The Croton River: Black Rock Park

2016 Delineation of Hydrilla and other Submersed Aquatic Vegetation (SAV) in the Croton River: Black Rock Park

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2016 *Delineation of Hydrilla and other Submersed Aquatic Vegetation (SAV) in the Croton River: Black Rock Park* Report

Croton River: Black Rock Park
Village of Croton-on-Hudson, Westchester County, New York

Introduction

In late October 2013, a New York Botanical Garden Project survey team discovered hydrilla (*Hydrilla verticillata*) in the Croton River System while conducting a rare species inventory. Hydrilla is a highly invasive submersed aquatic plant that can result in significant negative ecological, recreational and economical impacts. Hydrilla is a relatively new invader to New York, with known populations on Long Island (eight sites), in a small pond in Orange County, a small pond in Rochester, and several small private ponds in Broome County. Extensive infestations have been documented in the Cayuga Lake Inlet (Tompkins County) and the Erie Canal/Towanda Creek (Towanda, Erie and Niagara Counties). A continuing step in the development of a Management Action Plan for this infestation is the delineation of hydrilla in the river, along with the other submersed aquatic vegetation (SAV). The results of this survey can be directly compared to data collected during previous surveys, such as the aquatic plant mapping in 2014 and the tuber monitoring in 2015.

SOLitude Lake Management is a partner of the Lower Hudson Partnership for Regional Invasive Species Management (LH PRISM), and received funding for this survey by the LH PRISM, following the submittal of a detailed scope of work. Due to a funding cap, only the Black Rock Park section of the Croton River was surveyed for this project. In addition to the delineation of the hydrilla and SAV, the scope of work included hydrilla tuber monitoring.

Additional sites in the Croton River were also surveyed by SOLitude Lake Management in 2016 as part of a NYSDEC directed herbicide application in the river. For a variety of reasons this herbicide application did not occur in 2016. However, we still conducted Pre-treatment (July) and post-treatment (October) surveys, along with tuber monitoring in the river proper. The data collected during this survey will be provided to the NYSDEC to enhance the long term management efforts of hydrilla in the Croton River.

Procedures

Point Intercept Aquatic Plant Surveys

The Point Intercept Method (PIM) of sampling aquatic macrophytes is generally accepted by lake managers as a suitable procedure to map submersed aquatic macrophytes in a lake. The PIM is designed to be utilized by volunteer and citizen science groups, and is the method preferred by the NYSDEC. Prior to conducting the initial hydrilla delineation 2014, the *2013 Monitoring Report of the Cayuga Inlet and Southern Cayuga Lake Monoecious Hydrilla Eradication Project* (Johnson, 2014) was reviewed to develop similar surveying protocols for this project. In 2016, we used similar survey protocols, but we increased our effort from 29 GPS-referenced sites in 2014 to 93 GPS-referenced sites in 2016.

The total number of sample locations is typically based on the total acreage of the lake. As a rule of thumb, one sample location per acre (minimum 50 sample locations) is surveyed at a given site. A 50 meter by 50 meter grid is considered standard and was overlaid to establish sampling locations (Johnson, 2014). For the 2014 survey at Black Rock Park, we utilized a 40 meter by 40 meter grid to increase the number of sampling points to 29. This year, we further decreased our grid size to 20 meters by 20 meters, which gave us 93 sites to sample. This additional effort was conducted due to the increased abundance and distribution of hydrilla at this location. Table 1 below is a summary of the sampling areas, including code, description, date surveyed, the number of GPS-referenced sampling locations (if applicable), and notes.

Table 1 2016 Sample Site Summary

Section	Description	Date	# Sites	Notes
A	Black Rock Park SAV	10/4/16	93	2014: 29 sites were surveyed
A	Black Rock Park Tuber	10/25/16	6	2015: 2 sites were surveyed

Before the survey began, sample locations were plotted on a grid overlay map of the target locations focusing on the littoral areas. Since there is no boat launch in the area, a canoe was carried in at the park (following permission from the Village of Croton-on-Hudson) to access the site. At GPS-referenced sites, using the overlay grid loaded onto the GPS unit, the canoe was paddled to the first sample location. On arrival, the GPS coordinates of the sample location was recorded using a Trimble GeoXH 2008 series handheld GPS unit with sub-meter accuracy. The water depth was also measured, using a handheld depth gun (HawkEye digital sonar system, or equivalent), or a calibrated metal pole, as appropriate to the conditions. The water depth was recorded on a field log. Any other pertinent field notes (such as floating fragments of hydrilla or established beds not sampled) regarding the sample location were also recorded on a field log.

Next, a weed rake attached to a 10 meter-long piece of rope is tossed from a random side of the boat. It is important to toss the weed rake the full 10 meters (a loop at the end of the rope is attached to the boat to prevent losing the anchor). The weed rake is slowly retrieved along the bottom, and carefully hoisted into the boat. To determine the overall submersed vegetation amount, the weed mass is assigned one of five densities, based on semi-quantitative metrics developed by Cornell University (Lord, et al, 2005). These densities are: **No Plants** (empty anchor), **Trace** (one or two stems per weed rake, or the amount that can be held between two fingers), **Sparse** (three to 10 stems, but lightly covering the weed rake, or about a handful), **Medium** (more than 10 stems, and covering all the tines of the wed rake), or **Dense** (entire weed rake full of stems, and one has trouble getting the mass into the boat). See the Appendix of this report for pictures of these representative densities. These densities are abbreviated in the field notes as 0, T, S, M, and D. Next, the submersed weed mass is sorted by genus (or species if possible) and one of the five densities (as described above) is assigned to each genus and/or species. This procedure is then repeated for the remaining sample points.

Following methods established at Cayuga Lake Inlet for the monitoring of hydrilla, we utilized two weed rake tosses per site. The tosses were conducted from opposite sides of the canoe and were labeled Toss A, and Toss B, respectively. The data for both of these tosses are included on Table #2, in the Appendix. Each density was assigned a numeric value: 0 for no plants, 1 for trace, 2 for sparse, 3 for medium, and 4 for dense plants. The mean of these three values for all tosses (rounded up) are also displayed on Table #2. These mean values were used to assign overall densities, as depicted on the distribution maps in the Appendix. For example, if toss A was dense density (4), and toss B was sparse density (2) for the same macrophyte, the mean density would be medium (4+2=6/2=3). Although using two tosses is ideal for detecting the presence of target species (and species occurring infrequently), these procedures and associated calculations tend to decrease the overall abundance per site. However, our primary goal was to delineate hydrilla, so two tosses per site should result in a greater frequency of occurrence for target species.

A sample of each different macrophyte is collected and placed in a bottle or Ziploc-type bag with a letter or number code (A, B, 1, 2, etc.). If possible, these samples included both submersed and floating leaves (if any), seeds, and flowers (if present), to facilitate identification. These bottles are placed in a cooler stocked with blue-ice packs or ice, and returned to Allied Biological's lab for positive identification and photographing. Regionally appropriate taxonomic keys are used to identify the aquatic macrophytes (a list of references is included in the appendix) to the lowest practical taxa, typically to species.

The weed rake used for aquatic macrophyte surveys has a specific design. It is constructed with two 13.5-inch wide metal garden rakes attached back to back with several hose clamps. The wooden handles are removed and a 10 meter-long nylon rope is attached to the rake heads.

Hydrilla Tuber Monitoring

For the tuber monitoring at the Croton River in 2016, we employed methods established by Johnson (2013). That is, we used a post hole digger with modified handles (to sample deeper water sites) for all sediment core samples. The corer removes a consistent plug of sediment with a surface area of 187 cm^2 to a depth of 20 cm. Although slightly larger than the corer utilized by Johnson (173 cm^2), we can compensate for the larger surface area while calculating our final tuber density, expressed in tubers/m^2. We planned on collecting three to five cores per site (depending on the suitability of sediments), and compositing them into a single sample. The collected sediment plugs were sieved on site.

Processing the sediment samples is conducted with a custom-designed sieve with a 0.16 inch (0.4 cm) metal mesh. The sediment and sieve is placed in the water on site and gently shaken to remove sediment particles. The remaining larger sediment and plant material is examined for tubers and turions. Any hydrilla tubers or turions are collected and placed in a Ziploc-type bag, labeled with the sample location, site number and date. Any remaining organic and inorganic material is discarded. This process is repeated until the entire composited sediment sample has been passed through the sieve. Back at the laboratory, the tubers and turions at each site are counted, photographed, and tuber density per m2 is calculated depending on the number of cores (and the surface area per core).

We are confident that three cores per site will be suitable to establish baseline tuber densities. However, we fully expect that future monitoring efforts will likely need to increase to 10 cores per site, or even 22 cores per site (as per Johnson, 2013), especially if hydrilla management occurs at this site, when we would expect to see a decline in the number of tubers recovered. The author refers the reader to refer to Nawrocki (2016) for a detailed discussion on the interpretation of tuber density results.

Macrophyte Summary

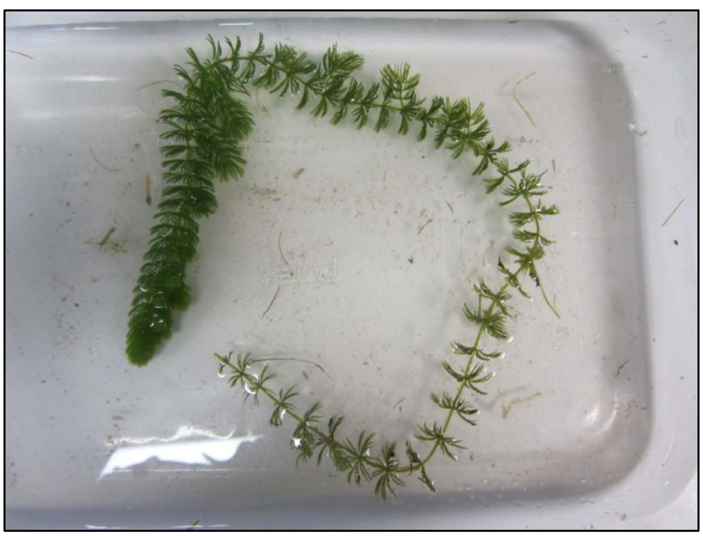
The following aquatic macrophytes were collected in the Croton River: Black Rock Park in 2016. The respective macrophyte percent abundance data are summarized in Table #1 in the Appendix, organized by overall distribution (all 93 sites). The distribution of all the aquatic macrophytes is summarized in Table #2. In addition, the distribution of each individual macrophyte is depicted on separate maps located in the Appendix of this report, organized by sample site section.

Below is a short description of each macrophyte and a picture. Sixteen submersed macrophytes (plus benthic filamentous algae) were collected during the October 2016 survey at Black Rock Park. Minimal floating macrophytes (water lilies or duckweeds) were observed on this date, which is consistent with previous data collected at this site. When possible, pictures of aquatic macrophytes represent the actual plants located at the Croton River, either taken in the field, or from samples returned to SOLitude Lake Management's laboratory. All other photos are from the archives at SLM.

Hydrilla (*Hydrilla verticillata*) Common Name: Hydrilla, waterweed. **Exotic, aggressive, Invasive.)** : Hydrilla is native to parts of Asia, and was introduced to the Northeast region in the mid-1900's. Hydrilla is the perfect weedy species, able to outcompete desirable native species due to an array of adaptations. These include growing in a variety of substrates, moving or still waters, tolerating up to 10 ppt salinity, and adept at low-light growth. It is typically rooted in the substrate, but can persist in drifting mats. Although similar to common waterweed, hydrilla has strongly serrated leaves (visible with the naked eye), and have a barbs on the underside of the midrib. The leaves are typically arranged in whorls of 4 to 8, but lower parts of the plant can be in whorls of three, or even opposite in arrangement. Hydrilla readily reproduces via stem fragmentation, and produces turions and hardy tubers to overwinter. Two distinct forms occur in the Northeast: monoecious (generally found in the north) and dioecious (generally more robust and found in southern climes.

Eurasian Water Milfoil (*Myriophyllum spicatum*. Common Names: Asian Water milfoil. **Aggressive, Exotic, Invasive**.): Eurasian water milfoil has long (2 meters or more) spaghetti-like stems that grow from submerged rhizomes. The stems often branch repeatedly at the water's surface creating a canopy that can crowd out other vegetation, and obstruct recreation and navigation. The leaves are arranged in whorls of 4 to 5, and spread out along the stem. The leaves are divided like a feather, resembling the bones on a fish spine. Eurasian water milfoil is an exotic originating in Europe and Asia, but its range now includes most of the United States. It's ability to grow in cool water and at low light conditions gives it an early season advantage over most other native submersed plants. Although it can reproduce via fruit production, it typically also reproduces via fragmentation.

Heart Pondweed (Potamogeton perfoliatus: Common Names: Redhead pondweed, heart pondweed, perfoliate pondweed. Native.): Heart pondweed is similar to other clasping-leaf pondweeds. The alternate leaves of heart pondweed tend to be shorter (ranging from 1 to 6 cm), somewhat rounded, and completely wrap around the base of the stem, the latter being a distinguishing characteristic. Leaves typically have 7-15 veins. Stipules are present, but tend to disintegrate later into the season. Floating leaves are not produced, but cylindrical flower spikes adorned with fruit are produced. Fruits have a short beak and 3 indistinct dorsal ridges. Heart pondweed prefers clear soft water, but can occur in shallow or deep water, with a preference for sandy substrates.



Coontail (*Ceratophyllum demersum*. Common Names: coontail, hornwort. Native.): Coontail has long trailing stems that lack true roots, although it can become loosely anchored to sediment by modified leaves. The leaves are stiff, and arranged in whorls of 5-12 at each node. Each leaf is forked once or twice (only), and has teeth along the margins. The whorls of leaves are spaced closer at the end of the stem, creating a raccoon tail appearance. Coontail is tolerant of low light conditions, and since it is not rooted, it can drift into different depth zones. Coontail can also tolerate cool water and can over winter as a green plant under the ice. Typically, it reproduces via fragmentation. Bushy stems of coontail provide valuable habitat for invertebrates and fish (especially during winter), and the leaves are grazed on by waterfowl.

Long-leaf Pondweed (*Potamogeton nodosus*. Common Name: Long-leaf pondweed. **Native.**): Long-leaf pondweed has stems up to two meters long that originate from a branching rhizome. Submersed leaves can be up to 30 cm long, lance-shaped, and taper to a long leaf stalk. Floating leaves also taper on long leaf stalks, which distinguish this pondweed from other similar pondweed species. Flowers and fruit are produced on a thick cylindrical spike. Fruits are somewhat oval, have a short beak, and a lumpy dorsal ridge. Long-leaf pondweed prefers flowing water versus lakes. It inhabits a variety of sediments and can tolerate eutrophic conditions and turbid water. Long-leaf pondweed fruit are grazed on by waterfowls, and portions of the plant are eaten by muskrat, beaver, deer and even moose. Long-leaf pondweed offers excellent invertebrate habitat. Researchers estimate a 20 by 60 meter standing patch can support 33 million invertebrates.

Sago Pondweed (Stuckenia *pectinata*: Common Name: Sago, Sago Pondweed. **Native.**). The stems of sago pondweed originate from fine rhizomes studded with starchy tubers. The leaves are three to 10 cm long and very thin, resembling pine needles, complete with a sharp point. The branches often are forked several times, resulting in a fan-like arrangement. Stipules are fused to the leaves creating a stipular sheath. Flowers and fruit are produced on a slender stalk that can be submersed, or float on the water. Sago pondweed is widespread, and often inhabits water one to two meters deep. It can tolerate a variety of sediment types and a wide range of water conditions. It is adapted to thrive in low-light, high turbid conditions, and is often the last surviving plant when such conditions persist for an extended amount of time. Sago pondweed is considered a top food producer for waterfowl, which graze heavily on its fruit and tubers. Juvenile fish also utilize sago pondweed as a food source and shelter.

Curly-leaf Pondweed (*Potamogeton crispus*. Common Name: curly-leaf pondweed. **Exotic, Invasive.**): Curly-leaf pondweed has spaghetti-like stems that often reach the surface by mid-June. Its submersed leaves are oblong, and attached directly to the stem in an alternate pattern. The margins of the leaves are wavy and finely serrated, hence its name. No floating leaves are produced. Curly-leaf pondweed can tolerate turbid water conditions better than most other macrophytes. In late summer, curly-leaf pondweed enters its summer dormancy stage. It naturally dies off (often creating a sudden loss of habitat and releasing nutrients into the water to fuel algae growth) and produces vegetative buds called turions. These turions germinate when the water gets cooler in the autumn and give way to a winter growth form that allows it to thrive under ice and snow cover, providing habitat for fish and invertebrates.

Common Waterweed (*Elodea Canadensis*: Common Names: elodea, common waterweed. **Native.**): Common waterweed has slender stems that can reach a meter in length, and a shallow root system. The stem is adorned with lance-like leaves that are attached directly to the stalk that tend to congregate near the stem tip. The leaves are populated by a variety of aquatic invertebrates. Male and female flowers occur on separate plants, but it can also reproduce via stem fragmentation. Since common waterweed is disease resistant, and tolerant to low-light conditions, it can reach nuisance levels, creating dense mats that can obstruct fish movement, and the operation of boat motors. There is some debate about identifying Elodea to species in New York. *Elodea canadensis* can easily be confused with *Elodea nuttallii* (slender waterweed), which also occurs throughout the state. For the purposes of this study, waterweed samples collected were assumed to be *E. canadensis*.

Benthic Filamentous Algae: Filamentous algae is a chain or series of similar algae cells arranged in an end to end manner. Benthic filamentous algae is attached to a hard substrate, such as logs, rocks, a lake bottom, or even other aquatic plants. When growing in heavy densities, benthic filamentous algae can appear as brown or green mats of vegetation that can reach the surface. When large pieces break off the bottom substrate they become floating filamentous algae patches. Benthic filamentous algae can comprise an entire range of morphologies, but flagellated taxa are far less common.

Water Stargrass (*Zosterella dubia* (=*Heteranthera dubia*): Common Name: Water stargrass. **Native.**)): Water stargrass has slender free-branched stems that originate from rhizomes. The leaves are narrow and alternate, attaching directly to the stem. Leaves can be up to 15 cm long, and lack a prominent midvein, a distinguishing characteristic. Water stargrass can inhabit a wide range of water depths and sediment types, and can tolerate reduced clarity environments. Yellow star-shaped flowers are produced by midsummer, but reproduction is usually via over wintering rhizomes. Water stargrass is a locally important waterfowl food source, and provides suitable cover and foraging for fish.

Brittle Naiad (*Najas minor*. Common Names: brittle water nymph, European naiad. **Exotic, Invasive.**): Brittle naiad is a submersed annual that flowers in August to October. It resembles other naiads, except its leaves are highly toothed with 6-15 spinules on each side of the leaf, visible without the aid of magnification. The leaves are opposite, simple, thread-like, and usually lime-green in color, often with a "brittle" feel to them. Brittle naiad fruit are narrow, slightly curved, and marked with 10-18 longitudinal ribs, resembling a ladder.

Brittle Naiad has been introduced from Europe in the early 1900's, and can be found in most of the northeastern states. Brittle naiad prefers sandy and gravel substrates, but can tolerate a wide range of bottom types. It's tolerant of turbid and eutrophic conditions. Waterfowl graze on the fruit.

Muskgrass (*Chara* sp. Common Names: muskgrass, stonewort, chara. **Native.**): Muskgrass is actually a multi-branched algae that appears as a higher plant. It is simple in structure and has rhizoids instead of true roots. The branches of muskgrass have ridges that are often encrusted with calcium carbonate. This grants the entire plant a "crusty" feel and appearance. The side branches develop in whorls that look like the spoke in a wheel. Muskgrass is easily identified by a pungent, skunky odor. It prefers softer sediments, and can often be found in deeper water than other plants. As such, it's considered an early pioneer, the first species to colonize a disturbed lakebed.

Leafy Pondweed (*Potamogeton foliosus*: Common Name: leafy pondweed. **Native**.): Leafy pondweed has freely branched stems that hold slender submersed leaves that become slightly narrow as they approach the stem. The leaf contains 3-5 veins and often tapers to a point. No floating leaves are produced. It produces early season fruits in tight clusters on short stalks in the leaf axils. These early season fruits are often the first grazed upon by waterfowl during the season. Muskrat, beaver, deer and even moose also graze on the fruit. These fruit are often required to distinguish this pondweed from several other thin-leaved pondweeds that occur in the region. It inhabits a wide range of habitats, but usually prefers shallow water. It has a high tolerance for eutrophic conditions, allowing it to even colonize secondary water treatment ponds.

Small Duckweed (*Lemna minor.* Common Names: Small duckweed, water lentil, lesser duckweed **Native**.). Small duckweed is a free floating plant, with round to oval-shaped leaf bodies typically referred to as fronds. The fronds are small (typically less than 0.5 cm in diameter), and it can occur in large densities that can create a dense mat on the water's surface. Each frond contains three faint nerves, a single root (a characteristic used to distinguish it from other duckweeds), and no stem. Although it can produce flowers, it usually reproduces via budding at a tremendous rate. Its population can double in three to five days. Since it is free floating, it drifts with the wind or water current, and is often found intermixed with other duckweeds. Since it's not attached to the sediment, it derives nutrients directly from the water, and is often associated with eutrophic conditions. It over winters by producing turions late in the season. Small duckweed is extremely nutritious and can provide up to 90% of the dietary needs for waterfowl. It's also consumed by muskrat, beaver and fish, and dense mats of duckweed can actually inhibit mosquito breeding.

Slender Naiad (*Najas flexilis*: Common Names: slender naiad, bushy pondweed. **Native**.): Slender naiad has fine-branched stems that can taper to lengths of one meter, originating from delicate rootstalks. Plant shape varies; sometimes compact and bushy, other times long and slender, depending on growing conditions. The leaves are short (1-4 cm long) and finely serrated (magnification required), tapering to a point. It is found in a variety of habitats, and can colonize sandy or gravelly substrates. If conditions are ideal, it can reach nuisance densities. It is a true annual, and dies off in the fall, relying on seed dispersal to return the next year. It is an important food source for waterfowl.

Spikerush (*Eleocharis* sp.: Common Names: hairgrass, spikerush. **Native**.): The stems of spikerush are usually slender and short (up to 12 cm long), that emerge from tufts of fine spreading rhizomes. Sometimes the stems are topped with a spikelet of a tight spiral of flowers and eventually nutlets. The nutlets widely vary in surface patterns, and this characteristic is needed for identification to species level. Spikerush prefers firmer substrates of moist shorelines or into the water up to 2 meters deep, and can tolerate turbid conditions. The leaves provide suitable food for waterfowl, and excellent habitat and shelter for aquatic invertebrates.

Ribbon-leaf Pondweed (*Potamogeton epihydrus*: Common Name: ribbon-leaf pondweed **Native**.): Ribbon-leaf pondweed has flattened stems and two types of leaves. The submersed leaves are alternate on the stem, lack a leaf stalk, and are long tape-like in shape. Each leaf, which can reach lengths up to 2 meters long, has a prominent stripe of pale green hollow cells flanking the midvein, and 5 to 13 other veins. Stipules are not fused to the leaf. Floating leaves are egg or ellipse-shaped, and supported by a leaf stalk about as long as the leaf itself. Fruiting stalks are located at the top of the stem and packed with flattened disk-shaped fruits. It is typically found growing in low alkalinity environments, and in a variety of substrates. Seeds are highly sought after by all manner of waterfowl.

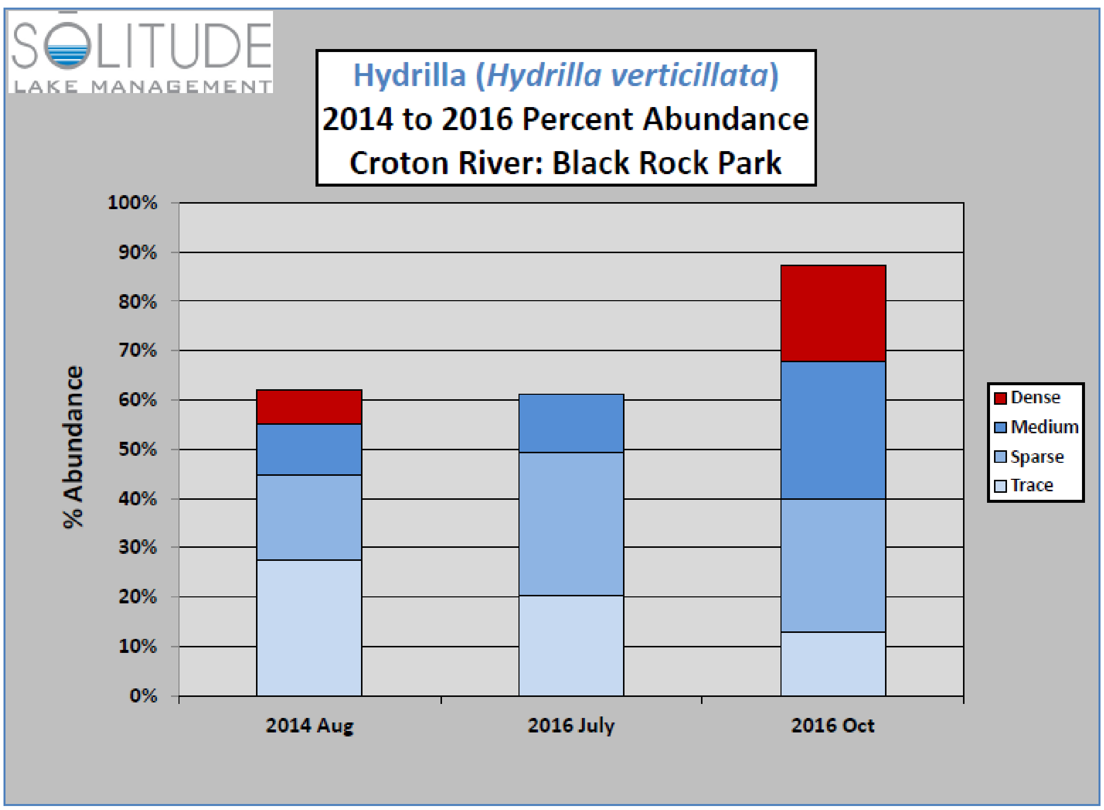
Black Rock Park Macrophyte Abundance and Distribution Discussion

In October 2016, the Black Rock Park section of the Croton River system was surveyed for the presence of submersed aquatic vegetation (SAV) and specifically for the delineation of hydrilla. For this discussion, it would be helpful for the reader to refer to the distribution tables and the individual species maps, located in the Appendix of this report. The following discussion is based on species abundance, presented in the order of most abundant to least abundant. The discussion on hydrilla is expanded due to the importance of this invasive species at this site.

At Black Rock Park, we surveyed 93 sites situated on a 20 meter by 20 meter grid. This is the same 93 sites surveyed in July 2016, and similar to the 29 sites surveyed in 2014. Submersed aquatic plants were collected at 90 (or 97%) of the sites surveyed. There was a fairly even distribution of sites between trace, sparse, medium and dense. Trace sites accounted for 18 (or

20%) of the sites in October, while sparse sites accounted for 20 (or 22%) of the sites surveyed. Medium sites accounted for 30 (or 33%) sites, while 22 (or 24%) dense sites were collected. Therefore, nuisance submersed aquatic plants totaled 52 (or 57%) sites. Overall submersed aquatic plants occurred throughout the impoundment at Black Rock Park. Many of the dense sites occurred along the west shoreline and near the concrete structure that bisects the basin.

Hydrilla was the dominant submersed aquatic plant we collected in October. It occurred at 81 (or 87%) of the sites sampled. This means that hydrilla is now outcompeting Eurasian water milfoil at this location. In 2014, and even in July of 2016, Eurasian water milfoil was the most commonly occurring aquatic plant documented at this site. In October, most of the sites were considered medium (26, or 32%) or dense (18, or 22%) abundance. Therefore, hydrilla was considered nuisance at 54% of the sites. In 2014, only 28% of the hydrilla sites were classified as medium or dense. Below is a graph that depicts the sample station percent abundance changes for hydrilla from 2014 through 2016. Trace (12, or 15%) and sparse (25, or 31%) hydrilla sites rounded out the abundance at this location. Hydrilla occurred throughout basin from the waterfall at the north to the spillway located below the park. Seven dense sites occurred along the west shoreline with another seven dense sites along the east shoreline.



Eurasian water milfoil, another invasive species, was the second most commonly occurring submersed aquatic plant at the Black Rock Park location. It occurred at 78 (or 84%) of the sites surveyed in October 2016. Most sites were considered trace (54%) or sparse (27%) abundance. However, medium (15%) and dense (4%) sites were also present. In 2014, Eurasian water milfoil had a similar distribution, occurring at 76% of the sites with an even distribution between trace, sparse and medium density. No dense sites were collected that year. Eurasian water milfoil was scattered throughout the basin. All three dense sites and several medium sites were located in the open water just north of the concrete structure.

The next two native species occurred at a much reduced abundance compared to the two invasive species discussed above. Heart pondweed (*P. perfoliatus)* occurred at 32 (or 34%) of the sites and coontail occurred at 25 (or 27%) of the sites surveyed. Both had similar abundance in July 2016, but coontail only occurred at 17% of the sites in 2014. All heart pondweed sites were considered trace and sparse density, and generally were restricted to shallow water shoreline sites. Coontail typically occurred at trace or sparse density, but one dense site was collected. In the upper part of the basin, coontail generally preferred open water sites.

Long-leaf pondweed (14, or 15%), Sago pondweed (9 sites, or 10%) curly-leaf pondweed (8 sites, or 9%) and common waterweed (6 sites, or 6%) were also observed. All of these are desirable native species save for curly-leaf pondweed. Typically, all these species occurred at trace density. It is possible that common waterweed abundance and distribution was underestimated at this location due to the prolific growth of hydrilla, as it is difficult to distinguish both of these plants in the field. Benthic filamentous algae occurred at 5 (or 5%) of the sites, and were all considered trace abundance.

The following aquatic plants occurred at five or fewer sites (with the number in parenthesis indicating the number of sites): Water stargrass (5), brittle naiad (2), muskgrass (2), leafy pondweed (1), small duckweed (1), slender naiad (1), ribbon-leaf pondweed (1), and spikerush (1). Note that the ribbon-leaf pondweed identification was confirmed with the presence of seeds. It's possible the flat-stem pondweed collected in 2014 was actually ribbon-leaf pondweed. Likewise, the pondweed sp. collected at one site in July was probably ribbon-leaf pondweed.

Table 2, below, summarizes the changes in aquatic plant abundance from the July 2016 sampling event to the October 2016 sampling event. Most aquatic plant abundances changed +/-5% which could be explained as seasonal variation. It would also be expected to see a slight increase in distribution (and abundance) from July to October based on later season growth. Notable changes include hydrilla, which increased 26%, the largest increase and becoming the dominant aquatic plant at this location. Also notably was a decrease in filamentous algae from 32% in July to 5% in October. Three desirable native plants exhibited decreases of 8% or more. These included long-leaf pondweed (30% in July to 15% in October), Wild Celery (10% in July to 0% in October), and leafy pondweed (9% in July to 1% in October). Wild celery is a native aquatic plant of concern in the Croton River system, due to recent reductions in historical growth of this plant following large storm events in 2011 and 2012. In July we collected wild celery at 9 sites, while during our October survey, we did not collect it at any sites.

Table 2 Black Rock Park % abundance Changes July to October 2016

Aquatic Plant	July 2016	October 2016	% Change
Hydrilla	61%	87%	+26%
Eurasian Water Milfoil	72%	84%	+12%
Heart Pondweed	29%	34%	+5%
Coontail	25%	27%	+2%
Wild Celery	10%	0%	-10%
Long-leaf Pondweed	30%	15%	-15%
Sago Pondweed	6%	10%	+4%
Curly-leaf Pondweed	8%	9%	+1%
Common Waterweed	5%	6%	+1%
Benthic Filamentous Algae	32%	5%	-27%
Water Stargrass	4%	5%	+1%
Brittle Naiad	2%	2%	-
Muskgrass	4%	2%	-2%
Leafy Pondweed	9%	1%	-8%
Small Duckweed	1%	1%	-
Slender Naiad	1%	1%	-
Ribbon-leaf Pondweed	0%	1%	+1%
Spikerush	0%	1%	+1%

Hydrilla Tuber Monitoring Results

Tuber collection at Black Rock Park was conducted on October 25, 2016. Six locations were selected to establish baseline tuber density for use in future monitoring efforts. A map of these GPS-referenced locations is included in the Appendix of this report. Table #3, below, is a summary of the data collected at each sampling location. The table includes the site name, description, the number of cores collected at the site, the tuber density (m^2) and the turion density (m^2).

Table 3: 2016 Black Rock Park Hydrilla Tuber Monitoring Results

Sample Location	Site	Description	# Cores	Tubers (m^2)	Turions (m^2)
Black Rock Park	BRP-1	East Shore; North	3	712.0	53.4
	BRP-2	West Shore; North	3	1904.6	0.0
	BRP-3	Concrete Structure; West Shore	3	1637.6	35.6
	BRP-4	Concrete Structure; East Shore	3	498.4	0.0
	BRP-5	East Shore; South	3	801.0	0.0
	BRP-6	West Shore; South	3	1637.6	0.0

The tuber density ranged from 498.4 tubers per m2 to 1,904.6 tubers per m2. Turion density ranged from 0.0 turions per m2 to 53.4 turions per m2. However, only two sites had turions (BRP-1 and BRP-3). The lowest tuber density was collected along the east shore by the concrete structure. The water here was deeper, and the sediment was rocky. The highest tuber density was along the west shore, north of the concrete structure. Abundant hydrilla growth occurred in this area, and during the SAV mapping hydrilla produced flowers in this area. The picture to the left depicts the tubers collected at BRP-3 on October 25th.

In 2015, North Carolina State conducted tuber monitoring at the Croton River as part of a larger Hudson River hydrilla survey. Two sites were located at Black Rock Park for this project. We selected two of our sites (BRP-3 and BRP-4) based on the sampling stations used by NC State to be able to compare the data from 2015 to 2016. Table #4, below is a summary of the 2015 and 2016 tuber densities from these two sites. As can be seen, the tuber density at site BRP-3 increased from 161.499 tubers per m^2 in 2015 to 1,637.6 tubers per m^2. This represents an increase of greater than 10 fold (+1014%). This increase is supported in the literature (Nawrocki, 2016). The tuber density at BRP-4 nearly doubled from 283.9543 tubers per m^2 in 2015 to 498.4 tubers per m2 (+176%) in 2016. The higher the tuber density in the sediment, the longer control needs to be conducted to exhaust the tuber bank. Hydrilla tubers can persist in the sediment and remain viable for a minimum of 6 years (Nawrocki, 2016) and possibly as long as 10 years. There is some anecdotal information that depleting the tuber bank in a flowing water system might not take as many years as a lake system, depending on the sediment type.

Table 4: 2015 vs. 2016 Hydrilla Tuber Density Changes

Station	2015	2016	% Change
BRP-3	161.499	1637.6	+1014%
BRP-4	283.9543	498.4	+176%

Summary of Findings

- In 2016, with funding from the LH PRISM, SOLitude Lake Management conducted GPS-referenced Point Intercept Aquatic Plant mapping at the Black Rock Park section of the Croton River to support potential treatment of hydrilla in the river proper. The study also included hydrilla tuber monitoring.

- On October 4, 2016, the vegetation mapping was conducted at the same 93 GPS-referenced points established during the July Pre-treatment survey of the entire Croton River.
- On October 25, 2016, tuber sampling was conducted at Black Rock Park at six sampling locations.
- Hydrilla was the dominant submersed aquatic plant collected during our survey. It occurred at 87% of the 93 sampling sites. 54% of these sites were considered medium or dense abundance.
- Based on the October results, hydrilla is now out-competing another exotic invasive plant, Eurasian water milfoil, at this location.
- In 2014, hydrilla occurred at 62% of the sites surveyed, although only 29 sites were surveyed. In 2014, medium and dense sites accounted for 28% of the total sites sampled.
- Fifteen different submersed aquatic plants were collected/observed during the October survey. In addition, one floating aquatic plant (small duckweed) and filamentous algae were also collected.
- Notable decreases in percent abundance includes benthic filamentous algae (-27%), long-leaf pondweed (-15%), wild celery (-10%) and leafy pondweed (-8%).
- Despite collecting wild celery at nine sites in July, we did not collect or observe wild celery at any sites in October.
- Hydrilla tuber densities ranged from 498.4 tubers per m^2 to 1,637.6 tubers per m^2.
- Comparing hydrilla tuber density from 2015 (NC State) and 2016, we observed nearly an 11 fold increase at site BRP-3, and nearly a two fold increase at site BRP-4.

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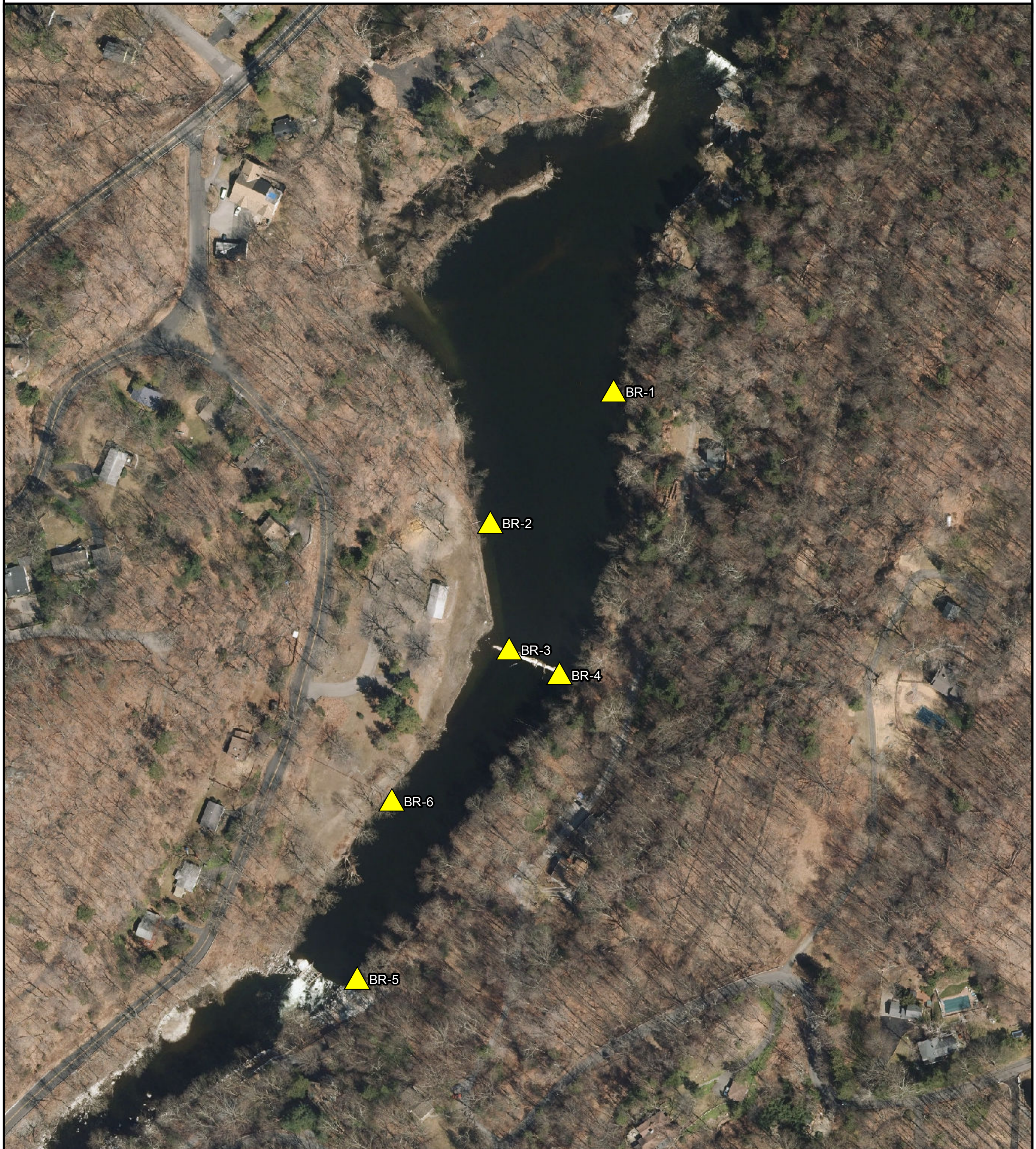
Appendix A: Location Maps and Data Tables

Appendix B: Section A Maps

BLACK ROCK PARK
Hydrilla Tuber Sampling

SŌLITUDE LAKE MANAGEMENT



Croton River
Black Rock Park
Hydrilla Tuber Sampling
October 25, 2016

Sampling Crew: E. Mayer, B. Arvidson, C. Doyle

Site	Latitude (NAD83)	Longitude (NAD83)
BR-1	41.215826°	-73.865381°
BR-2	41.215221°	-73.866141°
BR-3	41.214637°	-73.866032°
BR-4	41.214519°	-73.865724°
BR-5	41.21312°	-73.866978°
BR-6	41.213941°	-73.866758°

N

0 20 40 80 Meters

Croton River
Section A - Black Rock Rark
Aquatic Macrophyte Abundance Distribution
October 4, 2016

	Total		Trace		Sparse		Medium		Dense	
	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%
Total Sites	93									
Overall Abundance	90	97%	18	20%	20	22%	30	33%	22	24%
Hydrilla	81	87%	12	15%	25	31%	26	32%	18	22%
Eurasian Water Milfoil	78	84%	42	54%	21	27%	12	15%	3	4%
Heart Pondweed	32	34%	24	75%	8	25%	0	0%	0	0%
Coontail	25	27%	21	84%	3	12%	0	0%	1	4%
Long-leaf Pondweed	14	15%	13	93%	0	0%	1	7%	0	0%
Sago Pondweed	9	10%	9	100%	0	0%	0	0%	0	0%
Curly-leaf Pondweed	8	9%	8	100%	0	0%	0	0%	0	0%
Common Waterweed	6	6%	6	100%	0	0%	0	0%	0	0%
Benthic Filamentous Algae	5	5%	5	100%	0	0%	0	0%	0	0%
Water Stargrass	5	5%	5	100%	0	0%	0	0%	0	0%
Brittle Naiad	2	2%	2	100%	0	0%	0	0%	0	0%
Muskgrass	2	2%	2	100%	0	0%	0	0%	0	0%
Leafy Pondweed	1	1%	1	100%	0	0%	0	0%	0	0%
Small Duckweed	1	1%	1	100%	0	0%	0	0%	0	0%
Slender Naiad	1	1%	1	100%	0	0%	0	0%	0	0%
Ribbon-Leaf Pondweed	1	1%	1	100%	0	0%	0	0%	0	0%
Spikerush	1	1%	0	0%	1	100%	0	0%	0	0%

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 4, 2016

Sample Point	Sample	Water Depth (feet)	Latitude (NAD83)	Longitude (NAD83)	Overall Abundance	Benthic Filamentous Algae	Brittle Naiad	Common Waterweed	Coontail	Curly-leaf Pondweed	Eurasian Water Milfoil	Heart Pondweed	Hydrilla	Leafy Pondweed	Long-leaf Pondweed	Muskgrass	Ribbon-Leaf Pondweed	Sago Pondweed	Slender Naiad	Small Duckweed	Spikerush	Water Stargrass
1	A				T								T									
1	B				T						T											
1	M	0.50	41.21738°	-73.864935°	T						T		T									
2	A																					
2	B				T						T		T									
2	M	1.00	41.217289°	-73.864692°	T						T		T									
3	A																					
3	B																					
3	M	1.00	41.217084°	-73.864819°																		
4	A				T						T		T									
4	B				T						T											
4	M	0.50	41.217191°	-73.865042°	T						T		T									
5	A				S			T			S		S									T
5	B				T			T			T		T									
5	M	4.50	41.217011°	-73.865102°	S			T			S		S									T
6	A				T						T	T	T									
6	B				S						S		S					T				
6	M	1.00	41.21689°	-73.864875°	S						S	T	S					T				
7	A				S					T	T		S									
7	B				M						S		M									
7	M	6.00	41.21672°	-73.865022°	M					T	S		M									
8	A																					
8	B				T						T											
8	M	8.00	41.216827°	-73.865202°	T						T											
9	A				M					T	T	T	M		T							
9	B				T						T		T									
9	M	4.00	41.216909°	-73.865384°	S					T	T	T	S		T							
10	A				S					S	T	T	S		T							
10	B				S				T		T	S	T									
10	M	0.50	41.217016°	-73.865592°	S				T	T	T	S	S		T							
11	A				M				M		T	S	S		M							
11	B				D	T		T	D		S	T	T		S							
11	M	2.00	41.216945°	-73.865934°	D	T		T	D		S	S	S		M							
12	A				M						T	S	M					T				
12	B				M						M		T		T							
12	M	3.00	41.216831°	-73.86568°	M						S	T	S		T			T				
13	A																					
13	B				T								T									
13	M	15.50	41.216749°	-73.865489°	T								T									
14	A				T						T											
14	B																					
14	M	18.00	41.216658°	-73.865285°	T						T											
15	A				S					T	T		S									
15	B				T						T		T									
15	M	3.50	41.216595°	-73.865091°	S					T	T		S									
16	A				S						S		S									
16	B				S					T	T		S		T			T				
16	M	3.00	41.216451°	-73.865293°	S					T			S		T			T				
17	A																					
17	B																					

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 4, 2016

Sample Point	Sample	Water Depth (feet)	Latitude (NAD83)	Longitude (NAD83)	Overall Abundance	Benthic Filamentous Algae	Brittle Naiad	Common Waterweed	Coontail	Curly-leaf Pondweed	Eurasian Water Milfoil	Heart Pondweed	Hydrilla	Leafy Pondweed	Long-leaf Pondweed	Muskgrass	Ribbon-Leaf Pondweed	Sago Pondweed	Slender Naiad	Small Duckweed	Spikerush	Water Stargrass
17	M	8.50	41.216519°	-73.865435°																		
18	A				S						S	T	S									
18	B				M			T			M		M									
18	M	5.50	41.216601°	-73.865675°	M			T			M	T	M									
19	A				T						T		T									
19	B				T						T	T	T									
19	M	4.50	41.21672°	-73.865848°	T						T	T	T									
20	A				S						T		S									
20	B				S							T	T									
20	M	4.00	41.216624°	-73.866126°	S						T	T	S									
21	A				T						T											
21	B																					
21	M	16.50	41.216566°	-73.865929°	T						T											
22	A				M						S		M					T				
22	B				D				T		M		D	T	T		T					
22	M	2.00	41.216467°	-73.86578°	D				T		M		D	T	T		T	T				
23	A				S								S									
23	B				M								M									
23	M	5.50	41.216375°	-73.865557°	M								M									
24	A				S					T	S		T									
24	B				M						M		T		T			T				
24	M	1.50	41.216274°	-73.865325°	M					T	M		T		T			T				
25	A				S					T	S		S									
25	B				D						S		D									
25	M	4.00	41.216069°	-73.865337°	M					T	S		M									
26	A				M						S		M									
26	B				M						M		S									
26	M	9.50	41.216159°	-73.865516°	M						M		M									
27	A				S						S		T									
27	B				S						S		S									
27	M	2.00	41.216246°	-73.86573°	S						S		S									
28	A				M						M		S									
28	B				S						S		T									
28	M	5.00	41.216329°	-73.865904°	M						M		S									
29	A																					
29	B				T						T		T									
29	M	16.00	41.216415°	-73.866089°	T						T		T									
30	A				T	T			T		T	T	T									
30	B				T						T											
30	M	7.00	41.216505°	-73.866302°	T	T			T		T	T	T									
31	A				S						T		S									
31	B				S						S		S									
31	M	6.00	41.216202°	-73.866558°	S						S		S									
32	A				T						T	T	T									
32	B				T						T		T									
32	M	6.00	41.216382°	-73.866492°	T						T	T	T									
33	A				S				T		S		S									
33	B				M			T			M		S									
33	M	9.00	41.216258°	-73.866247°	M			T	T		M		S									
34	A																					

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 4, 2016

Sample Point	Sample	Water Depth (feet)	Latitude (NAD83)	Longitude (NAD83)	Overall Abundance	Benthic Filamentous Algae	Brittle Naiad	Common Waterweed	Coontail	Curly-leaf Pondweed	Eurasian Water Milfoil	Heart Pondweed	Hydrilla	Leafy Pondweed	Long-leaf Pondweed	Muskgrass	Ribbon-Leaf Pondweed	Sago Pondweed	Slender Naiad	Small Duckweed	Spikerush	Water Stargrass
34	B				T						T											
34	M	14.50	41.216145°	-73.866038°	T						T											
35	A				T			T														
35	B				T						T											
35	M	15.00	41.216028°	-73.865821°	T			T			T											
36	A				M						S		M									
36	B				M						M		S									
36	M	4.50	41.215958°	-73.865599°	M						M		M									
37	A				M						S		M									
37	B				S					T	S		S									
37	M	4.00	41.215868°	-73.865445°	M					T	S		M									
38	A				M						S	S	M									
38	B				D						S	S	D		T							
38	M	1.50	41.215655°	-73.865353°	D						S	S	D		T							
39	A				S						S		S									
39	B				M			T	M		M		S									
39	M	8.50	41.215754°	-73.865583°	M			T	S		M		S									
40	A				M				S				M									
40	B				M				S		T		M									
40	M	6.00	41.215814°	-73.865757°	M				S		T		M									
41	A				S						S		S									
41	B				S						S		T									
41	M	12.00	41.215923°	-73.865969°	S						S		S									
42	A				S				T		S											
42	B				S						S											
42	M	12.00	41.216016°	-73.866159°	S				T		S											
43	A				M						S	S	M									
43	B				M				T		T	T	M									
43	M	1.50	41.216117°	-73.866396°	M				T		S	S	M									
44	A				D							T	D			T		T				
44	B				D	T					T		D									
44	M	2.00	41.215839°	-73.866325°	D	T					T	T	D			T		T				
45	A				S								S			T						
45	B				T								T									
45	M	12.00	41.215777°	-73.866097°	S								S			T						
46	A				T								T									
46	B				S				S													
46	M	12.50	41.215686°	-73.865912°	S				T				T									
47	A				S								S									
47	B				M				T				M									
47	M	6.50	41.215618°	-73.865705°	M				T				M									
48	A				M				T		T		M									
48	B				S						T		S									T
48	M	4.50	41.215484°	-73.865456°	M				T		T		M									T
49	A				S								S		T							
49	B				M								M									
49	M	5.00	41.21522°	-73.865362°	M								M		T							
50	A				S				S													
50	B																					
50	M	12.00	41.21531°	-73.865591°	T				T													

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 4, 2016

Sample Point	Sample	Water Depth (feet)	Latitude (NAD83)	Longitude (NAD83)	Overall Abundance	Benthic Filamentous Algae	Brittle Naiad	Common Waterweed	Coontail	Curly-leaf Pondweed	Eurasian Water Milfoil	Heart Pondweed	Hydrilla	Leafy Pondweed	Long-leaf Pondweed	Muskgrass	Ribbon-Leaf Pondweed	Sago Pondweed	Slender Naiad	Small Duckweed	Spikerush	Water Stargrass
51	A																					
51	B																					
51	M	14.50	41.215409°	-73.86581°																		
52	A				T								T									
52	B				D				T		T		D									
52	M	6.50	41.215529°	-73.866015°	M				T		T		M									
53	A				D						T		D								T	
53	B				D							T	D								S	
53	M	1.50	41.215616°	-73.86621°	D						T	T	D								S	
54	A				D						T	T	D		T							
54	B				D							S	D									
54	M	2.00	41.215369°	-73.866166°	D						T	S	D		T							
55	A				D				T		D		T									
55	B				D						D		S									
55	M	4.50	41.215249°	-73.865914°	D				T		D		S									
56	A																					
56	B				T				T													
56	M	12.00	41.215169°	-73.8657°	T				T													
57	A				S						T	T	S									
57	B				M				T		S		M									T
57	M	1.00	41.215026°	-73.865491°	M				T		S	T	M									T
58	A				M						T		M									
58	B				S						S	T	S									
58	M	1.50	41.214816°	-73.865501°	M						S	T	M									
59	A				M				T		M		M									
59	B				D				T		M		D									
59	M	7.00	41.214891°	-73.86567°	D				T		M		D									
60	A				M						M		M									
60	B				D						D		M									
60	M	6.50	41.215015°	-73.865879°	D						D		M									
61	A				D						T	T	D									
61	B				D				T		T		D									
61	M	1.00	41.21509°	-73.866076°	D				T		T	T	D									
62	A				D						T		D									
62	B				D						M	T	D									
62	M	3.00	41.21492°	-73.866086°	D						S	T	D									
63	A				D				T		D		T									
63	B				M				S		M		S									
63	M	7.50	41.214807°	-73.865834°	D				S		D		S									
64	A				M						S	T	M									T
64	B				D						M		D									
64	M	4.00	41.214718°	-73.865635°	D						M	T	D									T
65	A				M						S		M									
65	B				D						S		D									
65	M	2.50	41.214546°	-73.865719°	D						S		D									
66	A				D						S		D									
66	B				D						M		D									
66	M	9.00	41.214603°	-73.865898°	D						M		D									
67	A				M						M		M									
67	B				M						S	T	M									

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 4, 2016

Sample Point	Sample	Water Depth (feet)	Latitude (NAD83)	Longitude (NAD83)	Overall Abundance	Benthic Filamentous Algae	Brittle Naiad	Common Waterweed	Coontail	Curly-leaf Pondweed	Eurasian Water Milfoil	Heart Pondweed	Hydrilla	Leafy Pondweed	Long-leaf Pondweed	Muskgrass	Ribbon-Leaf Pondweed	Sago Pondweed	Slender Naiad	Small Duckweed	Spikerush	Water Stargrass
67	M	4.50	41.214646°	-73.86602°	M						M	T	M									
68	A				S						T	T	S									
68	B				M	T					T		M		T							
68	M	2.00	41.214528°	-73.866181°	M	T					T	T	M		T							
69	A				D						S		D									
69	B				M						S		M									
69	M	2.50	41.214458°	-73.866037°	D						S		D									
70	A				M						T		M									
70	B				M						S		M									
70	M	4.50	41.214376°	-73.865809°	M						S		M									
71	A				D						T		D									
71	B				D						T		D									T
71	M	2.50	41.214202°	-73.865978°	D						T		D									T
72	A				M						T		M									
72	B				M								M									
72	M	6.50	41.214285°	-73.866178°	M						T		M									
73	A				S							T	S									
73	B				M						T	T	M									
73	M	5.00	41.214363°	-73.86631°	M						T	T	M									
74	A				M						T		M		T							
74	B				S							T	S									
74	M	7.00	41.214189°	-73.866355°	M						T	T	M		T							
75	A				M						T		M									
75	B				D				T		T		D									
75	M	4.50	41.214097°	-73.866161°	D				T		T		D									
76	A				M						T	T	M									
76	B				D							T	D									
76	M	4.00	41.213904°	-73.866279°	D						T	T	D									
77	A				M						T		M									
77	B				M						S		M									
77	M	9.00	41.213957°	-73.866417°	M						S		M									
78	A				S	T	T					T	S									
78	B				M	T					T		M									
78	M	4.50	41.214047°	-73.866613°	M	T	T				T	T	M									
79	A				D		S				T	S	D									
79	B				M						S	S	M									
79	M	4.00	41.213945°	-73.866756°	D		T				S	S	D									
80	A				T								T									
80	B				S						T		S									
80	M	7.50	41.213877°	-73.86659°	S						T		S									
81	A				M						T		M									
81	B				M						T	T	M		T			T				
81	M	1.50	41.213792°	-73.866437°	M						T	T	M		T			T				
82	A				S								S									
82	B				T				T				T					T				
82	M	2.00	41.213616°	-73.866518°	S				T				S					T				
83	A				T						T											
83	B				T								T									
83	M	7.00	41.21369°	-73.866664°	T						T		T									
84	A				S								S									

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 4, 2016

Sample Point	Sample	Water Depth (feet)	Latitude (NAD83)	Longitude (NAD83)	Overall Abundance	Benthic Filamentous Algae	Brittle Naiad	Common Waterweed	Coontail	Curly-leaf Pondweed	Eurasian Water Milfoil	Heart Pondweed	Hydrilla	Leafy Pondweed	Long-leaf Pondweed	Muskgrass	Ribbon-Leaf Pondweed	Sago Pondweed	Slender Naiad	Small Duckweed	Spikerush	Water Stargrass
84	B				S						T		S									
84	M	6.00	41.213797°	-73.86685°	S						T		S									
85	A				M								M									
85	B				S								S					T		T		
85	M	4.50	41.213671°	-73.866968°	M								M					T		T		
86	A				S				T		T		S									
86	B				S						T		S									
86	M	9.50	41.213541°	-73.866806°	S				T		T		S									
87	A				D				T			T	D		T							
87	B				M						T		M									
87	M	1.50	41.213482°	-73.866615°	D				T		T	T	D		T							
88	A				S						T	S	S						T			
88	B				T						T	S	T									
88	M	2.00	41.2133°	-73.866753°	S						T	S	S						T			
89	A				S								S									
89	B				T								T									
89	M	8.50	41.213416°	-73.866932°	S								S									
90	A				M							T	M									
90	B				D						T		D									
90	M	3.00	41.213504°	-73.867127°	D						T	T	D									
91	A				T						T		T									
91	B				T				T		T		T									
91	M	1.50	41.213346°	-73.867257°	T				T		T		T									
92	A																					
92	B				T						T											
92	M	9.00	41.213262°	-73.867064°	T						T											
93	A				T						T	T	T									
93	B				S						T	S	S									
93	M	1.50	41.213184°	-73.86689°	S						T	S	S									

Benthic Filamentous Algae Distribution

SŌLITUDE LAKE MANAGEMENT

Croton River
Section A- Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

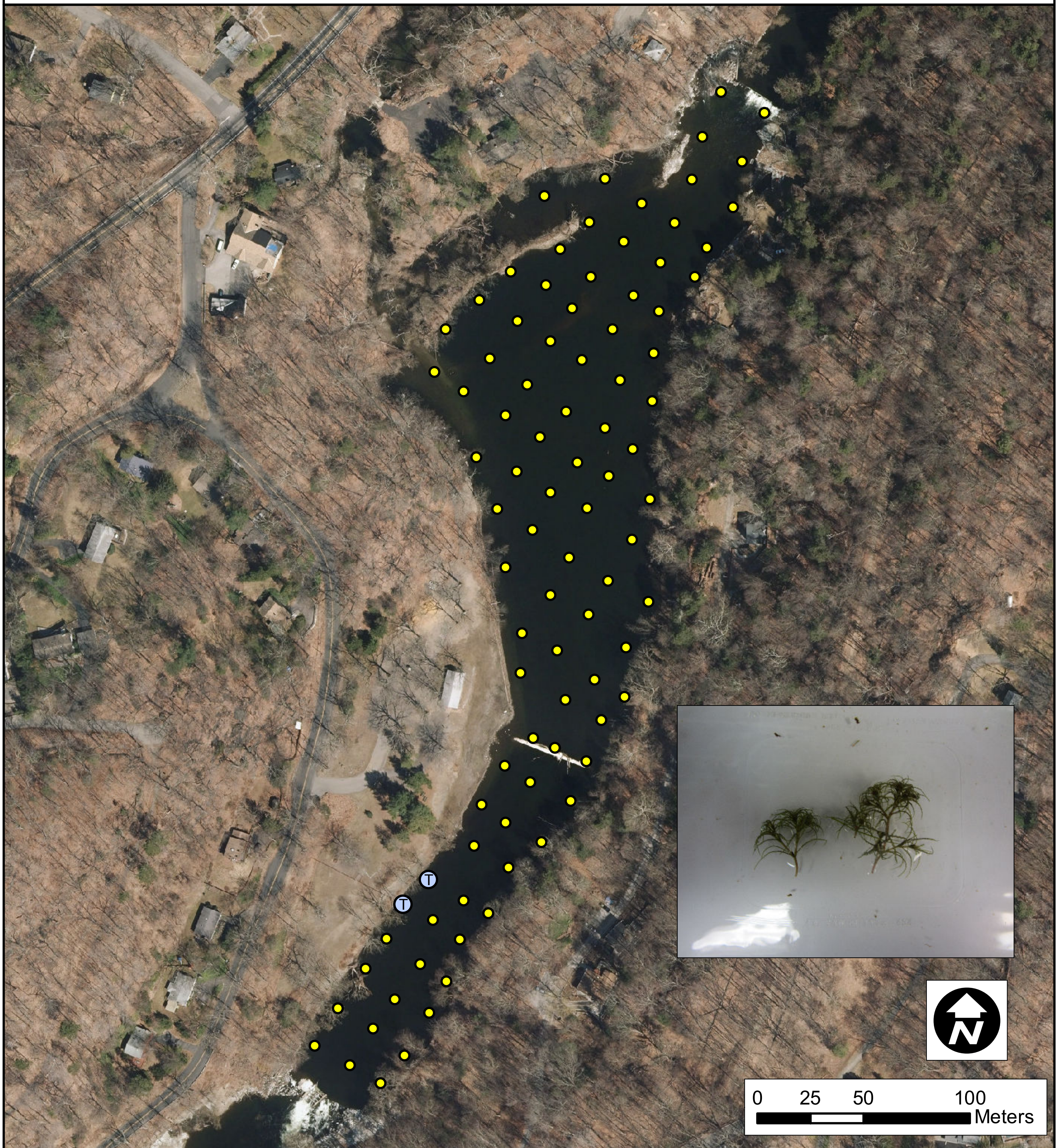
Abundance	Sites	Percent
Total	5	5%
Trace	5	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Brittle Naiad (*Najas minor*) Distribution

SOLITUDE LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	2	2%
Trace	2	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Common Waterweed (*Elodea canadensis*) Distribution

SOLITUDE LAKE MANAGEMENT

Croton River
Section A- Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

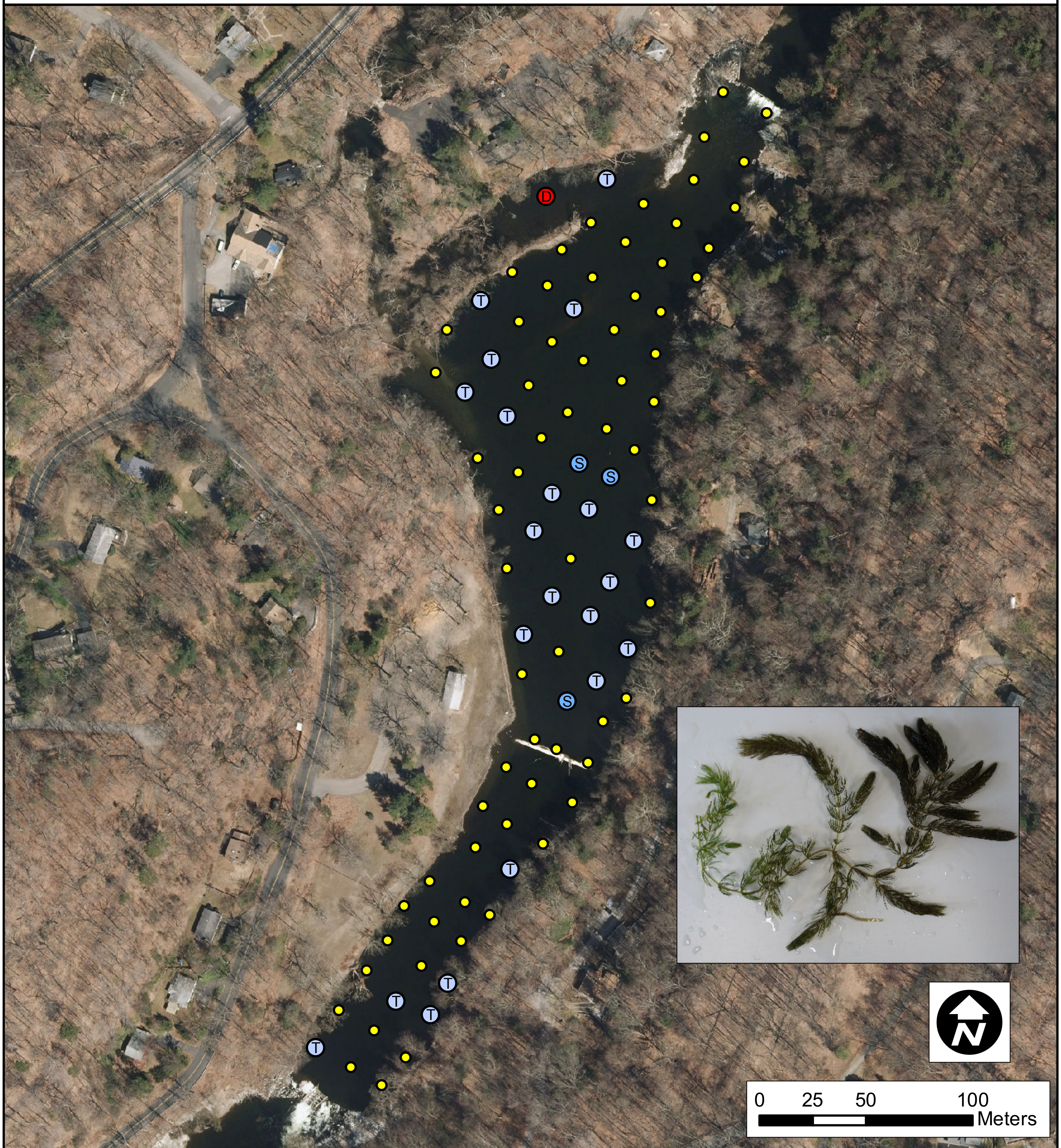
Abundance	Sites	Percent
Total	6	6%
Trace	6	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Coontail (*Ceratophyllum demersum*)
Distribution

SŌLITUDE
LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

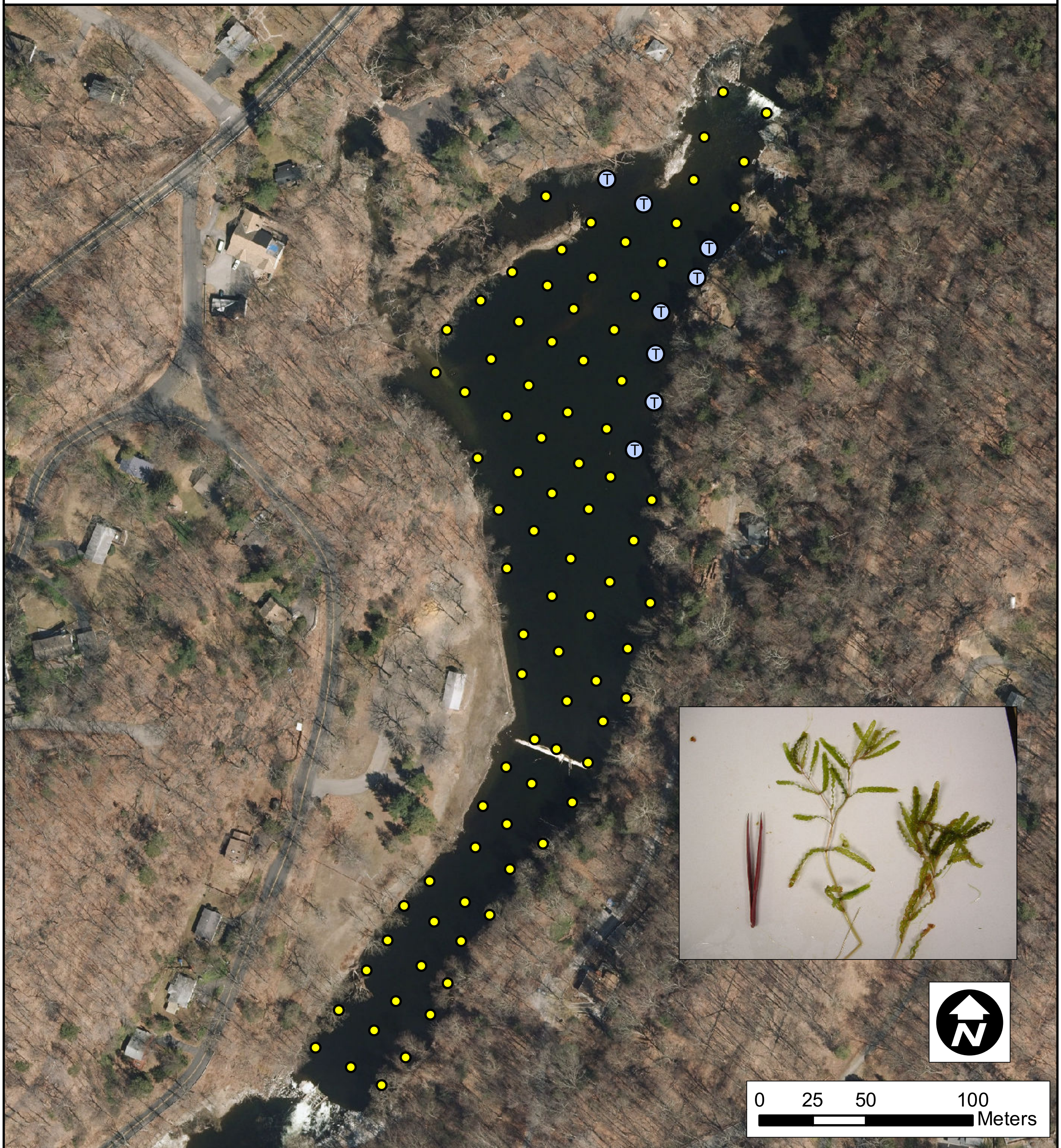
Abundance	Sites	Percent
Total	25	27%
Trace	21	84%
Sparse	3	12%
Medium	0	0%
Dense	1	4%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Curly-Leaf Pondweed (*Potamogeton crispus*) Distribution

SOLITUDE LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

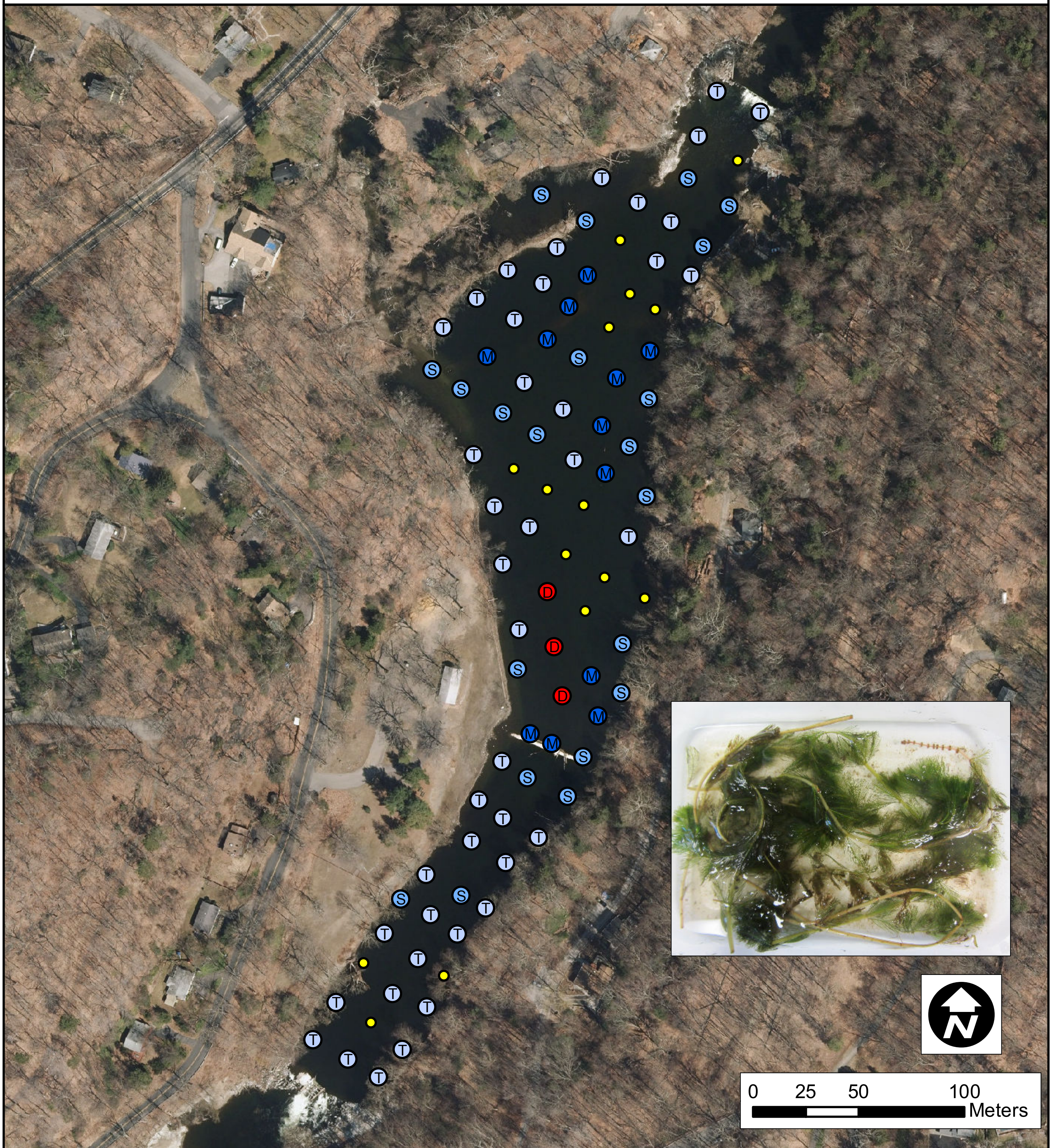
Abundance	Sites	Percent
Total	8	9%
Trace	8	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Eurasian Water Milfoil (*Myriophyllum spicatum*) Distribution

SŌLITUDE
LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	78	84%
Trace	42	54%
Sparse	21	27%
Medium	12	15%
Dense	3	4%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Heart Pondweed (*Potamogeton perfoliatus*) Distribution

SOLITUDE LAKE MANAGEMENT

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

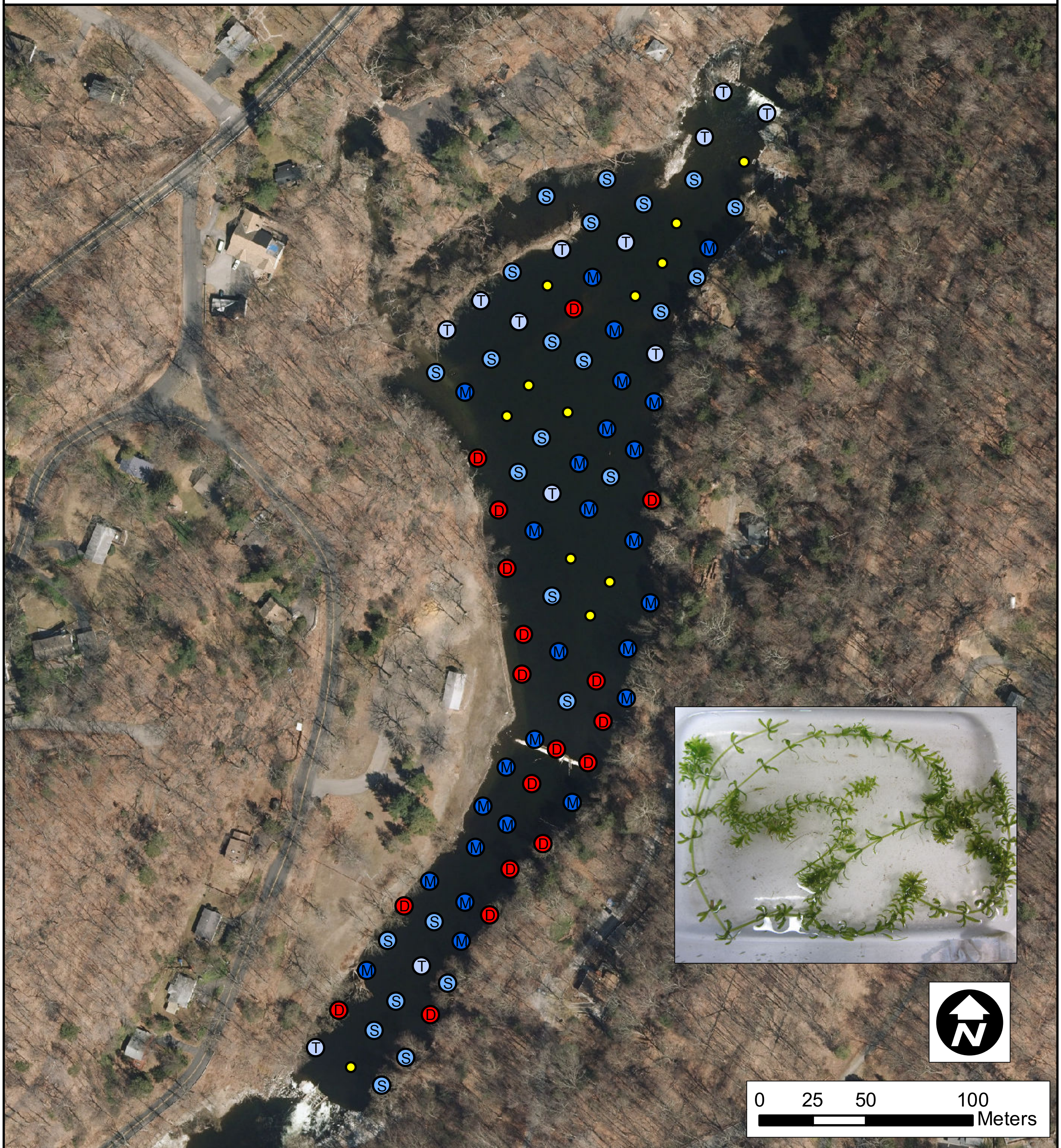
Abundance	Sites	Percent
Total	32	34%
Trace	24	75%
Sparse	8	25%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Hydrilla (*Hydrilla verticillata*) Distribution

SŌLITUDE
LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

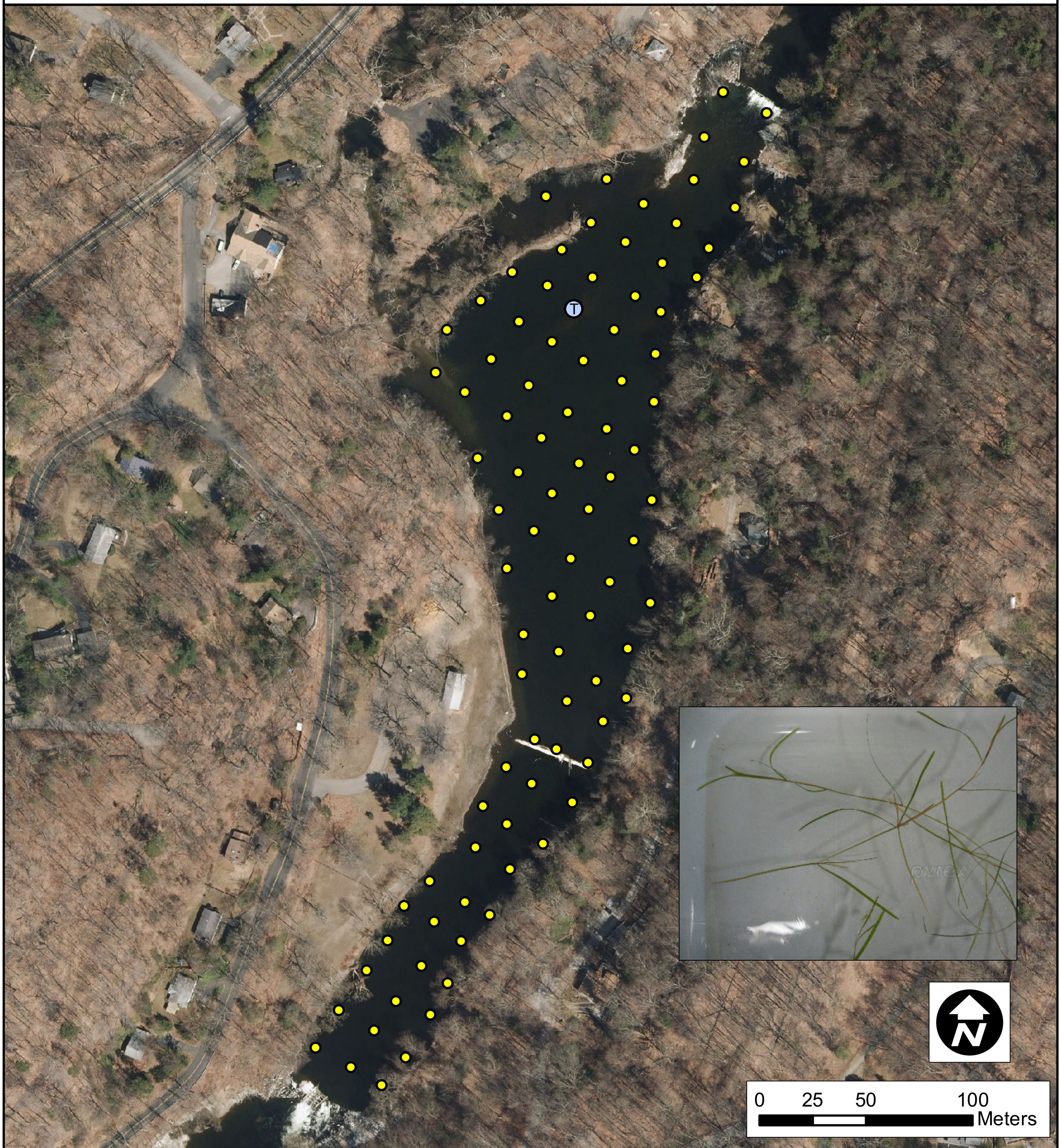
Abundance	Sites	Percent
Total	81	87%
Trace	12	15%
Sparse	25	31%
Medium	26	32%
Dense	18	22%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Leafy Pondweed (*Potamogeton foliosus*) Distribution

SŌLITUDE
LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	1	1%
Trace	1	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Long-leaf Pondweed (*Potamogeton nodosus*) Distribution

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	14	15%
Trace	13	93%
Sparse	0	0%
Medium	1	7%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Muskgrass (*Chara species*) Distribution

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Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

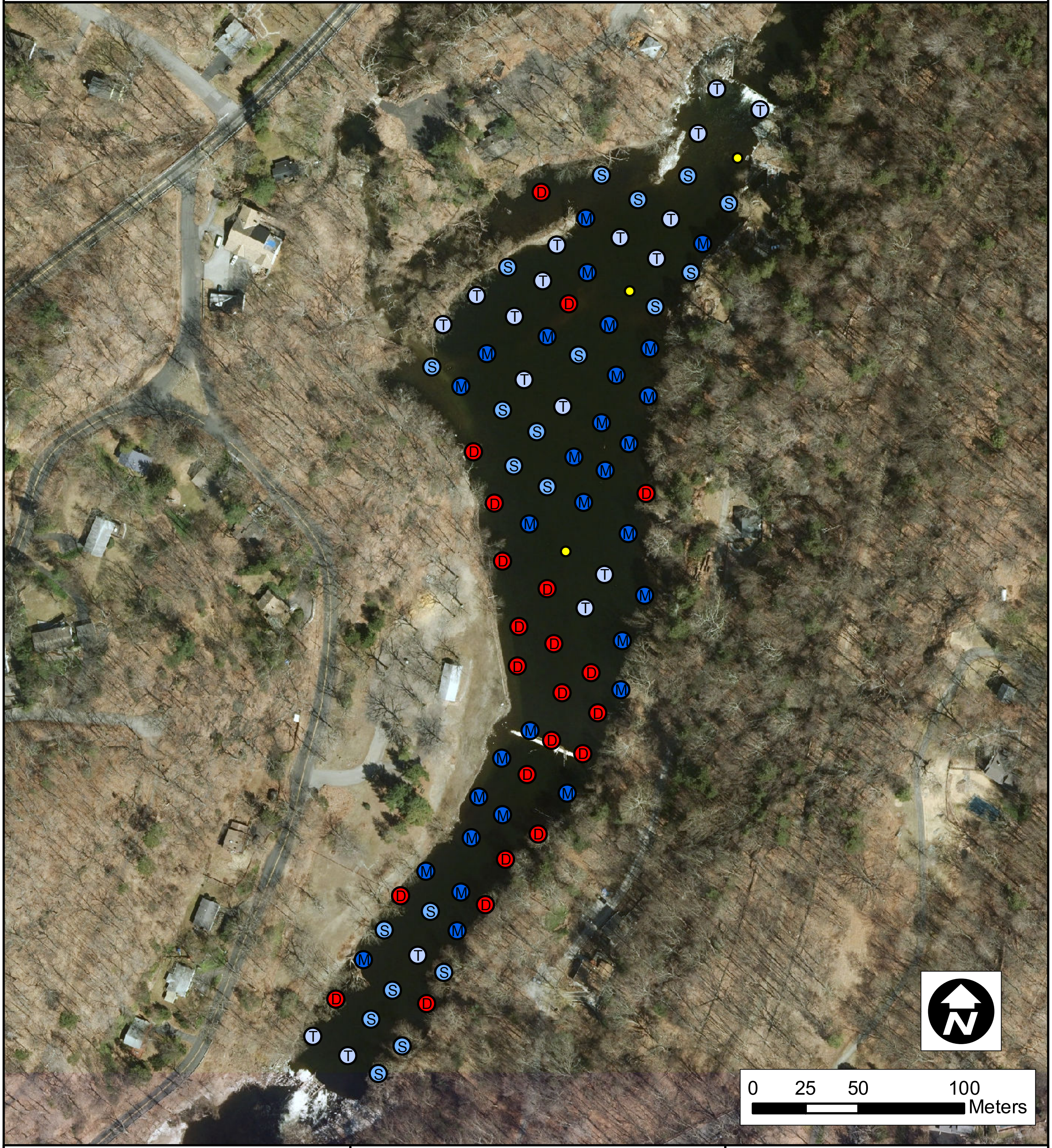
Abundance	Sites	Percent
Total	2	2%
Trace	2	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Overall Aquatic Plant Abundance

SOLITUDE LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	90	97%
Trace	18	20%
Sparse	20	22%
Medium	30	33%
Dense	22	24%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Ribbon-leaf Pondweed (*Potamogeton epihydrus*) Distribution

SOLITUDE LAKE MANAGEMENT

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	1	1%
Trace	1	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Sago Pondweed (*Stuckenia pectinata*) Distribution

SŌLITUDE LAKE MANAGEMENT

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

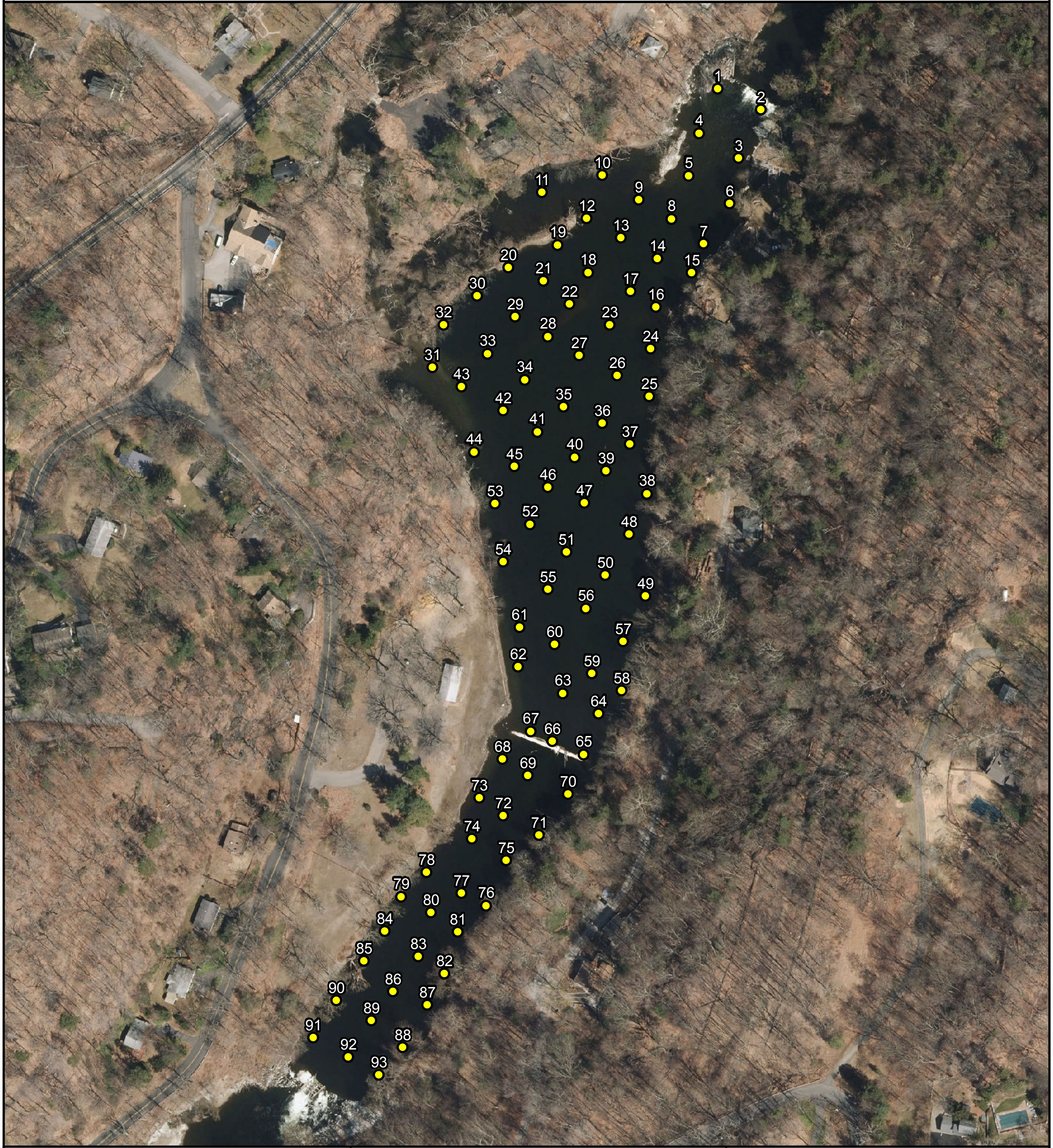
Abundance	Sites	Percent
Total	9	10%
Trace	9	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Sample Point Location

SOLITUDE LAKE MANAGEMENT



Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Sample Point

N

0 25 50 100 Meters

Slender Naiad (*Najas flexilis*) Distribution

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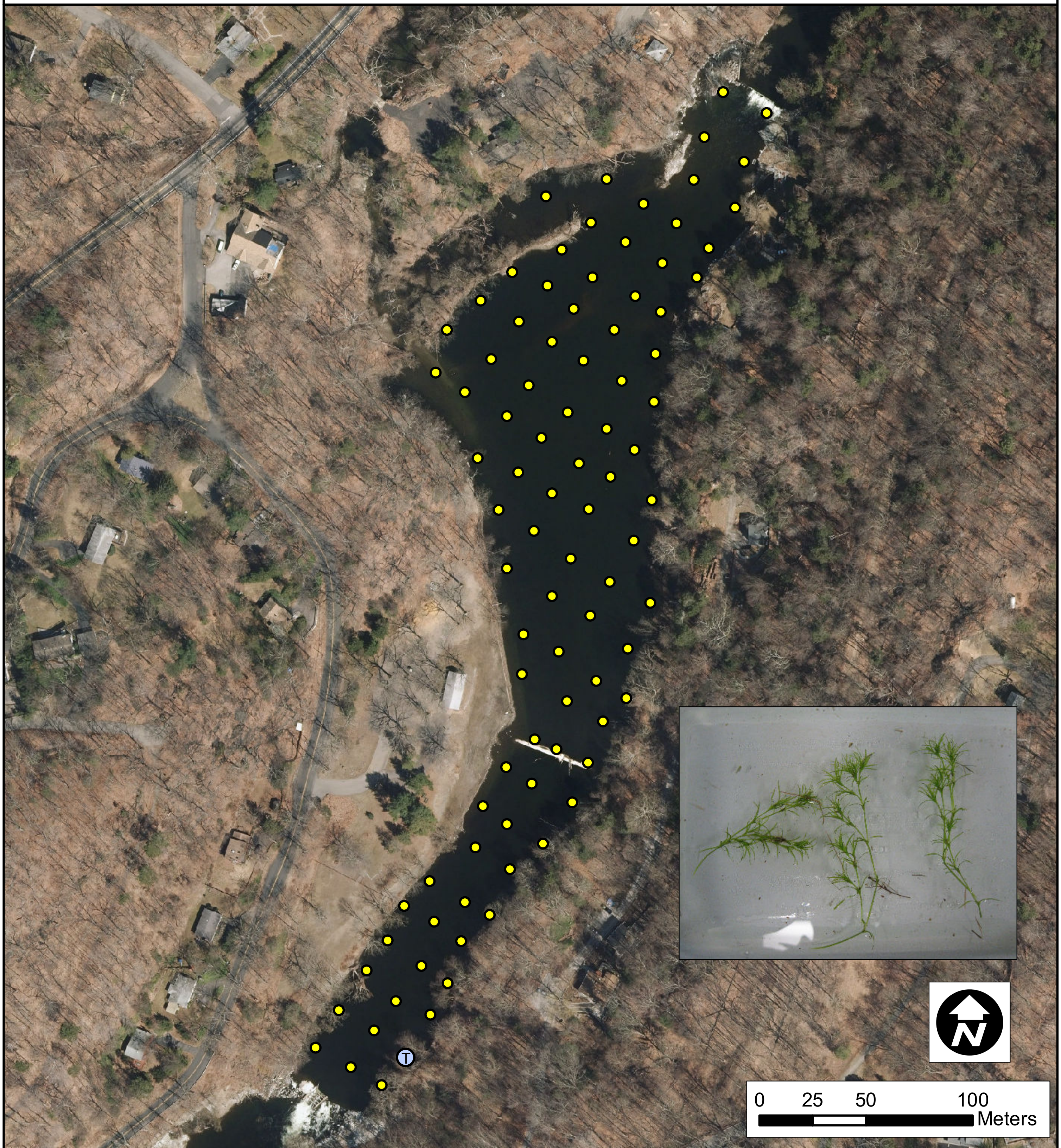

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	1	1%
Trace	1	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Small Duckweed (*Lemna minor*) Distribution

SŌLITUDE LAKE MANAGEMENT

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	1	1%
Trace	1	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Spikerush (*Eleocharis* sp.) Distribution

SŌLITUDE
LAKE MANAGEMENT

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	1	1%
Trace	0	0%
Sparse	1	100%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Water Stargrass (*Zosterella dubia*) Distribution

Croton River
Section A - Black Rock Park
Aquatic Vegetation Survey
October 04, 2016
93 Sites

Percent Distribution

Abundance	Sites	Percent
Total	5	5%
Trace	5	100%
Sparse	0	0%
Medium	0	0%
Dense	0	0%

Plant Density

- = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

Submersed Aquatic Plant Density

Trace

Medium

Sparse

Dense

Allied Biological