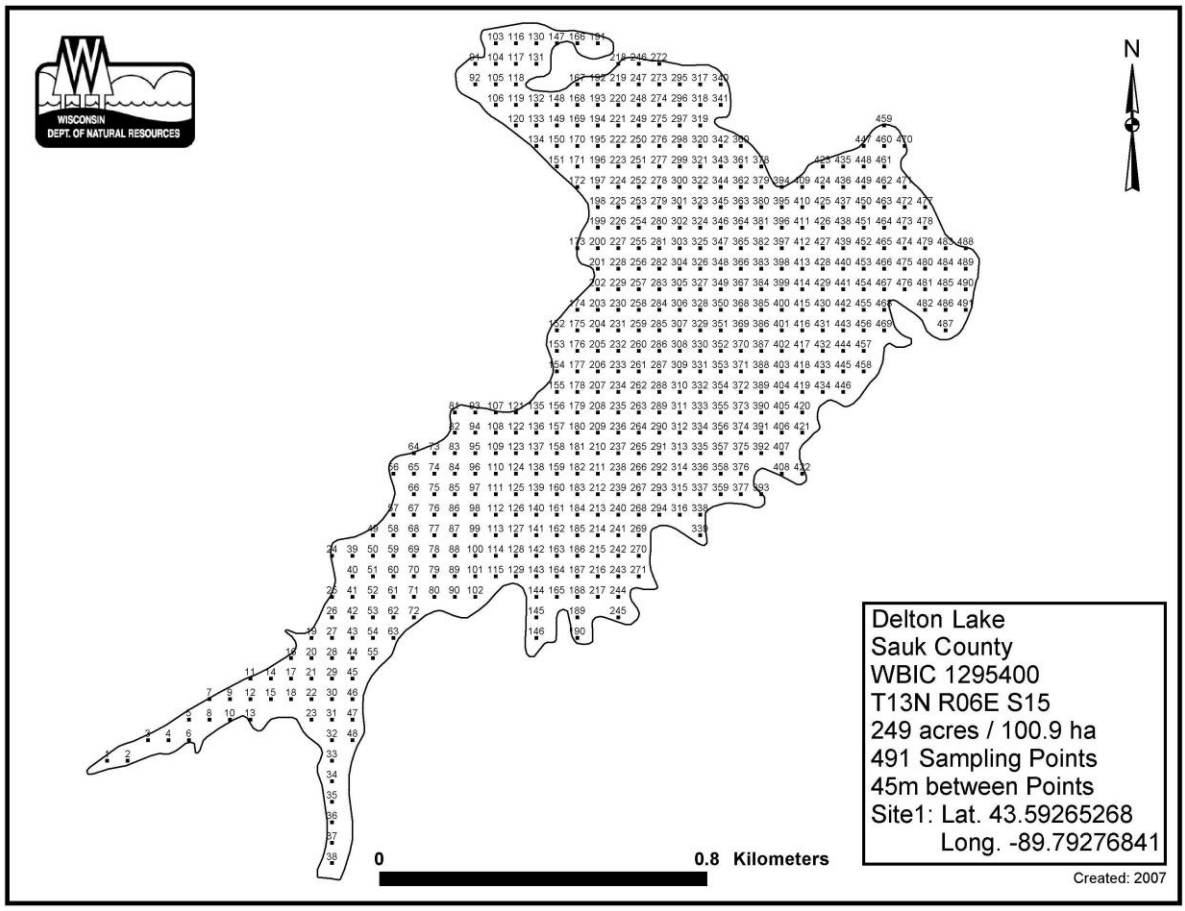
2014 Lake Delton Summer Aquatic Macrophyte Survey



Performed by Aquatic Engineering, Inc.

2014 Lake Delton Summer Aquatic Macrophyte Survey

By J.E. Britton[1], and Doug Appel[2]

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In cooperation with the Wisconsin Department of Natural Resources (SPL-339-14), the Village of Lake Delton, Delton Sportsman's Club and the residents of Lake Delton.

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Introduction

A whole lake aquatic plant survey of Lake Delton was conducted during the summer of 2014 by the staff of Aquatic Engineering, Inc. This was the second formal macrophyte survey conducted on Lake Delton, with the first conducted in 2003.

A technical survey of aquatic plant density and distribution is essential for understanding the lake ecosystem due to the major ecological role they play and the sensitivity to water quality parameters that plants require (Dennison et al, 1993). The quantitative survey performed in 2014 will provide some useful information toward future management of Lake Delton, including fish habitat improvement, sensitive species protection, aquatic plant management, and water resource regulation.

Ecological Role

Aquatic macrophytes (plants) provide the source of the food web in a lake and a foundation for sustaining all other biota within the lake. Plants and algae within a lake provide food and oxygen for fish and wildlife. The plants provide food, habitat and cover for the animals and invertebrates that many other aquatic macro organisms depend on. Plants improve water quality, protect shorelines and lake bottoms, and add aesthetics to a lake, however, they also may impact recreation.

Water Quality

Plants within the aquatic ecosystem can serve as indicators of water quality because of their sensitivity to water quality parameters, such as clarity and nutrient levels (Dennison et al, 1993).

Analysis performed within Lake Delton showed a pH range between 8-9. The range shows that the waters in Lake Delton are “hard” waters. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes (Shaw et al, 2004).

Background and History

Lake Delton is a drainage lake located in Sauk County, Wisconsin, near Wisconsin Dells (T13N, R6E, S15; WBIC 1295400). It is an impoundment on Dell Creek with a surface area of 267 acres, a maximum depth of 20 feet, and an average depth of approximately 12 feet. The dam sustaining Lake Delton is just upstream of the Wisconsin River within the Village of Lake Delton.

Methods

Field Methods

The technical survey study performed was based on the rake-sampling method by Hauxwell et al. (2010) using a point-intercept sampling design, with sites located on a geo-referenced sampling grid placed over the entire lake. From this method, the Wisconsin Department of Natural Resources (WI DNR) created 491 sampling points throughout the entirety of Lake Delton (Fig. 1). Application of this methodology allows: 1) assessment of frequencies of occurrence of different plant species, as well as estimates of species richness, abundance, and maximum depth of colonization; and 2) comparisons of aquatic plant variables over time and among lakes.

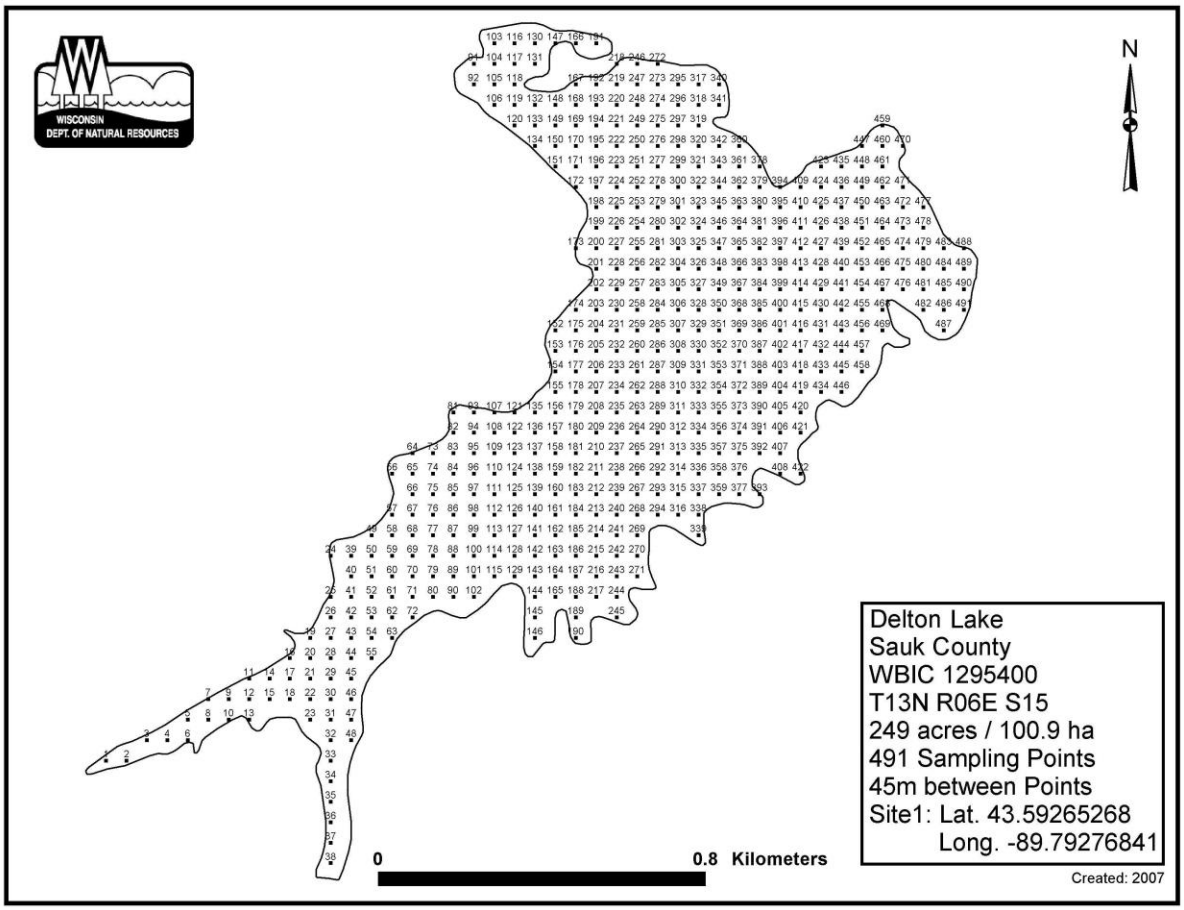

Figure 1. The 491 sampling point grid generated by the Wisconsin DNR for the Lake Delton aquatic macrophyte survey.

To begin the study, a qualitative survey is visually completed and specimens are collected. The quantitative survey is carried out by visiting each of the 491 pre-established GPS survey locations, and dropping a rake to determine depth, sediment type by texture, rake fullness, and species present on the rake sample. Technicians also visually examined and species present within 6 feet of the sampling point and would record the data as visually observed. The rake fullness parameter is determined by the relative amount of vegetation hanging on the rake head when it is retrieved and a value of 1-3 is assigned (Fig. 2). From the vegetation hanging on the

rake, a relative distribution of species collected is also determined and the same rating is assigned, with 3 being the dominant species on the rake, 2 being a moderate abundance, and 1 being the species is very minimal in the rake sample. The data is recorded by hand in the field and later entered into a database for further statistical analysis.

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 2. Illustration of rake fullness ratings used during the survey.

Data Analysis

All data from the field sampling was entered into the standard Wisconsin Aquatic Plant Management field spreadsheets (Appendix B) (Hauxwell et al, 2010). With the data entered, the following was calculated:

Individual Species Statistics

Frequency of occurrence within vegetated areas (%): Number of sites at which a species was observed divided by the total number of vegetated sites. Frequency of occurrence is sensitive to the number of sample sites included. Including non-vegetated sites will lower the frequency of occurrence.

Frequency of occurrence at sites shallower than maximum depth of plants: Number of sites a species was observed at divided by the total number of sites shallower than maximum depth of plants.

Relative frequency (%): This is proportional value that reflects the degree to which an individual species contributes to the sum total of all species observations. The sum of the relative frequencies of all species is 100%. Relative frequency is not sensitive to whether all sampled sites, including non-vegetated sites, are included. Relative frequency does not take into account aquatic moss, freshwater sponges, filamentous algae, or liverworts.

Relative frequency (squared): This value is only part of a calculation and is not used directly.

Number of sites where a species was found: This is the sum of the number of sites at which a species was recorded on the rake.

Average rake fullness: Mean rake fullness rating, ranges from 1-3.

Number of visual sightings: This is the total number of times a plant was seen within 6 feet of the boat, but not collected on the rake.

Summary Statistics

Total number of sites visited: Total number of sites where depth was recorded, even if a rake sample was not taken. There were a few sites on sampling grid that ended up being on shore, or was near impossible to navigate, and therefore, not all of the 149 sampling sites the WI DNR had created were sampled.

Total number of sites with vegetation: Total number of sites where at least one plant was found on the rake. If no plants were found on the rake, yet a visual of a plant was recorded right next to the sampling point, the number would still be zero due to no vegetation actually being collected.

Total number of sites shallower than the maximum depth of plants: Total number of sites where the depth was less than or equal to the maximum depth at which plants were found. This value is used for frequency of occurrence calculations at sites shallower than the maximum depth of plants.

Frequency of occurrence at sites shallower than maximum depth of plants: Number of times plants were recorded at a site divided by the total number of sites sampled that were shallower than the maximum depth of plants.

Simpson's Diversity Index: A nonparametric estimator of community heterogeneity. It is based on relative frequency and thus is not sensitive to whether all sampled sites (including non-vegetated sites) are included. The closer the Simpson Diversity Index is to 1, the more diverse the community. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Maximum depth of plants: This is the depth of the deepest site sampled at which vegetation was present. Please note that his value does not take into account aquatic moss, freshwater sponges, filamentous algae, or liverworts.

Number of sites sampled using rake pole/rope: This indicates which rake type was used to take a sample. Protocol suggests a 15ft pole rake, and a 25ft rope rake for sampling.

Average number of all species per site (shallower than max depth): Mean number of species found at sample sites which were less than or equal to the maximum depth of plant colonization.

Average number of species per site (vegetated sites only): Mean number of species found at sample sites where vegetation was present.

Average number of native species per site (shallower than max depth): This does not include Eurasian water milfoil, Curly-leaf pondweed, Purple loosestrife, Spiny naiad, or Reed canary grass.

Average number of native per site (vegetated sites only): This does not include Eurasian water milfoil, Curly-leaf pondweed, Purple loosestrife, Spiny naiad, or Reed canary grass.

Species richness: Total number of species observed not including visual sightings. Please note that this value does not include aquatic moss, freshwater sponges, filamentous algae, or liverworts.

Species richness (including visuals): Total number of species observed including visual sightings recorded within 6 feet of the sample site (but does not include additional species found during the qualitative boat survey).

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. Species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each species found in the lake and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI = \Sigma(c1+c2+c3+\ldots cn)/\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Lake Delton is within the Northern Central Hardwood Forests Ecoregion.

NHI Species Review

The Wisconsin Natural Heritage Inventory (NHI) lists species and natural communities that are known or suspected to be rare in Wisconsin. The species are legally designated into different categories varying from endangered (END) or threatened (THR) to advisory capacity of special concern (SC). The regions of Lake Delton are in Section 17, township 13N and Range 6E.

The NHI list is below with all the circumstantial species in this area (Table 1).

Scientific Name	Common Names	WI Status	Federal Status	Group
Alder thicket	Alder thicket	NA		Community~
Ameletus lineatus	A Mayfly	SC/N		Mayfly~
Artemisia frigida	Prairie Sagebrush	SC		Plant
Asplenium trichomanes	Maidenhair Spleenwort	SC		Plant
Atrytonopsis hianna	Dusted Skipper	SC/N		Butterfly
Bombus affinis	Rusty-patched Bumble Bee	SC/N		Bee
Buteo lineatus	*Red-shouldered Hawk*	THR		Bird~
Carex festucacea	Fescue Sedge	SC		Plant~
Chlosyne gorgone	Gorgone Checker Spot	SC/N		Butterfly
Cycleptus elongatus	Blue Sucker	THR		Fish~
Dry cliff	Dry Cliff	NA		Community
Dry prairie	Dry Prairie	NA		Community
Emergent marsh	Emergent Marsh	NA		Community~
Emydoidea blandingii	Blanding's Turtle	SC/P		Turtle~
Floodplain forest	Floodplain Forest	NA		Community~
Fusconaia ebena	Ebonyshell	END		Mussel~
Gymnocarpium jessoense ssp. parvulum	Northern Oak Fern	SC		Plant
Hemlock relict	Hemlock Relict	NA		Community
Hesperia metea	Cobweb Skipper	SC/N		Butterfly
Houstonia caerulea	Azure Bluets	SC		Plant
Macrhybopsis hyostoma	Shoal Chub	THR		Fish~
Moist cliff	Moist Cliff	NA		Community
Moist sandy meadow	Moist Sandy Meadow	NA		Community

Myosotis laxa	Small Forget-me-not	SC		Plant~
Northern dry forest	Northern Dry Forest	NA		Community
Northern dry-mesic forest	Northern Dry-Mesic Forest	NA		Community
Ophisaurus attenuatus	Slender Glass Lizard	END		Lizard
Phemeranthus rugospermus	Prairie Fame-flower	SC		Plant
Pine relict	Pine Relict	NA		Community
Platanthera flava var. herbiola	Pale Green Orchid	THR		Plant~
Platanthera hookeri	Hooker's Orchid	SC		Plant
Plethobasus cyphyus	Sheepnose	END	LE	Mussel~
Polyodon spathula	Paddlefish	THR		Fish~
Primula mistassinica	Bird's-eye Primrose	SC		Plant~
Pseudognaphalium saxicola	Cliff Cudweed	THR		Plant
Rhondodendron lapponicum	Lapland Azalea	END		Plant~
Sand barrens	Sand Barrens	NA		Community
Scleria triglomerata	Whip Nutrush	SC		Plant~
Setophaga cerulea	Cerulean Warbler	THR		Bird
Simpsonaias ambigua	Salamander Mussel	THR	SOC	Mussel~
Southern dry forest	Southern Dry Forest	NA		Community
Southern dry-mesic forest	Southern Dry Mesic Forest	NA		Community
Southern sedge meadow	Southern Sedge Meadow	NA		Community~
Springs and springs run, hard	Springs and Springs Runs, Hard	NA		Community~
Stream--fast,hard,cold	Stream--Fast, Hard, Cold	NA		Community~
Tritogonia verrucosa	Buckhorn	THR		Mussel~
Vaccinium cespitosum	Dwarf Bilberry	END		Plant
Vireo bellii	Bell's Vireo	THR		Bird
White pine-red maple swamp	White Pine-Red Maple Swamp	NA		Community

Information retrieved from http://dnr.wi.gov/topic/NHI/data February 3, *2017.*

Table 1. Natural Inheritance Inventory (NHI) review for the Lake Delton region.

Lake Delton has overcome the dam failure of 2008 which devastated all ecosystems. This man-made lake is constantly adjusting to that event. All soft sediment was completely washed away when the Lake Delton dam was breached which is one example of how the natural ecosystems drastically changed. Over the past 8 years, since the dam failure, the lake has started to regrow and adapt. The NHI lists many species but it is not limited to those that are defined.

Results

Physical Data

The method for an aquatic plant survey called for a rake sampling device to the bottom and recording the depth, sediment composition by feel, and subsequent vegetation pulled. This device is constructed by welding two rake heads, and then the rake can either be placed on a pole (ideally a long telescopic pole), or on the end of a rope for the deeper areas. The rake head is 13.8 inches (35 centimeters) long, with 14 tines on each side. For this survey, AEI technicians were able to use a graduated 20 foot telescopic pole. This pole was used at all sampling locations, and a rope was never needed.

The sediment composition in Lake Delton was fairly evenly distributed between muck or sand, although, sand was found more often (Fig. 3). There were a few locations on the northern end of the lake that did have rock as the component of the lake bottom. When determining the depths at each sample site, it was determined that the average depth in Lake Delton is 10.1 feet (Fig. 4). The maximum depth found in Lake Delton was 22 feet, while the median depth was 10.5 feet.

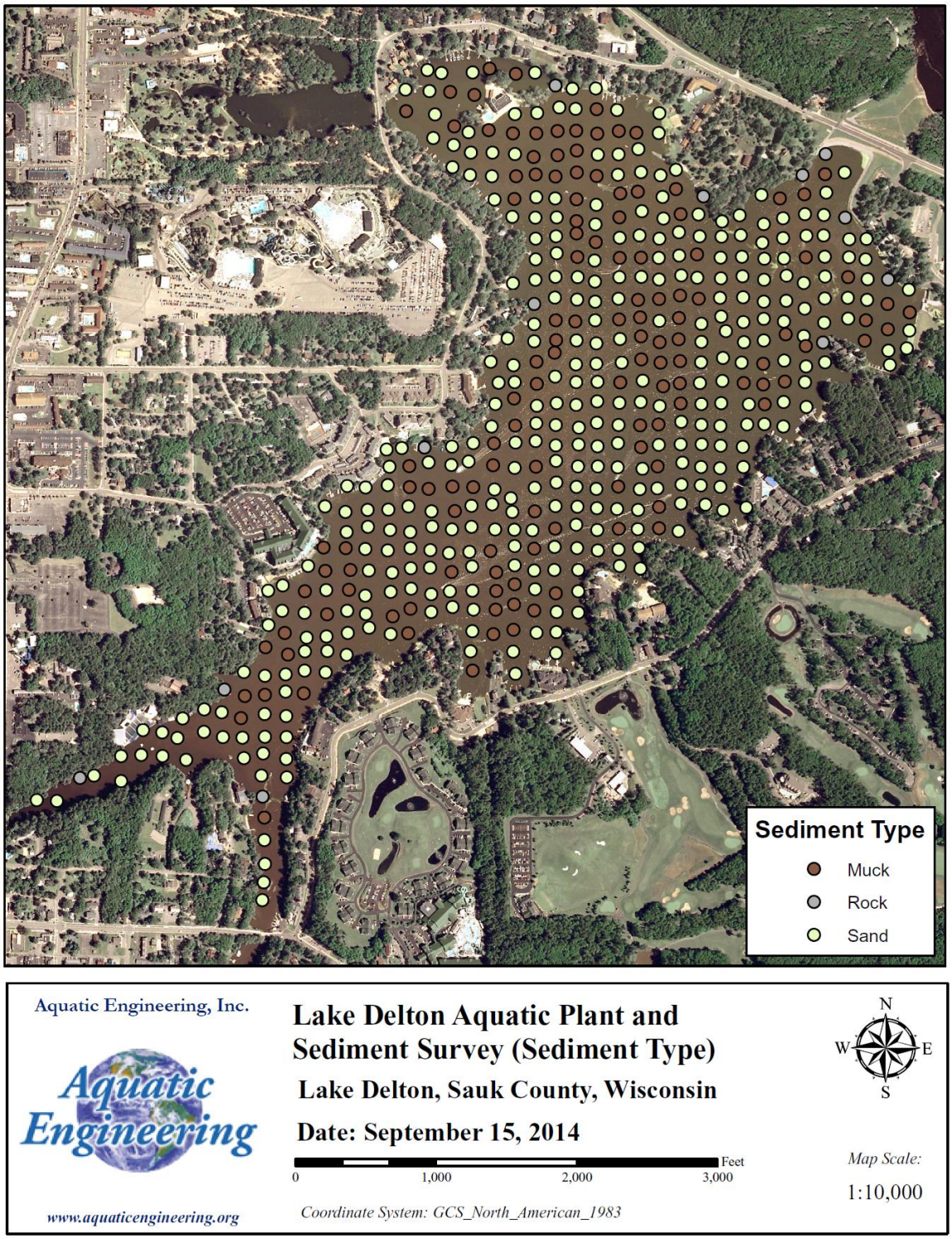

Figure 3. Sediment composition and distribution recorded during the Lake Delton aquatic macrophyte survey.

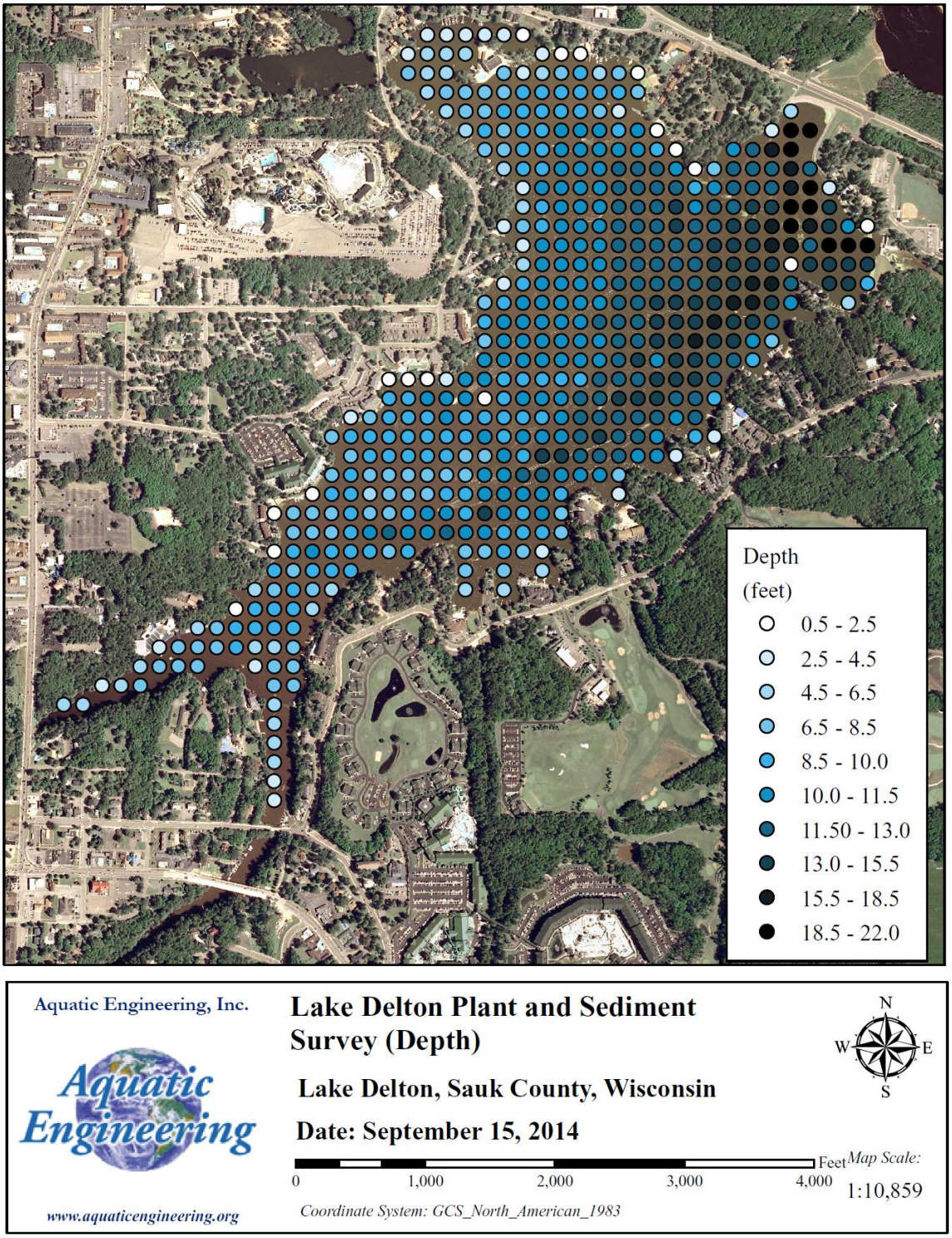

Figure 4. Depth recorded at each sampling location during the Lake Delton aquatic macrophyte survey.

Vegetation Data

During the Lake Delton aquatic macrophyte survey, there were only 7 out of the 491 points sampled that produced a positive vegetation sample. Of these seven locations, there was only one point that produced a rooted vegetation sample. The other six points that resulted in vegetation were from the floating plant species of lesser duckweed (*Lemna minor*) and common watermeal (*Wolffia columbiana*). The summary statistics for the macrophyte survey are displayed in Table 1.

The floating species of duckweed and watermeal are easily pushed around the lake, therefore, calculations to determine the littoral zone only take into account the single point that resulted in a rooted vegetation sample. From this single location, it was determined that the maximum depth of colonization was 3.5 ft (Fig. 5). This graph was calculated by the DNR spreadsheet where data was entered and does not take into account any visual sightings of plants, but only plants collected on the rake.

If the visuals were included, the maximum depth of colonization would be around 9 ft (Fig. 6). However, the maximum depth of colonization is likely less than 9 ft because the plants were spotted at the 9 ft location, and the plants themselves were likely in waters around 6 feet. With the calculation of a maximum depth of colonization at 3.5 ft, Lake Delton still recorded a very low value for frequency of vegetation occurrence at sites less than maximum depth of colonization, with 2.57%.

The Lake Delton aquatic macrophyte survey produced results showing a reduced diversity of plant population. This was determined by the Simpson's Diversity Index of 0.57. The closer the Simpson's Diversity Index is to 1.00, the more diverse a community. Therefore, Lake Delton's index of 0.57 is not impressive and has much room for improvement.

Out of the 272 locations less than the maximum depth of colonization, there was an average of 0.05 species collected. However, this number increased to an average of 1.86 species per site when looking at the 272 sites less than the maximum depth of colonization that produced a vegetation sample.

There was only one exotic invasive species found within the lake, Eurasian water milfoil (*Myriophyllum spicatum).* Lake Delton had a low species richness, with a value of 3 species collected with a rake, and 7 species collected with a rake including visual sightings. During the sampling, there was a maximum of two species encountered at only six single sample locations (Fig. 7).

Table 1. Summary statistics calulculated from the Lake Delton aquatic macrophyte survey.

Total number of sites visited	**491**
Total number of sites with vegetation	**7**
Total number of sites shallower than maximum depth of plants	**272**
Frequency of occurrence at sites shallower than maximum depth of plants	**2.57**
Simpson Diversity Index	**0.57**
Maximum depth of plants (ft)**	**3.5**
Number of sites sampled using rake on Rope (R)	**0**
Number of sites sampled using rake on Pole (P)	**491**
Average number of all species per site (shallower than max depth)	**0.05**
Average number of all species per site (veg. sites only)	**1.86**
Average number of native species per site (shallower than max depth)	**0.05**
Average number of native species per site (veg. sites only)	**1.86**
Species Richness	**3**
Species Richness (including visuals)	**7**

** Did not include duckweed or watermeal. Also did not include visuals.

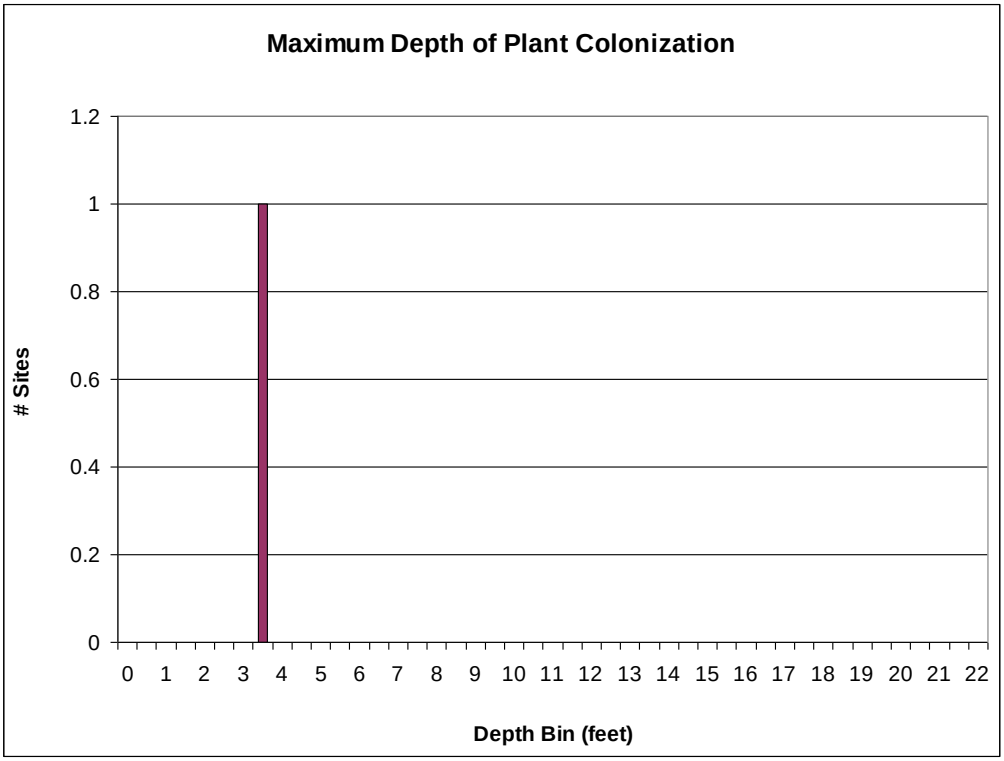

Figure 5. Maximum depth of colonization for the Lake Delton aquatic macrophyte survey, only using data when a plant was collected by the rake.

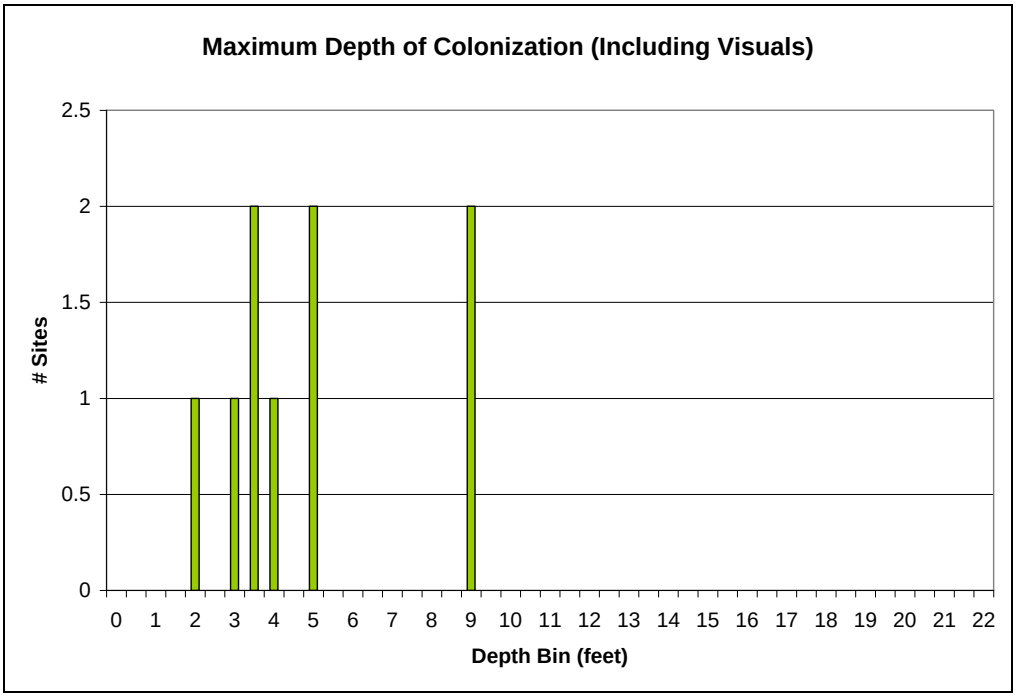

Figure 6. Maximum depth of colonization for the Lake Delton aquatic macrophyte survey, using data that includes visual sightings of vegetation.

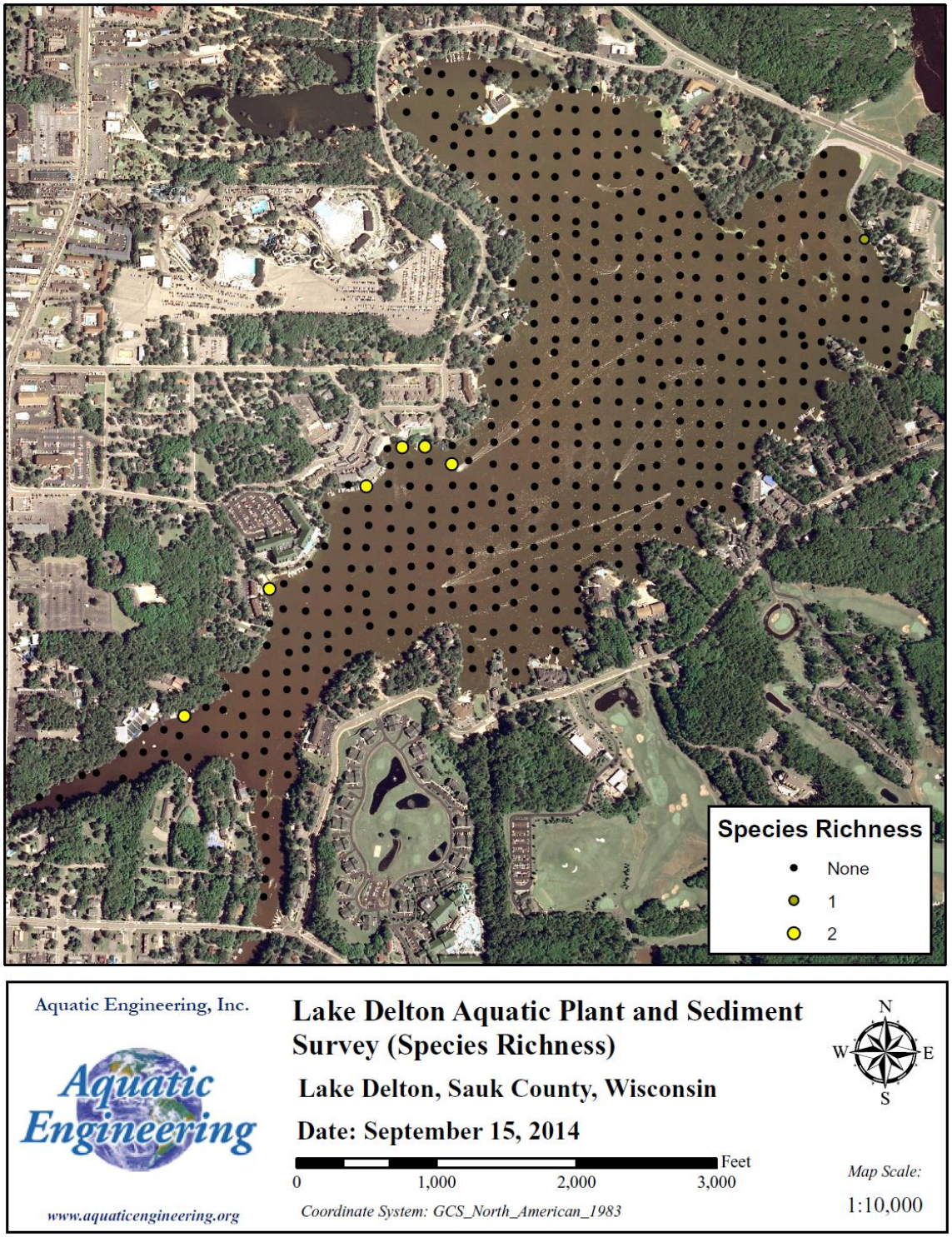

Figure 7. Species richness calculated at each individual site during the Lake Delton aquatic macrophyte survey.

The calculation of the Floristic Quality Index (FQI) for Wisconsin lakes is based on vigorous calculations made by Stanley Nichols (1999). This method applies to specific eco-regions found in Wisconsin. Lake Delton is located within the Northern Central Hardwood Forest eco-region, and calculations from the aquatic macrophyte survey are compared to averages within the eco-region. Nichols reported Average Mean C for the Northern Central Hardwood Forests Region of 5.6, putting Lake Delton just below average for this part of the state with a Mean C of 5.2 (Table 2). The FQI falls far below the average of the region of 20.9, with Lake Delton registering 11.6. These numbers indicate the lake has few species that can tolerate disturbance or pollution, and a lower number of species overall.

Table 2. Calculation of Floristic Quality Index from species found during the 2014 Lake Delton summer aquatic macrophyte survey.

Species	**Common Name**	**C**	**species present=1**	
Bidens cernua	Nodding beggartick	8	1	8
Lemna minor	Small duckweed	4	1	4
Stuckenia pectinata	Sago pondweed	3	1	3
Vallisneria americana	Wild celery	6	1	6
Wolffia columbiana	Common watermeal	5	1	5
N			5	
mean C				5.2
FQI				11.62755

The total vegetation sampled during the Lake Delton survey, when found, was thin and minimal (Table 3). When a rake sample was pulled during the sampling in vegetated areas, there was an average rake fullness rating of 1.00 (Fig. 8). This means that the vegetation was rarely encountered, and was minimal when collected.

When looking at each individual species found during the survey, it is clear that small duckweed (*Lemna minor*) and watermeal (*Wolffia columbiana*) were the dominant species within the lake. Both species were found at 85.17% of the sites where vegetation was collected (which was 6 out of 7). When duckweed and watermeal were found, they were found at low densities, with watermeal having an average rake fullness of 1.67 and duckweed having an average rake fullness of 1.5.

Water celery (*Vallisneria americana*) was the only other species collected by the rake during survey. This plant was found at 14.29% of the sites where vegetation was collected (1 out of 7). When this plant was pulled at the one site, it covered the rake, and therefore, had an average rake fullness rating of 3.00.
Eurasian water milfoil (*Myriophyllum spicatum*), nodding beggartick (*Bidens cernua*), sago pondweed (*Stuckenia pectinata*), and woolgrass (*Scirpus cyperinus*) were the remaining species that were collected during the Lake Delton survey. These species were not found in high numbers, and were only recorded as visual sightings.

Eurasian water milfoil is of particular concern on this lake. Although it was only found as visual sightings during the survey, they were found in high numbers later in the season that required physical removal.

Specific species distribution and density maps are located in Appendix A.

Table 3 shows the results of the 2003 quantitative survey performed on Lake Delton. During 2003, results show finding 12 species within Lake Delton. Of these 12 species, 10 are submerged, while duckweed and watermeal are floating vegetation.

The results from 2003 clearly show more species found within Lake Delton. Since 2003, Lake Delton has lost establishment of many submerged aquatic plants. These plants include coontail (*Ceratophyllum demersum*), common waterweed (Elodea Canadensis), slender naiad (Najas flexis), curly-leaf podweed (Potamogeton crispus), Leafy pondweed (*Potamogeton foliosus*), Floating-leaf pondweed (*Potamogeton natans*), Flat-stemmed pondweed (*Potamogeton zosteriformis*), and Water stargrass (*Zosterella dubia*). These plants, with the exception of curly leaf pondweed, are native to the area and provide beneficial functions toward the overall lake quality and a thriving plant community.

In 2003, we also see that Lake Delton held a more diverse community of plants (Table 4), calculated by Simpson's Diversity Index. There was also a higher FQI value (15.18) in 2003 due to the establishment of plants that are more sensitive that represented a lake that was not as effected by human development and use.

Table 3. Individual statistics for vegetation species found during the 2014 Lake Delton summer aquatic macrophyte survey.

	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Relative Frequency (%)	Number of sites where species found	Average Rake Fullness	visual sightings
Total vegetation					1.00	
Myriophyllum spicatum Eurasian water milfoil						5
Bidens cernua Nodding Beggartick						1
Lemna minor Small duckweed	85.71	2.21	46.2	6	1.50	61
Stuckenia pectinata Sago pondweed						2
Vallisneria americana Wild celery	14.29	0.37	7.7	1	3.00	1
Wolffia columbiana Common watermeal	85.71	2.21	46.2	6	1.67	52
Scirpus cyperinus Woolgrass						1

Table 4. Individual species statistics from the 2003 Lake Delton quantitative aquatic macrophyte survey.

Plant Taxon	Common Name	Frequency of Occurrence (% sites)	Average Density (out of 5)
Overall Plants	NA	33	0.30
Ceratophyllum demersum	Coontail	8	0.04
Elodea canadensis	Common waterweed	10	0.08
Lemna spp	Common duckweed	NA*	NA
Myriophyllum spicatum	Eurasian water-milfoil	7	0.02
Najas flexilis	Slender naiad	15	0.08
Potamogeton crispus	Curly-leaf pondweed	1	0.00
Potamogeton foliosus	Leafy pondweed	1	0.00
Potamogeton natans	Floating-leaf pondweed	NA*	0.00
Potamogeton pectinatus	Sago pondweed	7	0.04
Potamogeton zosteriformis	Flat-stemmed pondweed	3	0.02
Vallisneria americana	Wild celery	24	0.18
Zosterella dubia	Water stargrass	4	0.01

*denotes plant taxa documented during qualitative plant survey

Table 5. Biological and diversity index values for Lake Delton aquatic plant survey August 5 and 6, 2003, Lake Delton (Sauk County), WI.

Index	Score	Interpretation
Simpson's	.83	average
Floristic Quality Index	15.18	very low

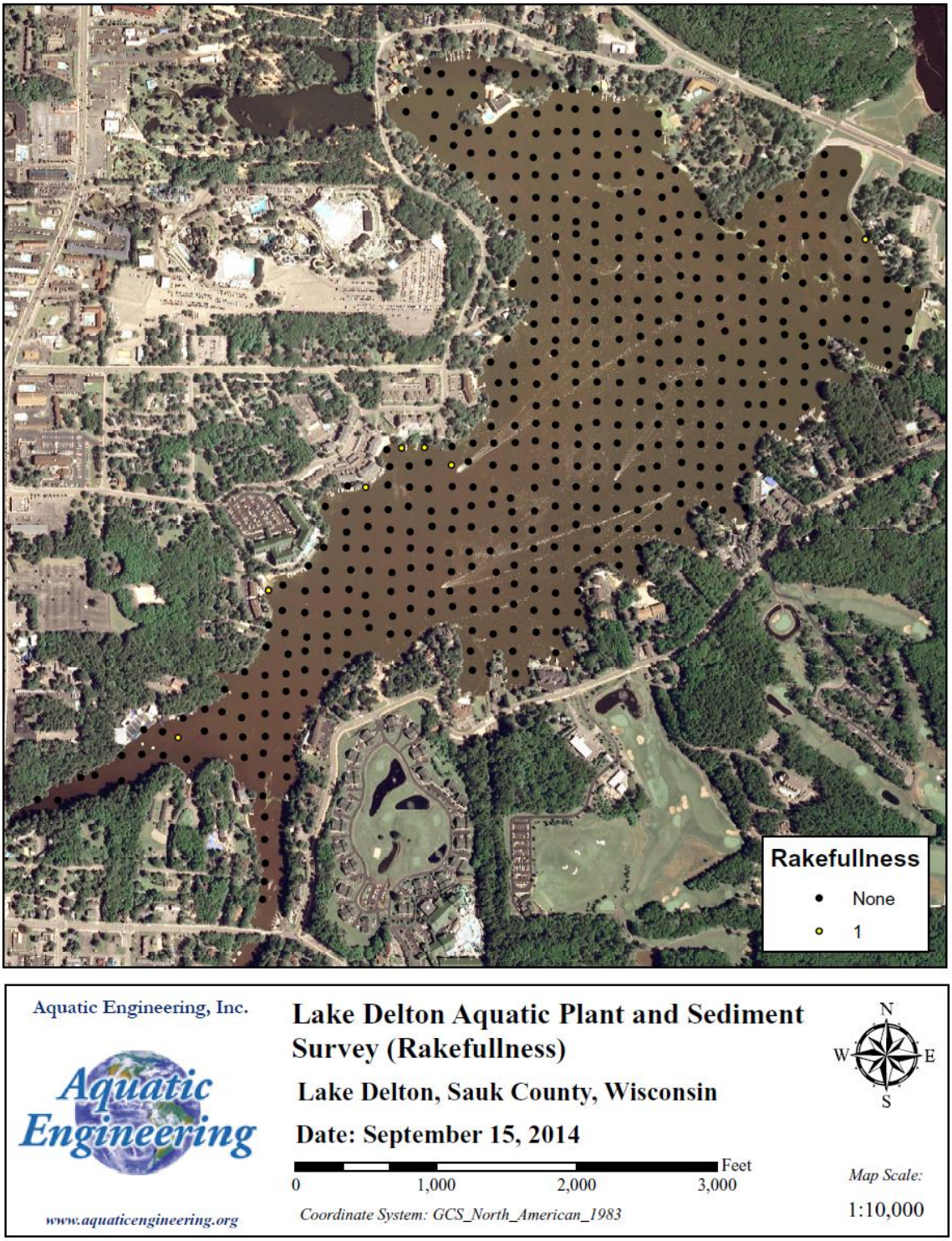

Figure 8. Rake fullness rating for all sample points of the Lake Delton aquatic macrophyte survey.

Discussion, Conclusion and Recommendations

After the 2014 Lake Delton aquatic macrophyte survey, it can be concluded that the lake severely lacks an aquatic plant community. Only seven of the 491 sampling points produced a plant record. Only one of the 491 sampling points actually produced a rooted vegetation sample. The lake only held a total of seven species, two of which were emergents. Including visuals, there were only 8 locations where a rooted aquatic macrophyte was found throughout the entire 267 acre lake. One of these species that was sighted the most was Eurasian water milfoil (EWM) and accounted for five of the eight locations where vegetation was found.

It's a concern that Lake Delton holds such a depleted aquatic community. Lake Delton has always struggled to maintain a beneficial macrophyte community. After the accidental and tragic breach in 2008, the lake essentially began a "new" macrophyte life as the lake bottom was exposed for a year, sediments washed away and a door was opened for EWM. During this survey and historically, the dominant species in the lake was the exotic invasive species, Eurasian water milfoil. Even though it was dominant, it was a fairly contained population of plants. However, later in the year, the population of Eurasian water milfoil had grown to a point that required physical removal of the plants (Fig. 9). EWM is an opportunistic species that can quickly spread to nuisance levels and dominate a lake while negatively affecting native communities and lake recreational use. It is essential to keep a keen eye on the population of Eurasian water milfoil and quickly act on managing the species when the species begins to spread and reproduce erratically. The same can be said about curly-leaf pondweed, because they possess similar characteristics and can quickly increase in numbers if not watched managed properly. The Village has been and is committed to a through monitoring program throughout the growing season annually. It's highly recommended that these efforts continue. It's further, recommended that physical removal and selective herbicide treatments to isolated beds of EWM (too dense for hand removal) should continue in a manner consistent with WDNR emergency response protocols.

Some of the plants found in the survey of Lake Delton were native and beneficial to the lake. However, they would be more beneficial if they were found in higher numbers and densities. The FQI of Lake Delton can be raised by the establishment of native and sensitive species within the lake. High numbers of these species, and a greater increase in species richness in general also raises the FQI value. It is recommended that Lake Delton plant a variety of native aquatic plant species within the lake and on the lake shore. The survey shows that the aquatic plant community is almost nonexistent within the lake. The planting of large numbers of native plant species can benefit the lake exponentially. Native submerged plants may provide assistance to combat any further establishment of exotic invasive species and stabilize shorelines. A thriving plant community may also help absorb nutrients within the water that could potentially be used by nuisance algal species. An establishment of native emergent species may also absorb these nutrients before reaching the water itself. Future management strategies and plans must be discussed in order to improve the Lake Delton plant community to a point where it may be a self sustaining ecosystem that combats nuisance algal and plant species, while overall contributing to the overall water quality of Lake Delton.

It is important that a lake have a healthy and diverse aquatic plant community because of the vital roles that they play within a lake ecosystem. Plants can help to improve lakes by utilizing nutrients, trapping pollutants, stabilizing shorelines and lake bottoms, and providing habitat or food to the fish and wildlife. The plants of a lake provide the base of the food chain that provides the energy to maintain the lake ecosystem. A well established native plant community can also help to defend the lake against invasive species. It is important to closely monitor the distribution and density of aquatic macrophyte species, and the data from this survey should provide assistance toward future management decisions of Lake Delton. Specifically, this information

will be used to supplement the formal comprehensive plan update to follow this summer survey and SPL-339-14. This report and subsequent recommendations serve to fulfill SPL-3339-14 planning grant deliverables and we would to thank the Wisconsin Department of Natural Resources for their involvement, participation and continued support for the Village of Lake Delton's interests and Lake Delton.

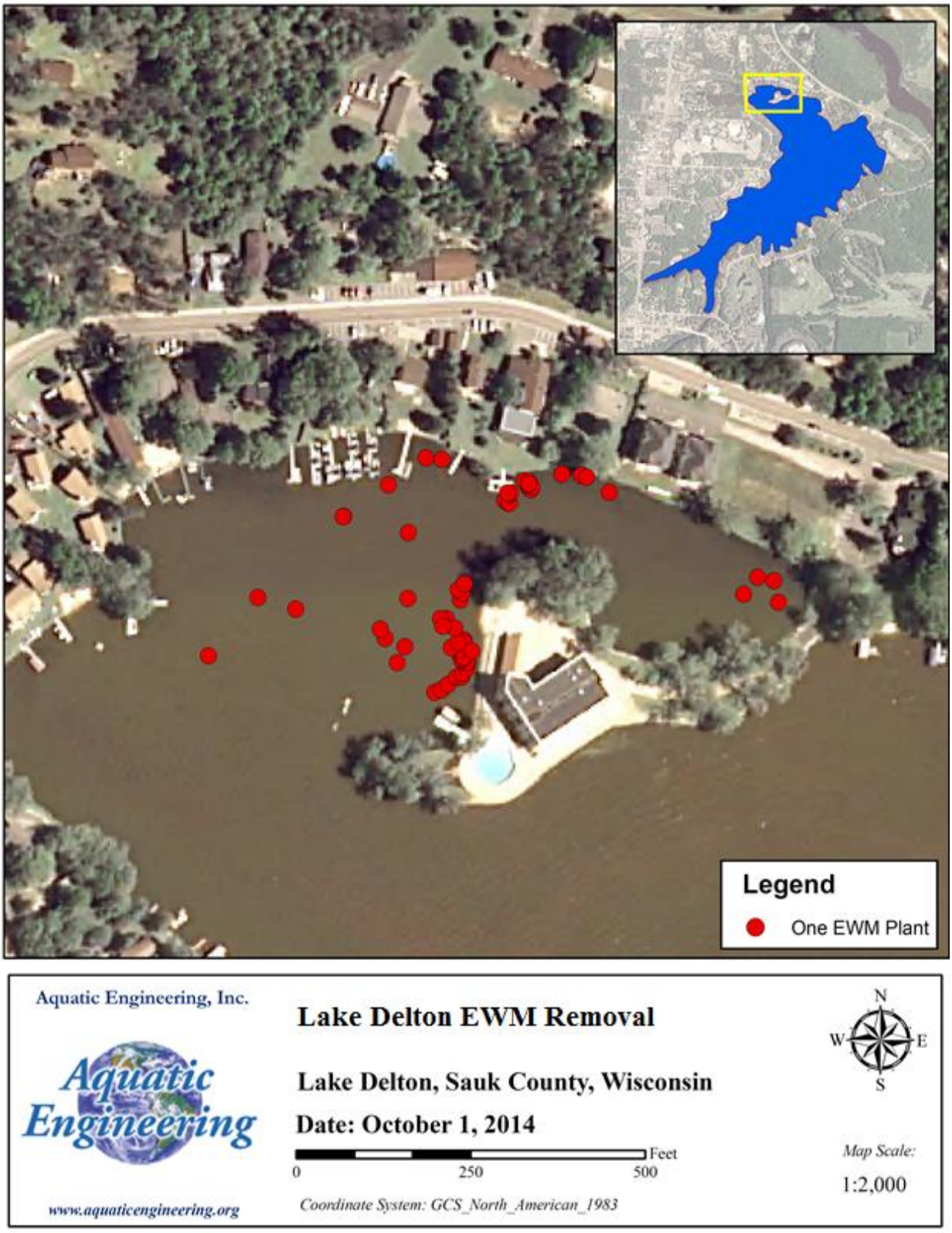

Figure 9. Map of Eurasion water milfoil plant removal locations on October 1, 2014.

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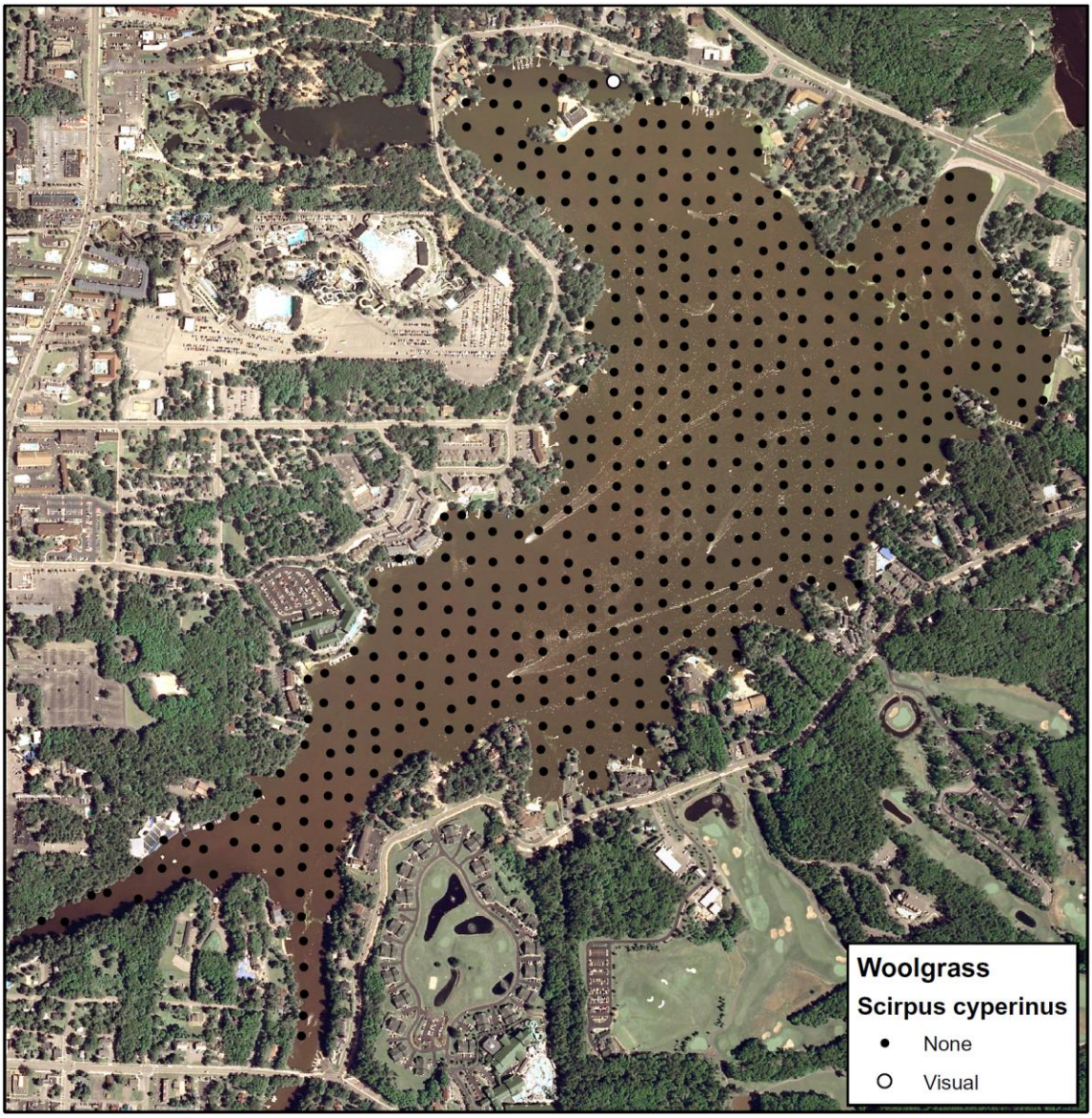
Appendix A



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Lake Delton Aquatic Plant and Sediment Survey (Woolgrass)

Lake Delton, Sauk County, Wisconsin

Date: September 15, 2014

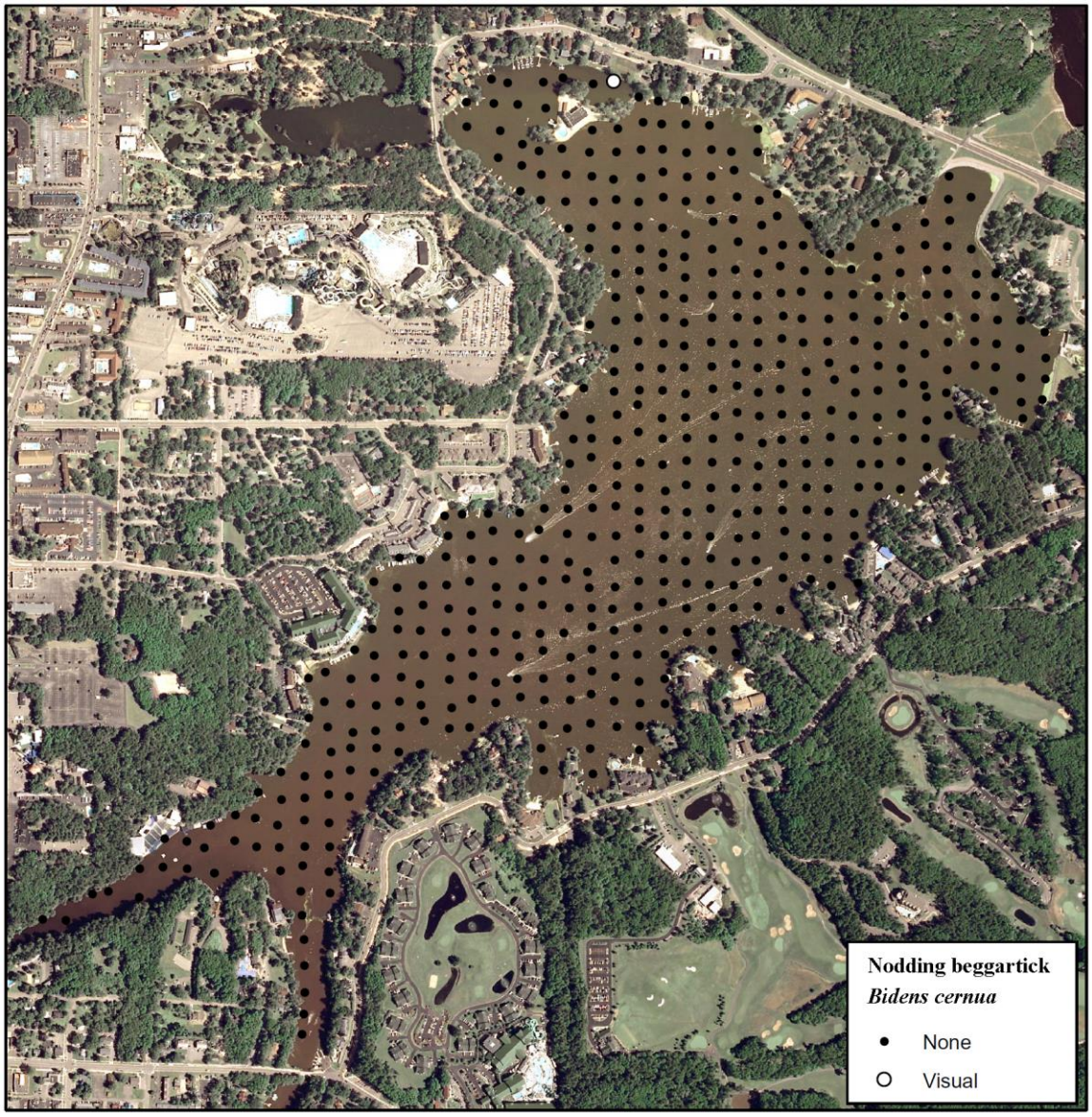
0 1,000 2,000 3,000 Feet

Coordinate System: GCS_North_American_1983

N W E S

Map Scale:

1:10,000



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Lake Delton Aquatic Plant and Sediment Survey (Nodding beggartick)

Lake Delton, Sauk County, Wisconsin

Date: September 15, 2014

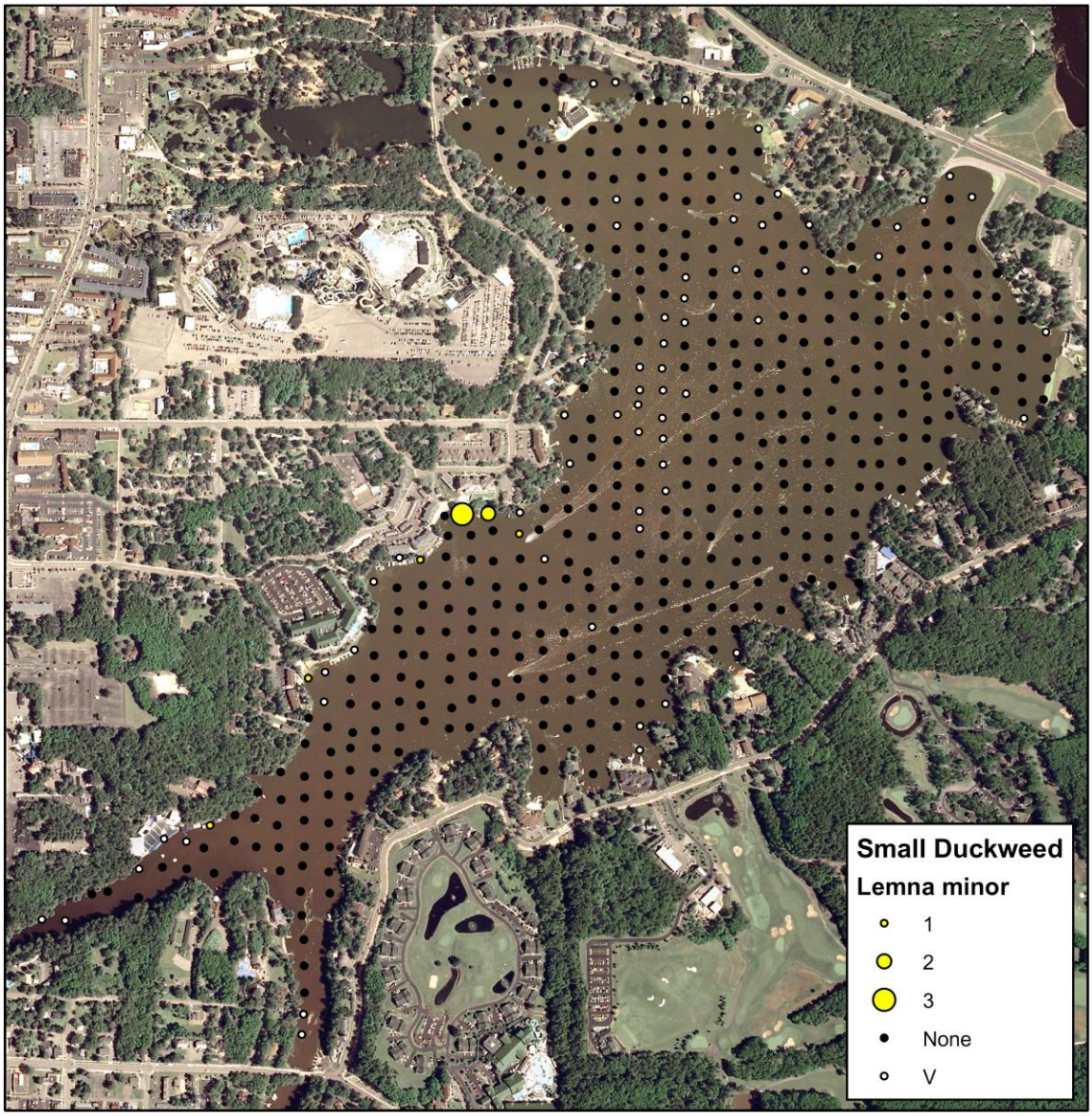
0 1,000 2,000 3,000 Feet

Coordinate System: GCS_North_American_1983

N W E S

Map Scale:

1:10,000



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Lake Delton Aquatic Plant and Sediment Survey (Small Duckweed)

Lake Delton, Sauk County, Wisconsin

Date: September 15, 2014

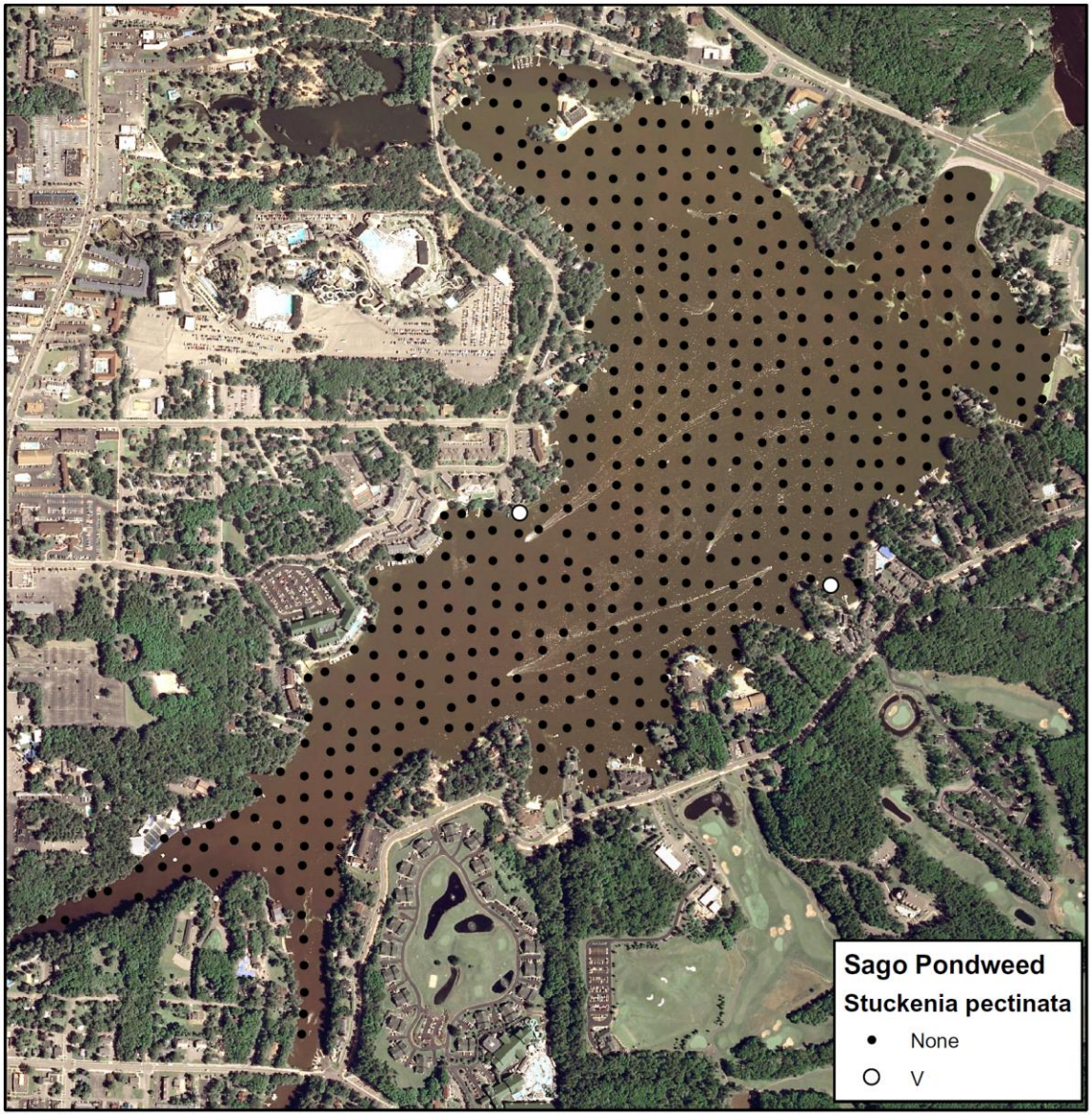
0 1,000 2,000 3,000 Feet

Coordinate System: GCS_North_American_1983

N W E S

Map Scale:

1:10,000



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Lake Delton Aquatic Plant and Sediment Survey (Sago Pondweed)

Lake Delton, Sauk County, Wisconsin

Date: September 15, 2014

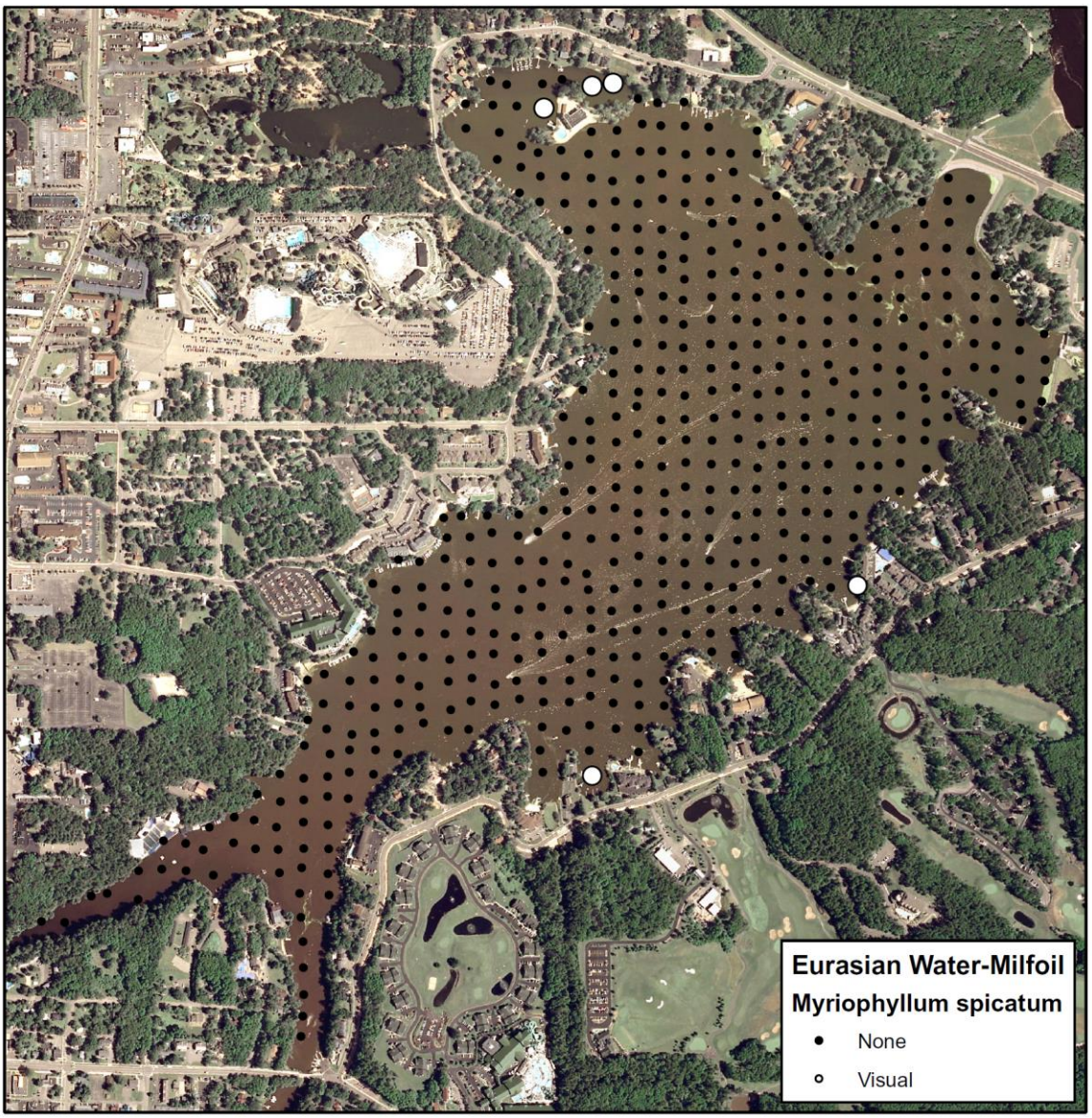
0 1,000 2,000 3,000 Feet

Coordinate System: GCS_North_American_1983

N W E S

Map Scale:

1:10,000



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Lake Delton Aquatic Plant and Sediment Survey (Eurasian Water-Milfoil)

Lake Delton, Sauk County, Wisconsin

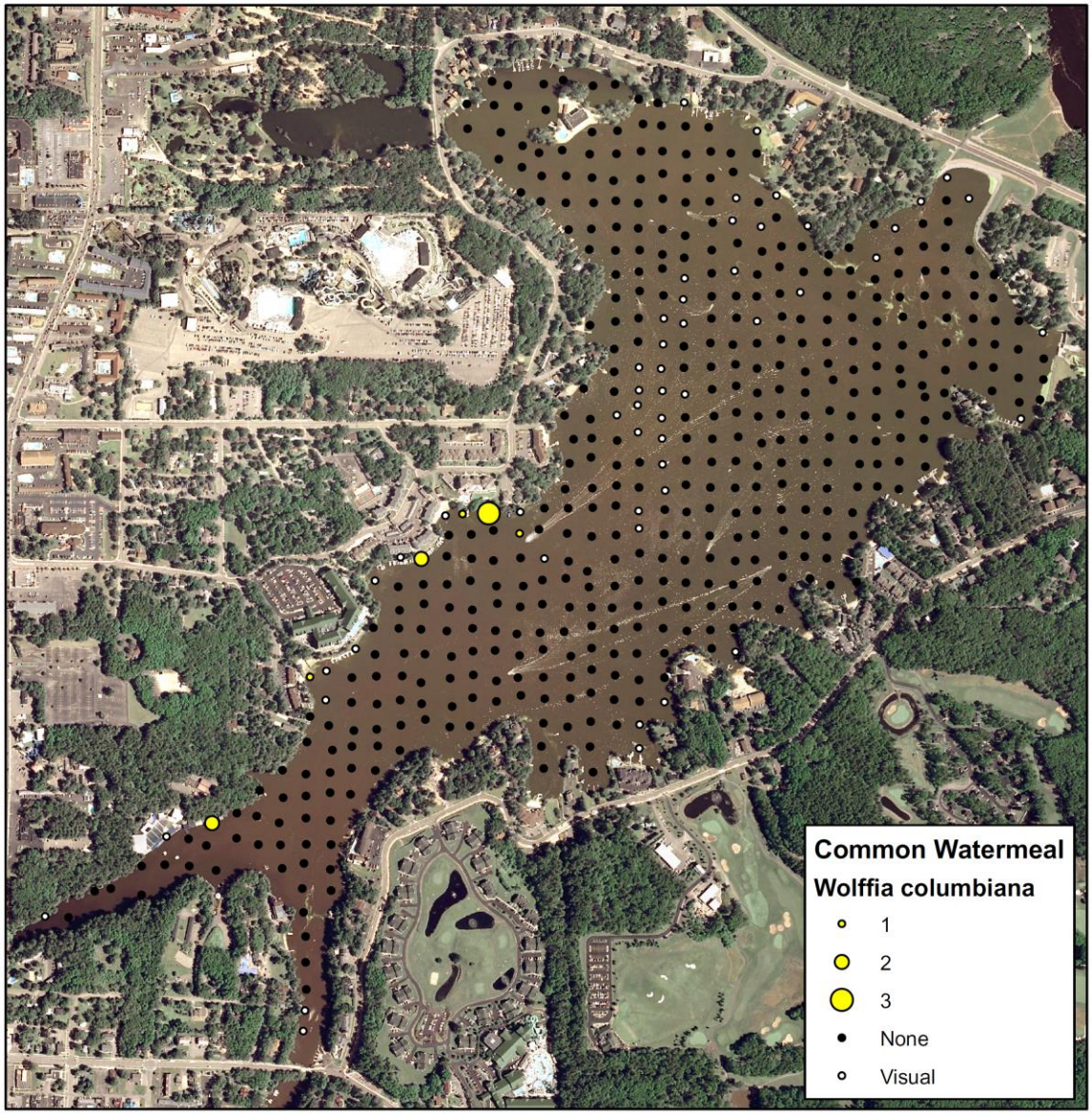
Date: September 15, 2014

N W E S

0 1,000 2,000 3,000 Feet

Map Scale: 1:10,000

Coordinate System: GCS_North_American_1983



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Lake Delton Aquatic Plant and Sediment Survey (Common Watermeal)

Lake Delton, Sauk County, Wisconsin

Date: September 15, 2014

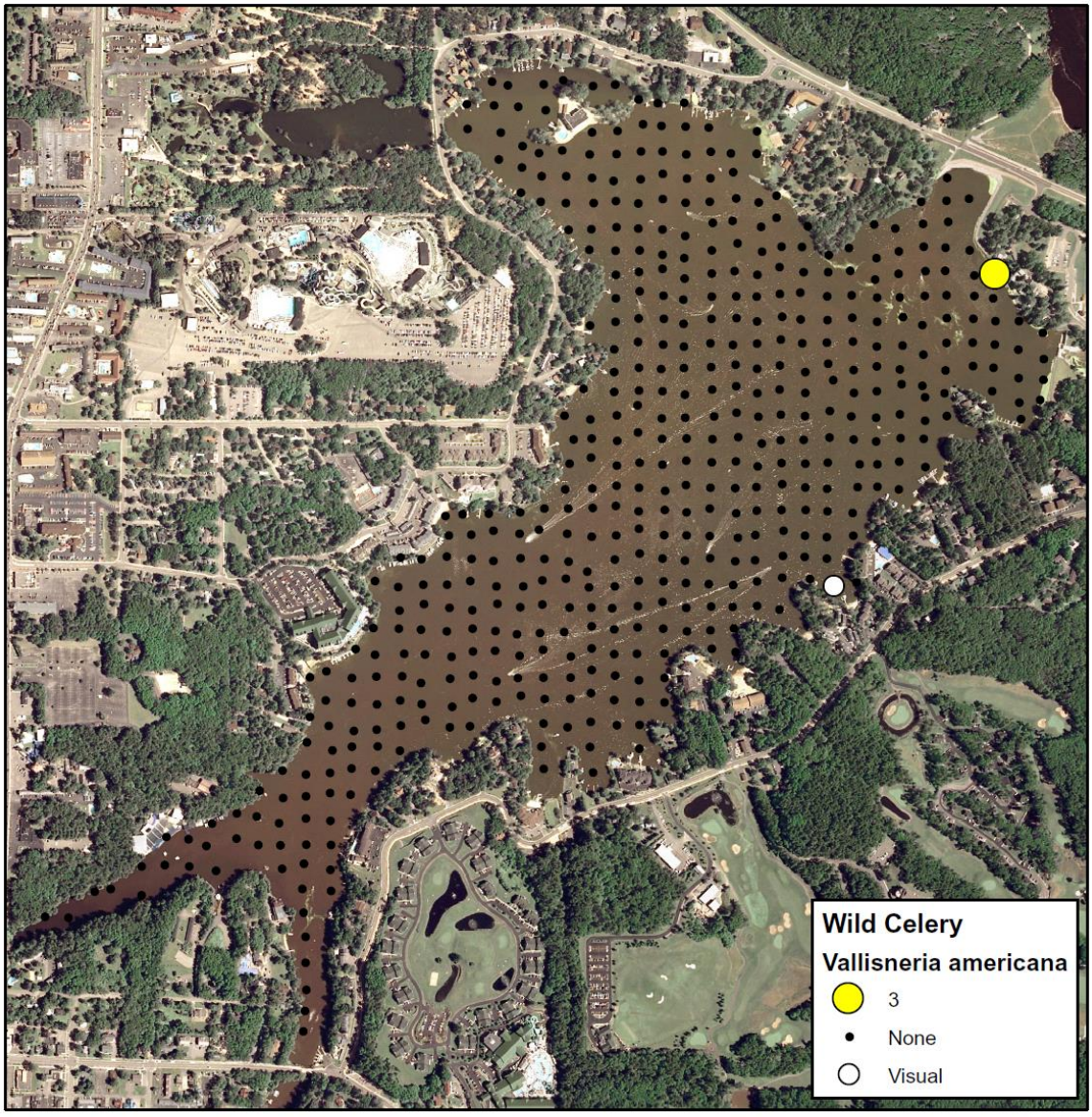
0 1,000 2,000 3,000 Feet

Coordinate System: GCS_North_American_1983

N W E S

Map Scale:

1:10,000



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Lake Delton Aquatic Plant and Sediment Survey (Wild Celery)

Lake Delton, Sauk County, Wisconsin

Date: September 15, 2014

0 1,000 2,000 3,000 Feet

Coordinate System: GCS_North_American_1983

N W E S

Map Scale:

1:10,000

Appendix B