2024

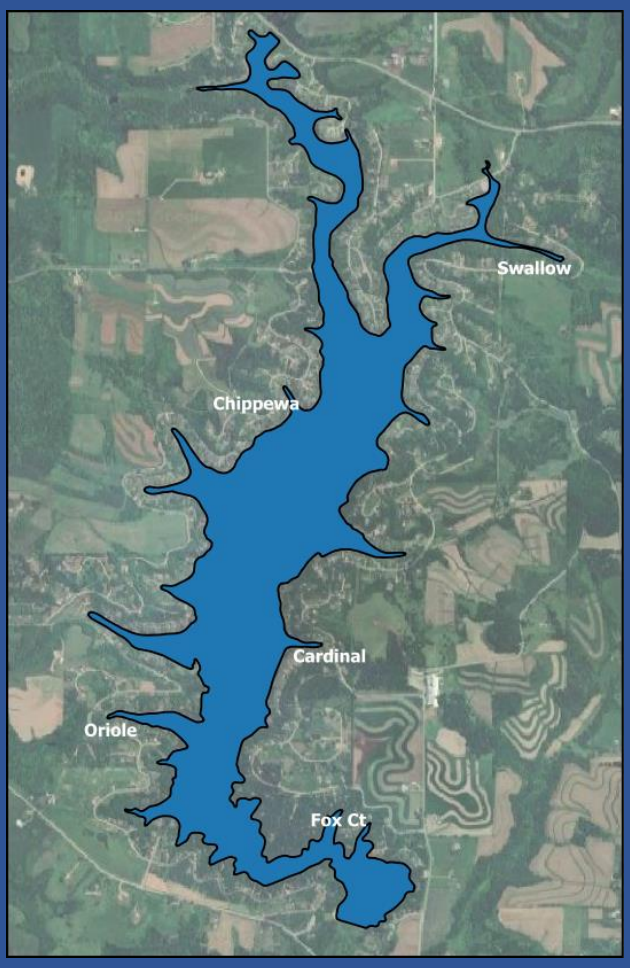
Aquatic Plant & EWM Bed Survey Report

Sauk County, Wisconsin

SubPI Surveys of Cardinal, Chippewa, Fox Court Oriole, & Swallow Bays August 5th, 2024

EWM Bed Survey September 9-11th, 2024

Report completed January 31st, 2025



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Lake Redstone Protection District

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1.0 Summary of Results

1.1 Sub-Point-Intercept Surveys of 5 Bays

- Cardinal, Chippewa, Fox Court, Oriole, and Swallow Bays were surveyed August 5th, 2024 using sub-point-intercept survey methods to gauge occurrence of all aquatic plant species.
- There were 314 total sample points among the 5 bays, 56 of which (17%) had aquatic vegetation present. There were only 14 of those sample points with EWM present.
- The deepest rooting depth among all bays was 5.5 feet deep, which is consistent with previous surveys.
- There was a total of 9 species detected among all 5 bays, which is very low species richness and consistent with previous surveys.
- The average aquatic plant occurrence in 2024 was among the lowest since 2014. The only year of lower plant occurrence was 2019, just before dredging occurred.
- There was a declining trend in native and non-native aquatic plant occurrence from 2014 through 2022, an increase in 2023, and then a decline again in 2024.
- Chi-square tests were done for Swallow, Oriole, Chippewa, and Cardinal Bays. When comparing 2024 native species occurrence with that of most recent previous surveys, there were no statistically significant (SS) increases in native plant species and there were three instances of SS decreases.
- When comparing 2023 native species occurrence with the first year surveyed for the three bays that were surveyed for more than two years, there were 6 statistically significant (SS) declines in native plant species, 3 SS declines in filamentous algae, and 1 increase in native plants.
- Bay-wide surveys of ***all bays*** suggest there is no consistent trend in EWM occurrence between 2014 and 2024. EWM occurrence in subPI surveys of bays is among the lowest since 2014 despite no herbicide treatment since 2018.
- Due to the low occurrence of native plant species in Lake Redstone, protection of all native plant species is recommended.

1.2 EWM Bed Survey of Littoral Zone

- An EWM best survey of entire near-shore area of Lake Redstone was conducted September 11-13th, 2024.
- There were 56 beds of EWM delineated, resulting in 18.6 acres of EWM lake-wide.
- The EWM delineated is lower than 2023 (21 acres) and 2022 (32 acres).
- Of the EWM acreage, the majority was considered “highly scattered” (3.39 acres) or “scattered” (8.87 acres).
- All EWM was found within 20 feet of the shoreline and 6 feet or shallower.
- Small-scale manual removal of EWM that is causing recreational use impairment is recommended.

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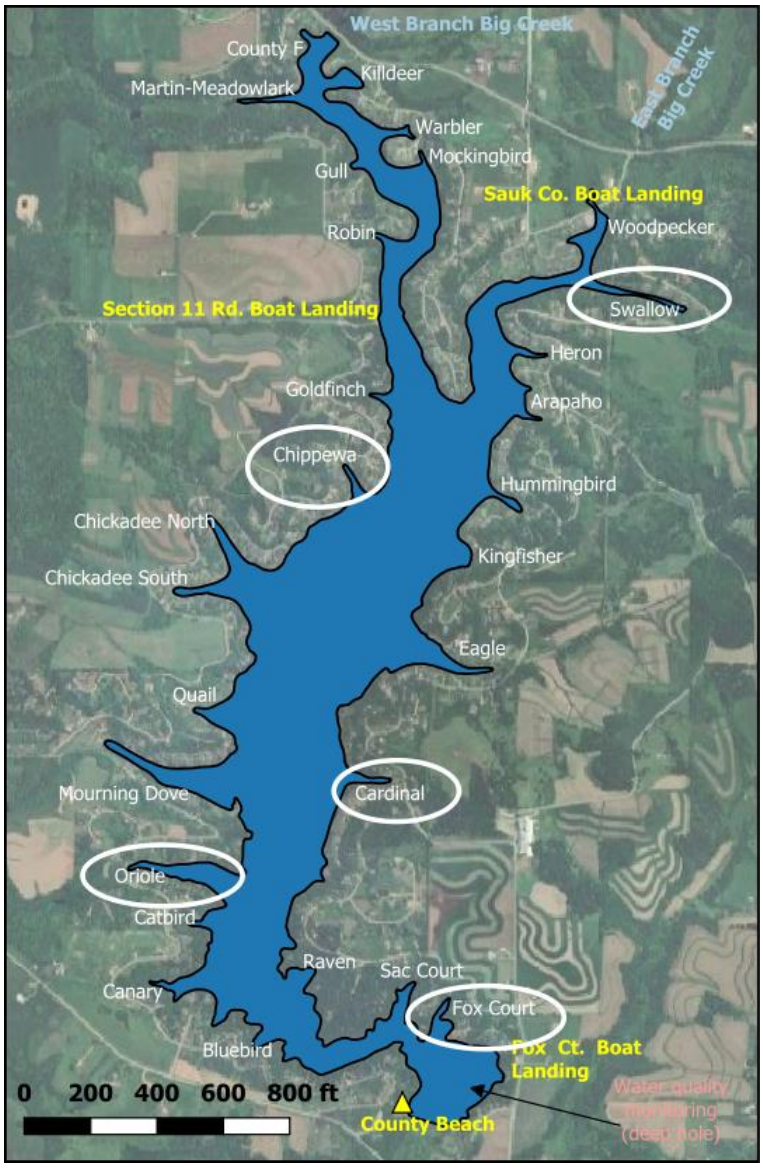
2.0 Introduction

2.1 Recent Management History

The Lake Redstone Protection District (LRPD) partnered with Aquatic Plant and Habitat Services to complete aquatic plant surveys of 5 bays and EWM bed survey in 2024 and continue statistical tracking of EWM occurrence where control activities may be needed. Dredging occurred in Lake Redstone from July through December of 2019 to remove sediment from 27 locations, protect lake property values, maintain and improve the lake, and aim to improve water quality[1]. In June 2021, Aquatic Plant Management LLC (APM) was hired for three days to manually remove EWM from 2 locations in Arapaho Bay and several areas near the mouth of Hummingbird Bay. In June 2022, APM LLC was hired for 4 days to use diver assisted suction harvesting targeting dense colonies near the Section 11 boat landing and Chippewa Bay. Water clarity was a significant issue for divers during manual removal and DASH, which lead to unsatisfactory results. As a result, LRPD is not pursuing the use of DASH or hired manual removal in the near future. No herbicide treatment occurred in any bays in 2019 through 2023.

Figure 1 – Lake Redstone Map of Bays



2.2 Study Site

Lake Redstone (WBIC 1280400) is located in the Town of La Valle in northwestern Sauk County, Wisconsin. The lake is an impoundment of West and East Branches of Big Creek, although other intermittent streams also flow into the lake. Water flows out of Lake Redstone over a top draw dam at the southern end directly into Big Creek for a short stretch before flowing into the Baraboo River. Lake Redstone was created in the 1960's with the intent of creating >1500 lots for development. The lake's surface area is 635 acres, maximum depth is 36.5 feet, mean depth is 14 feet, and the shoreline length is 17.5 miles. The lake is considered an Area of Special

[1] https://www.lakeredstonepd.org/dredging-meeting-minutes. June 2018 Dredging Informational Meeting PowerPoint Presentation.

Natural Resource Interest due to the presence of certain plant or animal species or unique ecological communities identified in the WDNR Natural Heritage Inventory. Lake Redstone is classified as a eutrophic system based on data collected since 1979 with low water clarity (Secchi depth of 2-3 feet since 2009). Bays circled in Figure 1 indicate those surveyed with a sub-point-intercept survey in 2024 (Cardinal, Chippewa, Fox Ct., Oriole, Swallow). The entire littoral zone (where plants can grow) was also surveyed for Eurasian watermilfoil.

2.3 Goals and Objectives

GOAL: Survey aquatic plants in select bays in order to guide management decisions, specifically related to EWM management. Survey littoral zone of Lake Redstone to delineate beds of EWM.

2.3.1 Objectives:

1. Complete a sub-point-intercept survey of all aquatic plants in 5 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. Complete a an EWM bed survey of the littoral zone and create maps to illustrate EWM locations and density.

3.0 Methods

Field survey methods and explanations of surveys statistics such as those in Table 1 are described in Appendix A.

4.0 Results

Table 1 – Summary Statistics of 5 Bays Surveyed in 2024

Bay & Year		1	2	3	4	5	6 Average # of species per site				7 Species Richness		8	
		Total # sites visited	Total # sites w/ vegetation	Max. depth of plants	Total # sites shallower than max. depth of plants	Littoral frequency (%)	a) Shallower than max. depth	b) Vegetated sites only	c) Native shallower than max. depth	d) Native at veg. sites only	a) Total # species on rake at all sites	b) Including visuals	Simpson's Diversity Index	Littoral frequency of EWM (%)
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**
	2022	69	20	5	52	38.5	0.58	1.50	0.46	1.26	4	5	0.60	12
	2023	69	37	5	61	60.7	1.25	2.05	0.98	1.71	6	7	0.74	26
	2024	71	29	5	60	48.3	0.63	1.31	0.57	1.21	5	7	0.40	5
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**
	2021	63	18	6*	39	46.2	0.77	1.67	0.46	1.20	6	6	0.76	28
	2022	68	22	5.5	39	56	0.82	1.45	0.46	1.29	8	10	0.78	33
	2023	67	33	11	58	56.9	1.00	1.76	0.50	1.45	7	8	0.69	50
	2024	71	19	5	33	57.6	1.12	1.95	0.94	1.72	8	9	0.80	15
Fox Ct	2024	39	1	3.5	7	14.3	0.14	1.00	0	0	1	1	0.00	14
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**
	2021	55	6	6	28	21.4	0.36	1.67	0.14	1.33	4	5	0.58	21
	2023	52	16	5.5	28	57.1	0.89	1.56	0.36	1.25	4	4	0.57	54
	2024	52	6	5.5	28	21.4	0.39	1.83	0.21	1.50	3	4	0.63	18
Chippewa	2023	31	20	6	31	64.5	0.77	1.20	0.19	1.00	5	5	0.42	58
	2024	32	1	0.5	3	33.3	0.33	1.00	0.33	1.00	1	4	0.00	0

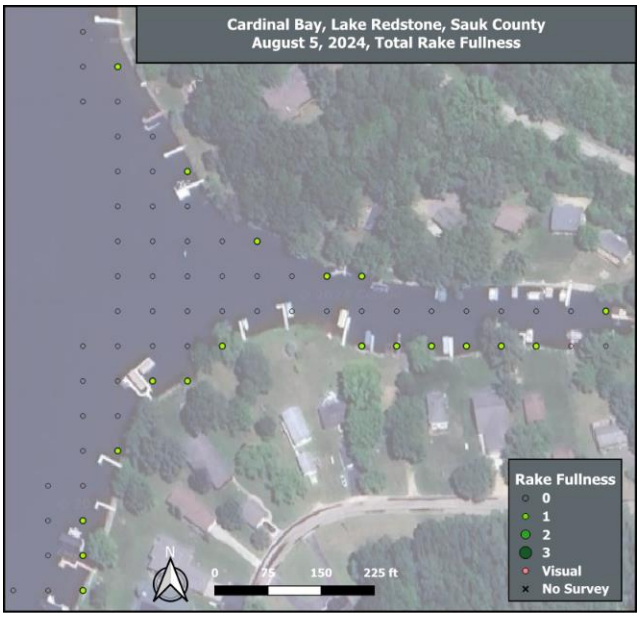
EWM with adventitious roots was found at 12 feet but was likely not rooted at that depth. Furthermore, the next deepest sample point of plant occurrence was 6 feet deep.* ***Herbicide treatment occurred during the years listed in red text. The results of these herbicide treatment years is considered post-treatment.*

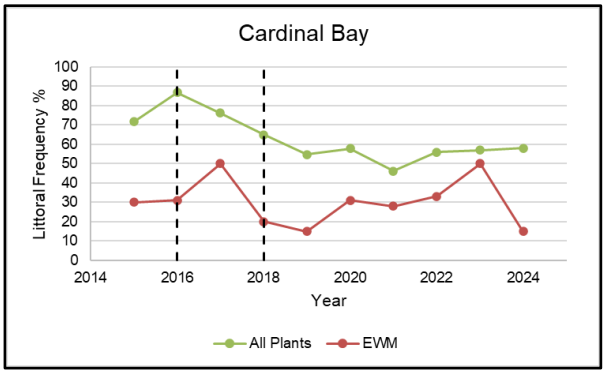
Results in BOLD text with blue shading are post-dredging (dredging occurred after the 2019 surveys).

4.1 Cardinal Bay 2024

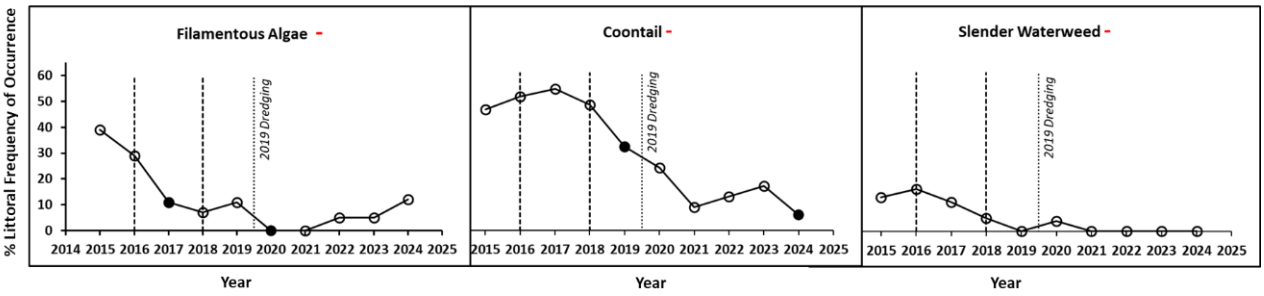
- Max rooting depth = 5ft (11 feet in 2023)
- 58% Littoral frequency all plants.
- Plant occurrence is lower than 2023.
- Most common plant was wild celery at 10 sites. There were more native plants than EWM in Cardinal compared to past years.
- Chi-squared tests[2] revealed a statistically significant decrease in coontail and EWM in 2024 compared to 2023. There was a statistically significant decrease in coontail, EWM, slender waterweed, and filamentous algae when comparing 2015 data to 2024. EWM chi-square graph is in the EWM Section.
- Cardinal Bay is NOT designated as a critical habitat area

CARDINAL BAY Common Name	CARDINAL BAY Scientific Name	Frequency of Occurrence at Veg. Sites (%)	Littoral Frequency (%)	Relative Frequency (%)	# Sites	Average Rake Fullness	# Visual
Wild celery	*Vallisneria americana*	52.63	30.30	27.78	10	1.00	1
Sago pondweed	*Stuckenia pectinata*	42.11	24.24	22.22	8	1.00	2
Small pondweed	*Potamogeton pusillus*	36.84	21.21	19.44	7	1.00	3
Eurasian water milfoil	*Myriophyllum spicatum*	26.32	15.15	13.89	5	1.00	6
Filamentous algae		21.05	12.12	-	4	1.00	2
Slender naiad	*Najas flexilis*	15.79	9.09	8.33	3	1.00	1
Coontail	*Ceratophyllum demersum*	10.53	6.06	5.56	2	1.00	0
Large duckweed	*Spirodela polyrrhiza*	5.26	3.03	2.78	1	1.00	2
Duckweed	*Lemna sp.*	5.26	3.03	2.78	1	1.00	1
Water star-grass	*Heteranthera dubia*	-	-	-	-	-	3





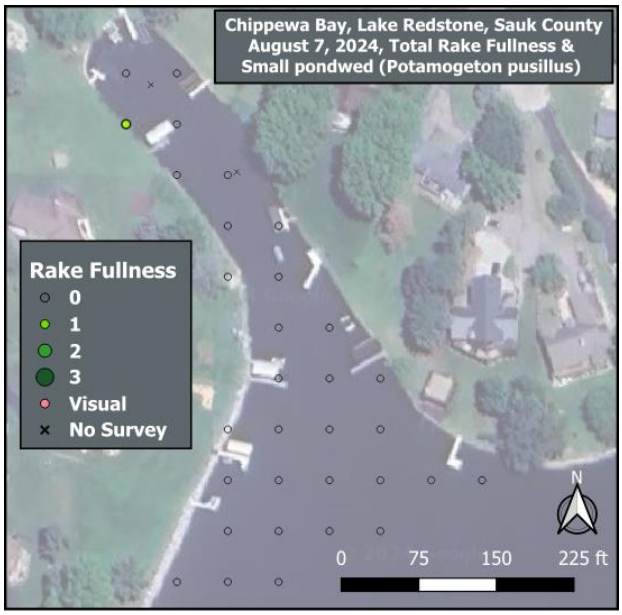
Cardinal Bay 2015-2024 Chi-Square Graphs



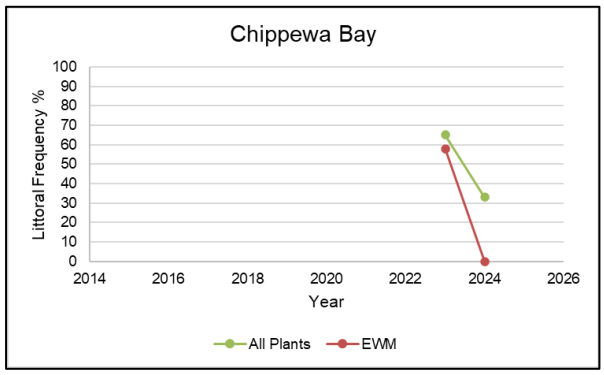
[2] *Percent littoral frequency is on the y-axis and year is on the x-axis. Only species with a statically significant change (using Chi-squared tests) for most recent year vs 2024 or the first year vs 2024 are displayed. The dashed vertical lines represent years when herbicide treatments were done with the exception of the dashed line in 2019 that represents dredging as labeled. Open circles represent* ***no*** *statistically significant change compared to previous year, solid circles represent a statistically significant change compared to previous year. Statistically significant changes between the first year of surveying and 2024 data are represented by* **+** *or* **–** *adjacent to plant names.*

4.2 Chippewa Bay 2024

- Max rooting depth = 0.5ft (6 feet in 2024). The unusually low max rooting depth is likely a function of extremely low plant occurrence.
- 33% Littoral frequency all plants (65% in 2023).
- Plants were detected on the rake at only ONE sample point. This plant was small pondweed. White water lily, EWM, and wild celery were observed near sample points but not on the rake.
- Chi-squared tests[2] revealed a statistically significant decrease in EWM in 2024 compared to 2023. EWM chi-square graph is in the EWM Section.
- Chippewa Bay is NOT designated as a critical habitat area

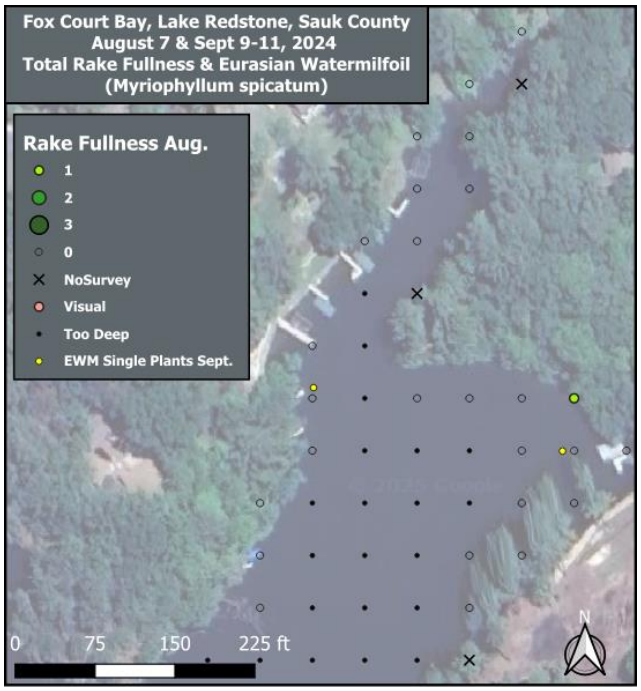


CHIPPEWA BAY Common Name	CHIPPEWA BAY Scientific Name	Frequency of Occurrence at Veg. Sites (%)	Littoral Frequency (%)	Relative Frequency (%)	# Sites	Average Rake Fullness	# Visual
Small pondweed	*Potamogeton pusillus*	100	33.33	100	1	1	0
Filamentous algae		100	33.33		1	1	3
Eurasian water milfoil	*Myriophyllum spicatum*						1
White water lily	*Nymphaea odorata*						2
Wild celery	*Vallisneria americana*						1

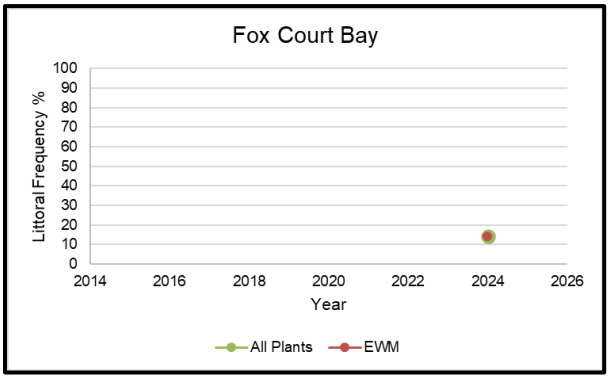


4.3 Fox Court Bay 2024

- Max rooting depth = 3.5 ft.
- 14% Littoral frequency.
- This bay was surveyed to due to EWM concerns. There was reportedly one area with high EWM occurrence in 2024 among the 4 docks along the northwestern shoreline. The EWM in that area was manually removed by property owners before the survey occurred. Manual removal in shallow areas is currently the best approach for small-scale EWM control on Lake Redstone.
- No chi-square analysis was completed for Fox Court Bay because 2024 was the first year of subPI surveys.
- EWM was the only plant detected and it was found on the rake at 1 sample point. Low plant occurrence was likely due to the limited sunlight in the narrow section of the bay and deeper water in the central area of the bay. Future subPI surveys of Fox Court Bay is not recommended. EWM bed surveys or photos of EWM before and after hand pulling would be a better approach for this bay.
- Fox Court Bay is designated as a critical habitat area.



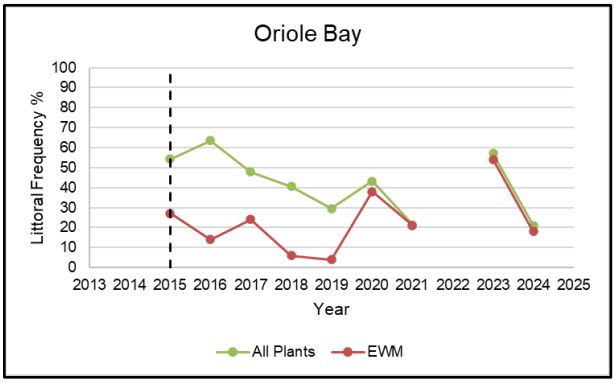
FOX CT BAY Common Name	FOX CT BAY Scientific Name	Frequency of Occurrence at Veg. Sites (%)	Littoral Frequency (%)	Relative Frequency (%)	# Sites	Average Rake Fullness	# Visual
Eurasian watermilfoil	*Myriophyllum spicatum*	100	14.29	100.00	1	1.00	0
Filamentous algae		200	28.57		2	1.50	2

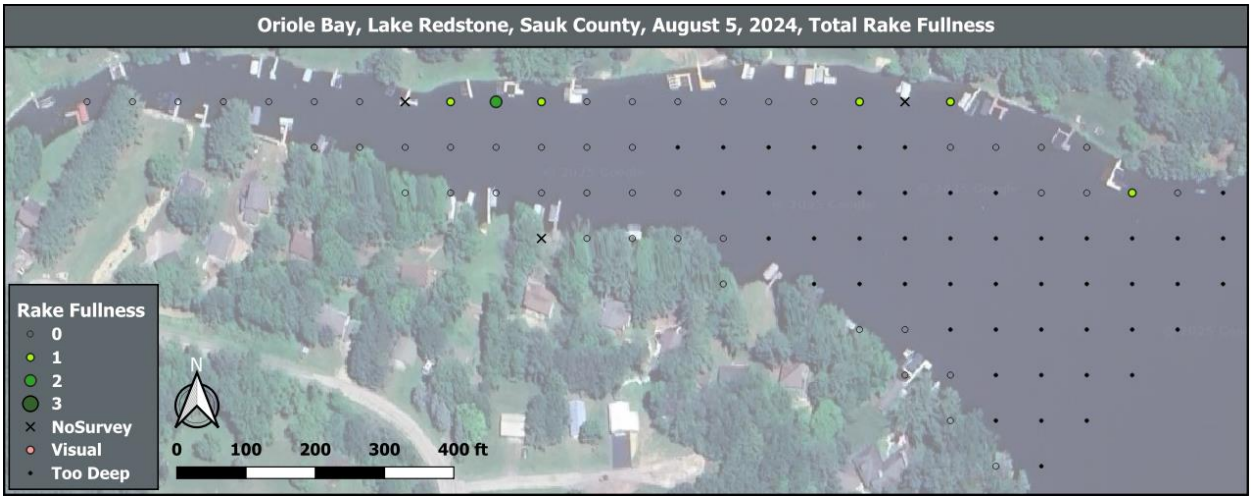


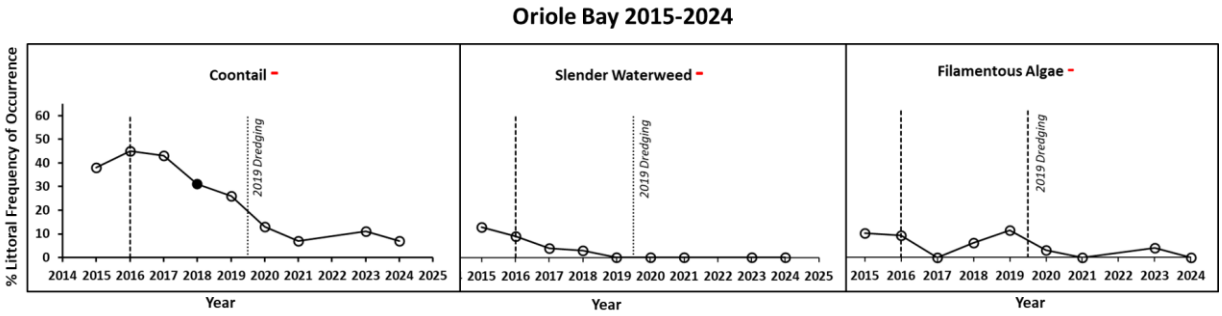
4.4 Oriole Bay 2024

- Max rooting depth = 5.5ft (6 feet in 2023)
- 21% Littoral frequency all plants (57% in 2023).
- Most common plant was EWM at 5 sites (2023 was EWM at 15 sites).
- Chi-squared tests[2] revealed a statistically significant decrease in EWM in 2024 compared to 2023. There was a statistically significant decrease in coontail, slender waterweed, and filamentous algae when comparing 2015 data to 2024. EWM chi-square graph is in the EWM Section.
- Oriole Bay is designated as a critical habitat area.

ORIOLE BAY Common Name	ORIOLE BAY Scientific Name	Frequency of Occurrence at Veg. Sites (%)	Littoral Frequency (%)	Relative Frequency (%)	# Sites	Average Rake Fullness	# Visual
Eurasian water milfoil	*Myriophyllum spicatum*	83.33	17.86	45.45	5	1.20	0
Small pondweed	*Potamogeton pusillus*	66.67	14.29	36.36	4	1.00	0
Coontail	*Ceratophyllum demersum*	33.33	7.14	18.18	2	1.00	0
White water lily	*Nymphaea odorata*						1
Filamentous algae							1



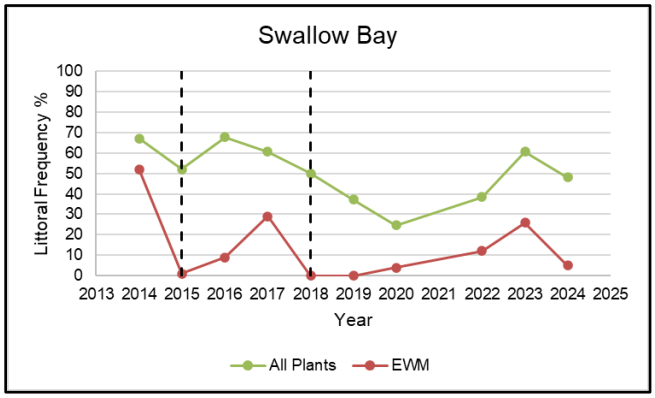


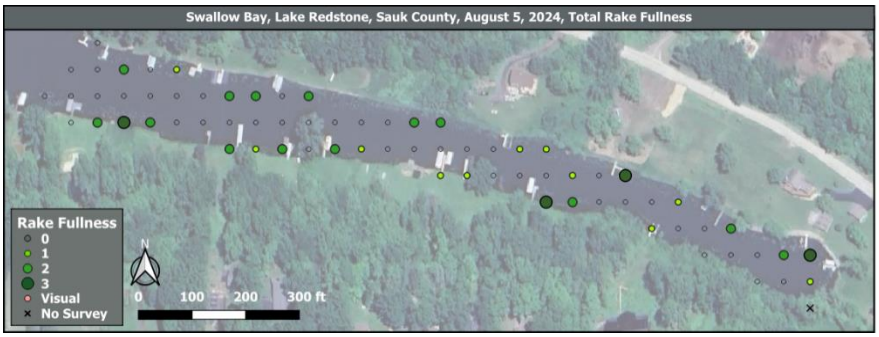


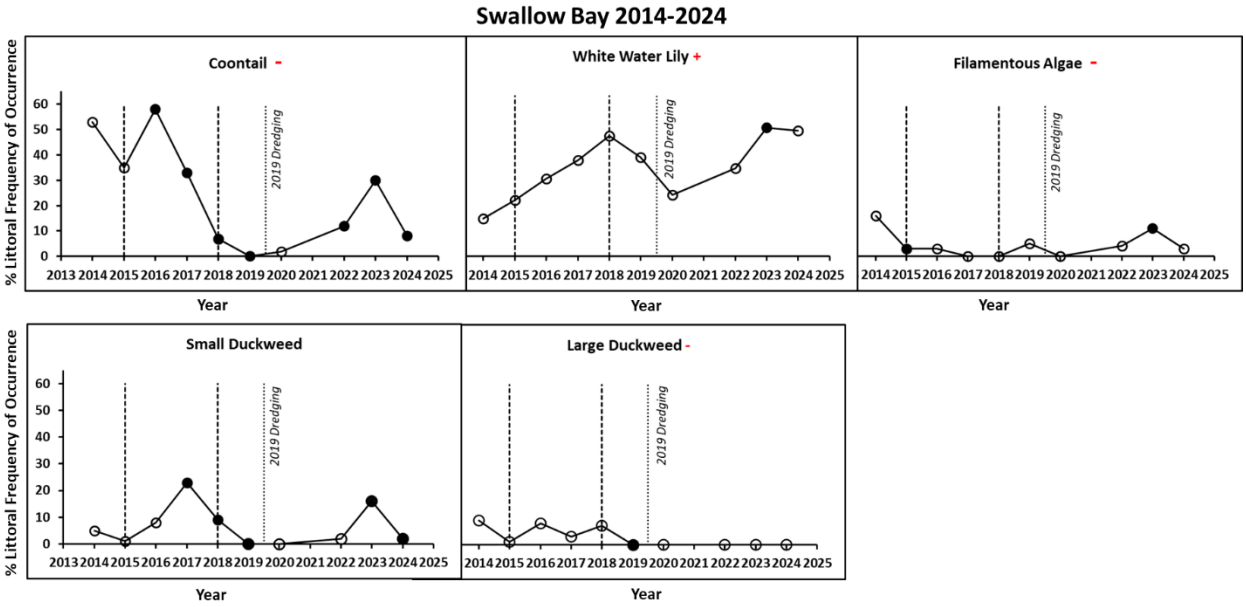
4.5 Swallow Bay 2024

- Max rooting depth = 5ft (same in 2023)
- 48% Littoral frequency all plants (61% in 2023).
- Most common plant was white water lily at 28 sites (2023 was 29 sites).
- Chi-squared tests[2] revealed a statistically significant (SS) decrease in EWM, coontail, and small duckweed in 2024 compared to 2023. There was a SS decrease in coontail, EWM, large duckweed, and filamentous algae when comparing 2014 data to 2024. There was a SS increase in white water lily in 2024 compared to 2014. EWM chi-square graph is in the EWM Section.
- Swallow Bay is designated as a critical habitat area.

SWALLOW BAY Common Name	SWALLOW BAY Scientific Name	Frequency of Occurrence at Veg. Sites (%)	Littoral Frequency (%)	Relative Frequency (%)	# Sites	Average Rake Fullness	# Visual
White water lily	*Nymphaea odorata*	96.55	46.67	75.68	28	1.79	16
Coontail	*Ceratophyllum demersum*	17.24	8.33	13.51	5	1.00	0
Eurasian watermilfoil	*Myriophyllum spicatum*	10.34	5.00	8.11	3	1.00	0
Filamentous algae		6.90	3.33		2	1.00	0
Slender waterweed	*Elodea nuttallii*	3.45	1.67	2.70	1	1.00	0
Duckweed	*Lemna sp.*	3.45	1.67	2.70	1	1.00	1
Small pondweed	*Potamogeton pusillus*						1
Arrowhead	*Sagittaria sp.*						2



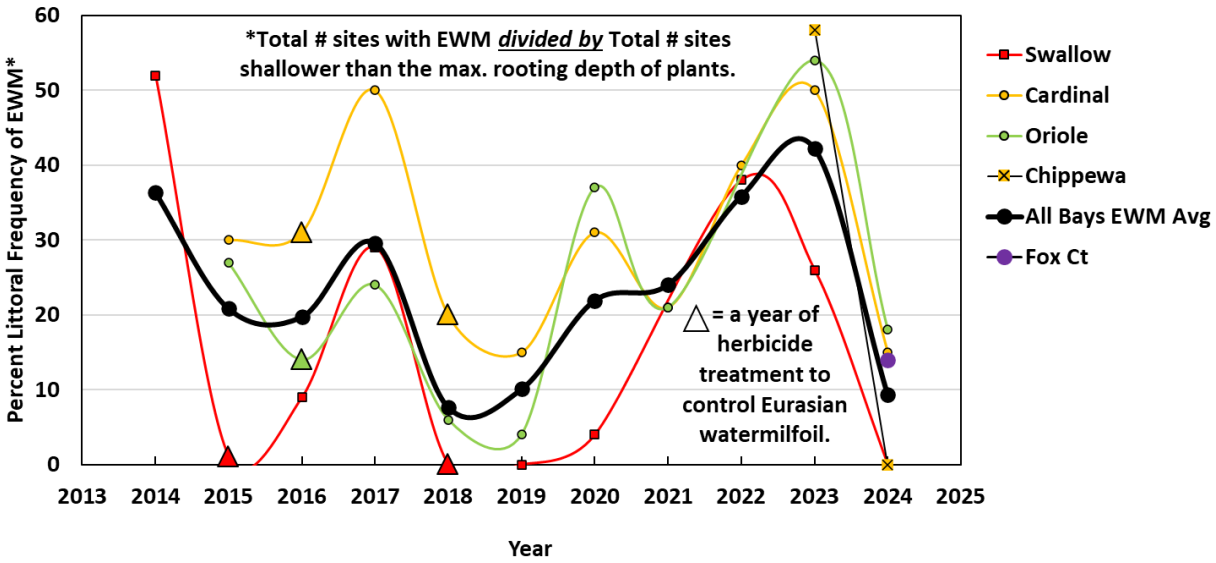




4.6 Eurasian Watermilfoil Results & Management History

Eurasian watermilfoil (EWM) was found in all 5 bays and was the most commonly occurring plant species in 2 bays. Figure 2 illustrates EWM littoral frequency in five of the bays surveyed in 2024. ***In summary, there was a distinct decline in EWM in 2024 after 5 years of EWM increase from 2019 through 2023.*** The decline occurred despite no herbicide treatment in any of the bays since 2018.

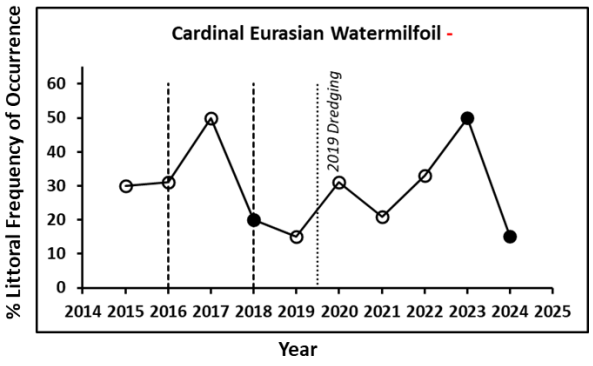
Figure 2 – Eurasian Watermilfoil Littoral Frequency Graph

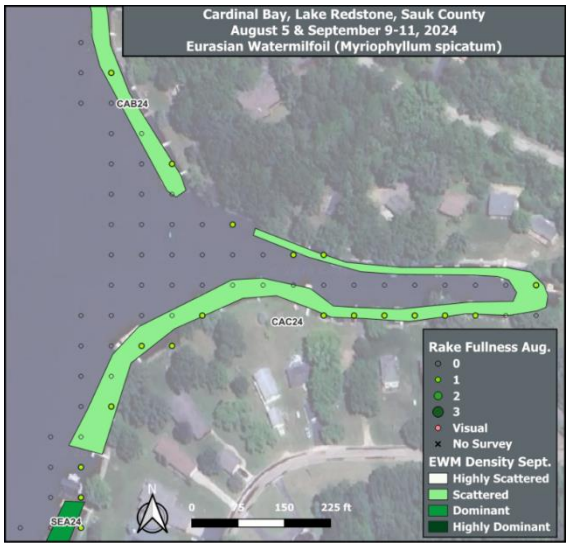


4.6.1 Cardinal Bay EWM 2024

- EWM was the fourth most common plant with occurrence at 5 sites (another 6 visual).
- Herbicide was applied in Cardinal Bay in 2016 and 2018.
- Navigation impairment caused by EWM was not observed in 2024. There was a clear channel down the middle of Cardinal Bay allowing for navigation. The near shore areas between docks had greater EWM occurrence and density, likely causing some nuisance for near-shore areas.
- A chi-squared test of EWM revealed a statistically significant decrease in EWM between 2015 and 2024 and between 2023 and 2024.

Figure 3 - Cardinal Bay Eurasian Watermilfoil Map & Chi-Square Graph

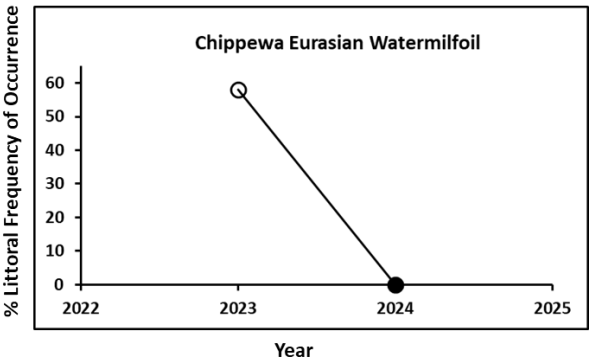


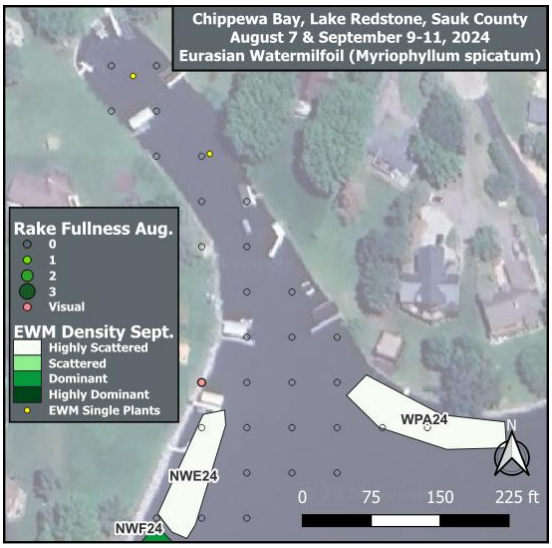


4.6.2 Chippewa Bay EWM 2024

- EWM was detected near one sample point but not on the rake.
- No herbicide treatment has been conducted in Chippewa Bay.
- Diver assisted suction harvest (DASH) was used to control EWM at several locations in and near Chippewa Bay in June 2022. Water clarity was a significant issue for divers, leading to unsatisfactory results. As a result, LRPD is not pursuing the use of DASH in the near future.
- Chi-squared tests[2] revealed a statistically significant decrease in EWM in 2024 compared to 2023.

Figure 4 – Chippewa Bay Eurasian Watermilfoil Map & Chi-square Graph

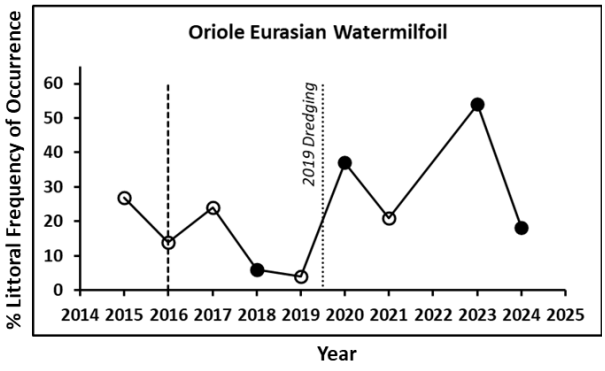


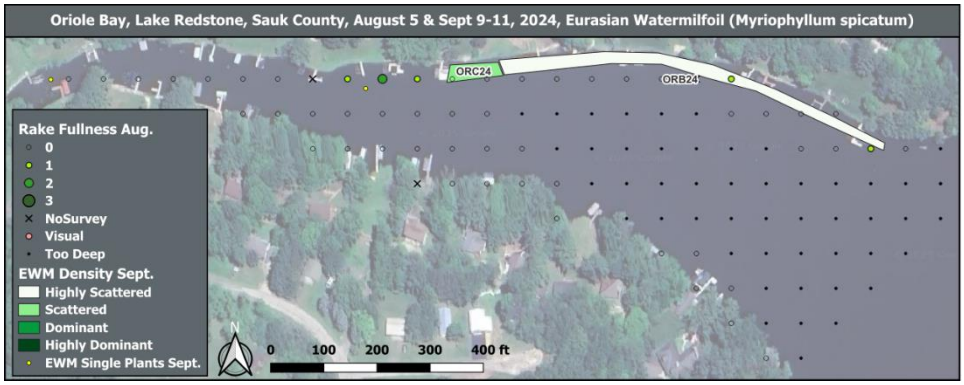


4.6.3 Oriole Bay EWM 2024

- EWM was the most common species with occurrence at 5 survey points (0 visual).
- Herbicide was applied in Oriole Bay in 2016.
- Chi-squared tests[2] revealed a statistically significant decrease in EWM in 2024 compared to 2023.
- Navigation impairment caused by EWM was not observed in 2024.

Figure 5 – Oriole Bay Eurasian Watermilfoil Map & Chi-Square Graph



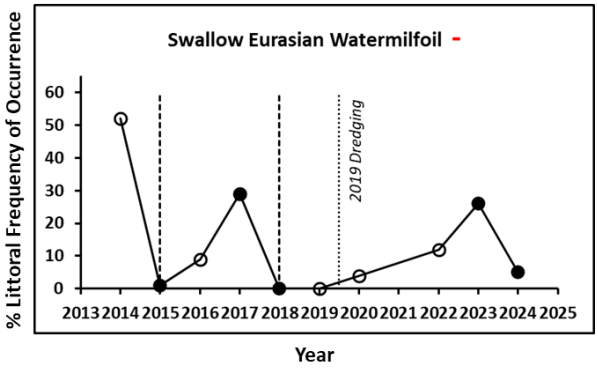


4.6.4 Fox Court Bay EWM 2024 – See Fox Court Section on page 12.

4.6.5 Swallow Bay EWM 2024

- EWM was found at 3 sites (0 visual), third most common plant species in 2024.
- Herbicide treatment was done in 2015 & 2018 to control EWM.
- Chi-squared tests[2] revealed a statistically significant decrease in EWM in 2024 compared to 2023 and when comparing 2014 data to 2024.
- Navigation impairment caused by EWM was not observed in 2024. There was a clear channel down the middle of Swallow Bay allowing for navigation.

Figure 6 – Swallow Bay Eurasian Watermilfoil Map 2024 & Chi-square Graph



4.7 Eurasian Watermilfoil Bed Survey Results

EWM beds were surveyed September 9-11th, 2024. There were 56 beds of EWM documented with a total of 18.57 acres (Table 2, Table 3). Figure 7 illustrates EWM beds in Lake Redstone and the locations of 8 higher resolution maps included in this section.

Table 2 – EWM Bed Acreage by Density 2022-2024

Density	2022 Acres	2023 Acres	2024 Acres
Highly Scattered	8.2	9.58	3.39
Scattered	4.3	7.56	8.87
Dominant	6.6	3.44	5.71
Highly Dominant	12.8	0.56	0.6
Total	**31.9**	**21.14**	**18.57**

** 2022-2023 Surveys completed by Cason Lake & Water Management LLC*

Figure 7 – Locator Map for EWM Beds

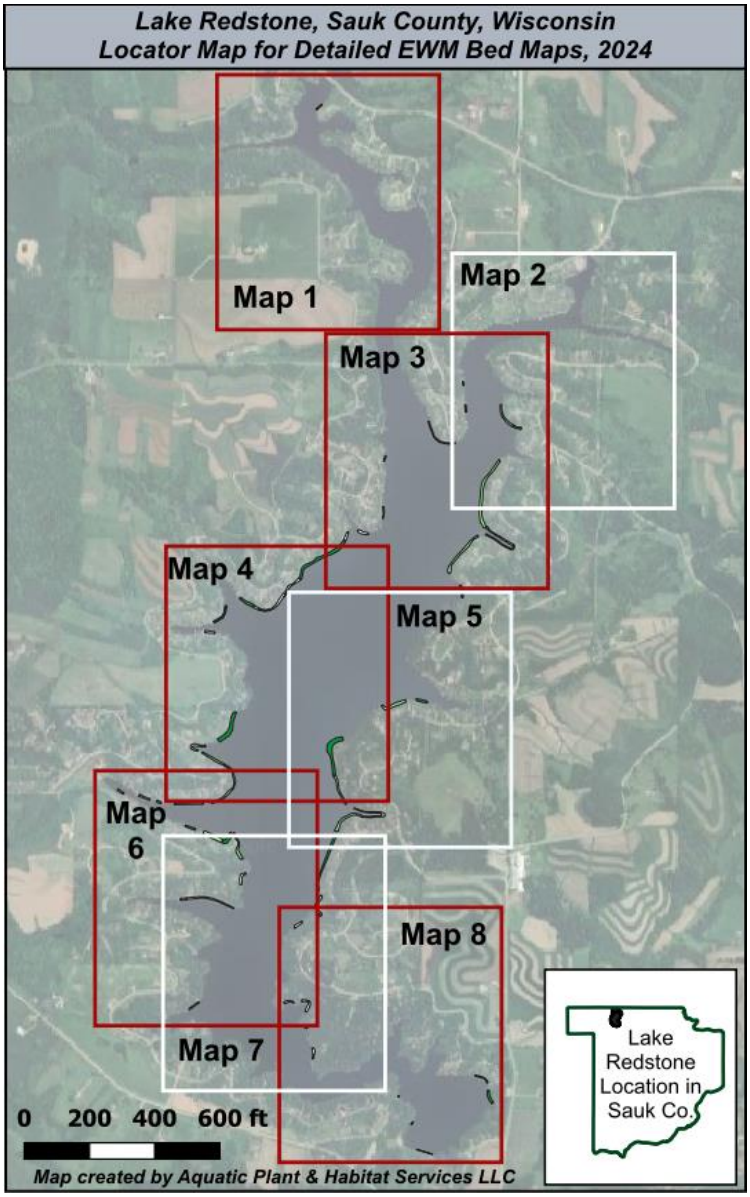
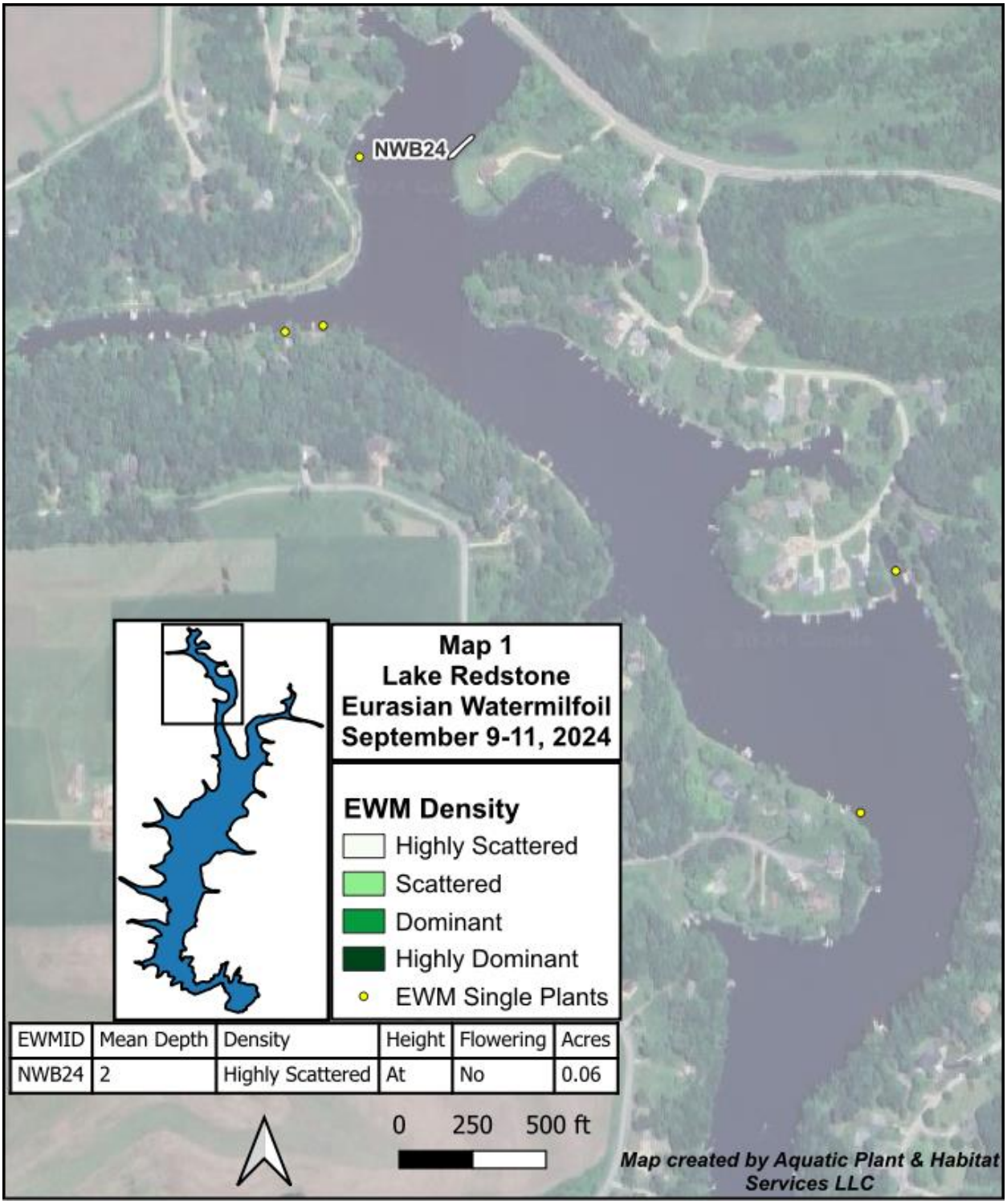
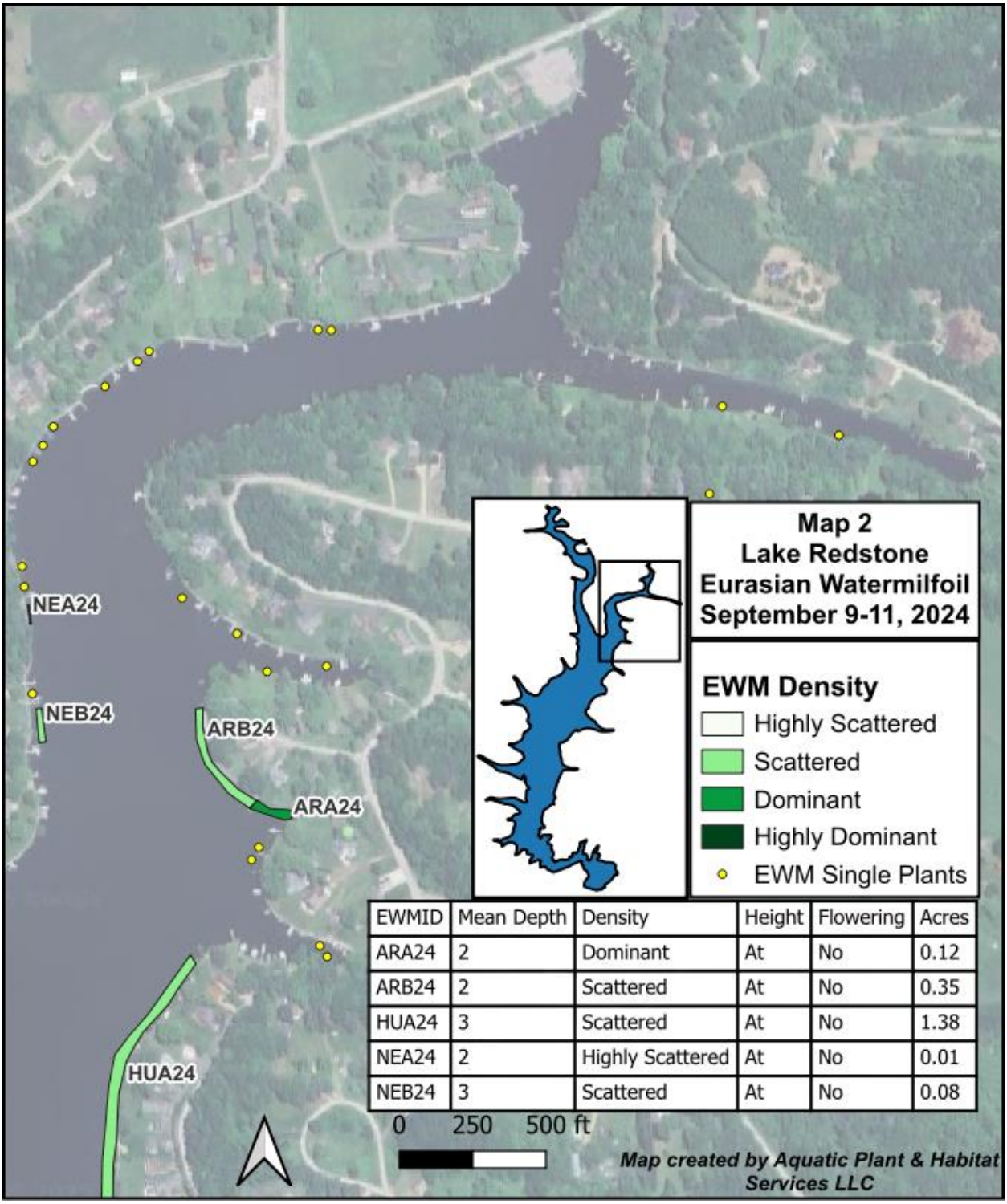


Table 3 – Redstone EWM Beds, 2024

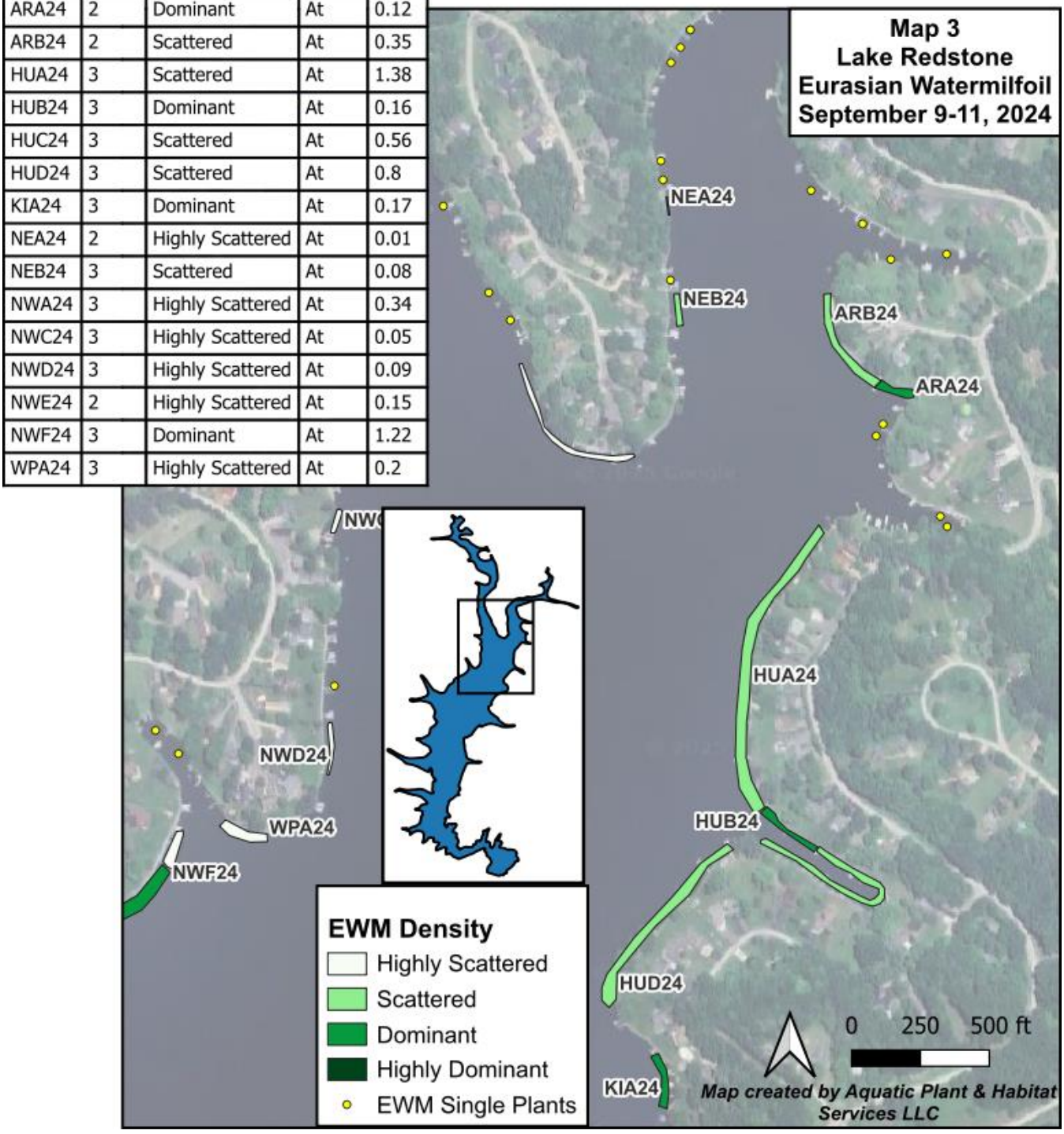
EWMID	Mean Depth (ft)	Density	Height	Flower	Acres
ARA24	2	Dominant	At	No	0.12
ARB24	2	Scattered	At	No	0.35
CAA24	3	Dominant	At	No	1.21
CAB24	2	Scattered	At	No	0.42
CAC24	3	Scattered	At	No	1.04
CANA24	3	Highly Scattered	At	No	0.13
CBA24	4	Dominant	At	No	0.01
CBB24	4	Highly Scattered	At	No	0.03
CBC24	1	Scattered	At	Yes	0.07
CBE24	2	Highly Dominant	At	Yes	0.13
CBE24	3	Scattered	At	No	0.25
CHA24	2	Highly Dominant	At	Yes	0.15
CHB24	3	Scattered	At	No	0.1
CHC24	3	Dominant	At	No	0.29
CHD24	3	Highly Dominant	At	No	0.32
CHE24	2	Highly Scattered	At	No	0.15
EAA24	2	Dominant	At	No	0.18
EAB24	4	Scattered	At	No	0.53
HUA24	3	Scattered	At	No	1.38
HUB24	3	Dominant	At	No	0.16
HUC24	3	Scattered	At	No	0.56
HUD24	3	Scattered	At	No	0.8
KIA24	3	Dominant	At	No	0.17
MDA24	2	Highly Scattered	At	No	0.35
MDB24	1	Dominant	At	Yes	0.07
MDC24	1	Scattered	At	No	0.15
MDD24	1	Scattered	At	No	0.09
MDE24	1	Dominant	At	No	0.14
MDF24	3	Scattered	At	No	0.56
MDG24	3	Dominant	At	No	0.34
MDH24	3	Scattered	At	No	0.44
NEA24	2	Highly Scattered	At	No	0.01
NEB24	3	Scattered	At	No	0.08
NWA24	3	Highly Scattered	At	No	0.34
NWB24	2	Highly Scattered	At	No	0.06
NWC24	3	Highly Scattered	At	No	0.05
NWD24	3	Highly Scattered	At	No	0.09
NWE24	2	Highly Scattered	At	No	0.15
NWF24	3	Dominant	At	No	1.22
NWG24	3	Scattered	At	No	0.62
ORA248	3	Highly Scattered	At	No	0.23
ORB24	3	Highly Scattered	At	No	0.52
ORC24	3	Scattered	At	No	0.09
QUA24	2	Dominant	At	No	0.9
QUB24	2	Highly Scattered	At	No	0.31
QUC24	2	Scattered	At	No	0.35
QUD24	3	Dominant	At	No	0.07
QUE24	2	Scattered	At	No	0.58
RAA24	3	Highly Scattered	At	No	0.28
RAB24	3	Highly Scattered	At	No	0.13
SEA24	3	Dominant	At	Yes	0.83
SEB24	3	Scattered	At	No	0.41
SEC24	2	Highly Scattered	At	No	0.16
SED24	3	Highly Scattered	At	No	0.15
SEE24	3	Highly Scattered	At	No	0.05
WPA24	3	Highly Scattered	At	No	0.2
Total Acres					**18.57**

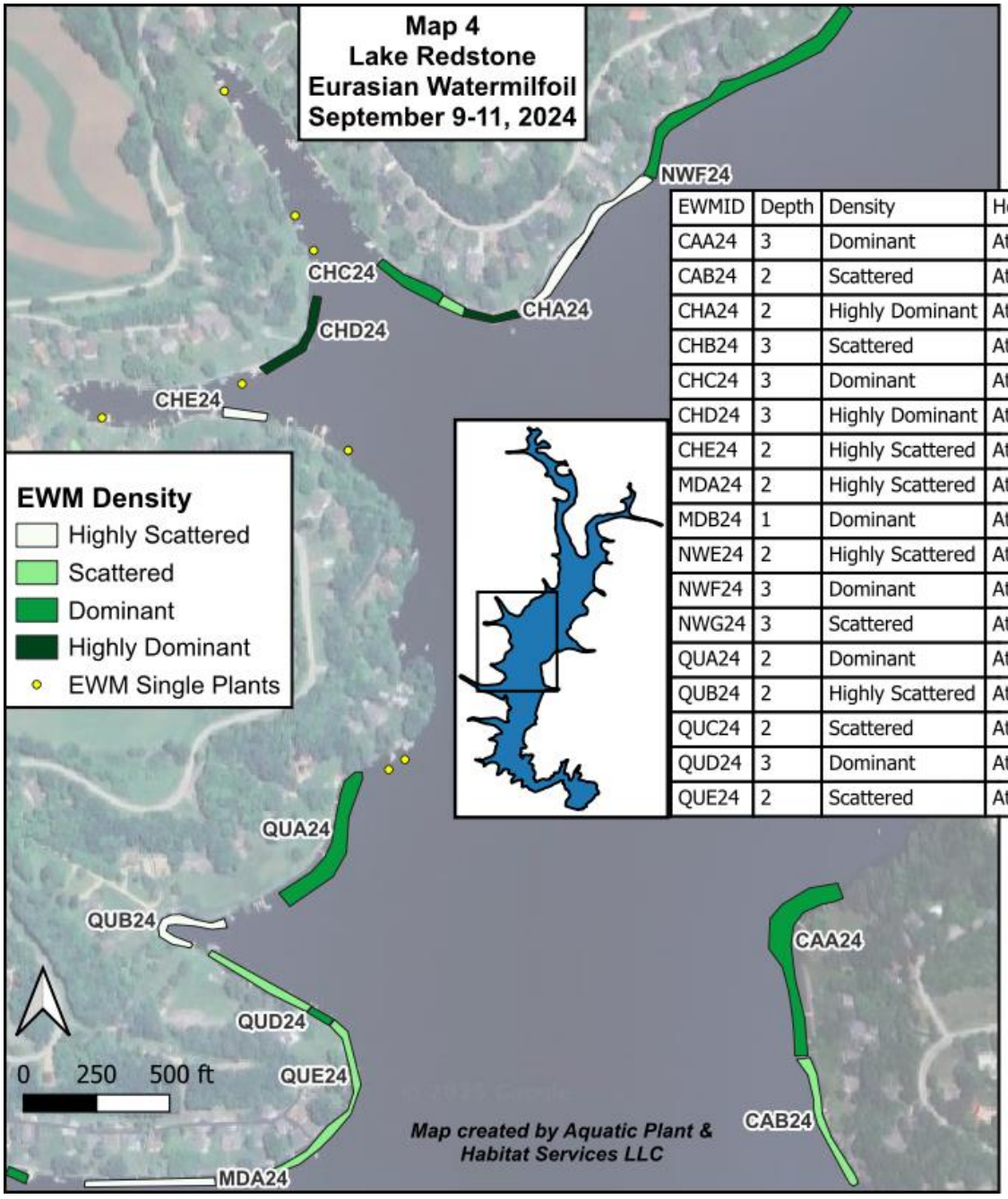

NWB24
Map 1
Lake Redstone
Eurasian Watermilfoil
September 9-11, 2024
EWM Density
Highly Scattered
Scattered
Dominant
Highly Dominant
EWM Single Plants
EWMID | Mean Depth | Density | Height | Flowering | Acres
NWB24 | 2 | Highly Scattered | At | No | 0.06
0 250 500 ft
Map created by Aquatic Plant & Habitat Services LLC



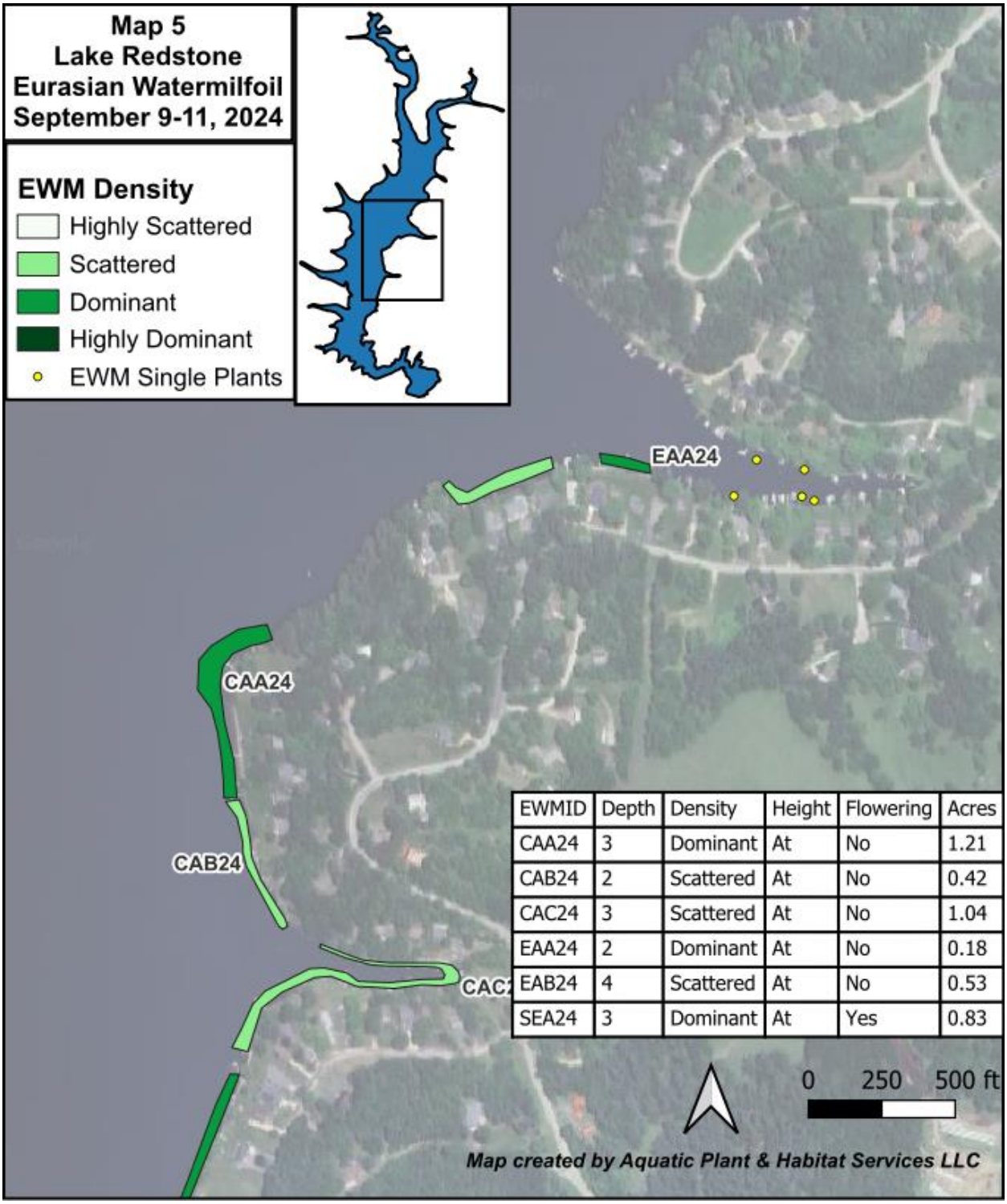
EWMID	Mean Depth	Density	Height	Flowering	Acres
ARA24	2	Dominant	At	No	0.12
ARB24	2	Scattered	At	No	0.35
HUA24	3	Scattered	At	No	1.38
NEA24	2	Highly Scattered	At	No	0.01
NEB24	3	Scattered	At	No	0.08

EWMID	Depth	Density	Height	Acres
ARA24	2	Dominant	At	0.12
ARB24	2	Scattered	At	0.35
HUA24	3	Scattered	At	1.38
HUB24	3	Dominant	At	0.16
HUC24	3	Scattered	At	0.56
HUD24	3	Scattered	At	0.8
KIA24	3	Dominant	At	0.17
NEA24	2	Highly Scattered	At	0.01
NEB24	3	Scattered	At	0.08
NWA24	3	Highly Scattered	At	0.34
NWC24	3	Highly Scattered	At	0.05
NWD24	3	Highly Scattered	At	0.09
NWE24	2	Highly Scattered	At	0.15
NWF24	3	Dominant	At	1.22
WPA24	3	Highly Scattered	At	0.2

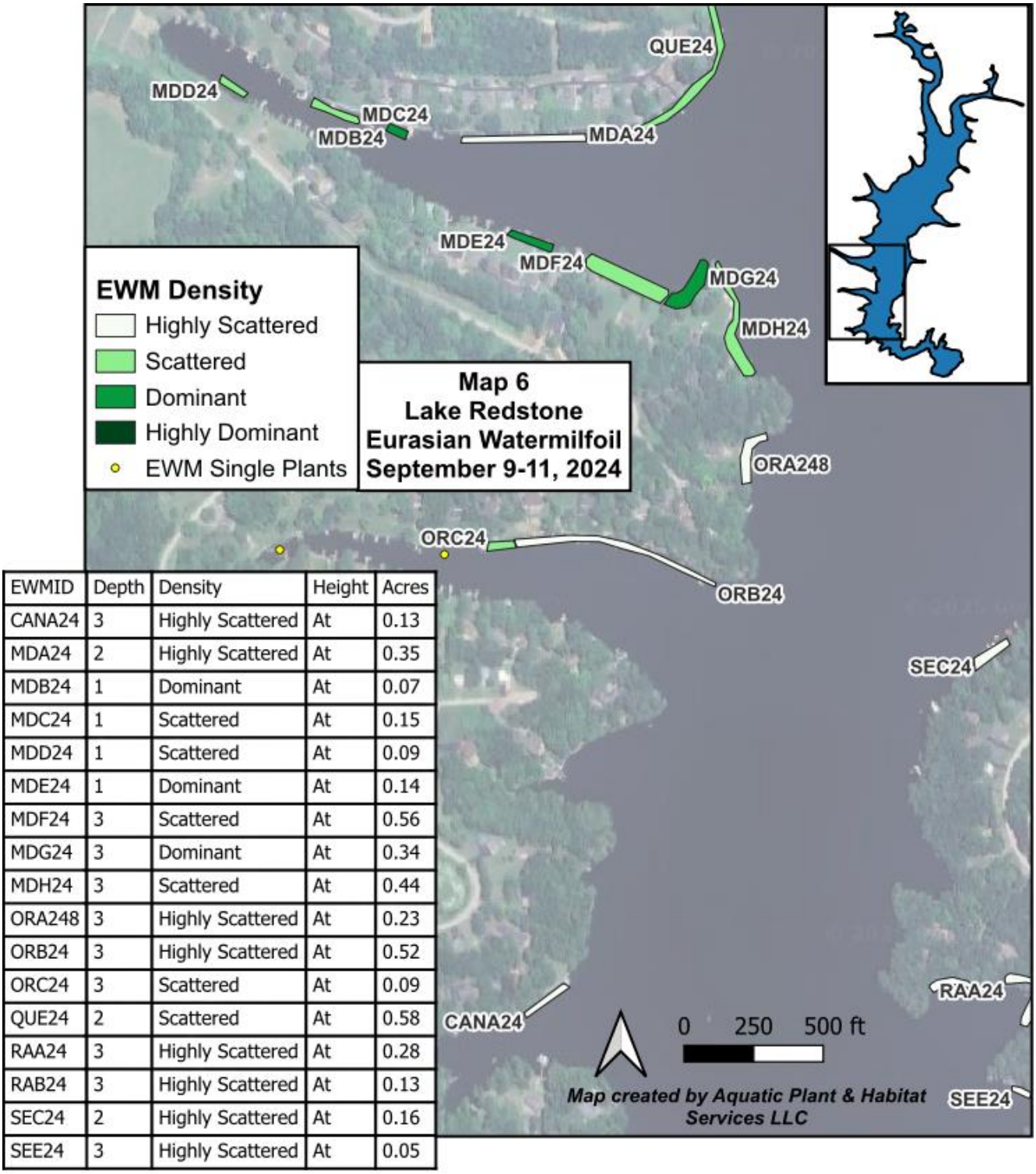




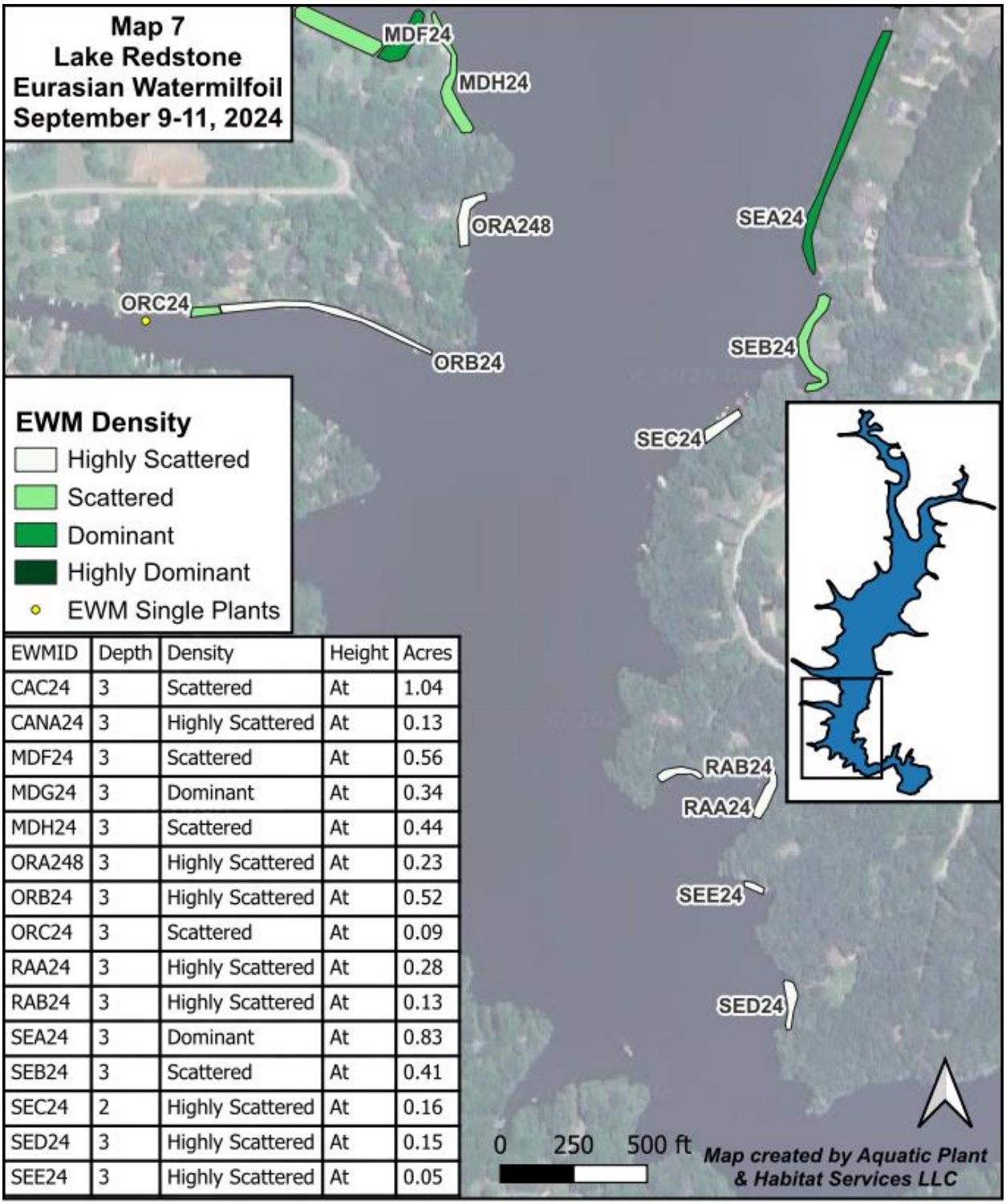
EWMID	Depth	Density	Height	Flowering	Acres
CAA24	3	Dominant	At	No	1.21
CAB24	2	Scattered	At	No	0.42
CHA24	2	Highly Dominant	At	Yes	0.15
CHB24	3	Scattered	At	No	0.1
CHC24	3	Dominant	At	No	0.29
CHD24	3	Highly Dominant	At	No	0.32
CHE24	2	Highly Scattered	At	No	0.15
MDA24	2	Highly Scattered	At	No	0.35
MDB24	1	Dominant	At	Yes	0.07
NWE24	2	Highly Scattered	At	No	0.15
NWF24	3	Dominant	At	No	1.22
NWG24	3	Scattered	At	No	0.62
QUA24	2	Dominant	At	No	0.9
QUB24	2	Highly Scattered	At	No	0.31
QUC24	2	Scattered	At	No	0.35
QUD24	3	Dominant	At	No	0.07
QUE24	2	Scattered	At	No	0.58



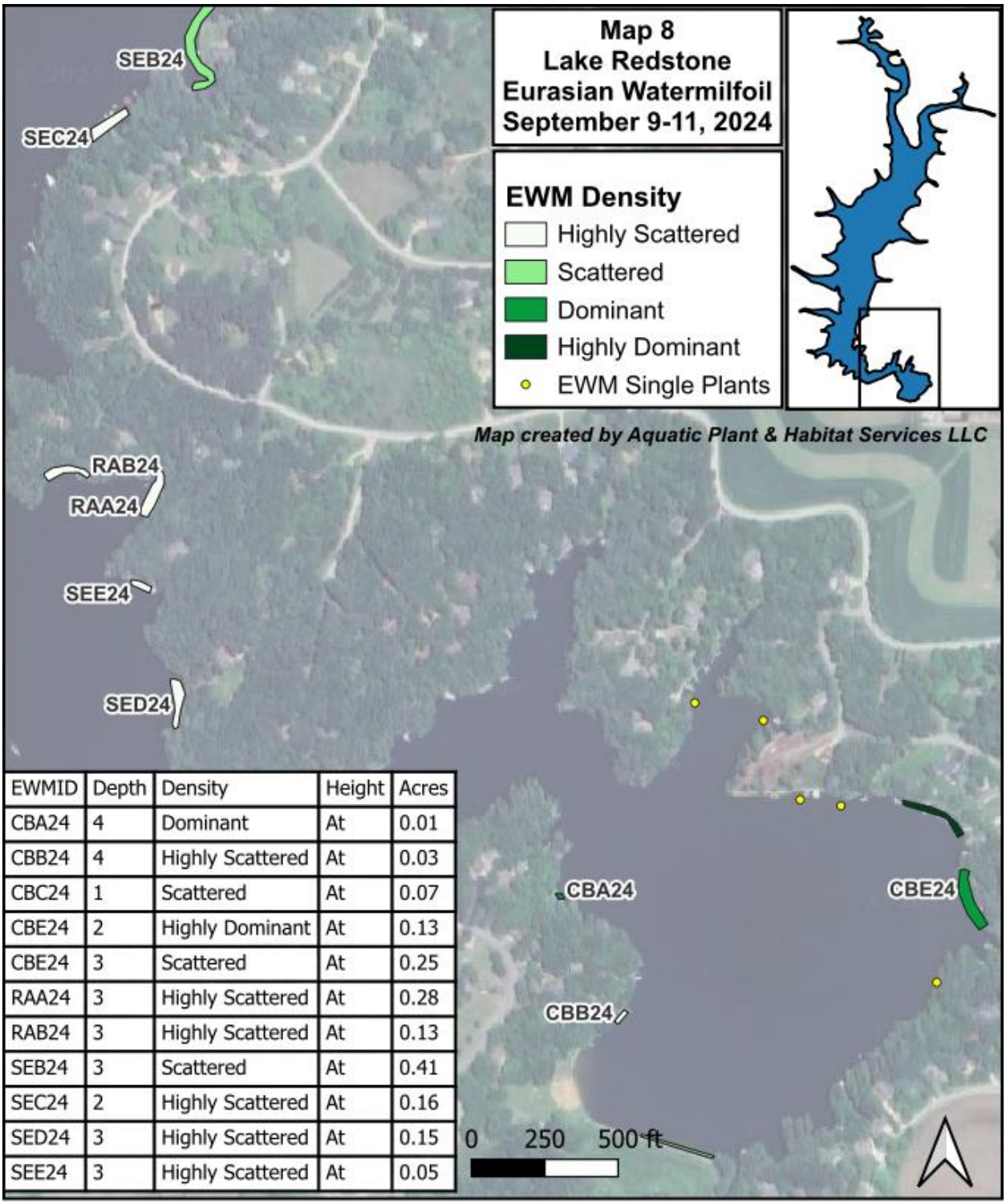
EWMID	Depth	Density	Height	Flowering	Acres
CAA24	3	Dominant	At	No	1.21
CAB24	2	Scattered	At	No	0.42
CAC24	3	Scattered	At	No	1.04
EAA24	2	Dominant	At	No	0.18
EAB24	4	Scattered	At	No	0.53
SEA24	3	Dominant	At	Yes	0.83



EWMID	Depth	Density	Height	Acres
CANA24	3	Highly Scattered	At	0.13
MDA24	2	Highly Scattered	At	0.35
MDB24	1	Dominant	At	0.07
MDC24	1	Scattered	At	0.15
MDD24	1	Scattered	At	0.09
MDE24	1	Dominant	At	0.14
MDF24	3	Scattered	At	0.56
MDG24	3	Dominant	At	0.34
MDH24	3	Scattered	At	0.44
ORA248	3	Highly Scattered	At	0.23
ORB24	3	Highly Scattered	At	0.52
ORC24	3	Scattered	At	0.09
QUE24	2	Scattered	At	0.58
RAA24	3	Highly Scattered	At	0.28
RAB24	3	Highly Scattered	At	0.13
SEC24	2	Highly Scattered	At	0.16
SEE24	3	Highly Scattered	At	0.05



EWMID	Depth	Density	Height	Acres
CAC24	3	Scattered	At	1.04
CANA24	3	Highly Scattered	At	0.13
MDF24	3	Scattered	At	0.56
MDG24	3	Dominant	At	0.34
MDH24	3	Scattered	At	0.44
ORA248	3	Highly Scattered	At	0.23
ORB24	3	Highly Scattered	At	0.52
ORC24	3	Scattered	At	0.09
RAA24	3	Highly Scattered	At	0.28
RAB24	3	Highly Scattered	At	0.13
SEA24	3	Dominant	At	0.83
SEB24	3	Scattered	At	0.41
SEC24	2	Highly Scattered	At	0.16
SED24	3	Highly Scattered	At	0.15
SEE24	3	Highly Scattered	At	0.05



EWMID	Depth	Density	Height	Acres
CBA24	4	Dominant	At	0.01
CBB24	4	Highly Scattered	At	0.03
CBC24	1	Scattered	At	0.07
CBE24	2	Highly Dominant	At	0.13
CBE24	3	Scattered	At	0.25
RAA24	3	Highly Scattered	At	0.28
RAB24	3	Highly Scattered	At	0.13
SEB24	3	Scattered	At	0.41
SEC24	2	Highly Scattered	At	0.16
SED24	3	Highly Scattered	At	0.15
SEE24	3	Highly Scattered	At	0.05

5.0 Discussion

5.1 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 lurk in wait of forage. Aquatic plants 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. 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. There is no overabundance of vegetation in Lake Redstone. Rather, the aquatic plant community is extremely sparse and all native plant species should be protected.

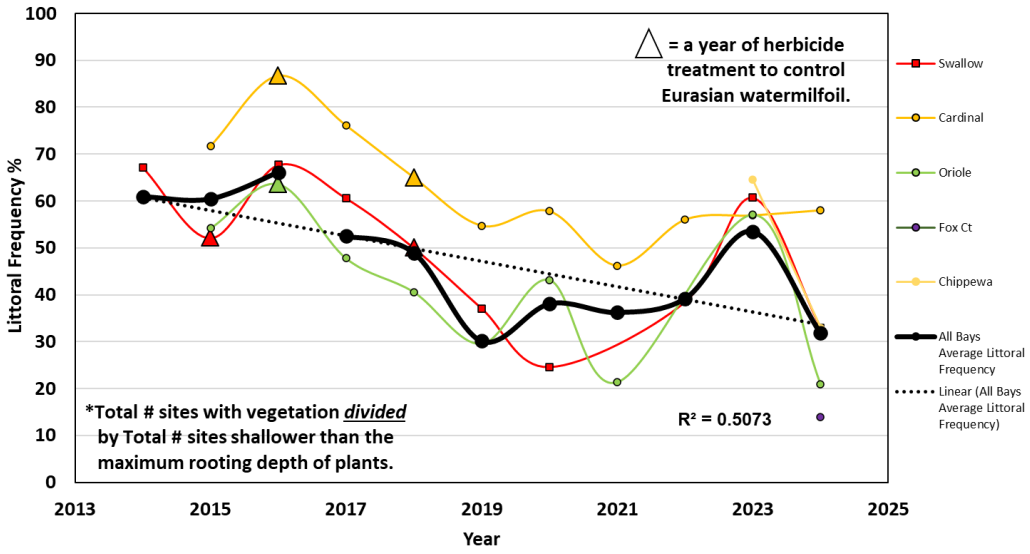
5.2 Changes in Native Plant Occurrence

Chi-square tests were done for Swallow, Oriole, Chippewa, and Cardinal Bays. When comparing 2024 native species occurrence with that of most recent previous surveys, there were no statistically significant (SS) increases in native plant species and there were three instances of SS decreases. When comparing 2023 native species occurrence with the first year surveyed for Cardinal, Oriole, and Swallow, there were 6 statistically significant (SS) declines in native plant species, 3 SS declines in filamentous algae, and 1 increase in native plants. There was a declining trend in native and non-native aquatic plant occurrence from 2014 through 2022, an increase in 2023, and then a decline again in 2024. As discussed in the updated Aquatic Plant Management Plan in 2023, the continued work by the LRPD to decrease nutrient input (especially phosphorus) and promote shoreland protection to decrease surface water runoff is expected to increase water clarity in the years to come. Increased water clarity is expected to allow more plants to grow and at greater depths with is better for overall lake ecology.

5.3 Reduced Plant Occurrence (Native & Non-native Species)

Figure 8 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. The bays that were surveyed since 2014 were selected each year based on perceived high aquatic plant abundance, particularly EWM, and therefore the bays are all thought to be representative of bays with overall high plant occurrence in Lake Redstone. Figure 8 illustrates littoral frequency for the bays surveyed in 2024 as well as the average littoral frequency for *all bays* surveyed since 2014. A linear trendline[3] of the average littoral frequency among all bays[4] suggests the littoral frequency of aquatic plants (combined native and non-native) was on a downward trend from 2014 through 2022 with an R value of 0.72.[5] Surveys in 2023 weakened the R value down to 0.42, suggesting aquatic plants could be on the rise. The sharp drop in aquatic plant occurrence in 2024 increased the R value to 0.51. Figure 8 illustrates that the average aquatic plant occurrence in 2024 was among the lowest since 2014. The only year of lower plant occurrence was 2019, just before dredging occurred.

Figure 8 – Littoral Plant Frequency Graph



[3] 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.

[4] All bays surveyed includes all those surveyed in a given year except for County F Bay in 2019 & 2020 (see 2020 report for more information).

[5] **R-squared** value measures the **trendline** reliability - the nearer **R**^{2} is to 1, the better the **trendline** fits the data. The **R**^{2} value in 2022 was much stronger at 0.72.

5.4 Using Criteria to Prioritize EWM Control

The Aquatic Plant Management Plan that was finalized in May 2023 included Table 4 to help guide management decisions. Under the "Size & Location" criteria, a trigger frequency of 36% is mentioned and is based on the littoral frequencies of EWM the year before they were treated with herbicide 2014-2018. None of the bays surveyed in 2024 had EWM littoral frequency greater than 36%.

Table 4 – Herbicide Treatment Criteria

Criteria for Prioritizing Eurasian Watermilfoil Control					
SIZE & LOCATION	**DENSITY**	**TRAFFIC**	**IMPAIRMENT**	**HABITAT**	**SURVEY DATA**
•Is the area in a sheltered bay or exposed shoreline? •If exposed, is the EWM bed >0.5 ac? •If sheltered, is the EWM frequency at least 36%?	•Is EWM the dominant species? •Is EWM rake fullness >2 on average?	•Is the EWM in an area of high boat traffic? •Is the EWM causing obstruction to navigation for more than a single riparian landowner?	•Is this area causing beneficial use impairment? (aquatic plants prevent activities such as angling, boating, swimming, or other navigation /recreation)	•Is EWM the dominant species to the detriment of native plant species? •Would the proposed treatment have limited impact on native plants?	•Has a pre-treatment survey been completed using standardized methods to document location, size, density, and height?
HOW TO USE THESE CRITERIA – Answer the 6 questions for a particular bed of EWM. If the answer is "yes" for most questions (ideally 4 or more), then that bed of EWM may be considered high priority for control actions. For beds of EWM with fewer "yes" answers, control actions can still be considered but perhaps that area is not the highest priority. This graphic is meant to help the LRPD prioritize if control actions should take place in any given year. Areas that do not receive attention in a given year may be considered higher priority the following year depending on conditions. Any herbicide permit application is subject to conditions in NR107, with particular attention to NR107.05 and NR107.08.					

Graphic & criteria developed by Aquatic Plant & Habitat Services LLC

6.0 General Management Recommendations

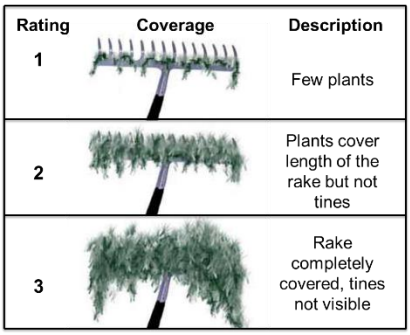
1. **All native aquatic plants should be protected**, especially due to the declining trend in plant occurrence 2014-2022 and again in 2024. Hand removal of nuisance aquatic plants, even native plants, is permitted by Chapter NR 109 but the removal cannot occur in a designated sensitive area without a permit (identified in the updated APMP and includes Oriole, Fox Ct, and Swallow Bays), is limited to a single area no more than 30 feet wide measured along shore, and must not harm the overall aquatic plant community.
2. **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.
3. **Conduct aquatic plant surveys** of bays in 2025 as needed. Since EWM and overall plant occurrence was very low in 2024, whether subPI surveys in bays will be needed in 2025 should be determined based on observed plant growth in early summer 2025. If plant occurrence continues to be low, subPI plant surveys could be suspended for a time.
4. **Utilize herbicide treatment criteria in Table 4** to determine whether herbicide treatment should occur. Based on criteria, no herbicide treatment is recommended due to very low native plant and EWM occurrence. Manual removal in shallow areas is currently the best approach for small-scale EWM control on Lake Redstone.
5. **Protect overwintering shoreline habitat for weevils** as an additional tool that is no-cost and lasting for controlling EWM. Weevils will not eliminate all EWM but rather help keep its growth “in check.”

7.0 Appendix A – Methods

7.1 Field Methods

Field methods followed the standardized protocol developed by the Wisconsin Department of Natural Resources (WDNR) in Hauxwell et. al (2010)[6] and WDNR Aquatic Plant Treatment Evaluation Protocol[7]. SubPI Surveys were completed August 5th and 7th while the EWM bed survey was completed September 9-11th, 2024. Point-intercept maps were previously generated for Cardinal (71 pts), Chippewa (32 pts), Oriole (104 pts), and Swallow (72 pts). A new subPI map was created for Fox Ct. with 50 sample points.

Figure 9 – Rake Fullness Illustration



For the subPI surveys, the survey coordinates were uploaded to a Garmin device, allowing navigation to each survey 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 2015 was 11 feet. A double-sided rake head on a telescopic pole was used to sample each point for aquatic plants, depth, and dominant sediment type. 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 9). 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.

For the EWM bed survey, boundaries of EWM were visually determined from a boat and mapped while navigating along the bed perimeter. Each EWM bed was assigned a letter identifier followed by the year (e.g., A24). Beds were then classified as highly scattered, scattered, dominant, or highly dominant EWM.

[6] *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.*

[7] *https://apps.dnr.wi.gov/swims/Documents/DownloadDocument?id=158140137*

7.2 Data Analysis Methods

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, these statistics should not be used to compare to other lakes where a whole-lake survey has been done. Explanations of summary statistics are in Table 6. ***Individual species statistics*** assess the plant species composition in the 5 bays and allow for comparisons of the plant community within the bays (Table 5). 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 the most recent prior survey to 2024. The tests also compared differences from the first year of the bay being surveyed to 2024.

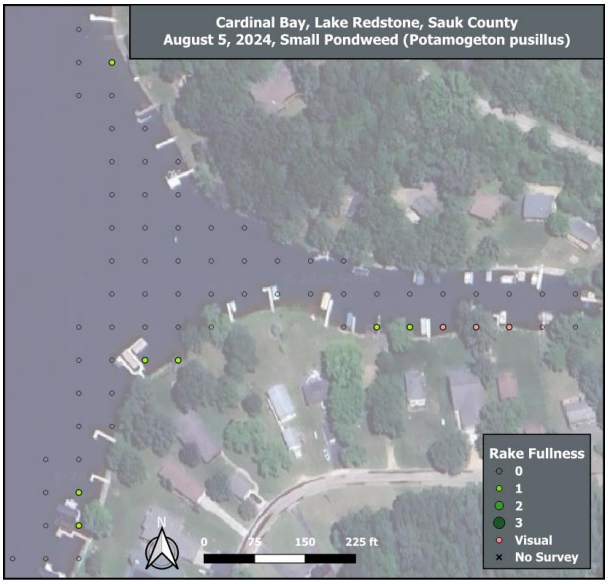
Table 5 – Individual Species Statistics Explanations

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%.

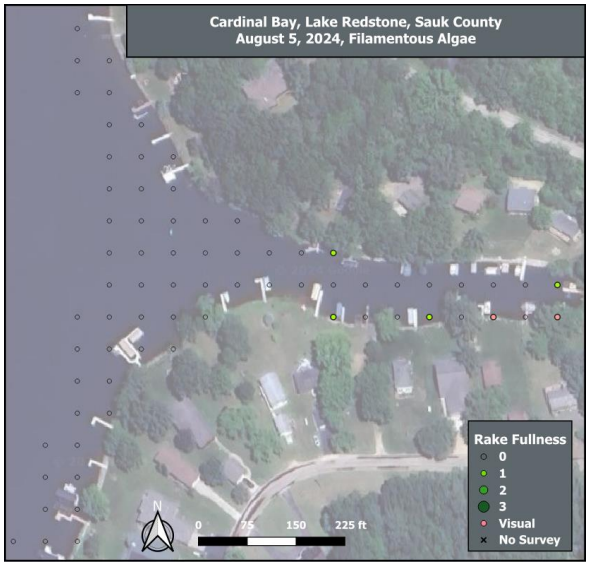
Table 6 – Summary Statistics Explanations

	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).

8.0 Cardinal Bay subPI Maps




Cardinal Bay, Lake Redstone, Sauk County
August 5, 2024, Slender Naiad (Najas flexilis)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
75
150
225 ft


Cardinal Bay, Lake Redstone, Sauk County
August 5, 2024, Filamentous Algae
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
75
150
225 ft

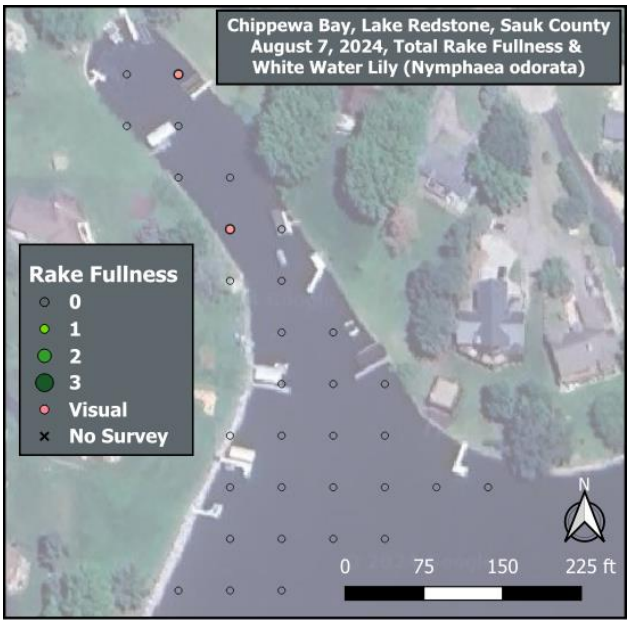

Cardinal Bay, Lake Redstone, Sauk County
August 5, 2024, Wild Celery (Vallisneria americana)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
75
150
225 ft

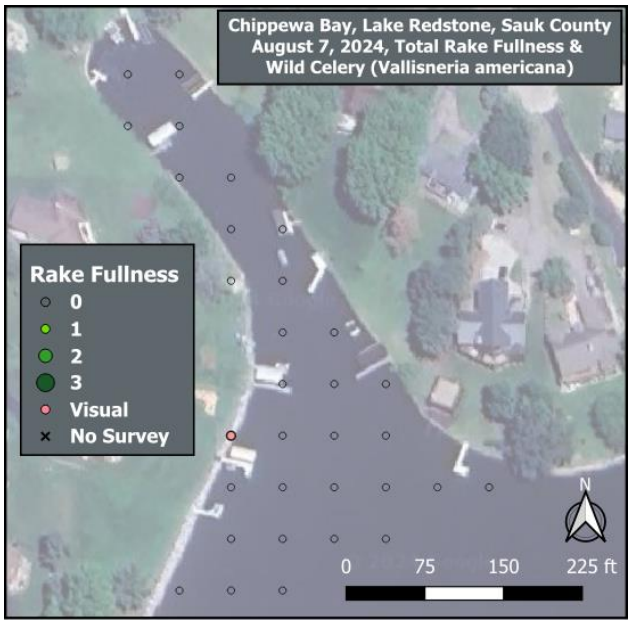

Cardinal Bay, Lake Redstone, Sauk County
August 5, 2024, Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
75
150
225 ft

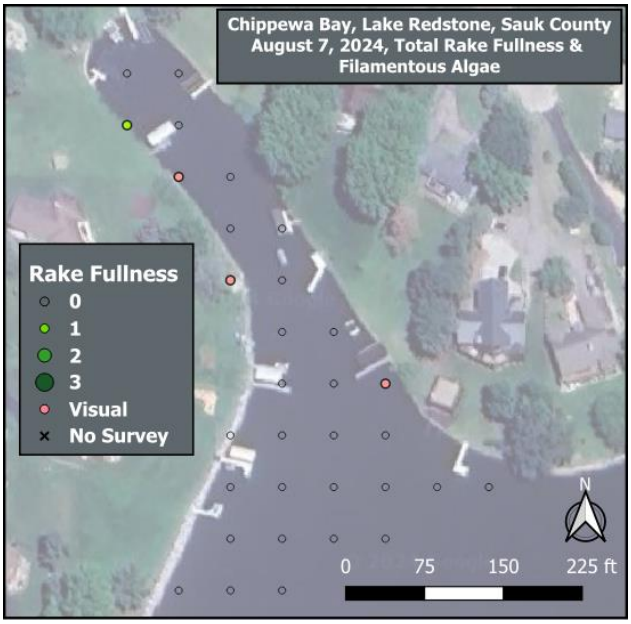

Cardinal Bay, Lake Redstone, Sauk County
August 5, 2024, Large Duckweed (Spirodela polyrrhiza)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
75
150
225 ft

9.0 Chippewa Bay subPl Maps

Small pondweed map is included with the total rake fullness map in the Chippewa Bay results section.



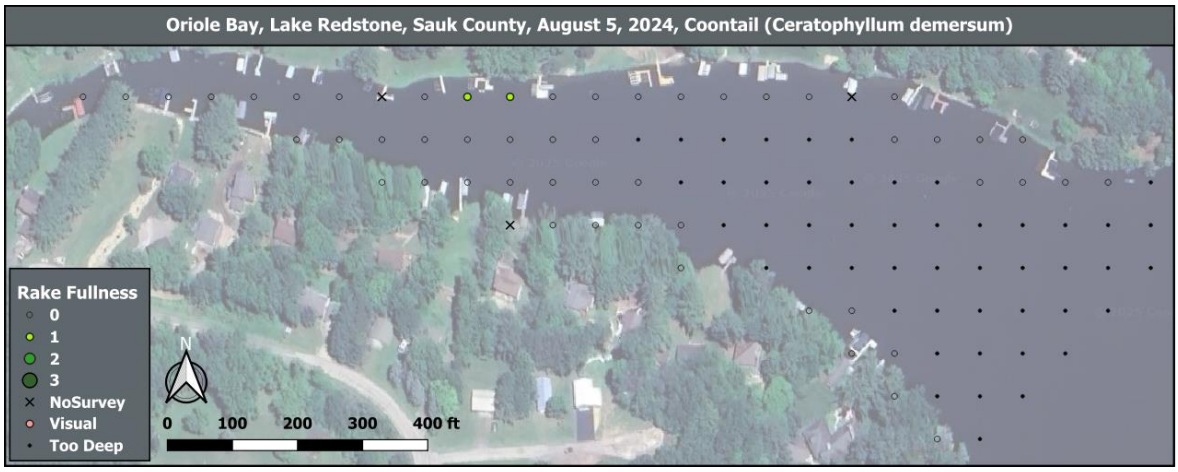


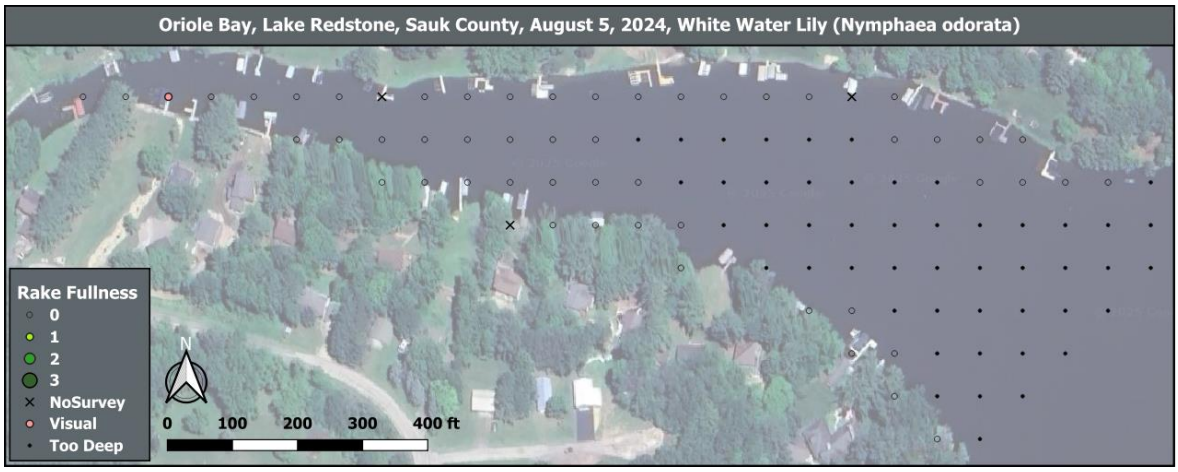


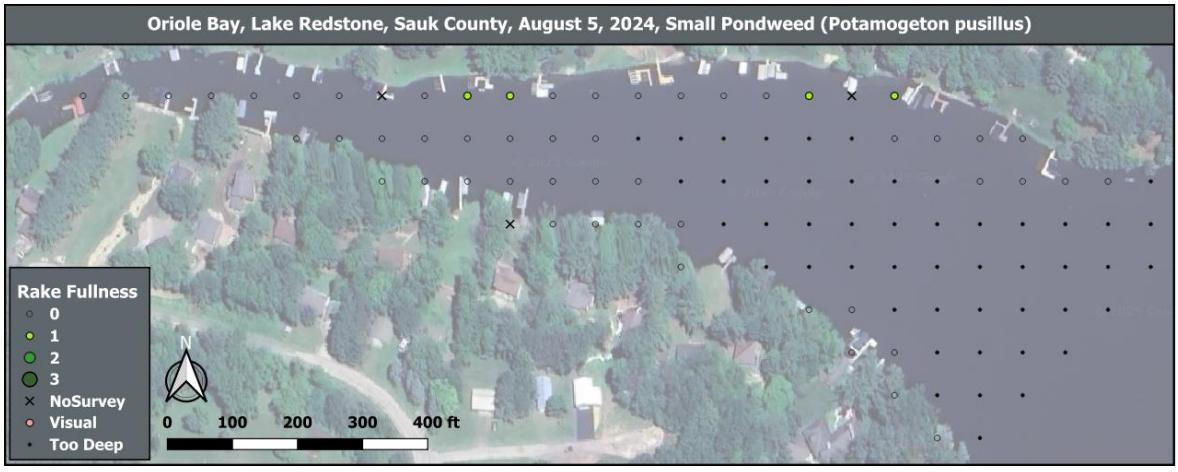
10.0 Fox Court Bay subPI Maps

Native species were not detected during the subPI survey of Fox Court. Total Rake and EWM maps are in respective sections of this report.

11.0 Oriole Bay subPI Maps





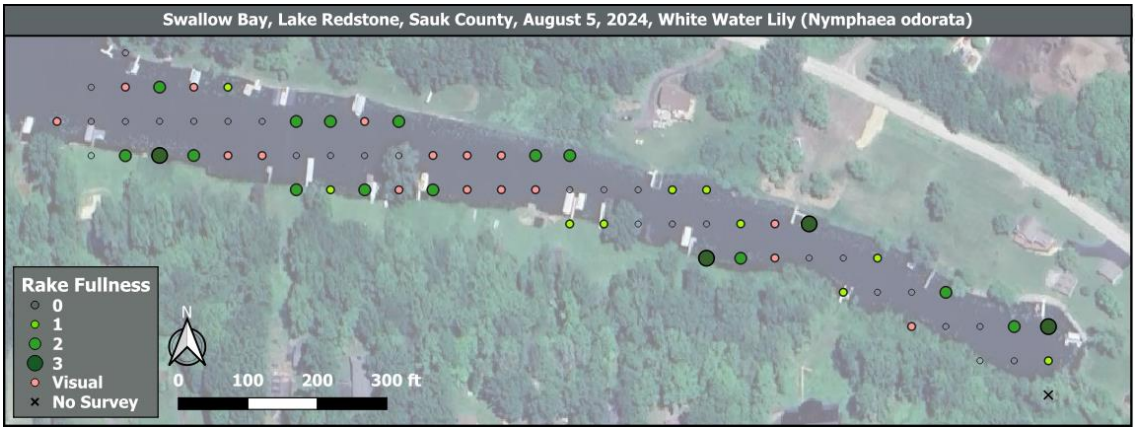


12.0 Swallow Bay SubPl Maps


Swallow Bay, Lake Redstone, Sauk County, August 5, 2024, Arrowhead (Sagittaria sp.)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
100
200
300 ft


Swallow Bay, Lake Redstone, Sauk County, August 5, 2024, Duckweed (Lemna sp.)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
100
200
300 ft


Swallow Bay, Lake Redstone, Sauk County, August 5, 2024, Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
100
200
300 ft


Swallow Bay, Lake Redstone, Sauk County, August 5, 2024, White Water Lily (Nymphaea odorata)
Rake Fullness
0
1
2
3
Visual
No Survey
N
0
100
200
300 ft