North & South Twin Lake
Protection & Rehabilitation District

P.O. Box 152
Conover, WI 54419

November 15, 2018

Dear WDNR Review Team;

Enclosed please find the 2018 Monitoring and Control Strategy Report for North and South Twin Lakes created by Onterra in collaboration with the North South Twin Lakes Protection and Rehabilitation District (The Lake District) and North South Twin Lakes Riparian Association (NSTLRA). As you are aware, in November of 2017 The Lake District was formed in order to be more able to financially share the costs associated with the management challenges of our Twin Lakes by all riparian’s. Going forward in this correspondence we shall refer to The Lake District as the governing body who has assumed the responsibilities from NSTLRA including adoption of the 2017 Lake Management Plan as well as future management activities, grants, monitoring, education and other practices associated with stewardship for the Twin Lakes.

First of all, it is important to note that The Lake District and its Riparian's are very concerned regarding the continued expansion of the EWM colonies in the Twin Lakes. A survey of riparian's conducted in 2016 identified what they considered to be an eroding lake quality of primary concern. In our conversations, educational newsletters and other correspondence, we have explained to them that the lake quality as measured by water clarity, phosphorus level and algae population are relatively unchanged from 20 years ago. However, they define lake quality as the diminishing ability to fish, swim, boat and generally recreate because of the explosion of EWM. Thus, as representatives of the riparian constituency we are expected to act responsibly in development and implementation of long-term management practices to improve the quality of this unique resource in the best interest of the stakeholders of the Twin Lakes.

Over the past 3 years we have been very systematic and thorough in our approach as we updated our Lake Management Plan utilizing feedback from our riparian's for guidance, increased our knowledge of invasive species and alternative management techniques to mitigate or suppress the impact of EWM on the resource. We are very cognizant that some management activities can have an impact on native plants, fishes and the lake ecosystem.

The Lake District has been very diligent in attending conferences, contacting other associations and districts, discussing treatment strategies with various applicators as well as consulting with lake experts at UWSP, SePro, Vilas County, Onterra and others to ensure we make the best risk-based decisions for the Twin Lakes as we possibly can.

We acknowledge that management activities such as herbicidal treatments can impact some native species in the Twin Lakes and as such our planned management activities have been very attentive to those concerns. Thus, our active management plan described in this report will collect data both pre and post treatments, to better understand any impacts which will assist us in future strategic and adaptive lake management activities.

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Today our problem and the management solution are twofold;

1) South Twin Lake has exploded to an EWM concentration of over 40% of the littoral area. What is most concerning is the highly dominant and surface matting that is currently discussed in detail in the report. Historical whole lake treatments with 2,4-D have been ineffective to achieve control because of the rapid breakdown of the herbicide by microbials which do not allow for adequate contact time for desired efficacy at the concentration levels approved by the WDNR.

Additionally, it is possible that the EWM may be developing some resistance following several treatments with 2,4-D. It is logical to consider alternative treatment methodologies to improve probability of success. As we looked at many other recent lake treatment activities, we concluded that Triclopyr, having similar auxin mimicking characteristics as 2,4-D, would have similar contact time challenges and thusly was excluded as a viable whole lake treatment alternative. Then as we researched the mode of action of Fluridone, using a treatment methodology over an extended period of time at a low dose, that this herbicide was the most probable alternative to achieve longer term control of South Twin.

In discussions at annual membership meetings of both the NSTLRA and The Lake District this summer, we discussed our lake management plan in great detail answering many questions from interested riparian's. Our plan was very favorably received and as such, a budget taking into consideration the whole lake treatment of S Twin with Fluridone was approved. We intend to apply for monitoring and control grants as well as treatment permits in the coming months to effectuate this strategy. These grant requests will also include proper monitoring to maximize our learning experience. We intend to treat in spring of 2019 with active DASH and/or hand harvesting in subsequent years to enhance the long-term control of EWM on S Twin.

2) Of equal concern is the rapidly expanding and increased density of EWM colonies in N Twin. This summer we actively spent 8 days of DASH harvesting on the 25 acres treated in spring 2017 to mitigate the migration of EWM further into N Twin. However, since our 2018 grant was not approved, we were not able to treat the 14 acres south of the Lakota landing which has seen significant expanse as well as increased % of highly dominant and surface matting of EWM.

This area must be addressed in 2019 in order to retard the explosion of EWM into the northern 75% of N Twin and avoid the challenges we are currently experiencing on S Twin. Thus, you will see we have identified a large-scale spot treatment using ProcellaCOR as the best management solution to accomplish control over this 14-acre colony of EWM. ProcellaCOR, which we understand, was used in Wisconsin only this past year, is the best herbicide because of its rapid absorption as well selective impact on EWM which we expect will have limited impact on natives.

Our research leads us to believe that ProcellaCOR, while not having a significant track record, has minimal risk when treating a 14-acre spot of a 2700-acre lake. Further, the outcome of the use of ProcellaCOR will provide us with excellent data as we pursue an adaptive management approach on the Twins. We, as well as others, can learn from the experience with ProcellaCOR in 2019. We intend to include this N Twin management activity in our grant and permit applications for 2019.

It is also important that you know we have been very active in our outreach to other stakeholders of the Twin Lakes. We have had meetings with the stakeholder groups listed below. During these meetings we shared our intended management activities, our reasoning for choosing those management activities and we answered their questions.

- Pioneer Lake Association

- Mole Lake Tribe

- Lac du Flambeau Tribe

- GLFWIC

We desire to be as transparent as possible to all stakeholders in our partnership to effectively manage our valuable resource, The Twin Lakes.

So, we submit this report to provide ample time for the WDNR review team to evaluate our planned management activities for 2019 and beyond and ask any questions of either The Lake District or Onterra.

We are very disappointed with the WDNR denial of grant and permits in 2018 and believe we have more than adequately provided support for why our intended management activities as described in this letter and report sufficiently justify approval of our upcoming grant applications and permits for 2019. These proposed activities are critical to reversing and controlling the EWM impact on the Twin Lakes.

Please do not hesitate to reach out to either of us with any comments or questions regarding our correspondence.

Respectfully submitted,

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North & South Twin Lakes
Vilas County, Wisconsin

2018 EWM Monitoring & Control Strategy Development Report

January 2019

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Funded by: North and South Twin Lake Protection & Rehabilitation District
Wisconsin Dept. of Natural Resources (ACEI-184-16)

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1.0 INTRODUCTION

Photograph 1.0-1. North & South Twin Lakes, Vilas County.

North and South Twin Lakes, Vilas County, are approximate 2,788- and 642-acre drainage lakes, respectively (Photo 1). North Twin Lake flows into South Twin Lake, and South Twin Lake is drained via the Twin River flowing into Pioneer Lake. The outlet is controlled by a dam operated by the Wisconsin Valley Improvement Corporation (WVIC). Eurasian water milfoil (*Myriophyllum spicatum*; EWM) was first documented in this system in 2001.

The North and South Twin Lake Riparian Association (NSTLRA) was formed in 1995 and has been the primary management entity of the Twin Lakes. NSTLRA completed a Lake Management Plan in 2000 (Vilas County Land, Air, and Water Conservation Department) with a Phase II update being completed in 2006 (Onterra, LLC). Annual EWM Control & Monitoring Reports guided aquatic invasive species (AIS) management activities since 2007, with an update to the aquatic plant portion of the Lake Management Plan being completed in January of 2012.

With Onterra's assistance, a Wisconsin Department of Natural Resources (WDNR) AIS-Education, Prevention, and Planning Grant was secured in December 2015 by the NSTLRA to conduct an updated Comprehensive Lake Management Plan. The lake management planning process provided for a holistic understanding of the Twin Lakes ecosystem involving assessments of the aquatic plant community, water quality, watershed, shoreline condition, fisheries data integration, and stakeholder perceptions of the lakes. The *North and South Twin Lakes Comprehensive Management Plan* was finalized and approved by the WDNR in June 2018.

In November 2017, the North and South Twin Lake Protection and Rehabilitation District (NSTLPRD, Lake District) was formed and has taken the responsibility for carrying out the activities outlined within the Comprehensive Management Plan.

1.1 Report Specifics

The NSTLRA have conducted management of EWM on the Twin Lakes since 2001 using both hand-harvesting and herbicide application. The *North and South Twin Lakes Comprehensive Management Plan* (June 2018) contains 31 pages of expanded discussion specific to Eurasian watermilfoil (EWM) and EWM management within the North and South Twin Lakes. The Implementation Plan Section (5.0) of the Comprehensive Management Plan contains management goals and associated management actions, including those the District constructed to manage and monitor the EWM population of North and South Twin Lakes. Reference to the Comprehensive Management Plan will improve understanding of this document. It can be accessed here:

https://dnr.wi.gov/lakes/grants/project.aspx?project=128402234

A draft of this document, the *2018 EWM Monitoring & Control Strategy Assessment Report* was provided to the Lake District, WDNR, Vilas County Land Conservation Department, Lac du Flambeau Band of Lake Superior Chippewa Indians, Mole Lake Sokaogon Chippewa Community, and Great Lakes Indian Fish and Wildlife Commission (GLIFWC) on November 15, 2018. The final report retains the original three-page cover letter the District attached to the report Onterra authored.

The WDNR assembled a Technical Review Team on December 13, 2018 and shared their aggregated comments to the District and Onterra during a December 17, 2018 meeting/teleconference. Their full comments are available in Appendix D as well as response comments by the Lake District, SePRO, and Onterra. The WDNR's comments are being interpreted as critical of the use of herbicide management techniques on both lakes, and conveyed preference for the Lake District to consider mechanical harvesting to remedy issues of navigation impediment caused by EWM. GLIFWC's comments are also interpreted as critical of herbicide treatment, which are also included within Appendix D with response comments by WDNR, Lake District, SePRO, and Onterra.

2.0 WHOLE-LAKE HERBICIDE TREAMENT OF SOUTH TWIN

2.1 Background on Whole-Lake 2,4-D Treatments

From an ecological perspective, whole-lake treatments are those where the herbicide may be applied to specific sites, but when the herbicide dissipates from where it was applied and reaches equilibrium within the entire mixing volume of water (of the lake, lake basin, or within the epilimnion of the lake or lake basin); 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 whole-lake 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."

Predicting success and native plant impacts from whole-lake treatments, is also better understood than for spot treatments. This is particularly true for whole-lake 2,4-D treatments, as there is an increasingly large database of lakes that adopted this herbicide use-pattern. However, with any whole-lake chemical treatment, both the positive and negative effects of this type of treatment strategy are anticipated to occur at a lakewide scale, whereas the impacts from spot treatments are mostly contained within and around the application sites.

Figure 2.1-1 shows point-intercept data comparison from 19 whole-lake 2,4-D treatments in the Northern Lakes and Forests Ecoregion believed to have invasive milfoil populations consisting of only pure-strain EWM (no documented hybrid watermilfoil). Nine of the projects have data past one year after treatment (YAT) whereas others have not progressed as far (6) or the data was not collected (4). Properly implemented whole-lake herbicide treatments can result in minimal EWM, sometimes zero, being detected for a year or two following the treatment (Figure 2.1-1). Some whole-lake treatments have been effective at reducing EWM populations for 5 or more years following the application, whereas others have rebounded sooner. The two data series in red represent the 2010 (red) and 2016 (dark red) whole-lake treatments on South Twin Lake. Please note that lake with hybrid watermilfoil have not resulted in as long of control from whole-lake 2,4-D treatments.

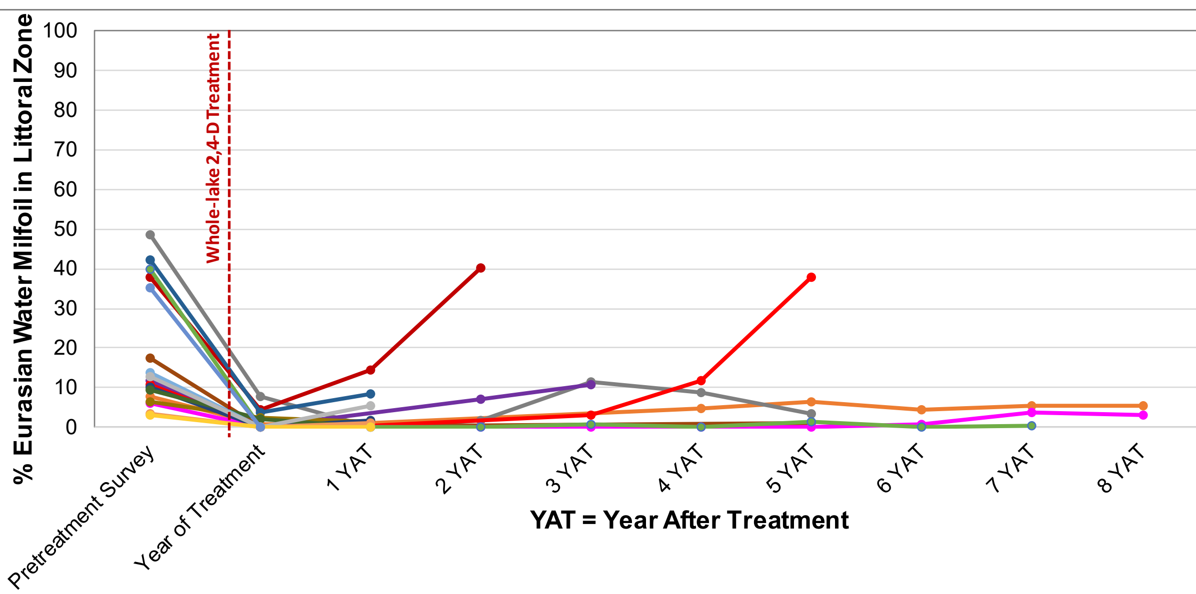


Figure 2.1-1. Littoral frequency of occurrence of EWM in lakes managed with whole-lake 2,4-D treatments. Red data series = South Twin Lake 2009-2015 and dark red data series = South Twin 2015-2018.

Lake manager's ability to predict lake-wide herbicide concentrations has improved but understanding the degradation period is not as apparent. In some cases, the biological breakdown of 2,4-D through microbial activity has been slower than typically observed. 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 16 additional Onterra-monitored projects to this dataset yields a mean 2,4-D half-life of approximately 29.5 days (Heath et al. 2018a, Heath et al. 2018b). Figure 2.1-2 shows that the 2,4-D half-lives of the 3 whole-lake treatments on South Twin Lake are relatively low compared to other lakes within the current database.

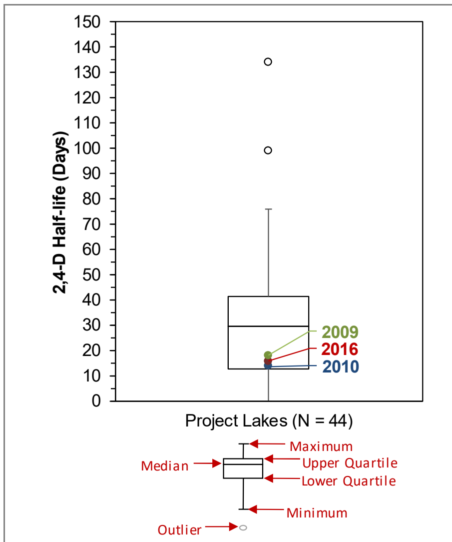


Figure 2.1-2. 2,4-D half-life of South Twin Lake project lakes compared with WDNR/Onterra database.

Some native plants are resilient to whole-lake 2,4-D treatments, either because they are inherently tolerant of the herbicide's mode of action or they emerge later in the year than when the herbicide is active in the lake. Other species, particularly dicots, some thin-leaved pondweeds, and naiad species, can be impacted and take a number of years to recover (Nault et al. 2018). Often during the year of treatment, overall native plant biomass can be lessened but typically (not always) rebounds the following year. However, the preceding statements are a bit of a generalization because some case studies have had varying levels of EWM control even at high concentration and exposure times and others case studies had collateral native plant impacts greater than would be assumed considering the concentrations and exposure times achieved.

2.2 South Twin Lake Aquatic Plant Community

Nearly every summer since 2008, a point-intercept survey has been completed on South Twin Lake by either WDNR or Onterra staff. A substantial decrease in EWM frequency of occurrence occurred following the whole-lake 2,4-D amine treatments conducted during the spring of 2009 and spring of 2010 (Figure 2.2-1). During the summer of the 2010 treatment, EWM was not detected during the point-intercept survey and was only located at one sampling location in 2011. EWM had begun to show signs of rebound during the 2013 and 2014 surveys. In 2015 the littoral frequency of occurrence of EWM increased significantly compared to 2014, and at 37.7% (Map 1), was higher than any survey since data collection began in 2008. Following a whole-lake 2,4-D amine treatment during spring of 2016, the year of treatment point-intercept survey found EWM frequency of occurrence to be 4.4%. In 2017, the EWM littoral frequency of occurrence increased

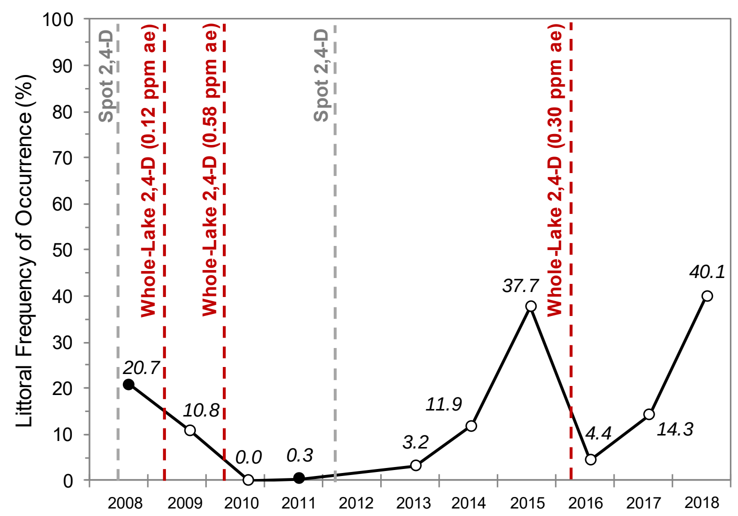


Figure 2.2-1. Littoral occurrence of EWM from South Twin Lake from 2008-2018. Open circle represents a statistically valid change from previous survey (Chi-square α = 0.05).

over three-fold to 14.3%. In 2018, the population almost tripled again to 40.1%. Nault et al. 2016 investigated point-intercept data from almost 400 Wisconsin Lakes that had EWM populations. Within this dataset, 89.4% of lakes contained EWM populations less than 40%. This indicates that South Twin Lake has an EWM population roughly within the top 10% of lakes across Wisconsin.

Figures 2.2-2 to 2.2-6 show how specific native plant occurrences have changed over time on South Twin Lake. These figures only highlight those species with a littoral occurrence of at least 2% in one of the point-intercept surveys. The full matrix of all aquatic plant frequencies over time can be found in Appendix A.

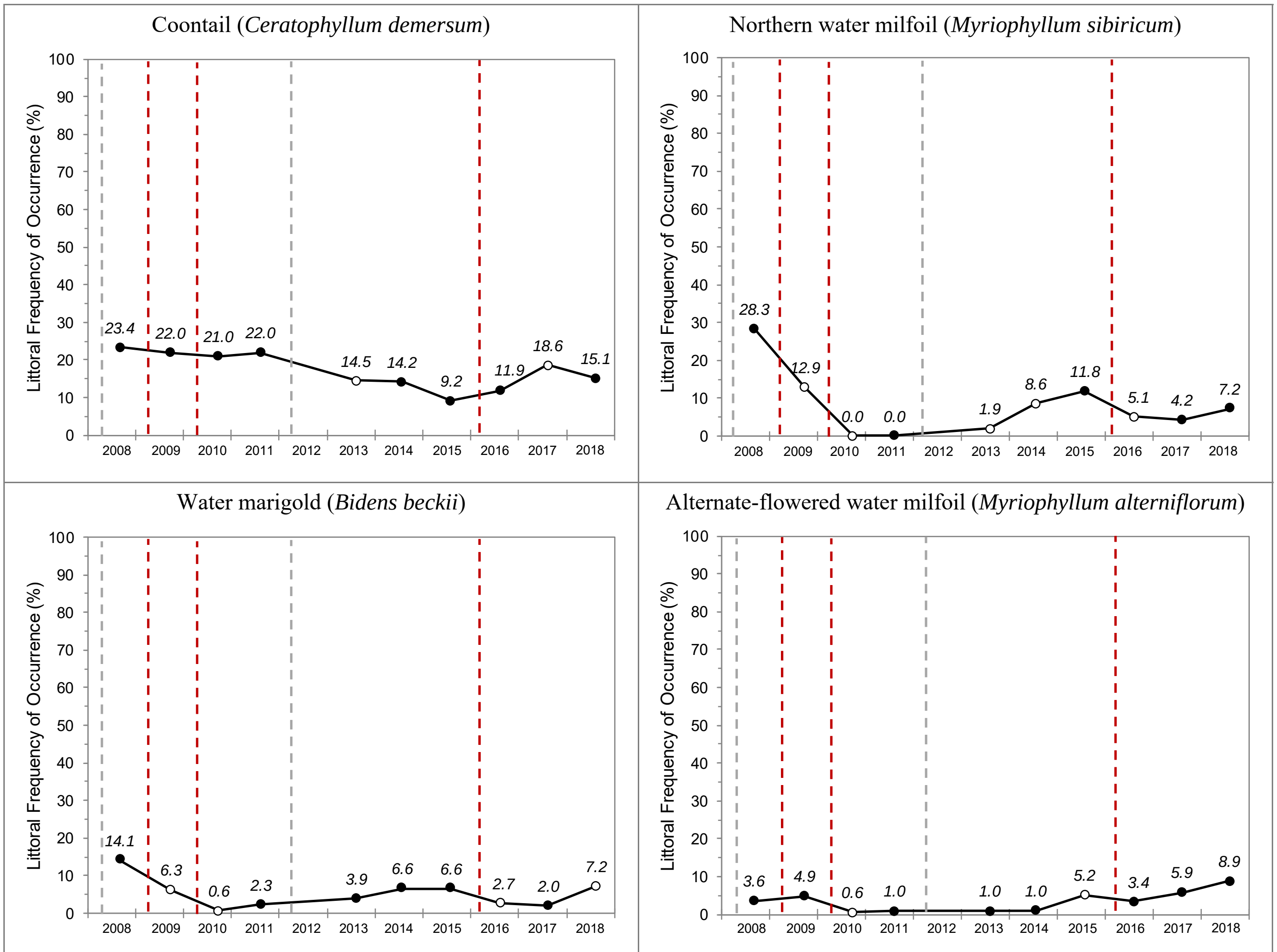


Figure 2.2-2. Littoral occurrence of dicot species. Open circle represents a statistically valid change in occurrence from previous survey (Chi-square α = 0.05). Red-dashed lines indicate whole-lake herbicide treatments, gray-dashed line indicates spot treatments.

EWM is a dicot (broad-leaved plant) and the herbicides (2,4-D) which have been used in South Twin Lake in an effort to control EWM were historically believed to only have impacts to dicot species. Research conducted by the US Army Corps of Engineers, the WDNR, and private consultants have shown that certain non-dicot native plants are sensitive as well at whole-lake concentrations and exposure times (Nault et al. 2018). Figure 2.2-2 shows how the dicot species in South Twin Lake have changed over time. Coontail populations were steady at approximately 22% during and following the 2009-2010 whole-lake efforts, but reduced to 9.2% during the period of no active management. The population of coontail has increased following the last whole-lake 2,4-D treatment, although it is unknown if it is from a causative relationship.

Populations of northern water milfoil and water marigold were highest prior to the 2009 whole-lake control efforts. These populations were reduced significantly following the 2009-2010 control efforts and were in the process of rebounding in 2015. The 2016 whole-lake 2,4-D treatment in 2016 again reduced the lake-wide populations of these species with population increases occurring in recent years. Alternate-flowered watermilfoil had slightly lowered populations from 2010 to 2014, but has had some of the highest populations in recent years.

Three monocot species were also shown to decline from 2015 to 2016 on South Twin Lake (Figure 2.2-3). Onterra's experience is that flat-stemmed pondweed is sensitive to early season herbicide treatments, potentially because this plant can be observed actively growing at the time of treatment whereas some others are not. It is important to note that this species rebounded following the first round of whole-lake 2,4-D treatments, only to decline significantly in the absence of management from 2013 to 2015. Reductions in water stargrass and needle spikerush were also observed following the spring 2016 treatment. These species had higher littoral frequencies in 2017, but not enough to be statistically valid. The population of these species remained relatively similar from 2017 to 2018.

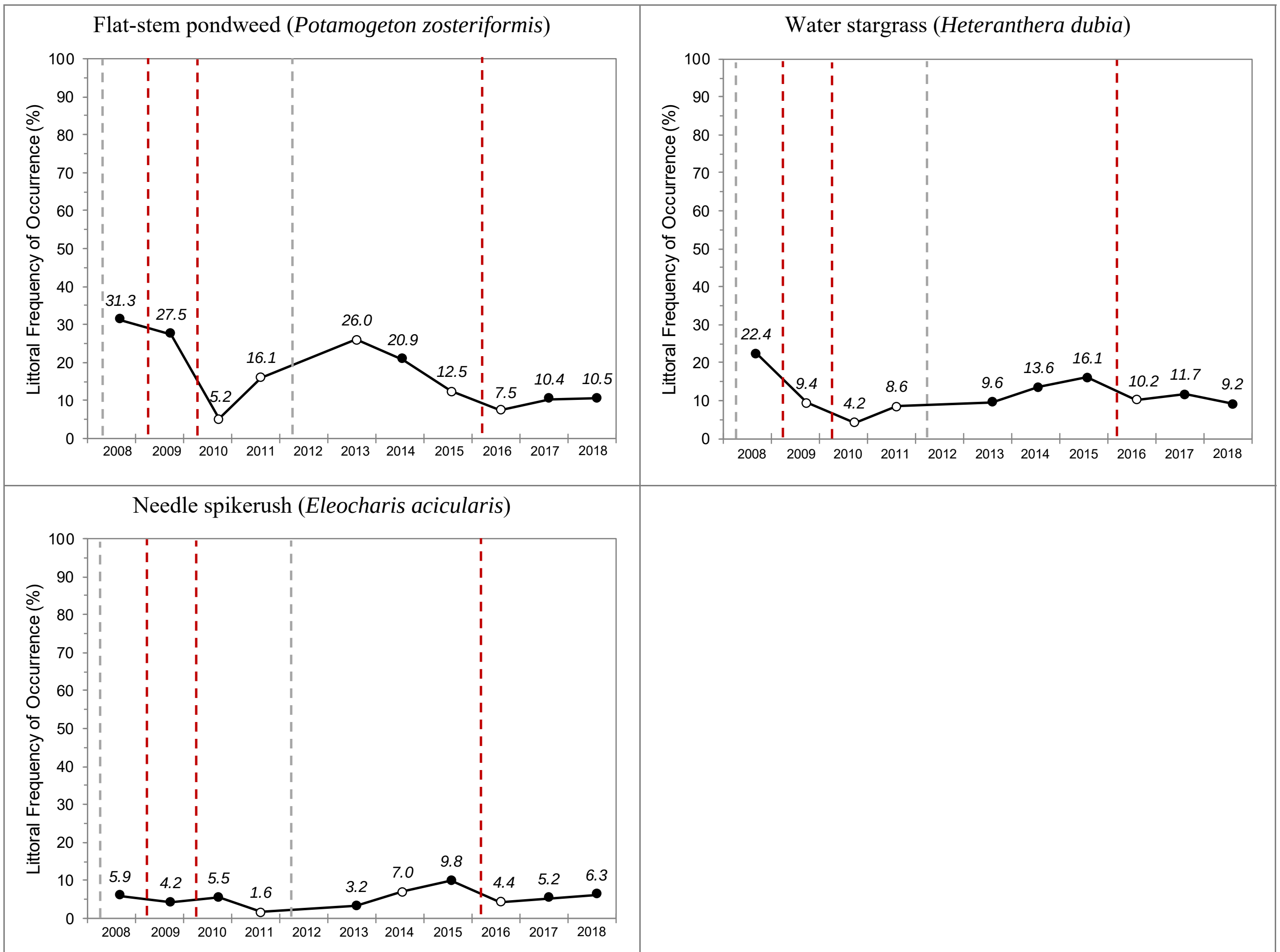


Figure 2.2-3. Littoral occurrence of monocot species that had statistically valid declines in 2016. Open circle represents a statistically valid change in occurrence from previous survey (Chi-square α = 0.05). Red-dashed lines indicate whole-lake herbicide treatments, gray-dashed line indicates spot treatment.

Four monocot species were found to have statistically valid increases following the 2016 herbicide control actions on South Twin Lake (2.2-4). While fluctuations in the occurrence of variable-leaf pondweed have been observed since 2008, potentially in response to herbicide treatment, this species has been resilient and maintained a relatively stable population over this time period. However, the population declined substantially in 2018. Common waterweed and clasping-leaf pondweed followed similar population trends, with large declines in 2018.

Muskgrasses, a group of macro-algae, are almost universally resilient to most herbicide treatments. As an algae, herbicides are not moved through (translocated) the tissue as the "plant" is made up of colonies of cells. The populations of muskgrasses has fluctuated over time on South Twin Lake, with an increasing population trend from 2013-2017. For unknown reasons, the muskgrasses population of South Twin reduced sharply in 2018.

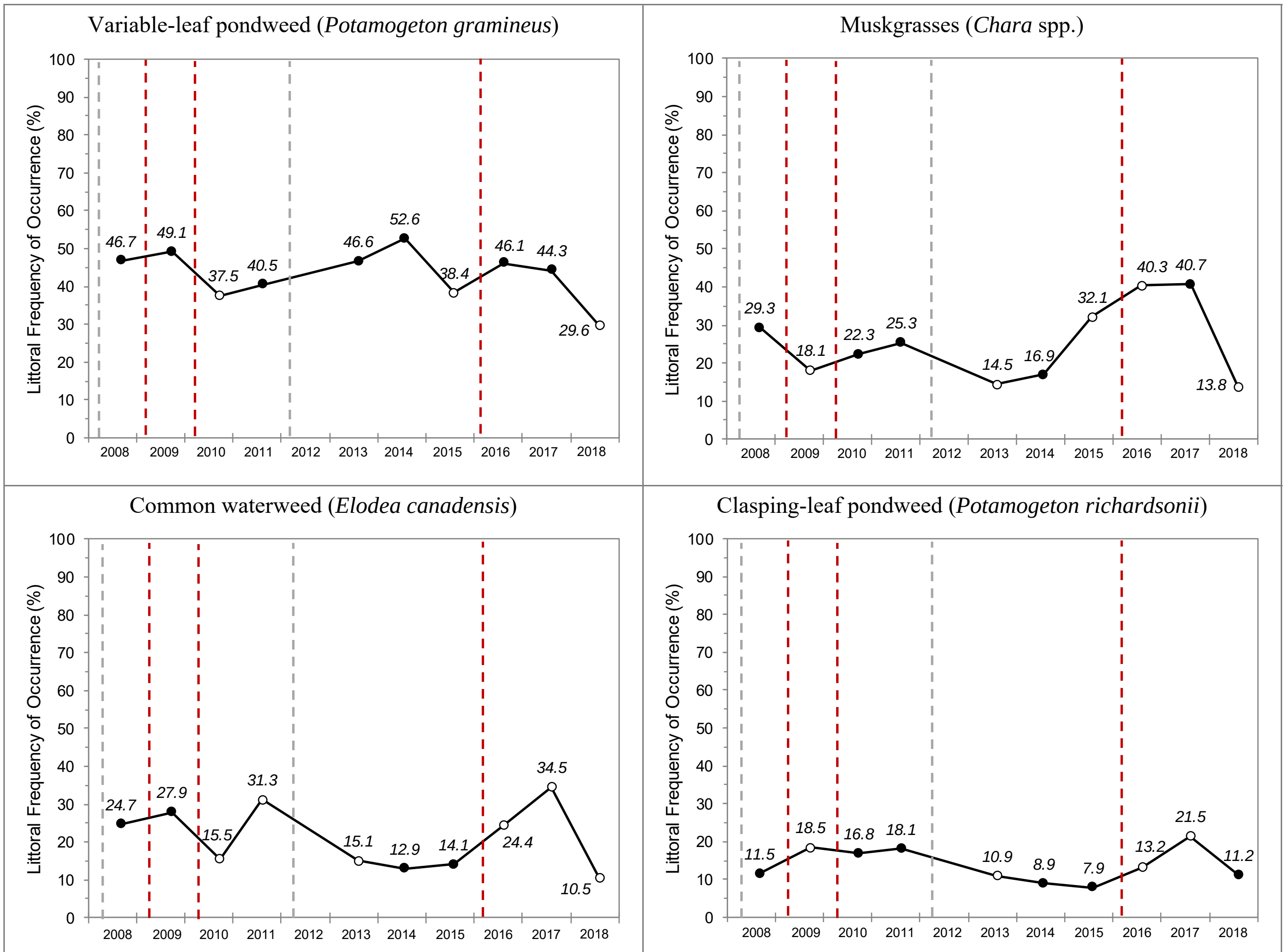


Figure 2.2-4. Littoral occurrence of monocot species that had statistically valid increases in 2016. Open circle represents a statistically valid change in occurrence from previous survey (Chi-square α = 0.05). Red-dashed lines indicate whole-lake herbicide treatments, gray-dashed line indicates spot treatment.

Six additional monocot species were shown to have non-statistically valid changes following the 2016 herbicide treatment (Figure 2.2-5). Onterra's experience has been that fern-leaf pondweed and small pondweed are often impacted by early season 2,4-D treatments. Fern-leaf pondweed maintained a stable population from 2008-2017, with the only statistically valid change occurring in 2018. Thin-leaved pondweeds, primarily composed of small pondweed, appeared to be greatly impacted from the

2010 2,4-D treatment, potentially as a result of the higher than target herbicide concentrations experienced. The population had rebounded in 2013 to almost pretreatment levels when the population trended down again in absence of herbicide management. An increase in thin-leaved pondweeds was observed in 2018.

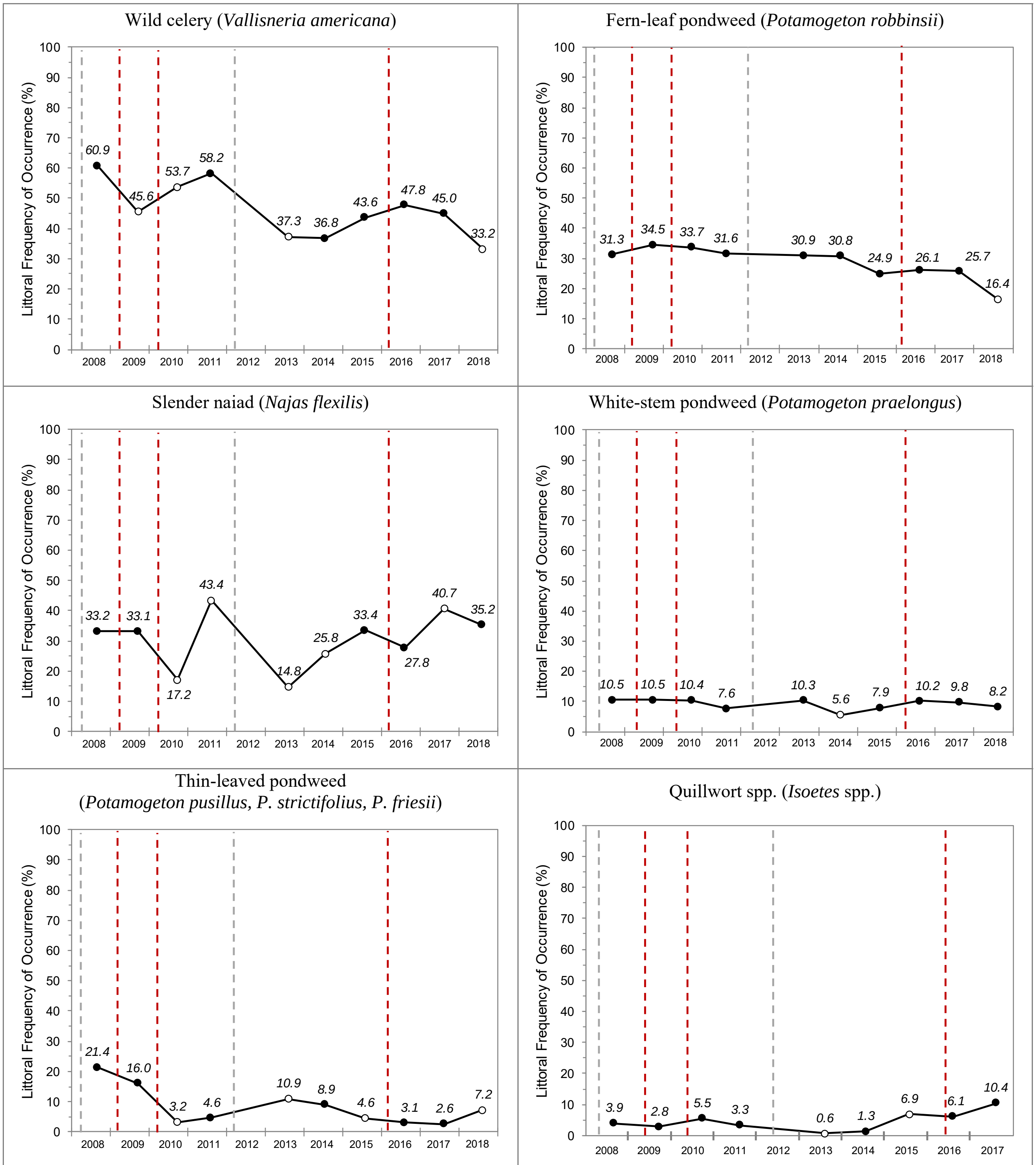


Figure 2.2-5. Littoral occurrence of monocot species that had no statistically valid changes in 2016. Open circle represents a statistically valid change in occurrence from previous survey (Chi-square α = 0.05). Red-dashed lines indicate whole-lake herbicide treatments, gray-dashed line indicates spot treatment.

While the point-intercept survey is a valuable tool to understand the overall plant population of a lake, it does not offer a full account (census) of where a particular species exists in the lake. The Late-Season EWM Mapping Survey is a meander-based mapping survey conducted when the plant is believed to be at its peak growth stage (late-summer), allowing for a true assessment of the amount of this exotic within the lake. EWM occurrences are mapped by Onterra using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter would be mapped using polygons (areas) and would be qualitatively assigned a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques would be applied to locations considered as *small plant colonies* (<40 feet in diameter), *clumps of plants*, or *single or few plants*. While the methods are consistent over time, decisions on how populations get mapped and assigned density designations are subjective.

Please note that Figure 2.2-6 represents the acreage of mapped EWM polygons, not EWM mapped within point-based methodologies (*single or few plants, clumps of plants,* or *small plant colonies*). In 2008, prior to the whole-lake 2,4-D treatments during the spring of 2009 and 2010, approximately 135 acres of South Twin Lake contained colonized EWM. About 13 acres of the lake was *highly dominant* or *surface matting* at that time. In 2018, approximately 145 acres of South Twin Lake contained colonized EWM with over 71 acres *highly dominant* or *surface matting* colonies (Map 2). The drastic increase of colonized EWM by almost one hundred acres between 2017 and 2018 has resulted in numerous riparian concerns brought up to the lake district. While the colonized EWM acreage in 2018 was higher than any previous year, the acreage is relatively similar to 2008 and 2015, corresponding to the years prior to previous whole-lake 2,4-D treatments.

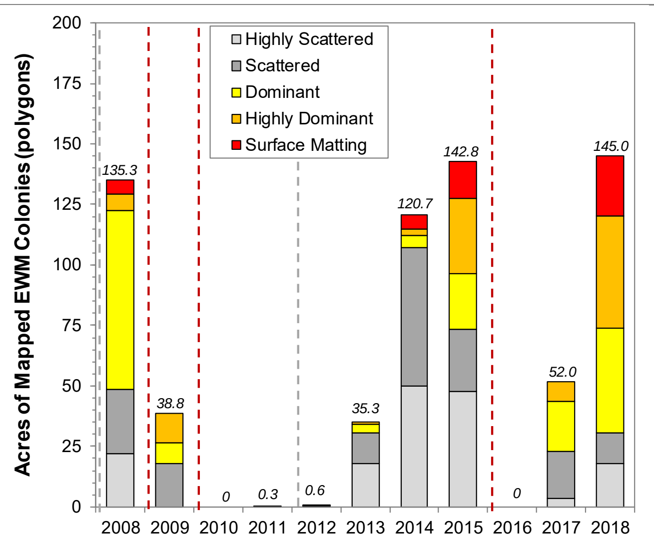


Figure 2.2-6. Acreage of Eurasian watermilfoil found in South Twin Lake from 2008 to 2018. Created using data from Onterra 2013-2016 peak biomass surveys.

Photograph 2.2-1. Surface-matted EWM on South Twin Lake. August 2018.

The scientific literature has a number of specific examples of declining native vegetation in communities dominated by EWM (Madsen et al. 1991; Boylen et al. 1999, Madsen 1999). These examples are largely based upon aquatic plant population changes within dense EWM colonies. More recent multi-lake studies suggest that "[EWM] invasion does not correlate with decreased native macrophyte abundance at a landscape scale" (A. Mikulyuk et al, unpublished manuscript). This could be interpreted as suggesting that EWM populations may not be outcompeting native plants as often as traditionally thought; displacement of native species by EWM is likely occurring in localized areas and the impact may be undetectable at a lake-wide scale or across the landscape.

The 2018 point-intercept survey yielded indicated some reductions in native plant occurrences during 2018. Figure 2.2-7 investigates the average number of native plant species at each point-intercept sampling location. Reductions in plant species per site are noted following the 2009 and 2010 whole-lake 2,4-D treatments. These data also show a lowered native plant population from 2017 to 2018 when no chemical treatment or hand-harvesting occurred. During this time period, colonized EWM acreage expanded by almost one hundred acres and the EWM littoral frequency of occurrence almost tripled. Aquatic plant populations are known to fluctuate over time; continued monitoring would be needed to understand if these changes are in response to the increased EWM population and EWM density or if they are related to other factors.

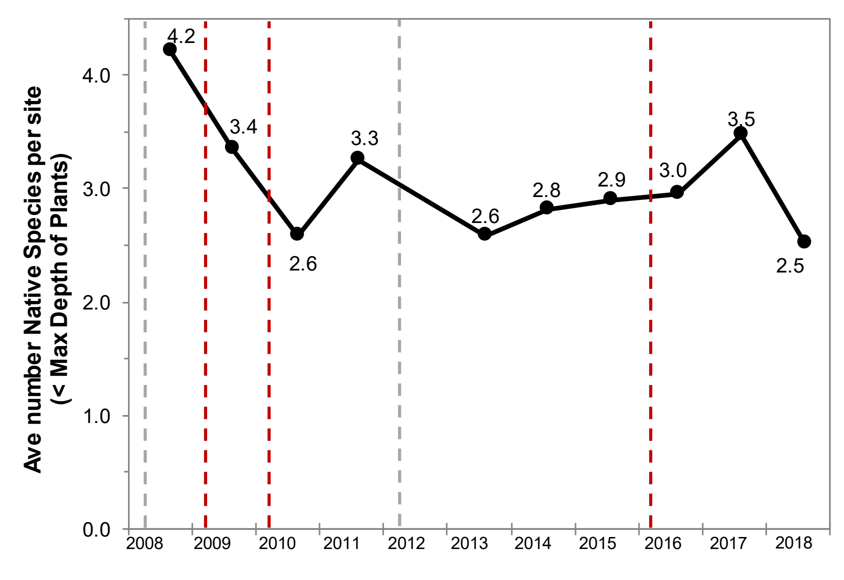
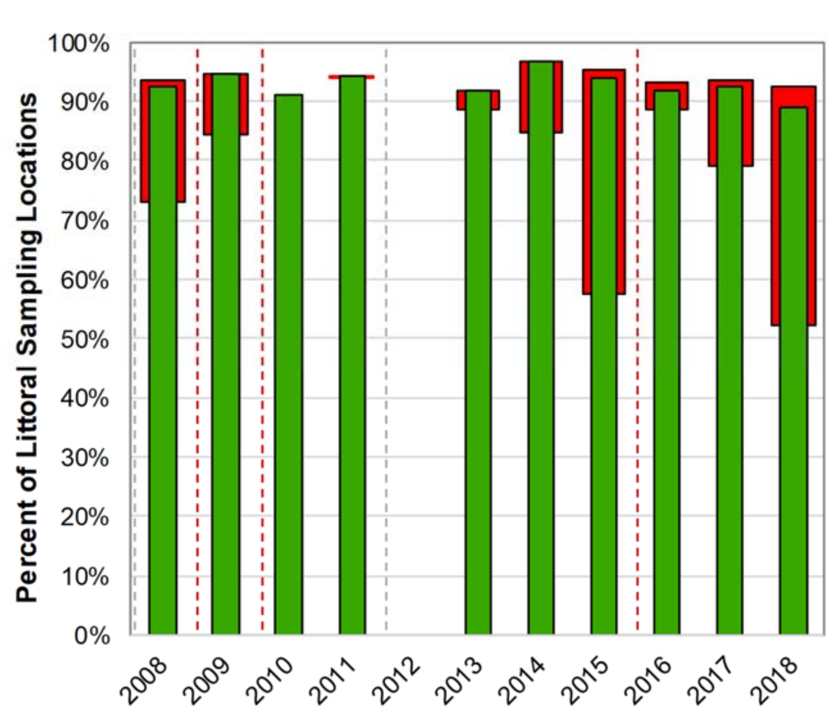
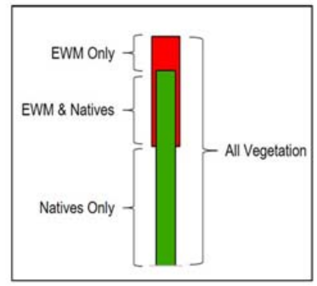


Figure 2.2-7. South Twin Lake Average Number of Native Plant Species per site. Red-dashed lines indicate whole-lake herbicide treatments, gray-dashed line indicates spot treatment.

Figure 2.2-8 displays the number of point-intercept survey sampling locations that contained either native plants only, EWM plants only, or native plants and EWM plants from surveys completed in 2008-2018 on South Twin Lake. Embedded on the figure is also a table that indicates the percent of the littoral zone that is vegetated and the percent of the littoral zone that contains native plants. The range of change in these metrics is relatively narrow. The lowest percent vegetated occurred in 2010 following the spring 2010 whole-lake 2,4-D treatment. The lowest percent native vegetation occurred during 2018. The largest amount of EWM only (3.3%) also occurred in 2018. The data explored in this figure will be valuable for understanding impacts of future management actions.





	Percent Vegetated	Percent Natives
2008	93.8%	92.4%
2009	94.7%	94.7%
2010	90.9%	90.9%
2011	94.4%	94.4%
2012	-	-
2013	92.0%	92.0%
2014	96.7%	96.7%
2015	95.4%	93.8%
2016	93.2%	91.9%
2017	93.5%	92.5%
2018	92.4%	89.1%

Figure 2.2-8. Percent of South Twin littoral point-intercept sampling locations containing native plants, EWM, or native plants and EWM. Red-dashed lines indicate whole-lake herbicide treatments, gray-dashed line indicates spot treatment.

2.3 South Twin Lake EWM Management Discussion

During the summer 2017 Planning Committee meetings, Onterra outlined three broad potential EWM population goals for consideration including a recommended action plan to help reach each of the goals (Figure 2.3-1). Each management goal was discussed and considered for applicability. The following paragraphs provide brief overview of these extensive conversations. Additional management strategies were also discussed and the District developed a specific management action to "Investigate and Study Alternative Management Methodologies."

1. **No Coordinated Active Management**
   (Let Nature Take its Course)
   - Focus on education of manual removal by property owners
2. **Minimize navigation and recreation impediment**
   (Nuisance Control)
   - Accomplished through professional hand-harvesting of areas or lanes
   - Hand-harvesting may not be able to accomplish this goal and herbicides or a mechanical harvester may be required
3. **Reduce EWM Population on a lake-wide level**
   (Lake-Wide Population Management)
   - Would likely rely on herbicide treatment strategies (risk assessment)
   - Will not "eradicate" EWM
   - Set triggers (thresholds) of implementation and tolerance

Figure 2.3-1. Potential EWM Management Goals. Presented by Onterra at Planning Committee meetings.

Let Nature Take its Course: On some lakes, the EWM population plateaus or reduces without active management. Some lake groups decide to periodically monitor the EWM population, typically through an annual or semi-annual point-intercept survey, but do not coordinate active management (e.g. hand-harvesting or herbicide treatments). Individual riparians could choose to hand-remove the EWM within their recreational footprint, but the lake group would not assist financially or by securing permits if necessary. In most instances, the lake group may select an EWM population threshold or "trigger" where they would revisit their management goal if the population reached that level.

The District discussed this management goal, but quickly dismissed it as a possibility for South Twin Lake. The extent of the EWM population in 2015 and again in 2018 was such that District members were clear that they wanted the Board of Directors to conduct EWM management.

Nuisance Control: The concept of ecosystem services is that the natural world provides a multitude of services to humans, such as the production of food and water (provisioning), control of climate and disease (regulating), nutrient cycles and pollination (supporting), and spiritual and recreational benefits (cultural). Some lake groups acknowledge that the most pressing issues with their EWM population is the reduced recreation, navigation, and aesthetics compared to before EWM became established in their lake. Particularly on lakes with large EWM populations that may be impractical or unpopular to target on a lake-wide basis, the lake group would coordinate (secure permits and financially support the effort) a strategy to improve the navigability within the lake. This is typically accomplished by designing common-use navigation lanes through EWM colonies that would be managed through mechanical harvesting.

The District considered mechanical harvesting options during the management planning project and again while developing a management strategy for 2019. This included discussion of costs, risk assessment, and likelihood of meeting management expectations. On South Twin Lake and in parts of North Twin Lake, navigation and recreation impediments caused by EWM colonies have been documented. Mechanical harvesting of navigation lanes or clear-cutting particularly high-use areas is likely to reduce these impediments. The WDNR has expressed preference for the District to consider non-herbicide management actions such as mechanical harvesting for South Twin Lake. The District has provided perspective on mechanical harvesting and is included in Appendix D. In summary, the District acknowledges that a nuisance relief goal through mechanical harvesting may be applicable in the future. At this time, the District would like to address more than just the nuisance conditions caused by EWM by conducting population management strategies. The District is also concerned that the large presence of EWM in South Twin Lake further exposes new areas of North Twin Lake to EWM establishment.

Lake-Wide Population Management: Some believe that there is an intrinsic responsibility to correct for changes in the environment that are caused by humans. For lakes with EWM populations, that may be to manage the EWM population at a reduced level with the perceived goal to allow the lake to function as it had prior to EWM establishment. Due to the inevitable collateral impacts from most forms of EWM management, lake managers and natural resource regulators question whether that is an achievable goal. The WDNR maintains a cost-share grant funding program for projects that aim to reduced established aquatic invasive species populations.

In early EWM populations, the entire population may be targeted through hand-harvesting or spot treatments. This was the response strategy at South Twin in the early-to mid-2000s when EWM was in the process of expanding and establishing.

On more advanced or established populations, this may be accomplished through large-scale control efforts such as water-level drawdowns or whole-lake herbicide treatment strategies. Large-scale management can reduce EWM populations for several years, but will not eradicate it from the lake. Subsequent smaller scale management (e.g. hand-harvesting or spot treatments) is typically employed to slow the rebound of the population until another large-scale effort may be considered again. Large-scale control efforts, especially using herbicide treatments, can be impactful of some native plant species as well as carry a risk of environmental toxicity. Some argue that the impacts of the control actions may have greater negative impacts to the ecology of the system than if the EWM population was not managed.

The District ultimately created an EWM population management goal for inclusion within *North and South Twin Lakes Comprehensive Management Plan* (June 2018), including a trigger for when that an action would be considered for implementation, short-term management discussion, monitoring strategy, and success criteria. The plan contains supplemental information on how the district arrived at this perspective, including solicitation of stakeholder input, technical review meetings, etc.

As outlined in the, the District would initiate discussion, planning, and pretreatment stages of a whole-lake herbicide treatment when EWM populations measured from the point-intercept survey exceed 12%. This threshold was based upon coupling the South Twin Lake point-intercept data at these levels with the Late-Summer EWM Mapping Survey data. When EWM populations exceeded this approximate benchmark in the past, *highly dominant* and *surface matted* conditions started becoming apparent. This threshold was exceeded in 2017 (14.3% EWM LFOO), resulting in the District investigating various large-scale herbicide control strategies in tandem with developing a lake management plan.

While understood in terrestrial herbicide applications for years, tolerance evolution is an emerging topic amongst aquatic herbicide applicators, lake management planners, and researchers. Herbicide tolerance is when a population of a given species develops reduced susceptibility to an herbicide over time. This occurs in a population when some of the targeted plants have an innate tolerance to the herbicide and some 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.

In general, hybrid watermilfoil (*M. spicatum* x *sibiricum*) typically has thicker stems, is a prolific flowerer, and grows much faster than pure-strain EWM (LaRue et al. 2012). These conditions may likely contribute to this plant being particularly less susceptible to chemical control strategies (Glomski and Netherland 2010, Poovey et al. 2007, Nault et al. 2018). In lakes that contain both EWM and hybrid watermilfoil (HWM), concern exists that the more-easily controlled EWM component of a lake's invasive milfoil population may be controlled by herbicide treatment, but the slightly less-susceptible HWM component will survive, rebound in a short period of time, and then comprise a larger proportion of the invasive milfoil population.

If genetic variation in the target population exists, particularly the presence of hybrid watermilfoils, repetitive treatments with the same herbicide may cause a shift towards increased herbicide tolerance in the population. Rotating herbicide use-patterns, can help avoid population-level herbicide tolerance evolution from occurring. Concern exists that the past use-history of 2,4-D on South Twin Lake may have resulted in a population of more-tolerant invasive watermilfoils to auxin hormone mimic herbicides, which includes also triclopyr. In 2013, an invasive milfoil sample from each lake was collected and sent to a lab in lower Michigan (GenPass, LLC) for genetic analysis where they confirmed the sample to be pure-strain EWM. Two samples from South Twin Lake and two samples from North Twin Lake were sent to Montana State University for DNA testing in October 2018, both being confirmed as pure-strain EWM. With much less genetic diversity being present within pure-strain EWM populations, it is unclear if herbicide tolerance shifts can occur in these populations.

The Lake District AIS Committee believe that a whole-lake liquid 2,4-D amine treatment at typical target concentrations (0.3 to 0.4 ppm ae) is not likely to meet goals. This may be partially due to the quick degradation pattern that occurs in the lake, a potential lowered susceptibility of the current EWM population to this active ingredient, or potentially unidentified factors. Initially, the planning committee investigated a whole-lake triclopyr treatment for their next whole-lake control option. Triclopyr has a similar mode of action to 2,4-D, but is broken down via photolysis (exposure to sunlight) and therefore may have a longer degradation pattern. But because both 2,4-D and triclopyr are auxin hormone mimic herbicides, the Lake District AIS Committee is concerned that a whole-lake triclopyr treatment will again result in too short of control to balance the secondary impacts to the native plant community.

The Lake District AIS Committee then discussed other whole-lake treatment options that have been recently used in Wisconsin to target difficult invasive milfoil populations including a combination of an auxin herbicide with endothall and fluridone. The simultaneous exposure to endothall and 2,4-D has been shown to provide increased control of EWM in outdoor growth chamber studies (Madsen et. al 2010). A handful of HWM treatments in Wisconsin utilizing this strategy have been conducted to date. A few treatments resulted in relatively quick rebound of HWM (i.e. two years) whereas others haver resulted in longer control. Impacts to native plants from these treatments were largely confined to species sensitive to the endothall component (e.g. flat-stem pondweed, fern-leaf pondweed), but the magnitude of declines of those species was large.

When considering a fluridone treatment of South Twin Lake, the Lake District AIS Committee considered both liquid and pelletized formulations. Liquid fluridone treatments result in a high initial concentration that tapers off over time as the herbicide degrades and pelletized fluridone treatments gradually reach peak concentrations over time (extended release) which allows for a lower, sustained lake-wide herbicide concentration. Ultimately the AIS Planning Committee ultimately trended towards a whole-lake pelletized fluridone treatment. The risk assessment within *North and South Twin Lakes Comprehensive Management Plan* (June 2018) investigated native aquatic plant sensitivity and impact of other aquatic organisms and human health. The following section expands upon the technical aspects of fluridone treatment on South Twin Lake.

2.4 Background on Whole-lake Fluridone Treatments

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

In Wisconsin, a four-lake pilot project was conducted in the late-1990s and early-2000s. Liquid fluridone treatments within this study had peak fluridone concentrations of 12.4-15.9 ppb on three of the lakes, whereas the fourth had a peak concentration of 5.7 ppb. These treatments provided reduced EWM populations for up to four years, but resulted in native plant impacts that exceeded "acceptable levels" (Wagner et al. 2007). A revised use-pattern for fluridone was adopted on other midwestern lakes, particularly in Michigan, that initially targeted 6 ppb with a bump treatment later in the summer to bring the concentration back up to 6 ppb (6-bump-6). These use-patterns produces relatively high herbicide pulses that taper off slowly as the herbicide degrades. Manufacturers of fluridone (SePRO) believe that the high herbicide pulses are the mechanism causing the native plant impacts. (Dr. Mark Heilman, personal comm.).

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. For many of these initial treatments, the target concentration (4 ppb) was based upon theoretical equilibrium when mixed with the entire epilimnion. Because of the extended release rate and herbicide degradation, the 4-ppb initial target is not expected to be achieved, rather a prolonged period of 1.5 to 2.5 ppb is observed. 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. 2018a, Heath et al. 2018b).

Figure 2.4-1 shows the fluridone concentration monitoring data from the six pelletized fluridone projects in Wisconsin that have concluded monitoring. All pelletized fluridone treatments to date have targeted lakes that are believed to have invasive milfoil populations largely or entirely composed of HWM. These lakes have also had an herbicide use history where a whole-lake auxin herbicide failed to reach desired managed goals.

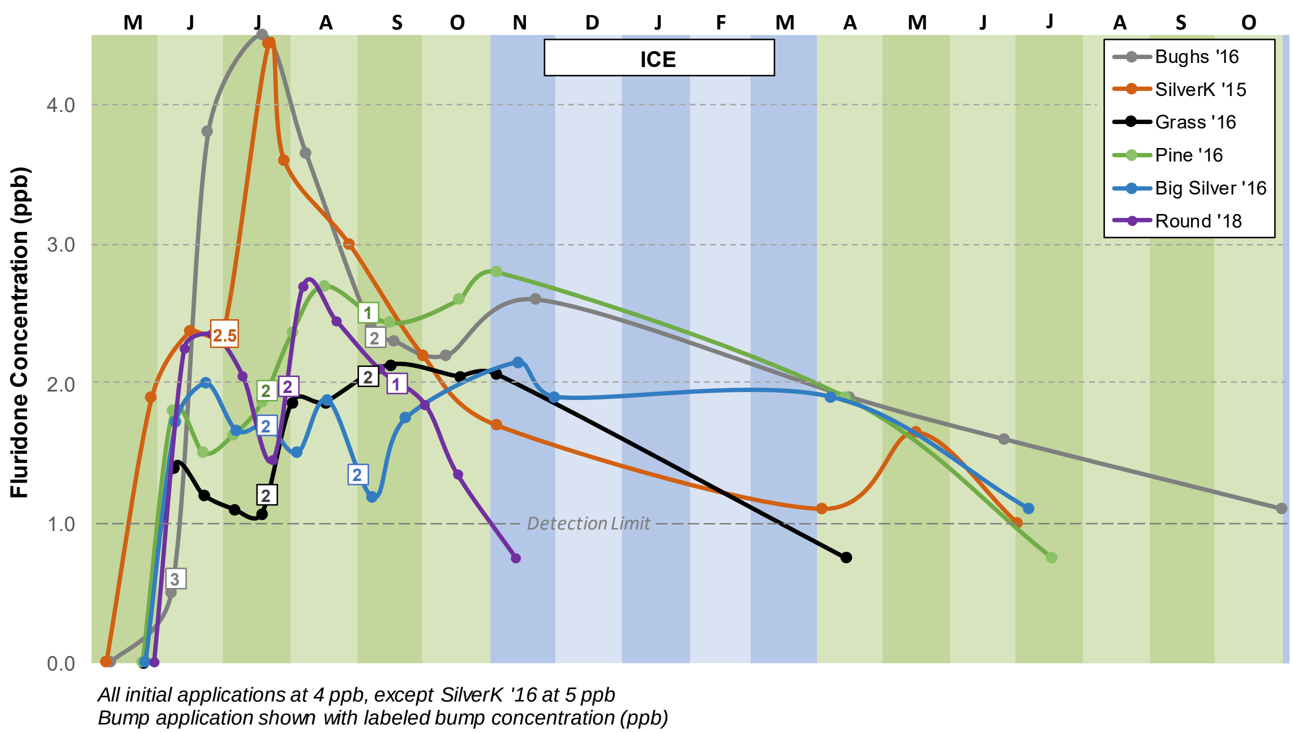


Figure 2.4-1. Fluridone Concentration Monitoring Results from five pelletized treatments in Wisconsin. Data shown are average surface concentrations, lines smoothed for ease of visualization. Initial application dates as follows: Bughs-5/10/2016, SilverK-5/8/2015, Grass-5/25/2-16, Pine-5/25/2016, Big Silver-5/26/2016, Round – 5/30/2018.

Silver Lake in Kenosha County was the first pelletized fluridone treatment in Wisconsin. The initial application rate was 5 ppb and a single 2.5 ppb bump occurred. The other five treatments had initial application rates of 4 ppb and two bump treatments ranging from 1-3 ppb.

The evolved goal of the pelletized fluridone use pattern is to maintain between 1.5 ppb and 3.0 ppb throughout the growing season, with detectable levels of the herbicide being observed within the lake going into ice-on. It is anticipated that herbicide degradation is minimal over the winter as fluridone is primarily broken down by sunlight, specifically UV-B (300-320 nm), but also by UV-A (320-380) spectrums. These wavelengths are absorbed by ice and snow, not allowing much penetration to fluridone in the lake during the winter. Fluridone was above detectable levels following ice-out on all lakes except Grass Lake and Round Lake. Please note it is possible to plan a pelletized treatment to be below detectable limits by the end of the first growing season, but it is unclear if that will result in reduced efficacy.

Figure 2.4-2 shows the level of EWM control from the five pelletized fluridone treatments shown in Figure 2.4-1 as well as George Lake, which was treated in 2017. Please note that a point-intercept survey was not completed during the year of treatment on some lakes (Big Silver, Pine, and Grass), as the lakes were still in the process of being treated (i.e. had active herbicide concentrations). On most lakes, EWM die-off is noted in mid-summer but continues slowly over the course of the summer. During the year after treatment (YAT), all lakes contained HWM populations below 2% of the littoral zone. While the data are limited in their length of time post treatment, the magnitude of HWM reduction and length of control is greater than previous whole-lake auxin treatments that occurred on these lakes. HWM rebound is largest on Bughs Lake, with all other lakes containing approximately 5% or less HWM at 2 YAT. Please note that Bughs Lake has a past history of fluridone treatment, whereas the others have not. Silver Lake in Kenosha County is the only lake that has progressed to 3 YAT, with 0.8% of the littoral zone containing HWM.

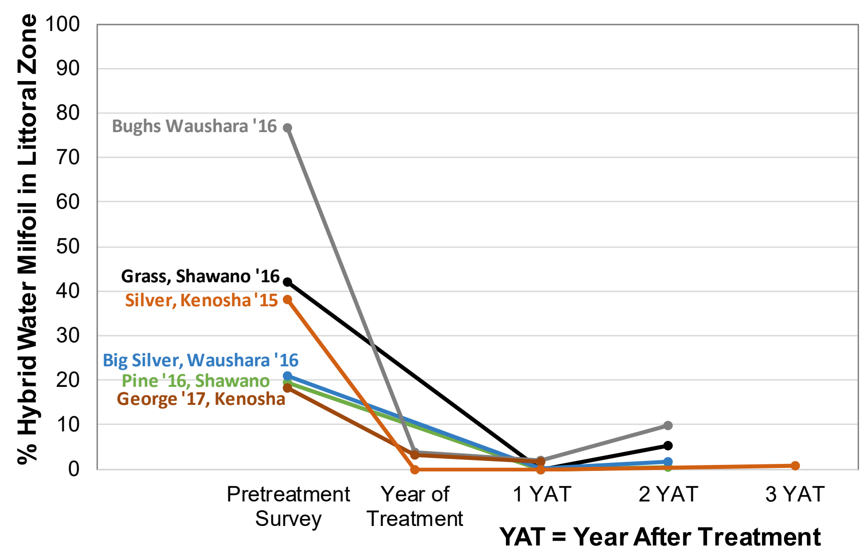


Figure 2.4-2. Littoral frequency of occurrence of HWM in lakes managed with whole-lake pelletized fluridone treatments.

Many lake groups initiate a whole-lake herbicide strategy with the intention of implementing smaller-scale control measures (herbicide spot treatments, hand-removal) when EWM/HWM begins rebounding. This is referred to as Integrated Pest Management (IPM). The IPM strategy is best understood for Big Silver Lake, Grass Lake, and Pine Lake (all Onterra-monitored projects). To date, Pine Lake has had almost no HWM detected and has not conducted IPM. However, HWM rebound on Grass Lake has occurred faster than desired, potentially due to lower than target fluridone concentrations being achieved (1.64 ppb average year of treatment achieved concentration). This lake contained a targeted hand-harvesting program utilizing Diver Assisted Suction Harvesting (DASH) in 2018. Big Silver Lake conducted IPM in 2017 and 2018 to a high degree, implementing DASH and scuba surveillance monitoring for 6 days in 2017 and for 12 days in 2018. Big Silver has approved 15 days of DASH efforts and is planning a spot herbicide treatment in 2019 with the goal of maintaining the reduced EWM population that occurred following the 2016 pelletized fluridone treatment.

Collateral native plant impacts associate all whole-lake herbicide management activities. Investigating the potential impacts of the management strategy on a given lake in terms of sensitive species and potential magnitude of change is important when making management decisions. Table 2.4-1 outlines the species present within South Twin and an analysis of each species' corresponding perceived susceptibility to fluridone.

The SonarOne® Product Label outlines generalized sensitivity of select native plants to fluridone at label-approved rates. Table 2.4-1 indicates that 14 out of top 20 species from South Twin Lake have some sensitivity to fluridone. The product label also indicates that "selectivity is dependent upon dosage, time of year, stage of growth, method of application, and water movement…lower rates will increase selectivity of some species listed as controlled or partially controlled." The maximum application rate of fluridone is 150 ppb, with most invasive milfoil control projects targeting concentrations below 15ppb. Therefore, it is important to investigate other case studies to determine the dose-dependent response of aquatic plant species.

The "Liquid Case Studies" referenced are a large dataset of liquid fluridone field trials (many are 10-15 ppb or 6-bump-6) compiled by the WDNR Science Services and made available in spreadsheet format. The pelletized case studies are those shown in Figure 2.4-1 and 2.4-2 that targeted lower fluridone concentrations but may have had longer exposure times than the liquid case studies.

Table 2.4-1. Aquatic plant species list and potential sensitivity to differing fluridone use-patterns.

Scientific Name	Common Name	2018 LFOO	Fluridone Sensitivity						
			SonarOne® Label	Liquid Case Studies*	Pelletized Case Studies				
					Pine	Grass	Silver	Bughs	SilverK
Myriophyllum spicatum	Eurasian watermilfoil	*40.1*	*C*	↓	↓	↓	↓	↓	↓
Najas flexilis	Slender naiad	*35.2*	*CT*	↓ to X	↓	↓	↓	-	X
Vallisneria americana	Wild celery	*33.2*	*PC*	↓ to X	X	↓	X	X	↓
Potamogeton gramineus	Variable-leaf pondweed	*29.6*	*CT*	↓ to X to ↑	X	X	↓	↑	↑
Potamogeton robbinsii	Fern-leaf pondweed	*16.4*	*CT*	X to ↑	-	-	-	-	-
Ceratophyllum demersum	Coontail	*15.1*	*CT*	↓ to X	X	X	-	↓	↓
Chara spp.	Muskgrasses	*13.8*	*NC*	↓ to X to ↑	X	X	X	↑	X
Potamogeton richardsonii	Clasping-leaf pondweed	*11.2*	*CT*	↓ to X	↑	X	-	-	↓
Elodea canadensis	Common waterweed	*10.5*	*CT*	↓ to X	X	X	↓	↓	X
Potamogeton zosteriformis	Flat-stem pondweed	*10.5*	*CT*	↓ to X to ↑	X	X	↑	-	X
Heteranthera dubia	Water stargrass	*9.2*	-	X to ↑	-	-	↑	↑	↓
Myriophyllum alterniflorum	Alternate-flowered watermilfoil	*8.9*	*C*	-	-	-	-	-	-
Isoetes spp.	Quillwort spp.	*8.6*	-	X	-	-	-	-	-
Potamogeton praelongus	White-stem pondweed	*8.2*	*CT*	↓ to X	X	X	↓	↓	X
Myriophyllum sibiricum	Northern watermilfoil	*7.2*	*C*	↓	-	-	-	-	-
Bidens beckii	Water marigold	*7.2*	-	↓ to X	-	-	X	-	-
Potamogeton pusillus	Small pondweed	*6.6*	*CT*	↓ to X	-	-	X	↑	-
Eleocharis acicularis	Needle spikerush	*6.3*	-	-	-	-	-	-	-
Nitella spp.	Stoneworts	*5.3*	*NC*	↓ to X to ↑	X	X	↓	-	↑
Potamogeton amplifolius	Large-leaf pondweed	*0.3*	*CT*	↓ to X to ↑	-	-	-	-	X

LFOO = littoral frequency of occurrence

SonarOne® Label: C = controlled, CT = controlled, tolerant at lower use rates, PC = partially controlled, NC = not controlled, - = not listed

* Fluridone sensitivity of Liquid Case Studies inferred from Wagner KI, WDNR Science Services, 2006, unpubl.

Pelletized Case Studies Analysis compares Pretreatment to 1 YAT:
↓↑ = statistically valid declines/increases observed. X = population remains statically unchanged. - = no data available.

Overall, the selectivity of the pelletized fluridone strategy for the plants in South Twin Lake appears to be greater than for the liquid case studies. This reduced sensitivity is likely the product of a dose-dependent response and is also speculated that pelletized applications are able to avoid high concentration peaks that are often associated with liquid fluridone applications. But it is important to note that these case studies are in a relatively different region of the state and it is an extremely limited dataset to draw conclusions from.

Figure 2.4-3 investigates the population changes within the available pelletized case studies for eight of the nine most frequent native plants from South Twin Lake; these lakes did not contain fern-leaf pondweed populations. The analysis presented suggests that some plant species, such as common waterweed are particularly sensitive to fluridone as only one lake did not yield large reductions in this species following the management strategy. Slender naiad populations dipped during the year after treatment but indicated signs of quick rebound. Coontail populations on Bughs Lake and Big Silver Lake both reduced by about 40% when comparing the pretreatment point-intercept survey with the year after treatment survey. Minimal data regarding large-leaf pondweed is available from the pelletized case studies. However, more data exists from the similar Illinois pondweed, with statistically valid declines being observed in some lakes.

South Twin Lake contains a healthy population of off-shore hard-stem bulrushes. The margins of these communities have been delineated in 2007, 2011, and 2016. Fluridone sensitivity data is not available for bulrush communities based upon the available field trial database. The pelletized fluridone label lists bulrush as "not controlled" at labeled use rates.

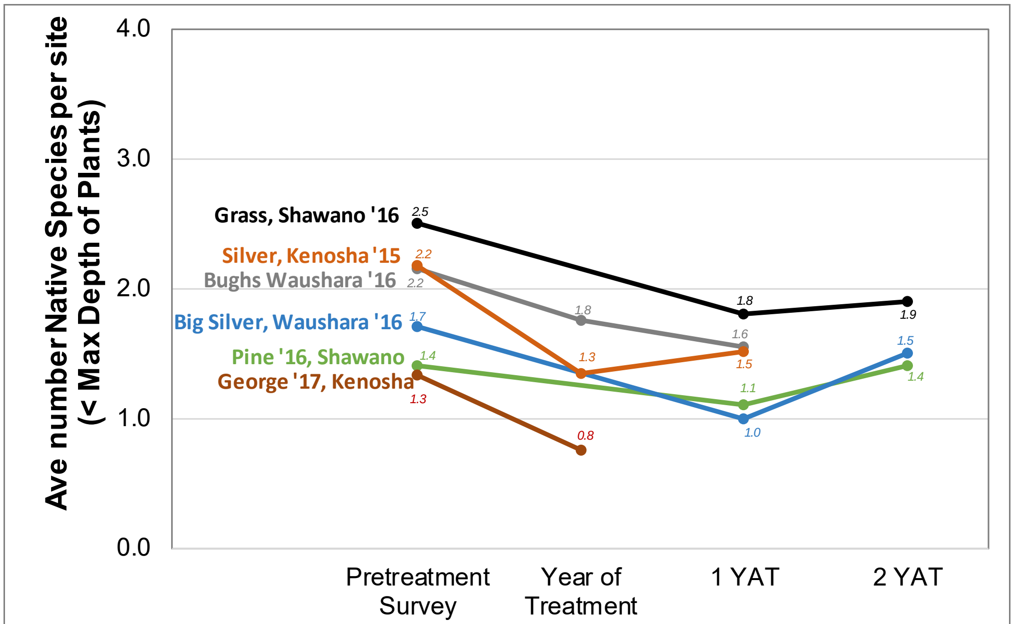


Figure 2.4-4. Average Number of Native Plant Species per site in lakes managed with whole-lake pelletized fluridone treatments. YAT = year after treatment.

Figure 2.4-4 investigates the average number of native plant species at each point-intercept sampling location for the available pelletized fluridone case studies. Changes in the average number of native plant species at each sampling location can be indicative of how the native vegetation architecture (aka lake-scape) changes following large-scale management. As explored in Section 2.2 (Figure 2.2-7), previous whole-lake 2,4-D treatments resulted in reductions in this metric on South Twin Lake. Comparing the pretreatment survey to the year after treatment survey, the average reduction of this metric is 0.6 species per site. The 2018 average number of native species per site on South Twin Lake is 2.5 after this metric reduced by 1.0 species in absence of management actions.

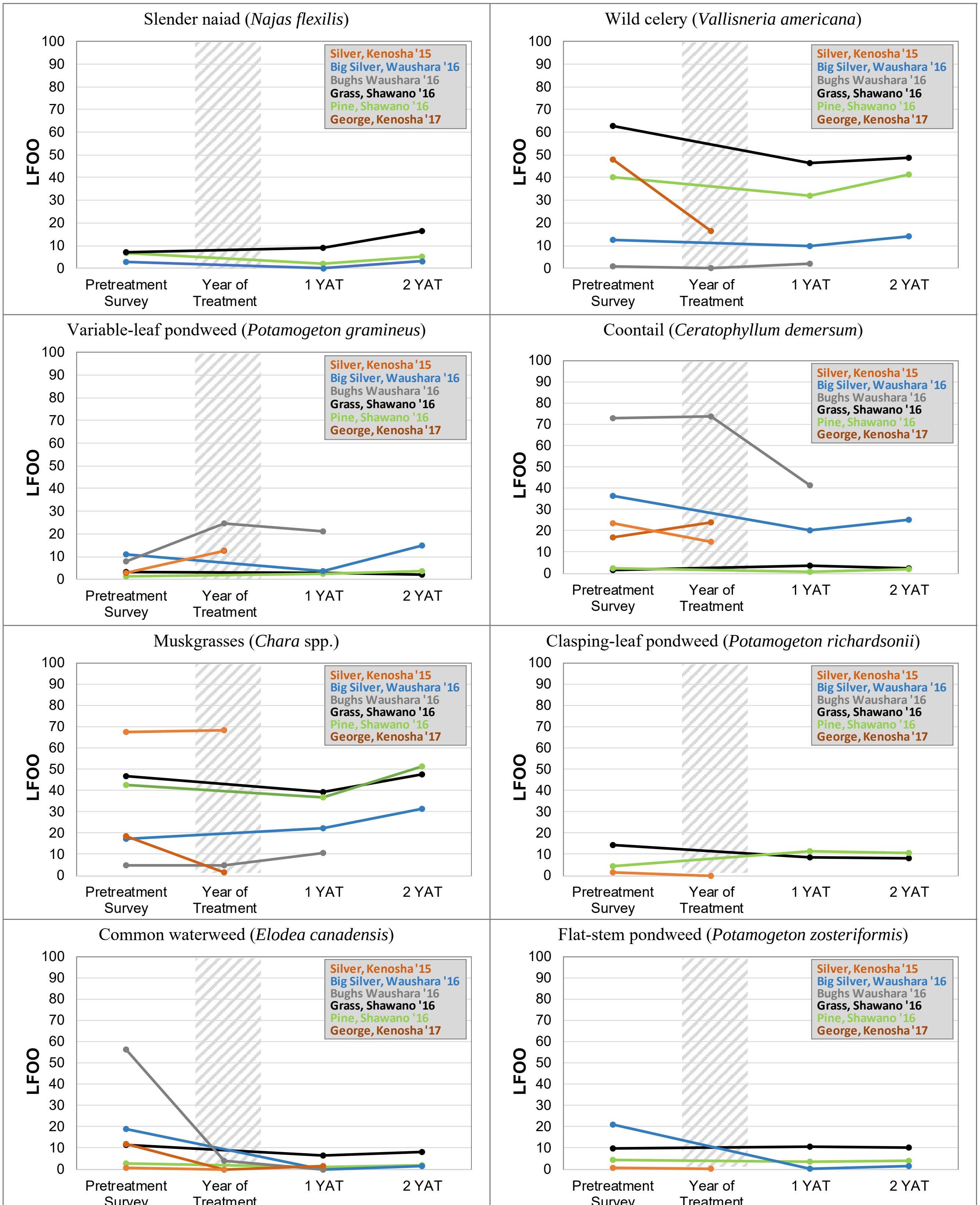


Figure 2.4-3. Littoral frequency of occurrence of select native plants in lakes managed with whole-lake pelletized fluridone treatments. YAT = Year after treatment.

2.5 South Twin Lake 2019 EWM Control Strategy Discussion

Lake District AIS Committee is resolved that the next step in EWM management on South Twin Lake should be a whole-lake pelletized fluridone treatment. This perspective was reached following independent research by members of the Lake District AIS Committee on fluridone. Onterra provided perspective of fluridone projects it has planned and monitored in Wisconsin, including providing the NSTLRA AIS Committee with a formal report of a liquid fluridone treatment (Frog Lake in Florence County) and two formal reports of pelletized fluridone treatments (Pine and Grass Lakes in Shawano County and [Big] Silver Lake in Waushara County). Additional reports were provided to the NSTRLPRD AIS Committee by the WDNR (Bughs Lake in Waushara County, Silver Lake in Kenosha County, and George Lake in Kenosha County). The Lake District has had additional conversations with herbicide applicator firms and has held multiple conference calls with the Senior Aquatics Technology Leader at the firm that makes fluridone, SePRO (Dr. Mark Heilman).

For South Twin Lake specifically, SePRO recommended direct application over colonized areas of EWM (178.8 acres) to achieve a lake-wide 4 ppb initial pelletized fluridone treatment, with an understanding that the measured concentrations within South Twin Lake's epilimnion would be approximately 2-3 ppb because of the extended release rate and herbicide degradation. Once measured herbicide epilimnetic concentrations are observed below 2 ppb, additional bump treatments would occur to keep the concentration between 2-3 ppb for the majority of the growing season (Map 2).

The strategy was outlined within the *North and South Twin 2016-2017 EWM Control & Monitoring Report* (Feb26-2018), which included the rationale for the treatment approach, documentation of stakeholder perceptions, and risk assessment of the use of fluridone. The strategy was subsequently outlined with a February 1 AIS-Established Population Control Grant application and a Chemical Aquatic Plant Control Permit Application (Form 3200-004). The WDNR indicated the grant application was ineligible because the draft management plan lacked the specifics of the fluridone strategy and the annual report containing this information was not received by WDNR at least 60 days prior to the application deadline. The treatment permit was denied for 1) concern of additional native plant impacts beyond those that have not rebounded from the previous whole-lake actions, as well as 2) the WDNR did not feel that the level of EWM within the lake warranted the treatment. Each one of these reasons for permit denial are discussed below:

1. In addition to aquatic plant management activities (i.e herbicide treatment and hand-harvesting), natural environmental changes such as water level fluctuations, precipitation, temperature, length of the growing season, etc. can impact aquatic plant composition within a lake. The natural variability of aquatic plant populations can make it difficult to evaluate the impacts of aquatic plant management activities. Within South Twin Lake, it is clear that some native plants have been reduced from the large-scale herbicide treatments, especially the higher-than-anticipated concentrations that occurred during the 2010 treatment. The data also show that some of the native plant declines may not be associated with the control program, as the declines occur and/or continue during years without active management occurring. Some of the native plant species that were impacted from past management had higher populations in 2018, whereas others decreased in population from 2017 to 2018.

2. The EWM population documented in South Twin during 2018 was greater and of higher density than all previous surveys. With EWM at over 40% of littoral point-intercept locations, South Twin Lake has one of the highest EWM populations in northern Wisconsin.

The Lake District continues to plan for a pelletized fluridone treatment during the spring of 2019. The fluridone use-pattern proposed in 2018 is being proposed again for 2019. The *North and South Twin Lakes Comprehensive Management Plan* (June 2018) contains discussion of risk assessment for Fluridone. For convenience, Appendix B contains the WDNR Fact Sheet on fluridone as well as toxicological perspective from the herbicide manufacturer (SePRO). Since this report was finalized, an additional study by Jin et al. (2018) was released on sublethal toxicity of the endangered delta smelt (*Hypomesus transpacificus*). This study showed sublethal impacts to the tested species at 80 ppb with a static exposure of 6 hours (the lowest dose tested). While this is within the labeled use rate for fluridone (maximum application rate is 150 ppb), it is a rate over 25 times that being anticipated in South Twin Lake (achieving 1.5-3 ppb), but only 4 times greater than the initial application area dose (approximately 20 ppb).

EWM control over the summer will be slow, with symptoms being observed approximately a month after treatment but damaged EWM persistence for a few months. By mid-summer (approximately 2 months after application), skeletal plants will start to degrade. Removing large amounts of plant biomass could have indirect ecological impact. Some lake managers have been more 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 relatively slow EWM die-off and subsequent decomposition of plant material is also likely to minimize a resulting reduction of oxygen levels within the lake.

The Lake District anticipates that the 4-ppb initial application will occur in mid-May once South Twin Lakes becomes stratified and the Native American communities have finished their spring open-water spear harvest. The Lake District met with representatives of the Lac du Flambeau Band of Lake Superior Chippewa Indians and Mole Lake Sokaogon Chippewa Community. The Lake District also had a phone conversation with representatives of the Great Lakes Indian Fish & Wildlife Commission (GLIFWC). Delaying implementation of initial treatment may allow EWM to increase carbohydrate storage, resulting in a slower control over the summer.

Volunteer-based monitoring of temperature profiles will help drive final and bump dosing strategies. The Lake District would monitor the fluridone concentration within the lake approximately every two weeks, dictating when and how much additional herbicide bump treatments are required. The Lake District anticipates two bump treatments will be required, likely each at 2 ppb. Herbicide dissipation out of South Twin lake into downstream Pioneer Lake is discussed within *North and South Twin 2016-2017 EWM Control & Monitoring Report* (Feb26-2018). The Lake District has also been in direct communication with the Pioneer Lake Association, whom have not expressed concerns about the projected 2019 treatment plans.

In conjunction with the proposed whole-lake fluridone treatment on South Twin Lake, EWM mapping surveys and point-intercept surveys would be conducted the *year prior to treatment* (2018) and the *years after treatment* (2020 and 2021). Please note that surveys would not be conducted during the *year of treatment* (2019), as the lake is in the process of active treatment. Based upon prior whole-lake treatment results, the Lake District created a management trigger of 12% EWM littoral frequency of occurrence (LFOO). When this trigger is exceeded, the District will consider the applicability of large-scale management strategies for South Twin Lake. In the past when EWM LFOO exceeded 12% in a given year, the following year the population approached or exceeded 40%. The Lake District has set their expectations for an EWM population below 12% for 3-5 years.

Native plant impacts are anticipated from any whole-lake management action, but evaluation of the long-term success will also take into account the native plant impacts and population rebound. In review of this document, the WDNR requested the District develop more specific success criteria for native plant impacts from a potential 2019 fluridone treatment on South Twin Lake. The District encourages further conversation with the WDNR in developing success criteria for native plants, as it is unclear if that has been attempted before.

Many lake groups initiate a whole-lake herbicide strategy with the intention of implementing smaller-scale control measures (herbicide spot treatments, hand-removal) when EWM/HWM begins rebounding. This is referred to as Integrated Pest Management (IPM). From its own experience, the Lake District understands that EWM population rebound is inevitable following a whole-lake treatment. The District developed a specific management action within its recently created *Comprehensive Management Plan* to "Develop Long-Term Contingency Strategy for Rebounding EWM Populations in South Twin Lake." When EWM rebound and survivorship is documented, the Lake District would enact an integrated pest management strategy consisting of follow-up control measures to ensure longevity of control. Preferably, this would include hand-harvesting, potentially with diver assisted suction harvesting, or herbicide spot treatment. The District has more financial capabilities than it had in the past as a lake association, and is prepared to extend significant efforts towards IPM.

3.0 SPOT HERBICIDE TREATMENT OF NORTH TWIN LAKE

3.1 Background on Spot Herbicide Application Strategies

From an ecological perspective, herbicide spot treatments are those where the herbicide is applied at a scale where dissipation will not result in significant lake wide concentrations; impacts are anticipated to be localized to in/around the application area. A cooperative research project between the Wisconsin Department of Natural Resources, U.S. Army Corps of Engineers Research and Development Center, and private lake management consultants coupled quantitative aquatic plant monitoring with field collected herbicide concentration data to evaluate efficacy, selectivity, and longevity of chemical control strategies implemented on a subset of Wisconsin lakes and flowages (Nault et al. 2015). Data collected within this project indicated that almost all spot treatments investigated did not reach sufficient herbicide concentration and exposure times (CETs) laboratory research indicate are needed for plant mortality. While it may be possible that environmental stressors in field settings may change the CETs required for control, continued unpredictability of EWM control from herbicide spot treatments has resulted in alternative management strategies to be considered. Ongoing field trials are assessing the efficacy (EWM control) and selectivity (collateral native plant impacts) of herbicides that may require short exposure times (diquat, florpyrauxifen-benzyl) or herbicide combinations (diquat/endothall, 2,4-D/endothall, etc.).

3.2 North Twin Lake Management History

Prior to 2017, the majority of the known EWM population in North Twin Lake is on the southern end of the lake near the island and the border with South Twin Lake. This area in the southern end of the lake near the island has been targeted with aquatic herbicides from 2007 to 2013 (Figure 3.2-1). These treatments were moderately impactful in reducing the EWM density within the treatment areas during the season that the herbicides were applied, but were ineffective at fully killing the target plants and significant rebound occurred by the following year. The justification for rotating herbicide treatment techniques and increasing application rates over this period was to increase efficacy as long-term goals were not being met. In 2014, the NSTLRA opted to postpone herbicide treatment strategies until a more efficacious use-pattern could be developed. These locations were targeted with professional-based hand-harvesting from 2014 to 2016, allowing for seasonal reduction of EWM density.

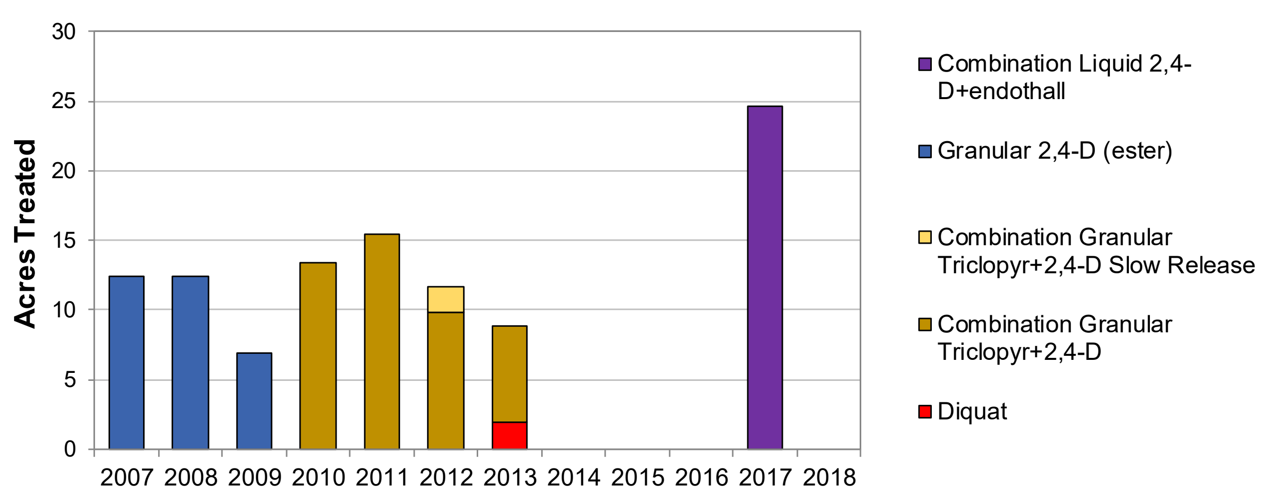


Figure 3.2-1. North Twin Lake Herbicide Treatment History. No herbicide treatments took place in 2014-2016, and 2018.

A 2017 large-scale spot-treatment occurred on North Twin Lake using a combination of 2,4-D (4.0 ppm ae) and endothall (1.5 ppm ai) in an effort to increase efficacy. The 2017 late-season EWM mapping survey indicated reductions in the EWM populations within the application areas was observed, however survivorship of EWM was documented (Figure 3.2-2). A point-intercept sub-sample survey was conducted over the three treatment areas (N=94). During the spring prior to treatment, 34.0% of the quantitative sampling locations contained EWM. A 56.3% reduction was observed as only 14.9% of sampling locations contained EWM during the mid-September 2017 post treatment assessment (statistically valid - Chi-square $\alpha = 0.05$). Additional EWM rebound resulted in 25.5% of sampling locations containing EWM during the late-summer of 2018.

The 2018 Late-Season EWM Mapping Survey also noted an increased EWM population compared to 2017, but the mapping data indicate a lowered population compared to pretreatment. In 2018, after the sub-sample point-intercept survey was completed, Aquatic Plant Management, LLC conducted 8 days of hand-harvesting using a Diver-Assisted Suction Harvesting (DASH) component. They worked east to west in the southeastern treatment area up to the red-line on the map (Figure 3.2-2), removing approximately 933 pounds of EWM.

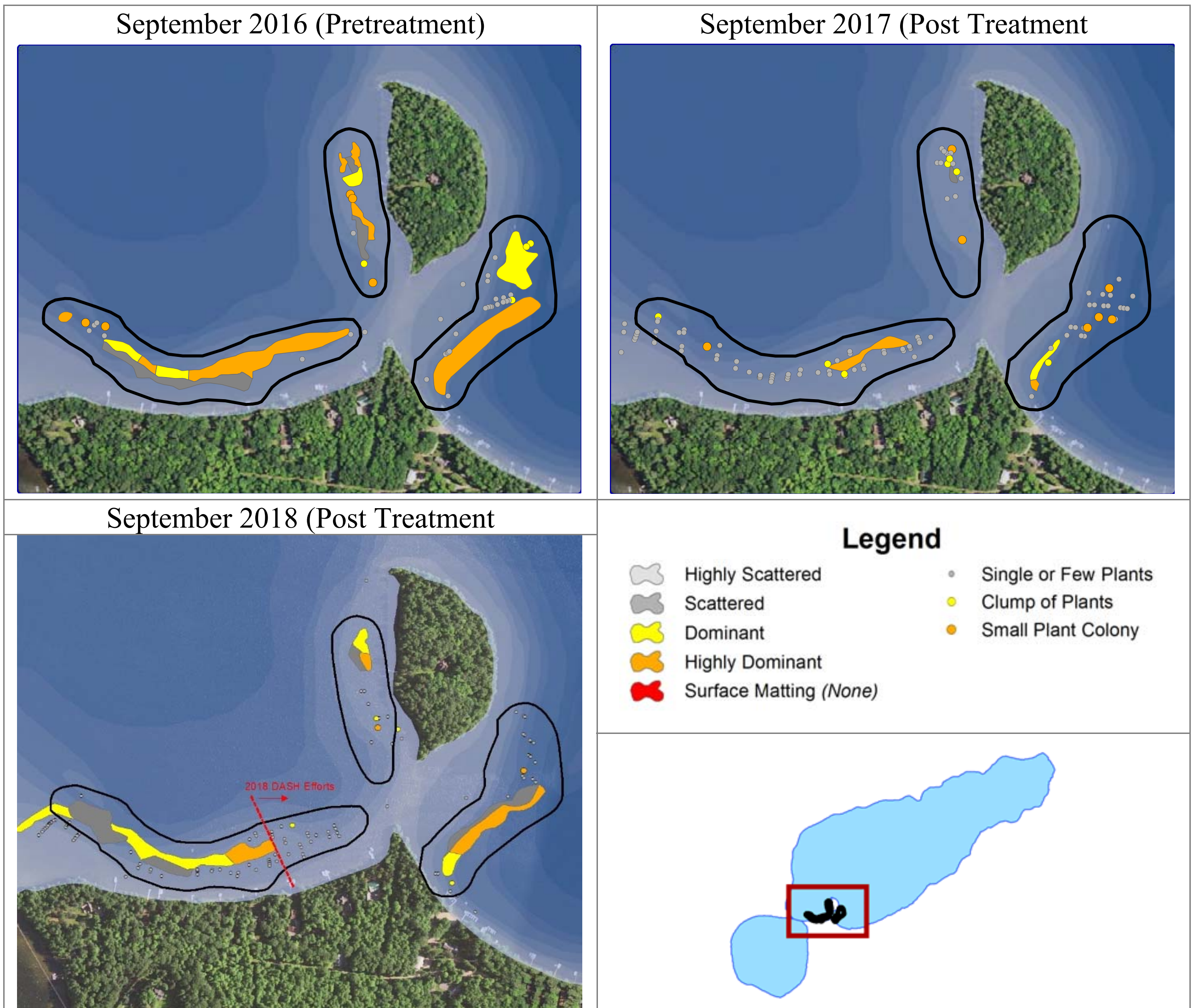


Figure 3.2-2. North Twin Lake Late-Season EWM Mapping Survey results.

During 2007 to 2013 when herbicide treatments took place on North Twin Lake, point-intercept sub-sampling took place to understand how the native and non-native plant population reacted to the control measures that took place. These data allow a historic understanding of the aquatic plant populations within this part of the lake (Figure 3.2-3) and are compared to the post treatment surveys during the late summer of 2017 (red) and 2018 (blue).

During 2017 and 2018, coontail and flat-stem pondweed populations were as low or lower than the range of frequencies during 2007-2013. Wild celery, slender naiad, and muskgrasses were all towards the highest range or higher during 2017 compared to the historic dataset. The other plant species were closer to the average population levels of the historic dataset.

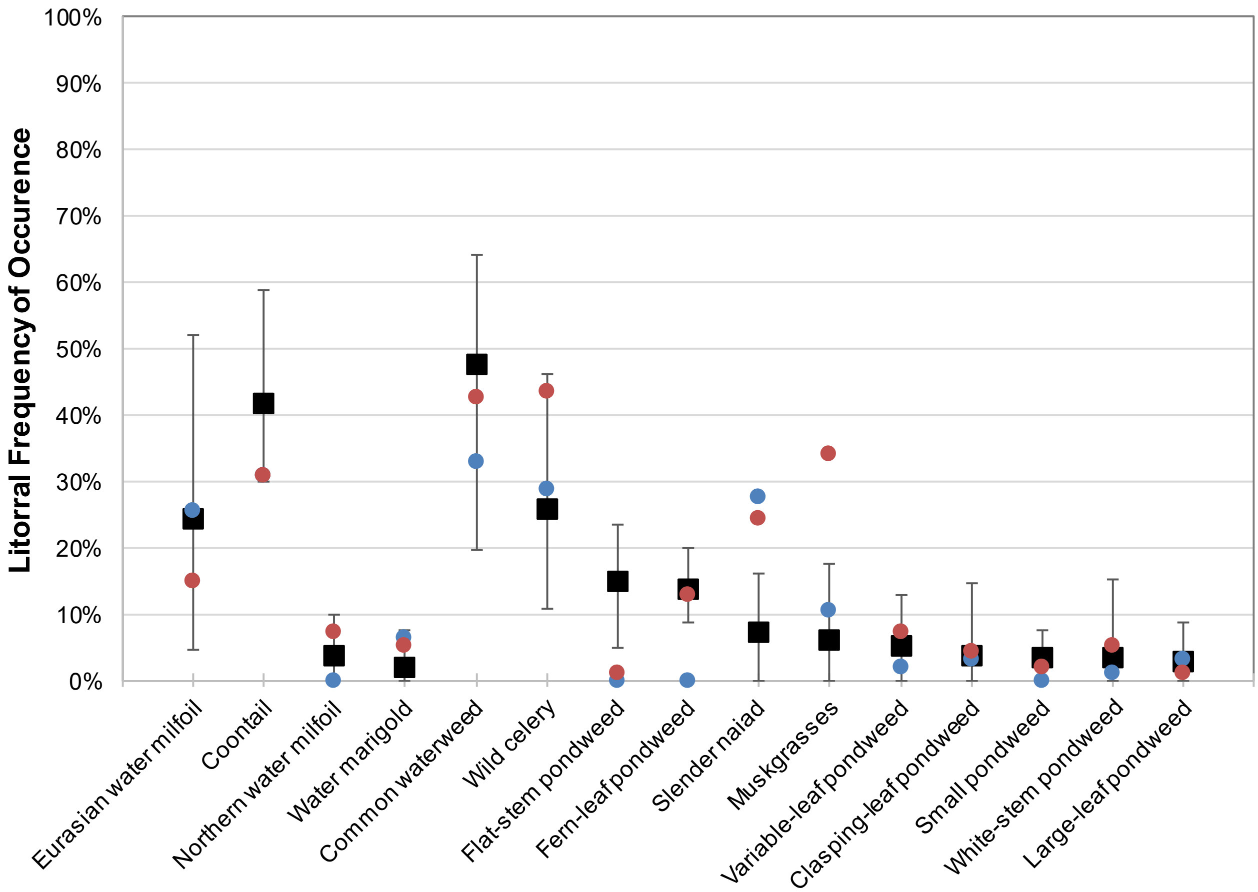


Figure 3.2-3. Historic average aquatic plant frequencies (2007-2013) compared to post treatment data within 2017 treatment areas. Square symbol represents mean frequency of occurrence pooled from all sites from 2007-2013, black error bars represent range of annual frequencies during the time period. Red circles represent 2017 post treatment frequencies, blue circles represent 2018 post treatment frequencies.

3.3 North Twin Lake 2019 EWM Control Strategy Discussion

As outlined in the *North and South Twin Lakes Comprehensive Lake Management Plan* (June 2018), the NSTRLPRD created a strategy where the entirety of the EWM population on North Twin is being considered for active management. The goal of the Lake District is to use hand-harvesting as a preferred control mechanism, but has established a management trigger when herbicide spot treatment would be considered.

As follow-up measures from the 2016 large-scale spot treatment in the southern end of the lake near the island, the NSTLRPRD intends to implement 3 weeks of professional hand-harvesting with DASH in 2019. In addition to a greater amount of effort in 2019, the Lake District believes that greater strides in EWM population management can be achieved by implementing the strategy earlier in the growing season when EWM and native plants are at an earlier growth stage.

If the following trigger is met, the Lake District would consider conducting herbicide spot treatments: "colonized areas where a sufficiently large treatment area can be constructed to hold concentration and exposure times (preference to *dominan*t or greater density AIS populations)." The management action also indicates that spot treatments would likely need to be conducted with herbicides that require short exposure times. At the current time, the Lake District is interpreting this trigger as areas over three acres that have over a third of the colonized acreage as *highly dominant* or *surface matted* densities.

The area extending north from the entrance to South Twin Lake towards the Lakota Street boat landing experienced large increases in EWM density during the past few years (Map 3). This site surpasses the Lake District's threshold for consideration for herbicide spot treatment. This prompted the collection of pretreatment data during the late-season of 2018. Applying a 60-foot buffer around the EWM colony in this area results in a 14.3-acre site (Map 3, Figure 3.3-1). Using a 23-meter spacing, just over 100 point-intercept sub-sample locations were placed over this site. Data was collected in mid-October, with EWM being located at approximately 60% of sampling locations.

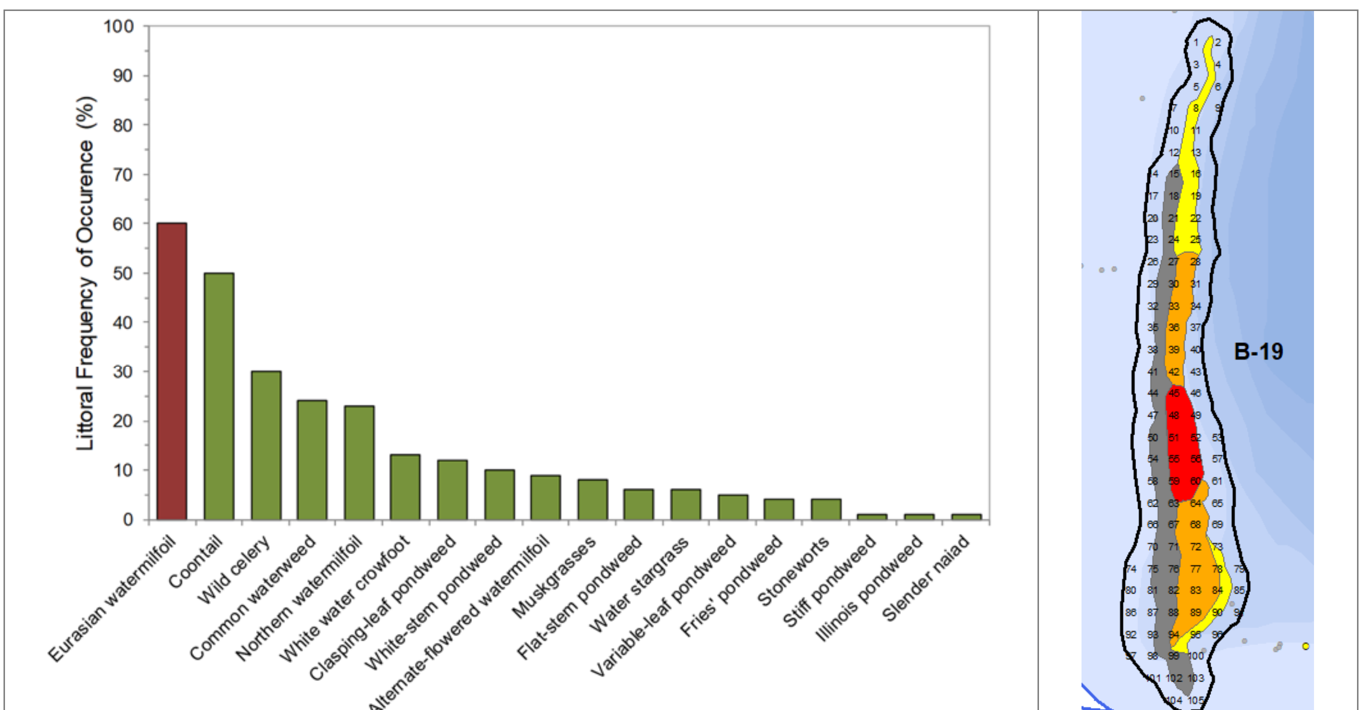


Figure 3.3-1. Point-intercept Sub-Sample Results from October 2018 survey. October 16, 2018

Table 3.3-1. Herbicide Treatment History of B-19

Year	Acres	Herbicide
2010	1.6	Granular triclopyr/2,4-D
2011	2.1	Granular triclopyr/2,4-D
2012	2.9	Granular triclopyr/2,4-D
2013	1.9	Diquat

Multiple herbicide treatments have taken place on the southern few acres of this location (Table 3.3-1). The combination granular triclopyr/2,4-D treatments took place with the commercially available Renovate® MaxG product (SePRO). Each successive year, the herbicide dose was increased as the level of control was not meeting expectations. The 2013 diquat treatment resulted in about two years of reduced milfoil.

Lake District has determined B-19 as priority of herbicide treatment during spring of 2019 and are currently investigating potential treatment options. The lack of previous treatment success in this area is likely due to rapid dissipation from the small and exposed specifics of the treatment site. Based on the results of the 2016 large-scale spot treatment, the Lake District does not believe that the combination 2,4-D and endothall use-pattern will meet expectations. The Lake District investigated Aquastrike ™ (UPI), which is a commercially available combination of diquat and endothall. Concern exists whether this herbicide (particularly the diquat component) has the capacity to kill the entire plant, or simply impacts the above ground biomass and the plant rebounds from unaffected root crowns. The long-term control of EWM targeted with diquat/endothall continue to be evaluated on many lakes across Wisconsin.

At the time of this report, the Lake District is trending towards florpyrauxifen-benzyl, commercially available as ProcellaCOR™ (SePRO). This herbicide is specifically designed to control invasive milfoil in short exposure time scenarios. ProcellaCOR™ is in a new class of synthetic auxin mimic herbicides (arylpicolinates) with short concentration and exposure time (CET) requirements compared to other systemic herbicides. Uptake rates of ProcellaCOR™ into EWM were two times greater than reported for triclopyr (Haug 2018, Vassios et al. 2017). ProcellaCOR™ is primarily degraded by photolysis (light exposure), with some microbial degradation. The herbicide is relatively short-lived in the environment, with half-lives of 4-6 days in aerobic environments and 2 days in anerobic environments (WSDE 2017). The product has a high affinity for binding to organic materials (i.e. high KOC).

Netherland and Richardson (2016) and Richardson et al. (2016) indicated control of select non-native plant species with the active ingredient in ProcellaCOR™, including invasive watermilfoils (EWM and HWM) at low application rates compared with other registered spot treatment herbicides. The majority of native plants tested to date also suggest greater tolerance to the is mode of action. Water lilies, pickerelweed, arrowheads, and native watermilfoils have shown sensitivity to ProcellaCOR™. Coontail may also be impacted at higher application rates. Because this is a new herbicide, data available from field trials is relatively limited.

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 (Faribrother and Kapuska 1996). 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:

- 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,

The EPA Ecological Risk Assessment places the risk to non-target wildlife into the "no risk concern" category and the impacts to bees, birds, reptiles, amphibians, and mammals in the "practically non-toxic" category. The EPA has also indicated that there are no risks of concern to human health. There are no restrictions on swimming, drinking, fish consumption, or turf irrigation. However, there would be an approximate 1-day waiting period of the proposed application for shoreland irrigation due to concerns of herbicidal impacts.

Additional information from the WDNR related to aquatic herbicide regulation and the WDNR's Chemical fact sheet for florpyrauxifen-benzyl are included in Appendix C. Appendix C also includes the relevant chapter on ProcellaCOR™ from the State of Washington Department of Ecology *Final Supplemental Environmental Impact Statement for State of Washington Aquatic Plant and Algae Management* (August 14, 2017).

For Site B-19 in North Twin Lake, SePRO recommends 8 Prescription Dose Units (PDU) of ProcellaCOR™ EC per acre-foot, which equates to 15.4 ppb (Map 3). This is slightly higher than the typically recommended use rate for invasive watermilfoils (3-5 PDU) to account for herbicide dissipation that is likely from this site. The maximum application rate of this formulation of ProcellaCOR™ is 25 PDU. Because the product has a high affinity for binding to organic materials, SePRO recommends closely spaced application transects for this treatment. SePRO has granted a 3-year warrantee on the outcome of the treatment at this use rate. The Lake District would accompany the herbicide treatment with post treatment herbicide concentration samples to couple with a post treatment EWM mapping survey and point-intercept sub-sample survey to evaluate efficacy and selectivity from the treatment.

The Lake District believe that an approximately 14-acre treatment within the 2,883-acre North Twin Lake offers a good trial opportunity with minimal lake-wide risk, particularly if native plant impacts exceed projections. The Lake District is highly concerned that if left unmanaged, the EWM population within this tract will continue to expand into North Twin and potentially increase to levels observed in South Twin Lake.

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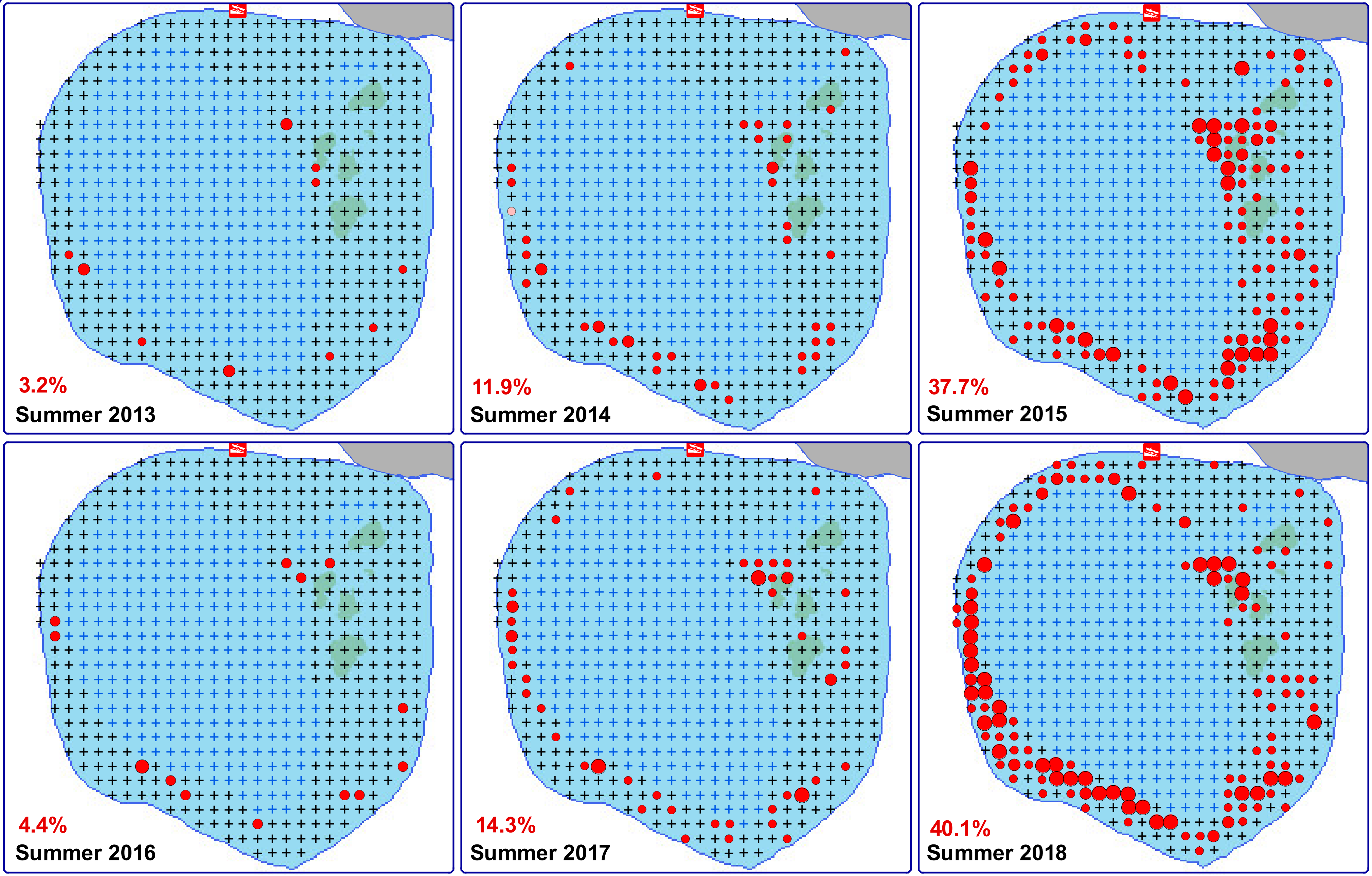
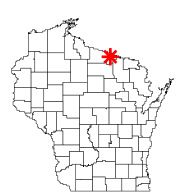


N
W E
S
2,200
Feet

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

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plants: Onterra, 2013-2018
Map Date: August 13, 2018


Project Location in Wisconsin

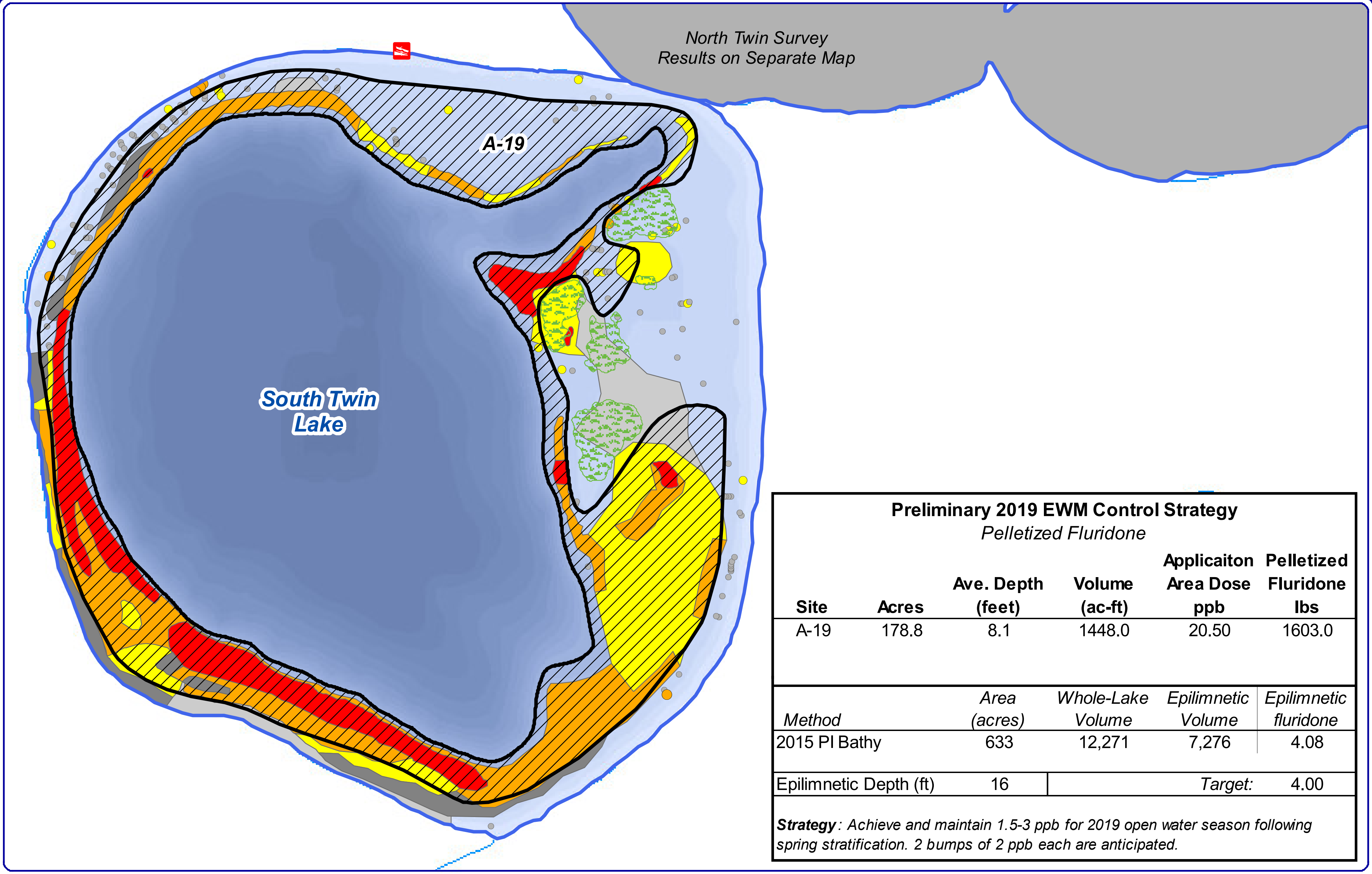
Large-Scale 2,4-D Treatment Occured During Spring 2016

Legend

- EWM Total Rake Fullness = 3
- EWM Total Rake Fullness = 2
- EWM Total Rake Fullness = 1
- No EWM on Rake
- Too Deep
- Bulrush Community

Map 1
South Twin Lake
Vilas County, Wisconsin

2013 - 2018 EWM Point-Intercept Survey Results



Preliminary 2019 EWM Control Strategy

Pelletized Fluridone

Site	Acres	Ave. Depth (feet)	Volume (ac-ft)	Applicaiton Area Dose ppb	Pelletized Fluridone lbs
A-19	178.8	8.1	1448.0	20.50	1603.0

Method		*Area (acres)*	*Whole-Lake Volume*	*Epilimnetic Volume*	*Epilimnetic fluridone*
2015 PI Bathy		633	12,271	7,276	4.08
Epilimnetic Depth (ft)		16		*Target:*	4.00

Strategy*: Achieve and maintain 1.5-3 ppb for 2019 open water season following spring stratification. 2 bumps of 2 ppb each are anticipated.*

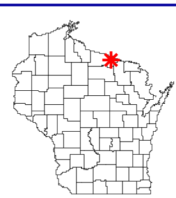
990

Feet

Onterra, LLC
Lake Management Planning

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

Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra, 2015
EWM Survey: Onterra, 2018
Map date: October 3, 2018 - EJH



Project Location in Wisconsin

Legend

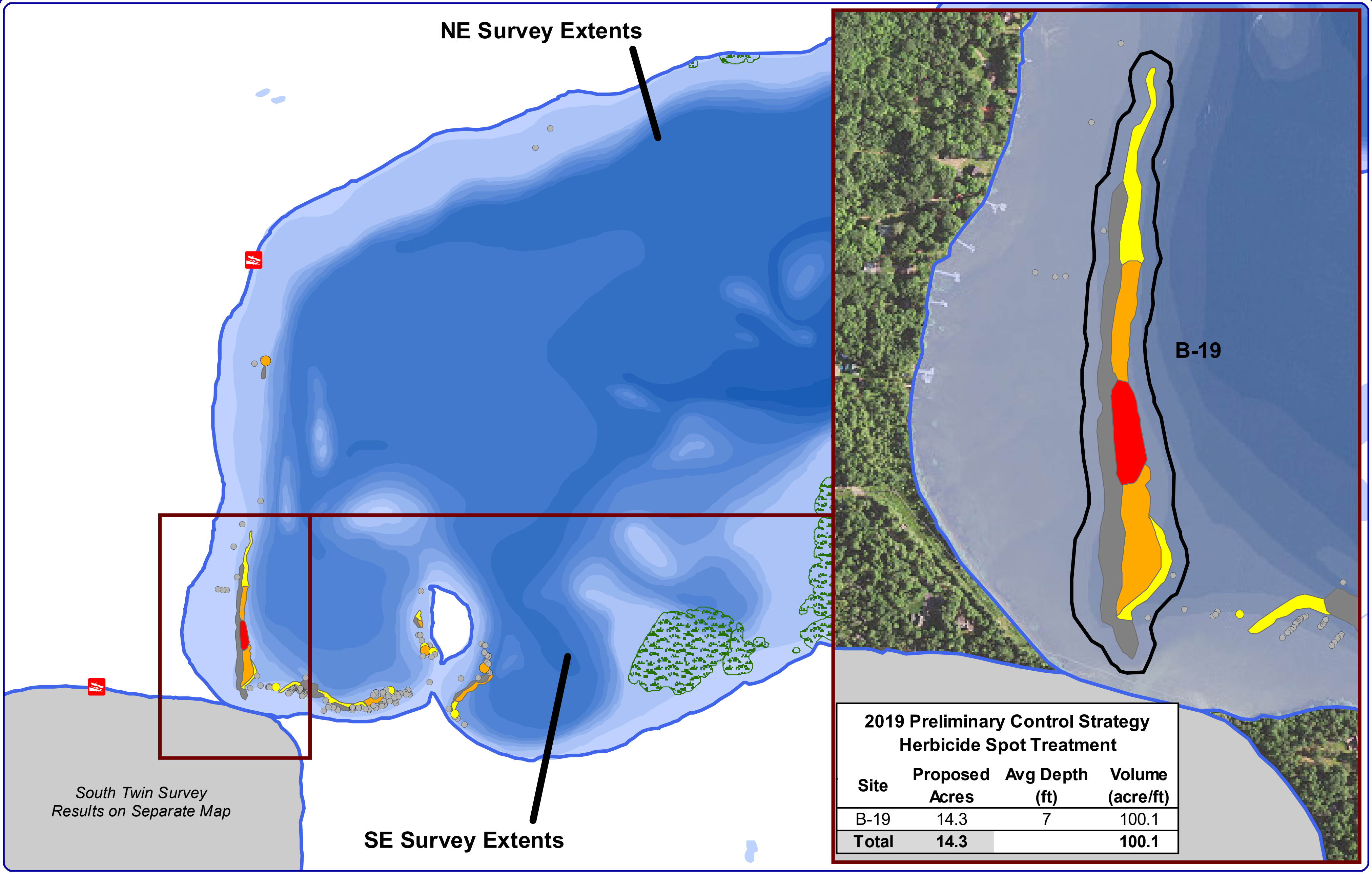
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- Bullrush Community *(Summer 2016)*
- Preliminary 2019 Herbicide Application Area

Map 2

South Twin Lake

Vilas County, Wisconsin

2019 Preliminary EWM Treatment Strategy



2019 Preliminary Control Strategy
Herbicide Spot Treatment

Site	Proposed Acres	Avg Depth (ft)	Volume (acre/ft)
B-19	14.3	7	100.1
Total	**14.3**		**100.1**

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- Bullrush Community *(Summer 2016)*

Project Location in Wisconsin

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Sources:
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Bathymetry: WDNR, digitized by Onterra
Orthophotograph: NAIP, 2017
Aquatic Plants: Onterra, 2018
Map Date: October 3, 2018 - EJH

Map 3

North Twin Lake

Vilas County, Wisconsin

2019 Preliminary EWM Treatment Strategy