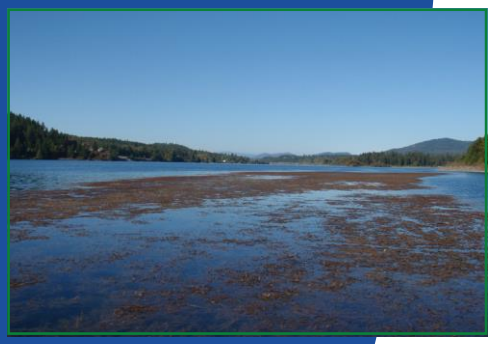
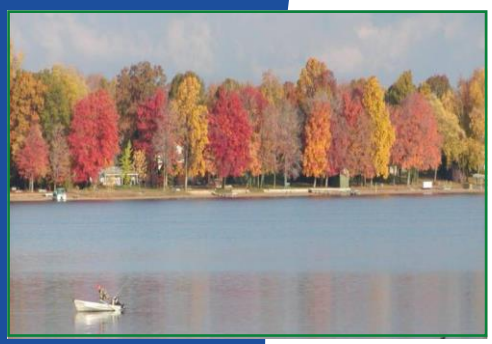
2014 Milfoil Solution® Progress Report at Big Cedar Lake, Peterborough County, Ontario

Prepared for:

BIG CEDAR LAKE STEWARDSHIP ASSOCIATION





Prepared by:

EnviroScience
Excellence In Any Environment

5070 Stow Rd.
Stow, OH 44224
800-940-4025
www.EnviroScienceInc.com

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1.0 Introduction

Since its widespread introduction, the exotic-invasive Eurasian watermilfoil (*Myriophyllum spicatum*, herein referred to as milfoil) has become one of the most problematic plants in North American lakes. Rapid growth and reproduction by seed, stolon and fragment allows this plant to create dense, monotypic stands that displace native species. In turn, these dense beds can reduce biodiversity, cause detrimental changes to water quality and impact the aesthetics and recreational use of the water. Since 2011, EnviroScience has implemented the **Milfoil Solution®** process at Big Cedar Lake, in Peterborough County, Ontario to combat nuisance populations of milfoil using the milfoil weevil (*Euhrychiopsis lecontei)*.

The milfoil weevil is a native insect to North America that began feeding on Eurasian watermilfoil once it was introduced. This milfoil-specialist completes its entire life cycle on the plant (egg $\rightarrow$ larvae $\rightarrow$ pupae $\rightarrow$ adult) and is capable of producing multiple generations in one growing season. Throughout the fall months, weevils move to shore to overwinter in dry, loose soils and returns to the water as the ice recedes in the spring to continue the process. The most significant impacts to milfoil occur during the larval life stage of the insect. During the larval stage, weevils feed on the meristem (growing tip) of the plant and burrow through the stem. This disrupts nutrient flow within the plant and allows air to escape the stem, reducing its natural buoyancy causing it to collapse. This process also leaves the weakened plant susceptible to secondary infection. Over time, milfoil stands become weakened diminishing their ability to compete with native species and prepare for winter months.

Although milfoil weevils are present throughout the southern extent of Ontario and the northern U.S. states, they are often in populations unable to cause significant declines. Milfoil Solution® is utilized to increase weevil populations to aid in reducing nuisance stands of milfoil. This year marked the fourth consecutive stocking season at Big Cedar Lake. This report was prepared on behalf of the Big Cedar Lake Stewardship Association and outlines the progress of the program to date at Big Cedar Lake.

The table below outlines the Milfoil Solution® program for Big Cedar Lake, including site establishment and the number of weevils stocked:

Year	Survey/Stocking Dates	Sites Established	Sites Stocked	Number of weevils
2011	Initial: 9, 11, 15 August Follow-up: 18 September	S1-S5, M1, M2	S1-S5 5 private stocking sites	30,000 (Lake Association) 23,000 (Private Stocking)
2012	Initial: July 1/17, 2012 Follow-up: August 27/28, 2012	S6 (formerly M1), New Location for S3	S1-S6 7 private stocking sites	35,000 (Lake Association) 27,000 (Private Stocking)
2013	Initial: June: 7,12,18, 31; July 8 Late season: August 23, 2013	New Location for S1, S3, S5	S1-S6 5 Private stocking sites	32,500 (Lake Association) 22,000 (Private Stocking) 12,500 (In Kind from ES)*
2014	Initial: June 24, 26; July 11, July 26 Late season: August 27, 2014	New Location for S3	S1-S6 2 Private Stocking Sites	28,000 (Lake Association) 1,000 (Private Stocking) 4,800 (In Kind from ES)*

* To begin our lab culture, 2,400 adult weevils were collected from Big Cedar Lake from an area located away from the established stocking sites. At the end of the culturing program, 4,800 weevil eggs and the remaining adults used in the culturing process were re-stocked at the boat launch located south of S3 (3,000) and S5 (1800). The number of adults stocked were not formally assessed and is estimated to be approximately 500 weevils.

2.0 Survey Methods

An initial survey is performed prior to weevil stocking at each site with a late-season survey conducted six to eight weeks later. These surveys provide the opportunity to compare and monitor changes in the aquatic plant community and the weevil populations between sites and seasons. These surveys are integral in monitoring changes that occur in both the augmented weevil population and the health of the milfoil over the course of the program in order to make informed management decisions. Qualitative observations in these surveys include the overall density and health of milfoil, identification of native plant species present, and the presence of weevils and weevil-

induced damage. Quantitative measurements include milfoil density and weevil population density. Milfoil density is determined by randomly collecting stems throughout the milfoil bed using a 0.09 m^2 quadrat. This sample is then converted to the number of stems per square meter (stems/m^2). Weevil population density (number of weevils per stem) is determined through lab analysis of 30 stems sampled from three transect lines at each site.

3.0 2011-2013 Summary

Throughout the first three seasons of the Milfoil Solution® Program at Big Cedar Lake, we have seen many positive results related to weevil stocking efforts. These include:

- Establishment of six stocking sites with consistently healthy weevil populations.
- The return of overwintering weevils in high density.
- Relocation of S1, S3 and S5 due to collapses of the milfoil plant communities.
- High weevil densities during initial and late-season surveys at all sites.
- Large decrease in milfoil density at S2 over the 2013 season.
- Major decrease in milfoil density at all sites in comparison to the milfoil density observed in 2012.
- Milfoil at most sites appeared to be brittle and bent over by the end of the 2013 season.

4.0 2014 Surveys and Weevil Stocking

S1 – S1 was stocked on July 26, 2014 with 5,000 weevils. Prior to stocking, milfoil at S1 composed 60% of the plant community and was 1.5m below the surface. Milfoil density at the time of the initial survey was 64.81 stems/m^2 with 50% of the milfoil showing signs of larval damage. Weevils were observed at this site in all life stages (Egg, larval, pupal and adult) with a density of 1.27 weevils/stem.

By the late season survey milfoil composed 70% of the plant community with 20% of the stems showing signs of weevil damage. Milfoil density decreased at S1 to 53.70 stems/m^2 by the late-season and did not flower. Weevil density during the late-season survey consisted of 0.13 weevils/stem with weevils observed in the egg, adult and larval life stages. The native plant species coontail (*Ceratophyllym* demersum), fern pondweed (*P. robinsii*), flat-stemmed pondweed (*Potamogeton zosteriformis*), Large-leaf pondweed (*P. amplifolius*), Richardson's pondweed (*P. richardsonii*), tape grass (*Vallisneria americana*), water marigold (*Megaladonta beckii*) and water starweed (*Zosterella dubia*) were also observed at this site.

S2 – S2 was stocked on June 26, 2014 with 5,000 weevils. At the time of stocking, milfoil was 1.5m below the surface and composed 60% of the plant community with a density of 57.41 stems/m^2. Stems appeared to be heavily damaged with 50% showing signs of larval feeding. Weevils were present throughout the site with all life stages present. Weevil density at the time of the initial survey was 0.43 weevils/stem.

Milfoil remained well below the surface of the water (1.5m down) by the late-season survey and comprised 45% of the plant community with a decrease in density to 29.63 stems/m^2. At this time 60% of the milfoil showed signs of larval feeding and were beginning to bend over and collapse in the water column. Weevils were observed in all life stages during the late-season survey with a density of 0.27 weevils/stem.

The following native species were present throughout S2: Canada waterweed (*Elodea canadensis*), coontail, fern pondweed, flat-stem pondweed, large-leaf pondweed, Richardson's pondweed, tape grass, water marigold, water naiad (*Najas flexilis*) and water starweed,

S3 (2013 Location) – Similar to previous seasons, S3 needed to be relocated due to insufficient milfoil at the time of stocking. ES biologists surveyed this site

in addition to the new location of S3. Milfoil at this site was sparse composing 40% of the plant community with 90% showing signs of larval damage at the time of the initial survey. By the late-season survey, milfoil comprised 30% of the bed with 80% of the remaining plants showing signs of weevil damage. Milfoil remained 1.5m below the surface of the water. Weevils were observed at the site in all life stages during the initial and late-season surveys.

Eleven native aquatic plant species were present, including: Canada waterweed, coontail, flat-stemmed pondweed, large-leaf pondweed, northern watermilfoil (*Myriophyllum sibiricum*), Richardson's pondweed, Robbins pondweed, tape grass, water marigold, water naiad, water starweed. The invasive-exotic, curly-leaf pondweed (*Potamogeton crispus*) was also observed at S3 (2013).

S3 (2014) – The new location of S3 was established on July 11, 2014 located just west of the 2011 S3 stocking location. In total, 5,000 weevils were stocked at this site. Prior to stocking, milfoil was 15cm below the surface and composed 85% of the plant community with a density of 109.26 stems/m^2. Stems appeared to be heavily damaged with 70% showing signs of larval feeding. Weevils were present throughout the site with all life stages present. Weevil density at the time of the initial survey was 0.73 weevils/stem.

Milfoil remained well below the surface of the water (50cm down) and by the late-season survey and composed 80% of the plant community with a density of 96.30 stems/m^2. Milfoil was heavily damaged with 70% of the plants showing signs of larval feeding. At this time, milfoil was beginning to bend over and collapse in the water column. Weevils were observed in all life stages during the late-season survey with a density of 0.27 weevils/stem.

The following native species were present throughout S3 (2014): Coontail, fern pondweed, flat-stem pondweed, northern milfoil, *Nitella sp.*, Richardson's pondweed, small pondweed, tape grass, water naiad and water starweed.

S4 – S4 was stocked with 5,000 weevils on June 24, 2014. Milfoil at this site was moderately dense and composed 75% of the plant community during the initial visit with a density of 96.30 stems/m^2. Weevils were observed in the egg, larval and pupal life stages during the initial survey with a density of 0.53 weevils/stem. At this time, 75% of the milfoil stems showed signs of damage. By the late-season survey, milfoil at this site decreased to 68.52 stems/m^2 composing 60% of the plant community. At the time of late-season survey, the milfoil remained 2m below the surface and was collapsing with 60% showing signs of larval damage. Weevils were observed in the egg, larval and pupal life stages with a density of 0.23 weevils/stem.

The remaining plant community was composed of Canada waterweed, coontail, fern pondweed, flat-stemmed pondweed, large-leaf pondweed and Richardson's pondweed.

S5 (2013) – In 2013, S5 was moved to a new location east of the original site. Due to an increase in milfoil at the original S5 site, the 2013 location was not restocked. During the initial survey, milfoil at the 2013 location was moderate to dense comprising 70% of the plant community with a density of 77.78 stems/m^2. Milfoil density decreased to 62.96 stems/m^2 by the late-season survey and composed 75% of the plant population. Milfoil remained just below the surface with 70-80% showing signs of weevil damage throughout both surveys. Weevils were observed in all life stages with an initial density of 0.37 weevils/stem and a late-season density of 0.13 weevils/stem. The remainder of the plant community consisted of Canada waterweed, coontail, fern pondweed, flat-stem pondweed, Robbin's pondweed, tape grass, sago pondweed (*Stuckenia pectinatus*), water marigold and white water lily.

S5 (2014) – In 2014, the original S5 location was restocked with 8,000 weevils over two dates (6,000 on June 24 and 2,000 on July 11) due to an apparent resurgence of dense milfoil. Milfoil at this site was dense at the time of stocking composing 70% of the plant community with a density of 90.74 stems/m^2.

Roughly 30% of the plants were showing signs of larval damage and remained 0.5-1.0m below the surface of the water. Weevils were present in all life stages with a density of 0.10 weevils/stem.

During the late season survey, milfoil was just below the surface of the water and remained constant with a density of 72.22 stems/m^2, composing 70% of the plant community. Larval damage to the plants was observed to increase to include 65% of the stems. Weevils were observed in all life stages with an increased density of 0.45 stems/m^2.

The remainder of the plant community consisted of bladderwort (*Utricularia vulgaris*), Canada waterweed, coontail, fern pondweed, flat-stemmed pondweed, large-leaf pondweed, northern milfoil, tape grass, water naiad, white water lily and yellow water lily (*Nuphar variegatum*).

S6 – This site was not stocked in 2014, however initial and late-season surveys were performed. During the initial survey, tape grass and flat-stem pondweed were the dominant species present in the plant community. Milfoil composed 25% of the plant community and was 1.5m below the surface with a density of 77.78 stems/m^2. Weevils were observed in all life stages with 70% of the plants showing signs of damage. Weevil density at the time of the initial survey was 0.33 weevils/stem.

By the late-season survey, tape grass remained the dominant species composing 60% of the plant community whereas milfoil accounted for 30% of the plant community. Milfoil density remained 1m below the surface with a constant density of 48.15 stems/m^2. Weevil density decreased to 0.07 weevils/stem with weevils observed in the larval and pupal life stages. At the time of the late season survey, 80% of the milfoil showed signs of damage and was bent over and collapsing.

Fern pondweed, flat-stemmed pondweed, large-leaf pondweed, Richardson's pondweed, tape grass, water marigold and water naiad were all present at this site.

M2 – Monitoring site (M2) was set up as a site that has not received any weevil augmentation since the beginning of the program. Milfoil at this site only composed 25% of the plant community with a density of 29.63 stems/m^2 during the initial survey. At the time of sampling, milfoil was 1.5m below the surface with 70% showing signs of weevil damage. Weevils were present in all life stages with a density of 1.33 weevils/stem.

During the late-season survey, milfoil density increased to 81.48 stems/m^2 and composed 90% of the plant community. Milfoil remained 1m below the surface of the water with 60% showing signs of larval damage. Weevil density decreased to 0.13 weevils/stem with weevils observed in the larval, pupal and adult life stages. Fern pondweed, flat-stemmed pondweed, Richardson's pondweed, tape grass and water naiad were also observed at M2.

5.0 Discussion

Overall, the results of the 2014 surveys show continued positive response due to weevil stocking. These positive results include:

- Relocation of S3 due to collapse of the milfoil stand.
- Continued reduction in milfoil density following 2013 at all sites with exception to the original S5 site.
- High early season weevil density at all sites.
- Milfoil remained below the surface of the water at all sites and did not flower.
- Milfoil at S1, S2, S4, S6 remained 1-2m below the surface in late August.
- Milfoil at most sites appeared to be brittle and bent over by the end of the 2014 season.

Throughout four years of stocking at Big Cedar Lake, we have observed continual success with respect to suppression and reduction of nuisance milfoil. Most notably are the consecutive collapses of several large milfoil stands, reduction of overall milfoil density and the maintenance of other sites well below the surface of the water.

In addition to these successes, the overall amount of private stocking was also reduced in 2014. Of the four private stocking sites, two were not stocked while a third was stocked at a reduced amount due to a lack of milfoil. While performing surveys, ES biologists also returned to 2013 private stocking sites where milfoil was also sparsely populated.

Similar to 2013, a cold-wet start to the spring and summer this year likely attributed to slowed growth of milfoil at Big Cedar Lake. This late start to the season provided the opportunity for overwintering weevils to become established in the lake prior to the plants reaching the surface. Although the weather conditions limited milfoil growth early in the season, they do not overshadow the impact of weevil stocking at Big Cedar Lake, rather they are supplemental to the success of the stocking program.

Milfoil remained well below the surface of the water making the act of stocking somewhat difficult. However, the benefits of low lying milfoil greatly outweighed the difficulty of stocking. In addition to weevils returning from overwintering, stocking on low lying beds of milfoil allowed weevils to limit the amount of upward milfoil growth. This limited the plant’s ability to reach the surface, branch out profusely and flower. This lack of “matting” and flowering not only increases the amount of light to competing native species but also limits the amount of sexual reproduction of the plant. In addition plants remaining well below the surface provides considerable recreational and aesthetic benefits that can be severely impeded by “matting” stands of milfoil.

Although we observed a continual positive progression at most stocking sites, one area of concern in 2014 was the original stocking site of S5. This site was stocked across 2011 and 2012 with 17,800 weevils as well as additional private stocking that occurred

directly adjacent. During the initial survey in 2013, ES biologists noticed large “holes” within the milfoil stand and heavily damaged milfoil indicative of a collapsing bed. Rather than stocking on an already collapsing bed, ES biologists set up a new location for S5 to the east of the original location. Although collapsing of the bed occurred at the original site, by 2014 milfoil began to return aggressively.

ES biologists made the decision to restock this original location in 2014 with 8000 weevils (in addition to private stocking which occured directly adjacent). The quick resurgence of milfoil at this site following collapse was surprising especially since other collapsed sites at Big Cedar Lake did not return the following year. As aquatic plant communities can be very dynamic, it is difficult to speculate what caused such a quick resurgence of milfoil at this site. Although we observed this quick return, by the end of the season, milfoil remained just below the surface without matting or flowering. In addition, S5 showed an increase in the amount of larval damage present leaving the plants weakened. It is also important to point out that milfoil density did not increase over the duration of the 2014 growing season as it has in previous years at this site.

Even with the resurgence observed at S5, we have seen a very positive progression within Big Cedar Lake to reducing milfoil to non-nuisance levels. As milfoil density decreases, re-establishment of the native aquatic plant community has been observed throughout many of the stocking sites. Big Cedar Lake boasts a very healthy native plant community that can compete with milfoil for space. This allows the lake to transition into a more natural distribution of native plants, a balanced lake food-web ecology and improved recreational and aesthetic value. Overall, the successful response to stocking at Big Cedar Lake over the past four years has been very encouraging.

5070 STOW ROAD, STOW, OHIO 44224
330-688-0111 / TOLL FREE: 800-940-4025 / FAX: 330-688-3858

Table 1. Average Weevil Population Density (weevils/stem) in Big Cedar Lake

Site	Parameter measured	August 10, 2011	Sept. 18, 2011	July 1 and 17, 2012	August 27, 2012	June 7,12,18, 31; July 8, 2013	August 23, 2013	June 24, 26, July 11, 2014	August 27, 2014
S1	Total weevils	2.00	20.00	8.00	47.00	7.00	51.00	38.00	4.00
	Total stems	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.07**	**0.67**	**0.27**	**1.57**	**0.23**	**1.70**	**1.27**	**0.13**
S2	Total weevils	2.00	10.00	8.00	33.00	53.00	27.00	13.00	8.00
	Total stems	30.00	20.00	29.00	30.00	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.07**	**0.50**	**0.28**	**1.10**	**1.77**	**0.90**	**0.43**	**0.27**
S3	Total weevils	28.00	66.00	24.00	9.0	35.00	36.00	22.00	8.00
	Total stems	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.93**	**2.20**	**0.80**	**0.30**	**1.17**	**1.20**	**0.73**	**0.27**
S4	Total weevils	23.00	8.00	30.00	16.00	11.00	32.00	16.00	7.00
	Total stems	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.77**	**0.27**	**1.00**	**0.53**	**0.37**	**1.067**	**0.53**	**0.23**
S5	Total weevils	10.0	25.00	36.00	27.00			3.00	13.00
	Total stems	30.00	30.00	30.00	30.00	**--**	**--**	30.00	29.00
	Avg. weevils/stem	**0.33**	**0.83**	**1.20**	**0.90**			**0.10**	**0.45**
S5 (2013)	Total weevils					26.00	23.00	11.00	13.00
	Total stems	**--**	**--**	**--**	**--**	30.00	30.00	30.00	30.00
	Avg. weevils/stem					**0.88**	**0.77**	**0.37**	**0.13**
M1/S6	Total weevils	7.00	20.00	20.00	24.00	45.00	41.00	10.00	2.00
	Total stems	30.00	30.00	30.00	29.00	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.23**	**0.67**	**0.67**	**0.83**	**1.50**	**1.37**	**0.33**	**0.07**
M2	Total weevils	2.00	29.00	19.00	30.00	--	35.00	40.00	4.00
	Total stems	30.00	30.00	26.00	30.00	--	30.00	30.00	30.00
	Avg. weevils/stem	**0.07**	**0.97**	**0.73**	**1.00**	--	**1.17**	**1.33**	**0.13**

Table 2. Average Density of EWM (stems/m^2) in Big Cedar Lake

Site	August 10, 2011	September 18, 2011	July 1 and 17, 2012	August 27, 2012	June 7,12,18, 31; July 8, 2013	August 23, 2013	June 24, 26, July 11, 2014	August 27, 2014
S1	103.70	188.89	301.06	245.98	81.48	75.93	64.81	53.70
S2	88.89	211.11	192.86	334.68	155.56	51.85	57.41	29.63
S3	244.44	114.81	160.70	504.63	137.04	122.22	109.26	96.30
S4	25185	355.56	109.21	403.16	155.56	151.85	96.30	68.52
S5	470.37	692.59	238.68	439.53	--	--	90.74	72.22
S5 (2013)	--	--	--	--	137.04	133.33	77.78	62.96
M1/S6	466.67	159.26	149.92	409.87	122.22	166.67	77.78	48.15
M2	237.04	244.44	81.84	259.61	--	70.37	29.63	81.48

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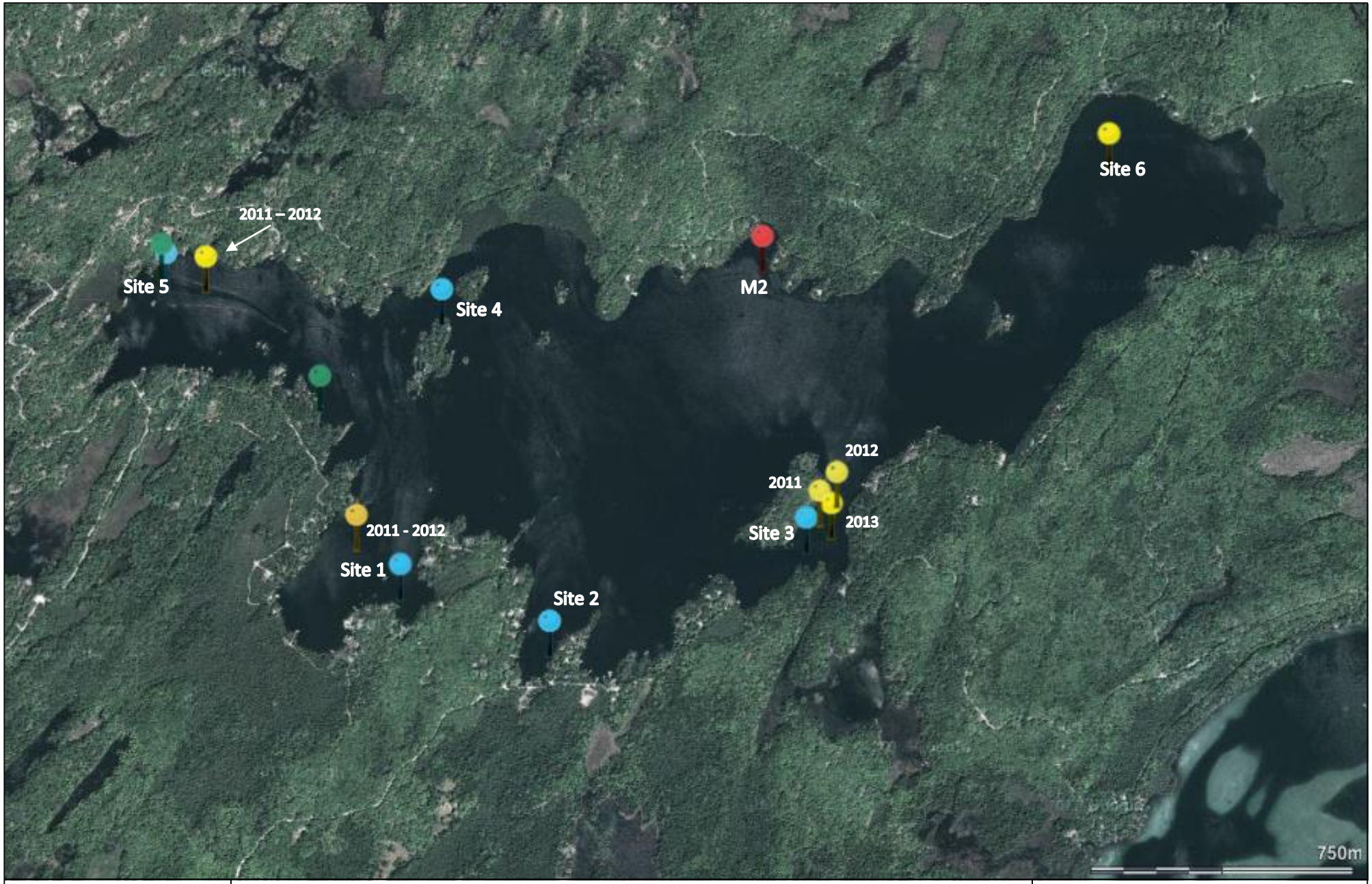

Big Cedar Lake

Peterborough County, Ontario
2014 Stocking Sites

2014 Weevil Stocking Sites

2014 Private Stocking Sites

2011-2013 Weevil Stocking Sites

2011-2014 Monitoring Site

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