2012 Milfoil Solution® Progress Report for Big Cedar Lake, Ontario

Prepared for:

Big Cedar Lake Stewardship Association

Prepared by:

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1.0 Introduction

Eurasian watermilfoil (*Myriophyllum spicatum*, hereafter referred to as milfoil) is an exotic aquatic species that tolerates a wide range of growing conditions and out-competes native vegetation. Monocultures of milfoil limit recreational use, reduce biodiversity, and can cause detrimental changes to water temperature and dissolved oxygen in severe infestations. The native North American beetle, the milfoil weevil (*Euhrychiopsis lecontei)*, has been augmented in Big Cedar Lake, Ontario, to suppress the growth of milfoil through EnviroScience's **Milfoil Solution®**.

The milfoil weevil is native to Ontario waters and Big Cedar Lake and is the natural predator of milfoil. Augmenting the indigenous weevil population to accelerate this predator/prey relationship is the goal for all **Milfoil Solution®** programs in order to establish a self-sustaining weevil population that suppresses milfoil below nuisance levels. For most of our clients, this process takes anywhere from three to five years, depending on the size of the milfoil infestation.

This insect is a specialist herbivore of milfoil and damages the plant in multiple ways. The most significant impact is caused by weevil larvae as they feed on the meristem, or growing tip, and burrows through the stem. Nutrient flow in the plant is disrupted and the stem loses buoyancy and collapses in the water column. A cascading effect pulls neighboring plants lower into the water column and the rate of photosynthesis is significantly reduced in these stems. The adult weevil also feeds on the plant and will move from plant to plant as it needs fresh, healthy tips for mating, laying eggs and feeding. The life cycle of the milfoil weevil from egg to adult occurs over 20 to 30 days and is dependent on temperature. Each female has the potential to lay 2 to 4 eggs per day, and 3 to 4 generations are produced each summer depending on seasonal conditions. The last generation of the summer concentrates on moving to the shoreline to overwinter under dry leaf litter. In the spring, the weevil is known to head back to water as soon as ice-off and starts reproducing when water temperatures reach approximately 15 °C.

The following is the projected Milfoil Solution® program at Big Cedar Lake as outlined in the proposal:

Year	Survey Dates	Sites Established	Weevils Stocked
2011	Initial: 9, 11, 15 September Follow-up: 18 September	S1-S5, M1, M2 5 private stocking sites	30,000 (Lake Association) 23,000 (Private Stocking)
2012	Initial: July 1/17, 2012 Follow-up: August 27/28, 2012	S1-S5, S6 (formerly M1), M2 7 private stocking sites	35,000 (Lake Association) 27,000 (Private Stocking)
2013	--	--	20,000
2014	--	--	15,000
2015	--	--	*Survey*

2.0 Survey Methods

An initial survey is performed prior to weevil stocking and a follow-up survey is conducted six to eight weeks later. Qualitative observations include overall milfoil density and health, 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 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 approximately 30 stems sampled from three transect lines at each site. Weevil densities (Table 1) and milfoil densities (Table 2) were recorded for six stocking sites (S1 - S6) and one monitoring site (M2). Due to the random nature of sampling, these results are best viewed over multiple years as survey locations often may not exhibit a high number of weevil life stages or a stable pattern in milfoil growth.

3.0 Results and Weevil Stocking

Stocking Sites (S1-S6): A total of 35,000 weevils were stocked throughout six sites (S1-S6) as part of a lake-wide management program (see attached map). S6 was formerly established as

M1 in 2011, but per the Client's request was stocked with weevils in 2012. Surveys at most sites revealed a native weevil population. Orange buoys were placed at each stocking site and location was recorded using a GPS unit.

- **S1 –** 5,000 weevils were stocked at S1. Milfoil was moderately dense with green and red tips and composed about 95% of the plant community, although the stems did not reach the surface of the water. Biologists noted both weevil adults and larvae in the field, with approximately 25% of the bed showing weevil-induced damage. Laboratory sample analysis from the initial survey included a weevil density 0.27 weevils/stem. Milfoil density during the initial survey was 301.06 stems/$m^{2.}$

  During follow-up survey, milfoil was 50cm below the water's surface and 90% of the milfoil showed signs of weevil damage and was brittle and bent over in the water column. All weevil life stages (eggs, larvae, pupae and adults) were observed in the field and weevil density increased to 1.57 weevils/stem. Milfoil density at this site decreased from the initial survey to 245.98 stems/m^2 during the follow-up survey.

- **S2** – 5,000 weevils were stocked at S2. During the initial survey, all weevil life stages were observed in the field, with approximately 85% of the bed showing weevil-induced damage. Weevil density at this site was 0.80 weevils/stem at the time of the initial survey. In addition, milfoil density consisted of 192.86 stems/m^2, composed about 98% of the plant community and did not reach the surface of the water.

  During follow-up survey milfoil was dense, composed 80% of the plant community and was 75cm below the water's surface. Weevil damage was observed and approximately 95% of the milfoil was brittle, brown and bent over in the water column. Adults and larvae were observed in the field and weevil density increased to 1.10 weevils/stem. Milfoil density appeared to increase to 334.68 stems/m^2 at S2 between the initial and follow-up surveys.

- **S3 –** A dramatic collapse in the milfoil bed following the 2011 stocking season occurred at S3. Upon arriving for the initial survey, the remaining plant community consisted of

10% milfoil in comparison to 75% in 2011. In addition, weevils in all life stages were observed on remaining milfoil stems at the time of the initial survey with the majority of stems showing signs of weevil damage.

This site had to be moved 10m east of the previous stocking site due to the buoy was moved to reflect the new stocking location. 5,000 weevils were stocked at the new S3 location. Milfoil at the new site was dense and composed about 98% of the plant community. Adults and larvae were observed in the field and 40-50% of the milfoil bed appeared to be damaged by weevils. Weevil density during the initial survey consisted of 0.80 weevils/stem whereas milfoil density was approximately 160.70 stems/m^2.

During follow-up survey, biologists noted that milfoil composed 95% of the plant community and 25% was at the water's surface, with some flowering. Adult, larval and pupal lifestages were all observed in the field with approximately 60% of the milfoil at this site showing signs of weevil damage. Weevil density decreased between the initial and follow-up surveys to 0.30 weevils/stem whereas milfoil density increased to 504.63 stems/m^2.

- **S4 –** 5,000 weevils were stocked at S4. Milfoil was moderately dense, composed about 70% of the plant community, and was approximately 1.5m below the surface with a density of 109.21 stems/ m^2. Biologists noted weevils in all life stages in the field with approximately 80% of the bed showing weevil-induced damage. Weevil density was high during the initial survey and consisted of 1.00 weevils/stem.

  Milfoil was dense during the follow-up survey and composed approximately 90% of the plant community but was still 1.5m below the water's surface. Milfoil density appeared to increase to 403.16 stems/m^2. In addition, 90% of the milfoil was damaged by weevils, brittle and bent over in the water column. Adults, larvae and pupae were observed in the field with a decreased weevil density of 0.53 weevils/stem.

- **S5** – 10,000 weevils were stocked at S5. Milfoil was moderately dense, composed about 80% of the plant community, and was approximately 0.5m below the surface. Milfoil density consisted of approximately 238.68 stems/ m^2. Weevil density during the initial survey was the highest at S5 with 1.20 weevils/stem. Approximately 75% of the bed showed signs of weevil-induced damage and weevils were present in all lifestages. Biologists also observed that there were large open areas within the stocking bed where milfoil was absent.

  During follow-up survey, milfoil was dense (439.53 stems/m^2) and composed approximately 90% of the plant community, however the milfoil did not reach the water's surface. All life stages of weevils were noted in the field and 95% of the milfoil appeared to consist of weevil damage. Weevil density was observed to decrease to 0.90 weevils/stem through laboratory sample analysis.

- **S6** – 5,000 weevils were stocked at S6, which was formerly established as the monitoring site M1 in 2011. Milfoil was dense and composed about 99% of the plant community. Biologists noted adults and eggs in the field with approximately 60 – 70 % of the bed showing weevil-induced damage. Laboratory sample analysis from the initial survey consisted of a weevil density of 0.67 weevils/stem. Milfoil density was approximately 149.92 stems/ $m^{2.}$

  During follow-up survey, milfoil was moderately dense and composed approximately 95% of the plant community but was still below the water's surface. Adults and larvae were observed in the field, with roughly 80% of the bed exhibiting weevil-induced damage. Both weevil density and milfoil density increased between the initial and follow-up surveys to 0.83 weevils/stem and 409.87 stems/m^2 respectively.

Private Stocking Sites: A total of 27,000 weevils were stocked throughout seven private stocking locations. Full surveys were not contracted at the private stocking locations and plant samples were not collected for analysis, but weevil life stages and damage indicative of an indigenous weevil population were observed at all sites. Orange buoys were placed at each of the private stocking locations and location was recorded using a GPS unit.

Monitoring Site (M1 and M2): Two monitoring sites were established to compare stocking sites to untreated conditions over the course of the program. These sites are located in the northeast portion of the lake and both contain a native weevil population.

- **M1 –** Monitoring Site 1 was changed to Stocking Site 6 in 2012.

- **M2**- At the initial survey, milfoil was dense, healthy, green and composed about 90% of the plant community. Biologists noted all weevil life stages in the field with approximately 25% of the bed showing weevil-induced damage. Weevil density consisted of 0.73 weevils/stem during the initial survey with evidence of larval and adult damage to 85% of the samples. Milfoil density during the initial survey was 81.84 stems/ m^2.

  During follow-up survey, milfoil was moderately dense and composed approximately 60% of the plant community and was roughly 60cm below the water's surface. Adults, pupae and larvae were observed in the field, with approximately 90% of the bed exhibiting weevil-induced damage. Weevil density increased at M2 to 1.00 weevil/stem whereas milfoil density appeared to increase to 259.61 stems/m^2.

Native aquatic plant species recorded throughout Big Cedar Lake in 2012 included: Richardson's pondweed (*Potamogeton richardsonii*), Illinois pondweed (*P. illinoensis*), Water marigold (*Megalodonta beckii*), Coontail (*Ceratophyllum demersum*), Eelgrass/Water Celery (*Valisneria americana*), Elodea (*Elodea canadensis*), Fern pondweed (*P. robbinsii*), Flat-stem pondweed (*P. zosteriformis*), Large leaf pondweed (*P. amplifolius*), Northern watermilfoil (*Myriophyllum sibiricum*), Slender naiad (*Naias flexilis*) Small pondweed (*P. pusillus*), and Water stargrass (*Zosterella dubia*).

4.0 Discussion

Overall, results from the 2012 initial and follow-up surveys show successful establishment of a healthy weevil population in Big Cedar Lake. Some of the positive responses that have been observed in 2012 include:

- The weevil population density has increased at three of six stocking sites over the course of the 2012 growing season.

- An increase in weevil density and decrease in milfoil density were observed at S1 over the course of the 2012 growing season.

- The location of S3 had to be moved 10m to the east due to a drastic decline in the milfoil population at the original stocking location from 2011.

- Milfoil samples from all sites exhibited indicators unique to a weevil population such as holes in the stems and extensively damaged areas where larvae have burrowed through the stems. In general, the majority of milfoil stems at each milfoil bed appeared to consist of weevil damage.

- Milfoil at most sites appeared to be brittle and bent over following the 2012 season. These stems also appeared to have extensive weevil damage.

Following the 2011 season, weevil density at all sites showed promising results that weevils are capable of overwintering at Big Cedar Lake and larger populations are becoming established. Although these positive results were observed, milfoil stem density increased at most sites at the time of the follow-up survey. High milfoil density was a common occurrence observed across lakes in Ontario during 2012 and may be attributed to ideal growing conditions that have occurred throughout the past year. A mild winter followed by an early spring and dry summer provided optimal conditions for milfoil growth in 2012. These natural fluctuations and the seasonal variability within aquatic ecosystems can influence aquatic plant growth.

Observing long-term oscillations between weevil populations and milfoil density is natural and reflects the predator-prey nature of biological control. Data at some sites may not follow what is considered a “normal” pattern which is why multiple years of surveys are crucial to comprehensively assess how the milfoil and weevil populations are interacting. Milfoil grows quickly and can differ from season to season, so it may take the weevil population a year to “catch up” before it can bring the milfoil back down to a manageable level. This pattern has been observed in a number of other projects in lakes across Michigan and other states implementing the Milfoil Solution® process. While the weevil population may have been hindered by the province-wide surge in milfoil growth this season, it is expected to increase long-term.

It is also important to note that weevil densities were well within range of 2011 densities. Weevil density measurements are based on collecting 30 milfoil stems across 3 transects for each stocking site. With such large increases in milfoil density, it is not surprising to observe low numbers of weevils collected at some sites. These include decreases in weevil density in sites S3, S4 and S5. Since weevils may be overlooked with this type of sampling, qualitative data such as field observations provide supplementary information to determine success. All sites consisted of weevil damage to a majority of the stems with weevils found in multiple life stages. With this in mind, it is important to mention that weevil densities remained healthy throughout the 2012 season even with such explosive milfoil growth observed in Big Cedar and province wide. It is common to see different sites within a lake respond differently throughout a season however results of the 2012 season appear to be promising for the 2013 season at Big Cedar Lake.

Throughout consecutive seasons overall stem density and infestation of milfoil is expected to decrease as the augmented weevil population grows. As a biological control, the Milfoil Solution® process is most successful when introduction of the milfoil weevil occurs over multiple, successive growing seasons to ensure that the weevil population reaches high densities in the lake to maintain the milfoil to non-nuisance levels. Signs of milfoil suppression include:

- ✓ Reduction in density of the milfoil
- ✓ Maintenance of the stems below the lake surface at a non-nuisance level
- ✓ Open areas within the stocking sites

A secondary effect of the process, native aquatic plants replace exotic milfoil as it is outcompeted and becomes a less dominant species in the plant community. Over the course of the program, areas of infestation transition into a more natural distribution of native plants, restoring a balanced lake ecology that supports a healthier fishery while improving recreational and aesthetic value. A total of thirteen native aquatic species were identified throughout the survey sites and will continue to be monitored over the course of the program to monitor positive changes in the plant community.

5.0 Recommendations

Based on results over the past two seasons the stocking program is progressing as expected. The current proposal includes stocking from 2011 to 2014, with 20,000 weevils contracted in 2013. Based on this proposal, it is the recommendation of EnviroScience to focus attention on the newly established site S6 and S3 and less on areas such as S1 which have shown high weevil populations and decreases in density over the 2012 season. Adjustments to where specific quantities of weevils will be stocked will occur following early season site visits and observations at the beginning of the 2012 season.

However, it is also important to note the importance of stocking aggressively in attempts to cause large-scale declines in milfoil density. Increasing the current number of weevils proposed for 2013 will provide the opportunity to aggressively stocking more sites, thus providing better results. Increasing the proposed 20,000 weevils in 2013 to quantities stocked in 2012 (35,000 weevils) would provide the opportunity to target more areas within Big Cedar Lake in need of increased weevil populations. If the Big Cedar Lake Stewardship Association is interested increasing the current number of weevils for 2013, please contact Milfoil Solution staff to provide a proposal for increased stocking quantity.

In addition to continuation of the Milfoil Solution® program, there are many practices that can contribute to the success of the stocking program and decrease the potential of increasing milfoil density such as:

- Limiting the amount of boat traffic in stocked sites and dense milfoil beds. Milfoil weevils typically reside in the upper 60cm of the plant, if heavy boat traffic occurs throughout the patch these plants can be damaged and impact the weevils ability to flourish. Driving through dense patches should also be limited since fragments of the plant can be dispersed throughout the lake capable of starting a new population.

- Providing a natural shoreline can increase weevil habitat for overwintering. In the fall months, weevils move to shore to overwinter in loose soils and leaf litter, leaving a 1-3m buffer adjacent to shore where grasses can grow and leaves can collect provides suitable habitat for weevils through these winter months.

- Milfoil stems that are floating in the water or washed up on shore can be collected and removed. If left alone, these fragments can move freely through the waterbody and can root to start a new plant. Once dried or composted, milfoil is often used as mulch in gardens and flower beds.

As part of a lake-wide strategy to manage Eurasian watermilfoil infesting Big Cedar Lake, it is key to recognize that suppressing this invasive species will be a gradual process that will require continued support from the Big Cedar Lake Stewardship Association. Thank you for choosing our natural program to manage Eurasian watermilfoil safely and sustainably.

Please contact EnviroScience/Milfoil Solution LLC. at (800) 940-4025, or e-mail at kborrowman@enviroscienceinc.com with questions regarding this report.

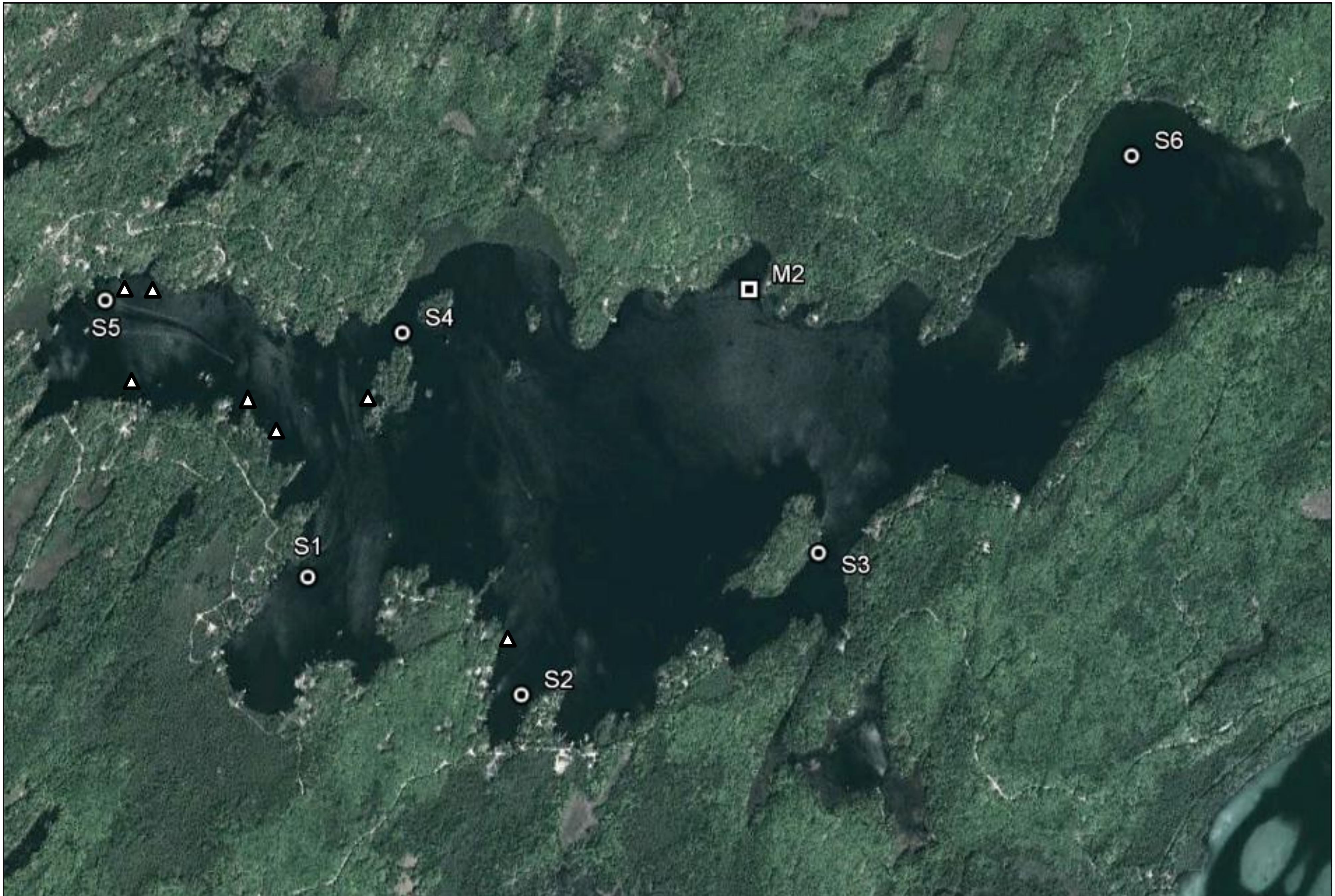
EnviroScience, Inc.
Lake Management Division
Milfoil Solution®

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

Site	Parameter measured	August 10, 2011	September 18, 2011	July 1 and 17, 2012	August 27, 2012
S1	Total weevils	2.00	20.00	8.00	47.00
	Total stems	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.07**	**0.67**	**0.27**	**1.57**
S2	Total weevils	2.00	10.00	8.00	33.00
	Total stems	30.00	20.00	29.00	30.00
	Avg. weevils/stem	**0.07**	**0.50**	**0.28**	**1.10**
S3	Total weevils	28.00	66.00	24.00	9.0
	Total stems	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.93**	**2.20**	**0.80**	**0.30**
S4	Total weevils	23.00	8.00	30.00	16.00
	Total stems	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.77**	**0.27**	**1.00**	**0.53**
S5	Total weevils	10.0	25.00	36.00	27.00
	Total stems	30.00	30.00	30.00	30.00
	Avg. weevils/stem	**0.33**	**0.83**	**1.20**	**0.90**
M1/S6	Total weevils	7.00	20.00	20.00	24.00
	Total stems	30.00	30.00	30.00	29.00
	Avg. weevils/stem	**0.23**	**0.67**	**0.67**	**0.83**
M2	Total weevils	2.00	29.00	19.00	30.00
	Total stems	30.00	30.00	26.00	30.00
	Avg. weevils/stem	**0.07**	**0.97**	**0.73**	**1.00**

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
S1	103.70	188.89	301.06	245.98
S2	88.89	211.11	192.86	334.68
S3	244.44	114.81	160.70	504.63
S4	25185	355.56	109.21	403.16
S5	470.37	692.59	238.68	439.53
M1/S6	466.67	159.26	149.92	409.87
M2	237.04	244.44	81.84	259.61



Big Cedar Lake

Peterborough County, Ontario

2012 Stocking Sites

- Weevil Stocking Sites
- Private Stocking Sites
- Monitoring Site

200 m 600 m

1000 ft 3000 ft

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