Appendices

Aquatic Plant, Soft Sediment, & Depth Surveys

of the

Kiel Millpond & Sheboygan River

Manitowoc County, Wisconsin

Project initiated by:
City of Kiel
Short, Elliot, Hendrickson, Inc.

Survey and report completed by:
Aquatic Plant & Habitat Services, LLC
Sara Hatleli
N4236 State Highway 54
Black River Falls, WI 54615
715-299-4604
Sarahatleli97@gmail.com

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ABSTRACT

Four surveys were conducted on the Kiel Millpond and upstream segment of the Sheboygan River in Manitowoc County, Wisconsin in 2014. An early-season aquatic invasive species survey was completed on May 25th. A summer aquatic plant survey was completed on August 1st. Both plant surveys employed methods from Hauxwell (2010). Lastly, a soft sediment depth survey and cross section depth survey were conducted on August 2nd. During the early season survey, 252 survey points were attempted based on the point intercept map generated by the WDNR and 247 points were successfully visited revealing Eurasian water-milfoil (*Myriophyllum spicatum,* EWM) at 62 sites and curly-leaf pondweed (*Potamogeton crispus,* CLP) at 26 sites. CLP was also visually observed at 36 additional locations. The same 252 sample points were attempted for the summer aquatic plant survey, 248 of which were successfully visited to sample depth, substrate, and aquatic plant abundance. A total of 12 species were documented at survey points, an additional 5 species were visually observed within 6 feet of a survey point but not on the rake. The aquatic plant community yielded a moderate Simpson Diversity Index of 0.84 and below average Floristic Quality within the ecoregion of 15.33. Average conservatism was slightly below the mean for the region at 5.1. Coontail (*Ceratophyllum demersum*), small duckweed (*Lemna minor*), and watermeal (*Wolffia sp.*) were the most common species with a combined relative frequency of 57% suggesting a somewhat homogeneous plant community. CLP and EWM were both found during the summer aquatic plant survey at 77 and 14 sites, respectively. Lake sediment was predominantly rock (126 points or 51%) while 103 points (42%) were dominated by muck sediment. The same 248 survey points from the summer plant survey were used to assesss depth of soft sediment. The majority of those sites (55%) had no soft sediment detected, which corroborates with the high occurrence of rocky substrate at many sites. Approximately 30% of sites had a soft sediment depth between 0.5 and 2 feet. Seven transects were used to assess cross sectional depths and their locations were based on a similar survey conducted by the Wisconsin Department of Natural Resources in 1994. Transect widths ranged from 135-310 feet and depths ranged from 0.5-9.5 feet. Management recommendations are as follows; 1) Protect native aquatic plants. 2) Shore land owners could manage some nuisance vegetation with hand-pulling. 3) Conduct water quality monitoring monthly from May-September to track nutrient levels. 3) Implement shore land restoration, especially at city-owned properties. 5) Reduce coontail abundance in the millpond possibly by using mechanical harvesters and monitor to ensure it is not replaced by EWM or CLP.

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BACKGROUND AND STUDY SITE

The City of Kiel has partnered with Short, Elliot, & Hendrickson (SEH) Inc. to develop and aquatic plant management plan for the Kiel Millpond and segment of the Sheboygan River. Aquatic Plant and Habitat Services LLC was recruited to complete an early season invasive species survey, summer aquatic plant survey, soft-sediment depth survey, and cross sectional depth survey. These surveys were completed in May and August of 2014.

The study site included a stretch of the Sheboygan River and a small millpond in the City of Kiel (WBIC 50700 & 5560113) totaling 13 acres in Manitowoc County, Wisconsin (T17N, R21E, S30). The Kiel Millpond was created by a 10-ft dam owned by the city and maintained to provide recreational opportunities. The project area continues upstream from the millpond and ends at the railroad tressel on the western edge of the city (Figure 1). Water quality data from a 1994 WDNR study indicates the water was clear with the Secchi disk reaching the bottom (5ft). Total phosphorus was high in May and August with levels of 86 µg/l and 54 µg/l respectively, which suggest the water is eutrophic, or nutrient-rich. Eurasian water-milfoil and curly-leaf pondweed were documented in the river before this survey.

Figure 1 – Aerial Photo of Project Area

METHODS

Field Methods

The WDNR generated a point-intercept map for the project area that included 252 sample points (Figure 2). The latitude/longitude coordinates were uploaded to a hand-held GPS unit (Garmin 76CSx), which was used at 30 feet of resolution to navigate to each point for the plant and soft sediment depth surveys.

Early Season Eurasian Water-milfoil and Curly-leaf Pondweed Survey

The early season survey was completed on May 25, 2014. A double-sided rake head on a telescopic pole was used to sample each point for curly-leaf pondweed and Eurasian water-milfoil, depth, and dominant sediment type (muck, rock, or sand). The rake fullness rating for total coverage of plants on the rake and a separate rake fullness rating for each species present were recorded (Figure 3). Any survey points that were inaccessible were recorded as such and no sample was taken.

Summer Aquatic Plant Survey

A comprehensive aquatic plant survey was done on August 1st, 2014 during which substrate type, depth, and species rooted in standing water were recorded per methods in Hauxwell et al. (2010). A double-sided rake head on a telescopic pole was used to sample each point. The rake fullness rating for total coverage of plants on the rake and a separate rake fullness rating for each species present were recorded (Figure 3). Aquatic plants found within 6 feet of the sample point but not found on the rake were counted as visual observations. Species that were greater than 6 feet from any sample point were recorded to note their presence as part of a boat survey, but were not counted in statistical calculations. These boat survey species were only recorded if their roots were in standing water. Any survey points that were inaccessible were recorded as such and no sample was taken. Two voucher specimens of each species were collected to provide to the City of Kiel and the herbarium at UW-Madison. Specimens were also used to verify plant identification using Crow and Hellquist (2000) and Skawinski (2010).

Soft Sediment Depth Survey

The depth of soft sediment was assessed on August 2nd, 2014 at the same survey points used in the plant surveys. The GPS unit was used to navigate to survey points and a ¾" galvanized steel pipe with capped ends and marked at one-foot intervals was pushed into the sediment. The pipe was pushed until reaching hard sediment or rock, also known as the "point of refusal." The one-foot interval markings on the pipe allowed for quick assessment of total depth of the sediment and water combined (Figure 4).

Cross Sectional Depth Survey

Seven transects were established based on locations in a 1994 survey by the WDNR (Figure 5). Depths were measured at intervals ranging from 10 to 25 feet starting at the east bank (Figure 4). Latitude and longitude coordinates at each end of the transects were collected using a GPS unit. Transects were identified using the same numbering system illustrated in Figure 5.

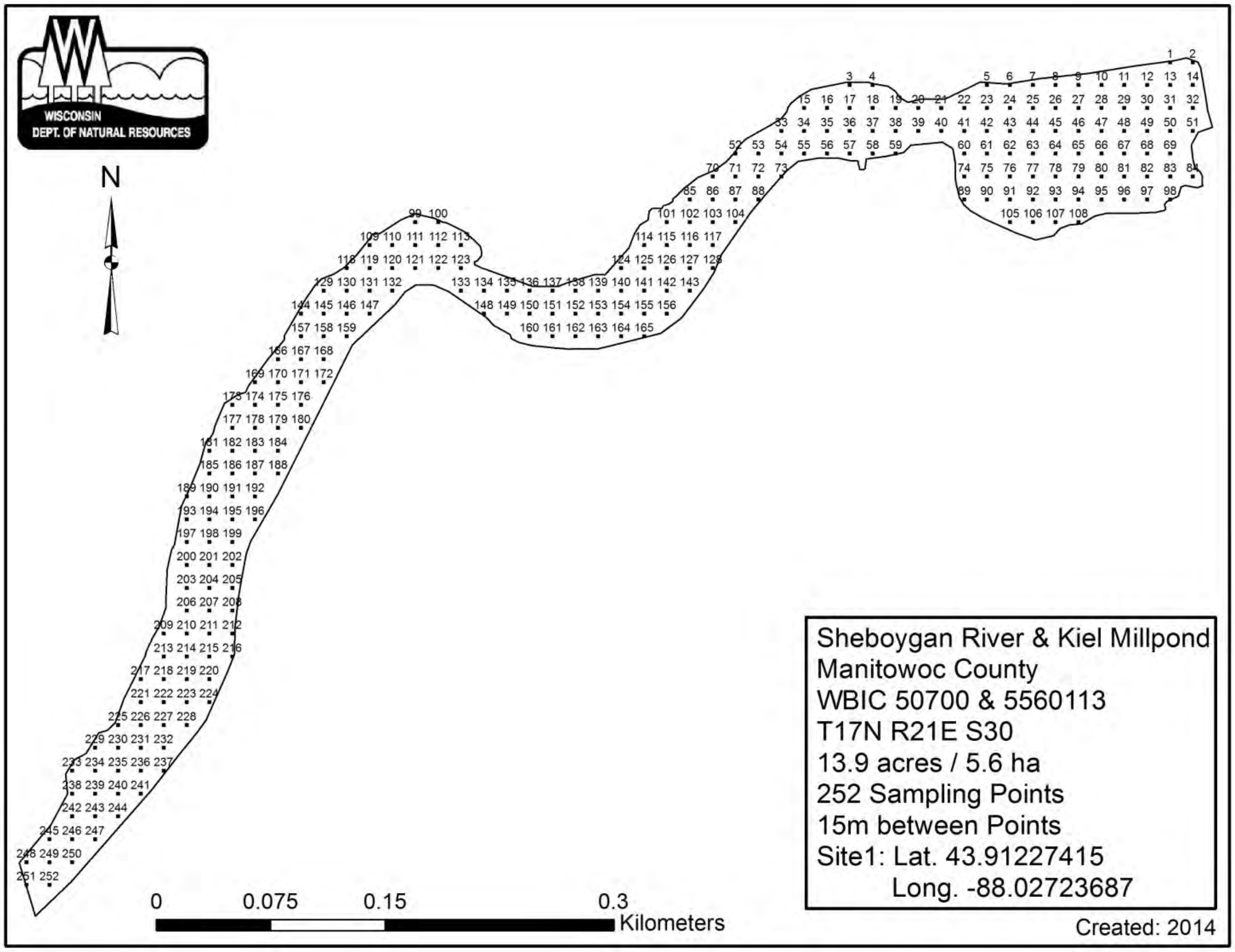

Figure 2 -Point Intercept Survey Map of Kiel Millpond & Sheboygan River

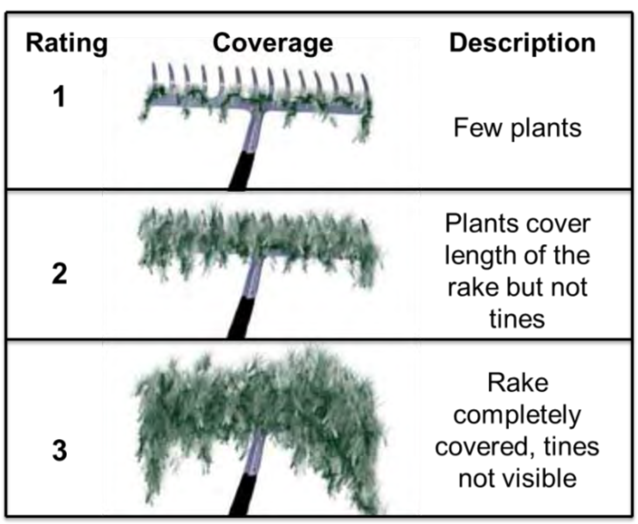

Figure 3 - Rake Fullness Rating Illustration

Figure 4 - Photos of Soft Sediment and Transect Field Surveys

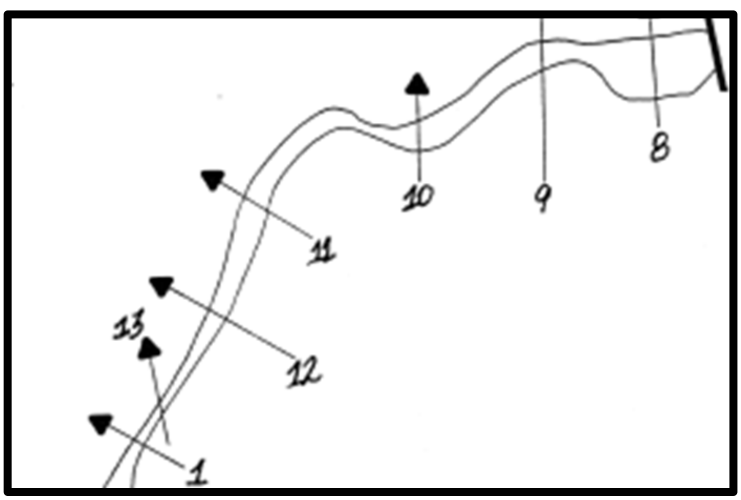

Figure 5 - Transects from the Cross Section Depth Survey, 1994

Data Analysis Methods

Soft Sediment Depth and Cross Sectional Depth Surveys

The water depth values collected during the aquatic plant survey were subtracted from the depth of soft sediment + water to yield the depth of soft sediment at each site. Sediment depth data were forwarded to project partner, SEH Inc., for analysis and mapping. The depth measurements and GPS coordinates of transects were also forwarded to SEH for analysis and mapping.

Early Season and Summer Aquatic Plant Surveys

The "Aquatic Plant Survey Data Workbook" was downloaded from the UW-Extension Lakes page (UWEX, 2013) and the spreadsheet was populated with data collected from the project area. Per guidelines in Hauxwell (2010), species that were recorded as visuals (i.e., within 6 feet of a survey point but not sampled with the rake) were not included in Simpson Diversity Index and FQI calculations for the summer aquatic plant survey. Also, filamentous algae data were not used in any statistical calculations but were collected to gauge their frequency throughout the project area.

Summary Statistics for the Summer Aquatic Plant Survey

From the "Aquatic Plant Survey Data Workbook," several summary statistics were calculated (Table 1). These statistics provide a general overview of the plant community within the project site. Floristic Quality Index (FQI) is summarized in Table 1, but elaborating on this metric developed by Nichols (1999) is worthwhile. Aquatic plant species associated with lake communities and native to Wisconsin were assigned a Coefficient of Conservatism (C) ranging from 0 to 10. The C value estimates the likelihood of that plant species occurring in an environment that is relatively unaltered from pre-settlement conditions. As human disturbance increases, species with a lower C value occur more frequently while more sensitive species with a higher C value occur less frequently. To calculate floristic quality, the mean C value of all species found in the lake is multiplied by the square root of the total number of plant species in the lake. Only plants found on the rake are included in the calculations. In other words, the FQI metric incorporates the C values of species found during the survey to compute how close the aquatic plant community is to one of undisturbed conditions. A higher FQI value assumes a healthier aquatic plant community. Floristic quality values can be compared on a statewide level, but Nichols (1999) recommends comparing values within one of the four ecoregional-lake types. Kiel Millpond and Sheboygan River fall within the "Southeastern Till Plain" ecoregional-lake type.

Table 1 – Explanation of Summary Statistics for Summer Plant Survey

	Summary Statistic		Explanation of Statistical Calculation
1	Total number of sites visited		The total number of sites sampled, which is not necessarily equal to the number of survey points because some sites may not be accessible.
2	Total number of sites with vegetation		Number of sites where at least one plant was found on the rake (does not include moss, sponges, algae, or liverworts).
3	Maximum depth of plants		Depth of deepest site where at least one plant was found on the rake (does not include moss, sponges, algae, or liverworts).
4	Total number of sites shallower than maximum depth of plants		Number of sites where depth was less than or equal to the maximum depth where at least one plant was found on the rake.
5	Frequency of occurrence at sites shallower than maximum depth of plants		Total number of sites with vegetation (2) / Total number of sites shallower than maximum depth of plants (4).
6	Average number of species per site (split into four subcategories)	a)	Shallower than maximum depth – the average number of species found per site at sites less than or equal to the maximum depth where at least one plant was found on the rake (4).
		b)	Vegetated sites only – the average number of species found per site at sites where at least one plant was found on the rake (2).
		c)	Native species shallower than maximum depth – Same explanation as 6(a), non-native species excluded from average.
		d)	Native species at vegetated sites only – Same explanation as 6(b), non-native species excluded from average.
7	Species Richness (split into two subcategories)	a)	Total number of species found on the rake at all sites (does not include moss, sponges, algae, or liverworts
		b)	Including visuals – Same explanation as 7(a) and including visual observations within 6 feet of the sample sight
8	Simpson's Diversity Index		Estimates the heterogeneity of a community by calculating the probability that two individuals randomly selected from the data set will be different species. The index ranges from 0-1, and the closer the value is to one, the more diverse the community. Visual observations (within 6 feet of sample point) are not included in calculation of index.
9	Coefficient of Conservatism (C)		This is not a statistical calculation, but rather a value assigned to each plant species based on how sensitive that species is to disturbance. C values range from 1 to 10 with higher values assigned to species that are more sensitive to disturbance (Nichols, 1999).
10	Floristic Quality Index		How similar the aquatic plant community is to one that is undisturbed (Nichols, 1999). This index only factors species raked at survey points and does not include non-native species. The FQI is calculated using coefficient of conservatism (C) values (9).

Individual Species Statistics for the Summer Aquatic Plant Survey

From the "Aquatic Plant Survey Data Workbook," several individual species statistics were calculated (Table 2). These statistics assess the plant species composition and allow for comparisons of the plant community within the project site.

Table 2 – Explanation of Individual Plant Species Statistics

	Individual Statistic	Explanation of Statistical Calculation
11	Average Rake Fullness	Mean rake fullness rating ranging from 1 to 3 for the entire lake or for a particular species.
12	Number of sites where a species was found	The total number of survey points where a particular species was found on the rake.
13	Number of visual sightings	The total number of times a particular species was visually observed within 6 feet of a sampling point, but not collected on the rake
14	Frequency of Occurrence (split into two subcategories	a) Among vegetated sites only – The number of sites at which a particular species is found on the rake divided by the total number of vegetated sites (Table 1, #2)
		b) Among sites shallower than the maximum depth of plants – The number of sites at which a particular species is found on the rake divided by the total number of sites less than or equal to the maximum depth of plants (Table 1, #4)
15	Relative frequency (%)	This value represents the degree to which a particular species contributes to the total of all observations. The sum of all relative frequencies is 100%.

RESULTS

Soft Sediment Depth Survey

The majority of survey sites (55%) had no soft sediment detected. Many of these sites were comprised of rocky substrate. Although some soft sediment may appear settled among the rocks, there was not enough soft sediment to register a difference from the total water depth. Approximately 30% of sites had sediment depths of 0.5-2 feet, 11% of sites had sediment depth between 2.5 and 4 feet, while the remaining 5% of sites had sediment depths between 4.5 and 6 feet (Figure 6). SEH Inc. completed a map to display these findings in the Aquatic Plant Management Plan.

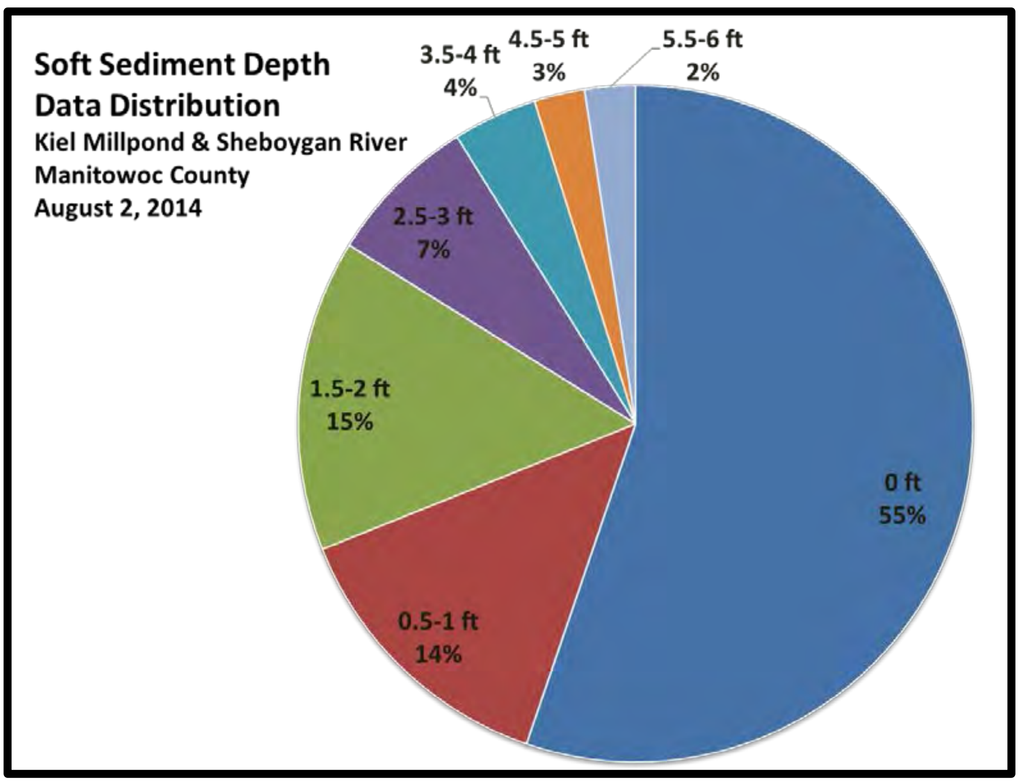

Figure 6 - Soft Sediment Depth Pie Chart

Cross Sectional Depth Survey

The widest transect (#8) was located in the millpond and was 310 feet wide and a maximum depth of 6 feet. The most narrow transect (#10) was near the east bank gravel boat landing and had a total width of 135 feet and maximum depth of 4.5 feet. Transect #13 was on the upstream end of the project site near the railroad bridge and had the greatest depth of 9.5 feet (Table 3). Approximate transect location is illustrated in Figure 5.

Table 3 – Cross Section Depth Survey Results

Transect	Total Width (ft)	Survey Interval (ft)	Max Depth (ft)	Min Depth (ft)
1	140	10	6	2
8	310	25	8.5	2.5
9	170	15	7	0.5
10	135	10	4.5	0.5
11	140	10	5.5	2
12	160	15	5.5	3
13	140	10	9.5	1.5

Early Season Aquatic Plant Survey

A total of 252 survey points were attempted based on the WDNR point intercept survey map (Figure 2). A total of 247 survey points were actually visited during the survey on May 25, 2104. One survey point was inaccessible because it was located under a building near the millpond dam. Four survey points were not accessible because anglers were present. These four survey points were attempted twice each, but anglers were present each time and survey crew felt courtesy was important.

Curly-leaf pondweed (CLP) and Eurasian water-milfoil (EWM) were found during the May 25th survey. Of the 247 survey points visited, (EWM and/or CLP) were found at 79 of those sites. The maximum depth at which invasive species were found was 7 feet. The number of sites shallower than this maximum depth of 7 feet was 234. Therefore, invasive species were found at 33.76% of sites shallower than the maximum depth of invasive plants.

CLP was found at 26 sites while EWM was found at 62 sites (Figure 7, Figure 8). CLP was more commonly located visually (36 sites) than sampled on the rake while EWM was visually observed at 2 survey points. Survey points where CLP was found on the rake ranged in depth from 2 to 6 feet predominantly with muck sediment (17 points) but also with rocky substrate (9 points). EWM was found growing in depths ranging from 1.5 to 7 feet predominantly in muck sediment (32 points), then in rocky substrate (24 points), and least commonly in sand sediment (6 points).

Table 4 - Summary Statistics for Early Season Plant Survey

	Summary Statistic	Results
1	Total number of sites visited	**247**
2	Total number of sites with invasive plant species	**79**
3	Maximum depth of invasive plant species	**7 feet**
4	Total number of sites shallower than maximum depth of invasive plant species	**234**
5	Frequency of occurrence at sites shallower than maximum depth of invasive species	**33.76%**

Table 5 - Plant Species Statistics for Early Season Plant Survey

Common Name	Scientific Name	Average Rake Fullness	# Sites	# Visual
Curly-leaf pondweed	*Potamogeton crispus*	1	26	36
Eurasian water-milfoil	*Myriophyllum spicatum*	1.02	62	2

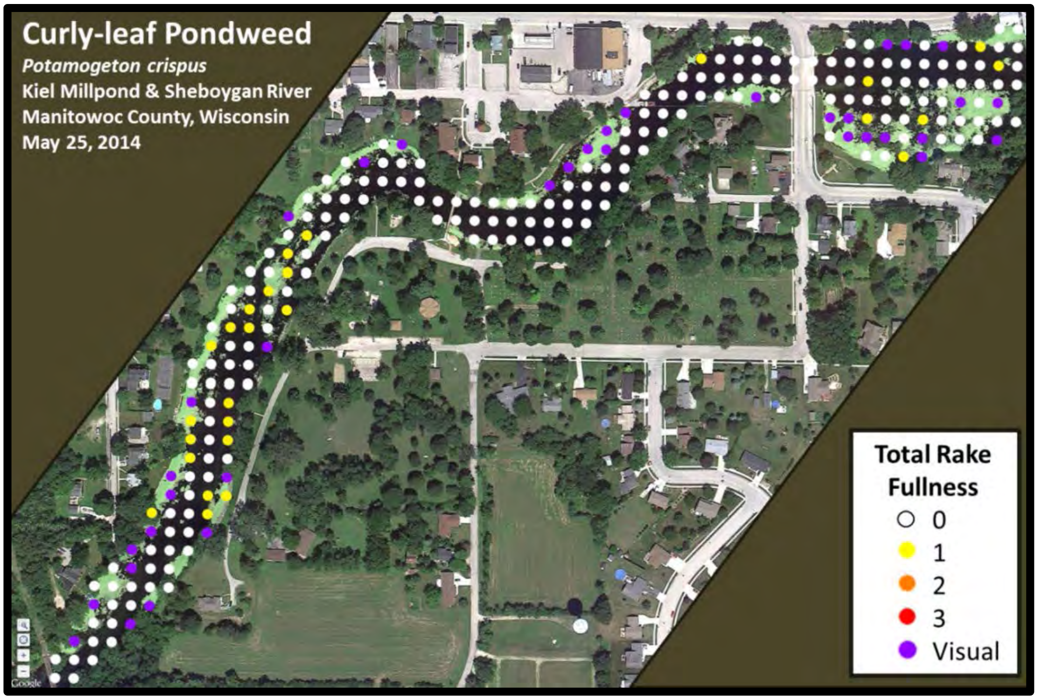

Figure 8 - Early Season CLP Locations and Total Rake Fullness

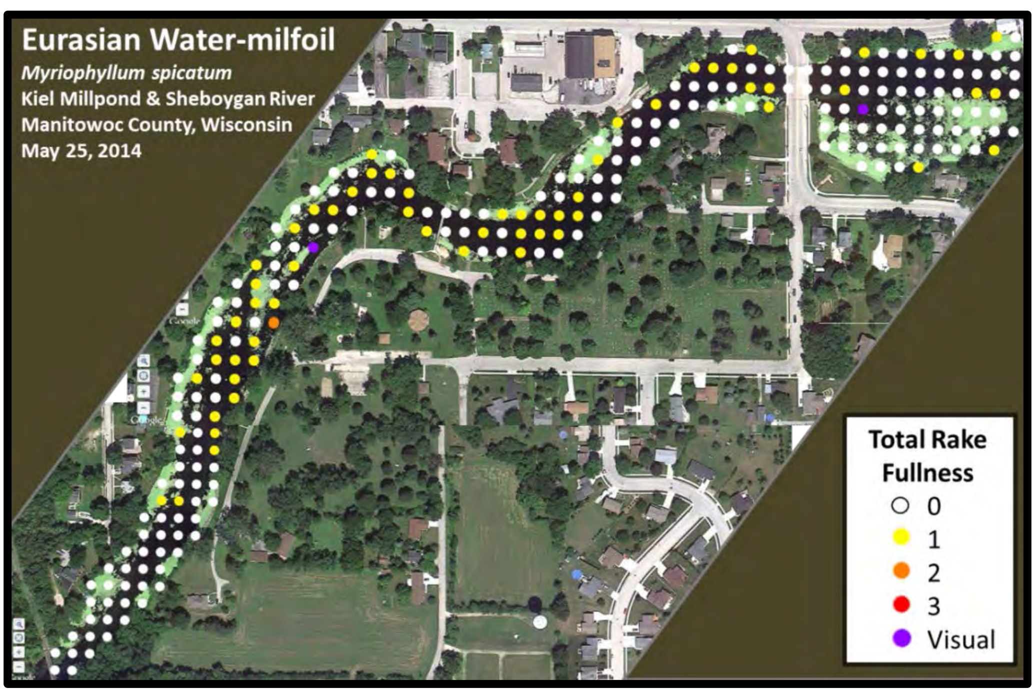

Figure 7 – Early Season EWM Locations and Total Rake Fullness

Summer Aquatic Plant Survey

A total of 248 survey points were visited out of a possible 252 because four points were on land or blocked by floating bogs with thick emergent vegetation. Of the 248 visited survey points, 236 were the same depth or shallower than the maximum rooting depth of plants (7 feet) and 182 of those sites surveyed had vegetation (Table 6). The majority of the sites had a total rake fullness of 1 (42%), 28% had a total rake fullness of 2, and 30% had a total rake fullness of 3 (Figure 9). The average number of species found at the 182 points was 3.97 and the average rake fullness was 1.87.

A total of 12 species of aquatic plants were found on the rake and five additional species were observed within 6 feet of a survey point, but were never found on the rake (Table 8). Filamentous algae is not counted as one of the 12 species. Coontail, small duckweed, and common watermeal were the most common species found at 20%, 19%, and 18% of survey points (≤ maximum rooting depth) respectively. Together they accounted for 57% of the total relative frequency suggesting a somewhat homogeneous plant community.

Simpson Diversity Index includes only the 12 species raked at survey points and was calculated as 0.84 on a scale from 0 to 1 (Table 6). The Floristic Quality Index (FQI) only factors species raked at survey points and does not include non-native species or plants not identified to species (i.e., *Wolffia sp.*). Therefore, 9 plant species were used to calculate FQI, which is lower than the average number of species (14) for the Southeastern Till Plain ecoregion. The FQI value was 15.33, which was lower than the mean value of 20.9 for the same ecoregion. Lastly, the average C value of 5.1 was slightly lower than the average for other lakes in the same ecoregion of 5.6 (Table 7).

High Value Species

Large-leaf pondweed (*Potamogeton amplifolius*) is a species identified in Wisconsin Administrative Code NR 109 as "high value species…….. known to offer important values in specific aquatic ecosystems." Large-leaf pondweed was found within 6 feet of survey point number 201, which is located mid-channel in the upstream quarter of the project area. There were no findings of rare plant species nor were any species with high conservatism values of 9-10 present.

Table 6 - Summary Statistics for the Summer Aquatic Plant Survey

	Summary Statistic			Results
1	Total number of sites visited			248
2	Total number of sites with vegetation			182
3	Maximum depth of plants			7 feet
4	Total number of sites shallower than maximum depth of plants			236
5	Frequency of occurrence at sites shallower than maximum depth of plants			77.12%
6	Average number of species per site	a)	Shallower than maximum depth	3.06
		a)	Vegetated sites only	3.97
		a)	Native shallower than maximum depth	2.68
		a)	Native species at vegetated sites only	3.51
7	Species Richness	a)	Total # species found on rake at all sites	12
		a)	Including visuals	17
8	Simpson's Diversity Index			0.84
9	Mean Coefficient of Conservatism (C)			5.1
10	Floristic Quality Index			15.33

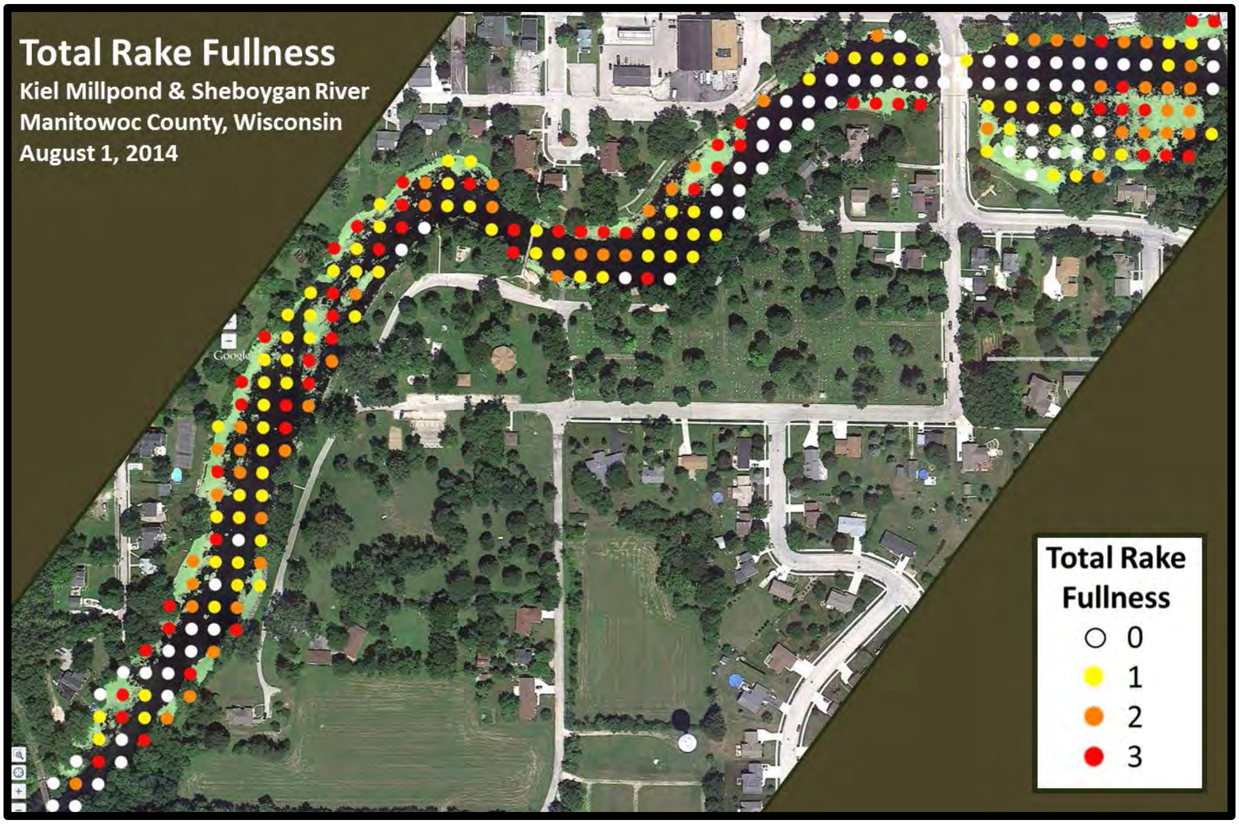

Figure 9 - Total Rake Fullness of Summer Plant Survey

Table 7 – Conservatism Values and FQI Results

Scientific Name	Common Name	C Value
Ceratophyllum demersum	Coontail	3
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Najas flexilis	Slender naiad	6
Nymphaea odorata	White water lily	6
Potamogeton zosteriformis	Flat-stem pondweed	6
Spirodela polyrhiza	Large duckweed	5
Utricularia vulgaris	Common bladderwort	7
	N	**9**
	Mean C	**5.1**
	FQI	**15.33**

Table 8 – Individual Species Statistics for the Summer Aquatic Plant Survey

Scientific Name	Common Name	Avg. Rake Full.	# Sites	# Visual	Freq. Occur. Veg. Sites	Freq. Occur ≤max depth	Rel. Freq. %
Ceratophyllum demersum	Coontail	1.69	145	2	79.67	61.44	20.06
Lemna minor	Small duckweed	1.51	138	26	75.82	58.47	19.09
Wolffia sp.	Watermeal	1.01	135	23	74.18	57.20	18.67
Elodea canadensis	Common waterweed	1.18	104	0	57.14	44.07	14.38
Potamogeton zosteriformis	Flat-stem pondweed	1.27	81	9	44.51	34.32	11.20
Myriophyllum spicatum	Eurasian water milfoil	1.18	77	2	42.31	32.63	10.65
Filamentous algae	Filamentous algae	1.25	55	10	30.22	23.31	
Potamogeton crispus	Curly-leaf pondweed	1.07	14	8	7.69	5.93	1.94
Heteranthera dubia	Water star-grass	1.00	9	0	4.95	3.81	1.24
Utricularia vulgaris	Common bladderwort	1.14	7	1	3.85	2.97	0.97
Nymphaea odorata	White water lily	1.00	6	17	3.30	2.54	0.83
Spirodela polyrhiza	Large duckweed	1.00	6	0	3.30	2.54	0.83
Najas flexilis	Slender naiad	1.00	1	1	0.55	0.42	0.14
Carex comosa	Bottle brush sedge	*	*	1	*	*	*
Typha latifolia	Broad-leaved cattail	*	*	4	*	*	*
Polygonum amphibium	Water smartweed	*	*	1	*	*	*
Potamogeton amplifolius	Large-leaf pondweed	*	*	1	*	*	*
Sparganium sp.	Bur-reed	*	*	1	*	*	*

****Visual Only***

Filamentous Algae

Filamentous algae are single algal cells that are microscopic as individuals but they form long filaments of cells that become visible to the naked eye. The filaments entwine to form a mat that resembles wet wool or cotton and remain submerged until enough air is trapped among the filaments to cause a floating mat. Filamentous algae are found in backwaters and near shore areas where nutrients (especially phosphorus) are readily available. At non-nuisance levels, the algae can provide cover for small aquatic organisms that serve as food for fish. However, floating mats of algae are not aesthetically pleasing and they interfere with recreation such as swimming and fishing.

Filamentous algae were present in the project area as floating mats of algae and/or as submersed algae entwined with aquatic plants (Figure 10). It was found at 55 sites with an average rake fullness of 1.25 and was visually observed near another 10 survey sites. Reducing surface input of nutrients into the river is an important step toward management of nuisance algae.

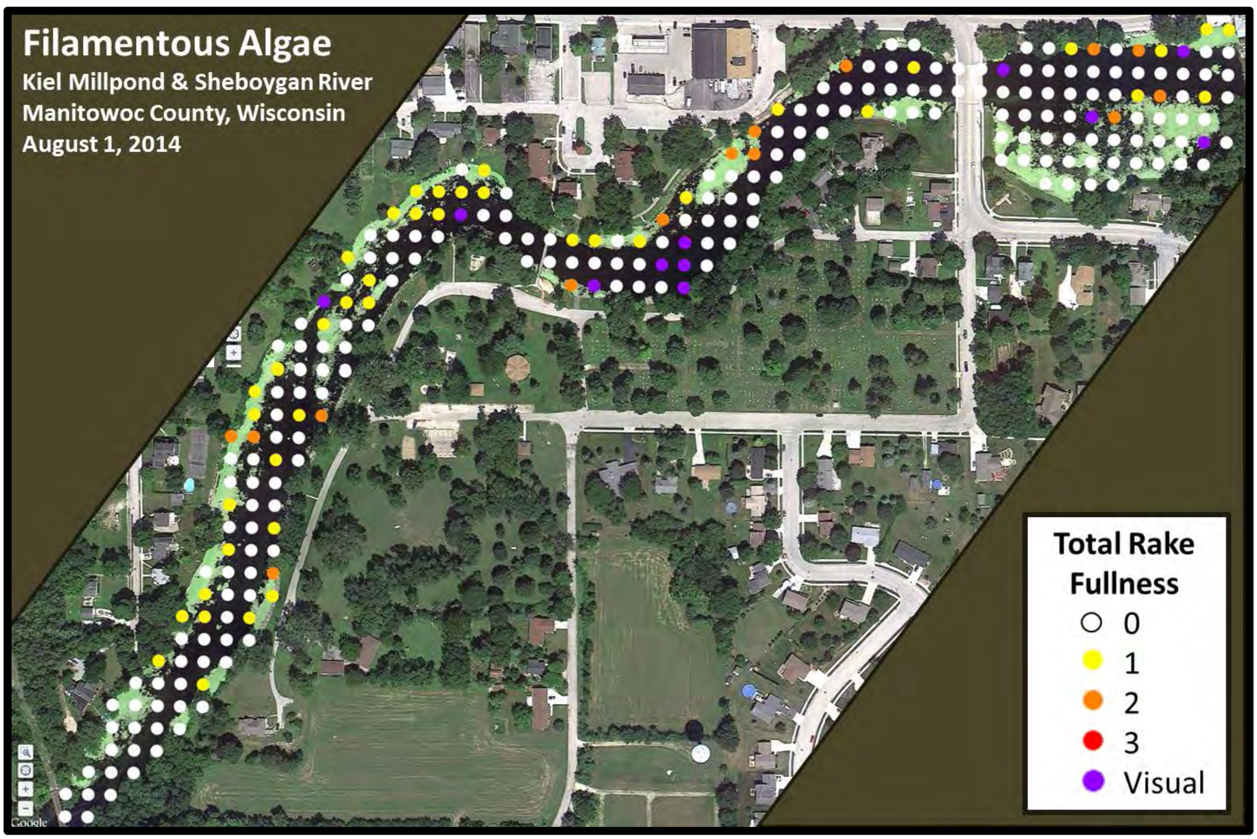

Figure 10 - Filamentous Algae Locations & Rake Fullness

Eurasian Water-milfoil

Eurasian water-milfoil (EWM) was found throughout the project area at 77 sites compared to 62 sites during the spring survey. Most EWM findings had a rake fullness of 1, some had a rake fullness of 2, and only one site had the most abundant rake fullness possible of 3 (Figure 11). The relative frequency was 10.65% and average rake fullness was 1.18.

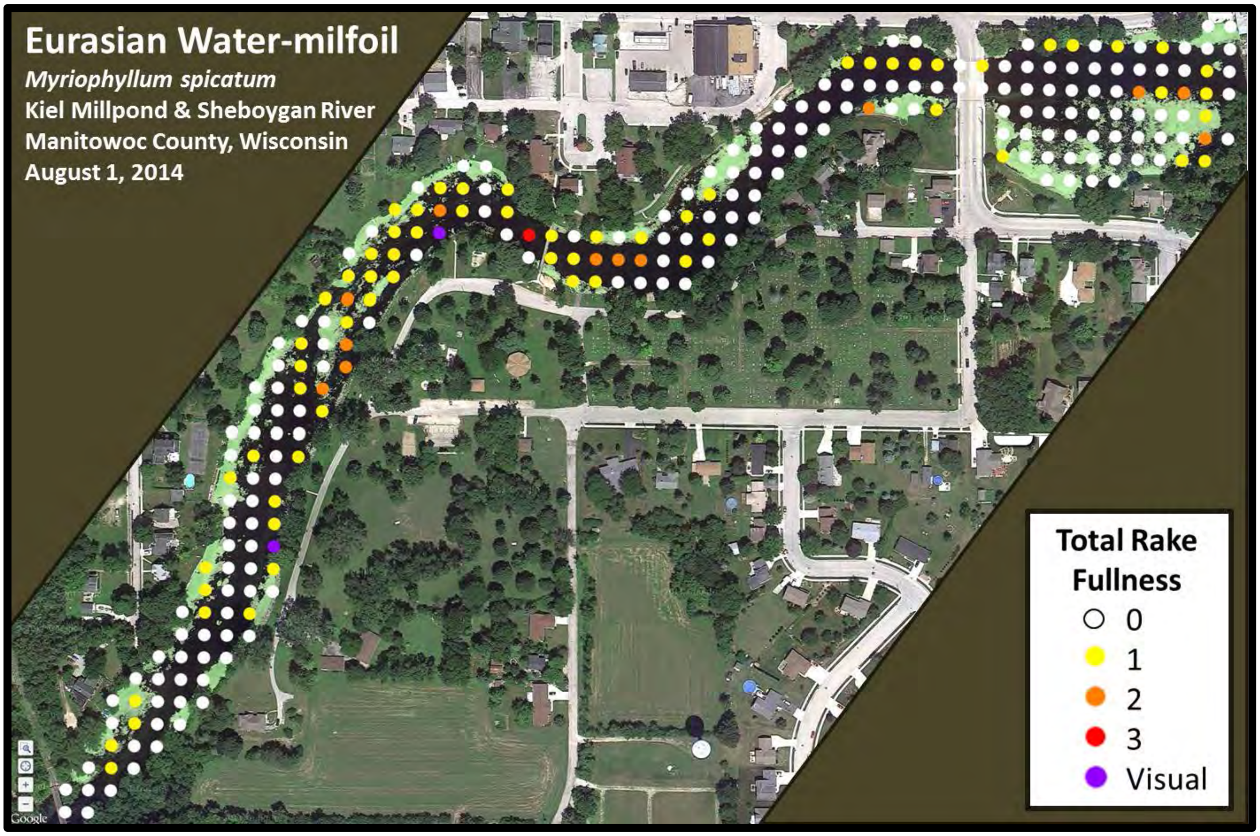

Figure 11 - Summer EWM Locations and Rake Fullness

Curly-leaf Pondweed

Curly-leaf pondweed (CLP) was found at 14 sites during the summer in comparison to 26 sites during the spring survey. The average rake fullness was 1.07. Although CLP is surveyed in the spring because it begins to die back in July, the summer survey revealed specimens that were still quite healthy.

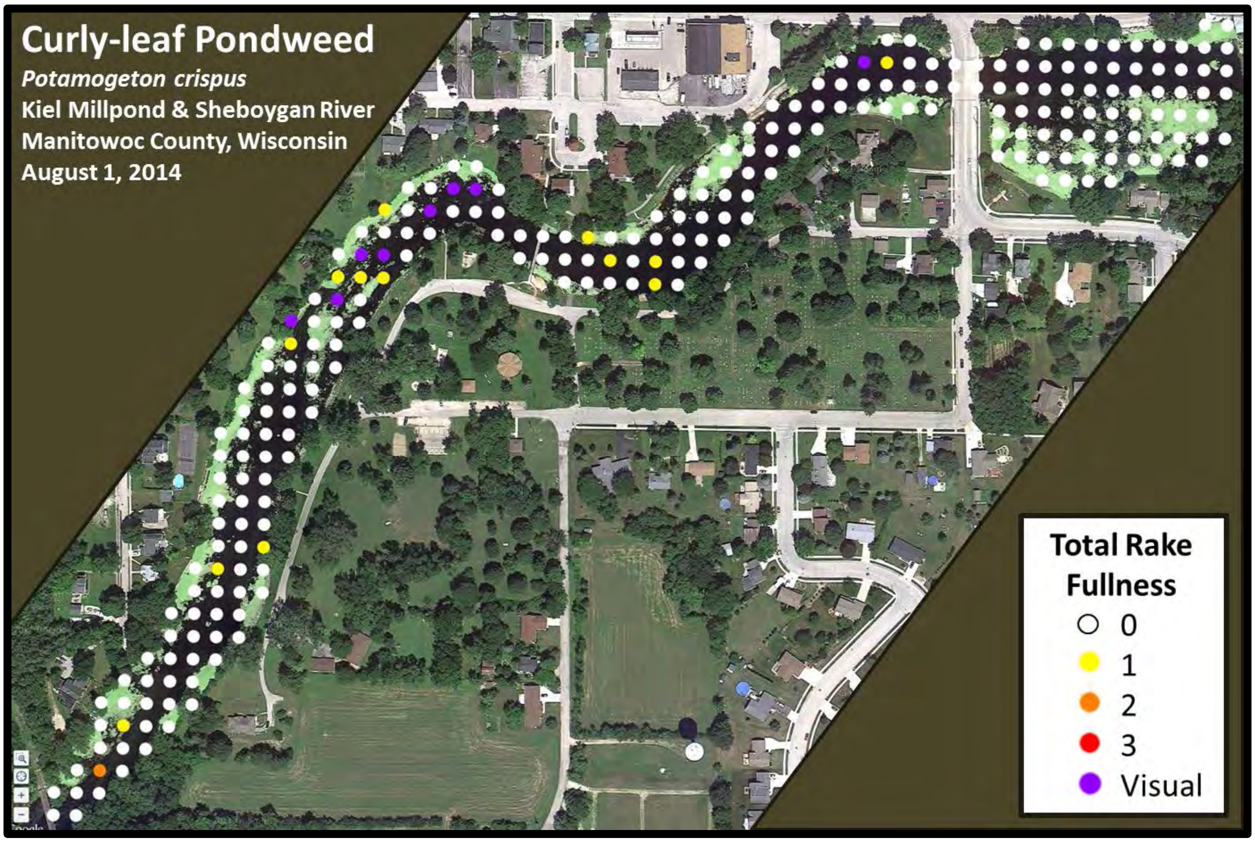

Figure 12 - Summer CLP Locations and Rake Fullness

Lake Sediment

The dominant lake sediment type within the project area was rock at 126 points (51%). Muck was also common as the dominant sediment type at 103 points (42%) while sand was rare at only 19 points (7%). The millpond alone was dominated by muck-bottom sites, especially in the southern half. The majority of the river segment west of the bridge was rocky bottom with some sand and mucky sites (Figure 13).

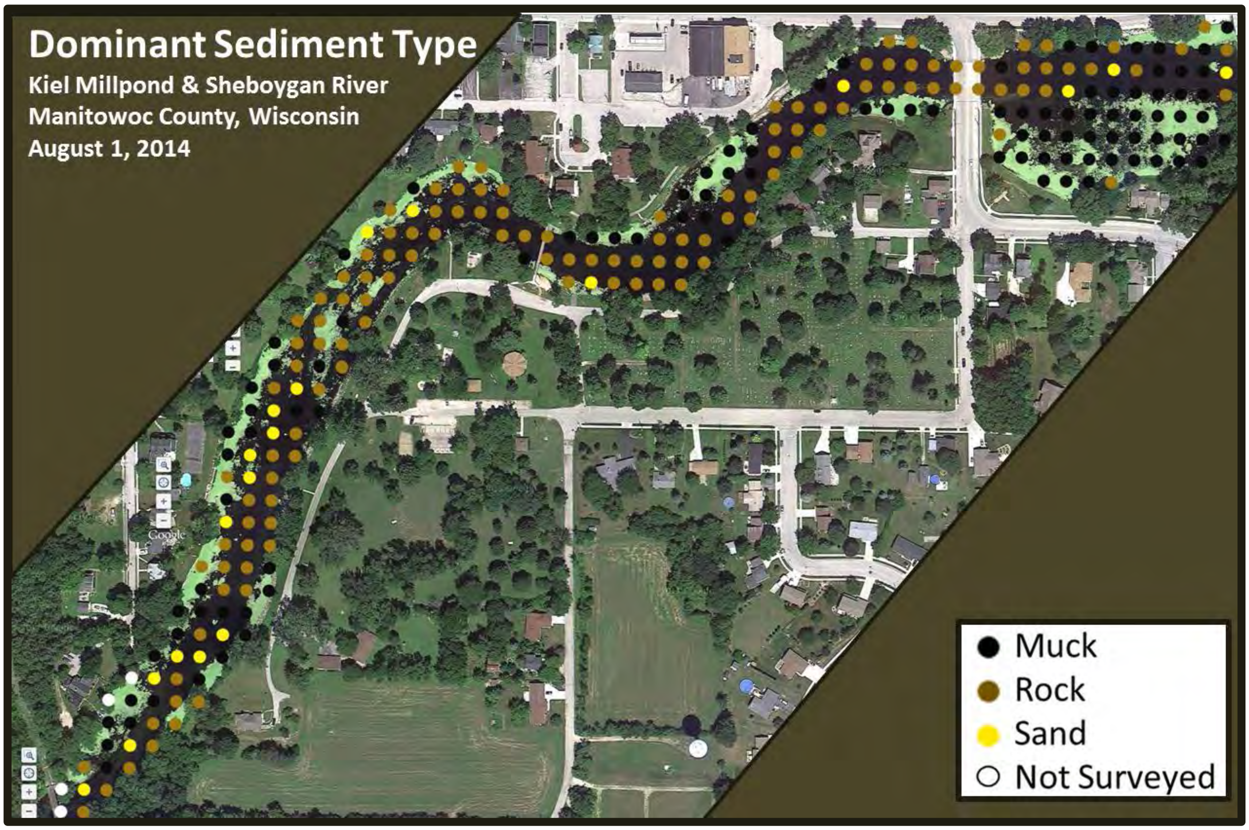

Figure 13 - Dominant Sediment Type Locations

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Aquatic plants serve important functions in lake and river systems. They provide structural habitat for small invertebrates that are an important food source for juvenile game fish and adult panfish. Plants also provide structural habitat for juvenile and small fish to hide from predators and vice versa as larger predators may lurk in the shadows of plants in wait of forage. Aquatic plants also provide foraging and/or hiding structure for reptiles, amphibians, and waterfowl. The shorelines of lakes are buffered from wave action when aquatic plants absorb some of the wave energy. Aquatic plants are important consumers of nutrients that would otherwise be available in lake systems for nuisance algal growth. For these reasons, native aquatic plants should be protected and a healthy aquatic plant community should be promoted.

There are times when native aquatic plants grow to nuisance levels that hinder the aforementioned functions and benefits and also negatively impact recreation. An overabundance of vegetation can cause dissolved oxygen depletion in the water as plants decompose, thereby reducing the oxygen available to fish and other aquatic organisms. Although the natural growth and senescence of aquatic plants is an important part of the cycling of nutrients in lakes, when there are too many plants the system may be out of balance and cause a release of excess nutrients as plant die. The excess nutrients could then serve to increase vegetation and also feed algae blooms.

Overall, the project area has a moderate species richness of 12 species found on the rake and an additional 5 species observed near some survey points. Three of the 12 species are small, floating species with roots that do not establish in the sediment (small duckweed, common watermeal, and large duckweed). These three species were found concentrated in areas with little or no flow and sometimes abundant enough to blanket the surface (Figure 14). Furthermore, small duckweed and watermeal were found in the second and third highest relative frequencies. Options for immediate control of nuisance levels of free-floating species are limited. Landowners could harvest plants within a 30-foot wide section along their shoreline, which would only provide a short-term reprieve unless done regularly. Since these species are often found in nutrient-rich waters, limiting nutrient loading in the Sheboygan River may limit plant growth in a sustainable and more permanent manner.

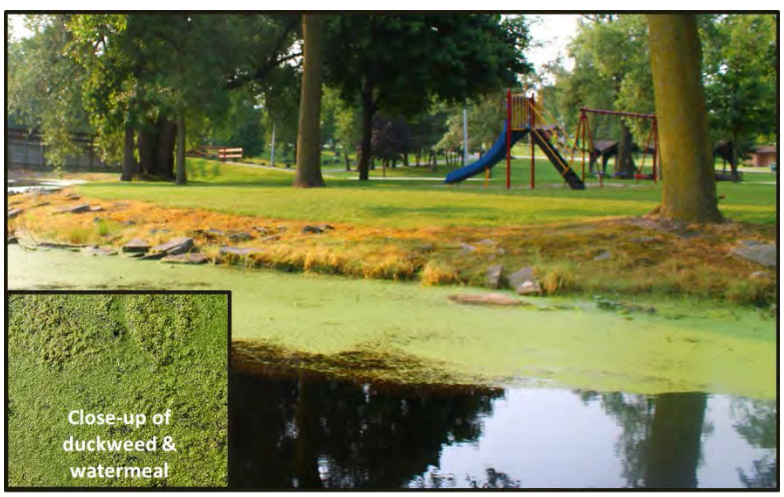

Figure 14 – Blanket of Duckweed and Watermeal

Much of the shoreline throughout the project had no vegetative buffer as demonstrated in Figure 14. Allowing growth of a vegetative buffer along the shoreline would decrease nutrient loading from surface water run-off. Larger scale nutrient management would also be beneficial on a watershed scale, but would require the cooperative efforts of various stakeholders, management professionals, and municipalities. Water quality monitoring would help gauge nutrient levels and therefore is recommended monthly May through September.

Eurasian water-milfoil (EWM) and curly-leaf pondweed (CLP) were the only aquatic invasive species (AIS) found and they occurred throughout much of the project area, including the thalweg where water flow is higher than near-shore areas. EWM had a much higher frequency of occurrence than CLP during the spring survey (EWM 62, CLP 26). However, CLP was observed within 6 feet of survey points at 36 additional survey points, which make the frequency of those two species seem much more comparable. During the summer survey, EWM had a much higher relative frequency of 10.65% than CLP at 1.94%

Although aquatic invasive species are a threat to the project area, the native plant species appeared to pose more of a nuisance in terms of navigation, recreation, and aesthetics. The blanket of duckweed and watermeal is substantial and conspicuous on aerial photo maps, especially in the southern half of the millpond and west bank of the river. Furthermore, the coontail posed a significant hindrance to navigation in the southern half of the millpond. Reducing coontail density would be beneficial for aquatic organisms, including fish, but should be monitored closely to ensure EWM and CLP are not colonized the areas once dominated by nuisance coontail. The use of mechanical harvesters would be a feasible option for management of nuisance vegetation in the millpond.

Protecting native species that occurred with low frequency is recommended. Such species include water star-grass, common bladderwort, white water lily, and slender naiad. Large duckweed also had relatively low occurrence but is not of particular concern for protection because it is often associated with small duckweed, which was present in very high abundance.

Table 9 - Management Recommendations Summary

1. Protect native aquatic plants that were found at low frequencies as they provide important structural habitat and contribute to healthy lake systems.
2. If necessary, shore land owners can hand pull or rake perceived nuisance vegetation in a <30-foot-wide area that is parallel to shore.
3. Conduct volunteer monitoring for water quality (temperature, dissolved oxygen, Secchi, phosphorus, and chlorophyll *a)* to track nutrient levels. .
4. Implement shoreland buffers, especially at city-owned properties, to limit surface water nutrient loading. Explore the feasibility of a watershed-scale nutrient management effort if one has not already been initiated.
5. Reduce coontail abundance in the southern half of the millpond, possibly by using mechanical harvesters. Monitor sites with reduced nuisance native plants to ensure they are not being replaced by EWM and/or CLP.

REFERENCES

Crow, G.E. and C.B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America, Volumes 1 & 2. University of Wisconsin Press. Madison, Wisconsin.

Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, Wisconsin. 46pp.

Nichols, S.A. 1999. Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management. 15(2):133-141.

Skawinski, P.M. 2010. Aquatic Plants of Wisconsin: A photographic field guide to submerged and floating-leaf aquatic plants.

UWEX. 2013. Aquatic Plant Survey Data Workbook. University of Wisconsin Extension Aquatic Plant Management in Wisconsin. 1 Aug. 2014. http://www.uwsp.edu/cnr-ap/UWEXLakes.

APPENDIX A – PLANT SURVEY MAPS

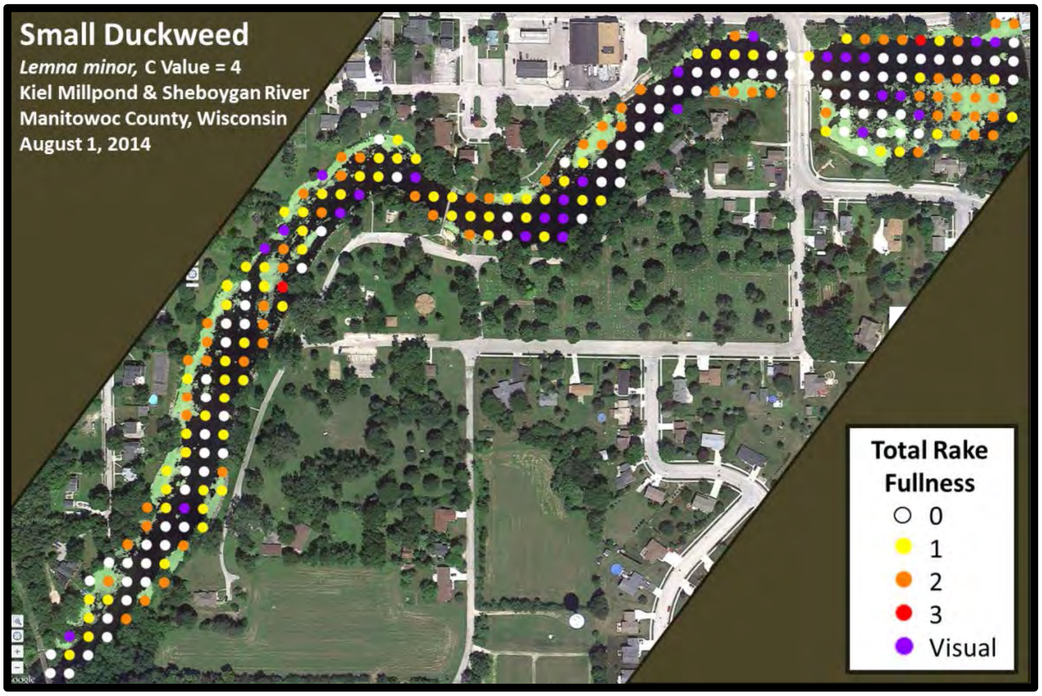

Figure 15 - Small Duckweed Locations & Rake Fullness

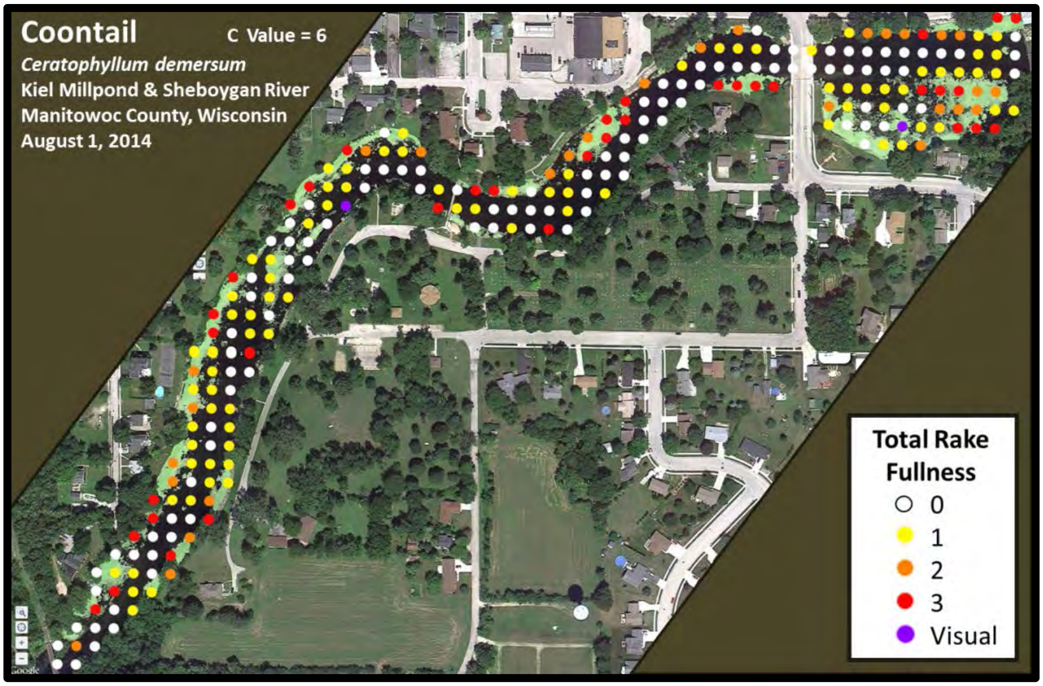

Figure 16 - Coontail Locations & Rake Fullness

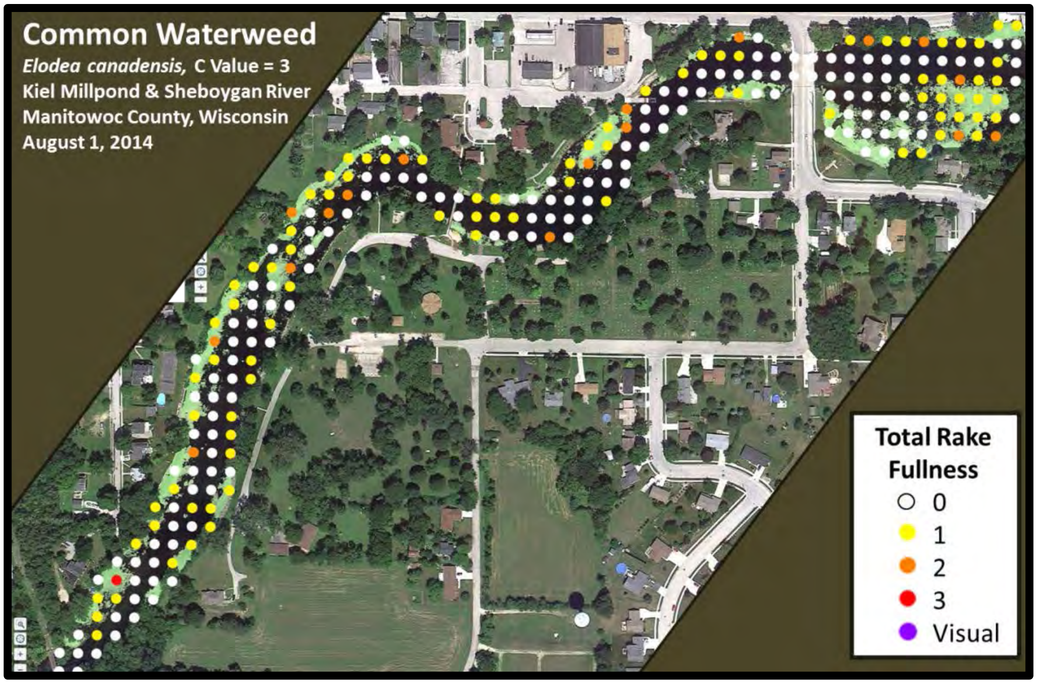

Figure 17 - Common Waterweed Locations & Rake Fullness

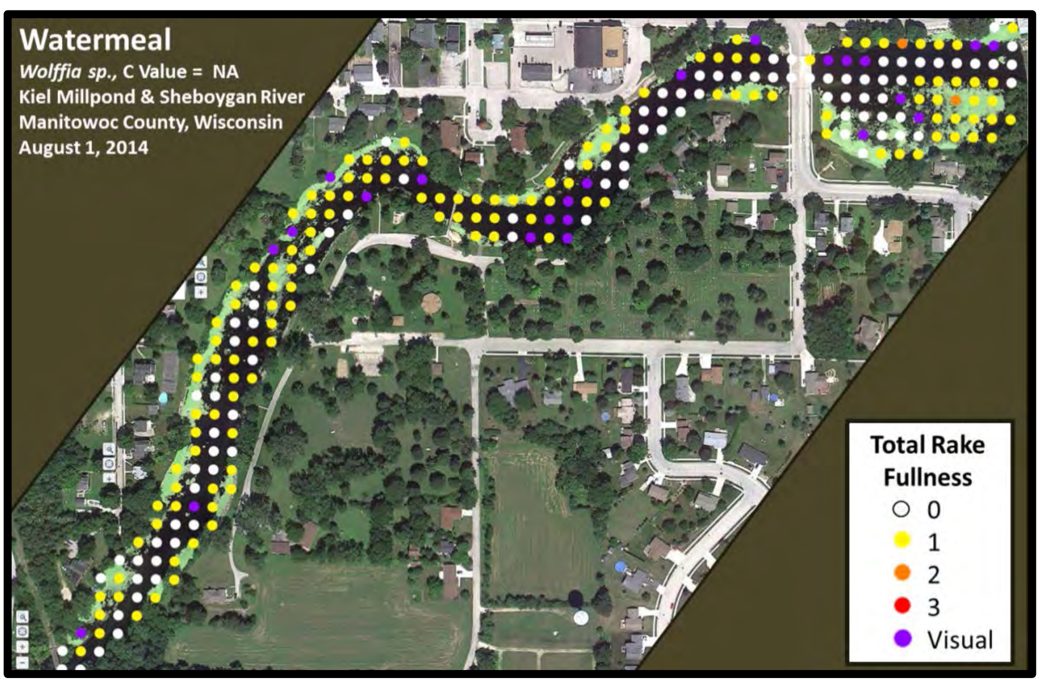

Figure 18 - Watermeal Locations & Rake Fullness

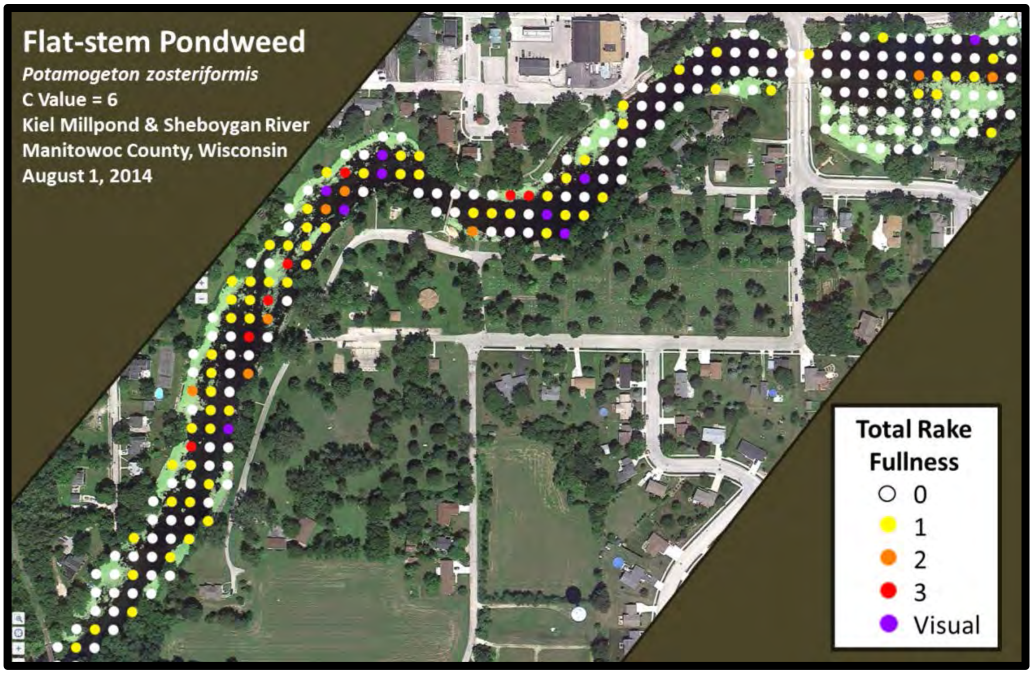

Figure 19 - Flat-stem Pondweed Locations & Rake Fullness

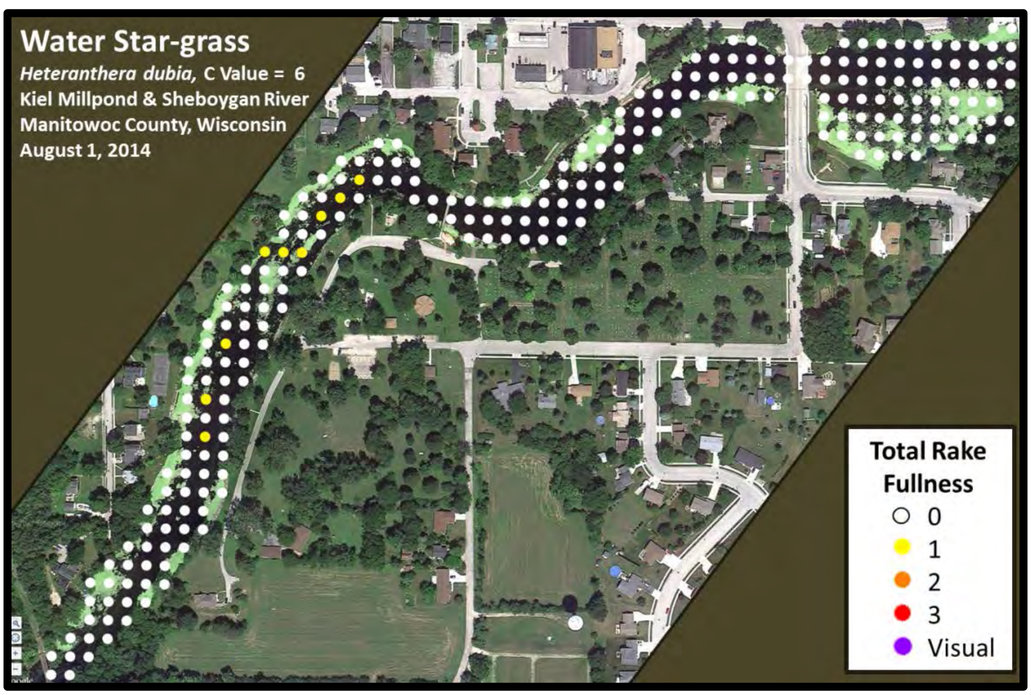

Figure 20 - Water Star-grass Locations & Rake Fullness

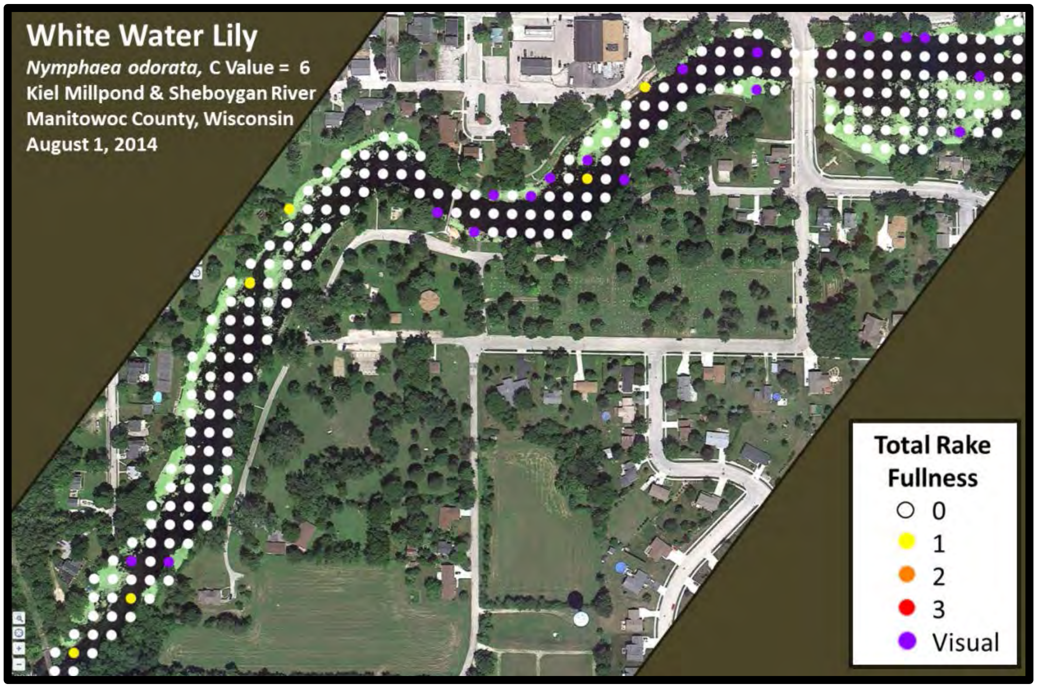

Figure 21 - White Water Lily Locations & Rake Fullness

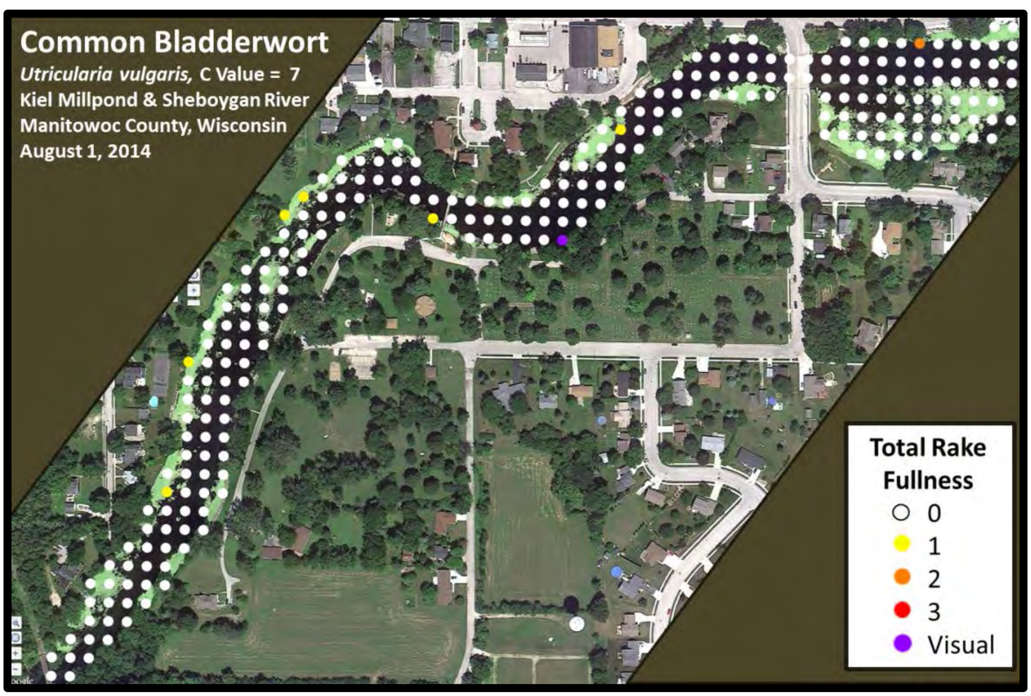

Figure 22 - Common Bladderwort Locations and Rake Fullness

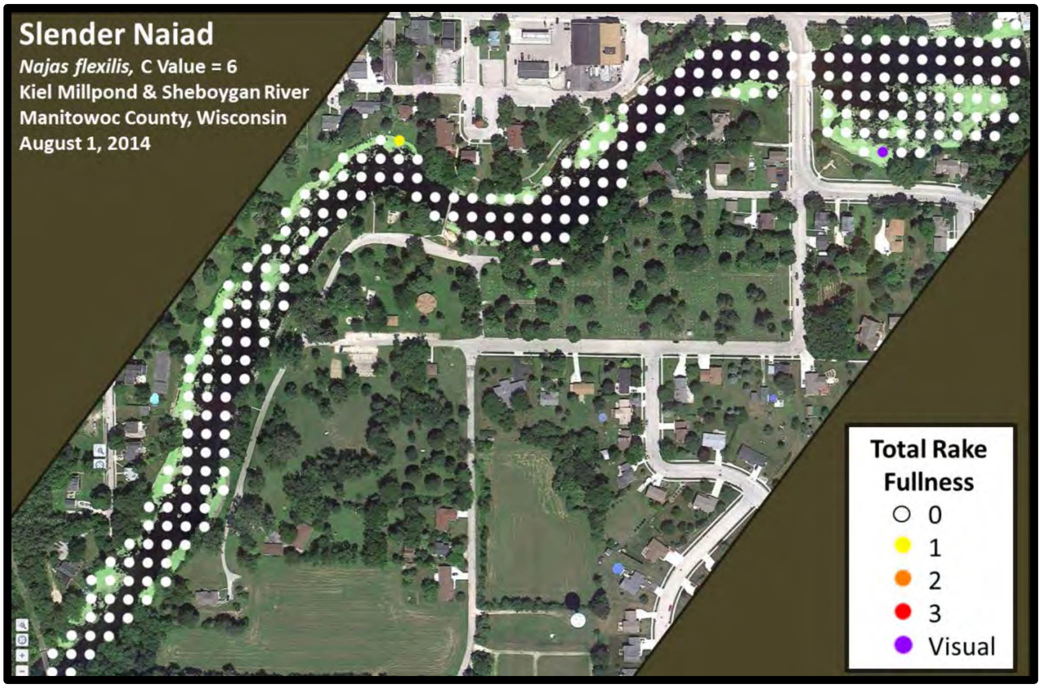

Figure 23 - Slender Naiad Locations & Rake Fullness

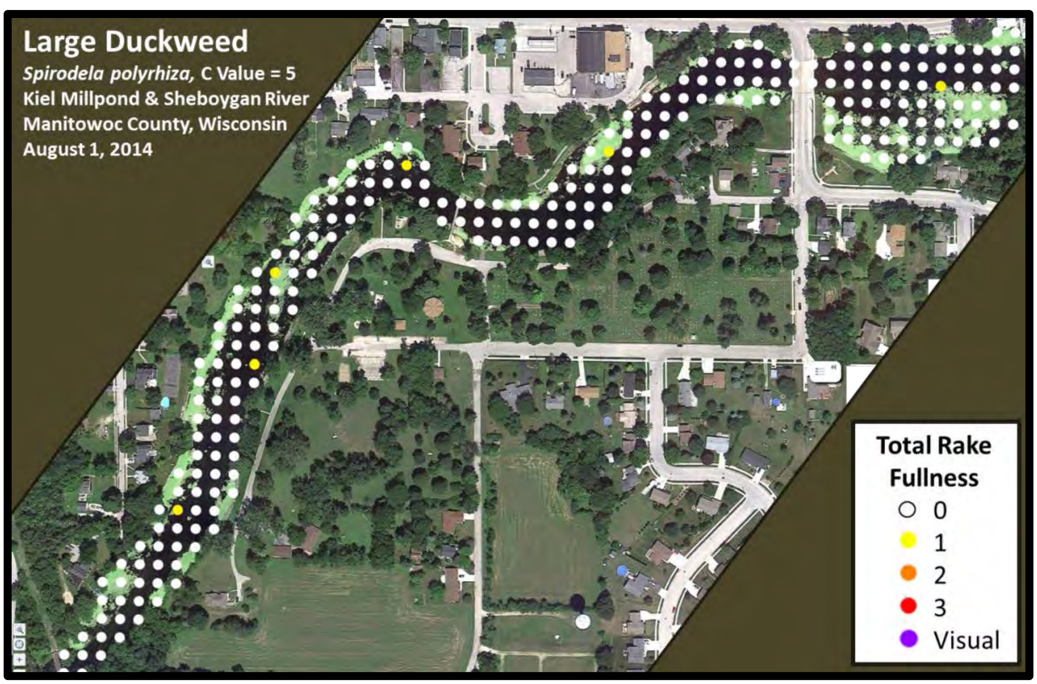

Figure 24 - Large Duckweed Locations & Rake Fullness

Preliminary Results: Early Season Aquatic Plant Survey

Kiel Millpond & Sheboygan River

Manitowoc County, Wisconsin

Project initiated by:
City of Kiel
Short, Elliot, and Hendrickson, Inc.

Survey and report completed by:
Aquatic Plant & Habitat Services, LLC
Sara Hatleli
N4236 State Highway 54
Black River Falls, WI 54615
715-299-4604
sarahatleli97@gmail.com

BACKGROUND

The City of Kiel has partnered with Short, Elliot, & Hendrickson (SEH) Inc. to initiate a lake management process in 2014. Aquatic Plant and Habitat Services LLC (APHS) is partnering with SEH to complete certain aspects of the lake management planning. This report of initial findings is intended to fulfill item #1 in the proposal submitted to SEH.

> *"A spring survey (May or June) will be conducted with the express intent of surveying for Curly-leaf pondweed and Eurasian water-milfoil. Survey points will be those252 points generated by the Wisconsin Department of Natural Resources. Methods will follow Hauxwell et al. (2010)[1]. A summary of results will be submitted to SEH within one week of the survey. Two voucher specimens (if found) will be collected, pressed, mounted, and submitted to the Wisconsin State Herbarium and the City of Kiel via SEH."*

A complete report (including an abstract, introduction, field methods, data analysis methods, results, discussion, and management recommendations based on this survey, a soft sediment depth survey, and cross-sectional depth survey) will be submitted to SEH by December 31, 2014 or earlier if requested and agreed upon by all parties.

STUDY SITE

The study site includes a stretch of the Sheboygan River and a small millpond in the City of Kiel (WBIC 50700 & 5560113) totaling 13 acres in Manitowoc County, Wisconsin (T17N, R21E, S30). The Kiel Millpond is created by a 10-ft dam owned by the city and maintained to provide recreational opportunities. The project area continues upstream from the millpond and ends at the railroad tressel on the western edge of the city. The water of the Sheboygan River is dystrophic, meaning it is tea-colored due to the high concentrations of humic substances and organic acids. This is natural in some lakes and rivers and not cause for concern. Eurasian water-milfoil and curly-leaf pondweed were documented in the river before this survey.

METHODS

Field Methods

The Wisconsin Department of Natural Resources generated a map of 252 sample points within the 13-acre project area. The survey points were spaced approximately 50ft (15m) apart (Figure 1). Methods followed Hauxwell, 2010[1]. The sample points were uploaded to a hand-held GPS unit (Garmin 76CSx), which was used at 30 feet of resolution to navigate to each point. A double-sided rake head on a telescopic pole was used to sample each point for invasive species of aquatic plants, depth, and dominant sediment type (muck, rock, or sand). The rake fullness rating for total coverage of plants (native species and invasive species) on the rake and a separate rake fullness rating for each invasive species present were recorded (Figure 2). Any survey points that were inaccessible were recorded as such and no sample was taken. The survey was conducted on May 25, 2014. Two voucher specimens of invasive species were collected to provide to SEH/City of Kiel and the herbarium at UW-Madison. Specimens were also used to verify plant identification using Crow and Hellquist (2000) and Skawinski (2010).

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[1] Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, Wisconsin, USA.

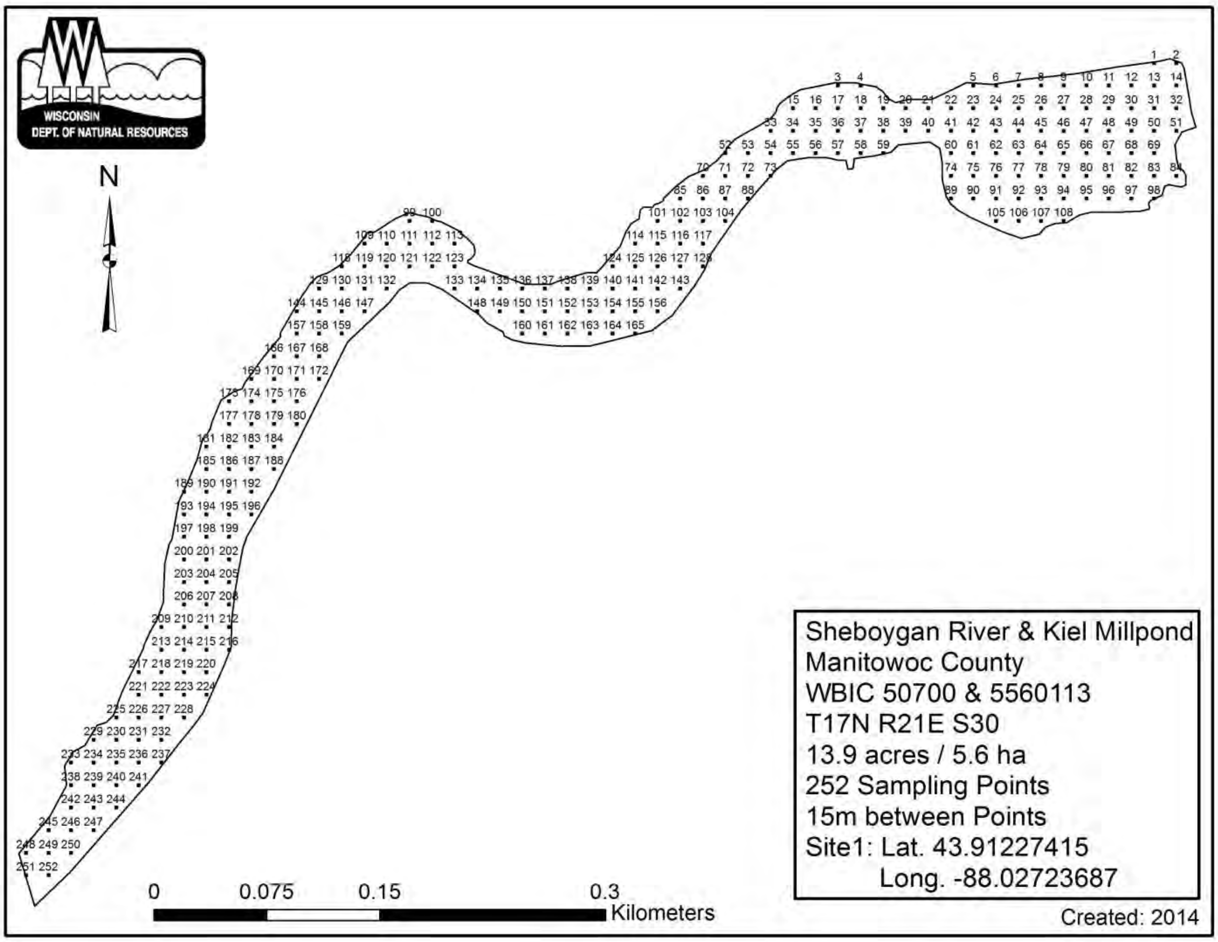


Figure 1 - Point Intercept Survey Map of Kiel Millpond & Sheboygan River

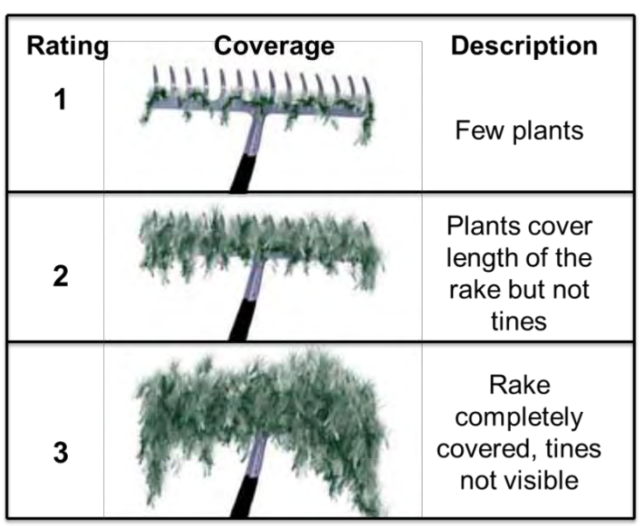


Figure 2 – Rake fullness rating illustration adapted from Hauxwell (2010).

Data Analysis Methods

Survey data were used to calculate various summary statistics. The "Aquatic Plant Survey Data Workbook" was downloaded from the UWEX Lakes page (2013) and the spreadsheet was populated with data collected from the Kiel Millpond and Sheboygan River.

Summary Statistics

From the "Aquatic Plant Survey Data Workbook," several summary statistics were calculated (Table 1). These statistics provide a general overview of the invasive species from a whole-lake perspective and can be used in management decisions.

Table 1 – Summary statistics for invasive plant species survey data and explanations for calculating statistics

	Summary Statistic	Explanation
1	Total number of sites visited	The total number of sites sampled, which is not necessarily equal to the number of survey points because some sites may not be accessible.
2	Total number of sites with CLP or EWM	Number of sites where at least one invasive species was found on the rake
3	Maximum depth of invasive species	Depth of deepest site where at least one invasive species was found on the rake
4	Total number of sites shallower than maximum depth of invasive species	Number of sites where depth was less than or equal to the maximum depth where at least one invasive species was found on the rake.
5	Frequency of occurrence at sites shallower than maximum depth of invasive species	Total number of sites with invasive species (2) / Total number of sites shallower than maximum depth of invasive species (4).

Individual Species Statistics

From the "Aquatic Plant Survey Data Workbook," several individual species statistics were calculated (Table 2). These statistics take a closer look at the invasive species composition in Kiel Millpond and Sheboygan River.

Table 2 - Individual statistics for invasive plant species survey data and explanations for calculating statistics

	Individual Statistic	Explanation
11	Average Rake Fullness	Mean rake fullness rating ranging from 1 to 3 for the entire lake or for a particular species.
12	Number of sites where a species was found	The total number of survey points where a particular species was found on the rake.
13	Number of visual sightings	The total number of times a particular species was visually observed within 6 feet of a sampling point, but not collected on the rake

RESULTS

A total of 252 survey points were attempted based on the WDNR point intercept survey map (Figure 1). A total of 247 survey points were actually visited during the survey on May 25, 2104. One survey point was inaccessible because it was located under a building near the millpond dam. Four survey points were not accessible because anglers were present. These four survey points were attempted twice each, but anglers were present each time and survey crew felt courtesy was important.

Invasive Aquatic Plant Species Survey

Curly-leaf pondweed (CLP) and Eurasian water-milfoil (EWM) were found during the May 25th survey. A total of 247 survey points were visited and invasive species (EWM and/or CLP) were found at 79 (of those sites. The maximum depth at which invasive species were found was 7 feet. The number of sites shallower than this maximum depth of 7 feet was 234. Therefore, invasive species were found at 33.76% of sites shallower than the maximum depth of invasive plants (79 divided by 234) (

Table 3).

Curly-leaf pondweed was found at 26 sites while Eurasian water-milfoil was found at 62 sites. CLP was more commonly located visually (36 sites) than sampled on the rake while EWM was visually observed at 2 survey points (Table 4). Survey points where CLP was found on the rake ranged in depth from 2 to 6 feet predominantly with muck sediment (17 points) but also with rocky substrate (9 points). EWM was found growing in depths ranging from 1.5 to 7 feet predominantly in muck sediment (32 points), then in rocky substrate (24 points), and least commonly in sand sediment (6 points).

A high abundance of coontail (*Ceratophyllum demersum*) and presence of *Nitella sp.* (a macroalgae), western waterweed (*Elodea nutallii*), and bladderwort (*Utricularia sp.*), were noted; however the complete aquatic plant survey in summer 2014 will provide a full species list.

Table 3 – Summary statistic results for the invasive plant species survey.

	Summary Statistic	Results
1	Total number of sites visited	**247**
2	Total number of sites with invasive plant species	**79**
3	Maximum depth of invasive plant species	**7 feet**
4	Total number of sites shallower than maximum depth of invasive plant species	**234**
5	Frequency of occurrence at sites shallower than maximum depth of invasive species	**33.76%**

Table 4 – Individual species statistics for the invasive species survey

Common Name	Scientific Name	Average Rake Fullness	# Sites	# Visual
Curly-leaf pondweed	*Potamogeton crispus*	1	26	36
Eurasian water-milfoil	*Myriophyllum spicatum*	1.02	62	2

Depth Survey

The maximum depth recorded in the project site was 9ft at survey point 231 in the Sheboygan River. The maximum depth recorded in the Kiel Millpond was 8.5ft at survey points 28 and 29 in the north central area of the basin. The average depth was 4.29ft while the median depth was 4ft (Figure 3). Twenty-five percent (25%) of sites were between 0 and 3 feet deep while 65% were 3.5-6 feet and the remaining 10% were 6.5-9 feet deep.

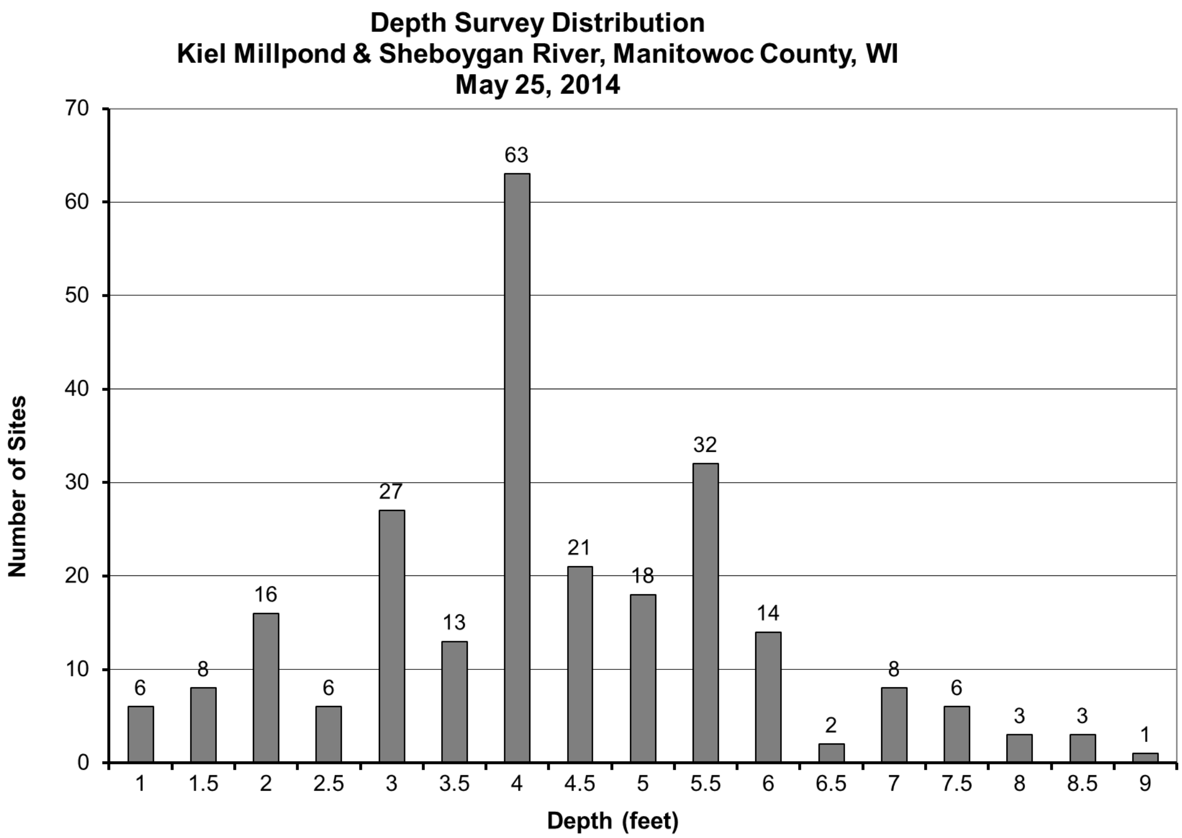


Figure 3 - Depth Survey Results

Sediment Survey

The dominant sediment type recorded on May 25, 2014 was muck at 131 survey points (53%) followed by rock at 92 points (37%) and sand at the remaining 24 points (10%). Not surprising, the majority of the rock and sand sites seemed to be located in the thalweg (the line of lowest elevation in a waterway) where flowing water prevents sedimentation of finer and lighter materials such as fine organics or muck.

DISCUSSION

Curly-leaf pondweed can tolerate low light conditions and low temperatures allowing it to out-compete many native species because it can grow while lakes are ice-covered. CLP usually senesces as the native aquatic plant species mature in summer, making it difficult to obtain actual presence and abundance data during the summer aquatic plant survey. Therefore, this early season survey was important to assess the occurrence and rake fullness ratings of CLP.

Overall, Eurasian water-milfoil and/or curly-leaf pondweed were found at approximately one-third of the 252 survey points in the project area. The rake fullness rating for both species was 1 at most sites. There were no monotypic stands of either species observed during the survey. However, coontail (*Ceratophyllum demersum*) was observed at many sites with a rake fullness rating of 3. These initial results indicate that CLP may not be as much of a nuisance plant as the native coontail. The summer aquatic plant survey should provide more insight in this regard.

REFERENCES

Crow, G.E. and C.B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America, Volumes 1 & 2. University of Wisconsin Press. Madison, Wisconsin.

Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, Wisconsin. 46pp.

Skawinski, P.M. 2010. Aquatic Plants of Wisconsin: A photographic field guide to submerged and floating-leaf aquatic plants.

Summary of Results

for the

Kiel Millpond & Sheboygan River Surveys

On August 1st and 2nd of 2014, Aquatic Plant and Habitat Services LLC completed an aquatic plant survey, soft sediment depth survey, and cross sectional depth survey of the Kiel Millpond and upstream segment of the Sheboygan River ending at the railroad bridge. The information presented here is intended to serve as a brief overview of the results from those surveys for the purpose of updating the City of Kiel during a conference call scheduled for August 28th, 2014. Further data analysis and more detailed information will be included in a final report to the City of Kiel via SEH Inc.

Aquatic Plant Survey

- Maximum rooting depth of plants was 7 feet
- 248 survey sites were visited, 236 of which were 7 feet deep or shallower
- 182 sites with plants / 236 sites shallower than max. root depth = 77.12% sites with veg.
- Number of different species found = 17 (12 species actually at survey sites)
- Eurasian water-milfoil was found at 77 sites (compared to 62 in May 2014)
- Curly-leaf pondweed was found at 14 sites (compared to 26 in May 2014)
- Coontail was the most common plant found at 145 survey sites. Other common plants included flat-stem pondweed, common waterweed, duckweed, and watermeal (all native species)

Soft Sediment Depth Survey

- Same 248 survey sites were used to assess soft sediment depth
- 126 sites were rock with no soft sediment
- 103 sites were muck with soft sediment depths ranging from 0-6 feet
- 19 sites were sand with soft sediment depths ranging from 0-2.5 feet
- Maps created by SEH will illustrate soft sediment to better understand locations of sediment deposition

Cross Sectional Depth Survey

- 6 transects were measured starting at the east bank and working toward the west bank. Depth was measured at intervals along transects similar to methods used during the 1994 WDNR survey.
- One transect was in the millpond near the widest point and the rest were within the Sheboygan River
- Total transect width ranged from 135 feet to 170 feet in the river segments and 310 feet in the millpond
- Depth along transects ranged from 1.5 feet to 9.5 feet

Twohigs
234 5th St.

CITY OF KIEL
SHEBOYGAN RIVER ACTIVITY LOG

DATE	TIME OF DAY	ACTIVITY DESCRIPTION
6/15		3 kayaks
6/17		1 swimmer (1+ hrs)
6/25	2:15	Family of 3 fishing
7/4	10:15	2 canoes / 4 kayaks
	2:30 - 4:00	1 canoe / 7 kayaks
	4:30	2 kayaks
7/11	afternoon	man / 2 boys fishing
		1 boat → 3 people
		1 kayak
7/12	afternon	4 people fishing
		2 boys on kayak
	3:45	2 boys on kayak
7/17	afternoon	man fishing
7/18	morning	man fishing
	noon	man enjoying lunch in turnaround
7/27	AM	2 adults in paddle boat
	afternoon	2 men canoeing
8/1	PM	hired people taking
8/2	a.m	water samples
	pm	2 people boating
8/3	a.m.	2 adults in 2 kayaks

CITY OF KIEL
SHEBOYGAN RIVER ACTIVITY LOG

DATE	TIME OF DAY	ACTIVITY DESCRIPTION
8/6.	a.m.	2 kayaks
8/9	pm	2 girls in blow up boat
8/27	2:45	3 kayaks

Management Options for Aquatic Plants

Updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
No management	N	Do not actively manage plants	Minimizing disturbance can protect native species that provide habitat for aquatic fauna, reduce shoreline erosion, may improve water clarity, and may limit spread of invasive species	May allow small population of invasive plants to become larger, more difficult to control later
			No financial cost	Excessive plant growth can hamper navigation and recreational lake use
			No system disturbance	May require modification of lake users' behavior and perception
			No unintended effects of chemicals	
			Permit not required	
Mechanical Control	May be required under NR 109	Plants reduced by mechanical means	Flexible control	Must be repeated, often more than once per season
		Wide range of techniques, from manual to highly mechanized	Can balance habitat and recreational needs	Can suspend sediments and increase turbidity and nutrient release
a. Handpulling/Manual raking	Y/N	SCUBA divers or snorkelers remove plants by hand or plants are removed with a rake	Little to no damage done to lake or to native plant species	Very labor intensive
		Works best in soft sediments	Can be highly selective	Needs to be carefully monitored
			Can be done by shoreline property owners without permits within an area <30 ft wide OR where selectively removing exotics	Roots, runners, and even fragments of some species, particularly Eurasian watermilfoil (EWM) will start new plants, so all of plant must be removed
			Can be very effective at removing problem plants, particularly following early detection of an invasive exotic species	Small-scale control only

Management Options for Aquatic Plants

Updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
b. Harvesting	Y	Plants are "mowed" at depths of 2-5 ft, collected with a conveyor and off-loaded onto shore	Immediate results	Not selective in species removed
		Harvest invasives only if invasive is already present throughout the lake	EWM removed before it has the opportunity to autofragment, which may create more fragments than created by harvesting	Fragments of vegetation can re-root
			Usually minimal impact to lake ecology	Can remove some small fish and reptiles from lake
			Harvested lanes through dense weed beds can increase growth and survival of some fish	Initial cost of harvester expensive
			Can remove some nutrients from lake	
Biological Control	Y	Living organisms (e.g. insects or fungi) eat or infect plants	Self-sustaining; organism will over-winter, resume eating its host the next year	Effectiveness will vary as control agent's population fluctates
			Lowers density of problem plant to allow growth of natives	Provides moderate control - complete control unlikely
				Control response may be slow
				Must have enough control agent to be effective
a. Weevils on EWM	Y	Native weevil prefers EWM to other native water-milfoil	Native to Wisconsin: weevil cannot "escape" and become a problem	Need to stock large numbers, even if some already present
			Selective control of target species	Need good habitat for overwintering on shore (leaf litter) associated with undeveloped shorelines
			Longer-term control with limited management	Bluegill populations decrease densities through predation

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Pathogens	Y	Fungal, bacterial, or viral pathogen introduced to target species to induce mortalitiy	May be species specific May provide long-term control Few dangers to humans or animals	Largely experimental; effectiveness and longevity unknown Possible side effects not understood
c.	Allelopathy	Y	Aquatic plants release chemical compounds that inhibit other plants from growing	May provide long-term, maintenance-free control Spikerushes (*Eleocharis* spp.) appear to inhibit Eurasian watermilfoil growth	Initial transplanting slow and labor-intensive Spikerushes native to WI, and have not effectively limited EWM growth Wave action along shore makes it difficult to establish plants; plants will not grow in deep or turbid water
d.	Native plantings	Y	Diverse native plant community established to compete with invasive species	Native plants provide food and habitat for aquatic fauna Diverse native community more repellant to invasive species	Initial transplanting slow and labor-intensive Nuisance invasive plants may outcompete plantings Transplants from another lake or nursery may unintentionally introduce invasive species Largely experimental; few well-documented cases

Management Options for Aquatic Plants

Updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
Physical Control	Required under Ch. 30 / NR 107	Plants are reduced by altering variables that affect growth, such as water depth or light levels		
a. Fabrics/ Bottom Barriers	Y	Prevents light from getting to lake bottom	Reduces turbidity in soft-substrate areas	Eliminates all plants, including native plants important for a healthy lake ecosystem
			Useful for small areas	May inhibit spawning by some fish
				Need maintenance or will become covered in sediment and ineffective
				Gas accumulation under blankets can cause them to dislodge from the bottom
				Affects benthic invertebrates
				Anaerobic environment forms that can release excessive nutrients from sediment
b. Drawdown	Y, May require Environmental Assessment	Lake water lowered with siphon or water level control device; plants killed when sediment dries, compacts or freezes	Winter drawdown can be effective at restoration, provided drying and freezing occur. Sediment compaction is possible over winter	Plants with large seed bank or propagules that survive drawdown may become more abundant upon refilling
		Season or duration of drawdown can change effects	Summer drawdown can restore large portions of shoreline and shallow areas as well as provide sediment compaction	May impact attached wetlands and shallow wells near shore
			Emergent plant species often rebound near shore providing fish and wildlife habitat, sediment stabilization, and increased water quality	Species growing in deep water (e.g. EWM) that survive may increase, particularly if desirable native species are reduced
			Success demonstrated for reducing EWM, variable success for curly-leaf pondweed (CLP)	Can affect fish, particularly in shallow lakes if oxygen levels drop or if water levels are not restored before spring spawning
			Restores natural water fluctuation important for all aquatic ecosystems	Winter drawdawn must start in early fall or will kill hibernating reptiles and amphibians
				Navigation and use of lake is limited during drawdown

Management Options for Aquatic Plants

Updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
c.	Dredging	Y	Plants are removed along with sediment	Increases water depth	Severe impact on lake ecosystem
			Most effective when soft sediments overlay harder substrate	Removes nutrient rich sediments	Increases turbidity and releases nutrients
			For extremely impacted systems	Removes soft bottom sediments that may have high oxygen demand	Exposed sediments may be recolonized by invasive species
			Extensive planning required		Sediment testing may be necessary
					Removes benthic organisms
					Dredged materials must be disposed of
d.	Dyes	Y	Colors water, reducing light and reducing plant and algal growth	Impairs plant growth without increasing turbidity	Appropriate for very small water bodies
				Usually non-toxic, degrades naturally over a few weeks.	Should not be used in pond or lake with outflow
					Impairs aesthetics
					Effects to microscopic organisms unknown
e.	Non-point source nutrient control	N	Runoff of nutrients from the watershed are reduced (e.g. by controlling construction erosion or reducing fertilizer use) thereby providing fewer nutrients available for plant growth	Attempts to correct source of problem, not treat symptoms	Results can take years to be evident due to internal recycling of already-present lake nutrients
				Could improve water clarity and reduce occurrences of algal blooms	Requires landowner cooperation and regulation
				Native plants may be able to better compete with invasive species in low-nutrient conditions	Improved water clarity may increase plant growth

Management Options for Aquatic Plants

Updated Oct 2006

Option	Permit Needed?	How it Works	PROS	CONS
Chemical Control	Required under NR 107	Granules or liquid chemicals kill plants or cease plant growth; some chemicals used primarily for algae	Some flexibility for different situations	Possible toxicity to aquatic animals or humans, especially applicators
		Results usually within 10 days of treatment, but repeat treatments usually needed	Some can be selective if applied correctly	Often affect desirable plant species that are important to lake ecology and compete with invasive species
		Chemicals must be used in accordance with label guidelines and restrictions	Can be used for restoration activities	Treatment set-back requirements from potable water sources and/or drinking water use restrictions after application, usually based on concentration
				May cause severe drop in dissolved oxygen causing fish kill, depends on plant biomass killed, temperatures and lake size and shape
				Often controversial
a. 2,4-D (e.g. Weedar, Navigate)	Y	Systemic[1] herbicide selective to broadleaf[2] plants that inhibits cell division in new tissue	Moderately to highly effective, especially on EWM	May cause oxygen depletion after plants die and decompose
		Applied as liquid or granules during early growth phase	Monocots, such as pondweeds (e.g. CLP) and many other native species not affected.	May affect native dicots such as water lilies and coontail
			Can be used in synergy with endothall for early season CLP and EWM treatments	Cannot be used in combination with copper herbicides (used for algae)
			Can be selective depending on concentration and seasonal timing	Toxic to fish
			Widely used aquatic herbicide	

Management Options for Aquatic Plants

Updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
b.	Endothall (e.g. Aquathol)	Y	Broad-spectrum[3], contact[4] herbicide that inhibits protein synthesis	Especially effective on CLP and also effective on EWM	Affects many native pondweeds
			Applied as liquid or granules	May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring	Not as effective in dense plant beds; heavy vegetation requires multiple treatments
				Can be selective depending on concentration and seasonal timing	Not to be used in water supplies; post-treatment restriction on irrigation
				Can be combined with 2,4-D for early season CLP and EWM treatments, or with copper compounds	Toxic to aquatic fauna (to varying degrees)
				Limited off-site drift	
c.	Diquat (e.g. Reward)	Y	Broad-spectrum, contact herbicide that disrupts cellular functioning	Mostly used for water-milfoil and duckweed	May affect non-target plants, especially native pondweeds, coontail, elodea, naiads
			Applied as liquid, can be combined with copper treatment	Rapid action	Toxic to aquatic invertebrates
				Limited direct toxicity on fish and other animals	Must be reapplied several years in a row
					Ineffective in muddy or cold water (<50°F)

Management Options for Aquatic Plants

Updated Oct 2006

	Option	Permit Needed?	How it Works	PROS	CONS
d.	Fluridone (e.g. Sonar or Avast)	Y; special permit and Environmental Assessment may be required	Broad-spectrum, systemic herbicide that inhibits photosynthesis	Effective on EWM for 1 to 4 years with aggressive follow-up treatments	Affects native milfoils, coontails, elodea, and naiads, even at low concentrations
			Must be applied during early growth stage	Some reduction in non-target effects can be achieved by lowering dosage	Requires long contact time: 60-90 days
			Available with a special permit only; chemical applications beyond 150 ft from shore not allowed under NR 107	Slow decomposition of plants may limit decreases in dissolved oxygen	Often decreases water clarity, particularly in shallow eutrophic systems
			Applied at very low concentration at whole lake scale	Low toxicity to aquatic animals	Demonstrated herbicide resistance in hydrilla subjected to repeat treatments
					Unknown effect of repeat whole-lake treatments on lake ecology
e.	Glyphosate (e.g. Rodeo)	Y	Broad-spectrum, systemic herbicide that disrupts enzyme formation and function	Effective on floating and emergent plants	RoundUp is often illegally substituted for Rodeo; surfactants in RoundUp believed to be toxic to reptiles and amphibians
			Usually used for purple loosestrife stems or cattails	Selective if carefully applied to individual plants	Cannot be used near potable water intakes
			Applied as liquid spray or painted on loosestrife stems	Non-toxic to most aquatic animals at recommended dosages	Ineffective in muddy water
				Effective control for 1-5 years	No control of submerged plants

Management Options for Aquatic Plants

Updated Oct 2006

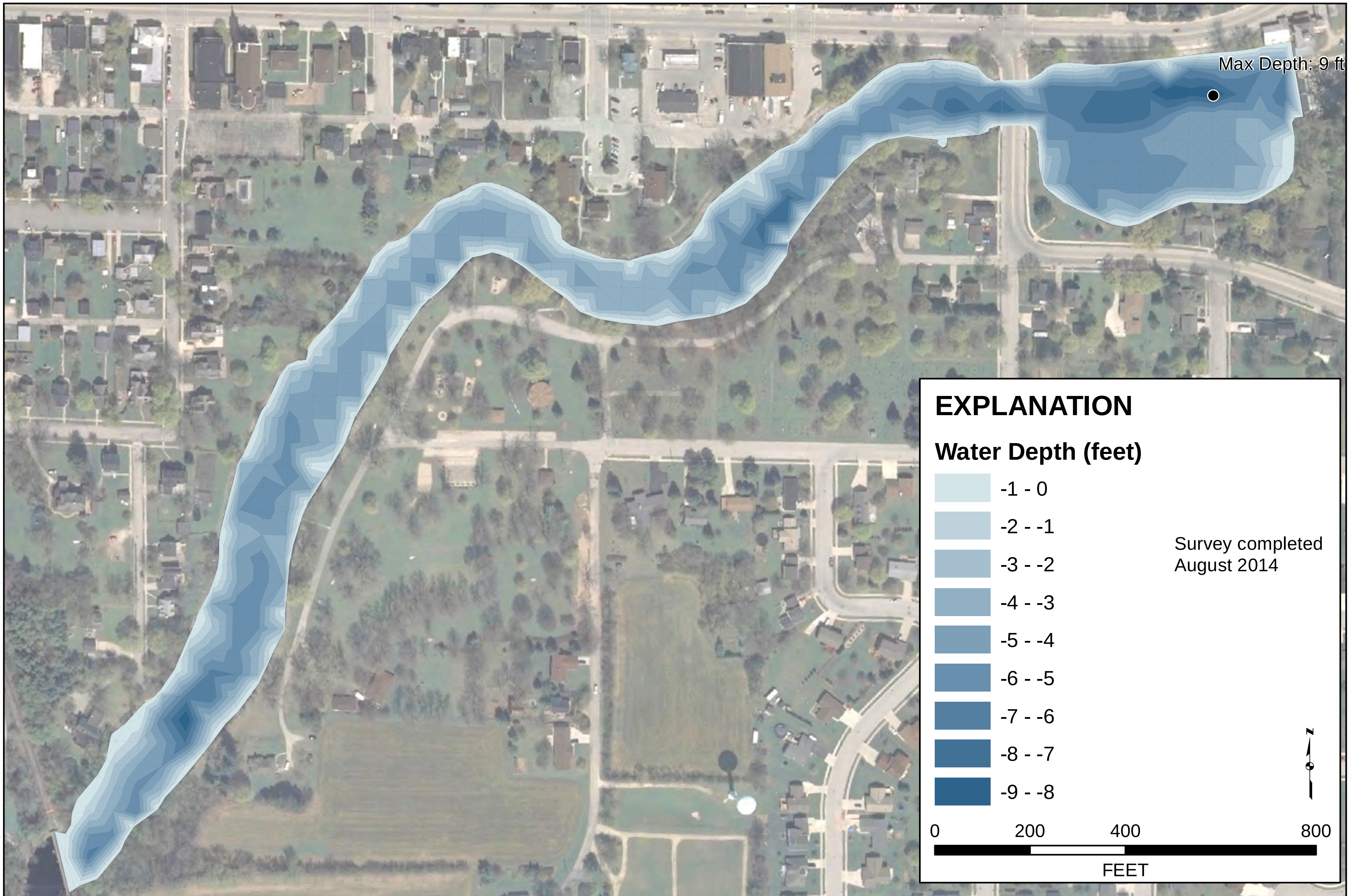
Option	Permit Needed?	How it Works	PROS	CONS
f. Triclopyr (e.g. Renovate)	Y	Systemic herbicide selective to broadleaf plants that disrupts enzyme function	Effective on many emergent and floating plants	Impacts may occur to some native plants at higher doses (e.g. coontail)
		Applied as liquid spray or liquid	Most effective on dicots, such as purple loosestrife; may be more effective than glyphosate	May be toxic to sensitive invertebrates at higher concentrations
			Control of target plants occurs in 3-5 weeks	Retreatment opportunities may be limited due to maximum seasonal rate (2.5 ppm)
			Low toxicity to aquatic animals	Sensitive to UV light; sunlight can break herbicide down prematurely
			No recreational use restrictions following treatment	Relatively new management option for aquatic plants (since 2003)
g. Copper compounds (e.g. Cutrine Plus)	Y	Broad-spectrum, systemic herbicide that prevents photosynthesis	Reduces algal growth and increases water clarity	Elemental copper accumulates and persists in sediments
		Used to control planktonic and filamentous algae	No recreational or agricultural restrictions on water use following treatment	Short-term results
		Wisconsin allows small-scale control only	Herbicidal action on hydrilla, an invasive plant not yet present in Wisconsin	Long-term effects of repeat treatments to benthic organisms unknown
				Toxic to invertebrates, trout and other fish, depending on the hardness of the water
				Clear water may increase plant growth

[1]Systemic herbicide - Must be absorbed by the plant and moved to the site of action. Often slower-acting than contact herbicides.
[2]Broadleaf herbicide - Affects only dicots, one of two groups of plants. Aquatic dicots include waterlilies, bladderworts, watermilfoils, and coontails.
[3]Broad-spectrum herbicide - Affects both monocots and dicots.
[4]Contact herbicide - Unable to move within the plant; kills only plant tissue it contacts directly.
This document is intended to be a guide to available aquatic plant control techniques, and is not necessarily an exhaustive list.
References to registered products are for your convenience and not intended as an endorsement or criticism of that product versus other similar products.
Specific effects of herbicide treatment contingent on usage within label guidelines and in accordance with all applicable laws.
Please contact your local Aquatic Plant Management Specialist when considering a permit.

Aquatic Plant Control Techniques Not Allowed in Wisconsin

Updated Oct 2006

Option	How it Works	PROS	CONS
Biological Control			
a. Carp	Plants eaten by stocked carp	Effective at removing aquatic plants	Illegal to transport or stock carp in Wisconsin
		Involves species already present in Madison lakes	Carp cause resuspension of sediments, increased water temperature, lower dissolved oxygen levels, and reduction of light penetration
			Widespread plant removal deteriorates habitat for other fish and aquatic organisms
			Complete alteration of fish assemblage possible
			Dislodging of plants such as EWM or CLP turions can lead to accelerated spreading of plants
b. Crayfish	Plants eaten by stocked crayfish	Reduces macrophyte biomass	Illegal to transport or stock crayfish in Wisconsin
			Control not selective and may decimate plant community
			Not successful in productive, soft-bottom lakes with many fish predators
			Complete alteration of fish assemblage possible
Mechanical Control			
a. Cutting (no removal)	Plants are "mowed" with underwater cutter	Creates open water areas rapidly	Root system remains for regrowth
		Works in water up to 25 ft	Fragments of vegetation can re-root and spread infestation throughout the lake
			Nutrient release can cause increased algae and bacteria and be a nuisance to riparian property owners
			Not selective in species removed
			Small-scale control only
b. Rototilling	Sediment is tilled to uproot plant roots and stems	Decreases stem density, can affect entire plant	Creates turbidity
	Works in deep water (17 ft)	Small-scale control	Not selective in species removed
		May provide long-term control	Fragments of vegetation can re-root
			Complete elimination of fish habitat
			Releases nutrients
			Increased likelihood of invasive species recolonization
c. Hydroraking	Mechanical rake removes plants from lake	Creates open water areas rapidly	Fragments of vegetation can re-root
	Works in deep water (14 ft)		May impact lake fauna
			Creates turbidity
			Plants regrow quickly
			Requires plant disposal



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SUITE 300
APPLETON, WI 54911
PHONE: (920) 380-2800
www.sehinc.com

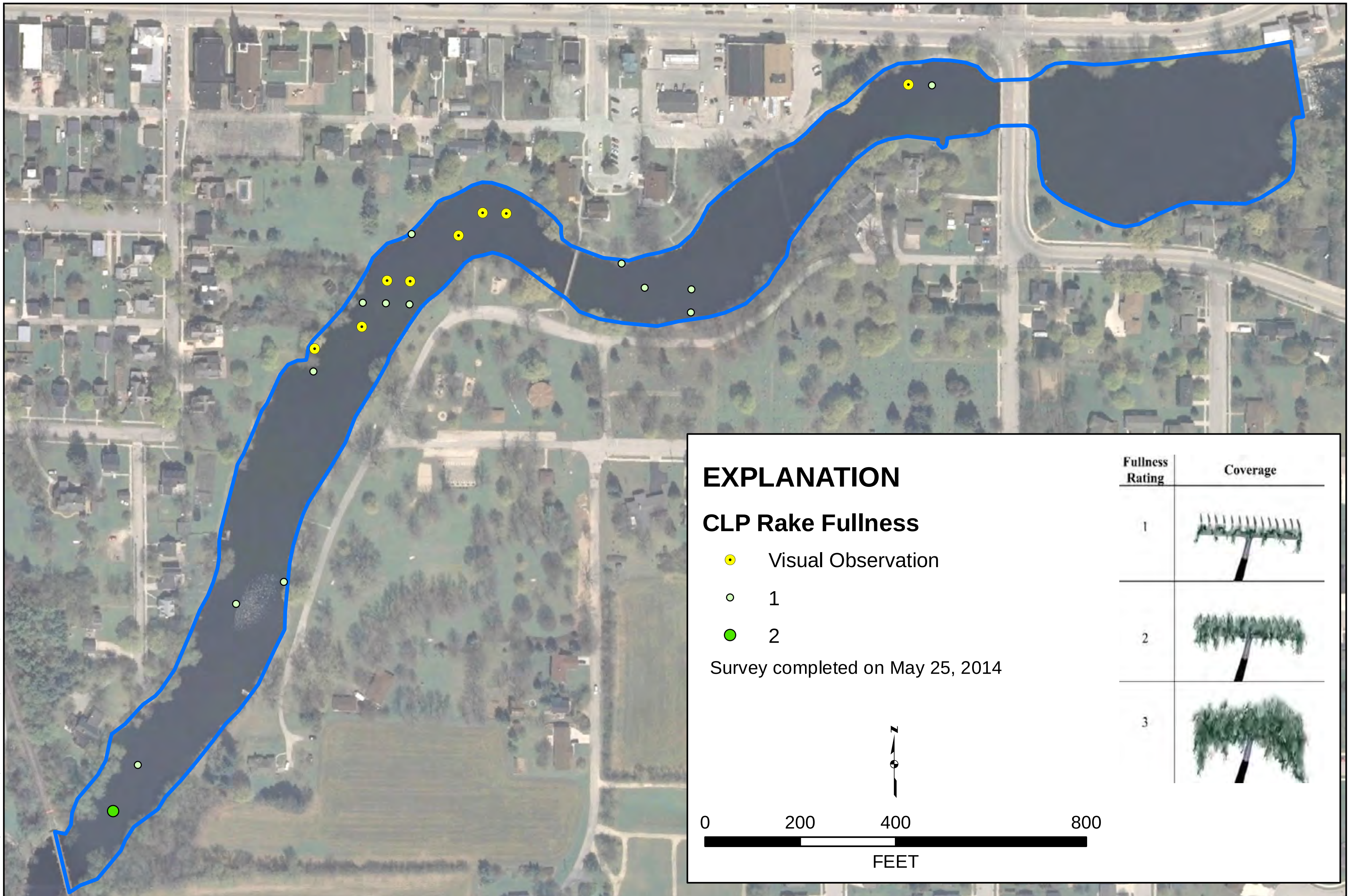
Project: KIELW 128562
Print Date: 9/14/2014

Map by: jmacholl
Projection: WISCRS Manitowoc (ft)
Source: APHS, WROC

Bathymetry

KIEL MILLPOND MANAGEMENT PLAN
Kiel, Manitowoc County, Wisconsin

Map



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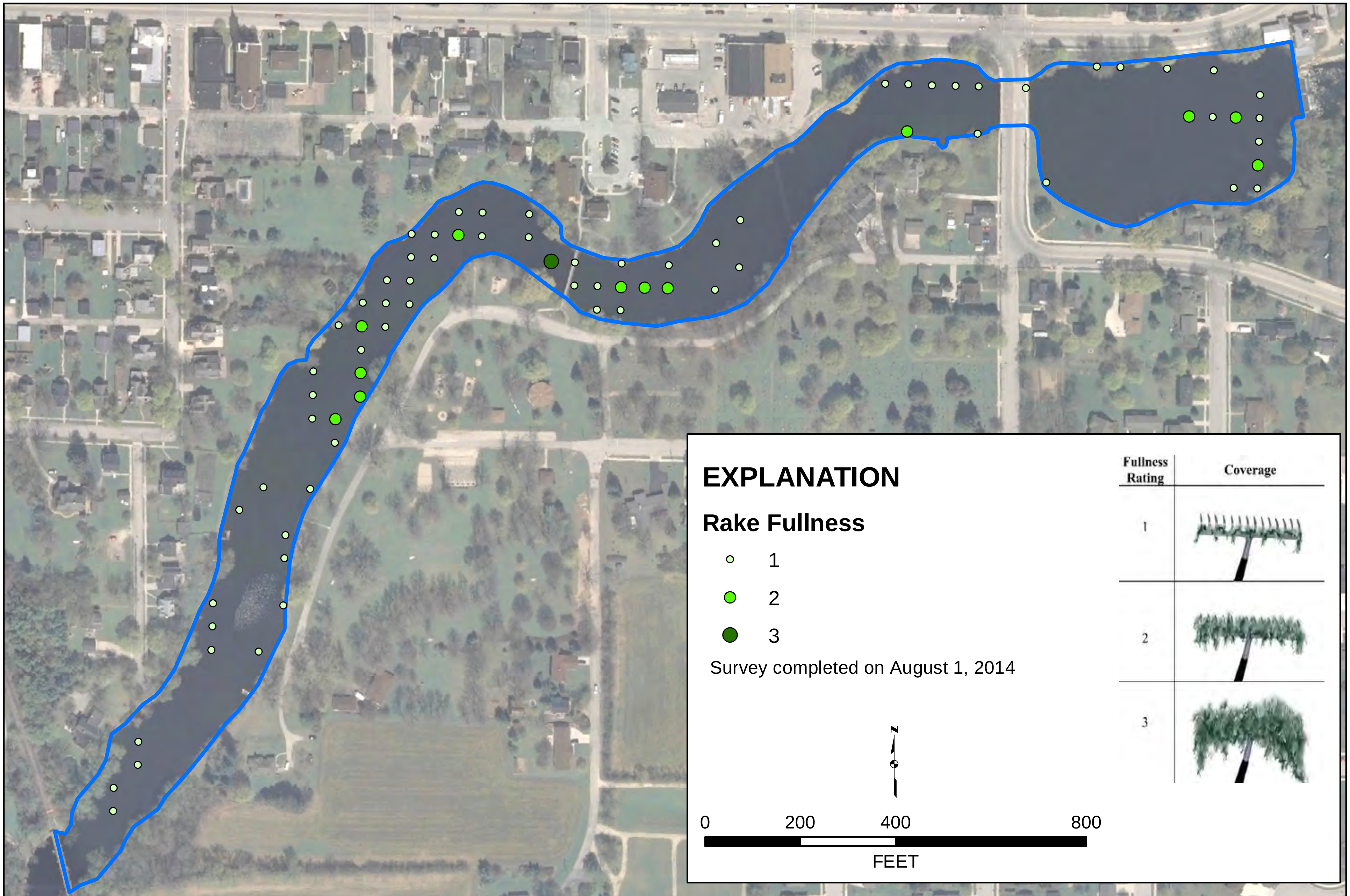
Source: APHS, WROC

CURLY-LEAF PONDWEED (Potamogeton crispus) RAKE FULLNESS
KIEL MILLPOND MANAGEMENT PLAN
Kiel, Manitowoc County, Wisconsin

Map



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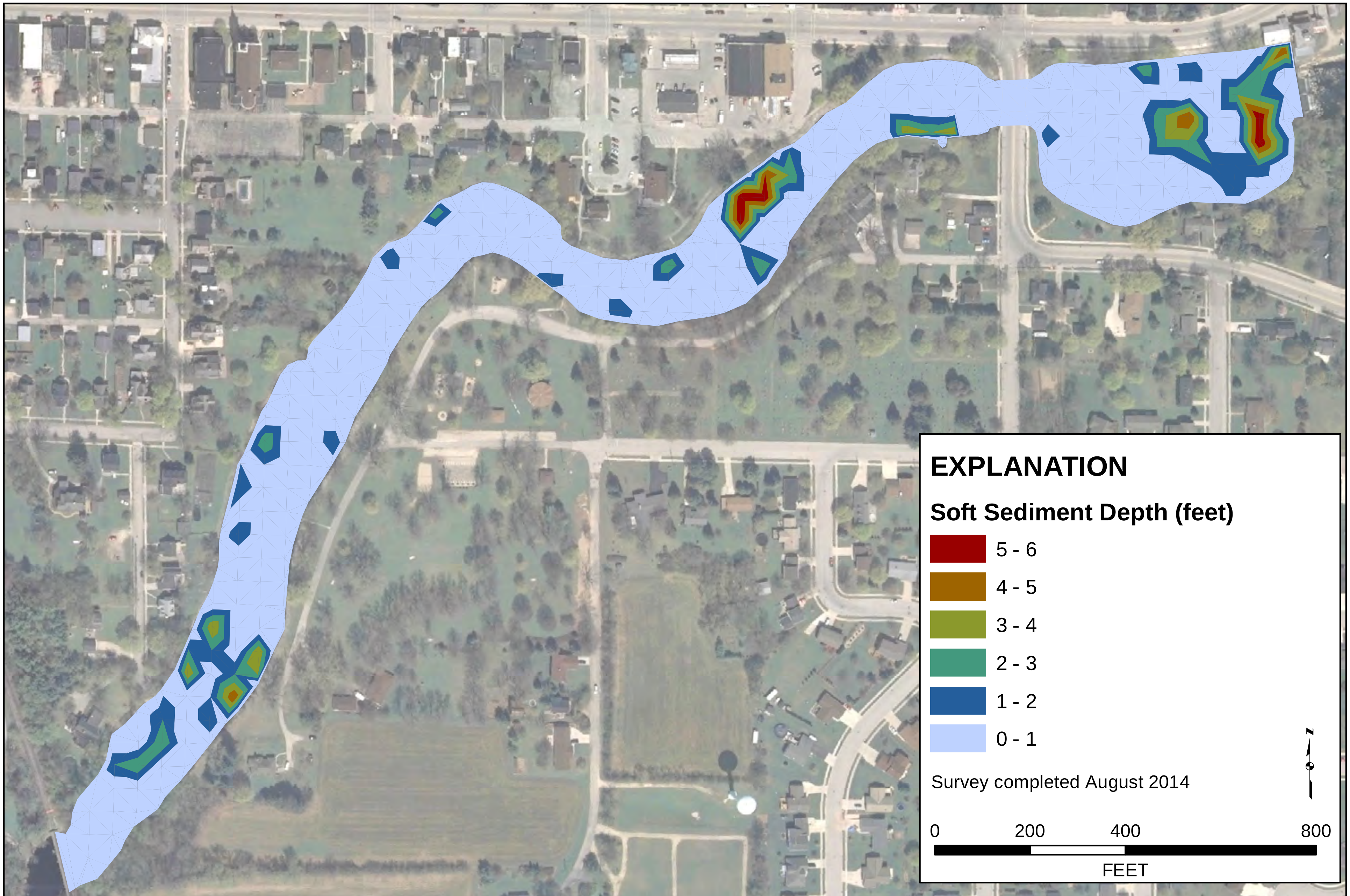
EURASIAN WATERMILFOIL (Myriophyllum spicatum) RAKE FULLNESS

KIEL MILLPOND MANAGEMENT PLAN
Kiel, Manitowoc County, Wisconsin

Map



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SUITE 300
APPLETON, WI 54911
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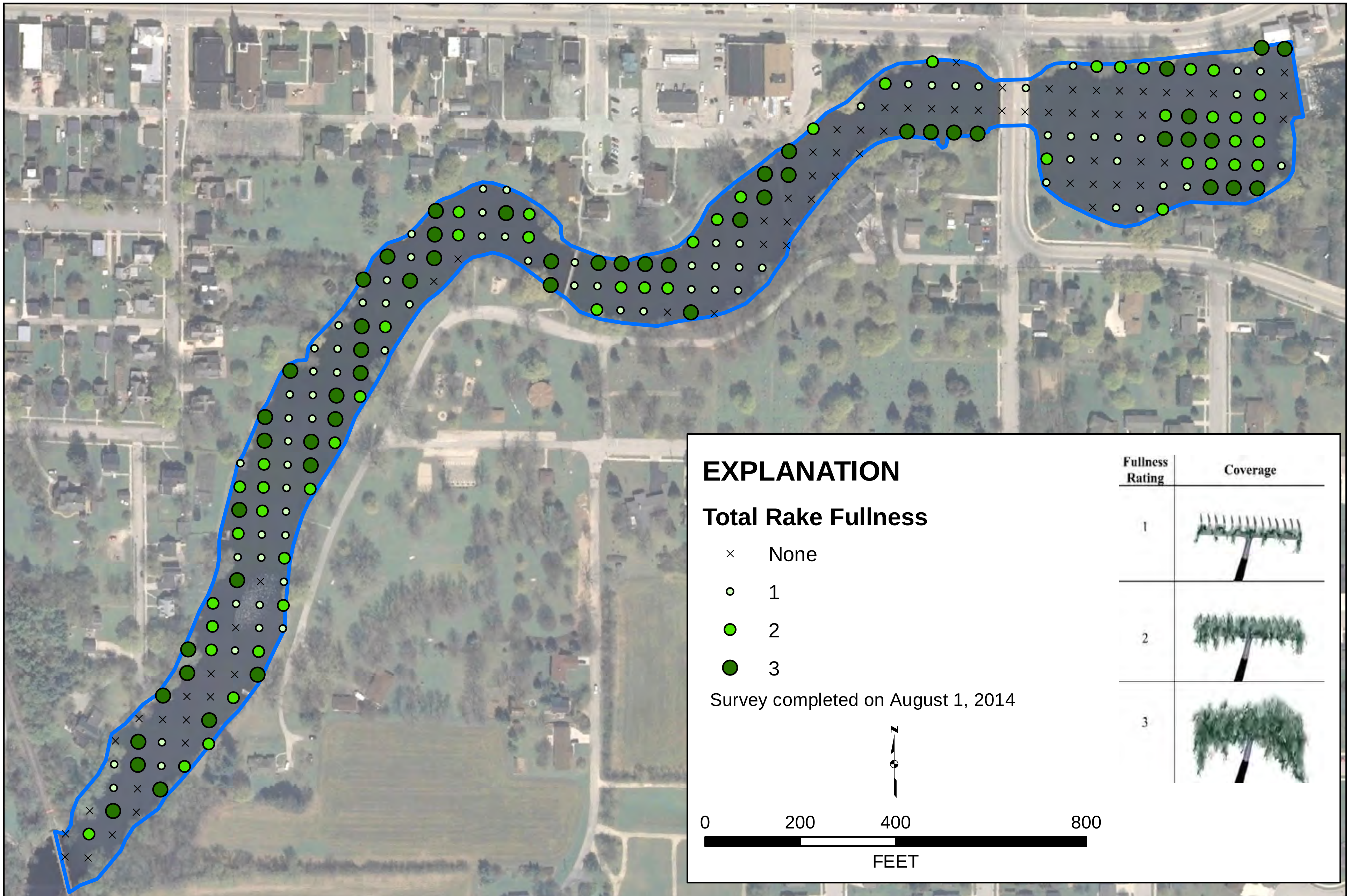
SOFT SEDIMENT DEPTH

KIEL MILLPOND MANAGEMENT PLAN
Kiel, Manitowoc County, Wisconsin

Map



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Source: APHS, WROC

TOTAL RAKE FULLNESS (PLANT DENSITY)

KIEL MILLPOND MANAGEMENT PLAN
Kiel, Manitowoc County, Wisconsin

Map

November 7, 2014

Kiel Mill Pond Management Harvesting Operation

Prepared by City of Kiel, Short Elliott Hendrickson Inc. (SHE), and the Kiel Mill Pond Aquatic Plant Management Plan Advisory Committee.

Introduction

The following document is the proposed method of completing aquatic plant harvesting by the City of Kiel and local volunteers in the Kiel Mill Pond which is located in Kiel, WI. The plant harvesting operation will be completed according to the following guidelines as approved by the Wisconsin Department of Natural Resources.

Objective and goals for the aquatic plant management activities include but are not limited to; making the Mill Pond more accessible for the City of Kiel and the surrounding communities' recreational use, provide outlets and paths for a variety of recreational vehicles and reduce the overall density of the different invasive plant life.

This project includes the millpond created by the dam, and that stretch of the Sheboygan River within the Kiel city limits between the Kiel Millpond Dam and the railroad tressel on the western edge of the City (Figure 2). The entire area covers approximately 13 acres immediately downstream of the Kiel Marsh Wildlife Area (Figure 3) with approximately 7,100 ft of shoreline, of which approximatley 4,200 ft is owned by the City. Most of this area (3,600 ft) is dedicated to the City's park system. The remaining 2,900 ft is divided between twenty-one private property owners.

Hingiss Park is a large, well-used City park located adjacent the mill pond and in addition to a variety of recreational facilities it also includes a footbridge across the Sheboygan River, fishing piers, and a rustic public boat launch. The park and the proximity to adjacent residential areas and downtown Kiel make the Mill Pond a substantial recreational destination for Kiel residents and the surrounding communities.

Plant Harvester

Water depths will be measured prior to active harvesting in approved harvesting areas. A copy of the harvesting permit with a map of the approved harvesting areas will be maintained on the harvester. While the harvester is in operation, aquatic plant fragments are recovered by the harvester to the fullest extent that is allowed by the machine and its operating system. Concerns or complaints regarding plant fragments or cut vegetation left over from the plant harvester will be addressed and proper action will take place if such situations arise.

Operators

Prior to each harvesting season, each operator will be required to review the harvesting permit and agree to the conditions of this permit.

a. Harvester operators as well as aquatic plant managers will be educated to understand and identify the common nuisance and invasive aquatic plants in the water body.

b. Harvester operators will receive clear instructions on their assigned harvesting route. Routes will be marked with buoys.

c. Harvester operators will also be trained to know the limitations of the plant harvester, such as depth of operation and proper distance from protected areas and shorelines. Shallow water areas will be harvested no deeper than three feet as instructed and approved.

d. Harvester operators will also be trained to stop harvesting if the cutting heads hit below the surface of the lake or a moderate number of fish are encountered. Attempts will be made to remove all possible fish from the harvested plants.

e. Harvester operators will be trained to recognize and gauge the cutter head depth to help ensure proper and safe plant harvesting operations.

Fish

If moderate sums of young-of-the year panfish or game fish species are encountered, harvesting is to be stopped by the operator. This location is then to be documented and recorded.

The harvester will then move to another approved area and restart cutting the designated and marked routes. The area again will be checked for fish prior to continuing plant harvesting.

If the DNR would determine that a significant fish spawning area needs to be protected, those areas may be limited or completely withdrawn from the approved harvesting area in the future.

Depth

The harvester does not harvest plants in less than 3 feet of water to prevent the disruption of the bottom sediments, turbidity, and or damage to the cutting heads.

Area

Kiel Mill Pond

Harvesting Focus

a. Harvesting areas will be scouted out prior to the running of the plant harvester. Detailed maps and provided GPS coordinates will ensure that only approved and documented areas will be affected by the operation of the plant harvester.

b. Cutting of rooted submergent (below surface) nuisance aquatic plants will be done between June and August. Under no circumstances will emergent vegetation (plants that have leaves above the water's surface) be cut. Harvester operators will also collect floating (not rooted) plant life if found in the designated cutting areas. The harvester will stay at least two harvester widths away from emergent vegetation and water lilys.

    i. This is to provide nuisance relief for boat access, fishing lanes, and recreational boat vehicle routes as marked on the map provided.

a. Eight (8) harvesting zones up to 30 feet wide will be cut to improve access for canoes and kayaks, enhance fishing conditions, and to improve aesthetics of the mill pond. At no time should the harvester cut emergent vegetation and should stay at least two harvester lengths away from emergent plant life. These zones are designated areas that are marked on the map provided.

Awareness

Plant harvesting will be conducted by the City of Kiel and the director of Public Works (Randy Neils). The harvesting plan has positive support from the local community members.

a. The harvesting plan and maps of the harvesting area will available to the public at Kiel City Hall and Kiel Library. Questions or concerns can be directed to the Kiel City Administrator or local elected officials at a regular Council meeting.

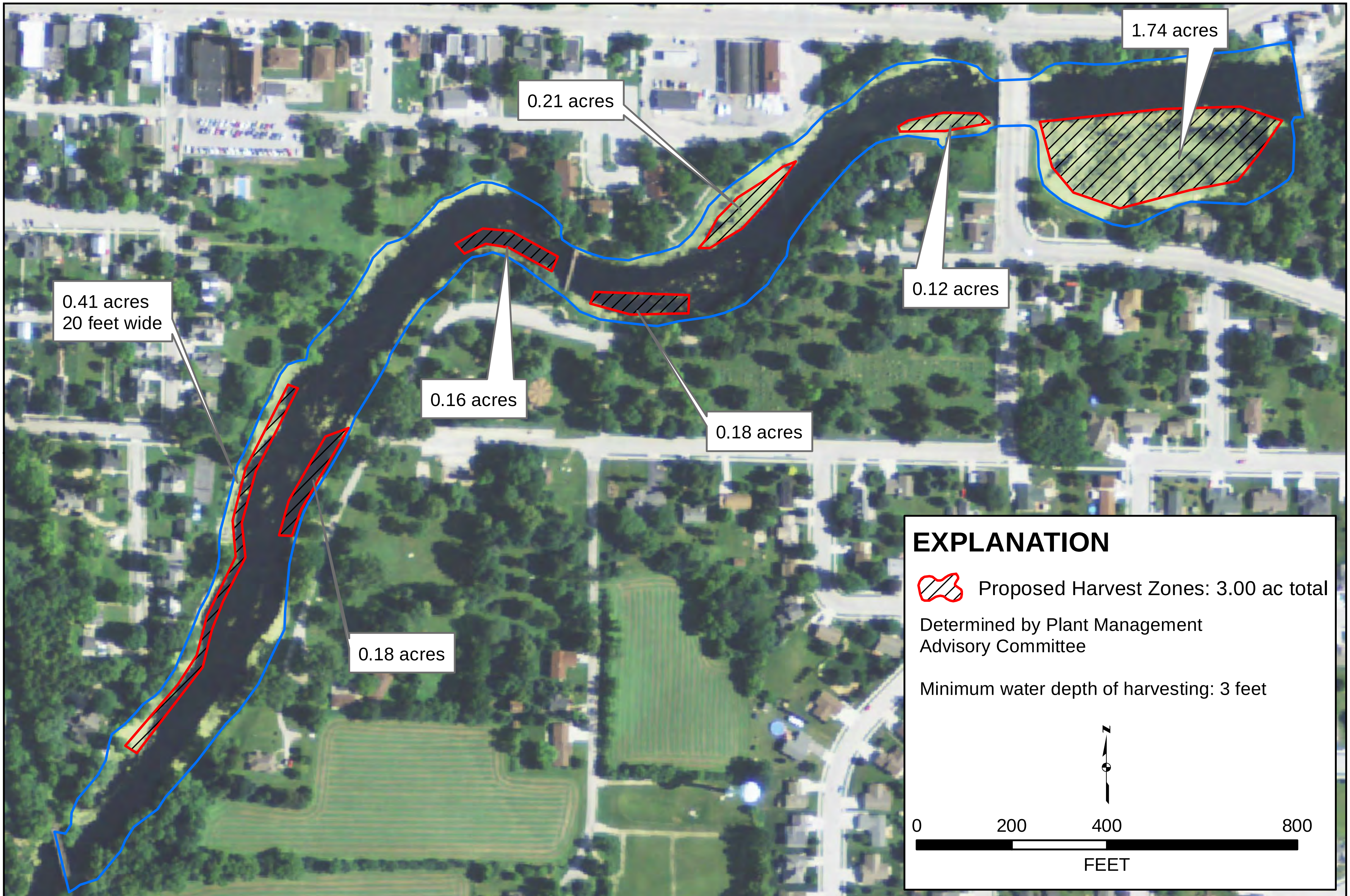
b. Maps of harvester activity and location of the cut lanes will be provided at the public boat launch in Hingiss park.

Recordkeeping

The City of Kiel shall maintain records of harvesting dates, harvesting areas, types and amounts of aquatic plants harvested, and any fish that are encountered. Records will then be provided to the DNR at the end of each harvesting season.

Disposal Locations

City of Kiel Brush and Debris Waste Site (8^{th} Street). The composted plant matter will then be available for community members to pick up for individual plant/garden use.



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Map by: jmacholl
Projection: WISCRS Manitowoc (ft)
Source: USDA NAIP

PROPOSED HARVEST ZONES

KIEL MILLPOND MANAGEMENT PLAN
Kiel, Manitowoc County, Wisconsin

Map

Sites SWIMS ID	Date	Time	Water Temp °C	Wind	pH	TSS mg/l	Total Phos mg/l	Ortho Phos mg/l	D.O. mg/l	Conductivity	Chloride mg/l	NO3-N mg/l
10021359 = Upstream of Highway 57	6/10/2014	1:42 a.m.	20.2	NE			0.16	0.2	7.54	529	26.08	10.13
363283 = Upstream of Rockville Mill Dam	6/10/2014	12:43 a.m.	20.1	NE		4	0.174	0.1	5.28	519	20.02	6.07
363273a = Upstream of Kiel POTW	6/10/2014	1:10 p.m.	19.5	NE			0.215	0.3	5.43	508	22.08	6.8
Kiel Mill Pond Dam	6/10/2014	1:26 p.m.	19.6	NE			0.187	0.3	3.08	508	20.87	8.58
363281a = Rail Road Crossing												
10015598 = Cty Rd MM Bridge	6/10/2014	1:26 p.m.	19.8	NE			0.174	0.3	3.99	517	21.06	8.26
203070 = Cty Rd G at St. Cloud	6/10/2014	11:15 a.m.	18	NE			0.225	0.4	5.45	700	26.75	6.01
10021359 = Upstream of Highway 57	6/17/2014	8:54 a.m.	20.9	SW	8.6			0.17	7.44	562	26.44	4.73
363283 = Upstream of Rockville Mill Dam	6/17/2014	8:35 a.m.	20.9	SW	8.4			0.23	6.24	570	24.04	4.04
363273a = Upstream of Kiel POTW	6/17/2014	8:27 a.m.	20.9	SW	8.4			0.2	6.52	490.8	20.19	2.9
Kiel Mill Pond Dam	6/17/2014	10:55 a.m.	20.8	SW	8.1	4		0.17	4.41	532	23.31	3.69
363281a = Rail Road Crossing	6/17/2014	11:05 a.m.	21	SW	8.2	0		0.24	4.5	537	20.67	2.83
10015598 = Cty Rd MM Bridge	6/17/2014	9:18 a.m.	20.1	SW	8.3			0.2	6.05	502	24.82	4.27
203070 = Cty Rd G at St. Cloud	6/17/2014	9:44 a.m.	19.4	SW	8.2			0.36	4.17	488.7	20.33	4.11
10021359 = Upstream of Highway 57	6/24/2014	8:51 a.m.	20.3	None	8.4			0.44	7.33	456.2	24.4	5.46
363283 = Upstream of Rockville Mill Dam	6/24/2014	8:37 a.m.	20.3	None	8			0.45	4.86	438.7	21.4	4.69
363273a = Upstream of Kiel POTW Discharge in Rockville	6/24/2014	8:17 a.m.	20.3	None	8.2			0.02	4.97	430.5	18.07	4.22
Kiel Mill Pond Dam	6/24/2014	9:51 a.m.	20.3	None	8	2		0.5	1.27	433.5	16.26	4.37
363281a = Rail Road Crossing	6/24/2014	10:53 a.m.	20.7	None	8.2	2		0.47	1.51	436.6	18.99	4.29
10015598 = Upstream of Cty Rd MM Bridge	6/24/2014	9:04 a.m.	20.1	None	7.9			0.41	2.76	436.3	20.08	5.42
203070 = Cty Rd G at St. Cloud	6/24/2014	9:24 a.m.	20.6	None	8.2			0.61	1.19	556	21.85	4.29
10021359 = Upstream of Highway 57	7/1/2014	8:32 a.m.	22.3	SW	8.2			0.59	6.98	549	24.83	3.84
363283 = Upstream of Rockville Mill Dam	7/1/2014	8:18 a.m.	22.3	SW	7.8			0.72	4.05	547	22.8	3.35
363273a = Upstream of Kiel POTW Discharge in Rockville	7/1/2014	8:06 a.m.	22.3	SW	7.9			0.57	4.24	539	20.49	3.29
363281a = Rail Road Crossing	7/1/2014	9:37 a.m.	22.4	SW	7.8	4.5		0.8	0.68	543	24.56	3.5
Kiel Mill Pond Dam	7/1/2014	9:48 a.m.	22.4	SW	7.8	3.7		0.75	0.54	544	19.3	3.29
10015598 = Upstream of Cty Rd MM Bridge	7/1/2014	8:50 a.m.	22.2	SW	8			0.68	0.54	551	25.93	3.48
203070 = Cty Rd G at St. Cloud	7/1/2014	9:10 a.m.	21	SW	7.9			0.78	2.9	729	31.89	3.57
10021359 = Upstream of Highway 57	7/8/2014	8:51 a.m.	22.5	W	8.5			0.71	7.16	736	30.12	4.79
363283 = Upstream of Rockville Mill Dam	7/8/2014	8:40 a.m.	22.6	W	8.3			1.44	4.92	751	24.79	4
363273a = Upstream of Kiel POTW Discharge in Rockville	7/8/2014	8:24 a.m.	22.7	W	8.2			0.75	5.25	745	23.73	4.86
363281a = Rail Road Crossing	7/8/2014	9:56 a.m.	22.4	W	8.1	1.5		0.82	1.87	746	22.47	3.74
Kiel Mill Pond Dam	7/8/2014	10:05 a.m.	22.5	W	7.9	1		0.27	1.65	738	20.35	3.53
10015598 = Upstream of Cty Rd MM Bridge	7/8/2014	9:08 a.m.	22.1	W	8.1			0.79	3.75	746	28.01	3.8
203070 = Cty Rd G at St. Cloud	7/8/2014	9:29 a.m.	21.7	W	8.2			0.75	7.36	906	33.37	4.13

10021359 = Upstream of Highway 57	7/15/2014	8:42 a.m.	20.6	NW	8.8			0.41		798	28.17	5.46
363283 = Upstream of Rockville Mill Dam	7/15/2014	8:29 a.m.	20.7	NW	8.5			0.51		792	26.51	4.93
363273a = Upstream of Kiel POTW Discharge in Rockville	7/15/2014	8:20 a.m.	20.7	NW	8.2			0.54		783	22.72	5.11
363281a = Rail Road Crossing	7/15/2014	9:53 a.m.	20.7	NW	8.2	1.5		0.57		786	22.45	3.18
Kiel Mill Pond Dam	7/15/2014	9:45 a.m.	20.6	NW	8.2	1.5		0.53		784	22.72	3.22
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203070 = Cty Rd G at St. Cloud	7/15/2014	9:18 a.m.	18.2	NW	8.3			0.46		862	29.94	3.98
10021359 = Upstream of Highway 57	7/22/2014	8:39 a.m.	23.9	SW	8.5		0.184	0.38	4.53	719	33.99	4.17
363283 = Upstream of Rockville Mill Dam	7/22/2014	9:57 a.m.	23	SW	8.4		0.245	0.41	2	662	22.53	2.95
363273a = Upstream of Kiel POTW Discharge in Rockville	7/22/2014	8:15 a.m.	22.7	SW	8		0.269	0.68	4.98	651	20.69	3.68
363281a = Rail Road Crossing	7/22/2014	8:25 a.m.	23.9	SW	7.8	2.3	0.262	0.72	3.58	722	27.14	3.13
Kiel Mill Pond Dam	7/22/2014	9:45 a.m.	22.9	SW	7.9	2.3	0.249	0.67	2.1	664	22.96	3.19
10015598 = Upstream of Cty Rd MM Bridge	7/22/2014	8:54 a.m.	22.5	SW	7.8		0.242	0.61	4.4	672	24.54	3.25
203070 = Cty Rd G at St. Cloud	7/22/2014	9:18 a.m.	23	SW	8		0.31	0.66	4.5	802	25.8	4.01
10021359 = Upstream of Highway 57	7/29/2014	8:17 a.m.	20	W	8.6			0.36	8.59	689	34.16	3.45
363283 = Upstream of Rockville Mill Dam	7/29/2014	8:05 a.m.	20.7	W	8.5			0.6	7.63	712	39.72	2.52
363273a = Upstream of Kiel POTW Discharge in Rockville	7/29/2014	7:54 a.m.	20.36	W	8.2			0.65	5.04	669	22.14	2.8
363281a = Rail Road Crossing	7/29/2014	9:24 a.m.	20.3	W	7.9			0.61	1.6	673	24.18	1.81
Kiel Mill Pond Dam	7/29/2014	9:35 a.m.	20.2	W	8			0.69	1.17	677	26.12	2.13
10015598 = Upstream of Cty Rd MM Bridge	7/29/2014	8:34 a.m.	20.5	W	8.1			0.58	3.83	715	25.22	2.41
203070 = Cty Rd G at St. Cloud	7/29/2014	8:56 a.m.	20.2	W	8.3			0.59	6.08	815	32.16	3.21
10021359 = Upstream of Highway 57	8/5/2014	8:33 AM	21	SW	8.9			1.6	8.29	717	28.21	3.79
363283 = Upstream of Rockville Mill Dam	8/5/2014	8:20 AM	22.8	SW	8.7			0.41	7.76	756	31.33	2.65
363273a = Upstream of Kiel POTW Discharge in Rockville	8/5/2014	8:08 AM	21.5	SW	8.3			0.66	5.02	691	18.84	2.71
363281a = Rail Road Crossing	8/5/2014	9:45 AM	21.3	SW	8.1			0.64	1.88	706	20.09	2.33
Kiel Mill Pond Dam	8/5/2014	9:55 AM	21.5	SW	8.1			0.64	1.53	702	20.44	2.15
10015598 = Upstream of Cty Rd MM Bridge	8/5/2014	8:55 AM	21.6	SW	8.2			0.53	3.21	735	21.59	2.83
203070 = Cty Rd G at St. Cloud	8/5/2014	9:15 AM	19.7	SW	8.3			0.67	4.62	790	23.21	3.51
10021359 = Upstream of Highway 57	8/12/2014	8:42 AM	20.2	N	8.8			0.4	7.26	660	42.65	3.76
363283 = Upstream of Rockville Mill Dam	8/12/2014	8:28 AM	22.58	N	8.6			0.57	6.1	730	38.28	2.72
363273a = Upstream of Kiel POTW Discharge in Rockville	8/12/2014	8:18 AM	21.4	N	8.3			0.76	4.41	681	22.45	2.32
363281a = Rail Road Crossing	8/12/2014	9:55 AM	21	N	8.1			0.61	0.82	660	29.57	1.99
Kiel Mill Pond Dam	8/12/2014	10:03 AM	21	N	7.9			0.6	0.72	657	29.58	1.97
10015598 = Upstream of Cty Rd MM Bridge	8/12/2014	9:00 AM	20.9	N	8.2			0.6	2.87	662	28.74	2.2
203070 = Cty Rd G at St. Cloud	8/12/2014	9:25 AM	20.8	N	8.5			0.48	5.32	756	31.01	3.7
10021359 = Upstream of Highway 57	8/19/2014	8:20 AM	20	S	8.8		0.218	0.25	8.2	675	49.35	1.38
363283 = Upstream of Rockville Mill Dam	8/19/2014	8:06 AM	21.6	S	8.6		0.215	0.27	7.04	747	45.41	1.59
363273a = Upstream of Kiel POTW Discharge in Rockville	8/19/2014	7:55 AM	20.1	S	8.2		0.177	0.45	4.73	585	24.59	1.44
363281a = Rail Road Crossing	8/19/2014	9:41 AM	20.1	S	7.9		0.222	0.55	1.01	675	31.28	0.6
Kiel Mill Pond Dam	8/19/2014	9:51 AM	20.2	S	7.8		0.232	0.25	0.75	621	28.29	0.58
10015598 = Upstream of Cty Rd MM Bridge	8/19/2014	8:38 AM	20.6	S	8.2		0.204	0.44	4.63	702	33.44	0.92
203070 = Cty Rd G at St. Cloud	8/19/2014	9:05 AM	19.6	S	8.1		0.256	0.6	5.45	697	33.45	1.16