty according to Thorp & Covich (2010), with clearly seen 5^{th} legs and other definitive characters. However, these species- *Thermocyclops crassus* and *Metacyclops sp.*- are found primarily in southeast Asia, being introduced species in North America.

Metacyclops is known in North America, including the southern United States. Previous reports from Minnesota are likely to be in error (Reid 1991). This does not preclude its presence however. *Thermocyclops crassus* is primarily Asiatic in distribution and its presence in Wisconsin would be surprising (Chaicharoen and others, 2011). There are three possible explanations- taxonomic error by the identifier, problems with the new taxonomic keys, or the actual presence of introduced species. It was not possible to get good digital pictures of the identifying characters due to equipment limitations, but the taxonomic features in these cases were very clear and are made with confidence. Whether these species are actually present or the taxonomic keys need revision is a question requiring further research. Their actual presence is not out of the question if recent immigrants have brought fishing gear from their country of origin or even if anglers from other parts of North America have utilized these lakes (particularly from Louisiana, USA or other southern regions). It is also possible that lack of comprehensive taxonomic study of Wisconsin freshwaters simply has missed these species in the past.

Table 1. The following species were identified from this survey. Species in parenthesis are preliminary identifications based on incomplete evidence. Species in brackets represent problematic taxa (see discussion).

ROTIFERA

Anuraeopsis fissa
Ascomorpha sp.
Asplanchna brightwelli
Asplanchna herricki
Asplanchna priodonta
Brachionus quadridentatus
Collotheca sp.
Colurella sp.
Conochilus unicornis
Euchlanis sp.
Filinia longiseta
Filinia terminalis
Gastropus sp.
Hexarthra mira
Kellicottia bostoniensis
Kellicottia longispina
Keratella crassa
Keratella cochlearis cochlearis
Keratella cochlearis hispida
Keratella cochlearis robusta
Keratella cochlearis tecta
Keratella earlinae
Lecane luna
Monostyla bulla
Monostyla closterocerca
Monostyla lunaris
Monostyla quadridentata
Notholca squamula
Notholca acuminata var extensa
Notomata sp.
Polyarthra sp.
Polyarthra dolichoptera
Polyarthra euryptera
Polyarthra major
Polyarthra remata
Polyarthra vulgaris
Pompholyx sulcata
Proales sp.
Synchaeta sp.
Trichocerca cylindrica
Trichocerca pusilla
Trichocerca lata
Trichocerca multicrinis
Trichotria tetractis
Trocosphaera sp.
unidentified rotifer

COPEPODA

cyclopoid nauplius
cyclopoid copepodid
calanoid nauplius
calanoid copepodid
Acanthocyclops sp.
Cyclops sp.
Diacyclops spp.
Mesocyclops sp.
[*Metacyclops* sp.]
Microcyclops sp.
Paracyclops chiltoni
[*Thermocyclops crassus*]
Diaptomidae
(*Arctodiaptomus arapahoensis*)
Heterocope septeptrionalis
(*Limnocalanus* sp.)
(*Osphrantium* sp.)
(*Senecella calanoides*)

CLADOCERA

Bosmina coregoni
Bosmina leideri
Bosmina longirostris
Bosmina longispina
Ceriodaphnia sp.
Ceriodaphnia lacustris
Ceriodaphnia laticaudata
Ceriodaphnia pulchella
Chydorus sp.
Chydorus faviformis
Chydorus sphaericus
Diaphanosoma sp.
Daphnia ambigua
Daphnia mendotae
Daphnia parvula
Daphnia pulex
Daphnia retrocurva
Leptodora kindtii
Acroperus harpae
Camptocercus sp.
Paralona pigra
Sida sp.
Simocephalus mirabilis

OSTRACODA

Cypridopsinae
Candonidae
Juvenile ostracod

TESTATE PROTIST

Arcella gibbosa
Centropyxis aerophila
Cyclopyxis arcelloides
Difflugia oblonga
Difflugia lobostoma
Trinema sp.
unidentifiable protist

Basic patterns in taxa diversity and abundance of the primary groups show that the Apple River Flowage, both north and south sites, supports the greatest abundance of zooplankton but also the greatest variation (Fig. 1). Big Lake (early season) and Church Pine (late season) had the lowest total zooplankton abundance of all sites. Taxonomic diversity was similar across all sampling sites (Fig. 2).

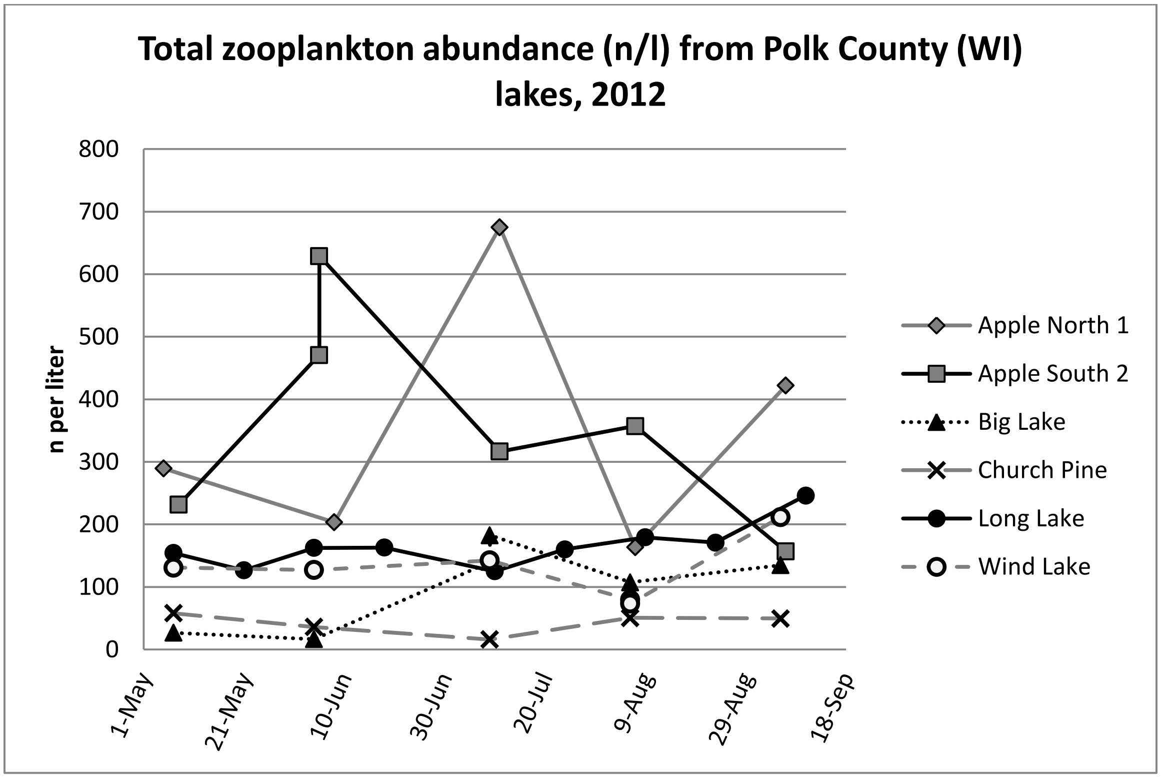

Figure 1. Total zooplankton abundance from six sampling sites in Polk Co., WI, 2012.

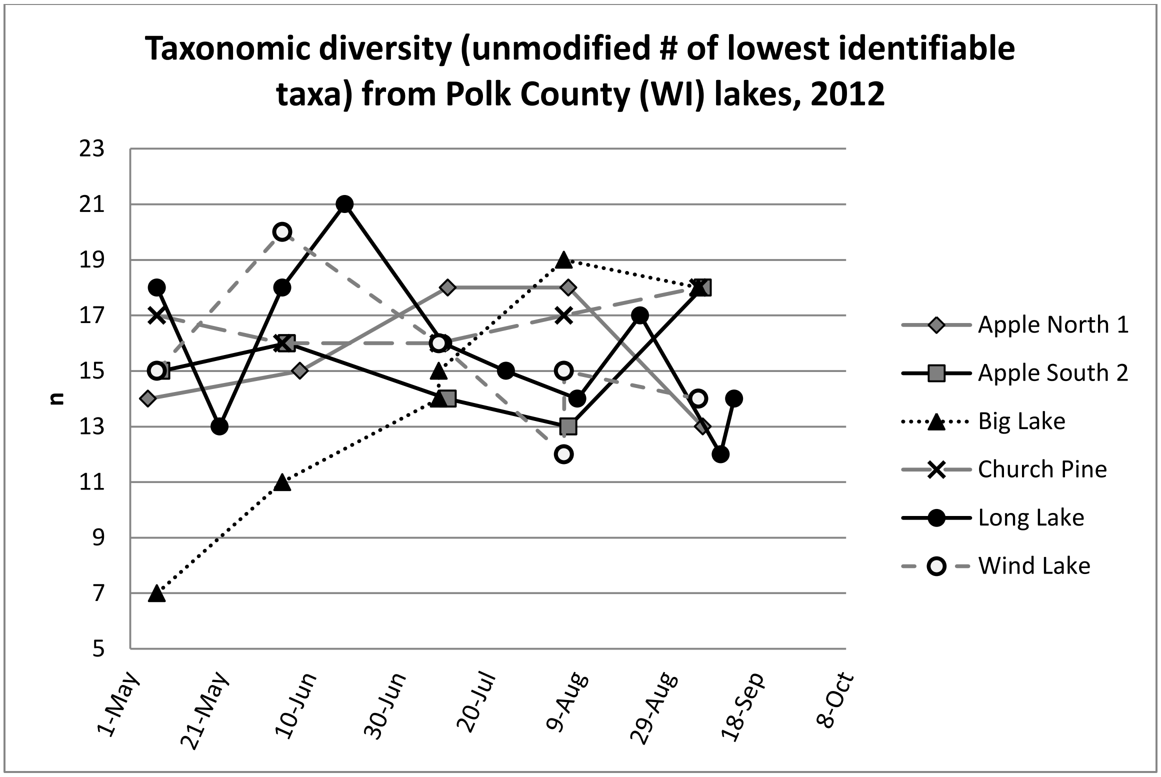

Figure 2. Total zooplankton taxonomic diversity (unmodified number of lowest identifiable taxa) from six sampling sites in Polk Co., WI, 2012.

The Apple River Flowage zooplankton were dominated by rotifers (Figs. 3 and 4), which is characteristic of flowing waters. Some cladocera are present but almost no copepods, which is somewhat unusual even for a flowing system. Abundance appears to fluctuate with the likely drivers being water retention time (higher flows reducing populations) and temperature (increasing productivity).

The Big Lake zooplankton community is dominated by rotifers, with an explosion in later summer (Fig. 5). Very low numbers of cladocera strongly suggest large populations of planktivorous fishes. The inverse relationship between cladoceran and rotifer populations appearing in the graphical representation are indicative of release from competition and predation on rotifers by elimination of larger crustaceans. Low numbers of crustacean plankton are an index of low algal grazing capacity.

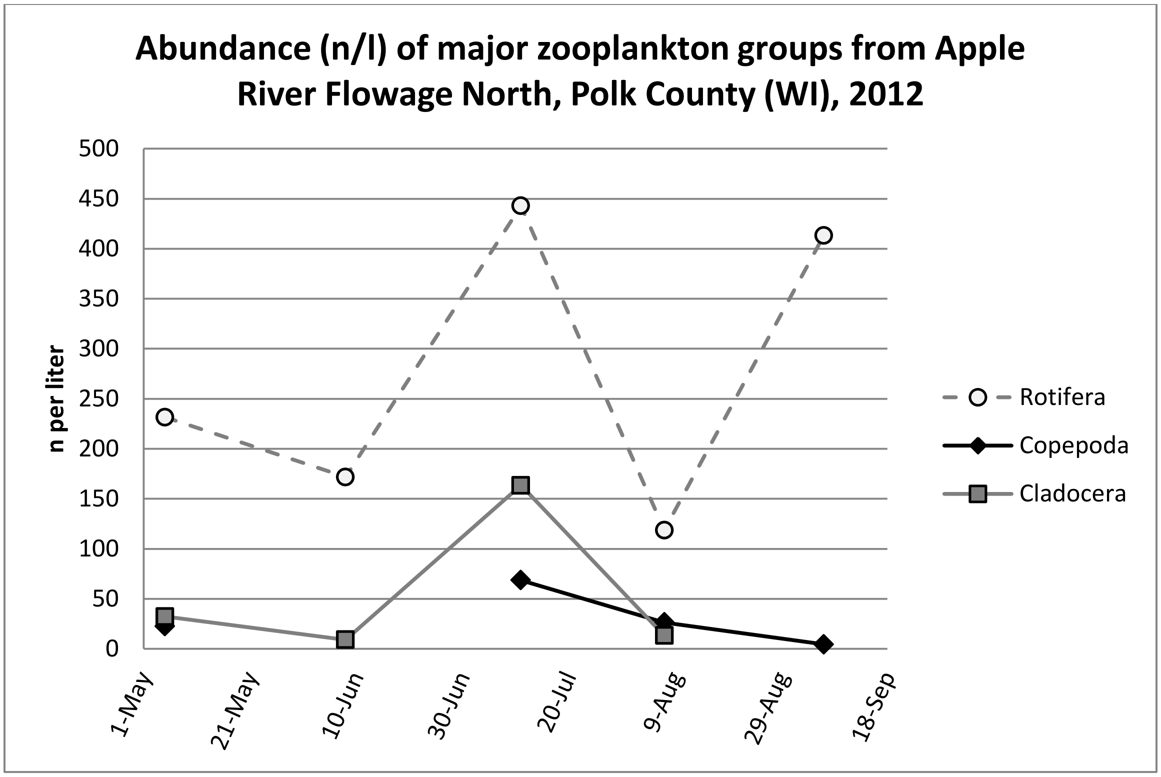

Figure 3. Zooplankton abundance (number per liter) from Apple River Flowage site 1 (north), Polk County, WI, 2012.

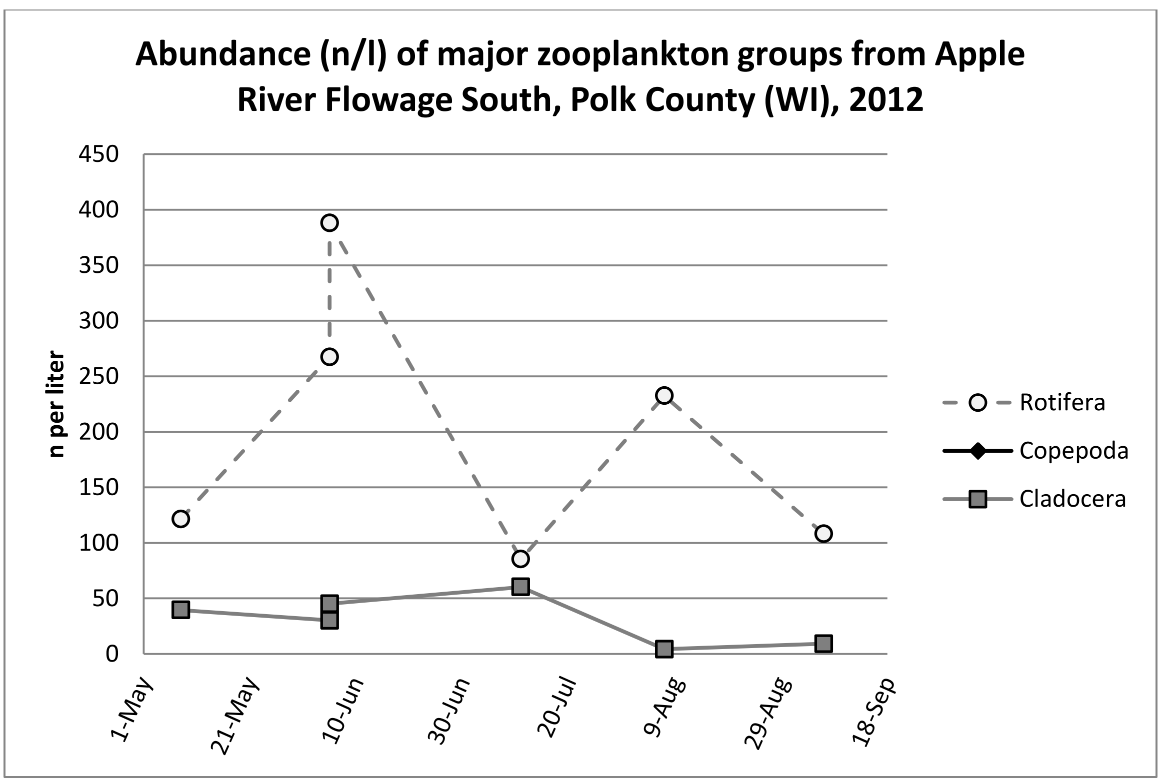

Figure 4. Zooplankton abundance (number per liter) from Apple River Flowage site 2 (south), Polk County, WI, 2012.

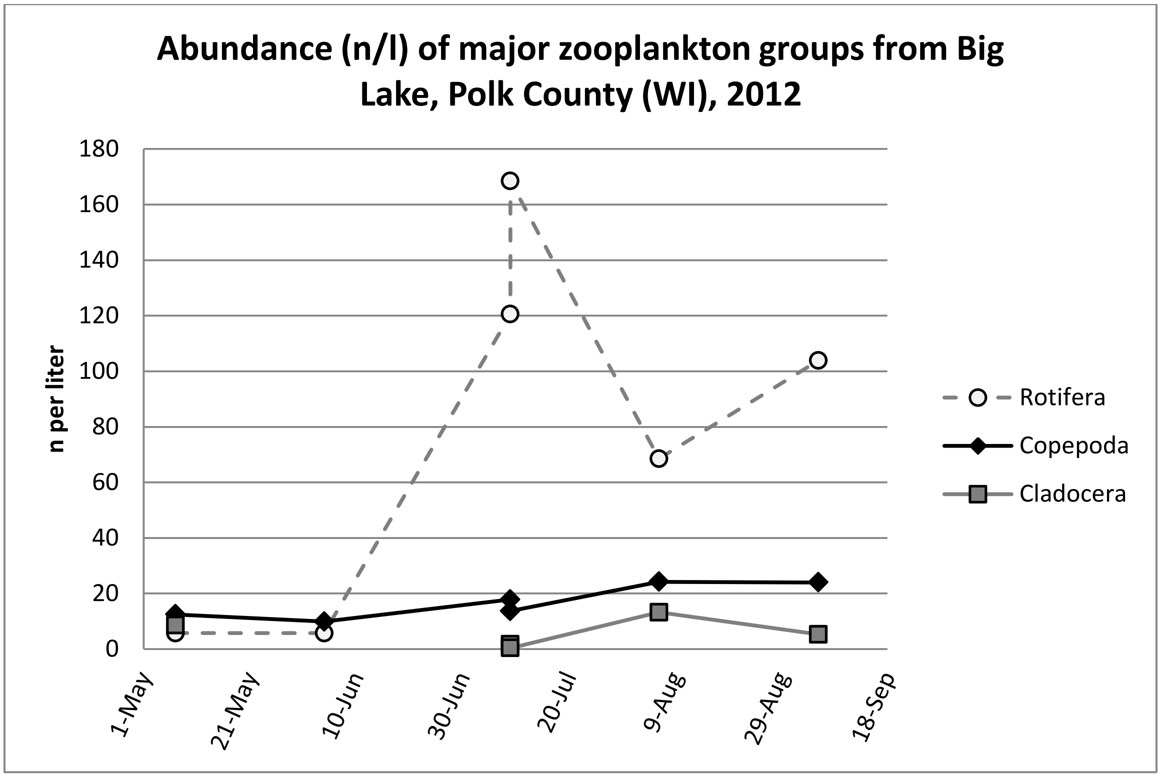

Figure 5. Zooplankton abundance (number per liter) from Big Lake, Polk County, WI, 2012.

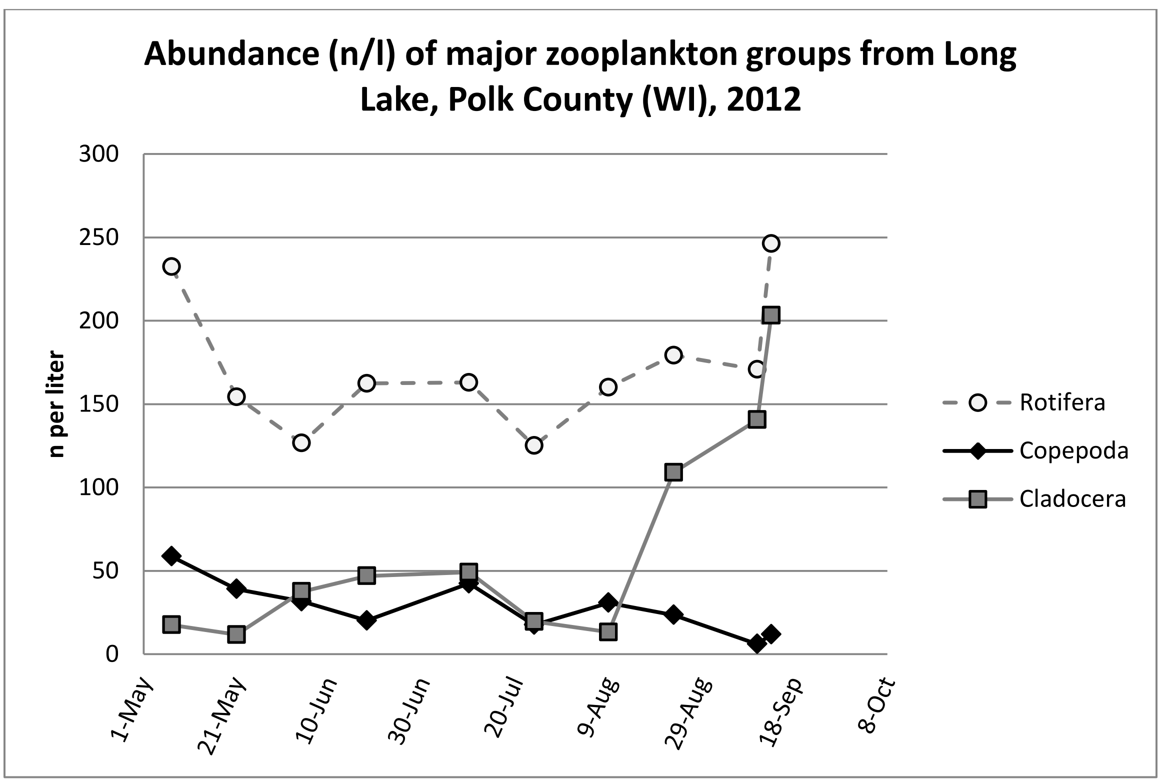

Figure 6. Zooplankton abundance (number per liter) from Long Lake, Polk County, WI, 2012.

Long lake shows a basic pattern similar to Big Lake, dominated by rotifers with (slightly) more crustacean plankton, but still lower than would be regionally expected (Lafrançois 2008, EOR 2009). The population explosion of cladocerans in late summer is primarily due to two groups (Fig. 6). One, the chydoridae and particularly *Paralona pigra*, generally indicative of the presence of macrophytes and shallower waters. Large numbers of *Bosmina coregoni* are also responsible for this trend, ironically they are often characteristic of clearer open waters, although they can be littoral as well. The concurrent drop in copepod abundance to near zero suggests that release from predation could also be a factor.

Wind Lake is again much like Big Lake and Long Lake in rotifer dominance and fewer crustaceans (Fig. 7). In particular, cladoceran numbers are very low relative to similar systems. Unlike Long lake, all groups increase in population in late summer, indicating increased productivity without any competitive interference. Overall patterns show a lake with high planktivorous fish populations and low grazing capacity. The patterns in Church Pine Lake (Fig. 8) are very similar with a much more dramatic population crash in mid-summer. It is unclear from the zooplankton data alone what may have caused this change.

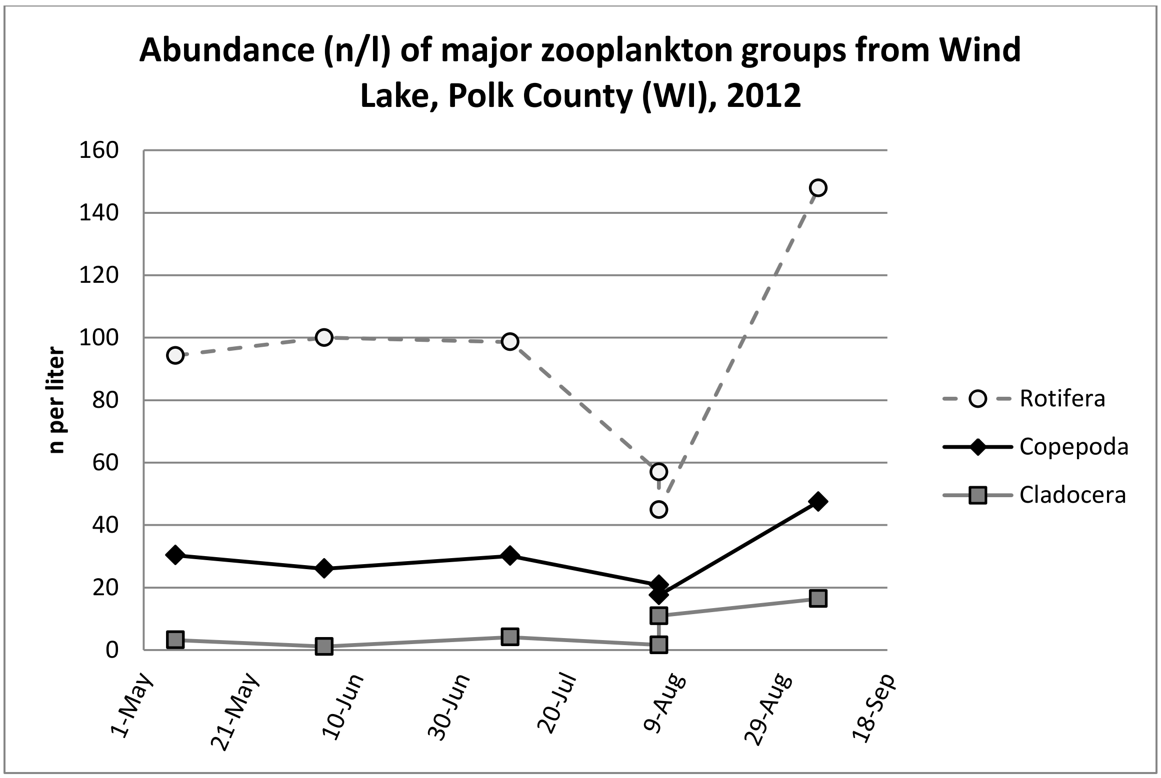

Figure 7. Zooplankton abundance (number per liter) from Wind Lake, Polk County, WI, 2012.

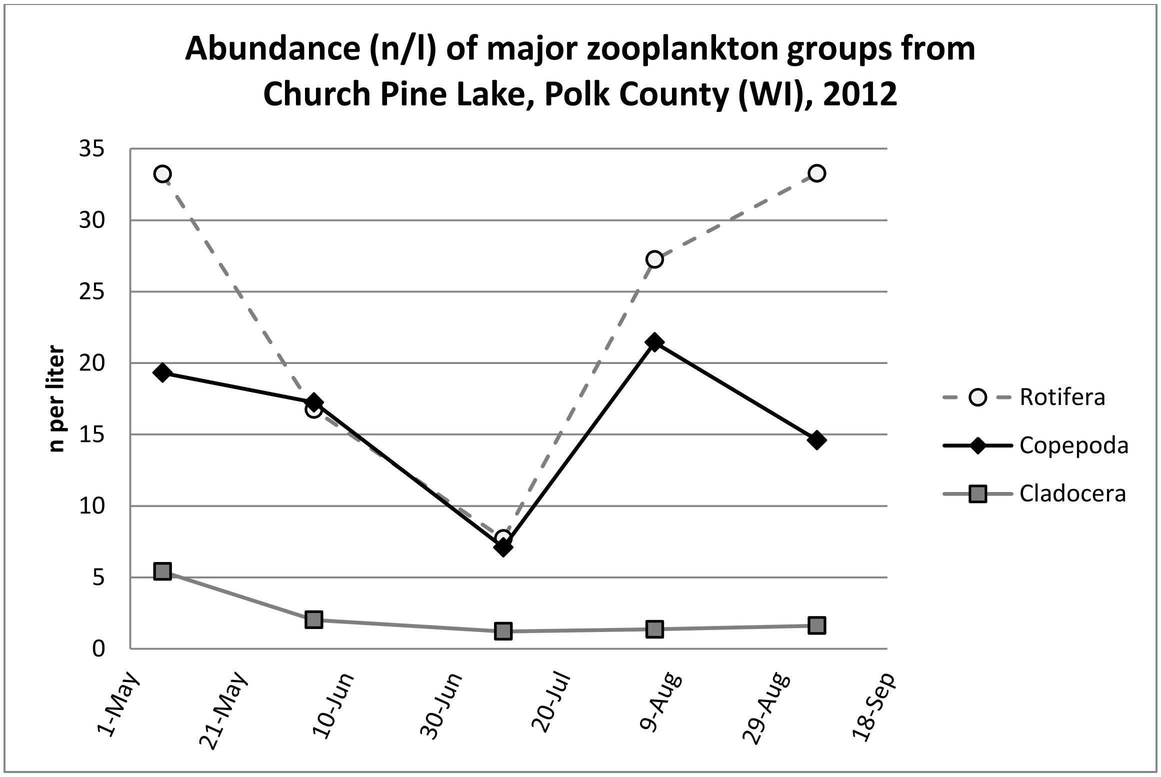

Figure 8. Zooplankton abundance (number per liter) from Church Pine Lake, Polk County, WI, 2012.

Conclusion and recommendations

In general the lakes in this study can be sorted into two groups. The Apple River Flowage sites show influence of flowing waters and other drivers typical of such systems, while Long, Big, Wind, and Church Pine Lakes show a similar pattern of very low cladoceran populations indicative of high planktivorous fish populations and low grazing capacity.

The data included as an attachment with this report can be analyzed more robustly to untangle some of the drivers of these lake ecosystems. Recommendations include:

- Statistically analyzing data against physical and water quality parameters using trend analysis and ordination techniques would help untangle the ecological significance of the zooplankton community data.
- Closely examining trends at the species level, particularly for Long Lake, where interesting dynamics are taking place in the zooplankton community that could shed light on ecosystem processes.
- More complete taxonomic investigation of the cyclopoid copepods in particular, but also the calanoid copepods, will help address the question of introduced species and/or problems with standard taxonomic keys.

Works Cited

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Appendix F

Lake Sediment Data

Soil and Plant Analysis Lab
Univ. of Wisconsin-Madison
8452 Mineral Point Rd
Verona, WI 53593-8696

Phone (608)262-4364
Fax (608)833-1277
http://uwlab.soils.wisc.edu/

Lab No. 7311 **Acct. No. 559447** **Client- Kaitlin Holm/Polk Cty Land & Water**

Re: 2 soil samples submitted September 5, 2012
Results emailed: September 19, 2012

Results reported on a 'dry weight' basis. Unit: 1,000 ppb = ppm = mg/kg = mg/liter. 1% = 10,000 ppm.

The UW Soil & Plant Analysis Lab Standard Operation Procedures of ICP-OES/MS are available from the following links:
http://uwlab.soils.wisc.edu/files/procedures/ICPOES.pdf
http://uwlab.soils.wisc.edu/files/procedures/ICPMS.pdf
http://uwlab.soils.wisc.edu/files/procedures/soil_icp.pdf
http://uwlab.soils.wisc.edu/files/procedures/plant_icp.pdf
http://uwlab.soils.wisc.edu/files/procedures/animal_icp.pdf

ELEMENTAL ANALYSIS PACKAGE 1- TOTAL MINERALS

Sample ID	P %	K %	Ca %	Mg %	S %	Zn ppm	B ppm	Mn ppm	Fe ppm	Cu ppm	Al ppm	Na ppm
ARF 8/22/12												
1.Site 1 N	0.15	0.14	1.62	0.33	0.41	54.44	8.12	769.57	53359.2	21.12	11092.4	127.2
2.Site 2 S	0.18	0.13	2.05	0.29	0.60	49.31	6.83	1310.96	32024.3	21.78	11899.2	157.9

Sample ID	Total N (%)
ARF 8/22/12	
1.Site 1 N	0.86
2.Site 2 S	0.83

Samples Analyzed By:
UW Soil & Plant Analysis Lab
8452 Mineral Point Road
Verona, WI 53593
(608) 262-4364

SOIL TEST REPORT

COOPERATIVE EXTENSION
University of Wisconsin-Extension
University of Wisconsin-Madison
Department of Soil Science

Results also available on-line at http://uwlab.soils.wisc.edu/reports
lab number: 7311 access code: bfvwb

LAB #: 7311

County	Account No.
Polk	559447

Date Received	Date Processed
9/5/2012	9/19/2012

Polk County Land and Water Resources Dept - Kaitlin Holm
100 Polk County Plaza--Ste 120
Balsam Lake, WI 54810

This Report is for:
Kaitlin Holm - Polk County Land & W
100 Polk Cty Plaza - Ste 120
Balsam Lake, WI 54810

Slope	Acres	Plow Depth	Irrigated
0%	0	7"	No

Soil Name
unknown (group O)

Field Name
ARF Site 1 North

Previous Crop
no crop

NUTRIENT RECOMMENDATIONS

Cropping Sequence	Yield Goal	Crop Nutrient Need N	Crop Nutrient Need P2O5	Crop Nutrient Need K2O	Legume N	Fertilzer Credit Manure N	Fertilzer Credit P2O5	Fertilzer Credit K2O	Nutrients to Apply N	Nutrients to Apply P2O5	Nutrients to Apply K2O
	per acre	lbs/a			lbs/a	lbs/a			lbs/a		
Corn, grain	131-150 bu	see below	90	70	0	0	0	0	see below	90	70
Soybean, grain	46-55 bu	0	50	130	0	0	0	0	0	50	130
Alfalfa, seeding	1-2.5 ton	0	65	145	0	0	0	0	0	65	145
Alfalfa, established	4.6-5.5 ton	0	105	340	0	0	0	0	0	105	340

There is no lime recommendation.

SUGGESTED N APPLICATION RATES FOR CORN (GRAIN) AT DIFFERENT N:CORN PRICE RATIOS

Previous Crop — Medium/Low Yield Potential Soils	N:Corn Price Ratio ($/lb N:$/bu) 0.05 Rate[1]	0.05 Range	0.10 Rate[1]	0.10 Range	0.15 Rate[1]	0.15 Range	0.20 Rate[1]	0.20 Range
	lb N/a (Total to Apply)[2]							
Corn, Forage legumes, Leguminous vegetables, Green manures[3]	125	110-140	110	100-115	100	95-110	95	85-100
Soybean, Small grains[4]	110	90-125	85	70-95	70	60-80	60	50-70

[1] Rate is the N rate that provides the maximum return to N (MRTN). Range is the range of profitable N rates that provide an economic return to N within $1/a of the MRTN.
[2] These rates are for total N applied including N in starter fertilizer and N used in herbicide applications.
[3] Subtract N credits for forage legumes, leguminous vegetables, green manures and animal manures. This includes 1st, 2nd and 3rd year credits where applicable. Do not subtract N credits for leguminous vegetables on sand and loamy sand soils.
[4] Subtract N credits for animal manures and 2nd year forage legumes.

Guidelines for choosing an appropriate N application rate for corn (grain)

1) If there is more than 50% residue cover at planting, use the upper end of the range.
2) For small grains grown on medium and fine textured soils, the mid to low end of the profitable range is the most appropriate.
3) If 100% of the N will come from organic sources, use the top end of the range. In addition, up to 20 lb N/a in starter fertilizer may be applied in this situation.
4) For medium and fine textured soils with 10% or more organic matter, use the low end of the range; for medium and fine textured soils with less than 2% organic matter, use the high end of the range.
5) If there is a likelihood of residual N, then use the low end of the range or use the high end of the range and subtract preplant nitrate test (PPNT) credits.
6) For corn following small grains on medium and fine textured soils, the middle to low end of the range is most appropriate.

For more information on the new N application rate guidelines for corn see http://uwlab.soils.wisc.edu/pubs/MRTN/

ADDITIONAL INFORMATION

Recommended rates are the total amount of nutrients to apply (N-P-K), including starter fertilizer.

This soil is not suited for growing alfalfa, or other crops where large amounts of potassium are removed (corn silage, forage legumes).

Because of the low potassium buffering capacity of this soil, retest every 2 years.

Starter fertilizer (e.g. 10+20+20 lbs N+P_2O_5+K_2O/a) is advisable for row crops on soils slow to warm in the spring.

Year 1: If corn is harvested for silage instead of grain add extra 30 lbs P_2O_5 per acre and 90 lbs K_2O per acre to next crop.

If alfalfa will be maintained for more than three years, increase recommended K_2O by 20% each year.

N.R.=Not required for calculation of lime requirement when soil pH is 6.6 or higher.

TEST INTERPRETATION

Cropping Sequence	Very Low / Low / Optimum / High / Very High / Excessive
Corn, grain	PPPPPPPPP KKKKKKKKKKKKKKKKKKKKKKK
Soybean, grain	PPPPPPPPPPPPPPPPPPPPPPPPPPP KKKKKKKKKKKKK
Alfalfa, seeding	PPPPPP KKKKKKKKKKKKKKKKK
Alfalfa, established	PPPPPP KKKKKKKKKKKKKKKKK
Rotation pH	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

LABORATORY ANALYSIS

Sample Identification	Soil pH	O.M %	Phosphorus ppm	Potassium ppm	60-69 Lime Req (T/a)	Calcium ppm	Magnesium ppm	Est. CEC (cmol/kg)	Boron ppm	Manganese ppm	Zinc ppm	Sulfate-Sulfur ppm	Sulfur Avail. Index	Texture Code	Sample Density	Buffer pH
1	6.9	19.6	7	56	0	3795	471	10		53				2	0.45	N.R.
Adjusted Averages	6.9	19.6	7	56		3795	471	10		53						

SECONDARY & MICRONUTRIENT RECOMMENDATIONS

Interpretations -----------------------> Ca-H Mg-OPT Mn-OPT

Response to added Ca is unlikely.

(continued on next page)

SECONDARY & MICRONUTRIENT RECOMMENDATIONS

Interpretations ------------------------> Ca-H Mg-OPT Mn-OPT

Soil Mg is optimum. Maintain level with dolomitic lime.

For forage legumes, incorporate 25-50 lbs S/a before seeding or topdress 15-25 lbs S/a on established stands. For corn, small grains, vegetables and fruit crops apply 10-25 lbs S/a. Higher rates should last 2 or more years.

Year 1,2,3,4: Response to Mn is unlikely.

Samples Analyzed By:
UW Soil & Plant Analysis Lab
8452 Mineral Point Road
Verona, WI 53593
(608) 262-4364

SOIL TEST REPORT

COOPERATIVE EXTENSION
University of Wisconsin-Extension
University of Wisconsin-Madison
Department of Soil Science

Results also available on-line at http://uwlab.soils.wisc.edu/reports
lab number: 7311 access code: bfvwb

LAB #: 7311

County	Account No.
Polk	559447

Date Received	Date Processed
9/5/2012	9/19/2012

Polk County Land and Water Resources Dept - Kaitlin Holm
100 Polk County Plaza--Ste 120
Balsam Lake, WI 54810

This Report is for:
Kaitlin Holm - Polk County Land & W
100 Polk Cty Plaza - Ste 120
Balsam Lake, WI 54810

Slope	Acres	Plow Depth	Irrigated
0%	0	7"	No

Soil Name
unknown (group O)

Field Name
ARF Site 2 South

Previous Crop
no crop

NUTRIENT RECOMMENDATIONS

Cropping Sequence	Yield Goal	Crop Nutrient Need			Fertilzer Credit				Nutrients to Apply		
		N	P2O5	K2O	Legume N	Manure N	P2O5	K2O	N	P2O5	K2O
	per acre	lbs/a			lbs/a	lbs/a			lbs/a		
Corn, grain	131-150 bu	see below	80	70	0	0	0	0	see below	80	70
Soybean, grain	46-55 bu	0	40	130	0	0	0	0	0	40	130
Alfalfa, seeding	1-2.5 ton	0	65	145	0	0	0	0	0	65	145
Alfalfa, established	4.6-5.5 ton	0	105	340	0	0	0	0	0	105	340

There is no lime recommendation.

SUGGESTED N APPLICATION RATES FOR CORN (GRAIN) AT DIFFERENT N:CORN PRICE RATIOS

Previous Crop	N:Corn Price Ratio ($/lb N:$/bu)							
Medium/Low Yield Potential Soils	0.05		0.10		0.15		0.20	
	Rate[1]	Range	Rate[1]	Range	Rate[1]	Range	Rate[1]	Range
	lb N/a (Total to Apply)[2]							
Corn, Forage legumes, Leguminous vegetables, Green manures[3]	125	110-140	110	100-115	100	95-110	95	85-100
Soybean, Small grains[4]	110	90-125	85	70-95	70	60-80	60	50-70

[1] Rate is the N rate that provides the maximum return to N (MRTN). Range is the range of profitable N rates that provide an economic return to N within $1/a of the MRTN.
[2] These rates are for total N applied including N in starter fertilizer and N used in herbicide applications.
[3] Subtract N credits for forage legumes, leguminous vegetables, green manures and animal manures. This includes 1st, 2nd and 3rd year credits where applicable. Do not subtract N credits for leguminous vegetables on sand and loamy sand soils.
[4] Subtract N credits for animal manures and 2nd year forage legumes.

Guidelines for choosing an appropriate N application rate for corn (grain)

1) If there is more than 50% residue cover at planting, use the upper end of the range.
2) For small grains grown on medium and fine textured soils, the mid to low end of the profitable range is the most appropriate.
3) If 100% of the N will come from organic sources, use the top end of the range. In addition, up to 20 lb N/a in starter fertilizer may be applied in this situation.
4) For medium and fine textured soils with 10% or more organic matter, use the low end of the range; for medium and fine textured soils with less than 2% organic matter, use the high end of the range.
5) If there is a likelihood of residual N, then use the low end of the range or use the high end of the range and subtract preplant nitrate test (PPNT) credits.
6) For corn following small grains on medium and fine textured soils, the middle to low end of the range is most appropriate.

For more information on the new N application rate guidelines for corn see http://uwlab.soils.wisc.edu/pubs/MRTN/

ADDITIONAL INFORMATION

Recommended rates are the total amount of nutrients to apply (N-P-K), including starter fertilizer.

This soil is not suited for growing alfalfa, or other crops where large amounts of potassium are removed (corn silage, forage legumes).

Because of the low potassium buffering capacity of this soil, retest every 2 years.

Starter fertilizer (e.g. 10+20+20 lbs $N+P_2O_5+K_2O$/a) is advisable for row crops on soils slow to warm in the spring.

Year 1: If corn is harvested for silage instead of grain add extra 30 lbs P_2O_5 per acre and 90 lbs K_2O per acre to next crop.

If alfalfa will be maintained for more than three years, increase recommended K_2O by 20% each year.

N.R.=Not required for calculation of lime requirement when soil pH is 6.6 or higher.

TEST INTERPRETATION

Cropping Sequence — Very Low | Low | Optimum | High | Very High | Excessive

Corn, grain
PPPPPPPPPPPPPPPP
KKKKKKKKKKKKKKKKKK

Soybean, grain
PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
KKKKKKKKKKK

Alfalfa, seeding
PPPPPPPPPP
KKKKKKKKKKKKKK

Alfalfa, established
PPPPPPPPPP
KKKKKKKKKKKKKK

Rotation pH
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

LABORATORY ANALYSIS

Sample Identification	Soil pH	O.M %	Phosphorus ppm	Potassium ppm	60-69 Lime Req (T/a)	Calcium ppm	Magnesium ppm	Est. CEC (cmol/kg)	Boron ppm	Manganese ppm	Zinc ppm	Sulfate-Sulfur ppm	Sulfur Avail. Index	Texture Code	Sample Density	Buffer pH
2	7.1	16.7	13	51	0	3291	304	6		101		823.0	3354	2	0.32	N.R.
Adjusted Averages	7.1	16.7	13	51		3291	304	6		101		823.0	3354			

SECONDARY & MICRONUTRIENT RECOMMENDATIONS

Interpretations -----------------------> Ca-H Mg-OPT Mn-L SAI-H

Response to added Ca is unlikely.

(continued on next page)

SECONDARY & MICRONUTRIENT RECOMMENDATIONS

Interpretations ------------------------>	Ca-H	Mg-OPT	Mn-L	SAI-H

Soil Mg is optimum. Maintain level with dolomitic lime.

Response to sulfur unlikely.

Year 1: Band 3 lbs Mn/a as sulfate or foliarly apply 1 or 0.15 lb Mn/a as sulfate or chelate forms, respectively.

Year 2: Band 5 lbs Mn/a as sulfate or foliarly apply 1.25 or 0.2 lb Mn/a as sulfate or chelate forms, respectively.

Year 3,4: Response to Mn is unlikely.

Appendix G

Modeling Data

Date: 3/27/2013 Scenario: Apple River Flowage North Current Conditions

Lake Id: Apple River Flowage North
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 4517.8 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 3011.9 acre-ft
Lake Surface Area <As>: 334 acre
Lake Volume <V>: 2004 acre-ft
Lake Mean Depth <z>: 6.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 51021.8 acre-ft/year
Areal Water Load <qs>: 152.8 ft/year
Lake Flushing Rate <p>: 25.46 1/year
Water Residence Time: 0.04 year
Observed spring overturn total phosphorus (SPO): 53 mg/m^3
Observed growing season mean phosphorus (GSM): 79 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		Loading (kg/ha-year)				Loading (kg/year)		
Row Crop AG	1718.41	0.50	1.00	3.00	14.5	348	695	2086
Mixed AG	254.44	0.30	0.80	1.40	1.7	31	82	144
Pasture/Grass	364.40	0.10	0.30	0.50	0.9	15	44	74
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	4.45	0.30	0.50	0.80	0.0	1	1	1
Rural Res (>1 Ac)	475.94	0.05	0.10	0.25	0.4	10	19	48
Wetlands	261.30	0.10	0.10	0.10	0.2	11	11	11
Forest	1438.84	0.05	0.09	0.18	1.1	29	52	105
Lake Surface	334.0	0.10	0.30	1.00	0.8	14	41	135

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

=

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	150				
% Phosphorus Retained by Soil		98	90	80	

Septic Tank Loading (kg/year) 0.90 7.50 24.00 0.2

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	1008.9	10543.0	5794.5	100.0
Total Loading (kg)	457.6	4782.3	2628.4	100.0
Areal Loading (lb/ac-year)	3.02	31.57	17.35	0.0
Areal Loading (mg/m^2-year)	338.58	3538.09	1944.56	0.0
Total PS Loading (lb)	0.0	8441.4	0.0	80.1
Total PS Loading (kg)	0.0	3829.0	0.0	80.1
Total NPS Loading (lb)	977.1	1995.6	5443.6	19.8
Total NPS Loading (kg)	443.2	905.2	2469.2	19.8

Wisconsin Internal Load Estimator

Date: 3/27/2013 Scenario: 6

Method 1 - A Complete Total Phosphorus Mass Budget

Method 1 - A Complete Total Phosphorus Mass Budget 58.3 mg/m^3
Phosphorus Inflow Concentration: 76.0 mg/m^3
Areal External Loading: 3538.1 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.23
Observed Phosphorus Retention Coefficient: 0.23
Internal Load: -5 Lb -2 kg

Method 2 - From Growing Season In Situ Phososphorus Increases

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 0.0 acre-ft
Anoxia Sediment Area: 0.0 acres

Just Prior To The End of Stratification

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 0.0 acre-ft
Anoxia Sediment Area: 0.0 acres
Time Period of Stratification: 30 days
Sediment Phosphorus Release Rate: 0 mg/m^2-day 0 lb/acre-day
Internal Load: 0 Lb 0 kg

Method 3 - From In Situ Phososphorus Increases In The Fall

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 0.0 acre-ft
Anoxia Sediment Area: 0.0 acres

Just Prior To The End of Stratification

Average Water Column Phosphorus Concentration: 50 mg/m^3
Lake Volume: 2004.0 acre-ft
Anoxia Sediment Area Just Before Turnover: 0.0 acres
Time Period Between Observations: 30 days
Sediment Phosphorus Release Rate: 0 mg/m^2-day 0 lb/acre-day
Internal Load: 272 Lb 124 kg

Method 4 - From Phososphorus Release Rate and Anoxic Area

Start of Anoxia Anoxic Sediment Area: 0.0 acre
End of Anoxia Anoxic Sediment Area: 0.0 acre
Phosphorus Release Rate As Calculated In Method 2: 0 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: 0 mg/m^2-day
Average of Methods 2 and 3 Release Rates: 0.0 mg/m^2-day
Period of Anoxia: 30 days

Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	0	0	0
Internal Load: (kg)	0	0	0

Internal Load Comparison (Percentanges are of the Total Estimate Load)

Total External Load: 10543 Lb 4782 kg

	Lb	kg	%
From A Complete Mass Budget:	-5	-2	0.0
From Growing Season In Situ Phosphorus Increases:	0	0	0.0
From In Situ Phososphorus Increases In The Fall:	272	124	2.5
From Phososphorus Release Rate and Anoxic Area:	0	0	0.0

Predicted Water Column Total Phosphorus Concentration (ug/l)

	Low	Most Likely	High
Nurnberg+ 1984 Total Phosphorus Model:	6	59	32

Osgood, 1988 Lake Mixing Index: 1.6

Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	-5	136.2	0
Internal Load (kg):	-2	61.8	0
External Load (Lb):	1009	10543	5795
External Load (kg):	458	4782	2628
Total Load (Lb):	1004	10679	5795
Total Load (kg):	456	4844	2628

Phosphorus Prediction and Uncertainty Analysis Module

Date: 3/27/2013 Scenario: 3

Observed spring overturn total phosphorus (SPO): 53.0 mg/m^3

Observed growing season mean phosphorus (GSM): 79.0 mg/m^3

Back calculation for SPO total phosphorus: 0.0 mg/m^3

Back calculation GSM phosphorus: 0.0 mg/m^3

% Confidence Range: 70%

Nurenberg Model Input - Est. Gross Int. Loading: 0 kg

Lake Phosphorus Model	Low Total P (mg/m^3)	Most Likely Total P (mg/m^3)	High Total P (mg/m^3)	Predicted -Observed (mg/m^3)	% Dif.
Walker, 1987 Reservoir	6	58	32	-21	-27
Canfield-Bachmann, 1981 Natural Lake	7	63	36	-16	-20
Canfield-Bachmann, 1981 Artificial Lake	7	55	33	-24	-30
Rechow, 1979 General	5	52	29	-27	-34
Rechow, 1977 Anoxic	6	67	37	-12	-15
Rechow, 1977 water load<50m/year	4	40	22		

				-39	-49
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	6	64	35	11	21
Vollenweider, 1982 Combined OECD	7	47	29	-19	-29
Dillon-Rigler-Kirchner	5	48	26	-5	-9
Vollenweider, 1982 Shallow Lake/Res.	5	39	23	-27	-41
Larsen-Mercier, 1976	6	63	35	10	19
Nurnberg, 1984 Oxic	6	58	32	-21	-27

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?	**Back** Calculation (kg/year)	**Model** Type
Walker, 1987 Reservoir	22	84	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	20	181	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	17	158	FIT	1	GSM
Rechow, 1979 General	19	78	FIT	0	GSM
Rechow, 1977 Anoxic	26	96	FIT	0	GSM
Rechow, 1977 water load<50m/year	15	59	FIT	0	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	21	106	FIT	0	SPO
Vollenweider, 1982 Combined OECD	15	81	FIT	0	ANN
Dillon-Rigler-Kirchner	19	69	P L	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	13	66	FIT	0	ANN
Larsen-Mercier, 1976	25	88	P Pin p	0	SPO
Nurnberg, 1984 Oxic	20	92	L	0	ANN

Expanded Trophic Response Module

Date: 3/27/2013 Scenario: 2
Total Phosphorus: 57.8 mg/m^3
Growing Season
Chorophyll a: 6.4 mg/m^3
Secchi Disk Depth: 1.7 m

Carlson TSI Equations:

TSI (Total Phosphorus): 63 TSI (Chlorphyll a): 49 TSI (Secchi Disk

Depth): 52

Water and Nutrient Outflow Module

Date: 3/27/2013 Scenario: 4

Average Annual Surface Total Phosphorus: 58.3mg/m^3

Annual Discharge: 5.10E+004 AF => 6.29E+007 m^3

Annual Outflow Loading: 7728.7 LB => 3505.7 kg

Date: 3/27/2013 Scenario: Apple River Flowage South Current Conditions

Lake Id: Apple River Flowage South
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 1485.3 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 990.2 acre-ft
Lake Surface Area <As>: 299.39 acre
Lake Volume <V>: 1796.34 acre-ft
Lake Mean Depth <z>: 6.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 63315.7 acre-ft/year
Areal Water Load <qs>: 211.5 ft/year
Lake Flushing Rate <p>: 35.25 1/year
Water Residence Time: 0.03 year
Observed spring overturn total phosphorus (SPO): 72 mg/m^3
Observed growing season mean phosphorus (GSM): 80 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	178.40	0.50	1.00	3.00	1.5	36	72	217
Mixed AG	29.00	0.30	0.80	1.40	0.2	4	9	16
Pasture/Grass	65.03	0.10	0.30	0.50	0.2	3	8	13
HD Urban (1/8 Ac)	5.91	1.00	1.50	2.00	0.1	2	4	5
MD Urban (1/4 Ac)	122.30	0.30	0.50	0.80	0.5	15	25	40
Rural Res (>1 Ac)	241.89	0.05	0.10	0.25	0.2	5	10	24
Wetlands	124.12	0.10	0.10	0.10	0.1	5	5	5
Forest	718.62	0.05	0.09	0.18	0.5	15	26	52
Lake Surface	299.4	0.10	0.30	1.00	0.7	12	36	121

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	150				
% Phosphorus Retained by Soil		98	90	80	

Septic Tank Loading (kg/year) 0.90 7.50 24.00
0.2

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	213.8	10754.8	1141.0	100.0
Total Loading (kg)	97.0	4878.4	517.6	100.0
Areal Loading (lb/ac-year)	0.71	35.92	3.81	0.0
Areal Loading (mg/m^2-year)	80.03	4026.41	427.19	0.0
Total PS Loading (lb)	0.0	10308.0	0.0	95.8
Total PS Loading (kg)	0.0	4675.7	0.0	95.8
Total NPS Loading (lb)	185.1	350.1	821.0	4.0
Total NPS Loading (kg)	84.0	158.8	372.4	4.0

Wisconsin Internal Load Estimator

Date: 3/27/2013 Scenario: 7

Method 1 - A Complete Total Phosphorus Mass Budget

Method 1 - A Complete Total Phosphorus Mass Budget 77 mg/m^3
Phosphorus Inflow Concentration: 62.5 mg/m^3
Areal External Loading: 4026.4 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.18
Observed Phosphorus Retention Coefficient: -0.23
Internal Load: 4459 Lb 2023 kg

Method 2 - From Growing Season In Situ Phososphorus Increases

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 0.0 acre-ft
Anoxia Sediment Area: 0.0 acres

Just Prior To The End of Stratification

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 0.0 acre-ft
Anoxia Sediment Area: 0.0 acres
Time Period of Stratification: 30 days
Sediment Phosphorus Release Rate: 0 mg/m^2-day 0 lb/acre-day
Internal Load: 0 Lb 0 kg

Method 3 - From In Situ Phososphorus Increases In The Fall

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 0.0 acre-ft
Anoxia Sediment Area: 0.0 acres

Just Prior To The End of Stratification

Average Water Column Phosphorus Concentration: 67 mg/m^3
Lake Volume: 1796.3 acre-ft
Anoxia Sediment Area Just Before Turnover: 0.0 acres
Time Period Between Observations: 30 days
Sediment Phosphorus Release Rate: 0 mg/m^2-day 0 lb/acre-day
Internal Load: 327 Lb 148 kg

Method 4 - From Phososphorus Release Rate and Anoxic Area

Start of Anoxia Anoxic Sediment Area: 0.0 acre
End of Anoxia Anoxic Sediment Area: 0.0 acre
Phosphorus Release Rate As Calculated In Method 2: 0 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: 0 mg/m^2-day
Average of Methods 2 and 3 Release Rates: 0.0 mg/m^2-day
Period of Anoxia: 14 days

Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	0	0	0
Internal Load: (kg)	0	0	0

Internal Load Comparison (Percentanges are of the Total Estimate Load)

Total External Load: 10755 Lb 4878 kg

	Lb	kg	%
From A Complete Mass Budget:	4459	2023	29.3
From Growing Season In Situ Phosphorus Increases:	0	0	0.0
From In Situ Phososphorus Increases In The Fall:	327	148	3.0
From Phososphorus Release Rate and Anoxic Area:	0	0	0.0

Predicted Water Column Total Phosphorus Concentration (ug/l)

	Low	Most Likely	High
Nurnberg+ 1984 Total Phosphorus Model:	27	52	5

Osgood, 1988 Lake Mixing Index: 1.7

Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	4459	163.6	0
Internal Load (kg):	2023	74.2	0
External Load (Lb):	214	10755	1141
External Load (kg):	97	4878	518
Total Load (Lb):	4673	10918	1141
Total Load (kg):	2120	4953	518

Phosphorus Prediction and Uncertainty Analysis Module

Date: 3/27/2013 Scenario: 4
Observed spring overturn total phosphorus (SPO): 72.0 mg/m^3
Observed growing season mean phosphorus (GSM): 80.0 mg/m^3
Back calculation for SPO total phosphorus: 0.0 mg/m^3
Back calculation GSM phosphorus: 0.0 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 0 kg

Lake Phosphorus Model	**Low** Total P (mg/m^3)	**Most Likely** Total P (mg/m^3)	**High** Total P (mg/m^3)	**Predicted** -Observed (mg/m^3)	**% Dif.**
Walker, 1987 Reservoir	1	52	5	-28	-35
Canfield-Bachmann, 1981 Natural Lake	1	54	6	-26	-33
Canfield-Bachmann, 1981 Artificial Lake	1	48	6	-32	-40
Rechow, 1979 General	1	45	5	-35	-44
Rechow, 1977 Anoxic	1	55	6	-25	-31
Rechow, 1977 water load<50m/year	N/A	N/A	N/A		

				N/A	N/A
Rechow, 1977 water load>50m/year	1	52	5	-28	-35
Walker, 1977 General	1	54	6	-18	-25
Vollenweider, 1982 Combined OECD	2	40	6	-36	-47
Dillon-Rigler-Kirchner	1	43	5	-29	-40
Vollenweider, 1982 Shallow Lake/Res.	1	34	5	-42	-55
Larsen-Mercier, 1976	1	53	6	-19	-26
Nurnberg, 1984 Oxic	1	51	5	-29	-36

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?	**Back** Calculation (kg/year)	**Model** Type
Walker, 1987 Reservoir	18	86	Tw	0	GSM
Canfield-Bachmann, 1981 Natural Lake	17	156	FIT	1	GSM
Canfield-Bachmann, 1981 Artificial Lake	15	138	FIT	1	GSM
Rechow, 1979 General	15	76	FIT	0	GSM
Rechow, 1977 Anoxic	19	90	FIT	0	GSM
Rechow, 1977 water load<50m/year	N/A	N/A	N/A	N/A	N/A
Rechow, 1977 water load>50m/year	21	81	FIT	0	GSM
Walker, 1977 General	15	97	FIT	0	SPO
Vollenweider, 1982 Combined OECD	11	74	FIT	0	ANN
Dillon-Rigler-Kirchner	15	70	P L	0	SPO
Vollenweider, 1982 Shallow Lake/Res.	9	62	FIT	0	ANN
Larsen-Mercier, 1976	19	86	P Pin p	0	SPO
Nurnberg, 1984 Oxic	15	90	L	0	ANN

Water and Nutrient Outflow Module

Date: 3/27/2013 Scenario: 5
Average Annual Surface Total Phosphorus: 77mg/m^3
Annual Discharge: 6.33E+004 AF => 7.81E+007 m^3
Annual Outflow Loading: 12674.5 LB => 5749.1 kg

Expanded Trophic Response Module

Date: 3/27/2013 Scenario: 3
Total Phosphorus: 80 mg/m^3
Growing Season
Chorophyll a: 11 mg/m^3
Secchi Disk Depth: 1.4 m
Carlson TSI Equations:
TSI (Total Phosphorus): 67 TSI (Chlorphyll a): 54 TSI (Secchi Disk Depth): 55

Date: 7/1/2013 Scenario: 71

Lake Id: Fox Creek
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 5053.4 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 3368.9 acre-ft
Lake Surface Area <As>: 65.78 acre
Lake Volume <V>: 65.78 acre-ft
Lake Mean Depth <z>: 1.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 3387.0 acre-ft/year
Areal Water Load <qs>: 51.5 ft/year
Lake Flushing Rate <p>: 51.49 1/year
Water Residence Time: 0.02 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	**|---- Loading (kg/ha-year) ----|**				**|----- Loading (kg/year) ----|**		
Row Crop AG	2175.31	0.50	1.00	3.00	83.9	440	880	2641
Mixed AG	53.72	0.30	0.80	1.40	1.7	7	17	30
Pasture/Grass	425.43	0.10	0.30	0.50	4.9	17	52	86
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	0.0	0.30	0.50	0.80	0.0	0	0	0
Rural Res (>1 Ac)	269.91	0.05	0.10	0.25	1.0	5	11	27
Wetlands	772.54	0.10	0.10	0.10	3.0	31	31	31
Forest	1356.49	0.05	0.09	0.18	4.7	27	49	99
Lake Surface	65.8	0.10	0.30	1.00	0.8	3	8	27

POINT SOURCE DATA

Point Sources	Water Load **(m^3/year)**	Low **(kg/year)**	Most Likely **(kg/year)**	High **(kg/year)**	Loading %

SEPTIC TANK DATA

Description		**Low**	**Most Likely**	**High**	**Loading %**
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	0.0				
% Phosphorus Retained by Soil		98	90	80	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	

0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	1170.1	2312.6	6485.0	100.0
Total Loading (kg)	530.8	1049.0	2941.6	100.0
Areal Loading (lb/ac-year)	17.79	35.16	98.59	0.0
Areal Loading (mg/m^2-year)	1993.79	3940.51	11050.15	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	1164.2	2295.0	6426.3	100.0
Total NPS Loading (kg)	528.1	1041.0	2915.0	100.0

Date: 7/1/2013   Scenario: Apple River Inlet Current Conditions

Lake Id: Apple Rever Inlet
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 7750.1 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 5166.7 acre-ft
Lake Surface Area <As>: 215 acre
Lake Volume <V>: 645 acre-ft
Lake Mean Depth <z>: 3.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 5225.9 acre-ft/year
Areal Water Load <qs>: 24.3 ft/year
Lake Flushing Rate <p>: 8.10 1/year
Water Residence Time: 0.12 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre	Low	Most Likely	High	Loading %	Low	Most Likely	High
	(ac)	**|---- Loading (kg/ha-year) ----|**				**|----- Loading (kg/year) ----|**		
Row Crop AG	1584.39	0.50	1.00	3.00	63.3	321	641	1924
Mixed AG	110.45	0.30	0.80	1.40	3.5	13	36	63
Pasture/Grass	724.60	0.10	0.30	0.50	8.7	29	88	147
HD Urban (1/8 Ac)	27.28	1.00	1.50	2.00	1.6	11	17	22
MD Urban (1/4 Ac)	25.54	0.30	0.50	0.80	0.5	3	5	8
Rural Res (>1 Ac)	594.72	0.05	0.10	0.25	2.4	12	24	60
Wetlands	1507.72	0.10	0.10	0.10	6.0	61	61	61
Forest	3175.37	0.05	0.09	0.18	11.4	64	116	231
Lake Surface	215.0	0.10	0.30	1.00	2.6	9	26	87

POINT SOURCE DATA

Point Sources	Water Load	Low	Most Likely	High	Loading %
	(m^3/year)	**(kg/year)**	**(kg/year)**	**(kg/year)**	

=

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	0.0				
% Phosphorus Retained by Soil		98	90	80	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	

0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	1154.1	2234.4	5737.8	100.0
Total Loading (kg)	523.5	1013.5	2602.7	100.0
Areal Loading (lb/ac-year)	5.37	10.39	26.69	0.0
Areal Loading (mg/m^2-year)	601.65	1164.85	2991.32	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	1134.9	2176.8	5546.0	100.0
Total NPS Loading (kg)	514.8	987.4	2515.7	100.0

Date: 7/1/2013 Scenario: Beaver Brook Main Stem Current Conditions

Lake Id: Beaver Brook Main Stem
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 4567.9 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 3045.3 acre-ft
Lake Surface Area <As>: 62.03 acre
Lake Volume <V>: 99.25 acre-ft
Lake Mean Depth <z>: 1.6 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 3062.3 acre-ft/year
Areal Water Load <qs>: 49.4 ft/year
Lake Flushing Rate <p>: 30.85 1/year
Water Residence Time: 0.03 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	1730.39	0.50	1.00	3.00	79.1	350	700	2101
Mixed AG	145.28	0.30	0.80	1.40	5.3	18	47	82
Pasture/Grass	325.15	0.10	0.30	0.50	4.5	13	39	66
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	3.96	0.30	0.50	0.80	0.1	0	1	1
Rural Res (>1 Ac)	348.32	0.05	0.10	0.25	1.6	7	14	35
Wetlands	537.98	0.10	0.10	0.10	2.5	22	22	22
Forest	1460.94	0.05	0.09	0.18	6.0	30	53	106
Lake Surface	62.0	0.10	0.30	1.00	0.9	3	8	25

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

=

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	0.0				
% Phosphorus Retained by Soil		98	90	80	

Septic Tank Loading (kg/year) 0.00 0.00 0.00
0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	976.3	1950.8	5380.8	100.0
Total Loading (kg)	442.8	884.9	2440.7	100.0
Areal Loading (lb/ac-year)	15.74	31.45	86.75	0.0
Areal Loading (mg/m^2-year)	1764.07	3524.95	9722.95	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	970.7	1934.1	5325.5	100.0
Total NPS Loading (kg)	440.3	877.3	2415.6	100.0

Date: 7/1/2013 Scenario: Beaver Brook West Current Conditions

Lake Id: Beaver Brook West
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 1336.9 acre
Total Unit Runoff: 8 in.
Annual Runoff Volume: 891.3 acre-ft
Lake Surface Area <As>: 8.3 acre
Lake Volume <V>: 8.3 acre-ft
Lake Mean Depth <z>: 1.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 893.5 acre-ft/year
Areal Water Load <qs>: 107.7 ft/year
Lake Flushing Rate <p>: 107.66 1/year
Water Residence Time: 0.01 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	935.86	0.50	1.00	3.00	93.8	189	379	1136
Mixed AG	20.55	0.30	0.80	1.40	1.6	2	7	12
Pasture/Grass	28.03	0.10	0.30	0.50	0.8	1	3	6
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	0.0	0.30	0.50	0.80	0.0	0	0	0
Rural Res (>1 Ac)	88.75	0.05	0.10	0.25	0.9	2	4	9
Wetlands	171.07	0.10	0.10	0.10	1.7	7	7	7
Forest	92.66	0.05	0.09	0.18	0.8	2	3	7
Lake Surface	8.3	0.10	0.30	1.00	0.2	0	1	3

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	0.0				
% Phosphorus Retained by Soil		98	90	80	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	

0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	449.6	890.0	2600.4	100.0
Total Loading (kg)	203.9	403.7	1179.6	100.0
Areal Loading (lb/ac-year)	54.17	107.23	313.31	0.0
Areal Loading (mg/m^2-year)	6071.37	12018.74	35117.37	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	448.8	887.8	2593.0	100.0
Total NPS Loading (kg)	203.6	402.7	1176.2	100.0

Date: 7/1/2013   Scenario: Beaver Brook East Current Conditions

Lake Id: Beaver Brook East
Watershed Id: 1

Hydrologic and Morphometric Data

Tributary Drainage Area: 10532.9 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 7021.9 acre-ft
Lake Surface Area <As>: 97.7 acre
Lake Volume <V>: 97.7 acre-ft
Lake Mean Depth <z>: 1.0 ft
Precipitation - Evaporation: 3.3 in.
Hydraulic Loading: 7048.8 acre-ft/year
Areal Water Load <qs>: 72.1 ft/year
Lake Flushing Rate <p>: 72.15 1/year
Water Residence Time: 0.01 year
Observed spring overturn total phosphorus (SPO): 0.0 mg/m^3
Observed growing season mean phosphorus (GSM): 0.0 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	3395.4	0.50	1.00	3.00	70.2	687	1374	4122
Mixed AG	526.1	0.30	0.80	1.40	8.7	64	170	298
Pasture/Grass	1015.9	0.10	0.30	0.50	6.3	41	123	206
HD Urban (1/8 Ac)	14.7	1.00	1.50	2.00	0.5	6	9	12
MD Urban (1/4 Ac)	307.5	0.30	0.50	0.80	3.2	37	62	100
Rural Res (>1 Ac)	452.6	0.05	0.10	0.25	0.9	9	18	46
Wetlands	1427.2	0.10	0.10	0.10	3.0	58	58	58
Forest	3350.7	0.05	0.09	0.18	6.2	68	122	244
Lake Surface	97.7	0.10	0.30	1.00	0.6	4	12	40

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	

0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	2158.7	4315.7	11328.3	100.0
Total Loading (kg)	979.2	1957.6	5138.5	100.0
Areal Loading (lb/ac-year)	22.10	44.17	115.95	
Areal Loading (mg/m^2-year)	2476.62	4951.16	12996.41	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	2150.0	4289.5	11241.2	100.0
Total NPS Loading (kg)	975.2	1945.7	5099.0	100.0

Appendix H

Meeting Agendas and Materials

Apple River Flowage Lake Management Plan
Water Quality Committee Meeting 1

Wednesday, February 20th, 2013
7-9 pm
Amery City Hall

Agenda

7:00 Introductions – roles and responsibilities (LWRD)

7:10 Schedule future meetings – *bring your calendar*
- March
- April
- May
- June

7:20 What is a lake management plan? (LWRD)
Review grant requirements (LWRD)
What do you want the plan to accomplish? (Committee)
What questions do you hope to have answered? (Committee)

7:40 Identify concerns
- Survey results (LWRD)
- Brainstorm concerns (Committee)

8:10 Initial study results – what did we learn about the flowage? (LWRD)

8:40 Additional concerns following the presentation? (Committee)
Prioritize concerns/issues for further discussion (Committee)

Any additions to: what do you want the plan to accomplish or what questions do you hope to have answered?

9:00 Adjourn

General Meeting Agenda

Background information for selected issues
Discuss potential goals and objectives
Discuss available tools and activities

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Lake Management Plan Development Rules and Roles

Overall Objective
Develop a Lake Management Plan for the Apple River Flowage

A management plan outlines strategies that everyone can live with and may guide new activities and grant funded projects

Ground Rules
RESPECT
CIVILITY
FOLLOW AGENDA TO STAY ON TRACK

It is important to **listen** to what others are saying
Don't interrupt when others are speaking
Everyone will have an opportunity for input

Water Quality Committee Role
Attend every meeting or make provisions for input outside of missed meeting
Share your knowledge of the lakes
Share your concerns about the lakes
Help develop lake management strategies
Review background information
Review draft documents
Decide when draft document is ready to forward to board for approval

Advisor Role
Bring information to assist in decision-making
Help committee understand natural systems
Help committee understand constraints of rules and regulations

Consultant Role
Guide meeting topics and flow
Keep discussion on track (may need to interrupt to keep discussion focused)
Establish procedure for discussion (suggestions appreciated, but only outside of meetings)
Bring background information
Ensure that public input is adequate for plan approval – provide public opportunity to comment
Write goals, objectives, and action items for the plan
Write draft and final plan documents

District Role
Participate as part of the committee
Review draft lake plan
Approve draft lake plan to forward to the WI DNR <u>or</u> disapprove draft plan and return to committee with elements that are not acceptable and suggestions for modifications

Purpose of the Study

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Due to this fact, lakes situated within feet of others can differ profoundly in the uses they support. Factors such as lake size, lake depth, water sources to a lake, and geology all cause inherent differences in lake quality.

Additionally, humans, by changing the landscape, can bring about changes in a lake. This arises because rain and melting snow eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a lake is not inherently problematic. However, water has the ability to carry nutrients, bacteria, sediment, and chemicals into a lake. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

The landscape can be divided into watersheds and subwatersheds, which define the land area that drains into a particular lake, stream, or river. Watersheds that preserve native vegetation and forestland and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to cause negative impacts on lakes, rivers, and streams.

Lake studies often examine the underlying factors that impact a lake's health (such as lake size, depth, and water sources) and the land use in a lakes watershed. Many forms of data can be collected and analyzed to gauge a lake's health including: physical data (oxygen, temperature, etc.), chemical data (including nutrients such a phosphorus and nitrogen), biological data (algae and zooplankton), and land use within a lake's watershed. By compiling this data, lakes can be classified based on their nutrient status and clarity levels.

Three categories commonly used are: oligotrophic, mesotrophic, and eutrophic.

- ✓ Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms.
- ✓ Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.
- ✓ Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms.

Lake studies often identify strengths, opportunities, challenges, and threats to a lake's health. These studies can identify practices already being implemented by lake residents to improve water quality and areas providing benefits to a lake's ecosystem. Additionally, these studies often quantify practices or areas on the landscape that have the potential to negatively impact the health of a lake.

The end product of a lake study is a Lake Management Plan, which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistically based on inherent lake characteristics (lake size, depth, etc.) and should align with lake resident's goals.

Included is a summary of the data and conclusions drawn from a 2012 lake study completed by the Polk County Land and Water Resources Department. This study collected and analyzed the following data to aid in the creation of a Lake Management Plan for the Apple River Flowage:

- ✓ Lake resident opinions
- ✓ Lake level and precipitation data
- ✓ In lake physical and chemical data
- ✓ Algae and zooplankton data
- ✓ Lake sediment chemistry
- ✓ Shoreline land use results
- ✓ Tributary monitoring results
- ✓ Watershed and subwatershed land use

This study also included a number of opportunities for members of the Apple River Flowage Protection and Rehabilitation District including:

- ✓ Pontoon classrooms
- ✓ A shoreline restoration workshop (upcoming)
- ✓ A series of five meetings to review the data collected and develop a Lake Management Plan

Summary

Lake information

The Apple River Flowage is located in southeastern Polk County, Wisconsin in the Town of Lincoln and within the Amery city limits. The Apple River Flowage is a 604 acre impoundment with a mean depth of six feet and a maximum depth of eighteen feet.

There are two inflows to the Apple River Flowage: the Beaver Brook Inlet and the Apple River Inlet. The Beaver Brook Inlet originates in Barron County and flows through the Joel Flowage to the Apple River Flowage; and the Apple River Inlet originates from Staples Lake and flows through White Ash Lake to the Apple River Flowage. The Apple River Flowage has one outlet which is located at the Amery Dam and flows to the Black Brook Flowage.

The Apple River Flowage and many of its tributaries (Beaver Brook Inlet originating at the Joel Flowage, Apple River Inlet, and the Apple River Outlet) are designated as Areas of Special Natural Resource Interest through their identification as Natural Heritage Inventory Waters.

The drainage basin: lake area ratio (DB: LA) compares the size of a lake's watershed to the size of a lake. If a lake has a relatively large DB: LA then surface water inflow (containing nutrients and sediments) occurs from a large area of land relative to the area of the lake. The DB: LA ratio for the Apple River Flowage is approximately 175:1, which is quite large.

The total phosphorus criterion for the Apple River Flowage (classified as a stream based on a residence time of less than fourteen days) is 0.075 mg/L. In 2011, the Apple River Flowage was proposed for the 303(d) list of Impaired Waters for the pollutant total phosphorus and the resulting impairment of excess algae growth. As of January 2013, the Flowage had not yet been formally listed.

Survey results

Ninety-two members of the Apple River Flowage Protection and Rehabilitation District completed a survey regarding the flowage (41% response rate). In this survey invasive species ranked as the 1st concern for the flowage, followed by aquatic plants in 2nd, and algae blooms in 3rd.

Around a quarter of respondents described the water quality of the Apple River Flowage as either poor (36%) or fair (32%). Fewer respondents described the water quality as good (14%) and zero respondents described it as excellent. The majority of respondents felt that in the time since they have owned their property, the water quality has degraded. Zero respondents perceived that water quality has improved.

In general, more respondents feel that algae often or always negatively impacts their enjoyment of the flowage as compared to never or rarely.

A third of respondents described the current amount of shoreline vegetation on the Apple River Flowage as just right (33%). Generally, more respondents felt there was too much shoreline vegetation as compared to not enough.

Although a combined 74% of respondents felt that shoreline buffers, rain gardens, and native plants are very important or somewhat important to water quality, nearly half (47%) of respondents are not interested in installing a shoreline buffer or rain garden on their property.

Respondents are making educated decisions when applying fertilizer to their property. Two thirds of respondents do not use fertilizer on their property (64%) and one third use zero phosphorus fertilizer (33%). Very few respondents use fertilizer but are unsure of its phosphorus content (5%), and zero respondents use fertilizer on their property that contains phosphorus.

Survey respondents were asked to choose all of the management practices they felt should be used to maintain or improve the water quality of the Apple River Flowage from a list of options. Over half of respondents felt that enhanced efforts to monitor for new populations of aquatic invasive species should be used to maintain or improve the water quality of the flowage (60%). Other management practices supported by many respondents include information and education opportunities (46%) and cost-sharing assistance for the installation of farmland conservation practices (41%).

Lake level and precipitation data

Seasonal precipitation totaled eighteen inches north of the 46 bridge and thirteen inches south of the 46 bridge. Shortly following precipitation events, water levels did increase in the flowage. The flowage is created by a dam within the city limits of Amery. Currently, the dam is used to maintain water levels on the flowage. Overall, water levels remained fairly constant over the sampling season.

Sampling procedure

Physical and chemical data were collected in-lake at two sites (Site 1, north and Site 2, south) on the Apple River Flowage from May 8th, 2012 through September 17th, 2012.

Spring turnover samples were taken on April 3rd, 2012. Fall turnover samples were taken on October 15th, 2012.

Turnover

Turnover events in lakes occur two times a year in Wisconsin. At spring and fall turnover, the temperature and density of the water is constant from the top to the bottom. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. The Apple River Flowage, with a maximum depth of eighteen feet, remained well mixed over the sampling season.

In stratified lakes, warmer surface waters are prevented from mixing with cooler bottom waters. As a result, nutrients can actually become trapped in the bottom waters of a lake that stratifies. Additionally, because mixing is one of the main ways oxygen is distributed throughout a lake, lakes that stratify have the potential to have very low levels of oxygen in the bottom waters. The Apple River Flowage did not stratify in 2012.

Chemical data

The total phosphorus criterion for the Apple River Flowage is 0.075 mg/L. In 2012, the summer index period (July 15th – September 15th) average total phosphorus was 0.0895 mg/L at site one (north) and 0.0680 mg/L at site two (south). The total phosphorus criterion was exceeded at both sites in 2012.

Nitrate/nitrite and ammonium are all inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/L can support summer algae blooms in lakes. Average growing season (excludes turnover) inorganic nitrogen was 0.02 mg/L at site one (north) and 0.03 mg/L at site two (south). Inorganic nitrogen concentrations at site one (north) are below the healthy limit which can support summer algae blooms in lakes and concentrations at site two (south) are at the healthy limit.

The total nitrogen to total phosphorus ratio (TN: TP) is a calculation that depicts which nutrients limit algae growth in a lake. The total nitrogen to total phosphorus ratio for both sites (north and south) indicate a nitrogen limited state during the growing season, which is fairly uncommon in Wisconsin.

Physical data

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. Oxygen levels remained above 5 mg/L near the surface but dropped below this threshold in the bottom waters.

Secchi depth serves as a general indicator of water quality. The average growing season secchi depth was 5.5 feet at site one (north) and 4.5 feet at site two (south).

Chlorophyll a (an indicator of algae) seems to have the greatest impact on water clarity when levels exceed 0.03 mg/L. Lakes which appear clear generally have chlorophyll a levels less than 0.015 mg/L. With the exception of site two (south) on August 7th, 2012, chlorophyll a levels on the flowage were below 0.015 mg/L.

Trophic state index

Trophic State Index (TSI) data indicates that in 2012 the Apple River Flowage was mildly eutrophic to eutrophic. Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms.

Shoreline survey

The shoreline inventory shows that the greatest land use at the ordinary high water mark is natural (93%), followed by rip rap (5%), and lawn (2%). A characterization of the shoreline buffer composition (area upland thirty-five feet from the ordinary high water mark) shows that the greatest land use is natural (82%), followed by lawn (17%), and hard surfaces (1%).

Tributary monitoring

The Apple River Inlet is contributing the greatest amount of phosphorus to the Apple River Flowage (8,442 pounds on an annual basis). The Beaver Brook Inlet is contributing 2,580 pounds of phosphorus on an annual basis. Total phosphorus concentrations were elevated on the East branch of the Beaver Brook Inlet (0.2472 mg/L).

The values for the Apple River Flowage Outlet are highlighted in red to serve as a reminder that these values represent the amount of phosphorus leaving the flowage via the outlet.

Site	Total Phosphorus (mg/L)	Discharge (L/s)	Instantaneous Load (mg/s)	Annual Load (lb/yr)
Fox Creek	0.0518	974.610	50.485	3,512.284
Apple River Inlet	0.0648	1,872.570	121.343	8,441.935
Apple River Outlet	0.0636	3,652.740	232.314	16,162.362
Beaver Brook Inlet	0.0836	443.520	37.078	2,579.577
Beaver Brook West	0.0586	125.496	7.354	511.631
Beaver Brook East	0.2472	60.048	14.844	1,032.704

Apple River Flowage Lake Management Plan
Water Quality Committee Meeting 1 Minutes
Wednesday, February 20th, 2013, Amery City Hall, 7-9 pm

Overview

Scheduled next meeting, reviewed grant requirements and purpose of lake management plans, public survey results, water quality study results, identified concerns and questions

Next meeting

Wednesday, March 27th, Amery City Hall, 7-9 pm

Identified committee concerns

- How do we solve the "mildly eutrophic" issue?
- High phosphorus—how can it be reduced in the Apple River Flowage?
- Basic knowledge about phosphorus—how it gets into the water, what it does, where it goes
- What education needs to be done?
- Under-informed about plant types and very basic and specific things in regard to biology, water quality, sediment, etc. – education
- How to deal with organic matter that seems to be excessive in most areas
- How to do sediment cores in various areas to really understand our situation
- What is possible for a shallow impoundment? What should/can we shoot for?
- Focus on specific areas or tributary of concern
- How to make water movement possible in bays that are not open—dead?
- Harvester results
- How to keep a balance chemically and with sediment when harvesting?
- How well harvesting helps in the long run?
- Keep water on river as clear as it was after harvesting

Questions to be answered at future meetings? What do you want the plan to accomplish?

- Used to be a nice body of water; 1979 onward for 8-10 years
  - After the drawdown, gradually filled in
- Downstream of the Flowage—High phosphorus levels? Where is it coming from?
- Watershed—who's involved?
- Water quality pretty good; excess nutrients but many assets
  - Lots of plants—not a lot of algae
  - Fish/birds
- Many positive comments after harvesting
- Reduce the negative, focus on the positive
- Briefly discussed dredging and drawdown as two options to address sediments

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Apple River Flowage Lake Management Plan
Water Quality Committee Meeting 2

Wednesday, March 27th, 2013
7-9 pm
Amery City Hall

Agenda

7:00 Introductions
Pick April meeting date

7:10 Initial study results continued (nutrient budget, algae)

7:40 Explore options for lake management

8:00 Review and discuss draft plan vision, guiding principle, goals, and objectives

9:00 Adjourn

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Enclosed are two documents for review for Wednesday's meeting:

1. A document providing examples of plan vision statements, guiding principles, goals, objectives, and actions. This is by no means a comprehensive list and may include options that are not priorities for the Apple River Flowage and may be lacking options that are priorities for the Flowage. The purpose of this document is solely to provide examples from other Lake Management Plans.

2. A document called Choosing Management Strategies for Lakes which was initially prepared for Portage County lakes. This document provides additional information on the wide range of management strategies available for lakes.

Vision *an overall statement for what you want the waterbody to look like*

The Apple River Flowage provides a healthy environment for people, wildlife, and plants

The Apple River Flowage is a clear waterbody, with moderate nutrient levels and diverse fish, wildlife, and plants

Guiding Principle *provides guidance on how the lake management plan will be implemented*

An understanding of data drives lake management decisions

Lake management decisions are driven by what is best for the resource

Communication regarding lake management is easy to understand, concise, and frequent

Lake residents and users are provided information to understand the ever evolving nature of lake management, the complexity of issues, the status of projects and activities, the costs and benefits of actions, and the opportunity and techniques to reduce or prevent any negative consequences of lake use and lakeside living

Financial decisions are made in cooperation with District members

Goals *broad statements of direction*

Objectives *measurable steps towards goals*

Actions *activities to accomplish objectives*

Goals and Objectives

Maintain and improve current water quality and in-lake nutrient levels

Reduce nutrient pollution to the flowage

Reduce runoff of nutrients and sediment from the watershed

Objectives may include:

- Engage residential owners in reducing runoff
- Reduce phosphorus loading from residential sources by X% or X pounds
- Support installation of residential best management practices/practices that reduce runoff to the flowage

- Engage agricultural producers in reducing runoff
- Reduce phosphorus loading from agricultural sources by X% or X pounds
- Support installation of agricultural best management practices/practices that reduce runoff to the flowage

Actions may include: providing technical assistance for property owners, cost sharing installation of best management practices, considering purchase of highly erodible/ecologically sensitive land if option arises, free evaluation of septic systems, stormwater practices in the City of Amery, education initiative

Encourage lake processes that minimize the release of nutrients from within the flowage

Objectives may include:

- Engage stakeholders in reducing internal loading
- Reduce internal loading by X%
- Support practices that reduce internal loading
- Conduct further studies to better understand internal loading

Actions may include: study to determine phosphorus release from CLP die off, slow-no wake to minimize disturbance of sediments, continue harvesting, conduct a study on results of harvesting, study to determine feasibility of dredging and drawdown to address sediments, education initiative

Protect, maintain, and enhance the fishery

Protect, maintain, and enhance fish and wildlife habitat

Objectives may include:

- Maintain desirable levels of game fish in the flowage
- Assess and improve fish habitat
- Balance fish populations to encourage zooplankton
- Increase understanding of options for attracting wildlife to property
- Protect existing natural areas with native vegetation
- Enhance shoreline vegetation

Actions may include: fish stocking, installation of fish sticks, communication with DNR, cost sharing shoreline buffers, purchase of ecologically sensitive land, conservation easements to preserve undeveloped lands, establishment of slow-no wake zones, enforcement of current slow-no wake requirements, education initiative

Maintain and enhance the natural beauty of the flowage

Promote the preservation and restoration of natural vegetation along the shoreline

Objectives may include:

- Maintain undeveloped natural areas where feasible
- Enhance natural beauty of developed areas
- Create areas for public use

Actions may include: incentives to encourage restoration/maintenance of buffers, conservation easements, installation of public fishing piers, creation of public parks with walking trails

Continue to collect in-lake water quality data

Measure lake management progress by collecting in-lake water quality data

Evaluate the progress of lake management efforts through monitoring

Objectives may include:

- Continue current data collection efforts
- Expand data collection efforts to include…provide a list
- Consider additional studies to quantify/update a nutrient budget

Actions may include: citizen lake monitoring data collection (secchi, chlorophyll a, total phosphorus), tributary sampling, track installation and effectiveness of watershed practices, quantify internal loading, study on impacts of harvesting, study on CLP die off

Increase information and education opportunities

Provide education regarding lake management

Expand education efforts emphasizing the following topics: …provide a list

Objectives and actions may include a list of avenues and methods to communicate information

For example:

Newsletter
Publish x times per year
Seek assistance from agency staff for appropriate articles

Manage native and invasive aquatic plants according to the goals, objectives, and actions outlined in the Aquatic Plant Management Plan

Implement the goals of the Aquatic Plant Management Plan

Improve water quality on the Apple River Flowage and downstream on the Apple River

Prevent the introduction of aquatic invasive species

Maintain navigation for fishing, boating, and access to lake residences

Maintain native aquatic plant functions

Minimize environmental impacts of aquatic plant management

Choosing Management Strategies for Lakes

A diversity of management strategies exist for lake protection. A review of water quality data, an understanding of lake users' perceptions, and the identification of concerns for a lake can guide which management strategies should be implemented for a particular body of water.

Each lake is unique in its physical characteristics (depth, size, location in the landscape), chemical characteristics (phosphorus, nitrogen, pH), assemblage of living and non-living organisms (fish, birds, wildlife, plants, sediments), and human uses (swimming, boating, fishing, scenic beauty). Additionally, lake users represent a diversity of perceptions and values related to concerns for a specific lake. Ultimately, for management strategies to be effective they must take into account scientific data and be supported by the majority of lake users. Management strategies must also align with current state and local regulations and ordinances and take into account availability of funding and volunteers. As a result, it is unlikely that two lakes will choose to pursue identical management strategies.

Despite the uniqueness of lakes and the people that represent them, management strategies do exist that will benefit all lakes. When considering management strategies to adopt, start with this list of best management practices that will benefit all lakes:

Nutrients (phosphorus and nitrogen) are a major source of lake water quality problems, so:
✔ Eliminate applications of lawn fertilizers. If fertilizing, use zero phosphorus fertilizers. In Polk County it is illegal to apply lawn fertilizers within 300 feet of a river/stream and 1,000 feet of a lake/pond/flowage
✔ Choose phosphorus free detergents and cleaning products
✔ Clean up and properly dispose of pet waste
✔ Don't burn leaves near the lake or rake yard waste into the lake
✔ Use natural vegetation, rain gardens, or landscaping to keep runoff from directly entering the lake
✔ If you are a farmer, request help from the Polk County Land and Water Resources Department to develop water quality-based best management practices for farmland that may impact the lake through surface runoff or groundwater inputs
✔ Join other landowners and lake users to establish a water quality monitoring program for your lake. WDNR provides Citizen Lake Monitoring training and data analysis at no cost

Fish and other aquatic life depend on natural vegetation near and on the lake shore, so:
✔ Maintain a natural vegetation buffer—including grasses/forbs, shrubs, and trees—of at least 35 feet from the lake ♻
✔ Don't remove aquatic plants, logs, or brush in front of your property unless absolutely necessary for lake access and recreational activities. Native aquatic plants help stop harmful aquatic invasive plants from becoming established. Follow state aquatic plant removal regulations and obtain permits when needed ♻
✔ Learn to identify aquatic invasive plant species, watch for them near your property and public landings, and help stop their spread. Check with WDNR for aquatic invasive plant removal rules ♻

♻ Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Septic systems contribute nutrients and other chemicals to groundwater and lakes, even if they are working properly, so:
✔ Locate your drain field as far from the lake shore as possible
✔ Pump your septic tank at least once every three years
✔ Consider installing an alternative or additional wastewater treatment system that can remove nitrogen and phosphorus, or explore community or other group wastewater treatment options
✔ Use household chemicals sparingly, try to choose less harmful products, and be mindful that chemicals put into a septic system could end up in the lake or your drinking water

The following management strategies should be implemented if they are applicable for your particular body of water.

Does your lake have areas less than 8 feet deep? These areas:	
May have these problems	**and may benefit from**
Sediment disturbance from boat motors	✔ No-wake speeds or electric motors only
Wind disturbance of sediments	✔ Moderate growth of aquatic plants to hold sediments in place
High density of aquatic plants	✔ Strategies to improve recreational access ✔ Tools from the phosphorus management toolbox
Shallow lakes may suffer from a lack of dissolved oxygen in winter	

Does your lake have a high percentage of its areas more than 18 feet deep? Deep lakes:	
May have these problems	**and may benefit from**
• Few aquatic plants • Biomass dominated by algae • Lack of oxygen near bottom • Release of phosphorus from sediments during low oxygen conditions	✔ Tools from the phosphorus management toolbox ✔ Minimizing near shore vegetation disturbance to provide habitat and protect water quality♻
The two storied fisheries of deep lakes, which include trout and walleye in cool, deep waters as well as panfish and bass in shallow waters, require management to stay in balance	

Is your lake a deep bowl protected from the wind? Lakes in deep bowls:	
May have these problems	**and may benefit from**
Runoff from steep shoreline areas	✔ Houses being set back from steep slopes ✔ Meandering, not direct, access to the lake ✔ Vegetative buffers to prevent erosion along slopes ✔ Shoreline buffers to intercept erosion and runoff ✔ Additional tools from the runoff management toolbox
Lack of mixing and oxygenation	✔ Monitoring dissolved oxygen concentrations ✔ Using mechanical aeration when necessary

♻ Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have wetlands along its shore? Lakes with adjacent wetlands:		
May have these problems		**and may benefit from**
Nutrient addition when water levels rise	✔	Retaining natural wetland vegetation and minimizing nutrient flow to wetlands
Natural limit to residential growth and development	✔	Appropriate zoning ordinances to avoid developing wetland areas
	✔	Maintaining vegetative buffers around wetlands
Wet soils and wetland vegetation in areas that people cross to access the lake	✔	Avoiding wet areas or installing a boardwalk over them to reduce disturbance
Compared to lakes without wetlands, these lakes may have more water quality fluctuations and more diverse wildlife habitat		

Does your lake experience natural water level fluctuations? Such lakes:		
May have these problems		**and may benefit from**
Aquatic invasive plant species that become established on bare sediments or in shallower, warmer water	✔	Looking for and removing aquatic invasive plants during low water periods. Check with WDNR for aquatic invasive plant removal rules ♻
Damage to unique habitats by human use during low water periods	✔	Establishing barriers to prevent vehicle access to the dry lake bed during low water periods
Sensitivity to changes in groundwater recharge	✔	Use of swales, rain gardens, and other management tools to encourage infiltration of rainwater and snowmelt
A large area less than 8 feet deep during some parts of the year	✔	No-wake speeds or electric motor only zoning
Winter fish kills	✔	Adding oxygen when necessary by mechanical aeration or by plowing snow off the lake surface to encourage plant growth
Flooding of septic systems during high water periods	✔	As great a septic system setback from the lake as possible
	✔	Use of mound systems
Shoreline erosion during high water periods	✔	Maintaining native vegetation and unmowed/uncropped buffer strips near the water's edge
Removal of woody material, leading to loss of potential habitat for fish during periods of high water	✔	Leaving fallen trees, logs, or branches in place or adding them to the exposed lake bed during low water periods

Does your lake have dissolved oxygen concentrations of less than 5 ppm (mg/l) in the upper one-third of the water column during winter? These lakes:		
May have these problems		**and may benefit from**
Winter fish kills	✔	Monitoring dissolved oxygen concentrations
	✔	Adding oxygen when necessary by mechanical aeration or by plowing off the lake surface to encourage plant growth

♻ Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have water hardness of more than 150 ppm as $CaCO_3$? If so, marl may form. Marl lakes:	
May have these problems	**and may benefit from**
High density of aquatic plants in shallow sediments	✔ Strategies to improve recreational access
Decreased water clarity caused by resuspension of marl by wind and boats	✔ Slow no wake zones at water depths of less than 8 feet (municipal rules may apply)
Gradual filling with marl	✔ Dredging to deepen parts of the lake 🌐
These lakes usually have good water clarity because marl formation removes phosphorus that would otherwise be used by algae	

Does your lake have water hardness of less than 90 ppm as $CaCO_3$? These lakes:	
May have these problems	**and may benefit from**
Low calcium concentrations, leading to greater response by algae to phosphorus additions	✔ Tools from the phosphorus management toolbox

Does your lake have water hardness of less than 25 ppm as $CaCO_3$? These lakes:	
May have these problems	**and may benefit from**
Higher mercury, aluminum, and zinc solubility when rainfall is acidic	✔ Efforts at personal, regional, and national scales to reduce electricity use and fossil fuel consumption
These lakes usually are less productive than other lakes, but often have the most diverse aquatic macrophyte communities	

Do the inorganic forms of nitrogen in your lake exceed 0.3 mg/l (as N) in spring? Lakes with these high nitrogen loads	
May have these problems	**and may benefit from**
Excessive near shore aquatic plants and attached algae and toxicity to some aquatic animals	✔ Eliminating nitrogen fertilizer applications by farmers and homeowners or limiting applications based on soil tests ✔ Alternative or additional wastewater treatment systems designed to remove nitrogen

What is the total phosphorus concentration in your lake between July 15th and September 15th (average of at least three surface samples)? Consult the following table to compare this value to the proposed criteria values for your lake type.
Stratified, two story fishery lakes, 15 µg/L
Stratified seepage lakes, 20 µg/L
Stratified drainage lakes, 30 µg/L
Non stratified drainage and seepage lakes, 40 µg/L
Apple River Flowage, stream with residence time less than 14 days, 75 mg/L

🌐 Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Has your lake reached its criteria value for total phosphorus? Such lakes:	
May have these problems	**and may benefit from**
• Excessive weeds and algae, including some that are toxic to animals • Winter fish kills • Poor aesthetics—green, turbid, smelly water	✔ Reducing phosphorus concentrations by implementing tools from the phosphorus toolbox ✔ Conducting an in-depth study of lake management and rehabilitation alternatives to control internal and external nutrient loading ✔ Establishing a water quality monitoring program

Phosphorus Management Toolbox
Implement one or more of the following tools to lower total phosphorus concentrations, or to keep concentrations from increasing:
✔ Eliminate phosphorus fertilizer use on your lawn or farm fields, or limit it based on soil test results. In Polk County it is illegal to apply lawn fertilizers within 300 feet of a river/stream and 1,000 feet of a lake/pond/flowage
✔ Don't burn leaves near the lake or rake yard waste into the lake
✔ Implement agricultural best land management practices based on water quality
✔ Install and maintain vegetative buffers, rain gardens, and filter strips that cause stormwater to infiltrate and limit runoff to the lake
✔ Choose phosphorus free automatic dishwater detergent and other "green" household cleaning products if your wastewater re-enters the soil through a septic system
✔ Install alternative or additional wastewater treatment systems designed to remove phosphorus, or consider options for connection to a community or other group wastewater treatment system, especially in areas where groundwater discharges to the lake.
✔ Check the runoff management toolbox and protection tools in the lake management toolbox for more community-based action and solutions.

Is your lake currently free of aquatic invasive species? Such lakes will benefit from:
✔ Protecting and maintaining native plant and animal communities
✔ Knowing how to identify invasive species and actively monitoring for them
✔ Using signs, newsletters, or more active methods to educate boaters and anglers and to encourage them to clean boats and trailers before launch

Does your lake already have aquatic invasive species? Such lakes will benefit from:
✔ Using the tools from the box above
✔ Encouraging boaters and anglers to clean boats and trailers after use to prevent the spread of the invasive species to other lakes
✔ Developing and following an aquatic plant management plan that contains and controls the invasive species

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Are there signs that your lake's ecosystem is out of its natural balance? Such lakes:	
May have these problems	**and may benefit from**
Geese on shoreline	✔ Maintaining a natural vegetation buffer onshore ✔ Avoiding mowing or cropping to the water's edge
Eroding shoreline	✔ Vegetative buffers to prevent erosion on slopes ✔ Shoreline buffers to intercept erosion and runoff ✔ Other shoreline stabilization methods such as rocks ✔ Maintaining in-lake aquatic plants to act as baffles and reduce the influence of waves ✔ Creating meanders rather than direct paths to the lake
Nuisance-level aquatic plant growth	✔ Creating an aquatic plant management plan

Is your lake's fishery dependent on stocking? Such lakes:	
May have these problems	**and may benefit from**
Lack of fish habitat	✔ Addition of woody material to the nearshore lake bottom
Lack of fish spawning areas or amphibian habitat	✔ Protection of native aquatic vegetation; avoid raking of the lake bottom or removal of vegetation ✔ Awareness of critical habitat locations and actively protecting them from disturbances
Stunted fish, rough fish, dominance of non-game fish	✔ Catch and release fishing ✔ Consulting a WDNR or other professional fishery manager

Are motorized watercraft used on your lake? Such lakes:	
May have these problems	**and may benefit from**
Conflicts between use	✔ Placing limits on motorized watercraft use by time or day, no-wake zones, and/or motor type ✔ Spatial/local boating ordinances to protect critical habitat
• Lake sediment disturbances in shallow water during high-use periods • Disturbance of plant beds and littoral vegetation • Decreased water clarity	✔ Selecting a boat launch area and parking lot appropriate to the lake's carrying capacity and meeting WDNR standards for access ✔ Using no-wake speeds or zoning for electric motors only ✔ Protecting shallow water vegetation and natural materials that keep sediments in place
Increase risk of invasive species introduction	✔ Using signs or more active methods to educate boaters and anglers and to encourage them to clean boats and trailers before launch ✔ Monitoring areas near boat landings to identify and control aquatic invasive species that do get established

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Does your lake have a public park or boat landing? Such lakes:	
May have these problems	**and may benefit from**
Increased nutrient runoff linked to vegetation disturbances	✔ Enhancing infiltration using native vegetation, including unmowed buffer strips
Water runoff from roofs, parking areas, and other paved, compacted, or impervious areas	✔ Directing runoff from these areas into a vegetated strip or rain garden away from the lake
Septic systems that experience heavy use	✔ Constructing these systems with as great a setback as feasible, on the soils that have the greatest capacity to adsorb nitrogen and phosphorus, and regularly inspecting, monitoring, and maintaining them ✔ Installing additional or alternative wastewater treatment systems that remove nitrogen and phosphorus, or exploring community or other group wastewater treatment options ✔ Installing water and energy-conserving plumbing fixtures and devises

Does your lake currently have residential development on it, or is residential development likely in the future? Such lakes:	
May have these problems	**and may benefit from**
Nitrogen and phosphorus loading from fertilized lawns	✔ Eliminating fertilizer applications or limiting them based on soil test results ✔ Using natural buffers that include native vegetation between the lawn and lake ✔ Minimizing amount of manicured lawn ✔ Using tools from the runoff toolbox
Nutrient loading from septic systems	✔ Using greater system setbacks from the lake whenever possible ✔ Encouraging or requiring the use of alternative or additional wastewater treatment systems that remove nutrients whenever systems are installed or replaced, or exploring community or other group wastewater treatment options
Destruction of shoreline vegetation and habitat	✔ Providing education for new landowners on keeping vegetated shorelines intact ✔ Restoring natural shoreline buffers and protecting critical habitat areas
Runoff that carries nutrients to the lake	✔ Using tools from the runoff toolbox ✔ Using protection tools from the lake management toolbox

Does your lake's watershed have off-lake residential development, or is such development likely in the future? Such lakes may benefit from:
✔ Using tools from the runoff management toolbox
✔ Using protection tools from the lake management toolbox

- Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

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Does your lake have agricultural land uses near the shore or in the watershed? Such lakes:	
May have these problems	**and may benefit from**
• Sediment and nutrient runoff inputs of nitrate or pesticides through groundwater • Increases in algae • Decreases in dissolved oxygen • Other water quality impacts	✔ Crops that require little nitrogen input ✔ Development and implementation of livestock grazing and manure spreading and storage plants and practices that protect water quality ✔ Vegetative filter strips along lakes, streams, and wetlands to limit runoff inputs and channelized flow to the lake ✔ Public support for county efforts to educate farmers and develop nutrient management plans based on water quality goals ✔ Public support for farmers who implement practices to protect water quality

Runoff Management Toolbox for Lake Watersheds
Implement one or more of the following tools to minimize the amount of surface runoff that carries nutrients and sediments to lakes:
✔ Implement road and building construction practices that meet Polk County erosion standards
✔ Implement agricultural best management practices to minimize runoff
✔ Use the local zoning ordinance to limit impervious surfaces that create runoff
✔ Install and maintain vegetative buffers and filter strips that cause stormwater to infiltrate and to limit runoff to the lake
✔ Use stormwater management practices, which may include rain gardens, streets without curb and gutter, and retention basins

Protection Tools in the Lake Management Toolbox
Implement one or more of the following tools to manage land to protect lakes:
Use legal tools, including:
✔ Zoning that limits potentially damaging land uses and implements the overall density provided for in the land use plan
✔ Overlay zoning that identifies special protections beyond those in the basic zoning ordinance, including shoreland setbacks, impervious surface limits, shoreland buffers, and mitigation measures
✔ Zoning standards adjusted for specific lakes or groups of lakes with similar physical characteristics
✔ Subdivision ordinances
Use voluntary tools, including:
✔ Purchase of development rights that permanently protect landscapes while retaining private ownership
✔ Conservation easements to restrict development or uses of land
✔ Purchase of land by state and local governments or not-for-profit organizations
✔ Conservation design which modifies subdivision ordinances to require protection of open space

Check Wisconsin Department of Natural Resources regulations: http://dnr.wi.gov/topic/Waterways/

Strategies are adapted from the publication: Choosing Management Strategies for Portage County Lakes by Byron Shaw, Nancy Turyk, Jen McNelly, Buzz Sorge, and Chris Mechenich.

Apple River Flowage Lake Management Plan
Water Quality Committee Meeting 2 Minutes
Wednesday, March 27th, 2013, Amery City Hall, 7-9 pm

Overview

Scheduled next meeting; presentations on watershed modeling and options for lake management; reviewed and discussed draft plan vision, guiding principles, goals, and objectives

Next meeting

Saturday, April 20th
10 AM – 12 PM
Amery City Hall

Plan vision, guiding principles, goals and objectives drafted at the meeting:

Vision

The Apple River Flowage is a healthy waterbody with moderate nutrient levels, which supports human recreational uses and diverse fish, wildlife, and plants.

Guiding Principles

Lake management decisions are driven by what is best for the resource based on information that includes the ever evolving nature of lake management.

Communication regarding lake management is easy to understand, concise, and frequent.

Goals and objectives

I. Reduce watershed nutrient pollution to the Apple River Flowage to improve water quality

Include a definition of who's in the watershed

A. Identify the residents and users in the watershed
B. Engage watershed residents and users in reducing nutrients, sediment, and pollutants to improve water quality.
C. Reduce phosphorus loading from watershed sources by at least X% (X pounds)
D. Support installation of best management practices, or practices that reduce runoff to the flowage

II. Minimize the release of nutrients from within the Apple River Flowage

Include a definition of internal loading

A. Engage watershed residents and users in reducing internal loading
B. Support practices that reduce internal loading
C. Conduct further studies to better understand internal loading

III. Protect, maintain, and enhance fish and wildlife habitat

A. Enhance native shoreline vegetation
B. Maintain desirable levels of game fish in the flowage
C. Assess and improve fish habitat
D. Increase understanding of options for attracting desirable birds, waterfowl, and wildlife to property
E. Protect existing natural areas with native vegetation

IV. Maintain and enhance the natural beauty of the Apple River Flowage

A. Promote the preservation and restoration of natural vegetation along the shoreline
B. Maintain undeveloped natural areas where feasible
C. Enhance natural beauty of developed areas
D. Create areas for public use

Apple River Flowage Lake Management Plan
Water Quality Committee Meeting 3

Saturday, April 20th, 2013
10 am - 12 pm
Amery City Hall

Agenda

10:00 Introductions
Pick May meeting date

10:10 Initial study results continued: algae data

10:20 Review and discuss draft plan goals and objectives (5-7, in italics)
Refine draft plan goals and objectives 1-4 (if necessary)
Review and discuss draft action items (in italics)

12:00 Adjourn

Katelin Holm, (715) 485-8637, katelin.holm@co.polk.wi.us

Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Enclosed are two documents for review for Saturday's meeting:

1. The first document is what we have come up with as a group so far for: vision, guiding principles, goals, objectives, and action items. Please review for any edits/additions/revisions prior to Saturday's meeting.

2. The second document is a draft of what LWRD has prepared so far for the Lake Management Plan. Keep in mind it may still have grammatical errors and there are still sections of the report that need to be added. This report is long and much of the information was already presented at previous meetings. Feel free to review as you like.

Apple River Flowage Lake Management Plan
Water Quality Committee Meeting 4

Tuesday, May 21st, 2013
7-9 pm
Amery City Hall

Agenda

7:00 Comment on and finalize vision, guiding principles, goals, objectives, and actions

7:30 Complete Implementation Plan

Please review the following documents for changes/comments. At the meeting we will work to fill in the blanks of the Implementation Plan table. In preparation for the meeting, start thinking about when various projects should be started and who might be the responsible parties.

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Jeremy Williamson, (715) 485-8639, jeremyw@co.polk.wi.us

Appendix I

Presentations

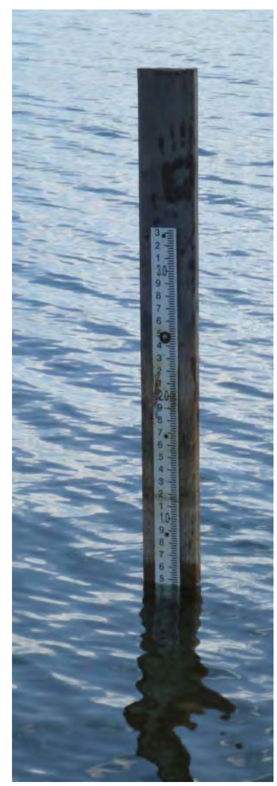
Apple River Flowage Water Quality and Biological Assessment

This project will be funded through a WDNR Lake Planning Grant. The grant award of $19,391 makes up 67% of the total project costs. The remaining 33% of the project costs are made up through volunteer hours, equipment use, and a District match of $3,000.

Project activities:

- Physical and chemical data
  - In lake (2 sites)
  - Tributary sampling (6 sites)
- Lake sediment dredge sampling
- Lake level and precipitation monitoring
- Phytoplankton (algae) monitoring
- Zooplankton monitoring
- Shoreline assessment
- Mapping and watershed delineation
- Sociological survey
- Educational programs
  - Shoreline restoration workshop
  - Pontoon classroom
  - Series of 5 meetings
- Final plan generation: Lake Management Plan

Project activities requiring volunteers:



- Lake level and precipitation monitoring: *This project will require two volunteers who are able to record lake level and any precipitation events on a daily basis. Ideally, this data will be collected at two sites: one North of Hwy 46 and one South of Hwy 46. LWRD will install a staff gauge (photo on right) in the water in front of volunteer's properties, provide a rain gauge for measuring precipitation, and provide data sheets for recording.*

- Sociological survey: *Volunteers are needed to review and distribute the survey.*

- Shoreline assessment: *This project will take place in late summer/early fall and will involve assessing the shoreline from the water. Volunteers will determine the land use (lawn, natural area, structure, riprap, etc.) of the shoreline (ft) and the first 35 feet of shoreline (ft^2).*

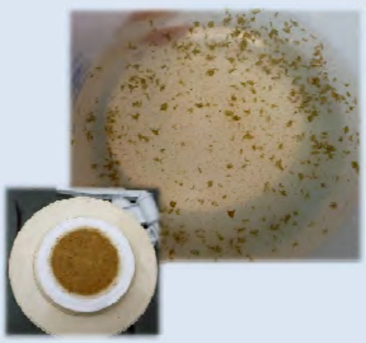
- Educational programs: *These events will take place later in the season. For now the only tasks are to determine the best time to hold educational programs and to generate interest in the programs. The series of five meetings will work towards generating the final Lake Management Plan. Ideally, these meetings would be attended by members of a water quality committee.*

Biweekly data collection

- Physical/chemical data
  - 2 sites
- Tributary flow
  - 6 sites

Monthly data collection

- Chemistry
  - Flowage
  - Tributary
- Metals
- Zooplankton
- Algae
- Chlorophyll a



Lake level and precipitation

- Volunteers
  - Dale Richardson
  - Norval Doddridge
- Purpose
  - Track/understand lake level changes

Sociological survey

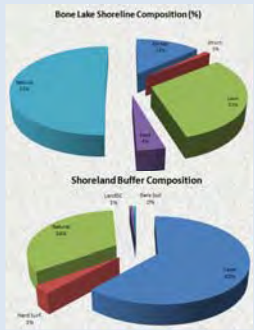
- Mailed end of June
  - 89/225 returned
  - 40% response rate
- Purpose
  - Public input for final plan
  - Identify interest in shoreline restoration workshop

Education opportunities

- Pontoon classroom
- Shoreline restoration workshop

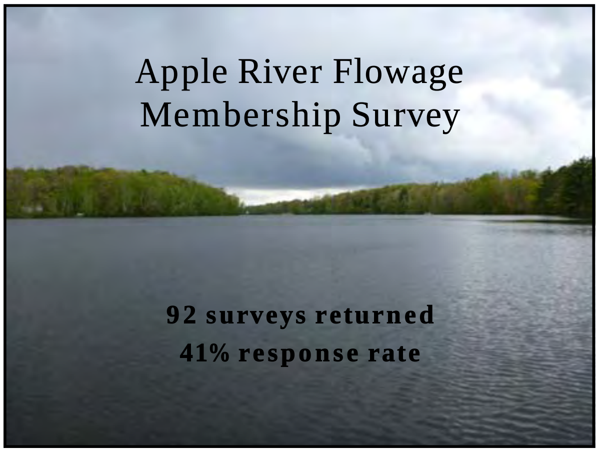
Shoreline survey

- Volunteer needs
  - 6 to 8 people
  - Late summer to fall
- Purpose
  - Sensitive areas
  - Erosion issues
  - Fish habitat



End products

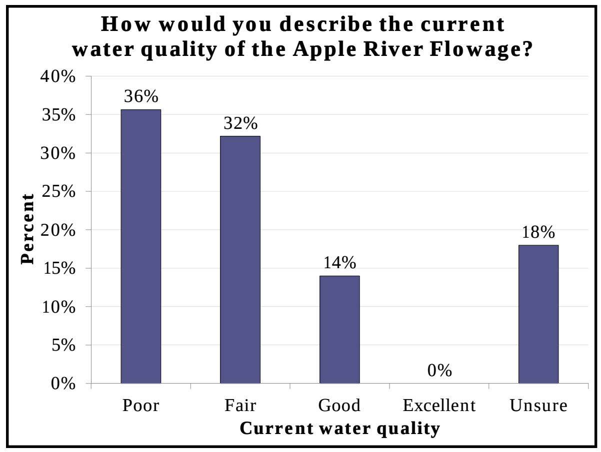
- Meeting with water quality committee
  - Set goals, objectives, and action items
- Final plan
  - Necessary for future grants
  - Roadmap for decision making

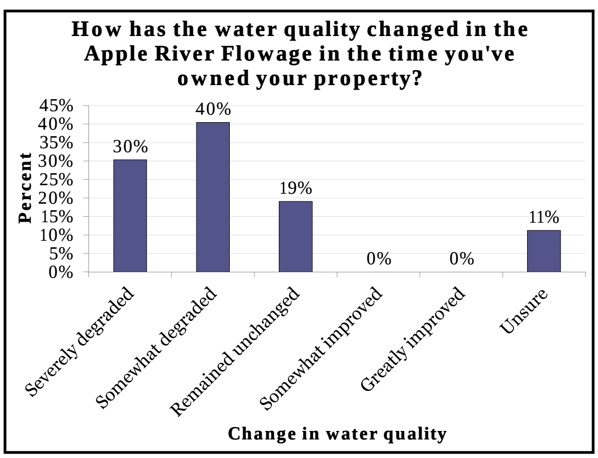


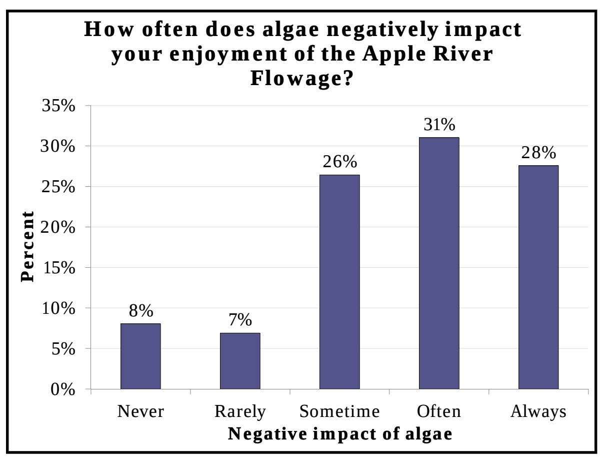
Property Ownership

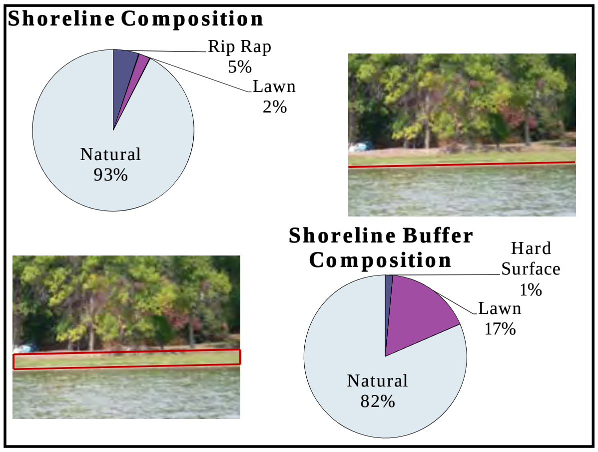
- Owned 19 years
- 59% full time residence
- 21% weekend, vacation, holiday

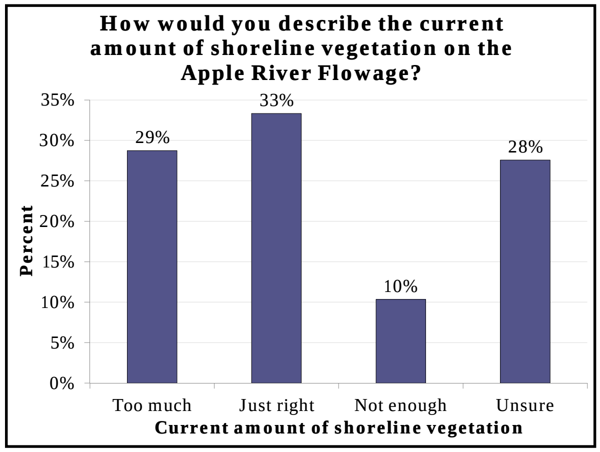
Concerns for the Apple River Flowage	Rank	Points
Invasive species (Eurasian water milfoil, zebra mussels, curly leaf, purple loosestrife)	1st	113
Aquatic plants (not including algae)	2nd	87
Algae blooms	3rd	63
Pollution (chemical inputs, septic systems, agriculture, erosion, storm water runoff)	4th	60
Property values and/or taxes	5th	50
Water clarity (visibility)	6th	39
Quality of fisheries	7th	29
Quality of life	8th	28
Water levels (loss of lake volume)	9th	24
Development (population density, loss of wildlife habitat)	10th	13
Water recreation safety (boat traffic, no wake zone)	11th	10
Other, describe (geese/muskrats, sediment, navigation)	12th	10











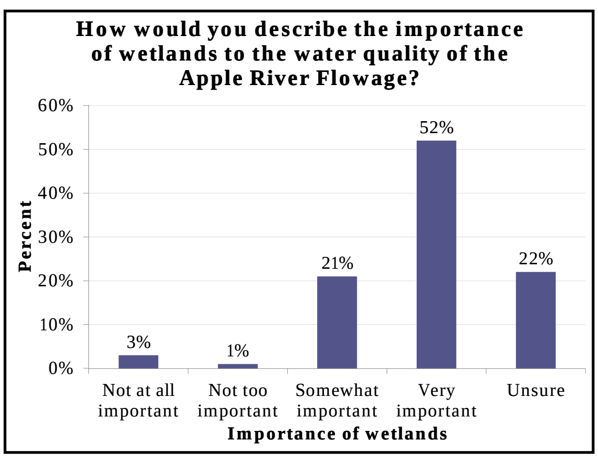
Importance of buffers, rain gardens, and native plants

- 74% very/somewhat important
- 8% not at all/not too important
- 18% unsure

- However…
- 47% not interested
- 28% installed
- 12% interested
- 15% unsure

Fertilizer use

- 64% do not use fertilizer
- 33% use zero phosphorus fertlizer
- 5% unsure
- 0% use phosphorus fertilizer

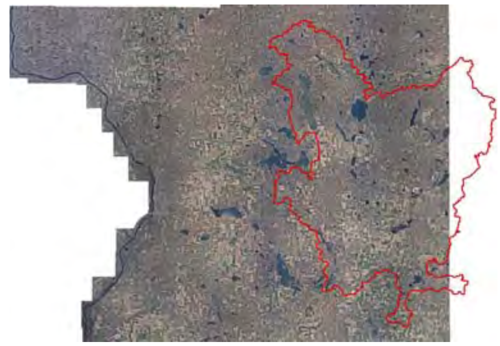


Management practices to improve water quality	**Percent**
Enhanced efforts to **monitor** for new populations of **aquatic invasive species**	60%
Information and education opportunities	46%
Cost-sharing assistance for the installation of **farmland conservation practices** (nutrient management plans, contour strips, conservation tillage)	41%
Collection of **sediment cores** to provide information concerning historical lake conditions	38%
Establishment of **slow-no-wake zones** to protect aquatic plants and fisheries habitat	35%
Cost-sharing assistance for the installation of **shoreline buffers and rain gardens**	27%

Apple River Flowage Water Quality

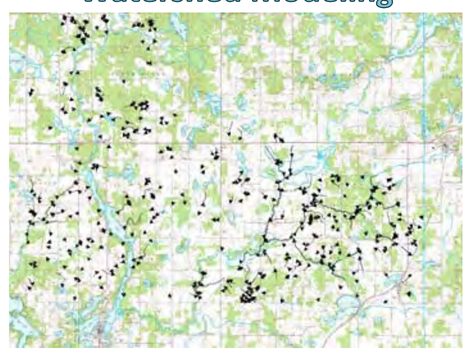
Jeremy Williamson
Water Quality Specialist
Polk County LWRD

Watershed Modeling



Watershed Modeling

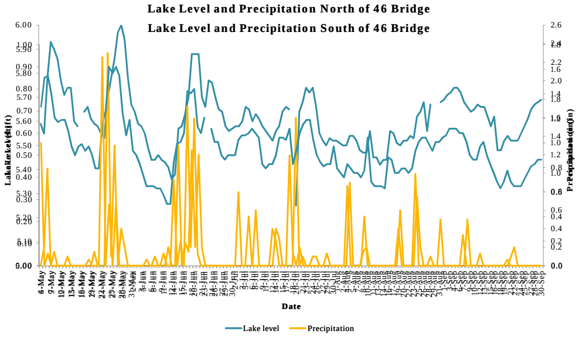
Watershed Modeling

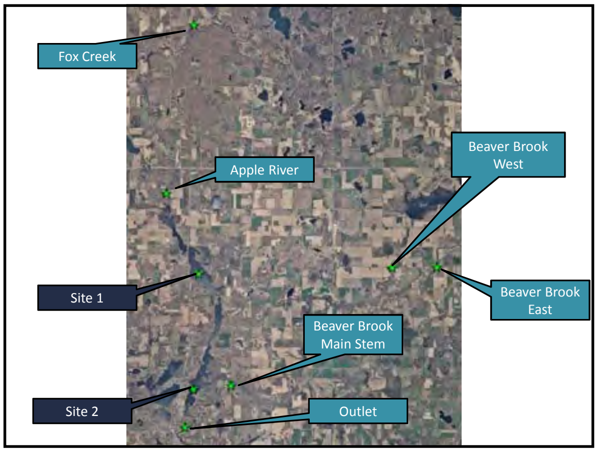


Watershed Modeling

Watershed Modeling

Lake Levels





Tributary Monitoring

Site	Total Phosphorus (mg/L)	Discharge (L/s)	Instantaneous Load (mg/s)	Annual Load (lb/yr)
Fox Creek	0.0518	974.610	50.485	3,512.284
Apple River Inlet	0.0648	1,872.570	121.343	8,441.935
Apple River Outlet	0.0636	3,652.740	232.314	16,162.362
Beaver Brook Main Stem	0.0836	443.520	37.078	2,579.577
Beaver Brook West	0.0586	125.496	7.354	511.631
Beaver Brook East	0.2472	60.048	14.844	1,032.704

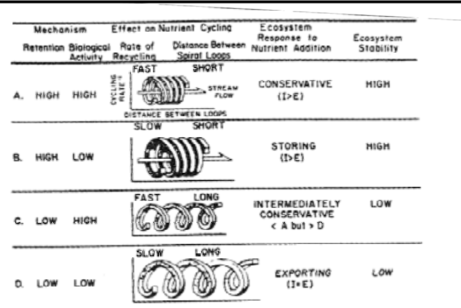


FIGURE 8-10 Hypothetical effects of interactions between distance of downstream movement (velocity × time) and measures of biological activity, such as bacterial metabolism, on organic matter or nutrient cycling in streams of low order (1–4). I = import; E = export. The spiraling rate of recycling reflects biological activity, in which the smaller the diameter of the loop, the faster the rate. Distance between spiral loops represents the extent of downstream displacement of a cycle by the flow of water. The effect of flow can be offset by retention mechanisms so that the higher the retention, the shorter the stream distance between cycles. The quantity of material being cycled is represented by the thickness of the spiraling line. (Modified from Minshall *et al.*, 1983.)

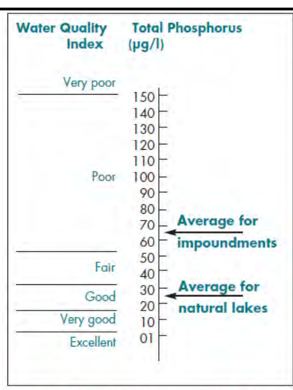
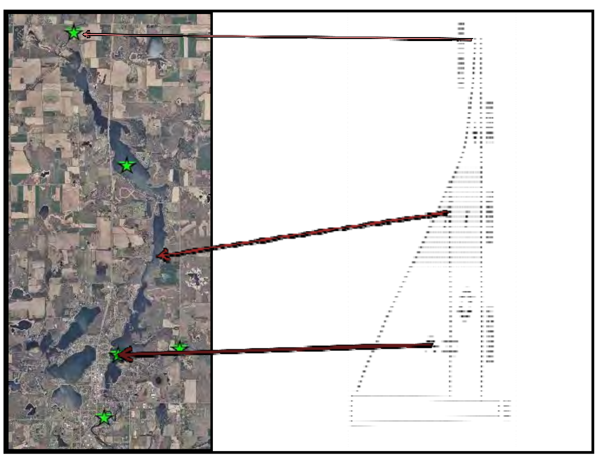
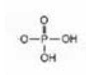
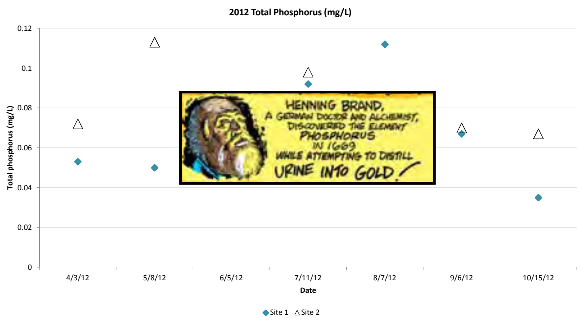


FIGURE 4. Total phosphorus concentrations for Wisconsin's natural lakes and impoundments. (*Adapted from Lillie and Mason, 1983.*)

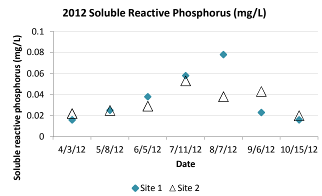


Total Phosphorus

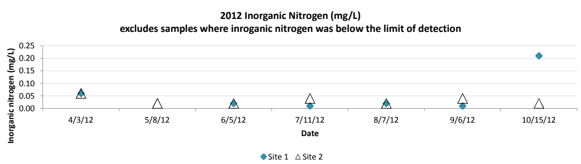


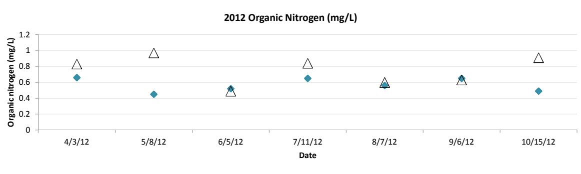


Soluble Reactive Phosphorus

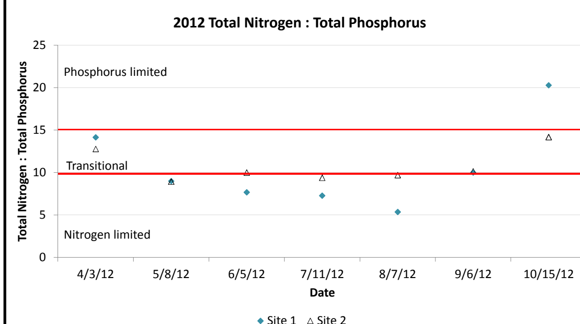


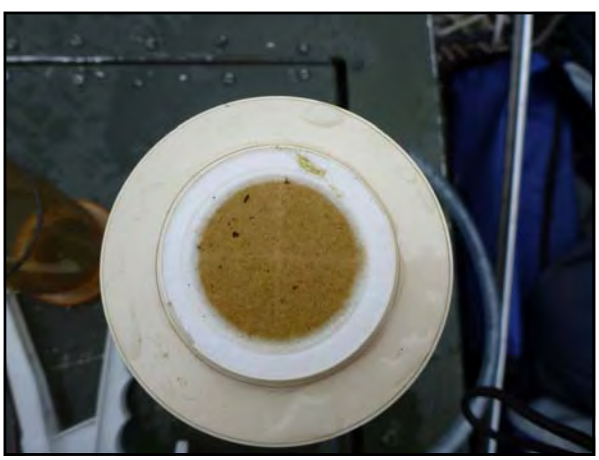
Nitrogen



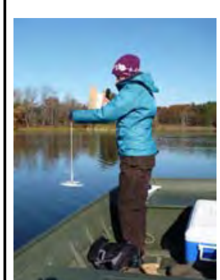


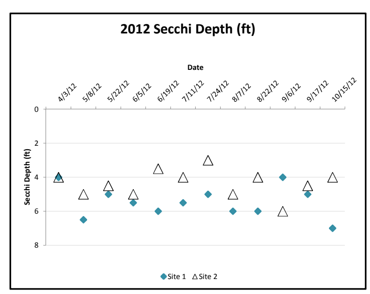
TN:TP ratio





Secchi Disc





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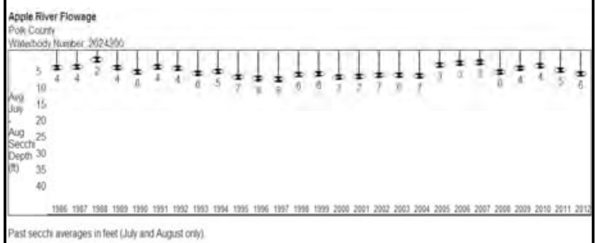
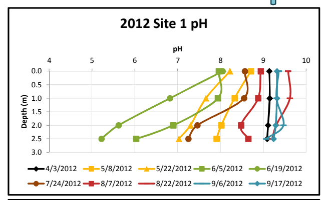
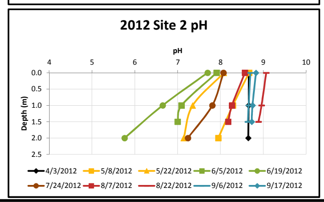
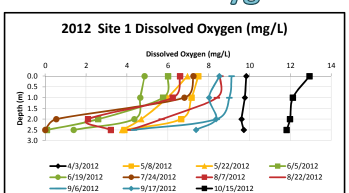


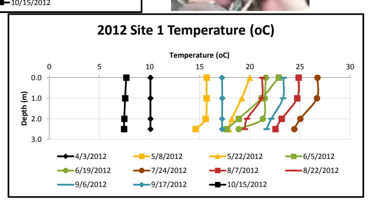
pH



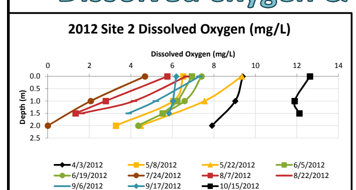


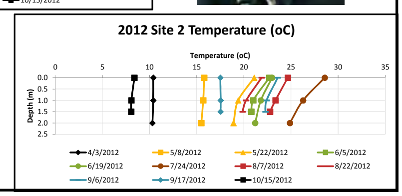
Dissolved oxygen & Temperature





Dissolved oxygen & Temperature

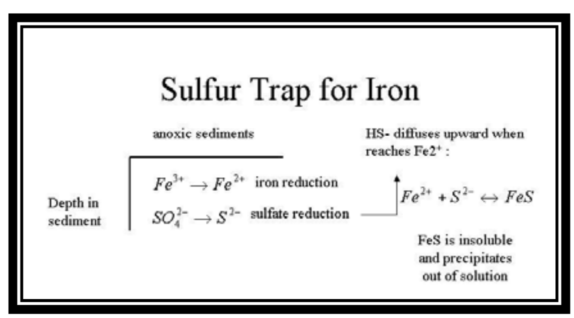




Sediment Chemistry

- P:Fe ratio 1:10-15
  - Indicates internal loading
- Site 1 P:Fe ratio is 1:35
- Site 2 P:Fe ratio is 1:18

Sediment Chemistry



Zooplankton & Algae

Should Be here soon.

Take Home Messages

Basins are very close in Trophic State Index

	TSI	General Description
	<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
	30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
	40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
Site 1	50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem, warm-water fisheries only
Site 2	60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth, full body recreation may be decreased
	70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
	>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Next Steps

- Complete watershed and sub-watershed modeling
- Develop a nutrient budget for both basins
- Delineate areas that are a benefit for water quality

Mitigation options to discuss

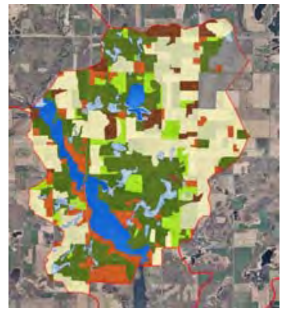
- **Shoreland Buffers**
- **Rain Gardens**
- **Sediment Ponds Near Inlets**
- **Stormwater practices in City of Amery, Turtle Lake**
- **Nutrient management**
- **No till**
- **Other agriculture BMPs**
- **Land acquisition**

Questions?

Apple River Flowage
Water Quality continued…

Jeremy Williamson
Water Quality Specialist
Polk County LWRD

Watershed Modeling – North Flowage



Land Use	Acres	Loading kg/yr	Loading kg/ha-yr
Church	4.4520	1	0.5
Flowage	334.0640	41	0.3
Forest	1438.8420	52	0.09
Grass	364.4020	44	0.3
Gravel Pits	224.8460	0	0
Mixed Ag	254.4350	82	0.8
Row Crop	1718.4080	695	1
Rural Res	475.9370	19	0.1
Water	53.3370	0	0
Wetland	261.2950	11	0.1
Totals	5130.0180	945.0000	3.1900

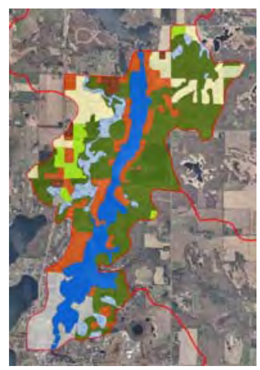
However……..

Watershed Modeling – North Flowage

Fox Creek and Apple River Proper contribute 3,829.2 kg (8441.9 lbs) of phosphorus per year or 80.1% of the external load

Internal Load – 1195.56 kg or 25%

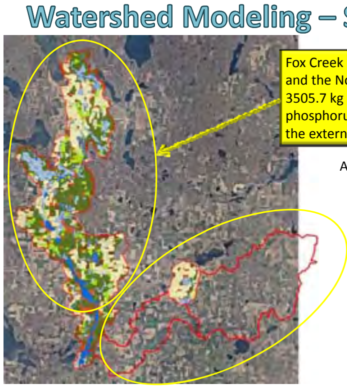
Watershed Modeling – South Flowage



Land_Use	Sum_Acres	Loading kg/yr	Loading kg/ha-yr
City	122.3040	25	0.5
Commercial	5.9050	4	1.5
Flowage	299.3850	36	0.3
Forest	718.6210	26	0.09
Grass	65.0340	8	0.3
Mixed Ag	28.9480	9	0.8
Row Crop	178.3960	72	1
Rural Res	241.8940	10	0.1
Wetland	124.1150	5	0.1
Totals	1784.6020	195.0000	4.6900

However……..

Watershed Modeling – South Flowage



Fox Creek and Apple River Proper and the North Flowage contribute 3505.7 kg (7712.54 lbs) of phosphorus per year or 71.9% of the external load

And….

Beaver Brook and its tributaries contribute 1170.0 kg (2574.0 lbs) of phosphorus or 24.0% of the external load

Internal Load – 1219.6 kg or 25 %

Watershed Modeling – North Flowage

Canfield Bachmann 1881 Artificial Lake Model: $P = \dfrac{0.8L}{z(0.0942L/z)^{0.639} + p}$

Condition	P concentration (µg/l)
Current	74.74
15% external load reduction	68.26
25% external load reduction	63.72
40% external load reduction	56.54
32% external load reduction	60.42

Actual current condition: 78.8 µg/l

Watershed Modeling – South Flowage

Canfield Bachmann 1881 Artificial Lake Model: $P = \frac{0.8L}{z(0.0942L/z)^{0.639} + p}$

Condition	P concentration (µg/l)
Current	74.74
15% external load reduction	68.60
25% external load reduction	64.72
40% external load reduction	58.31
32% external load reduction	61.77

Actual current condition: 80.0 µg/l

Questions?

Goals

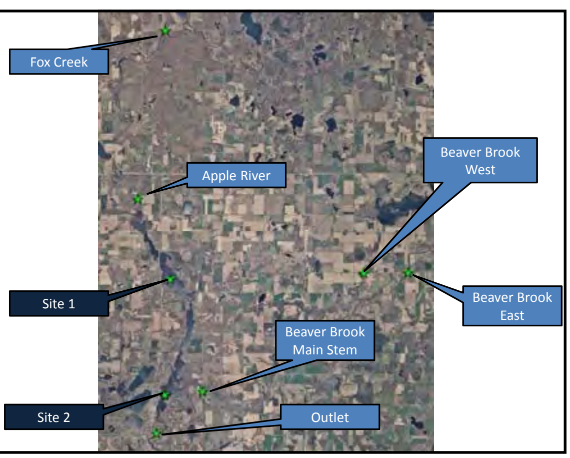
- Goal 1: Reduce excessive watershed nutrient inputs to the flowage to improve water quality
- Goal 2: Minimize the release of nutrients from within the Apple River Flowage to improve water quality
- Goal 3: Protect, maintain, and enhance fish and wildlife habitat

Goals continued…

- Goal:4 Maintain and enhance the natural beauty of the Apple River Flowage
- Goal 5: Evaluate the progress of lake management efforts through monitoring and data collection

Goals continued again…

- Goal 6: Provide information and education opportunities to residents and users
- Goal 7: Develop partnerships with a diversity of people and organizations
- Goal 8: Implement the Aquatic Plant Management Plan



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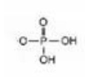
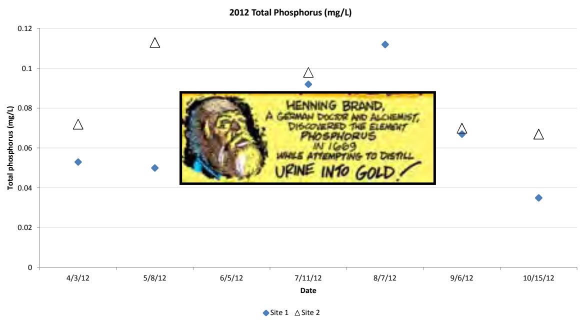
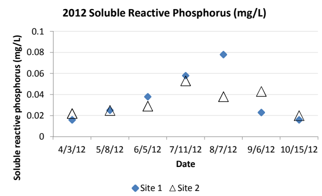
Total Phosphorus

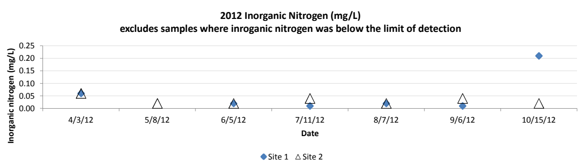


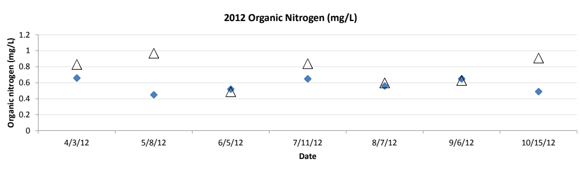


Soluble Reactive Phosphorus

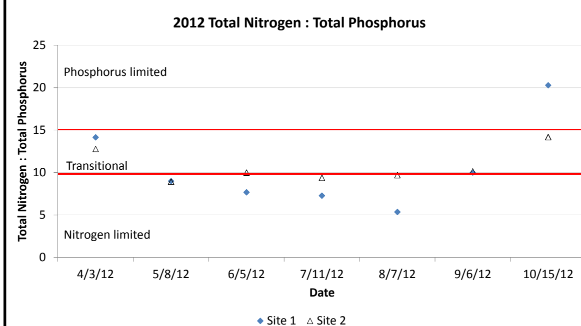


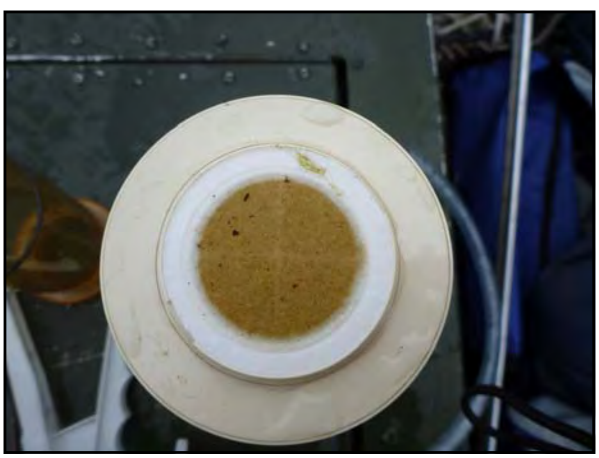
Nitrogen



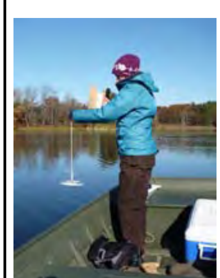


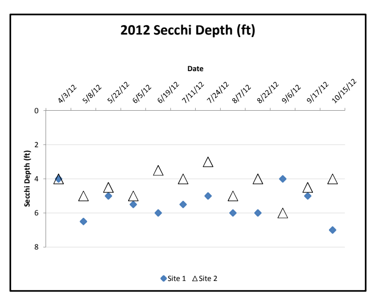
TN:TP ratio



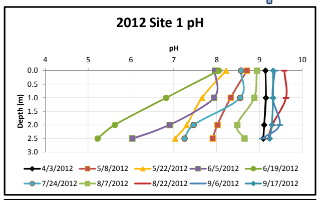


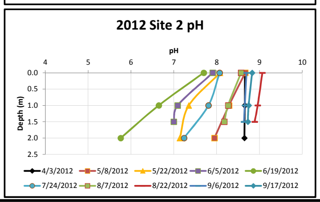
Secchi Disc



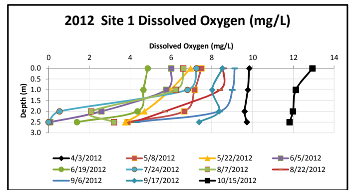


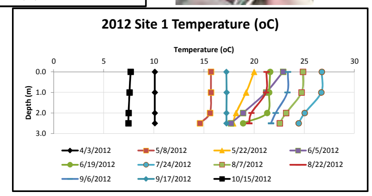
pH



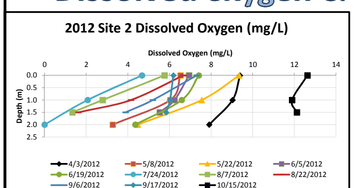


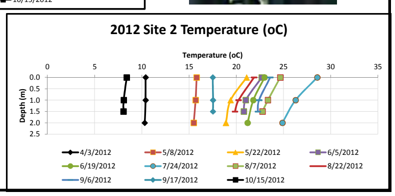
Dissolved oxygen & Temperature





Dissolved oxygen & Temperature





Sediment Chemistry

- P:Fe ratio 1:10-15
  - Indicates internal loading
- Site 1 P:Fe ratio is 1:35
- Site 2 P:Fe ratio is 1:18

Take Home

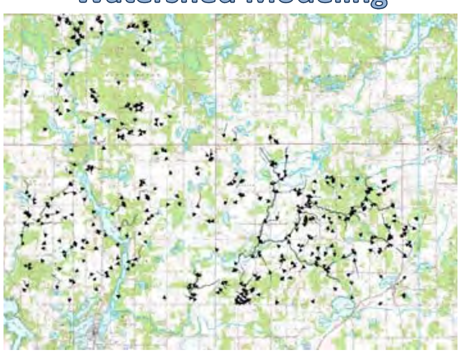
Basins are very close in Trophic State Index

	TSI	General Description
	<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
	30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
	40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
Site 1	50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem, warm-water fisheries only
Site 2	60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth, full body recreation may be decreased
	70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
	>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Watershed Modeling

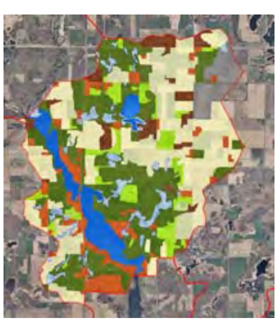
Watershed Modeling

Watershed Modeling



Watershed Modeling

Watershed Modeling – North Flowage



Land Use	Acres	Loading kg/yr	Loading kg/ha-yr
Church	4.4520	1	0.5
Flowage	334.0640	41	0.3
Forest	1438.8420	52	0.09
Grass	364.4020	44	0.3
Gravel Pits	224.8460	0	0
Mixed Ag	254.4350	82	0.8
Row Crop	1718.4080	695	1
Rural Res	475.9370	19	0.1
Water	53.3370	0	0
Wetland	261.2950	11	0.1
Totals	5130.0180	945.0000	3.1900

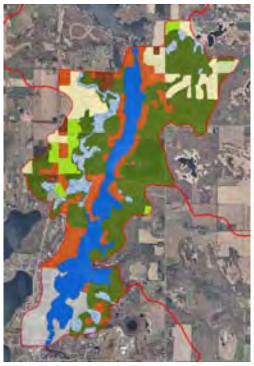
However……..

Watershed Modeling – North Flowage

Fox Creek and Apple River Proper contribute 3,829.2 kg (8441.9 lbs) of phosphorus per year or 80.1% of the external load

Internal Load – 1195.56 kg or 25%

Watershed Modeling – South Flowage



Land_Use	Sum_Acres	Loading kg/yr	Loading kg/ha-yr
City	122.3040	25	0.5
Commercial	5.9050	4	1.5
Flowage	299.3850	36	0.3
Forest	718.6210	26	0.09
Grass	65.0340	8	0.3
Mixed Ag	28.9480	9	0.8
Row Crop	178.3960	72	1
Rural Res	241.8940	10	0.1
Wetland	124.1150	5	0.1
Totals	1784.6020	195.0000	4.6900

However……..

Watershed Modeling – South Flowage

Fox Creek and Apple River Proper and the North Flowage contribute 3505.7 kg (7712.54 lbs) of phosphorus per year or 71.9% of the external load

And….

Beaver Brook and its tributaries contribute 1170.0 kg (2574.0 lbs) of phosphorus or 24.0% of the external load

Internal Load – 1219.6 kg or 25 %

Watershed Modeling – North Flowage

Canfield Bachmann 1881 Artificial Lake Model: $P = \frac{0.8L}{z(0.0942L/z)^{0.639} + p}$

Condition	P concentration (µg/l)
Current	74.74
15% external load reduction	68.26
25% external load reduction	63.72
40% external load reduction	56.54
32% external load reduction	60.42

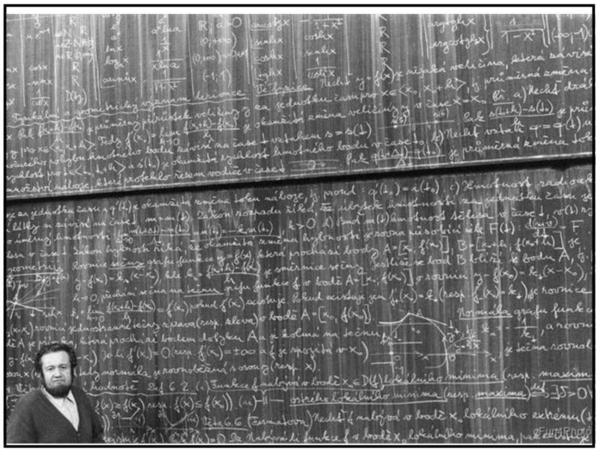
Actual current condition: 78.8 µg/l

Watershed Modeling – South Flowage

Canfield Bachmann 1881 Artificial Lake Model: $P = \frac{0.8L}{z(0.0942L/z)^{0.639} + p}$

Condition	P concentration (µg/l)
Current	74.74
15% external load reduction	68.60
25% external load reduction	64.72
40% external load reduction	58.31
32% external load reduction	61.77

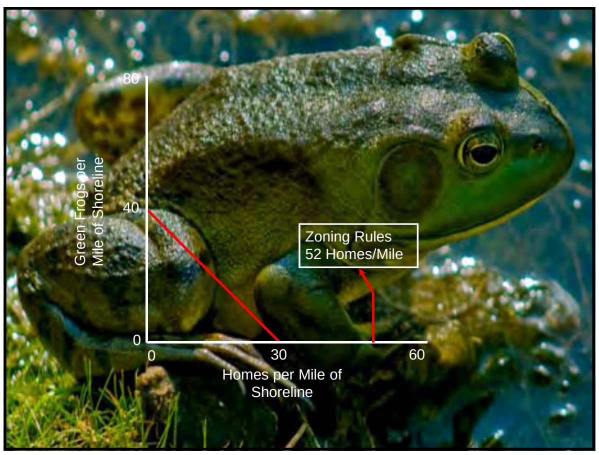
Actual current condition: 80.0 µg/l

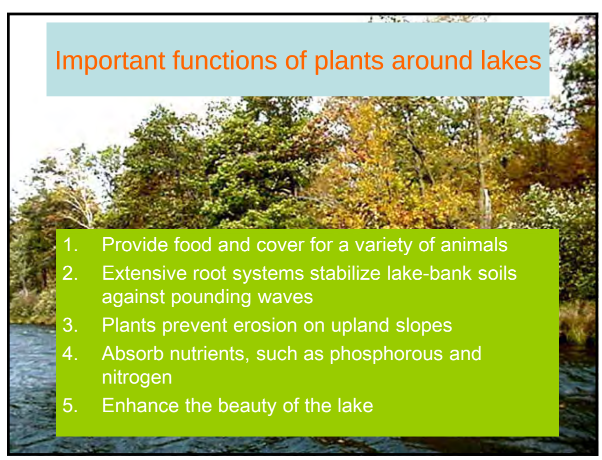


Questions?


Shoreline Restoration
Improving water quality and wildlife habitat


Problems with Traditional Lakeshores
• Shoreline erosion and sedimentation
• Excessive plant growth and algal blooms
• Loss of wildlife habitat
• Nuisance animals
• Loss of leisure time


Green Frogs per Mile of Shoreline
80
40
0
0
30
60
Homes per Mile of Shoreline
Zoning Rules
52 Homes/Mile

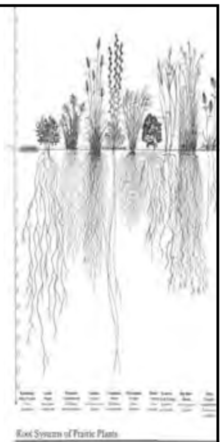

Important functions of plants around lakes
1. Provide food and cover for a variety of animals
2. Extensive root systems stabilize lake-bank soils against pounding waves
3. Plants prevent erosion on upland slopes
4. Absorb nutrients, such as phosphorous and nitrogen
5. Enhance the beauty of the lake

Root Systems

- Stabilize banks
- Stabilize shoreline
- Absorbsion of nutrients
- Absorbsion of water

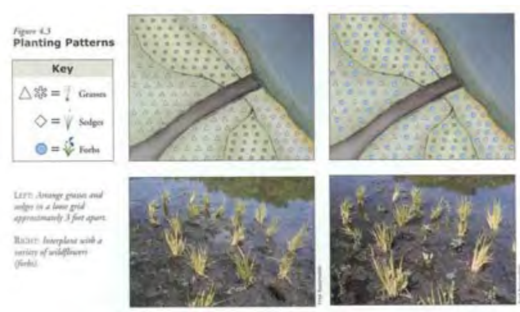
Why it works

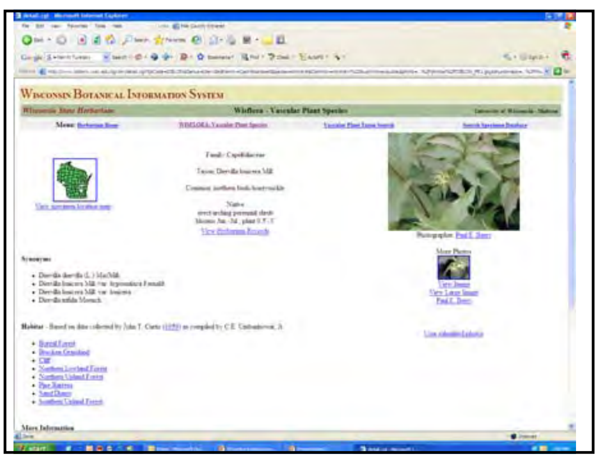
- In turf grass (i. e. lawn) water can only evaporate 0.4 meters out of the soil
- Native vegetation will evapotranspirate water from 2 meters or more from the soil.
- Wet Sponge vs. Dry Sponge



Design

- ✓ Involve landowner as much as possible
- ✓ Clump plants together
- ✓ Use native plants – RESEARCH THIS!
- ✓ Use reputable greenhouse/seed provider
- ✓ Use plenty of shrubs and trees






Shoreline Stabilization

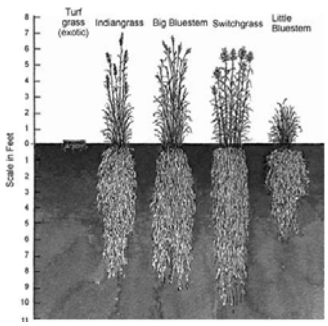
Questions?

Rain Gardens

Rain Gardens

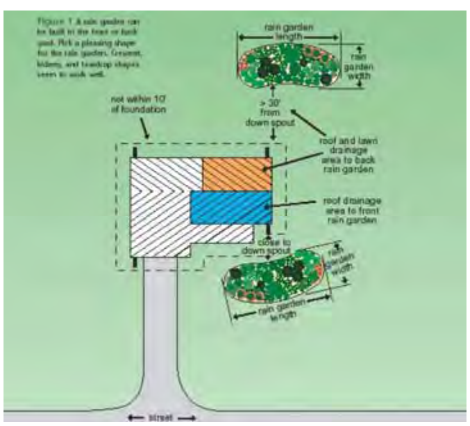
- Increases the amount of water filtering into ground
- Recharges groundwater
- Provides wildlife habitat
- Enhances beauty of yard and neighborhood
- Protects against flooding and drainage problems
- Protects lakes from damaging flows and reduces erosion
- Reduces the need for costly municipal stormwater treatment structures

Why They Work



Where Should the Rain Garden Go?

- At least 10 feet from house
- Flat area
- Below down spouts
- Not over septic system or sewer lateral
- Not where yard is wet
- Not directly under a large tree
- Not high traffic area



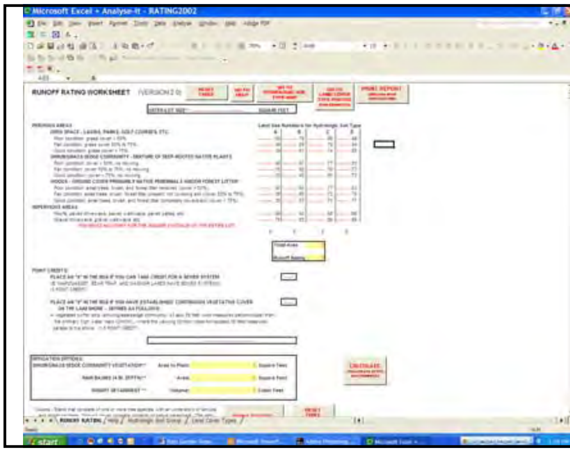
How Big should the Rain Garden Be?

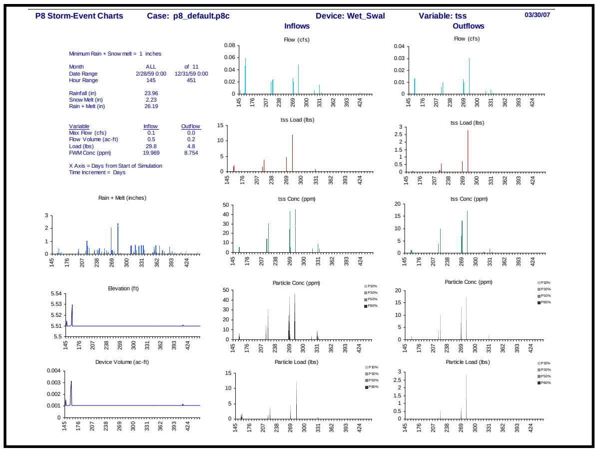
- How deep?
- What type of soil?
- How much roof and lawn drain to it?

Rain Garden Size Factor

	less than 30 ft from down spout			more than 30 ft from down spout
Soil	3-5 in. deep	6-7 in. deep	8 in. deep	All Depths
Sand	0.19	0.15	0.08	0.03
Loamy	0.34	0.25	0.16	0.06
Clayey	0.43	0.32	0.2	0.1

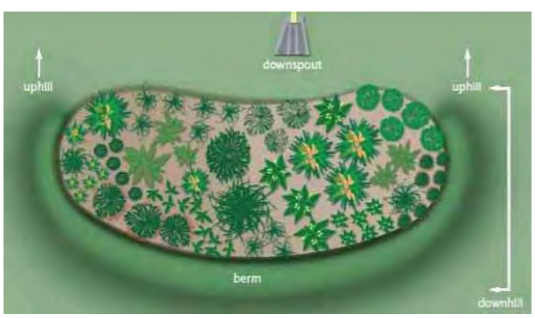
*If the recommended rain garden area is much more than 300 ft. divide it into smaller rain gardens





Design

- Water should flow evenly across the entire length
- Length should be perpendicular to slope and downspouts
- Rain gardens should have a maximum length of 15 ft (esp. on 8% slope or more)



Notice Length is Perpendicular

Burnsville

Maplewood

Plant Selection

- **Native**
- **Soil**
- **Sun/Shade**
- **Incorporate plenty of grasses, sedges and, rushes (allows for normal growth patterns)**
- Height of plant
- Bloom time
- Color

Example Plant List: Well Drained Soils

New England aster *Aster novae-angliae*
Spotted Joe-Pye weed *Eupatorium maculatum*
Sneezeweed *Helenium autumnale*
Torrey's rush *Juncus torreyi*
Prairie blazing star *Liatris pycnostachya*
Cardinal flower *Lobelia cardinalis*
Great blue lobelia *Lobelia siphilitica*
Wild bergamot *Monarda fistulosa*
Mountain mint *Pycanthemum virginianum*
Green bulrush *scirpus atrovirens*
Stiff goldenrod *Solidago rigida*
Culver's root *Veronicastrum virginicum*
Golden Alexander *Zizia aurea*

Example Plant List: Clay Soils

Sweet flag *Acorus calamus*
Swamp milkweed *Asclepias incarnata*
Water plantain *Alisma subcordatum*
Bottle brush sedge *Carex comosa*
Fox sedge *Carex vulpinoidea*
Wild blue flag iris *Iris virginica shrevei*
Torrey's rush *Juncus torreyi*
Cardinal flower *Lobelia cardinalis*
False dragon's head *Physostegia virginiana*
Arrowhead *Sagittaria latifolia*
Green bulrush *Scirpus atrovirens*
River bulrush *Scirpus fluviatilis*
Soft-stemmed bulrush *Scirpus validus*

Example Plant List: Shady Areas

Caterpiller Sedge *Carex crinita*
Cardinal Flower* *Lobelia cardinalis*
Ostrich Fern* *Matteuccia struthiopteris*
Virginia Bluebells *Mertensia virginica*
Sensitive Fern *Onoclea sensibilis*
Black Chokeberry *Aronia melanocarpa*
Red Osier Dogwood *Cornus serecia*
Low Bush Honeysuckle *Diervilla lonicera*
Pussy Willow *Salix caprea*
Blue Arctic Willow *Salix purpurea* Nanna

Special Case: Shoreland Area

- Should not replace native shoreland vegetation
- Should help protect riparian veg. from excessive flow and debris

Questions?

Jeremy Williamson
Water Quality Specialist
(715) 485-8639
jeremyw@co.polk.wi.us

Site Evaluation

Osceola Creek Project

Site Evaluation

Where is the Source

Infiltration
Erosion Potential

Is there Direct Drainage?

Will Stormwater Affect Use of Resource?

Fish & Wildlife

Eliminate
Stormwater
Pathway

Do
Nothing

Site Evaluation
Potential Stormwater Sources

Where is the Source

Infiltration
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Soils

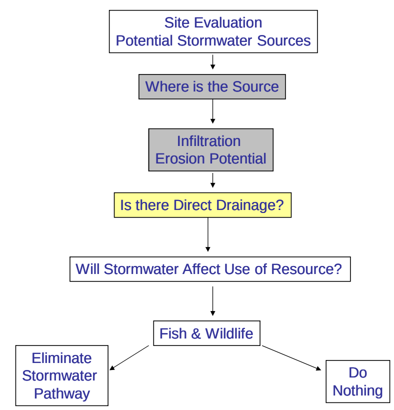
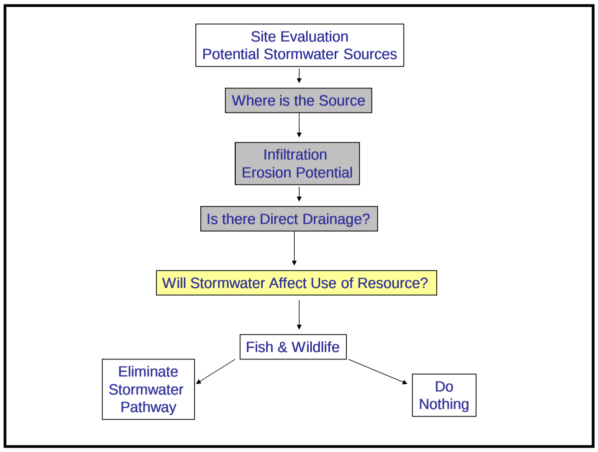



Photo by: Wisconsin DNR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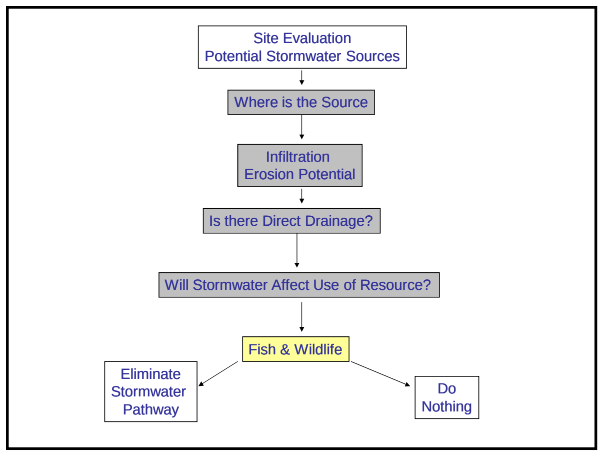
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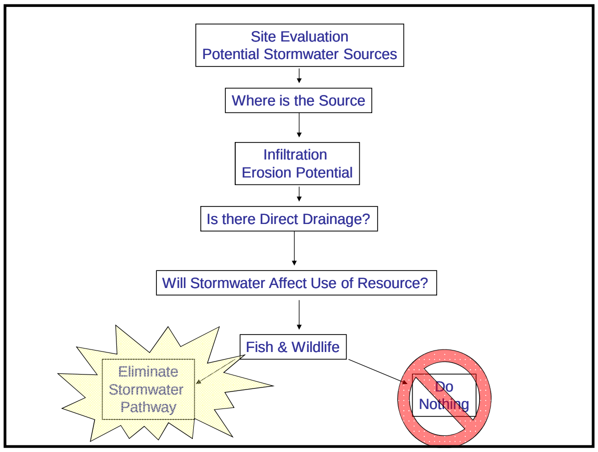

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