Waupaca Chain O' Lakes

Waupaca County, Wisconsin

2019 HWM Monitoring & Control Strategy Assessment Report

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Created by: Todd Hanke, Eddie Heath, and Tim Hoyman
Onterra, LLC
De Pere, WI

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1.0 INTRODUCTION

The Waupaca Chain O' Lakes consists of 22 lakes totaling approximately 792 acres in Waupaca County, Wisconsin (Figure 1.0-1). Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) was first documented in the Waupaca Chain in 2001. Genetic DNA analysis later confirmed that the milfoil was a hybrid (HWM) between EWM and the native northern watermilfoil. The Waupaca Chain O' Lakes District (WCOLD) is the local entity that oversees management of the Chain and has sponsored numerous WDNR funded grant projects. With the assistance of Onterra in 2015, the WCOLD was awarded a WDNR AIS-Education, Planning and Prevention Grant to aid in funding studies aimed at documenting the current state of the Chain's native and non-native aquatic plant populations to guide the development of future management strategies. Surveys conducted in 2015 found that HWM can be found throughout much of the project waters.

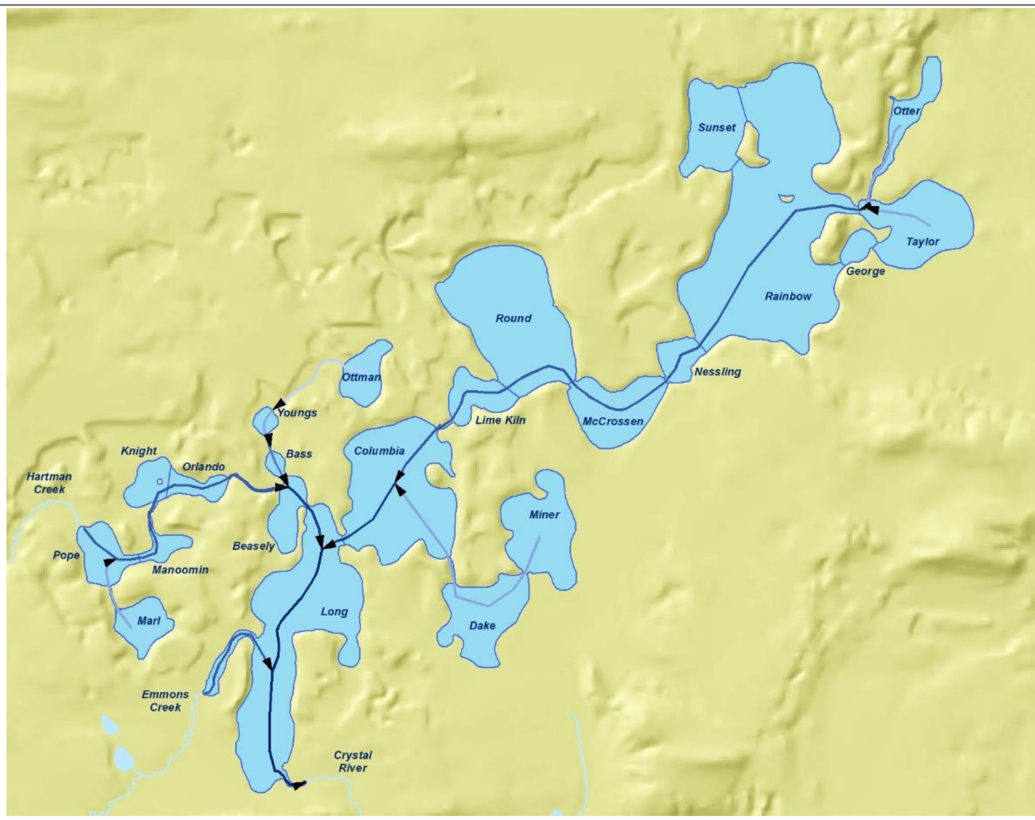


Figure 1.0-1. Waupaca Chain Flow and Lake Boundaries.

The concept of heterosis, or hybrid vigor, is important in regard to hybrid watermilfoil (HWM) management in the Waupaca Chain. The root of this concept is that hybrid individuals typically have improved function compared to their pure-strain parents. Hybrid watermilfoil typically has thicker stems, is a prolific flowerer, and grows much faster than pure-strain EWM (LaRue et al. 2012). These conditions likely contribute to this plant being particularly less susceptible to chemical control strategies (Glomski and Netherland 2010, Poovey et al. 2007). In a recent study of 28 whole-lake 2,4-D amine treatments in Wisconsin (Nault et al. 2017), HWM initial control was less and the longevity was shorter than pure-strain EWM control projects. Therefore, it appears that potentially most strains of HWM, but not all, are more tolerant of weak-acid auxin-mimic herbicide treatments (e.g. 2,4-D, triclopyr) than pure-strain EWM.

Due to the implementation challenges of hybridity (hybrid vigor), water exchange, and connectivity of treatment waterbodies, a 3-year trial program was developed within a February 1, 2017 AIS-EPC Grant Application for the Waupaca Chain 'O Lakes (ACEI-195-17). This report serves as the final deliverable for this grant.

1.1 Recent HWM Control Strategy Summary

During the first year of the three-year trial project, Dake Lake and Miner Lake were targeted for a whole-lake 2,4-D treatment and Otter Lake was targeted with a whole-lake treatment using a combination of 2,4-D and endothall. One spot treatment site in Columbia Lake was targeted with diquat in 2017 and resulted in seasonal HWM suppression. A limited hand-harvesting program was undertaken in 2017 which provided some modest seasonal reductions of HWM in the areas where harvesting efforts took place in Lime Kiln Lake.

Surveys conducted in 2017 in Otter, Dake and Miner Lakes showed that the whole-lake treatments conducted in the spring met the HWM control objectives for *the year of treatment*. No HWM was located during the late-summer mapping surveys in Dake Lake or Miner Lake following the treatment although two HWM occurrences were found on the point-intercept survey in Miner Lake. Minimal HWM was found in Otter Lake during surveys conducted in 2017. The reduction of the HWM population in 2017 initially exceeded the qualitative and quantitative success criteria for the whole-lake treatments and met lake managers control expectations. Continued monitoring in 2018 determined that the control actions implemented in Dake and Miner Lakes in 2017 led to longer term control that extended into the *year after treatment*. The 2018 monitoring showed that HWM rebound was occurring at a faster rate in Otter Lake. Some reductions in native plant communities were observed in the lakes that underwent whole-lake treatments and continued monitoring in 2018 allowed for a greater understanding of any potential longer-term native plant impacts.

In the second year of the project (2018), a whole lake 2,4-D/endothall treatment occurred in Bass and Beasley Lakes. Additionally, in 2018, a number of spot herbicide treatments took place around the system that utilized a combination of diquat and endothall. The integrated approach to HWM management in 2018 also included a professional hand harvesting strategy in select areas.

The 2018 monitoring surveys in Bass and Beasley Lakes showed the herbicide control strategy fell short of meeting control expectations for the *year of treatment*. Bass Lake saw a higher level of HWM reduction than Beasley Lake in 2018 possibly as a result of slightly higher herbicide concentrations measured in the days after the herbicide application. It was believed that the 2018 treatment resulted in seasonal control of HWM in Beasley Lake, meaning that the HWM was likely injured and knocked back for part/most of the growing season; however, plant mortality was likely not achieved. Continued monitoring that occurred in 2019 is discussed in sections 2.2 and 2.3 of this report.

Detailed analysis of the 2017 and 2018 HWM management and control activities were provided in each year's corresponding annual report. The combination of diquat/endothall (Aquastrike®) in spot treatments in 2018 attempted to get longer than seasonal control. The targeted sites that were located in more protected bays or areas of lower water exchange appeared to have been met with greater results than smaller sites that were in more exposed areas of the lake.

Professional hand-harvesting efforts in 2018 provided less than seasonal control in the targeted areas, such that the population was lowered for a portion of the growing season before rebounding by the time of the late-summer mapping survey. These efforts likely reduced the nuisance conditions within these areas for a period of time before rebound occurred.

1.2 2019 HWM Control Strategy

Herbicide Spot treatment

More isolated populations of dense HWM exist in the Chain that are not applicable for consideration in a whole-lake treatment herbicide use pattern, but may be appropriate for consideration for control through herbicide spot treatments or coordinated hand-harvesting. As discussed within the lake management planning project, control of EWM/HWM with small spot treatments with systemic herbicides is rarely effective due to rapid herbicide dissipation. Onterra's working definition of small spot treatments is less than 5 acres.

The long-term control of EWM/HWM targeted with diquat continues to be evaluated on many lakes across Wisconsin. As a contact herbicide, diquat does not move (translocate) through plant tissue. Therefore, only the exposed plant material is impacted by the herbicide. Concern exists whether this herbicide has the capacity to kill the entire plant or simply removes all the above ground biomass and the plant rebounds from unaffected root crowns. Diquat also has a high affinity for binding with organic particles. In shallow waters where the application equipment creates disturbance of the lake bottom, the diquat being applied will quickly bind to the suspended particles and be instantly unavailable to cause impacts to the target plants. In lakes with high organic material encrusted on the plant, this may also reduce the efficacy of the treatment.

When diquat is mixed with endothall, as is commercially available under the Aquastrike® brand, it is theorized to have even shorter exposure time requirements than diquat alone. While diquat does not have systemic activity, endothall has proven to have a high level of systemic activity (i.e. moves throughout the plant, including into the root crown) at cold water temperatures. The manufacturers of endothall (UPL) have shown that increased systemic activity of endothall occurs when water temperatures are colder (<60°F).

This herbicide use-pattern has shown promise controlling EWM in a few Wisconsin treatments. Eleven sites throughout the Chain were recommended for spot treatments in 2019 utilizing diquat alone or a combination of diquat and endothall as mixed within Aquastrike® (Map 1). These sites were chosen based on the presence of colonized HWM consisting largely of *dominant* densities or greater and in which at least a one-acre treatment site could be constructed with a reasonable sized buffer.

Professional Hand-Harvesting

As a part of an integrated HWM control strategy, the WCOLD continued a hand harvesting program for select locations in the Chain in order to continue to build an understanding of what role this management technique may have in future HWM management actions. Sites that are not of sufficient size to result in a successful herbicide treatment are considered for professional hand harvesting control actions. Specific sites to be prioritized for hand harvesting may include areas that are not being targeted through herbicide treatments, but are of higher use, high visibility to lake users, near public access locations, or otherwise prioritized by WCOLD members.

Professional hand harvesting firms can be contracted for these efforts and can either use basic snorkeling or scuba divers, whereas others might employ the use of a Diver Assisted Suction Harvest (DASH) which involves divers removing plants and feeding them into a suctioned hose for delivery to the deck of the harvesting vessel. The DASH methodology is considered a form of mechanical harvesting and thus requires a WDNR approved permit. DASH is thought to be more efficient in removing target plants than divers alone and is believed to limit fragmentation during the harvesting process.

A preliminary hand harvesting plan was developed following the 2018 Late-Season EWM Mapping Survey that focused on implementing integrated pest management as a follow-up management strategy to the whole-lake treatments that occurred in Dake, Miner, and Otter Lakes. In early summer 2019, Onterra conducted a focused Early Season AIS Survey (ESAIS Survey). The survey extent of the ESAIS survey was limited to mapping HWM within Dake, Miner, and Otter Lakes for use in guiding the hand harvesting program.

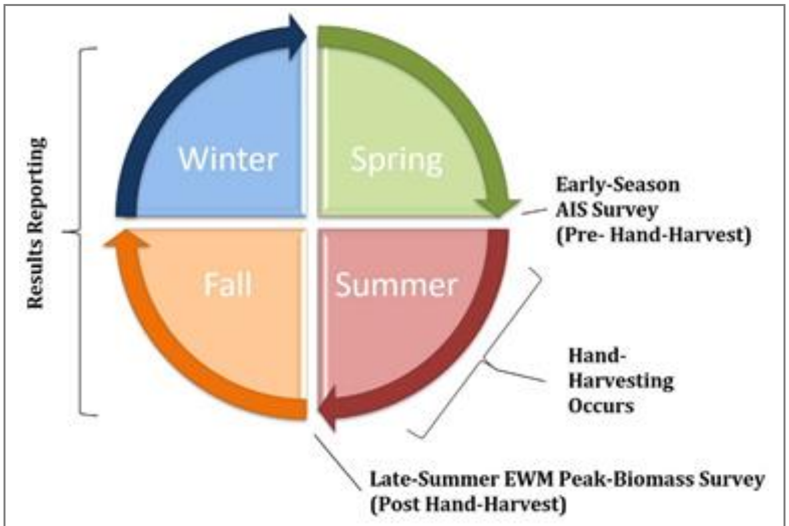


Figure 1.2-1. Hand-Harvesting Control and Monitoring Timeline.

Based on the results of the ESAIS Survey, the hand harvesting control strategy was revised and finalized (Figure 1.2-1). Hand-harvesting activities took place between the ESAIS (pre) and the late-summer HWM Mapping (post) surveys, allowing for evaluation of the management activity. Expectations of the hand-harvesting strategy were to achieve at least seasonal HWM suppression in the targeted areas.

2.0 2019 AQUATIC PLANT MONITORING RESULTS

2.1 Early-Season AIS Survey (ESAIS)

Onterra crews completed an ESAIS mapping survey on the Waupaca Chain O' Lakes on May 23 & 29. The purpose of the survey was to map HWM in the areas where hand-harvesting efforts were being considered (Otter, Dake, Miner), and to map CLP in all areas of the Chain. Based on the survey, some slight modifications to the preliminary hand-harvesting strategies were made in order to align with the HWM population that was mapped. Maps 2 and 3 display the results of the HWM mapping surveys in Otter Lake, Dake Lake, and Miner Lake and reflect the final hand-harvest work areas.

Eight sites, totaling approximately 4.39 acres, were included in the professional hand harvesting strategy in Dake and Miner Lake. These sites were further prioritized for removal effort as either first or second priority based on the size of the HWM population with the largest areas of HWM being given first priority for removal. In Otter Lake, the HWM population was found to be similar to the late-summer 2018 survey, and some small modifications were made to the hand-harvesting sites based on the survey. A total of 16 sites in Otter Lake, totaling 1.22 acres, were included with the hand-harvesting strategy.

Curly-leaf pondweed was mapped throughout the Waupaca Chain O' Lakes during the 2019 ESAIS survey. The results of the survey are displayed on Map 4. Curly-leaf pondweed was identified in Otter, Taylor, Miner, Long, Bass, Beasley, Knight, Manoomin, and Pope Lakes (Map 4). Overall, the CLP population consisted of relatively low-density occurrences; however, colonized CLP was located in

Bass, Pope, Miner, Long, and Otter Lakes. Compared to the 2016 survey, when CLP was also mapped throughout the Chain O' Lakes, the population appears to inhabit approximately the same footprint.

Based on the current extent of the CLP population, actively managing CLP is likely not necessary. It will be important to continue to periodically monitor CLP to gauge whether this species increases to a point where management warrants consideration.

2.2 Late-Season HWM Mapping Survey

The HWM population was mapped on October 2-3, 2019. During the survey, multiple Onterra field crews meandered the littoral zone of each lake and mapped HWM populations using sub-meter GPS technology. This meander-based survey, which mimics the methodology used in the ESAIS survey, was completed late in the growing season when HWM had reached its peak growth stage. Because HWM should be at or near its maximum density, the results of this survey provided an understanding of where HWM is in the lake and what its full impact on the ecology of the lake may be. As a result, these data are useful in determining the efficacy of control actions used during the summer months as well as assisting in the next year's management planning.

During the Chain-wide Late-Season mapping survey, all lakes with the exception of Ottman Lake were surveyed. Ottman Lake requires access through a private property and no HWM was located during surveys completed in 2015. The population of HWM was found to be widespread throughout the Chain with some of the largest and most dense colonies being found in Long Lake, Beasley Lake, and Columbia Lake (Maps 5 and 6). No HWM was located within the Upper Chain Lakes that include Marl, Pope, Manomin, Knight, and Orlando Lakes. A total of 23.3 acres of HWM was mapped throughout the Chain in the 2019 survey. Of the HWM acreage, approximately 8.2 acres was within Long Lake, 2.9 acres in Beasley Lake, and 2.9 acres in Bass Lake.

Using the same methodology and consistent density rating system, Late-Season HWM Mapping Surveys occurred in 2016 - 2019. It is important to note that Figure 2.2-1 only accounts for HWM that is mapped with area-based methodologies. Occurrences mapped with point-based methods (single or few plants, clumps of plants, small plant colonies) are not accounted for in Figure 2.2-1. The 23.3 acres mapped in 2019 remains less than the acreage delineated during 2016. The reductions in HWM acreage from 2017-2018 can be attributed to the whole-lake treatments in Dake and Miner Lakes, with additional HWM suppression occurring in Otter, Bass, and Beasley Lakes. Some of the increased acreage from 2018 to 2019 is a result of the HWM population rebound in these lakes.

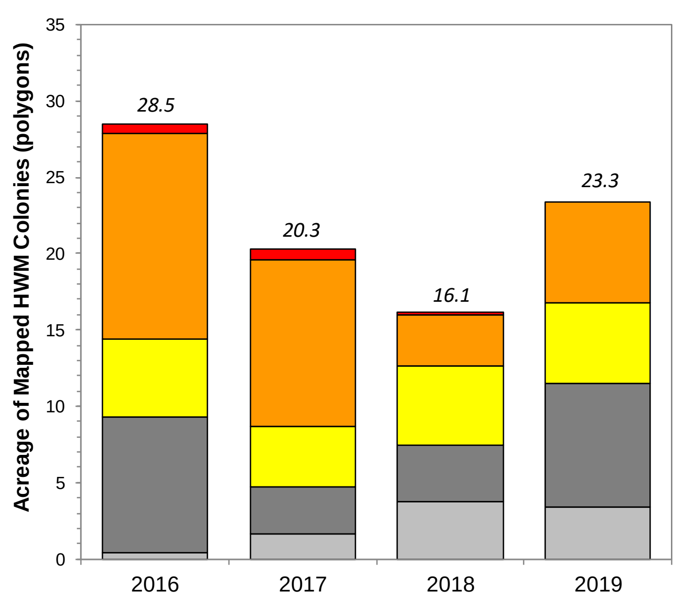


Figure 2.2-1. Acreage of HWM colonies in the Waupaca Chain from 2016-2019. Data from Onterra Late-Summer Mapping Surveys.

2.3 Spot Herbicide Treatment Efficacy

The sites that were targeted for herbicide control in 2019 with spot treatments are highlighted in Figures 2.3-1 through 2.3-4 where the left frame shows the pre-treatment HWM population mapped in late-summer 2018 and the right frame shows the post-treatment HWM population mapped in late-summer 2019. Sites A-19, C-19, E-19, F-19, G-19, J-19 & K-19 were treated with a combination of diquat and endothall (Aquastrike®). Sites B-19, D-19, H-19 & I-19 were treated with diquat (Tribune®).

Site A-19: Site A-19 is located along the eastern side of an island in Sunset Lake. The 2018 late-summer survey found a narrow strip of *dominant* and *highly dominant* density HWM as well a number of *singles*, *clumps*, and *small plant colonies*. After the spring 2019 application of Aquastrike®, the late-summer survey showed a decrease in the HWM population with a relatively small *highly dominant* colony as well as a *single plant*, *clumps of plants*, and a *small plant colony* present in the site (Figure 2.3-1).

Site B-19: Site B-19 is located on the northeast end of Sunset Lake. Before treatment, the site contained a *dominant* colony of HWM as well as several *small plant colonies* and a *clump of plants*. Diquat was applied in the site at .296 ppm in spring 2019. The post-treatment survey found a slight decrease in the HWM population; however, a small *dominant* colony remained as well as a number of *singles*, *clumps*, and *small plant colonies* (Figure 2.3-1).

Site C-19: Site C-19 is located on the south side of Rainbow Lake. The 2018 survey showed a narrow band of *dominant* density HWM present in the site. After treatment with a combination of diquat and endothall, the 2019 survey indicated a reduction in the size of the previous colony with smaller *highly scattered* and *highly dominant* colonies still present as well as a *clump of plants* (Figure 2.3-1).

Site D-19: Site D-19 is located in Sunset Lake between the western shore and an island. The 2018 survey indicated *highly dominant* and *dominant* density colonies present in the site as well as *singles*, *clumps*, and *small plant colonies* in the vicinity. The site was treated with diquat at .296 ppm in spring 2019. The post-treatment survey in 2019 found a slight reduction in the size of the *highly dominant* colony; however, most of the site remained approximately the same as the 2018 (Figure 2.3-2).

Site E-19: Site E-19 is along the southern shoreline on the east side of McCrossen Lake. The 2018 HWM mapping survey indicated a *dominant* and a *highly dominant* colony present in the site as well as a *clump*. The site was treated with Aquastrike® in spring 2019 and the late summer 2019 survey showed a reduction in the HWM population such that only one *small plant colony* remained in the treated area (Figure 2.3-2).

Site F-19: Site F-19 is located on the southern end of Nessling Lake. The 2018 survey indicated that a colonized area of HWM that consisted of *scattered*, *dominant*, and *highly dominant* densities was present in the site. The site was treated with Aquastrike® in spring 2019. The post-treatment survey found a core of *highly dominant* HWM remained in the site as well as several *clumps of plants* and *single plants* (Figure 2.3-2).

Site G-19: Site G-19 is located on the west side of Columbia Lake. The 2018 survey showed a colonized area of *scattered* and *highly dominant* HWM as well as two *clumps of plants* and two *small plant colonies* present in the site. The site was treated with Aquastrike® in spring 2019. The post-treatment survey in 2019 showed a reduction of HWM in the site; however, a smaller *dominant* colony remained present along with two *single plant* occurrences (Figure 2.3-3).

Site H-19: Site H-19 is in Columbia Lake near the public access. The 2018 survey showed areas of *highly scattered* or *highly dominant* HWM colonies. The site was treated with diquat in spring 2019 at .36 ppm. The post-treatment survey in 2019 showed a decrease in density in part of the site; however, areas of *highly scattered* and *scattered* HWM remained present in the site as well as several *singles*, *clumps*, and a *small plant colony* (Figure 2.3-3).

Site I-19: Site I-19 is on the north end of Otter Lake. The late-summer 2018 survey showed a colonized area of *dominant*, *highly dominant*, and *surface matting* HWM as well as additional *singles*, *clumps*, and *small plant colonies* in the area. The site was treated with diquat in spring 2019 at .296 ppm. The post-treatment survey in 2019 showed most of the site consisted of a *highly dominant* HWM colony (Figure 2.3-4).

Site J-19: Site J-19 is in George Lake. The 2018 survey indicated an area of *highly dominant* HWM as well as adjacent *singles*, *clumps*, and *small plant colonies*. The site was treated with Aquastrike® in spring 2019. The post-treatment survey in 2019 showed a colony of HWM of a *highly scattered*, *scattered*, and *dominant* density remained present in the site as well as several adjacent *singles* and *clumps of plants* (Figure 2.3-4).

Site K-19: Site K-19 is on the west end of McCrossen Lake. The 2018 survey showed a narrow band of *dominant* HWM in the site. The site was treated with Aquastrike® in spring 2019. The post-treatment survey found two occurrences of *single or few plants* in the site and no colonized areas of HWM (Figure 2.3-4).

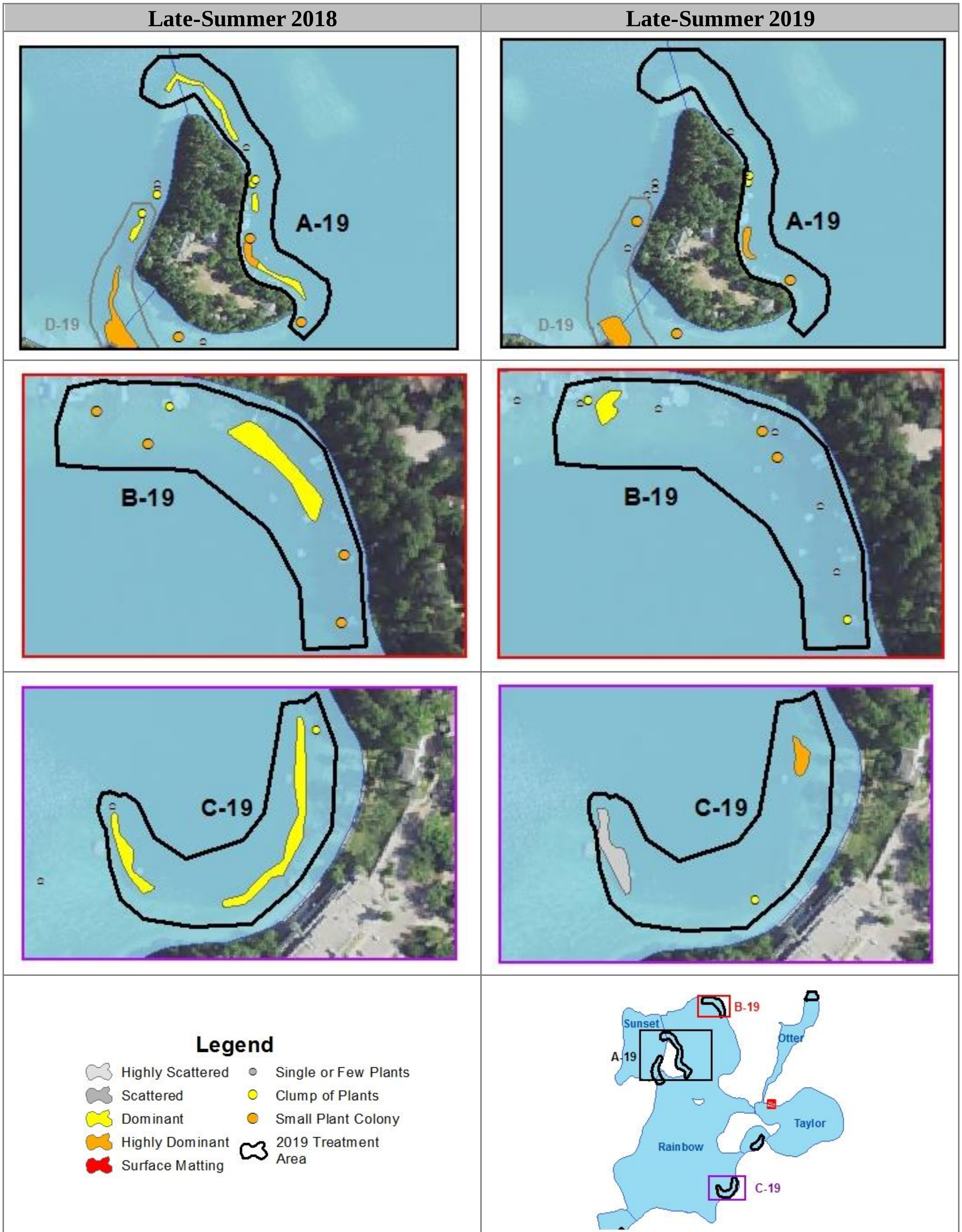


Figure 2.3-1. HWM Populations from before (2018) and after (2019) herbicide spot treatments at sites A-19, B-19, and C-19.

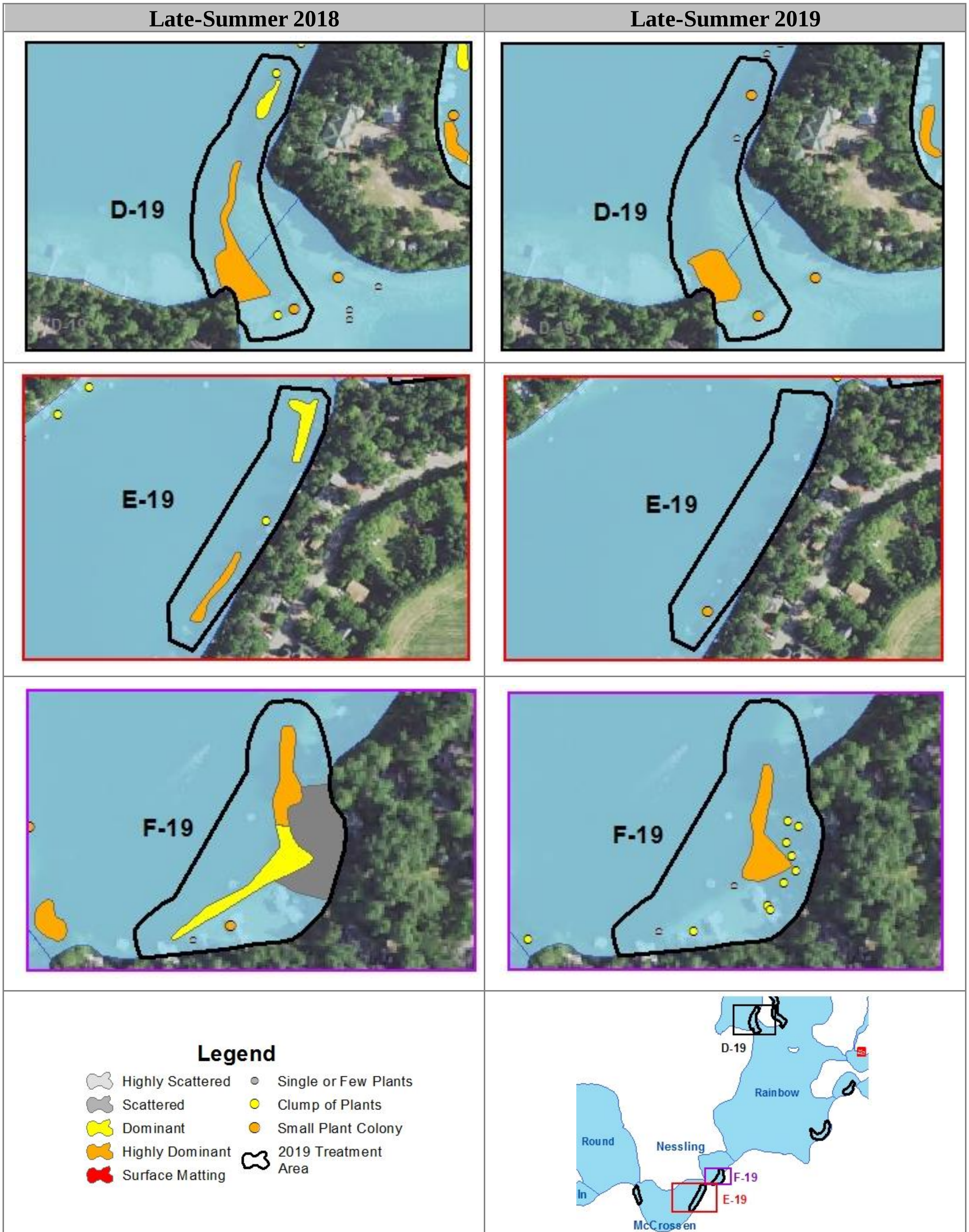


Figure 2.3-2. HWM Populations from before (2018) and after (2019) herbicide spot treatments at sites D-19, E-19, and F-19.

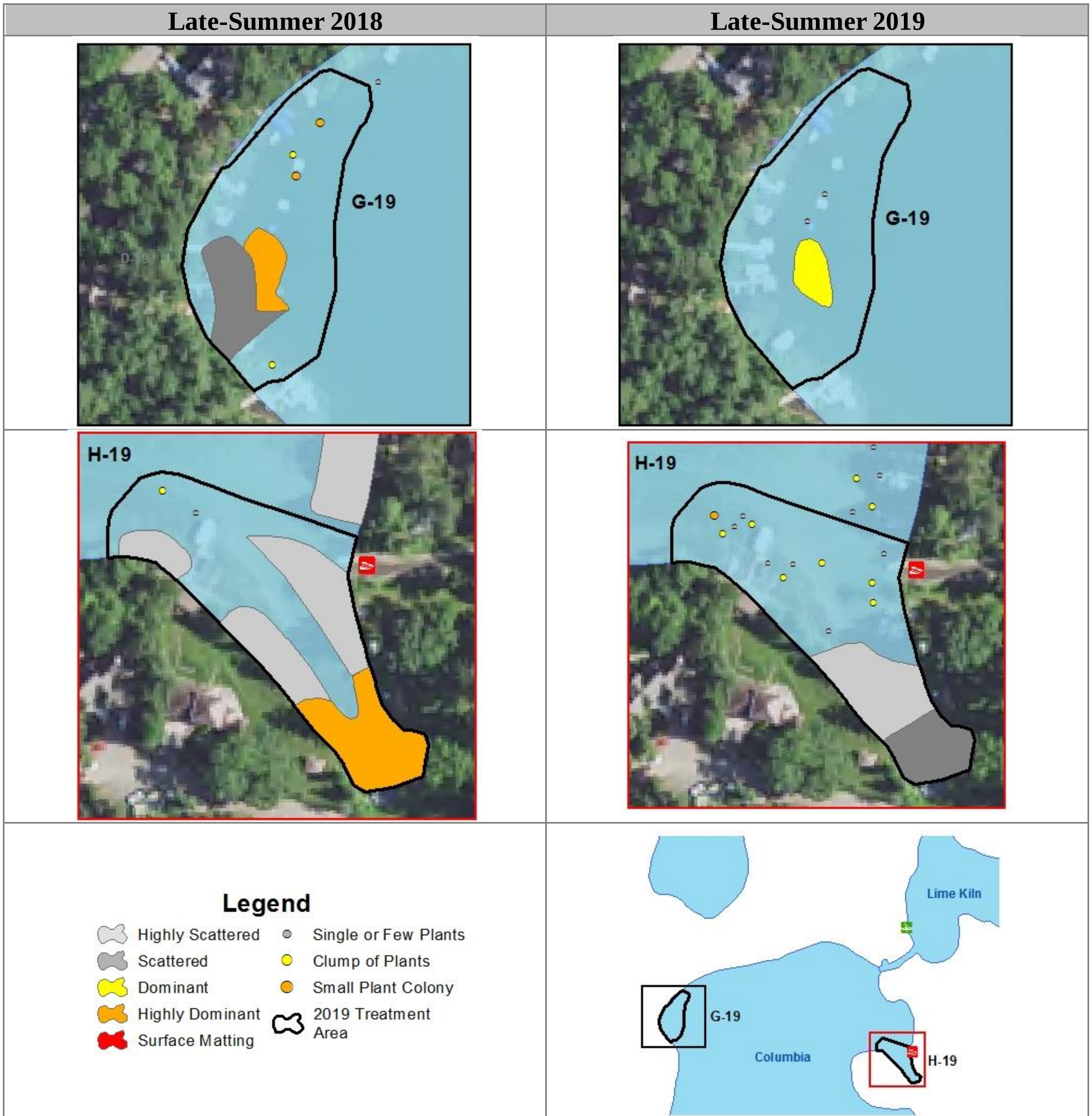


Figure 2.3-3. HWM Populations from before (2018) and after (2019) herbicide spot treatments at sites G-19 and H-19.

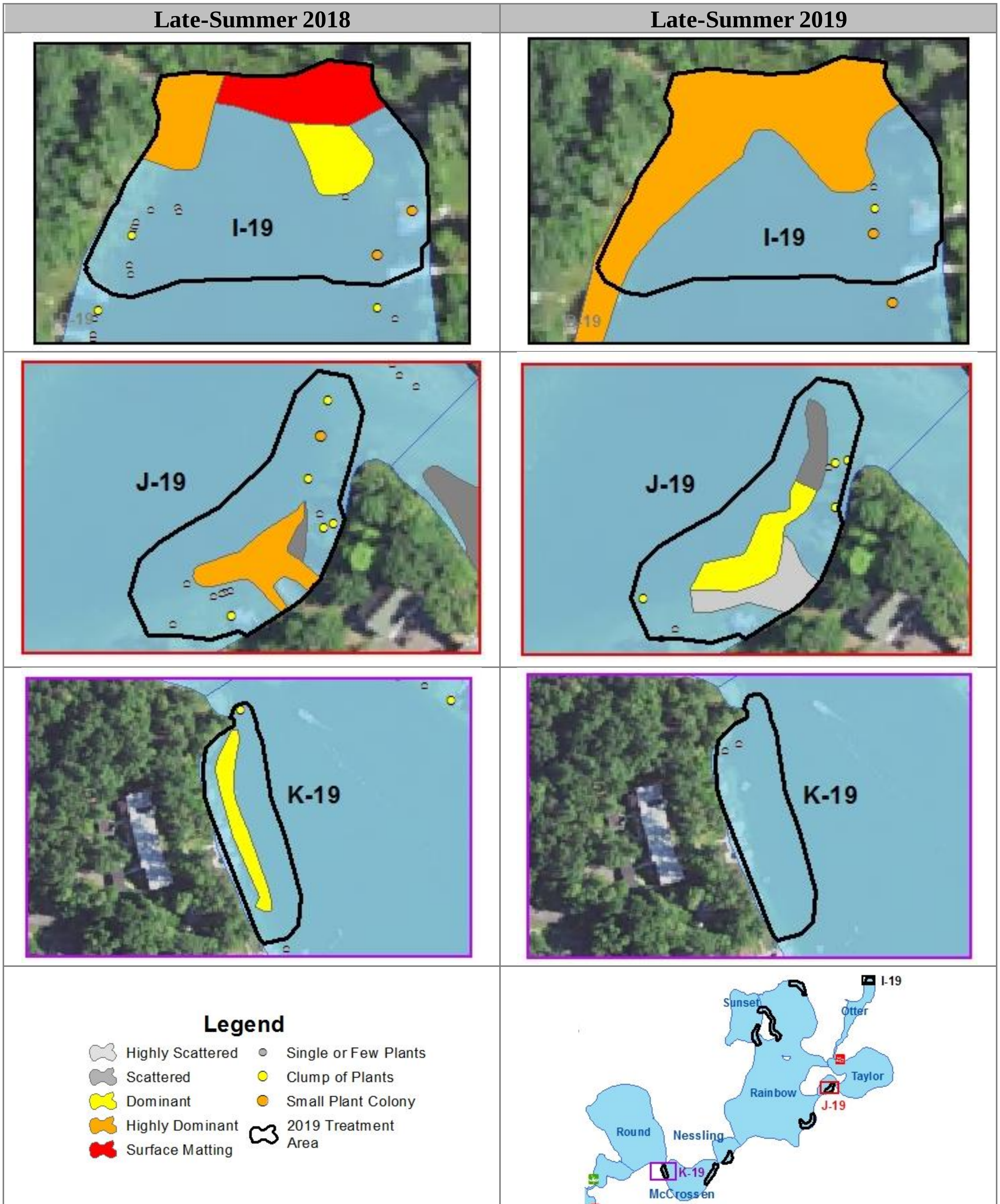


Figure 2.3-4. HWM Populations from before (2018) and after (2019) herbicide spot treatments in at sites I-19, J-19, & K-19.

2.4 Professional Hand-Harvesting Strategy Evaluation

The WCOLD contracted with DASH, LLC to provide professional hand-harvesting actions in 2019. Professional divers from DASH, LLC visited the Chain on July 15-18 and July 22-23, 2019. A total of 1,634 pounds of HWM was harvested from the permitted areas. A total of 660 pounds was harvested from Dake Lake, 624 pounds from Miner Lake, and 350 pounds from Otter Lake (Table 2.4-1). Details of the professional harvesting efforts are provided in a Summary report by DASH, LLC and included with this report as Appendix A.

2019 DASH Harvest Summary			
Lake	Site	Lbs. Harvested	Time (Man Hours)
Miner	A	410	7.4
Miner	B	163	3.5
Miner	C	15	1.0
Miner	D	-	-
Miner	E	36	2.5
Dake	F	660	12.2
Dake	G	-	-
Dake	H	-	-

2019 DASH Harvest Summary			
Lake	Sites	Lbs. Harvested	Time (Man Hours)
Otter	G-H-I-J	62	3.3
Otter	J-K-L-M-N-O	226	5.9
Otter	O-P-Q-R	62	3.6

Table 2.4-1. Professional DASH Summary from 2019 HWM Removal Efforts in Dake, Miner, and Otter Lakes. Table adapted from DASH, LLC Summary Report (Appendix A).

The sites that were targeted for HWM management in 2019 with professional hand-harvesting (DASH) efforts are evaluated in the figures below. Figure 2.4-1 displays the HWM population from surveys completed in 2019 in Otter Lake and the sites that were included in the professional hand harvesting strategy. The results show that the overall HWM population expanded between the two surveys, although where harvesting efforts took place, some sites showed a reduced HWM population (H-19, M-19) and others showed little change or an increase. Harvesting efforts in Otter Lake resulted in seasonal HWM suppression in most sites and assisted in reducing localized nuisance conditions.

Figure 2.4-2 displays the sites in Dake Lake and Miner Lake that were targeted in 2019 with professional DASH efforts. Site F-19 contained numerous *small plant colonies*, *clumps of plants*, and *single plants* in May 2019. Harvesting efforts yielded 660 pounds of HWM over 12.2 hours of dive time. The October 2019 survey indicated an increased HWM population in the site. Additional harvesting efforts would have been required to result in a reduced population.

Professional harvesting efforts were limited to 2.5 hours in site E-19 in 2019. The HWM mapping surveys indicated a reduction in HWM directly within the permitted area; however, HWM increased in size and density in the lakeward extent of the site (Figure 2.4-2).

Site A-19 in Miner Lake contained a number of point-based occurrences of HWM at the time of the May 2019 survey. Professional hand harvesting efforts yielded 410 pounds of HWM over 7.4 hours of dive time. The October 2019 mapping survey indicated the HWM population had expanded in the site to form a colony of *scattered* density (Figure 2.4-2). Additional harvesting efforts would have been required to result in a reduced population in the site.

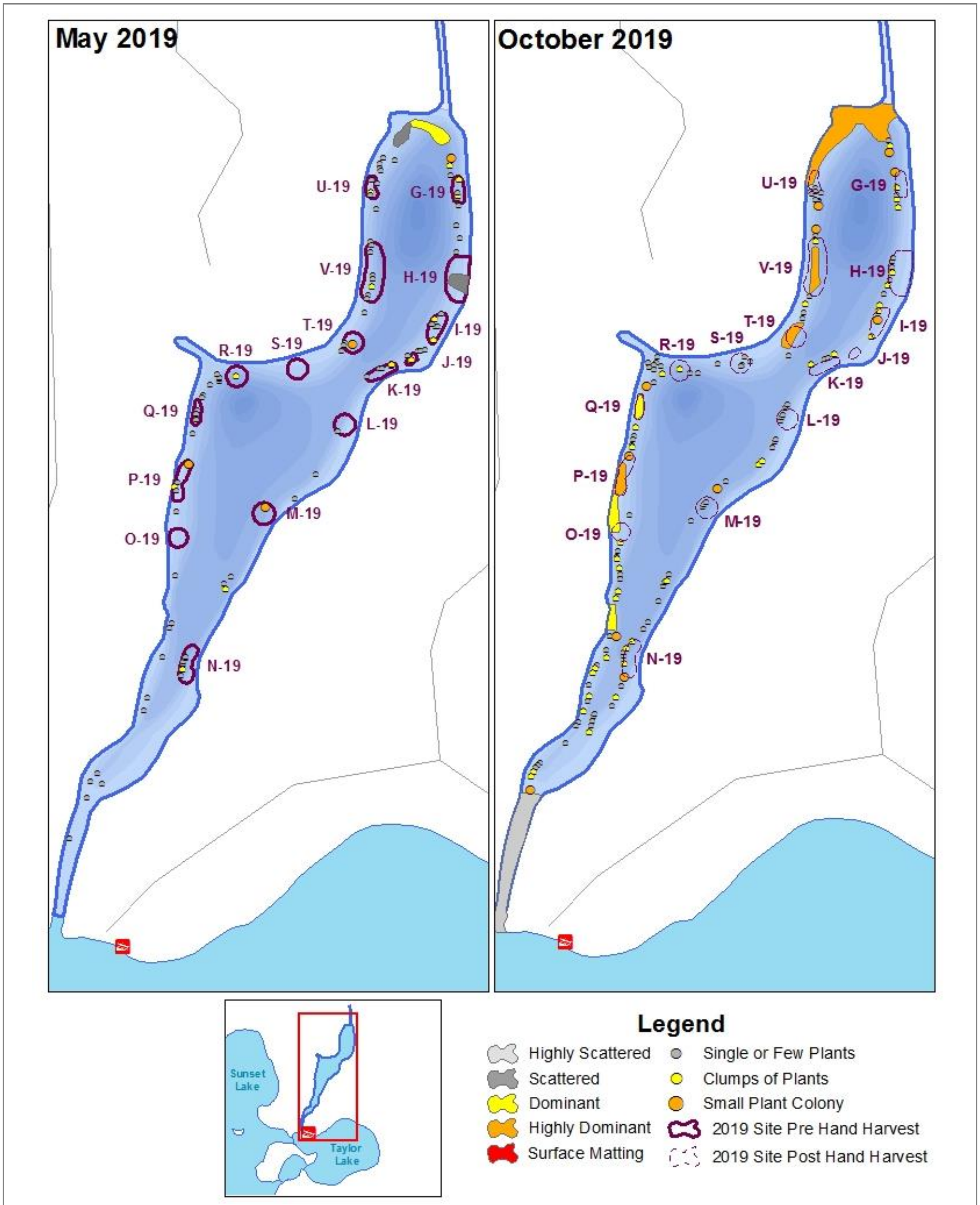


Figure 2.4-1. HWM Populations from before (May 2019) and after (October 2019) the Professional Hand-Harvesting Efforts in Otter Lake.

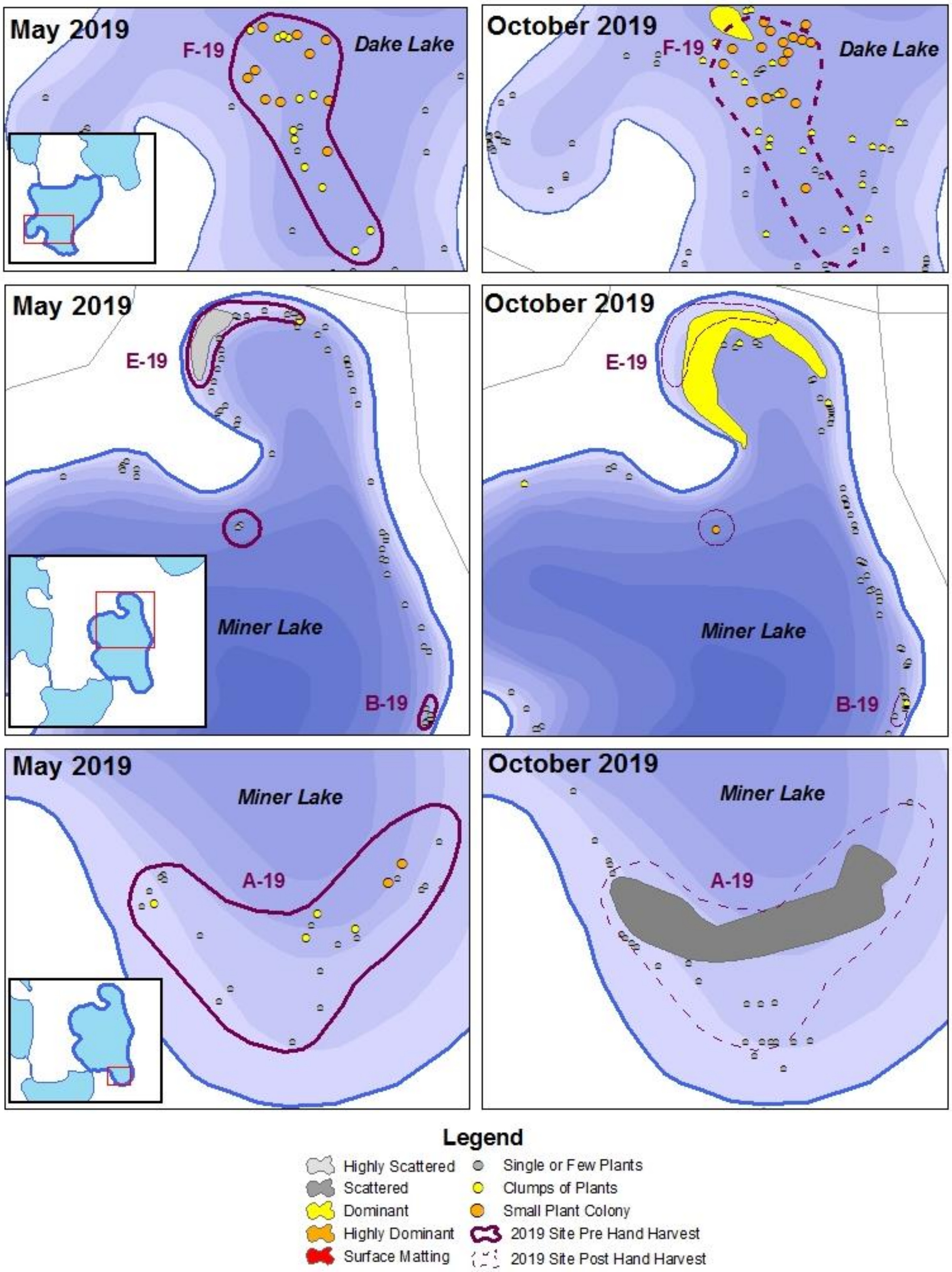


Figure 2.4-2. HWM Populations from before (May 2019) and after (October 2019) the Professional Hand-Harvesting Efforts in Dake Lake and Miner Lake.

2.5 Whole-Lake Herbicide Treatment Efficacy – Bass & Beasley Lakes (Year After Treatment)

In 2019, monitoring was completed to evaluate the whole lake treatments that occurred in 2018 in Bass and Beasley Lakes. Studies completed in 2019 represent one year after treatment and allow for an understanding of both the HWM population and the native plants.

A total of 2.7 acres of colonized HWM was mapped in Bass Lake in the late-summer 2017 survey of which the majority was designated as either *dominant* or *highly dominant* in density (Map 7). Following the spring 2018 treatment, the late-summer 2018 HWM mapping survey indicated that the HWM population was decreased in Bass Lake to 0.7 acres. An area of *scattered* and *highly scattered* plants remained present in the north side of Bass Lake in the late-summer 2018 survey. Continued monitoring during the year after treatment (2019) indicated that the entire littoral area of the lake contained either *scattered* or *dominant* density HWM. The density of HWM remains slightly lower than the pre-treatment population mapped in 2017.

The HWM population in Beasley Lake was found to have decreased in density in the majority of the Lake during the year of treatment. Acreage of colonized HWM in Beasley Lake were reduced from 2.5 acres in 2017 to 1.7 acres in 2018. Continued monitoring during 2019 indicated that the HWM inhabited essentially the same footprint as in the pre-treatment survey; however, remains at a lower density (Map 7). The 2018 whole-lake treatment resulted in a reduced HWM population in Beasley Lake through at least one year after treatment.

Point-intercept surveys were completed by Onterra staff in the Waupaca Chain O' Lakes in July 2019. Due to their relatively small size, Bass Lake (11 sampling points) and Beasley Lake (36 sampling points) did not have a large enough number of point-intercept sampling points on their own to allow for reliable statistical analysis. Given their proximity to each other and the fact that they were treated under the same strategy in 2018, the point-intercept sampling points was combined into one dataset (n=47) in the following analysis.

The littoral frequency of occurrence of HWM declined from 66.7% in 2017 to 28.0% in 2018 representing a statistically valid 63.8% decrease between the two surveys. The 2019 survey indicated that the HWM exhibited a statistically valid increase in frequency since 2018 and was approaching the pre-treatment frequency levels (Figure 2.5-1).

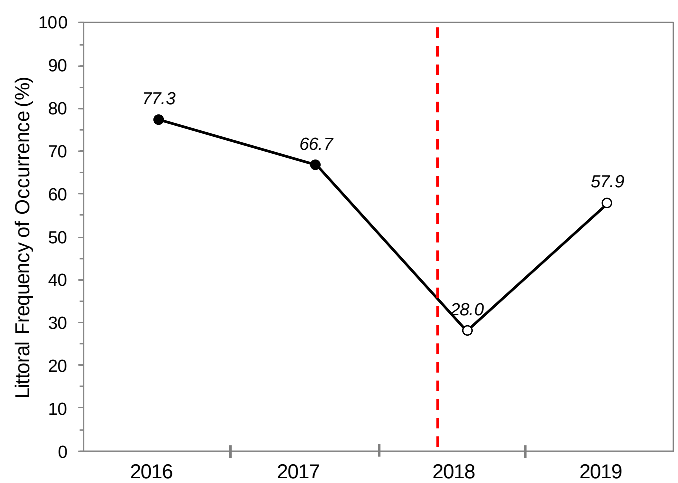


Figure 2.5-1. Littoral Frequency of Occurrence of HWM in Bass and Beasley Lakes from 2016-2019. Data from Onterra 2016-2019 Point-Intercept Surveys. Red dashed line indicates whole-lake treatment. Open circle indicates statistically valid difference from previous survey.

Slender naiad was the only native aquatic plant species that exhibited a statistically valid decrease in littoral frequency of occurrence between the 2017 and 2018 surveys. Monitoring in 2019 showed that the frequency of slender naiad rebounded to a similar or slightly higher level than pre-treatment. Muskgrasses as well as curly-leaf pondweed also showed statistically valid increases in frequency between the 2018 and 2019 surveys. Figure 2.5-2 displays the chi-square analysis for the 2016-2019 point-intercept surveys included in this analysis.

	Scientific Name	Common Name	LFOO (%)				2016-2017		2017-2018		2018-2019	
			2016	2017	2018	2019	% Change	Direction	% Change	Direction	% Change	Direction
Dicots	*Myriophyllum sibiricum X spicatum*	Hybrid watermilfoil	77.3	66.7	28.0	57.9	-13.7	▽	-58.0	▼	106.8	▲
Dicots	*Ceratophyllum demersum*	Coontail	18.2	33.3	20.0	47.4	83.3	△	-40.0	▽	136.8	△
Dicots	*Nymphaea odorata*	White water lily	13.6	6.7	12.0	10.5	-51.1	▽	80.0	△	-12.3	▽
Dicots	*Ranunculus aquatilis*	White water crowfoot	0.0	0.0	0.0	10.5		-		-		△
Dicots	*Myriophyllum sibiricum*	Northern watermilfoil	13.6	0.0	0.0	0.0	-100.0	▽		-		-
Dicots	*Utricularia vulgaris*	Common bladderwort	0.0	6.7	0.0	0.0		△	-100.0	▽		-
Non-dicots	*Potamogeton crispus*	Curly-leaf pondweed	9.1	0.0	0.0	21.1	-100.0	▽		-		▲
Non-dicots	*Chara spp.*	Muskgrasses	45.5	13.3	44.0	73.7	-70.7	▼	230.0	▲	67.5	▲
Non-dicots	*Elodea canadensis + Elodea nuttallii*	Common waterweed + Slender waterweed	31.8	33.3	24.0	52.6	4.8	△	-28.0	▽	119.3	△
Non-dicots	*Vallisneria americana*	Wild celery	45.5	13.3	32.0	42.1	-70.7	▼	140.0	△	31.6	△
Non-dicots	*Elodea canadensis*	Common waterweed	31.8	33.3	24.0	21.1	4.8	△	-28.0	▽	-12.3	▽
Non-dicots	*Najas flexilis*	Slender naiad	13.6	20.0	0.0	26.3	46.7	△	-100.0	▼		▲
Non-dicots	*Elodea nuttallii*	Slender waterweed	0.0	0.0	0.0	36.8		-		-		▲
Non-dicots	*Heteranthera dubia*	Water stargrass	13.6	0.0	8.0	10.5	-100.0	▽		△	31.6	△
Non-dicots	*Lemna turionifera*	Turion duckweed	0.0	0.0	4.0	10.5		-		△	163.2	△
Non-dicots	*Stuckenia pectinata*	Sago pondweed	9.1	6.7	0.0	0.0	-26.7	▽	-100.0	▽		-
Non-dicots	*Potamogeton zosteriformis*	Flat-stem pondweed	0.0	6.7	0.0	5.3		△	-100.0	▽		△
Non-dicots	*Potamogeton friesii*	Fries' pondweed	0.0	0.0	4.0	5.3		-		△	31.6	△
Non-dicots	*Najas guadalupensis*	Southern naiad	0.0	6.7	0.0	5.3		△	-100.0	▽		△
Non-dicots	*Spirodela polyrhiza*	Greater duckweed	0.0	0.0	0.0	5.3		-		-		△
Non-dicots	*Potamogeton illinoensis*	Illinois pondweed	0.0	0.0	0.0	5.3		-		-		△
Non-dicots	*Potamogeton richardsonii*	Clasping-leaf pondweed	0.0	6.7	0.0	0.0		△	-100.0	▽		-
Non-dicots	*Potamogeton pusillus*	Small pondweed	0.0	0.0	4.0	0.0		-		△	-100.0	▽
Non-dicots	*Potamogeton foliosus*	Leafy pondweed	4.5	0.0	0.0	0.0	-100.0	▽		-		-

▲ or ▼ = Change Statistically Valid (Chi-square; α = 0.05)
△ or ▽ = Change Not Statistically Valid (Chi-square; α = 0.05)

Figure 2.5-2. Chi Square analysis of aquatic plant species from 2016-2019 in Bass and Beasley Lakes. Whole-lake 2,4-D/endothall herbicide treatment occurred in spring 2018.

3.0 WAUPACA CHAIN HWM MANAGEMENT SUMMARY & CONCLUSIONS

Point-intercept surveys occurred surrounding the whole-lake treatments during the *year prior to treatment*, the *year of treatment*, and the *year after treatment*. The treatment would be considered a success if the *year after treatment* HWM population from the point-intercept survey was at least 70% less than the *year prior to treatment*. As shown in Table 3.0-1, all three lakes treated in 2017 (Dake, Miner, and Otter Lakes) exceeded this threshold during the *year of treatment*. HWM rebound in Otter Lake during the *year after treatment* resulted in this Lake not meeting success criteria. The initial level of HWM control achieved in Bass and Beasley Lakes was already less than the predetermined success criteria and monitoring completed in 2019 showed the population was nearing pre-treatment levels by the time of the *year after treatment*.

Table 3.0-1. Whole-Lake treatment Success Criteria Evaluation. Percent reductions between point-intercept surveys shown in brackets.

Comparsion	Dake			Miner			Otter			Bass/ Beasley		
Year Prior to Treatment		5.0			16.4			19.2			66.7	
Year of Treatment	100%	0.0	**78.9%**	78.6%	3.5	**90.0%**	100%	0.0	**30.7%**	58.0%	28.0	**13.2%**
Year after Treatment		1.1			1.6			13.3			57.9	

The whole-lake treatments that occurred in Dake, Miner, Otter, Bass, and Beasley Lakes in 2017-2018 attempted to achieve multiple-year efficacy. Sufficient herbicide concentrations and exposure times (CETs) were achieved in Dake, Miner, and Otter Lakes, whereas the influence of water exchange in Bass and Beasley was too great to achieve appropriate CETs for milfoil control. Future whole-lake treatments may be applicable to other protected lakes in the Chain and can be investigated for applicability if HWM populations reach levels where the financial and environmental costs of implementation are commensurate with the desired level of HWM population reduction.

The spot-herbicide treatments that occurred in the system in 2019 led to results that were consistent with expectations. Several sites showed a reduced HWM population compared to the pre-treatment levels indicating at least seasonal control was achieved. Many sites were found to still harbor remnant HWM plants after treatment and some amount of rebound or recovery is likely to manifest by the following growing season. The WCOLD will continue to discuss whether the addition of endothall to diquat produces results that warrant the much higher cost of implementation. Other herbicides and herbicide combinations may also be considered as success is proven on other systems.

4.0 2020 HWM MANAGEMENT STRATEGY DEVELOPMENT

Building on the knowledge obtained over the course of the past several years of active AIS management in the Chain, a greater understanding of the anticipated efficacy of different management techniques is developing. Table 4.0-1 outlines the management strategy criteria and the anticipated efficacy for an invasive milfoil population suppression program in the Chain. Please note that these criteria are generalized and over-simplified but can be used as a starting point for an active management discussion. The table outlines the herbicide or hand-harvesting management strategies that would be expected to achieve various levels of efficacy spanning a time frame from less than seasonal to multiple years. In the table below, seasonal control refers to approximately the period of time during the open-water growing season during which the majority of the recreational activities typically occur on the Chain.

Table 4.0-1. Invasive Milfoil Management Strategy Criteria and Anticipated Efficacy on Waupaca Chain.

		Efficacy	Herbicide	Hand-Harvesting
Population Suppression	Multi-Year	Multiple Year	• Properly dosed whole-lake treatment with no flow impacts	• Early infestations • Extremely small populations
		>Seasonal	• Broad-shaped spot treatments with no flow impacts • 5 acres or greater in open water • 4 acres & protected on two sides • 1 acre & enclosed on three sides(bay)	• Typically the goal, but seldom achievable
	Single Year	Seasonal	• Broad-shaped spot treatments with no flow impacts • 3 acres in open water • 2 acres & protected on two sides	• Achievable on small sites (< ½ acre) with sufficient effort applied
		<Seasonal	• All herbicide treatments not meeting above criteria	• Not worth the cost of implementation

Many of the recent herbicide spot treatments have been limited to seasonal or less than seasonal HWM reductions. The largest factor limiting greater control is the small size of the treatment areas. Ongoing studies are suggesting that with small spot treatments, less than 5 acres, the herbicide dissipates too rapidly to cause HWM mortality if traditional systemic herbicides like 2,4-D are used. Even in some cases where larger treatment areas are planned, their narrow shape or exposed location within a lake may result in insufficient herbicide concentrations and exposure times for long-term control. Spot herbicide treatments would likely need to embrace herbicides or herbicide combinations thought to be more effective under short exposure situations than with traditional weak-acid auxin herbicides. Herbicide manufacturers have acknowledged the lack of successes conducting EWM/HWM spot treatments and are working towards new solutions. As new herbicide products become available, proper testing and vetting should occur before wide-scale acceptance on a given system. Table 4.0-1 outlines the predicted level of HWM suppression based upon specific site characteristics for herbicide spot treatments.

Hand harvesting in the Chain has resulted in HWM population suppression; however, the length of population reduction has been shorter than desired especially considering the cost of implementation. If HWM occurrences were located in the Upper Chain, swift implementation of a sufficient effort of hand-harvesting (including DASH) could lead to multiple years of control. Follow-up hand harvesting of rebounding HWM following a whole-lake treatment would also fall into this category. But when targeting established HWM populations, as exist in much of the remainder of the Chain, achieving seasonal or slightly longer control is the goal. This level of HWM suppression provides seasonal relief for riparians and may be an important component of future management on the Chain. While the cost of implementation is higher to achieve seasonal HWM suppression with hand harvesting versus herbicide treatment, non-chemical methods are typically favored by lake managers and regulators as the risks are much less.

On some lakes, a coordinated HWM population suppression program is not achievable considering the current lake management tools. For instance, the only way to target the entirety of the HWM population in Long Lake would be with a whole-lake treatment. But the results of the trials on Bass and Beasley Lakes indicate that even with a combination of 2,4-D/endothall, achieving CETs to result in multiple years of control is not possible. Spot herbicide techniques may be applicable, but the narrow HWM bands will require a short CET requirement herbicide (e.g. diquat, diquat/endothall, etc.) to be implemented. These broad-spectrum herbicides have associated native plant impacts and would not be advisable to target the entire littoral zone of a lake. Therefore, subjective selection of where to implement herbicide spot treatments in a scenario like Long Lake becomes more of nuisance control strategy. The strategy could result in seasonal HWM suppression that would alleviate the unwanted conditions in riparian corridors. The use of a mechanical harvester could also provide some level of seasonal control without the risks of herbicide treatment.

2020 IPM Strategy: Spot Herbicide Treatments

As outlined in Table 4.0-1, scenarios where spot treatment sites are almost completely enclosed or protected from water movement and are of a larger and broader size or shape are the most likely to result in extended years of HWM control. Several of the EWM colonies in the Chain that were mapped in the late-summer of 2019 were of a size and density that may be too large to reasonably expect control with hand-harvesting efforts alone. Colonies that were mapped with area-based methodologies and were of at least a *dominant* or greater density meet the criteria for considering herbicide treatment in 2019. Map 8 displays eleven sites around the Chain that target HWM colonies marked as *dominant* or greater in density as well as adjacent occurrences for which at least a one-acre application area can be constructed with a reasonably sized buffer. Based on Table 4.0-1, the expected efficacy of these treatments would be seasonal control in most cases due to either size, location, or shape of the sites.

Site I-20 in Miner Lake is somewhat more protected and it is thought that a spot treatment may lead to control that extends beyond the 2020 growing season in this location (greater than seasonal efficacy). Site H-20 was targeted with professional hand harvesting in 2019 and the population expansion that was observed meets criteria for considering herbicide spot treatment in 2020. Depending on the herbicide chosen by the applicator for these treatments, attention needs to be paid to potential lake-wide impacts. This is particularly the case if low-acid herbicides such as 2,4-D and endothall are applied, as they will likely result in lake-wide concentrations sufficient to impact some sensitive native plants, but would be below concentrations that would impact HWM.

At all of the remaining seven sites included in the proposed treatment strategy, a contact herbicide such as diquat could be considered for herbicide spot treatment of these areas. Commonly used brands of diquat have a 2 gallon/surface acre maximum application rate. When mixed with the water volume in deeper sites (approximately greater than 5 feet), the concentrations may be lower than needed to provide the desired level of impact. In these instances, herbicide applicators may consider the addition of a low dose of copper. Another option often considered is to couple diquat with endothall under the commercially available Aquastrike® herbicide. As previously discussed, Aquastrike® has been used in recent years on the Waupaca Chain whereas the combination of diquat and copper would be a new approach to HWM management on the Chain. It should be understood the WDNR limits the permitting of spot-treatment management techniques that are not expected to achieve greater than seasonal control under any grant funded project and the costs would likely be out-of-pocket by the WCOLD.

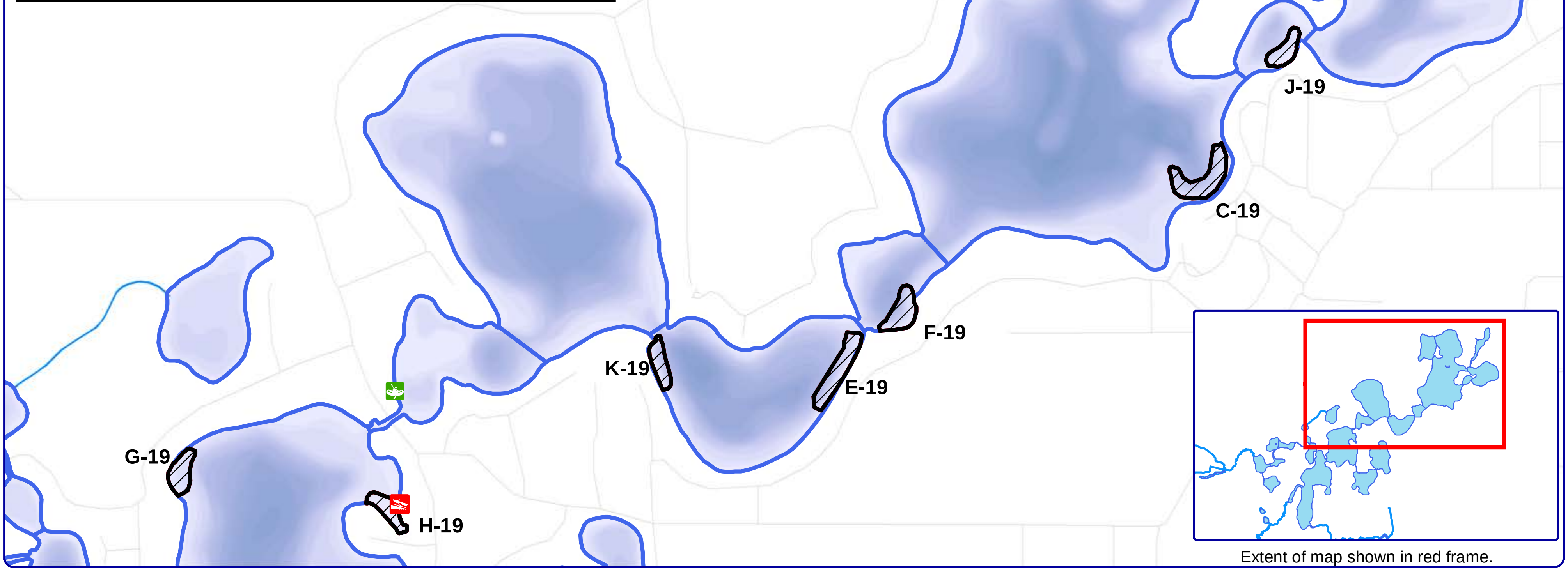
2020 IPM Strategy: Professional and/or Volunteer Hand-Harvesting

Much of the HWM population present in the Chain consists of isolated occurrences of relatively *small colonies* or *clumps of plants* that do not meet the threshold for considering herbicide control. However, the majority of these sites may be favorable for hand-harvesting control efforts. Generally clear water coupled with modest native plant populations in many parts of the Chain make hand harvesting a feasible control technique with a goal of achieving greater than seasonal control. No specific sites are included in an initial hand-harvesting strategy for 2020. The WCOLD may be interested in targeting HWM populations that are not suitable for herbicide control with a hand harvesting effort. Consideration should be made for sites of high riparian use or visibility or any areas otherwise prioritized by the WCOLD based on available resources. If the WCOLD is interested in contracting for DASH services in 2020, Onterra would assist in developing a strategy and creating the associated maps. The results of the 2019 Late-Season EWM Mapping Survey would be sufficient to guide the hand harvesting strategy in 2020.

It is important to understand that each riparian owner can legally harvest HWM and native plant species in a 30' wide area of one's frontage directly adjacent to one's pier without a permit. A permit is required if an area larger than the 30' corridor is being harvested or if a mechanical assistance mechanism, like DASH, is being used. Professional services to remove HWM also do not require a permit unless DASH or a mechanical device is being used in the process. Simply wading into the lake and removing HWM by hand with or without the aid of snorkeling accessories can be helpful in managing HWM on a small and individual property-based scale.

2019 Final Spot Treatment Areas

Site	Lake	Proposed Acres	Final Acres	Average Depth (feet)	Volume (acre-feet)
A-19	Sunset	3.7	3.7	6.0	22.0
B-19	Sunset	2.0	2.0	5.0	10.0
C-19	Rainbow	2.0	2.0	7.0	14.0
D-19	Sunset	2.0	2.0	5.0	10.0
E-19	McCrossen	1.8	1.8	7.0	12.5
F-19	Nessling	1.3	1.3	6.0	8.0
G-19	Columbia	1.1	1.1	6.0	6.7
H-19	Columbia	1.0	1.0	2.5	2.4
I-19	Otter	1.0	1.0	5.0	4.8
J-19	George	1.0	1.0	5.5	5.3
K-19	McCrossen	1.0	1.0	6.5	6.2
Total		**17.7**	**17.7**		**101.9**



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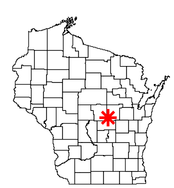


Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
EWM Survey: Onterra, 2019
Map Date: May 16, 2019 - EJH

Legend

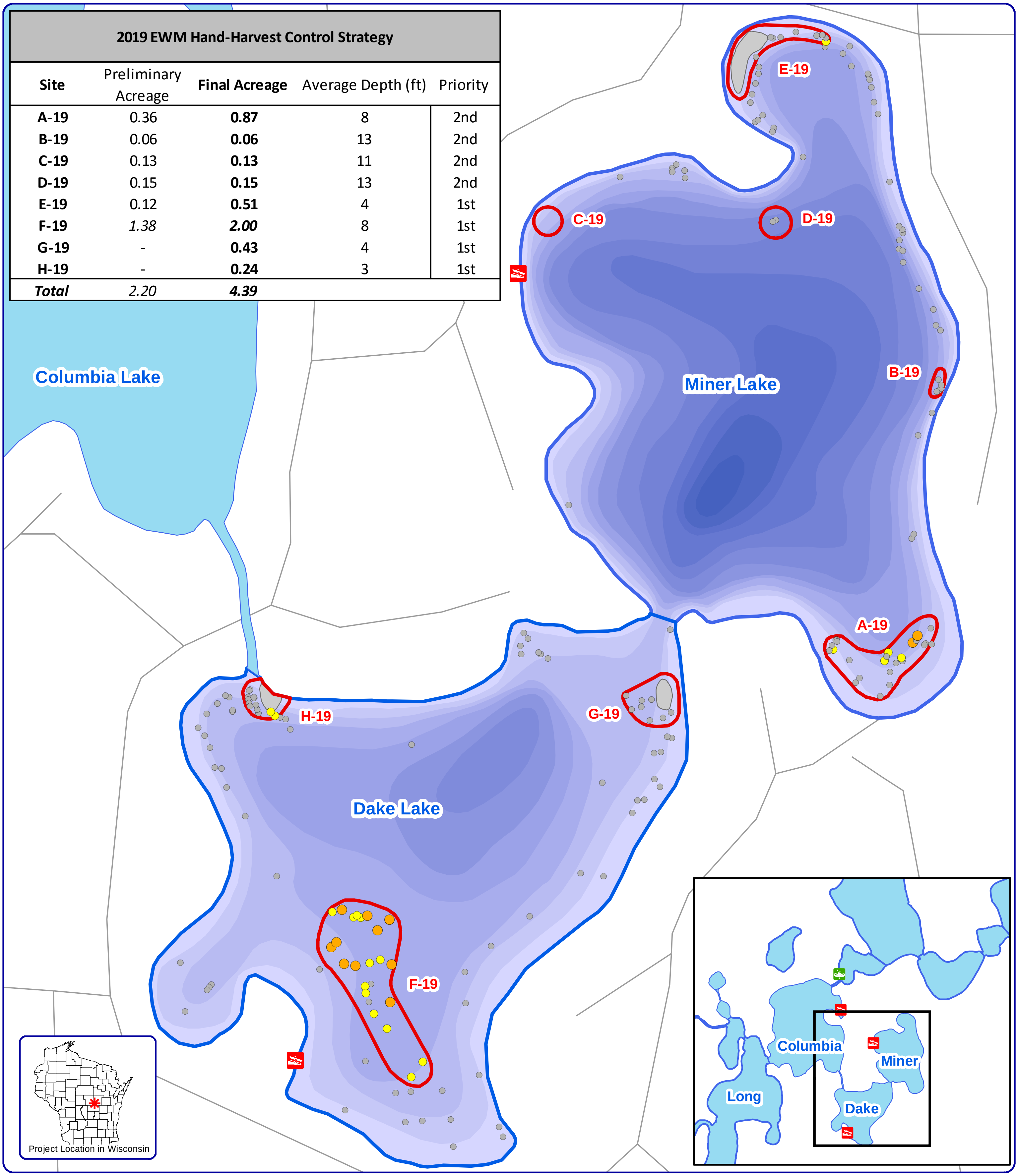
Final Herbicide Spot Treatment

Map 1
Waupaca Chain O' Lakes
Waupaca County, Wisconsin

2019 Final EWM Spot Treatment Strategy

2019 EWM Hand-Harvest Control Strategy

Site	Preliminary Acreage	Final Acreage	Average Depth (ft)	Priority
A-19	0.36	**0.87**	8	2nd
B-19	0.06	**0.06**	13	2nd
C-19	0.13	**0.13**	11	2nd
D-19	0.15	**0.15**	13	2nd
E-19	0.12	**0.51**	4	1st
F-19	*1.38*	***2.00***	8	1st
G-19	-	**0.43**	4	1st
H-19	-	**0.24**	3	1st
Total	*2.20*	***4.39***		



Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2019 Hand-Harvest Site

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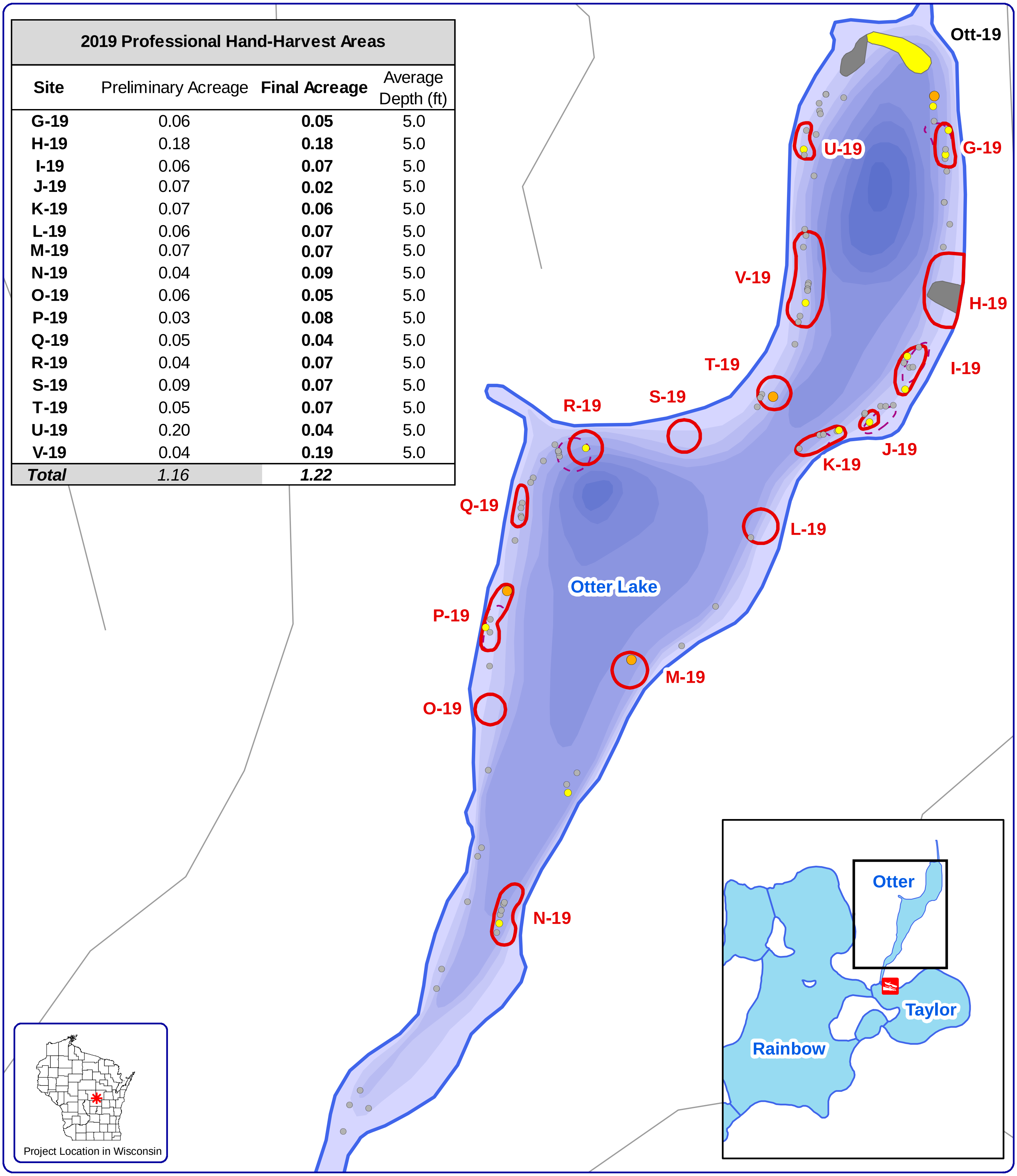
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2019
Map Date: June 11, 2019 AMS
Filename: DakeMiner_HWM_HH_T2019_Perm

Map 2
Dake & Miner Lakes
Waupaca County, Wisconsin

May 2019 HWM Results & Final 2019 Hand-Harvest Strategy

2019 Professional Hand-Harvest Areas			
Site	Preliminary Acreage	**Final Acreage**	Average Depth (ft)
G-19	0.06	**0.05**	5.0
H-19	0.18	**0.18**	5.0
I-19	0.06	**0.07**	5.0
J-19	0.07	**0.02**	5.0
K-19	0.07	**0.06**	5.0
L-19	0.06	**0.07**	5.0
M-19	0.07	**0.07**	5.0
N-19	0.04	**0.09**	5.0
O-19	0.06	**0.05**	5.0
P-19	0.03	**0.08**	5.0
Q-19	0.05	**0.04**	5.0
R-19	0.04	**0.07**	5.0
S-19	0.09	**0.07**	5.0
T-19	0.05	**0.07**	5.0
U-19	0.20	**0.04**	5.0
V-19	0.04	**0.19**	5.0
Total	*1.16*	***1.22***	



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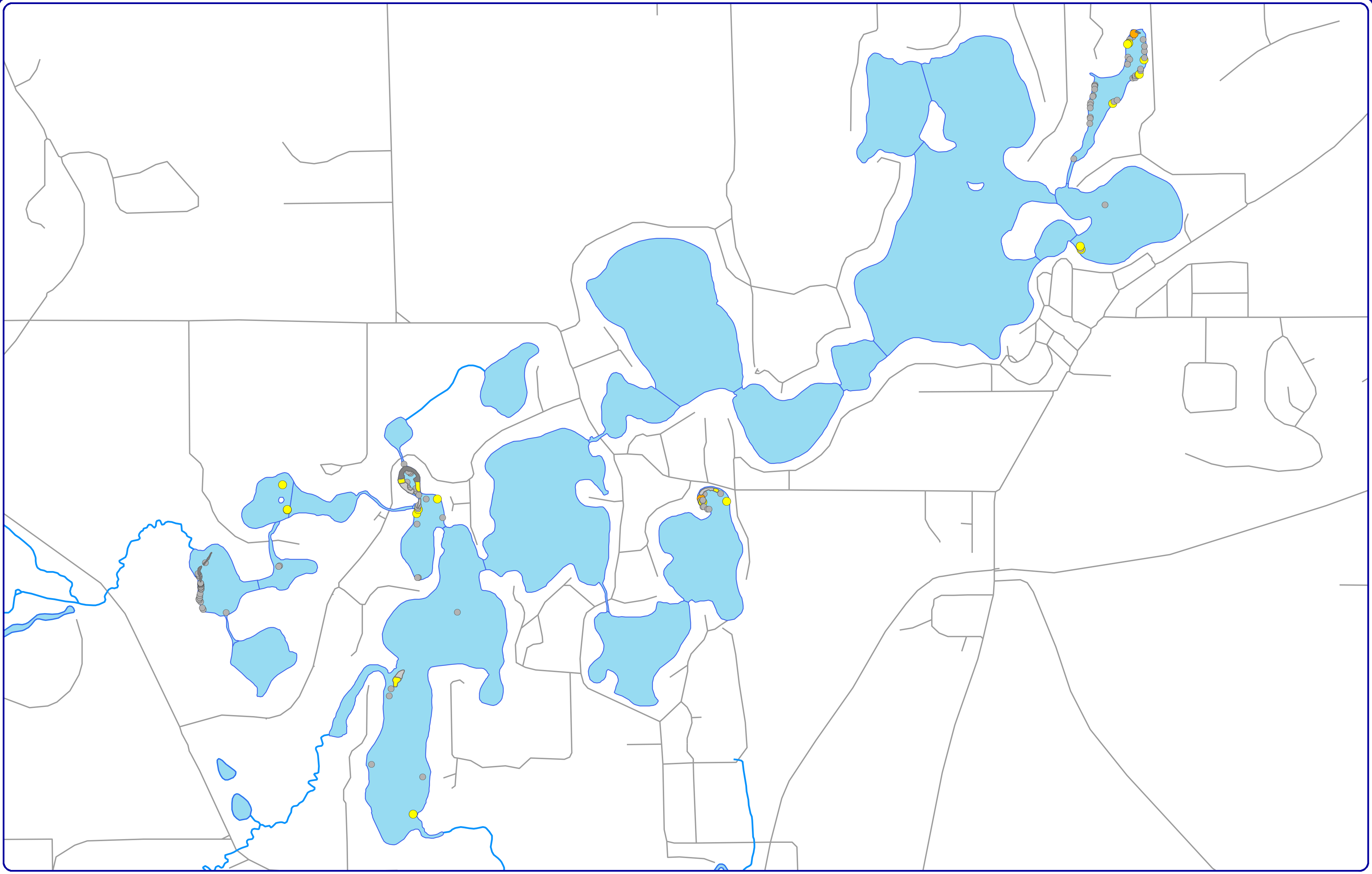
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2019
Map Date: June 19, 2019 AMS
Filename: DakeMiner_HWM_HH_T2019_Perm

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2019 Hand-Harvest Site

Map 3
Otter Lake
Waupaca County, Wisconsin
May 2019 HWM
Results & Final 2019 Hand Harvest Strategy



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Lake Management Planning

815 Prosper Rd
De Pere, WI 54115
920.338.8860
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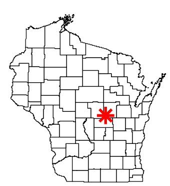
Sources:
Roads and Hydro: WDNR
EWM Survey: Onterra, 2016
Map Date: March 12, 2020
Filename: *WaupacaChain_CLP_ESAIS_May2019.mxd*



Project Location in Wisconsin

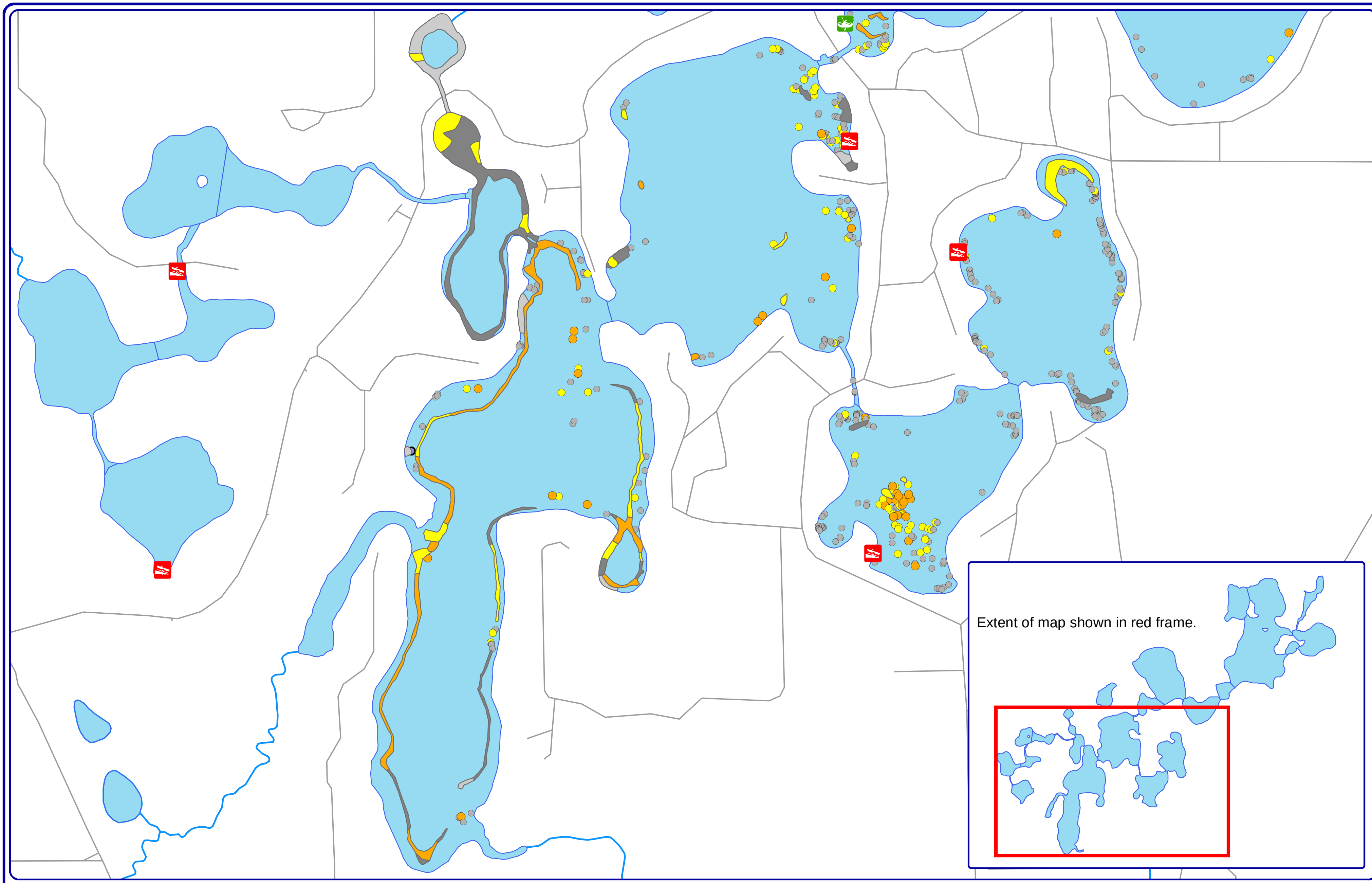
Legend

Survey Date: May 29, 2019

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matted
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

Map 4
Waupaca Chain O' Lakes
Waupaca County, Wisconsin

May 2019 ESAIS Survey Results: CLP



Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matted
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- Boat Landing

Map 5
Waupaca Chain O' Lakes - West
Waupaca County, Wisconsin

October 2019 HWM Survey Results

Onterra LLC
Lake Management Planning
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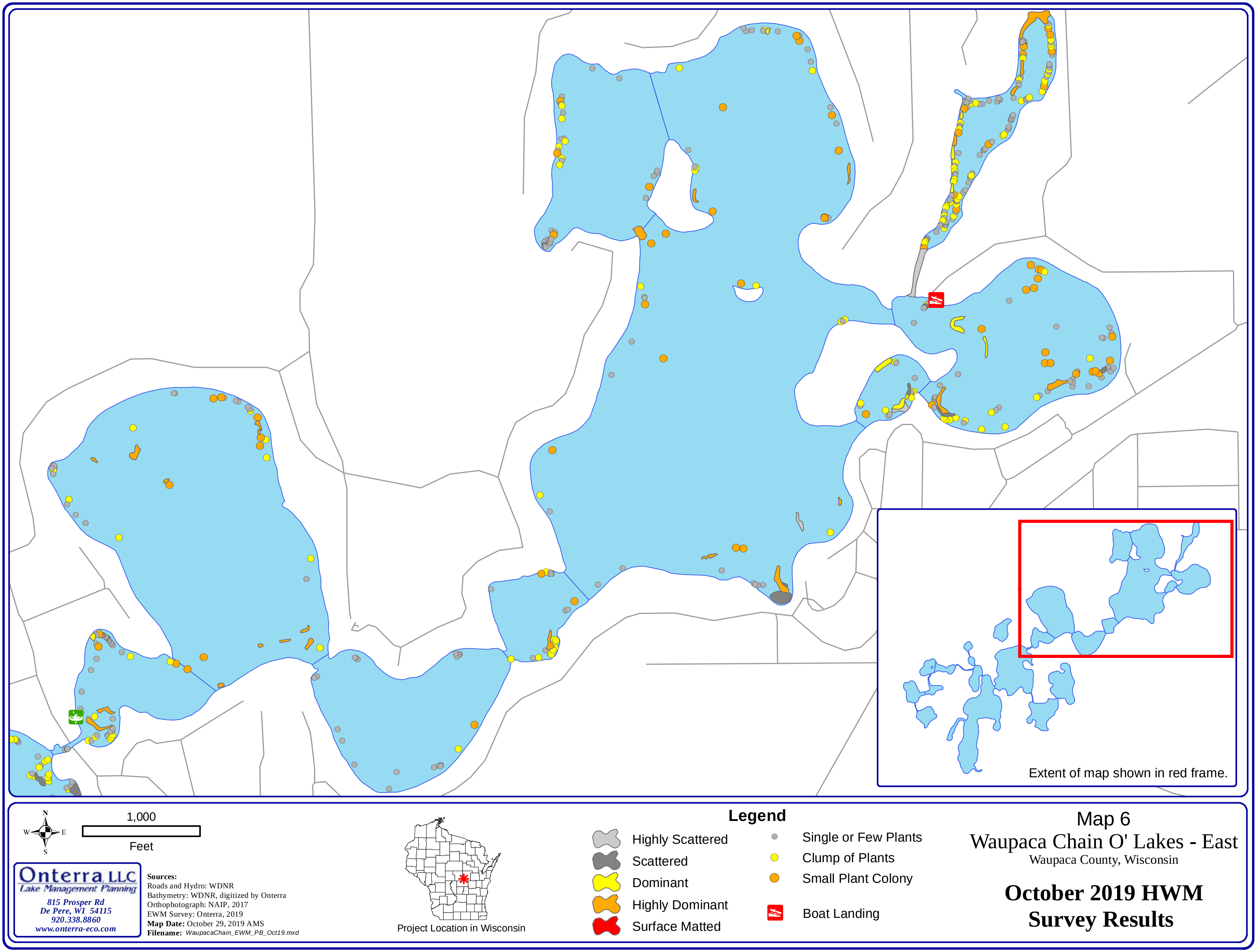
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Orthophotograph: NAIP, 2017
EWM Survey: Onterra, 2019
Map Date: October 29, 2019 AMS
Filename: *WaupacaChain_EWM_PB_Oct19.mxd*



Extent of map shown in red frame.
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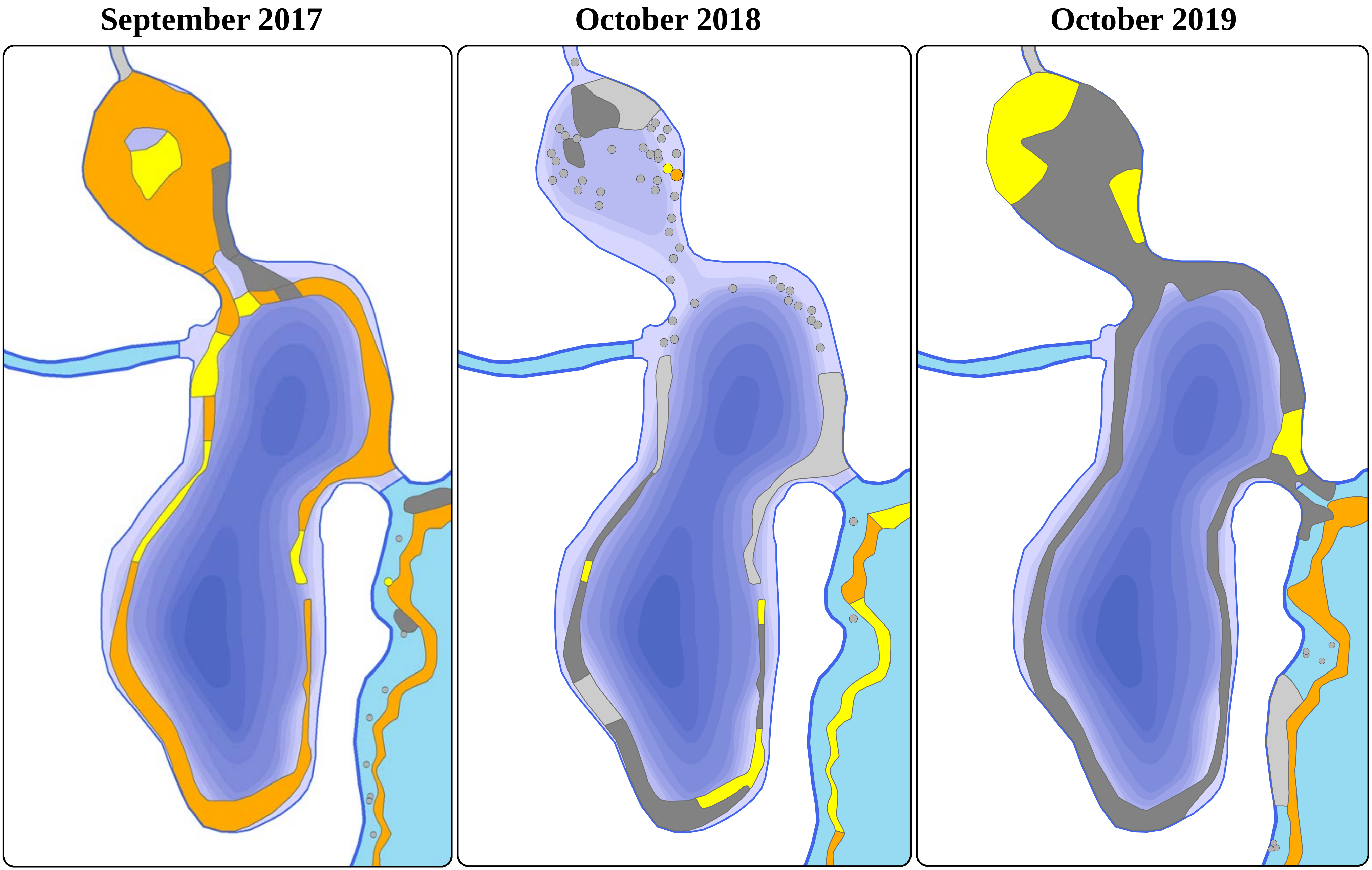
Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Orthophotograph: NAIP, 2017
EWM Survey: Onterra, 2019
Map Date: October 29, 2019 AMS
Filename: WaupacaChain_EWM_PB_Oct19.mxd
Project Location in Wisconsin
Legend
Highly Scattered
Scattered
Dominant
Highly Dominant
Surface Matted
Single or Few Plants
Clump of Plants
Small Plant Colony
Boat Landing
Map 6
Waupaca Chain O' Lakes - East
Waupaca County, Wisconsin
October 2019 HWM
Survey Results



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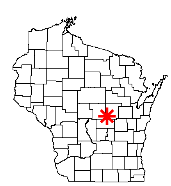
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2017-2019
Orthophotography: NAIP, 2017
Map Date: 11/11/2019 TWH
Filename: WaupacaChain_EWM_Bass-Beasley_2017-19.mxd

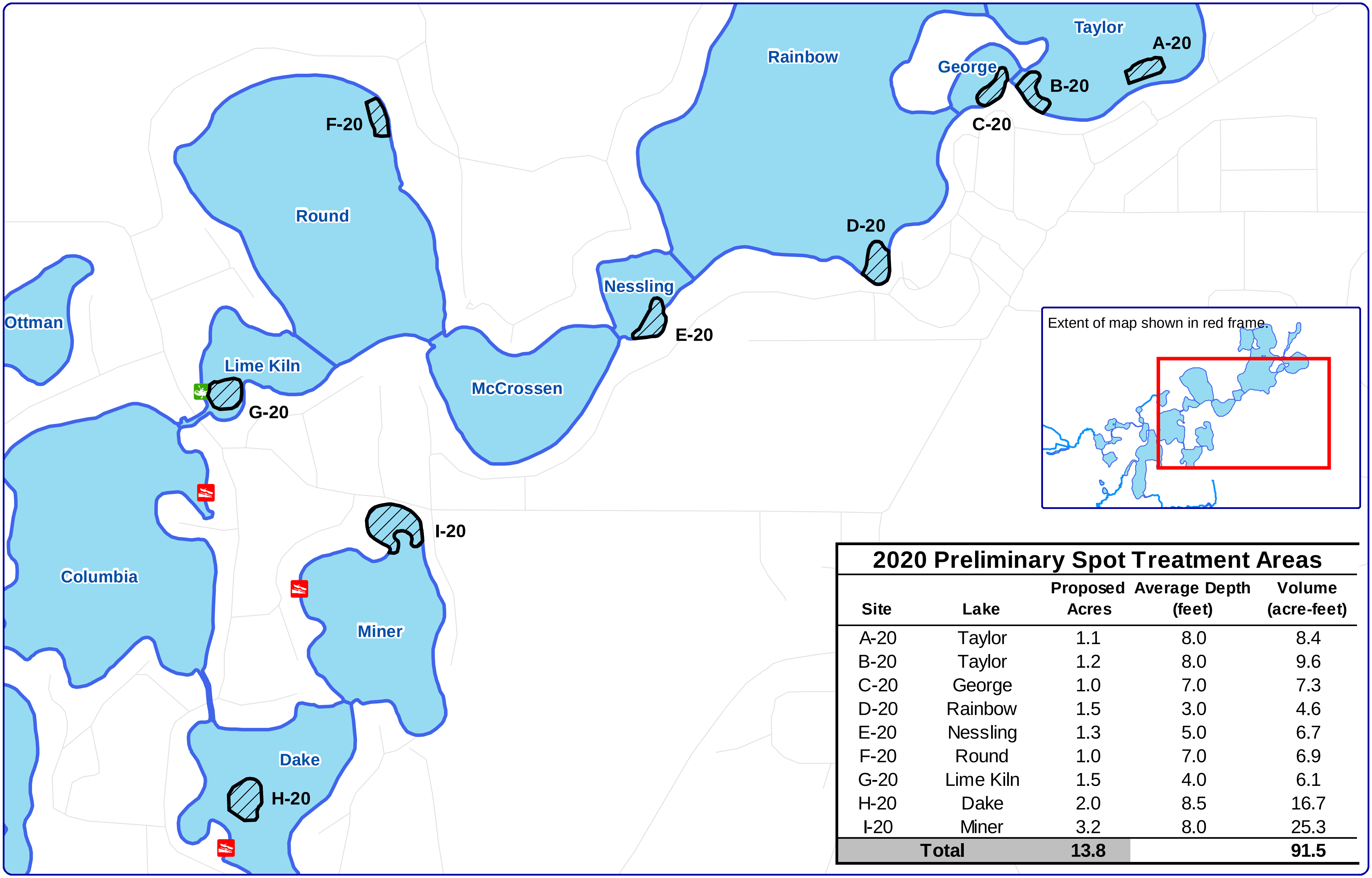


Project Location in Wisconsin

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

Map 7
Bass & Beasley Lakes
Wauapca County, Wisconsin
2017-2019 EWM Survey Results



2020 Preliminary Spot Treatment Areas

Site	Lake	Proposed Acres	Average Depth (feet)	Volume (acre-feet)
A-20	Taylor	1.1	8.0	8.4
B-20	Taylor	1.2	8.0	9.6
C-20	George	1.0	7.0	7.3
D-20	Rainbow	1.5	3.0	4.6
E-20	Nessling	1.3	5.0	6.7
F-20	Round	1.0	7.0	6.9
G-20	Lime Kiln	1.5	4.0	6.1
H-20	Dake	2.0	8.5	16.7
I-20	Miner	3.2	8.0	25.3
Total		**13.8**		**91.5**

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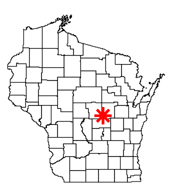
Feet

Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Plant Survey: Onterra, 2019
Map Date: March 13, 2020 - TWH



Project Location in Wisconsin

Legend

Proposed 2020 Herbicide Spot Treatment Area

Map 8

Waupaca Chain O' Lakes

Waupaca County, Wisconsin

2020 Proposed HWM Herbicide Treatment Strategy

A

APPENDIX A

Waupaca Chain 2019 DASH Summary - DASH, LLC

2019 DASH SUMMARY
Waupaca Chain O' Lakes, Waupaca County
Otter, Dake and Miner Lakes

Diver Assisted Suction Harvesting (DASH) of Eurasian Water Milfoil (EWM) took place on July 15, 16, 17, 18, 22 and 23. on the Waupaca Chain O' Lakes, Waupaca Co., Wisconsin. A survey performed by Onterra, LLC confirmed the locations of EWM on 1.16 acres at 16 separate areas on Otter Lake, 1.3 acres in 1 area of Dake Lake, and .82 acres in 5 areas of Miner Lake. All areas were exclusively targeted for EWM.

July 15, 2019

Area F (**Dake Lake**) was harvested for EWM using the DASH barge with one diver on hookah air supply and another person on the barge collecting the material in mesh bags. The wind was 5 mph, waves were calm, air temp was 78 degrees working at a depth of 8 feet.

Area F-19: 6 hours with a total of 266 lbs. of material harvested (approx. 5% non-target plants)

July 16, 2019

Areas A-19 (**Minor Lake**) was harvested using the DASH barge with one diver on hookah air supply and another person on the barge collecting the material in mesh bags. The wind was 5 mph, waves calm, air temp was 85 degrees working at a depth of 5 feet.

Area A: 7 hours, 25 minutes with a total of 410 lbs. of material harvested (approx. 5% non-target plants)

July 17, 2019

Areas C, E & B-19 (**Minor Lake**) were harvested using the DASH barge with one diver on hookah air supply and another person on the barge collecting the material in mesh bags. The wind was 5 mph, waves were calm, air temp was 88 degrees working at a depth of 15 feet.

Area C: 1 hour with a total of 15 lbs. of material harvested (approx. 5% non-target plants)

Area E: 2 hours, 30 minutes with a total of 36 lbs. of material harvested (approx. 5% non-target plants)

Area B: 3 hours, 30 minutes with a total of 163 lbs. of material harvested (approx. 5% non-target plants)

July 18, 2019

Area F-19 (**Dake Lake**) was harvested for EWM using the DASH barge with one diver on hookah air supply and another person on the barge collecting the material in mesh bags. The wind was at 0mph, waves were calm, air temp was 85 degrees working at a depth of 10 feet.

Area F: 6 hours, 10 minutes with a total of 394 lbs. of material harvested (approx. 5% non-target plants)

July 22, 2019

Areas G, H, I, J-19 <u>and</u> Areas O,P, Q & R (**Otter Lake**) were harvested for EWM using the DASH barge with one diver on hookah air supply and another person on the barge collecting the material in mesh bags. The wind was at 5 mph, waves were calm, air temp was 78 degrees working at a depth of 8 feet.

Areas G, H, I & J: 3 hours, 15 minutes with a total of 62 lbs. of material harvested (approx. 5% non-target plants)

Areas O, P, Q & R: 3 hours, 35 minutes with a total of 62 lbs. of material harvested (approx. 5% non-targeted plants)

July 23, 2019

Areas J, K, L, M & N-19 (Otter Lake) were harvested for EWM using the DASH barge with one diver on hookah air supply and another person on the barge collecting the material in mesh bags. The wind was at 5-10 mph, waves were calm, air temp was 80 degrees working at a depth of 9 feet.

Areas J, K, L, M & N: 5 hours, 55 minutes with a total of 226 lbs. of material harvested (approx.

Procedures used during the DASH operations

The lake bed was not removed or redistributed by the suction efforts. A float was used to suspend the suction nozzle off of the lake bed.

All harvested materials were placed in onion type mesh bags, drained, weighed, evaluated for plant species, and transferred to the designated plant disposal site.

Any plant fragments not retained in the bags were skimmed from the lake surface by using a pool pole/net.

Non-targeted species were similar at all locations and estimated to be 10% consisting of mostly Pondweeds.

Table 1 shows the pounds harvested, time spent and lbs. per hour. Total acreage was 1.8 acres. See attached map for harvest locations.

Table 1 2019 DASH Harvest Total by Area, Waupaca Chain O' Lakes, Waupaca Co., WI

Table 1

Site	Acreage	lbs. Harvested	Time (man-hours)	lbs. / hour
A (Miner)	.36	410	7:25	55.3
B (Miner)	.06	163	3:30	46.5
C (Miner)	.13	15	1	15
F (Dake)	1.38	660	12:10	54.2
E (Miner)	.12	36	2:30	14.4
G-H-I-J (Otter)	.37	62	3:15	19
O-P-Q-R (Otter)	.18	62	3:35	17.3
J-K-L-M-N (Otter)	.31	226	5:55	38.2
TOTAL	**1.16**	**1634**	**39:20**	**41.5**
Miner	0.67	624	14.25	
Dake	1.38	660	12:10	
Otter	0.86	350	12:45	