INTRODUCTION

In 2009, studies were completed by Onterra on the Phillips Chain of Lakes as part of a Wisconsin Department of Natural Resources (WNDR) funded lake management planning project that was initiated by the Phillips Chain of Lakes Association (PCOLA). These studies revealed that Eurasian water milfoil (EWM) was present within all four lakes of the Phillips Chain. Because the EWM infestation on the Phillips Chain of Lakes threatens the diverse, high quality native aquatic plant community and interferes with recreational activities, the Phillips Chain of Lakes Comprehensive Management Plan (June 2011) contains, amongst others, a goal to: *Control Existing and Prevent Further AIS Infestations within the Phillips Chain of Lakes*. The PCOLA took the first step in this process by successfully applying for a WDNR Aquatic Invasive Species (AIS) Education, Prevention, and Planning Grant to complete a chain-wide assessment of EWM in 2011 and develop potential control strategies for 2012. Subsequently, the PCOLA successfully received a one-year WDNR AIS Established Population Control Grant to carry out the control strategy in 2012. This report discusses the EWM control strategies initiated in 2012 on the Phillips Chain of Lakes.

Following the 2011 assessment of EWM (peak-biomass survey), conditional treatment permit maps were created proposing approximately 111 acres of treatment within Wilson Lake, 6.3 acres of treatment Duroy Lake, and 17.4 acres in Long Lake in 2012 (Map 1 and Map 2). All of the 2012 treatment sites were proposed to be treated with liquid 2,4-D; however, utilizing two different use strategies: 1) whole-lake treatments and 2) spot treatments.

Whole-lake treatments are those where the herbicide is applied to specific areas within the lake, but when the herbicide disperses and reaches equilibrium within the entire 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 the entire lake or basin. The application rate of whole-lake treatments is dictated by the volume of water in which the herbicide will reach equilibrium with. The target herbicide concentration is typically between 0.250 and 0.350 ppm acid equivalent (ae) when exposed to the target plants for 7-14 days or longer. However, these same rates have been shown to impact some native aquatic plant species, particularly dicot species, some narrow-leaf pondweeds, and naiad species. Whole-lake treatments are conducted on lakes where the target plant is widespread and abundant throughout the system.

Spot treatments are a type of control strategy utilized to target specific areas of the lake and not cause effects on a lake-wide or basin-wide level. The herbicide is applied to a specific area of the lake (treatment site) such that when it dilutes from that area its concentration is insufficient to cause significant effects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are typically applied at a much higher herbicide concentration rate than whole-lake treatments. For EWM, 2,4-D is typically applied between 2.0 and 4.0 ppm ae in spot-treatment scenarios.

Because the 2009 surveys showed that EWM was widespread and dominant throughout much of Wilson Lake, it was believed the only realistic option for control was to utilize the whole-lake treatment strategy. However, because of the rate of water flow through the system (residence time of 73 days), concerns were raised as to whether or not the herbicide would have sufficient concentration/exposure time to cause EWM mortality. To determine if herbicide treatments would be effective on Wilson Lake, three spatially targeted spot treatments totaling 9.6 acres were applied with liquid 2,4-D at a rate of 2.5 ppm acid equivalent (ae) in 2011. These spot treatment areas were met with great success and a whole-lake treatment strategy was proposed for Wilson Lake in 2012.

Unlike Wilson Lake, EWM is more isolated in Duroy and Long Lakes due to sediment and depth limitations, and a spot-treatment strategy was proposed for these lakes in 2012 to target only specific areas of the lake containing areas of dominant or greater EWM. Also, the water exchange rate in Duroy and Long Lakes (residence time of 22 days) is much greater than in Wilson Lake

With the very early ice-out in 2012, Onterra ecologists visited Wilson Lake on March 30, 2012 to assess the growth stage of EWM. While the plants were not visible from the surface, plants brought up with a rake exhibited approximately 8 to 10 inches of new, green growth. Water temperatures were still cool at around 47°F, and the growth of the EWM indicated that another three weeks or so of growth could be allowed before initiating the treatment. Onterra ecologists returned on April 20, 2012 to survey the proposed treatment areas in Wilson, Duroy, and Long Lakes and refine their boundaries as appropriate. None of the treatment areas needed refinement as their extents were unchanged from what was delineated in 2011. The EWM was observed to be actively growing at this time, with many plants exceeding one foot in length.

Temperature, dissolved oxygen, and pH profiles were recorded within each lake during this survey and show that all three lakes were not stratified and had sufficient dissolved oxygen throughout the entire water column (Figure 1). Water temperatures near the surface ranged from 47°F in Duroy Lake to 49°F in Wilson Lake. Dissolved oxygen was also similar between all three lakes ranging from 10.8 mg/L near the surface of Duroy to 10.1 mg/L in Wilson.

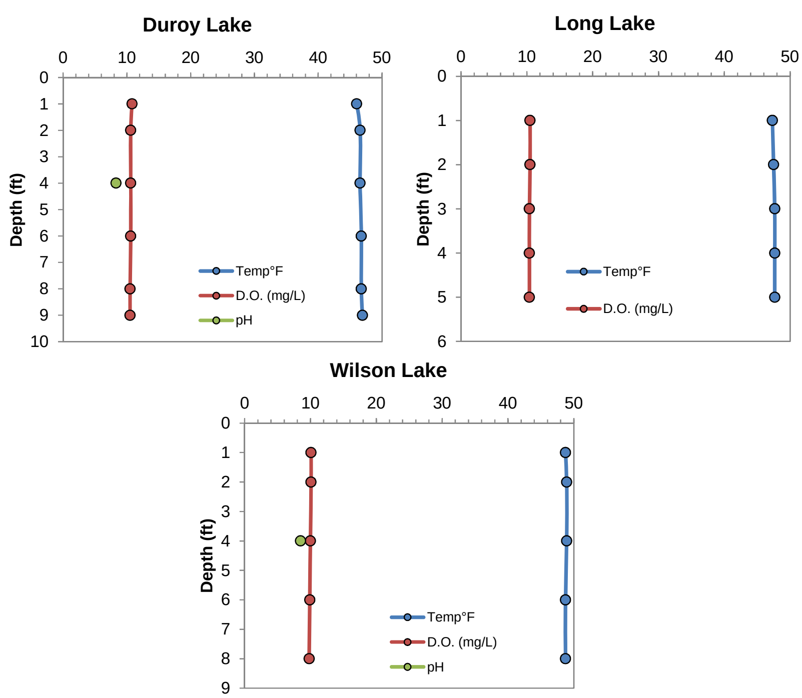

Figure 1. Temperature, dissolved oxygen, and pH profiles from April 20, 2012 pre-treatment surveys on Duroy, Long, and Wilson Lakes.

While the intent of the 2012 treatment on Wilson Lake was to control EWM on a lake-wide level, the spot-treatments on Duroy and Long Lakes were only intended to affect the specific areas to which they were applied. Although herbicide degradation may occur before the herbicide reached equilibrium with the entire volume of Duroy and Long Lakes, these concentrations were calculated prior to treatment to understand if there was a potential for unintended lake-wide herbicide impacts form the 2012 treatments. The calculations indicate that lake-wide 2,4-D concentrations would be approximately 0.034 in Duroy Lake and 0.049 in Long Lake if the herbicide from the treatment areas dissipated evenly throughout the entire volume of the lake prior to degradation, far below levels that would impact aquatic plants on a lake-wide basis.

The 2012 final treatment areas in Wilson Lake were treated by Stantec, Inc. on April 24, 2012. Treatment sites A-12, B-12, and C-12 were treated at 1.7, 1.0, and 1.0 ppm ae with liquid 2,4-D (DMA IV), respectively in order to reach a lake-wide concentration of 0.331 ppm ae The applicator reported ambient air temperatures of 45°F and north-northwest winds at approximately five miles per hour at the time of application. Stantec, Inc. also treated sites within Duroy and Long Lakes and April 25, 2012 with liquid 2,4-D (DMA IV) at a rate of 3.0 ppm ae The applicator reported ambient air temperatures of 45°F and a southeast wind of approximately five miles per hour at the time of application.

2012 TREATMENT MONITORING

The goal of an herbicide treatment strategy is to maximize target species (EWM) mortality while minimizing impacts to valuable native aquatic plant species. Monitoring herbicide treatments and defining their success incorporates both quantitative and qualitative methods. As the name suggests, quantitative monitoring involves comparing number data (or quantities) such as plant frequency of occurrence before and after the control strategy is implemented. Qualitative monitoring is completed by comparing visual data such as EWM colony density ratings before and after the treatments.

Because a whole-lake treatment was conducted on Wilson Lake, the whole-lake point-intercept method as described by the WDNR Bureau of Science Services (PUB-SS-1068 2010) was used to complete a quantitative evaluation of the occurrences of EWM and native aquatic plant species in the summer of 2011 prior to the treatment, and in the summer of 2012 following the treatment. Conducting this survey before and after the treatment allows for a statistical comparison of aquatic plant occurrences and a quantitative determination of treatment efficacy on a lake-wide level. Based upon guidance from the WDNR, a point spacing of 78 meters was used resulting in 225 points evenly distributed across the lake (Figure 2). Quantitative assessments of spot-treatments also employ point-intercept methodology, though the sampling locations are only located within the areas being treated and not distributed across the entire lake. While Duroy and Long Lakes had spot-treatments of EWM in 2012, these areas were not quantitatively monitored due to logistical complications between Onterra and the herbicide applicator.

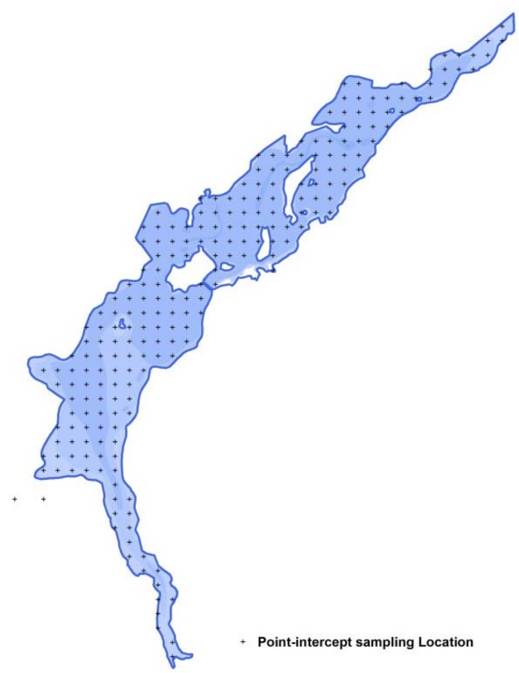

Figure 2. 2011 pre- and 2012 post-treatment point-intercept locations on Wilson Lake.

Quantitatively, a treatment is deemed successful if the point-intercept data show that the EWM frequency of occurrence following the treatment is reduced by at least a statistically valid 50% ($\alpha = 0.05$). Only those points that fell within the maximum depth of plant growth (littoral zone) are used in the analyses.

Qualitative monitoring of herbicide treatments includes comparing spatial data reflecting EWM locations and densities in late-summer prior to and immediately following the treatment when this plant is assumed to be at or near its peak growth. Comparisons of the survey results are used to qualitatively evaluate the 2012 herbicide treatments on the Phillips Chain. Qualitatively, a successful treatment on a particular site would include a reduction of EWM density as demonstrated by a decrease in density rating (e.g. highly dominant to dominant). In terms of a treatment as a whole (lake-wide), at least 75% of the acreage treated that year would decrease be one level of density as described above for an individual site.

Although it is never the intent of the treatments to impact native species, it is important to remember that in spot treatment scenarios like on Duroy and Long Lakes, these non-target impacts can only be considered in the context of the areas treated and not on a lake-wide basis. In other words, the impact of the treatments on a non-target species in the treatment areas cannot be extrapolated to the entire population of that plant within the lake, unless the plant species is only found in locations where the herbicide applications took place. However, on Wilson Lake where the herbicide was expected to dissipate throughout the entire lake and a whole-lake point-intercept survey was conducted, the non-target impacts can be considered on a lake-wide basis.

The 2012 whole-lake treatment on Wilson Lake was selected to participate in an herbicide concentration monitoring project being conducted by the WDNR and USACE. Water samples were collected at seven sites located around the lake both within and outside of herbicide application areas by a Wilson Lake volunteer (Map 1). Two sites just downstream of Wilson Lake in Long Lake were also sampled (Map 1). Samples were collected using a six-foot integrated sampler, and were collected at intervals of 0.25, 1, 2, 3, 5, 7, 10, 14, 21, and 28 days after treatment (DAT). The volunteer also collected temperature profiles at each of the nine sampling locations.

2012 TREATMENT RESULTS

As discussed above, two different treatment strategies were implemented on the Phillips Chain of Lakes in 2012. It is not appropriate to extrapolate the results of a whole-lake treatment strategy to current or future spot treatment strategies, or vice-versa. For clarity, the following section is separated into two sub-sections based upon the type of treatment strategy implemented.

Whole-lake Treatment Strategy – Wilson Lake

On August 21-22, 2012 Onterra ecologists visited Wilson Lake to complete the post-treatment assessment of the 2012 whole-lake treatment. During both the 2011 and 2012 point-intercept surveys, aquatic plants were located growing to a maximum depth of eight feet. Of the 209 point-intercept sampling locations visited in both years, 196 fell within or at the maximum depth of plant growth. Data collected from these 196 littoral sampling locations are used in the following analyses.

Prior to the treatment in the summer of 2011, 23 (11.7%) of the 196 sampling locations in Wilson lake contained EWM. Following the treatment, no EWM was recorded on the rake during the 2012 point-intercept survey, representing a statistically valid reduction in occurrence of 100% (Figure 3) and exceeding the quantitative success criterion (50% reduction in occurrence). While EWM was below detection limits during the 2012 point-intercept survey, it was not completely eradicated from the lake. The 2012 peak-biomass survey revealed that EWM acreage had declined from approximately 69 acres in 2011 to four acres in 2012 (Map 3). The remaining colonized area of EWM was located in the most upstream part of Wilson Lake, likely in an area where water exchange was the greatest, shortening the exposure time of the herbicide. In addition to these four acres of scattered EWM, Onterra ecologists also located a number of single plants, a few clumps of plants, and one small plant colony following the 2012 treatment (Map 3).

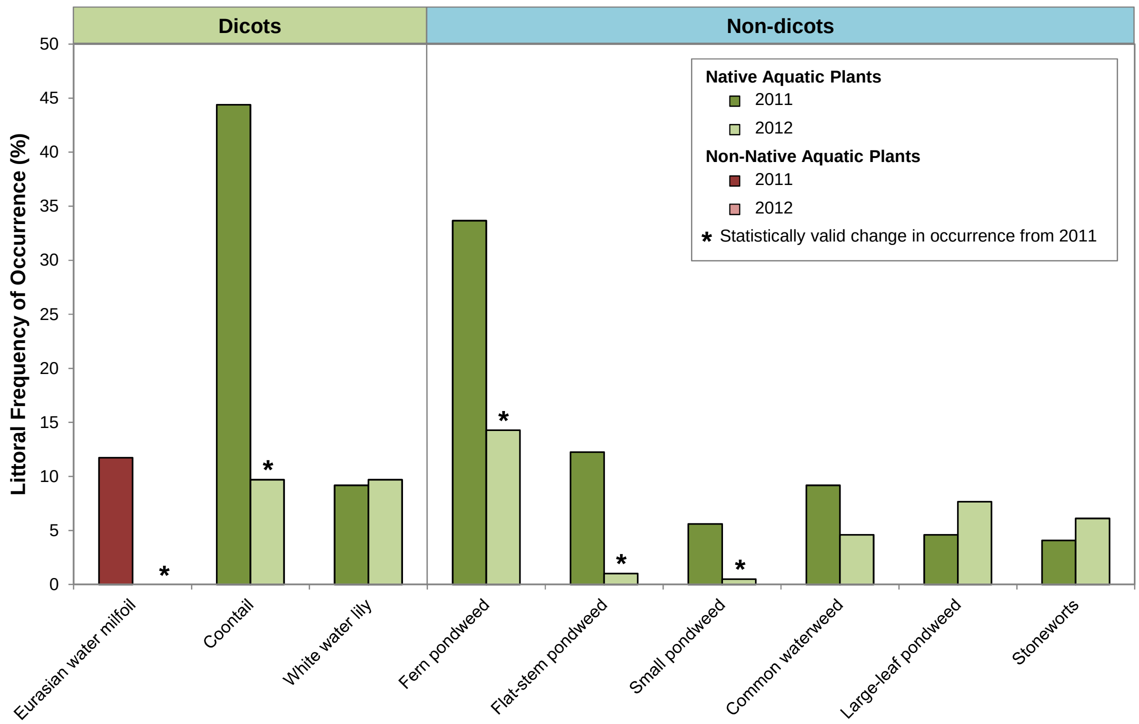

Figure 3. 2011 pre- and 2012 post-treatment littoral occurrence of aquatic plant species within Wilson Lake. Only those species with >5% littoral occurrence in either year are displayed. Created using data from 2011 and 2012 point-intercept surveys.

Data concerning native aquatic plant species were also collected at the same 196 point-intercept sampling locations during the summers of 2011 and 2012. Statistical analyses are only performed on those species that had a littoral occurrence of greater than 5% in at least one of the surveys. Figure 3 displays the littoral occurrence of these aquatic plants and illustrates that four native species (coontail, fern pondweed, flat-stem pondweed, and small pondweed) experienced statistically valid reductions in occurrence following the 2012 treatment. Coontail, like EWM, is a dicot and is susceptible to decline following an herbicide application. However, fern pondweed, flat-stem pondweed, and small pondweed are all monocots which were historically not thought to be particularly sensitive to dicot-selective herbicides like 2,4-D. Data gathered from Wilson Lake and other Wisconsin lakes with similar large-scale treatments since 2010 indicate that some of these plants are prone to decline following a long exposure, low-dose whole-lake treatment. While white water lily, large-leaf pondweed, and stoneworts had slightly higher occurrences in 2012 than in 2011, these increases were not statistically valid (Figure 3).

Table 1 provides a list of the aquatic plant species located in Wilson Lake during the 2011 and 2012 point-intercept surveys. During this timeframe, the native species richness of Wilson Lake declined from 25 to 18 species. It is important to note that only species found at low frequencies were those located in 2011 and not 2012, likely not demonstrating that the species was extirpated as a result of the treatment but continues to exist at levels undetected by the point-intercept survey methodology.

Table 1. Aquatic plant species located in Wilson Lake during 2011 pre- and 2012 post-treatment point-intercept surveys.

Life Form	Scientifc Name	Common Name	Coefficient of Conservatism (C)	2011 FOO *(Pre-treatment)*	2012 FOO *(Post Treatment)*
E	*Carex sp. (sterile)*	Sedge sp. (sterile)	N/A	0.5	
	Eleocharis palustris	Creeping spikerush	6	1.0	
	Sagittaria rigida	Stiff arrowhead	8	0.5	
	Schoenoplectus acutus	Hardstem bulrush	5		0.5
	Typha spp.	Cattail spp.	1	0.5	
FL	*Brasenia schreberi*	Watershield	7	1.0	0.5
	Nuphar variegata	Spatterdock	6	2.6	2.0
	Nymphaea odorata	White water lily	6	9.2	9.7
FL/E	*Sparganium emersum*	Short-stemmed bur-reed	8		0.5
Submergent	*Ceratophyllum demersum*	Coontail	3	44.4	9.7
	Chara spp.	Muskgrasses	7	3.1	
	Elodea canadensis	Common waterweed	3	9.2	4.6
	Myriophyllum sibiricum	Northern water milfoil	7	0.5	
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	11.7	
	Najas flexilis	Slender naiad	6	3.1	
	Nitella spp.	Stoneworts	7	4.1	6.1
	Potamogeton amplifolius	Large-leaf pondweed	7	4.6	7.7
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	2.6	0.5
	Potamogeton natans	Floating-leaf pondweed	5	1.5	2.0
	Potamogeton pusillus	Small pondweed	7	5.6	0.5
	Potamogeton robbinsii	Fern pondweed	8	33.7	14.3
	Potamogeton spirillus	Spiral-fruited pondweed	8	0.5	
	Potamogeton zosteriformis	Flat-stem pondweed	6	12.2	1.0
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A	0.5	
	Utricularia vulgaris	Common bladderwort	7		0.5
	Vallisneria americana	Wild celery	6	2.0	
S/E	*Eleocharis acicularis*	Needle spikerush	5	0.5	
FF	*Lemna trisulca*	Forked duckweed	6	3.1	0.5
	Lemna turionifera	Turion duckweed	2		1.0
	Spirodela polyrhiza	Greater duckweed	5	2.0	0.5

E = Emergent, FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent, FF = Free-floating

The native species richness, or number of native species, along with their coefficient of conservatism values were used to calculate the Floristic Quality Index (FQI) (for definition see Phillips Chain of Lakes Comprehensive Management Plan 2010) of Wilson Lake's aquatic plant community prior to treatment in 2011 and post-treatment in 2012 (equation shown below).

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Figure 4 compares the FQI components of Wilson Lake before and after treatment, as well as to median values to other flowages within the northern region of Wisconsin. Native plant species richness values fell from 25 to 18 following the treatment, while average conservatism values remained similar. Because the native species richness declined, the calculated FQI value declined from 30.0 to 25.0 following the treatment, falling below the median for northern flowages but remained above the median for lakes state-wide (Figure 4).

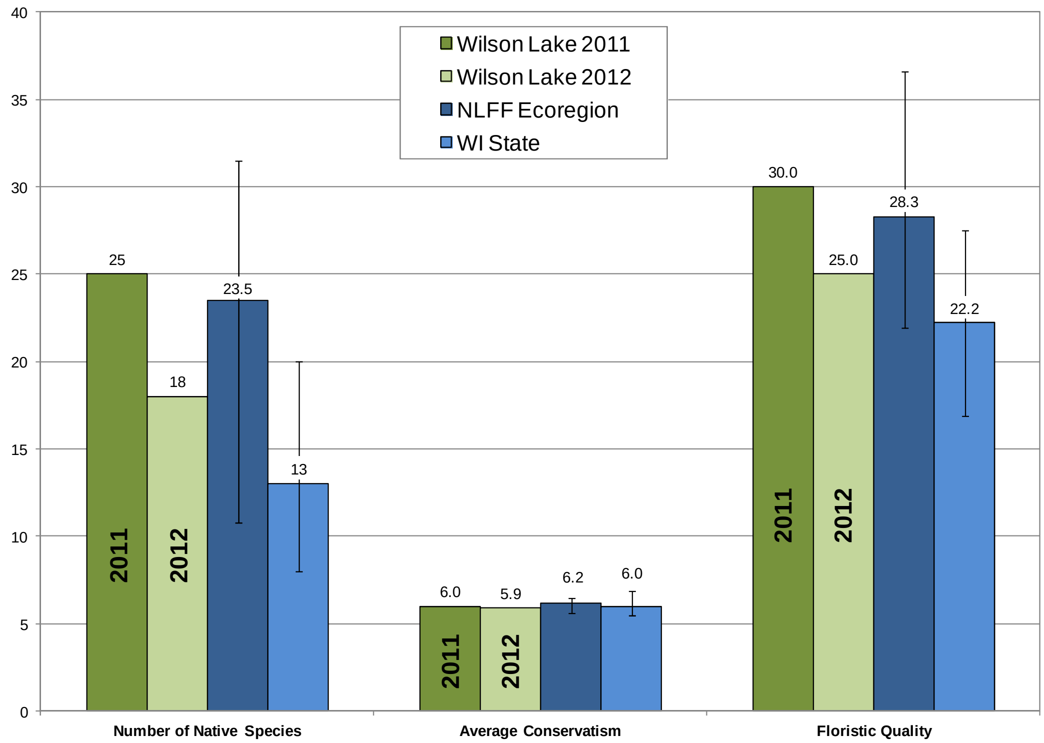

Figure 4. Wilson Lake Floristic Quality Analysis. Created using data from 2011 and 2012 point-intercept surveys. Analysis follows Nichols (1999). Error bars reflect inner quartile range (25th to 75th percentile).

Diverse aquatic plant communities are an important component of lake ecology as they have higher resilience to environmental disturbances. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food. While species richness is solely the total number of native plant species found within the lake, diversity takes into account how evenly those plant species are distributed within the community. An ecological tool called Simpson's Diversity Index is commonly used to determine a plant community's diversity. Using data collected from the 2011 pre- and 2012 post-treatment point-intercept surveys, the diversity of Wilson Lake's aquatic plant community remained relatively unchanged following the treatment (Figure 5). Diversity index values for Wilson Lake fall in line with the median for lakes in the northern region of Wisconsin and within the 75th percentile for lakes in the state (Figure 5).

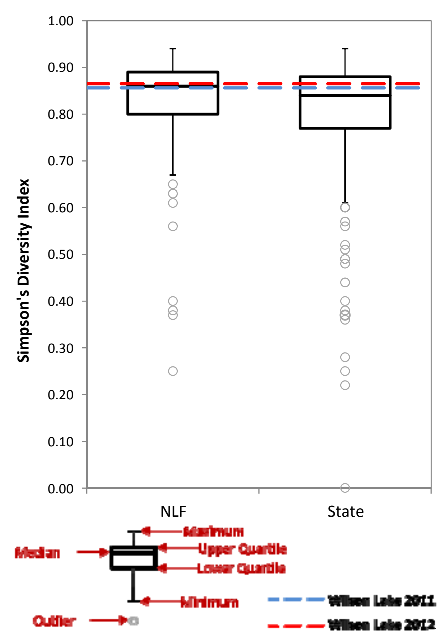

Figure 5. Wilson Lake Simpson's Diversity Index. Created using data from 2011 and 2012 point-intercept surveys.

While impacts to native species are never the intent of these treatments and measures are taken to minimize their impacts, it is to be expected that some native species will decline following treatment. Members of the WDNR and USACE continue to monitor aquatic plant communities of lakes that have undergone whole-lake treatments to understand the more long-term effects this treatment strategy. Their data collected annually for two and three years following whole-lake treatments indicate that some native plant species are showing signs of recovery, while others remain slower to recover. The 2012 treatment on Wilson Lake was extremely successful in reducing the EWM population, and continued monitoring of Wilson Lake's native plant community is proposed for 2013 to understand the longer-term effects of this treatment on the lake's plant community.

2012 Herbicide Concentration and Water Quality Monitoring on Wilson Lake

As indicated in Figure 1, Wilson Lake was thoroughly mixed and not stratified at the time of treatment. The herbicide was applied to the application areas with the intent that it would dilute to a lake-wide concentration of 0.331 ppm ae. Nine locations were sampled by an extremely dedicated volunteer (Daren Daily) to measure herbicide concentrations following the 2012 treatment (Map 1).

Sampling one day after treatment shows the herbicide dissipated from the application areas throughout the lake rapidly, as indicated by a drop in concentration to between 0.300 and 0.500 ppm ae at sam;oing locations within the application area (WI-A, WI-A2, WI-B, & WI-C) and an increase in herbicide concentration at sampling locations outside of application areas (WI-1, WI-2, & WI-3). Sample site WI-B saw declines in herbicide concentration one day after treatment, but then saw slow increases in concentration through 10 days following treatment. The average herbicide concentration from all of the seven sampling sites within Wilson Lake was 0.315 ppm ae, just below the target concentration of 0.331 ppm ae. Herbicide concentrations within Wilson Lake remained near the target concentration until 10 to 14 days after treatment, and declined to below 0.100 ppm ae between 21 and 28 days after treatment. Concentrations within upstream sights were higher than downstream sites, but downstream sites had slightly longer exposure times due to the herbicide coming from upstream. The two sampling sites located just outside the outlets of Wilson Lake in Long Lake had elevated levels of herbicide, but they never exceeded 0.100 ppm ae. Appendix A contains the USACE draft report with more detail regarding the herbicide concentration monitoring sampling study on Wilson Lake.

Mr. Daily also collected data regarding water temperature and water clarity in association with the herbicide treatment. Figure 6 displays the average water temperature from all nine sites during this timeframe. These data show that water temperatures remained relatively constant near 55°F until 10 days after treatment when water temperatures rose to 64°F. Daily high ambient air temperature data collected from a weather station in Phillips is also displayed and shows that high air temperatures were in the 70s to near 80°F from 7 to 10 days after treatment, explaining why water temperatures also rose. In the final sampling periods of 21 and 28 days after treatment, water temperatures were approximately 67°F.

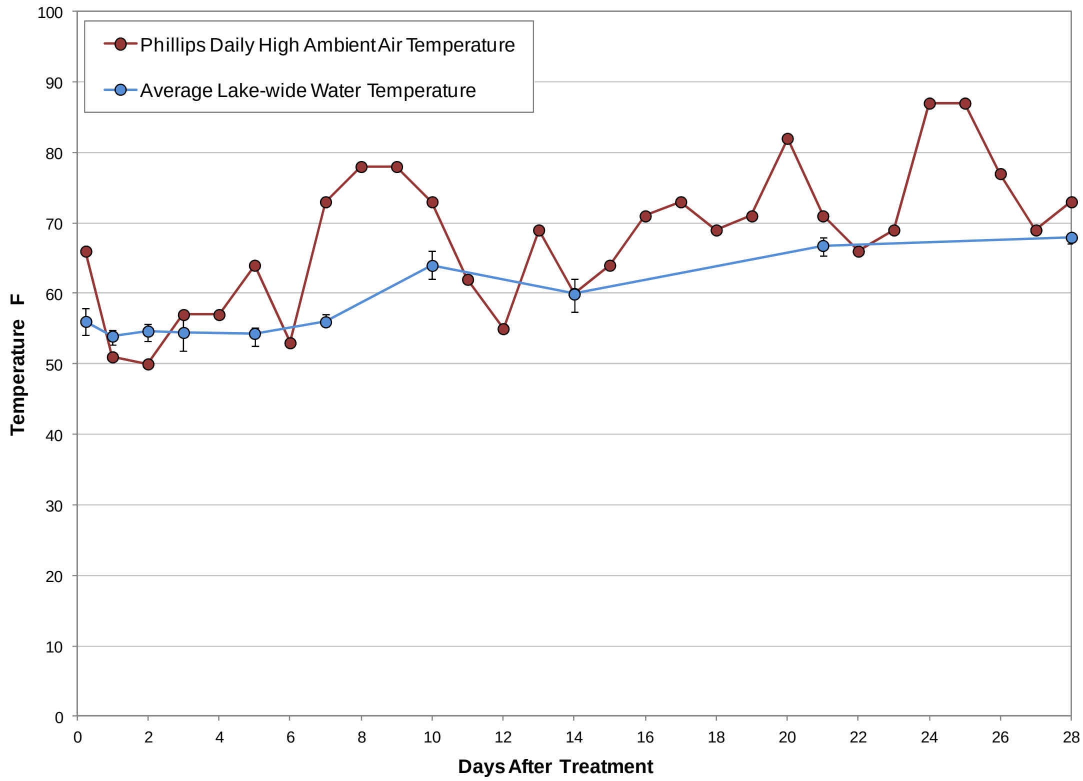

Figure 6. Wilson Lake average water temperatures and daily high ambient air temperatures in Phillips, WI. Created using data collected from Wilson Lake volunteer and National Weather Service. Water temperature data compiled from 7 herbicide concentration monitoring locations within Wilson Lake at 4 feet deep. Error bars represent range.

Secchi disk measurements were also collected at Wilson Lake's deep hole following the 2012 treatment (Figure 7). Over the 28-day sampling period following the treatment, water clarity fluctuated within a range of 1 foot; however, water clarity was the same (3.5 feet) immediately following the treatment as it was at 28 days after treatment (Figure 7). These data indicate that the treatment did not have significant effect on Wilson Lake's water clarity.

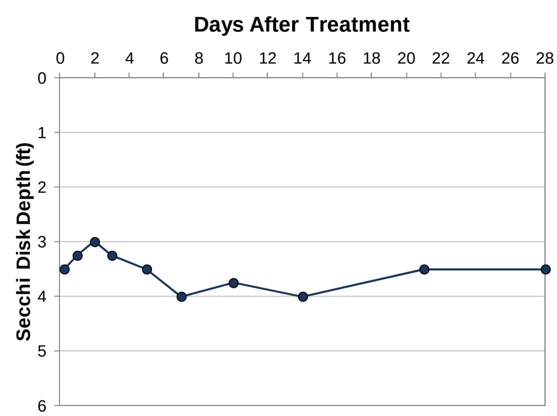

Figure 7. Wilson Lake Secchi disk clarity values. Created using data collected by Wilson Lake volunteer.

Spot Treatment Strategy

As discussed above, a spot treatment strategy is when a specific AIS colony is targeted for control with no intended effects outside of the target area. This strategy relies on relatively high dose of herbicide to be effective since the herbicide rapidly dilutes in these scenarios.

Duroy Lake

In 2012, 6.3 acres of EWM in the northeastern portion of Duroy Lake were targeted with liquid 2,4-D at a rate of 3.0 ppm ae (Map 2). As mentioned earlier, no quantitative monitoring (sub-sampling) was conducted within this treatment area. The majority of A-12 was comprised of highly dominant EWM prior to treatment. Following the 2012 treatment, 78% of the highly dominant EWM was reduced by one density rating to dominant (Map 4), exceeding the qualitative success criteria (75% reduction). While the success criterion was met, lake managers anticipated a greater level of control from the treatment. The cause for the slightly underachieving treatment results is likely because the site is located near the mouths of two inlets where flow is higher, and the herbicide likely dissipated at a faster rate.

The 2012 EWM peak-biomass survey showed that while the EWM within site A-12 was reduced in density, EWM within the northeastern portion of lake expanded in area since 2011 (Map 2 and Map 4). EWM within the eastern and southeastern portions of Duroy Lake was relatively similar in area in 2012 to what was mapped in 2011. Comparing the EWM in Duroy Lake in 2012 to what was initially mapped in 2009 shows that EWM occupies much of the same area of the lake and has not expanded, likely due to limitations of substrate type and water depth.

Long Lake

Approximately 17.4 acres of EWM was targeted with liquid 2,4-D at a rate of 3.0 ppm ae in Long Lake (Map 2). Prior to treatment, these areas contained dominant and scattered EWM. Following the 2012 treatment, only a handful of single EWM occurrences could be located within the treatment area (Map 4), indicating that 100% of the acreage treated had been reduced by at least one density rating and exceeding the qualitative success criteria (75% reduction). The success within this treatment area was better than what was to be expected, likely a result of the treatment area being within a more isolated area of the lake where water exchange and wind were reduced. No other areas of EWM were located within Long Lake in 2012.

2013 CONTROL STRATEGY

Overall, the 2012 EWM treatments were met with success in terms of reducing the chain's EWM populations. Quantitative and qualitative success criteria were met on Wilson Lake, while the qualitative criteria were met on Duroy and Long Lakes. However, the whole-lake treatment on Wilson Lake did have some adverse impacts to the lake's native aquatic plant community with four species exhibiting statistically valid reductions in occurrence and the lake's Floristic Quality Index declining following treatment.

The WDNR-funded AIS Established Population Control Grant that the PCOLA received in February 2012 was intended as a one-year trial period of treatment on the Phillips Chain to determine if the strategies carried out in 2012 would be effective at controlling EWM. The treatments conducted on Wilson and Long Lakes were very successful. While the treatment on Duroy Lake met the qualitative success criteria, it did not reach a level of control that was expected.

The 2012 peak-biomass survey on the Phillips Chain indicates that the only areas of EWM that would be proposed for treatment in 2013 are located in Duroy Lake (Map 4). Likely the only way to overcome the short exposure times caused by flow within this area is to apply a granular formulation of this herbicide and at a higher concentration. It is theorized that a granular herbicide may provide a longer exposure time by sinking to the bottom and releasing the herbicide. In addition, an expanded buffer (40-foot) was used for A-13 to increase the size of the treatment area in an attempt to increase the herbicide's exposure time. Treatment site A-13 is proposed to be treated with granular 2,4-D at a rate of 4.0 ppm ae. However, there are concerns regarding the success of another treatment within this area and its proximity to northern wild rice populations.

Implementing AIS Control Strategies in Wild Rice Waters

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842, within which the Phillips Chain of Lakes falls. The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) represent the eleven Chippewa Tribal Nations within the Upper Midwest to protect and enhance the natural resources of the ceded territory, particularly as they relate to the treaty rights of the member tribes.

As discussed above, wild rice is a valuable emergent grass found within the Phillips Chain of Lakes ecosystem. In addition to the ecosystem services this plant provides, it also holds great cultural significance to the Native American communities of this area. For this reason, GLIFWC focuses on the "preservation and enhancement of manoomin (wild rice) in ceded territory lakes." The state of Wisconsin works actively with GLIFWC to review all activities that have the potential to negatively impact wild rice populations. While the use of herbicides to control aquatic invasive species has broad intentions of benefiting the lake ecosystem, the herbicides may have the capacity to impact non-target plants such as wild rice.

Little information exists regarding the impacts of aquatic herbicides on wild rice, particularly as it applies to collateral effects on wild rice associated with targeted herbicide treatments of AIS in lakes. Natural wild rice populations are known to fluctuate greatly and unpredictably from year to year; therefore, linking population changes of wild rice to herbicide use in field settings can be problematic. Two studies (Nelson et al 2003; Madsen et al. 2008) evaluated the effects of various herbicides and concentrations on wild rice within outdoor mesocosums (tanks that replicate natural conditions). While this research concludes that wild rice is susceptible to aquatic herbicides, closer investigation of this research may indentify potential herbicide use patterns that would minimize the impact on wild rice.

<u>Timing:</u> Herbicide treatments targeting AIS in Wisconsin typically occur early in the season before water temperatures reach 60-65°F. Many of the native aquatic plant species have not began growing at this time of year, increasing the selectivity of the control strategy towards the target AIS. At this time of year, EWM and CLP are more nubile and actively growing, which makes them more vulnerable to the control strategy. On the other hand, mature wild rice was shown to be resistant to aquatic herbicides (Nelson et al 2003). It may be suggested that herbicide treatments targeting AIS within areas of wild rice be conducted late in the summer when the wild rice is mature and not vulnerable to the control strategy. While there may be some potential for late season EWM treatments, CLP has senesced (died back) by this time of year and cannot be targeted in this manner.

The seedling growth stage of wild rice is likely the stage present (unless the rice has not yet germinated) when early season herbicide treatments are conducted. Research indicates that four weeks after wild rice seedlings were exposed to various herbicides and doses, the plant height and number of seed heads and tillers were unaffected by the treatment (Nelson et al 2003). This suggests that the reproductive capacity of the seedling wild rice was also unaffected by the treatment. However, the biomass of the seedling wild rice was reduced and the magnitude of effect increased with dose. While conducting a targeted spot treatment of wild rice when the plant is in the seedling stage may impact the biomass of wild rice, it may not have reproductive impacts on the population.

Dose: As discussed above, a greater dose of herbicide resulted in a greater reduction in the biomass of the seedling wild rice plants (Nelson et al. 2003). Within this study, two doses of 2,4-D (1.0 & 2.0 ppm ae) were tested with exposure times of 7 days. An ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants have shown that sustaining herbicide concentrations of 1.0-2.0 ppm ae for even 1 day in spot treatment scenarios is likely impossible and should not be expected. Measured herbicide concentration and exposure times in association with 2,4-D treatments on Duroy Lake would likely be significantly less than those used in this study, potentially suggesting that the dose-dependent effects on the wild rice biomass would also be significantly less.

Monitoring and Evaluation Strategy

The PCOLA understand the ecological and cultural importance of wild rice within the Phillips Chain of Lakes. They are also concerned with the threat that EWM poses to the native plants, including wild rice, within the chain. A detailed herbicide treatment monitoring strategy has been devised that would evaluate the efficacy and selectivity of the control strategy.

Efficacy: In association with the 2012 spot treatments, only qualitative evaluation methodologies were conducted in which pre- and post treatment EWM mapping surveys were compared to one another. In addition to continuing to evaluate the success of the control program using qualitative methods, the 2013 treatment monitoring strategy will implement quantitative methods using a modified point-intercept methodology consistent with the Appendix D of the WDNR Guidance Document, *Aquatic Plant Management in Wisconsin* (WDNR 2010). In general, a sub-sample point-intercept grid will be placed over the larger treatment areas to yield approximately 4 points per acre (Figure 8).

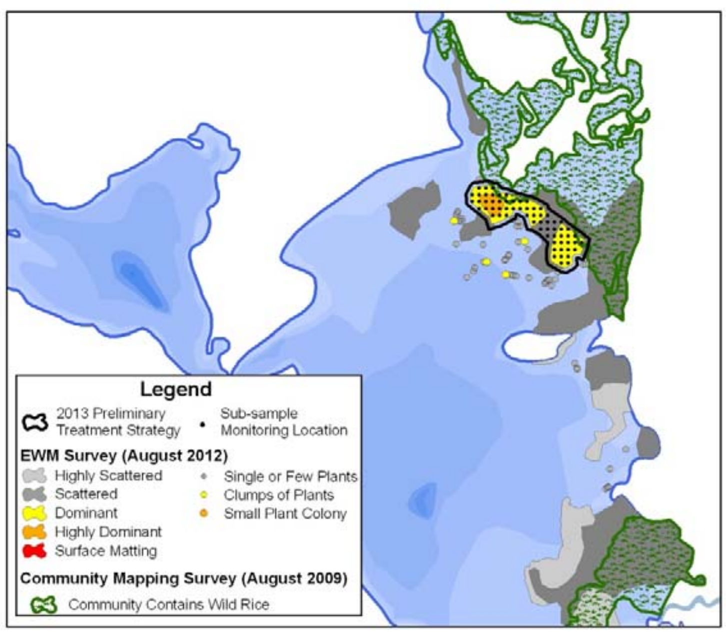

Figure 8. 2013 Quantitative monitoring plan for Duroy Lake.

Quantitative sampling would be conducted the spring just previous to the treatment (pretreatment) and the late-summer (August-September) following the treatment (post treatment).

Selectivity: Unfortunately, the quantitative methodology described above will not allow an understanding of how non-target native plants were impacted by the treatment strategy. To that end, the same sub-sample locations will be sampled each August-September and compared annually.

A major limitation of the point-intercept method is the inability to use this technique to evaluate emergent and/or adjacent wetland areas due to the inability to navigate in these areas. As an emergent plant, it is impossible for the point-intercept method to evaluate the treatment impacts on the adjacent areas of wild rice. Similar to the qualitative methodologies used to map and compare EWM colonies and densities, a methodology has been developed to monitor changes in wild rice populations over time. While wild rice populations were not specifically delineated during the 2009 lake management planning studies on the Phillips Chain of Lakes, the emergent plant communities that contained wild rice are displayed on Map 4 and Figure 8. A subsequent survey would be completed during the summer of 2013 in which wild rice colonies would be specifically delineated and assigned a two-tiered density rating (dense or sparse). While it is understood that wild rice populations fluctuate from year to year, a multi-year dataset may provide insight to whether the herbicide application is directly affecting its population. If a drastic reduction in the wild rice population is observed that has not been observed on similar, non-treated systems, lake managers will be able to attribute the change to the control strategy.

As occurred in 2012 in association with the whole-lake treatment on Wilson Lake, herbicide concentration monitoring at strategic locations throughout the system would take place to understand the concentration/exposure time of the herbicide at different time periods and locations following the treatment. This information would indicate whether or not the amount of herbicide applied is sufficient for causing EWM mortality and if any adjustments in treatment strategy need to be made. It was also allow an understanding of herbicide concentrations and exposure times within the wild rice colonies.

In August of 2012, Onterra ecologists escorted WDNR and GLIFWC staff on the Manitowish Chain and Eagle River Chain of Lakes to allow the agency staff to gain a firsthand understanding of the survey and monitoring strategy discussed above. Onterra was later invited by GLIFWC to attend a Voigt Intertribal Taskforce Workshop with the purpose of sharing the monitoring strategies with representatives of the tribal nations that GLIFWC represents.

While this site is proposed for treatment in 2013, PCOLA members must understand that following a multi-agency review, this treatment may not be permitted in 2013 due to its proximity to wild rice and location within an area of high water exchange.

For these reasons, the WDNR does not support a multi-year, grant-funded AIS control project on the Phillips Chain at this time; however, they do support another one-year trial control project to determine if a higher-dose treatment will be effective in Duroy Lake. If agreed upon, it is recommended that the PCOLA apply for WDNR grant funds during the February 1, 2013 cycle to cover the costs of implementing the control and monitoring strategy outlined above. In addition, the project would include another whole-lake point-intercept survey on Wilson Lake to understand the effects of the 2012 whole-lake treatment on the lake's plant community one year following treatment and a chain-wide peak-biomass survey of EWM in late-summer 2013. If the proposed 2013 treatment on Duroy Lake is postponed; the mapping of wild rice, whole-lake point-intercept survey on Wilson Lake, and the chain-wide assessment of EWM should occur to align the PCOLA to implement a control strategy in 2014.

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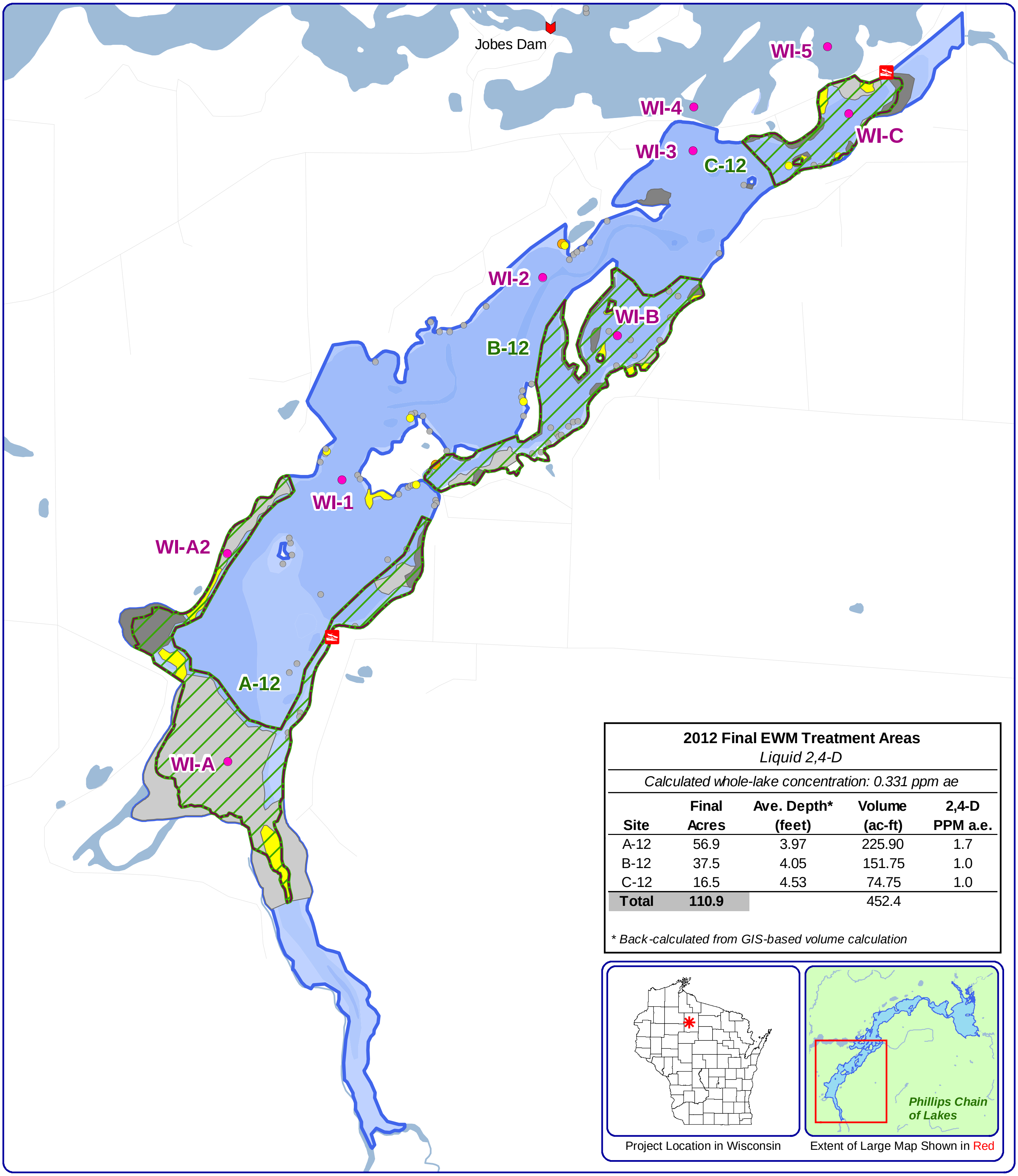

2012 Final EWM Treatment Areas
Liquid 2,4-D

Calculated whole-lake concentration: 0.331 ppm ae

Site	Final Acres	Ave. Depth* (feet)	Volume (ac-ft)	2,4-D PPM a.e.
A-12	56.9	3.97	225.90	1.7
B-12	37.5	4.05	151.75	1.0
C-12	16.5	4.53	74.75	1.0
Total	**110.9**		452.4	

** Back-calculated from GIS-based volume calculation*

Project Location in Wisconsin

Phillips Chain of Lakes

Extent of Large Map Shown in Red

N W E S

1,200
Feet

2011 EWM Survey (August 2011)
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Herbicide Concentration Monitoring Location
- 2012 Conditional Treatment Area
- 2012 Final Treatment Area

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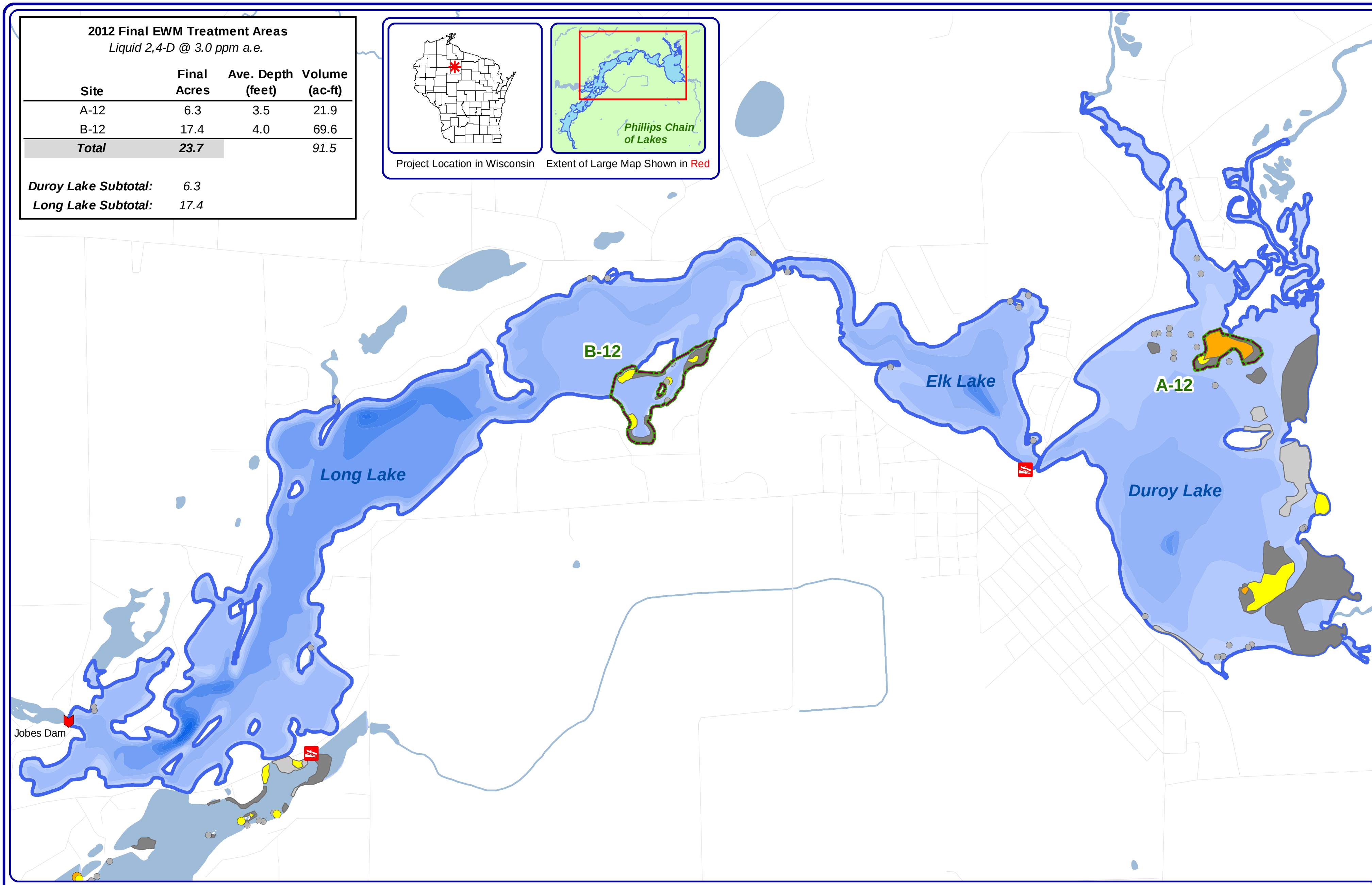
Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2011
Map Date: January 2, 2013
Filename: Map1_Wilson_EWM_2011PB_T2012.mxd

Map 1
Wilson Lake
Price County, Wisconsin
2011 EWM Locations & 2012 Treatment Areas

2012 Final EWM Treatment Areas

Liquid 2,4-D @ 3.0 ppm a.e.

Site	Final Acres	Ave. Depth (feet)	Volume (ac-ft)
A-12	6.3	3.5	21.9
B-12	17.4	4.0	69.6
Total	***23.7***		*91.5*
Duroy Lake Subtotal:	*6.3*		
Long Lake Subtotal:	*17.4*		



2011 EWM Survey (August 2011)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2012 Conditional Treatment Area
- 2012 Final Treatment Area

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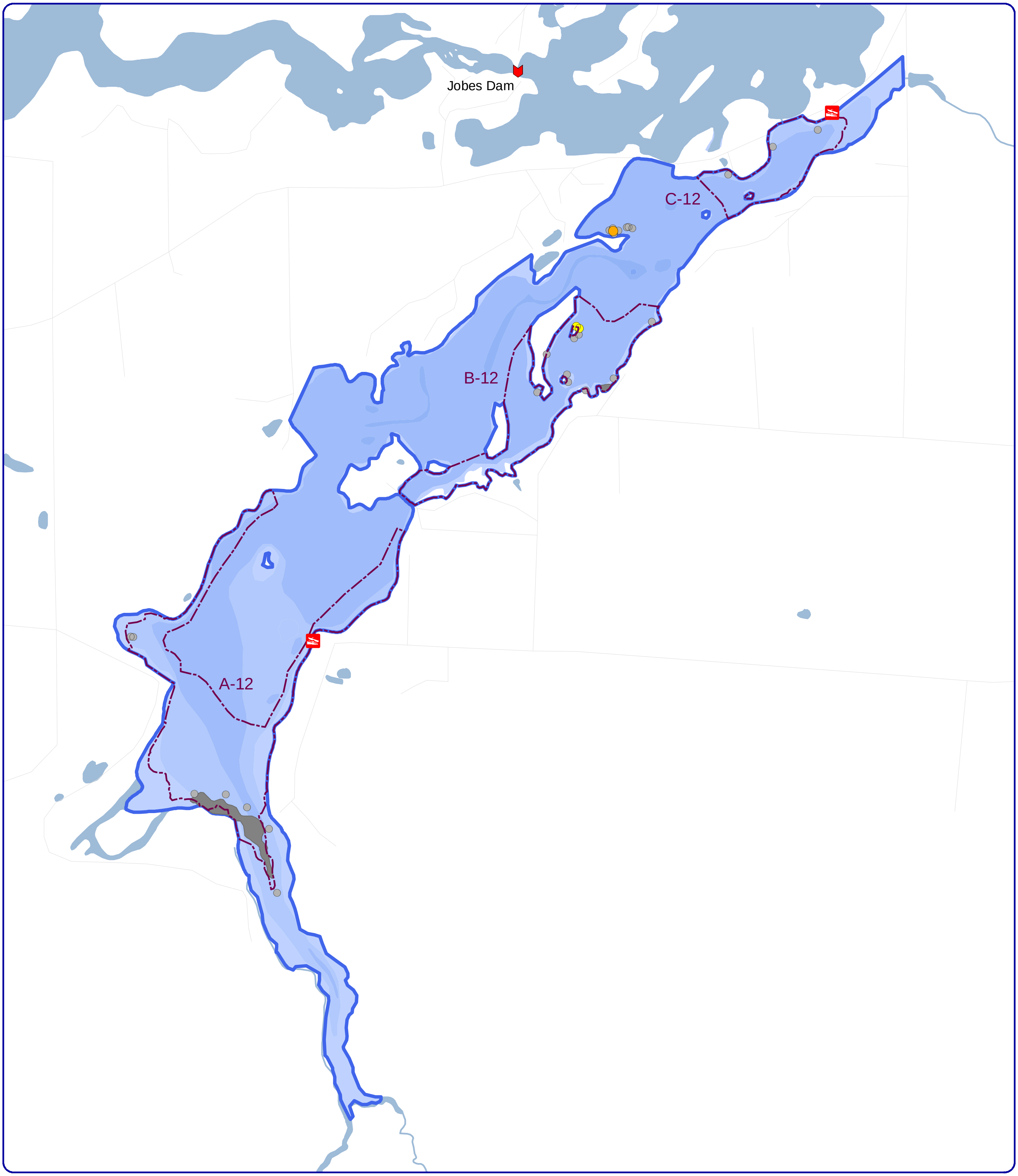
Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2011
Map Date: January 3, 2013
Filename: Map2_Duroy-Elk-Long_EWM_2011PB_T2012.mxd

Map 2
Duroy, Elk, & Long Lakes
Price County, Wisconsin

2011 EWM Locations & 2012 Treatment Areas



N
W E
S

1,400

Feet

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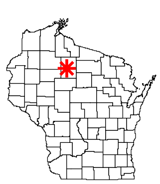
Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2012
Map Date: January 3, 2013
Filename: Map3_Wilson_EWM_T2013_Cond1.mxd



Project Location in Wisconsin

2012 EWM Survey (September 2012)

Highly Scattered
Scattered
Dominant
Highly Dominant
Surface Matting
Single or Few Plants
Clumps of Plants
Small Plant Colony
2012 Final Treatment Area

Map 3

Wilson Lake

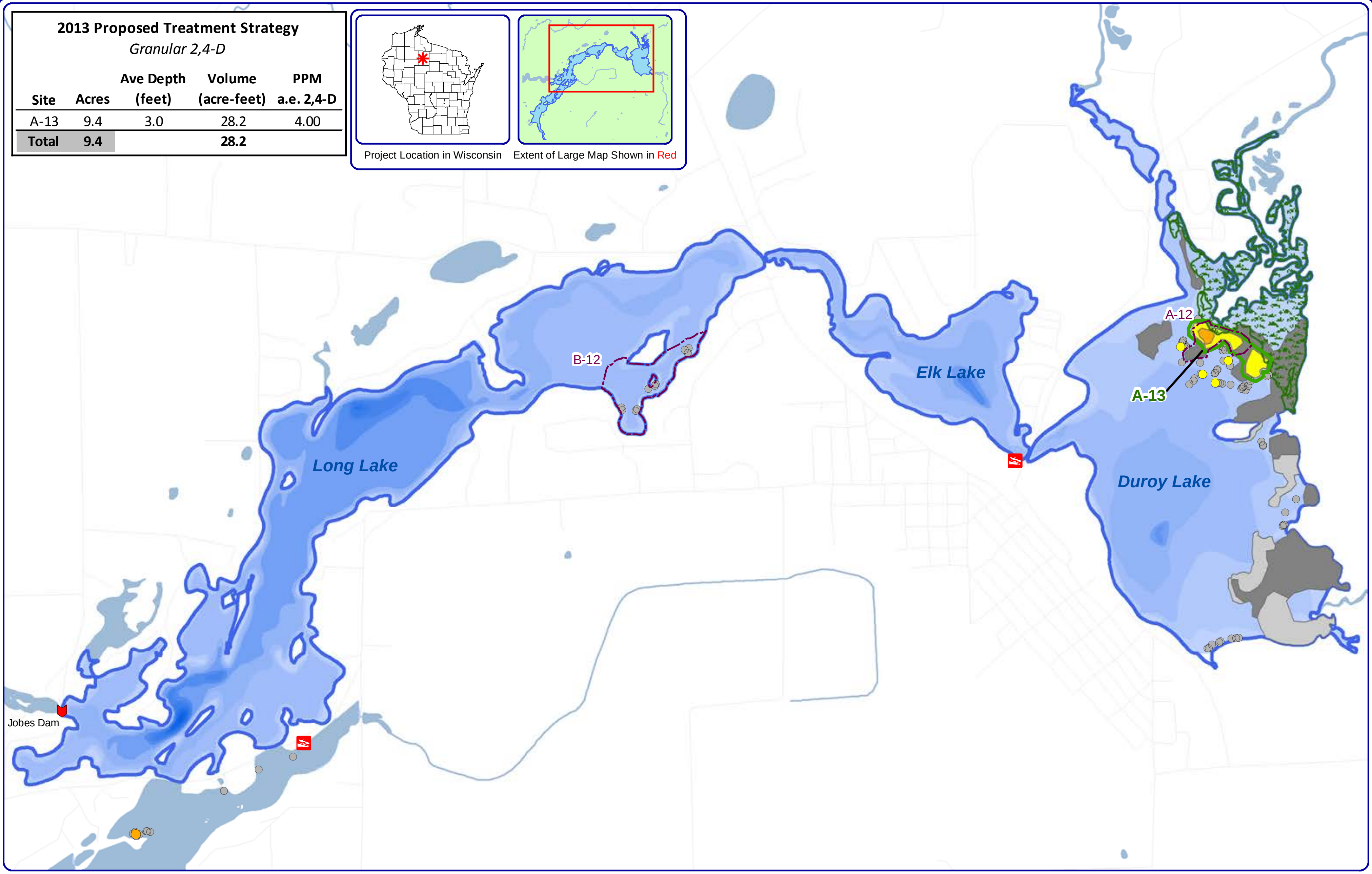
Price County, Wisconsin

2012 EWM Locations

2013 Proposed Treatment Strategy

Granular 2,4-D

Site	Acres	Ave Depth (feet)	Volume (acre-feet)	PPM a.e. 2,4-D
A-13	9.4	3.0	28.2	4.00
Total	**9.4**		**28.2**	



N
W E
S

1,900
Feet

2012 EWM Survey (September 2012)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2012 Final Treatment Area
- 2013 Conditional Treatment Area
- Plant Community Containing Wild Rice (*Zizania palustris*)

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Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2012
Map Date: January 3, 2013
Filename: Map4_Duroy-Elk-Long_T2013_Cond1.mxd

Map 4

Duroy, Elk, & Long Lakes

Price County, Wisconsin

2011 EWM Locations & 2012 Treatment Areas