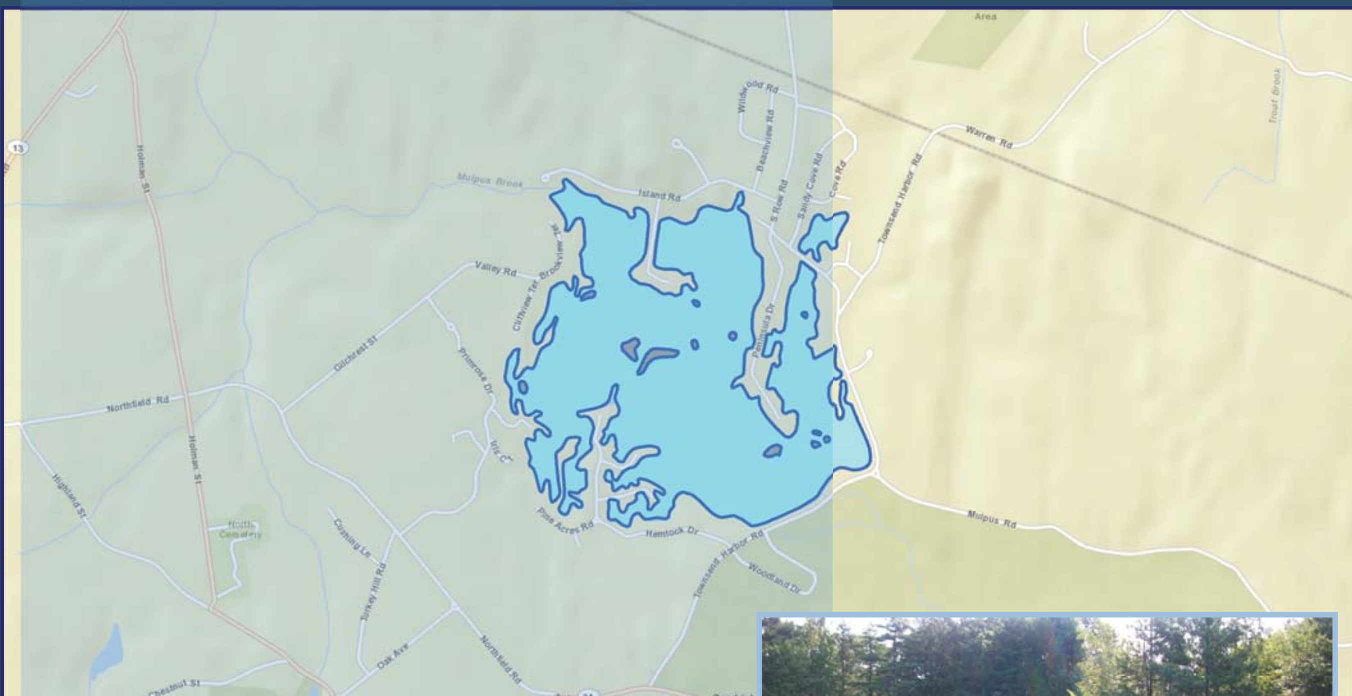
Aquatic Weed Survey and Water Quality Analysis of Hickory Hills Lake

2014 Project Completion Report



Prepared For:

Hickory Hills Landowners, Inc.
Lake Management Group
PO Box 298
Lunenburg, MA 01462

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Prepared By:

AQUATIC CONTROL TECHNOLOGY
11 John Road, Sutton, MA 01590

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Introduction

Please accept this as our Completion Report on the 2014 Aquatic Weed Survey and Water Quality Analysis of Hickory Hills Lake. As you know, Aquatic Control has been working with the Hickory Hills Landowners (HHL) for many years on a variety of lake management issues and has performed periodic vegetation surveys and water quality studies of the lake, most recently in 2012. The scope of this year's project is replicative of the first comprehensive point survey executed in 2012.

Around 2008, due to increased concern about nuisance vegetation and other issues, the HHL began taking a more active approach to lake management, primarily through the formation of the Lake Management Group (LMG). The purpose of the LMG is to investigate a variety of management topics and issues facing Hickory Hills Lake and provide detailed solutions to the Board of Directors. This has also included either directly implementing certain solutions or facilitating with Lake Management Contractors to perform work.

Historically, the management of Hickory Hills Lake was limited to periodic weed inspections by ACT and lake residents, mechanical weed harvesting of nuisance vegetation in high-use recreational areas and herbicide treatments of Little Hickory Lake in 2001 & 2006. A mechanical Hydro-Raking project was conducted in various public & private areas of the lake in 2011. Since July 2011, active management of the Fanwort (*Cabomba* caroliniana) found in the lake has taken place. Multiple strategies: quarantining infestation areas, suction-harvesting, and volunteer surveying, among others, have been implemented to mitigate the species spread. During 2013, an herbicide treatment program was performed in Little Hickory Hills Lake to reduce nuisance (native) vegetation.

This project, including detailed and quantitative assessment of the lake's aquatic vegetation along with testing of water quality, is designed to support the increased level of management activity at the lake and provide an on-going, standardized and repeatable method of monitoring the condition of the lake.

General Lake Characteristics

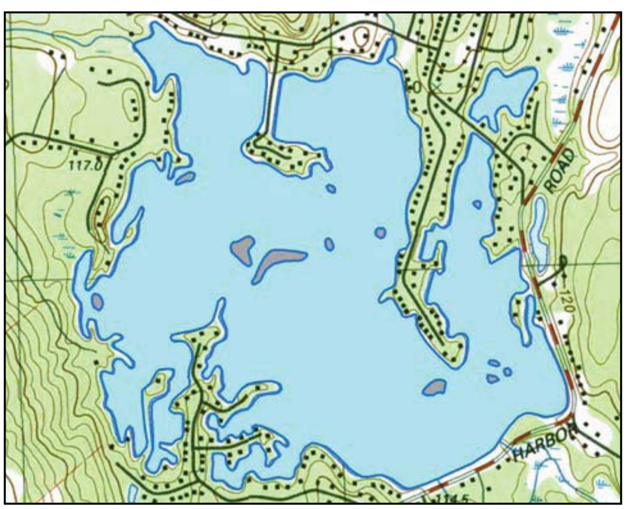


Figure 1 – Lake Map

Hickory Hills Lake (Figure 1 –left & Attachment A - Map 1) is an approximately 314-acre enhanced (impounded) waterbody with a maximum depth of 20 feet and an average depth of 8.9 feet. It's largely irregular shoreline, encompassing over 9 linear miles, creates an abundance of shallow coves and backwater areas, capable of supporting abundant plant growth. Mulpus Brook is the primary source of surface water inflow to the lake. Sediment deposits have accumulated at this inlet area, forming an expansive, shallow "delta" with abundant emergent and floating vegetation. There are numerous other smaller inlets to the lake, which enter into various cove areas and comprise the remaining surface inflow to the lake.

The dam and outlet structure are located in the southeast corner of the lake and consists of ~100-foot concrete overflow spillway and nine 6-foot wide and 18" inch deep stoplog bays. There is also a low-level gate valve which allows for additional lowering of the lake's water level. The outlet of the lake continues eastward as Mulpus Brook, through a series of small ponds and wetlands before emptying into the Nashua River.

Methodology

The following assessment tasks were performed as part of this project,

Table 1 – Project Tasks

Task	Description
Aquatic Vegetation Assessment and Measurements of Water Depth	Pre-determined sample points were located at the vertexes of an 80-meter grid (See Attachment A - Map 2) and downloaded into a handheld Garmin GPS unit. At each point, water depth was measured with Lowrance sonar unit. Data was collected on species type, relative abundance and biomass. Vegetation was observed visually and with the aid of an underwater camera system. Plants were physically sampled with a throw-rake as necessary, except in areas of known fanwort growth.
Water Quality Sampling	Water quality samples were collected at three locations – one near the lake outlet, one from the Mulpus Brook inlet cove and one from Little Hickory Lake.
Field WQ Measurements	At each sample location, field measurement of temperature, dissolved oxygen and water clarity were performed. Samples were collected from each station for algal identification and enumeration. One sample was collected from the lake outlet station for zooplankton identification/enumeration.

Field work for this project was conducted on September 12th and 16th. Water samples were analyzed by Microbac Laboratories of Worcester, MA. Phytoplankton (algae) samples were analyzed by ACT staff while the zooplankton samples were analyzed by Dr. Ken Wagner from Water Resource Services in Wilmington, MA.

Water Depth (Bathymetry) Results

Water depth data collected at each sample point was used to produce a contour map of the lake's bathymetry (See Attachment A - Map 3). The maximum water depth observed in the lake this year was 17.5-feet and the average was approximately 8.9-feet. There were some differences in the water depths measured at each point as compared to last year, likely due to several factors – 1) using different equipment, 2) inherent error in the Sonar due to bottom type and weed cover and 3) GPS accuracy. As there is not necessarily a reason to consider one data set as more accurate, we continue to use the 2012 data for Table 2 and for the Bathymetry map – Map 3.

The accuracy of the bathymetry map is based on the discrete number of data points and the precision of the measuring equipment and should not be considered an exact depiction of water depths in the lake or used for navigational purposes. It is however useful to visualize the bottom contours of the lake and to determine the size and extent of the littoral zone and other depth-related characteristics.

The following table shows the approximate surface area between each depth contour and the rough volume of water in each depth zone.

Table 2 – Lake Depth Areas & Volumes

Water Depth (feet)	Approximate Surface Area (acres)	% of total area	Approximate Volume (acre-ft)	% of total volume
0-3	32.4	10.2	909.4	28.1
3-6	44.4	14.0	817.9	25.3
6-9	55.7	17.5	679.7	21.0
9-12	72.4	22.8	442.2	13.7
12-15	57.6	18.1	247.3	7.6
15-18	37.3	11.7	110.9	3.4
18+	18.3	5.7	27.5	0.9
Totals	**318.1 acres**	**100%**	**3,234.9 acre-ft**	**100%**

Distribution of Aquatic Vegetation

The lake supports a diverse and abundant growth of native plants throughout the littoral area with the densest growth occurring in areas with water depths of 8-feet or less. Plant growth is present at lower density and biomass in water depths of 8 feet to 12 feet. In areas greater than 12-feet of water, the assemblage is dominated by stonewort (*Nitella sp*.), a form of "macro-algae" which provides beneficial, low-growing bottom cover and fish habitat.

The point-intercept survey methodology used during this year's project is same as the 2012 project. This allows for a detailed, quantitative analysis of the lake's vegetation. At each data point, the relative bottom cover and biomass (height in the water column) was recorded for each plant species observed. Percent bottom cover is an estimate of the extent of growth per unit area for a certain species. It is determined from visual observations, not exact physical measurement and averages the variation in growth in the area surrounding the data point. While partially a subjective measurement, percent bottom cover is quantitative and with an experienced observer, the parameter is reasonably accurate and consistent across the data points.

While percent bottom cover gives a measurement of the proportion of lake bottom covered with plants, the parameter of biomass relates to the height and amount of growth in the in the water column. It is measured on a scale of 0-4 where,

Table 3 – Biomass Scale

Biomass Factor	Description
0	No Plants
1	Low-growing, bottom cover, usually less than a foot or two off the bottom depending on water depth. Likely not visible depending on water depth and clarity. Generally not problematic or a management concern.
2	Plants are clearly growing upwards through the water column, but most extend less than mid-way to the surface. May be visible from the surface depending on water depth and clarity. Likely not problematic or of management concern
3	Plant heights are reaching the upper half of the water column, but remain at least a foot or more beneath the surface. Clearly visible and may be problematic depending on species and location.
4	Plant growth is at or near the surface, may be topped out with emergent portions. Floating leaf plants like waterlilies are included in this factor. Plants are likely problematic in recreational or other high-use areas.

Overall, about 53.5% of the bottom in Hickory Hills Lake is covered with plant growth. If you do not include algae growth (filamentous or macro forms, i.e. stonewort), which occur mainly in the deeper areas, the percent bottom cover drops to ~43%. A majority of this growth is made up of submersed species and only about 3-4% of the plant cover in the lake is from floating leaf species, waterlilies and watershield. Map 4 shows the total percent plant cover (not including algae) at each data point.

Bladderwort (*Utricularia sp.*) and tapegrass (*Vallisneria americana*) have been the historically dominant species. The following table presents the species observed during the survey along with their lake-wide average percent cover and their percent occurrence (% of sample points where present).

Table 4 – List of Plant Species with Lake-wide % Cover and %Occurrence

Common Name	Scientific Name	Abbreviation	Lake-Wide Average % Cover	Change from 2012	% occurrence	Change from 2012
Bladderwort	*Utricularia purpurea*	U	12.4	-3.20%	50.7	-13.60%
Tapegrass	*Vallinsneria Americana*	V	10.8	2.60%	44.5	7.40%
Stonewort	*Nitella sp.*	Ni	9.8	-8.90%	46.9	-5.50%
Robbins pondweed	*Potamogeton robbinsii*	Pr	9.4	2.60%	62.7	-12.70%
Largeleaf pondweed	*Potamogeton amplifolius*	Pa	2.6	1.10%	24.9	5.90%
Watershield	*Brasenia schreberi*	B	1.7	-0.70%	10.5	-3.30%
Naiad	*Najas sp.*	Nj	1.6	1.12%	13.9	-7.70%
White waterlily	*Nypmphaea odorata*	Ny	1	0.12%	9.1	2.40%
Filamentous algae	*Various*	Fa	0.8	-3.55%	6.7	-5.20%
Ribbonleaf pondweed	*Potamogeton epihydrus*	Pe	0.7	-0.60%	8.1	-7.10%
Slender spikerush	*Eleocharis sp.*	Eo	0.4	-0.70%	1.9	0.80%
Mermaid Weed	*Prospernica palustris*	Mw	0.4	0.26%	2.4	1.00%
Submersed arrowhead	*Saggitaria sp.*	Sg	0.4	0.06%	2.9	-0.40%
Thinleaf pondweed	*Potamogeton pusilus*	Pp	0.2	-0.30%	3.8	-4.80%
Floatingleaf pondweed	*Potamogeton natans*	Pn	0.2	0.20%	3.8	-3.80%
Snailseed pondweed	*Potamogeton bicupulatus*	Pb	0.1	-0.10%	0.5	-0.50%
Coontail	*Ceratophyllum demersum*	Cd	0.1	0	1	0.50%
Yellow waterlilly	*Nuphar variegatum*	Nu	0	-0.10%	0	-0.50%
Quillwort	*Isoetes sp.*	Io	0	-0.05%	0	-0.50%
Duckweed	*Lemna minor*	Lm	0	-0.02%	0	-0.50%
		Total:	**52.6**	**-9.90%**		

The attached maps (Map 5A-Q) show the location and biomass of each observed species. Bladderwort continues to be the dominant plant in the lake, despite decreasing in coverage from 15.6% to 12.4% and frequency of occurrence from 64.3% to 50.7%. Tapegrass increased in coverage lake-wide to the second most dominant species, from 8.2% to 10.8%. Robbins pondweed was observed at 62.7% points, up from 52.4% in 2012, becoming the most commonly observed plant in the lake. Stonewort is still prevalent in the lake, even though it decreased in cover from 18.7% to 9.8% and frequency from 52.4% points to 46.9%.

Fanwort was not observed at any of the data points, but was found at numerous locations within the lake. Some pioneer infestations were recorded with the on-board GPS and shared with the LMG to be included with their Google Maps based mapping.

In terms of Little Hickory, Point #'s 186, 187, 202 & 194 are located in that basin of the lake. Two additional points, #209 & 210 were also collected there. After an herbicide treatment in 2013, vegetation is at a desirable density. It is dominated by Robbins pondweed, with lesser amounts of thinleaf pondweed and stonewort. This needs to be monitored since residents of Little Hickory do not have the option of traveling to areas less populated by dense vegetation as on the main lake.

Water Quality Results

Figure 2 – Sampling Locations

On September 16th, samples were collected from three stations in the lake (see Figure 2 – Left) corresponding to the Mulpus Brook Cove, the main lake near the outlet and Little Hickory. The results of the laboratory analyses are provided in the table below followed by a brief description of the parameter and interpretation of the data.

Table 5 – Water Quality Results (ND = Non-Detect)

Parameter	Unit	Main Lake	Mulpus Brook Cove	Little Hickory
pH	S.U.	6.8	6.8	6.8
Alkalinity	mg CaCO3/ml	10	8.8	12
Turbidity	NTU	0.64	0.50	0.66
Conductivity	µmhos/cm	170	170	320
Nitrate	mg/l	ND (0.05)	ND (0.05)	ND (0.05)
Ammonia	mg/l	0.10	0.098	0.14
Total Kjeldahl Nitrogen	mg/l	ND (0.5)	ND (0.5)	ND (0.5)
Total phosphorus	mg/l	0.012	0.009	0.013
Total Dissolved Phosphorus	mg/l	0.007	0.007	0.009
True Color	Pt-Co	10	10	10
Apparent Color	Pt-Co	10	10	10
E. Coli	CFU/100 ml	<10	<10	<10

pH – The pH measurement scale is from 0 to 14, where zero is extremely acidic, 7 is neutral, and 14 is the most basic. A pH range of about 5.5 – 8.5 is desired for maintaining a healthy fishery. The results of this year's testing were all slightly acidic, but well within the desirable range and all three stations showed similar results. The lake's pH is dependent on a number of factors and often will fluctuate over the course of the summer. Alkalinity (see below) in the water may help to attenuate these fluctuations.

Total Alkalinity – Alkalinity is a measure of the buffering capacity of a waterbody against acid additions such as acid rain and pollution, which can be detrimental to wildlife populations. Total alkalinity measures the presence of carbonates, bicarbonates and hydroxides. Values below 20 mg/l are a signal that the lake may be susceptible to fluctuations in pH. The results of testing show all three stations were both slightly below this level, which is not uncommon for lakes in this region.

Turbidity – Turbidity is a measure of the light attenuation in the water and is related to the suspended and dissolved particles in the water. Generally, turbidity values will rise with higher solids in the water. Typically, turbidity values in lakes and pond rarely rises above 5 NTU. The turbidity results were all below 1 unit and show a desirably low level of solids.

Conductivity – Conductivity is a measure of the water's ability to conduct electricity and is related to the amount of dissolved minerals that are present. Most natural waters have conductivity readings between 50 and 500 umhos/cm and the results from Hickory Hills Lake were all within this typical range.

Nitrogen - Nitrogen is a vital nutrient in the pond environment for plant and algae growth. Nitrogen exists in water as various compounds, with relative amounts governed by such things as atmospheric influence, precipitation, biological activity and water chemistry. Total Kjeldal nitrogen (TKN) is a measure of the nitrogen contained in organic compounds, such as proteins and amino acids, and as ammonia. It is created from biological growth and decomposition. A concentration of 1.0 mg/l or below is considered desirable. All samples from this study were within this threshold.

Ammonia is a transitional product in the breakdown of organic nitrogen into nitrate. It is typically short-lived in the pond environment except under conditions of low dissolved oxygen. High levels of ammonia typically indicate a highly eutrophic pond with prolonged anaerobic (devoid of oxygen) conditions. The results of all the samples indicated desirably low concentrations of ammonia.

Nitrate is another form of nitrogen in the water. Nitrate nitrogen is usually the most prevalent form of inorganic nitrogen in the water and results from such things as natural aerobic bacterial activity and fertilizer use. It is also the form that is most readily available for plant and algae growth. All samples showed non-detectable levels of nitrate (<0.05 mg/l)

Phosphorus - Phosphorus is generally considered to be the limiting nutrient for plant and algae growth, with total phosphorus concentrations of 0.03 mg/l or more being to sufficient to stimulate algae blooms or excessive plant growth. Total phosphorus analyses measure both particulate and dissolved phosphorus. Particulate phosphorus is generally not biologically available so dissolved phosphorus more readily supports plant and algae growth. All of the values obtained during this study were desirably low. Phosphorus values can change significantly over the course of a season and need to be tested more often to find a normal range for the lake. While rooted plant growth generally obtains most of its nutrients from the sediment, water column phosphorus has a more direct effect on algae growth.

True Color/Apparent Color - Apparent color is the color of the unfiltered water that is caused by suspended and dissolved matter. True color is the color of filtered water due to dissolved constituents only, like tannic and humic acid. Color results show a low level of color, due exclusively to dissolved material.

Bacteria - Coliform bacteria are naturally occurring in pond systems as well as resultant from human and animal inputs. *E. Coli is* specific to human and animal waste products. In general, acceptable values in "swimmable waters" for *E. Coli* bacteria are less than 230 organisms per 100 ml. All sample collected showed desirably low levels of bacteria.

Overall, the results show excellent water quality at all three stations with desirably low levels of phosphorus and nitrogen. The results obtained this year are comparable to past sampling results from the lake. There was little difference between the results from the three stations.

For more a more detailed illustration of how this year's water quality compares to past studies, the following table shows a chronology of results from the main lake station.

Table 6 – Comparison of Historical WQ Results at the Main Lake Station

Parameter	Unit	Main Lake Station Result					
		2014	2012	2010	2008	2006	2003
pH	S.U.	6.8	6.53	7.14	6.91	6.28	7.4
Alkalinity	mg CaCO3/ml	10	14.5	10.6	8.6	11	11
Turbidity	NTU	0.64	0.490	0.48	0.43	0.75	0.61
Conductivity	µmhos/cm	170	117	NT	NT	NT	NT
Nitrate	mg/l	ND (<0.05)	ND (<0.1)	<0.1	<0.1	0.12	0.22
Ammonia	mg/l	0.10	ND (<0.1)	<0.05	NT	NT	<0.2
Total Kjeldahl Nitrogen	mg/l	ND (0.5)	0.200	NT	NT	NT	NT
Total Phosphorus	mg/l	0.012	ND (<0.01)	<0.01	<0.02	0.007	0.013
Total Dissolved Phosphorus	mg/l	0.007	ND (<0.01)	NT	NT	NT	NT
Chlorophyll-A	mg/m^3	NT	ND (<0.1)	NT	NT	NT	NT
True Color	Pt-Co	10	10	8	14	0	16
Apparent Color	Pt-Co	10	10	10	20	34	24
E. Coli	CFU/100 ml	<10	10	NT	NT	NT	NT

Results for pH, alkalinity, turbidity, total phosphorus, and color show relatively stable levels over the sampling period with no discernable trends apparent. Results for nitrate appear to have decreased over the sampling period which is desirable and shows improved water quality, although all the results are already within acceptable ranges. Other parameters were not consistently tested over the sampling period.

Temperature and dissolved oxygen measurements were taken at each sample location.

Table 7 – Temperature/Dissolved Oxygen Results

Depth (meters)	Main Lake		Mulpus Brook Cove		Little Hickory	
	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)	Temp (°C)	DO (mg/l)
Surface	20.0	8.16	18.6	6.99	18.2	8.40
1	20.0	8.16	18.6	7.82	17.8	8.39
2	19.9	8.19	18.6	8.10	17.7	8.28
3	19.9	8.22	-	-	17.6	8.32
4	19.9	8.08	-	-	17.6	5.20
5	19.9	7.02	-	-	-	-

In general, the water column at all three stations was well mixed and oxygenated with levels at or slightly below normal saturation levels. There was a noticeable drop in oxygen near the bottom of the Little Hickory station, but this is not uncommon due to the oxygen demand from decomposition processes in the sediment, especially in small waterbodies or isolated coves with more organic material and reduced circulation.

Water clarity was good at all stations, with Secchi disk transparency readings to the bottom of the lake – about 15-feet at the main lake station and 6-10 feet at the other two locations. Samples were collected for algae identification and enumeration, the results of which are presented below.

Table 8 – Phytoplankton Results

Station	Approximate Cell Count	Dominant Species
Main Lake	43,500 cells/ml	*Eudorina* (green) *Microcystis* (blue-green) *Dictyosphaerium* (green) *Merisomopedia* (blue-green)
Little Hickory	17,000 cells/ml	*Dictyosphaerium* (green) *Sphaerocystis* (green) *Scenedesmus* (green)

Both samples showed a relatively low density of microscopic algae which corresponds with the observations of good water clarity and low nutrient levels. The Main Lake station had significantly higher cell counts than Little Hickory and was approaching the threshold for bloom conditions (> 50,000 cells/ml). This is likely caused by the unseasonably warm weather that persisted through the end of August and well into September.

One sample was collected from the main lake station for zooplankton identification and enumeration. Zooplankton are tiny animals that live throughout the water column and comprise an important component of the food. The zooplankton was sampled by vertical tow using a net with a mesh aperture of 80 micrometers through 30 meters of water, resulting in a concentrated sample representing 948 liters of lake water. Samples were examined at 40X to 100X magnification under brightfield optics to determine types present, richness, abundance through enumeration and size of the organisms present. The preserved samples were analyzed by Dr. Ken Wagner.

Overall, the sample showed a relatively low density and biomass of zooplankton. Total counts were slightly lower than in 2012, however there were more species and with an increased average size and biomass. This is not unusual for lakes with low to moderate amounts of microscopic algae and is often the case later in the summer due to predation by fish. The sample contained species in the *Rotifera*, *Copepoda* and *Cladocera* taxons with Copepods being the dominant form. In 2012, the *Rotifera* taxon was dominant. Additional sampling in the future and at different times of the year would be required to further assess zooplankton in Hickory Hills Lake. The zooplankton data sheet is included as Attachment D.

Management Recommendations

With a few exceptions, the assemblage of aquatic weeds in Hickory Hills Lake has remained relatively stable over the years. Robbins pondweed, tapegrass, and bladderwort remain the primary species within the shallower areas of the lake. Stonewort continues to sparsely populate the deeper regions of the lake. Although not consistently documented through this study due to its scattered distribution, fanwort continues to spread with new infestations being regularly observed by the LMG.

Aquatic plants are an important component of the lake's ecosystem, providing valuable fish and wildlife habitat. Generally, the literature suggests a 20-40% cover of aquatic vegetation is ideal for warm water fisheries like Hickory Hills Lake. Excluding stonewort, which is a low-growing, beneficial bottom cover, the lake exhibits about a 43% cover of aquatic plants, which is on the upper of the ideal range. Non-native species are not considered suitable habitat and are generally considered a threat to the ecosystem. With the exception of fanwort, all other species observed in the lake were native.

Non-native species should be actively managed in order to limit their population and spread in the lake and minimize adverse effects on native flora and fauna. It may also be necessary to manage native species, when they are present in recreational/ high-use areas of the lake or are expanding beyond a desirable level.

The most common plant in the lake, bladderwort, is a NATIVE species, but can become a nuisance under certain conditions. We understand residents have expressed concern about the abundant growth of bladderwort and its impact on recreation in the lake. Bladderwort has been present in the lake for quite some time and varies in abundance from year to year based on numerous environmental factors such as water clarity, water temperature, water level and other climatic patterns and conditions.

Bladderwort is sometimes referred to as “aquatic tumbleweed” because it’s only loosely anchored to the bottom and very often forms floating “rafts” that can move around the lake. Bladderwort propagates from year to year primarily by dropping winter buds (or turions). It can also spread vegetatively by tubers or fragments and by seed, although these are not the primary means of reproduction. We would not recommend managing bladderwort (or other native plants) lake-wide, however nuisance growth in priority areas could be managed as needed.

With the presence of fanwort, as well as localized areas of nuisance, native plant growth, there are a number of in-lake management techniques that may be appropriate for Hickory Hills Lake. In addition to implementing vegetation control methods, a management plan should also include an appropriate level of monitoring to regularly document the lake’s condition, guide/evaluate the program and identify any changes or new infestations of non-native species.

Drawdown

Historically, it is our understanding that the lake has been drawn down (lowered) 18-inches in the winter for shoreline maintenance. This year, based on recommendations in the 2012 Report, it has been lowered 3-feet. It will be important to monitor plant growth next year to assess what effect the deeper drawdown has on the plant assemblage. It would also be a good idea to collect photos of some of the larger exposed areas to document conditions. We understand that the LMG is also conducting a drawdown survey of the residents, which should yield useful data. While drawdown is not likely to be a stand-alone solution for fanwort due to its depth of growth, increasing the depth of drawdown should provide an improved degree of nuisance plant control along the higher use, shoreline areas of the lake.

As stated in the 2012 Report, according to Table 2, a three-foot drawdown would expose ~32.4 acres of the lake bottom and retain ~72% of the lake water volume. Due to ice scour, plant control may extend an additional 6-12 inches below the actual lowered level of the lake. A six foot drawdown would expose significantly more area – 24.2% but only leave ~46% of the total lake water volume.

A three-foot drawdown is unlikely to have any adverse impacts to the lake environment, but a six-foot drawdown would require more assessment including a review of potential impacts on shallow wells, adjacent wetlands, refill rates and other concerns. The ability to further lower the lake using the current outlet structure would need to be conducted prior to considering any further increase in the drawdown depth. Given the bathymetry of the lake, the amount of water volume that would be lost and the additional study required, we do not recommend pursuing any further drawdown below 3-feet at this time. All drawdowns require filing an NOI with the Conservation Commission. Drawdowns over 3-feet require enhanced review and coordination with the Department of Fish & Game.

Mechanical Harvesting & Hydro-Raking

Mechanical harvesting was used at Hickory Hills Lake in the past to reduce problematic plant growth along developed areas of the lake, but has not been used since approximately 2010 due to equipment problems and the discovery of fanwort. The Hydro-Raking project conducted in 2011 met with mixed results. At this point, with the expanding occurrence and frequent discovery of new locations of fanwort in the lake, we do not recommend any further harvesting (or Hydro-Raking) at this time due to the increased likelihood of fragmentation.

Herbicide Treatment

Several USEPA / State registered herbicides are available for control of the plants present in Hickory Hills Lake. Herbicide selection would be based on the target plants and configuration/size of the treatment area. Herbicide treatment does not pose a significant risk to humans or fish/wildlife when conducted by licensed applicators in accordance with the product label. Treatment costs generally range from $300-$800 or more per acre depending on the herbicide used and the layout/extent of the treatment area.

We do not recommend or believe it's desirable to embark on widespread vegetation control using herbicides at Hickory Hills Lake. Rather, herbicide treatment is presented as one option for managing localized areas of nuisance growth and as a tool in the ongoing battle against fanwort. Desirable densities of native species were achieved with a Sonar (fluridone) treatment performed by ACT in Little Hickory Lake in 2013. The following table describes the active ingredients available for use in aquatic systems.

Table 9 – Aquatic Herbicide Matrix

Active Ingredient	Trade Names	Plants Controlled	Irrigation Restriction Label
Copper (algaecides & herbicides)	Copper sulfate; K-Tea; Cutrine Plus; Captain; Komeen, Nautique	Algae – filamentous & microscopic; curlyleaf pondweed other submersed	None
Sodium Carbonate Peroxyhydrate	Phycomycin; GreenClean	Algae – filamentous & microscopic	None
Diquat	Reward	Milfoil & other submersed plants; duckweed & watermeal	3-5 days
Endothall	Aquathol K (herbicide); Hydrothol 191 (algaecide)	Pondweeds and algae	7-14 days
Fluridone	Sonar & generics	Watermeal, duckweed, milfoil, fanwort and other submersed plants	30-day min (often 60-90 days with multiple applications
Glyphosate	Rodeo & generics	Cattails, phragmites, purple loosestrife, waterlilies, etc.	None
2,4-D	Navigate	Milfoil, water chestnut, waterlilies	~ 30 days. If known uses are present, residue testing is required
Triclopyr	Renovate 3; Renovate OTF	Milfoil, purple loosestrife	180 days or required residue testing
Imazapyr	Habitat	Phragmites and mose emergent vegetation/lilies	Up to 120 days; requires residue testing

Imazamox	Clearcast	Pondweed, milfoil, hydrilla	Residue testing required
Flumioxazin	Clipper	Fanwort, milfoil, other submersed and floating plants (watermeal)	~5-days
Products Pending MA Department of Agricultural Resources (DAR) Registration			
Penoxsulam	Galleon	Hydrilla, milfoil, watermeal	Residue testing required
Bispyribac-sodium	Tradewind	Milfoil; hydrilla; some floating and emergent weeds	Extended; requires residue testing
Carfentrazone	Stingray	Floating & Emergent plants	Up to 14 days

Specifically for fanwort, Sonar (fluridone) and Clipper (flumioxazin) are the only two herbicides shown to provide effective control. Sonar has been used extensively for many years to provide systemic ("root-killing") control of fanwort under various treatment conditions. Typically treatments are conducted with both liquid and slow-release pellet formulations to provide the needed target concentration and exposure time (typically at least 60-days).

Since Sonar herbicide requires a long contact time with the target plants, it can be challenging to use effectively in smaller treatment areas and areas subject to high dilution (near inlets, small sections of shoreline, etc). It is best suited for larger areas or isolated cove areas with little or no water exchange. Sonar can be fairly broad-spectrum (affecting a wide variety of plant species) at high doses, however many plants, such as fanwort, can be controlled at lower dose ranges. Although Sonar is somewhat more expensive than Clipper herbicide, its systemic properties make it the preferred option when suitable treatment conditions can be maintained.

Clipper is currently registered in Massachusetts and has provided excellent, seasonal control of fanwort in New England lakes. It is still fairly costly compared to other contact herbicides, but is generally less expensive than Sonar in most situations. Clipper is a broad-spectrum herbicide and affects a wide range of plant species, but because it's a contact herbicide, significant re-growth is usually seen in the year after treatment. From our experience, fanwort is highly susceptible to Clipper herbicide and cumulative reductions in the extent and density of infestations is observed after multiple years of treatment. Clipper works very quickly and only requires a contact time measured in hours, making it a viable alternative to Sonar herbicide in otherwise challenging situations.

MassDEP is currently including conditions on the permits issued for Clipper. They are 1) maximum dose that can be applied is 200 ppb (the label lists 400 ppb as the max dose), 2) No more that ¼ of the waterbody can be treated in any one year, 3) Treated areas cannot be re-treated for three consecutive years unless the area is in the vicinity of a high-use area such as a boat ramp, swimming beach, etc. Prior conditions, which have been lifted include freshwater mussel surveys. Some areas of the lake with fanwort, such as the Island Road Beach and Boat Launch should meet DEP's requirements allowing consecutive years of treatment. As we've discussed in the past, this would be one potential area where treatment may be useful to target a repeatedly problematic area of fanwort growth.

For control of bladderwort, the herbicide of choice would likely be Reward (diquat) herbicide. Sonar and Clipper herbicides do provide marginal control of bladderwort, but higher doses are required and control in subsequent years is often limited. Reward herbicide works fairly well on bladderwort, is economical to use, can be used on a smaller partial lake basis and provide seasonal control of bladderwort. Reward could also be used on some of the other natives species in the lake, but not all. For example, we've had some preliminary discussion with the LMG on treating mermaid-weed (*Proserpinaca palustris*) in Proctor Cove.

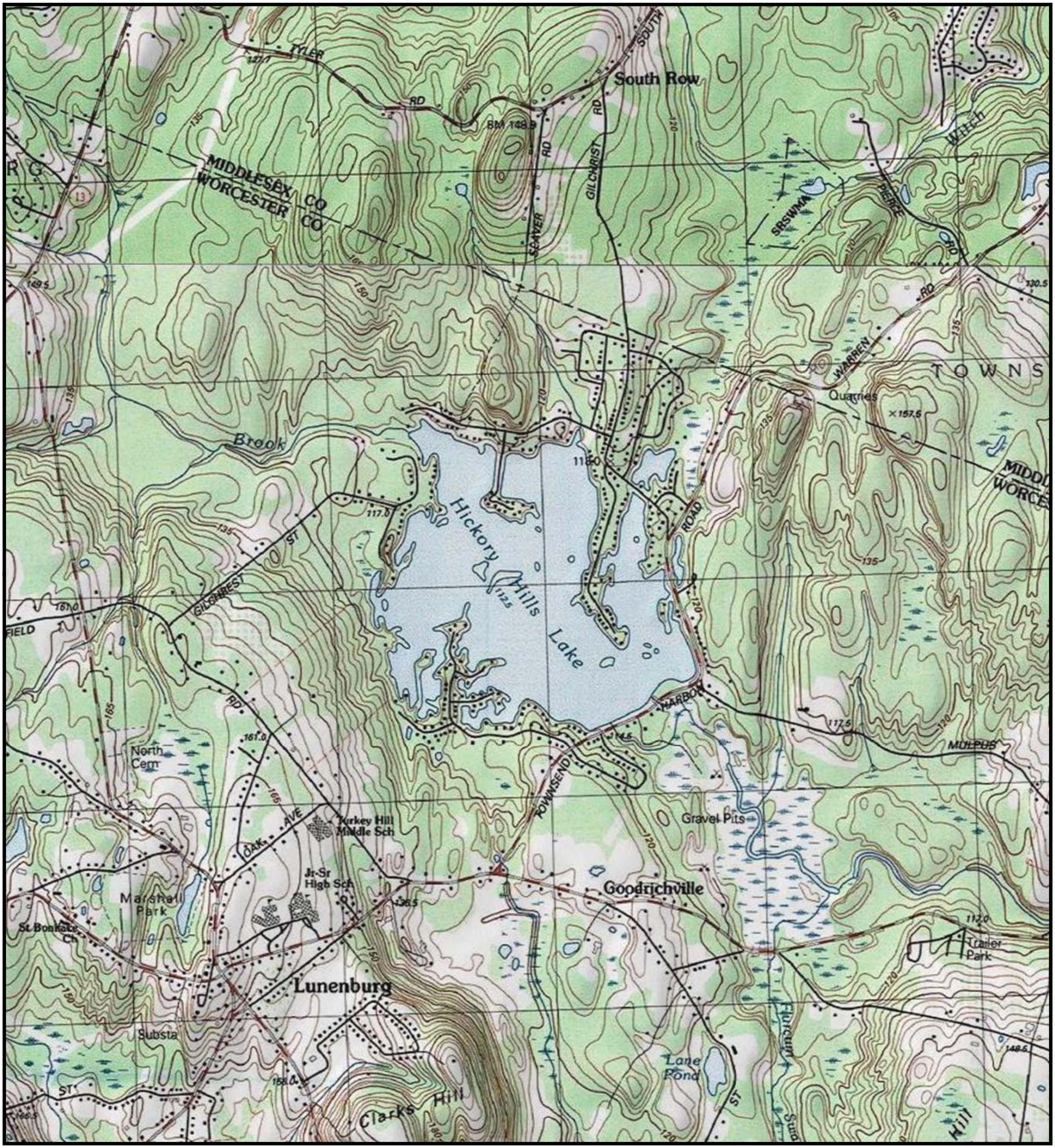
Other Management Techniques

We understand that the LMG has implemented its own multi-faceted fanwort management program, including, among other tasks, volunteer plant surveying and suction harvesting. As always, we'd welcome the opportunity to work with you as needed on planning and implementing this work, including discussions on the appropriateness of herbicide treatment.

Other control methods would either not be cost-effective or applicable at Hickory Hills Lake. There are no biological control agents (i.e. grass carp, insects) currently permitted for general use in Massachusetts. No known insects target the species found in the lake and effectiveness and impacts of grass carp in large multi-use waterbodies is too uncertain and generally not recommend even in states where they are legal. Aeration is sometimes effective in reducing algal blooms, but provides no control over vascular plants. Bottom weed barriers are effective for small swim or dock areas applications Covering larger areas is cost prohibitive (>$40,000 just for material) and may have negative impacts to macro-invertebrates and fish.

One final recommendation would be to continue repeating this monitoring project on an annual basis and at a similar scale. Monitoring is an important part of Lake Management for early detection of invasive/exotic species that can quickly overrun a lake. As always, we're happy to continue being involved in the on-going discussion about monitoring and implementation of management techniques at Hickory Hills Lake.

Attachment A – Maps



Hickory Hills Lake

Lunenburg, MA

Locus Map

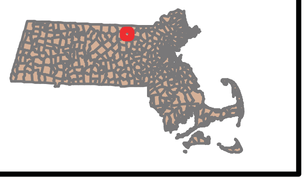
FIGURE:	SURVEY DATE:	MAP DATE:
1	9/12 & 9/16/14	12/1/14

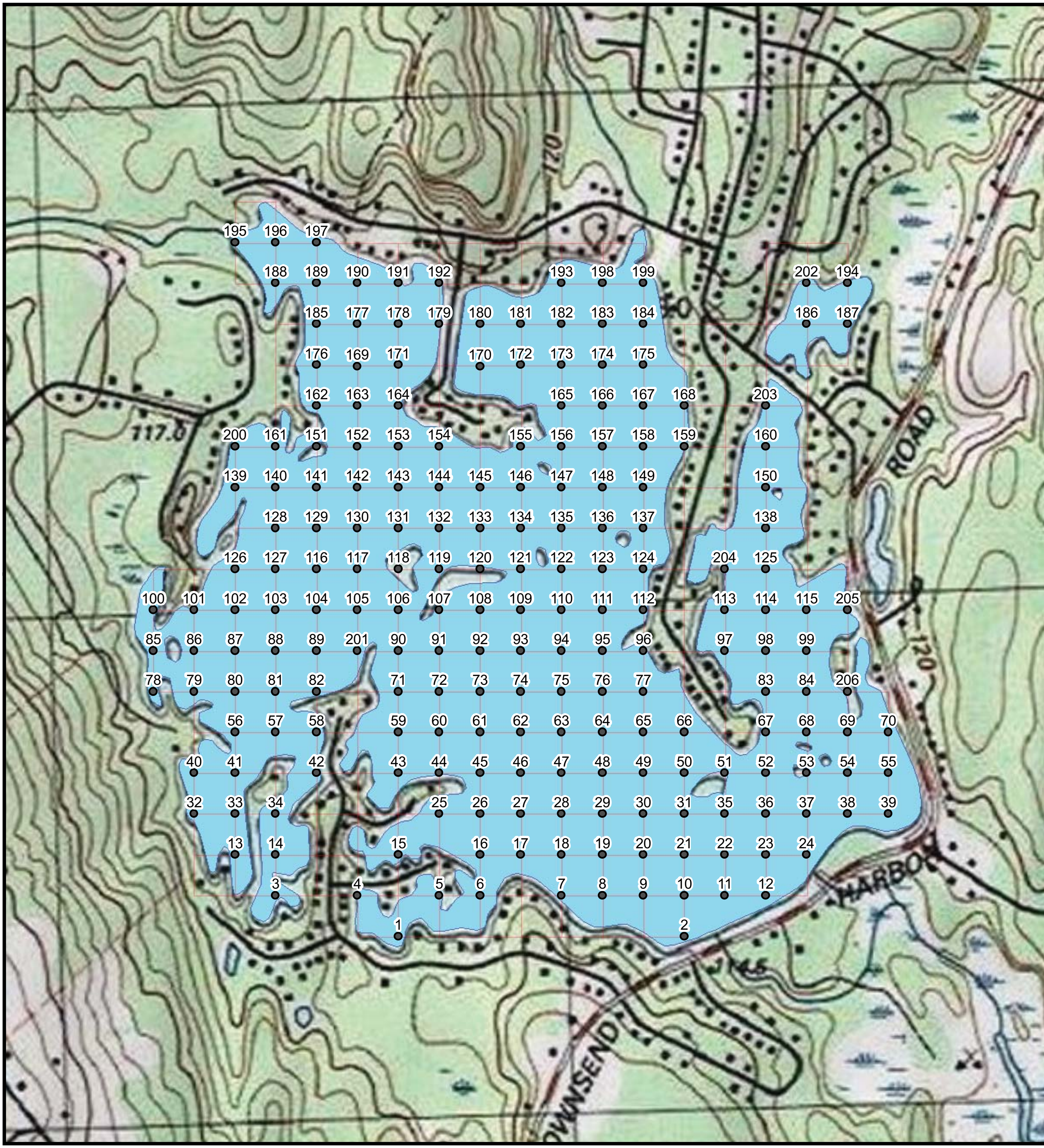
Legend:

N

0 500 1,000 2,000 3,000 4,000 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM





Hickory Hills Lake

Lunenburg, MA

Data Points

FIGURE:	SURVEY DATE:	MAP DATE:
2	9/12 & 9/16/14	12/1/14

Legend:

N

0 250 500 1,000 1,500 2,000 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
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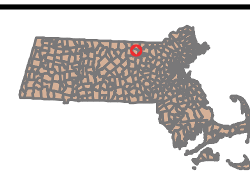

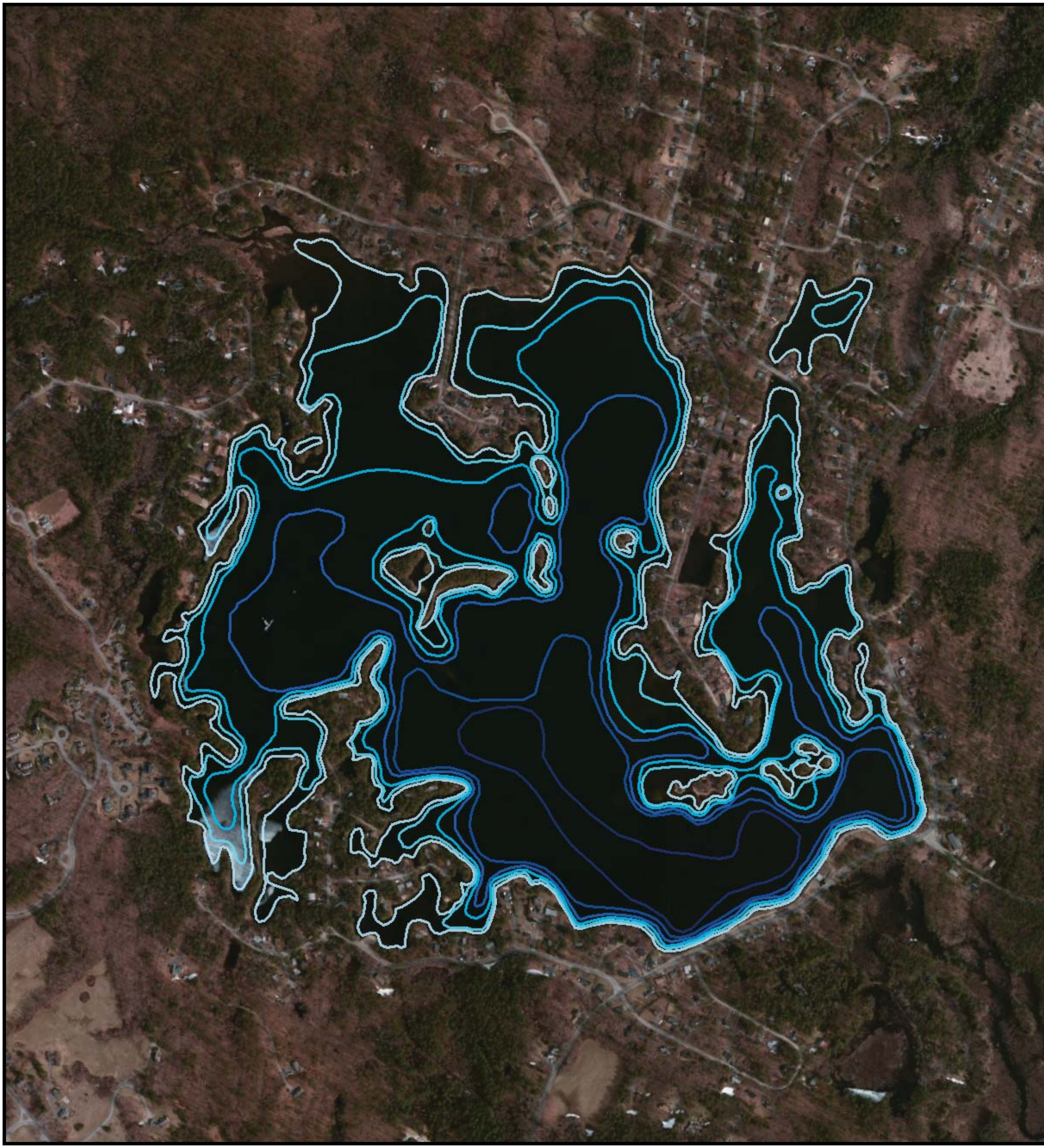

Hickory Hills Lake

Lunenburg, MA

Bathymetry

FIGURE:	SURVEY DATE:	MAP DATE:
3	9/12 & 9/16/14	12/1/14

Legend:

Water Depth (ft)

3
6
9
12
15
18

0 250 500 1,000 1,500 2,000 Feet

N

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PHONE: (508) 865-1000
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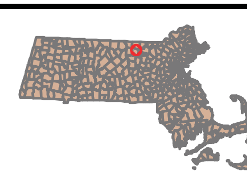

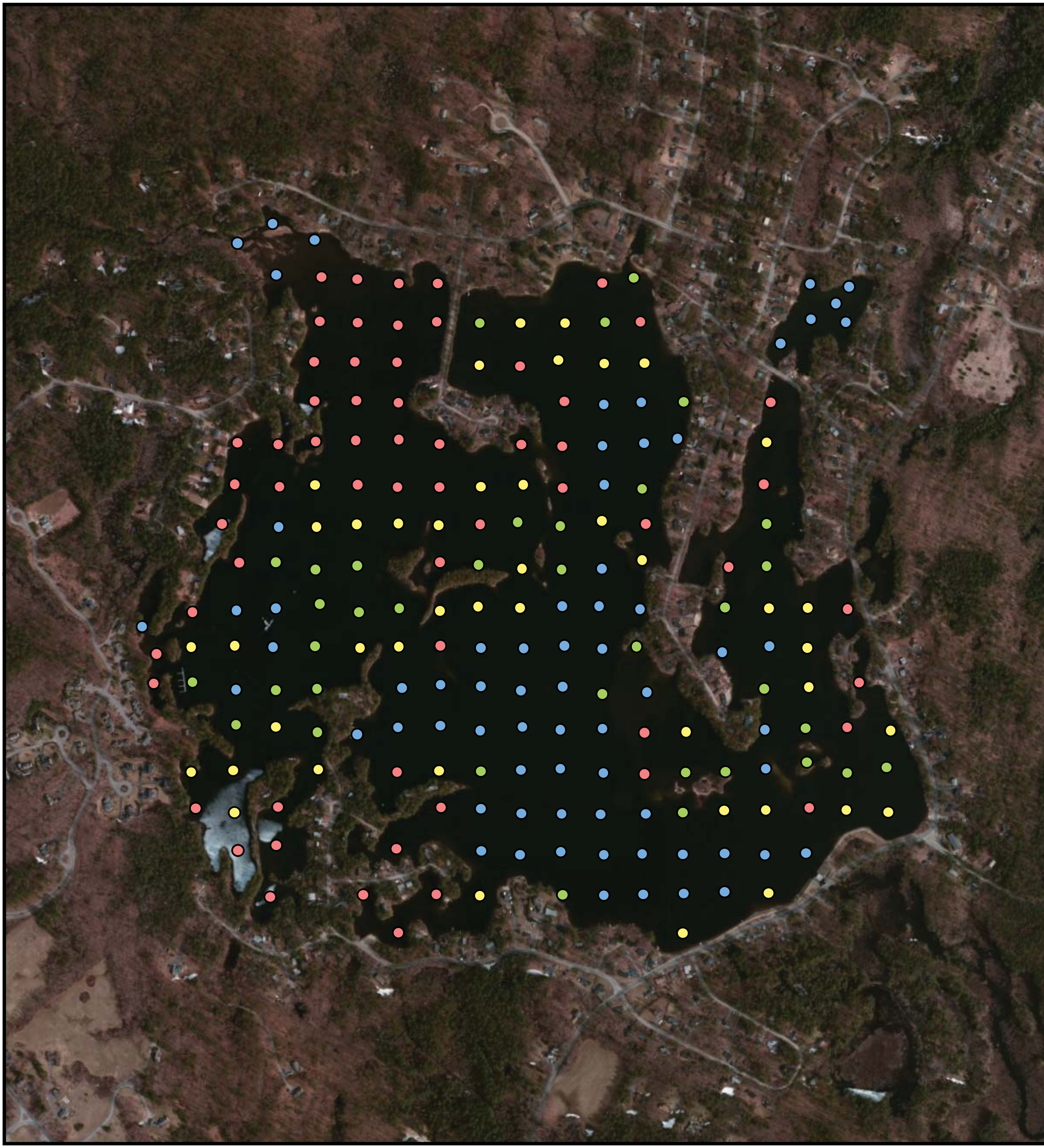

Hickory Hills Lake

Lunenburg, MA

Total Percent Plant Cover

FIGURE:	SURVEY DATE:	MAP DATE:
4	9/12 & 9/16/14	12/1/14

Legend:

Cover (%)

- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 100

0 250 500 1,000 1,500 2,000 Feet

N

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PHONE: (508) 865-1000
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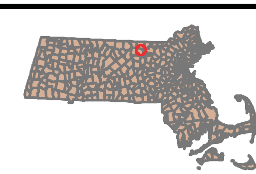
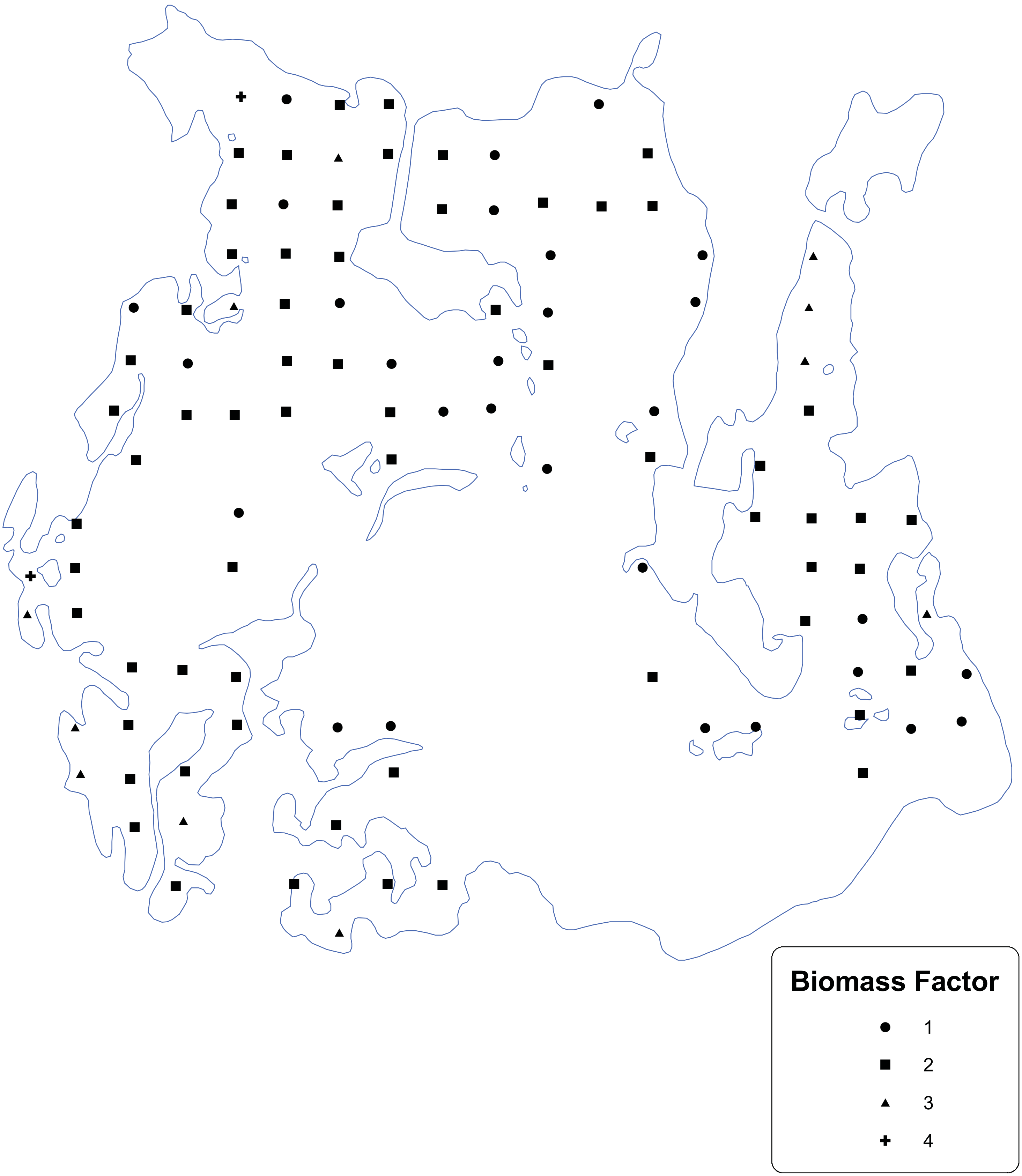
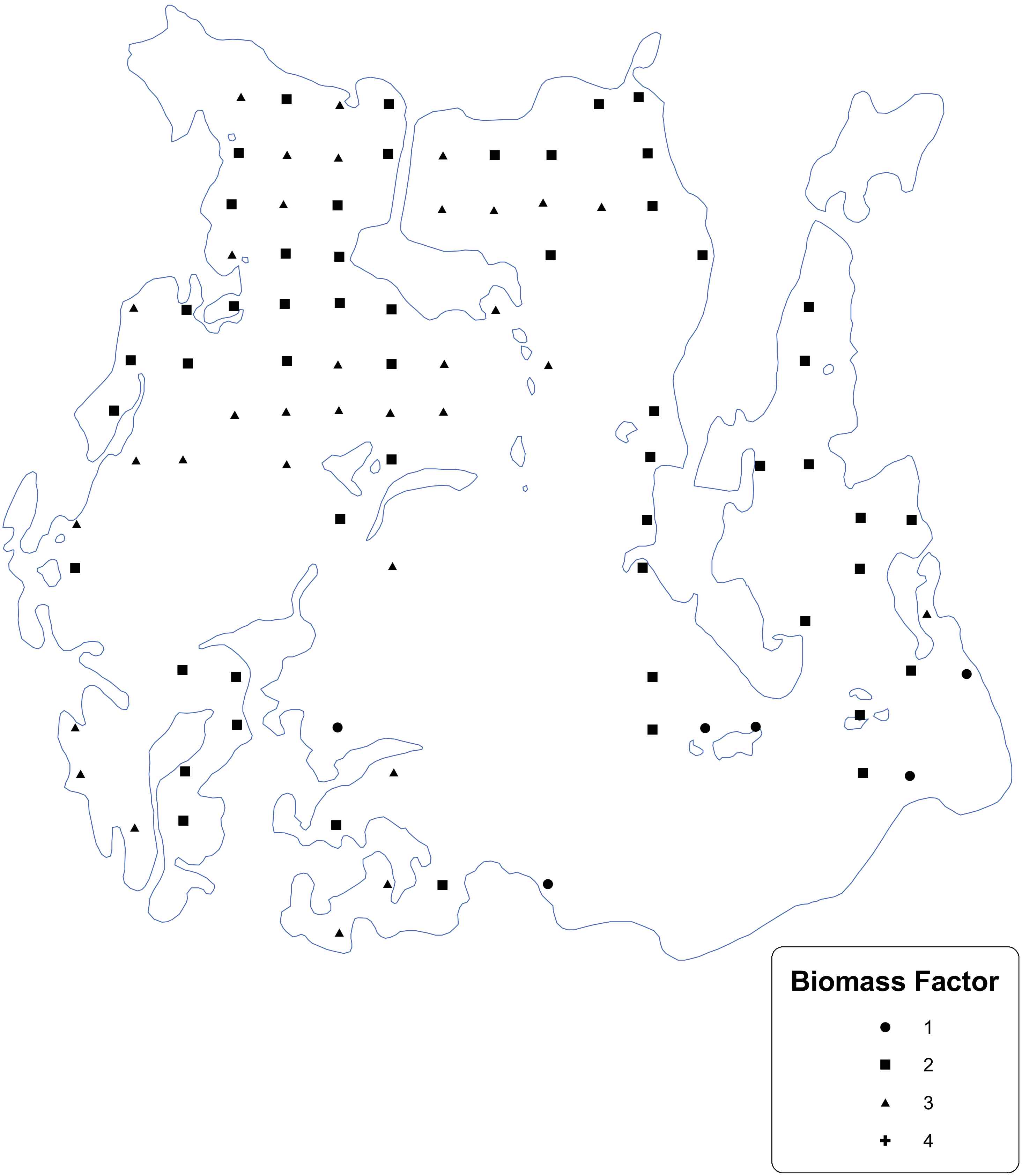


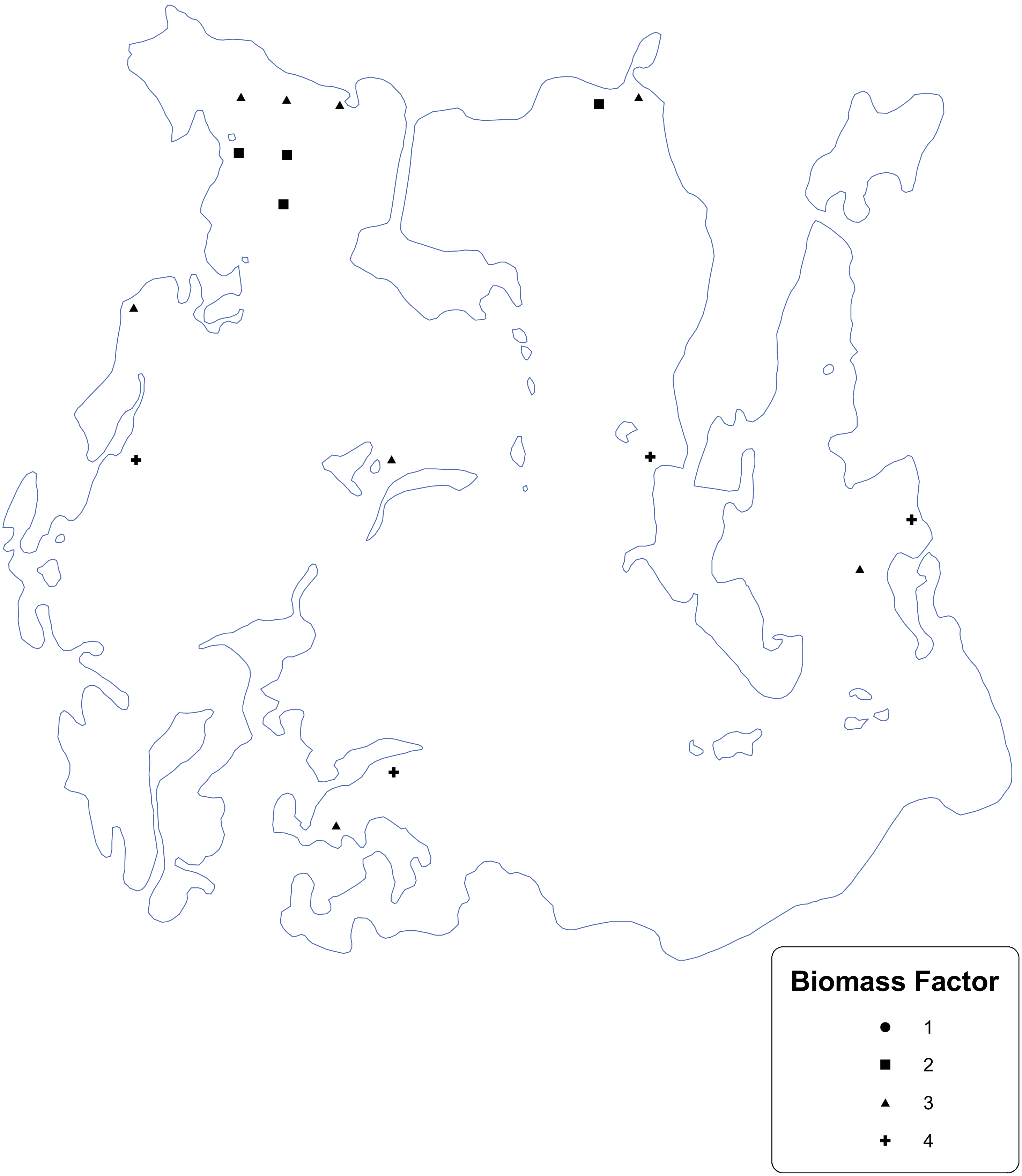
<u>Figure 5A</u>: Bladderwort
Distribution and Biomass



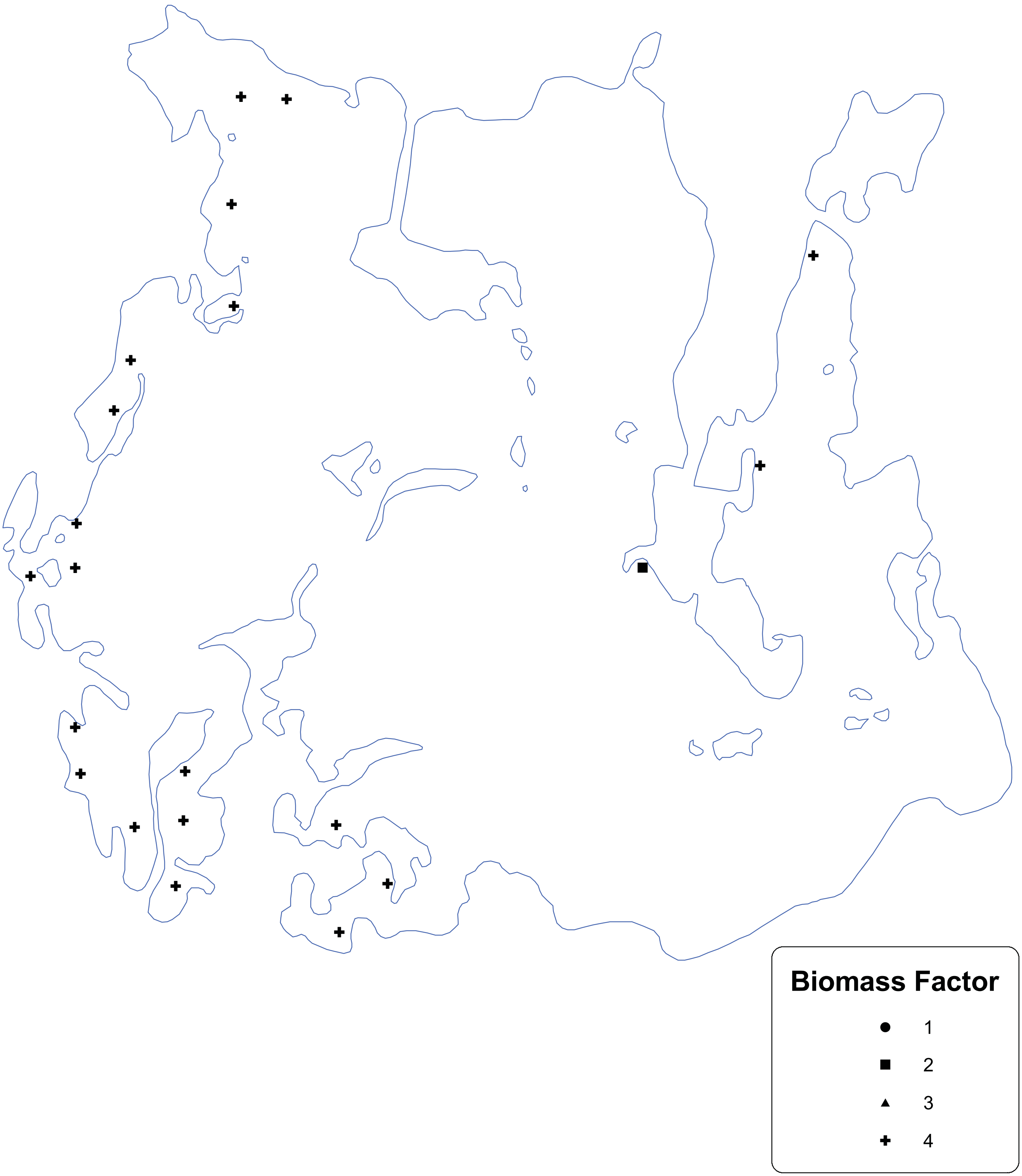
<u>Figure 5B</u>: Tapegrass
Distribution and Biomass



<u>Figure 5C</u>: Ribbonleaf pondweed
Distribution and Biomass



<u>Figure 5D</u>: Watershield
Distribution and Biomass



<u>Figure 5E</u>: Robbins pondweed
Distribution and Biomass

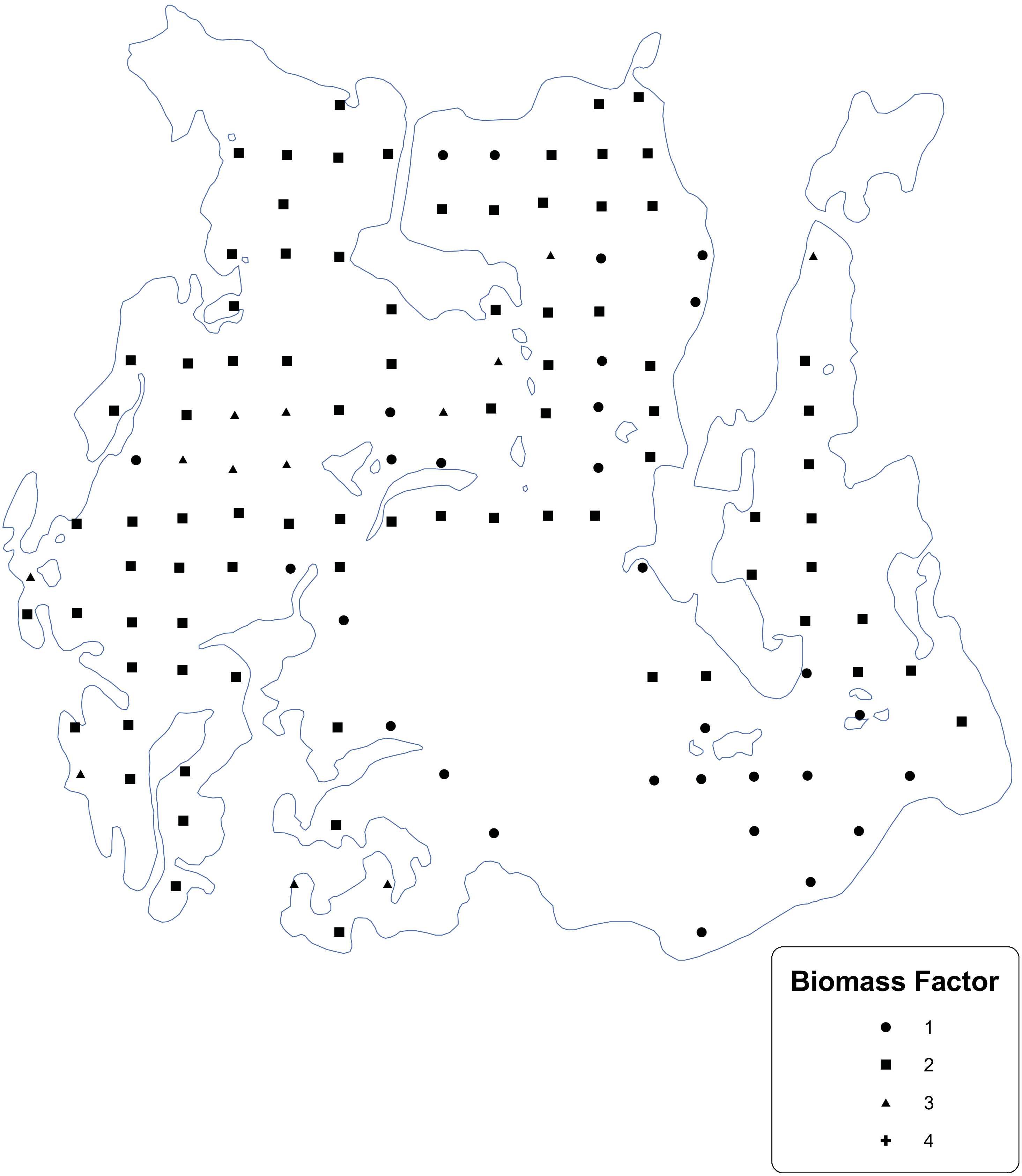


Figure 5F: Stonewort
Distribution and Biomass

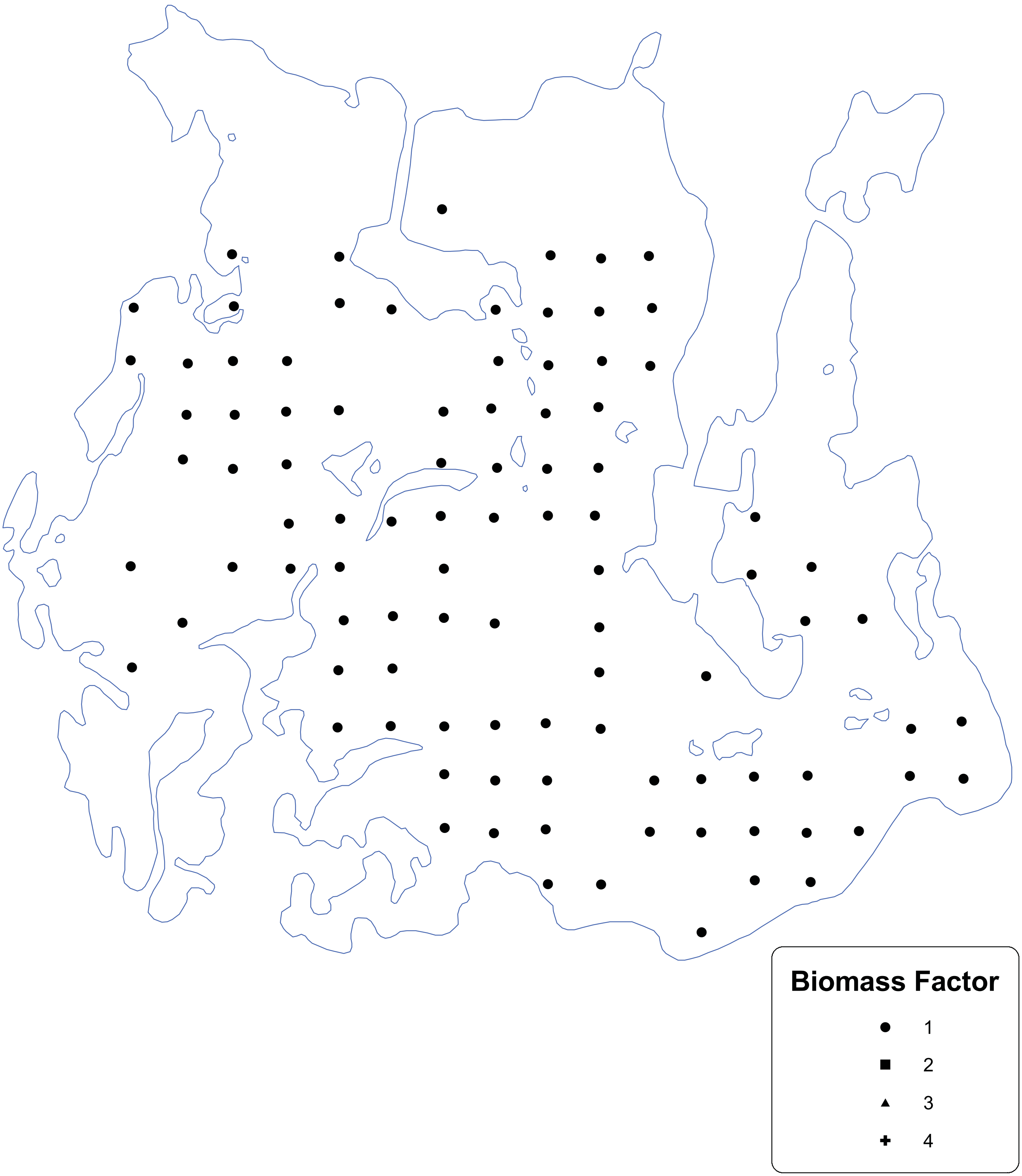


Figure 5G: Thinleaf pondweed
Distribution and Biomass

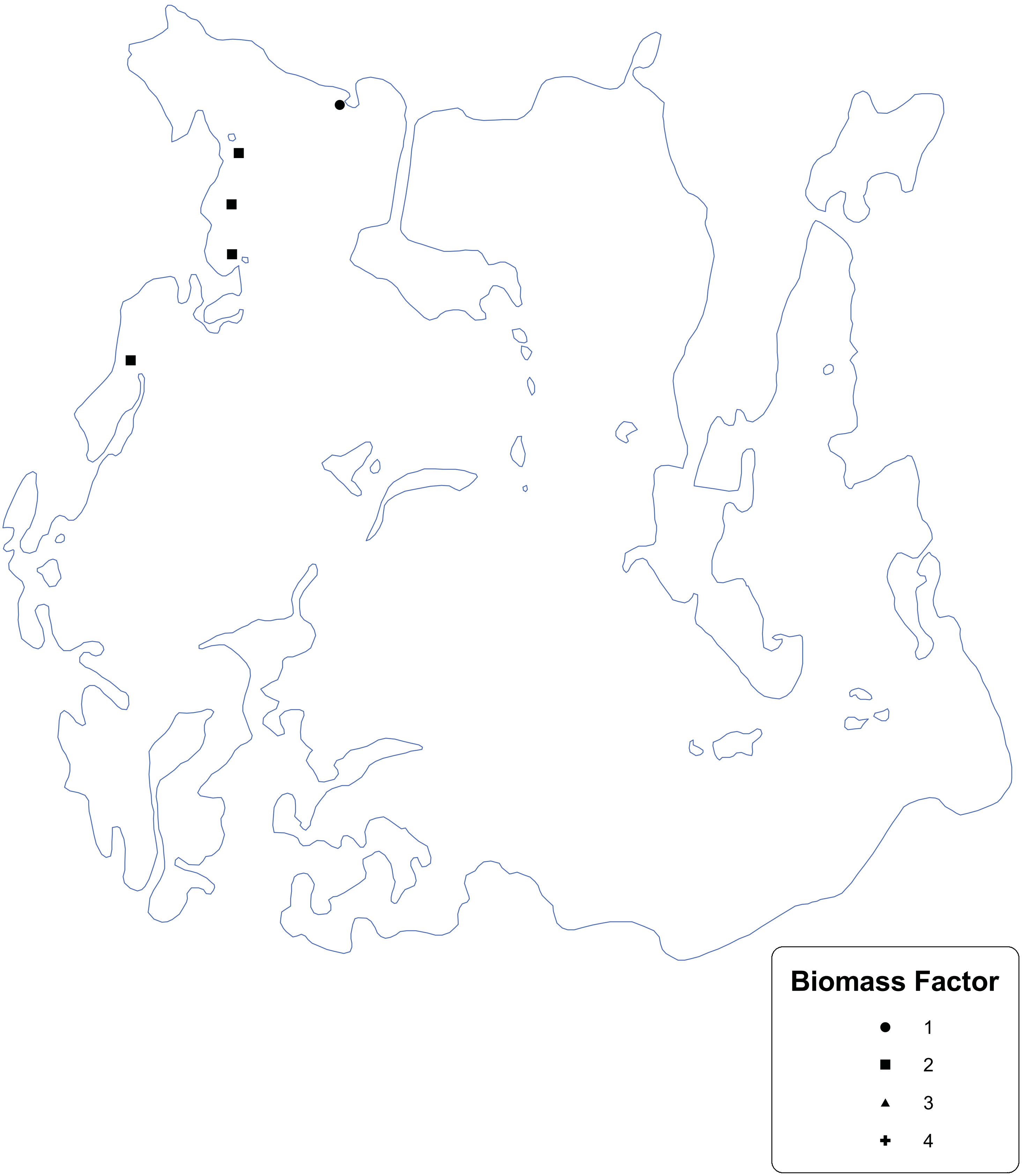


Figure 5H: Slender spikerush
Distribution and Biomass

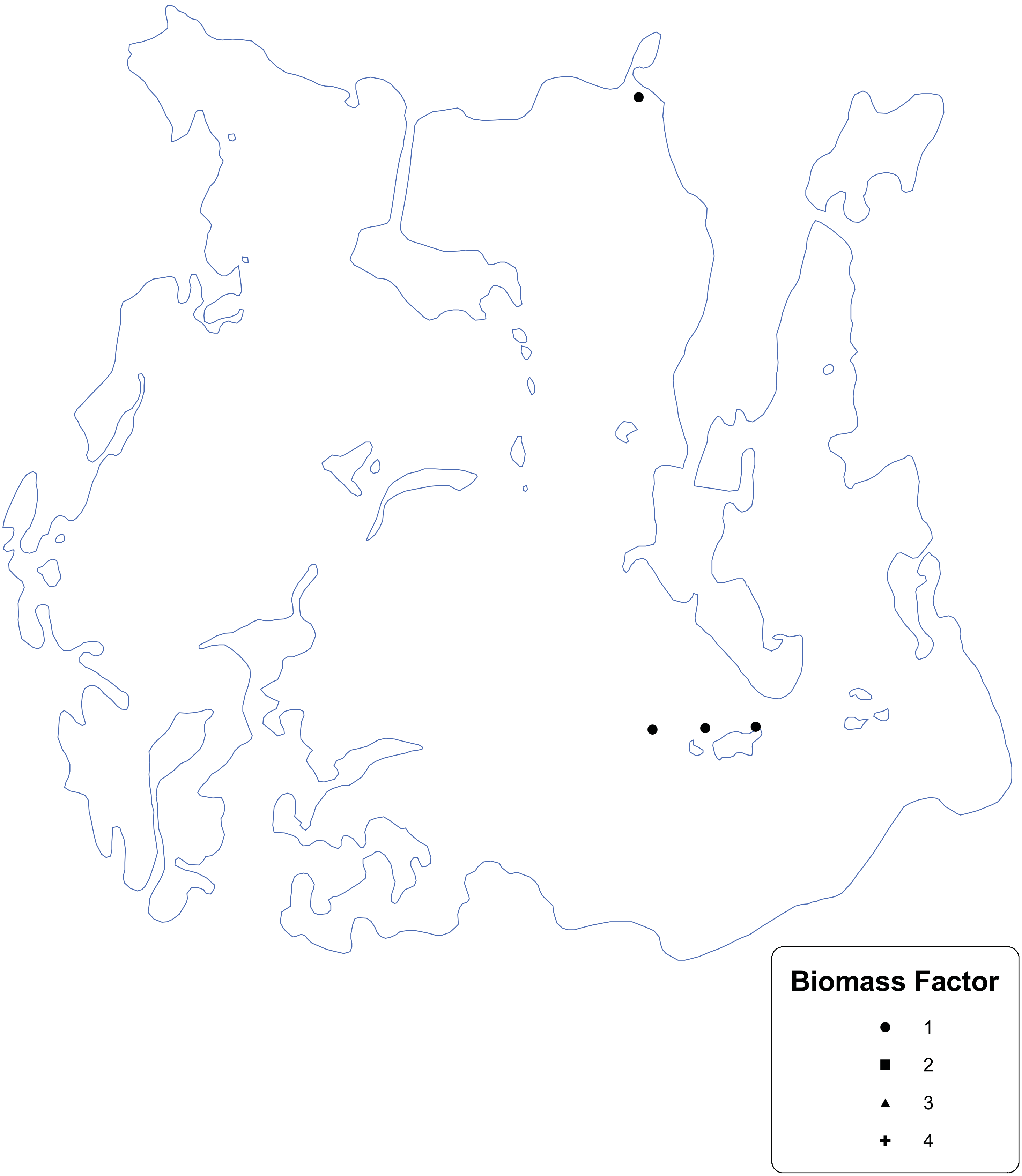


Figure 5I: Mermaid weed
Distribution and Biomass

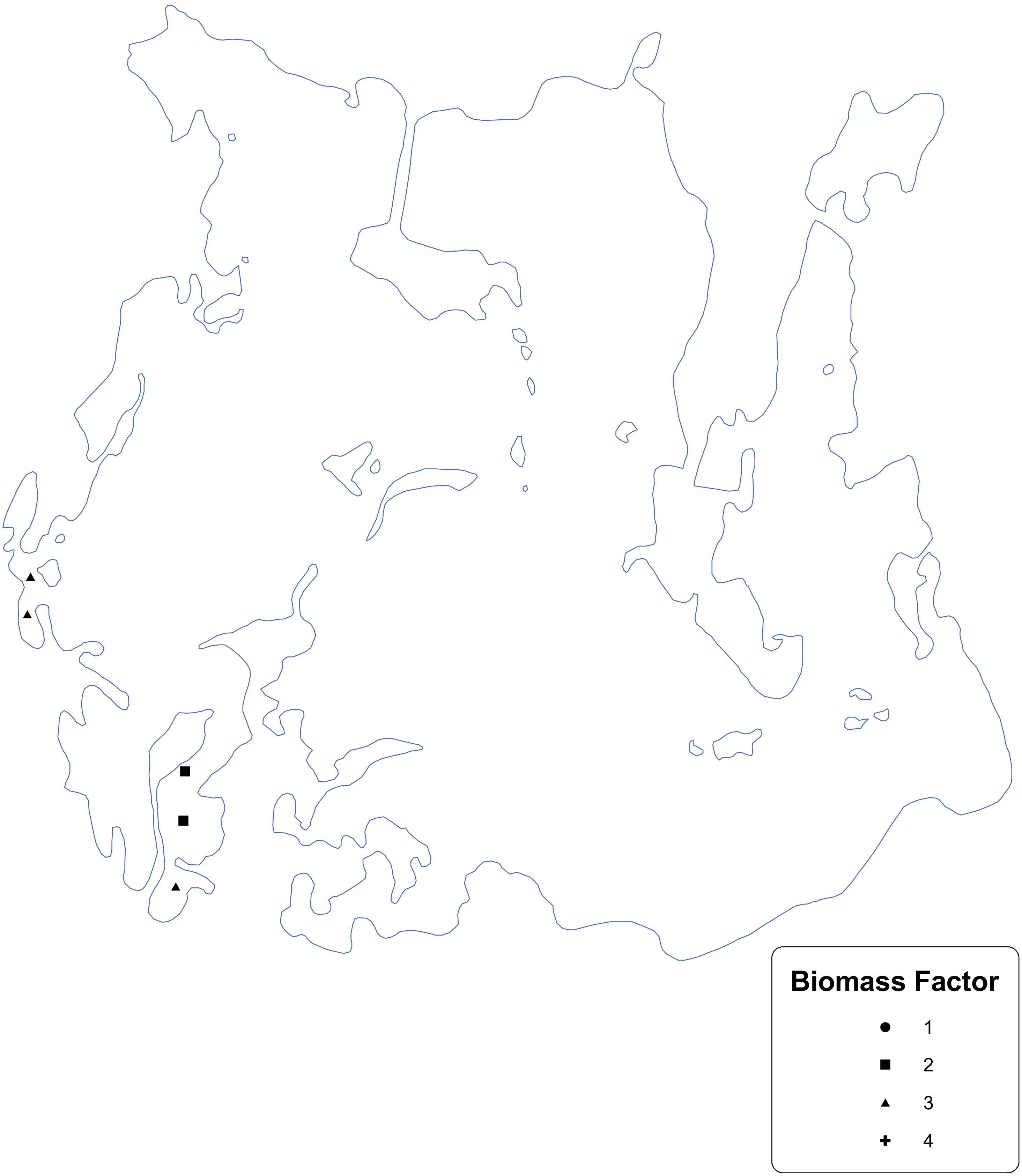
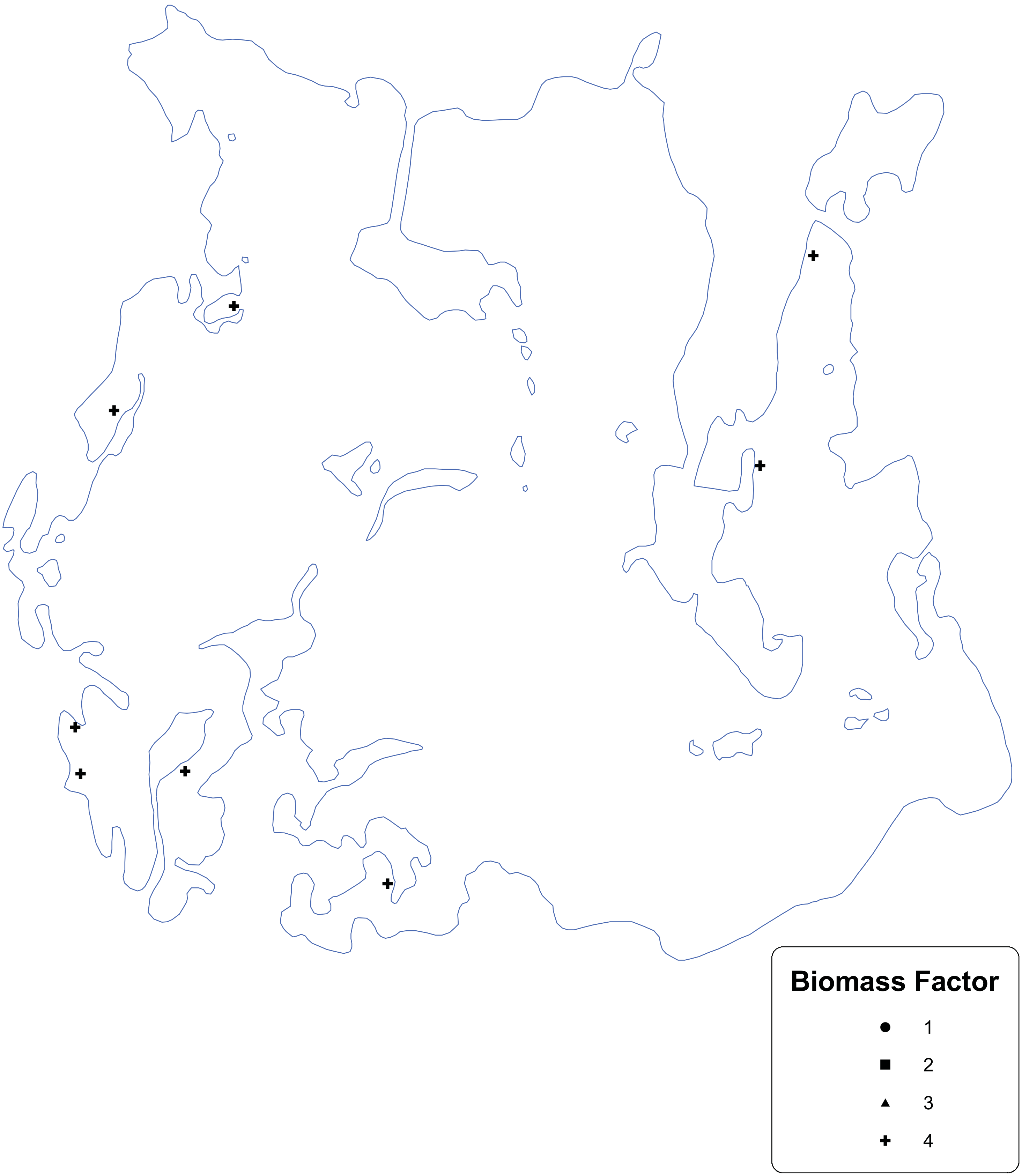


Figure 5J: Floatingleaf pondweed
Distribution and Biomass



<u>Figure 5K</u>: Largeleaf pondweed
Distribution and Biomass

Biomass Factor

●	1
■	2
▲	3
✚	4

Figure 5L: Snailseed pondweed
Distribution and Biomass

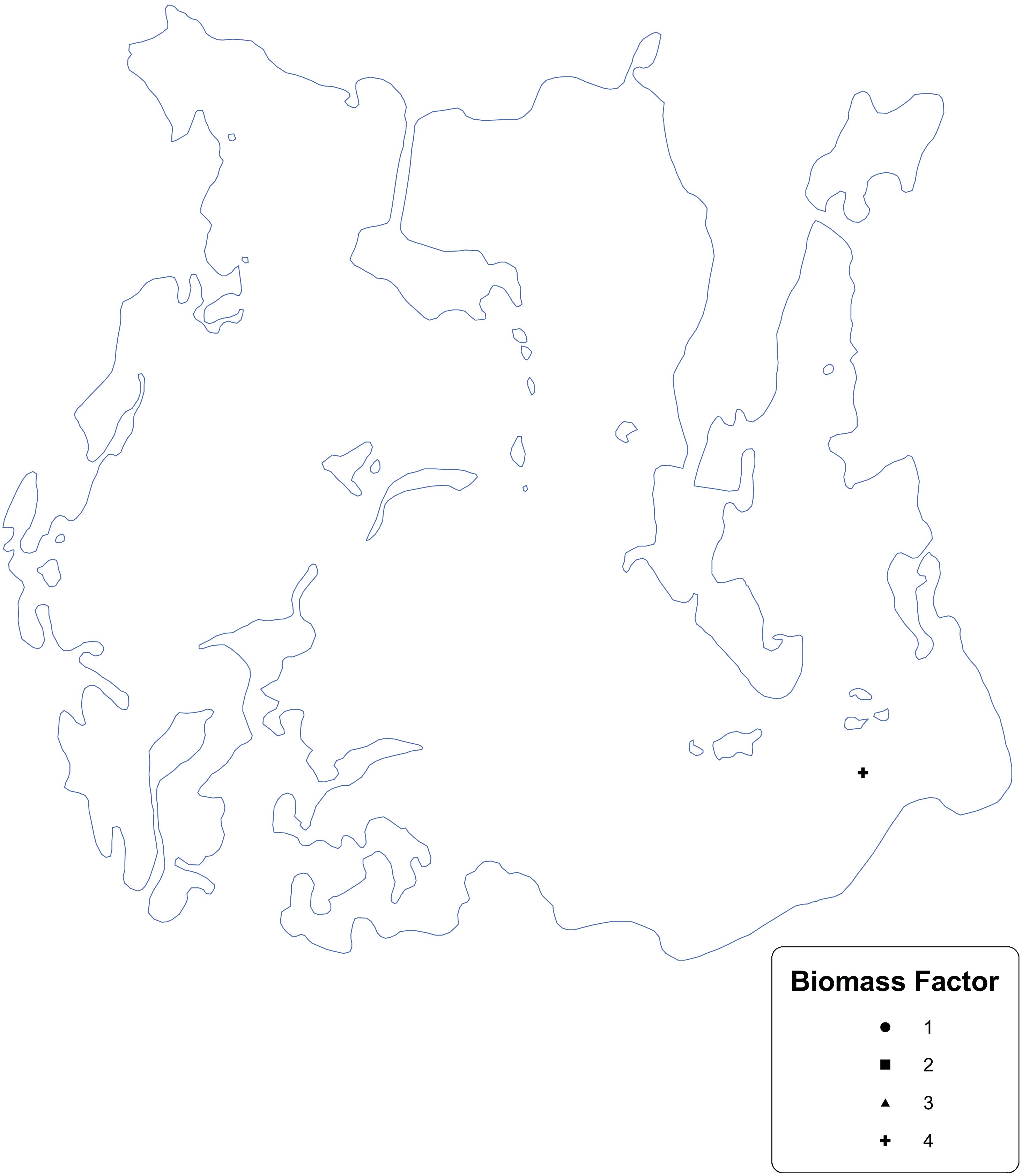


Figure 5M: Naiad
Distribution and Biomass

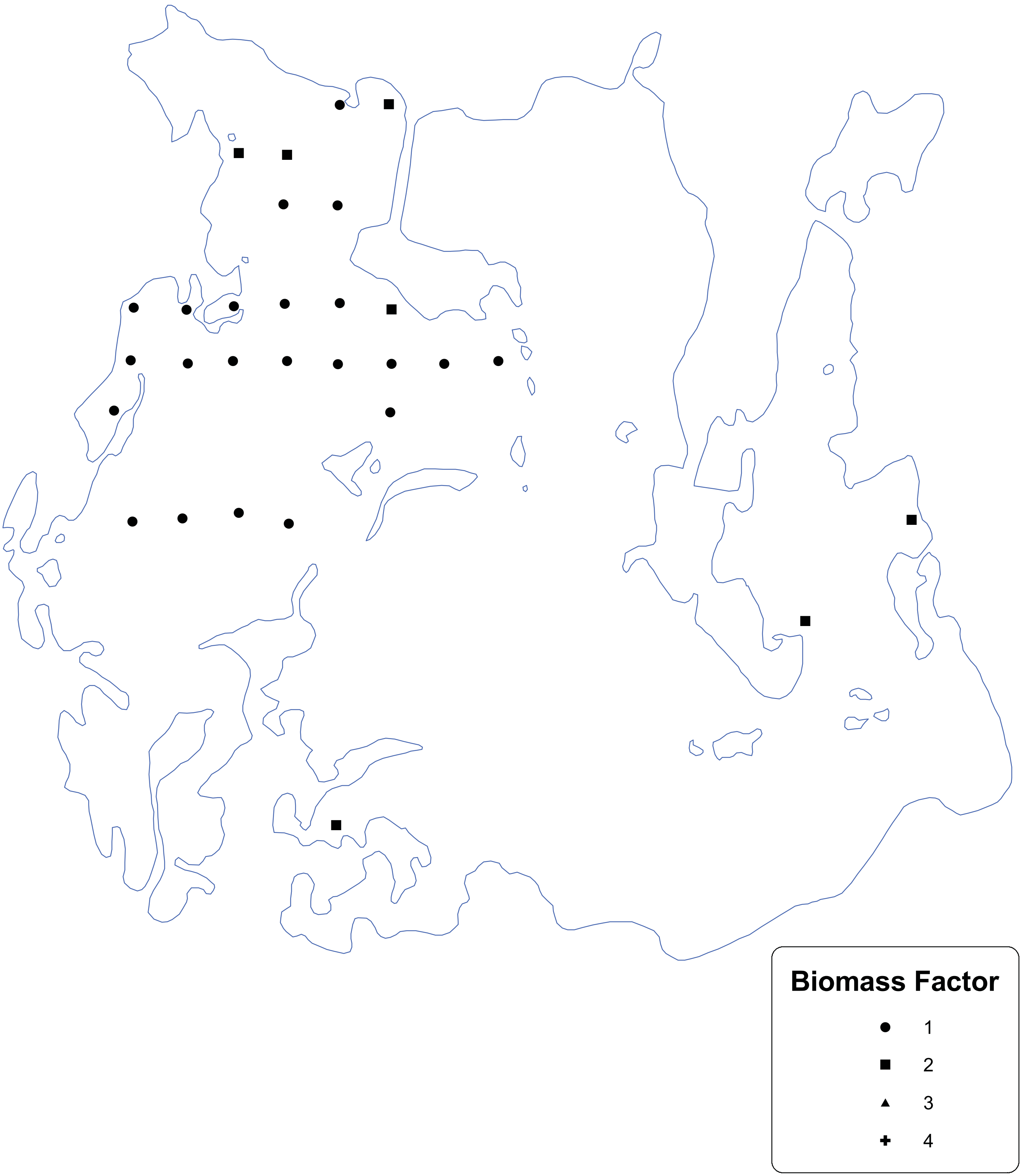
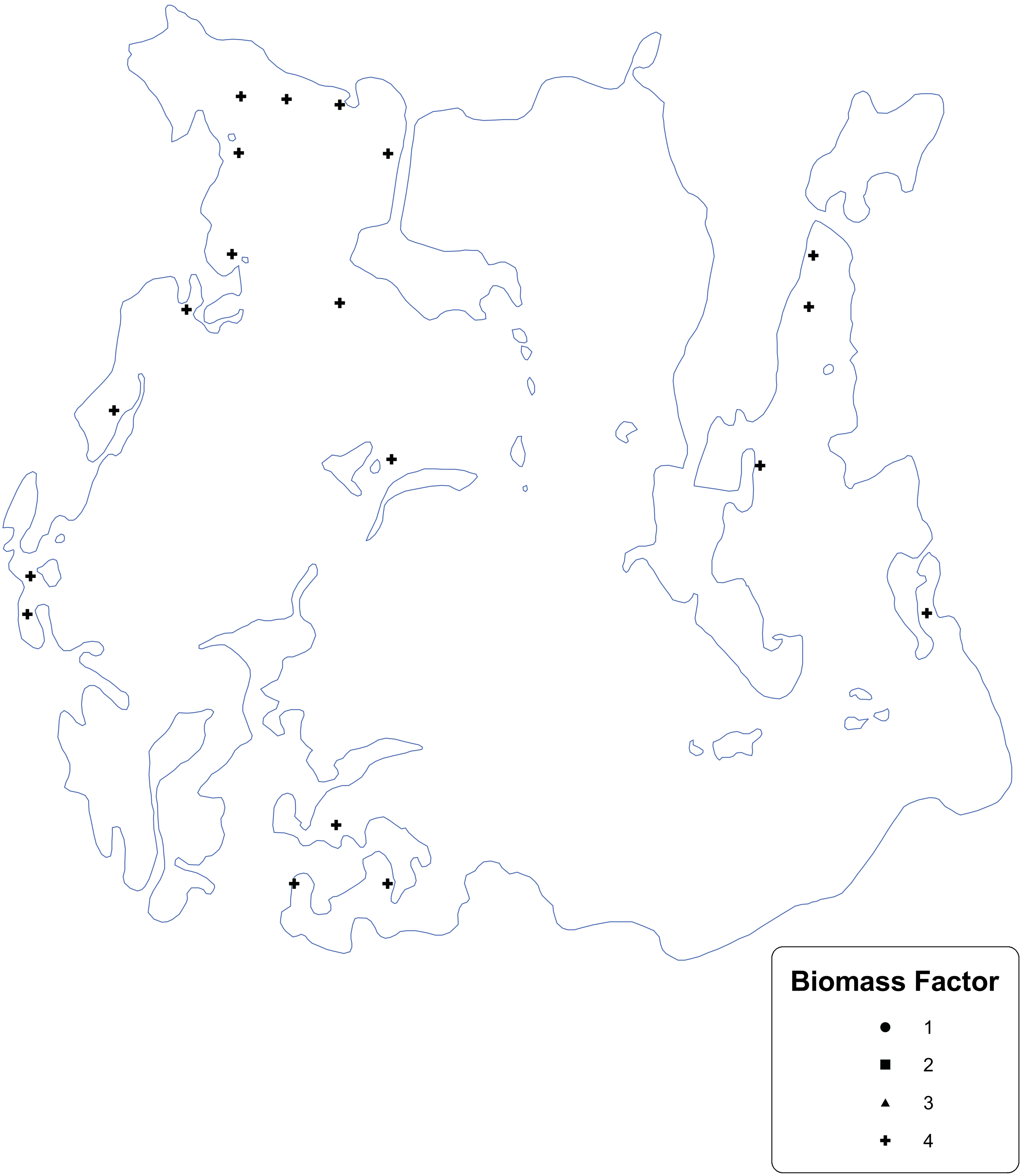
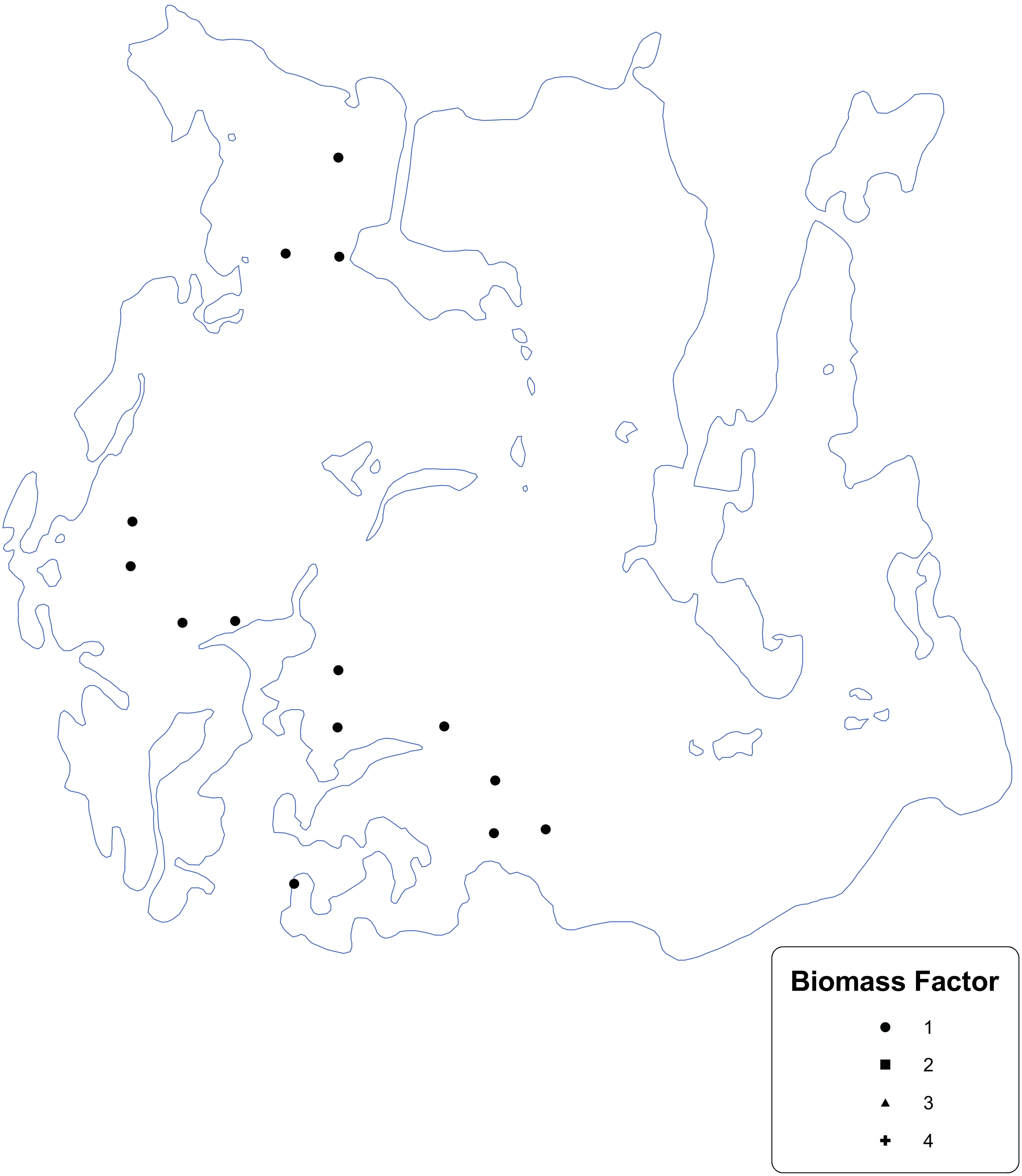


Figure 5N: White waterlily
Distribution and Biomass



<u>Figure 5O</u>: Filamentous algae
Distribution and Biomass



<u>Figure 5P</u>: Arrowhead
Distribution and Biomass

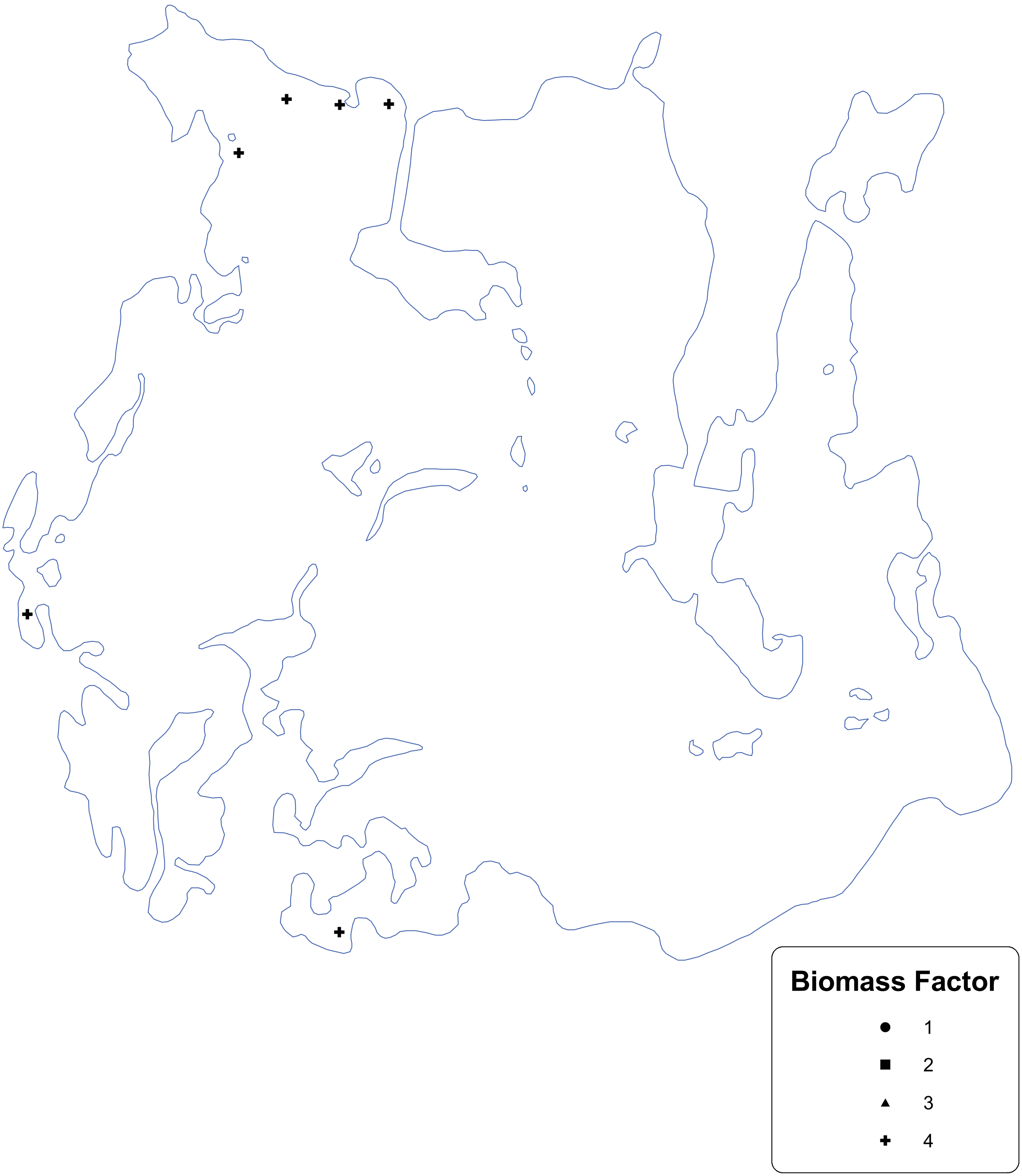
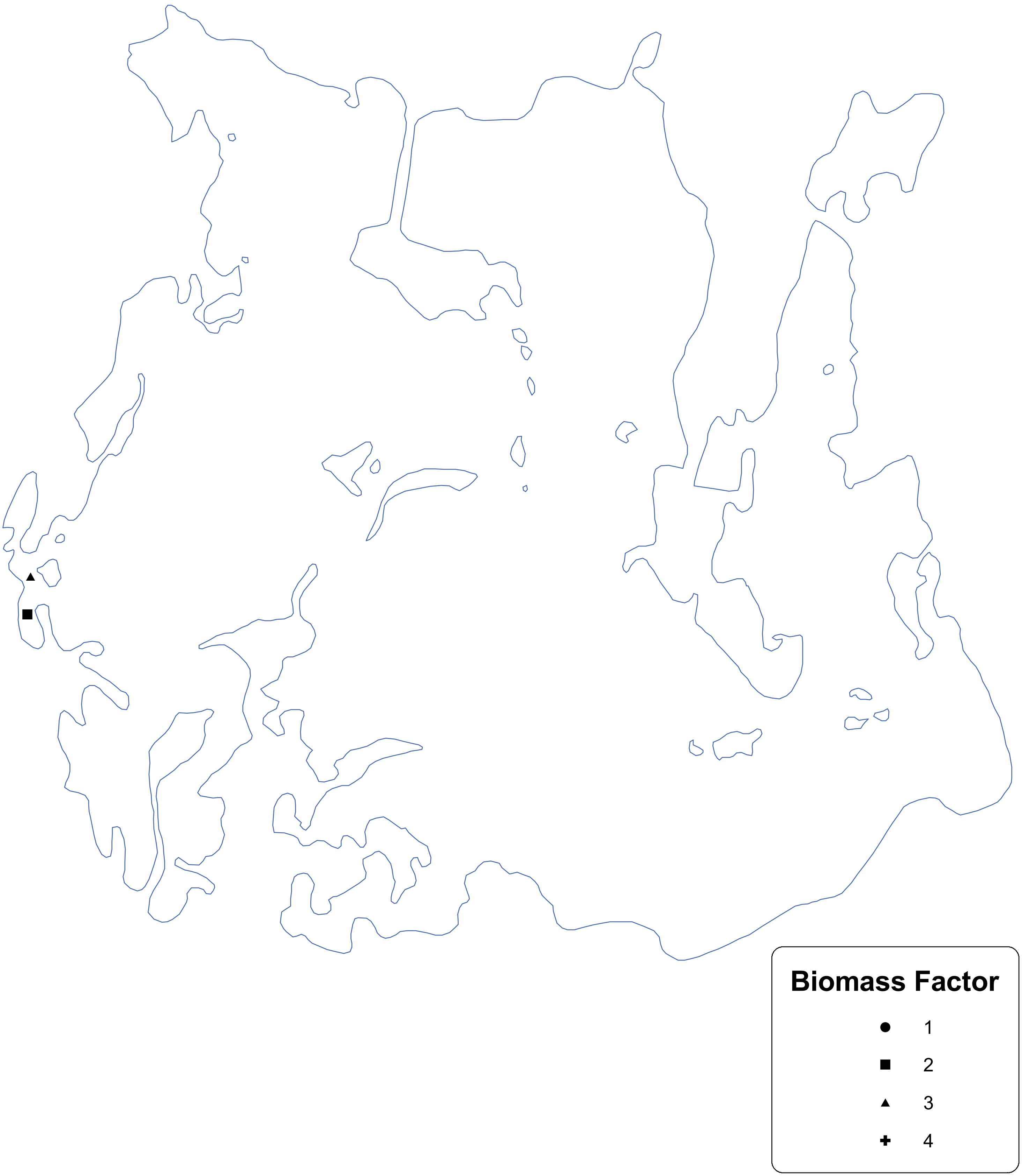


Figure 5Q: Coontail
Distribution and Biomass



Attachment B – Survey Point Data Sheet

Point	Depth	LAT	LONG_	U	Ubio	V	Vbio	Pe	PeBio	B	Bbio	PR	PrBio	Ni	NiBio	Pp	PpBio	Eo	EoBio	Mw	MwBio	Pn	PnBio	Pa	PaBio	Pb	PbBio	Nj	NjBio	Ny	NyBio	Fa	FaBio	Sg	SgBio	Cd	CdBio
1	4.3	42.60559528	-71.70981665	40	3	5	3			10	4	40	2																					10	4		
2	12.5	42.60560467	-71.70300275									10	1	60	1																						
3	3.8	42.60622602	-71.71289231	20	2					30	4	10	2							30	3			20	2												
4	2.8	42.60626893	-71.71066322	30	2							50	3																	5	4	5	1				
5	4.2	42.60627422	-71.7089104	20	2	30	3			20	4	20	3									10	4							5	4						
6	9.3	42.60625787	-71.70787306	10	2	60	2																	5	2												
7	11.9	42.60627254	-71.70589174			10	1							30	1																						
8	12.8	42.60626567	-71.70489756											5	1																						
9	13.8	42.60628654	-71.70395401																																		
10	13.8	42.60630121	-71.70298641																																		
11	13.5	42.60633213	-71.70200874											10	1																						
12	13.2	42.60631529	-71.70095799									5	1	60	1																						
13	6.4	42.60704443	-71.71367015	30	2	30	3			20	4																										
14	4.1	42.60713998	-71.71275132	50	3	10	2			20	4	10	2							10	2																
15	6	42.60708584	-71.70987868	40	2	20	2	5	3	20	4	5	2															5	2	5	4						
16	11.6	42.60705289	-71.70783819											5	1																						
17	11.7	42.60697947	-71.70691308									5	1	5	1																	5	1				
18	12.4	42.60703454	-71.70593608											5	1																	5	1				
19	17.4	42.60698978	-71.70490268																																		
20	12.8	42.60700378	-71.70398461											5	1																						
21	13.3	42.60699556	-71.70301239											5	1																						
22	13.7	42.60701719	-71.7020136									5	1	5	1																						
23	13.5	42.60699246	-71.70103418											10	1																						
24	15.3	42.60702155	-71.70005542									5	1	5	1																						
25	5.2	42.60781841	-71.70879808	35	2	35	3	15	4															15	3												
26	12.3	42.60779478	-71.70785135									20	1	5	1																						
27	12.8	42.60771255	-71.70688726											5	1																	10	1				
28	13.3	42.60771154	-71.70591756											5	1																						
29	13.6	42.60770232	-71.70497971																																		
30	14.2	42.60771314	-71.70389852									5	1	5	1																						
31	12.5	42.60773803	-71.70301566									5	1	40	1																						
32	3.6	42.60779117	-71.71468645	30	3	20	3			20	4	30	3									5	4														
33	7	42.60771892	-71.71375363	30	2							30	2																									
34	5.8	42.60782151	-71.71271612	30	2	20	2			10	4	10	2							10	2	5	4														
35	12.4	42.60777508	-71.702025									5	1	70	1																						
36	12.9	42.60778883	-71.70102093									10	1	60	1																						
37	5.5	42.60782562	-71.69998242	20	2	40	2																	20	3	5	4										
38	12.8	42.60778656	-71.69909494			5	1					5	1	60	1																						
39	12.6	42.60775153	-71.69808777											60	1																						
40	5	42.60843256	-71.71479114	30	3	5	3			10	4	20	2									5	4														
41	7.7	42.60846734	-71.71379286	30	2							30	2																								
42	6.3	42.60847991	-71.71174625	60	2	10	2																														
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45	12.8	42.60846131	-71.70785227											30	1																	10	1				
46	13.5	42.60848243	-71.70689631											5	1																						
47	13.1	42.60850724	-71.70594589											5	1																						
48	13.1	42.6084323	-71.70491056											5	1																						
49	5.3	42.60842158	-71.70393239			30	2											40	1					10	2												
50	4.3	42.6084458	-71.70294634	10	1	5	1					5	1					10	1																		
51	5.2	42.60846307	-71.70199659	20	1	10	1											20	1																		
52	2	42.60851403	-71.70102504																																		
53	5.7	42.60863255	-71.70004126	10	2	20	2					5	1																								
54	12.5	42.60844647	-71.69907642	10	1									40	1																						
55	12.4	42.6085468	-71.69812834	10	1							20	2	10	1																						
56	9.2	42.60926932	-71.71372203	10	2							20	2	10	1									5	2												
57	7.6	42.60923546	-71.71277513	10	2	30	2					20	2											10	3												
58	6.9	42.60914284	-71.71176989	10	2	10	2					20	2																								
59	11.7	42.60923604	-71.70984037											10	1																	10	1				

Point	Depth	LAT	LONG_	U	Ubio	V	Vbio	Pe	PeBio	B	Bbio	PR	PrBio	Ni	NiBio	Pp	PpBio	Eo	EoBio	Mw	MwBio	Pn	PnBio	Pa	PaBio	Pb	PbBio	Nj	NjBio	Ny	NyBio	Fa	FaBio	Sg	SgBio	Cd	CdBio
60	11.8	42.60926572	-71.70883044											10	1																						
61	13.1	42.60918248	-71.70786694																																		
62	12.9	42.60924434	-71.70686061																																		
63	13.2	42.60920486	-71.70594681																																		
64	13.6	42.60921593	-71.70493989											5	1																						
65	7.9	42.60915541	-71.70393976	10	2	30	2					20	2											20	3												
66	10.5	42.60916639	-71.70293218									5	2	40	1									10	2												
67	10.7	42.60921199	-71.70104222									5	1																								
68	10.3	42.60923244	-71.70007587	20	1							20	2											10	2												
69	8.7	42.6092518	-71.69907507	20	2	20	2					30	2																								
70	5.9	42.60920445	-71.69803631	10	1	20	1																														
71	11.9	42.60993266	-71.7097449									10	1	10	1																						
72	11.7	42.60999234	-71.70882231											5	1																						
73	12.9	42.60996896	-71.70786275											5	1																						
74	12.6	42.60989218	-71.70690377											5	1																						
75	13.5	42.60996644	-71.70589945																																		
76	11.4	42.60983937	-71.70494425											40	1																						
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78	3	42.61000182	-71.7156958	5	3							5	2							10	3			5	3					10	4			20	4	5	2
79	7.9	42.6100247	-71.71476063	10	2							30	2																								
80	9.8	42.60989687	-71.7137258									20	2											5	2												
81	10.3	42.60989084	-71.71277563									20	2	20	1																	10	1				
82	10.1	42.6099185	-71.7117859																													40	1				
83	5.1	42.60993401	-71.70107257	5	2	5	2					5	2	20	1													5	2								
84	10.2	42.60996745	-71.69999499	20	1							20	2	20	1									10	2												
85	2	42.61052686	-71.71563537	20	4					30	4	10	3							20	3			10	3					30	4					5	3
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88	10.4	42.61065653	-71.71283539									20	2																								
89	10.8	42.61066893	-71.71184063	10	2							20	2	10	1																						
90	11.1	42.61066801	-71.7098242									5	2	60	1																						
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93	12.9	42.61064303	-71.70682733																																		
94	13.1	42.61069031	-71.70585645																																		
95	12.9	42.61063742	-71.70495414											5	1																						
96	3.1	42.61067706	-71.70412651	5	1	20	2			20	2	5	1																								
97	11	42.61058117	-71.70207605									5	2	10	1									5	2												
98	10.2	42.61068938	-71.7009512	5	2							5	2	5	1									5	2												
99	8.9	42.61066482	-71.70004251	20	2	40	2	5	3																												
100		42.61100882	-71.71597928																																		
101	4.7	42.61126505	-71.71477069	30	2	30	3			20	4	10	2																								
102	10.4	42.61129883	-71.71372144									10	2															5	1			10	1				
103	10.9	42.61133923	-71.71278225									20	2															5	1								
104	10.7	42.61142003	-71.71172261	10	1							10	2															10	1								
105	11.4	42.61127193	-71.71078417									10	2	20	1													5	1								
106	10.5	42.611342	-71.70981858			10	2					10	2	30	1																						
107	9.8	42.61130378	-71.70884896									5	2	60	1																						
108	12.5	42.61137913	-71.70792947									5	2	50	1																						
109	12.6	42.61135876	-71.7069285									5	2	60	1																						
110	12.8	42.61138801	-71.70591102									5	2	10	1																						
111	12.6	42.61139246	-71.70502732									5	2	20	1																						
112	4.8	42.61133722	-71.70404906			5	2																														
113	9.5	42.61137645	-71.70201763	20	2							20	2	10	1																						
114	9.7	42.61136488	-71.70096	20	2							40	2																								
115	4.8	42.61136807	-71.70002818	30	2	20	2																	10	3												
116	10.7	42.61202923	-71.71183317									30	3	5	1																						
117	9.8	42.6120988	-71.71082684			20	3					10	3	20	1																						
119	4.6	42.61216502	-71.70885139	10	2	60	2	10	3			20	1																	5	4						

Point	Depth	LAT	LONG_	U	Ubio	V	Vbio	Pe	PeBio	B	Bbio	PR	PrBio	Ni	NiBio	Pp	PpBio	Eo	EoBio	Mw	MwBio	Pn	PnBio	Pa	PaBio	Pb	PbBio	Nj	NjBio	Ny	NyBio	Fa	FaBio	Sg	SgBio	Cd	CdBio
120	10.8	42.61211808	-71.70792217									5	1	30	1																						
121	12.4	42.61205563	-71.70687125											70	1																						
122	12.8	42.61204071	-71.70592862	10	1									20	1																						
123	12.4	42.61205446	-71.70496353									5	1	20	1																						
124	5.9	42.61220852	-71.70399207	30	2	20	2	5	4			10	2											5	3												
125	9.2	42.61211154	-71.7010102			20	2					10	2											20	2												
126	9.6	42.61214817	-71.71365523	20	2	30	3	10	4			10	1																								
127	11	42.61215772	-71.71277597			20	3					20	3	10	1																						
128	10.6	42.61278251	-71.71271235	10	2							10	2	5	1																						
9128	2.9	42.61283356	-71.71406846	70	2	10	2			10	4	10	2									10	4	5	3			10	1	5	4						
129	10	42.61278209	-71.71180082	5	2	20	3					30	3	20	1																						
130	8.7	42.61282979	-71.71084193	5	2	20	3					20	3	10	1									10	3												
131	9.6	42.61284814	-71.70984616			20	3					10	2	30	1									10	2												
132	9.3	42.61281772	-71.70888266	30	2	20	3					10	1															10	1								
133	10	42.61283222	-71.7078785	30	1	20	3					30	3	10	1																						
134	11.6	42.61287916	-71.70697971	10	1							5	2	30	1																						
135	12	42.61281176	-71.70595871									5	2	30	1																						
136	12.7	42.61290053	-71.70496554									5	1	50	1																						
137	9.7	42.61284705	-71.70391856	20	1	30	2					30	2											5	2												
138	8.1	42.61285627	-71.70101465	10	2							40	2																								
139	3.3	42.6135342	-71.71376755	60	2	10	2			5	4	10	2	20	1	5	2							5	2			20	1								
140	9.9	42.61349271	-71.71269273	5	1	10	2					40	2	20	1													10	1								
141	7.6	42.61352498	-71.71184205									20	2	20	1													20	1								
142	8.6	42.6135306	-71.71082608	10	2	30	2					40	2	10	1									20	3			20	1								
143	7.6	42.61348986	-71.70986594	10	2	40	3																	10	4			30	1								
144	7.6	42.61349254	-71.70885944	20	1	30	2					10	2											10	3			20	1								
145	7.3	42.61349623	-71.70786736			20	3																	10	3			20	1								
146	11.4	42.61353889	-71.70684963	20	1							20	3	30	1													5	1								
147	5.9	42.61348207	-71.70591094	20	2	60	3					20	2	20	1																						
148	12	42.61353873	-71.70490628									5	1	10	1																						
149	12	42.61347109	-71.70399617									5	2	40	1																						
150	7.6	42.61355289	-71.7010874	60	3	10	2					20	2																								
151	3.1	42.61428966	-71.71182856	70	3	20	2			10	4	10	2	5	1							10	4	5	2			10	1								
152	7.2	42.61432067	-71.71086774	30	2	10	2																	20	3			10	1								
153	7.8	42.61433627	-71.70983937	20	1	30	2							10	1									20	3			10	1	5	4						
154	8	42.61425027	-71.70886086			20	2					20	2	10	1									10	3			20	2								
155	5.6	42.61425094	-71.7069005	30	2	10	3					30	2	10	1									5	3												
156	10.6	42.61421582	-71.70592192	40	1							10	2	30	1																						
157	11.6	42.61422864	-71.70495808									5	2	5	1																						
158	11.5	42.61427675	-71.7039629											5	1																						
159	4.7	42.61436166	-71.70315354	5	1							5	1																								
160	4.9	42.61429452	-71.70101599	60	3	5	2																							5	4						
161	3.9	42.61424071	-71.71272039	50	2	30	2																	5	3			20	1	5	4						
162	4.3	42.61500749	-71.71186083	30	2	20	3					20	2	10	1	5	2													5	4						
163	6	42.61502107	-71.71085735	10	2	40	2					10	2											10	3							30	1				
164	6.6	42.61498033	-71.70984532	20	2	60	2					10	2	5	1																	20	1				
165	9	42.61500849	-71.70587397	20	1	20	2					10	3	20	1									10	3												
166	10.1	42.61496407	-71.70492682									10	1	5	1																						
167	11	42.61500087	-71.7040292											5	1																						
168	5.1	42.61501201	-71.70302019	5	1	20	2					5	1																								
169	5	42.61570419	-71.71089758	10	1	60	3	5	2			10	2											10	3			5	1								
170	6.2	42.61564552	-71.70791304	10	2	20	3					10	2	10	1									10	3												
171	4.7	42.61569589	-71.70987918	70	2	20	2																					10	1								
172	7.4	42.61563571	-71.70694266	20	1	40	3					10	2											10	3												
173	7.8	42.61574023	-71.70601672	10	2	40	3					10	2											10	2												
174	8.4	42.61568433	-71.70492162	10	2	20	3					20	2											10	3												
175	8.1	42.61569254	-71.70395879	10	2	40	2					10	2											5	2												
176	4.2	42.61570243	-71.71187005	70	2	30	2			20	4					5	2																				
177	4	42.61639721	-71.71083773	20	2	30	3	5	2			30	2											10	2			10	2								

Point	Depth	LAT	LONG_	U	Ubio	V	Vbio	Pe	PeBio	B	Bbio	PR	PrBio	Ni	NiBio	Pp	PpBio	Eo	EoBio	Mw	MwBio	Pn	PnBio	Pa	PaBio	Pb	PbBio	Nj	NjBio	Ny	NyBio	Fa	FaBio	Sg	SgBio	Cd	CdBio
178	4.4	42.61635714	-71.70986602	50	3	50	3					10	2																			5	1				
179	5.2	42.61641422	-71.70893286	80	2	10	2					10	2																	5	4						
180	4.5	42.61639243	-71.70790097	20	2	20	3					10	1																								
181	5.6	42.61639536	-71.70692766	20	1	30	2					20	1																								
182	8.8	42.61639721	-71.70585763			20	2					20	2											20	3												
183	9	42.6164164	-71.70490318									20	2											10	3												
184	6.2	42.61642805	-71.70405661	10	2	60	2					20	2											5	2												
185	3.4	42.6164211	-71.7117372	30	2	30	2	10	2			20	2			5	2							10	2			5	2	40	4			10	4		
186	5	42.61647617	-71.69996532									5	1	20	1	10	1																				
187	5	42.6164304	-71.69912486									10	2	20	1																						
188	1.8	42.61724185	-71.71278385																																		
189	2	42.61720179	-71.71170426	90	4	20	3	5	3	5	4																			5	4						
190	2	42.61716583	-71.71084838	30	1	30	2	10	3	10	4																			20	4			5	4		
191	3.4	42.61709056	-71.70984222	40	2	20	3	10	3			10	2			5	1							5	3			5	1	5	4			10	4		
192	3.6	42.6170971	-71.70892063	50	2	20	2																					5	2					20	4		
194	3	42.61705996	-71.69905596	5	1					5	4	30	1			10	1																				
195	4	42.6178026	-71.71372077																																		
196	1	42.61814995	-71.71287663																																		
197	3	42.6178601	-71.71186628																																		
198	3.6	42.61710875	-71.70497384	10	1	40	2	10	2			20	2																								
199	3.7	42.61720489	-71.70422458			10	2	5	3			5	2					20	1																		
200	3.1	42.61426644	-71.71370485	10	1	30	3	5	3					10	1									20	3			10	1								
201	10.9	42.61064311	-71.71075081									10	1	60	1																						
202	4	42.61710045	-71.69999097					20	4			50	2			5	1																				
203	3.1	42.61500891	-71.70093385	20	3					30	4	5	3									5	4							10	4						
204	5.2	42.61209411	-71.70192031	20	2	20	2			10	4											10	4							20	4						
205	6.3	42.61134719	-71.69907549	20	2	10	2	20	4																			20	2								
206	4.7	42.61004364	-71.69878732	30	3	20	3																	20	3					20	4						
316	4	42.61604835	-71.70069605																																		
318	7	42.61675939	-71.69936366																																		

Attachment C – Lab Reports

61 Louisa Viens Drive
Dayville, CT 06241
Fax: 860-774-2689
Phone: 860-774-6814
Toll-Free: 800-334-0103

ANALYTICAL DATA REPORT

prepared for:

Aquatic Control Technology
11 John Road
Sutton, MA 01590
Marc Bellaud

Report Number: E409G55
Project: Hickory Hills

Received Date: 09/16/2014
Report Date: 10/27/2014

Premier Laboratory, Inc
Authorized Signature

CT DPH #PH-0465 | EPA #CT00008 | MA DEP #M-CT008 | ME DHHS #CT0050 | NH ELAP #2020
NJ DEP #CT007 | NY ELAP #11549 | PA DEP #68-04413 | RI DOH #LAO00300 | VT DOH #VT11549

101-000000434949

PREMIER LABORATORY
A MICROBAC LABORATORY

61 Louisa Viens Drive
Dayville, CT 06241
Fax: 860-774-2689
Phone: 860-774-6814
Toll-Free: 800-334-0103

Report No: E409G55
Client: Aquatic Controls Technology
Project: Hickory Hills

CASE NARRATIVE / METHOD CONFORMANCE SUMMARY

This report is incomplete unless all pages indicated in the pagination at the bottom of the page are included, along with a copy of the chain of custody and any subcontracted analyses reports, if applicable, for the sample(s) in this report. Subcontractor results are identified by 'SUB' next to the analysis.

Premier Laboratory received three samples from Aquatic Controls Technology on 09/16/2014. The samples were analyzed for the following list of analyses in accordance with MA DEP regulations unless otherwise indicated:

Alkalinity, Total by SM2320B in DW/WW
  SM2320B
Apparent and True Color
  SM2120B
E. coli by EPA Modified 1603 mTEC
  1603[1603]
Nitrate as N by SM4500-NO3 F in DW/WW
  SM4500-NO3-F
Specific Conductance by SM2510B in DW/WW
  SM2510B
pH by SM 4500-H+B
  SM 4500-H+B

Ammonia as N by 350.1 in WW
  350.1[350.2]
Dissolved Phosphorus, Total as P by 365.1
  365.1[365.1]
Kjeldahl Nitrogen (TKN) by 351.1 in WW
  350.1[351.1]
Phosphorus, Total as P by 365.1 in DW/WW
  365.1[365.1]
Turbidity by SM2130B in DW
  SM2130B

Non-Conformances:

Work Order:

None

Sample:

None

Analysis:

None

101-000000434949

Premier Laboratory
Analytical Data Report

Report No: E409G55
Date Received: 09/16/2014 17:17

Customer: Aquatic Controls Technology
Project: Hickory Hills

Parameter	Result	DL	Units	Completed	By	Dilution
(1) Hickory Hills Mulpus Brook Cove						
Date Collected: 09/16/2014 14:00	**Matrix: Aqueous**					
Phosphorus as P by 365.1, Dissolved	0.0070	0.0050	mg/L	09/18/2014 15:10	JJT	
Color by SM2120B	10		Color Units	09/16/2014 21:15	HEB	
True Color	10		Color Units	09/16/2014 21:15	HEB	
Alkalinity by SM2320B	8.8	1.0	mg/L	09/22/2014 16:23	HEB	
Ammonia as N by 350.1	0.098	0.050	mg/L	09/18/2014 14:49	JJT	
Kjeldahl Nitrogen, Total (TKN) by 351.1	ND	0.50	mg/L	09/19/2014 10:38	JJT	
Nitrate as N by SM4500-NO3 F	ND	0.050	mg/L	09/16/2014 18:46	KWA	
Phosphorus as P by 365.1	0.0090	0.0050	mg/L	09/18/2014 15:11	JJT	
Specific Conductance by SM2510B	170	1.0	Micromhos/cm	09/19/2014 21:58	AM	
Turbidity by SM2130B	0.50	0.10	NTU	09/16/2014 21:00	HEB	
pH by SM 4500-H+B	6.8		pH Units	09/16/2014 21:00	HEB	
E. coli by EPA Modified 1603 (mTEC)	<10		col/100ml	09/16/2014 18:06	AM	10
(2) Hickory Hills Main Lake						
Date Collected: 09/16/2014 14:00	**Matrix: Aqueous**					
Phosphorus as P by 365.1, Dissolved	0.0070	0.0050	mg/L	09/18/2014 15:11	JJT	
Color by SM2120B	10		Color Units	09/16/2014 21:15	HEB	
True Color	10		Color Units	09/16/2014 21:15	HEB	
Alkalinity by SM2320B	10	1.0	mg/L	09/22/2014 16:23	HEB	
Ammonia as N by 350.1	0.10	0.050	mg/L	09/18/2014 14:23	JJT	
Kjeldahl Nitrogen, Total (TKN) by 351.1	ND	0.50	mg/L	09/19/2014 10:39	JJT	
Nitrate as N by SM4500-NO3 F	ND	0.050	mg/L	09/16/2014 18:47	KWA	
Phosphorus as P by 365.1	0.012	0.0050	mg/L	09/18/2014 15:12	JJT	
Specific Conductance by SM2510B	170	1.0	Micromhos/cm	09/19/2014 21:58	AM	
Turbidity by SM2130B	0.64	0.10	NTU	09/16/2014 21:00	HEB	
pH by SM 4500-H+B	6.8		pH Units	09/16/2014 21:00	HEB	
E. coli by EPA Modified 1603 (mTEC)	<10		col/100ml	09/16/2014 18:06	AM	10
(3) Hickory Hills Little Hickory						
Date Collected: 09/16/2014 14:00	**Matrix: Aqueous**					
Phosphorus as P by 365.1, Dissolved	0.0090	0.0050	mg/L	09/18/2014 15:13	JJT	
Color by SM2120B	10		Color Units	09/16/2014 21:15	HEB	
True Color	10		Color Units	09/16/2014 21:15	HEB	
Alkalinity by SM2320B	12	1.0	mg/L	09/22/2014 16:23	HEB	
Ammonia as N by 350.1	0.14	0.050	mg/L	09/19/2014 14:34	JJT	
Kjeldahl Nitrogen, Total (TKN) by 351.1	ND	0.50	mg/L	09/19/2014 10:40	JJT	
Nitrate as N by SM4500-NO3 F	ND	0.050	mg/L	09/16/2014 19:00	KWA	
Phosphorus as P by 365.1	0.013	0.0050	mg/L	09/18/2014 15:15	JJT	
Specific Conductance by SM2510B	320	1.0	Micromhos/cm	09/19/2014 21:58	AM	
Turbidity by SM2130B	0.66	0.10	NTU	09/16/2014 21:00	HEB	
pH by SM 4500-H+B	6.8		pH Units	09/16/2014 21:00	HEB	
E. coli by EPA Modified 1603 (mTEC)	<10		col/100ml	09/16/2014 18:06	AM	10

AQUATIC CONTROL TECHNOLOGY

E409G55
34

Microbac Laboratories Inc., 100 Barber Ave, Worcester, MA 01606 Phone: 508-595-0010 Fax: 508-595-0008

PARAMETERS REQUESTED	Hickory Hills Lake: Mulpus Brook Cove	Main Lake	Little Hickory		
TIME SAMPLE TAKEN	2PM	2PM	2PM		
PH	•	•	•		
TOTAL ALKALINITY	•	•	•		
SUSPENDED SOLIDS					
DISSOLVED SOLIDS					
TURBIDITY	•	•	•		
CONDUCTIVITY	•	•	•		
CHLORIDE					
KJELDAHL NITROGEN	•	•	•		
AMMONIA NITROGEN	•	•	•		
NITRATE NITROGEN	•	•	•		
TOTAL PHOSPHORUS	•	•	•		
TOTAL DISSOLVED PHOSPHORUS	•	•	•		
TRUE COLOR	•	•	•		
APPARENT COLOR	•	•	•		
TOTAL COLIFORM BACTERIA				Preserved Upon Receipt at Lab	
FECAL COLIFORM BACTERIA				Initials MN	
E.COLI BACTERIA	•	•	•	Date 9/16/14 1750	
CHLOROPHYLL - A	•	•	•		

A.C.T. JOB#

TITLE: Hickory Hills Lake.

TASK: Survey Sampling

DATE SAMPLED: 9/16/14

SAMPLED BY: D. Meringolo

MICROBAC LAB: [signature] 9/16/14 1515

REC'D BY: ~~[signature] 9/16/14 1550~~

REC'D DATE & TIME:

Jon Tiew 9/16/14 1550 17.1°C

Jon Tiew 9/16/14 1717 3.0°C

[signature] 9/16/14 1717

NOTE: Aquatic Control requires the following minimum detection limits for all samples: Nitrate(<0.1 mg/l): Ammonia (<0.1 mg/l): Total and Dissolved Phosphorus (<0.01 mg/l) and Alkalinity (<5 mg/l). Total and dissolved phosphorus detection limits of <0.001 mg/l are only to be performed upon Aquatic Control's request and at an additional charge.

Attachment D – Zooplankton Report

TAXON	Hickory 9/16/14 (#/L)	Hickory 9/16/14 (UG/L)
PROTOZOA		
Ciliophora	0.0	0.0
Mastigophora	0.0	0.0
Sarcodina	0.0	0.0
ROTIFERA		
Conochilus	0.5	0.0
Keratella	3.1	0.3
Polyarthra	0.3	0.0
Ptygura	0.3	0.0
COPEPODA		
Copepoda-Cyclopoida		
Cyclops	1.0	2.5
Copepoda-Calanoida		
Diaptomus	3.6	1.7
Other Copepoda-Nauplii	6.8	17.9
CLADOCERA		
Bosmina	0.5	0.5
Daphnia pulex	0.3	1.5
Diaphanosoma	0.5	0.5
SUMMARY STATISTICS		
DENSITY		
PROTOZOA	0.0	0.0
ROTIFERA	4.2	0.3
COPEPODA	11.4	22.2
CLADOCERA	1.3	2.5
OTHER ZOOPLANKTON	0.0	0.0
TOTAL ZOOPLANKTON	16.9	25.1
TAXONOMIC RICHNESS		
PROTOZOA	0	
ROTIFERA	4	
COPEPODA	3	
CLADOCERA	3	
OTHER ZOOPLANKTON	0	
TOTAL ZOOPLANKTON	10	
S-W DIVERSITY INDEX	0.74	
EVENNESS INDEX	0.74	
MEAN LENGTH (mm): ALL FORMS	0.39	
MEAN LENGTH: CRUSTACEANS	0.48	