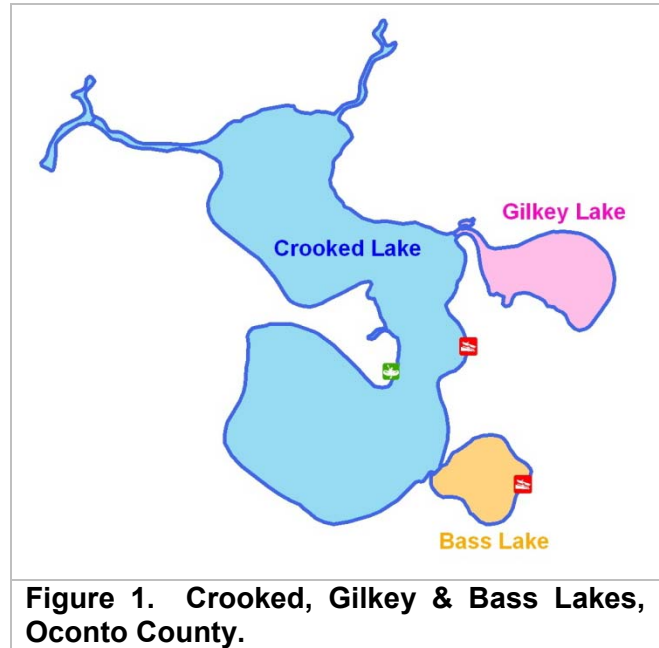


INTRODUCTION

Crooked Lake, Oconto County, is an approximate 143-acre drainage lake with a reported maximum depth of 37 feet. Gilkey and Bass Lakes, 20 and 12 acres, respectively, are smaller seepage lakes directly connected and flowing into to Crooked Lake. Gilkey Lake has a reported maximum depth of six feet and flows into Crooked Lake's northeast side, while Bass Lake has a reported maximum depth of 11 feet and is connected to Crooked Lake via a small channel on the lake's southeast side. Eurasian water milfoil (*Myriophyllum spicatum*; EWM) was first documented from Crooked, Gilkey, and Bass Lakes in 2002. Since 2008, the Crooked Lake Protection & Rehabilitation District (CLPRD) has been actively managing the EWM population through strategically targeted herbicide applications and volunteer based hand harvesting removal efforts. Curly-leaf pondweed (*Potamogeton crispus*), another non-native exotic plant species commonly found in Wisconsin, was discovered within Crooked Lake in 2014. Volunteer based efforts have been made to hand-remove the small, localized population.

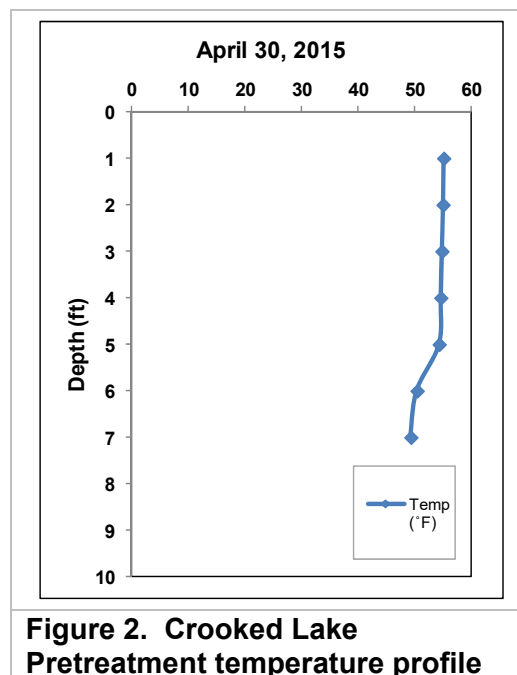


Following effective control of EWM within Bass Lake in 2014, Onterra ecologists located low-density occurrences of EWM consisting of *clumps of plants, single or few plants* and *small plant colonies* during the late summer of 2014 within the Crooked Lake system (Map 1). While herbicide control of EWM was not proposed to occur in Bass or Gilkey Lakes in 2015, a small area totaling 2.4 acres, targeting the largest known EWM population in Crooked Lake was recommended for herbicide control in 2015 (Map 1). This location was targeted for control with herbicides almost every year since 2012 with only marginal success. The 2015 strategy was to target this location with a combination of liquid 2,4-D at the maximum application rate of 4.0 ppm ae and liquid endothall at a rate of 1.5 ppm ae. An additive or a synergistic advantage is theorized when combining 2,4-D and endothall. 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).

In addition to the 2.4-acre herbicide application area, several other known areas of EWM in portions of Crooked Lake and Bass Lakes were recommended for control through the use of professional hand-harvesting efforts. These locations identified in 2014 would be refined during an early summer 2015 survey from which the final hand-harvesting strategy would be determined. The CLP levels observed in 2014 consisted of point-based occurrences and it was recommended that these relatively small known areas of CLP be targeted for removal through a volunteer based effort during 2015. This report discusses the aquatic invasive species (AIS) monitoring and control activities conducted in 2015.

PRETREATMENT CONFIRMATION AND REFINEMENT SURVEY

On April 30, 2015, Onterra staff conducted the EWM Spring Pretreatment Confirmation and Refinement Survey on the Crooked Lake system. During this survey, the proposed herbicide control site within Crooked Lake was visited. A temperature profile collected in Crooked Lake indicated the lake was weakly stratified with water temperatures in the mid to low 50's°F (Figure 2). Sufficient EWM warranting treatment was confirmed in the originally proposed treatment area. The EWM was visible from the surface in the proposed herbicide treatment area and was observed to still be brown but had actively growing, green tips. Native plant growth was observed to be minimal, being mostly comprised of fern-leaf pondweed. No alterations of the herbicide treatment area were made. Given the water temperature and growth stage of EWM, Onterra recommended that the treatment delay for a short period to allow for more active growth in the EWM which would allow for sufficient herbicide uptake.



The 2,4-D and endothall spot treatment was conducted by Schmidt's Aquatic Plant Control on May 9, 2015. The applicator reported 5 mph winds out of the northwest during the application and a near surface water temperature of 64°F.

EARLY SEASON AIS SURVEY (ESAIS)

On June 4, 2015, Onterra ecologists completed the Early-Season AIS Survey on the Crooked Lake system. This is a meander-based survey of the littoral areas of the lakes designed to locate and map occurrences of non-native plants. While EWM is usually not at its peak growth at this time of year, the water is typically clearer during the early summer allowing for more effective viewing of submersed plants, and EWM is often growing higher in the water column than many of the native aquatic plants at that time of year. The EWM mapped during the Early-Season AIS Survey is refined during the Late-Summer Peak-Biomass survey. In addition, the locations of EWM occurrences located during early summer were used to finalize the hand-harvesting control strategy and were then provided to the professional hand-harvesting firm to aid in their hand-removal efforts (Map 2). Please note that while EWM was not located in the area where the herbicide treatment took place approximately one month earlier (Map 1), an insufficient amount of time passed to allow for an evaluation of the treatment's efficacy.

In addition to mapping EWM during the Early-Season AIS Survey, ecologists are also looking for potential occurrences of other non-native aquatic plants. One in particular, curly-leaf pondweed (*Potamogeton crispus*; CLP) is at or near its peak growth in early summer before naturally senescing (dying back) in mid-summer, making early summer the most probable time to locate this species. Onterra ecologists located several CLP occurrences in the approximate area in which it was documented in 2014 in the eastern portion of Crooked Lake during the June 2015 survey (Map 2). Volunteers from the CLPRD were provided GPS locations to aid in hand-removing these plants.

HAND HARVESTING CONTROL ACTIVITIES

The CLPRD hired Lake and Pond Solutions Co. to professionally hand-harvest EWM in 2015. Lake and Pond Solutions utilizes Diver Assisted Suction Harvest (DASH) allowing for EWM to be suctioned out of the lake creating minimal fragmentation and spread of the plant. The DASH system is considered a form of mechanical harvesting and thus requires a WDNR permit prior to being implemented. On July 28, 2015, Lake and Pond Solutions harvested a total of 28 pounds of EWM from Crooked and Bass Lakes over the course of 14 combined diver hours (Photo 2). Following completion of removal efforts in the designated sites, some amount of time was dedicated towards searching for additional EWM occurrences in the lake and this time is included in the 14 total diver hours. Details of the hand-harvesting efforts as reported by Lake and Pond Solutions are included as appendix to this report (Appendix A).



Photo 2. DASH Operation on Crooked Lake, Oconto County. Photos provided by the CLPRD.

Volunteer based removal efforts targeting CLP were conducted on two occasions during 2015 by volunteers from the CLPRD. During an early-June visit, they located and removed CLP within the area marked during Onterra's ESAIS Survey. CLP was not located during the second visit, either because it escaped detection or had started to senesce (die-back) for the season.

AIS CONTROL EFFICACY

Herbicide Treatment Results

The late-summer EWM Peak-Biomass Survey was conducted on Crooked Lake on September 3, 2015 to qualitatively assess the herbicide treatment and hand-harvesting areas as well as to understand the peak growth (peak biomass) of the EWM population throughout the vegetated area of the lakes. The spot treatment on Crooked Lake achieved short-term success with no EWM plants being located in the site following the treatment (Figure 3). Additional surveys in 2016 will allow a better understanding as to whether the EWM plants were completely controlled or will rebound from the seasonal control that was observed.

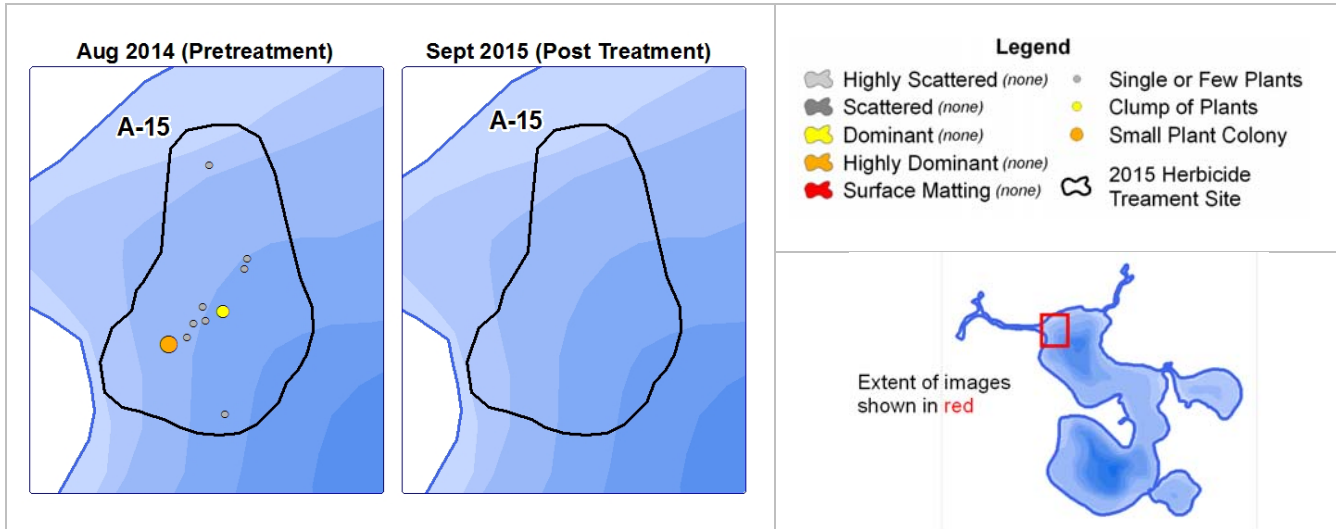


Figure 3. August 2014 Pre- and September 2015 Post Herbicide Treatment Survey Results for Site A-15 in Crooked Lake.

Professional Hand Harvesting Results

A total of 28 pounds of EWM was removed during Lake and Pond Solutions visit to Crooked Lake. A single plant was reportedly removed from site X-15 in Bass Lake and no EWM was located in the site during the post-harvesting survey (Figure 4). Efforts to remove EWM from site W-15 in Bass Lake resulted in approximately 20 plants being harvested. Only one *single or few plants* occurrence was found in the site following hand-harvesting efforts (Figure 4). Hand removal efforts within sites X-15 and W-15 in Bass Lake resulted in successful control in 2015.

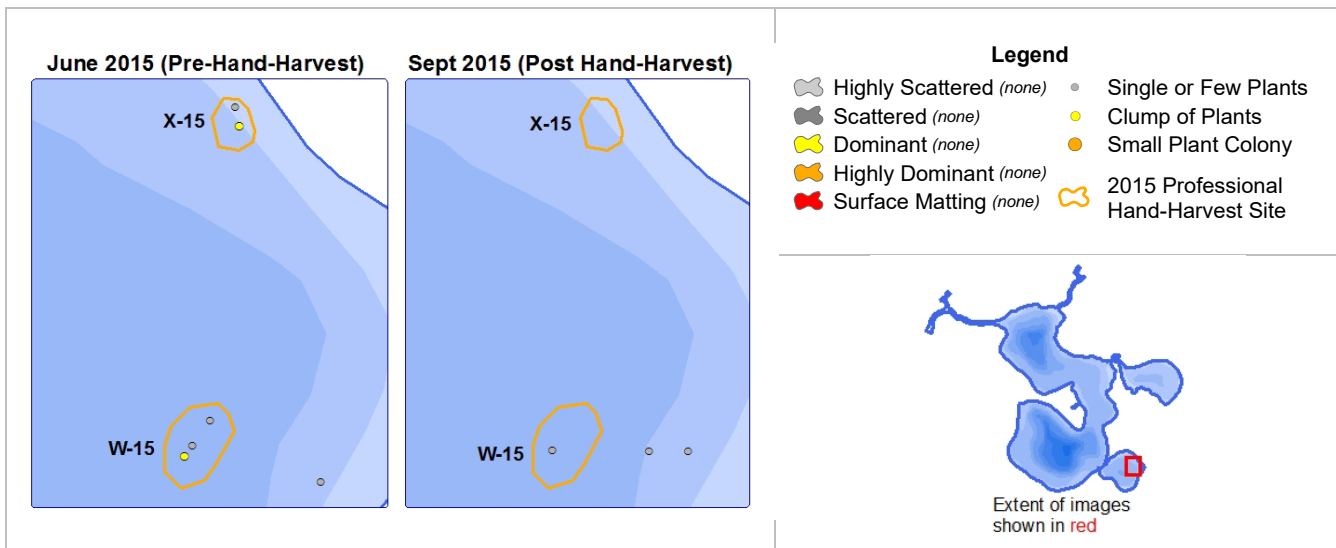


Figure 4. Bass Lake June 2015 Pre- and September 2015 Post Hand-Harvest Survey Results.

The majority of the EWM harvest from the DASH operation came from site Z-15 in Crooked Lake. The post hand-harvesting survey indicated that the EWM within site Z-15 had been reduced from a number of *small plant colonies*, *clumps of plants* and *single or few plants* before harvesting to only one *single or few plants* occurrence after the removal efforts (Figure 5). Prior to hand-harvesting, a *clump of plants* was mapped within site Y-15 in Crooked Lake. Following removal efforts, no EWM was

found inside the extents of the site Y-15, however, another *clump of plants* was located just north of the site (Figure 5). Hand removal efforts within sites Z-15 and Y-15 in Crooked Lake led to successful control in 2015 and should be monitored in the following years for signs of re-growth or re-colonization of EWM within the sites.

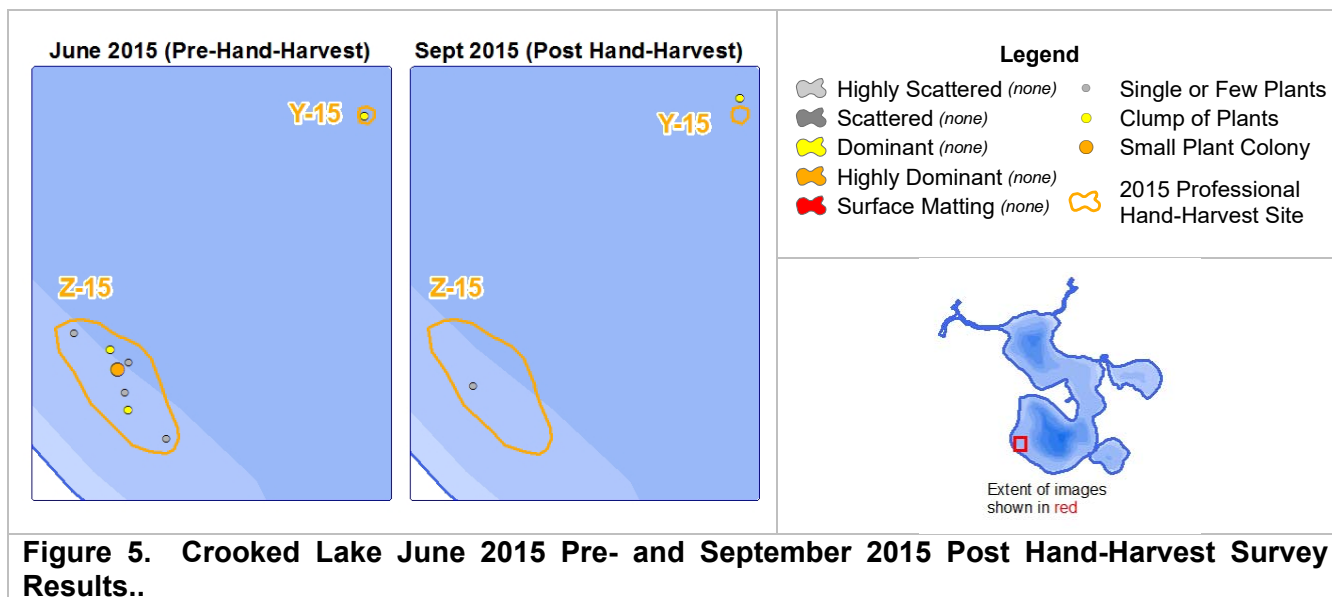


Figure 5. Crooked Lake June 2015 Pre- and September 2015 Post Hand-Harvest Survey Results..

2015 EWM PEAK BIO-MASS SURVEY RESULTS

Following the control efforts conducted in 2015, only a relatively small amount of low density EWM occurrences were located during the late summer survey. Two *single or few plants* were located in Gilkey Lake, a handful of *single or few plants* were located in Bass Lake, and only one *clump of plants* and a few *single or few plant* occurrences were located in Crooked Lake (Map 3). Overall, the 2015 EWM population within this system was at a very low level. Local observations noted by some lake residents indicated a reduction of EWM may have occurred over the early part of the growing season. Plant communities are subject to inter-annual population changes driven largely by environmental factors. Numerous lakes in northern Wisconsin were observed to have a suppressed EWM population in 2015 and it is possible that environmental conditions affecting EWM growth in Crooked Lake may have contributed to the low EWM populations observed later in the growing season.

CONCLUSIONS & DISCUSSION

Overall, the EWM control efforts in Crooked Lake were successful with reductions of EWM being evident in both the herbicide control and hand-harvesting control sites. The late summer 2015 survey indicated that EWM continues exists at low levels in the Crooked Lake system. The CLP population in Crooked Lake was found to be slightly more than was observed in 2014, although is still considered relatively small. In certain lakes, CLP can become so abundant that it hampers recreational activities within the lake. In instances where large CLP populations are present, its mid-summer die-back can cause significant algal blooms spurred from the release of nutrients during the plants' decomposition. However, in some lakes, mostly in northern Wisconsin, CLP appears to integrate itself within the community without becoming a nuisance. While it is not known how CLP will react in Crooked Lake, it is recommended that the known plant occurrences be monitored in 2016 and considered for hand-removal through either a professional or volunteer based effort. The hand-harvesting should occur as

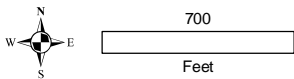
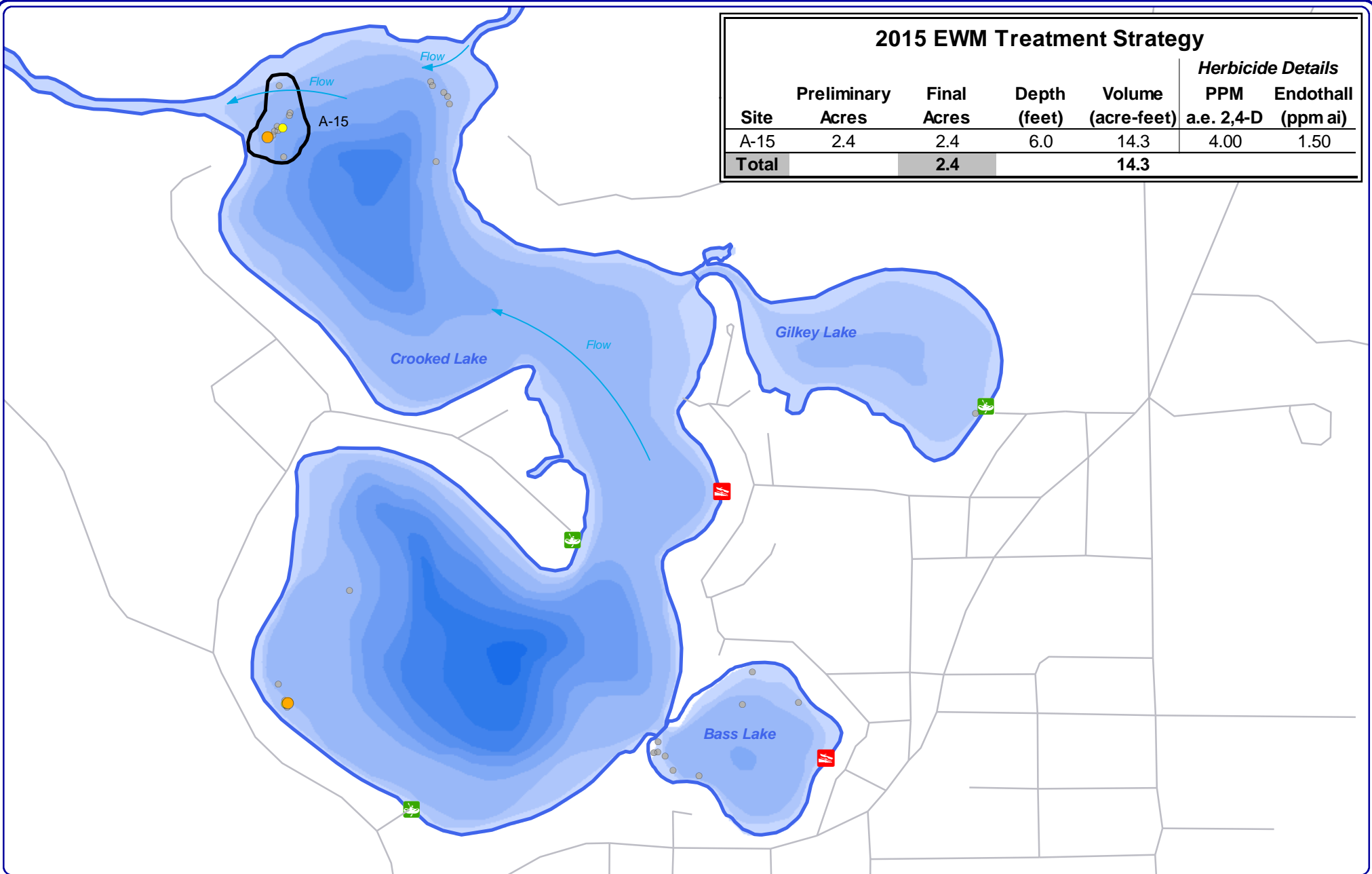
early as possible so that the plants can be removed before they are able to produce and deposit their reproductive structures (turions). Continued monitoring of these areas following hand-removal will be required to determine if these efforts were effective and if CLP has since spread to other areas of these lakes.

With the current low EWM and CLP populations in Crooked Lake, no herbicide control methods are warranted at this time. It is recommended that both the CLP and EWM populations be monitored in 2016 through a June ESAIS survey and a late summer EWM Peak-Biomass Survey. With no herbicide treatment being recommended for 2016, it is proposed that Onterra conduct the 2016 ESAIS Survey as early in the seasonal spectrum as possible (i.e. late-May or early-June), to maintain ample opportunity within the summer growing season to conduct the hand-harvesting activities if warranted.

The CLPRD has recently been awarded an, AIS-Education, Prevention, & Planning Grant from the WDNR that after two years of lake monitoring and stakeholder education/input, will result in an updated Comprehensive Lake Management Plan for the system. The management planning process will result in the creation of a long-term strategy to address all matters of concern, not just the presence of EWM and CLP. It would include assessments of the water quality, watershed, shoreline condition, fisheries, native aquatic plant communities, and stakeholder perceptions on the lake. An important component of this process will allow the CLPRD to objectively review their ongoing EWM management activities, outline appropriate thresholds of when specific control strategies warrant implementation, and establish measureable success criteria standards to monitor future control strategies.

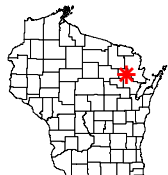
2015 EWM Treatment Strategy

Site	Preliminary Acres	Final Acres	Depth (feet)	Volume (acre-feet)	Herbicide Details	
					PPM a.e. 2,4-D	Endothall (ppm ai)
A-15	2.4	2.4	6.0	14.3	4.00	1.50
Total		2.4		14.3		



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Sources:
 Roads and Hydro: WDNR
 Aquatic Plants: Onterra, 2014
 Map Date: December 30, 2015
 File Name: Crooked_2014PB_T2015.mxd



Project Location in Wisconsin

Legend

- Highly Scattered (none found)
- Scattered (none found)
- Dominant (none found)
- Highly Dominant (none found)
- Surface Matting (none found)
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- 2015 Final Herbicide Treatment Site

Map 1
 Crooked Lake
 Oconto County, Wisconsin
**August 2014 EWM
 Survey Results & Final
 2015 Treatment Areas**

2015 Final Control Strategy
Professional Hand-Harvest (DASH)

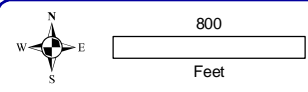
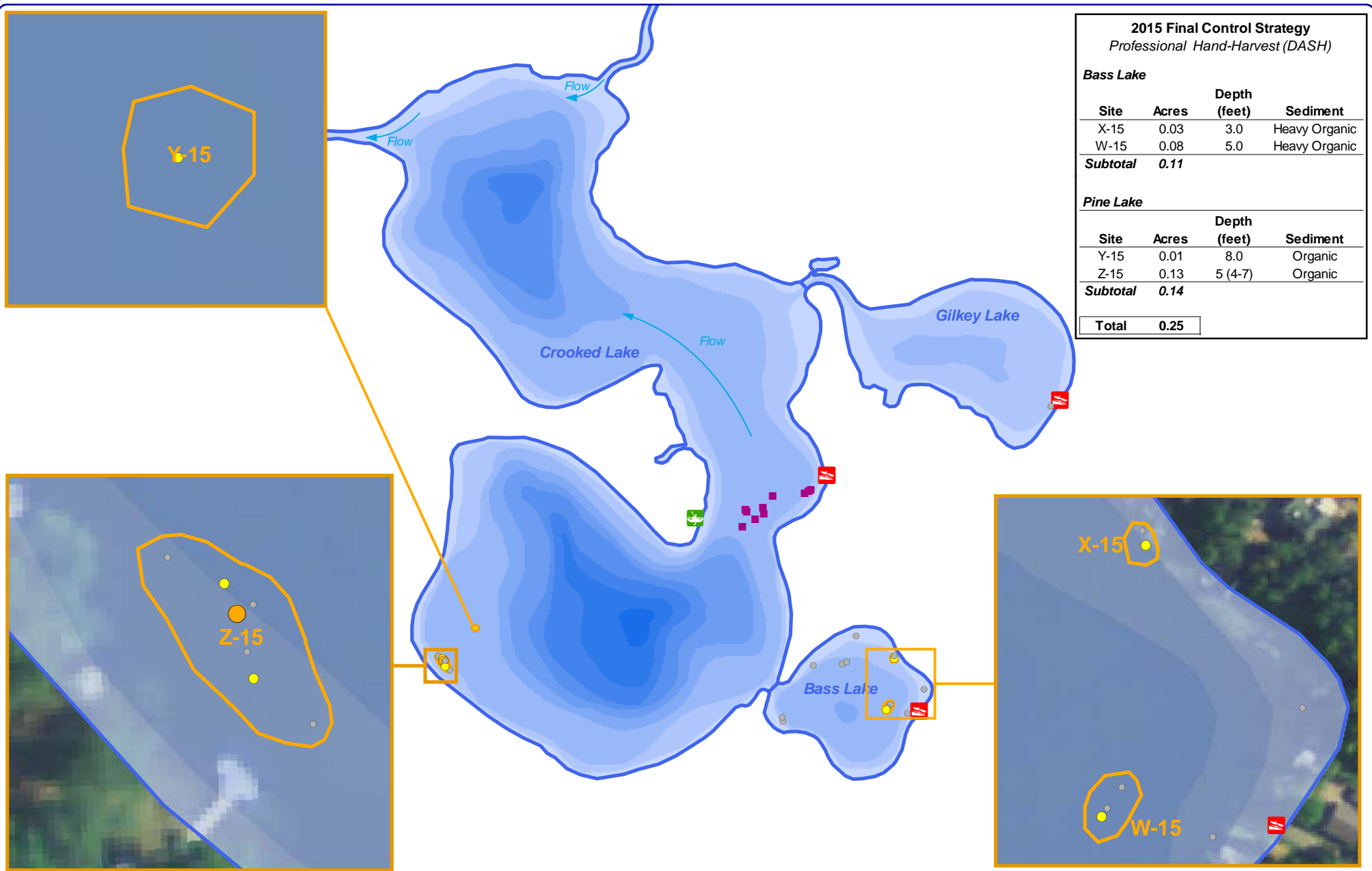
Bass Lake

Site	Acres	Depth (feet)	Sediment
X-15	0.03	3.0	Heavy Organic
W-15	0.08	5.0	Heavy Organic
Subtotal	0.11		

Pine Lake

Site	Acres	Depth (feet)	Sediment
Y-15	0.01	8.0	Organic
Z-15	0.13	5 (4-7)	Organic
Subtotal	0.14		

Total	0.25
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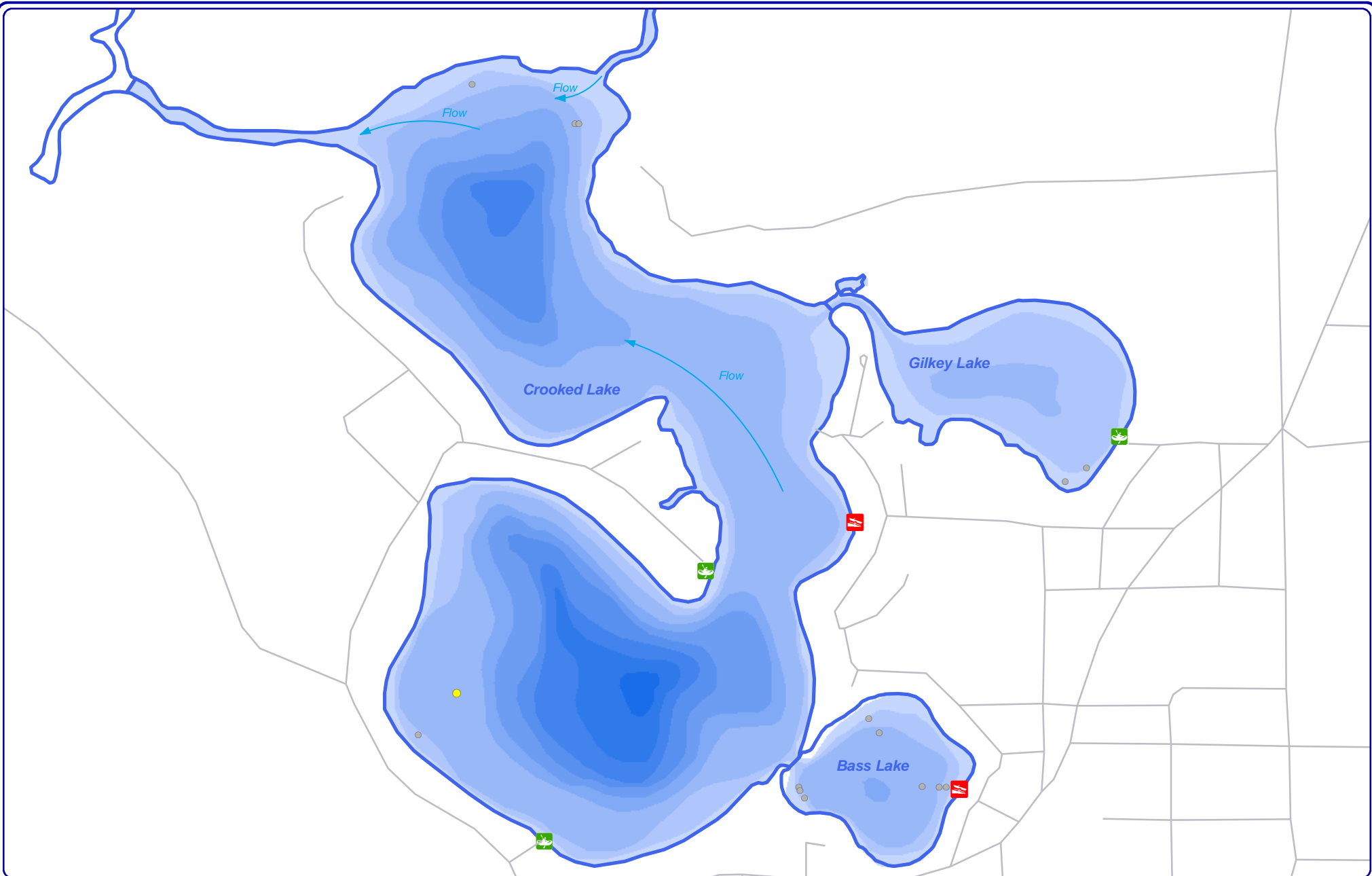
Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plants: Onterra, June 2015
Map Date: June 22, 2015
File Name: Crooked_EWM_HH_2015Perm1.mxd



Legend

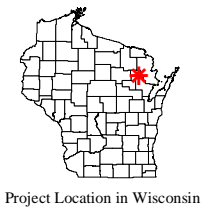
- Highly Scattered (none found)
- Scattered (none found)
- Dominant (none found)
- Highly Dominant (none found)
- Surface Matting (none found)
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- CLP Occurrence
- Final 2015 Professional Hand-Harvesting Location

Map 2
Crooked Lake System
Oconto County, Wisconsin
June 2015 EWM & CLP
Survey Results & Final 2015
Hand-Harvest Strategy



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Sources:
 Roads and Hydro: WDNR
 Aquatic Plants: Onterra, 2015
 Map Date: December 30, 2015
 File Name: Crooked_EWMPB_Aug15.mxd



Legend

- Highly Scattered (none found)
- Scattered (none found)
- Dominant (none found)
- Highly Dominant (none found)
- Surface Matting (none found)
- Single or Few Plants
- Clump of Plants
- Small Plant Colony (none found)

Map 3
 Crooked Lake
 Oconto County, Wisconsin
**September 2015 EWM
 Survey Results**