

2011 Water Quality Management Plan Update

Mukwonago River Watershed, Wisconsin

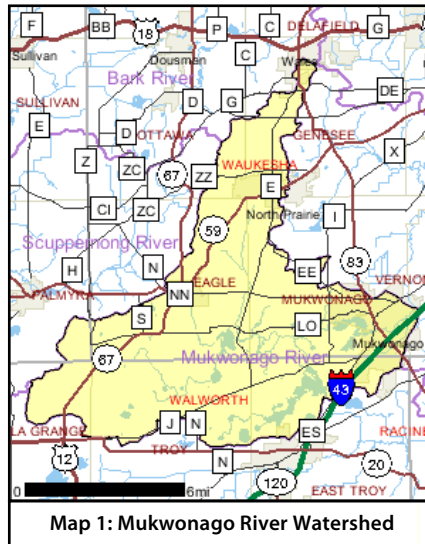
December 2011

The Mukwonago River Watershed is the smallest of the Fox River Basin watersheds (86 square miles) and lies mainly in Walworth and Waukesha counties, with a small portion falling in Jefferson County. The villages of Eagle, Mukwonago, North Prairie, and Wales lie within the watershed.

There are nearly 50 miles of perennial streams in the watershed. Jericho Creek in the Village of Eagle and an unnamed ditch in the Village of Mukwonago are listed as supporting a cold water aquatic community. The Mukwonago River is listed as an Outstanding Resource Water in the state. None of the streams in the watershed are listed as impaired on the 303(d) list.

There are fifteen lakes in the watershed, the largest being Lake Beulah (834 acres) in Walworth County.

This may be the least disturbed watershed in the Southeast Fox River Basin. There are diverse and unique populations of warm water forage fish, game fish, mussels, amphibians, and invertebrates. Development of this watershed has increased rapidly in the past five to ten years. Impervious surfaces are becoming more abundant and stormwater runoff is increasing. Many of the historic areas that supported agriculture are now supporting suburban housing development.



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Watershed Details

Population and Land Use

The majority of the land cover in the Mukwonago River Watershed is agricultural (46%). The remaining rural land uses include forests (26%), wetlands (11%), and open water and open space (10%). Suburban land use only makes up four percent of the total land use in the watershed. Grasslands and urban spaces are even scarcer, with only two percent and one percent of the watershed’s total area, respectively.

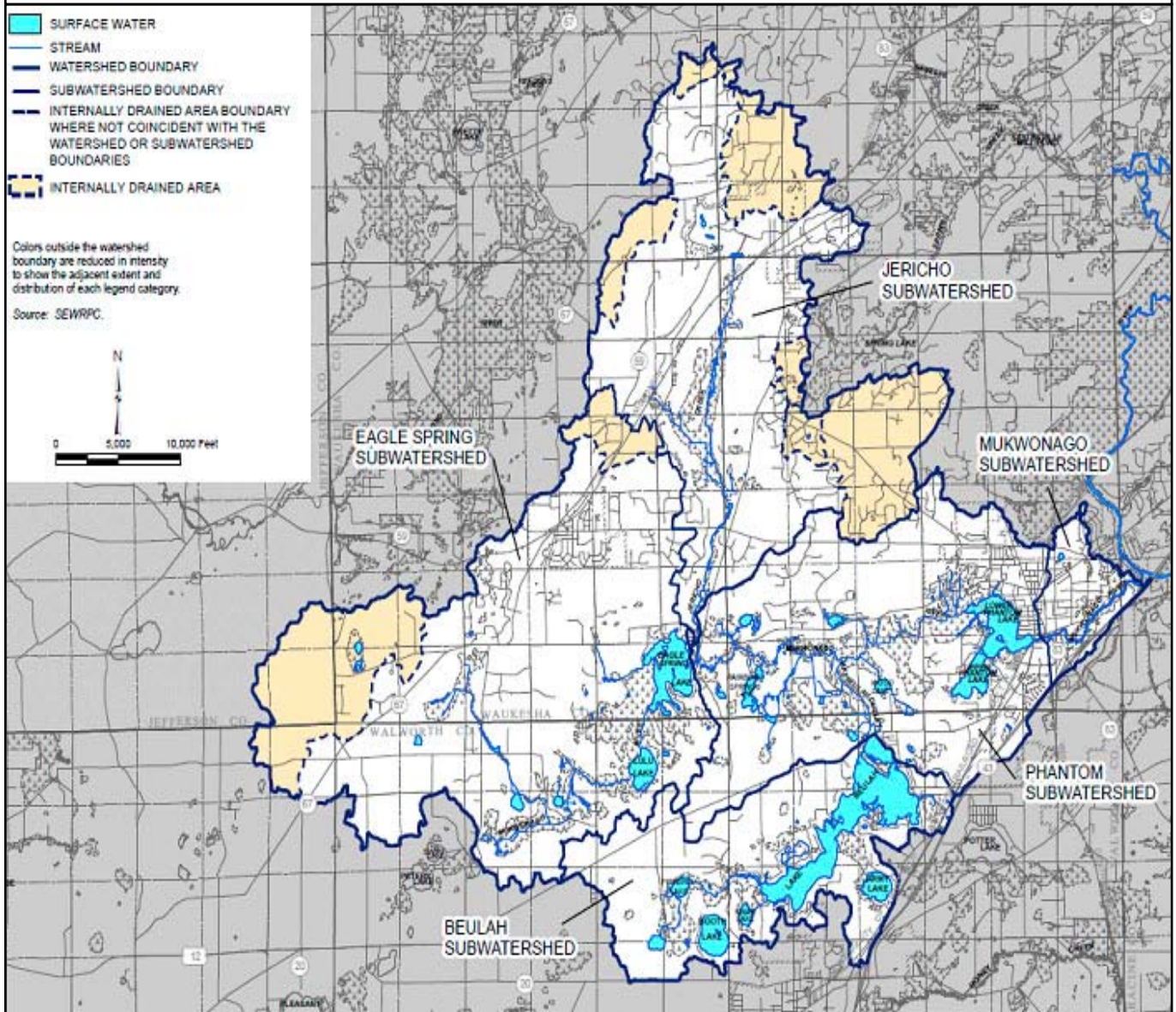
Table 1: Mukwonago River Watershed Land Use

Land Use	Acres	Percent of Area
Agriculture	25,503.13	46.21%
Forest	14,583.10	26.43%
Wetland	5,748.46	10.42%
Open Water & Open Space	5,240.51	9.50%
Suburban	2,322.25	4.21%
Grassland	1,282.77	2.32%
Urban	492.6	0.89%
Barren	10.90	0.02%
Total Acres in Watershed	55,183.72	

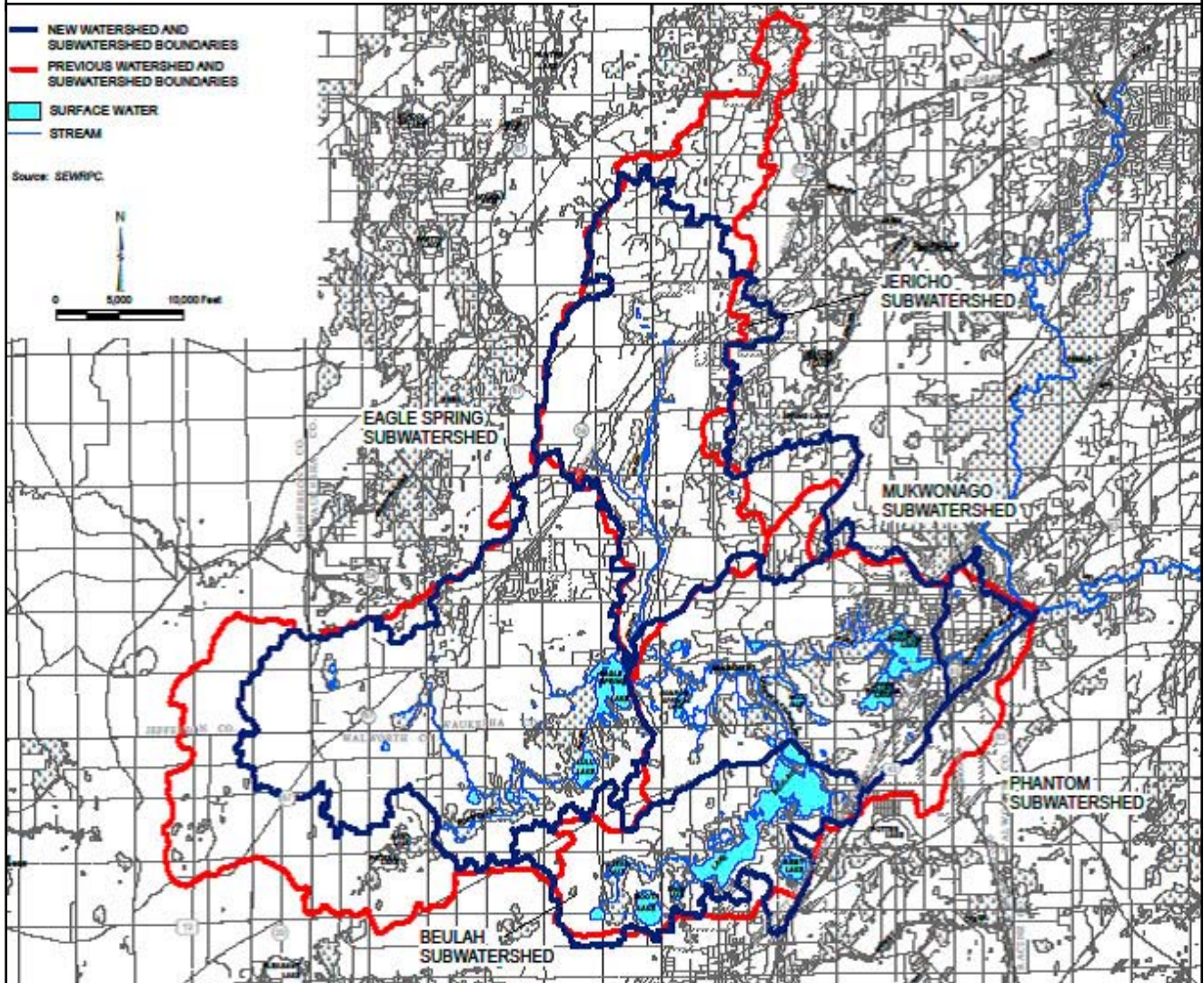
## Hydrology

The Mukwonago River Watershed may be considered to be composed of five subwatersheds: the Eagle Spring subwatershed, the Jericho subwatershed, the Beulah subwatershed, the Phantom subwatershed, and the Mukwonago subwatershed (see Map 2). It should be noted that the watershed boundary shown in the majority of the maps in this plan is not the same as the official WDNR watershed boundary. The Southeastern Wisconsin Regional Planning Commission (SEWRPC) developed a custom watershed boundary in 2010 based upon a detailed analysis. The SEWRPC watershed is smaller, 74 square miles versus 86, and does not include the Village of Wales. See Map 3 for a visual comparison of the two watershed boundaries.

Map 2: Surface Water Resources within the Mukwonago River Watershed: 2005



Map 3: Boundary Comparison



The surface-water resources consist of lakes, streams, and ponds. The major lakes of the watershed are Lulu Lake, Eagle Spring Lake, Lake Beulah, Upper Phantom Lake, and Lower Phantom Lake. Please see Table 2 for summary of the physical characteristics of these lakes.

Table 2: Hydrology and Morphometry of Major Lakes within the Mukwonago River Watershed: 2009

Parameter	Lulu Lake	Eagle Spring Lake	Lake Beulah	Upper Phantom Lake	Lower Phantom Lake
Surface Area (acres)	95.5	279.2	834.0	107.0	433.0
Percent of Area <3.0 feet deep	10.8 (10.4 acres)	28.0 (78.3 acres)	13.0 (108.4 acres)	8.1 (8.7 acres)	79.00 (342.1 acres)
Percent of Area >6.0 feet deep	78.6 (75.1 acres)	13.3 (37.2 acres)	--	--	--
Percent of area >20.0 feet deep	52.5 (50.2 acres)	0.0	34.0 (283.6 acres)	12.2 (13.1 acres)	0.0
Total Watershed Area (acres)	-- a	16,076.1	6,534.0	-- b	
Total Watershed Area excluding internally drained areas (acres)	--	13,127.7	6,534.0	--	39,191.0
Ratio of Watershed Area to Lake Area	--	57.6	7.8	--	106.9
Volume (acre-feet)	2,292.0	1,005.1	14,279.0	1,154.0	1,555.0
Residence Time (years)	0.16 (58 days)	0.07 (26 days)	3.34 (1,219 days)	0.98 (358 days)	0.04 (15 days)
Maximum Length of Lake (miles)	0.55	1.18	2.60	0.70	1.70
Maximum Width of Lake (miles)	0.42	0.65	1.30	0.40	0.80
Length of Shoreline (including islands) (miles)	2.07	7.44	15.30	2.00	5.60
Length of Natural Shoreline (including islands) (miles)	2.07	2.11	2.99	0.54	4.81
Mean Depth (feet)	24.0	3.6	17.0	11.0	4.0
Maximum Depth (feet)	40.0	8.0	58.0	29.0	12.0
Ratio of Mean Depth to Maximum Depth	0.60	0.45	0.29	0.38	0.33

a Watershed area was not calculated for Lulu Lake.

b Watershed area was not calculated for Upper Phantom Lake.

Source: Wisconsin Department of Natural Resources and SEWRPC.

The Mukwonago River provides the major inflow into Eagle Spring Lake, entering the Lake from the south where it discharges from Lulu Lake. Lulu Lake is situated immediately upstream of Eagle Spring Lake and is accessible from Eagle Spring Lake by a navigable channel. The Eagle Spring Lake outflow is controlled by two outlet structures—a dam with a manually operated control gate (Wambold dam) and a former mill race (locally known as the Kroll dam)—both located at the east side of Eagle Spring Lake just west of CTH E. The confluence of Jericho Creek and the Mukwonago River is located about 350 feet downstream of the Wambold dam structure. The southernmost lake outlet from the former mill race joins the Mukwonago River about 500 feet downstream of the dam structure. The difference in elevation between the lakes decreases with increasing discharges at the Wambold dam, indicating that the Wambold dam influences water levels in both Lakes. This is consistent with the surface water elevation profile developed by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff from the 2005 Waukesha County DTM data.

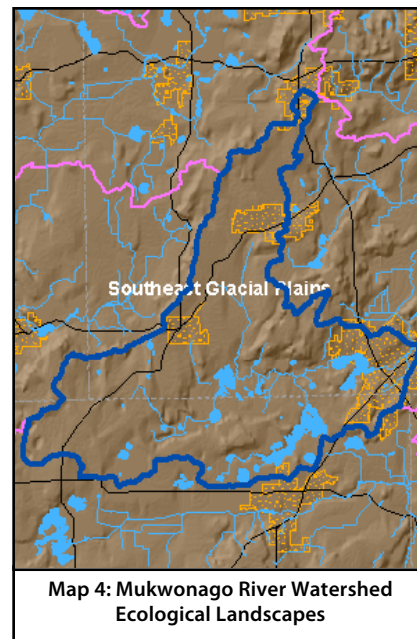
SEWRPC staff measured low flow discharge for several sites on Jericho Creek in November, 2007. Jericho Creek contributes about one-third of the total low flow discharge to the Mukwonago River, with the remaining two-thirds coming from Eagle Spring Lake, downstream of the confluence of Jericho Creek with the Mukwonago River.

Downstream of its confluence with Jericho Creek, the Mukwonago River continues easterly, passing through Lower

Phantom Lake and ultimately discharging into the Fox River in Waukesha County, about 8.5 miles downstream from Eagle Spring Lake. The Mukwonago River more than doubles its normal flow between the outlet of Eagle Spring Lake and the outlet of the Phantom Lakes. This is due to flow from numerous springs and seeps distributed throughout this section of the river. In addition, the Lake zBeulah outlet discharges into the Mukwonago River prior to it entering Lower Phantom Lake. The Lake Beulah outlet was found to be roughly equivalent to the discharge from Eagle Spring Lake.

## Ecological Landscapes

The Southeast Glacial Plains Ecological Landscape makes up the bulk of the non-coastal land area in southeast Wisconsin. This ecological landscape is made up of glacial till plains and moraines. Most of this ecological landscape is composed of glacial materials deposited during the Wisconsin Ice Age, but the southwest portion consists of older, pre-Wisconsin till with a more dissected topography. Soils are lime-rich tills overlain in most areas by a silt-loam loess cap. Agricultural and residential interests throughout the landscape have significantly altered the historical vegetation. Most of the rare natural communities that remain are associated with large moraines or are in areas where the Niagara Escarpment occurs close to the surface.



Historically, vegetation in the Southeast Glacial Plains consisted of a mix of prairie, oak forests and savanna, and maple-basswood forests. Wet-mesic prairies, southern sedge meadows, emergent marshes, and calcareous fens were found in lower portions of the landscape. End moraines and drumlins supported savannas and forests. Agricultural and urban land use practices have drastically changed the land cover of the Southeast Glacial Plains since Euro-American settlement. The current vegetation is primarily agricultural cropland. Remaining forests occupy only about 10% of the land area and consist of maple-basswood, lowland hardwoods, and oak. No large mesic forests exist today except on the Kettle Interlobate Moraine which has topography too rugged for agriculture. Some existing forest patches that were formerly savannas have succeeded to hardwood forest due to fire suppression.

## Historical Note

The Village of Eagle in Waukesha County is located in the Mukwonago River Watershed. Eagle's water tower stands on the very place where one of the largest glacial diamonds was found in 1876. The diamond may have been transported to that site by glaciers during one of the Ice Ages. It was found when Charles Woods was digging a well at the summit of what is today called Diamond Hill. Eventually his wife, Clarissa Woods, took it to a jeweler, Samuel B. Boynton from Milwaukee, who thought the stone was a topaz. Boynton offered her one dollar for the stone, but she did not immediately accept the offer.

When Boynton finally purchased the stone, he took it to Chicago and had the stone examined by a gemologist and found out it was a rough diamond weighing 15.37 carats and was valued at \$700.00. When news leaked out about the stone, Clarissa Woods filed suit on Mr. Boynton, feeling that she had been cheated. The suit between Clarissa Woods and Mr. Boynton lasted for several years. However, Clarissa Woods lost the case. During this time, Boynton sold the diamond to Tiffany's in New York City for \$850.00. The diamond remained uncut because they could not prove possession. It remained at Tiffany's until the First World War. Then, J.P. Morgan bought the diamond as a gift for The American Museum of Natural History, in New York City. It was placed in the J.P. Morgan exhibit along with the Star Sapphire of India and the de Long Ruby.

On October 29, 1964, the Eagle Diamond became part of the national headlines. A major jewelry theft occurred from the American Museum of Natural History, where 24 stones were stolen from the fourth floor of the museum. The star Sapphire of India (563 carats) and the de Long Ruby and the Eagle Diamond (valued at \$25,000 at the time) were taken. The total value of the theft was \$410,000.00. Most of the stones were recovered, but the Eagle Diamond disappeared. The Eagle Diamond was not the largest diamond at the American Museum of Natural History, but it was part of one most of the most dramatic events in the museum's history.

## Watershed Condition

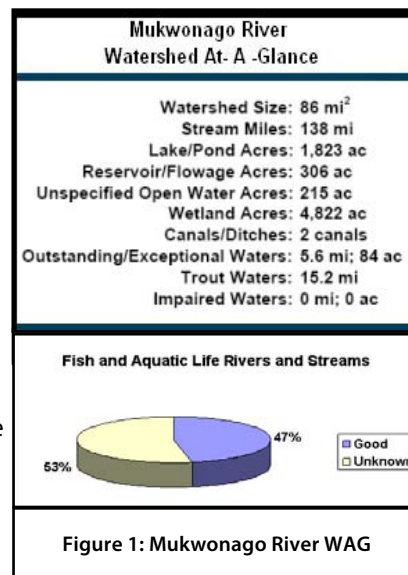
### Overall Condition

A total of six miles of Exceptional Resource Waters can be found along the Mukwonago River and Lulu Lake contributes 84 acres of Outstanding Resource Waters. Over 15 miles of trout waters are located along stretches of Jericho Creek and Mukwonago River. There are no impaired waters within the watershed.

### River and Stream Condition

According to the WDNR's Register of Waterbodies (ROW) database, there are over 137 miles of streams and rivers in the Mukwonago River Watershed; 47 miles of which have been entered into the WDNR's assessment database. Of these 47 miles, approximately 47% are meeting Fish and Aquatic Life uses and are specified as in "good" condition. The condition of the remaining stream miles is not known or documented.

Additional uses for which the waters are evaluated include Fish Consumption, General Uses, Public Health and Welfare, and Recreation. As Table 3 shows, these uses have not been directly assessed for the watershed. However, a general fish advisory for potential presence of mercury is in place for all waters of the state.



**Table 3: Designated Use Support Summary for Mukwonago River Watershed Rivers and Streams  
(all values in miles)**

Use	Supporting	Fully Supporting	Not Supporting	Not Assessed	Total Size
Fish Consumption				46.78	46.78
Fish and Aquatic Life	19.8	2.33		24.65	46.78
General				46.78	46.78
Public Health and Welfare				46.78	46.78
Recreation				46.78	46.78

### Jericho Creek

Jericho Creek, a six-mile tributary to Mukwonago River in Waukesha County, is designated as a cold Class II Trout water. Macroinvertebrate data collected in 2004 indicate that Jericho Creek has good water quality, while fish data collected in 2008 indicates fair water quality.

### Mukwonago River

The Mukwonago River is a 16.8-mile-long river in Walworth and Waukesha Counties. Mile 1.86 through 5.51 (from the mouth) is classified as a Class I trout water. Mile 9.65 through 16.81 of Mukwonago River is classified as a Class II trout water, and the last 0.08 miles of the river is a Class III trout water. Both fish and macroinvertebrate data collected since 2001 indicate good water quality in the Mukwonago River.

### Lake Health

The WDNR's ROW database shows that there are over 306 acres of reservoirs and flowages (from Eagle Spring Lake and Swan Lake), 1,823 acres of lakes and ponds, and 215 acres of unspecified open water in the Mukwonago River Watershed. Of these, approximately 2,423 lake acres are entered into the state's assessment database. Ninety-two percent of these 2,366 acres are indicated as supporting Fish and Aquatic Life use. A little over 240 acres have not been assessed for Fish and Aquatic Life use. Lake Beulah is the largest lake in the watershed at over 830 acres, followed by Lower Phantom Lake at over 370 acres. The following water narratives summarize the most recent information available for lakes and flowages in the watershed.

**Table 4: Designated Use Support Summary for Mukwonago River Watershed Lakes (all values in acres)**

Use	Supporting	Fully Supporting	Not Supporting	Not Assessed	Total Size
Fish Consumption				2,423.49	2,423.49
Fish and Aquatic Life	726.24	1,457		24.25	2,423.49
General				2,423.49	2,423.49
Public Health and Welfare				2,423.49	2,423.49
Recreation				2,423.49	2,423.49

Lulu Lake, Eagle Spring Lake, Lake Beulah, Lower Phantom Lake, and Upper Phantom Lake represent typical mesotrophic, hardwater, alkaline lakes that are considered to have relatively good water quality, be moderately fertile, and be capable of supporting abundant aquatic plant growth and productive fisheries (see Appendix, Figure 1<sup>1</sup>). Physical and chemical parameters reported for each of these lakes indicate that the water quality ranges within the “fair” to “very good” range, depending upon the parameters considered. Total phosphorus levels were found to be generally below the level considered to cause nuisance algal and macrophytic growths. Summer stratification was likely to occur in Upper Phantom Lake, but unlikely to occur in Lower Phantom Lake or Eagle Spring Lake, due to their shallow depths. The surface waters of all the lakes remain well oxygenated and support healthy fish populations. Neither summerkill nor winterkill of fishes has been reported to be a problem, which indicates that the lakes provide adequate oxygenated water for fish and aquatic organisms. Internal releases of phosphorus from the bottom sediments were not considered to be a problem in any of the lakes.

Aquatic plant management practices within the Mukwonago River system have focused on the control of nonnative, invasive species. The three public inland lake protection and rehabilitation districts in the watershed—Eagle Spring Lake Management District, Lake Beulah Management District, and the Phantom Lakes Management District—have conducted aquatic plant management programs in concert with their local communities. These aquatic plant management activities have focused on the control of Eurasian water milfoil within the lakes and of purple loosestrife in their shoreland wetland margins. Such interventions are conducted in accordance with their respective aquatic plant management plans, and with WDNR permits issued pursuant to Chapters NR 107 and NR 109 of the Wisconsin Administrative Code.

**Army Lake**

Army Lake is a natural lake managed for largemouth bass and panfish. This small lake has clear, fertile water, equal amounts of soft and sandy shore, and few fish management problems. Unimproved access is provided by one narrow frontage road and two liveries offer access for launching, picnicking, and swimming. The Salvation Army maintains a camp on the east shore which accommodates up to 250 guests and provides a swimming beach and boats. There are only 14 lakeshore dwellings, and frontage is only 20% developed. Of the remaining shore, 15% is tamarack bog (10 acres) and 85% is wooded and maintained for camping and picnicking by resort owners. The lake is presently land-locked; the outlet has been ditched and rarely flows (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Army Lake (East Troy Lake), T-4-N, R-18-E, Sec. 16, Surface Acres = 76, S.D.F. = 1.14, Maximum Depth = 17 feet).

<sup>1</sup> SEWRPC Community Assistance Planning Report No. 226, *A Lake Management Plan For Eagle Spring Lake, Waukesha County, Wisconsin, October 1997*; SEWRPC Community Assistance Planning Report No. 226, 2nd Edition, *A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, in draft*; SEWRPC Community Assistance Planning Report No. 230, *A Lake Management Plan for the Phantom Lakes, Waukesha County, Wisconsin, Volume One, Inventory Findings, Volume Two, Alternatives and Recommended Plan, January 2006*; and RJN Environmental Services, LLC., *Lake Beulah Management Plan, April 2010*.

See SEWRPC Community Assistance Planning Report No. 226, *A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, October 1997*, a second edition of which is currently in preparation; SEWRPC Community Assistance Planning Report No. 230, *A Lake Management Plan For the Phantom Lakes, Waukesha County, Wisconsin, Volume Two, Alternatives and Recommended Plan, January 2006*, which refined and updated SEWRPC Memorandum Report No. 81, *Aquatic Plant Management Plan for Phantom Lakes, Waukesha County, Wisconsin, July 1993*; and, RJN Environmental Services LLC, *Aquatic Plan Management Plan: Lake Beulah, Walworth County, Wisconsin, May 2010*

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### **Beulah Lake**

Beulah Lake (Lake Beulah) is an impounded series of natural lakes managed for largemouth bass and panfish with northern pike present but not common to the fishery. The shoreline is highly irregular with many bays and peninsulas. Originally this was a chain of three lakes; however, a dam on the outlet (built around 1840) created one sheet of water with five major basins separated by shallows. Weeds are a problem in the shallow bays and flooded connecting channels. Public access is provided but restricted in construction to accommodate light fishing boats only. Fee launching is provided at four private ramps. Nearly 200 acres of wetland occupy the shoreline. There are four private camps on the lake (Girl Scouts, Y.M.C.A., and church groups) (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Beulah Lake, T-4-N, R-18-E, Surface Acres =712, S.D.F. =2.54, Maximum Depth 58 feet).

### **Booth Lake**

Booth Lake is a natural basin lake managed for largemouth bass and panfish; in addition, yellow perch and bullheads are common to the fishery. The lake is nearly circular with a small island in the center. The water is generally quite clear and much of the shoreline is sand and gravel. One town road provides difficult access, and a town park provides restricted access - fee swimming, boat launching for residents of the township only. Boats are also available at two resorts, one of which maintains a swimming beach. A Girl Scout camp exists on the north shore and accommodates 160-170 girls for two week periods through the summer. The lake's small acreage, the centrally located island, and heavy use by swimmers, canoeists, and row boat anglers indicate the necessity for outboard motor control in some degree. The lake is landlocked and occupies a simple basin in glacial drift (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Booth Lake, T-4-N, R-17-E, Sec. 13, 24, Surface Acres = 108, S.D.F. = 1.08, Maximum Depth = 24 feet).

### **Brown Lake**

Brown Lake is a small clear lake in outwash deposits at the edge of a ground moraine. The lake occupies part of a marshy valley draining southward to the Mukwonago River below Eagle Spring Lake. A small spring stream is a major water source and enters on the east shore from the base of the moraine. There are 19 acres of adjoining marsh and waterfowl make limited use of the lake. Largemouth bass and pan fish comprise the fishery. Public access is not available and the lake may be classed as semi-wilderness in appearance (Source: 1963, Surface Water Resources of Waukesha County Brown Lake T5N, R18E, Section 30 Surface Acres = 11. 5, S. D. F. = 1. 14, Maximum Depth = 40 feet).

### **Eagle Spring Lake**

Eagle Springs Lake is an impoundment of the Mukwonago River above the inlet of Jericho Creek. The dam has a 12-foot head and affects the water level upstream to the Walworth County line. Largemouth bass and pan fish provide a fishery with northern pike making a lesser contribution. Weeds are the major use problem; winterkill is avoided by the high flow-through rate. The inlet is navigable and boats travel at will between this lake and Lulu Lake in Walworth County. The shore line is very irregular and there is much additional frontage due to several islands. Access other than by navigable water is not available (Source: 1963, Surface Water Resources of Waukesha County Eagle Spring Lake T5N, R17E, Sections 35 and 36 Surface Acres = 227, S.D.F. = 1.89, Maximum Depth = 12 feet.). UPDATE - Public access to the lake is available by WDNR boat ramp near Wambold Dam in Eagleville.

### **Hogan Lake**

Hogan Lake is a small, shallow, irregular lake in glacial deposits. The lake has an outlet tributary to the Mukwonago River. The fish, population is limited to pan fish and minnows because of winterkill conditions and the lack of suitable habitat. This is a marl basin somewhat unusual for its location. The lake is entirely within the bounds of a licensed shooting preserve and is therefore without access. Its principal value is aesthetic, though waterfowl make some use of the area (Source: 1963, Surface Water Resources of Waukesha County Hogan Lake T5N, R18E, Section 31 (8) Surface Acres = 8, S.D.F. = 2.28, Maximum Depth = 3 feet).

### **Lower Phantom Lake**

Lower Phantom Lake is an impoundment on the Mukwonago River at Mukwonago created by a dam of approximately eight-foot head. Northern pike, pan fish, and largemouth bass comprise the fishery. Weed and algae control has been necessitated frequently in the shallower shore areas. Phantom Ranch Bible Camp and a YMCA camp occupy parts of the shore line. Access is possible from several road ends; however, parking facilities are inadequate. A considerable portion of the west shore is classed as deep marsh in wetlands inventory and the inlet valley is primarily marshland



(Source: 1963, Surface Water Resources of Waukesha County Lower Phantom Lake T5N, R18E, Sections 26 and 35 Surface Acres = 166, S.D.F. = 1.81, Maximum Depth = 10 feet). UPDATE - Public access is available by fishing pier and boat ramp in Phantom Glen Park in Mukwonago.

Since 1981 the Phantom Lakes Management District (PLMD) has sought to protect and improve the overall well-being of the Phantom Lakes (Upper and Lower) as well as educate lakeshore residents and the local citizenry on matters concerning land and lake use laws, boating safety issues, and general environmental aspects that might effect the lakes. The PLMD is responsible for fish stocking and monitoring the health of the various forms of wildlife that inhabit the lakes and they operate a harvester which attempts to maintain a delicate relationship between the desirable aquatic plant life and the noxious weeds that occasionally make life difficult for recreationists (from Phantom Lakes Management District Mission Statement).

### **Lulu Lake**

Lulu Lake is a natural lake managed for northern pike, largemouth bass, and panfish. This was once called Deep Lake since most of its basin is over 20 feet deep. The shores are entirely marshy save for a narrow gravel bank on part of the east shore. Access is afforded by the outlet channel, which is navigable from Eagle Spring Lake and through private campgrounds on the south shore. A trailer rental and one cottage are the only developments on the lake. A Milwaukee Boys Club maintained the northwest shore in its natural state. The 368 acres of equally woody and marshy wetlands adjoining its shore line classify this lake as aesthetically outstanding (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Lulu Lake, T-4-N, R-17-E, Surface Acres = 95, S.D.F. = 1.10, Maximum Depth = 40 feet).



Lulu Lake in Fall. Photo by SEWRPC

### **Mukwonago Park Pond**

Mukwonago Park Pond is a very small spring pond completely within the Mukwonago County Park. The pond supports largemouth bass and pan fish and contains several good springs, generally maintaining some open water year-round. Its banks are sodded to the water line. Tiling provides an outlet to Roxy Pond, also in the park.

(Source: 1963, Surface Water Resource of Waukesha County Mukwonago Park Pond T5N, R18E, Section 29 (14) Surface Acres = 1.4, S.D.F. = 1.01 (est.), Maximum Depth = 5 feet).

### **Peters Lake**

This is an aging pothole lake, heavily vegetated, with an average depth of probably three to four feet, obviously suffering annually from winterkill. A modest development of small cottages exists on the west shore; however, most dwellings are abandoned, and the lake is seldom visited except during waterfowl hunting season. Aesthetic values are high since the lake is surrounded by high gravel hills of the glacial moraine. A low gravel ridge separates the lake from Swift Lake to the northeast. Emergent vegetation is found around the entire shore and opportunities for wildlife observation are excellent. Presently public access is not available (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Peters Lake, T-4-N, R-17-E, Surface Acres = 60, S.D.F. = 1.11, Maximum Depth = 8 feet).

### **Pickerel Lake**

Pickerel Lake is a natural drainage lake managed for largemouth bass and panfish, with northern pike common to the creek in the early portion of the season. This is a small, nearly circular lake with private frontage but accessible by navigable inlet and outlet. Only three owners have lake frontage. The presence of several duck blinds suggests the importance of this small lake for pass shooting. About 50 acres of marsh adjoin the lake shores, enhancing its aesthetic value (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Pickerel Lake, T-4-N, R-17-E, Surface

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Acres = 27, S.D.F. = 1.10, Maximum Depth = 31 feet).

#### **Rainbow Springs Lake**

Rainbow Springs Lake is a small, irregular lake in a marshy valley of glacial deposits. Largemouth bass and pan fish comprise the fishery; however, occasional winterkill, and fluctuating water levels somewhat limit fishing opportunities. The lake is entirely within the bounds of a licensed shooting preserve and therefore lacks public access. Members of the now-defunct Rainbow Springs recreation resort used to utilize the lake for fishing and swimming. Adjoining wetlands, proximity to the Mukwonago River, and the semi-wilderness appearance of the lake basin, add to the value of this area for waterfowl, marsh fur bearers, and wildlife observation (Source: 1963, Surface Water Resources of Waukesha County Rainbow Springs Lake T5N, R18E, Section 31 Surface Acres = 6.5, S.D.F. = 1.93, Maximum Depth = 12 feet).

#### **Swan Lake**

Swan Lake is a typical small blocked drainage lake, spring and runoff fed, managed for largemouth bass and panfish. All surrounding land is owned by one person, thus access is not available. Vegetation along shore is primarily emergent forms, and floating or submergent forms are present but not in problem proportions. A small outlet flows to Beulah Lake over a dike impounding less than 6" of water (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Mud Lake, T-4-N, R-18-E, Surface Acres = 23, S.D.F. = 1.04, Maximum Depth = 12 feet).

#### **Roxy Pond**

Roxy Pond is a small elongate lake in the Mukwonago County Park. Springs and seepage are the chief water sources, and a tiled outlet carries water to a small stream tributary to the nearby Mukwonago River. Recently the lake was chemically treated to remove the fish population, and largemouth bass were introduced. Presently this species constitutes the fishery supplemented by bullheads and northern pike. Park facilities are provided for swimming and boating. Lack of emergent vegetation and the park environment limit use by waterfowl (Source: 1963, Surface Water Resources of Waukesha County Roxy Pond T5N, R18E, Section 29 (16) Surface Acres = 17, S.D.F. = 1.38, Maximum Depth = 8 feet).

#### **Swift Lake**

Swift Lake is managed for largemouth bass and bluegills. This shallow depression in the moraine is landlocked and therefore suffers water level fluctuations and occasional winterkill. Additionally, much of the bottom is vegetated; emergent plants are found around the entire shore line. Largemouth bass were reintroduced in 1960 following a winterkill. Public access is lacking, as are commercial facilities. Considerable development and small size have reduced the potential of this lake for other than limited recreation (Source: 1961, Surface Water Resources of Walworth County, WI: WI-DNR Swift Lake, T-4-N, R-17-E, Surface Acres = 17, S.D.F. = 1.21, Maximum Depth = 12 feet).

#### **Upper Phantom Lake**

Upper Phantom Lake is a small, irregular lake in outwash deposits augmented in acreage by a dam with about an eight-foot head on the outlet to Lower Phantom Lake. The fishery consists of pan fish, northern pike, and largemouth bass. In 1961, algae, weed, and snail control was necessitated on the beaches. Access is available for boat launching, however, parking is prohibited. There are no adjoining wetlands of consequence (Source: 1963, Surface Water Resources of Waukesha County Upper Phantom Lake T5N, R18E, Section 35 Surface Acres = 111 S.D.F. = 1.42, Maximum Depth = 29 feet).

#### **Wood Lake**

Wood Lake is a small kettle lake in moraine drift. A small outlet stream flows to the Mukwonago River. Largemouth bass and pan fish constitute the fishery. The water is clear and the bottom primarily gravel. The lake is in a single ownership and has retained a semi-wilderness appearance with great aesthetic value. Public access is not available. Waterfowl and marsh fur bearers make moderate use of this area (Source: 1963, Surface Water Resources of Waukesha County Wood Lake T5N, R18E, Section 33 Surface Acres = 19, S.D.F. = 1.15, Maximum Depth = 23 feet).

## Wetland Health

### Wetland Status

The Mukwonago River Watershed is the smallest of the Fox River Basin watersheds (86 square miles) and lies mainly in Walworth and Waukesha counties, with a small portion falling in Jefferson County. Roughly eight percent of the current land uses in the watershed are wetlands. About 79% of the original wetlands in the watershed are estimated to exist. Of these wetlands, the majority include forested wetlands (27%) and emergent wetlands (47%), which include marshes and meadows.

### Wetland Condition

Little is known about the condition of the remaining wetlands but estimates of reed canary grass (RCG) infestations, an opportunistic aquatic invasive wetland plant, into different wetland types has been estimated based on satellite imagery. This information shows that reed canary grass dominates three percent of the existing emergent wetland habitats and two percent of the remaining forested wetlands. Reed canary grass domination inhibits successful establishment of native wetland species.

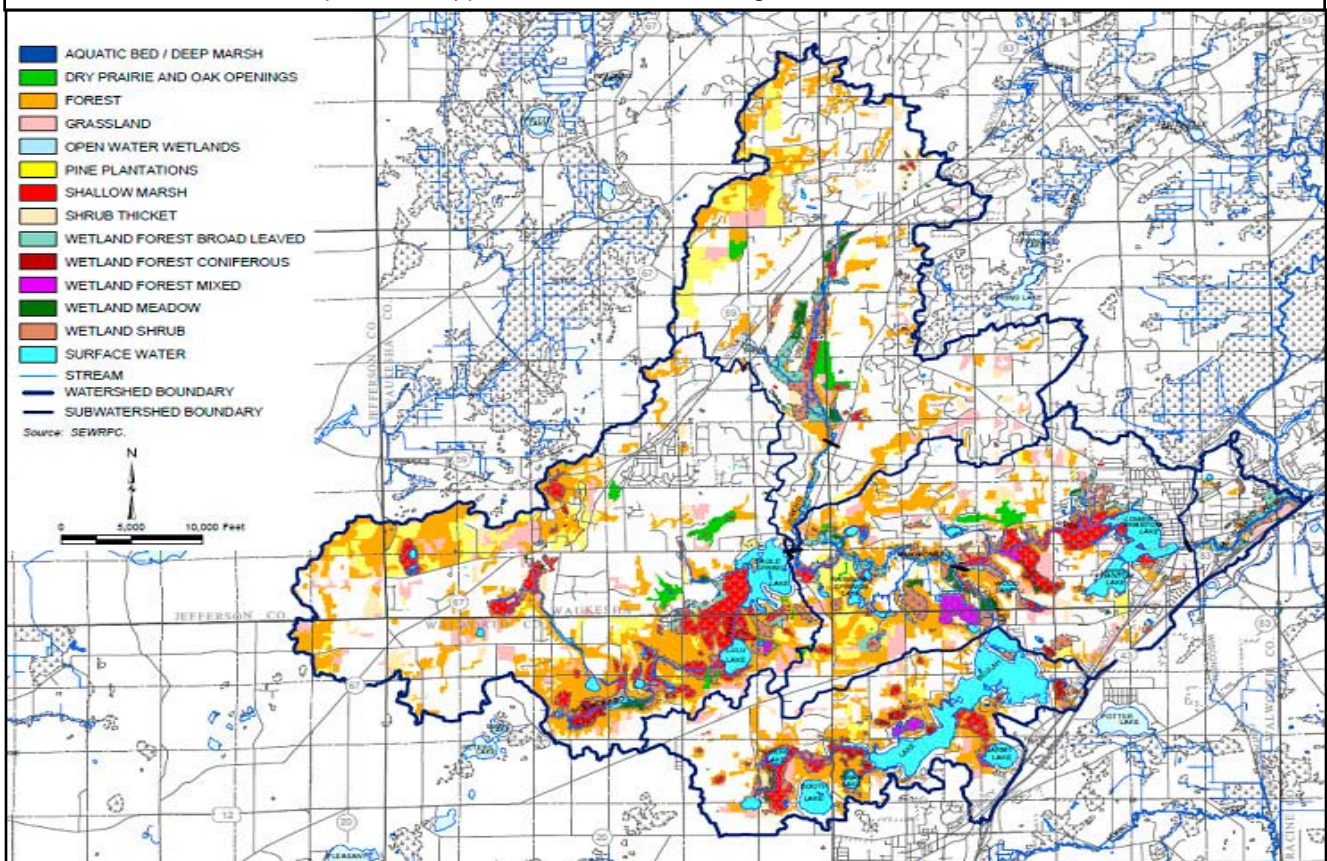
### Wetland Restorability

Of the 1,137 acres of estimated lost wetlands in the watershed, approximately 73% are considered potentially restorable based on modeled data, including soil types, land use, and land cover (Chris Smith, DNR, 2009).

## Biological Characteristics of Wetlands

Map 4 shows the major natural cover types both within and outside of the riparian buffers distributed throughout the Mukwonago River watershed based upon the WDNR 2005 wetland inventory. The riparian buffers are comprised of a variety of wetland, shallow marsh, deep marsh, prairie, grassland, shrubs, and forest and pine plantation vegetation

Map 4: Cover Types Within the Mukwonago River Watershed: 2009



communities. The riparian buffers correspond with the moderate to very high groundwater recharge potential areas, as shown in Map 5.

More than 180 vegetation surveys, including wetland delineations and environmental corridor and natural area assessments, were conducted throughout the Mukwonago River watershed from 1947 through 2006. Five rare State-designated threatened plant species were found to occur in several areas of the watershed. In addition, 17 State-designated species of special concern were also observed to occur within this watershed. A total of 611 native plant species were found within the Mukwonago River watershed.

Some of the most abundant species that were found during field surveys in the Mukwonago River Watershed included marsh aster, Joe-pye weed, silky dogwood, black willow, bur oak, marsh milkweed, swamp aster, boneset, tussock sedge, beaked willow, white oak, water hemlock, ciliated brome grass, shooting star, great water dock, swamp thistle, sage willow, prairie dropseed, hoary puccoon, shrubby cinquefoil, kittentails, woolly sedge, brook lobelia, Ohio goldenrod, death camas/white camas, and fen muhly grass.

Of the 107 nonnative species recorded, the nine most dominant invasive plant species included common buckthorn, hybrid honeysuckle, reed canary grass, glossy buckthorn, Kentucky bluegrass, deadly nightshade, garlic-mustard, multiflora rose, and smooth brome grass. The presence of these invasive nonnative species threatens the quality and abundance of native plants and wildlife species within riparian buffers. Consequently, management of nonnative invasive species is an important issue to consider in order to protect the ecological integrity of the riparian corridors within the Mukwonago River system.

### Invasive Species in Wetlands

Nonaquatic invasive vegetation species include reed canary grass, which is dominant throughout the watershed, as shown on Map 6. Significant stands of phragmites have also been located, and are shown on Map 6 on page 14. Invasive terrestrial vegetation species found include garlic mustard, European buckthorn, and purple loosestrife, which were found among the nonnative plants on streambanks and shoreland areas throughout the watershed.

### Groundwater

Flow in the Mukwonago River system is dependent upon groundwater discharges from multiple aquifers, including the surficial shallow sand and gravel aquifer and the shallow bedrock aquifer<sup>2</sup>. Groundwater enters the spring complex upstream of Lulu Lake through “boils” from a bedrock source, entering the springs through preferential flow paths within the fractured bedrock. The sand and gravel aquifer also contributes to this spring complex, which feeds Lulu Lake. A similar relationship was reported for the Lake Beulah area which also received a small contribution of groundwater from the deep aquifer.

#### Lake Beulah Issues Related to Village of East Troy Municipal Well No. 7

Village of East Troy municipal well No. 7, which is located in the Troy Bedrock Valley near the southwestern shore of Lake Beulah, northeast of the intersection of Stringers Bridge Road and St. Peters Road, is constructed in the shallow aquifer. The well has been online and pumping, part time, since August of 2008. Concerns regarding the effect of the well on Lake Beulah and the Mukwonago River have been raised by the Lake Beulah Management District and the Lake Beulah Protective and Improvement Association. The determination of the effects of the well is an important issue that is being studied by consultants for both the Lake Management District and the Village.

The Troy Bedrock Valley, which trends through southern Milwaukee and Waukesha Counties and across Walworth County, contains up to 500 feet of glacial deposits in its

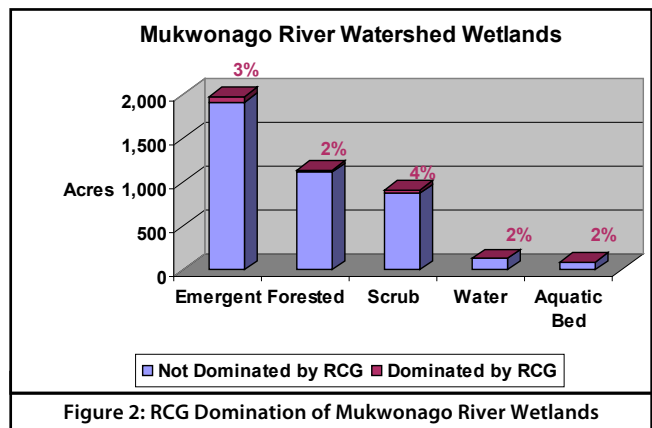


Figure 2: RCG Domination of Mukwonago River Wetlands

deepest parts. The bedrock is close to the ground surface in locations along the sides of the Valley. Several tributary bedrock valleys project outward from the Troy Bedrock Valley. Many of the smaller tributary valleys are poorly mapped and some may be currently unknown.

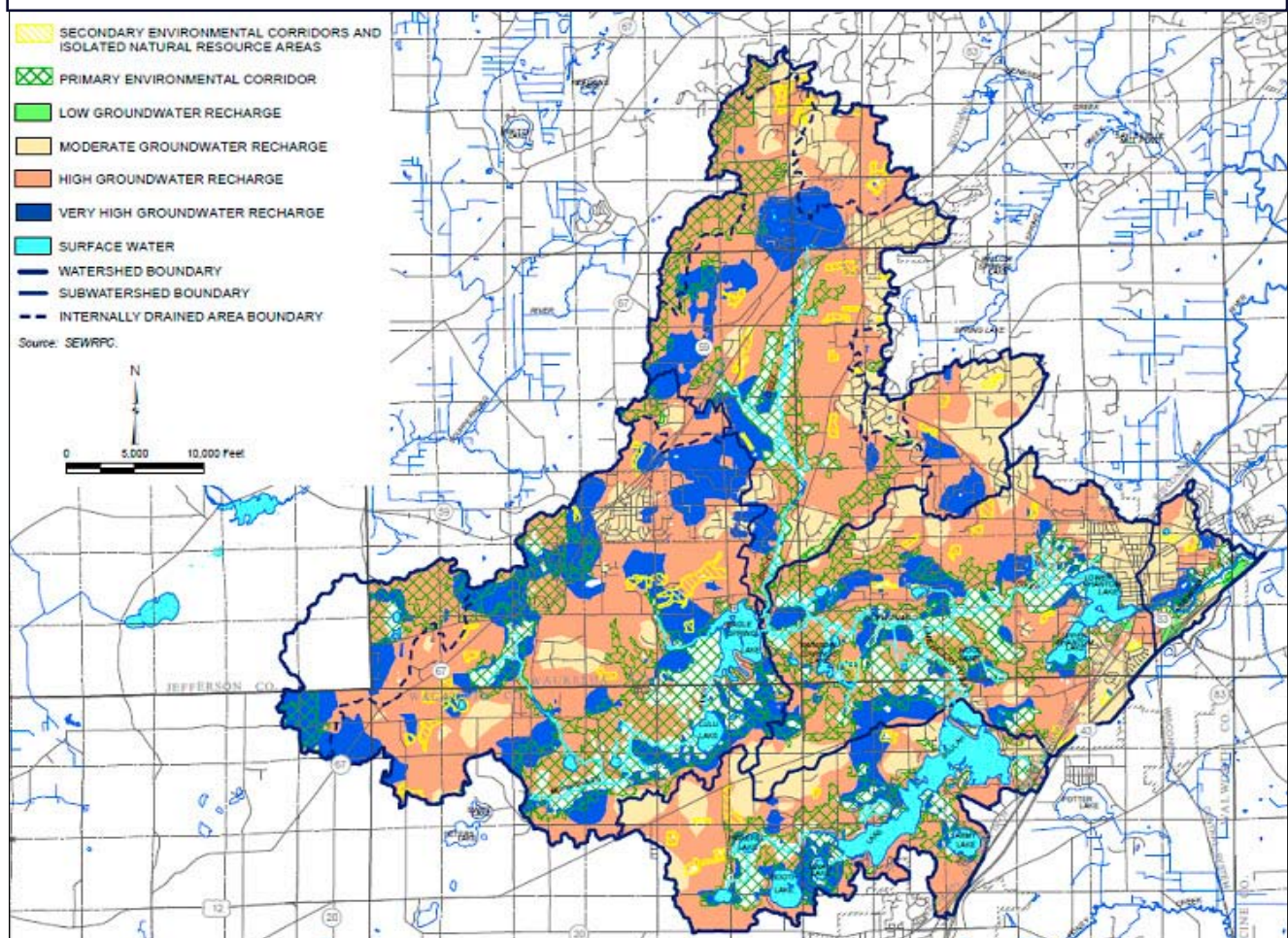
The glacial deposits within the Valley range from dense clay to coarse sand and gravel. Many of the sand and gravel deposits are saturated and permeable and can serve as prolific shallow aquifers that can support high-capacity wells. The Troy Bedrock Valley also contains ecologically and economically significant surface water features including streams, lakes, springs, and wetlands. Existing pumping and potential increases in pumping from the aquifers has created significant concern over the potential impact of groundwater withdrawals on these surface water features. It is difficult to quantify the impact that a well or group of wells will have on the flow system in a complex aquifer system.

In summary, the Mukwonago River streamflow is highly dependent upon groundwater discharge. Hence, it is also dependent upon recharge of the local shallow aquifer that ultimately discharges into the River. Therefore, management efforts to protect and maintain groundwater recharge will help protect and sustain discharge in the Mukwonago River and its associated high quality aquatic community.

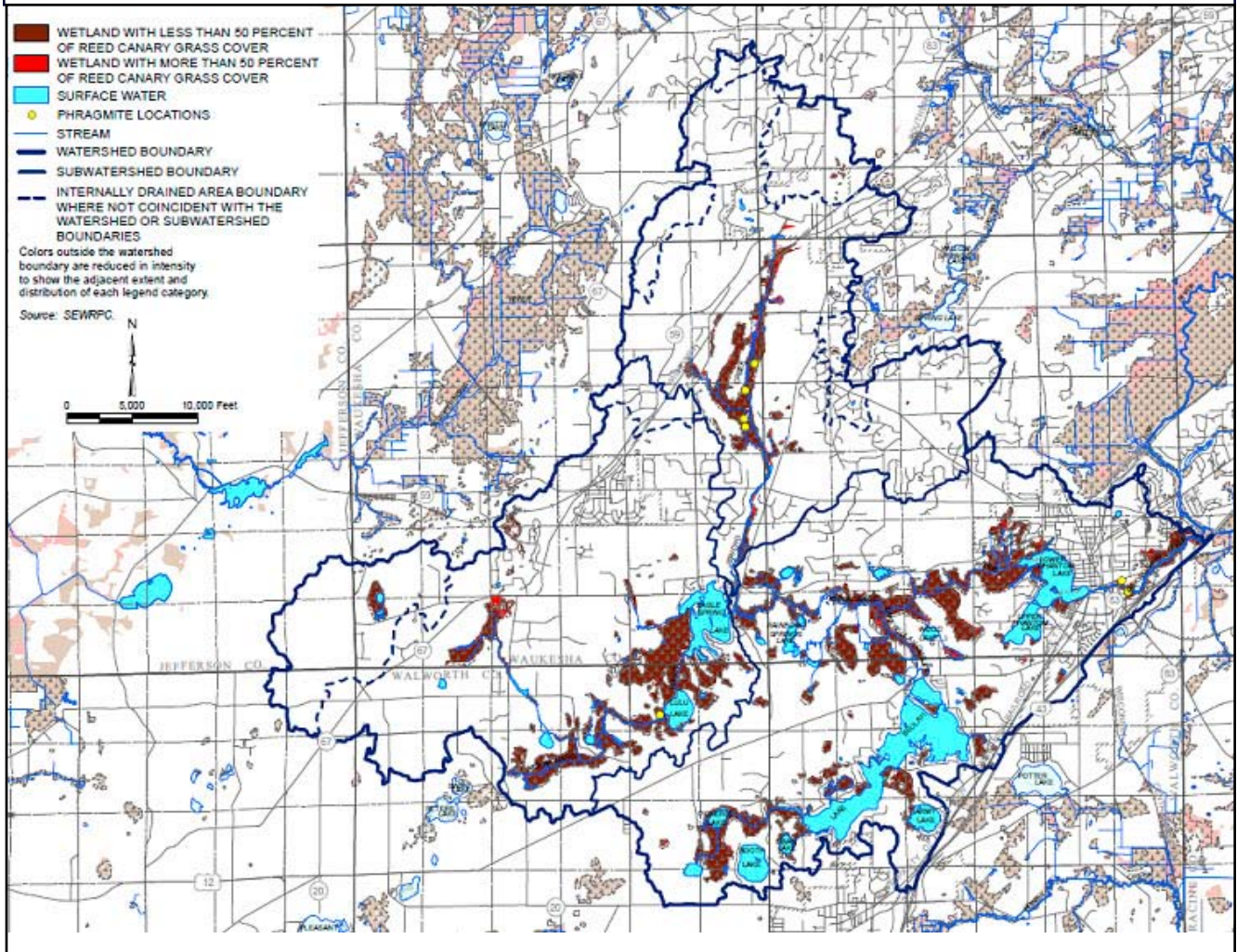
The following groundwater information is for Walworth and Waukesha counties (from Protecting Wisconsin's Groundwater through Comprehensive Planning website, <http://wi.water.usgs.gov/gwcomp/>), which roughly approximates to the Mukwonago River Watershed.

Two municipal water systems within the Mukwonago River Watershed have wellhead protection plans: East Troy and Mukwonago. East Troy also has a wellhead protection ordinance in place. Walworth and Waukesha counties have both

Map 5: Environmental Corridors and Groundwater Protection Areas



Map 6: Distribution of Exotic Invasive Reed Canary Grass and Phragmites Non-Native Plant Species



adopted animal waste management ordinances.

From 1979 to 2005, total water use in Walworth County has increased from about 10<sup>2</sup>.0 million gallons per day to 15.3 million gallons per day due to increases in all use categories. The proportion of county water use supplied by groundwater has increased from around 89% to about 99% during the period 1979 to 2005.

During the same time period, total water use in Waukesha County has increased from about 28.0 million gallons per day to about 39.7 million gallons per day. The increase in total water use over this period is due to increases in all use categories except aquaculture through 2000. While domestic and commercial uses continued increasing between 2000 and 2005, public use and losses, industrial, and irrigation uses all declined. The proportion of county water use supplied by groundwater has generally been greater than 99% during the period 1979 to 2000, but decreased in 2005 to 86%.

### Private Wells

Ninety percent of 340 private well samples collected in Walworth County and 97% of 664 private well samples collected in Waukesha County from 1990 through 2006 met the health-based drinking water limit for nitrate-nitrogen. Land use affects nitrate concentrations in groundwater. An analysis of over 35,000 Wisconsin drinking water samples found that

<sup>2</sup> Hilary Erin Gittings, "Hydrogeologic Controls on Springs in the Mukwonago River Watershed, SE Wisconsin," Master of Science Thesis, University of Wisconsin-Madison, 2005.

drinking water from private wells was three times more likely to be unsafe to drink due to high nitrate in agricultural areas than in forested areas. High nitrate levels were also more common in sandy areas where the soil is more permeable. In Wisconsin's groundwater, 80% of nitrate inputs originate from manure spreading, agricultural fertilizers, and legume cropping systems.

A 2002 study estimated that 21% of private drinking water wells in the region of Wisconsin that includes Walworth and Waukesha counties contained a detectable level of an herbicide or herbicide metabolite. Pesticides occur in groundwater more commonly in agricultural regions, but can occur anywhere pesticides are stored or applied. A total of 5,128 acres of land in Walworth County are in atrazine prohibition areas. Over three quarters (76%) of 33 private well samples collected in Walworth County and 90% of 61 private well samples collected in Waukesha County met the health standard for arsenic.

## Potential Sources of Contamination

There are no Concentrated Animal Feeding Operations (CAFOs) in the Mukwonago River Watershed; nor are there any licensed landfills or Superfund sites within the watershed.

WDNR's Remediation and Redevelopment (RR) Program oversees the investigation and cleanup of environmental contamination and the redevelopment of contaminated properties. The RR Program provides information about contaminated properties and other activities related to the investigation and cleanup of contaminated soil or groundwater in Wisconsin through its Bureau for Remediation and Redevelopment Tracking System (BRRTS) database (WDNR 2010e).

The database shows that there are 10 sites in the Mukwonago River Watershed that are specified as "open", meaning "contamination has affected soil, groundwater, or more and the environmental investigation and cleanup need to begin or are underway." These sites include three Leaking Underground Storage Tank (LUST) sites and seven Environmental Repair (ERP) sites. A summary of these sites is included in the table below.

**Table 4: Open-status Bureau for Remediation and Redevelopment Tracking System (BRRTS) sites in the Mukwonago River Watershed**

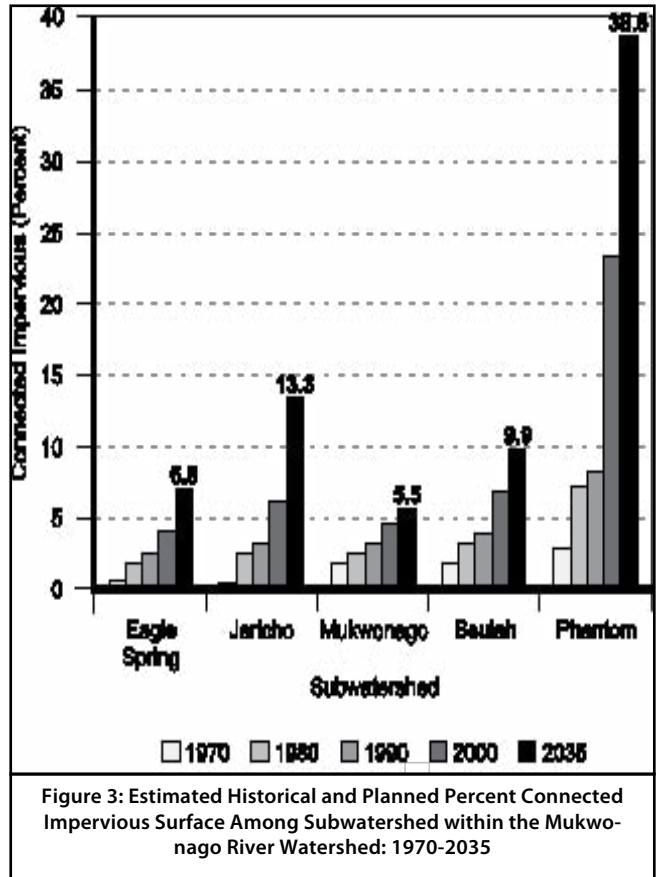
WDNR BRRTS #	Site Name, Location	Start Date	Activity Type	Remediation Activities	Waste Activities	Substance
268553728	Kettle Moraine Substation, Village of North Prairie	05/06/2009	ERP	2	0	Lead (Metals)
368553378	Rainbow Springs Pro Shop, Town of Mukwonago	02/25/2009	ERP	1	0	Gasoline - Unleaded and Leaded (Petroleum)
365553028	Lakewood Farms, Village of East Troy	11/13/2008	LUST	1	0	Volatile Organic Compounds (VOC); Petroleum - Unknown Type
268551443	Soo Line, Wisconsin Avenue - Oconomowoc, Village of Mukwonago	05/05/2008	ERP	4	0	Pesticides, Herbicides and Insecticides; Metals; VOC
268549806	Old World Wisconsin, Town of Eagle	05/15/2007	ERP	4	1	Chrysene (PAH); Diesel fuel & Polynuclear Aromatic Hydrocarbons (Petroleum)
268547261	Horn Feeds Inc., Village of Mukwonago	09/23/1999	ERP	4	0	Unspecified (DATCP Project)
268215749	Chapman Oil Bulk Plant, Village of Eagle	02/17/1999	ERP	1	0	Diesel fuel (Petroleum)
368196496	The Kettle Of Eagle (Citgo), Village of Eagle	06/06/1998	LUST	3	1	Gasoline - Unleaded & Leaded (Petroleum)
368220496	Amoco Lease Site, Village of Mukwonago	01/20/1994	LUST	1	0	Gasoline - Unleaded and Leaded (Petroleum)
268000831	Horn Oil Co. - Soo Line RR, Village of Mukwonago	08/05/1993	ERP	4	0	Petroleum - Unknown Type

The Petroleum Environmental Cleanup Fund Award (PECFA) program was created in response to enactment of federal regulations requiring release prevention from underground storage tanks and cleanup of existing contamination from those tanks. PECFA is a reimbursement program returning a portion of incurred remedial cleanup costs to owners of eligible petroleum product systems, including home heating oil systems. As of May 31, 2007, \$24,333,140 has been reimbursed by the PECFA program to clean up 187 petroleum-contaminated sites in Walworth County. This equates to \$241 per county resident, which is less than the statewide average of \$264 per resident. Over \$70 million has been spent in Waukesha County on petroleum cleanup from leaking underground storage tanks, which equates to \$186 per county resident.

### Point and Nonpoint Pollution

This watershed has a Nonpoint Source (NPS) Watershed Rank of high due to high rankings for lakes and groundwater resources. Streams in the watershed are ranked as a medium priority for NPS pollution. Furthermore, Upper and Lower Phantom Lake, Lake Beulah, Eagle Spring Lake, and Lulu Lake have all been ranked as high lakes for NPS pollution.

**Runoff from Urban Development and Impervious Surfaces**  
 Urban land use in the Mukwonago River watershed is



Source: SEWRPC



The Mukwonago River Wetland, Roughly One-Quarter Mile Upstream from County Road I. Photo by SEWRPC

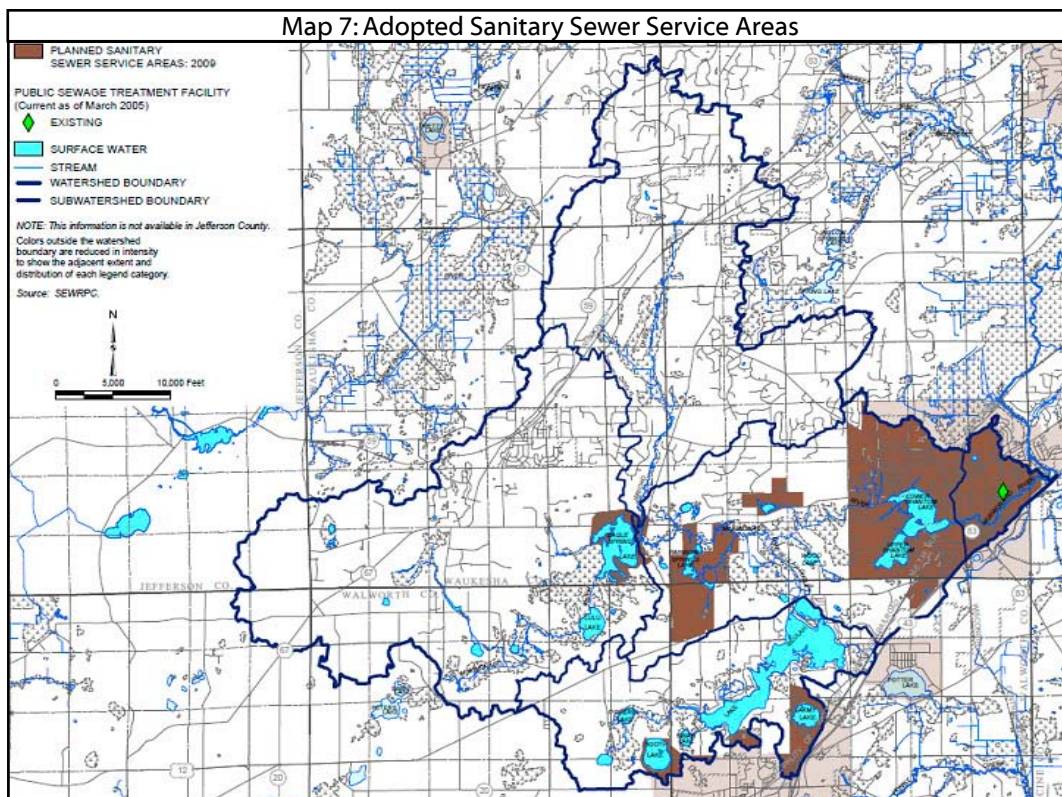


expected to increase between the present and 2035. The percentage of impervious surfaces in a watershed that is directly connected to the stormwater drainage system can help evaluate the impacts of urbanization on a stream system. Studies show that 6 to 11 percent imperviousness in a watershed is approximately the point at which negative biological impacts could be expected to occur in coldwater systems. As of 2000, the Mukwonago River watershed had about 20 percent urban land overall, corresponding to about 6 percent directly connected imperviousness. At the same time, the Eagle Spring, Jericho, Beulah, and Phantom subwatersheds (shown in Figure 3) were also below the threshold level of 6 to 11 percent. The Mukwonago subwatershed exceeded this threshold, with approximately 25 percent connected impervious surface. However, it is important to note that 98 % of the water in the Mukwonago watershed flows through this sub-watershed, with much less development in the upstream sub-watersheds.

The Mukwonago and the Jericho subwatersheds are expected to exceed 38 and 13 percent connected impervious surface by 2035 based upon the 2035 planned land use from the Waukesha and Walworth County comprehensive plans. Although urban density development has proceeded at accelerated rates in the Mukwonago and Jericho sub-watersheds compared to the other subwatersheds, development is expected to continue to occur in all the subwatersheds, collectively increasing the risks of degradation of water quality and the fishery. It is important to note that preservation of substantial riparian buffers throughout the entire Mukwonago River watershed has likely mitigated the negative impacts of development here.

### Sewer Service Areas/Facility plans

Sanitary sewer service areas, including existing and planned sewage treatment facilities, are shown in Map 7 on the following page. These sewer service areas have been delineated through a local sewer service area planning process. As part of this process, the community concerned, assisted by SEWRPC, determines a precise sewer service area boundary consistent with local land use plans and development objectives. Sewer service area plans include detailed maps of environmentally significant areas within the sewer service area. Following adoption of the plan by the designated management agency for the sewage treatment plant, local sewer service area plans are considered for adoption by SEWRPC as a formal amendment to the regional water quality management plan. The Commission then forwards the plans to the WDNR for approval. It should be noted that, despite its proximity to the Mukwonago River, the Village of Mukwonago sewage treatment plant discharges to the Fox River.



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## Stormwater Permits

Within the watershed, the Village of Mukwonago, Village of North Prairie, Village of Wales, Town of Mukwonago, and Town of Genesee are Phase 2 municipal separate storm sewer systems (MS4s) with general permits. These permits require the municipalities to meet the EPA's standard six minimum measures, including urban stormwater outreach and public involvement with the general public, construction site and long-term stormwater runoff controls, illicit discharge detection and elimination programs and general good housekeeping measures (pollution prevention) at the municipality's own properties and in the programs the municipality operates. In addition, the State of Wisconsin requires municipal stormwater permittees to reduce the amount of sediment (total suspended solids) entering the waters of the state through the MS4 systems by 20%, with the ultimate goal of reaching 40% reductions. These reductions are applied to all of the urbanized areas of the municipality, and should consider the waterways receiving the stormwater runoff when improvements are implemented. All of the MS4 permittees in the Mukwonago River Watershed participate in the Waukesha County Information & Education program, which is lead by the Waukesha County Parks & Land Use Department.

There are nine Tier 2 industrial permitted facilities, two permitted scrap auto recycling facilities, and four permitted non-metallic mining sites within the Mukwonago River watershed. These facilities all have standard permit language to follow to minimize the pollutants of concern reaching the nearby waters of the state.

## Existing Stormwater Management Systems

A variety of stormwater management features are located in the Mukwonago River watershed. Approximate locations of these stormwater best management practices (BMPs) are shown in Map 8<sup>3</sup> on the following page. Some of these BMPs include wet and dry detention basins, grass swales, filter strips, infiltration basins and trenches, and constructed and artificial prairies, kettles, and wetlands.

Installation and maintenance of appropriate stormwater BMPs are an important part of maintaining good water quality within the Mukwonago River watershed. Because they have been implemented over time, not all BMPs in the watershed were designed and constructed based on current technical standards. New BMPs in the watershed are designed based on current technical standards for stormwater management that include criteria intended to protect water quality. Older stormwater BMPs could have increased functionality for water quality improvement if modifications are made to bring them up to the current standards. Also, BMPs that promote infiltration of precipitation are important in the watershed for maintenance of stream baseflows and coldwater stream characteristics.

## Waters of Note

### Trout Waters

Class I trout streams are high quality trout waters that have sufficient natural reproduction to sustain populations of wild trout, at or near carry capacity. Consequently, streams in this category require no stocking of hatchery trout. These streams or stream sections are often small and may contain small or slow-growing trout, especially in the headwaters. Class II trout streams may have some natural reproduction, but not enough to utilize available food and space. Therefore, stocking is required to maintain a desirable sport fishery. These streams have good survival and carryover of adult trout, often producing some fish larger than average size. Class III trout waters are marginal trout habitat with no natural reproduction occurring. They require annual stocking of trout to provide trout fishing. Generally, there is no carryover of trout from one year to the next (<http://dnr.wi.gov/fish/species/trout/streamclassification.html>).

The entire six-mile stretch of Jericho Creek is classified as a Class II trout water. The Mukwonago River is a 16.8-mile-long river in Walworth and Waukesha Counties. Mile 4.08 through 9.68 (from the mouth) is classified as a Class II trout water. Mile 9.68 through 9.76 of Mukwonago River is classified as a Class III trout water, and Mile 11.97 through 15.47 of the river is a Class I trout water.

<sup>3</sup> These data were compiled from field inventories and information obtained from local communities by Waukesha County. Similar BMP inventories are not available for Jefferson and Walworth Counties.

Map 8: Stormwater Best Management Practice Sites

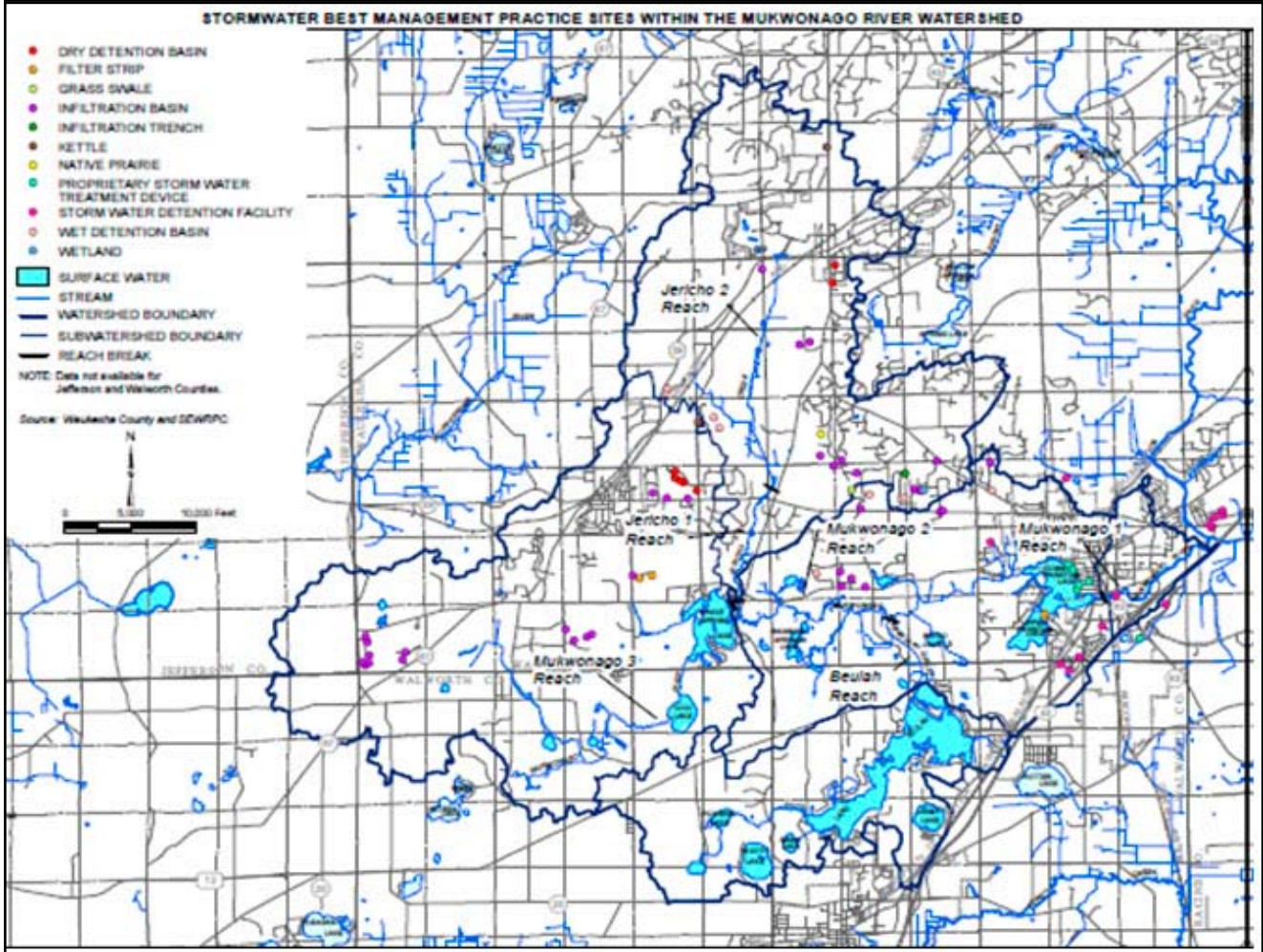


Table 5: Mukwonago River Watershed Trout Waters

WADRS ID	Official Waterbody Name	Local Waterbody Name	WBIC	Start Mile	End Mile	Trout Class	Trout ID	Counties
18111	Jericho Creek	Jericho Creek	768300	0	6	CLASS II	1817	Waukesha
897059	Mukwonago River	Mukwonago River	765500	4.08	9.68	CLASS II	1816	Waukesha
897203	Mukwonago River	Mukwonago River	765500	9.68	9.76	CLASS III	2948	Waukesha
10498	Mukwonago River	Mukwonago River	765500	11.97	15.47	CLASS I	707	Walworth, Waukesha

Outstanding and Exceptional Resource Waters

Wisconsin has designated many of the state’s highest quality waters as Outstanding Resource Waters (ORWs) or Exceptional Resource Waters (ERWs). Waters designated as ORW or ERW are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORW and ERW status identifies waters that the State of Wisconsin has determined warrant additional protection from the effects of pollution. These designations are intended to meet federal Clean Water Act obligations requiring Wisconsin to adopt an “antidegradation” policy that is designed to prevent any lowering of

water quality, especially in those waters having significant ecological or cultural value.

Outstanding Resource Waters (ORWs) typically do not have any point sources discharging pollutants directly to the water (for instance, no industrial sources or municipal sewage treatment plants), though they may receive runoff from nonpoint sources. New discharges may be permitted only if their effluent quality is equal to or better than the background water quality of that waterway at all times. No increases of pollutant levels are allowed. If a waterbody has existing point sources at the time of designation, it is more likely to be designated as an Exceptional Resource Water (ERW). Like ORWs, dischargers to ERW waters are required to maintain background water quality levels; however, exceptions can be made for certain situations when an increase of pollutant loading to an ERW is warranted because human health would otherwise be compromised (<http://dnr.wi.gov/org/water/wm/wqs/orwerw/>). A 5.6-mile section of Mukwonago River, which coincides with the river's Class II trout water, is listed as an Exceptional Resource Water (ERW). Furthermore, Lulu Lake is recognized as an Outstanding Resource Water (ORW).

**Table 6: Mukwonago River Watershed Outstanding and Exceptional Resource Waters**

WADRS ID	Official Water-body Name	Local Water-body Name	WBIC	ORW/ERW	ORW/ERW ID	Start Mile	End Mile	Code Reference	Counties
10506	Lulu Lake	Lulu Lake	768800	ORW	1630	null	null	102.10(1m)19	Walworth
897059	Mukwonago River	Mukwonago River	765500	ERW	1629	4.08	9.68	102.11(1)(d)40	Waukesha

### Impaired Waters

This watershed contains no impaired waters to date.

### Fish Consumption

No specific fish consumption advisories are in effect for waterbodies in the Mukwonago River Watershed at this time. The Fox River, which lies at the mouth of the Mukwonago River, however, does have a fish consumption advisory in effect for polychlorinated biphenyls (PCBs) and a general fish consumption advisory for potential presence of mercury is in place for all waters of the state.

### Aquatic Invasive Species

Curly-leaf pondweed, Eurasian water-milfoil, and zebra mussels have spread throughout many of the lakes in the Mukwonago River Watershed. Freshwater jellyfish have also been documented in Upper Phantom Lake and milfoil hybrids have been found in Lake Beulah and a pond at Mukwonago Park. In addition, Jericho Creek and Mukwonago River have been invaded by rusty crayfish.

**Table 7: Mukwonago River Watershed Aquatic Invasive Species**

Database Key	Name	Bio. Common Name	Status	Start Date	WBIC
22552204	Beulah Lake	Curly-leaf Pondweed	Verified and Vouchered	12/31/1991	766600
22553370	Eagle Spring Lake	Curly-leaf Pondweed	Verified and Vouchered	12/31/2005	768600
34912716	Lower Phantom Lake	Curly-leaf Pondweed	Verified and Vouchered	08/06/1980	766000
22553952	Phantom Lake, Upper	Curly-leaf Pondweed	Verified and Vouchered	12/31/2005	766000
28619757	Pickereel Lake	Curly-leaf Pondweed	Verified and Vouchered	06/06/2007	767100
1100	Army Lake (East Troy)	Eurasian Water-milfoil	Verified and Vouchered	06/01/1995	740200
34925373	Beulah Lake	Eurasian Water-milfoil	Verified and Vouchered	12/31/1991	766600
1101	Booth Lake	Eurasian Water-milfoil	Verified and Vouchered	06/01/1995	740400
1131	Eagle Spring Lake (Eagle)	Eurasian Water-milfoil	Verified and Vouchered	08/01/1994	768600
1280	Lower Phantom Lake (Howitt)	Eurasian Water-milfoil	Verified and Vouchered	01/01/1997	765800
1132	Lulu Lake	Eurasian Water-milfoil	Verified and Vouchered	08/01/1994	768800
1410	Peters Lake	Eurasian Water-milfoil	Verified and Vouchered	03/24/2004	741400

1293	Pickrel Lake	Eurasian Water-milfoil	Verified and Vouchered	01/01/1997	767100
1130	Roxy Pond (Mukwonago Park)	Eurasian Water-milfoil	Verified and Vouchered	06/01/1995	767400
1411	Swift Lake	Eurasian Water-milfoil	Verified and Vouchered	03/24/2004	741800
1312	Upper Phantom Lake	Eurasian Water-milfoil	Verified and Vouchered	01/01/1980	766000
1129	Beulah Lake (Beaulieu)	Eurasian Water-milfoil (hybrid)	Verified and Vouchered	01/01/1987	766600
1285	Mukwonago Park Pond	Eurasian Water-milfoil (hybrid)	Verified and Vouchered	01/01/1994	767500
Database Key	Name	Bio. Common Name	Status	Start Date	WBIC
22592378	Jericho Creek	Rusty Crayfish	Verified and Vouchered	-	768300
22592581	Mukwonago River	Rusty Crayfish	Verified and Vouchered	-	765500
9963293	Eagle Spring Lake	Zebra Mussel	Verified and Vouchered	01/01/2005	768600
191	Lake Beulah	Zebra Mussel	Verified and Vouchered	01/01/1999	766600
7	Lake Beulah Outlet	Zebra Mussel	Verified and Vouchered	01/01/1999	766300
8	Lake Beulah Outlet	Zebra Mussel	Verified and Vouchered	01/01/1999	766300
187	Lower Phantom Lake	Zebra Mussel	Verified and Vouchered	01/01/2002	765800
47	Mukwonago River	Zebra Mussel	Verified and Vouchered	01/01/2002	765500
188	Upper Phantom Lake	Zebra Mussel	Verified and Vouchered	01/01/2002	766000
22557041	Upper Phantom Lake	Freshwater Jellyfish	Verified and Vouchered	-	766000

### Species of Special Concern

The following table contains federally-listed Threatened, Endangered, Proposed, and Candidate species that have been observed in Walworth and Waukesha counties, in which the Mukwonago River Watershed is located.

Table 8: Federally-Listed Threatened, Endangered, Proposed, and Candidate Species in Walworth and Waukesha Counties			
Species	Status	Habitat	Taxa
Whooping crane ( <i>Grus americanus</i> )	**Non-essential experimental population	Open wetlands and lakeshores	Bird
Eastern massasauga ( <i>Sistrurus catenatus catenatus</i> )	Candidate	Open to forested wetlands and adjacent upland areas	Reptile
Eastern prairie fringed orchid ( <i>Platanthera leucophaea</i> )	Threatened	Wet grassland	

\*\*Whooping Crane - On June 26, 2001, a nonessential experimental population of the whooping crane was designated in a 20-state area of the eastern United States. The first release of birds occurred in Wisconsin in 2001, and the counties listed are those where the species has been observed to date. It is unknown at this time which counties the species will occupy in the future, as the birds mature and begin to exhibit territorial behavior. For purposes of section 7 consultation, this species is considered as a proposed species, except where it occurs within the National Wildlife Refuge System or the National Park System, where it is treated as a threatened species (<http://www.fws.gov/midwest/endangered/lists/wisc-spp.html>).

A full list of special concern plants and animals for this watershed can be found on the state's Natural Heritage Inventory (NHI).

### State Natural Areas

#### Beulah Bog

Beulah Bog lies in a series of four kettle holes and features an undisturbed bog



Beulah Bog, Photo by Thomas Meyer (WDNR photo)

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with many unusual plants more typical of northern bogs. Classical stages of ecological succession are exhibited in the bog including: a shallow bog lake dominated by watershield with white and yellow waterlilies and extensive floating mud flats; an advancing, quaking sedge and sphagnum mat between 25 and 50 feet wide; northern wet forest of tamarack and bog shrubs and; a wet open moat surrounding the main bog, dominated by wild calla and cattails. Undisturbed bogs in this area are rare and the site supports a number of regionally rare plants with more northern affinities including dense cotton grass, large and small cranberry, and small bladderwort. The site harbors at least six species of insectivorous plants and the state-threatened plant, kitten tails (*Bessya bullii*), is also found here. The bog lake provides habitat for several dragonfly species and other invertebrates. Beulah Bog is owned by the DNR and was designated a State Natural Area in 1975.

#### **Clifford F. Messinger Dry Prairie & Savanna Preserve**

Stretching across more than 20 miles of kettle moraine topography of kettle holes, interlobate moraine, and outwash plains in southeastern Wisconsin, this preserve consists of sixteen separate sites, grouped into five units, containing prairie and oak opening communities. Each site has a unique flora which together characterizes the presettlement flora of the region. The prairies are dominated by big and little blue-stems, Indian grass, prairie drop-seed, and side-oats grama. Flowering plants include pasque flower, bird's-foot violet, purple prairie-clover, hoary puccoon, old-field goldenrod, and blazing-star. Although each has its distinctive character, two sites deserve discussion here. Bald Bluff Dry Prairie is the largest dry prairie of the group and the most diverse in terms of plant species. It also has historical significance: it was visited by Abraham Lincoln when he was in the U.S. Army and it is thought to be a Native American signal hill. Whitewater Oak Opening, covering 120 acres of rugged morainal topography, is dominated by bur oak on the ridge tops and south and southwest-facing slopes, by red oak on the north-facing slopes, and by white oak in other places. Like the few other remnant oak openings in the state, it has been invaded by shrubs and other woody growth over the years, especially honeysuckle and prickly ash. However, a wildfire in the 1950's opened up the site to a certain extent, and this natural fire is being mimicked by prescribed burning, reinstating this crucial process of the oak opening ecosystem. Clifford F. Messinger Dry Prairie and Savanna Preserve is owned by the DNR and was designated a State Natural Area in 1990.

#### **Eagle Centre Prairie**

Eagle Centre Prairie features a remnant prairie and bur oak opening situated on broken, gravelly interlobate moraine. Scattered, large, open-grown bur oaks with white and black oak are interspersed with prairie-like openings. A moderate number of native prairie and savanna species have persisted, and those that are especially resistant to grazing can still be found in abundance including pasque flower, prairie smoke, and the state-threatened kitten tails (*Besseyia bullii*). Other species include purple love grass, prairie dropseed, side-oats grama, death camas, purple prairie clover, bird's-foot violet, whorled milkweed, shooting star, showy goldenrod, silky aster, and thimbleweed. Dense thickets of shrubs and saplings occur under large oaks, especially in more mesic draws and kettles. Management practices such as brushing, prescribed burning, and interseeding of native species will help restore and maintain the vigor of the prairie and oak opening. Eagle Centre Prairie is owned by the Waukesha Land Conservancy and was designated a State Natural Area in 2002.

#### **Eagle Oak Opening**

Eagle Oak Opening was the first oak opening found in a statewide search and contains an example of kettle hole moraine topography and large numbers of open-grown white and bur oaks. Most of the former oak opening has reverted to dry-mesic forest but there are areas where some of these prairie species can still be found. Species include big and little blue-stem, Indian grass, side-oats grama, prairie drop-seed, blue-eyed grass, prairie buttercup, alum-root, prairie smoke, New Jersey tea, bird's-foot, prairie violets, shooting-star, pale-spiked lobelia, white camas, goldenrods, and asters. There is also a showy display of pasque flowers in the spring. The area has many glacial formations including kettle holes with ephemeral ponds that are important habitat for amphibians. Eagle Oak Opening is owned by the DNR and was designated a State Natural Area in 1968.

#### **Lulu Lake**

Lulu Lake is an assemblage of exceptionally high quality and diverse wetland and upland communities on glacial topography in the Kettle Moraine region. Many of the natural communities protected here have been virtually eliminated from southeastern Wisconsin. The focal point of the area is the 95-acre Lulu Lake, a 40-foot deep, hardwater drainage kettle lake fed by the Mukwonago River and situated at the base of glacial deposits. The clear waters harbor a diverse fish, amphibian, and reptile fauna, including pugnose shiner (*Notropis anogenus*), Blanding's turtle (*Emydoidea blandingii*), and pickerel frog (*Rana palustris*). A large wetland complex with patches of calcareous fen and shrub carr embedded within

a sedge meadow matrix surrounds the lake on the north and west. An inlet stream contains many rare species such as beaked spike-rush (*Eleocharis rostellata*), slender bog arrow grass (*Triglochin maritimum*), Ohio goldenrod (*Solidago ohioensis*), lesser fringed gentian (*Gentianopsis procera*), Kalm's lobelia (*Lobelia kalmii*), and downy willow herb (*Epilobium strictum*). A small bog surrounded by tamarack forest is also present along with a good complement of other northern bog species including the uncommon dragon's mouth orchid (*Arethusa bulbosa*). Scattered patches of prairie grow within the oak opening and woodlands and harbor the state-threatened kitten tails (*Besseyia bullii*). Other rare species include the dion skipper butterfly (*Euphyes dion*). Lulu Lake is owned by the DNR and The Nature Conservancy and was designated a State Natural Area in 1977.

### **Mukwonago River**

The Mukwonago River is among the cleanest and most biologically diverse streams in southeastern Wisconsin and provides critical habitat for a number of rare, threatened, and endangered species of fish and invertebrates. Between Eagle Spring and Phantom Lakes, the river is designated an Exceptional Resource Water, with clear, warm water and a maximum depth of 2'. The bottom is composed of sand, rocks and gravel and contains many large glacial boulders. At least 53 species of fish, including the state-threatened longear sunfish (*Lepomis megalotis*) and state-endangered starhead topminnow (*Fundulus dispar*) have been found here. In fact, the two-mile stretch of river from the natural area downstream to its confluence with the Fox River, contains the last known self-sustaining longear sunfish population in Wisconsin. Among the other fish inhabiting the stream are grass pickerel, rosyface shiner, sand shiner, banded killifish, tadpole madtom, rainbow darter, and brook silverside. Longnose gar are often seen patrolling the waters. Equally diverse is the freshwater mussel fauna. This reach of the Mukwonago is one of the most biologically-rich mussel habitats in the state. Sixteen species are found here, including Wisconsin's only remaining viable population of the state-endangered rainbow shell (*Villosa iris*). Rare dragonflies known from the stream are the fragile forktail (*Ischnura posita*) and the double-striped bluet (*Enallagma basidens*). Beds of coontail and other submerged aquatics are common in the stream, while the banks contain bulrushes, sedges and other emergent plant species. The 44-acre State Natural Area lies within the larger Mukwonago River Watershed corridor, a mosaic of natural communities including forest, savanna, wetlands, and lakes. This diverse landscape is home to a wide array of native plants and animals and is an important stopover site for a number of Neotropical migratory birds. Mukwonago River is owned by the DNR and was designated a State Natural Area in 2005.

### **Pickerel Lake Fen**

Pickerel Lake Fen is a diverse alkaline fen that originates at the base of a glacial ridge from seeps and springs. The fen has a rich flora and is quite large for a fen. Shrub encroachment is confined largely to the first 25 meters bordering the upland. Downslope, towards Pickerel Lake, the fen becomes quaking and eventually grades into rushes and cattails. Unusual plant assemblages are found including large populations of shrubby cinquefoil, pitcher plant, sedges, bulrushes, and blue-joint grass. Showy species such as marsh blue violet, swamp milkweed, Joe-Pye weed, boneset, and several goldenrods are common. The uplands are no longer farmed and now show evidence of invasion by prairie plants. The site has been used for foraging by sandhill cranes. Pickerel Lake Fen is owned by the Wisconsin Chapter of The Nature Conservancy and was designated a State Natural Area in 1986.

The Nature Conservancy has established its Mukwonago River Watershed project office on 40 acres located on the north side of Pickerel Lake. The land, which is largely dominated by oak openings, an extremely rare plant community, is at a high point, and there are good views of Pickerel Lake. The fen itself is located south of Pickerel Lake and is a fragile environment.

Fens are among the rarest types of wetlands in North America, including Wisconsin. They are



ESL Dam. Photo by SEWRPC

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dependent upon natural springs and, as a result, have never been common. Pickerel Lake Fen is tied for first place with Ottawa Lake Fen as the most biologically diverse fen in southeast Wisconsin and is one of the few fens in conservation protection. Several rare or endangered species are also protected at the preserve. Pickerel Lake Fen is dedicated as a State Natural Area.

The Nature Conservancy has owned and managed land at Pickerel Lake Fen Preserve since 1985 when the Emmerich and Muth families donated 38 acres. The Emmerichs also donated a conservation easement on additional land to help protect the calcareous fen. The Conservancy acquired another 40 acres in 2000 and located its Mukwonago River Watershed project office at the preserve.

Conservancy staff and volunteers, together with local landowners, are using periodic prescribed fires and manual removal to control non-native, invasive species like buckthorn and honeysuckle, which rim the edge of the fen and are slowly advancing on the interior. Left unchecked, they will out-compete the native vegetation and would eventually take over completely (<http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/wisconsin/placesweprotect/pickerel-lake-fen-preserve.xml>).

## Other Nature Preserves

### **Newell and Ann Meyer Nature Preserve**

As a major portion of the headwaters of the Mukwonago River, this preserve rises from springs on the Newell and Ann Meyer Nature Preserve. In 2006, Newell and Ann Meyer donated the land to The Nature Conservancy through their estate, which constitutes the largest gift of land and assets ever made in Wisconsin for conservation. The preserve is adjacent to the southern unit of the Kettle Moraine State Forest and is located about three miles northwest of the Conservancy's Lulu Lake and Crooked Creek preserves.

The Meyers' generous gift of land and other financial assets allowed the Conservancy to establish the nature preserve, open it to the public in 2009 and begin restoration efforts. Prior to the Meyers' acquisition of the land, about two-thirds of it was in agricultural production. In the coming years, the Conservancy will restore about 200 acres to native prairie.

Prairies and other grasslands are invaluable in the protection of bird species that nest only in these wide open, grassy landscapes. They include bobolinks, which arrive at the preserve each year after a migration of some 5,000 miles from South America.

Forty-two acres of oak woods on the property will be enhanced by the removal of invasive plants including buckthorn, honeysuckle and garlic mustard. The Conservancy will also improve the health of the wetlands at the preserve by removing purple loosestrife, Phragmites, and other wetland invaders (<http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/wisconsin/placesweprotect/newell-and-ann-meyer-nature-preserve.xml>).

### **Crooked Creek Preserve**

Crooked Creek Preserve takes its name from the winding river that runs through it and like the Newell and Ann Meyer Nature Preserve harbors a major portion of the headwaters of the Mukwonago River. It is a landscape of steep ridges, kettle lakes, and wetlands inhabited by sandhill cranes and other interesting plants and wildlife. It's also a great place to see and participate in restoration of the land as Conservancy volunteers remove pine plantations and restore parts of the preserve to prairie and oak savanna. The Nature Conservancy bought the 197-acre property from Aurora University (formerly George Williams College) in August, 2000.

The Conservancy has spent nearly 10 years removing white and red pines from the preserve to prevent soil erosion into the river and to restore the oak savannas that once existed on the property. The pines don't naturally occur in the area but have spread over the years from sites where they were planted, surrounding many of the oak trees native to the area, reducing the sunlight that reaches them, and starting to kill their lower branches (<http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/wisconsin/placesweprotect/crooked-creek-preserve.xml>).



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## Rainbow Springs Lake

In 2008, the state bought the 970-acre Rainbow Springs property for \$10.8 million with funding from the Knowles-Nelson Stewardship Program in an attempt to help preserve the nearly pristine Mukwonago River system. Two golf courses located on the property were closed in 2010, but the future of the site remains in question at this time.

### Watershed Actions

#### Grants/Projects

##### *Targetted Runoff Management Grant – Nature Conservancy Stabilization 1/1/2011 – Active*

Project calls for stabilization of and grade stabilization practices to control sediment delivery to Pickerel Lake and the Mukwonago River System. Project oversight by Walworth County staff.

##### *Lake Planning Grants - Lake Beulah Water Quality Monitoring 04/01/2008 - Complete*

The Lake Beulah Management District hired contractors to monitor water quality to evaluate impacts to the lake, such as surface water runoff and stress to the aquifer. The district also studied the question of whether chemical constituents can be used as tracers for groundwater in a lake. The final report contained the following elements: 1) Results of surface water chemistry monitoring, including two lake sites; 2) Results of streamflow and stream chemistry monitoring; 3) Results of private well and piezometer monitoring (5 nests); 4) Results of lake bed temperature probes (2) monitoring; 5) Development of a database regarding the quality of the groundwater and surface water discharging into the lake and the natural fluctuations of the temperature of the discharging groundwater. Two paper copies and one electronic copy of the final plan (including an electronic copy of the database) were provided to the department. Exact details for all deliverables are described in the project description of grant application.

##### *Urban Stormwater Planning Grant - Village of Mukwonago: SW Utility Formation 01/01/2008 - Complete*

Cost-share analysis and development of a storm water utility or alternative storm water financing mechanism. The village's Storm Water Utility Feasibility Study was completed, and officially accepted by the Village Board on February 2, 2010, "with approval to continue into the implementation phase." A Public Hearing to discuss methodologies was held by Paul Moderacki, Village Administrator, on August 10, 2010.

##### *River Planning Grant - Phantom Lake Management District: Planning for Mukwonago & Lower River Basin 07/01/2007 - Complete*

This was part of a multi-phased program to gather information, assess, and determine how best to coordinate and cooperate on projects with Phantom Lakes Management District, Lake Beulah, Eagle Springs Management Districts, The Nature Conservancy and Friends of the Mukwonago River. This project also resulted in a stream protection plan, data, information and analyses of the upper reaches of the Mukwonago River. All of the data and information collected is included in a single comprehensive river protection plan. The results were also communicated to the citizens through I&E programs of the Friends of the Mukwonago River, The Nature Conservancy, and governmental meetings. Once the grant was complete, the department looked for every single deliverable, even minor ones, and if they were not adequately addressed, only a partial reimbursement (at the department's discretion) was made to the applicant. A full description of the project scope and deliverables is available in the grant application, which is part of this agreement. The DNR was provided with two paper copies and an electronic copy of the final report which entails all the items in the project description. Information was disseminated to the public as described in the grant application.

##### *River Protection Grants - The Nature Conservancy - Mukwonago River 07/01/2007 - Complete*

1.) Successful drawdown of two impoundments on the upper Mukwonago River followed by removal of the two dams with negative impact down stream. 2) Permanently mitigated the risk of either dam breaching causing negative impacts down stream. 3) Restored the functional wetland system to the areas of the current impoundments by recreating approximately 15 acres of wetland. 4) Repaired several areas around the two impoundments that have been altered by the fisheries operation to return features to historic conditions. Once the grant was completed, the department looked for every single deliverable, even minor ones, and if they were not adequately addressed, only a partial reimbursement (at the department's discretion) was made to the applicant. A full description of the project scope and deliverables is available in the grant application, which is part of this agreement. The DNR was provided with two paper copies and an

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electronic copy of the final report which entails all the items in the project description. Information was disseminated to the public as described in the grant application.

*River Planning Grant - Eagle Spring Lake Management District: Mukwonago River Plan 07/01/2006 - Complete*  
Development of a management and protection plan to enhance the water quality and biological integrity of the stream and its riparian corridor. A full description of the project scope and deliverables is available in the grant application, which is part of this agreement. The DNR was provided with two paper copies and an electronic copy of the final report. Information was disseminated to the public as described in the grant application.

*Urban Stormwater Planning Grant - Village of Mukwonago: Storm Water Plan Development 10/01/2005 - Complete*  
Developed municipal runoff ordinances in compliance with Chapter NR151, mapped the area's drainage systems, developed a stormwater management plan, and provided for public involvement & education. Storm Water Plan developed; formally adopted by the Village of Mukwonago in fall of 2009, per final report.

*Lake Protection Grant - Walworth County: Shoreline Habitat Restoration 09/01/2005 - Complete*  
Walworth County was able to continue the Walworth County Lakes Specialist position for one year. The Lakes Specialist provided educational information to lake residents regarding shoreline stabilization and shoreline restoration. The Lakes Specialist also designed shoreline restoration projects for interested landowners, provided technical assistance to contractors, and held workshops on shoreland restoration. The project deliverable was a report containing the following: 1) Copies of the shoreland restoration designs; 2) Copies of the fliers for each restoration workshop, and 3) Details regarding the accomplishments of the Lakes Specialist over the year of the grant. Two paper copies and one electronic copy of the report were provided to the Department of Natural Resources

*Lake Planning Grant - Lake Community Planning Inventory-Walworth Co. 10/01/2004 - Complete*  
The Walworth County Land Use and Resource Management Department developed a survey to send out to 99 units of government and lake associations in Walworth County that are directly involved with the 36 lakes in Walworth County. The survey inquired about institutional tools, laws, ordinances, studies, and educational programs that currently exist or are needed. The project deliverables include a copy of the survey and the final report containing the analysis of the completed surveys. The grantee provided a final report to the DNR Lake Coordinator. The DNR received both a paper and an electronic PDF copy of the final report along with grantee's final payment request.

*Lake Planning Grant - Lakeshore Landowners survey Grant-Walworth Co. 10/01/2004 - Complete*  
The Walworth County Land Use and Resource Management Department developed a survey to send out to approximately 6,000 lakeshore landowners. The survey inquired about landowner knowledge, views, perceptions and interest in water quality problems and water quality protection measures. The project deliverables included a copy of the survey and the final report containing the analysis of the completed surveys. The grantee provided a final report to the DNR Lake Coordinator. The DNR received both a paper and an electronic PDF copy of the final report along with grantee's final payment request.

*River Planning Grant - Mukwonago River-Watershed Nutrient Study 07/01/2004 - Complete*  
The Eagle Spring Lake Management District applied for a river planning grant to help fund a water quality monitoring study on tributaries of the Mukwonago River. The purpose of the project was to determine nutrient loading problems to the streams and use the data to work with local government on land use and development issues. Two local organizations (Mukwonago River Initiative and Friends of Mukwonago River) also utilized the project to gain membership and financial support for future projects. Ten water samples were collected five times per year for 2004 through 2006. Lab analysis was done by UWSP and included conductivity, total and reactive phosphorus, ammonia, nitrate-nitrite nitrogen, Total Kjeldahl Nitrogen, chloride, and total solids. Lab costs totaled \$9,639.00. Total project costs were \$12,308.00. Therefore, sponsor match was about \$3,100.00, to be shared by Eagle Spring and Phantom Lakes Management District. Mukwonago River is an ERW and these tributaries are vital to its protection. The district utilized press releases, newsletters, mailings, and public presentations for I&E Efforts. Area school groups will be involved in sampling and data evaluation. A final report was submitted to the WDNR at the end of the project period.

*Lake Planning Grant - Lake Beulah Groundwater Modeling & Mapping 04/01/2004 - Complete*

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The LBMD undertook a project to understand the hydrology and hydrologic response of the Lake Beulah subwatershed. Piezometers were installed at various locations around the lake, inlet/outlet monitoring was conducted and a water budget for Lake Beulah was established. The project deliverable for this grant was the submittal of two paper copies and one electronic copy (on a CD-ROM) of the final report to the WDNR. The final report contained the following elements: 1) Summarized raw data for the piezometers; 2) Summarized inflow/outflow data; 3) Estimates of precipitation, evaporation and overland flow; 4) Modeling of groundwater contribution and aerial distribution to Lake Beulah; 5) A discussion of the accuracy of the model; and 6) Results of simulations conducted on the model to evaluate impacts to the lake and groundwater during stresses (such as a high capacity well withdrawal).

*Lake Planning Grant - Eagle Spring Lake Sediment Impact Analysis 10/01/2003 - Complete*

Phase 1 - Sediment Impact Analysis. AUSACOE sediment study consisting of: a) Collection of 12 sediment cores. 6 cores were analyzed for phosphorus (P) release from the marl layer and 6 cores will be analyzed for P release from the organic (i.e. peat) layer. Three cores of each were tested in oxic conditions and three cores of each were tested in anoxic conditions. b) Collection of three sediment cores used to estimate compaction due to sediment dewatering. c) Collection of nine sediment cores to estimate internal phosphorus loading in the surface marl layer as a result of sediment dewatering. An electronic version and paper copy of a report of "a" through "c" above and a separate report containing the following elements: 1) Long term water budget; 2) Analysis of the capacity of the two Eagle Spring Lake outlets (i.e. dams); 3) Mapping of potential lake bed to be exposed during a lake drawdown; and 4) Recommendations for extent of drawdown (depth, duration and rate).

*Lake Planning Grant - Eagle Spring Lake Hydraulic Analysis-Phase 1 10/01/2003 - Complete*

Hydraulic Analysis: Phase II contained these three items: a) Lake refill study calculated potential refill times based on the last 35 years of precipitation records. Probability plots of refill times were prepared to assess variability. b) Downstream impact study included analysis of downstream floodplain impacts, analysis of potential downstream river bed scour and analysis of potential impacts to Lower Phantom Lake. c) A groundwater model was developed by USGS for Eagle Spring and Lulu Lakes. The project deliverables were an electronic version and paper copy of project report containing the following elements: 1) Lake refill study; 2) Analysis of downstream impacts due to proposed lake drawdown; and 3) Analysis of impacts to local wells. Scope change amendment #2 in May 2005 was to add a specific line item for a sediment and coring dating study for \$2,000. Scope change amendment #3 in July 2005 was to add a specific line item for development of a marl budget for Eagle Spring Lake for \$4,080. The "downstream impact" line item was adjusted down \$6,080 on September 27, 2005, to account for this.

*Lake Planning Grant - Upper & Lower Phantom Lakes Planning Program 10/01/2001 - Complete*

This was Phase II of a comprehensive planning program for Upper and Lower Phantom Lakes. This proposal complemented and completed the planning program initiated during 2000 with Phase I. Phase II activities developed, analyzed, and identified feasible alternative management measures for the lakes. The deliverables included a SEWRPC Community Assistance Planning Report, or equivalent, at least two public informational meetings to be held during the project period, and the distribution of targeted informational materials at the annual meeting of the district. The DNR was provided with both a paper copy and an electronic copy of the final report. Information was disseminated to the public as described in the grant application.

*Lake Protection Grant - The Nature Conservancy: Pickerel Lake Fen-Campbell 09/01/2001 - Complete*

Purchase of approximately 39 acres of the Campbell property with 1,500 feet of lake frontage. This will help to facilitate land management, maintain high water quality, and provide a link to high quality natural areas.

*Lake Protection Grant - Eagle Spring Lake Management District: Mukwonago Watershed Feasibility Study 07/01/2001 - Complete*

Studies and surveys to correct and improve the watershed conditions. Consultant tested if a drawdown strategy will work. This was to update management plan, make recommendations to residents, and hold public meetings. The Department of Natural Resources was provided with both a paper copy and an electronic copy of the final report. Scope change: Additional sediment samples were deemed necessary to provide information for the report. Labor for sampling was included in this grant with no cost increase to grant total or SLOH testing. Scope change: Came in under budget for fish assessment, seed bank study, mussel survey, and aquatic plant survey so it was used for part of a re-

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imbursement on the Wetland Vegetation survey. This survey was in the Feasibility Study which was already submitted. There was a slight cost increase which was funded by local funds.

*Lake Planning Grant - Phantom Lake Management Plan-Phase 1 04/01/2001 - Complete*

Preparation of a lake management plan for the Phantom Lakes. 1) Updated and quantified the description of existing conditions. 2) Identified existing and potential future water quality. 3) Assessed the degree and intensity of recreational water use. 4) Assessed the response of aquatic plants in the Lakes to external nutrient loads and the impact. 5) Formulated appropriate management actions. This was the first phase of the project. Phantom Lakes Management. District held an informational meeting during the planning program to inform interested persons of the studies and update Lake Management Plan recommendations.

*Lake Protection Grant - Walworth County Shoreland Protection Initiative 01/01/2001 - Complete*

Walworth County implemented the Shoreland Protection Initiative project that includes: 1) A baseline lakeshore inventory; 2) Ten lakeshore demonstration sites; 3) The preparation of lake lawn and yard nutrient management plans; 4) Fact sheets on lakeshore stabilization, shoreland buffers, shoreland regulations and lawn care; 5) An annual lakeshore inventory and distribution of shoreland regulation materials; 6) Formation of a Walworth Co. Lakes Association and meetings with and newsletter pertaining to Walworth Co. lakes; 7) Workshops, information packets and news articles pertaining to the Fox River Basin Partnership Team Lakes Initiative; and 8) The formation of the Walworth County Land Conservancy.

*Lake Planning Grant - Booth Lake Management Plan 07/01/2000 - Complete*

This project was proposed by Booth Lake Management District to be a multitasked information gathering by the district and SEWRPC on Booth Lake. Project elements were as follows: Recreation use survey, ID of citizen concerns, assessment of land use and lake use, development of a management plan, public information meetings, and water quality monitoring. The water quality monitoring consisted of 1) Fish survey; 2) Aquatic plant survey; 3) Ambient water quality and water quality modeling. The DNR was provided with both a paper copy and an electronic copy of the final report. Information was disseminated to the public as described in the grant application.

*River Planning Grant - Waukesha County Land Conservancy: Mukwonago River Video 04/01/2000 – Complete*

The Waukesha Land Conservancy developed a video of the Mukwonago River to be used for educational programs on the river protection efforts and recruitment of new members.

*Lake Planning Grant - Phantom/Eagle Springs Project WET 11/01/1999 - Complete*

Phantom Lake Management District proposed to complete a recreational use survey on area lakes. The following items were some of the deliverable results of this project; project WET teacher training In-Service; integration of project WET and Adopt-A-Lake in school districts. This was a cooperative project between Upper and Lower Phantom Lakes and Eagle Springs Lake districts. The DNR was provided with both a paper copy and an electronic copy of the final report. Information was disseminated to the public as described in the grant application. Expanded the project description to include review and update jurisdictional boundaries to include all riparian properties. Developed and implemented an ordinance for inspection and pumping of private sewage systems installed prior to 1979. PLMD performed a private sewage system evaluation. This evaluation consisted of a field study within the identified area to visually evaluate the type, status, and use of their private sewage disposal systems. Public meeting were conducted and educational materials were provided during these field contacts with district residents. Results of sewage system evaluation were used as input to the Lake Management Plan.

*Lake Protection Grant - Jefferson County Lake Classification 10/01/1999 - Complete*

Jefferson County Land and Water Conservation Department undertook a lake classification process. The resulting lake classification system enabled the county and other lake management entities to implement appropriate lake management strategies in a priority-driven and efficient manner. It resulted in the protection and restoration of the water quality and natural ecosystems of the lakes in Jefferson County. A full description of the project scope and project deliverables is available in the grant application, which is a part of this agreement.

*Lake Protection Grant - Waukesha County Lakes Classification Project 09/01/1999 - Complete*

This grant was for Phase I of Waukesha County's lake classification project. The county formed a Waterbody Classifica-

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tion Subcommittee, held a number of public participative workshops, reviewed the existing water resources database and identified additional information needed, defined lake classification criteria, and developed a public information campaign.

*Lake Planning Grant - Eagle Spring Lake Management Plan 01/01/1999 - Complete*

The purpose of this project was to produce a document for a SEWRPC Memorandum Report. The document included elements of the Project WET/Adopt-A-Lake curricula into the lake management plans of Eagle Spring and Upper and Lower Phantom lakes, identified any refinements to those plans and identified informational needs present in the community. The report drew on data gathered from a recreational use survey and the DNR Self Help Monitoring Program.

*Lake Planning Grant - Phantom Lake Management Plan 01/01/1999 - Complete*

This project was one of two planning grant projects for the Eagle Spring and Phantom Lake Watershed. The project involved 1) A recreational use survey; 2) Quantification of water quality conditions; 3) Teacher training in-service session for the Project WET/Adopt-A-Lake program; 4) Production of a report for inclusion in SEWRPC documents; 5) Determination of planning needs; and 6) Public information programming.

*Lake Planning Grant - Lake Beulah Sediment, Ground Water and Historical Analysis 10/01/1998 - Complete*

The Lake Beulah Management District undertook water quality analysis of Lake Beulah that included sediment core sampling, ground water flow direction analysis, and historical data management and analysis. The DNR was provided with both a paper copy and an electronic copy of the final report. Information was disseminated to the public as described in the grant application.

*Lake Planning Grant - Lake Beulah Nonpoint Source Identification and Public Education 10/01/1998 - Complete*

The Lake Beulah Management District undertook a watershed inventory/nonpoint source identification analysis and did a public education program. The DNR was provided with both a paper copy and an electronic copy of the final report. Information was disseminated to the public as described in the grant application.

*Lake Planning Grant - Eagle Spring Septic Systems Evaluation 04/01/1998 - Complete*

The Eagle Spring Lake Management District: 1.) Provided information on maintenance of household onsite sewage disposal systems to residents within the district; 2.) Conducted a visual inspection of onsite sewage disposal systems. This inspection sought to identify failed or failing onsite sewage disposal systems; 3.) Inspectors discussed details of the individual septic system, any operational problems, age of system, load to system, and maintenance history; 4.) Reviewed existing data pertaining to the soils and other pertinent information relating to the suitability of onsite sewage disposal systems in the Eagle Spring Lake area; 5.) Formulated a district on site sewerage disposal policy and made management recommendations for district consideration. The Department of Natural Resources was provided with both written and electronic copies of the final report.

*Lake Planning Grant - Eagle Spring Lake Water Quality Monitoring and Analysis 10/01/1996 - Complete*

The Eagle Spring Lake Management District proposed to continue water quality monitoring on Eagle Spring Lake. The data collected was used to assess and refine lake and watershed management activities planned for Eagle Spring Lake. The Department of Natural Resource was provided with a paper copy and an electronic copy of the final report for the project. Information about the project results was disseminated to the public by newsletter and public meeting.

*Lake Protection Grant - Waukesha County Shoreland Management 04/01/1996 - Complete*

Waukesha County proposed to evaluate the ecological impact of provisions in the county's shoreland ordinance violations. This grant agreement covered the following first year project activities contained in the project application proposal: (1) Hiring and training of a full-time limited term staff person who conducted an inventory of selected lakes to establish a baseline status and database of riparian development; (2) Printing and distributing "Guide to Waukesha County Permit, Licensing and Land Development" to local officials and real estate development industry and consultants (3) Conducting shoreland protection focused land use regulation training sessions for township officials; (4) Analyzing DNR research data on impact of shoreland stabilization techniques; (5) Compiling water quality information and education packet for distribution by lake groups to lake residents; and (6) Assisting staff in the documentation of and follow up of alleged shoreland code violations.

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*Lake Planning Grant - Mukwonago Park Pond Eurasian Water-milfoil Weevil Study 04/01/1996 - Complete*

Waukesha County proposed to evaluate the effect of the supplemental enhancement of weevil populations as a selective aquatic plant management technique to control *Myriophyllum spicatum*. Project activities resulted in a field evaluation of experimental weevil stocking, a status report and presentation to the lake group, and a final report including feasibility recommendations. The Department of Natural Resources was provided with a paper copy and an electronic copy of the final report. Information about the project was disseminated to the public by fact sheet distribution, public meeting, and summary report mailing.

*Lake Planning Grant - Lake Beulah Aquatic Plant Management Plan 03/31/1995 - Complete*

Produced an aquatic plant survey including list of common aquatic plants and their distribution, map of plant beds, sensitive areas, shoreline development and access locations, a table of lake hydrography and morphology, description of fisheries and wildlife, and a description of lake use. Developed an aquatic plant management plan. Disseminated information to the public by public meetings, local newspaper articles, public library, and sportsman's club newsletter.

*Lake Planning Grant - Eagle Spring Lake USGS Water Quality Monitoring & WS Mapping 12/23/1991 - Complete*

Water quality monitoring during 1992-1996. Water quality analyses and lake-depth profiles have been published annually by USGS. A watershed map was produced. A final progress report on water quality trends in Eagle Spring Lake was produced. USGS made a public presentation on water quality trends in the lake. Information was disseminated to the public by newsletter, local newspaper articles, public meetings, and summary report mailings.

*Lake Planning Grant - Eagle Spring Lake Management Plan 01/01/1990 - Complete*

Developed a lake management plan which included elements listed under 'Proposed Phase II Planning Program', attached to the application. Information was disseminated to the public by newsletter, local newspaper articles, public meetings and report mailings. Project results were reposted at the Village of Eagle Public Library and the Town of Eagle Town Hall.

## Monitoring

### **Lakes Baseline and Trends Monitoring**

River Monitoring to comply with Clean Water Act implementation - water quality standards: use designations, criterion, permit issuance and compliance, assessments and impaired waters management. Fisheries projects include a wide variety of "baseline" monitoring and targeted fieldwork to gain specific knowledge related to Wisconsin's fish communities.

In close cooperation with UW Extension and Wisconsin Sea Grant, education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers, and other water users how to prevent transporting aquatic invasive species when moving their boats. Additional initiatives include monitoring and control programs.

### **Volunteer Monitoring**

The Citizen Lake Monitoring Network, the core of the Wisconsin Lakes Partnership, involves over 1,000 citizen volunteers statewide. The goals are to collect high quality data, to educate and empower volunteers, and to share this data and knowledge. Volunteers measure water clarity, using the Secchi Disk method, as an indicator of water quality. This information is then used to determine the lakes trophic state. Volunteers may also collect chemistry, temperature, and dissolved oxygen data, as well as identify and map plants, watch for the first appearance of Eurasian water-milfoil near boat landings, or alert officials about zebra mussel invasions on Wisconsin lakes. Monitoring work in this watershed consists of lake monitoring and surveys for water quality, aquatic plants, aquatic invasive species, and ice observations.

### **Volunteer Stream Monitoring in the Mukwonago River Watershed**

Two Volunteer Stream Monitoring stations have been monitored by four volunteers from 2003 through 2010 in the FX06-Mukwonago River Watershed. One station is located in the Mukwonago River at Beulah Road, and the other is located in Jericho Creek at County Highway LO. Both stations are monitored using Level 1 procedures and are entered into the Water Action Volunteers (WAV) database (<http://www.uwex.edu/erc/wavdb/>). On average, stations in the watershed were monitored monthly from May through October for biotic index, flow, dissolved oxygen, instantaneous temperature and transparency.

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Volunteers also collected macroinvertebrates twice a year to determine a biotic index for each stream monitored. Streams are considered in poor quality if biotic index is between 1.0-2.0, fair quality if between 2.1-2.5, and in good quality if the index is between 2.6-3.5. Generally, biotic index values rated streams in the watershed to be in fair to good quality (ranging from 2.3-3.5), except on one field event in Jericho Creek on 08/03/2005. The lack of stoneflies in the stream during the field event dropped the biotic index to 1.8, indicating poor quality. In general, Jericho Creek had biotic index scores between fair and good quality ranges.

Stream flow was only measured at Jericho Creek and varied depending on season and local weather patterns each year. Generally, there was a higher flow rate in the spring than late summer and fall. Average stream flow measurements for the twenty-eight field events was 18.4 cubic feet per second (cfs) and ranged from 0.7 to 43.4cfs.

Overall, volunteers recorded dissolved oxygen levels in the watershed ranging from 5-14mg/l, which are sufficient to sustain aquatic life. Temperature measurements, used to classify streams as cold, cool or warm water habitats, and which are indicative of the ability of a habitat to sustain aquatic species, were manually recorded at both stations. Maximum instantaneous temperatures were below 25°C for all streams, suggesting they may be cold water streams. Stream transparency measurements indicated good water quality with 100% of measurements less than 10 NTU in both streams.

### Basin/Watershed Partners

The *Nature Conservancy* is a private, non-profit conservation organization, whose mission is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. For centuries, early settlers and their descendents have cared for the lands in the Mukwonago River Watershed, making it one of the highest quality waterways in the state. In 1983, The Nature Conservancy joined that partnership, first protecting and later purchasing the former Milwaukee Boys Club Camp. Today, the Conservancy owns 1,274 acres within the watershed and has helped to protect an additional 360 acres through its work with individual landowners and partner organizations. A group of dedicated volunteers has been vital in helping staff maintain an active science and land management program. The Conservancy owns four preserves in the Mukwonago Watershed, including: Lulu Lake Preserve (438 acres), Crooked Creek Preserve (197 acres), Pickerel Lake Fen (78 acres), and the Newell and Ann Meyer Nature Preserve (374 acres).

In addition, the *Southeast Fox Partnership Team* has taken an active interest in preserving remaining high quality, undeveloped lands and water features in the area. Within the Southeast Fox Basin, the Mukwonago River Watershed has outstanding remaining natural features the partnership considers worthy of preservation. Networking with other interested parties, the partnership anticipates developing a strategy that will preserve these key natural resource features for future generations to study, use and enjoy.

In 2006, as part of the *Wisconsin Ephemeral Pond Project (WEPP)*, the Wisconsin Department of Natural Resources and the Southeastern Wisconsin Regional Planning Commission began intensive mapping to update the digital Wisconsin Wetland Inventory in southeast Wisconsin. Improved mapping methods, applied to recent high-resolution digital imagery, allow the new maps to identify previously unmapped wetlands, including ephemeral ponds. WEPP began monitoring selected ephemeral ponds to characterize the variety of types, their ecological significance, and to develop guidelines for protection and restoration. This project builds on initial mapping efforts, involving citizens in the inventory and monitoring process. This project is being piloted in 2008 in Southeastern Wisconsin's coastal counties.

### Priority Issues and Water Quality Goals

- Sedimentation from bank erosion impacts water quality and available habitat.
- Wetlands are severely impacted by reed canary grass (reduced diversity).
- Aquatic invasive species are present and should be monitored and controlled in consideration with established management plans.
- Highway runoff contributes urban pollutants, sediment, and nutrients, as well as high or flashy flows, to local waterways.

- There is a lack of adequate stream buffers in portions of the watershed.
- Runoff from previously developed and developing areas can have a significant negative impact to water quality and habitat through the introduction of urban pollutants, sediment, and nutrients, as well as high or flashy flows, to the Mukwonago river and its tributaries.
- The public and private dams in the Mukwonago River Watershed should be inspected and maintained in accordance with state regulations. Consideration should be given to the future use and impacts of these dams.
- Stormwater management efforts should consider watershed resources such as environmental corridors, habitat, and open space. Stormwater management in the Mukwonago River Watershed should also be implemented considering the overall impacts to the resources, and strategically located in areas that will provide the greatest benefit to the resources.
- Additional information on endangered and threatened resources in the watershed should be obtained and tracked.
- Public outreach should be continued or implemented on the value of the resources in the watershed.



The Mukwonago River. Photo by Brooke Robinson

## Recommendations

The Southeastern Wisconsin Regional Planning Commission completed the Mukwonago River Watershed Protection Plan in 2010 detailing the conditions of the land and water resources in the watershed. The recommended plan is based upon a three-tiered framework approach, focused on the reconnection of the main waterways that collectively



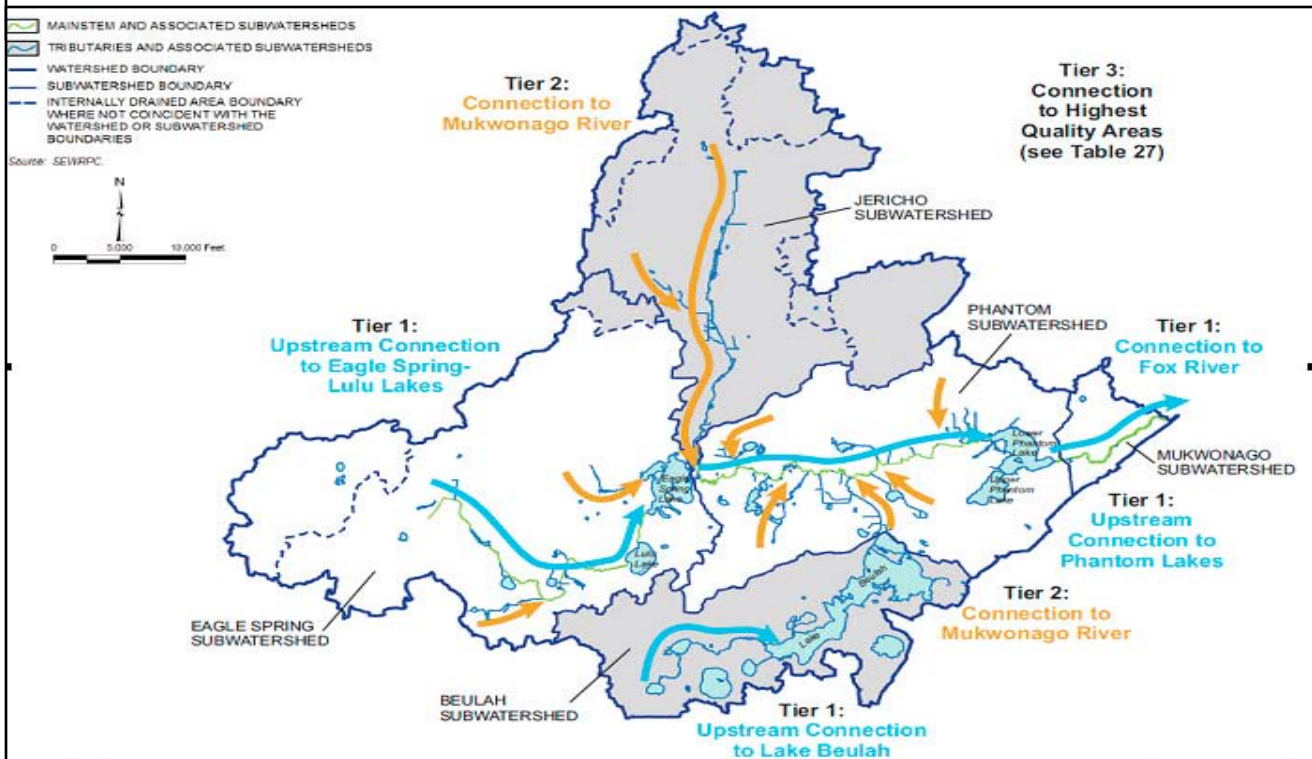
Phantom Dam, SEWRPC Photo

form the Mukwonago River system (see Map 9). These are the three components of this strategy:

- Tier 1—Restoring connectivity and habitat quality between the mainstem of the Mukwonago River and the Fox River, the mainstem of the Mukwonago River upstream of Lower Phantom Lake, the mainstem of the Mukwonago River flowing into Eagle Spring-Lulu Lakes, and the unnamed tributary stream upstream of Lake Beulah and Lake Beulah;



Map 9: instream Three Tier Prioritization Strategy



- Tier 2—Restoring connectivity and habitat quality between the tributary streams and the mainstem of the Mukwonago River; and,
- Tier 3—Expanding the connection of highest-quality fish, mussels and other invertebrates, and habitat sites within subwatersheds.

The Tier 1 prioritization is based upon the understanding that the Fox River and major lakes including Eagle Spring-Lulu, Phantom, and Beulah are the most diverse resources and greatest assets in the watershed for the maintenance of high quality recreation as well as a sustainable fishery. This prioritization is also based upon the understanding that within river systems the widest and deepest downstream areas are generally associated with a greater abundance and diversity of fishes compared to narrower and shallower upstream areas.

The Tier 2 prioritization is based upon the understanding that, through their connection with the mainstem of the Mukwonago River, the tributaries are the next most diverse resources and greatest assets that have the potential to restore and maintain a sustainable fishery. Tributary streams that are connected to the associated mainstem of stream systems have a greater potential for increased fish abundance and diversity via access to feeding, rearing, and spawning, as well as refuge from thermal stress or low-water periods.

The Tier 3 approach is a “catch-all” that enables stakeholders to link the goals of habitat restoration and improvement of recreational options with ongoing activities throughout the watershed. This strategic element provides the flexibility for communities and stakeholders to take advantage of opportunities throughout the watershed that may arise independently of the primary strategy of restoring linkages with the Fox River and major Lakes within the Mukwonago River system.

Additional information on the Mukwonago River Watershed can be found in the SEWRPC Community Assistance Planning Report no. 309, “Mukwonago River Watershed Protection Plan”, dated June 2010. <http://www.sewrpc.org/SEWRPCFiles/Publications/CAPR/capr-309-mukwonago-river-watershed-protection-plan.pdf>

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**Additional recommendations for the Mukwonago River Watershed include:**

- Coordinate planning and implementation of construction and long-term stormwater management controls among local, county and state authorities, including state transportation projects.
- Consider the many unique and threatened / endangered resources in the watershed when planning and implementing stormwater controls.
- Coordinate outreach efforts to improve awareness of the valuable resources in the watershed.
- Plan developments with consideration for protection and / or enhancement of natural resources and habitat areas that define the unique character of the Mukwonago River Watershed.
- Aquatic resources, including fish and aquatic plants, should be monitored and managed in consideration of existing and revised plans. Evaluation of the plans over time should be done to review and revise the success of the activities and available resources.

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Jericho Road Crossing, SEWRPC Photo

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Wisconsin DNR's mission involves preserving, protecting, and restoring natural resources. Watershed Planning provides a strategic review of water condition to enhance awareness, partnership outreach, and the quality of natural resource management.

# Mukwonago River Watershed