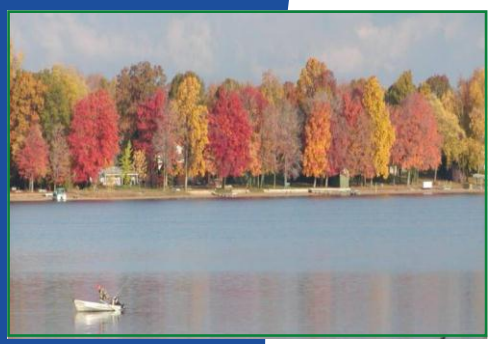
2013 Milfoil Solution® Progress Report at Loch Garry

Prepared for:

The Township of North Glengarry, Ontario



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1.0 Introduction

The exotic-invasive, Eurasian watermilfoil (*Myriophyllum spicatum*, herein after referred to as milfoil) has become one of the most troublesome aquatic plants in North America. The ability to displace native species creating dense monotypic beds can limit recreational use, reduce biodiversity and cause detrimental changes to water quality. In Ontario, milfoil has spread throughout the southern, central and near north regions of the province. In 2012 and 2013, EnviroScience implemented the **Milfoil Solution®** process at Loch Garry, a 363 hectare lake in Glengarry County, ON to deal with nuisance populations of milfoil using the milfoil weevil (*Euhrychiopsis lecontei)*.

The milfoil weevil is a native insect to North America that began to feed on Eurasian watermilfoil when it was introduced. The milfoil weevil spends its entire life cycle on the plant through the growing season impacting milfoil growth in multiple ways. The most significant impacts are caused during their larval lifestage as they feed on the meristem, or growing tip of the plant, and burrow through the stem. This causes nutrient flow within the plant to be disrupted. Additionally, the stem loses buoyancy and collapses creating a cascading effect which pulls neighboring plants lower into the water column.

Stocking programs are typically approached over a 3-5 year program to cause significant declines in nuisance populations of milfoil throughout a lake or waterway. This year marked the second consecutive stocking season at Loch Garry. This report outlines the progress of the program to date at Loch Garry and provides recommendations for following seasons.

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

Site	Initial Survey/ Stocking Date	Final Survey Date	Number of Weevils
S1	July 19, 2013	September 5, 2013	12,500
S2	--	--	0
S3	July 24, 2013	September 5, 2013	12,500
S4	July 14, 2013, July 19, 2013	September 5, 2013	12,500
S5	July 24, 2013	September 5, 2013	12,500
M1	July 24, 2013	September 5, 2013	0
		Total	50,000

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 us with 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 2011-2012 Summary

Four stocking sites (S1-S4) and one monitoring site (M1) were established at Loch Garry in 2012 and 40,000 weevils stocked within the month of July. We have noticed several positive responses to milfoil weevil stocking in the 2012 season including:

- Establishment of a healthy weevil population in Loch Garry.
- Damage caused by weevil larvae feeding at all stocking sites by the late-season survey.
- Decreases in milfoil density at three of the four stocking sites in 2012.

4.0 2013 Surveys and Weevil Stocking

S1 – S1 was stocked on July 19, 2013 with 12,500 weevils. Prior to stocking, milfoil at S1 consisted of thick clusters composing 80% of the plant community. Milfoil density at the time of the initial survey was 203.70 stems/m^2 and 25% of the milfoil showed signs of larval damage (See Table 2). By the late season survey composed 60% of the plant community with 25% of the stems showing signs of weevil damage. Milfoil density decreased at S1 to 62.96 stems/m^2 by the late-season and did not appear to have a flowering event. Weevil density during the initial survey consisted of 0.03 weevils/stem and remained relatively similar by the late-season survey with 0.04 weevils/stem (See Table 1). The native plant species flat-stemmed pondweed (*Potamogeton zosteriformis*), Robbins pondweed (*P. robinsii*) and white water lily (*Nymphaea odorata*) were also observed at this site.

S2 – This site was not stocked in 2013 due to a lack of milfoil. While performing an initial survey in July 2013, ES biologists used a GPS unit to locate the position of the stocking site. Upon arrival, the milfoil bed appeared to have collapsed since the following season. ES biologists were able to locate the anchor and rope used to secure the buoy confirming the site, however the buoy was missing (likely due to ice movement). During the late-season survey, ES biologists

returned to S2 and could not locate milfoil at the site using visually searching by boat and by snorkeling.

S3 – Similar to S2, ES biologists were not able to locate milfoil during the initial survey. However, since milfoil is prevalent in the surrounding area, the location of the stocking site was moved to a dense milfoil bed 300m to the west. In total, 12,500 weevils were stocked at the newly established on July 24th, 2013. Milfoil at this site was dense and composed 90% of the plant community with 20% showing larval damage. Milfoil density consisted of 181.48 stems/m^2. Weevil density at the time of the initial survey consisted of 0.17 weevils/stem. Milfoil remained the dominant plant species at the site by the late season survey composing 80% of the plant community and decreased in density to 133.33 stems/m^2. During the late season survey, weevil density was slightly lower at 0.07 weevils/stem with weevils observed in the pupal lifestage. At this time, ES biologists observed that there was no apparent flowering event at this site. In addition, 25% of the plants showed weevil damage and many plants had dropped out of the water column. Flat-stemmed pondweed, Richardson's pondweed (*P. richardsonii*) and white water lily were also observed at S3.

S4 – S4 was stocked with 8,600 weevils on July 14, 2013 with a second installment on July 19th of 3,900 weevils totaling 12,500. Milfoil at this site was moderately dense and composed 90% of the plant community during the initial visit. Milfoil density consisted of 66.67 stems/m^2. By the late-season survey, milfoil at this site decreased dramatically to 11.11 stems/m^2 composing 70% of the plant community. At the time of late-season survey, much of the milfoil that was remaining appeared to be damaged and were collapsing out of the water column. Milfoil at S4 did not reach the surface of the water (staying just below the surface) and did not flower. The remaining plant community was composed of Canada waterweed (*Elodea canadensis*) and flat-stemmed pondweed. Weevil density remained low at this site throughout the season with an initial density of 0.07 weevils/stem. Weevils were not observed in samples collected to determine weevil density during the late-season survey.

S5 – In 2013, a new stocking site was established along the northern shoreline of Loch Garry and stocked with 12,500 weevils. During the initial survey, milfoil was the only plant observed at this site. This was the densest site stocked in Loch Garry this season with 218.52 stems/m^2. Milfoil density decreased to 155.56 stems/m^2 by the late-season survey and composed 90% of the plant population. Flowering was not observed at this site, however 20% of the plant community matted on the surface of the water. The remainder of the plant community consisted of Canada waterweed and sago pondweed (*Stuckenia pectinatus*). Weevils were not observed at this site during the initial survey however weevil density consisted of 0.24 weevils/stem by the late-season survey.

M1 – Monitoring site (M1) was set up as a site that has not received any weevil augmentation since the beginning of the program. Milfoil at this site was dominant however only composed 50% of the plant community with a density of 96.30stems/m^2. During the late-season survey, milfoil density decreased to 62.96 stems/m^2 with 40% of the plants flowering. Weevil density at M1 for both the initial and late-season surveys consisted of 0.17 weevils/stem. Canada waterweed, flat-stemmed pondweed, Robbins pondweed (*P. robinsii*), slender pondweed (*P. pusillus*) and sago pondweed were also observed at M1.

5.0 Discussion

Overall, the results of the 2013 surveys shows continued positive response due to weevil stocking. These positive results include:

- Dramatically lower milfoil density in comparison to 2012 at all sites.
- Milfoil density decreased at all sites in the 2013 season between the initial and late-season surveys.
- Milfoil at two stocking sites completely collapsed prior to the 2013 stocking (S2 and S3).

- Stocked milfoil weevils successfully overwintered and returned to the lake.
- Flowering was not observed within the stocking sites in 2013.
- An increase in native plant species observed from three in 2012 to eight in 2013.

The results of the 2013 season show great progress and build upon earlier successes observed in the stocking program. Most notably are the decreases in milfoil density, collapse of milfoil at S2 and S3, the establishment of a weevil population at Loch Garry and successful declines at new sites after only one season.

Successful Overwintering and Dispersal of Weevils:

Prior to stocking in the 2012 season, a very low indigenous weevil population was noted. During the initial survey in 2013, weevils were observed at S1, M1 and the new location of S3. Adult weevils were also observed by ES biologists at S4 during the initial survey but were not captured in samples collected to determine density. Increased presence of weevils at the stocking sites is indicative of successful overwintering by weevils stocked in 2012. Additionally, high densities observed at the newly established S3 and the monitoring site suggests that weevils are dispersing throughout the lake to new locations.

As the lakes open up in the spring, weevils make their way back into the water, locate milfoil beds and begin to mate as water temperature reaches 15^{o}C. Following the 2012 stocking season, ES biologists returned to S3 and did not observe milfoil at the site and moved the location of the stocking site 300m to the west of the original location. While performing the initial survey at the new location for S3, ES biologist noticed a high weevil density. Due to the new site's proximity to the initial stocking location and suitable overwintering sites, it is most likely that weevils returning to the water located this dense patch of milfoil.

Similarly, a higher weevil population was observed in the spring at M1, likely due the close proximity of S4 to this site. This site was set up to compare differences between sites that are stocked and left with no management. However, by the end of the 2012 season, weevils were observed at M1 and by the spring of 2013 this site had the second highest weevil density of all sites surveyed. Weevil density at this site remained constant at 0.17 weevils/stem throughout 2013 and showed positive results attributed to weevil stocking. Although this adds to our overall positive response of weevil stocking in Loch Garry, a new monitoring site should be designated with considerable distance to stocking efforts.

Complete Collapse of Milfoil Beds:

One of the greatest successes to date is the collapse of S2 and S3 in Loch Garry following the first season of stocking. This is not a rare occurrence in weevil stocking projects and has been observed at several other lakes in 2012 and 2013. Weevil larval feeding impacts the ability of the plant to overwinter and causes weakened plants to collapse to the bottom of the lake. In lakes such as Loch Garry with high turbidity and low light penetration, this response to larval feeding can severely limit the plant's ability to grow. Once collapsed, milfoil can become light limited leading to large "holes" in the plant community. It is likely that milfoil at these sites collapsed following the 2012 season.

Drastic changes in milfoil density have been observed to occur naturally and typically happen over a 10-15 years. Such a decline was notice in Loch Garry roughly eight years ago and followed by a return of high density. Concerns have arisen related to the return of high milfoil density at these sites following a collapse. Unlike previous milfoil disappearances in Loch Garry, weevil stocking allows the opportunity for established weevils to feed on the plant prior to re-establishing high densities. Sites that have collapsed at other lakes in Ontario have consisted of sparse milfoil with stunted growth in the following years.

Increase in Native Plant Species Presence:

In addition, to herbivore pressure, the opportunity arises for native plant species to move into the newly opened sites. In 2013 ES biologists observed eight native plant species in comparison to three observed in 2012. This points towards re-establishment of native plant populations throughout the lake. Establishment of a native plant community is beneficial for the overall health of the lake ecosystem. These communities provide food and cover for invertebrates and fish and are a vital part of the complex lake ecosystem food-web.

Decreases in Flowering Milfoil:

The amount of milfoil reaching the surface, branching and flowering can also be reduced by weevil stocking. As milfoil reaches the surface, the plant branches out creating thick mats. At this point, flowering and seed production occurs helping spread the milfoil infestation. Although these flowering events can occur multiple times a season, flowering was not observed at any of the stocking sites and was only observed at the monitoring site and throughout other sections of the lake.

Decreases in Milfoil Density and the Influence of cold weather

Decreases in milfoil density were observed at all sites in Loch Garry in comparison to the late-season survey of 2012 and the initial survey in 2013. Results in Loch Gary were similar to other lakes stocked in Ontario this season, however all other stocking in the province are at later stages of their program.

As mentioned in the 2012 report, milfoil stocking does not always show results by the end of the first season. Rather, the efforts of the first stocking season are best observed in the following summer.

As mentioned in the 2012 report, the milfoil infestation at Loch Garry is among the thickest observed by EnviroScience biologists in the province. In addition to

the ideal growing conditions for milfoil at Loch Garry (a shallow and highly-eutrophic ecosystem), the mild winter and dry-hot summer of 2012 provided ideal conditions for milfoil growth. The weather conditions at the beginning of the 2013 summer provided some reprieve from excessive growth. The cold-wet start to the spring and summer of 2013 slowed the growth of milfoil at Loch Garry and across the province in general. Within the region, June was the wettest month on record since 2002 (Environment Canada, 2013).

In addition to providing a late start to the season for milfoil growth, this colder start to the season provided the opportunity for overwintering weevils to become established in the lake prior to the plants reaching the surface and branching profusely. Although the weather conditions limited milfoil growth early in the season, they do not overshadow the impact of weevil stocking at Loch Garry, rather they are supplemental.

To help illustrate how successful weevil stocking has been in Loch Garry, regardless of the cold temperatures, it is best to compare success to other programs in the province. Although other programs in the province are in their later stages, it is possible to compare the success of weevil stocking at newly established sites. Eight new stocking sites were established in Ontario in 2013. Of these, five sites decreased in density whereas three showed increases in milfoil density by the late-season survey (See Table 3). Change in density ranged from a decrease in density of 29% to an increase of 111% of the initial milfoil density. Sites established at Loch Garry showed the greatest decrease in milfoil by 29% at S3 and 27% at S5. Not only does this table compare success of new sites within Loch Garry to other projects, it also illustrates that increases in milfoil density have occurred at stocking sites across the province regardless of the cold start to the summer.

Throughout consecutive seasons overall stem density and infestation of milfoil is expected to decrease as the augmented weevil population grows. 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

Overall, we have seen positive results to the stocking efforts at Loch Garry. 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 bay to maintain the milfoil to non-nuisance levels.

6.0 Recommendations

The Milfoil Solution® process is dependent on the successful establishment of weevil populations over several seasons. It is essential to note the importance of adaptive management in biological control applications. Management of dynamic ecosystems is dependent on the inclusion of best available knowledge to inform management techniques. Following the 2013 season, observed damage within milfoil beds in Loch Garry is suggestive that a weevil population has become established.

In comparison to other lakes, the size and extent of the milfoil infestation at Loch Garry is among the worst infestations observed in recent years in Ontario. This is apparent through collected field data and site visits performed by EnviroScience biologists, and also province-wide research conducted by staff prior to working with EnviroScience.

Based on the severity of the infestation within Loch Garry, we feel that the aggressive approach followed to date should be continued for an additional three seasons. As we have already established several successful stocking sites, this would allow us to focus on more area of the lake and build on our current success. With this in mind, it is important to consider that many of our clients in the US and recently in Ontario have achieved management in less time than anticipated.

Following the 2012-2013 stocking season, EnviroScience has several recommendations to address current challenges in Loch Garry. These include:

Restocking Established Sites: Following the 2012 season, it was apparent that existing weevil populations needed to increase greatly to cause significant declines in milfoil density. These sites were re-stocked in 2013 and responded positively. Following the 2013 season, EnviroScience recommends restocking the newly established S3 and S5 in the 2014 season. Although declines in density were observed at S3 and S5, re-stocking in 2014 would greatly increase their overall reduction. In addition, S1 and S4 could also be re-stocked in 2014 however, following the late-season survey in 2013 these sites appear to have reduced greatly and will likely not need to be restocked in 2014.

Establishing New Stocking Sites in 2014: The positive results of the 2013 season provide us with the opportunity to expand the weevil stocking program to new sections of the lake. In addition to re-stocking S3 and S5, new sites could be established along the southern shoreline of the lake to provide reprieve from nuisance milfoil populations.

Increasing the Size of the Stocking Project Following the 2013 Season: Increasing the current size of the project to aggressively approach problem areas

throughout the lake was first suggested in 2012. This is dependent on greatly increasing the number of weevils. Following the successful results of the 2013 season it is apparent that increasing weevil population at Loch Garry is leading to reductions of milfoil within the lake. As with many biological control programs, more aggressive approaches can provide greater success in a shorter length of time. EnviroScience biologists recommend re-stocking Loch Garry in 2014 with 50,000 weevils or greater to continue building upon previous successes.

Of the management options suggested above, it is the recommendation of EnviroScience/Milfoil Solution to move forward in 2014 by re-stocking sites S3 and S5 at Loch Garry as well as establishing new sites in sections of the lake requested by the client. It is also recommended by EnviroScience staff to agree to a management project well before the 2014 growing season. Contracts are fulfilled on a first come first served basis.

If you have any questions or comments please contact EnviroScience at (800) 940-4025, or e-mail at kborrowman@enviroscienceinc.com.

Warm Regards,
Lake Management Division
EnviroScience

Table 1: Weevil population analysis (weevils/stem) in Loch Garry

Site #	Parameter Measured	July 5 and 23, 2012	August 31, 2012	July 14,19, 24, 2013	September 5, 2013
S1	Total weevils Total stems **Avg. weevils/stem**	1.00 30.00 **0.03**	0.00 30.00 **0.00**	1.00 30.00 **0.03**	1.00 28.00 **0.04**
S2	Total weevils Total stems **Avg. weevils/stem**	0.00 30.00 **0.00**	1.00 30.00 **0.03**	**	**
S3	Total weevils Total stems **Avg. weevils/stem**	1.00 30.00 **0.03**	0.00 30.00 **0.00**	5.00 30.00 **0.17**	2.00 29.00 **0.07**
S4	Total weevils Total stems **Avg. weevils/stem**	0.00 30.00 **0.00**	3.00 30.00 **0.10**	0.00 30.00 **0.00**	0.00 28.00 **0.00**
S5	Total weevils Total Stems **Avg. weevils/stem**	**	**	0.00 30.00 **0.00**	7.00 29.00 **0.24**
M1	Total weevils Total stems **Avg. weevils/stem**	0.00 30.00 **0.00**	1.00 29.00 **0.03**	5.00 30.00 **0.17**	2.00 30.00 **0.17**

Table 2: EWM density (stems/m^2) in Loch Garry

Site #	July 5 and 23, 2012	August 31, 2012	July 14, 19, 24, 2013	September 5, 2013
S1	697.69	483.00	203.70	62.96
S2	593.30	408.53	**	**
S3	491.92	479.87	181.48	133.33
S4	161.03	317.71	66.67	11.11
S5	*	*	218.52	155.56
M1	234.00	494.18	96.30	62.96

*****S5 was not established until 2013
****** No milfoil was present at S2 in 2013

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Table 3: EWM density (stems/m^2) at New Stocking Sites of 2013

Lake	Site #	Initial Survey	Late-Season Survey	Percent Change
Loch Garry	**S3**	181.48	133.33	27% Decrease
Loch Garry	**S5**	218.52	155.56	29% Decrease
Big Cedar	**S1**	81.48	75.93	7% Decrease
Big Cedar	**S3**	137.04	122.22	11% Decrease
Big Cedar	**S5**	137.04	133.33	3% Decrease
Big Cedar	**S6**	122.22	166.67	36% Increase
Long Lake	**S5**	118.52	133.33	12% Increase
Rondeau Bay	**S3**	66.67	140.74	111% Increase

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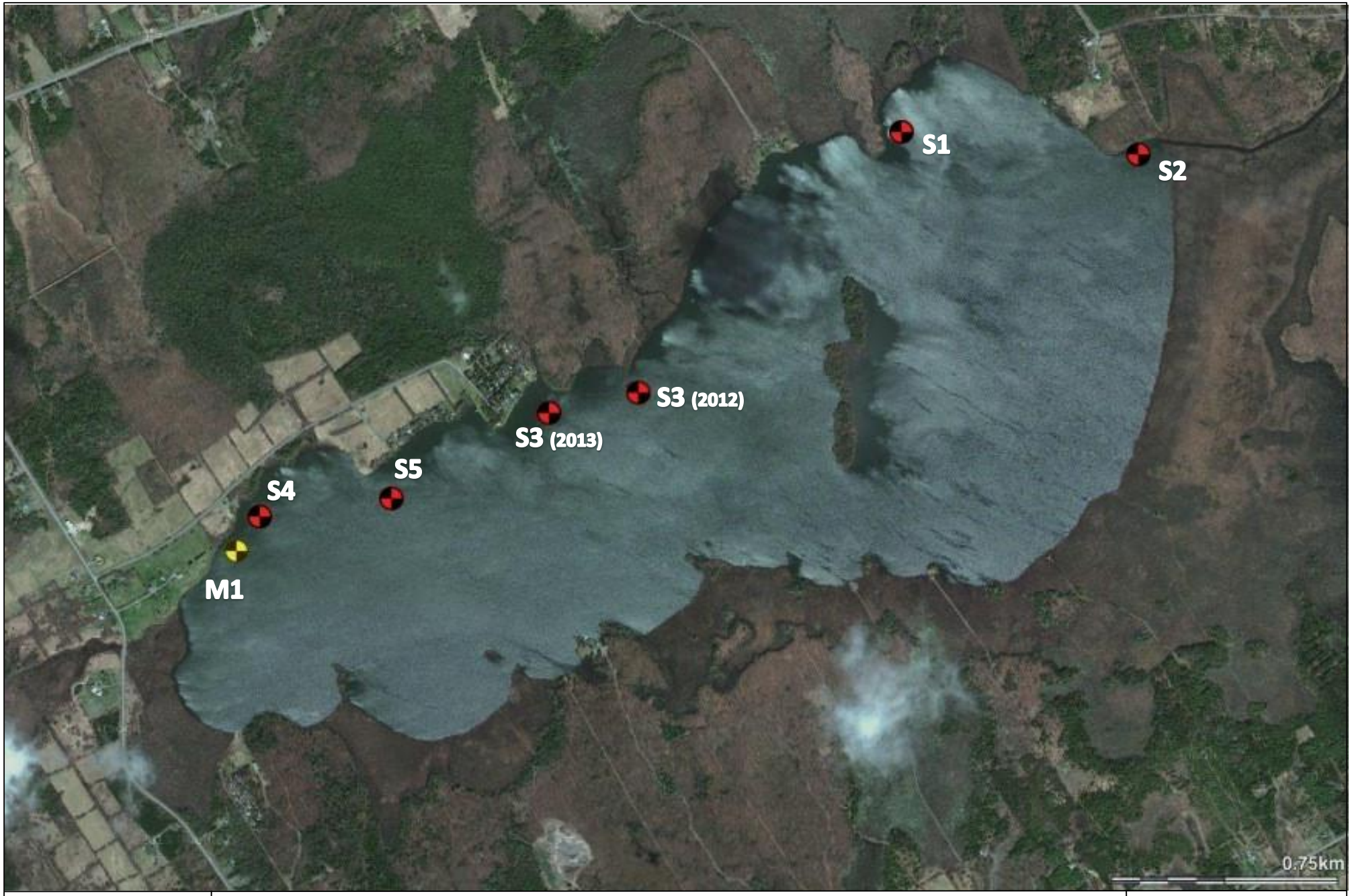

Loch Garry

Glengarry County, Ontario

Weevil Stocking Sites

Monitoring Sites

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MILFOIL SOLUTION