2019 Point-Intercept Plant Surveys

At Long Lake, Long Lake-Katherine Abbott Pond, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake

Prepared for
Valley Branch Watershed District

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Executive Summary

As authorized by the Managers, a subcontractor for Barr conducted point-intercept aquatic plant surveys at Long Lake, Long Lake-Katherine Abbott Pond, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake in 2019. A summary of results is as follows:

- None of these lakes are considered nutrient impaired (i.e., not supporting aquatic life due to stress from excessive nutrients).
- Five of the lakes were treated with herbicide to contain invasive Eurasian watermilfoil (EWM), and one lake was treated with herbicide to contain curly-leaf pondweed (CLP). All had a favorable response.
- EWM was managed by harvesting in Lake Elmo.
- Several other aquatic invasive species are present in the lakes: reed canary grass, purple loosestrife, narrow-leaved cattail, hybrid cattail, and yellow iris. In some lakes, management may be needed to prevent further increases (see Section 4).
- There was an increased frequency of invasive CLP in five lakes. This was primarily due to the timing of the survey, which took place before the plant's natural senescence in 2019 and after the plant's senescence in 2018. However, CLP frequencies in Lake Jane and Long Lake were higher than frequencies observed in 2013 through 2018. CLP management may be needed in these lakes to prevent further increases.
- This report outlines survey methods and more extensive results. Tables and figures follow the discussion. Locations of the surveyed lakes are shown in Figure 1.

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1 Assessing Lake Health

Barr used two tools in assessing the health of the lakes. The first is called the Lake Plant Eutrophication IBI, used to measure the response of a lake plant community to eutrophication (excess nutrients). This tool is important because the Minnesota Pollution Control Agency (MPCA) will use it in the future to identify impaired lakes.[1] The other tool, used to assess plant diversity, is called the Simpson Diversity Index. Both tools are described in greater detail below.

1.1 Lake Plant Eutrophication IBI

The Minnesota Department of Natural Resources (MNDNR) developed the Lake Plant Eutrophication IBI to assist the MPCA with determining lake impairment based on the plant community. The Lake Plant Eutrophication IBI includes two metrics to assess the viability of aquatic life. The first metric is taxa richness—the estimated number of taxa (species) in a lake. The second metric is floristic quality index (FQI). This metric distinguishes the quality of the plant community, which is a reflection of the quantity of nutrients in the lake. Barr analyzed the 2019 survey results to determine taxa richness and FQI scores and compared them with MNDNR impairment thresholds (a minimum of 12 taxa [species] and an FQI score of at least 18.6) to determine whether the lakes were impaired.

1.2 Plant Diversity—Simpson Diversity Index

The Simpson Diversity Index considers both the number of species present and the evenness of species distribution. The values, from 0 to 1, represent the probability that two individual plants randomly selected from the lake will belong to different species. Increasing values indicate increasing probability that two randomly selected plants will represent different species. Barr analyzed the 2019 survey results to determine Simpson Diversity Index values.

[1] Minnesota Department of Natural Resources. 2016. Lake Plant Eutrophication IBI, June 23, 2016: *An Assessment of Aquatic Plant Community Response to Anthropogenic Eutrophication.*

2 2019 Sample Methods

Barr's subcontractor, Matt Berg, of Endangered Resource Services, LLC, conducted point-intercept plant surveys in six VBWD lakes and Long Lake-Katherine Abbott Pond on June 24, June 27, and June 29, 2019. Survey locations are shown in Figure 1. Berg located equally spaced preset points in the field with a global positioning system (GPS) and took measurements at each point. His measurements included the following:

1. Individual species present
2. Overall density of plants, as measured by rake method
3. Density of individual species, as measured by rake method
4. Water depth
5. Dominant sediment type

Barr's subcontractor, Endangered Resource Services, LLC, used a rake (pictured above) to collect plants for the plant surveys. Rake fullness is a measure of plant density.

3 Results

3.1 Long Lake and Long Lake-Katherine Abbott Pond

3.1.1 Eurasian Watermilfoil (EWM) Treatment History in Long Lake

Eurasian watermilfoil (EWM, *Myriophyllum spicatum*) has been documented in Long Lake since May of 2007. By 2010, EWM extent had increased to 52 acres—nearly the entire littoral zone (area of the lake where plants grow[2]). Beginning in 2011 and continuing through 2016, the Friends of Long Lake completed five herbicide treatments to reduce EWM extent in the lake. The treatments were successful, and after the 2016 treatment, EWM extent had been reduced to 0.3 acres. Each of the five treatments involved application of sufficient 2,4-D to attain and sustain a whole-lake concentration that was lethal to EWM. This approach consistently reduced EWM in all areas of the lake except for the area immediately adjacent to the lake's inlet. Barr hypothesized that dilution from the lake's inflow prevented the herbicide concentration in this area from being sustained long enough to kill the EWM.

In 2018, Eurasian watermilfoil in Long Lake, pictured above, expanded to an extent of 35 acres, but was reduced to 2 acres by herbicide treatment in 2019.

A 2017 VBWD plant survey of Long Lake-Katherine Abbott Pond revealed that EWM was prevalent in the pond and that the pond was a source of EWM in Long Lake. Additions of EWM to Long Lake from Long Lake-Katherine Abbott Pond and the spread within the lake caused EWM extent to increase from 0.3 acres in June of 2016 to 20 acres in May of 2018.

The Friends of Long Lake considered using a new herbicide, ProcellaCOR, to treat all of the EWM in Long Lake in 2018. However, the herbicide was expensive and its use for all 20 acres of EWM was cost-prohibitive. The group applied for an MNDNR permit to treat the lake—including Long Lake-Katherine Abbott Pond—with 2,4-D. They hoped the 2018 treatment would reduce EWM to such a small area that use of the new herbicide to treat remaining areas would be affordable in 2019. However, the MNDNR did not approve the permit application and, instead, suggested the use of Fluoridone for the 2018 treatment. Although Fluoridone has successfully been used to treat other lakes, the cost was prohibitive (approximately four times more expensive than 2,4-D). Hence, no treatment occurred in 2018, and EWM continued to spread to an extent of 35 acres, documented in July.

Some EWM did not survive the winter, reducing EWM in Long Lake to 23 acres by April of 2019. The Friends of Long Lake obtained an MNDNR permit and treated 26 acres with 2,4-D on May 13, 2019 (Figure 2). Post-treatment monitoring showed that average 2,4-D concentrations 1 and 4 days after treatment were 460 µg/L and 518 µg/L, respectively—a lethal herbicide dose (at least 300 µg/L 2,4-D for at least 4 days). Despite the lethal dose, a June 29 plant survey documented 2 acres of EWM (Table 3 and

[2] The area of Long Lake containing plants in 2010 was 53.71 acres. EWM extent was 52.31 acres which was 97 percent of the plant growth area of the lake.

Figure 3). The surviving EWM was located near treatment area boundaries, either inside or outside of treatment areas.

3.1.2 Long Lake-Katherine Abbott Pond

Pictured above, canopied coontail in Long Lake-Katherine Abbott Pond.

A VBWD plant survey of Long Lake-Katherine Abbott Pond during June of 2017 documented EWM in 98 percent of the pond, while a VBWD survey in May of 2018 documented EWM in 71 percent of the pond. Although no treatment occurred in 2018, EWM was not observed in July 2018, May 2019, or June 2019 (Table 4 and Figure 4). The surveys indicate that EWM can and does become prevalent throughout the pond, but can also be naturally reduced so as not to be observed. Although the mechanisms for its rise and fall are not known, the pond should be considered a potential source of EWM for Long Lake and should be surveyed with Long Lake. Future Long Lake herbicide treatments should include Long Lake-Katherine Abbott Pond whenever EWM is present to prevent the pond from infesting the lake with EWM.

3.1.3 Plant Diversity in Long Lake

The initial 2011 herbicide treatment reduced EWM extent and improved plant diversity in Long Lake. Subsequent herbicide treatments have sustained the lake's improved plant diversity. Long Lake diversity index values increased from 0.40 before the initial 2011 treatment to 0.80 after the treatment. Prior to the 2011 herbicide treatment, there was a 40 percent probability that two individual plants randomly selected from the lake would belong to different species; after the treatment there was an 80 percent probability. From 2011 to 2019, diversity fluctuated between 0.77 and 0.85 and was 0.82 in 2019 (Table 5).

3.1.4 Long Lake MNDNR Plant IBI

The 2019 Long Lake plant community meets the criteria of the MNDNR Plant IBI and is not impaired. A total of 14 species were observed in Long Lake, 17 percent more than the impairment threshold of 12 species. The lake's FQI of 19.5 was 5 percent more than the impairment threshold of 18.6. Long Lake met the MNDNR Plant IBI criteria from 2010 through 2019, but had low FQI values in 2013 and 2014 (Table 6).

Bearded stonewort, pictured above, was first observed in Long Lake in 2017.

3.1.5 Bearded Stonewort *(Lychnothamnus barbatus)* in Long Lake

Barr's subcontractor observed bearded stonewort *(Lychnothamnus barbatus)*, a good plant, in Long Lake in 2017 (Table 7). This species was not seen in North America until 2012 and not seen in Minnesota until 2015. Few populations have been documented in the world. Long Lake is the third lake in Minnesota and the first lake in Ramsey County with

bearded stonewort. The plant was spreading along the southeastern shoreline in 2018 and had increased in frequency from 1 percent in 2017 to 2 percent in 2018. The plant frequency remained at 2 percent in 2019.

3.1.6 Significant Changes in Long Lake Plant Frequency

The Long Lake plant community was relatively stable between 2018 and 2019, but a few significant changes in plant frequency occurred. The effective herbicide treatment significantly reduced EWM frequency in 2019. Coontail, curly-leaf pondweed (CLP), and filamentous algae significantly increased in frequency while Chara significantly decreased. The significant change in CLP was due, in part, to the change in survey timing between 2018 and 2019. The 2018 plant survey occurred in July, after the natural senescence of CLP, while the 2019 survey occurred in June, prior to the natural senescence. The 2019 CLP frequency of 29 percent was higher than all previous surveys except 2012 (41 percent) (Table 7); however, density was low at nearly all locations and was not considered problematic.

3.1.7 Other Aquatic Invasive Species (AIS) in Long Lake

Although EWM is the AIS of primary concern in Long Lake, three other AIS were present in 2019 (Table 1 and Table 2). CLP was prevalent in 2019, but not problematic, as discussed in the previous paragraph. Reed canary grass (*Phalaris arundinacea*) and narrow-leaved cattail (*Typha angustifolia*) were each sighted at one location in 2019, but were not problematic.

3.2 Lake DeMontreville

3.2.1 EWM Treatment History

EWM was first observed in Lake DeMontreville in 2007 and was treated with 2,4-D in 2009. After the 2009 herbicide treatment, it was not observed again until 2011. EWM remained at low levels during 2011, but its extent increased by an order of magnitude between June of 2012 and June of 2013. Since 2014, the Lake DeMontreville Olson Association (LDO) has annually funded herbicide treatments to attain seasonal relief from EWM. 2,4-D was used for the 2014 through 2017 treatments and diquat was used for the 2018 and 2019 treatments. The June 11, 2019, treatment included 8.5 acres (Figure 5) and was effective in controlling EWM within the treated areas—reducing EWM extent from 13 acres in July 2018 to 3 acres in June 2019 (Table 8 and Figure 6). VBWD's subcontractor indicated surviving EWM was heavily burned by the herbicide but had small healthy regrowth from root crowns.

3.2.2 Plant Diversity

VBWD point-intercept plant surveys have documented good plant diversity in Lake DeMontreville from 2012 through 2019. Simpson Diversity Index values during this period have fluctuated between 0.86 and 0.90, and a value of 0.89 was documented in 2019 (Table 9).

3.2.3 MNDNR IBI

The 2019 Lake DeMontreville plant community meets the criteria of the MNDNR Lake Plant Eutrophication IBI and is not impaired. A total of 19 plant species were observed in 2019, which is 58 percent greater than the impairment threshold of 12 species. The lake's 2019 FQI score of 24.6 was 32 percent higher than the impairment threshold of 18.6. The Lake DeMontreville plant community has

consistently met the criteria of the MNDNR Lake Plant Eutrophication IBI from 2012 through 2019 (Table 10).

3.2.4 Significant Changes in Plant Frequency

Significant changes in plant frequency in 2019 include:

- Significant year-over-year increases in the frequency of nitella (*Nitella sp.*), filamentous algae, and CLP.
- Significant year-over-year decreases in frequency of coontail (*Ceratophyllum demersum*) and common waterweed (*Elodea canadensis)*.

The 2019 change in CLP frequency is due to a change in timing of the plant survey. The 2019 plant survey occurred prior to CLP senescence, while the 2018 survey occurred after CLP senescence.

3.2.5 Other AIS

Although EWM is the AIS of primary concern in Lake DeMontreville, reed canary grass (*Phalaris arundinacea*), hybrid cattail (*Typha x glauca*), yellow iris (*Iris pseudacorus*), and CLP were observed in 2019 (Table 1 and Table 2).

Yellow iris, pictured above, was common along much of the Lake DeMontreville shoreline in 2019.

In 2019, yellow iris was common along much of the lakeshore, especially near the boat landing, indicating a rapid spread has occurred. Although VBWD's subcontractor did not observe yellow iris during the 2016 through 2018 VBWD plant surveys, he had observed it during 2013 through 2015 surveys. The first Lake DeMontreville siting of yellow iris was in 2013 when a few plants were observed near the boat landing. These plants were hand removed by Barr staff during June of 2014, but the yellow iris reappeared in 2015 on the south shoreline. The rapid spread of yellow iris in 2019 is concerning because it competes with native shoreland vegetation. The root system of yellow iris forms a dense mat which compacts the soil and inhibits seed germination of other plants. Hence, removal of this rapidly spreading invasive species is recommended either by digging it up or spraying with glyphosate. An MNDNR permit would be required for either method of removal.

In 2019, there was a single sighting of reed canary grass and hybrid cattail in the northwest corner of the lake. Because the infestations were small and no change in frequency occurred between 2018 and 2019, Barr does not consider them problematic.

In 2019, CLP frequency was within the range of previous years—12 percent in 2019, compared with a range of 2 percent to 49 percent from 2012 through 2017 (Table 11). CLP was not observed in 2018 because the survey occurred after natural senescence. CLP density was low in 2019 and was not considered problematic.

3.3 Lake Olson

3.3.1 EWM Treatment History and Changes in Post-Treatment EWM Extent

EWM was first observed in Lake Olson during 2012. Between 2012 and 2013, EWM extent doubled from 2 to 4 acres. Over the years, the LDO has conducted several treatments. The first was a small-scale, unsuccessful 2,4-D treatment in 2014, with EWM extent increasing to 24 acres by June of that year. Despite an additional small-scale 2,4-D treatment in 2015, EWM extent increased to 28 acres by June 2015. Small-scale 2,4-D treatments in 2016 and 2017 reduced EWM extent to 21 acres by June 2017. Switching to a different herbicide, diquat, in 2018, reduced EWM extent to 7 acres. The EWM remaining was primarily outside of the treated areas. On June 11, 2019, 6.5 acres were treated with diquat (Figure 7), reducing EWM extent to 1 acre (Table 12 and Figure 8).

3.3.2 Plant Diversity

Increasing EWM extent from 2012 through 2016 resulted in decreasing plant diversity. Simpson Diversity Index values declined from 0.92 in 2012 to 0.85 in 2016. Herbicide treatments since 2016 have reduced EWM extent in the lake and improved diversity. Simpson Diversity Index values increased from 0.85 in 2016 to 0.88 in 2019 (Table 13).

3.3.3 MNDNR IBI

The 2019 Lake Olson plant community meets the criteria of the MNDNR Lake Plant Eutrophication IBI and is not impaired. A total of 21 plant species were observed in 2019, which is 75 percent greater than the impairment threshold of 12 species. The 2018 FQI score of 26.2 was 41 percent higher than the impairment threshold of 18.6 (Table 14). The Lake Olson plant community has consistently met the criteria of the MNDNR Lake Plant Eutrophication IBI during the 2012 through 2019 period.

3.3.4 Significant Changes in Plant Frequency

Significant changes in several Lake Olson plant species occurred in 2019. The successful 2019 EWM herbicide treatment caused a significant decline in EWM frequency. A significant increase in CLP occurred due to a change in timing of the 2019 plant survey. The 2019 plant survey occurred prior to CLP senescence while the 2018 survey occurred after senescence. Filamentous algae significantly increased in frequency in 2019.

Significant frequency differences were seen for common waterweed (increase), southern naiad (*Najas guadalupensis,* increase*),* and fern pondweed (*Potamogeton robbinsii,* decrease*)*; however, these frequencies remained within the range observed since 2012. Nitella was observed at a higher frequency in 2019 (17 percent) than 2012 through 2018 (6 to 12 percent). Slender naiad (*Najas flexilis*) was observed at a frequency of 3 percent in 2018 and was not observed in 2019. This is the first time this species has not been observed since monitoring began in 2012.

3.3.5 Bearded Stonewort *(Lychnothamnus barbatus)* in Lake Olson

Barr's subcontractor observed bearded stonewort *(Lychnothamnus barbatus)*, a good plant, in Lake Olson for the first time in 2019 (Table 15). It was observed at one location in the southwest corner of the lake. As noted previously, this species was first observed in Long Lake in 2017, first observed in Minnesota in 2015, and first observed in North America in 2012.

Bearded stonewort, pictured above, was first observed in Lake Olson in 2019.

3.3.6 Other AIS

Although EWM is the AIS of primary concern in Lake Olson, five additional AIS were observed during 2019: CLP, yellow iris, hybrid cattail, purple loosestrife, and reed canary grass (Table 1 and Table 2).

In 2019, low-density CLP was observed at eight sample locations and was not problematic. CLP has consistently been present at low frequencies (7 percent or less) and low density since 2014. CLP was more prevalent in 2012 and 2013, ranging in frequency from 28 to 43 percent (Table 15).

In 2019, yellow iris and hybrid cattail were observed at a single location in the southwest corner of the lake—the same location where they were observed in 2018. Because they were only found at one location and had not increased in extent, they were not problematic in 2019.

In 2019, purple loosestrife was observed in the channel between Lake Olson and Lake DeMontreville. It was also found in the southwest corner of the lake in 2018, and all plants were removed by Barr's subcontractor. Purple loosestrife was not problematic in 2019. However, it should be watched in the future and management initiated if it spreads and increases in extent.

Reed canary grass has annually been observed since point-intercept surveys began in 2012. Although the infestation had not spread in previous years, it spread from one location in 2018 to three locations in 2019. Although not problematic in 2019, management should be considered to prevent further spread of this invasive species.

3.4 Lake Jane

3.4.1 History of EWM and Treatment

The first sighting of EWM occurred in 2012 when a few scattered plants were observed near the east shore (about 0.1 acre). From 2012 through 2015, EWM extent increased to 44 acres. In May of 2015, the Lake Jane Association treated 7.9 acres with 2,4-D and EWM extent was reduced to 31 acres. No treatment occurred in 2016 and EWM extent increased to 69 acres. In 2017, the Lake Jane Association treated 11.1 acres with 2,4-D and EWM extent was reduced to 26 acres. In 2018, the Lake Jane Association treated 12 acres with ProcellaCOR EC (Florpyrauxifen-benzyl) and EWM extent was reduced to 9 acres. In 2019, the Lake Jane Association treated 12 acres with ProcellaCOR

Pictured above, EWM observed in Lake Jane in June 2019 was severely burned from the herbicide treatment.

EC (Figure 9). Despite the herbicide treatment in spring of 2019, the VBWD June 2019 plant survey indicated EWM extent tripled between July 2018 (9 acres) and June 2019 (27 acres) (Table 16 and Figure 10). While most EWM plants observed in June 2019 were severely burned by the spring herbicide treatment, some individuals showed regrowth from severely burned root crowns.

The MNDNR completed a pre-treatment survey on June 12, 2019, and a post-treatment survey on August 7, 2019. The survey included sample points within or adjacent to the treatment area. EWM was observed at 40 of the 70 sample points in the pre-treatment survey and at five sample points in the post-treatment survey (Figure 11). Hence, frequency of occurrence of EWM in the survey area was reduced from 57 percent prior to the treatment to 7 percent after the treatment. Surviving EWM was either near the edge or outside of the treatment area.

The 2019 data are consistent with 2018 MNDNR data indicating that it takes some time for EWM to collapse when exposed to ProcellaCOR. In 2018, MNDNR documented that EWM frequency was reduced from 72% to 51% 3 weeks after treatment and further reduced to 1% 6-plus weeks after treatment (Cattoor, 2019). The VBWD June 2019 plant survey occurred less than 3 weeks after treatment and showed more EWM within the treated area than the MNDNR post-treatment survey more than 6 weeks after treatment (Figure 9, Figure 10, Figure 11).

3.4.2 Plant Diversity

Lake Jane plant diversity has been good throughout the 2012 through 2019 monitoring period. Simpson Diversity Index values have fluctuated between 0.89 and 0.92 during this period, with a value of 0.90 in 2019 (Table 17).

3.4.3 MNDNR IBI

The 2019 Lake Jane plant community meets the criteria of the MNDNR Lake Plant Eutrophication IBI and is not impaired. A total of 22 plant species were observed in 2019, which is 83 percent greater than the impairment threshold of 12 species. The 2019 FQI score of 28.4 was 52 percent higher than the impairment threshold of 18.6 (Table 18).

A total of six species that had been present in 2018 were not observed in 2019: water star-grass (*Heteranthera dubia),* spiny-spored quillwort *(Isoetes echinospora),* small duckweed *(Lemna minor),* flat-stem pondweed *(Potamogeton zosteriformis),* white water crowfoot *(Ranunculus aquatilis),* and softstem bulrush *(Schoenoplectus tabernaemontani*). The change was not statistically significant, but reduced the number of species and FQI to the lowest values observed since 2012: 22 species and an FQI of 28.4 in 2019 compared with 26 to 31 species and FQI values of 30.8 to 33.1 from 2012 through 2018 (Table 18).

The Lake Jane plant community has consistently met the criteria of the MNDNR Lake Plant Eutrophication IBI during the 2012 through 2019 period.

3.4.4 Significant Changes in Plant Frequency

The Lake Jane plant community was relatively stable in 2019. However, significant changes occurred in two aquatic invasive species, EWM and CLP, and one native species, Illinois pondweed (*Potamogeton illinoensis,)* (Table 19). EWM frequency increased significantly in 2019 despite herbicide treatment to control it. CLP frequency also increased significantly due, in part, to the change in survey timing between 2018 and 2019. The 2018 plant survey occurred in July, after the natural senescence of CLP, while the 2019 survey occurred in June, prior to the 2019 natural senescence. In 2019, CLP frequency was higher than frequencies observed from 2012 through 2018 (26 percent in 2019 compared with 1 to18 percent).

The significant increase in Illinois pondweed frequency in 2019 (29 percent) was preceded by a significant decline in 2018 (from 22 percent in 2017 to 10 percent in 2018). The 2019 Illinois pondweed frequency was within the range observed prior to 2018 (18 to 30 percent) (Table 18).

3.4.5 Other AIS

Although EWM is the AIS of primary concern in Lake Jane, three additional AIS were observed during 2019 (CLP, purple loosestrife, and narrow-leaved cattail) (Table 1 and Table 2). CLP and purple loosestrife have been present in Lake Jane since point-intercept monitoring began in 2012. Purple loosestrife has been observed annually at a single location, although the location has changed from near the boat landing (2012 through 2016) to the southwest corner of the lake (2017 and 2018) and then near the boat landing again (2019).

As noted earlier, CLP increased significantly in 2019 due, in part, to a change in the timing of the plant survey. However, the 2019 CLP frequency of 26 percent was higher than all previous surveys (1 to 18 percent). CLP density in 2019 was low at most locations, moderate at a few locations, and dense at one location in the southwest corner of the lake. The increased frequency of CLP in 2019 indicates management may be needed to prevent further increases in CLP extent.

Narrow-leaved cattail (*Typha angustifolia*) has been present at one location on the southeast side of lake from 2015 through 2019 and is not problematic.

3.5 Lake Elmo

3.5.1 History of EWM and EWM Removal

Lake Elmo EWM extent has fluctuated over time. EWM extent declined from 2012 through 2014 (from 71 acres to 51 acres), increased from 2014 to 2016 (from 51 acres to 80 acres), declined from 2016 through 2018 (from 80 acres to 30 acres), and increased from 2018 through 2019 (from 30 acres to 49 acres) (Table 20 and Figure 12).

The Lake Elmo Association conducted three small-scale EWM removal projects from 2015 through 2017. A dive team removed less than an acre of EWM in 2015. Mechanical harvesting was done in 2016 and

Pictured above, a typical rake full of EWM observed in Lake Elmo in June 2019.

2017, with about 10 acres of EWM at the north end of the lake removed in 2016 and about 4 acres on the east and northeast side of the lake removed in 2017.

In 2018, equipment problems with the mechanical harvester prevented removal. In 2019, 33 cubic yards of EWM (dry biomass total) was removed from 3.1 acres using harvesting (pulling custom rakes along the bottom and collecting the EWM floating to the surface and scuba diving). The harvesting occurred from May 28 through June 2, 2019. The harvested areas are shown in Figure 13.

3.5.2 Hybrid Milfoil

In 2018, the Minnesota Aquatic Invasive Species Research Center (MAISRC) collected milfoil samples from Lake Elmo and determined that both Eurasian watermilfoil and hybrid milfoil were present (Newman et al., 2019). Hybrid milfoil is a cross between the native milfoil (*Myriophyllum sibiricum*) and EWM. Hybrid milfoil has been shown to be more aggressive and more resistant to herbicide treatment than EWM. It generally requires a higher dose of herbicide to attain control. Hybrid milfoil reproduces by both fragments and seeds, and its seeds are generally viable.

3.5.3 Plant Diversity

Lake Elmo plant diversity has been good throughout the 2012 through 2019 monitoring period. Simpson Diversity Index values have fluctuated between 0.88 and 0.91 during this period, with a value of 0.90 in 2019 (Table 21).

3.5.4 MNDNR IBI

The 2019 Lake Elmo plant community met the criteria of the MNDNR Lake Plant Eutrophication IBI and is not impaired. A total of 25 plant species were observed in 2019, which is 108 percent greater than the impairment threshold of 12 species. The 2019 FQI score of 26.8 was 44 percent higher than the impairment threshold of 18.6 (Table 22). The Lake Elmo plant community has consistently met the criteria of the MNDNR Lake Plant Eutrophication IBI from 2012 through 2019.

3.5.5 Significant Changes in Plant Frequency

The Lake Elmo plant community was relatively stable in 2019, and only two species changed significantly in frequency: southern naiad (decrease) and common watermeal (*Wolffia columbiana*, increase). Filamentous algae also increased to its highest frequency since 2012—19 percent in 2019 compared with 3 to 14 percent from 2012 through 2018 (Table 23).

3.5.6 Other AIS

Although EWM is the AIS of primary concern in Lake Elmo, two additional AIS were observed in 2019 (CLP and narrow-leaved cattail) (Table 1 and Table 2).

CLP was collected on the rake at one location and observed at a second location. Density was low and CLP was not problematic.

Narrow-leaved cattail has been observed in Lake Elmo since monitoring began in 2012. The cattail community is located along the western and southern shores of the lake and has remained stable over the monitoring period. It is not problematic.

3.6 Silver Lake

3.6.1 History of EWM and Treatment

EWM has been present in Silver Lake since 1992. The Silver Lake Improvement Association (SLIA) has conducted herbicide treatments to control EWM nearly annually since 1995. Most have been small-scale treatments to attain seasonal relief. However, large-scale treatments to attain long-term reduction occurred in 2007 and 2008. Treatments were not needed again until 2012. Small-scale treatments to attain seasonal relief occurred from 2012 through 2015 and in 2017. Despite no EWM treatment or removal in 2018, Silver Lake EWM extent declined by an order of magnitude—from 30 acres in 2017 to 0.3 acres in 2018. The cause of the decline is unknown. Because EWM extent increased from June 2018 to spring 2019, nearly 4 acres of EWM in the south and southwest areas of the lake were treated with diquat in May 2019 (Figure 14). Although EWM was not observed within the treated area during the June 2019 plant survey, 0.3 acres of EWM was observed in the untreated northwest corner of the lake (Table 24 and Figure 15).

3.6.2 History of CLP and Treatment

CLP presence in Silver Lake has been documented since 2006. The SLIA has conducted herbicide treatments to control CLP since 2007. Large-scale treatments to attain long-term CLP reduction occurred from 2007 through 2009. Treatments were not needed again until 2013. Small-scale treatments to attain seasonal relief occurred in 2013, 2016, and 2017. CLP was not observed in 2018 because the plant survey occurred after natural senescence of CLP. CLP was present in the spring of 2019 and 1.75 acres were treated with diquat (Figure 14). The treatment was effective and CLP was not observed during the June 2019 survey.

3.6.3 Plant Diversity

Plant diversity in Silver Lake has fluctuated widely during the monitoring period. Causes of the fluctuations include damage to the plant community from the 2007 and 2008 herbicide treatments and subsequent water-quality degradation and positive impacts from recent improvements to the lake's water quality. Simpson Diversity Index values have fluctuated between 0.61 and 0.83 during the 2006 through 2019 monitoring period.

In 2019, coontail, pictured above, decreased in frequency (from 64 percent in 2018 to 57 percent in 2019).

Plant diversity during 2018 and 2019 was lower than 2013 through 2017 due to dominance by coontail in 2018 and by coontail and filamentous algae in 2019. Diversity values represent the probability that two individual plants randomly selected from the lake will belong to different species. Dominance by one or two types of plants reduces the probability that two randomly selected plants will represent different species. Coontail increased in frequency from 26 percent in 2017 to 64 percent in 2018 and diversity responded accordingly, with a reduction in Simpson Diversity Index values from 0.82 in 2017 to 0.67 in 2018. Coontail decreased in frequency from 64 percent in 2018 to 57 percent in 2019, but filamentous algae increased in frequency from 19 percent in 2018 to 89 percent in 2019. These changes resulted in a slight increase in the Simpson Diversity Index value from 0.67 in 2018 to 0.68 in 2019. However, the 2019 diversity value remained well below the 2017 value of 0.82 (Table 25).

3.6.4 MNDNR IBI

The 2019 Silver Lake plant community meets the criteria of the MNDNR Lake Plant Eutrophication IBI and is not impaired. A total of 17 plant species were observed in 2019, which is 42 percent greater than the impairment threshold of 12 species. The 2019 FQI score of 23.5 was 27 percent higher than the impairment threshold of 18.6 (Table 26).

The Silver Lake plant community has generally failed to meet the MNDNR Lake Plant Eutrophication IBI since 2007. The 2007 and 2008 CLP and EWM treatments significantly damaged the native plant community. The data indicate the plant community met IBI criteria in 2006 and in June of 2007, but did not meet IBI criteria from August 2007 through 2012. Over time, the plant community has improved such that the Silver Lake met the IBI criteria about half the time from 2013 through 2016 and fully met the criteria from 2017 through 2019 (Table 26).

3.6.5 Significant Changes in Plant Frequency

The Silver Lake plant community was relatively stable in 2019, and only one rooted aquatic plant species, slender naiad, changed significantly in frequency (decrease). Filamentous algae increased to its highest frequency since 2017 when it was first documented in the lake: 89 percent in 2019 compared with 19 percent in 2018 and 29 percent during 2017.

3.6.6 Other AIS

EWM and CLP are the AIS of concern in Silver Lake and both were treated with herbicide in 2019. After treatment, EWM was observed at one location, but CLP was not observed. The June 2019 plant survey documented four additional AIS in the lake (Table 1 and Table 2).

Narrow-leaved cattail was observed at a location in the northeast area of the lake first in 2017, then again in 2018 and 2019. Reed canary grass was observed in that same location in 2017 and 2018. It moved to a different location in 2019, but was still in the northeast area of the lake.

Purple loosestrife was observed at a location in the southwest corner of the lake first in 2018, then again in 2019.

Yellow iris, pictured above, was observed at one location along the southern shoreline in 2019.

Yellow iris was first observed in 2019 along the southern shoreline.

The current infestations of reed canary grass, narrow-leaved cattail, purple loosestrife, and yellow iris are not problematic.

4 Summary

The MNDNR developed a Lake Plant Eutrophication IBI to measure the response of a lake plant community to eutrophication (excessive nutrients). The MPCA will use this IBI to identify lakes that are nutrient impaired (i.e., not supporting aquatic life due to stress from excessive nutrients). In 2019, Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake met the criteria of the MNDNR Lake Plant Eutrophication IBI and are not impaired.

In 2019, lake associations treated EWM in Silver Lake, Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane with herbicide and harvested EWM in Lake Elmo.

- **Silver Lake**—Nearly 4 acres of EWM in the south and southwest areas of the lake were treated with diquat in May 2019 (Figure 14). The treatment was effective and EWM was not observed in the treated area in June; however, 0.3 acres of EWM were observed in the untreated northwest corner of the lake (Table 24 and Figure 15).
- **Long Lake**—The 2,4-D treatment of 26 acres in May 2019 (Figure 2) reduced EWM extent from 23 acres in April of 2019 to 2 acres in June of 2019 (Table 3 and Figure 3).
- **Lake DeMontreville**—The diquat treatment of 8.5 acres in June 2019 (Figure 5) reduced EWM extent from 13 acres in July of 2018 to 3 acres in June of 2019 (Table 8 and Figure 6).
- **Lake Olson**—The diquat treatment of 6.5 acres in June 2019 (Figure 7) reduced EWM extent from 7 acres in July of 2018 to 1 acre in June 2019 (Table 12 and Figure 6).
- **Lake Jane**— The VBWD June plant survey indicated EWM extent in Lake Jane increased from 9 acres in July 2018 to 27 acres in June 2019 (Table 16 and Figure 10). The ProcellaCOR EC treatment of 12 acres in June 2019 (Figure 9) reduced EWM frequency within and adjacent to the treated area from 57 percent to 7 percent per MNDNR pre- and post-treatment surveys (Figure 11). MNDNR indicates it takes some time for EWM to collapse after treatment with ProcellaCOR. Much of the EWM present within the treatment area in June was gone by August (Figure 10 and Figure 11). Even with the removal of EWM from the treated area by August, the June VBWD plant survey data indicate EWM extent increased in 2019.
- **Lake Elmo**—On May 28 through June 2, 2019, 3.1 acres of EWM were removed from Lake Elmo using harvesting and scuba diving Figure 13). Despite the harvesting, EWM extent increased from 30 acres in July 2018 to 49 acres in June 2019 (Table 20 and Figure 12).

CLP was present in all lakes and treated in some:

- **Silver Lake—**The 2019 diquat treatment of 1.75 acres of CLP in Silver Lake was effective, and CLP was not observed in the lake in June (Table 27).
- **Lake DeMontreville, Lake Olson, and Lake Elmo—**In 2019, CLP was present in DeMontreville, Olson, and Elmo at frequencies similar to previous years and was not problematic.

- **Lake Jane—**In 2019, CLP frequency in Lake Jane was higher than frequencies observed in surveys completed from 2012 through 2018. CLP management may be needed to prevent further increases.

- **Long Lake**—CLP frequency in 2019 was higher than frequencies observed from 2013 through 2018 surveys, but lower than the frequency observed in 2012. CLP management may be needed to prevent further increases.

EWM is the AIS of primary concern in all six lakes and CLP is a second AIS of concern in Silver Lake, Lake Jane, and Long Lake. In addition, several other AIS were present in 2019.

- **Reed canary grass** was present in Long Lake, Lake DeMontreville, and Silver Lake, but was not problematic. However, in Lake Olson, it had spread from one location in 2018 to three locations in 2019. Management in Lake Olson should be considered to prevent further spread.

- **Purple loosestrife** was present in Lake Olson, Lake Jane, and Silver Lake and was not problematic.

- **Narrow-leaved cattail** was present in Long Lake, Lake Jane, Lake Elmo, and Silver Lake and was not problematic.

- **Hybrid cattail** was present in Lake DeMontreville and Lake Olson and was not problematic.

- **Yellow iris** was present in Lake DeMontreville, Lake Olson, and Silver Lake. It was not problematic in Lake Olson or Silver Lake (where it was first observed in 2019). Common along the Lake DeMontreville shoreline in 2019, yellow iris appears to have spread rapidly (it was not observed in surveys from 2016 through 2018). Removal of this rapidly spreading AIS species is recommended.

5 References

Newman, RM and RA Thum. 2019. Eurasian and Hybrid Watermilfoil Genotype Distribution in Minnesota. Final Report to the Minnesota Aquatic Invasive Species Research Center. August 2019.

Cattoor, Kylie. 2019. Email communication from Kylie Cattoor, MNDNR, to Meg Rattei on October 31, 2019.

Tables

Description of Tables

Table 1 summarizes the results of the 2019 aquatic plant surveys of six VBWD lakes. The following data are presented:

- **Number of species**—the number of different plant species that were either collected on the rake or observed in the lake (e.g., water lilies or cattail beds not collected on the rake but observed). This number includes both invasive and native species.
- **Number of native species**—the number of native plant species that were either collected on the rake or observed in the lake.
- **Number of native species collected on rake**—only native plants collected on the rake were used for this statistic.
- **Number of invasive species**—the number of invasive plant species that were either collected on the rake or observed in the lake.
- **Maximum depth of plant growth**—the maximum depth that plants were found in the lake.
- **Frequency of occurrence**—the frequency with which plants were found in water shallower than the maximum depth of plant growth.
- **Average rake fullness**—the density of plant growth, as measured by rake fullness on a scale of 1 to 4, where:
  - 1 = less than 1/3 of the rake head full of plants.
  - 2 = from 1/3 to 2/3 of the rake head full of plants.
  - 3 = more than 2/3 of the rake head full of plants
  - 4 = rake head is full, with plants overtopping.
- **Simpson Diversity Index Value**—index used to measure plant diversity, which assesses the overall health of the lake's plant communities. The index, with scores ranging from 0 to 1, considers both the number of species present and the evenness of species distribution. The scores represent the probability that two individual plants randomly selected from the lake will belong to different species. A high score indicates a more diverse plant community—a higher probability that two randomly selected plants will represent different species.

Table 2 summarizes invasive species data from the six VBWD lakes surveyed in 2019. The table shows the frequency of occurrence for species collected on the rake and includes species that were observed (Present = P), but not collected on the rake.

Tables 3, 4, 8, 12, 16, 20, and 24 summarize Eurasian watermilfoil (EWM) extent for the period of record for Long Lake, Long Lake-Katherine Abbott Pond, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and 2017 through 2019 for Silver Lake. EWM extent is shown as acres of EWM in the lake and as a percent of the plant-growth area.

Tables 5, 9, 13, 17, 21, and 25 summarize Simpson Diversity Index values for the period of record in Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake.

Tables 6, 10, 14, 18, 22, and 26 summarize MNDNR Lake Eutrophication Plant IBI values for the period of record in Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake.

Tables 7, 11, 15, 19, 23, and 27 show species frequency for the period of record in Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake.

Table 1 Valley Branch Watershed District: Lake plant survey summary statistics (June 2019)

Lake	Number of Species*	Number of Native Species*	Number of Native Species Collected on Rake*	Number of Invasive Species	Maximum Depth of Plant Growth (feet)	Frequency of Occurrence (%)	Average Rake Fullness	Simpson Diversity Index Value
Jane	25	21	20	4	23.0	96	2.93	0.90
Elmo	28	25	18	3	24.0	84	1.80	0.90
Olson	27	21	18	6	20.0	94	2.21	0.88
DeMontreville	23	18	18	5	18.5	89	2.06	0.89
Silver	21	16	12	5	10.5	72	1.22	0.68
Long	17	13	11	4	20.0	75	1.38	0.82

*Filamentous algae, aquatic moss, and liverworts were not included in number of species.

Table 2 Valley Branch Watershed District: June 2019 invasive species summary
Frequency of occurrence at sites shallower than maximum depth of plant growth (percent or observed*)

Lake	*Myriophyllum spicatum* (Eurasian watermilfoil)	*Potamogeton crispus* (curly-leaf pondweed)	*Phalaris arundinacea* (reed canary grass)	*Lythrum salicaria* (purple loosestrife)	*Typha angustifolia* (narrow-leaved cattail)	*Typha glauca* (hybrid cattail)	*Iris pseudacorus* (Yellow iris)
Elmo	29.11	1.27			12.66		
Jane	24.44	25.56		P	P		
Olson	3.33	6.67	P	P		P	P
DeMontreville	4.12	12.37	P			P	P
Silver	0.87		P	P	0.87		P
Long	6.45	29.03	P		P		

*Observed in the lake but not collected on the rake (Present = P).

Table 3 Long Lake acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM (DOW 82.011800)

Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/15/2010	52.31	53.71	97.39%
8/1/2011	4.89	22.67	21.56%
4/29/2012	2.44	31.47	7.74%
6/18/2012	7.24	21.06	34.39%
5/16/2013 (Partial Survey)	14.28	--	--
6/24/2013	7.88	50.43	15.62%
5/24/2014	9.75	39.94	24.41%
6/25/2014	4.77	47.68	10.00%
5/9/2015	5.5	52.81	10.41%
6/22/2015	0.40	54.72	0.73%
5/1/2016	3.78	50.34	7.51%
6/27/2016	0.33	51.94	0.64%
6/27/2017	5.58	50.24	11.10%
5/20/2018	20.36	46.97	43.33%
7/29/2018	34.71	53.51	64.87%
4/28/2019	23.09	45.21	51.07%
6/29/2019	2.17	47.15	4.60%

Table 4 Long Lake – Katherine Abbott Pond acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM

Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/27/2017	2.88	2.93	98.32%
5/20/2018	2.08	2.93	70.80%
7/29/2018	0	2.93	0%
4/28/2019	0	2.93	0%
6/29/2019	0	2.93	0%

Table 5 Simpson Diversity Index values for Long Lake, Washington County, MN (DOW 82.011800)

Year	Month	Day	Diversity
2010	June	15	0.40
2011	August	1	0.80
2012	June	18	0.85
2013	June	24	0.81
2014	June	25	0.83
2015	June	22	0.77
2016	June	27	0.78
2017	June	27	0.84
2018	July	29	0.80
2019	June	29	0.82

Table 6 MNDNR Plant IBI: Long Lake, Washington County, MN (DOW 82.011800)

Year	Month	Day	MNDNR Species Richness Plant IBI Criterion*	Long Lake Species Richness**	Percent Difference between MNDNR Criterion and Long Lake Species Richness	MNDNR Floristic Quality Index (FQI) Plant IBI Criterion*	Long Lake FQI**	Percent Difference between MNDNR Criterion and Long Lake FQI	Does Long Lake Meet MNDNR Plant IBI Criteria?
2010	June	15	≥12	14	17	≥18.6	21.3	15	Yes
2011	August	1	≥12	13	8	≥18.6	18.9	2	Yes
2012	June	18	≥12	13	8	≥18.6	18.9	2	Yes
2013	June	24	≥12	12	0	≥18.6	17.6	-5	No
2014	June	25	≥12	12	0	≥18.6	17.0	-9	No
2015	June	22	≥12	16	33	≥18.6	20.0	8	Yes
2016	June	27	≥12	17	42	≥18.6	21.8	17	Yes
2017	June	27	≥12	16	33	≥18.6	21.8	17	Yes
2018	July	29	≥12	15	25	≥18.6	19.9	7	Yes
2019	June	29	≥12	14	17	≥18.6	19.5	5	Yes

*Criteria for North Central Hardwoods—2B Deeper Water Lakes (≥ 15’ Max Depth)

**Limited to species selected by MNDNR for FQI computations. Does not include filamentous algae, aquatic moss, liverworts, and several emergent species.

Table 7 Percent frequencies of occurrence in vegetated depth range of plants in Long Lake, Washington County, MN (DOW 82.011800)

Year	Month	Day	*Myriophyllum sibiricum*	*Myriophyllum spicatum*	*Ceratophyllum demersum*	*Ranunculus aquatilis*	*Utricularia vulgaris*	*Elodea canadensis*	*Heteranthera dubia*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton foliosus*	*Potamogeton pusillus*	*Potamogeton sp.*	*Potamogeton nodosus*	*Stuckenia pectinata*	*Najas flexilis*	*Nitella spp.*	*Lychnothamnus bgarbatus*	*Chara spp.*	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*	Wolffia columbiana	Filamentous Algae	Aquatic Moss	*Bolboschoenus fluviatilis*	*Eleocharis acicularis*	*Phalaris arundinacea*	*Schoenoplectus acutus*	*Sparganium eurycarpum*	*Typha glauca*	*Typha angustifolia*	*Typha sp.*	*Salix spp.*
			Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Free-float	Free-float	Free-float	Free-float	Algae	Mosses	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Upland
			Dicot	**Dicot**	**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot				Monocot	Monocot	Monocot	Monocot			Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	**Eudicot**
			Native	**Non-Native**	Native	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native		Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Hybrid	**Non-Native**		**Non-Native**
2010	06	15	1	92					8		6			P			2				2	2	1					P	1	2	P			1	1
2011	08	1		29	5		P		2		2		2				16			8	P	11			15	3	P	5	P	2					
2012	06	18		29	9				21		41		5				26	2		17	2	5			16		2	2	2	2		2			
2013	06	24		19	5				3		25		5				7			11	2	1			20		1	1	P	1		P			
2014	06	25		10	10			2	2		11		14				1			20		2			17		1	2	P	1		P			
2015	06	22		1	6			26	1		6		8		P	P	1	1		26	1			1	25		P	1	P	P		P			
2016	06	27		1	10	3		31	2		10		4		1		1	1		29	1	1	P		37		P	1	P	P		P			
2017	06	27		14	13	3		28	2	1	17	P	1		2			5	1	31	2	2	2	2	20				P						
2018	07	29		58	28			22	1		7	P	7		3			6	2	31	3		1	3	10	3		P		P					
2019	06	29		6	42			23	4		29		3		4		2	6	2	12		5			19	3	P	1	P	P			P		

*P = Present—Observed but not collected on the sampling rake

Table 8 Lake DeMontreville acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM (DOW 82.010100)

Sample Date	EWM Extent: acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/18/2012	5.39	137.07	3.93%
6/24/2013	50.88	144.45	35.22%
5/24/2014	53.08	143.93	36.88%
6/28/2014	26.75	146.94	18.20%
5/10/2015	58.01	149.40	38.83%
6/21/2015	20.60	157.29	13.10%
5/1/2016	38.28	156.25	24.50%
6/26/2016	19.04	147.06	12.95%
5/21/2017	44.27	144.49	30.64%
6/25/2017	14.15	146.42	9.66%
7/30/2018	12.74	154.91	8.23%
6/24/2019	2.58	142.69	1.81%

Table 9 Simpson Diversity Index values for Lake DeMontreville, Washington County, MN (DOW 82.010100)

Year	Month	Day	Diversity
2012	June	18	0.89
2013	June	24	0.90
2014	June	28	0.90
2015	June	21	0.90
2016	June	26	0.86
2017	June	25	0.87
2018	July	30	0.87
2019	June	24	0.89

Table 10 MNDNR Plant IBI: Lake DeMontreville, Washington County, MN (DOW 82.010100)

Year	Month	Day	MNDNR Species Richness Plant IBI Criterion*	Lake DeMontreville Species Richness**	Percent Difference between MNDNR Criterion and Lake DeMontreville Species Richness	MNDNR Floristic Quality Index (FQI) Plant IBI Criterion*	Lake DeMontreville FQI**	Percent Difference between MNDNR Criterion and Lake DeMontreville FQI	Does Lake DeMontreville Meet MNDNR Plant IBI Criteria?
2012	June	18	≥12	22	83	≥18.6	26.4	42	Yes
2013	June	24	≥12	24	100	≥18.6	27.6	48	Yes
2014	June	28	≥12	22	83	≥18.6	27.9	50	Yes
2015	June	21	≥12	24	100	≥18.6	28.6	54	Yes
2016	June	26	≥12	19	58	≥18.6	24.6	32	Yes
2017	June	25	≥12	22	83	≥18.6	25.5	37	Yes
2018	July	30	≥12	20	67	≥18.6	25.7	38	Yes
2019	June	24	≥12	19	58	≥18.6	24.6	32	Yes

*Criteria for North Central Hardwoods—2B Deeper Water Lakes (≥ 15' Max Depth)

**Limited to species selected by MNDNR for FQI computations. Does not include filamentous algae, aquatic moss, liverworts, and several emergent species.

Table 11 Percent frequencies of occurrence in vegetated depth range of plants in Lake DeMontreville, Washington County, MN (DOW 82.010100)

Year	Month	Day	*Ceratophyllum demersum*	*Myriophyllum spicatum*	*Myriophyllum sibericum*	*Ranunculus aquatilis*	*Elodea canadensis*	*Heteranthera dubia*	*Isoetes echinospora*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton friesii*	*Potamogeton illinoensis*	*Potamogeton pusillus*	*Potamogeton robbinsii*	*Potamogeton zosteriformis*	*Stuckenia pectinata*	*Najas flexilis*	*Najas s guadalupensis*	*Vallisneria americana*	*Chara sp.*	*Nitella sp.*	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*	*Wolffia columbiana*	*Nymphaea odorata*	*Polygonum amphibium*	Filamentous Algae	Aquatic moss	*Eleocharis acicularis*	*Eleocharis palustris*	*Lythrum salicaria*	*Iris Pseudacorus*	*Phalaris arundinacea*	*Sagittaria graminea*	*Schoenoplectus acutus*	*Schoenoplectus tabernaemontani*	*Typha angustifolia*	*Typha latifolia*	*Typha glauca*
			Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Free-float	Free-float	Free-float	Free-float	Float-leaf	Float-leaf	Algae	Mosses	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent
			Dicot	**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot		Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot			Monocot	Monocot	Monocot	Monocot	**Dicot**	**Dicot**			Monocot	Monocot		Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot
			Native	**Non-Native**	Native	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	**Non-Native**	**Non-Native**	Native	Native	Native	**Non-Native**	Native	Native	**Non-Native**
2012	06	18	38	4	5	4	8	5		4	49		9	41	12	50		2		4	6	11		22		1	3		6	1	1	P	P		1				P	P	P	1
2013	06	24	50	33	12	5	22	7		3	42	1	7	30	26	48	2	2		2	5	3	1	28	1		4	P	33			P		P	P				P	P	1
2014	06	28	61	19	13	3	32	7		3	10	1	7	25	19	39		4	1	7	10	3		17			3	P	14	3	1	P			1						1
2015	06	21	61	17	1	5	30	2	1	6	31		6	18	17	45		6	8	12	13	6		15			3	P	27	6	2	P		P	P		P	P			1
2016	06	26	70	16		3	68	4			2		6	5	4	12		4	18	14	30	11		14			5	1	39	1			P		P		P	P			1
2017	06	25	53	14		5	64	1		1	17		3	13	4	2			17	18	35	10	3	5	3	2	3	P	31	6		P			P		P				P
2018	07	30	49	12			24	1		1			3	24	5	3	P	1	8	21	45	4	3	23		3	4	P	16	2					P	1					P
2019	06	24	25	4			10	1		2	12		4	21	6	3			4	12	48	26	2	14		4	3	1	28	5	1			P	P						1

*P = Present—Observed but not collected on the sampling rake

Table 12 Lake Olson acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM (DOW 82.010300)

Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/18/2012	2.17	88.03	2.46%
6/24/2013	3.55	89.01	3.99%
5/24/2014	22.96	87.11	26.36%
6/28/2014	23.96	89.02	26.92%
5/9/2015	31.77	89.26	35.59%
6/21/2015	28.13	87.02	32.33%
5/1/2016	53.49	89.26	59.93%
6/26/2016	17.56	89.26	19.67%
5/21/2017	43.61	89.26	48.86%
6/25/2017	21.03	88.80	23.68%
7/30/2018	6.58	89.26	7.38%
6/27/2019	1.43	89.26	1.60%

Table 13 Simpson Diversity Index values for Lake Olson, Washington County, MN (DOW 82.010300)

Year	Month	Day	Diversity
2012	June	18	0.92
2013	June	24	0.91
2014	June	28	0.90
2015	June	21	0.90
2016	June	26	0.85
2017	June	25	0.86
2018	July	30	0.87
2019	June	27	0.88

Table 14 MNDNR Plant IBI: Lake Olson, Washington County, MN (DOW 82.010300)

Year	Month	Day	MNDNR Species Richness Plant IBI Criterion*	Lake Olson Species Richness**	Percent Difference between MNDNR Criterion and Lake Olson Species Richness	MNDNR Floristic Quality Index (FQI) Plant IBI Criterion*	Lake Olson FQI**	Percent Difference between MNDNR Criterion and Lake Olson FQI	Does Lake Olson Meet MNDNR Plant IBI Criteria?
2012	June	18	≥12	21	75	≥18.6	25.6	38	Yes
2013	June	24	≥12	21	75	≥18.6	25.3	36	Yes
2014	June	28	≥12	23	92	≥18.6	27.1	46	Yes
2015	June	21	≥12	25	108	≥18.6	29.2	57	Yes
2016	June	26	≥12	23	92	≥18.6	27.1	46	Yes
2017	June	25	≥12	24	100	≥18.6	27.8	49	Yes
2018	July	30	≥12	21	75	≥18.6	26.6	43	Yes
2019	June	27	≥12	21	75	≥18.6	26.2	41	Yes

*Criteria for North Central Hardwoods—2B Deeper Water Lakes (≥ 15' Max Depth)

**Limited to species selected by MNDNR for FQI computations. Does not include filamentous algae, aquatic moss, liverworts, and several emergent species.

Table 15 Percent frequencies of occurrence in vegetated depth range of plants in Lake Olson, Washington County, MN (DOW 82.010300)

Year	Month	Day	*Ceratophyllum demersum*	*Myriophyllum spicatum*	*Myriophyllum sibericum*	*Ranunculus aquatilis*	*Elodea canadensis*	*Heteranthera dubia*	*Isoetes echinospora*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton illinoensis*	*Potamogeton nodosus*	*Potamogeton pusillus*	*Potamogeton robbinsii*	*Potamogeton zosteriformis*	*Najas flexilis*	*Najas guadalupensis*	*Stuckenia pectinata*	*Vallisneria americana*	Chara sp.	*Lychnothamnus barbaratus*	*Nitella sp*	*Lemna trisulca*	*Nymphaea odorata*	*Polygonum amphibium*	Filamentous algae	Aquatic moss	*Calamagrostis canadensis*	*Eleocharis acicularis*	*Eleocharis palustris*	*Iris virginica*	*Iris pseudacorus*	*Lythrum salicaria*	*Phalaris arundinacea*	*Sagittaria cristata*	Sagittaria graminea	Schoenoplectus acutus	Schoenoplectus Tabernaemontani	Typha angustifolia	Typha glauca
			Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Free-float	Float-leaf	Float-leaf	Algae	Mosses	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent
			Dicot	**Dicot**	**Dicot**	**Dicot**	**Dicot**	Monocot		Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot			Monocot	Monocot	**Dicot**	**Dicot**			Monocot	Monocot	Monocot	Monocot	Monocot	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot
			Native	**Non-Native**	Native	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native		Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	**Non-Native**	**Non-Native**	Native	Native	Native	**Non-Native**	Native
			Ceratophyllum demersum	*Myriophyllum spicatum*	*Myriophyllum sibericum*	*Ranunculus aquatilis*	*Elodea canadensis*	*Heteranthera dubia*	*Isoetes echinospora*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton illinoensis*	*Potamogeton nodosus*	*Potamogeton pusillus*	*Potamogeton robbinsii*	*Potamogeton zosteriformis*	*Najas flexilis*	*Najas guadalupensis*	*Stuckenia pectinata*	*Vallisneria americana*	Chara sp.	*Lychnothamnus barbaratus*	*Nitella sp*	*Lemna trisulca*	*Nymphaea odorata*	*Polygonum amphibium*	Filamentous algae	Aquatic moss	*Calamagrostis canadensis*	*Eleocharis acicularis*	*Eleocharis palustris*	*Iris virginica*	*Iris pseudacorus*	*Lythrum salicaria*	*Phalaris arundinacea*	*Sagittaria cristata*	Sagittaria graminea	Schoenoplectus acutus	Schoenoplectus Tabernaemontani	Typha angustifolia	Typha glauca
2012	06	18	27	3	12	4	11	16		10	28	23		30	10	19	3			2	25		12	15	1	P	7	18		4	1				1				1	P	
2013	06	24	38	5	10	3	11	12		7	43	17		25	7	21	13		P		10		6	20	1		8	14		3	1				P				1	P	
2014	06	28	57	28	8	2	23	24	1	1	3	13		22	10	17	11	2	P	3	25		4	19	1		19	13		1	1				P				P	P	
2015	06	21	37	28	2	P	23	6		3	5	13	1	6	21	15	8	4	P	5	38		7	11	1		9	15		4	1	P			P	P			P	P	
2016	06	26	50	19		3	67	4			1	8	P	3	8	6	8	4	1	6	53		9	8	1	P	23	13	P	5	P				P		2		P	P	
2017	06	27	58	25		2	58	1		2	5	17	P	2	10	3	2	14	1	10	55		9	3	1	P	18	8	P	2			P		P		2	P	P		
2018	07	30	48	10			30	1		1			P	10	8	4	3	15	1	22	53		6	12	1	P	9	8	P	3			P	P	P		1	P			P
2019	06	27	38	3		1	15	2		1	7	4	1	18	21	3		5		16	53	1	17	13	1		18	11		3		P	P	P	P			P	P		P

*P = Present—Observed but not collected on the sampling rake

Table 16 Lake Jane acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM (DOW 82.010400)

Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/18/2012	0.10	118.54	0.08%
6/28/2013	1.68	121.82	1.38%
6/27/2014	24.08	112.61	21.38%
5/9/2015	44.16	125.08	35.31%
6/21/2015	31.01	126.77	24.46%
6/27/2016	68.71	131.23	52.36%
6/27/2017	26.26	126.40	20.77%
7/29/2018	9.07	128.01	7.09%
6/24/2019	26.87	126.45	21.25%

Table 17 Simpson Diversity Index values for Lake Jane, Washington County, MN (DOW 82.010400)

Year	Month	Day	Diversity
2012	June	18	0.92
2013	June	28	0.91
2014	June	27	0.92
2015	June	21	0.92
2016	June	27	0.90
2017	June	27	0.89
2018	July	29	0.89
2019	June	24	0.90

Table 18 MNDNR Plant IBI: Lake Jane, Washington County, MN (DOW 82.010400)

Year	Month	Day	MNDNR Species Richness Plant IBI Criterion*	Lake Jane Species Richness**	Percent Difference between MNDNR Criterion and Lake Jane Species Richness	MNDNR Floristic Quality Index (FQI) Plant IBI Criterion*	Lake Jane FQI**	Percent Difference between MNDNR Criterion and Lake Jane FQI	Does Lake Jane Meet MNDNR Plant IBI Criteria?
2012	June	18	≥12	28	133	≥18.6	31.6	70	Yes
2013	June	28	≥12	31	158	≥18.6	33.1	78	Yes
2014	June	27	≥12	29	142	≥18.6	32.3	74	Yes
2015	June	21	≥12	26	117	≥18.6	30.8	66	Yes
2016	June	27	≥12	27	125	≥18.6	30.8	66	Yes
2017	June	27	≥12	27	125	≥18.6	30.8	66	Yes
2018	July	29	≥12	28	133	≥18.6	31.9	72	Yes
2019	June	24	≥12	22	83	≥18.6	28.4	52	Yes

*Criteria for North Central Hardwoods—2B Deeper Water Lakes (≥ 15' Max Depth)

**Limited to species selected by MNDNR for FQI computations. Does not include filamentous algae, aquatic moss, liverworts, and several emergent species.

Table 19 Percent frequencies of occurrence in vegetated depth range of plants in Lake Jane, Washington County, MN (DOW 82.010400)

Year	Month	Day	*Ceratophyllum demersum*	*Bidens beckii*	*Myriophyllum spicatum*	*Myriophyllum sibericum*	*Ranunculus aquatilus*	*Elodea canadensis*	*Heteranthera dubia*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton friesii*	*Potamogeton illinoensis*	*Potamogeton nodosus*	*Potamogeton pusillus*	*Potamogeton praelongus*	*Potamogeton robbinsii*	*Potamogeton zosteriformis*	*Stuckenia pectinata*	*Najas flexilis*	*Najas guadalupensis*	*Vallisneria americana*	*Zannichellia palustris*	*Isoetes echinospora*	Chara sp.	*Nitella sp*	*Brasenia schreberi*	*Nymphaea odorata*	*Polygonum amphibium*	*Lemna minor*	*Lemna trisulca*	*Riccia fluitans*	*Wolffia columbiana*	Isoetes echinospora	Aquatic moss	Filamentous algae	*Carex pellita*	*Eleocharis acicularis*	*Eleocharis erythropoda*	*Iris virginica*	*Juncus articus variation balticus*	*Juncus canadensis*	*Juncus efflusus*	*Juncus pelocarpus*	*Juncus pilocarpus f. submersus*	*Lythrum salicaria*	*Phalaris arundinacea*	*Sagittaria cristata*	*Schoenplectus tabernaemontani*	*Typha angustifolia*	*Typha X glauca*	*Polygonum amphibium*
			Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Float-leaf	Float-leaf	Float-leaf	Free-float	Free-float	Free-float	Free-float	Quillwort	Mosses	Algae	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent
			Dicot	**Dicot**	**Dicot**	**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot				**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot				Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	**Dicot**
			Native	Native	**Non-Native**	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	**Non-Native**	**Non-Native**	Native	**Non-Native**	**Non-Native**	Native
2012	06	18	33		P	22	15	32	7	21	16	1	24		8	14	62	16	1	8	6	6			16		1	6	P	2	1		1			2		4				P	2		P	P	2	P	P	P	
2013	06	28	24		2	21	9	17	3	15	12		30		6	21	66	10	1	8	5	2	2	1	15	1	1	2		1	1	P	1			5		7	1		1				2	P	P	3	1	P		
2014	06	27	25		19	20	5	27	7	6	8	2	30	2	7	16	57	14	P	5	13	6	1	1	22		2	2			1				1	2	1	1	1		1	1	P			P	P	4	P		P	
2015	06	21	23	1	23	9	2	30		7	11	2	19	7	7	14	53	12	2	4	17	4			17	2	1	3			7				1	16		3								P	P	3	P	P		
2016	06	27	14		41	3	1	46	P	7	18		18	9	1	9	54	5	1	2	37	5	2	1	18	3		5	P							10	1	5	1	P	P	P				P	1	1	P	P		
2017	06	27	17		24		1	62	1	2	17		22	8		3	33	2	P	3	20	11			16	7	1	3			3			1		2		2	1		1	1			P	P	P	1	P	P		P
2018	07	29	14		9		1	59	3	7	1		10	2	1	6	36	1		9	34	17			18	2	1	2		1	10			1	1	4		2	1						1	P	P	2	P	P		P
2019	06	24	13		24			60		3	26		29	6	1	6	40			2	27	12			22	3	1	2			9				3	6		2	1						1	P		2		P		P

*P = Present—Observed but not collected on the sampling rake

Table 20 Lake Elmo acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM (DOW 82.010600)

Sample Date	EWM Extent: acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/18–19/2012	71.09	112.68	63.09
6/28/2013	52.69	109.61	48.07
6/27/2014	50.58	112.42	44.99
6/21/2015	67.52	113.53	59.47
4/30/2016	58.77	123.62	47.54%
6/27/2016	78.58	123.31	63.73%
7/29/2016*	80.15	126.60	63.31%
6/27/2017	57.32	120.19	47.69%
7/30/2018	30.12	116.26	25.91%
6/27/2019	49.43	157.19	31.45%

*July 29, 2016, data collected by the Lake Elmo Association

Table 21 Simpson Diversity Index values for Lake Elmo, Washington County, MN (DOW 82.010600)

Year	Month	Day	Diversity
2012	June	18–19	0.91
2013	June	28	0.89
2014	June	27	0.88
2015	June	21	0.88
2016	June	27	0.89
2016	July	29	0.88
2017	June	27	0.91
2018	July	30	0.89
2019	June	27	0.90

July 29, 2016, data collected by the Lake Elmo Association

Table 22 MNDNR Plant IBI: Lake Elmo, Washington County, MN (DOW 82.010600)

Year	Month	Day	MNDNR Species Richness Plant IBI Criterion*	Lake Elmo Species Richness**	Percent Difference between MNDNR Criterion and Lake Elmo Species Richness	MNDNR Floristic Quality Index (FQI) Plant IBI Criterion*	Lake Elmo FQI**	Percent Difference between MNDNR Criterion and Lake Elmo FQI	Does Lake Elmo Meet MNDNR Plant IBI Criteria?
2012	June	18–19	≥12	31	158	≥18.6	31.1	67	Yes
2013	June	28	≥12	28	133	≥18.6	28.0	51	Yes
2014	June	27	≥12	25	108	≥18.6	25.4	37	Yes
2015	June	21	≥12	26	117	≥18.6	26.9	45	Yes
2016	June	27	≥12	26	117	≥18.6	26.9	45	Yes
2016	July	29	≥12	26	117	≥18.6	26.5	42	Yes
2017	June	27	≥12	29	142	≥18.6	29.2	57	Yes
2018	July	30	≥12	24	100	≥18.6	25.3	36	Yes
2019	June	27	≥12	25	108	≥18.6	26.8	44	Yes

* Criteria for North Central Hardwoods—2B Deeper Water Lakes (≥ 15' Max Depth)

**Limited to species selected by MNDNR for FQI computations. Does not include filamentous algae, aquatic moss, liverworts, and several emergent species.

Table 23 Percent frequencies of occurrence in vegetated depth range of plants in Lake Elmo, Washington County, MN (DOW 82.010600)

Year	Month	Day	*Ceratophyllum demersum*	*Elodea canadensis*	*Myriophyllum spicatum*	*Myriophyllum sibericum*	*Ranunculus aquatilus*	*Utricularia vulgaris*	*Heteranthera dubia*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton foliosus*	*Potamogeton friesii*	*Potamogeton illinoensis*	*Potamogeton natans*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton richardsonii*	*Potamogeton strictifolius*	*Potamogeton zosteriformis*	*Najas flexilis*	*Najas guadalupensis*	*Stuckenia pectinata*	Chara sp.	*Nitella sp*	*Nymphaea odorata*	*Polygonum amphibium*	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*	Wolffia columbiana	Filamentous algae	*Riccia fluitans*	*Ricciocarpus natans*	*Carex comosa*	*Carex pellita*	*Carex scoparia*	*Eleocharis acicularis*	*Eleocharis erythropoda*	*Eleocharis palustris*	*Equisetum fluviatile*	*Iris virginica*	*Juncus canadensis*	*Phalaris arundinacea*	*Phragmites australis*	*Polygonum amphibium*	*Schoenplectus acutus*	*Schoenoplectus pungens*	*Schoenoplectus Tabernaemontani*	*Sparganium eurycarpum*	*Typha angustifolia*	*Typha glauca*
			Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Float-leaf	Float-leaf	Free-float	Free-float	Free-float	Free-float	Algae	Liverwort	Liverwort	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent
			Dicot	**Dicot**	**Dicot**	**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot			**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot				Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	**Non-Native**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot
			Native	Native	**Non-Native**	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	**Non-Native**
2012	06	18-19	29	8	44	1	7	1		P	3	P	P	13	12		1	P	1	7	1	28	5	37	1	12	P	1				5			P			3	1	3	P			4			4	P	5	P	17	
2013	06	28	26	3	37	P	4	1			P		1	7	9		P	P		3	1	21	1	33	1	13		4				8		P	P	1	1		1	P	P	1		1	1		3	P	4	P	16	
2014	06	27	43	5	34		1	P			P		P	4	9			P		4	4	18	1	31		9	P	1		1		14			P	1	P		1	P	P			3	P		5	P	3			16
2015	06	21	41	3	45	P	3	1	1	P	P			4	13		1			7		12	3	35		13	P	5		7		11	3					3	P	P	P		P	P		3	P	3		17	
2016	06	27	43	8	43		6	P	3	P	1			9	10		1			6	P	23	1	34		18	P	4	1	3		8		1					P	P			1	P		5	P	P		15	1
2016	07	29	40	8	39		3	P	3	P	P			11	10	P				4	1	28	3	29		11	P	3		1		3						1	P	P				P		5	P	3		1	15
2017	06	27	42	6	32		9	3	1	P	3			13	10	1	P			4		29	6	21	1	14		4	4	5	4	4	P					1			P				P	P	3	P	P		13	1
2018	07	30	43	5	25			P	P	3				9	12	P				9		35	8	14		16	P	1	3	3		5			1			P	1		P		1		P	P	4	P	P		16	
2019	06	27	33	4	29		1	3	1	1	1			8	9		P			3		20	5	13		13		6	4	6	5	19						P			P				P	P	3	P	P		13	

*P = Present—Observed but not collected on the sampling rake

July 29, 2016, data collected by the Lake Elmo Association

Table 24 Silver Lake acres of EWM, acres of plant growth, and percentage of plant-growth area with EWM (DOW 62.000100)

Sample Date	EWM Extent: acres of EWM	Acres of Plant Growth	Percentage of Plant-Growth Area with EWM
6/25/2017	30.43	69.78	43.61%
7/29/2018	0.32	68.99	0.46%
4/29/2019	0.30	--	--
6/24/2019	0.31	69.03	0.45%

Table 25 Simpson Diversity Index values for Silver Lake, Ramsey County, MN (DOW 62.000100)

Year	Month	Day	Diversity
2006	June	7	0.83
2006	July	26	0.79
2007	June	11	0.79
2007	August	13	0.66
2011	August	1	0.77
2012	July	20	0.61
2013	August	13	0.81
2014	August	5	0.79
2015	August	20	0.77
2016	August	9	0.80
2017	June	25	0.82
2018	July	29	0.67
2019	June	24	0.68

Table 26 MNDNR Plant IBI: Silver Lake, Ramsey County, MN (DOW 62.000100)

Year	Month	Day	MNDNR Species Richness Plant IBI Criterion*	Silver Lake Species Richness**	Percent Difference between MNDNR Criterion and Silver Lake Species Richness	MNDNR Floristic Quality Index (FQI) Plant IBI Criterion*	Silver Lake FQI**	Percent Difference between MNDNR Criterion and Silver Lake FQI	Does Silver Lake Meet MNDNR Plant IBI Criteria?
2006	June	7	≥12	19	58	≥18.6	25.7	38	Yes
2006	July	26	≥12	15	25	≥18.6	22.0	18	Yes
2007	June	11	≥12	13	8	≥18.6	19.4	4	Yes
2007	August	13	≥12	12	0	≥18.6	18.5	-1	No
2008	June	23	≥12	9	-25	≥18.6	16.7	-10	No
2008	August	24	≥12	7	-42	≥18.6	15.1	-19	No
2009	June	2	≥12	10	-17	≥18.6	16.1	-13	No
2009	August	9	≥12	8	-33	≥18.6	13.8	-26	No
2010	June	16	≥12	7	-42	≥18.6	12.1	-35	No
2010	August	6	≥12	9	-25	≥18.6	14.0	-25	No
2011	August	1	≥12	11	-8	≥18.6	16.6	-11	No
2012	July	20	≥12	8	-33	≥18.6	14.1	-24	No
2013	August	13	≥12	13	8	≥18.6	18.6	0	Yes
2014	August	5	≥12	11	-8	≥18.6	15.7	-16	No
2015	August	20	≥12	14	17	≥18.6	19.0	2	Yes
2016	August	9	≥12	11	-8	≥18.6	16.0	-14	No
2017	June	25	≥12	20	67	≥18.6	23.9	29	Yes
2018	July	29	≥12	17	42	≥18.6	22.3	20	Yes
2019	June	24	≥12	17	42	≥18.6	23.5	27	Yes

* Criteria for North Central Hardwoods—2B Deeper Water Lakes (≥ 15' Max Depth)

**Limited to species selected by MNDNR for FQI computations. Does not include filamentous algae, aquatic moss, liverworts, and several emergent species.

Table 27 Percent frequencies of occurrence in vegetated depth range of plants in Silver Lake, Washington County, MN (DOW 62.000100)

Year	Month	Day	Surveyor	*Ceratophyllum demersum*	*Elodea canadensis*	*Myriophyllum spicatum*	*Myriophyllum sibericum*	*Ranunculus aquatilus*	*Ranunculus sp.*	*Heteranthera dubia*	*Potamogeton amplifolius*	*Potamogeton crispus*	*Potamogeton foliosus*	*Potamogeton praelongus*	*Potamogeton pusillus*	*Potamogeton nodosus*	*Potamogeton richardsonii*	*Potamogeton robbinsii*	*Potamogeton sp.*	*Potamogeton zosteriformis*	*Najas flexilis*	*Najas guadalupensis*	*Najas sp.*	*Stuckenia pectinata*	Chara sp.	*Nitella*	*Chara and Nitella*	*Nymphaea odorata*	*Lemna minor*	*Lemna trisulca*	*Spirodela polyrhiza*	Wolffia columbiana	Aquatic moss	Filamentous algae	*Riccia fluitans*	*Eleocharis acicularis*	*Eleocharis sp.*	*Iris virginica*	*Iris pseudocorus*	*Lythrum salicaria*	*Phalaris arundinacea*	*Schoenplectus tabernaemontani*	*Typha angustifolia*	*Typha sp.*
				Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Float-leaf	Free-float	Free-float	Free-float	Free-float	Mosses	Algae	Liverwort	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent
				Dicot	**Dicot**	**Dicot**	**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot			**Dicot**	Monocot	Monocot	Monocot	Monocot				Monocot	Monocot	Monocot	Monocot	**Dicot**	**Non-Native**	Monocot	Monocot	Monocot	Monocot
				Native	Native	**Non-Native**	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	**Non-Native**	**Non-Native**	**Non-Native**	Native	**Non-Native**	Native	
2006	06	7	VBWD	97	49	70	3		6	12	12	21		1			1	1	1	22	25				1	2		3		14							1							
2006	07	26	VBWD	97	41	56	10		1	14	10	1						1		1	29				3	1		2		9													
2007	06	11	Fortin	81	56	48	3				6	2							12		11					1		2	1	28													1
2007	08	13	Fortin	96	32	8						1							5		7									34													
2008	6	23	U of M	54	17					1				1							1				4			3		14					1							
2008	8	24	U of M	11	12					2	1			3							1				3			5		5					3							
2009	6	2	U of M	3	29					2		1													26	1		4	1	1					1							1
2009	8	9	U of M	1	44	1				6				1							1				40			8	1						3							1
2010	6	16	MnDNR		22	6		1			1	62												9	55																	
2010	8	6	MnDNR	3	25	16				4	1	1			2									3	34																	
2011	8	1	MnDNR	2	13	42	4			3		5	10	2										2	21			6														3
2012	7	20	MnDNR		4	71	9					8	1	1										1	24			3														1
2013	8	13	MnDNR	10	2	11	19					3	2	1							2			2	2	30		7								2						
2014	8	5	MnDNR	22	2	63				1		38			13						4			4		44		5								1						
2015	8	20	MnDNR	39	2	7	1	1		7		2	6							1			5	1			47	8								1						
2016	8	9	MnDNR	46	3	19				4		17		1									8	2			29	8								2						

Table 27 (Continued)

Year	Month	Day	Surveyor	Ceratophyllum demersum	Elodea canadensis	Myriophyllum spicatum	Myriophyllum sibericum	Ranunculus aquatilus	Ranunculus sp.	Heteranthera dubia	Potamogeton amplifolius	Potamogeton crispus	Potamogeton foliosus	Potamogeton praelongus	Potamogeton pusillus	Potamogeton nodosus	Potamogeton richardsonii	Potamogeton robbinsii	Potamogeton sp.	Potamogeton zosteriformis	Najas flexilis	Najas guadalupensis	Najas sp.	Stuckenia pectinata	Chara sp.	Nitella	Chara and Nitella	Nymphaea odorata	Lemna minor	Lemna trisulca	Spirodela polyrhiza	Wolffia columbiana	Aquatic moss	Filamentous algae	Riccia fluitans	Eleocharis acicularis	Eleocharis sp.	Iris virginica	Iris pseudocorus	Lythrum salicaria	Phalaris arundinacea	Schoenplectus tabernaemontani	Typha angustifolia	Typha sp.
				Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Submersed	Free-float	Free-float	Free-float	Free-float	Mosses	Algae	Liverwort	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent	Emergent
				Dicot	**Dicot**	**Dicot**	**Dicot**	**Dicot**	**Dicot**	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot				**Dicot**	Monocot	Monocot	Monocot	Monocot				Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot	Monocot
				Native	Native	**Non-Native**	Native	Native	Native	Native	Native	**Non-Native**	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	Native	**Non-Native**	**Non-Native**	**Non-Native**	Native	**Non-Native**		
2017	06	25	VBWD	26	3	31		P		P		32	P	P	1	P				1	1			P	40			5	4	1	3	2		29		2		P			P		1	
2018	07	29	VBWD	64	1	1				4			P		2	1				P	4				30			9	3	2	2	2	1	19		2		P		P	P	P	1	
2019	06	24	VBWD	57		1				3	P				2	1				P		1			38			6	3	2	3	3	1	89	1	2		P	P	P	P	P	1	

*P = Present—Observed but not collected on the sampling rake

Figures

Description of Figures

Figure 1 shows locations of Long Lake, Long Lake-Katherine Abbott Pond, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake.

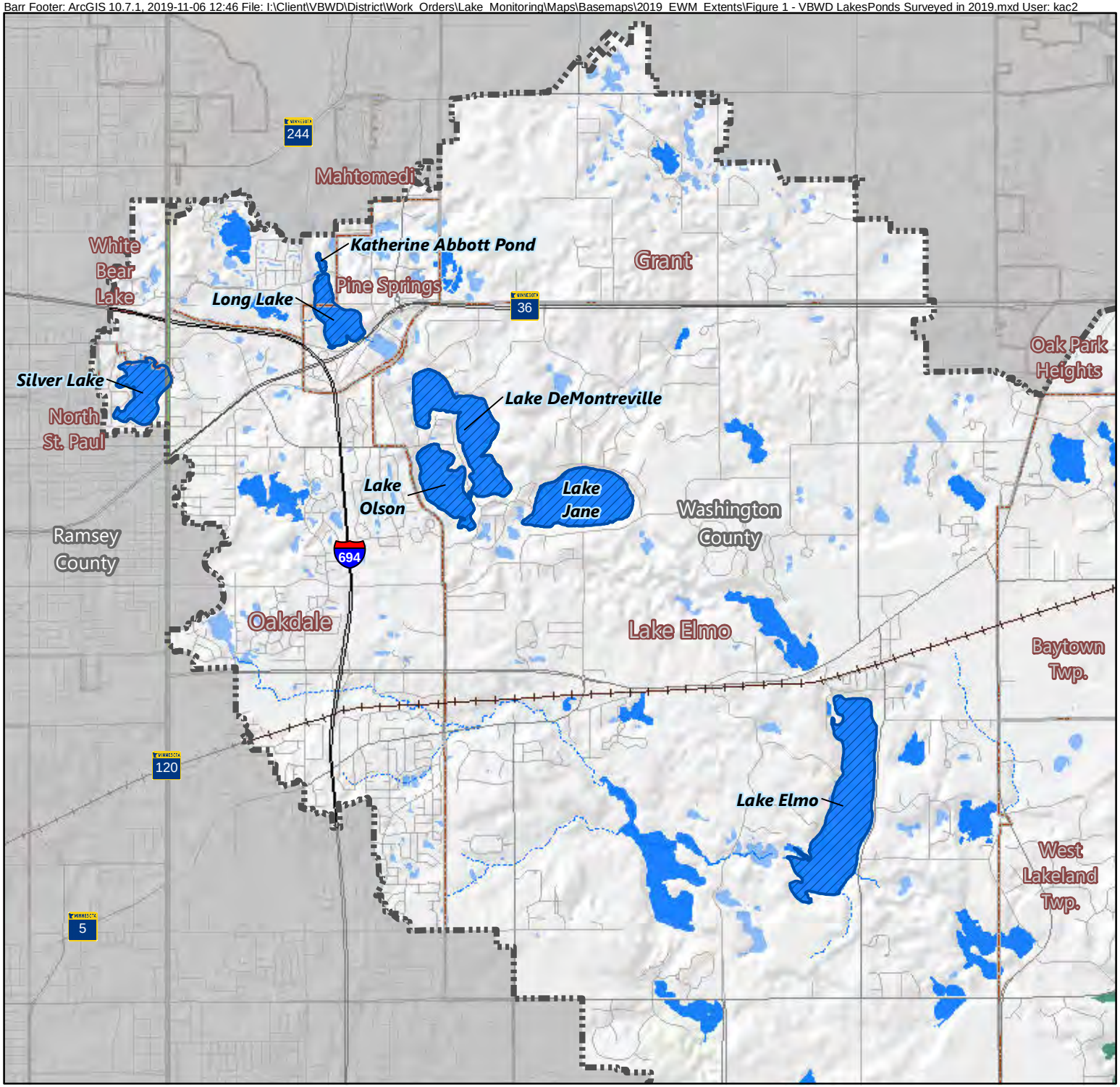
Figures 2, 5, 7, 9, and 14 show 2019 herbicide treatment areas in Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, and Silver Lake

Figures 3, 4, 6, 8, 10, 13, and 15 show 2019 EWM extent in Long Lake, Long Lake-Katherine Abbott Pond, Lake DeMontreville, Lake Olson, Lake Jane, Lake Elmo, and Silver Lake.

Figure 11 shows 2019 pre- and post-treatment EWM in Lake Jane

Figure 12 shows 2019 harvested areas in Lake Elmo

Barr Footer: ArcGIS 10.7.1, 2019-11-06 12:46 File: I:\Client\VBWD\District\Work_Orders\Lake_Monitoring\Maps\Basemaps\2019_EWM_Extents\Figure 1 - VBWD LakesPonds Surveyed in 2019.mxd User: kac2



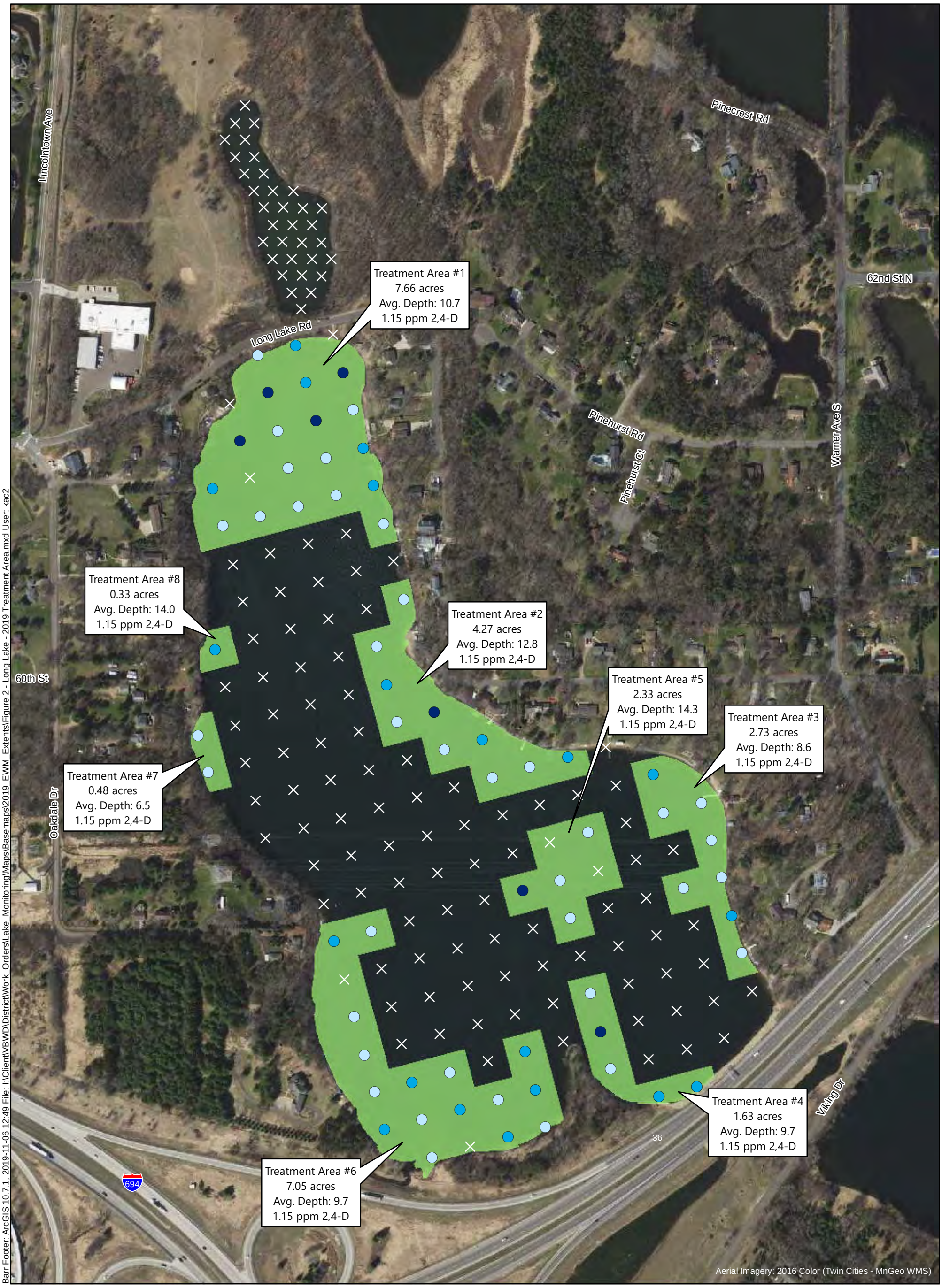
Lake/Pond Surveyed in 2019
Major Waterbody
Stormwater Pond
District Legal Boundary
Municipal Boundary
County Boundary

N

Miles
0 1 2

Figure 1

VBWD LAKES/PONDS SURVEYED IN 2019
Ramsey & Washington County
Valley Branch Watershed District



EWM Survey Results (April 2019)

- Not Observed
- Density = 1
- Density = 2
- Density = 3

Treatment Areas

N

Feet

0 150 300 600

Prepared by Margaret Rattei and Kelly Wild, Barr Engineering, for Valley Branch Watershed District based on results of a survey done by Matt Berg on April 28, 2019.
The Valley Branch Watershed District prepared this map to assist the Friends of Long Lake.

Figure 2

TREATMENT DESIGN FOR EURASIAN WATERMILFOIL BASED ON APRIL 2019 PLANT SURVEY RESULTS
Long Lake (82011800)
Washington County
Valley Branch Watershed District

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

Approximate Extent of EWM

Maximum Depth of Plant Growth

N

Feet

0 125 250 500

Figure 3

LONG LAKE EURASIAN WATERMILFOIL EXTENT, JUNE 2019
Long Lake (82011800)
Washington County
Valley Branch Watershed District

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

Approximate Extent of EWM

N

Feet

0 30 60 120

Figure 4

LONG LAKE-KATHERINE ABBOTT POND EURASIAN WATERMILFOIL EXTENT, JUNE 2019
Long Lake-Katherine Abbott Pond
Washington County
Valley Branch Watershed District

Barr Footer: ArcGIS 10.7.1, 2019-11-06 13:05 File: I:\Client\VBWD\District\Work_Orders\Lake_Monitoring\Maps\Basemaps\2019_EWM_Extents\Figure 4 - Long Lake-Katherine Abbott Pond June 2019 EWM Extent.mxd User: kac2

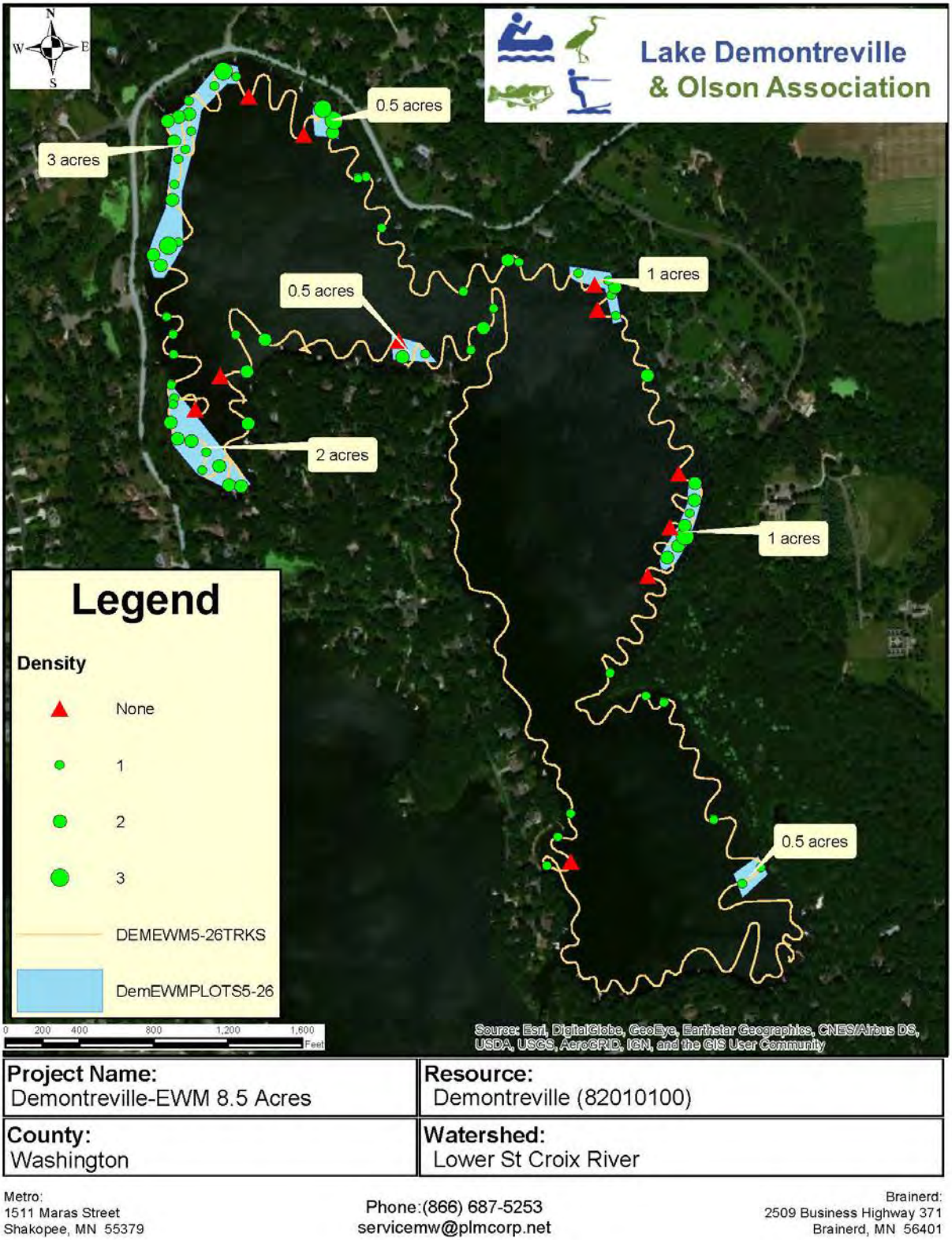


Figure 5. Lake DeMontreville 2019 herbicide treatment areas (Figure credit: PLM Lake and Land Management Corp. and Lake DeMontreville Olson Association)

Barr Footer: ArcGIS 10.7.1, 2019-11-06 12:47 File: I:\Client\VBWD\District\Work_Orders\Lake_Monitoring\Maps\Basemaps\2019_EWM_Extents\Figure 6 - Lake DeMontreville June 2019 EWM Extent.mxd User: kac2

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

Approximate Extent of EWM

Maximum Depth of Plant Growth

N

Feet

0 225 450 900

Figure 6

LAKE DEMONTREVILLE
EURASIAN WATERMILFOIL
EXTENT, JUNE 2019
Lake DeMontreville (82010100)
Washington County
Valley Branch Watershed District

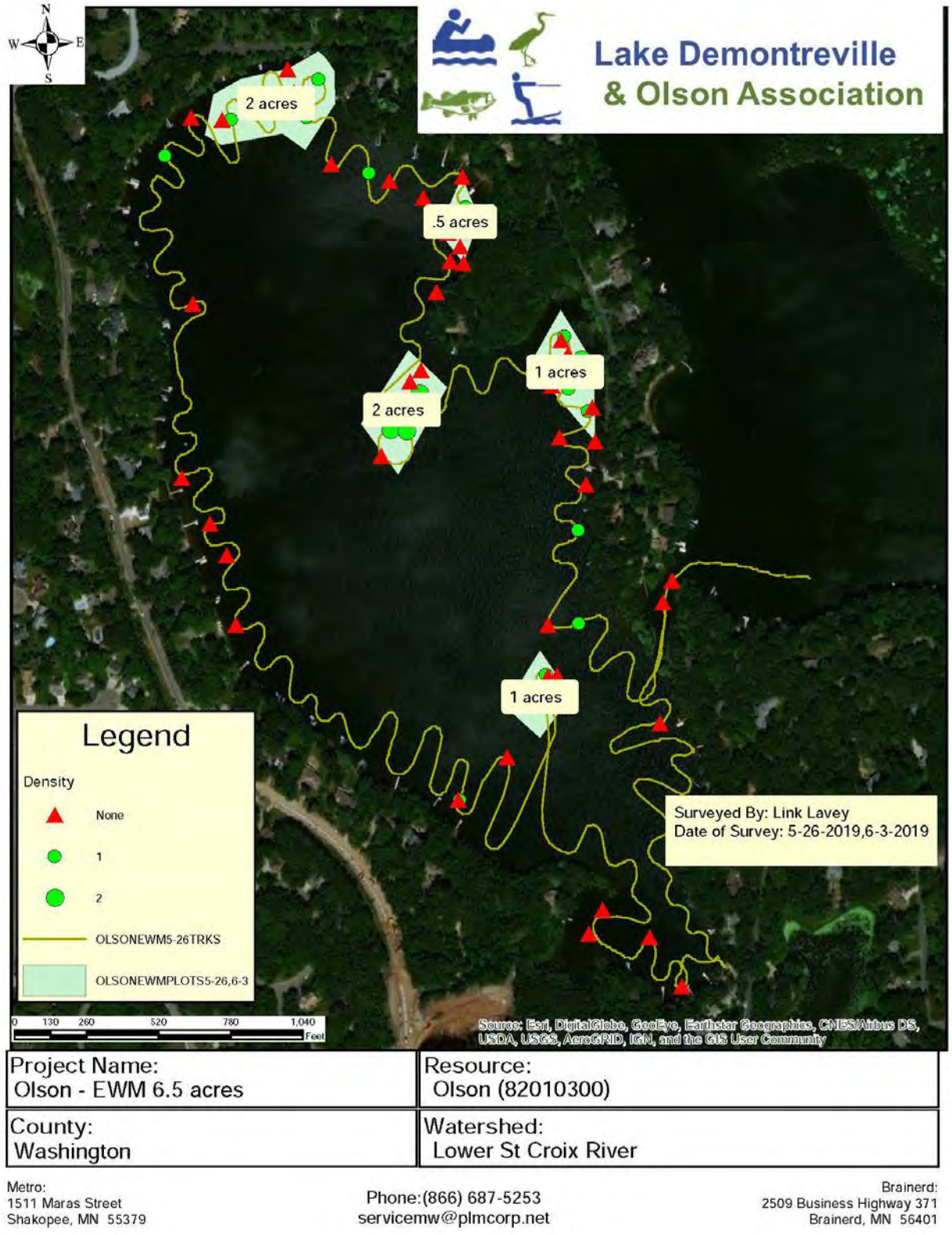
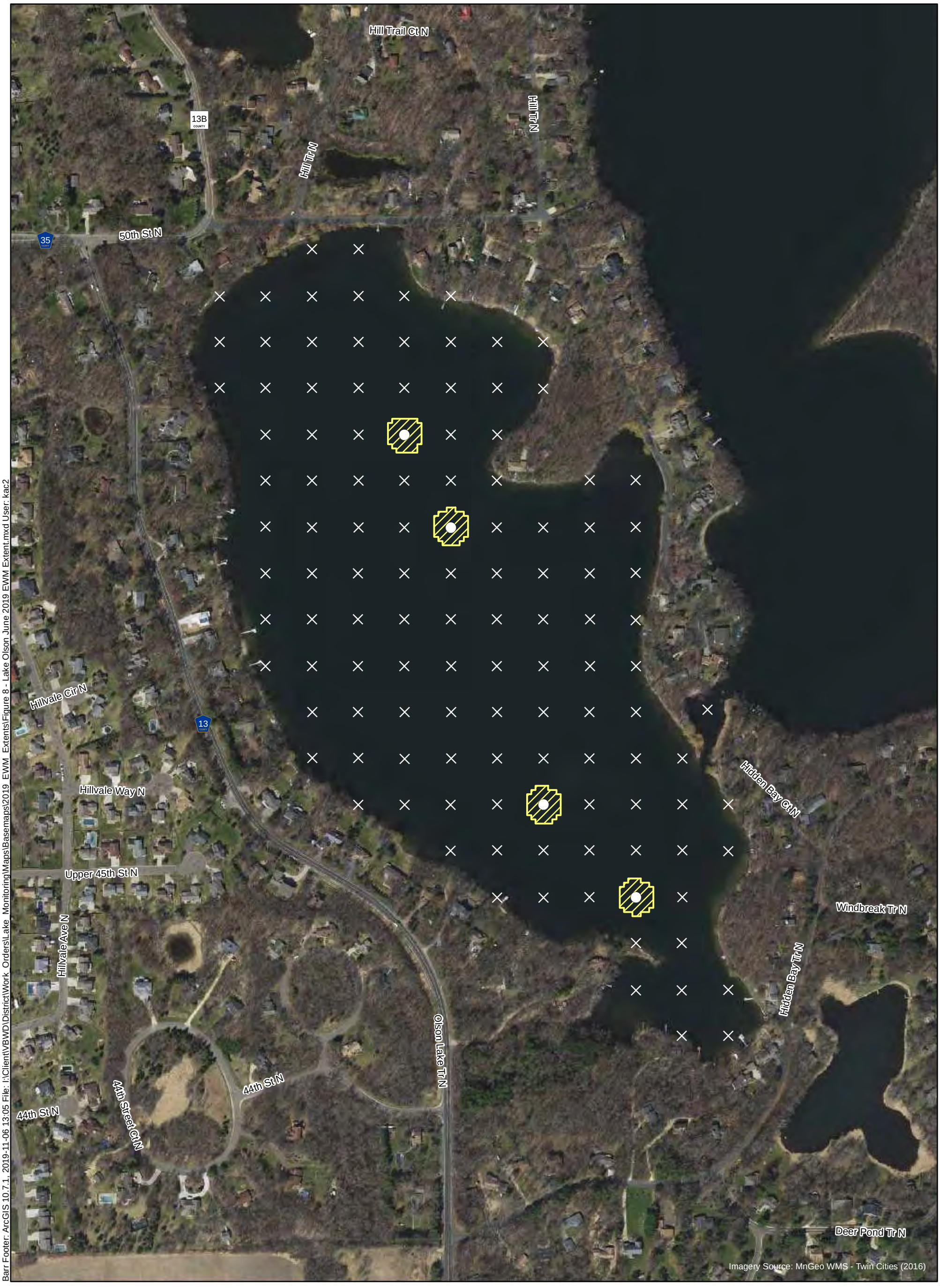


Figure 7. Lake Olson 2019 herbicide treatment areas (Figure credit: PLM Lake and Land Management Corp. and Lake DeMontreville Olson Association)



Barr Footer: ArcGIS 10.7.1 2019-11-06 13:05 File: I:\Client\VBWD\DistrictWork Orders\Lake Monitoring\Maps\Basemaps\2019 EWM Extents\Figure 8 - Lake Olson June 2019 EWM Extent.mxd User: kac2

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

Approximate Extent of EWM

N

Feet

0 175 350 700

Figure 8

LAKE OLSON EURASIAN WATERMILFOIL EXTENT, JUNE 2019
Lake Olson (82010300)
Washington County
Valley Branch Watershed District

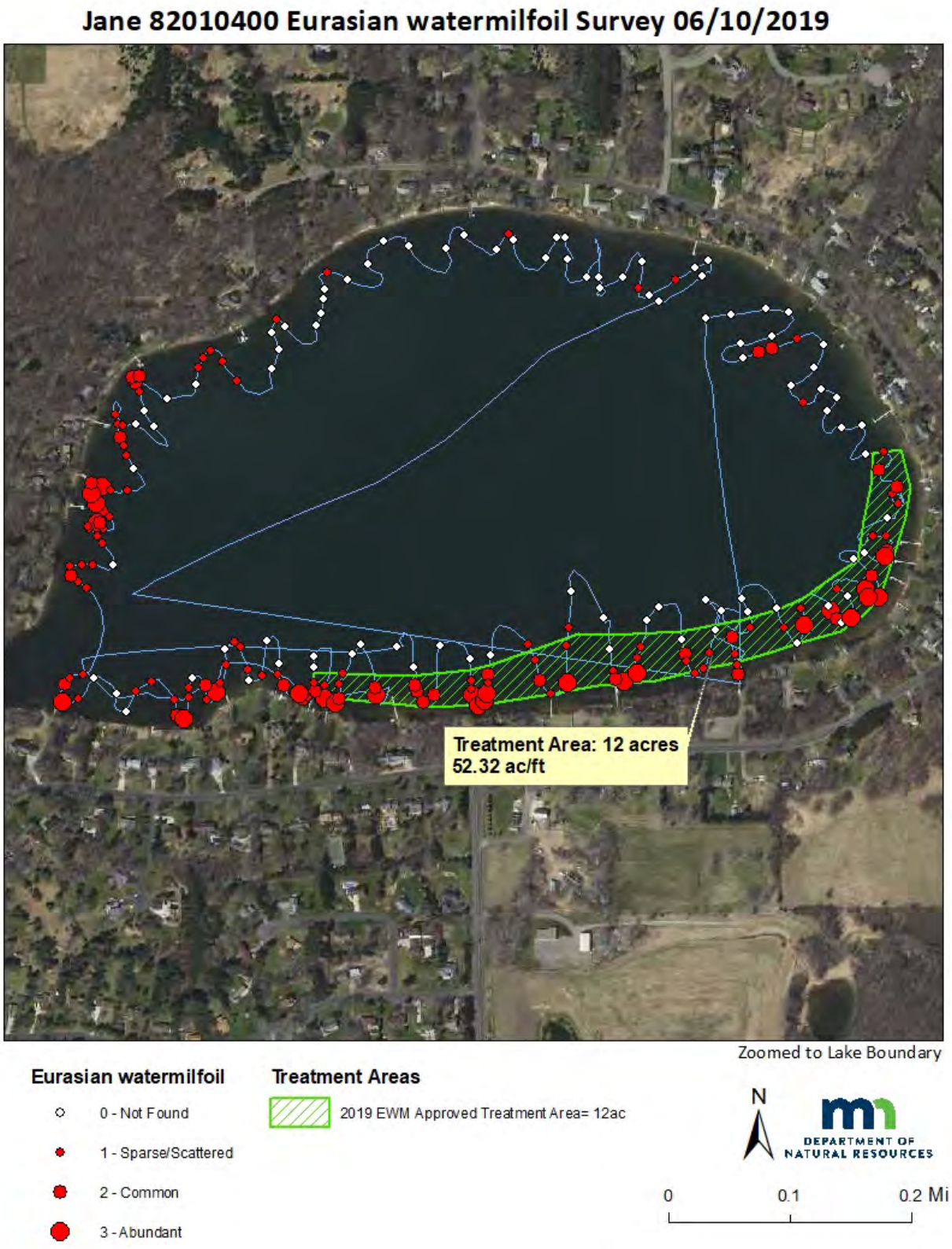


Figure 9. Lake Jane 2019 herbicide treatment area (Map Credit: MnDNR)

Jamaca Blvd N
53rd St N
Jerome Ave N
Isle Ave N
Jamaca Ave N
Jasper Ave N
Highland Ct N
Jane Ct N
Jane Rd N
Hidden Bay Tr N
Birch Bark Tr N
Cherrywood Tr N
23-ft
Lake Jane Tr N
Irvin Ct N
Ivy Ct N
42nd St N
Irish Ct N
Irvin Cir N
Isle Ave N
Jamaca Ave N

Imagery Source: MnGeo WMS - Twin Cities (2016)

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

Approximate Extent of EWM

Maximum Depth of Plant Growth

N

Feet

0 250 500 1,000

Figure 10

LAKE JANE EURASIAN WATERMILFOIL EXTENT, JUNE 2019
Lake Jane (82010400)
Washington County
Valley Branch Watershed District

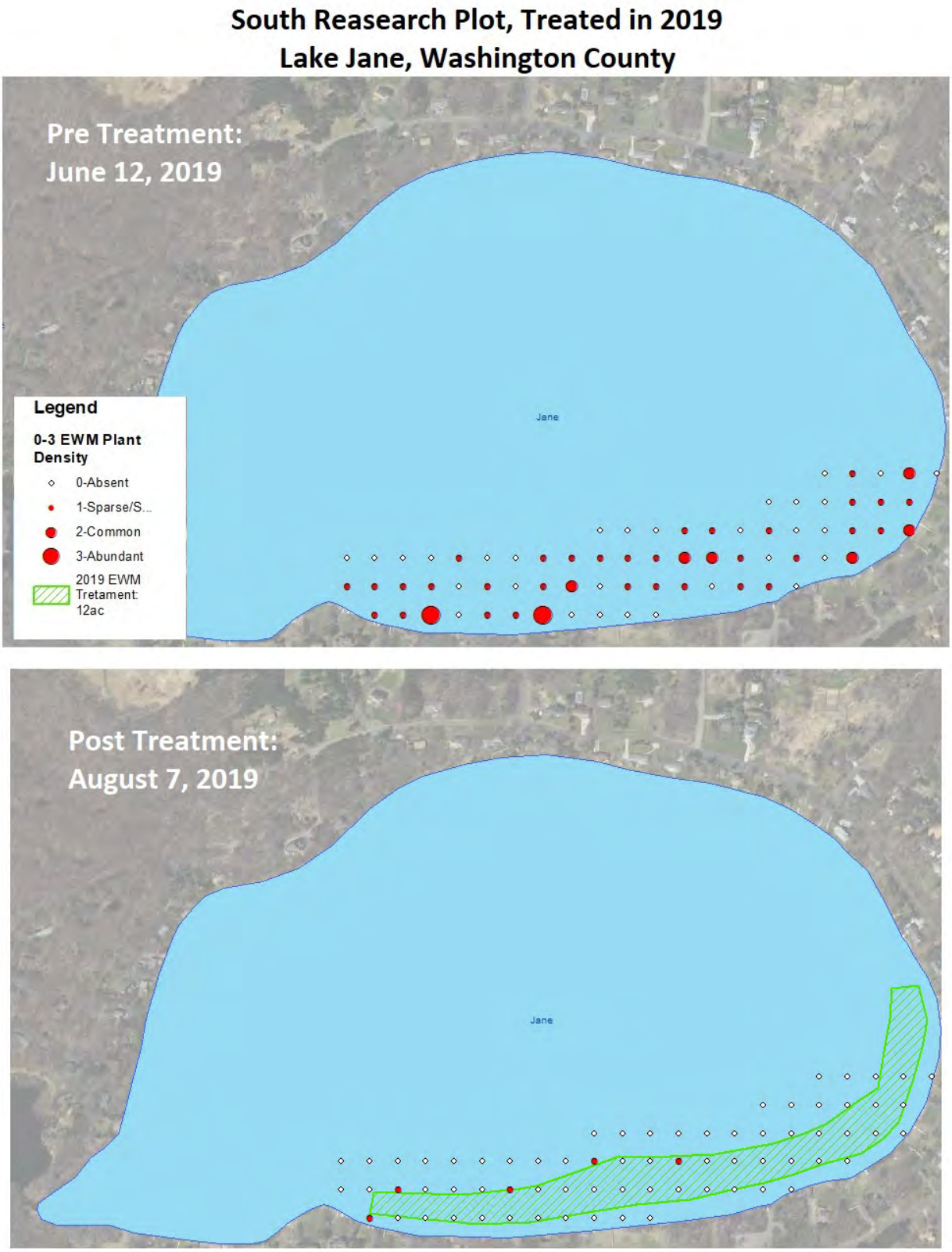
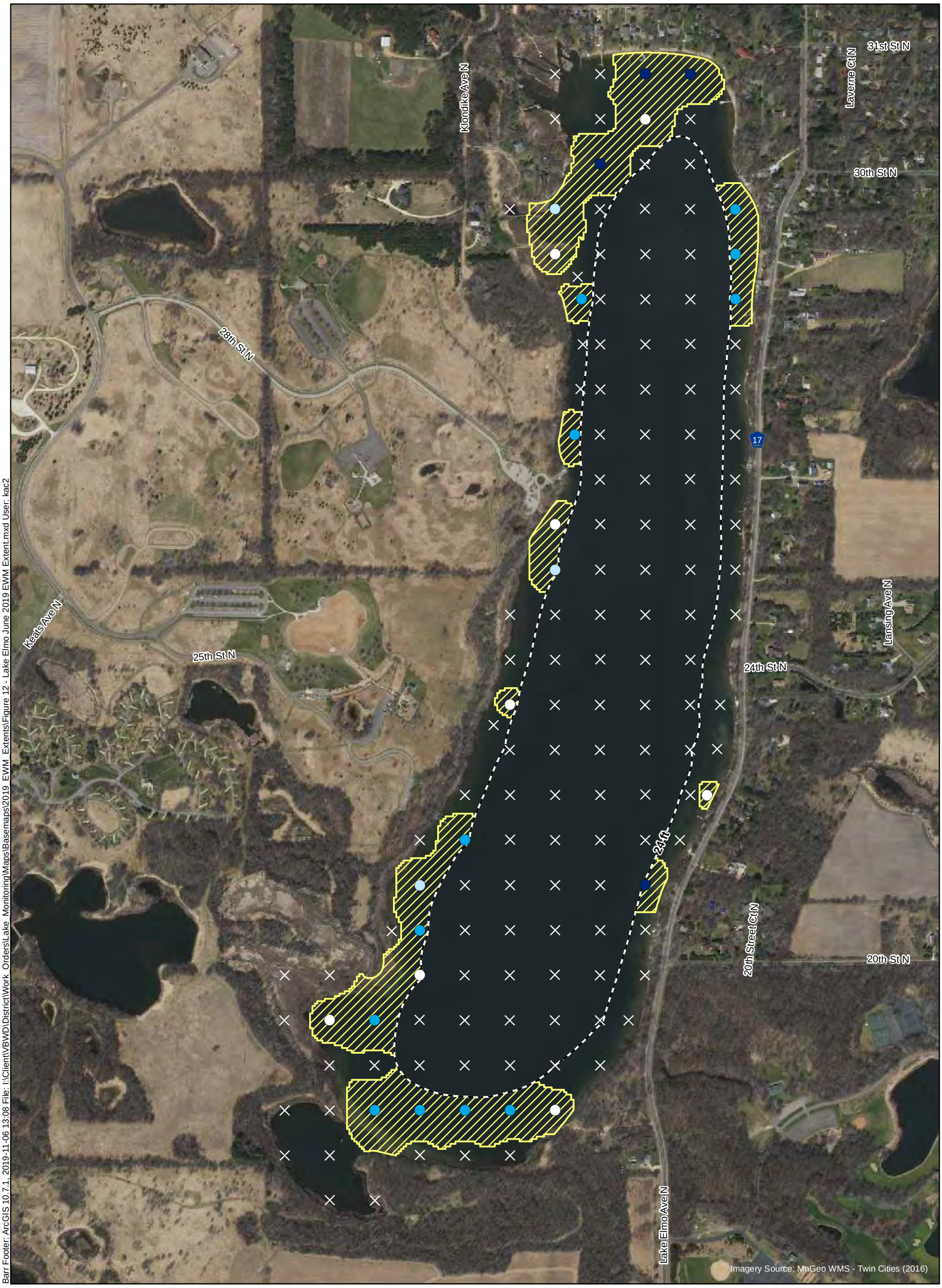


Figure 11. Lake Jane Pre- and Post-Treatment EWM (Map Credit: MNDNR)



Barr Footer: ArcGIS 10.7.1, 2019-11-06 13:08 File: I:\Client\VBWD\DistrictWork_Orders\Lake_Monitoring\Maps\Basemaps\2019_EWM_Extents\Figure 12 - Lake Elmo June 2019 EWM Extent.mxd User: kac2

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

- Approximate Extent of EWM
- Maximum Depth of Plant Growth

N

Feet
0 300 600 1,200

Figure 12

LAKE ELMO EURASIAN WATERMILFOIL EXTENT, JUNE 2019
Lake Elmo (82010600)
Washington County
Valley Branch Watershed District

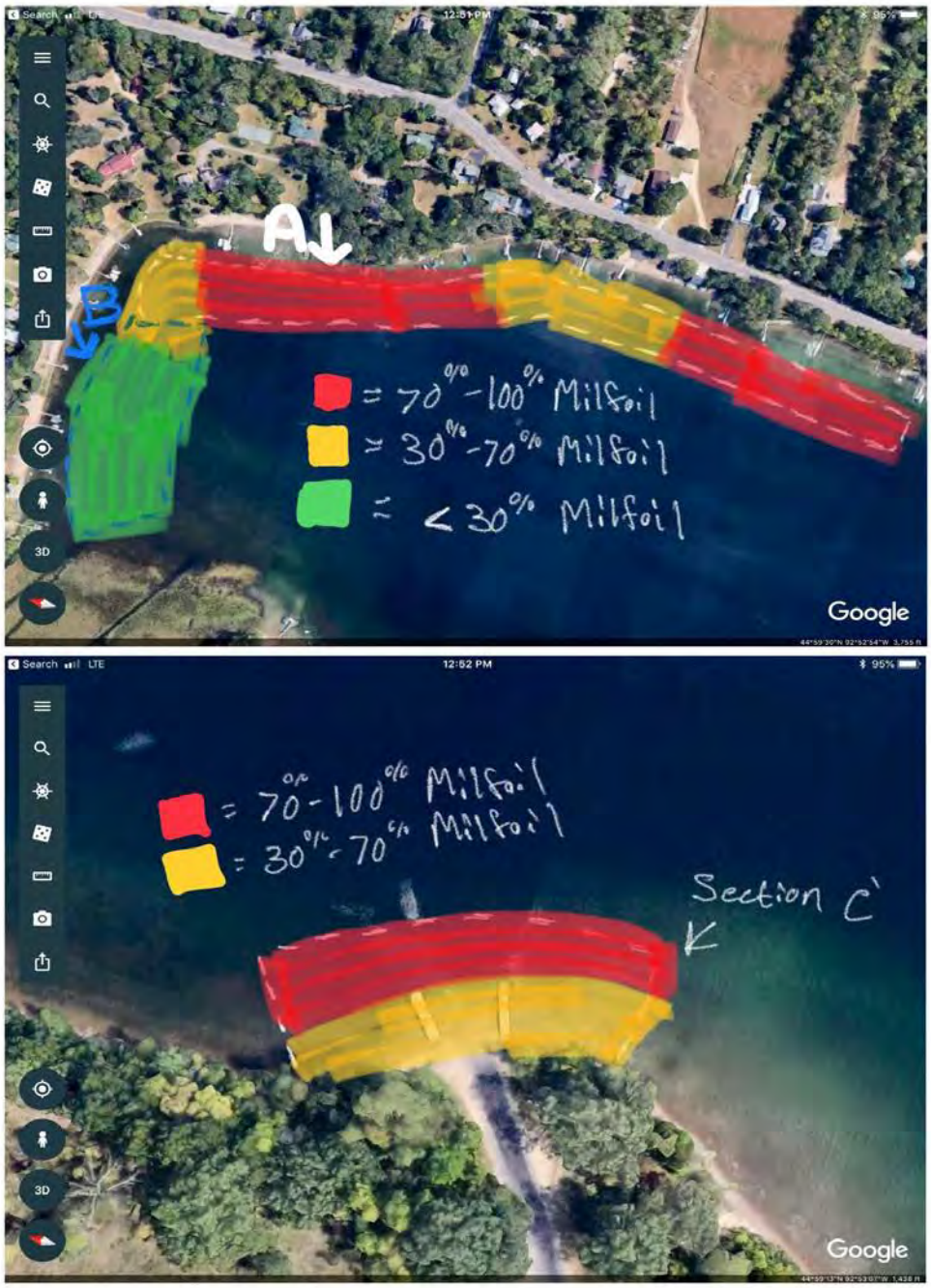


Figure 13. Lake Elmo 2019 harvested areas (Map Credit: Premier Lake Harvesting)

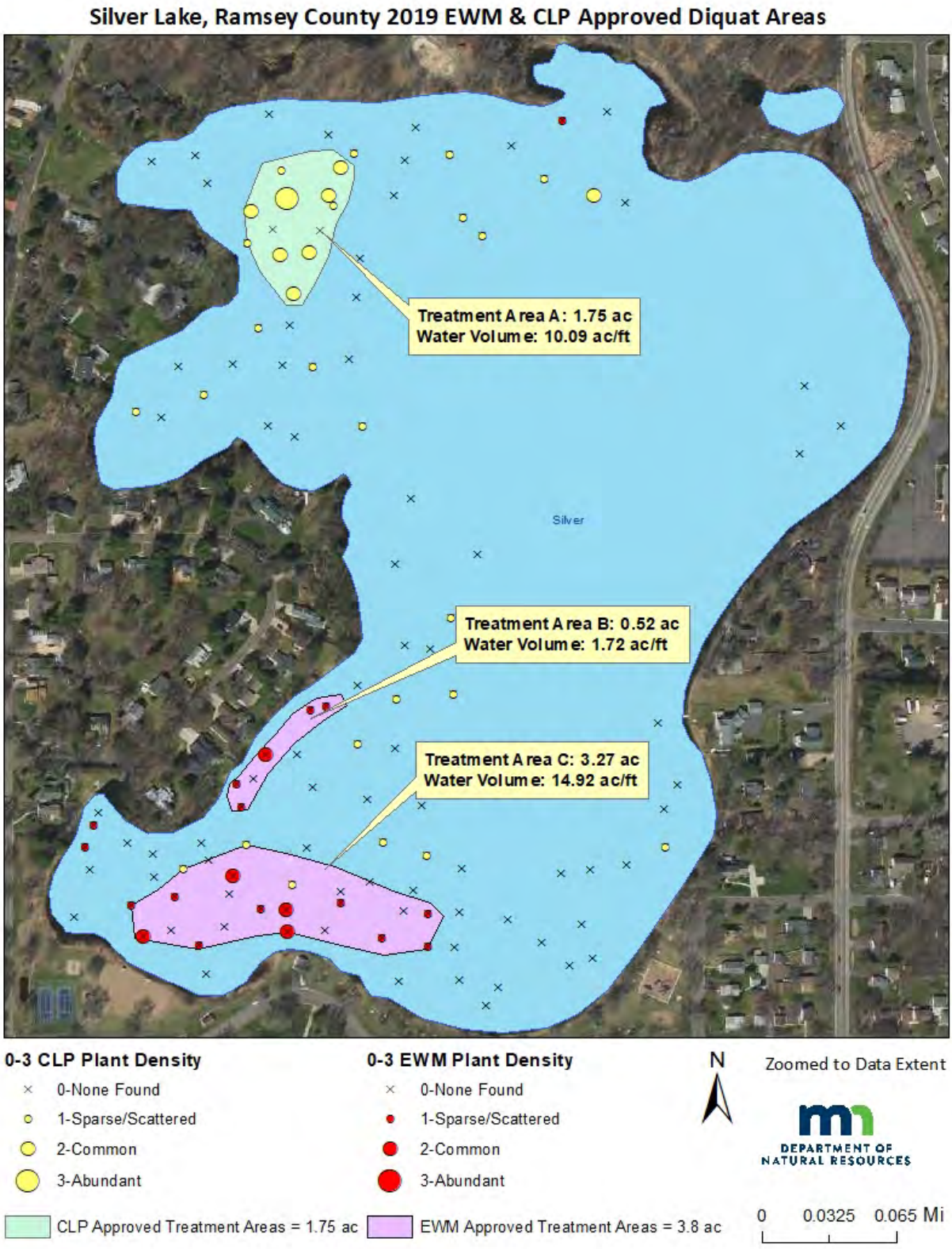


Figure 14. Silver Lake 2019 herbicide treatment areas (Map Credit: MNDNR)

Barr Footer: ArcGIS 10.7.1, 2019-11-06 12:48 File: I:\Client\VBWD\District\Work_Orders\Lake_Monitoring\Maps\Basemaps\2019_EWM_Extents\Figure 15 - Silver Lake June 2019 EWM Extent.mxd User: kac2

EWM Survey Results

- Not Observed
- Visual Only (None on Rake)
- Density = 1
- Density = 2
- Density = 3
- Density = 4

Approximate Extent of EWM

Maximum Depth of Plant Growth

N

Feet

0 125 250 500

Figure 15

SILVER LAKE EURASIAN WATERMILFOIL EXTENT, JUNE 2019
Silver Lake (62000100)
Ramsey County
Valley Branch Watershed District