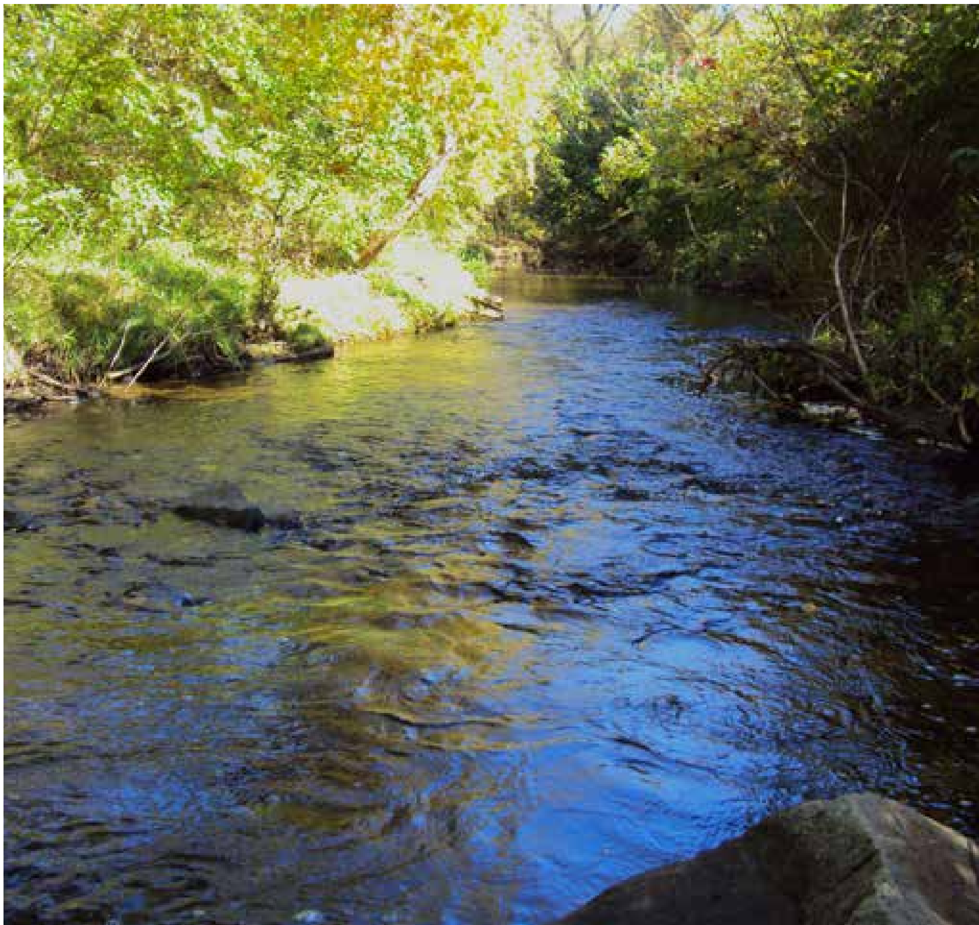
Applied Ecological Services, Inc.™

FINAL REPORT
By Applied Ecological Services, Inc.
April 2021

Crystal Creek Watershed-Based Plan

A Watershed-Based Guide for Protecting and Restoring Watershed Health



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CRYSTAL CREEK WATERSHED-BASED PLAN
McHenry County, Illinois

A Watershed-Based Guide for Protecting and Restoring Watershed Health

FINAL REPORT

APRIL 2021
(AES #19-0568)

Prepared by:

Applied Ecological Services, Inc.™

120 West Main Street
West Dundee, Illinois 60118
http://www.appliedeco.com
Phone: (847) 844-9385

for

City of Crystal Lake
100 W. Woodstock St.
Crystal Lake, Illinois 60014
Phone: 815-356-3738

ACKNOWLEDGEMENTS

Funding for the Crystal Creek Watershed-Based Plan was provided by the City of Crystal Lake. Elizabeth Maxwell (City Planner) acted as Watershed Coordinator for the Watershed Steering Committee and worked closely with watershed partners and Applied Ecological Services, Inc. (AES) to produce the watershed planning document.

The Watershed Steering Committee consists of representatives from various municipal, governmental, private, and public organizations as well as local residents. Key partners include the City of Crystal Lake, the Village of Algonquin, the Village of Lake in the Hills, the Village of Lakewood, McHenry County, McHenry County Soil & Water Conservation District, McHenry County Conservation District, Crystal Lake Park District, Fox River Study Group, Crystal Lake STP #2, Lake in the Hills SD STP, and Environmental Defenders of McHenry County. These partners played an important role in providing input on plan content, watershed goals & objectives, various planning approaches, and input on potential watershed projects.

Applied Ecological Services, Inc. (AES) conducted analysis, presented at Watershed Steering Committee and stakeholder meetings, summarized results, and authored the Crystal Creek Watershed-Based Plan.

People from the following entities attended meetings and/or provided data:

Applied Ecological Services, Inc.: Cecily Cunz, Collin Smith, Steve Zimmerman
City of Crystal Lake: Elizabeth Maxwell, Abigail Wilgreen, Michael Magnuson
Crystal Lake Park District: Ann Viger, John Fiorina
Crystal Lake STP #2: Daniel Langguth
Environmental Defenders of McHenry County: Nancy Schietzelt
Fox River Study Group: Cindy Skukrud
Lake in the Hills SD STP: Tamara Mueller
McHenry County Conservation District: Gabe Powers
McHenry County: Scott Kuykendall, Joanna Colletti
Resident, Friends of the Hackmatack: Nancy Williamson
School District 155: Steve Olson
School District 47: Dave Schuh
Village of Algonquin: Michele Zimmerman
Village of Lake in the Hills: Dan Kaup, Guy Fehrman, Peter D’Agostino, Tom Migatz
Village of Lakewood: Jeannine Smith

All photos by Applied Ecological Services unless otherwise noted.

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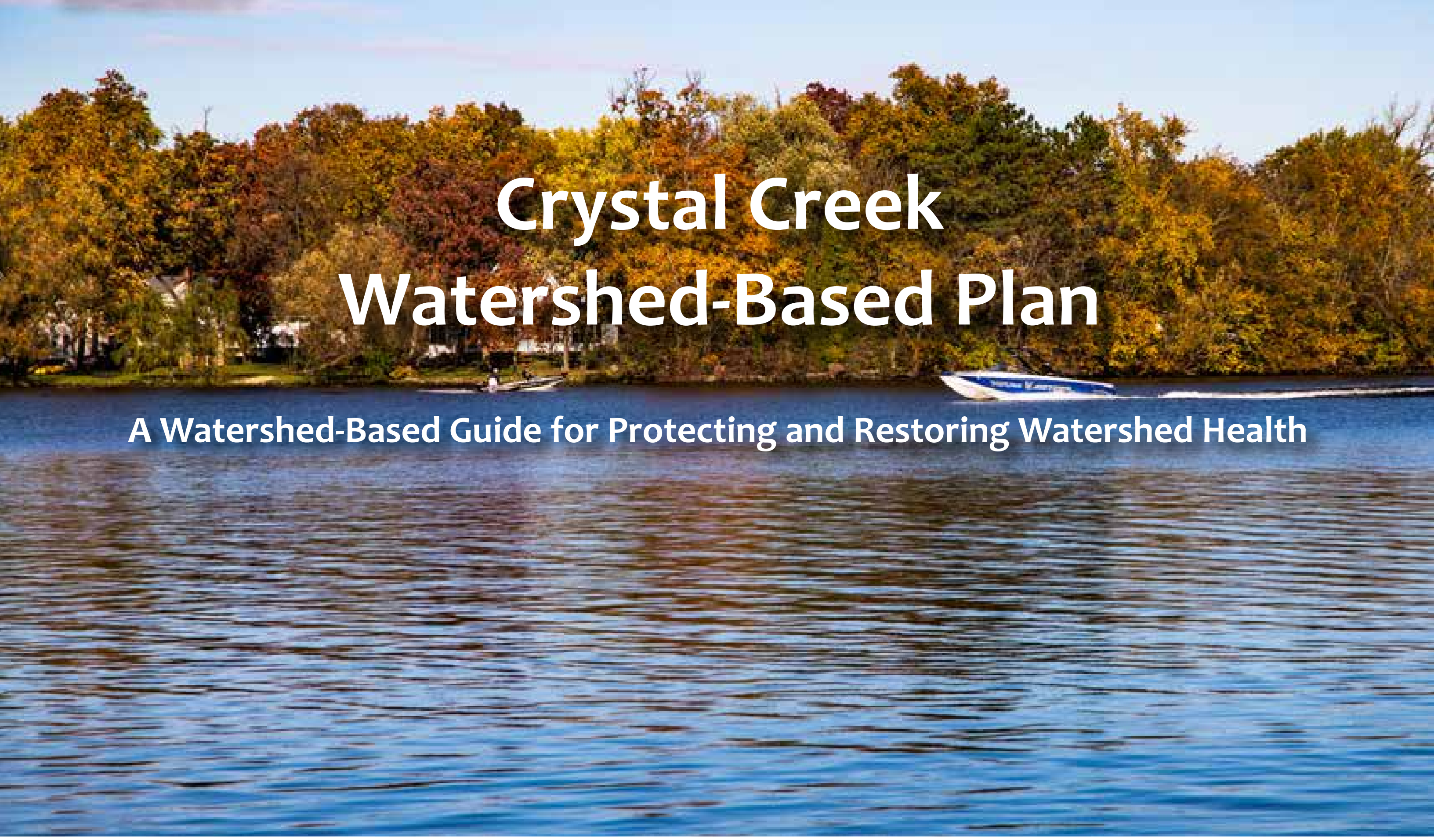
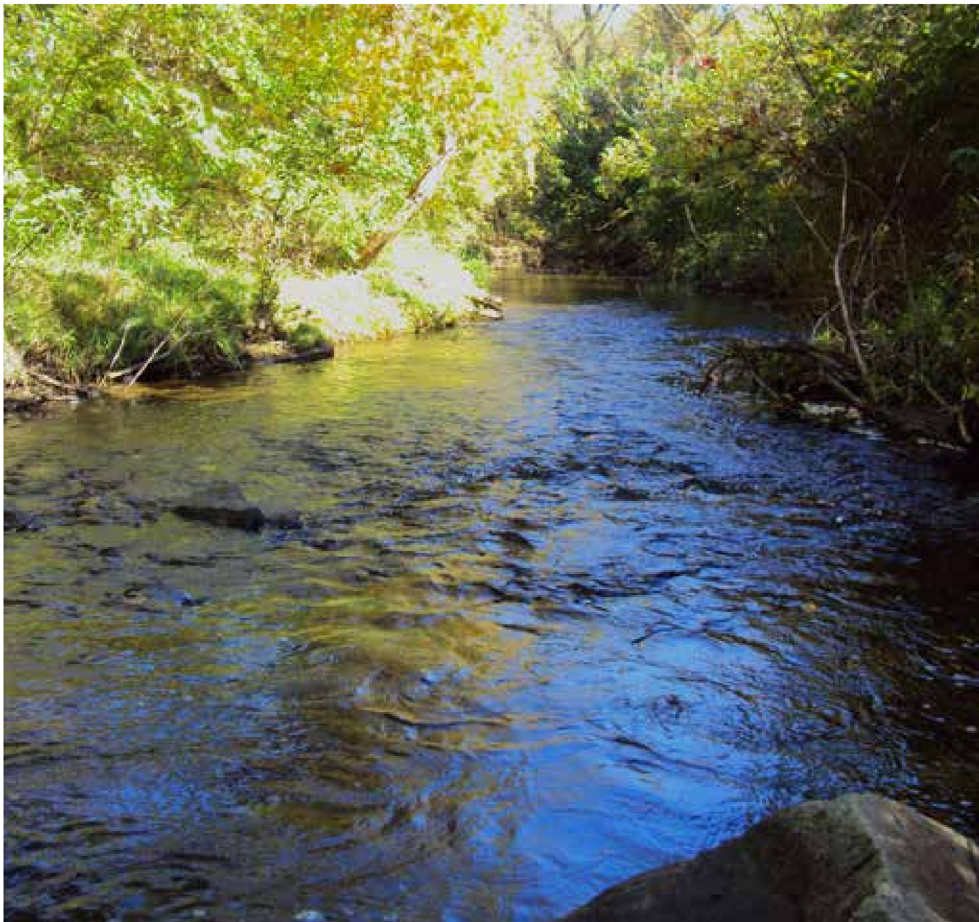
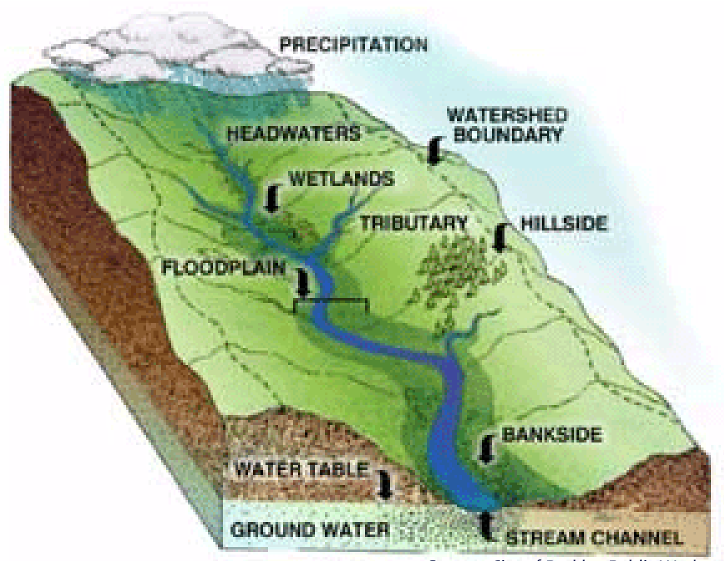




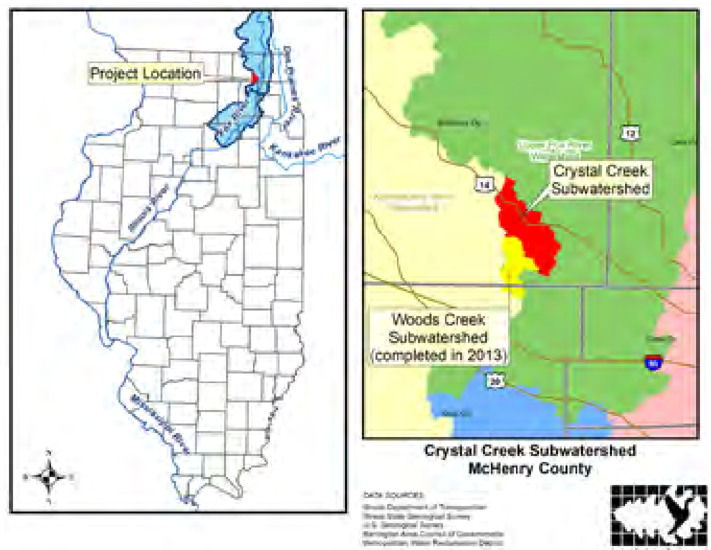
INTRODUCTION

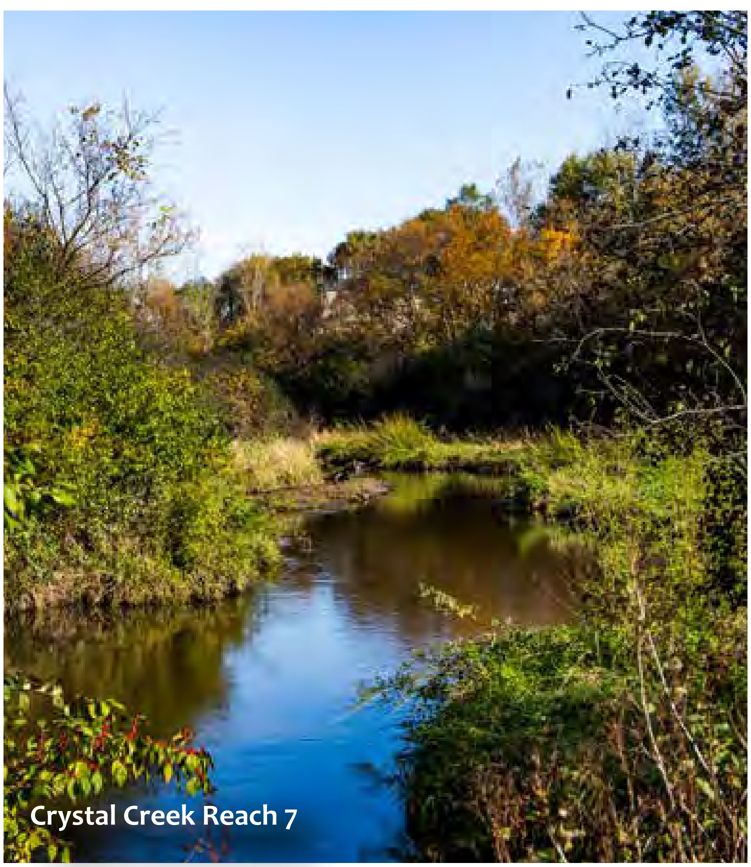
People live, work, and play in their "watershed" every day. A watershed is best described as an area of land where surface water drains to a common location such as a stream, river, lake, or other body of water. The source of groundwater recharge to streams, rivers, and lakes is also considered part of a watershed. Despite the simple definition for a watershed, they are complex in that there is interaction between natural elements such as climate, surface water, groundwater, vegetation, and wildlife as well as human elements such as urban development and agriculture that produce polluted stormwater runoff, increases to impervious surfaces, altered stormwater flows, and degradation or fragmentation of natural areas. Depending on size, other names for watersheds might include basins, sub-basins, and subwatersheds.

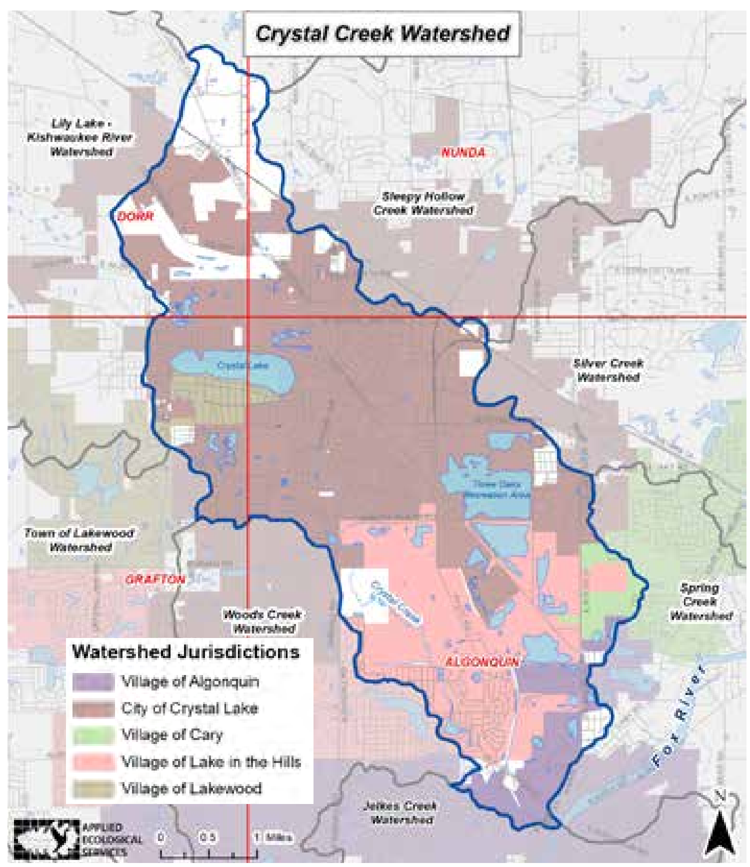


Source: City of Berkley Public Works

Crystal Creek watershed is located in northeast Illinois in McHenry County. Crystal Creek and its tributaries account for approximately 9.1 stream miles and drain approximately 18.8 square miles (12,037.1 acres) of land. The Crystal Creek watershed and Woods Creek watershed to the southeast (for which, a watershed-based plan was completed in 2013) together form the Crystal Lake Outlet watershed (HUC: 071200061201). The Crystal Creek watershed drains to the Upper Fox River Basin. The Upper Fox drains portions of Jefferson, Kenosha, Racine, Walworth, and Waukesha counties in Wisconsin and McHenry, Lake, Kane, and Cook Counties in Illinois. The Lower Fox River Basin extends south and west through DeKalb, DuPage, Grundy, Kendall, LaSalle, Lee, and Will Counties. The Fox River joins the Illinois River in Ottawa, Illinois.




Crystal Creek Reach 7



WATERSHED PLANNING

The watershed-based planning process is a collaborative effort involving voluntary stakeholders. The primary focus is to restore impaired waters and protect unimpaired waters by developing an ecologically-based management plan for the Crystal Creek watershed that focuses on improving water quality. The plan protects green infrastructure by creating protection policies, implementing ecological restoration, and educating the public. Another important outcome is to improve the quality of life for people in the watershed for current and future generations.

The primary purpose of this plan is to spark interest and give stakeholders a better understanding of the Crystal Creek watershed and to promote and initiate plan recommendations that will accomplish the goals and objectives of this plan. This plan was produced utilizing a comprehensive watershed-based planning approach that involved input from stakeholders, municipal representatives, and analysis of complex watershed issues by Applied Ecological Service's planners, ecologists, GIS specialists, and engineers.

GOALS

Goal 1: *Assess and improve policies and regulations to protect and support our natural resources.*

Goal 2: *Improve surface water quality.*

Goal 3: *Protect groundwater quantity and quality and improve groundwater recharge.*

Goal 4: *Protect, manage, and restore natural components of the Green Infrastructure Network and improve fish and wildlife habitat.*

Goal 5: *Manage and mitigate for existing and future structural flood problems.*

Goal 6: *Build stakeholder awareness of watershed issues through education and stewardship while increasing communication and coordination among stakeholders.*

THE PAST

A complex interaction existed between several ecological communities including prairies, savannas, woodlands, and wetlands prior to European settlement in the 1830s. The prairie-savanna landscape was maintained and renewed by frequent lightning strike fires, fires ignited by Native Americans, and grazing by bison and elk. Fires ultimately removed dead plant material, exposing the soils to early spring sun, and returning nutrients to the soil. Running through the prairie-savanna landscape were meandering stream corridors and low wet depressions consisting of sedge meadow, marsh, wet prairie and highly unique seeps, springs, and fen wetlands hydrated by alkaline rich groundwater discharge. Back then most precipitation was absorbed in upland prairie and savanna communities and within the extensive wetlands that existed along stream corridors.

"Algonquin Township is more broken than any other township within the county, there being many bluffs and hills in the region of Algonquin village and in fact all along the Fox River. The land is about equally divided between prairie and timber. It is adapted to both small grain and pasture lands and is used for such purposes. Crystal Lake lies in section 6 of this township, and runs over into a portion of Grafton township. From it flows the outlet of the lake that joins the Fox River at the Village of Algonquin. Big Spring Creek is another water course found within the township."

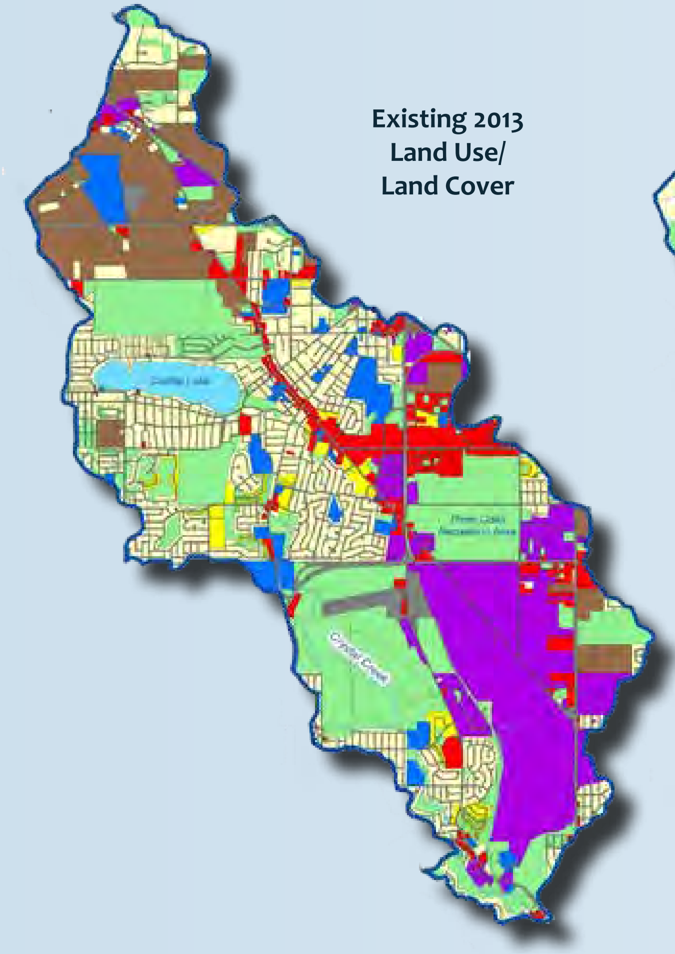
Highlights from "History of McHenry County, Illinois", Munsell, 1922

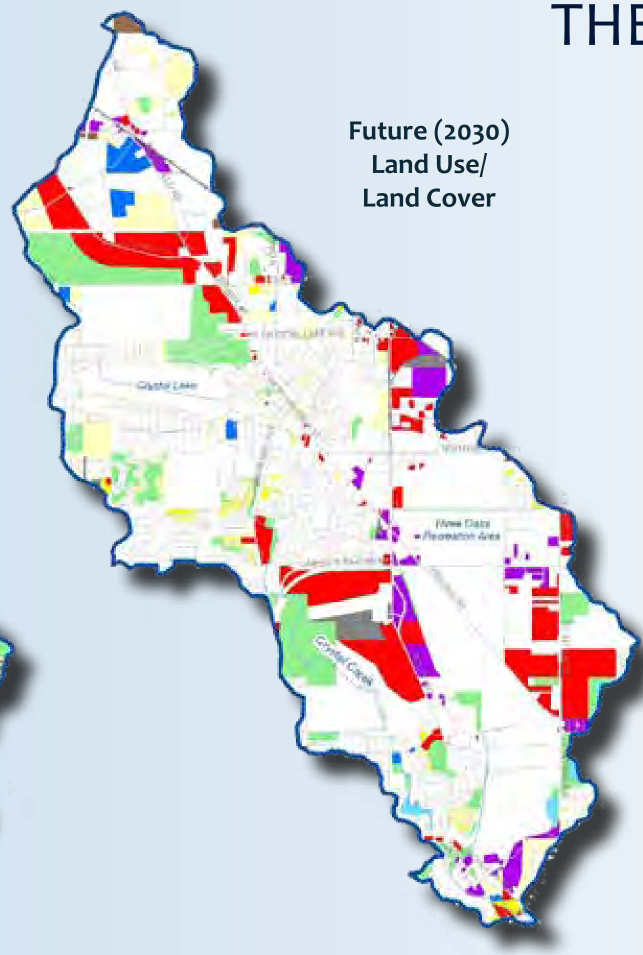
THE PRESENT

European settlement resulted in drastic changes to the fragile ecological communities. Fires no longer occurred, prairie was tilled under for farmland or developed, wetlands were drained, and many stream reaches were channelized. The earliest aerial photographs taken in 1939 depict Crystal Creek watershed when row crop farming was the primary land use but before residential and commercial development seen today. Forested lands around in the steep, southern portions of the watershed remained, but those in the flatter portion north of Crystal Lake had been converted to farmland by 1939.

Today, residential development dominates the watershed. Retail and commercial development is also common along Virginia Road. An 18-hole golf courses occupies an area directly south of Crystal Lake. Some farmland remains in the northern portion of the watershed, and quarries exist in the eastern portion near the Three Oaks Recreation Area.

THE FUTURE





On the Future land use map (above, right), areas in white depict where the land use remains unchanged, while the colors represent what the land use is expected to change to. The largest loss of a current land use/land cover is expected to occur on agricultural land (-925 acres; -7.7%) where land is expected to be developed to mostly commercial/retail, industrial, and single-family uses. Other significant losses occur on open space land use areas throughout the watershed (-476.7 acres; -4.0%) as these areas will eventually become developed. Conversely, commercial/retail development is predicted to increase the most (+973.0 acres; +4.4%) followed by single-family residential (+411.4 acres; +3.4%).

CHALLENGES & THREATS

Surface Water

- According to IL EPA's most recent 2018 Integrated Water Quality Report and Section 303(d) List, Crystal Creek (IEPA Segment Code IL DTZR 01) is considered impaired for *Primary Contact* due to high Fecal Coliform levels.
- IL EPA determined that neither Crystal Lake (ILVTZH) or Three Oaks North (ILWTJ) and South (ILWTG) Lakes are impaired.
- Recent water quality data collected within Crystal Creek indicates likely overall impairment from elevated total phosphorus, total nitrogen, total suspended solids, and fecal coliform.

Land Use & Habitat

- Urban land use in the watershed is the single largest nonpoint source contributor of nitrogen (11%), phosphorus (26%), and sediment (25%) to streams, followed by septic systems and croplands.
- Current development policy within the watershed communities can be improved to further protect water quality and green infrastructure.
- 35% of the riparian areas along streams and tributaries in the watershed are in poor condition or lacking entirely.

Groundwater

- Groundwater resources lie close to the surface within Cyrstal Creek watershed, creating rare ecosystems like Lake in the Hills Fen.
- 62% of Crystal Creek watershed is within a Highly Sensitive Aquifer Recharge Area, where contaminants from the surface can move rapidly through the sand and gravel deposits to wells and groundwater fed streams.

LAKES

Crystal Lake

In 1863, Charles Dole of Chicago's Armour and Dole established an estate at Crystal Lake including the lake bottom. Ice houses lined the shore to hold ice cut from Crystal Lake for shipping to Chicago. Due to the popularity of the quality ice, boarding houses and resorts were built on the north shore to accommodate vacationers. In 1921 the Crystal Lake Park District was established in order to ensure public access to Crystal Lake. The resorts surrounding Crystal Lake maintained popularity throughout the 1920s. Today, the lake remains public and is surrounded by over 150 residential homes. Crystal Lake Park District currently has two public access points Main Beach and West Beach. An additional 6 private beaches managed by homeowner associations are also maintained along the lakeshore.

Three Oaks Recreation Area

The City of Crystal Lake opened Three Oaks Recreation Area in 2010 at the sight of the abandoned Vulcan Lakes quarry. The recreation area hosts various activities such as swimming, scuba diving, fishing and boating in the manmade lake as well as trails throughout the recreation areas 28 acres of restored native prairie.

Goose, Willow, and Scott Lakes

Goose, Willow, and Scott Lakes are formed by a series of three damns on Crystal Creek beginning south of Willow Street. Willow Lake and Scott Lake are the two smallest lakes within Lake of the Hills and the Crystal Creek Watershed and do not have public access. Goose Lake can be accessed at Horner Park in Lake in the Hills and is stocked seasonally with walleye, sunfish, perch and catfish.

Crystal Lake

ECOLOGICALLY SIGNIFICANT NATURAL AREAS

Lake in the Hills Fen

ADID & Other High Quality Wetlands

According to the ADID inventory for McHenry County, there are 688 acres of high-quality wetlands in the Crystal Creek watershed. There is a large ADID wetland complex within the Lake in the Hills Fen in Lake in the Hills. Larsen Prairie, owned by McHenry County Conservation District, is classified as an Important Natural Area Inventory site by IDNR (Category I and II-R) and the majority of the site is comprised by an ADID wetland complex.

McHenry County Natural Area Inventory Sites

The McHenry County Conservation District identified one Natural Area Inventory Site in the Crystal Creek watershed. "Lake in the Hills Fen" is an almost 500-acre complex of unstratified glacial drift composed of limestone gravel and is owned, protected, and managed by the Village of Lake in the Hills, McHenry County Conservation District, and the State of Illinois. A portion of the site is also classified as an Important Natural Area Inventory site by IDNR (Categories I, II, and III). A fen is a peat forming wetland that relies on groundwater input and often contains rare plants, animals, and insects. Lake in the Hills Fen includes ADID wetlands as well as nine native communities including calcareous floating mat, graminoid fen, low shrub fen, calcareous seep, sedge meadows and marsh, perennial stream, dry gravel prairie, and mesic gravel prairie; it contains over 400 species of native plants including 40 of which are classified as uncommon, rare, or endangered.

Lippold Park (Source: CLPD)

Other Ecologically Significant Areas

Crystal Lake Park District manages natural areas within Lippold Park which was formally a sod farm prior to being converted to a 310-acre recreational area and includes 60 acres of restored wetlands.

The Village of Algonquin owns and maintains the 12-acre Towne Park which is located adjacent to Crystal Creek and along the Prairie Trail. Towne Park was previously restored, including streambank stabilization as well as riparian buffer restoration to a native oxbow wetland, and prairie.

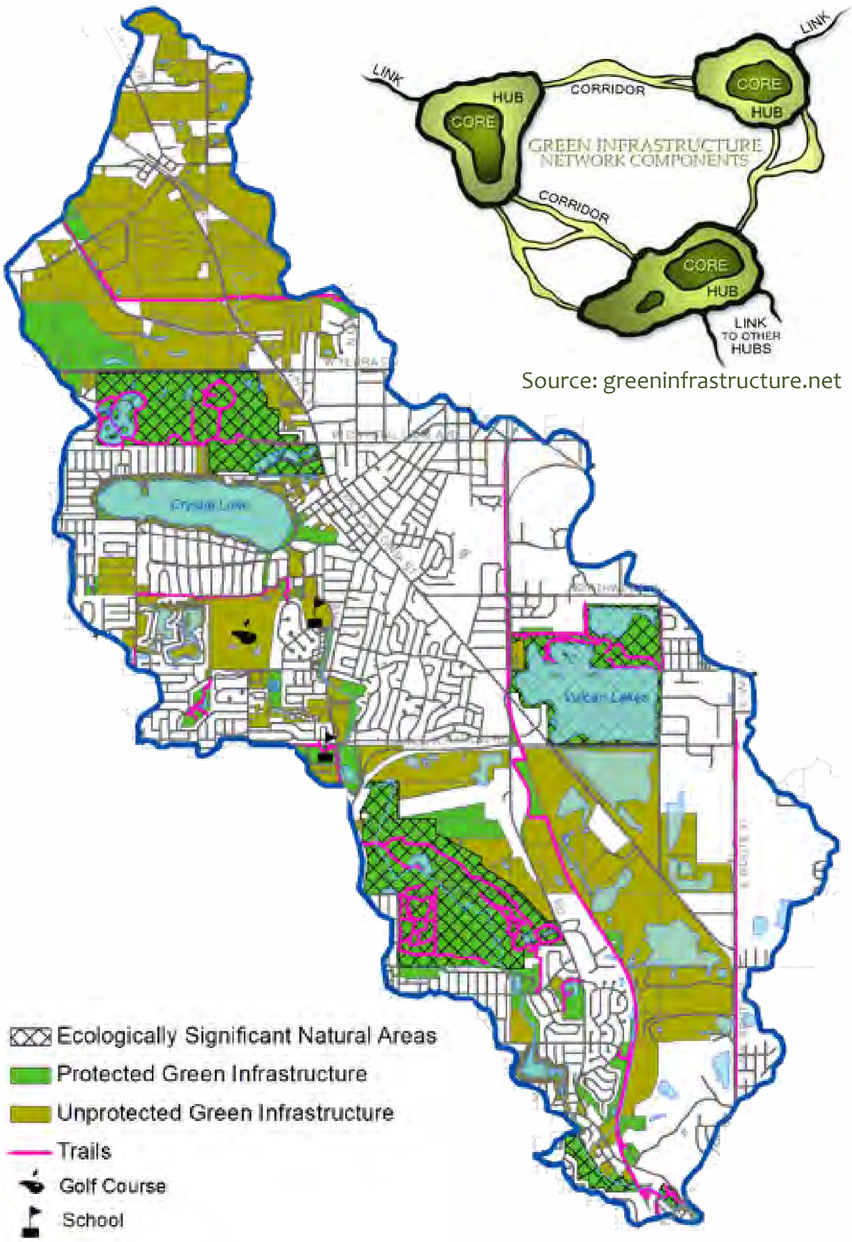
East of Towne Park and the Route 31 bypass is a remnant mesic oak woodland owned by the Village of Algonquin. The oak woodland is located on a steep slope adjacent to Crystal Creek. The woodland is one of few remaining mesic oak woodlands in the watershed. The site harbors 200+ year old red oaks but the area is being invaded by an overabundance of sugar maple that are producing heavy shade and inhibiting oaks from regenerating.

GREEN INFRASTRUCTURE & YOUR BACKYARD

A Green Infrastructure Network is a connected system of natural areas and other open space that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to wildlife and people. The network is made up of hubs and linking corridors. Hubs generally consist of the largest and least fragmented areas such as Lake in the Hills Fen, Lippold Park, and Three Oaks Recreation Area. Corridors are generally formed by private residential parcels along Crystal Lake, Crystal Creek, and its tributaries. Corridors are extremely important because they provide habitat conduits between hubs. However, most parcels forming corridors are not ideal green infrastructure until landowners embrace the idea of managing stream corridors or creating backyard habitats.

Any property owner can improve green infrastructure. Create a safe place for wildlife by providing a few simple things such as food, water, cover, and a place for wildlife to raise their young. The National Wildlife Federation's Certified Wildlife Habitat® and the Conservation Foundation's Conservation@ Home programs can help you get started.

GREEN INFRASTRUCTURE NETWORK



Source: greeninfrastructure.net

RAIN BARREL

Source: Rainbarrelsource.com.

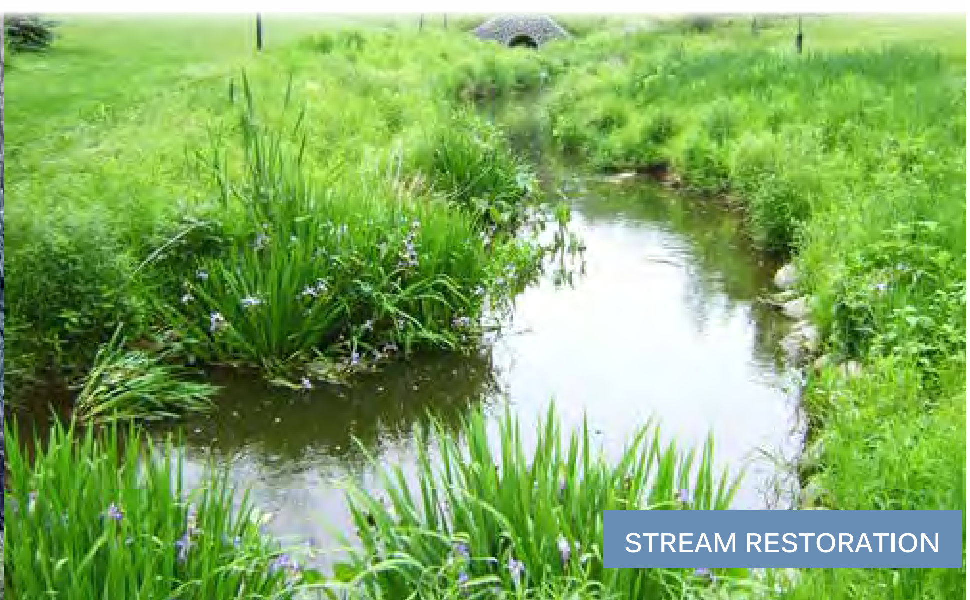

RAIN GARDEN

Creating a rain garden, or a small vegetated depression, to capture water is another way of promoting infiltration while beautifying your yard and providing additional habitat. Disconnecting your roof downspouts and capturing that runoff in rain barrels not only reduces the amount of runoff entering streams, but also serves as a great source of water for irrigating your yard.

If a portion of a stream runs through your backyard, here are some tips to help properly manage your piece of the green infrastructure network:

1. A NATURAL, MEANDERING STREAM IS A HAPPY STREAM
   Work with experts to restore degraded streams.
2. REMOVE NON-NATIVE SPECIES
   Identify and remove plants that are out of place (see photo guide, right).
3. PLANT NATIVE BUFFERS
   Plants adapted to the Midwest climate can help control erosion by stabilizing banks, while buffers protect the health of streams.
4. NO DUMPING
   Avoid dumping yard waste and clear heavy debris jams.
5. MANAGE CHEMICAL USE
   Avoid over fertilizing lawns or spilling/dumping chemicals near waterways.

For more detailed information, check out the Lake County Stormwater Management Commission's booklet, "Riparian Area Management: A Citizen's Guide," at www.lakecountyil.gov/stormwater.


STREAM RESTORATION

REMOVE THESE NON-NATIVE AND INVASIVE SPECIES


COMMON REED

BUCKTHORN


REED CANARY GRASS


PURPLE LOOSESTRIFE


GARLIC MUSTARD


TEASEL

STREAM & RIPARIAN AREA RESTORATION

DETENTION BASIN RETROFITS

NA

ACTION PLAN

THe Crystal Creek Watershed-Based Plan includes an Action Plan developed to provide stakeholders with recommendations to address plan goals. The Action Plan includes programmatic and site-specific recommendations. Programmatic recommendations are general watershed-wide remedial, preventatitve, and regulatory actions. Site-specific recommendations include actual locations where projects could be implemented to improve water quality, green infrastructure, and aquatic and terrestrial habitats.

Programmatic recommendations include...

- Ordinance and Policy Recommendations
- Rainwater Harvesting & Re-use
- Native Landscaping
- Street Sweeping
- Septic System Maintenance
- Green Infrastructure Planning
- Conservation Design & Low Impact Development
- Water Quality Trading & Adaptive Management

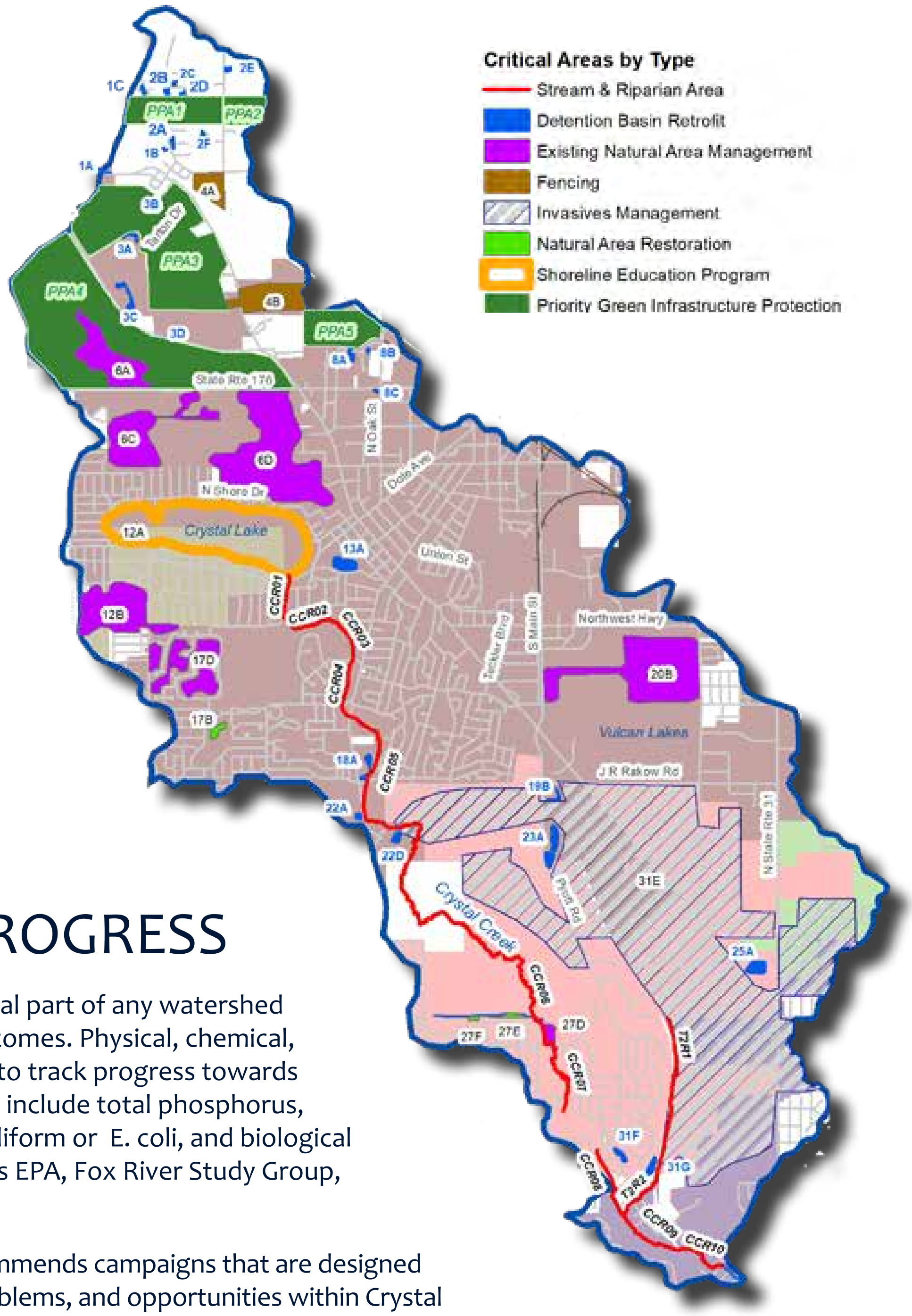
Site-specific recommendations include...

- Stream & Riparian Area Restoration
- Detention Basin Retrofits
- Other Management Measures:
    - Natural Area Management & Restoration
    - Fencing
    - Invasives Management
    - Shoreline Education Program
    - Prioirty Green Infrastructure Protection

The recommended programmatic and site-specific management measures provide a solid foundation for protecting and improving watershed conditions over time, and should be updated using the Report Cards established for each goal as projects are completed or other opportunities arise. Key implementation stakeholders are encouraged to organize partnerships and develop various funding arrangements to help delegate and implement the recommended actions. More details on the action plan and implementation can be found in the full waterhsed plan document.

ATURAL AREA RESTORATION

CRITICAL AREAS



MEASURING PLAN PROGRESS

A water quality monitoring plan is an essential part of any watershed plan to evaluate plan implementation outcomes. Physical, chemical, and biological data will be collected over time to track progress towards acheiving water quality improvements and will include total phosphorus, total nitrogen, total suspended solids, fecal coliform or E. coli, and biological monitoring. Monitoring partners include Illinois EPA, Fox River Study Group, and the Steering Committee.

The Information & Education (I&E) Plan recommends campaigns that are designed to enhance understanding of the issues, problems, and opportunities within Crystal Creek watershed. The intention is to promote general acceptance and stakeholder participation in selecting, designing, and implementing recommended Management Measures to improve watershed conditions. The first step in understanding the issues, problems, and opportunities within Crystal Creek watershed is to gain a better perspective on how the watershed evolved over time into what exists today. The goal of the I&E Plan is to equip municipal staff, elected officials, and other key stakeholders with the tools necessary to establish watershed-based practices and create changes in behaviors that will improve the overall health of the watershed.

HOW YOU CAN HELP CRYSTAL CREEK WATERSHED

The degradation of water resources seen today in the Crystal Creek Watershed occurred over almost 200 years of landscape changes. Fortunately, there are actions outlined in the plan that can be taken to mitigate existing issues and improve water quality over time. The future health of the watershed is largely dependent on how stormwater and natural resources are managed. That includes implementing proven and environmentally-sensitive practices and approaches to restoration, such as those identified in this executive summary and the watershd plan, to improve water quality and stream health in the watershed. You can help the Crystal Creek watershed by starting in your own backyard and supporting local water quality improvement efforts.

There is no single fix for the water quality and flooding problems in the Crystal Creek Watershed. These problems are the cumulative result of decisions made since people moved to the watershed in the 1800s. It will take all stakeholders and actions at every scale in order to positively impact watershed resources. This watershed-based plan is the first step in helping watershed residents and stakeholders understand what can be done to restore the valuable resources of the Crystal Creek Watershed.

All photos by AES unless otherwise noted.

For more information on how you can help, contact the City of Crystal Lake:

100 W. Woodstock St., Crystal Lake, IL 60014
815-459-2020
Elizabeth Maxwell: emaxwell@crystallake.org
Mike Magnuson: mmagnuson@crystallake.org

or visit the City website at:
www.crystallake.org

CRYSTAL LAKE PARK DISTRICT
The Village of Lakewood — Quality Living in a Natural Setting
Village of Lake in the Hills
Village of Algonquin 1890
City of Crystal Lake, IL. Incorporated September, 1914
Applied Ecological Services, Inc.™

1.0 Introduction

1.1 Crystal Creek Watershed Setting

Each of us lives in a watershed or area of land drained by a river/stream system or body of water such as a lake (Figure 1). Despite this relatively simple definition, a watershed is a complex interaction between natural elements such as climate, surface water, groundwater, vegetation, and wildlife and human-created features such as agriculture and urban development that produce polluted stormwater runoff, increase impervious surfaces, alter stormwater flows, and increase erosion. Other common names given to watersheds, depending on size, include basins, sub-basins, subwatersheds, and Subwatershed Management Units (SMUs).

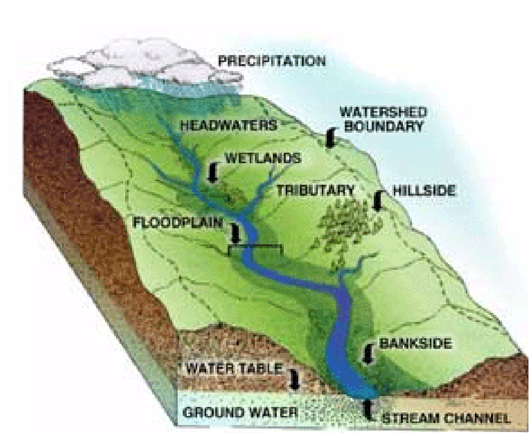


Figure 1. Hypothetical Watershed Setting (Source: City of Berkley-Public Works).

Crystal Creek watershed is located in northeast Illinois in McHenry County (Figure 2). Crystal Creek and its tributaries account for approximately 9.1 stream miles and drain approximately 18.8 square miles (12,037.1 acres) of land surface. The Crystal Creek watershed and Woods Creek

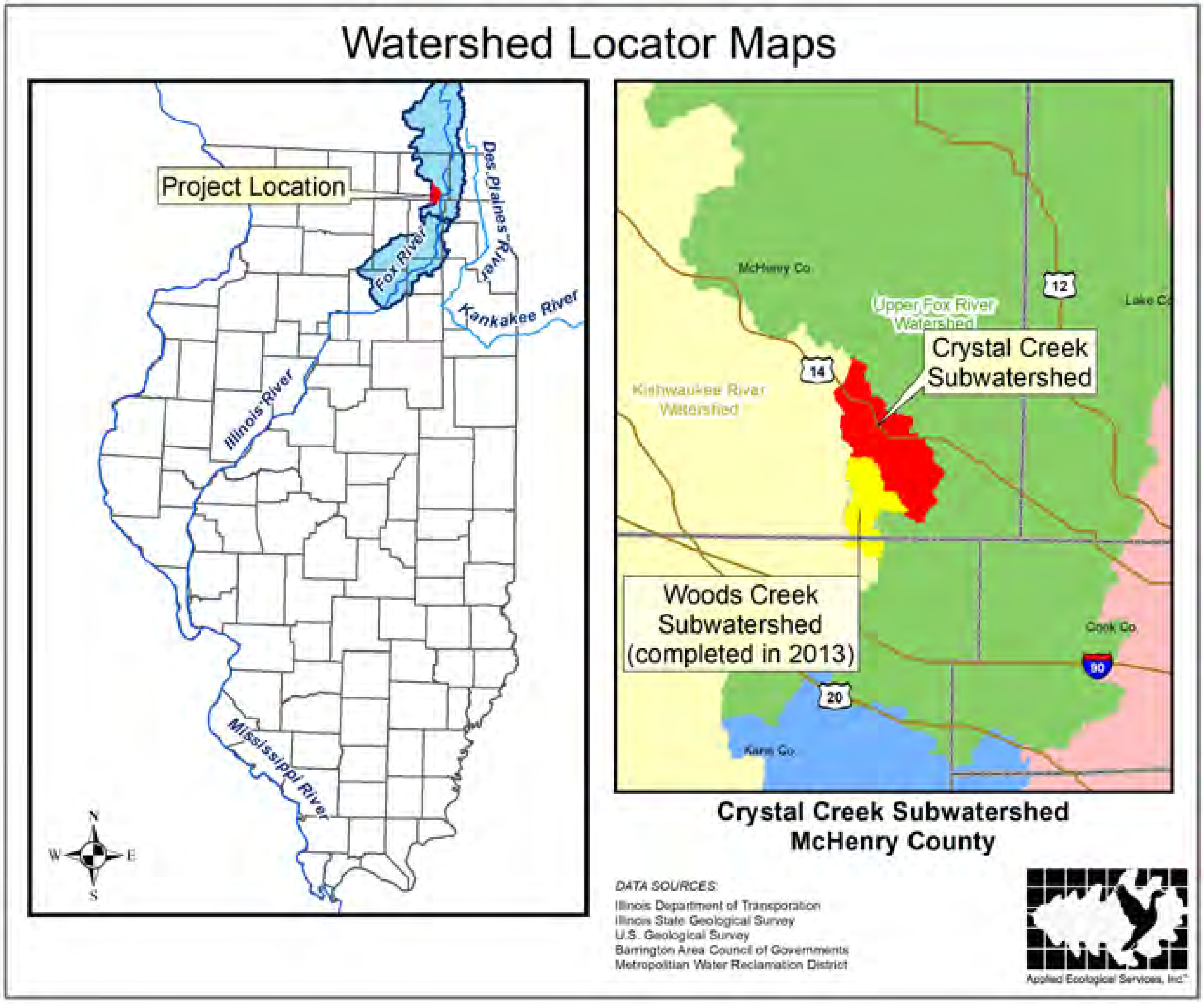


Figure 2. Watershed locator maps.

watershed to the southeast (for which, a watershed-based plan was completed in 2013) together form the Crystal Lake Outlet watershed (HUC: 071200061201). The Crystal Creek watershed (and Crystal Lake Outlet) drain to the Upper Fox River Basin. The Upper Fox drains portions of Jefferson, Kenosha, Racine, Walworth, and Waukesha counties in Wisconsin and McHenry, Lake, Kane, and Cook Counties in Illinois. The Lower Fox River Basin extends south and west through DeKalb, DuPage, Grundy, Kendall, LaSalle, Lee, and Will Counties. The Fox River joins the Illinois River in Ottawa, Illinois. From there the Illinois River flows southwest across the heart of Illinois before joining the Mississippi River north of St. Louis, Missouri.

Pre-European settlement ecological communities in the Crystal Creek watershed were undoubtedly balanced ecosystems with clean water and diverse with plant and wildlife populations. The mosaic of prairie, oak savanna, and wetlands were largely maintained and shaped by frequent fires ignited by both lightning and the Native Americans that inhabited the area. Herds of bison and elk also helped maintain the ecosystem via large scale grazing. During these times most of the water that fell as precipitation was absorbed in upland prairie and savanna communities and within the extensive wetlands that existed along stream corridors.

Ecological conditions changed drastically following European settlement in the mid-1800s. Large-scale fires no longer occurred, and bison and elk were extirpated. The majority of prairie and savanna was tilled under and drain tiles were installed throughout wet areas as farming became the primary land use by the early 1900s and continued through the 1980s. Heavy residential and commercial development in the 1990s and 2000s followed which led to additional alteration and fragmentation of the natural landscape and resulted in impervious surfaces that greatly reduce the ability of precipitation to infiltrate into the ground. Today, the Crystal Creek watershed is dominated by a variety of land uses including residential subdivisions, commercial/ industrial centers, farmland, gravel mining operations, schools, and recreational facilities all within the jurisdictions of Crystal Lake, Algonquin, Lake in the Hills, Lakewood, and Cary.

With landscape change came negative impacts to the environment. Streams and adjacent wetlands began to suffer from erosion causing sediment loading and deposition, invasive species establishment, loss of habitat, and nutrient inputs. In 2004, Crystal Creek (Crystal Lake Outlet) appeared on the Illinois Environmental Protection Agency's (Illinois EPA) 303d impaired waters list. The segment of the Fox River at Crystal Creek's confluence is also impaired. Crystal Creek, Woods Creek Lake, and the Fox River segment also appeared on subsequent 303d lists. Impacts to Illinois EPA "Designated Uses" are primarily the result of nutrients, total suspended solids, and fecal coliform originating from various sources.

Local governments have been concerned about the health of the Crystal Creek watershed since it began showing signs of degradation in the early 2000s. The jurisdictions also recognize that watershed issues are so complex and inter-related that it is essential for stakeholders including individual landowners, organizations, and governments to work together to protect and restore the health of the watershed. Watershed planning is entirely voluntary. The process of creating this Watershed-Based Plan for Crystal Creek unites volunteer stakeholders and helps them understand the watershed and initiate projects that improve water quality and enhance natural resources and open space.

1.2 Project Scope & Purpose

In early 2019, the City of Crystal Lake, in partnership with Algonquin, Lake in the Hills, Lakewood, Cary, and McHenry County, decided to pursue an watershed-based plan for Crystal Creek that would meet the Illinois Environmental Protection Agency (Illinois EPA) and United States Environmental Protection Agency (USEPA) Section 319 of the Clean Water Act. Ultimately, the intent is to develop and implement a Watershed-Based Plan designed to achieve water quality standards. This plan builds on a previous watershed-based plan completed for the adjacent Woods Creek in 2013. The Crystal Creek watershed and Woods Creek watershed together form the Crystal Lake Outlet watershed (HUC: 071200061201). The City of Crystal Lake, acting as watershed Coordinator, hired Applied Ecological Services, Inc. (AES) in October 2019 to assist in developing the plan. Crystal Lake together with representatives from Algonquin, Lake in the Hills, Lakewood, Cary, McHenry County, Crystal Lake Park District, Fox River Study Group, and residents formed the Watershed Steering Committee which met regularly during the planning process. Crystal Lake budgeted and paid for this plan independently and the Villages of Algonquin and Lake in the Hills contributed additional funding for water quality sampling, and putting the final plan in InDesign.

The watershed planning process is a voluntary exercise among stakeholders with the primary scope to develop an ecologically-based management plan for Crystal Creek watershed that focuses on improving water quality by protecting green infrastructure, creating protection policies, implementing ecological restoration, and educating the public.

The primary purpose of this plan is to spark interest and give stakeholders a better understanding of Crystal Creek watershed to promote and initiate plan recommendations that will accomplish the goals and objectives of this plan. This report was produced via a comprehensive watershed planning approach that involved input from stakeholders and analysis of complex watershed issues by watershed planners including ecologists, GIS specialists, and environmental engineers.

The Watershed Steering Committee held regular, public meetings throughout 2019 and 2020 to guide the watershed planning process, establishing goals and objectives, and to address watershed issues while encouraging participation of stakeholders to develop planning and support for watershed improvement projects and programs.

Interests, issues, and opportunities identified by the Steering Committee were addressed and incorporated into the Watershed-Based Plan. The plan acknowledges the importance of managing remaining open space to meet many of the goals and objectives in the plan and provides scientific and practical rational for protecting appropriate open space from traditional development and entering into relationships with public, private, and non-profit entities to manage these properties to maximize watershed benefits. In addition, ideas and recommendations in this plan are designed to be updated through adaptive management that will strengthen the plan over time as additional information becomes available.

1.3 USEPA Watershed-Based Plan Requirements

In March 2013, the United States Environmental Protection Agency (USEPA) released watershed protection guidance entitled Nonpoint Source Program and Grant Guidelines for States and Territories. The document was created to ensure that Section 319 funded Watershed-Based Plans and projects make progress towards restoring waters impaired by nonpoint source pollution. Applied Ecological Services, Inc. consulted USEPA's Handbook for Developing Watershed Plans to Restore and Protect Our Waters (USEPA 2008) and Chicago Metropolitan Agency for Planning's (CMAP's) Guidance for Developing Watershed Implementation Plans in Illinois (CMAP 2007) to create this watershed plan. Having a Watershed-Based Plan will allow Crystal Creek watershed stakeholders to access 319 Grant funding for watershed improvement projects recommended in this plan. Under USEPA guidance, "Nine Elements" are required in order for a plan to be considered a Watershed-Based Plan.

USEPA Nine Elements

Element A: Identification of the causes and sources or groups of similar sources of pollution that will need to be controlled to achieve the pollutant load reductions estimated in the watershed-based plan;

Element B: Estimate of the pollutant load reductions expected following implementation of the management measures described under Element C below;

Element C: Description of the BMPs (non-point source management measures) that are expected to be implemented to achieve the load reductions estimated under Element B above and an identification of the critical areas in which those measures will be needed to implement

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement the plan;

Element E: Public information/education component that will be implemented to enhance public understanding of the project and encourage early and continued participation in selecting, designing, and implementing/maintaining non-point source management measures that will be implemented;

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious;

Element G: Description of interim, measurable milestones for determining whether non-point source management measures or other control actions are being implemented;

Element H: Set of environmental or administrative criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards;

Element I: Monitoring component to evaluate the effectiveness of the implementation efforts over time.

1.4 Planning Process

Watershed Steering Committee

The Watershed Steering Committee first met in November 2019 to kick off the planning process and become familiar with the watershed and steps in the planning process. The Steering Committee met regularly throughout the planning process, as detailed in Table 1. The committee generally consisted of representatives from Crystal Lake, Algonquin, Lake in the Hills, Lakewood, Cary, McHenry County, Crystal Lake Park District, Fox River Study Group, and residents and was led by the City of Crystal Lake.

The Steering Committee helped develop goals for the watershed

Table 1. Crystal Creek Watershed Steering Committee meeting schedule.

Date	Agenda	Summary
Nov. 12, 2019	• Kickoff • Watershed Planning Summary • Stakeholder Involvement	The Watershed Coordinator detailed the background on why a watershed plan is needed and who helped make it happen. AES summarized the Nine Elements needed in a USEPA approved watershed plan and outlined the planning process.
Jan. 14, 2020	• Watershed Field Inventory Results	AES summarized the results of the “Watershed Resource Inventory” field investigation including the inventory methodology and survey results for the streams, riparian areas, detention basins, natural/ open space areas, and other sites.
Mar. 10, 2020	• Watershed Background: Part 1 • Code & Ordinance Review	AES updated stakeholders with watershed information including geology, pre-settlement conditions. Topography, jurisdictions, & demographics. AES also detailed the process for the Code & Ordinance review. A discussion followed regarding upcoming water quality monitoring.
May 2020	• Watershed Background: Part 2	This in-person meeting was postponed due to COVID-19. AES presented the Watershed Background Part 2 material at the following meeting.
Jul. 14, 2020	• Water Quality Inventory • Pollutant Loading Model Results • Goals Workshop discussion	AES first reviewed the presentation prepared for the postponed May meeting covering the second part of the Watershed Background conditions. AES then summarized the designated use impairments, wastewater treatment plants, water quality monitoring locations and results, the results of the pollutant loading model, “hot spot” analysis, and water quality targets in the watershed. This was followed by a discussion on the potential goal topics and the process for the upcoming Goals Workshop.
Oct. 6, 2020	• Goals Workshop	AES led a virtual goals workshop for Crystal Creek stakeholders that began with detailing the existing conditions in the watershed with poll questions throughout. This was followed by exercises to prioritize the goals and identify flood problem areas.
Nov. 10, 2020	• Programmatic Action Plan • Site Specific Action Plan • Critical Areas	AES presented the Programmatic and Site-Specific Action Plans and the Critical Areas to the Steering Committee.
Jan. 19, 2020	• Water Quality Monitoring Plan • Plan Evaluation Report Cards • Education and Outreach	AES first reviewed the water quality monitoring plan for the watershed and the report cards developed for each plan goal/objective. Finally, the Watershed Coordinator reviewed the Information and Education Plan with the Watershed Steering Committee.

and identified problem areas and opportunities. Meetings were initiated by the Watershed Coordinator and generally covered one or more watershed topics. Meetings were devoted to development of watershed assessment findings, goals and objectives, and action plan items. A list of the meetings is included in Table 1. Complete meeting presentations are included in Appendix A.

1.5 Using the Watershed Management Plan

The information provided in this Watershed-Based Plan is prepared so that it can be easily used as a tool by any stakeholder including elected officials, federal/state/county/municipal staff, and the general public to identify and take actions related to watershed issues. This section of the report summarizes what the user can expect to find in each major section of the Watershed-Based Plan.

Section 2.0: Mission, Goals, and Objectives
Section 2.0 of the report contains the Crystal Creek Watershed Steering Committee mission and goals/objectives identified by watershed stakeholders. Goal topics generally include watershed policy, protecting and restoring water quality, groundwater recharge, protection of green infrastructure, flood reduction, and education and communication. In addition, "measurable objectives" were developed for each goal so that the progress toward meeting each goal can be measured in the future by evaluating information included in Section 8.0: Measuring Plan Progress & Success.

Section 3.0: Watershed Characteristics, Problems, & Opportunities
An inventory of the characteristics, problem, and opportunities in Crystal Creek watershed is examined in Section 3.0. Resulting analysis of the inventory data led to recommended watershed actions

that are included in Section 5: Management Measures Action Plan. Inventory results also helped identify causes and sources of watershed impairment as required under USEPA's Element A.

Section 4.0: Causes & Sources of Watershed Impairment
This section of the plan includes a list of causes and sources of watershed impairment as identified in Section 3.0 and by watershed stakeholders that affect IEPA "Designated Uses". As required by USEPA, Section 4.0 also addresses all or portions of Elements A, B, & C including an identification of the "Critical Areas", pollutant load reduction targets, and estimate of pollutant load reductions following implementation of recommended Management Measures identified in Section 5.0.

Section 5.0: Management Measures Action Plan
A "Management Measures Action Plan" is included in Section 5.0 to provide stakeholders with

action items for watershed-wide improvements and direct stakeholders towards specific sites in the watershed where measures can be implemented resulting in the greatest watershed benefits.

The Action Plan is divided into a Programmatic Action Plan and a Site-Specific Action Plan. Action recommendations are presented in table format with references to entities that would provide consulting, permitting, or other services needed to implement specific measures. The tables also outline project priority, implementation schedule, sources of technical and financial assistance, and cost estimates. The Programmatic Action Plan recommends action items with general applicability throughout the watershed whereas the Site-Specific Action Plan identifies specific sites where recommended measures would improve water quality, expand and enhance natural resources/open space, and minimize flooding. This section addresses all or a portion of USEPA's Elements C & D.

Inventory Topics *Included* in Plan

Section 3.0 includes summaries and analysis of the following inventory topics:

- 3.1 Geology & Climate
- 3.2 Pre-European Settlement Landscape & Present Landscape
- 3.3 Topography, Watershed Boundary, Subwatersheds
- 3.4 Jurisdictions, Roles & Responsibilities
- 3.5 Demographics
- 3.6 Existing and Future Land Use/Land Cover
- 3.7 Transportation Network
- 3.8 Impervious Cover Impacts
- 3.9 Open Space/Green Infrastructure Network
- 3.10 Ecologically Significant Natural Areas
- 3.11 Drainage System
  - Crystal Creek & Tributaries
  - Detention Basins
  - Wetlands & Wetland Restoration
  - Floodplain and Flood Problem Areas
- 3.12 Groundwater/Community Water Supply
- 3.13 NPDES Permits, Wastewater & Septic Systems
- 3.14 Water Quality
- 3.15 Pollutant Loading

Inventory Topics *Not Included* in Plan

The following watershed inventory topics are not covered in this plan either because the item is not found in the watershed or because the information was not readily available to document the information.

- Levees
- Irrigation
- Drainage (Tiles and Ditches)
- Drainage Districts
- Livestock
- Combined Sewer Systems and Drainage Locations
- Industrial Point Sources
- Air Quality

Section 6.0: Information/Education Plan

This section addresses USEPA Element E by providing an Information/Education component to enhance public understanding and to encourage participation in selecting, designing, and implementing recommendations provided in the plan. This is accomplished by providing a matrix that outlines each recommended education action, target audience, package/vehicle for implementing the action, lead entity, and what the expected outcomes or behavior change will be.

Sections 7.0 & 8.0: Plan Implementation & Measuring Plan Progress & Success

A list of key stakeholders and discussion about forming watershed partnerships and implementing watershed improvement projects is in included in Section 7.0, as well as an identification of potential future studies and a process to amend the plan. Section 8.0 includes two monitoring components; 1) a "Water Quality Monitoring Plan" that includes specific locations and methods where future sampling should occur and a set of "Criteria" that can be used to determine whether pollutant load reduction targets are being achieved over time and 2) "Report Cards" for each plan goal used to measure milestones and to determine if Management Measures are being implemented on schedule, how effective they are at achieving plan goals, and need for adaptive management if milestones are not being met. Sections 7.0 and 8.0 address USEPA Elements F, G, H, and I.

Sections 9.0 & 10.0: Literature Cited and Glossary of Terms

Section 9.0 includes a list of literature that is cited throughout the report. The Glossary of Terms (Section 10.0) includes definitions or descriptions for many of the technical words or agencies that the user may find useful when reading or using the document.

Appendix

The Appendix to this report is included on the attached CD. It contains Steering Committee meeting presentations (Appendix A), results of the local ordinance review (Appendix B), results of the watershed field inventory (Appendix C), raw data used to develop the pollutant loading and reduction models (Appendix D), and a list of potential funding opportunities (Appendix E).

1.6 Prior Studies and Projects

Various studies have been completed describing and analyzing conditions within Crystal Creek watershed. This Watershed-Based Plan uses existing data to analyze and summarize work that has been completed by others and integrates new data and information. A list of known studies is summarized below.

- Hey and Associates developed the **Crystal Lake Watershed Stormwater Management Design Manual** in 2007. The manual details guidance for the design of stormwater management systems within Crystal Lake watershed.
- The Village of Algonquin completed the IEPA-approved **Woods Creek Watershed-Based Plan** in 2013 to help guide development in the adjacent Woods Creek watershed.
- **Municipal comprehensive plans** are available for the City of Crystal Lake (2012), Village of Algonquin (2008), Village of Lake in the Hills (2002; last amended April 25, 2013), and the Village of Cary (2015), as well as the Lakewood Comprehensive Plan Update (2010) Future Land Use Map for the Village of Lakewood.
- In 2012, the City of Crystal Lake and Cowhey, Gudmundson & Leder developed and adopted the **Green Infrastructure Vision Study and Report.**
- **The City of Crystal Lake's 2030 Comprehensive Plan** was updated in 2012 and includes extensive sections detailing Green Infrastructure and Parks and Recreation.
- McHenry County developed and adopted the **McHenry County Water Resources Action Plan** in 2011. The McHenry County WRAP Task Force completed an update that was adopted on November 17, 2020. The updated WRAP is a comprehensive guide designed to educate decision-makers from the county, municipalities, businesses and individuals about water resources, the potential threats to those resources, and Best Management Practices that can help protect or restore them. The County and the City also updated their Stormwater Management Ordinance.
- McHenry County's **Groundwater Protection Action Plan** (McHenry County 2009) addresses groundwater issues by presenting model policies that all local government can consider and modify to address their individual needs.
- **Illinois State Water Survey** has completed a number of groundwater studies for the 11-county Northeastern Illinois Regional Water Supply Planning area, which includes McHenry County and Crystal Creek watershed (2009 and 2012) and should release an updated study in 2020.
- **The McHenry County ADID wetland inventory** was developed in 1998. This study was conducted to identify the values of individual wetlands and identify wetlands of such high value that they merit special consideration for protection.
- McHenry County Conservation District (MCCD) completed a **Natural Area Sites Inventory (MCNAI)** that was last updated in 2005. The inventory identifies one site within the watershed: Lake in the Hills Fen.
- **Fox River Study Group (FRSG)** has been collecting and analyzing water quality data within the Fox River basins since 2002 at DTZR-02.
- Existing **McHenry County Geographic Information System (GIS) data** for Crystal Creek watershed was obtained and used to analyze various data related to wetlands, soils, land use, and other relevant information.
- In February 2019, Illinois State Water Survey produced a report entitled **Water Quality Trend Analysis for the Fox River Watershed: Stratton Dam to the Illinois River** that was based on water quality data collected by Fox River Study Group.

2.0 Mission, Goals, & Objectives

2.1 Crystal Creek Watershed Steering Committee Mission

The Crystal Creek Watershed Steering Committee is comprised of watershed stakeholders dedicated to the preservation, protection, and improvement of the Crystal Creek watershed. The Watershed Steering Committee's mission is to:

> *"Improve water quality through refined stormwater management, flood reduction, enriched natural area management, groundwater recharge protection, utilization of green infrastructure, and control of invasive species. The goal is to enhance ecosystem benefits within Crystal Creek watershed and ultimately the Fox River through education and stewardship."*

2.2 Goals & Objectives

Watershed stakeholders were presented with information about the character and quality of watershed resources over four meetings prior to developing goals. During these meetings stakeholders listed a variety of issues, concerns, and opportunities that were sorted into six general topics to be addressed in the watershed plan. A virtual goal workshop was held on October 6, 2020, during which stakeholders were given the opportunity to prioritize the goals.

The voting process was developed to ensure the most critical objectives were adequately addressed in the planning process and within the watershed-based plan. Participants were asked to each prioritize the goals for themselves from most important to least important. Results were tallied via polling during the meeting and then weighted according to how they were prioritized, with more points awarded for more highly ranked goals. The results of the voting process were as follows:

1) Policy – *Received a weighted score of 72*

2) Surface water quality – *Received a weighted score of 65*

3) Groundwater – *Received a weighted score of 60*

4) Green Infrastructure Network & Habitat – *Received a weighted score of 58*

5) Flooding – *Received a weighted score of 26*

6) Education, Stewardship & Communication – *Received a weighted score of 20*

The six topics were used as goals for Crystal Creek watershed. Objectives for each goal were also formulated and are very specific where feasible and designed to be measurable so that future progress toward meeting goals can be assessed. Goals and objectives ultimately lead to the development of action items. The goals reference various sections throughout the plan including the Green Infrastructure Network (Section 3.10), Ecologically Significant Areas (Section 3.11), the Watershed Drainage System and inventory (Section 3.12), Groundwater (Section 3.13), Water Quality Assessment (Section 3.16), and the Management Measures Action Plan (Section 5.0). More detail can be found on each of these topics within the referenced sections.

The Management Measures Action Plan section of this report is geared toward addressing watershed goals by recommending programmatic and site-specific Management Measure actions to address each goal. The goals and objectives are examined in more detail when measuring plan progress and success via milestones and "Report Cards" in Section 8.2.

Goal 1: Assess and improve policies and regulations to protect and support our natural resources.

Objectives:

1. Local governments adopt, support, and implement recommendations in the Crystal Creek Watershed-Based Plan.
2. Encourage local governments to enhance stormwater management design policies and standards similar to those contained the Crystal Lake Watershed Stormwater Management Design Manual.
3. Local governments include parcels identified in this Plan as Priority Green Infrastructure Protection Areas and High Priority/Critical Area Green Infrastructure Network (see Sections 5.2.3 and 3.10) in their municipal comprehensive plans and development review maps.
4. Encourage local governments to incorporate Conservation Design or Low Impact Development standards where new development is planned on Priority Green Infrastructure Protection Areas identified in this Plan (see Sections 3.10 and 5.2.3).
5. Encourage developers to protect sensitive natural areas, restore degraded natural areas and streams as part of the development process. Encourage donation of highly sensitive natural areas such as high-quality habitat, to a public agency or conservation organization for long term management with dedicated funding such as impact fees, Special Service Areas (SSA's) or a one-time donation.

Goal 2: Improve surface water quality.

Objectives:

1. Stabilize 4.8 miles of moderately to highly eroded streambank, degraded channel, and or average to poor riparian buffer using bioengineering techniques, ecological restoration & long-term management.
2. Daylight 0.4 miles of stream and restore using bioengineering techniques at CCR04.
3. Encourage installation of natural shoreline buffers along private residential lots around Crystal Lake, Goose Lake, and Scott Lake through changes to stormwater and zoning ordinances that incentivize these treatments.
4. Retrofit 20% of "Critical Area" detention basins by naturalizing with native vegetation.
5. Encourage no-till practices on existing farmed lands located on Priority Green Infrastructure Protection Areas.
6. Encourage the implementation of rotational grazing and strategic fencing on 68 acres of existing horse and cow pasture.

Goal 3: Protect groundwater quantity and quality and improve groundwater recharge.

Objectives:

1. Implement model policies included in county "Groundwater Protection Action Plans" for Sensitive Aquifer Recharge Areas (SARS) where development or re-development is planned in Priority Green Infrastructure Protection Areas.
2. Implement low impact development or conservation design on all Green Infrastructure Network Parcels proposed for development.

Goal 4: Protect, manage, and restore natural components of the Green Infrastructure Network and improve fish and wildlife habitat.

Objectives:

1. Implement conservation development on 93 acres of existing oak-hickory woodland Priority Protection Areas if/when developed.
2. Prepare and implement ecological restoration & management plans for 465 existing degraded open space natural area acres at Lippold Park.
3. Install appropriately spaced and designed grade control structures throughout 2.6 miles of stream within LITH Fen.
4. Implement ecological management of all good quality riparian buffers along 0.5 miles of stream.
5. Restore and maintain 3.3 acres of prairie at Four Colonies Park.
6. Continue long term ecological management on 206 restored acres at Wedgewood Subdivision & Three Oaks Recreation Area.
7. Implement ecological restoration and management of 9.4 wetland, stream, and buffer area acres owned by LITH Sanitary District.
8. Implement long term ecological management of all well-established naturalized detention basins.

Goal 5: Manage and mitigate for existing and future structural flood problems.

Objectives:

1. Conduct annual dam and water control structures integrity inspections at Crystal Lake, Scott Lake, and Goose Lake.
2. Implement stormwater management measures to reduce runoff as development occurs within Subwatershed Management Units 1, 2, and 6 that are ranked as "Highly Vulnerable" to future development and associated impervious cover.

Goal 6: Build stakeholder awareness of watershed issues through education and stewardship while increasing communication and coordination among stakeholders.

Objectives:

1. Inform stakeholders and the general public that a Watershed-Based Plan has been developed for Crystal Creek watershed.
2. Implement the Crystal Creek Watershed-Based Plan Information & Education Campaign.
3. Increase environmental stewardship opportunities and encourage stakeholders to participate in watershed plan implementation and restoration campaigns to increase activism in the watershed.
4. Inform public officials of the benefits of conservation design and low impact development and the importance of ordinance language changes that promote these developments.
5. Create targeted educational information for riparian and shoreline landowners.

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3.0 Watershed Characteristics, Problems, and Opportunities

3.1 Geology, Climate, & Soils

Geology

The terrain of the Midwestern United States was created over thousands of years as glaciers advanced and retreated during the Pleistocene Era or "Ice Age". Some of these glaciers were a mile thick or more. The Illinoian glacier extended to southern Illinois between 300,000 and 125,000 years ago. It is largely responsible for the flat, farm- rich areas in the central portion of the state that were historically prairie. Only the northeastern part of Illinois was covered by the most recent glacial event known as the Wisconsin Glacial Stage that began approximately 70,000 years ago and ended around 14,000 years ago (Figure 3). During this period the earth's temperature warmed and the ice slowly retreated leaving behind moraines and glacial ridges where it stood for long periods of time (Hansel 2005). A tundra-like environment covered by spruce forest was the first ecological community to colonize after glaciers retreated. As temperatures continued to rise, tundra was replaced by cool moist deciduous forests and eventually by oak-hickory forests, oak savannas, marshes, and prairies.

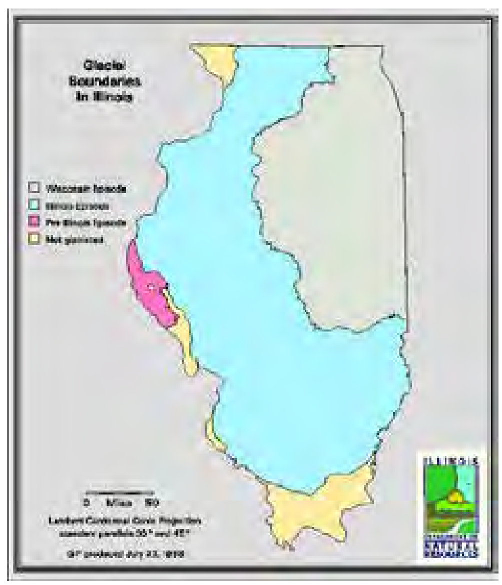


Figure 3. Glacial boundaries in Illinois.

The nearby Fox River was formed at the end of the Wisconsinan glaciation as a stream at the edge of the Valparaiso Moraine system and an older moraine to the west. Crystal Creek watershed is part of this Valparaiso Moraine system, which created the picturesque rolling hills and valleys found there today (Hansel 2005). The composition of the soil in Crystal Creek watershed is also a remnant of that ancient ice movement. Above the bedrock lies a layer of deposits left behind from the glaciers, consisting of clay, silt, sand, and gravel (Hansel 2005).

Climate

The northern Illinois climate can be described as temperate with cold winters and warm summers where great variation in temperature, precipitation, and wind can occur on a daily basis. Lake Michigan does influence the study area to some degree but not as much as areas immediately adjacent, south, and east of the lake where it reduces the heat of summer and buffers (warms) the cold of winter. Surges of polar air moving southward or tropical air moving northward cause daily and seasonal temperature fluctuations. The action between these two air masses fosters the development of low-pressure centers that generally move eastward and frequently pass over Illinois, resulting in abundant rainfall. Prevailing winds are generally from the west but are more persistent and blow from a northerly direction during winter.

The Weather Channel website (www.weather.com) provides an excellent summary of climate statistics including monthly averages and records for most locations in Illinois. Data for Crystal Lake represents the climate and weather patterns experienced in Crystal Creek watershed (Figure 4). The winter months are fairly cold, averaging highs in a range of 30°F-40°F while winter lows are in the range of 10°F-20°F. Summers are warm with average highs around 70°F- 80°F and summer lows around 50°F- 60°F.

Fairly typical for the Midwest, the current climate of Crystal Creek watershed consists of an average rainfall of 37 inches and average snowfall of 35 inches. According to data collected in Crystal Lake, the most precipitation on average occurs in August (4.86 inches) while January receives the least amount of precipitation with 1.90 inches on average.

Soils

Deposits left by the Wisconsin glaciation 14,000 years ago are the raw materials of present soil types in the watershed. These raw materials include till (debris) and outwash. A combination of physical, biological, and chemical variables such as topography, drainage patterns, climate, and vegetation, have interacted over centuries to form the complex variety of soils found in the watershed. Most soils formed under wetland, woodland, and prairie vegetation. The most up to date soils mapping provided by the USDA Natural Resources Conservation Service (NRCS) was used to summarize hydric soils, soil erodibility, the extent of soil types, and hydrologic soil groups within the Crystal Creek watershed (Tables 2-5; Figures 5-7).

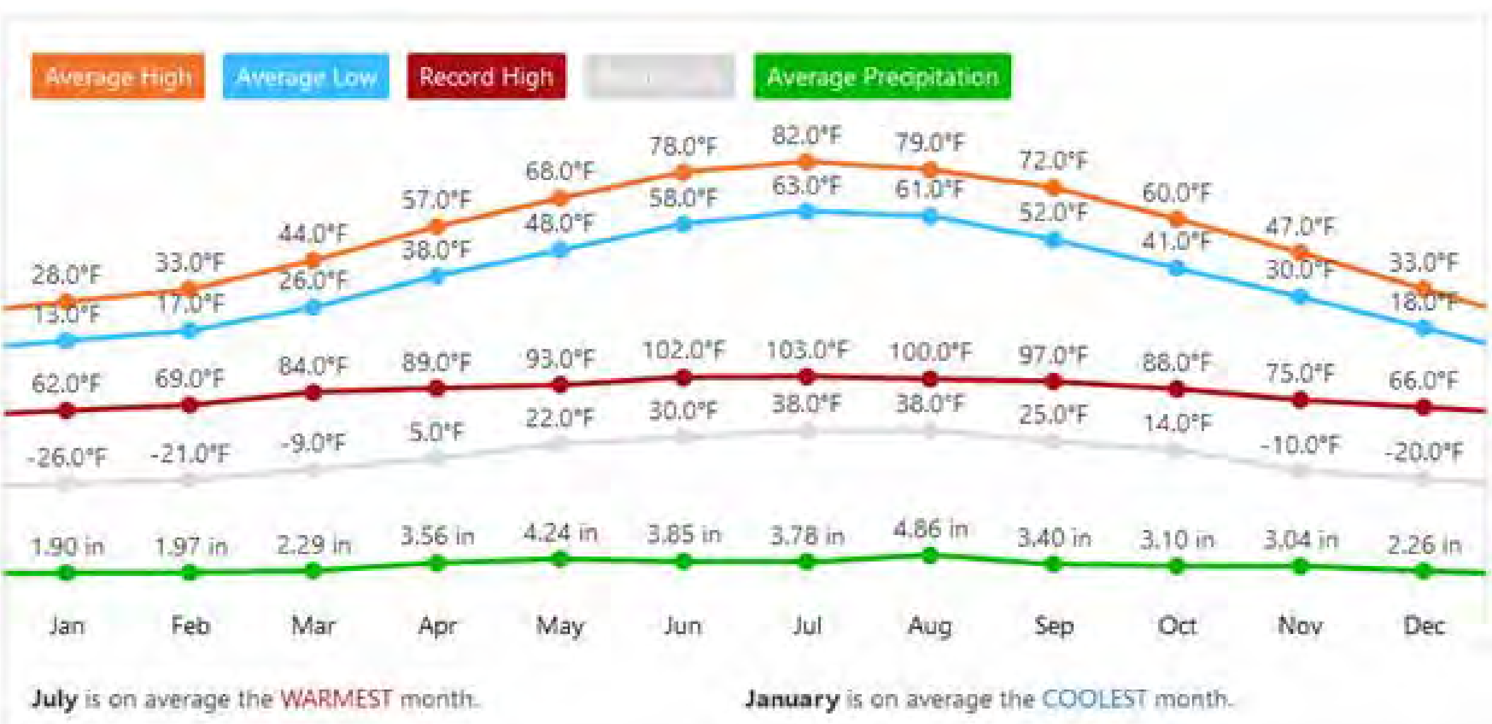


Figure 4. Climate records for Crystal Lake, IL (The Weather Channel)

Hydric Soils

Wetlands or "Hydric Soils" generally form over poorly drained clay material associated with wet prairies, marshes, and other wetlands and from accumulated organic matter from decomposing surface vegetation. Hydric soils are important because they indicate the presence of existing wetlands or drained wetlands where restoration may be possible. Most of the wetlands in Crystal Creek watershed were intact until the late 1830s when European settlers began to alter significant portions of the watershed's natural hydrology and wetland processes; and "by 1860 the majority of Illinois' acreage was farmland" (VandeCreek, 2016). Where it was feasible wet areas were drained, streams channelized, and prairie and woodland cleared to farm the rich soils.

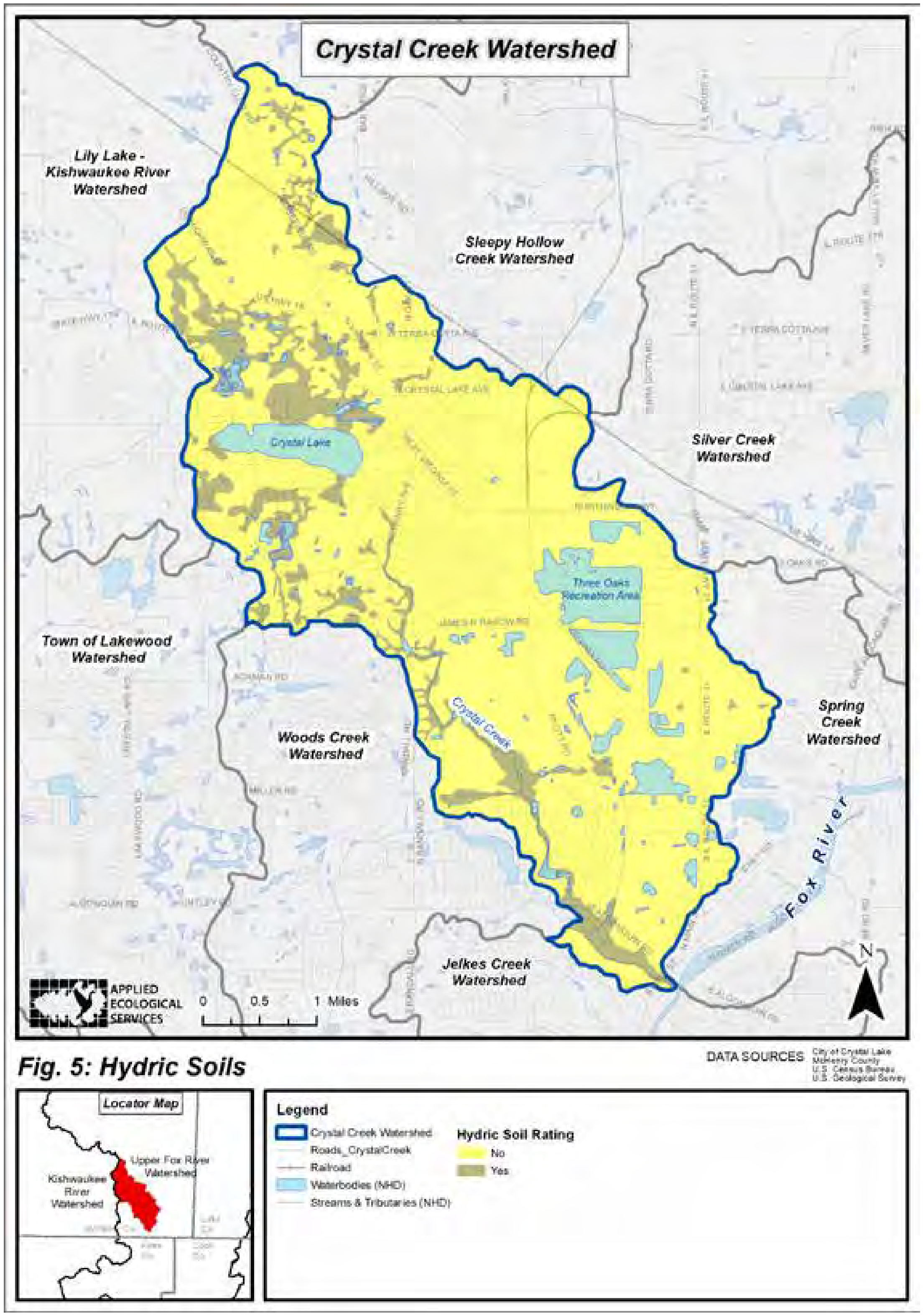


Fig. 5: Hydric Soils

There are 1,483.5 acres (12% of the watershed) of hydric soils in the watershed; 10,553.6 acres (88%) are not hydric. The locations of hydric soils are often an accurate indicator of the location of existing or drained wetlands; while the definition of "wetland" under pre-European settlement surveys did not identify any acreage within the watershed as wetland. According to current inventories of existing wetlands, 806.1 acres (7% of the watershed) remain today, which depicts the extent of wetland loss over time. The locations of hydric soils in the watershed are depicted on Figure 5. Existing wetlands and wetland restoration opportunities are discussed in detail in Section 3.12.4.

Soil Erodibility

Soil erosion is the process whereby soil is removed from its original location by flowing water, wave action, wind, and other factors. Sedimentation is the process that deposits eroded soils on other ground surfaces or in bodies of water such as streams and lakes. Soil erosion and sedimentation reduces water quality by increasing total suspended solids (TSS)

Table 2. Hydric Soil Classification and percent of watershed area.

Soil Type	Acreage	Percent
Hydric	1,483.5	12.3%
Non-Hydric	10,553.6	87.7%
Total	12,037.1	

in the water column and by carrying attached pollutants such as phosphorus, nitrogen, and hydrocarbons. When soils settle in streams and lakes they often blanket rock, cobble, and sandy substrates needed by fish and aquatic macroinvertebrates for habitat, food, and reproduction.

Figure 6 and Table 3 indicate soil susceptibility to erosion within the watershed, based on a selection of particular attributes such as soil type and the percent slope on which a soil is located. It is important to know the location of highly erodible soils as these areas have the highest potential to degrade water quality during farm tillage or development. Based on mapping, 604 acres (5%) were rated as having a severe potential erosion hazard, 5,195 acres (43%) were rated as a moderate potential erosion hazard, and 3,982 acres (33%) were rated as a slight potential erosion hazard (2,257 acres were not rated due to data availability).

The majority of the highly erodible soils in the watershed are located in the southwest portion of the watershed. The majority of the watershed is at a moderate to low risk for erosion due to the relatively flat landscape in the watershed; the lack of steep slopes reduces the potential erosion hazard of soils. The soils with a severe potential for erosion were primarily located along the slopes adjacent to Crystal Creek. As such, this potential for sediment contribution and erosion is problematic and documented in this plan (see Section 3.12). Streambank and channel restoration will be important in the future to control erosion to downstream waterbodies

Bur oak at Nunda Township Cemetery

Hydrologic Soil Groups

Soils also exhibit different infiltration capabilities and have been classified to fit what are known as "Hydrologic Soil Groups" (HSGs). HSGs are based on a soil's infiltration and transmission (permeability) rates and are used by engineers and planners to estimate stormwater runoff potential. Knowing how a soil will hold water ultimately affects the type and location of recommended infiltration Management Measures such as wetland restorations and detention basins. More important, however, is the link between hydrologic soil groups and groundwater recharge areas. Groundwater recharge is discussed in detail in Section 3.13.

HSG's are classified into four primary categories; A, B, C, and D, and three dual classes, A/D, B/D, and C/D. Dual classes represent soils that are in the D class naturally based on their characteristics, but when adequately drained are represented by the first of the two letters. Figure 7 depicts the location of each HSG in the watershed. The HSG categories and their corresponding soil texture, drainage description, runoff potential, infiltration rate, and transmission rate are shown in Table 4, while Table 5 summarizes the acreage and percent of each HSG.

Moderately to well drained areas (Hydrologic Groups B and B/D) account for 7,628 acres or 63% of the watershed. Excessively and well drained (Hydrologic Group A, A/D) areas make up an additional 501 acres or 4% of the watershed. Somewhat poorly drained soils of the C and C/D group make up 1652 acres (14%), while there was no acreage identified as being poorly drained (class D). The remaining 2,257 acres (19% of watershed) have unknown hydrologic soil groups, the same area which the soil erodibility map was unable to classify (typically includes quarries

Table 3. Soil erodibility and percent of watershed area.

Soil Erodibility Type	Acreage	Percent
Severe	603.5	5.0%
Moderate	5,194.5	43.2%
Slight	3,982.4	33.1%
Not rated	2,256.7	18.7%
Total	12,037.1	

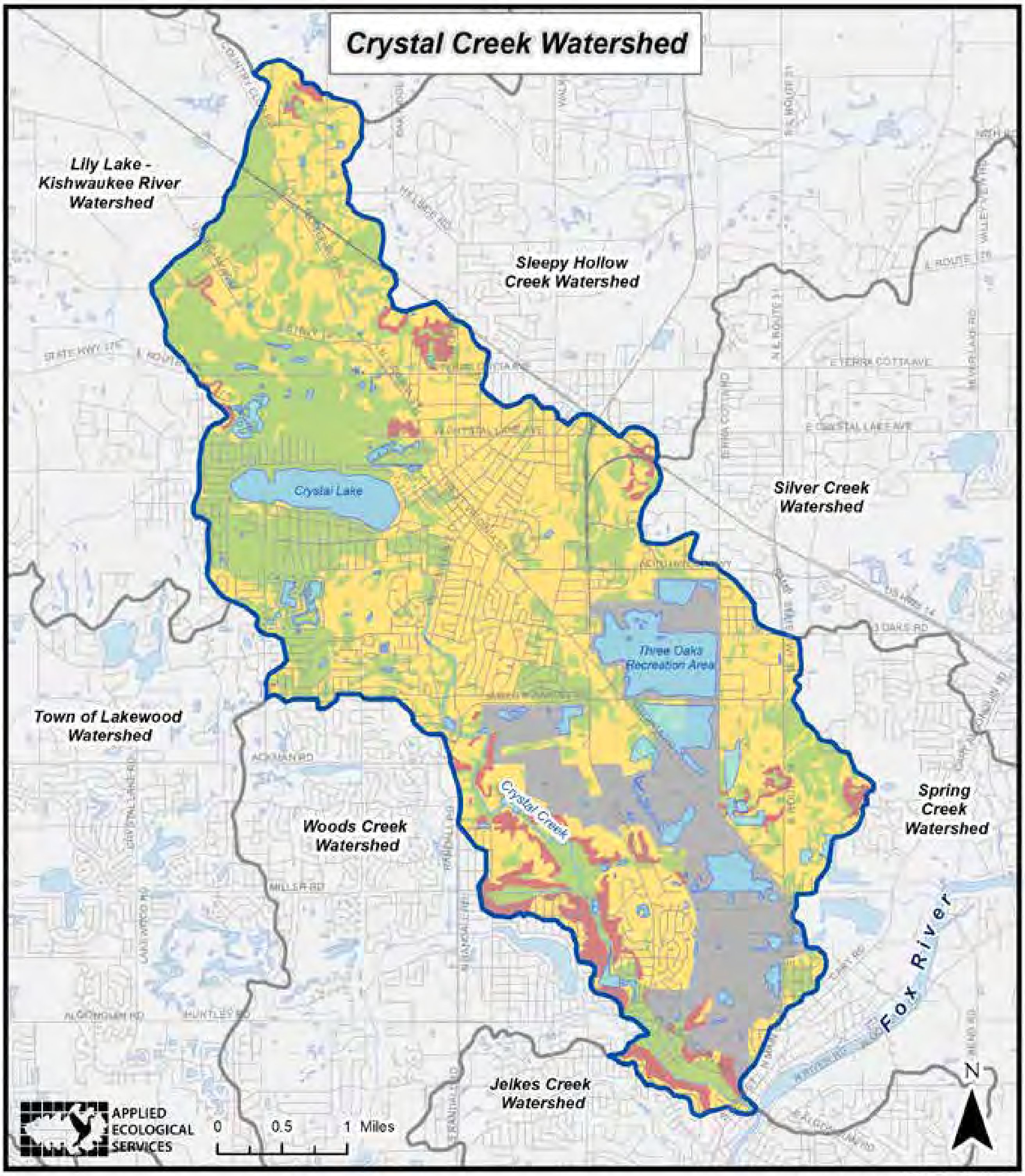
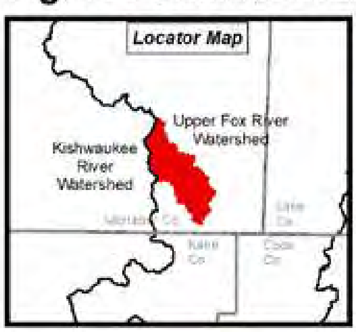


Fig. 6: Potential Erosion Hazard

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey



Legend

- Crystal Creek Watershed
- Roads_CrystalCreek
- Railroad
- Waterbodies (NHD)
- Streams & Tributaries (NHD)

FOR - Potential Erosion Hazard (Road/Trail) - Dominant Component

- Severe
- Moderate
- Slight
- Not rated

Table 4. Hydrologic Soil Groups and their corresponding attributes.

HSG	Soil Texture	Drainage Description	Runoff Potential	Infiltration Rate	Transmission Rate
A	Sand, Loamy Sand, or Sandy Loam	Well to Excessively Drained	Low	High	High
B	Silt Loam or Loam	Moderately Well to Well Drained	Moderate	Moderate	Moderate
C	Sandy Clay Loam	Somewhat Poorly Drained	High	Low	Low
D	Clay Loam, Silty Clay Loam, Sandy Clay Loam, Silty Clay, or Clay	Poorly Drained	High	Very Low	Very Low

and gravel pits such as those around the Three Oaks Recreation Area lakes).

Table 5. Hydrologic soil group and percent of watershed area.

Hydrologic Soil Group	Acreage	Percent
A	25.0	0.2%
A/D	475.7	4.0%
B	6,326.5	52.6%
B/D	1,301.6	10.8%
C	852.4	7.1%
C/D	799.2	6.6%
Unclassified	2,256.7	18.7%
Total	12,037.1	

3.2 Pre-European Settlement Ecological Communities & Changes

An ecological community is made up of all living things in a particular ecosystem and is usually named by its dominant vegetation type. The original public land surveyors that worked for the office of U.S. Surveyor General in the early and mid-1800s mapped and described natural and man-made features and vegetation while creating the "rectangular survey system" for mapping and sale of western public lands of the United States (Daly & Lutes et. al., 2011). Ecologists know by interpreting survey notes and hand drawn Federal Township Plats of Illinois (1804-1891) that a complex interaction existed between several ecological communities including prairies, savannas, and wetlands prior to European settlement in the 1830s.

The surveyors described the majority of Crystal Creek watershed as "Prairie" (8,591 acres or 71%). "Forest" was identified along in most of the northern portion of the watershed as well as the southernmost tip (2,905 acres, 24%), portions are identified as open water (308 acres, 3%), and a small portion (232 acres, 2%) were identified as "cultural" or areas that had been settled. (Figure 8; Table 6). This mixture of "Prairie" and "Timber" was widely described in the mid-1800s as the surveyors and early settlers moved west out of the heavily forested eastern portion of the United States and encountered a much more open environment that ecologists now refer to as "Savanna". The prairie-savanna landscape was maintained and renewed by frequent lightning strike fires, fires ignited by Native Americans, and grazing by bison and elk. Fires ultimately removed dead plant material, exposing the soils to early spring sun, and returning nutrients to the soil. Running through the prairie-savanna landscape were meandering stream corridors and low wet depressions consisting of sedge meadow, marsh, wet prairie and highly unique seeps, springs, and fen wetlands hydrated by alkaline rich groundwater discharge.

The landscape was described in History of McHenry County, Illinois (1922) as:

> *Algonquin Township is more broken than any other township within the county, there being many bluffs and hills in the region of Algonquin village and in fact all along the Fox River. The land is about equally divided between prairie and timber. It is adapted to both small grain and pasture lands and is used for such purposes. Crystal Lake lies in section 6 of this township, and*

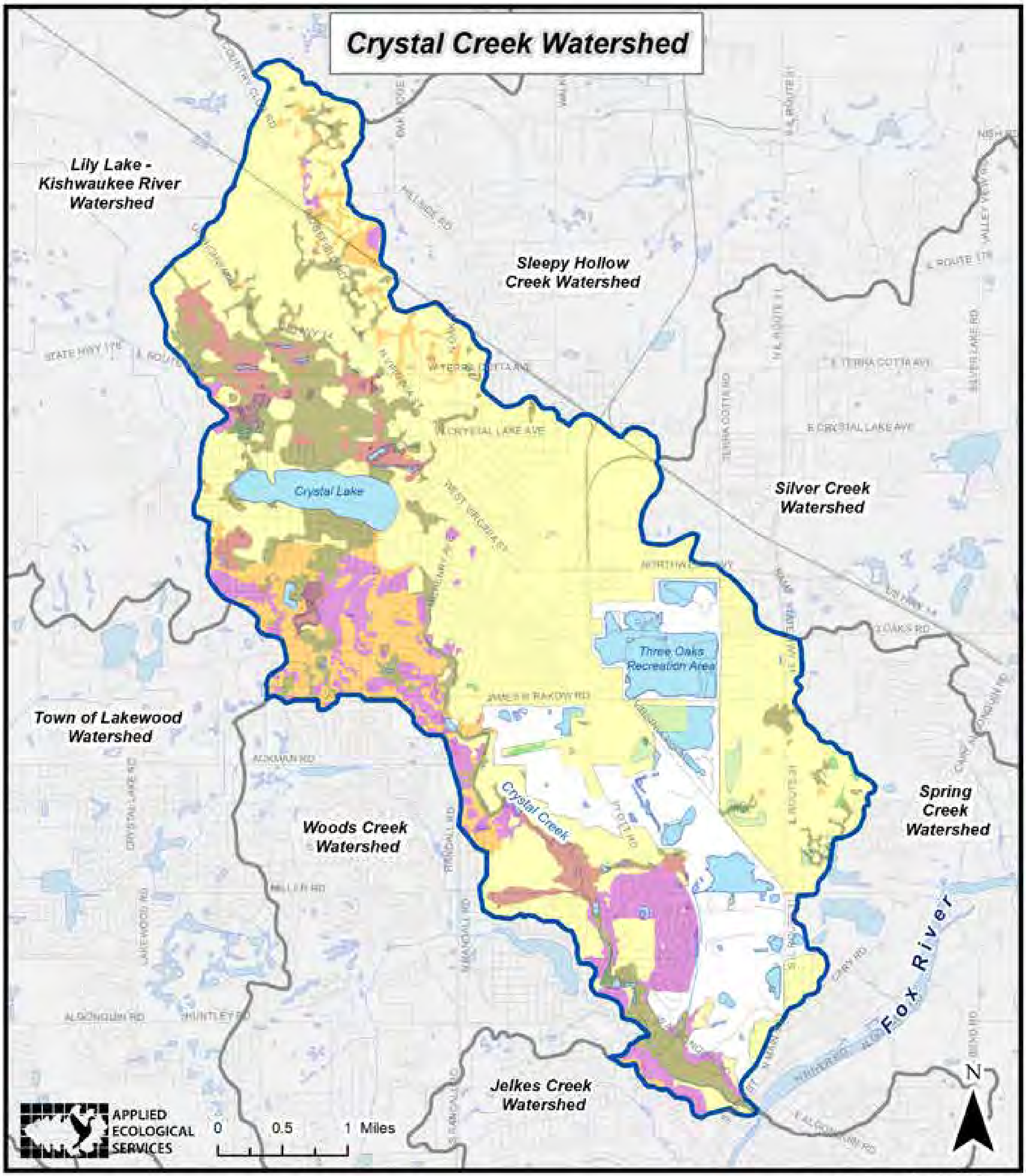
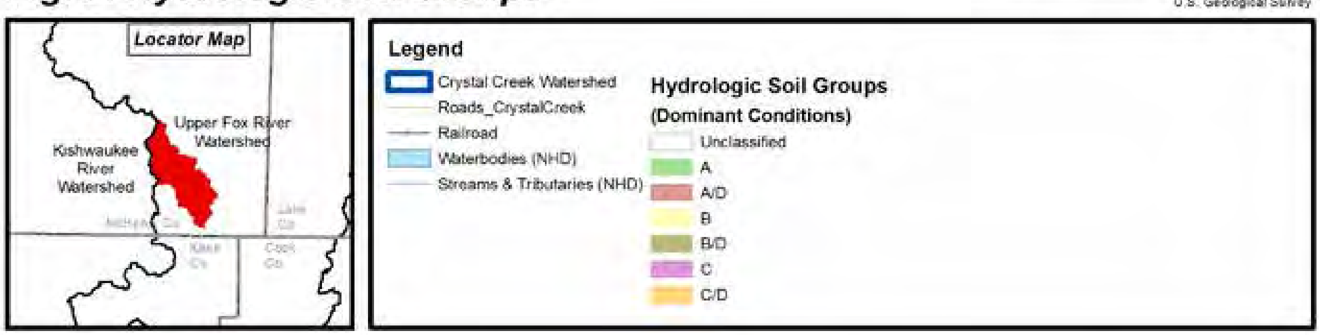


Fig. 7: Hydrologic Soil Groups

DATA SOURCES City of Crystal Lake McHenry County U.S. Census Bureau U.S. Geological Survey



Pre-European settlement prairie landscape at LITH Fen

runs over into a portion of Grafton township. From it flows the outlet of the lake that joins the Fox River at the Village of Algonquin. Big Spring Creek is another water course found within the township.

(Munsell, 1922)

European settlement resulted in drastic changes to the fragile ecological communities. Fires no longer occurred, prairie was tilled under for farmland or developed, wetlands were drained, and many stream reaches were channelized. The earliest aerial photographs taken in 1939 (Figure 9) depict Crystal Creek watershed when row crop farming was the primary land use but before residential and commercial development seen today. Forested lands around in the steep, southern portions of the watershed remained, but those in the flatter portion north of Crystal Lake had been converted to farmland by 1939. Farmland can clearly be seen throughout the watershed. The quarries resulting in the Three Oaks Recreation Area had not yet been excavated.

Figure 10 shows a 2019 aerial image of Crystal Creek watershed. Residential development now dominates the watershed. Retail and commercial development is also common along Virginia Road. An 18-hole golf courses occupies an area directly south of Crystal Lake. Some farmland remains in the northern portion of the watershed, and quarries exist in the eastern portion near the Three Oaks Recreation Area. Also apparent on the 2011 image is the Lake in the Hills Fen Conservation are adjacent to the Lake in the Hills Airport. Although the surrounding area is generally degraded, this conservation area and the remaining forested lands south of Algonquin Road, contain most of the remaining ecological communities in the watershed. The Savanna complex which covered a significant portion of the watershed is now dominated by residential homes. Unfortunately, oak regeneration is no longer occurring and the oak community may be lost forever without drastic intervention.

With degraded ecological conditions comes the opportunity to implement ecological restoration to improve the condition of Crystal Creek watershed. Present day knowledge of how pre-European settlement ecological communities formed and evolved provides a general template for developing present day natural area restoration and management plans. One of the primary goals of this watershed plan is to identify, protect, restore, and manage remaining natural areas.

Table 6. Early 1800s pre-settlement landcover.

Early 1800s Pre-Settlement Landcover	Acreage	Percent
Prairie	8,591.1	71.4%
Forest	2,905.3	24.1%
Water	308.4	2.6%
Cultural	232.3	1.9%
Total	12,037.1	100%

Pre-European settlement savanna

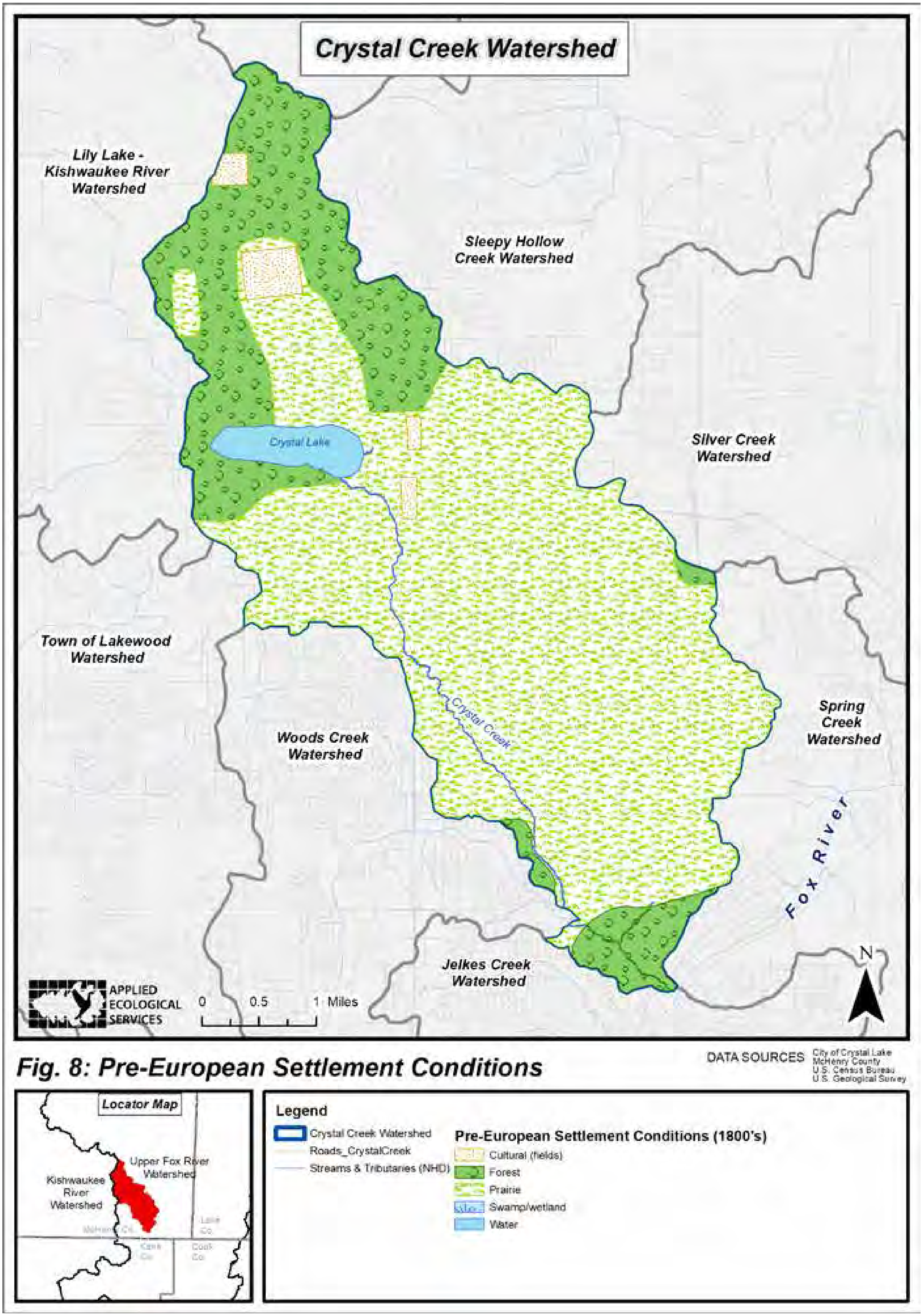


Fig. 8: Pre-European Settlement Conditions

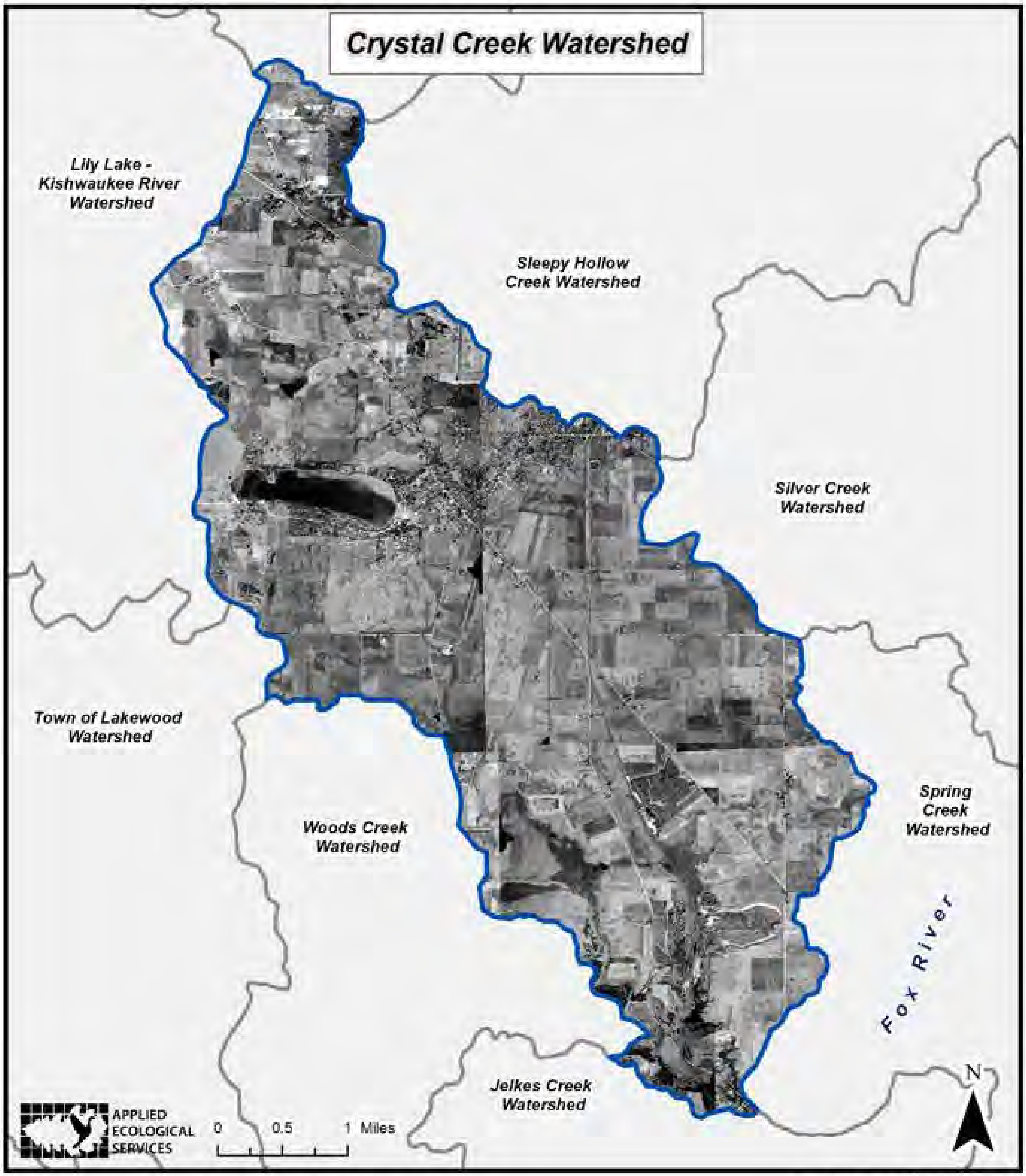


Fig. 9: 1939 Aerial Photography

DATA SOURCES City of Crystal Lake
McHenry County
U.S. Census Bureau
U.S. Geological Survey

Legend

Crystal Creek Watershed

The location of streams and open water in 1937 is not known.

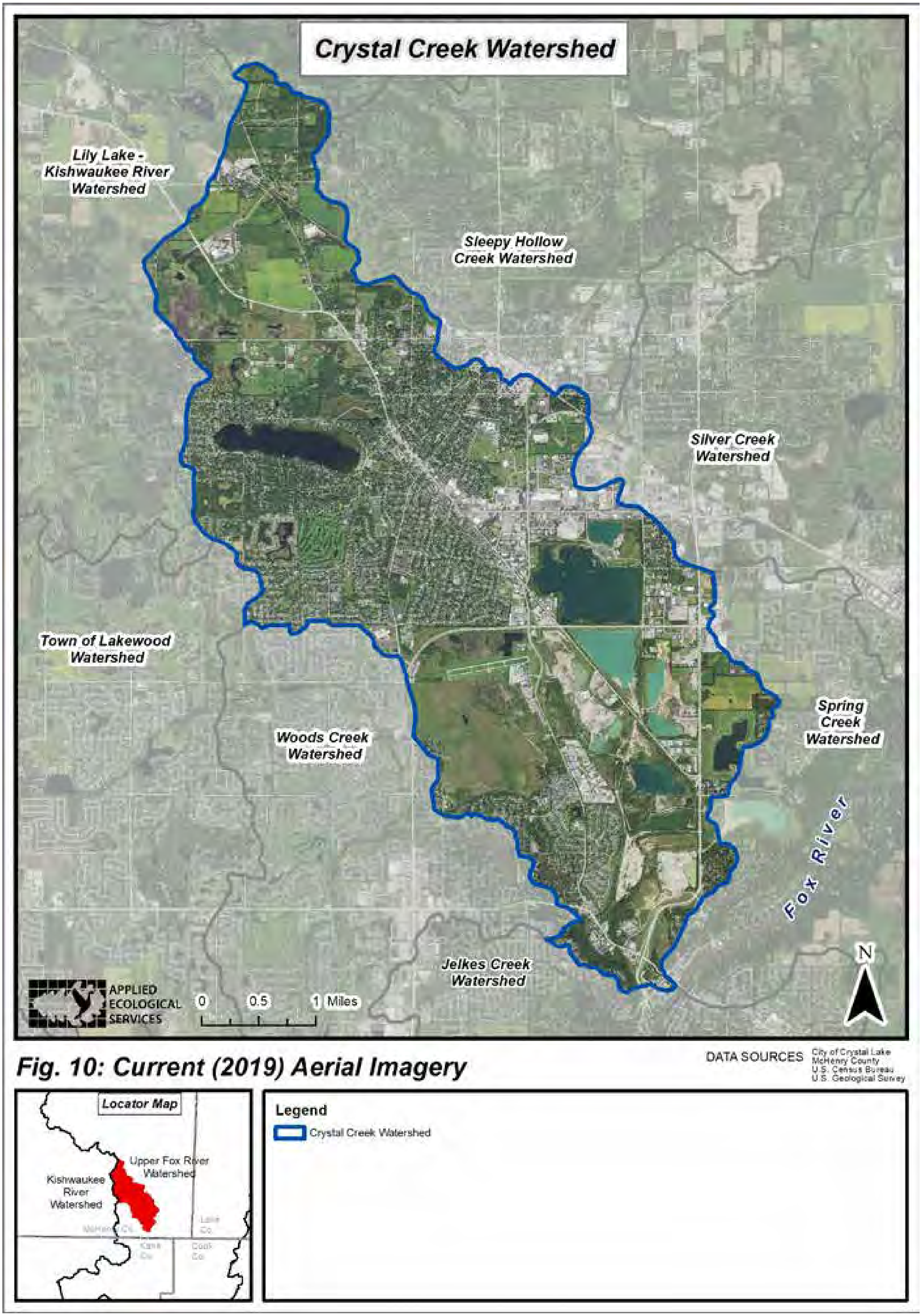


Fig. 10: Current (2019) Aerial Imagery

Rolling topography of Crystal Creek watershed at LITH Fen

3.3 Topography, Watershed Boundary, & Subwatershed Management Units

Topography & Watershed Boundary
The Wisconsin glacier that retreated 14,000 years ago formed the topography and defined the Crystal Creek watershed boundary. Topography refers to elevations of a landscape that describe the configuration of its surface and ultimately defines watershed boundaries. And, the specifics of watershed planning cannot begin until a watershed boundary is clearly defined.

The Crystal Creek watershed boundary was updated in 2011 for this study using the most up-to-date 2-foot topography data from McHenry County. The refined watershed boundary was then input into a GIS model (Arc Hydro) that generated a Digital Elevation Model (DEM) of the watershed (Figure 11). Crystal Creek watershed is 12,037.1 acres or 18.8 square miles in size.

The Crystal Creek watershed generally drains from north to south before entering the Fox River within the municipality of Algonquin. The highest point in the watershed (989 feet above sea level) is found in northern end of the watershed. As expected, the lowest point (727 feet above sea level) is found where Crystal Creek enters the Fox River. The difference in the highest and lowest points reflects a 262-foot change in elevation. The DEM (Figure 11) depicts the bluffs in the southern portion of the watershed, near the Village Algonquin, which were described in 1922, while most of the land in the remainder of the watershed is relatively flat. Depressional areas can be seen along stream reaches. The DEM also shows the low lands adjacent to Virginia Rd resulting from mass grading for quarries.

Rolling topography of Crystal Creek watershed at LITH Fen

Subwatershed Management Units (SMUs)
The Center for Watershed Protection (CWP) is a leading watershed planning agency and has defined appropriate watershed and subwatershed sizes to meet watershed management goals. In 1998, the CWP released the “Rapid Watershed Planning Handbook” (CWP 1998) as a guide to be used by watershed planners when addressing issues within urbanizing watersheds. The CWP defines a watershed as an area of land that drains up to 100 square miles.

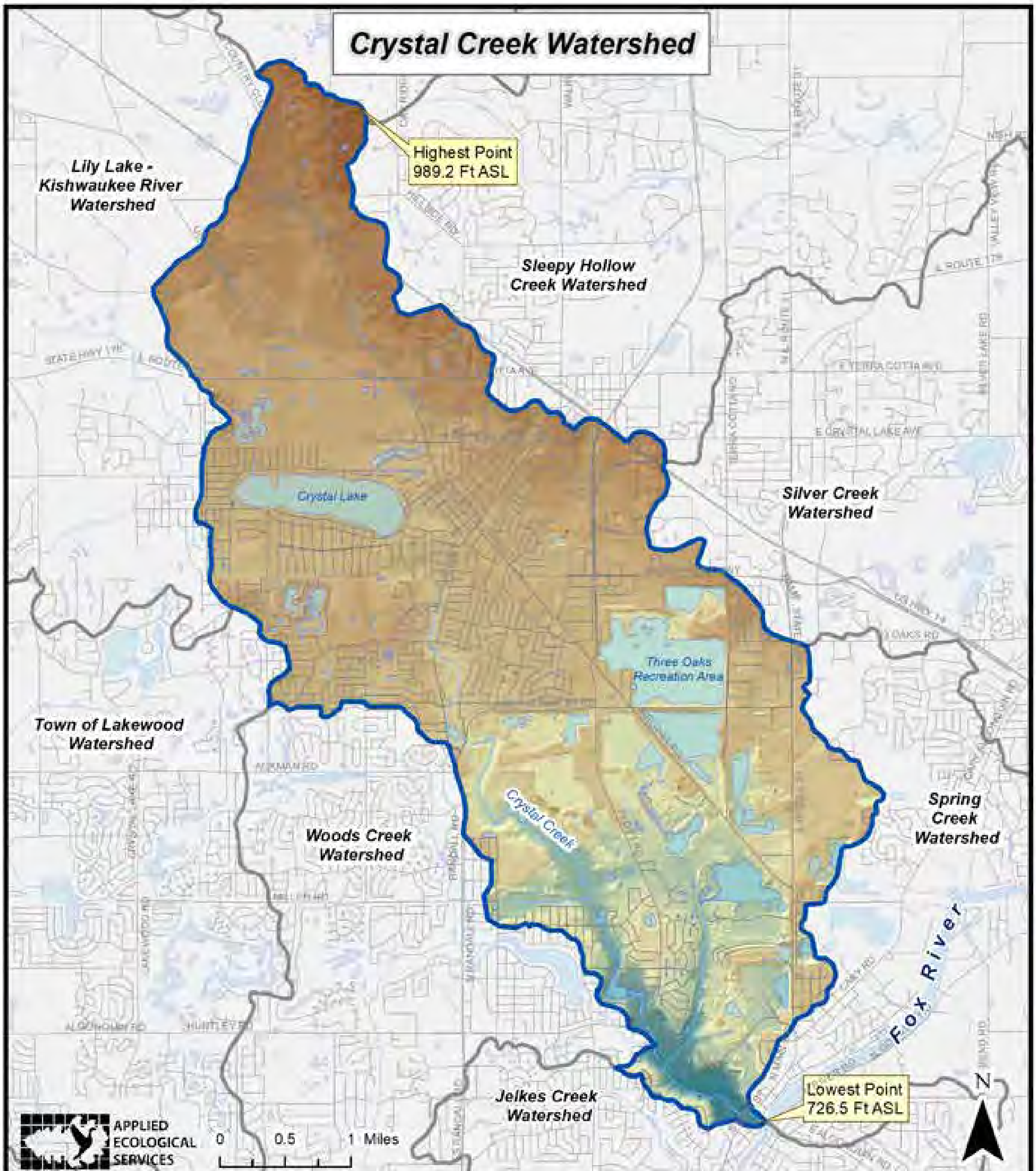
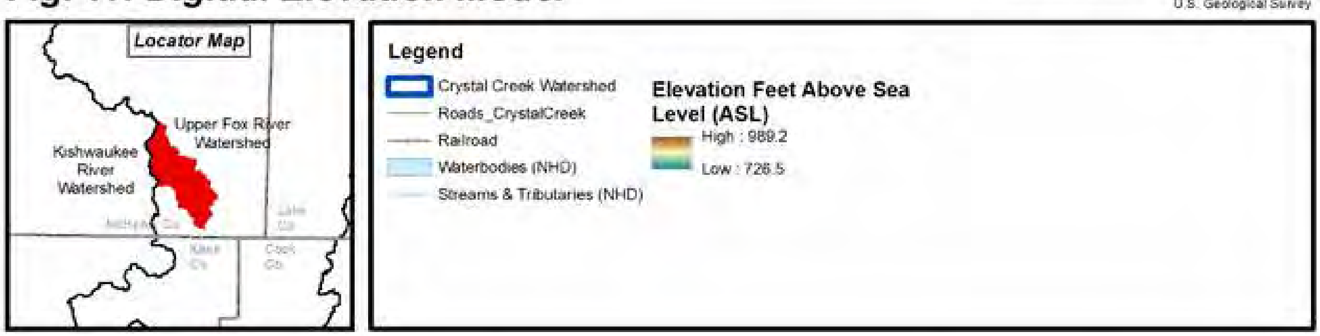


Fig. 11: Digitial Elevation Model

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey



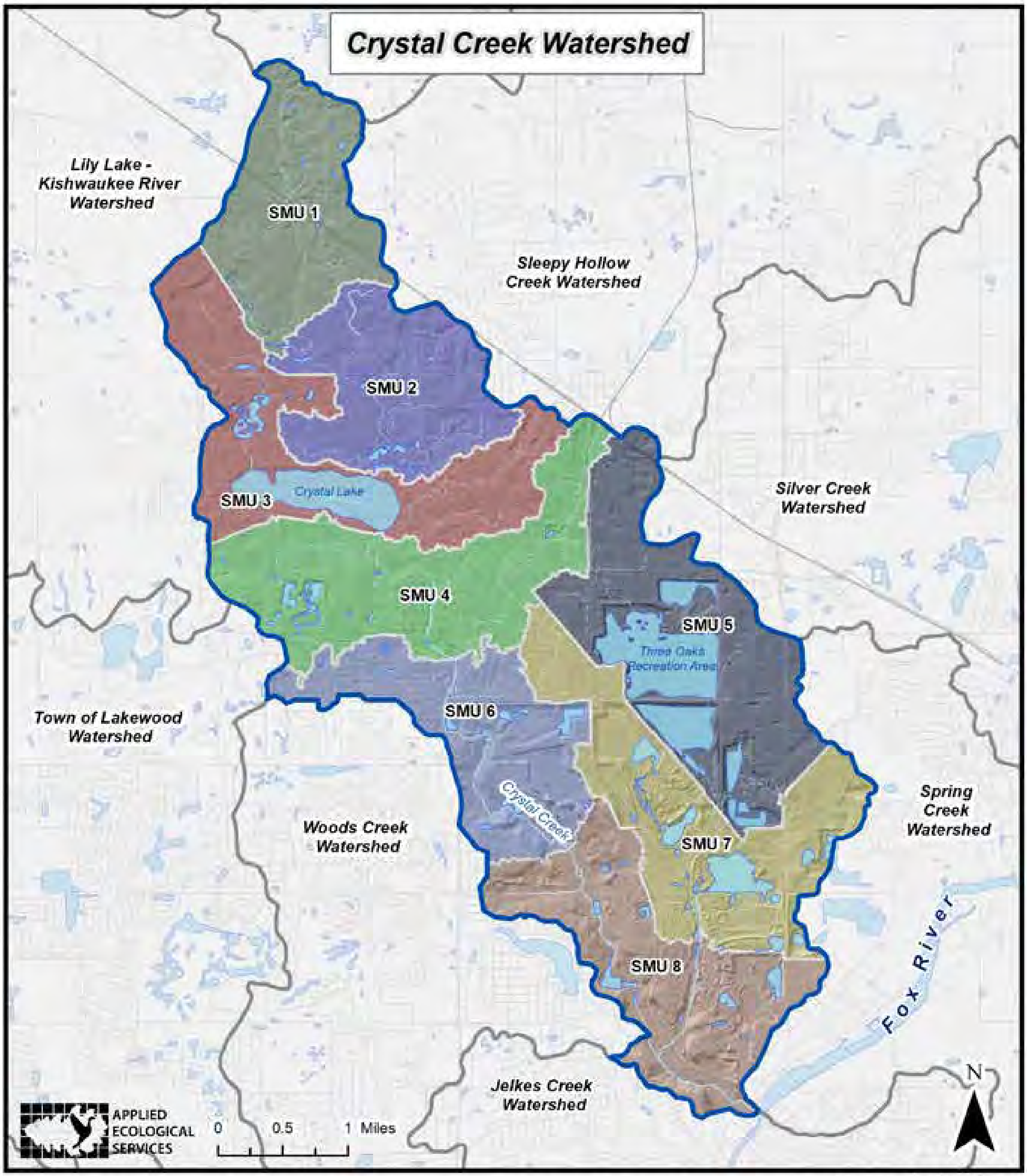


Fig. 12: Subwatershed Management Units (SMUs)

DATA SOURCES City of Crystal Lake McHenry County U.S. Census Bureau U.S. Geological Survey

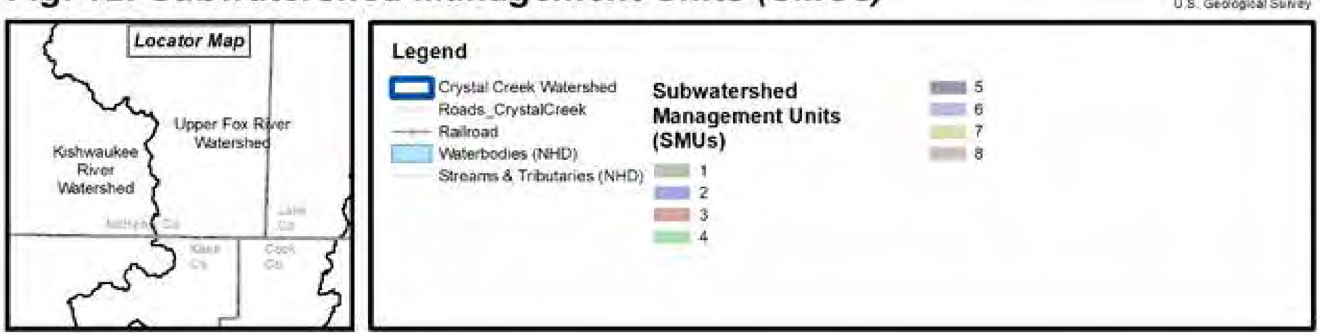


Table 7. Subwatershed Management Units and Size

SMU ID	Acreage	Square Miles
SMU 1	1,184.0	1.9
SMU 2	1,189.1	1.9
SMU 3	1,650.7	2.6
SMU 4	1,653.4	2.6
SMU 5	1,934.2	3.0
SMU 6	1,255.7	2.0
SMU 7	1,638.3	2.6
SMU 8	1,531.7	2.4
Total	**12,037.1**	**18.8**

Broad assessments of conditions such as soils, wetlands, and water quality are generally evaluated at the watershed level and provide some information about overall conditions. Though Crystal Creek watershed is only 18.8 square miles, this plan allows for a detailed look at watershed characteristics and problem areas. Additionally, an even more detailed look at smaller drainage areas must be completed to find site specific problem areas or "Critical Areas" that require immediate attention.

To address issues at a small scale, a watershed can be divided into subwatersheds called Subwatershed Management Units (SMUs). Crystal Creek watershed contains 8 SMUs as delineated using a combination of the Digital Elevation Model (DEM) and available storm sewer data from municipalities. Information obtained at the SMU scale allows for detailed analysis and better recommendations for site specific "Management Measures" otherwise known as Best Management Practices (BMPs). Table 7 presents each SMU and size within the watershed. Figure 12 depicts the location of each SMU boundary delineated within the larger Crystal Creek watershed.

3.4 Jurisdictions, Roles & Responsibilities

Crystal Creek watershed is located in McHenry county, contains portions of four townships/ unincorporated areas, and four municipalities (Table 8, Figure 13). Municipalities comprise 85% of the watershed area. The City of Crystal Lake occupies 6,366 acres (53%) in the central portion of the watershed. Lake in the Hills occupies 2,629 acres (22%) in the southern portion of the watershed. The Village of Algonquin occupies 682 acres (6%) at the southern portion of the watershed near the outlet. Cary occupies 224 acres (2%), and 389 acres (3%) of Lakewood is located directly south of Crystal Lake. The remaining 15% of the watershed falls within unincorporated areas in Dorr Township (906 acres/8%), Algonquin Township (441 acres/4%), Nunda Township (349 acres/3%) and Grafton Township (52 acres/0.4%).

Table 8. County, township, unincorporated, and municipal jurisdictions.

Watershed Jurisdictions		
County	Area (Acres)	% of Watershed
McHenry County	12,037.1	100.0%
Unincorporated Township Areas	Area (Acres)	% of Watershed
Unincorporated Dorr Township	906.4	7.5%
Unincorporated Algonquin Township	441.3	3.7%
Unincorporated Nunda Township	348.8	2.9%
Unincorporated Grafton Township	51.6	0.4%
Total	**1,748.1**	**14.5%**
Municipalities	**Area (Acres)**	**% of Watershed**
City of Crystal Lake	6,365.6	52.9%
Village of Lake in the Hills	2,628.5	21.8%
Village of Algonquin	682.1	5.7%
Village of Lakewood	388.8	3.2%
Village of Cary	224.0	1.9%
Total	**10,289.0**	**85.5%**

Crystal Lake City Hall

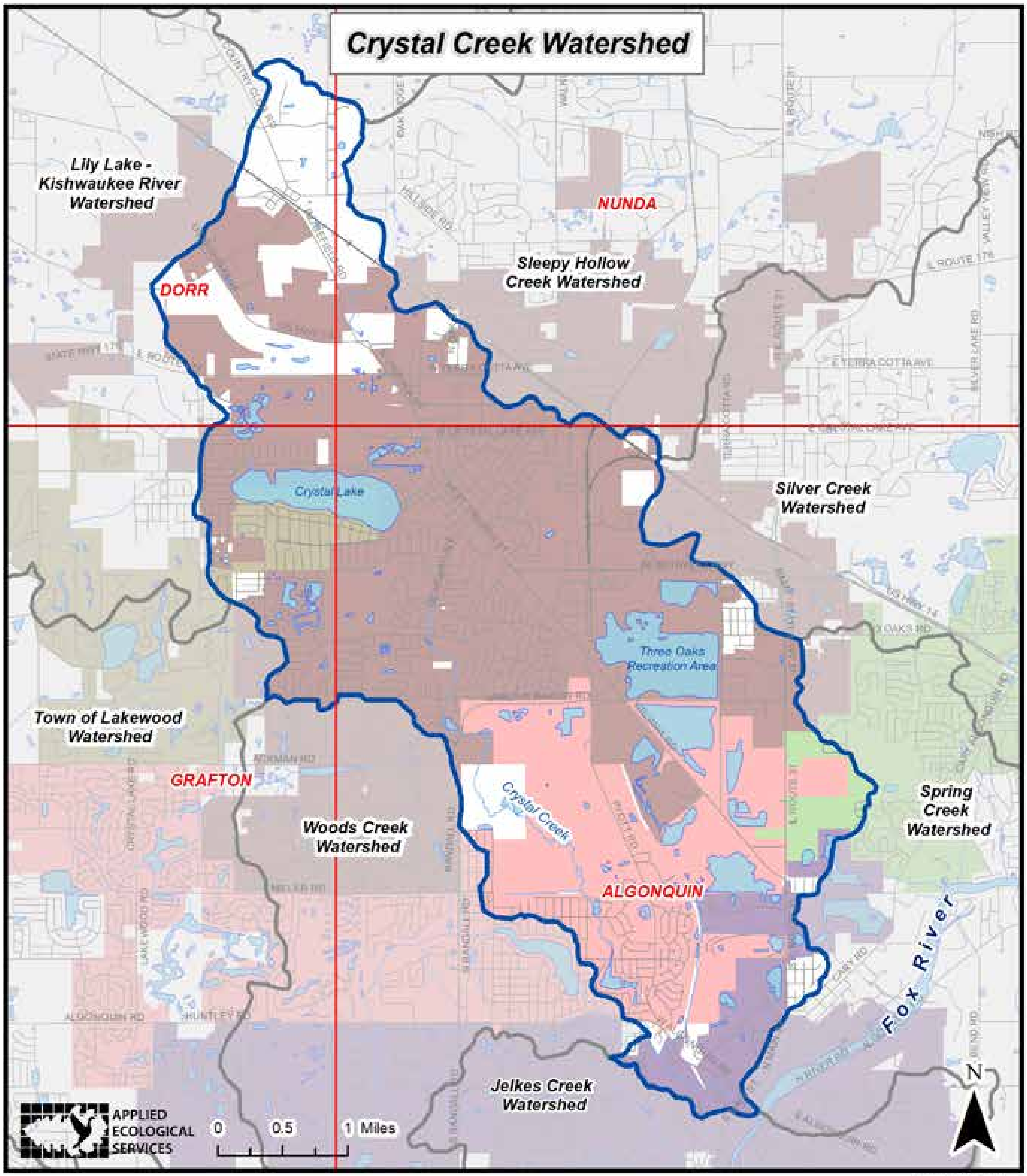


Fig. 13: Watershed Jurisdictions

DATA SOURCES: City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey

Jurisdictional Roles and Responsibilities

Natural resources throughout the United States are protected to some degree under federal, state, and/or local law. Watershed boundaries do not correlate with political boundaries and therefore, in order to properly protect water and other natural resources, cooperation and coordination among all of these entities is essential.

Other governments and private entities with watershed jurisdictional or technical advisory roles include the USFWS and IDNR, County Board Districts, and the McHenry Soil and Water Conservation Districts (SWCDs). The USFWS and IDNR play a critical role in natural resource protection, particularly for rare or high-quality habitat and threatened and endangered species. They protect and manage land that often contains wetlands, lakes, ponds, and streams. County Boards oversee decisions made by respective county governments and therefore have the power to override or alter policies and regulations. The SWCDs provide technical assistance to the public and other regulatory agencies. Although the SWCDs have no regulatory authority, they influence watershed protection through soil and sediment control and pre- and post-development site inspections.

Federal Government Roles and Protections

United States Army Corps of Engineers (USACE) - In the watershed area, the U.S. Army Corps of Engineers (USACE) regulate wetlands through Section 404 of the Clean Water Act. Land development affecting water resources (rivers, streams, lakes, wetlands, and floodplains) is regulated by the USACE when "Waters of the U.S." are involved. These types of waters include any wetland or stream/river that is hydrologically connected to navigable waters. The USACE primarily regulates filling activities and requires buffers or wetland mitigation for developments that impact jurisdictional wetlands. (USACE, 2020)

United States Department of Agriculture (USDA)- The United States Department of Agriculture, is the federal department responsible for developing and executing federal laws related to farming, forestry, rural economic development, and food. Agencies within the USDA include: Agricultural Marketing Service (AMS), Agricultural Research Service (ARS), Animal and Plant Health Inspection Service (APHIS), Center for Nutrition Policy and Promotion (CNPP), Economic Research Service (ERS), Farm Service Agency (FSA), Food and Nutrition Service (FNS), Food Safety and Inspection Service (FSIS), Foreign Agricultural Service (FAS), Forest Service (FS), National Agricultural Library (NAL), National Institute of Food and Agriculture (NIFA), Natural Resources Conservation Service (NRCS), Risk Management Agency (RMA), Rural Development (RD), Rural Utilities Service (RUS), Rural Housing Service (RHS), and Rural Business-Cooperative Service (RBS). The programs most relevant to the management of the Crystal Creek Watershed are discussed further in the following paragraphs. (USDA, 2020)

USDA Agricultural Research Service (ARS)- ARS is USDA's principal in-house research agency studying agricultural research and information. National Research Programs such as Nation Program 211: Water Availability and Watershed Management serve to effectively and safely manage water resources while protecting the environment and human and animal health. This goal is pursued by characterizing potential hazards, developing management practices, strategies and systems to alleviate problems, and providing practices, technologies, and decision support tools for the benefit of customers, stakeholders, partners, and product users. (USDA, 2020)

USDA Farm Service Agency (FSA)- The Farm Service Agency implements agricultural policy, administers credit and loan programs, and manages conservation, commodity, disaster and farm marketing programs through a national network of offices. The FSA's strives to support a market-oriented, economically and environmentally sound American agriculture that delivers an abundant, safe, and affordable food and fiber supply while sustaining quality agricultural communities. (USDA, 2020)

USDA Forest Service (FS)- The Forest Service works to sustain the health, diversity and productivity of America's forests and grasslands. The Forest Service seeks to support nature in sustaining life through their stewardship work. The Forest Service works in collaboration with communities and partners in providing access to resources and experiences that promote economic, ecological, and social vitality; and connecting people to the land and one another. (USDA, 2020)

USDA National Institute of Food and Agriculture (NIFA)- The National Institute of Food and Agriculture (NIFA) provides leadership and funding for programs that advance agriculture-related sciences. NIFA's mission is to invest in and advance agricultural research, education, and extension to solve societal challenges. NIFA invests in and supports initiatives that ensure the long-term viability of agriculture. NIFA applies an integrated approach to ensure that discoveries in agriculture-related sciences and technologies reach the people who can put them into practice. (USDA, 2020)

USDA Natural Resources Conservation Service (NRCS)- NRCS is the primary federal agency that works with private landowners to help them conserve, maintain and improve their natural resources to implement conservation practices that clean the air, conserve and clean the water, prevent soil erosion and create and protect wildlife habitat. They are also responsible for providing technical assistance to the USDA Farm Service Agency for sodbuster, wetland and highly erodible land determinations and compliance issues. (USDA, 2020)

USDA Rural Utilities Service (RUS)- RUS provides much-needed infrastructure and infrastructure improvements to rural communities. This includes water and wastewater treatment, electric power and telecommunications services. These services help to expand economic opportunities and improve the quality of life for rural residents. The Water and Environmental Programs (WEP) provides loans, grants and loan guarantees for drinking water, sanitary sewer, solid waste and storm drainage facilities in rural areas and cities and towns of 10,000 or less. Public bodies, non-profit organizations and recognized Indian tribes may qualify for assistance. WEP also makes grants to non-profit organizations to provide technical assistance and training to help rural communities with their water, wastewater and solid waste problems. (USDA, 2020)

United States Department of Transportation (USDOT)- USDOT's mission is to serve the United States by ensuring a fast, safe, efficient, accessible and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future. (USDOT, 2020)

United States Environmental Protection Agency (USEPA)- The mission of the USEPA is to protect human health and the environment. The EPA works to ensure that Americans have clean air, land and water, and that National efforts to reduce environmental risks are based on the best available scientific information. They also work to ensure that Federal laws protecting human health and the environment are administered and enforced fairly and effectively. As environmental stewardship is integral to U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade; these factors are similarly considered in establishing environmental policy. As well as ensuring that all parts of society have access to accurate information sufficient to effectively participate in managing human health and environmental risks. They also oversee that contaminated lands and toxic sites are cleaned up by potentially responsible parties and revitalized and chemicals in the marketplace are reviewed for safety. (USEPA, 2020)

United States EPA Office of Water (OW)- The Office of Water (OW) ensures drinking water is safe, and restores and maintains oceans, watersheds, and their aquatic ecosystems to protect human health, support economic and recreational activities, and provide healthy habitat for fish, plants and wildlife. OW is responsible for implementing the Clean Water Act and Safe Drinking Water Act, and portions of the Coastal Zone Act Reauthorization Amendments of 1990, Resource Conservation and Recovery Act, Ocean Dumping Ban Act, Marine Protection, Research and Sanctuaries Act, Shore Protection Act, Marine Plastics Pollution Research and Control Act, London Dumping Convention, the International Convention for the Prevention of Pollution from Ships and several other statutes. (USEPA, 2020)

United States Fish and Wildlife Service (USFWS)- USFWS and Illinois Department of Natural Resources (IDNR), along with Illinois Nature Preserves Commission (INPC) and Forest Preserve Districts, are responsible for protecting federal and state threatened and endangered species in the watershed--which are often found on land that contains wetlands, lakes, ponds, and streams. The USFWS and IDNR play a critical role in natural resource protection, particularly for rare or high-quality habitat and threatened and endangered species. They protect and manage land that often contains wetlands, lakes, ponds, and streams. Their programs function to: enforce federal wildlife laws, protect endangered species, manage migratory birds, restore nationally significant fisheries, conserve and restore wildlife habitat such as wetlands, help foreign governments with their international conservation efforts, and distribute hundreds of millions of dollars, through their Wildlife Sport Fish and Restoration program. (USFWS, 2020)

Federal Aviation Administration (FAA)- FAA's mission is to provide a safe, efficient aerospace system. The Federal Aviation Administration (FAA) plays a role in land use planning through advisory circulars such as AC 150/5200-33C "Hazardous Wildlife Attractants on or near Airports" which provides guidance on certain land uses that have the potential to attract hazardous wildlife on or near public-use airports. It also discusses airport development projects (including airport construction, expansion, and renovation) affecting aircraft movement near hazardous wildlife attractants. In which they recommend land uses such as wetlands, landfills, or detention basins should be outside of a 1-5-mile buffer zone, depending on the types of aircraft serviced by the airport. (FAA, 2020)

State Government Roles and Protections

Illinois Department of Agriculture (IDOA)- The Illinois Department of Agriculture advocates for Illinois' agricultural industry and provides necessary regulatory functions to benefit consumers, agricultural industry, and Illinois' natural resources. The Illinois Department of Agriculture's vision is to promote and regulate agriculture in a manner which encourages farming and agribusiness while protecting Illinois' consumers and our natural resources. The Illinois Department of Agriculture (IDOA) regulates pesticides and pesticide applicators, as well as the siting and construction of livestock production facilities, reduction of soil erosion on agricultural land, and oversees the groundwater monitoring network.

Two other noteworthy programs are the Conservation Practices Program and the Well Decommissioning Program. The Conservation Practices Program seeks protect and enhance natural resources and outdoor recreation in Illinois, with the Illinois Department of Agriculture overseeing the agriculture-related components. The Well Decommissioning Program seeks to seal abandoned wells to protect groundwater from direct contamination. (IDOA, 2020)

Illinois Department of Natural Resources (IDNR)- The Illinois Department of Natural Resources works to manage, conserve and protect Illinois' natural, recreational and cultural resources, further the public's understanding and appreciation of those resources, and promote the education, science and public safety of Illinois' natural resources for present and future generations. Offices within IDNR include: Architecture, Engineering and Grants; Compliance, Equal Employment Opportunity and Ethics; Grant Management & Assistance; Law Enforcement; Land Management (State Parks); Legal Affairs; Legislation; Mines & Minerals; Oil & Gas; Realty & Capital Planning; Resource Conservation; State Museums; Strategic Services; Water Resources; and World Shooting & Recreational Complex. (IDNR, 2020)

IDNR Office of Water Resources (OWR)- The Office of Water Resources is the lead state agency for water resources planning, navigation, floodplain management, the National Flood Insurance Program, water supply, drought, and interstate organizations on water resources. Interagency duties include the state water plan, drought response, flood emergency situation reports, and the comprehensive review of Illinois water use law. The Office of Water Resources consists of two Divisions: The Division of Capital Programs and The Division of Resource Management.

The Division of Capital Programs administers the Urban Flooding Mitigation program, water supply planning including water withdrawals from Federal reservoirs, stream gaging, and operation and maintenance of state facilities including Stratton Lock and Dam and Sinnissippi dam. The Division of Capital Programs is the Technical Liaison to the Illinois Emergency Management Agency and provides daily briefings on flood conditions of monitored streams throughout the state and its boundary waters during and following a flood or other disasters.

The Division of Regulatory Programs administers regulatory programs over construction in the floodways of rivers, lakes, and streams; construction in the shore waters of Lake Michigan; construction and operation of dams; construction in public bodies of water; and diversion of water from Lake Michigan. Resource Management inspects dams, gives permits, coordinates the National Flood Insurance Program and regulates floodplains. (IDNR, 2020)

IDNR Illinois Nature Preserves Commission (INPC)- The mission of the Illinois Nature Preserves Commission (INPC) is to assist private and public landowners in protecting high quality natural areas and habitats of endangered and threatened species; in perpetuity, through voluntary dedication or registration of such lands into the Illinois Nature Preserves System. The Commission promotes the preservation of these significant lands and provides leadership in their stewardship, management and protection. (IDNR, 2020)

Illinois Environmental Protection Agency (IEPA)- Illinois EPA works to safeguard the state's natural resources from pollution to provide a healthy environment for its citizens. Through partnership with businesses, local governments and citizens, Illinois EPA works to continue protection of the air we breathe and our water and land resources. IEPA Bureau of Air, Bureau of Land, Bureau of Water, and Office of Energy operate within their respective fields. (IEPA, 2020)

IEPA Bureau of Land- The Bureau of Land protects human health and the environment by regulating the transfer, storage, and disposal of waste, and by overseeing the cleanup of contaminated properties. The Bureau's permitting programs regulate a wide range of waste related activities, including those involving municipal waste, landscape waste, composted material, construction and demolition debris, potentially infectious medical waste, and hazardous waste. (IEPA, 2020)

IEPA Bureau of Water- The Bureau of Water is committed to ensuring that Illinois' rivers, streams, and lakes will support all uses for which they are designated including protection of aquatic life, recreation, drinking water supply and fish consumption. The Bureau works to ensure that every Illinois public water system provides water that is superior quality, meets all regulatory requirements, and that Illinois' groundwater resources are protected for designated drinking water and other beneficial uses. To accomplish this mission, the Bureau monitors the quality of the state's surface and groundwater resources; runs a municipal, stormwater, and industrial effluent permitting program; administers a permit program for community water supplies; regularly inspects sources of water pollution and drinking water treatment facilities; responds to citizen complaints; ensures compliance with regulatory standards; and enforces applicable regulatory requirements. (IEPA, 2020)

To assist, the Bureau provides a number of loan and grant programs designed to upgrade or build new wastewater, stormwater treatment and public water supply infrastructure, reduce nonpoint source pollution, conduct green infrastructure projects, and protect and restore Illinois' inland lakes and streams.

The Illinois EPA is the designated state agency in Illinois to receive 319 federal funds from U.S. EPA. The purpose of Illinois EPA's 319 program is to work cooperatively with units of local government and other organizations toward the mutual goal of protecting the water quality in Illinois through the control of nonpoint source (NPS) pollution. The program includes providing funding to these groups to implement projects that utilize cost-effective best management practices (BMPs) on a watershed scale. Projects may include structural BMPs such as detention basins and filter strips, non-structural BMPs such as construction erosion control ordinances and setback zones to protect community water supply wells. Technical assistance and information/education programs are also eligible.

NPDES Phase II Stormwater Permit Program

The Illinois EPA Bureau of Water regulates wastewater and stormwater discharges to streams and lakes by setting effluent limits, and monitoring/reporting on results. The Bureau oversees the National Pollutant Discharge Elimination System (NPDES) program. The NPDES program was initiated under the federal Clean Water Act to reduce pollutants to the nation's waters. This program requires permits for discharge of 1) treated municipal effluent; 2) treated industrial effluent; and 3) stormwater from municipal separate storm sewer systems (MS4's) and construction sites.

The Illinois EPA's NPDES Phase I Stormwater Program began in 1990 and applies only to large and medium-sized municipal separate storm sewer systems (MS4's), several industrial categories, and construction sites hydrologically disturbing 5 acres of land or more. The NPDES Phase II program began in 2003 and differs from Phase I by including additional MS4 categories, additional industrial coverage, and construction sites hydrologically disturbing greater than 1 acre of land. More detailed descriptions can be viewed on the Illinois EPA's web site.

Under NPDES Phase II, all municipalities with small, medium, and large MS4's are required to complete a series of Best Management Practices (BMPs) and measure goals for six minimum control measures:

- Public education and outreach
- Public participation and involvement
- Illicit discharge detention and elimination
- Construction site runoff control
- Post-construction runoff control
- Pollution prevention and good housekeeping

The Phase II Program also covers all construction sites over 1 acre in size. For these sites the developer or owner must comply with all requirements such as completing and submitting a Notice of Intent (NOI) before construction occurs, developing a Stormwater Pollution Prevention Plan (SWPPP) that shows how the site will be protected to control erosion and sedimentation, completing final stabilization of the site, and filing a Notice of Termination (NOT) after the construction site is stabilized.

Algonquin Township, Algonquin Village, Cary Village, Crystal Lake City, Dorr Township, Grafton Township, Lake In The Hills Village, Lakewood Village, and Nunda Township all maintain active MS4 permits. There are three NPDES permits within the watershed: Crystal Lake STP #2 (IL0028282 – 2 outfalls), Lake in the Hills SD STP (IL0021733), and Hanson Material Service – Yard 46 (ILG840090). For more detailed information regarding wastewater treatment and these permits, see Section 3.14.

There are no CAFOs or TMDLs within the watershed.

Illinois Department of Transportation (IDOT)- Illinois Department of Transportation works to maintain a statewide transportation system with the mission of enhancing quality of life of Illinois residents through reduced congestion and increased mobility. They plan, administer, construct, and maintain rail, highway, airport, transit, waterways, and trail systems through five regions across the state.

As it relates to watershed planning, all transportation projects, involving the use of state and federal funds are required to follow formal procedures designed to protect the natural and social environment, this includes wetlands, plants, animals, air and water quality, archaeological and historic sites, agriculture, and communities. IDOT also has numerous wetland compensation sites and wetland mitigation bank sites for when impacts of wetland sites are unavoidable. (IDOT, 2020)

County and Local Government Roles and Protections

McHenry County Board - McHenry County operates under the township form of county government. The governing body is the County Board. The primary function of the County Board is to establish the various budgets of the county funds and adopt ordinances and rules pertaining to the management and business of the county departments (McHenry County, 2020).

McHenry County Planning and Development- The primary function of the Planning and Development

Department is to “facilitate orderly, safe, and resilient development, the preservation of natural and historic resources, and the creation of communities of opportunity.” There is a Building Division, Community Development Division, Planning, Zoning, and Land Use Division, and a Water Resources Division; as well as several committees, commissions, and boards related to agriculture, community development and housing, historic preservation, gravel mining, regional planning, stormwater management, and zoning.

The Planning, Zoning, and Land Use Division is the point of contact for persons seeking to rezone property, obtain conditional use permits, request variations, and subdivide property within unincorporated McHenry County; Unincorporated areas in the watershed include 2,430 acres across four townships. This division also is responsible for developing and implementing plans and studies such as the 2030 & Beyond Plan, the 2030 Comprehensive Plan, the Comprehensive Economic Development Strategy, the Fox Valley Corridor Plan, and the Green Infrastructure Plan, and the Historic Preservation Plan; as well as the Unified Development Ordinance for implementing many of the policies contained in the 2030 Comprehensive Plan which results land use, subdivisions, etc.

The Water Resources Division oversees stormwater management and planning as well as the sustainable use of the County’s water supply. Public and private potable water supplies in McHenry County are 100% dependent on groundwater. This Division responds to concerns regarding site grading, flooding, drainage, and wetland; assist property owners in obtaining stormwater management permits; and review building permits for compliance with stormwater regulations. The Division also serves as the liaison to the Stormwater Management Commission, the Stormwater Technical Advisory Committee and the Groundwater Taskforce.

McHenry County Health Department- The McHenry County Health Department is involved in a broad spectrum of public health services. They oversee environmental health and permitting, animal control and records, administer a broad variety of clinical services, as well as overseeing and implementing a broad variety of public health planning and oversight. The Department’s environmental health programs serve to foster safe and healthy interrelationships between residents and their environment including public beach water quality, solid and hazardous waste, drinking and surface water analysis, groundwater protection, septic system and private well oversight, and environmental health ordinances among other services.

McHenry County Division of Transportation- McHenry County Division of Transportation oversees the Administration, Design, Construction, Maintenance, and Planning of transportation systems in McHenry. Some roles of the Division include defining the County’s snow and ice removal policy and de-icing, roadside tree planting and replacement policy, storm sewer maintenance, street sweeping, design of transportation infrastructure, and long-term planning of transportation services.

McHenry County Emergency Management- McHenry County Emergency Management department works to plan and train residents in disaster preparedness. This includes Natural Hazard Mitigation planning and flooding preparation.

McHenry-Lake County Soil and Water Conservation District (SWCD)- McHenry-Lake County SWCD provides technical assistance to the public and other regulatory agencies. They work to protect and maintain healthy soil and clean water for all generations. The Soil and Water Conservation District is a local resource for natural resource concerns for the residents of McHenry county. The Conservation District are actively involved with watershed planning in McHenry County, they serve as a resource for natural resources education for youth and adults, and are advocates for preserving prime farmland in McHenry County. Although the SWCD has no regulatory authority, it influences watershed protection through soil and sediment control and pre and post-development site inspections.

McHenry County Conservation District- McHenry County Conservation District’s mission is to preserve, restore and manage natural areas and open spaces for their intrinsic value and for the benefit of all generations. The mission and vision of the Conservation District serves to inspire respect for the land; promote sound environmental practices; promote the long-term viability of the county’s biodiversity; provide opportunities for responsible use of the land in concert with natural resources; promote environmental stewardship; provide quality experiences that promote green, healthy and balanced lifestyles; connect children to nature and; and foster public and private partnerships.

Municipalities

Watershed Municipalities (City of Crystal Lake, Village of Lake in the Hills, Village of Lakewood, Village of Cary, Village of Algonquin) and Unincorporated Townships- Municipalities in the watershed may or may not provide additional watershed protection above and beyond existing watershed ordinances under local City or Village Codes. Municipal codes present opportunities for outlining and requiring recommendations in this plan such as conservation development, Special Service Area (SSA) or watershed protection fees, and natural landscaping.

For example, the Village of Algonquin currently provides extra protection of Crystal Creek watershed south of Algonquin Road under the "Algonquin Zoning Ordinance" (adopted April 1, 2003 and updated in 2015). This ordinance contains the "Crystal Creek Watershed Protection Overlay District" which promotes preservation, protection, and enhancement of the natural areas associated with Crystal Creek by requiring specific development practices, site design, structural requirements, and watershed protection fees. The Village plans to use the watershed plan to update the existing zoning language. Other municipalities in the watershed are encouraged to do the same.

Water resources located on unincorporated land within McHenry County are ultimately regulated by the McHenry County Department of Planning and Development and Water Resources Division. Unincorporated areas include 1,123 acres in Algonquin Township, 906 acres in Dorr Township, 349 acres in Nunda Township, and 52 acres in Grafton Township. Development affecting water resources in these townships must be reviewed by the respective agencies listed above. McHenry County passed the "Conservation Design Standards and Procedures" in 2008 which was consolidated into the Unified Development Ordinance in 2014.

Land development in the county is regulated by the McHenry County Stormwater Management Ordinance (amended April 5, 2016) The ordinance is enforced by county agencies or by "Certified Communities". All of the municipalities in the watershed are certified. Crystal Lake, Lake in the Hills, Cary, and Lakewood are certified in McHenry County.

The City of Crystal Lake also developed the Crystal Lake Watershed Plan (2005), the Crystal Lake Watershed Design Manual (Hey, 2007), a Comprehensive

Table 9. Levels of Jurisdiction

Level of Jurisdiction	Entities
Federal	US Environmental Protection Agency (USEPA)
	- Office of Water
	US Army Corps of Engineers (USACE)
	US Department of Agriculture (USDA)
	- Natural Resources Conservation Service (NRCS)
	- Farm Service Agency (FSA)
	- Agricultural Research Service (ARS)
	- Forest Service (FS)
	- National Institute of Food and Agriculture (NIFA)
	- Rural Utilities Service (RUS)
	US Fish and Wildlife Service (USFWS)
	US Department of Transportation (USDOT)
	- Federal Aviation Administration (FAA)
State	Illinois Environmental Protection Agency (IEPA)
	- Bureau of Land
	- Bureau of Water
	Illinois Department of Natural Resources (IDNR)
	- Office of Water Resources (OWR)
	- Illinois Nature Preserves Commission (INPC)
	Illinois Department of Agriculture (IDOA)
	Illinois Department of Transportation (IDOT)
County	McHenry County Board
	McHenry County Planning and Development
	- Water Resources Division
	McHenry County Health Department
	McHenry County Division of Transportation
	McHenry County Emergency Management
	McHenry County Soil and Water Conservation District
Local	City of Crystal Lake
	Village of Lake in the Hills
	Village of Lakewood
	Village of Algonquin
	Village of Cary
Township	Unincorporated Nunda Township
	Unincorporated Dorr Township
	Unincorporated Grafton Township
	Unincorporated Algonquin Township
Special	McHenry County School Districts

Land Use Plan (most recently revised in 2012), and the Crystal Lake Stormwater Management Ordinance (adopted and updated in November of 2015). The Design Manual sets forth further guidelines to protect the quantity and quality of water reaching Crystal Lake as well as the shallow groundwater resources of the City of Crystal Lake, while the ordinance establishes reasonable rules and regulations for floodplain, watershed and stormwater management within the City.

Special Jurisdiction Roles and Protections

School Districts- The McHenry County Regional Office of Education (ROE) #44 works to provide high quality educational services for communities in McHenry. There are 18 public school districts, a special education district, and private institutions in McHenry County; within the watershed are elementary school district 47 and high school district 155. The southernmost portion of the watershed falls outside of ROE #44 and lies in Unit District 300.

3.5 Existing Policies and Ordinance Review

Protection of natural resources and green infrastructure during future urban growth will be important for the future health of Crystal Creek watershed. To assess how future growth might further impact the watershed, an assessment of local ordinances was performed to determine how development currently occurs in each local government. In this way, potential improvements to local ordinances can be identified. As part of the assessment, municipal governments were asked to compare their local ordinances against model policies outlined by the Center for Watershed Protection (CWP) in a publication entitled "Better Site Design: A Handbook for Changing Development Rules in Your Community" (CWP, 1998) and complete The Code & Ordinance Worksheet: A Tool for Evaluating Development Rules in Your Community (CWP, 2017).

CWP's recommended ordinance review process involves assessments of four general categories including Residential Streets & Parking Lots, Lot Development, Conservation of Natural Areas, and Runoff Reduction. Various questions with point totals are examined under each category. The maximum for the Suburban worksheet is 126 points and final scores are depicted as a percentage of the total. CWP also provides general guidance based on scores. Scores between 60 and 80 suggest that it may be advisable to reform local development ordinances. Scores less than 60 generally mean that local ordinances are not environmentally friendly and serious reform may be needed. Local government scores ranged from 59 to 68 with an average score of 63. McHenry County scored 59 points or 47%, the Village of Algonquin scored 63 points (50%), and the City of Crystal Lake scored 68 points or 54%, while. Although scores are relatively low, it should be noted that this assessment is meant to be a tool to local communities to help guide development of future ordinances and draw awareness to sections that might be easy to update to improve scores. Various policy recommendations are included in the Action Plan section of the report to address general ordinance deficiencies. The results of the review for each municipality can be found in Appendix B.

3.6 Demographics

The Chicago Metropolitan Agency for Planning (CMAP), through their On to 2050 Comprehensive Regional Plan, provides a regional framework plan for the greater Chicagoland area to plan more effectively with growth forecasts. CMAP's 2015 to 2050 forecasts of population, households, and employment was used to project how these attributes will impact Crystal Creek watershed (Table 10). CMAP develops these forecasts by first generating region wide estimates for population, households, and employment then meets with local governments to determine future land development patterns within each jurisdiction. The data is generated by Township, Range, and quarter Section and is depicted on Figures 14-16. Applied Ecological Services, Inc. (AES) used GIS to overlay the Crystal Creek watershed boundary onto CMAP's quarter Section data. If any part of a quarter Section fell inside the watershed boundary, the statistics for the entire quarter Section were included.

The combined population of the watershed is expected to increase from 47,115 in 2015 to 62,776 by 2050, a 33% increase. Household change follows this trend and is predicted to increase from 17,602 to 24,906 (42% increase). The highest population and household increases expected in the areas around downtown Crystal Lake, largely where mixed use and high-density residential housing exist in the Crystal Lake 2030 Comprehensive Plan. Other population and household increases are predicted within the village of Lake in the Hills north of Goose Lake, and around Three Oaks Recreation Area in areas where mixed-use development is anticipated. Additional population and housing growth in the form of single-family housing is anticipated near the village of Lakewood in the western portion of the watershed, and in the northern portion of the watershed. CMAP does not predict substantial population and household increase in the southeast corner of the watershed where a gravel quarry resides or the northwest portion where agriculture and open space exists. However, mixed use commercial, retail, industrial and institutional development is expected in this area- the gravel quarry area is expected to remain industrial. The employee population- defined as the number of employees who work within that area-is expected to grow largely in the same areas as total population growth, near Crystal Lake's downtown and directly north of Three Oaks Recreation Area. These are areas that are anticipating expansion of mixed commercial-retail and industrial land uses. Employee population is predicted to increase from 21,801 in 2015 to 29,123 by 2050, a 33.6% increase.

Socioeconomic Status

The portions of Algonquin, Crystal Lake, and Lake in the Hills within Crystal Creek watershed can best be described as actively growing with a vibrant community spirit. These "satellite" suburbs of the Chicago region offer excellent amenities such as parks, shopping, nature preserves, quality schools and libraries, safe neighborhoods, and are in close proximity to commuter rail and tollway access. A 2010 U.S. Census Bureau profile report of the area comprising Crystal Creek watershed revealed a mostly white population (>90%) with a median household income around $85,000. In addition, approximately 90% of housing units are owner occupied, around 40% of residents aged 25+ hold a bachelor's degree or higher.

Table 10. CMAP 2015 data and 2050 forecast data.

Data Category	2015	2050	Change 2015-2050	Percent Change
Total Population	47,115	62,776	15,661	33.2%
Total Households	17,602	24,906	7,304	41.5%
Employee Population*	21,801	29,123	7,322	33.6%

Source: Chicago Metropolitan Agency for Planning 2050 Forecasts
*Employee population = Number of people whose place of employment is within the watershed
**2015 Population per Household = 2.7; 2050 Population per Household = 2.5

Cornish Park Clock Tower in Algonquin near the outlet of Crystal Creek

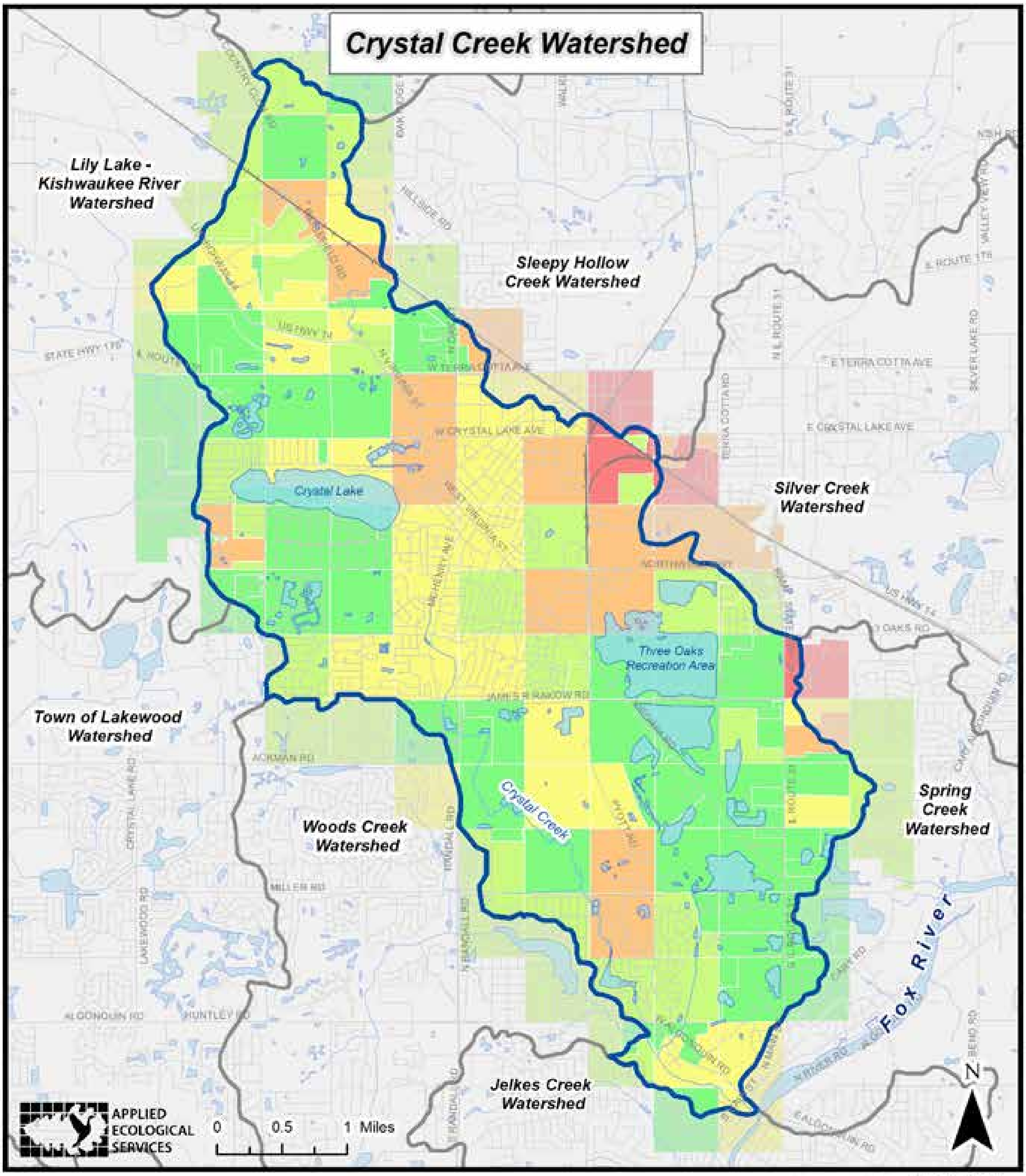
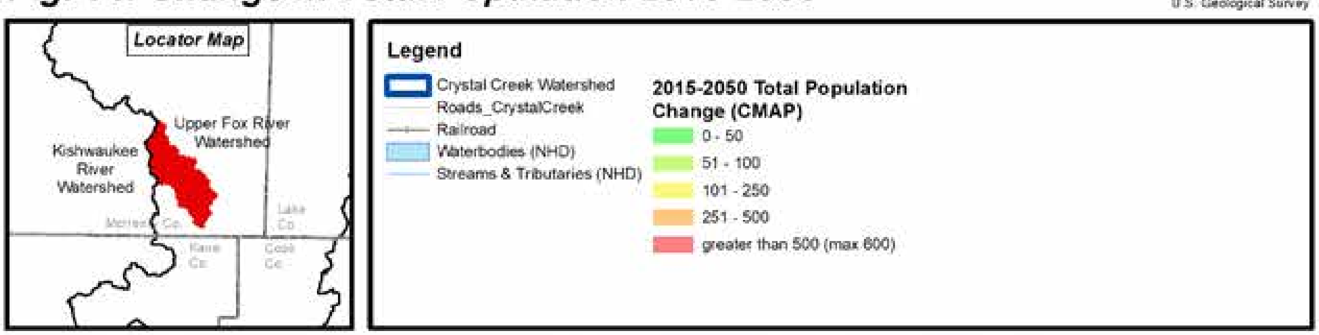


Fig. 14: Change in Total Population 2015-2050

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey



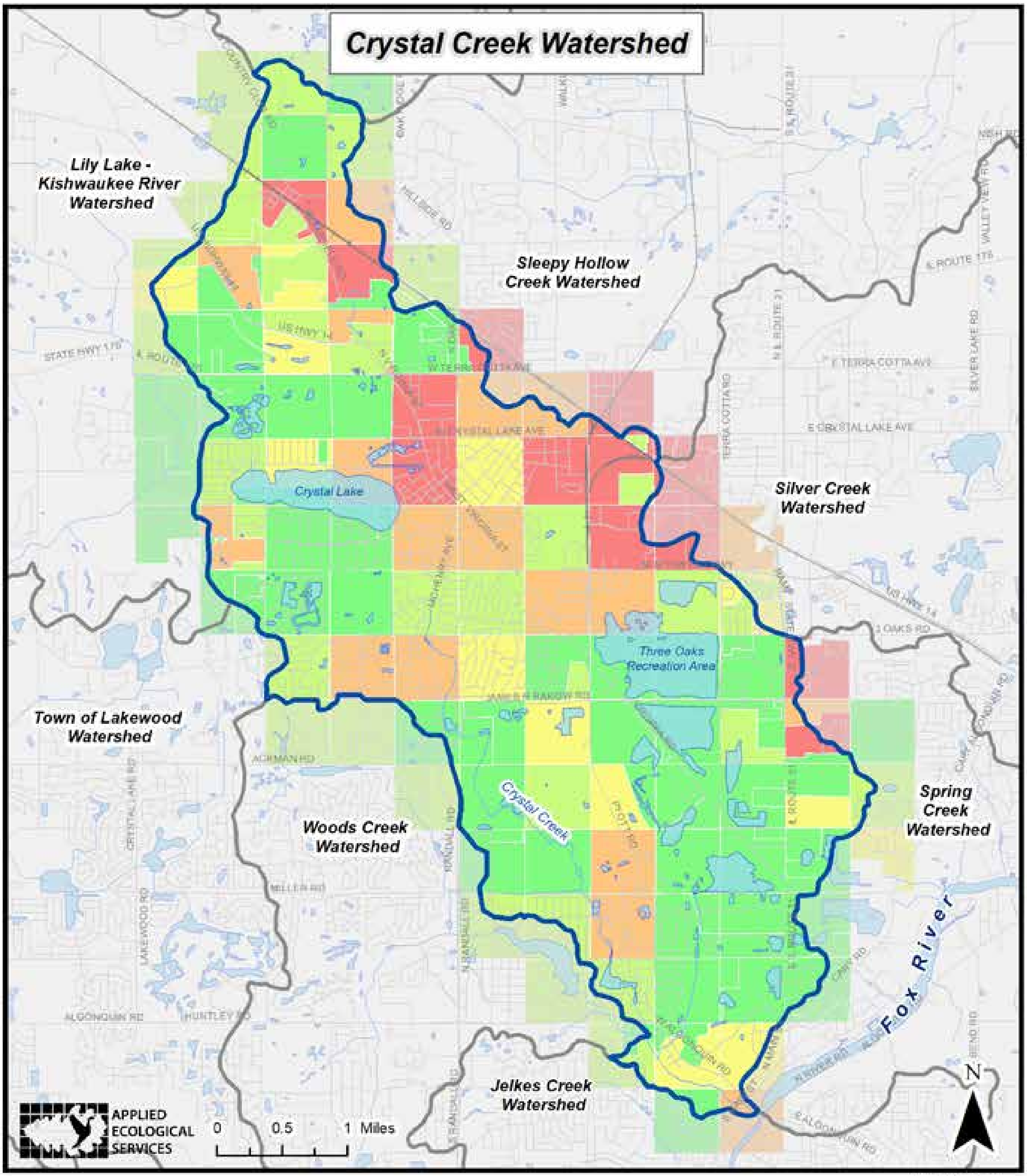


Fig. 15: Change in Total Households 2015-2050

DATA SOURCES City of Crystal Lake McHenry County U.S. Census Bureau U.S. Geological Survey

Legend
- Crystal Creek Watershed
- Roads_CrystalCreek
- Railroad
- Waterbodies (NHD)
- Streams & Tributaries (NHD)

2015-2050 Total Households Change (CMAP)
- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 150
- greater than 150 (max 264)

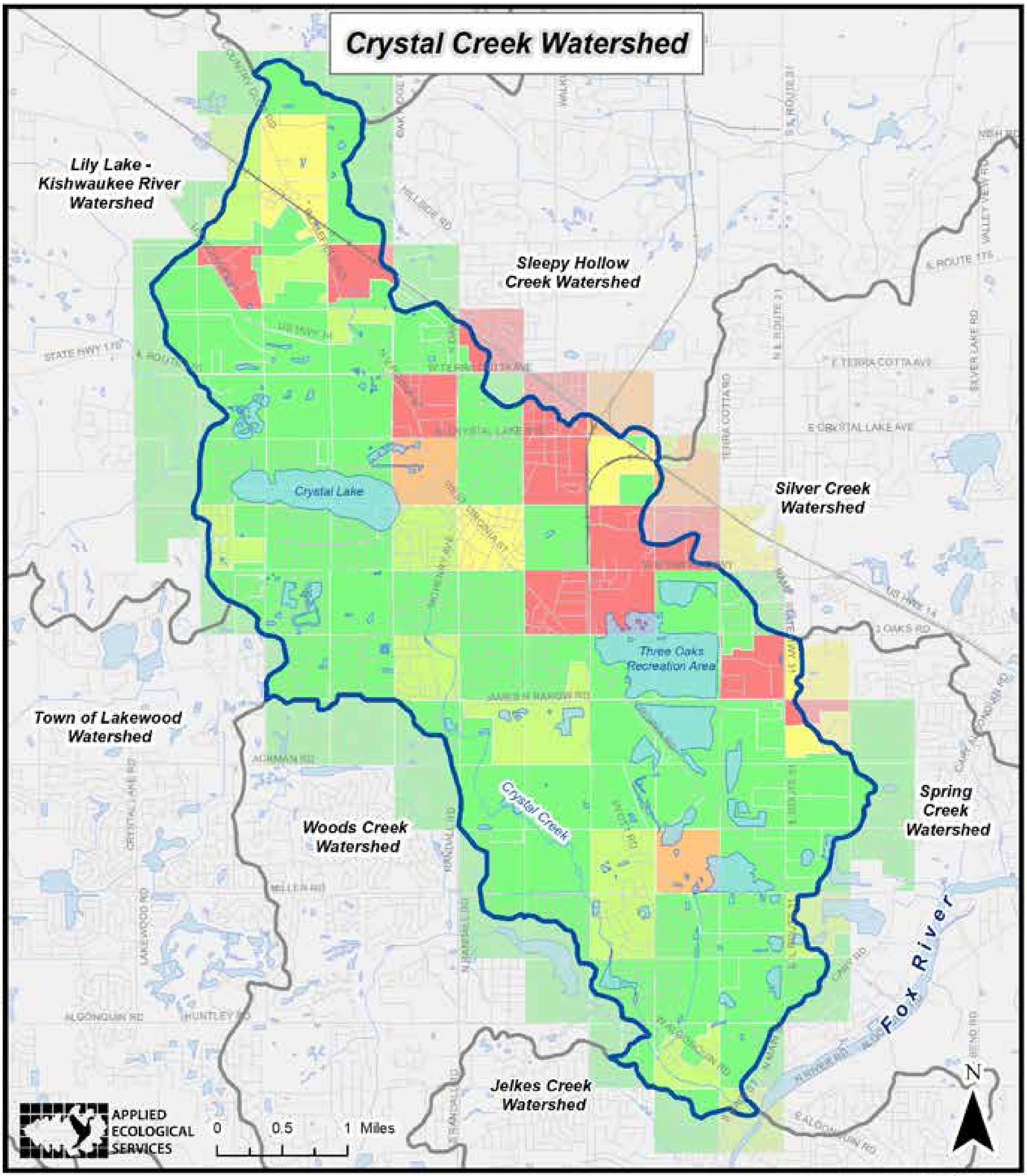


Fig. 16: Change in Number of Employees 2015-2050

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey

Legend

- Crystal Creek Watershed
- Roads_CrystalCreek
- Railroad
- Waterbodies (NHD)
- Streams & Tributaries (NHD)

2015-2050 Number of Employees Change (CMAP)

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- greater than 200 (max 387)

3.7 Existing & Future Land Use/Land Cover

2013 Land Use/Land Cover

Highly accurate land use/land cover data was produced for Crystal Creek watershed using several processes. First, the most recent land use/land cover data from the McHenry County was obtained and mapped in GIS. Next, aerial photography of the watershed was overlaid on municipal data so that discrepancies could be corrected. Finally, uncertainties in land uses and cover types were field verified and corrected if needed to produce the 2013 land use/land cover data and map for Crystal Creek watershed (Table 11; Figure 17).

Open space comprises the most acreage in the watershed (3,083.8 acres; 25.6%), followed by single-family residential (2,476.8 acres; 20.6%), industrial (1,885.3 acres; 15.7%), transportation (1,442.1 acres; 12.0%), and agriculture (1,337.9 acres; 11.1%). Single-family residential neighborhoods are located throughout most of the central portion of the watershed around the City of Crystal Lake and Crystal Lake itself. Open space acreage generally draws from large areas like Lake in the Hills Fen, Three Oaks Recreation Area, Lippold Park, and Crystal Lake County Club. Industrial land use is primarily in the southern portion of the watershed around the sand and gravel quarries. Transportation is spread throughout the watershed and near the Lake in the Hills Airport, agriculture is primarily located in the northern part of the watershed.

Other common land use/cover types include commercial/retail (742.4 acres, 6.2%), municipal/institutional (515.1 acres, 4.3%), and multifamily residential (242.5 acres; 2.0%). Commercial/residential along with multi-family housing occurs mostly along the primary roads through the watershed (Virginia St, Northwest Highway, and IL 31.) Municipal/institutional land is scattered throughout.

Developed land uses account for 7,380.3 acres or 61% of the watershed.

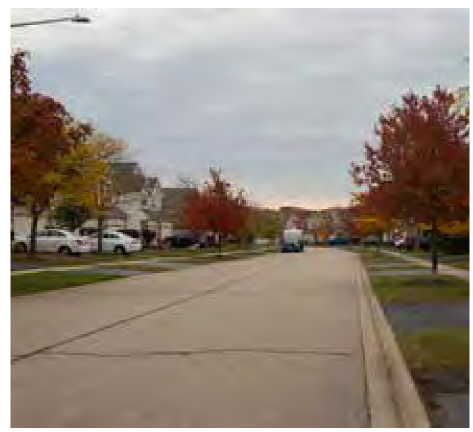
Table 11. 2013 land use/land cover classifications and acreage.

Land Use	Acreage	% of Watershed
Open Space	3,083.9	25.6%
Single-Family Residential	2,476.8	20.6%
Industrial	1,885.3	15.7%
Transportation	1,442.1	12.0%
Agriculture	1,337.9	11.1%
Commercial/Retail	742.4	6.2%
Municipal/Institutional	515.1	4.3%
Multi-Family Residential	242.5	2.0%
Water	235.0	2.0%
Utility	76.2	0.6%
Total	**12,037.1**	**100%**

Future Land Use/Land Cover Predictions

Information on predicted future land use/land cover for the watershed was first obtained from municipal comprehensive plans where available (McHenry County, City of Crystal Lake, Village of Algonquin, Village of Lake in the Hills, and Village of Lakewood). Available data was analyzed and GIS used to map predicted land use/land cover changes. The results are summarized in Table 12 and depicted on Figure 18.

Table 12 compares existing land use/land cover acreage to predicted future (2030) land use/land cover acreage. The largest loss of a current land use/land cover is expected to occur on agricultural land (-925 acres; -7.7%) in the northern portion of the watershed adjacent to US Highway 14 and in the eastern portion of the watershed adjacent to IL Route 31 where current agricultural land is expected to be developed to mostly commercial/retail, industrial, and single-family uses. Other significant losses occur on open space land use areas throughout the watershed (-476.7 acres; -4.0%) as these areas will eventually become developed.



Typical residential subdivision

Conversely, commercial/retail development is predicted to increase the most (+973.0 acres; +4.4%) followed by single-family residential (+411.4 acres; +3.4%). Most of the predicted commercial retail will occur along US Highway 14 in the northern portion of the watershed, along IL Route 31 in the east, and near Pyott road. Most of the single-family residential developments will occur north of US Highway 14 in areas that are currently agricultural.

Table 12. 2013 (current) and 2030 (predicted) land use/land cover, including percent change for each land use/ land cover relative to entire watershed area.

Land Use	Current Areas (Acres)	Current % of Watershed	Future Areas (Acres)	Future % of Watershed	Change (Acres)	Change (%)
Open Space	3,083.8	25.6%	2,607.2	21.7%	-476.7	-4.0%
Single-Family Residential	2,476.8	20.6%	2,888.2	24.0%	411.4	3.4%
Industrial	1,885.3	15.7%	1,874.4	15.6%	-10.9	-0.1%
Transportation	1,442.1	12.0%	1,427.2	11.9%	-14.8	-0.1%
Agriculture	1,337.9	11.1%	412.7	3.4%	-925.3	-7.7%
Commercial/Retail	742.4	6.2%	1,715.4	14.3%	973.0	8.1%
Municipal/Institutional	515.1	4.3%	499.1	4.1%	-16.0	-0.1%
Multi-Family Residential	242.5	2.0%	260.4	2.2%	17.8	0.1%
Water	235.0	2.0%	280.1	2.3%	45.1	0.4%
Utility	76.2	0.6%	72.7	0.6%	-3.5	0.0%
Total	**12,037.1**	**100.0%**	**12,037.1**	**100.0%**	**0.0**	**0.0%**

Noteworthy-Land Use/Land Cover Definitions:

Agricultural: Land use that includes out-buildings and barns, row & field crops and fallow field farms and pasture, includes dairy and other livestock agricultural processing. Also includes nurseries, greenhouses, orchards, tree farms, and sod farms.

Commercial-Retail: Land use that includes shopping malls and their associated parking, single structure office/hotels and urban mix (retail trade like lumber yards, department stores, grocery stores, gas stations, restaurants, etc.).

Industrial: Land use that includes industrial, warehousing and wholesale trade, such as mineral extraction, manufacturing and processing, associated parking areas, truck docks, etc. Industrial-Business Park: Land use that includes business and industrial parks in campus-like settings. This is suitable for administrative and professional offices, research and development parks, limited distribution, light manufacturing, and assembly operations.

Multi-family Residential: Land use that includes multifamily residences. These include duplex and townhouse units, apartment complexes, retirement complexes, mobile home parks, trailer courts, condominiums, and associated parking. Municipal/Institutional: Land use that includes medical facilities, educational facilities, government buildings, religious facilities, and others.

Open Space: Land use that is undeveloped. Open space can include green space (including parks, community gardens, and cemeteries), schoolyards, playgrounds, public plazas, and vacant lots.

Residential-Commercial Mixed: Land use that blends residential (typically multifamily) and commercial into one space.

Single Family Residential: Land use includes buildings designed for and occupied by one family. Transportation/Utility: Land use that includes railroads, rail rapid transit and associated stations, rail yards, linear transportation such as streets and highways, and airport transportation.

Wetland: Land cover that includes all wetlands on public and private land as mapped by McHenry County.

Water: Land cover that includes all bodies of water such as streams, rivers, and lakes as mapped by McHenry County.

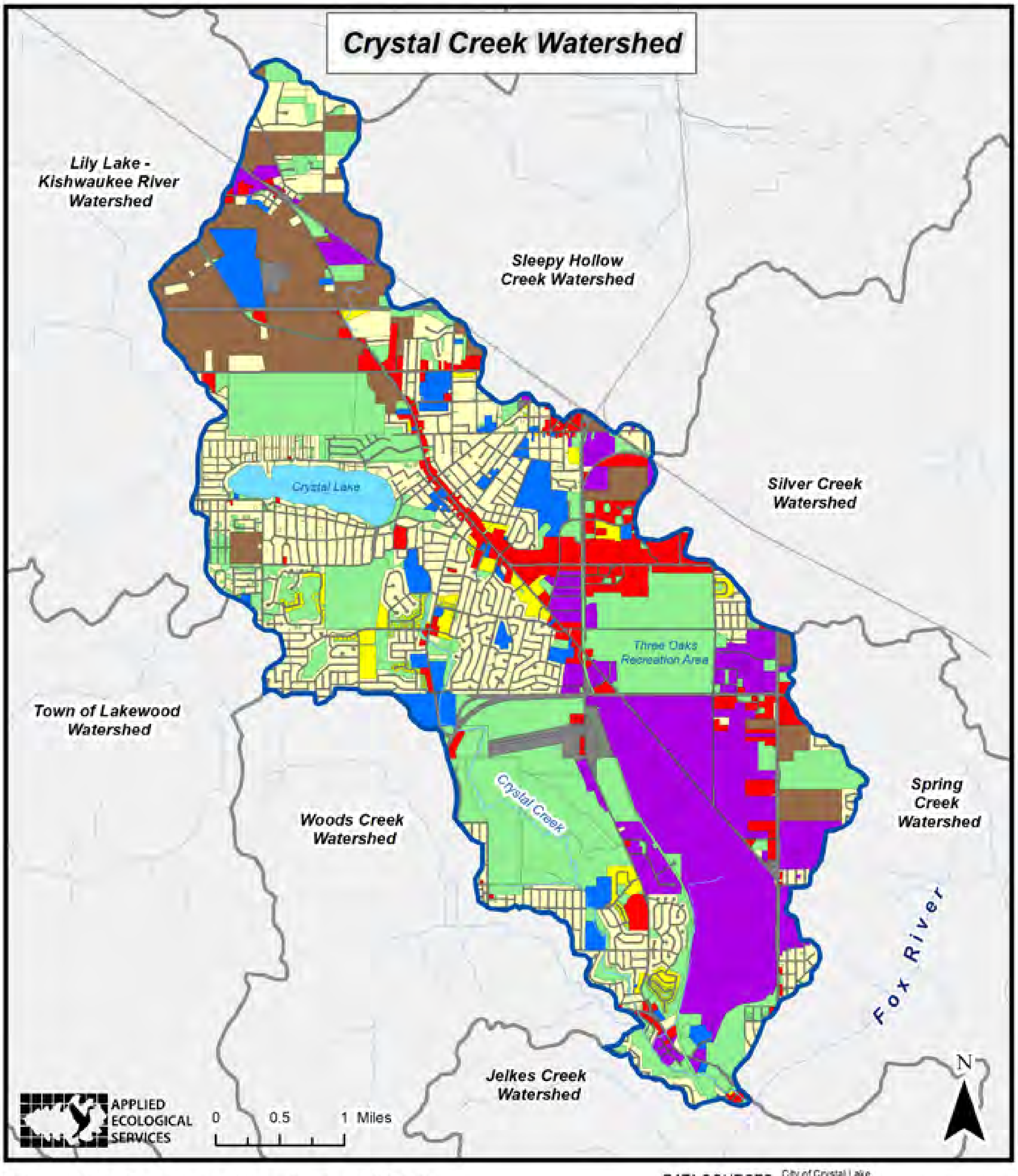
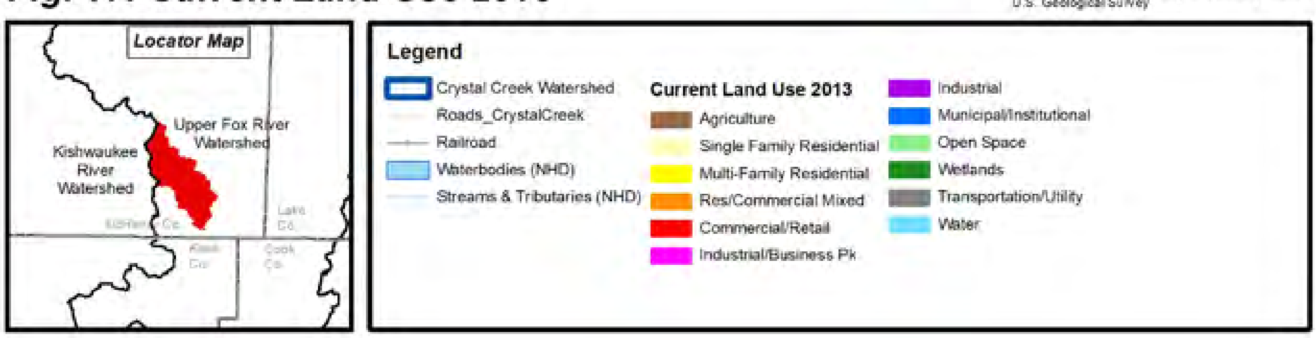


Fig. 17: Current Land Use 2013

DATA SOURCES City of Crystal Lake
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey



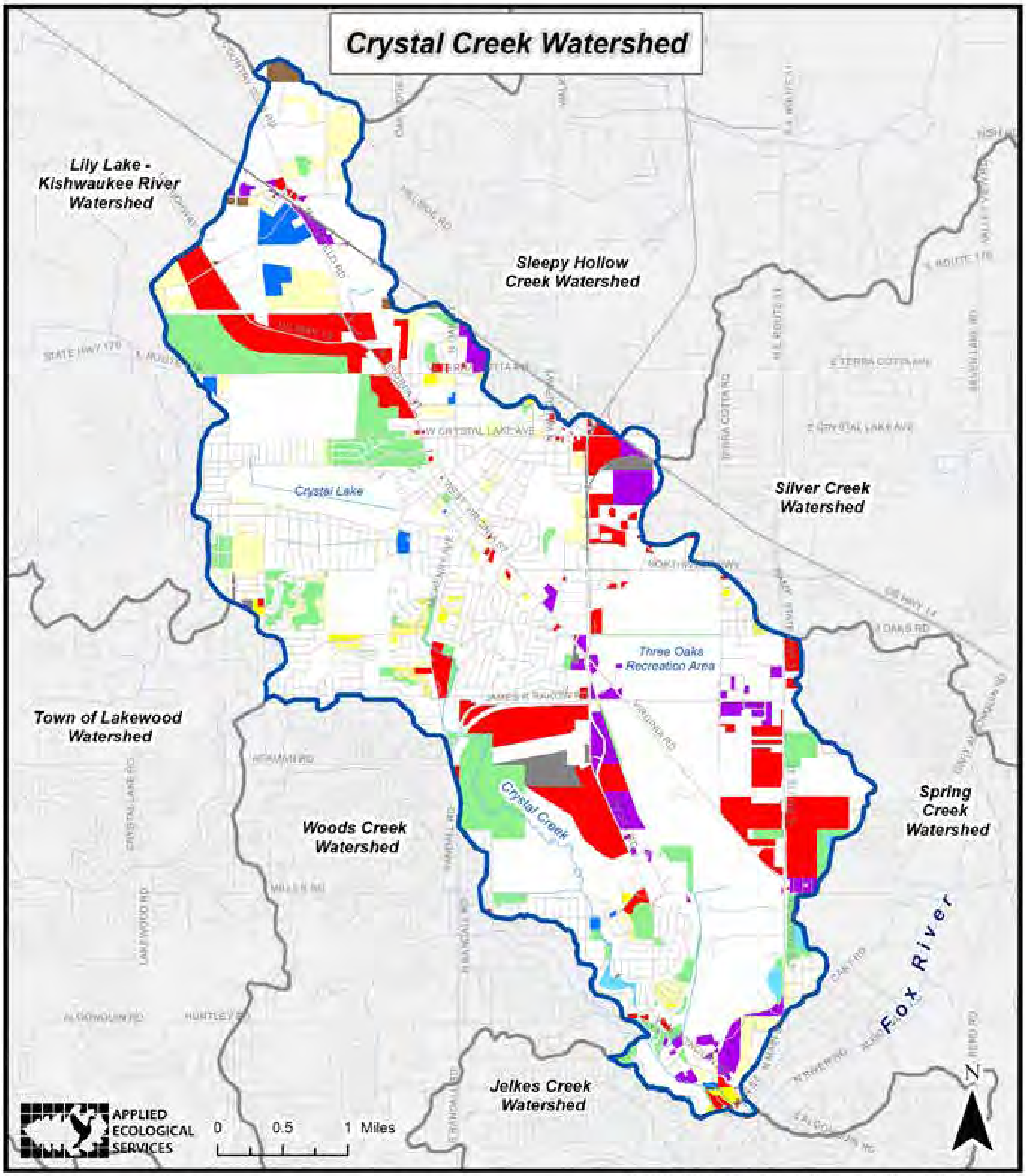
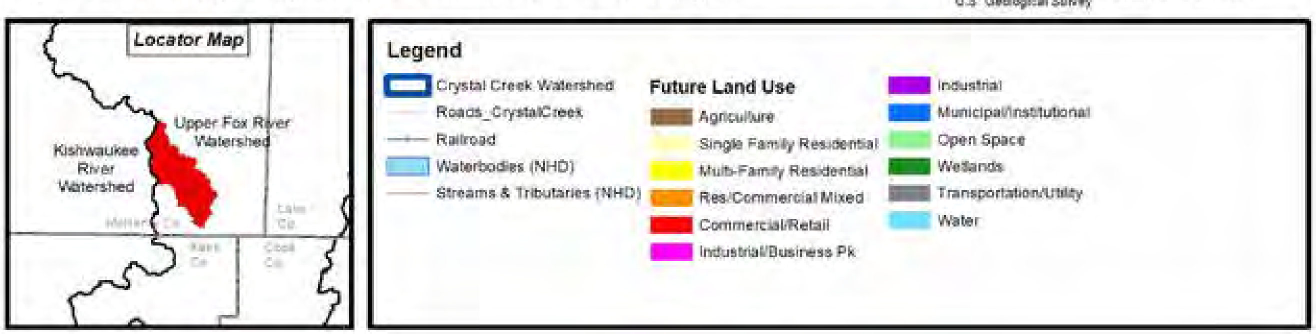


Fig. 18: Future (2030) Land Use/Land Cover Changes

DATA SOURCES City of Crystal Lake, Algonquin, Lake in the Hills, Lakewood
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey



3.8 Transportation Network

Roads

There are 165.1 miles of roads in the watershed. Local roads make up 152.6 miles and highways make up the remaining 12.5 miles. US Highway 14, IL Route 31, IL Route 176, Randall Road and Virginia Street are important arterials in the watershed (Figure 19) connecting nearby communities and moving large volumes of traffic. US Highway 14, IL Route 176, and IL Route 31/ Randall Road are designated as a Strategic Regional Arterials (SRA). SRAs are highways designated to accommodate long distance regional traffic. US Highway 14 and IL Route 176 are east-west arterial roads extending from Lake Michigan south of Evanston to Yellowstone National Park, and Lake Bluff, IL to Marengo, IL respectively. IL-31 and Randall Road are north-south arterials extending from just south of the WI border to Oswego, IL and from Crystal Lake, IL to Aurora, IL respectively. Virginia Street bisects the watershed diagonally (NW to SE) connecting US Highway 14 and IL Route 31.

Railroads

There are two passenger railroad lines that run through the watershed, both owned by Chicago & North Western Transportation Company. The first is Metra's Union Pacific North West passenger line, servicing Harvard/McHenry and includes the Crystal Lake station which is two stops away from the Harvard terminus. There is also a junction nearby with the Chicago & Northwestern Railway, where the McHenry Branch splits off toward the north. Union Pacific and C&NW merged in 1955.

Airport

Lake in the Hills 3CK Airport is a designated Federal Aviation Administration (FAA) reliever airport for Chicago O'Hare with one a 3,800 linear foot paved runway and 110 aircraft. The airport is located at 8397 Pyott Road in Lake in the Hills and is owned by the Village.

Algonquin Bypass

UPNW Metra railroad

In 2019, the airport won the Airport of the Year award from the Illinois Department of Transportation for "its cooperation and coordination with IDOT, commitment to safety, promotion of aviation events, and facility maintenance. (LITH, 2020)"

Walking/Bike Trails

Public trails are an important transportation component of Crystal Creek watershed. Crystal Lake, Lake in the Hills, and Algonquin have done an excellent job connecting 14.8 miles of multi-use (biking/ walking) trails across jurisdictions. As seen on Figure 19, trails extend across most of the watershed. The most important trails within the watershed is the Prairie Trail which extends from Genoa City, WI to Algonquin, IL where it joins the Fox River Trail; it runs north to south through the watershed. Another trail within the watershed is the Ridgefield Trace trail- The complete route extends primarily along Route 14 for 7.7 miles from

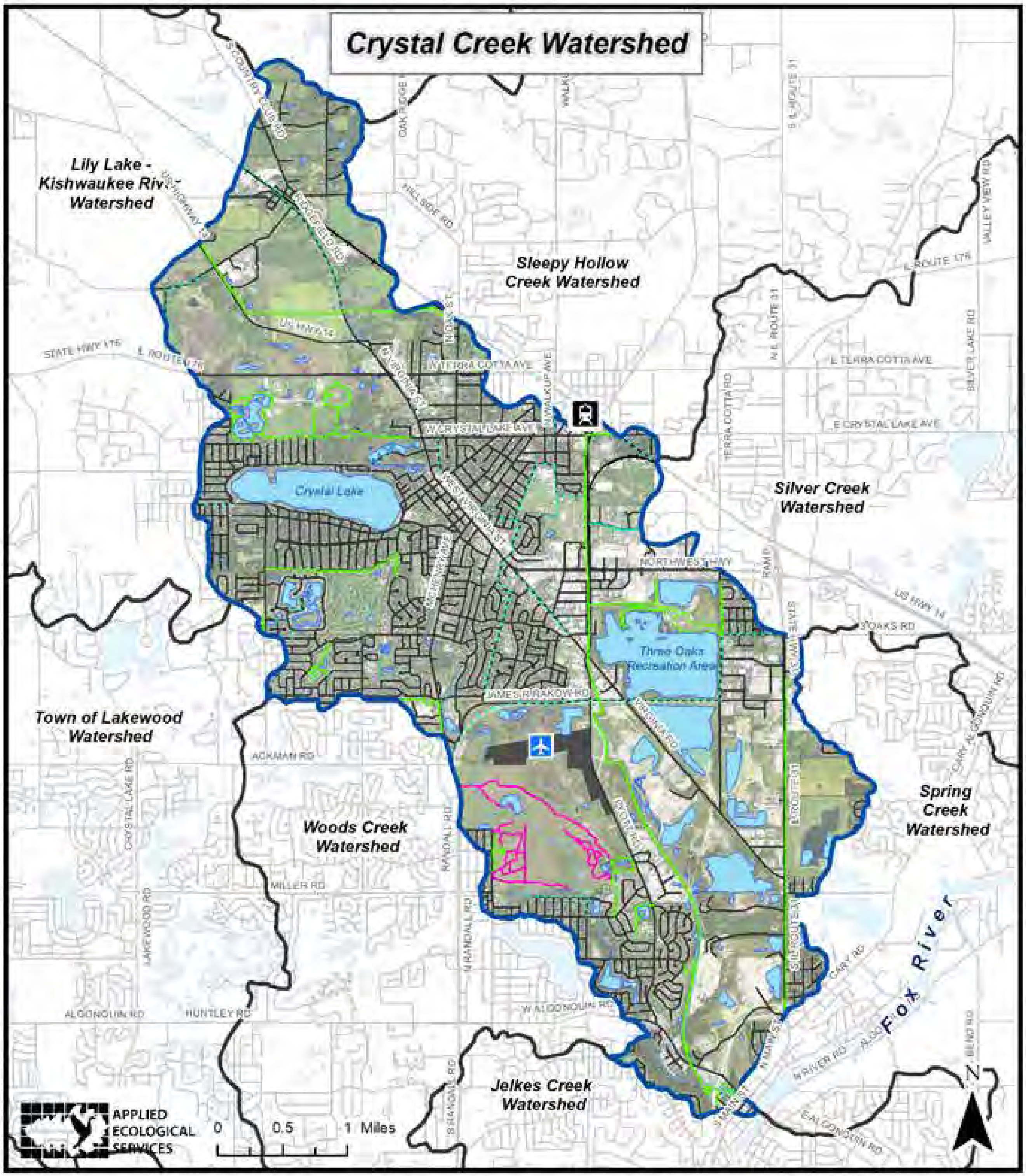


Fig. 19: Existing Transportation Network

DATA SOURCES City of Crystal Lake
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey

Legend

- Crystal Creek Watershed
- Waterbodies (NHD)
- Streams & Tributaries (NHD)
- Roads
- Railroad

Trails

- Future/Planned (CMAP)
- Bike Trail
- Hiking Trail
- Lake in the Hills Airport
- Crystal Lake Metra Station

Prairie Trail overpass (below) and trail (above)

Lake Ave. in Woodstock to Walkup Ave. in Crystal Lake. These trails give the community a unique opportunity to interact with nature as well as allowing cyclists to safely bike from point A to B rather than drive. These trails are essential as there are limited bike lanes within the watershed. As a multi-use trail, the Prairie Trail also serves as a hiking trail. Other trails for walking and hiking within in the watershed are the Lake in the Hills Fen, Lippold Park, and Three Oaks Recreation area.

Lake in the Hills 3CK Airport

3.9 Impervious Cover Impacts

Impervious cover is defined as surfaces of an urban landscape that prevent infiltration of precipitation (Schueler 1994). Imperviousness is an indicator used to measure the impacts of urban land uses on water quality, hydrology and flows, flooding/depressional storage, and habitat related to streams (Figure 20). Based on studies and other background data, Scheuler (1994) and the Center for Watershed Protection (CWP) developed an Impervious Cover Model used to classify streams within subwatersheds into three quality categories: Sensitive, Impacted, and Non-Supporting (Table 13). In general, Sensitive subwatersheds have less than 10% impervious cover, stable stream channels, good habitat, good water quality, and diverse biological communities. Impacted subwatersheds have between 10% and 25% impervious cover, somewhat degraded streams, altered habitat, and decreasing water quality. Non-Supporting subwatersheds generally have greater than 25% impervious cover, highly degraded streams, degraded habitat, poor water quality, and poor-quality biological communities. In addition, runoff over impervious surfaces collects pollutants and warms the water before it enters a stream resulting in negative biological impacts.

The following paragraphs describe the implications of increasing impervious cover:

Water Quality Impacts

Imperviousness affects water quality in streams and lakes by increasing pollutant loads and water temperature. Impervious surfaces accumulate pollutants from the atmosphere, vehicles, roof surfaces, lawns and other diverse sources. During a storm event, pollutants such as nutrients (nitrogen and phosphorus), metals, oil/grease, and bacteria (E. coli) are delivered to streams and lakes. According to monitoring and modeling studies,

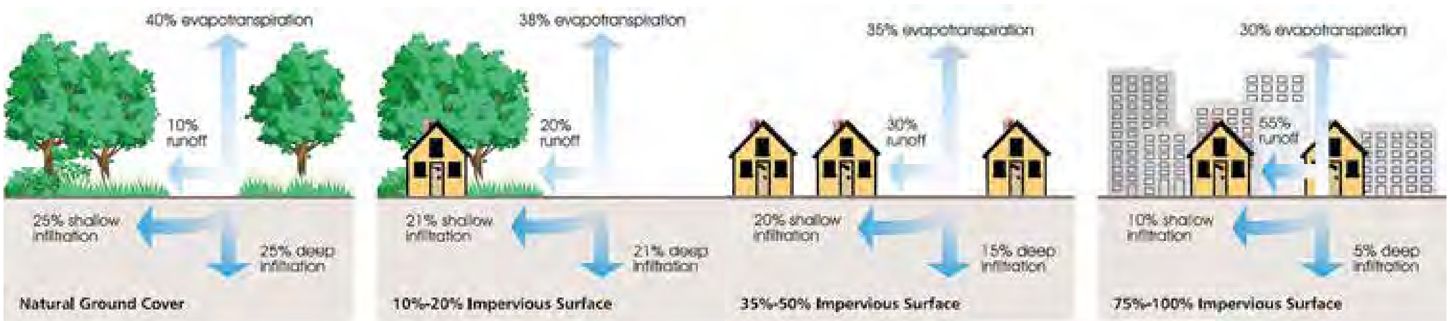


Figure 20. Relationship between impervious surfaces, evapotransporation, & infiltration.
Source: The Federal Interagency Stream Restoration Working Group, 1998 (Rev. 2001).

Sensitive Stream

Impacted Stream

Non-Supporting Stream

increased imperviousness is directly related to increased urban pollutant loads (Schueler 1994). Furthermore, impervious surfaces can increase stormwater runoff temperature as much as 12 degrees compared to vegetated areas (Galli, 1990). According to the Illinois Pollution Control Board (IPCB), water temperatures exceeding 90°F (32.2°C) can be lethal to aquatic fauna and can generally occur during hot summer months.

Hydrology and Flow Impacts
Higher impervious cover translates to greater runoff volumes thereby changing hydrology and flows in streams. If unmitigated, high runoff volumes can result in higher floodplain elevations (Schueler 1994). In fact, studies have shown that even relatively low percentages of imperviousness (5% to 10%) can cause peak discharge rates to increase by a factor of 5 to 10, even for small storm events. Impervious areas come in two forms: 1) disconnected and 2) directly connected. Disconnected impervious areas are represented primarily by rooftops, so long as the rooftop runoff does not get funneled to impervious driveways or a storm sewer system. Significant portions of runoff from disconnected surfaces usually infiltrate into soils more readily than directly connected impervious areas such as parking lots that typically end up as stormwater runoff directed to a storm sewer system that discharges directly to a waterbody.

Flooding and Depressional Storage Impacts
Flooding is an obvious consequence of increased flows

Category	% Impervious	Subwatershed Description
Sensitive	<10%	Stable stream channels, excellent habitat, good water quality, and diverse biological communities
Impacted	>10% but <25%	Somewhat degraded stream channels, altered habitat, decreasing water quality, and fair-quality biological communities.
Non-Supporting	>25%	Highly degraded stream channels, degraded habitat, poor water quality, and poor-quality biological communities.

Table 13. Impervious category & stream condition via the Impervious Cover Model (Zielinski 2002)

resulting from increased impervious cover. As stated above, increased impervious cover leads to higher water levels, greater runoff volumes, and high floodplain elevations. Higher floodplain elevations usually result in more flood problem areas. Furthermore, as development increases, wetlands and other open space decrease. A loss of these areas results in increased flows because wetlands and open space typically soak up rainfall and release it slowly via groundwater discharge to streams and lakes. Detention basins can and do minimize flooding in highly impervious areas by regulating the discharge rate of stormwater runoff, but detention basins do not reduce the overall increase in runoff volume.

Habitat Impacts

A threshold in habitat quality exists at approximately 10% to 15% imperviousness (Booth and Reinelt 1993). When a stream receives more severe and frequent runoff volumes compared to historical conditions, channel dimensions often respond through the process of erosion by widening, downcutting, or both, thereby enlarging the channel to handle the increased flow. Channel instability leads to a cycle of streambank erosion and sedimentation resulting in physical habitat degradation (Schueler 1994). Streambank erosion is one of the leading causes of sediment suspension and deposition in streams leading to turbid conditions that may result in undesirable changes to aquatic life (Waters 1995). Sediment deposition alters habitat for aquatic plants and animals by filling interstitial spaces in substrates important to benthic macroinvertebrates and some fish species. Physical habitat degradation also occurs when high and frequent flows result in loss of riffle-pool complexes.

Impervious Cover Estimate & Future Vulnerability

In order to assess which lands are most vulnerable to future changes in impervious cover, AES compares current impervious estimates to future impervious estimates based on comprehensive plans and future land use projections and then determines where the highest increase in impervious cover are likely to occur and which subwatersheds are most vulnerable to those changes. This assessment is by no means meant to prevent or deter future urbanization or land use change, but rather to determine which areas might be most in need of utilizing conservation design or low impact development when change does occur so as to protect remaining natural resources. This assessment is highly dependent on impervious cover and the potential of development in the future.

In 1998, the Center for Watershed Protection (CWP) published the Rapid Watershed Planning Handbook. This document introduced rapid assessment methodologies for watershed planning. The CWP released the Watershed Vulnerability Analysis as a refinement of the techniques used in the Rapid Watershed Planning Handbook (Zielinski 2002). The vulnerability analysis focuses on existing and predicted impervious cover as the driving forces impacting potential stream quality within a watershed. It incorporates the Impervious Cover Model described at the beginning of this subsection to classify Subwatershed Management Units (SMUs). SMUs are defined and examined in more detail in Section 3.3.

AES used a modified Vulnerability Analysis to compare each SMU's vulnerability to projected land use changes across Crystal Creek watershed. Three steps were used to generate a vulnerability ranking of the SMUs. The results are used to make and rank recommendations in the Action Plan related to curbing the negative effects of predicted land use changes on the watershed. The three steps are listed below and described in detail in the following pages:

- ➤ **Step 1:** Initial classification of SMUs based on existing (2013) land use/land cover and impervious cover
- ➤ **Step 2:** Future (2030) classification of SMUs based on predicted land use/land cover and impervious cover
- ➤ **Step 3:** Assign each SMU a vulnerability ranking based on forecasted changes in impervious cover and classification

Step 1: Initial Classification

Step 1 in the Vulnerability Analysis is an initial classification of each SMU based on existing (2013) measured impervious cover. Calculating existing (2013) and predicted (2030) impervious cover in Crystal Creek watershed begins with an analysis of land use/land cover. Existing (2013) impervious cover is calculated by assigning an impervious cover percentage for each land use/land cover category based upon the U.S. Department of Agriculture's (USDA) Technical Release 55 (TR55) (USDA 1986). TR55 provides estimates of impervious cover based on land use categories. Highly developed land such as commercial/retail for example is estimated to have over 70% impervious cover while a typical medium density residential development exhibits around 25% impervious cover. Open space areas generally have less than 5% impervious cover. GIS analysis is used to estimate the percent impervious cover for each SMU in the watershed using existing and predicted land use/land cover data. Each SMU then receives an initial classification (Sensitive, Impacted, or Non-Supporting) based on percent of existing impervious cover (Table 14; Figure 21).

All 8 SMUs are classified as Non-Supporting based on existing (2013) impervious cover.

Step 2: Predicted Future Impervious Cover Classification

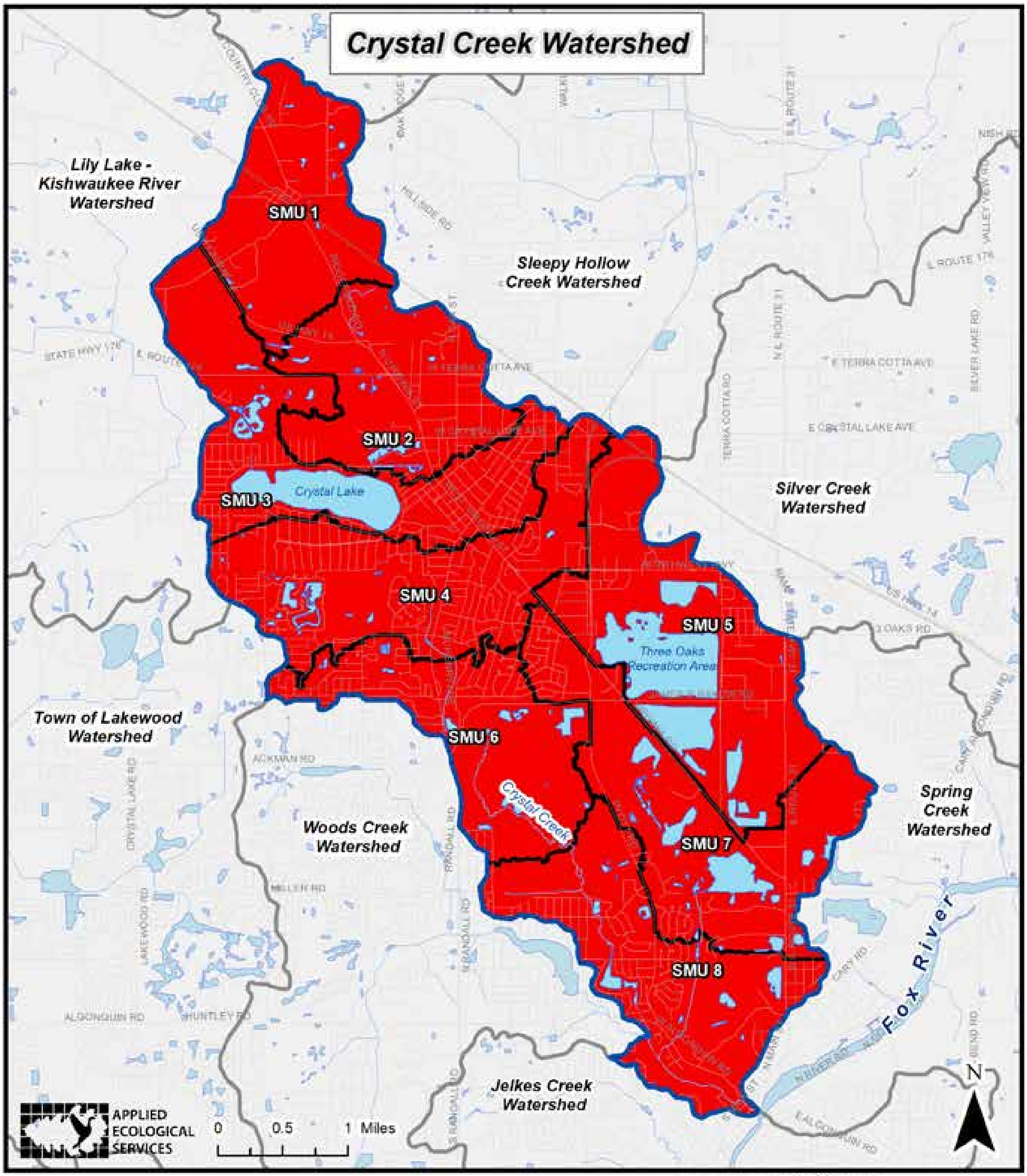
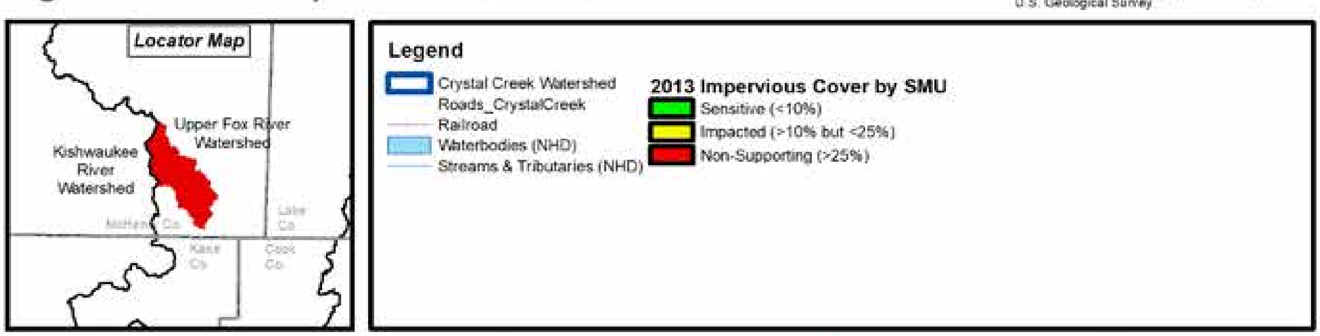


Fig. 21: Current Impervious Cover Classification

DATA SOURCES City of Crystal Lake
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey



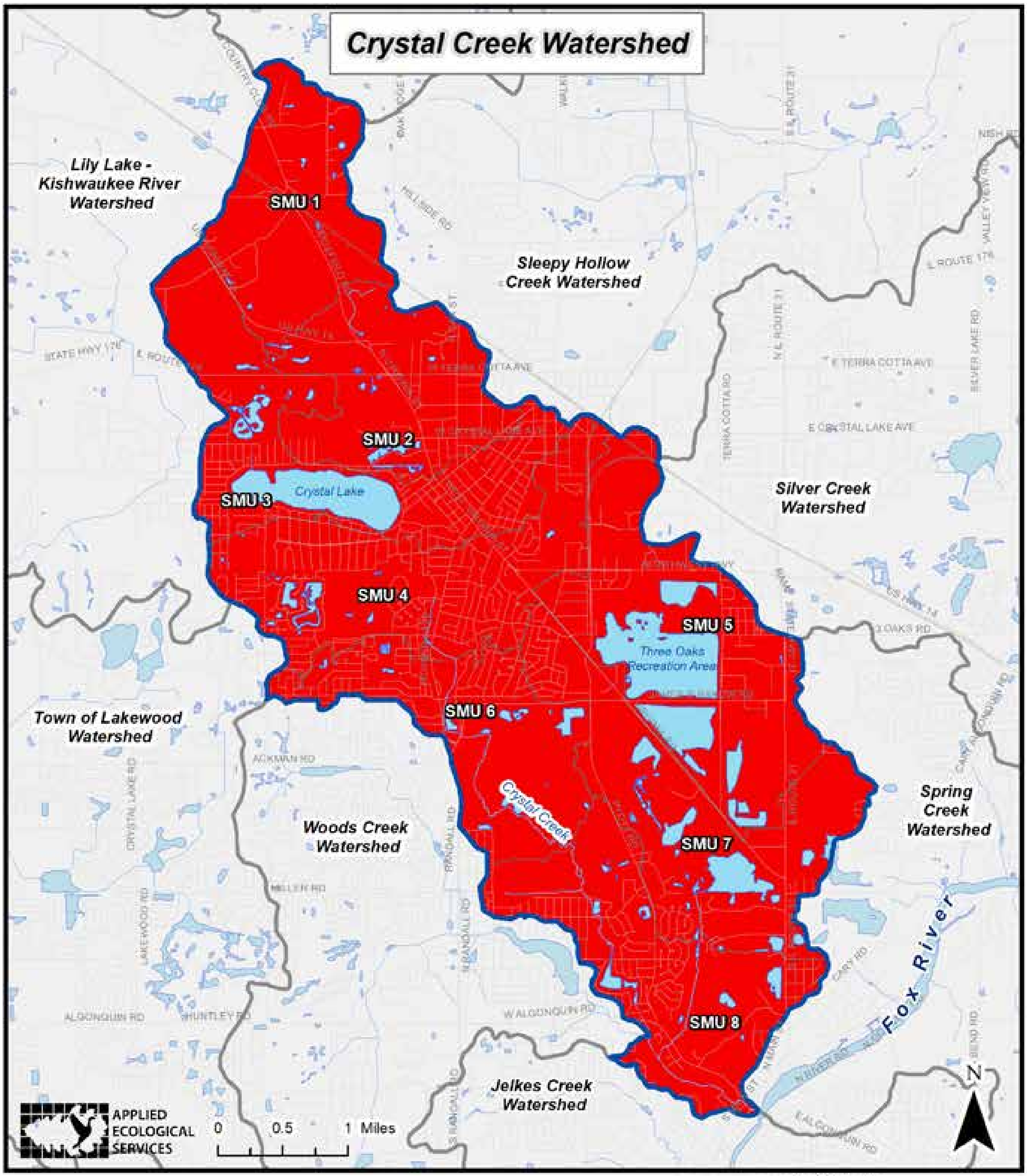


Fig. 22: Future Impervious Cover Classification

DATA SOURCES City of Crystal Lake
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey

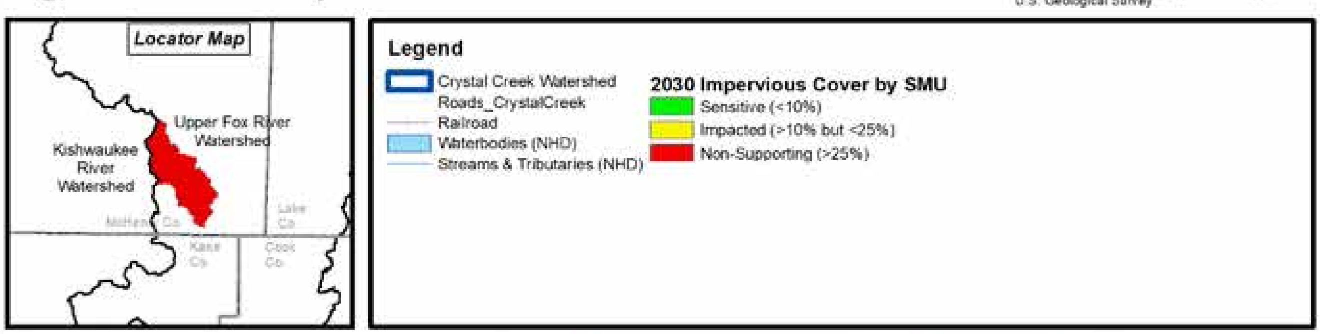


Table 14. Existing (2013) & predicted (2030) impervious cover for Subwatershed Management Units (SMUs).

SMU #	Step 1: Existing Impervious %	Existing (2013) Impervious Classification	Step 2: Predicted Impervious %	Predicted (2030) Impervious Classification	Percent Change	Step 3: Vulnerability
SMU 1	28.3%	Non-Supporting	46.4%	Non-Supporting	18.1%	High
SMU 2	35.3%	Non-Supporting	49.8%	Non-Supporting	14.6%	High
SMU 3	36.5%	Non-Supporting	44.3%	Non-Supporting	7.7%	Medium
SMU 4	54.0%	Non-Supporting	59.7%	Non-Supporting	5.7%	Low
SMU 5	49.1%	Non-Supporting	55.9%	Non-Supporting	6.7%	Medium
SMU 6	34.0%	Non-Supporting	52.1%	Non-Supporting	18.1%	High
SMU 7	59.1%	Non-Supporting	62.2%	Non-Supporting	3.2%	Low
SMU 8	44.2%	Non-Supporting	50.1%	Non-Supporting	5.9%	Low

Predicted (by 2030) impervious cover was evaluated in Step 2 of the vulnerability analysis by classifying each SMU as Sensitive, Impacted, or Non-Supporting based on predicted land use changes. Figure 22 depicts predicted 2030 impervious cover classifications for each SMU. This step identifies Sensitive and Impacted SMUs that are most vulnerable to future development pressure. All 7 SMUs are classified as Non-Supporting based on future (2030) impervious cover as well. (Table 14; Figure 22)

Step 3: Vulnerability Ranking
The vulnerability of each SMU to predicted future land use changes was determined by considering the following questions:

- Will the SMU classification change?
- Does the SMU classification come close to changing (within 2%)?
- What is the absolute change in impervious cover from existing to projected conditions?

Vulnerability to future development for each SMU was categorized as Low, Medium, or High:

Low = no change in classification; <6% change in impervious cover

Medium = 6-10% change in impervious cover

High = >10% change in impervious cover

The vulnerability analysis resulted in 3 High, 2 Medium, and 3 Low ranked SMUs (Table 14; Figure 23). SMUs 1, 2, and 6 are ranked as highly vulnerable to future problems associated with impervious cover. SMUs 3 and 5 are ranked as medium vulnerability; and SMUs 4, 7, and 8 are ranked as Low Vulnerability. While all SMUs are classified as Non-Supporting, the vulnerability analysis identifies those most at risk from the impacts of increasingly impervious cover.

The results of this analysis clearly point to the portions of the watershed where agriculture and open space currently exist and therefore define them as critical areas where future development could result in negative impacts to Crystal Creek and downstream waterways. It will be important to develop this area using Conservation Design standards that incorporate the most effective and reliable Stormwater Treatment Train practices whereby stormwater is routed through various Management Measures prior to being released from the site.

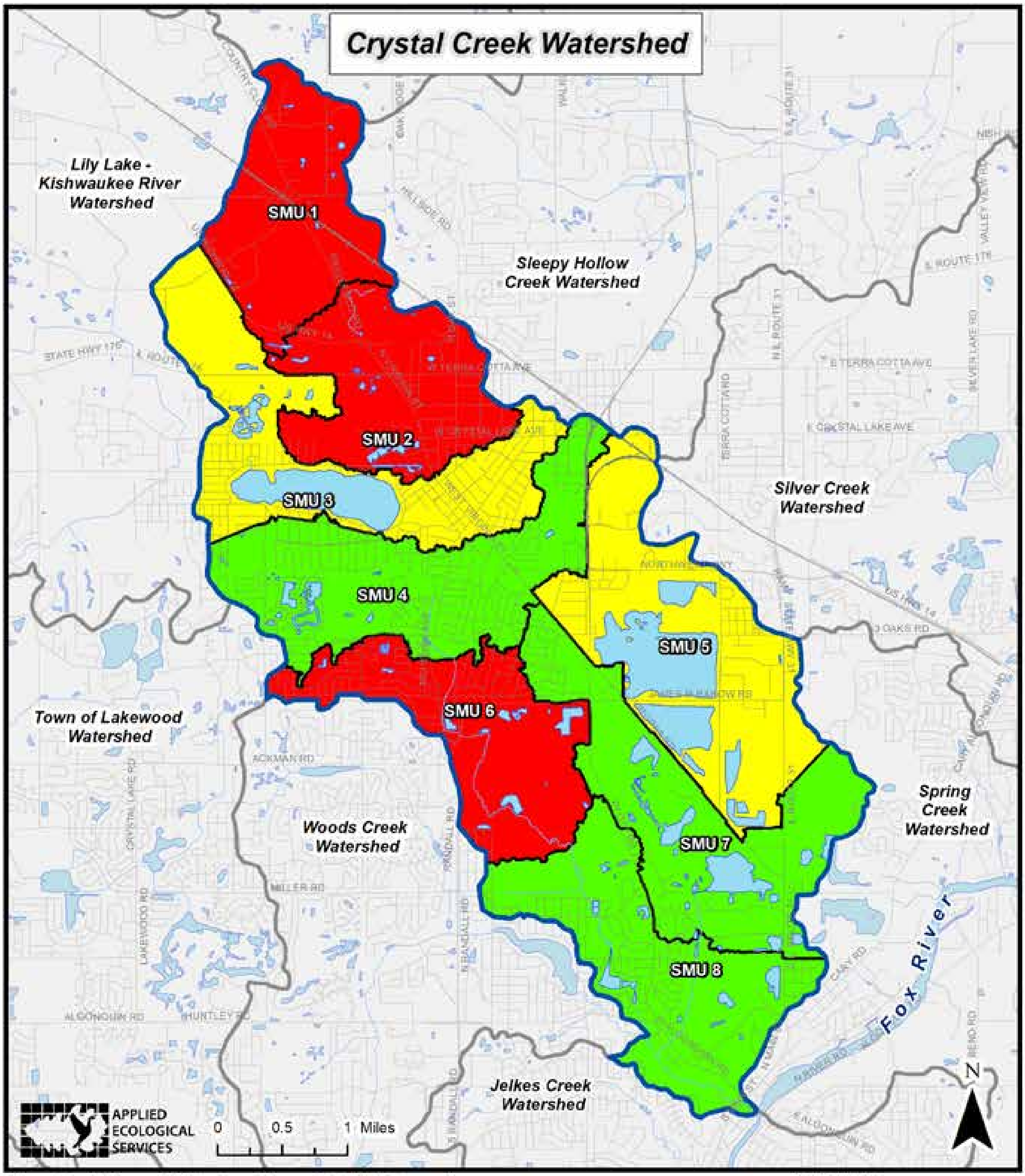
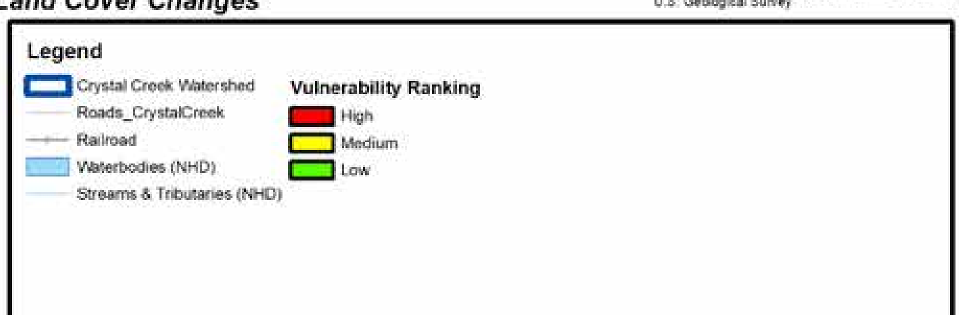


Fig. 23: Vulnerability Ranking of SMUs based on Predicted Future Land Use/Land Cover Changes

DATA SOURCES City of Crystal Lake
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey



Noteworthy-Conservation Design*

“Conservation Design” facilitates development while preserving the most valuable natural features and functions of a site. It does this through flexible land development techniques to the arrangement and construction of dwellings, roads, drainage systems, and infrastructure improvements in relation to valuable natural features.

Such flexibility is intended to retain or increase the development rights of the property owner and the number of occupancy units permitted by the underlying zoning designation, while encouraging environmentally responsible development.

“Conservation Design” is most appropriate in areas having natural and open space resources to be protected and preserved such as floodplains, groundwater recharge areas, wetlands, woodlands, streams, wildlife habitat, etc. The approach first takes into account the natural landscape and ecology of a development site rather than determining design features on the basis of pre-established density criteria. The general steps included below are generally followed when designing the layout of a development site:

Example
Conservation Design

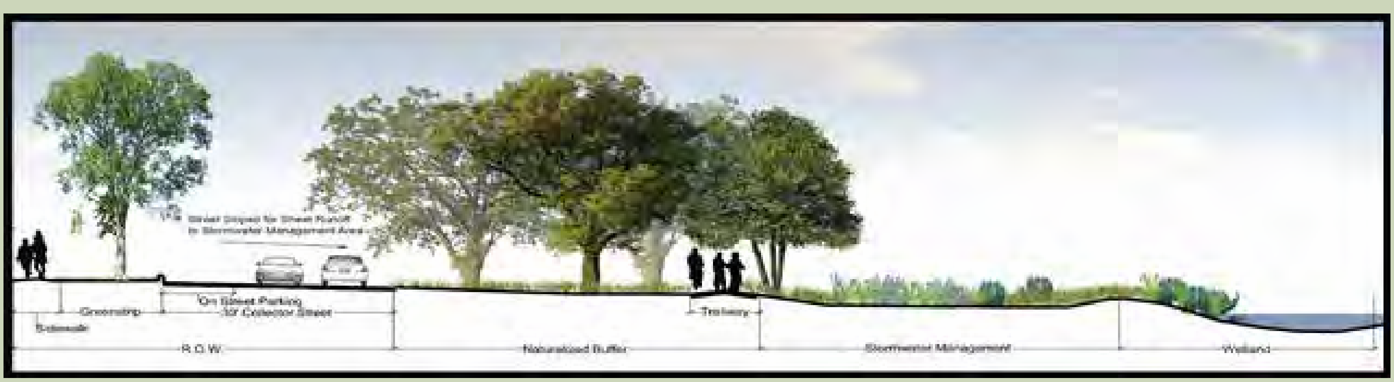
Step 1: Identify all natural resources, conservation areas, open space areas, physical features, and scenic areas and preserve and protect these areas from any negative impacts generated as a result of the development.

Step 2: Locate building sites to take advantage of open space and scenic views by requiring smaller lot sizes or cluster housing as well as to protect the development rights of the property owner and the number of occupancy units permitted by the underlying zoning of the property.

Step 3: Design the transportation system to provide access to building sites and to allow movement throughout the site and onto adjoining lands; roads should not traverse sensitive natural areas.

Step 4: Prepare engineering plans which indicate how each building site can be served by essential public utilities while at the same time acknowledging the need to preserve and protect environmental resources.

**Paraphrased from City of Woodstock, Illinois Conservation Design section of Unified Development Ordinance*



Example of Stormwater Treatement Train within Conservation District

3.10 Open Space Inventory, Prioritization, & Green Infrastructure Network

A major component of watershed planning includes an examination of open space to determine how it best fits into a "Green Infrastructure Network" which is best defined as an interconnected network of natural areas and other open space that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife (Benedict 2006). Natural features such as stream corridors, wetlands, floodplain, woodlands, and grassland are the primary components of green infrastructure. Working lands such as farms and undeveloped portions of existing parcels that abut natural areas are also considered components of a Green Infrastructure Network. This assessment is by no means meant to prevent or deter future urbanization or land use change, but rather to determine which areas might be most in need of utilizing conservation design or low impact development when change does occur so as to protect remaining natural resources, and to identify existing developed lands that could be managed for maximum green infrastructure benefit, restoration, and preservation. A three-step process was used to create a Green Infrastructure Network for Crystal Creek watershed:

- **Step 1:** All parcels of land in the watershed were categorized as open space, partially open space, or developed.
- **Step 2:** All open and partially open parcels were prioritized based on a set of criteria important to green infrastructure.
- **Step 3:** Prioritized open and partially open parcels, linking parcels, Ecologically Significant Areas, and stakeholder recommendations were combined to form a network.

For this watershed plan, an "open space" parcel is generally defined as any parcel that is not developed such as a nature preserve or agricultural field. "Partially open" parcels have been developed to some extent, but the parcels still offer potential green infrastructure opportunities. Examples of partially open parcels include school grounds and residential lots generally greater than two to three acres with minimal development. Parcels that are mostly built out such as commercial/retail areas and roads are considered "developed." Public versus private and protected versus unprotected status of open and partially open space parcels are other important green infrastructure attributes that are discussed in more detail below. Parcels range in size from less than 1 acre to 187 acres with a 1-acre average.

Open, Partially Open, & Developed Parcels

Step 1 in creating a Green Infrastructure Network was completed by categorizing all parcels in the watershed as open, partially open, or developed. Open parcels comprise approximately 4,317 acres or 36% of the watershed. Partially open parcels make up another 2,644 acres or 22% of the watershed. Developed parcels and unclassified roads account for another 5,076 acres or 42% of the watershed. Figures 24 and 25 summarize and depict Step 1 results used to develop the Green Infrastructure Network. Most open and partially open parcels are located along Crystal Creek and its tributaries, near Lake in the Hills Fen, Three Oaks Recreation Area, and Lippold Park and the northern agricultural portions of the watershed.

Public/Private Ownership of Open and Partially Open Parcels

The public or private ownership of each open and partially open parcel was determined from available parcel data. Developed parcels are not included in this summary. Publicly owned parcels include those owned by federal, state, county, or municipal government, park districts, and school districts. Public open and partially open parcels account for 30% and 6% of the open and partially open acreage respectively (Figures 26 & 28). Private ownership types include homeowners/business associations, land conservancy, commercial, residential, agricultural, etc. Private open parcels comprise 32% of the open and partially open acreage whereas private partially open parcels comprise

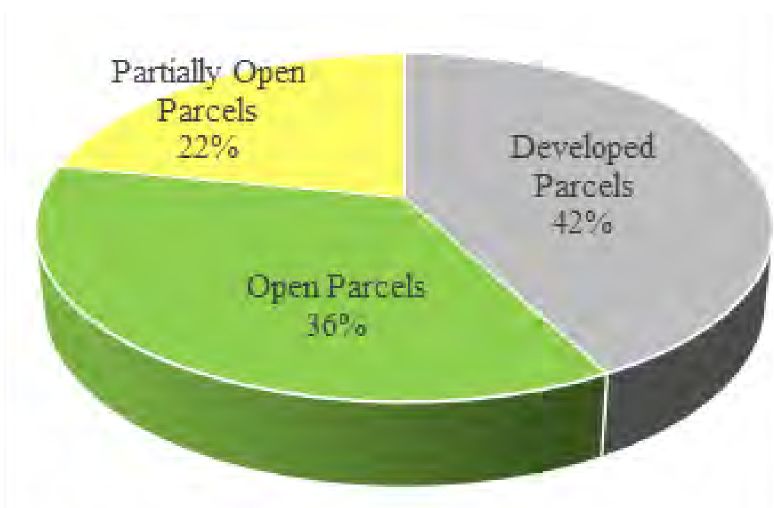


Figure 24. Distribution of open, partially open, and developed parcels.

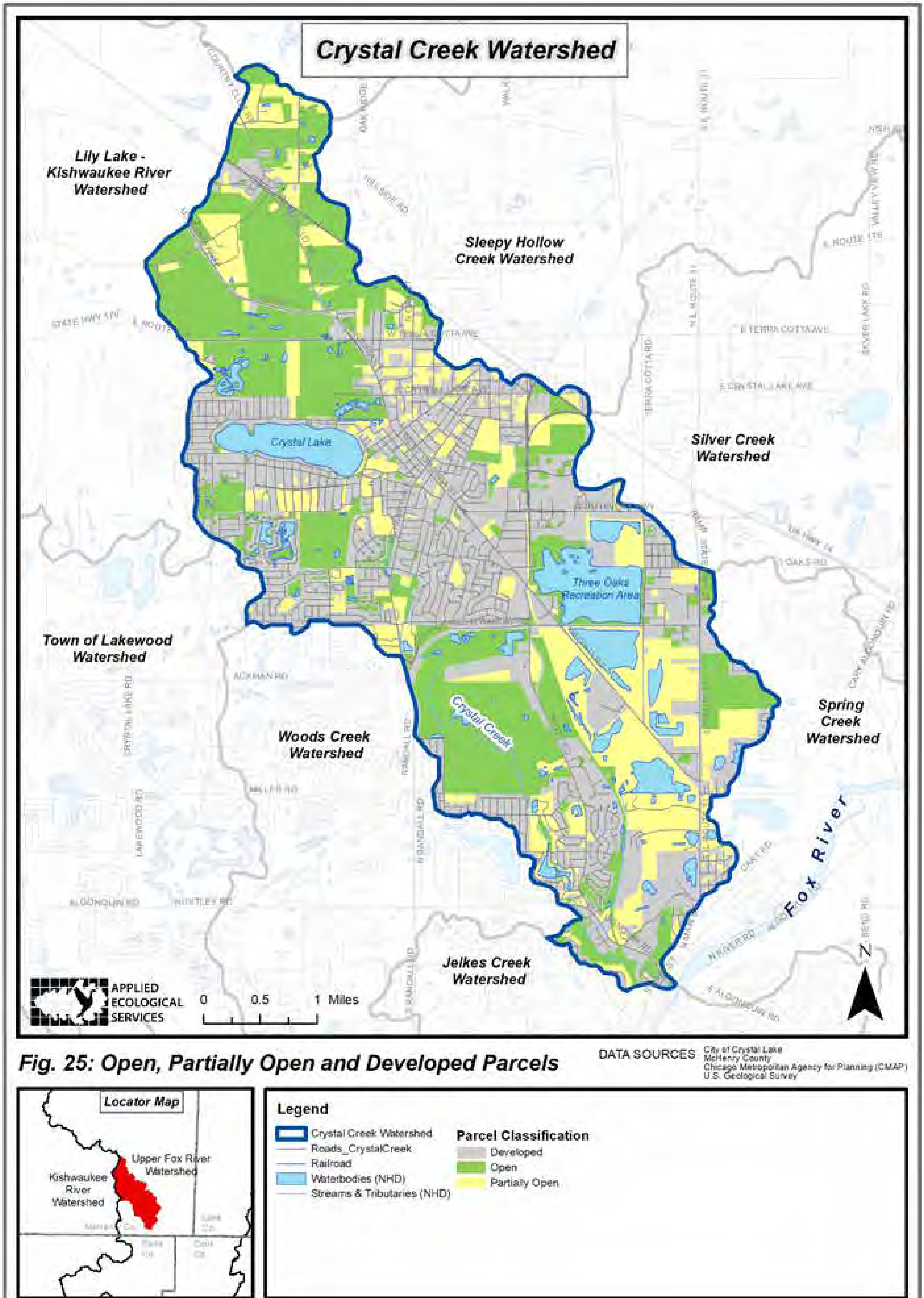


Fig. 25: Open, Partially Open and Developed Parcels

32%. Most public open and partially open parcels are owned by municipalities, park districts, and forest preserve districts.

Protected Status of Open and Partially Open Parcels

Preservation of open space is critical to maintaining and expanding green infrastructure and is an important component of sustaining water quality, hydrological processes, ecological function, and the general quality of life for both wildlife and people. Without preservation, open space can be converted to other less desirable land uses in the future. Protected open and partially open parcels account for about 36% of the open and partially open parcel acreage in the watershed while unprotected open and partially open parcels account for the remaining 64% (Figures 27 & 29). Most public open and partially open parcels are owned by municipalities, park districts, and forest preserve districts.

The most critical unprotected open and partially open parcels include land currently owned by Hanson Material Service along Tributary 2 and agricultural lands north of Lippold Park. All these areas are currently open space connected or adjacent to protected green infrastructure. Future development that incorporates conservation design and/or Stormwater Treatment Train systems will be extremely important in these areas to improve water quality and reduce stormwater runoff volume to Crystal Creek while also expanding the protected green infrastructure in the southern portion of the watershed.

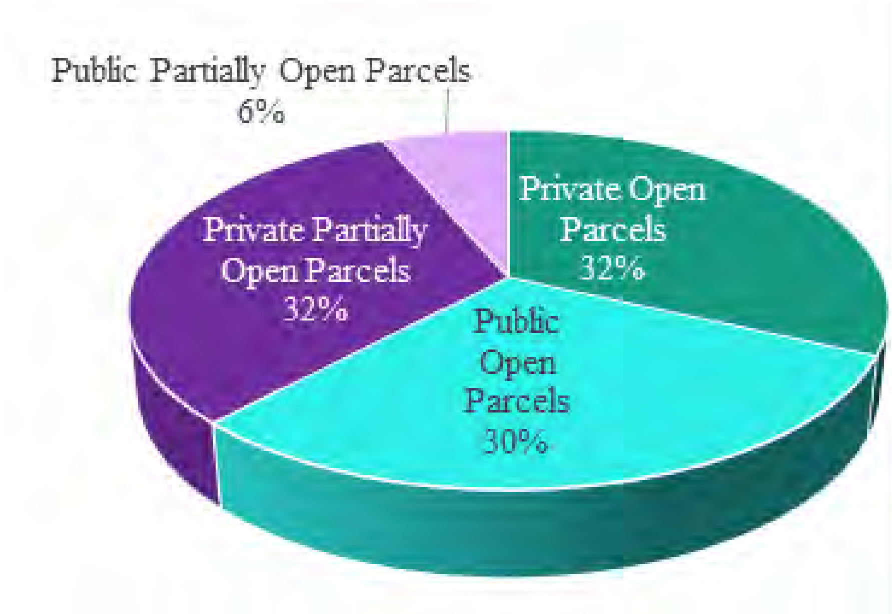


Figure 26. Distribution of private and public open and partially open parcels.

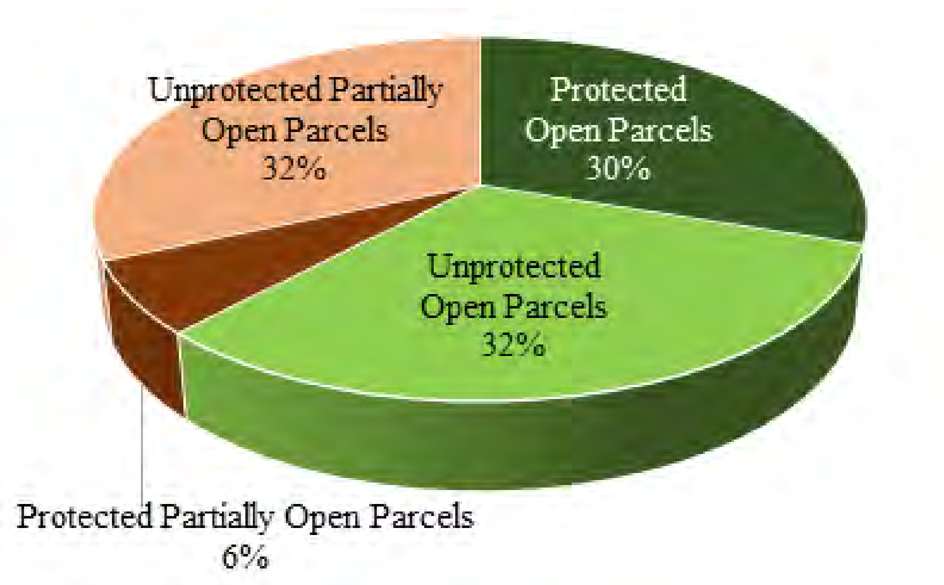


Figure 27. Distribution of protected and unprotected open and partially open parcels.

Open Space Parcel Prioritization

Step 2 in creating a Green Infrastructure Network for Crystal Creek watershed was completed by prioritizing open and partially open parcels. For this step, 11 prioritization criteria important to green infrastructure were examined via a GIS analysis (Table 15). If an open or partially open parcel met a criterion it received one point. If the parcel did not meet that criterion, it did not receive a point. This process was repeated for each open and partially open parcel and for all criteria. The total points received for each parcel were summed to determine parcel importance within the Green Infrastructure Network. Parcels with the highest number of points are more important to green infrastructure than parcels that met fewer criteria. Note: the prioritization process was not completed for developed parcels.

The combined possible total of points any one parcel can accumulate is 11 (11 of 11 total criteria met). The highest total value received by a parcel in the

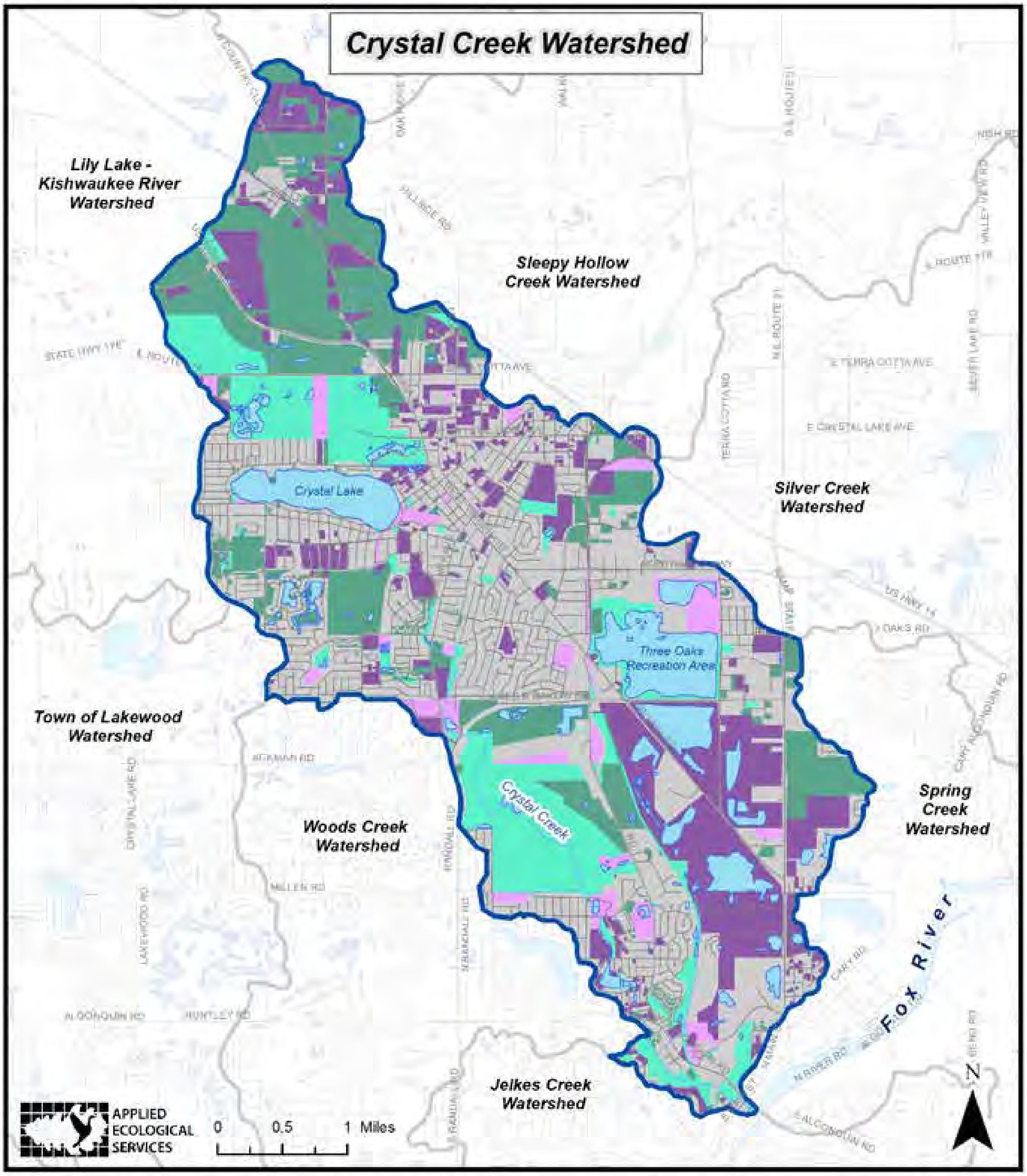


Fig. 28: Public vs Private Ownership of Open and Partially Open Parcels

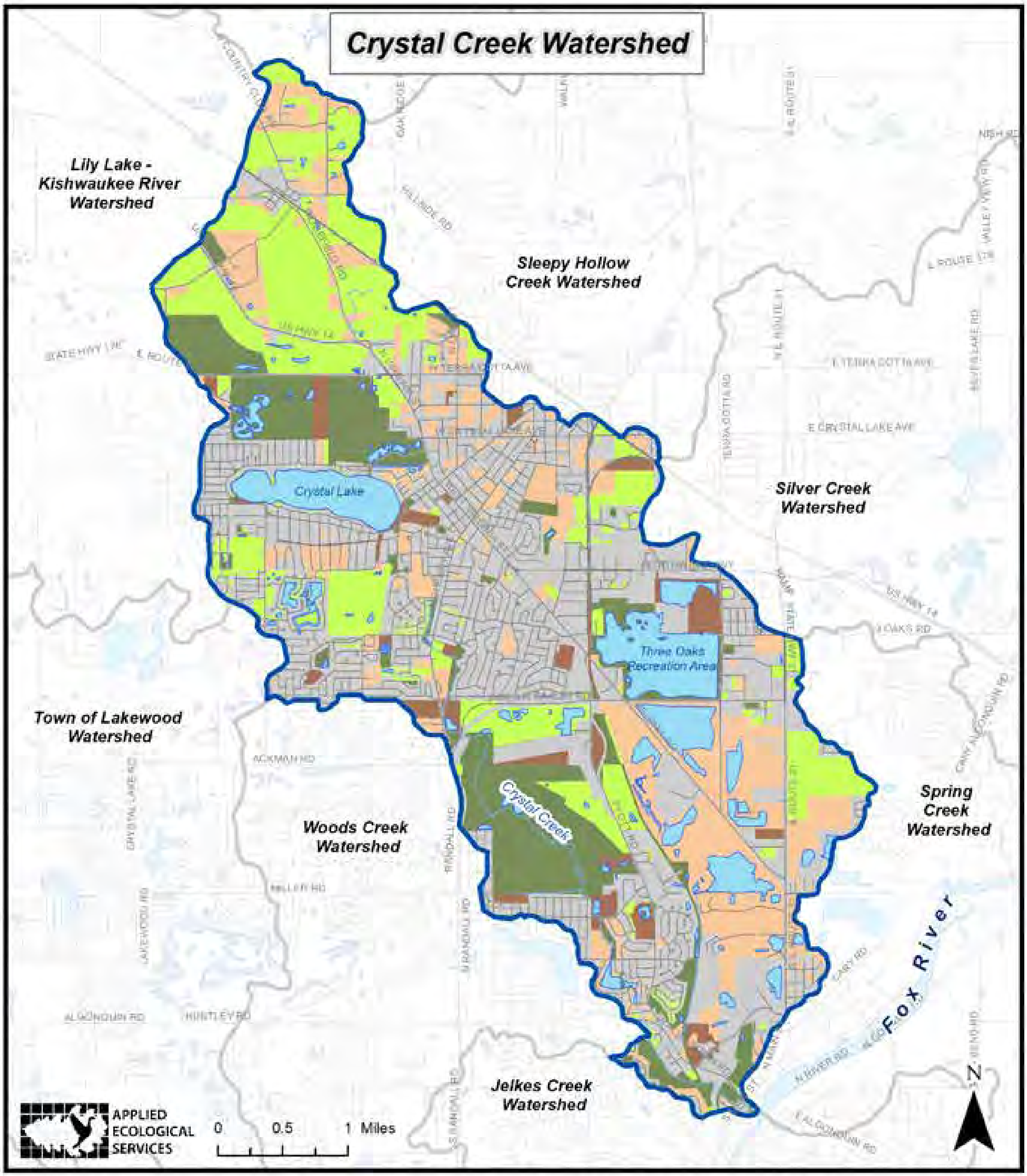


Fig. 29: Protection Status of Open and Partially Open Parcels

weighting process was 11 (having met 11 of the 11 criteria). After completion of the prioritization, parcels were categorized as "High Priority", "Medium Priority", or "Low Priority" based on point totals. Parcels meeting 7-11 of the criteria are designated High Priority for inclusion into the Green Infrastructure Network while parcels meeting 4-6 criteria are designated Medium Priority. Parcels with a combined value of 0-3 are categorized as Low Priority but are not necessarily excluded from the Green Infrastructure Network based on their location or position as linking parcels.

Towne Park

Figure 30 depicts the results of the parcel prioritization. An obvious correlation can be seen between High Priority green infrastructure parcels and their relation to Crystal Creek and its tributaries and/or existing Ecologically Significant Natural Areas. Many of the Medium Priority parcels abut existing protected green infrastructure such as Lake in the Hills Fen and Lippold Park. Much of the area including the gravel quarries along Tributary 2 are also Medium Priority. Parcel size did not play a role in the parcel prioritization process for this watershed plan.

Green Infrastructure Network

The final step (Step 3) in creating a Green Infrastructure Network for Crystal Creek watershed involves laying out the network by incorporating; 1) prioritized open space results from Step 2, 2) Ecologically Significant Areas (see Section 3.10), 3) information gathered during the watershed characteristics inventory, and 4) stakeholder recommendations. County and regional wide green infrastructure plans generally focus on natural features such as stream corridors, wetlands, floodplain, buffers, and other natural components. The Green Infrastructure Network created for Crystal Creek watershed captures all the natural components and other green infrastructure such as recreational parks, large residential lots, schools, and golf courses at the parcel level. Parcel level green infrastructure planning is important because land purchases, acquisitions, and land use changes almost always occur at the parcel level.

Perhaps the most important aspect of green infrastructure planning

Table 15. Criteria used to prioritize parcels for a Green Infrastructure Network.

Green Infrastructure Criteria
1. Open or partially open parcels that intersect FEMA 100-year floodplain
2. Open or partially open parcels within 0.5-miles of any headwater stream
3. Open or partially open parcels that intersect a wetland
4. Open or partially open parcels that intersect a high quality (ADID) wetland
5. Open or partially open parcels that intersect a potential wetland restoration site
6. Open or partially open parcels that are within 100 feet of a watercourse or lake
7. Open or partially open parcels in a "Highly or Moderately Vulnerable" Land Use/Land Cover SMU
8. Open or partially open parcels adjacent to or including private or public protected open space
9. Open or partially open parcels that intersect Highly Sensitive Aquifer Recharge Areas
10. Open or partially open parcels that intersect existing or planned trails
11. Open or partially open parcel that intersects an Ecologically Significant Natural Area site

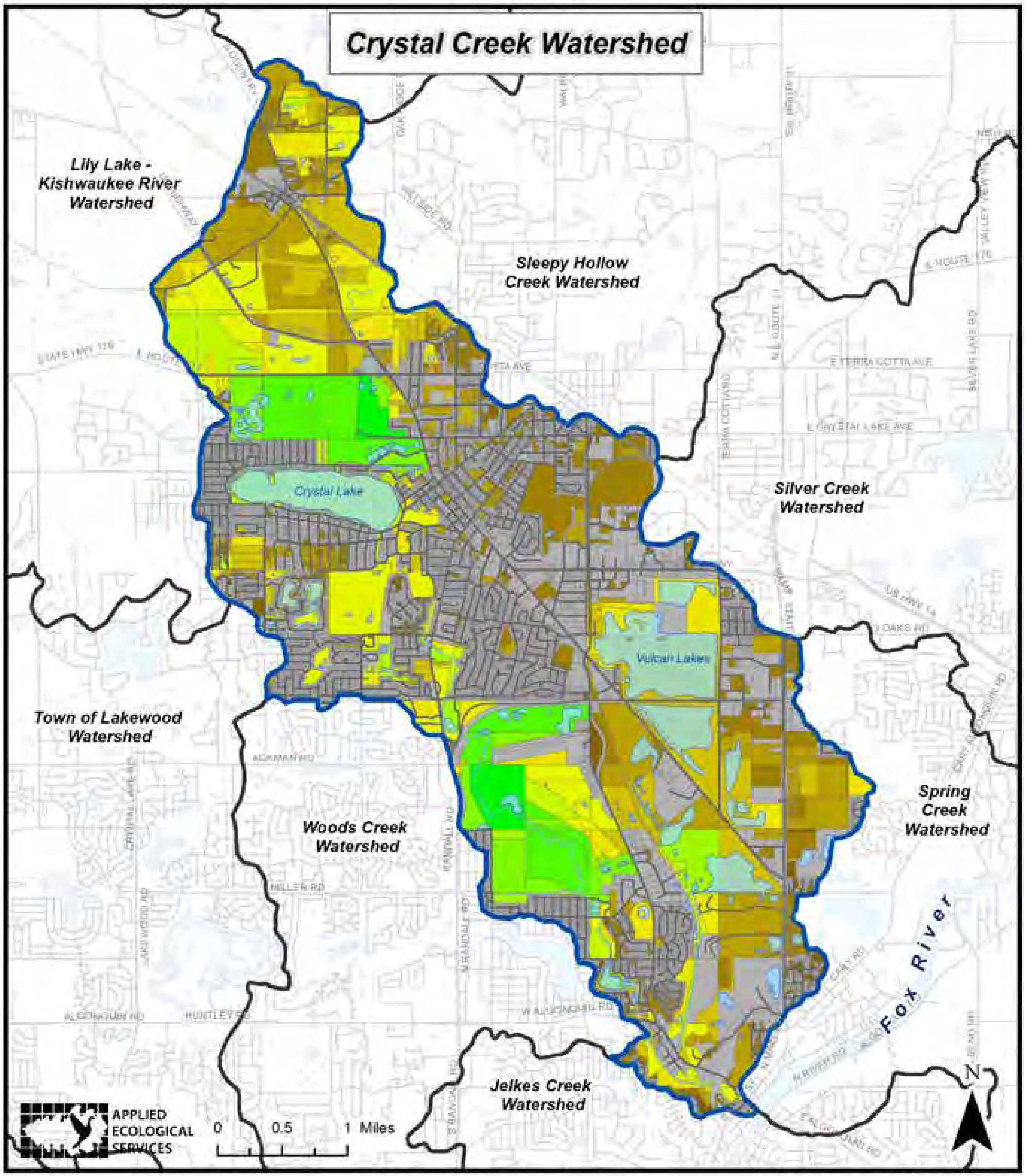
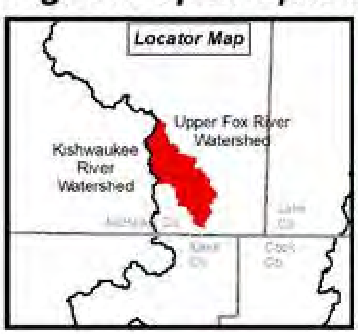


Fig. 30: Open Space Parcel Prioritization

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey



Legend

- Crystal Creek Watershed
- Roads_CrystalCreek
- Railroad
- Waterbodies (NHD)
- Streams & Tributaries (NHD)
- Developed Parcel

Prioritization Points Total

0 - Low, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 - High

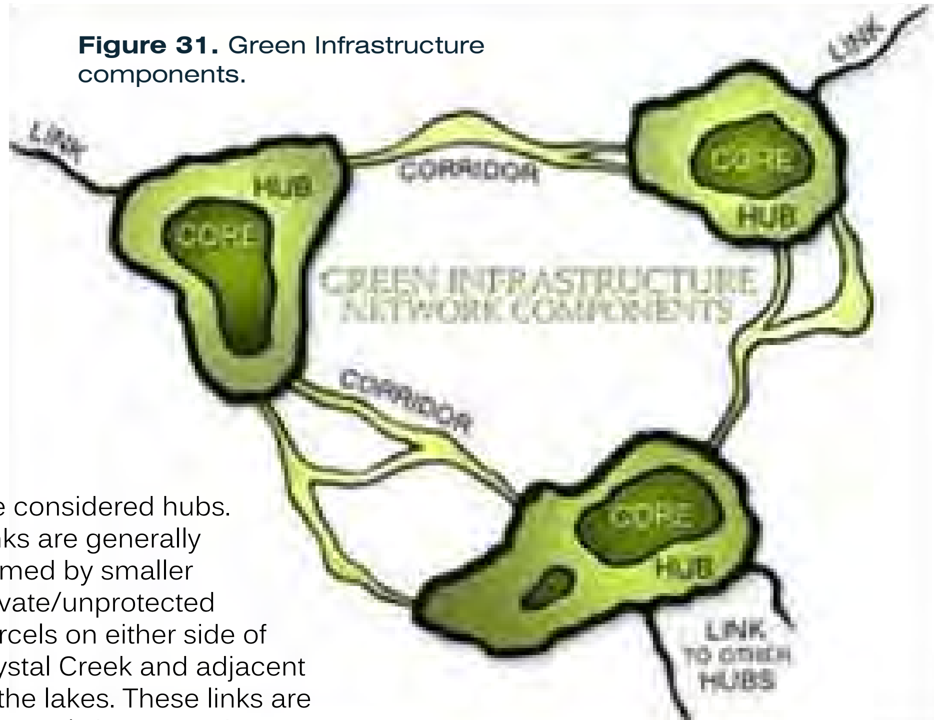
is that it helps communities identify and prioritize conservation opportunities and plan development in ways that optimize the use of land to meet the needs of people and nature (Benedict 2006). Green infrastructure planning provides a framework for future growth that identifies areas not suitable for development, areas suitable for development but that should incorporate conservation design standards, and areas that do not affect green infrastructure. This assessment is by no means meant to prevent or deter future urbanization or land use change, but rather to determine which areas might be most in need of utilizing conservation design or low impact development when change does occur so as to protect remaining natural resources, and to identify existing developed lands that could be managed for maximum green infrastructure benefit, restoration, and preservation.

Green Infrastructure Network *implementation* has several actions:

- ➤ Protect specific unprotected green infrastructure parcels through acquisition, regulation, and/or incentives.
- ➤ Incorporate conservation design standards on green infrastructure parcels where development is planned.
- ➤ Limit future subdivision of green infrastructure parcels.
- ➤ Implement long term management of green infrastructure.

The Green Infrastructure Network for Crystal Creek watershed is shown on Figure 32. The network is a system of Hubs, Links, and Sites (Figure 31). Hubs generally consist of the largest and least fragmented areas. Ecologically Significant Natural Areas and most of the immediate riparian corridors along Crystal Creek and its tributaries that are currently owned by local municipalities, park districts, or the conservation district are considered hubs. Links are generally formed by smaller private/unprotected parcels on either side of Crystal Creek and adjacent to the lakes. These links are extremely important because they provide biological conduits between hubs. However, most of the linking parcels are not ideal green infrastructure until residents embrace the idea of naturalizing lakeshore and streambank property. Sites are in many cases not connected to the larger green infrastructure network but can still provide important ecological and social values. The Green Infrastructure Network for Crystal Creek watershed consists of 765 parcels and totals 5,622 acres, of which 2,408 acres (43%) are protected.

Figure 31. Green Infrastructure components.



Most of the green infrastructure parcels that may become available for purchase in the future are located either in the northernmost portion of the watershed or along Tributary 2 extending north towards Three Oaks Recreation Area and will likely be developed. Other parcels or sections of parcels such as those adjacent to existing protected ecologically significant natural areas may be better utilized as protected natural open space via several potential tools; 1) acquisition, 2) regulation, 3) incentives, and/or conservation development. The simplest form of acquisition is through outright purchase or donation of land but can also occur through conservation easements and land trusts. Protection of land through state and federal regulation covers natural features such as wetlands or threatened and endangered species/important habitat. Local regulation protection occurs by enforcing stormwater, zoning, comprehensive plans, and subdivision ordinances. Regulatory action can also come in the form of Special Service Area assessments and Development Impact Fees. Land protection through incentives usually occurs on smaller private lands. Some incentives include landowner recognition/rewards or tax incentives. A more detailed list of the tools and methods for protecting green infrastructure are included in Table 16.

A Green Infrastructure Network can only be realized by coordinated planning efforts of local municipalities, park districts, developers, and private landowners. Crystal Lake, Algonquin, Lake in the Hills, Lakewood, Cary, and the park districts should follow the recommended process below to initiate and implement the Green Infrastructure Network for Crystal Creek watershed.

1. Identify and designate a lead Crystal Creek watershed stakeholder to serve as a "coordinator" and meet with other stakeholders to plan for future green infrastructure.

2. Include all green infrastructure parcels in updated community comprehensive plans and development review maps.

3. Create zoning overlay and update development ordinances to require conservation development design on all green infrastructure parcels.

4. Identify important unprotected green infrastructure parcels not suited for development then protect and implement long term management.

5. Work with private landowners along Crystal Lake and Crystal Creek and tributary corridors to manage their land for green infrastructure benefits.

6. The Green Infrastructure Network could be used to identify new trails and trail connections.

3.11 Ecologically Significant Natural Areas

Moderate to high quality wetlands, prairie, and woodlands are all considered "Ecologically Significant Natural Areas" within Crystal Creek watershed (Figure 33). Most of these areas are public and owned/managed by local municipalities. Ecological Significant Natural Areas provide habitat for and harbor uncommon or conservative plant and animal species. These areas also form much of the Greenway Infrastructure Network that interconnects land and waterways, supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life for communities and people.

ADID and Other High-Quality Wetlands

The Advanced Identification (ADID) wetland inventory was completed for McHenry County in 1998. This inventory identified the functional and ecological values of individual wetlands as well as wetlands where special protection should be enforced. Local communities and private landowners can use the ADID inventory to help them better understand the values and functions of wetlands under their jurisdiction. According to the ADID inventory for McHenry County, there are 688 acres of high-quality wetlands in the Crystal Creek watershed. A separate wetlands map and detailed ADID wetland information is found in Section 3.12. Three larger ADID wetland complexes are located in the watershed and are mapped on Figure 33. Two of these ADID wetlands are located in Lippold Park and on adjacent private property in the northern portion of the watershed. PPA2 is comprised of ADID wetland and oak woodland in the northern portion of the watershed. PPA4 is a large ADID wetland within an agricultural area that begins west of McHenry County Community College and extends south towards Crystal Lake. Additionally, there is a large ADID wetland complex within the Lake in the Hills Fen in Lake in the Hills. Larsen Prairie, owned by McHenry County Conservation District, is classified as an Important Natural Area Inventory site by IDNR (Category I and II-R) and the majority of the site is comprised by an ADID wetland complex.

McHenry County Natural Area Inventory Sites

The McHenry County Conservation District (MCCD) identified one Natural Area Inventory Sites (McNAI) in Crystal Creek watershed

Table 16. Tools for protection of green infrastructure (Source: Benedict 2006).

Tool	Method of Implementation
Land Acquisition	➤ Outright purchase ➤ Conservation easements ➤ Land donations ➤ Land trusts
Regulation	➤ Buffer or landscape ordinance ➤ Stormwater regulations ➤ Comprehensive plans ➤ Subdivision ordinances ➤ Development Impact Fee ➤ Zoning ➤ Mitigation and mitigation banking ➤ Wetland permitting ➤ Special Service Area taxes ➤ T&E species and habitats
Incentives	➤ Management agreements ➤ Landowner recognition and rewards ➤ Tax incentives ➤ Technical assistance from local agencies

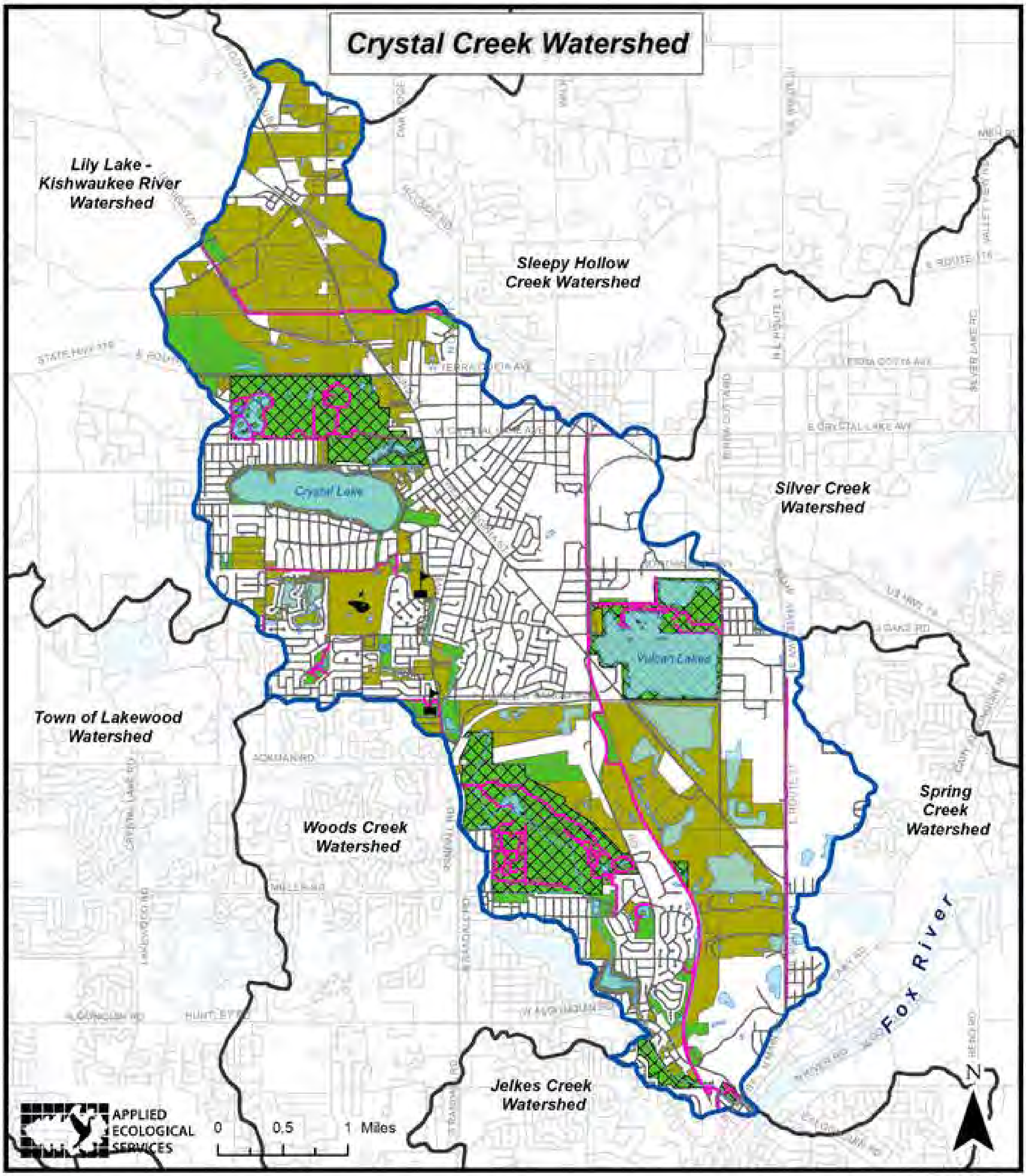
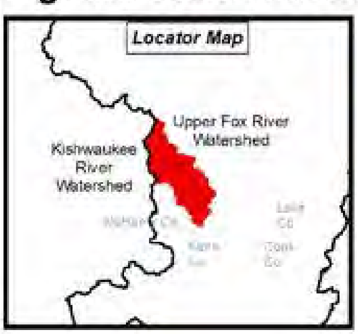


Fig. 32: Green Infrastructure Network

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey



(Figure 33). "Lake in the Hills Fen" is an almost 500-acre complex of unstratified glacial drift composed of limestone gravel and owned, protected, and managed by the Village of Lake in the Hills, McHenry County Conservation District, and the State of Illinois. A portion of the site is also classified as an Important Natural Area Inventory site by IDNR (Categories I, II, and III). A fen is a peat forming wetland that relies on groundwater input and often contains rare plants, animals, and insects (USFS, 2020). Lake in the Hills Fen includes ADID wetlands as well as nine native communities including calcareous floating mat, graminoid fen, low shrub fen, calcareous seep, sedge meadows and marsh, perennial stream, dry gravel prairie, and mesic gravel prairie (IDNR, 2010). Lake in the Hills Fen contains over 400 species of native plants including 40 of which are classified as uncommon, rare, or endangered (Village of Lake in the Hills, 2020).

Lake in the Hills Fen

Other Ecologically Significant Natural Areas

Crystal Lake Park District manages natural areas within Lippold Park which was formally a sod farm prior to being converted to a 310-acre recreational area and includes 60 acres of restored wetlands (Figure 33).

In 2010, the City of Crystal Lake opened Three Oaks Recreation Area on the site of former rock quarry. The recreation area includes two lakes with boating, scuba diving, and fishing opportunities. Bioswales and rain gardens were constructed around the parking lots and buildings in order to filter stormwater runoff before entering the lakes. Twenty-eight acres of native prairie with three miles of trails were also established.

The Village of Algonquin owns and maintains the 12-acre Towne Park

Three Oaks Recreation Area

Lake in the Hills Fen

which is located adjacent to Crystal Creek and along the Prairie Trail. Towne Park was restored in 2014 as part of the Illinois Department of Transportation's construction of the Route 31 Bypass through Algonquin. Restoration included streambank stabilization as well as riparian buffer restoration to a native oxbow wetland, and prairie. Additional streambank stabilization was conducted in 2018 in order to repair erosion and channel instability issues that were first noted after restoration in 2015.

East of Towne Park and the Route 31 bypass is a remnant mesic oak woodland owned by the Village of Algonquin (Figure 33). The oak woodland is located on a steep slope adjacent to Crystal Creek. The woodland is one of few remaining mesic oak woodlands in the watershed. The site harbors 200+ year old red oaks but the area is being invaded by an overabundance of sugar maple that are producing heavy shade and inhibiting oaks from regenerating. Ecological management including removal of must sugar maple, seeding the ground layer, and planting oaks is recommended.

There are no biologically significant streams found within the Crystal Creek watershed.

Village of Algonquin Mesic Oak Woodland

3.12 Watershed Drainage System

3.12.1 Crystal Creek & Tributaries

Crystal Creek is the primary stream in Crystal Creek watershed with 2 tributary streams accounting for approximately 9.1 stream and tributary miles. Crystal Creek begins at the southeastern corner of Crystal Lake and flows southeast for approximately 7.1 miles before joining the Fox River at Cornish Park in Algonquin.

In fall 2019, Applied Ecological Services, Inc. (AES) completed a field inventory of Crystal Creek and its tributaries. All streams and tributaries were assessed based on divisions into "Stream Reaches" (Table 17; Figure 34). Reaches are defined as stream segments having similar hydraulic, geomorphic, riparian condition, and adjacent land use characteristics. Methodology included walking all or portions of the stream reaches, collecting measurements, taking photos, and noting channel, streambank, and riparian corridor conditions. Numerous municipal stormwater point discharges were also encountered during the inventory but were not surveyed due to time and budget constraints as well as two wastewater treatment plants for Crystal Lake and Lake in the Hills; no industrial point sources were encountered. Detailed notes were also recorded related to potential Management Measure recommendations and their corresponding priority for eventual inclusion into the Action Plan section of this report. Results of the inventory and detailed summaries of each stream reach can be found in Appendix C. As a result of the survey, Crystal Creek was divided into 11 stream reaches and two tributaries were identified; each tributary was then broken into two reaches.

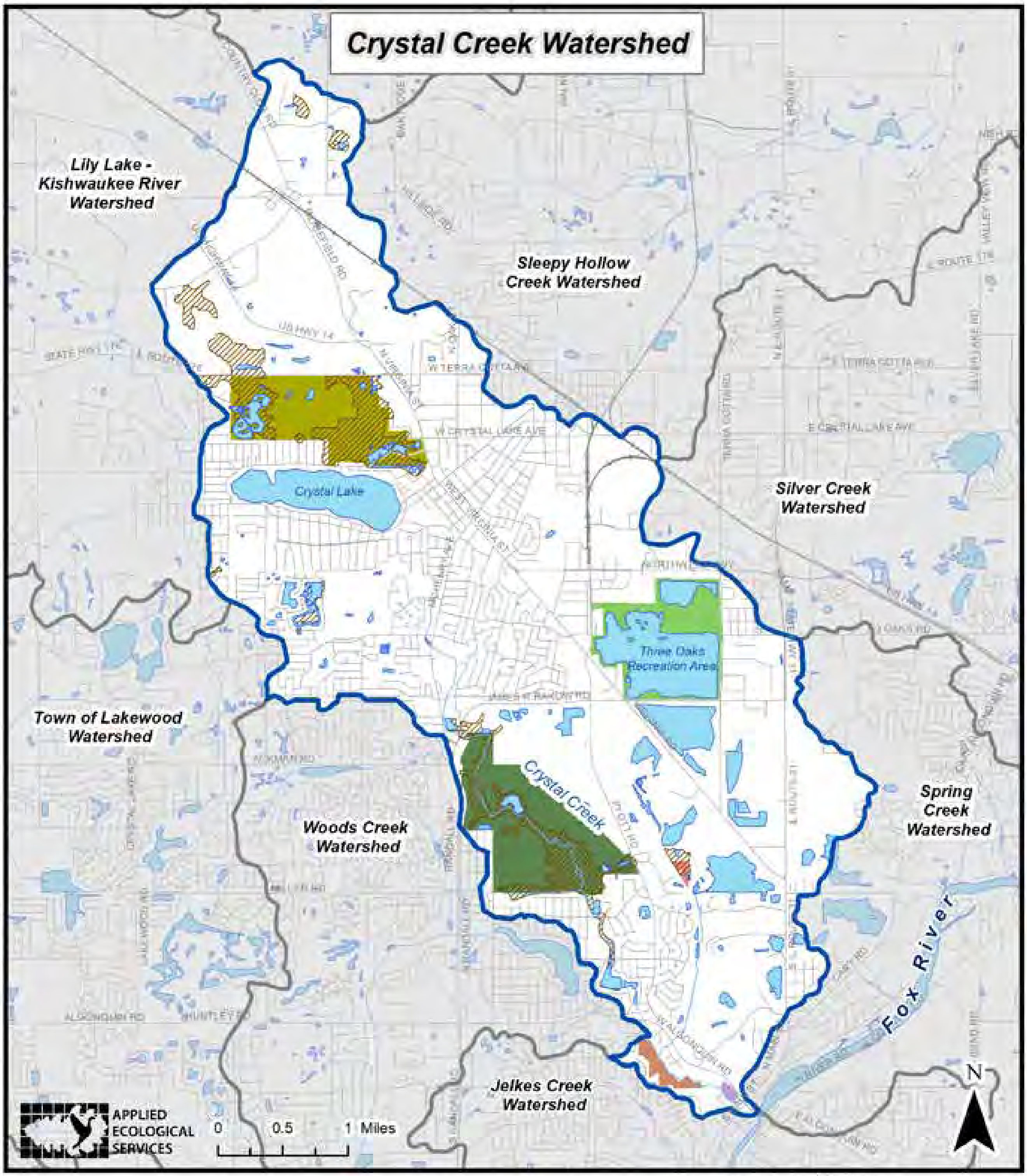
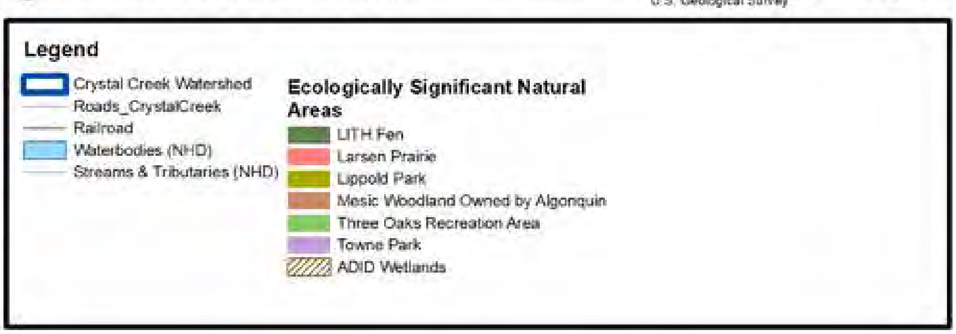


Fig. 33: Ecologically Significant Natural Areas

DATA SOURCES City of Crystal Lake
McHenry County
Chicago Metropolitan Agency for Planning (CMAP)
U.S. Geological Survey



Crystal Creek

The upper most reach of Crystal Creek (CCR1) begins at Crystal Lake and flows 1,774 lf through a residential neighborhood and Crystal Lake County Club. The stream channel is moderately channelized, with no erosion along its banks. The stream buffer is comprised of natural vegetation and turfgrass that is mowed right to the stream channel.

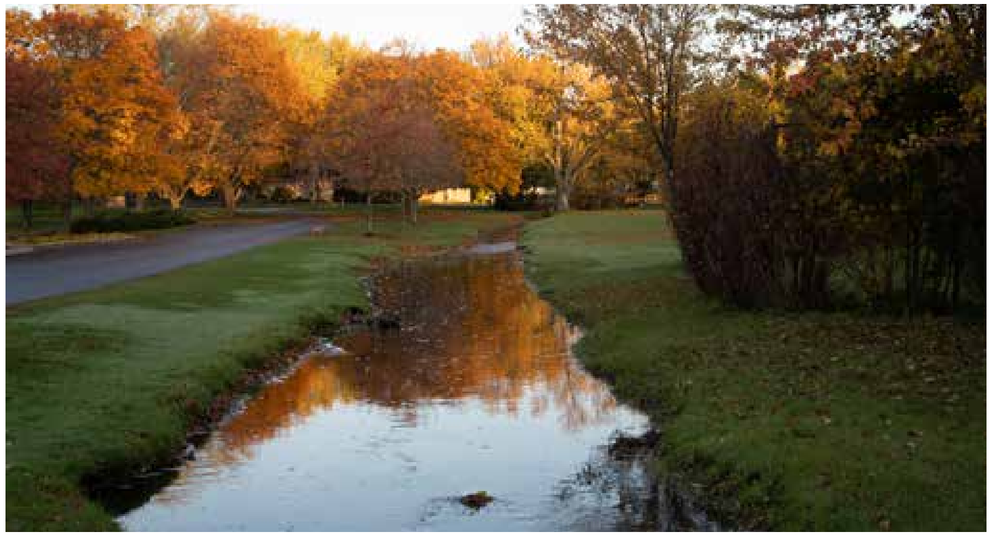
Reach 2 (CCR2) begins in a wooded area west of Crystal Lake County Club. The natural stream channel meanders 1,076 lf through woodland riparian area is good overall health with a mix of native species and second growth/weedy trees and shrubs.

Crystal Creek flows into a culvert northwest of Lundahl Middle School at Reach 3 (CCR3) and is piped (or buried) underneath the middle school's athletic fields for 1,896 lf and daylights south of St. Andrews Lane at Cress Creek Park.

Reach 4 (CCR4) of Crystal Creek flows from Cress Creek Park through a 3,081 lf wooded riparian corridor in a moderately channelized stream channel. A beaver dam located east of McHenry Avenue has caused water to back up into the riparian corridor from Barlina Road to the dam.

CCR4 transitions to Reach 5 (CCR5) north of Dartmoor Drive where Crystal Creek becomes highly channelized with a moderately eroded stream bank. The riparian corridor consists of mowed grass and second growth, weedy trees and shrubs. CCR 5 flows south for 3,758 lf though residential development on the east bank and a church campus on the west bank and through the Crystal Lake Waste Water Treatment Plant.

Crystal Creek enters Lake in the Hills Fen at Reach 6 (CCR6) south of Rakow Road. This natural stream channel winds southeast for 13,781 lf through the 229 acre state preservation area. The riparian area



Crystal Lake Country Club (CCR1)

Beaver Dam at Crystal Creek Reach 4 (CCR4)

Crystal Creek Reach 2 (CCR2)

Table 17. Summary of stream and tributary reaches and length.

Stream or Tributary Name	Abbreviation	Number of Reaches	Stream Length Assessed (ft)	Stream Length Assessed (mi)
Crystal Creek	CCR	11	37,404	7.1
Unnamed Tributary 1	T1	2	3,377	0.6
Unnamed Tributary 2	T2	2	7,417	1.4
Totals		**15**	**48,197**	**9.1**

Crystal Creek Reach 9 (CCR9)

Crystal Creek Reach 10 (CCR10) at Towne Park

is comprised of a high-quality fen, marsh, sedge meadow and prairie communities.

Crystal Creek exits Lake in the Hills Fen at Plum Street in Lake in the Hills (Reach 7) (CCR7) and continues south for 4,294 lf through weedy, secondary growth woodland and reed canary grass wetlands in a mildly channelized and eroded stream channel. At Willow Street, Crystal Creek goes through a series of three dams which forms Goose Lake, Willow Lake, and Scott Lake.

The stream reforms at Reach 8 (CCR8) north of Jessie Road and flows south for 1,759 lf through residential and commercial properties to Roger St. CCR8 has a narrow riparian buffer of second growth trees and shrubs. The stream channel is moderately channelized and eroded. Consequently, residents have placed various rocks along eroded banks in an attempt to stabilize the channel.

Reach 9 (CCR9) flows for 3,098 lf southeast parallel with Algonquin Road. Commercial properties make up the east bank with riparian area comprised of a parking lot built into the floodplain and secondary growth trees and shrubs. The highly eroded west bank contains a steep slope with a high-quality remnant oak woodland.

CCR9 transitions to Reach 10 (CCR10) at Prairie Trail west of Towne Park in Algonquin. The 1,774 lf stream channel cuts through Towne Park and was restored beginning in 2003 with ongoing maintenance as of 2020 and buffered by restored prairie and oak savanna.

Reach 11 (CCR11) is the last reach of Crystal Creek. The creek flows 909 lf east through a heavily armored stream channel from Towne Park through downtown Algonquin and enters the Fox River at Cornish Park.

Crystal Creek Reach 11 (CCR11) at Cornish Park

Confluence of Crystal Creek and the Fox River

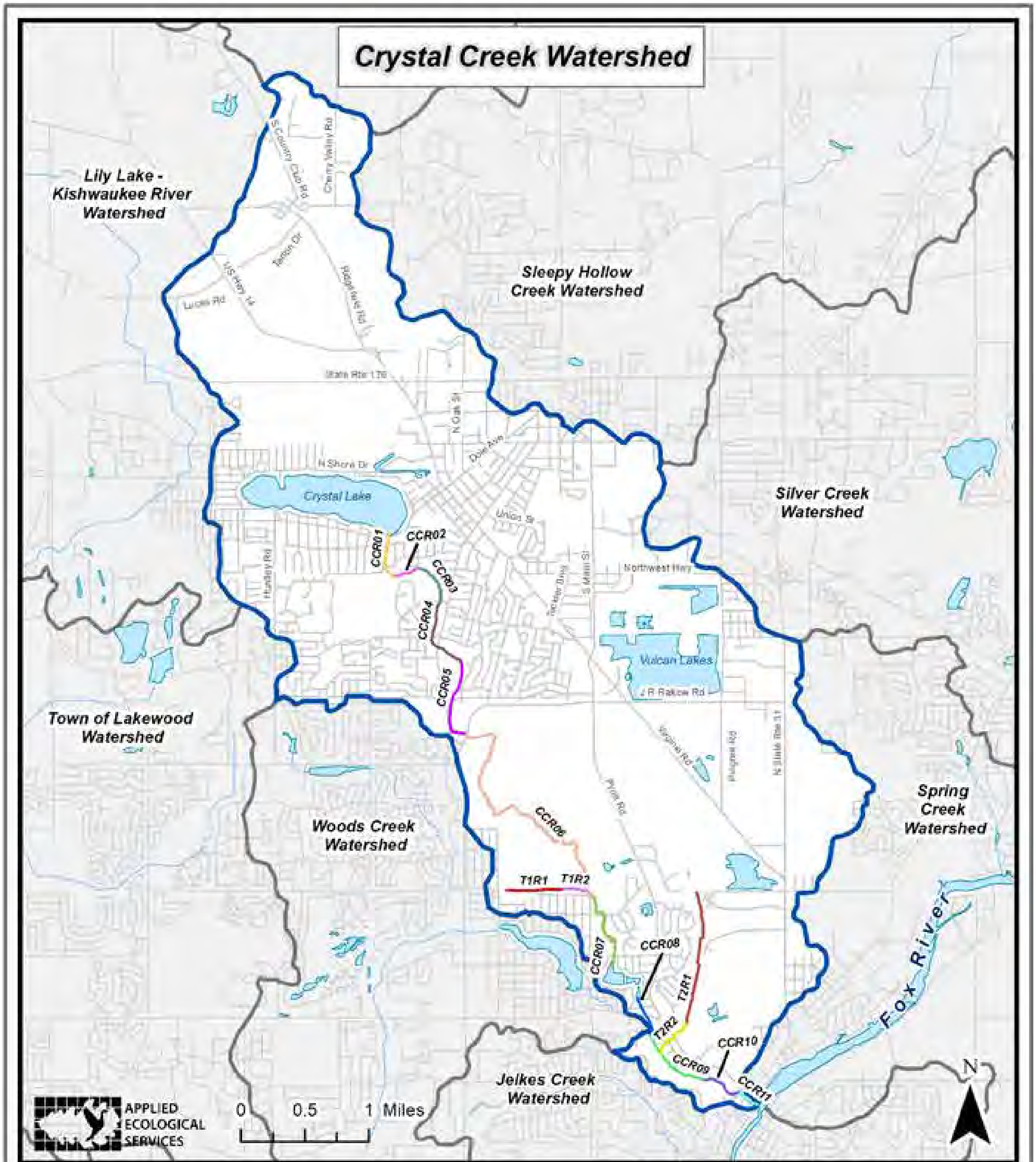
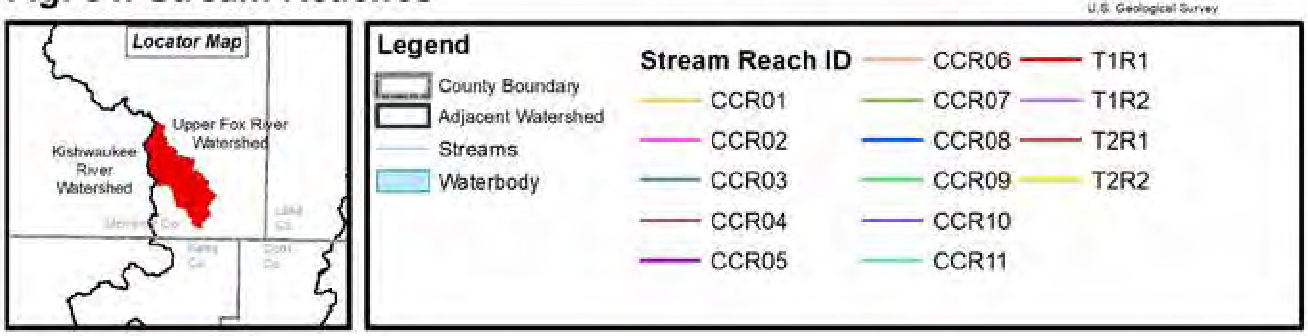


Fig. 34: Stream Reaches

DATA SOURCES City of Crystal Lake
McHenry County
U.S. Census Bureau
U.S. Geological Survey



Tributary Streams
Two additional small tributary streams join Crystal Creek (Table 17; Figure 34). Together these tributaries total approximately 2 miles. A brief description of each tributary stream is included below.

Crystal Creek Tributary 1(T1) begins east of Crystal Lake Road, north of Ryder Park and flows east for approximately 3,377 lf before emptying into Crystal Creek in Lake in the Hills Fen. The tributary is an old farm ditch dominated by weedy, second growth tees and shrubs. At Lake in the Hills Fen, it flows into a sedge meadow and fen before meeting Crystal Creek within the conservation area.

Crystal Creek Tributary 2 (T2) is a channelized ditch that likely drains the sand and gravel pits located to the east of Crystal Creek. The low quality tributary flows west through secondary growth trees and shrubs and enters Crystal Creek west of Algonquin Road.

Channelization along Crystal Creek Reach 10 (CCR10)

Stream Channelization
Riffles and pools are generally associated with naturally meandering streams and benefit the system by providing various habitats while oxygenating the water during low flow or summer heat. Channelized or ditched streams are often void of or have low quality riffles and pools. Berms are also common along channelized streams where landowners typically piled soils excavated from the channel. These spoil piles often inhibit natural flooding into adjacent floodplains. All stream reaches in the watershed were characterized as having none to low channelization (highly sinuous, no human disturbance), moderate channelization (some sinuosity but altered), or high channelization (straightened by humans).

Tributary 2

In many highly urbanized areas, all or portions of streams and tributaries were buried, covered, or forced into pipes underground rather than allowed to flow in their natural state. Typically, small streams might have been buried to help pave the way for development or to help expedite the flow of various wastes away from cities. It wasn't until more recently that the effects of burying streams on watershed hydrology were better understood; burying streams results in hydrological changes in the watershed, increased flooding, destruction of fish and wildlife habitat, and as much as 18 times higher levels of nitrogen being transported downstream (American Rivers, 2014 and Beaulieu, 2015). At least one section of Crystal Creek, Reach 3, is buried underground.

According to the stream inventory, 42% (20,267 lf) of stream and tributary length is naturally meandering; approximately, 24% (11,691 lf) is moderately channelized; and 30% (14,343 lf) is highly channelized. Crystal Creek Reach 3 makes up 4% of Crystal Creek's total length and is piped underground for approximately 1,896 lf. The most severe channelization is found along Crystal Creek between Heister Court and Rakow Road (CCR 5), between Towne Park and the Fox River (CCR11), and along Tributary 1 between Crystal Lake Road and Lake in the Hills Fen (T1R1) and from the gravel pits to the west of Algonquin Road (T2).

Channelized areas present opportunities for Management Measure projects such as artificial riffle and pool restoration and regrading or breaking of adjacent spoil piles for reconnection of the stream to adjacent floodplains. Table 18 and Figure 35 summarize and depict the location and severity of channelized stream and tributary reaches in the watershed. The Action Plan section of this report addresses opportunities for improving many of these channelized stream reaches.

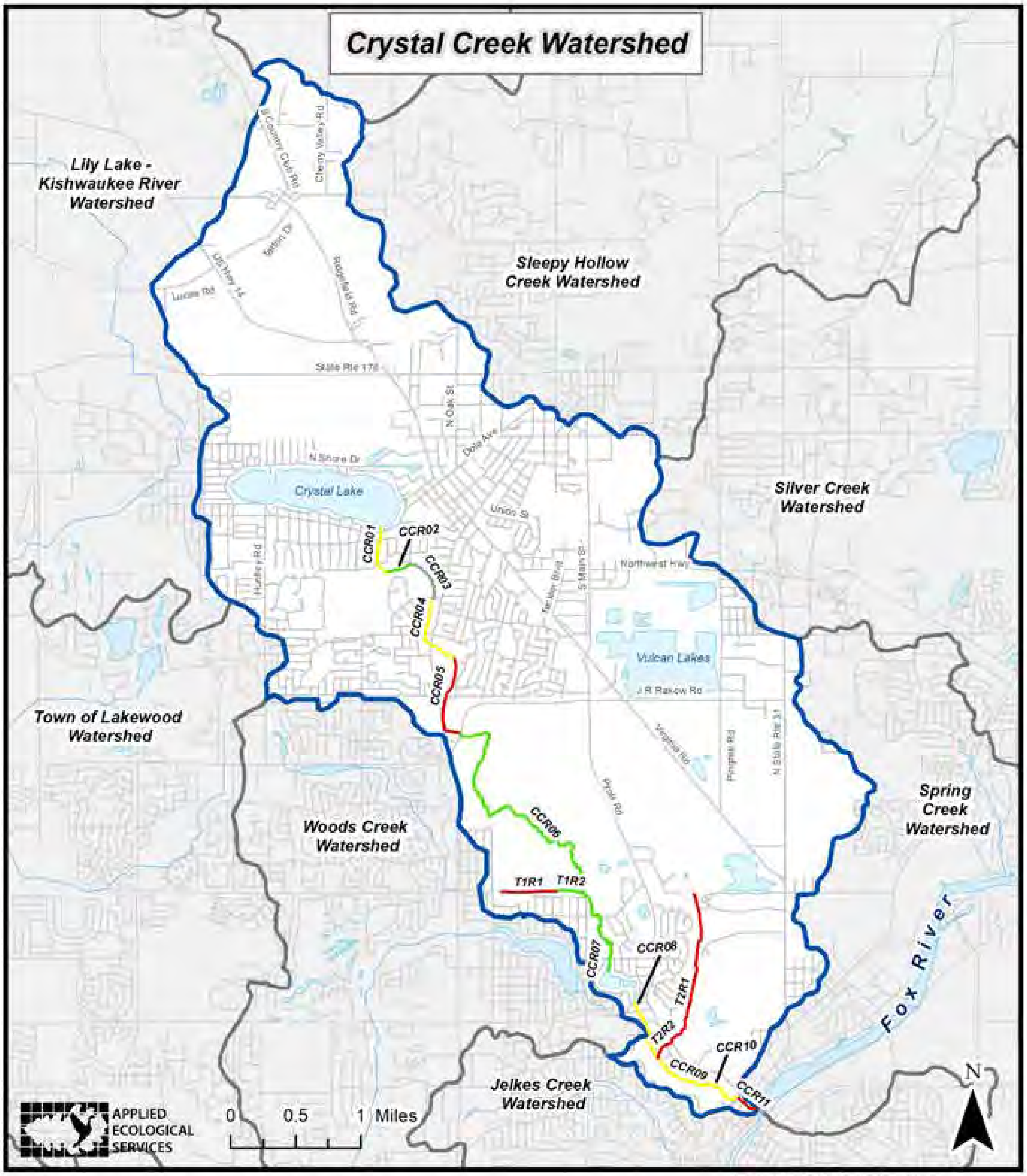


Fig. 35: Stream Channelization

DATA SOURCES City of Crystal Lake
McHenry County
U.S. Census Bureau
U.S. Geological Survey

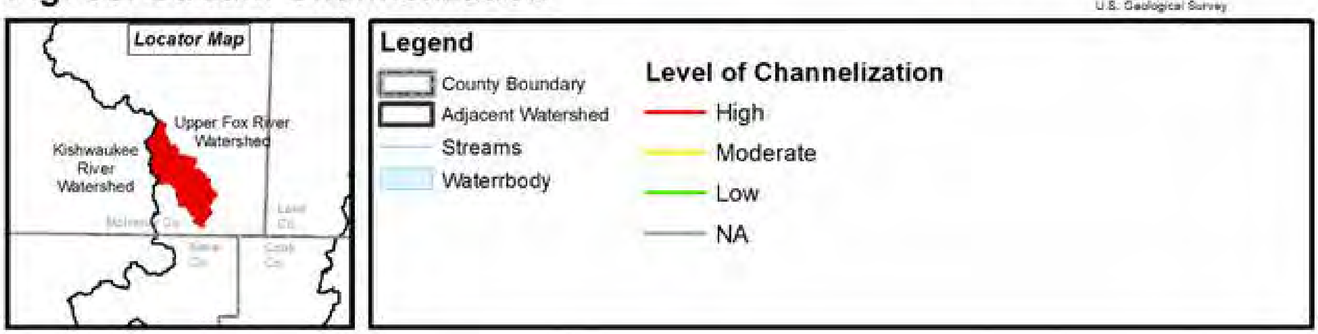


Table 18. Summary of stream and tributary channelization.

Stream or Tributary Name	Abbrev.	Total Stream Length Assessed (ft)	None or Low Channelization		Moderate Channelization		High Channelization		NA	
			Feet	Pct	Feet	Pct	Feet	Pct	Feet	Pct
Crystal Creek	CC	37,404	19,150	51%	11,691	31%	4,667	12%	1,896	5%
Tributary 1	T1	3,377	1,117	33%	0	-	2,259	67%	0	-
Tributary 2	T2	7,417	-	0%	0	-	7,417	100%	0	-
Totals		**48,198**	**20,267**	**42%**	**11,691**	**24%**	**14,343**	**30%**	**1,896**	**4%**

Table 19. Summary of stream and tributary bank erosion.

Stream or Tributary Name	Abbrev.	Total Stream Length Assessed (ft)	None or Low Erosion		Moderate Erosion		High Erosion		NA	
			Feet	Pct	Feet	Pct	Feet	Pct	Feet	Pct
Crystal Creek	CC	37,404	13,112	35%	19,297	52%	3,098	8%	1,896	5%
Tributary 1	T1	3,377	3,377	100%	0	-	0	-	0	-
Tributary 2	T2	7,417	0	-	7,417	100%	0	-	0	-
Totals		**48,198**	**16,489**	**34%**	**26,714**	**56%**	**3,098**	**6%**	**1,896**	**4%**

Table 20. Summary of stream and tributary riparian area condition.

Stream or Tributary Name	Abbrev.	Total Stream Length Assessed (ft)	Good Condition		Average Condition		Poor Condition		NA	
			Feet	Pct	Feet	Pct	Feet	Pct	Feet	Pct
Crystal Creek	CC	37,404	16,631	44%	9,354	25%	9,523	25%	1,896	5%
Tributary 1	T1	3,377	-	0%	3,377	100%	-	0%	-	0%
Tributary 2	T2	7,417	-	0%	-	0%	7,417	100%	-	0%
Totals		**48,198**	**16,631**	**35%**	**12,731**	**26%**	**16,940**	**35%**	**1,896**	**4%**

Streambank Erosion

Streambank erosion generally results following an instability in flow rate or volume in the stream channel, human alteration such as channelization, or change in streambank vegetation. Resulting sediment accumulation and transportation downstream causes significant water quality problems. Streambank erosion is moderate on average and is a reflection of increased impervious cover and stormwater runoff in the watershed.

Approximately 34% (16,489 lf) of the total stream and tributary length exhibits no or low bank erosion while moderate erosion is occurring along 56% (26,714 lf) of streambanks. Highly eroded streambanks are observed on Reach 9, between Roger Street and Prairie Trail where the stream is pinched between a parking lot and steep slope and accounts for 6% (3,098 lf) of the total stream length. Reach 9 is considered a "Critical Area" because it is actively contributing significant sediment loads downstream.

All highly eroded and some moderately eroded streambanks provide excellent opportunities for streambank stabilization projects. The location and severity of streambank erosion in the watershed is summarized in Table 19 and depicted on Figure 32. The Action Plan section of this report addresses and prioritizes opportunities for reducing streambank erosion.

Riparian Area Condition

Riparian corridors buffer streams and tributaries by filtering pollutants

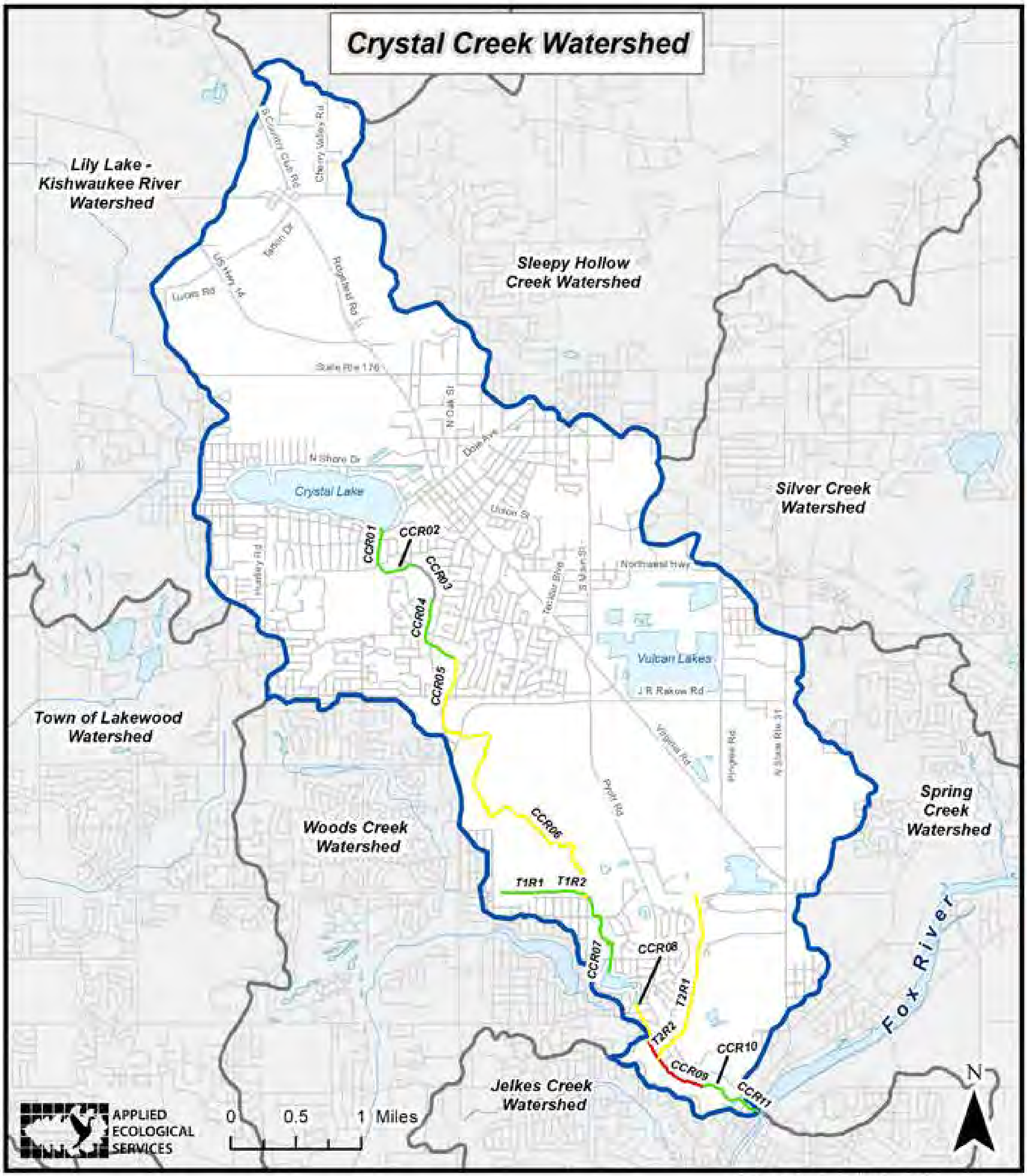
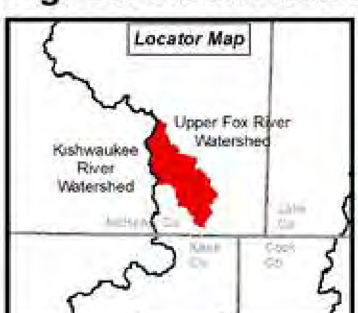
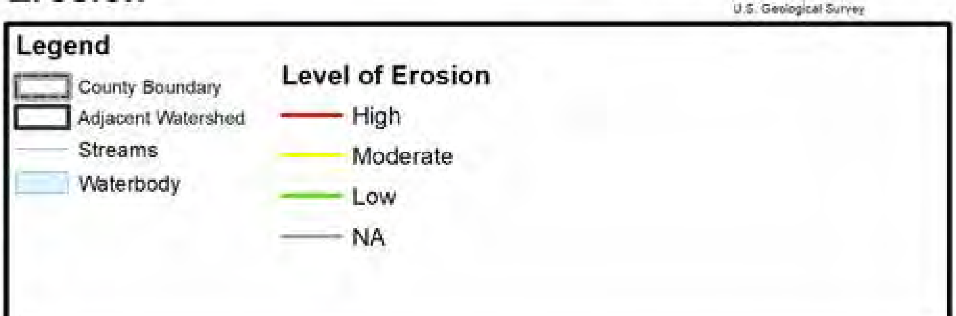


Fig. 36: Streambank Erosion

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey





from runoff during flood events. Buffers also provide beneficial wildlife habitat and extend or connect green infrastructure. The riparian corridor along streams and tributaries was assessed during the stream inventory by noting the "Condition" as it relates to riparian area function and quality of plant communities present. Riparian areas in "Good" condition typically connect hydrologically with streams and tributaries during flood events and have remnant or restored wetland plant communities. "Average" condition riparian areas retain some hydrological connection to the adjacent stream with somewhat degraded plant communities. Areas in "Poor" condition are usually found along channelized streams and have been heavily farmed in the past causing degraded plant communities to establish.

The location and condition of riparian areas in the watershed is summarized in Table 20 and Figure 37. Approximately 35% (along 16,940 linear feet of streams) of the riparian areas are "Poor" quality. Of the remaining reaches, 12,731 linear feet or 26% of riparian areas are in "Average" condition and 35% (16,631 linear feet) are in good condition.

Altered hydrology and invasive species are the leading causes of degraded conditions in the wetland riparian areas. Common reed (Phragmites australis), purple loosestrife (Lysimachia salicaria), reed canary grass (Phalaris arundinacea), common buckthorn (Rhamnus catharitica), sandbar willow (Salix interior), box elder (Acer negundo), and eastern cottonwood (Populus deltoids) are among the most abundant and problematic invasive plants. Fortunately, ecological restoration helps eradicate these species and encourages native plant establishment. The Action Plan section of this report lists and prioritizes opportunities for improving riparian areas through ecological restoration.

Eroded banks along Crystal Creek Reach 9 (CCR9)

Remnant oak woodland along Crystal Creek Reach 9

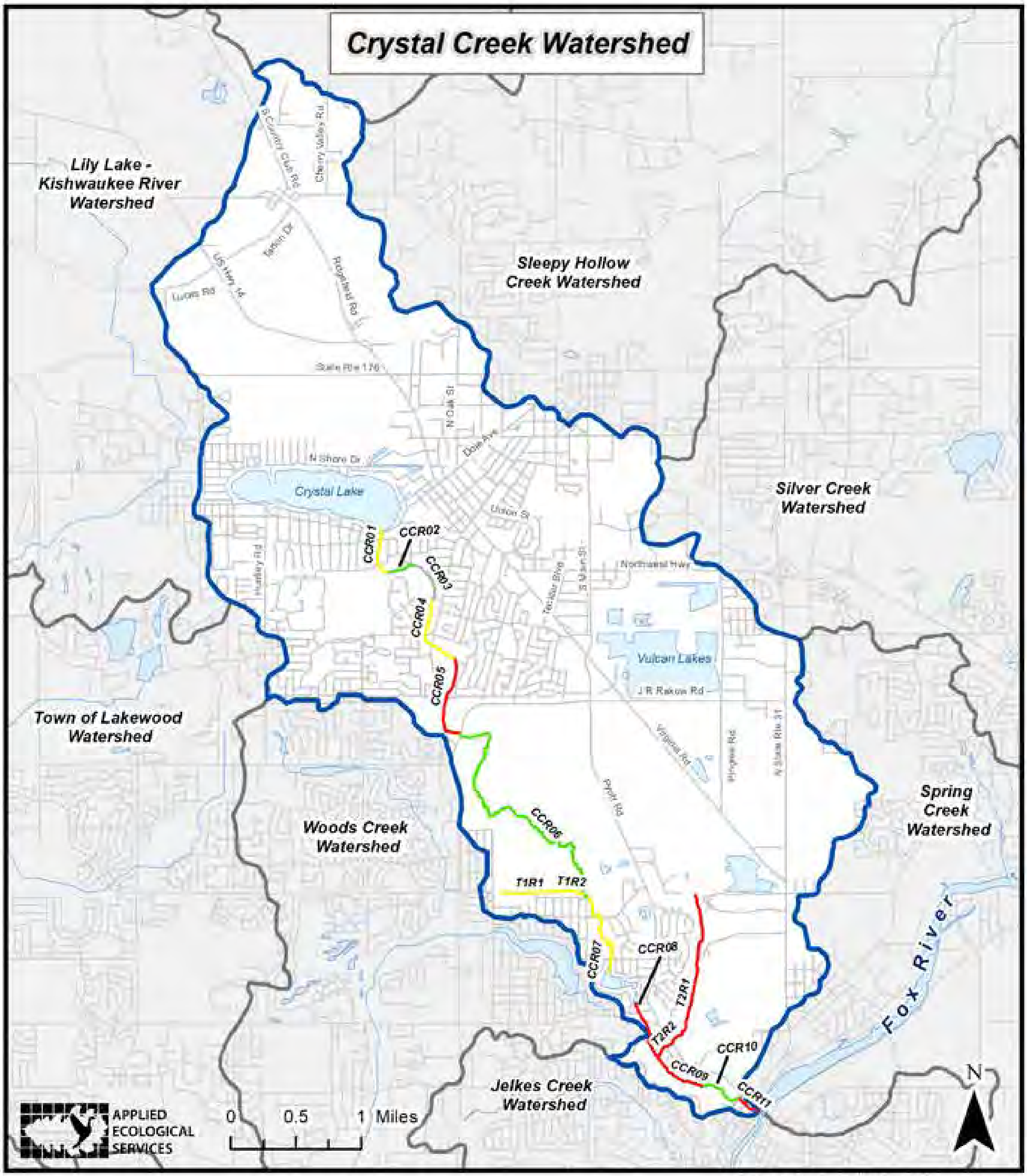
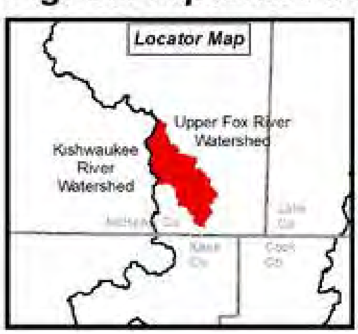
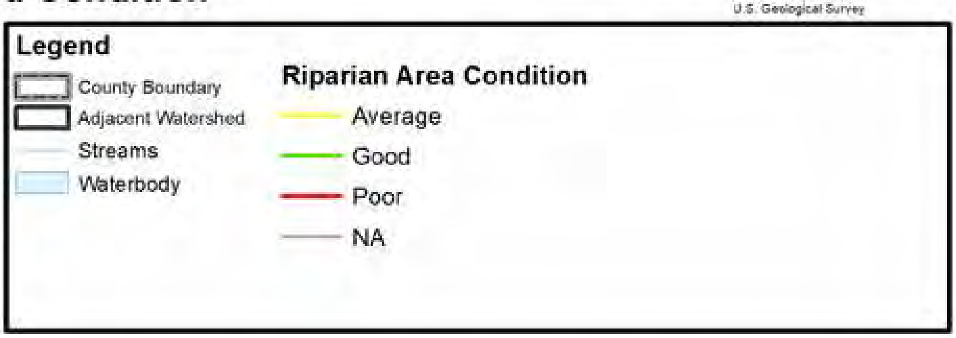


Fig. 37: Riparian Area Condition

DATA SOURCES City of Crystal Lake
McHenry County
U.S. Census Bureau
U.S. Geological Survey





3.12.2 Detention Basins

Development since the early 1990s significantly changed the way stormwater flowed across the land. Prior to the mid-1990s most stormwater sheet flowed or was tile drained off agricultural fields throughout much of Crystal Creek watershed. Planners and engineers quickly realized the benefits of storing stormwater runoff in detention basins. Detention basins are human made structures for the temporary storage of stormwater runoff with a controlled release rate. The controlled release rate for most basins in the watershed is between 0.04 and 0.05 cfs/ac as regulated by county stormwater ordinances. Detention basins can also provide excellent wildlife habitat and improve water quality if designed with the proper configuration, slopes, and water depths then planted with native prairie and wetland vegetation. Today, detention basins capture stormwater runoff from at least 50% of the watershed making the quality of water leaving these basins critically important to the health of Crystal Creek downstream.

Basins can be constructed to be wet bottom, wetland bottom, or dry bottom with various types of natural or manicured vegetation. Wet and wetland bottom basins typically hold water that is controlled by the elevation of the outlet structure. Wet bottom basins are usually greater than 3 feet deep and do not have emergent vegetation throughout whereas wetland bottom detention basins are shallow enough to be dominated by emergent wetland plants. Dry bottom basins are designed to drain completely after temporarily storing stormwater following rain events according to local stormwater ordinance requirements.

Crystal Creek watershed has 49 large detention basins (Figure 38) and numerous smaller ones. Applied Ecological Services, Inc. completed a basic assessment of detention basins in fall 2019.

Typical dry bottom turf grass detention at McHenry Community College.

Assessment methodology included a visit to each site and collection of data related to existing conditions. Detailed notes were recorded related to existing ecological/water quality improvement condition and potential retrofit Management Measures for eventual inclusion into the Action Plan section of this report. Results of the inventory and detailed summaries of each detention basin can be found in Appendix C. Eleven (12) dry bottom turf grass, 4 wet or wetland bottom w/turf grass slopes, 10 naturalized dry bottom, and 23 naturalized wet or wetland bottom basins were assessed (Table 21).

Of the 49 basins, 6 (12%) provide "Good" ecological and water quality benefits, 27 (55%) provide "Average" ecological and water quality benefits while 16 basins (33%) provide "Poor" ecological and water quality benefits (Table 21). Many were designed simply

Typical dry bottom natural detention east of Country Club Road

Naturalized wet bottom detention east of Sierra Court.

for stormwater storage and did not necessarily consider designs that would also improve water quality and wildlife habitat.

Many detention basins are turf grass bottom basins that do little to improve water quality or promote infiltration to replenish groundwater. This is because dry bottom basins planted with turf grass hold water for shorter periods following rain events and infiltrate less water compared to dry bottom basins naturalized with deep rooted vegetation. Most dry bottom basins are relatively easy to naturalize with native plantings. Naturalized dry bottom basins also provide excellent wildlife habitat and expand green infrastructure. All dry bottom basins in the watershed are maintained by either homeowner or business associations, Crystal Lake Park District, or municipalities.

Wet and wetland bottom detention basins are the most common in the watershed. Individual development sites tend to have basins that are all similarly planted. For example, most wet and wetland bottom basins in a development are planted with either turf grass along the basin slopes or are naturalized with native vegetation along the slopes and emergent edge. Basins planted with turf grass were designed with aesthetics in mind and not necessarily the potential water quality and habitat benefits. Because of this, most homeowner and business associations will likely disapprove of installing water quality retrofits such as native plant buffers unless they can be designed to look formal and require minimal maintenance. Most if not all wet and wetland bottom basins in the watershed are maintained by either homeowner or business associations, park districts, or municipalities.

Most of the wet and wetland bottom detention basins in the watershed are naturalized with native vegetation. Of these, most are owned by homeowner and business associations that have limited knowledge related to managing naturalized detention basins or hire contractors not qualified to manage natural areas. The result is basins that are overgrown with non-native and invasive species that provide limited ecological and water quality benefits. It is important for homeowner and business associations to begin implementing appropriate management by qualified ecological contractors. Management recommendations for naturalized detention basins are included in the Site-Specific Management Measures Action Plan.

Table 21. Summary of detention basin types, ecological condition, and acreage.

AES ID	Basin Type	Ecological Condition	Size (Acres)
1A	Dry	Poor	1.0
1B	Wet	Poor	1.0
1C	Dry	Poor	1.0
2A	Dry	Good	1.1
2B	Dry	Poor	1.0
2C	Wet	Poor	0.7
2D	Wet	Poor	0.8
2E	Wetland	Average	0.9
2F	Wetland	Good	1.4
3A	Dry	Poor	1.3
3B	Dry	Poor	3.3
3C	Wetland	Average	3.3
3D	Wetland	Good	2.5
6B	Wetland	Average	0.4
8A	Wetland	Average	2.6
8B	Dry	Poor	0.4
8C	Dry	Poor	0.4
9A	Dry	Poor	1.8
12C	Dry	Poor	1.0
12D	Wet	Poor	1.0
13A	Dry	Poor	7.0
14A	Dry	Average	10.0
14B	Dry	Average	1.2
14C	Dry	Average	2.4
14D	Dry	Poor	2.3
17A	Wet	Good	3.0
18A	Wetland	Average	2.4
19A	Dry	Average	3.8
19C	Dry	Average	1.9
19B	Wetland	Average	1.4
20A	Wetland	Average	1.6
21A	Dry	Average	0.3
21B	Dry	Poor	3.5
21C	Dry	Average	2.9
22A	Wetland	Good	1.1
22B	Wet	Average	2.8
22C	Wetland	Average	1.9
22D	Wetland	Average	2.1
23A	Dry	Average	7.7
25A	Dry	Average	5.6
27A	Wetland	Average	4.5
28A	Wetland	Average	15.8
28B	Wet	Average	1.5
31A	Wetland	Average	5.6
31B	Wetland	Average	1.2
31C	Wetland	Good	0.4
31D	Wetland	Average	0.5
31F	Wetland	Average	2.2
31G	Wet	Average	2.7

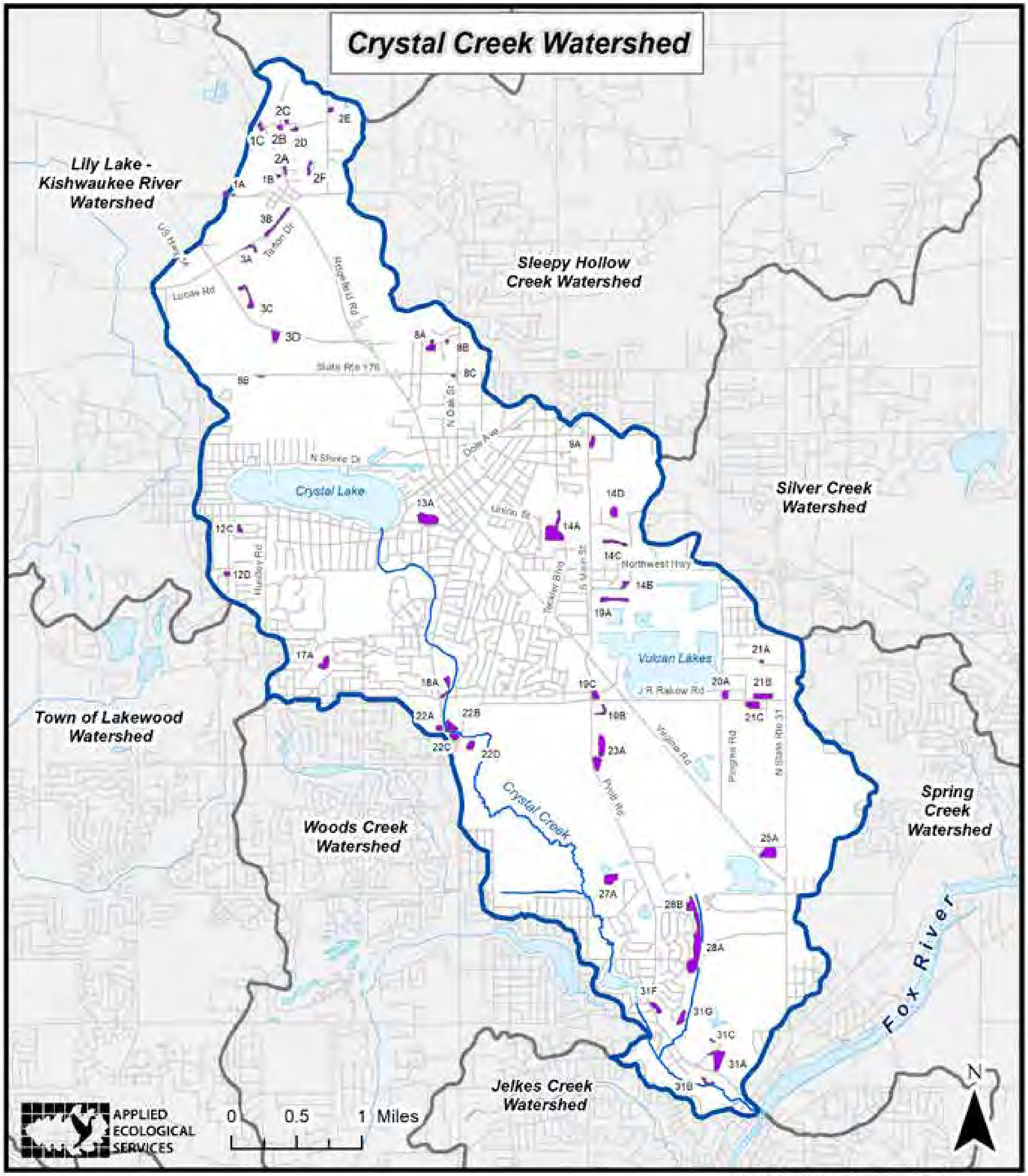
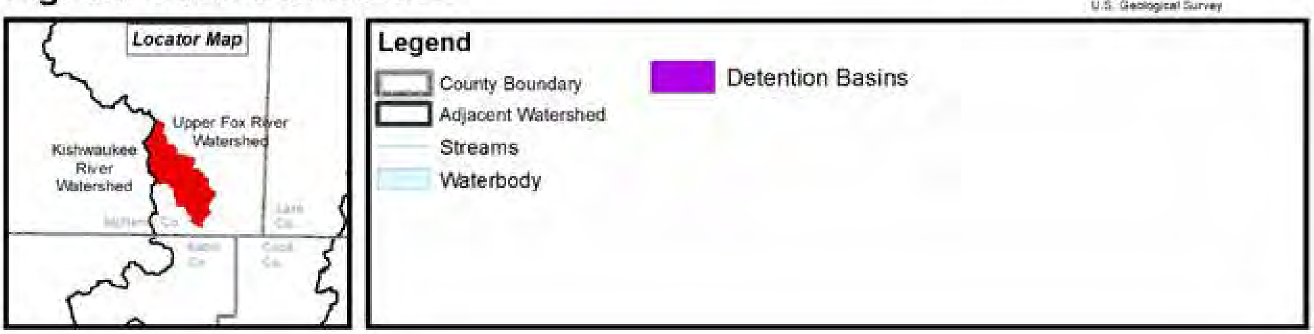


Fig. 38: Detention Basins

DATA SOURCES City of Crystal Lake
McHenry County
U.S. Census Bureau
U.S. Geological Survey



3.12.3 Lakes

Crystal Lake

In 1830 the lake was described as a beautiful sheet of water, now known as Crystal Lake" (Pfannkuche, 2005). In 1863, Charles Dole of Chicago's Armour and Dole established an estate at Crystal Lake including the lake bottom. Ice houses lined the shore to hold ice cut from Crystal Lake for shipping to Chicago. Due to the popularity of the quality ice, boarding houses and resorts were built on the north shore to accommodate vacationers. In 1921 the Crystal Lake Park District was established in order to ensure public access to Crystal Lake (Pfannkuche, 2005). The resorts surrounding Crystal Lake maintained popularity throughout the 1920s. During this period vacation homes were built in the woods along the south shore. Unhappy with the expansion of the City of Crystal Lake, the south shore residents split off and incorporated in 1933 as Lakewood.

Crystal Lake North Shore

Today, the lake remains public and is surrounded by over 150 residential homes. Crystal Lake Park District currently has two public access points Main Beach and West Beach. An additional 6 private beaches managed by homeowner associations are also maintained along the lakeshore.

Prior to European settlement, Crystal Lake was recharged via groundwater and direct precipitation. Today Crystal Lake is recharged through shallow groundwater from agriculture drainage tiles installed in 1917 (Hey and Associates, 2007). As of 2007, only 10% of the Crystal Lake watershed is drained by storm sewers located to the east of the lake (Hey and Associates, 2007).

In 1975, the City of Crystal Lake initiated the Crystal Lake Watershed Resources Management Study. The purpose of this study was to "suggest to the City of Crystal Lake ways and means if regulating the growth of the City while at the same time preserving the quality of the lake water and the natural beauty of the lake and its surroundings" (Bauer Engineering, 1975). The Crystal Lake Watershed Resources Management Study proposed guidelines to protect Crystal Lake aquifer recharge conditions, improve the quality of surface and sub-surface discharge to the lake, and reduce accumulated nutrients in the lake. The study also recommended preserving marsh-wetland and shallow water table outwash units through public acquisition, dedication, or preservation of agriculture areas (Bauer Engineering, 1975)

In following the plan, the City of Crystal Lake and Crystal Lake Park District converted Lippold Park (formally a sod farm) and Crystal Cove Pond to wetland treatment units to retain runoff pollutants (Hey and Associates, 2007) before entering Crystal Lake. The city also limited impervious coverage to 5-20% and banned any new point-source discharges to the lake.

In 2007, the City of Crystal Lake adopted the Crystal Lake Watershed Stormwater Management Design Manual which was updated again in 2013. The Manual was adopted in order to protect Crystal Lake by regulating the stormwater management practices of properties that develop in the watershed as well as defining the program elements, roles and responsibilities of the parties that will implement and sustain stormwater management in the Crystal Lake watershed. (Hey and Associates, 2013). As a companion to the Manual, the Crystal Lake Watershed Stormwater Management Program Implementation Plan was also produced to "present guidance for the design of stormwater management systems within the Crystal Lake watershed" (Hey and Associates, 2007). The goal of the guidelines in the Stormwater Management Implementation Plan is to protect the quantity and quality of water reaching Crystal Lake and the shallow groundwater resources of the City of Crystal Lake and surrounding area (Hey and Associates, 2007).

Three Oaks Recreation Area

The City of Crystal Lake opened the Three Oaks Recreation Area in 2010 at the sight of the abandoned Vulcan Lakes quarry. The recreation area hosts various activities such as swimming, scuba diving, fishing and boating in the manmade lake as well as trails throughout the recreation areas 28 acres of restored native prairie. (Openlands, 2019)

Three Oaks Recreation Area

Goose, Willow, and Scott Lake

Goose, Willow, and Scott Lakes are formed by a series of three damns on Crystal Creek beginning south of Willow Street. Willow Lake and Scott Lake are the two smallest lakes within Lake of the Hills and the Crystal Creek Watershed and do not have public access. Goose Lake can be accessed at Horner Park in Lake in the Hills and is stocked seasonally with walleye, sunfish, perch and catfish (LITH, 2020).

3.12.4 Wetlands & Potential Wetland Restoration Sites

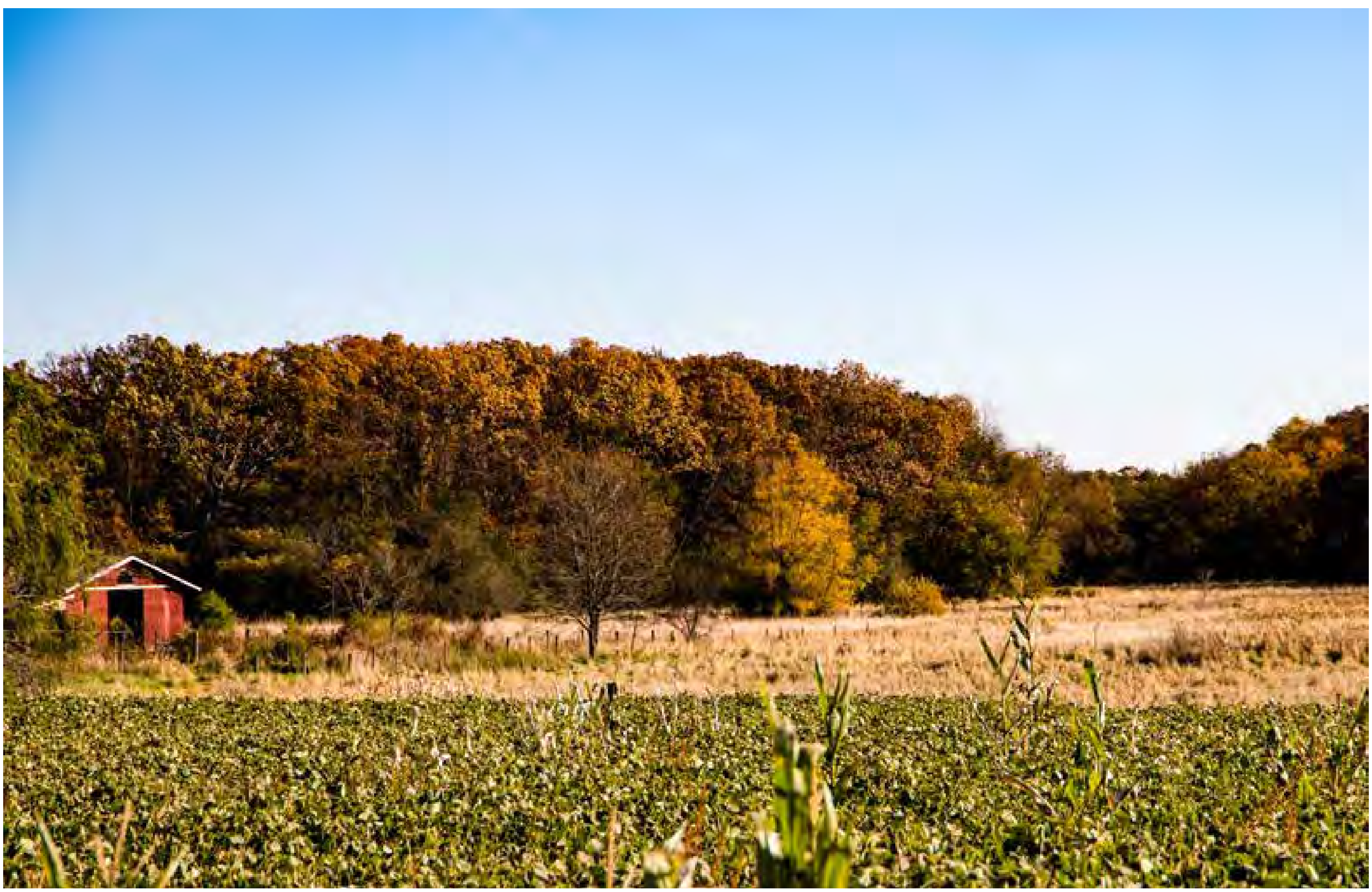
Most of the wetlands in Crystal Creek watershed were intact until the late 1830s when European settlers began to alter significant portions of the watershed's natural hydrology and wetland processes. Where it was feasible wet areas were drained, streams channelized, and savanna and prairie cleared to farm the rich soils. There were approximately 1,484 acres of wetlands in the watershed prior to European settlement based on the most up to date hydric soils mapping provided by the USDA Natural Resources Conservation Service (NRCS). According to existing wetland inventories, 806.1 acres or 54.3% of the pre-European settlement wetlands remain (Figure 39).

Functional wetlands do more for water quality improvement and flood reduction than any other natural resource. In addition, wetlands typically provide habitat for a wide variety of plant and animal species. They also provide groundwater recharge and discharge, filter sediments and nutrients, and maintain water levels in streams during drought periods. Wetland information and mapping is available for the entire Crystal Creek watershed via advanced wetland inventories and identification studies (ADID) for McHenry County. The wetland data was used to map and describe the existing wetlands in the watershed and to locate potential wetland restoration sites.

McHenry County ADID Wetland Inventories

The McHenry County ADID wetland inventory (NIPC 1998) was developed in 1998 and uses methodology similar to that used in nearby Lake County as well as other documented methods. Methods included evaluation of USDA wetland inventory maps, National Wetland Inventory (NWI) maps, county soil surveys, and low altitude aerial imagery. Site inspections are often conducted to verify the quality of wetlands. The ADID studies are designed to do two things: 1) identify the functions of individual wetlands and 2) identify wetlands of such high value that they merit special consideration for protection. Wetlands are ultimately categorized as "High Functional Value", "High Habitat Value", and "Other Wetlands".

Ten (10) individual wetland complexes wer e identified as either High Function Value or High-Quality Wetland in the Crystal Creek watershed. Of these, 5 are "High



ADID Wetland south of Lucas Road

Functional Value" and 5 exhibit "High Habitat Value". The remaining wetlands in the watershed are classified as "Other Wetlands". Data for each ADID wetland is summarized in Table 22 and mapped in Figure 39.

Most of the existing wetlands in Crystal Creek watershed were inspected by AES in fall 2019 during reconnaissance of the watershed (Table 23; Appendix C). In general, the wetlands in the watershed were disturbed by farming practices or development at some point in the last 150 years to the extent that hydrology has changed and invasive species such as common reed, reed canary grass, purple loosestrife, and buckthorn shrubs now dominate. Higher quality wetland remnants are also in decline primarily as a result of groundwater and surface water hydrology changes and shrub/tree encroachment. The highest quality fen, seep, and sedge meadow wetland remnants are found within Lake in the Hills Fen, which is ADID wetland L129. The ecological significance of these areas is discussed in more detail in Section 3.11.

Table 22. McHenry County ADID wetlands and attributes.

ADID ID #	Acres	ADID Attributes
K1168	1.6	High Functional Value: High stormwater storage capacity and sediment & nutrient removal.
L91	24.9	High Functional Value: High stormwater storage capacity and sediment & nutrient removal.
L40	144.0	High Quality Wetland
L52	199.6	High Functional Value: High stormwater storage capacity and sediment & nutrient removal.
L63	2.5	High Functional Value: High stormwater storage capacity and sediment & nutrient removal.
L3	8.6	High Quality Wetland
L9	10.9	High Quality Wetland
L28	32.1	High Functional Value: High stormwater storage capacity and sediment & nutrient removal.
L129	247.6	High Quality Wetland
L179	16.6	High Quality Wetland

Source: McHenry County ADID Wetland Inventory

Noteworthy- Wetland Protection

Protection of ADID wetlands is provided in McHenry and Kane Counties under existing Watershed Development Ordinances and the U.S. Army Corps of Engineers (USACE) via section 404 of the Clean Water Act. The USACE will generally require an Individual Permit (IP) for modifications to ADID wetlands. ADID wetlands are generally considered unmitigable. In rare cases where mitigation is allowed, as much as a 5:1 mitigation ratio is required. Additionally, ADID wetlands located within developed areas require a 100-foot buffer to aid in protection.

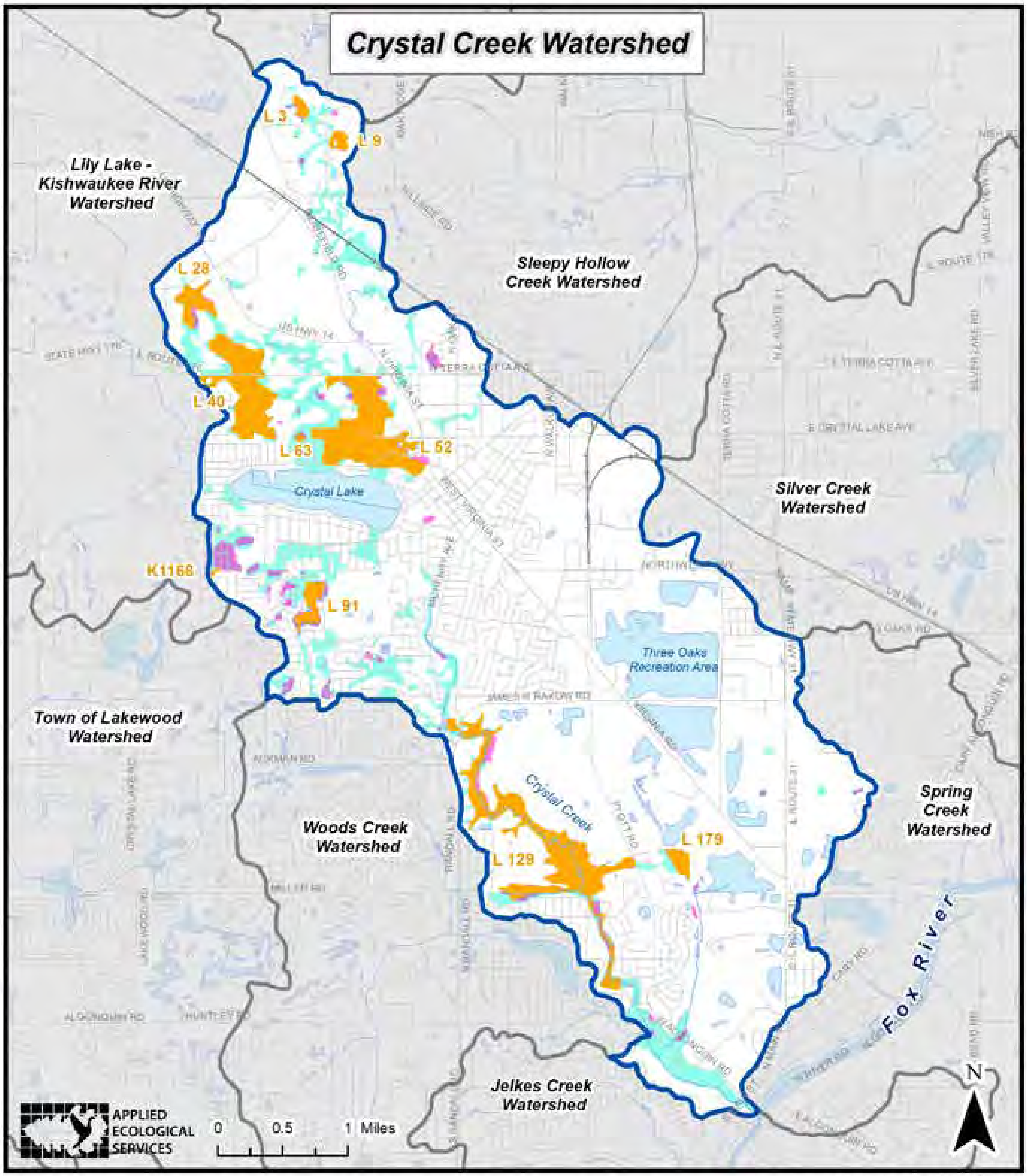


Fig. 39: Pre-European Settlement and Existing Wetlands

DATA SOURCES: City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey

Legend

- Crystal Creek Watershed
- Roads_CrystalCreek
- Railroad
- Waterbodies (NHD)
- Streams & Tributaries (NHD)

ADID Wetlands

- High Functional Value/High Quality Wetlands
- Wetland

Pre-Settlement Wetlands

- Wetland/Hydric Soil

Potential Wetland Restoration Sites

Wetland restoration projects are among the most beneficial in the context of improving watershed conditions. They are beneficial in improving basic environmental functions that historic wetlands once served such as storing water during flood events, increasing biodiversity, creating green infrastructure, and improving water quality. Wetland restoration projects can also be completed as part of a Wetland Mitigation Bank where developers are able to buy wetland credits for wetland impacts occurring elsewhere in the watershed.

Table 23. Wetland acreage by type.

Wetland Type	Acreage	Percent of Watershed
Pre-Settlement Wetlands	1,483.5	12.3%
Existing High Functional Value/High Quality Wetlands (ADID)	688.3	6.7%
Other Existing Wetlands	117.8	1.0%
Totals		**48,198**

Wetland restoration sites are those where wetlands once existed but no longer exist because of human impacts such as tile draining, filling, or stream channelization. Some of these sites can be restored. Potential Wetland Restoration Sites were identified using a Geographic Information Systems (GIS) exercise and specific criteria determined to be essential for restoration of a functional and beneficial wetland. The criteria used to identify potential sites was that at least 5 acres of drained hydric soils were identified on an open or partially open parcel.

During the field inventory conducted during the fall of 2019, AES reviewed potential wetland restoration sites identified via the GIS exercise and found that none of the remaining potential wetland restoration sites were considered potentially feasible. In most cases, the remaining hydric soils that were not already wetlands were either too small, too disturbed, or poorly located to make for a potentially feasible wetland restoration site.

Wetland complex at Lake in the Hills Fen

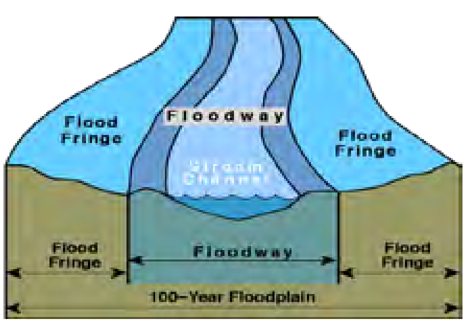
3.12.5 Floodplain & Flood Problem Areas

FEMA 100-Year Floodplain

Functional floodplains along stream and river corridors perform a variety of green infrastructure benefits such as flood storage, water quality improvement, passive recreation, and wildlife habitat. The most important function however is the capacity of the floodplain to hold water during significant rain events to minimize flooding downstream. The 100-year floodplain is defined by the Federal Emergency Management Agency (FEMA) as the area that would be inundated during a flood event that has a one percent chance of occurring in any given year (100 – year flood). 100-year floods can and do occur more frequently, however the 100-year flood has become the accepted national standard for floodplain regulatory purposes and was developed in part to guide floodplain development to lessen the damaging effects of floods.

The 100-year floodplain also includes the floodway. The floodway is the portion of the stream or river channel that comprises the adjacent land areas that must be reserved to discharge the 100-year flood without increasing the water surface. Figure 40 below depicts the 100-year floodplain and floodway in relation to a hypothetical stream channel. Figure 41 depicts the 100-year floodplain which occupies 618 acres or 5.1% of Crystal Creek watershed.

Figure 40. 100-year floodplain and floodway depiction.



Detail of identified flood problem areas, all near Crystal Lake

Table 24. Documented Flood Problem Areas.

FPA #	Location	Description
1	Country Club Area	High groundwater, no designated storm sewer system and floodplain area causes excessive yard flooding and minimal structure flooding.
2	Crystal Vista Area	High groundwater, no designated storm sewer system causes yard flooding, depressional areas with no outlets – 2019 completed a project which installed new storm sewer to alleviate a large depressional area in the rear yard of homes.
3	Green Oaks Area	High groundwater, no designated storm sewer system and failing drain tile. 2019 replaced existing drain tile which brought the groundwater down.
4	North Shore Area	High Groundwater, no designated storm sewer system, pockets of depressional areas with no outlet; structural and yard flooding – 2020 completed a project which installed storm sewer and water quality basins to clean the water before it enters the lake.
5	Pine/**Oriole Trail/**	Depressional area in the rear yard of homes holds water and during large events causes excessive yard flooding and some structure flooding – 2020 project to purchase up to 5 homes in the area to demolish and return to its natural area which will safely store stormwater during rain events.
6	Union Street Area	Undersized storm sewer or lack of storm sewer causes roadway flooding making some residential roadways unpassable. 2018 constructed a storm sewer to alleviate flooding of a residential street that caused excessive yard flooding; 2020 separate project in a different location to upsize an existing storm sewer to minimize street flooding.

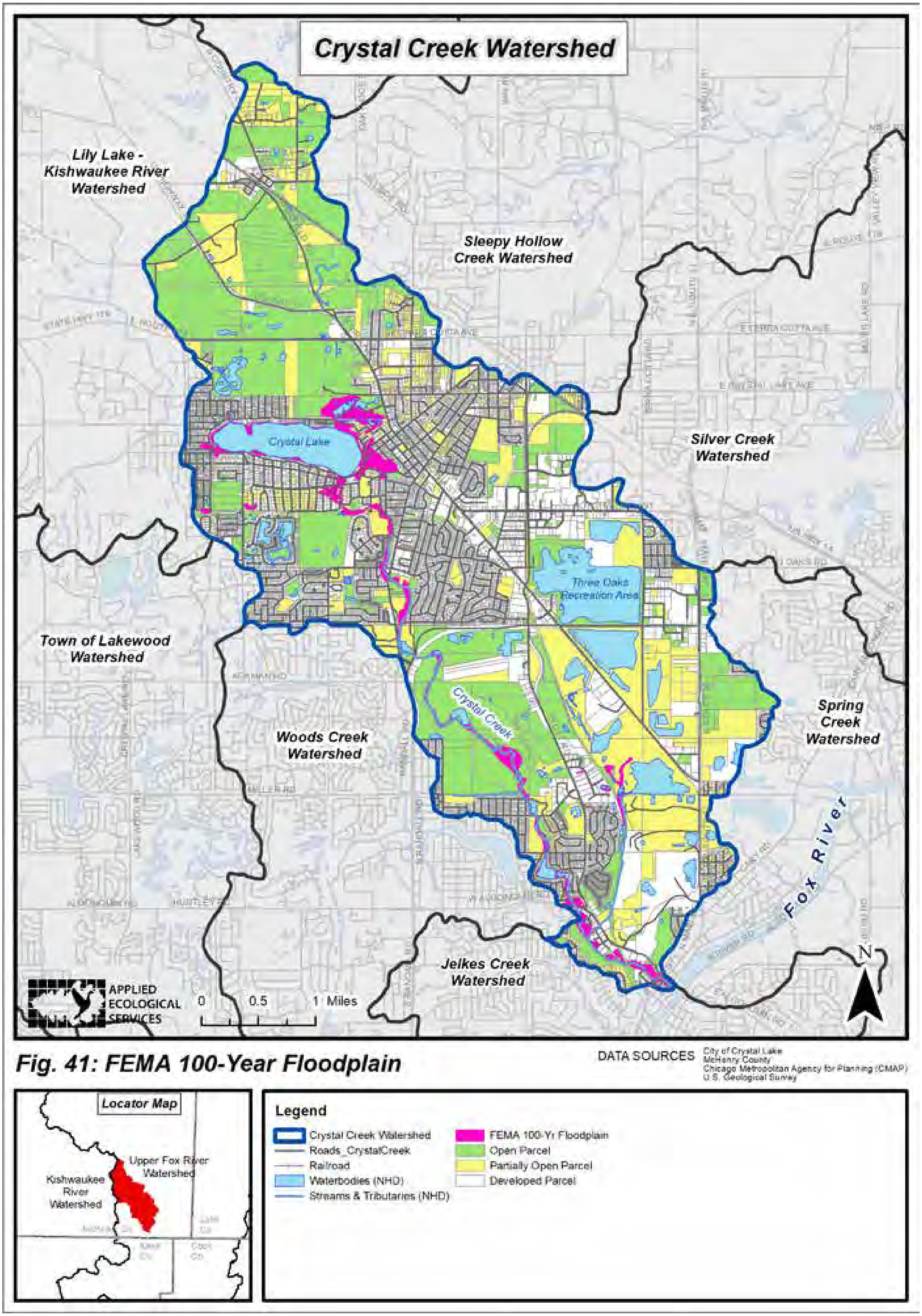


Fig. 41: FEMA 100-Year Floodplain

DATA SOURCES: City of Crystal Lake, McHenry County, Chicago Metropolitan Agency for Planning (CMAP), U.S. Geological Survey

Documented Flood Problem Areas
For this report, a Flood Problem Area (FPA) is defined as a location where documented flooding can or does cause structural damage. Information about the location and condition of documented FPAs was gathered by the City of Crystal Lake as well as during one of the watershed stakeholder meetings. Six (6) FPAs were identified and are detailed in Table 24.

3.13 Groundwater Aquifer Recharge & Community Water Supply

Groundwater is water that saturates small spaces between sand, gravel, silt, clay particles or crevices in underground rocks.Groundwater is an essential resource to McHenry County as underlying aquifers provide the drinking water supply for people and support many ecosystems by providing base flow for streams and contributing water to ponds, lakes, wetlands, and fens.

Groundwater is found in aquifers or underground formations that provide readily available quantities of water to wells, springs, or streams. Aquifers can be Confined aquifers where groundwater is confined between layers of clay, silts, dense rock or other materials or Unconsolidated shallow aquifers which are not confined by impermeable layers. Unconfined sand and gravel aquifers generally extend from just below the ground surface to depths of several hundred feet. These shallow aquifers are easily tapped and used by residences, farms, or entire communities.

Four major aquifer systems supply Northern Illinois communities that rely on groundwater. Those aquifers include the unconsolidated sand and gravels, the shallow Silurian dolomite bedrock, the deep Cambrian-Ordovician sandstone bedrock, and the very deep Elmhurst-Mount Simon sandstone bedrock. All but the Elmhurst-Mount Simon aquifer are utilized in the surrounding study area (Baxter & Woodman 2006).

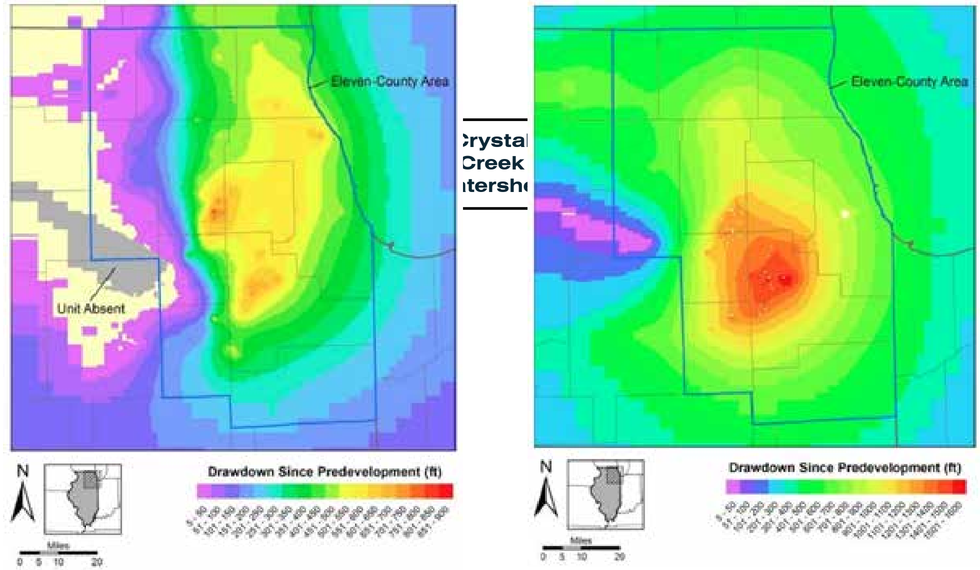


Figure 42. Year 2050 modeled groundwater drawdown in the Ancell Unit (left) and Ironton-Galesville Unit (right).

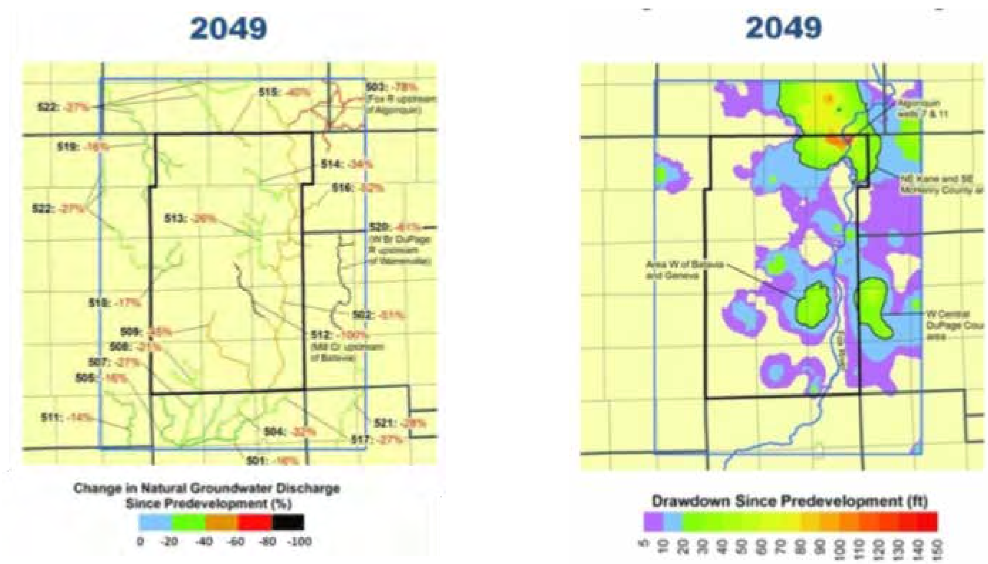


Figure 43. Modeled groundwater discharge and aquifer drawdown since predevelopment.

Groundwater studies conducted for the 11-county Northeastern Illinois Regional Water Supply Planning area by the Illinois State Water Survey (ISWS) suggest that drawdown currently exceeds 5 feet in shallow unconsolidated aquifers in much of southeastern McHenry County, and that these areas will expand significantly by 2050, possibly affecting groundwater availability (Meyer et al., 2009). The studies also suggest that reductions in groundwater discharge to streams currently exceeds 10 percent in some southeastern McHenry County streams, and that the number of streams affected to this degree will increase greatly by 2050. Land cover changes may also affect groundwater quality, as ISWS studies have demonstrated elsewhere in northeastern Illinois (Kelly & Wilson 2008). An Illinois State Water Survey (ISWS) Study from 2012 (ISWS, 2012) suggests that drawdown since predevelopment could reach 450 ft in the Ancell Unit and up to 900 feet in the Galesville Unit by 2050 (Figure 42).

Groundwater aquifer recharge is the process by which precipitation

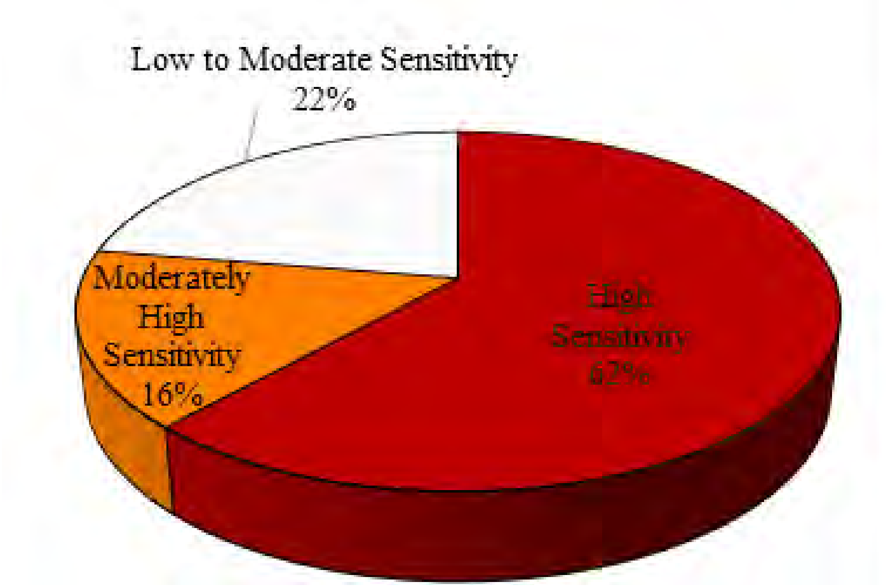


Figure 44. Distribution of aquifer recharge sensitivity.

reaches and re-supplies the groundwater aquifers. Conversely, groundwater discharge occurs when groundwater seeps out though permeable soils to low areas such as stream channels and other wetlands. Crystal Creek watershed is located in an area highly affected by future recharge and discharge issues. Figure 43 illustrates ISWS modeling that shows significantly lower levels of groundwater discharge (-40% to -60%) and significant shallow bedrock aquifer drawdown (70 to 100 feet) by 2049 compared to predevelopment conditions.

Sensitive Aquifer Recharge Areas (SARA) are generally defined as areas where the surface of the aquifer is close to the ground surface with highly permeable sand and gravel. In these areas, contaminants from the surface can move rapidly through the sand and gravel deposits to wells and groundwater fed streams. Figures 44 and 45 show the distribution of aquifer recharge sensitivity in Crystal Creek watershed. Within the Crystal Creek watershed 2,700 acres (22%) exhibit “Low to Moderate” sensitivity, 1,911 acres (16%) are “Moderately High”, and 7,426 acres (62%) exhibit “High” sensitivity to aquifer recharge. Almost 80% of the watershed is comprised of SARAs. In fact, based on a 2017 hydrogeology study, recharge rates within the Crystal Creek watershed are greater than 4-5 inches per year and exhibit the highest recharge rates in McHenry County (Gahala, 2017).

McHenry County is a leader in research and planning related to future groundwater issues. McHenry County’s Groundwater Protection Action Plan (McHenry County 2009) addresses groundwater issues by presenting model policies that all local government can consider and modify to address their individual needs. In McHenry County, a Sensitive Aquifer Recharge Areas (SARA) map was developed to delineate Moderately High and High potential for aquifer recharge/contamination areas. Figure 45 shows the Sensitive Aquifer Recharge Areas in Crystal Creek watershed. The policy recommendations focus on future groundwater withdrawals, land use and zoning, stormwater management, National Pollution Discharge Elimination Systems (NPDES), open space/natural areas, mining operations, wastewater reuse and septic systems, abandoned wells, storage tanks, and salvage yards.

Based on SARA mapping in Crystal Creek watershed, future groundwater policy will be an important issue and particular opportunities may present themselves down the line related to the gravel quarry operations in the southeast portion of the watershed along Tributary 2. When considering how redevelopment might occur in the future with the lands currently owned by Hanson Material Service, these SARAs should be prioritized for increased protection and restoration.

McHenry County Planning and Development maintains a list of groundwater and surface water studies and website. For more information, please visit: https://www.mchenrycountyil.gov/county-government/departments-j-z/planning-development/water-resources/groundwater-and-surface-water-studies-and-websites.

Community Water Supply

Groundwater is an essential resource within the Crystal Creek watershed as underlying aquifers provide the drinking water supply for many people. The water supply in communities within the watershed comes primarily from wells of varying depths. Private wells are scattered throughout the watershed. Seventeen (17) community water supply wells are located within Crystal Creek watershed, but only 12 are active (Table 25). One additional well is proposed for Crystal Creek Clear Water Company but is not yet constructed. It is important to note that future development projects that include infiltration best management practices will mostly benefit the shallow aquifers and not deep aquifers.

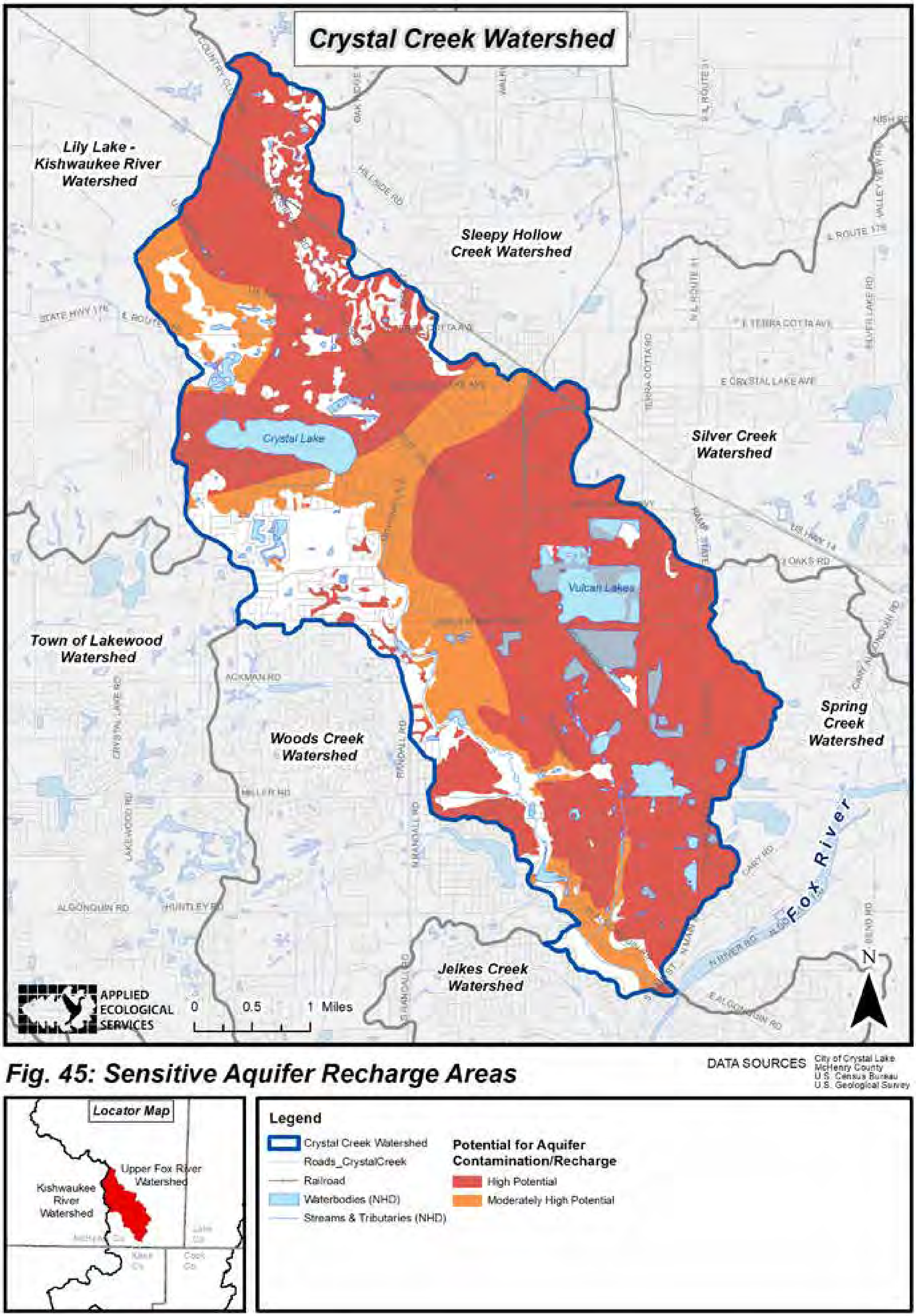


Fig. 45: Sensitive Aquifer Recharge Areas

Table 25. Community water supply wells within Crystal Creek watershed.

Well ID	CWS Name	Depth (ft)	Status	Aquifer Depth	Year Drilled
20167	Royal Oaks MHP	80	Active	Shallow	1900
20168	Royal Oaks MHP	258	Active	Shallow	1900
22145	Crystal Lake	45	Inactive	Shallow	1948
00590	Crystal Lake	206	Active	Shallow	1986
01767	Crystal Lake	206	Abandoned	Shallow	N/A
22146	Crystal Lake	1,295	Active	Deep	1963
01085	Crystal Lake	137	Active	Shallow	1995
01086	Crystal Lake	1,293	Active	Deep	1996
00591	Crystal Lake	250	Active	Shallow	1986
22148	Crystal Lake	1,300	Active	Deep	1973
00592	Crystal Lake	250	Active	Shallow	1986
20146	Aqua IL- Crystal Clear Water Co.	271	Active	Shallow	1961
20145	Aqua IL- Crystal Clear Water Co.	512	Active	Deep	1954
01823	Aqua IL- Crystal Clear Water Co.	270	Proposed	Shallow	N/A
20198	Lake in the Hills	113	Proposed	Shallow	1980
20196	Lake in the Hills	114	Abandoned	Shallow	1954
01190	Lake in the Hills	1,310	Active	Deep	2001
20216	Algonquin	955	Inactive	Deep	1977

Source: IEPA Source Water Assessment Program

3.14 NPDES Permits, Wastewater Treatment & Septic Systems

There are three National Pollution Discharge Elimination System (NPDES) permits within the watershed: Crystal Lake STP #2 (IL0028282 – 2 outfalls), Lake in the Hills SD STP (IL0021733), and Hanson Material Service – Yard 46 (ILG840090) (Figure 46). The first two are both wastewater treatment facility discharges, while the last is a general permit. Permit ILG840090 is a General NPDES Permit for Non-coal Mines held by Hanson Material Service- Algonquin Sand & Gravel and the outfall is on Crystal Creek just upstream of the confluence of Crystal Creek and the Fox River.

The Crystal Lake wastewater treatment facility #2 discharges under NPDES Permit No. IL0028282 and is located at 1100 Coventry Lane in Crystal Lake. Two discharges are covered under the permit: B01 STP Internal Outfall (which regulates normal discharges) and A01 Excess Flow Outfall which handles excess flows; both discharges are to Crystal Creek. The facility is required to stay within established discharge rates for biological oxygen demand, suspended solids, pH, fecal coliform, chlorine residual, ammonia nitrogen, total phosphorus, barium, and dissolved oxygen. The plant is only required to monitor total nitrogen, dissolved phosphorus, nitrate/nitrite, total Kjeldahl nitrogen, alkalinity, and temperature. It currently has a designed average flow of 5.8 million gallons per day (MGD) and design maximum flow of 14.5 MGD. IL0028282 NPDES permit standards are included in Table 26.

The same permit authorizes excess flows (A01 Excess Flow Outfall) need to fall under the following concentration limits (monthly average): BOD – 30 mg/L, Suspended Solids – 30 mg/L, ph – shall be in the range of 6 to 9 standard units, Chlorine residual – 0.75 mg/L, and must monitor only for ammonia nitrogen (as N), total phosphorus (as P), and dissolved oxygen.

The Lake in the Hills Sanitary District discharges under NPDES Permit No. IL0021733 and is located at 515 Plum Street in Lake in the Hills. This permit includes one outfall that discharges to Crystal Creek. The facility is required to stay within established discharge rates for biological oxygen demand,

Table 26. IL0028282 NPDES permit requirements for B01 STP Internal Outfall.

Parameter	Load Limits - lbs/day DAF (DMF)		Concentration Limits - mg/L	
	Monthly Ave. (lbs/day)	Daily Max. (lbs/day)	Monthly Ave. (mg/L)	Daily Max. (mg/L)
Flow: 5.8 MGD ave. & 14.5 MGD max.				
CBOD	484 (1209)	967 (2419)	10	20
Suspended Solids	580 (1451)	1161 (2902)	12	24
pH	Shall be in the range of 6 to 9 Standard Units			
Fecal Coliform	Daily maximum shall not exceed 400 per 100 mL (May through October)			
Amonia Nitrogen				
Apr-Oct	53 (133)	146 (363)	1.1	3.0
Nov-Feb	68 (169)	232 (580)	1.4	4.8
March	68 (169)	232 (580)	1.4	4.8
Total Phosphorus	48 (121)	-	1.0	-
Barium	97 (242)	193 (484)	2.0	4.0
Monitor Only	Total nitrogen, dissolved phosphorus, nitrate/nitrite, total Kjeldahl Nitrogen (TKN), alkalinity, temperature			
Dissolved Oxygen			**Not Less Than**	**Daily Minimum**
March	-	-	-	5.0
Aug- Feb	-	-	5.5	3.5

suspended solids, pH, fecal coliform, chlorine residual, ammonia nitrogen, total phosphorus, barium, and dissolved oxygen. The plant is only required to monitor total nitrogen, dissolved phosphorus, nitrate/nitrite, total Kjeldahl nitrogen, alkalinity, and temperature. It currently has a designed average flow of 4.5 million gallons per day (MGD) and design maximum flow of 10.4 MGD.

IL0021733 NPDES permit standards are included in Table 27.

Septic Systems

Septic systems, also referred to as Onsite Waste Water Treatment Systems, are common within the older, unincorporated portions of the Crystal Creek community. When septic systems are not maintained or fail, they pose real threats to groundwater and surface water quality, especially when they are located near streams or other water bodies. Failing septic systems can contribute high levels of nutrients (phosphorus and nitrogen) and bacteria (fecal coliform) to the environment. The failure rate of septic systems in the watershed is unknown. However, literature sources across the nation indicate a failure rate of approximately 20% (Brown, 1998; Mancl, 1984; Stout, 2003; UKCE, 2012).

While no specific data is available regarding the number of septic systems within the watershed, AES was able to estimate that based on the 2010 census data, there are approximately 666 septic systems in the watershed. This number was calculated based on the assumption that each household outside of a municipal boundary is likely to have a septic system. AES carefully reviewed and fact-checked the validity of this estimating method and is confident it is a reasonably accurate estimate and also used these estimates as part of the STEPL modeling (see Section 3.16). Table 28 depicts the estimated number of unincorporated households/septic systems by subwatershed management unit. Septic systems in McHenry County are regulated under the McHenry County Public Health Ordinance, Article X: An Article Regulating Wastewater & Sewage Treatment and Disposal for McHenry County Illinois. "The primary goal of the Private Disposal Program is to prevent the transmission of disease through the exposure to sewage (MCDH, 2020)."

The United States Environmental Protection Agency (USEPA) provides an excellent guide for septic system

Table 27. IL0021733 NPDES permit requirements for Lake in the Hills SD STP.

Parameter	Load Limits - lbs/day DAF (DMF)		Concentration Limits - mg/L	
	Monthly Ave. (lbs/day)	Daily Max. (lbs/day)	Monthly Ave. (mg/L)	Daily Max. (mg/L)
Flow: 4.5 MGD ave. & 10.4 MGD max.				
CBOD	375 (867)	751 (1735)	10	20
Suspended Solids	450 (1041)	901 (2082)	12	24
pH	Shall be in the range of 6 to 9 Standard Units			
Fecal Coliform	Daily maximum shall not exceed 400 per 100 mL (May through October)			
Amonia Nitrogen				
Apr-Oct	45 (104)	113 (206)	1.2	3.0
Nov-Feb	94 (217)	281 (651)	2.5	7.5
March	45 (104)	251 (581)	1.2	6.7
Total Phosphorus	38 (87)	-	1.0	-
Barium	75 (173)	150 (347)	2.0	4.0
Monitor Only	Total nitrogen, dissolved phosphorus, nitrate/nitrite, total Kjeldahl Nitrogen (TKN), alkalinity, temperature			
Dissolved Oxygen			Not Less Than	Daily Minimum
March	-	-	-	5.0
Aug- Feb	-	-	5.5	3.5

Table 28. Estimated number of households/septic systems by subwatershed management unit.

SMU #	Estimated Number of Rural Households (based on 2010 Census
1	101
2	64
3	50
4	53
5	168
6	76
7	32
8	122
TOTAL	666

owners called “A Homeowner’s Guide to Septic Systems” (USEPA, 2005). The guide makes it clear that septic system maintenance is the responsibility of the owner. The guide also explains how septic systems work, why and how they should be maintained, and what makes a system fail. Septic system owners or those proposing to install new systems are encouraged to regularly maintain septic systems and seek guidance from McHenry County Department of Health (accessible at https://www.mchenrycountyil.gov/county-government/departments-a-i/health-department/environmental-health/onsite-wastewater-treatment).

3.15 Water Quality Assessment

Crystal Creek is the primary stream in Crystal Creek watershed. Crystal Creek begins at Crystal Lake and flows southeast for approximately 6 miles before joining with Woods Creek just east of Craig Street. After joining Woods Creek, Crystal Creek flows southeast for about a mile to the Fox River. In addition, 2 tributaries flow to Crystal Creek accounting for 2 tributary miles.

Water quality is generally fair within Crystal Creek watershed according to available data. There are two wastewater treatment plant NPDES outfalls in the watershed. Municipalities discharging to Crystal Creek and tributaries are regulated by EPA’s NPDES Phase II Stormwater Permit Program. Additionally, an outfall draining settling ponds in a gravel mine also drains into Crystal Creek. Gravel mines are regulated by the general NPDES permit No. ILG84 for non-coal mines. Many stormwater discharges are located along

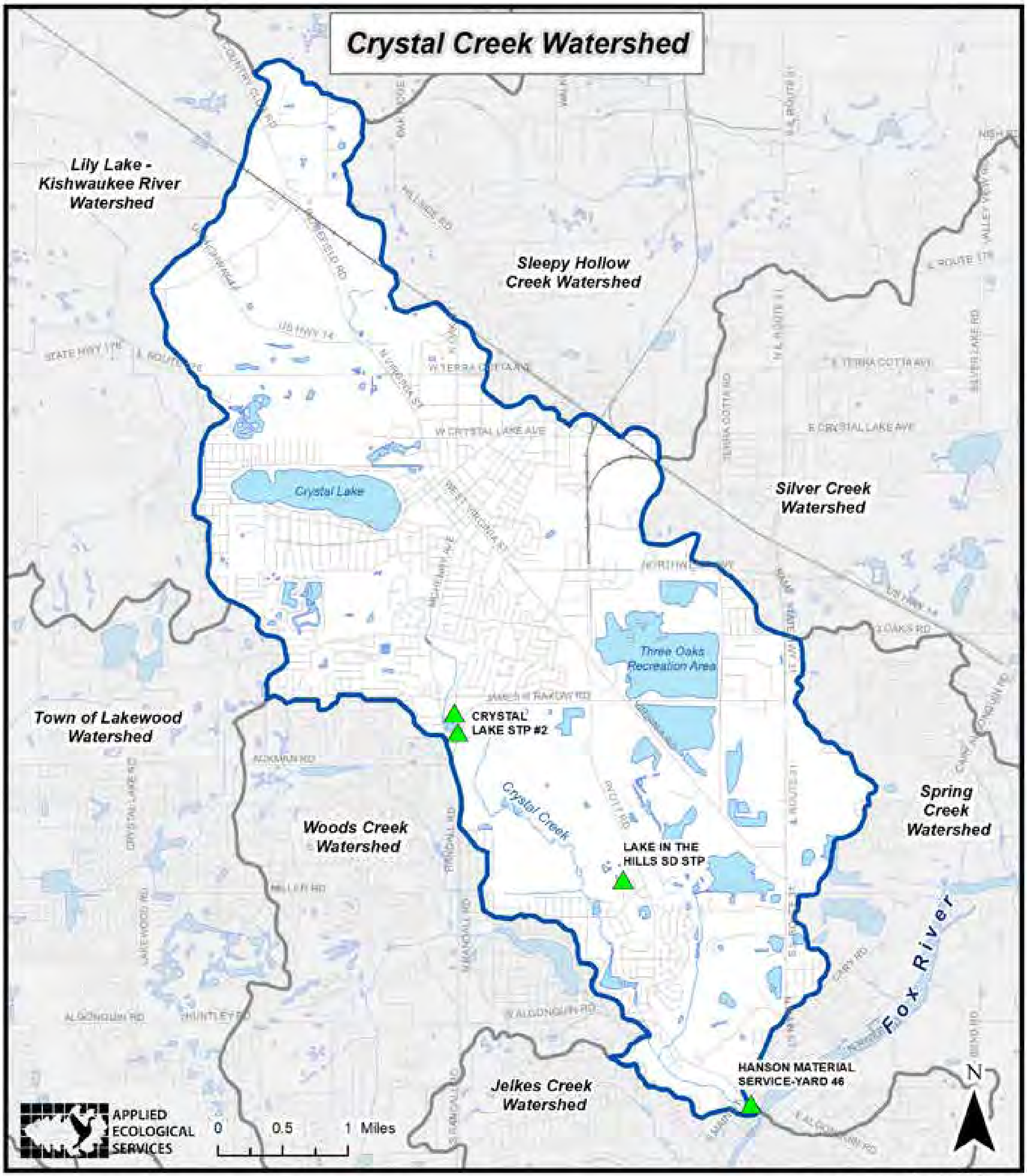


Fig. 46: NPDES Permitted Sites

DATA SOURCES City of Crystal Lake, McHenry County, U.S. Census Bureau, U.S. Geological Survey

Legend
- Crystal Creek Watershed
- Roads_CrystalCreek
- Railroad
- Waterbodies (NHD)
- Streams & Tributaries (NHD)
- NPDES Permitted Sites

Crystal Creek and its tributaries. However, the location of each discharge is not available for this study. Table 31 lists all known water quality and biological data collected in the watershed within the past 10 years while Figure 47 displays the location of each sample site where the data was collected. In general, the most recent data is analyzed so that recommendations and management strategies are based on the most current depiction of the water quality and biological conditions.

Section 305 (b) of the Federal Clean Water Act requires Illinois and all other states to submit to the USEPA a biennial report of the quality of the state's surface and groundwater resources called the Illinois Integrated Water Quality Report and Section 303d List. These reports must also describe how Illinois assessed water quality and whether assessed waters meet or do not meet water quality standards specific to each "Designated Use" of a stream or lake as defined by the Illinois Pollution Control Board (IPCB). When a waterbody is determined to be impaired, Illinois EPA must list potential causes and sources for impairment in the 303 (d) impaired waters list.

Streams

Illinois EPA developed six general Designated Uses for Illinois

Table 29. Illinois EPA Designated Uses and impairments for Crystal Creek.

Designated Use	Use Attainment	Impaired?	Cause of Impairment	Source of Impairment
Crystal Creek (Crystal Lake Outlet): ILDTZR01				
Aquatic Life	Fully Supporting	No	-	-
Fish Consumption	Not Assessed	-	-	-
Primary Contact Recreation	Not Supporting	Yes	Fecal Coliform	Urban Runoff/ Storm Sewers
Aesthetic Quality	Fully Supporting	No	-	-

Source: Illinois Integrated Water Quality Report and Section 303(d) List – 2018

Table 30. Illinois EPA Designated Uses and impairments for Crystal Lake and Three Oaks Recreation Area.

Designated Use	Use Attainment	Impaired?	Cause of Impairment	Source of Impairment
Crystal Lake: ILVTZH				
Aquatic Life	Fully Supporting	No	-	-
Fish Consumption	Not Assessed	-	-	-
Primary Contact	Not Assessed	-	-	-
Aesthetic Quality	Fully Supporting	No	-	-
Crystal Lake: ILVTZH				
Aquatic Life	Fully Supporting	No	-	-
Fish Consumption	Not Assessed	-	-	-
Primary Contact	Not Assessed	-	-	-
Aesthetic Quality	Fully Supporting	No	-	-
Crystal Lake: ILVTZH				
Aquatic Life	Fully Supporting	No	-	-
Fish Consumption	Not Assessed	-	-	-
Primary Contact	Not Assessed	-	-	-
Aesthetic Quality	Fully Supporting	No	-	-

Source: Illinois Integrated Water Quality Report and Section 303(d) List – 2018 surface waters. Crystal Creek is also known as Crystal Lake Outlet (HUC 07120061201; Illinois EPA #IL DTZR 01) and was assigned four Designated Uses. The Designated Uses assigned to Crystal Creek by Illinois EPA include: Aquatic Life, Fish Consumption, Primary Contact Recreation, and Aesthetic Quality. Crystal Creek is not supporting for Primary Contact due to high Fecal Coliform levels originating from urban runoff/ storm sewers. Table 29 includes a summary of Designated Uses and impairments for Crystal Creek.

Lakes

Illinois EPA determined that neither Crystal Lake or Three Oaks North and South Lakes are impaired and they all meet assessed Aquatic Life and Aesthetic Quality Designated Uses according to the Draft 2018 Illinois Integrated Water Quality Report and Section 303d List (Draft Illinois EPA 2018). Table 30 includes a summary of Illinois EPA Designated Uses and impairments for Crystal Lake, Three Oaks North, and Three Oaks South.

Noteworthy- Numeric Water Quality Standards

USEPA expects states to establish numeric water quality standards for nutrients (phosphorus and nitrogen) in lakes and streams. Currently, Illinois EPA has a numeric phosphorus standard and is working on developing nutrient criteria for streams. To date, Illinois EPA has not developed numeric standards for total suspended solids (TSS) in streams. Numeric criteria has been proposed by USEPA for nutrients based on a reference stream method for the Corn Belt and Northern Great Plains Ecoregion (Ecoregion VI) which includes Crystal Creek watershed. The USGS has published a document outlining recommended numeric criteria for sediment in streams for Ecoregion VI. These criteria are used in this report to assess the quality of Crystal Creek and tributaries to develop pollution reduction targets and measure future successes, even though Illinois EPA has not adopted these criteria as standards.

Illinois EPA and others have developed statistical guidelines for various pollutants other than nutrients and suspended sediment. Illinois also provides General Use water quality standards that apply to almost all waters and are intended to protect aquatic life, wildlife, agriculture, primary contact, secondary contact, and most industrial uses. Statistical guidelines and General Use water quality guidelines are also used in this report as a means to measure impairment and to determine pollutant reduction needs in Crystal Creek watershed. In the absence of numeric standards, proposed or recommended standards from USEPA and USGS were used.

- Phosphorus (USEPA): <0.0725 mg/L
- Nitrogen (USEPA): <2.461 mg/L
- Total suspended solids (USGS): <19 mg/L
- Fecal coliform (IEPA): <200CFU/100mL

Water Chemistry Monitoring

Crystal Creek & Tributaries

The Illinois EPA (IEPA) lists Crystal Creek as impaired for the Designated Use of Primary Contact Recreation. Available water quality and habitat data for Crystal Creek and its tributaries indicates moderate overall impairment. Total phosphorus (TP), total nitrogen (TP), total suspended solids (TSS) and fecal coliform (and/or E. Coli) are the primary impairments for Crystal Creek and tributaries.

Water quality monitoring within the Crystal Creek watershed has been ongoing for decades on both the streams and lakes by various entities. Table 31 details recent (2010-2020) chemical and biological water quality sample sites, the monitoring entities, approximate dates or date ranges of the sampling, and sampling regimes or parameters involved with each. Monitoring included five stream locations along Crystal Creek and nine lake locations across Crystal Lake and the lake at Three Oaks Recreation Area and are depicted in Figure 47. Sampling was conducted by IEPA, Fox River Study Group (FRSG), River Watch, North American Lake Management Society, and Applied Ecological Services (AES), and included various sampling regimes and sets of parameters.

AES analyzed historical water quality for Crystal Creek available via EPA's WQX/Storet water quality database for the last ten years (2010 through 2020). Average sample results for sampling site DTZR-02 at 2017 at Towne Park before the creek converges with the Fox River for dissolved oxygen, total suspended solids, chloride, total phosphorus, ammonia nitrogen (NH3), nitrate-nitrite nitrogen (NO2+NO3), total Kjeldahl nitrogen (TKN), and total nitrogen are reported in Table 32. The Illinois EPA sampled Crystal Creek 5 times in 2012 between June and October and twice in August and October of 2017 at DTZR-02. Monitoring results showed that NO2 + NO3, TKN, and Total Nitrogen (calculated) exceeded the recommended levels at 4.62 mg/l and 5.698 mg/l, respectively, as did total phosphorus which averaged 0.207 mg/l.

Fox River Study Group (FRSG) has been collecting and analyzing water quality data within the Fox River basins since 2002. AES downloaded and analyzed water quality data

Table 31. List of recent chemical and biological water quality sample sites.

Sample ID	Sampling Entity(s)	Date(s) Collected	Sampling Regime or Parameters
Biological Monitoring Stations			
RW-01 & 02	Illinois River Watch Network sampled at 2 locations in Crystal Creek at Scott Lake	2010-2017	Habitat, Aquatic vegetation, Fish community, RBP
Chemical Monitoring Stations			
AES-01	AES sampled at Tributary 2 near the intersection with Crystal Creek	5/14/2020, 6/8/2020	Chemical samples collected to establish baseline and post storm levels
AES-02	AES sampled at Woods Creek near the intersection with Crystal Creek	5/14/2020, 6/8/2020	Chemical samples collected to establish baseline and post storm levels
DTZR-02	IEPA sampled at Towne Park in Algonquin	2012 & 2017	Special and Intensive Basin Studies
	FRSG sampled near Towne Park in Algonquin	2010-2020	Chemical and physical samples collected regularly, including total phosphorus, ammonia, NO3, TKN, fecal coliform, and turbidity
	AES sampled at Towne Park in Algonquin	5/14/2020, 6/8/2020	Chemical samples collected to establish baseline and post storm levels
WTG-01,02 & 99	Illinois Environmental Protection Agency (IEPA) sampled at 3 locations on Three Oaks Recreation Area's lake	6/1/2017-10/19/2017	Ambient Lake & Harmful Algae Bloom studies parameters
VTZH-01, 03, 98, & 99	Illinois Environmental Protection Agency (IEPA) sampled 5 locations in Crystal Lake	2011 & 2017	Special, Ambient Lake, & Harmful Algae Blooms studies parameters
NALMS-1953	North American Lake Management Society (NALMS) sampled in Crystal Lake	9/9/2011	Management System Review, Depth, Temperature, Weather
RBP- Rapid Bioassessment Protocol			

Table 32. Illinois EPA Water Quality Sampling Results 2010-2020.

Parameter	Statistical, Numerical, or General Use Guidelines	Site DTZR-02 (IL EPA)
Max Temperature	< 90° F*	77.6
Average Dissolved Oxygen (DO)	> 5.00 mg/l*	8.08
Average Total Phosphorus (TP)	< 0.0725 mg/l**	0.2070
Average Nitrate-Nitrite (NO2+NO3)	1.798 mg/l**	4.620
Average Total Kjeldahl Nitrogen (TKN)	0.663 mg/l**	0.918
Average Nitrogen Ammonia (NH3)	< 15 mg/l*	0.140
Average of Total Nitrogen (TN) (mg/L), calculated	< 2.461 mg/l**	5.698
Average Total Suspended Solids (TSS)	< 19 mg/l***	17.7
Average Chloride	< 500 mg/l*	454

-Cells highlighted in red exceed recommended statistical, numerical, or General Use guidelines
* Illinois EPA General Use Standard
** Ambient Water Quality Criteria Recommendations: Rivers and Streams in Nutrient Ecoregion VI (USEPA 2000)
*** Present and Reference Concentrations and Yields of Suspended Sediment in Streams in the Great Lakes Region and Adjacent Areas (USGS 2006)

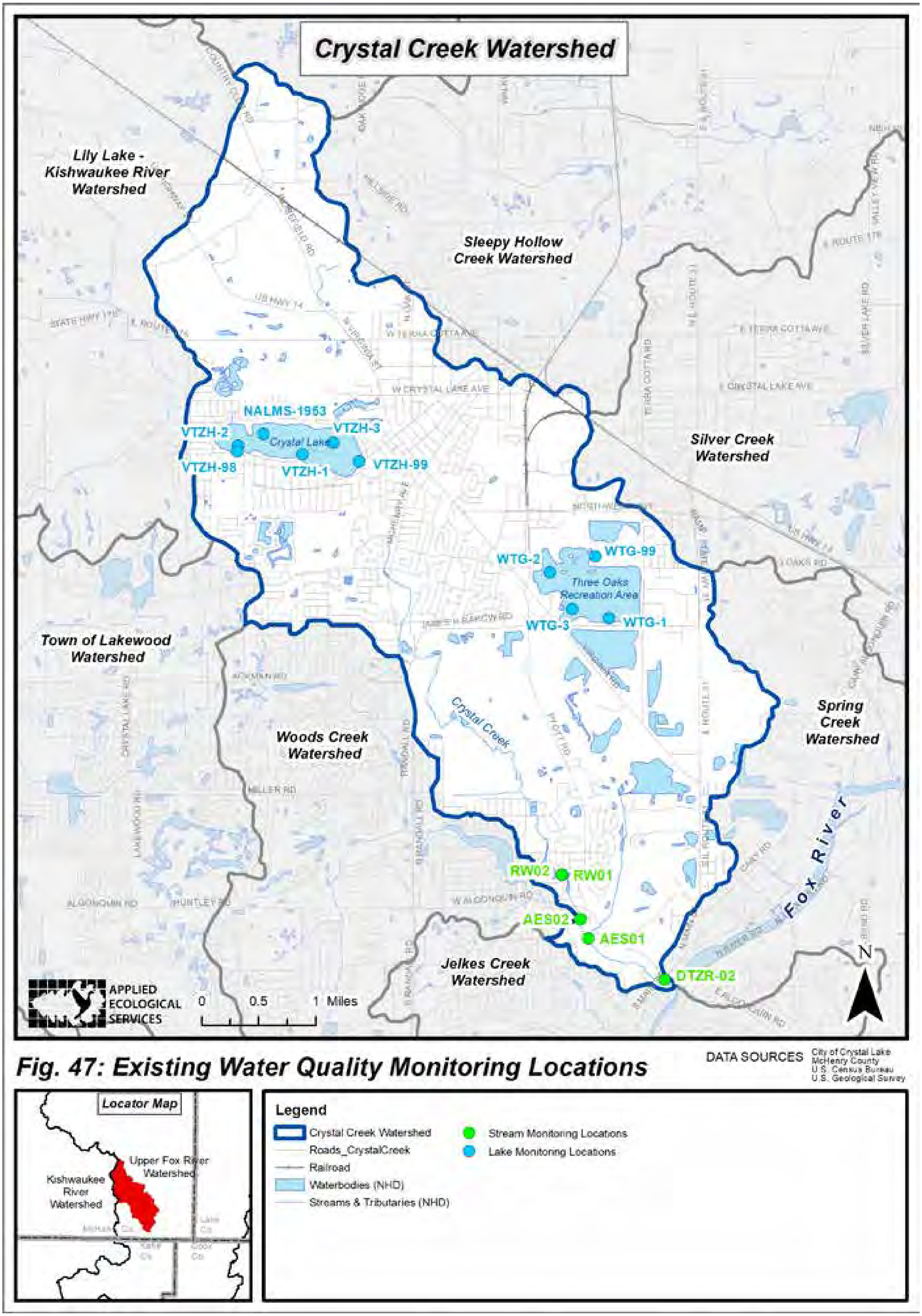


Fig. 47: Existing Water Quality Monitoring Locations

Table 33. Fox River Study Group Water Quality Sampling Results 2010-2020.

Parameter	Statistical, Numerical, or General Use Guidelines	Site DTZR-02 (IL EPA)
Average Total Phosphorus (TP)	< 0.0725 mg/l**	0.170
Average Nitrate Nitrogen (NO_3)	N/A	3.576
Average Total Kjeldahl Nitrogen (TKN)	0.663 mg/l**	0.973
Average Ammonia Nitrogen as N	< 15 mg/l*	0.089
Average Turbidity	< 14 NTU**	8.7
Average Fecal Coliform	< 200 CFU/100ml*	402.8

-Cells highlighted in red exceed recommended statistical, numerical, or General Use guidelines
* Illinois EPA General Use Standard
** Ambient Water Quality Criteria Recommendations: Rivers and Streams in Nutrient Ecoregion VI (USEPA 2000)
*** Present and Reference Concentrations and Yields of Suspended Sediment in Streams in the Great Lakes Region and Adjacent Areas (USGS 2006)

collected by FRSG at DTZR-02 from 2010-2020, which included total phosphorus, fecal coliform, ammonia nitrogen (NH_3), nitrate nitrogen (NO_3^-), total Kjeldahl nitrogen (TKN), turbidity, dissolved oxygen, pH, and chlorophyll-A. Average sample results for sampling site DTZR-02 from 2010-2020 for total phosphorus, fecal coliform, ammonia nitrogen (NH_3^+), nitrate nitrogen (NO_3^-), total Kjeldahl nitrogen (TKN), and turbidity are reported in Table 33. The average water quality values of the FRSG data depict total phosphorus, total Kjeldahl nitrogen, and fecal coliform as exceeding recommended criteria guidelines. It is important to note that there were no samples taken of nitrite nitrogen (NO_2^-), without which it is not possible to calculate total nitrogen for the Fox River Study Group water quality data.

In February 2019, Illinois State Water Survey produced a report entitled Water Quality Trend Analysis for the Fox River Watershed: Stratton Dam to the Illinois River that was based on FRSG water quality data. According to this study, annual water quality trends at Crystal Creek at Route 31 (DTZR-02) show that total phosphorus has been decreasing over time. Meanwhile, there has been no trend in ammonia nitrogen or total Kjeldahl nitrogen, but nitrate nitrogen has been increasing (ISWS, 2019). In addition to the IEPA sampling, Applied Ecological Services (AES) sampled three sampling stations including the IEPA DTZR-02 station to capture baseline and storm events water quality. Sample Site AES-01 was established to capture water quality data of Tributary 2 prior to joining Crystal Creek. Likewise, AES-02 captures Woods Creek before joining Crystal Creek. Site DTZR-02 is the most downstream testing site in the watershed and is the most representative of watershed-wide water quality conditions. It is important to note that the Woods Creek sample results (AES-02) and included as a measure of the pollutants coming from the Woods Creek watershed; these results were used to measure inputs from Woods Creek watershed and are not representative of Crystal Creek water quality conditions. Timeframe and budget allowed for one base flow grab sampling at each of the three locations on June 8, 2020 and another grab sample during a 3-inch storm event on May 14, 2020. The rationale behind this sampling is to capture a snapshot of water quality conditions when minimal run-off is occurring and another snapshot of water quality condition following a significant rain event when water is actively draining into Crystal Creek.

Water chemistry samples were sent to a certified laboratory for analysis for dissolved oxygen (DO), pH, total phosphorus (TP), nitrate nitrogen (NO_3), Nitrite (NO_2), total suspended solids (TSS), and E. coli. June 8, 2020 baseflow and May 14, 2020 post storm event data is summarized in Table 34. It is also important to note the following:

- Stream discharge information was also collected at each site by measuring stream dimensions and flow.
- Discharge data supplements grab sample data and was used to calculate pollutant loading estimates.
- Load estimates for Woods Creek were estimated using pollutant loading data as estimated within the Woods Creek watershed plan (2012), not the water quality data summarized here.

Sample bottles from TSS sampling at Lake in the Hills Fen

None of the water quality parameters sampled at AES-01 or AES-02 for June 8, 2020 base flow conditions exceeded recommended statistical, numerical, or Illinois EPA General Use guidelines, however, total phosphorus and total nitrogen were both elevated during base flow conditions at DTZR-02 (Table 34). An important finding is that total suspended solids (TSS) and E. coli are not problematic in Crystal Creek during base flow conditions. This evidence suggests that higher pollutant loads in Crystal Creek following storm events are causing water quality problems in Crystal Creek watershed.

Post storm event data collected on May 14, 2020 revealed elevated levels of total phosphorus (TP) and total suspended solids (TSS) compared to base flow conditions (Table 34). Total phosphorus (TP) levels at all three sites exceeded the recommended USEPA Ecoregion VI guideline of 0.0725 mg/l. Total suspended solids (TSS) levels collected during the May 14, 2020 storm event at all sites exceed the recommended USGS Ecoregion VI guideline and generally coincide with high total phosphorus (TP) levels. This is likely because phosphorus binds to sediment as it is transported downstream. Based on modeling, the source of this sediment likely originates from Woods Creek watershed and urbanized areas. E. coli at all three sampling locations also exceeded the IEPA General Use Standard Use Guidelines during the storm event on May 14, 2020. E.coli can be discharged into the watershed through improperly functioning septic systems, wildlife, or runoff

Table 34. Base flow (June 6, 2020) and storm event (May 14, 2020) water quality sample results for Sites AES-01, AES-02, DTZR-02

Parameter	Statistical, Numerical, or General Use Guidelines	Site AES-01		Site AES-02 (Woods Creek)		Site DTZR-02	
		Base	Storm	Base	Storm	Base	Storm
Dissolved Oxygen (DO) (mg/l)	>5.0 mg/l*	7.15	9.73	7.21	10.3	7.62	9.63
pH	>6.5 or <9.0*	8.22	7.91	8.12	8.32	8.26	7.96
Total Phosphorus (TP) (m/l)	<0.0725 mg/l**	0.023	0.155	0.055	0.08	0.186	0.213
Nitrate-Nitrite (NO2+NO3) (Calculated) (mg/l)	1.798 mg/l**	0.193	0.182	0.448	0.301	2.467	2.32
Ammonia Nitrogen (NH3) (mg/l)	<15 mg/l*	ND	ND	ND	ND	ND	ND
Average Total Kjeldahl Nitrogen (TKN)	0.663 mg/l**	ND	N/A	1.15	N/A	ND	N/A
Total Nitrogen (TN) (mg/L), calculated	<2.461 mg/l**	0.193	N/A	1.60	N/A	2.47	N/A
Total Suspended Solids (TSS) (mg/l)	<19 mg/l***	9.8	86	1.80	24.2	7.6	88.5
E. coli (MPN/mL)	<200 CFU/100ml*	113	>2,419.6	185	325.5	186	2,419.6
Chloride (mg/l)	<500 mg/l*	239	144	111	156	230	169
Velocity (m/s)	N/A	0.613	0.747	0.322	0.779	0.249	0.684
Discharge (Calculated) (m3/second)	N/A	0.467	1.22	0.436	2.96	1.84	7.61

-Cells highlighted in red exceed recommended statistical, numerical, or General Use guidelines, ND= not detected, N/A=Not Available (lab failure)
* Illinois EPA General Use Standard
** Ambient Water Quality Criteria Recommendations: Rivers and Streams in Nutrient Ecoregion VI (USEPA 2000)
*** Present and Reference Concentrations and Yields of Suspended Sediment in Streams in the Great Lakes Region and Adjacent Areas (USGS 2006)

from urban and agricultural areas. Additionally, heavy rain events may cause holding ponds and septic systems to overflow or excess sewer overflows into Crystal Creek.

During the March 2020 stakeholder meeting concerns surrounding whether the portion of Crystal Creek that runs through Lake in the Hills Fen (Crystal Creek Reach 7) was downcutting and possibly dewatering the fen and potentially contributing to sediment transport downstream. During the May 14, 2020 rain event sampling, AES collected one-time samples at the upstream and downstream ends of the fen to measure total suspended solids and results were as follows:

- Upstream of the fen, TSS was 29.8 mg/L,
- Downstream of the fen, TSS was 106 mg/L,
- This is a 255% increase in total suspended solids from one reach.

These results show that excessive erosion and downcutting is likely occurring on Crystal Creek Reach 7 within Lake in the Hills Fen and will need to be addressed.

Crystal Creek watershed-wide averages for TP, TN, and TSS were calculated by taking all of the individual sample results for these parameters at the DTZR-02 site and averaging them, since this is the most downstream and representative of water quality values in the entire watershed. The watershed-wide average readings were as follows:

- 0.173 mg/l of total phosphorus (vs. a target of <0.0725 mg/L),
- 5.032 mg/l of total nitrogen (vs. a target of <2.461 mg/L),
- 25.3 mg/l of total suspended solids (vs. a target of <19 mg/L), and
- 402.8 CFU/100ml (vs. a target of <200 CFU/100ml, based on FRSG's fecal coliform data as the most robust data source).

These watershed-wide averages will be used in the calculation of watershed-wide reduction targets.

Nutrients such as phosphorus and nitrogen are a necessary component of plant growth and are therefore included in many fertilizers. Unfortunately, both have adverse effects on water quality, with phosphorus being particularly detrimental to aquatic systems in excess quantities. These nutrients are applied as fertilizer, either in an agricultural setting or by applicators and the excess nutrients not absorbed by plants are then washed into waterways. Excess nutrients can cause algal blooms, accelerated plant growth, decreasing oxygen levels, and can lead to fish kills. Currently there is no Illinois state standard for nitrogen or phosphorus; however, the USEPA recommends a concentration of less than 2.461 mg/l of total nitrogen and 0.0725 mg/L of total phosphorus in streams. Nitrogen levels in Crystal Creek are particularly high, most likely a result of buried or piped stream sections, such as Crystal Creek Reach 3. According to research, nitrogen generally travels 18 times further in a buried stream than in an open stream due to the lack of plants and other organic matter that could feed on those nitrates, keeping streams healthy and oxygenated (Bliss, 2015). One solution is to daylight or unbury streams.

The ability to control erosion and excess sediment, and thereby total suspended solids, in waterways can be linked to the control of how development is handled as well as the condition of streambanks in the watershed. The construction process generally involves significant land disturbance and ecosystem destruction. The grading of sites, removal of vegetation, rerouting of natural drainage systems, and the addition of impervious surfaces, such as roads and parking lots, all interfere with water quality both in the short and long term. Removing vegetation and trees near the stream or floodplain removes the stability of the soil and increases bank erosion and sedimentation to nearby waterways. Alteration of natural drainage patterns can also significantly reduce the ability of the ecosystem to compensate for such increase in contaminants and sedimentation. Eroding streambanks also contribute additional sediments, particularly during and after rain events as peak flows scour away banks. High suspended sediment levels are problematic when light penetration is reduced, oxygen levels decrease, fish and macroinvertebrate gills are clogged, visual needs of aquatic organisms is reduced, and when sediment settles out in streams and lakes. There is no Illinois state guideline for total suspended solids, but the United States Geological Survey (USGS) recommends TSS do not exceed 19 mg/l for streams in the Crystal Creek watershed.

E. coli or fecal coliform can be used as indicators that a waterbody is contaminated by improperly functioning septic systems, wildlife, or runoff from urban and agricultural areas, which could carry other possible pathogens such as bacteria, viruses, and protozoans. While potential pathogens are too numerous to test for individually, the USEPA recommends E. coli testing "as the best indicator of health risk from water contact in recreational waters (USEPA, 2012)." Not only does the presence of excessive E. coli counts suggest there is a possible health risk in recreational contact with those waters, but the bacteria "can also cause cloudy water, unpleasant odors, and an increased oxygen demand (USEPA, 2012)." The Illinois general use standard requires that E. coli or fecal coliform levels do not exceed 200 CFU (colony forming units) per 100 ml of sample.

Lakes

Illinois EPA determined that neither Crystal Lake or Three Oaks Recreation Area are impaired. All three sites meet assessed Aquatic Life and Aesthetic Quality Designated Uses according to the Draft 2018 Illinois Integrated Water Quality Report and Section 303d List (Draft Illinois EPA 2018). More recent water quality sampling, however, suggests moderate impairment due to elevated nitrogen levels.

AES analyzed historical water quality for Crystal Creek watershed available via EPA's WQX/Storet water quality database for the last ten years (2010 through 2020). Water quality sampling data was conducted at Crystal Lake by the IEPA at 5 sites in August 8, 2011, and in June, July, and October of 2017 (Figure 47). The North American Lake Management Society collected additional depth and temperature data on September 9, 2011 at one site. All parameters sampled on Crystal Lake except nitrogen met the statistical, numerical, or general use guidelines for lakes. Three Oaks North was sampled by the Illinois EPA 4 times at 3 sites between June 1, 2017 and October 19, 2017. All water quality parameters sampled on Three Oaks except nitrogen met the statistical, numerical, or general use guidelines for lakes. Average values of all water quality parameters for both Crystal Lake and Three Oaks Recreation Area from 2010-2020 are included in Table 35.

Table 35. Illinois EPA water quality results for Crystal Lake and Three Oaks Recreation Area.

Parameter	Statistical, Numerical, or General Use Guidelines	Crystal Lake	Three Oaks
Max Temperature	<90° F*	79.7	79.6
Average Dissolved Oxygen (DO)	>5.0 mg/l*	7.01	10.4
Average pH	>6.5 or <9.0*	8.05	8.31
Average Total Phosphorus (TP)	<0.05 mg/l**	0.016	0.012
Average $NO_2 + NO_3$	0.015 mg/l****	0.05	0.09
Average Nitrogen Ammonia as N	see TN below	0.18	0.11
Average Kjeldahl nitrogen	<0.62 mg/l****	0.691	0.68
Average of Total Nitrogen (TN) (mg/L), calculated	<0.63 mg/l****	0.921	0.880
Average Total Suspended Solids (TSS)	<12 mg/l***	5.4	4
Average Chloride	<500 mg/l*	168.1	289.3

-Cells highlighted in red exceed recommended statistical, numerical, or General Use guidelines
* Illinois EPA General Use Standard
** Ambient Water Quality Criteria Recommendations: Rivers and Streams in Nutrient Ecoregion VI (USEPA 2000)
*** Present and Reference Concentrations and Yields of Suspended Sediment in Streams in the Great Lakes Region and Adjacent Areas (USGS 2006)

Biological Monitoring

The Illinois EPA uses biological data for determining "Aquatic Life" Use Attainment in streams because fish and macroinvertebrates are relatively easy to sample/identify and reflect specific and predictable responses to human induced changes to the landscape, stream habitat, and water quality.

Two indices have been developed that measure water quality using fish and macroinvertebrates - fish Index of Biotic Integrity (fIBI) and Macroinvertebrate Biotic Index (MBI). These indices are best applied prior to a project such as a stream restoration to obtain baseline data and again following restoration to measure the success of the project. Or, they can be conducted simply to assess resource quality in a stream or tributary reach.

Fish Index of Biotic Integrity (fIBI)

The fIBI is designed to assess water quality and biological health directly through several attributes of fish communities in streams. After the fish have been collected using electrofishing equipment and identified, the data is used to evaluate 12 metrics and a rating is assigned to each metric based on whether it deviates strongly from, somewhat from, or closely approximates the expected values found in a high quality reference stream reach. The sum of these ratings gives a total IBI score for the site. The best possible IBI score is 60. The Illinois EPA has determined that a score less than 41 indicates a stream is not fully supporting for "Aquatic Life" (Table 49). A manual for calculating IBI scores for streams in Illinois is available from Illinois DNR.

Fish sampling was historically conducted by IEPA in the last 1990s, but no additional ongoing fIBI monitoring recommendations are made due to high costs. Where possible however, fish sampling and

Table 36. Illinois EPA indicators of aquatic life impairment using MBI and fIBI scores.

Biological Indicator	MBI and fIBI Scores		
MBI	> 8.9	5.9 < MBI < 8.9	≤ 5.9
fIBI	≤ 20	20 < IBI< 41	≥ 41
Impairment Status - Use Support - Resource Quality			
Impairment Status	Severe Impairment	Moderate Impairment	No Impairment
Designated Use Support	Not Supporting	Not Supporting	Fully Supporting
Resource Quality	Poor	Fair	Good

Biologists collecting fish in stream

calculation of fIBI values should be built into future stream restoration projects.

Macroinvertebrate Biotic Index (MBI)
The MBI is designed to rate water quality using aquatic macroinvertebrate taxa tolerance to degree and extent of organic pollution in streams. The MBI is calculated by taking an average of tolerance ratings weighted by the number of individuals in the sample. The Illinois EPA has determined that an MBI score greater than 5.9 indicates a stream is not fully supporting "Aquatic Life" (Table 36). A manual for collecting and calculating MBI scores for streams is available from Illinois EPA.

Illinois River Watch conducted macroinvertebrate sampling annually between 2010 and 2017 at two locations in Scott Lake on Crystal Creek.

- Site 1 had MBI an average rating of 5.12 (Good), while
- Site 2 had an average MBI rating of 5.49 (Good).

MBI scores at Site 1 ranged from 4.46 to 5.43 (both Good) and from 4.97 (Good) to 6.17 (Fair) at Site 2 within the sampling period. This indicates that Crystal Creek on average fully supports Aquatic Life with the exception of 2 years (2012-2013) where the MBI score dropped slightly below the 5.9 threshold for fully supporting Aquatic Life Site 2.

3.16 Pollutant Loading Analysis

The USEPA modeling tool called STEPL (Spreadsheet Tool to Estimate Pollutant Loads) was used to estimate the existing nonpoint source load of nutrients (nitrogen & phosphorus) and sediment from Crystal Creek watershed as a whole and by individual Subwatershed Management Unit (SMU).

- STEPL model uses land use/cover category types, precipitation, soils information, existing best management practices, and other existing conditions data information.
- Model outputs average annual pollutant load for each of the land use/cover types.
- The results of this analysis combined with known outfall information from two wastewater treatment plants (WWTP) was used to estimate the total watershed load for nitrogen, phosphorus, and sediment and to identify and map pollutant load "Hot Spot" SMUs.

It is important to note that STEPL is not a calibrated model, although every effort was taken to include all current and available data. The STEPL model estimates pollutant loads for nitrogen, phosphorus, and sediment, but not fecal coliform or E. coli. Additionally, the water quality monitoring summarized in Section 3.15 captures all sources of pollution, both point and non-point. The STEPL model does not include point source discharges or inputs from Woods Creek watershed upstream. AES, used permit monitoring data from the WWTPs to estimate their contribution to pollutant loading and data from the Woods Creek Watershed-Based Plan to determine pollutant loading and impairment reduction targets for Crystal Creek watershed.

Annual pollutant loading from the WWTPs was calculated based on the designed average flow and the average effluent concentrations as monitored by each WWTP in their permit monitoring. Crystal Lake STP #2 and Lake in the Hills SD STP, the two WWTPs in the watershed, contribute the some of the highest estimated nutrient (nitrogen and phosphorus) loading to Crystal Creek watershed (Table 37). Annual nitrogen and phosphorus loading from Crystal Lake STP #2 is estimated at 279,951 lbs/yr and 5,028 lbs/yr respectively. Annual nitrogen and phosphorus loading from Lake in the Hills SD STP is estimated at 72,648 lbs/yr and 9,774 lbs/yr respectively.

The results of the STEPL model run at the watershed scale combined with estimated point source WWTP loading and Woods Creek watershed load estimates generated in the Woods Creek Watershed-Based Plan (Table 38; Figure 48) indicate that Crystal Creek watershed produces approximately:

- 428,836 lbs/yr of nitrogen,
- 29,046 lbs/yr of phosphorus, and
- 4,592 tons/yr of sediment.

The Woods Creek watershed, for which there is already an approved IEPA watershed-based plan, enters Crystal Creek watershed from upstream and outside of the watershed. Since pollutant loading was calculated as part of the Woods Creek watershed plan and Woods Creek is upstream of the Crystal Creek watershed, AES used the pollutant loading estimated within the Woods Creek plan to approximate probable loading originating from upstream of Crystal Creek and outside of the watershed. This approach is necessary because the water quality monitoring results for the most downstream location on Crystal Creek include all the pollutant sources from the Crystal Creek watershed, Woods Creek watershed, and the WWTPs. Both the Woods Creek and Crystal Creek pollutant load estimates were generated using the STEPL model. According to the STEPL modeling conducted in 2012, Woods Creek annually contributes 17,549 lbs/yr (4%) of nitrogen loading, 3,231 lbs/yr (11%) of phosphorus loading, and 2,530 tons/yr (55%) of sediment loading.

Table 37. Estimated average annual pollutant load from Crystal Lake STP #2 and Lake in the Hills SD STP.

Source	Ave. Flow MGD	Ave. Concentration (mg/l)			Annual Pollutant Load*		
		TN (mg/l)	TP (mg/l)	TSS (mg/l)	TN Load (lbs/yr)	TP Load (lbs/yr)	TSS
Crystal Lake STP	5.8	15.867	0.285	2.66	279,951	5,028	23
LITH SD STP	4.5	5.307	0.714	6.25	72,648	9,774	43

*Average daily flow (MGD) × average concentration (mg/l) × 3,042 (L-d-lb/gal-y-mg) = average annual load (lb-t/y)

Table 38. Estimated total existing (2019) annual pollutant loading by source at the watershed scale.

Source	N Load (lbs/yr)	% of Total Load	P Load (lbs/yr)	% of Total Load	Sediment Load (tons/yr)	% of Total Load
Urban	47,774	11.1%	7,489	25.8%	1,127	24.6%
Cropland	4,705	1.1%	1,100	3.8%	491	10.7%
Water/Wetland	967	0.2%	372	1.3%	302	6.6%
Septic	5,120	1.2%	2,005	6.9%	0	0.0%
Streambank	122	0.0%	47	0.1%	76	1.5%
Woods Creek (2012)*	17,549	4.1%	3,231	11.1%	2,530	55.2%
Crystal Lake WWTP*	279,951	65.3%	5,028	17.3%	23	0.5%
LITH WWTP*	72,648	16.9%	9,774	33.7%	43	0.9%
Total	**428,836**	**100.0%**	**29,046**	**100.0%**	**4,592**	**100.0%**

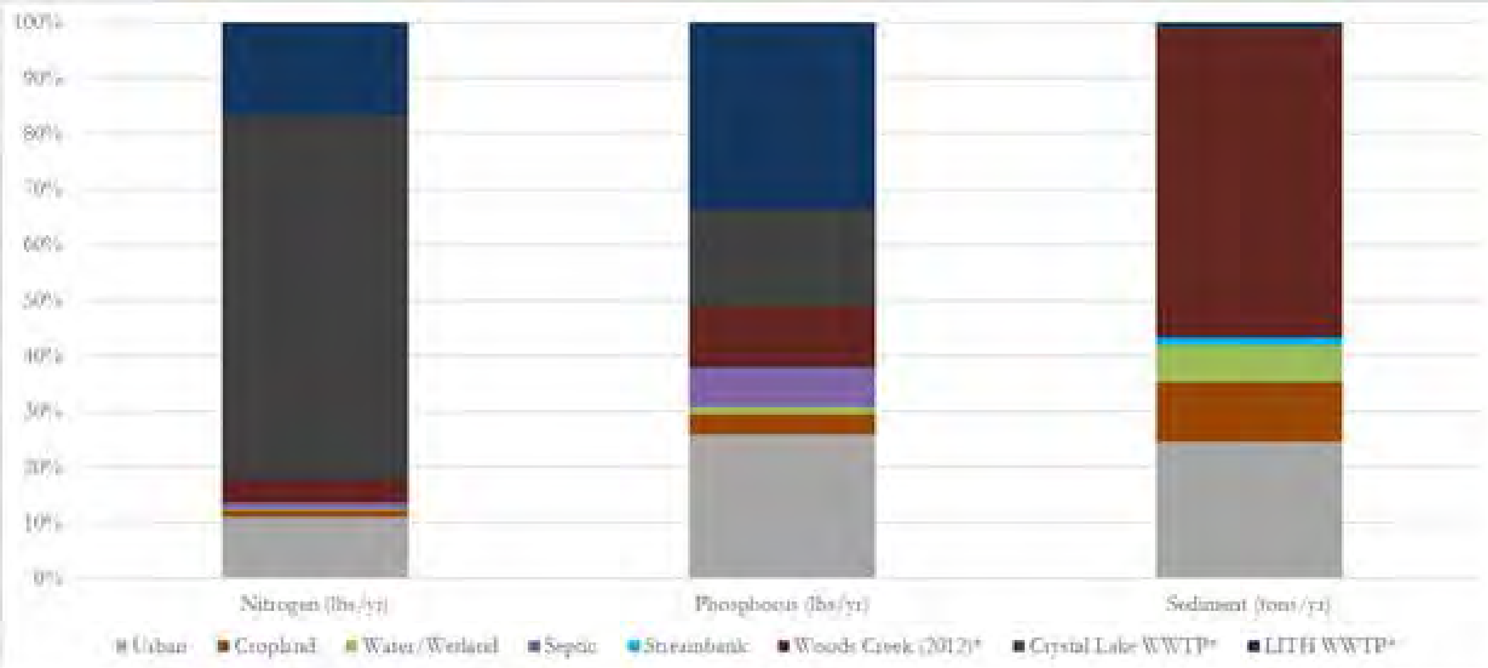


Figure 48. Estimated contributions to total existing (2019) pollutant load by source.

Together, the two WWTPs account for about 82% (352,599 lbs/yr) of the total annual load for nitrogen and 51% (14,802 lbs/yr) of the total annual load for phosphorus in the watershed. The annual load for total suspended solids/sediment (TSS) from the treatments plants is low compared to other sources, totaling 66 tons/yr or 1% of the total sediment load. It is important to note that the Crystal Lake and Lake in the Hills WWTPs are permitted point sources, and both do an excellent job of staying within their permitted discharge limits.

Excluding the wastewater and Woods Creek watershed contributions to pollutant loading, urban lands contribute the highest loads of nitrogen (47,774 lbs/yr: 11%), phosphorus (7,489 lbs/yr: 26%), and of sediment (1,127 tons/yr: 25%). Urban land is expected to be a significant pollutant contributor since it makes up roughly 60% of the watershed. Septic systems contribute the second highest nutrient loads after urban areas, with 5,120 lbs/yr (1%) of nitrogen and 2,005 lbs/yr (7%) of phosphorus per year, but do not contribute to sediment loading. Cropland contributes the second highest sediment loading in the watershed at 491 tons/yr (11%), and the third highest nutrient loading with 4,705 lbs/yr (1%) of nitrogen loading and 1,100 lbs/yr (4%) of phosphorus loading. The STEPL model suggests that 302 lbs/yr (7%) of the sediment loading originates from open water and wetland areas, likely due to the extent of these areas as they make up 26% of the watershed. Complete STEPL Model results and assumptions can be found in Appendix D.

Based on the pollutant loading estimates as detailed in Table 38, the nonpoint source share of the pollutant loading for Crystal Creek watershed is 14% of the total nitrogen loading, 38% of the total phosphorus loading, and 43% of the total suspended solids loading. The water quality improvements needed to meet pollutant loading for the Woods Creek watershed are identified in the Woods Creek Watershed-Based Plan, while the permitted pollutant loading attributed to Crystal Lake WWTP and LITH WWTP are not within the scope of this watershed planning effort. Section 4.0 of this report includes detailed information related to developing pollutant load reduction/ impairment targets just for Crystal Creek watershed and addressing “Critical Areas” to reach these targets.

The results of the STEPL model were also analyzed at the Subwatershed Management

Table 39. Pollutant load "Hot Spot" SMUs.

Hot Spot SMU	Size (acres)	N Load (lbs/yr)	N Load (lbs/yr)/ac	P Load (lbs/yr)	P Load (lbs/yr) /ac	TSS Load (t/yr)	TSS Load (t/yr) /ac	Aggregate Load Concentration
High Concentration Hot Spot SMUs								
SMU 5	1,934.20	10,181.1	5.3	2,009.6	1.0	394.4	0.2	6.5
SMU 7	1,638.30	8,833.8	5.4	1,517.3	0.9	269.4	0.2	6.5
Moderate Concentration Hot Spot SMUs								
SMU 1	1,184.00	5,864.4	5.0	1,264.0	1.1	272.3	0.2	6.3
SMU 4	1,653.40	8,357.0	5.1	1,435.5	0.9	202.0	0.1	6.0

Unit (SMU) scale (exclusive of the WWTP loading). This allowed for a more refined breakdown of pollutant sources and leads to the identification of pollutant load "Hot Spots". Hot Spot SMUs were selected by examining pollutant load concentration (load/acre) for each pollutant. Next, pollutant concentrations exceeding the 75% quartile and 50% quartile were calculated resulting in "High Concentration" and "Moderate Concentration" nonpoint source pollutant load Hot Spot SMUs and an aggregate pollutant contribution number was calculated based on each SMUs total load per acre (the sum of the load/acre of nitrogen, phosphorus, and sediment). SMUs with a total load concentration of 6.5 or higher were categorized as "High Concentration" pollutant load hot spots, while SMUs scoring a total load concentration between 6.0 and 6.5 were determined to be "Moderate Concentration pollutant load hot spots. Any SMU exhibiting pollutant load concentrations below the 50% quartile contribute a "Low Concentration" of pollutants relative to other SMUs. Table 39 and Figure 49 depict and summarize the results of the SMU scale pollutant loading analysis. Two of the 8 SMUs comprising Crystal Creek watershed are considered "High Concentration" pollutant load Hot Spots for nitrogen, phosphorus, and sediment based on STEPL modeling. Another two SMUs are considered "Moderate Concentration" pollutant load Hot Spots for various combinations of nitrogen, phosphorus, and sediment. The remaining four SMUs contribute "Low Concentrations" based on modeling.

SMUs 5 and 7 have the highest aggregate load concentrations relative to the remaining SMUs and are both considered "High Concentration" Hot Spot SMUs. For these two SMUs, pollutant loading is primarily driven by urban land uses. SMUs 1 and 4 were determined to be "Moderate Concentration" Hot Spot SMUs. While pollutant loading for SMU 4 is also predominantly driven by urban land uses, pollutant loading for SMU 1 is driven by both urban and cropland land uses. All other SMUs (SMUs 2, 3, 6, and 8) produce "Low Concentrations" of aggregate load concentrations based on the pollutant load "Hot Spot" SMU analysis.

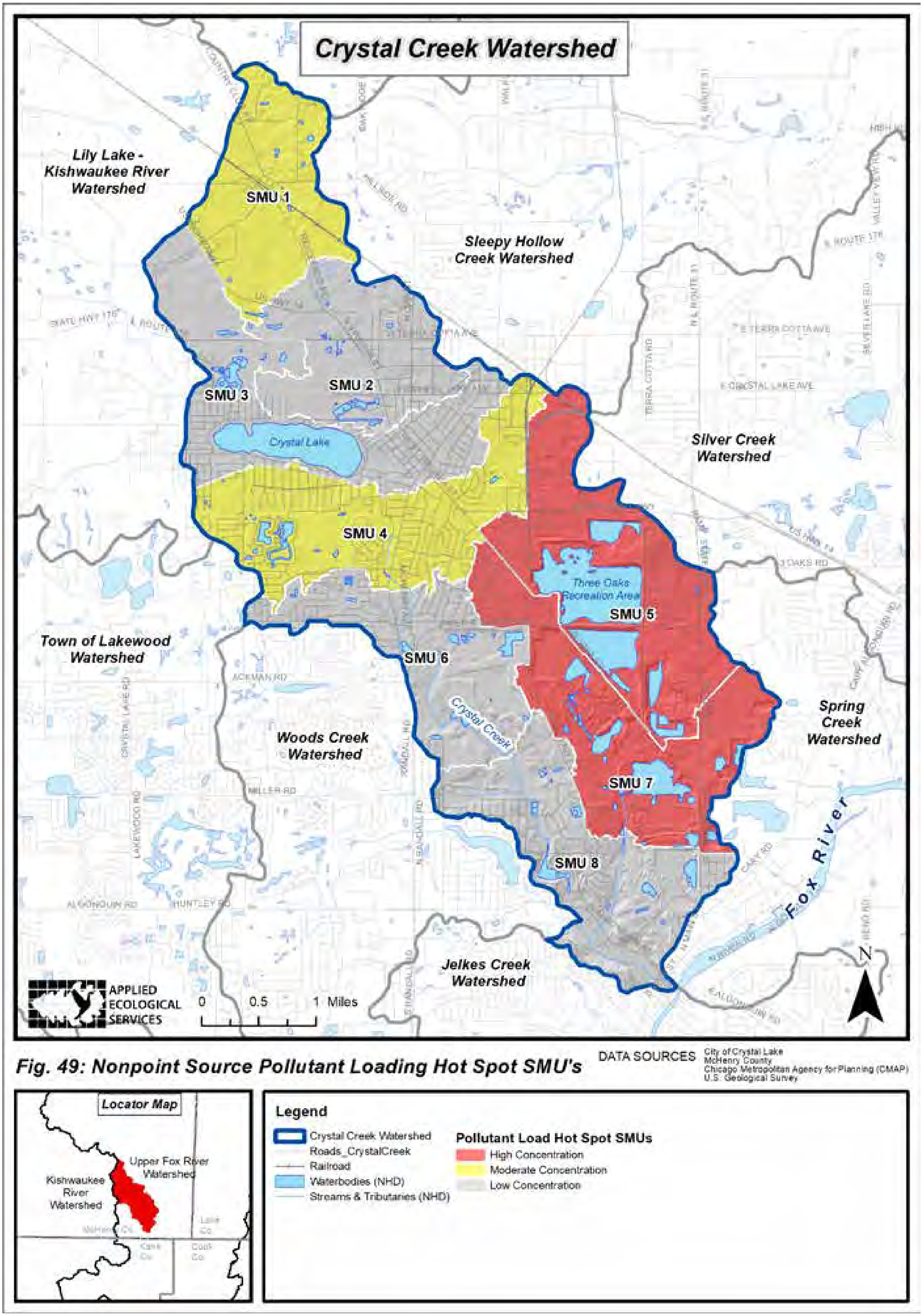


Fig. 49: Nonpoint Source Pollutant Loading Hot Spot SMU's

DATA SOURCES: City of Crystal Lake, McHenry County, Chicago Metropolitan Agency for Planning (CMAP), U.S. Geological Survey

4.0 Causes and Sources of Watershed Impairment

4.1 Causes & Sources of Impairment

The Illinois EPA lists Crystal Creek (AUID: ILDTZR01) as being impaired or not supporting for Primary Contact designated use due to high Fecal Coliform levels originating from urban runoff/ storm sewers. Recent water quality data collected by IEPA and Applied Ecological Services, Inc. for Crystal Creek indicates moderate overall impairment for nutrients and sediment. Illinois EPA determined that Crystal Lake (AUID: ILVTZH) and Three Oaks (AUIDs: ILWTJ and ILWTG) are fully supporting the Aquatic Life and Aesthetic Quality designated uses and have no impairments.

Causes and sources of impairment are based on Illinois EPA 303(d) impaired waters information for Crystal Creek (Illinois EPA code: ILDTZR01), items identified during the watershed characteristics inventory, and input from the Crystal Creek steering committee and stakeholders who met during the planning process to discuss the topic. Table 40 includes a summary of the known or potential causes and sources of watershed impairment.

Table 40. *Known* and *potential* causes and sources of watershed impairment.

Illinois EPA or other Impairment	Cause of Impairment	Known or Potential Source of Impairment
CRYSTAL CREEK		
Water Quality/ Aquatic Life	**Nutrients:** *Known impairment* (phosphorus and nitrogen)	➤ Urban runoff/storm sewers ➤ Streambank and lake shoreline erosion ➤ Failing septic systems ➤ Wastewater treatment plants ➤ Level of homeowner education ➤ Residential and agricultural fertilizer
Water Quality/ Aquatic Life	Total Suspended Solids: *Known impairment* ((TSS)/turbidity/sediment)	➤ Streambank and lake shoreline erosion ➤ Construction sites ➤ Existing & future urban runoff ➤ Agricultural runoff
Water Quality/ Aquatic Life	Chlorides *Potential impairment* (salinity)	➤ Deicing operations on roads & pavement ➤ Inadequate deicing policies
Water Quality/Primary Contact Recreation	Fecal Coliform *Known impairment* (Bacterial pathogens, *E. coli*)	➤ Urban runoff ➤ Storm sewers ➤ Failing septic systems ➤ Sewage overflows ➤ Waterfowl ➤ Pet and livestock waste
Habitat Degradation	Invasive and/or non-native plant species *Known impairment*	➤ Spread from existing and introduced populations ➤ Level of public education ➤ Lack of maintenance and management
Habitat Degradation	Lack of habitat characteristics *Known impairment*	➤ Stream channelization ➤ Streambank modification ➤ Inappropriate land management ➤ Loss of natural management mechanisms (i.e. fire) ➤ Wetland loss
Hydrologic and Flow Changes	Alteration of natural drainage channels; buried streams; impervious surfaces *Known impairment*	➤ Existing & future urban runoff ➤ Historic channelization of streams ➤ Buried or piped streams ➤ Wetland loss
Reduced Groundwater Discharge to Streams	Shallow aquifer drawdown *Known impairment*	➤ Human use ➤ Existing and future urban impervious surfaces
Structural Flood Damage	Encroachment in 100-year floodplain *Known impairment*	➤ Existing and future urban impervious surfaces ➤ Lack of designated storm sewer system ➤ Depressional areas with no outlets ➤ Failing drain tiles ➤ Buried or piped streams ➤ Channelized streams ➤ Wetland loss

Table 40. *Known* and *potential* causes and sources of watershed impairment. (Continued)

Illinois EPA or other Impairment	Cause of Impairment	Known or Potential Source of Impairment
CRYSTAL LAKE AND THREE OAKS		
Water Quality/Aquatic Life	Nitrogen *Potential impairment*	➤ Streambank and lake shoreline erosion ➤ Residential and agricultural fertilizer
Primary & Secondary Contact	Fecal Coliform *Potential impairment* (Bacterial pathogens, *E. coli*)	➤ Urban runoff ➤ Storm sewers ➤ Failing septic systems ➤ Waterfowl ➤ Pet and livestock waste

4.2 Critical Areas, Management Measures & Estimated Impairment Reductions

For this watershed plan a "Critical Area" is best described as a location in the watershed where existing or potential future causes and sources of an impairment or existing function are significantly worse than other areas of the watershed. Four Critical Area types were identified in Crystal Creek watershed and include:

1. Poorly designed/functional detention basins;
2. Highly degraded stream and riparian area reaches;
3. Priority green infrastructure protection areas in need of management and future protection; and
4. Other management measure recommendations.

Short descriptions of each Critical Area type are included below. Table 41 includes summaries of the current condition at each Critical Area (by type) and recommended Management Measures with estimated nutrient and sediment load reductions expected. The list of Critical Areas identified in the following paragraphs is a subset of the full management measures as found in the Action Plan section of this report. Figure 50 maps the location of each Critical Area.

Pollutant load reductions are evaluated for the majority of the Critical Area Management Measures based on efficiency calculations developed for the USEPA's Region 5 Model. Estimates of total suspended solids and nutrient load reduction from implementation of urban Measures is based on efficiency calculations developed by Illinois EPA. Pollutant reduction calculations for the two fencing projects were calculated using EPA's STEPL Model. Illinois EPA pollutant load reduction worksheets for each Management Measure, including Critical Areas, are located in Appendix D.

Critical Detention Basins

A detention basin inventory was completed as part of this plan that identifies basins needing water quality improvement retrofits (Appendix C). Twenty-five (25) basins meet the criteria of a Critical Area based of their ability to reduce pollutants, location within a highly vulnerable SMU, function, and size. Several critical area detention basins are located within the headwaters of Crystal Creek and also within highly vulnerable SMUs. Other Critical Area basins include large scale basins and those owned by a public entity that if retrofitted with natural vegetation, have the potential to improve water quality and extend the Green Infrastructure Network. A summary of the detention basins in the watershed is included in Section 3.12.

Critical Stream & Riparian Area Reaches

Critical stream and riparian area reaches are those with highly degraded riparian area conditions or highly eroded streambanks that are the likely source of high total suspended solids carrying attached phosphorus. Restoring riparian areas that have excellent ecological restoration and remediation potential or installing riparian buffers where they are currently lacking will reduce pollutant loading to streams, reduce downstream flooding, improve habitat, and augment the Green Infrastructure Network. Streambank stabilization and installation of artificial riffles or check dams along some of these reaches will greatly reduce sediment and phosphorus transport downstream while improving habitat and increasing oxygen levels. One reach, Crystal Creek Reach 3, is need of daylighting; stream daylighting improves water quality and habitat, allows for flood mitigation, and improves stormwater control. Twelve stream reaches (CCR01-10, T2R1, and T2R2) totaling 43,912 linear feet were identified as Critical Areas.

Section 3.12 includes a complete summary of streams and tributaries in the watershed.

Critical Green Infrastructure Protection Areas

Information obtained from existing and predicted future land use data, sensitive aquifer recharge areas, highly vulnerable SMUs, and green infrastructure sections of this report led to identification of five green infrastructure priority protection areas totaling 954 acres. All five are located in the northernmost portion of the watershed in parts of Crystal Lake and unincorporated McHenry County. Four of the five Priority Green Infrastructure Protection Areas are lands that are currently in agricultural production and have the potential to be developed in the future, while one is a degraded woodland that is currently for sale. For the areas that remain in agricultural production, it will be important to ensure that no-till farming is being utilized on those lands. If and when any of the areas are developed, development should follow Conservation Design or Low Impact Development standards and guidelines to help maintain and improve water quality and watershed conditions. This assessment is by no means meant to prevent or deter future urbanization or land use change, but rather to determine which areas might be most in need of utilizing conservation design or low impact development when change does occur so as to protect remaining natural resources, and to identify existing developed lands that could be managed for maximum green infrastructure benefit, restoration, and preservation.

Critical Other Management Measures

Several potential Management Measure projects were identified that fit under miscellaneous other categories. In total there were 14 Critical Area projects that fell into the other management measures, including 7 Existing Natural Area Management areas, 3 Natural Area Restorations, 2 areas needing fencing to restrict livestock access, 1 shoreline education program site, and 1 area in need of invasive species management. These areas were typically determined to be Critical Areas due to existing or potential future causes and sources of an impairment, their ability to reduce pollutant loading, or where existing function is significantly worse than other areas of the watershed. More information about other management measure recommendations can be found in Section 5.2.4.

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
DETENTION BASINS					
1A	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	23	28	117
1B	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	13	19	77
1C	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	3	6	26
2A	Dry detention basin with naturalized bottom and slopes in good ecological condition	Design and implement a project to maintain well-established naturalized basin	1	4	14
2B	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	1	2	11
2C	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	2	6	22
2D	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	3	5	23
2E	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	2	6	22
2F	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Design and implement a project to maintain well-established naturalized basin	2	7	25

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
3A	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	22	30	126
3B	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	4	5	29
3C	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	35	42	150
3D	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Design and implement a project to maintain well-established naturalized basin	5	6	37
8A	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	3	10	34
8B	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	3	6	29
8C	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	21	26	92
13A	Dry detention basin with turf bottom and slopes, too wet to mow, in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	13	23	79
18A	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	33	54	188

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
19B	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	62	85	361
22A	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Design and implement a project to maintain well-established naturalized basin	18	22	79
22B	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	9	13	53
22C	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	1	5	6
22D	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	18	25	84
23A	Dry detention basin with naturalized bottom and slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	95	86	283
25A	Dry detention basin with naturalized bottom and slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	26	32	235
31F	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	17	21	75
31G	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Design and implement a project to maintain well-established naturalized basin	17	21	75

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
STREAM AND RIPARIAN AREA REACHES					
CCR01	1,979 lf of stream exhibiting moderate channelization, low levels of erosion and average overall riparian area condition	Design, permit, and construct a project to install a native buffer and instream riffles	12	21	103
CCR02	1,076 lf of stream exhibiting low levels of channelization, low levels of erosion and good overall riparian area condition	Design and construct a project to remove second growth trees and shrubs and replant buffer with natives	7	12	62
CCR03	Buried section of Crystal Creek (should be approximately 1,896 lf) entirely piped underground	Design, permit, and construct a project to daylight stream, install pools and riffles, and restore riparian area with natives	NA	NA	NA
CCR04	3,081 lf of stream exhibiting moderate levels of channelization, low levels of erosion and average overall riparian area condition	Design and construct a project to remove invasive trees and shrubs, install a native buffer and remove beaver dam	78	106	588
CCR05	3,758 lf of stream exhibiting high levels of channelization, moderate levels of erosion and poor overall riparian area condition; reach also has moderate amount of debris jams and moderate sedimentation of the stream channel	Design, permit, and construct a project to restore riparian area with natives and armor stream channel where necessary	328	366	1242
CCR06	13,781 lf of stream exhibiting low levels of channelization, moderate levels of erosion and good overall riparian area condition	Design, permit, and construct a project to continue restoration and management of invasives, install spot stabilization as necessary, and install check dams throughout	607	692	1610
CCR07	4,294 lf of stream exhibiting low levels of channelization, low levels of erosion and average overall riparian area condition	Design, permit, and construct a project to remove invasives, restore riparian area with natives and armor stream channel where necessary	95	132	651

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
CCR08	1,759 lf of stream exhibiting moderate levels of channelization, moderate levels of erosion and poor overall riparian area condition	Design, permit, and construct a project to extend and restore riparian area and install spot stabilization as necessary	166	182	556
CCR09	3,098 lf of stream exhibiting moderate levels of channelization, moderate levels of erosion (east bank is low, west bank is high) and average overall riparian area condition (east bank is poor, west bank is good)	Design, permit, and construct a project to remove parking area on East bank and install native buffer, armor west bank and restore remnant oak woodland	286	304	868
CCR10	1,774 lf of stream exhibiting moderate levels of channelization, low levels of erosion and good overall riparian area condition	Design a project to continue long term maintenance and monitoring of riparian buffer	60	74	479
T2R1	5,662 lf of stream exhibiting high levels of channelization, moderate levels of erosion and poor overall riparian area condition	Design, permit, and construct a project to remove second growth trees and shrubs, replant buffer with natives, and regrade and spot stabilize streambanks where necessary	313	417	2246
T2R2	1,755 lf of stream exhibiting high levels of channelization, moderate levels of erosion and poor overall riparian area condition	Design and construct a project to remove second growth trees and shrubs, extend buffer, and replant buffer with natives	68	76	323
GREEN INFRASTRUCTURE PRIORITY PROTECTION AREAS					
PPA1	Agricultural area at headwaters of watershed	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA
PPA2	Large overgrown oak woodland with ADID wetland currently for sale	Utilize conservation design or low impact development when developed	NA	NA	NA

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
PPA3	Agricultural area at headwaters of watershed	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA
PPA4	Agricultural area with large ADID wetland that extends down to Crystal Lake	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA
PPA5	Oak hickory woodland with agriculture on western portion and rolling topography	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA
OTHER MANAGEMENT MEASURES					
6A	Large ADID wetland complex dominated by invasives	Design and implement a project to control invasive species so they do not spread to other adjacent wetlands in Lippold Park	14	24	236
6C	Large wetland complex within Lippold Park with patches of invasive species	Develop an ecological management plan and implement	33	71	430
6D	Wooded buffers surrounding large wetland complex within Lippold Park in need of tree and shrub removal	Develop an ecological management plan and implement	41	91	474
12B	Degraded wetland complex and woodland buffer	Develop an ecological management plan and implement	5	20	108
17D	Combination of wetland and open water natural detention with prairie buffers in good condition	Maintain good condition by continuing with natural area management	4	14	79
20B	Three Oaks Recreation Area - an old gravel quarry converted to recreational area and planted with native vegetation	Develop an ecological management plan and implement	59	109	1,152
27D	Degraded wetland filter related to water treatment plant effluent	Design and implement a project to perform ecological restoration and maintenance on wetland buffers	1	7	31
4A	Overgrazed horse pastures adjacent wetland	Utilize pasture rotation and fencing to restrict livestock access to wetland	3	7	28

Table 41. Critical Areas, Management Measures, & estimated nutrient and sediment load reductions.

ID #	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency		
			TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)
4B	Overgrazed cow pasture in oak savanna and wetlands	Utilize pasture rotation and fencing to restrict livestock access to oak savanna and wetland	3	6	28
17B	Four Colonies Park - mowed turf area adjacent to detention with walking path	Design and implement a project to convert turf grass to wet-mesic and dry prairie	7	27	158
27E	Degraded and silted in riparian buffer of Tributary 1	Design, permit, and implement a project to recreate historic drainage channel and restore degraded riparian buffer	3	11	68
27F	Degraded wetland areas adjacent to Tributary 1	Design, permit, and implement a project to restore wetlands and floodplain using rain gardens and other ecological techniques	1	4	24
12A	Overall manicured shorelines of residential homes along Crystal Lake	Implement educational program or incentive program to install naturalized shorelines and buffers in residential areas	51	170	1111
31E	Open gravel quarries with invasive species throughout	Design and implement a project to maintain invasive species on site	357	694	4557

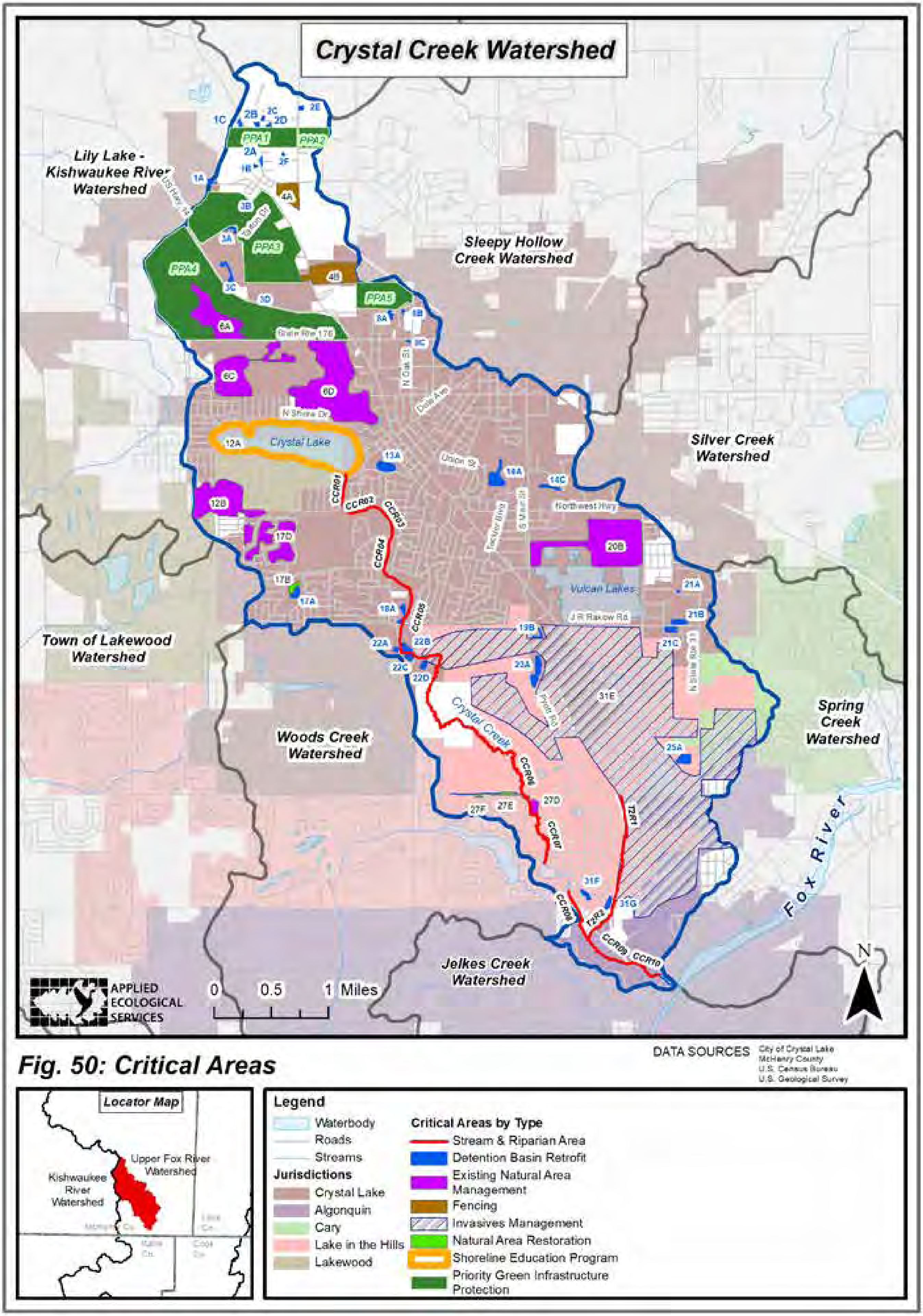


Fig. 50: Critical Areas

4.3 Watershed Impairment Reduction Targets

Establishing “Reduction Targets” is important because these targets provide a means to measure how implementation of Management Measures at “Critical Areas” is expected to reduce watershed impairments. Table 42 summarizes the basis for known impairments and Reduction Targets in Crystal Creek watershed as derived from Table 40. Reduction Targets listed in Table 42 are based on documented information, modeling results, and/or water quality standards and criteria set by the Illinois Pollution Control Board (IPCB 2011, USEPA (2000), and USGS (2006). It is important to note that for phosphorus, nitrogen, and total suspended solids (TSS) reduction targets the assumption is made that the percent decrease in sample concentration needed is approximately equal to the percent reduction in annual load needed.

Based on the results of the water quality inventory (as identified in Section 3.14), a 105% decrease in total nitrogen (TN), 140% decrease in total phosphorus (TP), a 33% decrease in total suspended solids (TSS), and a 101% decrease in fecal coliform is needed in Crystal Creek from all sources combined to reach target levels based on recommended numeric criteria proposed by USEPA (USEPA 2000), USGS (USGS 2006) and IEPA (2011). Furthermore, based on the pollutant load modeling (Table 38), the relative NPS contribution to total pollutant loads are 14% of nitrogen loading, 38% of phosphorus loading, and 43% of total suspended solids loading. Unfortunately, there is no way to determine the relative NPS contribution to total fecal coliform loading using available models or data.

Neither fecal coliform nor E. coli loading can be estimated via modeling, so a fecal coliform reduction target cannot be quantified. However, fecal coliform reductions will come as a result of implementing projects such as wetland restoration, vegetated swales, and septic/waste management systems. Wetland restorations or construction can reduce fecal coliforms by an average of 92% when installed between a field and a stream (Wolfson, 2010). In the case of septic systems, one study found that a full-scale septic tank/constructed wetland system reduced total coliforms by 37.4% with the septic tank alone and the constructed wetland reduced total coliforms by an additional 99.99% (Yelderman et. al, 2009). Vegetated swales reduce fecal coliform by 74% (Wolfson, 2010).

Watershed-Wide Reduction Targets for Nitrogen, Phosphorus, and Suspended Solids

Watershed-wide nitrogen and TSS reduction targets could be attained by addressing Critical Areas alone according to the pollutant reduction calculations; however, the total phosphorus reduction target could not be met. Critical Areas alone would remove 29,505 lbs/yr (227%) of the total nitrogen target and 3,044 tons/yr (1,068%) of the TSS reduction target. However, approximately 4,214 lbs/yr of total phosphorus reduction target (72%) could be removed by addressing Critical Areas. An additional 437 lbs/yr of phosphorus would be remove if all recommended management measures were implemented, which would achieve 79% of total phosphorus reduction target. Table 42 includes a column summarizing the overall impairment reduction expected after addressing Critical Areas.

Additional watershed-wide reduction targets were established for habitat degradation, hydromodification and flow changes, and structural flood problems. Habitat degradation and hydromodification and flow changes targets could be met by implementing riparian area restoration and by daylighting a buried section of stream. Each of the 6 flood problem areas can be addressed on a case by case basis to meet targets.

Table 42. Basis for known impairments, NPS Reduction Targets, & impairment reduction from Critical Areas.

Impairment: Cause of Impairment	Basis for Impairment	NPS Reduction Target	Reduction from Critical Area	Attainable?
Water Quality/ Aquatic Life: nitrogen in Crystal Creek	58,688 lbs/yr of NPS nitrogen loading based on STEPL model & 5.032 mg/l TN in water quality samples for Crystal Creek from all sources & 14% relative NPS contribution to nitrogen loading	>14.6% or 8,586 lbs/yr reduction in nitrogen loading to achieve 2.461 mg/l TN USEPA numeric criteria for streams in Ecoregion VI	2,293 lbs/yr or 27% nitrogen reduction from critical detention basins	Yes
			8,728 lbs/yr or 102% nitrogen reduction from critical stream and riparian area restorations	
			8,484 lbs/yr or 99% reduction from critical other management measures	
		Total	**19,505 lbs/yr or 227% total nitrogen reduction of from all Critical Areas combined**	
Water Quality/ Aquatic Life: phosphorus in Crystal Creek	11,013 lbs/yr of NPS phosphorus loading based on STEPL model & 0.173 mg/l TP in water quality samples for Crystal Creek from all sources & 38% relative NPS contribution to phosphorus loading	>53% or 5,850 lbs/yr reduction in phosphorus loading to achieve 0.0725 mg/l TP USEPA numeric criteria for streams in Ecoregion VI	577 lbs/yr or 10% phosphorus reduction from critical detention basins	No
			2,382 lbs/yr or 41% phosphorus reduction from critical stream and riparian area restorations	
			1,255 lbs/yr or 21% reduction from critical other management measures	
		Total	**4,214 lbs/yr or 72% total phosphorus reduction of from all Critical Areas combined**	
Water Quality/ Aquatic Life: turbidity/total suspended solids in Crystal Creek	1,996 tons/yr of NPS TSS loading based on STEPL model & 25.3 mg/l TSS in water quality samples for Crystal Creek from all sources & 43% relative NPS contribution to TSS loading	>14.3% or 285 tons/yr reduction in sediment loading to achieve 19 mg/l TSS based on USGS numeric criteria in Great Lakes Region	442 tons/yr or 155% TSS reduction from critical detention basins	Yes
			2,020 tons/yr or 709% TSS reduction from critical stream and riparian area restorations	
			582 tons/yr or 204% TSS reduction from critical other management measures	
		Total	**3,044 tons/yr or 1,068% TSS reduction from all Critical Areas combined**	
Water Quality/ Primary Contact Recreation: fecal coliform in Crystal Creek	Fecal coliform loading cannot be calculated via STEPL model & 402.8 CFU/100ml in water quality samples for Crystal Creek from all sources	101% decrease in fecal coliform from ALL SOURCES to achieve 200 CFU/100ml based on IEPA general use standard	Pollutant reduction cannot be assessed via modeling, but fecal coliform and pathogen reductions will occur by implementing wetland restoration, vegetated swales, and septic/waste management systems	Not Applicable

Table 42. Basis for known impairments, NPS Reduction Targets, & impairment reduction from Critical Areas.

Impairment: Cause of Impairment	Basis for Impairment	NPS Reduction Target	Reduction from Critical Area	Attainable?
Habitat Degradation: lack of habitat in streams	13,781 lf of degraded stream length within Lake in the Hills Fen	Install check dams throughout 13,781 linear feet of stream within LITH Fen	13,781 linear feet of degraded stream enhanced and restored	Yes
Habitat Degradation: invasive and/or non-native plant species in riparian areas	16,940 linear feet of riparian areas are currently in poor ecological condition	>50% or 8,470 lf of poor-quality riparian areas ecologically restored	8,470 lf or 50% areas restored addressing critical riparian areas	Yes
Hydromodification: hydrologic and flow changes	Approximately 1,896 linear feet of Crystal Creek buried/piped (Crystal Creek Reach 3)	100% of previously buried stream reach daylighted	Approximately 1,896 linear feet of CCR03 (100%) daylighted	Yes
Structural Flood Damage: structures in 100-year floodplain	**6 structural flood problem areas**	100% or X structural flood problem areas addressed	Not Applicable*	Not Applicable
Reduced Groundwater Discharge to Streams: shallow aquifer drawdown	>40% reduction in groundwater discharge and >70-foot drawdown of aquifer by 2049	>50% preservation of green infrastructure in Priority Protection Areas for all future development	>50% preservation of green infrastructure in Priority Protection Areas if developed using Conservation Design or Low Impact Development	Yes*

*Target will be met if Action Plan recommendations are implemented

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5.0 Management Measures Action Plan

Earlier sections of this plan summarized Crystal Creek watershed's characteristics and identified causes and sources of watershed impairment. This section includes an "Action Plan" developed to provide stakeholders with recommended "Management Measures" (Best Management Practices) to specifically address plan goals at general and site-specific scales. The Action Plan is divided into two subsections:

- Programmatic Measures: general remedial, preventive, and policy watershed-wide Management Measures that can be applied across the watershed by various stakeholders.
- Site-Specific Measures: actual locations where Management Measure projects can be implemented to improve surface and groundwater quality, green infrastructure, and flooding.

The recommended programmatic and site-specific Management Measures provide a solid foundation for protecting and improving watershed conditions but should be updated as projects are completed, or other opportunities arise. Lead implementation stakeholders are encouraged to organize partnerships with key stakeholders and develop various funding arrangements to help delegate and implement the recommended actions. The key stakeholders in the watershed are listed in Table 43. Note: recommendations in this Section are for guidance only and not required by any federal, state, or local agency.

Table 43. Key Crystal Creek watershed stakeholders/partners.

Watershed Stakeholder/Partner	Acronym/Abbreviation
Businesses	Business
City of Crystal Lake	Crystal Lake
Crystal Lake Park District	CLPD
Developers	Developer
Ecological Consultants	Consultant
Fox River Ecosystem Partnership	FREP
Golf Courses	GC
Illinois, McHenry, and Kane County Dept. of Transportation	DOTs
Illinois Environmental Protection Agency	IEPA
Kane County Development Department	KCDD
McHenry County Planning and Development Department	MCPDD
Residents or Owners	Resident/Owner
School Districts	School
The Land Conservancy of McHenry County	TLC
Townships (Algonquin, Dundee, Grafton, Rutland)	TWP
USDA Natural Resource Conservation Service (McHenry County)	USDA
US Army Corps of Engineers-Chicago Region	USACE
US Fish & Wildlife Service	USFWS
Village of Algonquin	Algonquin
Village of Lake in the Hills	LITH
Village of Lakewood	Lakewood
Crystal Creek Watershed Steering Committee	Steering Committee

5.1 Programmatic Management Measures Action Plan

Numerous types of programmatic Management Measures are recommended to address watershed objectives for each plan goal. The following pages include recommended measures that are applicable throughout the watershed and information needed to facilitate implementation of specific actions. A brief summary of the general programmatic measure types is included below:

Policy: Local, state, and federal government can help prevent watershed impairments in various ways through policy but specifically by adopting and/or supporting (via a resolution) the Crystal Creek Watershed-Based Plan, implementing green infrastructure policy, requiring conservation developments for new developments, protecting groundwater, reducing road salt usage and lawn fertilizers, requiring natural detention basins and naturalization of existing basins, and allowing use of native vegetation/landscaping.

Non-Structural: This includes a broad group of practices that prevent impairment through maintenance and management of Management Measures or programs that are ongoing in nature and designed to control pollutants at their source. Such programs include many of the agricultural programs available to farmers and street sweeping.

Structural: This includes a broad group of practices that prevent impairment via installation of in-the-ground measures. This plan focuses on implementation of naturalized stormwater measures/retrofits, permeable paving, vegetated filter strips/buffers, natural area restoration, wetland restoration, and use of rainwater harvesting devices.

Educational: Outreach is important to inform the public related to environmental impacts of daily activities and to build support for watershed planning and plan implementation. Topics typically address watersheds, water quality, land management, pet waste management, lawn fertilizer use, good housekeeping, etc.

5.1.1 Policy Recommendations

Various recommendations are made throughout this report related to how local governments can improve the condition of Crystal Creek watershed through policy. Policy recommendations focus on improving watershed conditions by preserving green infrastructure, protecting groundwater, minimizing road salts, minimizing lawn fertilizer, sustainable management of stormwater, and allowances for native landscaping. To be successful, the Crystal Creek Watershed-Based Plan would need to be adopted and/or supported by local communities. The process of creating and implementing policy changes can be complex and time consuming. And, although there are numerous possible policy recommendations for the watershed, the following policy recommendations are considered the most important and highest priority for implementation.

Plan Adoption & Implementation Policy Recommendations

- Watershed Partners adopt and/or support (via a resolution) the Crystal Creek Watershed-Based Plan and incorporate plan goals, objectives, and recommended actions into comprehensive plans and ordinances.

Green Infrastructure Network Policy Recommendations

- Each municipality consider incorporating the identified Green Infrastructure Network (GIN) into comprehensive plans and development review maps.

- Incorporate Green Infrastructure recommendations outlined by the Green Infrastructure Study and Report and the Crystal Lake 2030 Comprehensive Plan (both developed and adopted by the City of Crystal Lake in 2012), or updated plan(s) as prepared.

- Utilize tools such as protection overlays, setbacks, open space zoning, conservation easements, conservation and/or low impact development, etc. in municipal comprehensive plans and zoning ordinances to protect environmentally sensitive areas on identified Green Infrastructure Network parcels.

- Utilize tools such as Development Impact Fees, Stormwater Utility Taxes, Special Service Area (SSA) Taxes, etc. to help fund implementation of plan and future management of green infrastructure components where new and redevelopment occurs.

- Encourage developers to protect sensitive natural areas, restore degraded natural areas and streams, and then encourage donation of natural areas and naturalized stormwater management systems to a public agency or conservation organization for long term management with dedicated funding such as Development Impact Fees, Stormwater Utility Taxes, Special Service Area (SSA) Taxes, etc. In general, it is not recommended that these features be turned over to HOA's to manage where possible, as they lack the resources and experience to do so effectively.

- Establish incentives for developers who propose sustainable or innovative approaches to implement the watershed-based plan, including priority for preserving green infrastructure and using naturalized stormwater treatment trains.

- Encourage mitigation for wetlands lost prior to allowing development within the watershed.

Groundwater Policy Recommendations

- Encourage extensive stormwater management practices that clean and infiltrate water in any development or redevelopment.
- Limit impervious cover within new and redevelopments occurring within Subwatershed Management Units 1, 2, and 6 which are ranked as highly vulnerable to future impervious cover.

Road Salt Policy Recommendations

- Encourage each municipality/ township to supplement existing programs with deicing best management practices such as utilizing alternative deicing chemicals, anti-icing or pretreatment, controlling the amount and rate of spreading, controlling the timing of application, utilizing proper application equipment, equipment calibration, and educating/training deicing employees.
- Consider establishing additional new best management practice recommendations based on the results of various ongoing studies and research being produced by Illinois Tollway to reduce, re-use, and offset the impacts of winter roadway operations. These include converting invasives to energy, to harvest cattails for the purpose of removing excess nutrients, potentially quantifying chloride removal, re-using the plant mass for compost or compressed into an Energy product or potentially using the byproducts of the biomass as a replacement for beet juice on roadways (Illinois Tollway, 2019; Paap, 2019; and Wetlands Research, 2019).

Lawn Fertilizer and Paving Policy Recommendations

- Encourage local governments to extend phosphorus regulation to non-commercial applicators, require soil testing pre-application, or ban out-right.
- Encourage local governments to ban coal tar sealants within their jurisdiction.
- Encourage local governments to permit the use of pavement alternatives such as permeable pavers in appropriate areas.

Stormwater Management Facility Policy Recommendations

- Continue to aggressively implement the recommendations and requirements of the Crystal Lake Watershed Design Manual for new and redevelopment with Crystal Lake and encourage similar recommendations for remaining municipalities in the watershed.
- Encourage new development and redevelopment to use stormwater management techniques/ facilities that serve multiple functions including storage, water quality benefits, infiltration, and wildlife habitat.
- Encourage the use of reduced runoff volume from new and retrofitted detention basins.
- Encourage local governments to allow stormwater trees or create a stormwater tree program.

Native Landscaping/Natural Area Restoration

- Allow native landscaping within local ordinances.
- Ensure local “weed control” ordinances do not discourage or prohibit native landscaping.
- Include short- and long-term management with performance standards for restored natural areas and stormwater features within new and redevelopment.

5.1.2 Dry & Wet Bottom Detention Basin Design/ Retrofits, Establishment, & Maintenance

Detention basins are best described as human made depressions for the temporary storage of stormwater runoff with controlled release following a rain event. There are 49 large detention basins in Crystal Creek watershed and numerous smaller ones, and most are associated with residential and urban development. Most existing wet bottom basins are essentially ponds planted with turf grass along the slopes, and the majority of the dry bottom basins are similarly planted with turf grass from end to end. These attributes do not promote water quality improvement, good infiltration, or wildlife habitat capabilities.

Studies conducted by several credible entities over the past two decades reveal the benefits of detention basins that serve multiple functions. According to USEPA, properly designed dry bottom infiltration basins reduce total suspended solids (sediment) by 58%, total phosphorus by 26%, and total nitrogen by 30%. Wet bottom basins designed to have wetland characteristics reduce total suspended solids (sediment) by 78%, total phosphorus by 44% and total nitrogen by 20% (MDEQ, 1999).

Detention Basin Recommendations

Future detention basin design within the watershed should consist of naturalized basins that serve multiple functions, including appropriate water storage, water quality improvement, natural aesthetics, and wildlife habitat. There are also a large number of opportunities to retrofit existing dry or wet bottom detention basins by incorporating minor engineering changes and naturalizing with native vegetation. Site-specific retrofit opportunities are identified in the Site-Specific Action Plan. Location, design, establishment, and long-term maintenance recommendations for naturalized

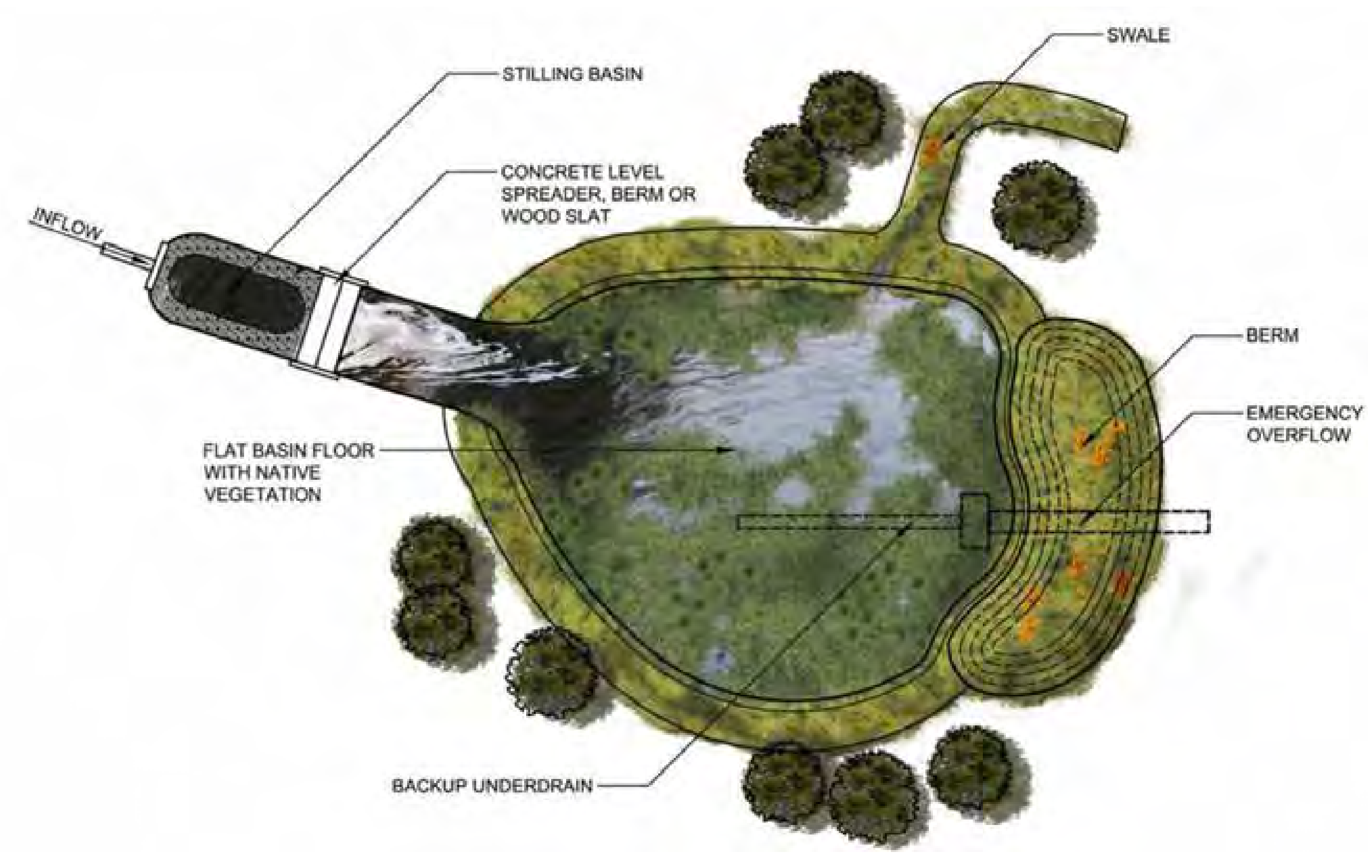


Figure 51. Naturalized dry bottom infiltration basin design.

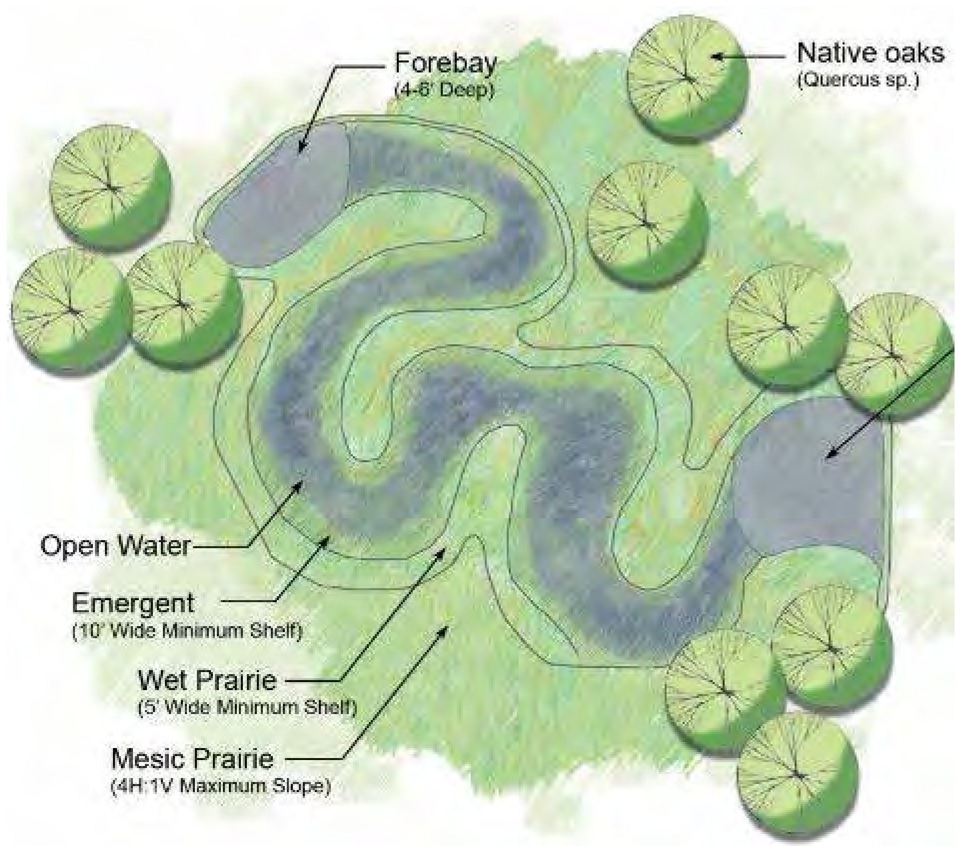


Figure 52. Naturalized wet bottom detention basin design.

detention basins are included below. Note: requirements of the McHenry County Stormwater Management Ordinance, such as volume and release rates, will apply to the design recommendations included below.

Detention Location Recommendations

- Naturalized detention basins should be restricted to natural depressions or previously drained hydric soil areas and adjacent to other existing green infrastructure in an attempt to aesthetically fit and blend into the landscape. Use of existing isolated wetlands for detention should be evaluated on a case-by-case basis.
- Basins should not be constructed in any average to high quality ecological community.
- Outlets from detentions should not enter sensitive ecological areas.

Detention Design Recommendations

- One appropriately sized, large detention basin should be constructed across multiple development sites rather than constructing several smaller basins.
- Side slopes should be no steeper than 4H:1V, at least 25 feet wide, planted to native mesic prairie, and stabilized with erosion control blanket. Native oak trees (Quercus sp.) and other fire-tolerant species should be the only tree species planted on the side slopes.
- Dry bottom basins should be planted to mesic or wet-mesic prairie depending on site conditions.
- A minimum 5-foot-wide shelf planted to native wet prairie and stabilized with erosion control blanket should be constructed above the normal water level in wet and wetland bottom basins. This area should be designed to inundate after every 0.5-inch rain event or greater.
- A minimum 10-foot-wide shelf planted with native emergent plugs should extend from the normal water level to 2 feet below normal water level in wet and wetland bottom basins.
- Permanent pools in wet and wetland bottom basins should be at least 4 feet deep.
- Irregular islands and peninsulas should be constructed in wet and wetland bottom basins to slow the movement of water through the basin. They should be planted to native mesic or wet prairie depending on elevation above normal water level.
- A 4-6-foot-deep forebay, accessible to operations & maintenance crews, should be built at inlet(s) of wet/wetland bottom basins to capture sediment; a 4-6-foot-deep micropool should be constructed at the outlet to prevent clogging.

Short Term (3 Years) Native Vegetation Establishment Recommendations

In most cases, the developer or owner should be responsible for implementing short term management of detention basins and other natural areas to meet a set of performance standards. Generally speaking, a minimum of three years of management is needed to establish native plant communities within detention basins. Measures needed include mowing during the first two growing seasons following seeding to reduce annual and biennial weeds. Spot herbiciding is also needed to eliminate problematic non-native/invasive species such as thistle, reed canary grass, common reed, purple loosestrife, and emerging cottonwood, willow, buckthorn, and box elder saplings. In addition, the inlet and outlet structures should be checked for erosion and clogging during every site visit. Table 43 includes a three-year schedule appropriate to establish native plantings around naturalized detention basins.

Long Term (3 Years +) Native Vegetation Maintenance Recommendations

Long term management of most detention basins associated with development should be the responsibility of the homeowner or business association or local municipality. Often, these groups lack the knowledge and funding to implement long term management of natural areas resulting in the decline of these areas over time. Future developers should be encouraged to donate naturalized detention basins and other natural areas to a local municipality or conservation organization for long term management who receive funding via a Special Service Area (SSA) tax. Table 45 includes a cyclical long-term schedule appropriate to maintain native vegetation around detention basins.

Table 44. Three-year cyclical schedule for naturalized detention basins.

Year 1 Establishment Recommendations
Mow prairie areas to a height of 6-12 inches in May, July, and September.
Spot herbicide non-native/invasive species throughout site in late May and again in August/September. Target thistle, reed canary grass, common reed, purple loosestrife, and all emerging woody saplings.
Check for clogging and erosion control at inlet and outlet structures during site visit & after >1" rain event.
Year 2 Establishment Recommendations
Mow prairie areas to a height of 12 inches in June and August.
Spot herbicide non-native/invasive species throughout site in May and again in August/September. Target thistle, reed canary grass, common reed, purple loosestrife, and all emerging woody saplings.
Plant additional emergent plugs if needed and reseed any failed areas in fall.
Check for clogging and erosion control at inlet and outlet structures during site visit & after >1" rain event.
Year 3 Establishment Recommendations
Spot herbicide non-native/invasive species throughout site in May and again in August/September. Target thistle, reed canary grass, common reed, purple loosestrife, and all emerging woody saplings.
Check for clogging and erosion control at inlet and outlet structures during all site visits & after >1" rain event.

Table 45. Three-year cyclical long-term maintenance schedule for naturalized detention basins.

Year 1 of 3 Year Maintenance Cycle
Conduct controlled burn in early spring. Mow to height of 12 inches in November if burning is restricted.
Spot herbicide problematic non-native/invasive species throughout site in mid-August. Specifically target thistle, reed canary grass, common reed, and emerging woody saplings such as willow, cottonwood, buckthorn, and box elder.
Check for clogging and erosion control at inlet and outlet structures during site visit & after >1" rain event.
Year 2 of 3 Year Maintenance Cycle
Spot herbicide problematic non-native/invasive species throughout site in August. Specifically target thistle, reed canary grass, common reed, and emerging woody saplings such as willow, cottonwood, buckthorn, and box elder.
Mow prairie areas to a height of 6-12 inches in November.
Check for clogging and erosion control at inlet and outlet structures during site visit & after >1" rain event.
Year 3 of 3 Year Maintenance Cycle
Spot herbicide problematic non-native/invasive species in August. Specifically target thistle, reed canary grass, common reed, and emerging woody saplings. Cutting & herbiciding stumps of some woody saplings may also be needed.
Check for clogging and erosion control at inlet and outlet structures during all site visits & after >1" rain event.
Cycle begins again with Year 1 of Maintenance Cycle above

5.1.3 Rain Gardens

Rain gardens have become a popular new way of creating a perennial garden that cleans and infiltrates stormwater runoff from rooftops and sump pump discharges. A rain garden is a small shallow depression that is typically planted with deep rooted native wetland vegetation. These small gardens can be installed in a variety of locations but work best when located in existing depressional areas or near gutters and sump pump outlets. Not only do rain gardens clean and infiltrate water, they also provide food and shelter for many birds, butterflies, and insects. Rain gardens are typically 100-300 square feet in size, should be installed outside of wetlands and floodplains, and planted with native plants to improve water quality and habitat benefits. They should be placed at least 10 feet away from any building or structure and need to be excavated to a depth of 18-24 inches below the exiting grade. Soil amendments are recommended to ensure support of native plants. After installation, rain gardens require ongoing maintenance to ensure they are performing properly.

The intent of a rain garden program for residents is to encourage and provide an incentive for applicants to install rain gardens on private property to “micro-manage” stormwater runoff as close to the source (like downspouts, driveways, sump pump discharges) as possible. Typically, this incentive comes in the form of a cost-share program designed to reimburse residents for a portion of the costs incurred by installing a rain garden on their property.

Rain Garden Recommendations
Information programs in the watershed should focus on teaching residents and businesses the beneficial uses of rain gardens. Local governments, schools, and public agencies in the watershed should also install demonstration rain gardens as a way for the general public to better understand their application. Local governments could hold rain garden training seminars and potentially provide partial funding to residents and businesses that install rain gardens.

5.1.4 Vegetated Swales (Bioswales)

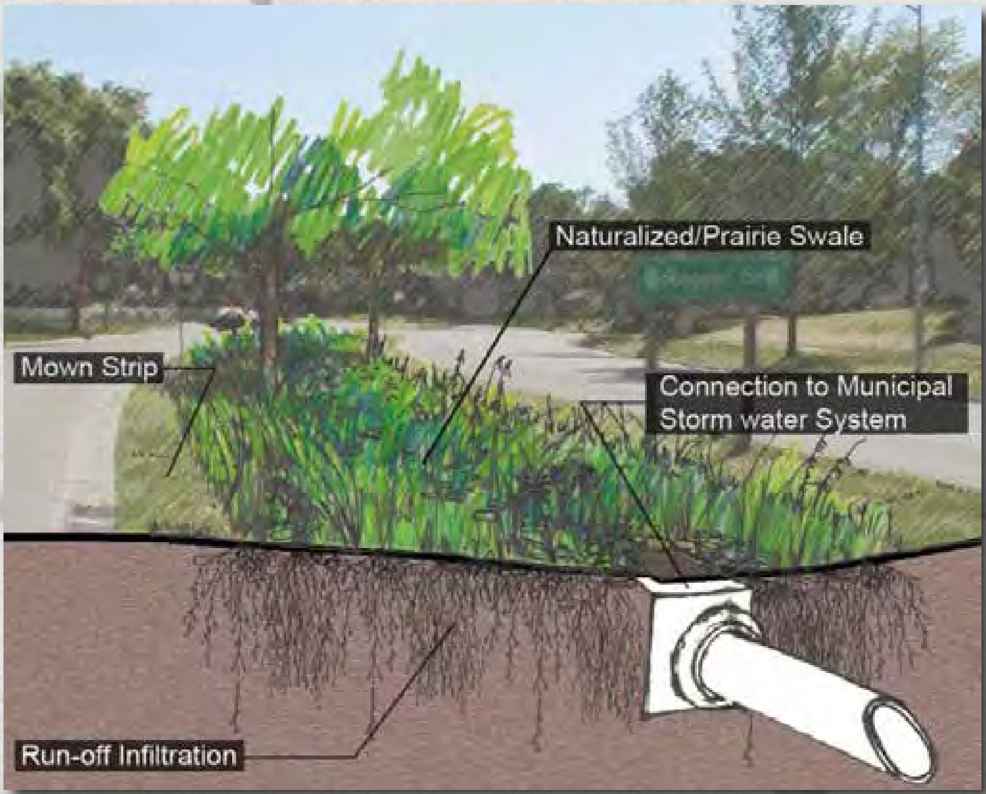
Vegetated swales, also known as bioswales, are designed to convey water and can be modified slightly to capture and treat stormwater for the watershed. Vegetated swales are designed to remove suspended solids and other pollutants from stormwater running through the length of the swale. The type of vegetation can dramatically affect the functionality of the swale. Turf grass is not recommended because it removes less suspended solids than native plants. In addition, vegetated swales can add aesthetic features along a roadway or trail. They can be planted with wetland plants or a mixture of rocks and plant materials can be used to provide interest.

Swales can be designed as either wet or dry swales. Dry swales include an underdrain system that allows filtered water to move quickly through the stormwater treatment train. Wet swales retain water in small wetland like basins along the swale. Wet swales act as shallow, narrow wetland treatment systems and are often used in areas with poor soil infiltration or high water tables.

Rain garden adjacent to single family home

Water quality is improved by filtration through engineered soils in dry swales and through sediment accumulation and biological systems in wet swales. According to USEPA, vegetated swales reduce total suspended solids (sediment) by 65%, total phosphorus by 25%, and total nitrogen by 10% (MDEQ, 1999).

Vegetated Swale Recommendations
Vegetated swales should be used in place of pipes or curbs in new and redevelopment where feasible. Swales can easily be integrated into various urban fabrics with curb cuts for water to access them from roadways, or they can be added between existing lots or in the grassy parkways between roads and sidewalks. Typically, swales are used in lower density settings where infiltration might be maximized. Dry swales should be used for smaller development areas with small drainages. Wet swales should be used along larger roadways, small parking areas, and commercial developments.



Rendering of dry vegetated swale with engineered soils. Overlay: One type of pervious pavers.

5.1.5 Pavement Alternatives

Pervious concrete, permeable asphalt, and paver systems are potential alternatives to conventional asphalt or concrete parking lots and roadways. These alternatives allow for natural infiltration of the water by allowing water that falls on the surface to flow to a storage gallery through holes in the pavement. Areas that are paved with pervious pavement produce less stormwater runoff than conventionally paved areas.

Traditionally, the quantity and quality of water running off of paved and other impermeable surfaces are the primary reason for the need for stormwater treatment. Pavement alternatives reduce runoff rates and volumes and can be used in almost every capacity in which traditional asphalt, concrete, or pavers are used.

Pavement alternatives capture first flush rainfall events and allow water to percolate into the ground. Pavement alternatives treat stormwater through soil biology and chemistry as the water slowly infiltrates. Groundwater and aquifers are recharged and water that might otherwise go directly to streams will slowly infiltrate, reducing flooding and peak flow rates entering drainage channels. Studies documented by USEPA show that properly designed and maintained pervious pavements reduce total suspended solids (sediment) by 90%, total phosphorus by 65%, and total nitrogen by 85% (MDEQ, 1999).

In recent years, concerns have been raised about the environmental effects of the use of coal-tar sealants. Coal-tar sealant is a surface treatment typically applied to protect asphalt on driveways and parking lots which contains polycyclic aromatic hydrocarbons (PAHs). PAHs are a group of chemicals that have been linked to cancer in humans and have been shown to be toxic to aquatic life and damaging to the environment (Needleman, 2015). According to studies, "PAHs are significantly elevated in stormwater flowing from parking lots and other areas where coal-tar sealcoats were used as compared to stormwater flowing from areas not treated with the sealant (USEPA, 2016)." Pervious concrete, permeable asphalt, and paver systems are all potential alternatives to the need for coal-tar sealants. Additionally, several states and municipalities have banned the use and/or sale of coal-tar sealants to further protect their communities.

Pervious Pavement Recommendations
Future development and redevelopment in the Upper South Brank Kishwaukee River watershed should consider the use of pavement alternatives, particularly for parking lots that receive high levels of public use. Pavement alternatives can be used in a variety of settings including parking lots, parking aprons, private roads, fire lanes, alleys. residential driveways, sidewalks, and bike paths. It is important to note that there are limitations to using pavement alternatives based on subsoil composition and they do require annual maintenance to remain effective over time.

Left: Filter strip along municipal building in Algonquin, Illinois; Right: Native landscaping near residential home. Source: Mike Halverson.

5.1.6 Vegetated Filter Strips

Vegetated filter strips are shallowly sloped vegetated surfaces that remove suspended sediment, and nutrients from sheet flow stormwater that runs across the surface. This Management Measure is often referred to as a buffer strip. The type of vegetation can dramatically affect the functionality of the filter strip. Filter strips can either be planted or can be comprised of existing vegetation. Turf grass should be avoided as it removes less total suspended solids than filter strips planted with native vegetation.

The wider they are the more effective filter strips are because the amount of time water has for interception/ interaction with the plants and soil within the filter strip is increased. When installed and functioning properly, the USEPA has documented that filter strips can reduce total suspended solids (sediment) by 73%, total phosphorus by 45%, and total nitrogen by 40% (MDEQ, 1999).

Vegetated Filter Strip Recommendations
Vegetated filter strips work in a variety of locations. Vegetated filter strips in rural and urban areas should be installed along streams, lakes, or ponds. Additionally, they can be used adjacent to buildings and parking lots that sheet drain. The water would then pass through the vegetated filter strip and into a waterway, such as a vegetated swale, stream, lake, pond, or other stormwater feature.

5.1.7 Natural Area Restoration & Native Landscaping

Natural area restoration and native landscaping are essentially one in the same but at different scales. Natural area restoration involves transforming a degraded natural area into one that exhibits better ecological health and is typically done on larger sites such as nature/ forest preserves. Native landscaping is done at smaller scales around homes or businesses and is often formal in appearance. Both require the use of native plants to create environments that mimic historic landscapes such as prairie, woodland, and wetland. Native plants are defied as indigenous, terrestrial or aquatic plant species that evolved naturally in an ecosystem. The use of native plants in natural area or native landscaping is well documented. They adapt well to environmental conditions, reduce erosion, improve water quality, promote water infiltration, do not need fertilizer, provide wildlife food and habitat, and have minimal maintenance costs.

Several environmental agencies support the use of native plants including Illinois Nature Preserves Commission (INPC), Illinois Department of Natural Resources (IDNR), McHenry County Conservation District (MCCD), McHenry County Soil and Water Conservation District, U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), National Wildlife Federation (NWF), and the Conservation Foundation (TCF).

Natural Area Restoration/Native Landscaping Recommendations
Large residential lots with existing natural components such as oak woodlands and wetlands and golf courses provide many of the best opportunities for natural area restoration and native landscaping at a larger scale. Homeowners interested in restoring natural areas or implementing native landscaping can find guidance through the agencies listed above or by contacting a local ecological consulting company. Backyard habitats can be certified through the National Wildlife Federation's Certified Wildlife Habitat program or the Conservation Foundation's

Conservation@Home program.

One golf course, the Crystal Lake County Club, falls within the watershed boundary. This golf course, like most golf courses, could improve its function as green infrastructure by implementing natural area restoration into existing designs. The Audubon Cooperative Sanctuary Program (ACSP) is an education and certification program that helps golf courses protect the environment by providing guidance for outreach and education, resource management, water quality and conservation, and wildlife habitat management. A golf course becomes certified under the program when implementing and documenting recommended environmental management practices. Annual program membership fees are $200.

5.1.8 Wetland Restoration

Approximately 678 acres or 46% of the historic wetlands in Crystal Creek watershed have been lost to farming and other development practices since European settlement in the 1830s. Wetlands are essential for water quality improvement and flood reduction in any watershed and also provide habitat for a wide variety of plant and animal species.

AES reviewed potential wetland restoration sites during the field inventory and unfortunately found no wetlands that were considered potentially feasible to restore. In most cases, the remaining hydric soils that were not already wetlands were either too small, too disturbed, or poorly located to make for a potentially feasible wetland restoration site. The wetland restoration process involves returning hydrology (water) and vegetation to soils that once supported wetlands. The USEPA estimates that wetland restoration projects can reduce suspended solids (sediment) by 77.5%, total phosphorus by 44%, and total nitrogen by 20% (MDEQ, 1999).

Wetland Restoration Recommendations

Local governments should consider requiring "Conservation Design" that incorporates wetland restoration on parcels slated for future development. Another potential option is to restore wetlands as part of a wetland mitigation bank where wetlands are restored on private land and become "fully certified." Then, developers are able to buy wetland mitigation credits from the wetland bank for wetland impacts occurring elsewhere in the watershed. It is also possible that in the future, Illinois EPA may require more strict nutrient policies for wastewater treatment plants. Wetland banks may provide an opportunity for plant owners to buy "water quality trading credits." The Site-Specific Action Plan section of this report identified sites where wetland restoration might be feasible.

Wetland restoration at Carrington Reserve Conservation Development in West Dundee, Illinois

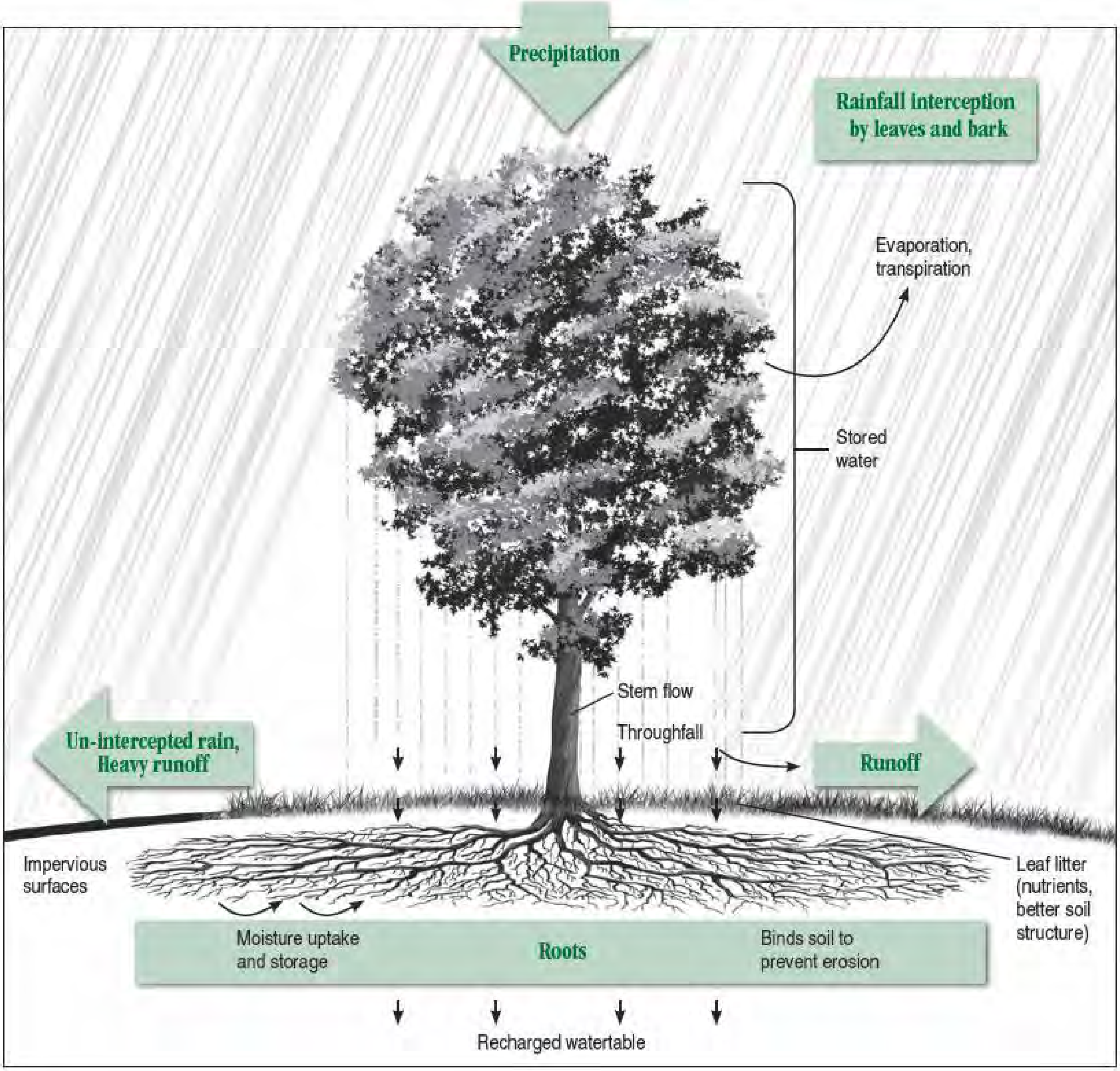


Figure 53. Illustration of how trees help with stormwater management (Source: Fazio, 2010).

5.1.9 Stormwater Trees/ Tree Planting Program

Trees provide extensive evapotranspiration and cooling benefits improve water and air quality, provide habitat, increase property values, and improve aesthetics in urban landscapes (see Figure 53). Trees play a valuable role in trapping absorbing stormwater, reducing pollutants, and holding soils in place during rain events and help to recharge groundwater supplies. A 25-foot canopy diameter tree can process the runoff of a 2,400 square foot adjacent impervious surface (EPA, 2016). Depending on the size and species, one tree can store 100 gallons or more of stormwater (Fazio, 2010).

Implementing a successful stormwater tree program can be complicated. Space and soil quality constraints can often be the limiting factors on whether a site is appropriate for installing stormwater trees. Other constraints include finding an appropriate species of tree, steep slopes, utility lines, impervious surfaces and pre-existing structures. With a little planning and engineering, many of these constraints can be overcome.

In 2016, the USEPA produced a Technical Memorandum on Stormwater Trees that provides detailed information on the benefits and challenges to implementing an effective Stormwater Tree program and maintaining the trees over time. This report is available on the EPA's website at https://www.epa.gov/green-infrastructure/stormwater-trees.

Municipalities in the watersheds should consider adopting a stormwater tree or tree planting program where these are not already in place.

5.1.10 Street Sweeping & Yard Waste Management

Street sweeping is often overlooked as a Management Measure option to reduce pollutant loading in watersheds. With over 165 miles of roads in the watershed, municipal street sweeping programs could help reduce nonpoint source pollutants from urban areas in Crystal Creek watershed. Street sweeping works because pollutants such as sediment, trash, road salt, oils, nutrients, and metals that would otherwise wash into stormsewers and streams following rain events are gathered and disposed of properly. The USEPA and Center for Watershed Protection (CWP) report similar pollutant removal efficiencies for street sweeping; weekly street sweeping can remove between 9% and 16% of sediment and between 3% and 6% of nitrogen and phosphorus (MDEQ, 1999; CWP 2017).

Yard waste, such as grass clipping and leaf litter, can also impact water quality when not managed correctly. "Grasscycling and composting are two techniques homeowners can use to reduce waste disposal and possible water contamination as well as save time, money and energy while returning valuable nutrients back into their lawns and gardens. (Gibb, 2012)" Composting of yard waste and grasscyclying, or leaving grass clippings on a lawn, can keep nutrients such as nitrogen in place. When grasscycling or composting, it is important to keep clippings on the lawn and off sidewalks, driveways, or other impervious surfaces where they might otherwise get washed into adjacent drainage systems or become a safety hazard (Gibb, 2012).

Street Sweeping & Yard Waste Management Recommendations

It is likely that the municipalities in the watershed already implement street sweeping to some degree. The frequency of street sweeping is a matter of time and budget and should be determined by each municipality. While weekly street sweeping provides the best results, this may be an unrealistic goal for most municipalities; any increase to the frequency of street sweeping should result in additional improvements in water quality. Homeowners should also compost yard waste and practice grasscycling at home.

Routine street sweeping is an effective Management Measure. Source: USGS.

5.1.11 Stream & Riparian Area Restoration & Maintenance

Moderate amounts of channelization and erosion in Crystal Creek watershed are common, predominantly due to the influences of urbanization on streams. Stream surveys reveal that about 62% (29,812 lf) of stream length in the watershed is moderately to highly eroded and 54% (26,034 lf) is moderately to highly channelized. In addition, riparian areas adjacent to streams are suffering as 35% are in poor ecological condition.

In many highly urbanized areas, all or portions of streams and tributaries were buried, covered, or forced into pipes underground rather than allowed to flow in their natural state. It wasn't until more recently that the effects of burying streams on watershed hydrology were better understood; burying streams results in hydrological changes in the watershed, increased flooding, destruction of fish and wildlife habitat, and as much as 18 times higher levels of nitrogen being transported downstream (Beaulieu, 2015). "Daylighting" is the process of exposing a previously buried stream or tributary. Stream daylighting improves water quality and habitat, allows for flood mitigation, and improves stormwater control (American Rivers, 2014). Daylighting can also provide additional economic revitalization, recreational opportunities, and can prove cost effective versus repairing failing culverts or maintaining piped systems (American Rivers, 2014).

Stream and riparian area restorations are one of the best Management Measures that can be implemented to improve water quality and the overall health of the watershed. This work involves improvements to a stream channel using artificial pool-riffle complexes, streambank stabilization using a combination of bioengineering with native vegetation and hard armoring with rock if needed, and adjacent riparian area improvements via removal of non-native vegetation and replacement with native species. These practices are typically done together as a way to improve water quality by reducing sediment transport, increasing oxygen, and improving habitat. The USEPA cites that as much as 90% of sediment, phosphorus, and nitrogen can be reduced following stream restoration. The downside to stream restoration is that it is technical and expensive. Stream restoration projects include detailed construction plans, often complicated permitting, and construction that must be done by a qualified contractor.

Stream restoration project in Barrington, IL.

With so many individual landowners with parcels intersecting Crystal Creek and its tributaries, routine maintenance of stream systems is challenging. In many cases, landowners simply do not have the knowledge or are not physically capable of maintaining streams on their property. Stream maintenance includes an ongoing program to remove blockages caused by accumulated sediment, fallen trees, etc. and is a cost-effective way to prevent flooding and streambank erosion.

Riparian buffers are defined as land adjoining any water body including ponds, lakes, streams, and wetlands. In 2010 the Southeastern Wisconsin Regional Planning Commission (SEWRPC) produced a document entitled "Managing the Water's Edge: Making Natural Connections" (SEWRPC, 2010). The research presented in SEWRPC's document was conducted to determine if an optimal riparian buffer design or width could be determined that effectively reduces pollutants, provides water quality protection, helps prevent channel erosion, provides adequate fish and wildlife habitat, enhances environmental corridors, augments baseflow, and moderates water temperature.

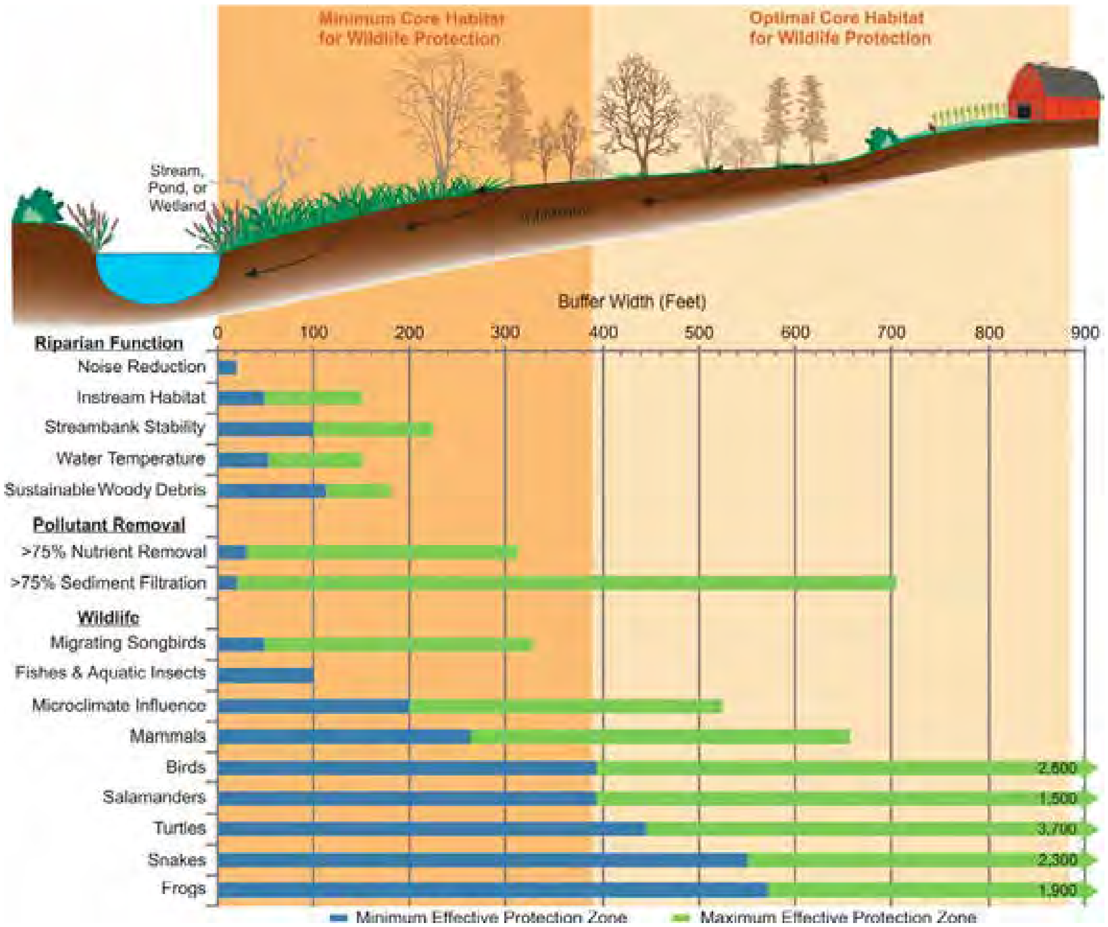


Figure 54. Riparian function, pollutant removal, and wildlife benefits for various buffer widths (Source: SEWRPC) 2010).

Interestingly, no consensus of optimal buffer width could be determined but what is apparent is that many riparian corridors no longer fulfill their potential due to encroachment by agricultural and urban development. SEWRPC's document summarizes how to maximize both water quality protection and conservation of aquatic and terrestrial wildlife populations using buffers as shown in Figure 54.

As described in SERWPC's document, implementing the green infrastructure network to connect open space and other natural area features should be embraced, whereby 75% minimum of the total stream length should be naturally vegetated to protect the functional integrity of the water resource and 75-foot-wide minimum riparian buffers are recommended from the top edge of each stream bank that are naturally vegetated to protect water quality.

Stream & Riparian Area Recommendations

There are many opportunities to implement stream and riparian area restoration in the watershed. These opportunities are identified in the Site-Specific Action Plan. All stream and riparian area opportunities are identified in the Site-Specific Action Plan. The Lake County Stormwater Management Commission (LCSMC) is a leader in the Chicagoland area when it comes to managing stormwater and has developed an excellent guide for riparian owners called "Riparian Area Management: A Citizen's Guide." This short flyer can be found on Lake County's website and is intended to educate landowners about debris removal and riparian landscaping. It is also important to note that not all debris in streams is harmful. The American Fisheries Society has created a short document called "Stream Obstruction Removal Guidelines" which is meant to clarify the appropriate ways to maintain obstructions in streams to preserve fish habitat.

While there is already one daylighting project recommended in the watershed (Crystal Creek Reach 3 – see the Site-Specific Action Plan), there may be other smaller drainage systems, particularly north of Crystal Lake, where daylighting is appropriate. American Rivers has produced a report entitled "Daylighting Streams: Breathing Life into Urban Streams and Communities" that provides detailed information on the importance of daylighting as well as clear case studies. It is available on the web at https://americanrivers.org/wp-content/uploads/2016/05/AmericanRivers_daylighting-streams-report.pdf.

5.1.12 Septic System Maintenance

Septic systems and onsite wastewater treatment systems (OWTS) are common in the portions of the Crystal Creek watershed that fall outside of municipal boundaries within older residential areas; it is estimated that roughly over 660 septic systems likely exist in the watershed. Septic systems in McHenry County are regulated under the McHenry County Public Health Ordinance, Article X: An Article Regulating Wastewater & Sewage Treatment and Disposal. When septic systems are not maintained and subsequently fail, they can contribute high levels of nutrients and bacteria to the surrounding environment. The failure rate of septic systems in the watershed is unknown. However, literature sources across the nation indicate a failure rate of approximately 20% (Brown, 1998; Mancl, 1984; Stout, 2003; UKCE, 2012).

Septic System Recommendations
Septic owners in McHenry County should contact the McHenry County Department of Health to schedule a septic system inspection to ensure that they are designed and operating properly. More information and resources are available online at https://www.mchenrycountyil.gov/county-government/departments-a-i/health-department/environmental-health/onsite-wastewater-treatment. In addition, the United States Environmental Protection Agency (USEPA) provides an excellent guide for septic system owners called “A Homeowner’s Guide to Septic Systems (USEPA, 2005).” The guide explains how septic systems work, why and how they should be maintained, and what makes a system fail.

Conservation Tillage (no till) farming. Source: farmprogress.com.

5.1.13 Agricultural Management Practices

Despite Crystal Creek watershed being fairly urbanized, agriculture makes up 11% of the land use, covering roughly 1,338 acres. Pollutant loading estimates using USEPA’s STEPL model point to cropland as the third largest nonpoint source contributor of sediment loading in the watershed, at 491 tons/yr of sediment (11% of total loads). Watershed-wide changes to agricultural practices can have a dramatic effect on pollutant loading in the watershed. Fortunately, there are numerous agricultural measures and funding sources that can be utilized by farmers to implement practices on their land to improve water quality and soil health, while reducing soil and nutrient losses. Many recommended programs are offered through the McHenry County Soil and Water Conservation Districts, U.S. Department of Agriculture (USDA), Natural Resource Conservation Program (NRCS), and the Farm Service Agency (FSA). These agencies are discussed in depth in Section 3.4.

USDA NRCS- Environmental Quality Incentive Program (EQIP)
The NRCS’s Environmental Quality Incentive Program (EQIP) is a voluntary conservation program that provides technical and financial assistance to individuals/entities to address soil, water, air, plant, animal and other related natural resource concerns on their land. EQIP offers financial and technical help to assist participants to install or implement structural and management practices on eligible agricultural land. As the most popular and most utilized conservation program offered by NRCS, EQIP assists thousands of producers annually in working towards: reducing contamination from agricultural sources such as animal feeding operations, efficiently utilizing nutrients and therefore reducing input costs and nonpoint source

pollution, and increasing soil health to improve resiliency to drought and increasingly volatile weather.

This program is available to farmers, ranchers, and forest landowners who own or rent agricultural land. EQIP assistance can be used for agricultural operations such as: conventional and organic agriculture, specialty and commodity crops, forestry and wildlife, livestock operations, and historically underserved farmers. Historically underserved farmers including beginning farmers, farmers with limited resources or those in socially disadvantaged groups, as well as military veterans, are eligible for increased or advance payments following changes in the 2018 Farm Bill.

Other expansions of EQIP under the 2018 Farm Bill include expanding eligibility regarding with whom NRCS can enter into an EQIP contract. Under these expansions, NRCS can enter into contracts with water management entities when they are in support of water conservation or an irrigation efficiency project. Eligible entities include: States, irrigation districts, ground water management districts, or other similar entities.

Beginning in 2020, States may provide increased EQIP payment rates for high-priority practices. Eligible high-priority practices include those that address specific causes of ground or surface water impairment relating to excessive nutrients, address the conservation of water to advance drought mitigation and declining aquifers, meet other environmental priorities and other priority resource concerns identified in habitat or other area restoration plans, or is geographically targeted to address a natural resource concern in a specific watershed. NRCS State Conservationists may designate up to 10 practices to be eligible for increased payments.

No-till is a land management option within the EQIP program and is the leading recommendation for farmers in Upper South Branch Kishwaukee River watershed. With no-till, the land is left undisturbed from harvest through planting, preserving a canopy of crop residue on the surface to protect the soil from erosion. Along with soil conservation benefits, high fuel prices are driving a switch to no-till for many farmers. Eliminating tillage passes reduces both fuel and labor expenses (USDA, 2020).

Agricultural Conservation Easement Program (ACEP)

The Agricultural Conservation Easement Program (ACEP) was created in the 2014 Farm Bill through the combination of the previously separate Wetlands Reserve Program (WRP), Grassland Reserve Program (GRP), and Farm and Ranch Lands Protection Program (FRPP). These programs were originally ratified in 1990, 1996, and 2002 Farm Bills respectively.

The Agricultural Conservation Easement Program assists landowners, land trusts, and other entities protect, restore, and enhance wetlands, grasslands, and working farms and ranches through conservation easements. There are two components to ACEP, the Agricultural Land Easements component and the Wetland Reserve Easement component. The NRCS Agricultural Land Easements component helps American Indian tribes, state and local governments, and nongovernmental organizations protect working agricultural lands and limit non-agricultural uses of the land. NRCS Wetland Reserve Easements component, helps to restore, protect, and enhance enrolled wetlands through the purchase of easements and assistance in restoration (NSAC, 2019).

ACEP - Wetland Reserve Easements (WRE)

The Wetlands Reserve Easement program (WRE) is a voluntary program offering farmers the opportunity to protect, restore, enhance, and protect wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. The goal of NRCS is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.

Land that's eligible for enrollment in ACEP as a Wetland Reserve Easement includes farmed or converted wetland that can be successfully restored as natural wetland habitat in a cost-effective manner. NRCS prioritizes applications for Wetland Reserve Easements based upon their potential for protecting and enhancing habitat for migratory birds and other wildlife.

NRCS enters into purchase agreements with eligible landowners which include the right to develop and implement a wetland reserve restoration easement plan. These plans aim to restore, protect, and enhance the functions and value of the site's wetlands.

Landowners who choose to enroll land in a Wetland Reserve Easement may sell a conservation easement or enter into a cost-share restoration agreement with NRCS to restore and protect wetlands. These easement options include:

- Permanent Easements – These are conservation easements in perpetuity, with NRCS paying 100 percent of the value of the easement to purchase it, and 75 to 100 percent of the cost to restore it.

- 30-Year Easements – Under 30-year easements, NRCS pays 50 to 75 percent of the value of the easement to purchase it, and 50 to 75 percent of the cost to restore it.

- Term Easements – The length of term easements is determined by applicable state laws. NRCS pays 50 to 75 percent the value of the easement to purchase, and 50 to

75 percent of the cost to restore it.

- 30-Year Contracts – 30-year contracts are only available to enroll acreage owned by American Indian Tribes, and program payment rates are similar to that of 30-year easements.

Landowners and NRCS then develop a plan for the restoration and maintenance of the wetland. As a requirement of the program, landowners voluntarily limit future use of the land, yet retain private ownership.

ACEP's wetlands component also includes a wetlands reserve enhancement partnership option (formerly known as the Wetlands Reserve Enhancement Program, WREP) through which NRCS partners with states, non-governmental organizations, or Native American Tribes to protect, restore, and enhance high priority wetlands.

This partnership option is a voluntary program in which NRCS, and eligible partners sign an agreement to leverage resources in restoring high priority wetland protection, restoration, and enhancement to improve habitat for migratory birds and other wildlife. Benefits include wetland restoration and protection of critical areas, ability to cost-share restoration or enhancement beyond NRCS requirements through leveraging resources, and the ability to participate in the management and monitoring of projects with the support of the NRCS's expertise in restoration practices.

Wetland reserve easements enable landowners to reduce impacts from flooding, recharge groundwater, enhance and protect wildlife habitat and provide outdoor recreational and educational opportunities. As with the original WREP, producers can retain grazing rights as part of a wetland easement if the grazing activity is consistent with long-term wetland protection and enhancement goals for which the easement was established. The easement payment would be reduced by an amount equal to the grazing value (USDA, 2020).

ALE- Agricultural Land Easements (ALE)

The purpose of the Agricultural Land Easement (ALE) component is to protect farms and ranches from development, specifically to ensure farm viability for future generations, and to conserve grazing land, rangeland, pasture and shrub land. NRCS provides financial assistance to eligible partners for purchasing Agricultural Land Easements that protect the agricultural use and conservation values of eligible land.

In the case of working farms, the program helps farmers and ranchers keep their land in agriculture. The program also protects grazing uses and related conservation values by conserving grassland, including rangeland, pastureland and shrubland. Eligible partners include American Indian tribes, state and local governments and non-governmental organizations that have farmland, rangeland or grassland protection programs.

Farm west of Castleberry Drive

Above: Grass waterway on highly erodible agricultural land . Source: NRCS.

For Agricultural Land Easements, NRCS can contribute up to 50 percent of the fair market value of the agricultural land easement. Where NRCS determines that grasslands of special environmental significance will be protected, NRCS may contribute up to 75 percent of the fair market value of the agricultural land easement. Eligible entities can now include cash contributions, landowner contributions, or other non-USDA federal funding to satisfy the match requirements.

The 2018 Farm Bill removed the requirement that all agricultural land easement enrollments under ACEP must have a conservation plan, it is now required only for the portions of the agricultural land easement that are highly erodible cropland.

Additionally, the 2018 Farm Bill adds a new priority in evaluating proposals for easements that maintain agricultural viability. This priority includes easements that allow a producer to: productively operative a farm or ranch on the protected land; maintain the long-term affordability of the protected land; maintain an economically sustainable farm business on the land; and maintain the land in a way that enables its agricultural use for future generations.

The 2018 Farm Bill also allows for entities holding an ALE to add deed terms that address mineral development. In instances when mineral development rights are reserved and exercised under ACEP, the activity should be consistent with the conservation and agricultural purposes of the land and all provisions of the program. Under the agricultural land easement component, ACEP funds are provided to non-profits (such as land trusts), state and local agencies, and Indian tribes to purchase easements. Agricultural land easements are permanent; in states that do not allow permanent easements, the easements will be as long-term as allowed by law.

To qualify for an ALE the easement must have prime, unique, or productive soil (or contain historical or archaeological resources, protect grazing uses by restoring and conserving land, or further a state or local policy consistent with program purposes.) The easement must also be either cropland, rangeland, or grassland; contain forbs or shrub land for which grazing is the predominant use; be located in an area which is historically grassland, forbs, or shrubs and could provide ecologically significant habitat; or be pastureland or non-industrial private forestland which contributes to economic viability of a parcel and serves as a buffer to protect such land from development (USDA, 2020).

Farm Service Agency (FSA)-Conservation Reserve Program (CRP)
The USDA Farm Service Agency's (FSA) CRP is a voluntary program that contracts with agricultural producers so that environmentally sensitive agricultural land is devoted to conservation benefits. The Food Security Act of 1985, as amended, authorized CRP. The program is implemented by FSA on behalf of USDA's Commodity Credit Corporation. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length.

CRP participants establish long-term, resource-conserving vegetative species, such as approved grasses or trees (known as "covers"), to control soil erosion, improve the water quality and enhance wildlife habitat. The long-term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat. CRP protects millions of acres of American topsoil from erosion and is designed to safeguard the nation's natural resources. By reducing water runoff and sedimentation, CRP protects groundwater and helps improve the condition of lakes, rivers, ponds and streams. The vegetative covers also make CRP a major contributor to increased wildlife populations in many parts of the country.

Additionally, there is a CRP Grasslands program which helps landowners and operators protect grassland, rangeland, and pastureland while maintaining the areas as grazing lands. The program emphasizes support for grazing operations, plant and animal biodiversity, and grassland

and land containing shrubs and forbs under the greatest threat of conversion.

The following conservation practices are eligible under CRP, and thus land must be suitable for any of these practices: Grass Waterway, Shallow Water Area for Wildlife, Contour Grass Strip, Filter Strip, Riparian Buffer, Denitrifying Bioreactor on Filter Strip and Riparian Buffer, Saturated Filter Strip and Riparian Buffer, Habitat Buffers for Upland Birds, Wetland and Buffer SAFE Practices, Wetland Restoration on Floodplain and Non-Floodplain, Prairie Strips, Windbreaks, Shelterbelts, Living Snow Fences, Marginal Pastureland Wetland Buffer and Wildlife Habitat Buffers, Long Leaf Pine Establishment, Duck Nesting Habitat, Pollinator Habitat, Bottomland Timber Establishment on Wetlands, Farmable Wetlands Program (FWP) Constructed Wetland, FWP Aquaculture Wetland Restoration, FWP Flooded Prairie Wetland, Farmable Wetlands and Farmable Wetland Buffer, and Wellhead Protection Area Practices.

In order to be eligible for the CRP, the landowner must have owned or operated the land for at least 12 months prior to submitting the offer (or there are certain extenuating circumstances). Cropland must be planted to an agricultural commodity, have a weighted average erosion risk of eight or higher, be enrolled in a CRP contract currently, or be located in a CRP conservation priority area; there are no CRP conservation priority areas in the watershed.

Enrollment in CRP is offered in the form of general enrollment or continuous enrollment. In general enrollment, during annual enrollment periods, producers have the opportunity to offer land for the program which is then ranked according to the factors of the Environmental Benefits Index. This index considers: wildlife habitat benefits resulting from covers on enrolled land, water quality benefits, on-farm benefits from reduced erosion, long-term benefits that will endure beyond the contract period, air quality benefits from reduced wind erosion, and cost. Under continuous enrollment, environmentally sensitive land may be enrolled at any time though is not subject to competitive bidding (FSA, 2019).

Other Agricultural Recommendations

Principles of Soil Health

Improving water quality in runoff from agricultural lands can often be achieved by maintaining soil health and following soil health principles. There are five principles of soil health; they include soil armor, minimizing soil disturbance, plant diversity, continual live plant/ root, and livestock integration. Armoring the soil refers to cover for the soil and controls erosion and evaporation rates, maintains soil temperatures, reduces compaction, suppresses weed growth and provides habitats for species. Minimizing soil disturbance reduces erosion, increases infiltration, and helps keep organic matter in the soil. Diversifying crop rotations can improve biodiversity, improves infiltration and nutrient cycling, and reduces pests. Providing some type of live plant root on a year-round basis is important for building soil health, ensuring that there is food for the soil web continuously throughout the year. Finally, integrating animals or livestock in the form of grazing can help balance the carbon to nitrogen ration, manage crop rotation, and help suppress weeds by fulfilling the natural symbiotic relationships between plants, animals, and the soil web (Fuhrer, 2018). Landowners should work with their local USDA-NRCS representative and cropping consultant to implement a system that will work for them.

Regenerative Agriculture

Regenerative agriculture promotes a method of farming that encourages the regeneration of topsoil, improves water quality, increases biodiversity, and supports carbon sequestration in effort to mitigate the effects of climate change (Terra Genesis International, 2016). The practice is guided by a holistic approach of making appropriate, context-specific recommendations for farmers based on agroecology and restoration ecology methodologies with the goal of rebuilding quantity and quality of topsoil while creating equitable and just relationships amongst all stakeholders. By rebuilding soil organic matter and soil health, yields should increase, and fewer inputs should be needed over time. Simultaneously, the improved biomass helps to sequester carbon and offset greenhouse gases, while the reduced disturbance of the soil improves water quality (Regeneration International, 2019). Many of the practices involved are recommended by NRCS, the McHenry County Soil and Water Conservation District, and the principles of soils health. Potential practices include "no-till/minimum tillage techniques, the use of cover crops, crop rotations, compost, and animal manures, the inoculation of soils with composts or compost extracts to restore soil microbial activity, and managed grazing (CSU Chico, 2017)."

The regenerative agriculture approach, research, and methodologies are ever evolving and need to be tailored to the context of individual farms. Many sources of additional information are available including online resources available from Regeneration International, Terra Genesis International, and California State University – Chico, among others.

Subsurface (Tile) Drainage Best Management Practices- Drainage Water Management

Subsurface drain tiles are a commonly used practice by farmers to help lower the water table of poorly drained fields and/or wet areas within fields. Unfortunately, nitrogen and phosphorus often find their way into tiles through cracks and macropores in the soil. The tiles then carry these nutrients to local streams.

Drainage Water Management, or

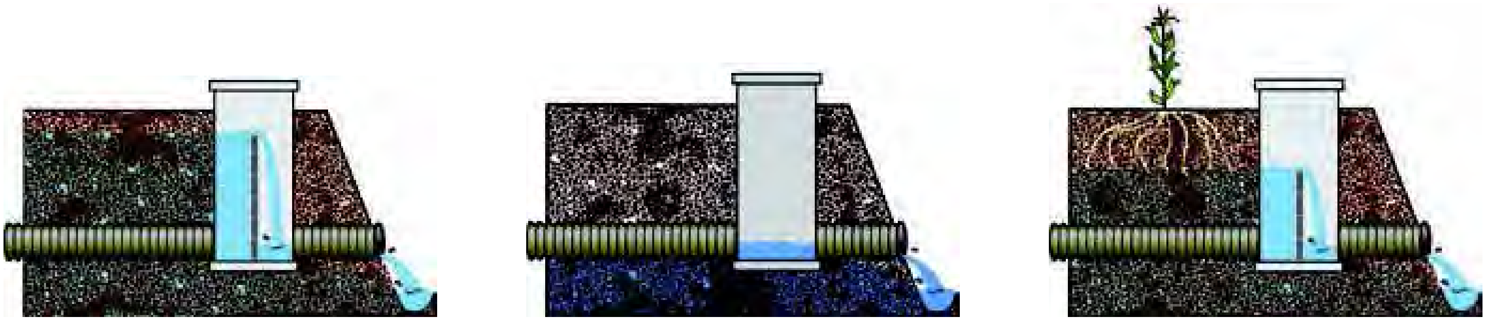


Figure 55. Use of tile control to raise water table after harvest (left), drawdown prior to seeding (middle), and raised again in midsummer (right) (Source: Purdue University).

management of the water table through control structures at drain tile outlets, is an approach to reduce the amount of nutrients that exit the tile lines. DWM is the process of managing the timing and the amount of water discharged from agricultural drainage systems. DWM is based on the premise that the same drainage intensity is not required at all times during the year. This is accomplished by adjusting the control structure so that the water table rises after harvest to limit drainage during the off-season. The water table can then be lowered a few weeks prior to planting in spring. The water table can also be raised in midsummer to store water for crops. With DWM, both water quality improvement and production benefits are possible. Water quality benefits are derived by minimizing unnecessary drainage, reducing the amount of nitrate that leaves farm fields. Producers who use DWM enjoy being able to better control their drainage water instead of the water controlling them (Cooke, 2004).

To ensure successful implementation of a DWM system on agricultural tile drainage, it is essential to have a DWM Plan. A properly prepared DWM plan considers landscape, soils, slope, and current or planned drainage systems as well as the size and location of water control structures and detailed sets of instructions for their operation and maintenance. This includes identification of the zones of influence for each water control structure and the target water elevations for each of the seasonal land uses. The Golden Rule of Drainage (as advocated by NRCS) is: Only release the amount of water necessary to ensure trafficable conditions for field operations and to provide an aerated crop root zone- any drainage in excess of this rule likely carries away nitrate and water that is no longer available for crop uptake (NRCS, 2020).

Subsurface (Tile) Drainage Best Management Practices- Subsurface Bio-Reactors

While properly designed and installed subsurface drainage tiles can reduce sediment and phosphorus losses on fields, they can expedite the movement of nitrate-nitrogen to nearby surface waters. BMPs such as subsurface Bioreactors seek to mitigate this issue by providing a subsurface solution to a subsurface problem. Bioreactors consist of a substrate (gravel and a carbon source, typically woodchips, though alternative substrates are being researched) placed underground through which tile water flows. The systems are designed to maintain drainage effectiveness and, once installed, do not require additional land to be taken out of production. The reactors are constructed such that during periods of high flow, the bioreactor is bypassed and water flows through the tile as usual.

Bioreactors work by providing a carbon source on which soil organisms colonize. These colonies consume the carbon from the woodchips, and "breathe in" the nitrate from the water which is then "breathed out" as nitrogen gas which enters the atmosphere (similar to how humans breathe in oxygen and breathe out carbon dioxide (Frankenberger, 2020).

Waste (Manure) Management

Livestock production within the agricultural industry is a producer of waste materials that need management. While there is not currently livestock production in the watershed, there could be in the future. These wastes primarily include manure from livestock; livestock manure is rich in plant nutrients. Manure that is properly applied increases soil fertility and may also improve soil physical properties, improperly applied manure can contaminate surface water and groundwater. In order to protect water quality while maximizing nutrient efficiency, producers must select the relevant best management practice for their crops.

The NRCS has produced the *Agricultural Waste Management Field Handbook* (AWMFH) to provide specific guidance for planning, designing, and managing systems where agricultural wastes are involved. It can help assist agricultural producers in organizing a comprehensive plan that results in the safe integration of waste management into overall farm operations. Material in this handbook covers a wide range

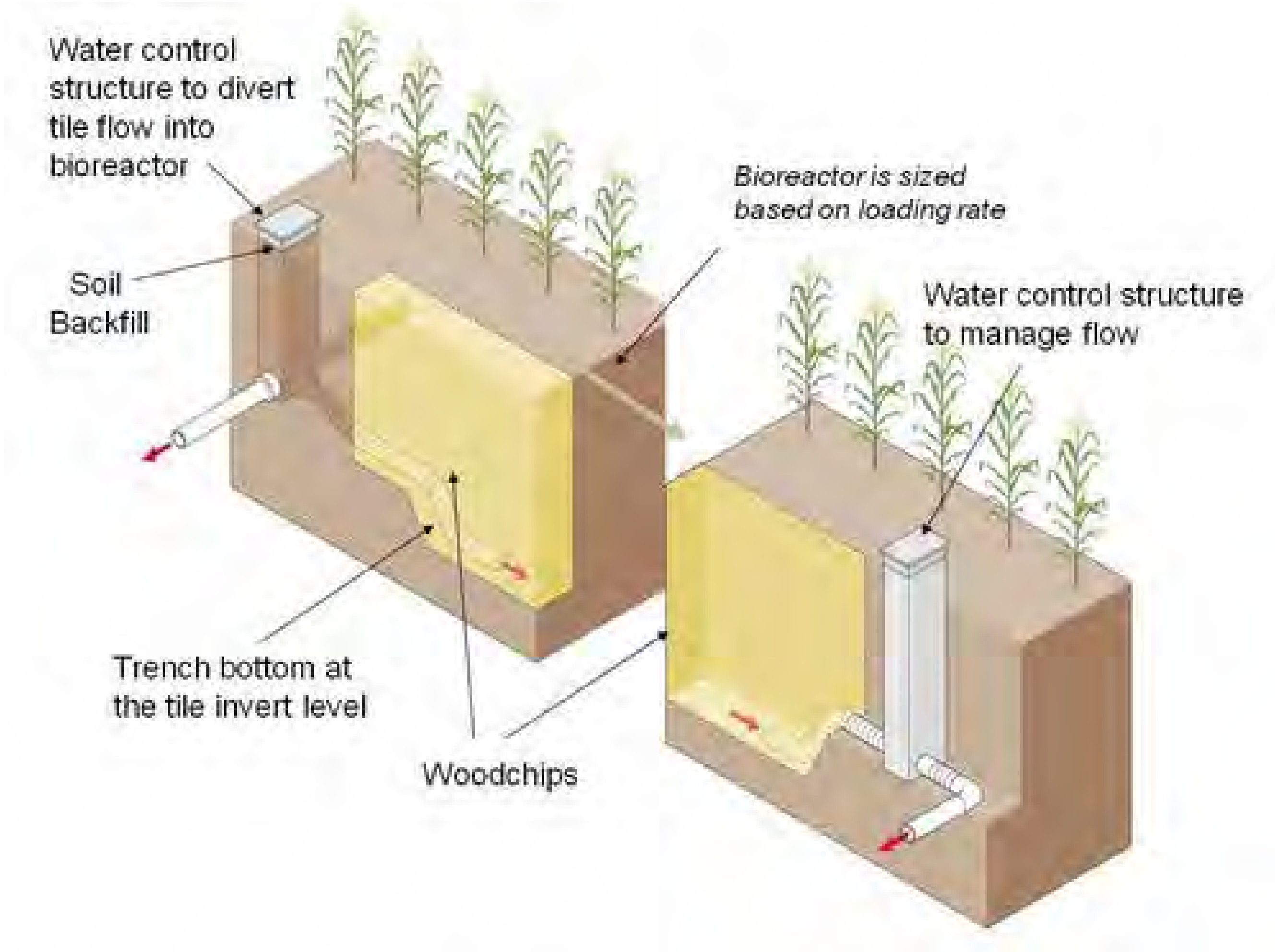


Figure 56. Subsurface Bioreactor (Source: Frankenberger.)

of activities from incorporating available manure nutrients into crop nutrient budgets to proper disposal of waste materials that do not lend themselves to resource recycling (NRCS, 2020).

Generally speaking, one of the most important manure best management practices is the development of a nutrient management plan; this involves accounting for all sources of crop-available nitrogen, performing manure testing to determine nutrient content, determining manure application rates based on crop nitrogen needs, and then applying fertilizer to manured fields only when needed to satisfy crop nutrient needs (UIUC - Extension, 2020).

Best management practices should be applied to the application of manure as well as the stockpiling and storage. When applying manure, generally speaking, attention should be given to not apply manure to sites with excessive slopes or highly erodible soils, or frozen or saturated soils. Manure should only be applied with properly calibrated equipment. Manure should be incorporated into soils as soon as possible after application to reduce losses. Other considerations are the establishment of a buffer zone of at least 100 feet between manure application and water resources, and the planting of permanent vegetation strips between surface waters and croplands to filter runoff. Similarly, manure stockpiles and livestock enclosures should be at least 100 feet away from any water supply, additionally vegetated filter strips should be established around the downhill side of stockpiles and enclosures. Stormwater should be redirected such that flow through stockpiles and enclosures is eliminated or reduced; and enclosures should be frequently cleaned (Colorado State University, 2020).

Agricultural Recommendations

Additional conservation practices and increases in the extent of reduced tillage practices in the Crystal Creek watershed are necessary to reduce cropland pollutant loading. AES recommends encouraging cropland landowners to increase their participation in reduced or low residue tillage or no-till on their lands. AES also recommends that agricultural landowners practice the principles of soil health and regenerative agriculture on their lands.

5.1.14 Downspout Disconnection/Rainwater Harvesting & Re-use

Downspout disconnection and rain barrel programs help reduce the amount of clean water that is used as well as reduce the amount of wastewater discharged to streams. Water harvesting and re-use via rain barrels and cisterns are important options to decrease the amount of stormwater runoff in a watershed. It is a simple, economical solution that can be done by any homeowner or business. On most homes and buildings, the water from roofs flows into downspouts and then onto streets, parking areas, or into storm sewers. Disconnecting downspouts and using either rain barrels or cisterns for re-use later can reduce the flood levels in local streams.

Water re-use differs based on the type of storage and water treatment. A rain barrel is typically attached to a downspout and collects water for later use, such as irrigation purposes. In many areas, irrigation can account for almost 50 percent of residential water consumption. Re-using water collected in a rain barrel is a great way of minimizing water consumption and reduce water bills.

A cistern also stores water from rooftop runoff to be used later. However, a cistern is often larger, sealed, and the water can be filtered for a wider variety of uses. Cistern water can be used many outdoor uses such as lawn and garden watering, irrigation, car washing, and window cleaning.

The primary purpose of rain barrels and cisterns is water storage. Rain barrels typically store 55 gallons each. Cisterns can store greater amounts. Rain barrels and cisterns also reduce outdoor water demand in summer months by reducing the potable water used for irrigation or other outdoor household uses.


Rain barrel connected to a downspout

Rainwater Harvesting & Reuse Recommendations
Education programs in the watershed should focus on teaching residents and businesses the beneficial uses of downspout disconnection, rain barrels and cisterns. Local governments in the watershed should aim to install demonstration projects as a way for the public to better engage in their water use and re-use around residential homes and businesses. Local governments and conservation organizations such as McHenry County Conservation District, McHenry County Soil and Water Conservation District, and the Crystal Lake Park District should sponsor programs where residents and businesses can purchase rain barrels.

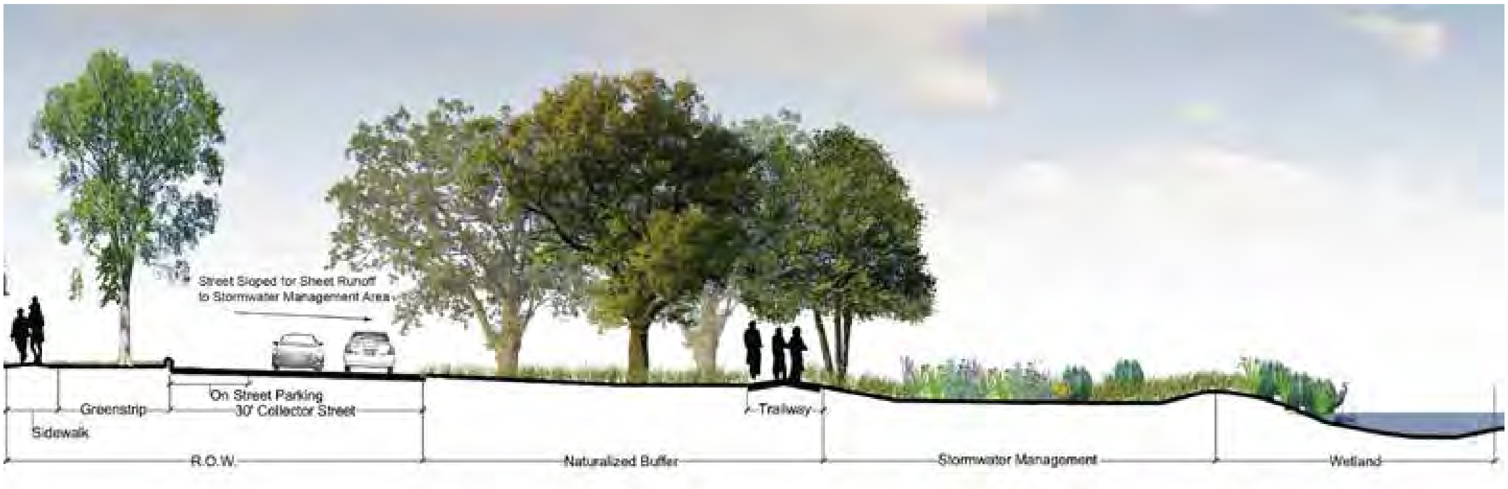


Figure 57. Stormwater Treatment Train within Conservation Development.

5.1.15 Conservation Design & Low Impact Development

Conservation design facilitates development density needs while preserving the most valuable natural features and ecological functions of a site. It does this by reducing lot size, especially lot width, while increasing the available land area to allow for open space and natural resources (Figures 57 - 59). The open space is typically preserved or restored as natural areas that are integrated with newer natural Stormwater Treatment Train features and recreational trails and serve as an amenity to the entire development. The open space allows the residents to feel like they have larger or more private lots because most of the lots adjoin the open space system.

Such flexibility is intended to retain or increase the development rights of the property owner and the number of occupancy units permitted by the underlying zoning designation, while encouraging environmentally responsible development. Conservation design is most appropriate in areas having natural and open space resources to be protected and preserved such as floodplains, groundwater recharge areas, wetlands, woodlands, streams, wildlife habitat, etc. It can also be used to preserve and integrate agricultural uses into the land pattern.

Figure 58. Traditional vs. Conservation Development Design (Elkhorn, WI).

Figure 59. Conservation/Low Impact development design.

The approach first considers the natural landscape and ecology of a development site rather than determining design features on the basis of pre-established density criteria. The general steps included below are generally followed when designing the layout of a development site:

Step 1: Identify natural resources, conservation areas, open space areas, physical features, and scenic areas and preserve and protect these areas from any negative impacts generated as a result of the development.

Step 2: Locate building sites to take advantage of open space and scenic views by requiring smaller lot sizes or cluster housing as well as to protect the development rights of the property owner and the number of occupancy units permitted by the underlying zoning of the property.

Step 3: Design the transportation system to provide access to building sites and to allow movement throughout the site and onto adjoining lands; roads should not traverse sensitive natural areas.

Step 4: Prepare engineering plans which indicate how each building site can be served by essential public utilities.

Figure 60. Greener Streetscape using LID practices. Source: "*Greening the Code*" Washington County, OR.

Prairie Crossing Conservation Development in Grayslake, Illinois

Low Impact Development (LID)
Low impact development (LID) focuses on the hydrologic impact of development and tries to maintain pre-development hydrologic systems, treating water as close to the source as possible (see Figure 60). LID principles can be incorporated into development or stormwater ordinances and used in new development or retrofitting existing developments. Green infrastructure systems are created to mimic natural processes that promote water infiltration, native plant evapotranspiration, and stormwater reuse.

Low impact development seeks to keep stormwater out of pipes and instead keep the entire infrastructure more natural and above ground. Solutions start at the lot scale such as rain gardens and overflows to swales adjacent to roads. Larger impervious areas, such as a commercial development may utilize constructed wetlands for stormwater storage while adding value to the area by enhancing aesthetics, site interest and the ecology.

Economics of Conservation Design and Low Impact Development
Both conservation developments and low impact development (LID) are not only environmentally sound choices, but economical ones for both developers and municipalities. Conservation design can produce some of its biggest cost savings in infrastructure costs such as site preparation, stormwater management, site paving, and sidewalks (Conservation Research Institute, 2005). According to a study conducted by Applied Ecological Services, Inc., the average savings created by choosing conservation development over more traditional footprints is 24% (Table 46) (AES, 2007). Not only do lots in conservation developments typically cost less to install, but they also "carry a price premium … and sell more quickly than lots in conventional subdivisions (Mohamed, 2006)." Another study conducted in Concord, Massachusetts found that over an eight-year period, a cluster development with protected open space had a 2.6% higher annual appreciation rate over "residential properties with significantly larger private yards, but without the associated open-space (Lacy, 1990)."

While low impact development covers a range of stormwater practices, it has some of the same cost benefits as conservation design. Typically LID practices "can cost less to install, have lower operations and maintenance costs, and provide more cost-effective stormwater management and water-quality services than conventional stormwater controls (ECONorthwest, 2007)." Similar to conservation design, cost savings from utilizing LID practices can be found as a reduction in the amount of drainage infrastructure and land disturbance required; additionally, property values can be increased by 12 - 16% (UNH Stormwater Center, 2011).

There is also evidence that combining both conservation and low impact development practices through holistic site design can create deeper cost savings for developers as well as increased ecosystem benefits – particularly by combining clustered site designing and naturalized stormwater management systems (Conservation Research Institute, 2005). Not only do conservation and low impact development practices provide a more economical possibility for developers and municipalities, but they can improve water quality, habitat, and property values in the watershed.

Table 46. Savings of Conservation Development over Traditional Subdivision Design for ten Midwestern conservation development projects.

Savings of Conservation Development over Traditional Subdivision Design (P=Project)
Positive numbers are savings of Conservation Development over Traditional.
Negative numbers are costs of Conservation Development over Traditional.

Project:	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Average
ITEM											
Grading	-$214,740	$257,832	$1,813,726	$2,215,025	$1,856,206	$1,862,988	$796,705	$291,957	$302,497	$2,852,312	51.00%
Roadway	$84,702	$18,754	-$16,477	-$130,230	$1,464,599	$1,187,386	$205,168	$9,231	-$9,963	$801,484	18.00%
Storm Sewer	$181,611	$31,220	$6,648	$89,676	$974,689	$547,184	$210,289	$65,501	$110,021	$678,302	40.00%
Sanitary Sewer	$41,614	-$4,365	$0	-$203,064	$850,962	$224,776	$72,436	-$15,502	$5,960	$423,458	6.00%
Water	$44,483	-$4,671	-$63,680	-$215,881	$905,157	$240,064	$76,815	-$16,257	$5,973	$451,084	5.00%
Ecological	-$56,500	-$74,857	-$277,472	-$400,321	-$407,131	-$625,084	-$160,341	-$93,954	-$264,513	-$380,992	-154.00%
Amenities	$17,572	-$16,202	-$94,399	-$226,216	$552,667	$221,666	$7,825	-$15,749	-$39,274	$266,982	6.00%
Contingencies	$132,055	$51,928	$342,087	$282,247	$1,549,287	$914,745	$302,225	$56,307	$27,675	$1,273,157	24.00%
Total Savings	$660,277	$259,639	$1,710,433	$1,411,235	$7,746,436	$4,573,725	$1,511,124	$281,534	$138,377	$6,365,787	
Total Percent Savings	19.00%	20.00%	33.00%	15.00%	43.00%	32.00%	25.00%	15.00%	4.00%	37.00%	24.30%*
Cost Savings Per Lot	$8,725.00	$6,978.00	$147,012.00	$29,012.00	$7,904.00	$20,077.00	$7,346.00	$4,078.00	$4,959.00	$67,676.00	$30,376.70

* Total Savings Percentage is *not* the percentage savings of all individual items added together, because dollar-values of items are different.
Visit www.appliedeco.com for more detailed info

5.1.16 Green Infrastructure Network Planning

A green infrastructure network provides communities with a tool to identify and prioritize open space land use or conservation opportunities and plan development that benefits both people and nature by providing a framework for future growth. It identifies areas not suitable for development, areas suitable for development but that should incorporate conservation or low impact design standards, and areas that do not affect green infrastructure.

Park Districts, Forest Preserve Districts, IDNR, and watershed stakeholders can use green infrastructure plans for trail routing, open space linkages, and natural area restoration decisions. Residents can use green infrastructure recommendations to reduce runoff from their properties and to see how their properties fit into the larger network. A Green Infrastructure Network for the watershed was developed in Section 3.10.

Green Infrastructure Network *implementation* has several actions:

- Protect specific unprotected green infrastructure parcels through acquisition, regulation, and/or incentives.
- Incorporate conservation or low impact design standards on green infrastructure parcels where development is planned.
- Limit future subdivision of green infrastructure parcels.
- Implement long-term management of green infrastructure.

The City of Crystal Lake developed the Green Infrastructure Study and Report and Chapter 11, Green Infrastructure, of the Crystal Lake 2030 Comprehensive Plan and both documents provide clear recommendations and guidance about protecting the Green Infrastructure Network. The Crystal Lake Watershed Stormwater Management Design Manual (Hey, 2007) also details extensive information on types of best management practices, requirements, and restrictions. While all three of these documents were developed by or for the City of Crystal Lake, it is recommended that remaining municipalities within the watershed utilize these recommendations as guidance documents.

Green Infrastructure Recommendations
A Green Infrastructure Network can only be realized by coordinated planning efforts of local municipalities, park districts, developers, and private landowners. Stakeholders should follow the recommended process below to initiate and implement the Green Infrastructure Network for the Crystal Creek watershed.

1. Municipalities in the watershed should follow the Green Infrastructure recommendations outlined by the Green Infrastructure Study and Report and Chapter 11, Green Infrastructure, of the Crystal Lake 2030 Comprehensive Plan (both developed and adopted by the City of Crystal Lake in 2012), as well as the Crystal Lake Watershed Stormwater Management Design Manual developed by Hey & Associates in 2007.
2. Include green infrastructure parcels in updated community comprehensive plans and development review maps.
3. Utilize tools such as protection overlays, setbacks, open space zoning, conservation easements, conservation and/or low impact development, etc. on green infrastructure parcels.
4. Utilize tools such as Development Impact Fees, Stormwater Utility Taxes, Special Service Area (SSA) Taxes, etc. to help fund future management of green infrastructure components where new and redevelopment occurs.
5. Identify important unprotected green infrastructure parcels not suited for development then protect and implement long term management.
6. Work with private landowners along stream/tributary corridors to manage their land for green infrastructure benefits.
7. Use the Green Infrastructure Network to identify new trails and trail connections.

Any property owner can improve green infrastructure too. Stakeholders can create a safe place for wildlife by providing a few simple things such as food, water, cover, and a place for wildlife to raise their young. The National Wildlife Federation's Certified Wildlife Habitat® and the Conservation Foundation's Conservation@Home programs can help get you started. Creating a rain garden, or a small vegetated depression, to capture water is another way of promoting infiltration while beautifying your yard and providing additional habitat. Disconnecting your roof downspouts and capturing that runoff in rain barrels not only reduces the amount of runoff entering streams, but also serves as a great source of water for irrigating your yard.

If a portion of a stream runs through your backyard, here are some tips to help properly manage your piece of the green infrastructure network:

1. *A natural, meandering stream is a happy stream* - Work with experts to restore degraded streams.
2. *Remove non-native species* - Identify and remove plants that are out of place.
3. *Plant native buffers* - Plants adapted to the Midwest climate can help control erosion by stabilizing banks, while buffers protect the health of streams.
4. *No dumping* - Avoid dumping yard waste and clear heavy debris jams.
5. *Manage chemical use* - Avoid over fertilizing lawns or spilling/ dumping chemicals near waterways.

For more detailed information, check out the Lake County Stormwater Management Commission's booklet, "Riparian Area Management: A Citizen's Guide," at www.lakecountyil.gov/ stormwater.

5.1.17 Water Quality Trading & Adaptive Management

While Illinois has not yet set up policies or a system to implement water quality trading or adaptive management, nearby Wisconsin has developed policies and a number of resources for both and their guidance could be used as a model or example to follow in Illinois. The following information is cited directly from a Wisconsin Department of Natural Resources (WDNR) document entitled "A Water Quality Trading How to Manual" (WDNR 2013).

Water Quality Trading presents a way for municipal and industrial NPDES permit holders to demonstrate compliance with water quality-based effluent limitations. Generally, trading involves a point source facing relatively high pollutant reduction costs compensating another party to achieve less costly pollutant reduction with the same or greater water quality benefit. In other words, trading provides point sources with the flexibility to acquire pollutant reductions from other sources in the watershed to offset their point source load so that they will comply with their own permit requirements, while simultaneously helping to fund water quality improvements nearby. Trading is not a mandatory program or regulatory requirement, but rather a market-based option that may enable some industrial and municipal facilities within the watershed to meet regulatory requirements more cost-effectively. With ever-tightening water quality standards and restrictions going into effect, trading may become economically preferable to other compliance options.

There are many benefits to trading:

1. Permit compliance through trading may be economically preferable to other compliance options.

Figure 61. Water quality trading components (source: WDNR).

2. New and expanding point source discharges can utilize trading to develop new economic opportunities in a region, while still meeting water quality goals.

3. Permittees, and the point and nonpoint sources that work cooperatively with them, can demonstrate their commitment to the community and to the environment by working together to protect and restore local water resources.

Adaptive management is sometimes confused with trading, since both options allow permittees to work with nonpoint or other point sources of phosphorus in a watershed to reduce the overall phosphorus load to a given waterbody. In Wisconsin, which has developed a numeric phosphorus criterion, adaptive management is solely focused on phosphorus compliance and improving water quality so that the applicable phosphorus criterion is met. Trading is not limited to phosphorus and may be used to meet limits for any pollutant for which a criterion has been established. Trading focuses on compliance with a discharge *limit* while adaptive management focuses on compliance with phosphorus *criteria*.

Water quality trading has seven components: pollutant, trading participants, pollution reduction credit, credit threshold, trade ratio, location, and timing (Figure 61). Each of these components must be adequately addressed in a trading strategy. The “pollutant” is simply the contaminant being traded. The “trading participants” are entities involved in the trade. “Credit” is the amount of a given pollutant that is available for trading. “Credit Threshold” is the amount of pollutant reduction that needs to be achieved before credits are generated. “Trade ratios” are put in place due to uncertainty margins. “Location” refers to the fact that the credit user and generator must discharge to the same waterbody. “Timing” is important because credits must be generated before they can be used to offsite the pollution.

For more information and guidance on water quality trading and adaptive management, see Wisconsin Department of Natural Resources (WDNR) document entitled “A Water Quality Trading How to Manual” (WDNR, 2013).

5.2 Site-Specific Management Measures Action Plan

Site-Specific Management Measure (Best Management Practice [BMP]) recommendations made in this section of the report are backed by findings from the watershed field inventory, overall watershed resource inventory, and input from stakeholders. In general, the recommendations address sites where watershed problems and opportunities can best be addressed to achieve watershed goals and objectives. The Site-Specific Management Measures Action Plan is organized by the jurisdiction in which recommendations are located making it easy for users to identify the location of project sites and corresponding project details. It is important to note that project implementation is voluntary and there is no penalty or reduction in future grant opportunities for not following recommendations. Site Specific Management Measures were identified within the following jurisdictional boundaries and are included in the Action Plan:

- *Algonquin*
- *Crystal Lake*
- *Lake in the Hills*
- *Lakewood*
- *Cary*
- *McHenry County*

Management Measure categories in the Site-Specific Management Measures Action Plan include:

- *Detention Basin Retrofits*
- *Streambank & Riparian Area Restoration*
- *Priority Green Infrastucture Protection Areas*
- *Other Management Measures*

Descriptions and location maps for each Management Measure category follow. Table 49 includes useful project details such as site ID#, Location, Units (size/length), Existing Condition, Management Measure Recommendation, Pollutant Load Reduction Efficiency, Priority, Owner/Responsible Entity, Sources of Technical Assistance, Cost Estimate, and Implementation Schedule.

Project importance, technical and financial needs, cost, feasibility, and ownership type were taken into consideration when prioritizing and scheduling Management Measures for implementation. High, Medium, or Low Priority was assigned to each recommendation. "Critical Areas" as discussed in Section 4.2 are all High Priority and highlighted in red on project category maps and the Action Plan table. For this watershed plan a "Critical Area" is best described as a location in the watershed where existing or potential future causes and sources of an impairment or existing function are significantly worse than other areas of the watershed. Cost estimates were typically developed based on a per acre or per linear foot cost (see Appendix D for details). Implementation schedule varies greatly with each project but is generally based on the short term (within 1-10 years) for High Priority/Critical Area projects and 10-20+ years for medium and low priority projects. Maintenance projects are ongoing.

The Site-Specific Management Measures Action Plan is designed to be used in one of two ways.

Method 1: The user should find the respective jurisdictional boundary (listed alphabetically in Table 49) then identify the Management Measure category of interest within that boundary. A Site ID# can be found in the first column under each recommendation that corresponds to the Site ID# on a map (Figures 62-65) associated with each category.

Method 2: The user should go to the page(s) summarizing the appropriate Management Measure category of interest then locate the corresponding map and ID# of the site-specific recommendations for that category. Next, the user should go to Table 49 and locate the jurisdiction where the project is located, then go to the project category and Site ID# for details about the project.

Pollutant Load Reduction Estimates

Where applicable, pollutant load reductions and/or estimates for total suspended solids (TSS), nitrogen (TN), and phosphorus (TP) were evaluated for each recommended Management Measure based on efficiency calculations developed for the USEPA's Region 5 Model. Estimates of total suspended solids and nutrient load reduction from implementation of urban Measures is based on efficiency calculations developed by Illinois EPA. Pollutant reduction calculations for the two fencing projects were calculated using EPA's STEPL Model. This watershed-based plan is focused on nutrients and total suspended solids because of the models used for estimating pollutant loading and reductions and references total suspended solids in tons per year (not pounds) in all cases.

Estimates of pollutant load reduction using the Region 5 Model and the STEPL model are measured in weight/year (tons/yr for total suspended solids and lbs/yr for nitrogen and phosphorus). The model was generally used to calculate weight of pollutant reductions for recommended Management Measures where calculation of such data is applicable. In summary, pollutant reductions were calculated for 49 detention basin retrofit projects, 14 stream & riparian area restoration projects, and 17 other management measure recommendations; there is no way to calculate the pollutant reduction gained from implementing the 5 priority protection areas. Spreadsheets used to determine pollutant load reductions can be found in Appendix D.

For context and as a general guide, estimated percent removal of total suspended solids, nitrogen, and phosphorus based on the Region 5 Model are depicted for various Management Measures in Table 47.

Table 47. Region 5 Model percent pollutant removal efficiencies for various Management Measures.

Management Measures	TSS	TN	TP
Vegetated Filter Strips	73%	40%	45%
Wet Pond/Detention	60%	35%	45%
Wetland Detention	77.5%	20%	44%
Dry Detention	57.5%	30%	26%
Infiltration Basin	75%	60%	65%
Streambank/Lake Shoreline Stabilization	90%	90%	90%
Weekly Street Sweeping	16%	6%	6%
Porous Pavement	90%	85%	65%
Manure Waste Management	na	80%	90%

Watershed-Wide Summary of Action Recommendations

All Site-Specific Management Measures, Education Plan (Section 6.0), and Monitoring Plan (Section 8.1) recommendation information is condensed by Category and summarized in Table 48. This information provides a watershed-wide summary of the "Total Units" (size/length), "Total Cost," and "Total Estimate of Pollutant Load Reduction" if all the recommendations in the Site-Specific Management Measures Action Plan, Education Plan, and Monitoring Plan are implemented. Key points include:

- 4,038 acres of restoration and maintenance (detention basins, riparian areas, green infrastructure, and other management measures) with a total cost of $3,857,700.

- 47,288 linear feet of stream restoration costing $4,779,800.

- 3,561 tons/year of Total Suspended Solids (TSS) would potentially be reduced each year, exceeding the 285 tons/year Reduction Target identified in Section 4.0.

- 5,040 pounds/year of Phosphorus (TP) would potentially be reduced each year, meeting 85% of the 5,850 pounds/year Reduction Target identified in Section 4.0.

- 23,534 pounds/year of Nitrogen (TN) would potentially be reduced each year, exceeding the 8,586 pounds/yr Reduction Target identified in Section 4.0.

- Education programs will cost $3,000 every 5 years to meet objectives (see Section 6.0).

- Water Quality Monitoring programs will cost $1,000 each five-year cycle.

Table 48. Watershed-wide summary of Management Measures recommended for implementation.

Management Measure Category	Total Units (size/length)	Total Cost Install/ Maintain	Estimated Load Reduction		
			TSS (t/yr)	TP (lbs/yr)	TN (lbs/yr)
Detention Basin Retrofits & Maintenance	126 acres	$656,200 install $182,200/yr maintenance	910	1,257	5,702
Streambank & Riparian Restoration					
Streams	47,288 lf	$4,779,800	2,064	2,453	8,980
Riparian Areas	43 acres	$99,500/yr			
Priority Green Infrastructure Protection Areas*	954 acres	n/a	n/a	n/a	n/a
Other Management Measures					
Existing Natural Area Management	631 acres	$1,725,200/ $60K/ yr	157	336	2,510
Natural Area Restoration	7 acres	$171,600	11	42	250
Fencing	68 acres	n/a	6	13	56
Golf Course Naturalization	129 acres	$518K/ $77K/yr	8	29	96
Invasives Management	1,838 acres	$368,000	357	694	4,557
Shoreline Restoration	242 acres	n/a	62	203	1,327
Information & Education Plan	Entire Plan	$3,000/ 5 yrs	n/a	n/a	n/a
Water Quality Monitoring Plan	Entire Plan	$1K every 5 years	n/a	n/a	n/a
TOTALS	**4,038 acres**	**$3,857,700**	**3,561 tons/ yr**	**5,040 lbs/yr**	**23,534 lbs/yr**
	47,288 lf	**$4,779,800**			
	Education	$3,000/ 5 yrs			
	Monitoring	**$1K every 5 years**			

** Cost estimates could not be quantified for priority protection areas, nor could pollutant load reductions be calculated via models.*

5.2.1 Detention Basin Recommendations

Applied Ecological Services, Inc. (AES) conducted an inventory of 49 large detention basins and numerous smaller ones in fall of 2019. The results of the detention basin inventory are summarized in Section 3.12.2 and detailed field investigation datasheets can be found in Appendix C. The benefits of storing stormwater runoff in detention basins and releasing water slowly are well documented. More recently, the benefits of proper slope and depth design and introducing native vegetation to improve water quality and provide wildlife habitat is becoming the new standard and is required in some local ordinances.

The condition of detention basins in the watershed varies. Twelve (12) dry bottom turf grass, 4 wet or wetland bottom w/turf grass slopes, 10 naturalized dry bottom, and 23 naturalized wet or wetland bottom basins were assessed. Of the 49 basins, 6 (12%) provide "Good" ecological and water quality benefits, 27 (55%) provide "Average" ecological and water quality benefits while 16 basins (33%) provide "Poor" ecological and water quality benefits. Many were designed simply for stormwater storage and did not necessarily consider designs that would also improve water quality and wildlife habitat.

Most of the wet and wetland bottom detention basins in the watershed are naturalized with native vegetation. Of these, most are owned by homeowner and business associations that have limited knowledge related to managing naturalized detention basins or hire contractors not qualified to manage natural areas. The result is basins that are overgrown with non-native and invasive species that provide limited ecological and water quality benefits. It is important for homeowner and business associations to begin implementing appropriate management by qualified ecological contractors.

All recommended detention basin retrofits and/or maintenance projects are shown by site ID# and priority on Figure 62. Details about each recommendation can be found in the Action Plan Table (Table 49) within the appropriate jurisdiction. Critical Area basins are the highest priority. Most basins are assigned a higher priority based on ability to treat polluted stormwater runoff and/or location in a highly vulnerable SMU. In some cases, publicly owned basins and other private basins with significant problems or opportunities are assigned High or Medium priority for retrofits because funding and implementation are usually easier on public land or where major problems/opportunities exist. Medium priority is given to most basins where native vegetation has been established but requires ongoing maintenance to prevent degradation.

In total there were 25 High Priority/Critical Area, 11 Medium Priority, and 10 Low Priority detention basin retrofit opportunities. Recommendations were not made for three basins that drain outside the watershed.

Example of a detention basin retrofit in West Dundee, IL

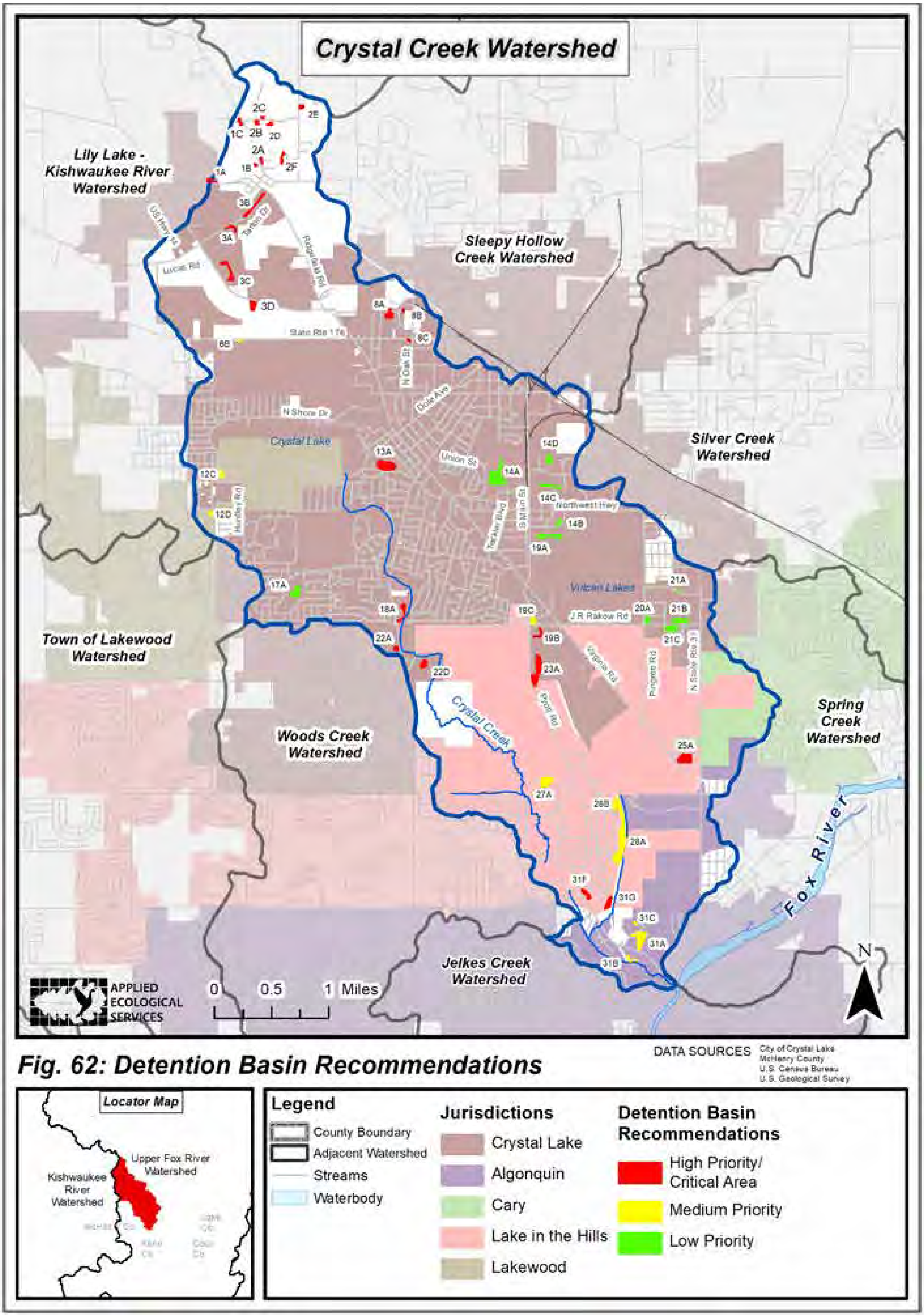


Fig. 62: Detention Basin Recommendations

5.2.2 Stream & Riparian Area Restoration Recommendations

Applied Ecological Services, Inc. (AES) completed a general inventory of Crystal Creek and its tributaries in fall of 2019. All streams and tributaries were assessed based on divisions into "Stream Reaches". Fifteen (15) stream reaches were assessed accounting for 48,197 linear feet or 9.1 linear miles. Detailed notes were recorded for each stream reach related to potential Management Measure recommendations such as improving streambank and channel conditions and maintaining riparian health long term. The results of the stream inventory are summarized in Section 3.12.1; detailed field investigation datasheets can be found in Appendix C.

The condition of stream reaches in the watershed varies. According to the stream inventory, 42% (20,267 lf) of stream and tributary length is naturally meandering; approximately, 24% (11,691 lf) is moderately channelized; and 30% (14,343 lf) is highly channelized. Crystal Creek Reach 3 makes up 4% of Crystal Creek's total length and is piped underground for approximately 1,896 lf. Approximately 34% (16,489 lf) of the total stream and tributary length exhibits no or low bank erosion while moderate erosion is occurring along 56% (26,714 lf) of streambanks; highly eroded streambanks account for 6% (3,098 lf) of the total stream length. Approximately 35% (along 16,940 linear feet of streams) of the riparian areas are "Poor" quality. Of the remaining reaches, 12,731 linear feet or 26% of riparian areas are in "Moderate" condition and 35% (16,631 linear feet) are in good condition.

Most stream restoration projects include at least one of the following three water quality and habitat improvement components; 1) removal of existing invasive vegetation including trees and shrubs from the banks and extending buffers where none currently exists followed by; 2) spot stabilization of banks using bioengineering, regrading of banks, and installation of native vegetation where necessary; and 3) restored riffles/grade controls in the stream channel to simulate conditions found in naturally meandering streams and to improve in-stream habitat. Short- and long-term maintenance then follows and is critically important in the development process and to maintain restored conditions.

There is one daylighting project recommended in the watershed - Crystal Creek Reach 3. Stream daylighting improves water quality and habitat, allows for flood mitigation, and improves stormwater control. Restoration of this reach is critical to improving the health of the watershed.

Figure 63 shows the location of all potential streambank/channel restoration projects by reach ID# and priority while Table 49 lists project details about each recommendation within the appropriate jurisdiction. Potential stream and riparian area restoration projects on public land and reaches exhibiting severe problems on private land are generally assigned as higher priority for implementation. Medium and Low priority was generally assigned to stream reaches exhibiting only minor problems. Recommendations are not made for stream reaches where restoration is not needed. In total, 43,911.7 linear feet of stream are considered High Priority/ Critical Area projects.

Example of stream restoration project at nearby Dixie Creek

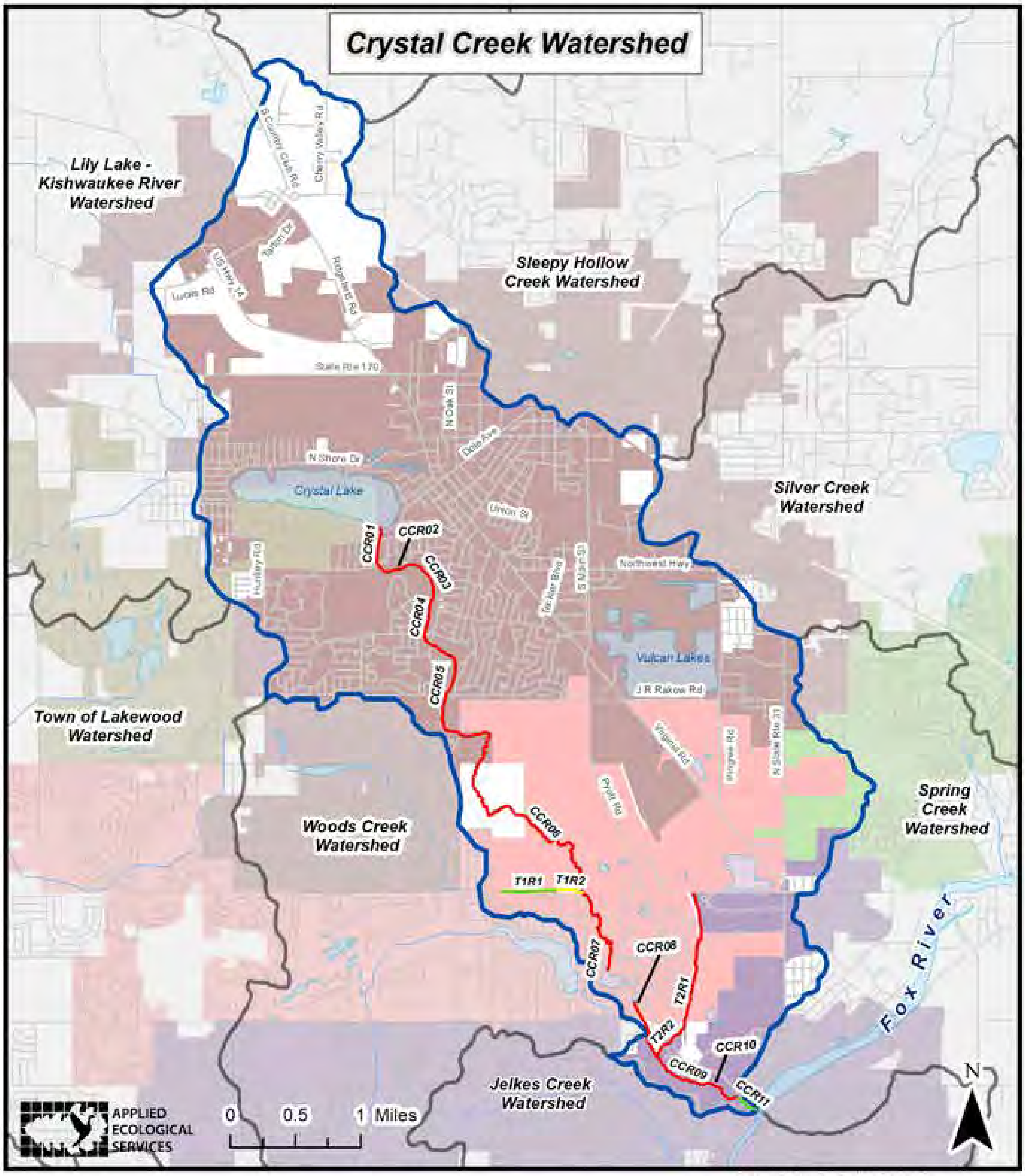
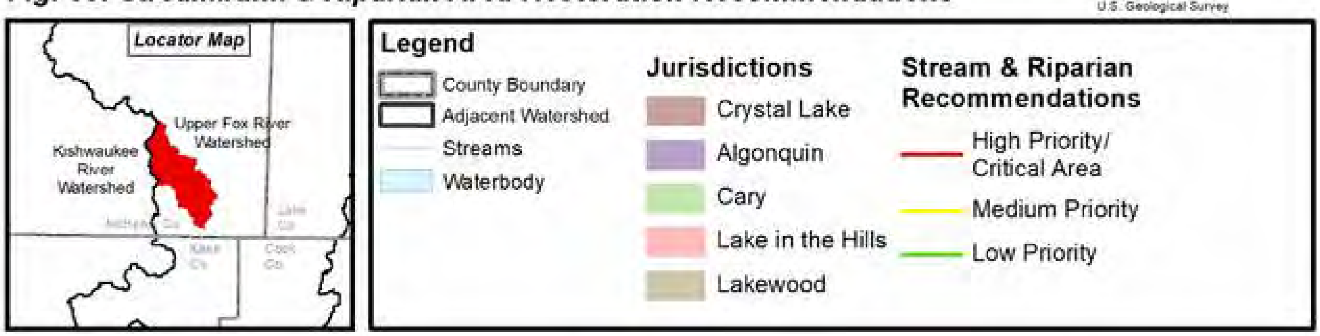


Fig. 63: Streambank & Riparian Area Restoration Recommendations



5.2.3 Priority Green Infrastructure Protection Area Recommendations

Priority Green Infrastructure Protection Areas are best described as large, unprotected parcels of land that are currently undeveloped with no plans for future development or similar parcels where future development is planned. The significance is that these parcels are situated in environmentally sensitive or important green infrastructure areas. This assessment is by no means meant to prevent or deter future urbanization or land use change, but rather to determine which areas might be most in need of utilizing conservation design or low impact development when change does occur so as to protect remaining natural resources, and to identify existing developed lands that could be managed for maximum green infrastructure benefit, restoration, and preservation.

For the Crystal Creek watershed plan, four of the five Priority Green Infrastructure Protection Areas are lands that are currently in agricultural production and have the potential to be developed in the future, while one is a degraded woodland that is currently for sale. For the areas that remain in agricultural production, it will be important to ensure that no-till farming is being utilized on those lands. If and when any of the areas are developed, development should follow Conservation Design or Low Impact Development standards and guidelines to help maintain and improve water quality and watershed conditions.

Five Priority Protection Areas (PPAs) totaling approximately 954 acres were identified in the watershed based on information obtained from existing and predicted future land use data (Section 3.6 and 3.7), sensitive aquifer recharge areas (Section 3.13), and green infrastructure (Section 3.10) sections of this report.

Figure 64 shows the location of all five Priority Green Infrastructure Protection Areas by site ID# while Table 49 includes management measure recommendations for each. All five sites are considered "Critical Areas". Cost estimates for implementing recommendations for these areas are not included due to varying individual landowner/site costs. In addition, pollutant reduction estimates cannot be determined for these areas.

PPA1 along either side of Country Club Rd north of W Hillside Rd

Top: PPA 2 east of Cherry Valley Rd and north of W Hillside Rd; Bottom: PPA 3 near McHenry County College, between Route 14 and Ridgefield Rd

Top: PPA 4 between I-176 and Route 14, north of Lippold Park; Bottom: PPA 5 north of Reserve Dr and west of N Oak St

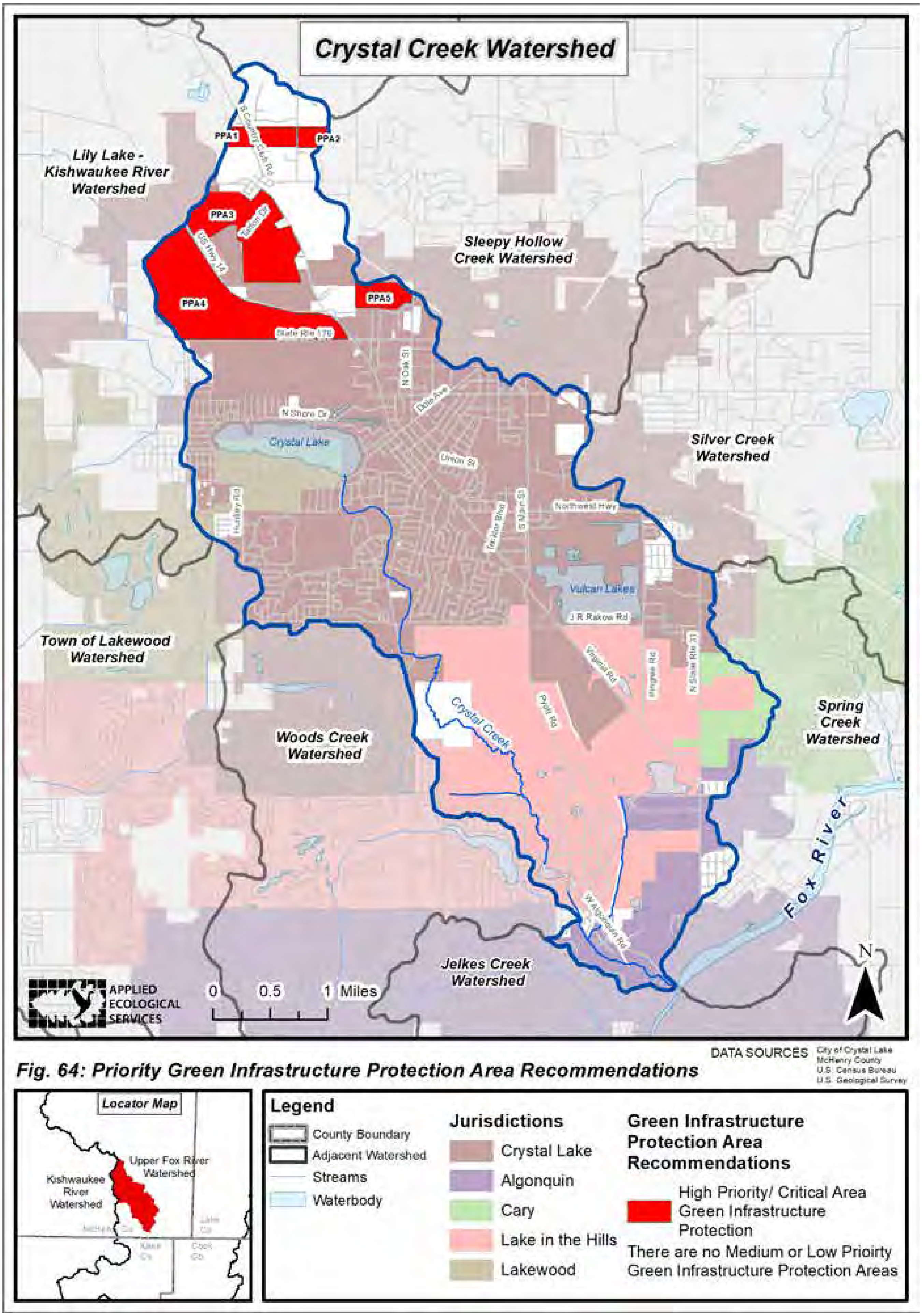


Fig. 64: Priority Green Infrastructure Protection Area Recommendations

5.2.4 Other Management Measure Recommendations

While completing the general inventory of Crystal Creek watershed, Applied Ecological Services, Inc. (AES) noted 17 potential Management Measure projects that fit under miscellaneous other categories including:

- 7 Existing Natural Area Management sites
- 3 Natural Area Restoration sites
- 2 sites in need of fencing to restrict livestock access
- 1 Golf Course Naturalization site
- 1 Invasives Management Area
- 3 Shoreline Education Program sites

Figure 65 shows the location of all "Other Management Measures" by type and ID# while Table 49 lists details about each recommendation within the appropriate jurisdiction.

Top: PPA1 West of Castleberry Rd; Bottom: Site 4B – fencing needed to restrict livestock access

Top: 12A – Crystal Lake shoreline; Bottom: 17C – Golf course naturalization at Crystal Lake Country Club

Top: 20D – Natural Area Management at Three Oaks Recreation Area; Bottom: 31E – Invasives Management on HMS properties

Existing Natural Area Management at sites 12B (top) and 17D (bottom)

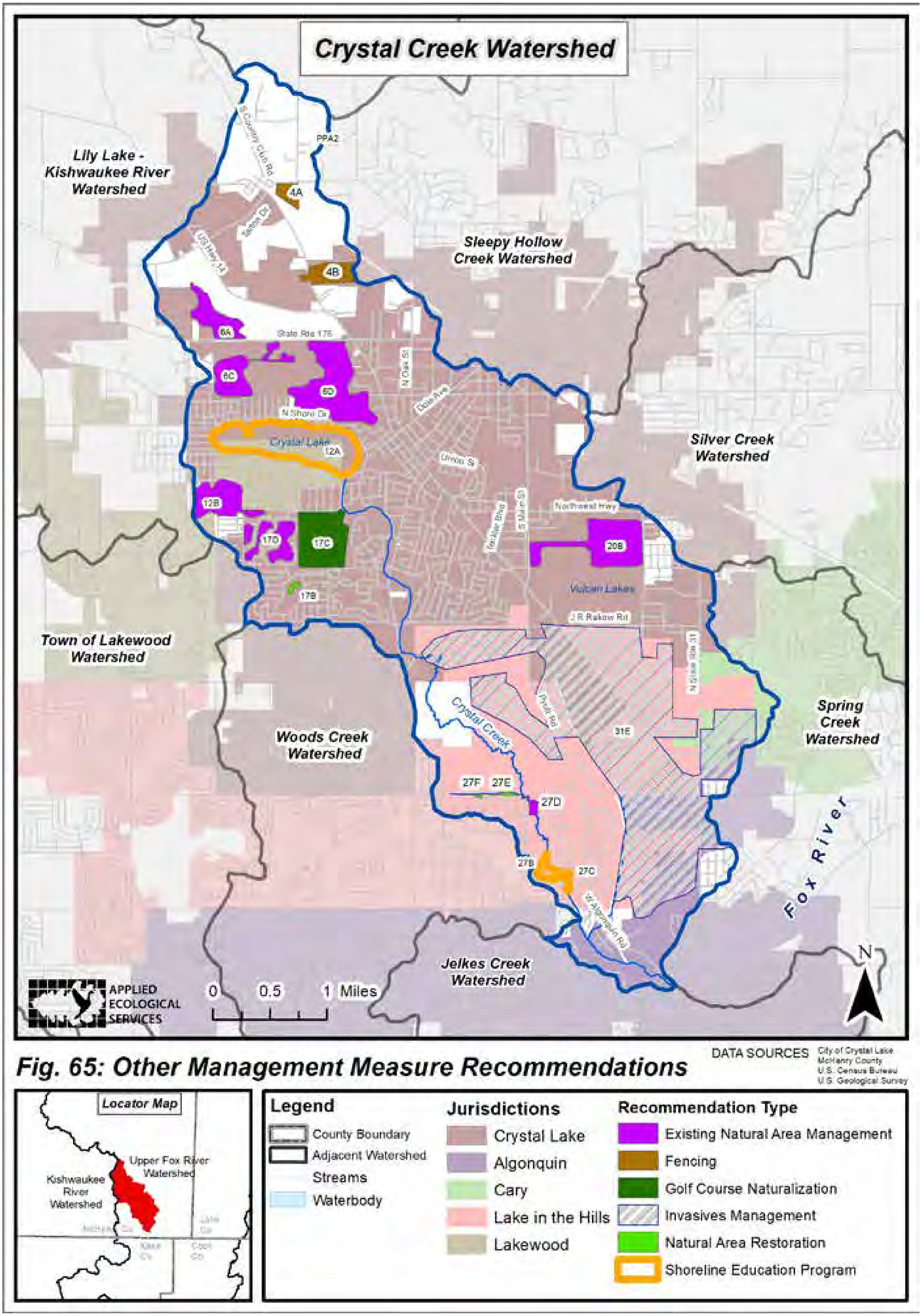


Fig. 65: Other Management Measure Recommendations

5.2.5 Site-Specific Management Measures Action Plan Table

Table 49. Site-Specific Management Measures Action Plan.

ALGONQUIN													
ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
DETENTION BASIN RETROFITS & MAINTENANCE (SEE FIGURE 62). Technical and Financial Assistance Needs: Technical assistance needed to implement detention basin retrofits is relatively low while financial assistance needs are moderate. Private landowners will need the greatest assistance.													
31A	See Figure 62 for project location	5.6	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	17	15	49	Medium	Algonquin	Ecological Consultant/ Contractor	-	$5,000/yr	10-20 Years
31B	See Figure 62 for project location	1.2	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	5	6	32	Medium	USPS	Ecological Consultant/ Contractor	-	$2,000/yr	10-20 Years
31C	See Figure 62 for project location	0.4	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Maintain well-established naturalized basin	13	16	57	Medium	Algonquin Public Works	Ecological Consultant/ Contractor	-	$1,000/yr	10-20 Years
31D	See Figure 62 for project location	0.5	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	3	5	20	Medium	Algonquin Public Works	Ecological Consultant/ Contractor	-	$1,000/yr	10-20 Years
STREAMBANK & RIPARIAN AREA RESTORATION RECOMMENDATIONS (See Figure 63). Technical and Financial Assistance Needs: Stream restorations are complex and require high technical and financial assistance needs to protect land, design, construct, monitor, and maintain the restoration. The project becomes more complex in areas that flow through several governing bodies or multiple private residences. Technical and financial assistance associated with stream maintenance is generally low for minor tasks such as removing debris.													
CCR09	See Figure 63 for project location	3,098.3	3,098 lf of stream exhibiting moderate levels of channelization, moderate levels of erosion (east bank is low, west bank is high) and average overall riparian area condition (east bank is poor, west bank is good)	Design, permit, and construct a project to remove parking area on east bank and install native buffer, armor west bank, restore remnant oak woodland, and maintain for three years to establish	286	304	868	High/ Critical Area	Algonquin, MCCD	USACE, Engineer, Environmental Consultant, McHenry County	$750,000	$45,000	1-10 Years
CCR10	See Figure 63 for project location	1,774.3	1,774 lf of stream exhibiting moderate levels of channelization, low levels of erosion and good overall riparian area condition	Continue long term maintenance and monitoring of riparian buffer	60	74	479	High/ Critical Area	Algonquin, MCCD	Environmental Consultant/ Contractor, Engineer, McHenry County	-	$7,000/yr	1-10 Years
T2R2	See Figure 63 for project location	1,755.0	1,755 lf of stream exhibiting high levels of channelization, moderate levels of erosion and poor overall riparian area condition	Design and construct a project to remove second growth trees and shrubs, extend buffer, replant buffer with natives, then maintain for three years so establish	68	76	323	High/ Critical Area	Various private owners	Environmental Consultant/ Contractor, Engineer, McHenry County	$50,000	$22,000	1-10 Years
OTHER MANAGEMENT MEASURES (SEE FIGURE 65). Technical and Financial Assistance Needs: Technical and financial assistance needed to implement these projects varies depending on complexity.													
31E	See Figure 65 for project location	1,837.8	Open gravel quarries with invasive herbaceous and woody species throughout	Implement maintenance plan to remove invasive species in perpetuity	357	694	4,557	High/ Critical Area	HMS	Ecological Consultant/ Contractor	-	$368,000	1-10 Years

CARY

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
OTHER MANAGEMENT MEASURES (SEE FIGURE 65). Technical and Financial Assistance Needs: Technical and financial assistance needed to implement these projects varies depending on complexity.													
31E	See Figure 65 for project location	1,837.8	Open gravel quarries with invasive herbaceous and woody species throughout	Implement maintenance plan to remove invasive species in perpetuity	357	694	4,557	High/ Critical Area	HMS	Ecological Consultant/ Contractor	-	$368,000	1-10 Years

CRYSTAL LAKE

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
DETENTION BASIN RETROFITS & MAINTENANCE (SEE FIGURE 62). Technical and Financial Assistance Needs: Technical assistance needed to implement detention basin retrofits is relatively low while financial assistance needs are moderate. Private landowners will need the greatest assistance.													
1A	See Figure 62 for project location	1.0	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	23	28	117	High/ Critical Area	McHenry Athletic Complex	Ecological Consultant/ Contractor	$18,000	$9,000	1-10 Years
3A	See Figure 62 for project location	1.3	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	22	30	126	High/ Critical Area	McHenry County College	Ecological Consultant/ Contractor	$23,400	$11,700	1-10 Years
3B	See Figure 62 for project location	3.3	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	4	5	29	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	$59,400	$9,900	1-10 Years
3C	See Figure 62 for project location	3.3	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	35	42	150	High/ Critical Area	McHenry County College	Ecological Consultant/ Contractor	-	$3,000/yr	1-10 Years
6B	See Figure 62 for project location	0.4	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	35	42	150	Medium	Crystal Lake Park District	Ecological Consultant/ Contractor	-	$1,000/yr	10-20 Years
8A	See Figure 62 for project location	2.6	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	3	10	34	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	1-10 Years
8B	See Figure 62 for project location	0.4	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	3	6	29	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	$7,200	$3,600	1-10 Years
8C	See Figure 62 for project location	0.4	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	21	26	92	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	$7,200	$3,600	1-10 Years
13A	See Figure 62 for project location	7.0	Dry detention basin with turf bottom and slopes, too wet to mow, in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	13	23	79	High/ Critical Area	Crystal Lake	Ecological Consultant/ Contractor	$105,000	$17,500	1-10 Years
14A	See Figure 62 for project location	10.0	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	71	104	365	Low	Crystal Lake	Ecological Consultant/ Contractor	-	$8,000/yr	1-10 Years
14B	See Figure 62 for project location	1.2	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	13	16	118	Low	Private owner	Ecological Consultant/ Contractor	-	$2,000/yr	10-20 Years
14C	See Figure 62 for project location	2.4	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	44	55	403	Low	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	1-10 Years

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
14D	See Figure 62 for project location	2.3	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	21	26	186	Low	Private owner	Ecological Consultant/ Contractor	$41,400	$20,700	10-20 Years
17A	See Figure 62 for project location	3.0	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Maintain well-established naturalized basin	28	72	250	Low	Crystal Lake Park District	Ecological Consultant/ Contractor	-	$3,000/yr	1-10 Years
18A	See Figure 62 for project location	2.4	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	33	54	188	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	1-10 Years
19A	See Figure 62 for project location	3.8	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	22	27	197	Low	Private owner	Ecological Consultant/ Contractor	-	$3,500/yr	10-20 Years
19B	See Figure 62 for project location	1.4	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	62	85	361	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$2,000/yr	1-10 Years
19C	See Figure 62 for project location	1.9	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	22	30	126	Medium	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	10-20 Years
20A	See Figure 62 for project location	1.6	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	17	22	160	Low	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	10-20 Years
21A	See Figure 62 for project location	0.3	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	29	36	252	Low	Private owner	Ecological Consultant/ Contractor	-	$1,000/yr	1-10 Years
21B	See Figure 62 for project location	3.5	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	27	33	244	Low	Private owner	Ecological Consultant/ Contractor	$63,000	$31,500	1-10 Years
21C	See Figure 62 for project location	2.9	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	22	27	202	Low	Private owner	Ecological Consultant/ Contractor	-	$3,000/yr	1-10 Years
22A	See Figure 62 for project location	1.1	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Maintain well-established naturalized basin	18	22	79	High/ Critical Area	Crystal Lake High School	Ecological Consultant/ Contractor	-	$2,000/yr	1-10 Years
22D	See Figure 62 for project location	2.1	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	18	25	84	High/ Critical Area	LITH	Ecological Consultant/ Contractor	-	$2,500/yr	1-10 Years
23A	See Figure 62 for project location	7.7	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	95	86	283	High/ Critical Area	LITH	Ecological Consultant/ Contractor	-	$7,000/yr	1-10 Years

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
STREAMBANK & RIPARIAN AREA RESTORATION RECOMMENDATIONS (See Figure 63). Technical and Financial Assistance Needs: Stream restorations are complex and require high technical and financial assistance needs to protect land, design, construct, monitor, and maintain the restoration. The project becomes more complex in areas that flow through several governing bodies or multiple private residences. Technical and financial assistance associated with stream maintenance is generally low for minor tasks such as removing debris.													
CCR01	See Figure 63 for project location	1,978.7	1,979 lf of stream exhibiting moderate channelization, low levels of erosion and average overall riparian area condition	Design, permit, and construct a project to install a native buffer, instream riffles, and maintain for three years to establish.	12	21	103	High/ Critical Area	Various private owners	USACE, Engineer, Environmental Consultant, McHenry County	$197,800	$20,000	1-10 Years
CCR02	See Figure 63 for project location	1,075.6	1,076 lf of stream exhibiting low levels of channelization, low levels of erosion and good overall riparian area condition	Design and construct a project to remove second growth trees and shrubs and replant buffer with natives then maintain for three years to establish	7	12	62	High/ Critical Area	Crystal Lake Park District	Environmental Consultant/ Contractor, Engineer, McHenry County	$30,000	$15,000	1-10 Years
CCR03	See Figure 63 for project location	1,896.4	Buried/piped reach of Crystal Creek on school property	Design, permit, and construct a project to daylight stream, install pools and riffles, restore riparian area with natives, then maintain for three years to establish	NA	NA	NA	High/ Critical Area	Lundahl Jr High & Middle School	USACE, Engineer, Environmental Consultant, McHenry County	$948,000	$25,000	1-10 Years
CCR04	See Figure 63 for project location	3,080.9	3,081 lf of stream exhibiting moderate levels of channelization, low levels of erosion and average overall riparian area condition	Design, permit, and construct a project to remove invasive trees and shrubs, install a native buffer, remove beaver dam, install riffles, and maintain for three years to establish	78	106	588	High/ Critical Area	Crystal Lake Park District, Crystal Lake, private owner	Environmental Consultant/ Contractor, Engineer, McHenry County	$275,000	$32,000	1-10 Years
CCR05	See Figure 63 for project location	3,757.6	3,758 lf of stream exhibiting high levels of channelization, moderate levels of erosion and poor overall riparian area condition; reach also has several debris jams and moderate sedimentation of the stream channel	Design, permit, and construct a project to restore riparian area with native vegetation and armor stream channel and install riffles where necessary	328	366	1,242	High/ Critical Area	Crystal Lake	USACE, Engineer, Environmental Consultant, McHenry County	$375,000	$40,000	1-10 Years
PRIORITY GREEN INFRASTRUCTURE PROTECTION AREAS (See Figure 64). Technical and Financial Assistance Needs: Technical assistance needed to implement no-till vary widely based on differences between individual farms but can be relatively low because NRCS can provide much of this information and matching funds. Implementing future conservation design and/or low impact development in Priority Protection Areas is mostly a matter of instituting policies and ordinances.													
PPA3	See Figure 64 for project location	302.1	Agricultural area at headwaters of watershed	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA	High/ Critical Area	Various private owners	NRCS, MCSWCD, McHenry County	The costs for implementing no-till vary by landowner/site while costs for implementing Conservation Design or LID cannot be determined		1-10 Years; If/ when parcels become available for development
PPA4	See Figure 64 for project location	490.8	Agricultural area with large ADID wetland that extends south to Crystal Lake	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA	High/ Critical Area	Various private owners	NRCS, MCSWCD, McHenry County	The costs for implementing no-till vary by landowner/site while costs for implementing Conservation Design or LID cannot be determined		1-10 Years; If/ when parcels become available for development

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
PPA5	See Figure 64 for project location	64.6	Oak hickory woodland with agriculture on western portion and rolling topography	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA	High/ Critical Area	Various private owners	NRCS, MCSWCD, McHenry County	The costs for implementing no-till vary by landowner/site while costs for implementing Conservation Design or LID cannot be determined		1-10 Years; If/ when parcels become available for development
OTHER MANAGEMENT MEASURES (SEE FIGURE 65). Technical and Financial Assistance Needs: Technical and financial assistance needed to implement these projects varies depending on complexity.													
4B	See Figure 65 for project location	47.3	Overgrazed cow pasture in oak savanna and wetlands with significant exposed/eroded soils	Utilize pasture rotation and fencing to restrict livestock access to wetland and reduce soil erosion	3	6	28	High/ Critical Area	Private owner	NRCS, MCSWCD	Costs vary by landowner/site	1-10 Years	
6A	See Figure 65 for project location	61.7	Large ADID wetland complex adjacent to Lippold Park dominated by invasives	Develop and implement maintenance plan to control invasive species.	14	24	236	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	$5,000	$30,850	1-10 Years
6C	See Figure 65 for project location	76.7	Large wetland complex within Lippold Park with scattered invasive species	Develop and implement maintenance plan to control invasive species.	33	71	430	High/ Critical Area	Crystal Lake Park District	Ecological Consultant/ Contractor	$5,000	$38,350	1-10 Years
6D	See Figure 65 for project location	197.2	Degraded wooded buffers surrounding large wetland complex within Lippold Park	Develop an ecological restoration & management plan and implement	41	91	474	High/ Critical Area	Crystal Lake Park District	Ecological Consultant/ Contractor	$20,000	$985,000	1-10 Years
12A	See Figure 65 for project location	227.3	Overall manicured shorelines of residential homes along Crystal Lake	Implement educational program or incentive program to install naturalized shoreline buffers in residential areas	51	170	1,111	High/ Critical Area	Various private owners	Ecological Consultant/ Contractor	Costs vary by landowner/site		1-10 Years
12B	See Figure 65 for project location	81.8	Degraded wetland complex and woodland buffer	Develop an ecological restoration & management plan and implement	5	20	108	High/ Critical Area	Grafton Township, Crystal Lake, Lakewood	Ecological Consultant/ Contractor	$15,000	$492,000	1-10 Years
17B	See Figure 65 for project location	3.3	Four Colonies Park - mowed turf area adjacent to detention with walking path	Design and implement a project to convert turf grass to wet-mesic and dry prairie and implement three years of management to establish	7	27	158	High/ Critical Area	Crystal Lake Park District	Ecological Consultant/ Contractor	$35,000	$12,000	1-10 Years
17C	See Figure 65 for project location	129.4	Crystal Lake Country Club- rough areas between fairways maintaed as mowed turf grass	Design and implement a project to remove turf in rough areas, replace with native vegetation, and maintain for three years to establish	8	29	96	Medium	Crystal Lake Country Club	Ecological Consultant/ Contractor	$518,000	$77,000	10-20 Years
17D	See Figure 65 for project location	57.4	Combination of wetland and open water natural detention with prairie buffers in good condition	Maintain good condition by continuing with natural area management	4	14	79	High/ Critical Area	Wedgewood Subdivision	Ecological Consultant/ Contractor	-	$20,000/yr	1-10 Years
20B	See Figure 65 for project location	149.0	Three Oaks Recreation Area - gravel quarry converted to recreational area and planted with native vegetation	Continue to conduct ecological management	59	109	1,152	High/ Critical Area	Crystal Lake/ Private owner	Ecological Consultant/ Contractor	-	$40,000/yr	1-10 Years
31E	See Figure 65 for project location	1,837.8	Open gravel quarries with invasive herbaceous and woody species throughout	Implement mainenance plan to remove invasive species in perpetuity	357	694	4,557	High/ Critical Area	HMS	Ecological Consultant/ Contractor	-	$368,000	1-10 Years

LAKE IN THE HILLS

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
DETENTION BASIN RETROFITS & MAINTENANCE (SEE FIGURE 62). Technical and Financial Assistance Needs: Technical assistance needed to implement detention basin retrofits is relatively low while financial assistance needs are moderate. Private landowners will need the greatest assistance.													
23A	See Figure 62 for project location	7.7	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	95	86	283	High/ Critical Area	LITH	Ecological Consultant/ Contractor	-	$7,000/yr	1-10 Years
25A	See Figure 62 for project location	5.6	Dry detention basin with naturalized bottom and slopes in average ecological condition	Maintain well-established naturalized basin	26	32	235	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$5,000/yr	1-10 Years
27A	See Figure 62 for project location	4.5	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	36	44	156	Medium	Private owner	Ecological Consultant/ Contractor	-	$4,000/yr	10-20 Years
28A	See Figure 62 for project location	15.8	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	11	34	115	Medium	Private owner	Ecological Consultant/ Contractor	-	$10,000/yr	10-20 Years
28B	See Figure 62 for project location	1.5	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	7	13	50	Medium	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	10-20 Years
31F	See Figure 62 for project location	2.2	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	17	21	75	High/ Critical Area	LITH Firestation	Ecological Consultant/ Contractor	-	$2,500/yr	1-10 Years
31G	See Figure 62 for project location	2.7	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	17	21	75	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$3,000/yr	1-10 Years
STREAMBANK & RIPARIAN AREA RESTORATION RECOMMENDATIONS (See Figure 63). Technical and Financial Assistance Needs: Stream restorations are complex and require high technical and financial assistance needs to protect land, design, construct, monitor, and maintain the restoration. The project becomes more complex in areas that flow through several governing bodies or multiple private residences. Technical and financial assistance associated with stream maintenance is generally low for minor tasks such as removing debris.													
CCR06	See Figure 63 for project location	13,780.6	13,781 lf of stream within LITH Fen exhibiting low levels of channelization, moderate levels of erosion and good overall riparian area condition	Design, permit, and constuct project to install install check dams throughout	607	692	1,610	High/ Critical Area	MCCD, LITH	USACE, Engineer, Environmental Consultant, McHenry County	$275,000	-	1-10 Years
CCR07	See Figure 63 for project location	4,294.0	4,294 lf of stream exhibiting low levels of channelization, low levels of erosion and average overall riparian area condition	Design, permit, and construct a project to remove invasives, restore riparian area with natives, armor stream channel where necessary, and maintain for three years to establish	95	132	651	High/ Critical Area	LITH, LITHSD, LITH Elementary	USACE, Engineer, Environmental Consultant, McHenry County	$859,000	$37,000	1-10 Years
CCR08	See Figure 63 for project location	1,758.6	1,759 lf of stream exhibiting moderate levels of channelization, moderate levels of erosion and poor overall riparian area condition	Design, permit, and constuct a project to extend and restore riparian area, install spot stabilization as necessary, and maintain for three years to establish	166	182	556	High/ Critical Area	Various private owners	USACE, Engineer, Environmental Consultant, McHenry County	$350,000	$25,000	1-10 Years

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
T1R1	See Figure 63 for project location	2,259.2	2,259 lf of stream exhibiting high levels of channelization, low levels of erosion and average overall riparian area condition; stream channel exhibiting moderate sedimentation	Design and construct a project to remove second growth trees and shrubs and replant buffer with natives	33	53	189	Low	LITH, MCCD, IDOC	Environmental Consultant/ Contractor, Engineer, McHenry County	$50,000	$22,500	10-20 Years
T1R2	See Figure 63 for project location	1,117.4	1,117 lf of stream exhibiting low levels of channelization, low levels of erosion and average overall riparian area condition	Design, permit, and construct project to restore riparian area, spot stabilize streambanks where necessary, then maintain for three years to establish	11	18	63	Medium	LITH, LITHSD	USACE, Engineer, Environmental Consultant, McHenry County	$140,000	$25,000	10-20 Years
T2R1	See Figure 63 for project location	5,661.9	5,662 lf of stream exhibiting high levels of channelization, moderate levels of erosion and poor overall riparian area condition	Design, permit, and construct a project to remove second growth trees and shrubs, replant buffer with natives, regrade and spot stabilize streambanks where necessary, then maintain for three years to establish	313	417	2,246	High/ Critical Area	MCCD, HMS	USACE, Engineer, Environmental Consultant, McHenry County	$480,000	$52,500	1-10 Years
OTHER MANAGEMENT MEASURES (SEE FIGURE 65). Technical and Financial Assistance Needs: Technical and financial assistance needed to implement these projects varies depending on complexity.													
27B	See Figure 65 for project location	10.9	Overall manicured shorelines of residential homes along Goose Lake	Implement educational program or incentive program to install naturalized shoreline buffers in residential areas	6	18	120	Medium	Various private owners	Ecological Consultant/ Contractor	Costs vary by landowner/site		10-20 Years
27C	See Figure 65 for project location	4.1	Narrow, naturalized buffers on residential shorelines of Scott Lake	Implement educational program or incentive program to increase buffer widths in residential areas	5	15	96	Medium	Various private owners	Ecological Consultant/ Contractor	Costs vary by landowner/site		10-20 Years
27D	See Figure 65 for project location	7.0	Degraded wetland and buffer adjacent to water treatment plant effluent wetland and Crystal Creek	Design and implement an ecological restoration project and conduct three years of maintenance to establish	1	7	31	High/ Critical Area	LITHSD	Ecological Consultant/ Contractor	$60,000	$27,000	1-10 Years
27E	See Figure 65 for project location	2.4	Degraded riparian buffer along Tributary 1 with silt deposition and drainage issues	Design, permit, and implement a project to recreate historic drainage channel and restore degraded riparian buffer	3	11	68	High/ Critical Area	LITHSD	USACE, Engineer, Environmental Consultant, McHenry County	$60,000	$21,600	1-10 Years
27F	See Figure 65 for project location	0.9	Lot with degraded wetland areas adjacent to Tributary 1	Design, permit, and implement a project to restore wetlands and floodplain using rain gardens and other ecological techniques	1	4	24	High/ Critical Area	LITHSD	USACE, Engineer, Environmental Consultant, McHenry County	$35,000	$8,000	1-10 Years
31E	See Figure 65 for project location	1,837.8	Open gravel quarries with invasive herbaceous and woody species throughout	Implement maintenance plan to remove invasive species in perpetuity	357	694	4,557	High/ Critical Area	HMS	Ecological Consultant/ Contractor		$368,000	1-10 Years

LAKEWOOD

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
DETENTION BASIN RETROFITS & MAINTENANCE (SEE FIGURE 62). Technical and Financial Assistance Needs: Technical assistance needed to implement detention basin retrofits is relatively low while financial assistance needs are moderate. Private landowners will need the greatest assistance.													
12C	See Figure 62 for project location	1.0	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	4	12	40	Medium	Private owner	Ecological Consultant/ Contractor	$18,000	$9,000	10-20 Years
12D	See Figure 62 for project location	1.0	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	1	14	122	Medium	Private owner	Ecological Consultant/ Contractor	$18,000	$9,000	10-20 Years
OTHER MANAGEMENT MEASURES (SEE FIGURE 65). Technical and Financial Assistance Needs: Technical and financial assistance needed to implement these projects varies depending on complexity.													
12A	See Figure 65 for project location	227.3	Overall manicured shorelines of residential homes along Crystal Lake	Implement educational program or incentive program to install naturalized shoreline buffers in residential areas	51	170	1,111	High/ Critical Area	Various private owners	Ecological Consultant/ Contractor	Costs vary by landowner/site		1-10 Years
12B	See Figure 65 for project location	81.8	Degraded wetland complex and woodland buffer	Develop an ecological restoration & management plan and implement	5	20	108	High/ Critical Area	Grafton Township, Crystal Lake, Lakewood	Ecological Consultant/ Contractor	$15,000	$492,000	1-10 Years

MCHENRY COUNTY

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
DETENTION BASIN RETROFITS & MAINTENANCE (SEE FIGURE 62). Technical and Financial Assistance Needs: Technical assistance needed to implement detention basin retrofits is relatively low while financial assistance needs are moderate. Private landowners will need the greatest assistance.													
1B	See Figure 62 for project location	1.0	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	13	19	77	High/ Critical Area	Alexander Lumber	Ecological Consultant/ Contractor	$18,000	$9,000	1-10 Years
1C	See Figure 62 for project location	1.0	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	3	6	26	High/ Critical Area	Ridgefield Estates	Ecological Consultant/ Contractor	$18,000	$9,000	1-10 Years
2A	See Figure 62 for project location	1.1	Dry detention basin with naturalized bottom and slopes in good ecological condition	Maintain well-established naturalized basin	1	4	14	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$1,500/yr	1-10 Years
2B	See Figure 62 for project location	1.0	Dry detention basin with mowed turf bottom and slopes in poor ecological condition	Design and implement a project to remove turf, naturalize basin, slope and buffer with natives, stop mowing and maintain for three years to establish	1	2	11	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	$18,000	$9,000	1-10 Years
2C	See Figure 62 for project location	0.7	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	2	6	22	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	$12,600	$6,300	1-10 Years
2D	See Figure 62 for project location	0.8	Wet-bottomed detention basin with mowed turf grass side slopes in poor ecological condition	Design and implement a project to naturalize buffer and slopes, stop mowing, and maintain for three years to establish	3	5	23	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	14,400	$7,200	1-10 Years
2E	See Figure 62 for project location	0.9	Wet-bottomed detention basin with naturalized side slopes in average ecological condition	Maintain well-established naturalized basin	2	6	22	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$1,500/yr	1-10 Years
2F	See Figure 62 for project location	1.4	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Maintain well-established naturalized basin	2	7	25	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$2,000/yr	1-10 Years
3D	See Figure 62 for project location	2.5	Wet-bottomed detention basin with naturalized side slopes in good ecological condition	Maintain well-established naturalized basin	5	6	37	High/ Critical Area	Private owner	Ecological Consultant/ Contractor	-	$2,500/yr	1-10 Years
STREAMBANK & RIPARIAN AREA RESTORATION RECOMMENDATIONS (See Figure 63). Technical and Financial Assistance Needs: Stream restorations are complex and require high technical and financial assistance needs to protect land, design, construct, monitor, and maintain the restoration. The project becomes more complex in areas that flow through several governing bodies or multiple private residences. Technical and financial assistance associated with stream maintenance is generally low for minor tasks such as removing debris.													
CCR06	See Figure 63 for project location	13,780.6	13,781 lf of stream within LITH Fen exhibiting low levels of channelization, moderate levels of erosion and good overall riparian area condition	Design, permit, and constuct project to install install check dams throughout	607	692	1,610	High/ Critical Area	MCCD, LITH	USACE, Engineer, Environmental Consultant, McHenry County	$275,000	-	1-10 Years

ID#	Location	Units (Acres or LF)	Existing Condition	Management Measure Recommendation	Pollutant Reduction Efficiency			Priority	Owner & Responsible Entity	Sources of Technical Assistance	Cost Estimate		Implementation Schedule (Years)
					TSS (tons/yr)	TP (lbs/yr)	TN (lbs/yr)				Design, Permit, Install	Annual Maintenance and/or 3 Yrs to Establish	
PRIORITY GREEN INFRASTRUCTURE PROTECTION AREAS (See Figure 64). Technical and Financial Assistance Needs: Technical assistance needed to implement no-till vary widely based on differences between individual farms but can be relatively low because NRCS can provide much of this information and matching funds. Implementing future conservation design and/or low impact development in Priority Protection Areas is mostly a matter of instituting policies and ordinances.													
PPA1	See Figure 64 for project location	68.0	Agricultural area at headwaters of watershed	Utilize no-till farming as long as property is in production; utilize conservation design or low impact development if developed	NA	NA	NA	High/ Critical Area	Private owner	NRCS, MCSWCD, McHenry County	The costs for implementing no-till vary by landowner/site while costs for implementing Conservation Design or LID cannot be determined		1-10 Years; If/ when parcels become available for development
PPA2	See Figure 64 for project location	28.2	Large overgrown oak woodland with ADID wetland currently for sale in fall 2019	Utilize conservation design or low impact development when developed	NA	NA	NA	High/ Critical Area	Private owner	McHenry County	The costs for implementing no-till vary by landowner/site while costs for implementing Conservation Design or LID cannot be determined		1-10 Years; If/ when parcels become available for development
OTHER MANAGEMENT MEASURES (SEE FIGURE 65). Technical and Financial Assistance Needs: Technical and financial assistance needed to implement these projects varies depending on complexity.													
4A	See Figure 65 for project location	20.6	Overgrazed horse pastures adjacent to wetland with significant exposed/ eroded soils	Utilize pasture rotation and fencing to restrict livestock access to wetland and reduce soil erosion	3	7	28	High/ Critical Area	Private owner	NRCS, MCSWCD	Costs vary by landowner/site		1-10 Years

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6.0 Information & Education Plan

This Information & Education Plan (I&E Plan) recommends campaigns that are designed to enhance understanding of the issues, problems, and opportunities within Crystal Creek watershed. The intention is to promote general acceptance and stakeholder participation in selecting, designing, and implementing recommended Management Measures to improve watershed conditions. The first step in understanding the issues, problems, and opportunities within Crystal Creek watershed is to gain a better perspective of how the watershed evolved over time into what exists today.

Due to the current conditions of water quality within the watershed, it is imperative that the Management Measure recommendations are closely linked with watershed information and education programs. Thorough public information and stakeholder education efforts will ultimately inspire local residents and community members to adopt recommended implementation actions. The cumulative actions of individuals and communities' watershed-wide can accomplish the goals of the watershed plan. Watershed health is of primary importance for the people of Crystal Creek watershed. When people begin to understand the issues related to water quality and natural resource protection, they begin to change their actions and activities, thereby improving the overall health of the watershed.

The Crystal Creek watershed leading stakeholders/partners - City of Crystal Lake, Village of Algonquin, Village of Lake-in-the-Hills, Village of Lakeview, and Crystal Lake Park District, became concerned for the health of the watershed and formed the Crystal Creek Watershed Steering Committee. The partnership believes that the process of creating and implementing this Watershed-Based Plan will unite stakeholders, help them understand the issues and opportunities facing the watershed, and initiate projects that improve watershed conditions. The partners are actively engaging the public in watershed activities such as: educating private landowners about how to manage their land for green infrastructure benefit, providing local schools with information about Crystal Creek watershed to support outdoor curriculums, and providing educational information about flood prevention.

Recommended Information & Education Campaigns
A successful I&E Plan first raises awareness among stakeholders of watershed issues, problems, and opportunities. The second step is to provide stakeholders with information on alternatives to implement to address the issues, problems, and opportunities. This I&E Plan includes the following components as referenced in USEPA's "*Handbook for Developing Watershed Plans to Restore and Protect Our Waters*" (USEPA 2008):

- Define I&E goals and objectives.
- Identify and analyze the target audiences.
- Create the messages for each audience.
- Package the message to various audiences.
- Distribute the message.
- Evaluate the I&E program.

Goals and Objectives
Development of an effective I&E Plan begins by defining goals and objectives. Goals were established for the Crystal Creek watershed based on facilitated stakeholder engagement, voting, and responses during the October 6th Goals workshop. The goals and objectives were then refined during the planning process. Objectives assigned to each goal are intended to be measurable where appropriate so that future progress can be assessed. The following goals refer to education and communication goals and objectives only (*objectives unrelated to communications have been left out of this section*).

Goal 6: Build stakeholder awareness of watershed issues through education and stewardship while increasing communication and coordination among stakeholders.
Objectives:
1. Inform stakeholders and the general public that a Watershed-Based Plan has been developed for Crystal Creek watershed.
2. Implement the Crystal Creek Watershed-Based Plan Information & Education Campaign.
3. Increase environmental stewardship opportunities and encourage stakeholders to participate in watershed plan implementation and restoration campaigns to increase activism in the watershed.
4. Inform public officials of the benefits of conservation design and low impact development and the importance of ordinance language changes that promote these developments.
5. Create targeted educational information for riparian and shoreline landowners.

Photos: (far left) Lake in the Hills Stormwater awareness sign; (near left) Village of Algonquin trail signage

Target Audiences

The recommended target audience for each education campaign is selected based on the ability to attain objectives. The target audience is a group of people with a common denominator who are intended to be reached by a particular message. The target audience of the watershed includes people of all demographics, locations, occupations, and watershed roles. There can be multiple target audiences depending on which topic is being presented. The overall umbrella target audiences selected to meet watershed goals and objectives include residential and agricultural landowners, homeowners, general public, local government, elected officials, businesses, schools, and stakeholders/residents. Once the target audience is identified for a specific education campaign, existing local programs and communication vehicles should be leveraged to help distribute the message.

Public Input

Creating and distributing a message for each audience is done via campaigns that address education goal objectives. The I&E Plan objectives for the Crystal Creek watershed were determined by the Steering Committee with feedback from stakeholder meetings. An I&E Plan matrix (Table 50) was developed as a tool to help implement the I&E Plan. Not only does the matrix include recommended education campaigns, it also includes columns for Target Audience, Communications Vehicles, Priority/ Schedule, Lead & Supporting Organizations, Outcomes/ Change in Action, and Estimated Cost.

Evaluation

The I&E Plan should be evaluated regularly to provide feedback regarding the effectiveness of the outreach campaigns. Evaluation conducted early on in the effort will help determine campaigns that are successful and those that are not. Based on the evaluation, information, money, and time can be saved by focusing on the campaigns that work. Those that do not work should be ended and/or refined. Section 8.2 of this plan contains a “Report Card” with milestones related to watershed education that can be used to evaluate I&E Plan implementation efforts.

The plan will be made available electronically on the City of Crystal Lake website upon IEPA approval at https://www.crystallake.org/your-government/departments/community-development/engineering/watershed.

Table 50. Information and Education Plan Matrix.

Education Action of Campaign	Target Audience	Communication Vehicles	Priority/ Schedule	Lead (Supporting) Organization	Outcomes, Change in Action	Estimated Cost
Inform the general public, that a Watershed-Based Plan has been developed for Crystal Creek watershed	General Public	Use as many existing forms of media such as social media, newsletters, websites, to inform the public about plan and ways that the public can obtain the plan and help implement projects.	Immediately following plan completion	Crystal Lake (remaining municipalities)	Spread awareness about the plan and its recommendations and encourage implementation by stakeholders to gain interest in implementing recommended actions.	$0
Educate private landowners along Crystal Creek and the various Lakes and stream corridors how to properly manage land to benefit green infrastructure.	Private landowner along Crystal Lake & Stream Reaches	Send a mailing letter with a brochure	Once every five years	Crystal Lake (remaining municipalities)	Encourage landowners to manage their land for water quality and green infrastructure benefits	$1,000
Provide schools with information about Crystal Creek watershed as a means to support outdoor curriculum within the watershed's green infrastructure.	Teachers/ Students	Provide schools with copies of the Crystal Creek Watershed Executive Summary. Integrate basic watershed planning and education into existing elementary, middle, and high school science curriculum and encouraging them to engage professional speakers.	As requested from schools	Municipalities (Crystal Lake)	Encourage student involvement and provide opportunities to discuss water quality and watersheds, to educate students about watershed planning and the importance of green infrastructure to improve overall watershed conditions	$2,000
Educate stakeholders about the best alternatives or management of phosphorus use	Stakeholders	Use newsletter to communicate to a wider variety of landowners the negative impacts of using fertilizer high in phosphorus	Publicize annually and soil testing as requested	Crystal Lake (remaining municipalities)	Encourage reduction in phosphorus usage, particularly for businesses and agricultural landowners	$0
Provide educational information on flood proofing to owners with structural flood problems	Property owners with flooding	Conduct personalized site meetings with landowners	As requested by landowners	Crystal Lake (remaining municipalities)	Educate landowners about flood mitigation and prevention, to develop options to mitigate for flooding, reduce future issues	$0

Education Action of Campaign	Target Audience	Communication Vehicles	Priority/ Schedule	Lead (Supporting) Organization	Outcomes, Change in Action	Estimated Cost
Install Crystal Creek Watershed Boundary signs along major roads in the watershed.	General Public	Design and install signs at key points along major roads in the watershed; signs should also contain a web address.	Following plan completion	Municipalities (Algonquin)	Inform stakeholders they are "Entering Crystal Creek Watershed", raise awareness	TBD
Educate residents and businesses about the benefits of constructing rain gardens and using rain barrels to capture stormwater.	Businesses; Homeowners	Steering Committee co-hosts an outdoor workshop with The Land Conservancy of McHenry County to discuss siting, construction, and planting of rain gardens; also sell and discuss rain barrel use	Once every three years	Steering Committee (Algonquin, Land Conservancy of McHenry County	Raise awareness about rain gardens, rain barrels, and downspout disconnection programs and relevance to water quality	$0 (volunteers)
Provide homeowner and business associations with the knowledge needed to maintain naturalized detention basins.	Business and Homeowner Associations	Steering Committee offer free workshops to business and homeowner associations that own naturalized detention basins. The workshops should stress maintenance of existing naturalized basins and retrofits to improve poorly functioning or poorly designed basins	Once every two years	Steering Committee (Crystal Lake, Algonquin, remaining municipalities)	Increase awareness of implementation projects and how management of detention basins can improve water quality	$0 (volunteers)
Maintain the existing Crystal Creek watershed information sharing website and link to partner websites.	Stakeholders	Website	Ongoing	Crystal Lake (remaining municipalities)	Increase awareness of the plan and its recommendations and encourage implementation by stakeholders, keep stakeholders updated on watershed outcomes	$0

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7.0 Plan Implementation

7.1 Plan Implementation Roles and Coordination/ Responsibilities

Identification of responsible entities for implementation of Management Measure recommendations was first mentioned in the Action Plan section of this report. These entities are key stakeholders that will be responsible in some way for sharing the responsibility required to implement the watershed plan. However, no single stakeholder has the financial or technical resources to implement the plan alone. Rather, it will require working together and using the strengths of individual stakeholders to successfully implement this plan. Key stakeholders are listed in Table 51.

There are several important first steps that Crystal Creek Watershed Steering Committee partners will need to accomplish prior to plan implementation. The partners include the City of Crystal Lake, Villages of Algonquin, Lake in the Hills, and Lakewood and Crystal Lake Park District.

1. Watershed partners are encouraged to adopt the Crystal Creek Watershed-Based Plan.
2. The partners will need to extend the Steering Committee or recruit “champions” within each municipality and other stakeholder groups to form a Watershed Implementation Committee that actively implements the Watershed-Based Plan and conducts progress evaluations.
3. The watershed partners may also need to hire and fund a Watershed Implementation Coordinator or find an employee internally to follow through on plan implementation.

Table 51. Key Crystal Creek watershed stakeholders/partners.

Watershed Stakeholder/Partner	Acronym/Abbreviation
Businesses	Business
City of Crystal Lake	Crystal Lake
Crystal Lake Park District	CLPD
Developers	Developer
Ecological Consultants	Consultant
Fox River Ecosystem Partnership	FREP
Golf Courses	GC
Illinois, McHenry, and Kane County Dept. of Transportation	DOTs
Illinois Environmental Protection Agency	IEPA
Kane County Development Department	KCDD
McHenry County Planning and Development Department	MCPDD
Residents or Owners	Resident/Owner
School Districts	School
The Land Conservancy of McHenry County	TLC
Townships (Algonquin, Dundee, Grafton, Rutland)	TWP
USDA Natural Resource Conservation Service (McHenry County)	USDA
US Army Corps of Engineers-Chicago Region	USACE
US Fish & Wildlife Service	USFWS
Village of Algonquin	Algonquin
Village of Lake in the Hills	LITH
Village of Lakewood	Lakewood
Crystal Creek Watershed Steering Committee	Steering Committee

Early on in the plan implementation process, the Steering Committee should assign or hire a Watershed Implementation Coordinator to call meetings and update the committee on plan implementation progress by way of the Report Cards (detailed in Section 8.2). If needed, adaptive management should be implemented accordingly by referencing the adaptive management recommendations on each Report Card then developing a strategy to either change the milestone(s) or decide how to implement projects or actions to achieve the milestone(s).

Report Cards can be evaluated at any time. However, it is recommended that they be evaluated at least every five years to determine if sufficient progress is being made toward achieving milestones or if adaptive management is needed.

7.2 Implementation Schedule

The development of an implementation schedule is important in the watershed planning process because it provides a timeline for when each recommended Management Measure should be implemented in relation to others. Critical Area/ High priority projects, for example, are generally scheduled for implementation in the short term. A schedule also helps organize project implementation evenly over a given time period, allowing reasonable time availability for developing funding sources and opportunities.

For this plan, each “Site Specific Management Measure” recommendation located in the Management Measures Action Plan (Section 5) contains a column with a recommended “Implementation Schedule” based on the short term for critical area (1-10 years) for high priority projects and 10-20+ years for medium and low priority project recommendations. Other recommendations such as maintenance activities have ongoing or as needed schedules. Some projects that are high priority could be recommended for long term implementation based on selected practices, available funds, technical assistance needs, and time frame. In addition, the “Information & Education” plan (see Section 6.0) and the “Monitoring Plan” are designed to be conducted annually and evaluated at least every five years to determine if progress is being made toward achieving plan goals and objectives.

7.3 Funding Sources

Opportunities to secure funds for watershed improvement projects are widespread due to the variety and diversity of Management Measure recommendations found in the Action Plan. Public and private organizations that administer various conservation and environmental programs are often eager to form partnerships and leverage funds for land restoration, preservation, and environmental education. In this way, funds invested by partners in the Crystal Creek watershed can be doubled or tripled, although actual dollar amounts are difficult to measure. A list of potential funding programs and opportunities is included in Appendix E. The list was developed by Applied Ecological Services, Inc. (AES) through involvement in other watershed and biodiversity studies.

Funds generally fall into two relatively distinct categories. The first includes existing grant programs, funded by a public agency or by other sources. These funds are granted following an application process. The Illinois EPA Nonpoint Source Management Program (Section 319 Grants) is one example: an applicant will submit a grant application to the program, and, if the proposed project meets the required criteria and if the funds appropriated have not been exhausted, a grant may be awarded.

The second category, one that can provide greater leverage, might be called “money to be found.” The key to this money is to recognize that any given project may have multiple benefits. It is important to note and explore all of the potential project benefits from the perspective of potential partners and to then engage those partners. Partners may wish to become involved because they believe the project will achieve their objectives, even if they have little interest in the specific objectives of the Watershed Plan.

It is not uncommon for an exciting and innovative project to attract funds that can be allocated at the discretion of project partners. When representatives of interested organizations gather to talk about a proposed project, they are often willing to commit discretionary funds simply because the proposed project is attractive, is a priority, is a networking opportunity, or will help the agency achieve its mission. In this way, a new partnership is assembled.

Leveraging and Partnerships
It is critically important to recognize that no one program has been identified that will simply match the overall investment of the Crystal Creek watershed partners in implementing the Watershed Plan. Rather, partnerships are most likely to be developed in the context of individual and specific land preservation, restoration, or education projects that are recommended in the Plan. Partners attracted to one acquisition may not have an interest in another located elsewhere for jurisdictional, programmatic, or fiscal reasons.

Almost any land or water quality improvement project ultimately requires the support of those who live nearby if it is to be successful over the long term. Local neighborhood associations, homeowner associations, and similar groups interested in protecting water resources, open space, preventing development, or protecting wildlife habitat and scenic vistas, make the best partners for specific projects. Those organizations ought to be contacted in the context of specific individual projects.

It is equally important to note that the development of partnerships that will leverage funding or goodwill can be, and typically is, a time-consuming process. In many cases, it takes more time and effort to develop partnerships that will leverage support for a project than it does to negotiate with the landowners for use or acquisition of the property. Each protection or restoration project will be different; each will raise different ecological, political and financial issues, and each will in all likelihood attract different partners. It is also likely that the process will not be fully replicable. That is, each jurisdiction or partner will have a different process and different requirements.

In short, a key task in leveraging additional funds is to assign responsibility to specific staff for developing relationships with individual agencies and organizations, recognizing that the funding opportunities might not be readily apparent. With some exceptions, it will not be adequate simply to write a proposal or submit an application; more often, funding will follow a concerted effort to seek out and engage specific partners for specific projects, fitting those projects to the interests of the agencies and organizations. Successful partnerships are almost always the result of one or two enthusiastic individuals or “champions” who believe that engagement in this process is in the interests of their agency. There is an old adage in private fundraising: people give to other people, not to causes. The same thing is true with partnerships using public funds.

Partnerships are also possible, and probably necessary, that will leverage assets other than money. By entering into partnerships with some agencies, organizations, or even neighborhood groups, a stakeholder will leverage valuable goodwill, and relationships that have the potential to lead to funds and other support, including political support, from secondary sources.

7.4 Additional Investigations

Over the course of the planning process a number of instances were identified that were beyond the scope of the initial planning process where additional research or discovery in the future might further plan goals and implementation. Additional potential watershed investigations that the Steering Committee could pursue in the future include, but are not limited to, the following:

- A more detailed study of where daylighting might be appropriate north of Crystal Lake

These additional investigations are considered High Priority/Critical Areas for future funding should the Steering Committee decide to pursue them in the future.

7.5 Plan Amendments

Data, research, and methodologies are continuously updating and evolving. In order to accommodate new and updated information, the Steering Committee may decide to update the plan by way of Amendment as often as yearly, if necessary. The process for updating the plan will be led by the Steering Committee and include amendments as agreed to and documented by the Steering Committee and attached to the final watershed-based plan as an Amendment. Amendments should be written as stand-alone documents that reference the plan and appropriate plan sections. The process is outlined as follows:

- Steering Committee researches and documents Amendment
- Steering Committee approves Amendment
- Steering Committee sends Amendment to IEPA for review and approval
- IEPA and Steering Committee agree to and make edits as necessary
- Steering Committee publishes Amendment

Amendments might include additional projects that were not identified during the planning process; new practices, methodologies, or programs that will improve implementation our watershed outcomes; the results or outcomes of any additional investigations (as identified in Section 7.4); updated McHenry County Water Resources Action Plan or Illinois State Water Survey groundwater research; or any similar findings that the Steering Committee and IEPA agree to.

The Steering Committee will house a link to the approved watershed-based plan and any approved amendments on its website, currently available at https://www.crystallake.org/your-government/departments/community-development/engineering/watershed.

8.0 Measuring Plan Progress & Success

It is essential to have a monitoring plan and evaluation component as part of any watershed plan to evaluate plan implementation progress and success over time. This watershed plan includes two monitoring/evaluation components:

- The "Water Quality Monitoring Plan" includes methods and locations where monitoring should occur and a set of criteria (indicators & targets) used to determine whether impairment reduction targets and other watershed improvement objectives are being achieved over time.
- "Report Cards" for each plan goal were developed that include interim, measurable milestones linked to evaluation criteria that can be evaluated by the planning committee over time.

8.1 Water Quality Monitoring Plan & Evaluation Criteria

Background Information

This subsection provides a monitoring plan that can be implemented to measure changes in watershed impairments related primarily to water quality. Water quality monitoring is performed by first collecting physical, chemical, biological, and/or social indicator data. This data is then compared to criteria (indicators & targets) related to established water quality objectives.

Available water quality data collected within the Crystal Creek watershed is summarized in Section 3.15. Sampling was conducted by IEPA, Fox River Study Group (FRSG), River Watch, North American Lake Management Society, and Applied Ecological Services (AES), and included various sampling regimes and sets of parameters.

Illinois EPA determined that Crystal Creek is not supporting for *Primary Contact* due to high Fecal Coliform levels originating from urban runoff/ storm sewers, while neither Crystal Lake or Three Oaks North and South Lakes are impaired according to the Draft 2018 *Illinois Integrated Water Quality Report and Section 303d List* (Illinois EPA 2018). Available water quality and habitat data for Crystal Creek and its tributaries indicates moderate overall impairment of Crystal Creek and tributaries for total phosphorus (TP), total nitrogen (TP), total suspended solids (TSS) and fecal coliform (and/or *E. coli*).

The water quality monitoring plan is designed to: 1) capture snapshots of water quality within Crystal Creek watershed over time; 2) assess changes in water quality following implementation of Management Measures, and 3) assess the public's social behavior related to water quality issues. It is crucial that representative water quality samples be carefully collected using method appropriate handling procedures. Unrepresentative samples or samples contaminated during collection or handling can prove useless. It is important that future monitoring be completed using protocol and methods used by the EPA for QAQC purposes. EPA Quality Assurance Project Plans (QAPPs) and Standard Operating Procedures (SOPs) can be found at https://www.epa.gov/sites/production/files/2015-06/documents/vol_qapp.pdf.

Physical, chemical, and biological water quality indicators in streams are typically measured during base flow and after significant (≥ 1.5 inches) storm events. Chemical parameters typically include nutrients (nitrogen and phosphorous) and total suspended solids. All samples should be analyzed by certified labs to ensure accurate results. Physical parameters, such as temperature, dissolved oxygen, pH, and water clarity (turbidity) should be collected in the field using properly maintained and calibrated field equipment. It is also important to obtain stream discharge calculations as a determination of potential pollutant loading. These calculations are easily obtained by measuring the stream width, average depth, and flow rate at the monitoring location. Biological (fish and macroinvertebrate) and habitat assessments may also be performed, site assessment criteria dependent.

When management measures are implemented, monitoring should ideally take place both before and after implementation to track the effectiveness of those projects. Management Measure implementation sampling locations should include points of water ingress and egress, such as the inflow and outflow points on a retrofitted detention basin as an example. To achieve the best results with respect to performance, Management Measure implementation monitoring should occur during or shortly after large rain events (≥ 1.5 inches). Biological and/or habitat assessments should also be included on any habitat improvement project, such as a stream restoration. Because funding for post implementation monitoring is typically limited, money should be built into the initial Management Measures project budget.

Monitoring Plan Implementation

Existing and recommended water quality monitoring regimes, including recommended monitoring entity, monitoring locations, schedule/monitoring frequency, type of parameters sampled, and expected costs, are outlined in Table 52. All existing monitoring should continue and in addition, AES recommends that physical, chemical, and *E. coli* (or fecal coliform) sampling at AES-01 should be added to the 5-year monitoring regimes. The Steering Committee and partners should work together to accommodate this additional sampling. This monitoring will yield data over time that will help track changes in watershed water quality over time. Figure 66 includes the location of all recommended monitoring locations. Note: monitoring locations related to individual Management Measures are not described or mapped as this monitoring will come later when projects are implemented.

Table 52. Recommended water quality monitoring programs/locations.

Monitoring Entity/ Program	Monitoring Location (See Figure 66)	Schedule/ Monitoring Frequency	Parameters Sampled	Cost to Implement
Existing Monitoring Programs				
Illinois River Watch Network	RW-01 & 02	Every 5 years	Biological	Not Applicable
Illinois EPA Intensive Basin and Special Study	DTZR-02; WTG-01,02 & 99; VTZH-01, 03, 98, & 99	Every 5 years	Physical; Chemical	Not Applicable
Fox River Study Group	DTZR-02	Monthly	Physical; Chemical	Not Applicable
New Monitoring Programs				
Steering Committee or other partners	AES-01	Every five years	Physical; Chemical; *E. coli* or fecal coliform	$1,000 each 5-year cycle
Project lead or landowner	Varies: Specific to each management measure	Pre and post implementation	Physical, Chemical	$5,000 for each project

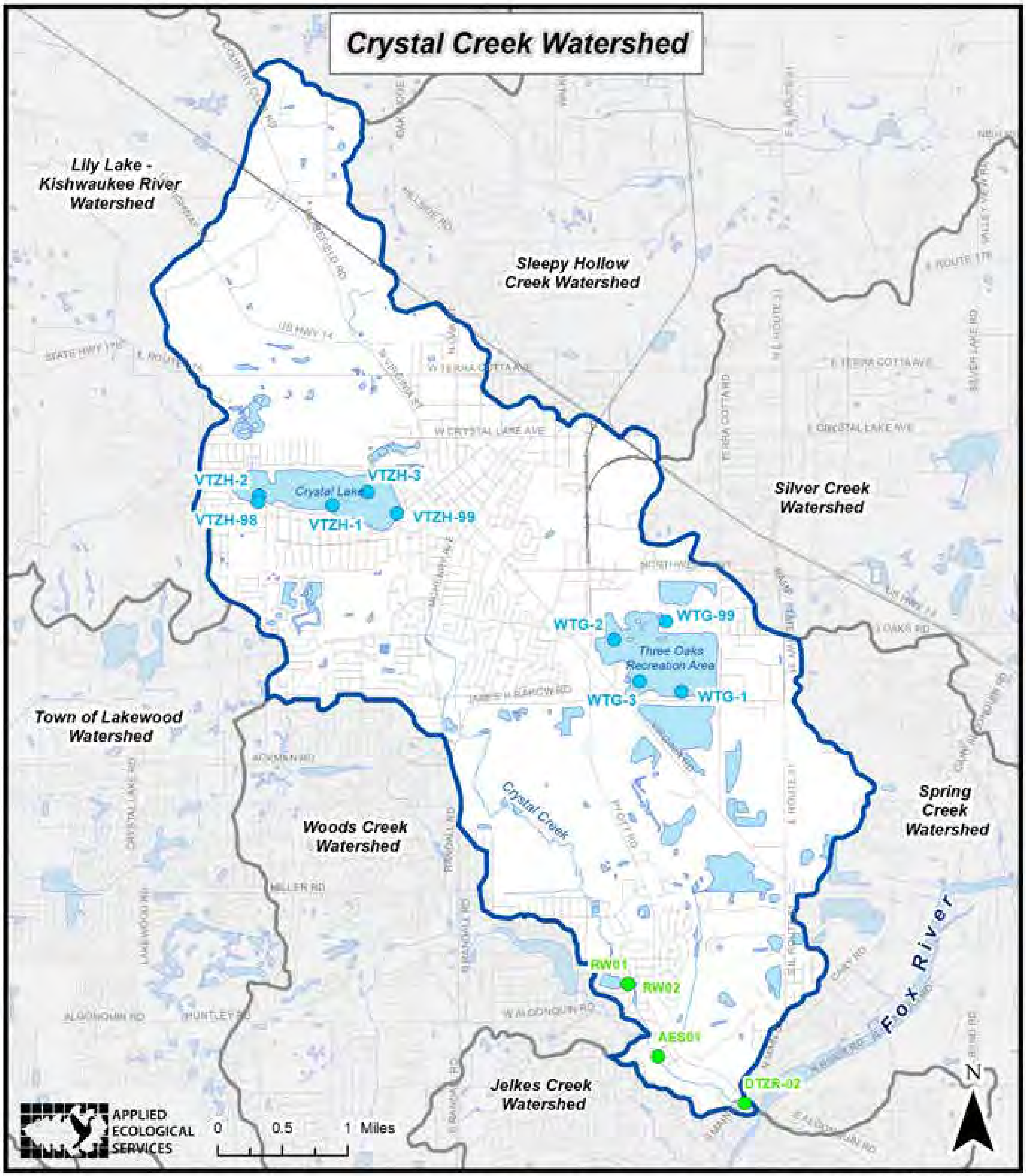
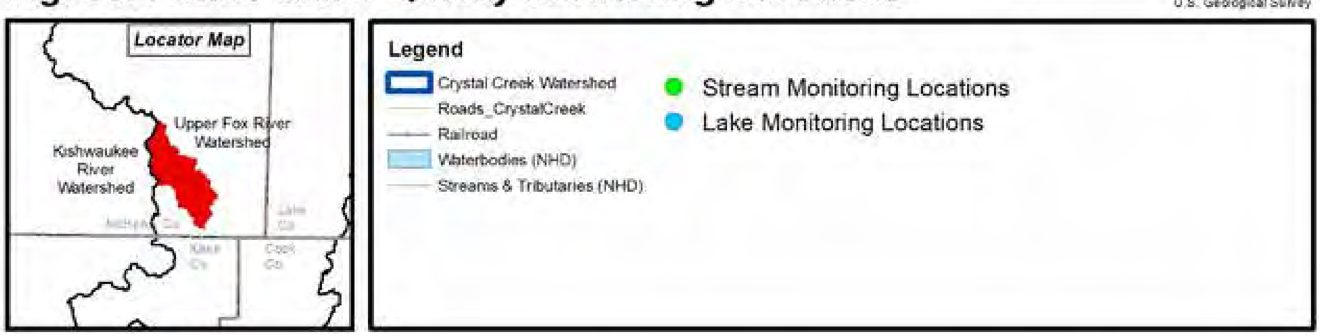


Fig. 66: Future Water Quality Monitoring Locations

DATA SOURCES City of Crystal Lake McHenry County U.S. Census Bureau U.S. Geological Survey



Physical and Chemical Monitoring Methods & Recommendations

Physical and chemical monitoring of water can be time consuming and expensive depending on the complexity of the monitoring program. Usually the budget and/or personnel available for monitoring limit the amount of data that can be collected. Therefore, the monitoring program should be developed to maximize the usable data given the available funding and personnel. Any monitoring program should be flexible and subject to change to collect additional information or use newer equipment or technology when available while maintaining a link to past data.

Streams

Future physical/chemical monitoring should continue according to the existing schedule/ frequency, averaged annually for each parameter, and then compared to target water quality values. Many different parameters can be included in physical monitoring of water quality in streams. Measurements of temperature, pH, conductivity, dissolved oxygen, and turbidity should be collected in the field for any monitoring done on Crystal Creek using portable instruments. The measurements can then be recorded on data sheets in the field or the units can be taken back to the lab and the data downloaded. Chemical parameters should generally include total phosphorus, total nitrogen, total suspended solids, chloride, and *E. coli* (or fecal coliform) at a minimum, all of which are already be monitored by an existing partner. One new sampling location, AES-02, is recommended in order to track water quality for Tributary 2 and should include the same minimum parameters as outlined above.

Unlike physical monitoring, chemical monitoring requires grab samples be collected and taken to certified labs for analysis and collection needs to follow handling procedures for samples as outlined in Table 53. Unrepresentative samples or samples contaminated during collection or handling are often useless. The collected samples should be submitted for analysis to a laboratory certified by the National Environmental Laboratory Accreditation Conference (NELAC). Alternatively, one of the Steering Committee partners could work with either of the WWTPs to save on sampling costs. Generally, the laboratory will work closely with the monitoring entity to assure that the samples are collected in the proper containers with preservatives for the parameter of interest.

Lakes

Most water quality samples related to pollutant loading are obtained from streams because the data provides estimates of pollutant loading following storm events. In lakes however, the water is usually slow to cycle through the system and different techniques are needed to assess water quality. In addition to collecting many of the parameters included in Table 53, biologists and limnologists often use “productivity” of a lake to assess its health. Productivity is measured via the Trophic State Index (TSI), an index that uses phosphorus and chlorophyll concentrations as the primary means to assess lake health. The state of Illinois set the standard for Total Phosphorus (TP) at 0.05 mg/l for lakes. When phosphorus levels exceed 0.05 mg/l, lake-wide algal blooms can occur leading to decreased water clarity, decreased light penetration, and increased total suspended solids.

The work required to collect physical and chemical data and develop TSI values for Crystal Lake and Three Oaks Recreation Area (North and South) is currently being done by Illinois EPA under the Volunteer Lakes Monitoring Program (VLMP) and Ambient Lakes Monitoring Program (ALMP). This monitoring should continue in the future on an annual basis for VLMP and every five years for ALMP.

Table 53. Stream monitoring water quality parameters, collection, and handling procedures.

Parameter	Statistical, Numerical, or General Use Guideline	Container	Volume	Preservative	Max. Hold Time
Physical Parameters Measured in Field					
pH	>6.5 or <9.0	These parameters are measured in the field			
Conductivity	<1,667 µmhos/cm				
Dissolved Oxygen	>5.0 mg/l				
Temperature	<90 F				
Turbidity	<14 NTU				
Chemical & Physical Parameters Analyzed in Lab					
Total Suspended Solids	<19 mg/l	Plastic	32 oz	Cool 4 oC	7 days
Biochemical Oxygen Demand	<5.0 mg/l	Plastic	32 oz	Cool 4 oC	48 hours
Ammonia Nitrogen, Nitrate-Nitrite, & Total Kjeldahl Nitrogen	Total Nitrogen (mg/L) calculated <2.461 mg/l	Plastic	32 oz	Cool 4 oC	28 days
Total Phosphorus	<0.0725 mg/l (streams)	Plastic	4 oz	Cool 4 oC	28 days
Chloride	<500 mg/l	Plastic	32 oz	Cool 4 oC	28 days
Fecal coliform or E. coli	<235 MPN/100mL	Plastic	4 oz	Cool 4 oC	<6 hours

Macroinvertebrate sampling in stream

Biological Monitoring Methods and Recommendations

The Illinois EPA uses biological data for determining "*Aquatic Life*" Use Attainment in streams because fish and macroinvertebrates are relatively easy to sample/identify and reflect specific and predictable responses to human induced changes to the landscape, stream habitat, and water quality.

Two indices have been developed that measure water quality using fish and macroinvertebrates - fish Index of Biotic Integrity (fIBI) and Macroinvertebrate Biotic Index (MBI). These indices are best applied prior to a project such as a stream restoration to obtain baseline data and again following restoration to measure the success of the project. Or, they can be conducted simply to assess resource quality in a stream or tributary reach.

Fish Index of Biotic Integrity (fIBI)

The fIBI is designed to assess water quality and biological health directly through several attributes of fish communities in streams. After the fish have been collected using electrofishing equipment and identified, the data is used to evaluate 12 metrics and a rating is assigned to each metric based on whether it deviates strongly from, somewhat from, or closely approximates the expected values found in a high quality reference stream reach. The sum of these ratings gives a total IBI score for the site. The best possible IBI score is 60. The Illinois EPA has determined that a score less than 41 indicates a stream is not fully supporting for "*Aquatic Life*" (Table 54). A manual for calculating IBI scores for streams in Illinois is available from Illinois DNR.

Fish sampling was historically conducted by IEPA during the 1990s, but no additional ongoing fIBI monitoring recommendations are made due to limited resources. Where possible however, fish sampling and calculation of fIBI values should be built into future stream restoration projects.

Macroinvertebrate Biotic Index (MBI)

The MBI is designed to rate water quality using aquatic macroinvertebrate taxa tolerance to degree and extent of organic pollution in streams. The MBI is calculated by taking an average of tolerance ratings weighted by the number of individuals in the sample. The Illinois EPA has determined that an MBI score greater than 5.9 indicates a stream is not fully

Table 54. Illinois EPA indicators of aquatic life impairment using MBI and fIBI scores.

Biological Indicator	MBI and fIBI Scores		
MBI	> 8.9	5.9 < MBI < 8.9	≤ 5.9
fIBI	≤ 20	20 < IBI< 41	≥ 41
Impairment Status - Use Support - Resource Quality			
Impairment Status	Severe Impairment	Moderate Impairment	No Impairment
Designated Use Support	Not Supporting	Not Supporting	Fully Supporting
Resource Quality	Poor	Fair	Good

supporting "*Aquatic Life*" (Table 54). A manual for collecting and calculating MBI scores for streams is available from Illinois EPA.

Habitat Monitoring Methods and Recommendations

Stream habitat assessments comprise a major component of physical water quality monitoring. Many habitat assessment methods are available for assessing streams such as those developed by Illinois DNR and Ohio EPA. The Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA is a quick, accurate, and straightforward analysis with dependable and repeatable results found to correlate well with biological integrity of streams in the Midwest. The QHEI is also used by the Illinois EPA to assess "Aquatic Life" Use Attainment in streams. It is composed of six criteria that are scored individually then summed to provide the total QHEI score. The best possible score is 100. QHEI scores from hundreds of stream segments indicate that habitat values greater than 60 generally support average quality warm-water fauna. Scores greater than 80 typify pristine habitat conditions that have the ability to support exceptional warm-water fauna (Ohio EPA 1999). Areas with habitat scores lower than 60 may support warm-water fauna but usually exhibit significant degradation. Table 55 summarizes QHEI score classifications. Stream restoration projects should strive to create conditions that produce QHEI scores of at least 60.

The index should be used on any stream reach and for stream restoration projects to document improvements. Prior to stream restoration, a QHEI evaluation should be completed by the project watershed coordinator, ecologist, or engineer. A follow-up QHEI for comparison purposes should be conducted by the same individual at least 2-4 years following project implementation after plant material grows and in-stream structures have had time to perform. QHEI forms and a narrative explaining how to use the index can be located on the web at http://rock.geo.csuohio.edu/norp/qhei.htm.

Table 55. QHEI score classes and characteristics.

QHEI	Class	Usual Characteristics
80-100	Excellent	Comparable to pristine conditions; exceptional assemblage of habitat types; sufficient riparian zone
60-79	Good	Impacts to riparian zone
30-59	Fair	Impacts to riparian zone; channelization; most in-stream habitat gone
0-29	Poor	All aspects of habitat in degraded state

Social Indicators of Water Quality
Quantifying social indicators of success in a watershed planning initiative is difficult. It is subjective to a large degree and complaints about poor conditions are often heard rather than compliments on improvements. The Great Lakes Regional Water Program (GLRWP), a leading organization that addresses water quality research, education, and outreach in Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin, defines social indicators as standards of comparison that describe the context, capacity, skills, knowledge, values, beliefs, and behaviors of individuals, households, organizations, and communities at various geographic scales. The GLRWP suggests that social indicators used in water quality management plans and outreach efforts are effective for several reasons including:

- Help watershed committee evaluate projects related to education and outreach;
- Help support improvement of water quality projects by identifying why certain groups install Management Measures while other groups do not;
- Measure changes that take place within grant and project timelines;
- Help watershed committee with information on policy, demographics, and other social factors that may impact water quality;
- Measure outcomes of water quality programs not currently examined.

GLRWP has developed a Social Indicators Data Management and Analysis Tool (SIDMA) to assist watershed stakeholders with consistent measures of social change by organizing, analyzing, and visualizing social indicators related to nonpoint source (NPS) management efforts. Detailed information about GLRWP's social indicator tool can be found at: http://35.8.121.111/si/Home.aspx.
To summarize, the SIDMA tool uses a seven step process to measure social indicators as shown in Figure 67.

Figure 67. Steps to measure social indicators.

Several potential social indicators could be evaluated by the Steering Committee using different strategies to assess changes in water quality. For example, surveys, public meetings, and establishment of interest groups can give an indication of the public feelings about the water quality in the watershed. It is important to involve the public in the water quality improvement process at an early stage through public meetings delineating the plans for improvement and how it is going to be monitored. Table 56 includes a list of potential social indicators and measures that can be used by the watershed committee to evaluate the social changes related to water quality issues.

Monitoring social indicators in the watershed should be the responsibility of the Watershed Steering Committee. On-line internet surveys are among the most popular method to gauge social behavior toward water quality. Demographic information on a county basis can be obtained from the U.S Census Bureau but will need to be modified based on the watershed boundary. This information is then followed by taking a randomized sample of individuals in the watershed from a phone directory or other means. Next, a survey should be developed that identifies citizens' perceptions of water quality problems and protection strategies. Citizens that respond to the survey should be given a chance to donate a small amount of money ($1 for example) to a not for profit environmental group then sent thank you letters while those that did not respond should be sent a second survey. The results of the survey can be used to develop appropriate media, citizen awareness, and watershed management activities to improve social behavior.

Table 56. Social indicators and measures to understand behavior toward watershed issues.

Social Indicator	Measure
Media Coverage	• # of radio broadcasts related to watershed protection • # of newspaper articles related to watershed protection • # of press releases relate to watershed protection • # of social media posts related to watershed protection
Resident Awareness	• # of residents who are aware a watershed plan exists • # of informational flyers distributed per given time period • % of citizens who are able to identify where pollution is originating from • % change in volunteer participation to protect water quality • % change in attendance at water quality workshops and "Volunteer Days"
Watershed Management Activities	• # of watershed signage along roads • # of schools helping implement the watershed monitoring plan • # of residents that perform ecological restoration on their properties • # of stream miles cleaned up per year • # of linear feet or miles of trails created or maintained each year • # of watershed partners who adopt the watershed management plan • # of watershed groups implementing plan recommendations

Water Quality Evaluation Criteria

Water quality criteria (expressed as measurable indicators & targets) need to be developed so that water quality objectives can be evaluated over time. The criteria are designed to be compared against data gathered from the Water Quality Monitoring Plan as well as other data and analyzed to determine the success of the watershed plan in terms of protecting and improving water quality. These criteria also support an adaptive management approach by providing ways to reevaluate the implementation process if adequate progress is not being made toward achieving water quality objectives.

Section 2.0 of this plan includes a water quality goal (Goal 2) with six objectives. Criteria are selected for each water quality objective to determine whether components of the water quality goal are being met (Table 57). Criteria are based on Illinois EPA water quality criteria, data analysis, reference conditions, literature values, and/or expert examination. Criteria are also designed to address potential or known sources of water quality impairment identified in Section 4.0. Future evaluation of the criteria will allow the steering committee to gage plan implementation success or determine if there is a need for adaptive management. Note: evaluation criteria are included for the water quality goal only; criteria for other plan goals are examined within the appropriate progress evaluation "Report Cards" in Subsection 8.2.

Table 57. Set of criteria related to water quality goal and objectives.

GOAL 2: Improve surface water quality to meet water quality standards.	
Water Quality Objective	**Criteria: Indicators and Targets**
1. Stabilize 4.8 miles of moderately to highly eroded streambank, degraded channel, and or average to poor riparian buffer using bioengineering techniques, ecological restoration & long-term management.	• *Linear Feet of Restored Stream*: 50% of “Critical Area” stream restoration projects implemented. • *Chemical & Physical Water Quality Standards*: <20 NTUs, <12 mg/l TSS, <0.0725 mg/l TP and <200 CFU/100mL fecal coliform in stream water samples. • *Biotic Indexes*: Macroinvertebrate communities achieve at least “Fair” resource quality. • *Social Indicator*: >50% of surveyed citizens know that streambank erosion is a problem in the watershed and are aware of and support stream restoration efforts.
2. Daylight 0.4 miles of stream and restore using bioengineering techniques at CCR04.	• *Linear Feet of Restored Stream*: All of “Critical Area” stream daylight project implemented. • *Chemical & Physical Water Quality Standards*: <20 NTUs, <12 mg/l TSS, <0.0725 mg/l TP and <200 CFU/100mL fecal coliform in stream water samples. • *Biotic Indexes*: Macroinvertebrate communities achieve at least “Fair” resource quality. • *Social Indicator*: >50% of surveyed citizens know that streambank erosion is a problem in the watershed and are aware of and support stream restoration efforts.
3. Install natural shoreline buffers along at least 25% of private residential lots at Crystal Lake, Goose Lake, and Scott Lake.	• *# of Lots with Buffers*: At least 25% of lake lots implement natural buffers. • *Social Indicator*: >50% of surveyed lake residents know the importance of having and maintaining a natural buffer and would be willing to implement buffer projects.
4. Retrofit 20% of “Critical Area” detention basins by naturalizing with native vegetation.	• *# of Detention Basin Retrofits*: 50% “Critical Area” detention basins naturalized. • *Social Indicator*: >50% of surveyed stakeholders understand the water quality and habitat benefits created by naturalizing detention basins with native vegetation.
5. Practice no-till on existing farmed Priority Green Infrastructure Protection Areas.	• *# of Acres in No-Till*: All “Critical Area” farmed Protection Areas in no-till. • *Social Indicator*: >75% of surveyed farmers understand the water quality benefits resulting from no-till.
6. Implement rotational grazing and strategic fencing on 68 acres of existing horse and cow pasture.	• *# of Acres in Sustainable Pasture*: All “Critical Area” pasture areas use sustainable practices. • *Social Indicator*: >75% of surveyed farmers understand the water quality benefits sustainable pastures.

8.2 Goal Milestones/ Implementation & Progress Evaluation "Report Cards"

Milestones are essential when determining if Management Measures are being implemented and how effective they are at achieving plan goals over given time periods. Tracking milestones allows for periodic plan updates and changes that can be made if milestones are not being met.

Watersheds are complex systems with varying degrees of interaction and interconnection between physical, chemical, biological, hydrological, habitat, and social characteristics. Criteria that reflect these characteristics may be used as a measure of watershed health. Goals and objectives in the watershed plan determine which criteria should be monitored to evaluate the success of the watershed plan.

A successful watershed plan involves volunteer stakeholder participation to get projects completed and must include a feedback mechanism to measure progress toward meeting goals. Watershed "Report Cards", developed specifically for each goal in this plan, provide this information.

Each Report Card provides:

1. Summaries of current conditions for each goal to set the stage for what efforts are needed
2. Most important performance criteria related to goal objectives (see Section 2.0)
3. Milestones to be met for various time frames
4. Monitoring needs and efforts required to evaluate milestones
5. Remedial actions to take if milestones are not met
6. Notes section

Report Cards were developed for each of the six plan goals and are located at the end of this section. The milestones are based on "Short Term" (1-10 years) and "Long Term" (10-20+ years) objectives. Grades for each milestone term should be calculated using the following scale:

- 80%-100% of milestones met = A
- 60%-79% of milestones met = B
- 40%-59% of milestones met = C
- < 40% of milestones met = failed

Report Cards should be used to identify and track plan implementation over time to ensure that progress is being made towards achieving the plan goals and to make corrections as necessary. Lack of progress could be demonstrated in factors such as monitoring that shows no improvement, new environmental problems, lack of technical assistance, or lack of funds. In these cases, the Report Card user should explain why other factors resulted in milestones not being met in the notes section of the Report Card.

Early on in the plan implementation process, the Crystal Creek Steering Watershed Committee should assign or hire a Watershed Implementation Coordinator to update the committee on plan implementation progress by way of the Report Cards. If needed, adaptive management should be implemented accordingly by referencing the adaptive management recommendations on each Report Card then developing a strategy to either change the milestone(s) or decide how to implement projects or actions to achieve the milestone(s).

Goal 1 Report Card

Assess and improve policies and regulations to protect and support our natural resources.

Current Condition:

Protection of natural resources and green infrastructure during future urban growth will be important for the future health of Crystal Creek watershed. Watershed partners completed Center for Watershed Protection Ordinance Review worksheets to assess their individual ordinances and determine where improvements might be made in protecting water quality and natural resources. Five Priority Protection Areas were also found in the watershed where additional guidance and ordinances will be crucial in the future. If and when any of the areas are developed, development should follow Conservation Design or Low Impact Development (LID) standards and guidelines to help maintain and improve water quality and watershed conditions

Criteria/Targets to Meet Goal Objectives:

- Number of local governments support and adopt the Crystal Creek Watershed-Based Plan.
- Number of additional local governments that adopt the Crystal Lake Watershed Stormwater Management Design Manual.
- Number of local governments that include the Green Infrastructure Network in comp. plans and development review maps.
- Number of local governments that incorporate Conservation Design or LID standards for all green infrastructure parcels where new development is planned on Priority Protection Areas.
- Number of local governments that institute Watershed Protection Fees, Development Impact Fees, or Special Service Area taxes for all new development to fund management of the Green Infrastructure Network.

Goal/Objective Milestones: **Grade**

1-10 Yrs: (Short)	1. All local governments adopt the Crystal Creek Watershed-Based Plan. 2. At least one local government adopts Crystal Lake Watershed Stormwater Management Design Manual or similar. 3. At least half of municipalities include Priority Green Infrastructure Protection Areas and Critical Area GIN in comp. plans and development review maps. 4. At least half of local governments adopt conservation design or LID where new development is planned on Priority Green Infrastructure Protection Areas.Educational signage is installed in at least three locations in the watershed. 5. At least half of developers protect sensitive natural areas, restore degraded natural areas and streams as part of the development process and donate them with dedicated funding for management.	
10-20 Yrs: (Long)	1. All local government adopts Crystal Lake Watershed Stormwater Management Design Manual or similar. 2. All municipalities include Priority Green Infrastructure Protection Areas and Critical Area GIN in comp. plans and development review maps. 3. All municipalities adopt conservation design or LID where new development is planned on Priority Green Infrastructure Protection Areas. 4. At least 75% of developers protect sensitive natural areas, restore degraded natural areas and streams as part of the development process and donate them with dedicated funding for management.	

Monitoring Needs/Efforts:

- Track number of local governments support and adopt the Crystal Creek Watershed-Based Plan.
- Track number of local governments that adopt Crystal Lake Watershed Stormwater Management Design Manual or similar.
- Track number of local governments that include Priority Green Infrastructure Protection Areas and Critical Area GIN in comp. plans and development review maps.
- Track number of local governments that incorporate Conservation Design or LID standards for all green infrastructure parcels where new development is planned on Priority Protection Areas.
- Track number of sensitive natural areas protected, restored and managed as part of new development standards.

Remedial Actions:

- Meet with public officials and municipal staff to discuss the importance of updating ordinances, conservation design, LID, and Watershed Protection Fees.
- Assess progress towards policy goals and target specific weak areas in education and outreach.

Notes:

Grade Evaluation: 80%-100% met = A; 60%-79% met = B; 40%-59% met = C; and < 40% = failed.

Goal 2 Report Card

Improve surface water quality.

Current Condition:

The Illinois EPA (IEPA) lists Crystal Creek as impaired for the Designated Use of Primary Contact Recreation. Available water quality and habitat data for Crystal Creek and its tributaries indicates moderate overall impairment. Total phosphorus (TP), total nitrogen (TP), total suspended solids (TSS) and fecal coliform (and/or *E. coli*) are the primary impairments for Crystal Creek and tributaries. IEPA determined that neither Crystal Lake or Three Oaks North and South Lakes are impaired. The watershed-wide average reading at DTZR-02 was 0.173 mg/l of total phosphorus, 5.032 mg/l of total nitrogen, and 25.3 mg/l of total suspended solids. For bacteria, FRSG's fecal coliform data is the most robust data source, which depicts a watershed-wide average of 402.8 CFU/100ml.

Criteria/Targets to Meet Goal Objectives:

- Linear Feet of Restored Stream
- # of Lake Lots with Natural Buffers
- # of Detention Basin Retrofits
- # of Acres in No-Till
- # of Acres in pasture rotation and strategic fencing
- Water Quality Standards: <19 mg/l TSS, <2.461 mg/l TN. and <0.0725 mg/l TP in stream samples.
- Biotic Indexes: Macroinvertebrate communities achieve at least "Fair" resource quality.
- Social Indicator: % of surveyed stakeholders that understand water quality benefits of various BMPs.

Goal/Objective Milestones:

		Grade
1-10 Yrs: (Short)	1. 25% (roughly 1.2 miles) of "Critical Area" stream restoration projects implemented. 2. 0.4 miles of stream daylighted and restored (CCR04). 3. 10% of lake lot owners install natural buffers. 4. 25% of "Critical Area" detention basins retrofitted. 5. 50% (397 acres) of row crop farming in no-till. 6. 100% (68 acres) of pastures implement rotation and strategic fencing.25% of "Critical Area" detention basins retrofitted. 7. 25% of stream water samples and macroinvertebrate samples show improvement from 2020 baseline data. 8. 25-50% of surveyed stakeholders understand BMP benefits.	
10-20 Yrs: (Long)	1. 50% (roughly 12,693 linear feet) of "Critical Area" stream restoration projects implemented. All 32 riparian buffers along priority stream reaches are enhanced. 2. 25% of lake lot owners install natural buffers. 3. 50% of "Critical Area" detention basins retrofitted. 4. 100% (793 acres) of row crop farming in no-till. 5. 50% of stream water samples and macroinvertebrate samples show improvement from 2020 baseline data. 6. 50-75% of surveyed stakeholders understand BMP benefits.	

Monitoring Needs/Efforts:

- Water chemistry and macroinvertebrate samples continue indefinitely to track changes in water quality.
- Track # of stream, shoreline, and detention retrofit projects implemented.
- Track acres of row crop farmland practicing no-till and number of pastures area using sustainable practices.
- Produce stakeholder survey related to BMPs and benefits.

Remedial Actions:

- Assess number of projects and actions that have been implemented versus water quality changes to determine if projects are effectively removing pollutants.
- Work with IEPA, McHenry County SWCD, and others identified to find funding for projects.
- Appropriate entities prepare budgets for implementing projects.
- Meet with applicable landowners to educate them on need for managing land for water quality benefits.

Notes:

Grade Evaluation: 80%-100% met = A; 60%-79% met = B; 40%-59% met = C; and < 40% = failed.

Goal 3 Report Card

Protect groundwater quantity and quality and improve groundwater recharge.

Current Condition:

Sensitive Aquifer Recharge Areas: 2,700 acres (22%) are “Low to Moderate” sensitivity, 1,911 acres (16%) are “Moderately High” sensitivity, and 7.426 acres (62%) are “High” potential for aquifer recharge sensitivity. ISWS modeling shows significantly lower levels of stream discharge (-40% to -60%) and significant shallow bedrock aquifer drawdown (70 to 100 feet) by 2049 compared to predevelopment conditions.

Criteria/Targets to Meet Goal Objectives:

- % of Sensitive Aquifer Recharge Areas (SARA) developed or re-developed using model policies in county “Groundwater Protection Plans”.
- # of Green Infrastructure Networks parcels proposed for development or re-development using conservation design or low impact development.

Goal/Objective Milestones:

		Grade
1-10 Yrs: (Short)	1. All municipalities adopt policy that protects Sensitive Aquifer Recharge Areas (SARA). 2. At least half of new and re-development in SARAs is developed using County policies. 3. At least half of all new and re-development in GIN using low impact development or conservation design.	
10-20 Yrs: (Long)	1. All municipalities adopt policy that protects Sensitive Aquifer Recharge Areas (SARA). 2. All new and re-development in SARAs is developed using County policies. 3. All new and re-development in GIN using low impact development or conservation design.	

Monitoring Needs/Efforts:

- Track # of new and redevelopments in SARAs that apply County policies.
- Track # of parcels in GIN using low impact development or conservation design.

Remedial Actions:

- Review policy changes made to protect Sensitive Aquifer Recharge Areas (SARS).
- Educate municipal representatives on the importance of County SARA policies.
- Educate municipal representatives on the importance of low impact development and conservation design.

Notes:

Grade Evaluation: 80%-100% met = A; 60%-79% met = B; 40%-59% met = C; and < 40% = failed.

Goal 4 Report Card

Protect, manage, and restore natural components of the Green Infrastructure Network and improve fish and wildlife habitat.

Current Conditions:

The historic landscape consisted of prairies, savannas, and wetlands prior to European settlement in the 1830s. Following European settlement, fires rarely occurred, prairies were tilled for farmland or developed, wetlands were drained, and several streams were channelized. Several "Ecologically Significant Areas" remain, including LITH Fen, Lippold Park, Three Oaks Recreation Area, and Towne Park.

- 54% of stream length is moderately to high channelized; 62% of stream length is moderately to highly eroded.
- 35% of riparian corridors in poor ecological condition; 61% in average to good condition.
- 49 total detention basins, 12% provide "Good" ecological and water quality benefits, 55% provide "Average" benefits, 33% of basins provide "Poor" ecological/water quality benefits.

Criteria/Targets to Meet Goal Objectives:

- # of acres of conservation development that occur on Priority Protection Areas.
- # of degraded natural areas acres at Lippold Park with management plans that are implemented.
- # of linear feet of stream at LITH Fen stabilized with check dams.
- # of acres of good ecological condition riparian buffers under long term management.
- # of acres restored and maintained at Four Colonies Park.
- # of natural area acres at Wedgewood Subdivision & Three Oaks Recreation Area under long term management.
- # of wetland, stream, and buffer acres at LITH Sanitary District restored and managed.
- # of existing/well established naturalized detention basins under long term management.

Goal/Objective Milestones:		Grade
1-10 Yrs: (Short)	1. All development on PPAs uses conservation design elements. 2. 50% of degraded natural areas at Lippold Park with management plans that are implemented. 3. All of stream reach within LITH fen stabilized with check dams. 4. All riparian areas that are in good ecological condition under long term management. 5. 3.3 acres at Four Colonies Park restored and managed. 6. All acresat Wedgewood Subdivision & Three Oaks Recreation Area under long term management. 7. All 9.4 applicable acres at LITH Sanitary District restored and under long term management. 8. All existing/well established detention basins under long term management.	
10-20 Yrs: (Long)	1. All development on PPAs uses conservation design elements. 2. 100% of degraded natural areas at Lippold Park with management plans that are implemented.	

Monitoring Needs/Efforts:

- Track acres of development within PPAs that uses conservation design elements.
- Applicable entities track number of acres at Lippold Park, Four Colonies Park, Wedgewood Subdivision, Three Oaks Recreation Area, LITH Sanitary District that plan and implement ecological restoration.

Remedial Actions:

- Locate and track grants that are being submitted for recommended stream, wetland, detention basin, and other projects and determine success rate.
- Public entities prepare annual budgets for restoring habitat and leverage mitigation dollars from proposed road expansions.
- Assist private detention basin owners with selecting ecological management companies and potential funding sources.

Notes:

Grade Evaluation: 80%-100% met = A; 60%-79% met = B; 40%-59% met = C; and < 40% = failed.

Goal 5 Report Card

Manage and mitigate for existing and future structural flood problems.

Current Condition:

- Six documented Flood Problem Areas (FPAs) were identified in the watershed.
- SMUs 1, 2, and 6 determined to be Highly Vulnerable to future development and associated impervious cover.

Criteria/Targets to Meet Goal Objectives:

- Annual inspection of dam/water control structures at Crystal Lake, Scott Lake, and Goose Lake by CL and LITH.
- % of new development that incorporates impervious reduction stormwater BMPs within SMUs 1, 2, and 6.
- # of identified FPAs that are mitigated for.

Goal/Objective Milestones:

		Grade
1-10 Yrs: (Short)	1. Dams/water control structures at Crystal Lake, Scott Lake, and Goose Lake inspected by annually by Crystal Lake and LITH. 2. All Priority Protection Areas are developed using conservation design or low impact development practices. 3. Mitigate flooding for 33% of FPAs.	
10-20 Yrs: (Long)	1. Dams/water control structures at Crystal Lake, Scott Lake, and Goose Lake inspected by annually by Crystal Lake and LITH. 2. All Priority Protection Areas are developed using conservation design or low impact development practices. 3. Mitigate flooding for 66% of FPAs.	

Monitoring Needs/Efforts:

- Track number of inspections of dam/water control at Crystal Lake, Scott Lake, and Goose Lake.
- Track number of stream projects that include floodplain reconnection.
- Track number of new developments that incorporate impervious reduction stormwater BMPs.
- Track number of mitigated Flood Problem Areas

Remedial Actions:

- Reassess municipal policy related to requiring impervious reduction stormwater BMPs in sensitive areas.
- Follow up with visits to Flood Problem Areas during flood events to determine if additional remedial work is needed.

Notes:

Grade Evaluation: 80%-100% met = A; 60%-79% met = B; 40%-59% met = C; and < 40% = failed.

Goal 6 Report Card

Build stakeholder awareness of watershed issues through education and stewardship while increasing communication and coordination among stakeholders.

Current Conditions:

The Crystal Creek watershed leading stakeholders/partners - City of Crystal Lake, Village of Algonquin, Village of Lake-in-the-Hills, Village of Lakeview, and Crystal Lake Park District, became concerned for the health of the watershed and formed the Crystal Creek Watershed Steering Committee. The partnership believes that the process of creating and implementing this Watershed-Based Plan will unite stakeholders, help them understand the issues and opportunities facing the watershed, and initiate projects that improve watershed conditions. The partners are actively engaging the public in watershed activities such as: educating private landowners about how to manage their land for green infrastructure benefit, providing local schools with information about Crystal Creek watershed to support outdoor curriculums, and providing educational information about flood prevention.

Criteria/Targets to Meet Goal Objectives:

- Number of stakeholders informed about the Crystal Creek Watershed-Based Plan.
- Number of Education Actions completed from Information & Education Campaign Matrix.
- Number of riparian landowners that are informed about healthy land management for green infrastructure benefit.
- Number of public officials that support conservation design and low impact development ordinance language changes.

Goal/Objective Milestones:

		Grade
1-10 Yrs: (Short)	1. At least 15 stakeholders attend Crystal Creek watershed educational meetings. 2. At least half of Education Actions completed from Information & Education Campaign. 3. At least 25% of riparian landowners are educated about healthy land management. 4. At least one municipality adopts conservation design and LID within their ordinances.	
10-20 Yrs: (Long)	1. At least 30 stakeholders attend Crystal Creek watershed educational meetings. 2. All Education Actions completed from Information & Education Campaign. 3. At least 50% of riparian landowners are educated about healthy land management. 4. At least 3 municipalities or the county adopt conservation design, LID within their ordinances.	

Monitoring Needs/Efforts:

- Track number of stakeholders attending Crystal Creek watershed educational meetings.
- Track number of Education Actions completed from Information & Education Campaign
- Track amount of information targeted to riparian landowners.
- Track number of public officials with each municipality that support conservation design and low impact development.

Remedial Actions:

- Ask partners for additional help and/or funding to implement the watershed plan and Information & Education Campaign.
- Meet with public officials to discuss the importance of conservation design and LID ordinance changes.
- Actively recruit stakeholders to attend watershed education campaigns.

Notes:

Grade Evaluation: 80%-100% met = A; 60%-79% met = B; 40%-59% met = C; and < 40% = failed.

9.0 Literature Cited

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10.0 Glossary

100-year floodplain: A 100-year flood is a flood that has a 1-percent chance of being equaled or exceeded in any given year. A base flood may also be referred to as a 100-year storm and the area inundated during the base flood is called the 100-year floodplain.

303(d) Impaired Waters: The Federal Clean Water Act requires states to submit a list of impaired waters to the USEPA for review and approval using water quality assessment data from the Section 305(b) Water Quality Report. States are then required to develop total maximum daily load analyses (TMDLs) for waterbodies on the 303(d) list.

305(b): The Illinois 305(b) report is a water quality assessment of the state's surface and groundwater resources that is compiled by the IEPA as a report to the USEPA as required under Section 305(b) of the Clean Water Act.

ADID wetlands: Wetlands that were identified through the Advanced Identification (ADID) process. Completed in 1992, the ADID process sought to identify wetlands that should be protected because of their high functional value. The three primary functions evaluated were:

1. Ecological value based on wildlife habitat quality and plant species diversity;
2. Hydrologic functions such as stormwater storage value and/or shoreline/bank stabilization value; and
3. Water quality values such as sediment/toxicant retention and/or nutrient removal/transformation function.

Applied Ecological Services Inc. (AES): A broad-based ecological consulting, contracting, and restoration firm that was founded in 1978. The company consists of consulting ecologists, engineers, landscape architects, planners, and contracting staff. The mission of AES is to bring wise ecological decisions to all land use activities.

Aquatic habitat: Structures such as stream substrate, woody debris, aquatic vegetation, and overhanging vegetation that is important to the survival of fish and macroinvertebrates.

Aquifer: A layer of permeable rock, sand, or gravel through which ground water flows, containing enough water to supply wells and springs.

Base flow: The flow that a perennially flowing stream reduces to during the dry season. It is often supported by groundwater seepage into the channel.

Bedrock: The solid rock that underlies loose material, such as soil, sand, clay, or gravel.

Best Management Practices (BMPs): See Management Measures

Biodiversity: The variety of organisms (plants, animals and other life forms) that includes the totality of genes, species and ecosystems in a region.

Bioengineering (or Soil Bioengineering): Techniques for stabilizing eroding or slumping stream banks that rely on the use of plants and plant materials such as live willow posts, brush layering, coconut logs and other "greener" or "softer" techniques. This is in contrast to techniques that rely on creating "hard" edges with riprap, concrete and sheet piling (metal and plastic).

Bio-infiltration: Excavated depressional areas where stormwater runoff is directed and allowed to infiltrate back into groundwater rather than allowing to runoff. Infiltration areas are planted with appropriate vegetation.

Center for Watershed Protection (CWP): Non-profit 501(c)3 corporation founded in 1992 that provides local governments, activists, and watershed organizations around the country with the technical tools for protecting some of the nation's most precious natural resources such as streams, lakes and rivers.

Certified Municipalities: A municipality that is certified to enforce the provisions of local stormwater ordinances. The municipality's designated Enforcement Officer enforces the provisions in the Ordinance.

Channelized stream: A stream that has been artificially straightened, deepened, or widened to accommodate increased stormwater flows, to increase the amount of adjacent land that can be developed or used for urban development, agriculture or for navigation purposes

Conservation development: A development designed to protect open space and natural resources for people and wildlife while at the same time allowing building to continue. Conservation design developments sometimes designate half or more of the buildable land area as undivided permanent open space.

Conservation easement: The transfer of land use rights without the transfer of land ownership. Conservation easements can be attractive to property owners who do not want to sell their land now but would support perpetual protection from further development. Conservation easements can be donated or purchased.

Clean Water Act (CWA): The CWA is the basic framework for federal water pollution control and has been amended in subsequent years to focus on controlling toxics and improving water quality in areas where compliance with nationwide minimum discharge standards is insufficient to meet the CWA's water quality goals.

Debris jam: Natural and man-made debris in a stream channel including leaves, logs, lumber, trash and sediment.

Designated Use: Appropriate uses are identified by taking into consideration the use and value of the water body for public water supply, for protection of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes. In designating uses for a water body, States and Tribes examine the suitability of a water body for the uses based on the physical, chemical, and biological characteristics of the water body, its geographical setting and scenic qualities, and economic considerations.

Detention basin: A man-made structure for the temporary storage of stormwater runoff with controlled release during or immediately following a storm.

Digital Elevation Model (DEM): Regularly spaced grid of elevation points used to produce elevation maps.

Discharge (streamflow): The volume of water passing through a channel during a given time, usually measured in cubic feet per second.

Dissolved oxygen (DO): The amount of oxygen in water, usually measured in milligrams/liter.

Downcutting: The action of a stream to deepen itself, often as a result of channelization.

Downspout disconnection: The process of disconnecting the downspout from a pipe or the paved area. Water is then redirected to flow into a rain barrel or to a lawn or garden where it can soak into the ground.

Ecology: The scientific study between living organisms and their interactions with their natural or developed environment, other organisms, and their abiotic environment.

Ecosystem: An ecological community together with its environment, functioning as a unit.

Erosion: Displacement of soil particles on the land surface due to water or wind action.

European settlement: A period in the early 1800s when European settlers moved across the United States in search of better lives. During this movement, much of the historical communities were altered for farming and other types of development.

Eutrophic: A waterbody having a high level of biological productivity. A typical eutrophic waterbody either has many aquatic plants and is clear or has few plants and is less clear. Both situations have potential to support many fish and wildlife.

Federal Emergency Management Agency (FEMA): Government agency within the Department of Homeland Security that responds to, plans for, recovers from, and mitigates against disasters/ emergencies, both natural and man-made.

Fee-in-lieu: Defined by the USACE and EPA as a payment "to a natural resource management entity for implementation of either specific or general wetland or other aquatic resource development projects" for projects that "do not typically provide compensatory mitigation in advance of project impacts."

Fen: Peat-forming wetlands that receive nutrients from sources other than precipitation: usually from upslope sources through drainage from surrounding mineral soils and from groundwater movement. Fens are characterized by their water chemistry which is neutral or alkaline with relatively high dissolved mineral levels.

Filamentous algae: Simple one-celled or multi-celled organisms (usually aquatic) capable of photosynthesis that are an indicator of high nutrient levels in the water column.

Filter strip: A long narrow portion of vegetation used to retard water flow and collect sediment for the protection of watercourses, reservoirs or adjacent properties.

Flash hydrology/flooding: A quickly rising and falling overflow of water in stream channels that is usually the result of increased amounts of impervious surface in the watershed.

Flood problem area (FPA): One or more buildings, roads or other infrastructure in one location that are repeatedly damaged by flooding.

Flow Regime: The pattern of flow variability for a particular river or region.

Floodplain (100-year): Land adjoining the channel of a river, stream, watercourse, lake or wetland that has been or may be inundated by floodwater during periods of high water that exceed normal bank-full elevations. The 100-year floodplain has a probability of 1% chance per year of being flooded.

Floodproofing: Any combination of structural and non-structural additions, changes or adjustments to structures or property which reduce or eliminate flood damage to real estate or improved real property, water and sanitary facilities, structures and contents.

Floodway: The floodway is the portion of the stream or river channel that includes the adjacent land areas that must be reserved to discharge the 100-year flood without increasing the water surface.

Geographic Information System (GIS): A computer-based approach to interpreting maps and images and applying them to problem-solving.

Geology: The scientific study of the structure of the Earth or another planet, especially its rocks, soil, and minerals, and its history and origins.

Global Positioning System (GPS): Satellite mapping system that enables locators and mapping to be created via satellite.

Green infrastructure network: An interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands, farms, and forests of conservation value; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life.

Greenways: A protected linear open space area that is either landscaped or left in its natural condition. It may follow a natural feature of the landscape such as a river or stream, or it may occur along an unused railway line or some other right of way. Greenways also provide wildlife corridors and recreational trails.

Groundwater recharge: Primary mechanism for aquifer replenishment which ensures future sources of groundwater for commercial and residential use.

Headwaters: Upper reaches of streams and tributaries in a watershed.

HUC Code: A hydrologic unit code (HUC) that refers to the division and subdivision of U.S. watersheds. The hydrologic units are arranged or nested within each other, from the largest geographic area (regions) to the smallest geographic area (cataloging units).

Hydraulic and Hydrologic modeling: Engineering analysis that predicts expected flood flows and flood elevations based on land characteristics and rainfall events.

Hydraulic structures: Low head dams, weirs, bridges, levees, and any other structures along the course of the river.

Hydric soil: Soil units that are wet frequently enough to periodically produce anaerobic conditions, thereby influencing the species composition or growth, or both, of plants on those soils.

Hydrologic Soil Groups (HSG): Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. A's generally have the smallest runoff potential and D's the greatest.

Hydrology: The scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hydrophytic vegetation: Plant life growing in water, soil or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content; one of the indicators of a wetland.

Illinois Department of Natural Resources (IDNR): A government agency established to manage, protect and sustain Illinois' natural and cultural resources; provide resource-compatible recreational opportunities and to promote natural resource-related issues for the public's safety and education.

Illinois Department of Transportation (IDOT): The Illinois Department of Transportation focuses primarily on the state's policies, goals and objectives for Illinois' transportation system and provides an overview of the department's direction for the future.

Illinois Environmental Protection Agency (IEPA): Government agency established to safeguard environmental quality, consistent with the social and economic needs of the State, so as to protect health, welfare, property and the quality of life.

Illinois Natural Areas Inventory (INAI): A survey conducted by the Illinois Department of Natural Resources to catalogue high quality natural areas, threatened and endangered species and unique plant, animal and geologic communities for the purpose of maintaining biodiversity.

Illinois Nature Preserves: State-protected areas that are provided the highest level of legal protection and have management plans in place.

Illinois Pollution Control Board (IPCB): An independent agency created in 1970 by the Environmental Protection Act. The Board is responsible for adopting Illinois' environmental regulations and deciding contested environmental cases.

Impervious Cover Model: Simple urban stream classification model based on impervious cover and stream quality. The classification system contains three stream categories, based on the percentage of impervious cover that predicts the existing and future quality of streams based on the measurable change in impervious cover. The three categories include sensitive, impacted, and non-supporting.

Impervious cover/surface: An area covered with solid material or that is compacted to the point where water cannot infiltrate underlying soils (e.g. parking lots, roads, houses, patios, swimming pools, tennis courts, etc.). Stormwater runoff velocity and volume can increase in areas covered by impervious surfaces.

Incised channel: A stream that has degraded and cut its bed into the valley bottom; indicates accelerated and often destructive erosion.

Index of Biotic Integrity (IBI): An index used to evaluate the heath of a stream based on the fish community present.

Infiltration: Portion of rainfall or surface runoff that moves downward into the subsurface soil.

Integrated Report: A bi-annual report combining the 303(d) Impaired Waters and 305(b) reports.

Invasive vegetation/plant: Plant species that are not native to an area and tend to out-compete native species and dominate an area (e.g. European buckthorn or garlic mustard).

Low Impact Development: Comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds.

Macroinvertebrate (aquatic): Invertebrates that can be seen by the unaided eye (macro). Most benthic invertebrates in flowing water are aquatic insects or the aquatic stage of insects, such as stonefly nymphs, mayfly nymphs, caddisfly larvae, dragonfly nymphs and midge larvae. They also include such things as clams and worms. The presence of benthic macroinvertebrates that are intolerant of pollutants is a good indicator of good water quality.

Macroinvertebrate Biotic Index (MBI): Method used to rate water quality using macroinvertebrate taxa tolerance to organic pollution in streams.

Management Measures: Also known as Best Management Practices (BMPs) are non-structural practices such as site planning and design aimed to reduce stormwater runoff and avoid adverse development impacts - or structural practices that are designed to store or treat stormwater runoff to mitigate flood damage and reduce pollution. Some BMPs used in urban areas may include stormwater detention ponds, restored wetlands, vegetative filter strips, porous pavement, silt fences and biotechnical streambank stabilization.

Marsh: An area of soft, wet, low-lying land, characterized by grassy vegetation and often forming a transition zone between water and land.

Meander (stream): A sinuous channel form in flatter river grades formed by the erosion on one side of the channel (pools) and deposition on the other (point bars).

Mitigation: Measures taken to eliminate or minimize damage from development activities, such as construction in wetlands or Regulatory Floodplain filling, by replacement of the resource.

Moraine (terminal): A ridge-like accumulation of till and other types of drift that was produced at the outer margin or farthest advance, of a retracting glacier.

Municipal Separate Stormwater Systems (MS4's): A system that transports or holds stormwater, such as catch basins, curbs, gutters, ditches, man-made channels, pipes, tunnels, and or/ storm drains before discharging into local waterbodies.

National Pollutant Discharge Elimination System (NPDES Phase II): Clean Water Act law requiring smaller communities and public entities that own and operate a Municipal Separate Storm Sewer System (MS4) to apply and obtain an NPDES permit for stormwater discharges. Permittees at a minimum must develop, implement, and enforce a stormwater program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable. The stormwater management program must include these six minimum control measures:

1. Public education and outreach on stormwater impacts
2. Public involvement/participation
3. Illicit discharge detection and elimination
4. Construction site stormwater runoff control
5. Post-construction stormwater management in new development and redevelopment
6. Pollution prevention/good housekeeping for municipal operations

National Wetland Inventory (NWI): U.S. Fish and Wildlife Service study that provides information on the characteristics, extent, and status of U.S. wetlands and deep-water habitats and other wildlife habitats.

Native Landscaping: A landscape that contains plants or plant communities that are indigenous to a particular region.

Native vegetation/plants: Plant species that have historically been found in an area.

Nitrogen: A colorless, odorless unreactive gas that forms about 78% of the earth's atmosphere. The availability of nitrogen in soil is important for ecosystem processes.

Natural community/area: an assemblage of plants and animals interacting with one another in a particular ecosystem.

No-net-loss: A policy for wetland protection to stem the tide of continued wetland losses. The policy has generated requirements for wetland mitigation so that permitted losses due to filling and other alterations are replaced and the net quality wetland acreage remains the same.

Nonpoint source pollution (NPS pollution): Refers to pollutants that accumulate in waterbodies from a variety of sources including runoff from the land, impervious surfaces, the drainage system and deposition of air pollutants.

Nutrients: Substances needed for the growth of aquatic plants and animals such as phosphorous and nitrogen. The addition of too many nutrients (such as from sewage dumping and over fertilization) will cause problems in the aquatic ecosystem through excess algae growth and other nuisance vegetation.

Open space parcel: Any parcel of land that is not developed and is often set aside for conservation or recreation purposes

Partially open parcel: Parcels that have been developed to some extent, but still offer some opportunities for open space and Best Management Practice (BMP) implementation.

Phosphorus: A nonmetallic element that occurs widely in many combined forms especially as inorganic phosphates in minerals, soils, natural waters, bones, and teeth and as organic phosphates in all living cells.

Point source pollution: Refers to discharges from a single source such as an outfall pipe conveying wastewater from an industrial plant or wastewater treatment facility.

Policy: A high-level overall plan embracing the general goals and acceptable procedures especially of a governmental body.

Pollutant load: The amount of any pollutant deposited into waterbodies from point source discharges, combined sewer overflows, and/or stormwater runoff.

Pool: A location in an active stream channel usually located on the outside bends of meanders, where the water is deepest and has reduced current velocities.

Prairie: A type of grassland characterized by low annual moisture and rich black soil characteristics.

Preventative measures: Actions that reduce the likelihood that new watershed problems such as flooding or pollution will arise, or that those existing problems will worsen. Preventative techniques generally target new development in the watershed and are geared toward protecting existing resources and preventing degradation.

Principles of Soil Health: The soil health foundation consists of five principles: 1) Soil armor; 2) minimizing soil disturbance; 3) plant diversity; 4) continual live plant/foot; and 5) livestock integration. These principles are intended to be applied in a systems approach, maximizing the soil building impact.

Programmatic Action: A series of steps to be carried out or goals to be accomplished.

Protection Area: Chicago Metropolitan Agency for Planning (CMAP) defines a "Protection Area" as an area that represents subsections of a watershed that have valuable characteristics; valuable either in the sense that (1) they contain resources and characteristics that may need to be protected and/or (2) property ownership or land use characteristics make the subsection a strong candidate for action (CMAP 2007).

Rain gage station: Point along a stream where the amount of water flowing in an open channel is measured. The USGS makes most streamflow measurements by current meter. A current meter is an instrument used to measure the velocity of flowing water. By placing a current meter at a point in a stream and counting the number of revolutions of the rotor during a measured interval of time, the velocity of water at that point is determined.

Rainwater Harvesting: The accumulation and storing of rainwater for reuse before it reaches an aquifer.

Recovering stream: A stream that is naturally regaining streambank equilibrium according to the Stream Evolution Model, wherein the stream naturally cycles through widening, deposition, and stabilization of its banks.

Regenerative agriculture: Farming and grazing practices that, among other benefits, reverse climate change by rebuilding soil organic matter and restoring degraded soil biodiversity – resulting in both carbon drawdown and improving the water cycle.

Regulatory floodplain: Regulatory Floodplains may be either riverine or non-riverine depressional areas. Projecting the base flood elevation onto the best available topography delineates floodplain boundaries. A flood prone area is Regulatory Floodplain if it meets any of the following descriptions:

1. Any riverine area inundated by the base flood where there is at least 640 acres of tributary drainage area.
2. Any non-riverine area with a storage volume of 0.75 acre-foot or more when inundated by the base flood.
3. Any area indicated as a Special Flood Hazard Area on the FEMA Flood Insurance Rate Map expected to be inundated by the base flood located using best available topography.

Regulatory floodway: The channel, including on-stream lakes, and that portion of the Regulatory Floodplain adjacent to a stream or channel as designated by the Illinois Department of Natural Resources-Office of Water Resources, which is needed to store and convey the existing and anticipated future 100-year frequency flood discharge with no more than a 0.1 foot increase in stage due to the loss of flood conveyance or storage, and no more than a 10% increase in velocities. Where interpretation is needed to determine the exact location of the Regulatory Floodway boundary, the IDNR-OWR should be contacted for the interpretation.

Remnant: a small fragmented portion of the former dominant vegetation or landscape which once covered the area before being cleared for human land use.

Retrofit: Refers to modification to improve problems with existing stormwater control structures such as detention basins and conveyance systems such as ditches and stormsewers. These structures were originally designed to improve drainage and reduce flood risk, but they can also be retrofitted to improve water quality.

Ridge: A line connecting the highest points along a landscape and separating drainage basins or small-scale drainage systems from one another.

Riffle: Shallow rapids, usually located at the crossover in a meander of the active channel.

Riparian: Referring to the riverside or riverine environment next to the stream channel, e.g., riparian, or streamside, vegetation.

Runoff: The portion of rain or snow that does not percolate into the ground and is discharged into streams by flowing over the ground instead.

Savanna: A type of woodland characterized by open spacing between its trees and by intervening grassland.

Sediment: Soil particles that have been transported from their natural location by wind or water action.

Sedimentation: The process that deposits soils, debris and other materials either on other ground surfaces or in bodies of water or watercourses.

Seep: A moist or wet place where groundwater reaches the earth's surface from an underground aquifer.

Socioeconomics: Field of study that examines social and economic factors to better understand how the combination of both influences something.

Special Service Area (SSA) Tax: Special taxing districts in municipalities that are established by ordinance, often at the request of developers of new housing subdivisions, in order to pass on the costs of the streets, landscaping, water lines, and sewer systems to homeowners who reside within.

Stakeholders: Individuals, organizations, or enterprises that have an interest or a share in a project. (see also Watershed Stakeholders).

Stormsewershed: An area of land whose stormwater drains into a common storm sewer system.

Stormwater management: A set of actions taken to control stormwater runoff with the objectives of providing controlled surface drainage, flood control and pollutant reduction in runoff.

Stormwater Treatment Train: An alternative approach to managing stormwater that uses a series of natural Best Management Practices (BMPs) that are sized, engineered, and ecologically designed for low maintenance. The STT mimics the natural hydrologic cycle by basically creating a landscape design that slowly moves water through natural features that infiltrate, evaporate, filter and clean stormwater. STT elements include rooftop treatments, vegetated swales, parking-lot treatments, landscaping that utilizes stormwater, and open space systems such as parks and rights-of-way.

Stream corridor: The area of land that runs parallel to a stream.

Stream monitoring: Chemical, biological and physical monitoring used to identify the causes and sources of pollution in the river and to determine the needs for reduction in pollutant loads, streambank stabilization, debris removal and habitat improvement.

Stream reach: A stream segment having fairly homogenous hydraulic, geomorphic and riparian cover and land use characteristics (such as all ditched agriculture or all natural and wooded). Reaches generally should not exceed 2,000 feet in length.

Streambank stabilization: Techniques used for stabilizing eroding streambanks.

Substrate (stream): The composition of the bottom of a stream such as clay, silt or sand.

Subwatershed: Any drainage basin within a larger drainage basin or watershed.

Subwatershed Management Unit (SMU): Small unit of a watershed or subwatershed that is delineated and used in watershed planning efforts because the effects of impervious cover are easily measured, there is less chance for confounding pollutant sources, boundaries have fewer political jurisdictions, and monitoring/mapping assessments can be done in a relatively short amount of time.

Swale: A vegetated channel, ditch or low-lying or depressional tract of land that is periodically inundated by conveying stormwater from one point to another. Swales are often used in natural drainage systems instead of stormsewers.

Threatened and Endangered Species (T&E): An “endangered” species is one that is in danger of extinction throughout all or a significant portion of its range. A “threatened” species is one that is likely to become endangered in the foreseeable future.

Till: A heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders deposited directly by and underneath a glacier without stratification.

Topography: The relative elevations of a landscape describing the configuration of its surface. Study and depiction (such as charts or maps) of the distribution, relative positions, and elevations of natural and man-made features of a particular landscape.

Total Maximum Daily Load (TMDL): A TMDL is the highest amount of a particular pollutant discharge a waterbody can handle safely per day.

Total suspended solids (TSS): The organic and inorganic material suspended in the water column and greater than 0.45 micron in size.

Treatment Train: Several Management Measures/Best Management Practices (BMPs) used together to improve water quality, infiltration and reduce sedimentation.

Trophic State Index (TSI): Trophic State is a measure of the degree of plant material in a body of water. It is usually measured using one of several indices (TSI) of algal weight (biomass): water transparency (Secchi Depth), algal chlorophyll, and total phosphorus.

Turbidity: Refers to the clarity of the water, which is a function of how much material including sediment is suspended in the water.

United States Army Corps of Engineers (USACE): Federal group of civilian and military engineers and scientists that provide services to the nation including planning, designing, building and operating water resources and other Civil Works projects. These also include navigation, flood control, environmental protection, and disaster response.

United States Environmental Protection Agency Section 319 (Section 319): Section 319 of the Clean Water Act encourages and funds nonpoint source pollution control projects (any indirect pollution, like runoff, stormwater discharge, road salt, sediment, etc.) or NPS reduction at the source.

United States Geological Survey (USGS): Government agency established in 1879 with the responsibility to serve the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

Urban runoff: Water from rain or snow events that runs over surfaces such as streets, lawns, parking lots and directly into storm sewers before entering the river rather than infiltrating the land upon which it falls.

USDA TR55 Document: A single event rainfall-runoff hydrologic model designed for small watersheds and developed by the USDA, NRCS, and EPA.

Vegetated buffer: An area of vegetated land to be left open adjacent to drainageways, wetlands, lakes, ponds or other such surface waters for the purpose of eliminating or minimizing adverse impacts to such areas from adjacent land areas.

Vegetated swale: An open channel drainageway used along residential streets and highways to convey stormwater and filter pollutants in lieu of conventional storm sewers.

Velocity (of water in a stream): The distance that water can travel in a given direction during a period of time expressed in feet per second.

Wastewater Treatment: Process that modifies wastewater characteristics such as its biological oxygen demand (BOD), chemical oxygen demand (COD), pH, etc. in order to meet effluent or water discharge standards.

Water Chemistry: The nature of dissolved materials (e.g. chlorides or phosphates) in water.

Water Quality Trading: An option for compliance with a water quality-based effluent limitation (WQBEL) in an NPDES permit. EPA's 2003 WQT Policy and 2007 WQT Toolkit for Permit Writers provide guidance to states, interstate agencies, and tribes on how to facilitate trading consistent with the CWA and its implementing regulations.

Waters of the United States (WOUS): For the purpose of this Ordinance the term Waters of the United States refers to those water bodies and wetland areas that are under the U. S. Army Corps of Engineers jurisdiction.

Watershed: An area confined by topographic divides that drains to a given stream or river. The land area above a given point on a waterbody (river, stream, lake, wetland) that contributes runoff to that point is considered the watershed.

Watershed Based Plan: A document that provides assessment and management information for geographically defined watershed, including the analysis, actions, participants, and resources related to development and implementation of the plan.

Watershed partner(s): Key watershed stakeholders who take an active role in the watershed management planning process and implementing the watershed plan.

Watershed Vulnerability Analysis: Rapid planning tool for application to watersheds and subwatersheds that estimates future and impervious cover and provides guidance on factors that might alter the initial classification or diagnosis of a watershed or subwatershed.

Wet meadow/sedge meadow: A type of wetland away from stream or river influence with water made available by general drainage and consisting of non-woody vegetation growing in saturated or occasionally flooded soils.

Wetland: A wetland is considered a subset of the definition of the Waters of the United States. Wetlands are land that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, under normal conditions, a prevalence of vegetation adapted for life in saturated soil conditions (known as hydrophytic vegetation). A wetland is identified based upon the three attributes: 1) hydrology, 2) hydric soils and 3) hydrophytic vegetation.