2020

Aquatic Plant Survey Report
Lake Redstone Bays

Sauk County, Wisconsin

Arapaho, Cardinal, Chickadee, County F, Eagle, Hummingbird, Killdeer, Martin-Meadowlark, Mourning Dove, Oriole, Quail, Swallow, & Woodpecker

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ABSTRACT

Aquatic plant surveys of thirteen bays in Lake Redstone, Sauk County Wisconsin, were completed in 2020 as an ongoing effort to gauge effectiveness of Eurasian watermilfoil (*Myriophyllum spicatum,* EWM) control activities and to assess changes in the plant community after dredging occurred in the bays in 2019. Arapaho, Cardinal, Chickadee, County F, Eagle, Hummingbird, Killdeer, Martin-Meadowlark, Mourning Dove, Oriole, Quail, Swallow, and Woodpecker Bays were surveyed August 11-13th, 2020. Each bay has its own management history with varying stages of pre-and post-treatment monitoring for EWM. Although some bays had been treated with herbicide in past years in an effort to control EWM, no bays were treated with herbicide in spring 2019 nor in 2020 because dredging took place July through December 2019. Although not a primary objective of dredging, it was expected to reduce EWM and overall plant occurrence. The surveys employed methods from Hauxwell (2010), but with a higher resolution survey grid than would be used on a whole-lake scale. EWM was found in 11 out of 13 bays in 2020 and was the most or second-most common plant in 9 of the bays. Unexpectedly, all 13 bays had higher or the same EWM occurrence in 2020 when compared to 2019. The increase in EWM was statistically significant in 5 of those bays. Littoral frequency of plants overall, native and non-native, was higher than the previous year (2019) when plants were scarcest. This was unexpected due to dredging removal of sediment along with seeds and roots. EWM occurrence was highest among all survey years for Oriole, Hummingbird, Chickadee, and Quail. When comparing ***native*** plant occurrence from the ***most recent*** previous survey to data collected in 2020, there were 2 statistically significant (SS) declines in native species and 3 SS increases in native plant species. When comparing ***native*** plant occurrence from the ***first*** survey to data collected in 2020, there were 17 SS declines in native species and 2 SS increases in native plant species.

Management Recommendations are as follows; 1) Protect native aquatic plants. 2) Control nuisance native vegetation with hand-pulling or raking, where permitted. 3) Continue water quality monitoring. 4) Conduct aquatic plant surveys of bays in 2021 as needed for management of EWM and plan for a whole-lake aquatic plant survey of Lake Redstone in 2021 or 2022. Revise list of bays to be surveyed in 2021 (possibly remove Killdeer, County F, and Woodpecker from survey list). 5) Consider genetic testing of milfoil to detect presence of hybrid milfoil. 6) Determine whether any EWM control efforts are needed in Chickadee, Oriole, Hummingbird, and Quail Bays.

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INTRODUCTION

The Lake Redstone Protection District (LRPD) partnered with Aquatic Plant and Habitat Services to complete aquatic plant surveys of 13 bays in 2020 as a continued effort in gauging effectiveness of EWM control activities and to measure conditions after dredging in 2019. Dredging occurred in Lake Redstone from July through December of 2019 to remove sediment from 27 locations, protect lake property values, meet obligations to maintain and improve the lake, and aim to improve water quality[1]. Due to the dredging project, there were no bays treated with herbicide in 2019 and 2020.

Study Site

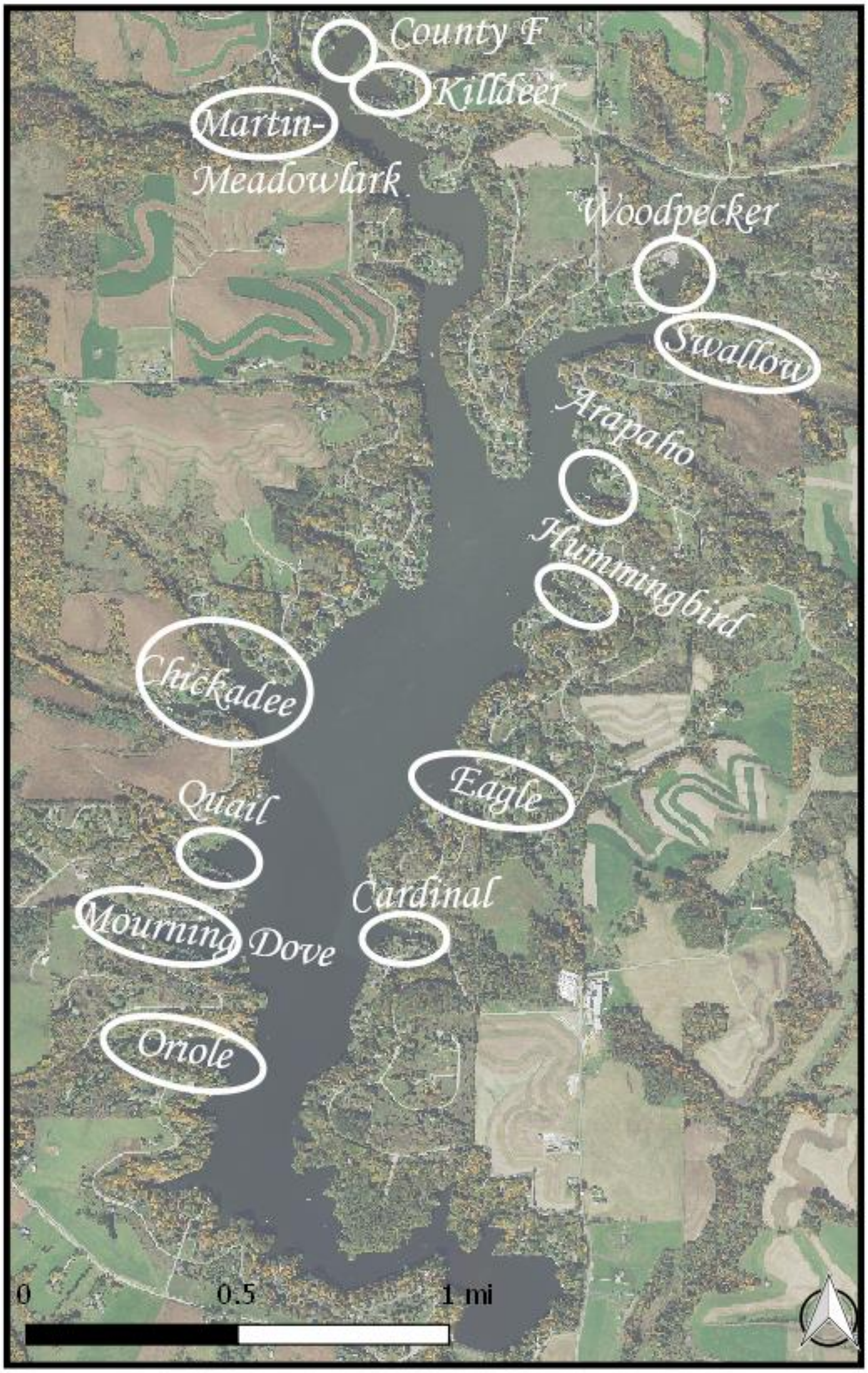
Lake Redstone is a drainage lake in Sauk County, Wisconsin with a surface area of 635 acres. The lake is an impoundment of Big Creek, which is a tributary of the Baraboo River, in Sauk County. The lake was created in 1965 with the construction of the dam on Big Creek initiated by a real estate developer with the intention of establishing 1,600 residential lots (Leverance & Panuska, 1997). The lake was dredged at 10 locations in the 1980's. Recent concerns about sedimentation prompted studies, one of which estimated annual sediment loading at 3,000 cubic yards per year[2]. Flooding in 2018 resulted in an additional 67,340 cubic yards of sediment loading in the bays[2]. The Lake District pursued dredging of 27 locations in 2019. The lake is considered an Area of Special Natural Resource Interest due to the presence of certain plant or animal species or unique ecological communities identified in the WDNR Natural Heritage Inventory. The 13 bays surveyed in 2020 are illustrated in Figure 1.

Water Chemistry & Clarity

Lake Redstone is one of 65 Long Term Trend Lakes in Wisconsin. Such lakes are monitored by volunteers and professionals from May through September annually to provide reference conditions for regional trophic classification and to track changes within and among lakes in Wisconsin. The lake has a flushing rate of about 1.8 times during the growing season (May-September), meaning an entire lake volume worth of water flows through the system nearly twice during that five-month monitoring period (Leverance & Panuska, 1997). Lake Redstone is classified as a eutrophic system based on data collected since 1979 (WDNR, 2021).

[1] https://www.lakeredstonepd.org/dredging-meeting-minutes. June 2018 Dredging Informational Meeting PowerPoint Presentation.
[2] https://www.lakeredstonepd.org/dredging-meeting-minutes. A Proposal for Dredging on Lake Redstone. Lake Redstone Protection District. May 18, 2019

Figure 1 – Lake Redstone Map of Bays Surveyed in 2020



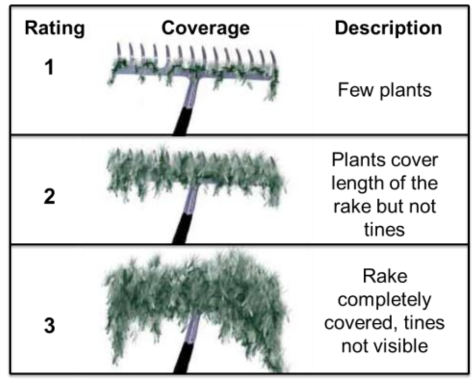
GOALS AND OBJECTIVES

GOAL: The main goal was to survey aquatic plants in select bays at a higher resolution (compared to whole-lake survey) for making management decisions, specifically related to EWM management, and to gauge post-dredging conditions of the aquatic plant communities.

OBJECTIVES:

1. Complete a survey of all aquatic plants in 13 bays at pre-determined survey points.
2. Analyze data and create maps of plant distribution, sediment type, and depth.
3. Compare results of the previous surveys using Chi-squared tests to identify statistically significant changes in native and invasive plant species since 2014.
4. Provide a final report.

Figure 2 – Rake Fullness Illustration



METHODS

Field Methods

Field methods followed the standardized protocol developed by the Wisconsin Department of Natural Resources (WDNR) in Hauxwell et. al (2010) and the surveys were completed August 11-13th, 2020. Previous plant survey dates are in List 1. Point-intercept maps were generated for Arapaho (55 pts), Cardinal (71 pts), Chickadee (121 pts), County F (73 pts), Eagle (115 pts), Hummingbird (65 pts), Killdeer (62 pts), Martin-Meadowlark (56 pts), Mourning Dove (123 pts), Oriole (104 pts), Quail (77 pts), Swallow (72 pts), and Woodpecker (86 pts) resulting in 1,080 sample points. The sample points were uploaded to handheld Garmin GPS that was used to navigate to each point in the bays. Points that were deeper than 12 feet were not surveyed based on previous findings that maximum rooting depth of any bay-wide survey since 2014 was 11 feet (Table 5) and average maximum rooting depth of 5.4 feet among all years of all bays that were surveyed in 2020. A double-sided rake head on a telescopic pole was used to sample each point for aquatic plants, 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 2). Any survey points that were inaccessible were recorded as such and no sample was taken. Aquatic plants found within 6 feet of the sample point but not found on the rake were counted as visual observations.

List 1 – Aquatic Plant Survey Dates

- Aug. 11, 2014
- July 17-18, 2015
- Aug. 17-18, 2016
- Sept. 8-9, 2017
- Aug. 24-25, 2018
- July 17, 2019 (Cardinal, Swallow, Eagle, & Oriole Bays). Aug. 3-4, 2019 (Arapaho, Chickadee, Cty F, Hummingbird, Killdeer, Martin-Meadowlark, Quail, & Woodpecker).
- Aug. 11-13, 2020

Data Analysis Methods

Survey data were used to calculate statistics including Simpson Diversity Index, species richness, Nichols (1999) Floristic Quality Index, frequencies, rake fullness and number of visual sightings among other summary statistics. Following 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. Also, filamentous algae occurrence was not used in some statistical calculations but data was collected to gauge its frequency throughout the 13 bays.

Summary Statistics

Summary statistics provide a general overview of the plant community in each bay and can be used to make comparisons among the bays and within the same bay over time. However, ***<u>these statistics should not be used to compare to other lakes where a whole-lake survey has been done</u>***. Explanations of summary statistics are in Table 2. Floristic Quality Index (FQI, Nichols 1999) is listed in Table 1 but is worth providing more explanation. The FQI incorporates aquatic plant species associated with lake communities and native to Wisconsin by using the Coefficient of Conservatism (C) ranging from 0 to 10. The C value estimates the likelihood of a 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 helps us understand 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 value, but Nichols (1999) recommends comparing values within one of the four ecoregional-lake types. Lake Redstone falls within the "Driftless" ecoregional-lake type. However, the ***<u>FQI values for each bay or even mean values of all bays cannot be compared to other lakes in the driftless region because the bays are not representative of a whole-lake survey</u>***.

Individual Species Statistics

Individual species statistics assess the plant species composition in the 13 bays and allow for comparisons of the plant community within the bays (Table 1).

Chi-squared tests

A chi-squared test of plant occurrence was done for all bays. The statistical test helps determine whether there is a significant difference between two data sets by comparing the number of sites a particular plant species was found in two different years. The alpha, or Type I error rate was set at 0.05, meaning there is a 5% chance of claiming there is a significant change when no real change has occurred. Chi-squared tests compared differences in plant occurrence from 2019 to 2020. The tests also compared differences from the first year of the bay being surveyed to 2020.

Table 2 – Summary Statistics Explanations

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 vegetation	Number of sites where at least one plant was found on the rake (does not include moss, sponges, filamentous 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, filamentous 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, filamentous algae, or liverworts
		b) Including visuals – Same explanation as 7(a) and including visual observations within 6 feet of the sample sight
8	Simpson 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 values (9).

Table 1 – Individual Species Statistics Explanations

Individual Statistic	Explanation
Average Rake Fullness	Mean rake fullness rating ranging from 1 to 3. See Rake Fullness Illustration.
Number of sites where a species was found	The total number of survey points where a particular species was found on the rake.
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.
Frequency of Occurrence FOO (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 2, #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 2, #4). Also known as **littoral frequency.**
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

The results for all 13 bays are summarized in Tables 3, 4, 5, and 6. Table 5 includes the summary statistics for 2020 as well as previous years. Table 6 covers floristic quality results for 2020 and previous years. Tables 3 and 4 list individual species found in each bay in 2020 and corresponding statistics for each species. Results are further described later in this section.

Table 3 - Plant Species Results for Arapaho, Cardinal, Chickadee, County F, Eagle, & Hummingbird Bays, 2020

Bay Name	Common Name	Scientific Name	Frequency of Occurrence at Vegetated Sites	Littoral Frequency	Relative Frequency	# Sites	Average Rake Fullness	# Visual
Arapaho*	Eurasian water milfoil	*Myriophyllum spicatum*	90.00	31.03	60.00	9	1.44	6
	Small pondweed	*Potamogeton pusillus*	20.00	6.90	13.33	2	1.00	1
	Sago pondweed	*Stuckenia pectinata*	20.00	6.90	13.33	2	1.00	0
	Coontail	*Ceratophyllum demersum*	10.00	3.45	6.67	1	1.00	0
	White water lily	*Nymphaea odorata*	10.00	3.45	6.67	1	1.00	5
Cardinal	Eurasian water milfoil	*Myriophyllum spicatum*	53.85	31.11	28.57	14	1.00	5
	Small pondweed	*Potamogeton pusillus*	50.00	28.89	26.53	13	1.00	2
	Coontail	*Ceratophyllum demersum*	42.31	24.44	22.45	11	1.00	1
	Sago pondweed	*Stuckenia pectinata*	11.54	6.67	6.12	3	1.00	1
	Wild celery	*Vallisneria americana*	11.54	6.67	6.12	3	1.00	4
	Slender waterweed	*Elodea nuttallii*	7.69	4.44	4.08	2	1.00	0
	Water star-grass	*Heteranthera dubia*	7.69	4.44	4.08	2	1.00	0
	Slender naiad	*Najas flexilis*	3.85	2.22	2.04	1	1.00	0
Chickadee	Eurasian water milfoil	*Myriophyllum spicatum*	100.00	55.42	70.77	46	1.26	2
	Coontail	*Ceratophyllum demersum*	30.43	16.87	21.54	14	1.21	0
	White water lily	*Nymphaea odorata*	4.35	2.41	3.08	2	1.00	3
	Small pondweed	*Potamogeton pusillus*	4.35	2.41	3.08	2	1.00	0
	Arrowhead	*Sagittaria sp.*	2.17	1.20	1.54	1	1.00	0
	Filamentous Algae		0.00	0.00	-	0	0.00	1
	Purple loosestrife	*Lythrum salicaria*	**	**	**	**	**	**
County F	White water lily	*Nymphaea odorata*	100.00	33.3	100.00	2	1.00	2
	Filamentous algae		100.00	33.33	-	2	1.00	1
	Curly-leaf pondweed	*Potamogeton crispus*	0.00	0.00	0.00	0.00	0.00	1
	Sago pondweed	*Stuckenia pectinata*	**	**	**	**	**	**
	Coontail	*Ceratophyllum demersum*	**	**	**	**	**	**
Eagle	Eurasian water milfoil	*Myriophyllum spicatum*	61.54	17.39	38.10	8	1.00	4
	Small pondweed	*Potamogeton pusillus*	38.46	10.87	23.81	5	1.00	2
	Sago pondweed	*Stuckenia pectinata*	23.08	6.52	14.29	3	1.00	3
	Wild celery	*Vallisneria americana*	23.08	6.52	14.29	3	1.00	0
	Slender waterweed	*Elodea nuttallii*	7.69	2.17	4.76	1	1.00	0
	Slender naiad	*Najas flexilis*	7.69	2.17	4.76	1	1.00	0
	White water lily	*Nymphaea odorata*	0.00	0.00	0.00	0	0.00	5
	Filamentous algae		0.00	0.00		0	0.00	2
	Arrowhead	*Sagittaria sp.*	**	**	**	**	**	**
Hummingbird	Eurasian water milfoil	*Myriophyllum spicatum*	88.00	40.00	62.86	22	1.18	4
	Coontail	*Ceratophyllum demersum*	28.00	12.73	20.00	7	1.00	0
	Small pondweed	*Potamogeton pusillus*	12.00	5.45	8.57	3	1.00	2
	White water lily	*Nymphaea odorata*	8.00	3.64	5.71	2	1.00	7
	Filamentous algae		8.00	3.64		2	1.00	2
	Slender waterweed	*Elodea nuttallii*	4.00	1.82	2.86	1	1.00	0
	Long-leaf pondweed	*Potamogeton nodosus*	0.00	0.00	0.00	0.00	0.00	1
	Sago pondweed	*Stuckenia pectinata*	0.00	0.00	0.00	0.00	0.00	3

** Arapaho Bay was also surveyed in 2015, but was labeled "Tanager Bay"*

***Plant species observed in the bay but not found at survey points*

Table 4 - Plant Species Results for Killdeer, Martin-Meadowlark, Mourning Dove, Oriole, Quail, Swallow, & Woodpecker Bays, 2020

Bay Name	Common Name	Scientific Name	Frequency of Occurrence at Vegetated Sites	Littoral Frequency	Relative Frequency	# Sites	Average Rake Fullness	# Visual
Killdeer	White water lily	*Nymphaea odorata*	100.00	40.00	100.00	2	1.00	23
	Small duckweed	*Lemna minor*	0.00	0.00	0.00	0	0.00	3
	Filamentous algae		0.00	0.00	-	0	0.00	3
	Eurasian watermilfoil	*Myriophyllum spicatum*	0.00	0.00	0.00	0	0.00	1
	Small pondweed	*Potamogeton pusillus*	0.00	0.00	0.00	0	0.00	1
Martin Meadow	Small duckweed	*Lemna minor*	50.00	12.12	36.36	4	1.00	8
	White water lily	*Nymphaea odorata*	37.50	9.09	27.27	3	1.33	15
	Filamentous algae		37.50	9.09		3	1.00	3
	Coontail	*Ceratophyllum demersum*	12.50	3.03	9.09	1	1.00	0
	Slender waterweed	*Elodea nuttallii*	12.50	3.03	9.09	1	1.00	0
	Small pondweed	*Potamogeton pusillus*	12.50	3.03	9.09	1	1.00	0
	Horned pondweed	*Zanichellia palustris*	12.50	3.03	9.09	1	1.00	0
	Eurasian watermilfoil	*Mryiophyllum spicatum*	**	**	**	**	**	**
Mourning Dove	Eurasian water milfoil	*Myriophyllum spicatum*	73.08	21.84	46.34	19	1.05	9
	Coontail	*Ceratophyllum demersum*	42.31	12.64	26.83	11	1.18	2
	Small pondweed	*Potamogeton pusillus*	23.08	6.90	14.63	6	1.00	6
	Slender waterweed	*Najas flexilis*	11.54	3.45	7.32	3	1.00	0
	Sago pondweed	*Stuckenia pectinata*	7.69	2.30	4.88	2	1.00	2
	Curly-leaf pondweed	*Potamogeton crispus*	0.00	0.00	0.00	0	0.00	2
	White water lily	*Nymphaea odorata*	0.00	0.00	0.00	0	0.00	4
	Water celery	*Vallisneria americana*	0.00	0.00	0.00		0.00	1
Oriole	Eurasian water milfoil	*Myriophyllum spicatum*	87.50	37.84	63.64	14	1.07	1
	Coontail	*Ceratophyllum demersum*	31.25	13.51	22.73	5	1.00	0
	Small pondweed	*Potamogeton pusillus*	18.75	8.11	13.64	3	1.00	0
	Filamentous algae		6.25	2.70	-	1	1.00	0
	White water lily	*Nymphaea odorata*	0.00	0.00	0.00	0	0.00	2
	Sago pondweed	*Stuckenia pectinata*	0.00	0.00	0.00	0	0.00	1
Quail	Eurasian water milfoil	*Myriophyllum spicatum*	75.00	48.00	42.11	24	1.21	2
	Coontail	*Ceraophyllum demersum*	56.25	36.00	31.58	18	1.44	1
	Small pondweed	*Potamogeton pusillus*	21.88	14.00	12.28	7	1.14	3
	Wild celery	*Vallisneria americana*	12.50	8.00	7.02	4	1.00	0
	Sago pondweed	*Stuckenia pectinata*	9.38	6.00	5.26	3	1.33	1
	Slender naiad	*Najas flexilis*	3.13	2.00	1.75	1	1.00	0
	White water lily	*Nymphaea odorata*	0.00	0.00	0.00	0	0.00	3
Swallow	White water lily	*Nymphaea odorata*	92.86	22.81	72.22	13	1.08	19
	Eurasian water milfoil	*Myriophyllum spicatum*	14.29	3.51	11.11	2	1.00	12
	Curly-leaf pondweed	*Potamogeton crispus*	7.14	1.75	5.56	1	1.00	1
	Coontail	*Ceratophyllum demersum*	7.14	1.75	5.56	1	2.00	1
	Small pondweed	*Potamogeton pusillus*	7.14	1.75	5.56	1	1.00	2
	Sago pondweed	*Stuckenia pectinata*	0.00	0.00	0.00	0	0.00	1
	Fillamentous algae		0.00	0.00	0.00	0	0.00	2
Wood-pecker	White water lily	*Nymphaea odorata*	100.00	10.00	100.00	1	2.00	8
	Fillamentous algae		0.00	0.00	-	0	0.00	2
	Purple loosestrife	*Lytrhum salicari*	**	**	**	**	**	**

***Plant species observed in the bay but not found at survey points*

Table 5 – Summary Plant Statistics for All Bays 2014-2020

Bay & Year		1 Total # sites visited	2 Total # sites w/ vegetation	3 Max. depth of plants	4 Total # sites shallower than max. depth of plants	5 Littoral frequency** (%)	6 Average # of species per site: a) Shallower than max. depth	b) Vegetated sites only	c) Native shallower than max. depth	d) Native at veg. sites only	7 Species Richness: a) Total # species on rake at all sites	b) Including visuals	8 Simpson's Diversity Index	Littoral frequency of EWM (%)
Martin-Meadowlark	2014	52	45	4	52	86.5	2.25	2.6	1.81	2.41	7	9	0.8	42
	2015	54	30	3	50	60.0	1.12	1.87	1.12	1.87	7	8	0.75	0
	2016	54	50	4	54	92.6	2.63	2.84	2.41	2.83	8	9	0.83	22
	2017	55	37	3	48	77.1	1.54	2.00	1.31	1.80	6	6	0.79	23
	2018	56	35	3	53	66.0	1.11	1.69	1.04	1.72	7	7	0.72	6
	2019	51	10	3	49	20.4	0.27	1.30	0.22	1.22	3	4	0.62	0
	2020	54	8	4	33	24.2	0.33	1.38	0.33	1.38	6	6	0.76	0
Swallow	2014	70	43	4	64	67.2	1.36	2.02	0.83	1.56	7	7	0.69	52
	2015	71	37	5	71	52.1	0.72	1.38	0.69	1.32	8	10	0.66	1
	2016	72	44	4	65	67.7	1.23	1.82	1.09	1.65	7	7	0.70	9
	2017	72	40	4	66	60.6	1.30	2.15	0.98	1.76	8	8	0.78	29
	2018	72	29	4	58	50.0	0.71	1.41	0.71	1.41	5	7	0.56	0
	2019	71	23	4	62	37.1	0.37	1.00	0.37	1.00	1	3	0	0
	2020	71	14	5	57	24.6	0.32	1.29	0.26	1.15	5	6	0.46	4
Cardinal	2015	67	33	7	46	71.7	1.15	1.61	0.85	1.39	7	8	0.74	30
	2016	65	39	6	45	86.7	1.73	2.00	1.42	1.83	9	11	0.83	31
	2017	66	35	7	46	76.1	1.61	2.11	1.11	1.65	8	9	0.76	50
	2018	61	39	11	60	65.0	1.10	1.69	0.90	1.54	10	11	0.75	20
	2019	59	29	9	53	54.72	0.70	1.28	0.55	1.16	5	7	0.71	15
	2020	62	26	7	45	57.8	1.09	1.88	0.78	1.52	8	8	0.79	31
Chickadee (Both Arms)	2015	119	14	4.5	32	43.8	0.78	1.79	0.44	1.56	6	7	0.69	34
	2019	120	13	5	50	26.0	0.32	1.23	0.12	1.00	4	6	0.61	18
	2020	119	46	6.5	83	55.4	0.78	1.41	0.23	1.19	5	5	0.45	55
Oriole	2015	68	26	9	48	54.17	0.90	1.65	0.63	1.36	5	5	0.70	27
	2016	62	28	7	44	63.6	0.91	1.43	0.77	1.26	6	6	0.69	14
	2017	56	22	9.5	46	47.8	0.76	1.59	0.52	1.09	5	6	0.57	24
	2018	56	13	6	32	40.6	0.56	1.38	0.50	1.23	5	6	0.62	6
	2019	60	8	5	27	29.6	0.37	1.25	0.33	1.13	4	5	0.48	4
	2020	60	16	7	38	43.2	0.59	1.38	0.22	1.00	3	5	0.52	38
Mourning Dove	2016	122	59	7.5	89	66.3	1.04	1.58	0.88	1.39	9	10	0.68	17
	2017	122	56	6.5	78	71.8	1.19	1.66	0.88	1.28	8	9	0.62	31
	2018	122	36	6	75	48.0	0.84	1.75	0.81	1.69	8	8	0.72	3
	2020	122	26	7.5	87	29.9	0.47	1.58	0.25	1.22	5	8	0.68	22
Eagle	2014	105	16	6.5	55	29.1	0.56	1.94	0.38	1.40	7	7	0.76	15
	2017	100	14	5	40	35.0	0.58	1.64	0.28	1.10	4	7	0.57	30
	2018	98	15	5	42	35.7	0.50	1.40	0.45	1.46	6	8	0.79	5
	2019	94	12	5	36	33.3	0.39	1.17	0.25	1.13	5	7	0.76	14
	2020	97	13	5.5	46	28.3	0.43	1.62	0.28	1.63	6	7	0.75	17
Hummingbird	2016	59	34	6	59	57.6	0.93	1.62	0.58	1.21	7	9	0.66	36
	2017	63	32	6	63	50.8	0.81	1.59	0.52	1.27	7	8	0.65	29
	2018	60	31	5.5	56	55.4	1.00	1.81	0.75	1.56	8	9	0.78	25
	2019	55	19	5	51	37.3	0.47	1.26	0.24	1.00	4	5	0.60	24
	2020	55	25	7	55	45.5	0.64	1.40	0.24	1.08	5	7	0.55	40
Woodpecker	2016	83	22	4.5	77	28.6	0.77	2.68	0.68	2.36	7	8	0.82	9
	2017	85	15	4	70	21.4	0.39	1.80	0.29	1.43	4	4	0.68	10
	2018	84	14	3.5	45	31.1	0.62	2.00	0.58	1.86	5	7	0.71	4
	2019	86	10	4	79	12.7	0.14	1.10	0.13	1.11	3	6	0.31	1
	2020	88	1	3	10	10.0	0.10	1.00	0.10	1.00	1	1	0.00	0
Arapaho*	2015	55	17	4	21	81.0	0.95	1.18	0.57	1.20	6	6	0.73	33
	2019	54	13	8	45	28.9	0.49	1.69	0.22	1.43	6	6	0.68	24
	2020	55	10	6	29	34.5	0.52	1.50	0.21	2.00	5	5	0.60	31
Killdeer	2017	62	5	3	10	50.0	1.00	2.00	0.60	2.00	4	4	0.72	40
	2019	61	4	4.5	32	12.5	0.16	1.25	0.16	1.25	2	2	0.48	0
	2020	62	2	2	5	40.0	0.40	1.00	0.40	1.00	1	4	0.00	0
Quail	2017	75	23	8.5	67	34.3	0.64	1.87	0.42	1.27	5	6	0.67	22
	2019	73	13	5	33	39.4	0.67	1.69	0.42	1.17	6	7	0.74	21
	2020	76	32	6	50	64.0	1.14	1.78	0.66	1.32	6	7	0.70	48
County F	2019	69	4	3.5	12	33.3	0.50	1.50	0.42	1.25	4	5	0.67	0
	2020	72	2	2.5	6	33.3	0.33	1.00	0.33	1.00	1	2	0.00	0

Arapaho Bay was also surveyed in 2015, but was labeled "Tanager Bay".

Herbicide treatment occurred during years listed in red text.

Table 6 – Floristic Quality Results for All Bays 2014-2020

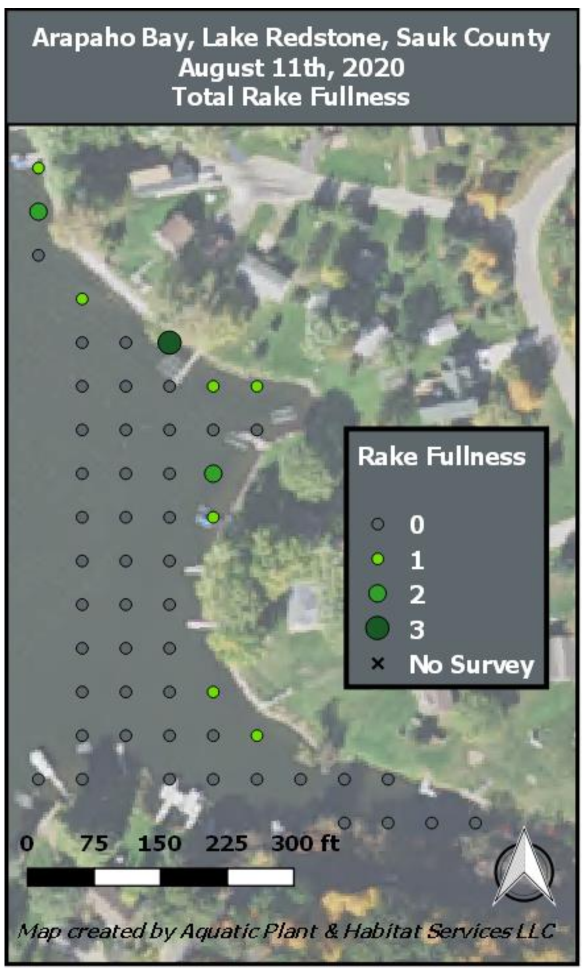
Bay & Year		Coontail, *Ceratophyllum demersum*	Slender waterweed, *Elodea nuttallii*	Water stargrass, *Heteranthera dubia*	Small duckweed, *Lemna minor*	Slender naiad, *Najas flexilis*	White water lily, *Nymphaea odorata*	Long-leaf pondweed, *Potamogeton nodosus*	Small pondweed, *Potamogeton pusillus*	Large duckweed, *Spirodela polyrhiza*	Sago pondweed, *Stuckenia pectinata*	Wild celery, *Vallisneria americana*	Horned Pondweed (*Zannichellia palustri*)	N (native species only)	Mean C	FQI
Martin-Meadowlark	2014	X	X	-	X	-	X	-	-	X	-	-	-	5	5.0	11.5
	2015	X	X	-	X	-	X	X	-	X	X	-	-	7	5.0	13.2
	2016	X	X	-	X	-	X	X	X	X	-	-	-	7	5.6	14.7
	2017	X	X	-	X	-	X	-	X	-	-	-	-	5	5.4	12.1
	2018	X	X	-	X	-	X	-	-	X	-	-	-	5	5	11.2
	2019	-	-	-	X	-	X	-	-	-	-	-	-	2	5	7.1
	2020	X	X	-	X	-	X	-	X	-	-	-	X	6	5.6	13.9
Swallow	2014	X	-	-	X	-	X	-	-	X	X	-	-	5	4.2	9.4
	2015	X	X	-	X	-	X	-	X	X	-	-	-	6	5.3	13.1
	2016	X	X	-	X	-	X	-	-	X	-	-	-	5	5.0	11.2
	2017	X	X	-	X	-	X	-	X	X	-	-	-	6	5.3	13.1
	2018	X	X	-	X	-	X	-	-	X	-	-	-	5	5	11.2
	2019	-	-	-	-	-	X	-	-	-	-	-	-	1	6	6
	2020	X	-	-	-	-	X	-	X	-	-	-	-	3	5.3	9.2
Cardinal	2015	X	X	-	X	-	-	-	X	-	X	X	-	6	5.0	12.2
	2016	X	X	X	X	-	-	-	X	X	X	X	-	8	5.1	14.5
	2017	X	X	X	-	X	X	-	X	-	-	X	-	7	5.4	14.4
	2018	X	X	X	X	X	-	-	X	X	X	X	-	9	5.2	15.7
	2019	X	-	-	-	-	-	-	X	-	X	X	-	4	4.8	9.5
	2020	X	X	X	-	X	-	-	X	-	X	X	-	7	5.4	14.4
Chickadee (Both Arms)	2015	X	X	-	-	-	X	-	X	-	X	-	-	5	5.2	11.6
	2019	X	-	-	-	-	X	-	-	-	-	-	-	2	4.5	6.4
	2020	X	-	-	-	-	X	-	X	-	-	-	-	3	5.3	9.2
Oriole	2015	X	X	-	-	-	-	-	X	-	X	-	-	4	5.0	10.0
	2016	X	X	-	-	-	X	-	X	-	X	-	-	5	5.2	11.6
	2017	X	X	-	-	-	X	-	X	-	-	-	-	4	5.8	11.5
	2018	X	X	-	-	-	-	-	X	-	X	-	-	4	5.0	10.1
	2019	X	-	-	-	-	X	-	-	-	X	-	-	3	4	6.9
	2020	X	-	-	-	-	-	-	X	-	-	-	-	2	5	7.1
Mourning Dove	2016	X	X	-	X	-	X	-	X	-	X	X	-	7	5.1	13.6
	2017	X	X	-	-	X	X	-	X	-	X	X	-	7	5.4	14.4
	2018	X	X	-	-	X	X	-	X	-	X	X	-	7	5.4	14.4
	2020	X	-	-	-	X	-	-	X	-	X	-	-	4	4.8	9.5
Eagle	2014	X	X	-	-	-	X	-	X	-	X	-	-	5	5.2	11.6
	2017	X	-	-	X	-	-	-	X	-	-	-	-	3	4.7	8.1
	2018	X	X	-	-	-	X	-	X	-	X	-	-	5	5.2	11.6
	2019	X	-	-	-	-	X	-	X	-	-	X	-	4	5.5	11
	2020	-	X	-	-	X	-	-	X	-	X	X	-	5	5.8	13.0
Hummingbird	2016	X	X	-	-	-	X	-	X	-	X	X	-	6	5.3	13.1
	2017	X	X	-	-	-	X	-	X	-	X	X	-	6	5.3	13.1
	2018	X	X	-	-	-	X	X	X	-	X	X	-	7	5.6	14.7
	2019	X	-	-	-	-	X	-	-	-	-	X	-	3	5	8.7
	2020	X	X	-	-	-	X	-	X	-	-	-	-	4	5.8	11.5
Woodpecker	2016	X	X	-	X	-	X	X	-	X	-	-	-	6	5.3	13.1
	2017	X	-	-	X	-	X	-	-	-	-	-	-	3	4.3	7.5
	2018	X	X	-	X	-	X	-	-	-	-	-	-	4	5	10
	2019	-	-	-	X	-	X	-	-	-	-	-	-	2	5	7.1
	2020	-	-	-	-	-	X	-	-	-	-	-	-	1	6	6
Arapaho*	2015	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
	2019	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
	2020	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
Killdeer	2017	X	-	-	X	-	X	-	-	-	-	-	-	3	4.3	7.5
	2019	-	-	-	X	-	X	-	-	-	-	-	-	2	5	7.1
	2020	-	-	-	-	-	X	-	-	-	-	-	-	1	6	6
Quail	2017	X	-	-	-	-	-	-	X	-	X	X	-	4	4.8	9.5
	2019	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
	2020	X	-	-	-	X	-	-	X	-	X	X	-	5	5	11.2
County F	2019	-	-	-	X	-	X	-	-	-	X	-	-	3	4.3	7.5
	2020	-	-	-	-	-	X	-	-	-	-	-	-	1	6	6

*This table includes only those species that were found on the rake at survey points and those that are listed in Nichols (1999). X=present. Herbicide treatment occurred during years listed in red text. * Arapaho Bay was also surveyed in 2015, but was labeled "Tanager Bay"*

Arapaho Bay

This was the third survey of Arapaho Bay, the first taking place in 2015 using the name "Tanager Bay." A total of 55 points were sampled and the maximum rooting depth was 6 feet compared to 8 feet in 2019. It is worth noting in 2019 that the maximum rooting depth of 8 feet occurred at only one sample point with the next deepest rooting depth of 5 feet. Twenty-nine sample points were ≤6 feet deep and only 10 of those sites had vegetation. A total of 5 species were found including EWM (maps in Appendix A). Similar to 2019 and 2015, Eurasian watermilfoil was the most common species found at 31% of littoral points in 2020, 24% in 2019, and 33% in 2015. After EWM, small pondweed and sago pondweed were the second-most common occurring species both at 7% of littoral points. Together they accounted for 86% of the total relative frequency, indicating the plant community is homogeneous as was the case in 2015 and 2019 (Table 3). The Simpson Diversity Index was 0.60 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include invasive species. Therefore, 4 species were counted yielding a floristic quality of 9.5 and an average C value of 4.8 (Table 6). Chi-squared tests revealed no statistically significant (SS) changes in the aquatic plant community when comparing 2019 to 2020 but there was a significant decrease in one native species (coontail) when comparing 2015 to 2020.

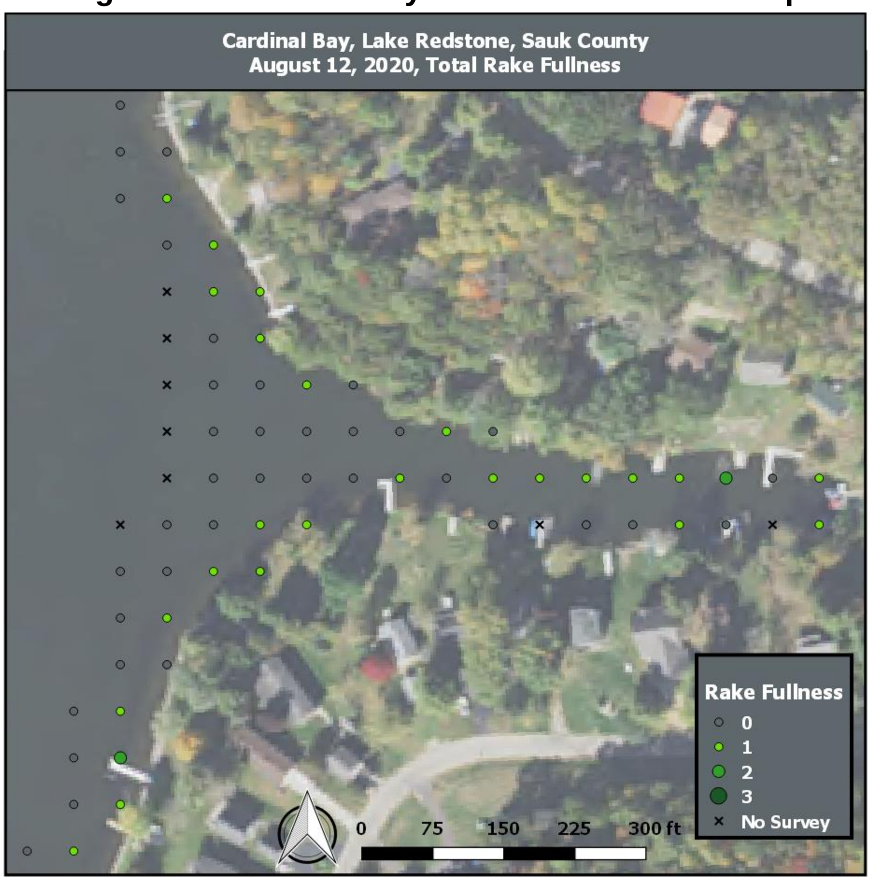
Figure 3 – Arapaho Bay Total Rake Fullness Map



Cardinal Bay

This was the sixth consecutive aquatic plant survey of Cardinal Bay (2015-2020). A total of 70 survey waypoints were attempted in Cardinal Bay, 62 of which were surveyed because 6 points were deeper than the maximum sampling depth of 12 feet and 2 were obstructed by docks. The maximum rooting depth was 7 feet. Forty-five survey points were ≤7 feet and 26 of those sites had vegetation (Table 5). A total of 8 species were found including EWM (maps in Appendix B). EWM was the most common species in 2020 and was the second-most common species in 2017, 2018, and 2019. The next most common plant was small pondweed and together they accounted for 55% of the total relative frequency, indicating the plant community is less homogeneous than 2017-2019 (Table 3). The Simpson Diversity Index for Cardinal Bay was 0.79 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include invasive species. Therefore, 7 species were counted with a floristic quality of 14.4 and average C value of 5.4. Chi-squared tests revealed a statistically significant (SS) decrease in filamentous algae when comparing 2019 to 2020, and SS decrease in filamentous algae and SS increase in small pondweed when comparing 2015 to 2020 (Appendix N).

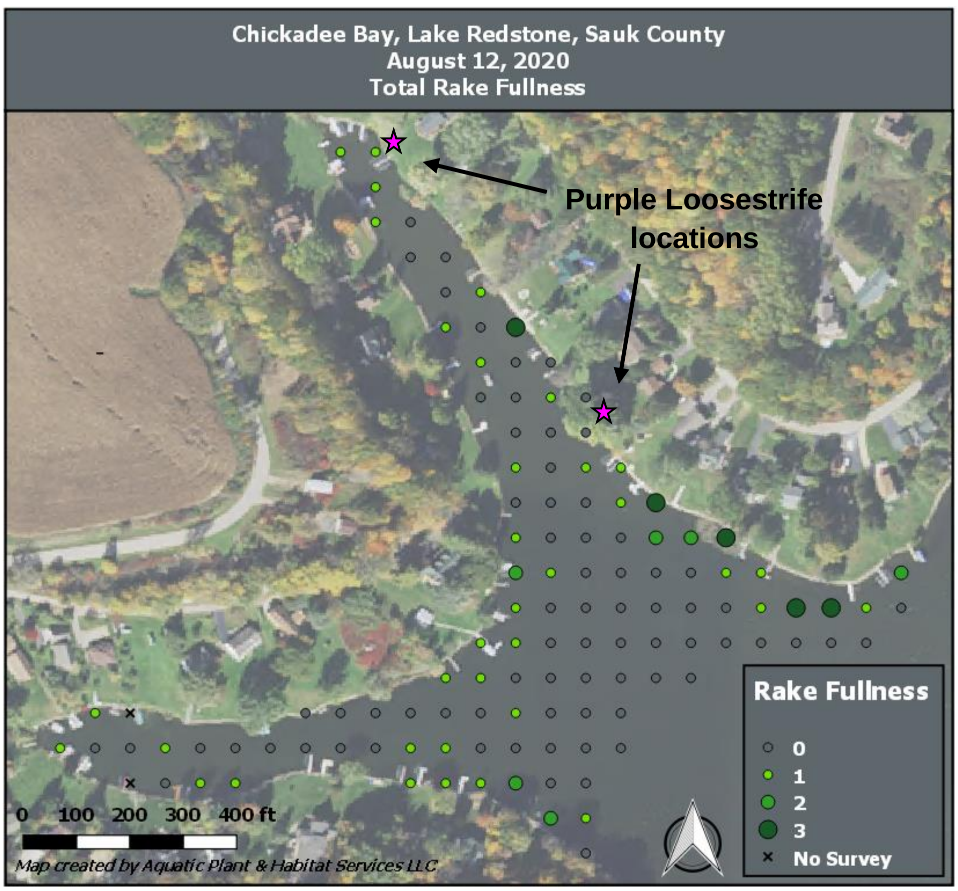
Figure 4 – Cardinal Bay Total Rake Fullness Map



Chickadee Bay

This was the third survey of Chickadee, the first of which occurred in 2015. The south arm of Chickadee Bay was also surveyed 2016 through 2018. Only results from the 2015, 2019, and 2020 surveys are listed here. There were 119 points surveyed in Chickadee Bay 83 of which were the same depth or shallower than the maximum rooting depth of 6.5 feet. There were 46 sites with vegetation compared to only 13 in 2019 (Table 5). A total of 5 species were found on the rake samples including EWM (maps in Appendix C). In addition, purple loosestrife (a non-native and invasive wetland species) was noted in the bay but not found at any sample points. Similar to 2019, EWM and coontail were the most common species found at 55% and 17% of littoral survey points respectively. Together they accounted for 92% of the total relative frequency, indicating an extremely homogeneous plant community in the bay (Table 3). The Simpson Diversity Index was very low at 0.45 on a scale of 0 to 1. The FQI only factors species raked at survey points and does not include visuals or aquatic invasive species. Therefore, only 3 species were included in the calculation, resulting in a floristic quality of 9.2 and average C value of 5.3 (Table 6). Chi-squared tests revealed a statistically significant (SS) increase in coontail and EWM in 2020 when compared to 2019, and SS increase in EWM in 2020 when compared to 2015 (Appendix N).

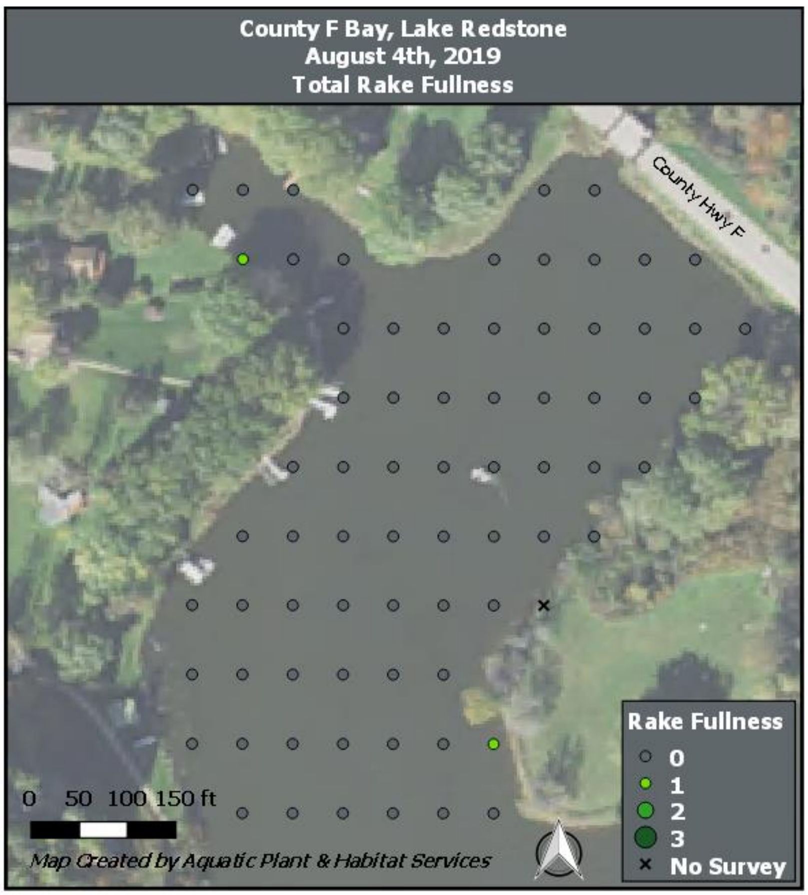
Figure 5 – Chickadee Bay Total Rake Fullness Map



County F

This was the second survey of the bay near County Highway F. There were 73 sample points attempted, 72 of which were actually surveyed because 1 site was terrestrial. The maximum rooting depth was very shallow at only 2.5 feet and only 6 sample points were 2.5 feet deep or shallower. The only species found was white water lily at two raked sample points (maps in Appendix D). Curly-leaf pondweed and filamentous algae were observed within 6 feet of sample points. Coontail and sago pondweed were also observed but not near any sample points. With only one species, the Simpson Diversity Index was zero on a scale of 0 to 1 and the floristic quality was 6 with an average C value of 6 (Table 6). Due to the very low plant occurrence in 2019 and 2020, it would be reasonable to suspend future sampling of this bay unless conditions change.

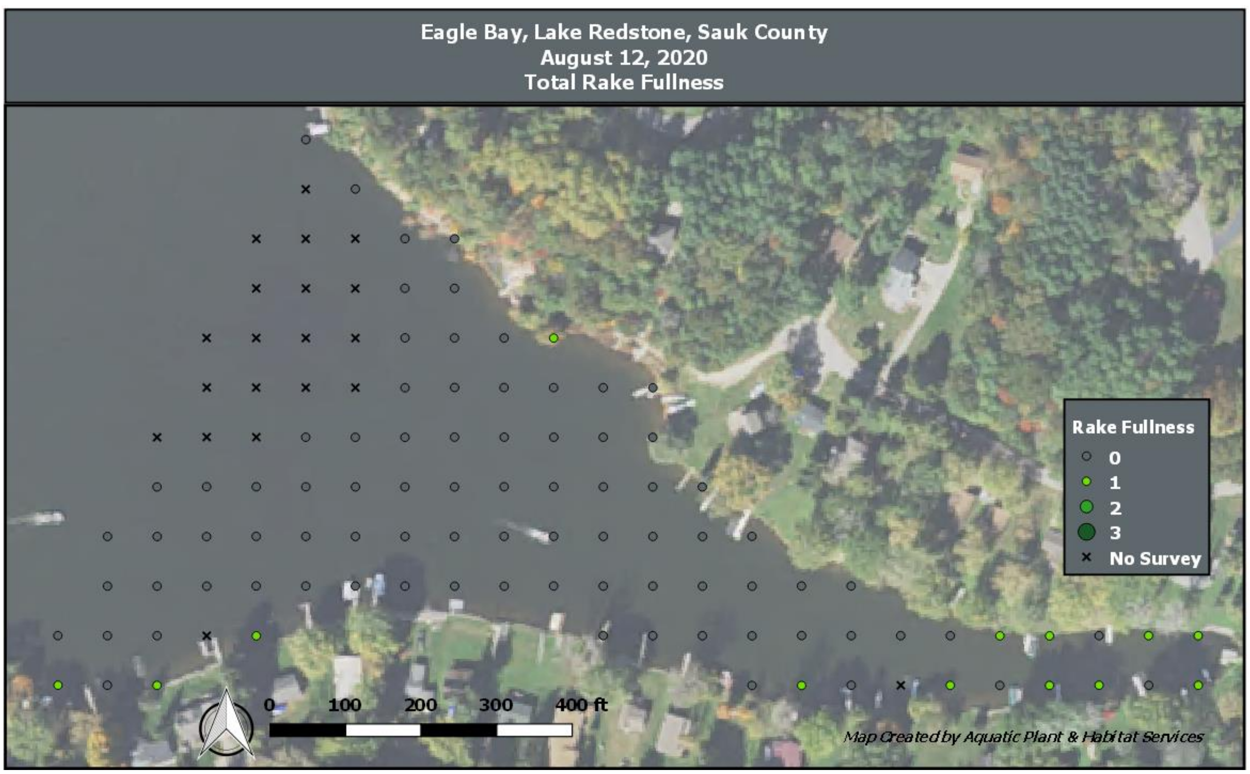
Figure 6 – County F Bay Total Rake Fullness Map



Eagle Bay

This was the fifth survey of Eagle Bay (2014 & 2017-2020). There were 97 points surveyed and 46 points were the same depth or shallower than the maximum rooting depth of 5.5 feet. Thirteen of those sites had vegetation (Table 5). A total of 7 species of aquatic plants were found, one of which was "visual only" (maps in Appendix E). Eurasian watermilfoil and small pondweed were the most common species found at low littoral frequency of 17% and 11%, respectively. Together they accounted for 62% of the total relative frequency, suggesting the plant community is homogeneous (Table 3). The Simpson Diversity Index was 0.75 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include visuals or aquatic invasive species. Therefore, 5 species were included in the calculation, yielding a floristic quality of 13 with an average C value of 5.8 (Table 6). Chi-squared tests revealed a statistically significant decrease in coontail when comparing 2014 data to 2020 (Appendix N).

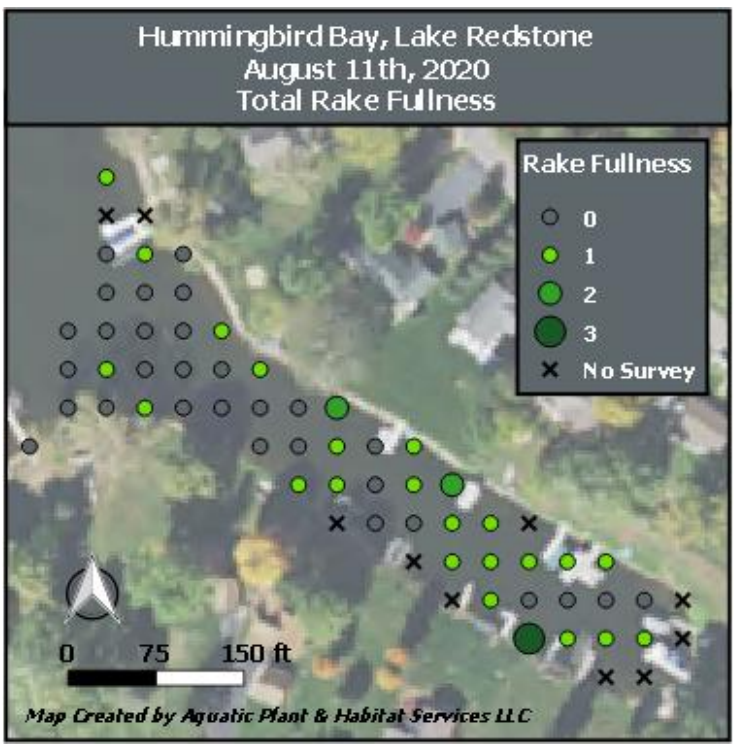
Figure 7 – Eagle Bay Total Rake Fullness Map



Hummingbird Bay

This was the fifth consecutive survey of Hummingbird Bay (2016-2020). Fifty-five points were surveyed out of a possible 65 because 10 points were obstructed by piers. There were 55 points the same depth or shallower than the maximum rooting depth of 7 feet and 25 of those sites surveyed had vegetation (Table 5). A total of 7 species of aquatic plants were found, two of which were "visual only" (maps in Appendix F). Filamentous algae is not counted as one of the 7 species. Eurasian watermilfoil and coontail were the most common species found at 40% and 13% of littoral survey points respectively. Together they accounted for 83% of the total relative frequency indicating a highly homogeneous plant community (Table 5). The Simpson Diversity Index was 0.55 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include visuals or aquatic invasive species. Therefore, 4 species were included in the calculation, yielding a floristic quality of 11.5 with an average C value of 5.8 (Table 6). Chi-squared tests revealed a statistically significant decrease in coontail in 2020 when compared to data from 2016 and a significant increase in EWM in 2020 when compared to 2019. (Appendix N).

Figure 8 – Hummingbird Bay Total Rake Fullness Map



Killdeer Bay

This was the third survey of Killdeer Bay (2017, 2019 and 2020). All 62 points were surveyed and there were only 5 points the same depth or shallower than the maximum rooting depth of 2 feet and only 2 of those sites surveyed had vegetation (Table 5). A total of 4 species of aquatic plants were found but only one species (white water lily) was actually found at sample points while 3 were near sample points but not on the rake (maps in Appendix G). Since only one plant species was found, the Simpson Diversity Index was zero on a scale from 0 to 1. The floristic quality value was of 6 with an average C value of 6 (Table 4). Chi-squared tests revealed a statistically significant decrease in EWM in 2020 when compared to data from 2017 (Appendix N). Due to the very low plant occurrence in 2017 (5 points), 2019 (4 points), and 2020 (2 points), it would be reasonable to suspend future sampling of this bay unless conditions change.

Figure 9 –Killdeer Bay Total Rake Fullness Map

Martin-Meadowlark Bay

This was the seventh consecutive survey of Martin-Meadowlark Bay (2014-2020). Fifty-four points were surveyed and 33 were the same depth or shallower than the maximum rooting depth of 4 feet. Only 8 of those sites surveyed had vegetation (Table 5). A total of 7 species of aquatic plants were found, one of which (EWM) was observed in the bay but not near any sample points (Maps in Appendix H). White water lily and small duckweed were the most common species found at 9% and 12% of littoral survey points respectively. Together they accounted for 64% of the total relative frequency, indicating a homogeneous plant community (Table 4). Chi-squared tests of all plant species revealed a statistically significant (SS) decrease in the occurrence of EWM, coontail, small duckweed, white water lily, large duckweed, and filamentous algae when comparing 2020 and 2014 data. The Simpson Diversity Index for Martin-Meadowlark Bay was 0.76 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include visuals or aquatic invasive species. Therefore, 6 species were included in the calculation, yielding a floristic quality of 13.9 with an average C value of 5.6 (Table 6).

Blue-green algae was observed in the farthest corner of Martin-Meadowlark Bay (Figure 10).

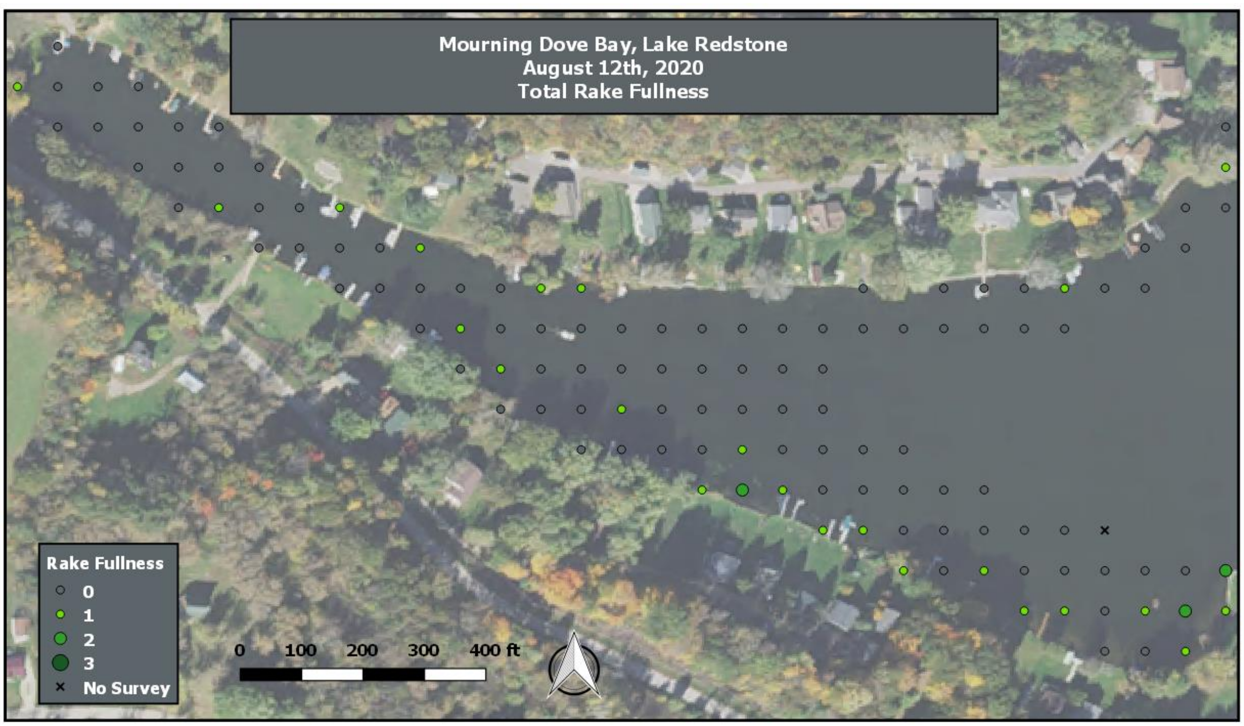
Figure 10 – Blue-green Algae in Martin Meadowlark Bay

Figure 11 – Martin-Meadowlark Bay Total Rake Fullness Map

Mourning Dove Bay

This was the fourth survey of Oriole Bay (2016-2018 and 2020). A total of 123 predetermined survey waypoints exist in Mourning Dove Bay and 122 were surveyed because one point was deeper than 12 feet. The maximum rooting depth was 7.5 feet. There were 87 survey points ≤7.5 feet deep and 26 sites had vegetation. A total of 8 species of aquatic plants were found, three of which were "visual only". Maps of plant species can be found in Appendix I. EWM and coontail were the most common species found at 22% and 13% of littoral survey points respectively and accounted for 73% of the total relative frequency, indicating the plant community in Mourning Dove Bay is homogeneous (Table 4). Chi-squared tests of all plant species revealed a statistically significant (SS) decrease in coontail, white water lily, and filamentous algae when compared to 2016 data and when compared to 2019 data. There was also a SS increase in EWM between the 2019 and 2020 data sets (Appendix N). The Simpson Diversity Index was 0.68 on a scale from 0 to 1. The FQI does not include aquatic invasive species. Therefore, 4 species were included in the calculation, yielding a floristic quality of 9.5 with an average C value of 4.8 (Table 6).

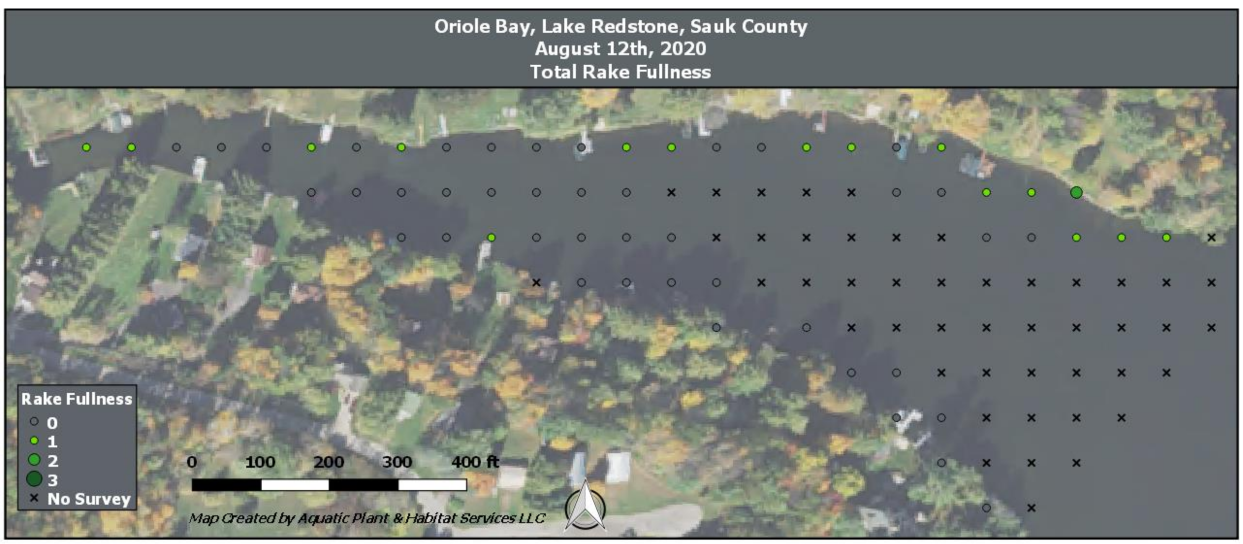
Figure 12 – Mourning Dove Bay Total Rake Fullness Map



Oriole Bay

This was the sixth consecutive survey of Oriole Bay (2015-2020). A total of 104 predetermined survey waypoints exist in Oriole Bay but about half are consistently deeper than 12 feet. This year there were 60 points actually surveyed with a maximum rooting depth of 7 feet. There were 38 survey points ≤7 feet deep and 16 sites had vegetation. A total of 5 species of aquatic plants were found, two of which were “visual only” and not including filamentous algae. Maps of plant species can be found in Appendix J. EWM was the most common species found at 38% of littoral survey points and alone accounted for 64% of the total relative frequency, indicating the plant community in Oriole Bay is homogeneous (Table 4). Chi-squared tests of all plant species revealed a statistically significant (SS) decrease in 2020 slender waterweed and coontail when compared to 2015 data. There was a SS increase in EWM between the 2019 and 2020 data sets (Appendix N). The Simpson Diversity Index for Oriole Bay was 0.52 on a scale from 0 to 1. The FQI does not include aquatic invasive species. Therefore, 2 species were included in the calculation, yielding a floristic quality of 7.1 with an average C value of 5 (Table 6).

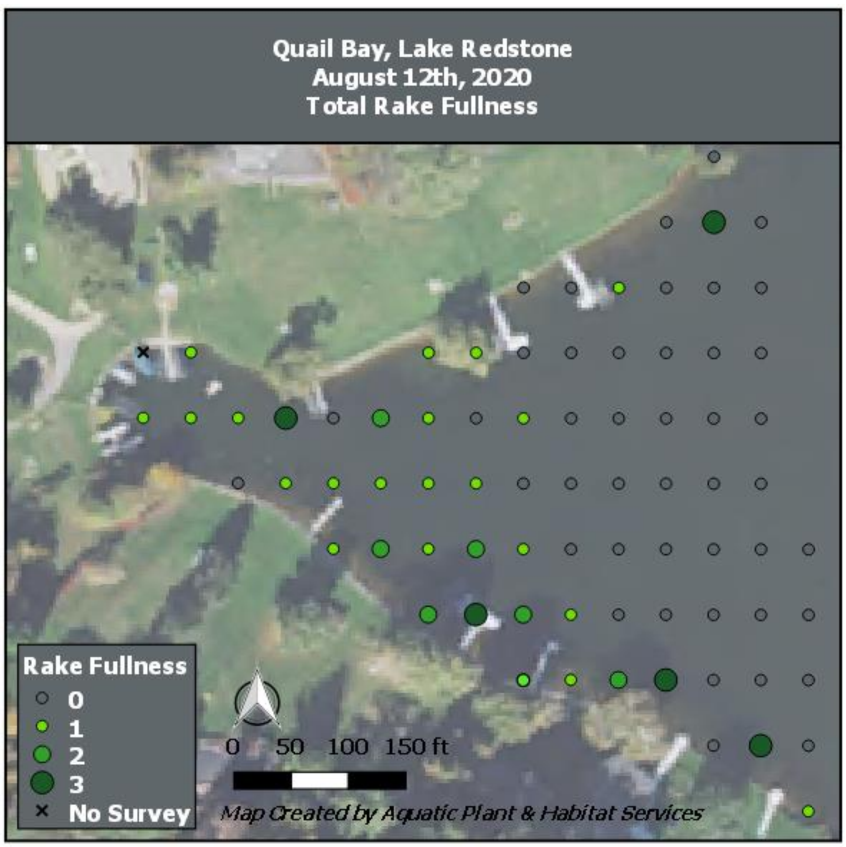
Figure 13 – Oriole Bay Total Rake Fullness Map



Quail Bay

This was the third plant survey of Quail Bay (2017, 2019, and 2020). There were 76 points surveyed, 50 of which were shallower than the maximum rooting depth of 6 feet and 32 sites had vegetation (Table 5). A total of 7 species of aquatic plants were found in Quail Bay, one of which was "visual only". Maps of plant species can be found in Appendix K. Coontail and EWM were the most common species found at 36% and 48% of littoral survey points respectively. Together they accounted for 74% of the total relative frequency indicating the plant community of Quail Bay is homogeneous (Table 4). Chi-squared tests of all plant species revealed a statistically significant (SS) increase in coontail, EWM, and wild celery when compared to 2019 and a SS increase in small pondweed when compared to 2017 (Appendix N). The Simpson Diversity Index was 0.70 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include aquatic invasive species. Therefore, 5 species were included in the calculation, yielding a floristic quality of 11.2 with an average C value of 5 (Table 6).

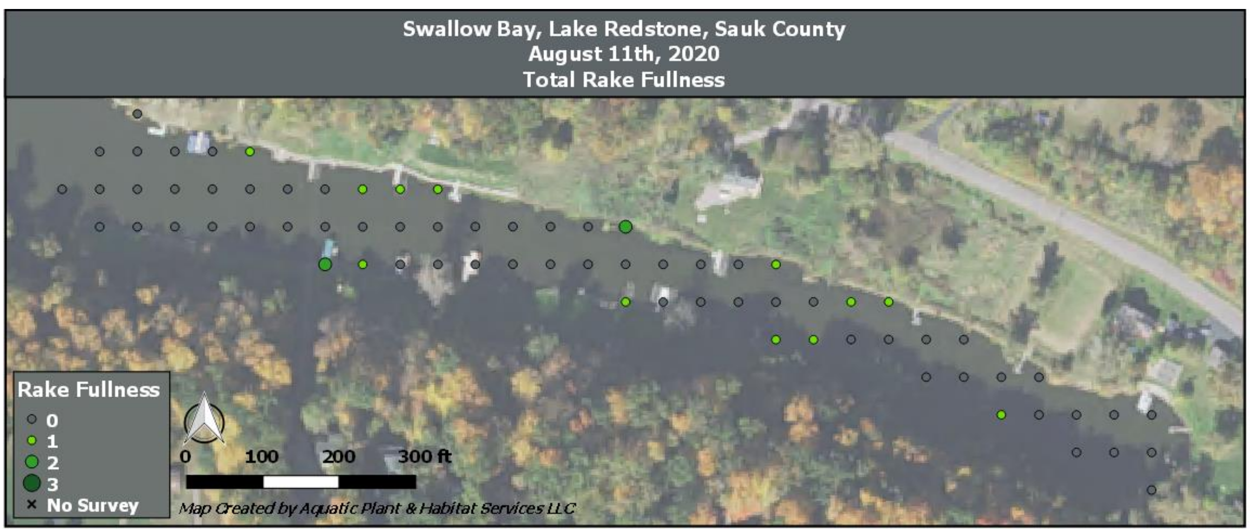
Figure 14 – Quail Bay Total Rake Fullness Map



Swallow Bay

In Swallow Bay all 71 points were surveyed, 57 were shallower than the maximum rooting depth of 5 feet. There were 14 sites with vegetation present and included a total of 6 species, one of which was visual only and not including filamentous algae (Table 5). The most common species was white water lily found at 23% of sites shallower than maximum rooting depth and a relative frequency of 72%. The Simpson Diversity Index for Swallow Bay was 0.46 on a scale from 0 to 1 suggesting the plant community in Swallow Bay is highly homogeneous. Maps of plant species can be found in Appendix L. Chi-squared tests of all plant species revealed a statistically significant (SS) decrease in large duckweed, coontail, EWM, and filamentous algae when compared to 2014 data (Appendix N). The FQI only factors species raked at survey points and does not include aquatic invasive species. Therefore, only 3 species were included in the calculation, yielding a floristic quality of 9.2 with an average C value of 5.3 (Table 6).

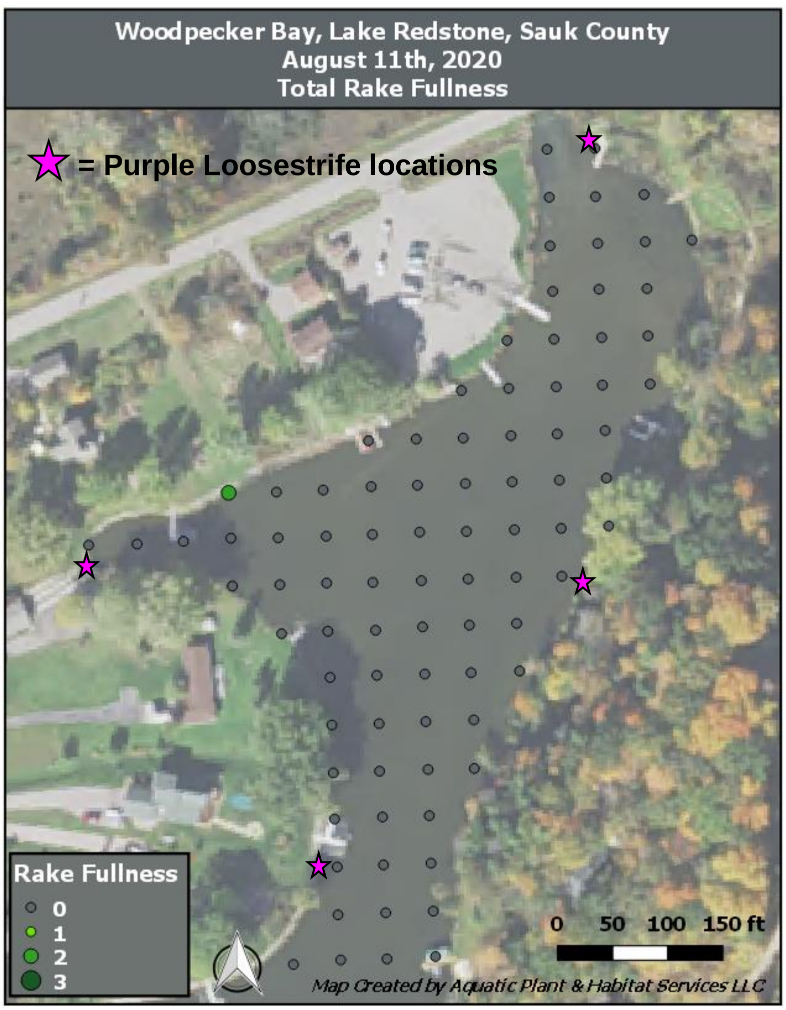
Figure 15 – Swallow Bay Total Rake Fullness Map



Woodpecker Bay

This was the fifth consecutive aquatic plant survey of Woodpecker Bay (2016-2020). A total of 88 survey waypoints were surveyed, only 10 which were shallower than the maximum rooting depth of 3 feet. Vegetation was present at only 1 survey point and was the lowest plant occurrence compared to past years (Table 5). Only one species of aquatic plant was found at that survey point (white water lily) while purple loosestrife was found along shore but not near any survey points. Filamentous algae was also documented. Maps of plant species can be found in Appendix M. A chi-squared test comparing data from 2016 and 2020 revealed a statistically significant decrease in large duckweed, small duckweed, EWM, filamentous algae, white water lily, and coontail (Appendix N). The Simpson Diversity Index was zero on a scale from 0 to 1. The FQI does not include aquatic invasive species or visual observations. Therefore only 1 species was included in the calculation, yielding a floristic quality of 6 with an average C value of 6 (Table 6). Even though there was greater plant occurrence in previous years, it would be reasonable to skip the plant survey in Woodpecker Bay in 2021 and resume sampling when/if needed.

Figure 16 – Woodpecker Bay Total Rake Fullness Map



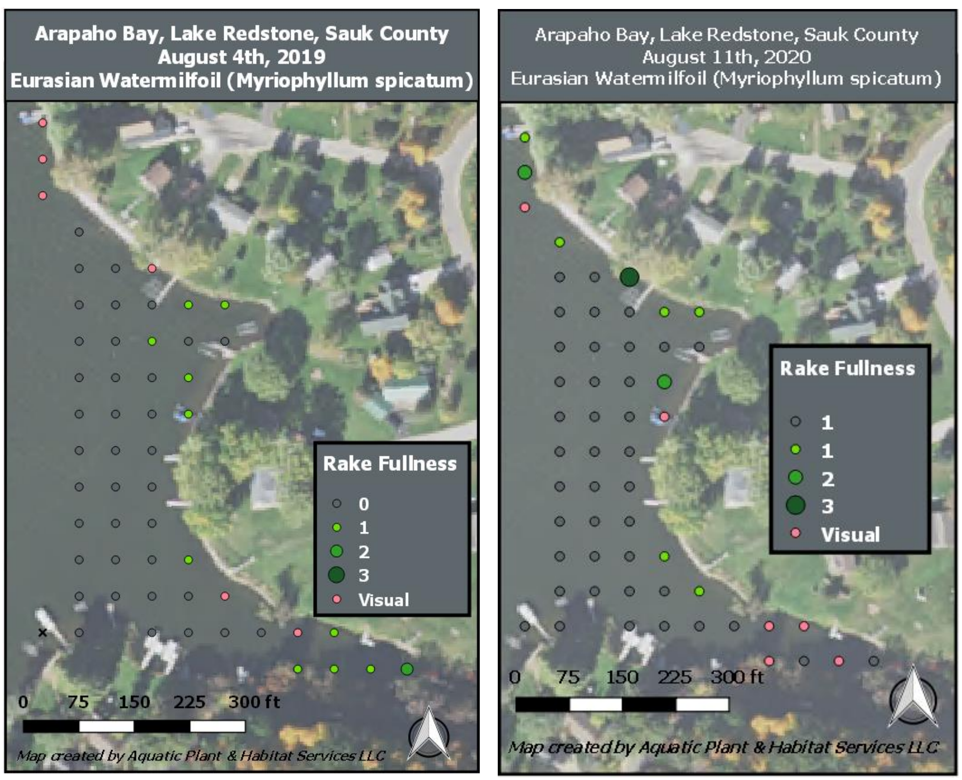
Eurasian Watermilfoil & Management History

Eurasian watermilfoil (EWM) was found in all bays except County F and Woodpecker. It was the most common plant in 8 bays (4 in 2019) and second-most common plant in one additional bay (4 in 2019). In 2020, littoral frequency of EWM was higher in 9 bays and the same level in 4 bays[3] when compared to 2019, although only 5 of the increases were statistically significant. When comparing EWM in 2020 to the first survey year for each bay, EWM occurrence was significantly lower in Killdeer, Martin-Meadowlark, Swallow, and Woodpecker Bays in 2020. There was no herbicide treatment of any bays in spring 2019 nor 2020 because dredging occurred in the second half of 2019. Each bay has its own management history and an assessment of EWM in each bay is included in this section.

Arapaho Bay EWM

EWM was the most common plant with scattered distribution at 9 sample points (11 in 2019) and visual observation at another 6 points (same as 2019). EWM littoral frequency was 31% in 2020, 24% in 2019, and 33% in 2015. No herbicide treatment has occurred in Arapaho Bay. A chi-squared test of EWM revealed no significant change in EWM between 2015 and 2020 nor between 2019 and 2020.

Figure 17 – Arapaho Bay Eurasian Watermilfoil Maps 2019-2020

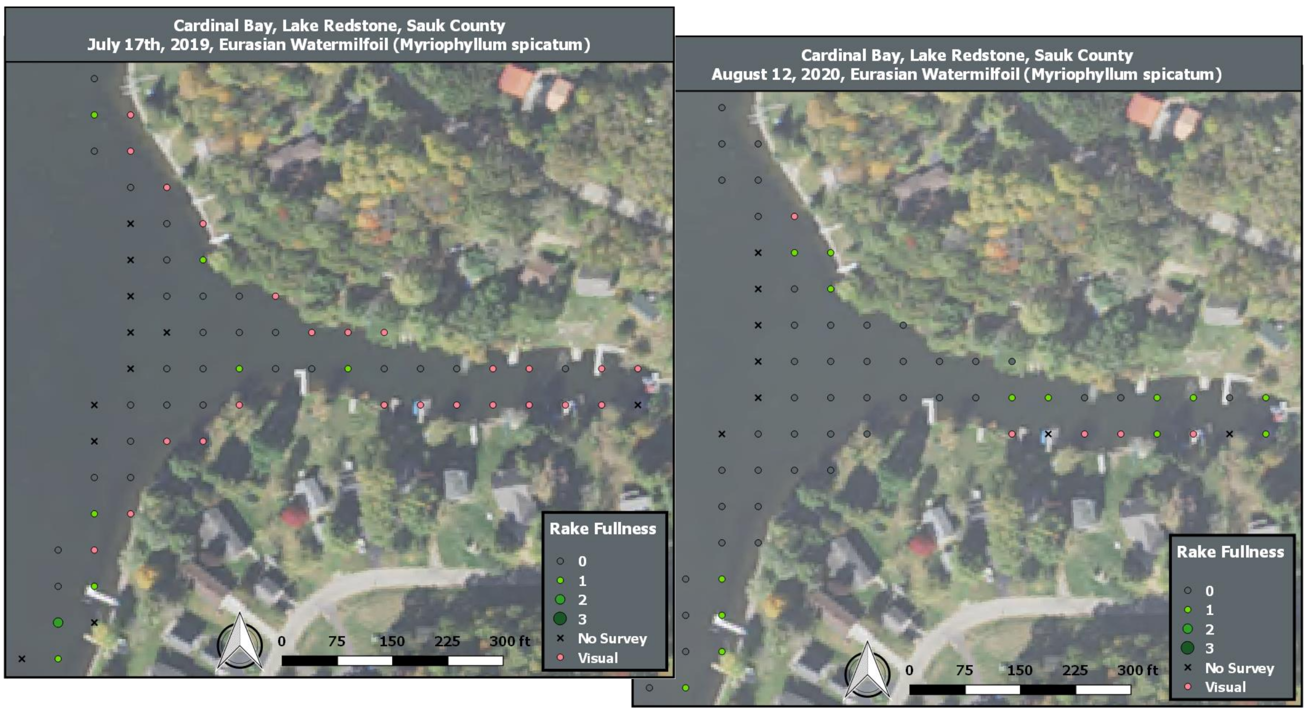


[3] Woodpecker Bay EWM littoral frequency was essentially the same with 0% occurrence in 2019 and 1% in 2020.

Cardinal Bay EWM

EWM was the most common plant with occurrence at 14 points (8 in 2019) and visual observation at another 5 points (24 in 2019). EWM littoral frequency was 31% in 2020, 15% in 2019, 20% in 2018, 50% in 2017, 31% in 2016, and 30% in 2015. Herbicide was applied in Cardinal Bay in spring of 2016 and 2018. A chi-squared test of EWM revealed no significant change in EWM between 2015 and 2020 nor between 2019 and 2020.

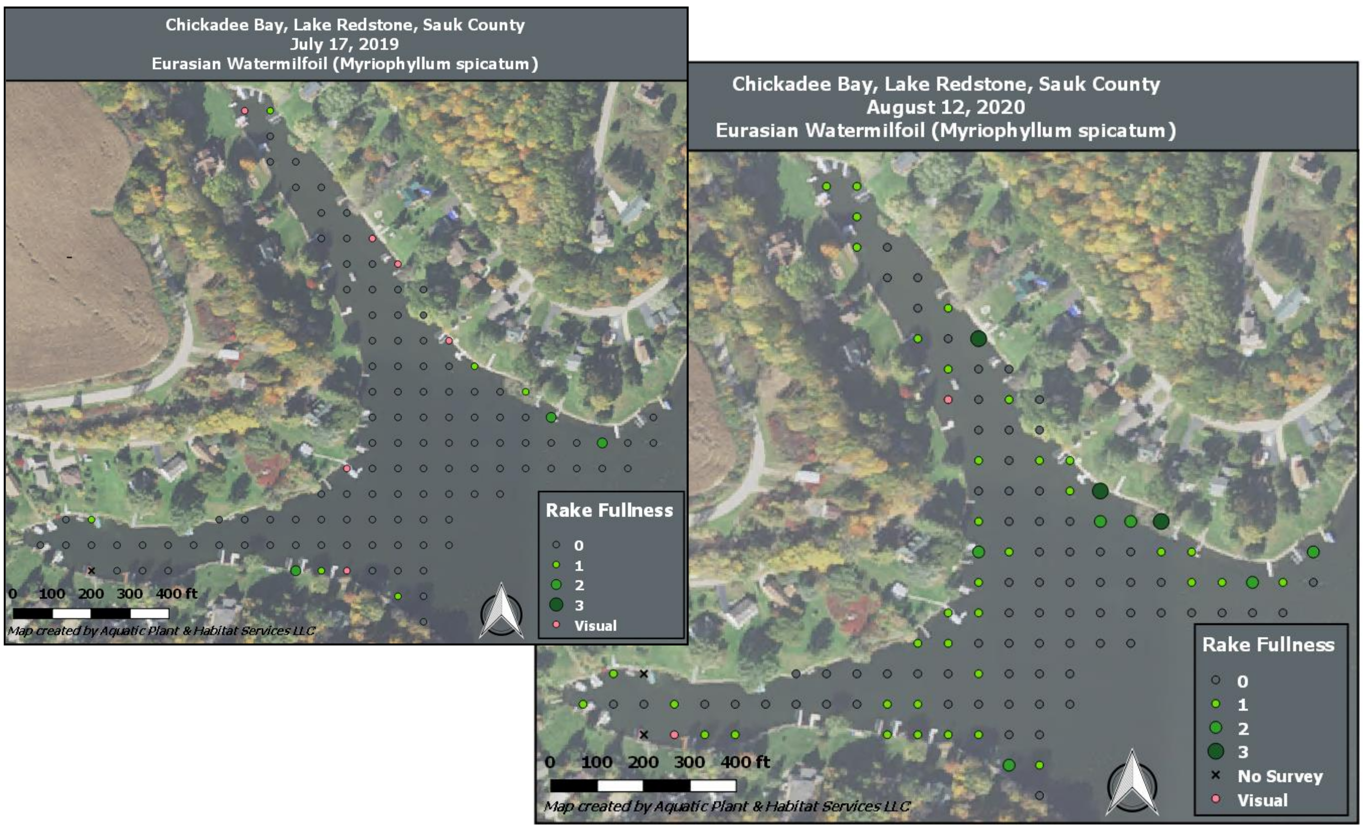
Figure 18 - Cardinal Bay Eurasian Watermilfoil Maps 2019-2020



Chickadee Bay EWM

EWM was the most common aquatic plant in 2020 and was found at 46 sites (9 in 2019) and 2 visual observations (6 in 2019). EWM littoral frequency was 55% in 2020, 18% in 2019, `and 34% in 2015. Herbicides were applied to the southern arm of Chickadee Bay in spring of 2016 to combat EWM. A chi-squared test of EWM data revealed a statistically significant increase between the whole-bay survey in 2015 and 2020 and between 2019 and 2020.

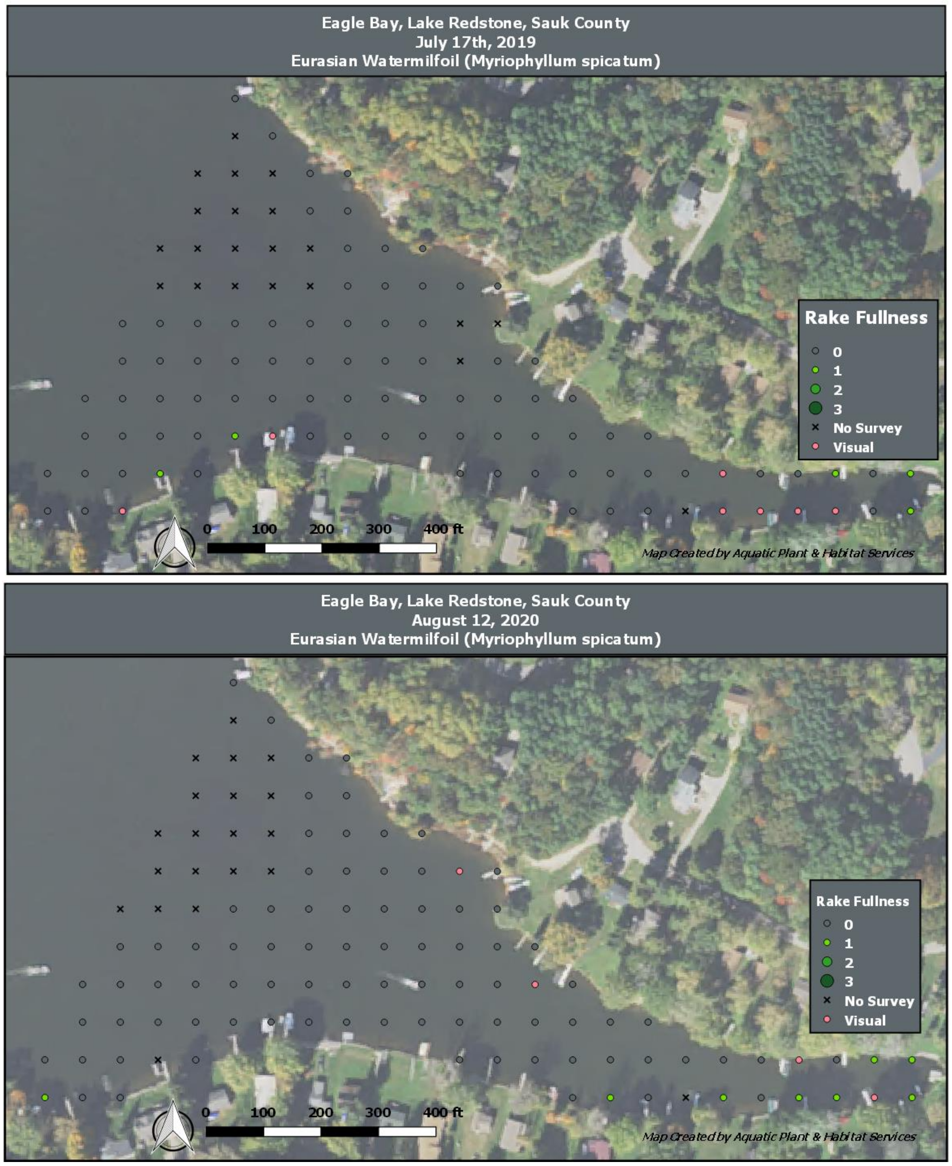
Figure 19 – Chickadee Bay Eurasian Watermilfoil Maps 2019-2020



Eagle Bay EWM

EWM was the most common plant species found at 8 survey points (5 in 2019) and another 4 visual observations (7 in 2019). Littoral frequency of EWM was 17% in 2020, 14% in 2019, 5% in 2018, 30% in 2017, and 15% in 2014. Herbicide treatment was done in spring 2018 to control EWM. Comparisons between 2019 and 2020 using chi-squared tests reveal no statistically significant different in EWM occurrence. The same is true when comparing 2014 data to 2020.

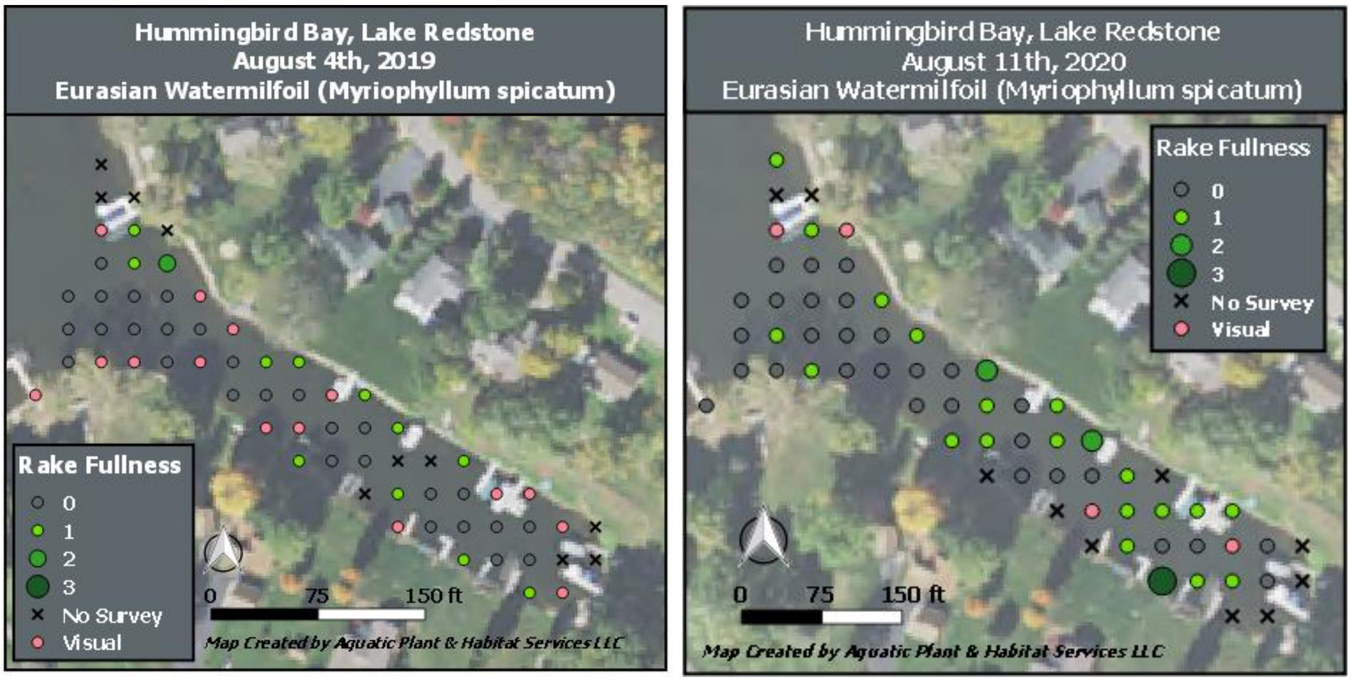
Figure 20 – Eagle Bay Eurasian Watermilfoil Maps 2019-2020



Hummingbird Bay EWM

EWM was the most common species found in Hummingbird Bay and was found at 22 survey points (12 in 2019) and another 4 visual observations (15 in 2019). EWM littoral frequency was highest in 2020 among all years at 40%, 24% in 2019, 25% in 2018, 29% in 2017 and 36% in 2016. Herbicide treatment was conducted in Hummingbird Bay in spring 2017. There was a statistically significant increase in EWM between 2019 and 2020.

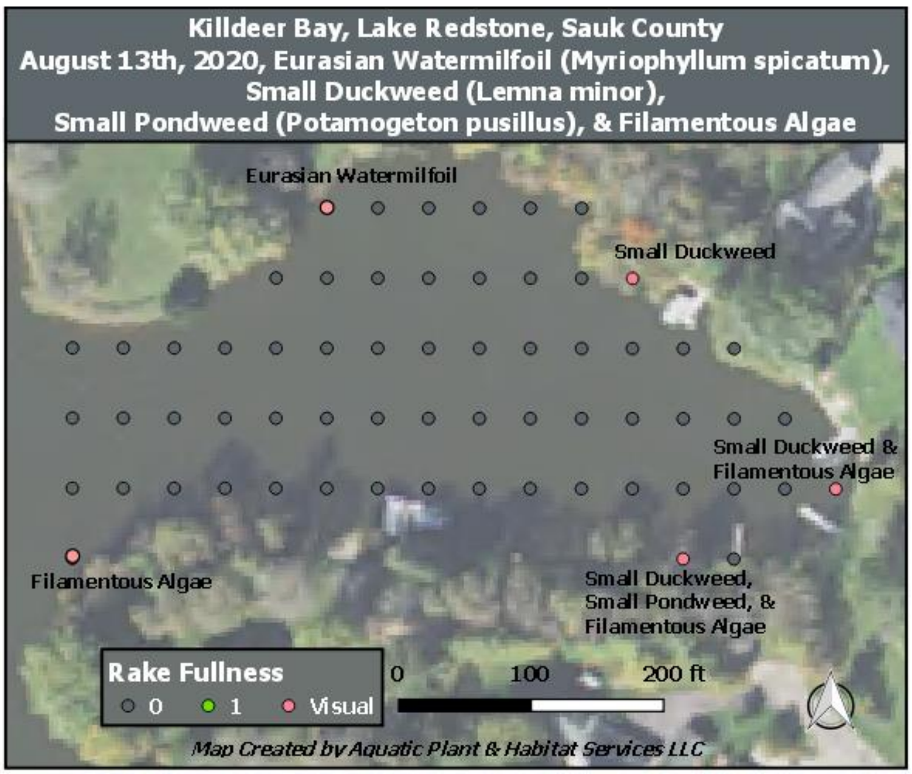
Figure 21 – Hummingbird Bay Eurasian Watermilfoil Maps 2019-2020



Killdeer Bay EWM

EWM was uncommon in the bay with only 1 visual observation and was not found on the rake at any sample points. EWM littoral frequency was 0% in both 2019 and 2020 but at 40% in 2017 (but still only at 4 points). No herbicide treatment was done in Killdeer Bay. There was a statistically significant decrease in EWM in 2020 when compared to 2017 even though the reduction was only from 4 points to 0 points.

Figure 22 – Killdeer Bay Map of Eurasian Watermilfoil, Small Duckweed, Small Pondweed, & Filamentous Algae



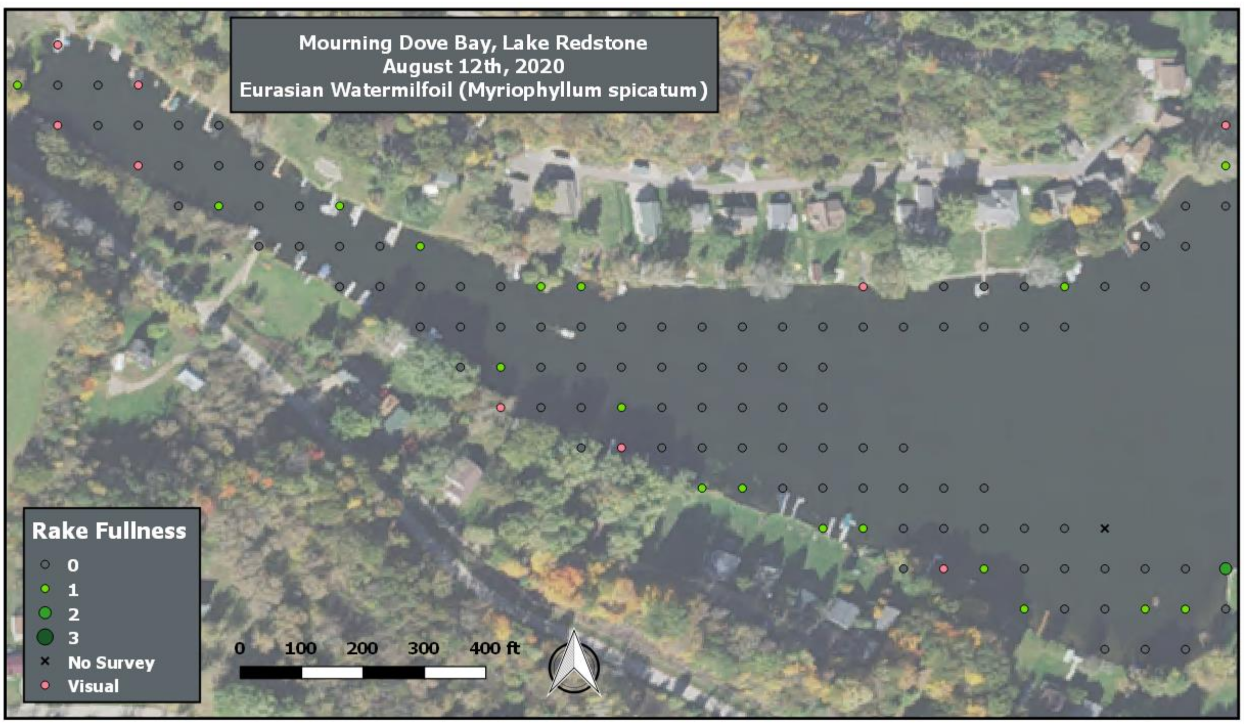
Martin-Meadowlark Bay EWM

EWM was observed in the bay in 2020 but was not near enough any sample points (within 6 feet) to be recorded as a visual observation, which is why no EWM map of Martin-Meadowlark Bay was created for this report. EWM littoral frequency was 0% in 2019 and 2020, 6% in 2018, 23% in 2017, 22% in 2016, 0% in 2015, and 42% in 2014. Herbicide treatment was done in 2015 to control EWM. There was a significant decrease in EWM in 2020 when compared to 2014.

Mourning Dove Bay EWM

EWM was found at 19 sites and visual observation at another 9 points making it the most common species in 2020. Littoral frequency was 22% in 2020, 3% in 2018, 31% in 2017, and 17% in 2016. Herbicide treatment was done in 2018 to control EWM. A chi-squared test of EWM data found a statistically significant increase when compared to 2018.

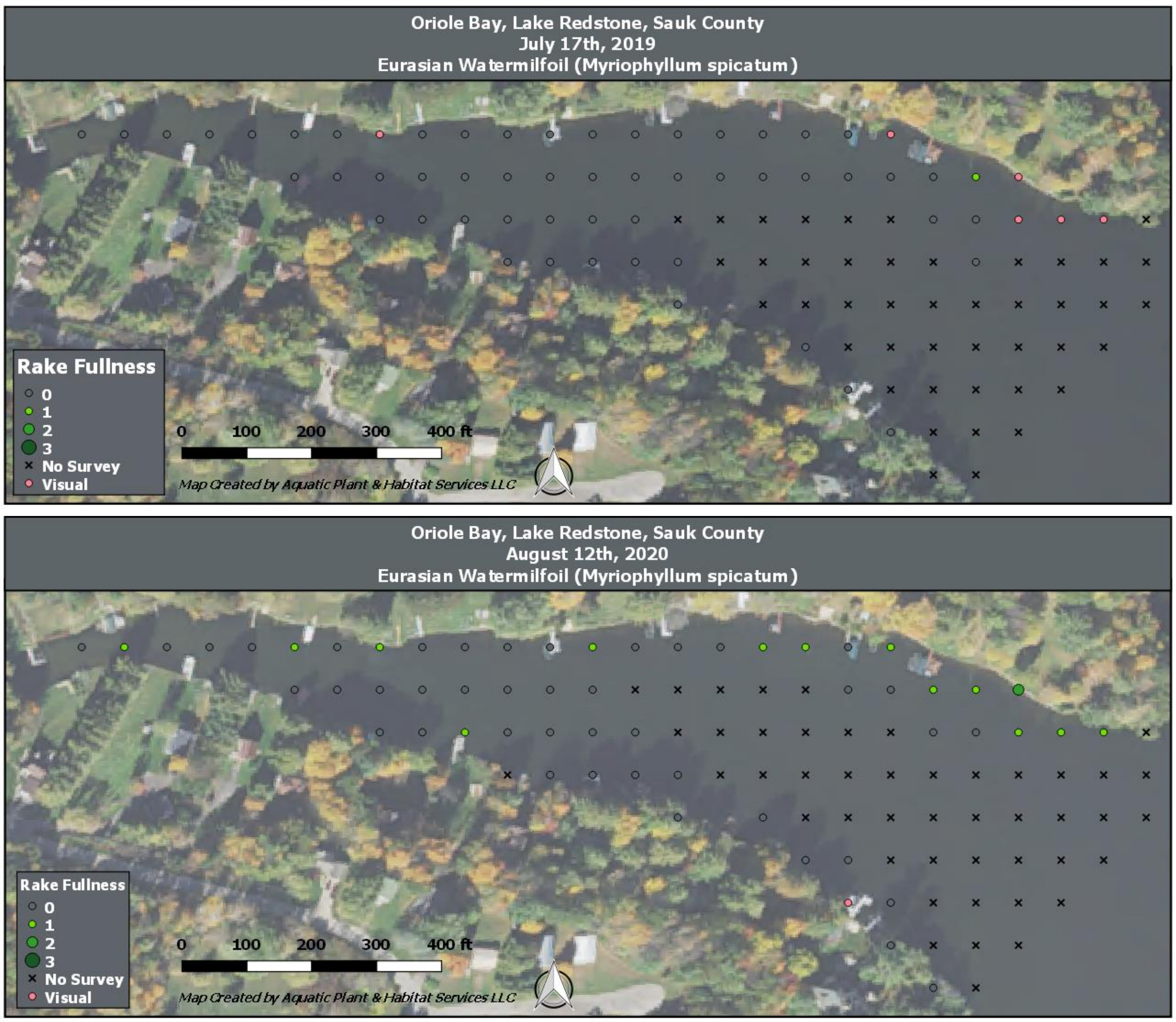
Figure 23 – Mourning Dove Bay Eurasian Watermilfoil Map



Oriole Bay EWM

EWM was found at 14 sites (1 site in 2019) and visual observation at another 1 point (6 in 2019) making it the most common aquatic plant species in 2020. Littoral frequency was 38% in 2020, 4% in 2019, 6% in 2018, 24% in 2017, 14% in 2016, and 27% in 2015. Herbicide treatment was done in 2016 to control EWM. A chi-squared test of EWM 2020 compared to 2019 revealed a statistically significant increase in occurrence. There was no significant change in EWM when comparing data from 2015 to 2020.

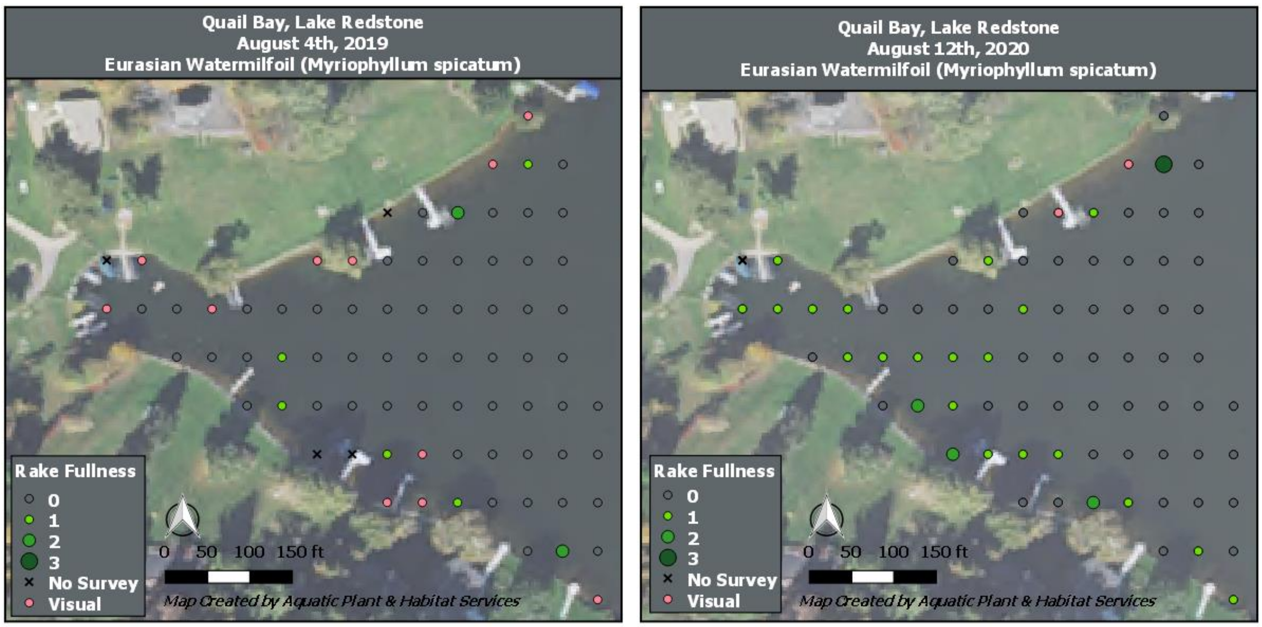
Figure 24 – Oriole Bay Eurasian Watermilfoil Maps 2019-2020



Quail Bay EWM

EWM was found at 24 survey points (7 in 2019) and another 2 visual observations (11 in 2019), making it the most common plant species distributed throughout Quail Bay. EWM littoral frequency was 48% in 2020, 21% in 2019 and 22% in 2017. Herbicide treatment has not been conducted in Quail Bay. There was no statistically significant difference in EWM when comparing 2017 and 2020 but there was a statistically significant increase in EWM when comparing 2019 to 2020.

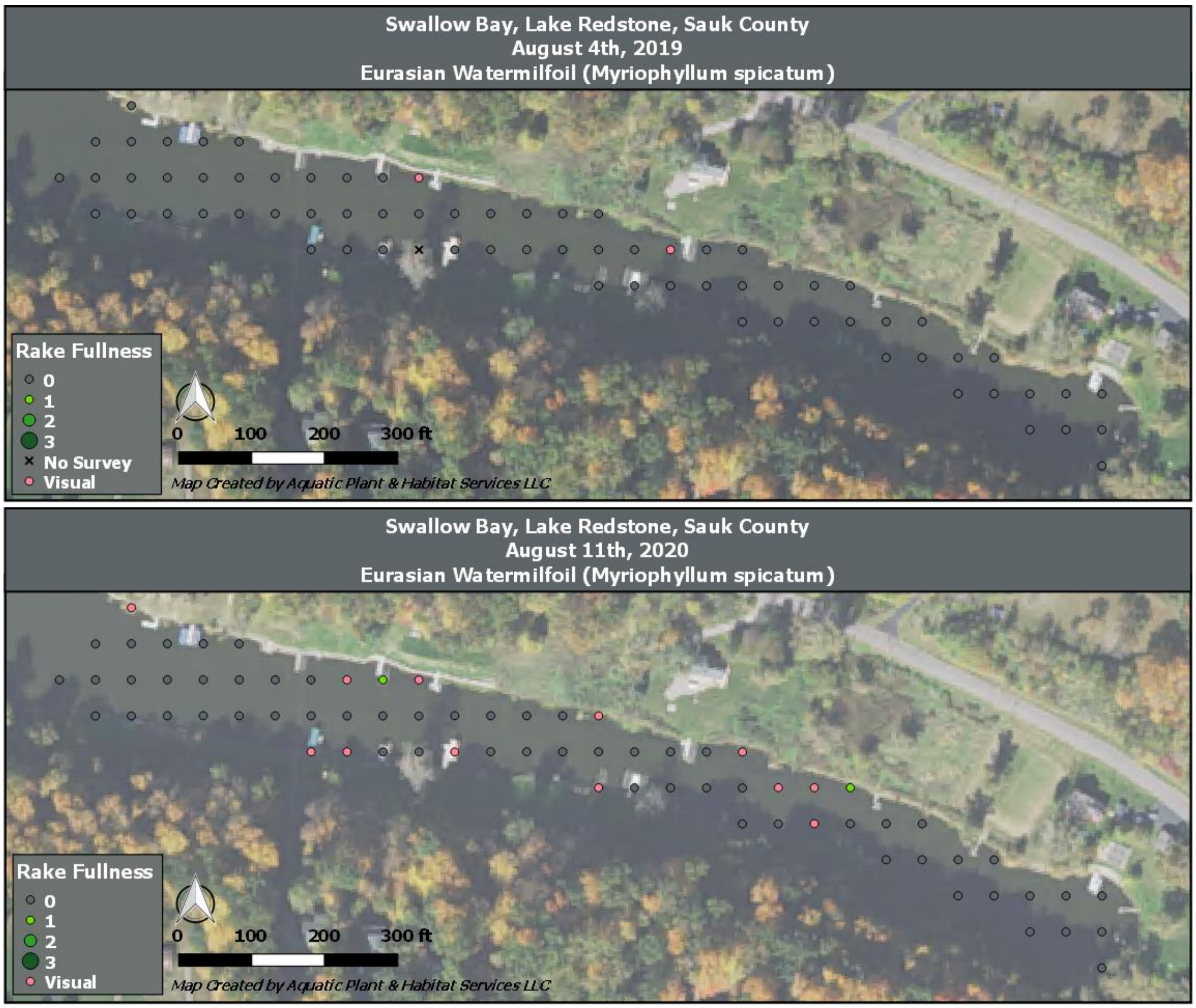
Figure 25 – Quail Bay Eurasian Watermilfoil Maps 2019-2020



Swallow Bay EWM

EWM was found at 2 survey points in 2020 (0 in 2019) and visually observed at another 12 points (2 in 2019). Littoral frequency of EWM was 4% in 2020, 0% in 2019 and 2018, 29% in 2017, 9% in 2016, 1% in 2015, and 52% in 2014. Herbicide treatment was done in spring 2015 and 2018 to control EWM. A chi-squared test of the 2014 EWM data compared to 2020 reveals a statistically significant decrease in EWM. There was no significant change in EWM between 2019 and 2020.

Figure 26 – Swallow Bay Eurasian Watermilfoil Map



DISCUSSION

Aquatic Plants are Necessary for Healthy Lakes

Aquatic plants serve important functions in lake 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 for nuisance algal growth. For these reasons, native aquatic plants should be protected in lakes 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 also negatively impact recreation. An overabundance of vegetation can cause oxygen depletion in the water as plants decompose, thereby reducing the oxygen available to fish and other aquatic organisms.

Changes in Native Plant Occurrence

With the August 2020 survey results, there were 2 statistically significant declines in native[4] plant species and 2 bays with SS declines in filamentous algae when compared to the most recent previous results. There were 3 SS increases in native plant species when comparing 2020 to the most recent previous surveys.

If we compare the August 2020 to the first year surveyed for each of the bays that have been surveyed for three years or more there were 17 statistically significant declines in native plant species and 5 SS declines in filamentous algae.[5] There were 2 statistically significant increases in native species when compared to the first year surveyed. Based on these results, it seems as though there is an overall decline in native plant occurrence and filamentous algae in the bays that are being studied. There was also a downward trend in EWM in most bays in 2019 but that was no longer the case in 2020. EWM occurrence is discussed further in this section.

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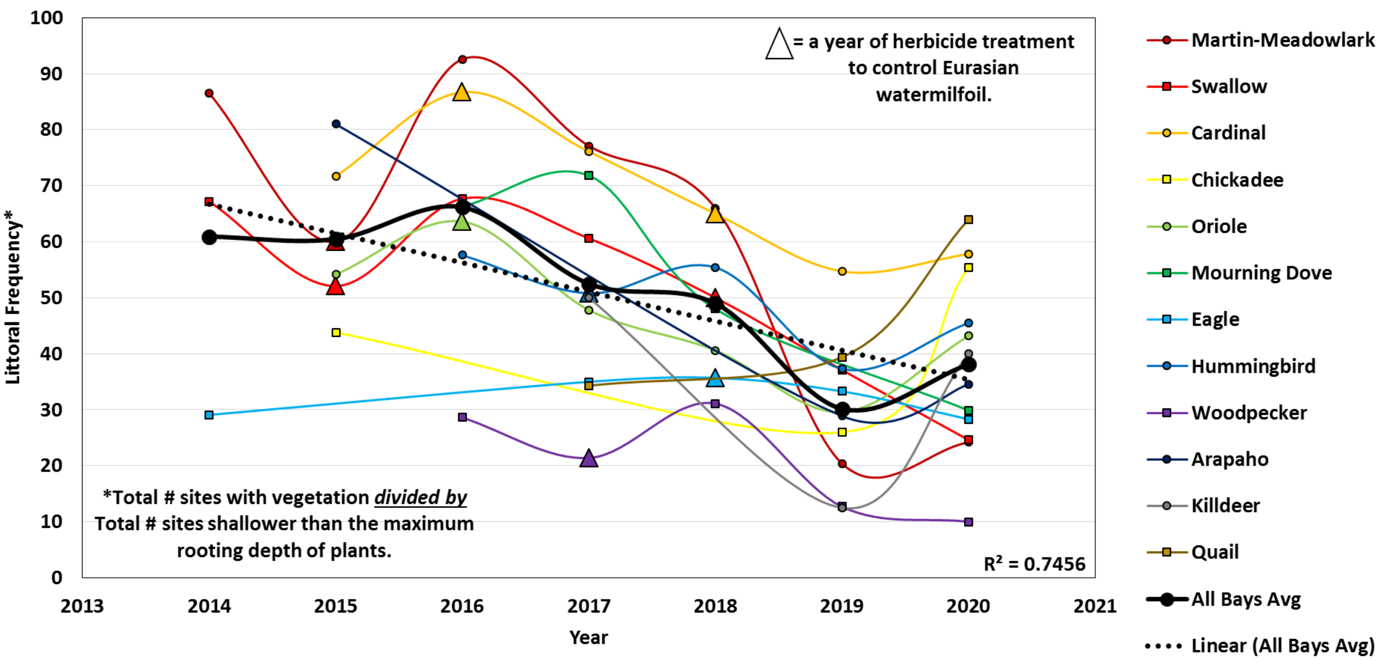
[4] There was a SS decrease of coontail and white water lily in Mourning Dove Bay between 2019 and 2020. There was a SS decrease in filamentous algae in Cardinal Bay and Mourning Dove Bay in 2020 when compared to 2019. There was a SS increase of coontail in Chickadee and Quail Bays and wild celery in Quail Bay between 2019 and 2020.

[5] Coontail SS decrease in 8 bays, small duckweed SS decrease in 2 bays, white water lily SS decrease in 3 bays, large duckweed SS decrease in 3 bays, and slender waterweed SS decrease in 1 bay. Small pondweed SS increase in 2 bays.

Reduced Plant Occurrence (Native & Non-native Species)

The graph in Figure 27 illustrates data already listed in Table 3 and Table 4 for bays surveyed for ≥3 years. The graph charts a function of the total number of sites where plants (native & non-native) *do* occur vs. the total number of sites where plants *could* occur, AKA littoral frequency, thereby factoring in water clarity because it only includes points that are equal to or shallower than the maximum depth of aquatic plants. In theory, if water clarity declines so do the number of points shallower than the maximum depth of plants. This graph shows that average littoral frequency[6] was lowest in 2019 and somewhat higher in 2020. A linear trendline[7] of the average littoral frequency among all bays except County F suggests the littoral frequency of aquatic plants (native and non-native) has been on a downward trend from 2014 through 2020 with an R2 value of 0.75.[8] This trends could be due to environmental factors such as the historic flooding in the area in 2018 that also likely impacted aquatic plant growth the following year (2019). The trend does not appear to be consistent among all bays treated with herbicide. In other words, herbicide treatment in a given year does not appear to be a main factor in driving down littoral frequency, although it can't be ruled out as a contributing factor.

Figure 27 – Littoral Plant Frequency Graph



6 Littoral frequency of County F not included because it was only surveyed for two years. County F was among the lowest in littoral frequency and maximum rooting depth in 2019 and 2020.

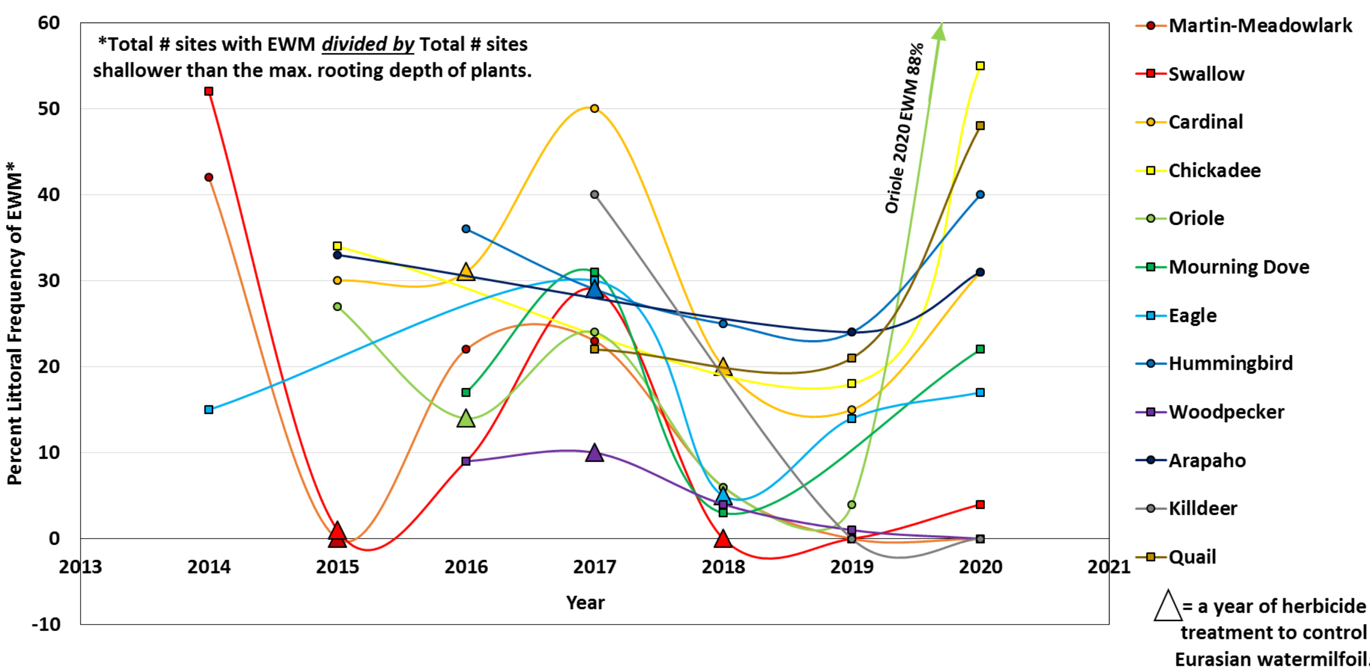
7 A **linear trendline** is a best-fit straight line that is used with simple **linear** data sets. Data is **linear** if the pattern in its data points resembles a line. A **linear trendline** usually shows that something is increasing or decreasing at a steady rate.

8 **R-squared** value measures the **trendline** reliability - the nearer $\mathbf{R}^2$ is to 1, the better the **trendline** fits the data.

EWM after Dredging in 2019

Figure 28 illustrates EWM littoral frequency in all bays from 2014 through 2020. ***In summary, all 13 bays had higher or the same EWM occurrence in 2020 when compared to 2019[9]. The increase in EWM was statistically significant in 5 of those bays.*** This was unexpected because the act of dredging removes sediment and along with it come roots and seeds. Therefore, EWM was not expected to increase in 2020 compared to pre-dredging conditions. However, EWM and non-native/invasive species in general thrive in disturbed environments and the dredging may have opened a niche for EWM to recolonize more quickly than native species. Further potential explanation is that root balls not fully removed and/or fragments of EWM readily grew in the dredged areas. Regrowth from seed is likely not a primary mechanism of recovery for EWM, although the possibility of some EWM seed germination isn't ruled out. Furthermore, it may be worthwhile to have samples from Lake Redstone genetically tested to rule out the presence of hybrid milfoil, which is the genetic cross between Eurasian watermilfoil and native northern watermilfoil (*Myriophyllum sibiricum*). Although Lake Redstone does not have northern watermilfoil present, the introduction of the hybrid strain could occur through boat traffic. The most recent genetic testing of Lake Redstone EWM was done in 2013 with results concluding the milfoil was Eurasian and not hybrid. However, hybrid milfoil testing periodically is recommended to detect whether it has been introduced into the system.

Figure 28 – Eurasian Watermilfoil Littoral Frequency Graph



[9] Mourning Dove Bay was not surveyed in 2019 because dredging was already underway in July. Data from 2020 is compared to 2018 for Mourning Dove Bay. Woodpecker Bay had essentially the same EWM occurrence in 2020 at 0% compared to 1% in 2019.

Identifying Trigger Frequencies for Herbicide Treatment

The following idea was presented in the 2017 report for Lake Redstone and is worth revisiting to help decide where herbicide treatment should occur, if at all. One possible management strategy is to identify a littoral frequency of EWM that triggers consideration for herbicide treatment the following spring. Littoral frequency is calculated by dividing the number of sites with EWM by the number of total sites shallower than maximum rooting depth of plants. Table 7 lists the littoral frequencies of EWM the year before they were treated with herbicide. Woodpecker Bay had low EWM littoral frequency of only 9% in 2016 but only the northern section of the bay was treated in 2017 and is not included in the table. If we take an average pre-treatment littoral frequency of EWM for all bays that had herbicide treatment (not including Woodpecker), the result is approximately 36%. When this concept was first published in the 2017 report, the average trigger frequency was close to this value at 40%. Of the bays surveyed in 2020, there were four with EWM frequencies higher than 36%. ***Chickadee Bay had 55% littoral frequency*** of EWM but the majority of EWM found was well below the lake surface and did not impair recreation (29 sites with EWM well below the surface, 19 sites with EWM at the lake surface). ***Oriole Bay had 38% littoral frequency*** with EWM growing at the lake surface at only 3 sample points while 12 points had EWM growing below the lake surface. ***Hummingbird Bay had 40% littoral frequency*** with EWM growing at the lake surface at 16 sample points while 10 points had EWM growing near or below the lake surface. Lastly, ***Quail Bay had 48%*** littoral frequency with EWM growing at the lake surface at 7 sample points while 19 points had EWM growing below the lake surface.

Table 7 – Past EWM Frequencies before Herbicide Treatment

Bay & Year		Littoral frequency of EWM	Average littoral frequency of EWM
Martin-Meadowlark	**2014**	42	**36**
Swallow	**2014**	52	
	2017	29	
Cardinal	**2015**	30	
	2017	50	
Chickadee*	**2015**	34	
Oriole	**2015**	27	
Eagle	**2017**	30	
Hummingbird	**2016**	36	
Mourning Dove	**2017**	31	

**The entire bay was surveyed in 2015 but only the southern arm of the bay was treated with herbicide in 2016.*

General Management Recommendations

Similar to previous years' recommendations, aquatic plants with low frequency of occurrence and/or higher conservatism value should be protected. These species include sago pondweed, small pondweed, slender waterweed, slender naiad, white water lily in some bays, long-leaf pondweed, water star-grass, horned pondweed, and wild celery. Coontail was a plant of high occurrence in previous surveys and hand removal of nuisance aquatic plants, such as coontail in some instances, is permitted by Chapter NR 109 but the removal cannot occur in a designated sensitive area (identified in Sefton & Graham 2009) without a permit, is limited to a single area no more than 30 feet wide measured along shore, and must not harm the overall aquatic plant community.

Volunteer water monitoring and early detection of aquatic invasive species is an important component of lake management. Continued water monitoring and AIS surveying is recommended, although no active control of CLP is also reasonable due to its low occurrence.

The Lake Redstone Protection District has done commendably in funding pre-post plant surveys, yielding valuable data since 2014. Increased plant occurrence overall and increased EWM occurrence despite dredging operations was unexpected for 2020. Continued plant surveys in bays are recommended where needed. It is reasonable to consider removing Killdeer, County F, and Woodpecker Bays from the survey list in 2021 based on their very low plant occurrence in 2020. In bays where EWM occurrence was above the 36% trigger level in 2020, discuss whether EWM control efforts are necessary in 2021.

Table 8 - Management Recommendations Summary

1. Protect native aquatic plants as they provide important structural habitat and contribute to a healthy lake system.
2. If necessary, shore land owners can hand pull or rake nuisance vegetation in a <30-foot-wide area that is contiguous and parallel to shore. Designated sensitive areas require a permit.
3. Continue volunteer water quality monitoring.
4. Conduct aquatic plant surveys of bays in 2021 as needed and plant for a whole-lake aquatic plant survey of Lake Redstone in 2021 or 2022. Consider removing Killdeer, County F, and Woodpecker Bays from the survey list in 2021 due to very low plant occurrence in 2020.
5. Consider genetic testing of milfoil in Redstone to detect whether hybrid watermilfoil is present in 2021.
6. Determine whether EWM control actions are needed in Chickadee, Oriole, Hummingbird, and Quail Bays

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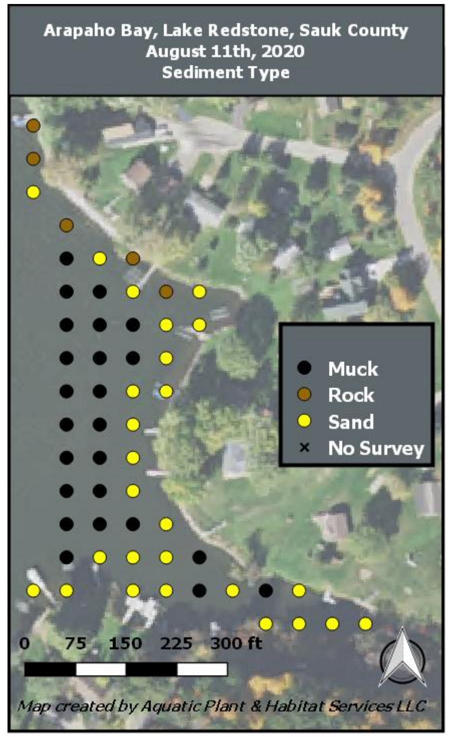
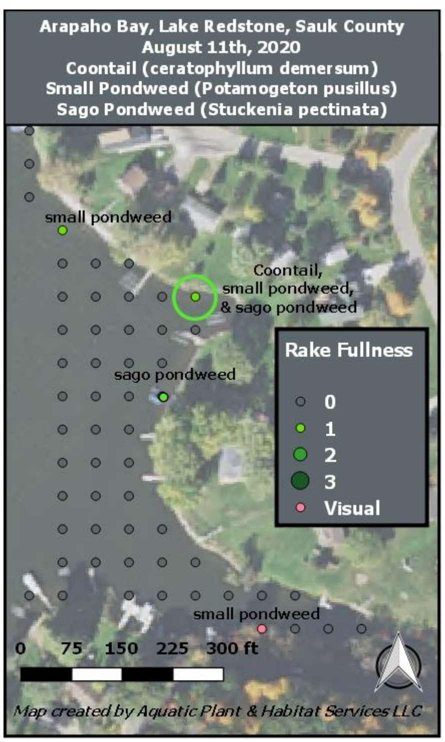
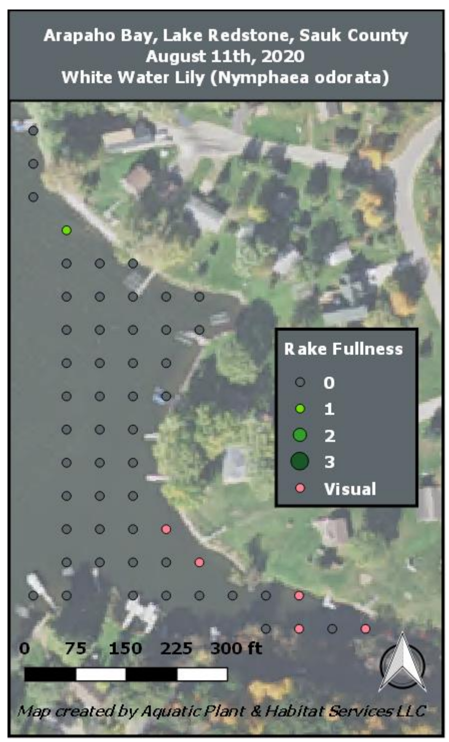
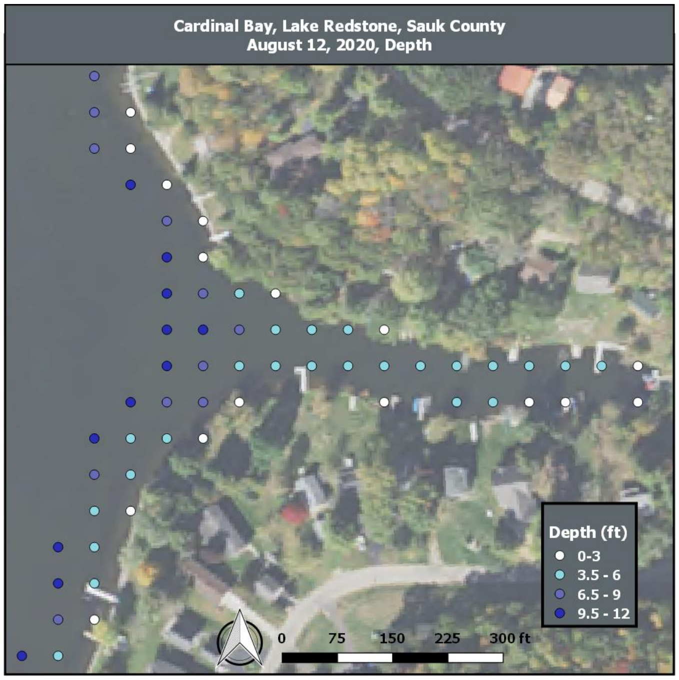
APPENDIX A – ARAPAHO BAY MAPS

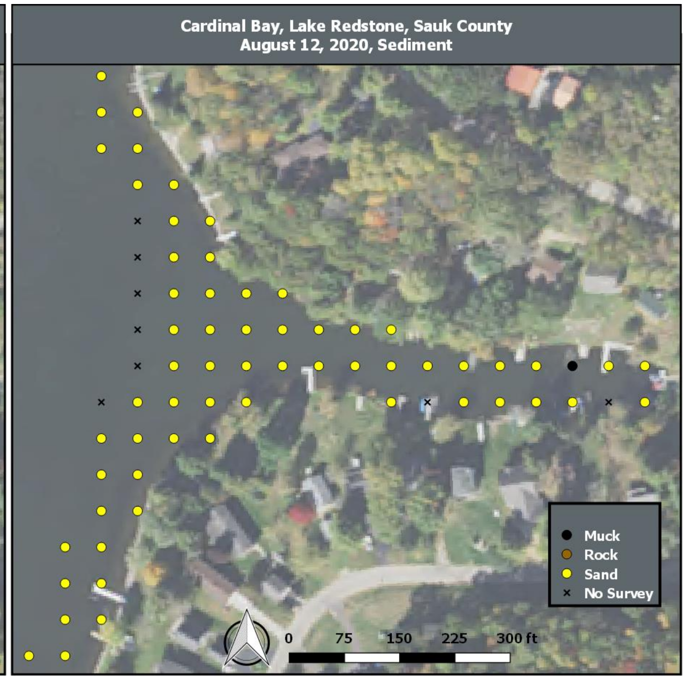


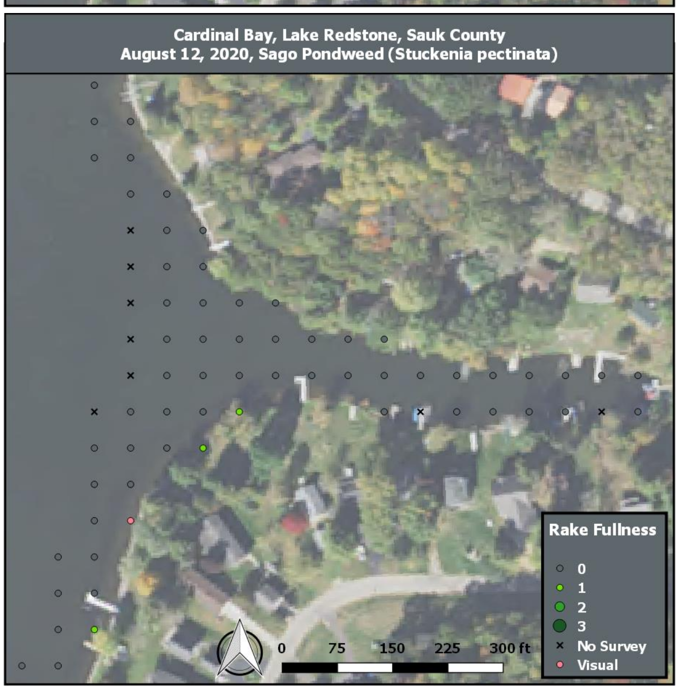


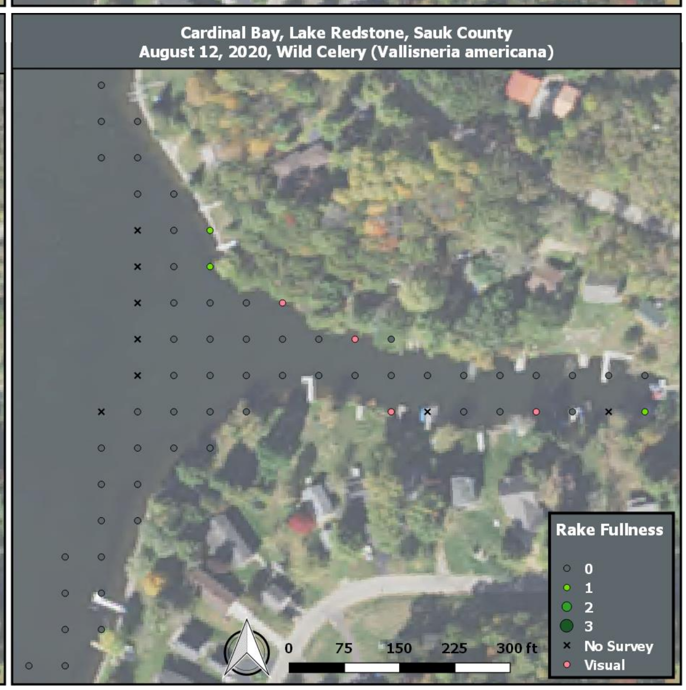


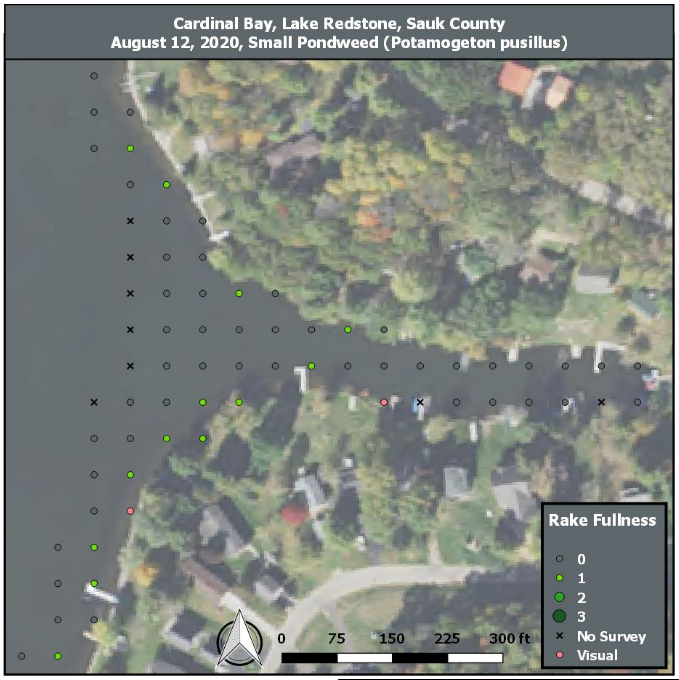
APPENDIX B – CARDINAL BAY MAPS

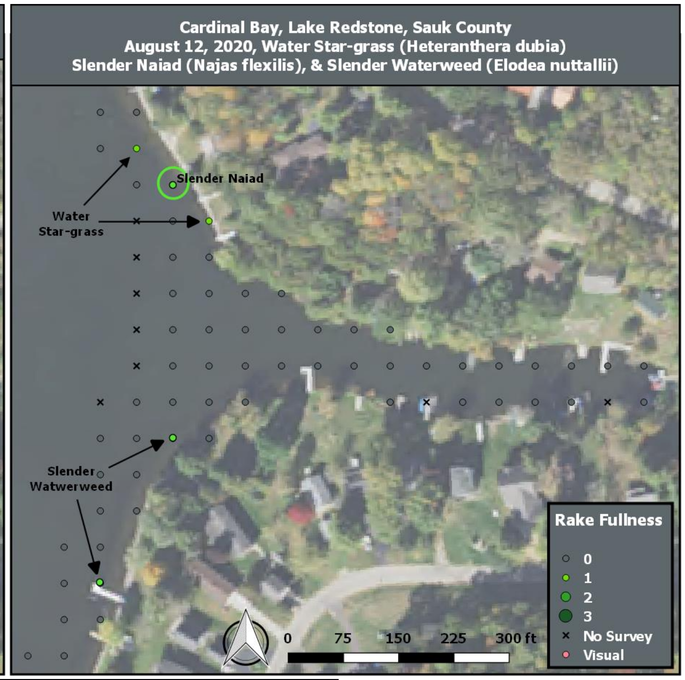


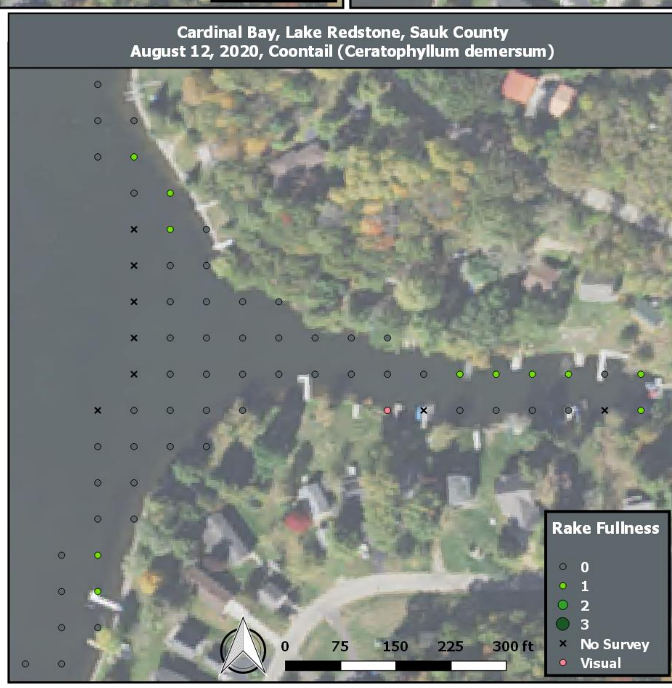




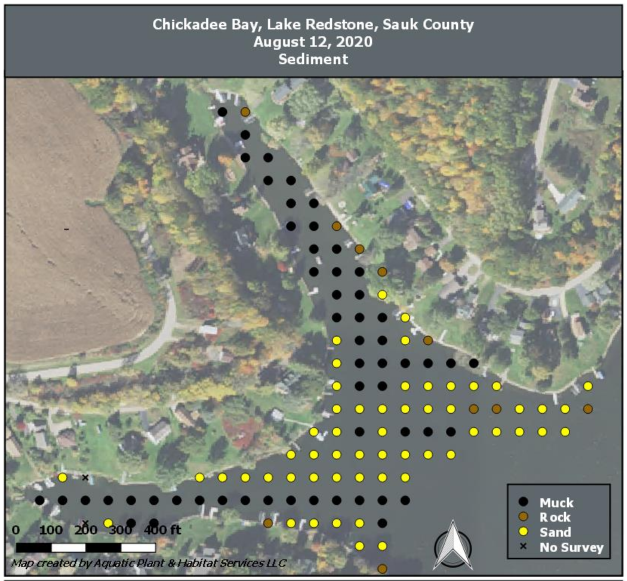


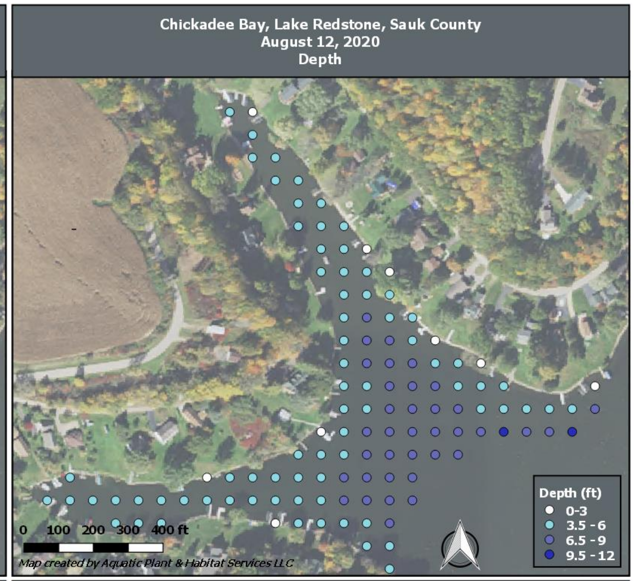

Cardinal Bay, Lake Redstone, Sauk County
August 12, 2020, Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
No Survey
Visual
0
75
150
225
300 ft


Cardinal Bay, Lake Redstone, Sauk County
August 12, 2020, Water Star-grass (Heteranthera dubia)
Slender Naiad (Najas flexilis), & Slender Waterweed (Elodea nuttallii)
Slender Naiad
Water
Star-grass
Slender
Watwerweed
Rake Fullness
0
1
2
3
No Survey
Visual
0
75
150
225
300 ft

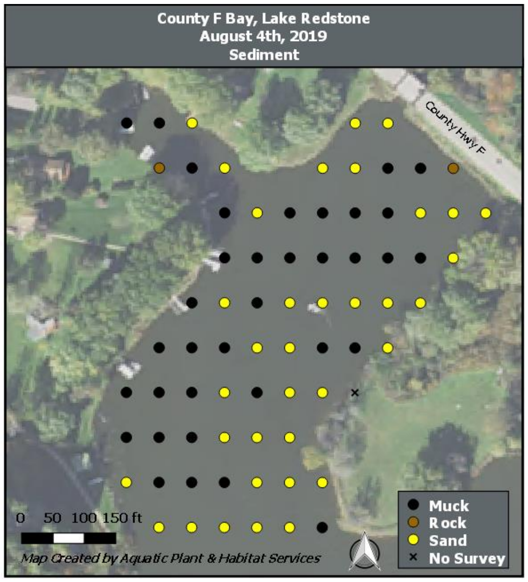

Cardinal Bay, Lake Redstone, Sauk County
August 12, 2020, Coontail (Ceratophyllum demersum)
Rake Fullness
0
1
2
3
No Survey
Visual
0
75
150
225
300 ft

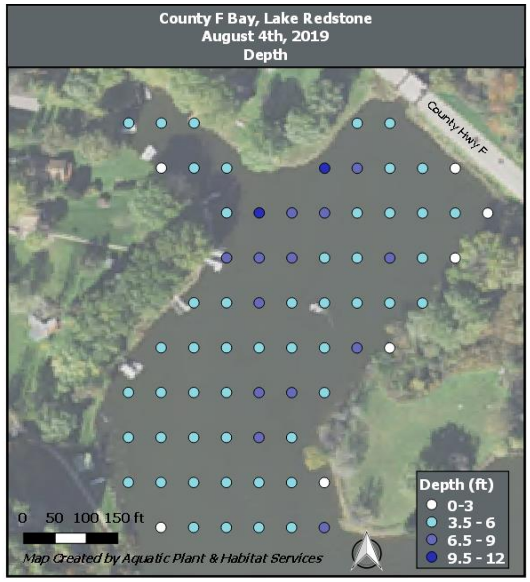
APPENDIX C - CHICKADEE BAY MAPS

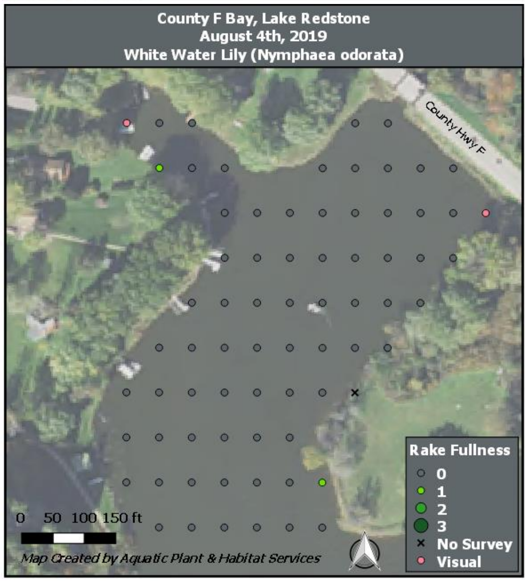


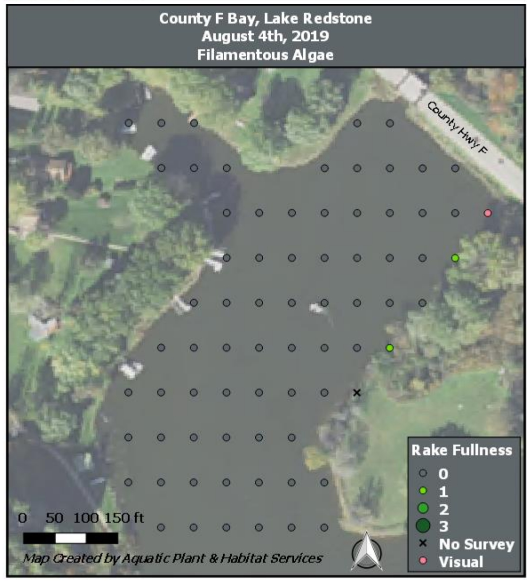


APPENDIX D – COUNTY F BAY MAPS

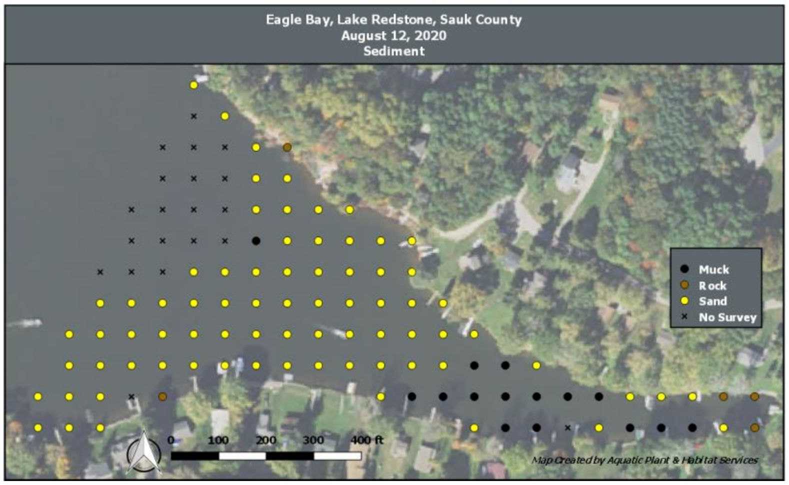


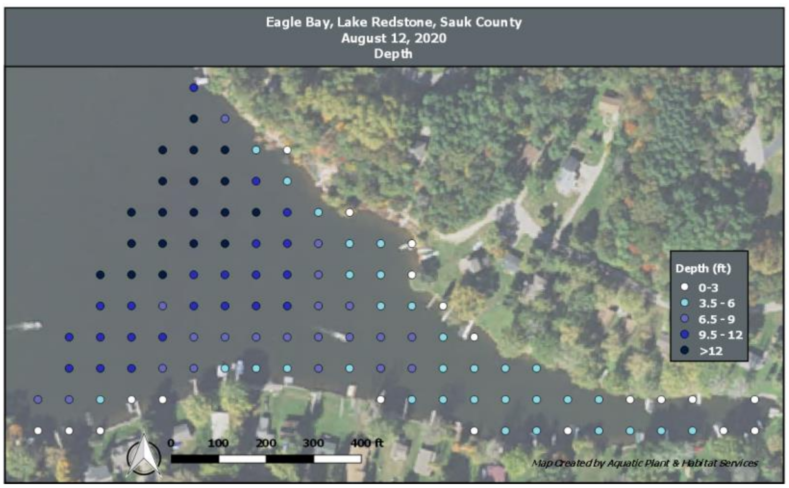


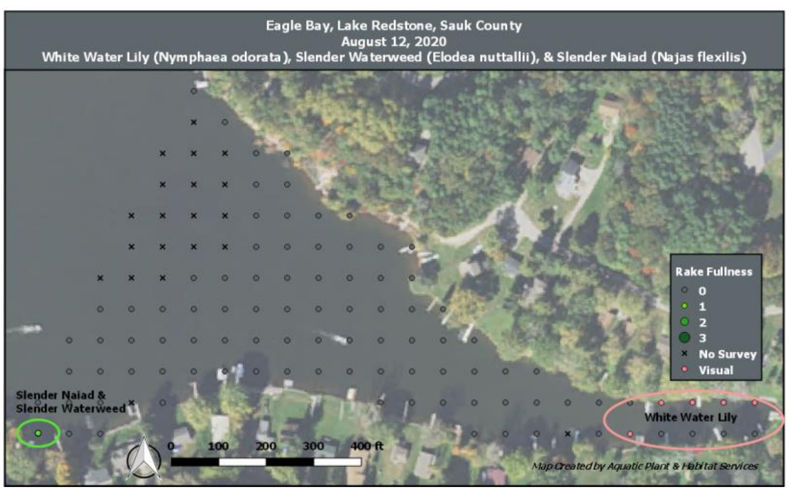


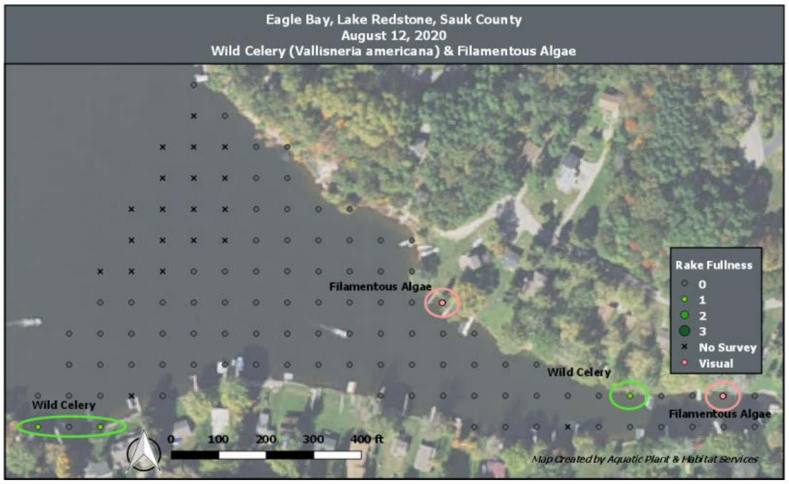


APPENDIX E – EAGLE BAY MAPS

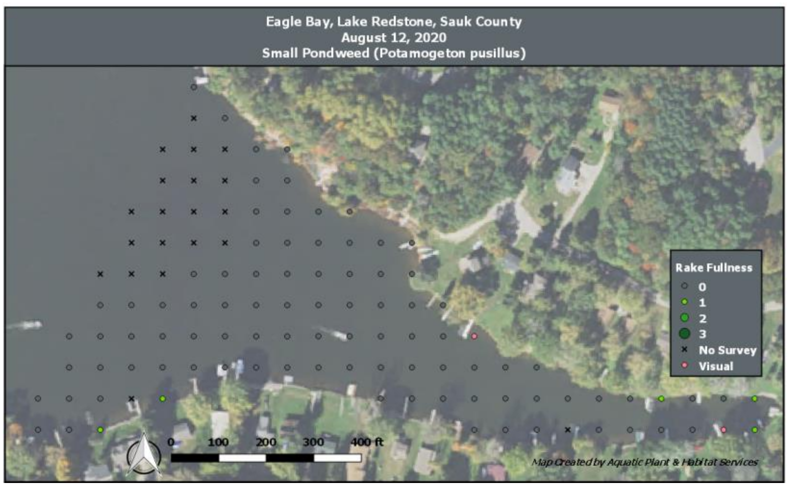




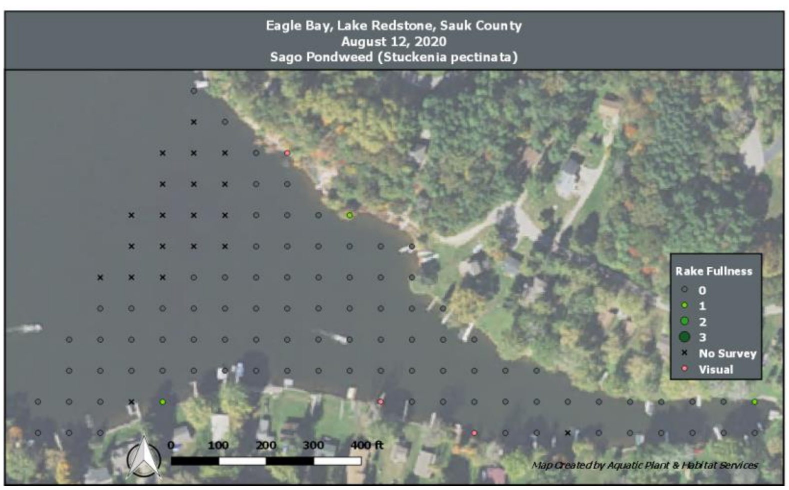




Eagle Bay, Lake Redstone, Sauk County
August 12, 2020
Wild Celery (Vallisneria americana) & Filamentous Algae
Filamentous Algae
Wild Celery
Wild Celery
Filamentous Algae
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services

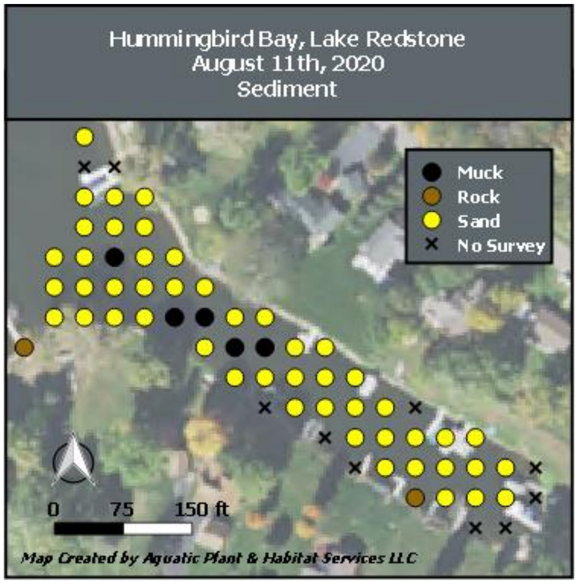


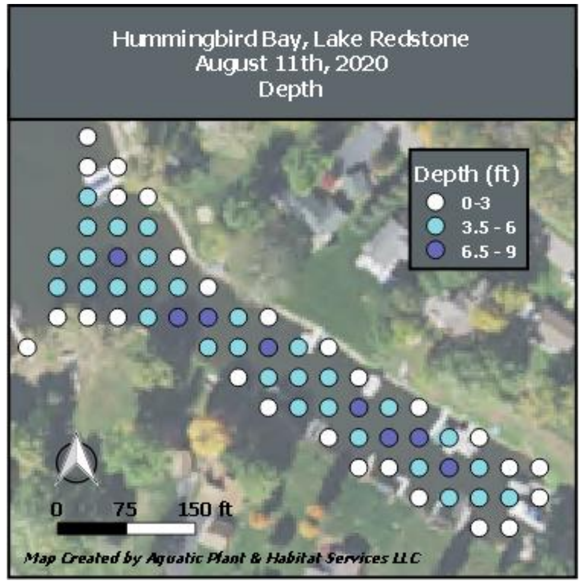
Eagle Bay, Lake Redstone, Sauk County
August 12, 2020
Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services

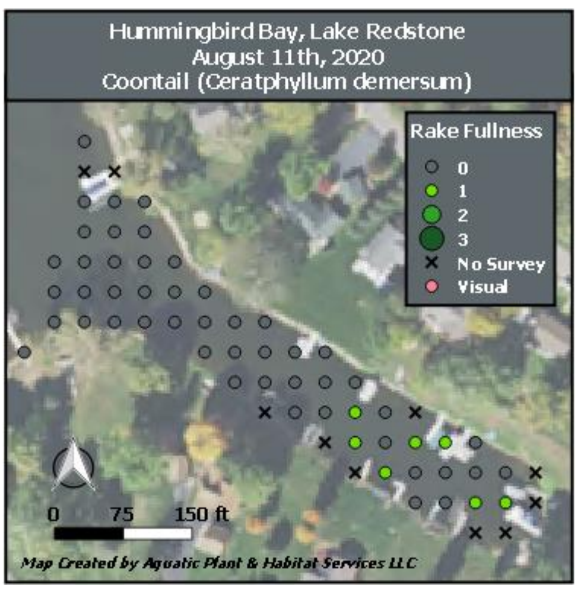


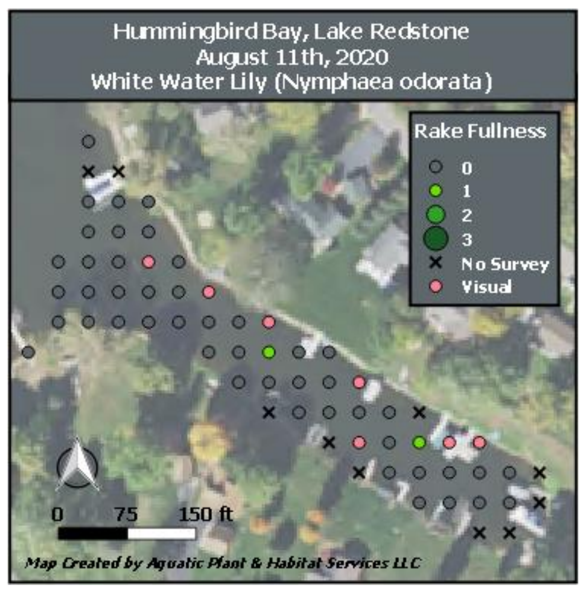
Eagle Bay, Lake Redstone, Sauk County
August 12, 2020
Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services

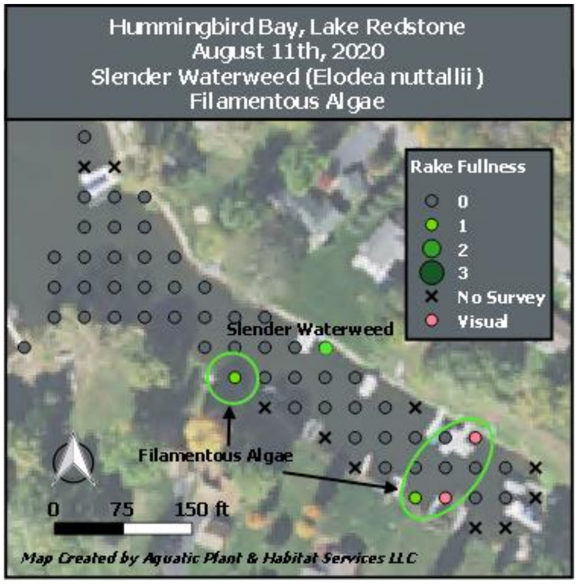
APPENDIX F – HUMMINGBIRD BAY MAPS

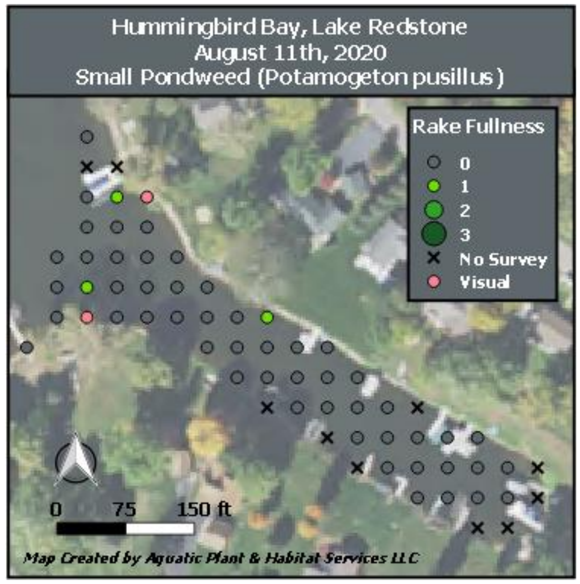


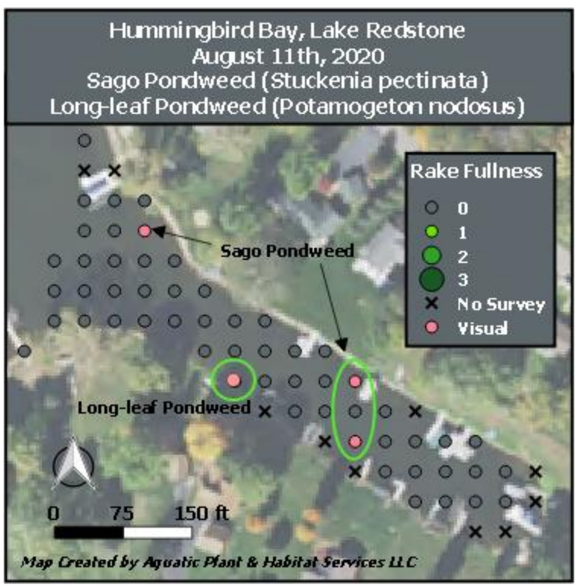




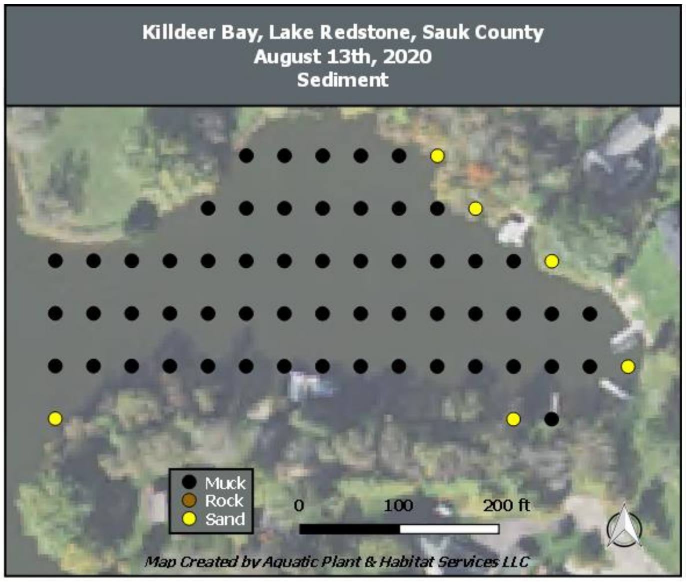


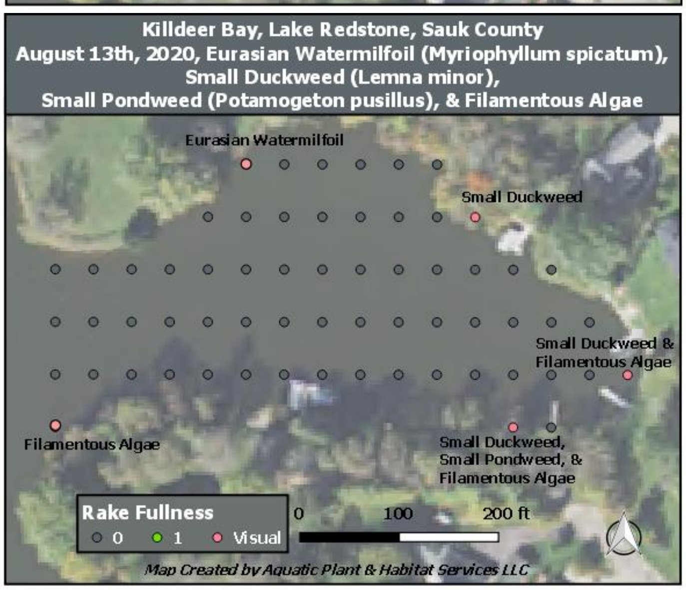

Hummingbird Bay, Lake Redstone
August 11th, 2020
Slender Waterweed (Elodea nuttallii)
Filamentous Algae
Rake Fullness
0
1
2
3
No Survey
Visual
Slender Waterweed
Filamentous Algae
0
75
150 ft
Map Created by Aquatic Plant & Habitat Services LLC


Hummingbird Bay, Lake Redstone
August 11th, 2020
Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
No Survey
Visual
0
75
150 ft
Map Created by Aquatic Plant & Habitat Services LLC

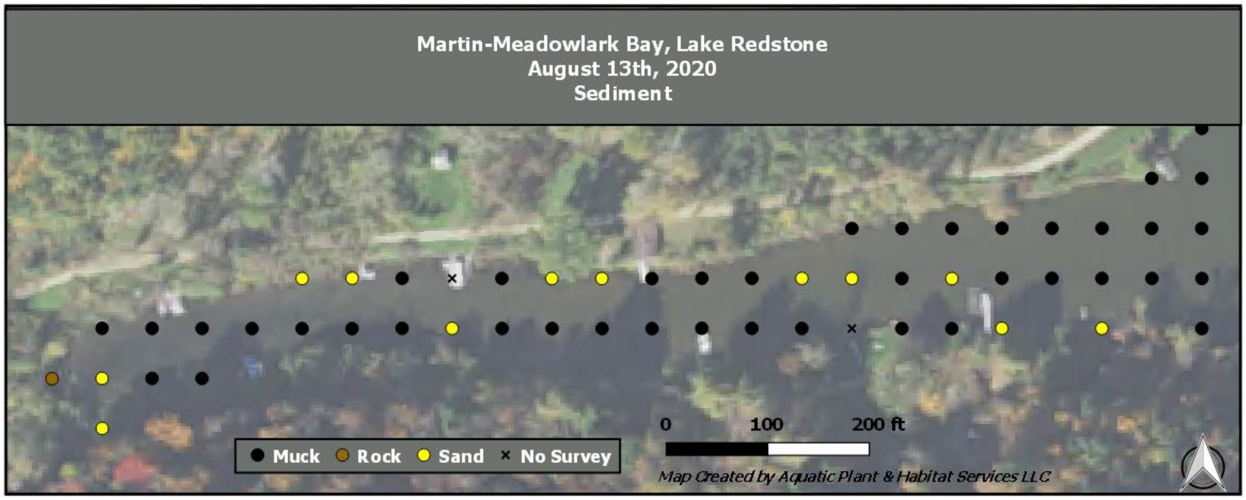

Hummingbird Bay, Lake Redstone
August 11th, 2020
Sago Pondweed (Stuckenia pectinata)
Long-leaf Pondweed (Potamogeton nodosus)
Rake Fullness
0
1
2
3
No Survey
Visual
Sago Pondweed
Long-leaf Pondweed
0
75
150 ft
Map Created by Aquatic Plant & Habitat Services LLC

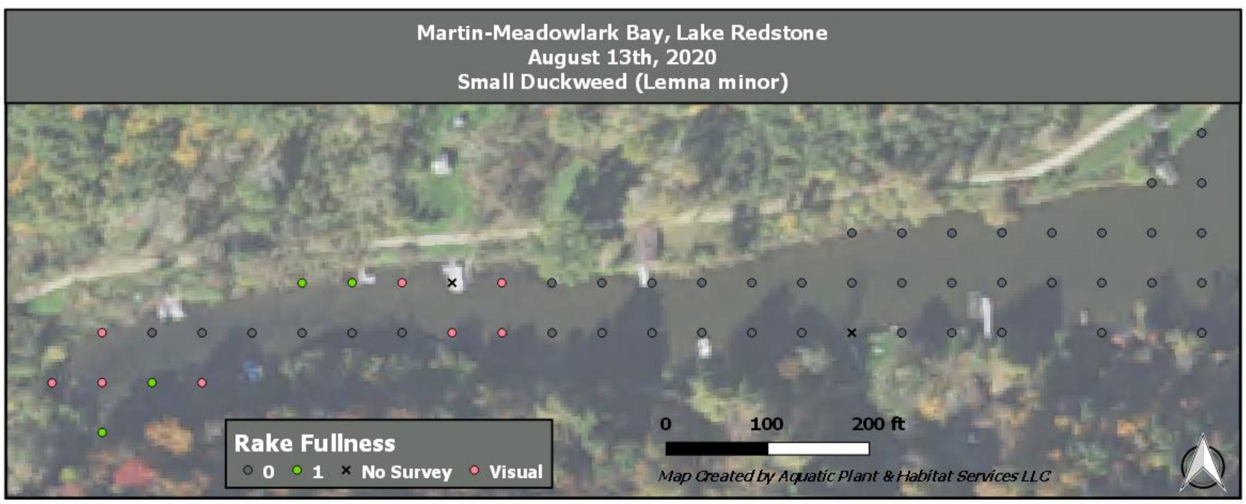
APPENDIX G – KILLDEER BAY MAPS

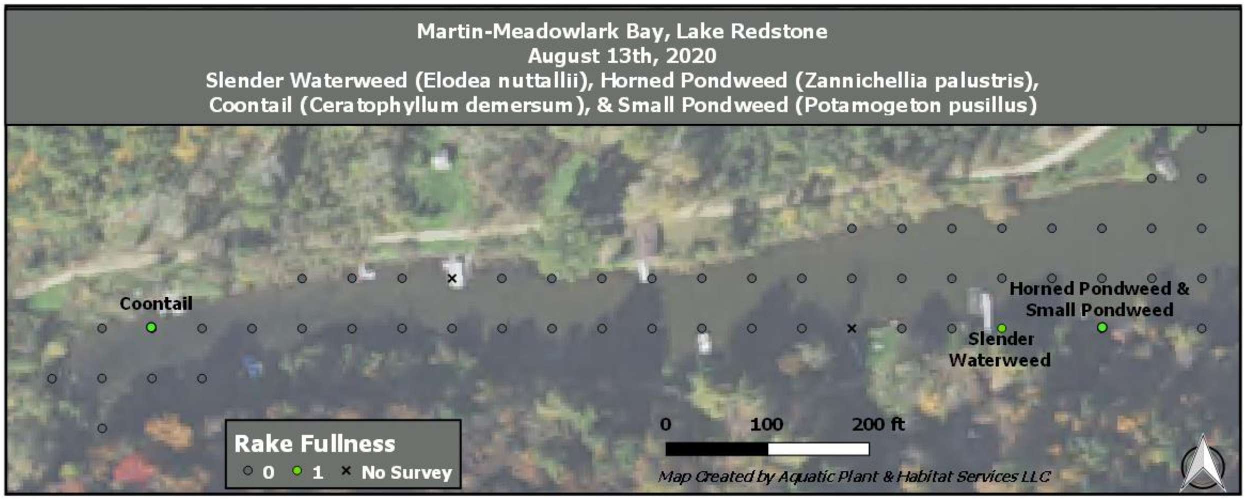


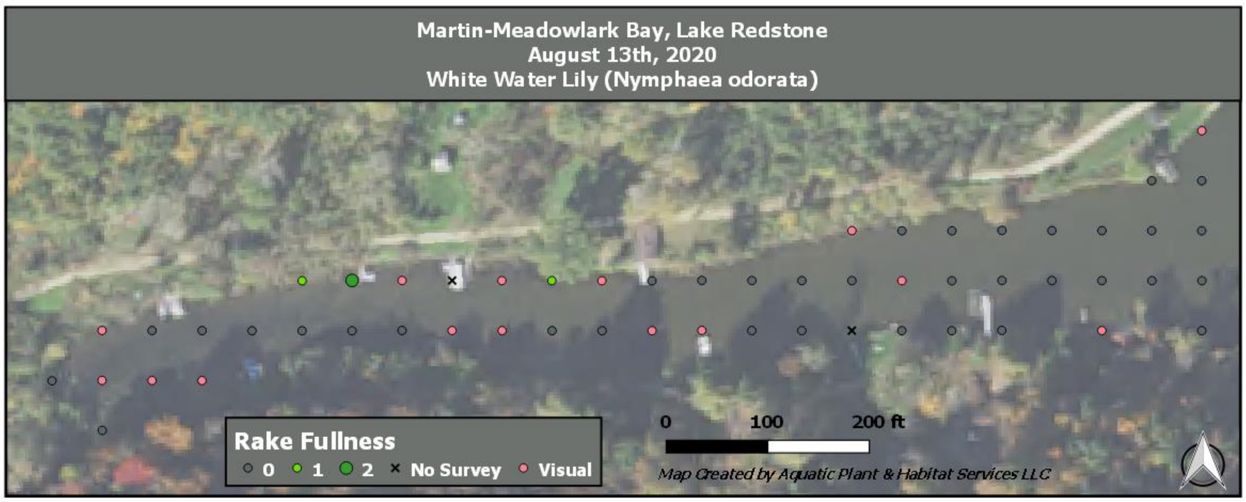


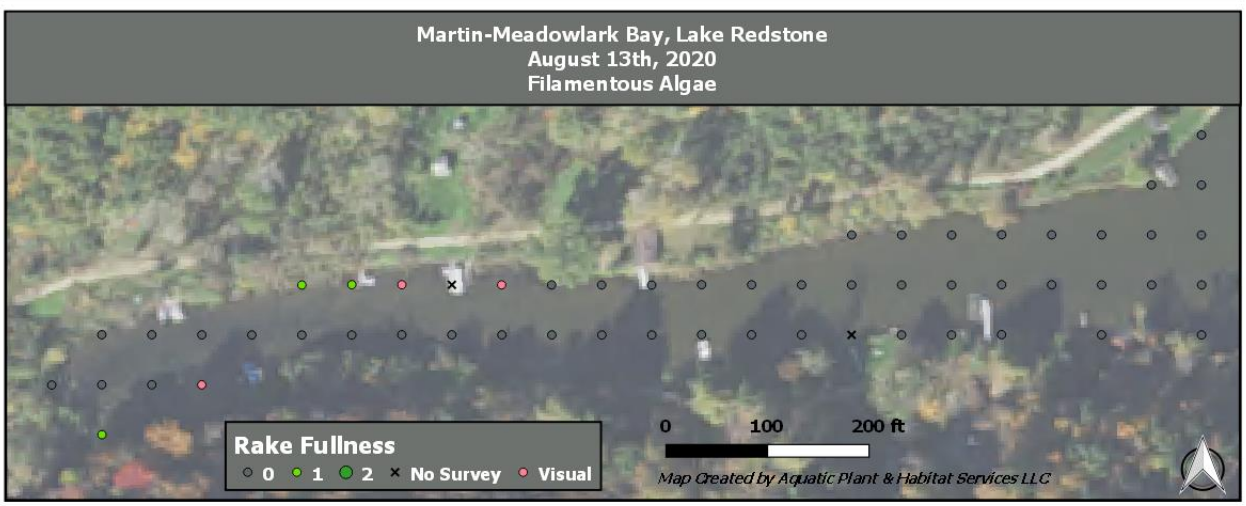
APPENDIX H – MARTIN-MEADOWLARK BAY MAPS



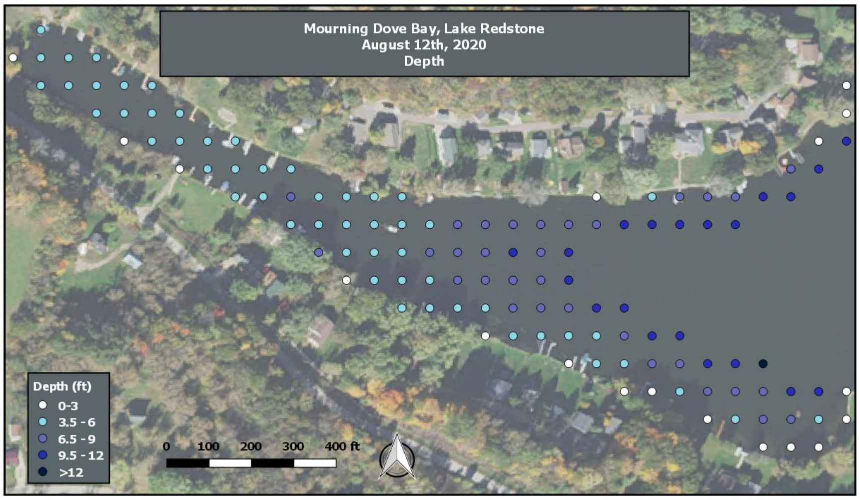


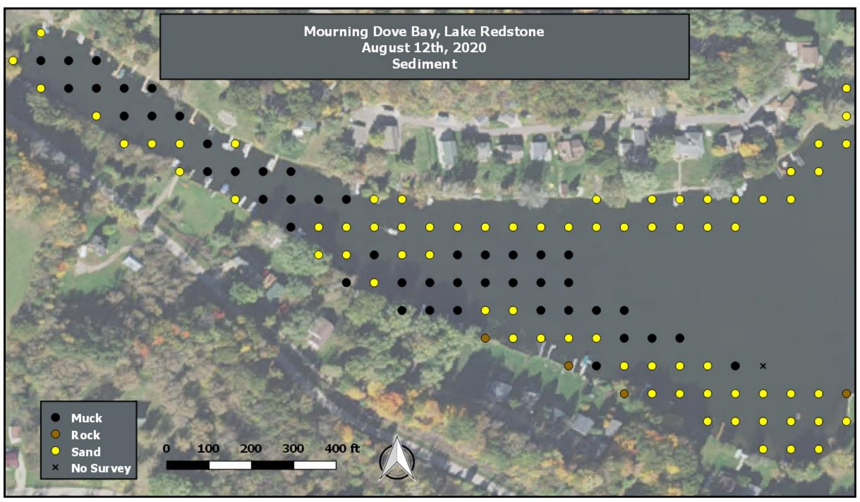

Martin-Meadowlark Bay, Lake Redstone
August 13th, 2020
Slender Waterweed (Elodea nuttallii), Horned Pondweed (Zannichellia palustris),
Coontail (Ceratophyllum demersum), & Small Pondweed (Potamogeton pusillus)
Coontail
Horned Pondweed &
Small Pondweed
Slender
Waterweed
Rake Fullness
0 1 No Survey
0 100 200 ft
Map Created by Aquatic Plant & Habitat Services LLC

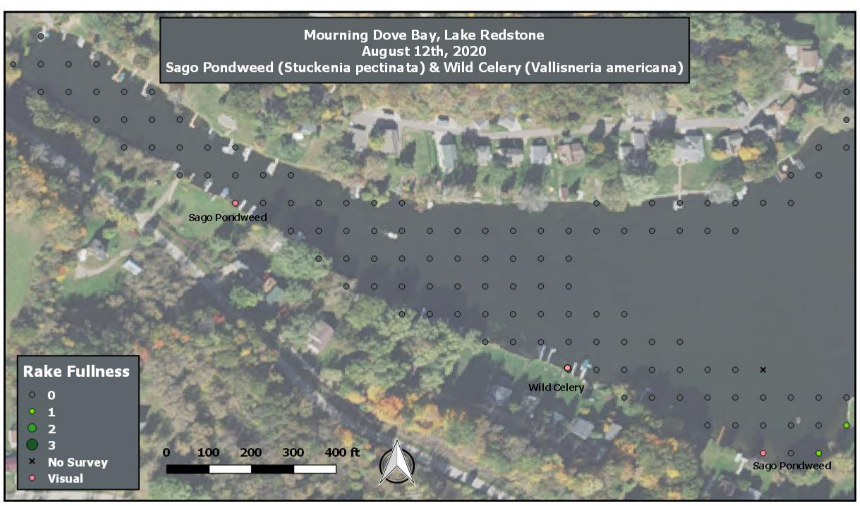

Martin-Meadowlark Bay, Lake Redstone
August 13th, 2020
White Water Lily (Nymphaea odorata)
Rake Fullness
0 1 2 No Survey Visual
0 100 200 ft
Map Created by Aquatic Plant & Habitat Services LLC

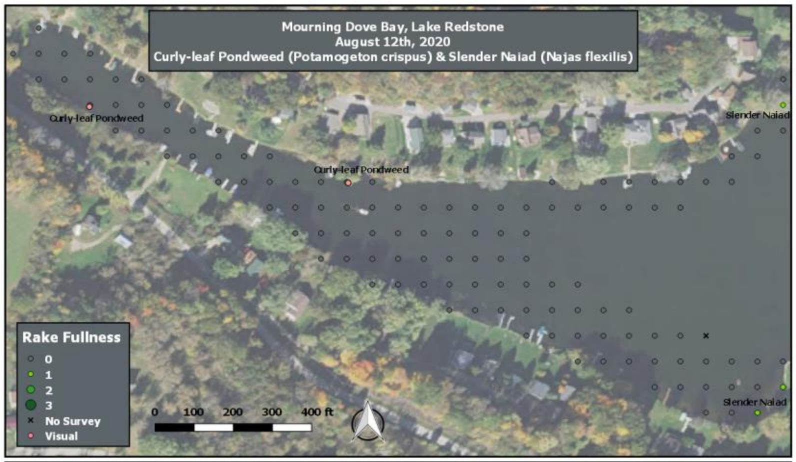

Martin-Meadowlark Bay, Lake Redstone
August 13th, 2020
Filamentous Algae
Rake Fullness
0 1 2 No Survey Visual
0 100 200 ft
Map Created by Aquatic Plant & Habitat Services LLC

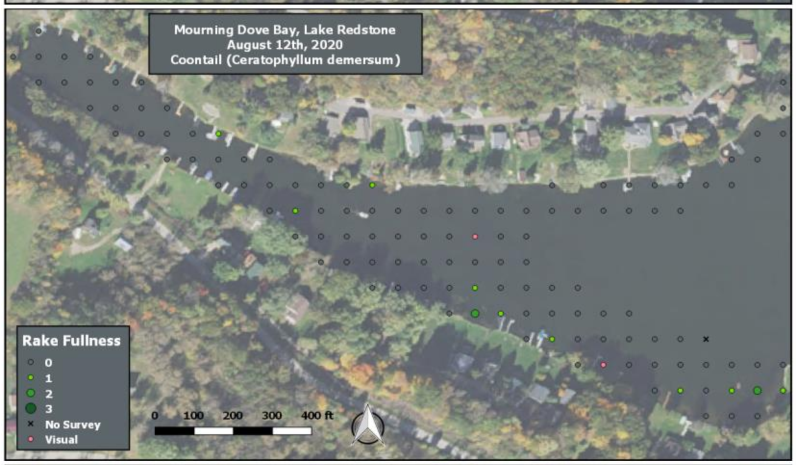
APPENDIX I – MOURNING DOVE BAY MAPS

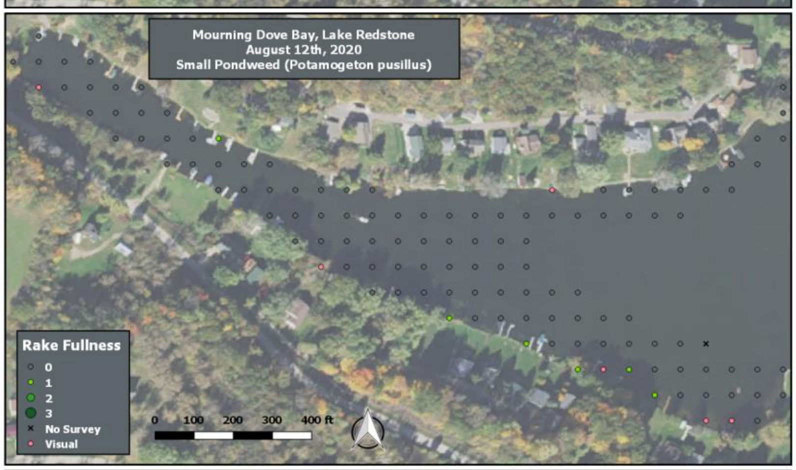


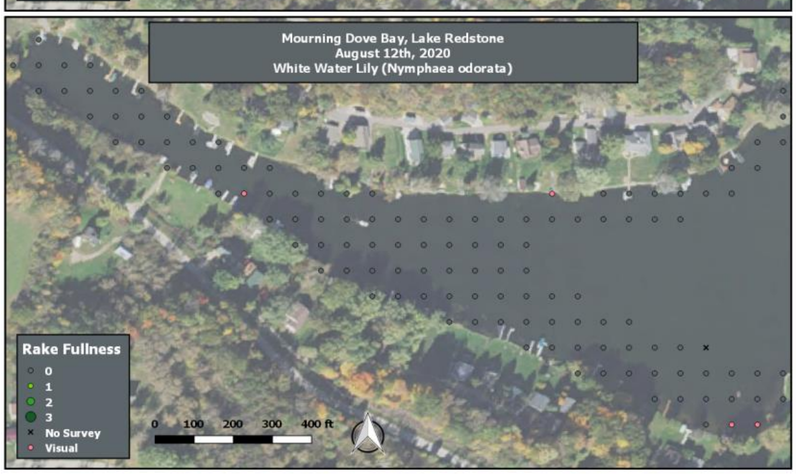




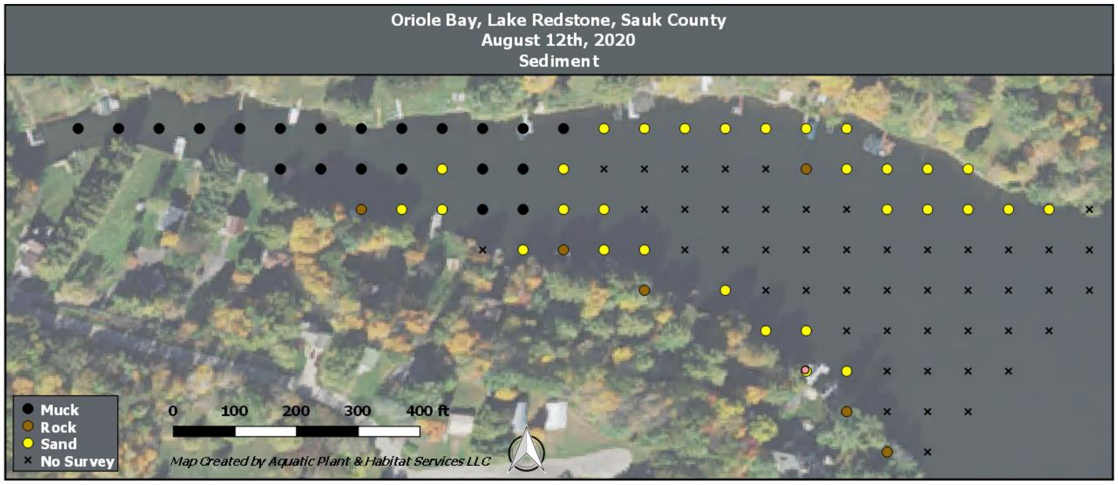

Mourning Dove Bay, Lake Redstone
August 12th, 2020
Curly-leaf Pondweed (Potamogeton crispus) & Slender Naiad (Najas flexilis)
Curly-leaf Pondweed
Curly-leaf Pondweed
Slender Naiad
Slender Naiad
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft

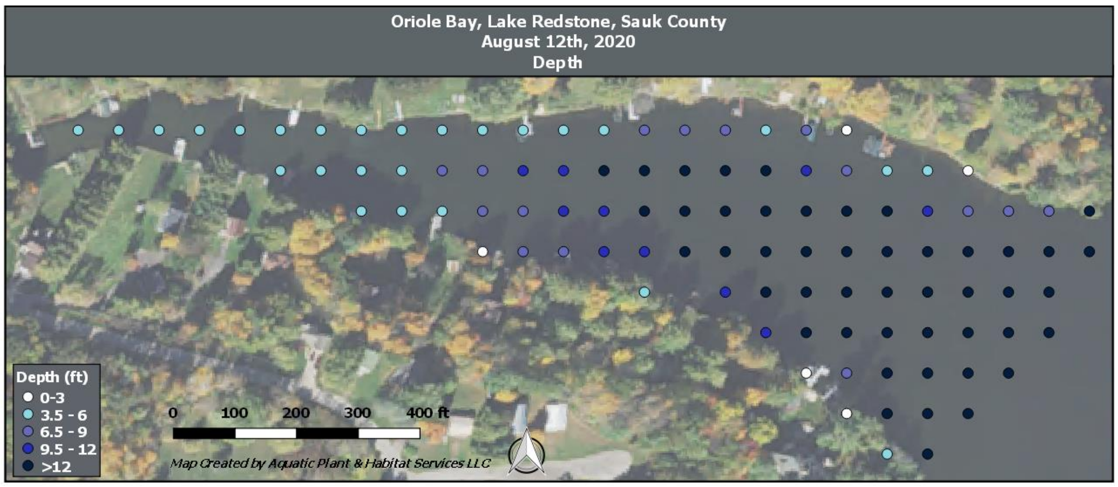

Mourning Dove Bay, Lake Redstone
August 12th, 2020
Coontail (Ceratophyllum demersum)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft

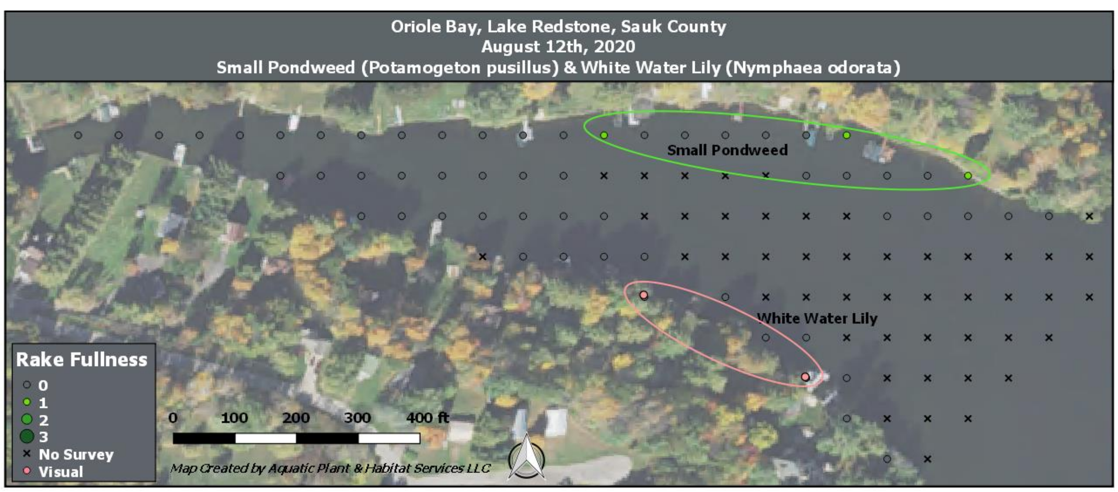

Mourning Dove Bay, Lake Redstone
August 12th, 2020
Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft

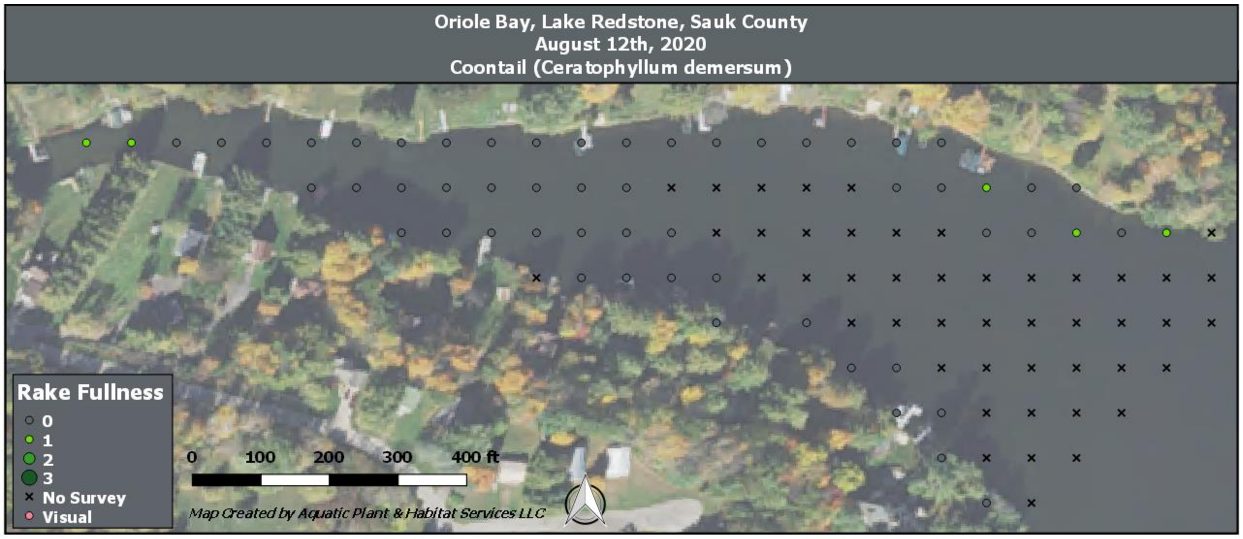

Mourning Dove Bay, Lake Redstone
August 12th, 2020
White Water Lily (Nymphaea odorata)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft

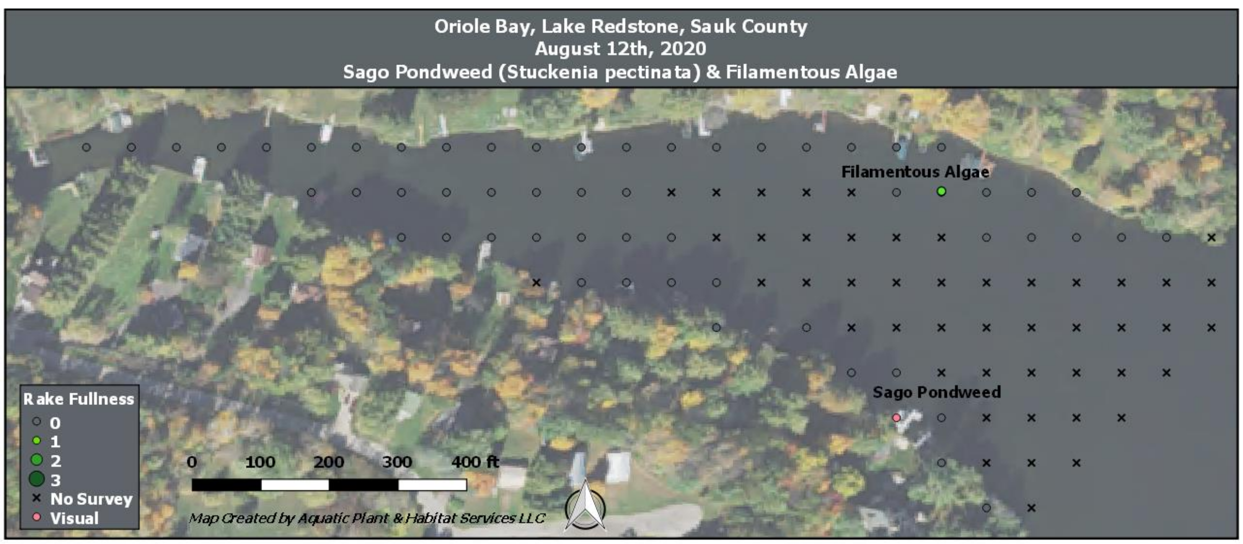
APPENDIX J – ORIOLE BAY MAPS



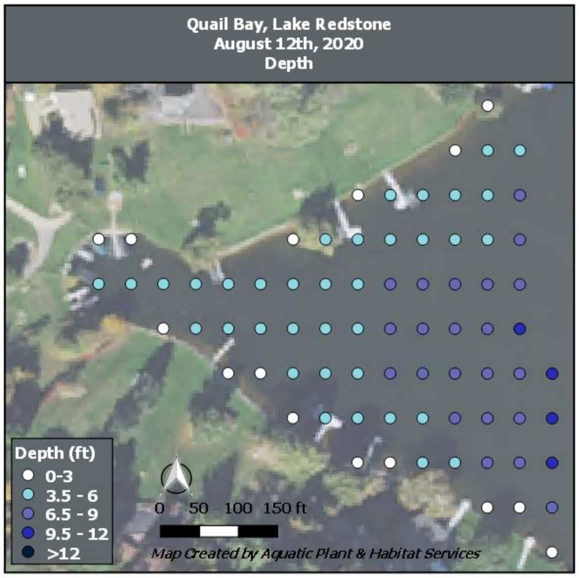


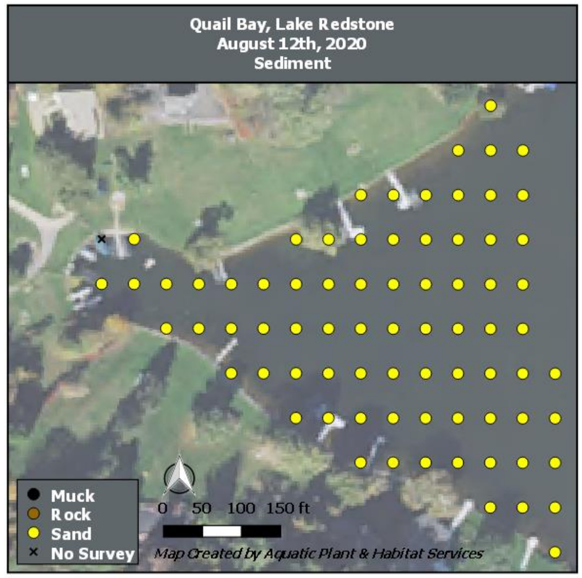


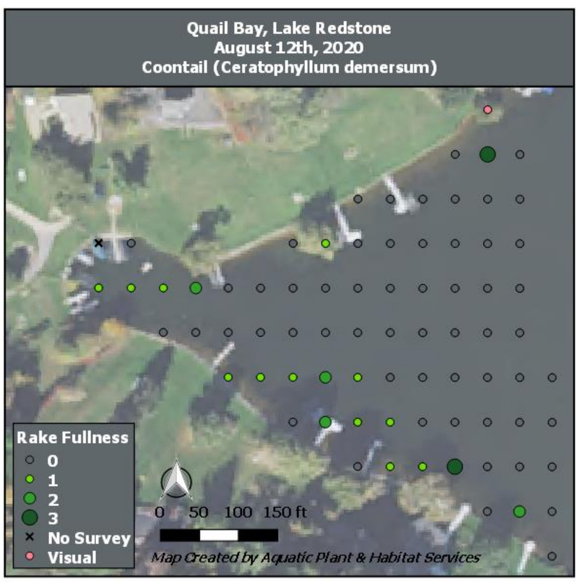

Oriole Bay, Lake Redstone, Sauk County
August 12th, 2020
Coontail (Ceratophyllum demersum)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services LLC

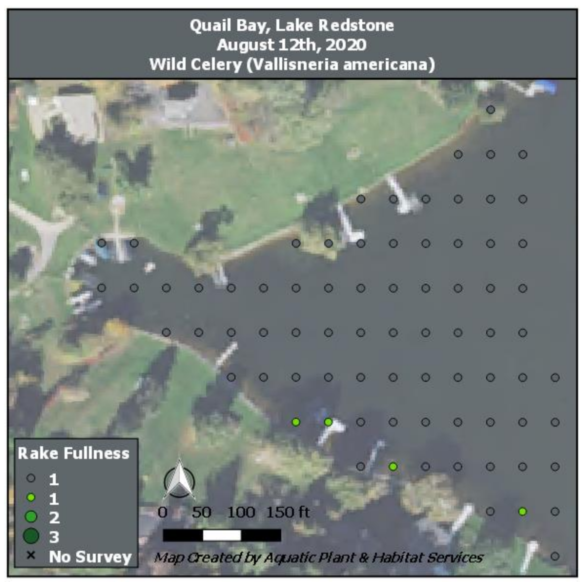

Oriole Bay, Lake Redstone, Sauk County
August 12th, 2020
Sago Pondweed (Stuckenia pectinata) & Filamentous Algae
Filamentous Algae
Sago Pondweed
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services LLC

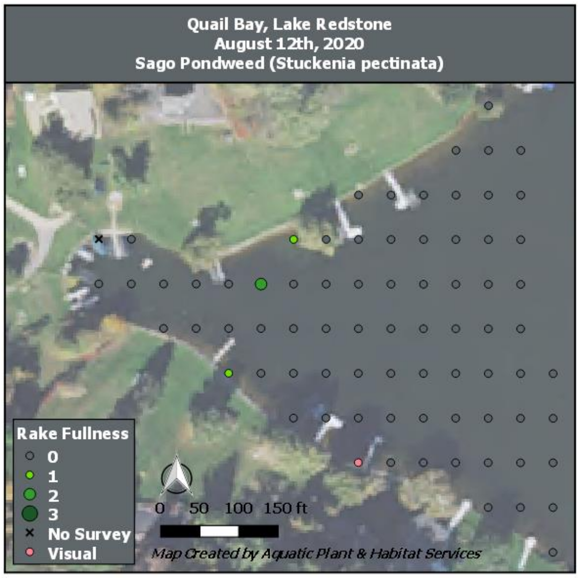
APPENDIX K – QUAIL BAY MAPS

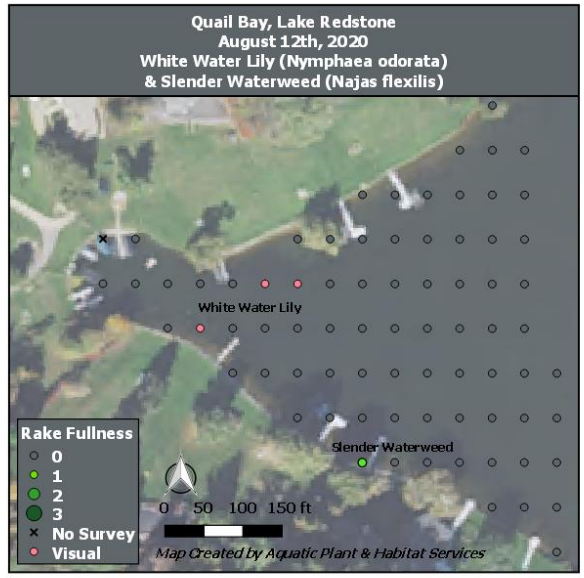


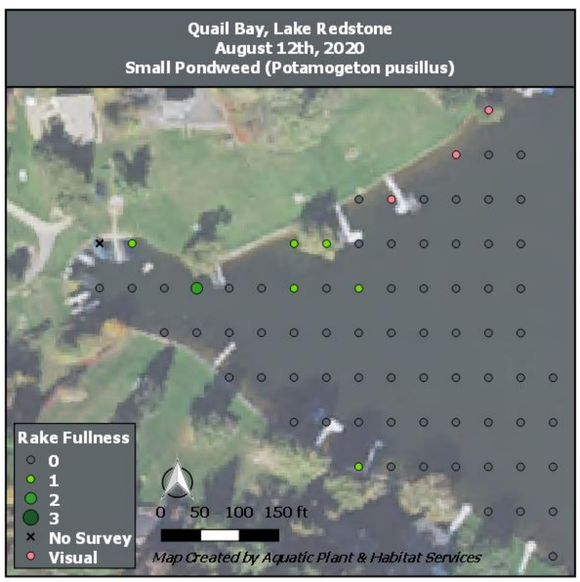




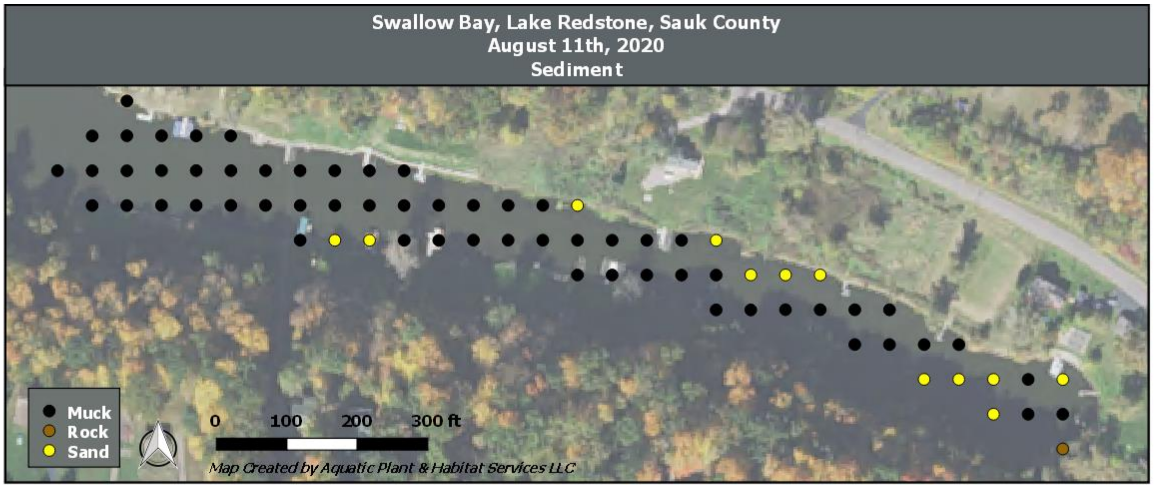


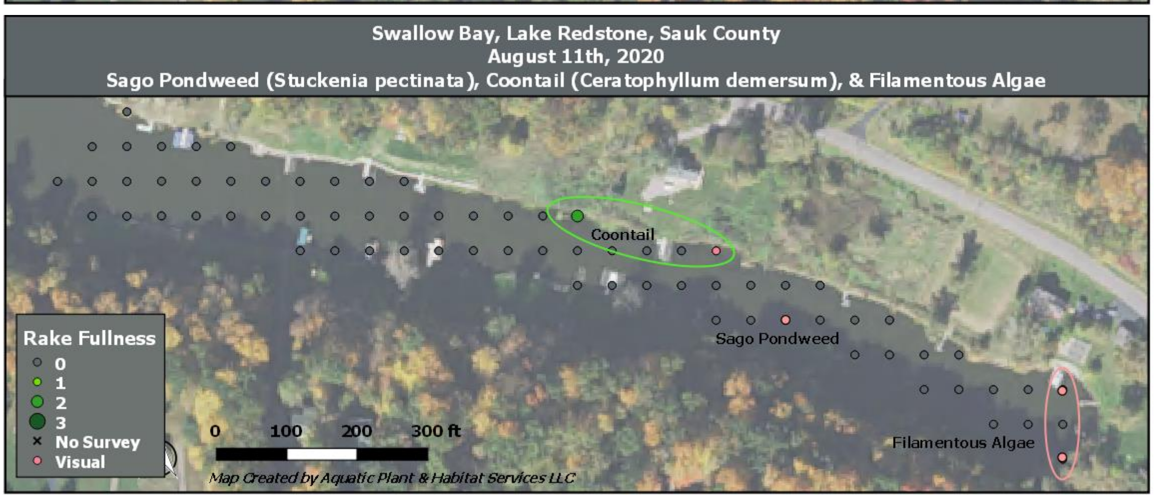

Quail Bay, Lake Redstone
August 12th, 2020
Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
No Survey
Visual
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services

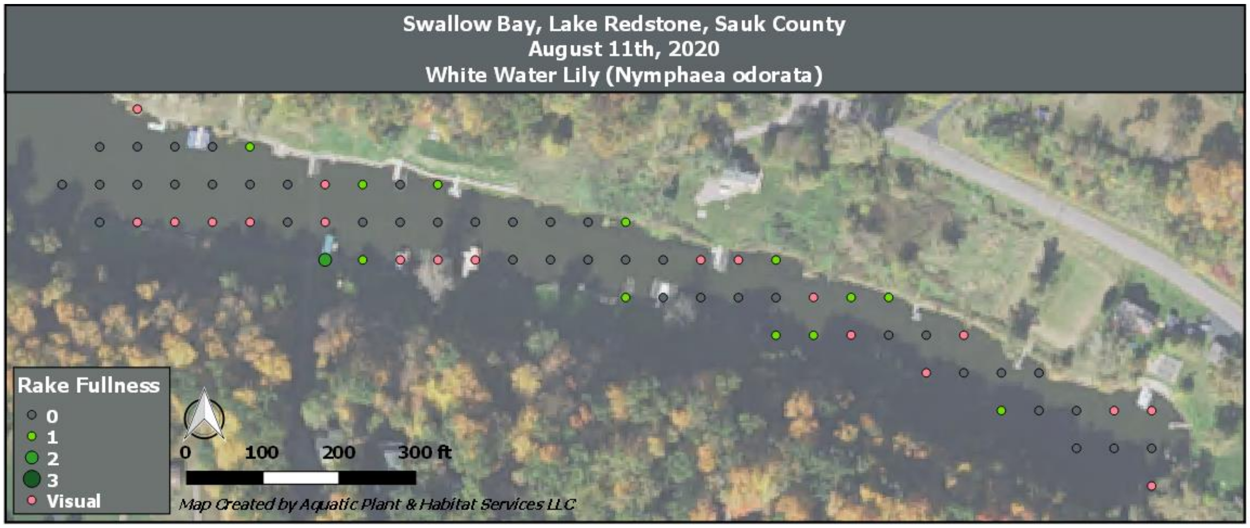

Quail Bay, Lake Redstone
August 12th, 2020
White Water Lily (Nymphaea odorata)
& Slender Waterweed (Najas flexilis)
White Water Lily
Slender Waterweed
Rake Fullness
0
1
2
3
No Survey
Visual
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services

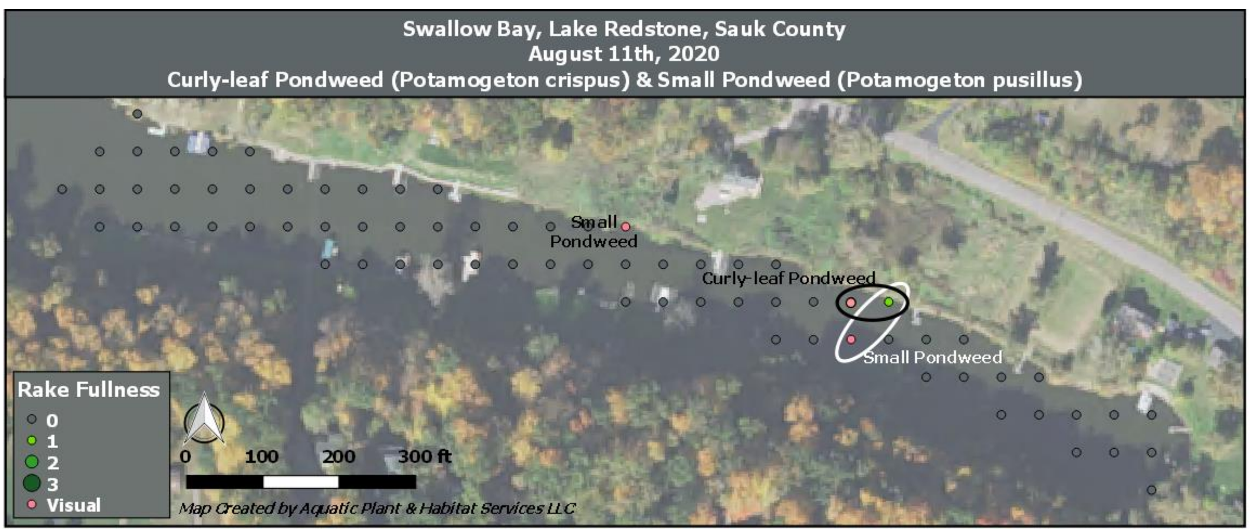

Quail Bay, Lake Redstone
August 12th, 2020
Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
No Survey
Visual
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services

APPENDIX L – SWALLOW BAY MAPS

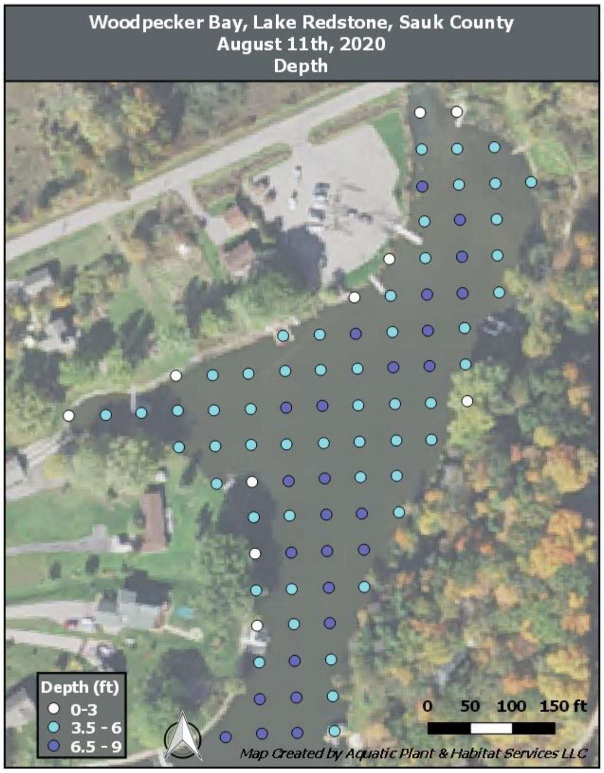


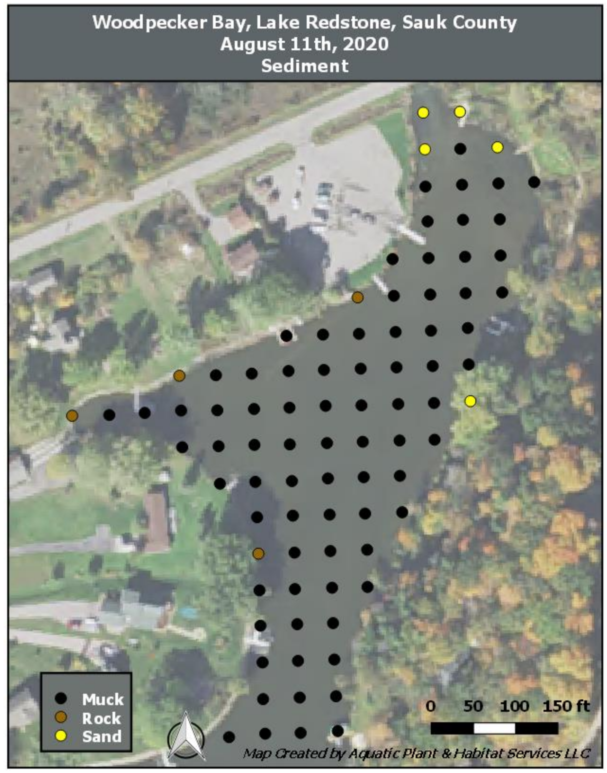



Swallow Bay, Lake Redstone, Sauk County
August 11th, 2020
White Water Lily (Nymphaea odorata)
Rake Fullness
0
1
2
3
Visual
0 100 200 300 ft
Map Created by Aquatic Plant & Habitat Services LLC


Swallow Bay, Lake Redstone, Sauk County
August 11th, 2020
Curly-leaf Pondweed (Potamogeton crispus) & Small Pondweed (Potamogeton pusillus)
Small Pondweed
Curly-leaf Pondweed
Small Pondweed
Rake Fullness
0
1
2
3
Visual
0 100 200 300 ft
Map Created by Aquatic Plant & Habitat Services LLC

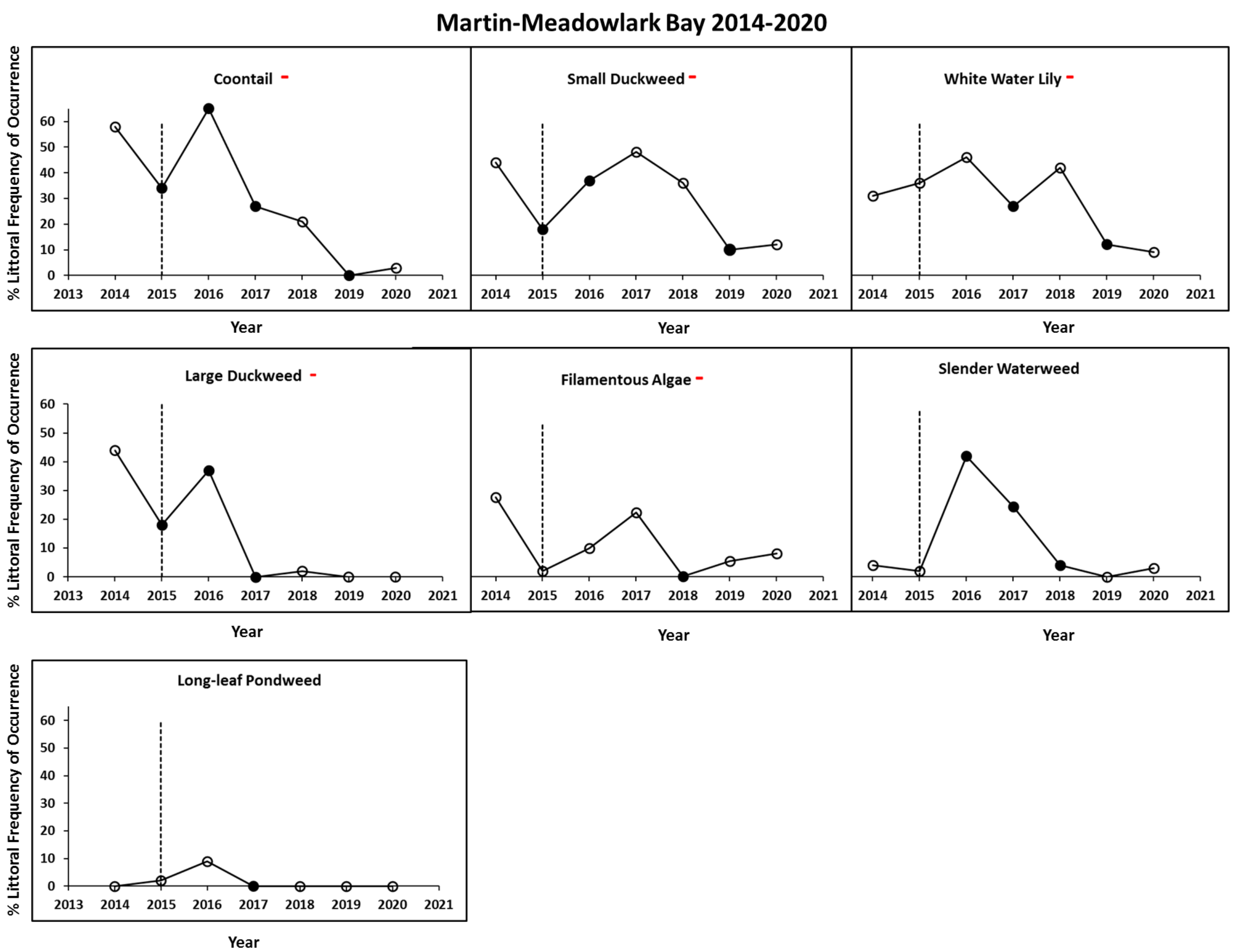
APPENDIX M – WOODPECKER BAY MAPS



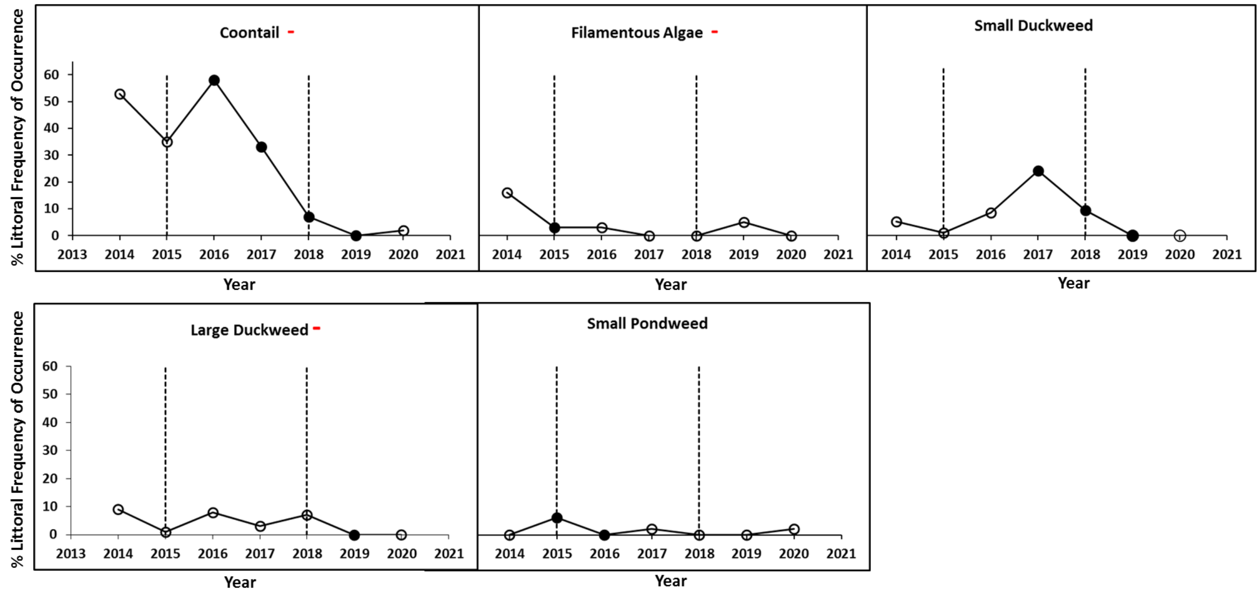


APPENDIX N – CHI-SQUARED TEST GRAPHS

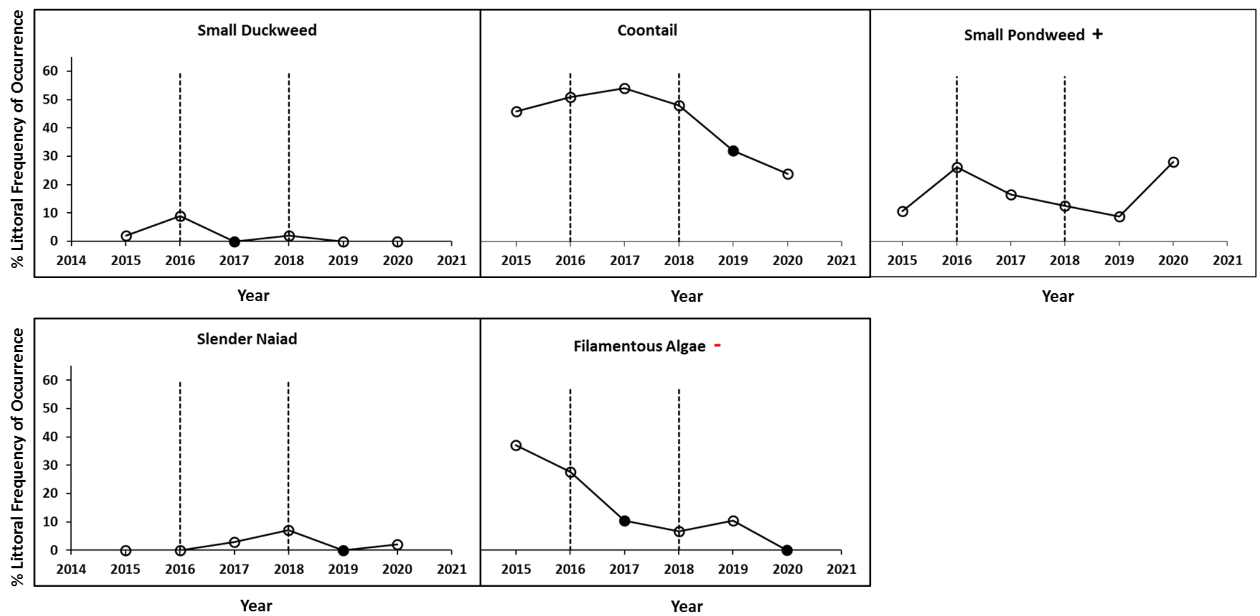
Percent littoral frequency (# sites plants found at points shallower than maximum rooting depth) is on the y-axis and each year a plant survey was completed is on the x-axis. Only species with a statically significant change (using Chi-squared tests) for at least one of the years are displayed. The dashed vertical lines represent years when herbicide treatments were done. Open circles represent ***no*** statistically significant change, solid circles represent a statistically significant change. Statistically significant changes between the first year of surveying and 2019 data are represented by **+** or **–** adjacent to plant names.



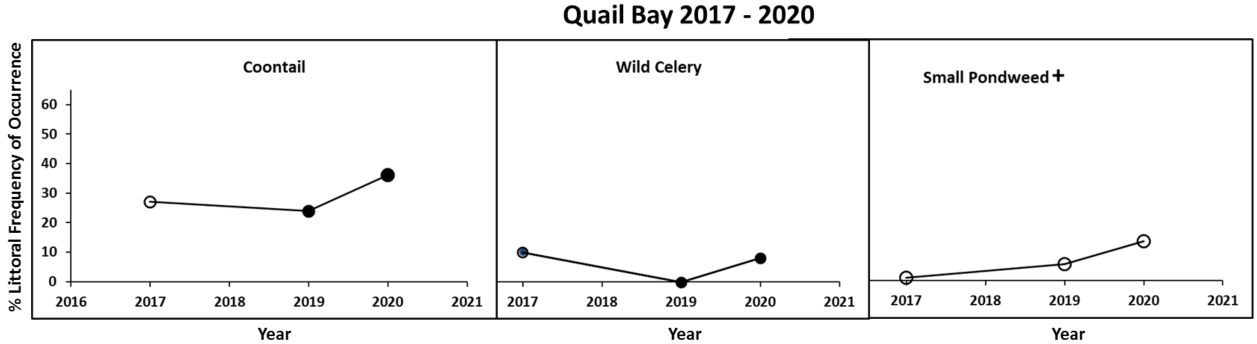
Swallow Bay 2014-2020



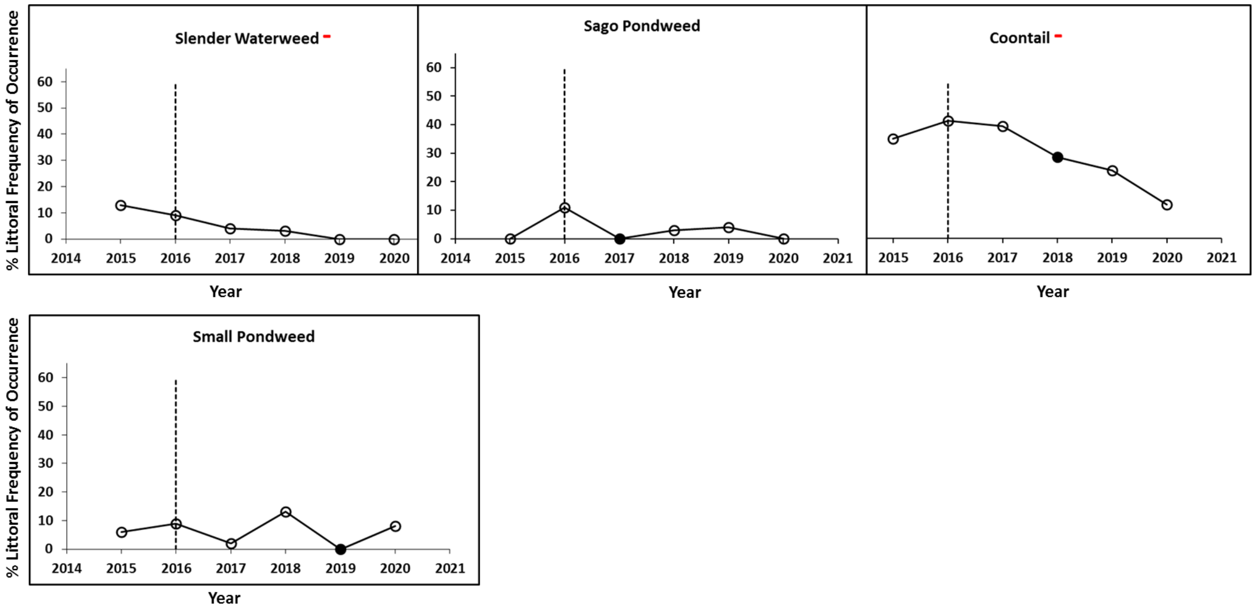
Cardinal Bay 2015-2020



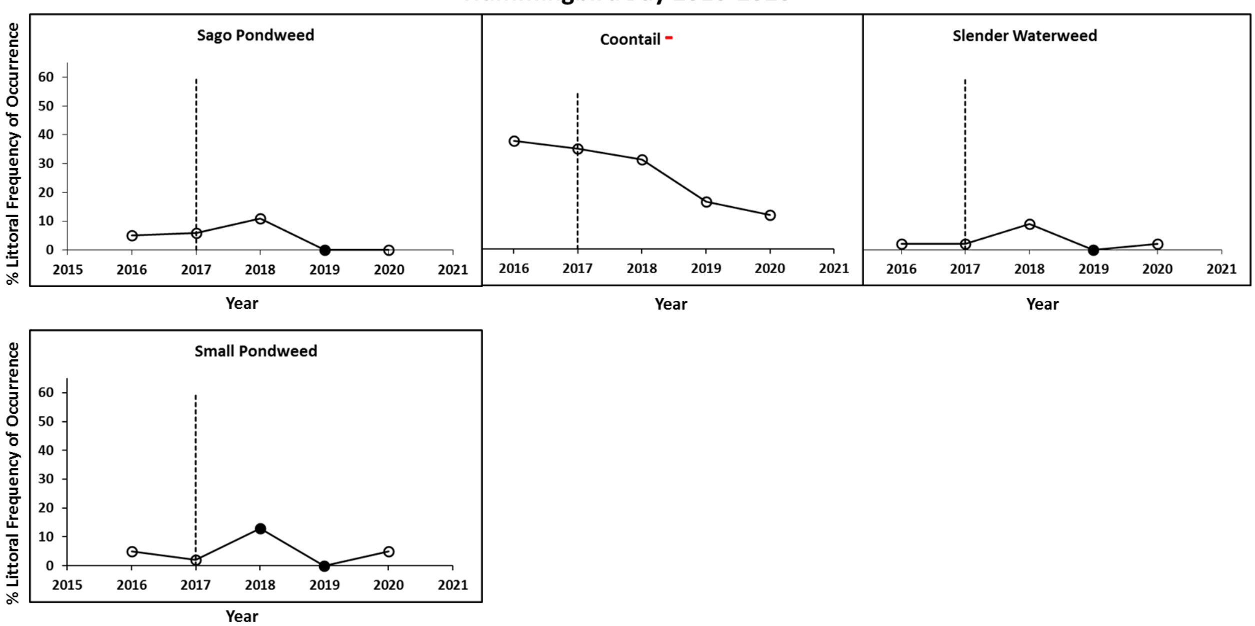
Quail Bay 2017 - 2020



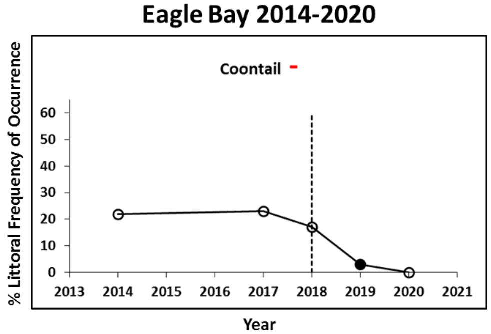
Oriole Bay 2015-2020



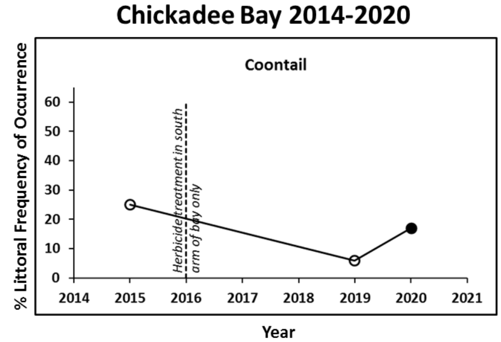
Hummingbird Bay 2016-2020



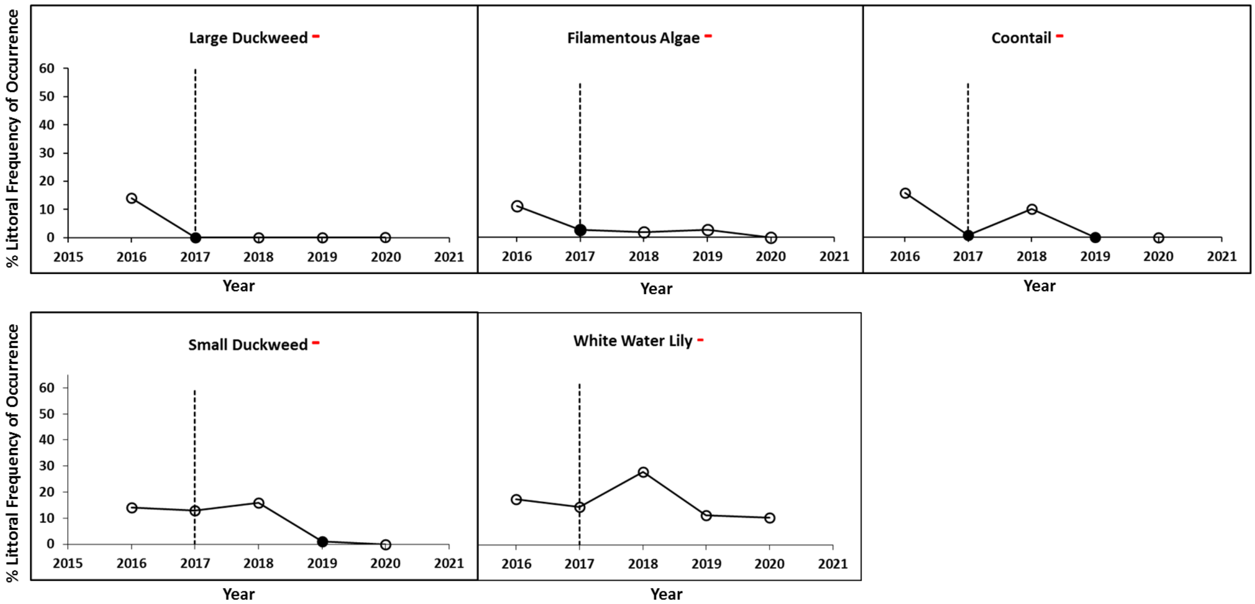
Eagle Bay 2014-2020



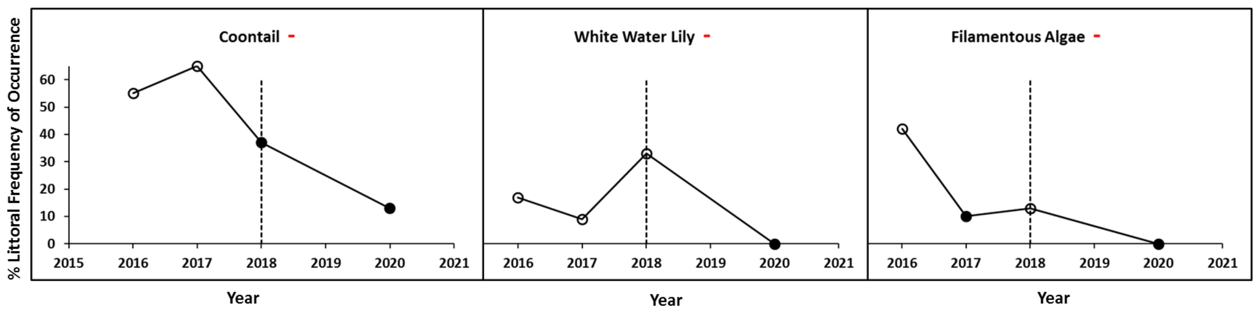
Chickadee Bay 2014-2020



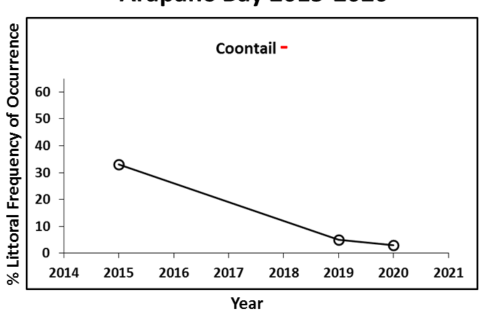
Woodpecker Bay 2016-2020



Mourning Dove Bay 2016-2020



Arapaho Bay 2015-2020



Chi-squared Test Results for Eurasian Watermilfoil