Technical Status Memorandum
For
Lakes Limerick and Leprechaun 2014
Aquatic Plant Management

December 2014

Prepared for
Lake Committee
Lake Limerick Country Club


Prepared by
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Contents

Acknowledgements

Thank you to all the Lake Limerick and Leprechaun volunteers who care about the health of their lakes and want to preserve their ecological and recreational uses. Special thanks to Debbie Moore, Tim Reber, and Larry Duvall for their assistance with this project.

Introduction

The goal of the 2014 year at Lake Limerick Country Club was to continue the lake management program that was implemented in 2005 in order to maintain good water quality, ecologically balanced and aesthetically pleasing lakes.

Over the last couple of years, by using proactive lake management practices, a balance between plant populations and algae has been obtained. Plants in Lakes Limerick and Leprechaun have changed from plant community dominance of non-native Brazilian Elodea to native species such as *Potamogeton amplifolius.*

The presence of aquatic plants is important for overall aquatic habitat, especially fisheries, as well as, to lessen the potential for toxic cyanobacteria blooms that could occur if no plants were present; however, too many plants could impede on the lake's beneficial uses such as boating, aesthetics, recreation and aquatic habitat. It is the balance of a healthy aquatic environment that enables both open water quality, and littoral aquatic plant communities that prevent negative impacts such as high nutrient concentrations leading to algal blooms, and low dissolved oxygen concentrations that limit other aquatic life such as fish. Negative impacts could also be transferred to downstream aquatic systems. Nutrients (phosphorus and nitrogen) from the lake's sediment are recycled throughout the lake and are taken up by plants and algae, creating perfect conditions for excessive plant and algae growth. For this reason, a lake management and monitoring plan at these two lakes is important.

Aquatic plant surveys were conducted at both Lake Limerick and Lake Leprechaun in June and again after the herbicide treatment in September to determine the reduction in plant biomass. Macrophyte populations are prevalent around the rim of each lake indicating the inflow of nutrients from shallow interflow groundwater and perhaps septic systems surrounding the lake. This is particularly true for the plant nutrient nitrogen.

In order to track nutrient concentrations relative to the potential for excess phytoplankton production, the monitoring program that was implemented in 2013 was also continued in 2014. The program was very successful at creating a historical database of water quality conditions in each lake throughout the year. Nutrient concentrations at the inlet and outlet locations to Lakes Limerick and Leprechaun fluctuated depending on precipitation amounts and nutrient sources. Higher nutrient concentrations at Lake Limerick occurred with lake turnover in the spring, internal cycling from the sediments, and heavy spring rains. Overall, Lakes Limerick and Leprechaun have good water quality. Spring turnover and depth helps Lake Limerick to maintain its resiliency, while shallower Lake Leprechaun requires a more proactive management strategy. Because of the abundance of internal and external sources of nutrients, it is important to continue to track areas of concern such as lake inlets or outlets to ensure that the lakes maintain their water quality.

The following report describes the history of the Lake Limerick and Lake Leprechaun monitoring programs and the two lake's statuses after the 2014 management year.

Lake Limerick

The aquatic plant control program for Lake Limerick in 2014 continued to build upon the efforts started in 2005. In 2014 the objective of management actions were designed to continue to control non-natives, but also to reduce the adverse impact of the native plant's density and coverage of the lake bottom. Endothal was used in addition to Diquat and Sonar in 2014 in order to greatly reduce the growth of the native plant *Potamogeton amplifolius.* At the same time the plant community was encouraged to develop in a sustained manner to promote habitat structure and direct competition to phytoplankton for nutrient uptake. The water quality monitoring program that was started in 2013 was maintained in 2014.

Aquatic Plants

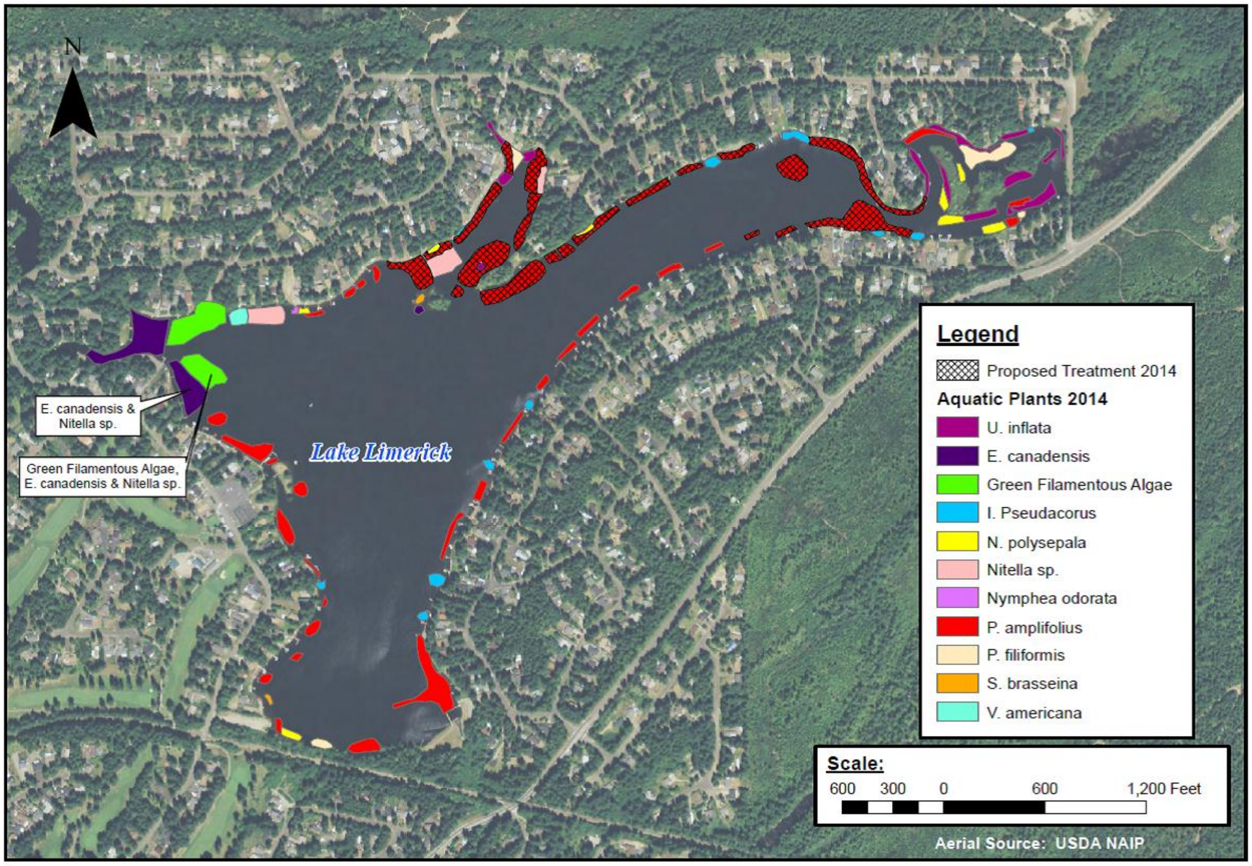
The area treated in 2014 was considered a small treatment compared to past treatments, and was slightly larger than the treatment in 2013 of 5 acres. 7.1 acres of aquatic plants were treated in 2014 in order to limit the increasing growth of the native plant call pond weed (*Potamogeton amplifolius*). The original intent of the aquatic plant management program was to control the non-native Brazilian elodea (*Egeria densa*). Elodea's dominance of the aquatic plant community has been greatly reduced since the 1990's and early 2000's and only a small strand was found during the 2014 aquatic plant survey.

A total of 7.1 acres were treated in 2014 by AquaTechnex, LLC. The first treatment was with the contact herbicide Diquat and Endothall. During the follow-up treatment the systemic herbicide Sonar PR was used. The purpose of the contact herbicide was to weaken the dominate plants within the target area and then to allow these same plants to start to regrow (10 to 14 days after the contact herbicide treatment) so that the systemic herbicide will kill non-native plants in the area and limit the regrowth and over production of the pond weeds (native plants) in the following summer. This is the same objective as the previous 2012 and 2013 treatment efforts.

Figure 1 illustrates the locations and type of plant communities within Lake Limerick during the June 2014 survey. Figure 1 also shows the red hatched areas where treatment took place in 2014. Figure 2 shows the decrease in *P. amplifolius* after the 2014 herbicide treatment.

Figure 3 illustrates the locations and type of plant communities within Lake Limerick as of the June 2013 survey. Figure 4 also shows the decrease in biovolume where treatment took place in 2013.

Figure 5 shows the 2012 aquatic plant map for Lake Limerick and the proposed treatment plan. Figures 6-8 depict plant surveys and proposed treatment zones for 2008-2011. The aquatic plant treatment program has been reduced from a total of 32 acres to not more than 12 acres in 2010, less than 5 in 2011, 2012, and 2013 and 7 in 2014.



2014 Lake Limerick Aquatic Plant Survey & Proposed Treatment

Figure 1. Lake Limerick plant map and treatment areas for 2014.

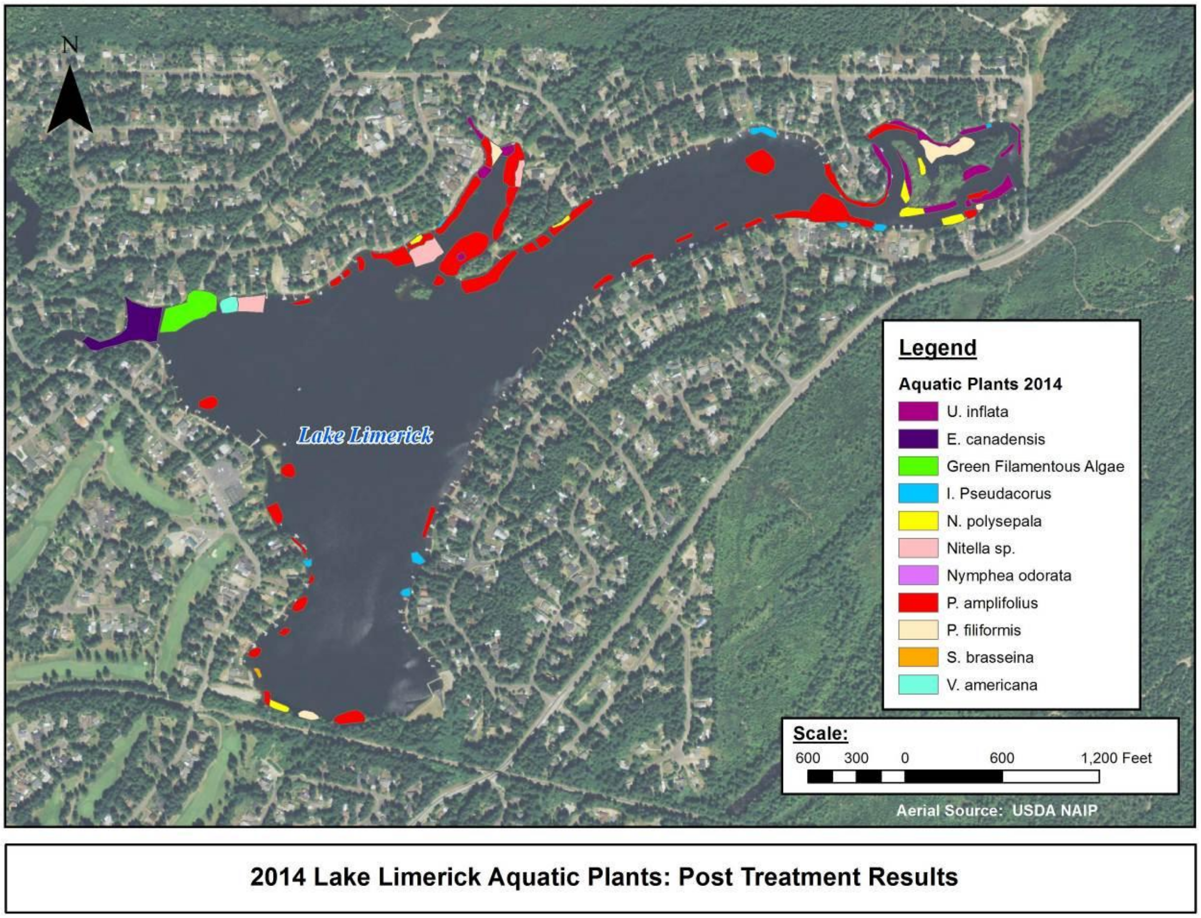


Figure 2. Lake Limerick post aquatic plant treatment map for 2014.
Note: A visual survey and sonar survey using Bio Base was taken late in the season (early September). Some plants, such as those on the east side of the lake, had already senesced, resulting in less plant biovoulme than peak summer amounts.

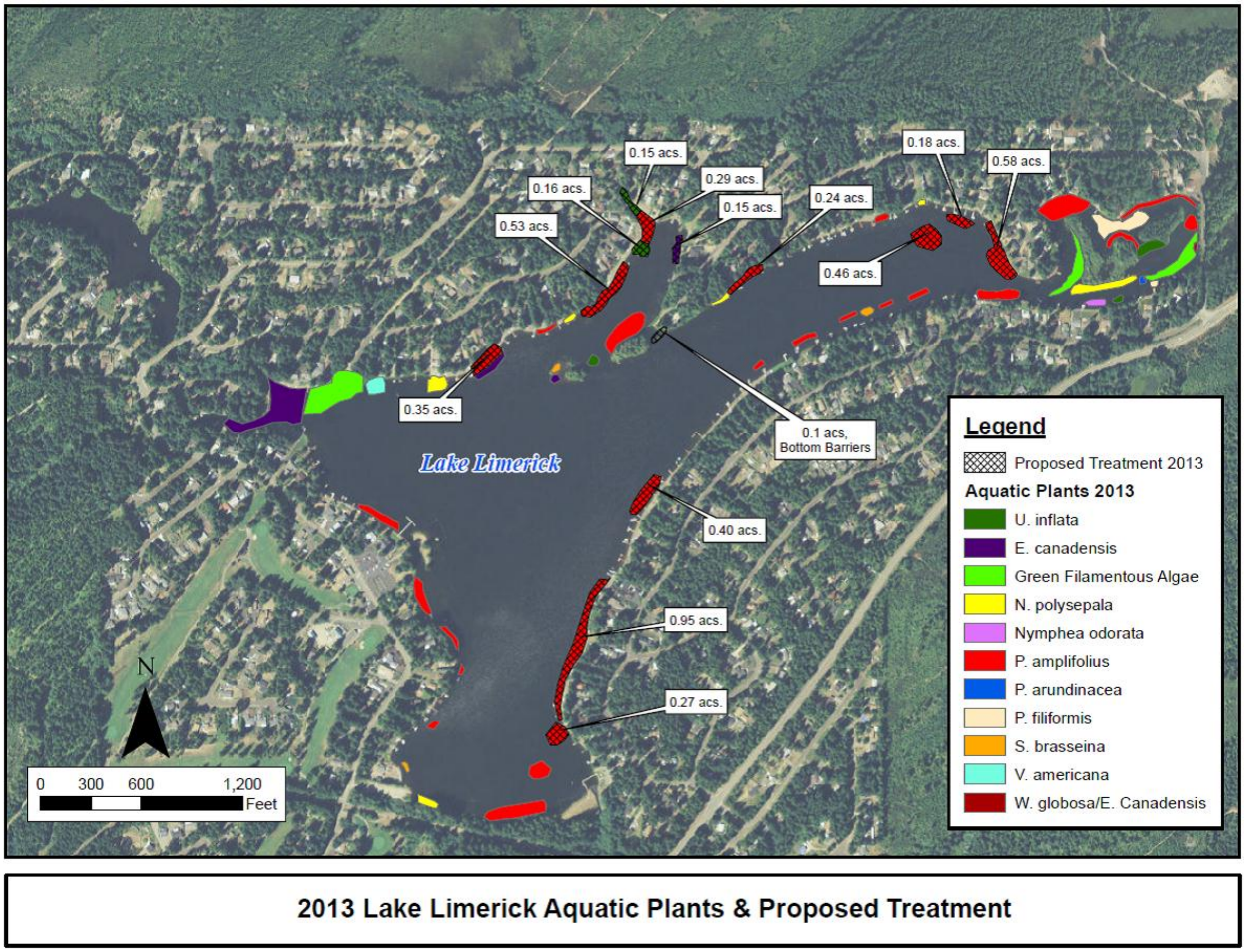
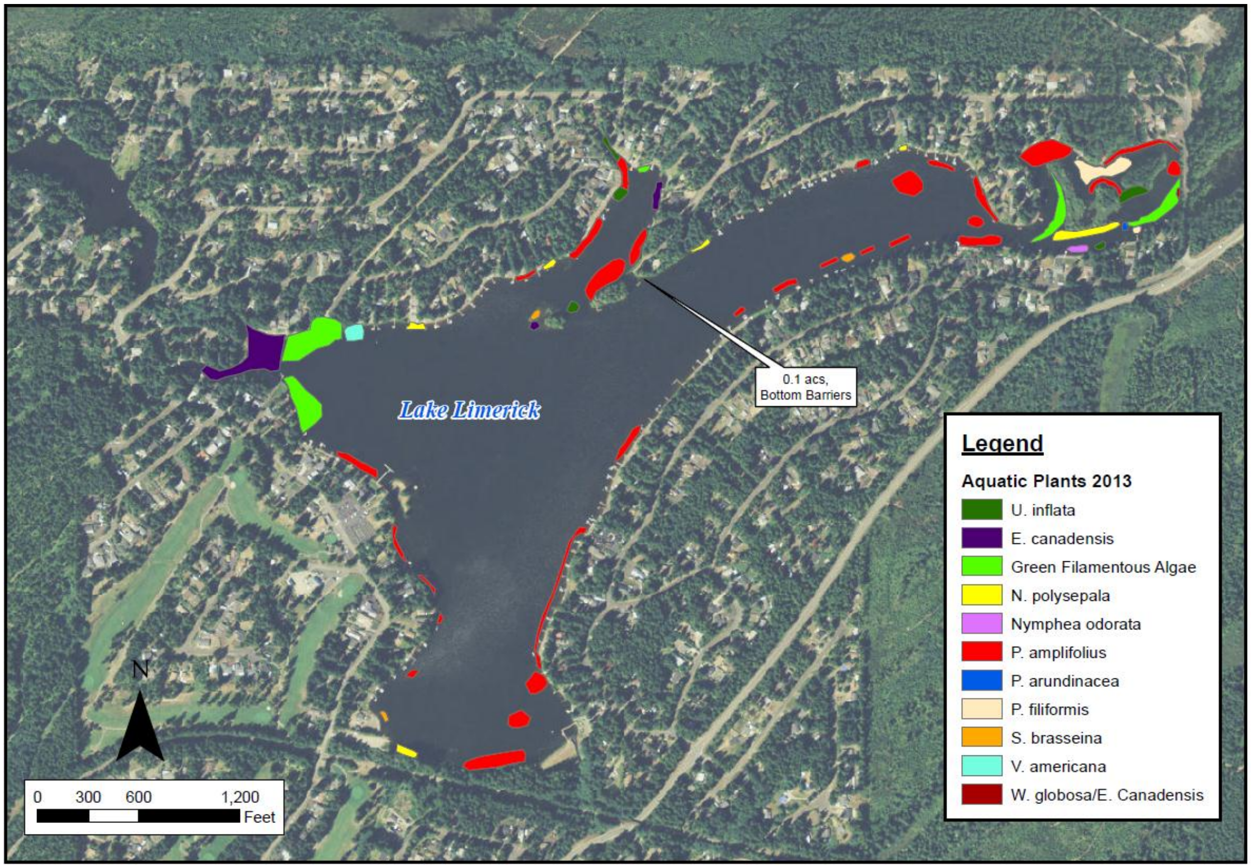
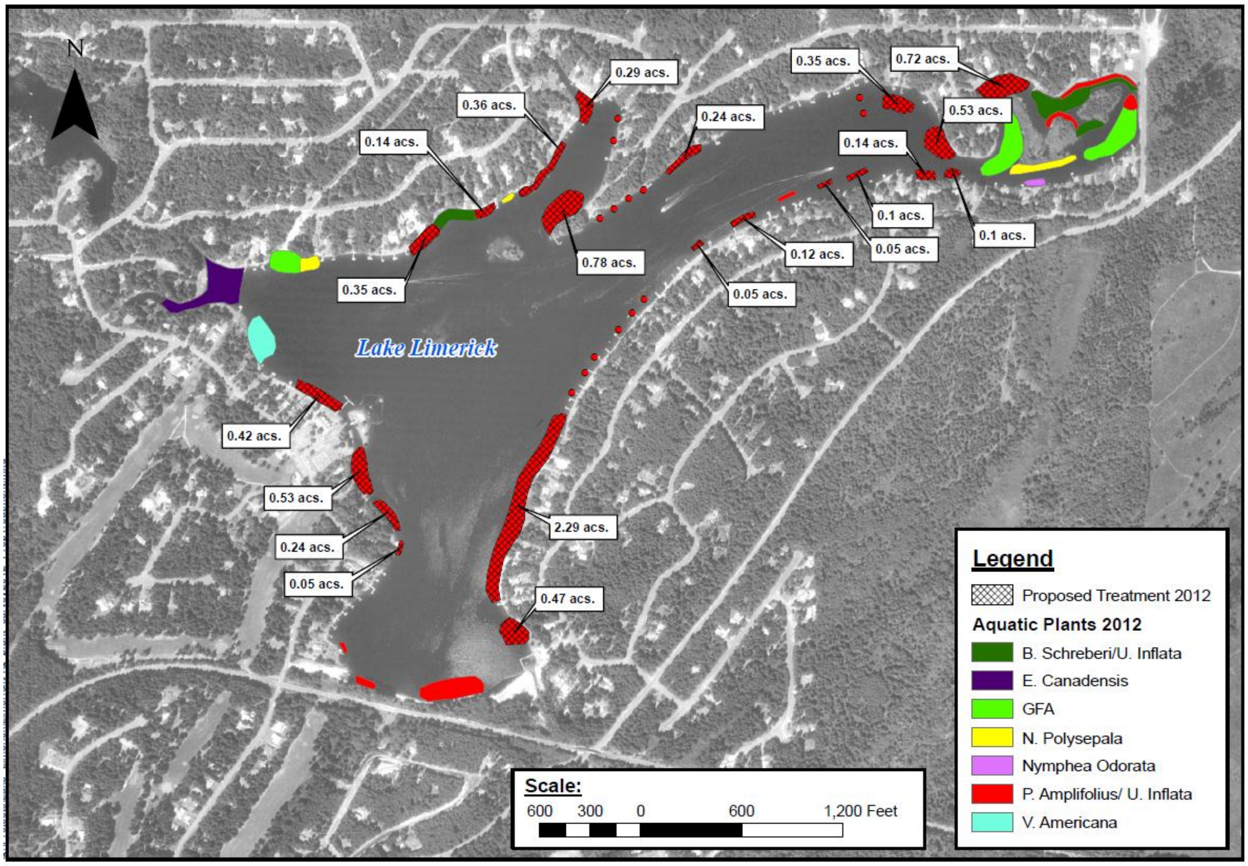


Figure 3. Lake Limerick plant map and treatment areas for 2013.



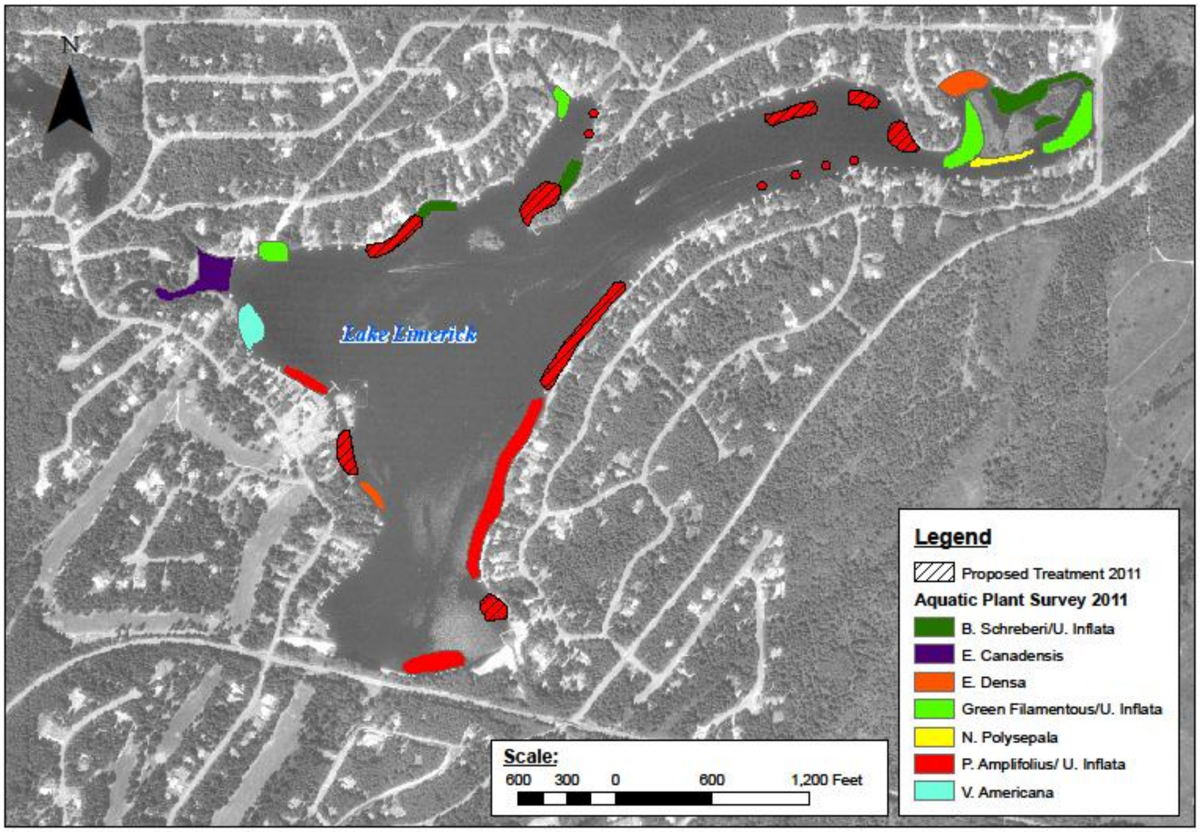
2013 Lake Limerick Post-Treatment Aquatic Plants

Figure 4. 2013 Lake Limerick post-treatment aquatic plant map



Lake Limerick Aquatic Plant & Proposed Treatment 2012

Figure 5. Lake Limerick plant map and treatment areas for 2012.



Lake Limerick Aquatic Plant June 2011 Proposed Treatment 2011

Figure 6. Lake Limerick plant map and treatment areas for 2011.

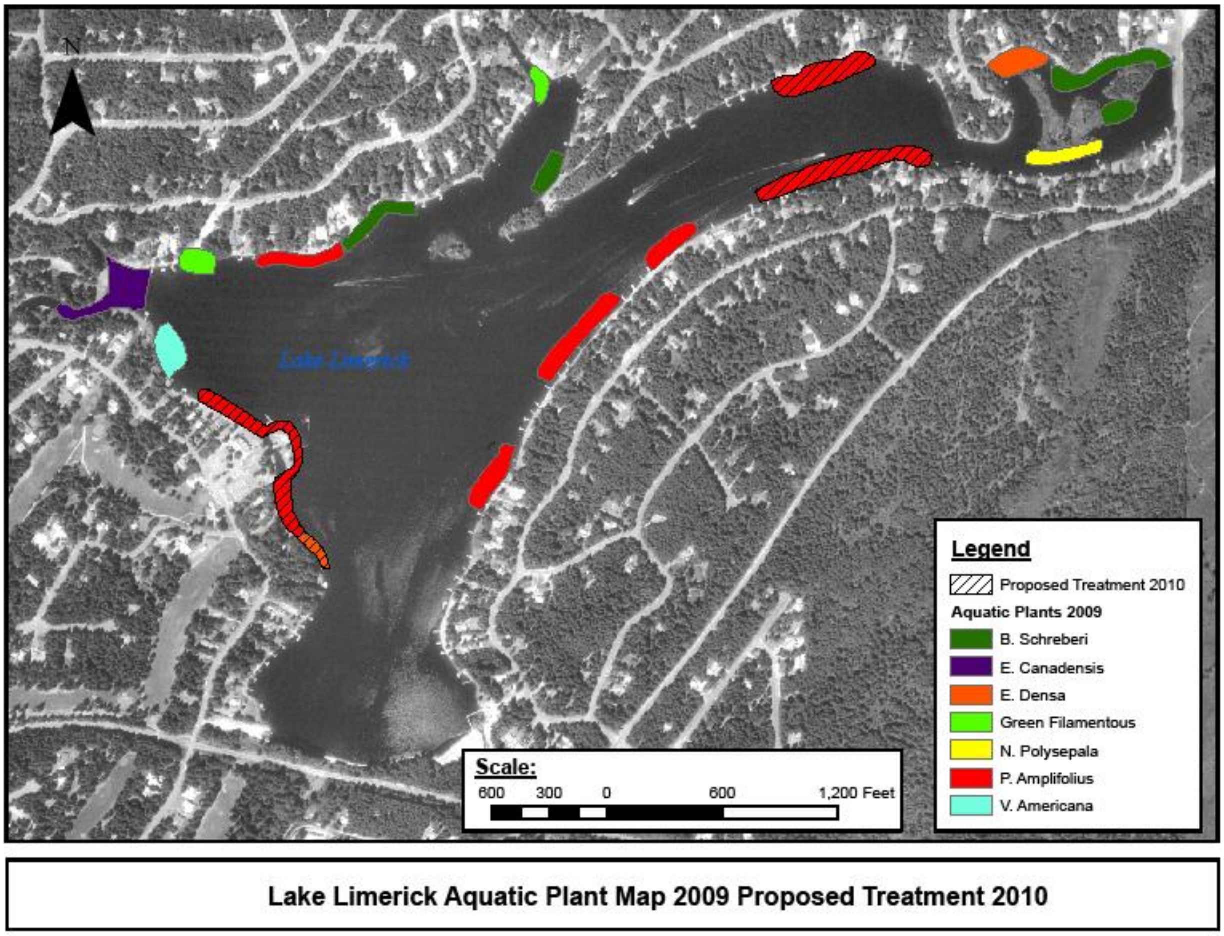


Figure 7. Lake Limerick aquatic treatment map for 2010.

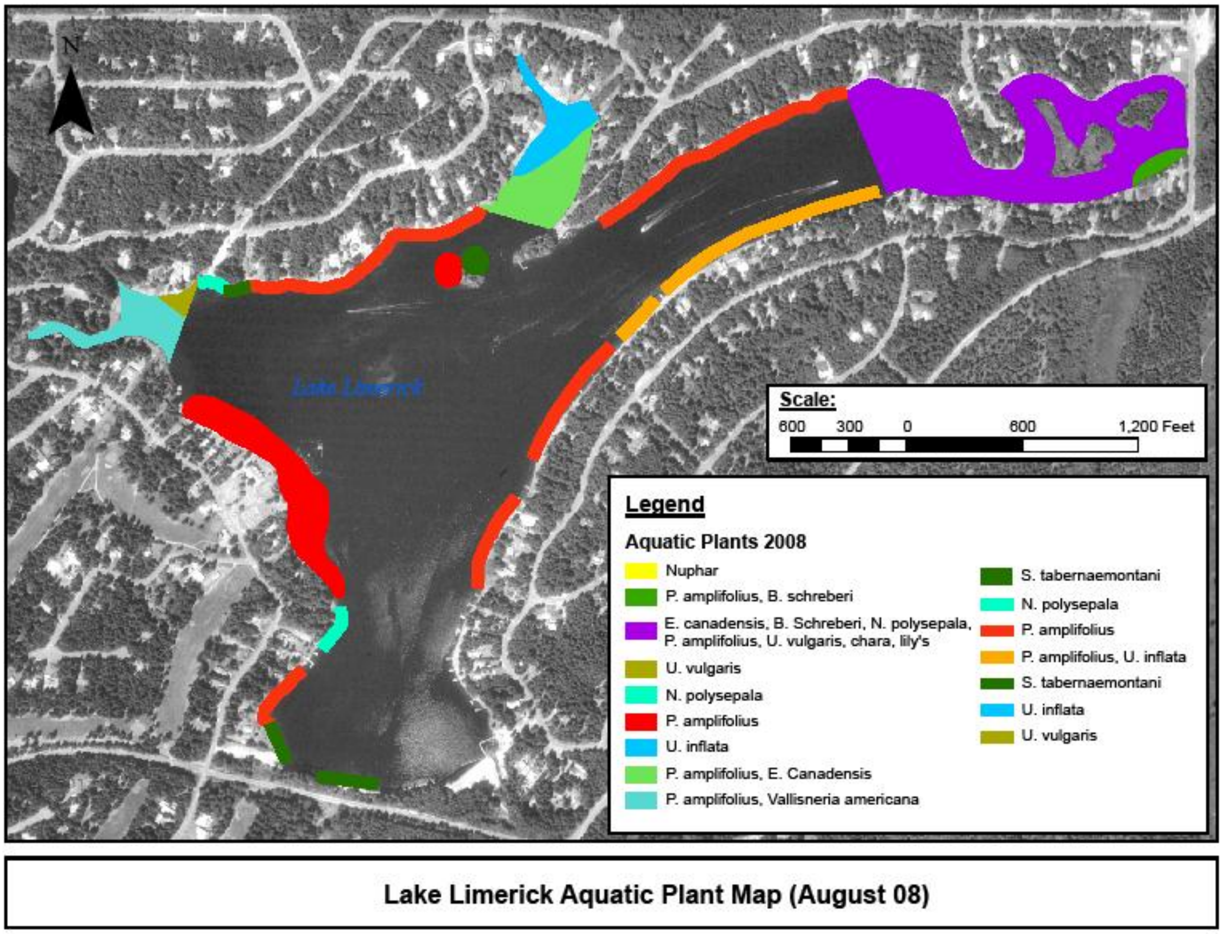


Figure 8. Lake Limerick aquatic plant coverage in August 2008.

Water Quality

During the 2014 management year, the level loggers that had been installed in 2013 were maintained at the two locations in Lake Limerick; below the dam and at the country club dock. A photograph of the level logger located at the dam site is below in Figure 9. Figure 10 shows the level logger located at the Lake Limerick Country Club dock. These level loggers provide accurate lake level data in 60 minute intervals in order to determine how the lake reacts to precipitation events or drought, and to aide in the development of a mass balance model. In 2015, the level logger data will be correlated to actual lake levels and will be used to manage the timing and movement of weir board adjustments at the Limerick dam site. The lake level fluctuations from December 2013 through November 2014 with corresponding precipitation can be seen below in Figures 11 and 12. Water quality samples and secchi disk measurements were collected from March through November at six different locations throughout the lake; at the dam surface and bottom, Banbury, King Cove, Tipperary, and Cranberry. The water quality monitoring sites are shown below in Figure 13. Water quality samples were analyzed for Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Chlorophyll *a*, and phytoplankton.

Figure 9. Level logger located at the Lake Limerick Country Club dock.

Figure 10. Level logger located below the Lake Limerick dam site.

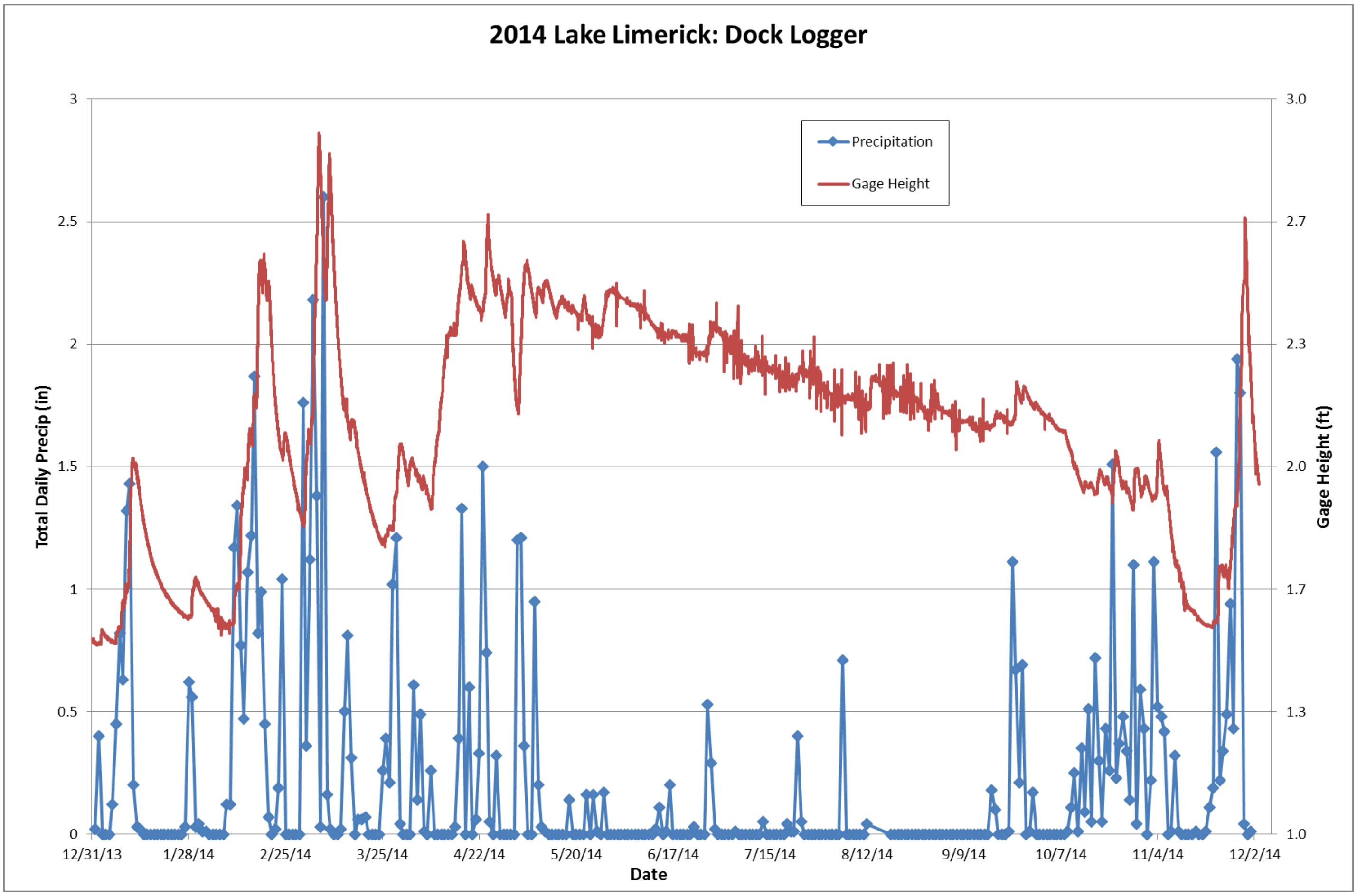


Figure 11. Lake Limerick level logger data and daily precipitation from December 2013 through November 2014.

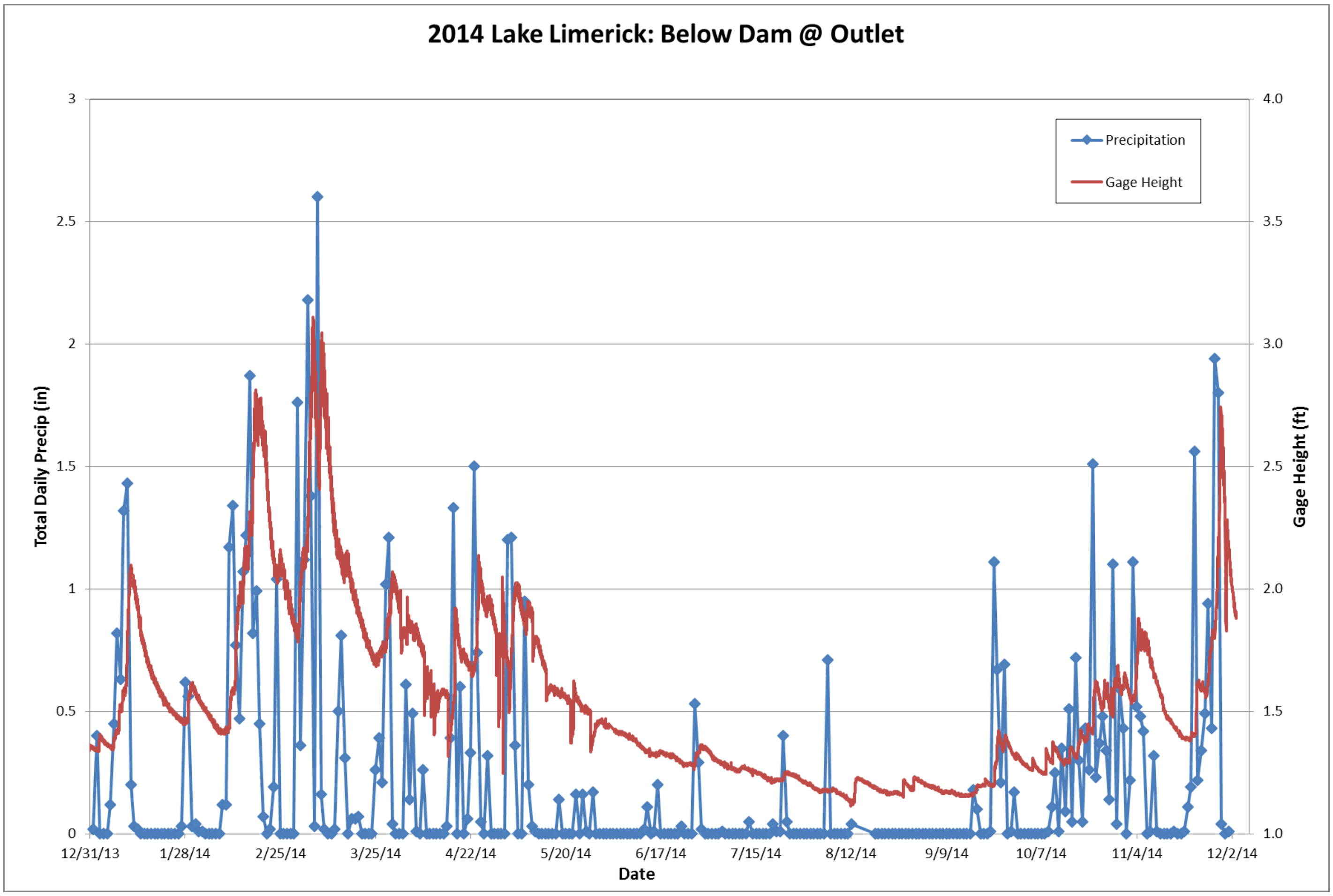


Figure 12. Lake Limerick below the dam level logger data and corresponding daily precipitation for December 2013 through November 2014.

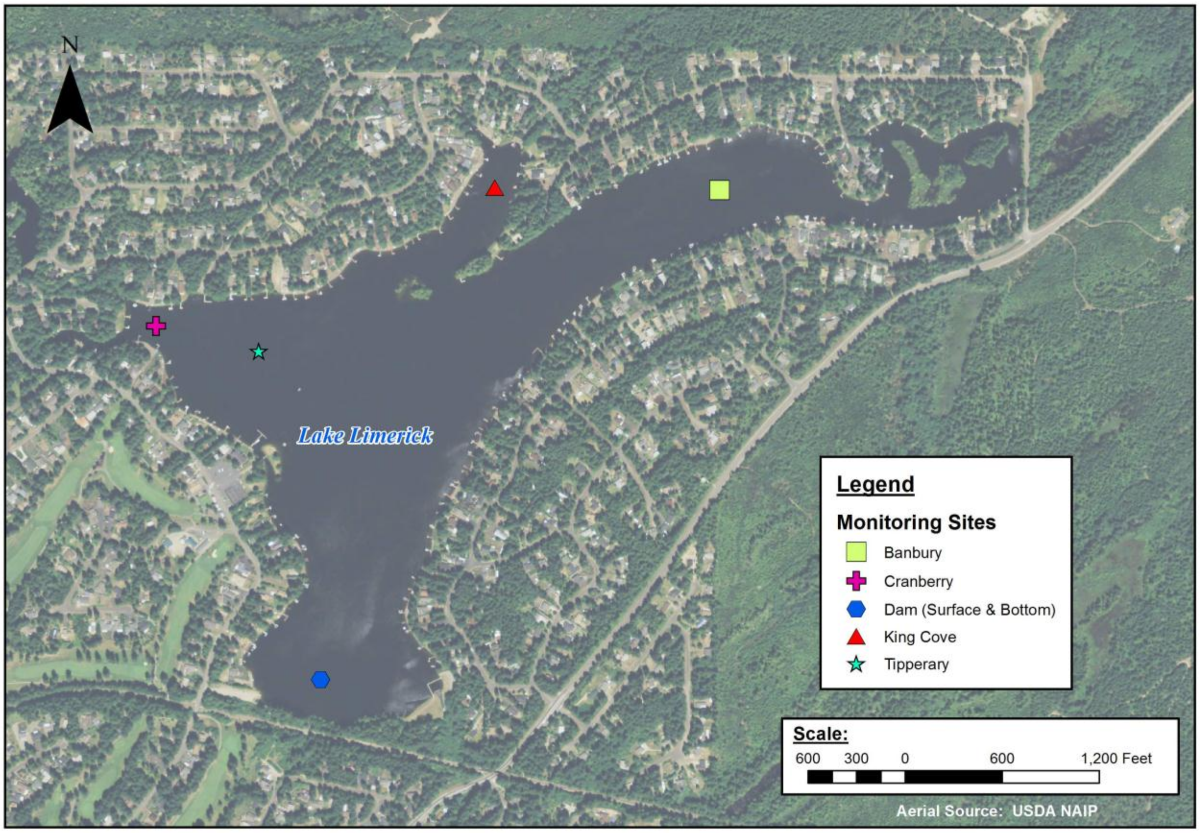


Figure 13. 2014 Lake Limerick water quality monitoring sites.

Figure 14 shows TP results for Lake Limerick during the spring through fall of 2014. 2014 TP concentrations were around 1 µg/L lower on average than the 2013 season. Concentrations at the surface dam site in 2014 averaged 11 µg/L compared to 12 µg/L in 2013. Average TP concentrations at the Cranberry sampling locations were lower in 2014 at 32 µg/L compared to an average of 36 µg/L in 2013. During the summer of 2014 Lake Limerick almost met its goal of a mean summer time TP concentration of 15 µg/L or less with peak lake average TPs of 25 µg/L or less at any given time. The Cranberry location is the only sampling site that exceeded the goal with an average of 32 µg/L. At these levels the occurrence of nuisance algal blooms and potential HABs (Harmful Algal Blooms) would be rare events if at all. Figure 15 shows SRP concentrations from March through November. SRP concentrations averaged 2-3 µg/L, slightly higher than 0-1 µg/L in 2013. The level of SRP reflects good water quality conditions. Chlorophyll *a* concentrations are shown in Figure 16, and ranged from .5-9.6 µg/L (Banbury), with the highest chlorophyll *a* concentrations occurring in April. The high concentrations most likely occurred due to heavy spring rains washing TP into the lake followed by lake turnover and days of sunshine. Summer average chlorophyll *a* concentrations ranged from 2-3.7 µg/. This low level of algal productivity is reflective of oligotrophic conditions (low algal productivity) and is a reflection of the TP concentration in the water column. The chlorophyll *a* management goal is to keep it below 4 µg/L for the summer average and below 8 µg/L during a periodic lake wide event. Lake Limerick almost met its goals for chlorophyll a production in 2014 with the exception of a periodic lake wide event exceeding 8 µg/L in April.

The low TP and Chlorophyll *a* concentrations are a function of the nutrient competition that exists from aquatic macrophytes and periphyton (rooted aquatic plants and the algae attached to the lake bottom and rooted plant structures) within the lake.

Figure 17 shows the percentage of each species of phytoplankton that is present in Lake Limerick. The systems is dominated by Chrysophyta, a healthy form of algae. There was almost no Cyanophyta, harmful algae, present during 2014.

Maintaining a balance between the rooted aquatic plant community and phytoplanktonic community will help maintain good water quality conditions in the lake. Continuing a water quality monitoring plan in the future will help to increase the Lake Limerick data set, monitor changes, and create a mass balance model of nutrient composition within the lake and sources of nutrients contributing to plant production.

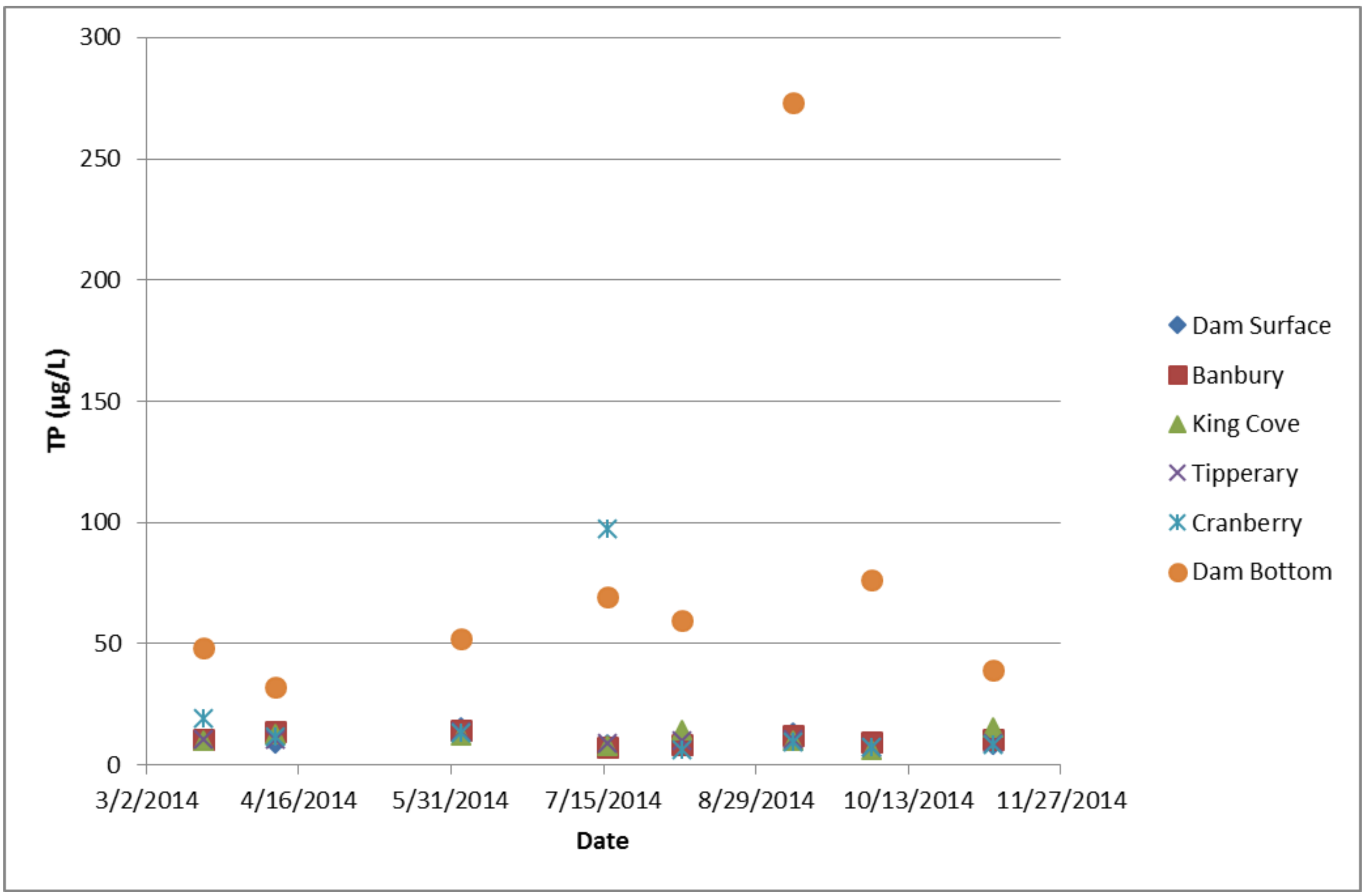


Figure 14. TP concentrations for Lake Limerick from March-November 2014.

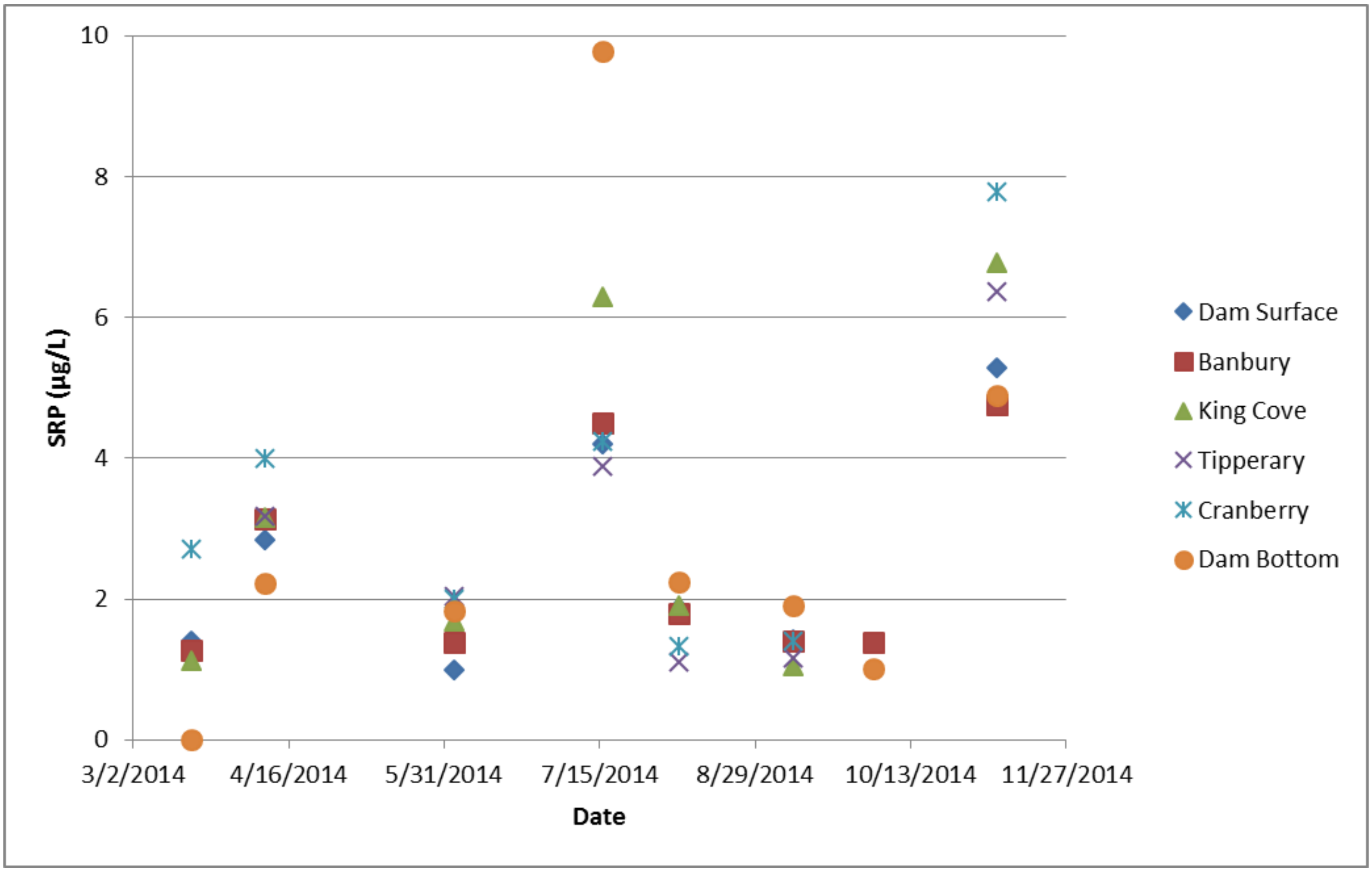


Figure 15. SRP concentrations for Lake Limerick from March-November 2014.

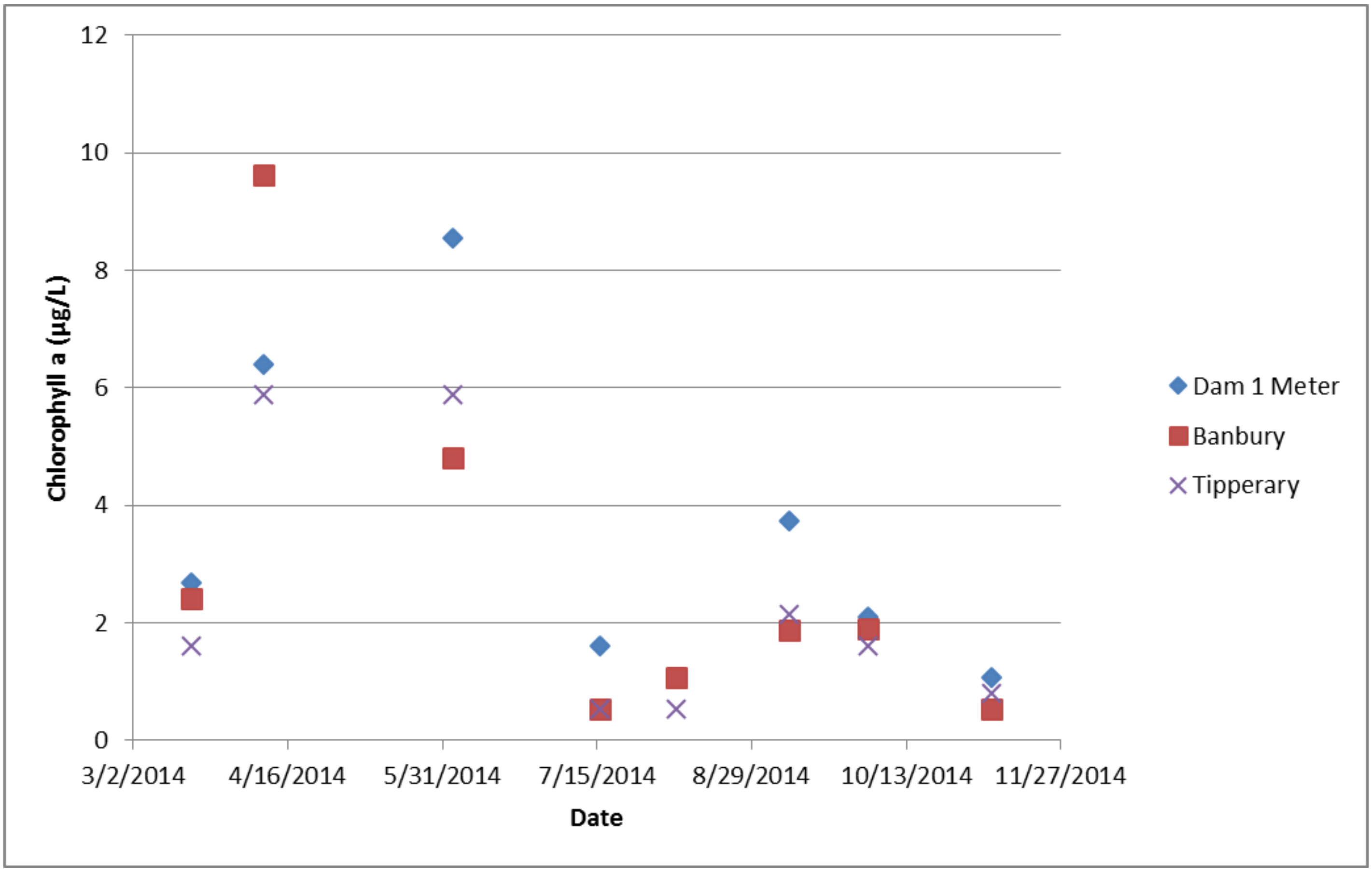


Figure 16. Chlorophyll a concentrations for Lake Limerick from March-November 2014.

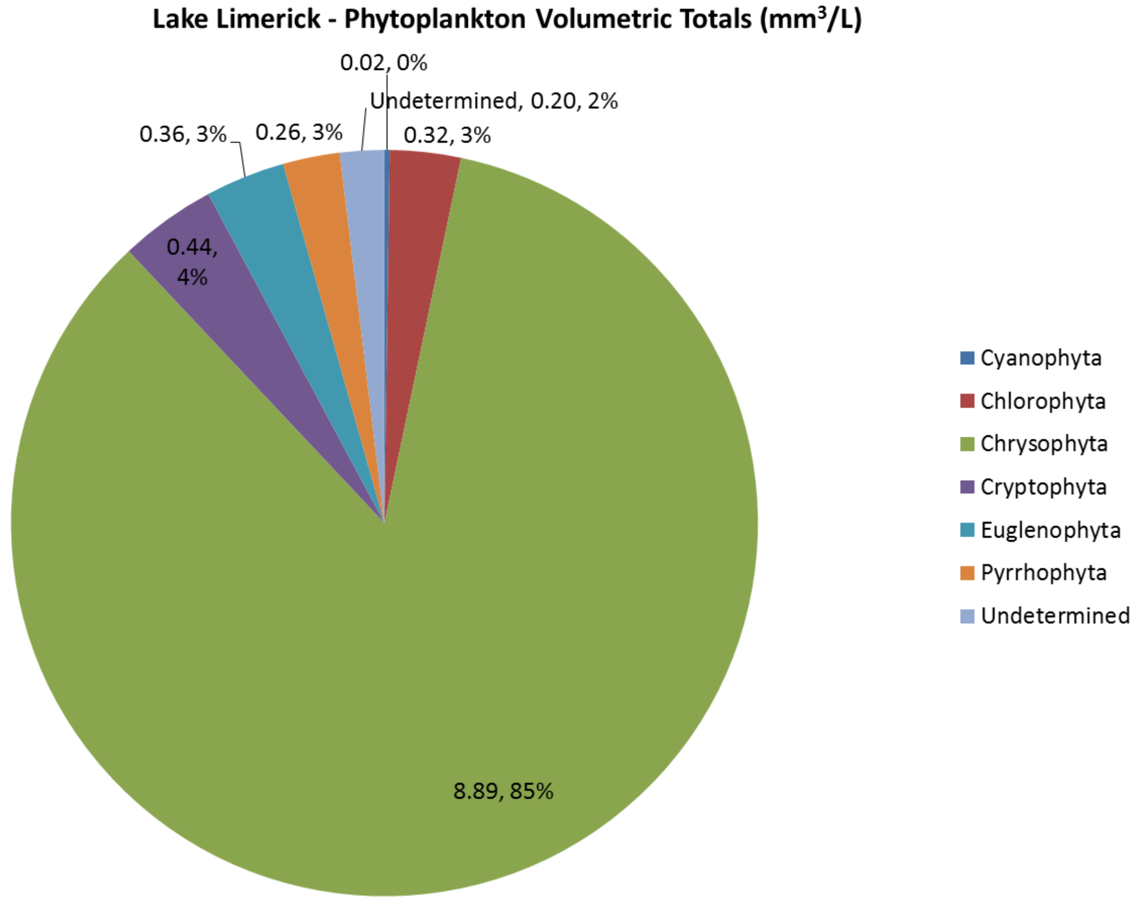


Figure 17. 2014 Lake Limerick phytoplankton volumetric totals.

Lake Leprechaun

The June Lake Leprechaun plant survey indicated that the plants (*Potamogeton amplifolius)* that had been knocked back in the 2012 herbicide treatment had started to grow back after not being treated in 2013. Therefore, a little over an acre was treated with herbicide at Lake Leprechaun during 2014. The water quality monitoring plan that was put in to place for Lake Leprechaun during 2013 was also continued during 2014.

Aquatic Plants

A little over an acre was treated during 2014 in the northern and eastern coves of Lake Leprechaun where thick groups of *Potamogeton amplifolius* were present. After treatment, the *P. amplifolius* was knocked down. Figure 18 shows the 2014 plant communities with the same protocol used in Lake Limerick on the same dates. Figure 19 shows Lake Leprechaun plant populations after the herbicide treatment. Figure 20 is a previous aquatic plant map and shows treatment zones from 2012.

The dominate plants observed in Lake Leprechaun in the past are listed in Table 1 and shown in Figure 21, which is a map of the relative coverage or those dominate plants within the lake during 2007. Figure 22 shows a map of the aquatic plant survey from 2009. It is evident from past aquatic plant maps that the balance of plants in Lake Leprechaun has been greatly improved due to proactive management and periodic herbicide treatments.

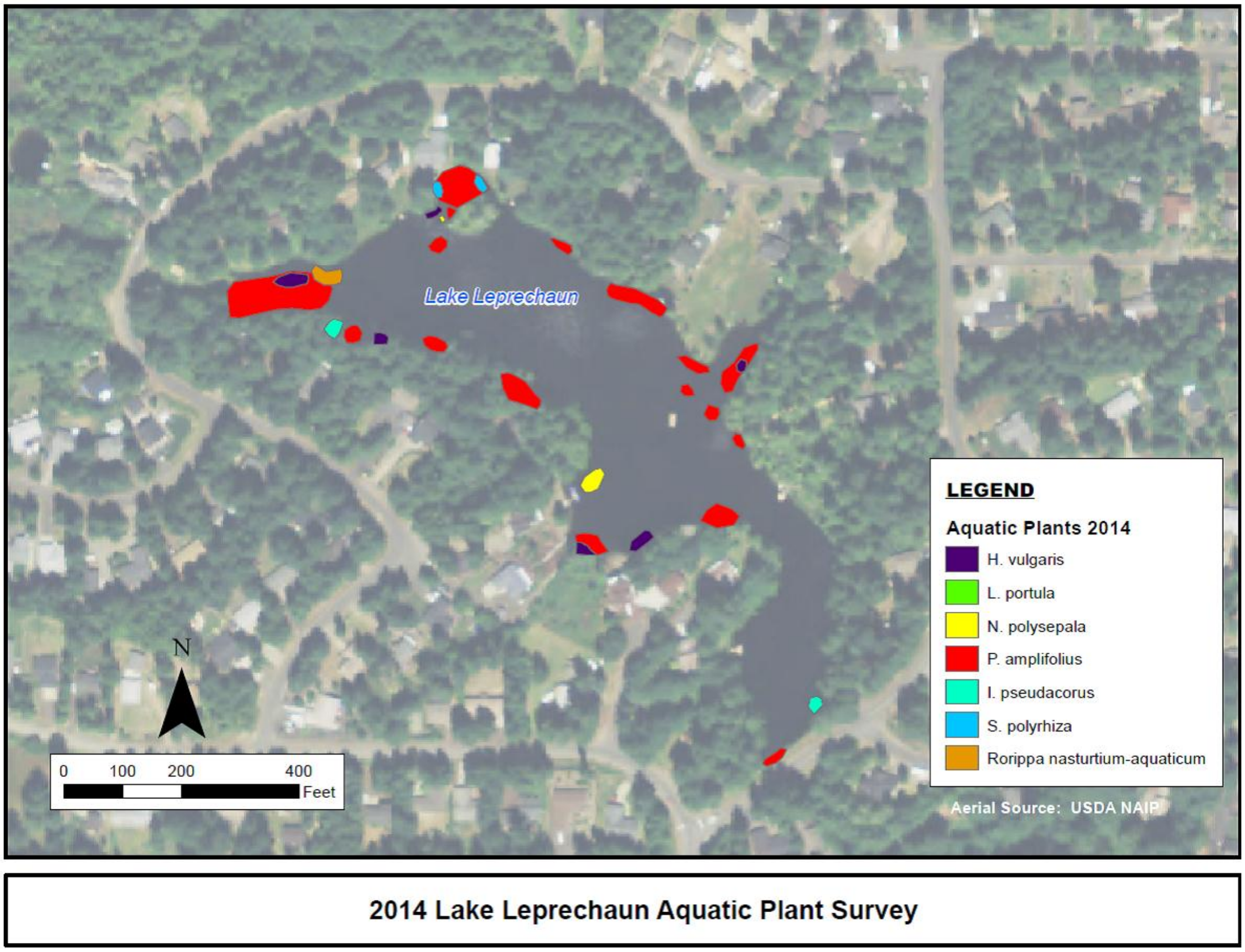


Figure 18. 2014 Lake Leprechaun aquatic plant survey.

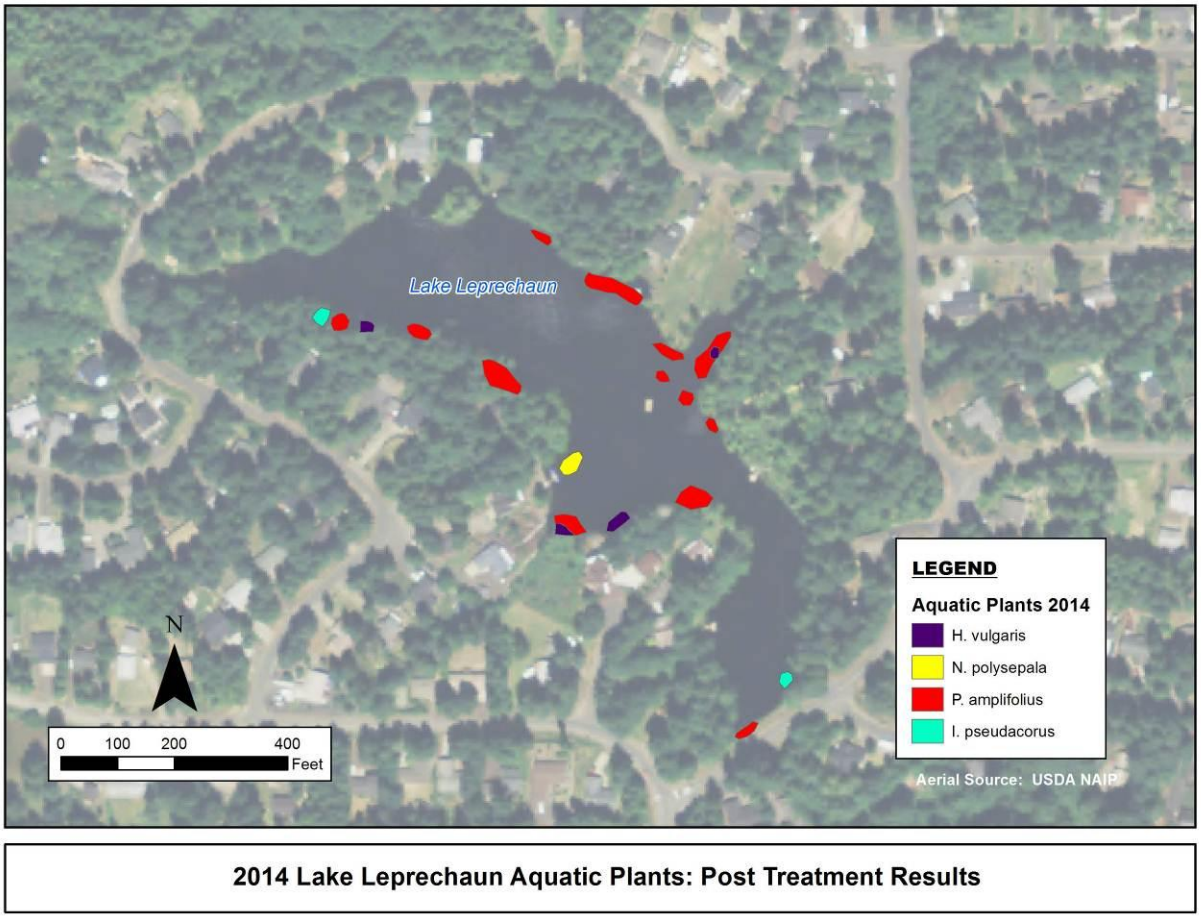


Figure 19. 2014 Post treatment Lake Leprechaun aquatic plant survey.

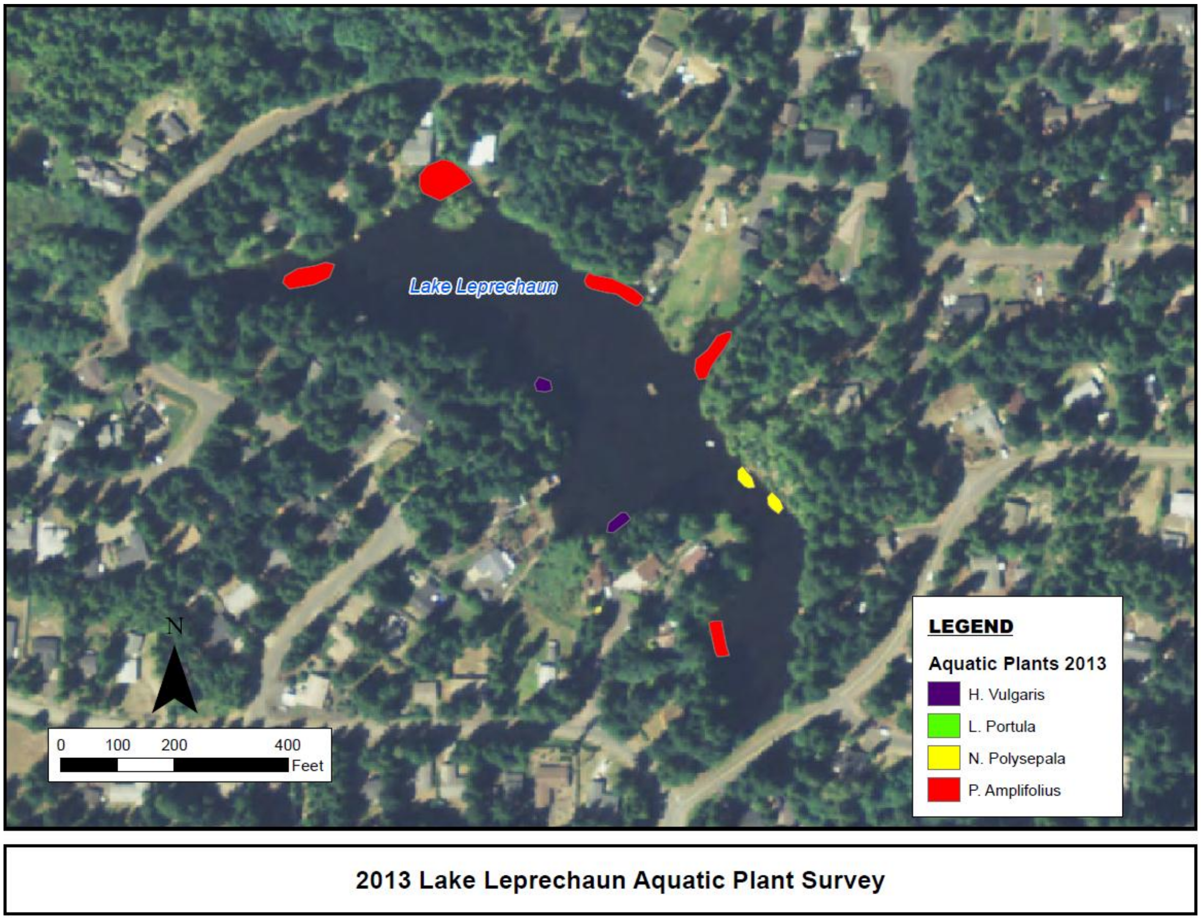


Figure 20. 2013 Lake Leprechaun aquatic plant survey.

Table 1. List of dominant aquatic plants observed in Lake Leprechaun in 2007.

Species Name	Common Name
Hippuris vulgaris	Common mares tail
Myriophyllum sibericum	Northern milfoil
Potamogeton amplifolius	Big leaf pond weed

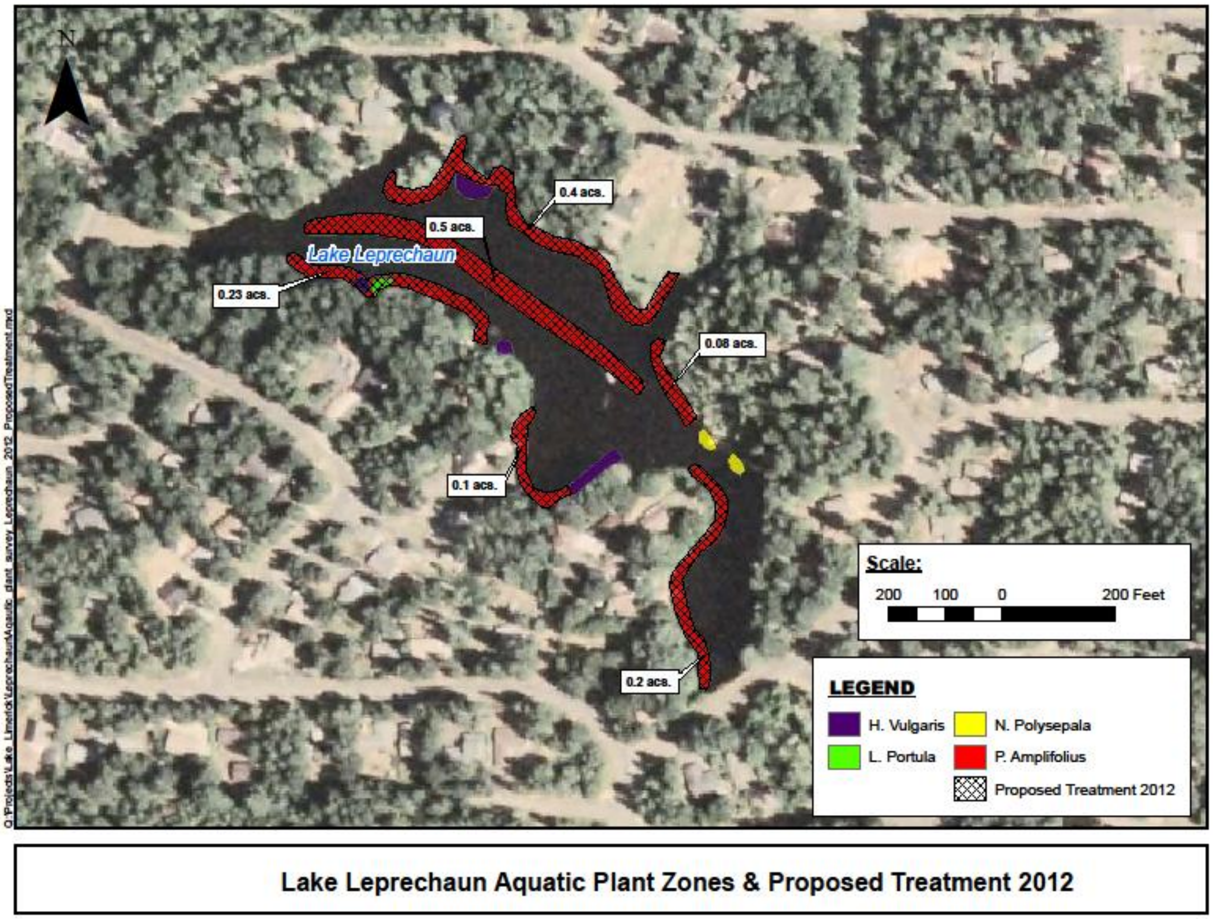


Figure 21. The 2012 Aquatic plant map of Lake Leprechaun showing treatment areas.

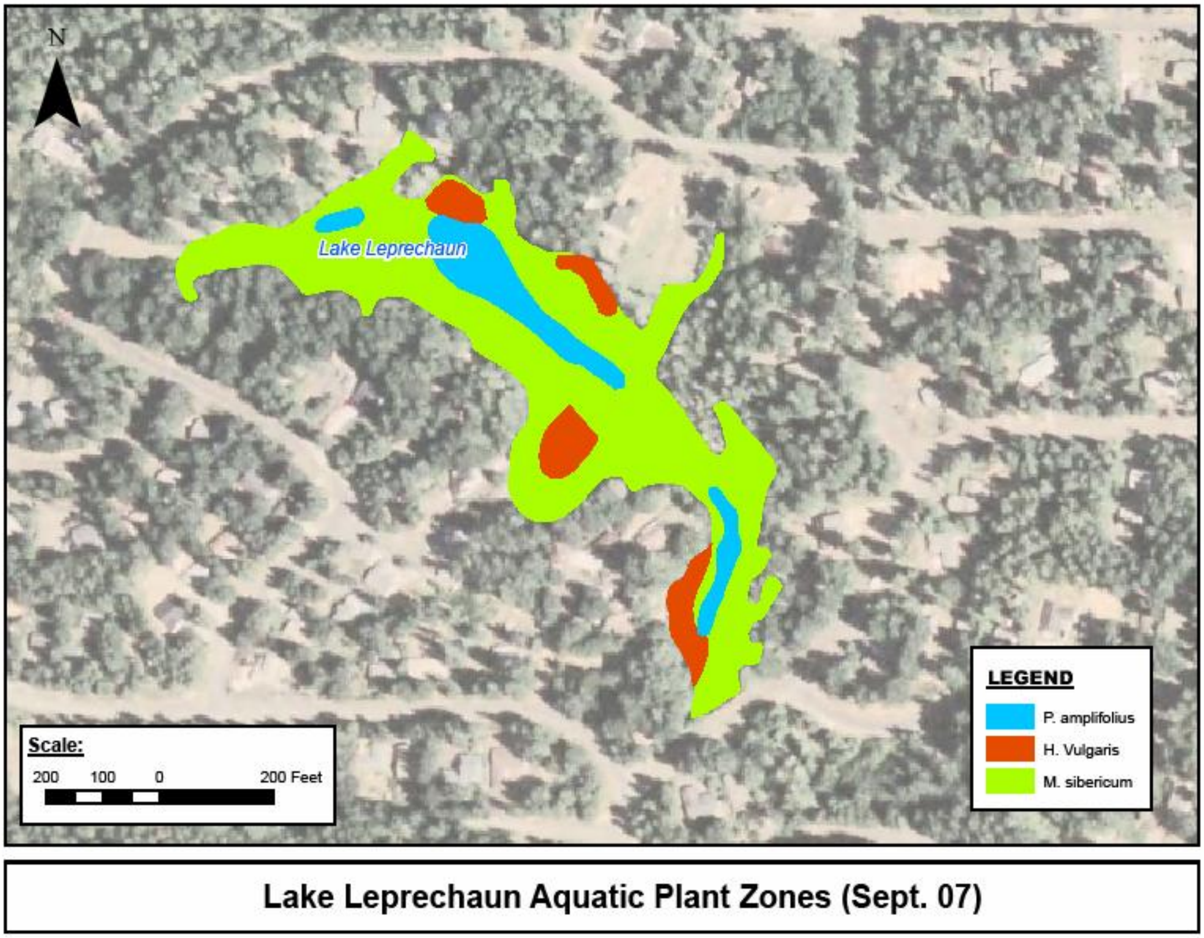


Figure 22. Aquatic Plant Map of dominant plants in Lake Leprechaun, 2007.

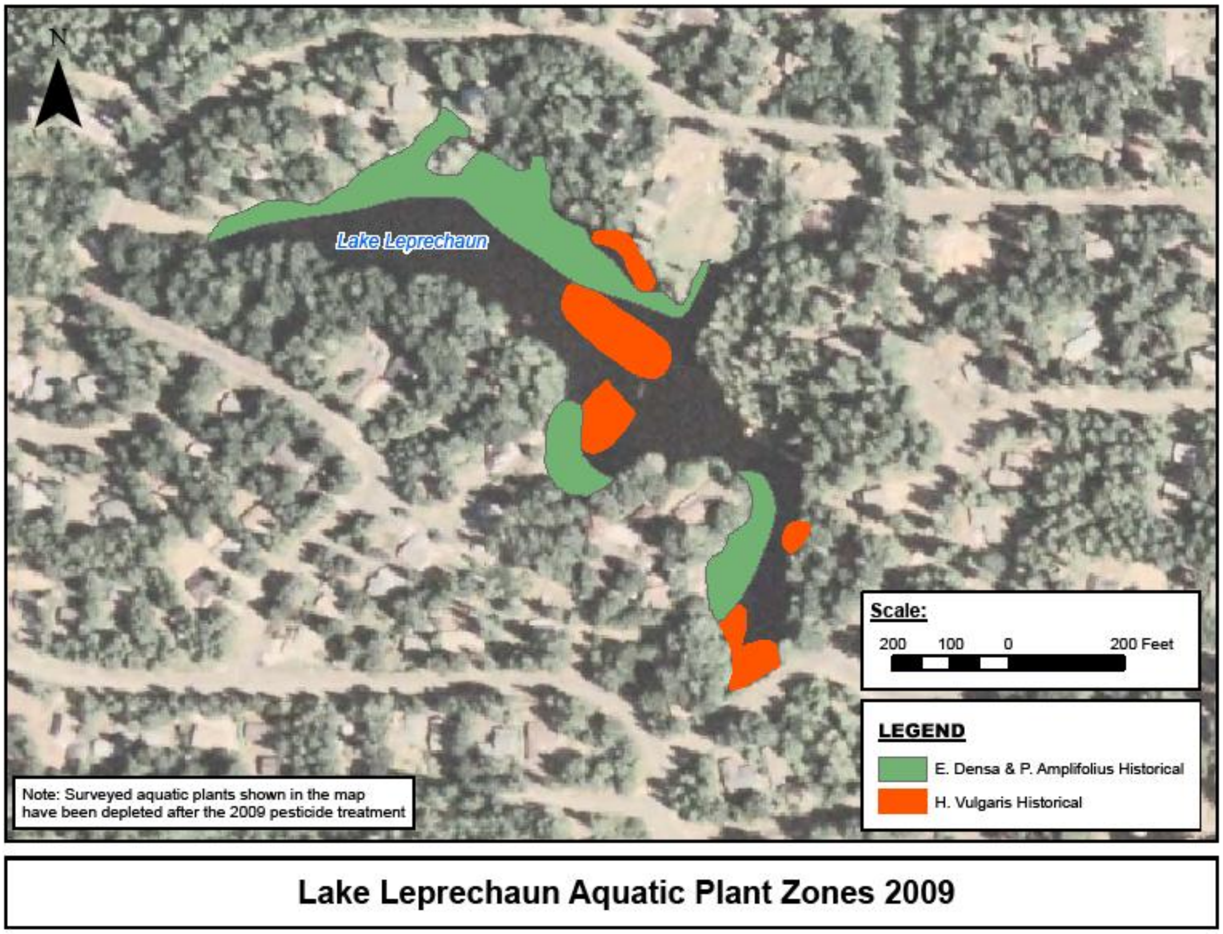


Figure 23. 2009 Aquatic plant map of plants showing to summer 2009 treatment areas.

Water Quality

A water quality monitoring program was implemented at Lake Leprechaun during the summer of 2013 and continued through 2014. A level logger was installed near the outlet of Lake Leprechaun in 2013 and was also maintained through 2014. Figure 24 shows the location of the level logger next to the outlet structure. Figure 25 shows lake level and corresponding daily precipitation. Water samples and Secchi disk transparency were collected from March-November at the outlet location as well. The water quality sampling site for Lake Leprechaun for 2014 is shown below in Figure 26. Water samples were analyzed for TP, SRP, Chlorophyll *a* and phytoplankton. Figure 27 depicts TP concentrations for Lake Leprechaun for 2014. Concentrations ranged from 9-17 µg/L, with highest concentrations in July. TP concentrations were slightly higher than concentrations in 2013. Figure 20 shows SRP concentrations. SRP concentrations averaged 3 µg/L during the summer sampling season. Chlorophyll *a* concentrations are shown in Figure 21 and ranged from 0.5-2.7 µg/L.

Figure 30 shows the volumetric phytoplankton distribution for Lake Leprechaun during 2014. The lake is also dominated by Chrysophyta, but has greater amounts of Chlorophyta and Cryptophyta that would be expected in shallower wetland-type systems.

Lake Leprechaun's water quality reflects good water conditions that also exist in Lake Limerick for similar reasons. The water quality goals are also the same as Lake Limerick. However, Lake Leprechaun is shallower than Lake Limerick so the management of aquatic macrophytes has to allow for a slightly higher level of production in order to maintain clear water and prevent Harmful Algal Blooms (HABs).

Figure 24. Lake Leprechaun level logger location.

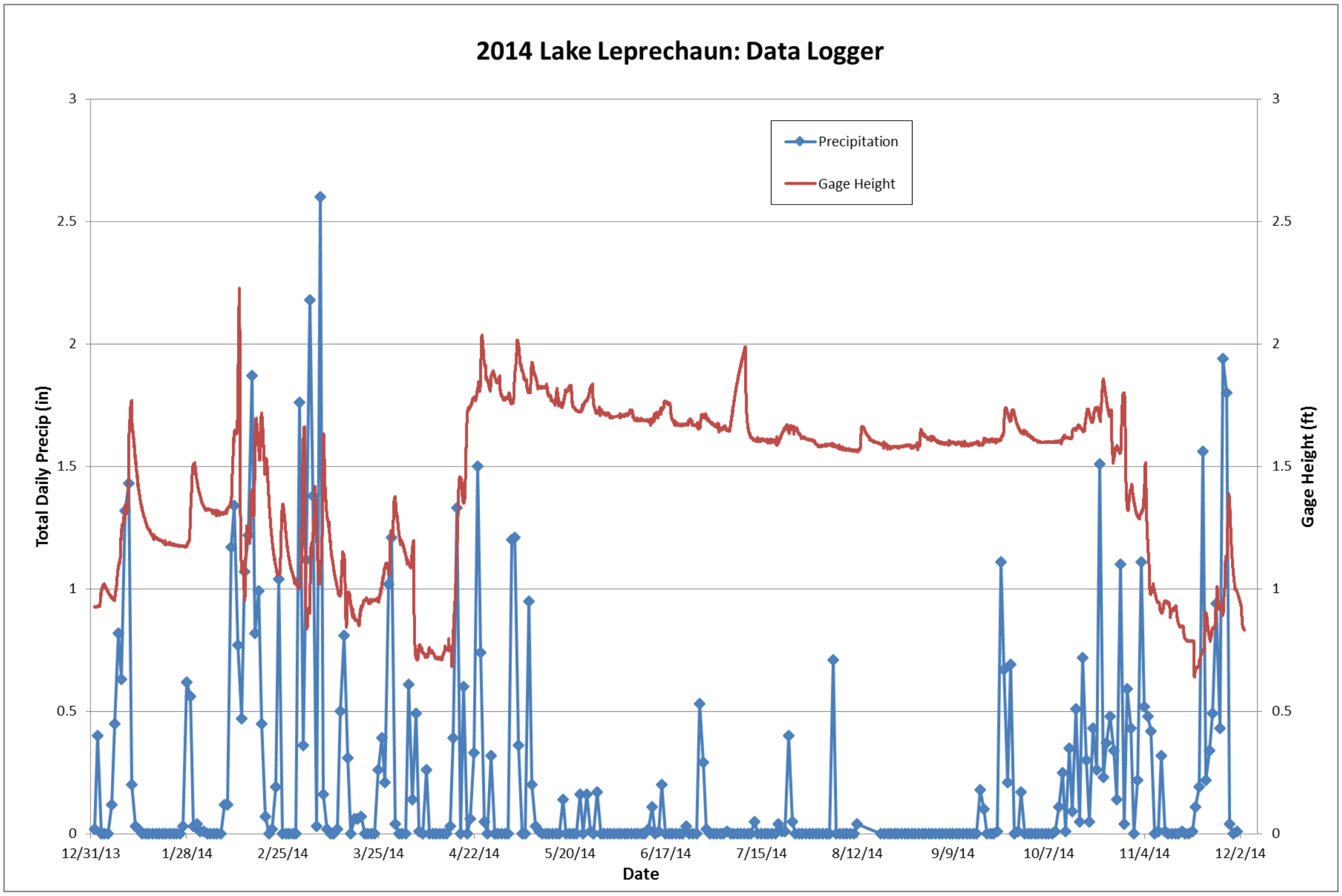


Figure 25. Lake Leprechaun level logger data and corresponding daily precipitation for May through November 2013.

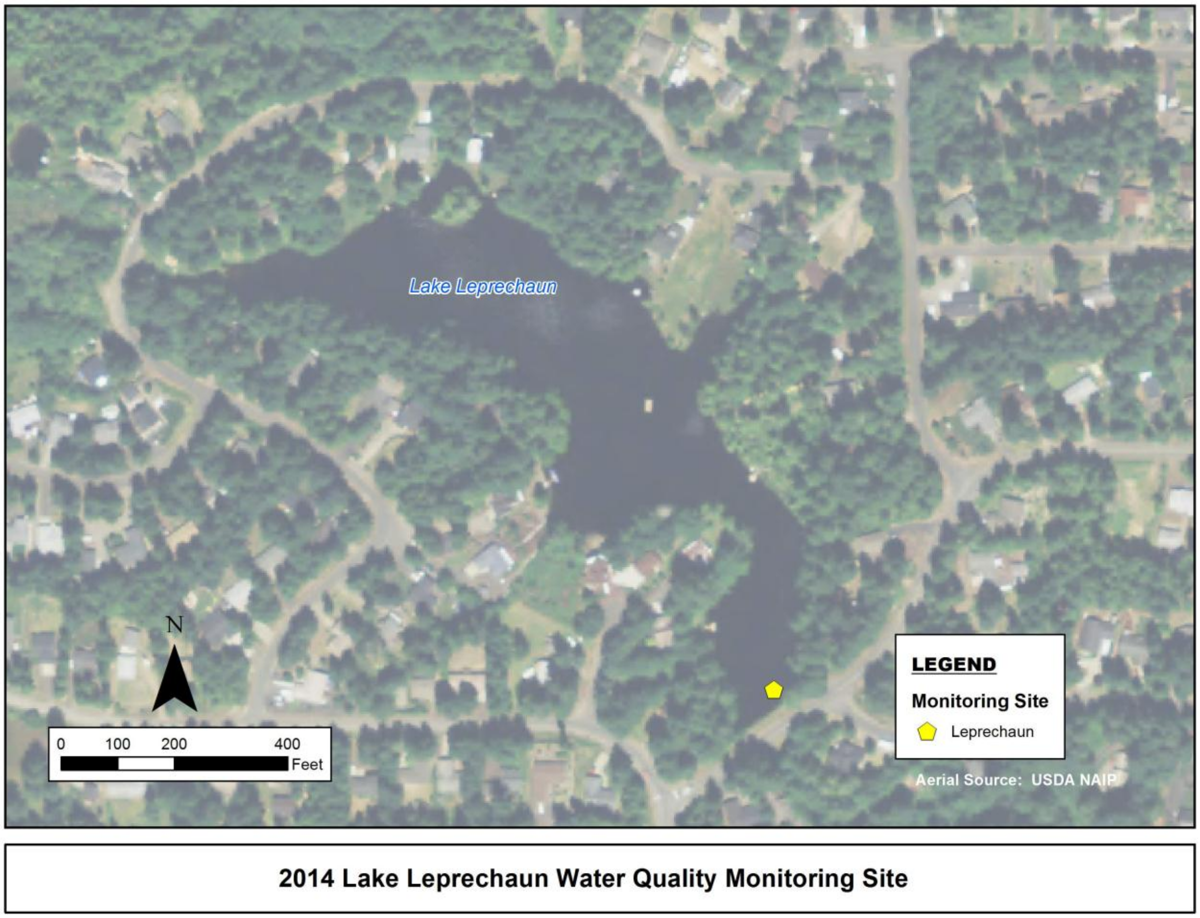


Figure 26. Lake Leprechaun water quality monitoring site.

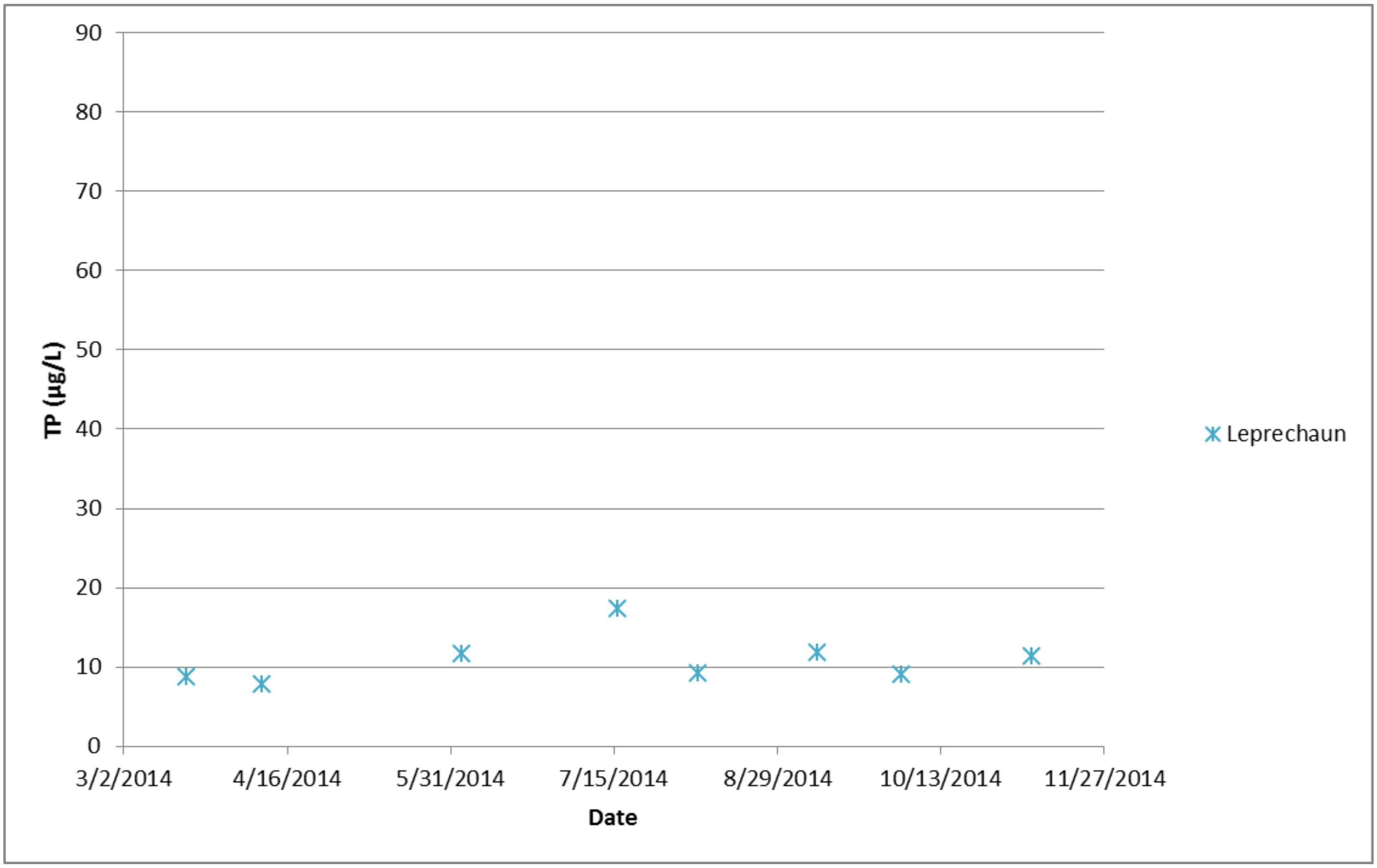


Figure 27. TP concentrations for Lake Leprechaun from March-November 2014.

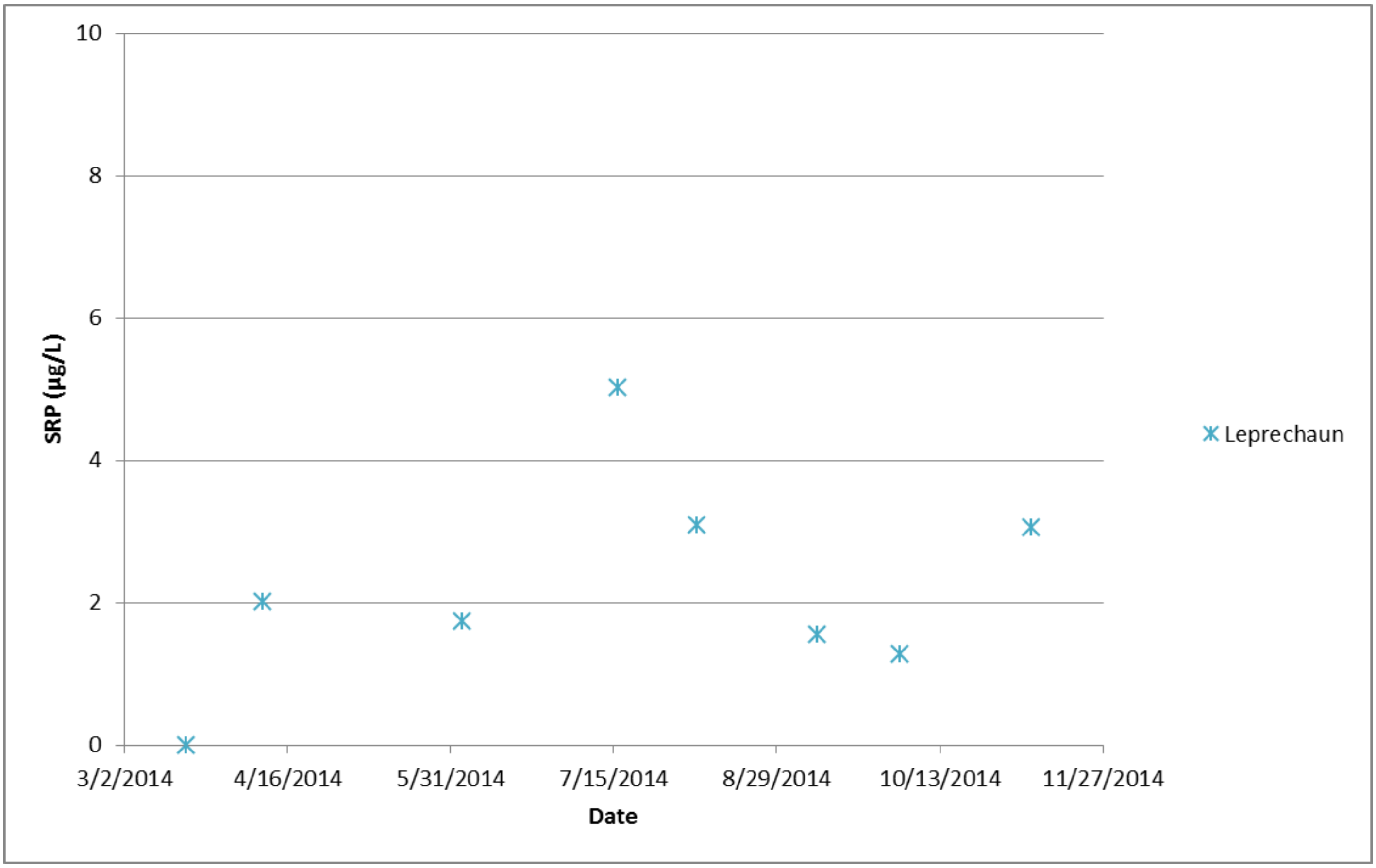


Figure 28. SRP concentrations for Lake Leprechaun from March-November 2014.

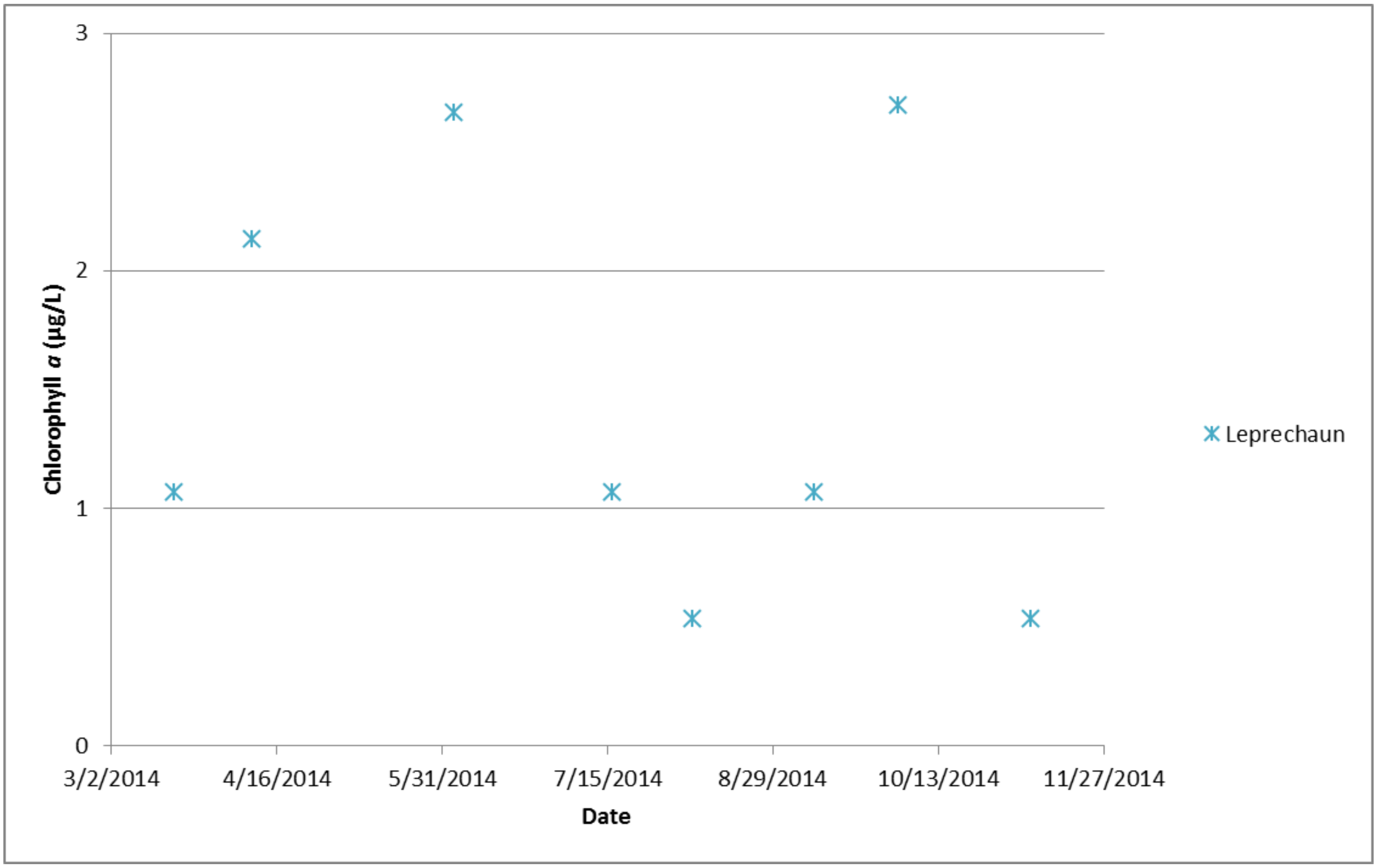


Figure 29. Chlorophyll a concentrations for Lake Leprechaun from March-November 2014.

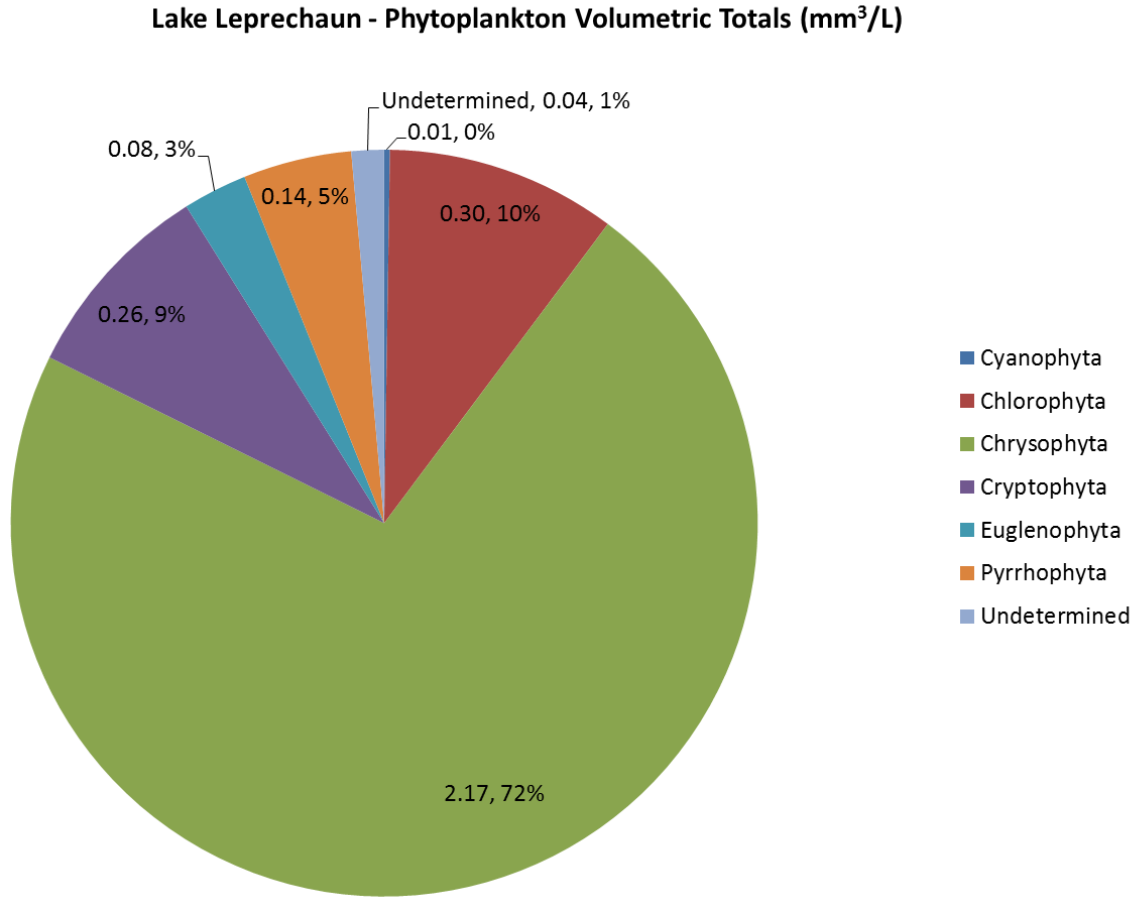


Figure 30. 2014 Lake Leprechaun phytoplankton volumetric totals.

BioBase Vegetation Mapping

A pilot study was conducted on Lake Limerick in September using BioBase sonar to determine the biovolume of plants remaining after the herbicide treatment. Figure 31 below was created by BioBase and shows the biovolume of plants around the outer edges of Lake Limerick. This figure helps us to determine aquatic vegetation hot spots or areas to watch in the future that may require heavier doses of herbicide the following year. This program can also be used to determine which type of plant gives off a certain heat signature in order to better characterize the populations of each plant in the lake. Figure 32 shows the distribution of plant biomass at certain depths throughout the lake. As expected, higher plant biovolumes are present at shallower depths.

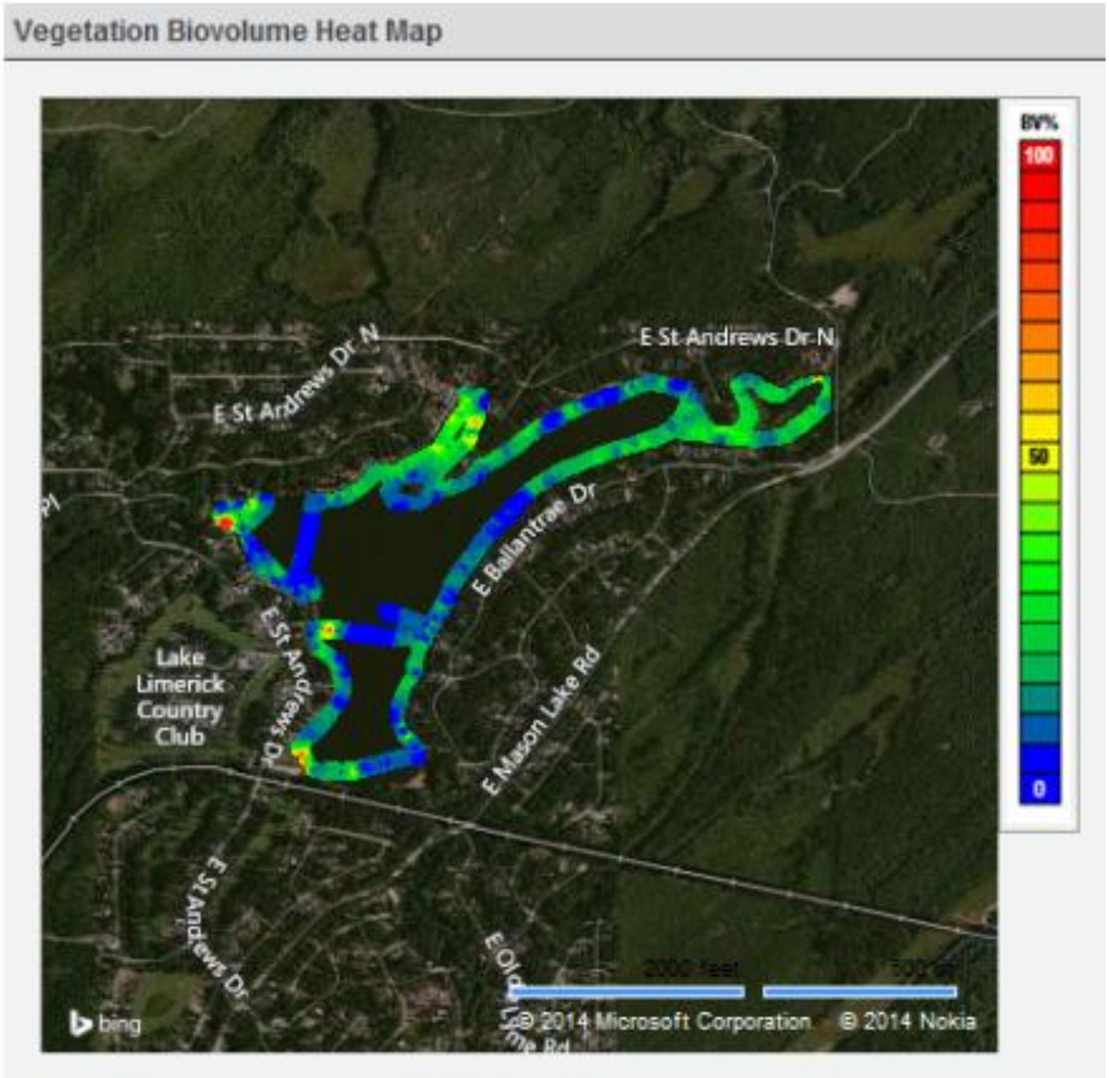


Figure 31. Lake Limerick plant biovolume.

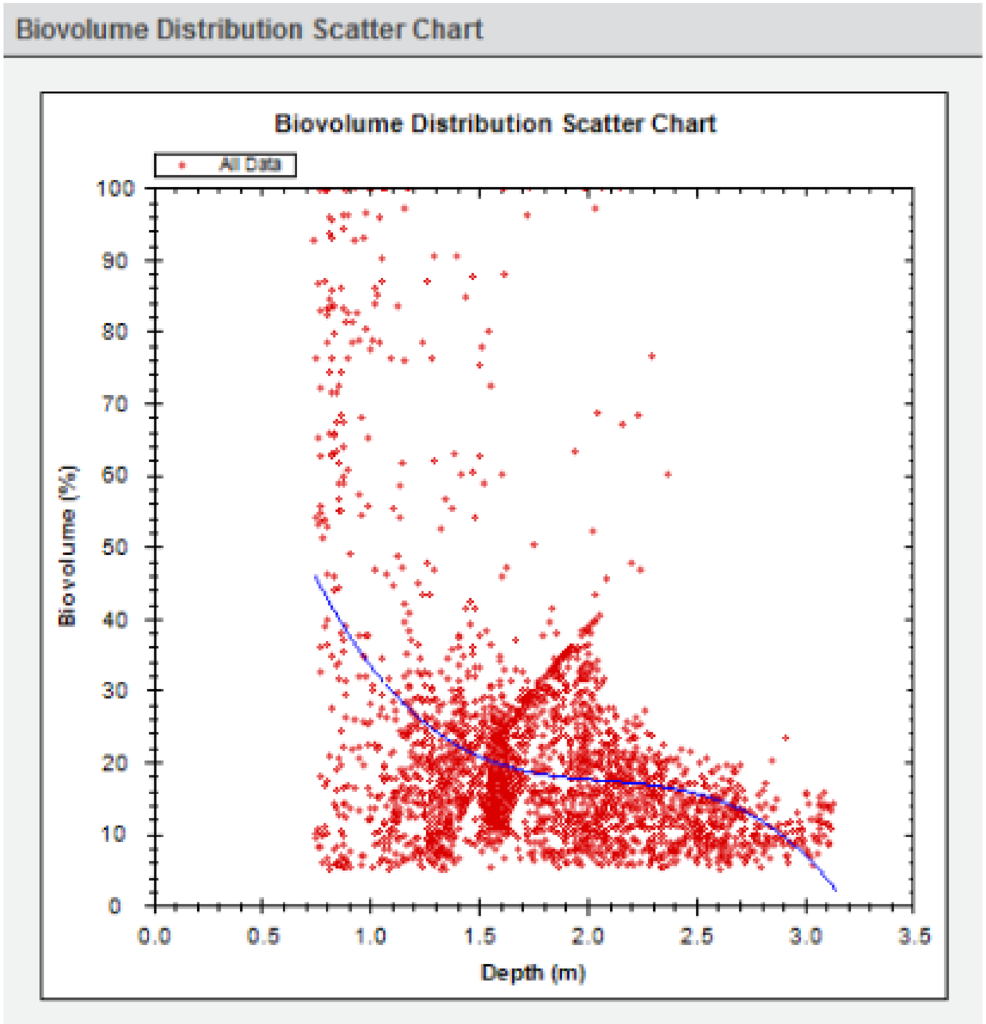


Figure 31. Lake Limerick plant biovolume distribution.

Permit Status

The herbicide permit through the Ecology was transferred to AquaTechnex (herbicide applicator) in 2011 and will continue to be administered by them in the future.

2015 Recommendations

- Aquatic plant mapping should be continued at both Lakes Limerick and Leprechaun in June 2015 to establish 2015 treatment zones and management plans for both lakes. An additional plant mapping should be conducted in September 2015 to assess the treatment effectiveness of the summer control activities to plan for the efforts that will be needed in 2016.

- Based upon the aquatic plant mapping and input for citizen observations LLCC should continue with it integrated adaptive aquatic plant management strategy to limit non-native species and control excess growth of native aquatic macrophytes. This needs to be done while maintaining a plant community structure and density that provides for both a healthy aquatic habitat and good water quality conditions. This is important not only for in-lake aquatic and fisheries habitat in Lakes Limerick and Leprechaun but also for habitat and water quality conditions downstream as well.

- It is recommended that water quality monitoring sample collection take place during July and September 2015 within the lakes and at the inlets and outlets to both lakes. A vertical profile of dissolved oxygen concentration and temperatures can be provided by Tetra Tech at the same time in order to ensure that levels throughout the water column are adequate for fish habitat. This will save on laboratory costs while monitoring any internal cycling of nutrients and external non-point sources, such as septic systems, during important summer months.

- It is also recommended that LLCC dredge Lake Leprechaun in order to reduce aquatic plant habitat and increase recreational benefits. An assessment of sediment composition and depth will help to determine the feasibility of this management decision.

- With the continuation of level logger maintenance and lake level data collection, correlations between actual lake level and level logger data can be made. The correlation will be useful in determining management of the weir boards and monitoring lake level.