INTRODUCTION

Kettle Moraine Lake is a 227-acre seepage lake in Fond du Lac County with a maximum depth of 30 feet and a mean depth of 6 feet. Eurasian water milfoil (*Myriophyllum spicatum*; EWM) was first documented in the lake in 1995. While curly-leaf pondweed (*Potamogeton crispus*; CLP) was not officially documented until 2004, reports of its occurrence in Kettle Moraine Lake go back to 1999. The Kettle Moraine Lake Association, Inc. (KMLA) has been actively managing EWM since the late 1990s, while CLP control strategies were initiated in 2003. In August 2012, with the assistance of Onterra, LLC, the KMLA successfully applied for a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS)-Established Population Control (EPC) Grant to fund EWM and CLP control and associated monitoring for five years (2012-2016). During the final year of the project, an updated AIS-related management plan would be created. Following a December 2016 grant application submission, the KMLA secured an AIS-Education, Prevention, and Planning (EPP) Grant to supplement the AIS plan update into a full *Comprehensive Management Plan*. This document will serve as the final deliverable for the AIS-EPC Grant (ACEI-126-13) and the AIS-related management planning components of the AIS-EPC Grant will be integrated into the final deliverable for the AIS-EPP Grant (AEPP-504-17). Remaining funds from the AIS-EPC Grant may be applied towards active management activities in 2018 if applicable.

Historic AIS Management

Records indicate that the application of herbicides to control aquatic plants and/or algae has occurred on an annual basis since 1991 in Kettle Moraine Lake. Treatment records detailing which herbicides were used and at what dosage are incomplete from 1991-2006; however, a complete record of treatments is available from 2007-2017 (Figure 1).

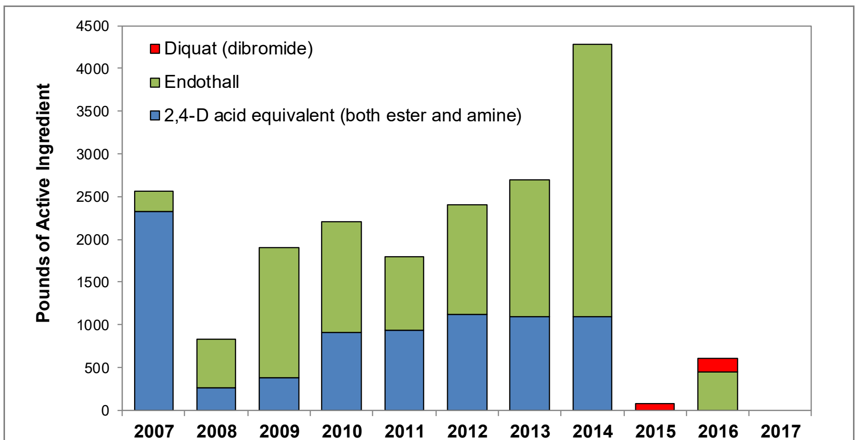

Figure 1. Kettle Moraine Lake herbicide treatment history from 2007-2017.

Over this 10-year period, a combination of 2,4-D, endothall, and/or diquat have been applied to Kettle Moraine Lake in an effort to control non-native aquatic plants. 2,4-D is an auxin mimic herbicide that gets translocated throughout the plant (acts systemically) and suppresses growth regulating hormones. 2,4-D is commonly used to target EWM in both spot- and large-scale treatment scenarios. Endothall, the herbicide typically used to control CLP and used during the control program reported on here, has historically been considered a contact herbicide. Recent studies by Scott Nissen (Colorado State University) have revealed significant amount of endothall translocation in some plant species from the foliage to the plant's roots, indicating that the plant should be reclassified as a systemic herbicide (Nissen and Ortiz in press). Unlike most herbicides that have a single mode of action, endothall impacts plants in multiple ways. The primary mode of actions is an inhibitor to lipid and protein synthesis; but endothall can also disrupt cell membranes (respiratory processes) or reduce proteolytic enzymes (Selden 2015).

Management from 2007 to 2013 consisted of applying 2,4-D to areas with EWM and endothall to areas with CLP. It was observed that the treatment would seem to achieve good CLP control each year, but the EWM population would rebound from the treatment later that season. This suggests that the herbicide use pattern was insufficient to completely kill the EWM and was only providing seasonal control.

In 2014, the KMLA adopted a large-scale (aka whole-lake) herbicide dosing strategy. From an ecological perspective, large-scale treatments are those where the herbicide may be applied to specific sites where the target AIS species is present, but when the herbicide dissipates from where it was applied and reaches equilibrium within the entire mixing volume of water of the lake, it is at a concentration that is sufficient to cause mortality to the target plant within that entire treated volume (Nault et al. 2012). A recent article by Nault et al. 2018 investigated 28 large-scale herbicide treatments in Wisconsin and found that "herbicide dissipation from the treatment sites into surrounding untreated waters was rapid (within 1 day) and lakewide low-concentration equilibriums were reached within the first few days after application." Herbicide exposure time in large-scale treatments is primarily dictated by herbicide degradation. Herbicides degrade differently, but typically take weeks to degrade in large-scale treatment scenarios.

The simultaneous exposure to endothall and 2,4-D has been shown to provide increased control of invasive milfoil in outdoor growth chamber studies (Madsen et. al 2010). A handful of EWM and hybrid EWM (HWM) treatments in Wisconsin utilizing this strategy have been conducted to date with promising results of control and selectivity towards native plants. A large-scale 2,4-D/endothall use-pattern was embraced in 2014 where the goal was to achieve a lake-wide concentration of 2,4-D at 0.25 ppm acid equivalent (ae) and endothall at 0.75 ppm active ingredient (ai). An updated bathymetric (depth contour) modeling study was conducted in the spring prior to the treatment, revealing higher water levels and a greater herbicide mixing volume. Herbicide concentration monitoring occurred at different locations and time period following the application. The results indicated that a lake-wide equilibrium concentration was achieved by 2 days after treatment and target concentrations were approximately reached. Formal monitoring concluded a highly efficacious treatment with minimal AIS being located during the growing season following the treatment.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality. As a part of the ongoing EWM management project, the KMLA been educated on the difference between spot-treatments and large-scale (whole-lake or basin-wide) treatments. Ongoing studies are indicating that in small spot treatments (working definition is less than 5 acres) the herbicide dissipates too rapidly to cause EWM mortality if systemic herbicides like 2,4-D are used (Nault et al. 2015). Even in some cases where larger treatment areas can be constructed, their narrow shape or exposed location within a lake may result in insufficient herbicide concentrations and exposure times for long-term control. Ongoing field trials are assessing the efficacy (AIS control) and selectivity (collateral native plant impacts) of herbicides that may be effective with shorter contact and exposure time (CET) requirements such as diquat or herbicide combinations (diquat/endothall, 2,4-D/endothall, etc.).

EWM survivorship from the 2014 treatment was largely contained in one area of the lake. During the spring of 2015, this location was targeted with a diquat, an herbicide with a short CET requirement often used in small or exposed spot treatment scenarios. Unfortunately, the 2015 control strategy did not meet control objectives as the EWM within this site rebounded by the end of the growing season.

Following incomplete control of EWM in the 2015 treatment area targeted with diquat, a more aggressive approach with a slightly different herbicide control strategy was recommended for 2016. A spot treatment was proposed to target EWM with a combination herbicide consisting of diquat and endothall using the commercially available Aquastrike® herbicide. The addition of the endothall component is theorized to have increased systemic activity on EWM to result in complete control. Some EWM survivorship was documented during the late-summer following the 2016 spot treatment, but at a much-lowered level.

The overall AIS population on Kettle Moraine Lake observed in 2016 was arguably the lowest it had been in over a decade. For the first time since coordinated active management began in 2007, herbicide control strategies were not proposed for Kettle Moraine Lake in 2017. Another justification for forgoing herbicide treatment in 2017 was to allow for aquatic plant studies that were being conducted as a part of a Comprehensive Lake Management Planning project to be completed in absence of large-scale AIS control activities. The KMLA did not want to abandon management and simply wait for AIS populations to reach levels that are again applicable for herbicide control. The KMLA piloted a professional-based hand-harvesting program in 2017 to evaluate what role this management technique may have in its integrated approach moving forward. The focus of these efforts was directed towards EWM, as hand-removal of CLP has additional challenges that may be better undertaken once the program is established. This report discusses the EWM and CLP monitoring and hand-harvesting control activities conducted on Kettle Moraine Lake during 2017 along with guidance for future AIS management.

2017 AIS CONTROL AND MONITORING

Monitoring Methodologies

A set of mapping surveys were used within this project to coordinate and qualitatively monitor the EWM hand-harvesting efforts (Figure 2). The first monitoring event on Kettle Moraine Lake in 2017 was the Early Season Aquatic Invasive Species (ESAIS) Survey. This late-spring/early-summer survey provides an early look at the lake to help guide the hand-harvesting management to occur on the system. This survey also corresponds with the peak growth stage of CLP. Following the hand-harvesting, Onterra ecologists completed the Late-Summer EWM Peak-Biomass Survey, the results of which serve as a post-treatment assessment of the hand-harvesting. The hand-removal program would be considered successful if the density of EWM within the hand-removal areas was found to have either remained approximately the same or decreased from the ESAIS Survey to the Late-Summer Peak-Biomass Survey.

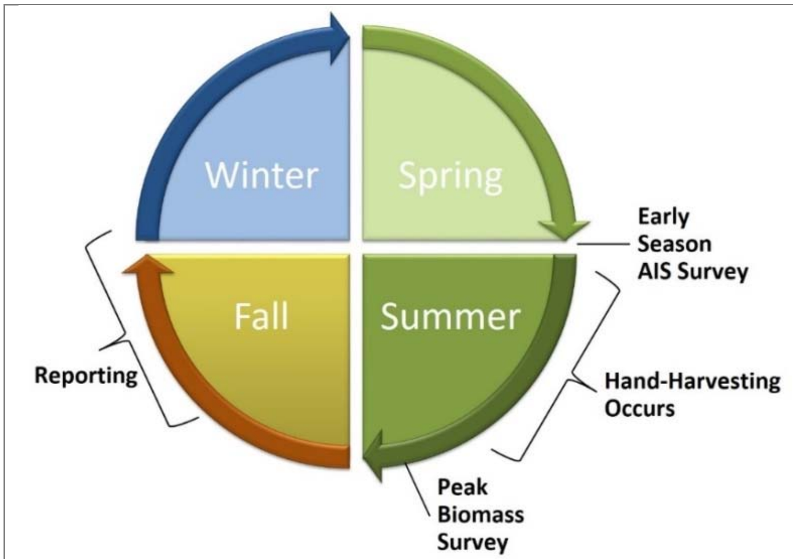

Figure 2. Project timeline diagram.

Early Season AIS Survey (ESAIS) Results

On June 1, 2017, Onterra ecologists conducted the ESAIS survey to map CLP at its peak growth stage and to assess the EWM population and finalize a hand-harvesting strategy for 2017. During the survey, the entire littoral area of the lake was surveyed and both CLP and EWM were mapped. A total of 34 acres of colonized CLP was located. Six acres were delineated as *dominant* and an additional 28 acres were delineated as *highly scattered* or *scattered* (Map 1). The largest concentrations of CLP were found on the western side of the lake. The CLP population was found to have increased significantly compared to levels observed the last time the population was mapped in June 2015 during which approximately 1.8 acres of *highly scattered* CLP was documented.

During the ESAIS survey, approximately 51.6 acres of colonized Eurasian watermilfoil was located in Kettle Moraine Lake (Map 2). Of these 52 acres, approximately one acre was delineated as *dominant* with the remaining 51 acres delineated as either *scattered* or *highly scattered*. The locations of EWM occurrences located during early summer were used to finalize the hand-harvesting control strategy and were provided to the professional hand-harvesting firm to aid in their hand-removal efforts (Map 2). The final hand-harvesting strategy included targeting all instances of colonized EWM described as being composed of a *dominant* density rating as well as targeting a *highly scattered* population in a high use area near an access and beach location (Map 2). Six sites totaling 3.82 acres were included in the final 2017 hand-harvesting strategy (Map 2).

Hand Harvesting Control Activities

The KMLA contracted with TSB Lakefront Restoration and Diving LLC in 2017 to provide professional hand-harvesting EWM control efforts. TSB utilizes Diver Assisted Suction Harvest (DASH), which involves a scuba diver manually extracting the plant (roots and all) and feeding the removed plants into vacuum tube that transports them to a bin on a boat/platform. They do not, however, simply vacuum the plants up, as that would be illegal. The DASH system is considered a form of mechanical harvesting and thus requires a WDNR permit prior to being implemented. Divers from TSB conducted harvesting efforts on August 1st through August 5th, 2017 with an approximate yield of 10,200 pounds of vegetation. Harvesting efforts were conducted at sites A-17, B-17, C-17 and F-17. Harvesting actions did not occur within sites D-17 or E-17 likely due to a lack of available time.

Late-Summer EWM Peak-Biomass Survey Results

The 2017 EWM Peak-Biomass Survey was conducted on September 22, 2017 to qualitatively assess the professional hand-harvesting actions and to map EWM at its peak biomass level. Prior to harvesting efforts, site A-17 contained a *dominant* colony of EWM during the June 2017 mapping survey (Figure 3). Following the professional harvesting efforts, a slight reduction in EWM was observed in the site during the late-summer survey. A smaller *dominant* EWM colony remained present in the site and much of the site was described as *scattered* in density (Figure 3). The EWM population in site A-17 was maintained at approximately the same level or a slightly reduced level between the pre and post-harvesting surveys.

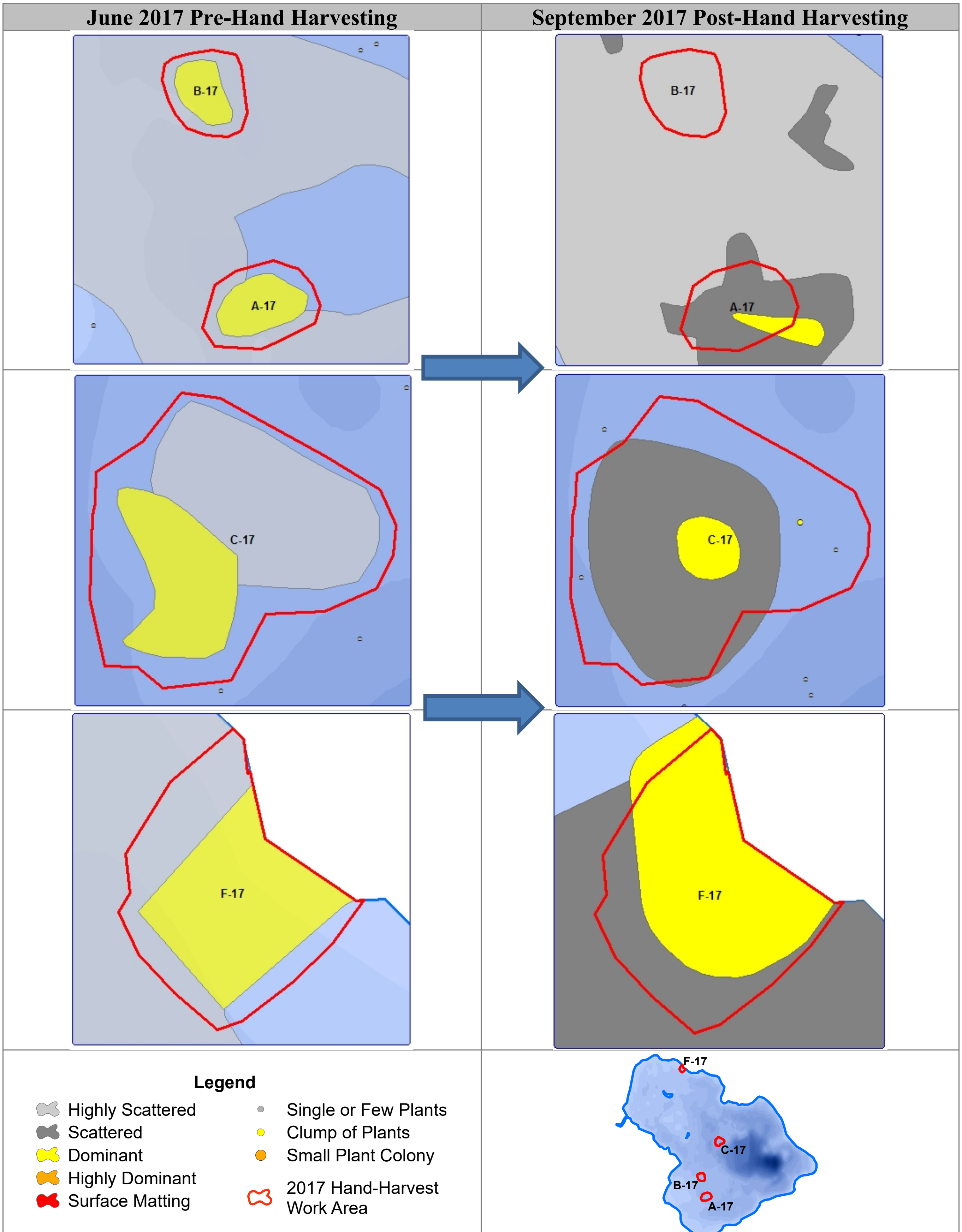

Figure 3. June 2017 pre- and September 2017 Post- Professional Hand-Harvesting EWM Survey Results.

Prior to harvesting actions, site B-17 surrounded a *dominant* EWM colony that was mapped during the June 2017 survey (Figure 3). After the professional harvesting efforts, the entire site was mapped as *highly scattered* in density during the late-summer survey. A clear reduction in EWM density (*dominant* to *highly scattered*) was observed in site B-17 between the pre and post-harvesting surveys.

Prior to harvesting actions, site C-17 surrounded an EWM colony that was of *dominant* and *highly scattered* densities (Figure 3). The post-harvesting survey indicated a slightly smaller *dominant* core of EWM at the site surrounded by a larger *scattered* area (Figure 3). Professional harvesting at site C-17 was sufficient to maintain the EWM population at approximately the same level between the pre and post-harvesting surveys.

A *dominant* EWM colony was identified within site F-17 during the pre-harvesting survey (Figure 3). Following the professional harvesting efforts, the EWM population was found to have expanded slightly in size and remained the same density. Professional harvesting activities in site F-17 did not result in a discernable difference between the pre and post harvesting surveys. Control expectations were not met for site F-17.

Eurasian watermilfoil was found throughout nearly all of the littoral areas of the lake during the late-summer 2017 survey. The lake-wide EWM population mapped during the late-summer survey was found to have increased since the June survey and expanded drastically compared to the late-summer 2016 survey (Map 3). Approximately 2.6 acres of colonized EWM was delineated as *dominant* or *highly dominant* while the majority of the population in the lake (42.3 acres) was delineated as *scattered* or *highly scattered*.

Point-Intercept Survey Results

Point-intercept surveys have been conducted annually on Kettle Moraine Lake since 2007 by a combination of WDNR, Fond du Lac County, and Onterra staff (Figure 4). From 2011 to 2015, two point-intercept surveys per year have been conducted on Kettle Moraine Lake, one in June which corresponds with the expected peak growth of CLP, and one in late summer which corresponds with the peak growth of EWM. A third point-intercept survey has been conducted on Kettle Moraine during the spring pretreatment time period (late-April to May) since 2012 for treatment monitoring purposes. During 2016-2017, only the spring and late summer point-intercept surveys were completed.

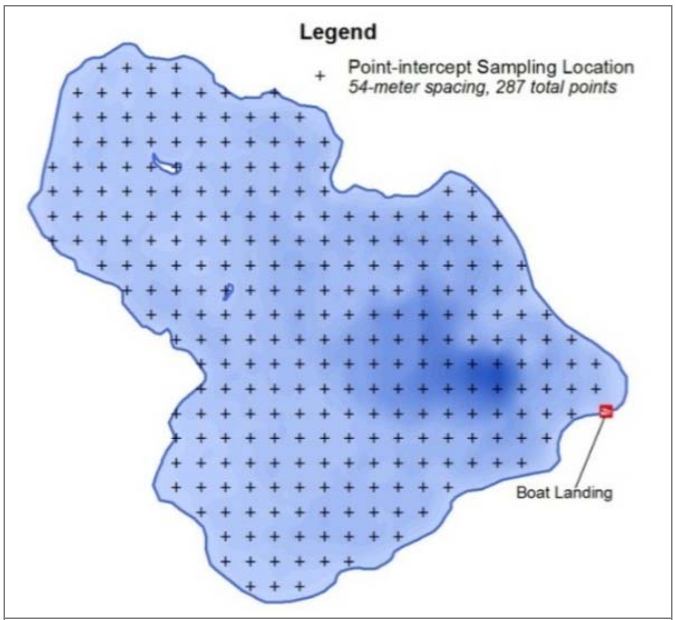

Figure 4. Whole-lake point-intercept survey sampling locations on Kettle Moraine Lake.

Figure 5 displays the littoral frequency of occurrences for CLP and EWM over the course of the last eleven years of monitoring on Kettle Moraine Lake. The CLP littoral frequency of occurrence (LFOO) figure shows datasets collected during early spring (April/May) and in June. The late-summer dataset is excluded from the CLP figure as the majority of the population has likely senesced (died back) by this time of year. The EWM LFOO figure shows all available datasets during this time period.

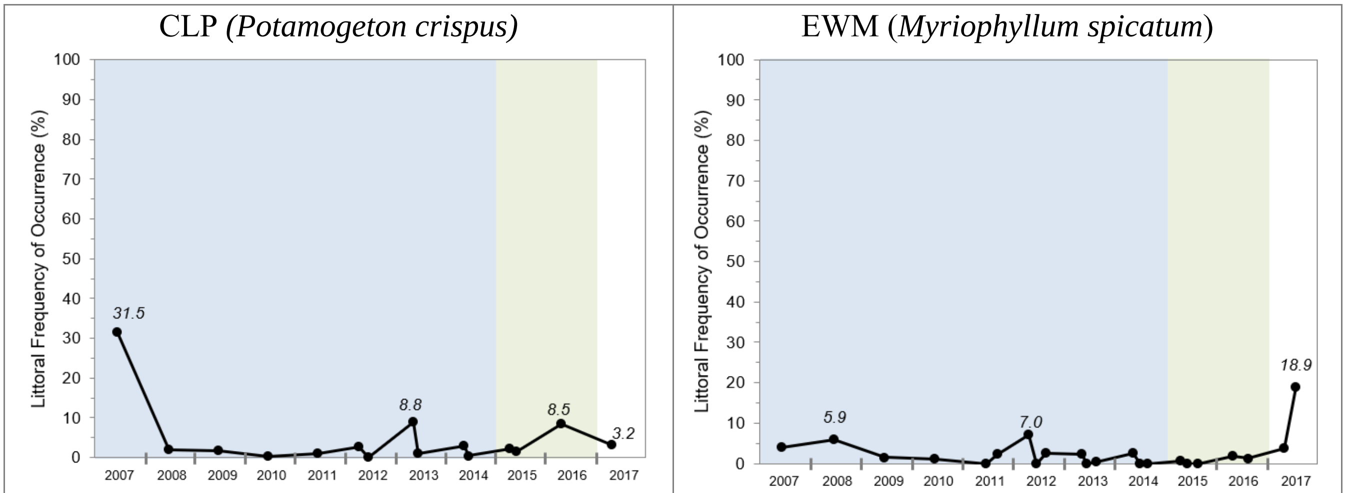

Figure 5. Littoral frequency of occurrence of AIS in Kettle Moraine Lake. Data labeled if LFOO>5% or 2017. Blue background indicates years with likely large-scale herbicide treatments (lake-wide impacts) and green background indicates years with herbicide spot treatments (impacts localized to application areas only).

Overall, the managed CLP populations has not exceeded 10% LFOO since 2007. 2017 was the only period with an EWM population over 10%, during a year with no herbicide management and three years since the last large-scale herbicide treatment.

Figure 6 displays the littoral occurrence of aquatic vegetation in Kettle Moraine Lake and total rake fullness ratings from 2007-2017. The littoral frequency of occurrence of aquatic vegetation ranged from 92% in 2012 to 98% in 2010; however, changes in littoral occurrence between these years were not statistically different (Chi-square $\alpha = 0.05$). While the littoral occurrence of aquatic vegetation has not changed from 2007-2017, changes in TRF ratings suggests the biomass of aquatic plants in Kettle Moraine Lake has fluctuated over this time period. From 2007 to 2010, an average of 85% of littoral sampling locations contained a TRF rating of 2 or 3. From 2011-2013, the average proportion of TRF ratings of 2 and 3 declined to 51% and declined further to 39% in 2014. From 2015-2017, the average proportion of TRF ratings of 2 and 3 increased to 81%.

The decline in aquatic plant biomass from 2011-2014 may be the result of increased herbicide (endothall and 2,4-D) use annually over this period to control EWM and CLP. As indicated in Figure 1, herbicide treatments completed from 2007-2014 likely had impacts at the lake-wide level. It is likely that this increased herbicide use resulted in the measured decline in the proportion of TRF ratings of 2 and 3, a surrogate for aquatic plant biomass. Herbicide treatments completed in 2015 and 2016 were designed to have localized impacts (spot treatments). The reduced herbicide use in 2015 and 2016 and lack of an herbicide application in 2017 may have led to the recovery in aquatic plant biomass in these years.

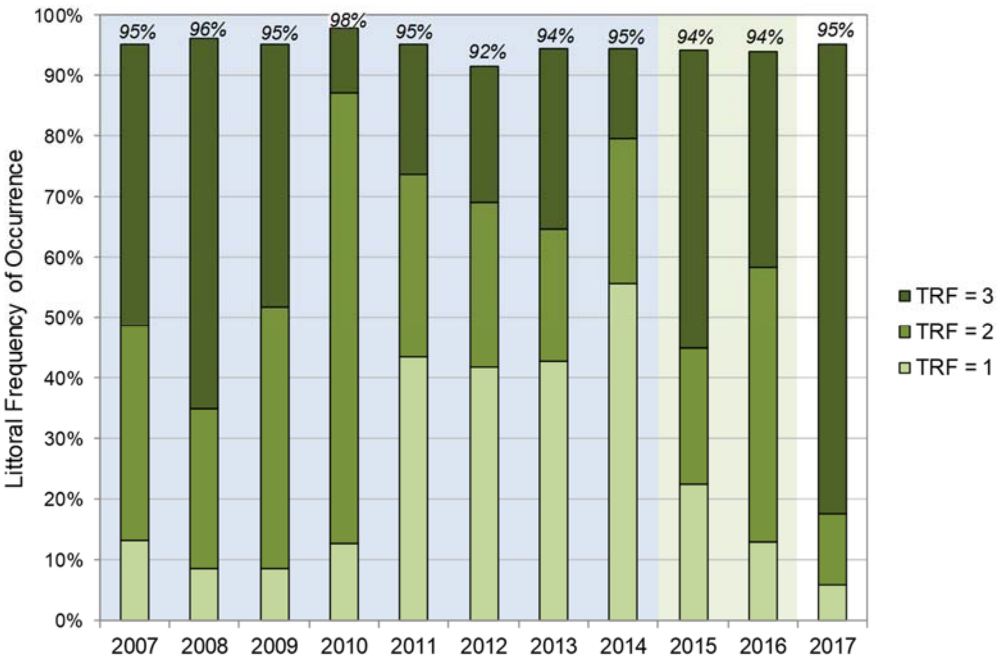

Figure 6. Kettle Moraine Lake 2007-2017 aquatic plant total rake fullness (TRF) ratings within the littoral zone. Blue background indicates years with likely large-scale herbicide treatments (lake-wide impacts) and green background indicates years with herbicide spot treatments (impacts localized to application areas only).

In addition to examining changes in the overall occurrence of vegetation in Kettle Moraine Lake from 2007 to 2017, changes in the occurrence of individual plant species were also investigated. Aquatic plant species which had a littoral occurrence of at least 5% in one of the 11 surveys were included in this analysis (Figure 7). Some species within Kettle Moraine Lake have similar morphological characteristics and cannot always be easily be identified in the field and therefore were combined for this analysis. For this analysis, common/slender waterweed refers to the combined occurrences of both *Elodea canadensis* and *E. nuttallii,* slender/southern naiad refers to the combined occurrences of *Najas flexilis* and *N. guadalupensis,* and large pondweed spp. refers to the collective occurrences of *Potamogeton amplifolius*, *P. illinoensis*, *P. gramineus,* and a hybrid *Potamogeton* species that is believed to be a cross between *P. amplifolius* and *P. illinoensis* (*P.* × *scoliophyllus*).

Of the 10 native species/lumped species that had a littoral occurrence of greater than 5% in at least one of the surveys from 2007-2017, seven have exhibited statistically valid changes in their littoral frequency of occurrence between years over this time period (Figure 7). The littoral occurrences of coontail, common/slender waterweed, muskgrasses, slender/southern naiad, and creeping bladderwort have fluctuated between years over this time period, but trends in their occurrence over time are not statistically significant (simple linear regression p-value > 0.05).

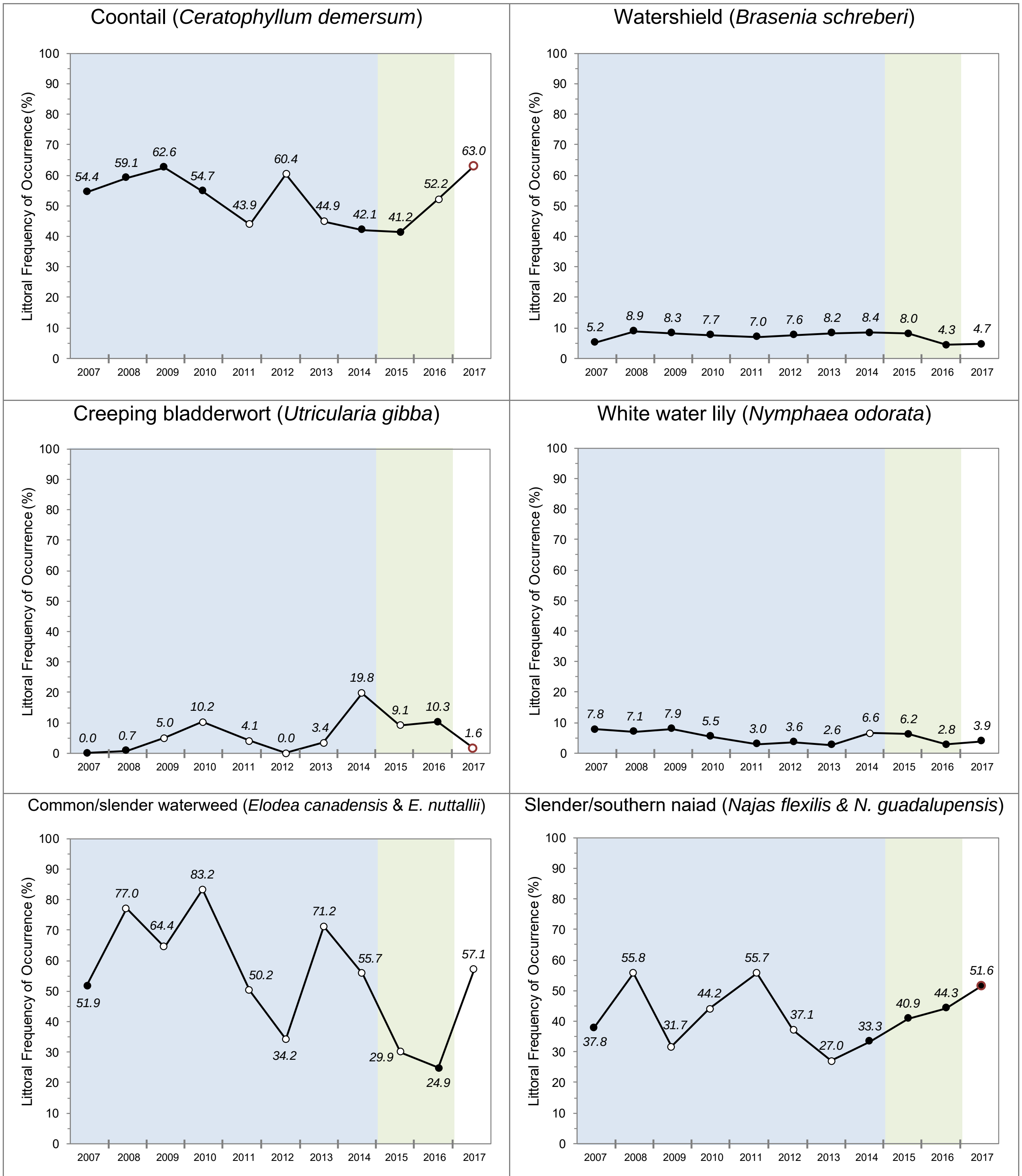

Figure 7. Littoral frequency of occurrence of select native aquatic plant species in Kettle Moraine Lake from 2007-2017. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05). Circle outlined with red indicates 2017 littoral occurrence was statistically different from littoral occurrence in 2007 (Chi-Square α = 0.05). Blue background indicates years with likely large-scale herbicide treatments (lake-wide impacts) and green background indicates years with herbicide spot treatments (impacts localized to application areas only).

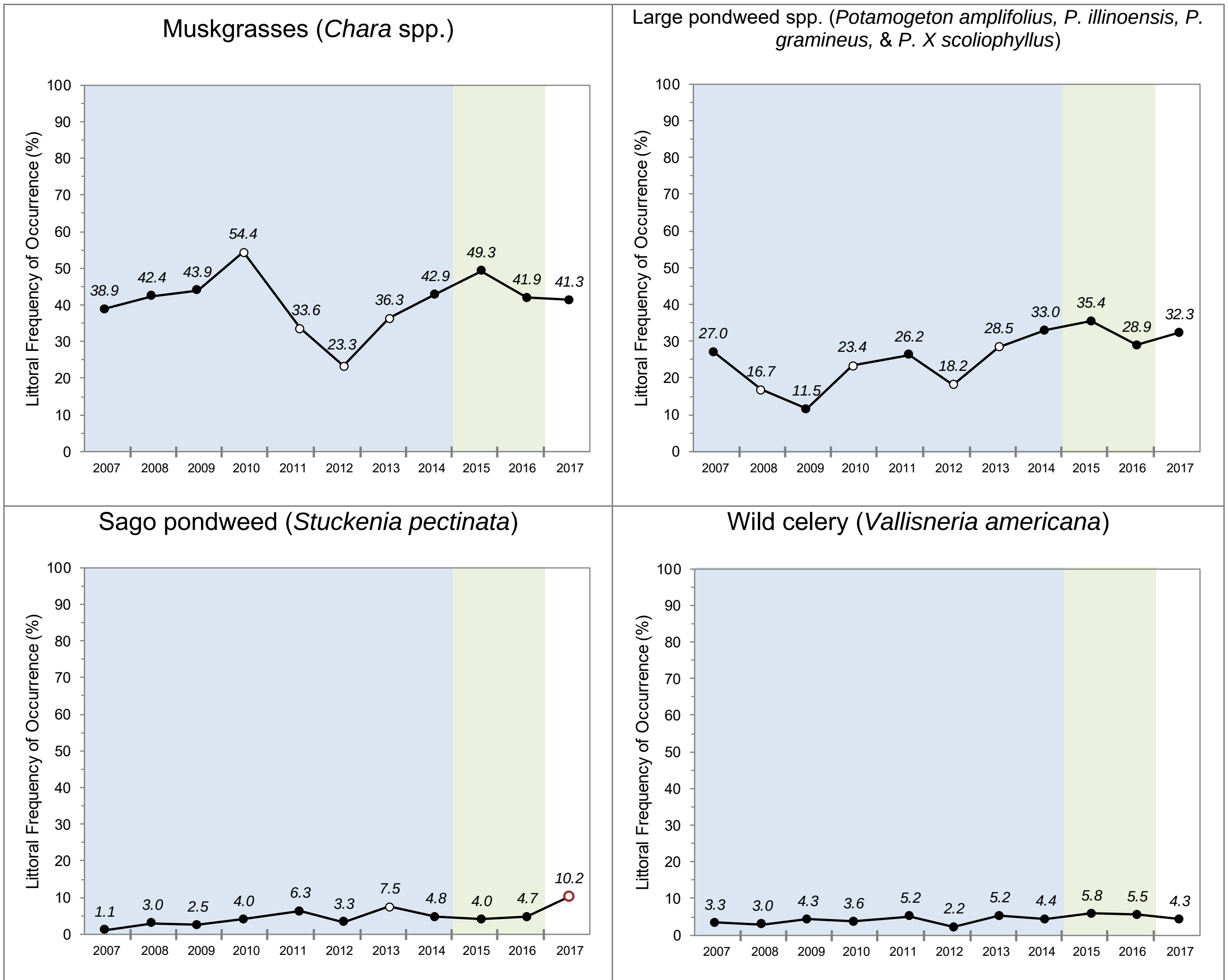

Figure 7, continued. Littoral frequency of occurrence of select native aquatic plant species in Kettle Moraine Lake from 2007-2017. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05). Circle outlined with red indicates 2017 littoral occurrence was statistically different from littoral occurrence in 2007 (Chi-Square α = 0.05). Blue background indicates years with likely large-scale herbicide treatments (lake-wide impacts) and green background indicates years with herbicide spot treatments (impacts localized to application areas only).

Large pondweed spp. has seen a statistically valid increasing trend (R^2 = 0.46; p-value = 0.02) from 2007-2017, increasing from an average littoral occurrence of around 20% to 30%. Similarly, the littoral occurrence of sago pondweed also displayed a statistically valid increasing trend (R^2 = 0.50; p-value = 0.01) since 2007, increasing from around 1% in 2007 to 10% in 2017. The littoral occurrences of watershield, white water lily, and wild celery were less variable between years and exhibited no statistically valid trends in occurrence over this time period.

Aquatic plant communities are dynamic and the abundance of certain species from year to year can fluctuate depending on climatic conditions, water levels, changes in clarity, herbivory, competition, and disease among other factors. Some of the declines measured in individual species occurrence may be attributable to these herbicide treatments; however, given the high degree of variability in the occurrence of most of these species, it is difficult to disentangle changes in occurrence due to herbicide applications and natural changes in environmental conditions. As discussed previously, none of the aquatic plant species were found to have declined in their littoral occurrence from 2007-2017 and no species were lost from the lake over this period.

CONCLUSIONS AND DISCUSSION

The AIS monitoring studies completed in 2017 on Kettle Moraine Lake found both the CLP and EWM populations had expanded significantly since 2016. Professional hand-harvesting proved effective during 2017, however the benefits were confined to rather small areas. However, the current EWM population within Kettle Moraine is too great for hand-harvesting to have a meaningful impact on the lake-wide population.

The repetitive use of large-scale herbicide treatments from 2007 to 2014 resulted in a lowered EWM population. As discussed earlier, these control strategies were necessary every year to maintain the lowered EWM population as rebound was occurring each year by the end of the season. The large-scale treatment in 2014 provided a few years of control without requiring subsequent large-scale management. By the late-summer 2017, the EWM population has increased to its highest levels since the point-intercept survey has been used to monitor the plant population of Kettle Moraine Lake.

Future AIS Management

Curly-leaf Pondweed

The theoretical goal of CLP management is to kill the plants each year before they are able to produce and deposit new turions. Not all of the turions produced each year sprout new plants the following year; many lie dormant in the sediment to sprout in subsequent years. This results in a sediment turion bank being developed. Normally a control strategy for an established CLP population includes 5-7 years of controlling the same area to deplete the existing turion bank within the sediment.

Early season herbicide treatments, particularly low-concentration whole-lake treatments, have shown large reductions in CLP biomass and decreased recurrence of CLP populations after multiple consecutive treatments (Skogerboe et al. 2008). Johnson et al. (2012) investigated 9 midwestern lakes that received five consecutive annual large-scale endothall treatments to control CLP. The greatest reductions in CLP frequency, biomass, and turions was observed in the first 2 years of the control program, but continued reductions were observed following all five years of the project. Following over a decade of large-scale treatments, the CLP population in Kettle Moraine is currently below levels that are impacting the ecological function of the lake and below level that are causing recreation of navigation impairment. As part of the *Comprehensive Management Planning* project, the KMLA will need to explore management triggers of when CLP-specific control strategies will be implemented.

Eurasian Watermilfoil

While understood in terrestrial herbicide applications for years, herbicide tolerance evolution is an emerging topic amongst herbicide applicators, lake management planners, and researchers. Herbicide tolerance is when a plant population develops reduced susceptibility to an herbicide use-pattern over time. This occurs in a population when some of the targeted plants have an innate reduced susceptibility to the herbicide and others do not. Following an herbicide treatment, the more tolerant strains will rebound whereas the more sensitive strains will be controlled. Thus, the plants that re-populate the lake will be those that are more tolerant to that herbicide resulting in a more tolerant population. Understanding this component as it relates to past and future EWM management actions in Kettle Moraine Lake warrants consideration and will be further examined as the KMLA develops an AIS control strategy within the *Comprehensive Management Planning* process.

The KMLA believes the current EWM population in Kettle Moraine Lake warrants consideration for another large-scale treatment. The KMLA would like to consider all available herbicide use-patterns to seek increased longevity of EWM control and minimize the costs and environmental impacts/risks of frequent herbicide management. At this time, three large-scale use patterns are being considered. These strategies are explored below. Please note that the herbicide application costs discussed should only be used as a general guide.

1. Auxin and Endothall Combination – 2,4-D & Endothall: This herbicide use pattern has been conducted on Kettle Moraine Lake in the past. The 2014 strategy adopted a dosing strategy of 0.25 ppm ae 2,4-D and 0.75 ppm ai endothall. The manufacturer of endothall, United Phosphorus Inc (UPI), recommends a maximum dosing strategy of 0.3 ppm ae 2,4-D and 1.0 ppm ai endothall. While it is likely that the higher herbicide concentrations will have greater impacts to the EWM population, a greater negative response of the native plant community is also anticipated and therefore is not likely to be considered. This higher herbicide dosing strategy could potentially cost $110,000 for product and application, assuming applicator technology allows for simultaneous application of both herbicides.

2. Auxin and Endothall Combination – Triclopyr & Endothall: Triclopyr and 2,4-D are both auxin growth hormone mimics. While their mode of actions is similar, triclopyr is degraded via photolysis (exposure to sunlight) whereas 2,4-D is broken down by microbes. Endothall is also broken down by microbial activity. Nault et al. 2018 indicated the 2,4-D half-life was shown to range from 4-76 days within the 28 lakes studies, with the "rate of herbicide degradation to be slower in lower-nutrient seepage lakes." Adding 12 additional Onterra-monitored projects to this dataset yields a mean 2,4-D half-life of approximately 30 days (Heath et al. 2018). Analysis of the large-scale 2,4-D treatment on Kettle Moraine in 2014 indicate the 2,4-D half-life was approximately 6 days, a much faster 2,4-D breakdown than typically observed. The endothall half-life was approximately 7 days. Substituting triclopyr for 2,4-D may yield longer exposure time of the auxin component and lead to a more efficacious treatment. A large-scale combination triclopyr (0.2 ppm ae) and endothall (0.75 ppm ai) treatment may cost $70,000 for product and application, assuming applicator technology allows for simultaneous application of both herbicides.

3. Slow Acting Enzyme Inhibitor Herbicide – Fluridone. Fluridone is a systematic herbicide that disrupts photosynthetic pathways (carotenoid synthesis inhibitor). This herbicide requires long exposure times (>90 days) to cause mortality to EWM. Herbicide concentrations within the lake are kept at target levels by periodically adding additional herbicide ("bump treatments") over the course of the summer based upon herbicide concentration monitoring results.

   The use of fluridone has a checkered past in Wisconsin, as early implemented treatments (mid-2000s) resulted in native plant impacts that exceeded "acceptable levels" (Wagner et al. 2007). These collateral impacts were based upon liquid fluridone treatments, typically employed at 6 ppb with a bump treatment later in the summer to bring the concentration back up to 6 ppb. This fluridone use-pattern, commonly referred to as 6-bump-6, produces two relatively high herbicide pulses that taper off slowly as the herbicide degrades.

A somewhat newer use-pattern of fluridone uses a pelletized product that gradually reaches a peak concentration over time (extended release) and results in a lower, sustained lake-wide herbicide concentration (1.5 to 3 ppb). Within a few limited Wisconsin field-trials, this use-pattern of fluridone appears to provide a similar level of efficacy as the 6-bump-6 approach, but with a lower magnitude (but still notable) of native plant impacts (Heath et al. 2018). Rough estimations for conducting a large-scale pelletized fluridone treatment on Kettle Moraine Lake targeting 4 ppb are $70,000 for product and application, considering two additional bump treatments at half initial treatment rates.

Two of the three explored herbicide use patterns (2,4-D/endothall and pelletized fluridone) have been confirmed to be effective in controlling "difficult" EWM and hybrid EWM (HWM) populations in Wisconsin for a few years following treatment with longer term success yet to be evaluated. While large-scale triclopyr treatments have occurred in Wisconsin, the combination of triclopyr and endothall likely has not although laboratory studies have shown promise (Madsen et al. 2010). These herbicide strategies could be considered aggressive and carry with them the potential for increased collateral impacts to the native plant community. It has been suggested that herbicide tolerance evolution is less likely to occur when multiple herbicide modes of action are used, such as the case when using combinations of an auxin-mimic and endothall. To date, only one population of invasive milfoil (HWM biotype from Townline Lake, MI [Berger et al. 2012]) has shown any form of reduced sensitivity to fluridone.

Table 1 outlines the species present within Kettle Moraine Lake and an analysis of each species' corresponding perceived susceptibility to fluridone, as well as generalized account of how the past 2,4-D/endothall combination treatments have impacted Kettle Moraine Lake specifically. The "Liquid Case Studies" referenced are a large dataset of liquid fluridone field trials (many are 6-bump-6) compiled by the WDNR Science Services and made available in spreadsheet format. The two pelletized columns are case studies monitored by Onterra where a fluridone concentration of 1.5-3 ppb was maintained for the majority of the summer as well as to had a purposeful and planned fluridone concentration above detectable levels (1 ppb) being within the lake at the end of the open water season. Because fluridone degrades via photolysis (ie sunlight), only limited degradation occurs over the winter and measurable fluridone concentrations were observed in two of the three waterbodies the following spring after ice-out.

Within the Onterra-monitored case studies, EWM/HWM populations were reduced to zero (or almost zero) in all instances during the year after treatment. The analysis presented in Table 1 suggests that some plant species, such as common waterweed and slender naiad are particularly sensitive to fluridone, regardless of the fluridone formulation or concentration. Other species may be less impacted by the lower concentrations of a pelletized formulation, but it is also important to note that this is a very limited dataset to draw opinions off of.

The KMLA have expressed interest in further understand the potential of a fluridone treatment for Kettle Moraine Lake, with the goal of getting increased longevity of EWM control compared to past strategies. Arguably the largest concern about a potential fluridone treatment on Kettle Moraine is the potential to impact the three most frequently encountered species within the lake (coontail, common waterweed, and southern naiad). While many lake users understand these to be the native plant species that can impact their recreation of the lake, this important biomass is important to the function of the Kettle Moraine Lake ecosystem. Removing large amounts of this biomass could have negative ecological impacts greater than those the EWM population may potentially be causing. That being said, some lake managers have been supportive of fluridone control options as the plant biomass takes months to be impacted by the treatment so there is not a sudden loss of habitat for fisheries or plankton that could impact ecological function of the system. The slower die-off and subsequent decomposition of plant material is likely to minimizing a resulting reduction of oxygen levels within the lake. If a fluridone use-pattern is further explored, advanced conversations about potential ecological response and how to best monitor it will be required. During a strategic planning meeting, the KMLA requested additional toxicological data about a potential fluridone treatment, which is included below for distribution to their constituents through this report.

Table 1. Aquatic plant species list and potential sensitivity to differing fluridone use-patterns.

			2,4-D/Endothall Sensitivity	Fluridone Sensitivity		
Scientific Name	Common Name	2017 LFOO	2014 KML (2013 vs 2014)	Liquid Case Studies*	Pelletized Cloverleaf**	Pelletized Big Silver**
Ceratophyllum demersum	Coontail	63.0	X	↓ to X	X	-
Elodea canadensis	Common waterweed	57.1	X	↓	X	↓
Najas guadalupensis	Southern naiad	51.2	X	↓ to X to ↑	↓	-
Chara spp.	Muskgrasses	41.3	↑	↓ to X to ↑	X	X
Potamogeton X scoliophyllus	Large-leaf X Illinois pondwee(	28.0	↑	↓ to X to ↑	-	-
Myriophyllum spicatum	Eurasian watermilfoil	18.9	↓	↓	↓	↓
Stuckenia pectinata	Sago pondweed	10.2	X	X to ↑	X to ↑	X
Brasenia schreberi	Watershield	4.7	X	X	-	-
Vallisneria americana	Wild celery	4.3	X	↓ to X	↓ to X	X
Potamogeton gramineus	Variable-leaf pondweed	4.3	↑	↓ to X to ↑	X	↓
Nymphaea odorata	White water lily	3.9	↑	↓ to X		X
Heteranthera dubia	Water stargrass	2.0	-	X to ↑	-	↑
Utricularia gibba	Creeping bladderwort	1.6	↑	X	-	-
Potamogeton crispus	Curly-leaf pondweed	1.6	↓	↓	↓	↓
Nuphar variegata	Spatterdock	1.2	X	X	-	-
Potamogeton nodosus	Long-leaf pondweed	0.4	-	X	-	-
Potamogeton illinoensis	Illinois pondweed	0.4	-	↓ to X to ↑	↓ to X	↓
Najas flexilis	Slender naiad	0.4	-	↓ to X	↓	↓

LFOO = littoral frequency of occurrence.
↓↑ = statistically valid declines/increases observed. X = population remains statically unchanged. - = no data availible.

* Fluridone sensitivity from Wagner KI, WDNR Science Services, 2006, unpubl.
** Fluridone sensitivity from Onterra case studies, 2017

The use of any aquatic herbicide poses environmental risks to non-target plants and aquatic organisms. The majority of available toxicity data has been conducted as part of the EPA product registration process. These laboratory studies are attempted to mimic field settings but can underestimate or overestimate the actual risk (Fairbrother and Kapustka 1996). This is exemplified when laboratory tests focus on high concentrations and short exposure times where field application relies long exposures of low concentrations. Federal and state pesticide regulations and strict application guidelines are in place to minimize impacts to non-target organisms based on the organismal studies. The use of aquatic herbicides includes regulatory oversight and must comply with the following list. Additional information from the WDNR on aquatic herbicide regulation is included within Appendix A along with the WDNR's fluridone fact sheet. Appendix B includes additional toxicological perspective from the herbicide manufacturer.

- Labeled and registered with U.S. EPA's office of Pesticide Programs;
- Registered for sale and use by the Department of Agriculture, Trade, and Consumer Protection (DATCP);
- Permitted by the Wisconsin Department of Natural Resources (WDNR); and
- Applied by a DATCP-certified and licensed applicator,

According to EPA product registration, fluridone does not appear to have any short-term or long-term impacts to fish, invertebrates, or birds at labeled rates. Toxicity studies on early life stages of walleye, smallmouth bass, and largemouth have documented minimum lethal concentrations much greater than approved use rates (1,800-13,000 ppb). Hamelink et al. 1986 assessed the impacts of technical grade fluridone (98-99% active ingredient) and a commercial formulation (48% active ingredient; 52% inert) on several invertebrate (amphipods, midge larvae, crayfish) and fish species (fathead minnow, channel catfish), concluding that fluridone does not have adverse impacts to non-target aquatic organisms at labeled use rates. However, Yi et al. 2011 conducted toxicity studies on male water mites that potentially have a more vulnerable life cycle than other aquatic invertebrates, using a commercially available liquid formulation of fluridone (Sonar®AS). Their results indicated the commercially available liquid formulation was 60-fold more toxic than the technical grade, with impacts observed as low as 10 ppb. This suggests that the inert ingredients themselves may be the cause of the increased toxicity. The inert components of liquid fluridone (Sonar®AS) and pelletized fluridone (Sonar®One) are different, and are outlined within Q16 of Appendix B.

The EPA-approved maximum application rate for the pelletized fluridone product being considered (Sonar®One) is 150 ppb. At these rates, there are no restrictions on swimming, fish consumption, or pet/livestock drinking water. There are irrigation restrictions such that specific plants, such as tomatoes and peppers, should not be watered with concentrations above 5 ppb for concerns of herbicidal impacts. The fluridone use pattern being considered for Kettle Moraine is between 1.5 and 3 ppb to be maintained for a single open water season.

While the KMLA would like to entertain a large-scale treatment in 2018, they are currently in the process of conducting a *Comprehensive Management Plan* and feel it would be appropriate for that project to conclude before initiating a large-scale management action. Once a *Comprehensive Management Plan* has received WDNR approval, the KMLA would be eligible for applying for another AIS-EPC Grant to provide partial cost coverage for a large-scale herbicide treatment and associated monitoring. The KMLA acknowledge that the potential for an increased AIS population in 2018 is high. The KMLA also understands that AIS populations are dynamic and, in some instances, population stability and even declines have occurred in absence of active management. Onterra ecologist/planners conveyed to the KMLA that the results of a future large-scale treatment are independent of the existing EWM population within the lake. Said another way, a large-scale treatment targeting EWM is anticipated to have the same outcome if the population is 5% or 50%, so postponing a treatment will not jeopardize long-term control goals. The KMLA would also like to allow the Wisconsin case studies to be evaluated for another year, providing additional data in determining the best AIS management tool moving forward.

As part of the *Comprehensive Management Planning* Project, an early-spring point-intercept survey, June ESAIS survey, late-summer point-intercept survey, and late-summer EWM mapping survey will be completed in 2018. With remnant funds from the KMLA's existing AIS-EPC Grant, consideration of continuing the EWM hand-harvesting program will be made following the June ESAIS survey. Areas of high-use may be a priority for these efforts.

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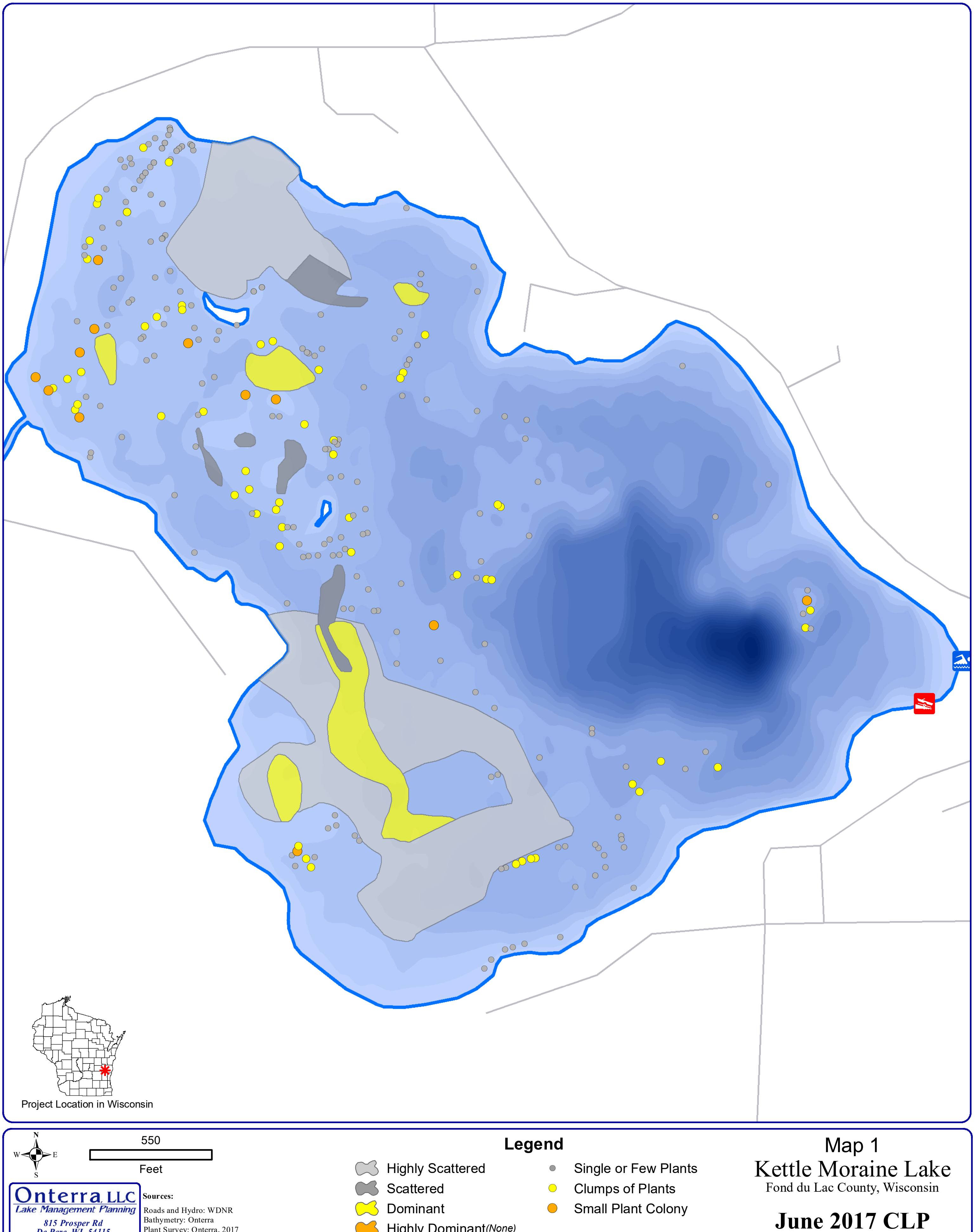

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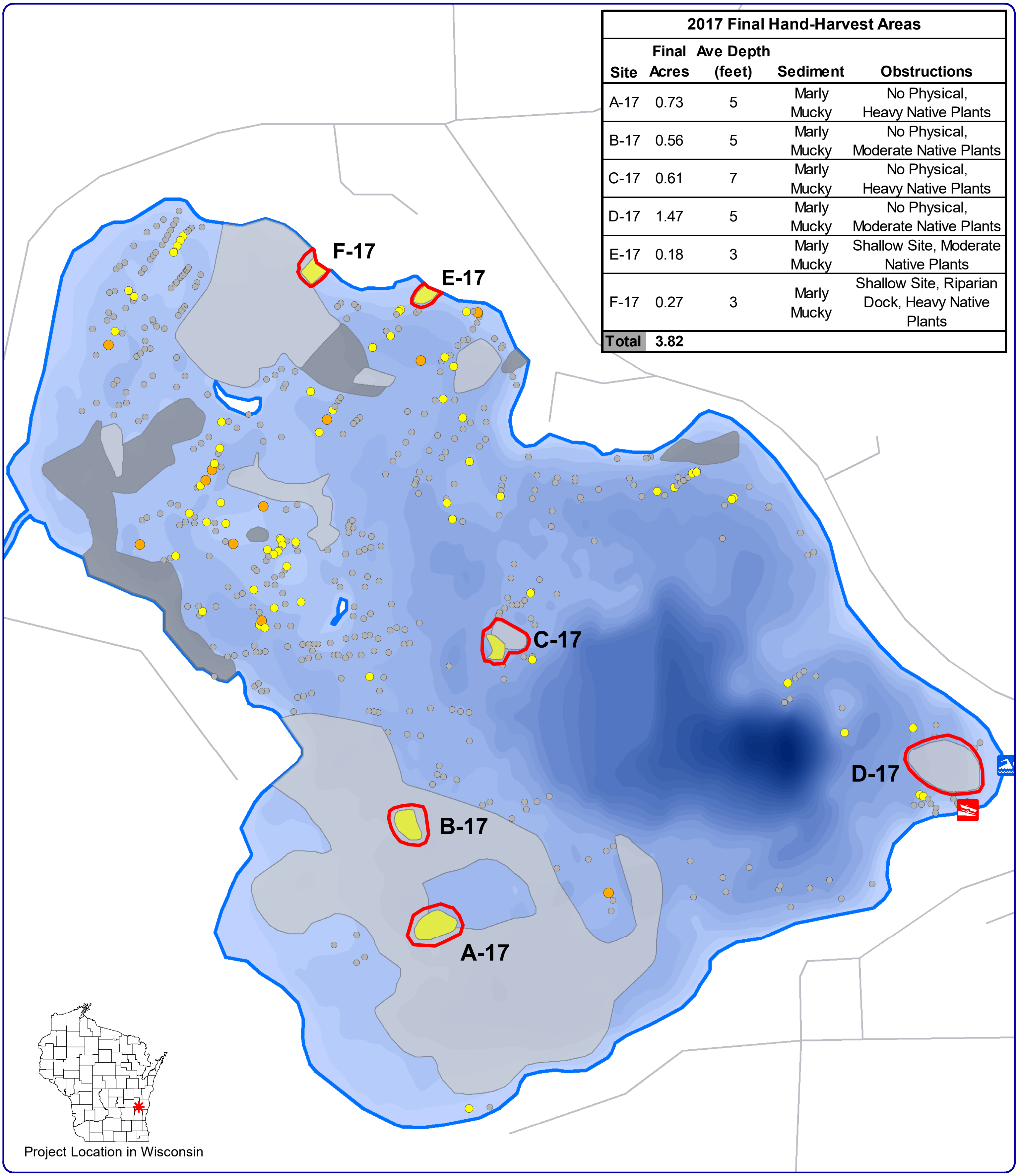
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra
Plant Survey: Onterra, 2017

Map Date: June 2, 2017
Filename: KM_CLP_June17.mxd

Map 1
Kettle Moraine Lake
Fond du Lac County, Wisconsin

June 2017 CLP Survey Results



2017 Final Hand-Harvest Areas

Site	Final Acres	Ave Depth (feet)	Sediment	Obstructions
A-17	0.73	5	Marly Mucky	No Physical, Heavy Native Plants
B-17	0.56	5	Marly Mucky	No Physical, Moderate Native Plants
C-17	0.61	7	Marly Mucky	No Physical, Heavy Native Plants
D-17	1.47	5	Marly Mucky	No Physical, Moderate Native Plants
E-17	0.18	3	Marly Mucky	Shallow Site, Moderate Native Plants
F-17	0.27	3	Marly Mucky	Shallow Site, Riparian Dock, Heavy Native Plants
Total	**3.82**			

N S W E

550 Feet

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant *(None)*
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Final DASH Site

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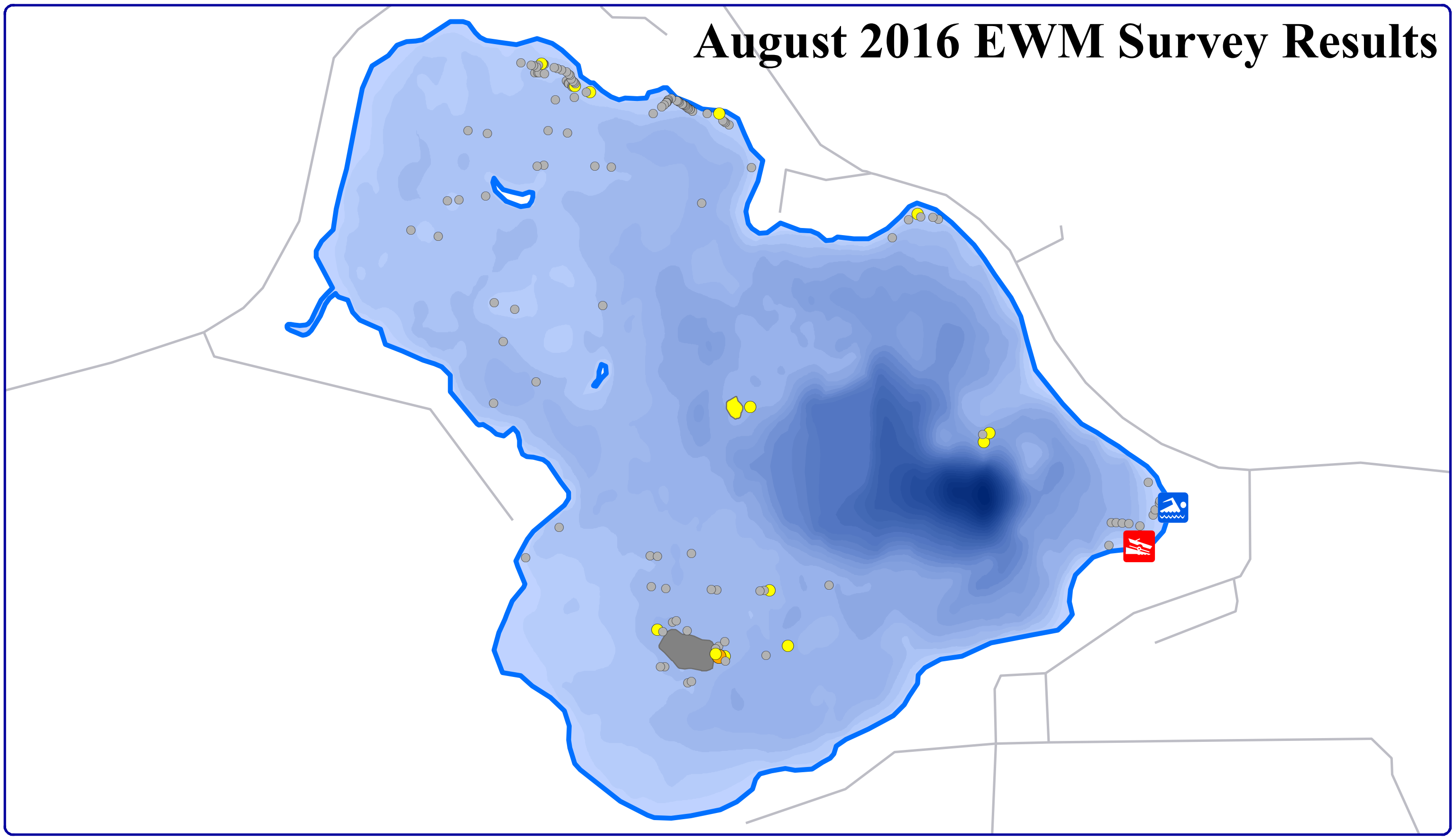
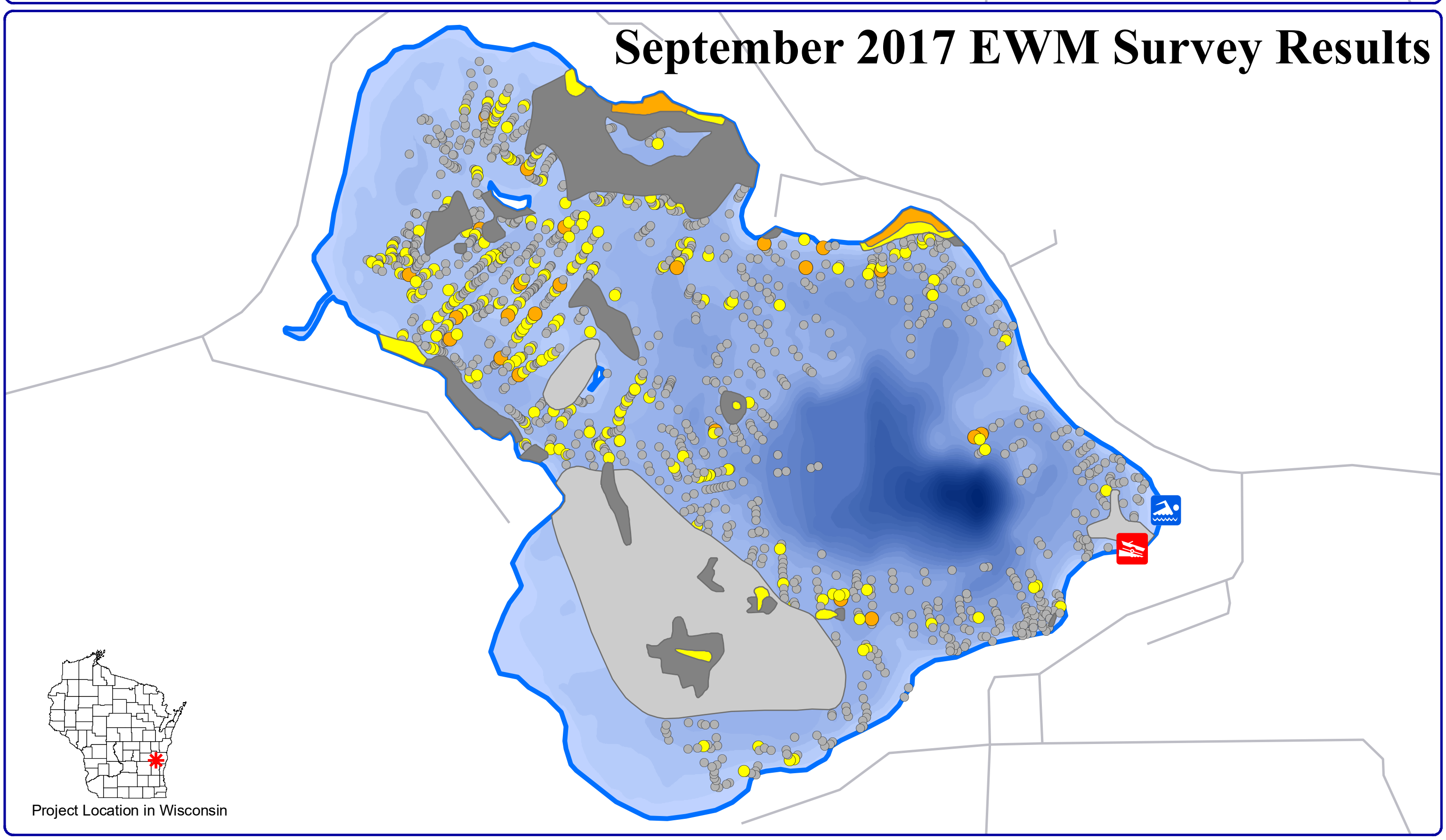
Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra
Plant Survey: Onterra, 2017

Map Date: July 18, 2017
Filename: *KM_EWM_June17.mxd*

Map 2
Kettle Moraine Lake
Fond du Lac County, Wisconsin

June 2017 EWM Survey Results & Hand Harvest Sites





900
Feet

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

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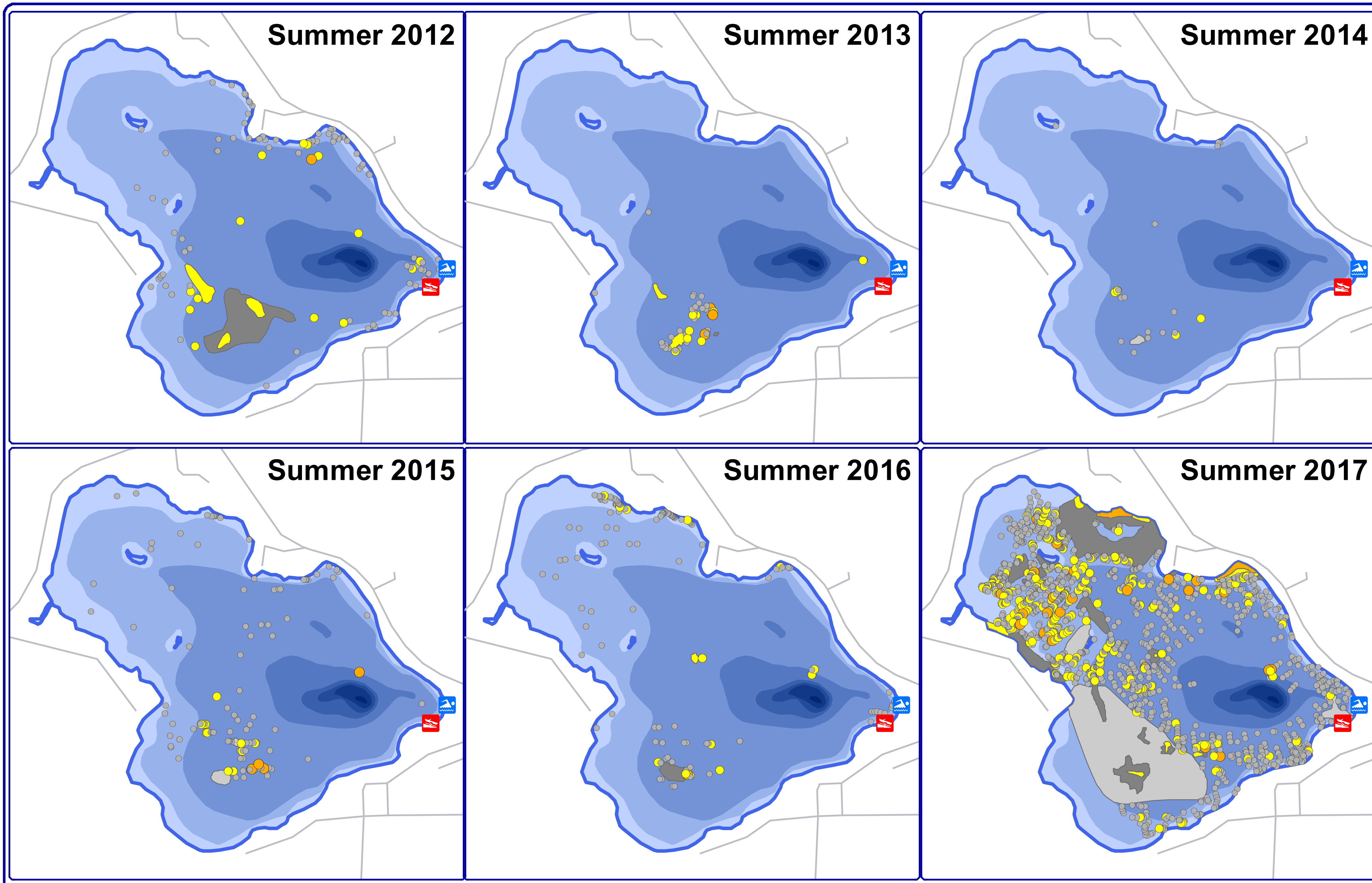
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR - Digitized by Onterra
Plant Survey: Onterra, 2016-2017
Map Date: March 7, 2018 - TWH
Filename: KM_EWMPB_2016-2017.mxd

Map 3
Kettle Moraine Lake
Fond du Lac County, Wisconsin

Late-Summer 2016 & 2017 EWM Survey Results



N
W E
S

600
Feet

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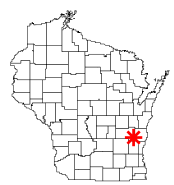
Sources:
Roads Hydro: WDNR
Bathymetry: WDNR
Plant Survey: Onterra, 2012-2017
Map Date: March 15, 2018
Filename: KettleMoraine_EWMPB_2012-2017.mxd



Project Location in Wisconsin

Legend

EWM Survey

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Public Landing
- Beach

Map 4

Kettle Moraine Lake

Fond du Lac County, Wisconsin

2012-2017 EWM Survey Results

A

APPENDIX A

WDNR Aquatic Herbicide Regulations FAQ
WDNR Chemical Fact Sheet (Fluridone)

Frequently Asked Questions about Aquatic Herbicide Use in Wisconsin

Prepared by Wisconsin Dept. of Natural Resources, Dept. of Health Services and Dept. of Agriculture, Trade, and Consumer Protection

June 23, 2011

Why are herbicides used in Wisconsin lakes and rivers?

Aquatic herbicides are used to reduce the abundance of invasive species to reduce spread to new water bodies, to help maintain a healthy native plant community that is beneficial for fish and other aquatic organisms, to improve navigational access to lakes and rivers and make boat navigation safer, and to control nuisance plant and algae growth that can pose a hazard to swimmers.

How is aquatic herbicide use regulated in Wisconsin?

In order to be used in Wisconsin, an aquatic herbicide must be all of the following:

1) Labeled and registered with U.S. EPA's office of Pesticide Programs;
2) Registered for sale and use by the Department of Agriculture, Trade, and Consumer Protection (DATCP);
3) Permitted by the Department of Natural Resources (DNR); and
4) Applied by a DATCP-certified and licensed applicator, with few exceptions.

Step 1) U.S. EPA's office of Pesticide Programs reviews the chemical and label.

Federal law requires herbicides to be registered with the Environmental Protection Agency (EPA) before they can be sold or used. The registration process determines potential risk to human health and the environment. The human health assessment includes sensitive groups such as infants, and risk is evaluated for both short-term and chronic effects. Ultimately, the EPA registers the herbicide if it determines that use of the pesticide will result in "no unreasonable adverse effects" as defined in federal law. This means that the benefits of using the pesticide according to the label outweigh the risks. Once an herbicide is registered, it is re-assessed by EPA every fifteen years.

Step 2) Herbicides must be registered by DATCP prior to sale or use in Wisconsin.

Most EPA-registered herbicide products are eligible to be registered for sale and use in Wisconsin by DATCP-licensed manufacturers and labelers. DATCP will not register an herbicide for use if it is prohibited for sale, use or distribution in Wisconsin, even if it is registered by EPA.

Step 3) DNR evaluates requests for use of chemicals in public waters when a permit application is submitted.

> When making a decision whether or not to issue a permit, the Department considers the appropriateness of the herbicide selected at the site, the likely non-target organism effects, the potential for adverse effects on the water body, as well as the potential hazard to humans. DNR may then issue the permit, issue the permit with conditions, or deny the permit. Permit conditions are frequently used to make sure that the herbicide is used responsibly and in accordance with best management practices for the plant being managed.

Step 4) Applied by a certified applicator.

> Most herbicide applications to water bodies in Wisconsin must be done by certified applicators. To become certified, an individual must complete a training course and pass a written exam. Businesses that provide herbicide application services must also be licensed by DATCP. A certified applicator is not needed only if the treatment area is less than ¼ acre in size and the product being applied is a granular herbicide.

Are herbicides safe?

The distinction between "EPA registered" and the terms "approved" or "safe" is important. Registration by the EPA does not mean that the use of the herbicide poses no risk to humans or the environment, only that for use in the U.S., the benefits have been determined to outweigh the risks. Because product use is not without risk, the EPA does not define any herbicide as "safe". It is prudent to minimize herbicide exposure whenever possible.

When an herbicide is registered, the EPA sets use requirements to minimize risk that are given on the herbicide label. When using herbicides it is important to follow the label instructions exactly, and never use an herbicide for a use not specified on the label.

What does the DNR do to minimize herbicide use and ensure that herbicides are used responsibly?

The Department of Natural Resources evaluates the benefits of using a particular chemical at a specific site vs. the risk to non-target organisms, including threatened or endangered species, and may stop or limit treatments to protect them. The Department frequently places conditions on a permit to require that a minimal amount of herbicide is needed and to reduce potential non-target effects, in accordance with best management practices for the species being controlled. For example, certain herbicide treatments are required by permit conditions to be in spring because they are more effective, require less herbicide and reduce harm to native plant species. Spring treatments also means that, in most cases, the herbicide will be degraded by the time peak recreation on the water starts.

The DNR encourages minimal herbicide use by requiring a strategic Aquatic Plant Management (APM) Plan for management projects over 10 acres or 10% of the water body or any projects receiving state grants. DNR also requires consideration of alternative management strategies and integrated management strategies on permit applications and in developing an APM plan, when funding invasive species prevention efforts, and by encouraging the use of best management practices when issuing a permit.

The Department also supervises treatments, requires that adjacent landowners are notified of a treatment and have an opportunity to request a public meeting, requires that the water body is posted to notify the public of treatment and usage restrictions, and requires reporting after treatment occurs.

How long do the chemicals stay in the water?

The amount of time an herbicide will stay in the water varies greatly based on a number of different factors, including the type of herbicide used. Residues may only be present in the water for a few hours, or for as long as a few months. Each herbicide has different characteristics that affect where the chemical moves (e.g. if it stays in the water column or settles into the sediment), how it is broken down, and how long it can be detected in water, sediments, and aquatic organisms. For more information on the environmental fate of a particular herbicide, please see the individual chemical fact sheets, available by request from your local lake coordinator (http://dnr.wi.gov/lakes/contacts/Contacts.aspx?role=LAKE_COORDINATOR). These are currently being updated and will be available online soon, as well.

Should I let my kids swim in the water?

None of the aquatic herbicides licensed for use in Wisconsin have swimming restrictions. Dilute amounts of herbicide may be present in the water, but EPA has determined that minimal exposure would result from adults or children swimming in treated waters.

Use restrictions for treated water vary by herbicide, but will always be listed on the herbicide label. To find out how to read an herbicide label, see http://www.epa.gov/pesticides/label/. Restrictions must be posted at public access points to the water body for at least one day near an herbicide treatment and sent to shoreline landowners in advance of the treatment. To minimize your risk of direct exposure, it is wise to stay a safe distance from the area being treated while herbicide applications are being made.

What if I accidently ingest some of the water while swimming or my pet drinks the water?

When assessing the risk posed by swimming in treated water, the EPA considers exposure from accidental swallowing of water, as well as from other routes such as through the skin. Any exposure to herbicide in the water while swimming or through accidental ingestion would be small and would not have toxic effects. Similarly, your pet should not have any side effects from swimming in or drinking treated water, so long as any applicable use restriction period is over.

Are there risks to drinking water?

In Wisconsin, most drinking water supplies come from groundwater, not surface water. For water bodies that are used for drinking water, treatments are required to be a minimum distance from any existing intakes (usually ¼ of a mile). Wells are not considered to be intakes, and therefore the setback distance does not apply. Some aquatic herbicides can move through the sediment into the groundwater, but even those that do move through soil have not been detected above drinking water thresholds in wells.

Campers that are treating surface water for drinking should obtain water from an alternate location until after any posted drinking water restrictions have passed.

Can I eat the fish?

There are no restrictions on eating fish for any currently registered aquatic herbicides following application to water. That does not mean you would not be exposed to the herbicide, just that the amount of herbicide that you might be exposed to is not toxic. A common concern with eating fish from treated water is that the herbicide concentration may be higher in fish tissues than in the water, and therefore exposure may be greater from fish than from exposure to lake water. The potential for bioaccumulation in fish varies by herbicide, and is evaluated by the EPA during the registration process.

Can I water my lawn/garden with lake water?

Many of the herbicides used in lakes and ponds are broadleaf herbicides which will damage garden plants including fruits and vegetables. Some aquatic herbicides will also affect grass. Whether you are watering your lawn or your garden, follow water usage restrictions to avoid any unintended damage. These restrictions on watering will be listed on the herbicide label and posted at boat landings and beaches. The limits vary widely, from no restriction to 120 days. If you are unsure about the herbicide used on the lake near your home, the safest option is to use water from your municipal supply or private well to water plants.

How can I find out if an aquatic herbicide treatment is scheduled for my lake, or has occurred recently?

Notices of herbicide applications and the use restrictions of the herbicides used are required to be posted along shore adjacent to a treatment area, as well as at public access points for the day of treatment through the end of the restricted use period. Additionally, landowners adjacent to a treatment area should be sent advance notification of the treatment by mail, email or newsletter. For a large-scale treatment (over 10 acres or over 10% of the area of the lake) all landowners around the lake would receive advance notification.

How can I be notified in advance of when and where an application will occur, even if I am not adjacent to the treatment area?

The DNR will notify any interested person of upcoming applications if they request to be notified in writing each year. To request notification, contact your local DNR aquatic plant management coordinator (http://dnr.wi.gov/lakes/contacts/Contacts.aspx?role=AP_MNGT).

Why can one person or group of people receive a permit to treat my lake if I don't want the treatment?

Any individual or group can request a permit from the DNR for a treatment since water bodies in the state are public property. The DNR is charged with evaluating any proposed treatments to consider the impact on the environment, and permits can be denied.

The permitting process requires that all landowners adjacent to the treated area be notified of the treatment. If you receive the notice and don't want the treatment to occur, you can send a written request to the applicant and the DNR requesting a public informational meeting on topics of concern to you regarding the treatment and alternatives. If 5 or more such requests are received within 5 days of the notice, the applicant is required to conduct such a meeting in a location near the water body.

What can I do to reduce the need for aquatic herbicide use?

Individuals can help reduce requests for herbicide use to control aquatic plants and algae by implementing best management practices on their property to prevent nutrients from running into the water and by preventing the spread of invasive species. To reduce runoff eliminate the use of fertilizers adjacent to a water body, rake leaves out of the street and off the lawn, plant a buffer strip of native vegetation on shore to reduce erosion and filter water coming off lawns, create a rain garden to filter and slow down water from driveways or rooftops, use a rain barrel to collect water from rooftops to use to water plants, or use a pervious option to pave driveways and sidewalks. To prevent the introduction of new invasive species and stop the spread of existing invasives, when boating remove plants, animals, and mud from your boat when leaving a boat launch, drain all water from your boat, and rinse your boat and equipment with hot or high pressure water or allow to dry for at least five days before moving to another water body.

Where can I find more information about a specific herbicide?

The DNR keeps a fact sheet on file for each herbicide used in aquatic systems. These fact sheets can be requested from your local DNR lake coordinator (http://dnr.wi.gov/lakes/contacts/Contacts.aspx?role=LAKE_COORDINATOR), and will be updated and available online soon, as well.

The EPA's risk assessments are available at http://www.epa.gov/pesticides/reregistration/status.htm.

Additional information can be found with these resources:

http://www.co.thurston.wa.us/health/ehipm/ehipm_aquaticreview.html
Health assessment of aquatic herbicides by Thurston County, Washington, Public Health and Social Services

http://extoxnet.orst.edu/pips/ghindex.html
Specific information on pesticides as well as toxicology

http://npic.orst.edu/
Information about pesticides, supported by EPA and Oregon State University

http://www.datcp.wi.gov/Plants/Pesticides/
WI Department of Agriculture, Trade, and Consumer Protection

January 2012

Fluridone Chemical Fact Sheet

Formulations

Fluridone is an aquatic herbicide that was initially registered with the EPA in 1986. The active ingredient is 1-methyl-3-phenyl-5-3-(trifluoromethyl)phenyl|-41H|-pyridinone. Both liquid and slow-release granular formulations are available. Fluridone is sold under the brand names Avast!, Sonar, and Whitecap (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Fluridone is an herbicide that stops the plant from making a protective pigment that keeps chlorophyll from breaking down in the sun. Treated plants will turn white or pink at the growing tips after a week and will die in one to two months after treatment as it is unable to make food for itself. It is only effective if plants are growing at the time of treatment.

Fluridone is used at very low concentrations, but a very long contact time is required (45-90 days). If the fluridone is removed before the plants die, they will once again be able to produce chlorophyll and grow.

Fluridone moves rapidly through water, so it is usually applied as a whole-lake treatment to an entire waterbody or basin. There are pellet slow-release formulations that may be used as spot treatments, but the efficacy of this is undetermined. Fluridone has been applied to rivers through a drip system to maintain the concentration for the required contact time.

Plants vary in their susceptibility to fluridone, so typically some species will not be affected even though the entire waterbody is treated.

Plants have been shown to develop resistance to repeated fluridone use, so it is recommended to rotate herbicides with different modes of action when using fluridone as a control.

Fluridone is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). It also is commonly used for control of invasive hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*), neither of which are present in Wisconsin yet. Desirable native species that are usually affected at concentrations used to treat the invasives include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (Utricularia spp.) also can be affected.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of fluridone (the time it takes for half of the active ingredient to degrade) ranges from 4 to 97 days depending on water conditions. After treatment, the fluridone concentration in the water is reduced through dilution due to water movement, uptake by plants, adsorption to the sediments, and break down from light and microbial action.

There are two major degradation products from fluridone: n-methyl formamide (NMF) and 3-trifluoromethyl benzoic acid. NMF has not been detected in studies of field conditions, including those at the maximum label rate.

Fluridone residues in sediments reach a maximum in one to four weeks after treatment and decline in four months to a year depending on environmental conditions. Fluridone adsorbs to clay and soils with high organic matter, especially in pellet form, and can reduce the concentration of fluridone in the water. Adsorption to the sediments is reversible; fluridone gradually dissipates back into the water where it is subject to chemical breakdown.

Impacts on Fish and Other Aquatic Organisms

Fluridone does not appear to have any apparent short-term or long-term effects on fish at application rates.

Fish exposed to water treated with fluridone absorb fluridone into their tissues. Residues of fluridone in fish decrease as the herbicide disappears from the water. The EPA has established a tolerance for fluridone residues in fish of 0.5 parts per million (ppm).

Studies on Fluridone's effects on aquatic invertebrates (i.e. midge and water flea) have shown increased mortality at label application rates.

Studies on birds indicate that fluridone would not pose an acute or chronic risk to birds. No studies have been conducted on amphibians or reptiles.

Human Health

The risk of acute exposure to fluridone would be primarily to chemical applicators. The acute toxicity risk from oral and inhalation routes is minimal. Concentrated fluridone may cause some eye or skin irritation. No personal protective equipment is required on the label to mix or apply fluridone.

Fluridone does not show evidence of causing birth defects, reproductive toxicity, or genetic mutations in mammals tested. It is not considered to be carcinogenic nor does it impair immune or endocrine function.

There is some evidence that the degradation product NMF causes birth defects. However, since NMF has only been detected in the lab and not following actual fluridone treatments, the manufacturer and EPA have indicated that fluridone use should not result in NMF concentrations that would adversely affect the health of water users. In the re-registration assessment that is currently underway for fluridone, the EPA has requested additional studies on both NMF and 3-trifluoromethyl benzoic acid.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

Wisconsin Department of Health Services
http://www.dhs.wisconsin.gov/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/

Hamelink, J.L., D.R. Buckler, F.L. Mayer, D.U. Palawski, and H.O. Sanders. 1986. Toxicity of Fluridone to Aquatic Invertebrates and Fish. Environmental Toxicology and Chemistry 5:87-94.

Fluridone ecological risk assessment by the Bureau of Land Management, Reno Nevada: http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/veis.Par.91082.File.tmp/Fluridone%20Ecological%20Risk%20Assessment.pdf

B

APPENDIX B

SePRO Sonar Risk Assessment

SONAR*

An Effective Herbicide That Poses Negligible Risk To Human Health And The Environment

Sonar is a highly effective aquatic herbicide used to selectively manage undesirable aquatic vegetation in freshwater ponds, lakes, reservoirs, rivers and canals. Sonar is absorbed through the leaves, shoots, and roots of susceptible plants, and destroys the plant by interfering with its ability to make and use food. As with any substance introduced into the environment, concerns arise about possible harmful effects on humans who may come into contact with it, and about its effects on wildlife and plants that we wish to protect and preserve. The following discussion, presented in a "Question and Answer" format, provides information regarding Sonar and evidence that Sonar presents negligible risk[1] to human health and the environment when applied according to its legally allowed uses and label directions.

Q1. What are the legally approved uses of Sonar?

A1. Sonar has been approved for use by the U.S. Environmental Protection Agency (USEPA) since 1986 for the management of aquatic vegetation in freshwater ponds, lakes, reservoirs, drainage canals, irrigation canals and rivers. Four different formulations have been approved for use—an aqueous suspension known as Sonar A.S. (USEPA Registration Number 67690-4) and three pellet forms known as Sonar SRP (USEPA Registration Number 67690-3), Sonar PR Precision Release (USEPA Registration Number 67690-12), and Sonar Q Quick Release (USEPA Registration Number 67690-3). There are no USEPA restrictions on the use of Sonar-treated water for swimming or fishing when used according to label directions. The Agency has approved Sonar's application in water used for drinking as long as residue levels do not exceed 0.15 parts per million (ppm) or 150 part per billion (ppb). For reference, one (1) ppm can be considered equivalent to roughly one second in 12 days or one foot in 200 miles, and (0.1) ppm can be considered approximately equal to one second in 120 days or one foot in 2,000 miles.

Sonar's USEPA-approved labeling states that in lakes and reservoirs that serve as drinking water sources, Sonar applications can be made up to within one-fourth mile (1,320 feet) of a potable water intake. For the control of Eurasian watermilfoil, curlyleaf pondweed and hydrilla where treatment concentrations are 0.01 to 0.02 ppm (10 to 20 ppb), this setback distance of one-fourth mile from a potable water intake is not required. Note that these effective treatment concentrations are well below the 0.15 ppm (150 ppb) allowable limit in water used for drinking.

Local public agencies may require permits for use of an herbicide in public waters. Therefore, the Sonar label states that the user must consult appropriate state or local water authorities before applying the herbicide.

[1]Throughout this document, we use the phrases "negligible risk" or "no significant risk." We use these terms because it is beyond the capabilities of science to prove that a substance is absolutely safe, i.e., that the substance poses no risk whatsoever. Any substances, be it aspirin, table salt, caffeine, or household cleaning products, will cause adverse health effects at sufficiently high doses. Normal exposures to such substances in our daily lives, however, are well below those associated with adverse health effects. At

some exposure, risks are so small that, for all practical purposes, no risk exists. We consider such risks to be negligible or insignificant.

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Q2. How does a product such as Sonar gain approval for use? (How does it become registered?)

A2. Federal law requires that an aquatic herbicide be registered with the USEPA before it can be shipped or sold in the United States. To obtain registration, manufacturers are required to conduct numerous studies (i.e., over 120 studies depending upon the intended uses) and to submit a thorough and extensive data set to USEPA to demonstrate that, under its conditions of use, the product will not pose a significant risk to human health and the environment and that the herbicide is effective against the target weeds or plants.

Individual states can establish registration standards that are more strict than federal standards, but not less strict.

Q3. What types of information must be submitted to regulatory agencies before an herbicide is registered?

A3. To register a herbicide, the manufacturer must submit information that falls into the following categories: product chemistry (for example, solubility, volatility, flammability and impurities), environmental fate (for example, how the substance degrades in the environment), mammalian toxicology (studies in laboratory animals used to assess potential health risks to humans), and wildlife and aquatic (for example, bird and fish) toxicology. If there are any residues in the environment, their levels must be determined. A manufacturer also conducts studies of product performance (or efficacy as a herbicide).

Q4. Have all of the data required for registration of Sonar been submitted to regulatory agencies, and have those agencies found the data acceptable?

A4. The data required for registration of Sonar by the USEPA is complete and has been accepted by the USEPA and by all states.

Q5. What happens to Sonar when it is used according to approved labeling -- that is, what is its environmental fate or what happens to Sonar once it is released or applied to the water?

A5. Tests under field conditions show that Sonar disappears from treated water in a matter of weeks or months, depending on a number of environmental factors such as sunlight, water temperature and depth. In lakes, reservoirs, rivers and canals where only a portion of the water body is treated, dilution reduces the level of Sonar relatively quickly following application.

Sonar does not persist in the environment. Its disappearance from aquatic environments is accomplished by several processes. First, the plants that are being treated absorb Sonar, thereby removing a portion of it from the water. Second, Sonar degrades or breaks down in the presence of sunlight by a process called "photo degradation." Photo degradation is the primary process contributing to the loss of Sonar from water. Third, adsorption of Sonar to hydrosoil (sediments) also contributes to its loss from water. As Sonar is released from hydrosoil back into the water, it is photo degraded.

Study results indicate that Sonar has a low bioaccumulation potential and therefore is not a threat to the food chain. Specifically, studies have shown that Sonar does not accumulate in fish tissue to any significant degree. The relatively small amounts of Sonar that may be taken up by fish following application are eliminated as the Sonar levels in water decline. In a study of crops irrigated with Sonar treated water, no residues of Sonar were found in any human food crops, and only very low levels were detected in certain forage crops. Consumption by livestock of Sonar-treated water and crops irrigated with Sonar-treated water was shown to result in negligible levels of Sonar in lean meat and milk. Sonar-treated water can be used immediately for watering livestock.

To ensure that residue levels of Sonar pose no significant risk, USEPA has established tolerances, or maximum legally allowable levels, in water, fish, and crops irrigated with Sonar-treated water, and other agricultural products (including eggs, milk, meat, and chicken). For example, the 0.15 ppm (150 ppb) concentration in water mentioned in the answer to Question #1 is the tolerance limit for water that is used for drinking. The recommended application rates of Sonar (detailed on the label) are established to ensure the product will do its job and that tolerance limits won't be exceeded.

Q6. How might people come into contact with Sonar after it is applied to an aquatic site?

A6. People could come into contact with Sonar by swimming in water bodies treated with the herbicide, by drinking water from treated lakes or reservoirs, by consuming game fish taken from treated waters, and by consuming meat, poultry, eggs or milk from livestock that were provided water from treated surface water sources.

Q7. Is it likely that people will be harmed because of those contacts?

A7. Extensive studies have demonstrated that contact with Sonar poses negligible health risks when the herbicide is used according to label instructions. The label for Sonar carries no restrictions for swimming or fishing in treated water or against drinking water treated with Sonar. Sonar does not build up in the body.

The conclusion that Sonar poses negligible health risks is evidenced by USEPA's toxicity rating for Sonar. The USEPA classifies herbicides according to their acute toxicity or potential adverse health effects and requires that a "signal word" indicating the relative toxicity of the herbicide be prominently displayed on the product label. Every herbicide carries such a signal word. The most acutely toxic herbicide category requires the signal word DANGER. However, if the product is especially toxic, the additional word POISON is displayed. Herbicides of moderate acute toxicity require the signal word WARNING. The least toxic products require the signal word CAUTION. Sonar labels display the word CAUTION, the USEPA's lowest acute toxicity rating category.

Q8. How do we know that humans are not likely to experience any harmful effects from Sonar's temporary presence in the environment?

A8. Companies that develop new herbicides are required to: 1) conduct extensive investigations of the toxicology of their product in laboratory animals; 2) characterize the ways by which people may contact the herbicide after it has been applied to an aquatic site; 3) determine the amount of exposure resulting from these possible contacts; and 4) demonstrate the fate of the herbicide in the environment. Before USEPA will register a herbicide, the Agency must establish with a high degree of certainty that an ample safety margin exists between the level to which people may be exposed and the level at which adverse effects have been observed in the toxicology studies.

Investigations of the toxicity of Sonar have been performed in laboratory animals under a variety of exposure conditions, including exposure to very high doses for short periods (acute studies), as well as repeated exposures to lower doses (which are still far in excess of any exposures that humans might actually receive) throughout the lifetime of the laboratory animals (chronic studies). Other special studies have been performed to evaluate the potential for Sonar to cause reproductive effects, cancer, and genetic damage. Study results indicate a low order of toxicity to mammalian species following acute exposures and repeat-dose exposures for up to a lifetime. In addition, repeated doses of Sonar did not result in the development of tumors, adverse effects on reproduction or on development of offspring, or genetic damage.

In characterizing the toxicity of a compound and its safety margin for exposures of humans and wildlife, toxicologists attempt to identify the maximum dose at which a chemical produces no toxicity. Another way of stating this is how much of the chemical can an organism be exposed to before it reaches a toxic level (recall from the footnote to the introduction on page 1 that all substances are toxic at some dose or level). This maximum non-toxic dose is usually established by studies in laboratory animals and is reported as the "no-observed-effect level" or NOEL. The dietary NOEL for Sonar (that is, the highest dose at which no adverse effects were observed in laboratory animals fed Sonar) is approximately 8 milligrams of Sonar per kilogram of body weight per day, abbreviated 8 mg/kg/day. This NOEL was derived from a study in rats that were fed Sonar in their regular diets every day for their entire two-year lifetime.

To put this NOEL into perspective, a 70-kg adult (about 150 pounds) would have to drink over 1,000 gallons of water containing the maximum legally allowable concentration of Sonar in potable water (0.15 ppm) daily for a significant portion of their lifetime to receive a dose equivalent to the 8 mg/kg/day NOEL. At most, adults drink about 2 quarts (one-half gallon) of water daily, which means that even if a person were drinking water with the maximum legally allowable concentration of Sonar, their margin of safety would still be at least 2,000. Similarly, a 20-kg child (about 40 pounds) would have to drink approximately 285 gallons of Sonar-treated water every day to receive a dose equivalent to the NOEL. Because children drink only about one quart of water daily, this provides a safety margin of greater than 1,000.

The above example calculation of safety margins is based on the assumption that potable water will contain levels of Sonar at its maximum allowable concentration of 0.15 ppm (150 ppb). In fact, the Sonar concentration achieved under typical applications is closer to 0.02 ppm (20 ppb), thereby providing a safety margin seven times greater. The point is that adults and children who drink water from potable water sources that have been treated with Sonar according to label instructions are at negligible risk.

Similarly, the levels of Sonar allowed in various food products pose negligible risk to human health. For example, even if Sonar were present at the maximum allowable limit of 0.05 ppm in meat, poultry, eggs, and milk, a 70-kg adult would have to consume almost 25,000 pounds of these foods daily (and again for a significant portion of a lifetime) to receive a dose equivalent to the dietary NOEL for Sonar. A child would have to consume over 7,000 pounds of these foods daily.

Because Sonar is used only intermittently in any one area, and because it disappears from the environment, there is virtually no way that anyone will be exposed continuously for a lifetime. Because the NOEL derives from a study involving daily exposures for a lifetime, the actual safety margin for people is, in fact, much greater than is suggested by the above illustrative examples.

Q9. How complete is the toxicology information upon which this conclusion rests?

A9. All toxicity studies required by the USEPA to obtain registration approval for Sonar have been completed.

Q10. What about the people who apply Sonar—are they at risk?

A10. The Sonar label states that individuals who use Sonar should avoid breathing spray mist or contact with skin, eyes, or clothing; should wash thoroughly with soap and water after handling; and should wash exposed clothing before reuse. These precautions are the minimum recommendations for the application of any pesticide. If Sonar is used according to label instructions, exposures to the product should be minimal and use should pose negligible risks to applicators.

Sonar has been shown to be of low acute toxicity in laboratory animal studies (that is, toxicity from a high dose exposure for a short period of time). Therefore, any exposure to the product (even undiluted) that might occur during use is unlikely to lead to adverse effects as long as label instructions are followed. As discussed in Question #7, Sonar's label carries the signal word CAUTION that corresponds to the USEPA's lowest acute toxicity rating category.

Studies in laboratory animals show that the lethal dose from a single oral exposure of Sonar is greater than 10,000 mg/kg. To put this into perspective, an adult would have to drink over one million gallons of Sonar-treated water (at the 0.15 [150 ppb] ppm maximum allowable limit) to receive a dose of 10,000 mg/kg; a 20-kg child would have to drink approximately 350,000 gallons.

Because applicators are more likely to contact the undiluted material than the general population, questions about the toxicity of Sonar following direct skin contact have been raised. A laboratory study of the toxicity of an 80 percent solution of Sonar applied to rabbit skin (a standard model to predict effects in humans) suggests that Sonar is minimally toxic by this route. In this study, when Sonar was repeatedly applied to the skin of rabbits for 21 days (in the largest amounts that could be applied practically), there were no signs of toxicity and only slight skin irritation was observed. Further, the dermal administration of the 80 percent solution of Sonar did not induce sensitization in guinea pigs.

Q11. Has there been any investigation of the possible harmful effects of Sonar on fish, wildlife, pets and livestock?

A11. The toxicity of Sonar has been investigated in laboratory studies in birds (including the bobwhite quail and mallard duck), in the honey bee (as a representative insect) and in the earthworm (as a representative soil organism), in five different species of freshwater and marine fish, and in other aquatic animals. These studies have involved exposures to high concentrations for brief periods as well as exposures lasting as long as an entire lifetime, including during reproduction.

Extensive studies have also been performed to evaluate the effects of Sonar on various aquatic and terrestrial plants (both those considered undesirable aquatic weeds and those native plants that we wish to protect). Studies in laboratory animals designed primarily to assess potential health risk in humans are also relevant to the assessment of potential health effects in mammalian wildlife, livestock, and pets.

In addition, **Sonar** has been monitored in water, plants and fish during field trials. This provides firsthand information on residue levels in the environment following application of Sonar.

Q12. What do these investigations reveal?

A12. A combination of the toxicity studies and residue monitoring data reveals that Sonar poses negligible risks to aquatic animals including fish, wildlife, pets, and livestock when used according to label directions.

As was done with laboratory mammals, toxicity studies were conducted to establish a dietary no-observed effect level (NOEL) for birds. This maximum, non-toxic chronic dose is 1,000 ppm in the diet. One thousand (1,000) ppm is 2,500 times the highest average concentration of total residue found in fish (0.40 ppm), about 2,100 times the highest concentration found in aquatic plants (0.47 ppm), and about 11,500 times the highest average concentration of Sonar found in the water at field trial sites (0.087 ppm). Because the residue levels in these “bird food” items are so far below the NOEL, it can be concluded is that there are negligible risks to birds that might be exposed to Sonar in their diet following application of Sonar.

The highest average Sonar concentration found in Sonar-treated water is below the lowest NOEL values for both short and long term exposures from freshwater and marine fish. Honeybees and earthworms are not particularly sensitive to Sonar. Sonar caused no deaths in honey bees when they were dusted directly with the herbicide, and earthworms were not affected when they were placed in soil containing more than 100 ppm Sonar.

Extensive testing of Sonar in laboratory animals used to assess potential risks to human health indicates that a large safety margin exists for mammalian species in general. Thus, Sonar poses negligible risk to pets, livestock, and mammalian wildlife that might drink from water treated with Sonar.

Q13. Can Sonar be used in environmentally sensitive areas?

A13. Sonar has been used in a wide range of aquatic environments in the United States without incident for almost 15 years. Florida canals and rivers are examples of environmentally sensitive areas that have been treated with Sonar. Some sites are habitats for the endangered Florida manatee. Although toxicity testing data for the manatee, or for other endangered species, cannot be collected directly, questions about whether Sonar treatment will pose any significant risk to the manatee can be answered with results of the mammalian toxicity studies.

The Florida manatee is an aquatic mammal that consumes up to 20% (one-fifth) of its body weight per day in aquatic plants. Treatment of canal water with Sonar according to label directions is expected to result in a maximum Sonar concentration of 0.15 ppm in the water and from 0.8 to 2.6 ppm in aquatic plants. Calculations show that it would be impossible for a manatee to ingest enough Sonar in its diet to cause any adverse effects, based on results of laboratory studies in other mammals. To reach the maximum non-toxic dose or NOEL for sensitive mammalian species, a manatee would have to drink more than 40 times its body weight per day in treated water, or eat at least 3 to 10 times its body weight per day in aquatic plants. This calculation indicates that treatment with Sonar in manatee habitats—as one example of an environmentally sensitive area—will pose negligible risk. In fact, application to Florida canals and rivers has been approved by the U.S. Fish and Wildlife Service, Florida Department of Environmental Protection, and the Florida Game and Fresh Water Fish Commission.

Sonar has also been used in other environmentally sensitive areas such as Disney World, Ducks Unlimited MARSH projects, Sea World, state and federal parks, and numerous fish and waterfowl management areas.

Q14. What is it that makes Sonar an effective aquatic herbicide while being a compound of relatively low toxicity to humans?

A14. Sonar inhibits a plant's ability to make food. Specifically, Sonar inhibits carotenoid synthesis, a process specific only to plants. Carotenoids (yellow, orange and red pigments) are an important part of the plant's photosynthetic (food making) system. These pigments protect the plant's green pigments (called chlorophyll) from photo degradation or breakdown by sunlight. When carotenoid synthesis is inhibited, the chlorophyll is gradually destroyed by sunlight. As a plant's chlorophyll decreases, so does its capacity to produce carbohydrates (its food source) through photosynthesis. Without the ability to produce carbohydrates, the plant dies.

Humans do not have carotenoid pigments. Therefore, the property of Sonar that makes it an effective herbicide at low doses does not affect the human body.

Q15. Will Sonar have an adverse effect on water quality?

A15. Extensive testing of a wide range of water bodies has shown no significant changes in water quality after Sonar treatment. In fact, Sonar has a practical advantage over certain other aquatic herbicides in this area. Specifically, the dissolved oxygen content of the water does not change significantly following Sonar treatment because the relatively slow herbicidal activity of the product permits a gradual decay of the treated vegetation. Maintaining adequate dissolved oxygen levels are critical to fish and other aquatic animals, which require oxygen to survive. This contrasts with the changes in water quality that can arise from the application of certain other aquatic herbicides that are “fast-acting.” The sudden addition of large amounts of decaying plant matter to the water body can lead to decreased oxygen levels and result in a fish kill. To avoid depressions in dissolved oxygen content, label directions for certain “fast-acting” aquatic herbicides recommend that only portions of areas of dense weeds be treated at a time. Because Sonar does not have any substantial impact on dissolved oxygen, it is possible to treat an entire water body with Sonar at one time.

Q16. Is there any reason for concern about the inert ingredients used in Sonar?

A16. Inert ingredients are those components of the product that do not exhibit herbicidal activity; that is, the components other than Sonar. Water is the primary inert ingredient in Sonar A.S., making up approximately 45% of the formulation. The second largest (approximately 10%) inert is propylene glycol; a compound used in facial creams and other health and beauty products. Other inert ingredients are added to serve as wetters, dispersants, and thickeners in the formulation. Trace amounts of an antifoaming agent and a preservative are also added. The primary inert ingredient in the pelleted formulations is clay, which makes up approximately 89% of the formulation. Small amounts of a binder or coating solution are also added to reduce the dustiness of the pellets. None of the inert ingredients in Sonar formulations are on the USEPA’s list of “Inerts of Toxicological Concern” or list of “Potentially Toxic Inerts/High Priority for Testing.” Thus, there is no reason for concern about the inert ingredients used in Sonar.

Q17. Is it important to follow label directions for use and disposal of Sonar?

A17. Yes. It is a violation of federal law to use products, including Sonar, in a manner inconsistent with product labeling or to improperly dispose of excess products or rinsate. Although the results of extensive toxicity testing in the laboratory and in field trials indicate a low order of toxicity to non-target plants, animals, and people, Sonar, like all chemicals, will cause adverse effects at sufficiently high exposure levels. Failure to follow label directions for use and disposal of Sonar could result in environmental levels that exceeds the tolerances for Sonar established to be protective of human health and the health of pets, livestock and other wildlife. In addition, improper use of Sonar could result in unintended damage to non-target plants.

Q18. If Sonar is used in conformance with label directions, is there any reason to be concerned that Sonar will pose risk to human health or the environment?

A18. As discussed in the answers to the previous questions, results of laboratory and field studies and extensive use experience with Sonar in a wide range of water bodies strongly support the conclusion that Sonar will pose negligible risks to human health and the environment when used in conformance with label directions.

In summary, it can be said that Sonar has a favorable toxicological profile for humans. It has an overall low relative toxicity and it is not a carcinogen, mutagen or reproductive toxicant. Sonar also has a very good environmental profile for an aquatic product because of: 1) its low toxicity to non-target organisms; 2) its non-persistent behavior when applied to water bodies (i.e., it readily breaks down to carbon, hydrogen, oxygen, nitrogen and fluorine); and 3) its low bioaccumulation potential, which means it does not build up in the body or in the food chain.