Aquatic Plant Management Plan for Lower Spring Lake

2023 - 2028

Jefferson County
Land and Water Conservation Department

This plan was approved by the Lower Spring Lake Protection and Rehabilitation District at their meeting on March 25th, 2023.

CONTRIBUTORS

Jefferson County Land and Water Conservation Department
311 S Center Street
Jefferson, WI 53549
920-674-7110

Marisa Wieder, Water Resources Management Specialist
marisau@jeffersoncountywi.gov

Lower Spring Lake Protection and Rehabilitation District Board
P.O. Box 434
Palmyra, WI 53156

Wisconsin Department of Natural Resources
Arthur Watkinson, Water Resources Management Specialist
Kristina Pechacek, Fisheries Biologist

TABLE OF CONTENTS

1.0 Introduction & Goals……………………………………………………………..… 5

2.0 Characteristics of Lower Spring Lake………………………………………..… 6
- 2.1 General Lake Characteristics, 6
- 2.2 Recreation Uses, 7
- 2.3 Lower Spring Lake Dam, 7
- 2.4 Water Quality, 7
- 2.5 Fish and Wildlife, 12

3.0 Aquatic Plants …………………………………….………………………….. 17
- 3.1 Aquatic Plants in Lower Spring Lake, 17
- 3.2 Invasive Species, 21
- 3.3 Beneficial Native Species of Note, 23
- 3.4 Plant Community Characteristics, 23

4.0 Public Input ……………………………………………………………………..…29

5.0 Aquatic Plant Management Techniques and previous use on Lower Spring Lake...30
- 5.1 Manual Removal of Aquatic Plants, 30
- 5.2 Mechanical Removal of Aquatic Plants, 31
  - Harvesting, 31
  - Diver Assisted Suction Harvesting, 33
  - Winter Water Drawdowns, 34
  - History of Winter Water Drawdown on Lower Spring Lake, 37
- 5.3 Chemical Treatment, 40
  - History of Chemical Treatment on Lower Spring Lake, 40
  - Eurasian Water Milfoil Response to Chemical Treatment 2008-2022, 44
  - Curly-leaf Pondweed Response to Chemical Treatment 2008-2022, 45
  - Native Plants Response to Chemical Treatment 2008-2022, 46
  - Chemical Treatment Permitting Decisions, 47

6.0 Aquatic Plant Management Recommendations……………………………………… 48
- 6.1 Impacts of Aquatic Invasive Species, 48
- 6.2 Aquatic Plant Management Goals, 48

7.0 Other Recommendations ………………………………………………………… 54
- 7.1 Treatment Monitoring Recommendations, 54
- 7.2 Communication and Education, 54
- 7.3 Apply for a DNR Grant to Create a Lake Management Plan, 55
- 7.4 Upper Spring Lake and the Scuppernong River, 55
- 7.5 Aquatic Invasive Species Monitoring, 56
- 7.6 Clean Boats, Clean Waters, 56
- 7.7 Factors Impacting Lake Quality, 57

References …………………………………………………………………………..…….. 59

Appendix A – Lower Spring Lake Watershed Map……………………..………………….60
Appendix B – Lower Spring Lake Dam Operating Orders …………..……………………61
Appendix C – Lower Spring Lake 2019 Dam Engineering Report ..……………………..64
Appendix D – Relative Frequency of Occurrence of All Plant Species Recorded in Lower Spring Lake from 2008–2022 ..……………………………………………………75
Appendix E – Public Comment on Previous Versions of the APM Plan ……………..….76
Appendix F – Lower Spring Lake's Harvesting Map in the Current DNR Permit ……...78
Appendix G – Proposed Updated Harvesting Map for Lower Spring Lake for Future DNR Permit Applications ………………………………………………………………79

1.0 – Introduction and Goals

Lower Spring Lake is a 109-acre lake located in Jefferson County. The western shore of the lake is located in the Village of Palmyra, with the remainder of the shoreline in the Town of Palmyra. The 27.1 square mile watershed is located in both Jefferson and Waukesha Counties.

There are 4 aquatic and wetland invasive plant species in Lower spring lake. The two invasive submerged plant species are Eurasian water milfoil and curly-leaf pondweed, the two emergent wetland species are purple loosestrife and yellow flag iris.

In 2008, the Department of Natural Resources (DNR) developed a new protocol for determining the need for herbicide applications to treat invasive plants and evaluating the results of chemical applications on both invasive and native plants which encourages organizations to have a current Aquatic Plant Management Plan approved by the DNR. . In 2011, the Lower Spring Lake Protection and Rehabilitation District adopted an Aquatic Plant Management Plan. In order to follow the DNR protocols and obtain a permit for future harvesting permit applications, the aquatic plant management plan must be updated. Lower Spring Lake's aquatic management plan was again updated in 2018, the Wisconsin DNR considers an aquatic plant management plan to be current for five years.

This document is an update to the 2018 Aquatic Plant Management Plan for Lower Spring Lake. It was developed by the Jefferson County Land and Water Conservation Department and the Lower Spring Lake Protection and Rehabilitation District with the assistance of the Wisconsin Department of Natural Resources.

2.0 – Characteristics of Lower Spring Lake

2.1 – General Lake Characteristics

Lower Spring Lake is an impoundment on the Scuppernong River and is located in the Town and Village of Palmyra, Jefferson County. The watershed of Lower Spring Lake includes portions of Jefferson and Waukesha Counties (Appendix A). A DNR public boat launch is accessible on the north shore of the lake. The Village of Palmyra has a public park located on the western side of the lake and includes a beach.

Table 2.0. Physical Characteristics of Lower Spring Lake

Watershed Area (mi^2)	Lake Area (acres)	Maximum Depth (feet)	Mean Depth (feet)	Shoreline Length (miles)
27.1	109	12	4	3.2

As part of the annual whole lake aquatic plant survey, depths throughout the lake are recorded and the bathymetry map can be updated each year using the most recent data (Figure 2.0).

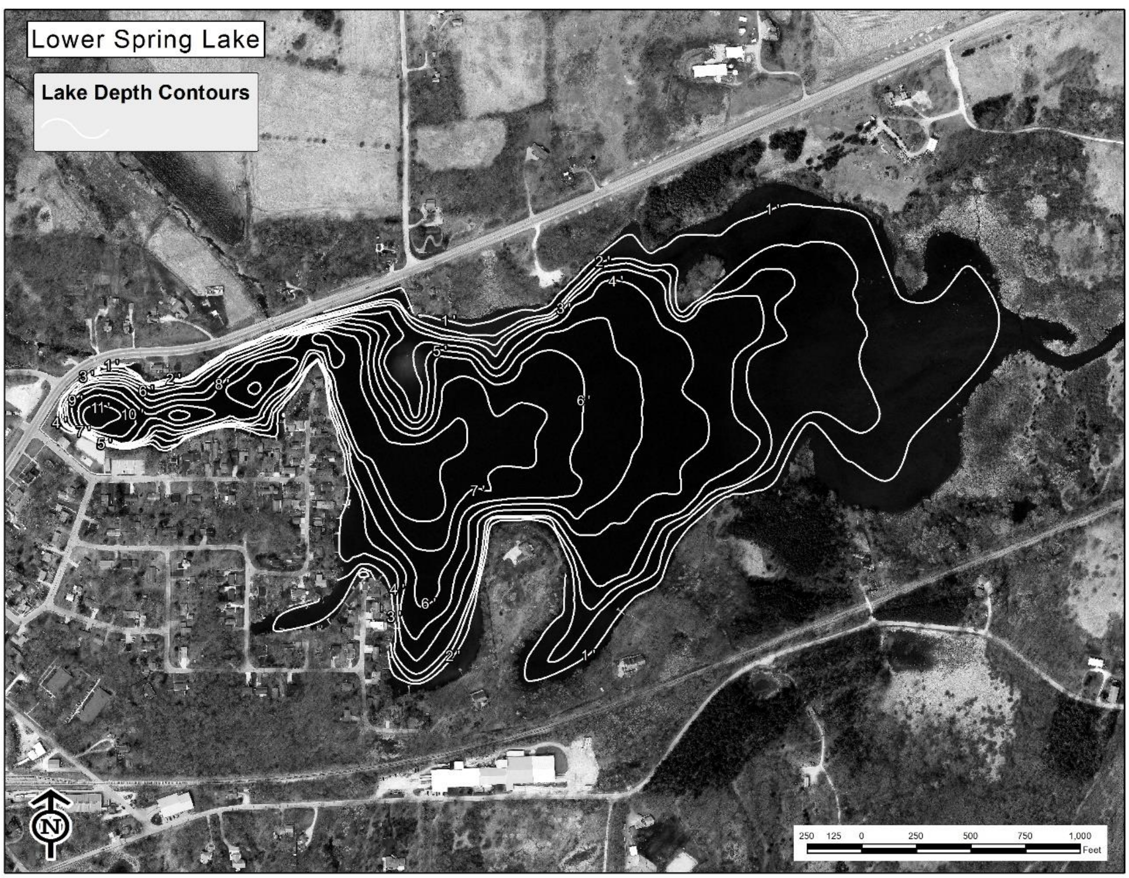


Figure 2.0: Depth contours on Lower Spring Lake

2.2 - Lake Recreation Uses

Lower Spring Lake is primarily used for fishing, boating and swimming. The current and desired uses expressed by the lake district and community have long included but are not limited to: Fishing both on water and from shore, cruising around the lake perimeter, tubing, water skiing, paddlesports, and swimming.

2.3 - Lower Spring Lake Dam

The dam on Lower Spring Lake is in the village of palmyra and impounds the lake. The dam was first installed on the river in the first half of the 19th century to power a mill. Lake maximum and minimum levels were first established in 1930 and those orders remain in effect today. The main reason for the concern about the damn management was the numerous partial failures in 1848, 1880, 1910, and 1929, in some cases causing considerable damage. Prior to the dam installation the area that is now lower spring lake most likely consisted of a wetland area. Currently, there are two spillways located on Lower Spring Lake. The western spillway is located under the Hwy 59 bridge over the scuppernong river and includes a waste section and raceway canal that was previously used to generate power. The dam operating orders are dictated by the DNR and can be found in Appendix B.

The dam was found to need repairs and updates to maintain compliance with state administrative code and operating orders. The village of palmyra and the Lower Spring Lake District worked cooperatively to have this work completed in October 2019. The Lower Spring Lake District was ultimately responsible for 25% of the project costs. Although the operating orders for the dam are nearly 100 years old, record searching and new engineering surveys during the replacement of the dam found that the datum conversions had been mostly consistent throughout the life of the dam, and the operating orders were still being followed. The one exception was a poorly documented adjustment to the spillway with resulted in a nearly six-inch raise in water levels in the early 1960s. This water level has been maintained as such since, although it is higher than the current operating orders. The engineering report detailing this info can be found in Appendix C.

Further upstream from Lower Spring Lake on the Scuppernong River, there is another dam that creates a 17-acre lake called Upper Spring Lake. During the 2008 flooding events, the dam at Upper Spring Lake was compromised on June 9 and the entire Upper Spring Lake impoundment was drained through Lower Spring Lake. It took more than 2 weeks for the water levels to get back to normal (and rain events didn't help the matter). Citizens noted that a large amount of sediment was deposited on the east side of the lake, and sediment settled out in other parts of the lake. One citizen estimated that 4 inches of sediment were deposited by his pier.

2.4 - Water Quality

Water quality sampling for water clarity, chlorophyll *a*, and total phosphorus has been performed for many years by citizen monitors at the deepest point of the lake. There is data for the 1994, 2000, and 2004-2022 summer seasons. This monitoring is done as part of the Department of Natural Resources Citizen Lake Monitoring Network program.

These three measurements give the best overall indication of a lake's water quality. Although year-round data is important, generally, when assessing the overall water quality based on these parameters, the analysis is limited to data collected during the growing season or summer months of June - August. This is when the lake is most productive and therefore there are greater impacts to water quality from nutrients and algae.

A Secchi disc, which is used to measure water clarity, is an 8-inch disc that is painted black and white. It is lowered into the water until it disappears from sight, then raised until it becomes visible – that depth is recorded as the water clarity reading. Materials suspended (especially algae) and dissolved in the water will affect the water clarity of a lake. Water clarity measurements can indicate the overall water quality of a lake. Figure 2.1 displays the average water clarity readings which have been measured since 2004. The average water clarity ranged from 2.9 feet to 7.0 feet.

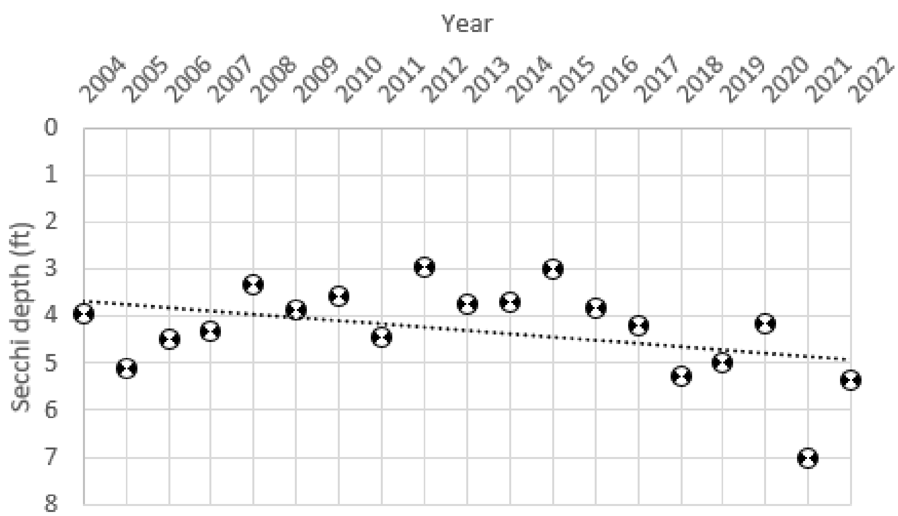


Figure 2.1. Average Summer Water Clarity Measurements for Lower Spring Lake

Chlorophyll *a* is the photosynthetic pigment found in plants. When filtered from lake water, it can be used to measure the lake's algae biomass with higher concentrations indicating algal blooms. Lower Spring Lake's average summer (June-August) chlorophyll *a* concentrations from 2005 through 2022 range from 3.43 µg/L to 29.3 µg/L (Figure 2.2). The chlorophyll *a* data from Lower Spring Lake has shown an increasing trend over the last approximately 2 decades. Fortunately, the recent measurements are still well below the WI DNR impairment threshold of 40 µg/L for shallow drainage lakes. These current concentrations are unusually low for a eutrophic system, but steps should still be taken to reduce nutrient inputs into the lake to prevent further increases in chlorophyll *a* concentrations.

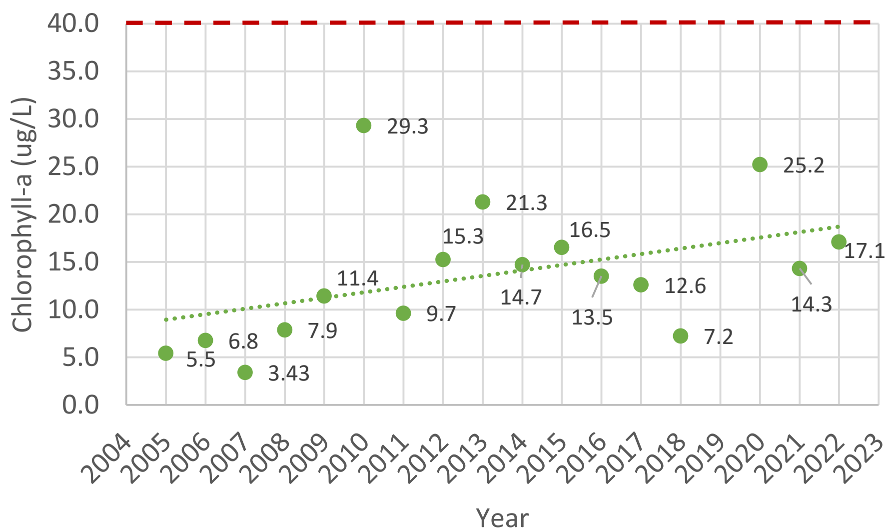


Figure 2.2: Average Summer Chlorophyll *a* (ug/L) in Lower Spring Lake. 40 µg/L is the impairment threshold for shallow drainage lakes like Lower Spring Lake, represented here by a red dashed line.

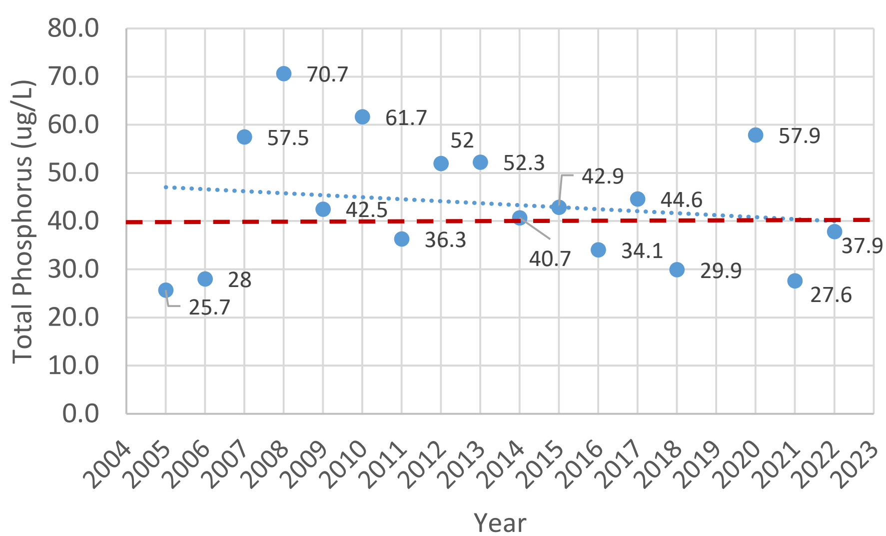


Figure 2.3: Average Summer Phosphorus in Lower Spring Lake

Phosphorus is the limiting nutrient in freshwater lakes meaning that its concentration in the water will directly affect the amount of algae and plant growth. This is because in freshwater lakes all of the other necessary factors for plant and algae growth are more readily available and abundant than phosphorus. One pound of phosphorus delivered to a lake can produce up to 500 pounds of algae. Sources of phosphorus include runoff from farmland, animal lots, construction sites, and lawns, as well as shoreline erosion, faulty septic systems, and natural sources. Phosphorus mostly is held in insoluble particles with calcium, iron, and aluminum. Phosphorus is released from particle form when the water is anoxic (has no oxygen). From 2005 to 2022, the average summer (June-August) phosphorus concentrations in Lower Spring Lake ranged from 25.7 µg/L to 70.7 µg/L (Figure 2.3).

By determining a lake's trophic state, its water quality can be characterized as eutrophic, mesotrophic, or oligotrophic. These trophic states are based on water clarity, total phosphorus concentration, and chlorophyll *a* concentration.

Oligotrophic lakes are clear, deep, and are mostly free of aquatic plants or large algae blooms. They contain low amounts of nutrients and therefore do not support large fish populations. However, they can develop a food chain capable of sustaining a desirable fishery of large game fish. These lakes also typically have sand or hard substrate bottoms and very cold water. These lake characteristics are naturally occurring and shaped by the natural history of the lakes and ecosystems. These factors are created over a very long time scale and do not shift easily unless there is marked influence from human activities such as nearshore development. Mesotrophic lakes have moderately clear water. They can have deep or shallow waters that are typically low in dissolved oxygen during the summer, and as a consequence, can limit cold water fish and cause phosphorus release from the bottom sediments. Mesotrophic lakes have moderate levels of productivity, meaning that their amount of fish species, plant population, and algae blooms are all very moderate. Eutrophic lakes are high in nutrients and support a large biomass that includes dense aquatic plants, can include frequent algae blooms, and very productive fisheries. Rough fish, such as carp, are often common in eutrophic lakes. These types of lakes exist in two states: One with clear water and an abundance of aquatic plant growth, or one with murky waters, little plants and copious amounts of algae.

A natural aging process occurs in all lakes to shallower and more eutrophic lakes. This process known as eutrophication takes place over hundreds to thousands of years and all lakes are slowly moving in that direction. This is a natural process that has been significantly accelerated by human interference. There is a natural amount of eutrophication that occurs in lakes but when human influences from runoff, pollution, increases of impervious surfaces in nearshore areas, and other disturbances are causing the lake to become eutrophic over a very short period of time it can be harmful to the lake ecosystem. It is important to point out that this aging process is accelerated by human activities that increase sediment and nutrient delivery to our lakes. These activities include agriculture, existing and new development, fertilizers, storm drains, etc. While these changes can be easily accelerated by humans and quickly create a 'new' average condition of lakes those changes take much longer to reverse. Even if the human activities that cause Eutrophication are reversed or stopped completely there will be a lag time in which the condition of the lake will continue to move towards more eutrophic until it eventually reaches a stable state. It is possible to reverse some effects of Eutrophication but this change occurs much more slowly than Eutrophication itself which is why prevention or restriction of these kinds of human interference is so vital.

The Trophic State Index (TSI) is determined using mathematical formulas that convert water clarity, total phosphorus, and chlorophyll *a* measurements into a TSI score on a scale of 0 to 110. Lakes that are less biologically productive (fewer plants, nutrients, and fish) have a low TSI. The scale is described in Table 2.1.

Table 2.1 Description of the Trophic State Index Scale

TSI Score	Description
TSI < 30	Classical oligotrophic: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae blocks sunlight).
TSI > 80	Algal scums, summer fish kills, few plants, rough fish dominant. Very poor water quality.

The Trophic State Index for Lower Spring Lake over time is displayed in Figure 2.4 contains average July and August calculations of water clarity, total phosphorus, and chlorophyll *a*. Based on 2022 data, Lower Spring Lake is characterized as a eutrophic lake in terms of water clarity, chlorophyll, and phosphorus. The chlorophyll data reveals that Lower Spring Lake is dominated by plants instead of algae. In addition, it shows the importance of protecting and enhancing native plant species as exotic species are targeted for management. If the native plants are not protected, then the severity and frequency of algae blooms in the lake will likely increase.

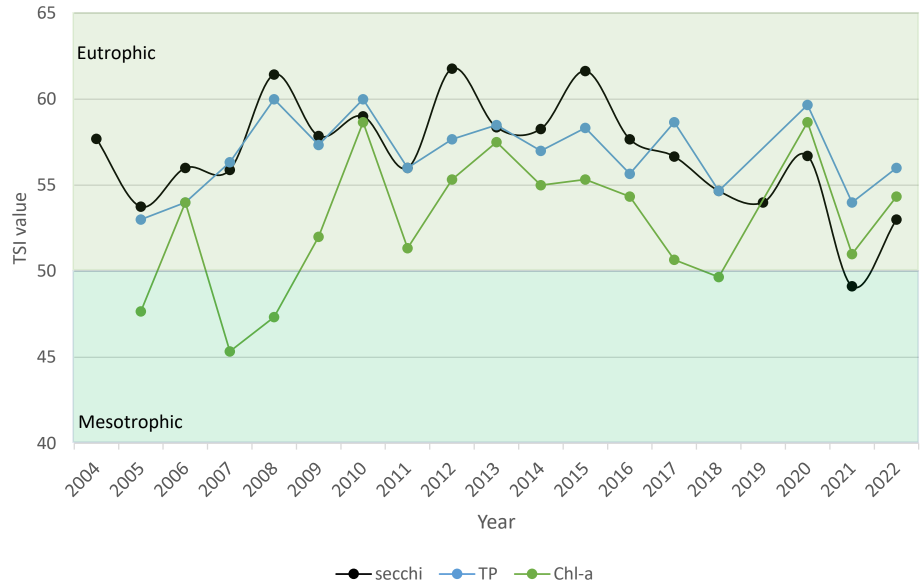


Figure 2.4: Trophic State Index for Lower Spring Lake**

*(**Note: This chart does not contain the entire Trophic State Index scale. Not shown is classic oligotrophic of 0-30, lower mesotrophic scales of 30-40, and eutrophic scales of 65 and greater.)*

A water quality index was developed for Wisconsin lakes using data collected in July and August (Lillie and Mason 1983). Table 2.2 shows this index. The 2022 average summer values for Lower Spring Lake fall within the 'fair' category for secchi depth and total phosphorus values, but the chlorophyll value falls in the 'poor' category.

Table 2.2: Water Quality Index for Wisconsin Lakes (adapted from Lillie and Mason 1983)

Water Quality Index	Secchi Depth (feet)	Chlorophyll a (ug/l)	Total Phosphorus (ug/l)
Excellent	> 19.7	< 1	< 1
Very Good	9.8-19.7	1-5	1-10
Good	6.6-9.8	5-10	10-30
Fair	4.9-6.6	10-15	30-50
Poor	3.3-4.9	15-30	50-150
Very Poor	< 3.3	> 30	> 150

2.5 - Fish and Wildlife

Freshwater sponges have been found in Lower Spring Lake. Freshwater sponges are aquatic animals that feed by filtering small particles from the water. They are thought to be sensitive indicators of pollution.

The following information on freshwater sponge identification is from the DNR:

- Size can vary from marble-sized to elongated masses; can be thin or thick encrusting layers
- Surface may be smooth, textured or wavy, or have finger-like projections

- Color may be green (because of algae that live inside their cells) or may be beige to brown or pinkish
- Feel delicate to very firm, but are not slimy or filmy

The best time to look for sponges is in late summer and early fall because they die back in the winter and begin a new growth cycle in the spring, and grow through the summer. In the late summer, the sponges form gemmules which are small spherical protective structures that contain cells from which the new sponges will grow in the spring. The gemmules are approximately the size of poppy seeds and are tan in color. Sponges grow in shallow water. Some sponges prefer the underside of logs and sticks.

The DNR reports that the fish population in Lower Spring Lake includes Largemouth Bass (common) and Bluegill (common). Other fish species documented in Lower Spring Lake include: Yellow Perch, Northern Pike, Rock Bass, Black Crappie, Golden Shiner, Common Carp, White Sucker, Lake Chubsucker, Black Bullhead, Yellow Bullhead, Pumpkinseed, Brook Silverside, Green Sunfish, Grass Pickerel, and Warmouth.

The DNR and the Palmyra Lions Club have both stocked fish in Lower Spring Lake. Table 4 reports the details of the DNR fish stocking. Table 5 reports the details of the Palmyra Lions Club fish stocking.

Table 2.3. DNR Fish Stocking of Lower Spring Lake

Year	Species	Age Class	Number Stocked	Average Fish Length (inches)
2019	Northern Pike	Small fingerling	1239	2.00
2018	Northern Pike	Small fingerling	1040	3.65
2017	Northern Pike	Small fingerling	1058	2.50
2016	Northern Pike	Small fingerling	2040	1.92
2015	Northern Pike	Small fingerling	1040	2.55
2014	Northern Pike	Small fingerling	1040	2.70
2013	Northern Pike	Small fingerling	1040	3.20
2012	Northern Pike	Small fingerling	1040	2.90
2011	Northern Pike	Small fingerling	1040	2.60
2010	Northern Pike	Small fingerling	1040	2.76
2009	Northern Pike	Small fingerling	1040	2.00
2008	Northern Pike	Small fingerling	1040	1.80
2006	Northern Pike	Small fingerling	1040	2.40
2002	Northern Pike	Small fingerling	468	2.90
2000	Northern Pike	Large fingerling	208	7.40
1999	Northern Pike	Large fingerling	208	7.30
1997	Northern Pike	Large fingerling	208	8.00

Table 2.4. Palmyra Lions Club Fish Stocking of Lower Spring Lake

Year	Species	Number Stocked
2018	Northern Pike	400
2013	Northern Pike	450
2009	Northern Pike	300
2005	Northern Pike	200
1996	Northern Pike	570
1995	Northern Pike	350

Lower Spring Lake's most recent fish sampling using electrofishing gear in the spring of 2021 and 2016. Electrofishing is conducted using a large boomshocker boat and is best for sampling young-of-the-year (YOY) fish and most adult fish of various species. To standardize fisheries data, total effort in the form of time spent electrofishing and/or miles of shoreline electrofished is recorded and presented as catch rates or catch-per-unit-effort (CPUE, number/mile). Spring electrofishing is used primarily to sample panfish species and Largemouth Bass. Electrofishing provides a snapshot of the fisheries population within a lake at a particular time of year. Other sampling events were conducted on Lower Spring Lake but are not comparable to spring electrofishing data.

<u>Northern Pike</u>

Fifteen Northern Pike (15) were sampled during 2021 spring electrofishing for a catch rate of 6/mile. The average length was 20.5 inches and the largest fish sampled was 28.2 inches. One Northern Pike was sampled in 2016 spring electrofishing for a catch rate of 0.5/mile.

Northern Pike catch rate data collected through electrofishing has limited value. Electrofishing does not allow for proper assessment of Northern Pike populations due to the body structure and swimming ability of the species. However, the relatively high number of Northern Pike sampled in 2021 spring electrofishing suggests Northern Pike are abundant enough to be sampled by an inefficient gear type. To properly evaluate Northern Pike populations, survey methods such as spring fyke netting must be used. Unfortunately, Lower Spring Lake has not been surveyed using fyke nets until this spring. The lake’s shallow water makes it difficult to accommodate the depth of fyke nets. The data from the 2023 spring fyke netting was not yet available at the time that this plan was completed.

<u>Largemouth Bass</u>

Eighty-one (81) Largemouth Bass were sampled in 2021 spring electrofishing for a catch rate of 32.4/mile. The average length was 13.3 inches with a maximum length of 19.1 inches. Thirty-seven (37) Largemouth Bass were sampled during the 2016 spring electrofishing for a catch rate of 18.5/mile. The average length was 13.8 inches with a maximum length of 19.6 inches.

The spring electrofishing catch rate for Largemouth Bass was average (50th percentile) in 2021 and below average in 2016 (25th percentile) compared to lakes across the state with similar characteristics (warm water temperatures and turbid water).

The mean length of Largemouth Bass sampled in spring electrofishing in both survey years was above average (95th percentile in 2021 and 99th percentile in 2016) for lakes across the state with similar characteristics.

The size distribution of Largemouth Bass in Lower Spring Lake across both survey years indicates a variety of sizes classes, or cohorts of bass produced each year, or year class. The wide range of size classes indicates that Largemouth Bass are naturally reproducing in the lake and bass up to 19.1 inches are present.

Bluegill

Forty-one (41) Bluegill were sampled in 2021 spring electrofishing for a catch rate of 41.0/mile. The average length was 5.2 inches with a maximum length of 7.8 inches. Twelve (12) Bluegill were sampled during the 2016 spring electrofishing for a catch rate of 24.0/mile. The average length was 6.0 inches with a maximum length of 7.1 inches.

The spring electrofishing catch rate for Bluegill was consistently below average (25th percentile) across all three sampling years while Pumpkinseed catch rate was average to above average (50th to 75th percentile) compared to lakes across the state with similar characteristics.

The mean length of Bluegill sampled in spring electrofishing in all survey years was above average (95th percentile in 2021 and 99th percentile in 2016) for lakes across the state with similar characteristics.

The size distribution of Bluegill across all survey years indicates a variety of sizes classes, or cohorts of Bluegill produced per year, or year class. The wide range of size classes indicates that Bluegill are naturally reproducing in the lake and Bluegill up to 7.8 inches are present.

Pumpkinseed

Seven (7) Pumpkinseed were sampled in 2021 spring electrofishing for a catch rate of 7.0/mile. The average length was 4.3 inches with a maximum length of 5.4 inches. No Pumpkinseed were sampled during the 2016 spring electrofishing.

The spring electrofishing catch rate for Pumpkinseed catch rate was average to above average (50th to 75th percentile) in both sampling years, compared to lakes across the state with similar characteristics.

The mean length of Pumpkinseed sampled in spring electrofishing in both years was above average (95th percentile in 2021 and 99th percentile in 2016) for lakes across the state with similar characteristics.

Yellow Perch
Nine (9) Yellow Perch were sampled in 2021 spring electrofishing for a catch rate of 9.0/mile. The average length was 5.2 inches with a maximum length of 9.7 inches. One (1) Yellow Perch was sampled during the 2016 spring electrofishing for a catch rate of 2.0/mile.

In summary, spring electrofishing surveys conducted in 2021 and 2016 show acceptable catch rates and excellent mean lengths for Largemouth Bass compared to similar lakes. Bluegill catch rates are below average compared to similar lakes statewide, however mean lengths are excellent. Catch rates were higher for all species sampled in 2021, compared to 2016 including Largemouth Bass, Bluegill, Pumpkinseed, Black Crappie and Yellow Perch.

Other Species
Other species sampled in the 2021 and 2016 spring electrofishing surveys included small populations of Black Crappie, Warmouth, Golden Shiner, Common Carp, Lake Chubsucker, White Sucker, Brown and Yellow Bullhead.

3.0 – Aquatic Plants

Lower Spring lake has a long and detailed history of aquatic plant surveys. Aquatic plants are a vital part of a healthy lake ecosystem. In fact, 90% of a lake's ecosystem depends on what happens in the vegetated shallow areas. Some valuable characteristics of aquatic plants are the following:

- Aquatic plants create a thriving habitat supplying food, shade, and shelter for a large variety of aquatic and terrestrial animals.
- Fruits and tubers of aquatic plants provide food for mammals, waterfowl, insects and fish.
- Aquatic plants are essential to the spawning success of many fish species.
- Aquatic plants photosynthesize, creating oxygen for the animals that live in shallow areas.
- Aquatic plants filter runoff from uplands to protect lake water quality.
- Plant roots create networks that stabilize sediments at the water's edge where waves might otherwise erode the lakeshore.
- Submersed plants absorb phosphorus and nitrogen over their leaf surface and through their roots.
- Plant use nutrients, making less available for nuisance algae blooms.
- Native aquatic plants limit the growth of exotic plants.

There have been many summer aquatic plant surveys in Lower Spring Lake: 1993, 2005, and 2008 through 2022. The surveys performed in 1993 and 2005 used a transect survey approach to sampling. The 2008 through 2019 and 2021-2022 surveys used the point intercept method which is now the DNR-recommended survey approach (Hauxwell et al. 2010). The 2020 survey included only a subset of the whole lake PI due to time constraints. Samples of pressed aquatic plants from many of the surveys were also given to the Wisconsin State Herbarium.

It is important to note that the 2008 plant survey was performed on June 18 and 19, 2008 after the extreme flooding event and upper dam failure. This means that the plant community was likely still experiencing direct effects of massive sedimentation from the dam failure and also that the extreme nutrient loading that occurred was likely contributing to higher than typical plant growth.

3.1 - Aquatic Plants in Lower Spring Lake

The species found in Lower Spring Lake in the 2008-2022 surveys are listed in Table 3.0 with a description of their ecological significance.

Table 3.0. Ecological Significance and Coefficient of Conservatism for Lower Spring Lake Aquatic Plants Identified in 2008-2022.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Carex comosa Bristly sedge	E	5	Nutlets are eaten by a variety of waterfowl.
Carex hystericina Bottlebrush sedge	E	3	Nutlets are eaten by a variety of waterfowl.
Ceratophyllum demersum Coontail	S	3	Provides good shelter for young fish, supports insects valuable as food for fish and ducklings, and fruits are eaten by waterfowl.
Chara spp. Muskgrass	S	7	A favorite food of waterfowl. Provides cover and food to young trout, largemouth and smallmouth bass.
Eleocharis sp. Spikerush species	E	varies	
Elodea canadensis Common waterweed	S	3	Valuable shelter and grazing opportunities for fish. Food for muskrats and waterfowl. Habitat for a wide variety of invertebrates.
Heteranthera dubia Water stargrass	S	6	Source of food for geese and ducks. Good cover and forage for fish.
Iris pseudacorus Yellow iris - Exotic species -	E		Grazed by muskrats and provides food for a variety of waterfowl. Provides cover for wildlife and waterfowl.
Iris versicolor Northern blue flag/Iris	E	5	Grazed by muskrats and waterfowl. Good cover for wildlife and waterfowl.
Lemna minor Small duckweed	FF	4	Important food source for ducks and geese. Consumed by muskrats, beaver, and fish. Shade and cover for fish and invertebrates. Extensive mats can inhibit mosquito breeding.
Lemna trisulca Forked duckweed	FF	6	Food source for waterfowl. Provides cover for fish and invertebrates.
Lythrum salicaria Purple loosestrife - Exotic species -	E		Little wildlife value: The seeds are low in nutrition, and the roots are too woody. The flowers are attractive to insects and produce nectar, regularly visited by honeybees.
Myriophyllum heterophyllum Various-leaved water milfoil	S	7	Fruit and foliage eaten by waterfowl. Foliage traps detritus for food and provides invertebrate habitat. Shade, shelter, and forage for fish.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Myriophyllum sibiricum Northern water milfoil	S	6	Leaves and fruit eaten by waterfowl. Foliage traps detritus and provides invertebrate habitat. Shade, shelter, and forage for fish.
Myriophyllum spicatum Eurasian water milfoil - Exotic species -	S		Waterfowl graze on fruit and foliage to a limited extent. Habitat for insects but not as good as other plants.
Najas flexilis Slender naiad/Bushy pondweed	S	6	One of the most important plants for waterfowl. Ducks eat the stems, leaves and seeds. Important to marsh birds and fish.
Najas guadalupensis Southern naiad	S	8	One of the most important plants for waterfowl. Ducks eat the stems, leaves and seeds. Important to marsh birds and fish.
Nelumbo lutea American lotus	FL	7	Fruit eaten by a variety of waterfowl. Rhizomes eaten by beaver and muskrat. Shade and shelter for fish and wildlife.
Nuphar advena	FL	8	Food for waterfowl, muskrat, beaver and porcupine. Shade and shelter for fish. Habitat for invertebrates.
Nuphar variegata Spatterdock	FL	6	Food for waterfowl, muskrat, beaver and porcupine. Shade and shelter for fish. Habitat for invertebrates.
Nymphaea odorata White water lily	FL	6	Provides shade and cover for fish and invertebrates. A food source for waterfowl, muskrat, and beaver.
Potamageton amplifolius Large-leaf pondweed	S	7	The broad leaves offer shade, shelter and foraging opportunities for fish. Valuable waterfowl food.
Potamogeton crispus Curly-leaf pondweed - Exotic species -	S		Winter and spring habitat for fish and invertebrates. Mid-summer die-off releases nutrients which may trigger algae blooms and create turbid water conditions.
Potamogeton friesii Fries' pondweed	S	8	A food source for ducks and geese. Also eaten by muskrat, deer, and beaver. Food source and cover for fish.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Potamogeton gramineus Variable pondweed	S	7	Fruits and tubers food for waterfowl. Foliage and fruit eaten by muskrat, beaver, and deer. Invertebrate habitat and forage for fish.
Potamogeton illinoensis Illinois pondweed	S	6	Ducks and geese eat the fruit. Provides excellent shade and cover for fish and invertebrates.
Potamogeton nodosus Long-leaf pondweed	S	7	Offers invertebrate habitat and foraging opportunities for fish. Ducks eat the fruit.
Potamageton pusillus Small pondweed	S	7	Locally important food source for ducks and geese. It is also grazed by muskrat, deer, beaver and moose. Food and cover for fish.
Potamogeton zosteriformis Flatstem pondweed	S	6	Food source for waterfowl and wetland mammals. Provides cover for fish and invertebrates. Supports insects valuable as food source for fish and waterfowl.
Ranunculus aquatilis Stiff water crowfoot	S	8	Fruit and foliage are eaten by waterfowl. Stems and leaves are valuable invertebrate habitat.
Sagittaria cuneata Arum-leaved arrowhead	E	7	Highly valued aquatic plant for wildlife. Waterfowl depend on high-energy tubers during migration. Shade and shelter to young fish.
Sagittaria latifolia Common arrowhead	E	3	Highly valued aquatic plant for wildlife. Waterfowl depend on high-energy tubers during migration. Shade and shelter to young fish.
Schoenoplectus acutus Hardstem bulrush	E	6	Habitat for invertebrates and shelter for young fish, especially northern pike. Nutlets eaten by waterfowl, marsh birds, and upland birds. Stems and rhizomes eaten by geese and muskrats. Nesting material and cover for waterfowl, marsh birds and muskrats.
Schoenoplectus tabernaemontani Soft stem bulrush	E	4	Habitat for invertebrates, shelter for young fish. Nutlets eaten by waterfowl, marsh birds, and upland birds. Stems and rhizomes eaten by geese and muskrats. Nesting material and cover for waterfowl, marsh birds and muskrats.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Spirodela polyrhiza Large duckweed	FF	5	Provides food for waterfowl, muskrat and fish. Rafts of duckweed offer shade and cover for fish and invertebrates.
Stuckenia pectinata Sago pondweed	S	3	Fruits and tubers are a very important food source for a variety of waterfowl. Supports insects that are eaten by game fish and also provides cover for young game fish.
Typha sp. cattail	E	1	Nesting habitat for many marsh birds. Shoots and rhizomes consumed by muskrats and geese. Submersed stalks provide spawning habitat and shelter for fish.
Utricularia vulgaris Common bladderwort	S	7	Provides food and cover for fish.
Vallisneria Americana Wild celery	S	6	Premiere source of food for waterfowl. All portions of plant are consumed. Good fish habitat providing shade, shelter and feeding opportunities.
Wolffia columbiana Common watermeal	FF	5	Ducks, geese, muskrats, and some fish eat this plant. A large floating mat can prevent mosquito larvae from reaching the surface for oxygen.

Key:
E = Emergent – plants with leaves that extend above the water surface
FL = Floating Leaf – plants with leaves that float on the water surface
FF = Free Floating – plants that float freely on the water surface
S = Submersed – plants with most of their leaves growing below the water surface

3.2 – Invasive Species

Eurasian water-milfoil (*Myriophyllum spicatum)*
Eurasian water milfoil (EWM) is an invasive species that was documented in the first aquatic plant survey in 1993 on Lower Spring Lake. In some lakes, EWM crowds out native aquatic plant species so that there is a monoculture of Eurasian water milfoil and a reduction in the diversity of plants in a lake. Milfoil in dense stands can provide a refuge for panfish and thus interferes with predator-prey interactions. The results can be over-populated, slow growing panfish and gamefish. Dense stands of milfoil can also hinder the movement of larger fish. In addition, milfoil can adversely impact recreational uses by hindering boating, swimming and fishing and impair the aesthetic quality of the lake.

Eurasian water milfoil mainly reproduces via plant fragments that are separated from the main plant naturally or augmented by boat propellers. Landowners who cut or rake aquatic plants in front of their lots may also disperse plant fragments. These cleared areas more likely than not will be re-vegetated by Eurasian water milfoil.

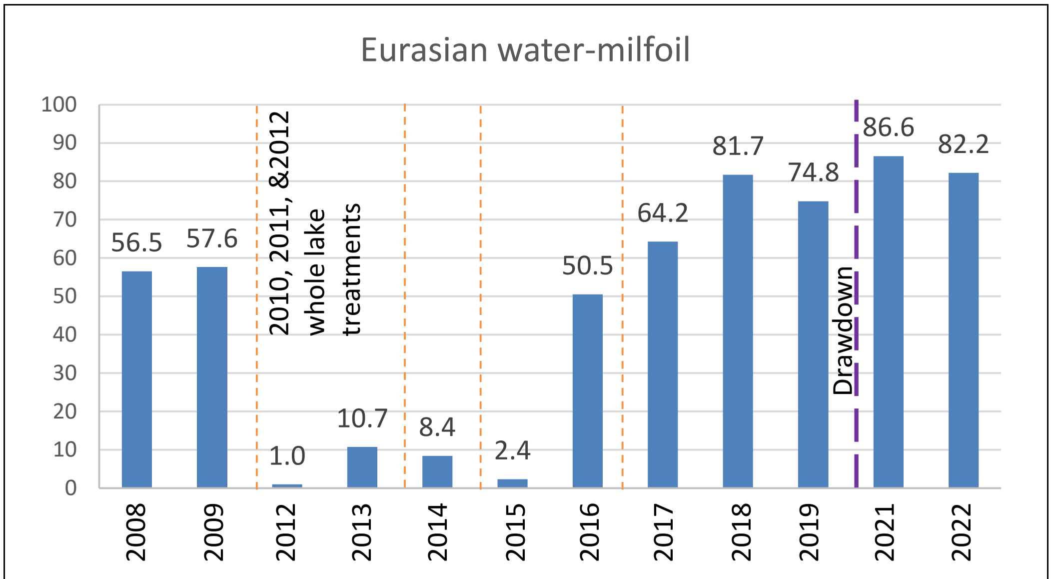


Figure 3.0: LFOO of EWM on Lower Spring Lake 2008-2022

Curly Leaf Pondweed (*Potamogeton crispus)*
Curly-leaf pondweed (CLP) is another exotic invasive species that was found in the 2008 aquatic plant survey on Lower Spring Lake. Curly-leaf pondweed starts growing under the ice and grows its spring and summer foliage in May. Because of this growth pattern, curly-leaf pondweed provides habitat for fish and insects in the winter and spring – a time when other plants are dormant. However, when curly-leaf pondweed dies-off (typically in mid-June to early-July), it creates a sudden loss of habitat. When it dies off it can also cause algal blooms and turbid water conditions. In addition, curly leaf pondweed can interfere with recreational activities in the spring because it can grow to the water's surface and cause surface matted plant masses.

The curly-leaf pondweed population on Lower spring lake has remained very sparse in occurrence through the years. In 5 of the last 10 whole lake aquatic plant surveys on Lower Spring Lake, curly-leaf pondweed was not observed at all during the survey. It appears that curly-leaf pondweed has not reached nuisance levels in the lake and is not likely to in the future.

Purple Loosestrife (*Lythrum salicaria)*
Purple loosestrife is a wetland plant that is invasive in the US. It forms thick dense stands that crowd out native vegetation and reduce species diversity. Purple loosestrife does not provide habitat that is equitable to our native species and is therefore not as beneficial to our native wildlife. It is a very fast spreading plant and does not have any native predators to keep it in check. It spreads very easily along lake edges and in wetlands and can be very difficult to eradicate.

Yellow Iris (*Iris Pseudacorus)*
Yellow Iris is a fast growing and fast spreading plant that frequently escapes cultivation and takes over native shoreline habitats in lakes and rivers. It forms thick dense stands that are unable to be used as nesting sites by waterfowl and wildlife, compacts soils, and alters the hydrology of nearshore areas. It is also toxic to wildlife so does not provide a food source. Seed pods from the yellow iris float and can be transported easily downstream to new locations. Yellow iris can be controlled through digging but it is important to get the entire rhizome as it can easily regrow from small bits of intact rhizome that are left behind. Digging can be a cumbersome task so if that is not possible clipping seed heads and disposing of them is another way to help reduce the spread of yellow iris.

3.3 – Beneficial Native Species of Note

American Lotus (*Nelumbo Lutea)*
American Lotus, a native plant, was documented in Lower Spring Lake as early as 1971. By 2022, the plant has found a home in several locations around the lake. It is a rooted aquatic plant whose large round leaves either float on or can be held above the surface of the water. Its flower is yellow and is positioned above the water. It is pointed out in this plan because it is a native plant that is not commonly found in area lakes. This plant is very abundant throughout the length of the Mississippi river in Wisconsin but is not commonly found in inland lakes. It is thought to have been spread intentionally to inland lakes several hundred years ago by Native American tribes who had many uses for the plant.

Yellow Pond Lily (*Nuphar advena*)
Yellow pond lily was first documented on Lower Spring Lake in 2021. It is listed in the state of Wisconsin as special concern because its extent is unknown but is thought to have been greatly reduced from pre-settlement times. This species has been recorded in Jefferson county previously, but prior to the 2021 finding in Lower Spring Lake it was last documented in the county in the 1940s. This plant is particularly sensitive to disturbance and its range was likely reduced as a result of human caused activities such as water quality degradation, urban development, and invasive species introduction. This plant is very beneficial to the ecosystem because it is a good indicator of negative impacts to the system – similar to a canary in a coal mine. It also provides good habitat for fish spawning, food for waterfowl, and habitat for aquatic invertebrates. Yellow pond lily is a close relative to spatterdock (*Nuphar variegata*) which is also found in Lower Spring Lake. This species can be distinguished from spatterdock by the shape of its stem, rounded rather than winged, and by its tendency to hold its leaves up out of the water at an angle.

3.4 - Plant Community Characteristics
When point-intercept surveys are performed, there are various data collected at each sampling location that are used to determine the quality, diversity, and density of the aquatic plant community in the lake. This helps us understand the current state of the lake but is especially useful when compared to previous survey years to identify trends in

the plant community over time. In addition, the data is essential for determining the effectiveness of the various aquatic plant management techniques and determining if the goals laid out in the aquatic plant management plan are being achieved. There are other data parameters collected as a part of this survey that help identify substrate type at each location, maximum depth of plant growth in the lake, and gauge the presence and extent of invasive species in the plant community. These data and other general statistics of all of the summer aquatic plant surveys are documented in Table 3.1.

Table 3.1. General Statistics of Summer Lower Spring Lake Aquatic Plant Surveys

	Total # points sampled	**Total # sites with vegetation**	**Max depth of plants**	**Average # species per site with vegetation**	**Average # native species per site with vegetation**	**Average rake fullness**	**Total number of species**
2008	220	160	10	2.20	2.16	1.50	26
2009	226	170	9.5	2.54	2.07	*	22
2012	213	129	10	1.82	1.82	1.57	24
2013	219	124	8	1.77	1.01	1.44	22
2014	195	124	8	1.56	1.45	1.53	26
2015	188	70	8	1.43	1.39	1.48	22
2016	189	133	10	1.72	1.32	1.43	23
2017	177	122	9	1.63	1.48	1.66	19
2018	143	111	9	1.58	1.39	1.63	23
2019	150	119	9	1.35	0.60	1.73	13
2020**							
2021	152	144	10.5	2.23	1.40	2.28	17
2022	157	151	10.5	2.36	1.60	2.12	16

** not calculated*

*** a subset of 55 points was completed in 2020 rather than the full PI so it is not comparable included as a comparison*

Dominant Native Species in the Plant Community

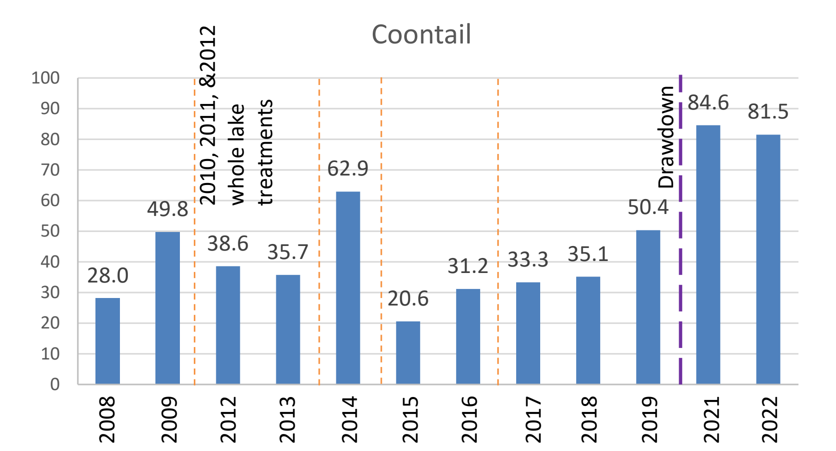


Figure 3.1: Littoral frequency of occurrence of Coontail in Lower Spring Lake from 2008-2022. Whole lake chemical treatments are indicated by orange dashed lines and the winter drawdown is indicated by a purple dashed line.

Coontail, which has been a hinderance to navigation on the lake, experienced a small decrease in 2022 from 2021 (figure 3.1). This is likely due to the increase in abundance of other native species which can be seen in the Frequency of occurrence tables and the following individual species graphs. As these other native species take up space and resources for growth there is less available for Coontail to take advantage of. Coontail is not sensitive to disturbance so when conditions cause other native species to decline Coontail can start to take over.

Common waterweed is another native species found in Lower Spring Lake. There was a large increase in the amount of common waterweed in Lower Spring Lake in 2022 from 2021 (figure 3.2). It is encouraging to see other native species populations becoming more well established. Common waterweed is smaller than Coontail and typically does not grow as near to the surface as Coontail and so is less often a hindrance to navigation.

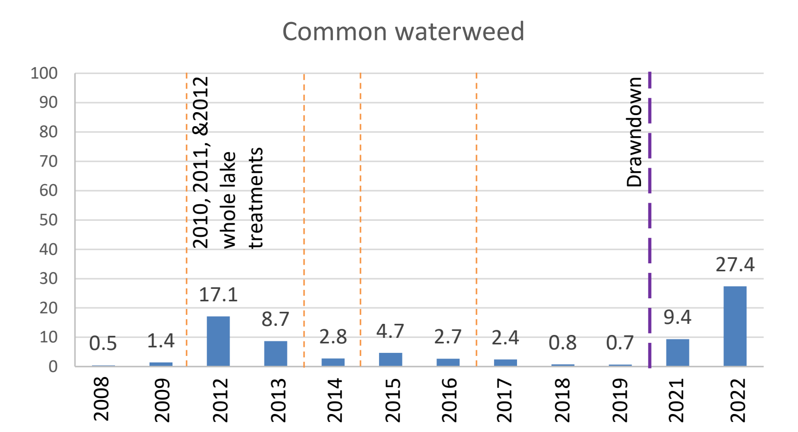


Figure 3.2: Littoral frequency of occurrence of Common waterweed in Lower Spring Lake from 2008-2022. Whole lake chemical treatments are indicated by orange dashed lines and the winter drawdown is indicated by a purple dashed line.

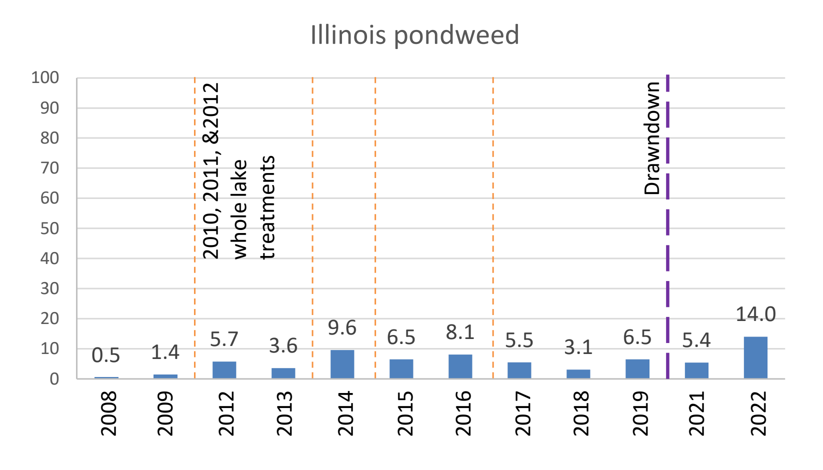


Figure 3.3: Littoral frequency of occurrence of Illinois pondweed in Lower Spring Lake from 2008-2022. Whole lake chemical treatments are indicated by orange dashed lines and the winter drawdown is indicated by a purple dashed line.

Illinois pondweed also increased since the previous survey(figure 3.3). The frequency of occurrence of Illinois pondweed in 2022 was almost triple the occurrence in 2021. A similar species, Variable-leaf pondweed was also documented in Lower Spring Lake in 2022 with a littoral frequency of occurrence of 1.9. This is a native species and it is encouraging to be finding new species that have never been documented in Lower spring before.

After a long-standing decreasing trend, white water lily also increased in Lower Spring since the last survey. While this is encouraging, it should be noted that many of the locations with White Water Lily are not accessible by boat because of the dense vegetation growth. Therefore, this survey only gives a very broad idea about how the white-water lily population is doing on Lower Spring Lake. White water lily's littoral frequency of occurrence through the years can be seen in figure 3.4.

Yellow Pond Lily, a special concern species, was first documented in Lower Spring Lake last spring. It was first documented in the plant survey last summer and was found again in 2022. There are several known populations on Lower Spring lake following some brief investigation. This plant is uncommon in the state and is being documented with special attention because of population declined statewide.

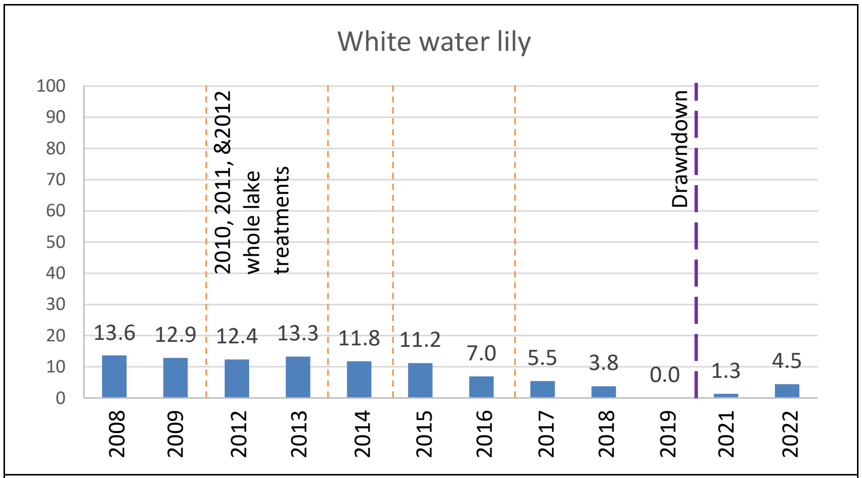


Figure 3.4: Littoral frequency of occurrence of White water lily in Lower Spring Lake from 2008-2022. Whole lake chemical treatments are indicated by orange dashed lines and the winter drawdown is indicated by a purple dashed line.

Wisconsin has numerous species of freshwater sponges. They grow on sturdy submerged objects usually on the lake bottom. Because they are sensitive to water conditions, their presence indicates high water quality and low levels of pollutants. Sponges are invertebrates, they grow by filter feeding, and provide habitat to a variety of other small organisms. In the 2022 survey freshwater sponge was found on the rake at 11 sampling locations, this was the first time that it was recorded in the aquatic plant surveys on Lower Spring Lake. A table of the frequency of occurrence for all plant species recorded in Lower Spring Lake from 2008-2022 can be found in Appendix D.

There was a small but notable decrease in Eurasian-water milfoil, Curly-leaf pondweed, and Coontail in Lower spring lake between 2021 and 2022. This is probably in part to the increase in desirable native species that seem to be increasing in abundance and taking away space and resources from the invasive and nuisance species. This trend was also seen in last year's analysis and it is encouraging to see it continue. The best defense against invasive species is a healthy native plant population. Further analysis of these results will be conducted by the County Land and Water Conservation Department over the 2022-2023 winter.

Average Coefficient of Conservatism and Floristic Quality Index

Coefficient of Conservatism

The Coefficient of Conservatism is a number on a scale from 0 to 10 that represents an estimated probability that a plant species is likely to occur in a lake unaltered from what is believed to be pre-settlement conditions. A Coefficient of 10 indicates the plant is almost certain to be found only in an un-degraded natural community, and a Coefficient of 0 indicates the probability is almost 0. Introduced plants were not part of the pre-settlement flora, so no coefficient is assigned to them. The data for the eco-region that includes Lower Spring Lake is for 68 lakes and the Coefficient of Conservatism values ranges from 6.87 to 2.12 with an average of 5.21.

Table 3.2

Year	Average Coefficient of Conservatism
2009	5.56
2012	5.31
2013	5.08
2014	5.1
2015	5.06
2016	5.22
2017	5.45
2018	4.9
2019	4.67
2021	5.71
2022	5.6

The 2022 average coefficient of Conservatism value is the second highest value ever calculated for this lake in the many years it was surveyed. This indicates that the plant community is becoming more diverse and is beginning to include some native species that have not been encountered in recent years, or ever on this lake, due to disturbances or less favorable conditions.

Floristic Quality Index

Table 3.3:	
Year	**Floristic Quality Index**
2009	22.2
2012	19.1
2013	17.6
2014	16.1
2015	20.9
2016	15.7
2017	18.1
2018	15.49
2019	11.43
2021	21.38
2022	17.7

The floristic quality index (FQI) is used to assess a lake's quality using the aquatic plants that live in it. Developed by Stan Nichols (WI Geological and Natural History Survey), the floristic quality index is the average coefficient of conservatism multiplied by the square root of the number of plants in the lake. The FQI varies around Wisconsin but ranges from 3.0 to 44.6 with a median of 22.2. Generally, higher FQI numbers mean better lake quality.

The lower FQI this year as compared to last year is likely because there were 4 fewer native species on the rake in 2022 than in 2021. Those species were still observed in the lake as visuals, but do not count towards the FQI since they were not sampled on the rake at a sampling location. This is what caused the FQI to be lower and the decrease appears more dramatic than it is in actuality. Some of these species were small duckweed, large duckweed, forked duckweed, and water celery which were all observed in the lake in 2022. This conclusion for the lower FQI is supported by the fact that the average coefficient of conservatism remained higher than previous years in 2022. Except for last year, this year's FQI was the highest recorded since 2017. This value is not far removed from the ecoregion median and is comparable to Lower Spring Lake's historic FQIs.

4.0 - PUBLIC INPUT

It is vital to have public input regarding aquatic plant management not only to determine the level of public acceptance for various control techniques but also to determine which areas of the lake are used or wanted to be used for different types of recreation.

4.1 - February 4th, 2023 Lower Spring Lake District Meeting

Arthur Watkinson of the DNR and Marisa Wieder of the Jefferson County Land and Water Conservation department were present to give updates and answer questions on winter water drawdowns, updating the harvesting permit, future use of chemical spot treatments, and the updates to the Lower Spring Lake Aquatic Plant Management plan. Marisa gave a presentation on the proposed updates to the draft and guided some discussion about ways to make the harvesting program more efficient. Overall there was not much input given regarding the proposed updates to the APM plan and the district seemed to be satisfied with the draft.

The district discussed current uses, desired uses and the current management efforts being undertaken to address invasive species on Lower Spring Lake. There was discussion of the harvesting program and the opportunity to reshape the goals and priorities of the program in order to achieve more desired results. The draft was continued to be updated by the County with input from the DNR and the final draft was shared with the district on March 22nd ahead of their next district meeting on March 25th.

Previous input given by the district and general community regarding updating the previous versions of the APM plan can be found in Appendix E.

5.0 – Aquatic Plant Management Techniques and Previous Use on Lower Spring Lake

Lower Spring Lake is fortunate to have such consistent and robust data collected on the plant community over time. Having a wealth of data, as we do, allows us to make the best-informed decisions about how to manage the aquatic plant community and invasive species on Lower Spring Lake.

5.1 - Manual Removal of Aquatic Plants

Hand Pulling or Raking - Shallow Areas Adjacent to Developed Lots

An option for every landowner is the manual removal of Eurasian water milfoil or curly-leaf pondweed. Manual removal of aquatic plants is regulated by Wisconsin Administrative Code NR 109. A DNR permit is not required for the manual removal of aquatic plants provided that the removal meets ALL of the following:

- Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured parallel to the shoreline. Any piers, boatlifts, swim rafts, and other recreational and water use devises must be located within that 30-foot-wide zone.
- Removal of nonnative plants designated by the DNR (such as Eurasian water milfoil, curly-leaf pondweed) is allowed when performed in a manner that does not harm the native aquatic plant community.
- Removal of plants from the water is required. This is very important because some plants can effectively re-root if they are left to float in the water.
- The location is not in a sensitive area or in an area known to contain threatened or endangered resources. No sensitive areas have been designated by the DNR in Lower Spring Lake.
- The removal does not interfere with the rights of other lakeshore owners.

Manual removal of plants other than Eurasian water milfoil and curly-leaf pondweed is not recommended. If native plants are removed from an area, then that location will be prone to colonization by Eurasian water milfoil and curly-leaf pondweed. The growth of these two species is much more of a nuisance than native plants because of their tendency to grow in dense populations that mat on the surface of the water.

If landowners are not sure which plants are exotic and which are native, they can contact the LWCD or the DNR for identification assistance.

Harvesting White Water Lilies for Navigational Access

There are some properties on Lower Spring Lake in which the adjacent water has an abundance of white water-lilies. It is clear that the properties that regularly use their boat are able to keep an area with open water from their pier to the area of the lake that doesn't have white water lilies. However, there are some properties that don't currently have piers or don't use their boat enough to keep an area open for navigation past the lilies.

Harvesting of the white water-lily tubers could be done by a nursery that is interested in re-selling them. A DNR permit is not needed for this type of manual removal if the removal happens in a single area parallel to the shore that is no more than 30 feet wide. This area must include any piers, boats, or other structures in the water associated with the lot. Once a navigation lane is open, then the landowners should keep it open by regularly accessing the lake. Otherwise, the white water-lilies will re-colonize the area. It should also be noted that taking out the white water-lilies will also make the area prone to the growth of Eurasian water milfoil or the native species of Coontail – both of which will likely lead to navigation difficulties.

In 2014, J&J Aquatic Transplant Nursery removed about 1,000 white water-lilies in an area on the northeast side of the lake. This was done to try to provide a landowner with access to the lake through the waterlilies. The practice was repeated at least for 2 years. The landowner reported that the practice worked well however he was too busy to install a pier.

There has previously been discussion by the District to have the white-water lilies harvested to provide navigational access to the river. Given the depth of the water in this area, the access would likely only be for paddle craft. This would require a permit from the DNR and the Lake District would need to apply for the permit.

5.2 - Mechanical Removal of Aquatic Plants

Harvesting

The Department of Natural Resources, through Administrative Code NR 109, regulates the harvesting of aquatic plants. An approved aquatic plant management plan and a DNR permit is required to use a mechanical harvester. The DNR permit can be issued for up to a 5-year period.

Mechanical harvesting is done to cut and collect invasive species, and sometimes native species if they have grown to nuisance levels, in order to obtain reasonable use of the lake for recreation. It is important to understand that mechanical harvesting could lead to adverse impacts if not implemented properly. When native plants are harvested it can impede the success of the plant management goals because native plants grow and expand into areas that were once populated by invasive plants and often effectively prevent invasives from recolonizing those areas. In addition, plant fragments from exotic species (such as Eurasian water milfoil) that are not captured by the harvester could take root and maintain the density of exotics in the lake. Native plants should be protected as much as possible from harvesting in order not only to achieve the goals of invasive species control, but also to maintain their benefits to the lake resources including maintaining clear water, supporting the fishery, etc.

The Lower Spring Lake Protection and Rehabilitation District has used mechanical harvesting for many years. Harvesting has been a useful tool to ensure control of invasive aquatic plants in areas where the water depths are conducive to active recreational activities. It has also been successful in maintaining recreational use in areas where native plants have been found to grow to nuisance levels. The District purchased the harvester and works with the Village of Palmyra to hire someone to operate the harvester during the summer. The harvester is docked at the boat launch during the summer.

Mechanical harvesting guidelines on Lower Spring Lake include:

- No harvesting in areas with less than 3 feet of water depth so that bottom sediments are not disturbed. Disturbed bottom sediments have the potential to release phosphorus into the water column which lead to increased algae blooms and further aquatic plant growth.
- The cutter blades be no closer than 1 foot from the bottom.
- You shall not harvest emergent plants (standing above the water level) or floating-leaf plant species.
- You shall not disturb spawning or nesting fish during the times and in the areas of the waterbody specified in your permit.
- You shall remove all game fish of catchable size, turtles, and other non-target organisms from the harvesting hopper immediately upon their capture, unless the action interferes with the safe operation of the equipment. In this instance, the organisms shall be unloaded when the equipment is docked for unloading. You shall take all precautions to avoid bycatch.
- You shall not cause a disturbance greater than a de minimus amount in any calendar year. Activities causing more than a de minimus disturbance are subject to Wis. State Statute Ch. 30. and require a permit under that chapter.
- You shall comply with local and county ordinances regarding disposal of aquatic plant materials.
- You shall not disturb the substrate of the waterbody via paddle wheels, cutter or roller bar.
- Any plants floating in the water after the cutting should be collected by the harvester to prevent these plants from re-rooting and continuing to grow in the lake.
- The harvester cannot be operated north of the two islands located in the lake.
- The harvester should only be operated in the designated areas identified in the harvesting map included in Appendix F.
- District representatives should monitor the harvesting operations to ensure that the permit conditions are being followed.

The DNR also has allowed cutting with the harvester in the finger bay (narrow bay located in the southwest) under some conditions:

- The water depths in the center of the channel must be greater than 3 feet. Once navigating into the bay, the harvester may not cut in depths of less than 3 feet.
- The DNR should be notified prior to cutting so they have the opportunity to evaluate and document plant growth in this area, as well as monitor the harvesting itself.
- The sediments in this bay are very flocculent, and the goal is to allow careful cutting so as not to create a plume of mud in the water.

The District should update the Department of Natural Resources and the Jefferson County Land and Water Conservation Department when they see improvements or problems with the aquatic vegetation in any area of the lake. If there are concerns about navigation in areas not permitted for harvesting that are at least 3 feet of depth, then the District should contact the DNR to inquire about possible amendments to their plan and harvesting permit. Appendix G shows a proposed new harvesting map to better prioritize areas for harvesting in Lower Spring Lake to make the program more efficient.

Table 5.0 shows the approximate amount of vegetation removed from the lake with the harvester. During years with an effective chemical treatment, it is the case that there are fewer plants and thus the harvester is deployed less and harvests fewer amounts of plants.

Table 5.0. Estimated Vegetation Removed with the Harvester

Year	Estimated Vegetation Removed	Details on Estimates
2005	810,000 lbs	
2006	396,000 lbs	
2007	756,000 lbs	
2008	499,000 lbs	
2009	461,610 lbs	
2010*	62,440 lbs	14 boat loads, 6 truck loads
2011*	68,000 lbs	16 partial boat loads, 8 partial truck loads
2012*		
2013*	88,000 lbs	32 boat loads, 11 truck loads
2014*	89,000 lbs	35 boat loads, 21 truck loads
2015*		Due to launch construction, only cut one day in the finger bay
2016	203,424 lbs	48 truck loads
2017*	250,000 lbs	59 truck loads
2018		Unsure – lack of records
2019		Unsure – lack of records
2020		Unsure – lack of records
2021		Numbers unclear due to false reporting by harvester operator
2022	862,000	431 harvester loads (harvester and truck loads were confused in reporting so total amount is unclear)

* Years when a chemical treatment occurred.

Diver Assisted Suction Harvesting

Diver Assisted Suction Harvesting (DASH) is a unique nuisance plant management technique that requires somewhat specific circumstances to be completely effective. This management tool can only be effective for small scale applications. It is regulated by NR 109 as it is a form of both manual and mechanical harvesting. Scuba divers remove nuisance plants manually, making sure to pull the roots and remove the entire plant. They then feed the plant into a suction hose that is part of a hydraulic harvester which delivers the plants to a boat where the plants are caught by a screen and the water is returned to the lake. The plants are placed in bags and removed from the lake.

Some factors will impact the effectiveness of DASH. These include:

- Sediment type – loose mucky sediments will end up getting disturbed in the process of removing the plant, and then will impact the visibility of the diver
- Depth – shallow areas are hard to access with this technique
- Time of year – on some lakes, the clarity of the water may be better in the early part of the summer compared to the end of summer
- Age of plants – some plants may be more likely to fragment when pulled; or the plants may have already released their seeds
- Associated plant community – if the target species is mixed in with a variety of native species, then the process will be slow because the diver needs to make sure they are only removing the target species
- Density of aquatic plants – if there is a large amount of target species that need to be removed, then the removal process will take a long time
- Size of area to be covered – if there is a large area to be covered, then the removal process will take a long time and can be cost prohibitive.

Winter Water Drawdowns

Winter water level drawdown to manage invasive aquatic plants is a tool that can be used on Lower Spring Lake because there is an outlet dam. The water is drawn down in the fall to a predetermined level and not returned to normal levels until the spring in order to expose the lakebed in shallow areas. The exposed soil freezes resulting in the killing of invasive species and their reproductive structures. A drawdown will also cause sediment compaction, up to 30%, which will also help prevent the re-establishment of the invasive species.

Water level drawdowns require a permit from the Department of Natural Resources and cooperation from the Village of Palmyra as the dam operator, the village of Palmyra must be the applicant for the permit. The water must be drawn down by October 1 to ensure that amphibians and turtles hibernate in the areas under the water to reduce their risk of freezing and perishing. Lower Spring Lake is confined to a 3-foot 8-inch drawdown due to the size of a box culvert under Highway 59. This would result in approximately 63 acres exposed and 46 acres under water.

The District could choose a smaller drawdown. It is important to expose the area south of the island during a drawdown because this area has historically had navigation problems due to the abundance of Eurasian water milfoil and the native species of Coontail which has grown to nuisance levels impacting avigation in recent years. A drawdown of 3 feet and 8 inches would expose this area whereas a 3-foot drawdown would not.

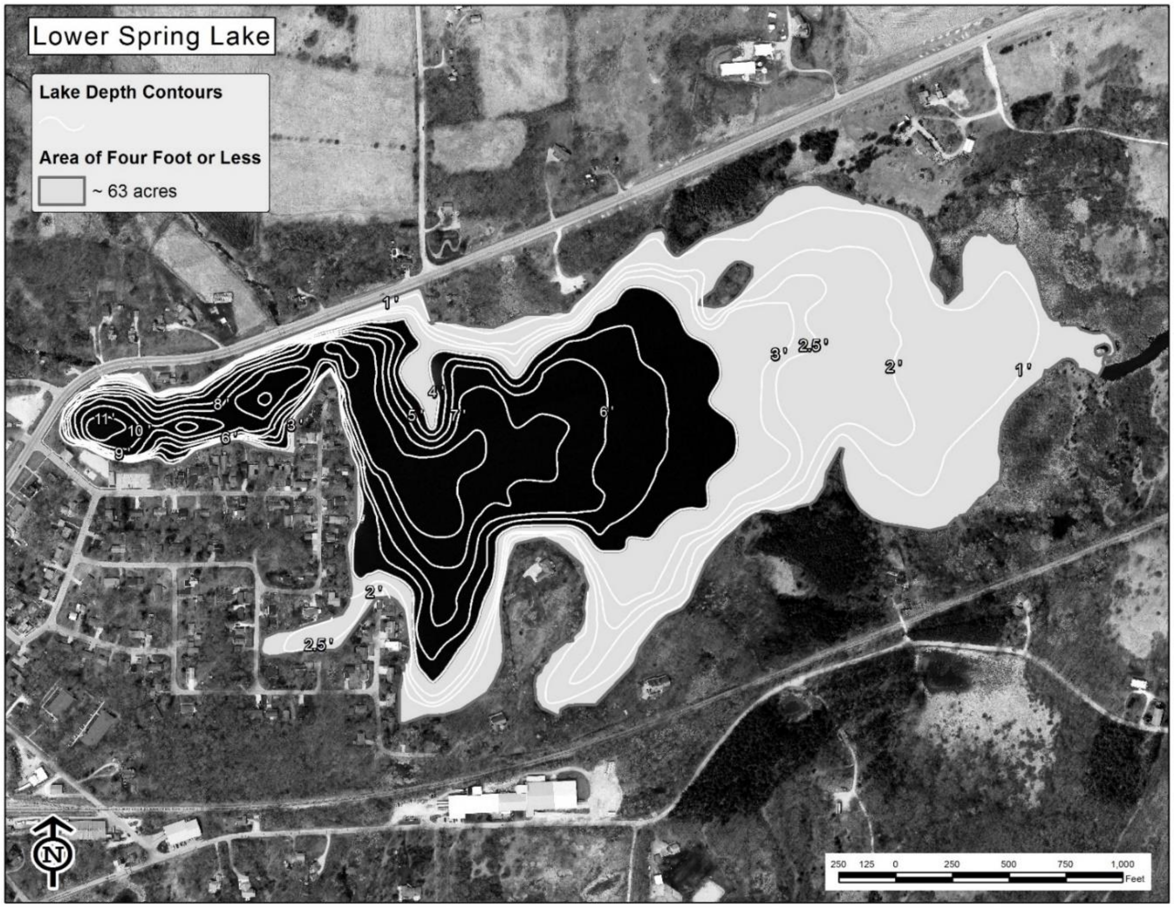


Figure 5.0: four-foot drawdown map, shaded areas above would be exposed by a four-foot drawdown. Due to the size of the box culvert at the dam, the maximum drawdown that can be achieved on Lower Spring Lake is 3.75 feet.

In order to determine how long it will take to draw the lake down by 4 feet, calculations can be done given the hydraulic residence time of the lake, or how long water spends in the lake. The DNR has calculated the median as 17 days, lower 90% confidence limit as 8 days, and upper 90% confidence limit as 31 days for the hydraulic residence time. Given the size of the lake, a volume per day for each residence time can be determined. Then the volume of water that will be drawn down can be divided by the volume per day to determine how long it will take to both draw down the lake by 4 feet and to return the 4 feet to the lake. These are as follows:

- The smallest amount of time = 7.5 days
- The median amount of time = 15.8 days
- The maximum amount of time = 28.9 days

The benefits of a drawdown include the following:

- Up to 30% permanent compaction of the sediment – if the conditions are cold and dry during the winter. It is important to note though, that not as much compaction happens with snow cover.
- Management of Eurasian water milfoil in areas where the sediment is exposed and freezes over the winter.
- Dense stands of Eurasian watermilfoil and Coontail in Lower Spring Lake may be reduced, which will allow for better fish movement.
- Native aquatic plant species that predominately reproduce by seeds will benefit.

The disadvantages of a drawdown include the following:

- Native aquatic plant species that reproduce mainly by fragmentation or cloning can be negatively impacted by winter drawdowns.
- There is a potential for an algae bloom after a winter drawdown as a result of more available phosphorus.
- The risk of a mild winter, or early heavy snow accumulation could compromise the effectiveness of the drawdown. However, the drawdown during the unseasonably mild winter of 2019-2022 still resulted in benefits to the native plant community and some control of EWM.
- Impacts to the fishery are unclear and there is very little data currently about the fishery in Lower Spring Lake. Results of a 2021 fish survey showed no negative impacts to the fish community as compared to results from before the 2019-2020 drawdown but this is a small amount of data.
- If there are springs that continue to flow during the winter drawdown, those areas will likely not have good invasive species control or sediment compaction.

Winter water drawdowns will impact aquatic plants in different ways. There is evidence that if the winter soil conditions remain moist, or if the soil is not frozen for several weeks, then Eurasian water milfoil may survive the drawdown. The extent of curly-leaf pondweed control resulting from a drawdown is unknown until the winter conditions are known. Curly-leaf pondweed turions (winter seeds) will only be damaged enough to prevent germination if the sediments freeze. If there is a lot of snow cover or a mild winter, then most will not be completely destroyed.

An important consideration for winter drawdowns is what will happen with the fish in the lake during the drawdown. The fish will either concentrate in the deep areas of the lake or swim up or downstream. Given that there is a dam upstream from Lower Spring Lake, there are not extensive areas for the fish to go. A winter drawdown can have both negative and positive impacts to the fishery, unfortunately at this time there is still not a lot of data about how fisheries are affected by drawdowns so it is difficult to anticipate every individual situation. If the drawdown coincides with a cold winter with little snow cover, then the ice could become very thick. This would mean that the fish don't have much water and that water could become anoxic leading to a fish kill. If this doesn't happen, then the fishery can naturally rebound. During a winter drawdown, fish predators can reduce the amount of forage fish over the winter. This increases the amount of larger zooplankton which in turn could result in greater water clarity and become a good food source for fish.

A restocking plan to assist the fishery in rebounding should be considered for years following drawdowns. This plan should be in place prior to drawdown. Stocking can happen in Spring or Fall. It would be important to work with the Palmyra Lions Club which has done fish stocking on Lower Spring Lake previously. The DNR has seen a positive response from fisheries after restocking. Fish growth is accelerated, the health of the fish will be better, and there is a good invertebrate response.

During a winter drawdown, there can be a temporary emergency fishing closure. The Lake District would apply for this closure with the DNR, there would be a public input session and published notice of the request. The fishery could then be re-opened when the lake reaches normal water levels – which could be done prior to the spring fishing opener.

History of Winter Water Drawdown on Lower Spring Lake

In July of 2019 a whole lake- aquatic plant survey was completed on Lower Spring lake to assess the health of the aquatic plant community and the extent and density of the aquatic invasive species populations of Eurasian water-milfoil and Curly-leaf pondweed. During the winter of 2019-2020, the water level on Lower Spring Lake was drawn down for the winter in order to expose shallow areas of the lake as a management technique for controlling the populations of invasive species in the Lake. The water level began lowering on September 9th, 2019 and was lowered a total of 3 feet and 8 inches by October 1st, 2019 until it was allowed to raise in the spring of 2020. In 2020, another aquatic plant survey was supposed to take place to measure the effects of the drawdown on the plant community, but complications due to the COVID pandemic and available staff time meant an entire lake plant survey was not able to be completed. In an effort to still have some data available for analysis, 55 points were selected from the 304 whole lake survey points to be assessed. About half of these points were in locations where the lake bed would have been exposed by the drawdown. The average depth of the sampling points in 2020 was 3.6 feet, the deepest point sampled was 6ft deep, and 49% of the sampled points would have had exposed lake bed by the drawdown. Of the whole lake survey data in 2019, only the data from the 55 points that were surveyed again in 2020 was considered in the analysis for this section.

Table 5.1 provides some basic metrics about the survey, including the number of points that were able to be sampled vs those that were not sampled due to excessive plant growth. During the 2020 survey, there were an average of 2.09 species sampled at each point, an increase from 1.59 species per point during the 2019 survey. This indicates an increase in diversity among the plant community present at the sampling locations. This increase in diversity is even more apparent when considering the total number of species sampled during the surveys, in 2020 there were 20 species documented, almost three times the number recorded in the 2019 survey in those same locations.

Table 5.1: General information from Lower Spring 2019 and 2020 plant surveys		
Lower Spring Lake	**7-29/30-2019**	**7-29-2020**
Total # sites sampled	31	55
# of sites non-navigable due to plant density	24	0
The average number of species per site	1.59	2.09
Total number of species (including invasives)	7	20
Simpson's Diversity Index	0.63	0.79

One additional metric of diversity that is used to evaluate the health of a plant community is the Simpson's Diversity Index. This measure of diversity takes into account the abundance of each individual species in the lake rather than just counting the total number of species present. The higher the index number on a scale of 0-1 the more evenly distributed the species abundance is in the plant community. This number also increased from 2019 to 2020 indicating that the species present were more evenly distributed through the plant community in 2020 than in 2019. Simply put, if you randomly sampled two plants from Lower spring lake in 2019 there would be a 63% chance that those two plants would be different species, in 2020 the chance two randomly sampled plants would be different species increased to 79%. The charts in figure 3 provide a good visual representation of this diversity. The pie chart showing the 2020 data has slices that are more similar in width than the slices of the pie chart showing the 2019 data.

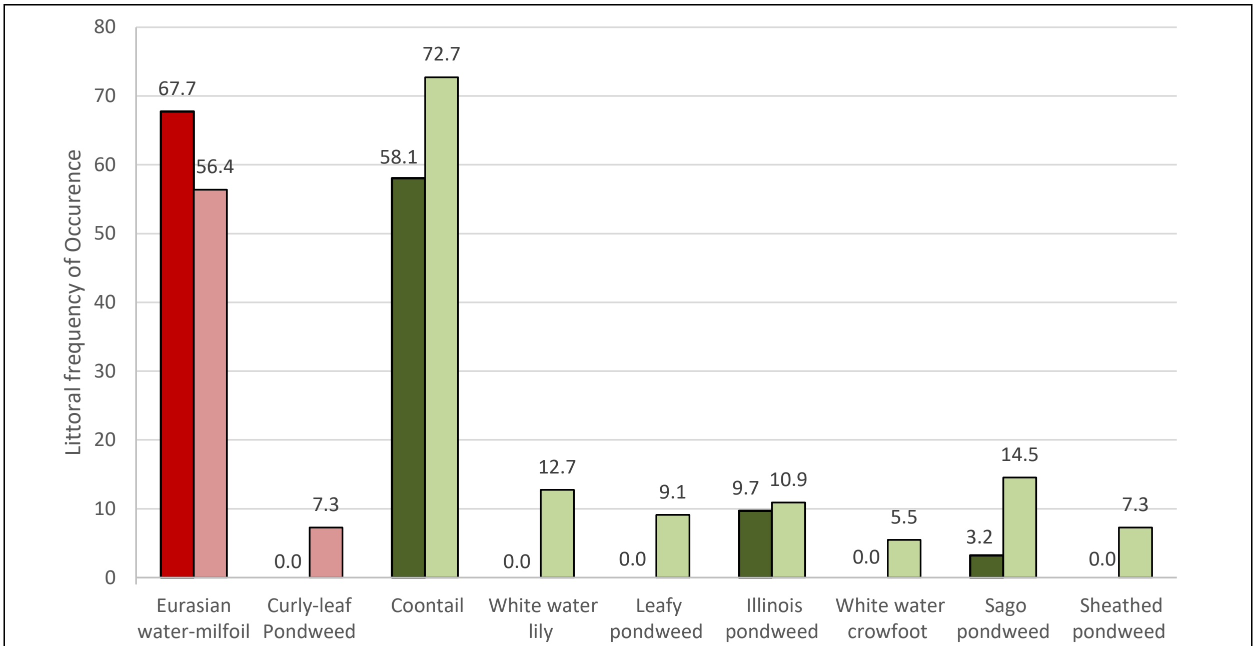


Figure 5.1: Littoral frequency of occurrence of all species with at least a 2% frequency of occurrence in one of the sample years. Darker colored bars (left) represent 2019 data while lighter colors (right) represent 2020 results. Red coloration indicates the species is invasive while all green colored data represents native plant species.*only species that had a least a 2% frequency of occurrence in one survey year were included in this figure*

Figure 5.1 provides the littoral frequency of occurrence of individual plant species during the 2019 and 2020 surveys. Eurasian water-milfoil experienced a decline in abundance in 2020 as compared to the 2019 survey while the seven most commonly encountered native species all experienced an increase in their frequency of occurrence. Curly-leaf pondweed was not encountered in the 2019 sampling of these points but was found to be present during the 2020 survey at these locations. Control of curly-leaf pondweed from a winter drawdown requires more severe freezing and less snow cover than required for Eurasian water-milfoil control. Although Curly-leaf pondweed was not documented in 2019 it is known to have been present in Lower Spring Lake since 2008. It is also one of the first plants to emerge in the spring and typically dies back by late June, since the 2019 and 2020 surveys took place in mid-July, they most likely underestimate the true presence of Curly-leaf pondweed in the lake.

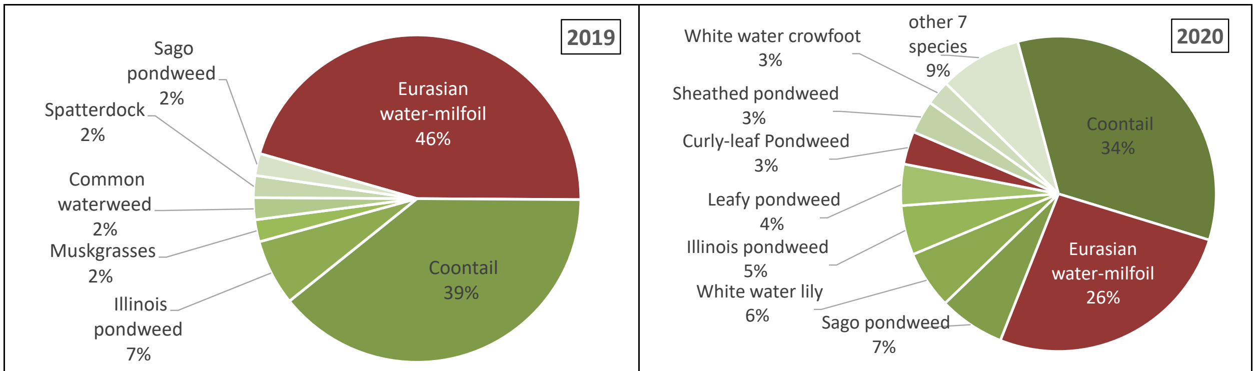


Figure 5.2: Relative frequency of occurrence of species in the plant community in the 2019 and 2020 surveys. Only species sampled on the rake are included in this analysis.

While figure 5.1 shows the individual changes in species presence, Figure 5.2 shows the shift in the percentage makeup of the plant community of Lower Spring Lake. In 2019 Eurasian water-milfoil made up 46% of the plant community in the sampled locations. An additional 39% of that plant community was made up of Coontail, meaning 85% of the plant community was made up of either Eurasian water-milfoil and Coontail in 2019. In 2020 the survey data showed that Eurasian water-milfoil made up 26% of the plant community, almost half the portion it made up in 2019. Coontail also saw a small reduction from 39% to 35% but the greatest change in the plant community is in the distribution of the other native species. In 2020 there was a greater number of native species present and they occupied a larger portion of the plant community in 2020 than they did in 2019. Eurasian water-milfoil and Coontail made up 60% of the plant community in 2020, a decrease from 85% in 2019. Having high diversity in the plant community is desirable because of the habitat it provides to wildlife and its increased ability to resist invasion by invasive species.

It is clear from the data analysis which considered many factors and used numerous metrics, that the 2019-2020 winter drawdown had a positive impact on both the control of Eurasian water-milfoil and the health of the native plant community in Lower Spring Lake. Winter water level drawdown can be a very powerful tool for aquatic plant management on Lower spring lake and it is the opinion of the Jefferson County Land and Water Conservation Department that a winter water level drawdown should be utilized again in the future to help manage the Eurasian water-milfoil in the lake. It is encouraging that even in a mild winter there was some control of the invasive, if the winter during future drawdowns were to be average or colder than average, the control of the invasive achieved would be even greater and even more success would be realized in the following summer as compared to the results presented here.

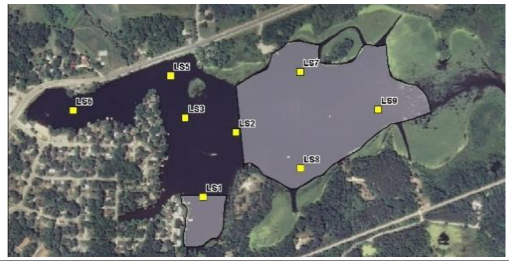
5.3 - Chemical Treatment

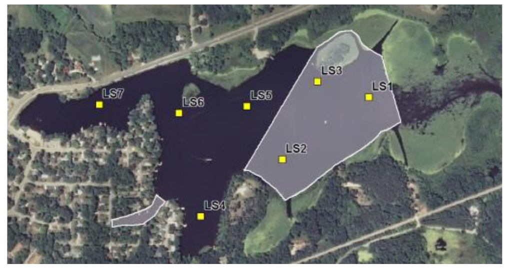
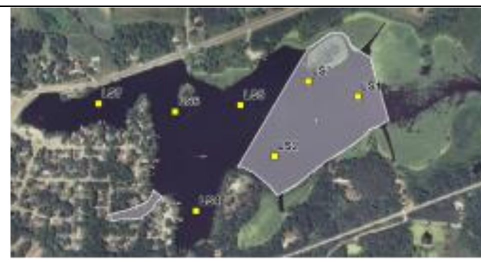
History of Chemical Treatment on Lower Spring Lake

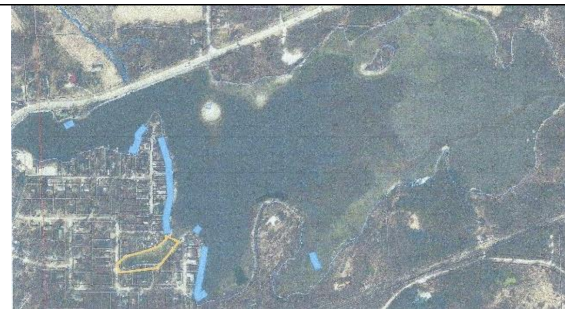
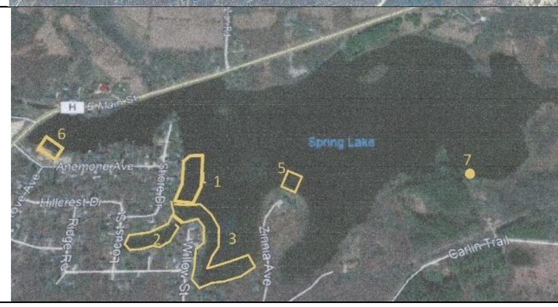
The control of aquatic plants through chemicals is regulated by the Department of Natural Resources through Administrative Code NR 107. Among other things, an annual permit for chemical control is required through the DNR.

When Lower Spring Lake first started to use a chemical treatment, areas along residential properties were targeted. Later, a 5-acre section that is south and west of the boat landing was added for a total of 15 acres of treatment. A granular formulation of the chemical 2, 4-D (Navigate) was used. These treatments occurred in late May or early to mid-June. At that time, it was believed 2,4-D was only effective on dicots (mainly milfoils), sparing most of the native species. However, this was not the case and these treatments took place during a time when native plants were actively growing and likely resulted in a detrimental impact on the native plant species in Lower Spring Lake. In addition, since there were probably more plants killed, the decomposition likely contributed to increased algal blooms.

In the last 15 years, the science of chemical treatments (especially those using 2, 4-D) has greatly advanced in Wisconsin due to pre-treatment and post-treatment plant surveys, and the collection of water samples to track the amount and location of chemicals in the water after treatment. As a result of this wealth of data collection, our understanding of the impact of chemical treatments on the whole plant community has improved and thus the permitting and use of chemical treatments as a management tool statewide has evolved. The whole-lake chemical treatments that have happened on Lower Spring Lake to reduce the Eurasian water milfoil and curly-lead pondweed populations are detailed in Table 5.2.

Table 5.2 Treatment history details by year on Lower Spring Lake	
2011 Treatment for Eurasian Water Milfoil - May 16, 2011, whole lake treatment - 39 acres (5 acres in SW bay, 34 acres in eastern part of lake) - Liquid 2, 4-D - Target application concentration of 0.275 mg/l ae	
2012 Treatment for Eurasian Water Milfoil - April 11, 2012, whole-lake treatment - Liquid 2, 4-D - 27.3 acres on east side of lake; target application concentration of 1 mg/l ae - 1.1 acres in finger bay; target application concentration of 0.5 mg/l ae	
2012 Treatment for Curly-Leaf Pondweed - April 11, 2012, whole-lake treatment - Endothall (Aquathol K) - 61 acres - Target application concentration of 1 mg/l ai (0.71 mg/l ae)	
2013 Treatment for Curly-Leaf Pondweed - May 13, 2013, whole-lake treatment - Endothall (Aquathol K) - 61 acres (chemical placed in entire lake except for northwest finger) - Target application concentration of 1 mg/l ai (0.71 mg/l ae)	
2014 Treatment for Eurasian Water Milfoil - May 19, 2014, whole lake treatment - Liquid 2, 4-D applied - 66 acres - Target application concentration of 0.35 mg/l ae	

2015 Treatment for Curly-Leaf Pondweed - May 12, 2015, whole lake treatment - Endothall (Aquathol K) applied - 61 acres - Target application concentration of 1 mg/l ai (0.71 mg/l ae)	
2015 Treatment for Eurasian Water Milfoil - May 12, 2015 whole lake treatment - Liquid 2, 4-D applied - 27.3 acres on east side of lake with a target application concentration of 1.25 mg/l ae - 1.1 acres in finger bay with a target application concentration of 0.5 mg/l ae	
2016 – No Treatment	
2017 Treatment for Eurasian Water Milfoil - May 10, 2017 whole lake treatment - Liquid 2, 4-D - 27.3 acres on east side of lake with a target application concentration of 1.25 mg/l ae - 1.1 acres in finger bay with a target application concentration of 0.5 mg/l ae	
2017 Treatment for Curly-Leaf Pondweed - May 10, 2017, whole lake treatment - Endothall was applied - 61 acres - Target application concentration of 1 mg/l ai (0.71 mg/l ae)	
2018 – finger bay and select shorelines	Diquat and evaluated on a property by property basis
2019 – finger bay and select shorelines, drawdown (winter ‘19-‘20)	
2020 – no treatment	

2021 – finger bay and shorelines	
2022 – finger bay and shorelines ** area 7 did not end up being treated due to inaccessibility from shallow water depth and early plant growth	

The Land and Water Conservation Department conducted the pre and post treatment plant surveys. In conjunction with the US Army Corps of Engineers and the Department of Natural Resources, lake district volunteers collected water samples after the chemical treatments to analyze them for chemical residuals. This sampling showed the amount of chemical and the length of time that the chemical was still active in the water. Coupled with the plant survey data, the effectiveness of each treatment could be determined

According to research on lakes throughout Wisconsin, spot treatments of 2, 4-D are ineffective (DNR 2014). Thus, only whole lake treatments were permitted. Generally, 3-5 years of control is expected from whole lake treatments, if repeated whole lake treatments are only resulting in seasonal control other management techniques need to be considered. If only seasonal control of invasive species is achieved through repeated whole lake treatments, the drawbacks of those frequent aggressive treatments begin to outweigh the benefit of minimal seasonal control. One possible exception is the treatment of enclosed bays – bays that have a small opening to the rest of the lake. In Lower Spring Lake, the only bay that would qualify is the “finger bay” located adjacent to Locust Street.

Studies on Wisconsin lakes have shown that 2, 4-D quickly moves through the water to mix throughout the water body. Therefore, spot treatments are not effective as the chemical will dissipate before fully impacting the plants. Flowages are notoriously difficult to manage invasive populations in while using chemical herbicide because of how quickly water moves through the systems. Using 2,4-D in spot treatments which is already know to dissipate quickly, in a flowage system with a low residence time for water, will not produce effective control of EWM. In these circumstances, minimal seasonal control is the best that can be hoped for and therefore spot treatments of 2,4-D are not recommended in these circumstances.

Eurasian Water Milfoil Response to Chemical Treatment 2008 - 2022

Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.

Figure 5.5: Diagram showing including a description and visual representation of the rake fullness methodology.

The average rake fullness of Eurasian water milfoil in the lake is determined for each summer plant survey. The rake fullness is defined as 1 = a few plants on the rake; 2 = approximately ½ the rake full with plants; 3 = rake overflowing with plants such that the rake head is not visible.

Table 5.3 shows the average rake fullness ratings for only EWM for all survey years on Lower Spring Lake from 2008-2022. We can see that when surveys began and whole lake treatments were being used the average rake fullness of EWM generally ranged from 1.0-1.3 and in the last five years since the whole lake treatments have ceased that the average rake fullness rating of EWM has increased slightly and has remained around 1.5.This does not necessarily indicate that the population of EWM in lower spring lake is increasing, but indicates that where there is EWM in the lake, it is more dense than in previous surveys.

Table 5.3: Average Rake Fullness of Eurasian Water Milfoil on Lower Spring Lake from 2008 to 2022

Year	Average Rake Fullness of EWM
2008	1.31
2009	1.10
2012	1.50
2013	1.10
2014	1.00
2015	1.25
2016	1.26
2017	1.38
2018	1.47
2019	1.46
2021	1.71
2022	1.49

The littoral frequency of occurrence (LFOO) is one of the tools that is used to determine the effectiveness of a chemical treatment. The LFOO only includes data from sampling sites less than the maximum depth of plant growth The 2008 survey has the LFOO in order of largest to smallest for that year's data in order to illustrate the plants that have either increased or decreased in FOO in the following years. Please note, emergent plants that grow along the shorelines were not included in the chart because they tend to be under-sampled by the survey techniques. The duckweed and water meal was also not included in the table. Though curly-leaf pondweed is included, it should be noted that the summer surveys typically occur after the plant naturally died back for the season.

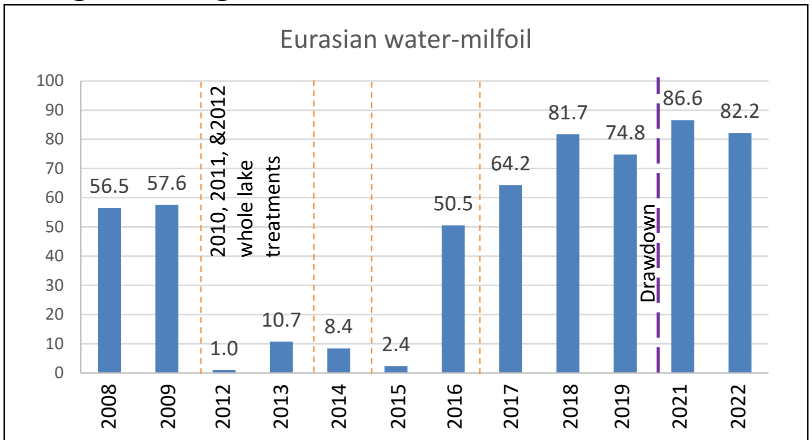


Figure 5.4: Littoral frequency of occurrence of EWM in Lower Spring Lake from 2008-2022. Whole lake treatments are indicated by an orange dashed line while the one winter drawdown is indicated by a purple dashed line.

In years that had whole lake treatments, the FOO of Eurasian water milfoil is less than that in 2008 except for one year. The 2017 summer FOO of EWM was more than any other year since 2008. It is postulated that the chemical treatment was not effective during 2017 and therefore didn't provide even seasonal control.

Curly-Leaf Pondweed (CLP) Response to Chemical Treatment 2008 – 2022

Lower Spring Lake received a chemical treatment with Endothall for curly-leaf pondweed in 2012, 2013, 2015, and 2017. In the years since the 2017 treatment, CLP has not been present as a dominant plant in Lower Spring Lake's plant community and has not been reported to be causing navigation or recreation impairments. The spring plant surveys are used to assess the amount of CLP in the lake because this is when CLP is at its peak. While mid-summer PI surveys capture the peak growth of the plant community as a whole, CLP has already died back for the year by that time. Though the spring surveys started in 2010, the 2010-2013 surveys only included a subset of survey points. The spring surveys with all of the survey points were implemented from 2014 to 2017, but have not been repeated since.

Native Plants Response to Chemical Treatment 2008 - 2022

Several plants appear in earlier surveys but have either reduced in LFOO or were not found in the lake for several years but then rebounded or were once again found during surveys in the years following the cessation of whole lake herbicide treatments. In order to determine if these reductions or disappearances are statistically significant, it is important to perform a statistical analysis called Chi-Square. This evaluation can also assess whether the decrease in exotics with treatment are statistically significant, meaning can the increase or decrease in a species be directly attributed to the treatment.

The 2008 and 2015 summer aquatic plant data were compared with the Chi-Square evaluation. 2008 was chosen as the baseline data because this survey pre-dates the whole lake treatments on the lake. 2015 was chosen because this is the year in which the treatment seemed to achieve the best seasonal management of the exotic species. The analysis resulted in 6 species that had statistically significant increases or decreases in population compared to 2008 (Table 5.4).

Table 5.4. Statistically Significant Changes in Lower Spring Lake Plants

Species	Change between 2008 and 2015	Change between 2008 and 2017
Myriophyllum spicatum, Eurasian water milfoil	Decrease	
Ceratophyllum demersum, coontail	Decrease	
Potamogeton nodosus, long-leaf pondweed	Decrease	Decrease
Potamogeton friesii, Fries' pondweed	Decrease	Decrease
Potamogeton Illinoensis, Illinois pondweed	Increase	Increase
Elodea canadensis, common waterweed	Increase	
Nymphaea odorata, white water lily		Decrease
Stuckenia pectinate, sago pondweed		Decrease
Chara spp., chara		Decrease

The Chi-Square evaluation was also performed to compare the 2008 and 2017 aquatic plant data. Again, the analysis resulted in six species that had statistically significant increases or decreases in population compared to 2008 (Table 17). In terms of white-water lily differences, the decrease in population may be due to changes in navigability due to plant growth in 2017. Floating leaf plant communities are difficult to measure using this survey method because navigation with a motor boat can be impossible with thick vegetation.

In general, it has been found that the aquatic plant community has become both more robust and diverse in the time since whole lake treatments have ceased on Lower Spring Lake. The aquatic plant community had shown a negative response over time to repeated whole lake chemical treatments but is now recovering. For more specific data and visual aids see section '3.0 Aquatic plants' above.

Beginning in 2022 a smaller scale grid of sampling locations was established within the recurring spot treatment areas. The intention is to survey these locations prior to and after treatments each year, or once a year in years without a treatment. This will allow us to have a greater amount of data that is directly related to the treatment areas and directly observe changes in the plant community that are linked to the chemical treatments.

Chemical Treatment Permitting Decisions

The data for each chemical treatment since 2010 continues to be evaluated by a technical team with the Department of Natural Resources and the Jefferson County Land and Water Conservation Department. The DNR team also makes permitting determinations and recommendations on treatments based on the data. For Eurasian water milfoil, the team agreed that the lake should not continue to receive whole lake chemical treatments every year. Several factors have been considered and led to this ultimate decision. Changes in understanding about how chemical treatment affects whole plant communities, specifically native species, has reshaped department and natural resource manager's goals related to invasive species management.

This is partially due to the impacts on native plant species. The decision is also related to the effectiveness of 2, 4-D in Lower Spring Lake. The treatments for EWM have shown seasonal declines, but the plant rebounds the next year.

6.0 – Aquatic Plant Management Recommendations

6.1 - Impacts of Aquatic Invasive Species

Nuisance levels of aquatic invasive plants will impede navigational and recreational use of the lake and can adversely impact native plant populations, fish and wildlife, and water quality. Invasive species can grow to the surface of the water which can significantly hamper boat passage and other recreational activities such as swimming. Invasive species are of concern because they can out-compete native plant species and form dense beds. These growth patterns negatively impact the native plants that provide many benefits to the lake. Reducing the extent and density of invasive species in the lake has resulted in improvements in the abundance and diversity of the native plants. As a result, the biological health of the system has improved. Ensuring that native plants are not impacted by invasive species management techniques is integral to ensuring that the benefits of plant management are achieved. If native plants are not protected in the lake, then one of the outcomes would be increased algal blooms and increased spread of the invasive species.

Fish are also impacted by the growth patterns of invasive species because dense beds of exotic species can prevent fish passage and do not supply ideal fish habitats. With the switch to native plant populations, the fish will have more rearing and refuge areas available to them.

6.2 - Aquatic Plant Management Goals

The 2011 aquatic plant management goal for Lower Spring Lake was to manage the plants in the lake to reduce and maintain the coverage of Eurasian water milfoil (EWM) and curly-leaf pondweed to 10% frequency of occurrence. However, prior to whole lake treatment, and in years after treatment has occurred the frequency of occurrence of EWM in Lower spring lake has been between 50and 60%. Since whole lake treatments have stopped, EWM frequency in Lower Spring Lake has oscillated between 75% and 87%. Time and improvements in understanding the ecology of EWM and the use of herbicide as a management tool have allowed us to understand that 10% frequency of occurrence of EWM in Lower Spring Lake is not a realistic goal. After many years of whole lake treatment back to back, it was determined through data analysis of the annual plant surveys and field observations that the control achieved by the chemical treatments was seasonal at best. It was also determined that the cumulative effects of whole lake chemical treatments were having negative long-term effects of the native plant community. This was also causing a negative feedback loop in which the native plant community became reduced and then the invasive plant community would expand to include the newly available space and resources. Given the data and experience with managing EWM of Lower Spring Lake, keeping EWM near 75% is a much more realistic goal. Optimizing the harvesting program and leveraging winter water drawdowns will be the best tools to keep EWM near target levels in the lake. Spot herbicide treatments can also be utilized for especially problematic areas that are unable to be harvested when permitted. As the native plant community continues to grow and become more diverse, it will also contribute to keeping EWM in check. In addition to EWM reduction, the main goal of the lake's APM plan has been to protect and enhance native plants in the lake. Encouraging a healthy native plant population will benefit recreational uses and the functioning of the lake ecology.

Results from herbicide concentration monitoring post treatments showed that the chemical used to target Eurasian water milfoil (2,4-D) did not stay in the lake long enough at the concentrations needed to effectively kill the plants. This is due to water flow and/or weather (wind and rain) that resulted in the chemical flushing out of the lake too quickly. This is a characteristic of Lower spring Lake and cannot be manipulated to retain the chemical any longer. Therefore, coverage of invasive species in the lake was not reduced to manageable levels long-term. In addition, statistically significant data indicate that native plants have been negatively impacted by the chemicals.

Curly-leaf pondweed has been present in Lower Spring Lake since 2008. In 2008 its frequency of occurrence in the lake was 6.5%, and in 2009 it rose to 17.1%. However, since 2009 its occurrence has not reached 6% again. In five of the last ten surveys on Lower Spring lake, it was not even found in the lake during the survey. Because curly-leaf pondweed has been in Lower Spring Lake for many years, this is likely as abundant as it will ever become. Although the abundance measurements may be skewed a bit low because of the survey time of year not aligning with the plant's peak growth time, the curly-leaf pondweed population in Lower Spring lake has not been impairing navigation or recreation and so is not a major management concern.

It is not likely that the Department of Natural Resources will approve whole-lake treatments of 2, 4-D on Lower Spring Lake anymore. Studies on Wisconsin lakes have shown that 2, 4-D quickly moves through the water to mix throughout the water body. Therefore, spot treatments are not effective as the chemical will dissipate before fully impacting the plants. The one location on Lower Spring Lake where 2, 4-D could be used as a spot treatment and have the intended management effects is the finger bay, located adjacent to Locust Street because this bay is small and the chemical may stay within the confines of the bay. The other bays of the lake are open to the rest of the lake and subject to whole lake mixing, therefore small-scale treatment with 2, 4-D will not achieve required contact exposure time and therefore will not successfully provide control of invasive species. As a flowage, Lower Spring lake experiences a lot of continuous water movement and mixing which quickly dissipates any chemical treatment, this is why chemical treatments are difficult to implement successfully in flowage systems.

It is recommended that the district maintain the implementation of their mechanical harvester according to the DNR guidelines. In addition, other techniques can be considered to supplement harvesting that may alleviate the abundance of invasive species that cause navigational problems. The district should consider updating its harvesting goals, map, and routine to more effectively manage EWM and navigation on Lower Spring Lake and prioritize areas according to desired types of recreation.

Special attention should also be paid to the depth of the cutting bar so that sediment is not disturbed during harvesting. This causes poor water quality and leads to increased algae blooms.

Given that the harvester cannot operate in water less than 3 feet of depth, there may be a time when invasive species materially impede navigation in some shallower areas of the lake. When this is the case, some chemicals (such as Diquat) that have a short exposure time required for treatment may be allowed to be applied on a small scale (not as a whole-lake treatment) as needed for navigational purposes. Winter water drawdowns have been successfully used on Lower Spring Lake in the past, and are another tool that should be used to control Eurasian water milfoil. The 2019-2020 winter drawdown, though the winter was unseasonably mild, did provide some amount of invasive species control as well as benefits to the native plant community.

Table 6.0 provides information on various management techniques for invasive species and outlines the pros and cons of each one. There are some practices that the district has tried in the past (such as milfoil weevils) that were not successful.

Table 6.0. Options for Management of Aquatic Invasive Species

Option	Notes	Pros	Cons
Manual Control: Hand pulling or manual raking	1 Mostly applicable adjacent to land 2 Works best in soft sediments	1 Can be highly selective 2 Can be done by shoreline property owners without permits by following certain guidelines 3 Can be effective at removing problem plants, particularly following early detection of an invasive species 4 No cost if being done by homeowners	Very labor intensive Native plants may be removed Invasive plants may re-populate area Roots, runners, and fragments of some plants (EWM) will start new plants, so all of the plant must be removed Small scale control only
Mechanical Control: Harvesting	Plants are “mowed,” collected, and off-loaded on shore	Immediate results EWM removed before it has the opportunity to autofragment (EWM grows to surface, flowers, and then fragments) Usually minimal impact to lake ecology Harvested lanes through dense weed beds can increase growth and survival of some fish Can remove some nutrients from lake	Not selective in species removed Fragments of plants not collected can re-root Can remove some small fish and reptiles in lake Improper operation can cause turbidity which can negatively impact the lake environment On-land disposal of plants must be arranged Initial cost of harvester expensive Requires maintenance and associated costs

Option	Notes	Pros	Cons
Mechanical Control: Diver Assisted Suction Harvesting	Divers pull and feed plants into a suction hose for collection	Selective for species removed Limited non-target ecological impact	Labor and equipment intensive On-land disposal of plants must be arranged
Physical Control: Winter Drawdown	Lake must be drawn down by October 1 Lake should be raised by spring fishing opener	Effective given drying and freezing occur Sediment compaction Mimics natural water fluctuation important for all aquatic ecosystems Not expensive Provide opportunity to consider other tools such as dredging	Plants with large seed bank or propagules that survive drawdown may become more abundant Can affect fish, particularly in shallow lakes if oxygen levels drop
Chemical Control: 2,4-D	Herbicide absorbed by plant and moves into leaves, stems, and roots Can be used in combination with endotholl	Effective at treating Eurasian water milfoil	Impacts native plants including native milfoils, contain, naiads, elodea, duckweeds, lilies, spatterdock, and bladderworts among others May cause oxygen depletion after plants die and decompose Ester formulations are toxic to fish and some invertebrates Some endocrine disruption in amphibians can occur

Option	Notes	Pros	Cons
Chemical Control: Endothall	Contact herbicide that prevents plants from making proteins Can be combined with 2,4-D	Especially effective on CLP and also effective on EWM May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring	Impacts both monocots and dicots including native species of pondweeds, and coontail Some formulations also kill chara and wild celery Some formulations are toxic to fish
Chemical Control: Diquat	Contact herbicide that disrupts cell membranes and interfers with photosynthesis Non selective Ineffective in cold water (<50°F)	Fast-acting herbicide	Kills a wide variety of native plants especially pondweeds, coontail, elodea, naiads Toxic to aquatic invertebrates Ineffective in muddy water – so bottom sediments cannot be disturbed during treatment A trace contaminant in diquat products is a carcinogen

7.0 Other Recommendations

7.1 - Treatment Monitoring Recommendations

It is recommended that pretreatment and posttreatment data be collected as a part of any large-scale management technique in order to understand the effectiveness of a technique. This is useful so that we can determine ways to improve the technique as well as determine whether the cost was worth the benefits.

1. Pre-treatment conditions
   - A whole-lake survey of the plant community using the point/intercept survey method should be completed before whole-lake treatment.
   - Small-scale herbicide treatment should also have a pretreatment plant survey. Sometimes this can be done with the point/intercept survey. On Lower Spring Lake smaller grids of sampling points have been designated to more accurately assess the areas being treated using herbicide.
   - When this survey is performed (spring or summer before) will depend on the target species and the timing of treatment.
   - Depending on the chemical and timing, it may be important to take temperature readings (at 2-foot depths) in the weeks leading up to treatment.

2. Post-treatment water quality sampling – **for chemical treatments only
   - For 4 weeks following the treatment, the citizen water quality monitor should measure water clarity using a secchi disc and dissolved oxygen concentrations throughout the lake. The Jefferson county LWCD has a dissolved oxygen meter that can be borrowed to complete this testing.
   - For some chemicals, water samples can be taken after treatment to document the amount of chemical in the water.
   - While these are not requirements for using chemical herbicides, they are strongly encouraged practices because they are so beneficial to understanding the effectiveness of chemical treatments.

3. Post-treatment plant survey
   - Following whole lake treatment: Point-intercept survey of the entire lake
   - Following small-scale treatment: Point-intercept survey of the area to be treated or other quantitative or qualitative methods. There is an existing subset of points that is focused on areas treated in the last five years, this subset was first surveyed in 2022 and should continue to be surveyed moving forward to get a more accurate idea of the effects of treatment in those areas.
   - Summarize results to evaluate the effectiveness on target plants, evaluate any harm or benefit to native plants, and revisit goals and recommendations of the aquatic plant management plan

7.2 - Communication and Education

It is important to keep the public informed about aquatic plant management on Lower Spring Lake. Therefore, it is recommended that the Lower Spring Lake District include time at their Board meetings to inform the public about the goals of the plan and the progress toward achieving the plan goals. These meetings are an important opportunity for the public to share their perspectives. In addition, if the goals or plans of aquatic plant management are updated, they should be presented to the public for their input with each update.

District meetings are only one way to educate citizens about the aquatic management plan and other lake issues or concerns. Other possibilities include local and regional newspapers, newsletters, or e-mail newsletters to district members and interested citizens.

7.3 - Apply for a DNR Grant to Create a Lake Management Plan

Applying for a WI DNR grant to create a whole lake management plan for Lower Spring Lake would be an excellent way to obtain more funding and input from stakeholders to better inform District goals. A Lake Management plan would include a much broader analysis of lake characteristics, health, and history and be beneficial in long-term planning for Lower Spring Lake. The district could collaborate with the Jefferson County Land and Water Conservation department to complete a grant application. A whole lake management plan typically includes a stakeholder survey that is curated by department sociologists and provides extremely valuable insight into the stakeholder's experience. This information would be very valuable for the district and help to shape future goals and desires.

7.4 - Upper Spring Lake and the Scuppernong River

The Scuppernong River flows into Upper Spring Lake before it flows into Lower Spring Lake. Because of the proximity of Upper Spring Lake, the Lower Spring Lake Protection and Rehabilitation District should pursue opportunities to work cooperatively with the owners of the Upper Spring Lake dam. Topics of concern to both lakes are similar and include nonpoint source runoff, the quality of the Scuppernong River, and aquatic invasive species.

Periodically, the Lower Spring Lake District should determine what exotic species have been documented in the Scuppernong River. The flow of the river is such that species found upstream of the lake will likely make it to Upper and Lower Spring Lake. Therefore, it is good to be prepared and look for the species that are in the Scuppernong River that may soon infest Upper and Lower Spring Lakes

Some invasives species that have been found upstream of Lower spring lake within the lake's watershed but are not yet present in Lower Spring Lake are:

- Phragmites
- Japanese knotweed
- Banded and Chinese Mystery snails
- Rusty crayfish
- Zebra mussel
- Asiatic clam (just outside of watershed)

7.5 - Aquatic Invasive Species Monitoring

Lower Spring Lake is vulnerable to introduction of new aquatic invasive species. As the District is working on controlling the existing, established invasive species, they should also be monitoring for the presence of new aquatic invasive species. It is much less expensive and more effective to control a new, small infestation of a nuisance species than to try to combat a species that is established throughout the lake. This early-detection-focused survey should be completed at least once a year although completing it more than once in different seasons will ensure that you are more likely to find species whose growth periods are at different times of the year, similar to the different growth peaks for EWM and CLP.

Training for citizens who are interested in monitoring the lake for new species is available through the UW-Extension Lake Program or the LWCD. If a new invasive species is found in the lake, the LWCD and DNR can assist with steps for controlling the new infestation, including a DNR rapid response grant if expenditures are needed to address the infestation. Control options for new species introductions will vary depending on the species found. It should be noted that DNR permits will likely be necessary for these control options.

Purple loosestrife has been identified along the shoreline of Lower Spring Lake. A purple loosestrife survey is advisable for monitors to document the location and density of purple loosestrife. There is a very effective biological control (a beetle) for large populations of purple loosestrife. Citizens across the state, including school groups, scouts, and lake organizations, have worked to raise the beetles, and place them in infested areas to control the loosestrife populations. For small populations of purple loosestrife, the most effective control is manual and chemical control. Prior to seed production, the stems should be cut and bagged. The remaining stalk is then treated with a chemical, such as rodeo, that is suitable for near water application.

Yellow Iris is also present on Lower Spring Lake. It is recommended that this population also be surveyed and monitored to track its abundance and spread. Landowners with invasive species along their shorelines should take action by removing them so that they are not able to continue spreading and so that they do not continue to move to other waterbodies downstream.

7.6 - Clean Boats, Clean Waters

The Clean Boats, Clean Waters volunteer watercraft inspection program assists Wisconsin residents in stopping the spread of aquatic invasive species. The Wisconsin DNR, UW-Extension, and Wisconsin Association of Lakes have put together a workshop to train volunteers to implement a boater education program in their community. Local partners, like the Jefferson County Land and Water Conservation Department, can provide these state standard trainings to new volunteers and help you navigate the process of participating in this program. Volunteers educate boaters at the boat landing on how invasive species can be spread. They also help boats check their boats, trailers, and gear for invasive species, distribute informational pamphlets, and provide boaters with information on infested waters. The Lower Spring Lake District should consider reviving its Clean Boats, Clean Waters Program.

7.7 - Factors Impacting Lake Quality

The water quality of a lake is not only related to a balanced aquatic plant community, but to a variety of watershed factors including agricultural runoff, pollution entering through storm drains, construction site erosion, shoreline erosion, and shoreland habitat. As the Lower Spring Lake Rehabilitation and Protection District move forward on protecting the lake, they should consider taking steps toward improving these factors also.

Other lake districts, including the Lake Ripley Management District, have budgeted money to help defray the costs of conservation practices for landowners who want to control nonpoint source pollution from agricultural and residential lands. In addition, the Jefferson County Land and Water Conservation Department can assist with addressing nonpoint source pollution through technical expertise and various cost-share programs that help improve habitat and reduce runoff on lakefront lots. The Lower Spring Lake District would certainly benefit from finding out more about these programs.

Construction site erosion can be a major source of sediment and nutrient pollution to the lake. Both the Village and Town of Palmyra have hired building inspectors whose job is to ensure that erosion control is installed before land disturbance and maintained until the site is vegetated. It is a good idea for the Lake District to find out more about the laws associated with erosion control and communicate the importance of construction site erosion control and enforcement to the Village and Town of Palmyra.

The land adjacent to our lakes and the shallow water next to the land are important areas for many reasons. These areas are where people use the waters for fishing, bird watching, swimming, getting their boats out on the water, or simply sitting and enjoying the view. The shoreland area is a vital place for many species that are dependent on native habitat during part of their life cycle. In fact, as much as 90% of the living things in lakes are found in shallow waters and shoreland areas.

How we manage our shoreland areas can impact our lakes positively or negatively A shoreland area containing a native plant garden can prevent pollutants carried by rainwater from reaching our lakes and also prevent shoreline erosion. In fact, when comparing native shoreland habitats to lawns, areas with lawns contribute 5 times as much runoff, 6 times more phosphorus, and 18 times more sediment to the water. These phosphorus and sediment inputs to the water can reduce water clarity and increase algae blooms which can cause a decrease in property values.

Development of our shorelands and shallow areas can negatively impact lake fish and wildlife. Shorelines that contain seawalls and rock riprap impede the movement of turtles and other animals that need to access the lake and the shoreland area. Increased development (lawns, impervious surfaces, bare ground, piers) has been linked to degraded aquatic plant habitat, decreases in green frog and uncommon bird populations, and a decline in fish species.

Many of the values lakefront property owners appreciate and enjoy about their properties—natural scenic beauty, tranquility, privacy, relaxation—are enhanced and preserved with good shoreland management. And studies have shown that healthy lakes with good water quality translate into healthy lakefront property values.

The Lake District should encourage landowners to install native vegetation next to the lake. The Jefferson County Land and Water Conservation Department can assist landowners with technical expertise as well as cost-sharing to defray the costs of implementing a native restoration.

REFERENCES

Cooke, G. Dennis, Eugene B. Welch, Spencer A. Peterson, Stanley A. Nichols. 2005. Restoration and Management of Lakes and Reservoirs. 3rd Edition.

Department of Natural Resources. 2014. Small-Scale Herbicide Treatments for Control of Invasive Aquatic Plants. Madison, WI. Miscellaneous Publication PUB-SS-1143 2014.

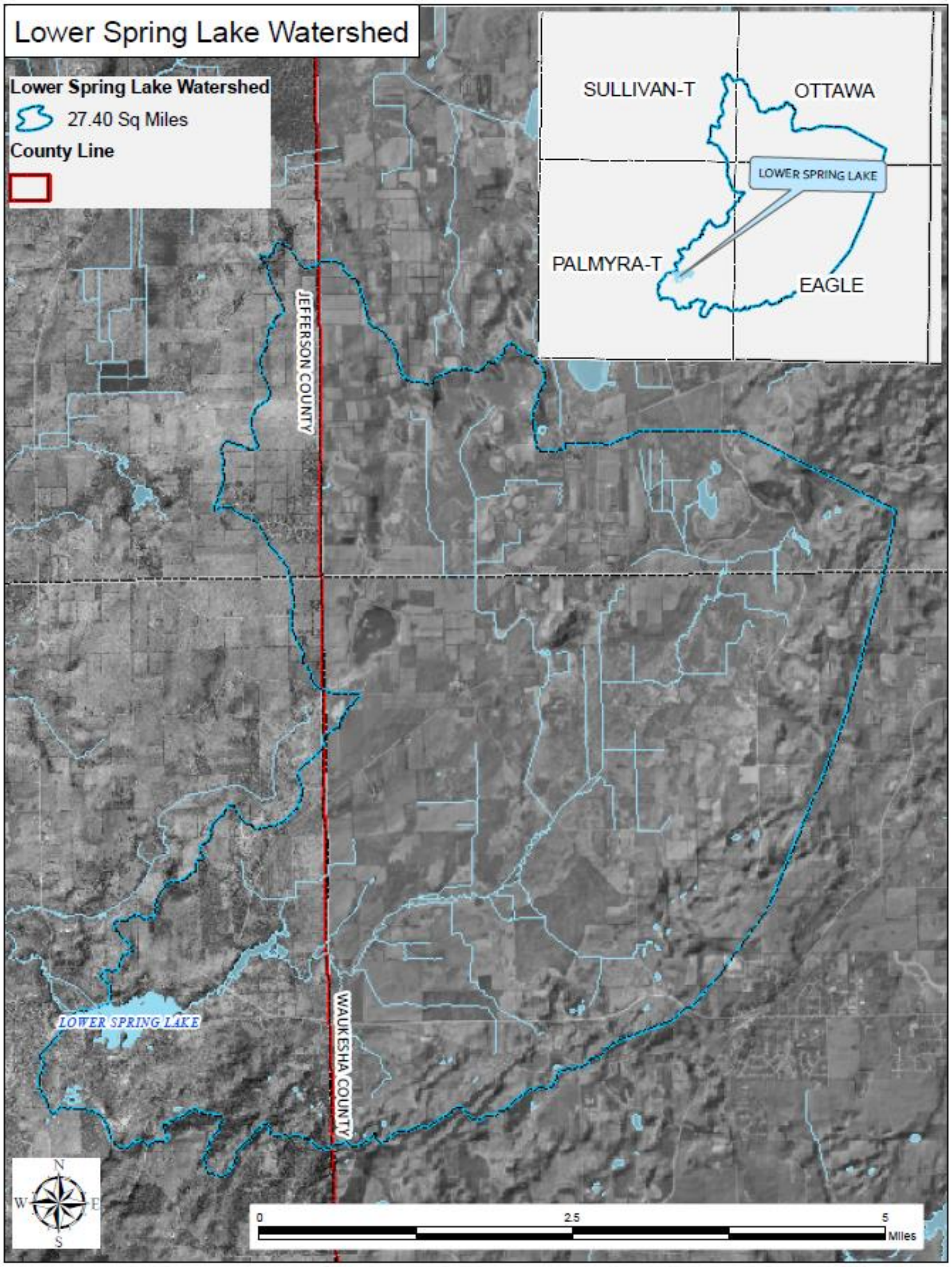
Hauxwell, Jennifer, Susan Knight, Kelly Wagner, Alison Mikulyuk, Michelle Nault, Megan Porzky, and Shaunna Chase. March 2010. Recommended Baseline Monitoring of Aquatic Plants in Wisconsin. Madison, WI: Department of Natural Resources.

Environmental Horizons, Inc. September 2005. An Aquatic Plant Management Plan for Lower Spring Lake. Racine, WI.

Nichols, Stanley A., James G. Vennie. 1991. Attributes of Wisconsin Lake Plants. Wisconsin Geological and Natural History Survey. Information Circular 73 1991.

Northern Environmental. January 25, 1994. Aquatic Macrophyte Survey: Lower Spring Lake. Mequon, WI.

Appendix A - Lower Spring Lake Watershed



Appendix B – Lower Spring Lake Dam Operating Orders

BEFORE THE

RAILROAD COMMISSION OF WISCONSIN

In the matter of the determination of the maximum and minimum levels to be maintained in Spring Lake, located at Palmyra, In Jefferson County, Wisconsin.

WP-350

- - - - - - - - - - - - - - - - - - -

1. On May 22, 1929, an application was filed by the owners of certain property in the vicinity of Spring Lake requesting the Commission to establish the maximum and minimum levels of that lake. After due notice a hearing was held at Palmyra on June 25, 1929. The following appearances were entered at said hearing:

Paul Mandabach, Secretary, for the National Association of Drug Clerks;
C. J. Kaiser, a riparian owner, for himself;
Ernst Mohr, a riparian owner, for himself;
Charles E. Williams, Attorney, for the Arthur J. Thorn Estate, and for himself;
R. F. Knowlton, for Mrs. R. F. Knowlton, a riparian owner;
Fred G. Heldt, a riparian owner, for himself;
H. L. Davy, a riparian owner, for himself;
A. L. Fox, for D. C. Fox, a riparian owner;
W. H. Uglow, a riparian owner, for himself;
H. G. Grell, County Highway Commissioner of Jefferson County, for the County.

2. The dam and spillway or gate section at the highway bridge is owned by the National Drug Clerks' Association, of which Mr. Paul Mandabach is the Secretary. Among other things the testimony at the hearing disclosed that the dam had partially failed in various years, particularly in 1848, 1880, 1910 and in 1929. The spring flood of 1929 occasioned considerable damage and it will be necessary to perform substantial repair work both to the dam and to its immediate surroundings. Either the flood gate section under the adjacent highway must be rebuilt with a flood capacity equal to that which existed prior to the failure of this section during the spring of 1929, or the gate section at the down stream

end of the concrete flume near the old mill must be enlarged to furnish a flood capacity equal to that which has existed at the bridge mentioned above prior to the spring of 1929.

3. It is not considered that any useful purpose will be accomplished by setting forth a detailed statement of the testimony taken at the hearing. The repairs hereinafter ordered are necessary. The Commission finds that the maximum and minimum levels of Spring Lake should be maintained as established in the following order; that the maximum level of Spring Lake is and it hereby is fixed at elevation 96.45, and the normal level will ordinarily be maintained at about 96.20 or 96.30 by means of the new gate section with the crest of the gates at elevation 96.00.

4. IT IS THEREFORE ORDERED that the concrete wall in the downstream end of the concrete flume at the mill be replaced with a gate section of two or more gates having a total clear width between piers of not less than 16 feet and a depth of 6 feet. The top of these gates should be at elevation 96.00, which is the elevation of the crest of the present spillway at that point, and the sill of the gates should be at elevation 90.00 when referred to the datum of the bench mark 4960 described as follows:

> Bench Mark 4960 is a bronze tablet marked "Railroad Commission of Wisconsin", set in top of downstream retaining wall of flume. Bench mark is about 4 feet left of flume gates. Elevation when referred to wall of old bridge, approximately elevation of Bench Mark 496B, is 97.70 feet.

The present gates in this flume, which formerly led to the wheel pit of the mill, should be maintained in a state of good repair to assist in discharging flood waters during times of special flood.

5. IT IS FURTHER ORDERED that as an alternative plan and as a substitute for the plan of construction set forth in paragraph 4, the owner of said dam may reconstruct the gate section at the highway bridge and provide the same with two or more gates with a

total clear span of not less than 16 feet, with a sill at elevation 92.00, in which case the gates at the end of the present concrete flume should be maintained in their present condition, in order that a sufficient flood capacity will be available. In case this plan is adopted a concrete apron must be constructed from the spillway to the ground beneath.

Plans for the repair work ordered should be submitted to the Commission for approval before construction is commenced. The repair work herein ordered is to be completed by September 1, 1930.

Dated at Madison, Wisconsin, this 2nd day of January, 1930.

RAILROAD COMMISSION OF WISCONSIN

Adolph Kanneberg

A. R. McDonald

Commissioners

AK-gh

Appendix C – Lower Spring Lake 2019 Dam Engineering Report

MSA **Memo**

To:	Kathy Weiss, President – Village of Palmyra
	Rob Davis, PE, Water Reg & Zoning Engineer – Wisconsin DNR
From:	Uriah Monday, PE, Senior Project Engineer – MSA Professional Services
Subject:	Spring Lake Ordered Water Levels
Date:	August 28, 2019

The purpose of this memo is to interpret Order WP-350 (hereinafter termed "Order") which governs water levels at Spring Lake in Palmyra. The interpretation is intended to put the dam that was demolished in 2018 and the new dam constructed in 2019 into the context of the Order. It is also intended to tie the vertical datum from the Order to modern (NAVD88) datum.

Summary of Order WP-350

The Railroad Commission of Wisconsin (at the time, this Commission was in charge of dams and waterways) issued Order WP-350 in 1930. A copy of the Order is included with this memo as Attachment #1. This Order came about because of a washout at the dam, and ordered the repair of the dam by means of constructing of a spillway with the following elevation information, based on a local datum referencing "Benchmark 496-C" with an elevation of 97.70:

- a spillway gate crest (top) elevation of 96.00
- a normal level of 96.20 to 96.30
- a maximum level of 96.45

We infer from the above information that:

- The spillway crest would be 1.7' below the elevation of the Benchmark.
- With respect to the spillway crest, the normal water elevation would be 0.2' to 0.3' above the spillway crest and a maximum level of 0.45' above the spillway crest.
- With respect to Benchmark 496-C, the normal water elevation would be 1.4' to 1.5' below the benchmark and a maximum level of 1.25' below the benchmark.

These inferences will be further examined in the following section of this memo.

Survey Information – Prior to Dam Reconstruction

Prior to producing plans for the project, I had a survey crew gather information on existing benchmarks and set project benchmarks. The beginning point for this survey was a National Geodetic Survey (NGS) benchmark on the northeast abutment of the highway bridge immediately upstream of the dam, stamped "1J38 2002" with a published elevation of 822.06. A datasheet for the NGS benchmark is included as Attachment #2 (see footnote).

The NGS benchmark is not the same as "Benchmark 496-C" referenced in the Order. According to the Order, Benchmark 496-C was set "about 4 feet left of the flume gates". A disk was found on the dam wall matching the locational description given in the Order. Photos of this benchmark can be found on Page 5 of this memo.

The results of the pre-project survey were shown in the benchmark table on Sheet ST1 of the project plan set from the 2018/2019 reconstruction, namely:

- BM #1 was the disk on the bridge (NGS benchmark) with a published elevation of 822.06
- BM #2 was the disk on the dam (Benchmark 496-C) with an elevation of 818.15
- BM #3 was an "X" mark cut in a concrete curb with an elevation of 820.37

Prior to dam demolition, I surveyed the elevation of the original spillway, starting at the NGS benchmark. This survey measured the spillway crest at an elevation of 817.05. See the Field Report from 12/7/2018, included as Attachment #3.

We infer from the above information that:

- The former spillway crest, per the Order, should have been 1.7' below Benchmark 496-C, or elevation 816.45. Instead, it was measured at 817.05.
- Based on Benchmark 496-C, the normal lake level given in the Order of 1.4' to 1.5' below the benchmark would have corresponded with a water elevation of 816.65 to 816.75. This is lower than the crest of the former spillway.
- Similarly, the maximum lake level given in the Order of 1.25' below the benchmark would have corresponded with a water elevation of 816.80 – again, lower than the spillway.

Since water levels are always above the spillway elevation, ***these observations indicate that either the disk on the dam was not actually Benchmark 496-C or that at some point in time the dam crest was raised.*** An examination of the WDNR's Field File indicates that:

- Benchmark 496-C has been used in inspections and dam surveys for the past 80 years, and is set in the top of a concrete wall that does not appear to have been raised or repaired. ***Therefore it is the same benchmark that was on the dam prior to demolition and was present in 1930 when the Order was written.***
- Following the Order the spillway was constructed with an elevation of 96.1 +/-, or 1.6' below Benchmark 496-C (Field File references: 7/8/1933 memo, 8/2/1949 memo, 7/20/1961 memo)
- The 7/13/1966 memo in the Field File records Benchmark 496-C as having an elevation of 818.13 (reflects datum modernization in 1966) and the spillway as having an elevation of 817.05. This is about a 1.1' difference. These measurements are corroborated by the

Footnote: This datum differs slightly from the datum used on the FEMA mapping. Commentary regarding this is included in the last section on Page 4 of this memo.

WDNR inspection from 9/13/2007 and MSA's Field Report from 12/7/2018, and differ from the 1.6' difference observed from 1961 and prior. ***Therefore it appears that an (unrecorded) modification was done to raise the spillway crest by about 0.5' in the mid 1960s.***

Additional Relevant Information

- Water elevations observed during inspections found in the DNR Field File dating back to 1966 range from about 817.2 to 817.4.
- A normal water elevation of 817.4 is named in the Inspection/Operations/Maintenance Plan approved by the WDNR in 2009.
- Upon project completion, I surveyed the elevation of the top of the installed gates and the crest of the side spillway. This survey measured the crests as 817.00, approximately 0.05' lower than the crest of the old spillway. See the Field Report from 7/3/2019, included as Attachment #4.

We infer from the above information that:

- If the 0.2' to 0.3' (normal) to 0.45' (maximum) as referenced in the Order was to be measured as depth over the spillway as it had existed for the last 50 years, this would translate to a normal elevation of 817.25 to 817.35, and a maximum of 817.50. The general operation of the dam using a normal water elevation of 817.4 would fit this assumption.

Concluding Opinion

Based on the above information presented, I conclude the following:

- The original Order intended that lake elevations would be held to a normal level of 96.20 to 96.30 and a maximum level of 96.45. These levels were referenced to a Benchmark 496-C with an elevation of 97.70.
- Up until around 1961, the crest of the dam was approximately 96.1, in general compliance with the Order.
- Elevation records imply that at some point between 1961 and 1966 the crest of the dam was increased by approximately 6". However, the level of the lake continued to be referenced to the crest, NOT the benchmark, as exhibited in maintaining of a "normal" lake level of 817.4 in the new datum. This is 0.75' below Benchmark 496-C and therefore equivalent to 96.95 in the old datum. Maintaining an elevation of 96.95 would be in violation of the Order.
- While likely a violation of the Order, this level has been "normal" for a significant period of time (50 years or so), and lowering the lake level to comply with the Order would have negative detrimental effect on lake habitat, recreational use of the lake, and/or property values. I recommend that the Village:
  - Allow the lake to passively govern its own level under non-storm conditions by leaving all gates closed. This will keep the level as close to the Order as possible,

without dropping the water level below the gate crest. I estimate this level will be about 0.2' to 0.3' over the crest under most conditions.

- Initiate the Department of Natural Resources level order modification process, so that the level that has been maintained over the last 50 years can be formalized / legalized. This would be an opportunity for other levels to be considered.

Commentary on Datum Referenced in Page 2 Footnote:
The NGS benchmark has a current listed elevation of 822.06, which is what I used when I conducted my survey and what was shown on the construction plan for the new dam. However, the benchmark's elevation was adjusted in the year 2012 from a prior-published elevation of 821.98. The elevation of 821.98 is what was used at the time of the FEMA Flood Insurance Study revision (published 2/4/1015, survey work done in 2011), and therefore this elevation should be referenced to stay consistent with published regulatory flood elevations.

Below are the recurrence-interval flood elevations (all in NAVD88 (2007)) for Spring Lake, as derived from the model information associated with the 2/4/2015 FIS report. These have NOT been adjusted to account for the higher capacity resulting from the dam reconstruction.

10-year flood:	817.38 NAVD88 (2007)
25-year flood:	817.45 NAVD88 (2007)
50-year flood:	817.56 NAVD88 (2007)
100-year flood:	817.65 NAVD88 (2007)
500-year flood:	818.98 NAVD88 (2007)

To try to avoid confusion, I have created the table below. It lists the various physical features mentioned in this memo by each of three datums: the old Railroad Commission local datum, the 2012 adjustment to the datum that I used on the plans for the new dam, and the 2007 datum that was used in the FEMA mapping.

Feature	*Local Datum referenced in Order*	*NAVD88 (2012) Used on 2018 Construction Plans*	**NAVD88 (2007) Used by FEMA**
NGS Benchmark "1J38 2002"	*101.61*	*822.06*	**821.98**
Benchmark 496-C (now gone)	*97.70*	*818.15*	**818.07**
Old Dam Crest (now gone)	*96.60*	*817.05*	**816.97**
New Dam Crest	*96.55*	*817.00*	**816.92**
Level Order – Normal Range	*96.20 to 96.30*	*816.65 to 816.75*	**816.57 to 816. 67**
Level Order – Maximum	*96.45*	*816.90*	**816.82**
Normal per IOM	*96.95*	*817.40*	**817.32**

The elevations referenced to NAVD88 (2007) are **in bold**, and <u>should be used for all future elevation reference for as long as the FEMA maps published on 2/4/2015 are valid</u>.

It should be noted that while the original 2018 construction plans used the NAVD88 (2012) datum, the as-built plans were modified to use the datum referenced in **bold** so that this issue has been rectified on the final document.

Photo 1 – Above: View of Benchmark 496-C, prior to demolition of dam. Spillway is to the left, under the steel plate; disk is to the right of the corner of the wall (cut off by edge of photo).

Photo 2 – Below: Closeup of Benchmark 496-C.

ATTACHMENT #2

```
                               DATASHEET DF9619
 DATASHEETS     Data Sheet Retrieval
The NGS Data Sheet

See file dsdata.pdf for more information about the datasheet.
PROGRAM = datasheet95, VERSION = 8.12.5.3
1        National Geodetic Survey,   Retrieval Date = JUNE  3, 2019
 DF9619
***********************************************************************
 DF9619  DESIGNATION -  1J38
 DF9619  PID         -  DF9619
 DF9619  STATE/COUNTY-  WI/JEFFERSON
 DF9619  COUNTRY     -  US
 DF9619  USGS QUAD   -  PALMYRA (1995)
 DF9619
 DF9619                         *CURRENT SURVEY CONTROL
 DF9619
______________________________________________________________________
 DF9619* NAD 83(1986) POSITION- 42 52 51.6    (N) 088 34 55.0    (W)
HD_HELD2
 DF9619* NAVD 88 ORTHO HEIGHT -   250.564 (meters)      822.06  (feet)
ADJUSTED
 DF9619
______________________________________________________________________
 DF9619  GEOID HEIGHT    -        -34.233 (meters)
GEOID12B
 DF9619  DYNAMIC HEIGHT  -        250.497 (meters)      821.84  (feet) COMP
 DF9619  MODELED GRAVITY -    980,344.5   (mgal)                       NAVD
88
 DF9619
 DF9619  VERT ORDER      -  SECOND    CLASS I
 DF9619
 DF9619.The horizontal coordinates were established by autonomous hand held
GPS
 DF9619.observations and have an estimated accuracy of +/- 10 meters.
 DF9619.
 DF9619.The orthometric height was determined by differential leveling and
 DF9619.adjusted by the WI DEPT OF TRANSP
 DF9619.in May 2012.
 DF9619
 DF9619.Significant digits in the geoid height do not necessarily reflect
accuracy.
 DF9619.GEOID12B height accuracy estimate available here.
 DF9619
 DF9619.Photographs are available for this station.
 DF9619
 DF9619.The dynamic height is computed by dividing the NAVD 88
 DF9619.geopotential number by the normal gravity value computed on the
 DF9619.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
 DF9619.degrees latitude (g = 980.6199 gals.).
 DF9619
 DF9619.The modeled gravity was interpolated from observed gravity values.
 DF9619
 DF9619;                     North         East     Units  Estimated Accuracy
 DF9619;SPC WI S     -    98,856.      715,844.      MT  (+/- 10 meters HH2
GPS)
 DF9619
```

Page 1

ATTACHMENT #2

```
                              DATASHEET DF9619
 DF9619_U.S. NATIONAL GRID SPATIAL ADDRESS: 16TCN7080848813(NAD 83)
 DF9619
 DF9619                          SUPERSEDED SURVEY CONTROL
 DF9619
 DF9619  NAVD 88 (04/20/07)  250.541  (m)          821.98   (f) SUPERSEDED
2 1
 DF9619  NAVD 88 (02/25/04)  250.506  (m)          821.87   (f) SUPERSEDED
2 1
 DF9619
 DF9619.Superseded values are not recommended for survey control.
 DF9619
 DF9619.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 DF9619.See file dsdata.pdf to determine how the superseded data were
derived.
 DF9619
 DF9619_MARKER: DD = SURVEY DISK
 DF9619_SETTING: 38 = SET IN THE ABUTMENT OR PIER OF A LARGE BRIDGE
 DF9619_SP_SET: BOX CULVERT ABUTMENT
 DF9619_STAMPING: 1J38 2002
 DF9619_MARK LOGO: WIDT
 DF9619_MAGNETIC: O = OTHER; SEE DESCRIPTION
 DF9619_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
 DF9619_SATELLITE: THE SITE LOCATION WAS REPORTED AS NOT SUITABLE FOR
 DF9619+SATELLITE: SATELLITE OBSERVATIONS - September 26, 2006
 DF9619
 DF9619  HISTORY     - Date     Condition        Report By
 DF9619  HISTORY     - 2001     MONUMENTED       WIDT
 DF9619  HISTORY     - 20060926 GOOD             WIDT
 DF9619
 DF9619                          STATION DESCRIPTION
 DF9619
 DF9619'DESCRIBED BY WI DEPT OF TRANSP 2001 (DJH)
 DF9619'THE STATION IS LOCATED ABOUT 22 KM EAST SOUTHEAST OF FORT ATKINSON,
9
 DF9619'KM WEST OF EAGLE AND 1 KM NORTHEAST OF PALMYRA.
OWNERSHIP--WISCONSIN
 DF9619'DEPARTMENT OF TRANSPORTATION. TO REACH THE STATION FROM THE
JUNCTION
 DF9619'OF STATE HIGHWAY 59 WITH STATE HIGHWAY 106 AT THE INTERSECTION OF
 DF9619'MAPLE STREET AND SECOND STREET IN THE VILLAGE OF PALMYRA, GO SOUTH
 DF9619'THEN EAST ON STATE HIGHWAY 59 FOR 0.6 KM TO MILL ROAD ON THE LEFT
AND
 DF9619'BOX CULVERT --C-28-20-64-- OVER THE SCUPPERNONG RIVER AND THE
STATION
 DF9619'ON THE LEFT. THE STATION IS A BRONZE WISCONSIN DEPARTMENT OF
 DF9619'TRANSPORTATION GEODETIC SURVEY CONTROL STATION DISK SET IN THE TOP
OF
 DF9619'THE NORTH END OF THE WEST ABUTMENT ABOUT 0.2 M ABOVE THE HIGHWAY
 DF9619'PAVEMENT.  THE STATION IS 9.0 M NORTHWEST OF THE CENTERLINE OF
STATE
 DF9619'HIGHWAY 59, 0.5 KM WEST OF THE CENTERLINE OF ZION ROAD, 0.1 KM EAST
 DF9619'OF THE CENTERLINE OF MILL ROAD,  AND 2.2 M WEST SOUTHWEST OF AN
 DF9619'ORANGE FIBERGLASS MARKER POST FOR A --FIBER OPTIC CABLE BURIED
 DF9619'BELOW-- SIGN.  ---NOTE2---THIS STATION HAS ALL QUADRANTS BLOCKED
 DF9619'ABOVE 25 DEGREES AND IS NOT SUITABLE FOR GPS OBSERVATIONS.
 DF9619
```

Page 2

ATTACHMENT #2

```
                            DATASHEET DF9619
 DF9619                        STATION RECOVERY (2006)
 DF9619
 DF9619'RECOVERY NOTE BY WI DEPT OF TRANSP 2006 (DRB)
 DF9619'RECOVERED IN GOOD CONDITION.  ADD-- THE STATION IS AT THE NORTH END
OF
 DF9619'THE EAST ABUTMENT (NOT WEST ABUTMENT) AND 0.3 M WEST OF A WHITE
 DF9619'PLASTIC WITNESS POST.  ---NOTE--- THE ORANGE --FIBER OPTIC CABLE
 DF9619'BURIED BELOW-- POST IS BROKEN AND LYING ON THE GROUND.

 *** retrieval complete.
 Elapsed Time = 00:00:04
```

Page 3

ATTACHMENT #3

MSA

FIELD REPORT

MSA - Madison Office
2901 International Lane, Suite 300
Madison, WI 53704

Date: 12/7/2018
Job #: 00384039
Project: Spring Lake Dam Reconstruction
Location: Village of Palmyra, Jefferson Co., WI
Contractor: Lunda Construction Company
Owner: Village of Palmyra
Weather: Sunny and Dry
Temp.: 20° F
Time: 12:00 PM to 3:00 PM
Present at Site: Uriah Monday and Kyle Busch (MSA)
Jeff Gwaltney (Village)
Neal Miller (Lunda)

TO: Project File

The following was noted:

1. Contractor completed upstream cofferdam installation. Proceeded with drawing down water in millrace channel by removing one of the side channel gates.
2. Village requested that Contractor preserve a pillar from the right wall of the dam when demolition starts. Contractor will set it aside on site and Village will pick it up.
3. MSA observed cofferdam for signs of seepage. Minor seepage noted between joints in sheeting. No seepage detected around ends.
4. MSA observed that lake level was very low (approx.. 2' below normal). Discussed with Village DPW and Village President, and checked Highway 59 dam opening. One gate was open very wide; MSA advised Village to close gate to try to return level to closer to normal.
5. Village closed gate. MSA measured level at time of closure and one hour later; no rise noted. Village will check levels over weekend.
6. MSA performed an elevation check on several features with an optical level; measurements noted below:

BS	*HI*	*FS*	*Elev*	*Description*
			822.06	*Benchmark #1 from plan (disk on NE bridge abutment)*
4.42	*826.48*			
		9.44	*817.04*	*Left end of existing spillway crest*
		9.43	*817.05*	*Right end of existing spillway crest*
		6.78	*819.70*	*Representative top of cofferdam*
		11.25	*815.23*	*Water surface upstream of cofferdam*

WRITTEN BY:

Uriah Monday, PE, CFM
Senior Project Engineer

cc: Village of Palmyra
Lunda Construction

ATTACHMENT #4

FIELD REPORT

MSA - Madison Office
1702 Pankratz St
Madison, WI 53704

Date: 07/03/2019
Job #: 00384039
Project: Spring Lake Dam Reconstruction
Location: Village of Palmyra, Jefferson Co., WI
Contractor: Lunda Construction Company
Owner: Village of Palmyra
Weather: Partly Cloudy
Temp.: 75° F
Time: 7:00 am – 10:00 am
Present at Site: Uriah Monday (MSA)
Scott Halbrucker (Village)
Neal Miller (Lunda)
Ryan Mulcahy (Mulcahy Shaw)

TO: Project File

The following was noted:

1. Mulcahy Shaw set the actuator operation range to 12" to 14" open on Left and Right gates (Gates #1 and #3, respectively).
2. The middle gate (Gate #2) still opens and closes with difficulty. After discussing, it was decided that the supplier will need to send someone to look at the gear box, as the actuator appeared to be responding appropriately to excess torque and there was no apparent problems with the slide or stem.
3. MSA checked on vegetation growth and erosion spots. Enough vegetation growth has occurred to warrant removal of silt fence EXCEPT for the portion running from Mill Road along the chain link fence to a "Danger Keep Out" sign (a length of about 40' – see Photo #2). The temporary orange perimeter fence may also be removed.
4. There are still some areas of minor rill erosion that need to be monitored and re-seeded if necessary. It appears that some of the rill erosion issue may actually be originating near the old driveway entrance from STH 59, where it appears runoff from the pavement can come through the curb cut and across the site. MSA suggested sandbags across this opening to keep water in the gutter line; village indicated that the highway may be reconstructed in 2023 and the curb cut could be abandoned at that time.
5. MSA checked lake levels. Water elevation is 1.0' below the top of the millrace wall, corresponding to an elevation of approximately 817.6. This level is slightly above the maximum ordered level.
6. MSA and Village performed elevation survey of dam structure for as-built with an optical level. A measurement log appears on the next page.

WRITTEN BY:

Uriah Monday, PE
Senior Project Engineer

cc: Village of Palmyra
Lunda Construction

ATTACHMENT #4

Page 2
Spring Lake Dam Reconstruction
7/3/2019

FIELD REPORT

BS	HI	FS	Elev	Description
			822.06	Benchmark #1 from plan (disk on NE bridge abutment)
4.13	826.19			
		5.82	820.37	Benchmark #2 from plan (cut "+" in curb at SW corner of Main St and Mill Rd, recorded as 820.37)
		7.62	818.57	Top of upstream end of wing wall, south side of millrace
		7.62	818.57	Top of upstream end of main wall, south side of millrace
		14.12	812.07	Upstream end of slab, south side of millrace
		9.19	817.00	Side spillway sill
		7.66	818.53	Top of east wall on side spillway, at sill location
		11.66	814.53	Top of wall above culvert entrance at downstream end of side spillway
			~808.3	Culvert invert measured as approx.. 6.2' below top of wall
		14.24	811.95	Slab on upstream side of side spillway sill
		9.18	817.01	Top of south gate (Gate #1)
		9.18	817.01	Top of center gate (Gate #2)
		9.19	817.00	Top of north gate (Gate #3)
		7.63	818.56	Top of upstream end of wing wall, north side of millrace
		7.61	818.58	Top of upstream end of main wall, north side of millrace
		14.12	812.07	Upstream end of slab, north side of millrace
		7.60	818.59	Top of main wall at gates, south side of millrace
		6.61	819.58	Crayon "+" on walkway slab
0.80	820.38			
		11.27	809.11	Top of downstream end of main wall, south side of apron
		15.95	804.43	Downstream end of slab, south side of apron
		14.35	806.03	Top of downstream end of wing wall, south side of apron
		1.65	818.73	Crayon "+" on inlet curb – turn point
7.24	825.97			
		9.86	816.11	Invert of bell of 15" RCP beach circulator pipe at lake
			816.28	Invert of 15" RCP beach circulator pipe at lake – determined by adding 2" to above measurement
		5.60	820.37	Benchmark #2 from plan (cut "+" in curb at SW corner of Main St and Mill Rd, recorded as 820.37)

Appendix D – Relative Frequency of Occurrence of All Plant Species Recorded in Lower Spring Lake from 2008 - 2022

Frequency of Occurrence at sites < max depth	2008	2009	2014	2015	2016	2017	2018	2019	2021	2022
Chemical (whole lake)	*None*	*None*	*2, 4-D*	*2, 4-D Endothall*	*None*	*2, 4-D*	*None*	*None*	*None*	*None*
Chemical (spot treatments)	*None*	*None*	*None*	*None*	*None*	*None*	*Diquat*	*Diquat*	*2,4 D aquathol K diqut*	*2,4 D aquathol K diqut*
Eurasian water milfoil	56.54	57.6	8.43	2.35	50.54	64.24	81.68	74.82	86.58	82.17
**Curly-leaf pondweed	6.54	17.05	v(2)	0	5.38	0.61	v(1)		5.37	1.27
Coontail	28.04	49.77	62.92	20.59	31.18	33.33	35.11	50.36	84.56	81.53
White water lily	13.55	12.9	11.8	11.18	6.99	5.45	3.82	v(9)	1.34	4.46
Illinois pondweed	0.47	1.38	9.55	6.47	8.06	5.45	3.05	6.47	5.37	14.01
Sago pondweed	5.14	5.53	6.74	5.29	12.37	v(2)	0.76	0.72	4.70	5.73
Chara spp.	5.14	3.69		4.71	3.23	1.21		0.72	2.01	3.18
Elodea	0.47	1.38	2.81	4.71	2.69	2.42	0.76	0.72	9.40	27.39
American lotus			v(3)	1.18	0.54	0.61	0.76	v(1)		V
Slender naiad	2.8	3.23	0.56	0.59	1.61	0.61				
Common bladderwort	0.47	0.92	1.12	v(1)	v(1)		v(1)		0.67	1.27
Water celery			v(2)	0.59	v(1)	0.61	v(2)	v(1)	1.34	V
Southern naiad			1.12							
Small duckweed	12.15	20.28	2.25	0.59	v(5)	3.64	1.53	v(5)	0.67	V
Large duckweed	7.01	8.29	1.12	v(2)	v(2)		2.29		V	V
Wolffia spp.	4.21	1.38	v(21)	0.59	v(2)	1.21	2.29	v(2)		V
Forked duckweed	2.8		v(2)		v(2)				1.34	V
Various-leaved watermilfoil	s		s	s	v(1)	1.21	1.53			
Spatterdock			v(1)	s	0.75	v(1)	v(1)	0.72		
Flat-stem pondweed		0.46	v(1)						7.38	3.18
Long-leaf pondweed	7.94	4.61							1.34	
Water star-grass										V
White water crowfoot	s				s				2.01	
Fries' pondweed	2.34									
Small pondweed		1.84								
Large-leaf pondweed	s	0.46								
Yellow Pond Lily									0.67	0.64
Turion Duckweed									0.67	
Variable-leaf pondweed										1.91

Appendix E – Public Comment on Previous Versions of the APM Plan

October 2009 Meeting

On October 24, 2009, the Land and Water Conservation Department and the Lower Spring Lake Protection and Rehabilitation District invited citizens to a meeting to discuss the future of Lower Spring Lake recreation and aquatic plant management.

The table below contains a list of recreational activities and the current location in which the activity occurs, and the area that was identified as a desired location for the activity. It is important to note that desired locations for certain activities may not be achievable due to a variety of factors including depth, permit conditions, and laws.

Public Input on Lake Use

Activity	Current Use Area	Future Wanted Use Area
Access to lake from properties with piers in bays containing shallow water and water lilies	2 properties on the south side of the lake	Same + 1 property on northeast side of lake for future pier
Boat access within lake	- north of small island west of boat landing when traffic south of the island is heavy	Same
Fast Boating	middle of lake	Same
Fishing	- throughout the lake - along Hwy 59 - edge of shallow bays	Same
Paddling	- throughout the lake - north of island east of boat launch - east side of lake to the river entering lake	Same
Swimming	- at Village Park - throughout the lake where there is adequate depth - in front of residential properties	Same + Wanted in the southeast corner of the bay east of Willow St
Habitat & Wildlife Viewing	- in southern bay containing water lilies - east side of lake - north of island that is east of boat landing	Same + Increase area on east side of lake
Winter Recreation	- motorcycles - ATVS - snowmobiles	May want to look into rules that would ensure safety of participants and residents

During the discussion on boating, it was also noted that boating access is sometimes limited in the bay east of Willow Street. In addition, boat access to the lake must be maintained at the DNR boat landing on the north side of the lake.

When talking about the boat launch, it was noted that there is no charge for use of the boat landing, and around 3-4 boats/day use the launch. During the winter, the lake also attracts ice fisherman. [Note: In 2015, the boat launch and parking area were updated by the DNR.]

During the public discussion, there was an idea to explore the placement of a fishing platform on the lakeshore adjacent to Hwy 59. Currently, the entire stretch of shoreline is mowed. This leaves the lake susceptible to runoff pollution from the highway. Native shoreline vegetation along this area could stop some of the road pollution (oil, grease, etc.) from entering the lake. Because this area is used by fisherman, a fishing platform could be built in order to accommodate fishermen. The Jefferson County Zoning Department and the Department of Natural Resources should be contacted for permit information for a fishing platform if this idea is pursued. The Jefferson County Land and Water Conservation Department should also be contacted regarding potential funding available to offset the costs of planting native vegetation along the lake.

In summary, the public expressed concerns about access to the lake from their properties in order to participate in a variety of recreational activities. They want the aquatic invasive plants controlled in such a way as their use of the lake is not impaired by them. Based on their input on fishing and wildlife viewing, the public was interested in maintaining and increasing the characteristics of the lake that support a good fishery and wildlife.

February 2010 Meeting

At the February 27, 2010 meeting of the Lower Spring Lake Management District, there was a discussion about future chemical treatment to control exotic aquatic plants. The group decided to move forward with a restoration approach to exotic plant management.

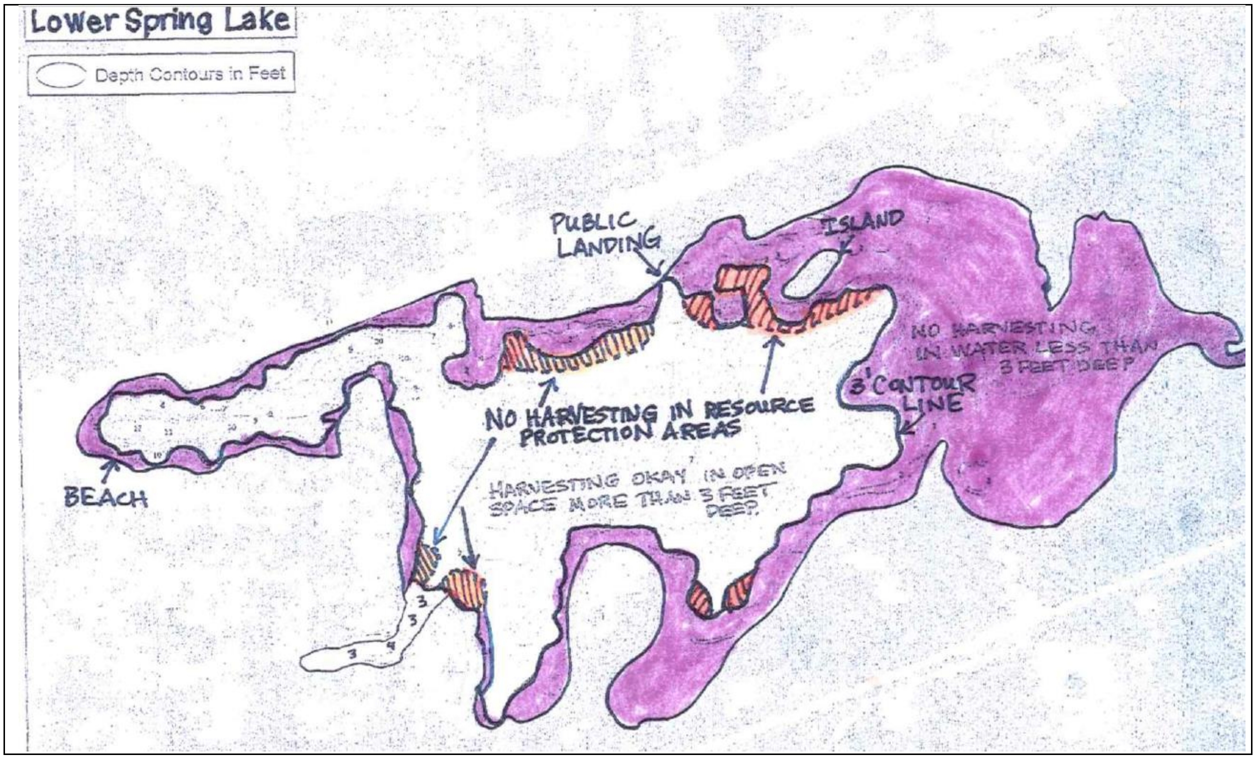
April 2017 Meeting

At the April 8, 2017 meeting, there was a discussion regarding the update to the aquatic plant management plan. Items of discussion included:

- Including a section regarding the harvesting of white water lilies to provide access to lots located in the eastern regions of the lake.
- Situations when the mechanical harvester can access the finger bay.

Please note that the Lower Spring Lake Management District discussed the management of invasive species at almost all of its meetings, but the meetings noted above were when the aquatic plant management plan was specifically discussed.

Appendix F – Lower Spring Lake's Harvesting Map in the Current DNR Permit



Appendix G – Proposed Harvesting Map for Lower Spring Lake for Future DNR Permit Applications