

INTRODUCTION

According to a 2016 acoustic-based bathymetry study Kelly Lake, Oconto County, is a 373-acre lake with a maximum depth of 44 feet (Photo 1). Eurasian water milfoil (*Myriophyllum spicatum*; EWM) was first discovered in Kelly Lake in 2012 by the Oconto County Aquatic Invasive Species Coordinator. Its presence was also confirmed during a 2012 point-intercept survey conducted by the Wisconsin Department of Natural Resources (WDNR). Onterra, LLC was subsequently contacted in the late summer of 2012 to conduct an EWM peak-biomass survey, which documented much more EWM than was previously thought to exist in Kelly Lake.



Photo 1. Kelly Lake, Oconto County

In the fall of 2012, the Kelly Lake Advancement Association (KLAA) successfully applied for a WDNR AIS Early Detection and Response Grant to conduct comprehensive studies and create a plan to control the EWM population on Kelly Lake. Due to the level of EWM found in the late summer of 2012, an herbicide treatment strategy targeting 13.2 acres of EWM was implemented in the spring of 2013. Post treatment surveys conducted in 2013 showed the treatment to be highly successful.

Based on the 2015 Late Summer EWM Peak-Biomass Mapping Survey, the EWM population in Kelly Lake continues to be lower than levels prior to the spring 2013 herbicide treatment. Professional and volunteer-based hand harvesting efforts were conducted in 2014 and 2015 in an effort to maintain the lowered EWM population within the lake. These efforts have provided some limited control in the targeted areas but have not kept pace with the expanding EWM population in some parts of the lake. The 2016 strategy included a continued hand-harvesting program as well as one area of the lake to be targeted with an herbicide treatment.

2016 EWM CONTROL STRATEGY

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to dilute herbicide concentration within aquatic systems. Understanding Concentration-Exposure Times (often referred to as CETs) is an important consideration for the use of aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time.

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. 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 (EWM control) and selectivity (collateral native plant impacts) of herbicides that may be effective with a shorter exposure time.

The amount of EWM located in August 2015 within a northwestern bay on Kelly Lake was at a level believed to be too large for hand-harvesting to be implemented successfully. Even though this EWM population was somewhat protected from wind and water movement by being situated in an isolated bay of the lake, Onterra did not anticipate an herbicide treatment with a systemic herbicide like 2,4-D would meet expectations. Therefore, this area was proposed to be targeted with diquat, an herbicide with shorter CET requirements (Map 1).

The low EWM population within other parts of Kelly Lake were proposed to be targeted with hand-harvesting control methods in 2016. Five preliminary locations totaling 2.26 acres were preliminarily proposed for professional-based hand-harvesting, but the locations and prioritization strategy would be finalized based on the June 2016 Early Season AIS (ESAIS) Survey.

PRE-TREATMENT CONFIRMATION AND REFINEMENT SURVEY

On April 26, 2016, Onterra ecologists conducted the EWM Spring Pre-treatment Confirmation and Refinement Survey on Kelly Lake. A temperature profile indicated the surface water temperatures were 50°F (10°C) with little change until 23 feet where some thermal stratification was observed. During this survey, the EWM was easily visible from the surface (24-foot Secchi depth reading) within the proposed treatment site. The deeper extents of the treatment site were investigated with a submersible camera. As a result of the survey, a minor adjustment to the treatment area extents was recommended but had no net impacts on the overall treatment acreage.

The herbicide treatment was conducted by Schmidt's Aquatic Plant Control on May 3, 2016 using a liquid formulation of diquat (Tribune) at the maximum label rate of 2 gallons per surface acre. The applicator reported a near-surface water temperature of approximately 11.1°C (°F) and east winds of 5.3 mph at the time of application.

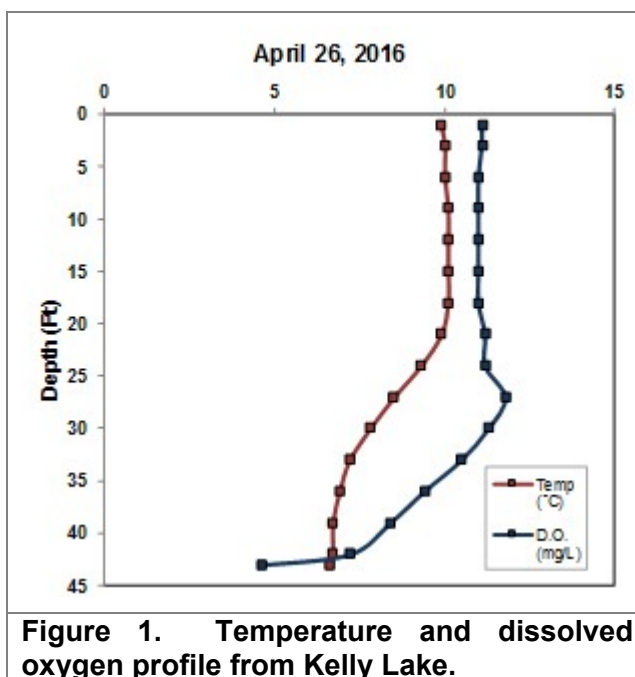


Figure 1. Temperature and dissolved oxygen profile from Kelly Lake.

EARLY SEASON AIS SURVEY RESULTS (PRE- HAND-HARVESTING)

On June 4, 2015, Onterra ecologists conducted the ESAIS Survey on Kelly Lake. During the survey, the EWM population was mapped using sub-meter GPS technology by using either 1) point-based or area-based methodologies. Large colonies >40 feet in diameter are mapped using polygons (areas) and were qualitatively attributed a density rating based upon a five-tiered scale from *Highly Scattered* to *Surface Matting*. Point-based techniques were applied to EWM locations that were considered as *Small Plant Colonies* (<40 feet in diameter), *Clumps of Plants*, or *Single or Few Plants*.

No alterations to the originally delineated 2.26-acre hand-harvesting sites were made based on this survey (Map 2). The KLAA contracted with Aquatic Plant Management, LLC (APM) to conduct

professional hand-harvesting of EWM in 2016. The hand harvesting firm was instructed to start working on A-16 based on its density and past history of EWM management. The firm was also advised to work on a limited number of sites (1 or 2) at a time and not moving on to new locations until all the EWM within that location has been removed. Onterra provided the spatial data from this survey to the KLAA and the professional hand-harvesting firm to aid the control efforts and reporting.

HAND-HARVESTING MANAGEMENT ACTIONS

APM conducted hand-harvesting activities on July 14-15 and August 17-18, 2016 spending a total of 17.47 hours (97.66 combined diver hours) actively hand-harvesting EWM within Kelly Lake and removing approximately 645 cubic feet of EWM from two locations (Table 1). APM focused on removing EWM within Site A-16 during the July visits and Site C-16 during the August visits. Details of the hand removal efforts as reported by APM are attached to this report as Appendix A.

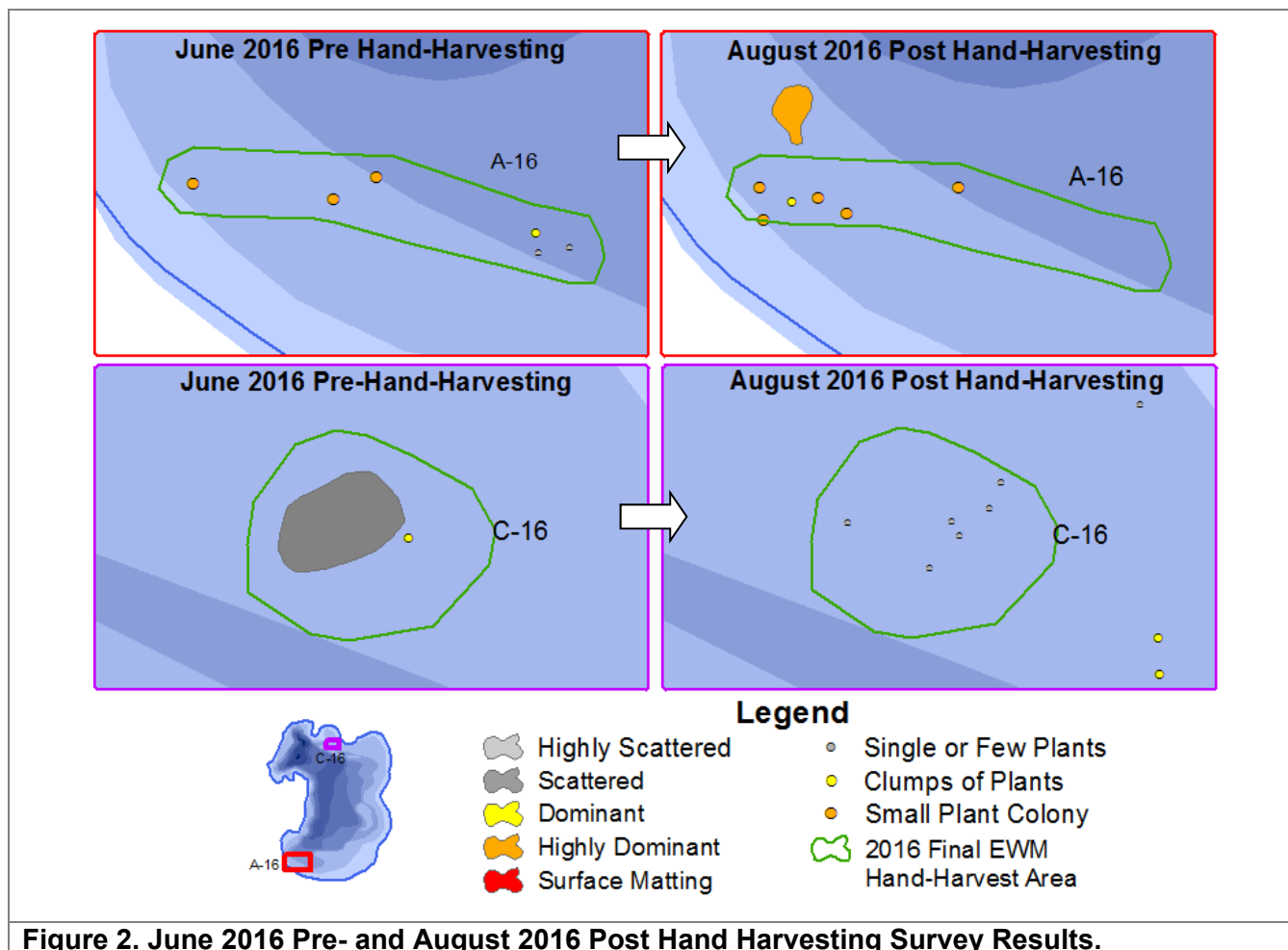
Table 1. Kelly Lake, 2016 professional hand-harvesting activities

Site	Time (Hours)	EWM Removed (Cubic Feet)
A-16	8:53	200
C-16	8:35	445
Total	17:28	645

LATE-SUMMER PEAK-BIOMASS SURVEY RESULTS (POST HAND-HARVESTING)

The Late-Summer EWM Peak-Biomass Survey was conducted on August 29, 2016 to qualitatively assess the 2016 control efforts as well as to understand the peak growth (peak-biomass) of the EWM population throughout the lake. During June 2016, site A-16 contained numerous point-based EWM locations, ranging from *single of few plants* to *small plant colonies* (Figure 2, top left frame). APM indicated that over the course of two days in July, they removed all the observable EWM within the site. During the late-August post-hand-harvesting survey, numerous *small plant colonies* were observed in the western part of the site while no EWM was observed from the eastern part of the site (Figure 2, top right frame). The EWM within this site at the end of the growing season may have been from rebounding plants that were incompletely removed during APM’s July efforts and/or from EWM population increases and expansion from other parts of the lake. A *highly dominant* EWM colony was observed just to the north of the western part of site A-16 during the late-summer survey.

APM divers noted that the *scattered* colony mapped by Onterra in June (Figure 2, bottom left frame) likely experienced a significant increase in EWM density as the summer progressed. The post-hand-harvesting assessment of this site indicated that the EWM population within this area had been reduced to only a few *single or few plants* (Figure 2, bottom right frame).



During the 2015 Late-Season EWM Peak-Biomass Survey, site B-16 contained a few *dominant* and *highly dominant* EWM colonies as well as additional EWM occurrences marked with point-based methods (Figure 3, left frame). During the June ESAIS Survey (not shown), approximately one month following the herbicide application targeting this site, the EWM population in this area appeared impacted but was found to be of greater size and density than the previous survey. It was anticipated that these plants would decline as the summer progressed from the treatment. That was not the case, as the Late-Summer EWM Peak-Biomass Survey confirmed that the EWM within this treatment site was not controlled and the population increased (Figure 3, right frame).

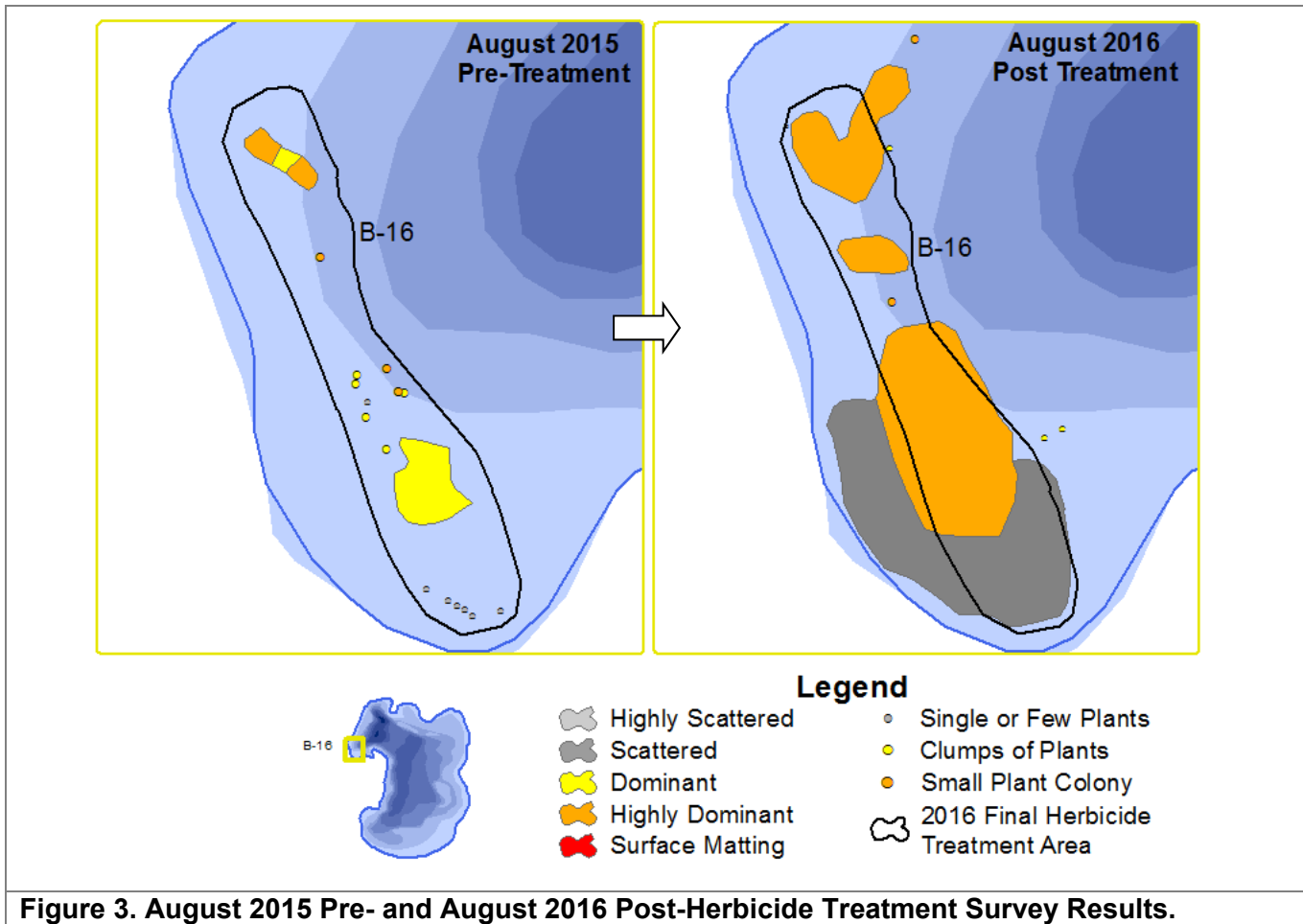


Figure 3. August 2015 Pre- and August 2016 Post-Herbicide Treatment Survey Results.

Analysis of wind data collected from a nearby weather station in Suring, WI (7 miles west of Kelly Lake) shows winds were calm at the beginning of the application and increased to approximately 4 mph as the application was being completed. The winds steadily increased to 15 mph out of the west-northwest by 4 hours after the treatment was completed. Onterra ecologist also reviewed data from other nearby weather stations and confirmed that winds greater than 12 mph were observed at noon on May 3, 2016 at all locations. Although it cannot be proven with the data available, wind conditions following the spring 2016 herbicide treatment may have reduced the treatment efficacy to some degree.

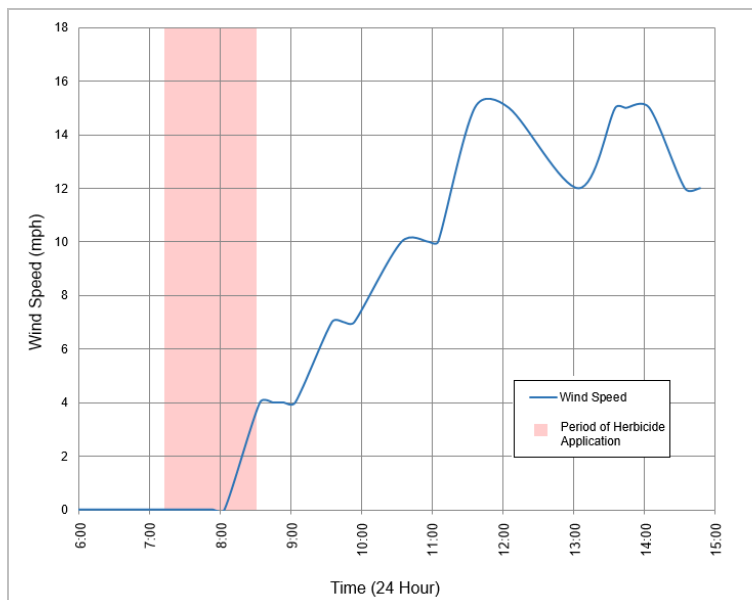


Figure 4. May 3, 2016 wind speed on Kelly Lake. Graph created using data from Weather Underground Station in Suring, WI.

EWM populations in Kelly Lake outside of those targeted for control increased slightly but continued to maintain at relatively low population within the lake. During the WDNR's 2012 point-intercept survey, EWM was found in 7% of the littoral zone. During the 2016 point-intercept survey conducted by Onterra as part of the current lake management planning project, EWM was found in 2.2% of the littoral zone.

CONCLUSIONS AND DISCUSSION

The professional hand-harvesting actions undertaken during 2016 in Kelly Lake were effective in controlling the EWM population at the targeted sites with an overall reduction in EWM observed between the June ESAIS survey and the late-summer survey. It will be important to monitor these sites in 2017 to determine if re-growth or re-colonization is occurring. Unfortunately, the professional hand-harvesting program only targeted 2 of the 5 sites proposed for control. EWM expansion in the sites not targeted was observed. This was not a fault of the hand-harvesting firm, as they were instructed not to move on to additional sites until they were able to fully remove the EWM with the sites they were working on. The fault of many hand-harvesting efforts is that the amount of effort (time) put forth is nowhere near what is needed to keep the population in check or reduce it. Unfortunately, the exact amount of effort that would be required to meet the KLAA's control expectations are difficult to quantify.

In addition to the 3 hand-harvesting sites not visited in 2016, two additional sites are preliminarily proposed for hand-harvesting in 2016 (Map 4). This includes the western part of A-16 and some EWM occurrences just to the north of that site (now A-17) as well as a small but *highly dominant* EWM colony in the northwestern part of the lake (E-17). If the KLAA intends to target all these sites in 2017, an effort 2-3 times (or more) what was applied in 2016 may be required.

An Early-Season AIS (ESAIS) survey will be conducted during June of 2017 to finalize the hand-harvesting strategy (including prioritization) and produce the mapping data needed to guide hand-harvesting strategies during the summer. A map of the results and a brief email-report would be provided to the KLAA following the ESAIS Survey as well as the compatible files for uploading onto the association's GPS unit. Onterra recommends that the professional hand-harvesting strategy include a follow-up visit to all sites at least 2 weeks after the main hand-removal event to remove any EWM that rebounds following the first pulling event and lead to more complete control at the targeted sites.

As noted earlier in the report, the 2016 herbicide treatment failed to meet expectations. While diquat is known to require a lower CET than 2,4-D, it is likely that the concentrations and exposure times surrounding the 2016 treatment of Kelly Lake were still insufficient to cause EWM mortality. This may be partly due to the increased winds following the treatment causing increased dissipation, but perhaps mainly because of the small size of the treatment site was unable to hold CETs.

The long-term control of EWM targeted with diquat continue to be evaluated on many lakes across Wisconsin. On some lakes, the preliminary results appear promising. As a contact herbicide, diquat does not move (translocate) through plant tissue. Therefore, only the exposed plant material is impacted by the herbicide. Concern exists whether this herbicide has the capacity to kill the entire plant, or simply removes all the above ground biomass and the plant rebounds from unaffected root crowns. Diquat also has a high affinity for binding with organic particles. In shallow waters where the

application equipment creates disturbance of the lake bottom, the diquat being applied will quickly bind to the suspended particles and be instantly unavailable to cause impacts to the target plants.

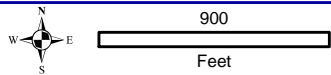
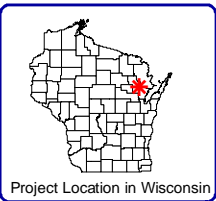
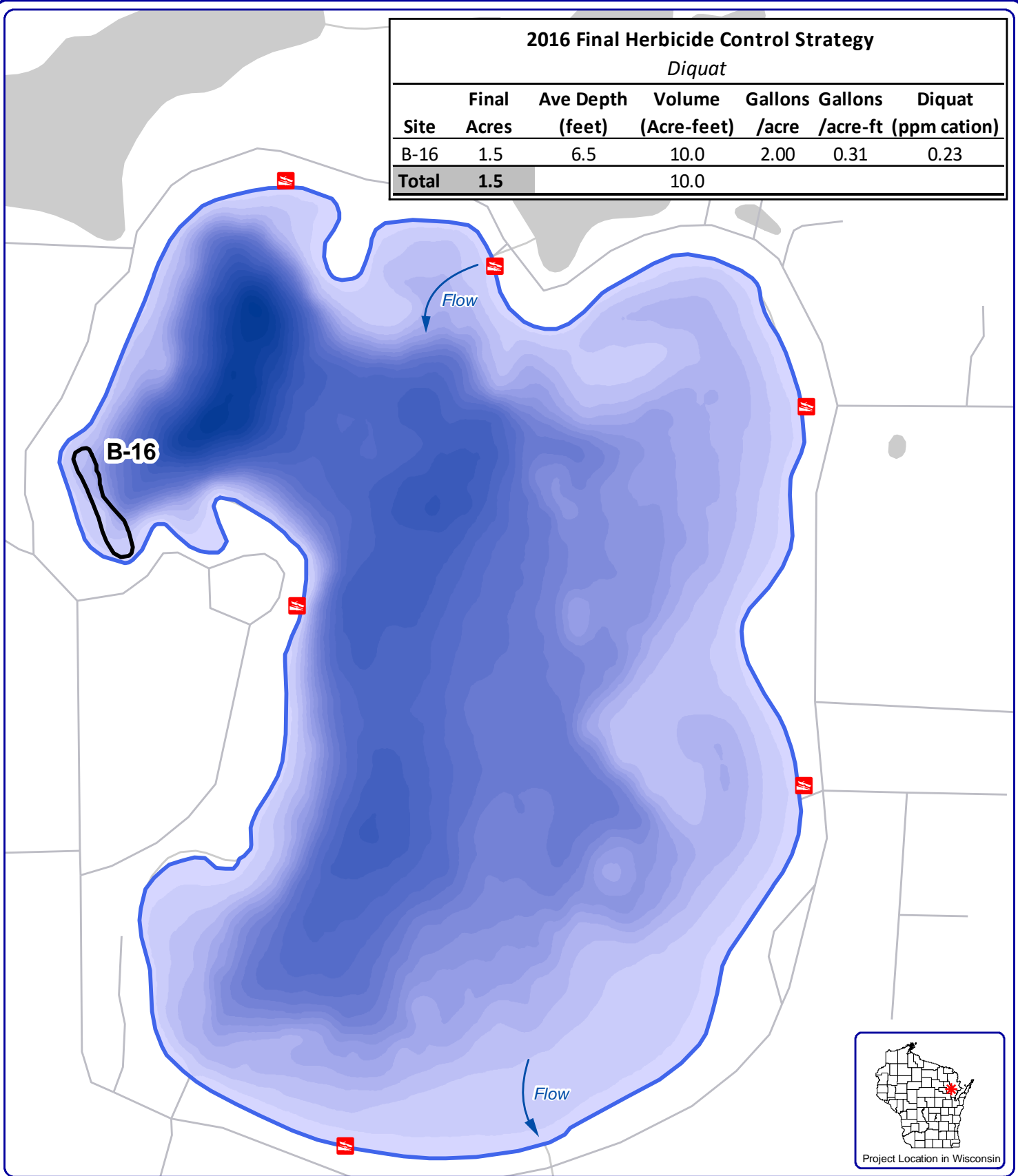
With the increasing EWM population in the area targeted with herbicides in 2016, a 2017 control strategy targeting 5.5 contiguous acres was constructed. Again, this area is in a semi-protected part of the lake and because of its larger size, is preliminarily recommended to be targeted with 2,4-D. Continued discussion with the KLAA, particularly as the development of a Comprehensive Lake Management Plan soon gets underway, regarding the 2017 herbicide strategy may result in an evolved strategy being formulated.

Overall, the control activities conducted on Kelly Lake to date have helped maintain a low EWM population level. However, the EWM population continues to slowly trend towards the population level before the wider-scale herbicide treatment took place during the spring of 2013. At current time, the low EWM population in Kelly Lake is not likely causing detectable ecological impacts within the lake. However, riparians have expressed concerns that their enjoyment of the lake has been reduced because the EWM has increased in density in some areas to levels that can limit recreation and navigation abilities.

2016 Final Herbicide Control Strategy

Diquat


Site	Final Acres	Ave Depth (feet)	Volume (Acre-feet)	Gallons /acre	Gallons /acre-ft	Diquat (ppm cation)
B-16	1.5	6.5	10.0	2.00	0.31	0.23
Total	1.5		10.0			



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Sources:
 Roads and Hyrdo: WDNR
 Bathymetry: WDNR - digitized by Onterra
 Orthophotography: NAIP, 2015
 Plant Survey: Onterra, 2016
 Map Date: December 30, 2016
 Filename: Map1_KelbyOonto_EWM_T2016Perm1.mxd

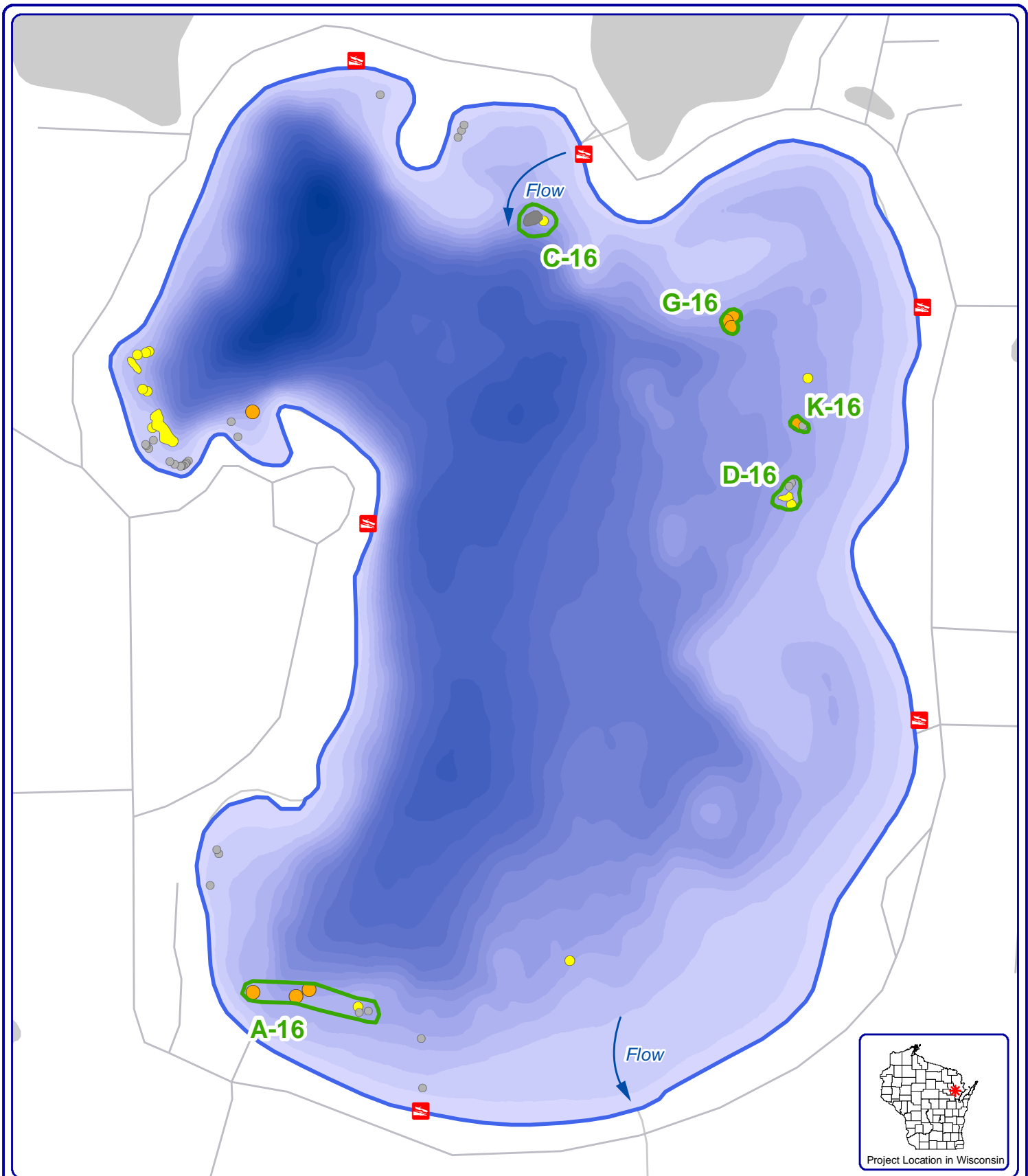
Legend

 2016 Final Herbicide Treatment Area

Map 1

Kelly Lake
 Oconto County, Wisconsin

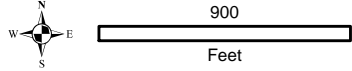
**Final 2016 EWM
 Herbicide Control Strategy**



Legend

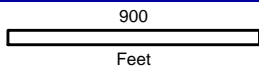
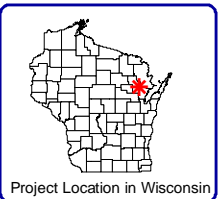
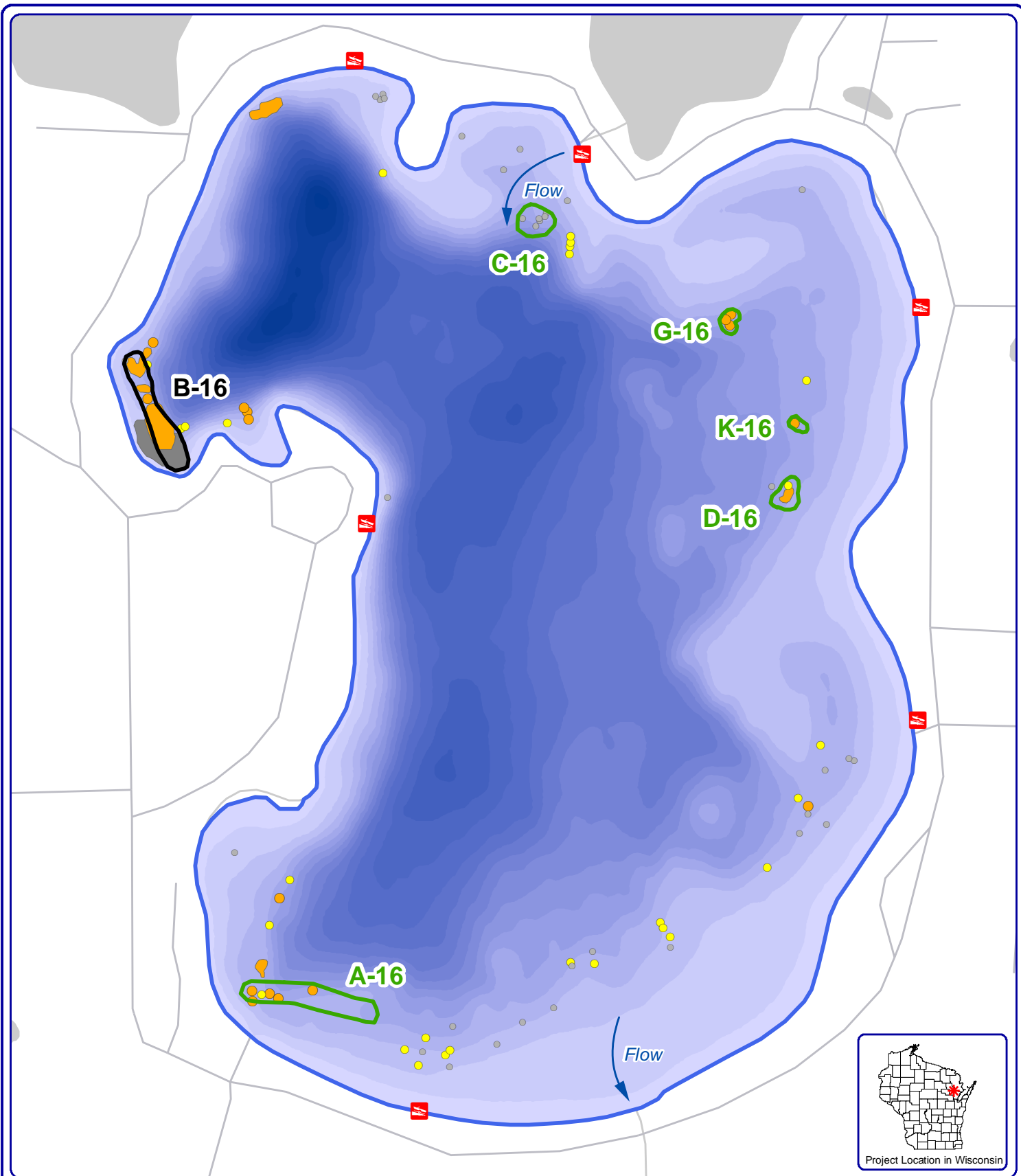
- Highly Scattered (*none*)
- Scattered
- Dominant
- Highly Dominant (*none*)
- Surface Matting (*none*)
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2016 Professional Hand Harvest Areas

Sources:
 Roads and Hydrd: WDNR
 Bathymetry: WDNR - digitized by Onterra
 Orthophotography: NAIP, 2015
 Plant Survey: Onterra, 2016
 Map Date: December 30, 2016
 Filename: Map2_KelyOconto_EWM_June16.mxd



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Map 2
 Kelly Lake
 Oconto County, Wisconsin
**June 2016 EWM
 Survey Results**



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Sources:
Roads and Hydr: WDNR
Bathymetry: WDNR - digitized by Onterra
Orthophotography: NALP, 2015
Plant Survey: Onterra, 2016
Map Date: December 30, 2016
Filename: Map3_KellyOconto_EWMPB_Aug16.mxd

- Highly Scattered (*none*)
- Scattered
- Dominant (*none*)
- Highly Dominant
- Surface Matting (*none*)

Legend

- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2016 Professional Hand Harvest Areas
- 2016 Herbicide Treatment Area

Map 3
Kelly Lake
Oconto County, Wisconsin
August 2016
EWM Survey
Results

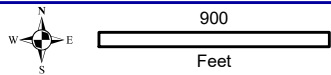
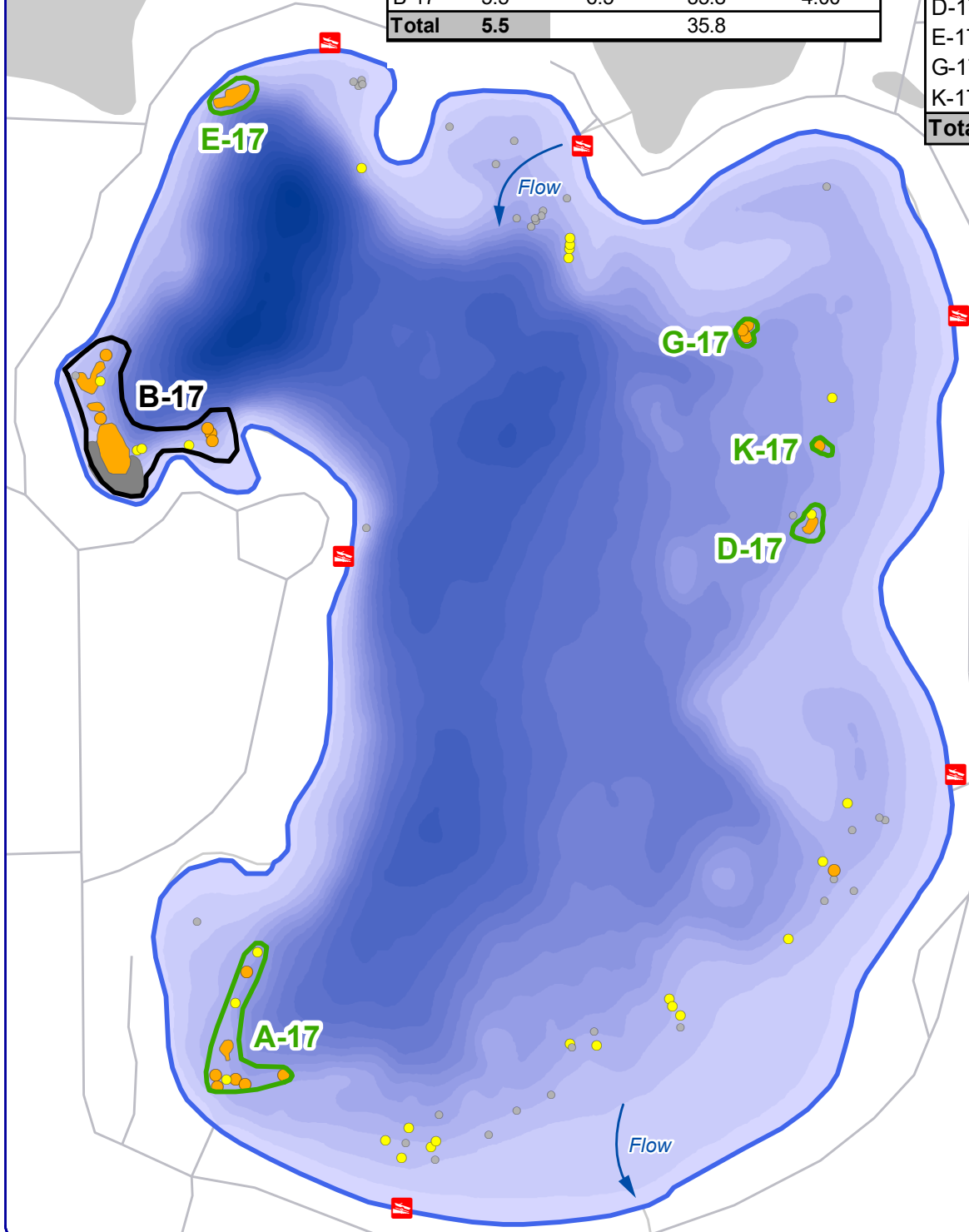
2017 Proposed Control Strategy

Liquid 2,4-D

Site	Proposed Acres	Ave Depth (feet)	Volume (Acre-feet)	2,4-D PPM ae
B-17	5.5	6.5	35.8	4.00
Total	5.5		35.8	

Hand-Harvest Work Zones

Site	Proposed Acres	Ave Depth (feet)
A-17	2.40	7.5
D-17	0.40	9.0
E-17	0.58	9.0
G-17	0.22	10.0
K-17	0.12	9.0
Total	3.72	



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Sources:
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 Bathymetry: WDNR - digitized by Onterra
 Orthophotography: NAIP, 2015
 Plant Surveys: Onterra, 2016
 Map Date: December 30, 2016
 Filename: Map4_KellyOconto_EWM_T2017Prelim1.mxd

- Legend**
- Highly Scattered (*none*)
 - Scattered
 - Dominant (*none*)
 - Highly Dominant
 - Surface Matting (*none*)
 - Single or Few Plants
 - Clumps of Plants
 - Small Plant Colony
 - 2017 Proposed Hand Harvest Areas
 - 2017 Proposed Herbicide Treatment Area

Map 4
 Kelly Lake
 Oconto County, Wisconsin
Proposed EWM Control Strategy