# AQUATIC MACROPHYTE SURVEY
# JULY 20-21, 2011
# LAKE WACCABUC
# LEWISBORO, NY

Allied Biological, Inc.
580 Rockport Road, Hackettstown, NJ 07840
ph (908) 850-0303 fax (908) 850-4994

# I. Introduction

On July 20 and 21, 2011 Allied Biological, Inc. conducted a detailed aquatic macrophyte survey utilizing the point intercept method at Lake Waccabuc (The Three Lakes) located in South Salem, New York (Westchester County). Due to the extreme heat wave, the survey was split into two days, and took approximately 11 hours of on-water time to complete. This survey is essential in order to determine the aquatic macrophytes that comprise the lake's submersed and floating macrophyte community and their relative abundance and distribution throughout the littoral zone. Lake Waccabuc is a 138 surface acre lake with a maximum depth of 44 feet. The littoral zone (defined as less than 15 feet deep) is restricted to the shoreline, the east and west ends of the lake, plus three coves. These are the North Cove (the largest), the Northeast Cove, and the South Outlet Cove. A canal connects Lake Waccabuc to Lake Oscaleta, and it too was surveyed, up to Oscaleta Road. Sediment type varies throughout the basin, but generally with softer organic-rich muck at the East end of the lake, and to an extent in the other coves to sandy sediment with medium to large rocks scattered about the remaining littoral zone.

There are several reasons for conducting this detailed point intercept survey at Lake Waccabuc in 2011. First, similar surveys were conducted at this site in 2008 and 2010. Since similar sampling procedures and sampling locations were utilized, a direct comparison of all the data sets will be possible. This is important to determine the changes in the submersed and floating macrophyte communities over time. This is especially important with regard to the invasive species that inhabit Lake Waccabuc. In 2008, Brazilian elodea was identified in the north cove during the survey. In 2009, aggressive control efforts were employed in the north cove to eradicate this invasive macrophyte, including suction harvesting and hand pulling. In 2010, Brazilian elodea was collected at one site. Unfortunately, this site was located outside of the North Cove, situated near the island. Divers were dispatched to this site following the survey. A rooted patch of Brazilian elodea (approximately six feet in diameter) was located and hand-pulled. Based on the presence of this aggressive invasive outside of the North Cove, one must assume it could have spread to other locations in the littoral zone of the main basin. Therefore, the survey was repeated to identify any additional isolated infestations of Brazilian elodea. Since the main goal of the 2011 survey was locating new infestations of Brazilian elodea, three weed anchor tosses per site were conducted, to increase the chance of discovering the target plant or any other RTE species. However, the same 120 sites that were sampled in 2010, were again sampled this year.

Table #1, below, summarizes the aquatic macrophytes collected or observed during the 2008, 2010 and 2011 surveys at Lake Waccabuc. An "X" in the column indicates the macrophyte was collected/observed in that year. A red "X" indicates an invasive species. The last column (labeled "change") indicates whether the macrophyte in question increased (+), or decreased (-) in abundance and distribution from 2010 to 2011. If plant abundance and distribution were similar both years, it is indicated by 0%.

The Appendix of this report contains bar graphs depicting the percent abundance data for each macrophyte over all three years. The overall bar represents the total frequency of the macrophytes occurrence for each respective sample year. The total bar is then divided by different colors, indicating a breakdown of the four measured densities (trace, sparse, medium and dense). If a color is not present, that macrophyte did not occur at that density. By examining these graphs, the change in macrophyte percent occurrence and abundance can be discerned between the all three sample events. Keep in mind, nuisance density macrophyte growth is typically considered medium and dense density.

**Table 1 Lake Waccabuc 2008/2010/2011 Aquatic Macrophyte Summary**

| Aquatic Macrophyte | Scientific Name | 2008 | 2010 | 2011 | Change |
|---|---|---|---|---|---|
| Arrowhead (rosette) | *Sagittaria sp.* | X | X | X | +6% |
| Bass Weed | *Potamogeton amplifolius* | X | X | X | +11% |
| Benthic filamentous Algae | | X | X | X | +52% |
| Brazilian Elodea | *Egeria densa* | X | X | | -1% |
| Brittle Naiad | *Najas minor* | | X | X | -1% |
| Common Waterweed | *Elodea canadensis* | X | X | X | +2% |
| Coontail | *Ceratophyllum demersum* | X | X | X | +7% |
| Creeping Bladderwort | *Utricularia gibba* | X | X | X | +1% |
| Curly-leaf Pondweed | *Potamogeton crispus* | X | | X | +2% |
| Dwarf Water Milfoil | *Myriophyllum tenellum* | X | X | X | -2% |
| Eurasian Water Milfoil | *Myriophyllum spicatum* | X | X | X | +18% |
| Flat-stem Pondweed | *Potamogeton zosteriformis* | X | | | |
| Floating Filamentous Algae | | X | X | X | +17% |
| Leafy Pondweed | *Potamogeton foliosus* | X | X | X | -2% |
| Ribbon-leaf Pondweed | *Potamogeton epihydrus* | | X | X | -1% |
| Robbin's Pondweed | *Potamogeton robbinsii* | X | X | X | +10% |
| Slender Naiad | *Najas flexilis* | | | X | +1% |
| Small Duckweed | *Lemna minor* | | X | | -2% |
| Spatterdock | *Nuphar variegata* | X | X | X | 0% |
| Spiral-fruited Pondweed | *Potamogeton spirillus* | X | X | X | +2% |
| Water Stargrass | *Zosterella dubia* | | X | X | +3% |
| Watershield | *Brasenia schreberi* | X | X | X | 0% |
| White Water Lily | *Nymphaea odorata* | X | X | X | +1% |

## II. Procedures

In 2011, the same sample locations were utilized as 2010. Since the goals of this survey were to locate any Brazilian elodea, additional sites were added to high risk areas (the coves and around the island) in 2010. It should also be noted that deeper water areas (total depth greater than 15 feet) are generally not surveyed due to the lack of aquatic macrophyte growth caused by poor light penetration. The sample locations are depicted on a map in the Appendix of this report.

The survey boat is piloted to the first sample location, using the 2010-logged GPS coordinates, loaded on a Trimble GeoXH 2008 series handheld GPS unit (sub-meter accuracy). The water depth was also measured, using a boat mounted depth finder, a handheld depth gun (HawkEye digital sonar system, or equivalent), or a calibrated metal pole, as appropriate to the conditions. The water depth is recorded on a field log (and confirmed with 2010 data), and is depicted on a map. Any other pertinent field notes regarding the sample location are also recorded on a field log.

Next, a weed anchor 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 anchor the full 10 meters (a loop at the end of the rope is attached to the boat to prevent losing the anchor). The weed anchor 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 anchor, or the amount that can be held between two fingers), **Sparse** (three to 10 stems, but lightly covering the anchor, or about a handful), **Medium** (more than 10 stems, and covering all the tines of the anchor), or **Dense** (entire anchor 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. Finally, overall floating macrophyte density within a 10 meter diameter of the survey boat is assigned a density, as well as an estimated density for each separate Genus (or species) observed. This data is recorded in the field notes. This procedure is then repeated for the remaining sample points.

The survey conducted at Lake Waccabuc in 2011 utilized three anchor tosses per site. The tosses were conducted from opposite sides of the boat and labeled Toss A, Toss B, and Toss C, respectively. The data for all three tosses are included on Table #2. 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 medium density (3), toss B was sparse (2), and toss C was trace density (1) for the same macrophyte, the mean density would be sparse (3+2+1=6/3=2). Although using three tosses is ideal for detecting the presence of many different aquatic macrophytes, these calculations tend to decrease the overall abundance per site. Therefore, very few sites will be classified as dense. The 2008 through 2011 percent abundance bar graphs depict this trend. However, as stated above, the primary goal of the survey was to locate patches of Brazilian elodea, even at the cost of generating a data set that might not be ideally comparable to the 2008 and 2010 data.

A sample of each different macrophyte is collected and placed in a bottle with a letter or number code (A, B, 1, 2, etc.). If possible, these samples should include 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. During the 2011 survey, representative samples of all macrophytes were collected and turned over to the 3LC for pressing and archiving. Regionally appropriate taxonomic keys (see the list in section VII) were used to identify the aquatic macrophytes.

The weed anchor 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.

## III. Macrophyte Summary

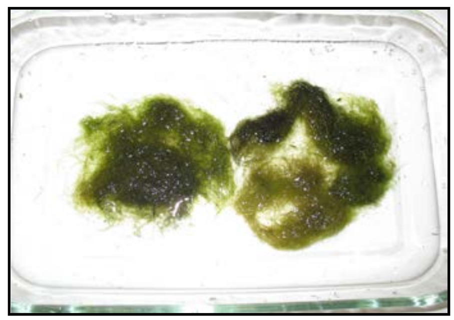
The following aquatic macrophytes were observed Lake Waccabuc during the July, 2011 aquatic macrophyte survey. A few additional macrophytes were observed during the survey (but not collected via anchor toss). These additional macrophytes are discussed in section IV. The data and maps are located in the Appendix of this report. The respective macrophyte percent abundance data are summarized on Table #1, while Table #2 summarizes the distribution data for each species collected. In addition, the distribution of each individual macrophyte is depicted on separate maps, organized according to most common occurrence to least common occurrence, and divided by submersed and floating types.

Below is a short description of each macrophyte collected or observed, and a picture. Unless otherwise noted, all pictures of macrophytes represent the actual plants collected or observed at Lake Waccabuc either taken in the field, or from samples returned to Allied Biological's laboratory. These descriptions are presented in alphabetical order.

**Arrowhead (Submersed Rosette)** (*Sagittaria* sp. Common Name: Arrowhead. **Native**.): This plant is the submersed rosette of a species of arrowhead. The submersed rosette lacks both flowers and seeds, so further identification is usually not possible. However, when the submersed rosette form is found, lake edges are usually inhabited by emergent arrowhead plants of similar species. Arrowhead has emergent leaves, and usually inhabits shallow waters at pond or lake edges, or along sluggish streams. It can tolerate a wide variety of sediment types and pH ranges. Arrowhead is very suitable for constructed wetland development due to its tolerance of habitats, and ability to act as a nutrient sink for phosphorous. Typical arrowhead reproduction is via rhizomes and tubers although seed production is possible if conditions are ideal. Arrowhead has high wildlife value, providing high-energy food sources for waterfowl, muskrats and beavers. Arrowhead beds provide suitable shelter and forage opportunities for juvenile fish as well.

**Bass Weed** (*Potamogeton amplifolius*. Common Names: Large-leaf Pondweed, Bass Weed, Musky Weed. **Native.**): Bass weed has robust stems that originate from black-scaled rhizomes. The submersed leaves of bass weed are among the broadest in the region. The submersed leaves are arched and slightly folded, attached to stems via stalks, and possess many (25-37) veins. Oval floating leaves, also with numerous veins, are produced on long stalks (ranging from 8-30 cm in length). Stipules are large (up to 12 cm long), free and taper to a sharp point. Flowers are produced by midsummer, (and fruit, later in the season) densely packed onto a spike. The fruit have three low ridges on its surface. Bass weed prefers soft sediments in water one to four meters deep. This plant is sensitive to increased turbidity and also has difficulty recovering from top-cutting, from such devices as boat propellers and aquatic plant harvesters. As its name implies, the broad leaves of this submersed plant provides abundant shade, shelter and foraging opportunities for fish. The high numbers of nutlets produced per plant make it an excellent waterfowl food source. Studies have demonstrated that bass weed can be established in littoral areas via stem clippings if growing conditions are ideal.

**Benthic or Floating 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 and floating filamentous algae can comprise an entire range of morphologies, but flagellated taxa are far less common. Typically, green algae and blue-green algae groups are represented by macroscopic filamentous algae.



**Brazilian Elodea** (*Egeria densa*. Common Names: Egeria, Anacharis, Brazilian waterweed. **Exotic, Aggressive, Invasive.**): Brazilian elodea is an aggressive exotic invasive submersed plant that originated from South America. It was introduced via the aquarium hobby trade, and is a top selling plant used as an oxygenator. The stems can be several meters long, and the strap-like leaves are situated in whorls of three to six, but usually four. The leaves are finely serrated, and are tightly packed together near the end of the stem. Brazilian elodea can be rooted or free floating, and due to its highly branching and buoyant nature, most of its biomass occurs at or near the surface. Submersed plants can quickly reach nuisance densities, crowding out native vegetation and floating mats can block light penetration needed for lower growing native submersed plants. Although it can be confused with *Hydrilla*, another invasive submersed plant, its lack of tuber production and leaf structure differentiates it. Although it can produce white flowers, it reproduces vegetatively in the United States. Two adventitious roots can be seen in the picture to the left. Waterfowl consume Brazilian elodea, and fish and invertebrates uses the stems for refuge and habitat.

**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 (usually less than 3.5 cm long) 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. Often the fruits are purplish in color. Although it can reproduce via fragmentation, its primary mode of reproduction is seed production. Brittle naiad has been introduced from Europe in the early 1900's, and can be found in most of the northeastern states. Brittle naiad can occur in water as deep as five meters, and although it prefers sandy and gravel substrates, it can tolerate a wide range of bottom types. It's tolerant of turbid and eutrophic conditions. Waterfowl graze on the fruit.

**Common waterweed** (*Elodea canadensis*: Common Names: Elodea, common waterweed. **Native.**): Common waterweed has slender stems that can reach a meter or more 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 occur in whorls of three (or occasionally two). 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. Common waterweed overwinters as an evergreen plant, and primarily reproduces via fragmentation. Its resistance to disease and tolerance of low-light conditions grant it a competitive advantage. Although common waterweed is considered a desirable native plant, it can reach nuisance levels, creating dense mats that can obstruct fish movement, and the operation of boat motors.

**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 stems. The lack of a true root system can have an affect its distribution in a lake basin, due to prevailing winds, water currents, and boat movement. The leaves are stiff, and arranged in whorls of five to 12 at each node. Each leaf is forked once or twice, 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 overwinter as an evergreen 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. Although considered a desirable native plant, it can reach nuisance density at the surface of a lake.

**Creeping Bladderwort** (*Utricularia gibba*. Common Names: creeping bladderwort, humped bladderwort, cone-spur bladderwort. **Native**.). Creeping bladderwort is a small (usually less than 10 cm long), delicate, free-floating stem. It often forms tangled mats in quiet shallow waters, often associated with bogs, or stranded on soil. It is sometimes mistaken for algae. It has short side braches that fork once or twice, a defining characteristic. Small bladders, used to capture live prey, are situated on these side branches, but they are few in number when compared to other bladderworts. Small yellow snap-dragon-like flowers are produced on a short stalk, typically developing in early summer, yet persisting for several weeks. Mats of creeping bladderwort offer limited cover and foraging opportunities for fish.

**Curly-leaf Pondweed** (*Potamogeton crispus*. Common Name: curly-leaf pondweed. **Aggressive, Invasive, Exotic.**): Curly-leaf pondweed is native to Europe, but was introduced to North America in the mid-1800's. This invader is very common in the northeast, and its range now includes most of the USA. Curly-leaf pondweed has spaghetti-like stems that often reach the surface by mid-June (up to four meters long). 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. Stipules are fused to the base of the stem, but disintegrate early in the season. Curly-leaf pondweed can tolerate turbid water conditions better than most other macrophytes, giving it a competitive advantage over most desirable native plants. 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.

**Dwarf Water Milfoil** (*Myriophyllum tenellum*. Common Name: Dwarf water milfoil. **Native**.): Dwarf milfoil, which does not look anything like other milfoil species, has slender unbranched stems ranging from 2 cm to 15 cm in height. The leaves are reduced to scales or "bumps". If the tips rise out of the water, they are capable of producing pale flowers and nut-like fruits (produced in late summer). These flowers are then wind pollinated. The toothpick-like stems arise from rhizomes in a chain. Dwarf milfoil is small and delicate, often overlooked even when visible in the shallows. It prefers sandy bottoms in water up to four meters deep, but typically only a few inches deep. Dwarf water milfoil provides suitable spawning habitat for panfish and adequate shelter for small invertebrates. The dense tufts of rhizome networks are ideal to stabilize bottom sediments.

**Eurasian Water Milfoil** (*Myriophyllum spicatum*. Common Names: Asian water milfoil. **Aggressive, Exotic, Invasive**.): Eurasian water milfoil has long (two to four meters long) spaghetti-like stems that grow from submerged rhizomes. The stems often branch repeatedly at the water's surface creating a canopy that can shade out other vegetation, and obstruct recreation and boat navigation. Low light conditions and high surface water temperatures promote canopy formation. The leaves are arranged in whorls of four to five, often spread out along the stem one to three centimeters apart. The leaves are divided like a feather, resembling the bones on a fish spine, typically with 14 to 20 pairs. 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 other native submersed plants. It can grow in water up to 15 feet deep, and prefers fine-textured inorganic sediments. In addition to reproducing via fruit production, it can also reproduce via fragmentation. It does not produce winter buds, and can persist under the ice as an evergreen plant. Waterfowl graze on Eurasian water milfoil, and its vegetation provides substandard habitat for invertebrates. However, studies have determined mixed beds of native pondweeds and wild celery can support more abundant and diverse invertebrate populations.

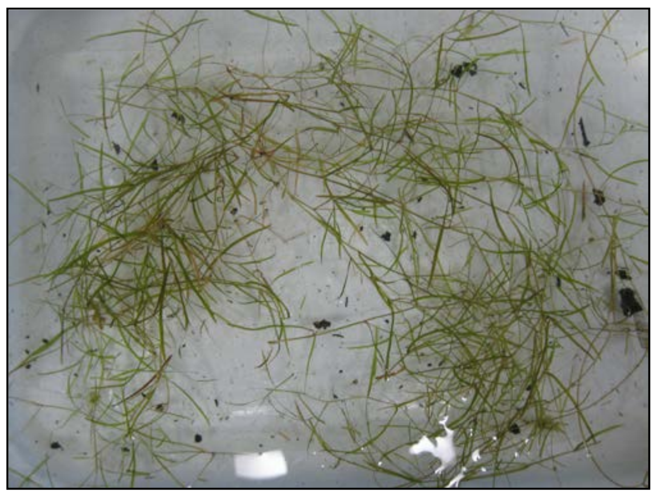
**Leafy Pondweed** (*Potamogeton foliosus*: Common Name: leafy pondweed. **Native**.): Leafy pondweed has freely branched stems that hold slender submersed leaves that become slightly narrower as they approach the stem. The leaf contains three to five veins, typically flanked by one to two rows of hollow (lacunae) cells. The leaves often taper to a point. Stipules are membranous and free from the stems in mature plants, but wrap around the stem in developing plants. No floating leaves are produced. It produces early season abundant fruits in tight clusters on short stalks in the leaf axils. The seeds are flattened with a dorsal wavy ridge and a short beak. 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. It inhabits a wide range of habitats, but usually prefers shallow water and softer sediments. In ideal habitats, it can reach nuisance densities. It has a high tolerance for eutrophic conditions, allowing it to even colonize secondary water treatment ponds.

**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 20 cm 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, and the plant is grazed on by muskrat, deer, beaver and moose. The ribbon-like leaves are often colonized by invertebrates, and offer foraging opportunities for fish and frogs.

**Robbin's Pondweed** (*Potamogeton robbinsii*. Common Name: Fern Pondweed. **Native**.). Robbin's pondweed has robust stems that emerge from spreading rhizomes. The rhizomes can be tightly spaced, creating a carpet of Robbin's pondweed that possibly could inhibit other submersed plants from becoming established. The leaves are strongly ranked creating a fern-like appearance most clearly seen while still submerged, yet still evident when out of the water. Its distinct closely-spaced fern-like leaves give it a unique appearance among the pondweeds of our region. Each leaf is firm and linear, with a base that wraps around the stem with ear-like lobes fused with a fibrous stipule. No floating leaves are produced. Whorls of flowers can be produced, but fruit rarely is produced. Robbin's pondweed thrives in deeper water, often inhabiting a thin margin at the edge of the littoral zone, beyond most other submersed plants. Under some circumstances, portions of Robbin's pondweed can over winter green. Robbins pondweed creates suitable invertebrate habitat, and cover for lie-in-wait predaceous fish, such as pickerel and pike.

**Slender Naiad** (*Najas flexilis*: Common Names: water nymph, northern water nymph, 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 can vary based on environmental conditions; from compact and bushy, to long and trailing slender stems, depending on growing conditions. The leaves are short (1-4 cm long) and taper to a point with very fine serrations (actually minute spines) that are often only visible under a microscope. The leaves broaden gently where they meet the stem. It is a prolific seed producer, generating seeds with faint pits longer than wide. It is found in a variety of habitats, and can colonize sandy or gravelly substrates. Slender naiad typically does not reach nuisance density, due to its low-growing structure in all but the shallowest of waters. It is a true annual, and dies off in the fall, relying on seed dispersal to return the next year. Stems, seeds and leaves are important food sources for waterfowl, marsh birds, and even muskrats.

**Spatterdock** (*Nuphar vareigata*. Common Name: Yellow pond lily, bullhead pond lily, spatterdock. **Native.**): Spatterdock leaf stalks emerge directly from a robust submerged fleshy rhizome often adorned with scars from previous flower stalks. Spatterdock has large (up to 25 cm) heart-shaped leaves with a prominent notch and two lower lobes. The leaf stalk sports a winged margin, setting it apart from another yellow pond lily, *N. advena*. Flowering occurs in the summer and, the flowers open during the day and close at night. Flowers are bulbous in shape with yellow sepals often tinted red at the base. Spatterdock typically inhabits quiet water less than two meters deep, such as ponds, shallow lakes and slow-moving streams. Occasionally, the leaves are held erect, above the surface of the water. The leaves offer shade and protection for fish, and the leaves, stems, and flowers are grazed upon by muskrats, beaver, and sometimes even deer.



**Spiral-fruited Pondweed** (*Potamogeton spirillus*. Common Name: Spiral-fruited pondweed. **Native.**): Spiral-fruited pondweed has slender stems that originate from a delicate, spreading rhizome. The stems tend to be compact and have numerous branches. Submersed leaves are linear with a curved appearance. Floating leaves are delicate, ellipse-shaped and range from seven to 35 mm long and two to 13 mm wide. Stipules are fused to the leaf blade for more than half of their length. Flowering occurs early in the season, with fruit production by mid-season. Nut-like fruits are produced on stalks of varies lengths. Shorter stalks tend to be on lower axils with fruit arranged in a compact head, while longer stalks tend to appear on upper axils, with fruit arranged in a cylindrical head. The fruit itself is a flatten disc with a sharply-toothed margin. Its smooth sides appear like a tightly coiled embryo, a distinguishing characteristic. Spiral-fruited pondweed prefers shallow water with sandy substrate, but can inhabit a wide range of bottom substrates. It serves as an important sediment stabilizer and cover for fish fry and invertebrates.

**Water Stargrass** (*Zosterella dubia* (=*Heteranthera dubia*): Common Name: Water stargrass, eelgrass. **Native.**): Water stargrass has slender free-branched slightly flattened 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. Although water stargrass appears to be a pondweed, it's actually not related to that diverse genus, being in the pickerelweed family. 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. Flowers are typically only produced in shallow water or stranded-on-shore plants. Water stargrass is a locally important waterfowl food source, and provides suitable cover and foraging opportunities for fish.

**Watershield** (*Brasenia schreberi*. Common Names: common water shield, water target. **Native**.): Watershield is a floating-leaf aquatic plant similar to water lilies. Its stem and leaves are elastic, and are attached to a rooted rhizome that acts as an anchor and source of stored nutrients. The leaf stalks are attached to the middle of the leaf, creating a bull's eye effect, hence its name water target. The leaves, which are typically much smaller than other water lilies, are green on the upper surface, and purple underneath. Maroon to purple small flowers (less than 3 cm in diameter) peak above the water's surface on short, stout stalks. Watershield is usually coated with a clear gelatinous slime on the stem and underside of the leaves. Watershield prefers soft-water lakes and ponds in sediments containing decomposing organic matter. Under ideal conditions, watershield can become aggressive, and reach nearly 100% coverage on the surface. The whole plant is consumed by waterfowl, and the floating leaves provide shade and cover for fish.

**White Water Lily** (*Nymphaea odorata.* Common Name: white water lily, fragrant water lily. **Native.**): White water lily leaf stalks emerge directly from a submerged fleshy rhizome. White water lilies have round floating leaves that can reach 30 cm in diameter. The floating leaves have a narrow notch (or sinus), and a green to purple underside. The white flowers are prominent and showy (seven to 20 cm) and arise from stalks from the rhizome. Flowering occurs during the summer, and the flowers open during the day, and close during the night. White water lilies are very common and typically inhabit quiet water less than two meters deep, such as ponds, shallow lakes and slow-moving streams. They inhabit a variety of sediment types, and can reach nuisance density under ideal circumstances. Nuisance density white lilies shade other macrophyte growth, compound sediment accumulations, and obstruct boat movement. The leaves offer shade and protection for fish, and the leaves, stems, and flowers are grazed upon by muskrats, beaver, and sometimes even deer. There is quite a bit of debate among aquatic macrophyte taxonomists regarding the placement of fragrant white water lily and tuberous white lily (*N. tuberosa*).

## IV. Discussion of the 2011 Lake Waccabuc Aquatic Macrophyte Results

For Lake Waccabuc, 25 maps are included in the Appendix. Twenty of these maps represent the distribution of aquatic macrophytes according to species at each sample location (including two maps that depict filamentous algae distribution). Four maps depict sample location distribution, water depth distribution, total floating aquatic vegetation distribution, and total submersed aquatic vegetation distribution for the data collected in 2011. The final map, a new addition in 2011, depicts Richness (number of individual species) per sample location. A total of 120 sample locations were surveyed for aquatic macrophytes at Lake Waccabuc in 2011. This includes four sites surveyed in the channel leading from Lake Waccabuc to the Oscaleta Road overpass. At the channel sites, only one rake toss was performed per site, due to the canal width. See section V. for a brief discussion on the canal aquatic (and wetland) macrophytes observed.

Fifteen submersed aquatic macrophytes (and benthic filamentous algae) were collected during the July 2011 survey at Lake Waccabuc. This represents an increase in one species as compared to 2010. Of these 15, three invasive species were observed: Eurasian water milfoil, brittle naiad, and curly-leaf pondweed. The latter macrophyte was collected in 2008, but not in 2010. Most important, Brazilian elodea was not collected are observed in 2011. The remaining observed species are considered desirable native species, although some of these species, such as coontail or common waterweed, could reach nuisance densities (often classified as medium or dense densities), negatively impacting lake uses.

Submersed macrophytes were collected at 113 (or 94%) of the sites surveyed in 2011, an increase of 17% compared to 2010. This increase could be explained by the additional weed anchor toss per site conducted this year (three in 2011 vs. two in 2010). Similar to last year, just over half of these sites (60, or 53%) were considered trace density, while 35 sites (or 31%) were considered sparse. Medium density sites accounted for 15 (or 13%) of the sites surveyed, while dense macrophytes were observed at three, or 3% of the sites. In 2011, we saw the highest percentage of sites that supported at least trace submersed growth. Trace sites increased, while sparse sites remained similar to last year. However, 2011 saw an increase in overall medium sites, while a decrease in dense sites.

Due to the basin morphology, submersed macrophytes at Lake Waccabuc are limited to the shorelines, including around the island, in the North Cove, in the Outlet Cove, and the East Inlet end of the lake. The highest density locations were in the East Inlet end (with seven medium sites), and the North Cove (two dense and three medium sites). Increased submersed macrophyte abundance was observed around the island in 2011 (one dense and one medium site, along with four sparse sites). The East end abundance is not a surprise as this location has historically supported high macrophyte densities. The North Cove abundance continues to rebound since the suction harvested project conducted in 2009. Sample site Richness appears to be returning to this cove, especially along the eastern shoreline (Richness six to nine species per site). A stretch of the North shore (sites 80, 81, and 88 to 90) was again devoid of submersed plants due to the rocky bottom and steep slopes of the littoral zone.

Several factors are at play influencing the submersed macrophyte abundance and distribution at this lake. The first is the presence of invasive species which can outcompete and displace desirable native species. Eurasian water milfoil still dominates the submersed community at Lake Waccabuc, and in 2011 it displayed an 18% increase in percent abundance, approaching abundance amounts observed in 2008. Second, aquatic macrophyte control projects (such as ongoing hand pulling efforts by the residents, and the 2009 suction harvesting project) affect the aquatic macrophyte assemblage. There is no doubt the aggressive suction harvesting project targeting Brazilian elodea altered the macrophyte community in that location, notably in dramatic increase in common waterweed observed in 2010. However, it appears to be returning to more stable steady state in 2011. Third, basin morphology also plays a large role in determining the suitability for submersed macrophytes to inhabit certain locations throughout the lake. Shallow coves with nutrient rich bottom sediments are choked with vegetation, whereas stretches of steep littoral zone shorelines and the presence of large rocks limit submersed macrophytes. Not only do these large rocks create unsuitable bottom substrate for all but the hardiest species, they make traditional weed anchor sampling difficult as the anchors become “hung up” often, preventing a full 10 meter drag. Finally, seasonal weather patterns (rainfall, ambient regional air temperatures, prevailing winds, storm events, winter ice cover) all play a role in the complex ecological function of a lake system.

New in 2011, sample location Richness (number of individual species) data was included and depicted on a map. At Lake Waccabuc, Richness ranged from zero to nine different macrophytes. Using all 120 sites, a calculated average Richness of 3.99 species was obtained with the 2011 data set. As expected, the highest Richness values occurred at the East Inlet end of the lake and the West end of the lake. The North Cove also supported high Richness values along the east shore. Additional Richness “hotspots” in 2011 include the North side of the island (Richness = 6), the interior of the Northeast Cove (Richness = 8), the far reach of the Outlet Cove (Richness = 9), and to the left of the swim area (Richness =7). In the canal, sample Richness ranged from 4 to 7, with the highest situated at the mouth to the main basin.

In 2011, the invasive Eurasian water milfoil was the dominant submersed macrophyte collected at Lake Waccabuc. Eurasian water milfoil has been the dominant submersed macrophyte all three years. This year it was collected at 89 (or 74%) of the sites surveyed. This represents a significant increase in abundance when compared to 2010, although still less than the abundance observed in 2008. Once again in 2011, most of the Eurasian water milfoil (64, or 72%) sites were considered trace density. At 24 of the sites (or 27%) the density was classified as sparse. The last site (representing 1%) was considered medium. When the percent abundance graph is examined, one can see the dip in abundance and distribution of Eurasian water milfoil in 2010. Despite an increase in sparse sites from 2010 to 2011, the number of medium sites remained the same. Again, this could reflect the sampling protocols employed in 2011 vs. 2010. Eurasian water milfoil was scattered about the entire basin on the lake. Heavier densities of Eurasian water milfoil occurred in the North Cove (four sparse sites and the lone medium site), around the island (all six sparse sites, and numerous heavy infestations observed in the field), and the western half of the basin (10 sparse sites). Eurasian water milfoil density was low throughout the East Inlet end of the lake.

Benthic filamentous algae was also collected at 89 (or 74%) of the sites surveyed in 2011. This represents a significant increase from 22% of the sites surveyed in 2010. This increase in frequency was primarily from trace sites and medium sites. Benthic filamentous algae is considered a nuisance, and its increased growth could be contributed to the recent heat wave along with excellent water clarity. Most often, benthic filamentous algae was observed growing on other macrophytes, but it was even present on rocks and the lake bottom in some locations during the dates of the survey. At 73 (or 82%) of these sites, the density was trace, while at 12 sites (or 13%) had sparse density. Finally, four sites (or 4%) were considered medium density. It was heaviest in the East Inlet Cove (with seven sparse and two medium sites). In the North Cove, it occurred at most all sites (save the deep ones) and supported two sites of medium density and one site of sparse density. Benthic filamentous algae also occurred at three sites (all trace) in the canal, and at all six sites (two sparse, four trace) around the island.

Bass weed occurred at 59 (or 49%) of the sites surveyed in 2011. In 2010, bass weed was collected at 38% of the sites surveyed, and has continued on a promising increasing trend since 2008, when it occurred at 31% of the sites surveyed. Most of the sites in 2011 (46, or 78%) the density were considered trace. At five sites (or 8%), the density was sparse, while at eight sites (or 14%) the density was classified as medium. Although an increase in overall sites was observed this year, there was a decline in dense sites. These could have been displaced by medium sites according to the three tosses employed in 2011. Bass weed continues to be scattered about the lake basin, preferring the shallow coves. The heaviest densities of bass weed continue to occur in the East Inlet end of the lake (five medium sites), with localized medium patches on the north side of the island, and at the lake outlet. The suction harvesting of the North Cove all but eliminated bass weed in this area. In 2008, the north cove supported four sites (one medium, two sparse and one trace) of bass weed, yet in 2010, only one trace site was collected. In 2011, bass weed continues to re-populate the North Cove, with four trace and one sparse site collected.

Coontail was collected at 38 (or 32%) of the sites surveyed at Lake Waccabuc in 2011, representing an increase in overall occurrence since the 2008 and 2010 surveys. Coontail occurred at a wide range of densities, with 26 sites (or 68%) being considered trace density. Eleven sites (or 29%) were considered sparse density, while one site (or 3%) was considered medium density. Coontail occurs prominently at four locations, including the canal, the East Inlet Cove, the West end of the basin, and the North Cove. Despite its reproductive strategy, coontail continues a slow re-colonization in the North Cove. It occurred at eight sites (only one more than 2010), but six of the sites were trace density and two were sparse.

Robbin's pondweed was collected at 24 (or 20%) of the sites surveyed at Lake Waccabuc in 2011. This represents double the sites this macrophyte was collected at 2010. Most of these sites (23, or 96%) were considered trace density. One site (or 4%) was considered sparse density. Most of the Robbin's pondweed sites continue to be in the East Inlet end of the lake. However, this year, two sites were observed at the West end of the lake, one trace site at the island, and three trace sites in the North Cove. Finally, three sites were located in the Northeast cove, and one trace site occurred at the outlet. The reappearance of this desirable macrophyte in North Cove is most encouraging.

Common waterweed occurred at 18 (or 15%) of the sites surveyed at Lake Waccabuc in 2011. Twelve sites of common waterweed (or 67%) were considered trace density, while six sites (or 33%) were considered sparse density. Most of the common waterweed collected in 2011 occurred in the North Cove (eight total sites, including four at sparse density). However, the overall common waterweed abundance appears to have decreased in this cove, likely due to the re-colonization of other macrophytes. Additional pockets of common waterweed were scattered about the lake basin. This included two sparse sites at the West end of the lake, a few sites near the swimming beach, and three sites in the East Inlet end of the basin. Again, the author refers the reader to the 2008 report for information regarding the taxonomy of common waterweed. In New York State, there continues to be concerns distinguishing common waterweed and slender waterweed to the point that some scientists prefer to call them *Elodea* sp. (personal communication, Robert Johnson, Cornell University, 2010). For the purposes of this report, the common waterweed collected at Lake Waccabuc shall be considered *E. canadensis*.

Arrowhead is a common native emergent macrophyte that occurs along the shoreline or shallow water of most lakes that also produces a submersed rosette form (leaves arranged in a radiating pattern at the base of a plant). The rosette is sometimes collected during weed anchor toss surveys, but due to its morphology and ability to hold fast into the sediment, it's often underestimated during point intercept surveys. This was certainly the case in 2011, as rosettes were observed quite abundant in several shallow water sites. Arrowhead rosettes were collected at 14 (or 12%) of the sites surveyed in 2011. Most of the sites (12, or 86%) were considered trace density, but two sparse sites were also collected. Arrowhead rosettes were most common along the southern shore of the East Inlet end of the basin (five sites), and the Outlet Cove (four sites). Three sites (including one sparse site) were located along the North shore, but also at the East end of the lake. Finally, three sites (including one sparse site) were located in the shallow Northeast Cove, and one along the North shore at the West end of the lake.

In 2011, water stargrass abundance was similar to data collected in 2010. This year, water stargrass occurred at 14 (or 12%) of the sites surveyed at Lake Waccabuc. Thirteen of the sites (or 93%) were considered trace, while the last site (7%) was considered sparse density. Water stargrass continues to be scattered about the entire basin, with isolated patches occurring along much of the south shoreline. Along this entire shoreline, numerous other small (five foot or less) patches were observed. Additional sites occurred in the Outlet Cove, in the Northeast Cove, and the North Cove. The North Cove re-colonization is promising despite only collecting this native macrophyte on two anchors. Additional small beds of water stargrass were observed in the North Cove. No flowers were present on any of the samples collected, so identification was confirmed via leaf and stem structures.

Leafy pondweed was collected at 7 (or 6%) of the sites surveyed in 2011. This is a slight decrease when compared to 2010. All seven sites were considered trace density. Leafy pondweed commonly occurred along the South shoreline at the East Inlet end of the lake and at the mouth of the Outlet cove. One site was collected in the Northeast Cove. This year, seeds were present on the samples collected, and used to confirm the identity of this desirable native macrophyte, and distinguish it from the spiral-seeded pondweed.

Brittle naiad was once again located in Lake Waccabuc this year. It occurred at four (or 3%) of the sites surveyed in 2011. At all four locations, the brittle naiad was considered trace density. Two sites were located along the south shoreline at the East Inlet end of the basin. The last two sites (one each) were located in the North Cove and the Northeast Cove, respectively. Last year, brittle naiad was restricted to the South shore of the main basin, so it appears to be “on the move”. Although considered an invasive macrophyte in New York, its delicate structure and late-season growth patterns limit its aggressiveness to out compete desirable native macrophytes.

Spiral-fruited pondweed was collected at four (or 3%) of the sites surveyed at Lake Waccabuc in 2011. All four sites were considered trace density. During the previous two surveys, it was located near site #119, but this was not the case in 2011. It occurred at two shallow water sites in the Northeast Cove (with one established patch to the left of the pontoon boat dock), and at two sites in the North Cove. However, in 2011 no seeds could be found on any of the collected samples to confirm its identification. Based on the leaf and stem structures, numerous pondweeds could be ruled out (such as leafy pond weed and small pondweed), but spiral-fruited pondweed could not be 100% confirmed based on the 2011 samples.

Creeping bladderwort was collected at three (or 3%) of the sites surveyed in 2011 at Lake Waccabuc. All three sites were considered trace density, which is typical for this delicate-stemmed bladderwort. Its abundance increased by one site this year. All three sites were located at the mouth of the canal, which is typical for the past two surveys. While travelling through the canal, small clumps of creeping bladderwort were observed, as well as in Lake Oscaleta, near the boat access.

Dwarf water milfoil was collected at two (or 2%) of the sites surveyed at Lake Waccabuc in 2011. Both sites were considered trace density, yet one must consider the low growing and delicate structure of this macrophyte. This represents a decrease in abundance compared to last year. The sites were located in a cove along the North shore (toward the West end of the lake), and in the Northeast Cove. Both of these sites have supported dwarf water milfoil growth in previous seasons. As can be seen by the 2008 picture, dwarf water milfoil covers the bottom at the West-most location, in about six inches of water.

Ribbon-leaf pondweed continues to have very limited abundance and distribution in Lake Waccabuc. In 2011, it was collected at two (or 2%) of the sites surveyed. Both were considered trace density. One was located in the canal to Lake Oscaleta, while the other site was located at the mouth of the canal. Although only collected at trace density, at both sites, the plants supported growth at the surface with floating leaves and seed-laden spikes. It was often mixed in with other macrophytes, especially water lilies. Its identity was confirmed with the presence of these seeds and the distinct submersed and floating leaves.

Curly-leaf pondweed was collected at two (or 2%) of the sites surveyed in 2011. In 2010, curly-leaf pondweed was not collected in Lake Waccabuc. This year, both sites were trace density, and located in the dense beds of macrophytes in the East Inlet end of the lake. Curly-leaf pondweed is a prolific early-season invasive macrophyte. It typically experiences a natural die-off in late June to early July, so the results of this survey (and those performed in 2008 and 2010) are no surprise. Should this survey be conducted in late May, curly-leaf pondweed abundance and distribution would likely be considerably higher.

One new macrophyte was collected in 2011: slender naiad (*Najas flexilis*). This is a highly desirable native macrophyte that is very common in New York. It occurred at only one (or 1%) of the sites surveyed. It was collected at trace density, located along the South shoreline in the West end of the lake. Even though only two sprigs of slender naiad were collected, they both contained seeds in the leaf axils, which were used to confirm the identity of the macrophyte.

Two aquatic macrophytes observed/collected during past surveys were not collected in 2011. These include small duckweed and Brazilian elodea. Small duckweed is a tiny floating macrophyte that typically collects among surface macrophytes, and in quiet coves. In 2011, it was not observed in the canal, or even at the East Inlet end of the lake. Brazilian elodea was first documented in 2008 in the North Cove, and was the target of an aggressive suction harvesting project in that cove during 2009. In 2010 it was located in a single patch on the North side of the island (outside the North Cove). During our 2011 survey, we increased the number of anchor tosses to three per site, and conducted an extensive visual survey in the North Cove, around the island, and along the North shoreline, from the North Cove to the canal. Although we did not find any Brazilian elodea this year, we recommend future vigilance regarding this aggressive invader. Its presence outside of the North Cove in 2010 was discouraging, but quick-acting volunteers hand pulled the established bed, preventing its further spread.

In 2011, three more floating macrophytes (and floating filamentous algae) rounded out the aquatic macrophyte assemblage at Lake Waccabuc. Floating macrophytes were observed at 67 (or 56%) of the sites surveyed in 2011, a slight increase from 2010. Thirty four (or 51%) of the sites were considered trace density, while another 28 (or 42%) were sparse density. At five sites (or 7%), the density was considered medium. The highest floating macrophyte densities were in the East Inlet end of the lake (all five medium sites were located here). Lesser densities (trace and sparse) floating macrophytes occurred in the Outlet Cove and at the West end of the basin. Although floating macrophytes occur along the South shore, they are limited to isolated patches. The North Cove now supports four sites of floating macrophytes, with three classified as sparse and one as trace.

Although watershield continues to be a dominant floating macrophyte observed at Lake Waccabuc, in 2011 white water lily shares that title. Watershield occurred at 41 (or 34%) of the sites surveyed, exactly the same number of sites observed in 2010. Most of the sites (30, or 73%) were considered trace density. Ten (or 24%) of the sites were considered sparse density, while one site (or 2%) was at medium density. Watershield is most common along the South shore at the East Inlet end of the lake, throughout most of the Outlet Cove, and along the North and South shorelines at the West end of the lake. Re-colonization of the North cove continues to be slow, with only two trace sites located here.

White water lilies were observed at 41 (or 34%) of the sites surveyed at Lake Waccabuc in 2011. Thirty three (or 80%) of these sites had trace density white water lilies. At seven sites (or 17%) the density was considered sparse, while at one site (or 2%) the density was considered medium. Overall percent abundance data is similar to last year, although more trace sites (and therefore less sparse and medium sites) were observed. White water lilies were scattered about the main basin, similar to the other floating macrophytes, although less so at the West end of the lake. The white water lilies at the East Inlet end of the lake are not considered nuisance density by themselves, but certainly are a nuisance in combination to the other floating macrophytes that occur in this area. Similar to watershield density, re-colonization of the North Cove is occurring, but at a slow pace. In 2011, three trace sites of white lilies and one sparse site was observed.

Floating filamentous algae abundance increased from 1% of the sites surveyed in 2010 to 18% of the sites in 2011. Although cause for concern, the 2011 abundance is similar to data collected in 2008 (when 17% of the sites supported this nuisance algae). Most sites (17, or 77%) were considered trace. The remaining five sites (or 23%) were considered sparse density. Floating filamentous algae was common in areas with high abundance of floating macrophytes. Therefore, it was most common in the East Inlet end of the basin, the Outlet Cove, and in the North Cove. It was largely absent from the West end of the lake, likely a function of the prevailing winds in the region.

Spatterdock abundance was virtually the same in 2010 and 2011 (and a slight increase when compared to 2008 data). In 2011, spatterdock was observed at 22 (or 18%) of the sites surveyed. At fifteen sites (or 68%), it occurred at trace density. At five sites (or 23%) it occurred at sparse density, while at two sites (or 9%) it was considered medium density. Spatterdock prefers the shallow nutrient rich sediments of the East Inlet end of the basin and the Outlet Cove. One additional site was located on the North shore between the Northeast Cove and the canal, and one trace site was located to the left of the swimming area. Spatterdock also occurred at all four sites in the canal.

## V. The Canal

The canal between Oscaleta Road and Lake Waccabuc was surveyed in 2011, just as it was during the previous two surveys. Due to the width of the canal, only one weed anchor toss was conducted at each canal station (Sites W1 through W4). This toss was targeted at the front of the boat, but a visual survey was also conducted in the water to either side of the boat. Due to the single toss conducted at these four locations, comparisons of the data to the other lake station sites (three tosses) should be limited.

Since the second field biologist on site had a strong background in wetland vegetation, in 2011 a short list of commonly occurring wetland plants observed in the canal was compiled. This list is summarized in Table #2, below, and includes both common and scientific nomenclature.

**Table 2 Wetland Plants Observed in the Waccabuc Canal in 2011**

| Common Name | Scientific Name |
|---|---|
| Sweet Pepper | *Clethra alnifolia* |
| Swamp Marigold | *Bidens* sp. |
| Swamp Azalea | *Rhododendron viscosum* |
| Alder | *Alnus serrulata* |
| Red Maple | *Acer rubrum* |
| White Oak | *Quercus alba* |
| Red Oak | *Quercus rubra* |
| New York Fern | *Thelypteris noveboracensis* |
| Sensitive Fern | *Onoclea sensibilis* |
| Japanese Honeysuckle Bush | *Lonicera japonica* |

# VI. Additional Aquatic Macrophytes Observed in 2011

In 2011, two more aquatic macrophytes were observed during the survey. Although not directly sampled via weed anchor tosses, the presence of these macrophytes is important to get a complete understanding of the aquatic macrophytes that inhabit Lake Waccabuc. The two macrophytes included flat-stem pondweed, and the emergent pickerelweed. The following are descriptions of each of these macrophytes. Also included is a description of small duckweed, which was not observed/collected in 2011. After the descriptions is a short summary on the abundance/location of these two macrophytes.

**Pickerelweed** (*Pontederia cordata*. Common Names: Pickerelweed. **Native.**): Pickerelweed is an emergent macrophyte with broad glossy green leaves adorned with many fine veins. Pickerelweed has a distinct heart-shaped leaf base and a flower spike crammed with blue flowers. It inhabits shallow water, along the shoreline preferring depths less than two meters deep. It often forms extensive beds in protected coves and bays of larger bodies of water. There is also a submerged form that produces narrow, ribbon-like leaves. The flowering stalk attracts insects, and the seeds are consumed by waterfowl. Underwater structures of the plant provide shelter for fish, and can be an important component of shoreline stabilization against wave action.

**Flat-stem Pondweed** (*Potamogeton zosteriformis*. Common Name: Flat-stem pondweed. **Native.**): Flat-stem pondweed is freely branched, emerging from a delicate rhizome system. The stems are strongly flattened with an angled appearance. The long leaves are stiff and linear with a prominent midvein, and numerous fine parallel veins. This prominent midvein distinguishes this pondweed from water stargrass. The stipules are firm and free, situated in the leaf axils. Flat-stem pondweed lacks floating leaves. It inhabits a variety of water depths from shallow water to that of several meters deep. It prefers soft sediment types. Although it produces nut-like fruit, it over winters primarily by rhizomes and winter buds. It can be a locally important food source to fauna, such as waterfowl, muskrat, deer, beaver, and moose. It also provides suitable habitat and food for fish and aquatic invertebrates.

**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.

Pickerelweed is a desirable native emergent macrophyte that typical inhabits lake edges and marsh areas. It can create dense stands and has distinct attractive blue-purple flowers. Small clusters of pickerelweed plants were observed in the canal (before and after site W2, and to the east of site W4). It was also common in the main basin along the South shoreline at the East Inlet end of the lake (between W7 and W9). A stand of pickerelweed was established in the open water at the mouth of the canal (near W5), as pictured on page 22 of this report. Finally, scattered isolated patches of pickerelweed occurred along the South shoreline at the West end of the basin (between W61 and W64).

Flat-stem pondweed was not collected on any weed anchor tosses in 2011. This is similar to the data collected in 2010, even though it occurred at four locations in 2008. This year, it was observed in the canal (East of W4), and again at the mouth of the canal. Each instance was a single plant, with the latter being a floating stem among the other heavy macrophyte growth. No samples were collected in 2011, so the identification of this pondweed was not confirmed (and indeed, it can be confused with ribbon-leaf pondweed or water stargrass).

## VII. Summary of Findings and 2012 Recommendations

On July 20 and 21, 2011 a point intercept aquatic macrophyte survey was performed at Lake Waccabuc. One hundred and twenty sites were surveyed in the littoral zone (and the canal), using procedures similar to the 2008 (one toss per site) and 2010 (two tosses per site) surveys for a direct comparison of the data. In 2011, three weed anchor tosses per site were conducted in an effort to locate any established patches of Brazilian elodea. The following is a summary of the findings of the 2011 survey:

- The primary goal of the survey was to locate any additional established patches of Brazilian elodea. We are happy to report that no Brazilian elodea was collected or observed during the 2011 survey.
- Total submersed vegetation had the highest abundance of the three surveys conducted since 2008. Submersed plants were collected at 94% of the sites surveyed this year.
- Eurasian water milfoil continues to be the dominant submersed macrophyte at Lake Waccabuc. Its abundance increased from 56% in 2010 to 74% this year. However, this is still lower than the 80% abundance observed in 2008. Therefore, Eurasian water milfoil abundance seems to vary from year to year at Lake Waccabuc.
- Most macrophyte abundance data was +/- 5% from data collected in 2010, which represents typical seasonal variation. Exceptions were bass weed (+11%), Eurasian water milfoil (+18%), coontail (+7%), and Robbin's pondweed (+10%). Some of these increases could be explained by the increased weed anchor tosses per site.
- Filamentous algae significantly increased in 2011. Floating filamentous algae increased 17%, while benthic filamentous algae increased 52% when compared to 2010. This could explain the reported reduction in unicellular phytoplankton and the increased water clarity (personal communication, 3LC members, 2011).
- Small duckweed was not collected or observed in 2011.
- One new submersed macrophyte was collected and its identity confirmed in 2011: slender naiad (*Najas flexilis*).

It is encouraging that Brazilian elodea was not collected or observed in Lake Waccabuc in 2011. However, it would be naïve to assume that the 2009 suction harvesting project succeeded in total eradication, especially with the evidence of a rooted patch outside of the North Cove discovered in 2010. Therefore, future monitoring for Brazilian elodea is recommended in 2012 and beyond. As discussed with the 3LC, the more littoral zone sites surveyed with point intercept methods and the more tosses per site, the greater the chance for locating new patches of this invasive macrophyte. In addition, diver surveys should be continued in 2012, with increased frequency in the North Cove, around the Island, and along the North shore from the North Cove to the canal.

The following recommendation has been made to the 3LC over the past two years. The plant community of Lake Oscaleta has not been sampled since 2008, and since it supports the most diverse macrophyte community of the Three Lakes, it should be a high priority for monitoring. Due to prevailing winds and boat movement, Lake Oscaleta is at risk from Brazilian elodea colonization. A mid- to late-season 2012 point intercept survey is recommended for this basin, utilizing two anchor tosses per site. An increase in sample sites (20 to 25) focusing on the West Cove (the likely area of invasion) is also recommended. As a side benefit, 2012 data could be compared to the 2008 survey results to assess any changes in the macrophyte assemblage in this basin.

## VIII. References


Borman, et al. 1999. *Through the Looking Glass: A Field Guide to Aquatic Plants.* Wisconsin Lakes Partnership, University of Wisconsin-Extension. Reindl Printing, Inc. Merrill, WI.

Fairbrothers, et al. 1962. *Aquatic Vegetation of New Jersey.* Extension Bulletin 382. Extension Service, College of Agriculture, Rutgers University, New Brunswick, NJ.

Fassett, Norman C. 1972. *A Manual of Aquatic Plants.* The University of Wisconsin Press, Milwaukee.

Hill, R. and S. Williams. 2007. *Maine Field Guide to Invasive Aquatic Plants and their Common Native Look Alikes.* Maine Center for Invasive Aquatic Plants and the Maine Volunteer Lake Monitoring Program. J.S McCarthy Printers, Augusta Maine.

Lord et al. 2005. *Effective Aquatic Plant Monitoring: Data and Issues from Waneta Lake* Presentation at the Northeast Aquatic Plant Management Society Annual Meeting. Saratoga Springs, NY.

Martin, Michael R. 2004. *Diagnostic-Feasibility Study and Lake & Watershed Management Plan for Lake Rippowam, Lake Oscaleta, & Lake Waccabuc.* Cedar Eden Environmental, LLC. 93 pp.

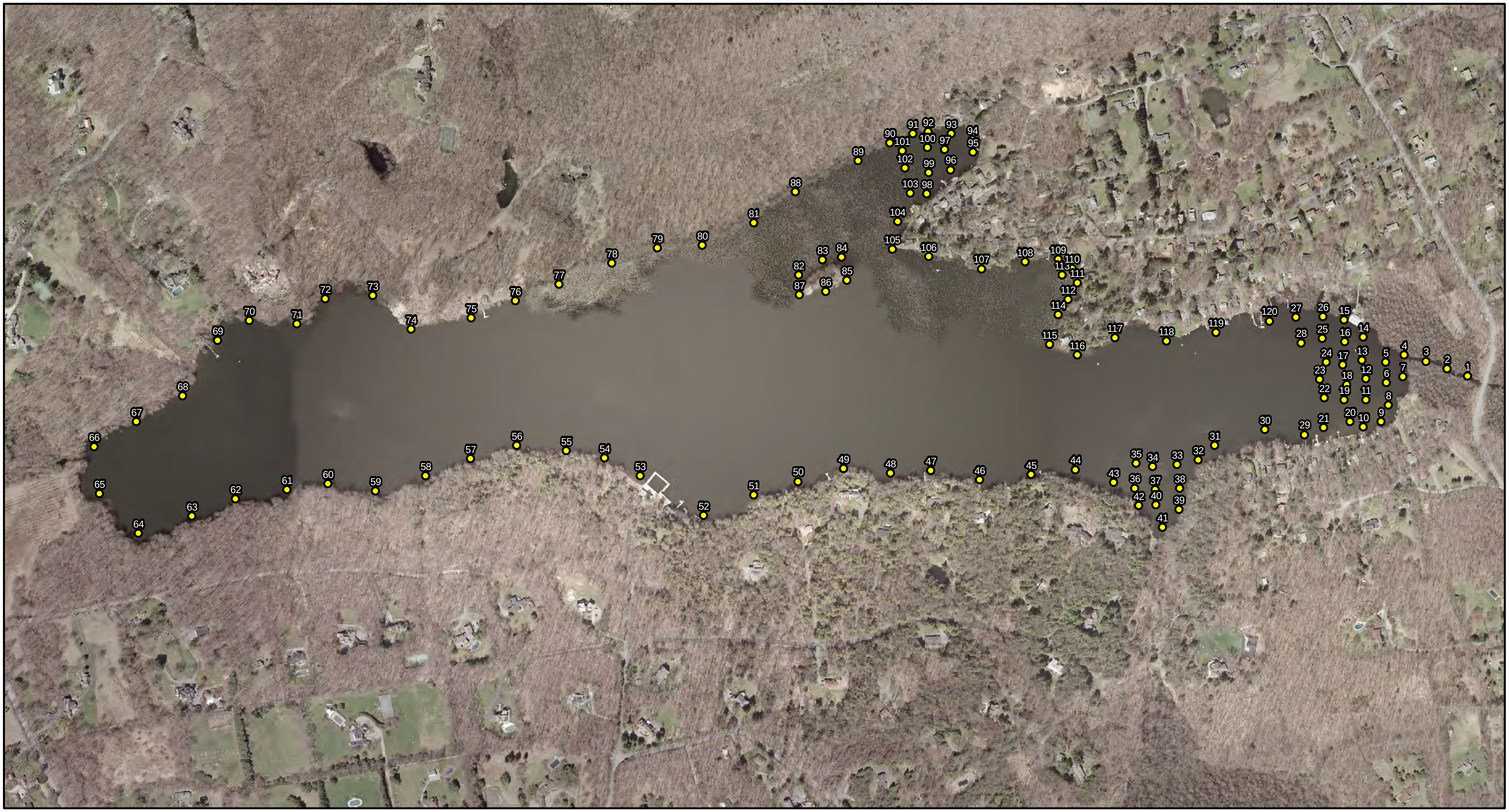
Skawinski, Paul M. 2011. *Aquatic Plants of Wisconsin: A Photographic Field Guide to Submerged and Floating-leaf Aquatic Plants.* 150 pages.

Tarver, et al. 1979. *Aquatic and Wetland Plants of Florida.* Bureau of Aquatic Plant Research and Control, Florida Department of Natural Resources. Tallahassee, Florida.

Young, S. M., and T. W. Weldy. 2006. New York Rare Plant Status Lists. New York Natural Heritage Program, Albany, NY. May 2006. 67 pages.

# Appendix

# Sample Point Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



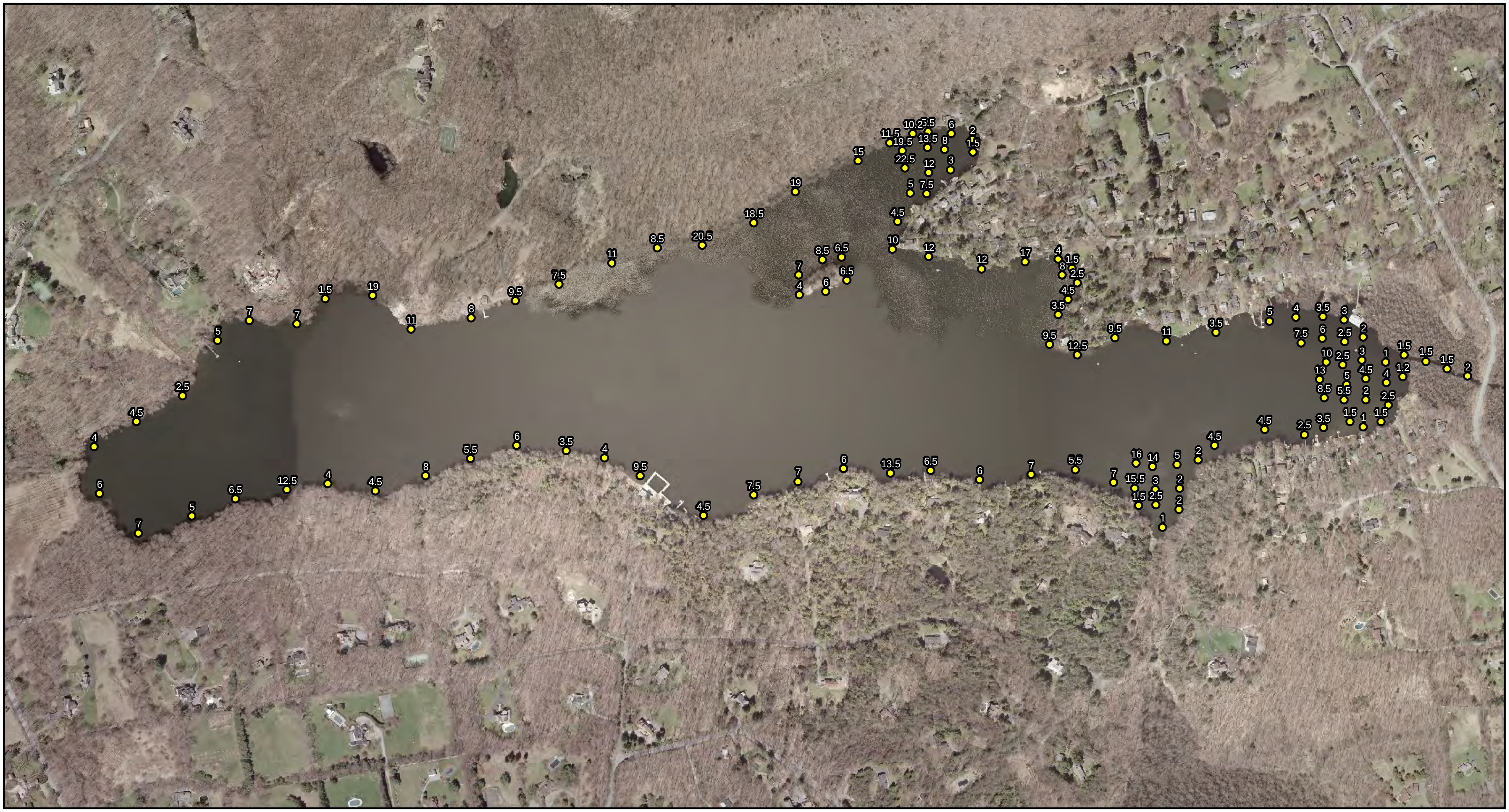

Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

Sample Point

N

0 325 650 1,300 Feet

# Water Depth Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011

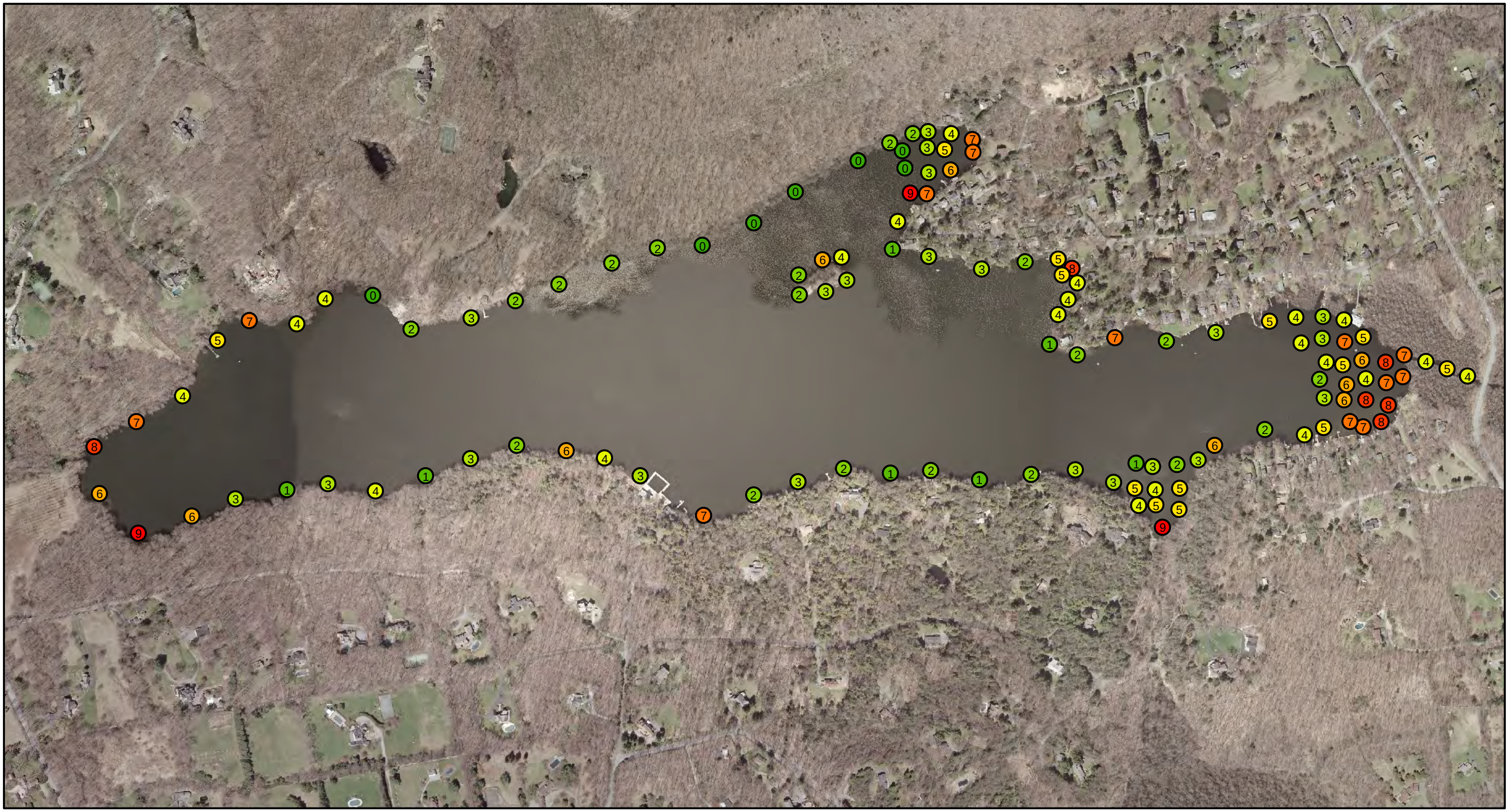


Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

Water Depth in Feet

0 325 650 1,300
Feet

# Aquatic Vegetation Sample Site Richness
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



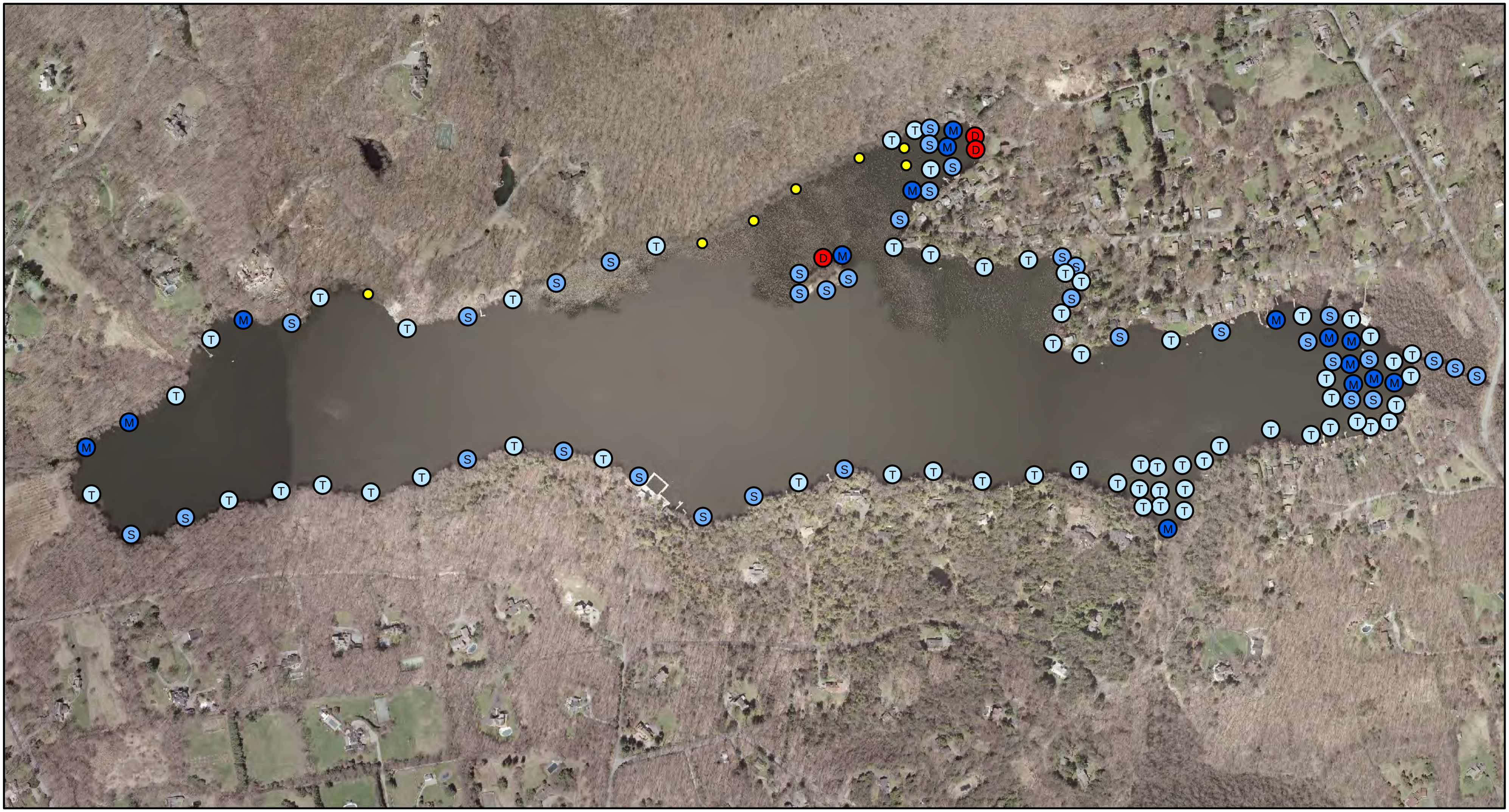
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

**Richness: Number of species/sample site**

0 1 2 3 4 5 6 7 8 9

0 325 650 1,300 Feet

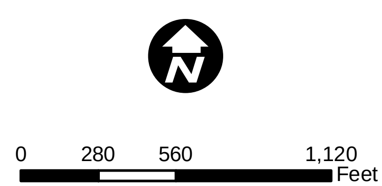
# Total Submersed Vegetation Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



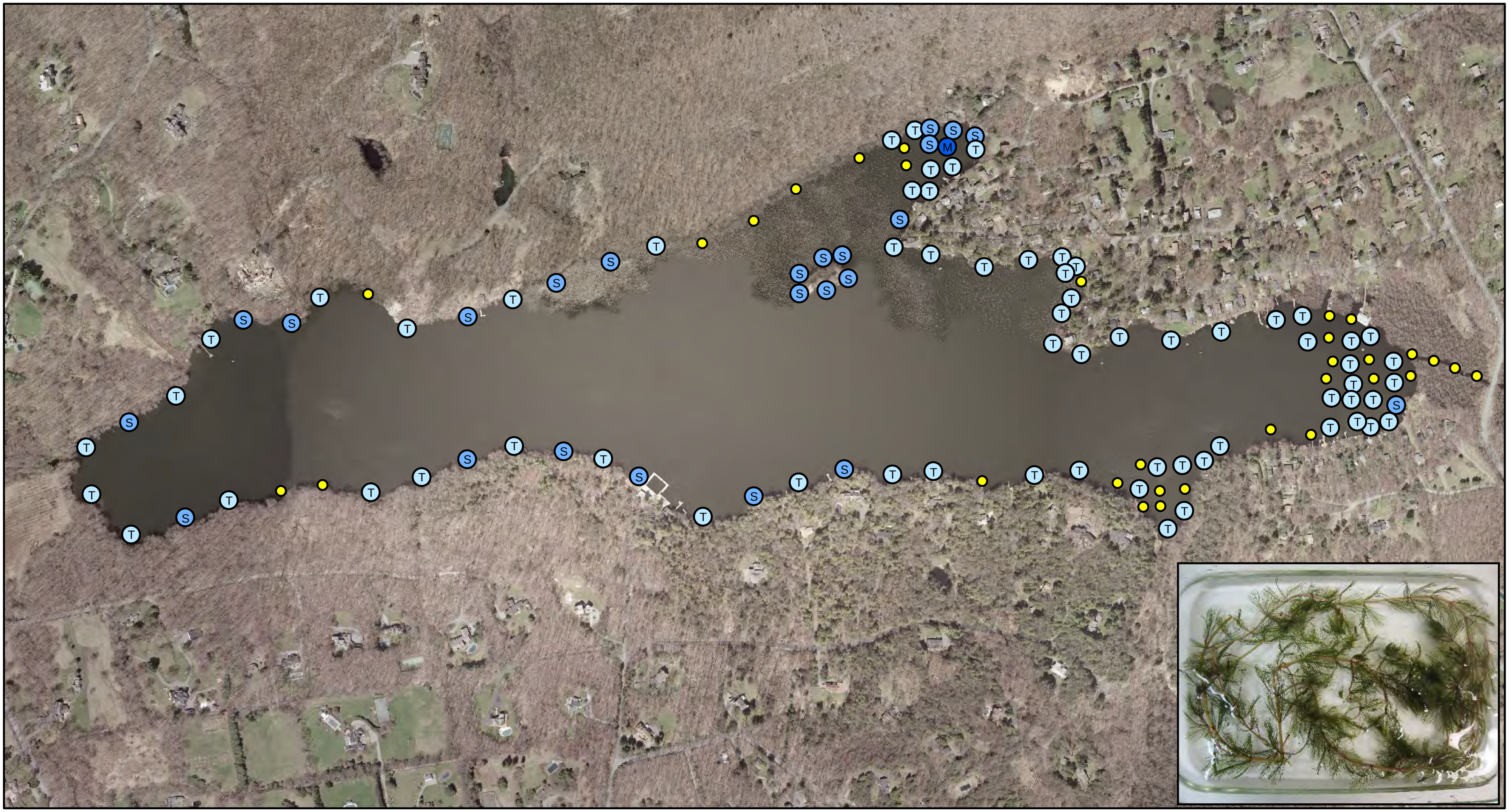
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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



# Eurasian Watermilfoil (*Myriophyllum spicatum*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011





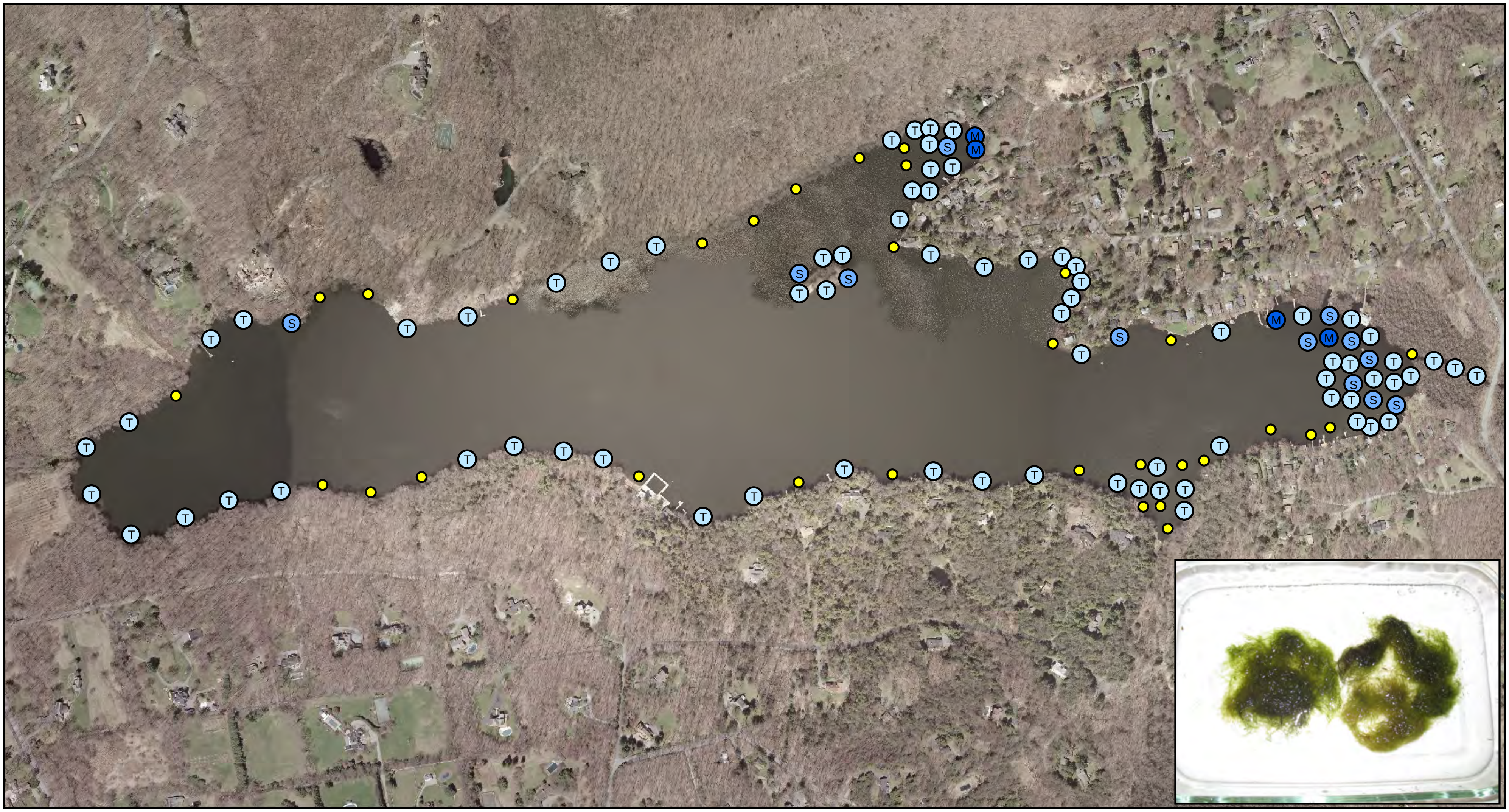
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com


LEGEND

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

0 280 560 1,120 Feet

# Benthic Filamentous Algae Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

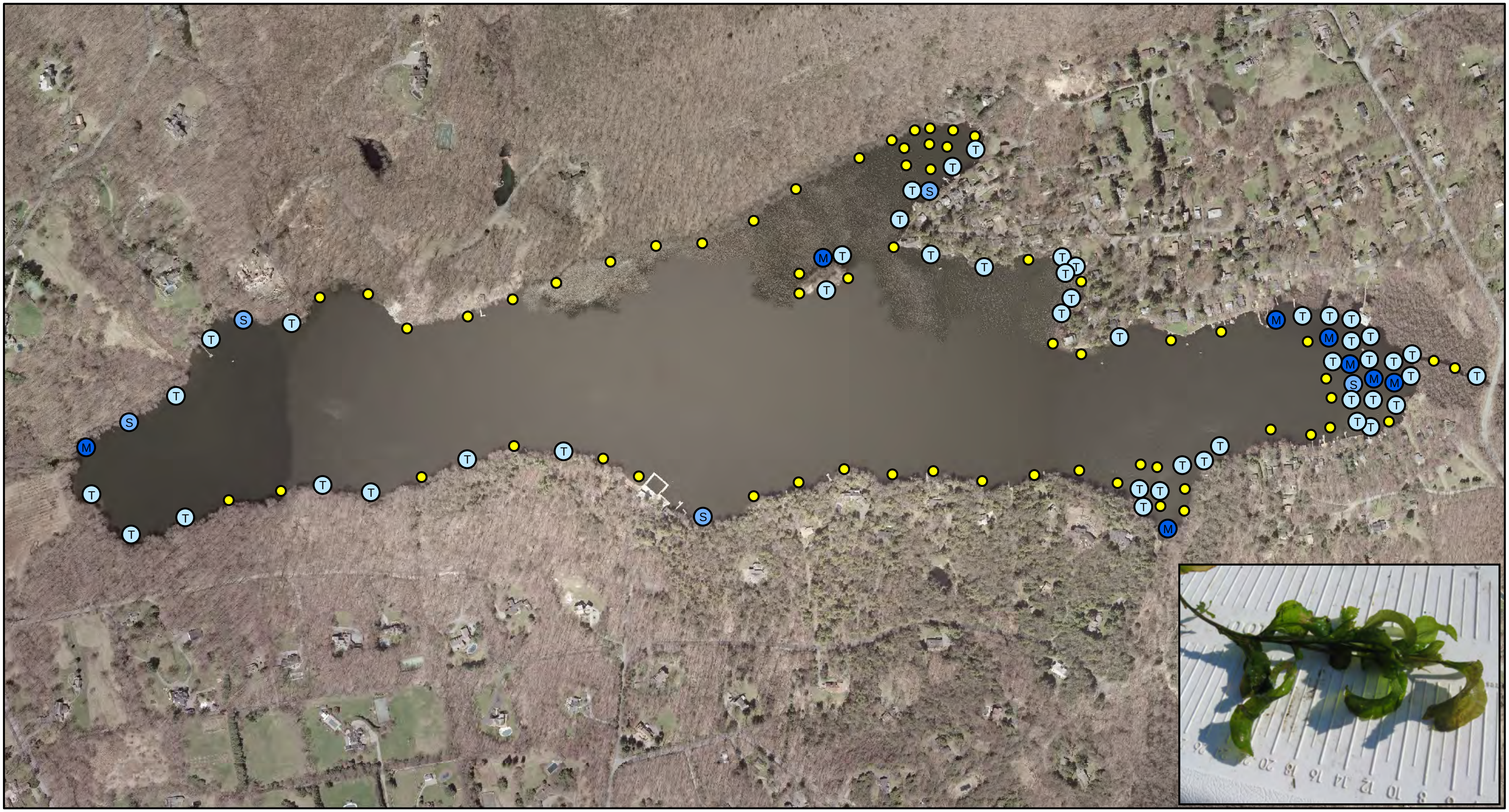
LEGEND

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

N

0 280 560 1,120
Feet

# Bass Weed (*Potamogeton amplifolius*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



Allied Biological

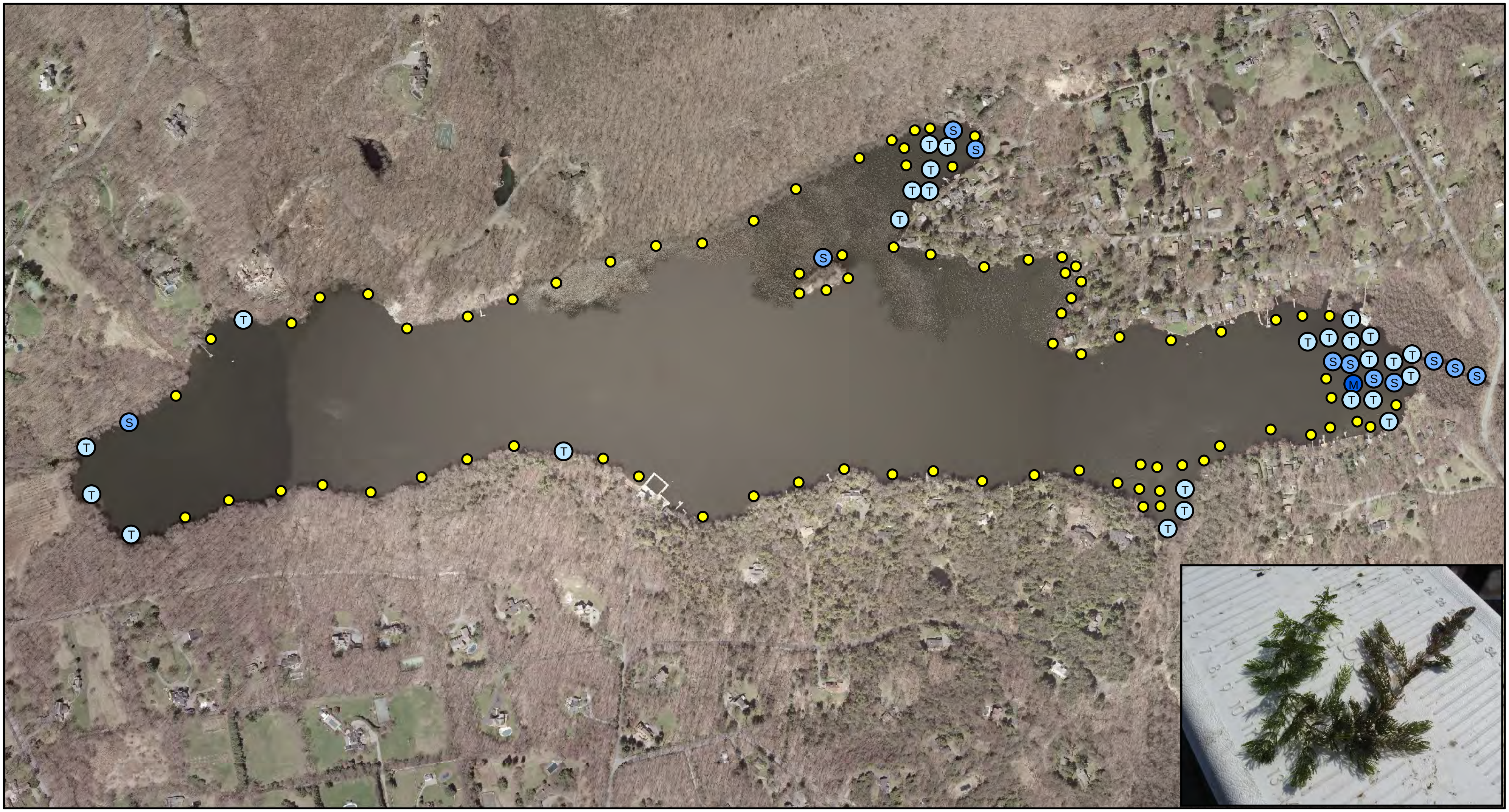
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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

0 280 560 1,120
Feet

# Coontail (*Ceratophyllum demersum*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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

0 280 560 1,120
Feet

# Robbins Pondweed (*Potamogeton robbinsii*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011

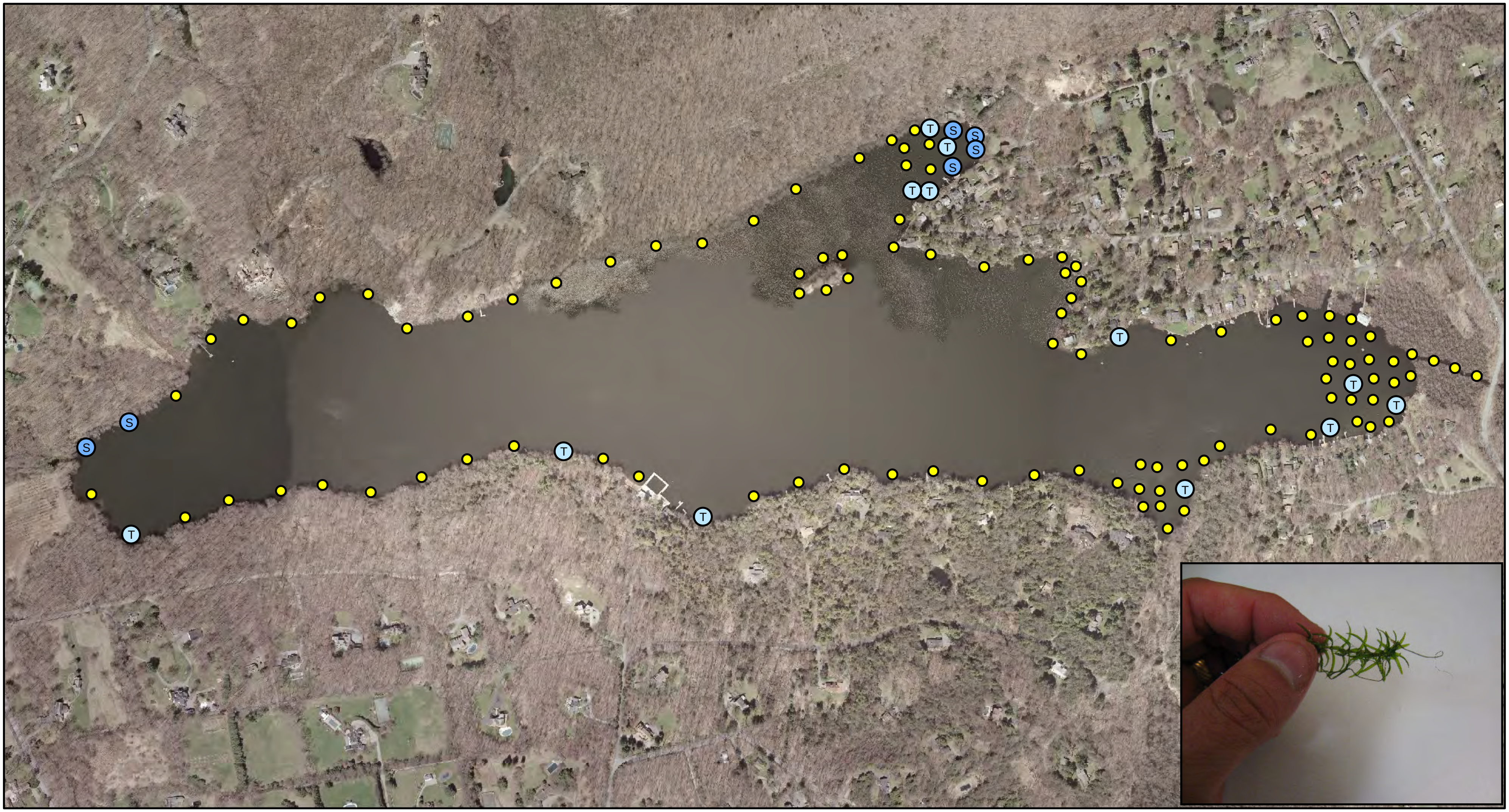
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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

0 280 560 1,120 Feet

# Common Waterweed (*Elodea canadensis*) Distribution
## Lake Waccabuc Aquatic Vegetation Survey
## July 20 and 21, 2011



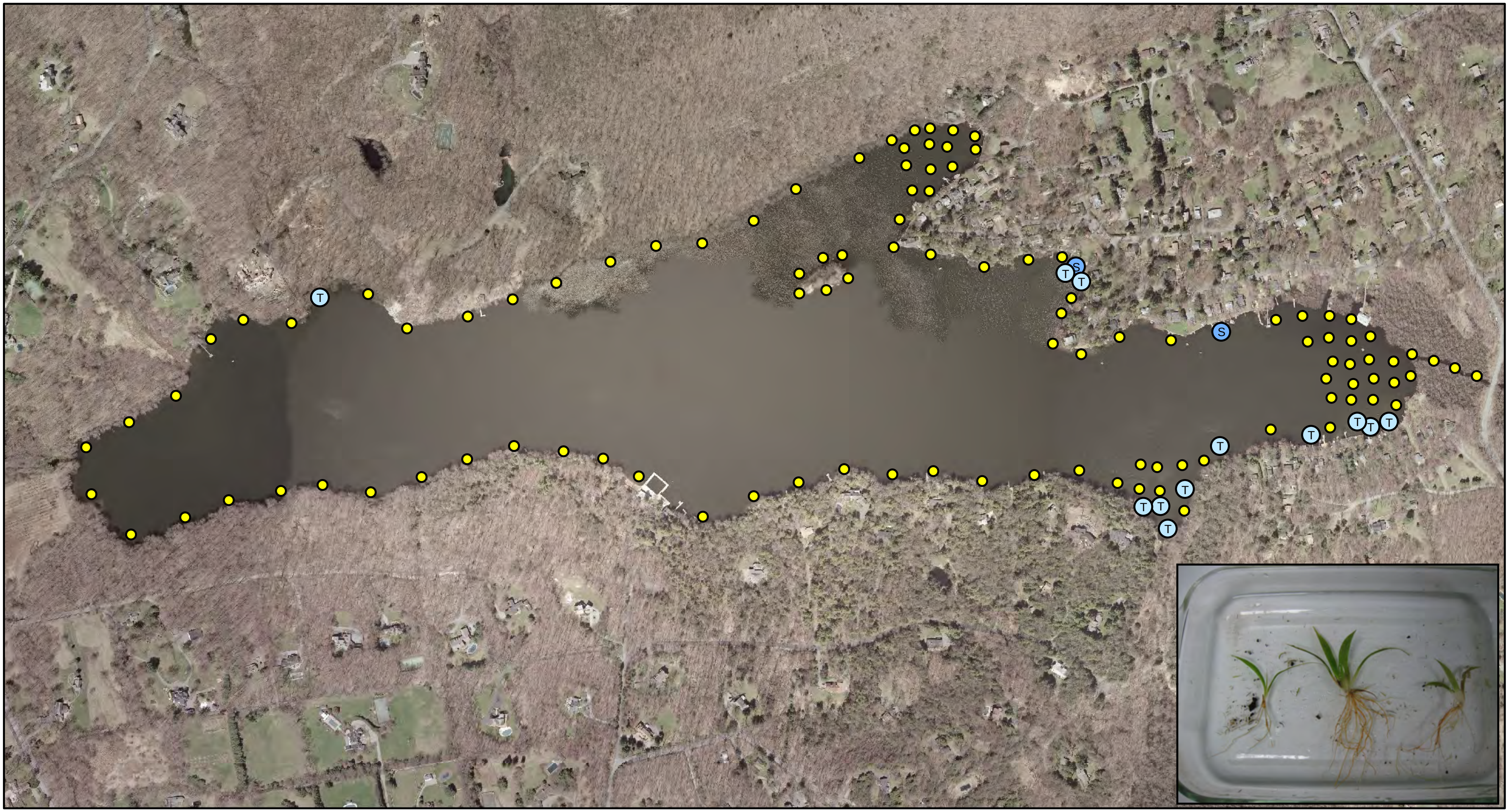
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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

0 280 560 1,120 Feet

# Arrowhead Rosette (*Sagittaria* sp.) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011




LEGEND

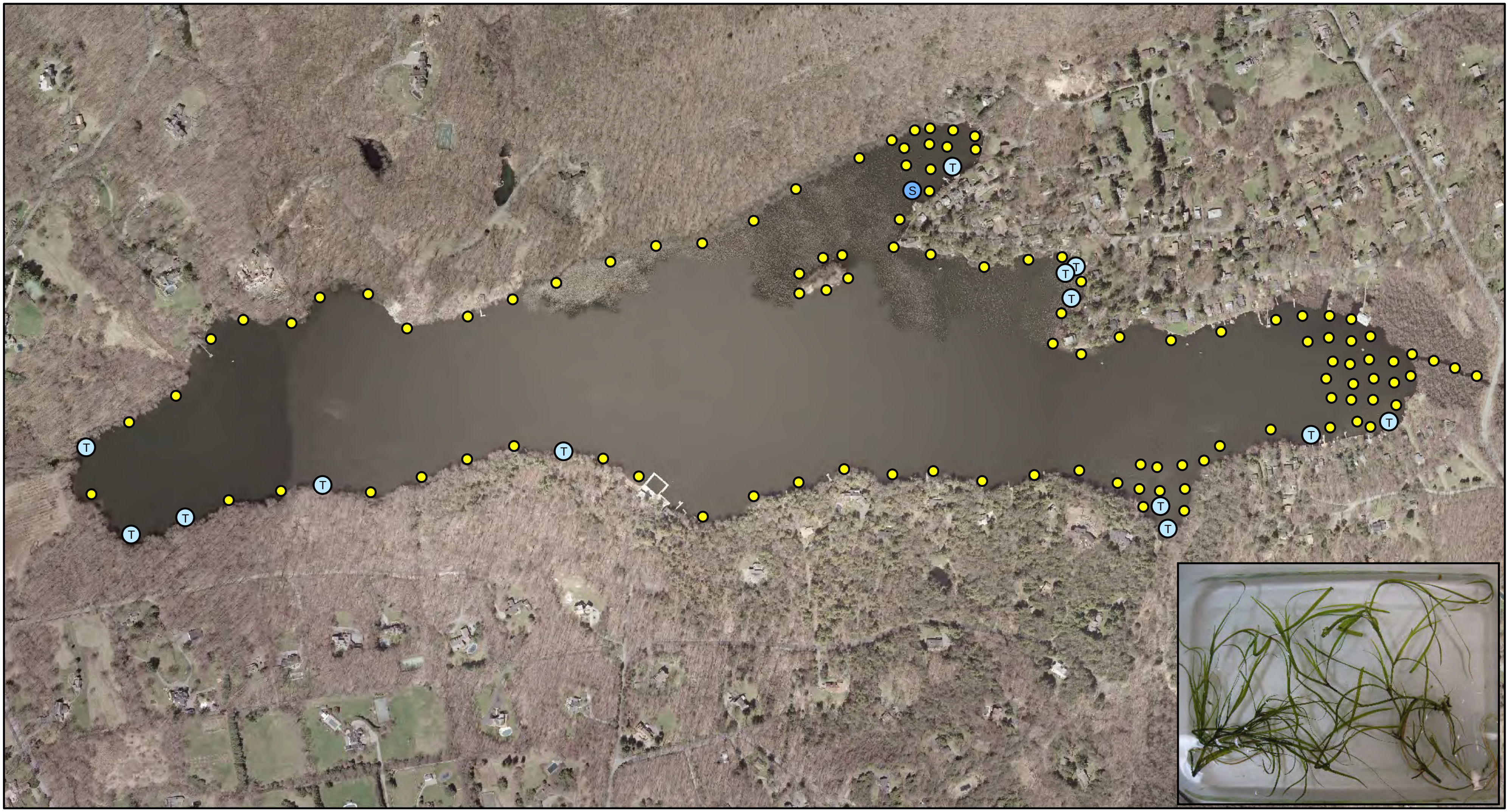
- (yellow dot) = No Plants
- T = Trace Plants
- S = Sparse Plants
- M = Medium Plants
- D = Dense Plants

0 280 560 1,120 Feet

N

Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

# Water Stargrass (*Zosterella dubia*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



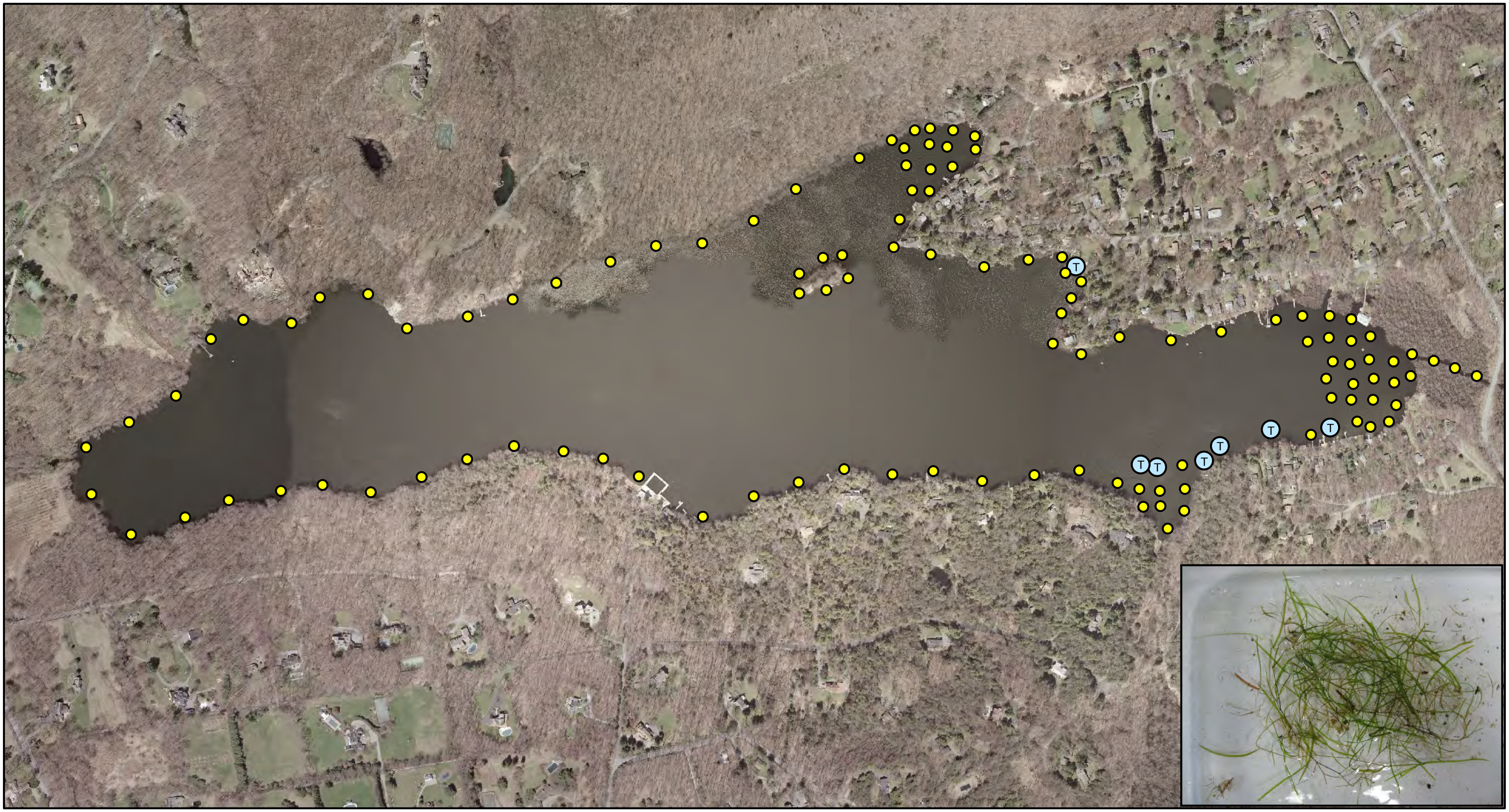
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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

0 280 560 1,120 Feet

# Leafy Pondweed (*Potamogeton foliosus*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

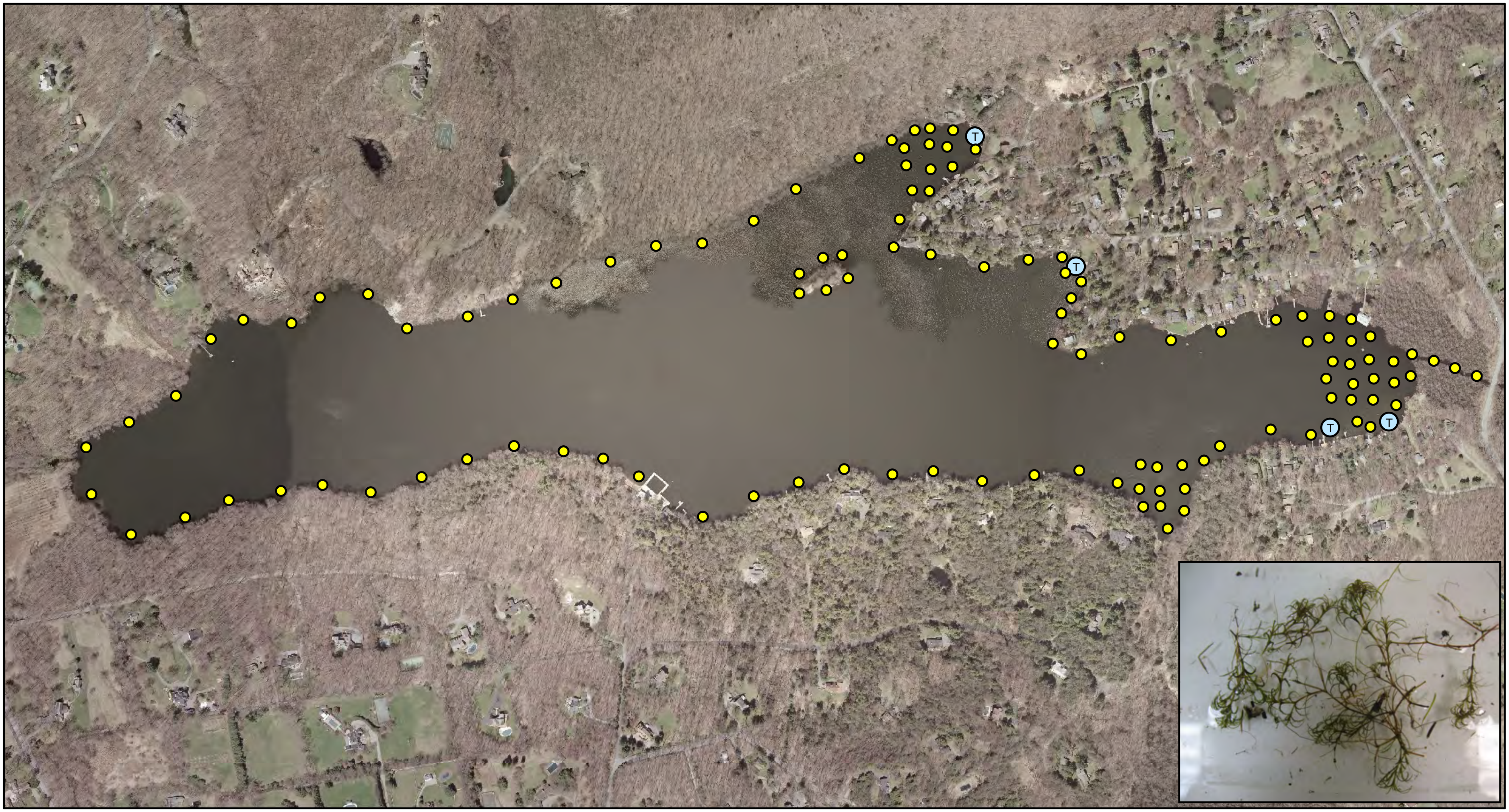
LEGEND

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

N

0 280 560 1,120 Feet

# Brittle Naiad (*Najas Minor*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011




Allied Biological

580 Rockport Road • Hackettstown, NJ 07840

800-245-2932 • www.alliedbiological.com


LEGEND

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

0 280 560 1,120 Feet

# Spiral-fruited Pondweed (*Potamogeton spirillus*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011


Allied Biological

580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

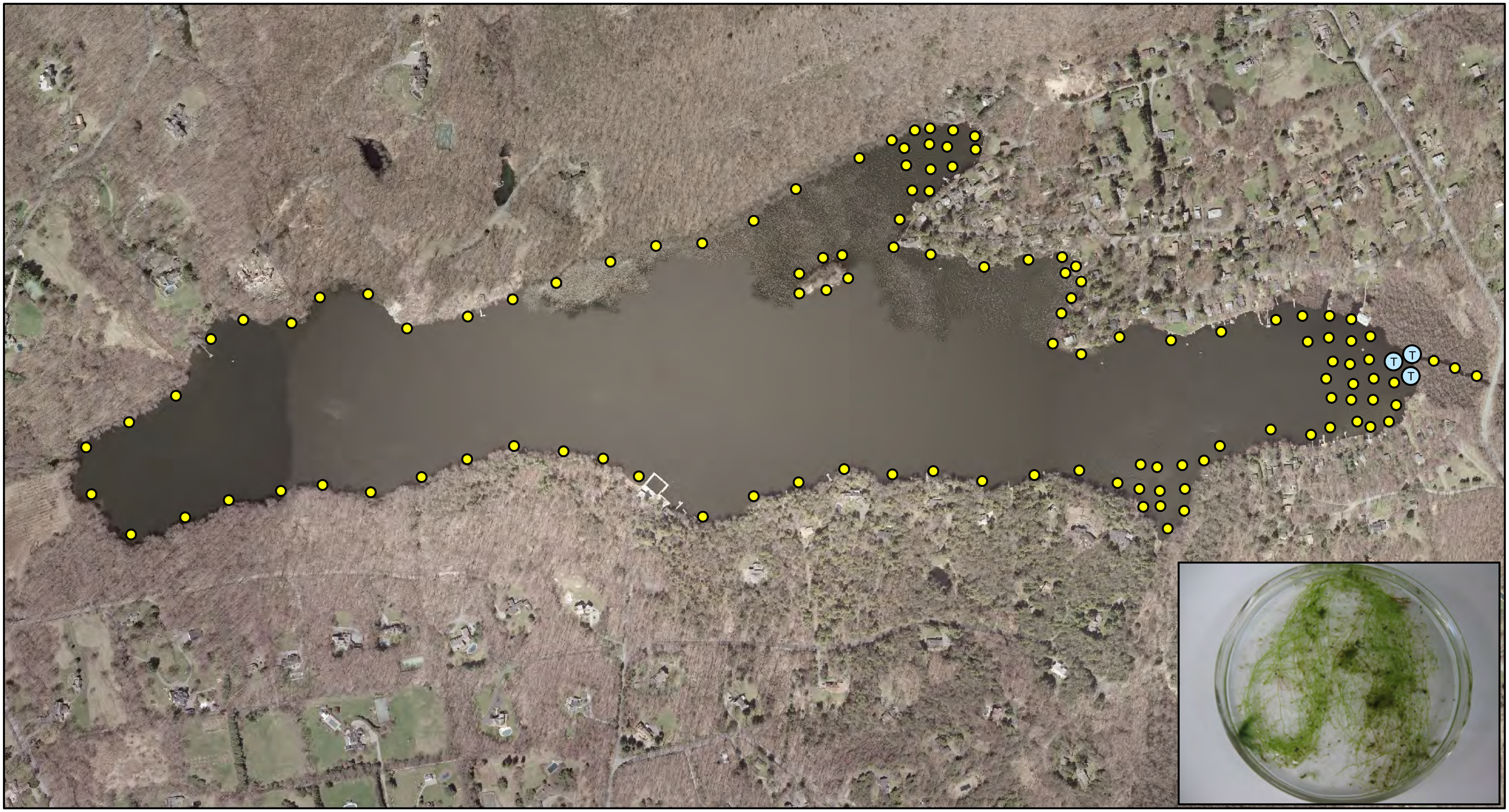

LEGEND

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

N

0 280 560 1,120 Feet

# Creeping Bladderwort (*Utricularia gibba*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011





Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com


LEGEND

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

N

0 280 560 1,120 Feet

# Dwarf Water Milfoil (*Myriophyllum tenellum*) Distribution
## Lake Waccabuc Aquatic Vegetation Survey
## July 20 and 21, 2011



Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

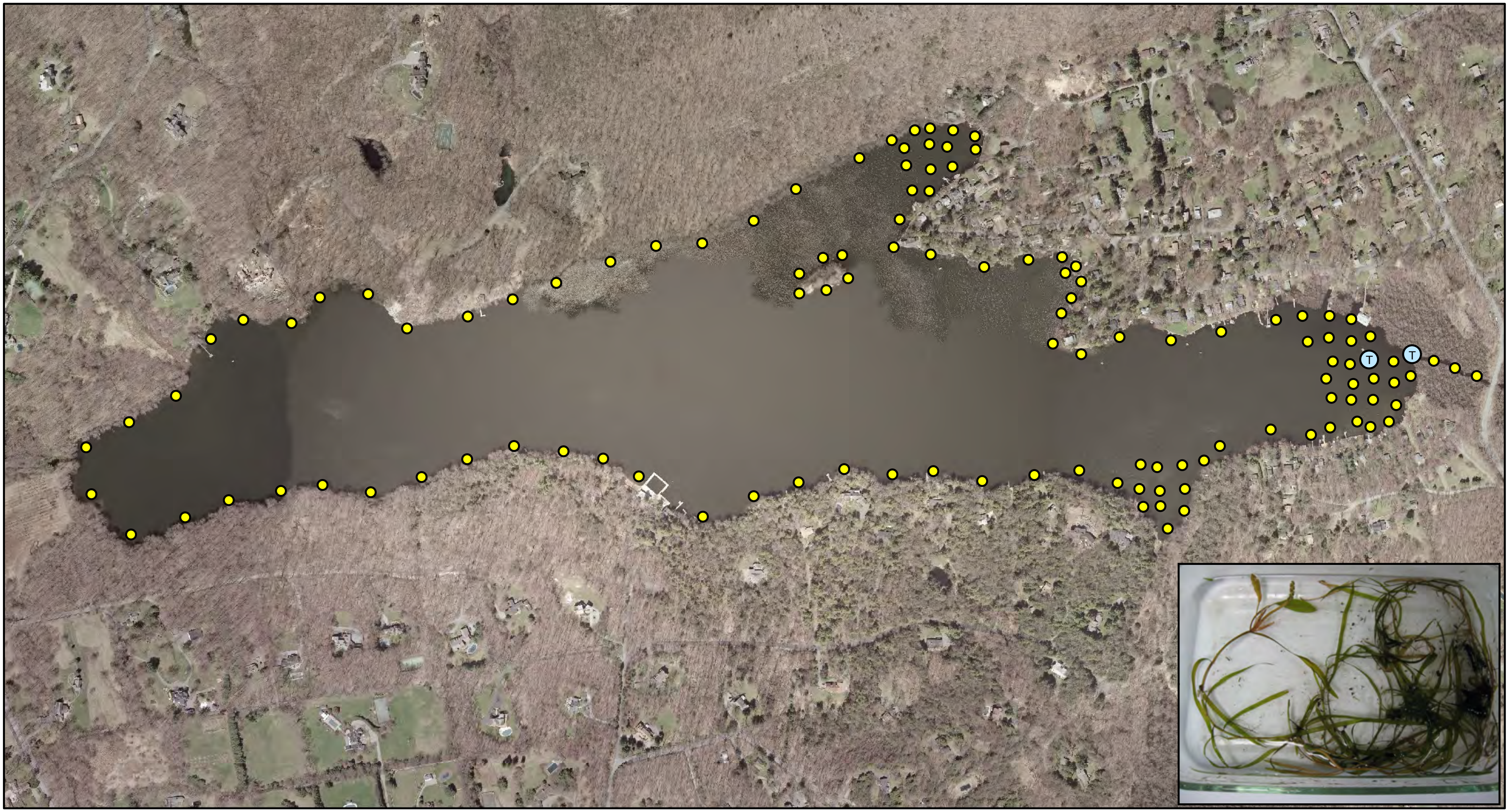

LEGEND

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

N

0 280 560 1,120 Feet

# Ribbon-leaf Pondweed (*Potamogeton epihydrus*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011





Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

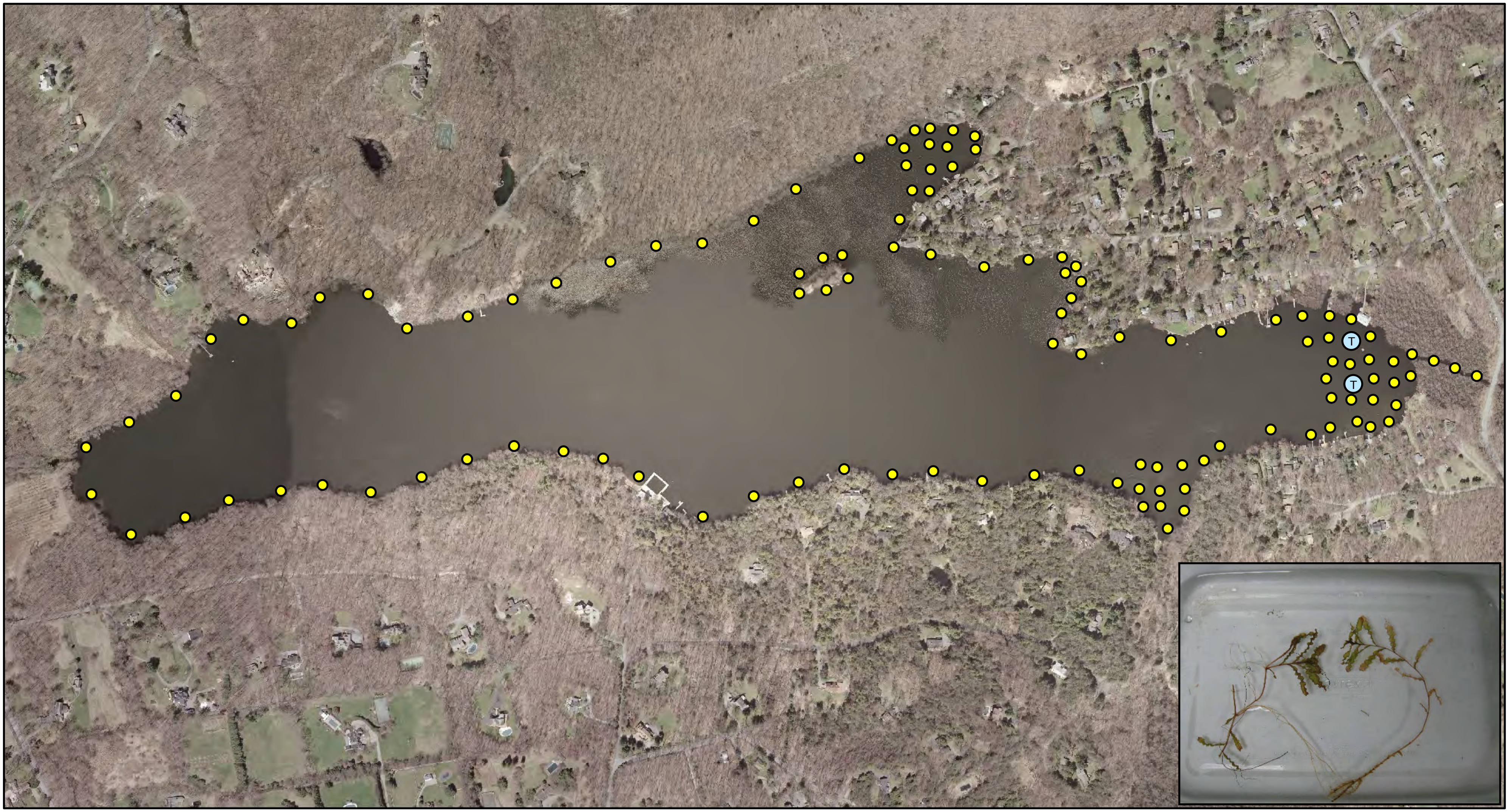

LEGEND

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

N

0 280 560 1,120 Feet

# Curly-leaf Pondweed (*Potamogeton crispus*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011





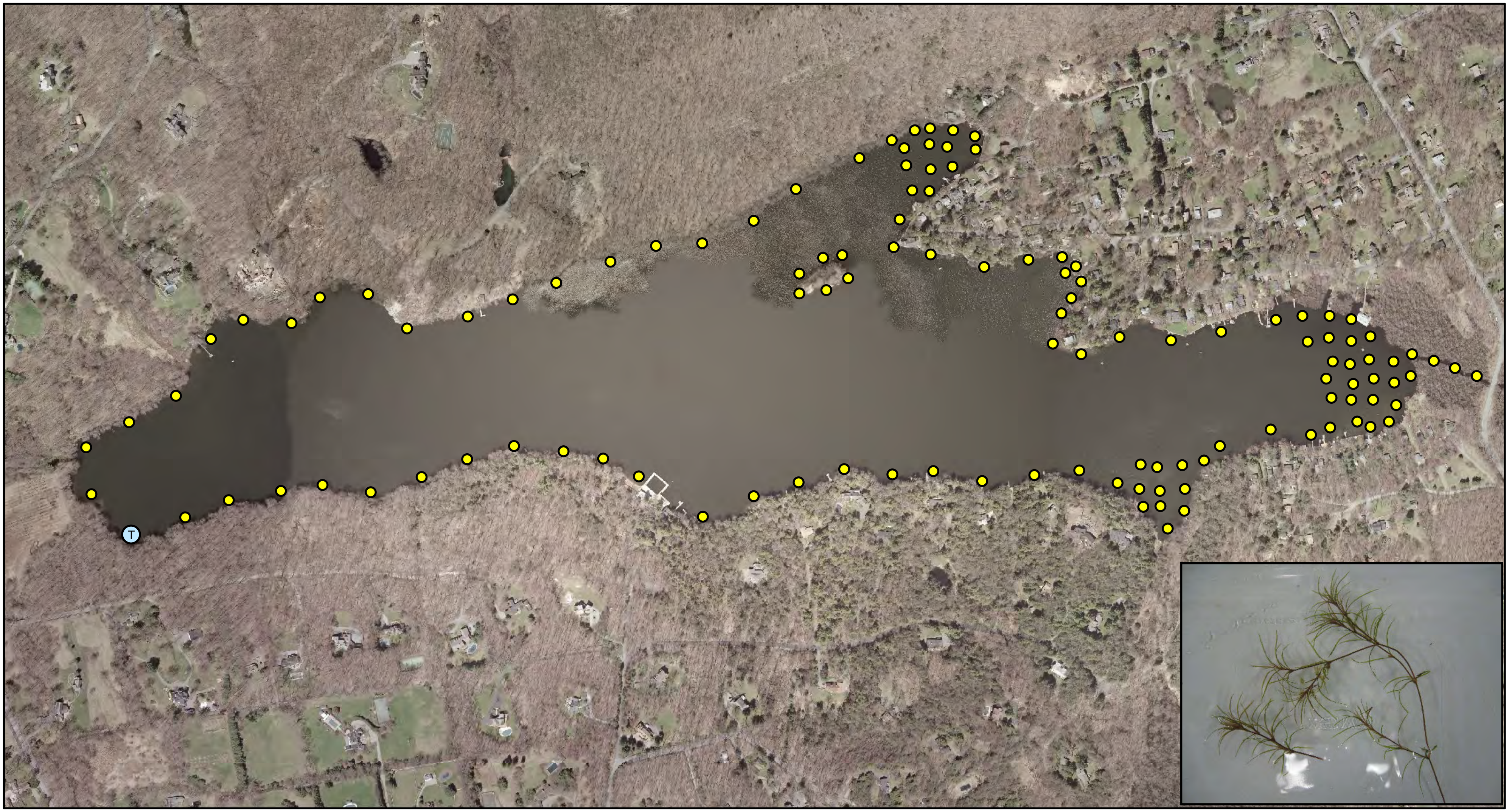
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com


LEGEND

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

0 280 560 1,120 Feet

# Slender Naiad (*Najas flexilis*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011




Allied Biological

580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

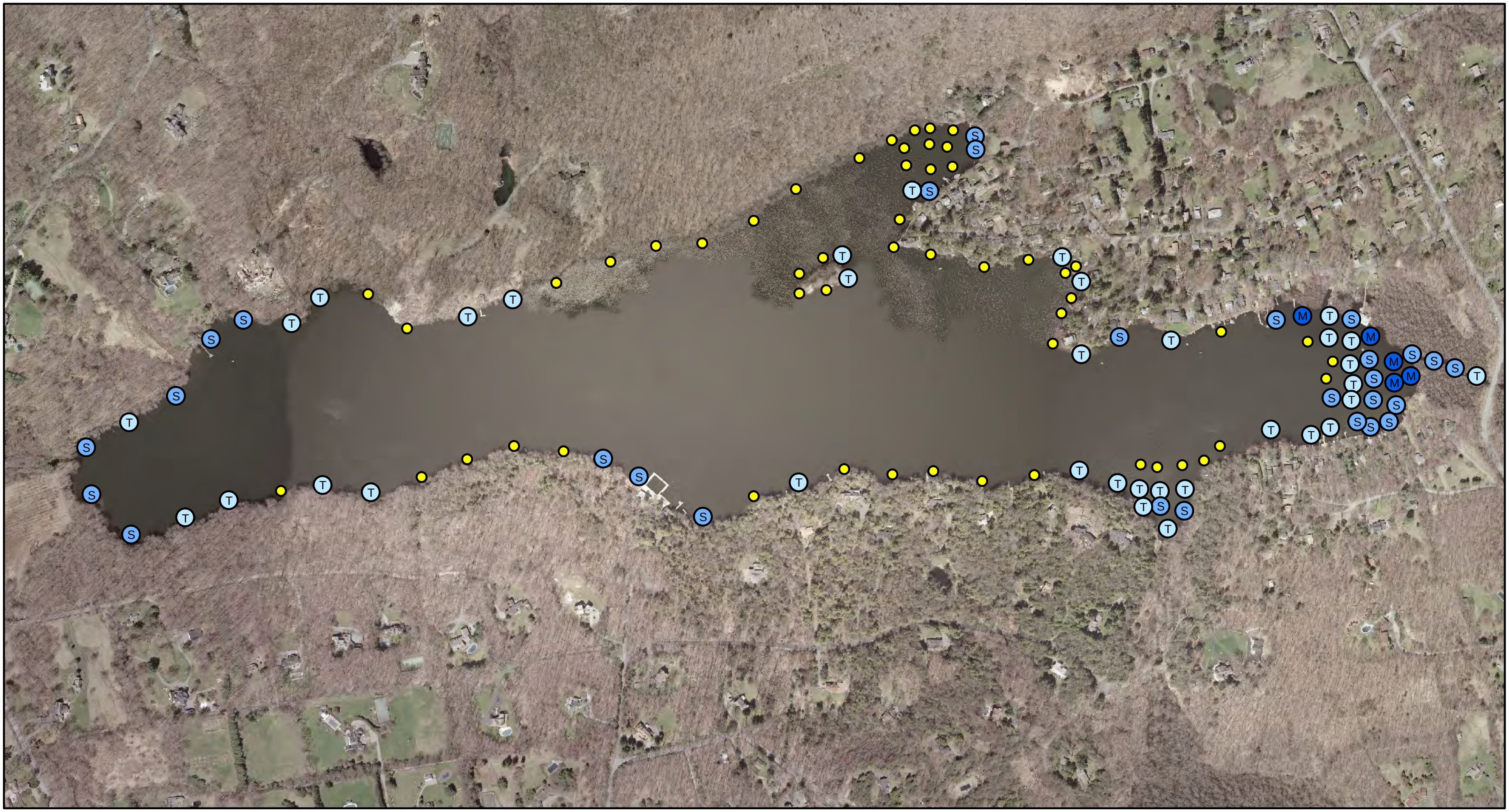
LEGEND

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

N

0 280 560 1,120 Feet

# Total Floating Vegetation Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



Allied Biological

580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

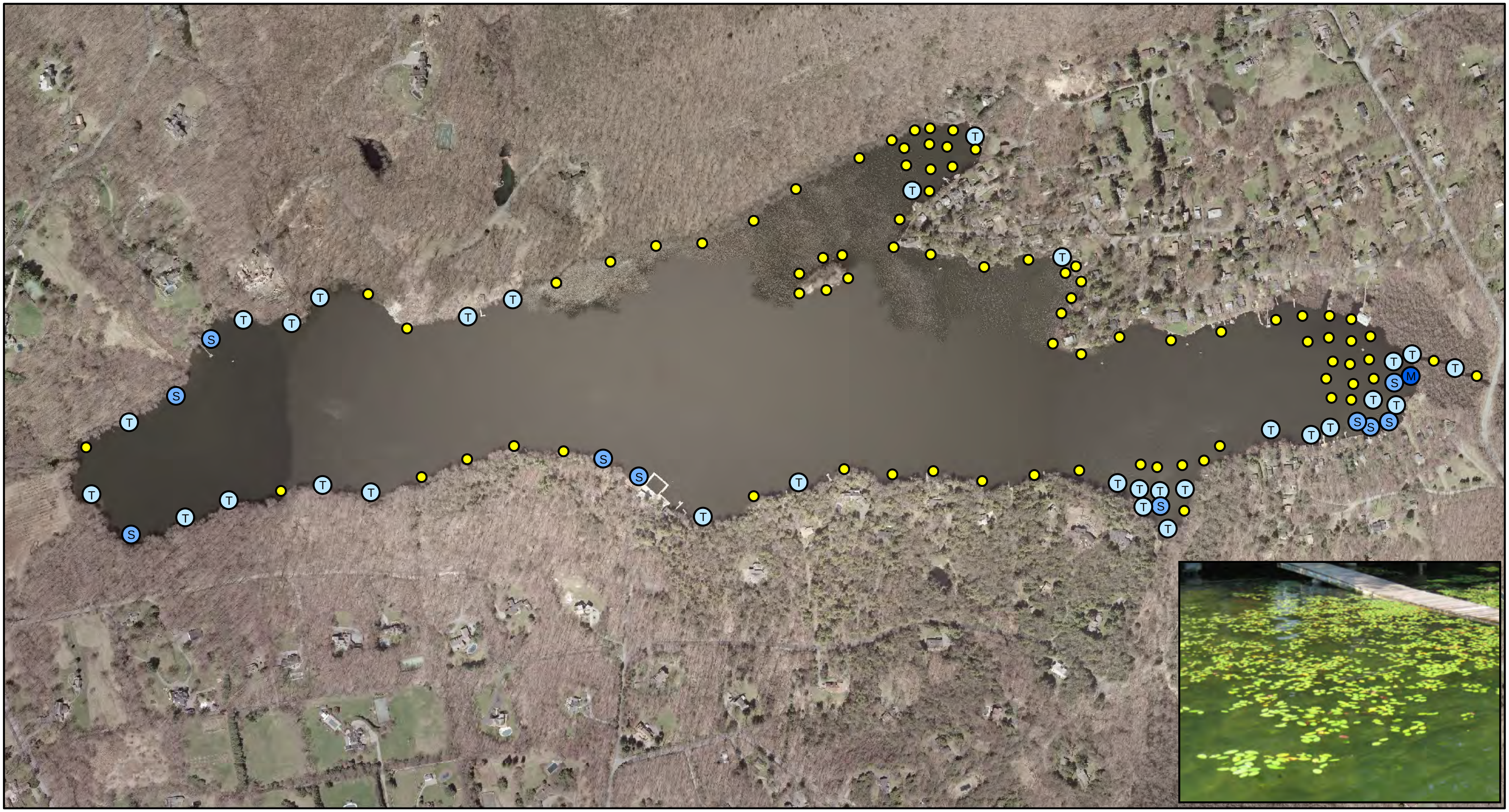
LEGEND

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

N

0 280 560 1,120
Feet

# Watershield (*Brasenia schreberi*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011



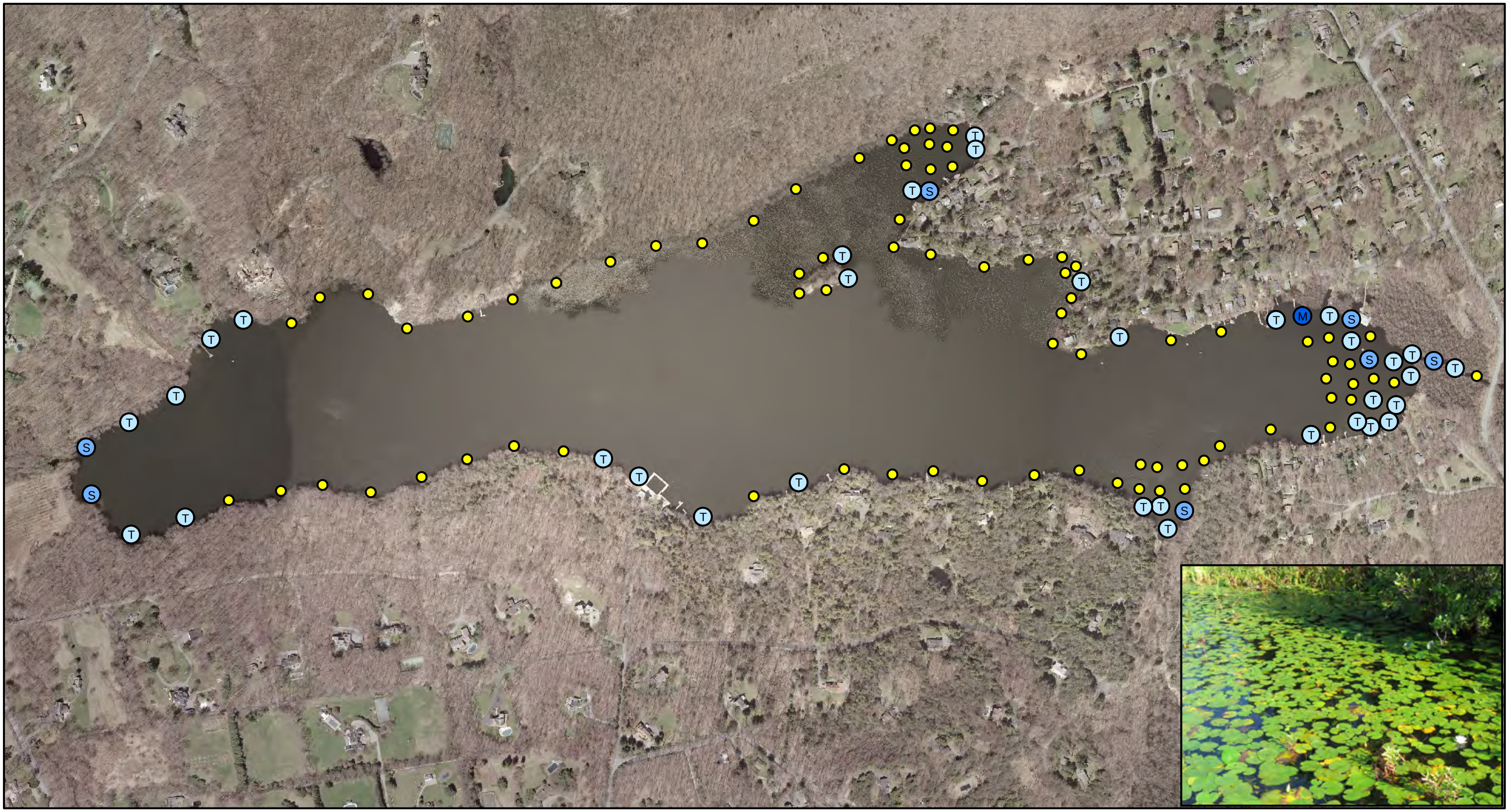
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

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

N

0 280 560 1,120 Feet

# White Water Lily (*Nymphaea odorata*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011





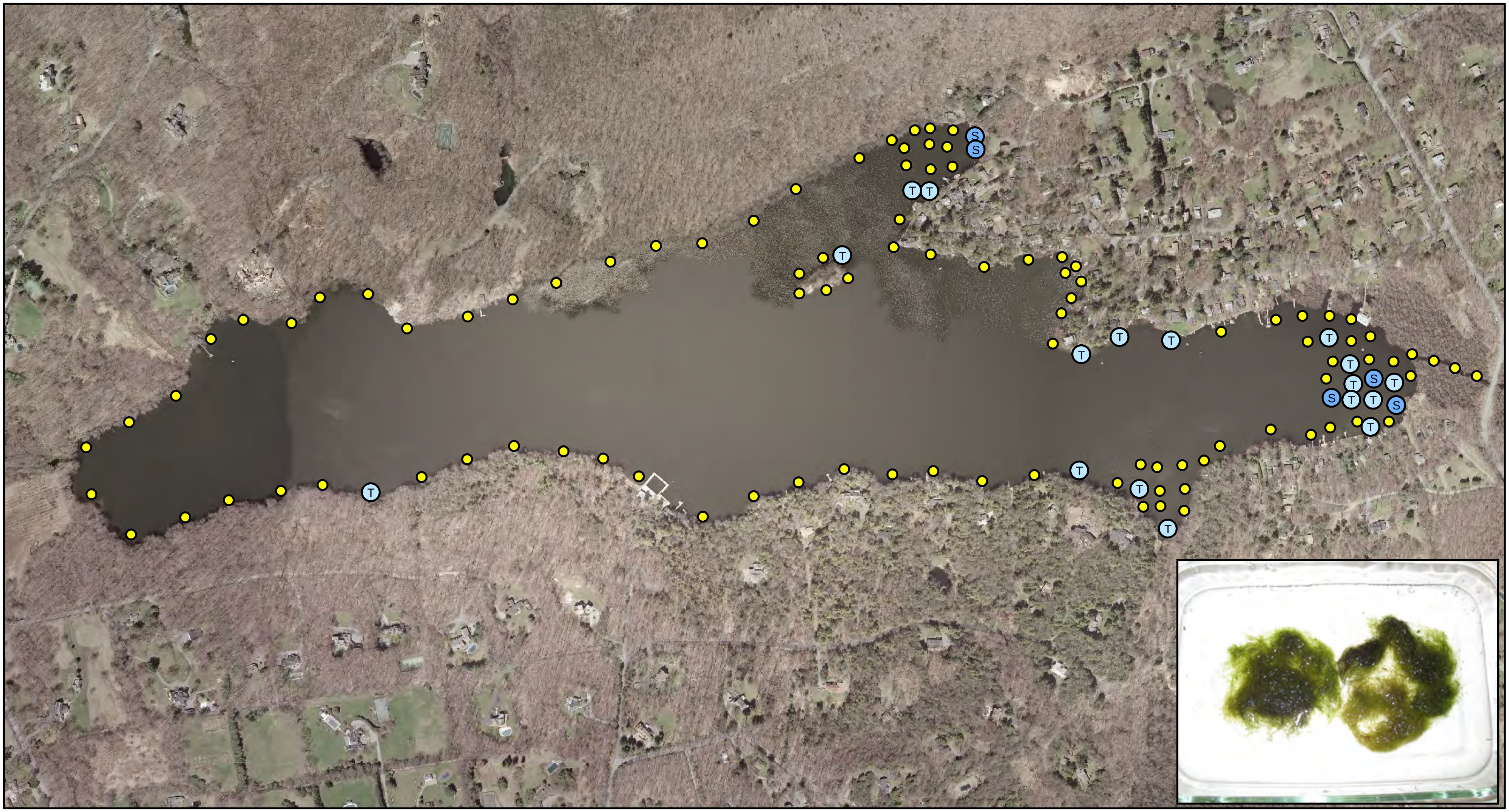
Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com


LEGEND

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

0 280 560 1,120 Feet

# Floating Filamentous Algae Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011




Allied Biological

580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com


LEGEND

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

0 280 560 1,120 Feet

# Spatterdock (*Nuphar variegata*) Distribution
# Lake Waccabuc Aquatic Vegetation Survey
# July 20 and 21, 2011

Allied Biological
580 Rockport Road • Hackettstown, NJ 07840
800-245-2932 • www.alliedbiological.com

LEGEND

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

0 280 560 1,120 Feet