Herbicide Treatment Analysis for *Potamogeton crispus*

Bone Lake, Polk County WI

2015

Surveys, mapping and analysis provided by: Ecological Integrity Service, LLC

Amery, Wisconsin

Abstract

The herbicide endothall was applied to reduce *Potamogeton crispus*-curly leaf pondweed (CLP) on May 20 and June 4, 2015 in Bone Lake, Polk County Wisconsin. There were seven treatment beds totaling 30.15 acres in area. A pretreatment survey was conducted on April 19 and a post treatment survey was conducted on June 12 and 16 to evaluate the effectiveness. The surveys showed that the treatment resulted in a statistically significant reduction in CLP frequency comparing before treatment frequency to after treatment frequency (71.1% before treatment to 11.8% after treatment). A comparison between the 2014 post treatment survey and the 2015 post treatment survey showed a small increase in CLP frequency. Comparing the 2014 pretreatment survey to the 2015 pretreatment survey showed a small decrease that was not statistically significant. A native plant species evaluation revealed a statistically significant reduction in one species, *Ceratophyllum demersum*-coontail. A turion analysis conducted on Oct. 17, 2015 showed a decrease in the turion density in all beds from 2014 to 2015. The turion density remains high in two of the treatment beds. The remaining CLP that was dense and near the surface in Bone Lake was mapped on June 15 and 16. There was 49.5 acres of dense CLP remaining in 2015.

Introduction

An herbicide treatment was conducted on Bone Lake on May 20, and June 4, 2015 to reduce *Potamogeton crispus*-curly leaf pondweed (CLP). There were 7 beds treated, totaling 30.15 acres. This was the 8th year of treatment on 3 of the 7 beds (Beds 2,3,4) and the 7th year in Bed 5. Beds 6-8 were treated in 2013 for the first time (so this is the third year of treatment). Figures 1-3 are maps showing the location of each bed treated and the acreage. Beds 6 and 7 were separated into parts to better determine mean depths for the applicator concentration calculation. Also, beds 7 and 8 were delineated into shallow and deep sub-polygons in order to target acceptable herbicide concentration. The difference in color in those beds on the map shows the depth distinction.

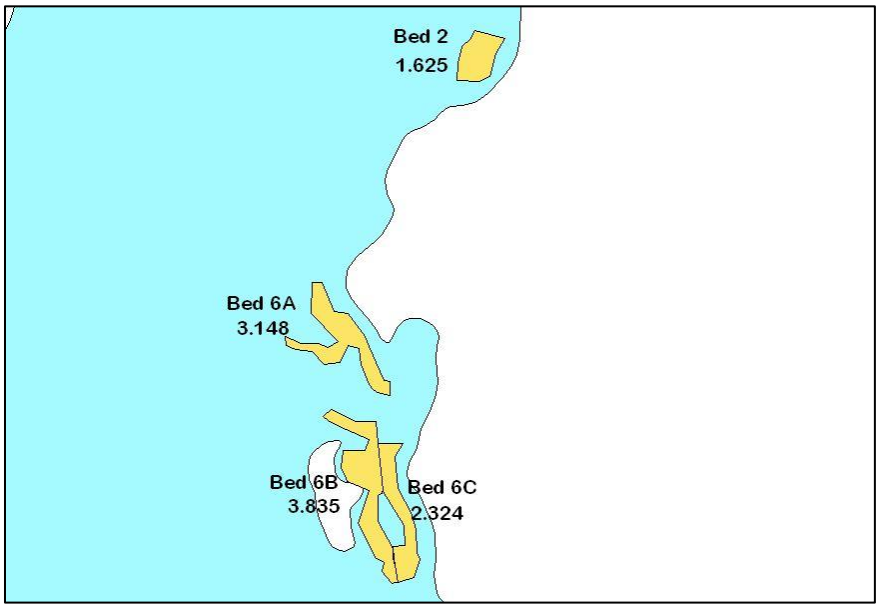


Figure 1: Bone Lake 2015 CLP treatment beds 2 and 6.

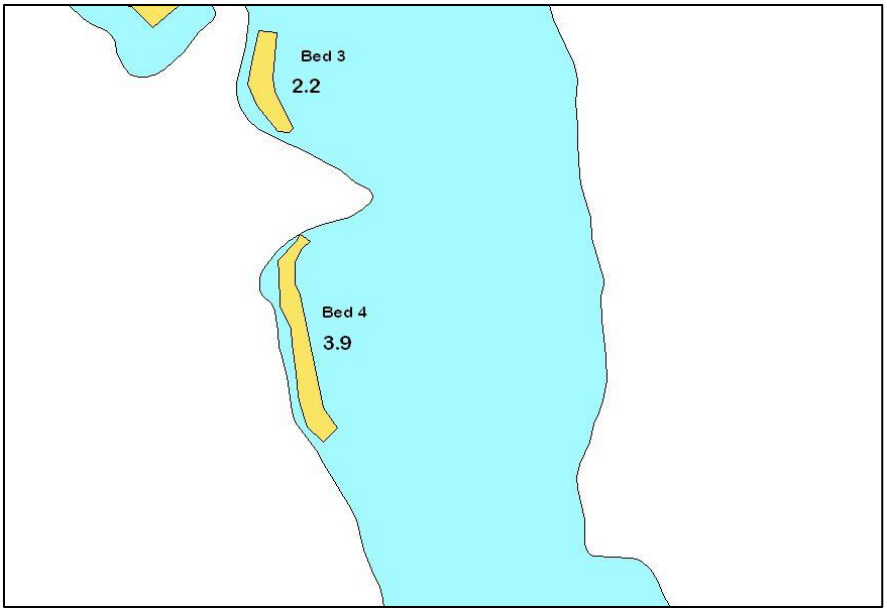


Figure 2: Bone Lake 2015 CLP treatment beds 3 and 4.

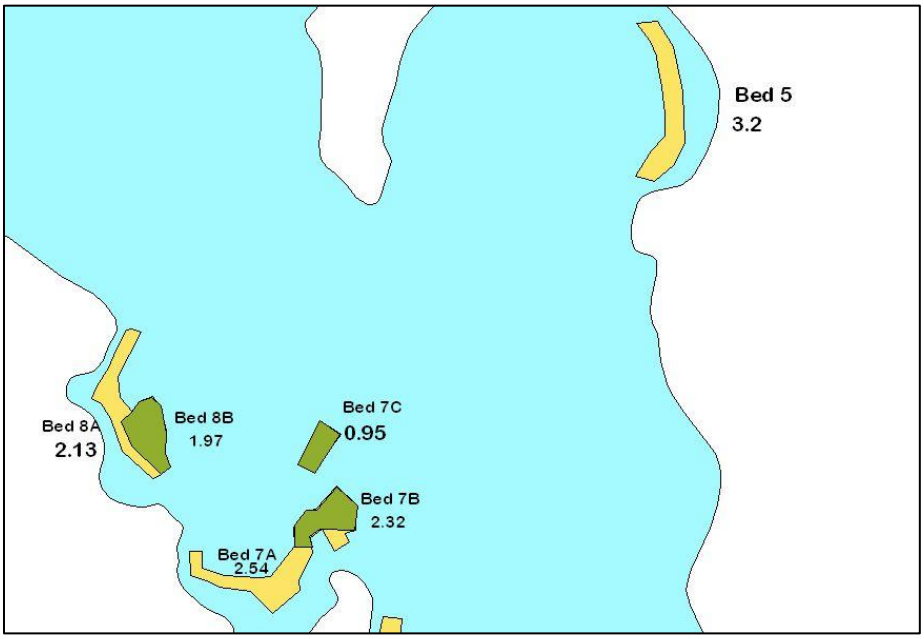


Figure 3: Bone Lake 2015 CLP treatment beds 5, 7 and 8.

The time between applications of herbicide was many days because a stringent protocol for application is adhered to. This protocol calls for no treatment unless wind speeds are less than 10 mph and forecast for less than 10 mph for 24 hours.

Bone 2015 CLP Treatment Bed Statistics							
Bed	**Acres**	**Mean depth**	**Acre feet**	**Date treated**	**Concen-tration(ppm)**	**Wind (mph)**	**Water Temp**
2	1.63	9.9	16.14	6/4/2015	2.5	1-5 (N/NE)	61°F
3	2.2	7.4	16.28	5/20/2015	2.0	0-5 (NW)	58°F
4	3.9	8.6	33.54	5/20/2015	2.0	0-5 (NW)	58°F
5	3.2	8.2	26.24	6/4/2015	2.0	1-5(N/NE)	61°F
6A	3.15	6.6	20.79	6/4/2015	2.0	1-5(N/NE)	61°F
6B	3.84	7.5	28.80	6/4/2015	2.0	1-5(N/NE)	61°F
6C	2.32	7.7	17.86	6/4/2015	2.0	1-5(N/NE)	61°F
7A	2.54	7.4	18.80	5/20/2015	2.0	0-5 (NW)	58°F
7B	2.32	10.7	24.82	5/20/2015	2.5	0-5 (NW)	58°F
7C	0.95	11.4	10.83	5/20/2015	2.5	0-5 (NW)	58°F
8A	2.13	6.2	13.21	5/20/2015	2.0	0-5 (NW)	58°F
8B	1.97	9.6	18.91	5/20/2015	2.5	0-5 (NW)	58°F
Total	30.15		246.22				

Table 1: Bone Lake 2015 CLP treatment bed data summary.

Table 2: Bone Lake CLP treatment bed descriptions.

Bed	Description
2	Bed 2 lies to the north on the east shore. It is the smallest bed. This bed has been treated for 7 years prior to 2014. The depth drops off quickly on the lake side and gets quite shallow near shore. The CLP has been most dense in the southern portion of the bed and quite sporadic in coverage on the north. The effectiveness of treatment has been most consistent in this bed, but only very effective the last four years. The northern portion of this bed was eliminated for treatment in 2015 as not CLP has been found there for some time.
3	Bed 3 lies on the western shore just north of Bed 4. This bed is the smallest but has a history of being very dense, especially in the northern half of the bed. Treatment results have been inconsistent, but effective the last four years.
4	Until 2013, Bed 4 was the largest bed, but has been shrinking due to reduced CLP. This bed borders deep water and has been very inconsistent in response to treatment. It has been speculated that wind may be a factor in the results so treatment has been limited to winds below 10 mph. The middle portion of the bed has been the most dense, with the north and south end being more sporadic. There are a large number of piers bordering this bed on the west shore.
5	This bed has been treated one year less than beds 2,3 and 4. It lies on the east shore, south of bed 2. Bed 5 has been very dense in the southern half of the bed. The treatment has been very inconsistent in terms of effectiveness including 2012, in which it responded the least of all beds to the herbicide. The 2013 and 2014 treatments were more effective. It also borders deep water.
6	Bed 6 is made up of three separate areas. This is one of the densest areas of CLP on Bone Lake. Historically navigation channels have been treated within the area of this bed. Also, the bed borders a sensitive habitat area established many years ago by the Wisconsin DNR. To reduce adverse effects on this area, the bay to the north of the bed has been avoided. This

	bed lies adjacent (east) of Eagle Island. Much of the bed reaches the surface each year. Treatment has been quite effective in 2013 and 2014.
7	Bed 7 is divided into two parts. One is a small portion to the north of the main part of the bed. The bed lies on the west shore north of bed 3. The bed is most dense in the middle portion with the west arm being very narrow in coverage and reduced in density as moving west. The small north portion that stands alone is dense, but in deep water (8-10 feet). Bed 7 historically has been very dense with CLP reaching the surface every year.
8	Bed 8 is just north of bed 7 on the west shore. It is relatively shallow and flat, but borders deep water on the lake side. This bed has been extremely dense in past years with CLP reaching the surface in most of the bed. Beds 6, 7 and 8 were treated first in 2013. Bed 8 had quite a large amount of CLP growing after treatment in 2014, mainly in deep water. This bed has been divided into a deep and shallow region to increase the effectiveness of the herbicide.

Methods

To conduct and analyze the treatment, two surveys are conducted following the protocol outlined in 2009 by the Wisconsin DNR. The first survey is referred to as a pretreatment survey. This involves going to predetermined GPS coordinates within the proposed treatment area. A high definition underwater camera as well as a rake is used to determine the presence of CLP at each sample point. Density is not measured as the plants are typically very small and density is very subjective and variable. The presence of CLP is simply determined. There are also points checked outside of the bed delineation to assure the boundary is correct (not recorded unless CLP was present).

The second survey is referred to as the post treatment survey. This survey involves going to the same GPS coordinates as the pre-treatment survey and doing a rake sample at the point. If any CLP is on the rake, the density of the CLP is recorded (see Figure 2 for reference). All other species are also recorded from the rake sample in order to verify no damage to the native plants.

Figure 4: Density rating system and example CLP rake sample.

When the surveys are complete, the frequency of occurrence is determined as well as the mean density for each bed and all beds combined. The frequency of occurrence for each native plant species sampled is also calculated. A chi-square analysis is then used to determine if the change in frequency is statistically significant ($p<0.05$). With a successful treatment, the chi-square analysis shows that the frequency of CLP is significantly reduced and the native plants are not significantly reduced.

The comparison for reduction is evaluated three ways. First, the result from the previous year's post treatment survey is compared to the present year post treatment survey. This reflects a long-term effectiveness. As more treatments are done in annual succession, these frequency values can become very similar since the CLP growth is reduced so much. This can make it appear the treatment is not progressing successfully since the frequency appears to not be reduced. Each year, turions which germinate in the fall/winter create new growth. The result may be a low frequency in the post treatment survey, but with turion germination, high frequency CLP growth can result the following spring.

Second, in order to reflect the effect the treatment has on new spring growth, a second comparison is done. This compares the frequency of CLP in the spring, pre-treatment survey to the post treatment results in that same year. This shows what the CLP growth was just before treating and the result after treatment.

The third evaluation is comparing the pretreatment survey of the previous year(s). Since the spring growth will reflect CLP growth after turion germination, a reduction in the pretreatment frequency can show an overall reduction in CLP due to reduced turion germination, thus reflecting an overall reduction in CLP and its turions.

In the end, we want to see a statistically significant reduction when comparing the pre-treatment frequency to the post treatment frequency. We would also like to see a consistent frequency reduction from year to year, depending on how low it is in both the pre and post treatment surveys of successive years. If the frequency in any post treatment survey is very low (less than 10% as an example), then lowering it even more may be difficult. Turions can remain viable for several years, which can affect reduction amounts achieved.

In order reflect potential future growth and the cumulative success of treatments, a turion analysis is conducted in the fall following treatment. This analysis involves going to sample points near the middle of the CLP bed (assuming this will reflect the highest density). At each sample point a sediment sampler is lowered to the lake sediment and a sediment sample is obtained. Two samples are obtained from each side of the boat at each location. The samples are then sifted with a screened bucket to isolate the turions. The turions are then counted and the density of turions is calculated in turions/square meter. Consistently successful treatments should show a trend of reduced turion density each year. This way we know the treatments are killing plants prior to turion production, resulting in overall reduction in CLP in those beds.

a

b

c.

Figure 5: Pictures showing turion density methods. A shows sediment sample; b shows separation; c Shows separated turions.

Results

A pre-treatment survey was conducted on April 19, 2015 and a post treatment survey was conducted on June 12 (in bed treated May 20) and June 16 (in bed treated June 4). Bed 2 was reduced significantly due to no CLP in the north portion of the bed. The comparison of the various surveys in 2014 and 2015 indicate some reductions that were significant and some not significant (and one small increase). Table 3 and Figures 6 and 7 summarize the frequency of occurrence from the various surveys. Table 4 summarizes the reductions and/or increases in frequency with chi-square results.

Bed	2015 pretreat frequency	2015 posttreat frequency	2014 pretreat frequency	2014 post treat freq.
2	72.2%	16.7%	52.0%	8.0%
3	72.7%	13.6%	77.3%	4.5%
4	47.8%	2.2%	44.4%	2.2%
5	58.8%	5.9%	47.0%	8.8%
6	81.25%	18.75%	93.6%	4.8%
7	77.8%	15.6%	95.3%	23.3%
8	85.3%	8.8%	96.9%	31.2%
All beds	**71.1%**	**11.8%**	**74.6%**	**11.3%**

Table 3: 2015 (and 2014) CLP survey statistic summary.

Survey Freq. Comparison	Significant reduction?	Chi-square P value
2015 Pre to 2015 Post	Yes	$P=2.3X10^{-43}$
2014 Post to 2015 Post	No, increase(not sig.)	P=0.89
2014 Pre to 2015 Pre	No	P=0.38

Table 4: Comparison and chi-square results of frequency in 2014 and 2015 surveys.

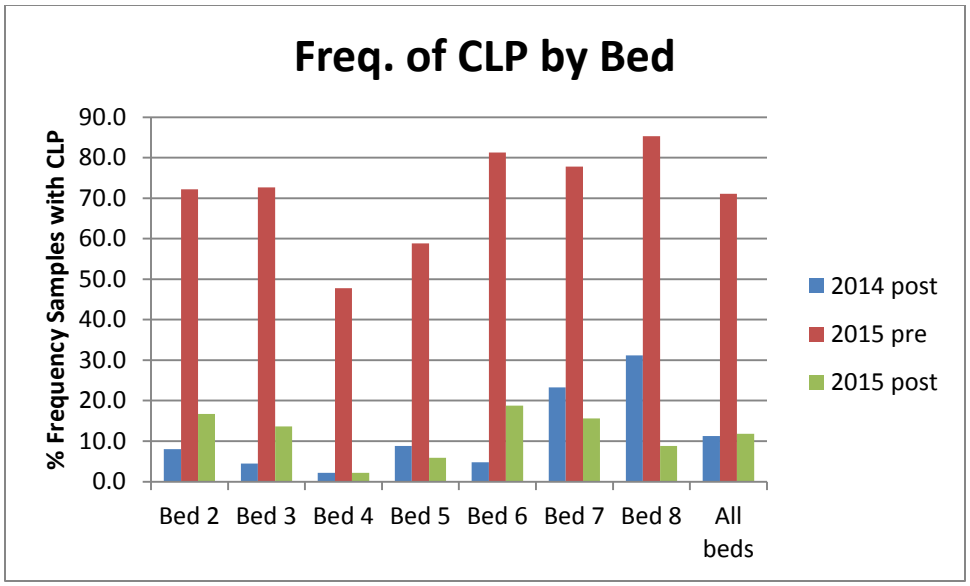


Figure 6: Frequency of occurrence of CLP 2014 to 2015 in each treatment bed.

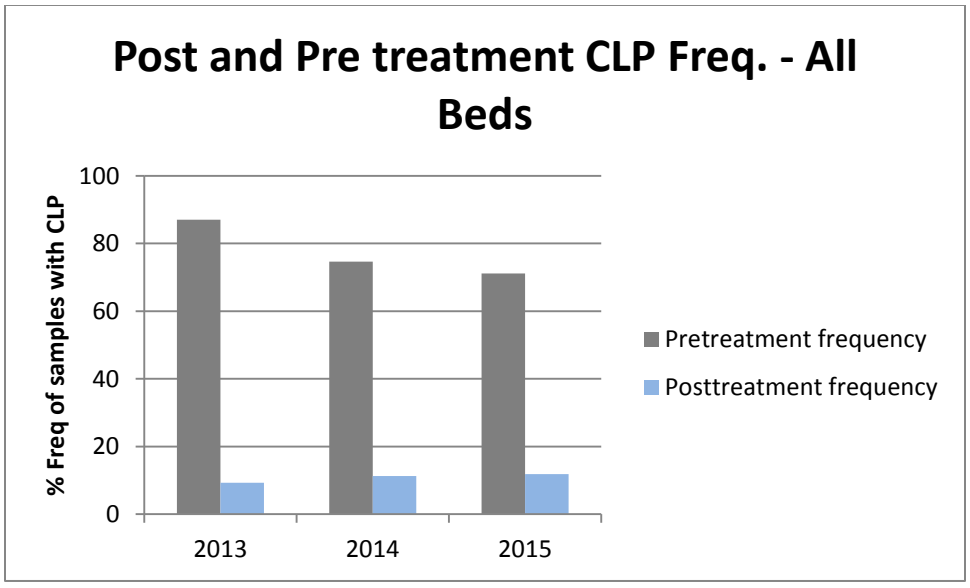


Figure 7: Frequency of occurrence of CLP in all beds pre and post treatment 2013-2015.

Density is also determined in the post treatment surveys only. Table 5 and Figure 8 show changes in mean density from the last three post treatment survey years.

Mean Density-All Beds	2013	2014	2015
Post treatment mean density (0-3 rating)	0.1	0.14	0.16

Table 5: Mean density statistics, 2013-2015, all beds.

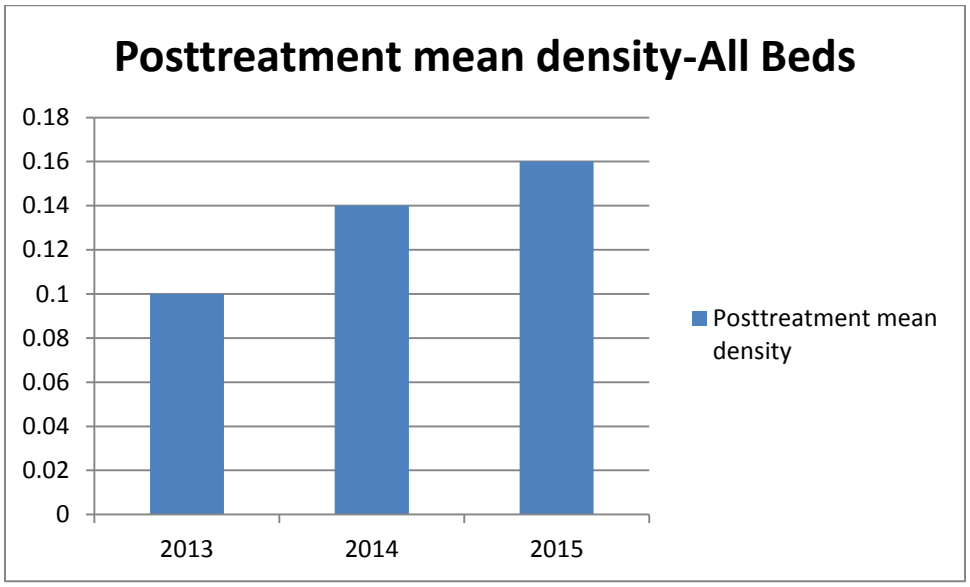


Figure 8: CLP mean density 2013-2015, all treatment beds.

Figures 9-12 show the frequency of occurrence in each bed in the pretreatment and post treatment surveys, 2015. The density is also displayed in the post treatment survey.

Pretreatment survey: **Red = CLP present** White = CLP absent

Post treatment survey: White=0 **Green = 1** Yellow = 2 **Red = 3**

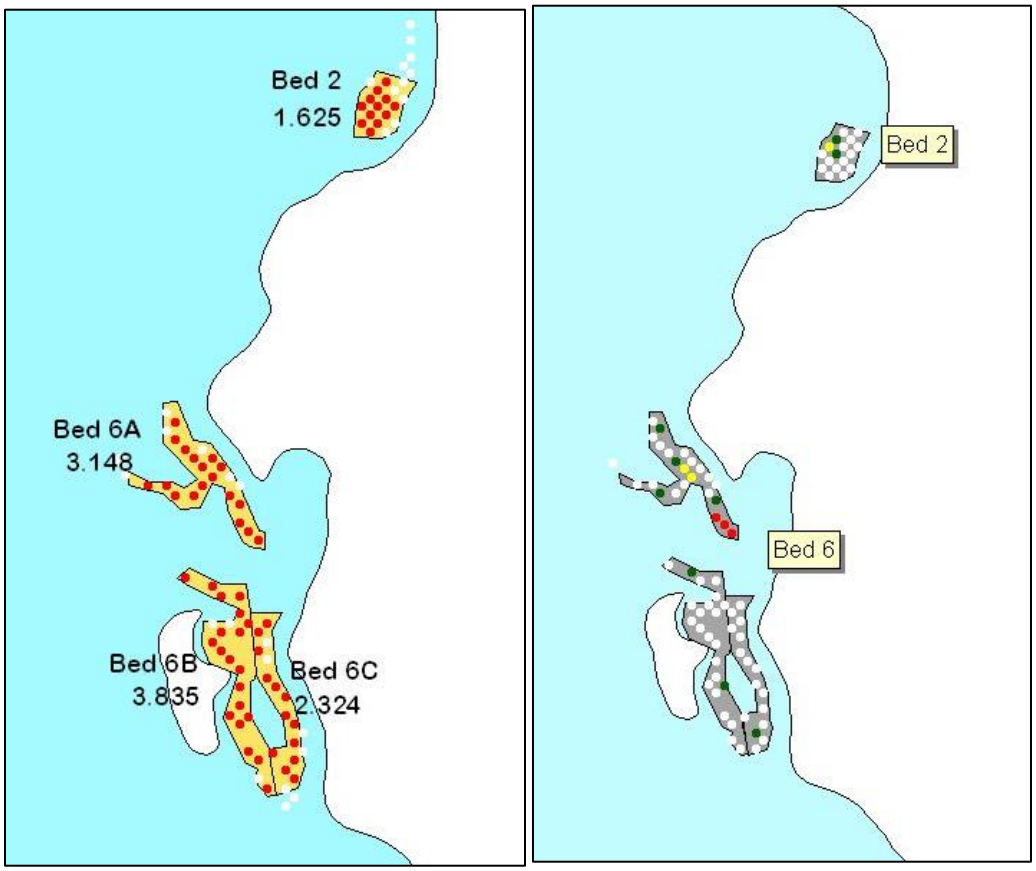


Figure 9: Pre and post treatment CLP distribution maps for Beds 2 and 6.

As the data shows, there was a significant reduction in CLP when comparing the pretreatment survey of 2015 and the post treatment survey of 2015. After the 2014 treatment, the CLP growth returned filling in much of the treatment polygons leading to a high frequency in the April pretreatment survey. After treatment occurred, the post treatment survey in June showed the frequency was significantly reduced.

A comparison between the 2014 post treatment frequency/density to the 2015 post treatments shows a slight increase (0.5%) in frequency in all beds. This indicates that the long-term reduction is not changed, but is not a big concern because the frequency in the post treatment in both 2014 and 2015 was low.

Comparing the pretreatment survey in 2014 to 2015 can show true long term reduction since this survey is conducted after the CLP has grown back in the winter/spring. This comparison shows a slight

decrease in frequency. This is a good trend even though small as it shows continued reduction in CLP. This reduction was not statistically significant.

The density in CLP in the post treatment surveys has shown small increases. The 2015 treatment occurred very late in the east side beds and appears to not have responded to herbicide as well as the west side beds, which got treated much earlier in the spring. This is likely reflected in the increased density values, especially in Bed 6.

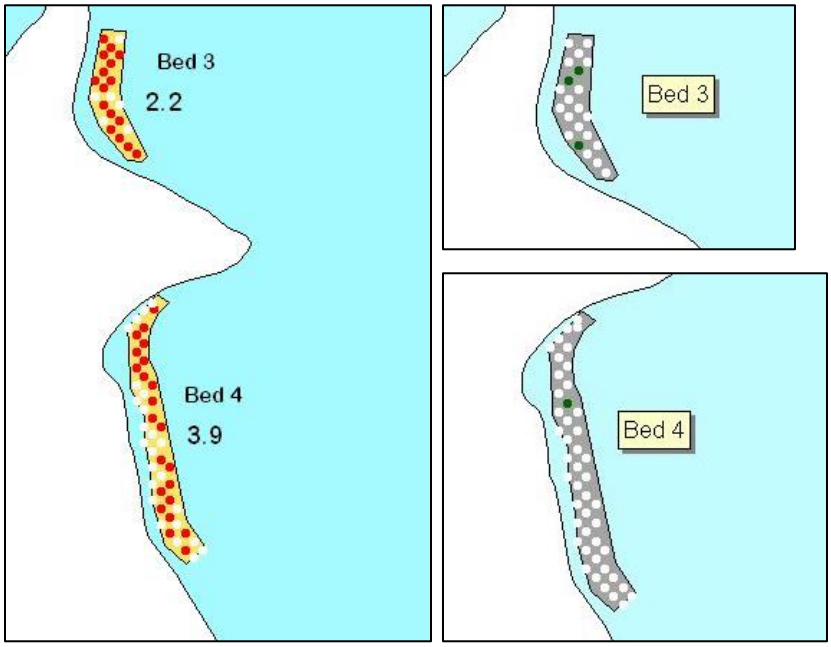


Figure 10: Pre and post treatment CLP distribution Beds 3 and 4.

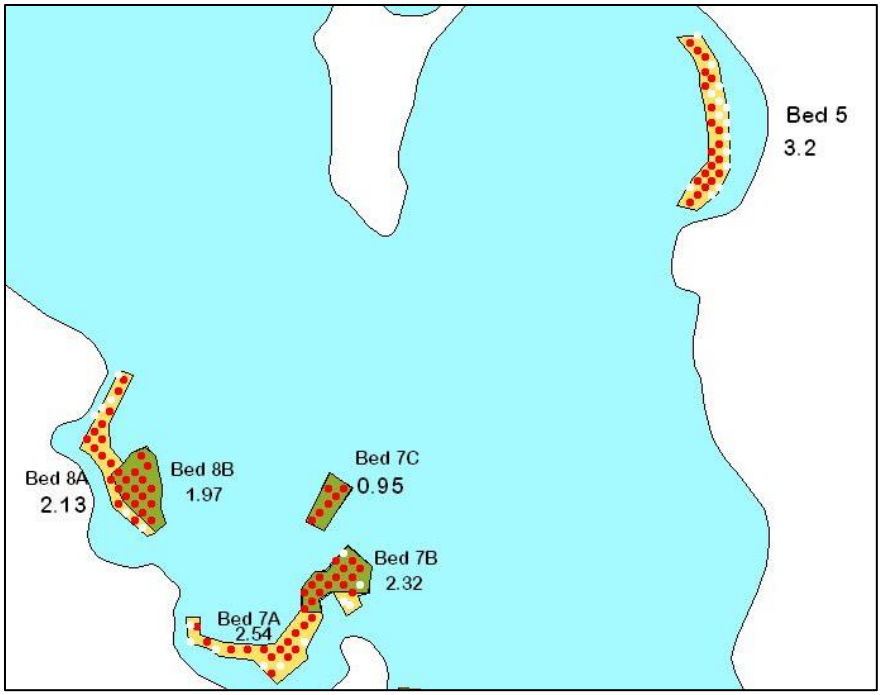


Figure 11: Pretreatment CLP distribution map Beds 5, 7 and 8.

Figure 12: Post treatment CLP distribution Beds 5,7 and 8.

Native Plant Response

In addition to the evaluation of the CLP changes, the native plant species are evaluated for any reductions, potentially due to herbicide application. Table 5 shows the frequency of native species in 2014 and 2015. A chi-square analysis is calculated to determine if the changes are statistically significant. One native species had a significant reduction; *Ceratophyllum demersum*-coontail. It Is possible this reduction is due to the herbicide as coontail could have been out of dormancy at the time of treatment. Endothall is a broad spectrum herbicide so it can affect most plant species. There were also increases in seven native species, so the herbicide had minimal impact on the native plants. Table 6 and Figure 13 summarize the native species data.

YEAR	*Potamogeton zosteriformis*	*Potamogeton richardsonii*	*Nitella sp.*	*Lemna triscula*	*Heterantehra dbuia*	*Ceratophyllum demersum*	*Bidens beckii*	*Potamogeton praelongis*	*Najas flexilis*	*Vallisneria americana*	*Myriophyllum sibiricum*	*Stuckenia pectinatus*	*Ranunculus aquatilis*	*Chara sp.*	*Elodea canadensis*
2014	0.00	0.01	0.01	0.16	0.02	0.39	0.01	0.02	0.01	0.06	0.08	0.01	0.00	0.00	0.00
2015	0.004	0.01	0.01	0.20	0.05	0.23	0.04	0.04	0.01	0.13	0.38	0.01	0.02	0.07	0.04
Change	**+**	**n/c**	**n/c**	**+**	**+**	**-**	**+**	**+**	**n/c**	**+**	**+**	**n/c**	**+**	**+**	**+**
Reduction Significant						Yes (p= 0.004)									

Table 6: Native plant frequency of occurrence, 2014 and 2015 with change and significance based upon chi-square analysis.

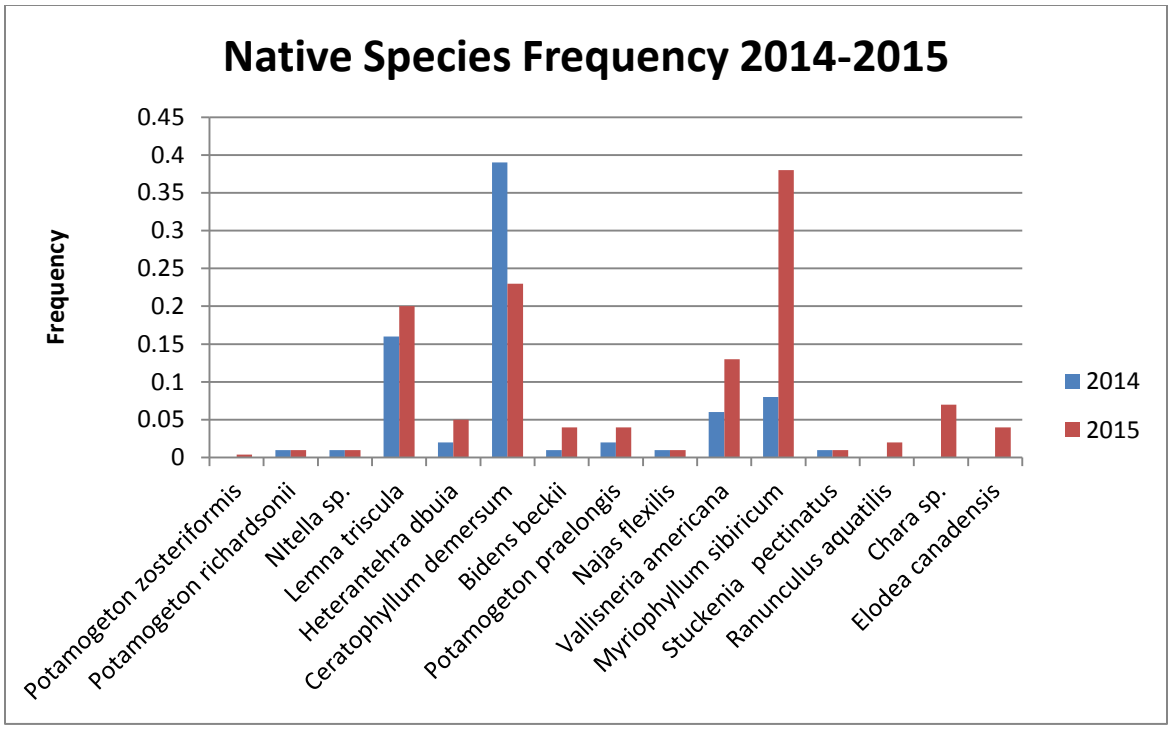


Figure 13: Native plant species frequency, all beds, 2014 and 2015 for comparison.

Turion Analysis

The turion analysis data collection was conducted on Oct. 17, 2015. Table 6 shows the turion density for each treatment bed in 2015, and previous years the analysis was conducted in all treatment beds.

Bed	2011(T/m2)	2012(T/m2)	2013(T/m2)	2014(T/m2)	2015(T/m2)
2	75	27	34.7	10.9	0
3	269	65	79.4	48.8	0
4	512	47	29.8	36.2	28.7
5	274	161	64.5	76	75.25
All (2-5)	296	75	49.6	43.0	25.99
6	n/a	n/a	421.6	384.1	303.2
7	n/a	n/a	165.3	178.4	38.2
8	n/a	n/a	489.4	271.3	258
All(6-8)	n/a	n/a	358.8	277.9	199.8

Table 7: Turion density data all treatment beds, 2011-2015.

There was a decrease in the turion density in all treatment beds. Bed 7 had the most dramatic decrease from 178.2 turions/m^2 to 38.2 turions/m^2. The mean turion density for all beds was separated based upon years of treatment. Beds 2-5 have been treated for more years and has more turion data going

back to 2011. Beds 6-8 only have turion density data going back to 2013. The mean turion density decreased for beds 2-5 and for beds 6-8 in 2015 compared to previous years.

Figures 14-16 show the turion density within each bed. The number of turions/m^2 is labeled adjacent to the sample point on the maps. The darker and larger the dot, the more turions, with white being zero.

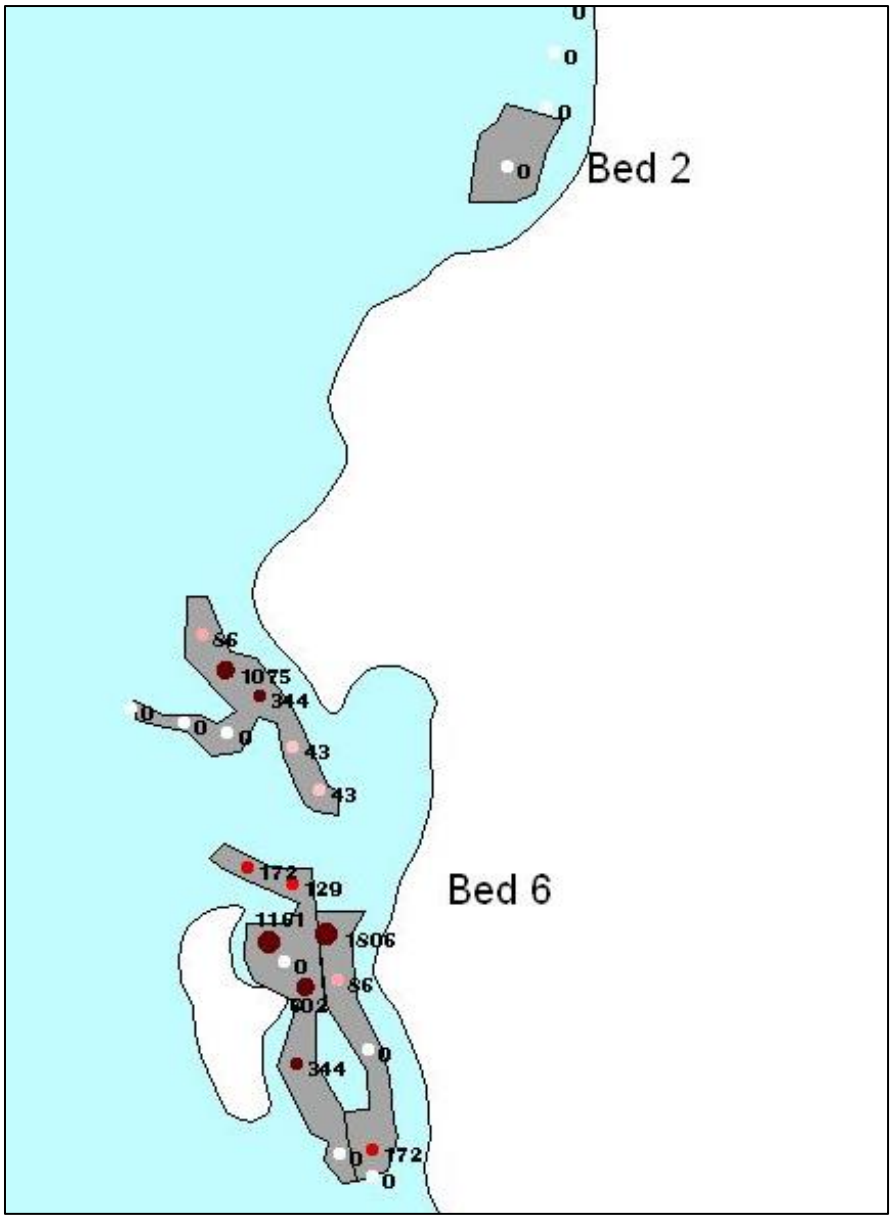


Figure 14: Turion density map for beds 2 and 6.

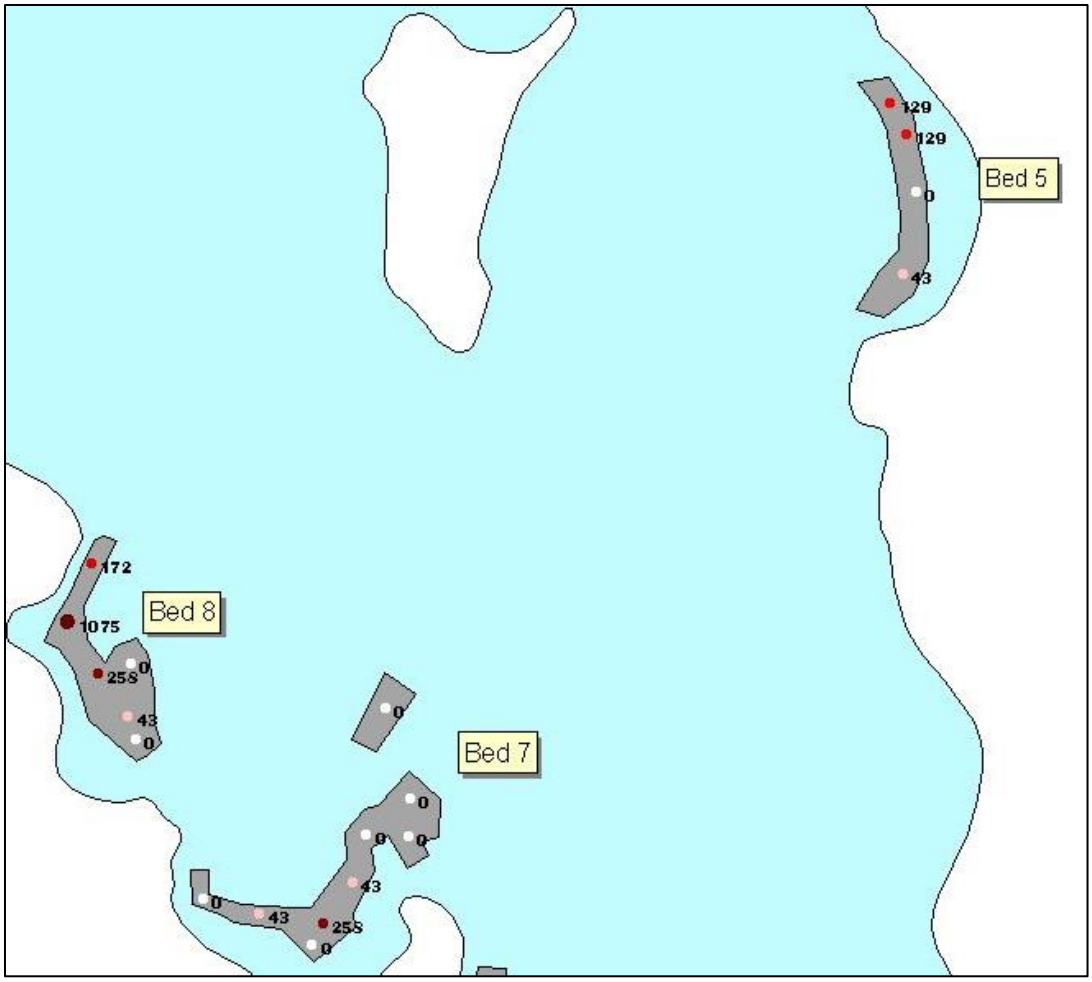


Figure 15: Turion density map for beds 5, 7 and 8.

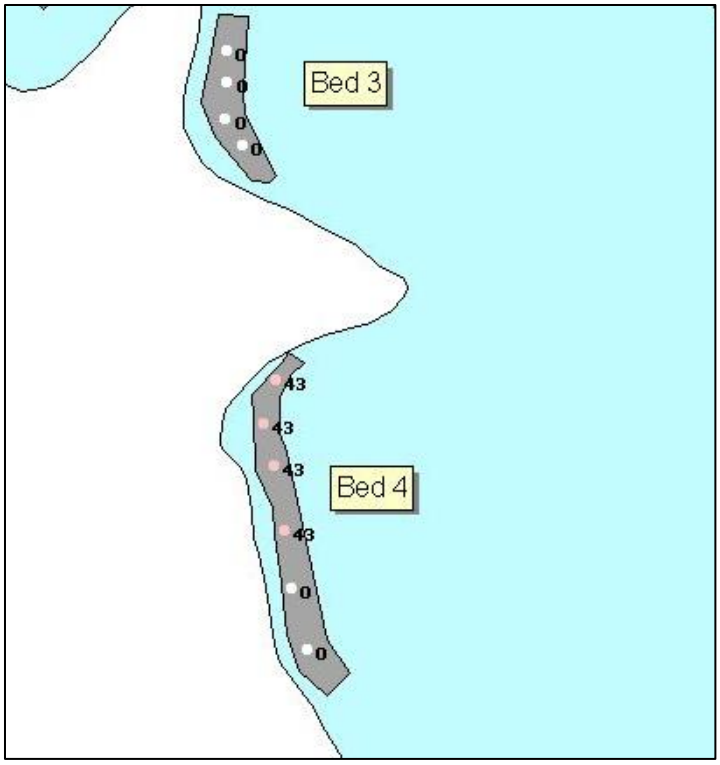


Figure 16: Turion density map for beds 3 and 4.

Figure 17 is a bar graph of the turion density by bed and all beds combined (separated as beds 2-5 and 6-8 due to total years of treatment).

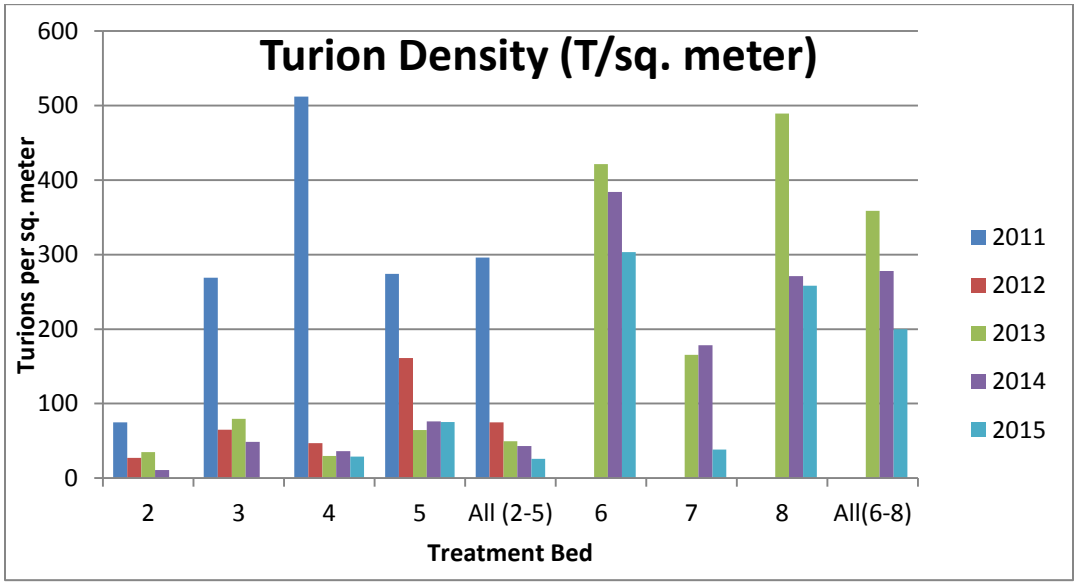


Figure 17: Turion density by bed 2011-2015.

Figure 18 graphically shows the turion density that has been occurring in all beds. As successful treatments continue, the turion density should continue to decrease, resulting in less CLP growing each spring within these treatment beds.

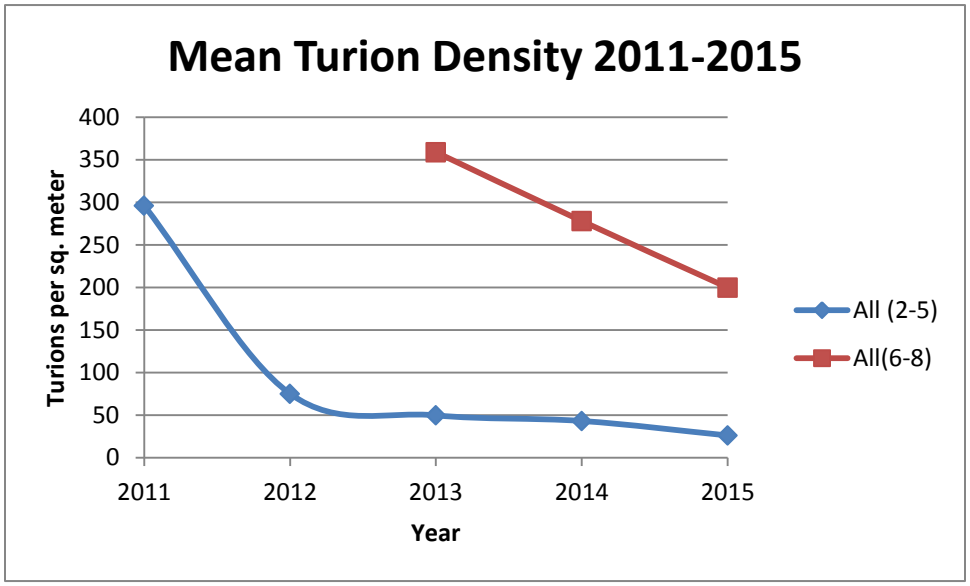


Figure 18: Mean turion density change, 2011-2015.

CLP Bed Mapping

On June 16 and 17, the CLP outside of the treatment beds was mapped. The 2015 mapping survey resulted in an increase in CLP coverage as compared to 2014. In 2014, the CLP was difficult to map due to lack of plants reaching the surface. In 2015, the CLP seemed to rebound likely responding to an earlier growing season due to an earlier ice out date.

Figures 19 and 20 show the CLP beds mapped in 2015. These beds have high density CLP that has growth near or reaching the surface. The total area was 49.5 acres.

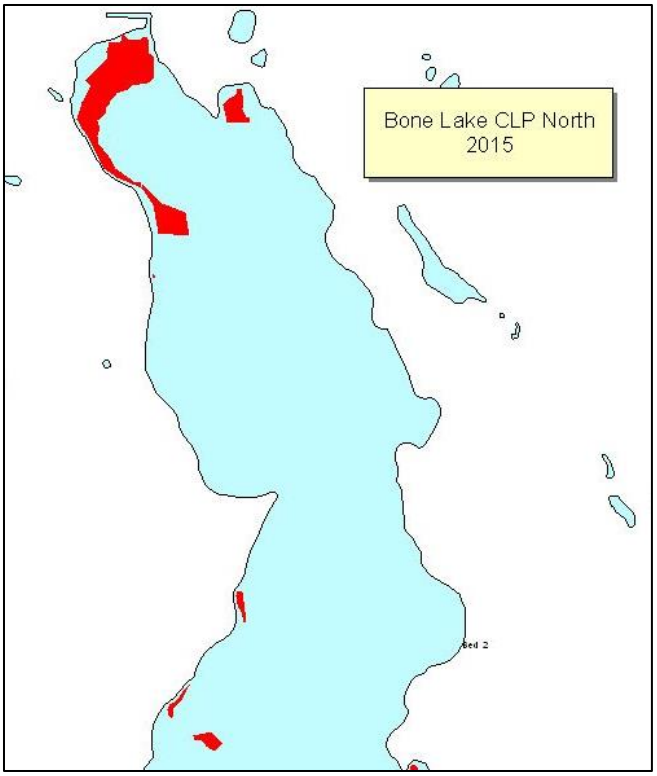


Figure 19: CLP map of dense, surface beds north.

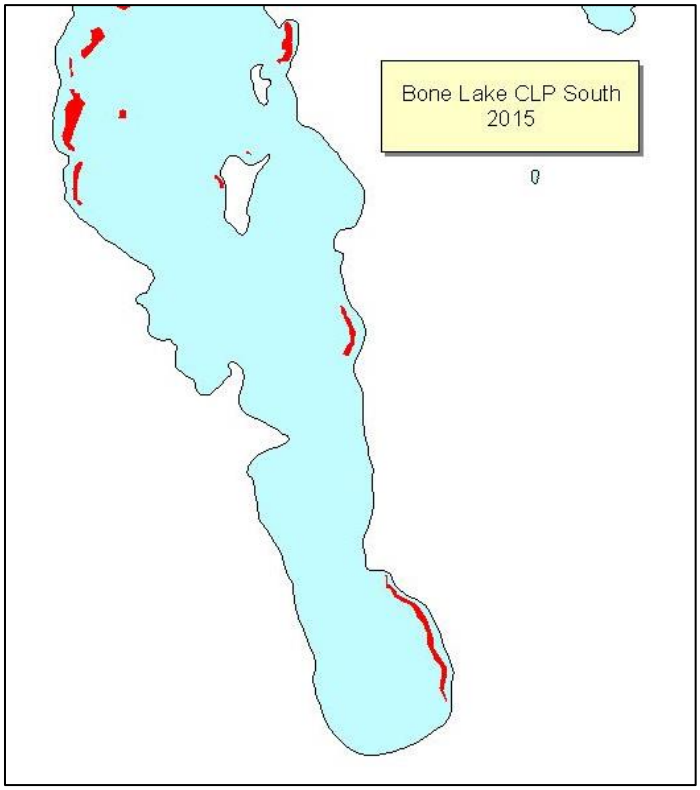


Figure 20: CLP map of dense, surface beds south.

Discussion

The data shows that the CLP treatment was successful in 2015 at reducing the CLP that was growing in April (before treatment). This reduction was much more profound in the western beds, which were treated much earlier in the spring than the eastern beds. This could be the result of older, larger plants being less susceptible to the herbicide (see density maps in figures 9 –12). The eastern treatment was delayed because there have been strict guidelines in regard to wind conditions for treatment put into place. Historically, treatments completed during or followed by even moderate wind speeds have reduced effectiveness of treatment. There was a slight increase from the 2014 post treatment to the 2015 post treatment, largely due to CLP growth after treatment in Bed 6 (6A). The pretreatment 2014 compared to pretreatment 2015, had a slight decrease but was not significant statistically. This does support some long term CLP reduction.

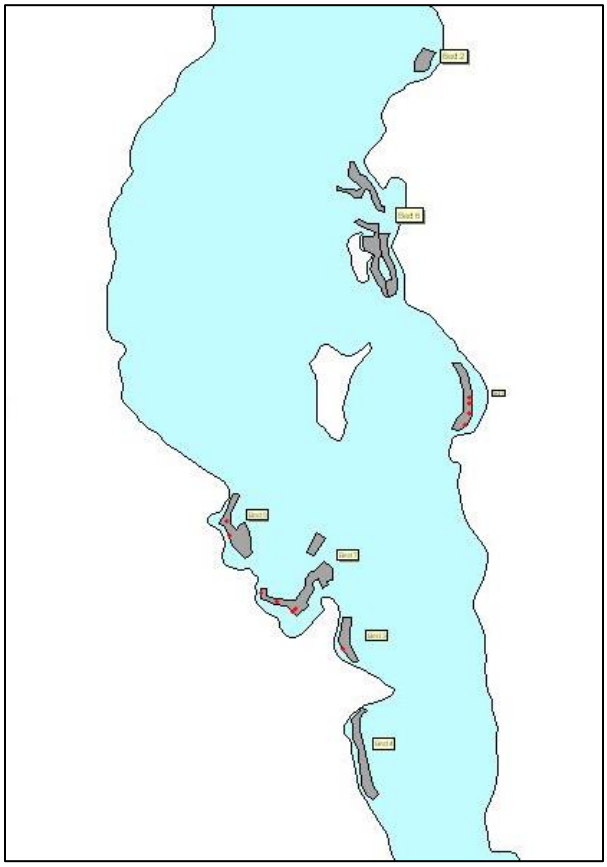
The native plants were affected very little, with a significant reduction in coontail. Coontail is one of only a few native plants that typically are not dormant (actively growing) during CLP treatment. As result, it can be more susceptible to herbicide application.

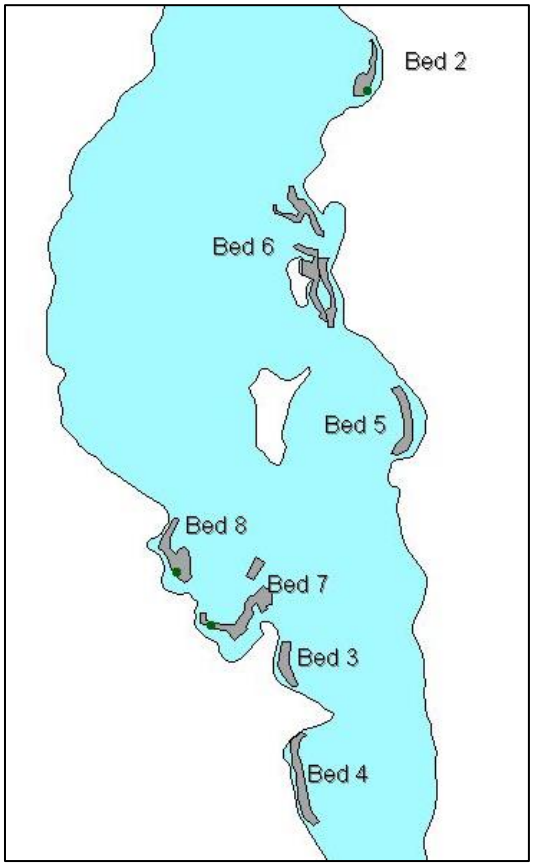
The turion density analysis showed a small decrease in turions in all beds. This supports a long term trend in CLP reduction. With more successful treatments in the future, the turion density should decrease resulting in less CLP growth each spring. This should eventually result in significant reduction in the treatment area within the treatment beds.

There remains a rather large area of dense CLP beds growing in Bone Lake. A survey of the CLP outside of the treatment areas at or near peak growth resulted in the delineation of 49.5 acres of CLP that is dense and at or near the surface.

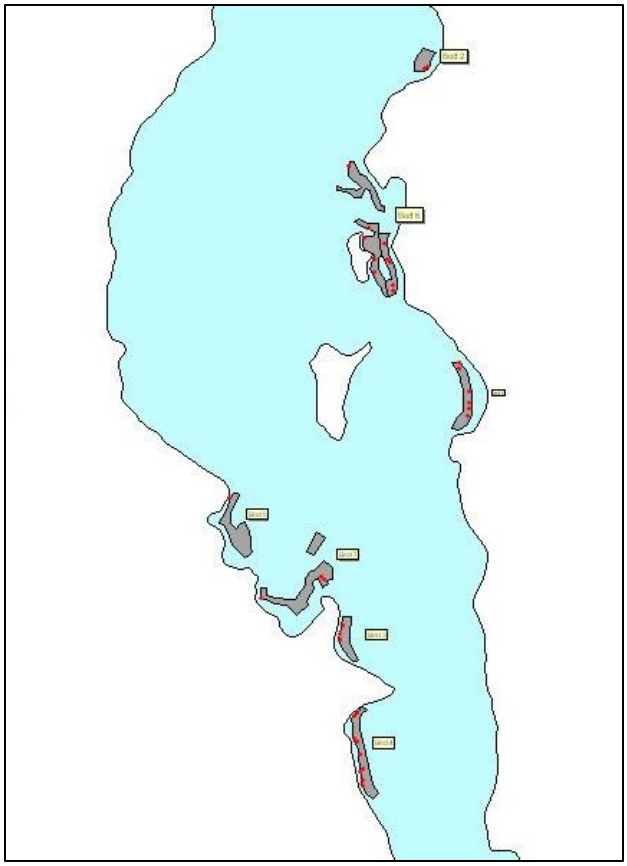
It is recommended that treatment continue in all treatment beds. Turion density is decreasing immensely in beds 2,3, 4 and 5. The spring pretreatment survey may lead to reduction in the treatment area within these beds. Beds 6,7 and 8 have not been treated as many years and so the treatment area should continue as the same size until further reductions are made.

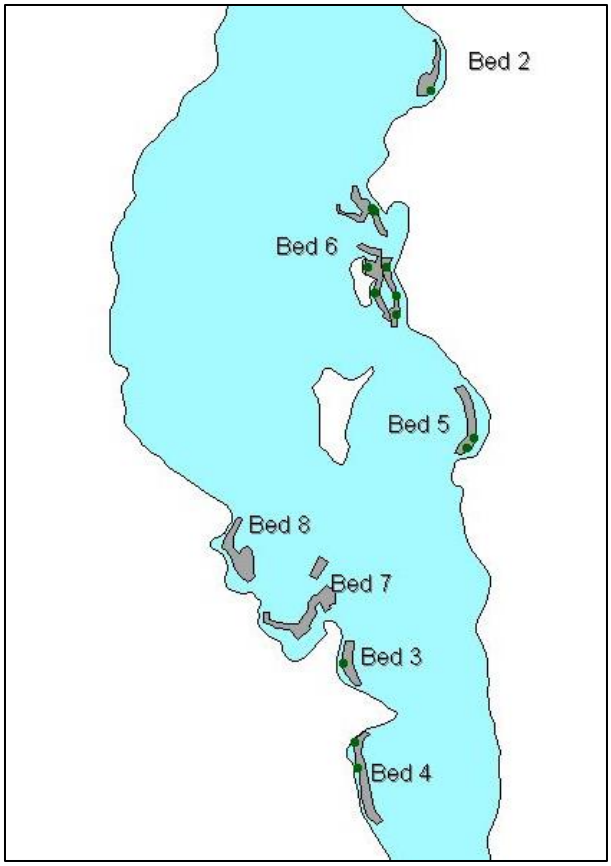
Appendix-Native Plant Distribution Maps



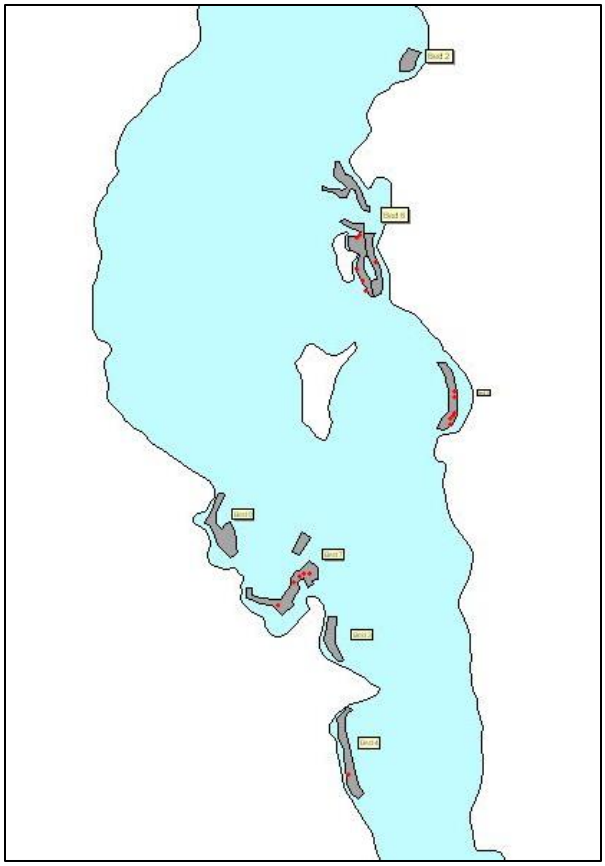


***Bidens beckii*-Water marigold 2015** **2014**

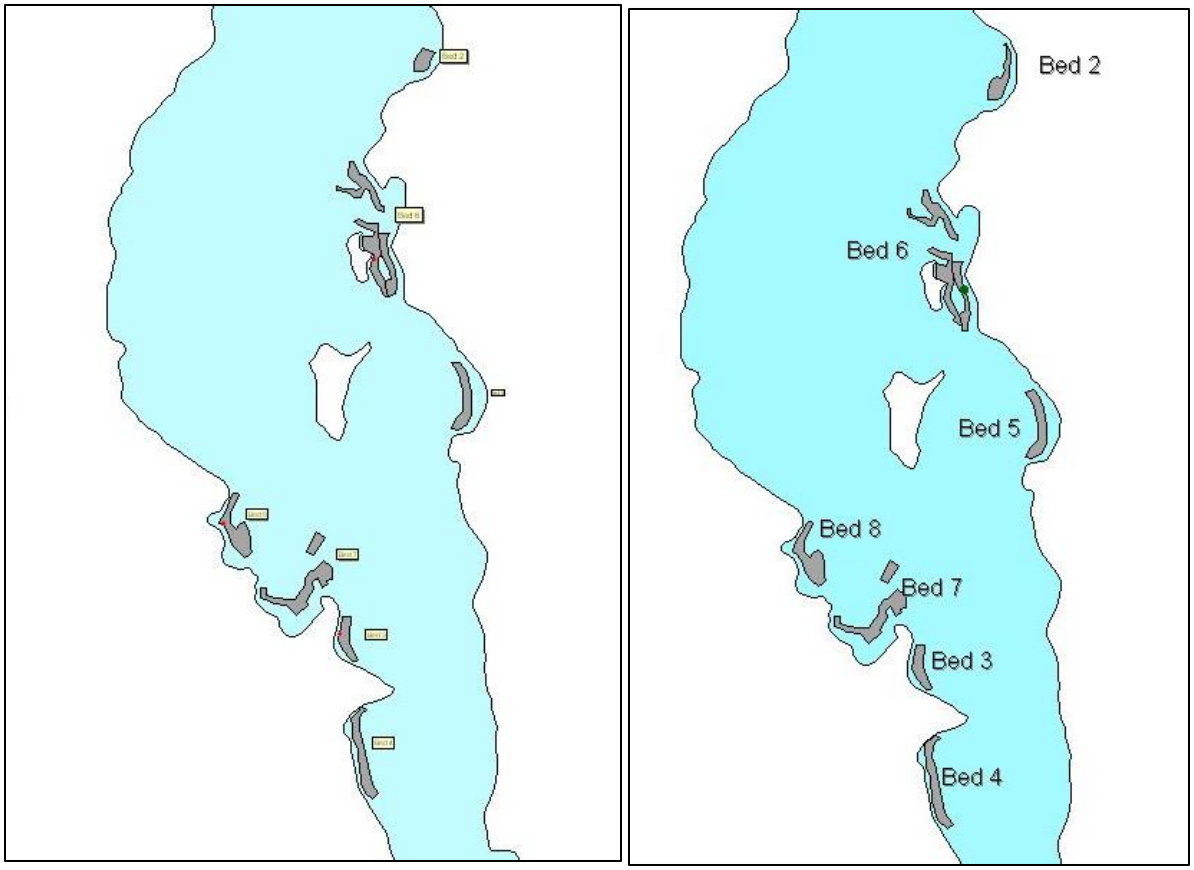




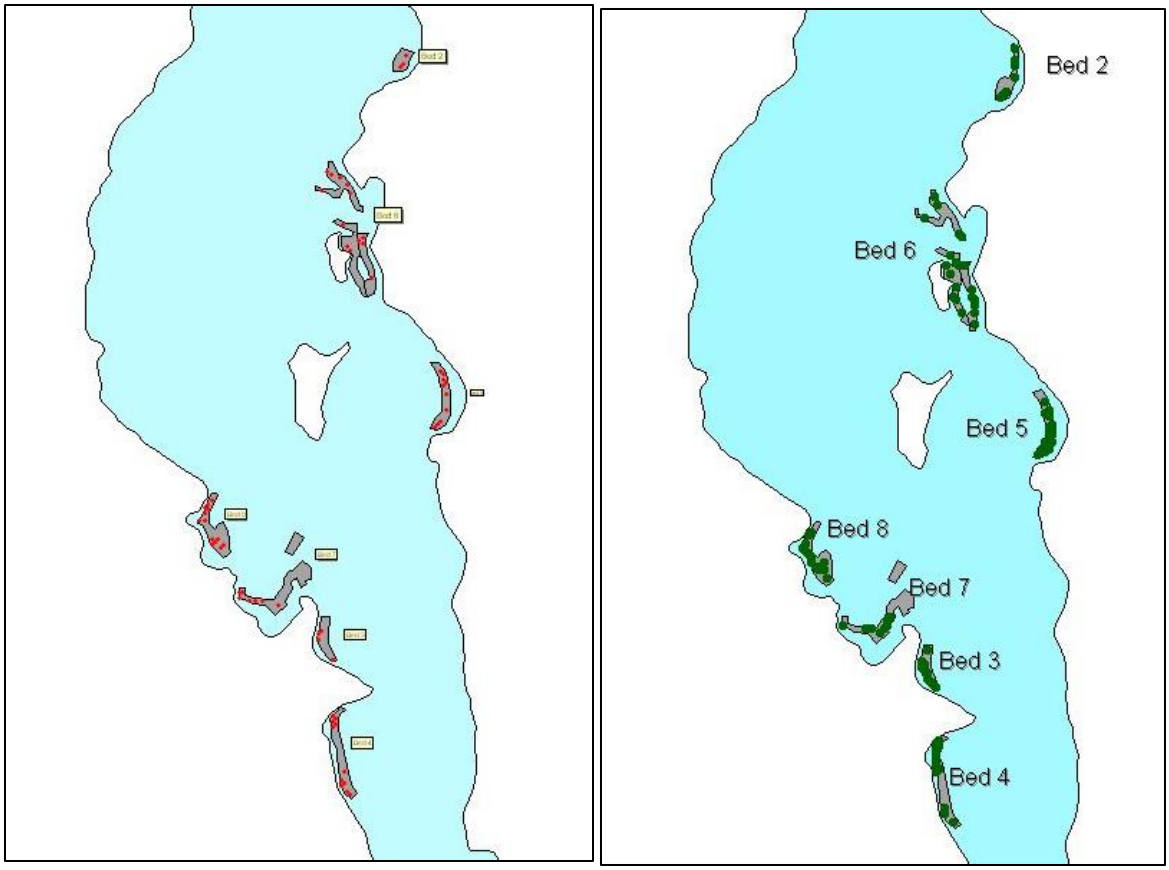
***Vallisneria americana*-Wild celery 2015** **2014**



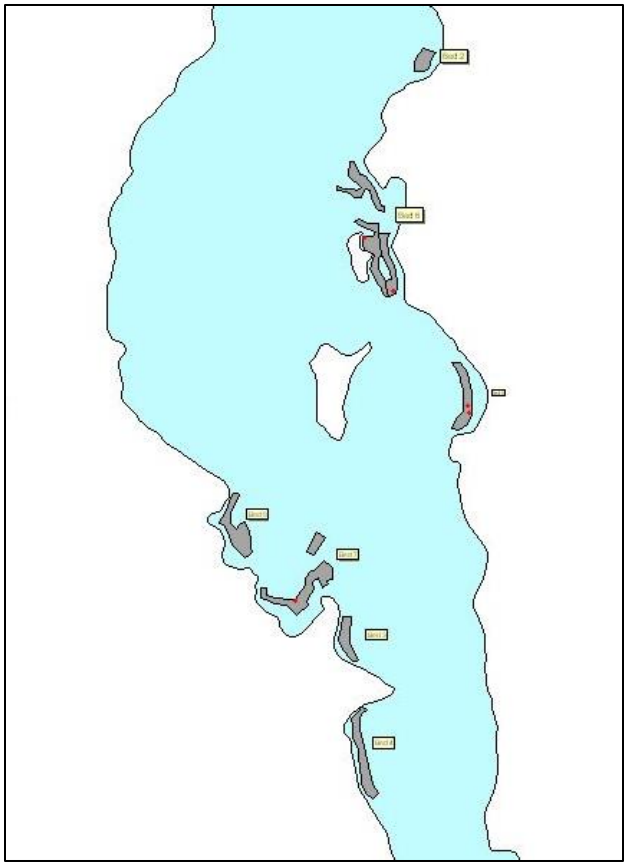
***Chara sp*.-muskgrass 2015** **Not sampled 2014**



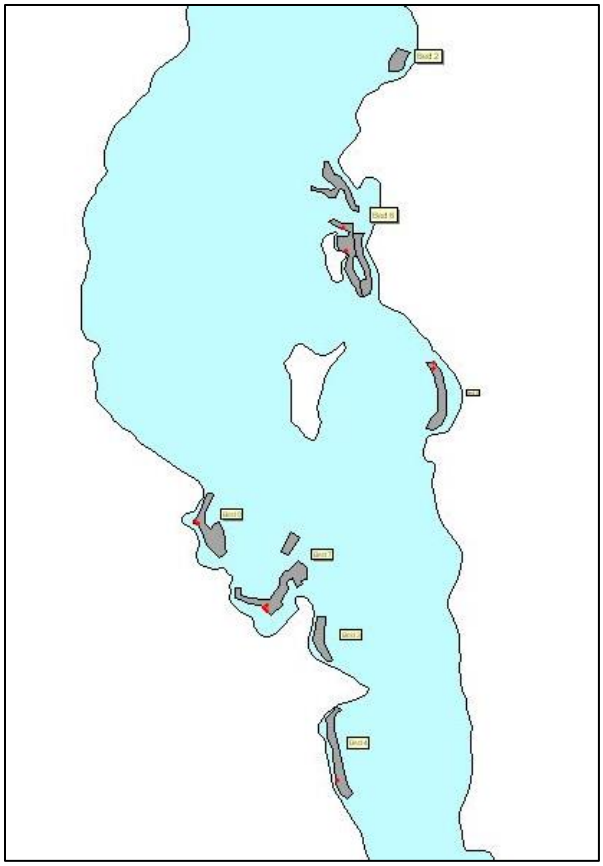
***Potamogeton richardsonii*-Clasping pondweed 2015 2014**



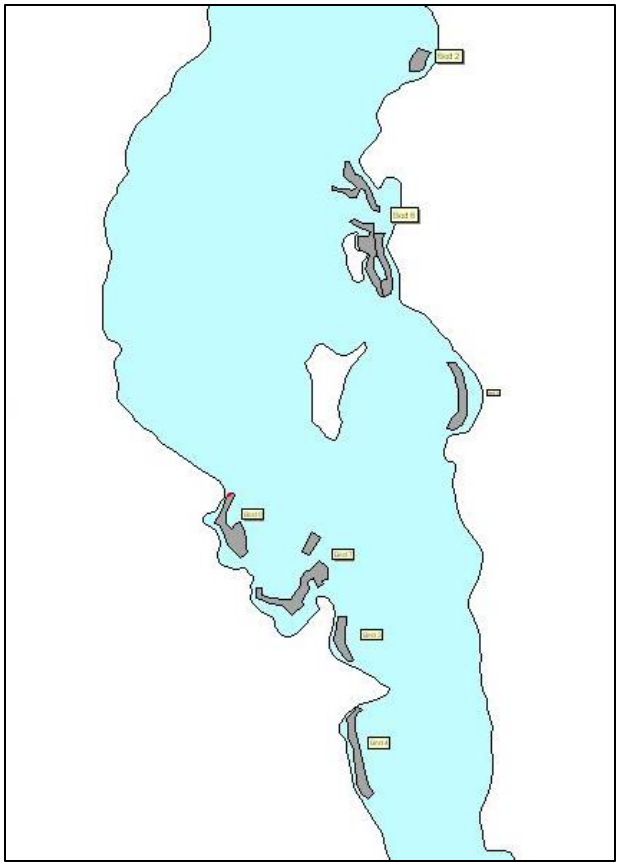
***Ceratophyllum demersum*-Coontail 2015** **2014**



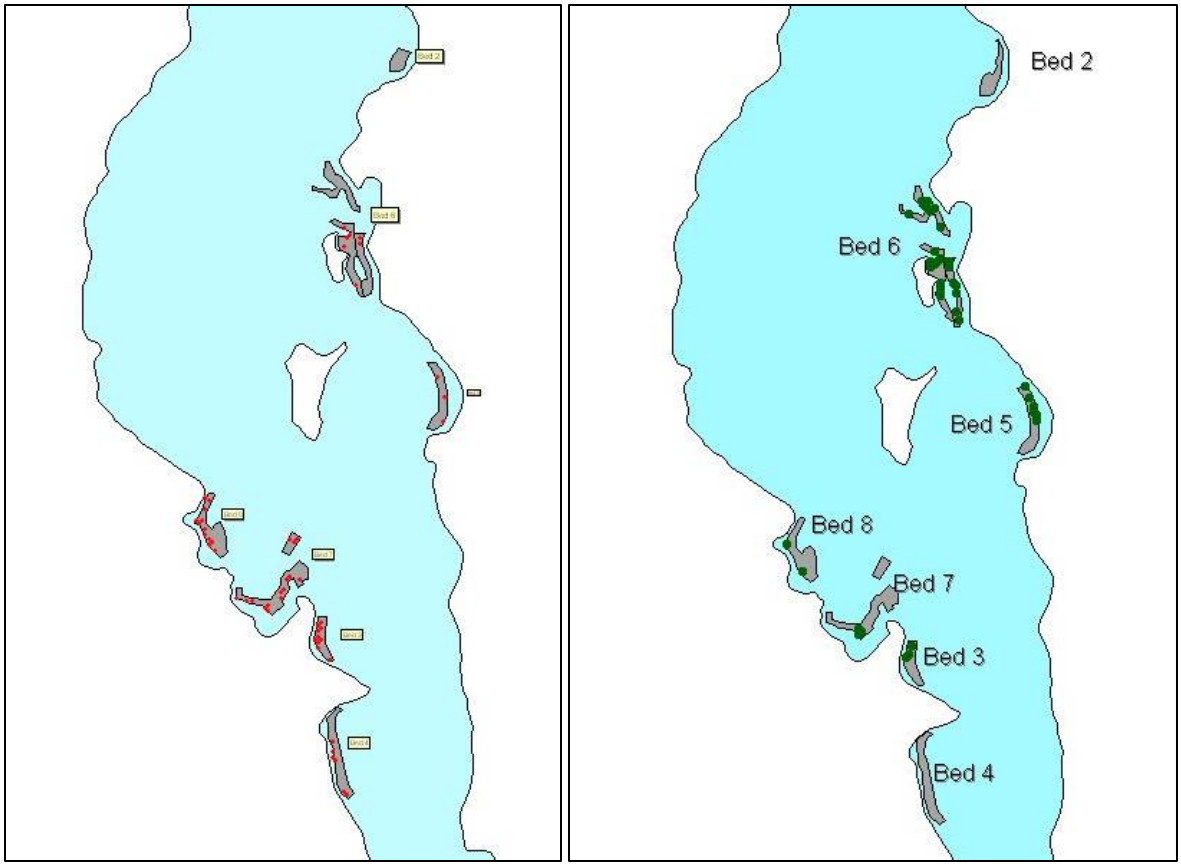
***Rununculus aquatilis*-Crowfoot 2015** **Not sampled 2014**



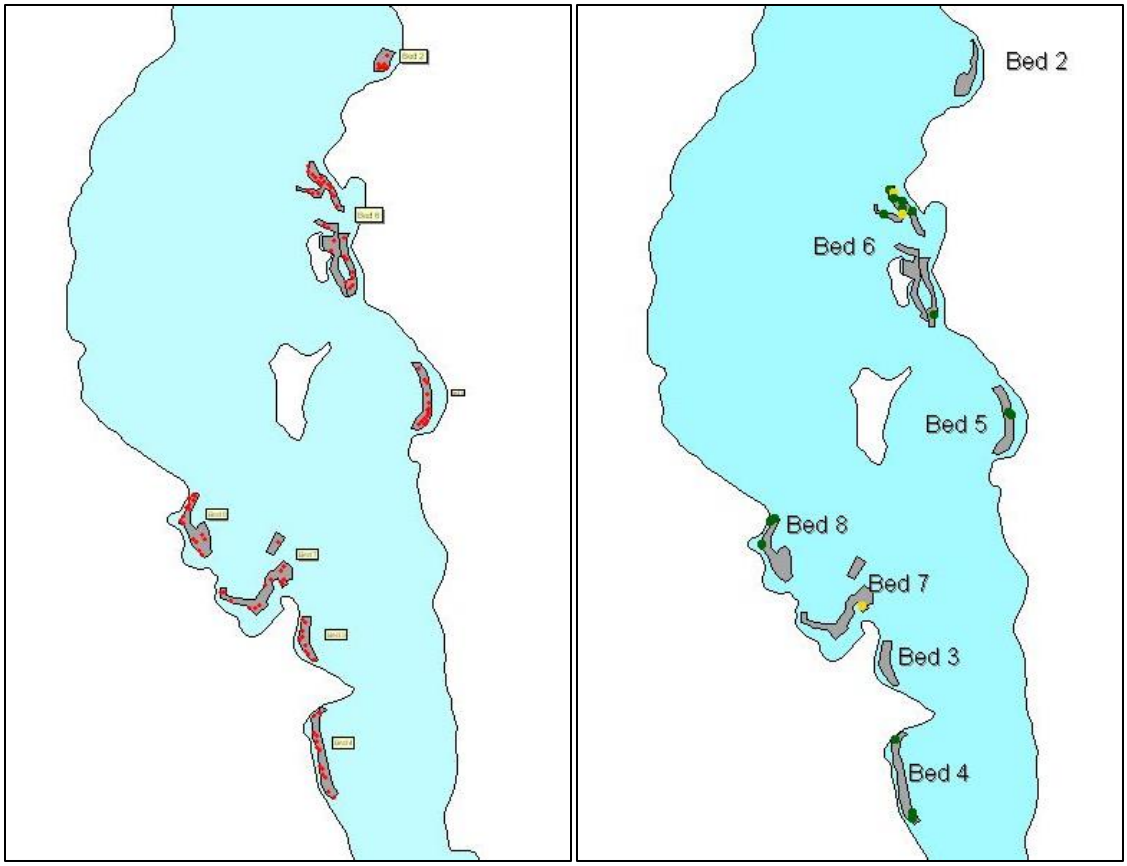
***Elodea canadensis*-Common waterweed 2015** **Not sampled 2014**



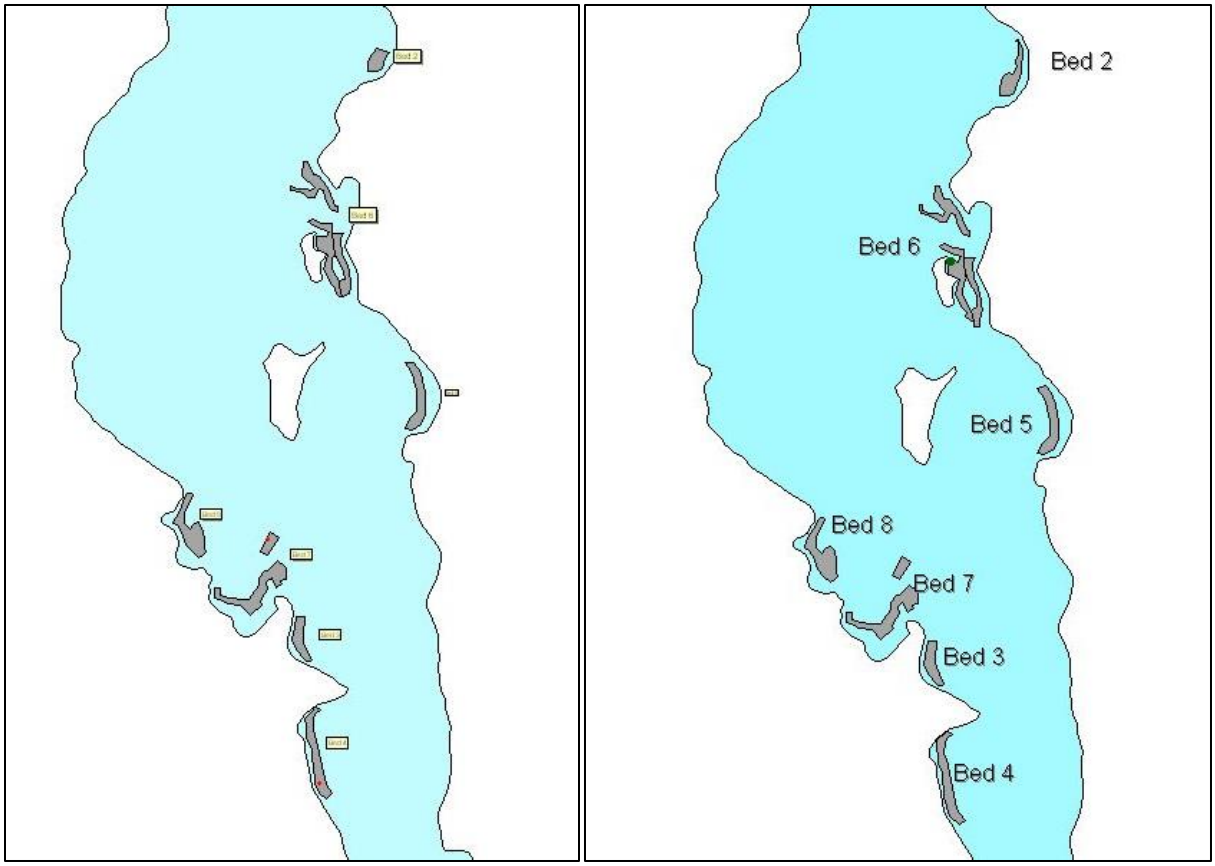
***Potamogeton zosteriformis*-Flatstem pondweed 2015** **Not sampled 2014**



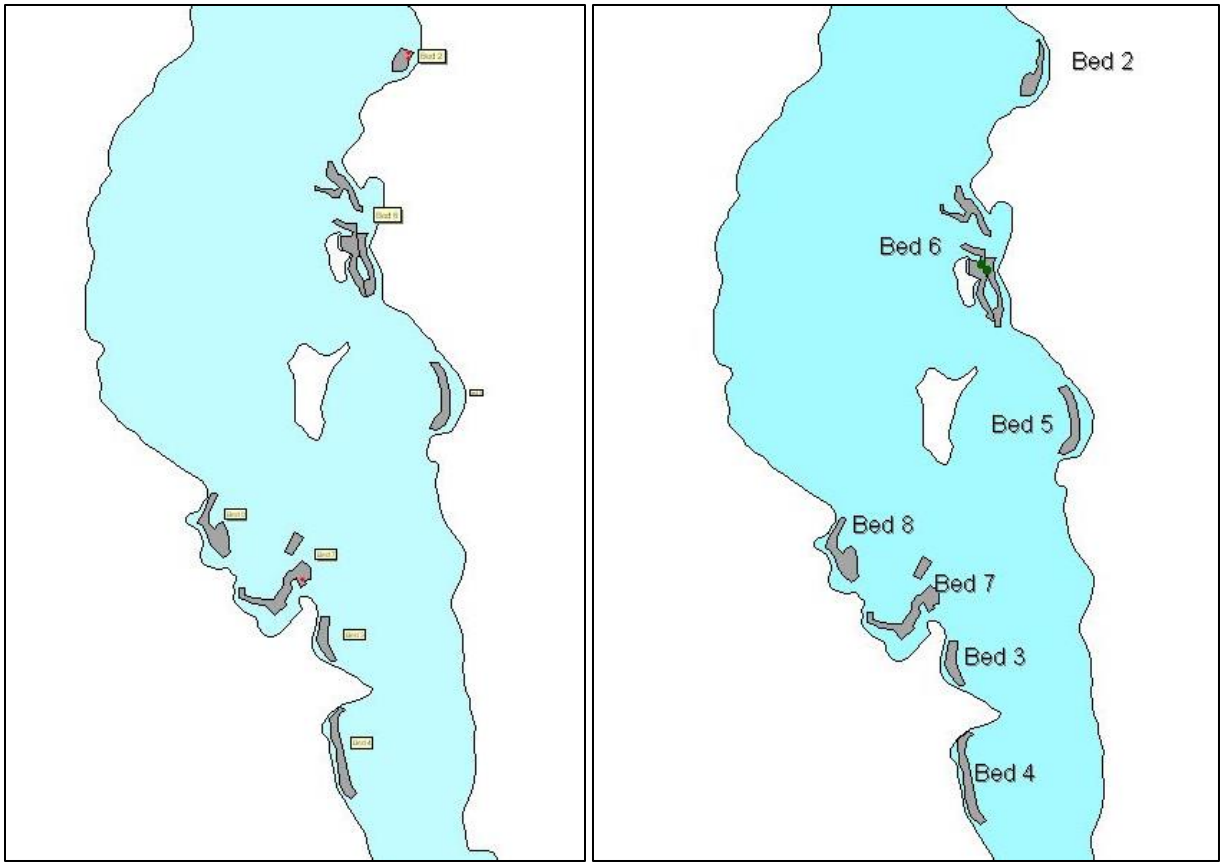
***Lemna triscula*-Forked duckweed 2015** **2014**



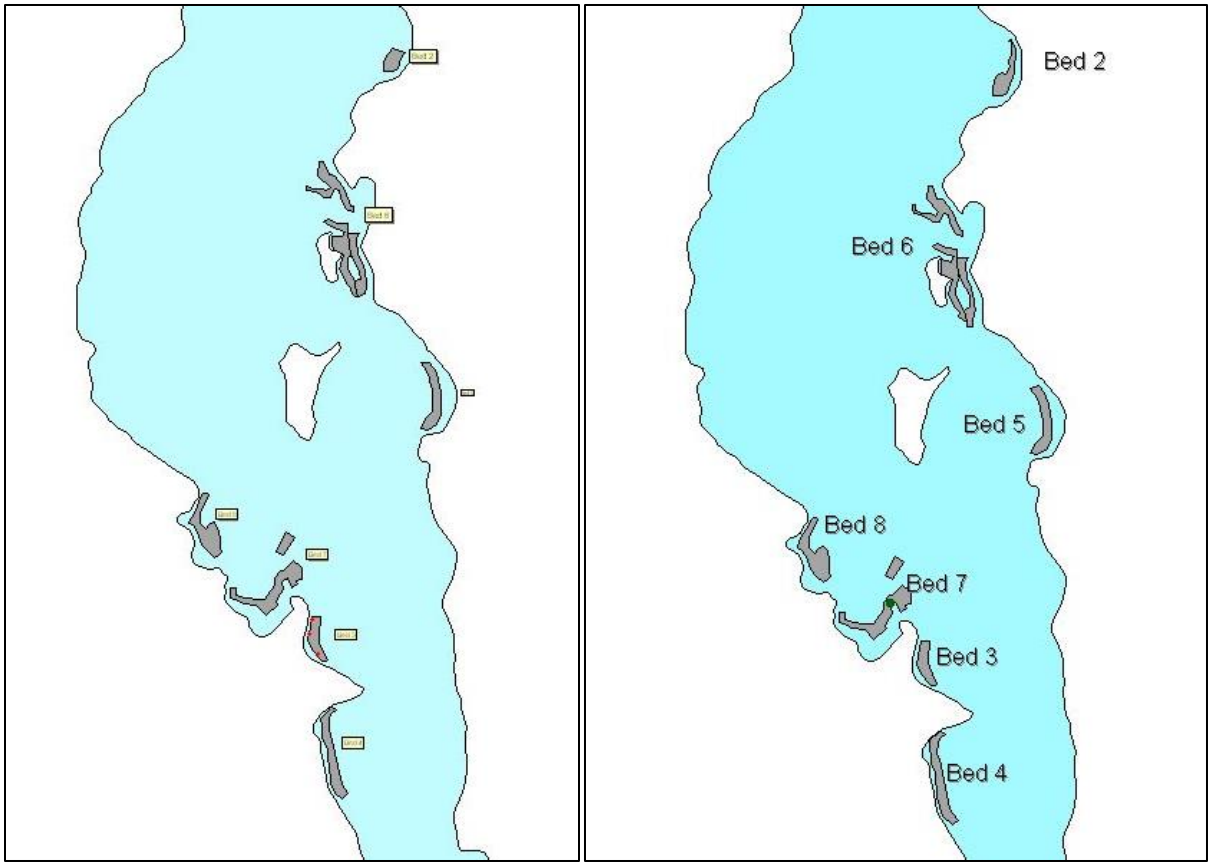
***Myriophyllum sibiricum*-Northern water milfoil 2015** **2014**



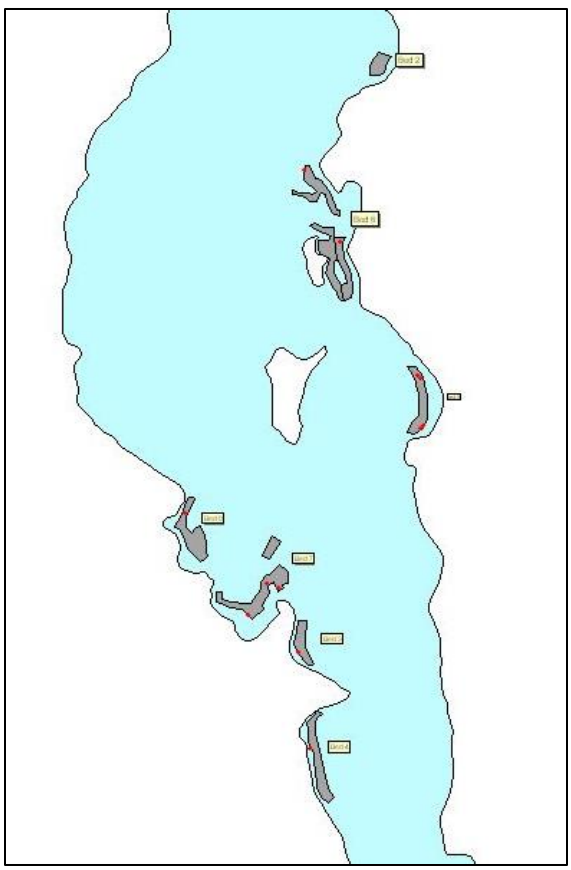
***Najas flexilis*-Slender naiad 2015** **2014**

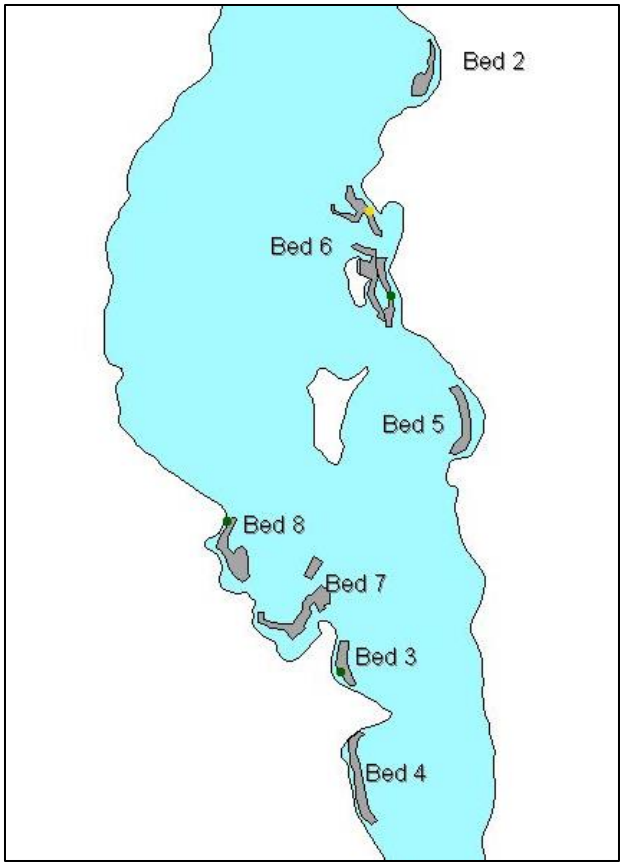


***Nitella sp*.-stonewort 2015** **2014**

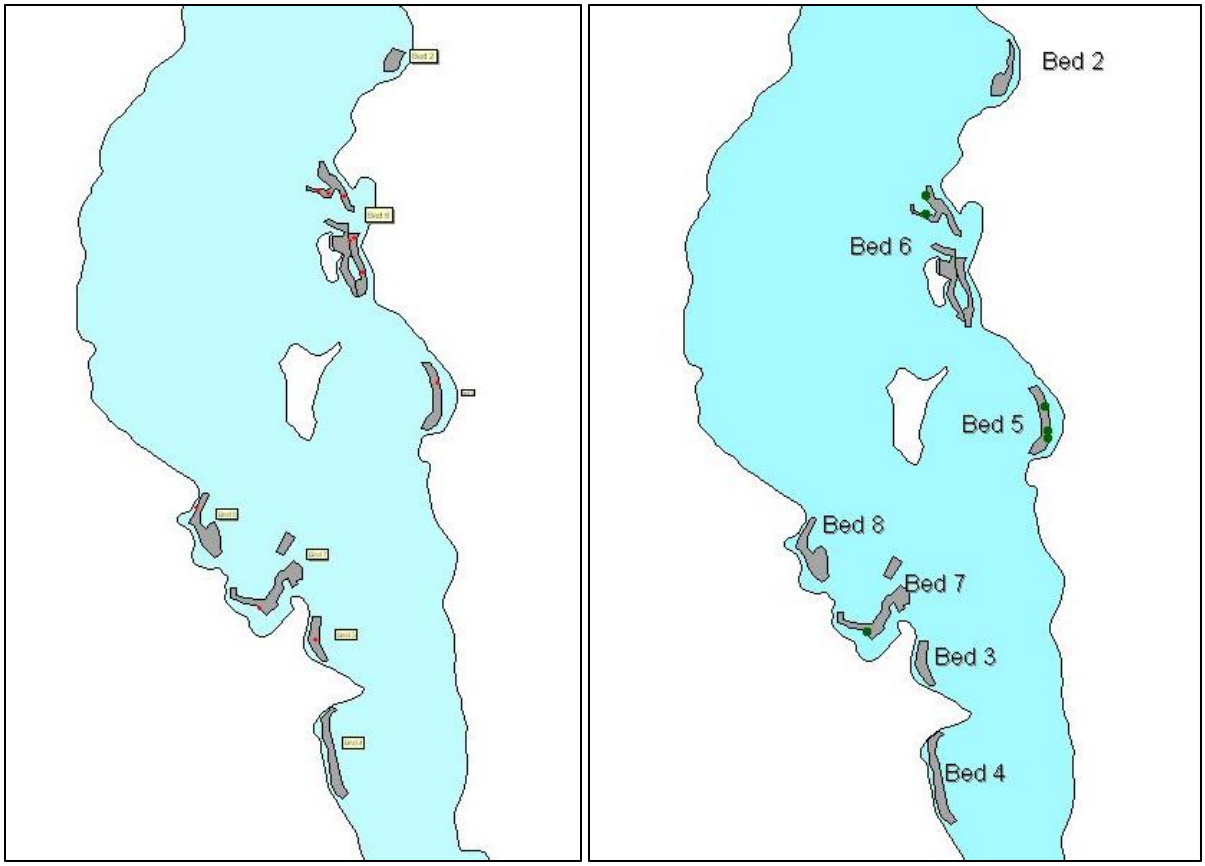


***Potamogeton pectinata*-Sago pondweed 2015** **2014**





***Heteranthera dubia*-Water stargrass 2015** **2014**



***Potamogeton praelongus*-Whitestem pondweed 2015 2014**