2014

Candlewick Streams and Lakes Conservation Plan: Executive Summary

Prepared for:

Candlewick Lake

A Community of Volunteers

Prepared by:

Olson Ecological Solutions, LLC

7/1/2014

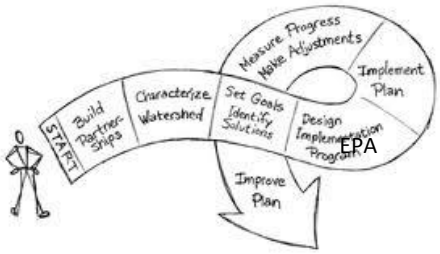
Executive Summary

Written by Rebecca Olson

Conserving Streams and Lakes in Your Watershed

Most of us can reminisce fondly of a time spent boating at the lake, fishing in a stream, or lounging by the shore. Lakes and streams are important assets to the people of the Midwest. Keeping them clean and healthy is vital if we want to continue to have these experiences with our children and grandchildren. Threats to water quality come from many upstream sources, so keeping our lakes and streams clean requires knowledge about the threats and long-range planning and forethought to address them.

Planning for lake and stream conservation brings together local people in a community to plan water quality improvements for their region. The region is defined by **watershed** boundaries, which encompass the area of land drained by a common watercourse such as a series of streams, rivers, ponds, and lakes.



A conservation planning effort brings together local landowners, homeowners, farmers, business owners, government officials, and environmental organizations to address common concerns regarding water quality. Poor water quality can cause problems such as beach closings, decreased fishing opportunities, dissatisfactory boating conditions, degraded aquatic habitat, and unpleasant algal mats. Causes of these problems stem from both point source and nonpoint source pollutants.

Point source pollutants come from single sources, such as construction sites or wastewater treatment plants. **Nonpoint source pollutants** come from many diffuse sources and concentrate in the water. In Illinois and Wisconsin, typical sources are fertilizer runoff from lawns and crop fields and soil loss from the erosion of steep slopes, streambanks, and crop fields. Local lake associations and other interested groups work with consultants and their community leaders to create a long-term conservation plan. They form a planning committee charged with making decisions on which the plan will be based, and they form a technical advisory committee to ensure that their decisions are supported by scientific study and current practices.

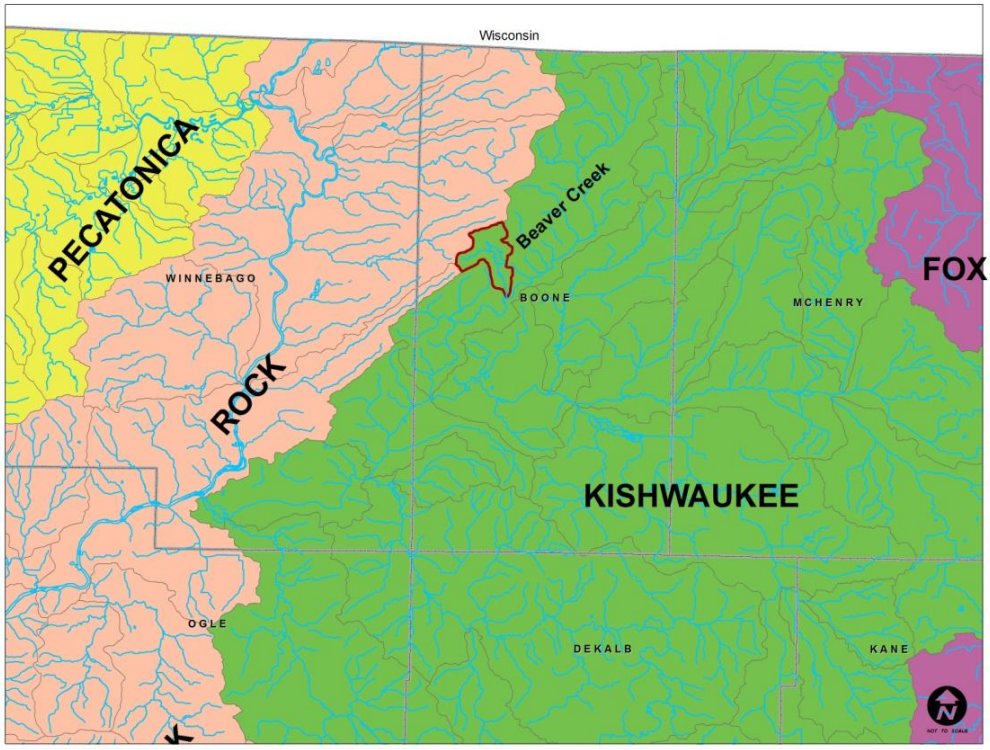
A **long-term conservation plan** records the goals and objectives of the planning committee, inventories the issues facing the watershed, lists projects and programs appropriate to achieve the goals and objectives, estimates the reduction of pollution into receiving lakes and streams if projects and programs are implemented, and provides cost estimates for such actions. With this information, the planning committee can prioritize projects within their watershed and know what results can be expected before ever spending a dime. They can then allocate funds and time to those projects that will yield the best benefit for the cost.

The process is funded in part by the Environmental Protection Agency through the Section 319 Clean Water Act. This program supports a wide variety of activities to manage nonpoint source pollution, including planning and implementing watershed-wide conservation plans and projects. States, territories, and tribes receive funding, which is distributed through grants to local organizations or individuals interested in planning for their area or implementing projects. Many grant agencies, including the Environmental Protection Agency, prefer to award grant funds to implement projects identified within a long-term, watershed-wide conservation plan. Receiving support from a grant agency is a great way to not only fund planning efforts and projects, but also to be a part of a bigger, regional effort toward lake and stream conservation.

Local Land and Water Conservation Planning Efforts

In 2008, a local planning effort led by the Chicago Metropolitan Agency for Planning and Kishwaukee River Ecosystem Partnership created plans for lands surrounding rivers, lakes, and streams feeding the Kishwaukee River. One of these plans addressed Beaver Creek, an area that included Candlewick Lake and its surrounding lands. This plan, called the *Beaver Creek Watershed Action Plan*, recommended that a separate planning effort take a closer look at the area surrounding Candlewick Lake. **As a second stage of the *Beaver Creek Watershed Action Plan*, the resulting *Candlewick Streams and Lakes Conservation Plan*, contained within this document, fulfills this recommendation.**

Figure A: Location of the Candlewick Lake Watershed and its relation to the Beaver Creek and Kishwaukee River watersheds.



Residents of Candlewick Lake had long been concerned about the water quality of their lake and spearheaded a planning effort to improve conditions with the support of the Illinois Environmental Protection Agency through the Section 319 program. They hired consultants from Olson Ecological Solutions and JadEco Natural Resource Consultants to guide the planning process. A cooperative planning effort ensued with the Candlewick Lake Association, residents of the surrounding area, and various local decision makers, planning agencies, and conservation groups protecting land, air, and water.

Over a 1.5-year planning process, individuals associated with the watershed were invited to public planning meetings hosted by the Candlewick Lake Association. Participation was largely dominated by residents of the Candlewick Lake community and also included staff from local municipalities and a few working farmers interested in conservation of our land and water. At these meetings, residents shared their concerns, and they helped to prioritize the goals, objectives, and projects that were most likely to be implemented and were most likely to improve water quality. The Candlewick Lake Water Conservation Planning Committee was formed to provide leadership during the planning effort and ensure that the plan would be implemented. Technical advice was garnered from the Technical Advisory Committee and Kishwaukee River Ecosystem Partnership as needed. Consultants evaluated the lands and waters that surrounded Candlewick Lake upstream of Beaver Creek; recommended conservation projects; predicted the benefits of each project; wrote the conservation plan; and proposed a budget, schedule, and sources of financial assistance for each project.

The *Candlewick Streams and Lakes Conservation Plan* provides a better understanding by more people of sources, uses of, and threats to our fresh water, and it recommends projects that care for the land, air, and water of our community where we boat, fish, swim, view wildlife, and otherwise enjoy the quiet and peace of the outdoors. Projects recommended by the plan focus on both present and future conditions, as most of the farmland upstream of Candlewick Lake is well situated for development. This plan is meant to be implemented by the local people, with assistance from governments and conservation groups with missions to protect land, air, and water. It does not suggest any regulatory requirements, and instead is intended to be used on a voluntary basis by people who want to see the projects come to fruition. It provides cost-effective solutions to environmental issues.

The plan contains six chapters that provide the following: (1) an overview of the water conservation planning effort; (2) inventory of the watershed's natural resources and challenges; (3) goals and objectives; (4) campaigns and recommended projects and practices to address challenges and maintain or improve water quality; (5) a schedule and budget for implementing projects and supporting education efforts; and (6) methods of monitoring the success of the plan. The plan provides a basis to allow various individuals and organizations to collaborate on education and projects. It is an advisory document, and should be amended from time to time as needs change.

The planning committee, technical advisors, and planning participants will meld to form the Candlewick Streams and Lakes Conservation Partnership. This partnership will propel projects from the plan into action and seek technical and financial assistance from like-minded organizations. They will have a

memorandum of understanding to indicate their intentions to act together toward common goals and causes without legal binding.

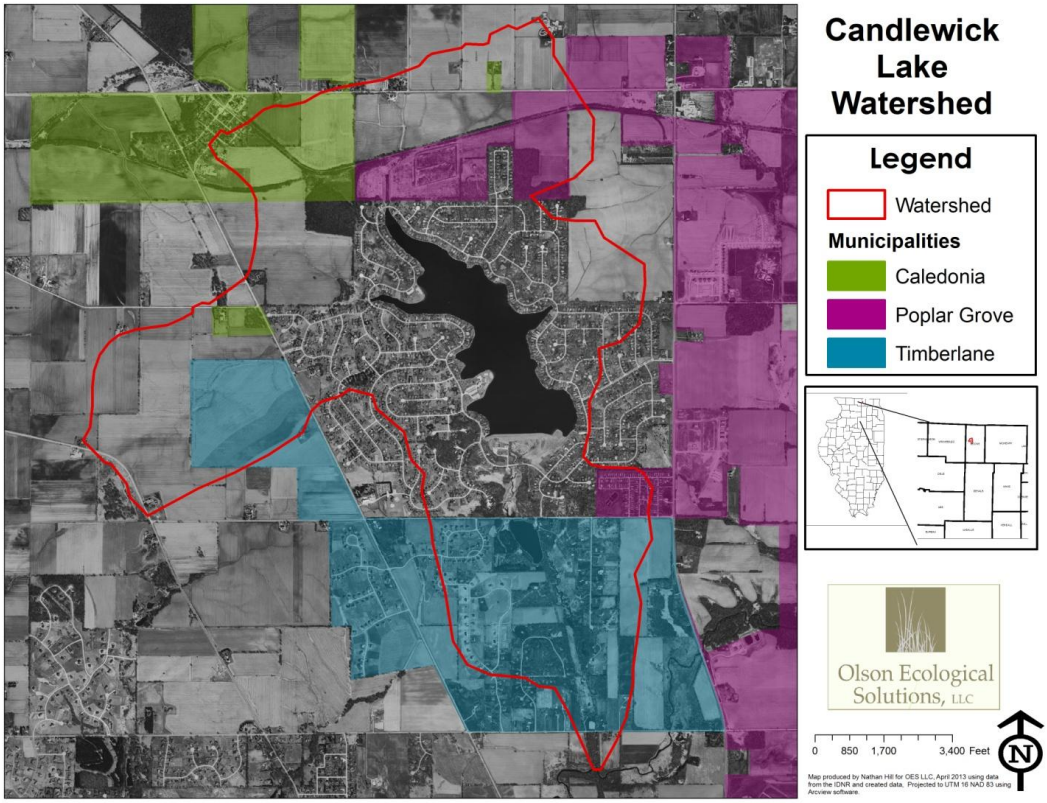
Some of the groups that are actively participating in the planning process are:

- Boone County Conservation District
- Boone County Soil and Water Conservation District
- Candlewick Lake Association
- Illinois Department of Agriculture
- Illinois Department of Natural Resources
- JadEco Natural Resource Consultants
- Kishwaukee River Ecosystem Partnership
- McHenry County Conservation District
- Olson Ecological Solutions, LLC
- Village of Poplar Grove

Candlewick Lake Area Description

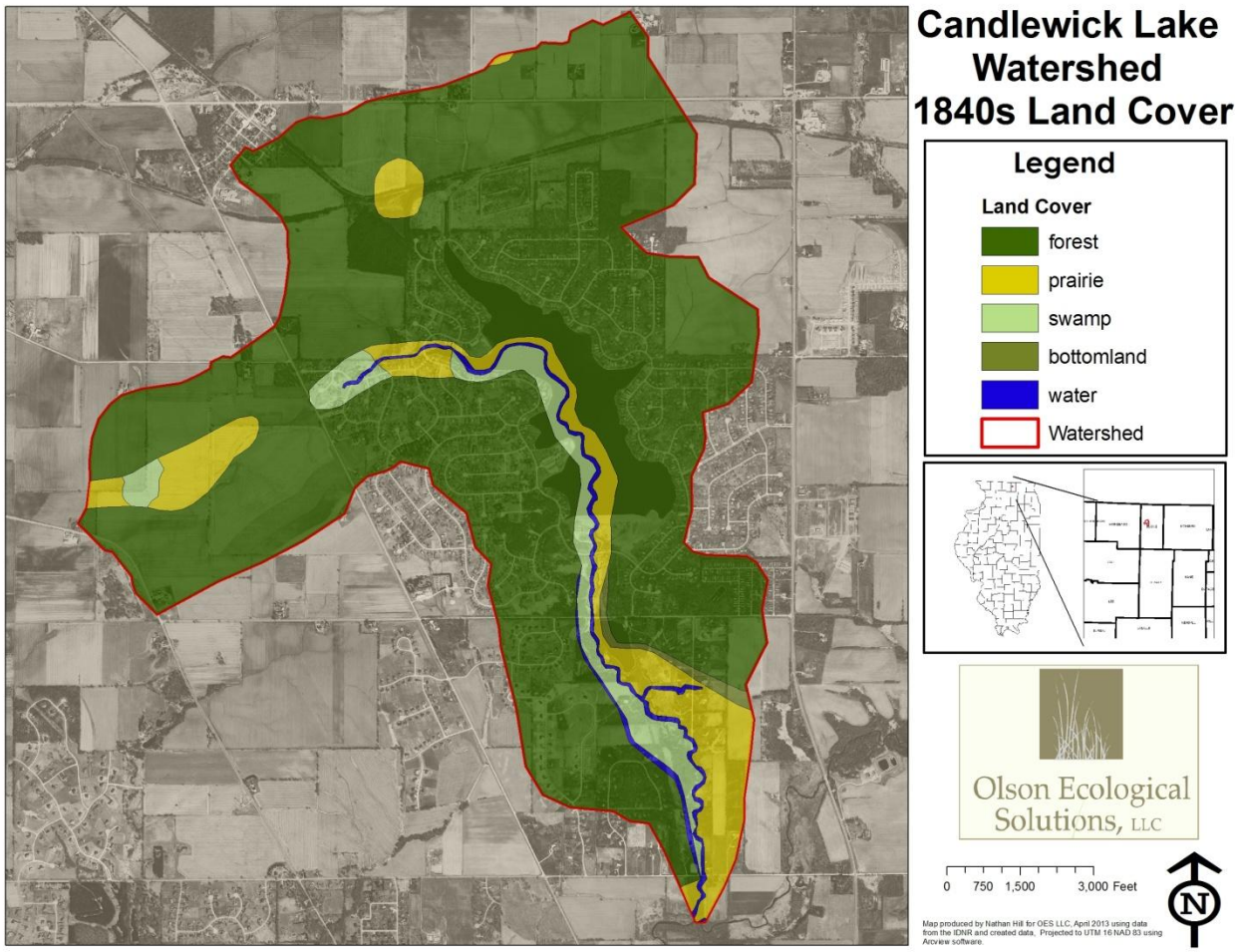
Candlewick Lake and the surrounding lands addressed by this plan are located in Boone County in north-central Illinois. Portions of the villages of Caledonia, Poplar Grove, and Timberlane are within the boundaries of our focus area, along with a 3.5-mile basin that drains 2,896 acres.

Figure B: Map of the Candlewick Lake Watershed



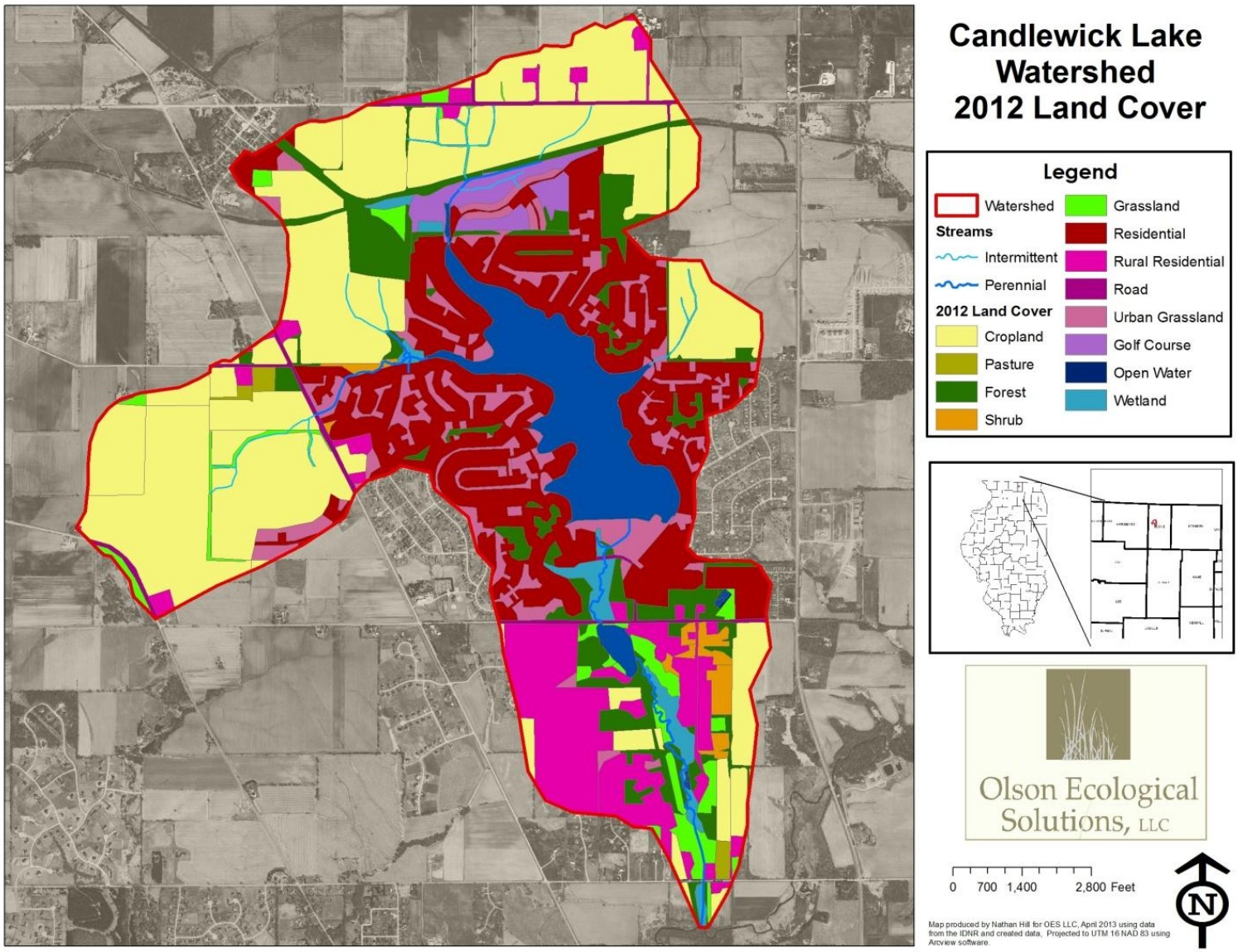
Historically, the watershed was mostly forested with prairie and wetlands (swamps) along its streams: There were no lakes.

Figure C: Historical Land Cover of the Candlewick Lake Watershed



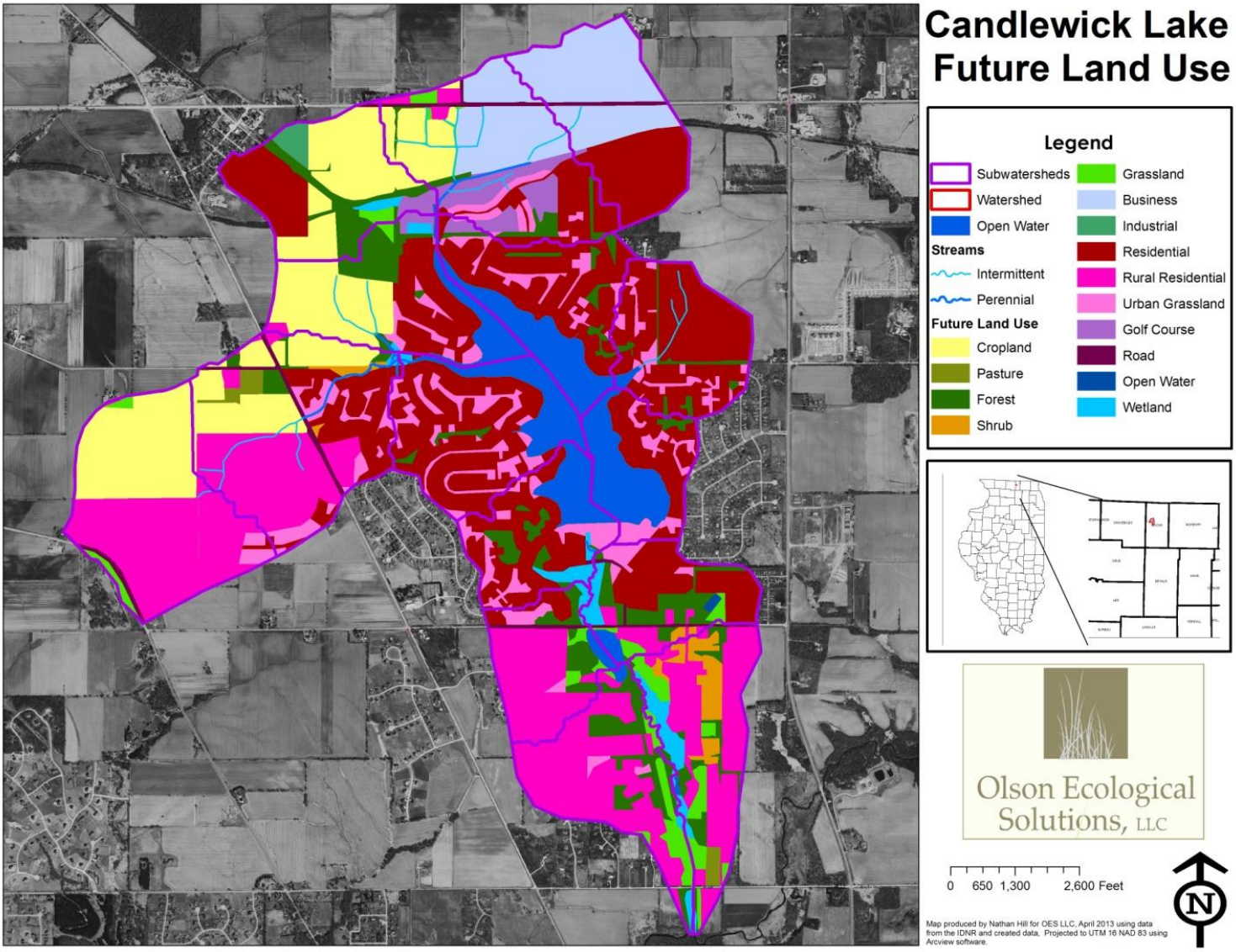
Today, there are two lakes and land uses consisting of 36% farms, 42% developed land, and 22% open space. The developed land, includes a large subdivision, rural residential properties, and a golf course. Most significantly, a subdivision with 1,850 homes surrounds the 210-acre Candlewick Lake and is managed by the Candlewick Lake Association. Boone Lake, a smaller lake of 11.6 acres, lies downstream of Candlewick Lake and is surrounded by rural residential homes. Savannah Oaks Golf Course is a 9-hole course upstream of Candlewick Lake designed with naturalized drainage systems.

Figure D: Current Land Cover Map of the Candlewick Lake Watershed.



Most of the current agricultural lands are desired for future development by developers and municipalities, as one farm is currently platted and approved for residential development and two other farms along the north and east tributaries of the lake appear in the Boone County Land Use Plan as future commercial and residential land uses.

Figure E: Projected Future Land Cover Map of the Candlewick Lake Watershed.



Candlewick Lake Area Assessment

The Candlewick Lake area consists of important agricultural soils and densely developed areas with few floodplains and wetlands to offer natural filtering. Highly erodible lands and farmed hydric soils are found in both farm and residential land uses, both upstream and downstream of Candlewick Lake. The area is an important farming area, with 66% of its soils designated as either "prime farmland" or "farmland of statewide importance," and the remaining soils are considered "prime farmland if drained or protected from flooding." Most of these farmlands are likely to be developed. The watershed only has 1.3% floodplain to manage runoff. There are currently 8.6% of wetlands to offer filtration, and there are an additional 13.7% of hydric soils with the potential to be restored as wetlands located along streams throughout the area. The wetlands are located mainly along the creek corridor between Candlewick Lake and Beaver Creek, upstream and downstream of Boone Lake. Highly erodible land accounts for 26.6% of the area.

Streams in the area begin in mostly flat to rolling farm land and flow through a subdivision situated around Candlewick Lake. Surface water passes from the lake over a dam and into Boone Lake, which is also fed by small streams running through surrounding rural residential properties. The water enters Beaver Creek and then the Kishwaukee River, an impaired stream on the Environmental Protection Agency's 303(d) list of 2012 (Environmental Protection Agency, 303(d) List).

Natural area types present in the area include forests, shrublands, grasslands, wetlands, and open water. The Boone County Conservation District owns 31 acres along the Long Prairie Trail north of the golf course, which form the only permanently protected natural areas in the area. The area is part of the Kishwaukee River Conservation Opportunity Area (IDNR, Illinois Wildlife Action Plan).

Candlewick Lake is most often used for fishing, boating, and swimming: These recreational uses have been diminished in recent years by decreasing water quality. The Illinois Environmental Protection Agency has identified the causes of water quality loss to be total suspended solids (TSS), total phosphorus (TP) and aquatic algae. Lake residents have noticed an infestation of Curly-leaf Pondweed *(Potamogeton crispus).* Nonpoint sources are likely, including the residential areas, dam, yard maintenance, farm land uses, and runoff from forest, grassland, and parkland. The only known point source pollution in the area is no longer in operation. It was a wastewater treatment plant that discharged into Candlewick Lake from 1979-1999 (ILM, 2011).

Water Conservation Plan Success Statement and Goals

The planning committee and technical advisors adopted a success statement to improve watershed conditions and the goals, objectives, campaigns and recommended projects and practices necessary to achieve it.

Success Statement for
Streams and Lakes Conservation
in the Candlewick Lake Area

"To sustain the recreational pursuits of fishing, boating, and swimming by cleansing the streams and lakes surrounding Candlewick Lake."

Goals for
Streams and Lakes Conservation
in the Candlewick Lake Area

1. Reduce the amount of soil washing into our streams and lakes.
2. Reduce the amount of nutrients entering our streams, lakes, and groundwater.
3. Maintain a healthy volume of water feeding Candlewick Lake with a consistent flow.
4. Treat pollution from future development before it enters our streams and lakes.
5. Coordinate with local municipalities to create policies that adhere to these goals.
6. Educate the community about land and water conservation and this plan.

Watershed Management Recommendations

Recommended objectives, projects and practices found in the *Candlewick Streams and Lakes Conservation Plan* address these goals through four campaigns: Streams and Lakes Campaign, Urban Campaign, Rural Campaign, and Future Development Campaign.

The Streams and Lakes Campaign includes projects and practices within streams and lakes and along their banks. The Urban Campaign concentrates our projects and practices within subdivisions and other developed areas. The Rural Campaign discusses practices to be carried out on working farms. Care has been taken to avoid costly solutions to temporary problems that will terminate when the land is developed. The Future Development Campaign works with local municipalities and developers to address the likely increase of storm water and runoff projected from future development.

In order to address the goals and satisfy the success statement, the planning committee and technical advisors prioritized projects to be implemented throughout the watershed. Consultants determined the existing opportunity within the watershed for each recommended practice, then decided a realistic project size to target for each practice to be completed within the ten-year life of this plan. They also determined the benefits of each practice and estimated how much pollution would be reduced from our streams and lakes upon implementation.

Opportunity areas throughout the watershed are presented in the map below. A table follows listing the various types of projects and their projected pollution load reductions. They are prioritized by their ability to reduce pollution in our lakes and streams. The targeted acreages, feet, or other unit of each project do not encompass all opportunities, but instead represent amounts that we deemed realistic to accomplish within ten years. If all projects and practices are implemented to their targeted amount, the potential for reducing the pollutants in our waters are as follows throughout the watershed:

Nitrogen – Reduce by 22% or 2,562 lb/yr
Phosphorous – Reduce by 23% or 618 lb/yr
Sediment – Reduce by 36% or 417 tons/yr

Figure F: Map of all opportunities for conservation projects and practices in the watershed.

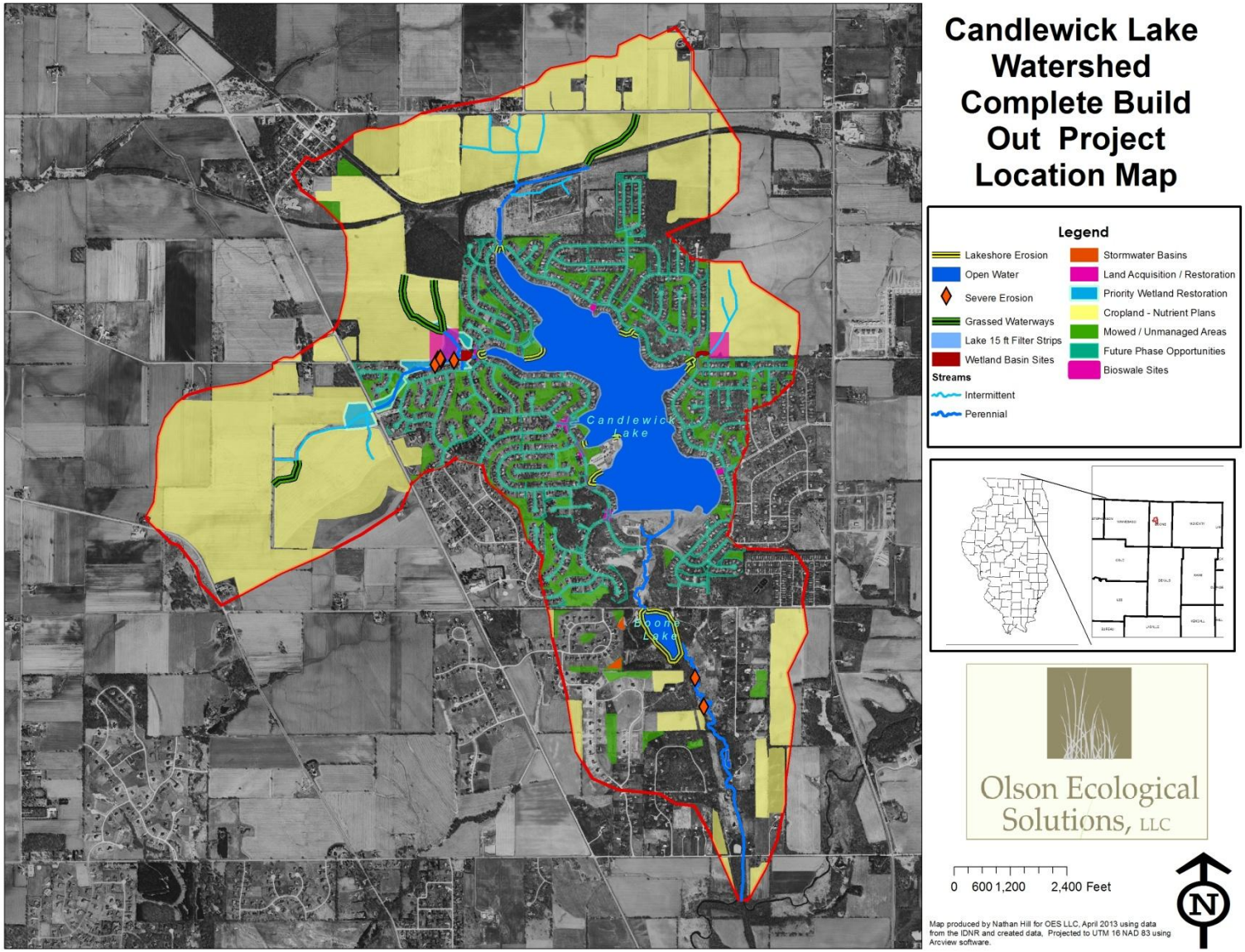


Figure G: Watershed-wide summary of best management practices to implement to reduce pollution in our lakes and streams.

Campaign	BMP Type	Target Area		Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity
					N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)		
STREAMS LAKES	Streambank Stabilization	575	ft.	$ 46,000	118	59	59	1.01%	2.22%	5.04%	High	Landowners
STREAMS LAKES	Grass-lined Channels	0.6	ac.	$ 264,000	388	16	18	3.33%	0.60%	1.56%	High	CLA Homeowners
STREAMS LAKES	Wetland Restoration, Water and Sediment Control Basin	1.8	ac.	$ 46,875	361	78	41	3.09%	2.94%	3.52%	High	CLA Landowners
STREAMS LAKES	Shoreline Stabilization	6,100	ft.	488,000	16	8	8	0.14%	0.29%	0.66%	Medium	CLA Homeowners
STREAMS LAKES/ URBAN	Wetland Restoration	28	ac.	360,000	39	11	5	0.33%	0.40%	0.39%	Medium	CLA Landowners
STREAMS LAKES	Urban Filter Strip	1	ac.	$ 7,500	5	1	0.23	0.04%	0.04%	0.02%	Low	CLA Homeowners
URBAN	Permanent Vegetative Cover	16.4	ac.	$ 123,000	19	1.23	0.26	0.16%	0.05%	0.02%	Medium	Lot owners
URBAN	Urban Stormwater Wetlands	3	ac.	$ 22,500	44	12	4	0.38%	0.45%	0.36%	Medium	CLA
URBAN	Porous Pavement	1	ac.	$ 283,140	15	1	0.47	0.13%	0.04%	0.04%	Medium	CLA Homeowners Villages County
URBAN	Rain Gardens	102	sites	$ 255,000	1.3	0.5	0	0.01%	0.02%	0.00%	Low	Homeowners
RURAL	Nutrient Management Plan	516	ac.	$ 43,860	965	239	0	8.27%	9.02%	0.00%	High	Landowners
RURAL	Conservation Tillage	158	ac.	$ -	418	104	194	3.58%	3.94%	16.60%	High	Landowners
RURAL	Grassed Waterway	4	ac.	$ 20,000	174	87	87	1.49%	3.28%	7.43%	High	Landowners
RURAL	Land Protection	10	ac.	$ 25,000							Low	Conservation Groups Landowners
Totals				**$1,984,875**	**2562**	**618**	**417**	**22%**	**23%**	**36%**		

Reaching and Educating the Residents of the Watershed

The projects and practices listed above reaching and educating the public, we would like to accomplish the following objectives within all four campaigns:

1. Increase awareness of nutrient runoff from lawns, driveways, rooftops, and farm fields and encourage behaviors that will reduce nutrient pollution in local streams and lakes.
2. Increase awareness of the connection between protecting our streams and lakes and improving people's quality of life, recreational opportunities, scenic amenities, community value, property value, and public health.
3. Promote partnerships with community groups that can assist in creating public awareness.
4. Enroll homeowners and landowners in a recognition program for implementing conservation projects and participating in land and water protection programs.
5. Deliver Urban Campaign education materials and invitations to events to all households within urban areas of the watershed.
6. Deliver Rural Campaign education materials and invitations to events to all households within the rural areas of the watershed.
7. Provide all municipalities and developers within the watershed with Future Development Campaign education materials and invitations to events and meetings.

*Objectives 1-4 are adopted from the EPA's "Ðeveloping an Outreach Strategy" website.

Future development is eminent within the watershed. Many of our education and public outreach efforts are aimed at assuring sound municipal policies for stormwater management within the watershed and making developers aware of the importance of designing systems to reduce pollutant loading into our steams and lakes and financial and technical assistance available to implement conservation practices.

Evaluating Our Success

A monitoring and evaluation plan is a critical component in the watershed planning process. This is necessary to evaluate the progress of the plan overtime as key goals and objectives are executed. To help track progress over time, this plan establishes monitoring of several parameters, including physical, chemical, and biological factors. By developing a water quality monitoring program, we provide a baseline from which we can evaluate current conditions as well as track changes over time following implementation of the plan goals and objectives. Future monitoring efforts should adhere to Illinois EPA established protocols and methods for quality assurance and quality control listed at http://www.epa.state.il.us/water/water-quality/methodology/index.html. Here you will find the Illinois EPA QAPP's (Quality Assurance Project Plans) and SOP's (Standard Operating Procedures).

2014

Candlewick Streams and Lakes Conservation Plan

Prepared for:

Candlewick Lake

A Community of Volunteers

Prepared by:

Olson Ecological Solutions, LLC

7/1/2014

Acknowledgements

This Candlewick Streams and Lakes Conservation Plan was made possible by the dedication and support of the planning committee, technical advisors, and participants in the planning process. Funding was provided by the Candlewick Lake Association and Illinois Environmental Protection Agency through Section 319 of the Clean Water Act. Many people generously gave their time and expertise. We would like to acknowledge the following individuals that were significantly involved in the planning process: Bonnie Marron, Chuck Hart, Charlie Sewell, Rich Witt, Bill Batzkall, and Lee Odden, and Theresa Balk.

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Written by: Rebecca Olson

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Written by: Rebecca Olson

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Chapter 1: Candlewick Streams and Lakes Conservation Planning Effort

Written by: Rebecca Olson

This first chapter of the Candlewick Streams and Lakes Conservation Plan provides an introduction to the planning process. This planning process includes the planning guidance used, funding sources, purpose, scope and limitations, process overview and timeline, and a list of planning participants. This chapter is intended to provide you with a framework for the plan. The chapters that follow provide the inventory of the area, goals and recommended projects, future scenarios if the recommended projects are completed, how to implement the projects, how to reach and educate the public, and how to evaluate and monitor success.

Conservation Planning Guidance

The Candlewick Streams and Lakes Conservation Plan is based on input from the local people that took part in the planning process and an inventory of the area's natural resources and threats to their health. This plan is consistent with Chicago Metropolitan Agency for Planning's Guidance for Developing Watershed Action Plans in Illinois dated June 2007, The Handbook for Developing Watershed Plans to Restore and Protect Our Waters (USEPA, 2008), and current conservation planning principles for watersheds. Total maximum daily load (TMDL) implementation plan requirements as defined by the Environmental Protection Agency are not applicable to this area and therefore are not considered.

Funding

Funding was provided by the Illinois Environmental Protection Agency through Section 319 of the Clean Water Act and the Candlewick Lake Association. Many organizations donated their time and staff resources, including the Kishwaukee River Ecosystem Partnership, USDA Natural Resources Conservation District, Boone County Soil and Water Conservation District, Boone County Conservation District, Illinois Department of Natural Resources, Illinois Department of Agriculture, Village of Poplar Grove, and Candlewick Lake Association. Many residents of the Candlewick Lake Community donated their time and effort to serve on a planning committee or be an active part of the planning process, provide photographic documentation of the area, and collect data about the area's streams and lakes.

Purpose

The need for this plan has been recognized by the Candlewick Lake Association and their community, the many agencies and individuals involved in creating the *Beaver Creek Watershed Action Plan Technical Report*, and the Illinois Environmental Protection Agency. The interests and focus of each of these groups may be slightly different, but their concern is the same: water quality of the streams and lakes surrounding Candlewick Lake and Beaver Creek.

The people of Candlewick Lake have noticed symptoms of poor water quality within the lake, which have affected the appearance of the lake, their ability to use the lake, and potentially the values of their homes. Candlewick Lake is the centerpiece of the community that surrounds it, and it is the attraction that has led many residents to move into the community. It is beautiful and peaceful to live next to a lake. It attracts people of all ages outdoors to relax, be active, get some fresh air, and talk with neighbors who are also outside enjoying the lake. People here have the opportunity to enjoy life in their own "backyard" by fishing, boating, swimming, lounging, picnicking, entertaining guests, walking, jogging, and otherwise enjoying the lake. If the water quality is poor, it affects the quality and economy of the entire community. Therefore, the Candlewick Lake Association has a large stake in keeping the lake clean and safe. Their thoughts have been echoed by agencies and individuals of the larger region in which they belong.

In 2008, local agencies and individuals came together to create the *Beaver Creek Watershed Action Plan Technical Report.* This plan and the process of creating it were similar to our plan and process, but for a larger area. The Beaver Creek plan stated the need for taking a closer look at the streams and lakes surrounding Candlewick Lake and providing a more detailed plan specifically for this area. It stated,

> "It would be important to undertake a subwatershed planning process focusing on the [Candlewick] lake to determine the sources of TSS and TP (the latter likely the problem behind the algae) and to recommend projects to limit inputs from these sources."
>
> - Beaver Creek Watershed Action Plan

The Illinois Environmental Protection Agency recognized the need for conservation planning within the Candlewick Lake area from their involvement with the Beaver Creek plan and from their own field assessments of the streams and lakes in the area, which are discussed in Chapter 2. Some of the agencies and individuals involved in the Beaver Creek planning process have also actively been involved in our planning process.

The success statement, goals, and projects and programs of this plan alleviate pressure on the area's lakes and streams from upstream sources of pollution. This plan addresses both current situations and

considers the future development that is already slated for the area. It helps to meet the goals of the Beaver Creek plan as well as its own goals, and we consider this plan to be supplementary to the Beaver Creek plan. This plan will serve as a guide for the people of the area to implement projects and programs, and it should be updated from time to time.

Scope and Limitations

The scope of this project is to stop much of the pollution that is entering streams and lakes from adjacent lands and upstream sources. This plan focuses on preventing pollution from getting into streams and lakes in the first place, which is a proactive approach to managing water quality. It does not address pollution already present within lakes and streams, which requires remedial actions. Integrated Lakes Management has developed the *Candlewick Lake Management Plan* (2011) that provides direction for removing pollution from Candlewick Lake, along with other recommendations. We intend that both our plan and Integrated Lakes Management's plan be used simultaneously. As more projects are built that will prevent pollution from entering streams and lakes, the need for remedial actions will fade away. However, this process will be gradual, and remedial actions will likely remain an important part of the solution for a long time.

This plan is designed to meet the needs of the people in addition to the needs of the area's land and water. The people of the area have various interests that need to continue to be met, some of which might interfere with conservation approaches to land management. This plan is designed to suggest reasonable options that result in a compromise that will achieve improvement to water quality and natural areas while allowing other interests to persist: mainly current uses of the land as farms and homes and future development. Therefore, the plan suggests very little land use change and instead recommends making smarter choices for caring for the area's land and water within the confines of current and planned land uses.

The planning committee chose to limit this plan to ten years and included the perceived long-term needs that would extend beyond the life of the plan. This plan should be reviewed and updated annually.

Planning Process Overview and Timeline

The process of creating a conservation plan for streams and lakes began late in 2012, when the Candlewick Lake Association began working with the Environmental Protection Agency's Section 319 program. This process was divided into three categories: Local Involvement, Watershed Inventory, and Streams and Lakes Conservation Plan, which are described in more detail below.

Local Involvement

Approximately one-third of the effort put forth to create the plan was spent engaging the local people in the planning process. Many individual meetings and phone conversations took place with landowners in addition to the meetings held for technical advisors and planning participants. Before any meetings took place, Joe Rush of JadEco Natural Resource Consulting contacted landowners who owned 20 acres or more within the local area to speak individually about the plan and invite them to become involved in the planning process. This only resulted in one landowner attending a planning meeting on one occasion; however, others indicated an interest in being informed even though they weren't planning to attend any meetings. The vast majority of meeting participants were residents of the Candlewick Lake Association, and staff of various local governments also regularly attended.

The planning committee met eight times and technical advisors congregated three times to weigh in on the contents of the plan. JadEcoNatural Resources Consulting organized and facilitated all of the meetings. We also recruited volunteers and held two training sessions for conducting field measurements of streambank and lake shore erosion. The schedule of meetings is presented in Figure 1.1 below.

Figure 1.1 – Schedule of meetings

Date	Group	Agenda
5/13/13	Technical Advisory	Review inventory
5/23/13	Planning	Introduction
7/9/13	Lake Management	Introduction
7/17/13	Planning	Concerns and goals
7/22/13	Planning	Concerns and goals
9/24/13	Planning	Committee formation
1/30/14	Technical Advisory	Review goals and recommend projects
2/19/14	Planning (committee only)	Recruit volunteers and plan 2/26/14 meeting
2/26/14	Planning	Prioritize projects
4/8/14	Volunteers	Instructional training session for streambank and lake shore assessment
4/19/14	Volunteers	Field training session for streambank and lake shore assessment
5/20/14	Technical Advisory	Review draft plan
6/12/14	Planning (committee only)	Review and approve draft plan
6/26/14	Planning	Present plan and shift to implementation phase

On May 13, 2013, the first technical advisory committee meeting was held. Representatives from federal, state, and local conservation organizations reviewed the inventory of natural features and provided their expertise and knowledge of the area.

On May 23, 2013, the first planning meeting was held, which engaged local residents, landowners, working farmers, and city officials in the planning process. Consultants from Olson Ecological Solutions and JadEco Natural Resource Consulting provided an introduction to the plan and process.

On July 9, 2013, the Lake Management Committee of the Candlewick Lake Association discussed how to move forward with the planning process. Most of the people on this committee were actively involved in the planning process.

On July 17 and 22, 2013, consultants asked participants to share with them their concerns for their land and water and asked them what was important to them and what goals should be the focus.

On September 24, 2013, a planning meeting was held, at which time individuals from the community volunteered to serve as official planning committee members. These members led the remainder of the planning process and will lead the community as they transition from the planning process to implementing the plan.

On January 30, 2014, consultants met with the Kishwaukee River Ecosystem Partnership to gain their feedback about a developed list of goals and project recommendations. The Partnership offered valuable insight and suggestions, which were incorporated into the plan.

On February 19, 2014, consultants met with the planning committee in a closed session to plan the upcoming planning meeting and discuss the need for volunteer assistance in assessing streambanks and lake shorelines and other tasks needed for the plan.

On February 26, 2014, participants in the planning process were given an "alternative futures analysis" and prioritized projects and programs. Nathan Hill of Olson Ecological Solutions provided the alternative futures analysis, which used computer modeling to demonstrate what would happen to the amount of pollutants entering the area's streams and lakes if all of the farmland was developed as scheduled. He also provided participants another future scenario, in which projects and programs designed to lessen pollutant loading into the streams and lakes were implemented throughout the watershed. This gave the participants a good idea of what would happen if we continue to treat our land and water with our conventional methods of land use and development versus what can be accomplished if we mindfully protect our land and water resources while continuing to live, work, and play in the area.

Participants then broke into four small groups and provided input about the list of projects and programs provided by the consultants and the Kishwaukee River Ecosystem Partnership. They decided which projects were feasible and which were more likely just "wishful thinking." Each group prioritized ten projects that they felt were the most feasible and had the best potential for improving the water quality of the area's streams and lakes. The results from the small groups were analyzed and combined to form the prioritized projects found in Chapter 3.

On April 8, 2014, consultants provided a group of volunteers with instruction on how to measure the severity of erosion occurring on the area's streambanks and lake shorelines.

On April 19, 2014, consultants followed up from the April 8th gathering and trained volunteers to measure the severity of erosion occurring on streambanks and lake shorelines in the field. A known priority area, "The Dip," was used as an example site.

On May 20, 2014, the consultants met with the planning committee to review the draft plan. Feedback provided by the group was incorporated into the final plan.

On June 12, 2014, the consultants met with technical advisors to review the draft plan. Feedback provided by the group was incorporated into the final plan.

On June 26, 2014, the planning committee and the consultants held a public outreach meeting to present the final plan, strategy for initiating implementation, and next steps to those who have been involved in the planning process and anyone else who is interested in attending this public meeting.

Candlewick Lakes and Streams Conservation Partnership

As a result of these meetings and local involvement, the Candlewick Streams and Lakes Partnership has been formed of people interested in being part of the solution to improving water quality of the area's lakes and streams. The partnership should be continued, with representation of the various interests and talents of people in the community, including lake residents, farmers, developers, village and county staff, local conservation groups and conservationists, land use planners, policy makers, engineers, landscape architects, and ecologists. The members of the current planning committee, named in Chapter 1, have already committed to forming and leading this partnership as we shift from planning to education, monitoring, and coordination of project implementation. They intend to sign a memorandum of understanding that will provide guidance for their work moving forward.

Watershed Inventory

As we were involving the local people in the planning process, Nathan Hill of Olson Ecological Solutions inventoried the current conditions of the watershed using readily available data. Rich Witt of Candlewick Lake assisted by gathering historic data pertinent to the inventory from the Candlewick Lake Association's records. In May 2013, the EPA reviewed a draft *Candlewick Lake Watershed Resource Inventory* and recommended further study to be submitted with the final plan. In the spring of 2014, new data was gathered, including an assessment of streambank erosion and a survey of farming practices to verify recorded land uses. Hill created a new land cover map to reflect information that was more current than what was readily available, and he ran a computer model using this land cover data file to estimate the current pollution loads entering the streams and lakes from upstream sources.

Streams and Lakes Conservation Plan

During early planning meetings, planning participants shared their concerns and found common ground in their desire to improve the water quality of Candlewick Lake, and they adopted a success statement and goals to accomplish this. They agreed that all streams, tributaries, ponds, and lakes within the watershed should be addressed by the plan. Participants determined which projects and programs should be included in the plan, and which should be prioritized. After these elements of the plan had been decided, Rebecca Olson and Nathan Hill of Olson Ecological Solutions and Joe Rush of JadEco Natural Resource Consultants wrote the plan to further develop these projects.

Watershed Planning Participants

Many people participated in the watershed planning effort, including residents; landowners and working farmers; representatives from federal, state, and local environmental and planning organizations; and staff and consultants of the Candlewick Lake Association. We would like to acknowledge the following individuals for their dedication to the planning effort.

Planning Committee Members:

1. Bonnie Marron, Chairman and Candlewick Lake Board Vice President
2. Chuck Hart, Vice Chairman
3. Charlie Sewell, Secretary
4. Rich Witt

Technical Advisory Committee and Kishwaukee River Ecosystem Partnership Members:

1. Joe Bybee, Illinois Department of Agriculture Regional Representative
2. Dan Kane, Boone County Conservation District Executive Director
3. John Kremer, McHenry County Conservation District
4. James Mulcahy, Boone County Soil and Water Conservation District
5. Jerry Paulson, Kishwaukee River Ecosystem Partnership Member
6. Nancy Williamson, Illinois Department of Natural Resources Ecosystem Administrator

Planning Participants:

1. Barb Applehans
2. Alan Ball
3. Bill Batzkall
4. Evelyn Brefeld
5. Jim Brefeld
6. Mary Budreau
7. Randy Budreau
8. Jen Callaghan
9. Joe Cangelosi
10. Pam Cangelosi
11. George Chorvat
12. Jim Cook
13. Stuart Davidson
14. Dominic DeMay
15. Ken Dillenburg
16. Roberta Drake
17. Ronald Drake
18. Duane Eckard
19. Bob Evans
20. Beverly Gaddis
21. Kathy Gatzkall
22. Steve Lambright
23. Joyce Lund
24. Leonnard Lund
25. Jeff Lutzow
26. Debby Mahon
27. Jo Clair Malpier
28. Bob McHoes
29. Dale Miedema
30. John Mills
31. Willa Moen
32. Sandy Morse
33. Doris Nelson
34. Lee Odden
35. Marge Olson
36. Don Parisi
37. Tom Pinkowski
38. Phil Saia
39. Karl Steiskal
40. Don Tripicchio

Village of Poplar Grove:

41. Gina DelRose
42. Mark Lynch

Consultants and Staff:

1. Theresa Balk, Candlewick Lake Association Assistant General Manager
2. Tracy Carter, Candlewick Lake Association General Manager
3. Nathan Hill, Olson Ecological Solutions
4. Rebecca Olson, Olson Ecological Solutions
5. Joe Rush, JadEco Natural Resource Consultants

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Chapter 2: – Candlewick Watershed Inventory

Written by Nathan Hill

Physical and Natural Features

This Chapter provides a compilation of all of known physical features and natural resource information for the watershed and surrounding communities.

Watershed Boundaries

The Candlewick Lake Watershed lies within the Kishwaukee Watershed, and the Winnebago Drift Section of the Northeastern Morainal Division in north-central Illinois. The Candlewick Lake Watershed lies largely within Caledonia and Poplar Grove Townships in Boone County. Candlewick Lake Watershed flowage is named Spring Brook and eventually drains into Beaver Creek. The Beaver Creek Watershed (Hydrologic Unit Code 0709000604) is a mostly rural watershed dominated by agricultural land use in the upper reaches (>90%) while the lower portion of the watershed features a more mixed land-use pattern that is increasingly becoming more urbanized (CMAP, 2008). Beaver Creek eventually empties into the Kishwaukee River and then into the Rock River. It contains 2,896 acres, based on delineation of watershed boundary using 1:24,000 scale Digital Raster Graphic topographic maps in GIS. The boundaries of the Candlewick Lake Watershed are roughly as follows: Illinois Route 173 forms the northern boundary, Caledonia Road borders the watershed on the west, Orth Road lies along the southern boundary, and Illinois Route 76 forms the eastern boundary.

Hydrology

Hydrology of the watershed is defined by stream reaches, floodplain, peak flow, and water bodies including Candlewick Lake, Boone Lake, small ponds, and wetlands.

Figure 2-1: Candlewick Lake Watershed boundaries

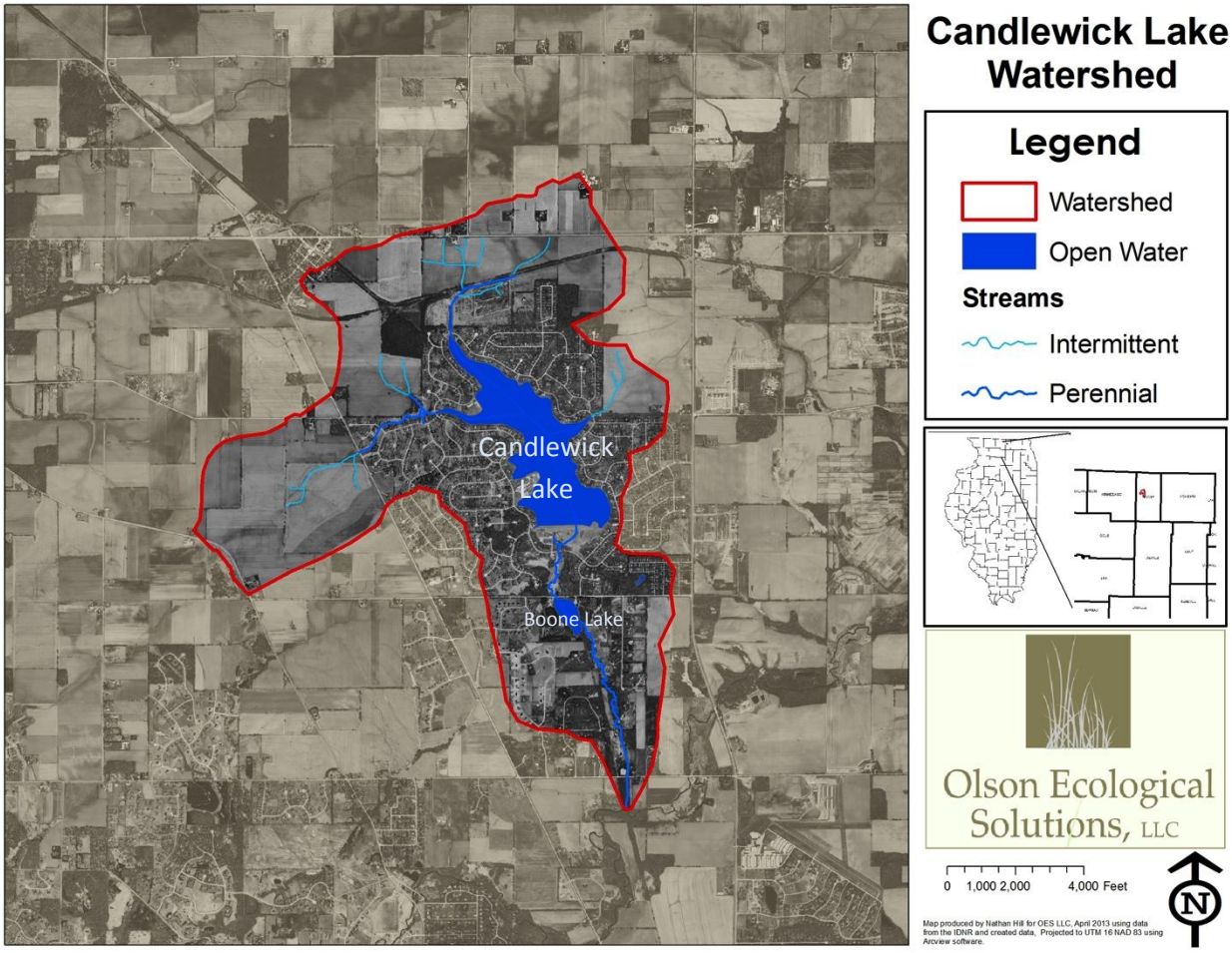


Figure 2 -2: Candlewick Lake Subwatersheds

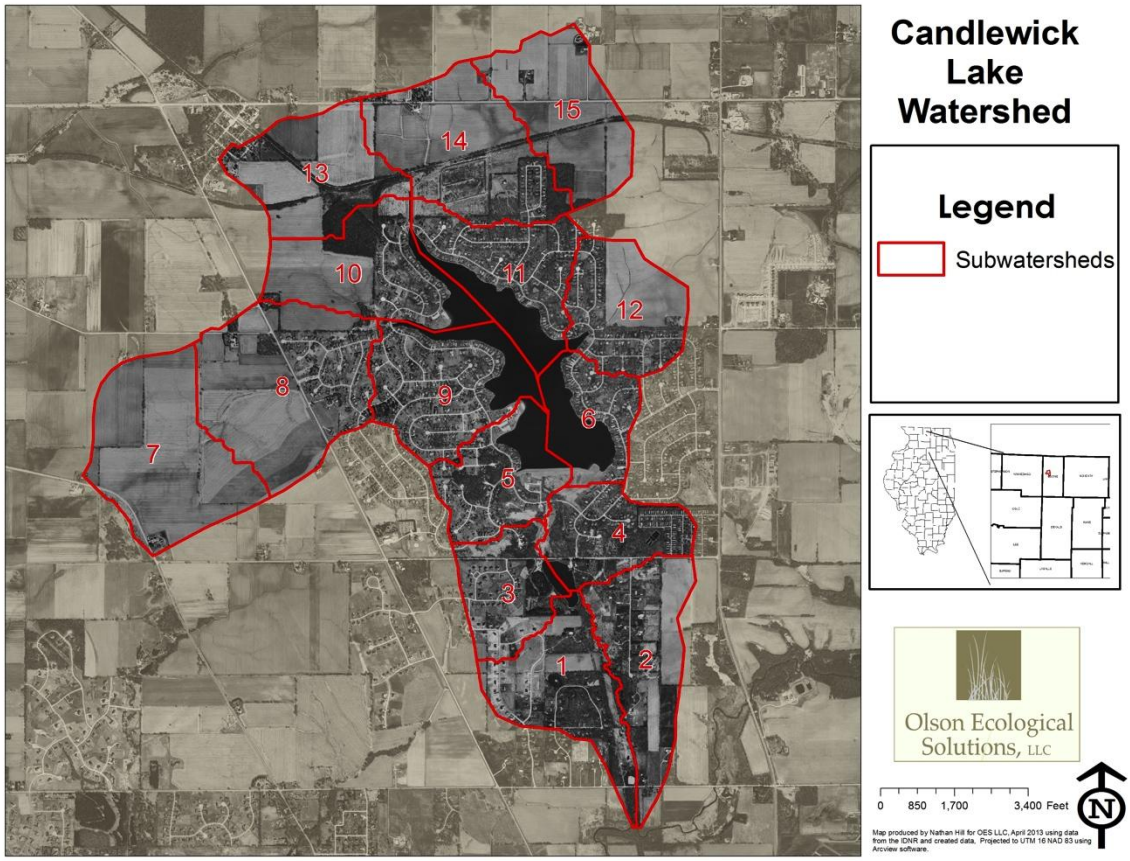


Table 2-1: Candlewick Lake Subwatershed Breakdown

Subwatershed ID	Acres	% Watershed
1	184	6.37%
2	192	6.65%
3	126	4.34%
4	137	4.74%
5	149	5.16%
6	122	4.21%
7	269	9.31%
8	311	10.73%
9	211	7.28%
10	206	7.11%
11	191	6.58%
12	163	5.63%
13	188	6.49%
14	255	8.79%
15	192	6.63%
	2896	100.00%

Stream Reaches

The watershed is named for the Candlewick Lake and it has three small, unnamed intermittent and perennial tributaries. The main channel, called Spring Brook, flows south from Candlewick Lake to the confluence of Beaver Creek. Beaver Creek is generally characterized as a medium gradient, 4th order stream. The headwaters of all three main tributaries begin as agricultural grassed waterways and outlet into perennial channels before entering the lake. The two main tributaries north and west of the lake drain 780 and 470 acres respectively. Where the lake's western drainage enters the lake is commonly referred to as "The Dip". The basin length of the Candlewick Lake watershed is about 3.5 miles running north to south, according to ortho-photography and GIS analysis. A GIS analysis measured all perennial and intermittent streams in the watershed as summarized in Figure 2.2. "Candlewick Lake Upstream" refers to the segment upstream of Candlewick Lake. Intermittent streams and grassed waterways only flow during and shortly after rain events.

Spring Brook Looking Upstream of Orth Rd.

Figure 2-3: Candlewick Lake Watershed Streams

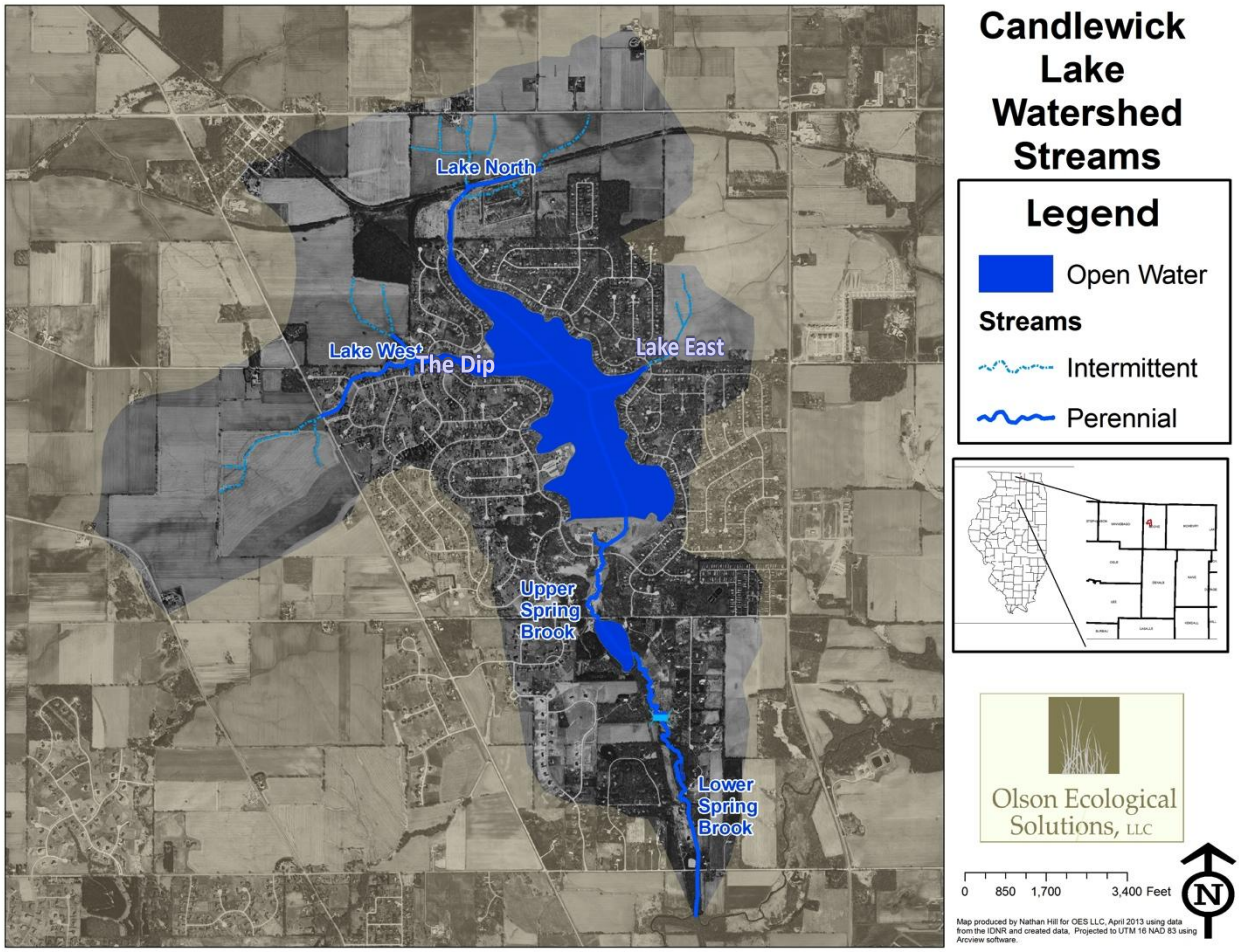
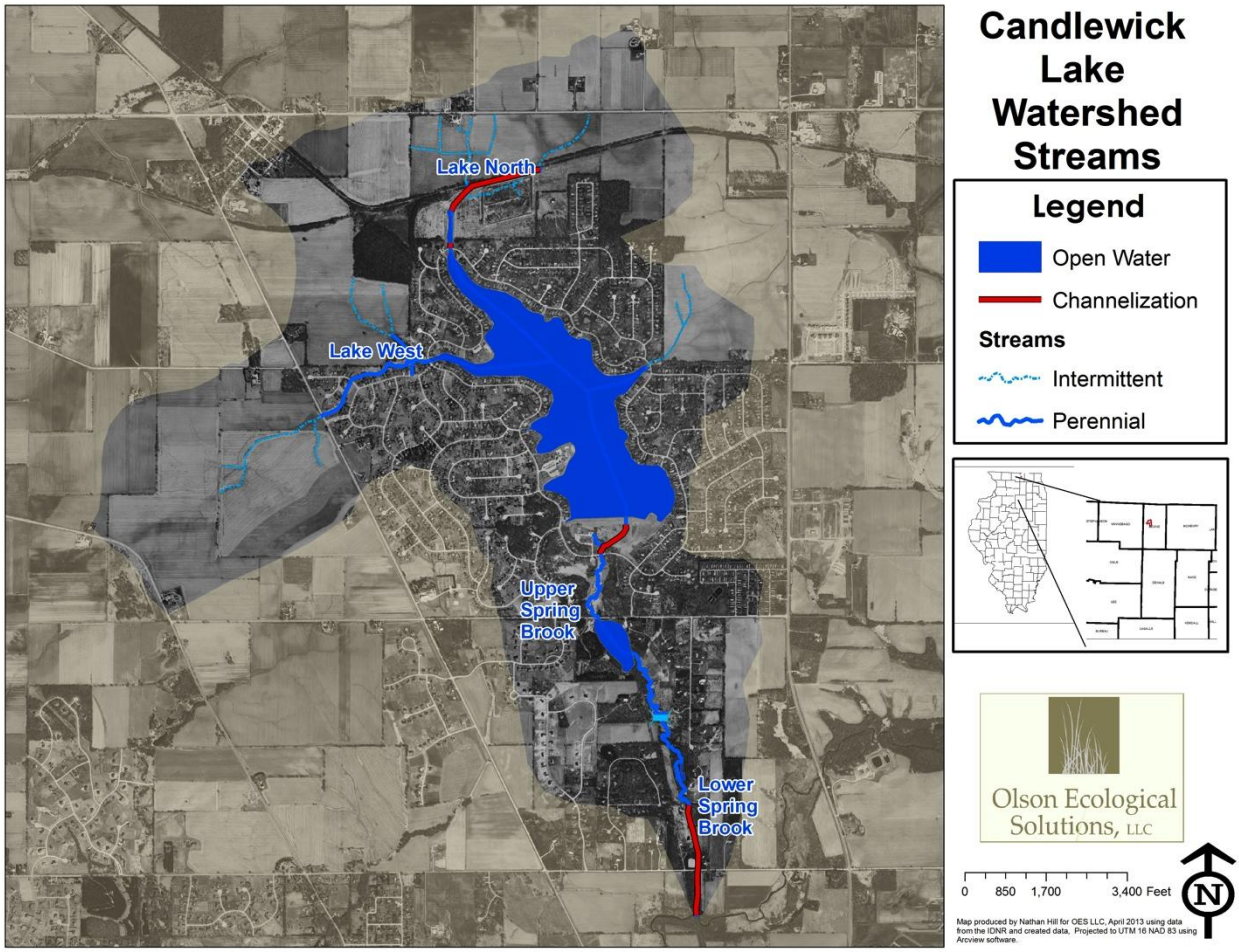


Table 2.2: Stream Length in Candlewick Lake Watershed

Stream Section	Type	Length: Linear feet	Length: Miles
Lake West	Intermittent	7,270	1.44
Lake North	Intermittent	7,953	1.50
Lake East	Intermittent	2,936	0.56
	Subtotal	***18,159***	***3.5***
Lake West	Perennial	4,089	0.77
Lake North	Perennial	3,093	0.59
Upper Spring Brook	Perennial	5,573	1.55
Lower Spring Brook	Perennial	5,574	1.55
	Subtotal	***18,329***	***3.5***
	Total	***36,488***	***7***

Figure 2-4: Stream Channelization in the watershed



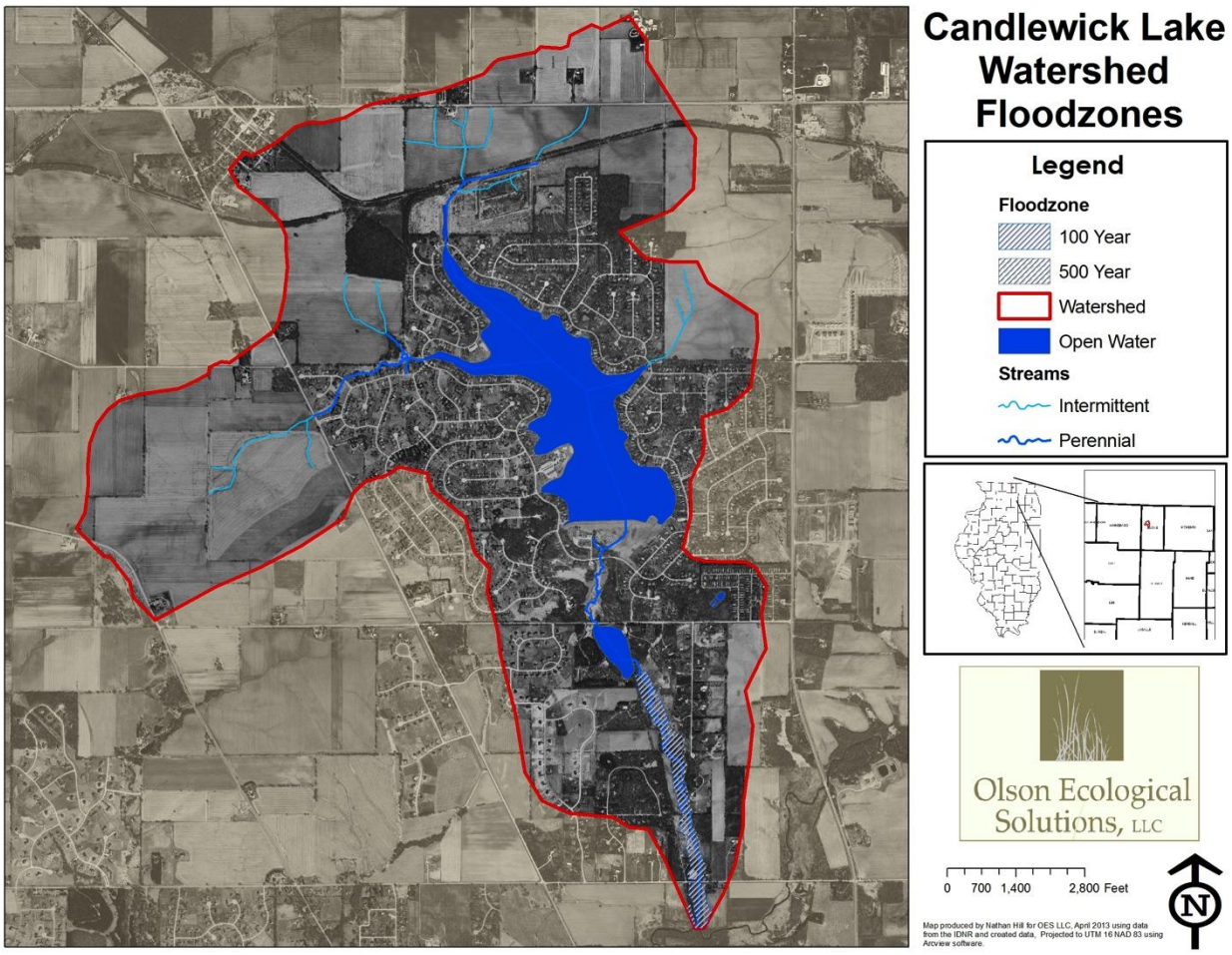
Stream Channelization

Of the total 18,329 feet of perennial streams around 8,000 feet have been historically channelized as illustrated in Figure 2-4.

Floodplain

Floodplain is an important component of stream ecology and serves to moderate flow rates and stream energy during high flow runoff conditions. The floodplain area of the Candlewick Lake Watershed is 37.44 acres (1.3% of the watershed), as identified by the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map 1996. Of this acreage, 34.14 acres are considered as the "Special Flood Hazard Areas" Inundated by 100-Year Flood," and 3.30 acres are considered 500-year floodplain (Figure 2-5). This floodplain extends for about one mile upstream of its confluence with the Beaver Creek.

Figure 2-5: Flood zones within the Candlewick Lake Watershed



Stream Flow

Measurements taken by Mead and Hunt in 1997 of Candlewick Lake inflows and outflow showed a total surface water inflow from tile and agricultural areas of 652 acre-feet of water and 160 acre-feet respectively. Rainfall accounts for 403 acre-feet and out flow at the dam was 1046.79 acre-feet.

Water Bodies

Candlewick Lake: The 210-acre Candlewick Lake (IEPA Assessment Unit IL-RPV) was formed by damming a headwater stream commonly called Spring Brook, a tributary to Beaver Creek. Construction on Candlewick Lake began in the early 1970s and reached full pool by 1975.

Sources of water to the lake include: direct precipitation, drain tile flows from agricultural fields, stormwater flows from residential development, and stormwater runoff from farm fields. The maximum depth of the lake is 28 feet with an average depth of 10.25 feet (Integrated Lakes Management). The lake is primarily used for fishing, boating, and swimming. The watershed

surrounding the lake is comprised of about 1,850 single family homes. The lake volume is approximately 2,127 acre-feet with direct evaporation of 556 acre-feet per year. Seepage is unknown. Annual runoff is 1773.20 acre-feet and outflow is 2,972 acre-feet per year (Mead and Hunt).

Candlewick Lake Boat Ramp

Boone Lake: The 11.6-acre Boone Lake was created downstream of the Candlewick Lake outlet on a headwater tributary to Beaver Creek named Spring Brook. Boone Lake is fed by a 234-acre watershed and has 3100 feet 0.6 miles of shoreline. The maximum depth is 14 feet with an average depth of 5.2 feet. The volume of Boone Lake is 71.2 acre-feet.

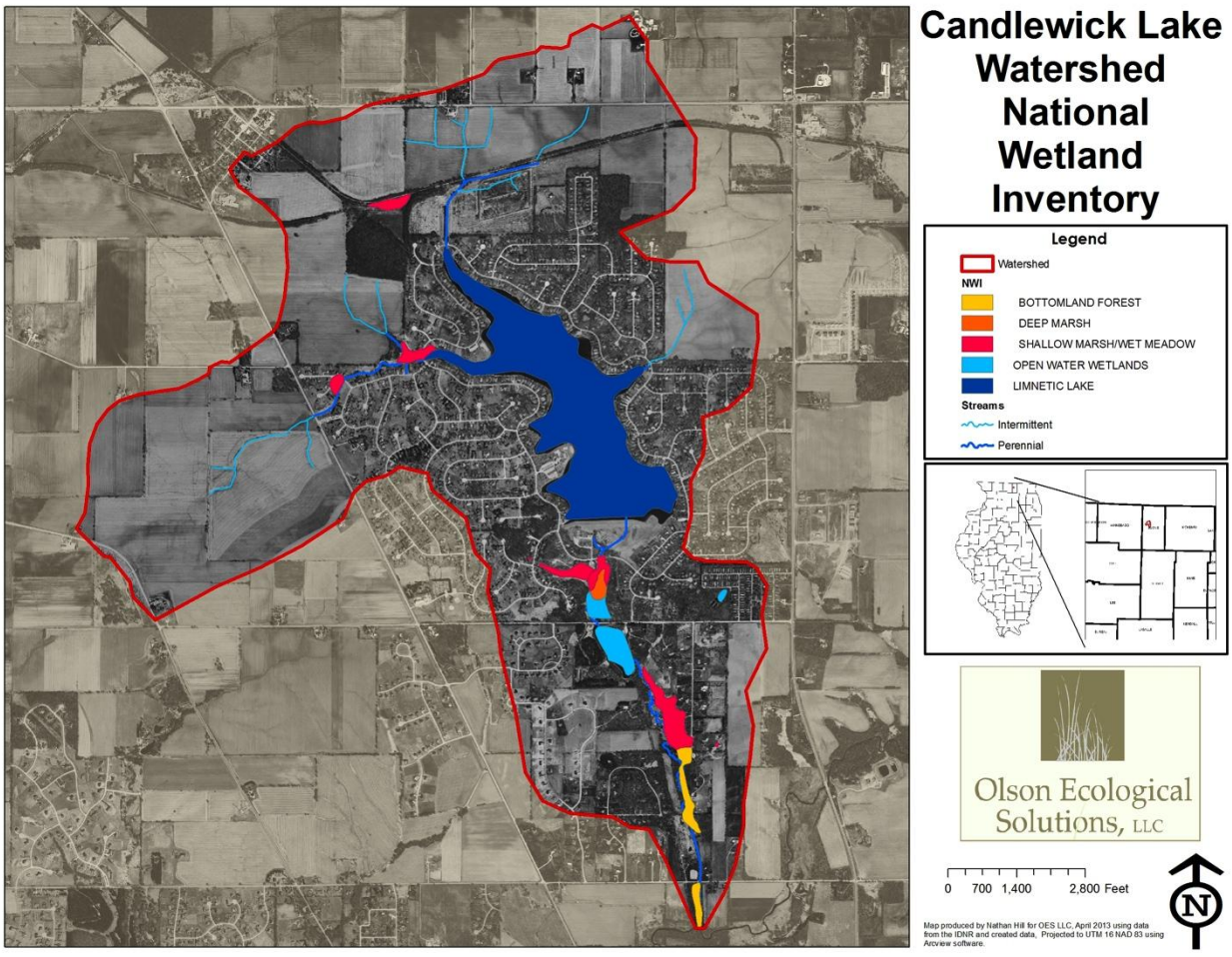
Boone Lake

Ponds: There are two smaller ponds, mostly man-made, that account for two acres within the watershed. One is a sediment pond to the north of Candlewick Lake. The other is located along the main stem of the tributary about one-half of a mile upstream of the confluence with Beaver Creek.

Wetlands

The watershed has a total of 248.3 acres of various National Wetland Inventory wetland types, representing 8.6% of the watershed and located mostly along the creek corridors (Figure 2-6). There are 30.5 acres of shallow marsh/wet meadow, 9.9 acres of bottomland forest, 2.7 acres of deep marsh, 190 acres of limnetic lake, and 15.1 acres of open water wetlands (National Wetland Inventory).

Figure 2-6: National Wetlands Inventory sites in the Candlewick Lake Watershed

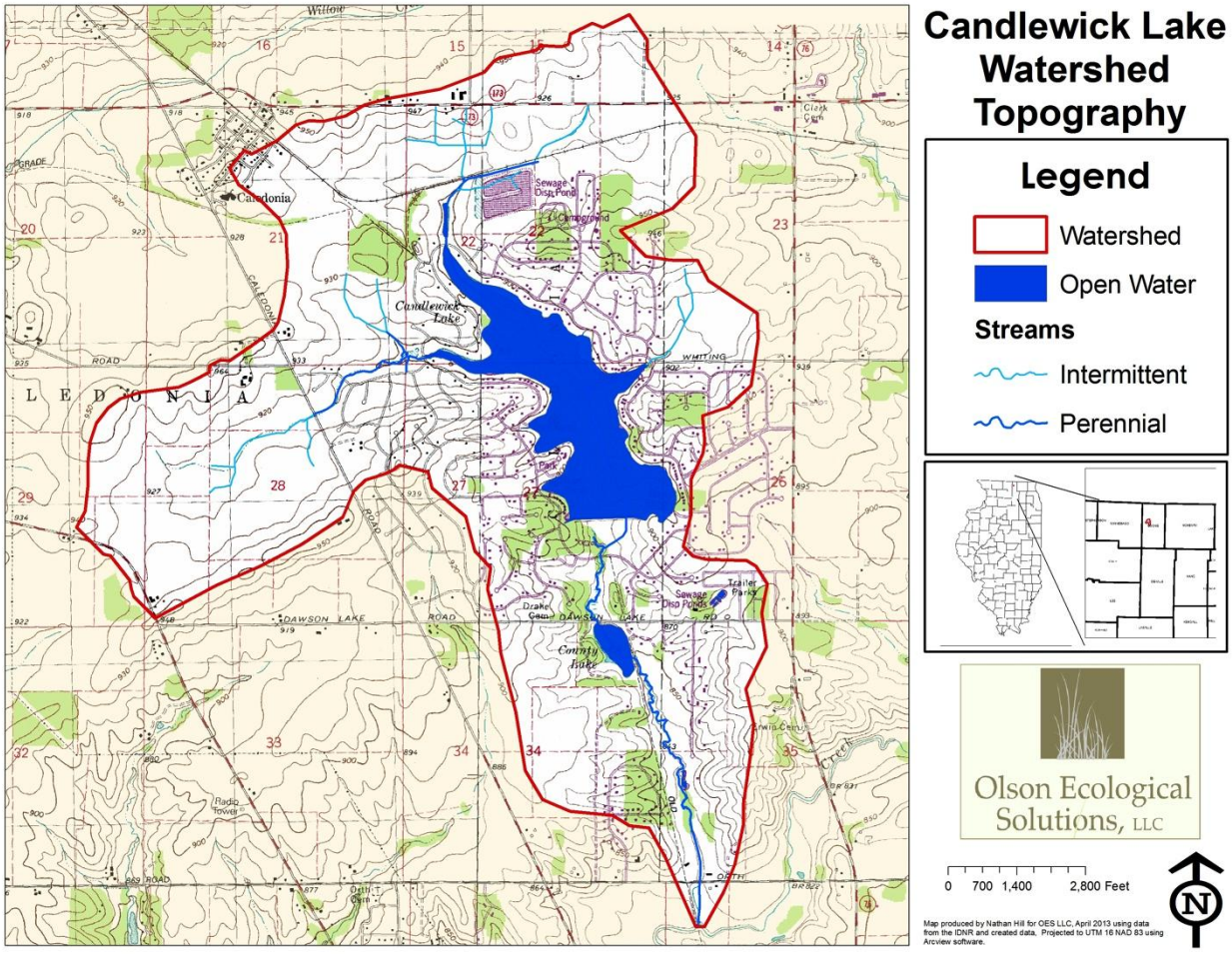


Topography

The topography of the Candlewick Lake Watershed is rolling terrain with moderate slopes (Figure 2-7), which is the result of both erosion processes and irregularities in the bedrock surface that influenced

total drift thickness. It has been glaciated during the Illinois episode and has a thin layer of glacial drift, with extensive areas of 50 feet or less of drift that overly the bedrock (Piskin and Bergstrom). The highest elevation in the watershed is 960 feet above sea level and the lowest point is 810 feet above sea level at the confluence with the Beaver Creek.

Figure 2-7: Candlewick Lake Watershed topographic relief



Soils

Soils in the watershed are defined by predominant soil associations, individual soil mapping units, hydric soils, and hydric soil groups.

Predominant Soil Associations

The Candlewick Lake Watershed is made up of predominantly three soil associations: Lawson-Sawmill-Darwin, Westville-Pecatonica-Flagg, and Fayette-Rozetta-Stronghurst.

Figure 2-8: Soil map unit map

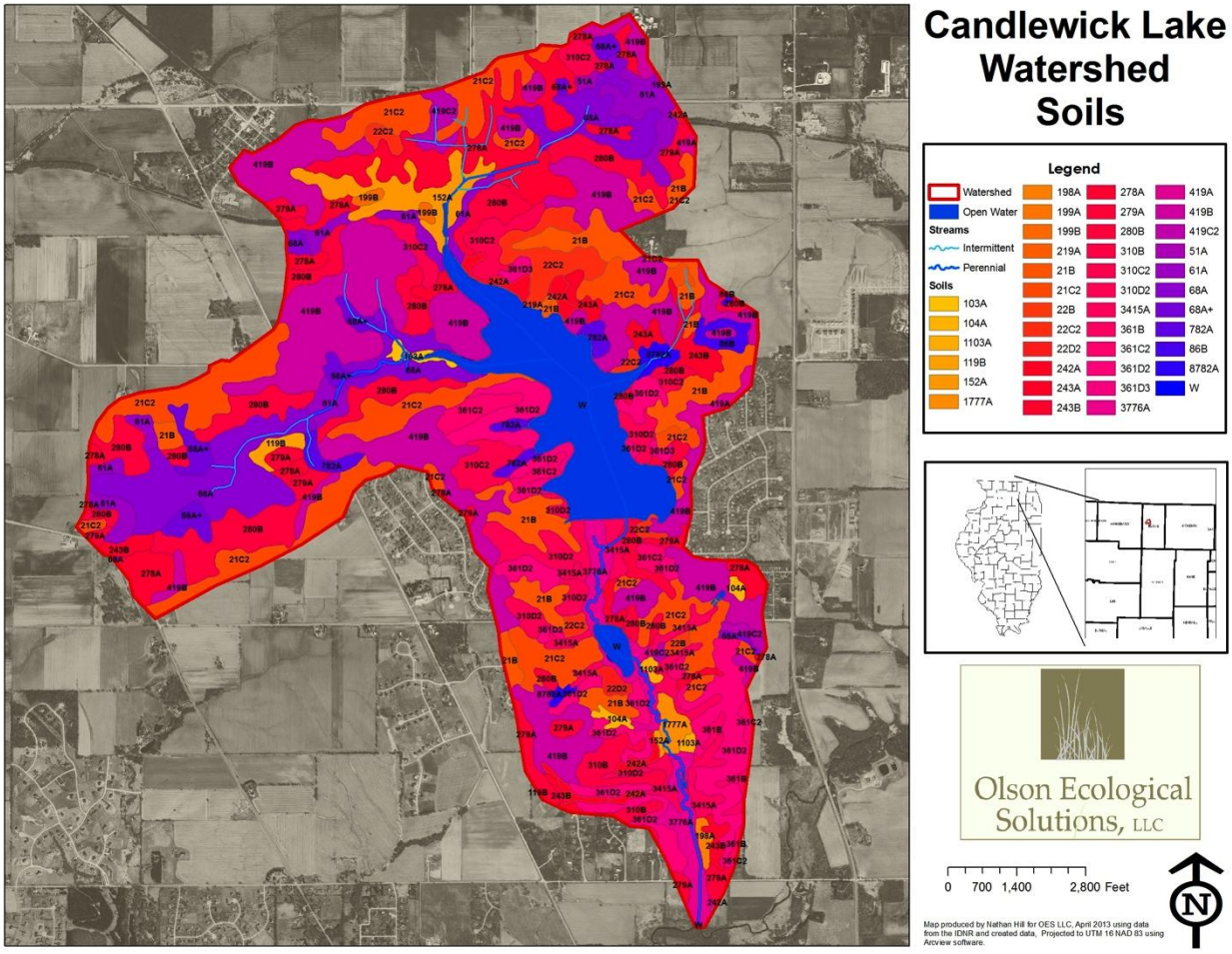


Table 2-3 Soil map unit acreage (hydric soils in ***italics***)

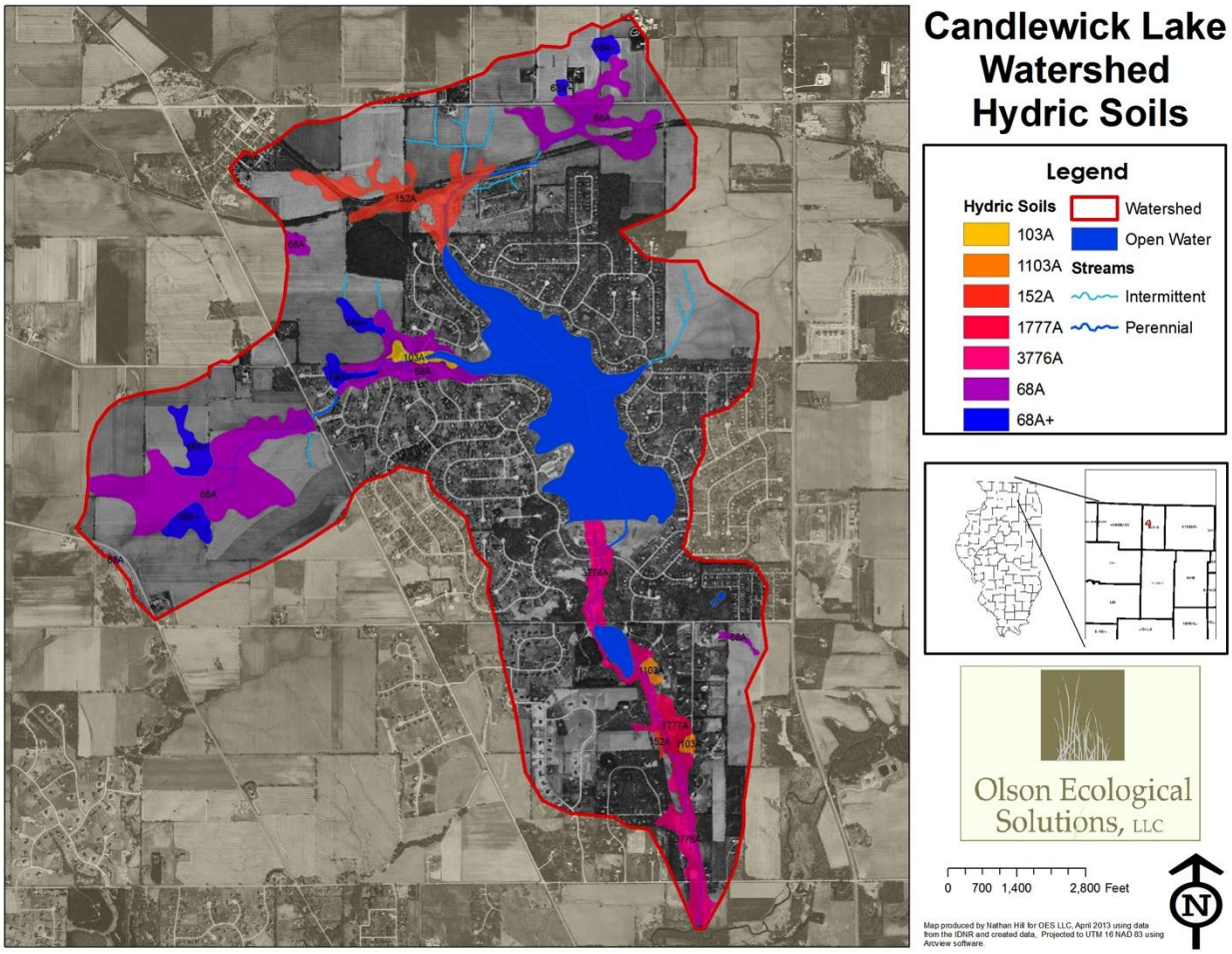
Map Unit	Name	ac
103A	***Houghton Muck, 0-2% slopes***	*5.88*
104A	Virgil silt loam, 0-2% slopes	6.82
1103A	***Houghton Muck undrained, 0-2% slopes***	5.28
119B	Elco silt loam, 2-5% slopes	8.00
152A	***Drummer silty clay loam, 0-2% slopes***	55.50
1777A	***Adrian muck, undrained, 0-2% slopes***	12.21
198A	Elburn silt loam, 0-2% slopes	4.72
199A	Plano silt loam, 0-2% slopes	3.61
199B	Plano silt loam, 2-5% slopes	2.55
219A	Millbrook silt loam, 0-2% slopes	1.34
21B	Pecatonica silt loam, 2-5% slopes	137.45

21C2	Pecatonica silt loam, 5-10% slopes	321.52
22B	Westville silt loam, 2-5% slopes	3.50
22C2	Westville silt loam, 5-10% slopes	56.68
22D2	Westville silt loam, 10-18% slopes	6.31
242A	Kendall silt loam, 0-2% slopes	28.72
243A	St. Charles silt loam, 0-2% slopes	15.65
243B	St. Charles silt loam, 2-5% slopes	36.25
278A	Stronghurst silt loam, 0-2% slopes	191.10
279A	Rozetta silt loam, 0-2% slopes	63.35
280B	Fayette silt loam, 2-5% slopes	233.75
310B	McHenry silt loam, 2-4% slopes	29.96
310C2	McHenry silt loam, 4-6% slopes	70.87
310D2	McHenry silt loam, 6-12% slopes	61.05
3415A	Orion silt loam, 0-2% slopes, frequently flooded	57.22
361B	Kidder loam, 2-4% slopes	10.33
361C2	Kidder loam, 4-6% slopes	35.60
361D2	Kidder loam, 6-12% slopes, eroded	187.55
361D3	Kidder loam, 6-12% slopes, severely eroded	7.64
3776A	***Comfrey loam, 0-2% slopes, occasionally flooded***	69.30
419A	Flagg silt loam, 0-2% slopes	14.96
419B	Flagg silt loam, 2-5% slopes	519.85
419C2	Flagg silt loam, 5-10% slopes	22.33
51A	Muscatune silt loam, 0-2% slopes	2.87
61A	Atterberry silt loam, 0-2% slopes	90.01
68A	***Sable silty clay loam, 0-2% slopes***	201.99
68A+	***Sable silty clay loam, 0-2% slopes, overwash***	45.43
782A	Juneau silt loam, 0-2% slopes	25.50
86B	Osco silt loam, 2-5% slopes	12.54
8782A	Juneau silt loam, 0-2% slopes, occastionally flooded	11.58
W	Water	219.10

Hydric soils

Hydric soils are poorly drained soils associated with wet prairies, forested floodplains, and wetlands. These soils are prone to flooding or wet conditions if they are not drained (NRCS, 2010). In the watershed, 395.6 acres of hydric soils comprise 13.7% of the soils in the watershed (Figure 2-9). They are predominately on the floodplains and major drainage areas, although there are a few isolated areas in shallow depressions on terraces.

Figure 2-9 Hydric soil map units



Hydrologic soil group

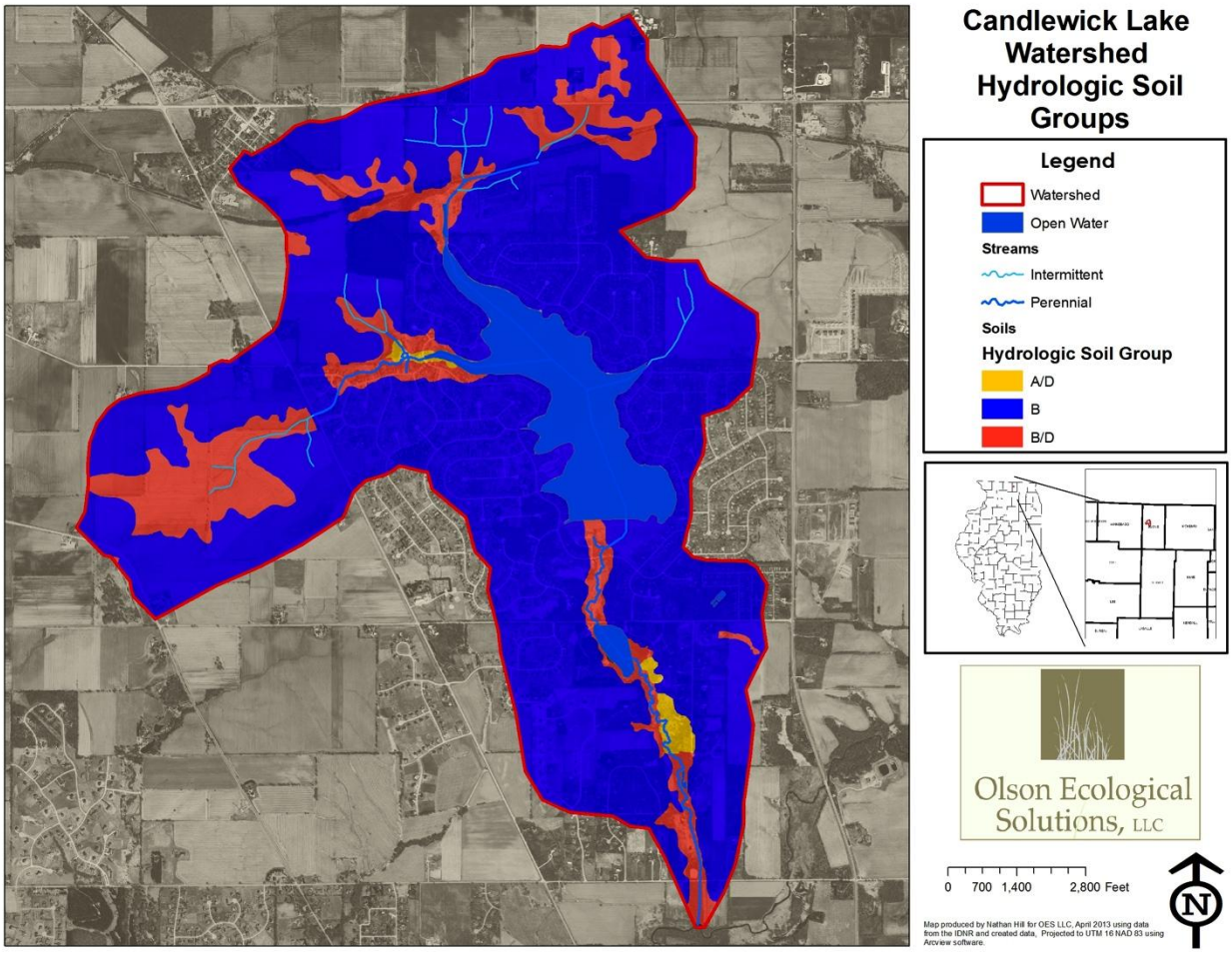
Hydrologic soil groups (HSG) help to define the runoff potential of soils. They are categorized into A, B, C, and D soils based on texture, permeability, and level of drainage. The ranking applies to hydric soils in their drained state. HSG A has the least runoff potential while HSG D has the greatest runoff potential. If the soils are not drained, they are assumed to have a runoff potential of HSG D soils. The Candlewick Lake Watershed has the following percentages of HSG (USDA, 1993).

Table 2-4 Hydrologic Soil Groups

Hydrologic Soil Groups in the Candlewick Lake Watershed	% Watershed
A/D	0.81%
B	78.77%
B/D	12.85%
Water	7.57%

The vast majority of the watershed is HSG B (78.8%). HSG A/D (0.81%) is found in the wettest areas and scattered throughout the watershed, mostly near streams. HSG B/D (12.85%) follows the streams and drainage areas of the watershed (see Figure 2-10).

Figure 2-10: Hydrologic Soil Groups in the Candlewick Lake Watershed

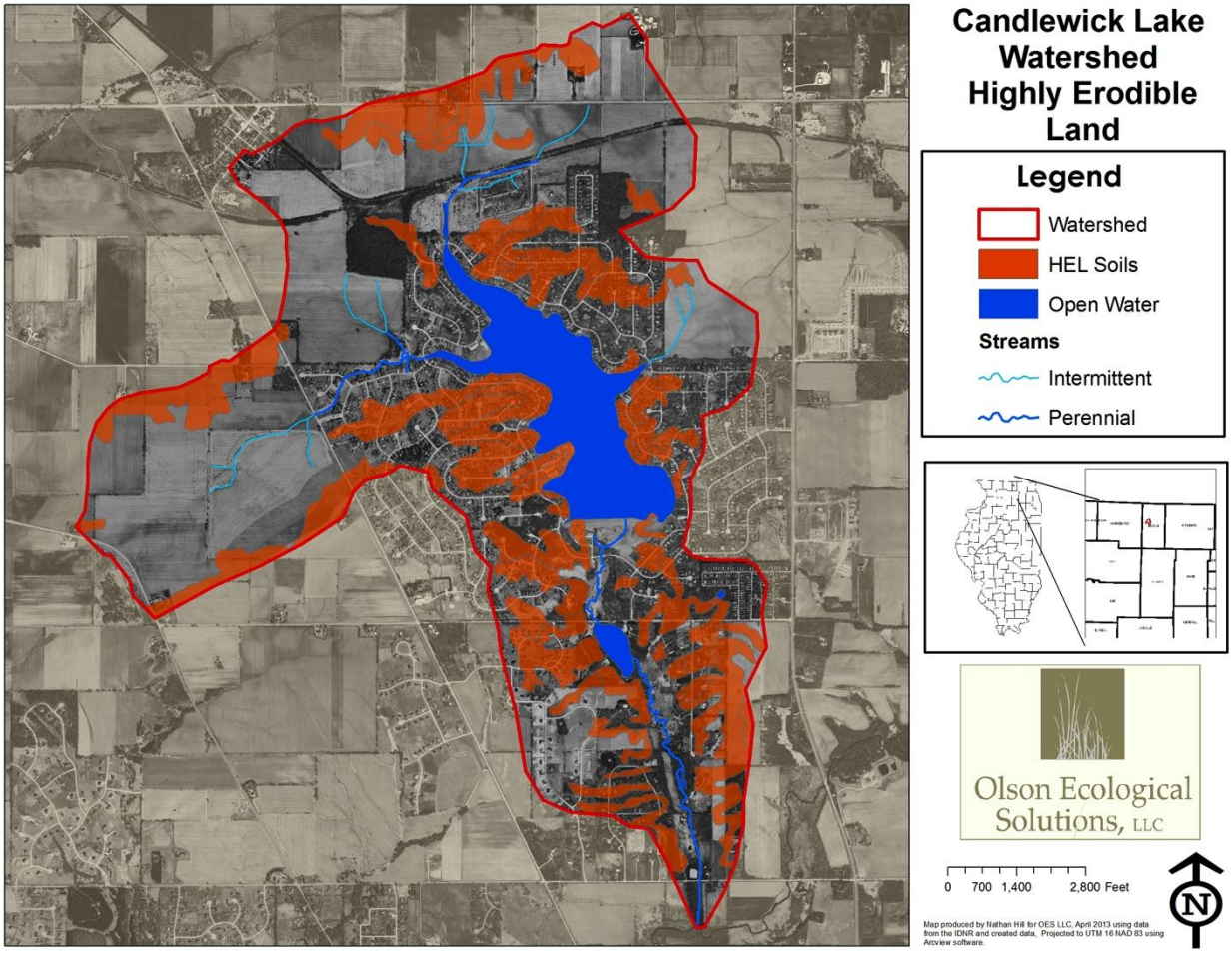


Soil Erodibility

Soil in the watershed is usually eroded by water. Wind is not a strong factor of erosion in north-central Illinois. Highly Erodible Land (HEL) percentages and soil erosivity (Kw) values provide insight to soil erodibility in the watershed. HEL is based on the erodibility index of a soil map unit and is determined by dividing the potential erodibility for each soil by the soil loss tolerance (T) value for each soil. A soil map unit with an erodibility index greater than 8 is an HEL (NRCS, FOTG).

There are 770 acres (26.6 % of the watershed) of soil considered HEL with slopes ranging from 5% to 30% (Figure 2-11). The tolerable soil loss for most soils is between 3 and 5 tons per acre per year. This is the amount of soil loss that can theoretically occur and be replaced by natural soil-building processes (Illinois Dept. of Agriculture, 2011). These HEL soils are also considered to be eroded in the Soil Survey.

Figure 2-11: Highly Erodible Lands (HEL) in the Candlewick Lake Watershed



Cropland Soil Erosion

There was limited cropland soil erosion data in the watershed. In 2011, the Boone County Soil and Water Conservation District measured soil erosion using Revised Universal Soil Loss Equation (RUSLE) at various transect locations throughout the County. At that time, 89% of sites were at or below Tolerable soil loss (T) levels 9% of sites were 1-2 T and 2% were less than 2 T. During the same transect, the District identified only 8% of the sites as having ephemeral gulley erosion (Illinois Dept. of Agriculture, 2011).

A survey of the watershed cropland during May of 2014 showed most of the fields were currently untilled corn stubble indicating the use of no tillage for beans. Only the northern most 158 acres of cropland showed tillage and residue levels consistent with fall mulch and spring tillage. The 158 acres would be an excellent candidate for no till as it contains about 50% HEL soils.

Many of the intermittent stream channels within the watershed and running through cropland were protected by grassed waterways. About 5450 feet of cropland ephemeral gully erosion remained unprotected and showed signs of gully erosion from both the survey Spring 2014 survey and historic aerial photographic investigation.

The Boone County Soil and Water Conservation District and Natural Resources Conservation Service indicated that no current Conservation Reserve Program or Environmental Quality Incentives Program projects were currently active in the watershed.

Construction Site Erosion

Both Caledonia and Poplar Grove Townships were listed as urbanized areas by the IEPA based on 2000 census data but the MS4 status report indicates that no permit is required for either. The construction sites and developments within the watershed obtain permit coverage under the State's General Storm Water NPDES Permit and develop Storm Water Pollution Prevention Plans (SWPPP) to manage storm water and reduce pollutants from the site. The IEPA as well as Boone County Soil and Water Conservation District provide inspections of these sites with staff that are a Certified Professional in Erosion and Sediment Control (CPESC). Currently, no new developments requiring NPDES storm water permits are being constructed in the watershed.

Prime Farmland

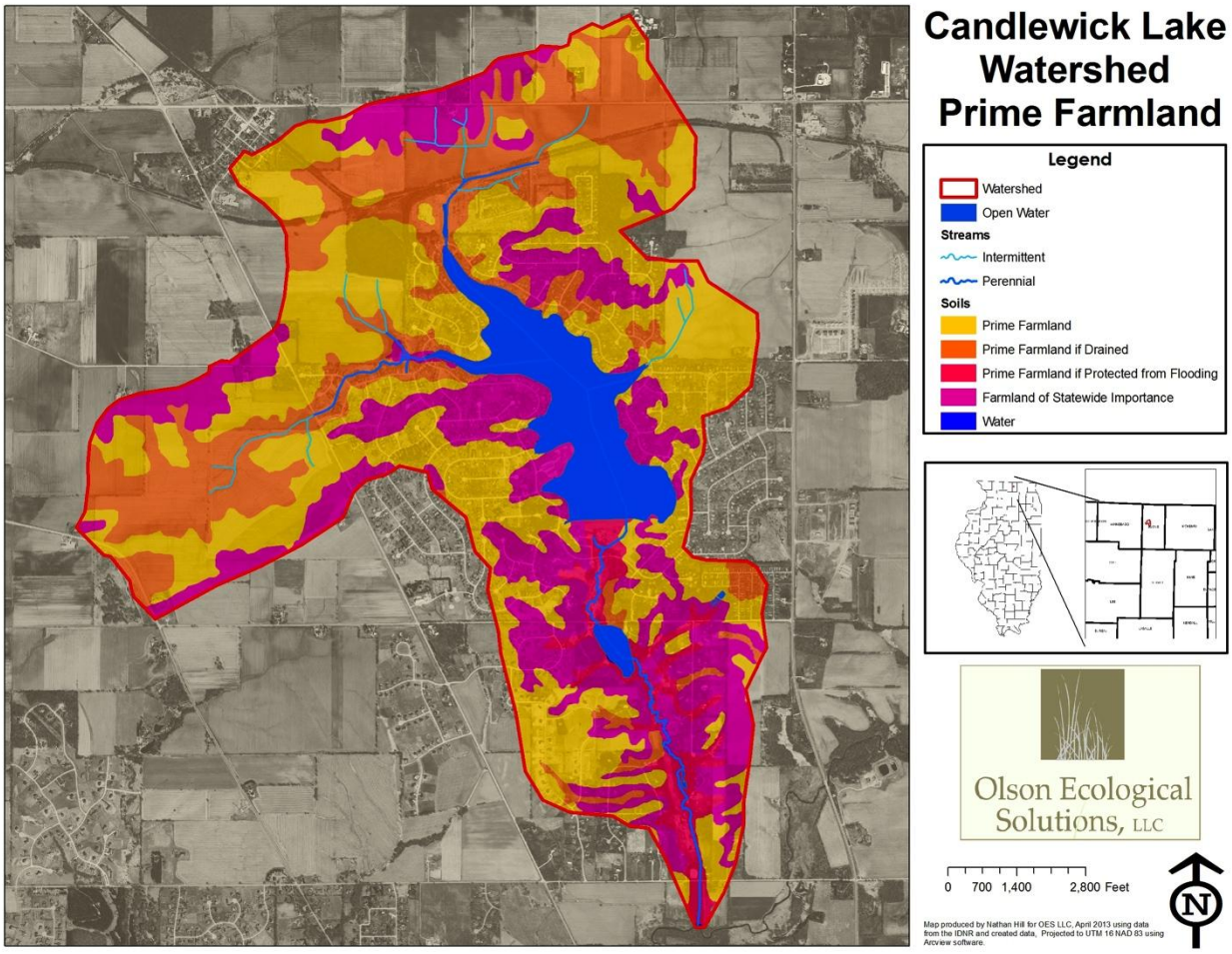
The United States Department of Agriculture's Natural Resources Conservation Service defines prime farmland as: "land best suited for producing food, feed forage, fiber, and oilseed crops, and also available for these uses. The land currently could be cropland, pasture land, range land, forest land, or other land but not urban build-up land or water. It has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed, including water management, according to modern farming methods. "

The criteria for identifying prime farmlands is entirely related to soil characteristics and other physical criteria. Almost all of the soils within the watershed have been identified as Prime or of Statewide Importance (Figure 2-12).

Table 2-5: Candlewick Lake Watershed Prime Farmland

Farmland Classification	Acres	%
Farmland of Statewide Importance	722	25%
Prime Farmland	1192	41%
Prime Farmland if Drained	637	22%
Prime Farmland if Protected from Flooding	126	4%
Water	219	8%
Total	**2896**	**100**

Figure 2-12: Prime farmland in the Candlewick Lake Watershed



Climate

Precipitation and Snow and Ice Cover

The Average precipitation for Boone County is 36.28 inches of rainfall annually. The average annual snowfall is 35.2 inches (ISWS, 2003).

Table 2-6: Normal Precipitation for Rockford IL

Precipitation-Related Normals

Normal	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prcp:	1.37	1.41	2.32	3.35	4.02	4.65	3.95	4.59	3.35	2.67	2.58	1.98
Snow:	10.2	7.7	4.8	0.9	0.0	0.0	0.0	0.0	0.0	0.1	1.7	11.3
Number of Days												
P001:	9.4	8.2	10.5	11.3	12.2	10.4	9.4	9.7	8.3	9.4	10.2	10.2
P010:	4.0	3.6	5.1	6.4	7.2	7.2	6.4	6.5	5.3	5.3	5.3	5.0
P100:	0.1	0.2	0.5	0.8	1.2	1.3	0.9	1.2	0.8	0.5	0.5	0.2
S001:	8.2	5.8	4.1	1.0	0.0	0.0	0.0	0.0	0.0	0.1	1.9	7.7
S010:	3.3	2.3	1.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.1
S100:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(http://www.isws.illinois.edu/atmos/statecli/newnormals/normals.USW00094822.txt)

Temperature

Average annual temperatures for the region are 49.2°F. Average winters experience highs in the 30s and lows in the teens, with an average of 133.5 days at or below 32°F and 11.6 days at or below 0°F. Average summers have highs in the 80s and lows in the 60s with 14.9 days at or above 90°F and 0.2 days over 100°F occurring about every other year. The average cooling degree days are 820 and the average heating degree days are 6569 (ISWS 2010). The median date for the last freeze of 32 degrees is April 27th and the median date for the first freeze date of 32degrees is October 10th (ISWS, 2008).

Table 2-7: Normal Temperatures for Rockford IL

Temperature-Related Normals

Normal	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High:	29.5	34.2	46.9	60.7	71.8	81.1	84.5	82.4	75.4	62.7	47.6	33.2
Mean:	21.5	25.9	37.2	49.4	60.1	69.8	73.8	71.9	63.9	51.7	38.9	25.4
Low:	13.5	17.7	27.5	38.1	48.4	58.5	63.0	61.3	52.4	40.7	30.3	17.7
CDD:	0	0	0	8	47	175	274	223	84	9	0	0
HDD:	1348	1093	862	476	198	31	3	11	117	422	782	1226
Number of Days												
T090:	0.0	0.0	0.0	0.0	0.6	3.4	5.7	4.0	1.1	0.1	0.0	0.0
T100:	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
T000:	5.5	2.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
T032:	29.0	25.0	21.8	7.5	0.5	0.0	0.0	0.0	0.3	5.1	16.8	27.4

(http://www.isws.illinois.edu/atmos/statecli/newnormals/normals.USW00094822.txt)

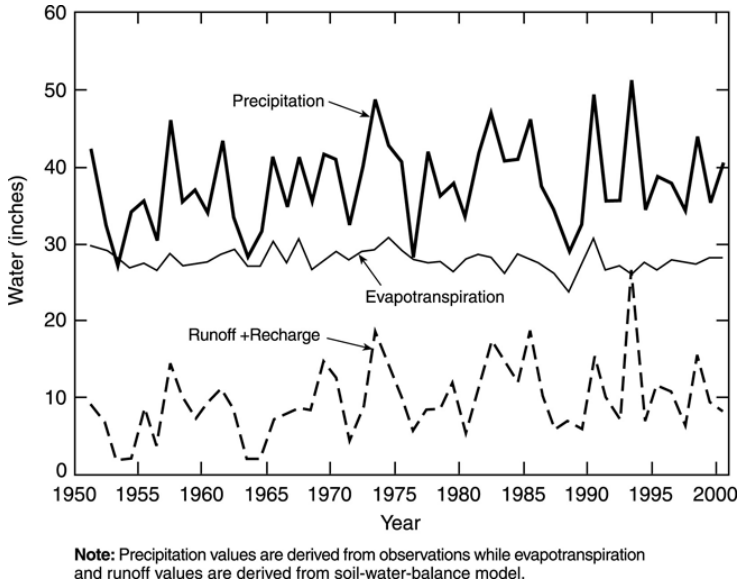
Wind Speed

The average annual wind speed for Boone County is just over 8 mph. Seasonal winds for Boone County range from about 9 mph in winter, 10 mph in spring, over 6 mph in summer, and over 8 mph in fall (Changnon, 2004).

Evaporation

The average Pan Evaporation for Rockford from May to October was 28.18 inches (Roberts & Stall, 1967). Evapotranspiration for the entire state averages 30 inches per year, as summarized and related to precipitation and runoff plus recharge (Figure 2-13) (ISWS, 2010).

Figure 2-13: **Time series of annual fluctuations of the difference between precipitation and evaporation, averaged for the entire state, 1951-2000**



Note: Precipitation values are derived from observations while evapotranspiration and runoff values are derived from soil-water-balance model.

(Illinois State Water Survey, 2010)

Habitat

The watershed provides aquatic and terrestrial habitat primarily in the form of streams, lakes, ponds, shrubby grasslands, wetlands, forest, and rural grasslands. This complex system can be discussed as natural areas, wetlands, potential wetland restoration sites, and any threatened and endangered plant species. Aquatic habitats are further described in the "Fish and Wildlife" section of this chapter.

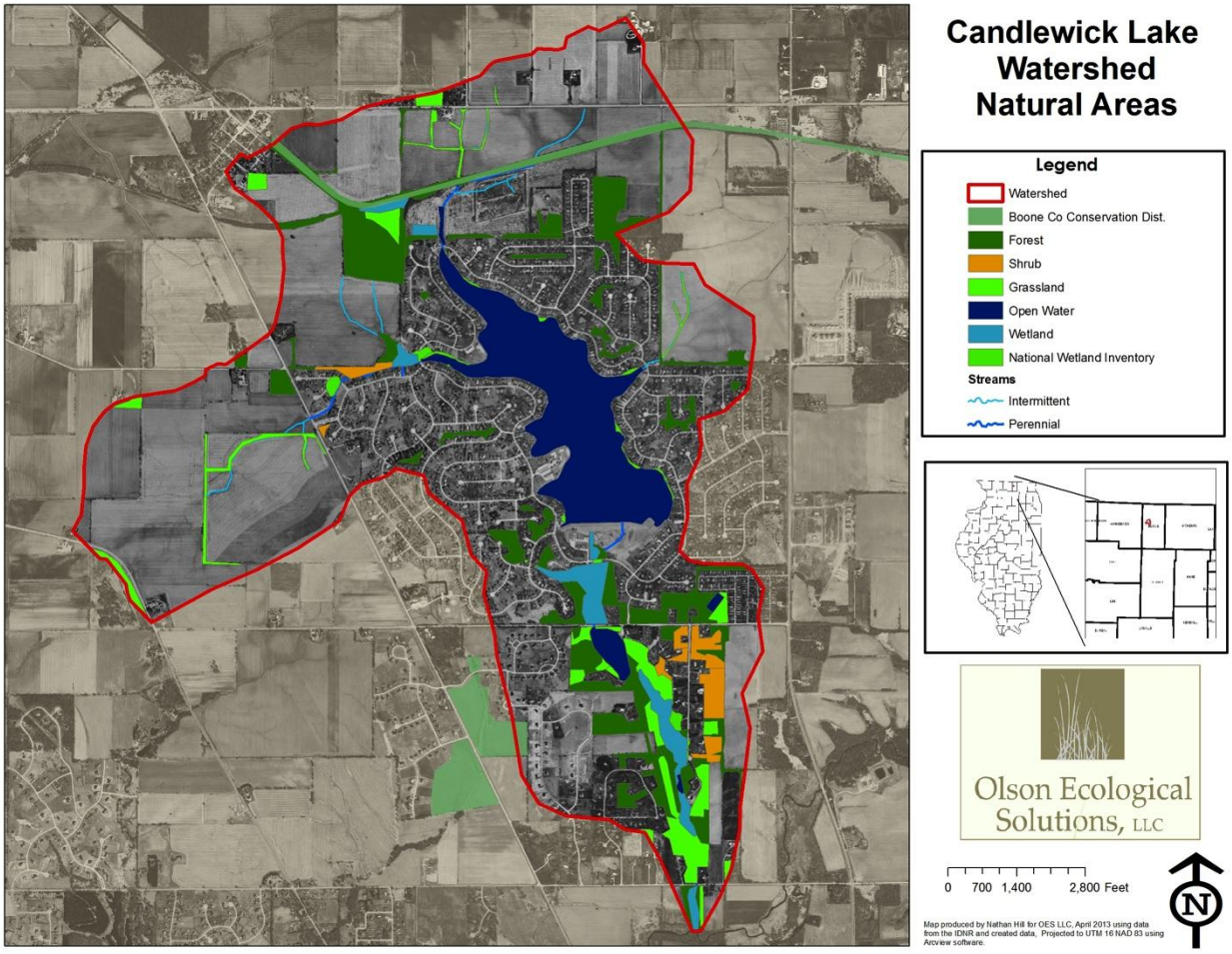
Natural Areas

Natural areas existed within and surrounding the watershed (Figures 2-14 and 2-15). Within the watershed the Boone County Conservation District manages the Long Prairie Trail that follows the Kenosha Division Line railroad bed turned into a recreation path. The habitat along the trail is a mix of remnant prairie grasses and flowers as well as adventive trees and shrub in pockets. Most of the woodlands in the watershed are comprised of secondary growth native tree species oak, cherry, maple and boxelder dominate the canopy with an understory of invasive buckthorn and honeysuckle with little

remnant herbaceous layer remaining. Other unprotected privately owned sites have been identified within the Candlewick Lake Association and they consist of cool season grasses with typical perennial invasive weeds and adventive native trees like, cedar, black cherry, box elder and silver maple. The riparian corridor along Spring Brook is a diverse mix of floodplain forest (dominated by box elder silver maple, honeysuckle and buckthorn) and open wet sedge meadows (dominated by reed canary grass,

The Illinois Wildlife Action Plan recognized this watershed as part of the Kishwaukee River Conservation Opportunity Area.

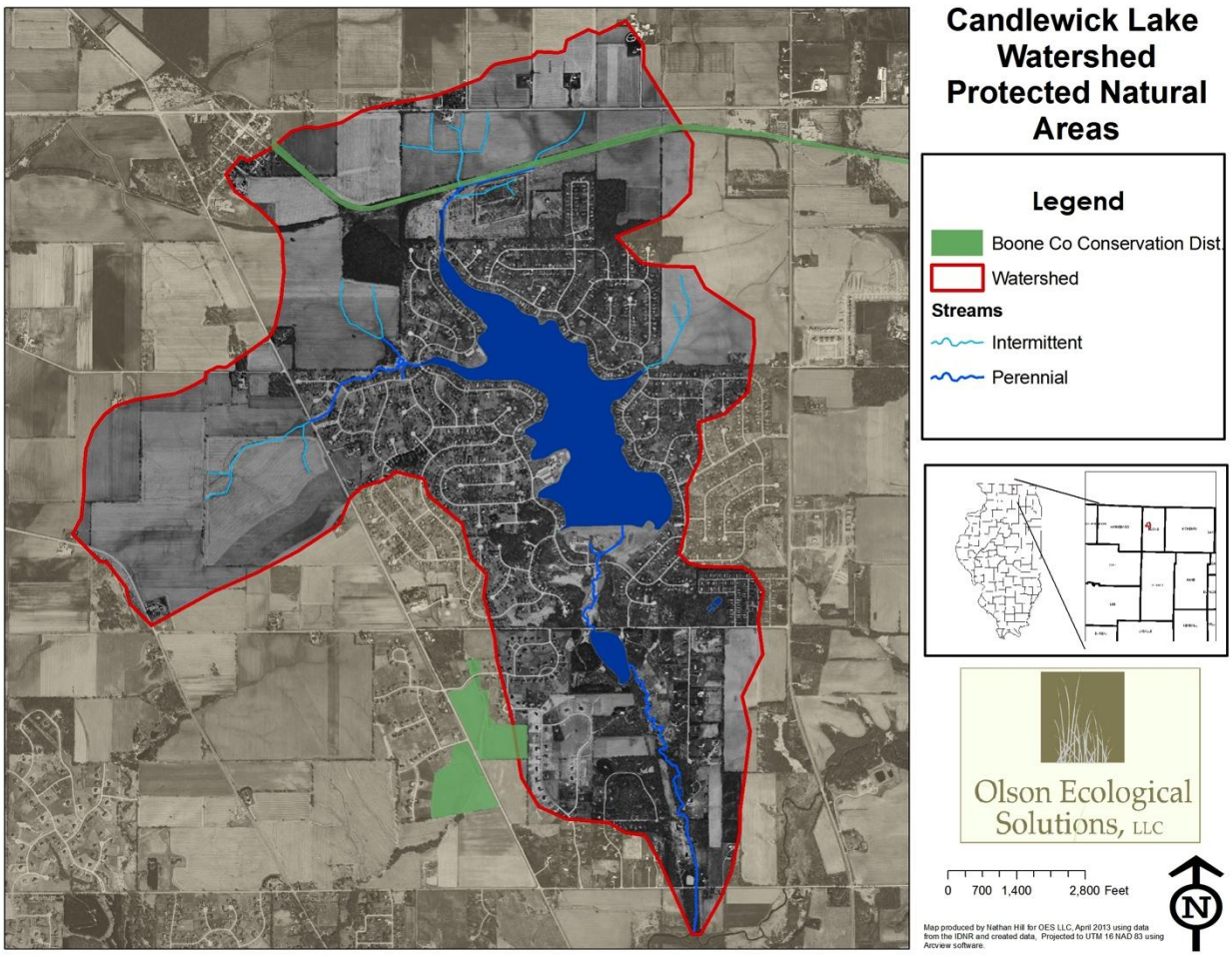
Figure 2-14: Natural areas within Candlewick Lake Watershed



Wetlands

Wetlands within the watershed were known from the National Wetland Inventory (NWI). A detailed wetland inventory was not conducted. Most of the wetlands identified by the NWI had both native and non-native vegetation present.

Figure 2-15: Protected natural areas connected to the Candlewick Lake Watershed



Photographs of wetlands within the Candlewick Lake Watershed: Left - a cattail marsh north of Dawson Lake Rd and Right -sedge meadow along Spring Brook.

Fish and Wildlife

Threatened and Endangered Species

No known threatened or endangered plants are within the watershed. Downstream along Beaver Creek, the State Threatened Spike Mussel (*Elliptio dilatata)* was found during recent surveys (Huff and Huff, 2005).

Species in Greatest Need of Conservation

There are many Species in Greatest Need of Conservation listed in the Illinois Comprehensive Wildlife Action Plan that are found within the watershed. Specific locations of these species are not known, but the species most likely utilize the mapped natural areas (IDNR, 2005).

Although not listed on the species in need of conservation, during the Stream bank inventory several dead shells of Cylindrical Papershell mussel ***(Anodontoides ferussacianus)*** were found along the banks of Spring Brook, no live mussels were observed.

Game fish species in Candlewick Lake

A survey was conducted September 2004 by District Fisheries Biologists from the Illinois Department of Natural Resources. They collected 621 fish including Bluegill (hybrid), Muskie, Black Crappie, Northern Pike, Bluegill, Smallmouth Bass, Channel Catfish, Walleye, Grass Carp, Yellow Bullhead, Green Sunfish, Yellow Perch, and Largemouth Bass. Biologists noted, "the lake appears to be in excellent shape from a fishery perspective" (IDNR, 2004). Candlewick Lake association has historically stocked sport fish in the lake, including Walleye, Muskie, and Bass.

Land Use and Population Characteristics

Land Use and Land Cover

Land uses and land cover have changed dramatically in the watershed throughout history. Forested areas (in green) dominated the landscape in the 1840s (Figure 2-16). In 1995, agriculture was the dominant land use, with residential development accounting for only 25% of the watershed. The most recent, readily available land cover data was derived using 2005 orthophotography, 2011 Google maps, local knowledge, and shapefiles of more recent grid files (2000-2007) from the Illinois geospatial data clearing house. It showed that 41% of the watershed was developed (See Table 2-8). Land actively used for agricultural purposes declined between 1995 and 2012 by 612 acres.

Table 2-8: Land Cover Change from 1970 to 2012

	Land Cover Category		
Year	Agricultural	Developed	Open Space
1970	1547	*1107**	242
1995	1657	734	505
1999	1565	883	448
2007	1255	1088	553
2012	1045	1205	646

** 1057 acres were classified BARREN due to development of Candlewick Lake.*

Figure 2-16: Historical land cover of the Candlewick Lake Watershed

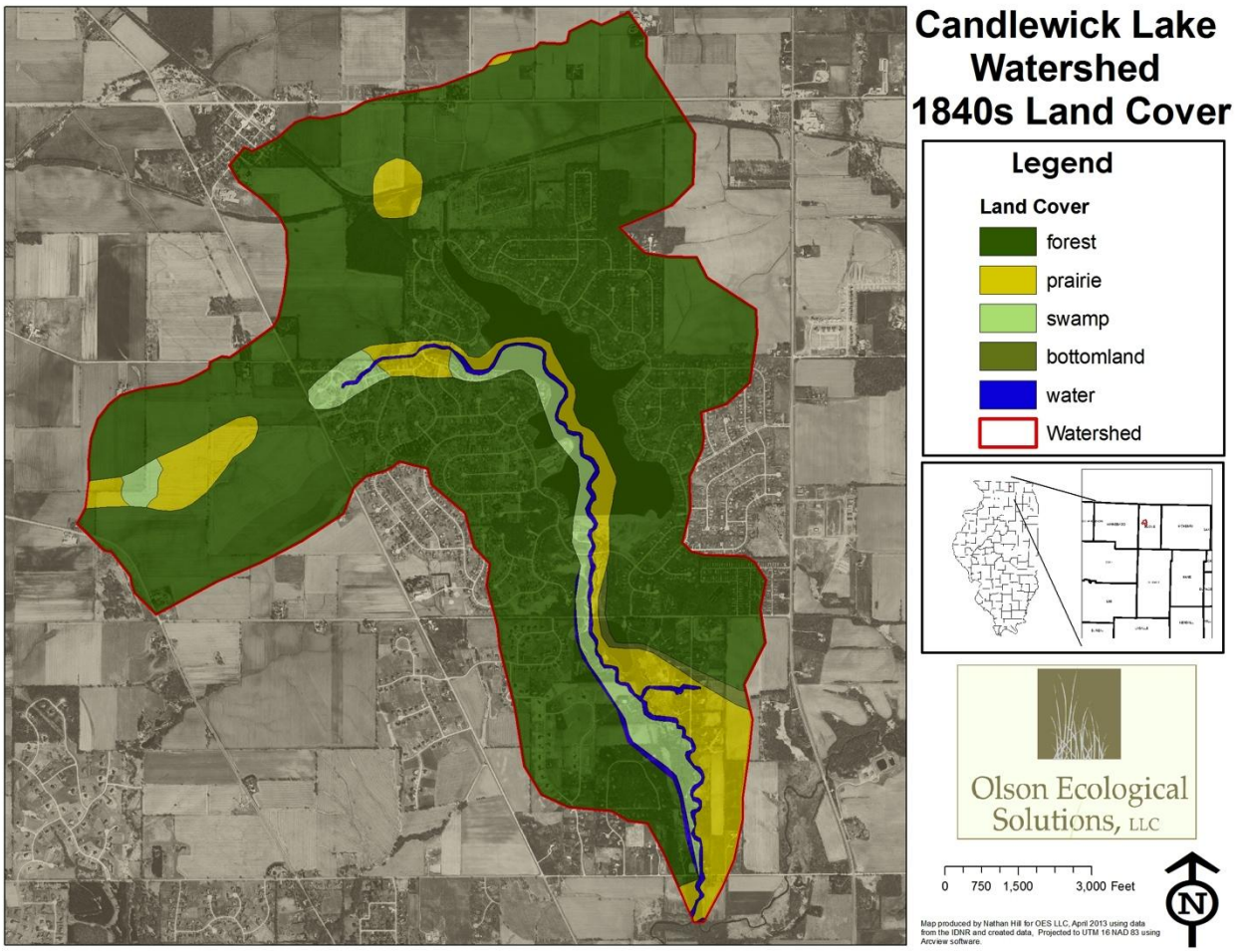


Table 2-9: Historical Land cover breakdown

Land Cover	Forest	Prairie	Swamp	Bottomland	Water
Acres	2418	281	134	18	46

Figure 2-17: Current land cover in the Candlewick Lake Watershed

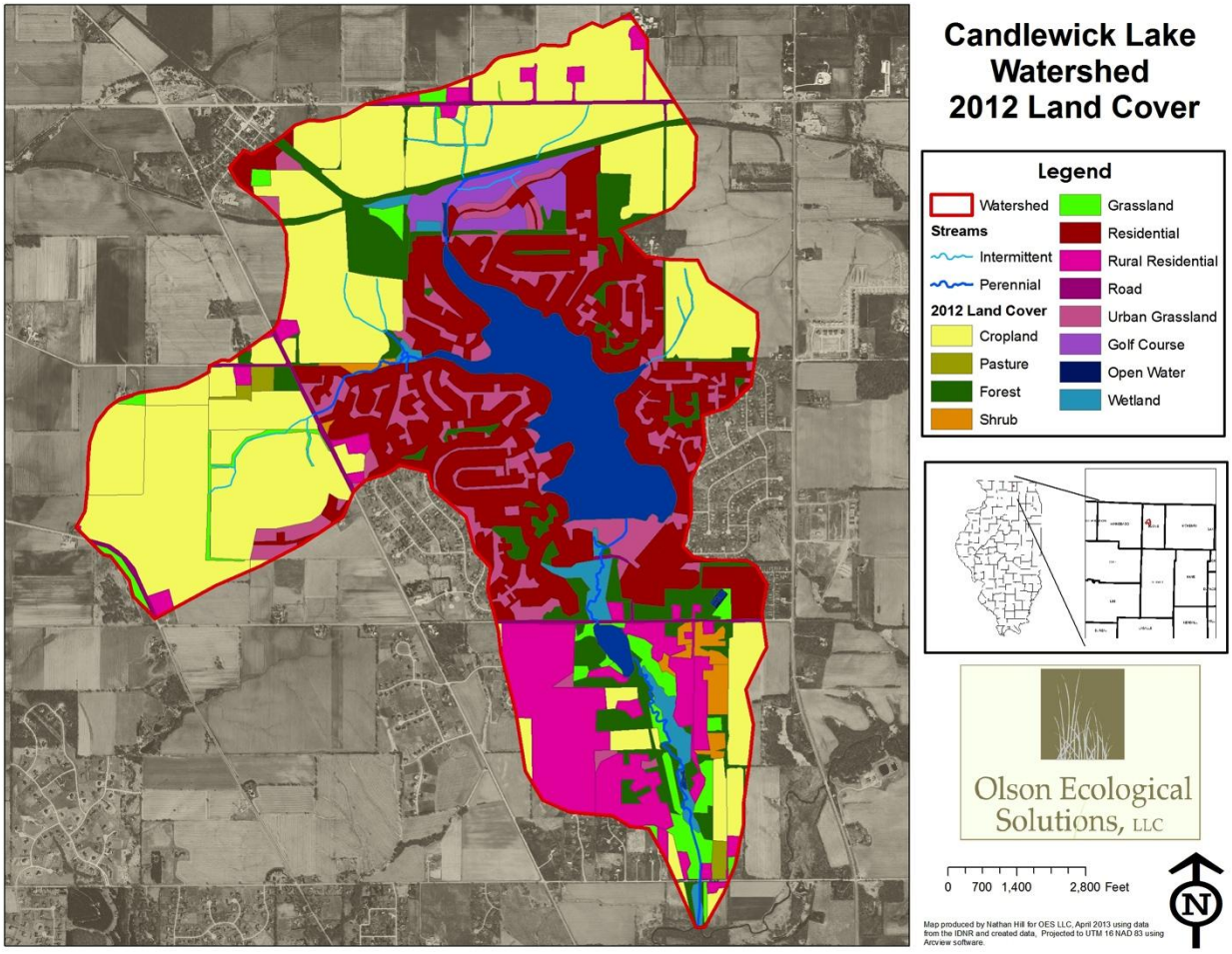


Table 2-10: Candlewick Lake Watershed Land Cover Breakdown

2012 Land Cover	Acres
Cropland	1033
Forest	253
Golf Course	56
Grassland	87
Open Water	224
Pasture	13
Residential	652
Roads	36
Rural Residential	262
Shrub	33
Urban Grassland	198
Wetland	49

Figure 2-18: Candlewick Lake Subwatershed Land Cover

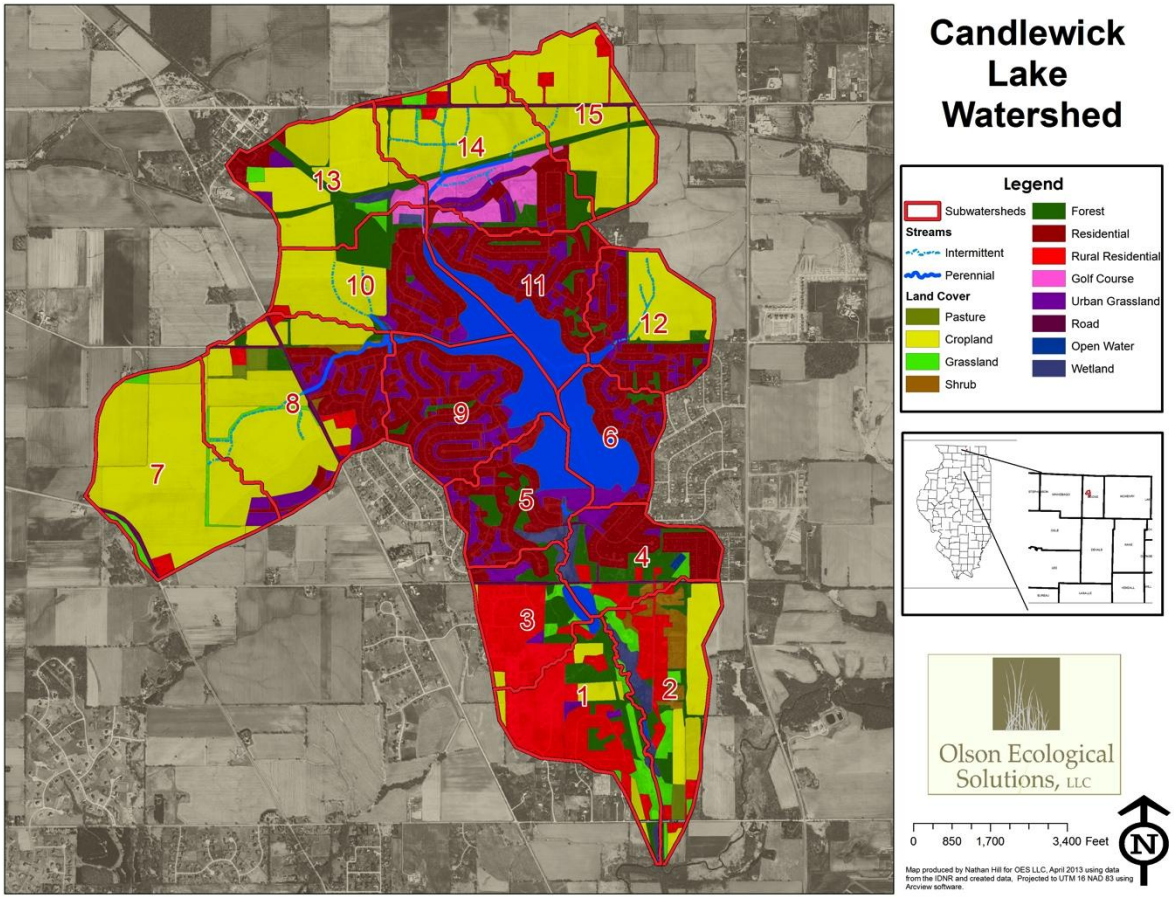


Table 2-11: Candlewick Lake Subwatershed Land Cover Breakdown

Sub	Crop land	Forest	Golf Course	Grass land	Open Water	Past ure	Reside ntial	Road	Rural Res.	Shrub	Urban Grasslnd	Wet land
1	22	34	0	18	2	0	0	0	100	0	3	4
2	60	19	0	23	1	5	0	1	41	25	0	17
3	3	18	0	5	4	0	10	4	72	0	7	3
4	0	29	0	6	7	0	59	5	14	2	9	7
5	0	13	0	0	29	0	73	0	0	0	25	9
6	0	3	0	0	54	0	48	0	0	0	17	0
7	241	0	0	11	0	0	2	4	5	0	7	0
8	173	9	0	6	0	8	62	9	11	5	25	1
9	0	4	0	0	43	0	125	0	0	0	37	1
10	76	26	4	2	25	0	55	0	2	0	13	3
11	0	12	3	0	54	0	104	0	0	0	18	0
12	64	10	0	2	3	0	67	0	0	0	17	0
13	120	31	7	7	0	0	12	1	0	0	6	4
14	114	28	41	8	0	0	34	7	9	0	16	0
15	158	17	1	0	0	0	2	5	9	0	0	0

Figure 2-19: Candlewick Lake Watershed Municipalities

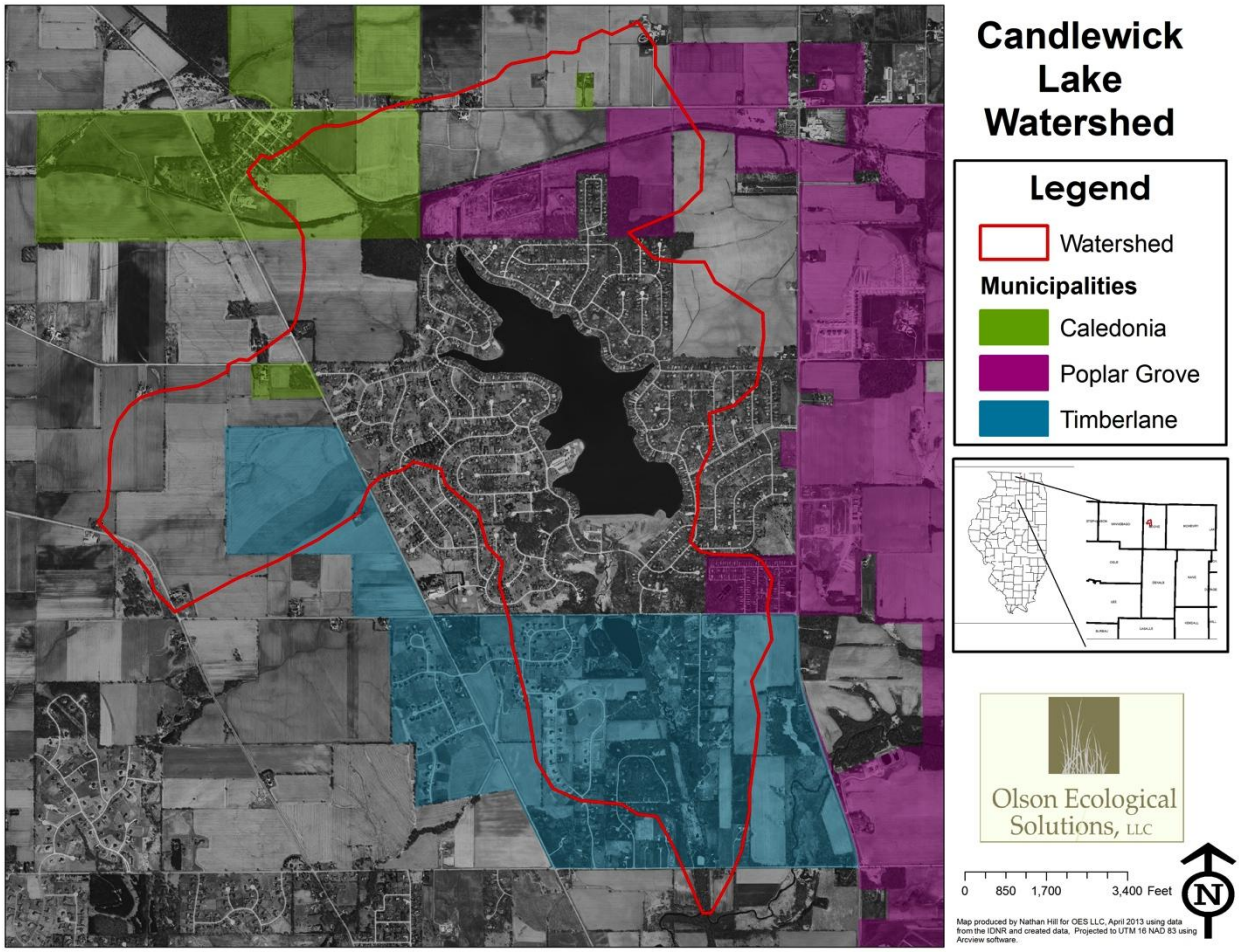
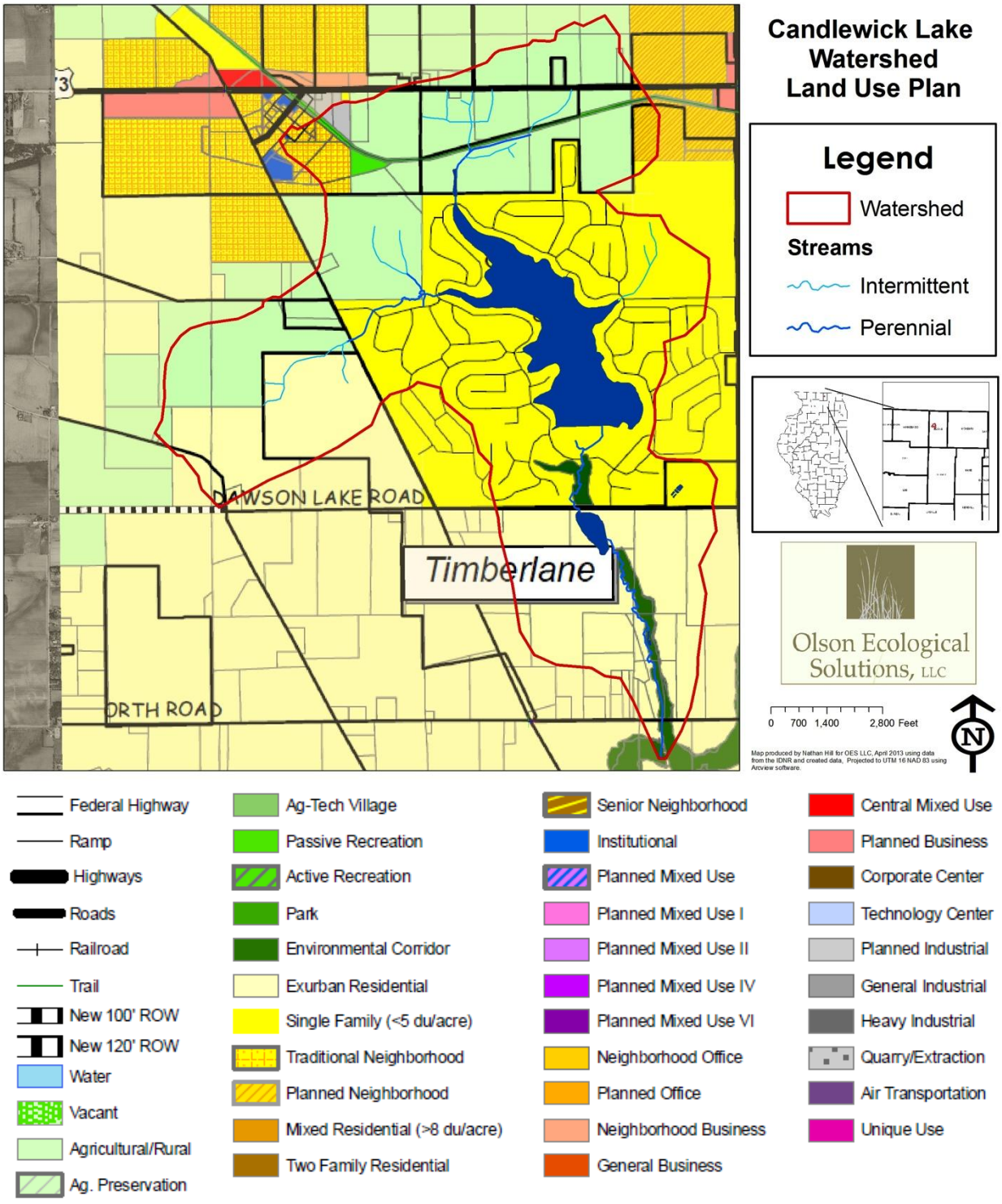


Table 2-12: Candlewick Lake Watershed Jurisdictions

Jurisdiction	Acres	% Watershed
Township		
Caledonia	2434	84.05%
Poplar Grove	448	15.47%
Belvidere	14	0.48%
Municipalities		
Caledonia	191	6.60%
Timberlane	633	21.86%
Poplar Grove	217	7.49%
Unincorporated Co	1855	64.05%

Figure 2-20 Boone Co Land Use Plan



Land Management Practices

Non-point Source Projects

Under Section 319 of the Clean Water Act, one planning project was undertaken to combat non-point source pollutant loading into the Beaver Creek Watershed. Chicago Metropolitan Agency for Planning and the Kishwaukee River Ecosystem Partnership collaborated to develop the *Beaver Creek Watershed Action Plan*. Candlewick Lake Association has also installed several non point source projects. In 1985, 160 of the 235 lots on the lake complied with some sort of shoreline stabilization using 4"-8" rock that extended a minimum of 1' above the water line and 1' deep. From 1999 to 2003, the Association added rock rip rap to the common areas at Castaway Park, Clubhouse Peninsula, and Firefly Bay. Several attempts at shoreline buffer strips have failed due to lack of management. In 2012, the Candlewick Lake Association began to identify sites around the lake to install native plant buffers, and the first project was installed June 2013 at a common area known as Firefly Bay. Also in 2013, management was resurrected for a filter strip of native vegetation at Friendship Park, and there is a contract for both natural areas to be managed in 2014.

Local Ordinances and Existing Protections

Local ordinances and comprehensive plans that apply to the watershed address stormwater management, flood control, and sediment and erosion control during construction in order to lessen associated problems.

This section references the Beaver Creek Watershed plan table identifying natural resource protections in local ordinances. The minimum standard to which local ordinances should be compared in this region is the set of model ordinances prepared by the Northeastern Illinois Planning Commission (NIPC) for stormwater management, soil erosion and sediment control, floodplain management, and stream and wetland protection. Table 2-13 includes a series of checklist questions adapted from the model ordinances, utilized to measure and compare the county and municipal ordinances for their water quality standards.

Table 13 . Comparison of County and Municipal Ordinances to Model Water Quality Standards.

Model Ordinance Element	Boone County	Belvidere	Capron	Poplar Grove
Stormwater Management				
Stormwater drainage and detention ordinance?	(in progress)	No	No, defers to Boone County	No
Include purpose to control of runoff volume, rate, and quality?	Addressed in Subdiv Code	Addressed in Subdiv Code	Mentioned in Subdiv Code	Mentioned in Subdiv Code
Promote use of natural drainage practices?	No	No	No	No
Require that peak post-development discharge from events less than or equal to 2-year, 24-hour be limited to 0.04 cfs/ac of watershed?	Peak of 0.2 cfs/ac for 100-yr event	Yes	No; 1.3"/hr for 5-yr event	No
Require detention design standards to maximize water quality benefits, preference for wet bottom/wetland basins?	No	Limited water quality design standards, no	No	No
Prohibit detention in the floodway?	Yes	Discouraged	No	No
Prohibit on-stream detention, unless provides regional stormwater storage, with accompanying BMPs?	Yes	Yes (but no BMP standards)	No	No
Prohibit direct discharge of undetained stormwater into wetlands?	No	Yes	No	No
Require formal maintenance contracts for new detention facilities?	No	Agreements required	No	No
Soil Erosion and Sediment Control				
Erosion and sediment control ordinance?	No Addressed in Subdiv Code	No Addressed in Subdiv Code, Natural Resource Protection Standards	No (small section of Subdiv Code mentions protection of top soil)	No (Zoning sometimes requires Erosion Control Plan)
Include purpose to limit sediment delivery to pre-disturbance levels and minimize effects on water quality, flooding?	No	No	No	No
Principles to minimize sediment transport from the site for all storms up to the 10-year frequency event?	Yes, limited	Yes, limited	No	No
Require ordinance applicability for any land disturbing activity >5,000 ft^2, or 500 ft^2 if adjacent to waterbody?	Yes, exceptions for Ag land	No	No	No

[24] Boone County and the municipalities within the county are outside of the seven counties for which the Areawide Water Quality Management Plan, administered by CMAP, applies. Illinois EPA is directly responsible for these jurisdictions' adherence to the Illinois Water Quality Management Plan.

Model Ordinance Element	Boone County	Belvidere	Capron	Poplar Grove
Site design requirements for sediment control measures, soil stabilization, construction, etc?	Yes, limited	No	No	No
Adopt "Illinois Urban Manual" and "Illinois Procedures and Standards for Urban Soil Erosion and Sediment Control"?	Yes, "Illinois Urban Manual"	Yes, "Illinois Urban Manual"	No	No
Require routine maintenance for all erosion and sediment control practices?	Yes	Yes	No	No
Require inspection of construction sites?	Yes	Yes	No	No
Provide effective enforcement mechanisms?	No	Yes	No	No
Floodplain Ordinance				
Floodplain management ordinance?	No, but in Zoning Code, overlay district	Yes, and in Zoning Code, Subdiv Code	No, defers to Boone County	No
Include a purpose of protection of hydrologic functions, water quality, habitat, recreation, and aesthetics?	No relation to water quality	No relation to water quality	No	No
Restrict modifications in floodway to appropriate uses?	Yes, some limits on uses (No increase in base flood elevation)	Yes, some limits on uses (No increase in base flood elevation)	No	No
Discourage stream channel modification and require mitigation?	No, defers to FEMA	Yes	No	No
Discourage onstream impoundments?	No	Yes	No	No
Require effective soil erosion and sediment control measures for all disturbances in the floodway?	No	No, not specific to floodway	No	No
Require protection of a minimum 25 ft native vegetation buffer along the channel?	No	25 ft wetland buffer; 75 ft shore buffer (no vegetation requirements)		
Stream and Wetland Protection				
Stream and wetland protection ordinance?	No	No	No	No
Include a purpose of protecting hydrologic, hydraulic, water quality, habitat, aesthetic, and social and economic values and functions of wetlands?	Mildly addressed in Zoning Code, no specifics	Addressed in Natural Resource Protection Ordinance	Mildly addressed in Subdiv Code	Mildly addressed in Subdiv Code
Protect beneficial function of streams, lakes, and wetlands from damaging modifications?	Yes, limited	Yes, mitigation allowed	No	No
Prohibit modification of high quality wetlands, lakes, and stream corridors?	No	No	No	No
Discourage modification of wetlands for stormwater management purposes?	No	No	No	No
Designate min 75 ft setback from edge of waterbodies, where development limited to minor improvements like walkways, signs, parks, etc?	No	75 ft buffer required (Subdiv Code)	No	No
Establish min 25 ft wide protected native vegetation buffer strip?	No	Yes, for wetlands	No	No
Prohibit watercourse relocation or modification (with exceptions if mitigated)?	No	Yes, mitigation allowed	No	No
Discourage armoring of channels and banks?	No	No	No	No

Model Ordinance Element	Boone County	Belvidere	Capron	Poplar Grove
Discourage culvert crossings of streams?	No	No	No	No
Discourage onstream impoundments?	No	No	No	No
Require adequate mitigation measures for approved waterbody modifications, including 1.5 to 1 acreage replacement, monitoring and maintenance, and full restoration of function?	No	Defers to IDNR standards	No	No

The purpose of this checklist is to scan county and municipal ordinances to determine whether Boone County, Belvidere, Capron, and Poplar Grove were meeting minimum recommended standards for protecting water quality. Through this comparison, it is evident that these jurisdictions have few specific stormwater management, soil and erosion control, floodplain management, or stream and wetland protection ordinances, with the exception of Belvidere's floodplain management ordinance. In some cases, these elements are addressed in zoning codes or subdivision regulations, but none meet all the minimum requirements of the model ordinances. Capron and Poplar Grove have very little language in their ordinances dealing with water quality. It has been suggested that detention for at least the 100-year storm is being provided in some jurisdictions through plat review, even though subdivision regulations do not strictly speaking require it. However, it is rate control for smaller, more frequent storms that helps prevent stream degradation, and other BMPs may not be generally required.

In 2008, Boone County developed a countywide stormwater management program under Public Act 94-675 (55 ILCS 5/5-1062.2). On December 11, 2011 the ordinance was adopted, containing minimum stormwater management standards for the municipalities and unincorporated area of the county. This was an opportunity for Boone County to make the critical decisions necessary for protecting Beaver Creek and other county water resources. It was recommended by Chicago Metropolitan Agency for Planning that Boone County follow the model ordinance elements presented in the Beaver Creek Watershed Plan and in doing so, develop a stormwater management ordinance that was both effective in practice and successful in achieving its purpose (CMAP, 2008). To date the plan has yet to be implemented into countywide ordinances.

Land and Water Conservation Measures

Boone County Conservation District owns and manages the Long Prairie Trail, a former Railroad right of way that has been converted to a multiple use recreation trail on the northern boundary of the watershed.

The NRCS delivers technical assistance, mostly focused on the development of individual farm or ranch conservation plans. They also conduct planning at a level larger than the individual farm or ranch in order to address many natural resource issues. No current land management program assitance is being performed on land within the waterhsed. (Nichols, per comm)

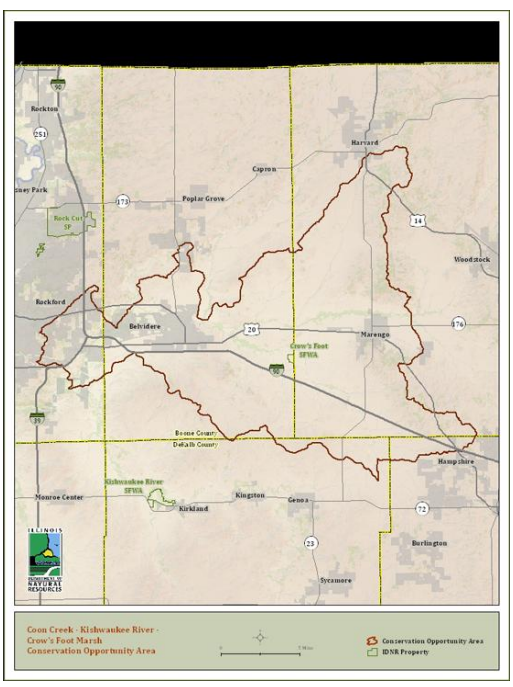
Master Plans

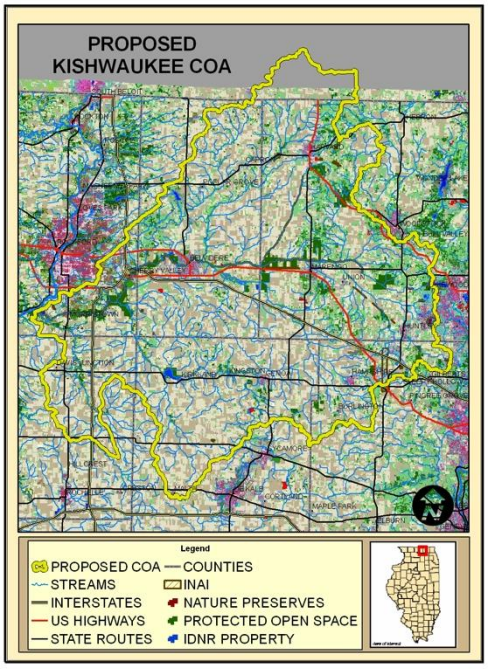
Candlewick Lake has a Lake Management Plan dated 2011, which was developed by Intergraded Lakes Management, Inc. The plan outlines concerns of Blue Green Algae growth, poor water quality, Northwest Bay Silt Pond, aeration, and dredging and suggests recommendations.

Kishwaukee River Conservation Opportunity Area (COA)

In August 2009, the Illinois Department of Natural Resources developed the Coon Creek/Crows Foot /Kishwaukee River COA. In 2011, the Kishwaukee River Ecosystem Partnership submitted a request to the IDNR to expand the area based on new monitoring data and local knowledge of resources. In 2012, KREP hosted a watershed tour of those sites for DNR officials. As of early 2013, that request was approved by a committee and was likely to be approved by others, considerably expanding the COA.

Figure 2-21: Kishwaukee River Conservation Opportunity Areas

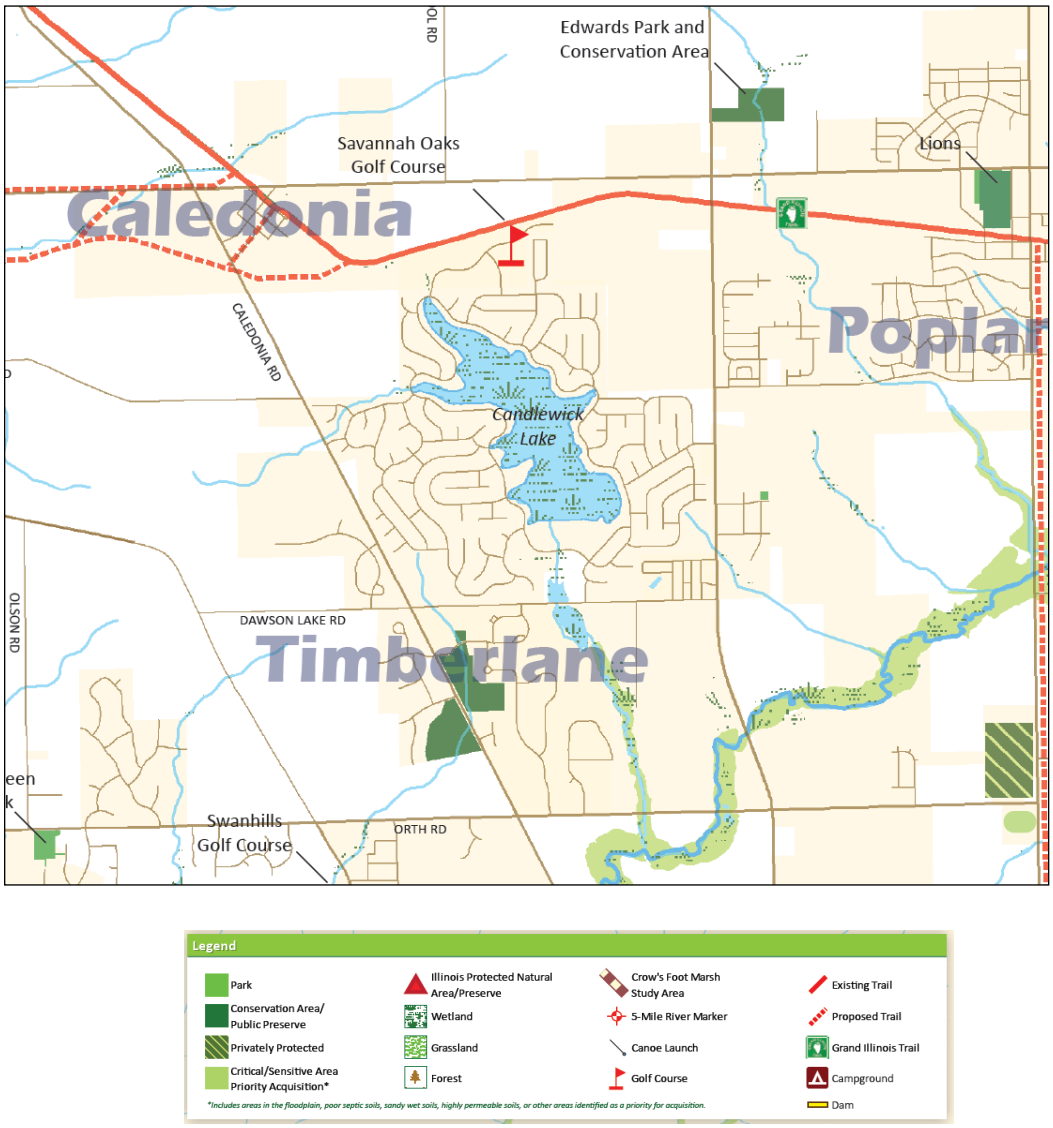




Winnebago Boone County Regional Greenways and Trails Plan

The Winnebago Boone County Regional Greenways and Trails Plan mapped potential greenways and trails in the area. Only small floodplain and wetland areas of the lower reaches of the watershed were identified as Critical/Sensitive Area /Priority Acquisition.

Figure 2-22: Boone Winnebago County Greenways Plan



Economic Development Plans

Growth Dimensions, the economic development group serving Boone County, did not identify economic development areas within the watershed.

Demographics

Population Statistics

Population statistics collected by the Kishwaukee River Ecosystem Partnership based on watershed breakdowns of the 2000 census block data indicate a population of 5,953 people for this upper portion of the Beaver Creek. However, dramatic development of residential housing in the watershed in the past 13 years indicate that this figure is much lower than the actual current population. No recent population data for the watershed has been collected or analyzed.

Land Ownership

Of the 2,896 acres in the watershed, all is privately owned except the Boone County Conservation District-owned parcels. The Candlewick Lake Association has 2,332 build able lots with 1,807 houses. Much of the privately-owned farms in the northeast and northwest portions of the watershed are currently agricultural use but sold and slated for residential development.

Table 2-14:Population demographic stats for Boone Co 2010

2010 Census Demographics by Age		
	Rockford MSA	*Boone County*
Total Population	**349,431**	**54,165**
Under 5 years	23,372	3,716
5 to 9 years	24,518	4,409
10 to 14 years	25,667	4,694
15 to 19 years	24,958	4,382
20 to 24 years	20,218	2,772
25 to 34 years	42,464	5,863
35 to 44 years	46,802	8,048
45 to 54 years	52,126	7,987
55 to 59 years	22,865	3,198
60 to 64 years	19,362	2,732
65 to 74 years	25,286	3,788
75 to 84 years	15,151	1,908
85 years and over	6,642	668
Median age (years)	38.1	36.8
18 years and over	260,167	38,481
Male	125,918	19,063
Female	134,249	19,418
21 years and over	246,795	36,365
62 years and over	58,404	7,937
65 years and over	47,079	6,364
Male	20,329	2,891
Female	26,750	3,473
Source: US Census Bureau, 2010 Census		

Water Body and Watershed Conditions

Water Quality Reports

Water quality was gleaned from existing water quality reports, water quality standards, watershed-related reports, and watershed action strategies.

Illinois Integrated Water Quality Report and Section 303(d) List and Water Quality Standards

The Illinois Environmental Protection Agency reported the condition of the surface and groundwater in the state through the *Illinois Integrated Water Quality Report and Section 303 (d) List-2012* to fulfill the requirements of Section 305(b), 303(d) and 314 of the Clean Water Act (IEPA, 2012). From this report, designated uses and water quality standards were identified for Candlewick Lake and Beaver Creek.

Illinois' water standards provide the basis for assessing whether the beneficial uses of the state's waters were being attained. Illinois' waters were designated for various uses including aquatic life, wildlife, agricultural uses, primary contact (e.g. swimming and waterskiing), secondary contact (e.g. boating and fishing), industrial use, drinking water, food-processing water supply, and aesthetic quality. The five designated uses for the Beaver Creek and Candlewick Lake were: Aquatic Life, Fish Consumption, Primary Contact, Secondary Contact, and Aesthetic Quality. Not enough information was assessed for Aquatic Life and Aesthetic Quality. The lake was not assessed for Fish Consumption, Primary Contact, or Secondary Contact. However the IEPA identified causes of total suspended solids, total phosphorous, and aquatic algae from unknown sources. Nonpoint sources are likely the source, including the residential areas, dam, yard maintenance, agricultural land uses, and runoff from forest, grassland, and parkland.

Watershed-Related Reports

Two existing reports related to the watershed: the *Beaver Creek Watershed Action Plan* by the Chicago Metropolitan Agency for Planning and Kishwaukee River Ecosystem Partnership (2008) and the *Upper Beaver Creek Subwatershed Plan* by the Kishwaukee River Ecosystem Partnership (2005).

Existing TMDL Reports

There were no TMDL Reports found for Candlewick Lake.

Source Water Assessments

Two Source water supply wells were identified within the watershed. Aqua Illinois-Candlewick, at Candlewick Lake (Facility No. 0075050) that 2 active public water supply wells and one that was abandoned. According to IEPA the deepest well is 917ft in deep bedrock and the shallow emergency well is 100ft deep located in sand and gravel. The wells produce 362,700 gallons per day (gpd) with around 1700 connections. Second is the Oak Lawn Mobile Home Park (Facility Number 0075275) that one public water supply well that is 329ft deep in shallow bedrock. There are no actual production

figures for pumpage of this well since there is no metering device. Both wells have a minimum setback or protection zone of 200ft. (IEPA). The facility serves around 190 service connections. Rural wells were located, and potential for agricultural chemical contamination of groundwater was assessed (see Figures 23- and 2-24).

Watershed Restoration Action Strategies

No Watershed Restoration Action Strategies were found for the Candlewick Lake Watershed.

Figure 2-23: Well boring locations in the Candlewick Lake Watershed

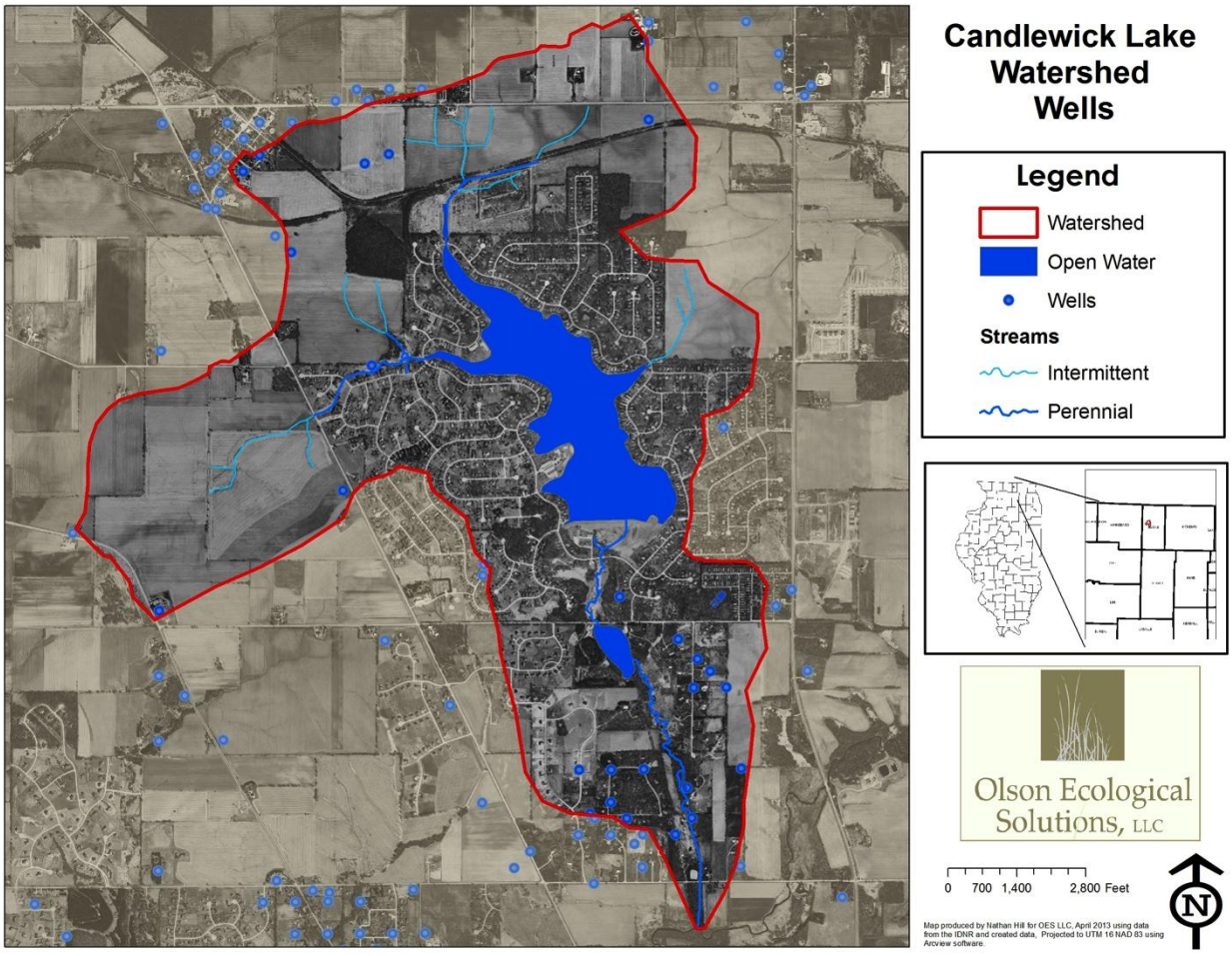
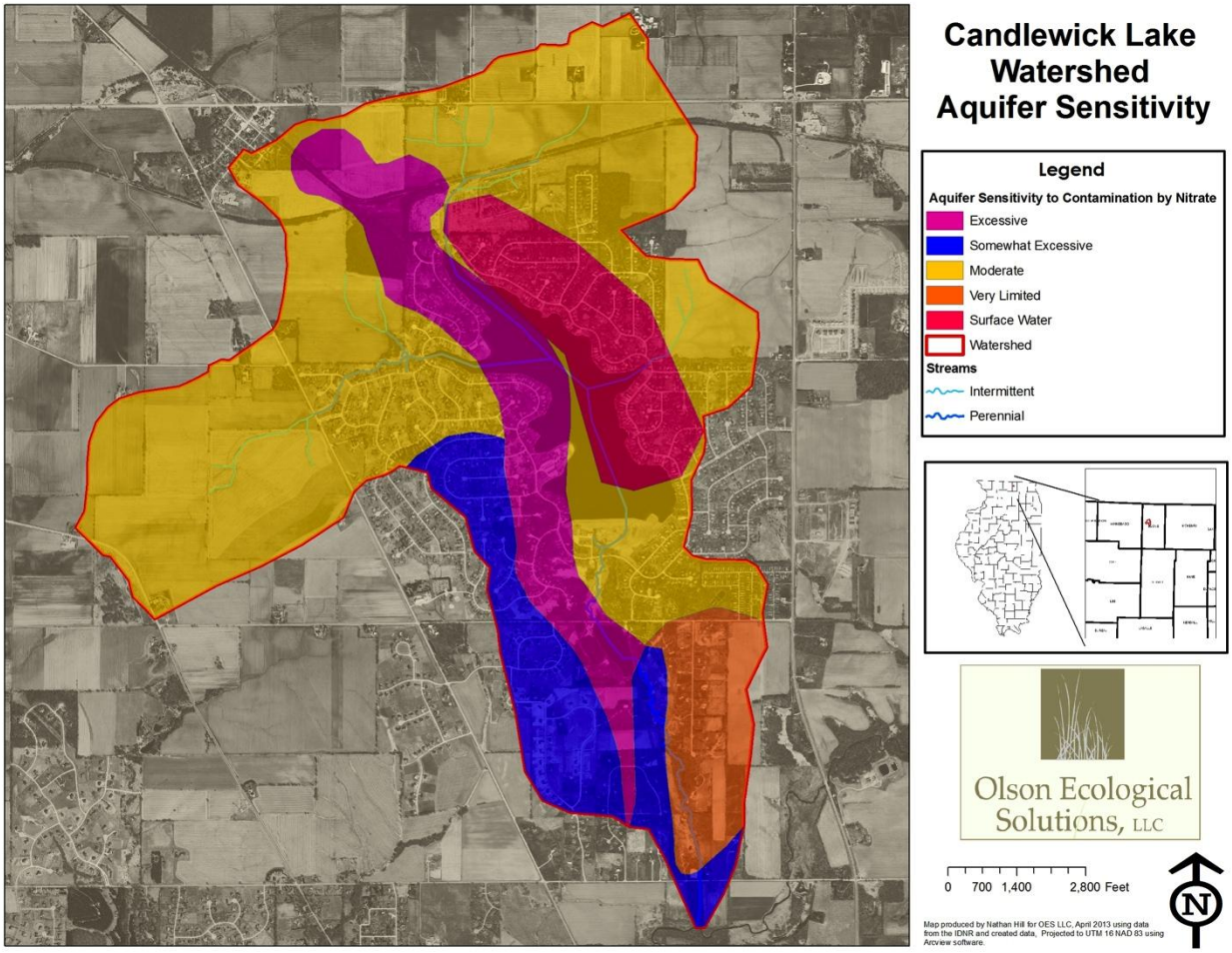


Figure 2-24 Potential for Agricultural Chemical Contamination



Pollutant Sources

Pollutants to water resources originate from both point and nonpoint sources. The only significant point source in the watershed is a wastewater treatment plant for the Candlewick Lake Association that discharged to the lake from 1979 to 1999. Nonpoint sources include mainly eroding stream banks and shorelines, tiled hydric soils, eroding HELs, livestock access to streams, and runoff from agricultural fields, residential lawns, and impervious surfaces.

Point Sources

Two NPDES permits are associated with the watershed; Aqua Inc. – Candlewick Lake STP IL0045527 and Oaklawn Mobile Home ILG551047 are active and wastewater permits. There are no permits for storm water, concentrated animal feed operations (CAFO), or industrial facilities.

Wastewater Permits

In 1979, a Waste Water Treatment Plant began discharging treated effluent into the lake. By 1990 it was overcapacity and needed replacement. A new Waste Water Treatment Plan was completed in 1999 and the discharge was rerouted to Beaver Creek (Integrated Lakes Management, 2011). Oaklawn Mobile Home Park also discharged directly into Beaver Creek.

Stormwater Permits

There are two stormwater outfalls that drain stormwater from the upstream watershed into the watershed, but no NPDES permits are associated with them.

Nonpoint Sources of Pollution

Nonpoint sources of pollution that affect groundwater and surface water in the watershed include a myriad of activities associated with agricultural and residential land uses, such as eroding stream banks and shorelines; channelized stream segments; tiled hydric soils; converting head waters to grass waterways; eroding HELs; soil compaction; baring land of native, vegetative cover; and runoff from agricultural fields, residential lawns, and impervious surfaces.

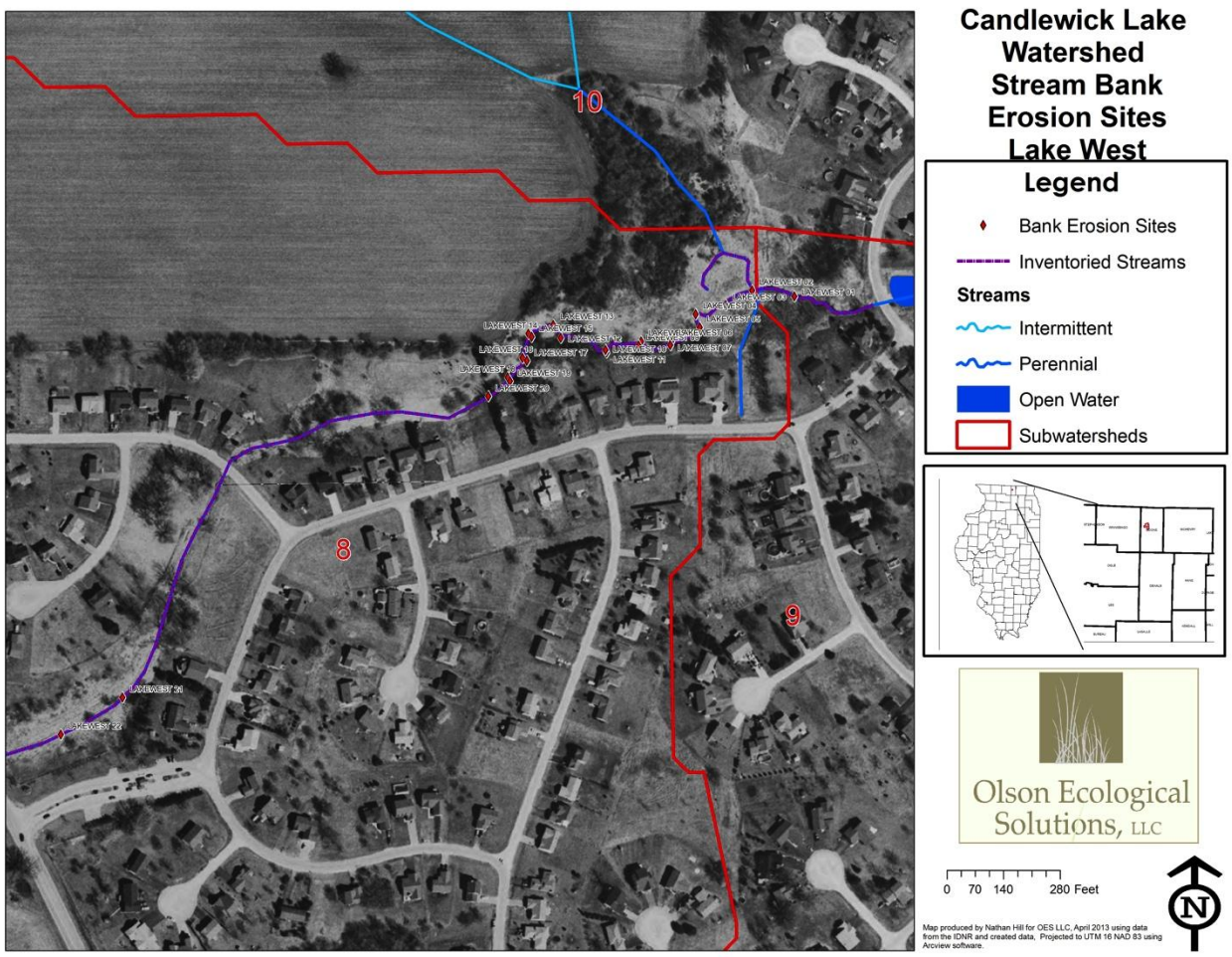
Stream bank and Shoreline Erosion

Stream bank erosion was assessed during May and June of 2014 along the Lake West, Lake North and Upper Spring Brook. Most of the sites identified were in the slight to moderate category with only a few severe erosion sites identified. See table 2-15 & 16 for specific site inventory data.

Due to the large number of smaller lots of private lands along the Spring Brook Creek Corridor it was difficult to attain permission from all the landowners along Lower Spring Brook so only about 8800 feet or about 50% of the perennial streams in the watershed were assessed for stream bank erosion. The Lake North Tributary had recently been modified when the golf course was developed and no bank erosion was noted on those sites.

Shoreline erosion inventory was done by volunteers= from the candlewick lake watershed committee via boat during May 2014.

Figure 2-25 Map of Lake West Stream Bank Erosion Sites



Tables 2-15 Lake West Stream bank Erosion Inventory

SITE CODE	LENGTH OF EROSION (ft)	AVERAGE HEIGHT (ft)	LATERAL RECESSION RATE	SEDIMENT LOAD REDUCTION (TONS/YR)	PHOSPHORUS LOAD REDUCTION (LBS/YR)	NITROGEN LOAD REDUCTION (LBS/YR)
LAKEWEST01	60	2.5	moderate	1.3	1.3	2.6
LAKEWEST02	75	2.5	moderate	1.6	1.6	3.2
LAKEWEST03	64	3.5	moderate	1.9	1.9	3.8
LAKEWEST4	100	2	moderate	1.7	1.7	3.4
LAKEWEST5	100	1	slight	0.2	0.2	0.4
LAKEWEST6	100	3	severe	6.4	6.4	12.8
LAKEWEST7	100	2	moderate	1.7	1.7	3.4
LAKEWEST8	85	1.5	moderate	1.1	1.1	2.2
LAKEWEST9	85	1	moderate	0.7	0.7	1.4
LAKEWEST10	30	1	moderate	0.3	0.3	0.5
LAKEWEST11	30	1.5	moderate	0.4	0.4	0.8
LAKEWEST12	100	2	severe	4.3	4.3	8.5
LAKEWEST13	100	3	severe	6.4	6.4	12.8
LAKEWEST14	30	1	moderate	0.3	0.3	0.5
LAKEWEST15	75	3	severe	4.8	4.8	9.6
LAKEWEST16	60	3	moderate	1.5	1.5	3.1
LAKEWEST17	100	2	moderate	1.7	1.7	3.4
LAKEWEST18	100	3	severe	6.4	6.4	12.8
LAKEWEST19	100	1	moderate	0.9	0.9	1.8
LAKEWEST20	100	1	moderate	0.9	0.9	1.8
LAKEWEST21	200	1	moderate	1.7	1.7	3.4
LAKEWEST22	200	1	moderate	1.7	1.7	3.4
TOTAL				47.9	47.9	95.6

Representative Stream section from Lake West "the Dip" Drainage

Figure 2-26: Map of Spring Brook Stream Bank Erosion Sites

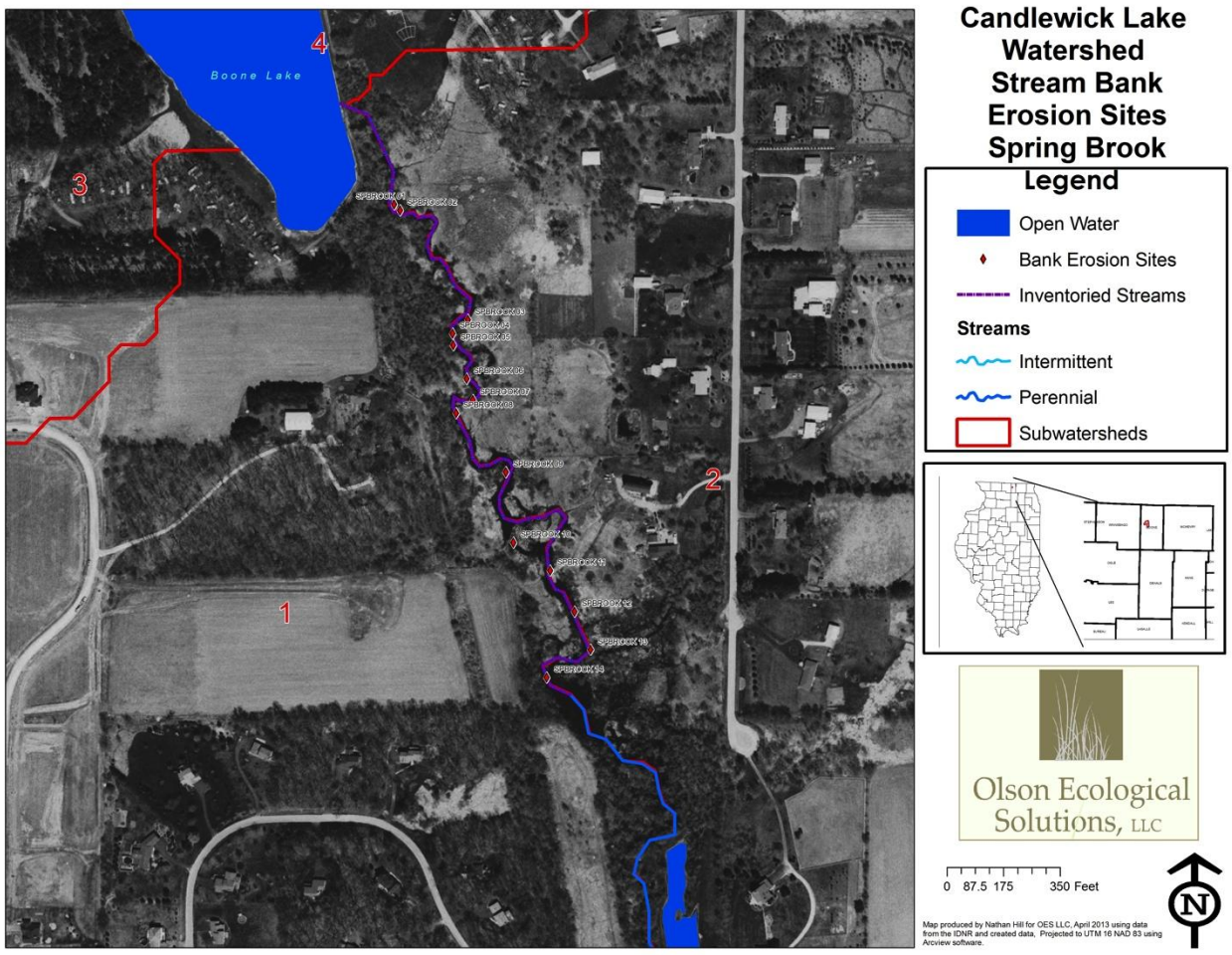


Table 2-16 Spring Brook Stream Bank Erosion Inventory.

SITE CODE	LENGTH OF EROSION (ft)	AVERAGE HEIGHT (ft)	LATERAL RECESSION RATE	SEDIMENT LOAD REDUCTION (TONS/YR)	PHOSPHORUS LOAD REDUCTION (LBS/YR)	NITROGEN LOAD REDUCTION (LBS/YR)
SPBROOK01	32	3.5	Moderate	0.6	0.6	1.2
SPBROOK02	21	2.5	Moderate	0.3	0.3	0.6
SPBROOK03	105	1.25	Slight	0.2	0.2	0.3
SPBROOK04	95	2.5	Moderate	1.3	1.3	2.6
SPBROOK05	55	3.25	Severe	3.8	3.8	7.6
SPBROOK06	35	2.5	Moderate	0.5	0.5	1
SPBROOK07	120	1.5	Slight	0.2	0.2	0.5
SPBROOK08	60	2	moderate	0.7	0.7	1.3
SPBROOK09	95	1.5	Slight	0.2	0.2	0.4
SPBROOK10	45	2.5	Severe	2.4	2.4	4.8
SPBROOK11	110	1	Slight	0.2	0.2	0.4
SPBROOK12	35	1.5	Slight	0.1	0.1	0.2
SPBROOK13	60	1	Slight	0.1	0.1	0.2
SPBROOK14	100	2.5	Moderate	0.4	0.4	0.9
TOTAL				11	11	22

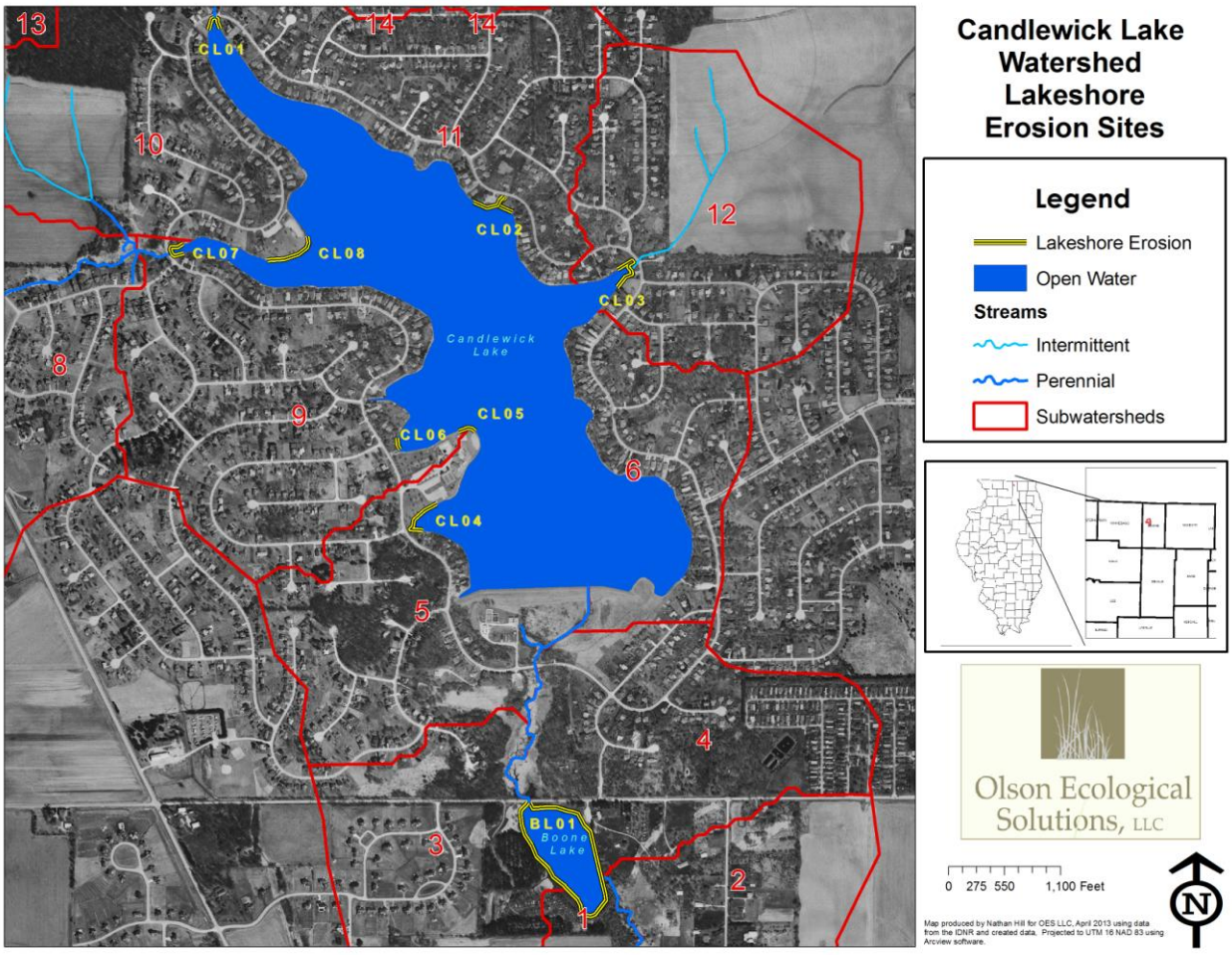
Representative Section of Spring Brook

Table 2-17 Candlewick and Boone Lake Shoreline erosion Inventory

SITE CODE	LENGTH OF EROSION (ft)	AVERAGE HEIGHT (ft)	LATERAL RECESSION RATE	SEDIMENT LOAD REDUCTION (TONS/YR)	PHOSPHORUS LOAD REDUCTION (LBS/YR)	NITROGEN LOAD REDUCTION (LBS/YR)
CL01	257	1	Slight	0.3	0.3	0.7
CL02	626	1	Slight	0.8	0.8	1.6
CL03	535	1	Slight	0.7	0.7	1.4
CL04	511	1	Slight	0.7	0.7	1.3
CL05	177	1	Slight	0.2	0.2	0.5
CL06	116	1	Slight	0.1	0.1	0.3
CL07	326	1	Slight	0.4	0.4	0.8
CL08	531	1	Slight	0.7	0.7	1.4
BL01	3100	1	Slight	4	4	7.9
TOTAL				7.9	7.9	15.9

Typical shoreline erosion on Candlewick Lake

Figure 2-27 – Candlewick and Boone Lake Shoreline Erosion.



Tiled Hydric Soils

The majority of hydric soils in the watershed have been artificially drained using sub-surface, perforated drain tile for farming purposes. In areas of defined drainage patterns, grassed waterways have been installed to safely carry surface water from agricultural fields to drainage ditches or natural streams without causing gully erosion. During early spring and excessive periods of precipitation, these tiles run for months before slowing down. Where hillside seeps, natural springs, or additional tile from uphill properties feed the tile system, some only stop during winter months when soils are frozen. The majority of the upper reaches of the tributaries are fed from sub-surface drain tiles, which are basically where the surface waters begin. The only known location of drained hydric soils is the fields upstream of Caledonia Road on the Lake West Drainage in Subwatersheds 7 and 8.

Livestock

Livestock grazing is limited to horse pastures on smaller farms in the southern portion of the watershed. The horse population is unknown but using aerial photographic investigation it is estimated at around 8 animal units.

Cropland Sources

A rotation of corn and beans is standard farming practice within the watershed. Information about fertilizer application is not readily available. Models indicate that agricultural row crop production contributes the highest amounts of nutrients in the watershed.

Urban Sources

Impervious surfaces in the watershed have been created by roads and residential roofs and driveways, which increase water velocity and runoff. The literature generally shows that water quality and habitat decline if there are more than 10-15% impervious surfaces in a watershed (Schueler, 1994 *IN* WIDNR, 2000).

Onsite Wastewater Systems

The number of homes on septic systems in the watershed is estimated at 190 with a failure percentage rate of 0.58 (EPA online STEPL database). All of the rural farmsteads, and parts of Caledonia in the watershed and all of the residential homes in Timberlane outside of Candlewick Lake and the Mobile home Park to the south are on septic.

The Boone County Health Department, as a condition of permit application approval for any septic system being installed, repaired, or altered requires that property owners acknowledge they are aware of and accept responsibility for servicing and maintaining their private sewage disposal system. [Illinois Department of Public Health Private Sewage Disposal Code Sec. 905.20(q)]

Wildlife Sources

There are no wildlife population estimates for the watershed. Geese have been identified as a source of phosphorus to the lakes. The Candlewick Lake Association since 2007 and just this past spring Boone Lake have been controlling the goose overpopulation. This process, permitted through the Illinois Department of Natural Resources, includes non-lethal techniques such as stopping the feeding of the geese, fencing, barrier plantings, and egg addling. Based on US Fish and Wildlife sources, it is estimated that 1 goose produces 0.5 lbs per year of phosphorus and a recent population of about 99 geese at Candlewick lake was reduced by 64 geese using a permitted charity goose harvest. Where the harvested geese were donated to local food pantries and reducing the P load by 32 lbs per year.

Watershed Modeling Nonpoint Source Pollution

Pollution loading estimates were generated using PLOAD model in BASINS, STEPL and the EPA Region 5 worksheet.

Model Development and Methods

Due to a lack of watershed storm event water quality sampling, we developed a local Event Mean Concentration (EMC) for the watershed. Using average values by land cover type from published sources of comparable watersheds in the Midwest. If no comparable land cover EMC was available, then we used the basic EMC table provided in the PLOAD model. Sources of TP and TN included but were not limited to natural sources, row crop production, and urban storm water. Sources of TSS included but were not limited to erosion from row crops, stream banks and urban storm water. Pathogen sources included natural sources (wildlife), septic systems, and pets in urban areas. The model results below should be viewed as a metric for comparison of various best management practices (BMP) and restoration scenarios rather than an exact representation of existing pollution load conditions.

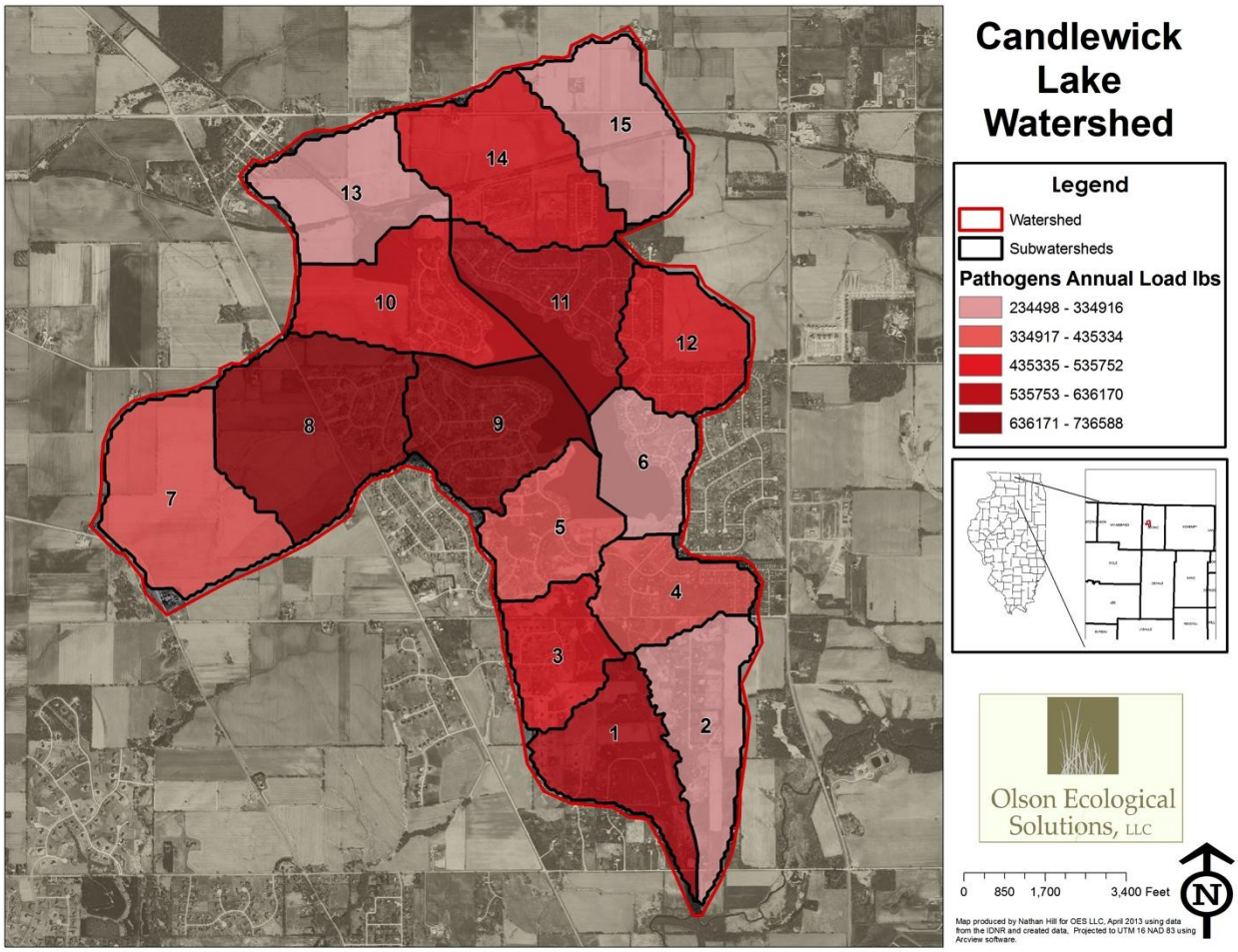
Table 2-18 – Total Pollution Loads by Land Use type using STEPL Model and EPA Region 4 Worksheet

Sources	N Load (lb/yr)	P Load (lb/yr)	Sediment Load (tons/yr)
Urban	4354.16	748.29	101.50
Cropland	5851.21	1449.80	723.69
Pastureland	70.22	6.78	1.52
Forest	77.83	37.71	3.28
Feedlots	0.00	0.00	0.00
Water/Wetland	979.28	246.89	194.61
Septic	43.75	17.14	0.00
Gully	173.70	86.90	86.90
Streambank	118.00	59.00	59.00
Total	11668	2653	1170

Table 2-19 – Total Pollution Loads by Sub Watershed using STEPL Model and EPA Region 4 Worksheet

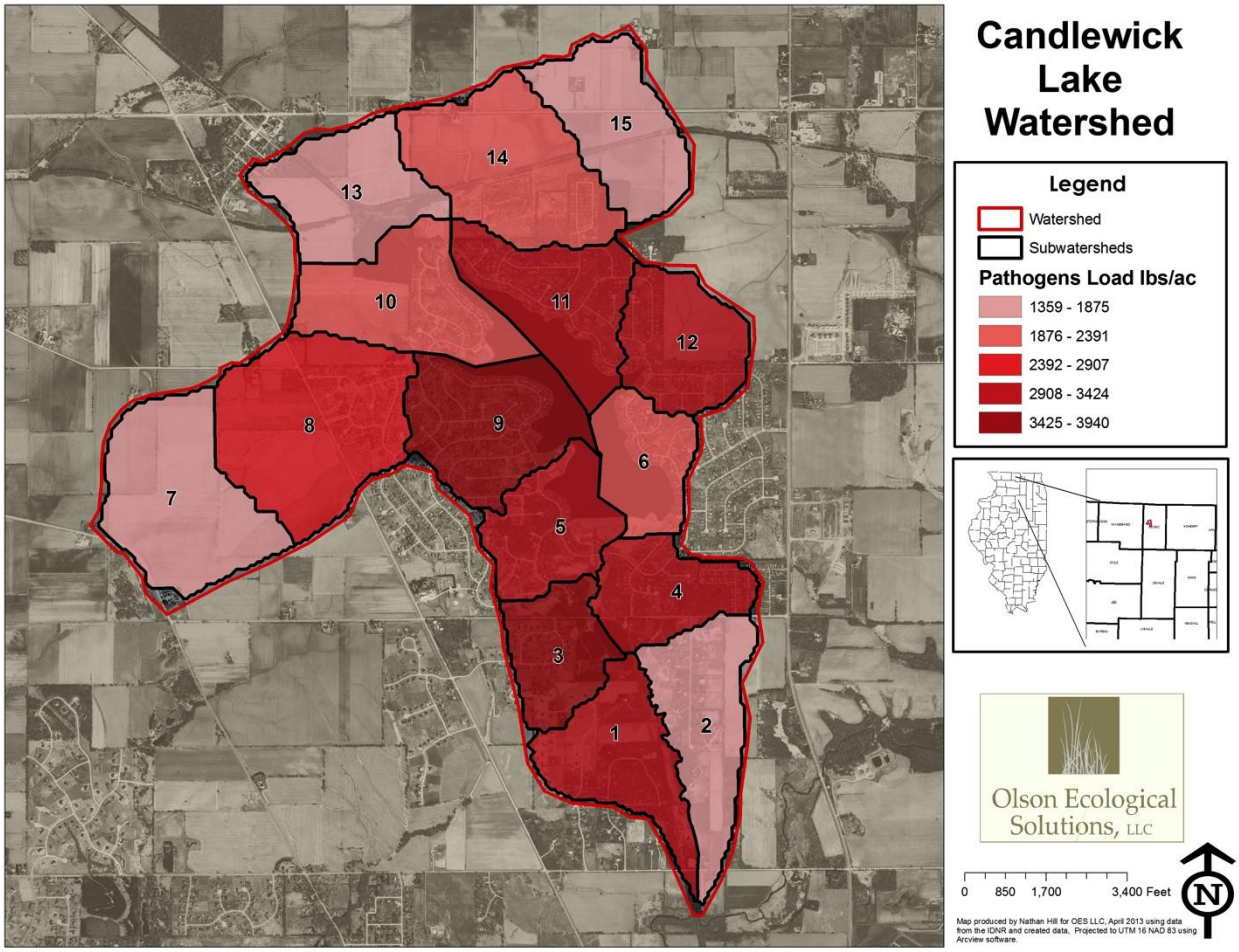
Sub-Watershed	N Load lbs/yr	P Load lbs/yr	Sediment Load t/yr
1	568	137	35
2	622	163	65
3	409	81	15
4	370	70	18
5	494	97	35
6	430	90	44
7	1435	351	171
8	1521	340	203
9	747	142	46
10	842	203	102
11	649	128	49
12	679	146	54
13	810	198	90
14	1084	252	111
15	1008	256	133
Total	11668	2653	1170

Figure 2-28: Candlewick Lake Subwatershed PLOAD Model – Annual Pathogen Loads



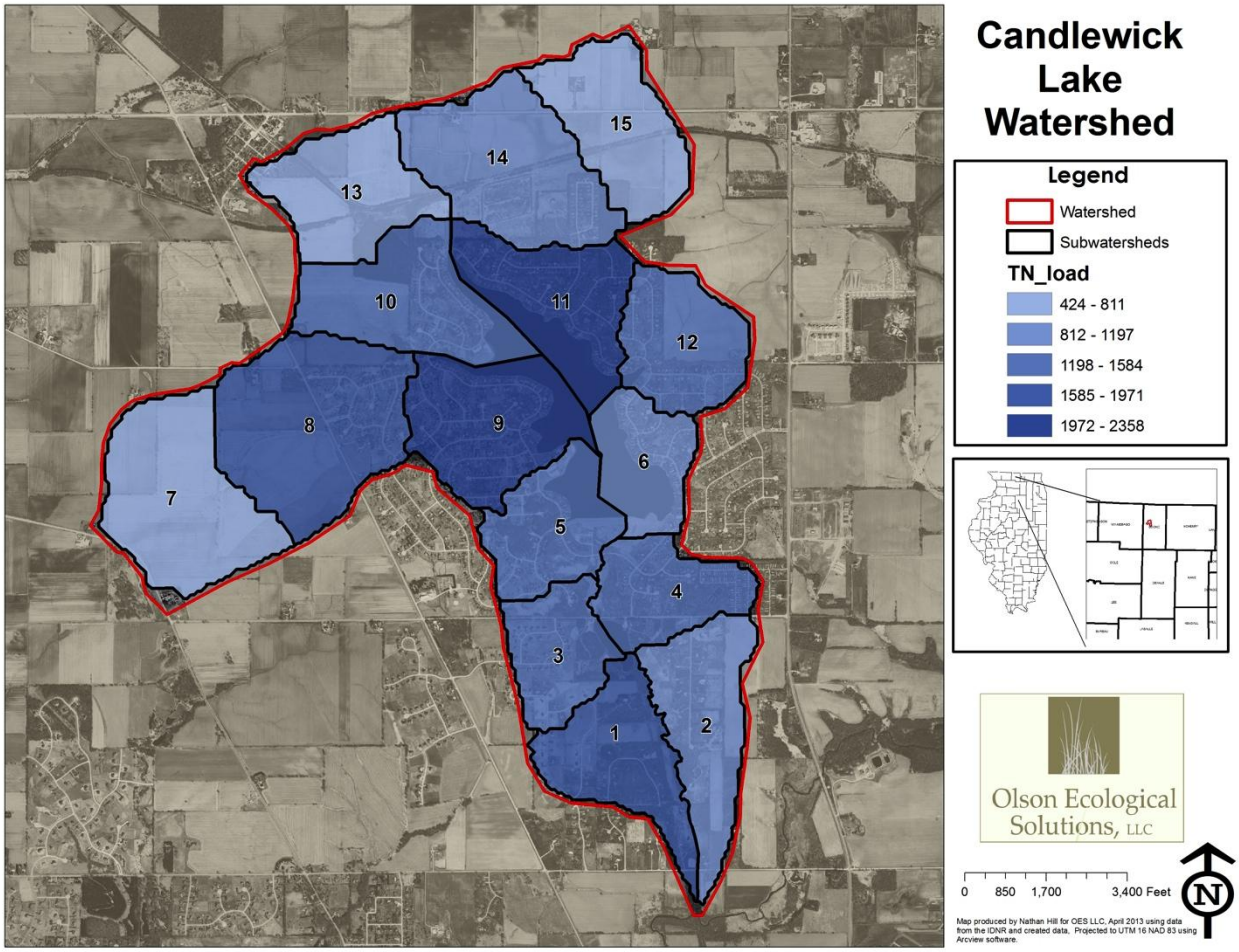
PLOAD model indicated that Subwatersheds # 8, 9 and 11 had the highest loading, respectively. This is likely due to the larger size of these subwatersheds. Subwatersheds 11 and 9 are dominated by residential land uses, but subwatershed 8 is about two-thirds agricultural land use and one-third residential.

Figure 2-29: Candlewick Lake Subwatershed PLOAD Model – Annual Pathogen Load in Lbs/Ac



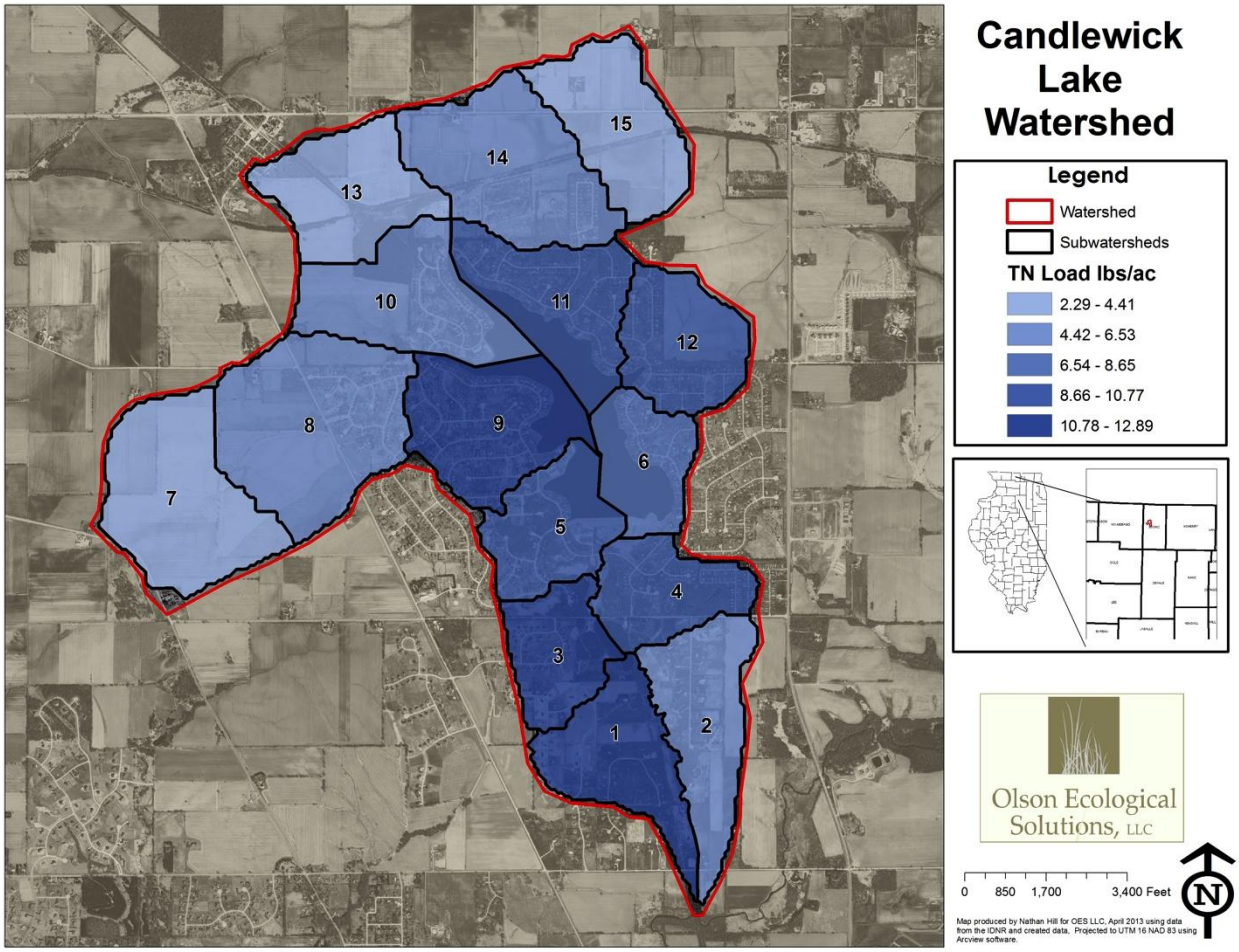
PLOAD model indicated that Subwatersheds # 3, 9, and 1 had the highest pathogen loading in pounds per acre respectively.

Figure 2-30: Candlewick Lake Sub Watershed PLOAD Model – Total Nitrogen Annual Loading



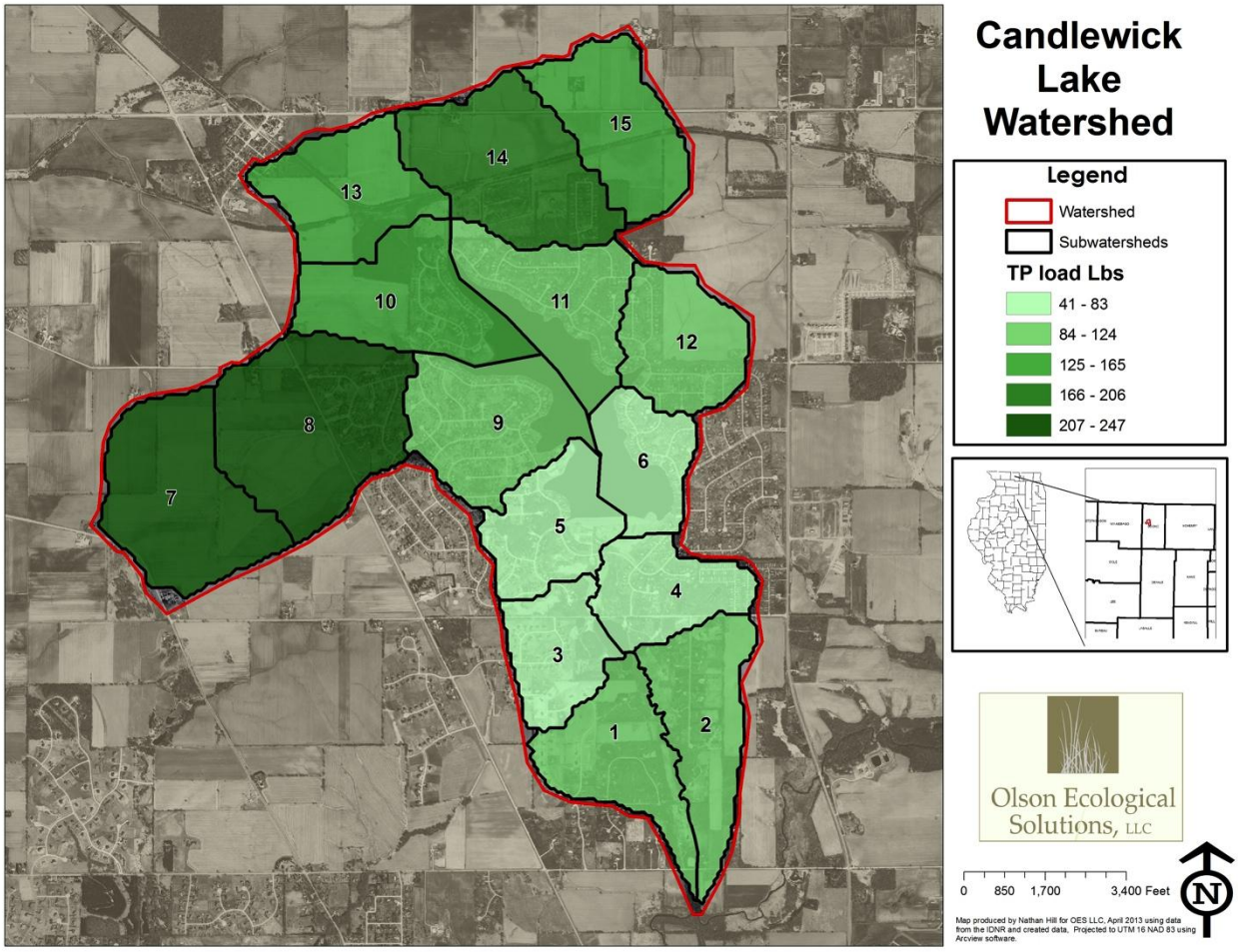
PLOAD Model indicated that Subwatersheds 9, 11, and 1 had the highest annual loading in pounds for Total Nitrogen, respectively.

Figure 2-31: Candlewick Lake Subwatershed PLOAD Model – Total Nitrogen Load in Lbs / Acre



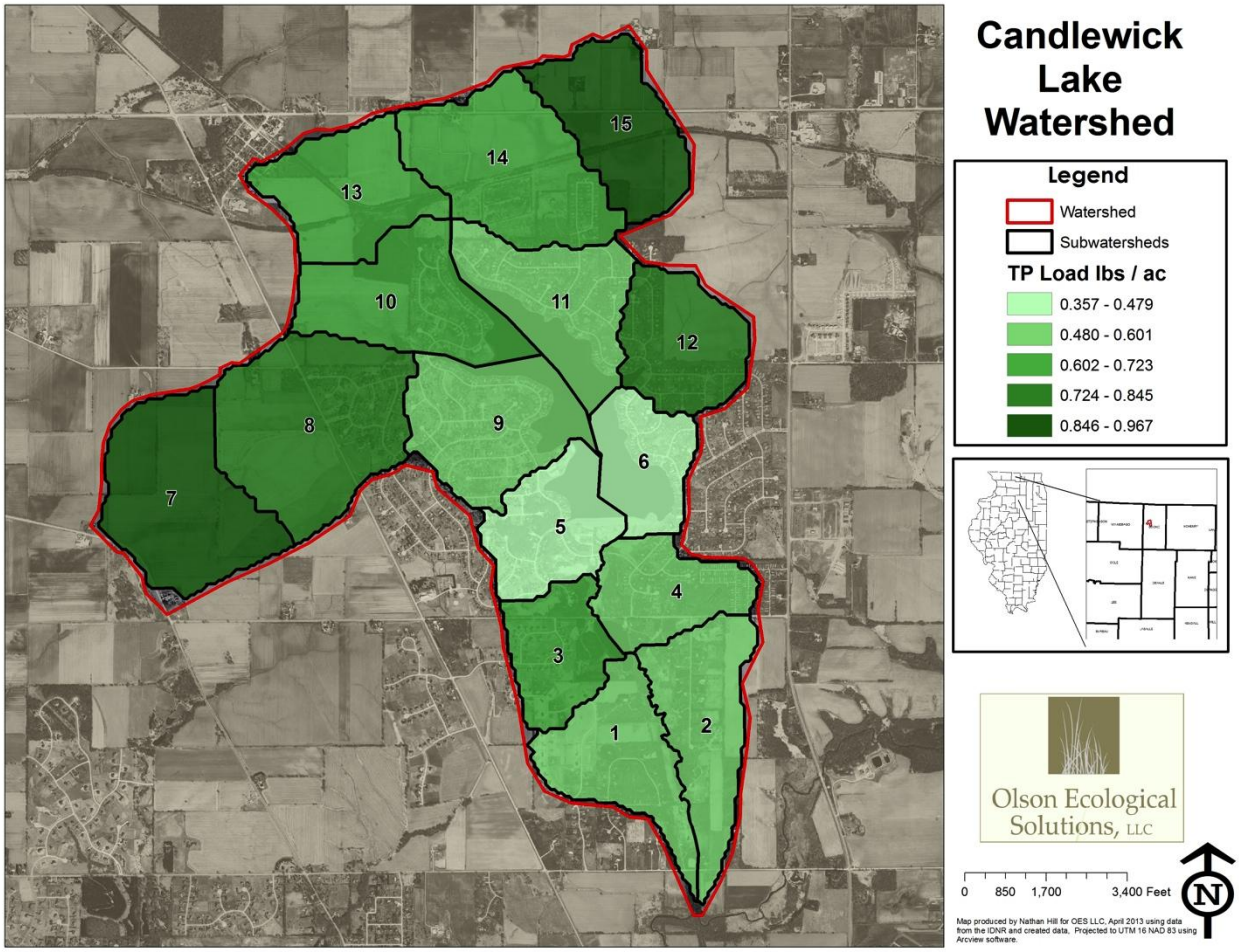
Subwatersheds # 3, 9 and 1 had the highest Total Nitrogen loads on a per acre basis, respectively.

Figure 1-32: Candlewick Lake Subwatershed PLOAD Model – Total Phosphorus Annual Load in Lbs



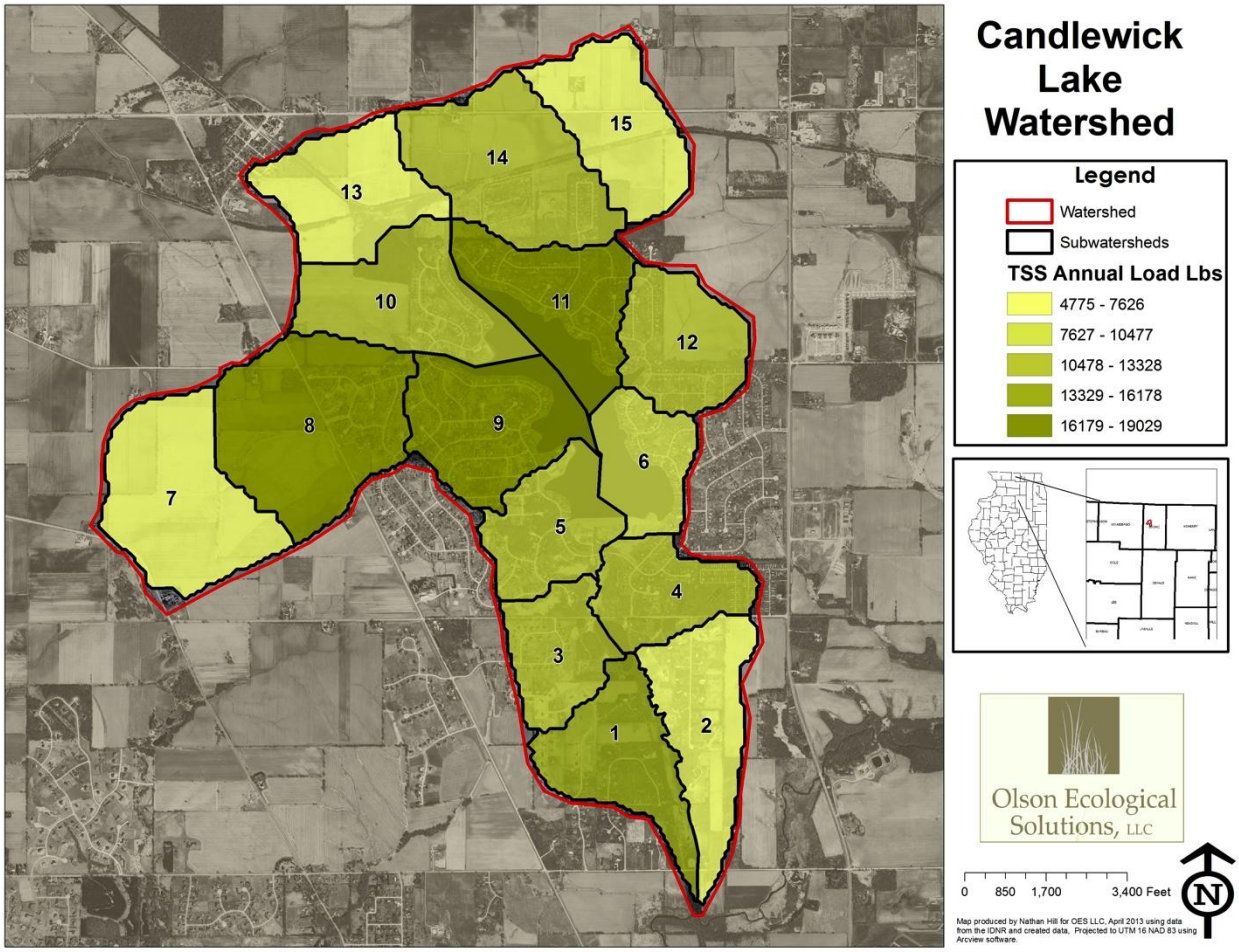
Subwatesheds # 8, 7, and 14 had the highest Total Phosphorus Annual loading in lbs.

Figure 2-33: Candlewick Lake Subwatershed PLOAD Model – Total Phosphorus Load in Lbs/Acre



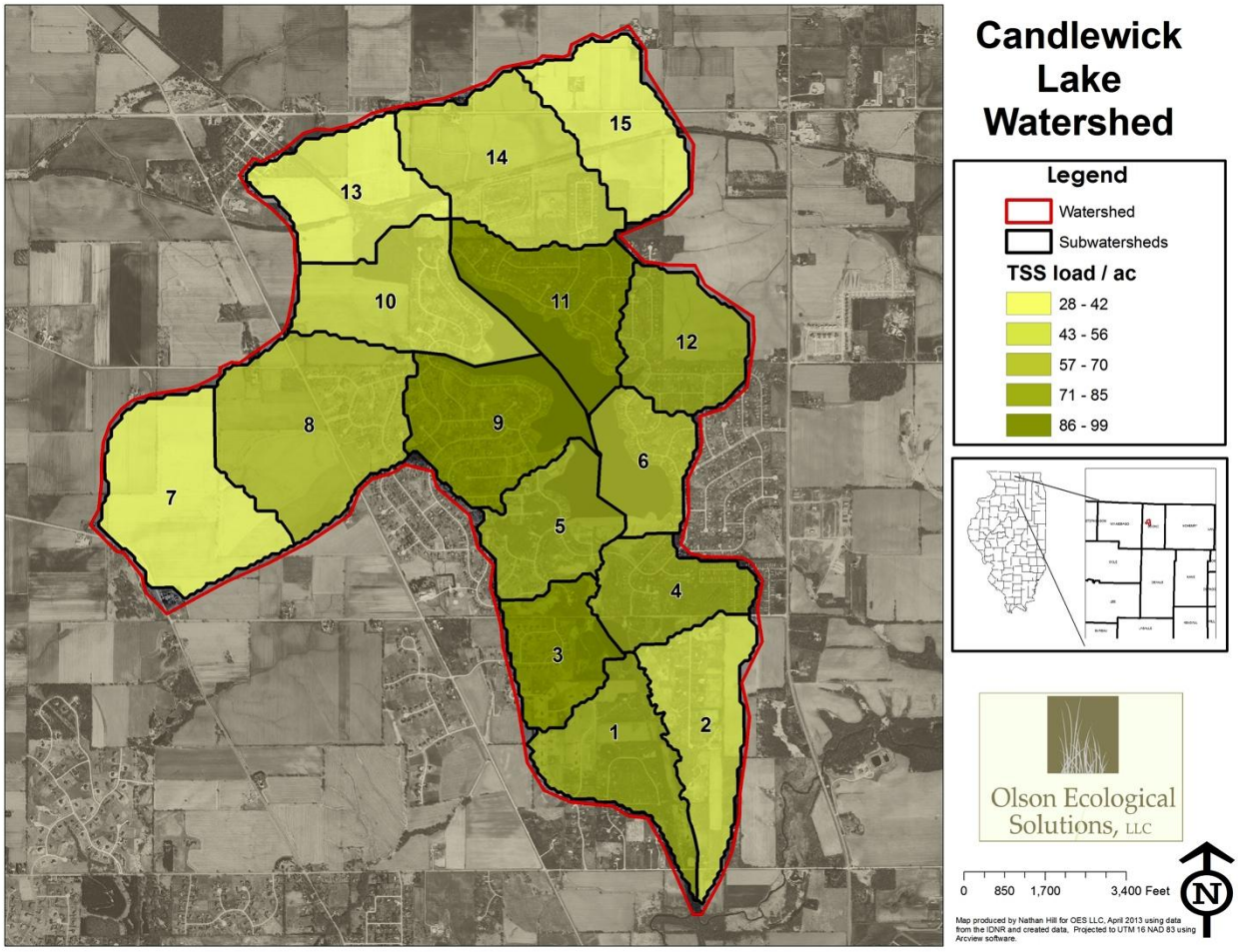
Subwatersheds # 7, 15, and 8 had the highest Total Phosphorus loading in pounds per acre, respectively.

Figure 2-34: Candlewick Lake Subwatershed PLOAD Model – Total Suspended Solids Annual Load in Lbs



Subwatersheds # 9, 8 and 11 had the highest Total Suspended Solids Annual loads in pounds, respective.y.

Figure 2-35: Candlewick Lake Subwatersheds PLOAD Model – Total Suspened Solids Load in Lbs/Acre



Subwaterhseds # 3,9, and 11 had the highest Total Suspended Solids load in lbs per acre, respectively.

Water Body Monitoring Data

Water Quality and Flow Data

National databases did not contribute water quality and flow data for the watershed, including STORET, national listing of fish advisories, NWISWeb, BEACH Program, WATERS, and National Sediment Inventory. Integrated Lakes Management performed water quality testing at Candlewick Lake during 2011. Average water clarity was 2.8 ft., Phosphorus concentrations averaged 0.10 mg/l, which were well over the 0.05 mg/l standard. The anoxic sediment was likely releasing phosphorus into the water. Nitrogen concentrations were below state standards averaging under 0.1, 0.2 and 1.7 mg/l for Ammonia, Nitrate/Nitrite and Kjeldahl Nitrogen respectively. Chloride concentrations were well below IEPA standard of 500 mg/l with an average of 37mg/l (Kubillus, 2011).

Table 2-20: Historic Water Quality Data

Year	TP	TKN
1977	0.07	0
1985	0.06	0.28
1990	0.05	0.5
1991	0.14	0
1992	0.17	0.9
1993	0.28	1.26
1994	0.28	1.7
1995	0.23	3
2007	0.157	1.15
2008	0.212	1.26

National Listing of Fish Advisories

There were no fish consumption advisories specifically for Boone Lake or Candlewick Lake because there were no fish samples available from either water body. However, there was a state-wide advisory for women of childbearing age and children under 15 to limit their consumption of predator fish species (fish that eat mainly other fish such as bass and pike) from all lakes and streams in Illinois, including waters not accessible to the public, to one meal per week due to mercury contamination (Hornshaw, Pers. Comm.).

Beach Closings

Beaches at Candlewick Lake were monitored as required by the Illinois Department of Health twice per month during the swimming season, and were closed a total of 30 days between 2009 and 2010 due to high levels of bacteria, averaging about 1 closure per year since 2001. The satisfactory level of E. coli ranges from <1/100mL to 209.8/100mL. Times of beach closings had much higher readings between 410/100mL and topping out at >2419/100mL. Boone Lake had remained closed since July 11, 2012 (287 days to the date of this publication 4/24/13) due to high bacteria levels. Results from two tests in July 2012 indicated shallow readings of 770.1 / 100ml and deep readings of 517.2 / 100ml (IDPH Beachguard System).

Volunteer Monitoring Program Data

The lake association of Candlewick Lake was involved in the Environmental Protection Agency's Volunteer Lake Monitoring (VLM) Program. Monitoring water chemistry and physical parameters allowed them to assess the water quality of their lake to make better decisions on management practices. VLM data for Nutrients and Sediment showed elevated levels of phosphorus in August maxing out at 0.157 mg/l in 2007 and 0.212 mg/l in 2008. Secci depth and trophic status were as follows: Oligotrophic depth(145in+), Mesotrophic (79-145in), Eutrophic (18-79in), Hypereutrophic (<18in)).

Table 2-21: VLM Median Secci Depth Candlewick Lake

Year	Depth in inches
2007	31.5
2008	33.5
2009	26
2010	20.5
2011	17
2012	24

Sediment Monitoring Data

Sediments were a problem within Candlewick Lake, as supported by sediment monitoring efforts throughout the history of the lake. The lake was dredged recently in 2010 and a total of 22,928 cubic yards were removed. In 2011, sediment sampling was conducted by Integrated Lakes Management (See Table 2-22).

Table 2-22: Average Candlewick Lake Sediment Sampling Results (Kubillus, 2011).

Near Outlet		North Bay	
Nitrogen, Total Kjeldahl (mg/kg) Normal Range 1,300-5,357	Phosphorus Total (mg/kg) Normal Range 394-1,115	Nitrogen, Total Kjeldahl (mg/kg) Normal Range 1,300-5,357	Phosphorus Total (mg/kg) Normal Range 394-1,115
3,840	563	5,167	573

Biological Indicators

Biological indicators in the watershed were sampled, including the algal toxin microcystin, fish, and invertebrates, resulting in rankings of trophic status and biological stream segments.

Algae

Candlewick Lake was a plant dominated lake in the early 1980s, and it became an algae dominated lake by the 1990s. In 2011, blue green algae made up close to 100% of the plankton algae observed in the lake, and microystin was about 50%. Candlewick Lake was sampled in August 2012 for algae ID/enumeration and toxin analysis. The Microcystin level was very high at ***14,800 ug/L*** (***>20 ug/L*** is usually considered "High"). Candlewick Lake Association issued a ***closure*** to all uses. Subsequent testing by the IEPA confirmed elevated microcystin within Candlewick Lake.

Fish - Index of Biotic Integrity (IBI)

No known IBI scores had been developed for the Candlewick Lake Drainage. Huff and Huff produced a report for the Poplar Grove WWTP expansion in 2005 and sampled several locations along Beaver Creek including locations just upstream and downstream of the Candlewick Lake drainage. IBI scores upstream of the Candlewick drainage on Beaver Creek were 40 and below the drainage it was 44. This IBI translated to a Good (41-34) and Very Good (49-42) rating on a scale of 12 (worst) to 60 (best). Karen Rivera provided an assessment of IDNR data on fish assemblages downstream on Beaver Creek - PQD-10: This station was located northwest of Belvidere upstream of the Squaw Prairie Road Bridge. The electric seine was used to sample an area 430' X 30' for a total sample time of 31 minutes. One long run was sampled. Beaver Creek had historically been an "A" rated stream through most of its length. However, the diversity of this site was considerably lower than for the previous samples, which were collected further downstream along Route 20 west of Belvidere. The previous location was not sampled due to a loss of access. Large fish collected from this area included only five species of Suckers, and Green Sunfish. Smaller fishes included 10 species of native Minnows, Stonecats, and two species of Darters. The IBI for this station was calculated at 40, a significant decrease from the 54 calculated in 2006 at the downstream station. Earlier samples collected from the Route 20 station scored 53 in 2001 and 54 in 1997 (Rivera 2011).

Candlewick Lake - Trophic Status

In 2011, the Trophic status of Candlewick Lake was determined to be Mesotrophic in the spring, changing over to Hypereutrophic by July. ILM preformed water quality testing in 2011 and found the Trophic State Index to be Hypereutrophic (ILM, 2011).

Biologically Significant Streams

The Candlewick Lake Watershed emptied into a stream segment of the Beaver Creek, the lower reaches of which were identified as Biologically Significant in the *Integrating Multiple Taxa in a Biological Stream Rating System* report (IDNR 2008).

Geomorphology

Geology provided subsurface framework and landscape (topography) of the watershed. It partially determined the degree to which erosion occurred and the rate and direction of flow of groundwater and surface water, thus influencing the water quality and biology of the watershed. Geologic materials produced the soils within a watershed. The lateral extent, thickness, and properties of the geologic materials, and their variability, were related to the geologic history of the watershed (Dave Larson, Pers. Comm.). Stream morphology, bedrock, quaternary deposits, and factors of soil formation explained the geomorphology of the watershed.

Stream Morphology

Spring Brook was a low gradient small stream averaging only about eight to20 feet in width. In the Upper reaches downstream of Boone Lake is a braided meandering stream with several beaver dams in

various condition of repair; some were old and still backing up water others were breached and flowing water in a concentrated narrow channel. No recent beaver activity was noted. The substrate varied from pools of muck and sediment that were heavily infested with Eurasian milfoil behind the beaver dams to gravel and sand bottom runs in open waters not affected by beaver dams. Other areas of the stream channel contained rock cobble substrate and were clear of aquatic vegetation. Overall Spring Brook is a dynamic and changing stream channel with varied dimensions exhibiting slight to moderate bank erosion mostly on outside bends of the channel.

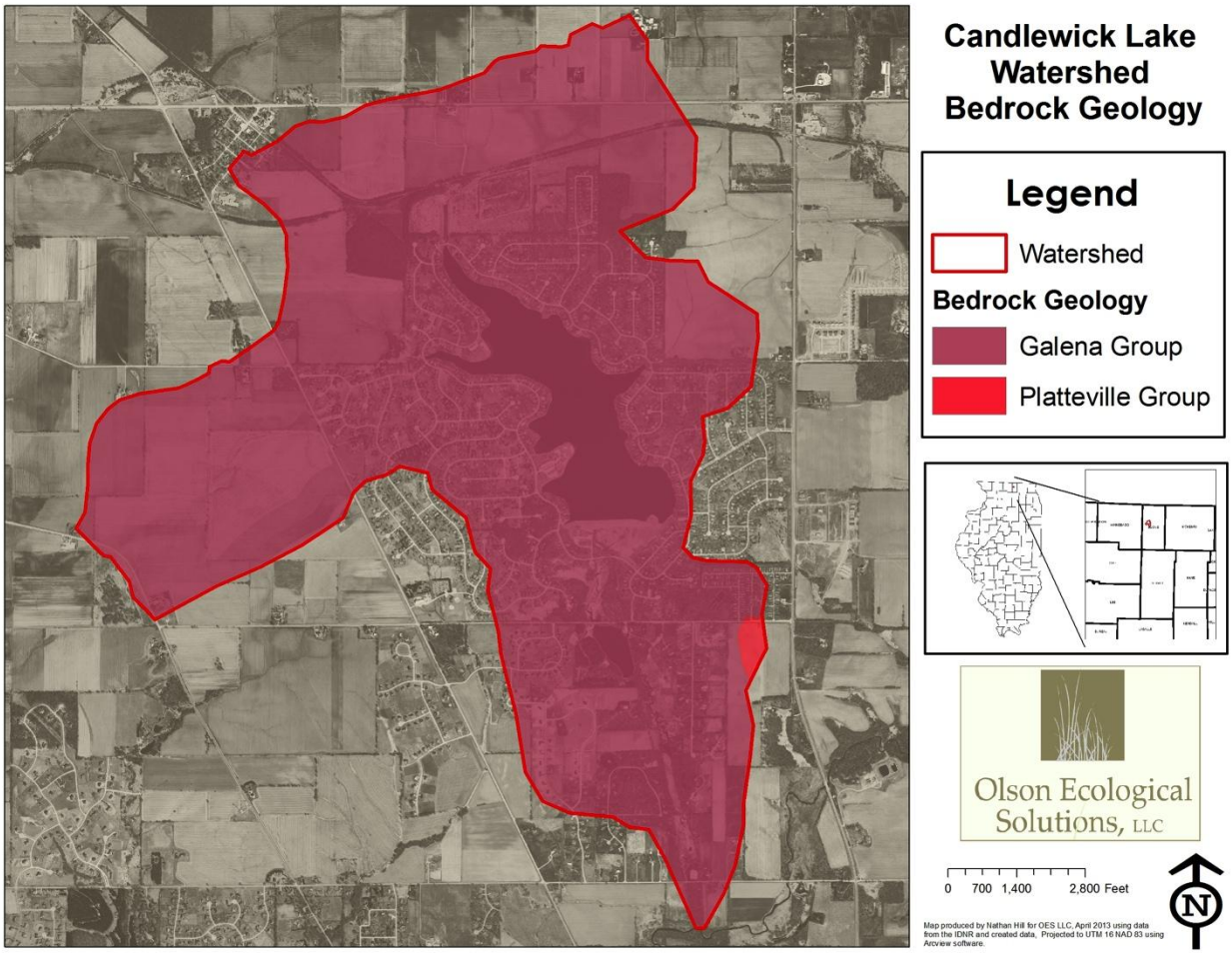
Bedrock

Bedrock in the watershed was of Galena and Platteville groups (see Figure 2-36). These groups were 300 to 350 ft. thick in a large area of Northern Illinois. These groups consisted almost entirely of carbonate rocks and were quarried extensively for building materials and agricultural limestone. Although largely dolomite, both groups contained limestone in parts of the areas.

Galena Group Dolomite bedrock was brown and gray; coarse grained; primarily pure; 0 - 76 meters (250 feet) thick; some cherty beds; some argillaceous beds; and clay (Kbentonite) beds. These cliff forming-rocks were exposed in the Kishwaukee River and Grove Creek gorges and many quarries throughout the area.

Platteville Group Dolomite bedrock was brown and gray; fine to very fine grained; 0 - 40 meters (130 feet) thick; and thinner bedded and more argillaceous than the Galena Group. These rocks were exposed in quarries and road cuts in northern Winnebago County (William, Kolata 1978).

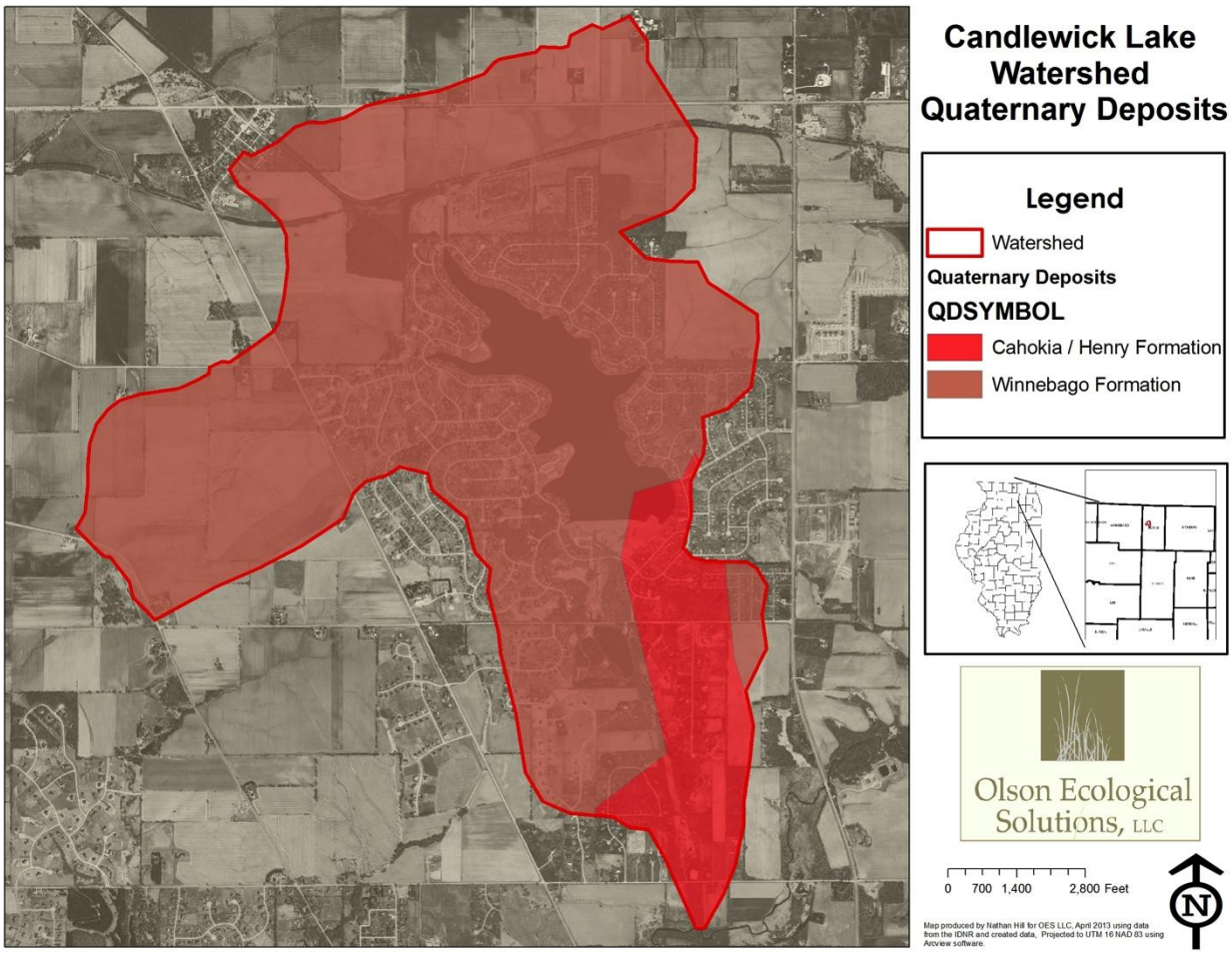
Figure 2-36: Bedrock geology of the Candlewick Lake Watershed



Quaternary Deposits

Quaternary deposits within the watershed included Cahokia/Henry and Winnebago formations (see Figure 2-37). The Cahokia/Henry Formation followed Candlewick Lake drainage to Beaver Creek. It consisted of channel and floodplain deposits of modern streams and rivers consisting of stratified silt containing sand and clay lenses. Winnebago Formation dominated a majority of the remaining watershed.

Figure 2-37: Quaternary deposits in the Candlewick Lake Watershed



Cultural Resources

No known information on cultural resources existed for the watershed.

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Chapter 3: Success Statement, Goals, and Objectives

Written by Rebecca Olson

Previous chapters have provided an overview of the planning process and painted a picture of the land and water surrounding Candlewick Lake. This chapter focuses on the success statement, goals, and objectives for the watershed, and future chapters provide guidance to meeting them.

Success Statement

The following success statement was adopted by the planning committee and technical advisors with support from planning participants.

Success Statement for
Streams and Lakes Conservation
in the Candlewick Lake Area

"To sustain the recreational pursuits of fishing, boating, and swimming by cleansing the streams and lakes surrounding Candlewick Lake."

Once this statement is satisfied, the implementation of the Candlewick Streams and Lakes Conservation Plan will be deemed successful. Maintenance of this success statement will be an ongoing responsibility of those who care about the area. In order to satisfy this statement, we propose the following goals, objectives, campaigns, and recommended projects and programs.

Goals

The following goals were adopted by the planning committee and technical advisors:

Goals for
Streams and Lakes Conservation
in the Candlewick Lake Area

1. Reduce the amount of soil washing into our streams and lakes.
2. Reduce the amount of nutrients entering our streams, lakes, and groundwater.
3. Maintain a healthy volume of water feeding Candlewick Lake with a consistent flow.
4. Treat pollution from future development before it enters our streams and lakes.
5. Coordinate with local municipalities to create policies that improve water quality.
6. Educate the community about land and water conservation and this plan.

Most of these goals relate to the simple desire to keep soil on the ground and out of our streams and lakes. Once soil gets into the water, it is a pollutant itself, and it also brings with it any pollutants that were applied to the soil.

When we refer to soil as a pollutant, we call it "sediment." When suspended in water, sediment clouds the water and cause problems. Cloudy water makes it difficult for fish to catch their food. It also doesn't let sunlight in to support healthy, underwater plant growth.

Other pollutants that come in with soil and stormwater runoff include fertilizers from farmers' fields and residents' lawns and manure from pets, cows, and geese and other wild animals. We are most concerned with phosphorous and nitrogen from fertilizers and pathogens from manure. Phosphorous and nitrogen are two main nutrients that encourage plant growth, and they have the potential to limit plant growth if there isn't enough of one or the other. They are desired when you are trying to grow crops or have a green lawn, but too much running into streams and lakes can cause harmful algae blooms and other aquatic weed infestations. Manure also provides nutrients for plants and can be used

as an organic fertilizer in your garden or on crop fields. However, it causes public safety concerns because swimming in water with pathogen counts that are too high can make people and pets sick.

The third goal is unique to Candlewick Lake. The lake is large compared to the area of land feeding it with its runoff. Therefore, a shortage of rain or detaining too much water upstream could cause the lake's water level to drop. Many land and water conservation practices encourage slowing down and detaining runoff, which has multiple benefits. Not only does it give water a chance to evaporate, infiltrate into the ground, and be taken up by plants and transpire; it also takes the energy out of the water that scours our streambanks. Since the lake is dependent on runoff to maintain its ordinary water levels, we want recommended projects and practices to be designed to cleanse the runoff without diminishing the volume of water entering the lake to the extent possible.

The goals above aim to satisfy the success statement and are to be fulfilled by meeting the following objectives.

Objectives

In order to address each of the five goals above, we propose the following objectives which can be measured.

Goal 1: Reduce the amount of soil entering our streams and lakes.

Objectives for Goal 1

1. Reduce the amount of sediment entering streams and lakes by 620 tons/yr (53%).

Goal 2: Reduce the amount of nutrients entering our streams, lakes, and groundwater.

Objectives for Goal 2

1. Reduce the amount of phosphorous entering streams and lakes by 620 lbs/yr (23%).
2. Reduce the amount of nitrogen entering streams and lakes by 2,600 lbs/yr (22%).

Goal 3: Maintain a healthy volume of water feeding Candlewick Lake with a consistent flow.

Objectives for Goal 3

1. Determine the water budget baseline for Candlewick Lake.
2. Determine the water volume requirements of Candlewick Lake.
3. Reduce flashy hydrology during storms for each stream reach feeding Candlewick Lake, Boone Lake, and Beaver Creek.
4. When designing recommended projects, determine how the project will affect the water budget and design projects to ensure a sufficient water supply to Candlewick Lake with a steady, gradual flow.

Goal 4: Treat pollution from future development before it enters our streams and lakes.

Objectives for Goal 4

1. Review plans for development and recognize the opportunities to improve water quality coming from the development.
2. Determine the pollution projected to come from the development before and after opportunities to improve water quality are implemented to estimate the pollution reduction possible.
3. Implement water quality projects to lessen the amount of pollution entering our streams and lakes from each planned development.

Goal 5: Coordinate with local municipalities to create policies that adhere to these goals.

Objectives for Goal 5

1. Adopt a common, updated ordinance or intergovernmental agreement for Timberlane, Poplar Grove, Caledonia, and Boone County to protect water quality under the guidance of the most current Boone County Regional Stormwater Management Plan.
2. Provide recommendations to protect water quality from this plan to all municipalities to be included in the ordinances or intergovernmental agreement.
3. Create a relationship with all local municipalities to promote cooperation in land and water conservation efforts.

Goal 6: Educate the community about land and water conservation and this plan.

Objectives for Goal 6

1. Increase awareness of nutrient runoff from lawns, driveways, rooftops, and farm fields and encourage behaviors that will reduce nutrient pollution in local streams and lakes.
2. Increase awareness of the connection between protecting our streams and lakes and improving people's quality of life, recreational opportunities, scenic amenities, community value, property value, and public health.
3. Promote partnerships with community groups that can assist in creating public awareness.
4. Enroll homeowners and landowners in a recognition program for implementing conservation projects and participating in land and water protection programs.
5. Deliver Urban Campaign education materials and invitations to events to all households within urban areas of the watershed.
6. Deliver Rural Campaign education materials and invitations to events to all households within the rural areas of the watershed.
7. Provide all municipalities and developers within the watershed with Future Development Campaign education materials and invitations to events and meetings.

*Objectives 1-4 are adopted from the EPA's "Đeveloping an Outreach Strategy" website.

The objectives can be fulfilled by following the recommended projects and practices within four campaigns in Chapter 4.

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Chapter 4: Campaigns and Recommended Projects and Practices

Written by Rebecca Olson

Chapter 3 addressed goals and objectives for the watershed. This chapter provides recommended projects and practices for implementation and supporting education. All of the projects and practices address the goals and objectives and lead to the fulfillment of our success statement in Chapter 3. Implementation projects and practices refer to on-the-ground protection, restoration, and construction projects to be implemented on lands, in streams, and on streambanks and lake shorelines throughout the watershed. Education efforts are also proposed to support the implementation projects. These recommended projects and practices are organized into four campaigns. In Chapter 5, we provide a schedule and cost estimates for implementing these projects and practices.

Campaigns

The area surrounding Candlewick Lake consists of rural homes, streams and lakes, and farms. The farms are likely to be developed with more homes and commercial buildings. For each of these different types of land uses, we have suggestions for conservation projects and practices. We have compartmentalized them into four "campaigns," so that efforts can be better organized.

Campaigns for Streams and Lakes Conservation in the Candlewick Lake Area

Urban Campaign

The Urban Campaign concentrates our projects and practices within subdivisions and other developed areas.

Future Development Campaign

The Future Development Campaign works with local municipalities and developers to address the likely increase of storm water and runoff projected from future development.

Streams and Lakes Campaign

The Streams and Lakes Campaign includes projects and practices within streams and lakes and along their banks.

Rural Campaign

The Rural Campaign discusses practices to be carried out on working farms. Care has been taken to avoid costly solutions to temporary problems that will terminate when the land is developed.

Recommended Implementation Projects and Practices

Consultants identified opportunities throughout the local area to address the goals and objectives of this plan and recommended them to planning participants and technical advisors for their input. These opportunities were prioritized through a two-step process: community input and technical assurance of water quality benefit. First, planning participants prioritized projects. Then consultants reviewed these priorities with technical advisors, predicted pollutant load reduction potential of various opportunities, and adjusted prioritized projects accordingly.

Planning participants prioritized projects during a meeting in February 2014 from a list of recommended projects provided by consultants. They gave priority to projects not only according to their perceived potential to cleanse lakes and streams, but also because they were considered projects that could be most easily accomplished. Consultants reviewed these priorities with technical advisors in May 2014. Consultants then modeled potential projects for their ability to reduce the amount of pollutants entering streams and lakes. Using the outcome of these models and input from technical advisors, the consultants adjusted the planning participants' prioritization of projects accordingly.

The recommended projects and practices are described below. To present the recommended projects and practices, we first provide the summary map and table and then provide details about the projects or practices along with their estimated potential to reduce pollutants entering our streams and lakes.

These new recommendations are followed by a list of previous recommendations by Integrated Lakes Management and their status of completion and a description of projects and practices already in place within the Candlewick Lake community.

Summary of Recommended Implementation Projects and Best Management Practices in the Watershed

There are many opportunities to improve water quality by preventing pollution from entering our streams and lakes. In Figure 4-1, we illustrate where all of the recognized opportunities are located. The projects and practices recommended in this chapter could occur in any of these areas. We do not assume that all opportunities are going to be realized, so each project and practice has a target amount to be accomplished within the ten-year life of this plan. The targeted amounts are listed for each type of water pollution control, known as **Best Management Practices (BMP)**, in Figure 4-2, along with the potential to reduce pollution if the targeted amount is achieved. The target amounts agree with the amounts of the measurable objectives in Chapter 3. The best management practices are applicable throughout the watershed, but some subwatersheds are prioritized over others.

If all projects and practices are implemented to their targeted amount, the potential for reducing the pollutants in the watershed are as follows:

Nitrogen – Reduce by 22% or 2,562 lb/yr
Phosphorous – Reduce by 23% or 618 lb/yr
Sediment – Reduce by 36% or 417 tons/yr

In general, the following subwatersheds are prioritized for each campaign and for each pollutant. These priorities take into consideration the pollutant load coming from each subwatershed and the potential to reduce those pollutants, although effectiveness of any given project or practice may be comparable throughout the watershed on an per-acre basis. More information is provided later in this chapter on a project by project basis.

Urban Campaign - Focus urban conservation practices within the residential areas that contribute the greatest amount of pollution to our streams and lakes, including parts of Subwatersheds 3, 5, 8, 9, and 11.

Streams and Lakes Campaign - Focus areas for streams and lakes are parts of Subwatersheds 8, 9, 11, and 12.

Future Development Campaign - Future development management practices and outreach programs should occur throughout the watershed. As of this time, future development is likely to occur in Subwatersheds 7, 8, 10, 12, 13, 14, and 15.

Rural Campaign - Of the agricultural subwatersheds, management practices and outreach programs should focus on Subwatersheds 1, 2, 7, 8, and 14 for greatest concentrated impact.

Nitrogen Reduction - To reduce nitrogen loading into streams and lakes, center efforts in Subwatersheds 3, 9, and 1, respectively (see Figures 2-31).

Phosphorous Reduction - To reduce phosphorous loading, target Subwatersheds 7, 15, and 8, respectively (see Figure 2-33).

Sediment and Total Suspended Solids Reduction - To reduce loading of sediments and total suspended solids, focus efforts in Subwatersheds 3, 9, and 11 (see Figure 2-35).

Nitrogen Reduction - To reduce pathogens entering streams and lakes, center efforts in Subwatersheds 3, 9, and 1, respectively (see Figures 2-29).

Figure 4-1: Map of all opportunities for conservation projects and practices in the watershed.

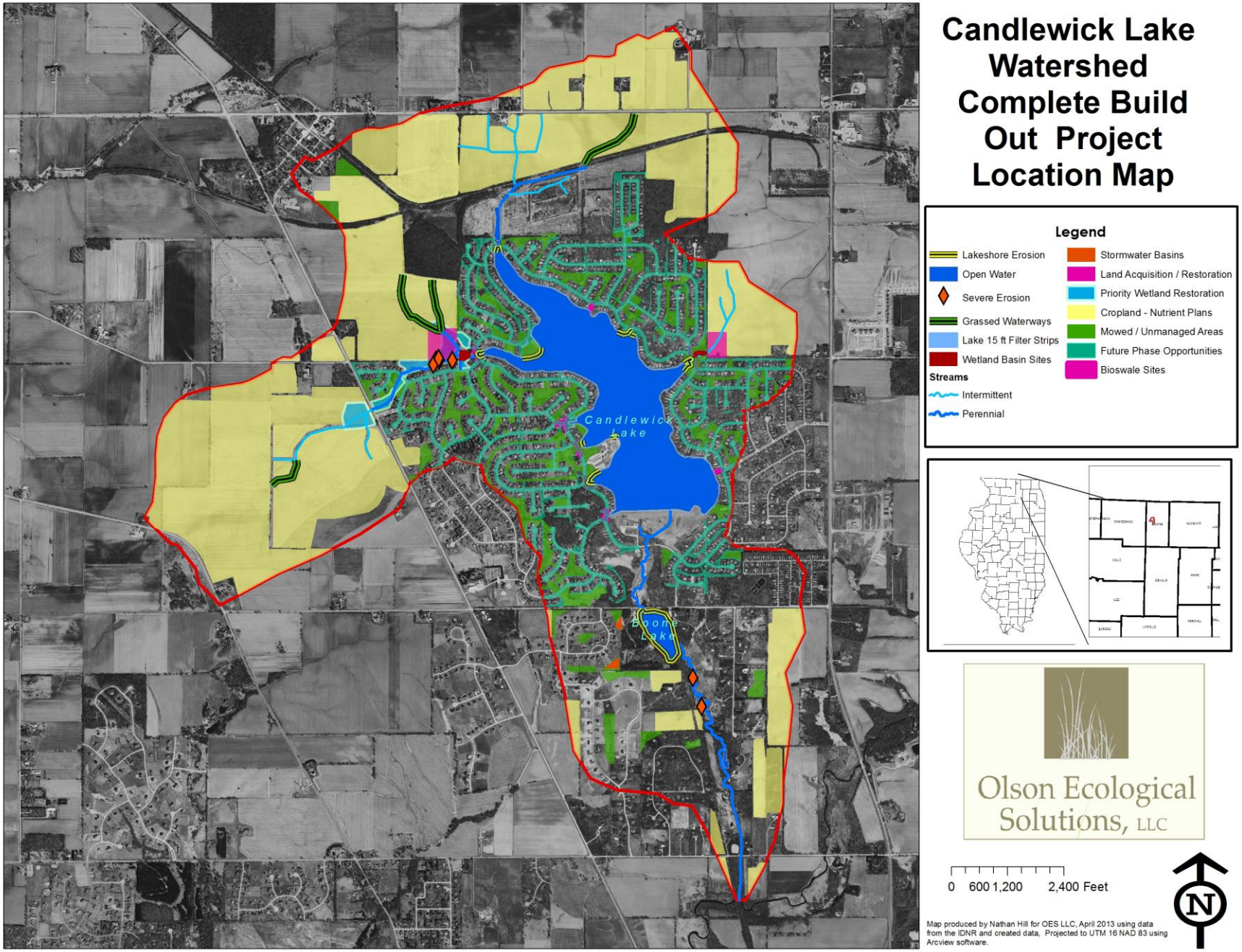


Figure 4-2: Watershed-wide Summary of Best Management Practices (BMP) Recommended for Implementation												
Campaign	**BMP Type**	**Target Area**		**Cost est.**	**Pollution Reduction Estimate**			**% Pollution Reduction in Watershed**			**Priority**	**Responsible Entity**
					N (lbs/yr)	**P (lbs/yr)**	**Sediment (tons/yr)**	**N (%)**	**P (%)**	**Sediment (%)**		
STREAMS LAKES	Streambank Stabilization	575	ft.	$ 46,000	118	59	59	1.01%	2.22%	5.04%	High	Landowners
STREAMS LAKES	Grass-lined Channels	0.6	ac.	$ 264,000	388	16	18	3.33%	0.60%	1.56%	High	CLA Homeowners
STREAMS LAKES	Wetland Restoration, Water and Sediment Control Basin	1.8	ac.	$ 46,875	361	78	41	3.09%	2.94%	3.52%	High	CLA Landowners
STREAMS LAKES	Shoreline Stabilization	6,100	ft.	488,000	16	8	8	0.14%	0.29%	0.66%	Medium	CLA Homeowners
STREAMS LAKES/ URBAN	Wetland Restoration	28	ac.	360,000	39	11	5	0.33%	0.40%	0.39%	Medium	CLA Landowners
STREAMS LAKES	Urban Filter Strip	1	ac.	$ 7,500	5	1	0.23	0.04%	0.04%	0.02%	Low	CLA Homeowners
URBAN	Permanent Vegetative Cover	16.4	ac.	$ 123,000	19	1.23	0.26	0.16%	0.05%	0.02%	Medium	Lot owners
URBAN	Urban Stormwater Wetlands	3	ac.	$ 22,500	44	12	4	0.38%	0.45%	0.36%	Medium	CLA
URBAN	Porous Pavement	1	ac.	$ 283,140	15	1	0.47	0.13%	0.04%	0.04%	Medium	CLA Homeowners Villages County
URBAN	Rain Gardens	102	sites	$ 255,000	1.3	0.5	0	0.01%	0.02%	0.00%	Low	Homeowners
RURAL	Nutrient Management Plan	516	ac.	$ 43,860	965	239	0	8.27%	9.02%	0.00%	High	Landowners
RURAL	Conservation Tillage	158	ac.	$ -	418	104	194	3.58%	3.94%	16.60%	High	Landowners
RURAL	Grassed Waterway	4	ac.	$ 20,000	174	87	87	1.49%	3.28%	7.43%	High	Landowners
RURAL	Land Protection	10	ac.	$ 25,000							Low	Conservation Groups Landowners
Totals				**$1,984,875**	**2562**	**618**	**417**	**22%**	**23%**	**36%**		

*CLA – Candlewick Lake Assoc.

Recommended Projects and Practices for each Best Management Practice

Streambank Stabilization

Streams and Lakes Campaign –

Repair banks along streams that have the most severe erosion problems.

We want to repair the banks along streams that have the most severe erosion to protect the stream bank from further scour and erosion. We can accomplish this by reducing the force of water against the bank and increasing the resistance of a bank to erosive forces using vegetative plantings, soil bioengineering, and/or structural systems. Some examples of methods that can be used are stormwater reduction; grade reduction; concrete, rip rap, stone toe protection; coir fiber logs with vegetative slope; and native plant installation.

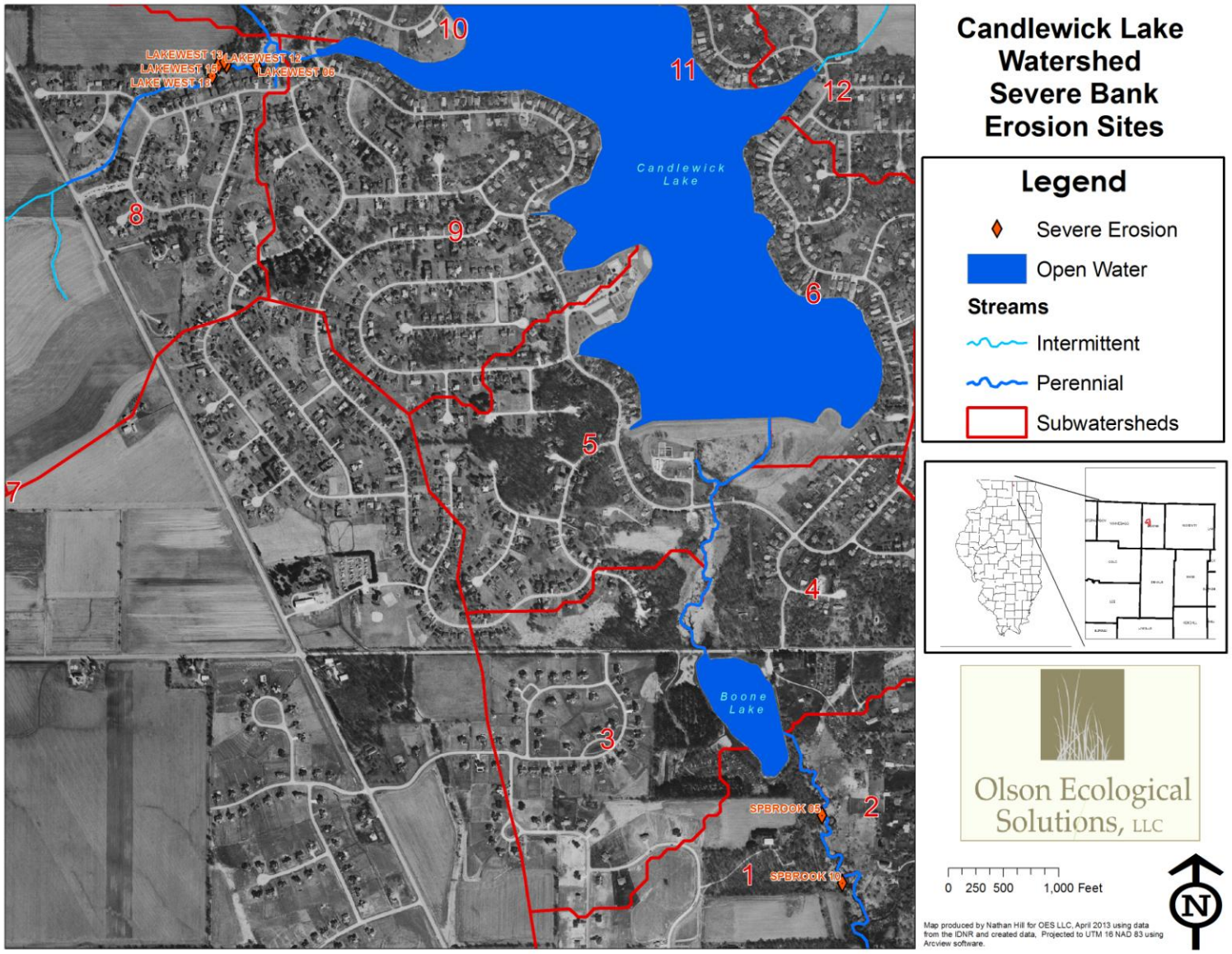
An eroding shoreline at Candlewick Lake (left).

Coir fiber logs with vegetative slopes stabilize streambanks and shorelines in areas with low flow and no wave action (right).

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
575 ft.	$ 46,000	118	59	59	1.01%	2.22%	5.04%	High	Landowners	8	1,2,8	18,329 ft.

This project addresses all objectives of Goals 1 and 2.

Figure 4-3: Project locations for repairing the most severe erosion along streams in the watershed.



Grass-lined Channels

Urban Campaign –

Create bio-swales closest to inlets feeding Candlewick Lake, and then throughout the Candlewick Lake community.

We recommend creating bio-swales closest to the inlets feeding Candlewick Lake. A **bio-swale** is a wide, gently sloped area that allows water to flow through it and holds water during and after a rain event. It is vegetated with native species. It acts as a sponge, allowing some of the water to seep down into the ground and the rest to be filtered by the native vegetation that grows in it. The ground will act as a filter, and water entering the lake as groundwater will be cleaner than if it had flowed directly over the surface without as much time for pollutants to settle out. This will, over time, help reduce the pollution in Candlewick Lake.

Other opportunities for bio-swales may exist in the watershed. As we focus on the Candlewick Lake community as a potential project area, we do not want to dismiss the potential for a bio-swale to be effective elsewhere in the watershed.

**This project was one of the "Top 3" priority projects according to planning participants.*

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
0.6 ac.	$ 264,000	388	16	18.3	3.33%	0.60%	1.56%	High	CLA Homeowners	9	5,6,9,10,11,12	30.6 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-4: Project locations for bio-swales closest to the inlets feeding Candlewick Lake.

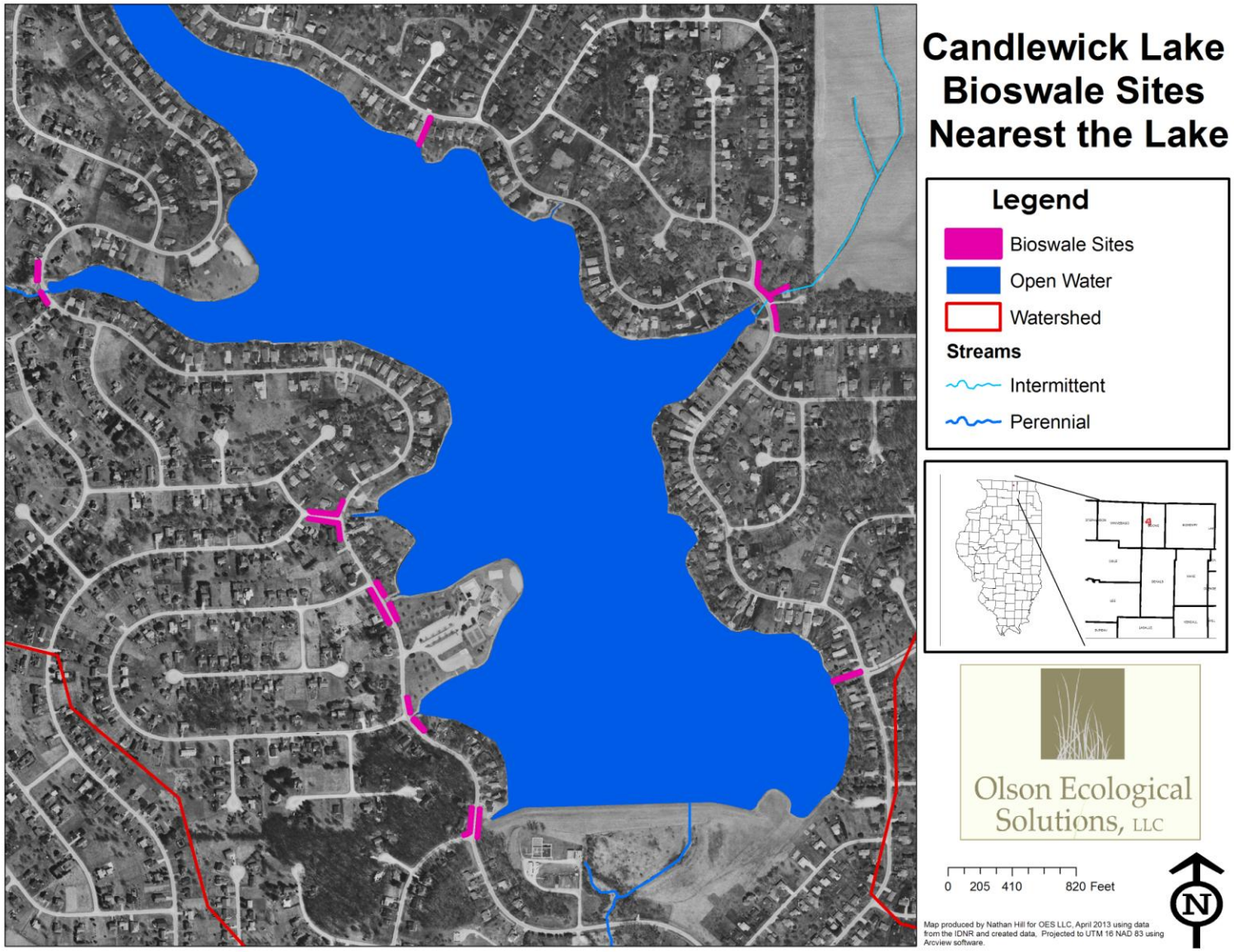
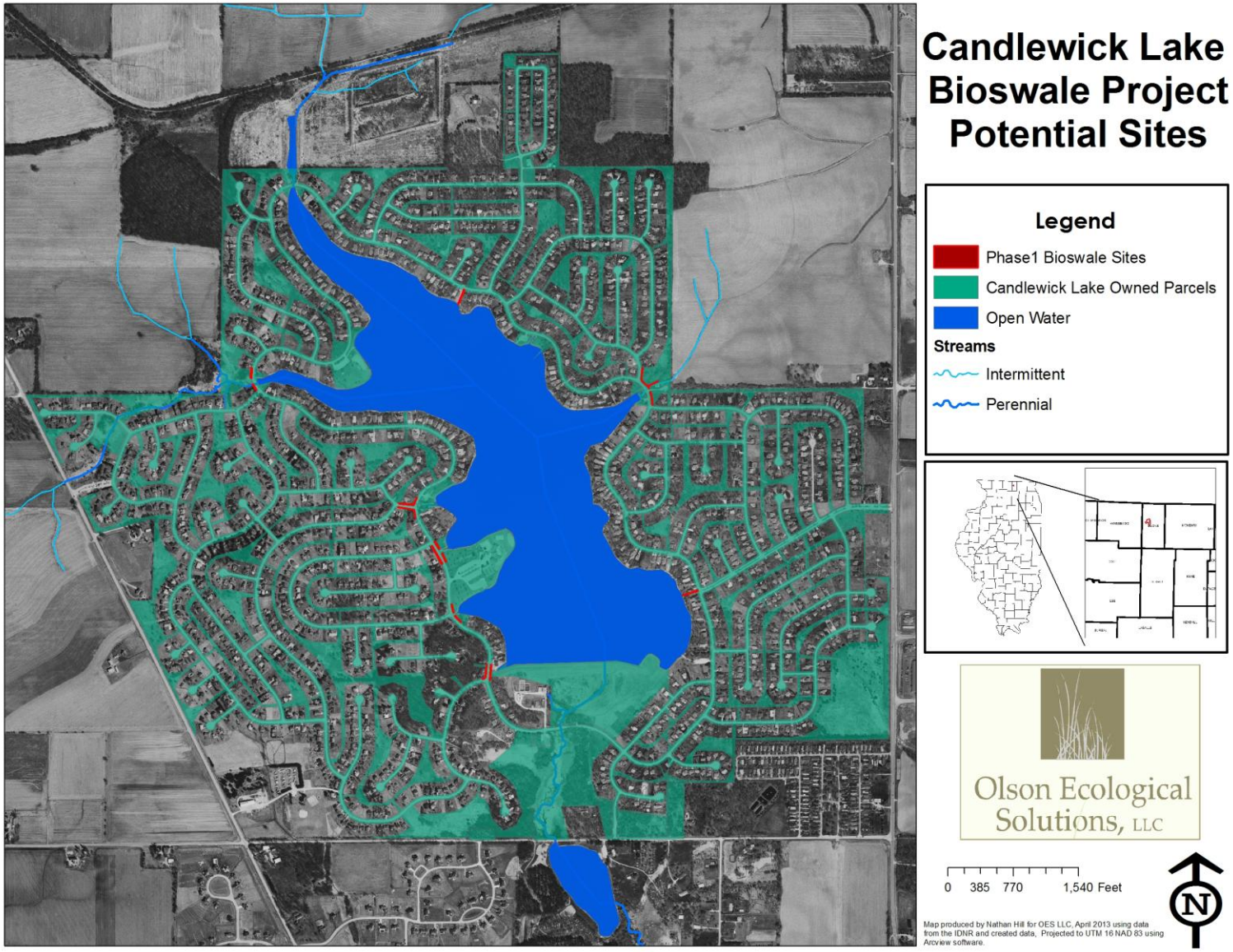
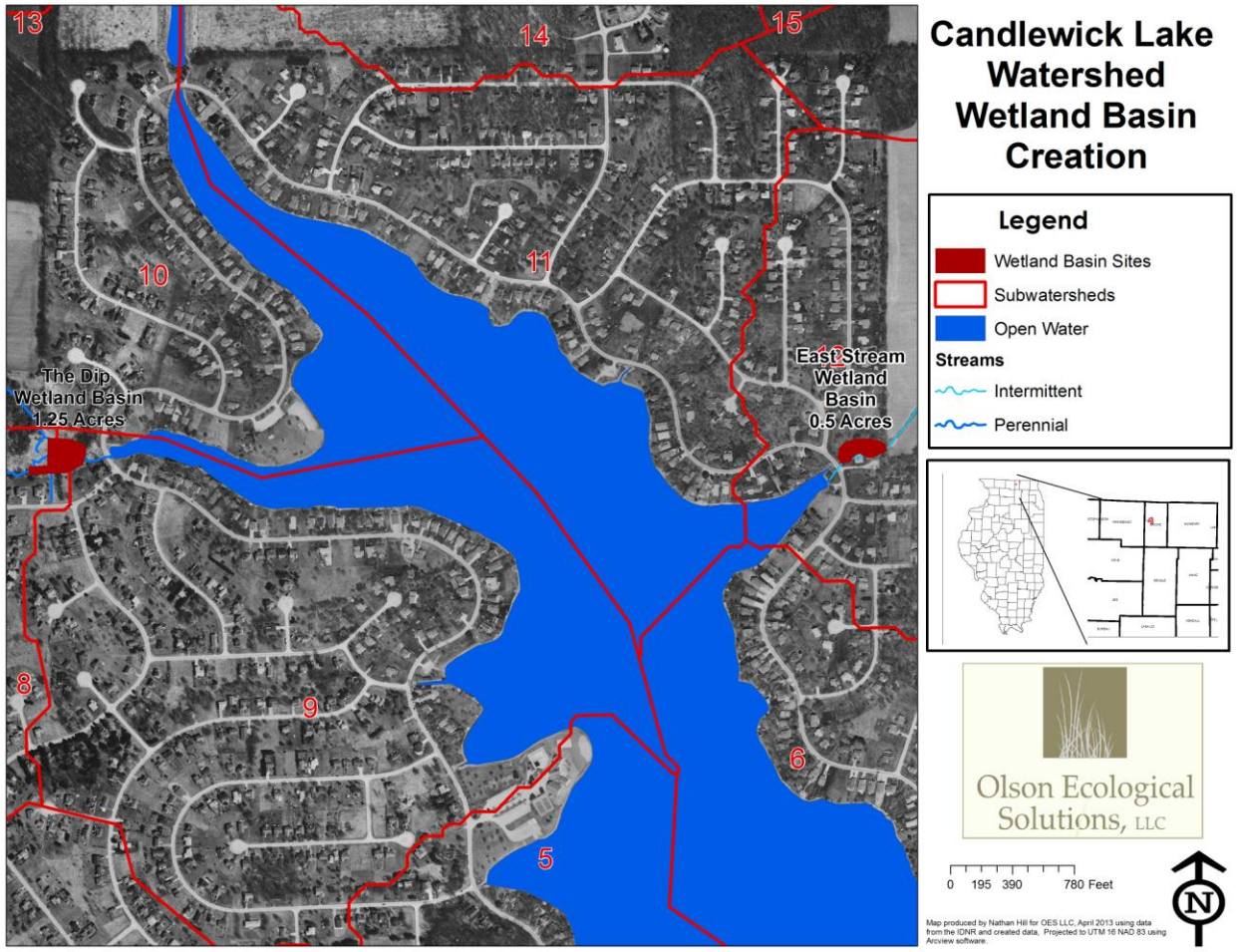


Figure 4-5: Project locations for bio-swales throughout the Candlewick Lake community.



Wetland Restoration with Water and Sediment Control Basins

Figure 4-6: Project locations for wetland restoration with water and sediment control basins



There are two areas upstream of Candlewick Lake that have potential for constructing wetlands and basins: the eastern stream and "the Dip" along the western stream. We recommend that Candlewick Lake Association have control of these projects, as the lake benefits from them the most. These projects will likely take up a lot of space, so the Candlewick Lake Association may have to buy land or enter into agreements with landowners in order to build them. The two projects associated with the areas on this map are described below.

Constructed wetlands around a basin were created by Olson Ecological Solutions (Hoffman).

Streams and Lakes Campaign –

Along the eastern stream that enters Candlewick Lake, create artificial wetlands and build a basin for water to travel through before entering the lake to filter out pollutants.

It is best to stop pollution where it is originating. However, that is not always possible. When everything has been tried upstream, there's still opportunity to filter out pollutants after they leave the source location and before they reach the lake.

We recommend treating the eastern stream with artificial wetlands, basin, and drainage system.

Artificial or constructed wetlands mimic natural wetlands in their ability to remove sediment, nutrients, and heavy metals from the water. Artificial wetlands do not necessarily have the same hydrologic regime as naturalized wetlands and are therefore termed differently.

We use the term basin to describe a depression dug along a drainage path to hold water. We intend to use basins to hold water only during large storms and let it out slowly to protect downstream drainage areas from eroding. Basins do not effectively capture fine particles like silt and clay, so they have limited potential to improve the water quality of the water that they are holding.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATER SHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
0.5 ac.	$ 17,500	83	21	8.9	0.71%	0.79%	0.76%	High	CLA Landowners	12	12	0.5 ac.

This project addresses all objectives for Goals 1 and 2 and Objectives 3 and 4 of Goal 3.

Streams and Lakes Campaign –

At "the Dip," redesign water flow and create artificial wetlands and a basin for water to travel through before entering the lake to filter out pollutants.

"The Dip" is an area that has been recognized by residents as a source of pollution to the lake and by the *Beaver Creek Watershed Action Plan* as a "Protection/Restoration Priority Area." Past efforts have routed water through it, and it continues to be a problem area. We recommend reattaching the stream to its associated floodplain and diverting the normal water flow through a system of constructed wetlands and a basin within the floodplain that will filter nutrients and sediments from the water before the water is metered out slowly into the lake. A drainage system will likely be necessary, such as a tile system or water control structure.

**This project was one of the "Top 3" priority projects according to planning participants.*

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
1.25 ac.	$ 29,375	278	57	32.3	2.38%	2.15%	2.76%	High	CLA Landowners	8	8,10	1.25 ac.

This project addresses all objectives for Goals 1 and 2 plus Objectives 3 and 4 of Goal 3.

Shoreline Stabilization

Streams and Lakes Campaign –

Stop erosion along any shoreline at Candlewick Lake with bare soil exposed.

Most of the Candlewick Lake shoreline (88%) has been stabilized with rock (rip rap). For the remaining 12% of shorelines that still have exposed, bare soil that is eroding, we would like to stop the erosion either by planting with native vegetation or covering the soil with a rock treatment like rip rap or stone toe protection. Other bioengineering techniques may also be helpful. In calmer areas, wetlands can emerge into the water and further protect the shoreline. In areas with a current, root wads or rock outcroppings could slow the water down so that it will not scour the shoreline. Reducing the slope down to the water may also be an effective possibility in some areas.

**This project was one of the "Top 3" priority projects according to planning participants.*

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
3,000 ft.	$ 240,000	7.7	3.8	3.8	0.07%	0.14%	0.32%	Medium	CLA Homeowners	11	5,6,9,10,11	24,987 ft.

This project addresses all objectives of Goals 1 and 2.

Streams and Lakes Campaign –

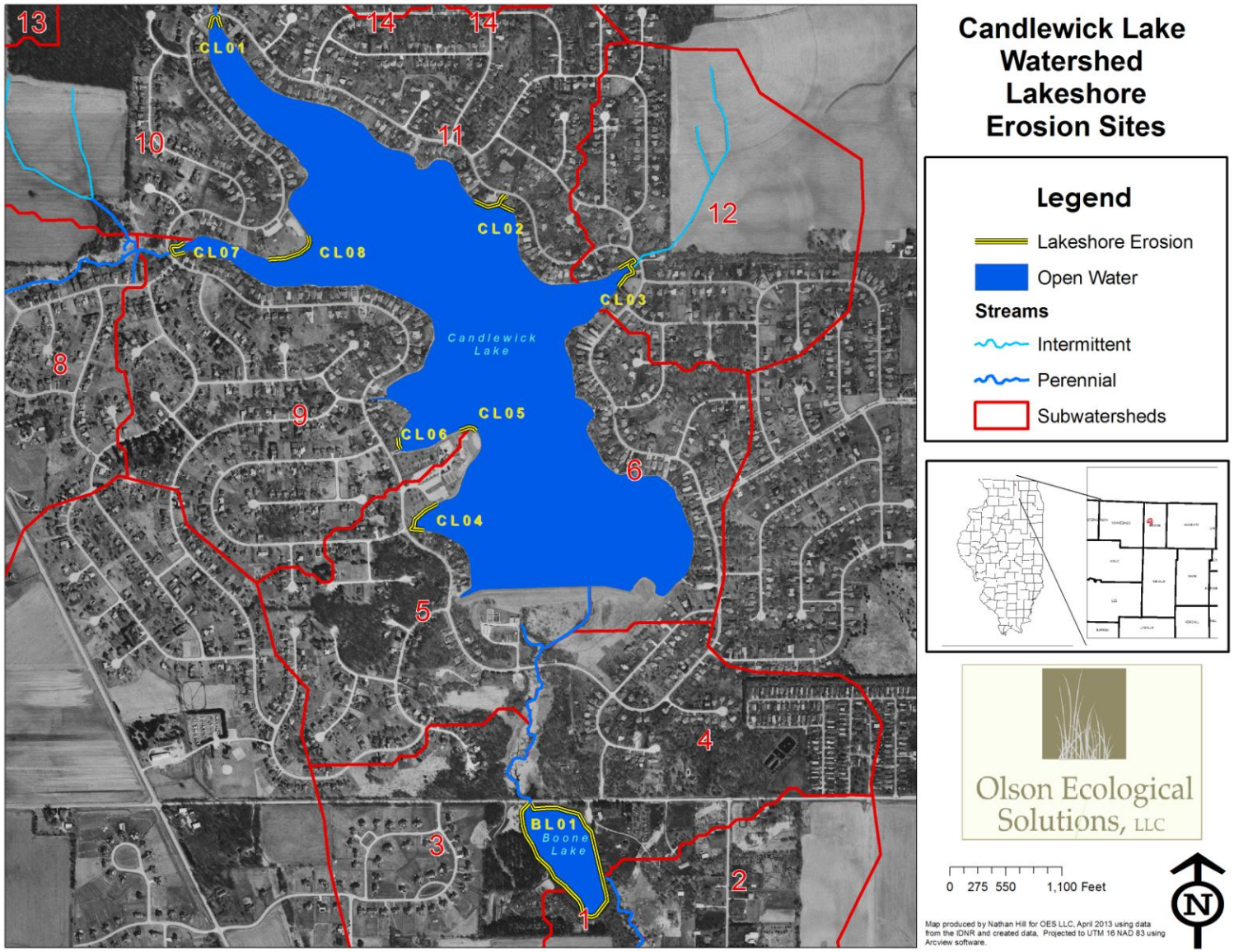
Stop erosion along shorelines with bare soil exposed at Boone Lake.

The shorelines surrounding Boone Lake are eroding at a slight rate. The bare, exposed soil averages about one-foot high all the way around the lake.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
3,100 ft.	$ 248,000	7.9	4	4	0.07%	0.15%	0.34%	Medium	Homeowners	N/A	1,3,4	3,100 ft.

This project addresses all objectives of Goals 1 and 2.

Figure 4-7: Locations of shoreline in need of repair at Candlewick and Boone Lakes.



Wetland Restoration

Streams and Lakes Campaign –

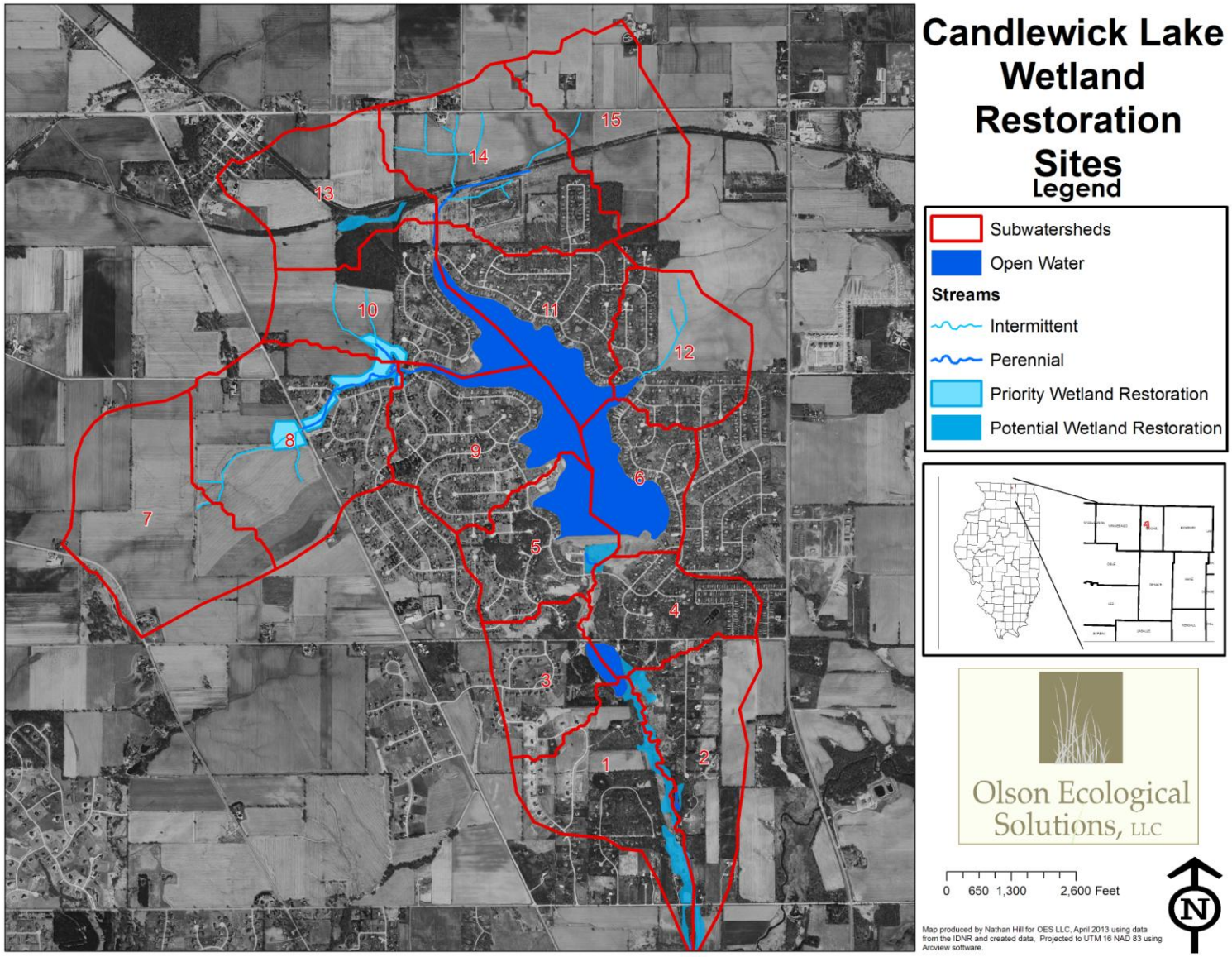
Create wetlands to filter pollution.

Wetlands act as natural buffers between land and water bodies. They filter nonpoint source pollutants such as nitrogen, phosphorous, and sediment, and they also filter pathogens and metals. Preserving and restoring wetlands can improve the water quality of adjacent streams and lakes and decrease the need for costly storm water and flood protection structures and facilities.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
13 ac.	$ 97,500	17.9	5	2.1	0.15%	0.19%	0.18%	Medium	Landowners	8	8,10	70.4 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-8: Locations of potential wetland restoration sites throughout the watershed.



Streams and Lakes Campaign –

Acquire land and install wetlands or other means of filtering pollution between the sources of pollution and Candlewick Lake.

To compliment the efforts to construct wetlands, a basin, and a drainage system along the eastern stream and "the Dip" along the western stream feeding Candlewick Lake, we recommend purchasing as much area as possible surrounding these other constructed features and restoring it to wetland. Doing so will further filter pollutants as they travel downstream. There are a total of 15 acres available at the two project sites. Just west of "the Dip," there are ten acres of wooded wetland that could be enhanced with better quality, native vegetation and cropland that could be converted to wetland. East of Whiting Park along the eastern stream, there are five acres of cropland that could be converted to wetland.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
15 ac.	$ 262,500	20.7	5.7	2.43	0.18%	0.21%	0.21%	Medium	CLA	8	8,10,12	15 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-9: Locations of potential land acquisition and wetland restoration sites associated with projects at the eastern stream and “the Dip” along the western stream.

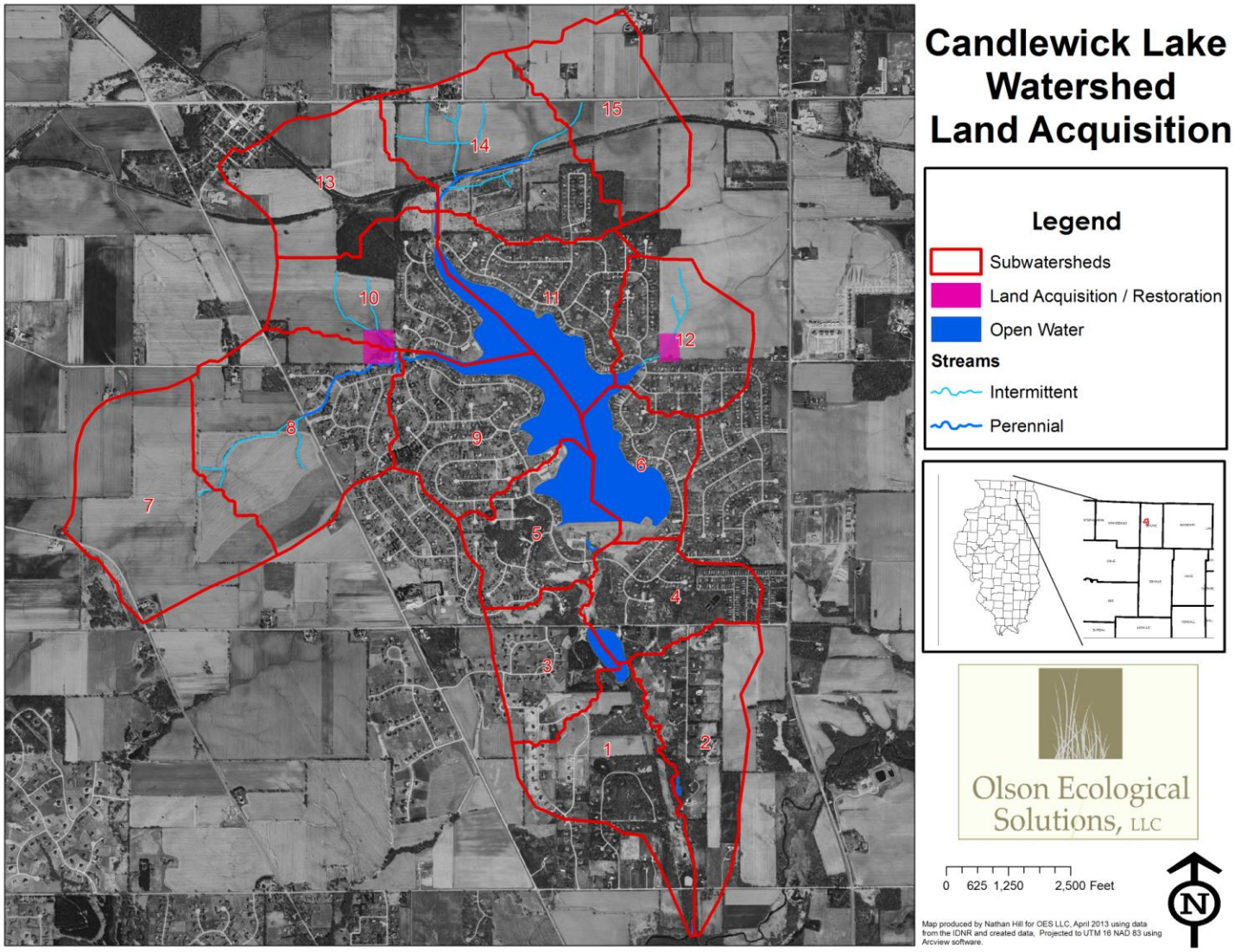
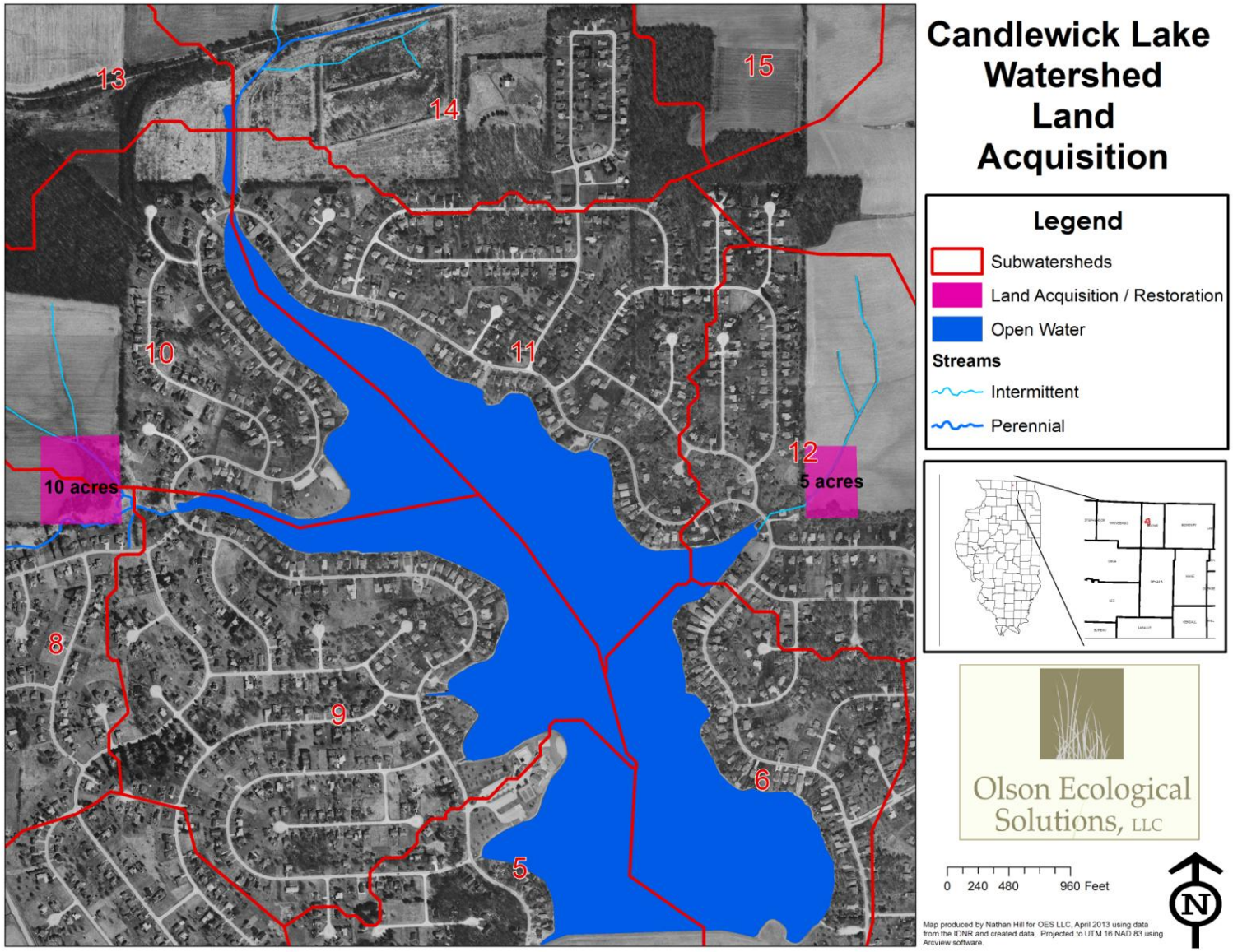


Figure 4-10: Close-up of locations for potential land acquisition and wetland restoration as identified in Figure 4-9.

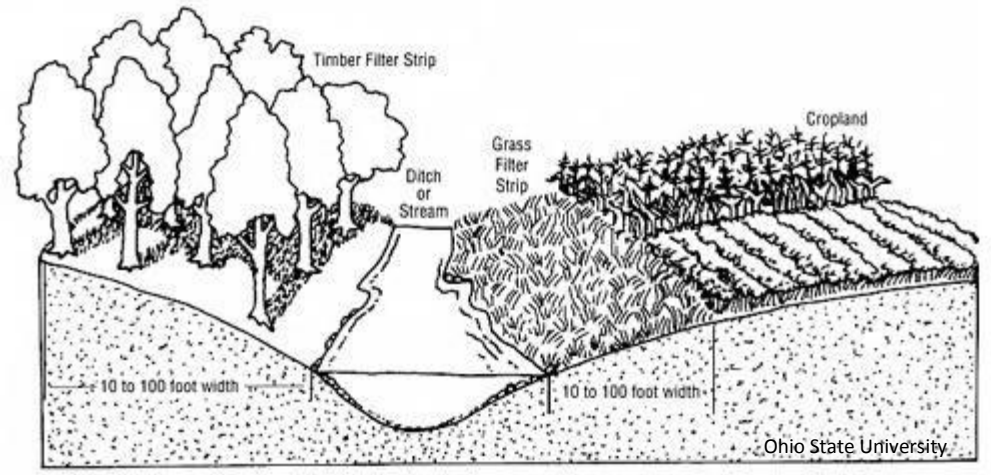


Urban Filter Strip

Streams and Lakes Campaign –

Continue to plant native vegetation around lake shores and inlets to filter incoming pollution.

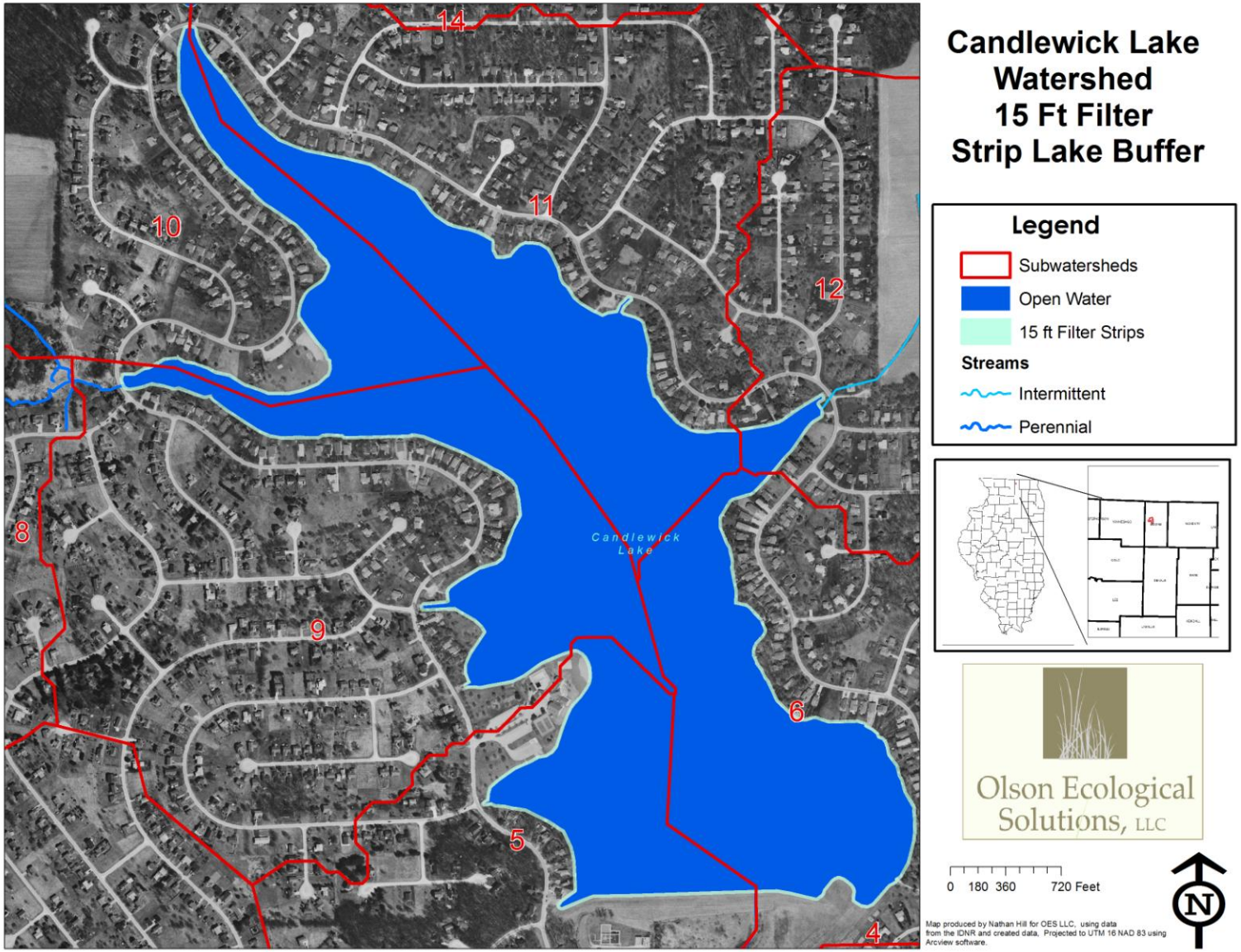
We suggest that the effort of planting native vegetation be continued around the lake shores and inlets to filter incoming pollution. The more areas we are able plant native vegetation near the water, the more opportunities we provide for the water to be filtered and will reduce the pollution entering Candlewick Lake. We recommend for each strip of native vegetation to be as wide as the space will allow, with a 15-foot minimum.



Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATER SHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
1 ac.	$ 7,500	5	1	0.226	0.04%	0.04%	0.02%	Low	CLA Homeowners	N/A	5,6,9,10,11	10.2 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-11: Locations of filter strips surrounding Candlewick Lake.



Permanent Vegetative Cover

Urban Campaign –

Change land use from mowed and unmanaged areas to prairie and wetlands on lots nearest to Candlewick Lake.

Mowed and unmanaged areas have some capacity to filter runoff, but this ability can be improved by instead planting native vegetation. Their extensive root systems change compacted soil into spongy earth that is able to soak in more rain water.

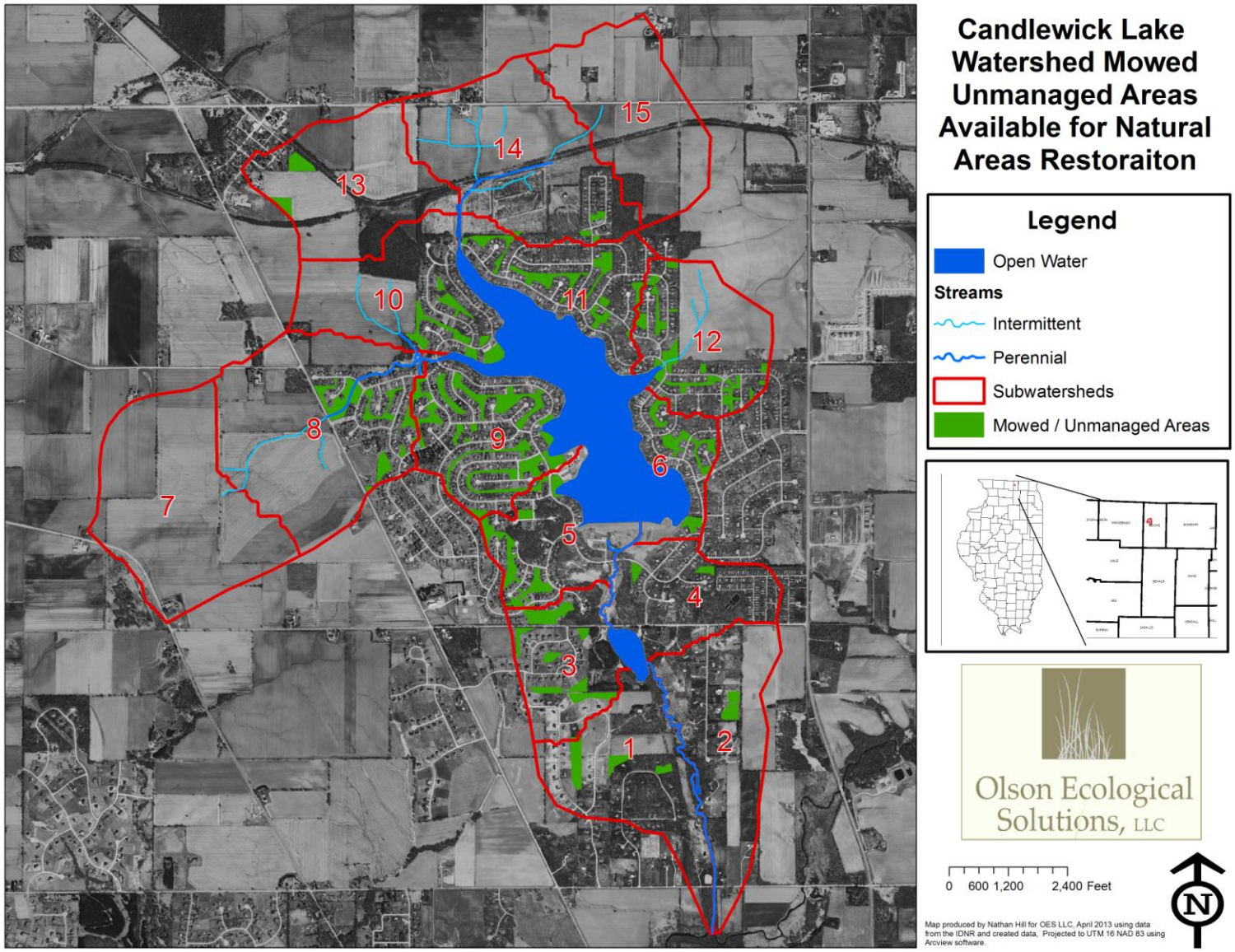
In addition to improving water quality, changing areas that are unmanaged or that only have mowed grass into prairie and wetland provides habitat for wildlife including important pollinators and makes the area more interesting and beautiful. This includes unused lawn spaces.

There are 164 acres of mowed and unmanaged areas within the watershed. We recommend a goal to treat 10% of them, or 16.4 acres.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
16.4 ac.	$ 123,000	18.5	1.23	0.26	0.16%	0.05%	0.02%	Medium	Lot owners	9,11	1,2,3,4,5,6,8,9,10,11,12	164 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-12: Locations of mowed and unmanaged areas within the watershed.



Urban Stormwater Wetlands

Urban Campaign –

Within existing, mowed storm water detention basins, plant native vegetation and install other features to filter pollution from the water.

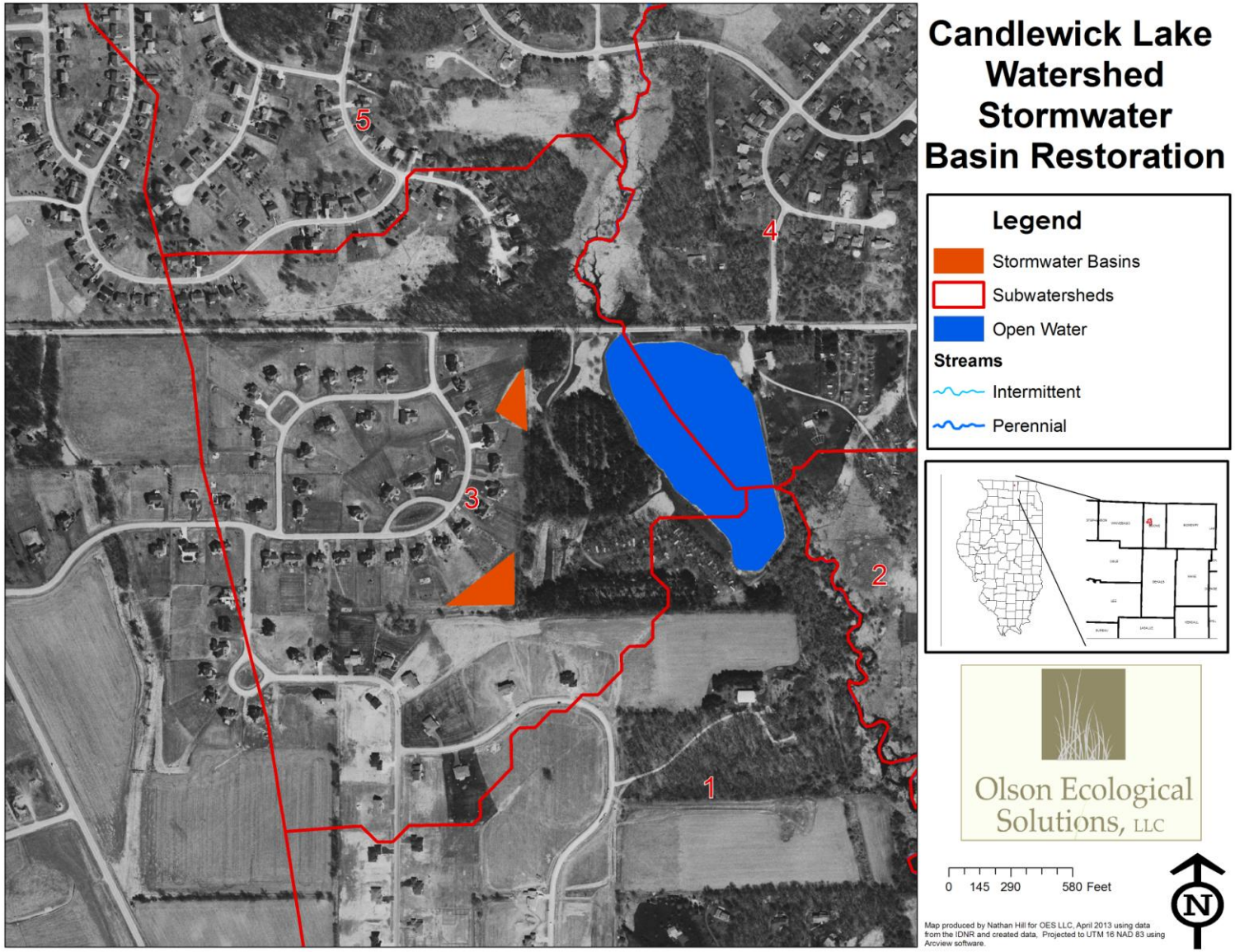
Stormwater detention basins already collect storm water and release it at a controlled rate so that downstream areas are not eroded or flooded. Existing storm water basins within the watershed are covered with mowed grass. By planting native vegetation instead, the ability of the basin to filter pollutants from the water will increase.

Two existing storm water basins are located within a subdivision just west of Boone Lake in Timberlane. Together they are three acres in size. We recommend a goal of planting both of them with native vegetation, as they are likely under the same ownership and therefore can be treated together as one project.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
3 ac.	$ 22,500	44	12	4.2	0.38%	0.45%	0.36%	Medium	CLA	3	1,3	3 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-13: Locations of existing storm water detention basins in the watershed.



Porous Pavement

Urban Campaign –

When pavement needs to be replaced or expanded, use pervious surfaces that allow water to percolate through or use another means of treating the storm water from the paved area.

Pavement typically does not allow water to penetrate. Instead, water sheets off of pavement and is directed either into a drain or open ditch, or simply over a grassy area along the side of the paved area and into the nearest waterway. Water leaving the pavement carries with it oil and grease from vehicles and other pollutants.

There are other products, referred to as **permeable paving,** that allow storm water to seep through its base and subbase and percolate into the soil below. Examples of permeable paving materials include pervious concrete, porous asphalt, paving stones, and concrete pavers. They can be used to pave lightly trafficked roads, parking lots, sidewalks and driveways. Although they look similar to conventional materials, they reduce runoff, trap sediment, and filter pollutants, effectively controlling storm water at the source.

There are over 100 acres of impervious surfaces in the watershed. There are about 75 acres of roads, 25 acres of driveways, and a 1.8-acre parking lot at the Candlewick Lake Recreation Center. We chose a goal of resurfacing only one acre with porous pavement because of the uncertainty of the schedule to re-pave these surfaces.

Target Area		Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATER SHED	All Subwatersheds	Total Opportunity Area Available	
			N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)						
1	ac.	$ 283,140	15	1	0.47	0.13%	0.04%	0.04%	Medium	CLA Homeowners Villages County	5	5,9	100	ac.

This project addresses all objectives of Goals 1 and 2 and Goal 3 Objective 4.

Rain Gardens

Urban Campaign –

Create rain gardens in lawns of homes and common areas within the watershed.

Rain gardens are gardens planted with native, water-loving vegetation in low areas of lawns or common areas. Storm water runoff from rooftops and paved surfaces are directed into the rain garden. The storm water is filtered by the native vegetation, and some of it is absorbed into the soil.

There are 2,040 homes within the watershed. We chose a goal to construct rain gardens for 5% of these homes, or 102 rain gardens. An average size of 1,000 square feet was used for calculating pollution reduction estimates. The actual size of a rain garden considers the amount of impervious surface that is draining into it and the permeability of the soils.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
102 sites	$ 255,000	1.3	0.5	0	0.01%	0.02%	0.00%	Low	Homeowners	9	1,3,8,9,10,11,12,	2,040 sites

This project addresses all objectives of Goals 1 and 2 and Goal 3 Objective 3.

Nutrient Management Plan

Rural Campaign –

Use nutrient management plans on crop fields within the watershed.

Nutrient management plans are used by farmers to manage the amount, form, placement, and timing of fertilizer application to their crop fields. They aim to supply enough nutrients to plants for optimum yield without having excess left in the soil. This minimizes nonpoint source pollution to streams and lakes and contamination of groundwater.

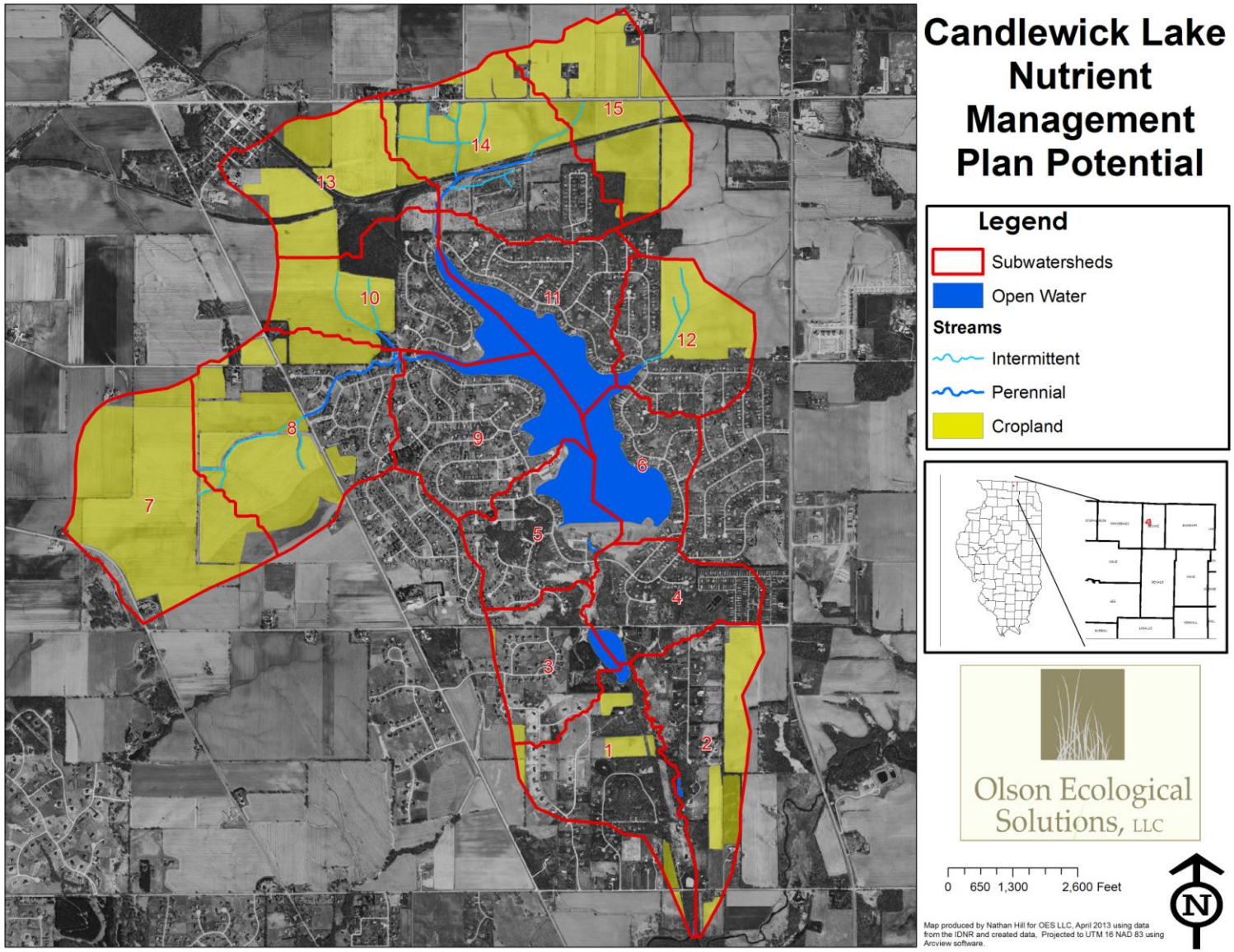
We recommend enhanced nutrient management planning, which involves soil testing and plant tissue testing to determine how much nutrients are already within the system, how the plants are using the nutrients, and how much more is needed for optimum yield. The Boone County Soil and Water Conservation Service offers a cost share for this type of nutrient management planning in the amount of $52.14 per acre, which we estimate to be 64% of the total cost of $85 per acre (Bonham et. al.).

The Boone County Soil and Water Conservation District is not aware of any farmers within the watershed with nutrient management plans. Therefore, we assume that all 1,032 acres of cropland in the watershed are eligible. We propose a goal of half this acreage being treated with nutrient management plans. Doing so will have a significant impact, accounting for more than an 8% reduction in nitrogen and 9% reduction in phosphorous for the watershed.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
516 ac.	$ 43,860	965.4	239.2	0	8.27%	9.02%	0.00%	High	Landowners	7	1,2,7,8,13,14,15	1,032 ac.

This project addresses all objectives of Goal 2.

Figure 4-14: Locations of croplands within the watershed that are eligible for nutrient management plans.



Conservation Tillage

Rural Campaign –

Use conservation tillage or no-till on crop fields throughout the watershed.

Conservation tillage is any method of soil cultivation that leaves the previous year's crop residue, like corn stalks or wheat stubble, on the field before and after planting the next crop. To realize a conservation benefit, at least 30% of the soil surface should be covered with residue after planting the next crop. **No-till** is a type of conservation tillage in which the farmer plants crops directly into residue that hasn't been tilled at all.

Conservation tillage improves both soil and water quality. It adds organic matter to the soil, conserves water by reducing evaporation at the soil surface, and reduces erosion and soil loss. Crop residues also provide food and cover for wildlife.

We conducted a drive-by survey of farming practices within the watershed, and we found that all but 158 acres were already being treated with conservation tillage. We recommend that the remaining 158 acres be converted to no-till farming practices. Doing so will make a significant reduction of sediment in our streams and lakes.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
158 ac.	$ -	417.8	104.4	194.2	3.58%	3.94%	16.60%	High	Landowners	14		158 ac.

This project addresses all objectives of Goals 1 and 2.

Grassed Waterway

Rural Campaign –

Address cropland gully erosion by installing grassed waterways.

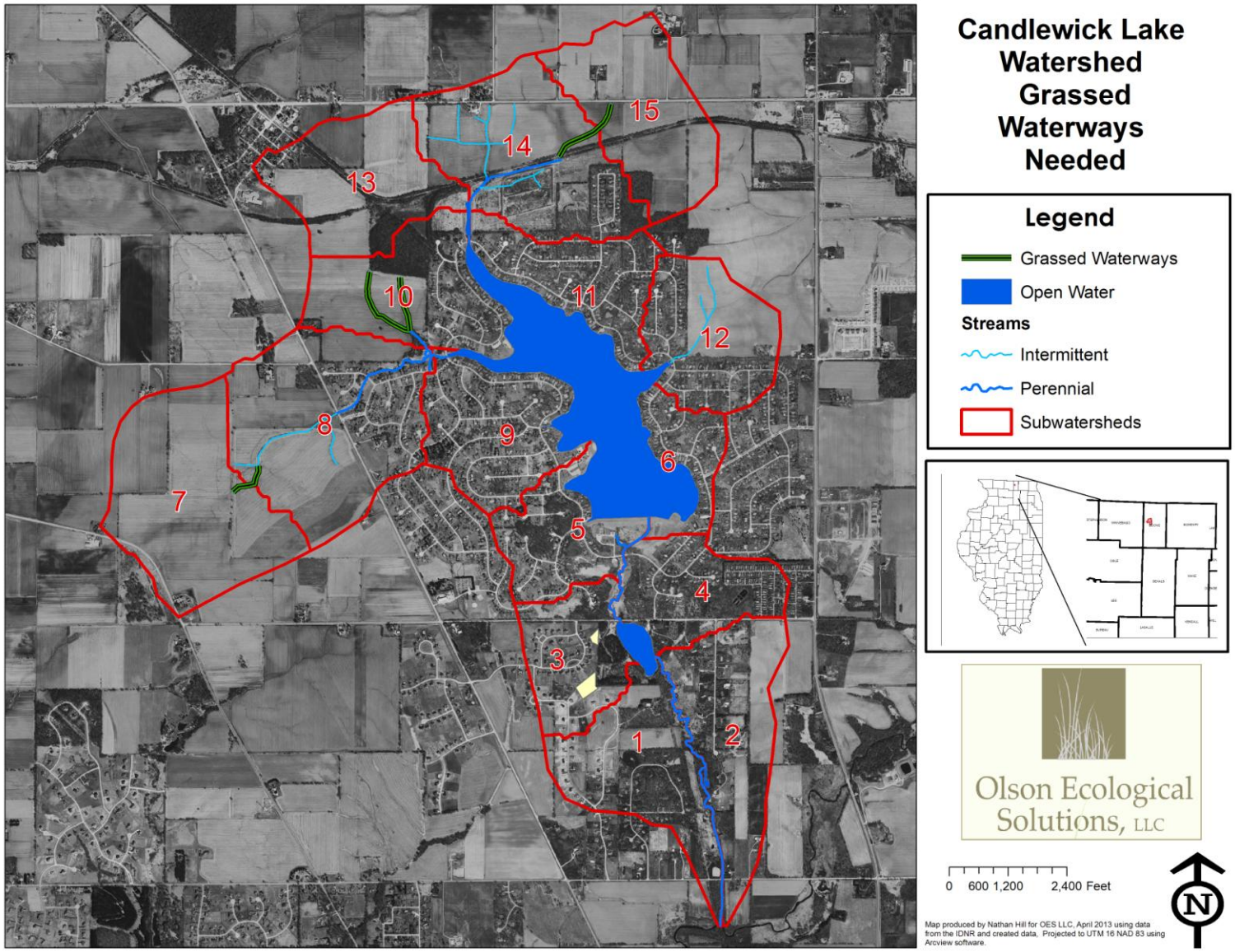
Grassed waterways are a specific type of conservation buffer that is located next to or within crop fields to drain runoff from the fields. They are generally broad and shallow and vegetated with perennial grasses like timothy and orchard grass. They prevent soil erosion, especially in areas of concentrated flow, and therefore protect water quality. They also filter pollutants before they enter the stream that drains the area.

There are opportunities within the watershed to create four acres of grassed waterways to treat ephemeral gully erosion. A length of 5,445 feet of gully erosion was identified using a Spring 2014 survey and aerial photography. Along this total length, waterways would average 32 feet in width. Within these targeted areas, gullys averaged 0.5-foot deep with a width of 0.5 foot at the bottom and 1 foot at the top. We recommend a goal of treating all four acres. This will significantly reduce pollutants and will filter over 7% of the current sediment loading in the watershed.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
4 ac.	$ 20,000	173.7	86.9	86.9	1.49%	3.28%	7.43%	High	Landowners	8	8,10,	4 ac.

This project addresses all objectives of Goals 1 and 2.

Figure 4-15: Locations of opportunities to create grassed waterways within the watershed.



Land Protection

Rural Campaign –

Secure permanent protection of open space from willing landowners that provide multiple benefits to water quality, water supply, and recreation and ecological connectivity.

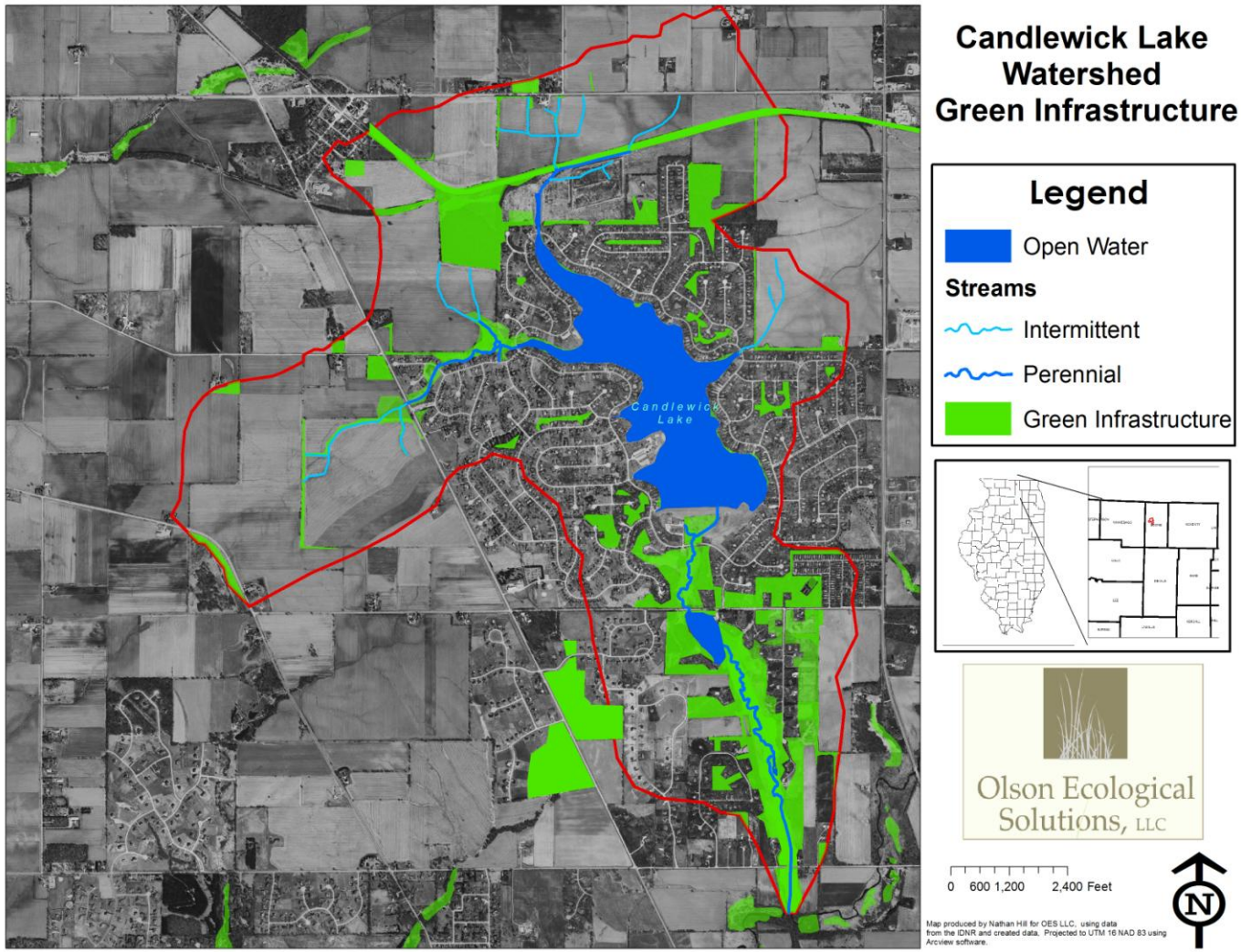
To support all of the recommendations in this plan, we recommend permanently protecting all lands that contribute to improving water quality, assuring a consistent water supply to Candlewick Lake. This includes sites of the conservation projects recommended above and properties that allow for recreation and ecological areas to connect to one another.

This recommendation doesn't have its own estimates for reducing pollution in our lakes and streams because it supports projects that provide the water quality benefits as projected above.

Target Area	Cost est.	Pollution Reduction Estimate			% Pollution Reduction in Watershed			Priority	Responsible Entity	PRIORITY SUBWATERSHED	All Subwatersheds	Total Opportunity Area Available
		N (lbs/yr)	P (lbs/yr)	Sediment (tons/yr)	N (%)	P (%)	Sediment (%)					
10 ac.	$ 25,000							Low	Conservation Groups Landowners	1,2		52 ac.

This project supports all objectives of Goals 1 and 2, Goal 3 Objective 3, and Goal 4 Objective 3.

Figure 4-16: Land protection opportunities to support water quality, water supply, and recreation and ecological connectivity.



Other Recommended Implementation Projects and Best Management Practices

In addition to the projects and practices recommended above, we recommend a few more for which it was difficult to estimate the water quality benefits and pollution reduction potential.

Urban Campaign –

1. Change from traditional lawn care practices to conservation methods, especially for lawns closest to lakes and streams (addresses all objectives of Goal 2).

Rural Campaign –

1. Create filter strips to filter pollution (addresses all objectives of Goals 1 and 2).
2. Add filters to the ends of drain tiles coming from crop fields (addresses all objectives of Goal 2).
3. Replace invasive vegetation that contributes to soil loss with native vegetation that holds soil in place with their extensive root systems (addresses all objectives of Goals 1 and 2).

Future Development Campaign –

1. Determine the amount of pollution to be expected from a new development and plan for filtering these pollutants before they reach the lake (addresses all objectives of Goal 4).
2. Design features to filter out pollutants and detain and slowly release storm water in new construction, such as filter strips, bio-swales, constructed wetlands, permanent vegetative cover, rain gardens, porous pavement, and naturalized detention basins, especially upstream of other project sites (addresses all objectives of Goals 1, 2, and 4 and Goal 3 Objectives 3 and 4).
3. Local municipalities, working with developers and residents, preserve a consistent, healthy supply of water to Candlewick Lake in light of future development under their jurisdiction (addresses Goal 3 Objective 4).

Recommended Education and Public Outreach Projects and Programs

Below, education and outreach projects are presented by campaign after a summary of resources and target audiences.

Education Resources – In addition to the Executive Summary of this plan, the following resources will be helpful in conducting the outreach plan:

- Best Management Practices Stormwater (Environmental Protection Agency)
  http://www.epa.gov/nrmrl/wswrd/wq/stormwater/bmp.html
- Greenscapes Activities List (Environmental Protection Agency)
  http://www.epa.gov/wastes/conserve/tools/greenscapes/pubs/activities.pdf
- Stormwater Outreach Materials and Reference Documents (Environmental Protection Agency)
  http://cfpub.epa.gov/npdes/stormwatermonth.cfm
- Using Smart Growth Techniques as Stormwater Best Management Practices (Environmental Protection Agency)
  http://www.epa.gov/smartgrowth/pdf/sg_stormwater_BMP.pdf
- Ecological Planning and Design Directory (Chicago Wilderness)
  http://www.chicagowilderness.org/index.php/what-we-do/protecting-green-infrastructure/epdd-resources/
- Resources - Restoring Nature to Health and Protecting Green Infrastructure (Chicago Wilderness)
  http://www.chicagowilderness.org/index.php/resources#resources_restoring
- Conservation Choices (Iowa Natural Resource Conservation Services)
  http://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/newsroom/factsheets/?cid=nrcs142p2_008506
- A Guide to Environmentally-sound Practices for Wisconsin Farmers (U.S. Department of Agriculture)
  http://clean-water.uwex.edu/pubs/pdf/farmland.pdf

Targeted Audiences for Education and Outreach Projects and Programs

- The Streams and Lakes Campaign will target lakefront homeowners and streamside landowners.
- The target audiences for outreach programs within the Urban Campaign include homeowners; lot owners; landscape companies; homeowners' associations; and the staff, board, and leaders of the Candlewick Lake Association.
- Outreach for the Rural Campaign will target farmers and land managers.
- When educating people about the Future Development Campaign, we will target municipalities, developers, builders, and contractors.

Education and Outreach Projects per Campaign

The four campaigns help organize education and outreach projects, as each campaign has a different target audience. Some of the proposed activities may be the same for all, and others will be specific to the needs of each campaign.

All Campaigns –

1. Implement conservation projects and programs in cooperation with the Kishwaukee River Ecosystem Partnership, its participating organizations, and others interested in local conservation of land and water. Doing so will lead to a more uniform and efficient approach to conserving the land and water resources of concern (supports Goal 6 Objective 3).
2. Generate basic awareness of stormwater pollution by running feature articles in newsletters, email blasts, and websites (addresses all objectives of Goal 6).
3. Educate people on at a more sophisticated level with training sessions and live presentations (addresses all objectives of Goal 6).
4. Build on existing recognition to promote land and water use changes by providing opportunities for volunteerism and community engagement in conservation projects (addresses all objectives of Goal 6).
5. Leverage other programs and partner with community organizations, such as promoting events hosted by others, adopting a community-wide recognition program like Conservation@Home or Wildlife Habitat Council and engaging local high schools in conservation efforts (addresses all objectives of Goal 6).

Urban Campaign –

1. Educate homeowners about changing traditional lawn care practices to conservation methods, especially on lawns bordering streams and lakes (addresses Goal 6 Objectives 1-5).
2. Write a series of feature articles about good housekeeping and lawn care based in Integrated Pest Management principles. Distribute them by newsletter, email, and website (addresses Goal 6 Objectives 1-5).

Future Development Campaign –

1. Adopt a common, updated ordinance or intergovernmental agreement for Timberlane, Poplar Grove, Claedonia, and Boone County to protect water quality under the guidance of the most current Boone County Regional Stormwater Management Plan (addresses Goal 5 Objective 1).
2. Developers and municipal staff understand the value of creating features to filter pollutants out of our water and be aware of financial and technical assistance available (addresses Goal 6 Objectives 1-3 and 7).
3. Host an annual development summit to discuss new and innovative ways to develop land (addresses Goal 6 Objectives 1-3 and 7).

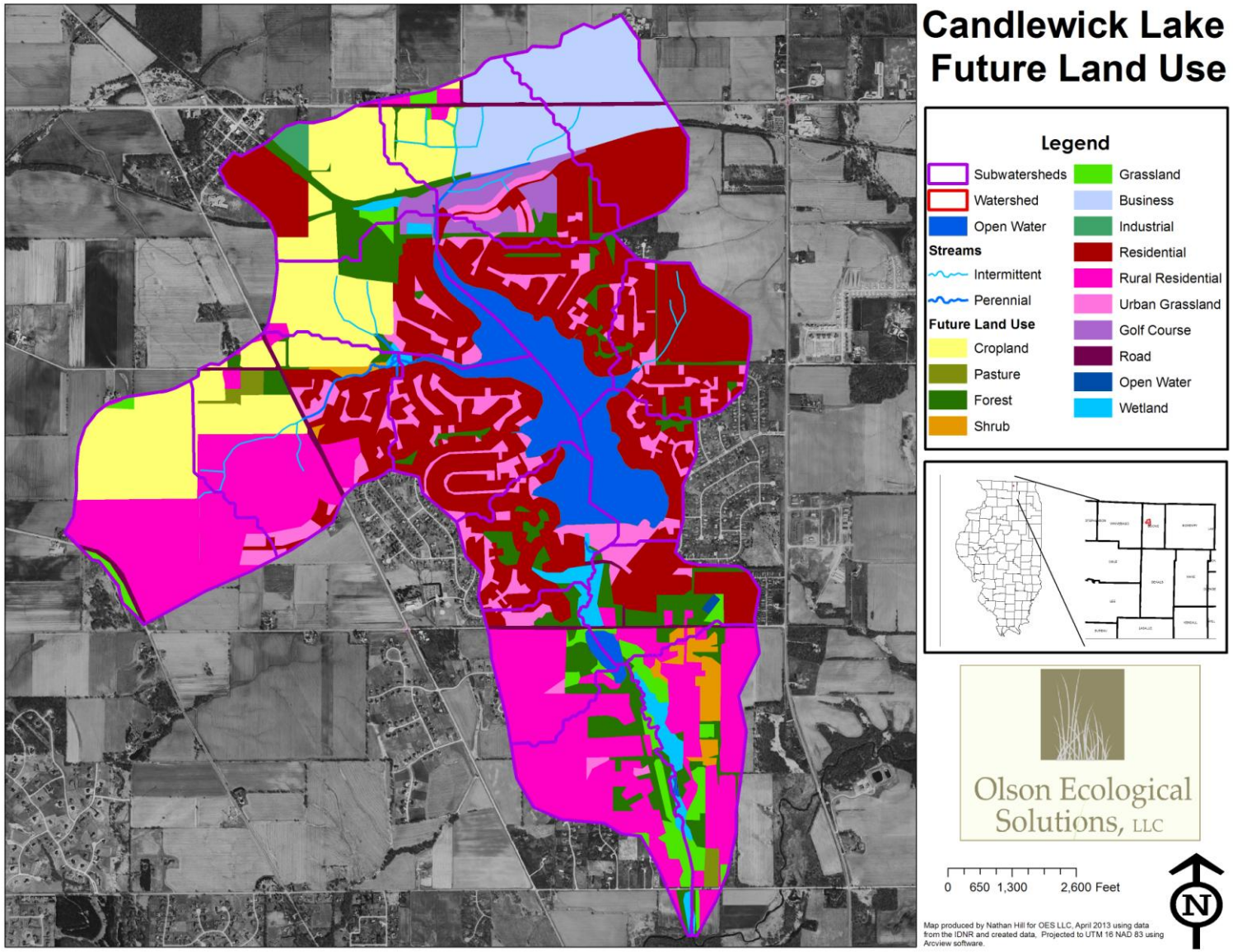
Future commercial and residential development is likely for all cropland in the watershed. One farm has been platted and approved for residential development, and others appear as residential and commercial uses on the Boone County Land Use Plan. When farmland is developed, we expect that the water coming from the developed areas will become more polluted unless measures are taken to combat pollution. However, development is not predicted to occur within the ten-year life of this plan. Therefore, we chose to focus on current conditions of the watershed as we assessed the potential for reducing pollution to our streams and lakes.

During this period of weak economic growth, it would be a strategic time to focus on developing policies and ordinances to support the principles of this plan. We recommend working with local villages, the county, and other decision makers to adopt common language in policies and ordinances that address cleansing stormwater discharged from developed areas. We recommend that this work be completed within the next five years in order to be prepared for the future development. This is a concern for an area greater than our watershed, and more recommendations can be found in the *Beaver Creek Watershed Action Plan.*

In addition to working with municipalities and decision-makers, the best way to get people who own houses, buildings, or land to invest in the features that filter pollutants, such as wetlands and prairies, is to start with the people who build and design the area. Landscapers and architects who build on these areas can include these features in the design. If included in the initial design, costs may be similar to designing conventional landscaping with fewer long-term management fees. Furthermore, the costs may be initially less than conventional designs if grants are sought and awarded.

Remember!!! It is important to remember that residential and commercial development is eminent in the future, and any implementation project or management practice pursued should consider the effects of future development and be designed to withstand pressure from the resulting additional stormwater.

Figure 4-17: Proposed future land uses within the watershed.



In-Lake Projects and Practices
Recommended by Integrated Lakes Management in 2011

In 2011, Integrated Lakes Management (ILM) offered a comprehensive look at water quality problems of Candlewick Lake and recommended solutions for improving them both inside and outside of the lake itself in the *Candlewick Lake Management Plan*. ILM focused on developing suggestions for dealing with pollution that is already present in the lake and stopping pollution coming from areas immediately adjacent to the lake. They also mentioned the importance of stopping pollution coming from sources further upstream and gave some examples.

Just as we recommend working to halt pollutants before they enter the lake, ILM also made such recommendations in their plan. We incorporate the suggestions of ILM, add more, structure them into projects and programs, estimate pollutant reductions, and estimate costs. We do not address the pollutants that are already in the lake, as ILM's plan covers these suggestions and the intent of our plan is to focus on proactive efforts of addressing pollution at its source.

We suggest that all recommendations for treatments in and around the lake offered by ILM continue to be followed. The in-lake recommendations that are not repeated within this plan are listed below for convenience. More information and details are provided within ILM's plan in Appendix A.

Streams and Lakes Campaign – √ = Completed and Ongoing

In-Lake Recommendations in *Candlewick Lake Management Plan 2011* by Integrated Lakes Management

Blue-green Algae Control

1. Educate lake users to tolerate an amount of aquatic weeds that improve lake health (covering 10-20% of lake). √
2. Herbicide aquatic plants only around piers and marinas and designate areas where plants should be encouraged. √
3. Don't replace grass carp as they die off. (Bow hunting and removing is also allowed.) √
4. Install desirable species of aquatic plants. (Chara, Am. Pondweed and Am. Waterweed are naturally coming back.) √
5. Warn lake users of dangers of blue-green algae by putting up warning signs by the beach, marina, and lakefront parks and posting warnings in the newsletter. (Newsletter √, signs in process.)
6. Aerate the bottom of the lake. √
7. Keep external sources of nutrients entering the lake to a minimum. (In process through this plan.)
8. Reduce phosphorous loading from internal sources. √

Streams and Lakes Campaign – √ = Completed and Ongoing

In-Lake Recommendations in *Candlewick Lake Management Plan 2011* by Integrated Lakes Management

Water Quality Improvement

1. Clean [and remove] goose feces off of ramps, parking areas, and shorelines at least weekly. (Beaches are cleaned daily, but other areas are not being cleaned.)
2. Test sediment for nutrient levels annually at multiple locations. (√ but not ongoing.)
3. Use artificial structures for fish habitat, not Christmas trees. √
4. Monitor water quality monthly or bi-monthly during the summer. √
5. Monitor E. coli at the beach routinely during swimming season. √
6. Schedule a visit from a lake consultant at least annually. √
7. Monitor, identify, and map aquatic growth. √

Streams and Lakes Campaign – √ = Completed and Ongoing

In-Lake Recommendations in *Candlewick Lake Management Plan 2011* by Integrated Lakes Management

Aeration

1. Continue to aerate the lake, and expand aeration to cover the entire lake. (This is not being completed due to expense; however, more thrusters may continue to be added.)
2. Install a circular system in the northwest bay to limit algae build-up. (Will add 2 units to the 3 existing units in the northwest bay ("the Dip") and add units to the north bay (Fisherman's Cove).)√
3. Manage aeration strategically throughout the year. √
4. Monitor lake temperatures, dissolved oxygen levels, and phosphorous in multiple locations. √
5. Make sure existing aeration system is functional. √

Streams and Lakes Campaign – √ = Completed and Ongoing

In-Lake Recommendations in *Candlewick Lake Management Plan 2011* by Integrated Lakes Management

Dredging

1. Determine where silt has settled within the lake and the need to dredge by conducting bathymetric mapping once every 10 years. √
2. Probe the silt pond every year or two and remove sediment as needed. √

Many of the recommended in-lake treatments are by nature reactive measures to treat pollution that has already entered the lake. Once enough proactive projects and programs are in place, there will be less need for reactive efforts. However, the reactive efforts remain important in the short-term to clear up current problems before the proactive projects will have a chance to take effect. Incorporating some reactive measures in the long-term may be necessary, depending on how successfully projects and programs are implemented upstream of and around the lake.

Projects and Practices Already in Place

The Candlewick Lake Association has been working for many years to improve the quality of Candlewick Lake. They have engaged in planning efforts, projects, and programs that are ongoing, many of which were proposed by Integrated Lakes Management (ILM) in their 2011 *Candlewick Lake Management Plan.* We recommend that all current efforts continue. All of these efforts are ongoing and funded unless otherwise noted.

Streams and Lakes Campaign –

√ Control geese populations at Candlewick Lake

The Candlewick Lake Association controls nuisance geese from gaining in numbers. Geese pollute the lake with their feces, which is deposited directly into the lake and washes in from the shore when it rains. The association addles eggs, which is a proven, humane method of controlling geese populations. The Association conducted a "Charity Goose Harvest" in June 2014 with the assistance of the U.S. Department of Agriculture and the Illinois Department of Natural Resources.

Streams and Lakes Campaign –

√ Dredge Candlewick Lake

The Candlewick Lake Association dredges the lake usually once every 15 to 20 years. More dredging may be necessary, but the need should diminish as more conservation projects are implemented. During this process, a hydraulic, floating dredge works like a giant vacuum to remove silt that has built up on the bottom of the lake and restore the lake's natural bottom. They know where the silt is located by conducting a bathymetric map of the lake. Silt is carried into the lake during storms. Most of it comes from eroding lake shorelines and upstream stream banks sloughing off when storm water puts pressure on them. Repeated pressure can weaken the banks, and eventually the banks fall into the stream or lake. Silt also comes from stormwater running over bare soil and carrying the soil with it into the nearest drainage swale or stream. Bare soil is often present in crop fields after crops are harvested, construction sites that are in progress, and shady areas or problem areas in lawns where grass doesn't grow.

Streams and Lakes Campaign –

√ Treat Candlewick Lake for pollution with an "alum treatment"

The Candlewick Lake Association has treats the lake with alum (aluminum sulfate and sodium aluminate) usually once every 10-14 years. The last treatment occurred in 2013. More treatments will likely be needed less frequently as pollution prevention projects are implemented upstream of the lake. Alum is nontoxic material that chemically binds with phosphorous and weighs it down so that it settles to the lake bottom that will not re-circulate. Phosphorous is commonly used in fertilizers to encourage lawns and crops to grow.

Once in the water, phosphorous in too great a quantity causes algae to flourish, which can take over the lake. Once the phosphorous is bound to the alum, it can no longer be used by algae.

Streams and Lakes Campaign –

√ Stabilize shorelines at Candlewick Lake

Most of the lake shore of Candlewick Lake (88%) has been stabilized with rock rip rap. This treatment covers up bare soil and stops it from sloughing off into the lake during storms. Rock of a certain size is a preferred material for stabilizing banks that experience a current or wave action. In areas where the water is quiet, it may be effective to plant native vegetation on a gentle slope to stop erosion. Plants may creep into the water, further protecting the shorelines.

Streams and Lakes Campaign –

√ Aerate Candlewick Lake

Aeration was recommended by Integrated Lakes Management to add dissolved oxygen to the lake and control phosphorous. The south end of the lake is currently aerated. The northwest bay ("the Dip") has three thrusters that keep the water from stagnating within the bay.

Streams and Lakes Campaign –

√ Monitor water quality within Candlewick Lake

Monitoring the water quality within Candlewick Lake helps us to understand current conditions and measure improvement as programs and projects are put into place. A Volunteer Lake Management Program is in place to gather and record water quality information about the lake. Monitoring efforts will be increased from the current VLMP efforts to include periodic monitoring of Ammonia, Nitrate, Nitrite, Total Kjeldahl Nitrogen (TKN), Total Phosphorus, Total Suspended Solids (TSS), and Fecal Coliform throughout the watershed.

Streams and Lakes Campaign –

√ Construct a silt pond to capture sediment and nutrients

A silt pond, meant to capture sediment and nutrients before they enter Candlewick Lake, is located between the Savanna Oaks Golf Course and Candlewick Lake. It may not be effective in improving water quality, according to Integrated Lakes Management and other sources, because it doesn't catch fine particles like silt and clay. This silt pond may need to be re-designed in order to fulfill its original intent. This effort is not currently funded. It will be combined with efforts to construct silt ponds in additional locations upstream of Candlewick Lake associated with recommended projects and stormwater control from future developments.

Streams and Lakes Campaign –

√ Monitor aquatic invasive species within Candlewick Lake and provide educational programming to lake users.

The Candlewick Lake Association monitors for invasive aquatic vegetation and zebra mussels. The lake was recently dominated by invasive vegetation, especially curly-leaf pondweed. Due to an integrated chemical control of curly-leaf pondweed, chara and other desirable, native, submerged plants are naturally coming back. The lake does not currently have zebra or quagga mussels, an invasive freshwater mussel that can overtake lakes and destroy property. They ruin the habitat for other freshwater mussels, leading to an unhealthy population of only one species instead of a diverse collage of species. In an effort to prevent zebra mussels and other invasive species from entering the lake, access to the lake by non-member boats is limited, and the Association provides educational materials and signage about aquatic invasive prevention.

Urban Campaign –

√ Treat stormwater from Savanna Oaks Golf Course before it enters Candlewick Lake

Savanna Oaks golf course was designed with a naturalized system with the intent to treat storm water before it enters the lake. The waterways through the golf course that lead to Candlewick Lake are protected from silt, fertilizer residue, and goose droppings with vegetated filter strips and bio-swales. We do not know how efficiently these practices are working. We recommend that they be monitored, evaluated, and maintained so that they function as intended.

Urban Campaign –

√ Collect leaves before they enter the lake with an organized effort

Decaying plant material can add to the problems being experienced by the lake. Collecting leaves before they enter the lake helps the water stay clean. Leaves do provide habitat for larvae and other small creatures in the lake, but the leaf collection program ensures that there aren't too many leaves.

Urban Campaign –

√ Restrict the use of fertilizers that contain phosphorous on lawns and educate homeowners

The residents of Candlewick Lake Association have been using fertilizers that do not contain phosphorous for some time. In 2012, the state of Illinois banned the use of fertilizers containing phosphorous for regular lawn care (Miller). This practice is helpful and should be continued, especially near the lake. It is recommended but not enforced for private homeowners to abide by this restriction. Common areas are maintained with phosphorous-free fertilizers.

Urban Campaign –

√ Plant long-rooted native vegetation along the lake shores of Candlewick Lake

Throughout this plan, we recommend filter strips around lakes and streams. The best filter strips are planted with native vegetation because their extensive root systems and rigid plant structure help to slow down runoff so that pollutants can drop out before the runoff enters the lake. The Candlewick Lake Association has planted two areas along the shoreline with native vegetation: Friendship Park and Firefly Bay. Friendship Park has a strip of native plants that catches pollutants before they run into the lake. Firefly Bay is a native planting that catches runoff within an overflow area as it comes out of a culvert and filters it for pollutants before it enters the lake.

Urban Campaign –

√ Restrict mowing near the shorelines of Candlewick Lake

Another option is to create "no-mow" areas to serve as filter strips around lakes and streams. Although native vegetation is preferred, just allowing any vegetation to grow taller will improve its ability to slow down the runoff and filter pollutants. No-mow areas are prevalent around Candlewick Lake. Common areas have unmowed buffers, and leaving unmowed buffers is promoted to private homeowners.

Implementing the vast amount of projects and programs recommended in this chapter would help us to reach our objectives, goals, and success statement. The information provided in this chapter allows us to predict how much reduction in pollutants we can realistically expect from implementing the projects and how much it is going to cost. Knowing this information upfront will help the local people make informed decisions on how to allocate their resources to improve the condition of our streams and lakes. In Chapter 5, we set forth a schedule for implementing these projects and practices over a ten-year period.

Chapter 5: Implementing the Recommended Projects

Written by: Rebecca Olson

Chapter 4 discussed the recommended implementation and education practices and projects and provided their pollutant load reduction estimates by grouping them according to the Environmental Protection Agency (EPA) best management practices (BMP) categories. This chapter utilizes the information learned in Chapter 4 to recommend measurable milestones, a schedule and budget, and suggested funding sources for each recommended project or practice. These planning elements are summarized in a ten-year implementation plan to the extent possible at the time of that this plan was written. Changes to the milestones, schedules, budgets, and sources of funding and technical assistance are likely, and they will be reviewed by the Candlewick Streams and Lakes Conservation Committee annually. Chapter 6 discusses monitoring and evaluation strategies for measuring our plan's success.

Summary of Schedule and Cost Estimates

Schedule Summary

The implementation plan is designed as a ten-year plan. The first year is separated from the rest. Next, projects are proposed that are scheduled for the second through sixth years, then projects proposed for the sixth through tenth years.

Dates for the plan run as follows:

Year 1: July 2014 through July 2015
Years 2 through 6: July 2015 through July 2020
Years 7 through 10: July 2020 through July 2024

During the first year, the Partnership will begin education efforts while the Candlewick Lake Association begins to construct bio-swales. It will be necessary to educate watershed residents about this plan, the existing problems within the watershed, and potential benefits of implementing the suggested projects before asking them if they would like to implement any projects on their private properties. A bio-swale construction project was already funded through Grant 3191411 and will possibly be constructed within the first year.

In Years 2 – 6, measurable milestones address many of the projects and practices recommended for implementation that have the highest potential for reducing pollutants from streams and lakes. Some of these projects will be completed within this time frame, while we suggest others be implemented a little bit each year. This allows for projects and practices to be combined to form an incentive program that can be continued throughout the years.

Years 7 – 10 will focus on projects that may take longer to carry out, although some of them may have begun in prior years. Many of these projects are continued from Years 2-6, and others are initiated during Years 7-10.

We recognize that many of the recommended projects and practices initiated during this plan will need to be continued long-term. There may be opportunities to exceed targeted goals, which should be explored. It is also possible that projects will formulate with combinations of the recommended projects and practices, and therefore their timing may change.

Cost Estimate Summary

Cost estimates were assigned to each project and practice to the best of our abilities within the scope of this plan. These cost estimates can be used for budgeting and scheduling purposes. When these projects are designed, more accurate cost estimates will be developed as the details of each project and practice are determined.

In order to complete all of the recommended measurable milestones scheduled within ten years, implementation will cost about $2 million, which will be supported by education in the amount of $190,700 (about 10% of implementation costs). These costs are spread over ten years as divided below.

Year 1

In Year 1, Candlewick Lake Association will spend $88,000 to construct bio-swales within inlets to Candlewick Lake. Proposed education efforts to launch this plan into action will add $13,700.

Years 2-6

In order to complete all of the recommended projects and practices in Years 2-6, $907,500 worth of projects will be implemented every year along with $98,500 in supporting education projects. This allows for an average annual budget of $181,500 for implementation, $19,700 in supporting education programs (about 9% of implementation costs).

Years 7-10

In order to complete all of the recommended projects and practices in Years 6-10, $989,400 in projects will be implemented along with $78,500 in supporting education programs. This allows for an average annual budget of $247,500 for implementation and $19,600 in supporting education programs (about 12.6% of implementation costs).

Financial Support and Matching Funds

Potential funding and technical assistance is available through various grant agencies and local environmental organizations suggested in this chapter. Costs can also be deferred by organizing volunteer efforts, as grant agencies recognize the value of volunteer time and allow that value to provide matching funds for their grant dollars. For example, if a grant is secured to support 60% of the cost of implementing a $100,000 project, then the financial assistance would be $60,000 from the grant agency and the local community would need to budget $40,000 in cash and value of volunteer time to match the other 40%.

Local sources of matching funds are recommended and usually required to qualify for grant funding. Local match can come from several sources, including local environmental organizations and associations, businesses, developers, municipalities, and private citizens. Funds can be in the form of cash or the value of volunteer time. The national average for the estimated value of volunteer time in 2013 was $22.55 per hour according to the Independent Sector. It is important to recognize this value, as many projects that benefit water quality rely on dedication and many hours spent by volunteers.

This plan has a success statement related to improving the water quality of the streams and lakes surrounding Candlewick Lake. Agencies and organizations that would potentially provide funding support for the priority projects and management practices recommended in this plan would be those with missions that address our success statement. There are several agencies that are active in improving water quality in northern Illinois through various programs. Some of the agencies and programs that are active in improving water quality are:

Boeing

Boeing is a foundation of the Boeing corporation headquartered in Chicago. They fund programs that educate and engage communities about the importance of taking action to reduce impacts on the environment and promoting environmental stewardship. Their geographic area is the Chicago Metropolitan Region, and they have included Boone County in a past project with Chicago Wilderness. To learn more, visit their website at:

http://www.boeing.com/boeing/companyoffices/aboutus/community/corp_cash_grants.page

Illinois Environmental Protection Agency (EPA)

Section 319 Program

The Environmental Protection Agency provided funding support for this plan through Section 319 of the Clean Water Act. The Section 319 Program also funds 60% of implementation of management practices and projects that address nonpoint sources of water pollution, with priority given to areas with a watershed-based plan such as this one. The other 40% of the project cost must come from another source and can be cash, the value of volunteer time, or a combination. Grant applications are due August 1st annually. Any entity eligible to receive funds from the state, and they typical range for project funding is $50,000 - $1.2M.

This grant funds implementation of a Watershed Based Plan or Total Maximum Daily Load (TMDL) Implementation Plan; Development of a Watershed Based Plan, TMDL or TMDL Implementation Plan; Best Management Practice Implementation; Information/Education/Outreach; Monitoring; and Research.

www.epa.state.il.us/water/watershed/forms/319-rfp.pdf

http://water.epa.gov/grants_funding/cwa319/319Guide.cfm.

State Revolving Fund (SRF)/Clean Water Initiative

Units of government including Sanitary Districts are eligible. Water Pollution Control Loan Program for wastewater projects and the Public Water Supply Loan Program for drinking water projects. These SRF programs will be the funding conduit for theGovernor's recently announced Clean Water Initiative, an initiative that will utilize the existing program capacity of the well-developed SRF programs to leverage funding available for water infrastructure over at least the next three fiscal years. Funds infrastructure projects such as replacing aging water mains, upgrading water towers, or bringing waste water treatment facilities in line with federal standards. NOTE: this is a low interest loan program not a grant program. www.epa.state.il.us/water/financial-assistance/state-revolving-fund.html

http://www.epa.state.il.us/water/financial-assistance/clean-water-initiative/index.html

Streambank Cleanup and Lake Shore Enhancement (SCALE) grants

Any entity is eligible to receive funds from the state with a typical grant amount of $3,500.

Provides funds to assist groups that have established a recurring stream or lakeshore cleanup. Each group can receive up to $3,500 for implementation of their streambank or lakeshore cleanup events in a calendar year.

www.epa.state.il.us/water/watershed/scale.html

Lake Education Assistance Program (LEAP)

LEAP funds are available to all school children whether they attend public or private schools, and for grades from kindergarten through graduate school. Funds are also available to not-for-profit organizations, such as lake associations, scouting groups, parks and communities. Grants are awarded in the amount of $500.

The IEPA provides funding for lake and lake watershed related educational field trips, seminars/workshops, projects, and activities. Projects and activities must have stated goals and involve the enhanced lake/lake watershed education of teachers, students, organizations and/or the community. Funding can be applied to such items as educational materials, scientific equipment, substitute teacher payment, buses/drivers, seminars, workshops, software, and visual materials.

www.epa.state.il.us/water/conservation/leap.html

Illinois Clean Lakes Program

Lake "owners" of lakes that have public access are eligible to receive grant funds.

Funding is provided in phases when funding is appropriated: Phase 1: $75,000 Phase 2: $300,000.

Two types of grant awards are authorized under ICLP. Phase I lake study grants are awarded to identify problems and sources of pollution, and to develop a feasible course of corrective action. A typical Phase I study period lasts two years. Phase II grants support the implementation of procedures recommended in the Phase I report to improve water quality, recreational and ecological aspects of the lake. Before a Phase II grant can be awarded, a Phase I study or equivalent must be conducted.

www.epa.state.il.us/water/conservation/iclp.html

McKnight Foundation

The McKnight Foundation uses their resources to "restore the water quality and resilience of the Mississippi River." It provides funding support for projects and management practices that restore and protect floodplains and wetlands and reduce agricultural pollution within the Mississippi River Basin including Illinois. They have four deadlines for initial inquiries throughout the year: February 1, May 1, August 1, and November 1. For more information, visit their website at:

http://www.mcknight.org/grant-programs/mississippi-river/.

State of Illinois – Illinois Department of Natural Resources (IDNR)

Open Space Lands Acquisition & Development (OSLAD) and Land & Water Conservation Programs

Local units of government can apply for acquisition and/or development of land for public parks and open space. Projects vary from small neighborhood parks or tot lots to large community and county parks and nature areas.

Acquisition: $750,000 max Development: $400,000 max Reimbursement: up to 50 percent (Applicants defined as disadvantaged eligible for up to 90 percent reimbursement.)

Examples Include: combo soccer/football fields, combo baseball/softball fields, park pavilions, picnic tables, grills, basketball and tennis courts, interpretive trail signage, fishing piers, wetland observation decks, extensions of trail loops, parking lot expansions, splash pads, trails with fitness stations, water quality basins with native plantings, shelters with picnic tables; preservation/ biological improvement of permanent wetlands, outdoor classroom / treehouse shelters, adventure / educational play structures and interpretive prairie gardens. Applications must be received between May 1 and July 1 of each calendar year.

www.dnr.state.il.us/ocd/newoslad1.htm

Park and Recreational Facility Construction Grant Program

Local governments can apply for park and recreation unit construction projects including acquisition, development, construction, reconstruction, rehabilitation, improvements, architectural planning and installation of capital facilities consisting, but not limited to, buildings, structures and land for park and recreation purposes and open spaces and natural areas.

Maximum grant amount up to 10 percent of total program appropriation. Reimbursement: up to 75 percent (Applicants defined as disadvantaged eligible for up to 90 percent reimbursement.)

Capital Expenditures for additional indoor/outdoor recreational purposes may include, but are not limited to, demolition, site preparation/improvements, utility work, reconstruction or improvement of existing buildings/facilities, expansion of buildings/facilities and new construction. Land Acquisition projects such as the construction of new public indoor/outdoor recreation buildings, structures and facilities; expansion of existing public indoor/outdoor recreation buildings,structures and facilities; general park purposes such as regional/ community/neighborhood parks; frontage on public surface waters for recreation use; open space/conservation purposes to protect floodplains, wetlands, natural areas, wildlife habitat and unique geologic/biologic features and additions to such areas. Application schedule and award dates vary.

www.dnr.state.il.us/ocd/newPARC1.htm

Federal Recreational Trails Program

Federal, state and local government agencies, not for profit organizations and private operators of recreational facilities open to the public can apply for funding assistance for acquisition, development, rehabilitation and maintenance of both motorized and non-motorized recreational trails.

Acquisition: Non-Motorized: no max Motorized: no max Development: Non-Motorized: $200,000: Motorized: no max Reimbursement: up to 80 percent

Examples Include: Trail construction and rehabilitation; restoration of areas adjacent to trails damaged by unauthorizedtrail uses; construction of trail-related support facilities and amenities; and acquisition from willing sellers of trail corridors through easements or fee simple title. Applications must be received between January 1 and March 1 of each calendar year.

www.dnr.state.il.us/ocd/gaoutnew.htm

Bike Path Grant Program

Local governments having statutory authority to acquire and develop land for public bicycle path purposes can apply. Grants assist eligible units of government acquire, construct and rehabilitate public, non-motorized bicycle paths and directly related support facilities.

Acquisition: no max Development: $200,000 Reimbursement: up to 50 percent.

Examples Include: Linear corridor land acquisition costs, including associated appraisal fees, and bicycle path development or renovation including site clearing and grading, drainage, surfacing, bridging,

fencing, signage and directly related support facilities such as potable water and restroom facilities. Applications must be received between January 1 and March 1 of each calendar year.

www.dnr.state.il.us/ocd/gaoutnew.htm

Boat Access Area Development Program

Local governments can apply for financial assistance for the acquisition, construction, and expansion/rehabilitation of public boat and canoe access areas on Illinois lakes and rivers.

Maximum: Non-Motorized: $80,000 Motorized: $200,000 Reimbursement: Acquisition: up to 90 percent Development: 100 percent.

Examples Include: Water frontage land acquisition for public access areas; new construction or renovation of boat/canoe launching ramps and courtesy docks, restrooms and security lighting, parking areas, access roads and walkways, other boating-related facilities deemed appropriate by IDNR. Applications must be received between July 1 and September 1 of each calendar year.

www.dnr.state.il.us/ocd/gaoutnew.htm

The Urban and Community Forestry Assistance Grant Program

Local units of government can apply for financial assistance to help develop, enhance and sustain local urban and community forests including the development of local municipal forestry programs and other activities that improve tree and urban forest health.

Maximum: no more than five percent of the amount of funds allocated for the grant program can go to one local unit of government. Reimbursement: 50/50 cost share.

Examples Include: Tree care/preservation ordinances, tree board establishment, tree inventories, Emerald Ash Borer reforestation, storm mitigation and reforestation, comprehensive urban forestry management plans, forest insect/disease mitigation plans, residual wood strategic plans, public education on urban forestry, training of city staff on treecare, tree planting/beatification, tree care demonstrations and utility conflict resolution. Grants are given annually as funds are allocated. Check the IDNR-Urban Forestry website for application posting.

www.dnr.state.il.us/orc/Urbanforestry/financialasst.html

Local Government Snowmobile Program

Local governments located in a region of Illinois with sufficient snow cover and having statutory authority to acquire and develop lands for public park and recreation purposes can apply. Grants provide up to 50 percent reimbursement of approved facility development/rehabilitation costs and 90 percent of approved trail corridor land acquisition costs for public snowmobile trails and areas in the state.

No maximum grant amount. Reimbursement: Acquisition: Linear: 90 percent Non-Linear: 50 percent Development: 100 percent.

Examples Include: Land acquisition for snowmobile areas/trail corridors; snowmobile trail construction and signage; trail grooming equipment; parking areas, security lighting, restroomfacilities and warming shelters; and snowmobiles and communication equipment for local agency patrol use. Applications must be received between January 1 and May 1 ofeach calendar year.

www.dnr.state.il.us/ocd/gaoutnew.htm

State of Illinois – Illinois Department of Transportation (IDOT)

The Illinois Safe Routes Program

Eligible project sponsors include schools and school districts, governmental entities and non-profit organizations. Projects may be organized on a variety of jurisdictional levels. Applications accepted: October 31, 2013 All applications due: January 31, 2014. Check for application deadlines each year.

Reimbursement program: 80/20 Federal/Local cost share with flexibilities SRTS FY14-15 total funding availability: $6M. Infrastructure improvement projects: $200,000 maximum. Non-infrastructure improvement projects: $30,000 maximum.

The Illinois Safe Routes to School Program (SRTS) uses a multidisciplinary approach to improve conditions for students who walk or bike to school. The program has three main goals: Enable and encourage children to walk and bicycle to school; make bicycling and walking to school a safer and more appealing transportation alternative; and facilitate the planning, development, and implementation of projects and activities that will improve safety and reduce traffic, fuel consumption, and air pollution in the vicinity of both public and private primary and middle schools. The program funds both infrastructure and non-infrastructure improvements. Key features of the Illinois SRTS Program include: Projects do not require a local match " 70-90 percent of funds support infrastructure projects. 10-30 percent of funds support non-infrastructure programs. " Projects must be included in an approved Illinois School Travel Plan.

http://www.dot.il.gov/saferoutes/SafeRoutesISRPContent.aspx

http://www.dot.il.gov/saferoutes/2013_14Announcement.PDF

Recreational Trails Program

All levels of government and private organizations are eligible.

$200,000 ($250,000 with local match) per application for non-motorized development projects. No maximum for acquisition projects and motorized projects.

Co-administered by IDOT and Illinois Department of Natural Resources (IDNR), the Recreational Trail Program (RTP) is open to all levels of government and private organizations toreceive RTP funds through an annual grant program. The RTP requires the funds to be divided among motorized trails (at least 30% of total project funding), non-motorized trails (at least 30% of total project funding), and diversified trails (up to 40% of total project funding). Diversified trails can accommodate both motorized and non-motorized use, or can accommodate more than one type of motorized or non-motorized use. The Illinois Greenways and Trails Council serves as Illinois' State Trails Advisory Board as required by law and

advises IDNR and IDOT regarding program administration and develops priorities for projects funded under the program.

http://www.dnr.illinois.gov/programs/pages/greenwaysandtrailscouncil.aspx

http://www.dnr.state.il.us/ocd/fy13Trailsmanual.pdf

U.S. Fish and Wildlife Service (FWS)

The U.S. Fish and Wildlife Service has two programs that may be supportive of some of our implementation projects: Partners for Fish and Wildlife and the Wildlife and Sport Fish Restoration Program.

Partners for Fish and Wildlife

The U.S. Fish and Wildlife Service provides small grants to purchase native seed mixes for prairie, wetland, and woodland restoration that provides wildlife habitat. Some of the recommended projects may qualify, such as constructed wetlands, because they will provide dual purposes of improving water quality and creating wildlife habitat. For more information, visit their website at:

http://www.fws.gov/partners/.

Wildlife and Sport Fish Restoration Program

The U.S. Fish and Wildlife Service funds 75% of the total cost of sport fish habitat restoration, land acquisition for sport fish habitat, aquatic education, and outreach projects. It is possible that projects in the Streams and Lakes Campaign may provide dual benefit to sport fish spawning habitat and water quality improvement. For more information, visit their website at:

http://wsfrprograms.fws.gov/.

The implementation plan for the priority projects and the area-wide recommendations presented in this Chapter provide a clear path to reaching the goals and success statement of this plan. In Chapter 6, we will discuss methods to measure our success.

Implementation Plan

The following tables outline a schedule and budget to implement measurable milestones of our recommended implementation and education, projects, practices, and programs. The schedule is organized by Year 1, Years 2-6, and Years 6-10.

Figure 5-1: Schedule for Year 1, July 2014 through July 2015 (1 of 3).

Campaign	BMP Type	Category	Interim, Measurable Milestone	Potential Funding/Tech. Support	Imp. Cost ($)	Edu. Cost (Match $)
ALL	Watershed Planning	Planning	Conduct quarterly meetings of the Candlewick Streams and Lakes Conservation Partnership (2 more meetings this year). Review this plan and make changes as needed.	N/A		$ 630
ALL	Watershed Planning	Planning	Meet annually with the Kishwaukee River Ecosystem Partnership and their associated environmental organizations to collaborate efforts and financial and technical assistance.	N/A		$ 677
ALL	Watershed Planning	Edu	Hold a public meeting to present the final plan. (Completed and already funded thorugh Grant No. 3191022.)	EPA		$ 2,102
ALL	Watershed Planning	Edu	Publicize this plan on the Candlewick Lake Association website.	N/A		$ 100
ALL	Watershed Planning	Edu	Write letters, emails (e-blasts), and/or newsletter articles to disseminate a cover letter and a link to this plan to all watershed residences. Provide a paper copy upon request.	N/A		$ 361
ALL	Various	Edu	Offer a public event that invites local experts to speak or provide demonstrations applicable to the year's projects or funding sources.	BCCD, CW, IDNR, IEPA, NLI, NRCS,		$ 1,402

Figure 5-1: Schedule for Year 1, July 2014 through July 2015 (2 of 3).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
ALL	Various	Edu	Promote water conservation events held by local organizations to residents of the watershed via newsletters, email blasts, and websites.	N/A		$ 226
ALL	Various	Edu	Engage the community conservation projects and programs including one local high school club or class. These can be volunteer work days or "Show Me, Help Me" events.	EPA (LEAP)		$ 2,255
STREAMS LAKES	Urban Filter Strip, Grassed-lined Channels	Edu	Write a feature article about filter strips, proposed bio-swales, and the upcoming event it in newsletters, email blasts, and websites.	N/A		$ 360
STREAMS LAKES	Urban Filter Strip, Grassed-lined Channels	Edu	Hold a public event to showcase the filter strips at Firefly Bay and Friendship Park and the proposed bio-swale locations.	N/A		$ 1,082
STREAMS LAKES	Urban Filter Strip, Grassed-lined Channels	Edu	Provide a training session for filter strip and bio-swale management for staff and volunteer leaders.	Blue Thumb, CW, Openlands, NLI, BCCD		$ 1,402

Figure 5-1: Schedule for Year 1, July 2014 through July 2015 (3 of 3).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
STREAMS LAKES	Grassed-lined Channels	Edu	Launch an incentive program and recognition program for private homeowners to enroll in bio-swale project. Focus on private landowners within targeted bio-swale locations.	Blue Thumb, Boeing, CW, Openlands, NLI, BCCD,	-	$ 2,255
STREAMS LAKES	Grassed-lined Channels	Imp	Construct bio-swales on several sites totaling 0.23 acres at the inlets to Candlewick Lake. (Already funded through Grant No. 3191411. This represents the first phase of multiple projects.)	IEPA (319)	$ 88,000	
FUTURE DEVELOP-MENT	Policy	Edu	Conduct a meeting with Boone County, Poplar Grove, Timberlane, and Caledonia to discuss current policies and ordinances to determine the current status of water quality protection in the watershed.	N/A		$ 812
Total Cost for Year 1					**$ 88,000**	**$ 13,663**

Figure 5-2: Schedule for Years 2-6, July 2015 through July 2020 (1 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
ALL	Watershed Planning	Planning	Conduct quarterly meetings of the Candlewick Streams and Lakes Conservation Partnership (4 meetings per year). Review this plan and make changes as needed.	N/A		$ 6,300
ALL	Watershed Planning	Planning	Meet annually with the Kishwaukee River Ecosystem Partnership and their associated environmental organizations to collaborate efforts and financial and technical assistance.	N/A		$ 3,383
ALL	Various	Edu	Publish feature articles about upcoming streams and lakes conservation projects and events in newsletters, email blasts, and websites on a quarterly basis (4 per year).	BCCD, Blue Thumb, CW, NLI, Openlands		$ 1,800
ALL	Various	Edu	Offer two public events per year that invite local experts to speak or provide demonstrations applicable to the year's projects or funding sources.	BCCD, CW, IDNR, IEPA, NLI, NRCS, Openlands		$ 14,020
ALL	Various	Edu	Hold a public event each year to showcase the filter strips at Firefly Bay and Friendship Park, the completed bio-swales, and attractions of new projects.	N/A		$ 5,412

Figure 5-2: Schedule for Years 2-6, July 2015 through July 2020 (2 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
ALL	Various	Edu	Provide an annual training session for natural area management for staff and volunteer leaders.	Blue Thumb, CW, Openlands, NLI, BCCD		$ 7,010
ALL	Various	Edu	Engage the community in conservation projects and programs, including a local high school class or club. These can be volunteer work days or "Show Me, Help Me" events.	EPA (LEAP)		$ 11,275
ALL	Various	Edu	Promote water conservation events held by local organizations to residents of the watershed via newsletters, email blasts, and websites.	N/A		$ 1,128
STREAMS LAKES	Various	Edu	Launch an annual incentive and recognition program for private landowners to enroll in streambank stabilization projects.	Blue Thumb, Boeing, CW		$ 11,250
STREAMS LAKES	Streambank Stabilization	Imp	Complete the stabilization of 287.5 feet of severely eroding streambank at a rate of 57.5 feet per year. (To be continued Years 6-10.)	IEPA	$ 23,000	
STREAMS LAKES	Grassed-lined Channels	Imp	Construct bio-swales on several sites totaling 0.37 acres at the inlets to Candlewick Lake. (This is a continuation of the first phase started in Year 1.)	IEPA	$ 176,000	

Figure 5-2: Schedule for Years 2-6, July 2015 through July 2020 (3 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
STREAMS LAKES	Wetland Restoration, Water and Sediment Control Basin	Imp	At "the Dip," redesign water flow and create artificial wetlands and a basin within a 1.25-acre site for water to travel through before entering the lake.	IDNR, IEPA, McKnight, USFWS	$ 29,375	
STREAMS LAKES	Wetland Restoration, Water and Sediment Control Basin	Imp	Along the eastern stream that enters Candlewick Lake, create wetlands and build a basin within a 0.5-acre site for water to travel through before entering the lake.	IDNR, IEPA, McKnigh	$ 17,500	
STREAMS LAKES	Shoreline Stabilization	Imp	Stabilize the 6% (1,500 feet) of the remaining eroded shore at Candlewick Lake with stone toe protection and native vegetation. Each year, stabilize 300 feet. (To be continued Years 6-10.)	IEPA	$ 120,000	
URBAN	Various	Edu	Launch an annual incentive and recognition program for private, lakefront homeowners to enroll in urban campaign projects such as shoreline stabilization, bio-swales, filter strips, permanent vegetated cover, porous pavement, rain gardens, and conservation-minded lawn care.	Blue Thumb, Boeing, CW		$ 11,250
URBAN	Wetland Restoration	Imp	Acquire 10 acres of wooded wetland and cropland west of "the Dip" and restore them to wetland.	BCCD, IDNR, IEPA, McKnight, USFWS	$ 175,000	

Figure 5-2: Schedule for Years 2-6, July 2015 through July 2020 (4 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
URBAN	Wetland Restoration	Imp	Acquire 5 acres of cropland east of Whiting Park and restore them to wetland.	BCCD, IDNR, IEPA, McKnight, USFWS	$ 87,500	
URBAN	Urban Filter Strip	Imp	Plant a 15 ft.-wide filter strip (or larger) of native vegetation around lake shores and inlets. Plant 0.5 acres at a rate of 4,350 square feet per year. (To be continued Years 6-10.	USFWS, IEPA	$ 3,750	
URBAN	Permanent Veg. Cover	Imp	Convert mowed and unmanaged areas to prairies and woodlands on 8.2 acres at a rate of 1.64 acres per year. (To be continued Years 6-10.)	IEPA, USFWS	$ 61,500	
URBAN	Urban Stormwater Wetlands	Imp	Plant native vegetation within 2 existing, mowed storm water retention basins in the Timberlane subdivision for a total of 3 acres.	IDNR, IEPA, USFWS	$ 22,500	
URBAN	Rain Gardens	Imp	Construct 51 rain gardens with an average size of 1,000 sq. ft. at a rate of 10 gardens per year. (To be continued Years 6-10.)	Blue Thumb	$ 127,500	

Figure 5-2: Schedule for Years 2-6, July 2015 through July 2020 (5 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Imp. Cost ($)**	**Edu. Cost (Match $)**
RURAL	Various	Edu	Launch an annual incentive and recognition program for private landowners to enroll in rural campaign projects such as nutrient management plans, conservation tillage, and grassed waterways.	NRCS		$ 11,250
RURAL	Nutrient Management Plan	Imp	Enroll 516 acres of cropland in nutrient management plan programs at a rate of 103 acres per year. (To be continued Years 6-10.)	McKnight, NRCS	$ 43,860	
RURAL	Conservation Tillage	Imp	Convert 158 acres of cropland to no-till farming practices.	McKnight, NRCS	$ -	
RURAL	Grassed Waterway	Imp	Construct grassed waterways on 4 acres at a rate of 0.8 acres per year.	McKnight, NRCS	$ 20,000	
FUTURE DEVELOP-MENT	Various	Edu	Host an annual development summit to discuss new and innovative ways to develop land.	Boeing, CW, IEPA, NLI, Openlands		$ 8,010
FUTURE DEVELOP-MENT	Policy	Edu	Conduct meetings with Boone County, Poplar Grove, Timberlane, and Caledonia to adopt common ordinances or an intergovernmental agreement to protect water quality in the watershed (estimate 8 meetings).	N/A		$ 6,494
Total Cost for Years 2-6					**$ 907,485**	**$ 98,581**
Cost per Year (5 years)					**$ 181,497**	**$ 19,716**

Figure 5-3: Schedule for Years 7-10, July 2020 through July 2024 (1 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Cost ($)**	**Volunteer Value (Match $)**
ALL	Watershed Planning	Planning	Conduct quarterly meetings of the Candlewick Streams and Lakes Conservation Partnership (4 meetings per year). Review this plan and make changes as needed.	N/A		$5,040
ALL	Watershed Planning	Planning	Meet annually with the Kishwaukee River Ecosystem Partnership and their associated environmental organizations to collaborate efforts and financial and technical assistance.	N/A		$ 3,383
ALL	Various	Edu	Publish feature articles about upcoming streams and lakes conservation projects and events in newsletters, email blasts, and websites on a quarterly basis (4 per year).	BCCD, Blue Thumb, CW, NLI, Openlands		$ 1,440
ALL	Various	Edu	Offer two public events per year that invite local experts to speak or provide demonstrations applicable to the year's projects or funding sources.	BCCD, CW, IDNR, IEPA, NLI, NRCS, Openlands		$11,216
ALL	Various	Edu	Hold a public event each year to showcase the filter strips at Firefly Bay and Friendship Park, the completed bio-swales, and attractions of new projects.	N/A		$4,330

Figure 5-3: Schedule for Years 7-10, July 2020 through July 2024 (2 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Cost ($)**	**Volunteer Value (Match $)**
ALL	Various	Edu	Provide an annual training session for natural area management for staff and volunteer leaders.	Blue Thumb, CW, Openlands, NLI, BCCD		$ 5,608
ALL	Various	Edu	Engage the community in conservation projects and programs including one high school class or club. These can be volunteer work days or "Show Me, Help Me" events.	EPA (LEAP)		$ 9,020
ALL	Various	Edu	Promote water conservation events held by local organizations to residents of the watershed via newsletters, email blasts, and	N/A		$ 902
STREAMS LAKES	Various	Edu	Continue an annual incentive and recognition program for private landowners to enroll in streambank stabilization projects. Add an initiative for wetland restoration projects.	Blue Thumb, Boeing, CW, IDNR, IEPA, USFWS		$9,000
STREAMS LAKES	Streambank Stabilization	Imp	Complete the stabilization of 287.5 feet of shoreline at a rate of 57.5 feet per year. (287.5 feet already address in Year 2-6.)	IEPA	$23,000	

Figure 5-3: Schedule for Years 7-10, July 2020 through July 2024 (3 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Cost ($)**	**Volunteer Value (Match $)**
STREAMS LAKES	Shoreline Stabilization	Imp	Stabilize the 6% (1,500 feet) of the remaining eroded shore at Candlewick Lake with stone toe protection and native vegetation. Each year, stabilize 300 feet. (1,500 feet already addressed in Year 2-6.)	IEPA	$120,000	
STREAMS L	Shoreline Stabilization	Imp	Stabilize 3,100 feet of Boone Lake shoreline at a rate of 620 feet per yeara.	IEPA	$248,000	
STREAMS L	Wetland Restoration	Imp	Create wetlands on 13 acres of opportunity sites throughout the watershed at a rate of 2.6 acres per year.	IDNR, IEPA, USFWS	$97,500	
URBAN	Various	Edu	Launch an annual incentive and recognition program for private, lakefront homeowners to enroll in urban campaign projects such as shoreline stabilization, bio-swales, filter strips, permanent vegetated cover, porous pavement, rain gardens, and conservation-minded lawn care.	Blue Thumb, Boeing, CW		$9,000

Figure 5-3: Schedule for Years 7-10, July 2020 through July 2024 (4 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Cost ($)**	**Volunteer Value (Match $)**
URBAN	Urban Filter Strip	Imp	Plant a 15 ft.-wide filter strip (or larger) of native vegetation around lake shores and inlets. Plant 0.5 acres at a rate of 4,350 square feet per year. (0.5 acres already addressed in Year 2-6.)	USFWS, IEPA	$3,750	
URBAN	Permanent Veg. Cover	Imp	Convert mowed and unmanaged areas to prairies and woodlands on 8.2 acres at a rate of 1.64 acres per year. (8.2 acres already addressed in Year 2-6.)	IEPA, USFWS	$61,500	
URBAN	Porous Pavement	Imp	Convert 1 acre of parking lot, driveways, sidewalks, roads, or combination to porous pavement when pavement needs to be replaced..	IEPA	$283,140	
URBAN	Rain Gardens	Imp	Construct 51 rain gardens with an average size of 1,000 sq. ft. at a rate of 10 gardens per year. (51 rain gardens already constructed in Years 2-6.)	Blue Thumb	$127,500	

Figure 5-3: Schedule for Years 7-10, July 2020 through July 2024 (5 of 5).						
Campaign	**BMP Type**	**Category**	**Interim, Measurable Milestone**	**Potential Funding/Tech. Support**	**Cost ($)**	**Volunteer Value (Match $)**
RURAL	Land Protection	Edu	Launch a public outreach project for owners of potential protected lands.	BCCD, NLI, Openlands		$9,000
RURAL	Land Protection	Imp	Secure permanent protection of 10 acres of open space from willing landowners on lands associated with water quality improvement projects, especially in areas of ecological and recreational connectivity.	BCCD, IDNR, IDOT	$25,000	$2,500
FUTURE DEVELOP-MENT	Various	Edu	Host an annual development summit to discuss new and innovative ways to develop land.	Boeing, CW, IEPA, NLI, Openlands		$ 8,010
Total Cost for Years 6-10					**$989,390**	**$78,448**
Cost per Year (4 years)					**$247,348**	**$19,612**

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Chapter 6: Monitoring and Evaluation of Plan

Written by: Joe Rush

A monitoring and evaluation plan is a critical component in the watershed planning process. This is necessary to evaluate the progress of the plan overtime as key goals and objectives are executed. To help track progress over time, this plan establishes monitoring of several parameters, including physical, chemical, and biological factors. By developing a water quality monitoring program, we provide a baseline from which we can evaluate current conditions as well as track changes over time following implementation of the plan goals and objectives. Note: Some monitoring locations relating to specific goals and objectives are not described and need to be developed based on the projects being implemented. Future monitoring efforts should adhere to Illinois EPA established protocols and methods for quality assurance and quality control listed at http://www.epa.state.il.us/water/water-quality/methodology/index.html. Here you will find the Illinois EPA QAPP's (Quality Assurance Project Plans) and SOP's (Standard Operating Procedures).

This chapter outlines current (historical) monitoring effort, recommended additional monitoring effort, costs associated with each program, and a procedure to collect water samples for monitoring chemical properties of the water in streams and at inlets. Since volunteerism is high in this watershed, we are recommending citizen scientist-based monitoring when applicable.

Current Monitoring Efforts

Currently, water quality monitoring efforts have focused on periodic in-lake assessments from consulting firms. Along with these periodic assessments, much of the ongoing water quality monitoring has occurred through the Illinois EPA's Volunteer Monitoring Program. Candlewick Lake has taken an active role in this program since 1995. Currently, they are classified as a Tier 3 Volunteer. This program allows the collection of physical and chemical properties and occurs May through October. The Tier 3 program includes the following parameters in which volunteers collect data:

Physical Parameters

- Secchi disk readings. These readings are used to document changes in transparency of the lake water. This can be an indicator of increasing or decreasing algal blooms and suspended solids. Secchi readings are collected on 3 sites through out Candlewick Lake 2 times per month.
- Temperature, depth, and dissolved oxygen profiles are collected at all three sites.

Chemical Parameters

- Grab samples at 1 ft depths are collected by a volunteer and shipped to an IEPA approved laboratory. Chemical analysis is performed on the sample for ammonia, nitrates, total phosphorous, suspended solids and volatile suspended solids.

- Another sample is collected at twice the secchi depth and filtered by the volunteer to assess Cholorphyll a concentrations. These samples, along with the 1 ft depth grab samples are analyzed by an approved IEPA lab at no cost to the volunteer.
- Again, this shipping and laboratory analysis is at no cost to the volunteers.
- These samples are collected 1 time per month at site 1.

Other Observations

- The volunteer records field observations of important environmental characteristics occurring on the lake. Characteristics such as water color, presence or absence of aquatic plants, presence of exotic species, as well as current and recent past weather conditions, and recent lake management activities are all recorded.

Blue-green Algae

Along with the VLMP data collection, Candlewick Lake Association performs periodic blue-green algae toxin assessments throughout the summer months. Blue-green algal blooms are exacerbated by increased nutrient loading, in particular nitrogen and phosphorus. While the presence of blue-green algal blooms does not necessarily indicate the production of toxins, the potential is there. Along with this potential and the fact that adverse health risks to stakeholders, their pets, and livestock can occur when toxins are present, Candlewick Lake Association takes and active roll in monitoring algal toxicity. During summer months, the lake is monitored for visual signs of a blue-green algal bloom. If blue-green algae is present, and algal scums are forming, samples are collected and sent to a lab for algal assays and subsequent toxin testing for microcystin toxins. While microcystin is the most commonly found blue-green algal toxin in Illinois, not all blue-green algae produce only microcystin. If the species composition from the algal assay warrants further testing for saxatoxins, anatoxins, or cylindrospermopsin, it is done on a case-by-case basis. Over time, as nutrient reduction goals and objectives are met, we anticipate less intense planktonic blue-green algal blooms.

Fish Population Assessments

Since fishing remains a major interest to stakeholders in the watershed, periodic fish population assessments are performed at Candlewick Lake to evaluate the game fish populations. These assessments are commonly performed in spring or fall, and have consisted of AC electrofishing methods to collect data on the fishery. Data collection includes catch per unit effort, length to weight relationships, species composition and density, and proportional stock densities. From these assessments, fish stocking and creel limits are constructed to improve the quality of fishing for stakeholders.

Phosphorus Sampling: Aeration System

The Candlewick Lake Association periodically collects water samples at the aeration system in an attempt to evaluate whether or not they are facilitating phosphorus recycling. Phosphorus recycling can be problematic if aeration systems pump nutrient-rich bottom sediments into the water column. Samples are normally collected at the aeration sites prior to initializing the system in the spring, and subsequently sampled again after the system is started. Samples are also collected several times throughout the summer months.

Sediment Mapping and Sediment Loading

Bathymetric surveys have been conducted in the past to understand the physical parameters of the lake, and sedimentation rate. The 2007 bathymetric survey conducted by the University of Idaho concluded very high sedimentation rates of 2 1/8" per year. Replication of this study as goals and objectives are completed can provide insight into the performance of the plan. As sediment pollutants are reduced, the sedimentation rates should decrease.

Aquatic Plant Surveys

It is very beneficial for a watershed / water body to have a native rooted aquatic macrophyte (aquatic plant) community established. Aquatic plant densities of about 20 - 25% lake surface can provide water quality benefits as well as biological benefits. They function to utilize available nutrients that could otherwise be utilized by planktonic algae. This is of particular importance when the system is dominated by harmful blue-green algal booms. Aquatic plants also provide oxygen production for biological systems, cover for growing juvenile fish to evade predation, and habitat to produce macro invertebrates as a food source for the biological food web. However, aquatic plants can also be consider a nuisance and problematic when they inhibit recreational uses on a lake. Aquatic plants can be a hindrance to uses such as skiing, and swimming and some stakeholders would even consider them aesthetically unpleasing.

Due to these differing views on the aquatic plant community, Candlewick Lake Association conducts annual aquatic plant surveys on Candlewick Lake as part of their management program. An evaluation of species composition, density, and location is conducted in the spring and several times throughout the summer. While the majority of the rooted aquatic plants are native, the invasive non-native curly-leaf pondweed is prevalent in this system as well. By conducting these surveys, the Association can target chemical treatments towards the eradication of curly-leaf pondweed while maintaining the native plant community. The current treatment program consists of chemically controlling curly-leaf pondweed anywhere it is found, and chemically controlling nuisance native species around docks, beaches and public fishing areas. This provides a balance between recreational access and biological need for native aquatic plants. Aquatic plant management is an important component in over-all water quality in the watershed.

Recommended Additional Monitoring Efforts

Along with the current monitoring efforts, additional water quality monitoring is recommended. While Candlewick Lake Association is currently monitoring Candlewick Lake, further monitoring is needed on Boone Lake and in the tributaries of the watershed. See the map below in Figure 6-2 for sampling locations.

Boone Lake

Very little information is available about Boone Lake. Physical attributes, water chemistry, and biological assessments are lacking on this site. Much of this is due to budgetary constraints for Boone

Lake and, therefore, much of what is being recommended for monitoring can be done by citizen scientists. Enrollment in volunteer-based programs such as the Illinois EPA's Volunteer Lake Monitoring Program could garnish valuable insight into the water chemistry for Boone Lake. Along with this, sediment mapping, aquatic plant surveys, and fisheries surveys would produce valuable insight into the current conditions as well as the changes observed over time.

River Watch

River watch is a statewide biological monitoring program in Illinois that uses trained volunteers to collect data on streams to evaluate long-term water quality trends and changes. River Watch consists of trained volunteers monitoring a 200 ft reach of stream one time per year between May 1st and June 30th. There are two main components to River Watch. A stream habitat survey consisting of recording physical observations of the stream and surrounding riparian habitat, and a biological survey consisting of random samples for benthic macro invertebrates. The benthic micro invertebrate species abundance and composition provides insight into pollution while the habitat survey provides insight into habitat changes.

Enrollment of the Candlewick Lake Watershed into the River Watch program can provide insight into water quality through macroinvertebrate assessments in stream tributaries. MBI's (Macroinvertebate Biotic Index) can be calculated to determine relative water quality for surrounding tributaries. Water quality changes can be tracked by monitoring these streams periodically for changes in macorinvertebrate species and abundances. River watch locations should be established upstream of Site 3 (The Dip) and upstream of Site 7 (Orth Rd) (See Figure -2). This would provide indicators for water quality into Candlewick Lake and then again downstream of Boone Lake on the lower reach of the watershed.

Sediment Mapping / Probing

Sedimentation is a main pollutant in the Candlewick Lake Watershed, and monitoring sedimentation will provide insight into implementation project success. Documentation of sedimentation in Candlewick Lake and Boone Lake will provide information to determine sedimentation rates, and the reduction in sedimentation from implementing the plan.

Ongoing tributary water quality monitoring

Seven sights were established for water quality monitoring (Figure 6.1) to establish a base-line of data for this plan. Continued monitoring of these seven sites is recommended to track changes over time. The following is the protocol for this program.

Costs Associated with each Program

Costs associated with each of the monitoring activities discussed above are presented below in Figure 6-1.

Figure 6-1: Current and recommended water quality and biological monitoring (1 of 2).

Waterbody	Monitoring Entity	Program	Monitoring Location	Monitor Freq.	Parameters Tested	Hired Costs	Material / Lab Costs	Min. Volun-teers Needed	Min. Volun-teer Hours Needed	Cash Needed ($) w/o Volunteer Assistance	Cash Needed ($) if Volunteers Are Used
Existing Monitoring Programs											
Candlewick Lake	Volunteers	IEPA VLMP	3 sites	2 x per month	Physical Chemical Biological	$0	$0	2	12.0	$0	0.00
Candlewick Lake	Consultant and Volunteers	Fish Population Assessment	Entire Lake	1 x per year	Biological	$2,800	$0	3	24.0	$2,800	2,000.00
Candlewick Lake	Consultant	Phosphorus sampling (aeration system)	3 aeration sites	4 x per year	Chemical	$2,400	$60	-	-	$2,460	$2,460
Candlewick Lake	Consultant	Aquatic Plant Survey	Entire Lake	5 x per year	Physical Biological	$2,200	$0	-	-	$2,200	$2,200
Candlewick Lake	Consultant	Blue-green Algae Toxin Assessment	Entire Lake (2 samples/ visit)	6 x per year	Chemical Biological	$2,400	$2,100	-	-	$4,500	$4,500

Figure 6-1: Current and recommended water quality and biological monitoring (2 of 2).											
Waterbody	**Monitoring Entity**	**Program**	**Monitoring Location**	**Monitor Freq.**	**Parameters Tested**	**Hired Costs**	**Material / Lab Costs**	**Min. Volun-teers Needed**	**Min. Volun-teer Hours Needed**	**Cash Needed ($) w/o Volunteer Assistance**	**Cash Needed ($) if Volunteers Are Used**
Additional Recommended Monitoring Programs											
Boone Lake	Volunteers	IEPA VLMP	1 site	2 x per month	Physical Chemical Biological	$0	$0	2	12.0	$0	0.00
Boone Lake	Consultant	Aquatic Plant Survey	Entire Lake	1 x per year	Physical Biological	$400	$0	-	-	$400	$400
Boone Lake	Consultant and Volunteers	Fish Population Assessment	Entire Lake	1 x per year	Biological	$2,800	$0	3	24.0	$2,800	$2,000
Candlewick Lake	Consultant or Volunteers	Sediment Mapping	Inlets	Every 2 years	Physical	$1,920	$0	2	60.0	$1,920	$0
Boone Lake	Consultant	Sediment Mapping	Entire Lake	Every 5 years	Physical	$3,000	$0	-	-	$3,000	$3,000
Candlewick Lake	Consultant	Sediment Mapping	Entire Lake	Every 5 years	Physical	$11,000	$0	-	-	$11,000	$11,000
Tributaries	Consultant or Volunteer	Water Quality Sampling	7	4 x per year	Physical Chemical Biological	$3,200	$3,400	2	40.0	$6,600	$3,400
Boone Lake	Consultant	Blue-green Algae Toxin Assessment	Entire Lake (2 samples/ visit)	6 x per year	Chemical Biological	$2,400	$2,100	-	-	$4,500	$4,500
Tributaries	Volunteers	River Watch (MBI's)	2	1 x /yr (May 1 - June 30)	Biological	$0	$0	2	32.0	$0	0.00
						$34,520	**$7,660**	**16**	**204.0**	**$42,180**	**35,460.00**

Tributary Water Quality Monitoring Procedure

Written by Catherine Haigh

It is a priority project to monitor water quality frequently. The budgets set forth are based on hiring consultants to perform the work, however, we have determined that volunteer effort is a viable source and volunteers will follow the protocol below and use the established sampling locations identified in Figure 6.1. It is important that water quality be monitored continuously, starting before the plan implementation begins, throughout the life of the plan, and beyond. This monitoring effort is the backbone for tracking what the plan is trying to accomplish.

Why should we sample the water?

Water sampling is an important process in determining the water quality of a body of water. Some important things to test for are; Ammonia, Fecal Coliform, Nitrate, Nitrite, Phosphorus, Total Suspended Solids and Total Kjeldahl Nitrogen. All of these occur naturally in bodies of water but at certain levels can be indicators of pollution and can cause problems in water bodies. Too many of any one of these can speed up the eutrophication process. Eutrophication is a natural process of nutrient loading leading to lowered dissolved oxygen. This process occurs naturally in any body of water but is sped up by pollutants. Increase in the eutrophication process can be detrimental to an aquatic ecosystem. Ammonia is nitrogen and hydrogen; it is a waste by-product of living organisms. It can also be from industrial and household chemicals and fertilizers. Fecal Coliform is a bacteria originating from the intestines of animals and is excreted as part of the fecal matter. Common sources are animal waste, sewage runoff, agricultural runoff and storm runoff. Nitrite is nitrogen and oxygen. It's a form of nitrogen, broken down from ammonia. It can produce serious illness in fish. Usually this form of nitrogen is short lived because it gets further broken down into nitrate. Nitrate is also nitrogen and oxygen. It is the third stage of the nitrogen cycle and too much can be detrimental. Phosphorus is an abundant element on Earth but occurs naturally only in small trace amounts in water systems. It can come from runoff of croplands and pastures, urban and sewage runoff. Total suspended solids can include a wide variety of material including silt, decaying plant matter, decaying animal matter, industrial wastes and sewage. A high concentration of TSS can decrease amount of light reaching plant matter causing lower levels of photosynthesis and cause plant death. Both of these can lower the dissolved oxygen which intern can cause fish kills and death of other aquatic organisms. The Total Kjeldahl Nitrogen is the sum of organic nitrogen and ammonia and is a necessary measurement to find the Total Nitrogen. This is also an indicator of pollution in a body of water.

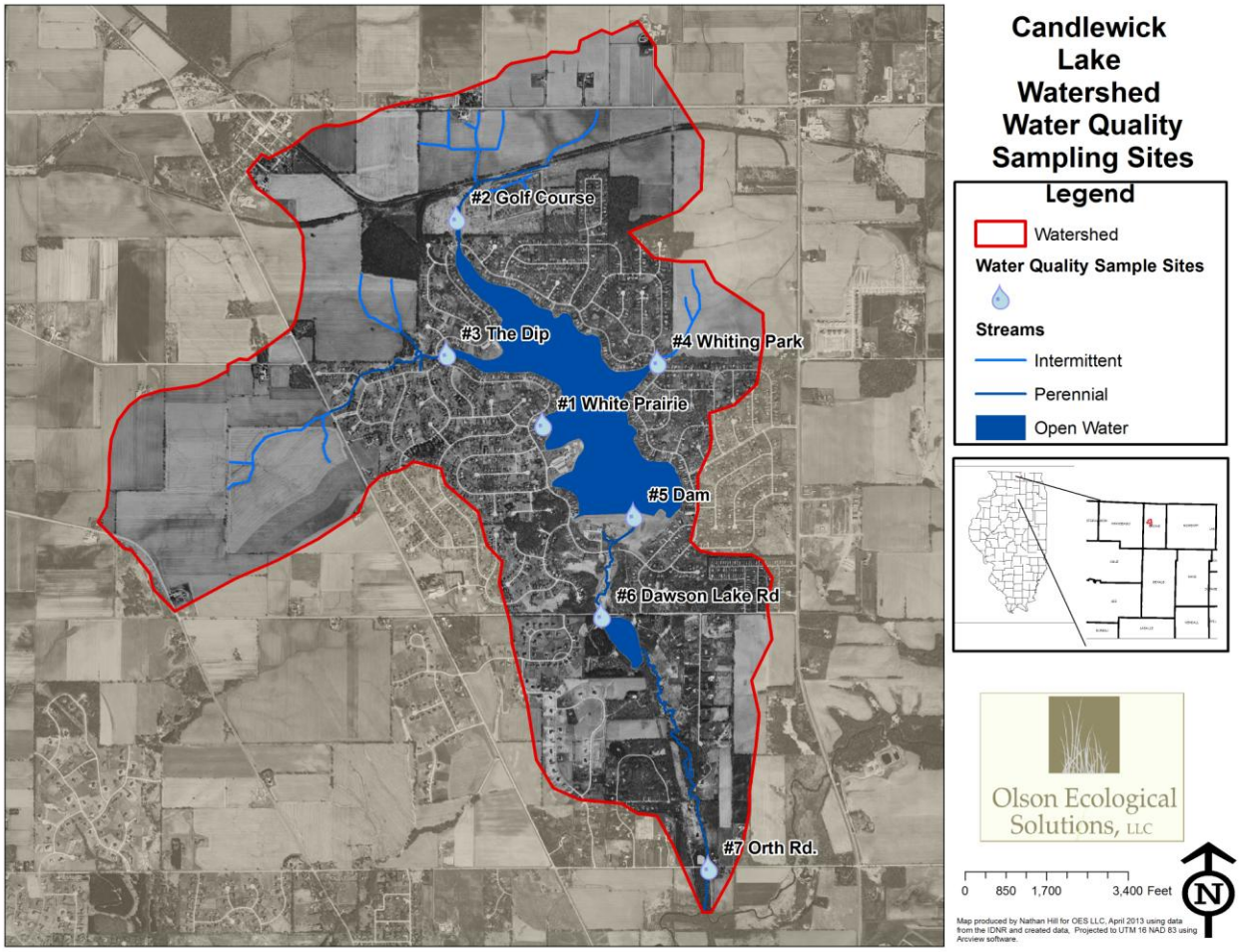
When should we sample?

The water sampling should occur in the spring after farmers apply fertilizer to the agricultural fields. It should also occur within 24 hours of a rain event totaling 0.1 inches of precipitation of more. Additional sampling throughout the year will help establish trends.

Where should we sample?

The seven locations are located at inlet sources where water is entering the lake. The exact locations and directions to them should be located on the map and a separate sheet directing you where to go.

Figure 6-2: Map of water sampling locations.



What will we need?

Checklist of gear needed in the field:

1. Two sample bottles per site
2. Labels for each bottle
3. Coolers(enough to fit every bottle with ice)
4. Ice
5. Rubber Boots
6. Map of sample site locations
7. Directions to each site
8. Chain of custody form
9. Pen/Marker

How do we collect the samples?

1. When you get to sample location rinse off both your hands and the outside of the closed bottles in stream to remove any bacteria that could affect test results.
2. Enter stream and locate the middle both the width and depth.
3. Make sure the current is coming toward you and that any disturbance you created getting into the stream is settled and washed downstream of you.
4. Next take the first bottle, still capped, and place under water at the middle location. Both the middle depth and middle width of the stream.
5. Remove cap while bottle is under water, allow bottle to fill completely, then replace cap while still under water.
6. Repeat for second bottle.
7. Label both containers with location, date and exact time sample was taken(To the minute)
8. Put bottles in cooler with ice.
9. Record information in chain of custody form.
10. Repeat steps 1-9 at each sample location
11. The last step is to return bottles to the Rock River Water Reclamation District within six hours of sampling and before 2:30. The Lab should have prior knowledge of you returning on that day.

What should we do with the samples?

The lab should be contacted a few days ahead of the sample day. When you call to order bottles let them know what tests are needed; (Is it TN, TP, TSS and fecal coliform or is it ammonia, fecal coliform, nitrate, nitrite, phosphorus, suspended solids, total kjeldah nitrogen?). When you pick up bottles let them know what day you will bring back water samples. Whichever day they are brought back they will need to be in by 2:30 and it can't be on a Friday. You can also order labels for each bottle so you can record the location, date and exact time the sample is taken on the bottle.

Lab Contact Info:
Mary Johnson
Laboratory Supervisor
Rock River Water Reclamation District
P.O. Box 7480
Rockford, IL 61126
Phone: 815-387-7523
Alternate Phone: 815-387-7522
Email: mjohnson@rrwd.dst.il.us

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GIS Data Documentation

Type: Water Bodies (polygons and line files)
Source/agency: OES
Date: 2013
Scale: 1:24,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Open water, including rivers and ponds, as well as creeks and manmade bodies of water.

Type: National Wetlands Inventory
Source/agency: US Fish and Wildlife Service
Date: 2009
Scale: 1:24,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Areas of known wetlands, http://www.fws.gov/wetlands/Data/DataDownload.html

Type: Township and County Borders
Source/agency: US Census Bureau
Date: 2000
Scale: 1:65,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Political boundaries within the two county area.

Type: Land Use Land Cover
Source/agency: United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS), Research and Development Division (RDD), Geospatial Information Branch (GIB), Spatial Analysis Research Section (SARS)
Date: 1987
Scale: 1:65,000
Projection: UTM_Zone_Number 16, Transverse_Mercator:
Description: Areas of land cover identified, NLCD 2001 Land Cover Class Definitions
11. Open Water - All areas of open water, generally with less than 25% cover of vegetation or soil.
12. Perennial Ice/Snow - All areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
21. Developed, Open Space - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes

22. Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.
23. Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.
24. Developed, High Intensity - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.
31. Barren Land (Rock/Sand/Clay) - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
32. Unconsolidated Shore* - Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
41. Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
42. Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
43. Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
51. Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52. Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
71. Grassland/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
72. Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73. Lichens - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74. Moss - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
82. Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
91. Palustrine Forested Wetland* -Includes all tidal and non-tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.
92. Palustrine Scrub/Shrub Wetland* - Includes all tidal and non-tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs or trees that are small or stunted due to environmental conditions.
93. Estuarine Forested Wetland* - Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
94. Estuarine Scrub/Shrub Wetland* - Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
95. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
96. Palustrine Emergent Wetland (Persistent)* - Includes all tidal and non-tidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season.
97. Estuarine Emergent Wetland* - Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens) and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands.
98. Palustrine Aquatic Bed* - The Palustrine Aquatic Bed class includes tidal and nontidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is below 0.5 percent and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, detached floating mats, and rooted vascular plant assemblages.
99. Estuarine Aquatic Bed* - Includes tidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, kelp beds, and rooted vascular plant assemblages.

Type: 100 and 500 Year Flood Zones
Source/agency: Illinois State Geological Survey
Date: 1996
Scale: 1:24,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: This is a statewide polygon feature class of 100 year and 500 year flood zones as of 1986 for the unincorporated areas of Illinois as indicated on Federal Emergency Management Agency (FEMA) National Flood Insurance Program (FIRM) maps and Flood Hazard Boundary maps.

Type: SOILS
Source/agency: U.S. Department of Agriculture, NRCS
Date: February 2006
Scale: 1:65,000
Geographic Coordinate System: UTM 16 NAD 83
Description: Soil Survey Geographic (SSURGO) database for Ogle + Lee Counties, Illinois

Type: HEL (Highly Erodable Land): United States Department of Agriculture
Source/agency: U.S. Department of Agriculture, NRCS
Date: February 2006
Scale: 1:65,000
Geographic Coordinate System: UTM 16 NAD 83
Descripion: Soil Survey Geographic (SSURGO) database for Ogle + Lee Counties, Illinois Soil map units having an erodibility index of 8 or greater

Type: Hydric Soils
Source/agency: U.S. Department of Agriculture, NRCS
Date: February 2006
Scale: 1:65,000
Geographic Coordinate System: UTM 16 NAD 83
Description: Soil Survey Geographic (SSURGO) database for Ogle + Lee Counties, Illinois

Type: Hydrologic Soil Groups
Source/agency: U.S. Department of Agriculture, NRCS
Date: February 2006
Scale: 1:65,000
Geographic Coordinate System: UTM 16 NAD 83
Description: Soil Survey Geographic (SSURGO) database for Ogle + Lee Counties, Illinois

Type: Relief / Topography
Source/agency: USDA, NRCS
Date: December 2000
Scale: 1:65,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Dataset containing contour elevations of the landscape.

Type: Prime Farmland
Source/agency: US Department of Agriculture
Date: January 2010
Scale: 1:24,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses. It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to

acceptable farming methods. In general, prime farmland has an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, an acceptable level of acidity or alkalinity, an acceptable content of salt or sodium, and few or no rocks. Its soils are permeable to water and air. Prime farmland is not excessively eroded or saturated with water for long periods of time, and it either does not flood frequently during the growing season or is protected from flooding. Users of the lists of prime farmland map units should recognize that soil properties are only one of several criteria that are necessary.

Type: Natural Areas (Forest and Grasslands)
Source/agency: OES
Date: February 2013
Scale: 1:24:000
Projection: Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Using the 1999 land cover created by the IDNR as a base, interpretation of the 2005 orthophotography and site knowledge new shapefiles for forest area and grasslands were created. Forests were defined as >80% canopy deciduous and coniferous trees. Grasslands were defined as cool and warm season grasses and prairie with very few shrubs and no trees.

Type: Publicly Protected Natural Areas
Source/agency: Illinois Natural History Survey IDNR
Publication_Date: April 1994
Scale: 1:24,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: Publicly protected open space including State Parks, State Forests, State, Natural Areas, State Conservation Areas, Illinois Natural Area Inventory Sites, Nature Preserves.

Type: Well Boring Locations
Source/agency: Illinois State Geological Survey
Date: 2008
Scale: 1:62,500
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: This file contains point locations from the ISGS Wells and Borings database. The attribute information include API number (the ID), well or boring type, longitude, and latitude. The spatial reference is geographic coordinates, decimal degrees, NAD83. The data are exported to a shapefile weekly from the Wells and Borings (source) database for Internet distribution.

Type: Leach Sensitivity (Pesticide and NO3)
Source/agency: Illinois State Geological Survey
Date: 1995
Scale: 1:250,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: This data set was created to classify soils and aquifer settings according to predictions of leaching potential. The classifications have not been validated by the results of water quality sampling. In addition, the use of these aquifer sensitivity ratings as predictors of water quality has not been

evaluated. Nonuniform use of fertilizers might reduce the reliability of water quality predictions, which can only be validated by careful comparison with water
quality data.

Type: Cultivated Land Cover
Source/agency: US Department of Agriculture
Date: 2007
Scale: 1:65,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: This feature dataset provides the estimated percentages of cultivated cropland.

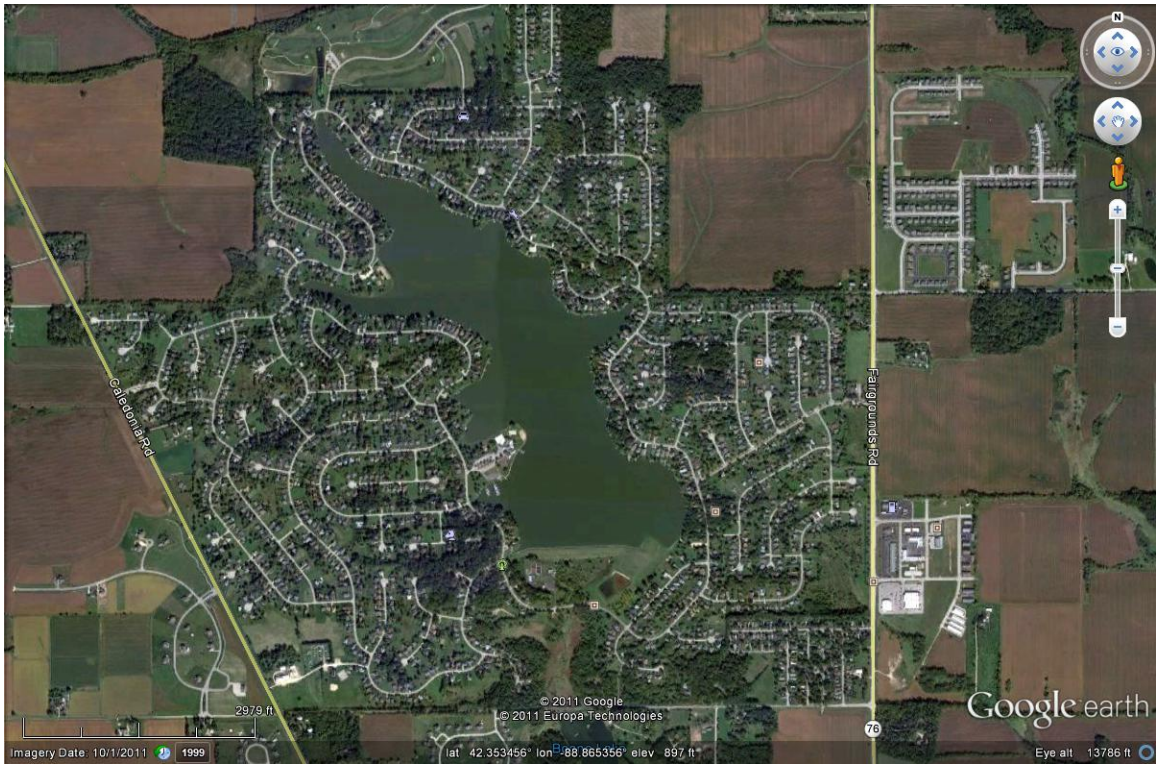
Type: Bedrock
Source/agency: Illinois State Geological Survey
Date: 2005
Scale: 1:500,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: This feature dataset shows the distribution and extent of the bedrock geologic units within the State of Illinois, as depicted on the map Bedrock Geology of Illinois.

Type: Quaternary Deposits
Source/agency: Illinois State Geological Survey
Date: 1996
Scale: 1:2,500,000
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Description: This feature dataset is a generalized version of Quaternary Deposits of Illinois. Updated to reflect the areal distribution of the Wedron and Mason Groups (Wisconsin and Hudson Episodes) and deposits of the Illinoian and pre-Illinoian episodes in Illinois as described in ISGS Bulletin 104. Episodes are diachronic temporal units.

APPENDIX A

Integrated Lakes Management, Inc.
Lake and Pond Management
Restoration ▪ Consulting

CANDLEWICK LAKE
LAKE MANAGEMENT PLAN
2011



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Lake stratification
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DRAFT

CANDLEWICK LAKE MANAGEMENT PLAN
2011

I INTRODUCTION:

The Candlewick Lake Association has been very proactive in terms of management and anticipation of needs for the lake. However the studies and testing of the lake occur in miscellaneous reports created over the years. The purpose of this Lake Management Plan is to tie these reports together and create a cohesive five year and longer plan with an estimated budget.

This Lake Management Plan incorporates a summary of previous lake studies made available to Integrated Lakes Management (ILM) which primarily involve water quality assessments and a history of various lake management projects. ILM conducted three water quality monitoring visits in 2011 to access the condition of the lake. During these visits several concerns were raised regarding the water quality, especially in the northwest bay by Constitution Drive; the need for a silt pond upstream of this bay; and the use of the existing aeration equipment.

A lake management plan should be considered as a fluid document requiring changes and updates as needed. No regulatory obligation exists to conduct a lake management plan. We suggest that this plan be prepared to directly address problems identified by the lake manager and lakes committee. Several of the previous reports were very technical and recommended that very detailed studies be performed to verify and identify changes in the lake. It has been said: “you can spend a lot of time and money investigating a problem and still not know exactly what is occurring, or you can spend that time and money on doing repairs”. The purpose of this document is to not create a report that will sit on a shelf because it is too technical to understand, but to identify the current problems in Candlewick Lake and to identify, with cost estimates, potential solutions and general timeline.

History

Candlewick Lake was constructed by damming a tributary to Beaver Creek in the early 1970s and reached full pool by 1975. Maximum depth of the lake is 28 feet in the 210 acre lake, with an average depth of 10.25 feet. The lake is used primarily for fishing, swimming, and boating. On average approximately 20 boats use the lake during summer weekends, with up to 40 boats observed during busy periods. There is a 75 horsepower (hp) maximum limit on boats traveling up to 30 mph, and unlimited hp for boats traveling at no wake speeds. One marina occurs in the southwestern portion of the lake. A swimming beach is located on the south central portion of the lake although a considerable amount of swimming occurs from piers.

Waterfront property appears to be entirely built out with single family homes surrounding the lake. There are currently 1850 homes located within the Candlewick Lake Association, with the potential for 356 more homes (2206 lots total). Most of the homes occupied throughout the year.

A community golf course occurs upstream of the northern inlet to the lake. This area also includes a silt pond that was constructed in 1981. Several small parks are located around the lake. The remaining portion of the 1,890 acre watershed is primarily agricultural.

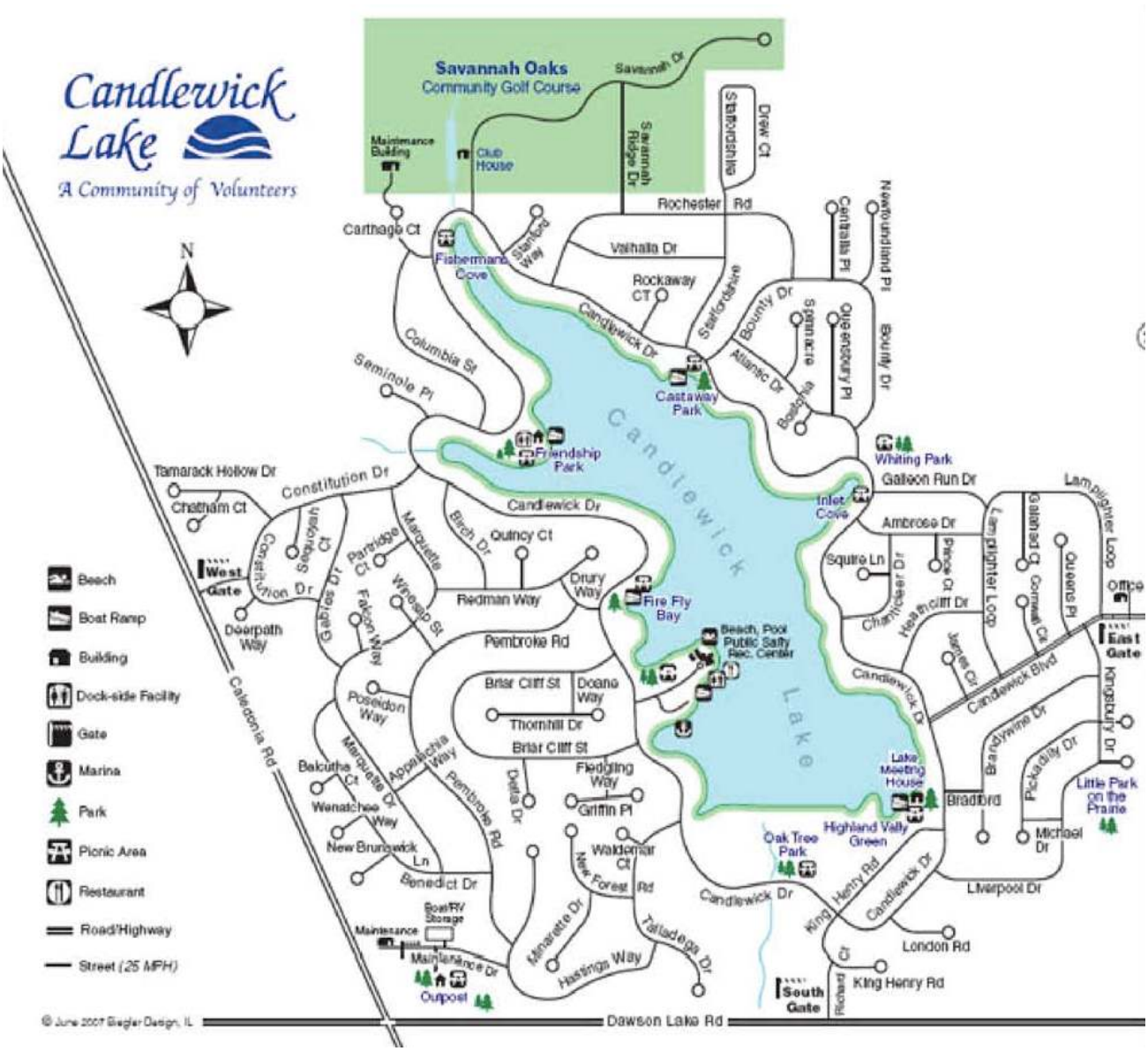


Figure 1: Road map and major amenities for Candlewick Lake.

In 1979 a sewage treatment plant began discharging treated household effluent into the lake, and by the early 1990s it was running over capacity and needed to be replaced. The new sewage

treatment plant was completed in 1999 and the discharge was rerouted downstream of the lake into Beaver Creek.

Discharge from the sewage treatment plant, runoff from the agricultural watershed, and fertilizers applied to the lawns within the watershed, have all have contributed nutrients to the lake. Initially the lake experienced significant aquatic weed growth and several methods were used to limit this growth, including installing grass carp (white Amur) in the lake in 1986, and weed harvesting between 1988-1990. However, by 1991 weeds were no longer present in the lake and algae became dominant.

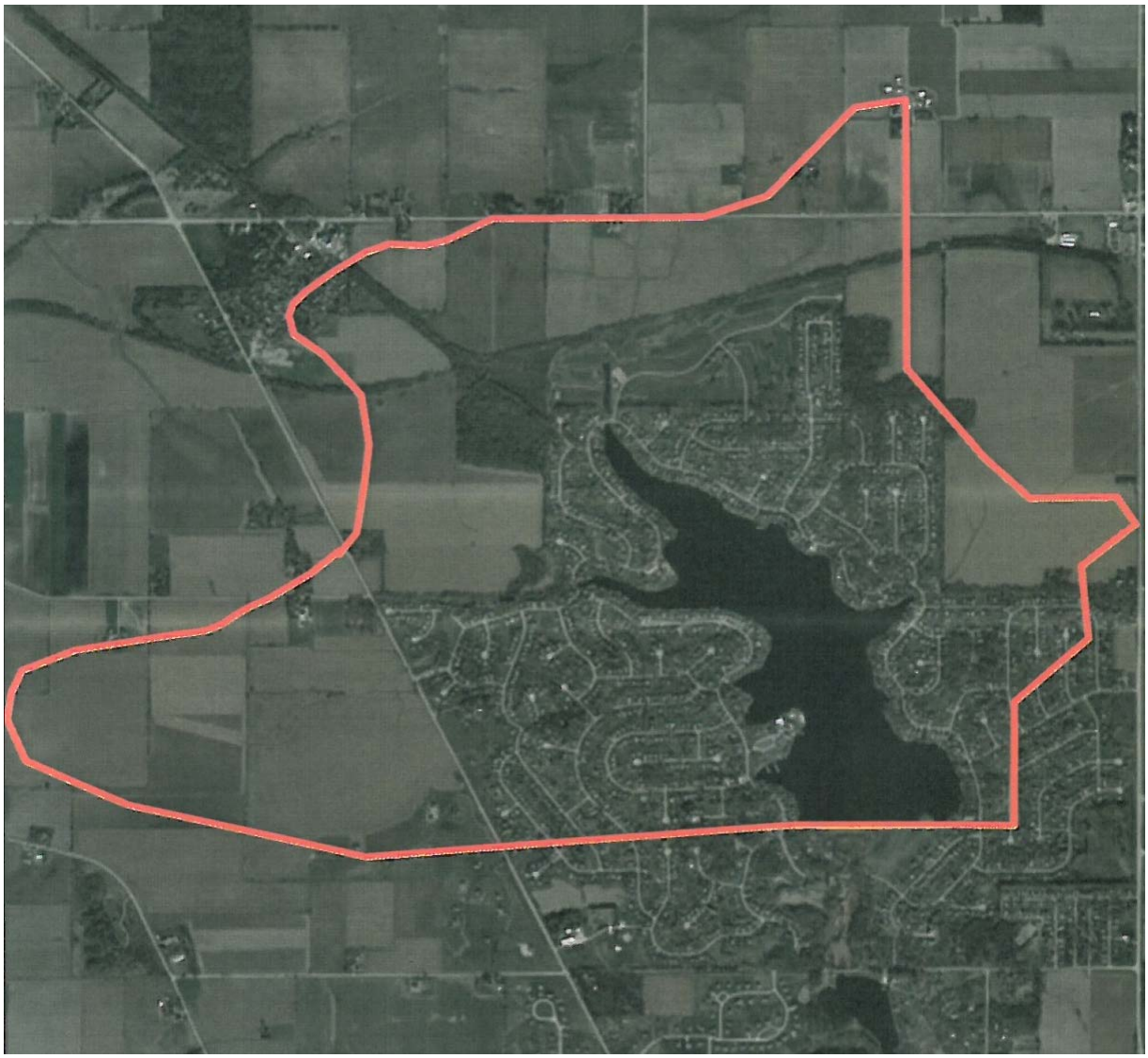


Figure 2: Aerial photograph with the Candlewick Lake watershed defined. Note the southern portion of the community does not drain directly into the lake.

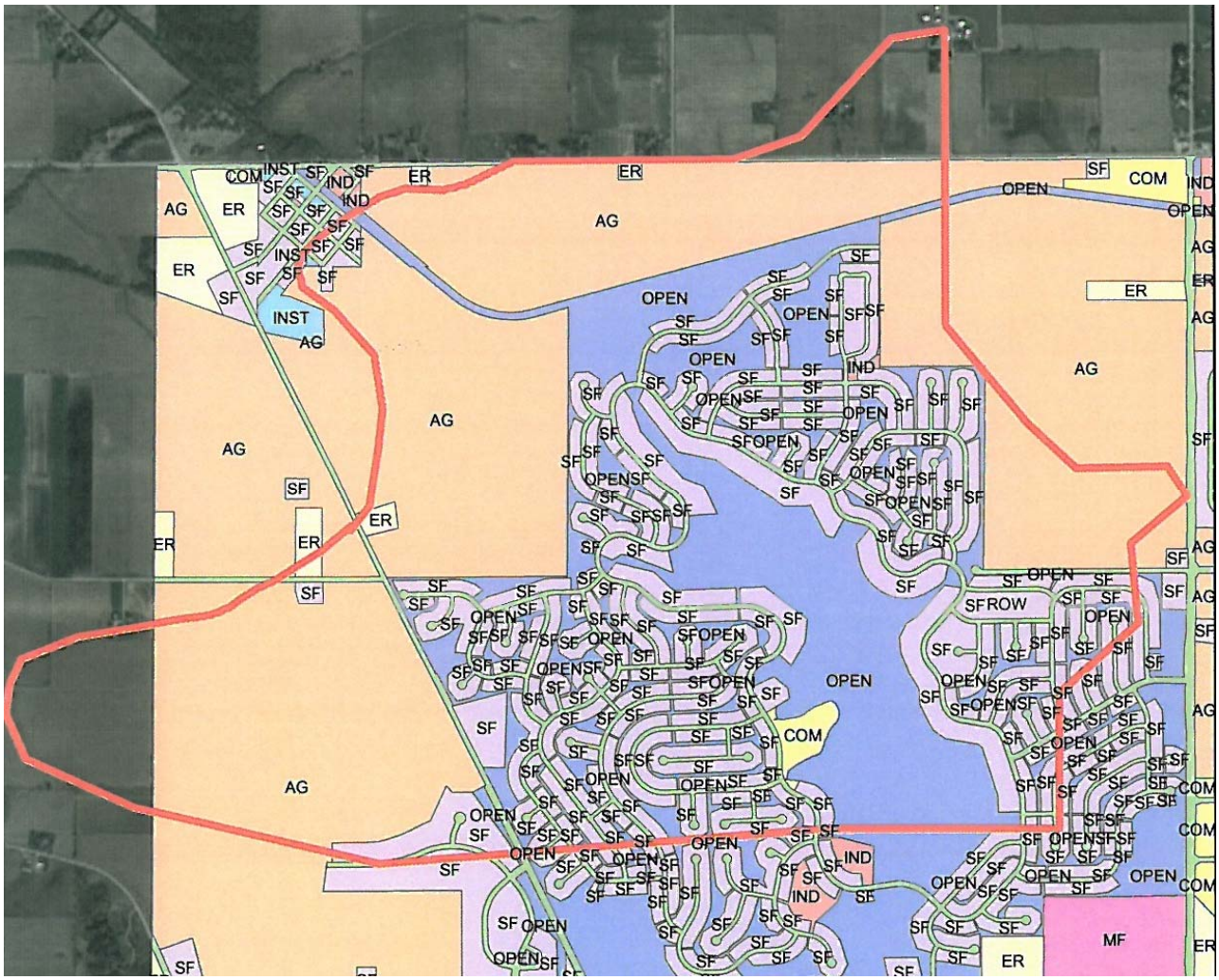


Figure 3: Land use for the Candlewick Lake area. A few areas within the watershed were not available. AG = agricultural; SF = single family homes; COM = commercial; OPEN = areas not matching these classifications (includes the lake, parks, golf course and other areas.

Figure 4: Typical home with mowed lawn, and seawall.

Figure 5: View of the Friendship Park with lawn and seawall.

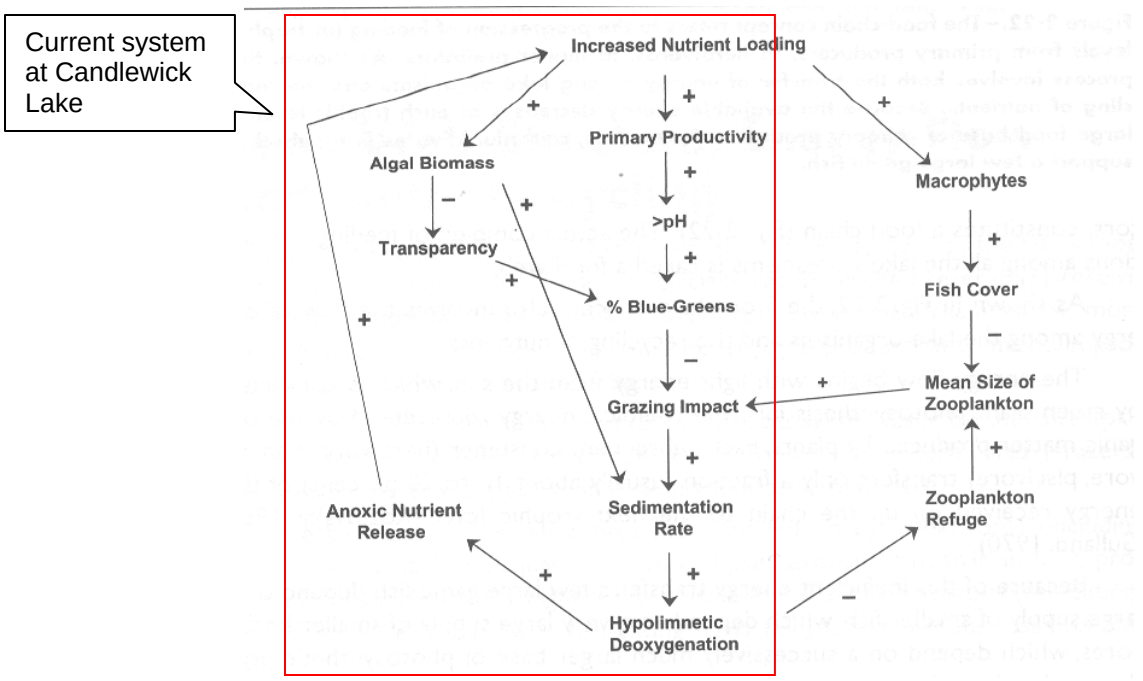


Figure 6: Lake ecology follows different paths depending on if the lake is dominated by plants (macrophytes) or algae. The dominance of aquatic plants creates zooplankton habitat, these zooplankton then graze on the algae.

Candlewick Lake has shifted from a plant dominated lake in the 1980s to an algae dominated lake. Although an algae dominated lake is more desirable for boating, it is not a healthier ecosystem for fish and for zooplankton (planktonic animals). These animals need aquatic plants to provide places to hide from predators.

With increased nutrient loading a lake will have an increase of rooted aquatic plants (macrophytes) or algae. Algae occurs as two types either planktonic, which represents small particles within the water or filamentous algae, which either occurs on the lake bottom and then floats to the surface, or only occurs on the surface. Of these three scenarios, the healthiest lakes are plant dominated with clear water. Aquatic plants provide areas for fish and zooplankton to hide. Zooplankton are very beneficial to a lake since they graze on planktonic algae and also provide food for planktivorous fish (Figure 5). For algae dominated lakes, filamentous algae represents a healthier system than planktonic algae, with blue-green algae blooms representing the worst case scenario.

Lakes can switch from one dominant form to another – sometimes very quickly. Typically the switch is from a plant dominated lake to an algae dominated lake. This can occur when all the plants are treated with herbicides, eaten by grass carp, or shortly after dredging. It is often much harder to change a lake dominated by planktonic algae back to a plant based lake, but it can occur with major restoration efforts.

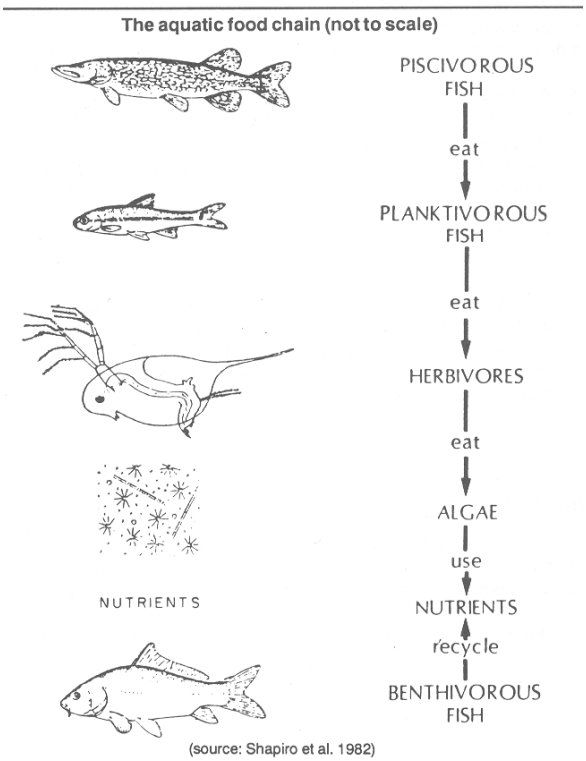


Figure 7: Aquatic food chain needed for a healthy lake. Candlewick Lake has an unbalanced system due to the lack of zooplankton herbivores to graze on the algae.

II CONCERNS:

Candlewick Lake is over forty years old and over this period the watershed has had substantial development of homes. Since lakes are often the lowest point in the landscape they accumulate sediment and nutrients and the water exiting the lake tends to be cleaner than the water that enters. As a lake ages it is natural for it to change from a clear lake with little sediment and few plants, to one becoming dominated by plants or algae as nutrients accumulate in the sediment and water column. The eutrophication process is natural, usually taking thousands of years, but man can greatly accelerate that process to occur in only decades by causing or allowing nutrients and sediments to flow into the lake. Reversal of the eutrophication process can occur with dredging and/or nutrient reduction. Unfortunately reducing nutrient loading in the water column can take a long time and positive effects may never be seen as long as the lake bottom sediments still contain nutrients. Internal loading of nutrients are a continuing source as long as the lake bottom becomes anoxic (void of oxygen) during the summer when the lake is stratified.

Problems observed at Candlewick Lake will be discussed individually with potential solutions and cost projections. The Candlewick Lake Association has evaluated different potential solutions and some of the typical solutions have been tried, or at least discussed at length. ILM will provide some "thinking outside of the box" ideas as well as tried and true potential solutions.

Issues that have been expressed regarding the lake include:

1. Blue green algae growth
2. Poor water quality
3. Installation of a Northwest Bay (Constitution Drive) silt pond
4. Aeration
5. Dredging

PROBLEM 1: BLUE GREEN ALGAE GROWTH

In reviewing the historical lake information it was noted that various water quality improvement tactics have been employed over the years. These included a lake bottom alum treatment in 2000; shoreline stabilization with rip rap; aeration and destratifier installation; dredging the northern portion of the lake in 2010, and the silt pond in 2001 and 2011; Volunteer Lake Monitoring; purchasing water quality testing equipment; goose egg addling and acquisition of swans; a leaf collection program; phosphorus fertilizer restrictions; bathymetric mapping and sediment analysis; and zebra mussel monitoring.

Currently some non-native aquatic weeds exist in the lake, mostly curly leaf pondweed along portions of the shoreline. In 2010 a contractor performed fairly aggressive treatment of the aquatic weeds and the lake association observed that after the weeds died, the lake became very turbid and the fishing became poor. In 2011, the association decided to maintain the lake with their maintenance staff, and only one algaecide application was performed in early June.

Figure 8: Water in the marina appearing as pea soup green due to algae (7/25/11).

Figure 9: The northwest bay showing a planktonic algae bloom (9/8/11)

Planktonic algae blooms create turbid water with a greenish color, while rooted aquatic plants are associated with clearer water. Sampling and analysis of algae samples identified various forms of blue green algae, mostly *Microcystis* and *Aphanizomenon*, and *Aphanocapsa*. All of these species can release toxins that can cause people and animals to become sick when significant quantities are ingested. Dogs have been known to die from drinking too much Microcystis contaminated water. When concentrated, Microcystis makes the water appear as if green paint has been deposited in the water. In 2011, blue-green algae made up close to 100% of the planktonic algae observed in the middle of the lake, with Microcystis representing about 50% during the mid to late summer (Chart 1).

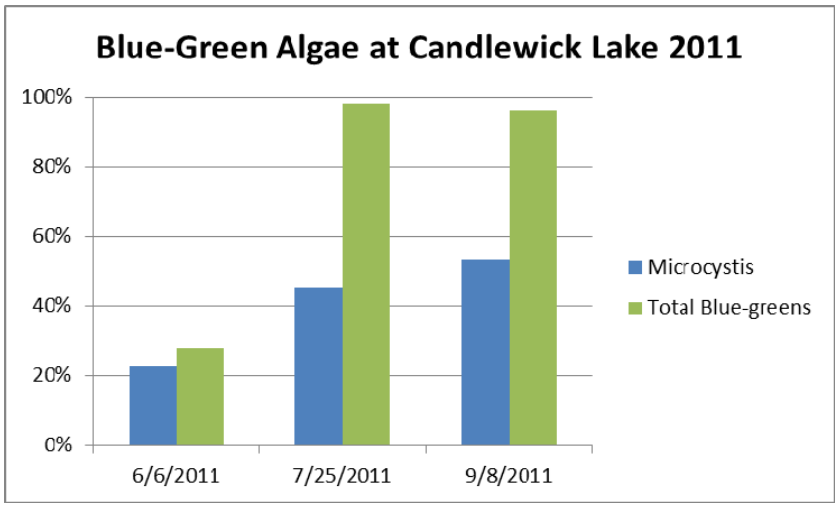


Figure 10: Blue-green algae represented almost 100% of the planktonic algae present in mid to late summer. Microcystis represented about 50%.

Chlorophyll *a* is the green pigment that is contained in algae, and is a rough determinant as to the amount of planktonic algae present in the water. A combination of water quality data from various sources shows that chlorophyll a has been monitored periodically since 1994. Concentrations above 20 µg/l represent algae blooms (red line in Chart 2). Algae blooms typically occur in mid to late summer, which is why early season samples have low levels.

Note that of the years samples were collected, algae blooms were observed in 1995, 2000, 2001, and 2011. Data was not available for every year.

It is interesting to note that algae blooms were observed in 2001, the year after the lake bottom algae treatment had been completed.

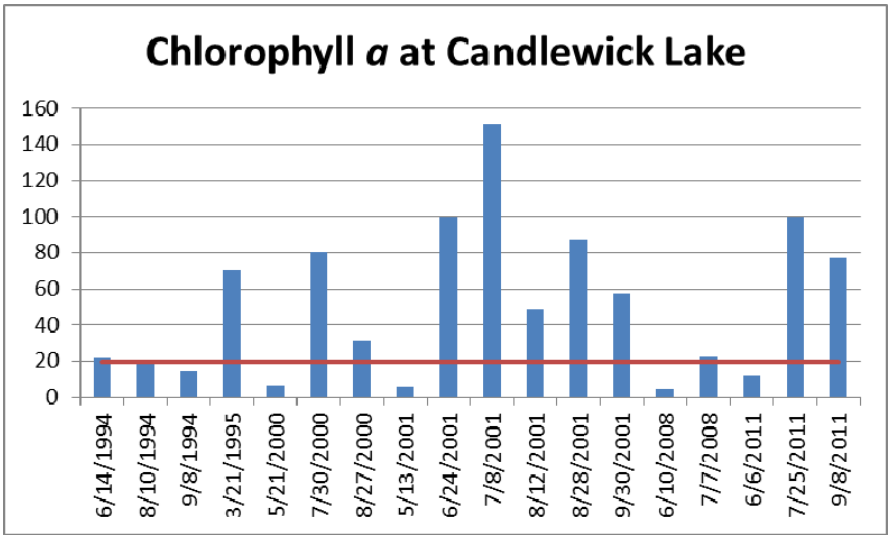


Figure 11: Periodic Chlorophyll a measurements taken at Candlewick Lake. Values above the red line indicate an algae bloom.

Another way of measuring algae blooms can be performed with a secchi disk, which measures water clarity. The lower the water clarity, the larger the algae bloom. More data is available for this measurement than for chlorophyll *a* (Chart 3), through the Volunteer Lake Monitoring Program. Not all dates are listed due to the large volume of data. The field data is included in the appendix.

Note that high water clarity typically occurs early in the growing season, but then it quickly drops to two feet or less as the water warms and algae begins to flourish. Water clarity had been higher in the 1980s when the lake was dominated by plants, but dropped in the 1990s when algae became the dominant species. Also notice that the water clarity was low in 2001, the year after the alum treatment, but was slightly higher in 2004 – 2009. Summer water clarity for 2010 and 2011 was about one foot.

Figures 12 & 13: Volunteer Lake Monitoring and Exotic Species advisory (including zebra mussels) posted at the boat ramp.

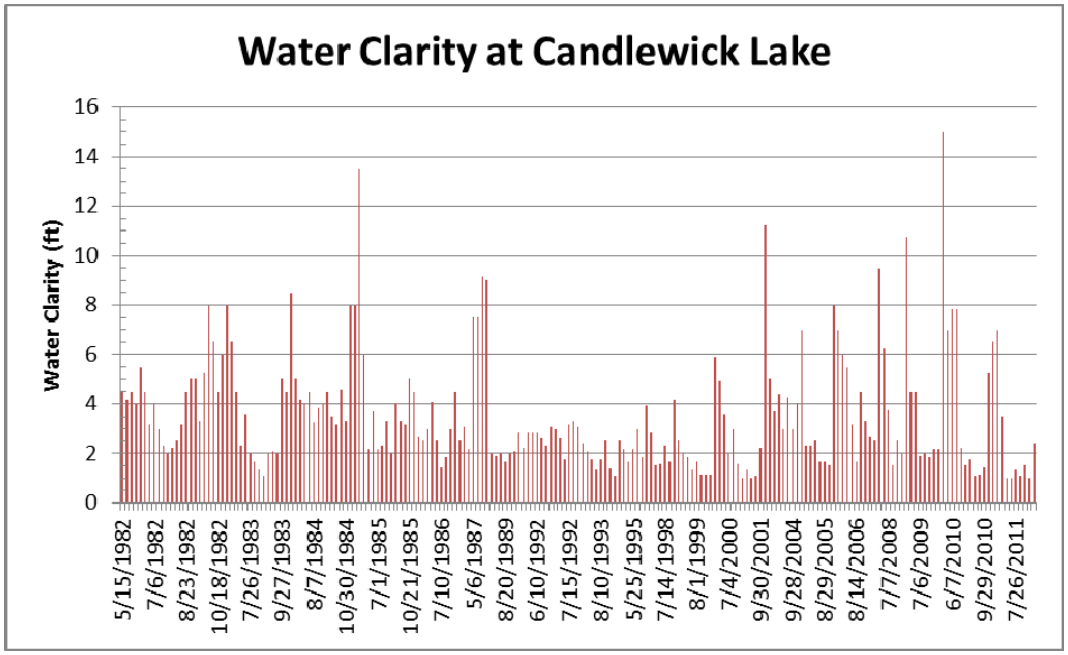


Figure 14: Average water clarity in Lake Carroll. Note not all dates are listed. Data is in the appendix.

Zebra mussel monitoring began in 2004 and to date have not been found at Candlewick Lake. These mussels are voracious eaters of plankton, but not of Microcystis. There are numerous reports of Microcystin algae blooms occurring after lakes have become dominated by zebra mussels.

Recommendations for managing algae / aquatic plant growth:

- ILM recommends that some aquatic plants be left in place to provide habitat for fish and zooplankton. Typically 10 – 20% (12 – 24 acres) of the lake should have aquatic plants to maintain healthy lake ecology. Some education of the lake users may be needed to promote weed tolerance at least in selected areas. A combination of methods is recommended which include selective herbicide use around piers and in marinas as needed. Curley leaf pond weed naturally dies back in early July, which is when the planktonic algae blooms occur. Costs for aquatic herbicide applications will vary with the type of chemical, but an estimated cost is $500/acre.

- It is recommended that the grass carp should not be replaced as they die off. Grass carp typically live 8 – 10 years and are one of the main factors that contribute to Candlewick Lake being an algae dominated lake. It is very difficult to maintain a low level of plant control with grass carp. They typically either eat all aquatic plants, or are too few to be effective. Also there is no control over which species and location of the areas that they feed upon. Selective herbiciding allows for greater control of plant coverage in a lake or pond.

- Desirable species of aquatic plants should be installed in selective areas. These species include chara (a rooted form of algae), and water lilies. Chara does not reach the surface and helps clarify the water. Water lilies grow in dense beds in selected areas, are quite pretty, and provide good habitat. Water lilies cost about $8/plant installed. Chara can be moved from other ponds or $5/lb. of seed installed

- Signs should be installed warning people of the hazards of blue-green algae. More information can be found at http://dnr.wi.gov/lakes/bluegreenalgae/. An example of a sign is included in the appendix. Signage information should include:
    - Do not swim in water that looks like "pea soup", green or blue paint, or that has a scum layer or puffy blobs floating on the surface
    - Do not let children play with scum layers, even from shore
    - Do not let pets swim in, or drink, waters experiencing blue-green algae blooms
    - Always take a shower after coming into contact with any surface water (whether or not a blue-green algae bloom appears to be present; surface waters may contain other species of potentially harmful bacteria and viruses)
- It is not recommended that blue-green algae be treated with algaecides once it has reached a certain coverage or concentration, since this may release toxins and a whole lake treatment would be needed to be effective.

- Enzymes and bacteria are not algaecides and are unproven as to their effectiveness of preventing algae growth. If used, biweekly applications are recommended by the manufacturer throughout the season. Aeration of the lake bottom is also needed if there is any chance for the bacteria and enzymes to be effective. Cost is variable depending on area covered and frequency of application – usually every 2 weeks.

PROBLEM 2: POOR WATER QUALITY

Sources of nutrients entering the lake should be kept at a minimum since lakes accumulate them in both the water and the sediment, making the lake more susceptible to algae blooms and aquatic plant growth. Candlewick Lake started with a high level of nutrient loading with the discharge from the community sewage treatment plant. Although this treatment plant no longer discharges into the lake, the nutrients remain in the sediment and are released into the water when the lake bottom becomes anoxic during the summer months.

The watershed for Candlewick Lake is very small and has less than a 10:1 watershed to lake ratio. Typically a 20:1 ratio should occur to maintain enough water in the lake. This means that in dry years, the lake may fall below normal pool for extended periods. Also the lake is more likely to accumulate nutrients and not flush them out. In the 1995 hydrologic budget, it was determined that the retention time of the lake is 1.0 year. This means that the time a single drop of water enters the lake; it will take a full year for that same drop to leave the lake. This allows particles and nutrients a long time to settle.

The Lake Association has been able to curtail some phosphorus from entering the lake, by placing a ban on phosphorus in lawn fertilizers; performing shoreline stabilization; providing a leaf clean up service; and restricting mowing near the shoreline. They have also tried to reduce the impact of the nutrient rich sediments by performing a lake bottom alum treatment and installing an aeration system to reduce nutrient recycling from the sediment into the water. They have also removed a significant amount of sediment in the northern section of the lake by dredging. However, the lake still contains high levels of nutrients and is considered hypereutrophic.

Phosphorus is the main nutrient that contributes to algae and rooted aquatic plant growth. The Illinois State Standard is 0.05 mg/l for total phosphorus and the recommended concentration limit for orthophosphorus is 0.01 mg/l. Although the total phosphorus concentrations have typically been well below 0.05 mg/l, lakes act as a sink and collect phosphorus in the sediments which then contribute to aquatic plant growth.

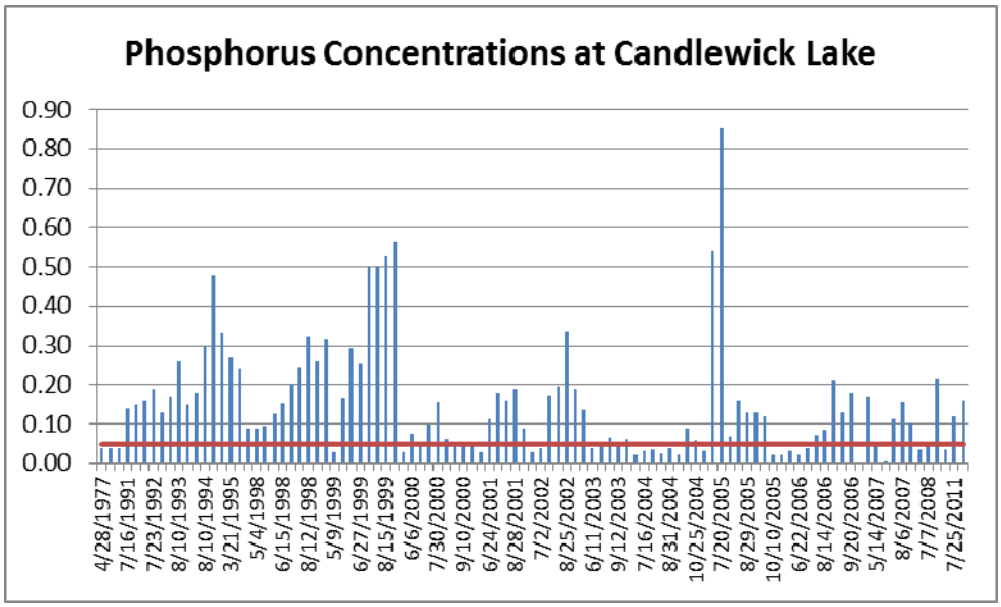
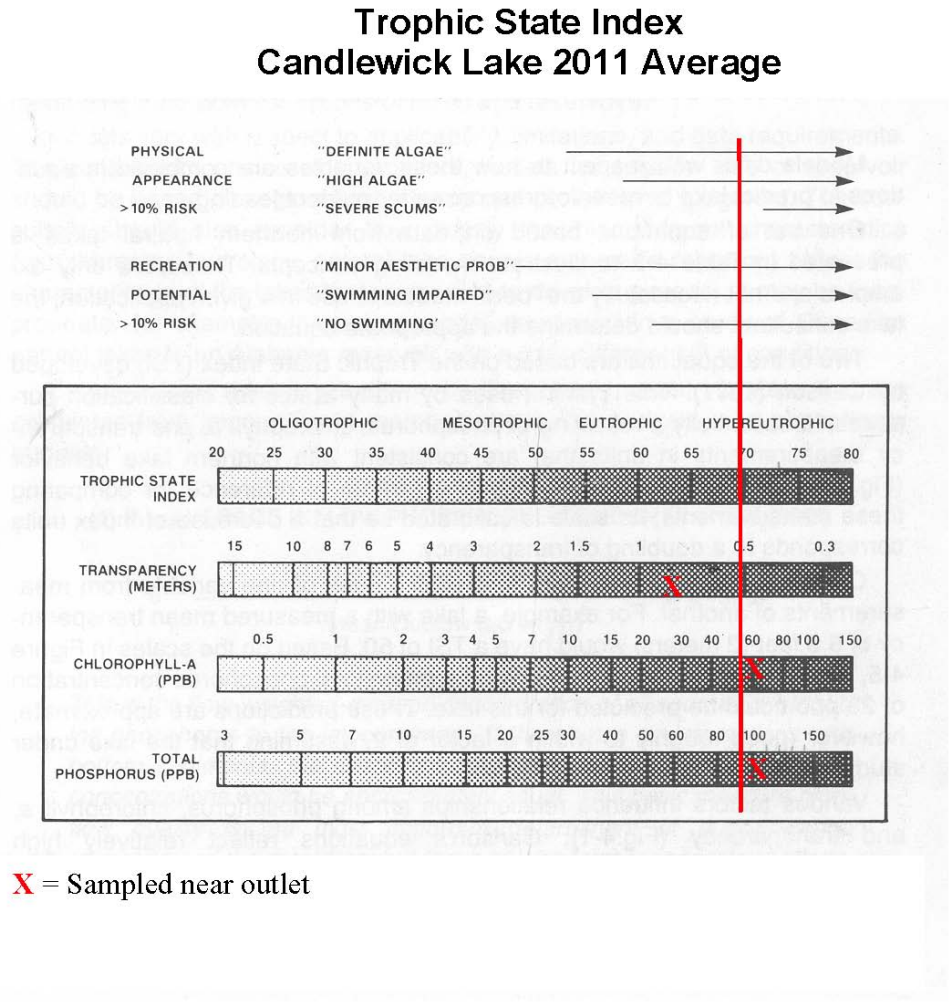


Figure 15: Total phosphorus at Candlewick Lake. Note the sharp drop in concentrations after the sewage treatment plant was diverted in 1999. Levels above 0.05 mg/l (red line) are above the IL State Standards.

The Trophic State Index (TSI) is often used to determine overall water quality in a lake based on the amount of nutrients present. Multiple samples collected over a season should be averaged to create a more accurate TSI calculation. Typically three parameters: total phosphorus, chlorophyll *a* and water clarity are used to determine the TSI. However, sometimes only one parameter such as phosphorus or water clarity is used in this calculation. TSI was calculated for the 2011 water quality testing performed by ILM (Figure 16).



From: The Lake and Reservoir Restoration Guidance Manual, Second Edition, U. S. Environmental Protection Agency, August 1990.

Figure 16: Trophic State Index (TSI) is based on water transparency, chlorophyll *a*, and total phosphorus. Candlewick Lake is in the hypereutrophic range, which is very nutrient rich.

When low oxygen conditions occur at the sediment / water interface, nutrients stored in the sediment can be released into the water. Candlewick Lake becomes well stratified in the

summer and dissolved oxygen drops to nearly zero at a depth below 14 feet as seen during the July 25th sampling (Figure 17).

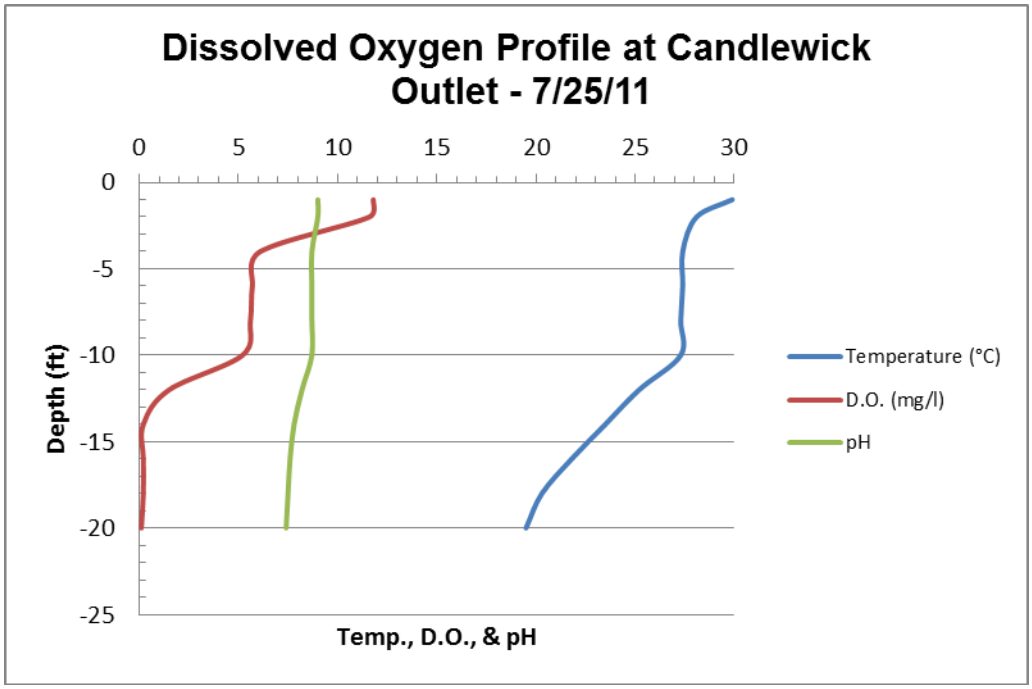


Figure 17: Dissolved oxygen profile shows anoxic conditions below 13 feet. Fish need 5 mg/l to survive, so fish are located in the upper portion of the water column.

Phosphorus measurements in the sediment were taken during the three 2011 water quality visits. Sediment samples are discrete and unlike water, show more variability depending on where the sample was collected. Standards for nutrients in sediment do not exist, but a study of many Illinois lakes lists normal and elevated concentrations for various parameters.

The sediment in the northern section of the lake (south of the dredging area) was much darker than the sediment collected near the outlet. This usually means that the darker sediment is more nutrient rich than the lighter sediment, which was observed during the 7/25/11 site visit, but not during the 9/8/11 sampling. Overall the nutrient concentration in the sediment appears to be within the normal range for lake bottom sediment based on "Sediment Classification for Illinois Inland Lakes" (1996 Update, IEPA). Data is in the appendix. Although Candlewick Lake is in the normal range for nutrients in the sediment, a "normal" Illinois Lake is still quite nutrient rich, and can still release nutrients into the water during anoxic conditions.

Recommendations for water quality improvement:

Two main categories of water quality improvement are needed, one involves reducing phosphorus loading from external sources and the other is from internal sources.

External nutrient loading

- External nutrient loading into the lake will be reduced by a larger fringe of prairie, wetland, and emergent plants along the shoreline and in the water. Some homeowners have a very narrow fringe of prairie plants and some just have unmowed areas. Establishing a native buffer will also reduce shoreline erosion. Estimated cost is $25/linear foot

- Enforcement and education of the residents regarding the use of no phosphorus lawn fertilizers to reduce nutrient loading from mowed lawns. Also liquid fertilizer should be used instead of a granular form. Liquid fertilizers will be absorbed by the soil and the plants very quickly and is less likely to wash into the lake by a heavy storm. The golf course should also use no phosphorus fertilizer.

    - Another way to help reduce nutrient loading into the lake is to not fertilize the lawn in a 20 - 30 foot zone around the lake. This unfertilized zone will trap much of the fertilizer that would normally wash into the lake during heavy rain events. The size of the unfertilized zone will affect the amount of fertilizer that washes into the lake.

- Waterfowl feces, especially from geese and swans, are important in the control of nutrients collecting in the water. Goose feces on the lawns and piers surrounding the lake is unsightly and a health hazard. People coming in contact with the feces can potentially get *Salmonella* or *Chlamydiosis*. Feces that wash into the lake contain oxygen demanding substances, nutrients, metals, organic solids, salts, as well as bacteria, viruses, and other microorganisms. Removal of goose feces off piers, parking areas, and lawns near the lake will significantly reduce nutrient loading in the lake from waterfowl.

    - The Lake Association currently rents 12 swans (+ 2 cygnets). The Lake Association will need to determine if these methods significantly reduce the goose population. Typically they do not. Usually multiple methods including dogs and other types of harassment are needed to control geese. One of the best methods to control resident geese is to have a native buffer along the shoreline. Residents should also be discouraged from feeding the geese.


Figures 18 & 19: Goose feces at the pier and parking lot at the marina on 9/8/11.

- Homeowners need to be concerned about pet waste washing into ditches and storm sewers. Pet wastes contribute nutrients to the lakes also. Routine cleanup of these wastes is an important aspect of reducing nutrient loading into the lakes.

Internal nutrient loading

- Nutrients in the sediment should be tested for total phosphorus and total kjeldahl nitrogen at least once annually at multiple locations to assist in showing trending and reduction as a result of improvement efforts made to reduce the flow of nutrients into the lake. Cost for these samples plus shipping is ~ $150.

- Although the Candlewick Lake staff had thought that the lake bottom alum treatment applied in 2000 had clarified the lake for a number of years, the data does not support this. In 2001 the chlorophyll *a* levels were quite high, indicating an algae bloom had occurred. Phosphorus concentrations were also quite high in 2001. Secchi readings were also very low, indicating low water clarity.

    - An estimated cost for a lake bottom alum treatment is $100,000 - $200,000 and is not recommended at this time.

- Christmas trees are not the best fish habitat for this lake. The trees degrade and contribute to nutrient loading. Artificial structures are preferred as for fish habitat.

Other

- Routine monitoring of water quality should be conducted on a monthly or bimonthly basis during the summer months when the lake is most stressed. Parameters tested should focus on phosphorus, chlorophyll *a* and water clarity (secchi depth). These parameters will allow for a trophic state index determination. Lab costs are about $100/set of samples, plus shipping.
    - The Lake Association should continue with the Volunteer Lake Monitoring Program.
        - Additional water quality tests could be collected by the volunteers and sent to a lab for analysis.
        - The community owns a quanta multi-parameter meter to collect dissolved oxygen profiles. The same person should be used to collect this data for consistency.

- A lakes consultant should visit the lake at a minimum of once per year to review the condition of the lake and note changes. Cost is ~ $1,500 - $2,000/visit.

- Monitor, identify and map aquatic plant growth. This will help determine the extent of the aquatic plants, their species, and if they are expanding their range. The lake maintenance staff may be able to do this with a gps. Data can be sent to ILM for mapping if needed.

- Algae identification should also be done, especially if planktonic algae blooms occur. If the bays have areas that appear as green paint, a sample should be sent to ILM to test for Microcystin toxins. Cost to test for Microcystin is $250/sample. Algae identification can be performed by ILM for $40/sample or sent to a phycology lab (Water's Edge or Phycotech) for ` $100/sample with species counts.

- E. coli or fecal coliform at the beach should be monitored routinely during the swimming season. This had been done biweekly from 2001 – 2005, but data was not available after that time. Beach closings should occur when there are exceedences.

Identifying sources:

- A nutrient budget update should be done since the last one done was part of the 1995 report. A nutrient budget identifies major nutrient sources and helps target areas for water quality improvement. Many changes have occurred since then that may alter the nutrient budget, such as routing the sewage treatment plant discharge by-passing the lake, and BMPs to improve water quality have been installed within the watershed. Estimated cost for a nutrient budget is $4,000.

- Macroinvertebrates in the inlet streams are a general indicator of water quality flowing into the lake. This could help determine poor water quality areas within the watershed that should be targeted for BMPs. If the inlet streams have good water quality, then water quality improvements should focus on the shoreline and internal nutrient loading from sediment in Candlewick Lake. Sampling of inlet streams should be done annually and the data submitted to the RiverWatch program. Estimated cost is $1,500.

PROBLEM 3: NORTHWEST BAY (CONSTITUTION DRIVE) SILT POND

One of the two main inlets to Candlewick Lake occurs at the northwest bay at Constitution Drive. This bay is fairly narrow at about 75 feet wide and the western 200 feet tends to collect blue-green algae during the summer. This area also collects a fair amount of sediment and the Lake Association is considering installing a silt pond upstream of the lake, similar to the one above the northern inlet.

Figure 20: NW bay inlet with algae bloom.

Figure 21: Silt pond above the north bay.

Silt ponds, depending on how they are designed typically collect sand grains and some silt particles, depending on the flow rate of the water. Most sediment tends to enter the lake during flood events and so the retention time in the silt pond is very short. This means that typically sand and some larger silt particles settle in the silt pond and the finer grained material, which the nutrients bind to, end up in the lake.

A silt pond upstream of Constitution Drive will collect the larger grained sediment, but not the fines, so the degree of nutrient loading into the lake would not change significantly. It may reduce the need for dredging in this bay, but likely will not reduce the blue-green algae scum.

Things to consider regarding a silt pond:

- Wetland areas occur upstream of Constitution Drive, and the stream is considered a Waters of the U.S. Constructing a silt pond within a wetland is considered a wetland impact. A discussion with Donna Jones from the Rock Island Army Corps said that onsite wetland mitigation may occur if the silt pond is designed to have a wetland shoreline that is equal to 1.5 X the acreage of the wetland area being impacted. This would reduce mitigation costs, but a five year period of maintenance and monitoring by a wetland specialist will be required.

  Engineering design and permitting will also be required. Watershed modeling may be needed to determine if the silt pond will cause flooding. In 1994 an engineering evaluation was performed on this stream by Jansen Engineering since upstream flooding had been occurring.

  Very rough cost estimates include:
  - Estimated cost for design and permitting $40,000 - $80,000

- 5 years of maintenance and monitoring $40,000 - $50,000
- Excavation costs $50,000 - $80,000
- Planting & matting $20,000 - $30,000

- Location of the silt pond would be behind several homes. This pond will likely become dominated with algae, and/or aquatic plants. Access for future dredging of the silt pond may be limited.

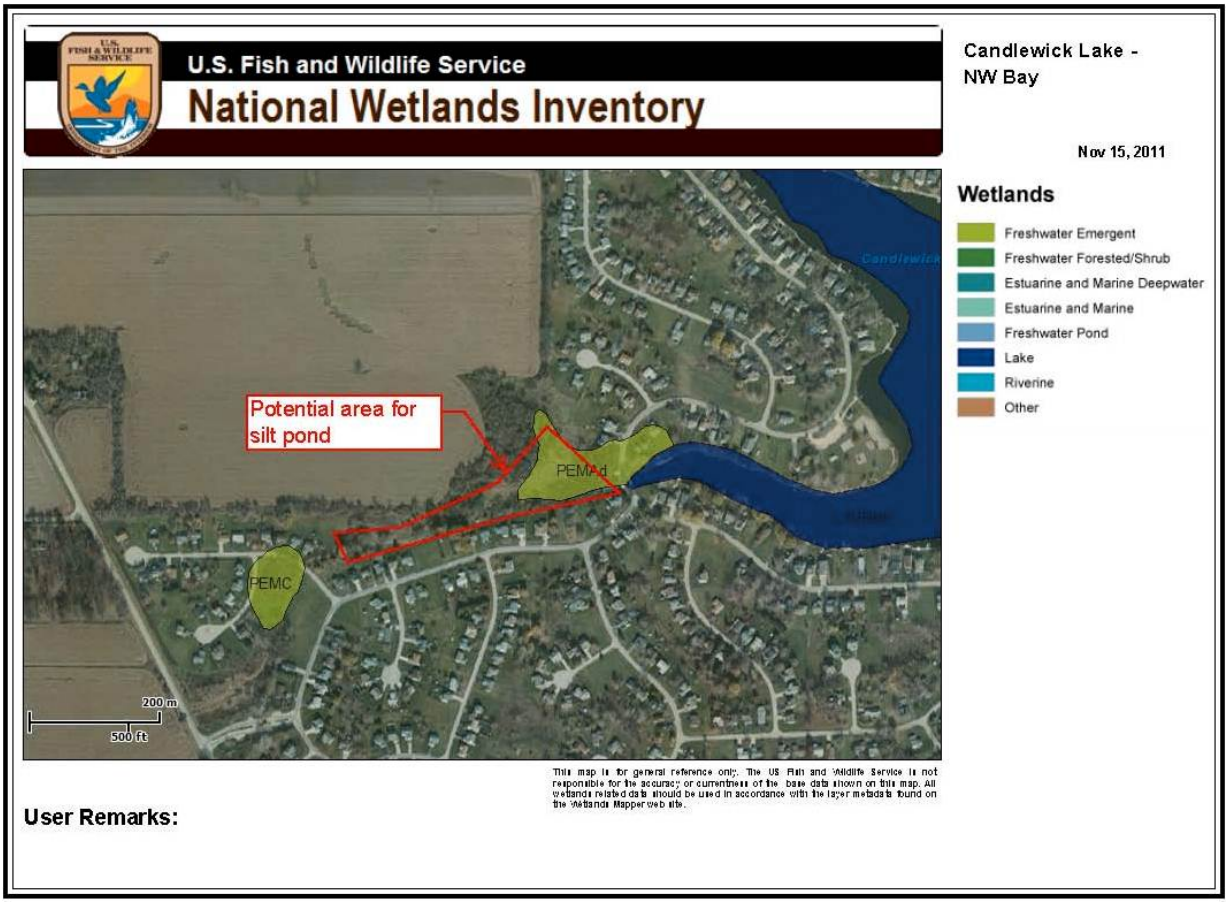


Figure 22: Wetland map and potential silt pond location. Light green areas indicate wetlands.

Alternatives to constructing a silt pond:

- Before entering the Candlewick property, branches of the stream run through agricultural areas. Taking a section of land out of production and creating a grass swale BMP or wetland in these areas may be another option in controlling sediment coming into the lake. Installing grass swales along the entire channel area would greatly reduce sediment and nutrients entering the stream and ultimately the lake. Depending on the wetland status of these channels and the amount of impact, this may be a cost effective manner to protect the lake. Purchasing the land may be required to perform this option.
    - Estimated costs $5/linear foot X ~ 4,000 feet = $20,000.

- Install a circulator aeration system in the northwest bay to create more water movement and reduce algal buildup. The area in need of aeration is about an acre and occurs close to the inlet culverts (figure 20). Several types of aeration were investigated and detailed information is in the appendix:
    - A small SolarBee unit would not require electricity and costs $43,300 installed.
    - Three circulator units using electricity. The electrical connections would need to be moved from the road to the lake, a distance of about 50 feet. Costs for these three units plus installation (not including electrical hookup) is $9,600
        - Monthly electrical costs are anticipated at $100/month to run all three units. Should use 6 months/year.

Figure 23: Area in NW bay proposed for aeration (provided by SolarBee).

Figure 24: If electrical aeration / circulator system is chosen, electric needs to be moved from the road to the lake.

It is recommended that the two alternative solutions be attempted. Agricultural BMPs around the channels would greatly help the lake reduce nutrient loading, and a circulator system would reduce algae build up in this bay.

PROBLEM 4: AERATION

The Candlewick Lake Association has had multiple experts review the aeration system and there appears to be a yearly debate among the Lake Association board on whether to run the aeration system or not. The debate is about whether the aeration is good for the lake water quality and fishery since observations have been made that phosphorus levels and turbidity have increased when the aerators are on, and decreased when they are off. This is contradictory from most studies, which show that phosphorus levels decrease with aeration since it stays bound to the sediment. When the lake is stratified, phosphorus levels will increase in the anoxic zone, but once fall turnover occurs, the phosphorus will be well mixed. Lower surface phosphorus levels in the summer may not fully represent the concentration in the lake when it is stratified.

Running the aeration units also increases the water temperature and destratifies the lake. Fishermen have complained that the warmer water is not good for the fish. However, this warmer water has adequate levels of dissolved oxygen. When the lake is stratified, cooler water exists at depth, but this area is anoxic and the fish stay in the warmer surface water. Overall the area available for fish should increase with aeration, since oxygen is more of a limiting factor then temperature.

As stated in the May 25, 2006 letter by Joe Rush, algal mats have occurred when the aeration units are running, and they have not occurred when the aerators are off. However, when the units are not running then planktonic blue-green algae occurs throughout the lake as observed by ILM in 2011. Blue-green algae blooms are the least desirable ecology for a lake and the most hazardous. Ecologically, a plant-based lake is the most desirable state, and algae mats are better ecologically than planktonic blue-green algae blooms. Harvesting equipment can be used to reduce algal matts along with algaecides.

This is a hard sell since swimmers and boaters prefer open water that is free of algal matts, and they are more tolerant of planktonic algae. However, when someone gets sick or a pet dies because of ingestion of the blue-green algae toxins, then it may be easier for people to tolerate algae matts.

From the data provided, the aeration history appears to be (see Figure 25 for locations):

1986 Aerators installed by peninsula
1993 Destratifier installed by the dam
2001 Aerators replaced and restarted.
2002 Destratifier stopped in July
2003 Aerators turned off
2004 Aerators placed around the structure (dam?) to prohibit ice buildup.
2006 Aeration system off

According to a document entitled “Lake Aeration & Circulation” (no date), Candlewick Lake has two methods to increase dissolved oxygen, an aeration system and a destratifier. The aeration system has three compressors that force air through hoses to the lake bottom, as the air rises, the cold anoxic water rises to the surface, where it is oxygenated. The destratifier is a mechanical pump that rests on a frame on the bottom near the dam. The pump has hoses that draw air into the pump, forces its way to the surface. The destratifier works similar to the aeration system but it provides more agitation, which was visible at the surface.

This paper also discusses multiple technical issues regarding the design of a circulation system that includes positioning and sizing of the various aeration units. If the units are positioned too far above the lake bottom, and anoxic zone exists below it, allowing phosphorus release from the sediment. If the diffuser is placed too close to the bottom, or if the system is oversized, sediment may be resuspended in the lake. So both sizing and location are critical.

ILM's aeration staff reviewed the aeration information provided and yielded the following comments:

- If aeration is being considered to oxygenate the deeper areas of the lake thereby increasing the zone of habitation for fish, then the current system should be sufficient to oxygenate the southern half of the lake. Turbidity and phosphorus concentrations will be elevated. If the need to oxygenate is to reduce phosphorus, expansion of the system is required to aerate the entire 210 acre lake.

- The destratifier is similar to an aspirating mixer. It pushes a jet of water ~15 degrees above horizontal along the bottom of the lake, this system has two hoses that run from the surface of the lake to the motor so surface air can be mixed with water before it leaves the pump. The bubbles in this jet of water rise to the surface carrying with it water from the bottom to the surface causing the lake to artificially turn over. If there is a large accumulation of sediment where the unit is placed by the dam, there would likely be turbid water during its initial operation. It appears that a 15HP motor operates the destratifier. .

- The theory of aeration is you slowly turn over the entire lake (once every 2 days or so), thereby aerating the entire body of water. With enough oxygen in these fully aerated lakes phosphorus binds up and is unusable by algae. If the system is undersized then phosphorus rich anoxic water is brought up from the bottom and displaced across the surface of the lake where it can disperse to less oxygenated areas and fuel algal growth. I imagine this is why in Joe Rush's 2006 report it states that "phosphorus levels are increasing when the aerators are running."

- The individual who originally sold this system in 1986 indicates that this system can effectively turn over the southern half of the lake in 2 days; he even has mathematical calculations to support his statement. Without doing the math myself I have to believe that this was an appropriate sized system for this portion of the lake…but what about the rest of the lake. I believe that the lack of complete aeration is really the root of the elevated phosphorus levels during the "activation periods".

- The Lake Association should collect temp/DO profiles and phosphorus data regularly in multiple locations (including the northern and middle sections of the lake) to fully understand their lake whether it be in the absence or presence of aeration.

- To properly aerate a lake this size would be a huge financial burden both initially through the purchase and continually through electrical costs and seasonal maintenance. Perhaps the Solar Bee would be an ideal system in this situation. It may have high initial costs but requires only sunlight to operate

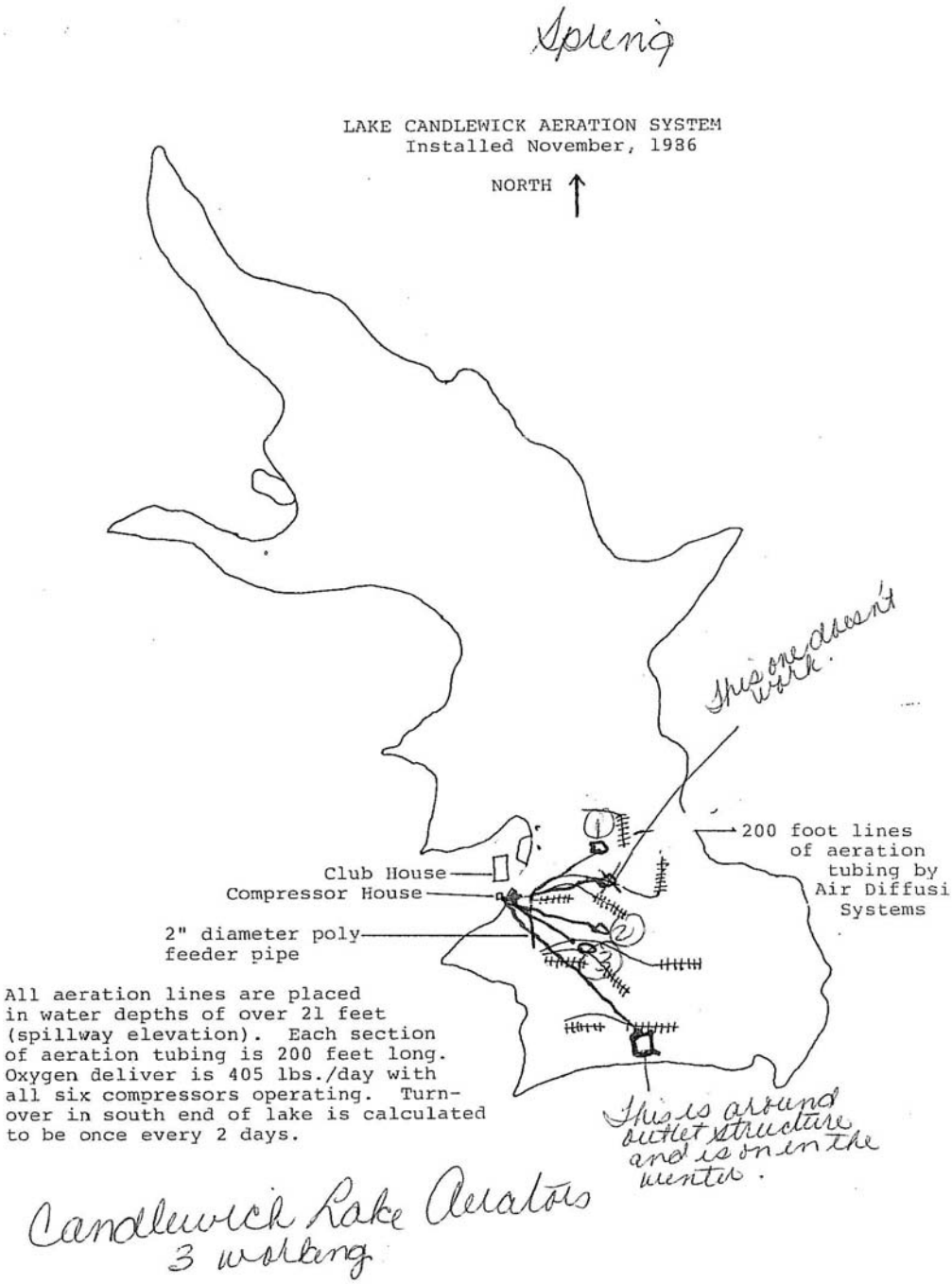


Figure 25: Aeration map of Candlewick Lake

Recommendations for aeration:

- Aeration in general is good for a lake. Since Candlewick Lake had received sewage treatment plant effluent for over twenty years, the lake water contains high phosphorus concentrations. The sediment theoretically should have very high phosphorus levels, although limited testing in 2011, showed phosphorus within the "normal" range for Illinois lakes.
    - The aeration system should be expanded to include the entire lake. Aerating the entire lake is needed to be effective to limit phosphorus concentrations and thus reduce algae. Estimated cost range from $75,000 to $200,000
    - The current aeration system should be evaluated to see if it is functional and to see if it is properly sized and has correct placement of the diffusers and destratifier. Estimated cost $5,000
        - Several site visits should be made early in the spring before the water warms. The visit should occur before the aerators are on, measure dissolved oxygen and phosphorus at multiple locations, then turn the aerators on and do the same measurements. A second site visit should occur 1 – 2 weeks later and the measurements repeated.
        - A diver may be used to determine the condition of the destratifier and the surrounding conditions. Estimated cost $2,200
        - Probing of the sediment near the destratifier is another option. Estimated cost $1,000.
- Aerators should not be turned on after the lake warms and begins to stratify. This may potentially cause a fish kill if anoxic water is spread throughout the lake. Suggested aerator start and stop dates are April 15 – October 15.

Figure 26: Suggested aeration for Candlewick Lake (provided by Clarke Aquatic Services).

PROBLEM 5: DREDGING

According to the 1995 nutrient budget prepared by ILM, agricultural areas make up 61% of the watershed and are the largest contributor of nutrients to the lake. Since 1995 agricultural practices have changed significantly, so their sediment and nutrient contributions to Candlewick Lake may be smaller than described in the report.

Dredging of the northern portion of the lake occurred in 2010. The northern silt pond was dredged in both 2001 and 2011.

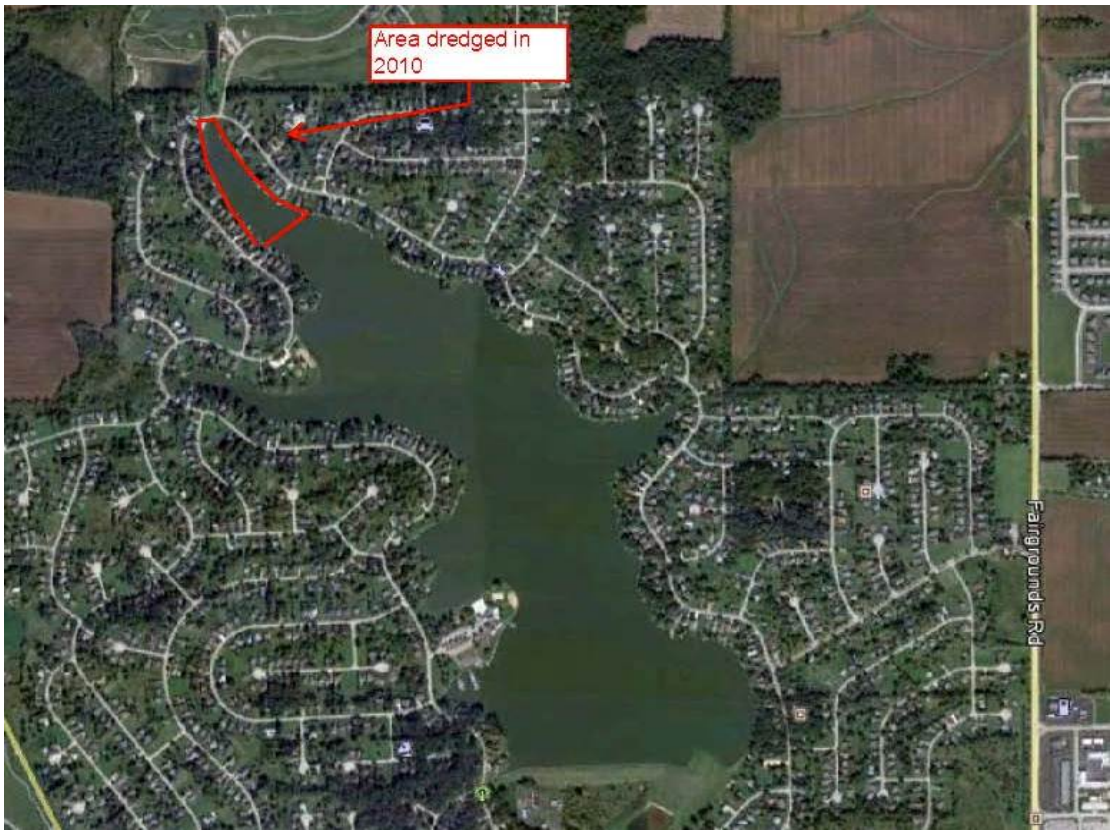


Figure 27: Approximate location of the 2010 dredging area.

Figure 28: North silt pond, which was dredged in 2011.


Figures 30 & 31: Sediment near the dam is much lighter in color than in the northern section of the lake. The light colored soil typically represents agricultural deposition.

Shoreline erosion has been reduced significantly with the installation of rip rap around the lake shoreline. Installation of native buffer strip above the rip rap would further reduce erosion.

Recommendations for controlling sedimentation include:

- Work with the owners of the agricultural areas to discuss installing BMPs such as grassed swales along the channels leading into Candlewick Lake. This recommendation was discussed under alternatives to constructing a silt pond.

- Require homeowners to plant prairie vegetation in a wider buffer strip along the lake. Currently a 6 foot no mow section is required. This should be expanded to 10 feet at a minimum and planted with deep rooted prairie plants. Costs are discussed in the water quality section under external nutrient loading.

- Investigate alternative designs for the northern silt pond, and potentially for the silt pond above the northwest bay. It is recommended that the association hire a watershed engineer who specializes in lake and river management to determine if alternative designs should occur to increase sediment retention in these areas. Some ideas may include creating wetlands out of the basins in order to filter the water; or to create multiple, deeper basins with wetlands between the basins. Both of these should allow more sediment to settle.
    - Kabbes Engineering is recommended for this review. An initial investigation for alternative methods would cost about $5,000.

- Bathymetric mapping should be done every 10 years to determine the need for dredging. It is recommended that this be done in the early spring before plants begin growing. Sonar technology should be used to collect thousands of data points of the lake bottom and make comparisons to previous data to determine changes in sediment volume and deposition areas. It is recommended that probing of the sediment occur if this has not been done in the past. Cost is about $10,000.
    - Probing of the silt pond should be done every 1 – 2 years with the sediment removed as needed. Typically, sediment basins are cleaned when the storage volume is reduced by 50%.

- Dredging or sediment removal of sections of the bays will need to occur at some time in the future and budgeting and planning should be done to allocate resources for that event. Costs for dredging can vary dramatically depending on the type of dredging and disposal of the sediment. The handling of dredged material and the cost to transport it are two factors that weigh heavily in any consideration of a dredging project. Costs for dredging alone can typically range from $10 - $30/cubic yard depending on the method, amount of material and the sediment disposal location.
    - Dredging of nutrient rich sediment should help reduce phosphorus loading into the lake.
    - Acquire a 10 year dredging permit from the Army Corps and a 5 year IEPA discharge permit. This will allow for dredging several times without the need to acquire permits each time maintenance sediment removal is performed.

III RECOMMENDATIONS:

This document should be considered as a living document with periodic upgrades and adjustments.

Various recommendations and cost estimates have been made under each problem area. This section will be used to prioritize these recommendations and estimate a timeline.

Many of these tasks can be completed by ILM. Please ask for a quote.

High priority:

- Education of the lake users about blue-green algae and when it is safe to swim in the lake. This should include signs at the swimming beach, marina and lakefront parks. Warnings should also be posted in newsletters.
- Plant rooted aquatic plants such as chara and white water lilies. These may need to be fenced if grass carp are eating them.
- Do not replace grass carp. Let them die off as they age.
- Perform selective aquatic herbicides and designate areas where plants should be encouraged.
- Clean goose feces off ramps, parking areas, and shorelines on a regular basis (at least weekly).
- Increase and diversify the native plant buffer zones around the lake.
- Develop a guidance manual for waterfront property owners addressing goose control, fertilizer use, shoreline stabilization, animal waste, yard waste, and natural area restoration.
- Perform dam inspections annually.
- Evaluate the effectiveness of swans for goose control. Swans also contribute to nutrient loading.
- Install a circulator system in the northwest bay to limit algae buildup.
- Evaluate the current aeration system to determine if it is functional and if it should be expanded to include the entire lake.
- Perform routine water quality monitoring and continue with the Volunteer Lakes Monitoring Program.

- Perform algae identification at least once annually. If blue-green algae is dominant then have microcystin concentration tested.

- E. coli or fecal coliform testing at the beach on a biweekly basis during the swimming season.

Moderate priority:

- Meet with the owners of the agricultural areas and determine the feasibility of installing grassed swales in the channels that drain to Candlewick Lake.

- Meet with an environmental engineer to determine:
    - The feasibility for modifying the silt pond to reduce nutrient and sediment loading into the lake.
    - The feasibility of a silt pond above the northwest bay.

- Monitor fish populations and follow the recommendations made by the IDNR in the 2011 survey.

- Perform a nutrient budget update on the lake.

- Plan for dredging in the future

- Monitor and map aquatic plant growth.

Low priority

- Test nutrients in the sediment.

- Perform bathymetric mapping of the entire lake (last done in 2007).

- Monitor macroinvertebrates in the inlet streams on an annual basis. Can be done through the RiverWatch program.

Recommended Timeline for Candlewick Lake

Annually	1. Aquatic weed control in selected areas 2. Monitor water quality (VLMP & consultant) 3. Homeowner and lake user education 4. Perform dam inspection 5. Remove goose feces from areas draining into the lake (weekly) 6. Identify algae and map aquatic weeds. 7. E. coli testing at the beach during the swimming season (biweekly) 8. Monitor macroinvertebrates in the inlet streams (RiverWatch) 9. Budgeting for long term projects
2012	1. Plant rooted aquatic plants in selected areas 2. Evaluate effectiveness of the swans 3. Install a circulator system in the northwest bay 4. Evaluate the current aeration system 5. Install signs regarding blue-green algae 6. Require homeowners to increase and diversify native plant buffers
2013	1. Meet with the owners of the agricultural areas about grassed swales 2. Meet with an environmental engineer regarding silt pond creation above the NW bay & modifications to north silt pond. 3. Update the 1995 nutrient budget 4. Plant rooted aquatic plants
2014	1. Test nutrients in the sediment 2. Install grassed swales in agricultural areas 3. Acquire permits for silt pond retrofits
2015	1. .Perform silt pond retrofits
2016	1. Perform bathymetric mapping 2. Monitor fish populations

APPENDIX

Summary of Candlewick Lake Reports Used in this Study

Date	Type of report	Author	Summary
2011	Water quality	ILM	Water quality testing for three site visits
2010	Timeline	CLA	Timeline of Candlewick Lake 1975- 2010
2010	Algaecides	Marine Biochemist	2010 Lake Treatment summary
2006	Aeration	Rush	5/25/06 Letter to Mr. McQuinn about aeration
NA	Aeration	NA	Lake Aeration & Circulation
NA	Wetland summary	NA	Wetland & Drainage Specifications
2011	Water quality		VLMP data 2009 - 2011
2008	Water quality		VLMP data 2008
2007	Water quality		VLMP data 2007
2006	Water quality		VLMP data 2006
2005	Water quality		VLMP data 2005
2004	Water quality		VLMP data 2004
2003	Water quality		Phosphorus data 1997 - 2003
2001	Water quality		VLMP data 2001
2000	Water quality		VLMP data 2000
1995	Water quality review	ILM	A review of ambient water quality data and potential pollution source loads for Candlewick Lake
1994	Hydrology of NW stream	Jansen Engineering	4/26/94 Letter to Steven Manning regarding hydrology of stream that flows into the northwest bay

CAUTION

WATER QUALITY ADVISORY

This water may contain blue-green algae capable of producing toxins that can be dangerous to humans and pets.

FOR YOUR SAFETY

- **If water is cloudy, looks like green paint or pea soup, or has a floating scum layer or floating clumps**
  - **-Do not swim or swallow water**
  - **-Do not allow pets to swim or drink**
  - **-Do not allow children to play in scum layer from shoreline**
- **Rinse off after swimming**

For more information please contact the

LOCAL HEALTH DEPARTMENT at (___) ____-_____

Should you let your kids or pets play in this?

BAD IDEA!

Algae are common in lakes and rivers. But at high concentrations a type called "blue-green" algae can make people and animals sick.

What to look for:

- Does the water look "pea soupy"?
- Does it smell swampy?

Blue-green algae can:

- irritate skin, eyes and nasal passages and make you sick.
- poison your pets or livestock – animals have died from it.

If you or your pets have come in contact with blue-green algae, **wash thoroughly.** Think you or animals are sick from it? Call a doctor or veterinarian immediately.

When in doubt, best keep out!

This poster prepared by the Minnesota Interagency Work Group on Blue-Green Algae.

In Wisconsin - http://dnr.wi.gov/lakes/bluegreenalgae/

Candlewick Lake Water Clarity

	inches	feet		inches	feet
5/15/1982	54.0	4.5	7/6/1992	21.0	1.8
5/24/1982	50.0	4.2	7/15/1992	38.0	3.2
6/1/1982	54.0	4.5	7/17/1992	40.0	3.3
6/7/1982	48.0	4.0	7/24/1992	37.0	3.1
6/14/1982	66.0	5.5	7/28/1992	29.0	2.4
6/21/1982	54.0	4.5	8/4/1992	25.0	2.1
6/28/1982	38.0	3.2	8/13/1992	21.0	1.8
7/6/1982	48.0	4.0	8/19/1992	16.0	1.3
7/12/1982	36.0	3.0	8/10/1993	21.0	1.8
7/20/1982	28.0	2.3	5/2/1994	30.0	2.5
7/26/1982	24.0	2.0	8/10/1994	16.8	1.4
8/3/1982	27.0	2.3	9/8/1994	13.0	1.1
8/8/1982	30.0	2.5	9/22/1994	30.0	2.5
8/17/1982	38.0	3.2	5/2/1995	26.0	2.2
8/23/1982	54.0	4.5	5/15/1995	20.0	1.7
9/1/1982	60.0	5.0	5/25/1995	26.0	2.2
9/9/1982	60.0	5.0	4/5/1998	36	3.0
9/22/1982	40.0	3.3	4/19/1998	22	1.8
9/30/1982	63.0	5.3	5/4/1998	47	3.9
10/5/1982	96.0	8.0	5/17/1998	34	2.8
10/13/1982	78.0	6.5	6/15/1998	18	1.5
10/18/1982	54.0	4.5	6/30/1998	19	1.6
10/25/1982	72.0	6.0	7/14/1998	28	2.3
6/20/1983	96.0	8.0	8/12/1998	20	1.7
6/28/1983	78.0	6.5	9/9/1998	50	4.2
7/8/1983	54.0	4.5	5/9/1999	30	2.5
7/11/1983	28.0	2.3	5/23/1999	24	2.0
7/17/1983	43.0	3.6	6/27/1999	22	1.8
7/26/1983	24.0	2.0	7/18/1999	16	1.3
8/5/1983	20.0	1.7	8/1/1999	20	1.7
8/10/1983	16.0	1.3	8/15/1999	14	1.2
8/15/1983	13.0	1.1	9/6/1999	14	1.2
8/22/1983	24.0	2.0	5/7/2000	14	1.2
9/8/1983	25.0	2.1	5/21/2000	71	5.9
9/11/1983	24.0	2.0	6/6/2000	59	4.9
9/27/1983	60.0	5.0	6/18/2000	43	3.6
10/4/1983	54.0	4.5	7/4/2000	24	2.0
10/25/1983	102.0	8.5	4/29/2001	36	3.0
7/8/1984	60.0	5.0	6/24/2001	19	1.6
7/17/1984	50.0	4.2	7/8/2001	12	1.0
7/24/1984	48.0	4.0	7/29/2001	16	1.3
7/31/1984	54.0	4.5	8/12/2001	12	1.0
8/7/1984	39.0	3.3	8/28/2001	13	1.1
8/13/1984	46.0	3.8	9/30/2001	27	2.3
8/19/1984	48.0	4.0	5/5/2002	135	11.3
9/12/1984	54.0	4.5	6/13/2004	60	5.0
9/19/1984	42.0	3.5	7/16/2004	44	3.7
9/23/1984	38.0	3.2	7/29/2004	53	4.4
10/13/1984	55.0	4.6	8/17/2004	36	3.0
10/30/1984	40.0	3.3	9/14/2004	51	4.3
5/8/1985	96.0	8.0	9/28/2004	36	3.0
5/16/1985	96.0	8.0	10/25/2004	48	4.0
5/29/1985	162.0	13.5	6/6/2005	84	7.0
6/6/1985	72.0	6.0	6/20/2005	28	2.3
6/8/1985	26.0	2.2	7/20/2005	28	2.3
6/12/1985	44.0	3.7	8/2/2005	30	2.5
7/1/1985	26.0	2.2	8/15/2005	20	1.7
7/8/1985	28.0	2.3	8/29/2005	20	1.7
8/1/1985	40.0	3.3	9/12/2005	18	1.5
8/26/1985	24.0	2.0	5/9/2006	96	8.0
9/4/1985	48.0	4.0	6/1/2006	84	7.0
9/24/1985	40.0	3.3	6/14/2006	72	6.0
10/2/1985	38.0	3.2	7/8/2006	66	5.5
10/21/1985	60.0	5.0	7/21/2006	38	3.2
10/30/1985	54.0	4.5	8/14/2006	20	1.7
5/20/1986	32.0	2.7	8/29/2006	54	4.5
5/31/1986	30.0	2.5	9/12/2006	40	3.3

Candlewick Lake Water Clarity

	inches	feet
6/4/1986	36.0	3.0
6/17/1986	49.0	4.1
7/2/1986	30.0	2.5
7/10/1986	17.0	1.4
7/14/1986	22.0	1.8
7/21/1986	36.0	3.0
7/28/1986	54.0	4.5
8/10/1986	30.0	2.5
8/12/1986	37.0	3.1
8/25/1986	26.0	2.2
5/6/1987	90.0	7.5
5/14/1988	90.0	7.5
5/14/1989	110.0	9.2
5/25/1989	108.0	9.0
6/14/1989	24.0	2.0
6/25/1989	23.0	1.9
7/14/1989	24.0	2.0
8/20/1989	20.0	1.7
9/4/1989	24.0	2.0
9/27/1989	25.0	2.1
10/12/1989	34.0	2.8
9/6/1990	27.0	2.3
7/11/1991	34.0	2.8
6/3/1992	34.0	2.8
6/10/1992	34.0	2.8
6/18/1992	31.0	2.6
6/19/1992	28	2.3
6/24/1992	37.0	3.1
6/26/1992	36.0	3.0
7/1/1992	31.0	2.6

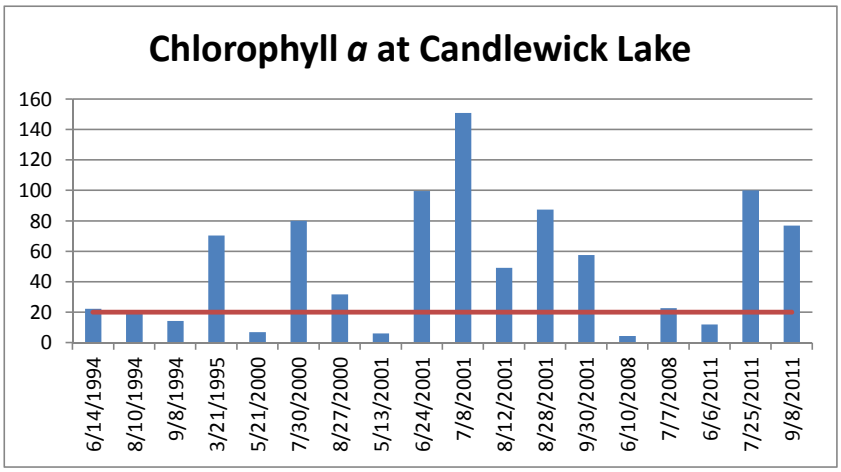
	inches	feet
10/3/2006	32	2.7
10/17/2006	30	2.5
6/10/2008	114	9.5
6/24/2008	75	6.3
7/7/2008	45	3.8
8/19/2008	18	1.5
9/23/2008	30	2.5
10/6/2008	24	2.0
5/18/2009	129	10.8
6/9/2009	54	4.5
6/22/2009	54	4.5
7/6/2009	23	1.9
7/20/2009	24	2.0
8/4/2009	22	1.8
8/18/2009	26	2.2
9/23/2009	26	2.2
5/3/2010	180	15.0
5/18/2010	84	7.0
6/7/2010	94	7.8
6/16/2010	94	7.8
7/1/2010	27	2.3
7/16/2010	18	1.5
8/4/2010	21	1.8
8/19/2010	13	1.1
9/5/2010	14	1.2
9/29/2010	17	1.4
5/24/2011	63	5.3
6/6/2011	78	6.5
6/8/2011	84	7.0
6/28/2011	42	3.5
7/12/2011	12	1.0
7/25/2011	12	1.0
7/26/2011	16	1.3
8/16/2011	13	1.1
8/29/2011	18	1.5
9/8/2011	12	1.0
10/11/2011	29	2.4

Total Phosphorus Concentrations at Candlewick Lake (Center)

	Shallow	Deep	IL Standard
4/28/1977	0.040		0.050
5/8/1985	0.037		0.050
4/30/1990	0.040		0.050
7/16/1991	0.140		0.050
6/24/1992	0.150		0.050
7/9/1992	0.160		0.050
7/23/1992	0.190		0.050
8/5/1992	0.130		0.050
8/19/1992	0.170		0.050
8/10/1993	0.260	0.290	0.050
4/28/1994	0.150		0.050
5/2/1994	0.180		0.050
8/10/1994	0.300		0.050
9/8/1994	0.480	0.250	0.050
9/22/1994	0.330	0.330	0.050
3/21/1995	0.270		0.050
5/2/1995	0.240		0.050
4/5/1998	0.090	0.120	0.050
5/4/1998	0.090	0.120	0.050
5/17/1998	0.094	0.133	0.050
6/2/1998	0.127	0.105	0.050
6/15/1998	0.152	0.167	0.050
6/30/1998	0.204	0.181	0.050
7/14/1998	0.243	0.517	0.050
8/12/1998	0.319	0.852	0.050
8/26/1998	0.259	0.441	0.050
9/9/1998	0.314	0.316	0.050
5/9/1999	0.028	0.030	0.050
5/23/1999	0.167	0.186	0.050
6/15/1999	0.294	0.305	0.050
6/27/1999	0.254	0.310	0.050
7/18/1999	0.503	0.420	0.050
8/1/1999	0.501	0.469	0.050
8/15/1999	0.525	0.530	0.050
9/6/1999	0.562	0.510	0.050
5/21/2000	0.028	0.054	0.050
6/6/2000	0.075	0.052	0.050
6/18/2000	0.054	0.084	0.050
7/4/2000	0.100	0.151	0.050
7/30/2000	0.156	0.077	0.050
8/16/2000	0.062	0.062	0.050
8/27/2000	0.052	0.096	0.050
9/10/2000	0.043	0.064	0.050
4/29/2001	0.041	0.080	0.050
5/13/2001	0.029	0.103	0.050
6/24/2001	0.112	0.114	0.050
7/8/2001	0.179	0.135	0.050
8/12/2001	0.158	0.126	0.050
8/28/2001	0.188		0.050
9/30/2001	0.089	0.089	0.050
5/5/2003	0.027	0.038	0.050
7/2/2002	0.040	0.366	0.050
7/21/2003	0.172	0.101	0.050
8/4/2002	0.197	0.114	0.050
8/25/2002	0.333	0.149	0.050
9/8/2002	0.188	0.324	0.050
10/6/2002	0.135	0.163	0.050
6/11/2003	0.038	0.423	0.050
8/5/2003	0.043	0.071	0.050
8/26/2003	0.066	0.796	0.050
9/12/2003	0.052	0.043	0.050
11/20/2003	0.062	0.052	0.050
6/13/2004	0.020	0.032	0.050
7/16/2004	0.032	0.050	0.050
7/29/2004	0.035	0.388	0.050
8/17/2004	0.025	0.200	0.050
8/31/2004	0.040	0.300	0.050
9/14/2004	0.020	0.350	0.050
9/28/2004	0.088	0.100	0.050
10/25/2004	0.058	0.150	0.050
6/6/2005	0.030	0.052	0.050
6/20/2005	0.540	0.970	0.050
7/20/2005	0.850	0.360	0.050
8/2/2005	0.067	1.200	0.050
8/15/2005	0.160	0.750	0.050
8/29/2005	0.130	0.510	0.050
9/12/2005	0.130	0.930	0.050
9/26/2005	0.120	1.000	0.050
10/10/2005	0.020	0.160	0.050
5/9/2006	0.020	0.020	0.050
6/1/2006	0.030	0.074	0.050
6/22/2006	0.020	0.310	0.050
7/8/2006	0.040	0.630	0.050
7/21/2006	0.072	0.510	0.050
8/14/2006	0.084		0.050
8/29/2006	0.210	0.730	0.050
9/12/2006	0.130	0.170	0.050
9/20/2006	0.180	0.250	0.050
10/3/2006	ND		0.030
10/26/2006	0.170	0.067	0.050
5/14/2007	0.054		0.050
6/5/2007	0.004		0.050
7/9/2007	0.112		0.050
8/6/2007	0.157		0.050
10/1/2007	0.103		0.050
6/10/2008	0.035		0.050
7/7/2008	0.052		0.050
8/19/2008	0.212		0.050
6/6/2011	0.034		0.050
7/25/2011	0.120		0.050
9/8/2011	0.160		0.050
Average	0.158	0.220	
Maximum	0.562	0.852	
Minimum	0.020	0.030	

Chlorophyll a at Candlewick Lake

	Chlorophyll a	
6/14/1994	22.4	20
8/10/1994	19.2	20
9/8/1994	14.4	20
3/21/1995	70.5	20
5/21/2000	6.94	20
7/30/2000	80.1	20
8/27/2000	31.7	20
5/13/2001	6.1	20
6/24/2001	99.7	20
7/8/2001	151	20
8/12/2001	49.3	20
8/28/2001	87.4	20
9/30/2001	57.7	20
6/10/2008	4.49	20
7/7/2008	22.8	20
6/6/2011	12	20
7/25/2011	100	20
9/8/2011	77	20



3400CF & 3400HCF

Water Circulator

3/4HP, 120 or 240V, Single Phase

3400CF Water Circulator Creates Directional Flow and Water Movement

Operation

⇒ Submersed motor in a horizontal position pushes the water to create directional flow using an open propeller design.

⇒ Moving water mixes and agitates the water, spreading oxygenated water throughout the body of water, eliminating stagnant areas, and mixing thermally and chemically stratified water.

⇒ Single open propeller design allows for greater water flow with a lower likelihood of clogging.

⇒ Coated stainless steel cage/propeller guard shall catch large debris and assist in reducing the likelihood of clogging while allowing for maximum water flow through the unit.

Quick Facts

⇒ Creates 34 Lbs. of Thrust

⇒ Available in 120 or 240V Single Phase Power

⇒ Complete Package includes Assembled Motor Unit, UV Resistant High Density Thermoplastic Horizontal Float, Two 50’ Braided Nylon Mooring Lines, and SJTOW Rated 3 Wire Power Cable

⇒ Operates in 4’ Depth

⇒ Total Component Listed by ETL to meet UL and CSA Standards for Safety in Water

⇒ Sacrificial Zinc Anode Installed for Corrosion Protection and use in Salt Water Applications

⇒ Series 300 Austenitic Stainless Steel Construction of Exposed Metal; Salt Water Compatible

⇒ 2 Year Warranty

⇒ UPS Shippable

⇒ Power Cable Potted Quick Disconnect on 12 Gauge Cord Options with Stainless Steel Strain Relief

⇒ Energy Efficient with Excellent GPM/kW Rates

⇒ Industrial Strength Design

⇒ Optional Power Control Panel with 24 Hour Mechanical Timer and Class A Human Rated GFI in 120V or 240V

⇒ Can be Used in Summer and Winter Applications

Features

Motor Unit

⇒ 3/4HP, 120 or 240V, Single Phase

⇒ 1750 RPM Motor

⇒ Oil Cooled, Continuous Duty Rated

⇒ Two Long Life Bearings

⇒ Thermal Overload Protection

⇒ Fully Unitized Heavy Duty Carbon Ceramic Mechanical Seal

⇒ Series 300 Austenitic Stainless Housing with Engineering Grade Thermoplastic Top

⇒ Protective Coated Series 300 Austenitic Stainless Steel Cage/Prop Guard with 18 Vertical Bars and 1.5” Spacing

⇒ UV Resistant 2 Blade Engineered Thermoplastic Propeller

Power Cable

⇒ SJTOW UL, CSA, & NEC Approved Underwater Rated Cable

⇒ 3 Wire

⇒ Available in 50’, 100’, 150’, and 200’ (250’, 300’, 400’ and 500 in 240V) Options (Cord Gauges depend on length)

⇒ Potted Quick Disconnect and Stainless Steel Strain Relief Standard on 12 Gauge or Larger Cords

⇒ 6’ Flex Sleeve Protection

Float

⇒ U.V. Resistant High Density Thermoplastic

⇒ Single Piece, Rectangular Float

⇒ Series 300 Stainless Steel Hardware

⇒ 5 Angling Position Series 300 Stainless Steel Plate

⇒ Two 50’ Braided Nylon Mooring Ropes

Optional Control Panel

⇒ U.L. Listed per N.E.C.

⇒ 15 Amp Class A Human Rated GFCI Breaker (120V)

⇒ 20 Amp Class A Human Rated GFCB (240V)

⇒ Surge Protector (240V)

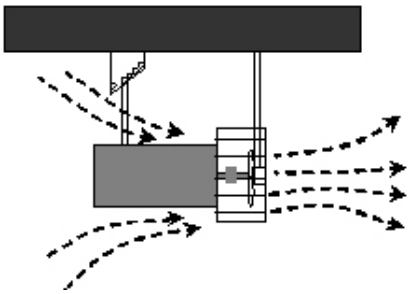
⇒ NEMA Type 3r/4x Weatherproof Enclosure

⇒ 24 Hour Mechanical Timer

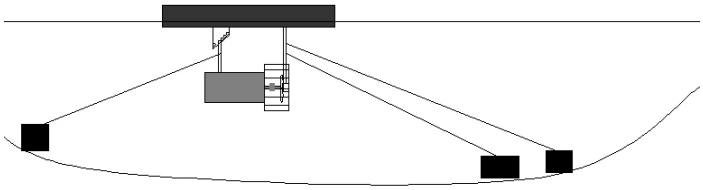
Kasco 3400CF & 3400HCF Specifications

Model #	HP	Cord Length	Cord Gauge*	Voltage/ Phase/Hz	Running Amps	Lock Rotor Amps	Thrust	Min. Depth of Operation	Shipping Weight	Number of Boxes
3400CF050	3/4	50’	16/3	120/1/60	6.7	18	34 Lbs.	4’	57 Lbs.	2
3400CF100	3/4	100’	14/3	120/1/60	6.7	18	34 Lbs.	4’	61 Lbs.	2
3400CF150	3/4	150’	12/3	120/1/60	6.7	18	34 Lbs.	4’	77 Lbs.	3
3400CF200	3/4	200’	12/3	120/1/60	6.7	18	34 Lbs.	4’	83 Lbs.	3
3400HCF050	3/4	50’	14/3	240/1/60	3.4	9	34 Lbs.	4’	57 Lbs.	2
3400HCF100	3/4	100’	14/3	240/1/60	3.4	9	34 Lbs.	4’	61 Lbs.	2
3400HCF150	3/4	150’	12/3	240/1/60	3.4	9	34 Lbs.	4’	77 Lbs.	3
3400HCF200	3/4	200’	12/3	240/1/60	3.4	9	34 Lbs.	4’	83 Lbs.	3
3400HCF250	3/4	250’	12/3	240/1/60	3.4	9	34 Lbs.	4’	89 Lbs.	3
3400HCF300	3/4	300’	12/3	240/1/60	3.4	9	34 Lbs.	4’	99 Lbs.	3
3400HCF400	3/4	400’	12/3	240/1/60	3.4	9	34 Lbs.	4’	113 Lbs.	3

* 12 AWG cords include potted quick disconnect and stainless steel strain relief.



During unit operation, water is circulated from 360^{O} around the unit. The Circulator draws in water and circulates it throughout the pond.



Assembly and Installation of Kasco equipment is quick and easy. Each unit includes an Owners Manual with specific steps to assemble, install, and operate the equipment properly. Note: A third mooring line can be used for securing the unit.

The motor unit attaches to the float using stainless steel hardware for an easy and secure assembly. The single piece, rectangular, U.V. resistant, high density thermoplastic float allows for excellent durability with low visibility. The 5 position angling plate allows for multiple angle settings with a simple adjustment.

Optional UL Approved Control Panel complete with Class A Human Rated GFCI Protection, 24 Hour Mechanical Timer,. NEMA Type 3r/4x weatherproof enclosure.

Kasco Marine, Inc.
800 Deere Rd.
Prescott, WI 54021
Ph: (715) 262-4488 * Fax: (715) 262-4487
www.KascoMarine.com * www.GotAlgae.com
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Rev. 5/10/11

Michael Christensen - East U.S. Manager
866-553-5590 • MikeC@SolarBee.com

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866-437-8076 • Amyd@SolarBee.com

Proposal for:

Candlewick Lake Association Poplar Grove, Illinois

c/o Sandy Kubillus - Integrated Lakes Management

December 1, 2011

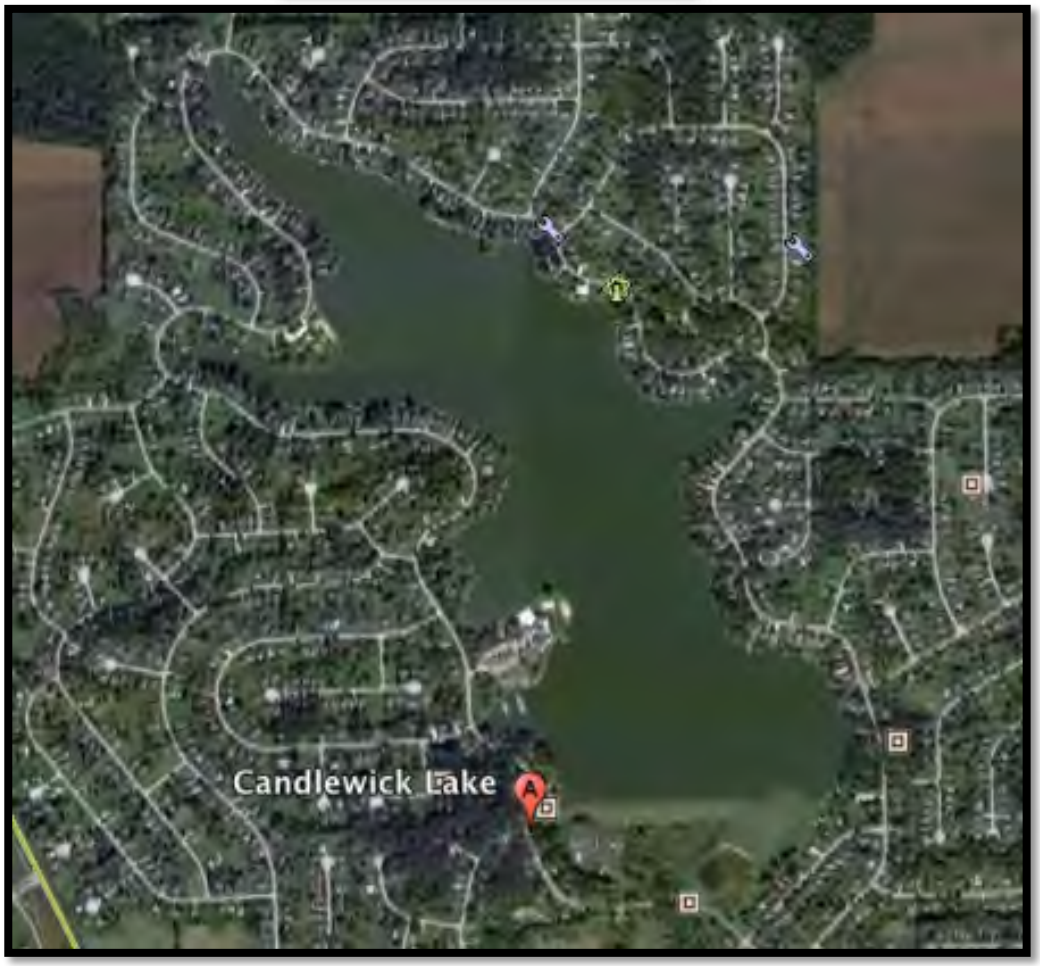


Photo of Candlewick Lake provided by Google Earth

3225 Highway 22 • Dickinson, ND 58601
Tel: (701) 225-4495 • Toll Free: (866) 437-8076 • Fax: (701) 225-0002
www.SolarBee.com

1.0 PROJECT DESCRIPTION

1.1 Name and Location of the Reservoir:

Candlewick Lake is located in Poplar Grove, Illinois. (GPS Coordinates: 42.356739, -88.878207)

1.2 Description of the Reservoir:

Candlewick Lake has an average length of 6,625 feet, width of 2,250 feet, an average depth of 10.25 feet, and a surface area of 210 acres. It was formed from a dam and has a 1,950 acre watershed from farmland. There are approximately 1,000 homeowners living around this lake which is used primarily for recreation.

We are proposing an epilimnetic solution for one small area of Candlewick Lake which is referred to as the Northwest Basin. The Northwest Basin has an average length of 240 feet, width of 70 feet, an average depth of 3 feet, and a surface area of 0.4 acres. (GPS Coordinates: 42.356559, -88.876814 of the Northwest Basin)

1.3 SolarBee Objectives, the Problems to Solve:

Epilimnetic deployment - Primary Objectives: To provide long-distance circulation in order to control harmful cyanobacteria (blue-green algae) blooms, improve fish habitats, reduce aquatic weed infestations and filamentous algae growth while improving the overall water quality of Candlewick Lake.

1.4 SolarBee's Recommendation:

To meet the above objectives, we recommend the installation of one (1) SB2500 v18 machine placed west of the boat dock in the Northwest Basin.

This machine should prevent surface water stagnation and associated harmful blue-green algae blooms, and in turn reduce the amount of algal biomass (and biochemical oxygen demand) going to the bottom. By controlling algal blooms and enhancing the distribution of dissolved oxygen in the water column, the lake should be healthier with improved water clarity and significantly reduced odors.

* If the Candlewick Lake Association is interested in treating the whole arm, inwhich, the Northwest Basin is located, we would recommend the installation of one (1) SB10000 v18 machine (price available upon request). SolarBee can propose an epilimnetic solution for the entire lake upon request.

1.5 Proposed Layout:

Photo of the Northwest Basin

Machine is not drawn to scale, and final placement will be determined prior to delivery and installation.

2.0 INVESTMENT OPTIONS

2.1 Recommended Machine:

Equipment Purchase (See Appendix A for details)

Quantity	Description	Purchase Cost Each	Purchase Cost Total
1	SB2500 v18 machine for the Northwest Basin:	$36,772	$36,772
		Total Equipment Cost:	$36,772
		Applicable Taxes:	to be determined
1	Factory Delivery, Installation and Startup:	$6,525	$6,525
		Total Delivery, Installation, and Startup Cost:	$6,525
		***Total Investment (excluding taxes):**	$43,297

Beekeeper cost of	$1,082	per year for years 1 & 2	(see Appendix C):	- Optional -
Beekeeper cost of	$2,598	per year for years 3, 4 & 5	(see Appendix C):	- Optional -

* Solar energy tax credits and accelerated depreciation can reduce the capital cost of this equipment by up to 50 percent. See Appendix G for more details.

5-Year Lease Purchase (See Appendix E for details):

Cost for recommended machine per above:	- Included -
Factory Delivery, Installation and Startup:	- Included -
Beekeeper cost for years 1 & 2 (see Appendix C):	- Included -
Beekeeper cost for years 3, 4 & 5 (see Appendix C):	- Included -
Total Monthly Lease Purchase Cost (excluding taxes):	$1,003

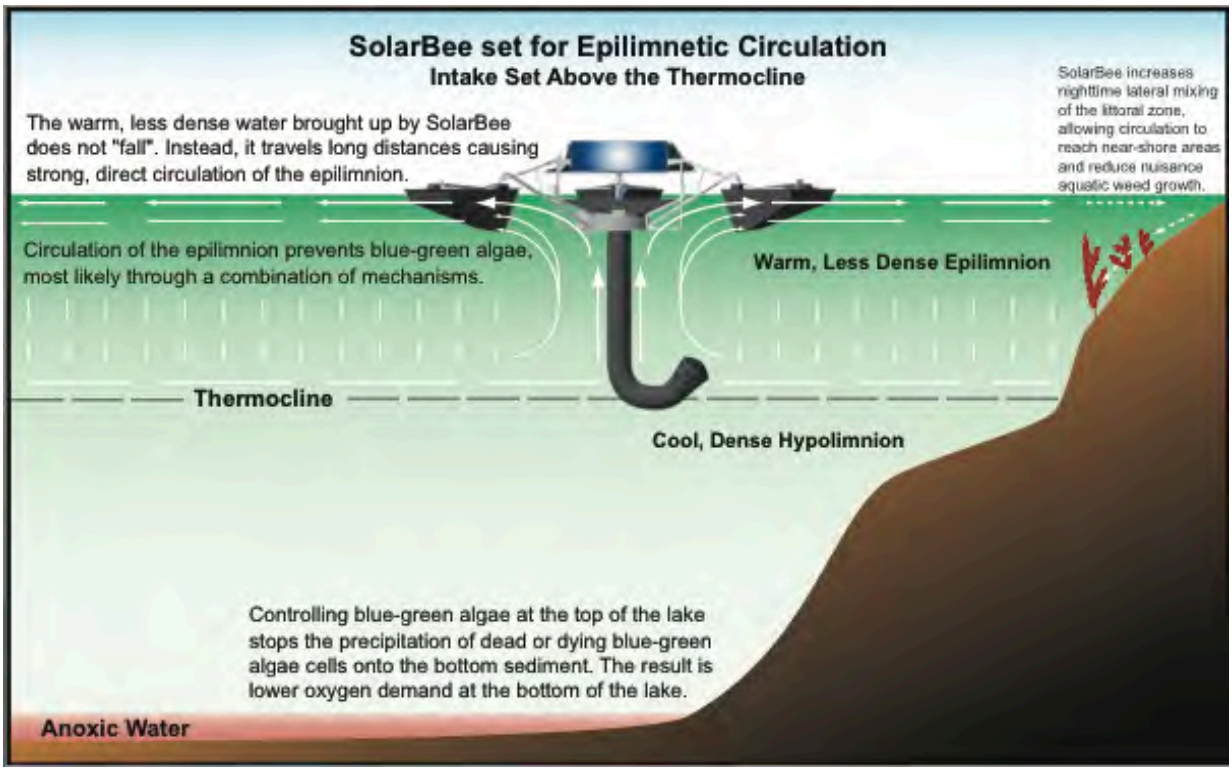
12-Month Rental (See Appendix F for details):

Monthly rental cost for recommended machine per above:	$995
Monthly Beekeeper cost during the term of the rental:	- Included -
Factory Delivery, Installation and Startup:	$6,525

Appendix A: Equipment

SB2500 v18:

The SB2500 v18 features a 2,500 gpm (3.6 MGD) total flow leaving the machine, near-laminar flow output for long-distance circulation, 316-stainless steel and non-corrosion polymer construction, 25-year life high-efficiency brushless electric motor designed to provide day and night operation with a solar-charged battery power system, digital control system for intelligent power management with factory programmed reverse functions and anti-jam routines specific to this application, SCADA outputs, three (3) 80-watt solar panels, 12" diameter intake hose, anchoring system, and bird deterrent. See Appendix D - SolarBee Limited Replacement Warranty for information on the most extensive warranty in the industry.



Appendix B: Factory Delivery and Field Services

SolarBee, Inc. sends a factory trained Delivery & Field Services Team with specialized equipment to deliver, assemble, place, and start up your SolarBee machine. A training session on operation and maintenance is also provided for your personnel. Each Team member undergoes training such as Fall Protection, Confined Space Entry, Working Over Water, and Water Quality Testing.

As part of our standard operating procedures, the factory trained Delivery & Field Services Team will conduct vertical profiles with a YSI multi-parameter submersible probe, and at each test point measure dissolved oxygen, pH, temperature and specific conductance at every foot from the surface down to a depth of 25 feet, and at 5-foot intervals thereafter. A Secchi depth measurement will also be made at each test location. GPS coordinates are recorded for each machine and test point location.

Your water quality is our highest priority. Our commitment continues long after the Delivery & Field Services Team leaves your location and we strive to maintain contact with all our customers. Our Customer Service, Application Engineering, and Science Departments are available for any questions regarding machine operation and water quality.

Appendix C: Beekeeper Service Program

The Beekeeper is a program that utilizes Factory Crews to service and maintain proprietary designed equipment. The Beekeeper provides for more than just maintenance and service:

- It extends the warranty during the term of the Beekeeper
- It covers damage from Acts of God and vandalism
- It provides for power system upgrades and updates
- It provides hardware, firmware, and software for computer upgrades
- It provides scientific and technical support
- It provides for scheduled and unscheduled field service calls
- and much more, please request the Beekeeper brochure for more details

Appendix D: General Provisions

Purchase of the SolarBee circulation equipment in this quotation is an "Equipment Purchase," not a "Construction Project":

SolarBee circulation equipment is portable, and can be easily relocated or removed entirely from the premises at any time. They do not become an integral part of any building or other structure, and never become part of "real estate". Therefore, to purchase SolarBee circulation equipment, the city or other organization purchasing SolarBees should use the same procedure as for purchasing other portable equipment, such as a forklift, a drill press, or an office desk. SolarBee reserves the right not to accept an order if the purchase is incorrectly characterized as a "construction" project. SolarBee, Inc. has not found any state or other jurisdiction where construction or contractor statutes apply to portable equipment that is sold by a factory, with on-site final assembly and startup performed by factory personnel.

Assumptions:

This quotation may be based on worksheets and calculations that have been provided to the customer, either previously or else attached to this quotation. The customer should bring to our attention any discrepancies in data used for these calculations.

Quotation Validity Term:

This quotation replaces all prior quotations for this project. It is valid until replaced by a subsequent quotation, or for 60 days, whichever occurs first.

Delivery Time:

Delivery time varies, but is usually within 4-8 weeks from order date.

Payment Terms:

For governmental entities, and for homeowners associations that have pre-approved credit, payment is due 20 days after invoice date, and invoicing occurs when the goods leave the factory. For private individuals, payment is due by credit card or cashier's check before the goods leave the factory.

Currency:

All prices shown are in U.S. Dollars, and all payments made must be in U.S. Dollars.

Add for Taxes, Governmental Fees, and Special Insurance Requirements:

Except as indicated above, no taxes, tariffs or other governmental fees are included in the quote shown above, nor are there any costs added for special insurance coverage the customer may require. It is the customer's responsibility to pay all local, state, and federal taxes, including, sales and use taxes, business privilege taxes, and fees of all types relating to this sale, whether they are imposed on either SolarBee, Inc. or the customer, or whether these taxes and fees are learned about after the customer orders the equipment. The customer's purchase order should indicate any taxes or fees due on equipment and/or services, and whether the customer will pay them directly to the governing body or include the tax payment with the purchase and SolarBee, Inc. will submit them to the governing body.

Regarding insurance, SolarBee, Inc. maintains adequate liability and workman's compensation insurance to generally comply with its requirements for doing business in all fifty U.S. states, and will provide at no charge certificates of insurance when requested. However, if additional insurance or endorsements beyond the company's standard policy are required by the customer, then the costs of those additional provisions and/or endorsements will be invoiced to the customer after the costs become known.

Maintenance and Safety:

The customer agrees to follow proper maintenance instructions regarding the equipment as contained in the safety manual that accompanies the equipment or sent to the customer's address. It is the customer's responsibility to make sure that the circulators are used in a manner that keeps the ponds safe for people that may access them.

Government Regulatory Compliance:

In all reservoir/tank systems the customer must comply with all applicable governmental regulations. It is the customer's sole responsibility to inquire about governmental regulations and ensure that SolarBees are deployed and maintained so as to remain in compliance with these regulations and guidelines, and to hold SolarBee, Inc. harmless from any liability caused by non-compliance with these regulations and guidelines.

SolarBee Limited Replacement Warranty:

All new and factory-refurbished SolarBee equipment is warranted to be free of defective parts, materials, and workmanship for a period of 2 years from the date of installation. In addition, the SolarBee brushless motor is warranted for a period of 10 years from the date of installation. Photovoltaic modules (solar panels) carry manufacturer warranties, some ranging up to 25 years (see manufacturers' warranty for details). This warranty is valid only for SolarBee equipment used in accordance with the owner's manual, and consistent with any initial and ongoing factory recommendations. This warranty is limited to the repair or replacement of defective components, at SolarBee's discretion. The first 2 years the warranty also includes both parts and labor. In lieu of sending a factory service crew to the site for minor repairs, SolarBee, Inc. may choose to send the replacement parts to the owner postage-paid and, in some cases, may pay the owner a reasonable labor allowance to install the parts.

Except as stated above, SolarBee and its affiliates expressly disclaim any and all express or implied conditions, representations and warranties on products furnished hereunder, including without limitation all implied warranties of merchantability or fitness for a particular purpose.

Please consult your state law regarding this warranty as certain states may have legal provisions affecting the scope of this warranty.

Limitation of Liability:

Many of the employees at SolarBee have extensive scientific and practical knowledge relating to solving water quality problems. From time to time, they may offer solicited or unsolicited advice, ideas, judgment or opinions on how to deal with certain situations, none of which offers a guarantee of future events. Due to the many factors, complexity and uncertainty involved in solving water problems, you agree to release and indemnify SolarBee and its affiliates, employees and agents from and against any and all claims, liabilities, costs and expenses which such indemnified party may incur or become subject to related to or arising out of any services or products furnished by SolarBee to you, except to the extent that any claim, liability or expense results from the gross negligence or intentional misconduct of an indemnified party as determined in a final judgment by a court of competent jurisdiction.

In no event will SolarBee or its affiliates be liable for any damages caused by failure of buyer to perform buyer's responsibilities or for following SolarBee advice.

In no event will SolarBee or its affiliates be liable for any lost profits or use or other punitive, special, exemplary, consequential, incidental or indirect damages, however caused, on any theory of liability, whether or not SolarBee has been advised of such damages, or reasonably could have foreseen the possibility of such damages, or for any claim against buyer by another party.

Method of acceptance of this quotation:

To accept this quotation, please issue a purchase order to SolarBee, Inc., 3225 Hwy. 22, Dickinson, ND 58601. The purchase order can be mailed, or it can be faxed to 701-225-0002 at the home office. The purchase order should refer to the date of this quotation, and will be assumed to include this entire quotation by reference.
If purchase orders are not utilized, please sign and date the last page of this proposal, provide billing information, and either fax to 701-225-0002 or email to Orderprocessing@SolarBee.com

Appendix E: Lease Provisions

Standard Agreement:

Pricing in the above quotation is based on 5 years, 60 monthly payments, and a $0 down payment. For a quotation based on other terms, please call SolarBee, Inc., at 1-866-437-8076.

Maintenance of the Equipment:

Lessee is to provide minor routine care and maintenance of the Equipment as described in the owners manual. The Beekeeper Service Program is required, and is included in the cost shown above for the term of the lease. See above Appendix C for description of the Beekeeper program.

Additional Lease Provisions:

If the lease option is selected, a master equipment lease/purchase agreement will be sent to lessee, that shall cover all terms and conditions of the lease.

Appendix F: Rental Provisions

Rental payment terms:

The installation day of the month is the anniversary day for determining when a new rental month begins. There are no partial months; if the equipment is in place on the first day of the rental month, a whole month of rental is due. Rental invoices will be provided each month and payment is due 30 days from the invoice date. The installation charge mentioned above will be added to the first month's rental invoice.

Rental period, month-to-month:

The rental period shall be for one month, beginning on the installation date, and shall continue automatically, for one month at a time beginning on each monthly anniversary of the installation date, until the longer of (a) 12 months, or (b) 90 days after written notice is received by SolarBee, Inc. from the renter to terminate the rental. Furthermore, SolarBee, Inc. has the right to terminate the rental agreement and re-possess the equipment at any time, without notice to the renter, if the renter becomes delinquent in rent payments.

Periodic rental cost adjustment:

The rental cost may be adjusted periodically by SolarBee, Inc. upon 90 day written advance notice to the renter, after the minimum rental period mentioned above. SolarBee, Inc. expects, but does not promise, to make such adjustments only once per year on the annual anniversary of the installation, and expects that adjustments will be limited to reflect (a) a general inflationary adjustment equal to the Consumer Price Index, and (b) any additional costs by the factory associated with keeping the rental equipment functioning properly and meeting the renter's goals for the project. The renter, at its option as mentioned above, may cancel the rental agreement with 90 day notice if the proposed new rental costs are ever not acceptable.

Rental conversion to purchase:

The renter may convert this rental to a purchase, at the price shown in the Equipment Purchase section above. To convert this rental to a purchase, the renter should request SolarBee Inc, at least 60 days before the desired purchase date, to supply a firm quotation to convert the rental to a purchase. When conversion to a purchase is made, 50% of prior rents paid will be applied to the purchase price, up to a maximum of 50% of the equipment purchase price. Title to the rental equipment does not pass to the renter unless and until payment of all outstanding rental invoices, and the conversion purchase price for the equipment, is received by the SolarBee, Inc.

Rental Equipment Availability:

SolarBee, Inc. has a limited supply of rental machines available; either new or slightly used or "demonstrator" equipment may be installed at the factory's option. If the equipment installed for a rental is slightly used, then the factory warrants that: (1) the equipment is clean, current, and in like-new condition with a full new-equipment warranty, and (2) the equipment is equivalent to new equipment with the very latest technology and improvements. Also note that SCADA or other remote monitoring options may have been included in the purchase cost in Section 2 above, but these components are not included with rental equipment. If a rental is desired, the SCADA remote monitoring equipment would be installed only after the equipment had been converted to a purchase, unless other provisions have been made.

Maintenance of the Equipment.

Renter is to provide minor routine care and maintenance of the Equipment as described in the owners manual. The Beekeeper Service Program is required and is included in the cost shown above for the term of the rental. See above Appendix C for description of the Beekeeper.

Appendix G: Solar Energy Tax Incentives

Solar Energy Tax Credits, Accelerated Depreciation and Other Incentives for Solar Equipment may be available to reduce the cost of your project:

Congress Extends Federal Investment Tax Credit for Commercial Solar Installations Through End of 2016: The commercial solar tax credit is 30% of the "tax credit basis" that a company has invested in “eligible property” that is “put into service”. A tax credit is a dollar-for-dollar reduction of an entity’s Federal tax burden. Check with your Tax Accounting Group.

Accelerated Depreciation: There are separate incentives for solar equipment depending on whether it will be put to use on a commercial or residential property. For businesses, when combined with incentives for accelerated depreciation of solar equipment, these credits help reduce the capital cost of new solar energy equipment by up to 50%. Check with your Tax Accounting Group.

If you do not qualify for the above incentives, you may want to check with your state for other possible incentives through the Renewable Portfolio Program for your state, and with your power company for rebates when displacing the need for power from the grid. Please contact SolarBee East U.S. Manager Michael Christensen, 866-553-5590 or MikeC@solarbee.com, for the links to various websites that may apply to you.

Lake Notes

Lake Aeration and Circulation

The purpose of aeration in lake management is to increase the dissolved oxygen content of the water. Various systems are available to help do this—by either injecting air, mechanically mixing or agitating the water, or even injecting pure oxygen.

Aeration can increase fish and other aquatic animal habitat, prevent fishkills, and improve the quality of domestic and industrial water supplies and decrease treatment costs. In some cases, nuisance algal blooms can be reduced or a shift to less objectionable algae species can occur. However, aeration can be misused. It is not a "cure-all" for a lake's ills. It's important to understand what aeration can and can't do for your lake so you don't end up with unexpected or unwanted results—and possibly a waste of money.

This issue in the *Lake Notes* series focuses on ***artificial circulation*** as a lake aeration technique. We'll explore its applicability, potential consequences, and other factors to be considered before deciding to invest in an artificial circulation system—or in reevaluating the system you already have in place.

Note to the Reader:
This *Lake Notes* fact sheet uses some rather complex terms that may be unfamiliar to you. In order to better understand their meaning, you are encouraged to first read another fact sheet in the *Lake Notes* series, "Lake Stratification and Mixing."

Artificial Circulation Systems

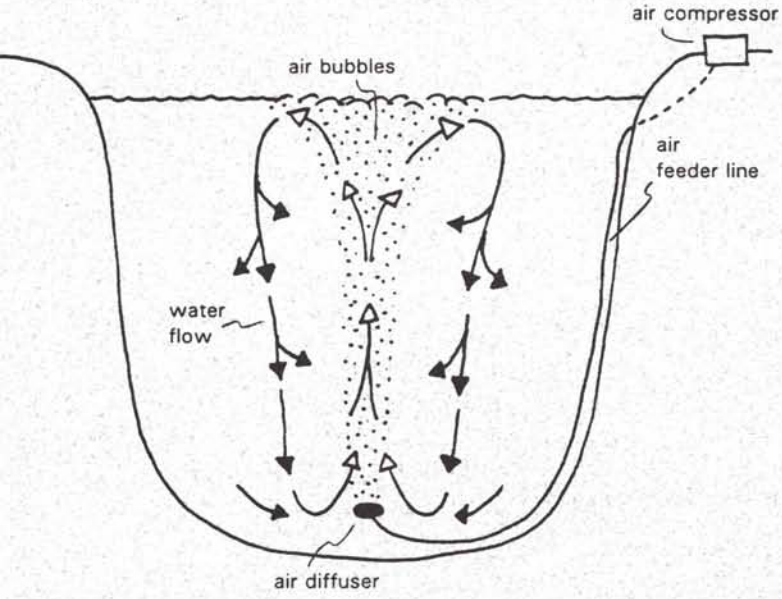
Lakes get much of their oxygen from the atmosphere through a process called diffusion. Artificial circulation increases a lake's oxygen by forcefully circulating the water to expose more of it to the atmosphere. Proper choice and design of an artificial circulation system depends on your lake management goals and the lake's physical characteristics.

Destratifiers

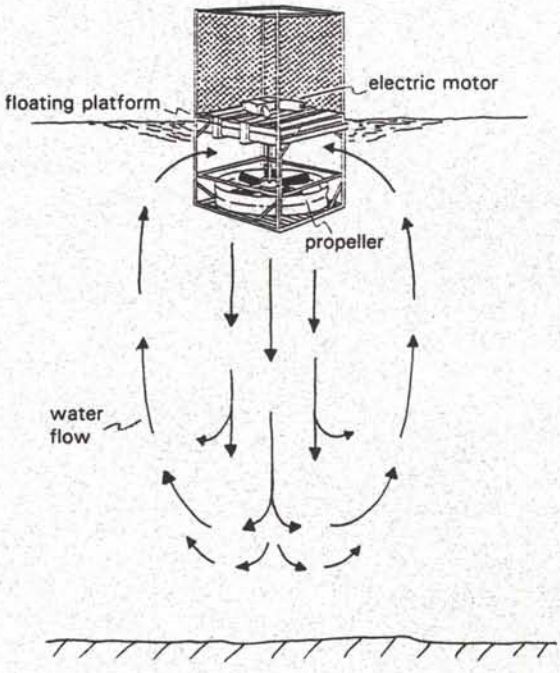
Destratification is a type of artificial circulation that completely mixes a stratified lake's waters from top to bottom and thereby eliminates or prevents summer stratification (the division of a lake into water layers of different temperatures). Two techniques are most common: air injection and mechanical mixing.

■ **Air Injection (Diffuser) Systems** are the most common destratification method. A compressor on shore delivers air through lines connected to a perforated pipe(s) or other simple diffuser(s) placed near the bottom, typically in the deep area of the lake. The rising air bubbles cause water in the hypolimnion (the cold, bottom water layer) to also rise, pulling this water into the epilimnion (warm, surface water layer). When the colder, hypolimnetic water reaches the lake surface, it flows across the surface and eventually sinks, mixing with the warmer epilimnetic water. If the system is adequately powered and enough air is injected, this process continues and the metalimnion (transition zone between the epilimnion and hypolimnion) is broken down. Eventually, the entire lake becomes of nearly equal temperature with oxygen distributed throughout. Many people are surprised to learn that the majority of oxygenation occurs through the water's contact with the atmosphere; relatively little oxygen increase occurs through direct diffusion from the bubbles. This aeration technique is

sometimes referred to as the ***air-lift*** method of circulation, since bottom waters are "lifted" to the lake surface through the action of the injected air.



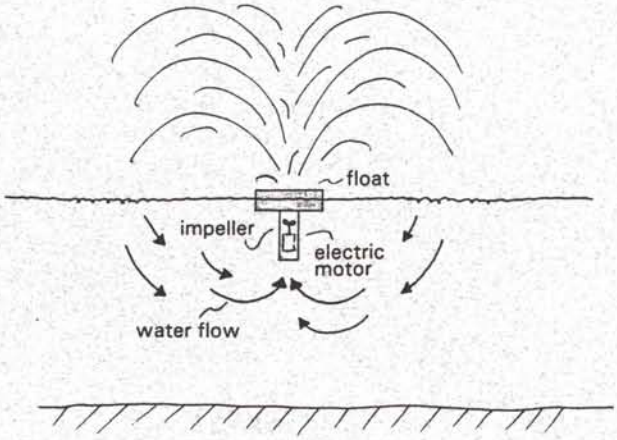
■ **Mechanical Axial Flow Pumps** use a "top-down" approach to set up a circulation pattern. A floatation platform and frame support an electric motor, gearbox, drive shaft, and large propeller (6–15 foot diameter). The propeller is suspended just a few feet below the water surface. Its rotation "pushes" water from the lake surface downward, setting up a circulation pattern that prevents thermal stratification. Oxygen-poor water from the lake bottom is circulated to the lake surface, where oxygenation from the atmosphere can then occur. These systems are being utilized in several Illinois water supply reservoirs.



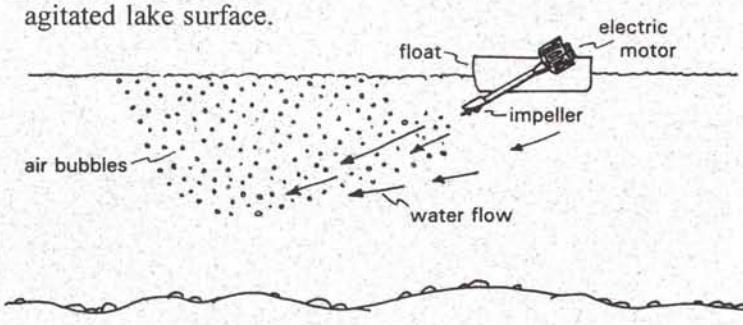
Other Systems

Other mechanical circulation systems include surface spray units, impeller-aspirators, and pump-and-cascade systems. While they do set up a circulation pattern in the water, they typically are not designed to destratify a lake. Hence, they probably have more applicability in non-stratified (shallow) lakes and ponds to enhance the water's oxygen content.

■ **Surface Spray** units consist of a float supporting an electric motor-driven impeller. The rapidly-turning impeller pulls water up a vertical tube and throws it out in an umbrella- or fountain-shaped spray a few to many feet above the lake surface. Atmospheric reaeration occurs in the sprayed water and at the agitated lake surface.



■ **Impeller-Aspirator** systems consist of an electric motor-driven impeller at the bottom of a hollow shaft extending at an angle down into the water. The assembly floats on the lake surface. The rapidly-turning impeller draws air down the shaft and propels water and air bubbles into the lake. Aeration takes place through air bubble/water contact and at the agitated lake surface.

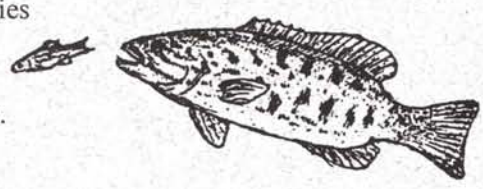


■ **Pump-and-Cascade** systems consist of a large pump that moves lake water to the top of a ramp-like chute containing numerous baffles. The water cascades down the ramp and falls back into the lake at a point located as far as possible from the water inlet (to prevent recycling of just-pumped water). Aeration occurs in the cascade chute and in the plunge pool as the water flows away from the ramp.

Effects of Destratification/ Circulation

■ **Dissolved Oxygen:** The most common result of destratification is an improvement in dissolved oxygen levels—and consequent benefits on warmwater fish and water supply quality.

■ **Fish:** Destratification is generally considered beneficial for warmwater fish. Fish require adequate dissolved oxygen levels and cannot survive in an oxygen-deficient hypolimnion. Warmwater fish (e.g., bass, bluegill) require a minimum dissolved oxygen concentration of 5 mg/L, and coldwater fish (e.g., trout) need 6-7 mg/L. Destratification allows warmwater fish to inhabit the entire lake, and enhances conditions for fish food organisms as well. However, because destratification warms the deep waters, some coldwater fish species may be eliminated or prevented from inhabiting that lake.



■ **Water Supply Quality:** A common result of destratification is an improvement in industrial and drinking water supply quality (in fact, the first artificial circulation system was used in 1919 in a small water supply reservoir). Under anoxic (without oxygen, anaerobic) conditions, lake bottom sediments release metals (iron, manganese) and gases (hydrogen sulfide)—which can cause taste and odor problems in drinking water. When the anoxic hypolimnion is eliminated, these problems are eliminated or greatly reduced as well. Water treatment costs also decrease.

■ **Phytoplankton:** The effects on phytoplankton (algae) are less predictable. Destratification *may* reduce algae through one or more processes: 1) algal cells will be mixed to deeper, darker lake areas, decreasing the cells' time in sunlight and thereby reducing their growth rate, 2) some algae species that tend to sink quickly and need mixing currents to remain suspended (e.g., diatoms) may be favored over more buoyant species such as the more noxious blue-greens, 3) changes in the lake's water chemistry (pH, carbon dioxide, alkalinity) brought about by higher dissolved oxygen levels can lead to a shift from blue-green to less noxious green algae or diatoms, and 4) mixing of algae-eating zooplankton into deeper, darker waters reduces their chances of being eaten by sight-feeding fish; hence, if more zooplankton survive, their consumption of algal cells also may increase.

While algal blooms have been reduced in some lake destratification/circulation projects, in other lakes phytoplankton populations have not changed or have actually increased. For shallow lakes, it's even less likely that complete circulation would result in any of the above-mentioned benefits. This is because algae are less likely to become light-limited in shallow lakes, nor would water chemistry changes be as pronounced.

■ **Phosphorus:** Destratification has the potential to reduce phosphorus (P) concentrations in some lakes. During summer stratification when the hypolimnion is oxygen-poor, P becomes more soluble (dissolvable) and is released from the bottom sediments into the hypolimnion. Because stratified lakes can sometimes partially mix, this allows greater amounts of P to "escape" into the epilimnion. These increased P levels in the lake's surface waters can potentially stimulate an algal bloom. For similar reasons, algal blooms often are seen at fall turnover. Because destratification increases the bottom water's oxygen content, it follows that P release from the sediments should be reduced, which in turn can lead to decreased algae abundance. However, the most suitable candidates for P reduction are deep, stratified lakes where a majority of the lake's P comes from anoxic, hypolimnetic sediments (i.e., internal sources). In lakes where the majority of P comes from external sources (such as watershed runoff, the atmosphere, waterfowl, septic systems), a reduction in sediment P release may not be enough to notice a change in algae abundance.

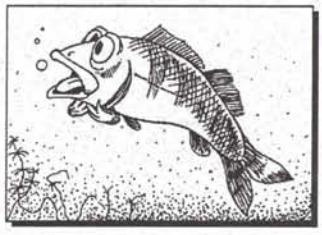
Winter Operation

Artificial circulation systems also can help prevent winter fishkills in ice-covered lakes. Low dissolved oxygen levels during winter occur because ice covering the lake prevents diffusion of atmospheric oxygen into the water. Even though photosynthesis by some algae and rooted aquatic plants occurs in the winter months under the ice, bacterial decomposition of organic matter on the lake bottom can consume

more oxygen than photosynthesis can replace. Furthermore, if enough snow covers the ice or if the ice is opaque, sunlight will be unable to penetrate and photosynthesis will stop. If under-ice oxygen levels become too low before ice-out, a partial or total fishkill will occur. Shallow lakes are most susceptible to dissolved oxygen depletion since they have a smaller amount of water as compared to deeper lakes.

Studies in Wisconsin and Minnesota have found that air diffuser systems seem most effective in providing efficient, reliable winter aeration. To save energy costs, the system can be run only on an as-needed basis. Careful monitoring of dissolved oxygen levels throughout the winter can be used to determine when, or even if, aeration in a particular year is necessary. Oftentimes, dangerously low oxygen levels do not appear in Illinois lakes until late winter. In most cases, if a lake's average dissolved oxygen level was found to be between 4 and 5 mg/L, start-up would be warranted. After you become more familiar with your lake's situation, start-up can be fine-tuned.

Turbulence from the rising air bubbles and uplifting of the slightly warmer bottom waters will begin opening the ice within a few hours after system start-up. Be aware that if the system is turned on when oxygen concentrations already have fallen too low, mixing of anaerobic bottom water with low-oxygen water just under the ice may cause the entire lake to have oxygen levels too low for fish survival.



Surface spray units, impeller-aspirators, and pump-and-cascade systems also can be used in the winter to keep an area ice-free. Of the three, pump-and-cascade systems appear to be the most reliable in averting winter fishkills. They also can be moved from lake to lake. On small lakes, their wintertime performance has compared favorably with air diffuser systems.

Design Considerations

There are several technical issues to consider when designing and installing an artificial circulation system. For example, if the air diffuser is positioned too far above the lake bottom, an anaerobic zone will remain below it. However, if the diffuser is placed on or too near the lake bottom—or if the system is oversized (mixing is too vigorous)—sediments may be stirred up and resuspended in the lake. If the system is undersized, mixing will be incomplete. In very large lakes, mixing will be limited unless more than one device is used.

To Aerate—or Not to Aerate?

It's a good idea to seek experienced professional help when considering the installation of and in designing a properly-sized aeration system. The first question to consider is whether your lake can really benefit from a destratification/circulation (or other) aeration system. Would summer and/or winter operation be most effective? Answering these questions requires background knowledge of your lake's physical and water quality characteristics. You also should have established lake use goals (e.g., what you'd like to use the lake for, how you'd like the lake to look). Seek out the advice of unbiased water quality professionals—don't limit your advice to just the individual or company proposing to sell you a system! By examining your lake's characteristics together with your goals, you can then better determine whether aeration, and what type of system, might meet your objectives.

Lake Notes . . . is a series of publications produced by the Illinois Environmental Protection Agency about issues confronting Illinois' lake resources. The objective of these publications is to provide lake and watershed residents with a greater understanding of environmental cause-and-effect relationships, and actions we all can take to protect our lakes.

This *Lake Notes* publication was prepared by Holly Hudson and Bob Kirschner of the Northeastern Illinois Planning Commission, Chicago, Illinois. Illustrations by Holly Hudson, University of Wisconsin-Extension, Wisconsin Department of Natural Resources, and Illinois State Water Survey.

For more information about other publications in this series and to request copies, please contact: Illinois Environmental Protection Agency, DWPC-Lake and Watershed Unit, P.O. Box 19276, Springfield, Illinois, 62794-9276; 217/782-3362.