INTRODUCTION

The Unified Lower Eagle River Chain of Lakes Commission (ULERCLC) successfully applied for a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS) Control Grant in August of 2010 to complete the fourth phase of a project aimed at reducing the Eagle River Chain's Eurasian water milfoil (EWM) infestation to manageable levels. This report discusses the fourth year of treatment under this grant-funded AIS control and prevention project. The chain-wide results will be presented first followed by the results from each lake individually. Additional information regarding the treatments completed in 2008, 2009, and 2010 can be found in their respective reports.

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 is an important consideration for 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. Much information on this issue has been gathered in recent years, largely as a result of a joint research project between the WDNR and US Army Corps of Engineers (USACE). Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) whole-lake treatments, and 2). spot treatments.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide 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 that 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 for EWM treatments is typically between 0.225 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 plant species, particularly dicot species, some thin-leaved pondweeds, and naiad species. This strategy was implemented in 2010 on Scattering Rice.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. This is the strategy currently and historically implemented on the Eagle River Chain of Lakes. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. For EWM, 2,4-D is typically applied between 2.25 and 4.0 ppm ae in spot treatment scenarios. A newly adopted term, 'micro-treatments' is being used to describe very small spot treatments (working definition is less than 5 acres). Because of their small size, it is extremely difficult to predict treatment effectiveness due to rapid dilution of the herbicide. Larger treatment areas tend to be able to hold effective concentrations for a longer time.

Following the 2010 peak-biomass survey, conditional treatment permit maps were created proposing 145.2 total acres of treatment on Cranberry, Catfish, Voyageur, Eagle, Scattering Rice, Otter, Yellow Birch, and Watersmeet Lakes (Table 1). On May 23 and 24, 2011, Onterra staff visited the Eagle River Chain to survey the proposed treatment areas and refine their boundaries as appropriate, primarily through the use of submersible video technology. As a result of the spring pre-treatment survey, the treatment strategy was reduced to 93 acres after little or no EWM was observed in a number of the originally proposed areas (Table 1). It is possible that the EWM within these areas was injured from the 2010 treatment to a point where it could not overwinter and continue growth in the spring.

Table 1. Eagle River Chain 2011 EWM Treatment Acreage.

Lake	Proposed Acres	Permit Acres
Cranberry	33.3	18.3
Catfish	18.6	11.8
Voyageur	2.7	0.6
Eagle	18.1	9.4
Scattering Rice	4.7	4.7
Otter	8.3	9.7
Lynx	0.0	0.0
Duck	0.0	0.0
Yellow Birch	6.9	5.8
Watersmeet	52.6	32.7
Total	**145.2**	**93.0**

During this survey, temperature, dissolved oxygen, and pH profiles were also collected from areas in Cranberry, Catfish, Eagle, Yellow Birch, and Watersmeet Lakes (Figure 1). Surface water temperatures ranged from 59°F in Eagle Lake to 64°F in Cranberry, and dissolved oxygen was greater than 5 mg/L at all depths sampled. Surface pH values ranged from 7.6 in Watersmeet to 8.1 in Yellow Birch Lake (Figure 1).

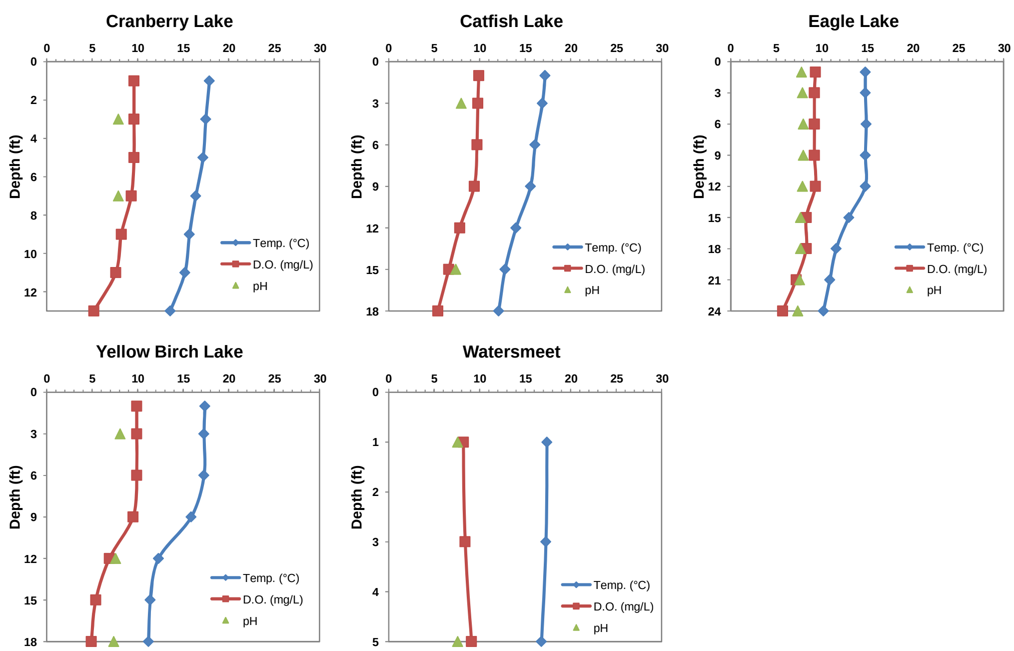


Figure 1. Temperature, dissolved oxygen, and pH profiles collected on five lakes in the Eagle River Chain. Collected May 24, 2011.

In 2010, both liquid and granular 2,4-D formulations were applied to EWM on the Eagle River Chain. Liquid 2,4-D (amine) was used in a large-scale treatment on Scattering Rice Lake while granular 2,4-D (ester) was applied to smaller treatment areas throughout the rest of the chain. Both strategies were shown to be successful at reducing the density and occurrence of EWM.

While no large-scale liquid treatments were proposed for 2011, it was recommended that the treatment sites be applied with granular 2,4-D because of the success observed in 2010. After discussions with their herbicide applicator, the ULERCLC decided that Navigate (ester) would the 2,4-D product used again for the 2011 spot treatments. On May 26 to June 2, 2011, the treatment sites were applied with granular 2,4-D by Schmidt's Aquatic Plant Control at a rate to achieve target concentrations of 2.0 to 3.5 ppm ae. The applicator reported the following wind conditions: May 26 – calm, May 27 – calm to 3 mph, May 31 – 5 to 15 mph, June 2 – 5 mph.

2010 TREATMENT MONITORING

The goal of herbicide treatments 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.

EWM treatment quantitative evaluation methodologies follow WDNR protocols in which point-intercept data are collected within treatment areas before and after the treatment. On the Eagle River Chain of Lakes, data of this type was collected at over 300 point-intercept sub-sample locations during the summer of 2011 (Figure 2). However, not all of those points were located within the areas where herbicide was directly applied and therefore not all points are used in the analysis of the 2011 treatment.

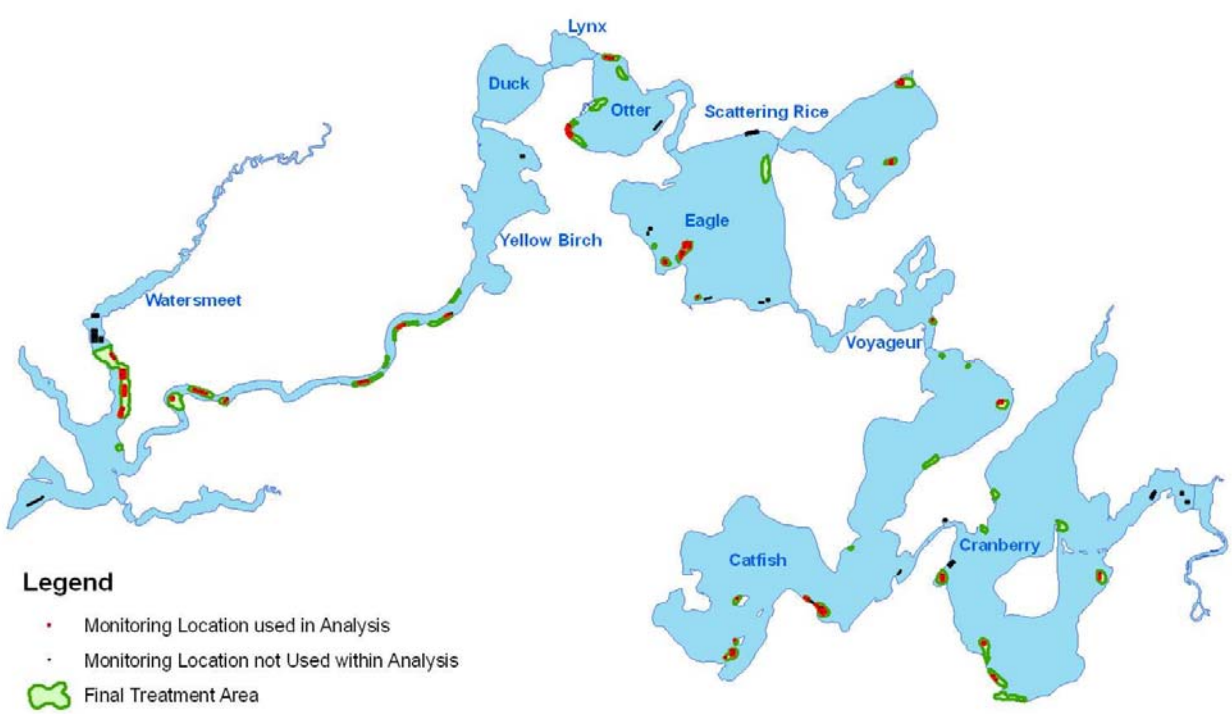


Figure 2. 2011 Quantitative monitoring plan for the Eagle River Chain of Lakes

The most comparative sub-sample data are those collected both the summer before and the summer immediately following the herbicide treatment. On the Eagle River Chain of Lakes, 162 point-intercept sub-sample locations fell into this category (Figure 2). At these sampling locations, EWM and native aquatic plant species presence and rake-fullness were documented along with water depth and substrate type. Specifically, these surveys aim to determine if significant differences in frequencies of occurrence of EWM and native species occur following the herbicide application.

Quantitatively, a specific treatment site is deemed to be successful if the EWM frequency following the treatments exhibits a statistically valid reduction by at least 50%. Evaluation of treatment-wide effectiveness follows the same criteria based upon pooled sub-sample data from all of the treatment sites. Further, a noticeable decrease in rake-fullness ratings within the fullness categories of 2 and 3 should be observed and preferably, there would be no rake tows exhibiting a fullness of 2 or 3 during the post treatment surveys.

Spatial data reflecting EWM locations were collected using a sub-meter Global Positioning System (GPS) during the late summers of 2010 and 2011, when this plant is assumed to be at its peak-biomass or growth stage. Comparisons of these surveys are used to qualitatively evaluate the 2011 herbicide treatment on the Eagle River 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 by 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, 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. While product labeling indicates that 2,4-D is selective towards broad-leaf (dicot) species at the concentration and exposure times used during the 2011 treatment on the Eagle River Chain of Lakes, emerging conclusions from the WDNR and USACE state that some narrow-leaf (monocot) species are also be impacted by this herbicide.

2011 CHAIN-WIDE TREATMENT SUMMARY AND CONCLUSIONS

Post treatment surveys were completed on the Eagle River Chain by Onterra on September 6 and 7, 2011. Chain-wide, 100% of the treatment acreage was observed to have reduced by at least one density rating, exceeding the qualitative success criteria (75% reduction) for the 2011 treatment. Figure 3 shows that over the course of annual treatments from 2008 to 2011, EWM colonial acreage has been reduced by 92% from 278 acres in 2007 to 23 acres in 2011. EWM density also decreased markedly over this period, from EWM mainly comprised of dominant, highly dominant, and surface matted areas in 2007 to scattered and highly scattered areas in 2011 (Figure 1).

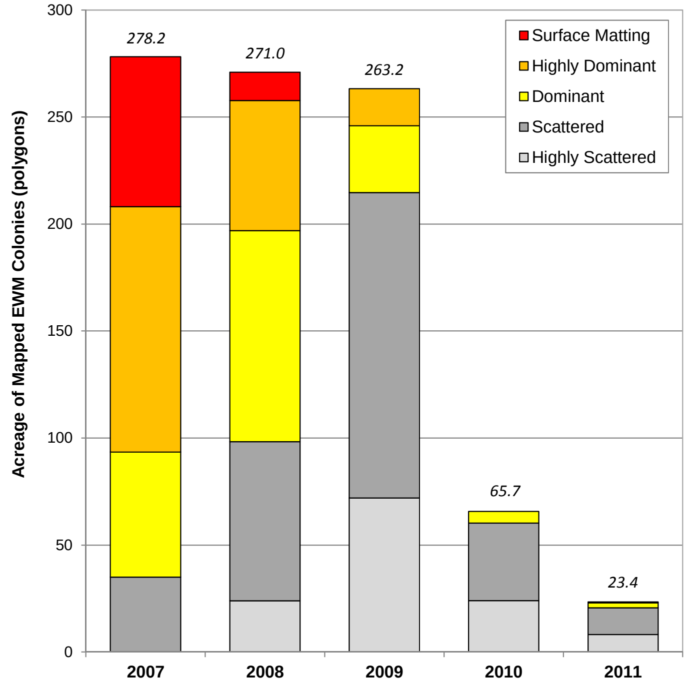


Figure 3. Acreage of mapped EWM colonies on the Eagle River Chain of Lakes from 2007-2011.

During the summer of 2010, 14.2% of the 162 point-intercept locations within the 2011 treatment areas contained EWM compared to 1.9% in 2011, representing a statistically valid reduction in occurrence of 87% and exceeding the chain-wide quantitative success criteria (50% reduction in occurrence) (Figure 4). Individually, Scattering Rice and Otter Lakes were the only lakes to show a statistically valid reduction in EWM occurrence in 2011 (Figure 4). While the other lakes saw reductions in EWM occurrence, these were not statistically valid and is likely a result of small sample size and relatively low occurrences of EWM in 2010 and 2011. Yellow Birch and Voyageur Lakes could not be statistically analyzed due to insufficient point-intercept sampling sizes.

A rake-fullness rating of 1-3 was used to determine the abundance of EWM at each of the 162 point-intercept locations. Figure 5 displays the chain-wide proportions of EWM rake-fullness ratings from the pre- and post-treatment surveys. This figures shows both the decline in EWM occurrence and that there were no rake-fullness ratings of 2 or 3 in 2011.

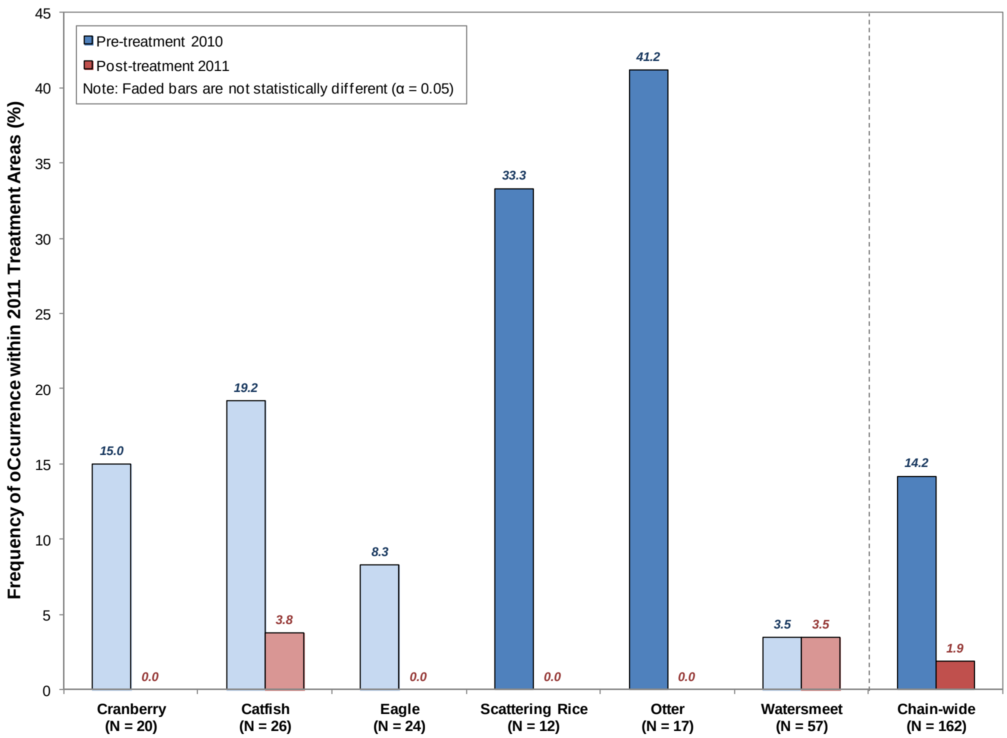


Figure 4. Eagle River Chain EWM percent occurrence in point-intercept locations displayed by lake comparing summer 2010 to summer 2011. Please note that Voyageur and Yellow Birch Lakes did not have sufficient sample sizes, and are not graphed, while no treatments occurred on Duck and Lynx Lakes in 2011.

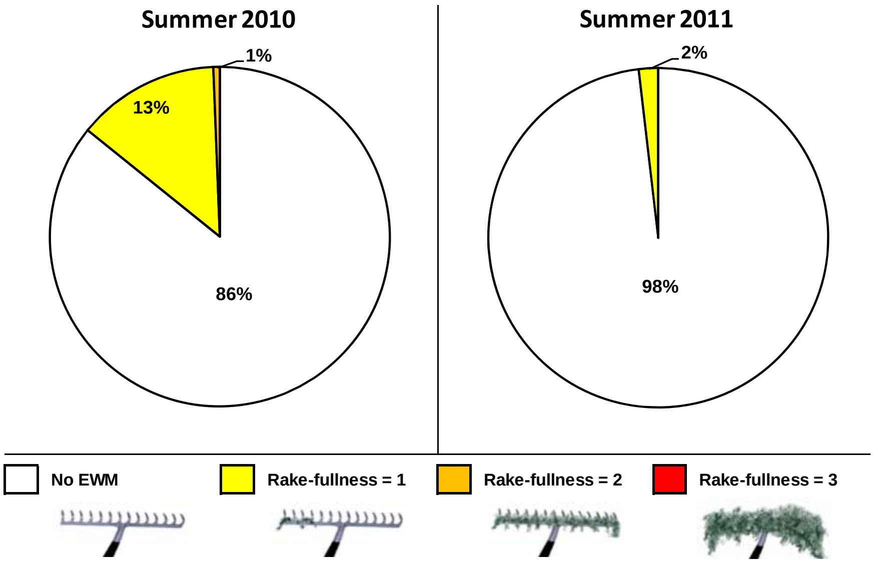


Figure 5. Eagle River Chain chain-wide proportions of EWM rake-fullness ratings from 162 point-intercept sub-sampling locations within 2011 treatment areas. Created using data from 2010 pre-treatment and 2011 post-treatment surveys.

Data concerning native aquatic plant species were also collected at the same 162 point-intercept locations during the summers of 2010 and 2011. Table 2 shows that within the 2011 treatment areas, coontail, northern water milfoil, and common waterweed exhibited statistically valid reductions in occurrence following the 2011 treatment. Like EWM, coontail and northern water milfoil are dicots and are particularly susceptible to herbicide treatments. Efforts are taken to minimize impacts to these species by applying herbicides early in the spring before these plants are actively growing. Unlike EWM, common waterweed is a non-dicot and was previously not thought to be sensitive to dicot-selective herbicides. However, data from 2010 and 2011 on the Eagle River Chain and other lakes in the northern region with similar treatments indicate that these species may be prone to decline following treatment.

Table 2. Statistical comparison of native aquatic plant frequency data within 2011 treatment areas on the Eagle River Chain from 2010 pre- and 2011 post-treatment surveys. Only species with greater than 5.0% frequency of occurrence in at least one of the two surveys are applicable for analysis.

	Scientific Name	Common Name	2010 FOO	2011 FOO	Percent Change	Direction	Chi-square Analysis	
							Statistically Valid	p-value
D	*Ceratophyllum demersum*	Coontail	36.4	17.9	-50.8	▼	Yes	0.000
	Myriophyllum sibiricum	Northern water milfoil	6.2	0.0	-100.0	▼	Yes	0.001
Non-dicots	*Elodea canadensis*	Common waterweed	43.2	9.9	-77.1	▼	Yes	0.000
	Potamogeton robbinsii	Fern pondweed	33.3	25.3	-24.1	▼	No	0.113
	Vallisneria americana	Wild celery	19.8	29.0	46.9	▲	No	0.052
	Potamogeton zosteriformis	Flat-stem pondweed	10.5	5.6	-47.1	▼	No	0.102
	Potamogeton richardsonii	Clasping-leaf pondweed	2.5	4.9	100.0	▲	No	0.239
	Potamogeton pusillus	Small pondweed	1.9	4.9	166.7	▲	No	0.125

2010 & 2011 N = 162
FOO = Frequency of Occurrence; D = Dicots
▲ or ▼ = Change Statistically Valid (Chi-square; α = 0.05)
▲ or ▼ = Change Not Statistically Valid (Chi-square; α = 0.05)

As discussed earlier, the observed declines to native species within the treatment areas cannot be extrapolated to the entire lake-wide population of these species as data was only analyzed from sample locations within treatment sites (Figure 2). To determine if the annual herbicide treatments are impacting native plant species on lake-wide levels, whole-lake point-intercept surveys would need to be conducted on each lake within the chain. Whole-lake point-intercept surveys were last conducted on the Eagle River Chain of Lakes in 2006 by Northern Environmental, Inc. The WDNR recommends that a replication of the whole-lake point-intercept survey occur approximately every 3-5 years when large scale manipulations are occurring. Whole-lake point-intercept surveys are scheduled to occur on each lake within the Eagle River Chain during the summer of 2012. Comparing these surveys to the ones conducted in 2006 will reveal if any long-term, lake-wide impacts to native aquatic plant species are occurring or if the declines observed are confined to areas being actively treated.

2012 CHAIN-WIDE TREATMENT STRATEGY

The 2011 treatment on the Eagle River Chain of Lakes was extremely successful in terms of reducing the density and occurrence of EWM. Chain-wide, both the qualitative and quantitative success criteria were met. The 93 acres of EWM that were treated in 2011 have been reduced to a proposed treatment of 50.5 acres for 2012.

At the start of this control project, only EWM colonies that were dominant or greater were targeted for treatment on the Eagle River Chain of Lakes. After numerous successful treatments, the threshold (trigger) for determining which areas warranted treatment was relaxed to include any colonized (polygon-based mapping techniques) area of EWM. The majority of the EWM that was observed in 2011 following the treatment was comprised of either low density colonies (highly scattered or scattered) or EWM mapped with point-based methods.

On the Eagle River Chain of Lakes, the EWM population is approaching a point at which the herbicide application areas are too small to consistently predict if they will cause EWM mortality. As indicated within the Introduction Section, it is extremely difficult in micro-treatment scenarios to keep a sufficient herbicide concentration exposed to the target plants long enough to be effective. Therefore, potential treatment sites less than 0.3 acres were not proposed for treatment due to their extremely small size and unlikely nature of being successful. Also, almost all proposed treatment areas include an expanded buffer (40 feet) as well as a higher granular 2,4-D application rate. For treatment sites greater than 1 acre, 2.5 ppm ae is proposed, whereas treatment sites less than one acre, 2.75 ppm ae is proposed. A slightly higher 2,4-D concentration (3.0 ppm ae) is proposed for the small treatment sites within the Eagle River downstream of Yellow Birch Lake.

Two granular 2,4-D products are widely used in Wisconsin: Navigate and Sculpin G. Sculpin G has an EPA-approved product label that sets the herbicide's maximum application rates volumetrically (up to 4.0 ppm ae). Up until recently, Navigate's EPA-approved label stated that it could only be applied at rates up to 200 lbs/acre. In deeper water treatments, this did not provide sufficient active ingredient to reach desired herbicide concentrations and therefore Sculpin G was often used on many lakes in these situations. An updated EPA approved label now allows Navigate to be dosed volumetrically up to 4.0 ppm ae. Because of Navigate's ester formulation, the updated label also includes a 24-hour swimming restriction, which is not included as a part of the amine-formulated Sculpin G label.

As mentioned in previous reports, one of the greatest successes of the Eagle River Chain control program is the commitment by volunteers to aid in this process. Some volunteers aid in coordination of the project, some provide data to the professional ecologists relating to EWM occurrences, some conduct EWM hand-removal, and others work to educate other stakeholders on the importance of aquatic invasive species and the Eagle River Chain system. Continued volunteer commitment will be needed for long-term success to continue.

CRANBERRY LAKE SUMMARY AND CONCLUSIONS

Approximately 18.3 acres of EWM were treated in Cranberry Lake in 2011 with granular 2,4-D (Navigate) at concentrations between 2.1 and 2.8 ppm ae (Map Cran 1). Following the treatment, all of the treatment areas were reduced by at least one EWM density rating, exceeding the qualitative success criteria (75% of acreage reduced) (Map Cran 2). In the summer of 2010, 15% of the 20 point-intercept locations within the 2011 treatment areas contained EWM compared to none in 2011 (Table 3). Despite a 100% reduction in occurrence, statistic analysis shows that this change is not valid at the predetermined confidence level ($\alpha = 0.05$), but was extremely close (valid at $\alpha = 0.10$).

Data concerning native aquatic plant species within the 2011 treatment areas indicate that one species, common waterweed, exhibited a statistically valid reduction in occurrence following the treatment (Table 3). Unlike EWM, common waterweed is a non-dicot and was previously not thought to be sensitive to dicot-selective herbicides. However, emerging data gathered from lakes in 2010 and 2011 with similar treatments indicate that some of these species may be prone to decline following a treatment. As discussed earlier, the declines observed to native species within the treatment areas cannot be extrapolated to the entire lake-wide population as data was only collected from areas within treatment sites. Comparing the upcoming 2012 whole-lake point-intercept survey with the 2006 survey will allow an understanding of how the aquatic plant community changed over this time period.

Table 3. Statistical comparison of aquatic plant frequency data within 2011 treatment areas on Cranberry Lake from 2010 pre- and 2011 post-treatment surveys. Only species with greater than 5.0% frequency of occurrence in at least one of the two surveys are applicable for analysis.

	Scientific Name	Common Name	2010 FOO	2011 FOO	Percent Change	Direction	Chi-square Analysis	
							Statistically Valid	p-value
Dicots	*Myriophyllum spicatum*	Eurasian water milfoil	15.0	0.0	-100.0	▼	No	0.072
Dicots	*Ceratophyllum demersum*	Coontail	45.0	20.0	-55.6	▼	No	0.091
Dicots	*Bidens beckii*	Water marigold	5.0	0.0	-100.0	▼	No	0.311
Dicots	*Myriophyllum sibiricum*	Northern water milfoil	5.0	0.0	-100.0	▼	No	0.311
Non-dicots	*Elodea canadensis*	Common waterweed	75.0	0.0	-100.0	▼	Yes	0.000
Non-dicots	*Potamogeton robbinsii*	Fern pondweed	60.0	50.0	-16.7	▼	No	0.525
Non-dicots	*Potamogeton zosteriformis*	Flat-stem pondweed	15.0	0.0	-100.0	▼	No	0.072
Non-dicots	*Vallisneria americana*	Wild celery	15.0	20.0	33.3	▲	No	0.677
Non-dicots	*Najas flexilis*	Slender naiad	5.0	0.0	-100.0	▼	No	0.311
Non-dicots	*Potamogeton epihydrus*	Ribbon-leaf pondweed	5.0	0.0	-100.0	▼	No	0.311
Non-dicots	*Potamogeton pusillus*	Small pondweed	5.0	0.0	-100.0	▼	No	0.311
Non-dicots	*Potamogeton vaseyi*	Vasey's pondweed	5.0	0.0	-100.0	▼	No	0.311
Non-dicots	*Potamogeton amplifolius*	Large-leaf pondweed	0.0	5.0	100.0	▲	No	0.311

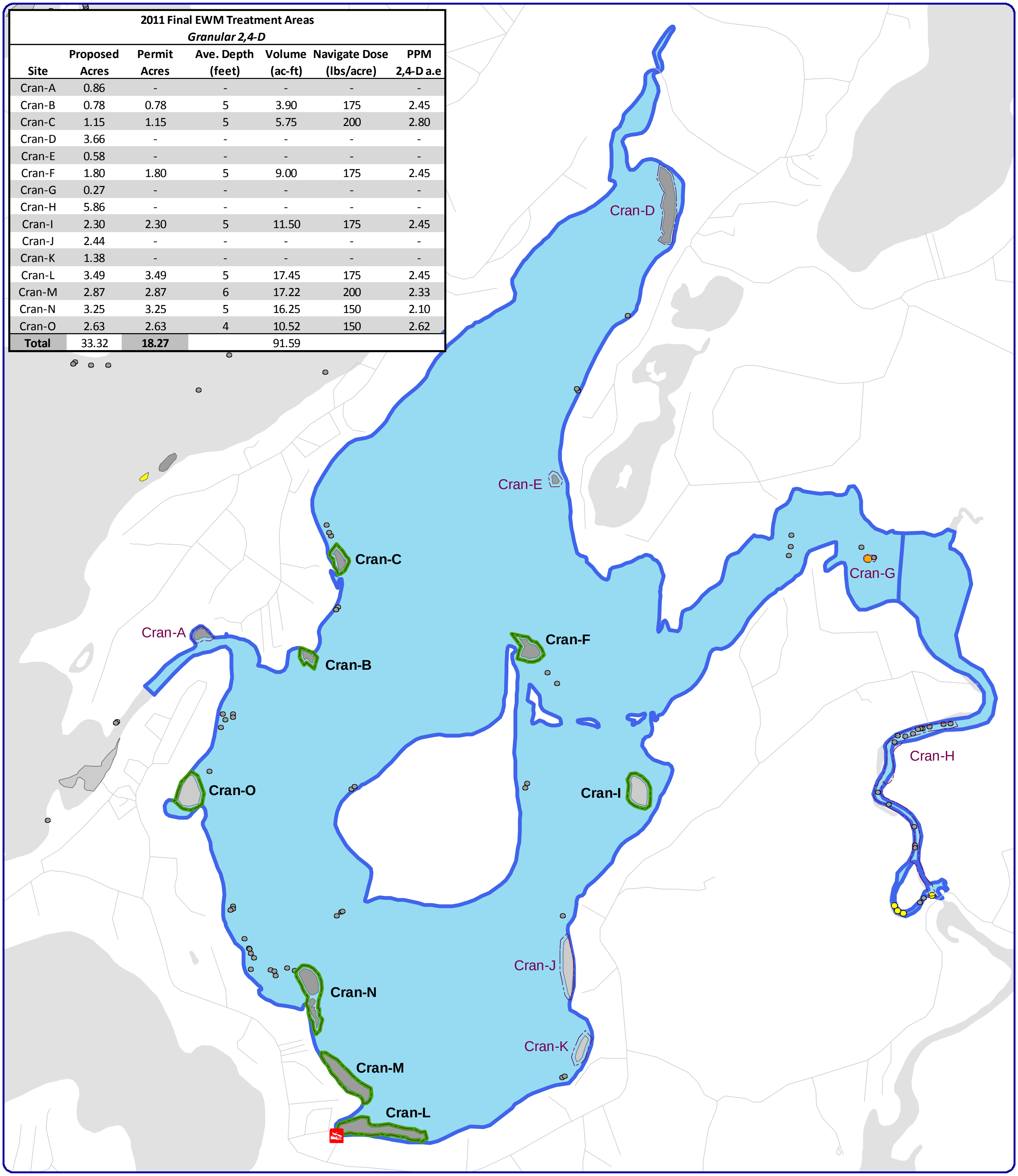
2010 & 2011 N = 20
FOO = Frequency of Occurrence
▲ or ▼ = Change Statistically Valid (Chi-square; $\alpha = 0.05$)
▲ or ▼ = Change Not Statistically Valid (Chi-square; $\alpha = 0.05$)

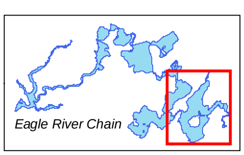
Overall, the 2011 treatment on Cranberry Lake was successful. None of the 2011 treatment areas on Cranberry Lake are proposed to be re-treated, and only 8.9 acres of EWM comprised of three treatment areas are proposed for treatment in 2012 (Map Cran 2). It is recommended that these sites be treated using granular 2,4-D at 2.5 ppm ae, similar to concentrations that were shown to be effective in 2011 (Map Cran 2).

2011 Final EWM Treatment Areas

Granular 2,4-D

Site	Proposed Acres	Permit Acres	Ave. Depth (feet)	Volume (ac-ft)	Navigate Dose (lbs/acre)	PPM 2,4-D a.e
Cran-A	0.86	-	-	-	-	-
Cran-B	0.78	0.78	5	3.90	175	2.45
Cran-C	1.15	1.15	5	5.75	200	2.80
Cran-D	3.66	-	-	-	-	-
Cran-E	0.58	-	-	-	-	-
Cran-F	1.80	1.80	5	9.00	175	2.45
Cran-G	0.27	-	-	-	-	-
Cran-H	5.86	-	-	-	-	-
Cran-I	2.30	2.30	5	11.50	175	2.45
Cran-J	2.44	-	-	-	-	-
Cran-K	1.38	-	-	-	-	-
Cran-L	3.49	3.49	5	17.45	175	2.45
Cran-M	2.87	2.87	6	17.22	200	2.33
Cran-N	3.25	3.25	5	16.25	150	2.10
Cran-O	2.63	2.63	4	10.52	150	2.62
Total	33.32	**18.27**		91.59		





Extent of large map shown in red.

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2011 Conditional Treatment Area
- 2011 Final Treatment Area

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Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra 2010-2011
Map Date: January 30, 2012
Filename: *Cran1_EWM_2010PB_T2011.mxd*

Cran 1

Cranberry Lake

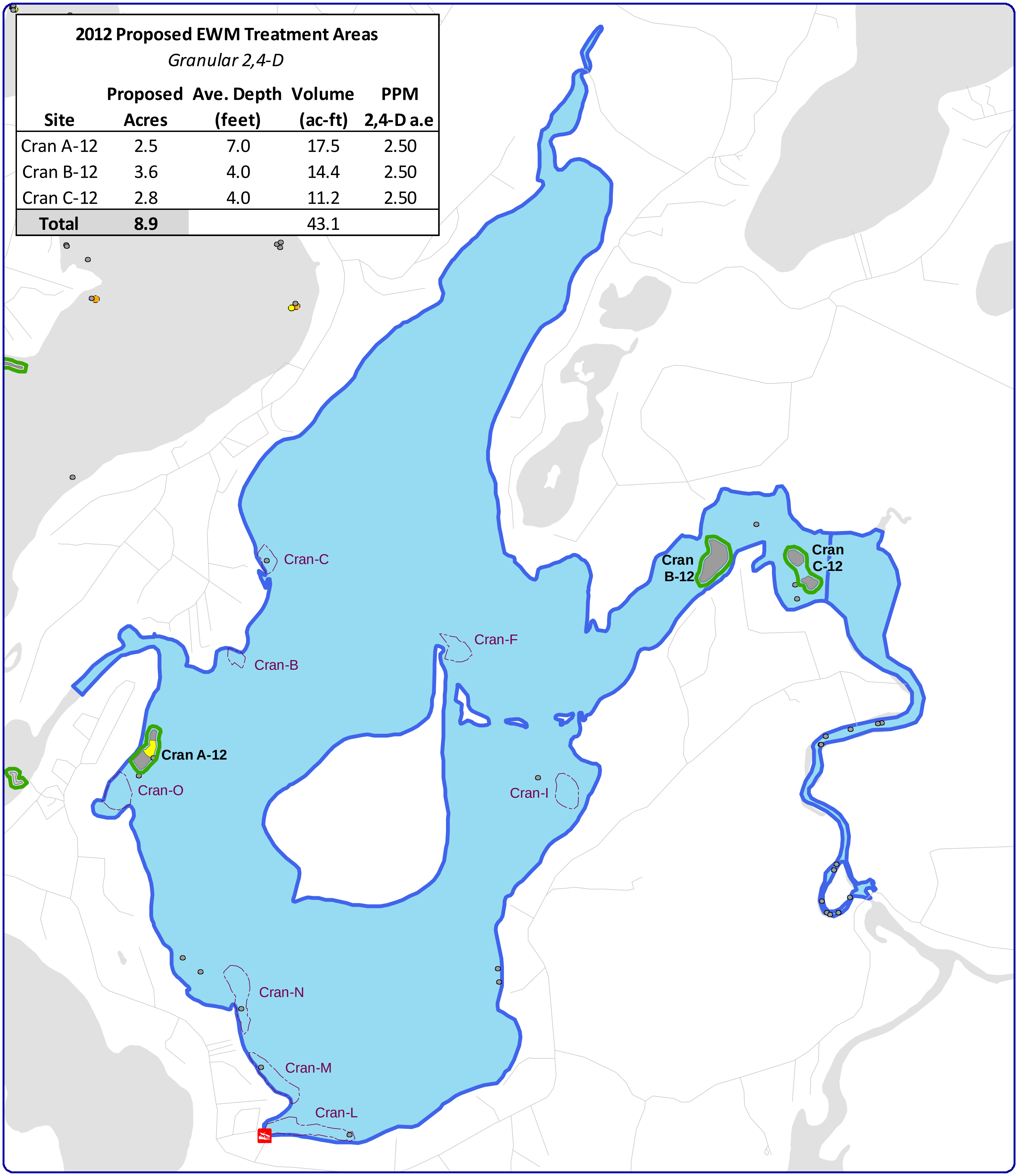
Oneida & Vilas Counties, Wisconsin

2010 EWM Locations & 2011 Treatment Areas

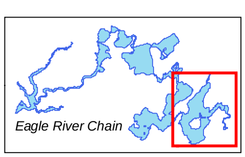
2012 Proposed EWM Treatment Areas

Granular 2,4-D

Site	Proposed Acres	Ave. Depth (feet)	Volume (ac-ft)	PPM 2,4-D a.e
Cran A-12	2.5	7.0	17.5	2.50
Cran B-12	3.6	4.0	14.4	2.50
Cran C-12	2.8	4.0	11.2	2.50
Total	**8.9**		43.1	



1,600
Feet



Extent of large map shown in red.

Legend

- Highly Scattered
- Scattered
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- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- 2011 Final Treatment Area
- 2012 Proposed Treatment Area

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Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra 2010-2011
Map Date: January 30, 2012
Filename: *Cran2_EWM_T2012_Cond1.mxd*

Cran 2
Cranberry Lake
Oneida & Vilas Counties, Wisconsin

2011 EWM Locations & 2012 Proposed Treatment Areas v.2