Schroon Lake Comprehensive Aquatic Plant Survey and Management Plan

Prepared for:

The Schroon Lake Watershed Management Plan Steering Committee

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Acknowledgements

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Background

A littoral survey for Eurasian watermilfoil (*Myriophyllum spicatum*) was undertaken in Schroon Lake, Warren County, NY from July-Sept 2011 by Lycott Environmental Inc. This work follows surveillance work conducted by Scout volunteers and a private firm (AE) in previous years of active milfoil management. Recent contracts have been through the three Towns (Schroon –lead, Chester and Horicon--supported). The current survey effort was a product of the Schroon Lake Watershed Management Plan Steering Committee and designed to confirm previously mapped milfoil sites as well as to locate any unmapped beds or areas of growth.

The current survey was conducted after extensive scouting and harvesting had been underway for several weeks in summer 2011. This is noteworthy as we may list a site as scattered (as observed) but was a very dense site only weeks prior. I will focus primarily on the Lycott survey results, but when appropriate will refer to recent Scout or AE mapping/harvesting operations.

Water body Description

Schroon Lake is considered an upper oligotrophic to lower mesotrophic lake (depending upon metric used to quantify trophic state). It has a surface area of 4,105 acres, ~24 miles of shoreline, and is situated within a 202,575-acre watershed. The watershed is primarily composed of forest (84%), but has substantial development along its shores. The shores of Schroon Lake are shared between the towns of Schroon, Chestertown and Horicon. The lake surface is around 808 feet elevation, though varies due to lake level control by Starbuckville Dam. The lakeshore is developed, including private residences, public areas (state & local parks, beaches, state boat launch etc) and 10 towns within its watershed; the largest of which is the Town of Schoon Lake on the northwest shore.

A comprehensive watershed management plan was published in 2010; a more thorough water body description can be found there (visit http://www.warrenswcd.org/reports.html to view a copy of that report).

Ecology of Eurasian Watermilfoil

Eurasian watermilfoil (hereafter milfoil) was unintentionally introduced to the United States from Eurasia, and was first identified in Washington, D.C., in 1942 (Remaley 2009). The species is a perennial dicot of the family Haloragaceae, and is typically found in greatest abundance in mesotrophic or slightly eutrophic lakes at depths less than five meters. However, the species can tolerate low alkalinity systems to hard-water lakes, and trophic states from eutrophic to oligotrophic (Madsen 1998). Plant growth is nitrogen limited (Smith and Barko 1990). Milfoil presence is influenced by turbidity, and is limited to the photic zone of water bodies (Smith and Barko 1990). Stems can grow to the water surface from depths of 10 meters if water clarity is high enough. Stems of milfoil are long, slender, branching, hairless, and become leafless toward the base. The grayish-green leaves of milfoil are finely dissected and occur in whorls of three or four along the lighter colored stem, with 14-24 pairs of fine, thin leaflets about .5 inch long

(Madsen 2005, Remaley 2009). These leaflets give milfoil a feathery appearance that is a distinguishing feature of the plant (Remaley 2009).

Milfoil can live in fresh to brackish water of rivers, reservoirs, natural lakes, and estuaries (Smith and Barko 1990, Madsen 2005). The species can reproduce sexually by seed production through the formation of a short inflorescence above the water surface composed of both pollen-forming and seed-bearing flowers that are wind pollinated (Smith and Barko 1990, Madsen 2005). However, the plant more commonly reproduces through vegetative production of rhizomes and stem fragmentation (Madsen et al 1988, Smith and Barko 1990). Rhizomes can spread the species a few meters by extending the root system in the sediment, but stem fragments can be transported long distances because they can survive for long periods of time before establishment (Madsen 2005). Stem fragmentation is the most important means by which the species spreads both within and across water bodies. Fragments are created through abscission of the stem through autofragmentation, which typically occurs after plants reach the surface (Madsen et al 1988, Smith and Barko 1990). In Adirondack lakes the highest fragmentation rates have been observed in late September (Madsen et al 1988). Within lakes and river systems, currents are thought to be the primary mode of transport within and across water bodies (Kimbel 1982). Recreational boat traffic is thought to be a mechanism of intra-lake dispersal, as weeds are often tangled in anchors and propellers. This is considered mechanical fragmentation, and humans can unintentionally transport mechanically fragmented segments between water bodies in bilge water, fish buckets, or even on shoes and clothing. Vegetative reproduction alone likely accounts for most milfoil spread within North America (Smith and Barko 1990).

Reproduction and growth strategies make the species a threat in many water bodies (Remaley 2009). The plants have shoots that branch profusely when they reach the surface, and can form large, floating mats of vegetation that prevent light penetration for native plants (Madsen et al 1991, Boylen et al 1996). This occurs in areas of high turbidity, where reaching the surface would dramatically increase photosynthetic capacity. Plants in clear waters do not generally extend to the surface (Nichols and Shaw 1986). The species is evergreen and maintains a large biomass throughout the winter, which combined with rapid spring growth once the water temperature reaches 15°C allows the species to reach dominance early in the growing season (Nichols and Shaw 1986). The species has also been shown to increase water temperatures, lower dissolved oxygen levels, and increase nutrient loading from the sediment (Smith and Adams 1986, Unmuth et al 2000). These changes in resources can effectively alter the diversity and richness of plant, macroinvertebrate, and fish assemblages (Valley and Bregiman 2001, Cheruvelil et al 2002). Monotypic beds may decrease the diversity of native aquatic plants and can drive local extinctions (Madsen et al 1991, Boylen et al 1999). This will impact food web structure and ecological stability of an invaded water body.

In addition to altering ecosystem function, milfoil affects recreation by interfering with swimming and boating and reducing the aesthetic appeal of water bodies. Alterations to fish populations may also impact the value of sport fisheries. Dense populations may alter discharge, sedimentation, and impart an unwanted taste and odor to the water, (Smith and Barko 1990, Madsen 2005), which may specifically affect water intake for local residents. Therefore, the ecological alterations caused by a milfoil invasion could have negative economic impacts on the local tourism industry and for the residents of the lake.

Milfoil Management History in Schroon Lake

Record keeping early on in a new aquatic plant management program often takes second place to actual in-lake management efforts. Despite honest efforts to keep track of management activities and results, the evolving organizational structure around such programs can lead to a difficult reconstruction of such management data after the fact. As such, the current report will not attempt to document year-to-year efforts of past management, but will compare our findings to all other findings (AE and Scout data) available. Original reports are likely available from AE, the Town or Schroon and/or the SLA. Here, we will instead focus primarily on the current status of milfoil growth in Schroon Lake and make recommendations for the best management strategy for future efforts.

Milfoil has been in area lakes at least as early as the mid 1980's (established beds documented in Lake George in 1985) and likely moved into Schroon Lake shortly thereafter (boats and boat trailers are well known vectors for the spread of aquatic organisms). *M. spicatum* was first documented in Schroon Lake in 1995, inspections started in 2000 and by 2006, 27 infestations were mapped. Active management (removal) of milfoil did not commence until June 2006.

While tens of thousands of milfoil plants have been removed from Schroon Lake over the course of it's management history, site data on the location and annual amounts of Eurasian watermilfoil removed are not available in a way that can be meaningfully analyzed for patterns to aid us in the future direction of management. However, much progress has been made from past efforts, and we are now at a point where we can be more strategic in our efforts to maximize gains made from future efforts. Additionally, up to date, comprehensive maps of the distribution *and* abundance of milfoil (particularly and annual series of pre and post-management maps) would help to measure progress made against methods used at a given site so that alternative methods could be considered at sites where progress has been less than desirable.

To that end, ESSLA and SLA have created a Milfoil Scout volunteer monitoring program where ca. ½ mile reaches of coastline are 'adopted' by scouts and visually surveyed from watercraft at least once per season. The most recent map from that program is presented in Figure 1a. This program could be a tremendous aid to active management if real-time coordination could be increased between scouts, program directors, and those conducting in-lake milfoil management. The more observers available to locate milfoil, the more complete our knowledge of the true distribution of the plants will be. However, the Scout program data shows only presence/absence data, with little-to-no indication of abundance, bed size, or other habitat characteristics (which can be important in management planning).

One directive from the Watershed Management Plan was to obtain the most comprehensive distribution/abundance map of milfoil feasible, and to use that as the basis of the future milfoil management plan. Lycott Environmental Inc was contracted to conduct the survey, create a current map, and develop a comprehensive milfoil management plan. The remainder of this report will be to present the methods employed, the findings (maps) and to provide recommendations for the direction of milfoil management in Schroon Lake going forward.

Figure 1a. Scout map zones.

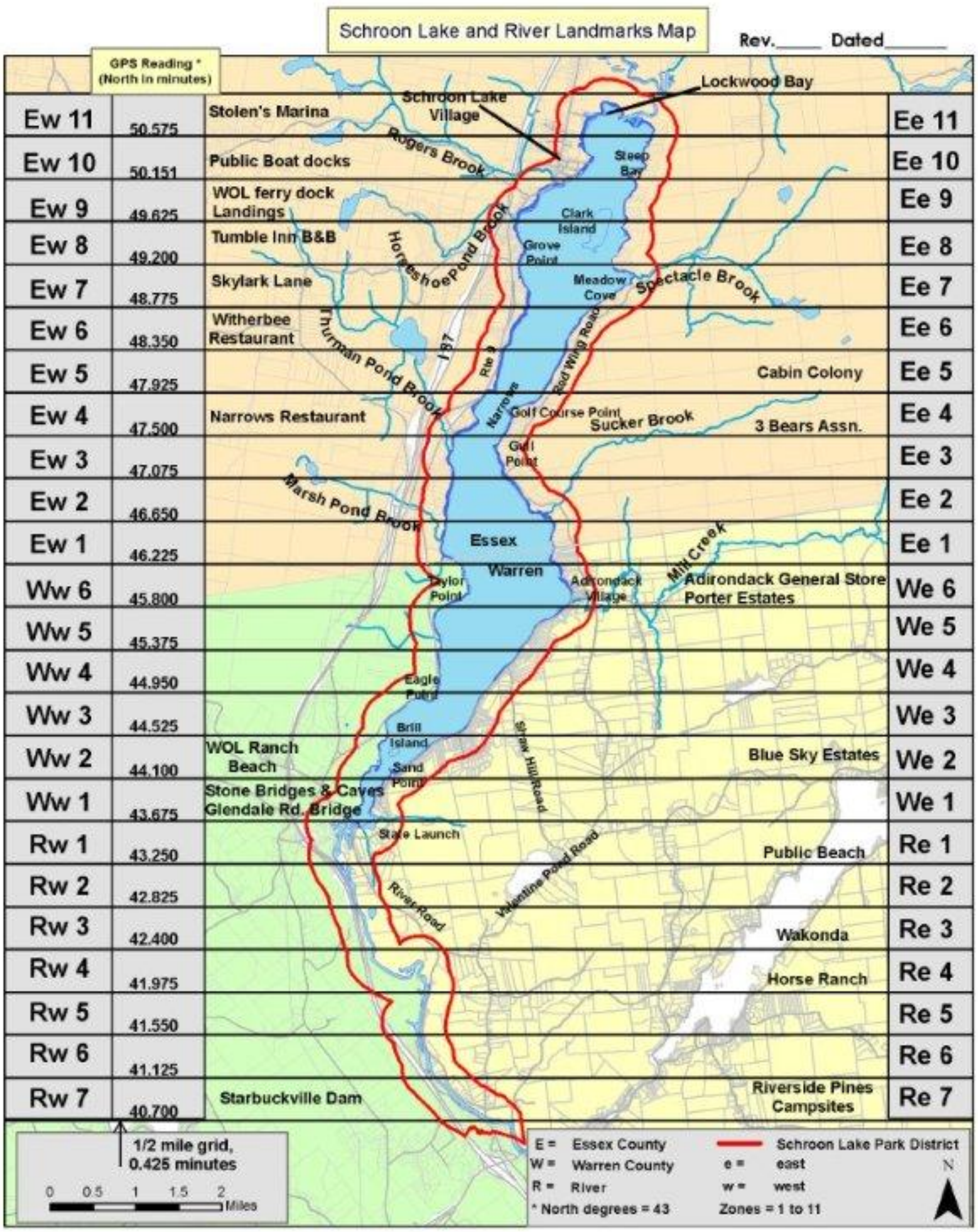
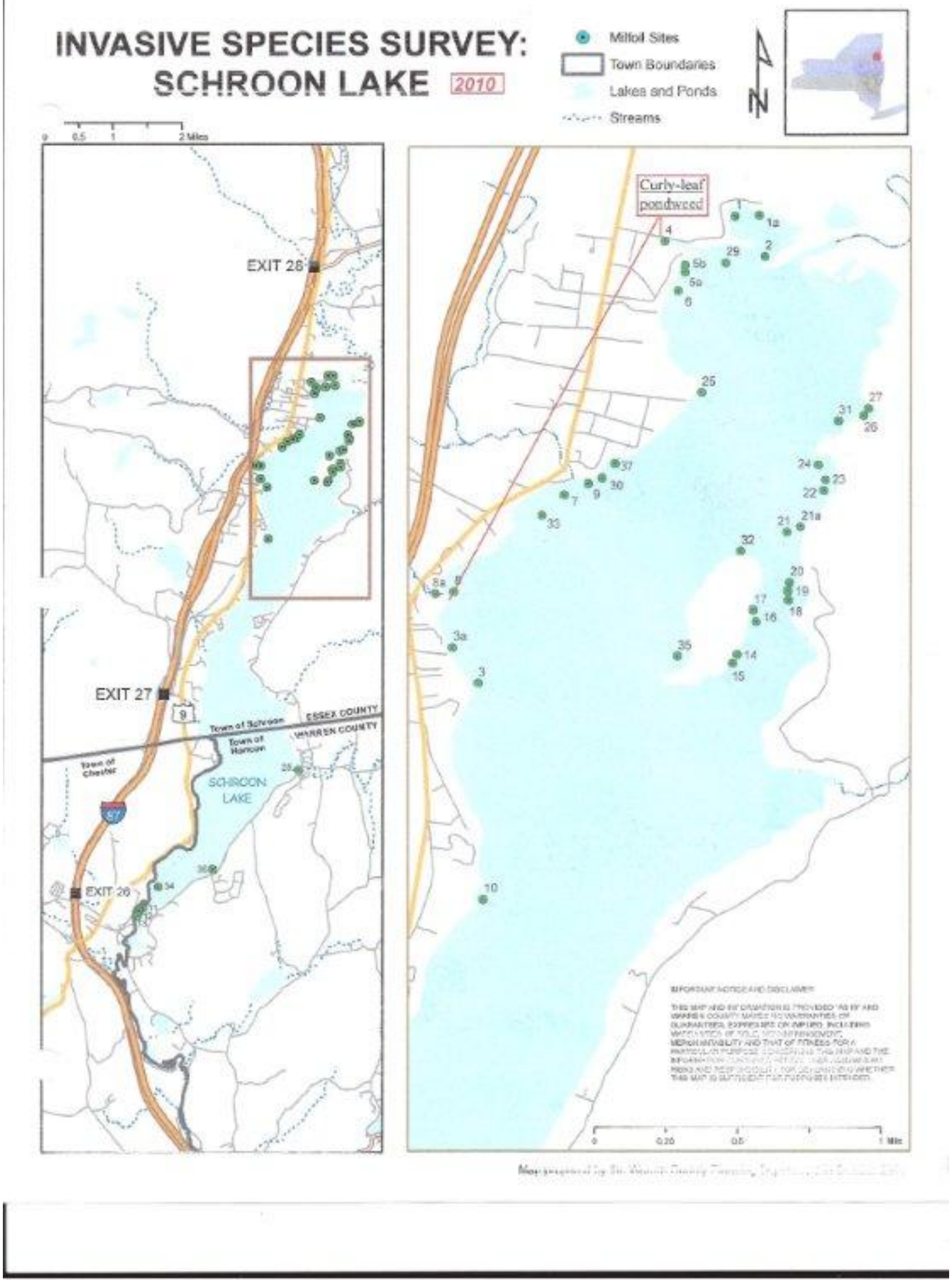


Figure 1b. AE 2010 EWM Map.



2011 Survey Methods

Many ecological survey methods have been developed and the details of any one method employed should take into account the habitat type surveyed, known ecology/biology of the target species, physical/logistical limitations the surveyors will encounter, and of course the goal of the survey. Rarely can we employ methods to locate every single individual of a target species at a particular time and in a particular survey area. Instead most ecologists rely upon one or more techniques that take a reasonable number of samples over a timeframe appropriate to the species in question and employ one or more statistical approaches to better understand the abundance and/or distribution of a species.

For submerged aquatic plant surveys, time of day (angle of sun relative to observer), amount of cloud cover, speed and direction of wind, water current, clarity and depth, other plants present, and the speed an observer is moving relative to water all impact the quality of the data gathered. Thus no single survey attempt can possibly locate all individuals of a target species unless the species is large, the survey area small, and time is unlimited. We have exactly the opposite on all counts with milfoil where the individual plant is very small compared to the area to be surveyed, and of course resources are always limited. Nonetheless, we can reasonably extrapolate from our observations and extensive experience of milfoil microhabitat preferences and produce a map that shows actual plants found as well as likely distribution of additional milfoil around those documented plants.

While the details of survey methods will vary by species etc, all must rely upon sound ecological principals and that the level of precision in the interpretation of the data match that of the efforts employed. There will certainly be variation across the individual scouts in terms of effort (amount of time spent in that ½-mile survey) and variation in individual's ability to correctly identify the target species. Nevertheless, the maps created of the lake to date do highlight many problem areas within the lake. Based upon Scout map data, past AE EOY reports, as well as the stated goal of the current survey, Lycott employed a modified, visual linear transect survey approach both from above the water (by boat) and in the water (by diver).

A diver snorkeled four, six-mile transects roughly parallel to shore while surface support conducted a transect survey ca. 50'-100' lakeside of the diver. This allows for two, simultaneous and roughly parallel linear transects along the littoral zones. All 24 miles of shoreline were surveyed in this way. In addition to the shoreline surveys, in bays and at tributary inputs multiple transects were done at ~ 50' intervals. This was usually accomplished by an unassisted diver, but in some cases was conducted by use of 'man-tows'-- a process where the diver is towed, at a rate not more than 3 mph, behind the boat to cover larger open areas.

Finally, as a modification on this approach, as dense areas of milfoil were encountered the diver would use a handheld GPS to map the boundaries of the beds (red or orange areas in Figures 2-10). This additional step allows us to consider alternative management approaches on a site-by-site basis (as opposed to having only presence/absence data within an area). This information also allows us to better create a time-budget for management at each site.

Lycott Survey Findings

In total, we located 15 scattered sites, 8 moderately-dense sites and 13 dense bed sites (Figures 2-10 and Appendix A). However, as many beds were nested within larger infested areas, only 18 sites were enumerated (Table 1). Within some of these sites individual beds were further mapped and labeled as sub-sites (e.g., Site 4 is a large area of scattered milfoil plants, within that site there are two small, but dense beds; 4a and 4b) (see Table 1, Figure 7 and Appendix A).

Table 1. Site numbers and sub-sites (beds within a larger site), location (WGS84), Lycott 2011 observations by site, Historical observations by sites (AE and/or Scout data), and Management Options for 2012-2014. HH= hand harvest, BB= benthic barrier, Renovate= herbicide. Most sites are located using the approximate centroid of the area and only one waypoint is noted. Sites that are more elongate are marked by two waypoints, one at the northern extent (N) and another at the southern extent (S) of plant distributions mapped. (table continues on next page)

Site #	Lat	Long	Lycott 2011 Observations	Scout* and/or AE° Data	Management Options
1	43.734015	-73.806413	Scattered	Dense*°	HH
2	43.733232	-73.759066	Moderate	Scattered*°	HH/Renovate
3 (N)	43.791639	-73.785800	Scattered	None*°	HH
3 (S)	43.787603	-73.786793	"	"	"
4 (N)	43.821204	-73.768740	Scattered	None*°	HH
4 (S)	43.809097	-73.771666	"	None*°	"
4a	43.813145	-73.768233	Dense	Scattered°	HH/BB
4b	43.818573	-73.768053	Dense	None*°	HHBB
5 (N)	43.830196	-73.767604	Scattered	Scattered°	HH
5 (S)	43.823718	-73.768754	"	"	"
5a	43.825593	-73.769498	Dense	Dense°	HH
5b	43.827379	-73.770990	Moderate	Dense°	HH
5c	43.828657	-73.769426	Dense	None*°	HH/BB
5d	43.829349	-73.768829	Dense	None*°	HH/BB
5e	43.829854	-73.768490	Dense	None*°	HH/BB
5f	43.828624	-73.771395	Scattered	Moderate°	HH/Renovate
6	43.834714	-73.757791	Scattered	Moderate°	HH
6a	43.834708	-73.759682	Moderate	Moderate°	HH/BB
6b	43.834612	-73.758727	Dense	None*°	HH/BB
7 (N)	43.839402	-73.751614	Scattered	Scattered*	HH
7 (S)	43.836140	-73.754101	"	"	"
7a	43.838757	-73.752510	Dense	Scattered°	HH/BB
8	43.843966	-73.753353	Scattered	Moderate°	HH
9	43.846146	-73.754073	Scattered	Moderate°	HH/Renovate
10	43.846681	-73.749372	Scattered	None°	HH/Renovate
11	43.837324	-73.740960	Scattered	Scattered*°	HH
12 (N)	43.835909	-73.744938	Scattered	Scattered°	HH
12 (S)	43.831192	-73.746814	"	"	"
12a	43.835530	-73.745245	Moderate	"	HH
12b	43.834961	-73.744521	Moderate	"	HH

Site #	Lat	Long	Lycott 2001 Observations	Scout* and/or AE° Data	Management Options
12c	43.831559	-73.746743	Moderate	None*°	HH
13	43.829747	-73.748403	Dense	Dense*	HH/BB
14	43.827707	-73.749267	Moderate	Scattered°	HH
15	43.825070	-73.750796	Dense	Dense*°	HH/BB
16	43.823762	-73.754229	Scattered	None*°	HH
16a	43.823643	-73.754637	Moderate	None*°	HH
16b	43.823557	-73.755116	Dense	None*°	HH/BB
16c	43.824359	-73.755898	Dense	None*°	HH/BB
16d	43.824794	-73.755267	Dense	Dense*	HH/BB
17	43.819281	-73.746676	Scattered	Scattered*	HH
18 (N)	43.818800	-73.745973	Scattered	Dense*	HH
18 (S)	43.816925	-73.747593	"	"	"

* Scout observations prior to Lycott survey and AE management in 2011. Additionally, the Scouts found and removed ~6 plants south of Sand Point which were not located during Lycott surveys.
° Most recent (2010 or 2011) AE data based upon number of plants harvested. Additionally, AE (2010 data) reports seven sites not noted by Lycott (2011), but in 2011 no milfoil was found or harvested at any of these seven sites by the Scouts or AE.

Southern Basin Sites

There were only three areas of milfoil growth located in the southern basin during our surveys. The southernmost site was well established and has been managed for several seasons. Our surveys noted plant growth further south and east than previously known and plants are scattered randomly throughout the mapped area, however this area was heavily managed in 2011 prior to our surveys and this site historically is a very dense area of growth. The docks at the inland harbor of Adirondack Lodges are privately owned and not technically part of the lake, but this area is an active milfoil site. This area was also managed just prior to our survey, however moderate milfoil growth as well as dense algae and other native plants were noted. Finally, north and south of the delta of the stream draining Thurman Pond in Schroon supports milfoil growth. While the Thurman Pond sits well north, the outlet drains into Schroon Lake just south of the Narrows and forms a large, shallow sand and gravel delta. It is primarily at the leading edge of the delta where milfoil is found.

Northern Basin Sites

In the northern basin, areas of milfoil growth were generally dense and more widely distributed. Often dense patches (beds) were nested within larger areas of scattered growth. These are delineated as red areas within larger shaded (white) areas on the following maps (Figures 2-10). See also Appendix B for site descriptions.

Other Invasive Species

AE noted the presence of another invasive plant, *Potemogeton crispis* (Curly-leaf Pondweed) in two locations, however we did not find any other invasive plants during our surveys. At this time *P. crispis* does not seem to be a threat, and is not behaving invasively in nearby lakes where it has been present for years. Nonetheless, given that the plant is rare in Schroon and can be invasive, consideration should be given to the possible removal of any known colonies of this species.

Figures 2-10. Google-Earth based maps of abundance and location of milfoil growth in Schroon Lake as noted by Lycott surveys. White areas are of scattered to sparse growth, orange areas are moderate growth and usually fairly well delineated bed, red areas are well-defined and very dense milfoil beds.

Figure 2. Inlet: Northernmost sites, plants randomly scattered throughout (white) shaded areas.

Figure 3. North Clark Island: Scattered (white), Moderate (orange) and Dense sites (red).

Figure 4. Southern end of Town of Schroon: Many large, dense beds nested within larger scattered area.

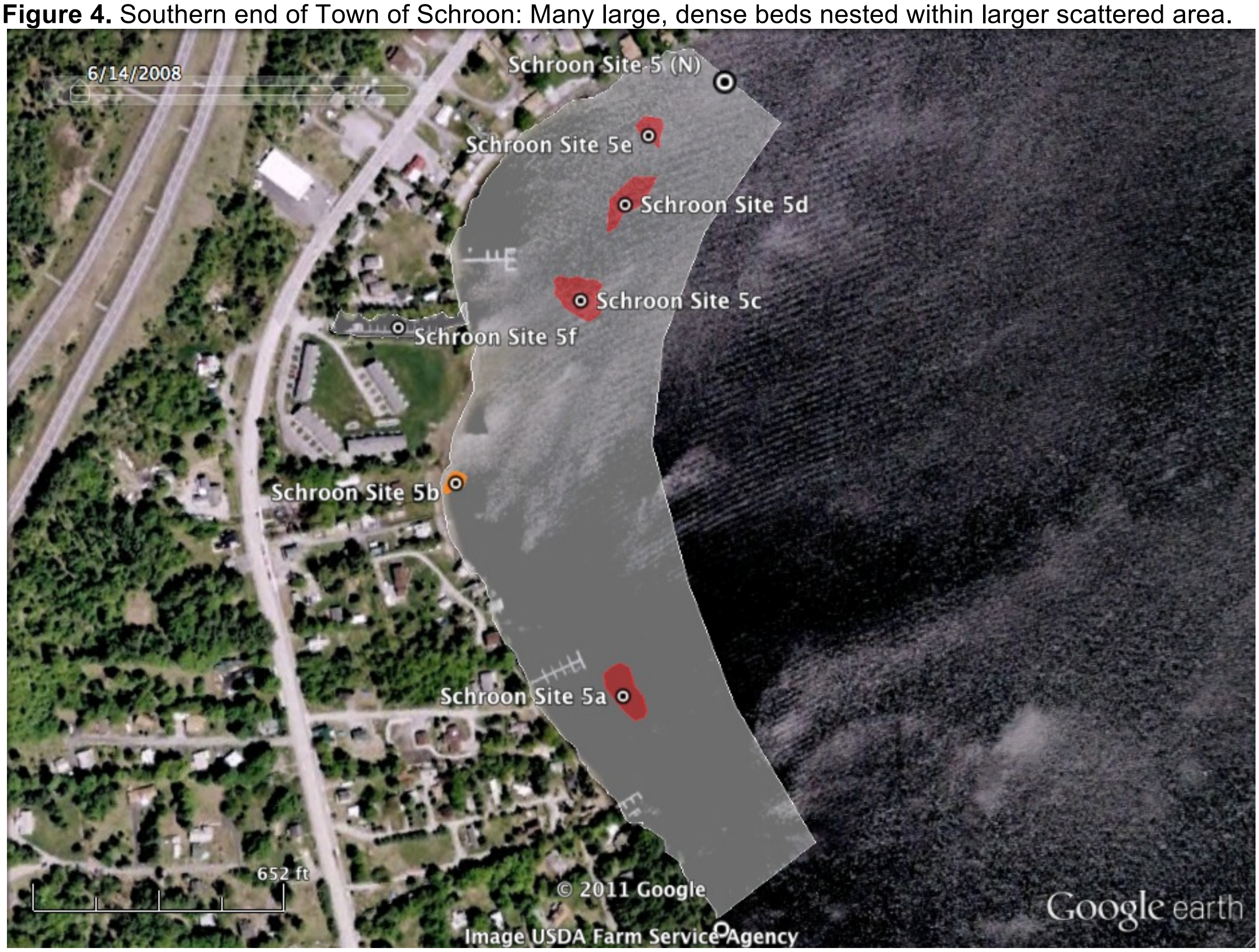


Figure 5. South Clark Island: Multiple dense beds and large scattered area at southern tip of island.

Figure 6. Meadow Cove: Large areas of scattered plants (17) and scattered clusters of plants (18).

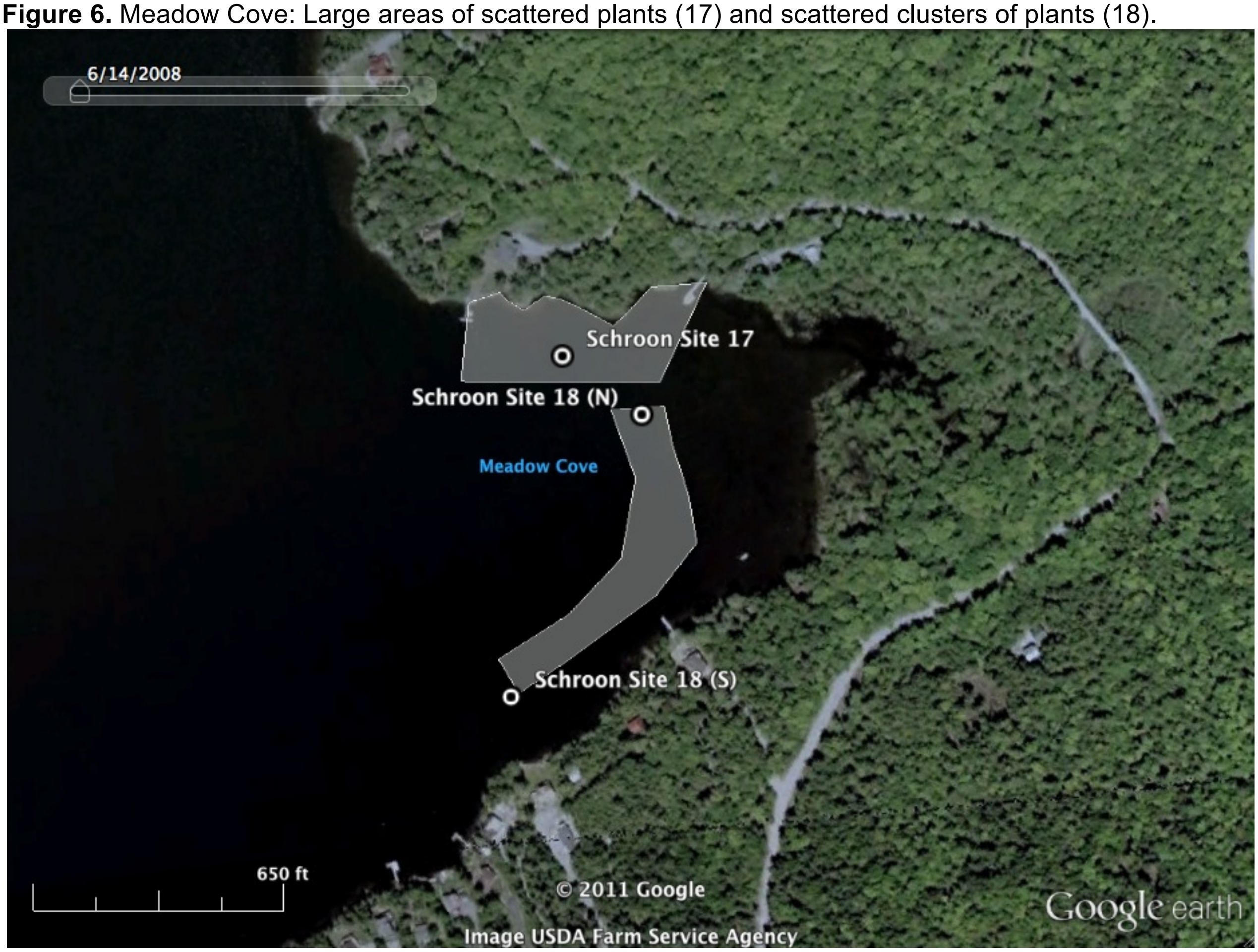
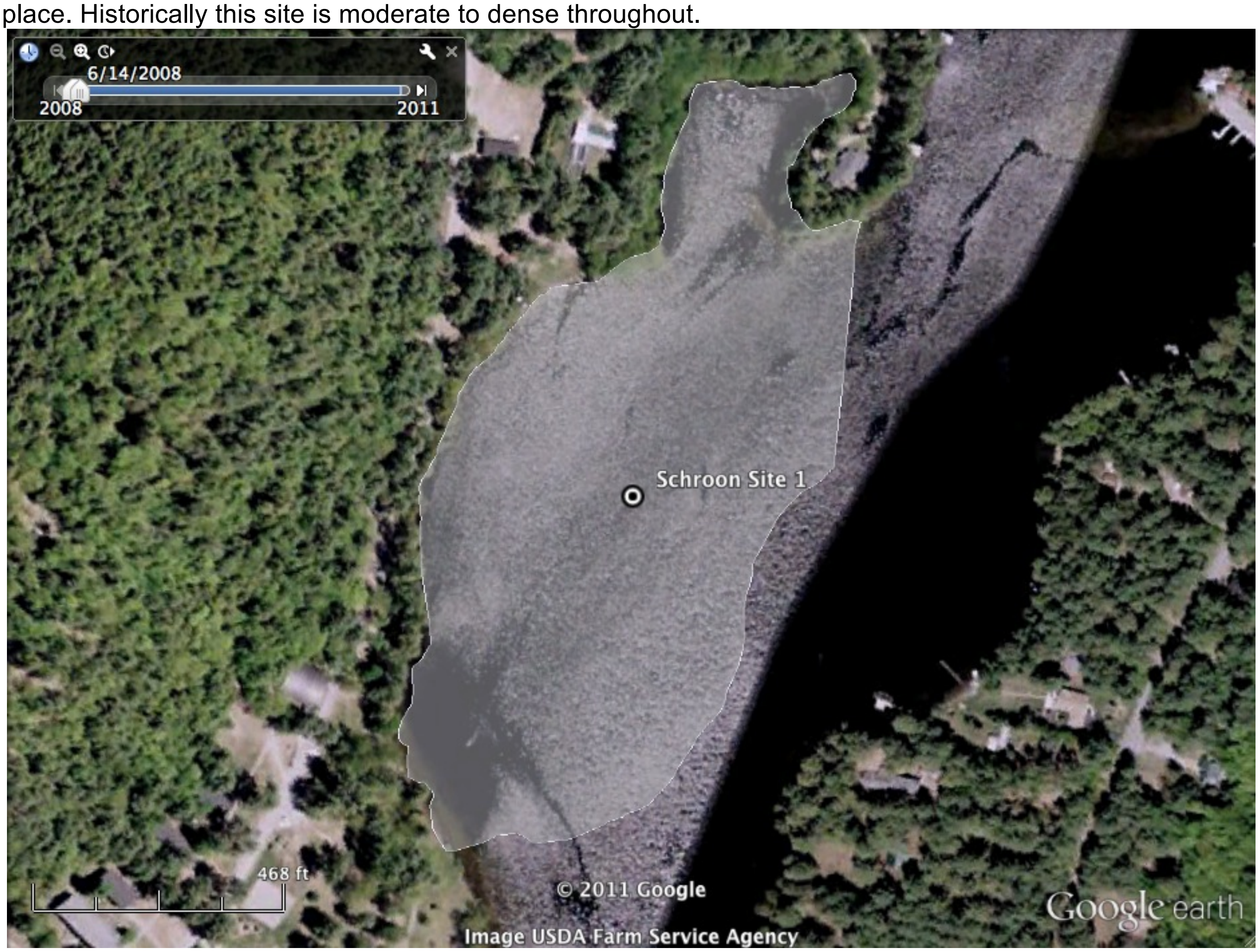


Figure 7. North of Narrows: Long scattered site with two small beds on Western shore, large area of scattered to moderate milfoil growth found.

Figure 8. South of Narrows: Scattered plants extend well north and south of the delta from Thurman Pond tributary.

Figure 9. Adirondack Lodges Marina: Moderate density of plants during our survey, but historically has been a dense site.

Figure 10. Outlet: Plants were scattered during our survey, but significant harvesting had recently taken place. Historically this site is moderate to dense throughout.



Management Recommendations for Schroon Lake 2012-2014

On a whole-lake scale, the natural (unmanaged) pattern of milfoil growth in a newly invaded lake results in what can be readily classified as three general abundance categories; scattered, moderate, and dense beds. These categories are not consistently quantified in the literature, but generally represent less than 1 plant per 10 square meters (scattered), 1~50 plants per square meter (dense), and 'moderate' is roughly everything else. Even in the field, densities are rarely measured directly, but instead a trained eye estimates density, an approach which is sufficient for most real-time management decisions and long-term site-specific data records. As sites are actually managed it is preferable to have plant counts so that inter-annual trends can be noted on a site-by-site basis. This also helps a manager to fine-tune their pre-management estimates of site densities. Nonetheless, in order to develop a thorough management plan, we first needed quantify and qualify the sites within the lake.

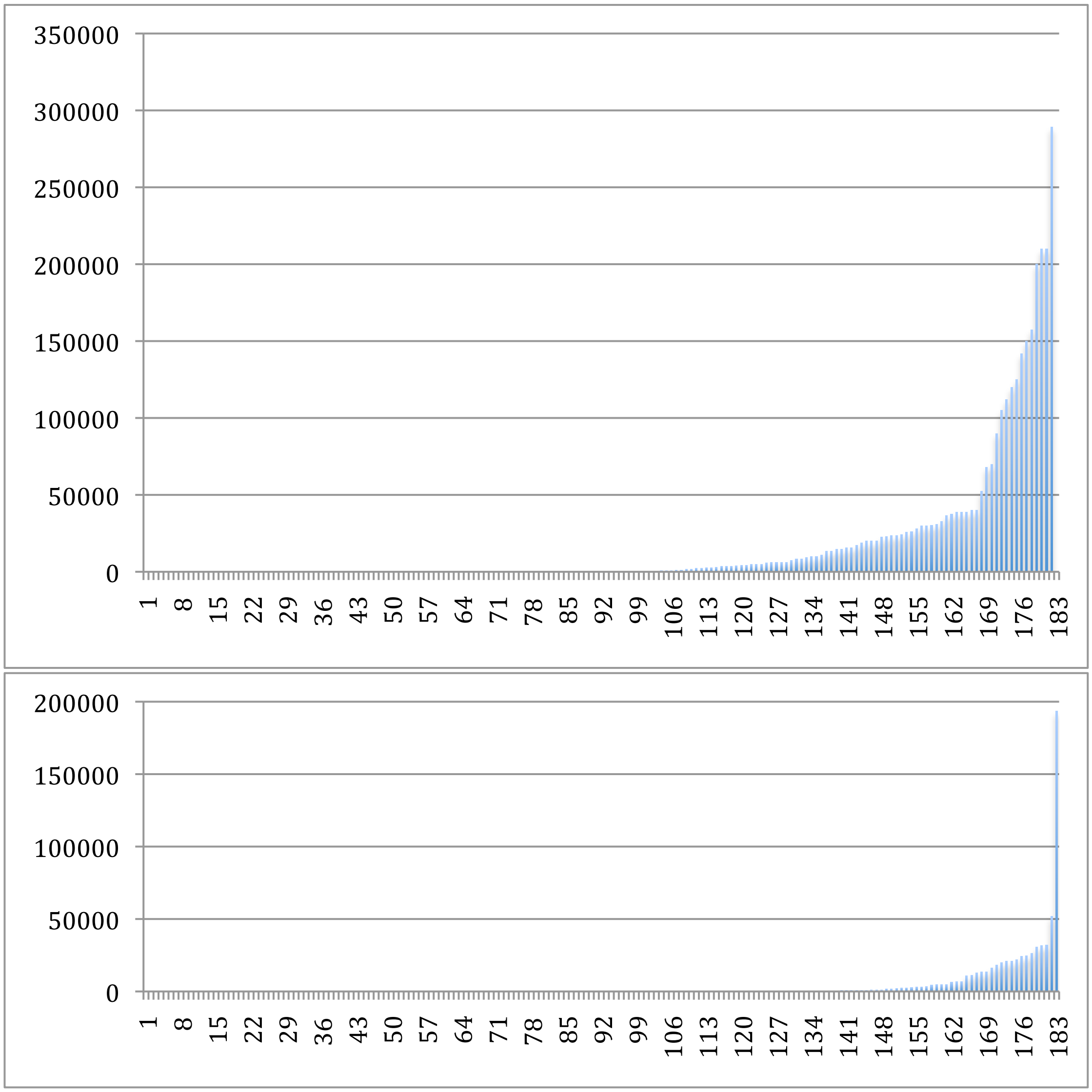
On the scale of an individual site or bay, milfoil density increases exponentially whereby individual sites quickly increase from scattered to dense, spending very little time in the 'moderate' stage of plant density. Thus, in an unmanaged lake with variation in habitat quality (depth, substrate type, presence/absence of competing species and/or herbivores and etc) and depending upon how the ecologist defines the boundaries of a site, the general rule is to observe many scattered sites, a lower number of moderate sites, and many dense sites. Eventually, if left unmanaged and there is little-to-no barrier to spread, dense sites will merge and in smaller lakes this can result in a 'ring' of dense milfoil parallel to, and along the entire shoreline filling most of the littoral zone (i.e., exponential growth). Milfoil reproduces by rhizome growth, seed production, and/or fragmentation and can grow as fast as one inch per day during optimal growth periods. Milfoil has been in Schroon Lake at least twenty years and possibly longer. Our survey indicates that there remains abundant available habitat for milfoil growth in Schroon Lake. Thus, *M. spicatum* has yet to reach an equilibrium and the population is actively growing.

However, the number of milfoil sites by category (scattered, moderate or dense) is impacted by strategic management (Figure 11). The number of dense sites should decrease over time with active annual management. The number of moderate sites may actually increase over the first several years of management (as dense sites are reduced to moderate sites), but eventually decline as well. The number of scattered sites may either increase or decrease depending upon many factors, but it is a reasonable goal, with an appropriate level of management resources available, for a lake the size of Schroon Lake to expect control of all known dense sites. Scattered sites will be a persistent nuisance, and thus will require at least annual surveillance and tracking.

Complete eradication of an invasive species like milfoil is no longer considered an obtainable goal in any lake larger than a few acres. And there is a persistent threat that the plant would be reintroduced even if eradication were feasible. Thus, several scattered sites will remain in an invaded lake, and maintenance-level management will need to be an annual investment for Schroon Lake in order to keep milfoil in check once control has been obtained. However, the primary goal of invasive species management is to limit the impact of the non-native species on the natural ecology (among other aspects) of the lake. If we can reduce all sites to scattered then we've largely negated the ecological impact of the invader.

Some specific sites, such as the area at the southwestern shore near the outlet (Site 1), will need significant annual effort and may never be reduced to scattered for more than a year at a time. Likewise the shallow bay just south of the canal of the Schroon Lake Marina (Site 8) will continue to support milfoil growth and most likely receives significant annual plant recruitment via boat traffic. Additionally, because this site is a large area of widely spaced plants, has a high density of emergent plant species, and is a relatively nutrient-rich bay, it will be difficult to locate and remove all milfoil plants without a significant time investment.

Figure 11. Top Panel: Number of Plants (Y-axis) by Site (X-axis) in 183 sites when first discovered (prior to any management). Bottom Panel: Number of Plants (Y) by Site (X) prior to 2010 management. Of the 183 sites plotted, 171 were cleared in 2010



With a vigilant surveillance and maintenance program, we should be able to successfully control milfoil in Schroon Lake within three-four years. Thus, our recommendations are for a large-scale hand-harvesting operation beginning in 2012 with seven weeks for a crew of 3-4 focusing first on the densest areas (red areas nested within white areas in Figures 2-10 and Appendix A). That will be followed by sweeps of the moderate (orange) and scattered areas (white) (Figures 2-10 and Appendix A). The intense seven-week effort in 2012 can be scaled back in 2013-2014. Each of these years are expected to need up to 6 weeks of active management with a crew of 3-4.

While there is some variation in milfoil recruitment across sites due to substrate type, 10+ years of data from Lake George shows that we typically get an average of 30-50% return of plants at cleared sites one-year following management, and ca. 10% of the original number by site in year two. Between years 3-5, we observe an exponential reduction in milfoil return rates. Thus we would expect in 2013 to harvest from all sites previously cleared in 2012.. Likewise, another 6-week effort would be budgeted for 2014. Due to the size of the lake, current distribution of milfoil and likelihood that milfoil continues to be introduced into the lake each summer, long-term expectations are approximately a 3-week maintenance program each summer (360-480 person*hours per year) following the large-scale 2012-2014 management plan presented herein.

Milfoil growth on the southeast shores of Schroon Lake seems limited by exposure to prevailing winds (wave action) along with a relatively narrow littoral zone in this area. This may generally preclude large-scale invasions of milfoil along these reaches (except in relatively protected areas such as a marina or sheltered, shallow bay). The variation in lake levels due to dam management will also help control/limit the spread of milfoil along steep rocky shorelines. Additionally, exposure to ice-scour will further limit milfoil (all plants actually) from impacted areas. As a result, the vast majority of the southern basin is less than ideal habitat for prolific milfoil spread (with a notable exception near the outlet). Thus the primary concern for future management focuses on the north basin.

On a lake-wide scale, Schroon Lake is well positioned for managers to gain control over the milfoil infestation. There will always be problem sites due to local conditions (management access, particularly good milfoil habitat in some sites, vagaries of weather/climate and harsh versus mild winters will either help or hinder management efforts), but with a concerted, large-scale effort over a three-year window, we can reasonably expect effective control of the majority of known sites as well as locate any sites not observed during our 2011 surveys.

Management Alternatives

Hand harvesting is recommended as the primary management tool for 2012. After this, a reevaluation of the plan should consider supplementing hand harvesting with other management options including benthic barrier and possible selective use of an herbicide.

In general, there are three approaches to the management of invasive species; 1) do nothing, 2) chemical treatments and 3) physical management. The 'do nothing' approach is sometimes recommended where there exists no viable methods for eradication or control of the target species or when the scale of the problem is unmatched by the level of resources available for management. This is not the case with Eurasian watermilfoil as there are numerous examples where milfoil has been successfully controlled by physical and/or chemical means within a reasonable resource budget. The 'do nothing' approach is of course the least expensive management option in the short term.

At present, chemical treatment (selective herbicide Renovate®) has been used in only one lake (Lake Luzerne) within the Adirondack Park and then only under special conditions. It is likely that in the near future more permits will be granted to allow the targeted use of Renovate in some lakes. Currently the APA requires the use of a limnocurtain to contain the herbicide within the target area. There are only a few sites in Schroon Lake where it would be feasible to install a limnocurtain and these are noted in Table 1 as sites where Renovate would be viable from a management perspective. When/if the limnocurtain requirement is lifted, other sites may be deemed suitable for herbicide treatment. While the price scales along with size of area treated, Renovate treatments are roughly $1500.00 per acre as of summer 2011 (water depth in treated area is also a factor). Results at Lake Luzerne and in many more lakes outside of the Park have been very encouraging. In 2010, Lycott treated 130 very dense acres of milfoil with Renovate in a 457-acre Fairlee Lake in Vermont. Milfoil had been physically managed there for nearly 15 years by a small, local group of divers, and each year the rate of milfoil growth/spread outpaced physical milfoil management efforts. In 2011 (post chemical treatment) a small milfoil bed of ca. 2000 sf was found at the mouth of the main tributary, and otherwise less than 300 plants were harvested throughout the remaining lake. In most situations, three years of control can be expected from a properly managed Renovate treatment.

Physical management can be further divided into three approaches: 1) Mechanical, 2) Hand harvesting by divers, and 3) Benthic barrier placement. Mechanical, can be either through a harvester machine (which is never recommended by Lycott as a means to control milfoil in a natural water body), or by diver-assisted suction harvesting (DASH). While mechanical harvesting can be financially efficient and will remove large amounts of biomass quickly, it often serves only to spread the plants further and creates more milfoil beds in subsequent years. DASH methods are much better at reducing the spread of plant fragments, but can re-suspend sediments and cause other negative impacts to aquatic animals if effluent is not properly contained. Hand harvesting is our primary recommendation for Schroon Lake, and is the least invasive approach as individual divers hand pick only milfoil, leaving all native plants behind. Benthic barrier is also a viable management tool and is often used in concert with hand harvesting and chemical treatments.

Benthic barrier is a general term for any material used to cover the bottom of a lake. It can be either fiberglass mesh or a solid material. In our experience, solid barrier panels are much more effective for milfoil management. It is simply a light-blocking material which prohibits photosynthesis in covered plants. Typically it takes ca. 30 days for complete control at which time the material can be removed and reused. Barriers are held in place by weights (rebar, concrete blocks, sandbags, or rocks when locally available). For new installations, barrier can be < $20,000 per acre and approximately half of that to reinstall the same material at another site. It is recommended to use barrier on small, dense beds. If barrier is considered, we would suggest purchasing enough barrier to cover 1/3 to 1/2 of suitable beds and reuse material as soon as 30-45 days later on remaining beds.

Table 2. Pros and Cons of Management Alternatives on Dense Milfoil Beds in Schroon Lake.

Management Approach	$/acre	Duration of Active Management	Impacts on Non-Target Plants	Observed Milfoil Recruitment 1-year Post Management	Observed Native Recruitment 1-year Post Management.
Renovate ®	~$1500.00	1 Day	Can have short-term effects on monocots-selectively kills milfoil	0-5%*	High
Benthic Barrier (PVC)	~$20,000 (new) ~$10,000 (reused)	30-45 Days	Kills all plants covered by barrier	0-25%**	Moderate-High
Hand Harvesting	~$10,000	2-3 days/acre	Selects only milfoil	30-50%***	Same as pre-management

* based upon 2011 Fairlee Lake, VT data
** based upon 10+ years of Lake George, NY data. Recruitment rates at treated sites highly dependent upon proximity to non-treated milfoil sites and presence of point-source nutrient inputs.
*** based upon 10+ years of Lake George, NY data. Recruitment rates vary by substrate type (sand, rocky, silt), proximity to source milfoil beds, density of native plants present at treatment site, and by presence of point-source nutrient inputs.

As of 2011, Schroon Lake has ca. 2 acres of milfoil suitable for benthic barrier and 6.5 acres suitable for Renovate treatment (with current APA limnocurtain restrictions in place).

Brief Comparison with Nearby Lakes Managed by Lycott Environmental

We have managed milfoil control programs on Lake George and Loon Lake for ten and two years respectively. Here I will briefly highlight some of the lake characteristics that we believe are relevant to milfoil management on Schroon Lake.

By some measures, Schroon Lake is classified as an oligotrophic lake. Other measures have Schroon as tending to mesotrophic with some areas (inland marinas, bays cut off from main flow etc.,) to be solidly mesotrophic or even eutrophic at times. This will be the case for most lakes with highly-developed shorelines and/or relatively high nutrient loading (natural or anthropogenic).

Table 3. Comparison of Schroon Lake to nearby lakes with *M. spicatum* management programs.

	(Watershed Area) (Surface Area)* WA:SA Ratio	Elevation (approx.)	Timeframe Invaded by *M. spicatum***	Trophic Status	Clarity*** (visibility)	Transient Boat Traffic
Lake George	(152,000)(28,160) ~5.4	395'	Pre-1985	Oligotrophic	20+'	Very High
Loon Lake	(8,204)(586) ~14	900'	mid 1990's	Mesotrophic	10'	Low
Schroon Lake	(202,575)(4,105) 49.35	810'	~1988-1992	Oligo-mesotrophic	6'-10'	High

* Surface and watershed areas given in acres.
** Estimates based upon pers. obs. and/or documented discoveries.
***Estimate based upon mid-summer observations, and given as distance a snorkeler could distinguish *M. spicatum* from other plant species.

Schroon naturally receives high nutrient loading compared to Lake George and Loon Lake due to the size of the watershed relative to the size of the lake (Table 3; Figure 12). Schroon can also receive anthropogenic nutrient loading from a developed shoreline, over-fertilizing lawns along the shoreline, any point-source inputs (outdated or damaged septic systems for example), from storm-water runoff where 'urban' areas like the Town of Schroon may contribute significant phosphorus and nitrogen during storm events, and due to proximity to a major highway. It isn't surprising then to find one of the heaviest infestations in the cove situated just down slope of the town center and at the mouth of a tributary. However, while Schroon receives relatively high nutrient input, it also has a shorter water retention time than other nearby lakes. Thus, some amount of the nutrient input will be carried downstream via Schroon River, particularly during large storm events.

Additionally, there are many natural factors that will limit the abundance of all macrophytes in Schroon Lake. Light is attenuated quickly in Schroon; this is largely due to suspended solids and natural tannins in the water (from the relatively high ratio of coniferous trees in the watershed). This gives the water its characteristic brownish-red appearance. Also, Schroon sits approximately 500' higher than Lake George, and thus typically experiences a longer period of ice cover in the littoral areas, narrowing the growth period for plants.

Factors that work to increase the persistence and prevalence of milfoil in Schroon will be the high nutrient loading (natural and human-sources), relatively high rate of transient boaters (increase probability of reintroductions), and the persistence of source sites which are nutrient-rich areas (inland marinas for example) which are higher on the trophic scale than the lake as a whole, have high water-retention times, and frequent input from fertilizers or storm-water runoff.

In ten years on Lake George, we have controlled milfoil growth in 181 of the 191 milfoil sites (Table 4) using only physical means. Most of the remaining sites likely can not be controlled solely with physical means, but we can limit the growth and spread in all but a few sites. Very large water bodies, with well established and widely distributed milfoil invasions can be controlled using primarily physical means. In Loon Lake we are 1-2 years away from control of the milfoil problem—again, there are a few areas that will remain problematic, but can be held in check physically.

Physical control can be successful when: well planned, the scope of the problem is well-defined (distribution and abundance), the management plan is adaptable and one can follow year-to-year progress on a site-by-site basis , there is strong local support and active volunteers to help locate any new areas of infestation, and when there is a serious, multiyear effort to bring established sites into controlled status. Schroon Lake has some natural attributes that help to limit milfoil spread in much of the lake. Schroon Lake, of course, also contains suitable habitat in localized areas that supports vast amounts of milfoil. However, the milfoil infestation is manageable and a concerted effort will control milfoil in a majority of the known sites within 3-4 years. Nonetheless, it has been our experience that not every milfoil site within a large lake responds well to hand harvesting. In the future, one or more of the alternative methods may need to be considered at specific trouble sites.

Figure 12. From Horne & Goldman. 1994.

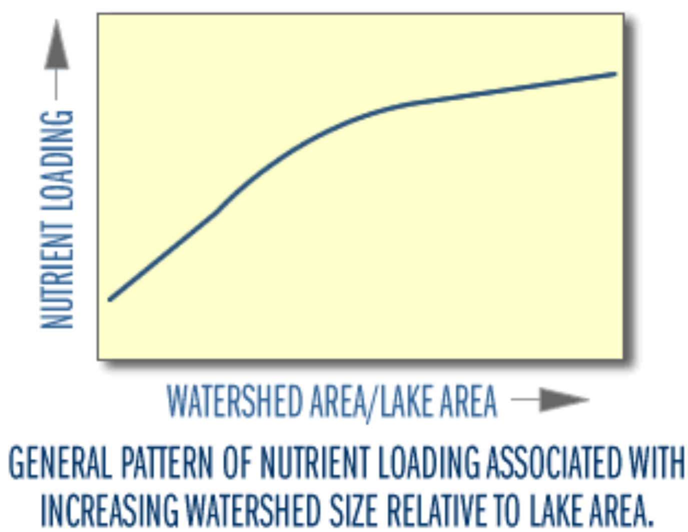


Table 4. Ten years of Lycott data from Lake George. Data represents sites at the end of each management year. Since resources were not sufficient to clear every site within a single year, the strategy has been to clear most scattered and moderate sites each year, and work a few of the larger bed sites each year.

Year	Total # of Milfoil Sites	Density of Milfoil Growth			Status	
		Bed	Moderate	Scattered	New	Cleared
2002	144	23	7	4	3	110
2003	146	22	6	3	2	114
2004	148	20	8	2	2	112
2005	149	18	10	2	1	115
2006	157	17	9	0	8	127
2007	160	14	8	6	3	132
2008	171	16	6	9	11	140
2009	179	9	6	0	8	164
2010	183	9	2	1	4	171
2011	191	8	11	0	8	172

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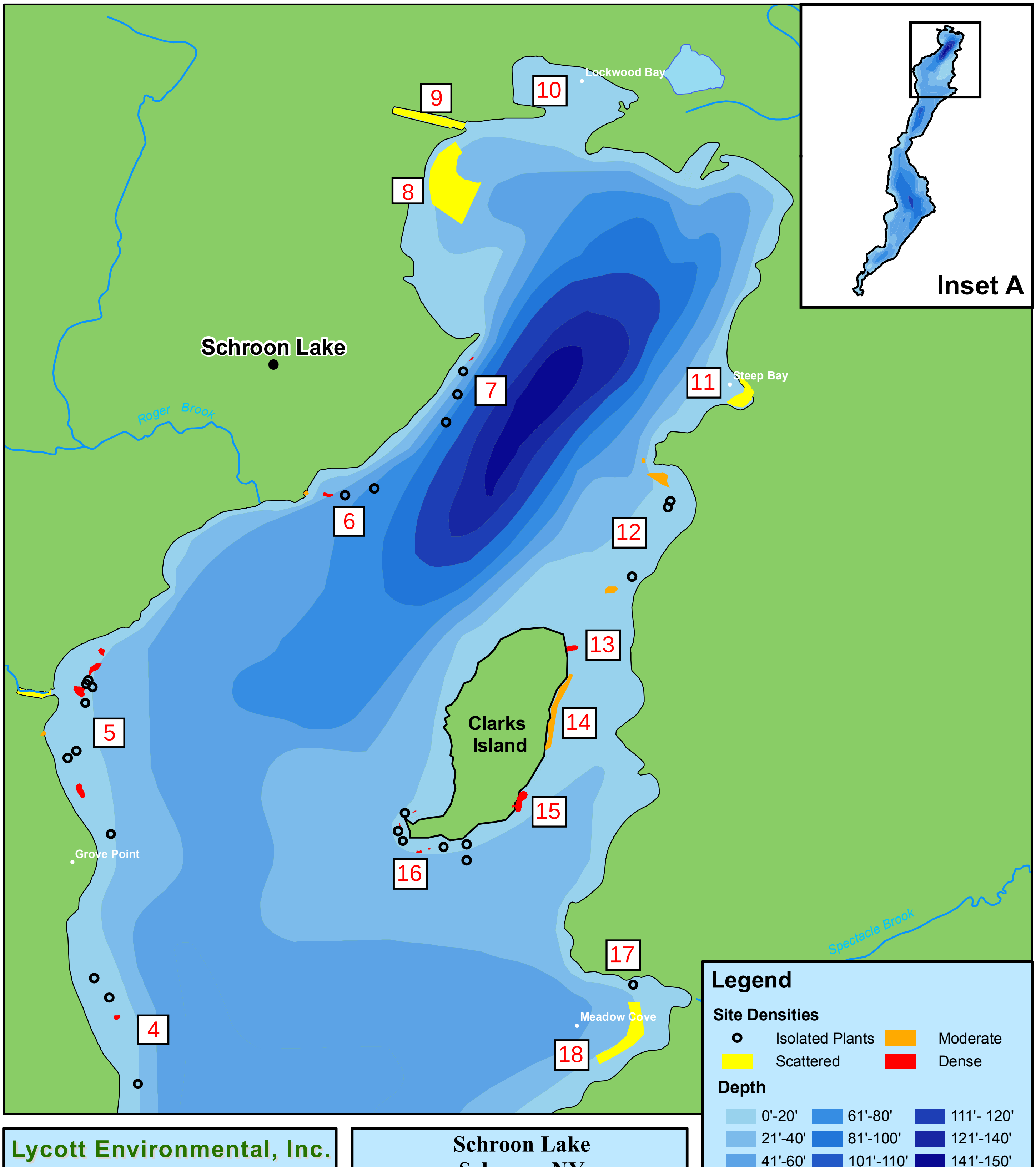
APPENDIX A

Comprehensive Maps of Lycott Environmental 2011 Schroon Lake
Eurasian Watermilfoil Survey Results (insets A-D) and Areas Surveys.

Distribution of Eurasian Milfoil (*Myriophyllum spicatum*)



Data Sources: USGS: Geographic Place Names (1981); NYS GIS Clearinghouse: National Hydrography Dataset (2007)

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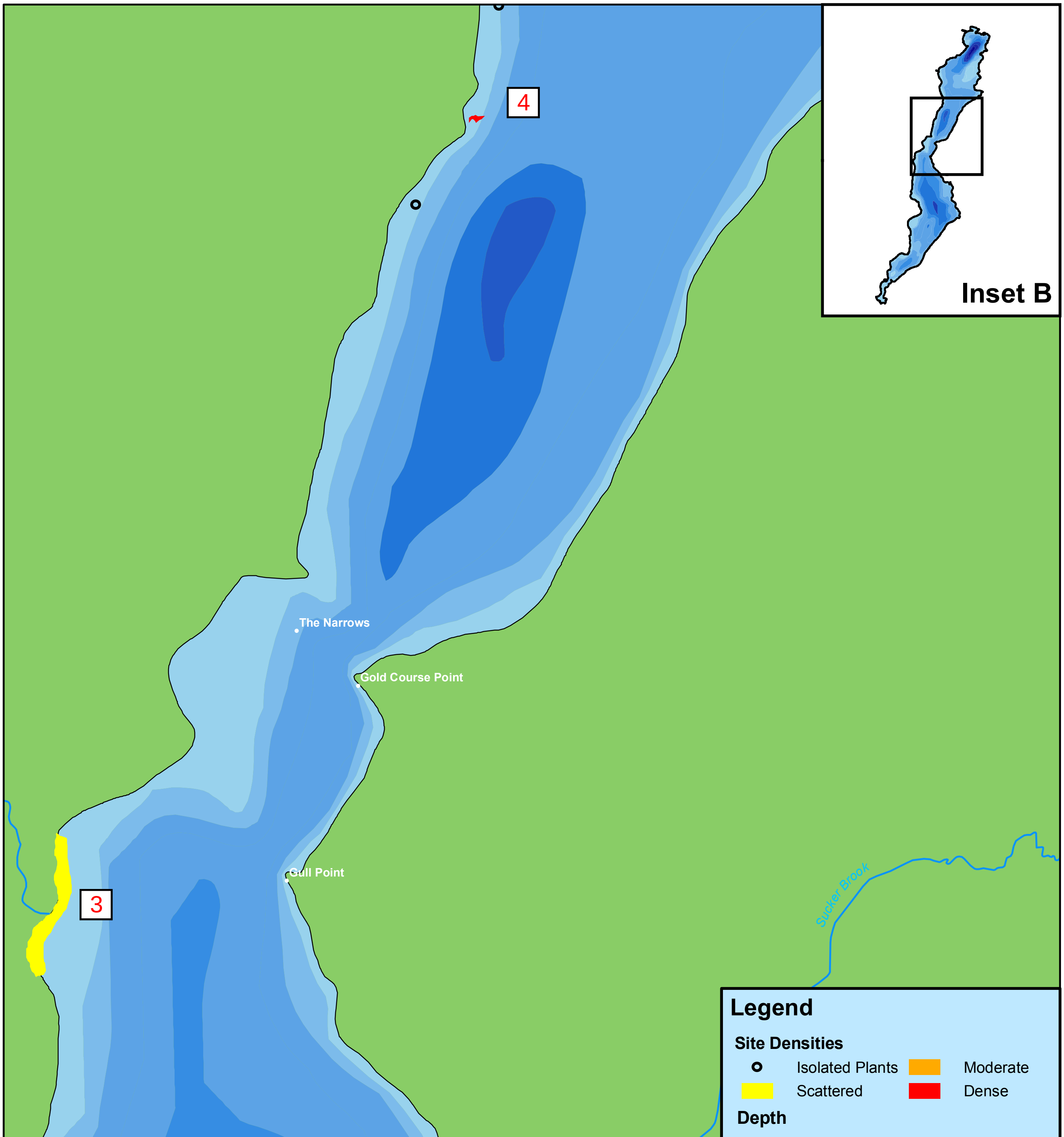
Schroon Lake
Schroon, NY
September 2011

Total Area:
4,217 acres

Distribution of Eurasian Milfoil (*Myriophyllum spicatum*)



Legend

Site Densities

- Isolated Plants
- Scattered
- Moderate
- Dense

Depth

0'-20'	61'-80'	111'- 120'
21'-40'	81'-100'	121'-140'
41'-60'	101'-110'	141'-150'

Meters: 0 150 300 450 600

1:18,500

Data Sources: USGS: Geographic Place Names (1981); NYS GIS Clearinghouse: National Hydrography Dataset (2007)

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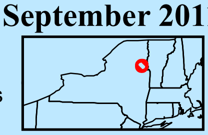

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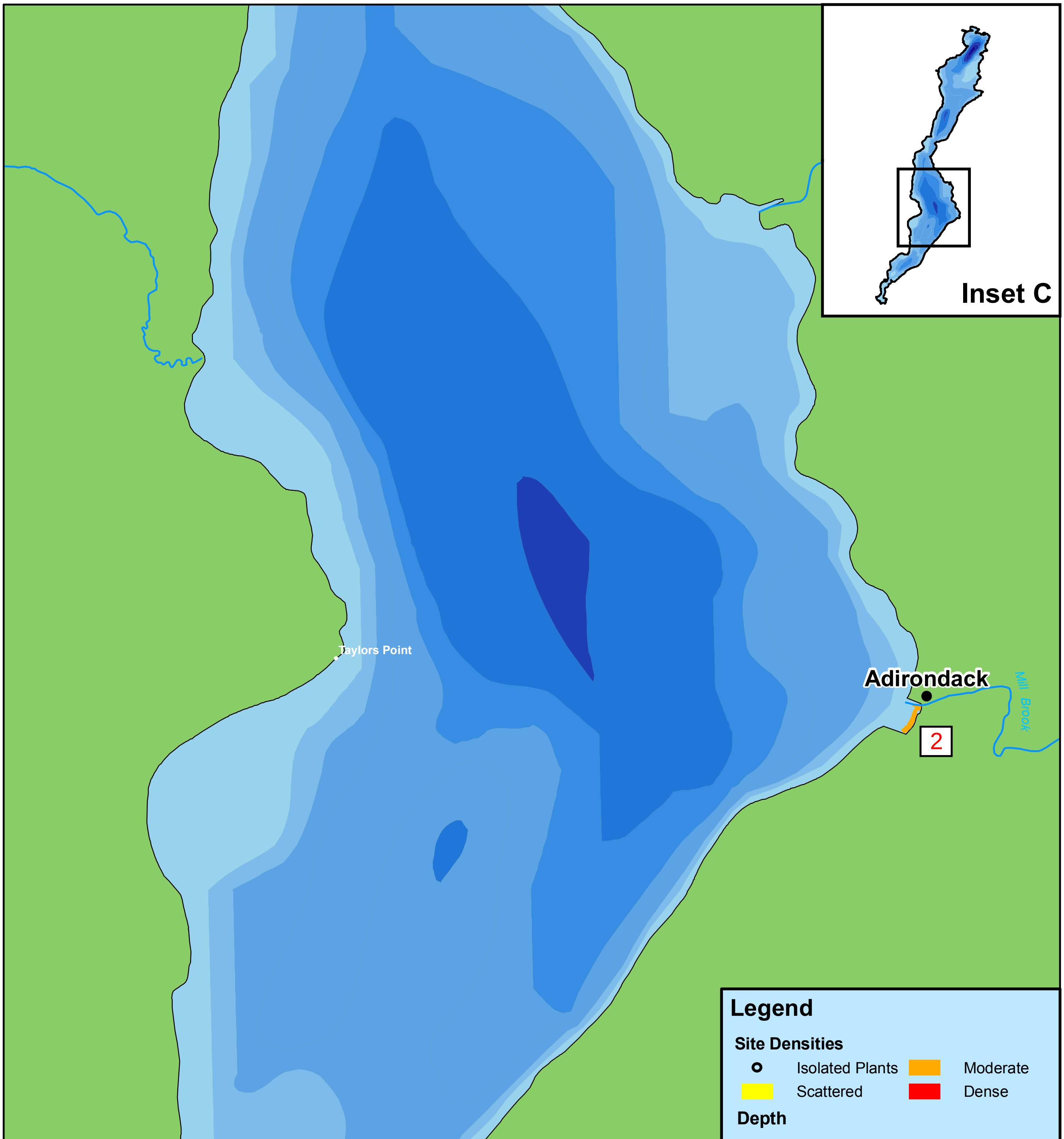
Distribution of Eurasian Milfoil (*Myriophyllum spicatum*)



Data Sources: USGS: Geographic Place Names (1981); NYS GIS Clearinghouse: National Hydrography Dataset (2007)

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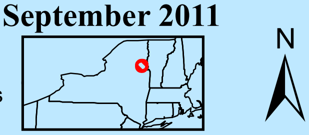
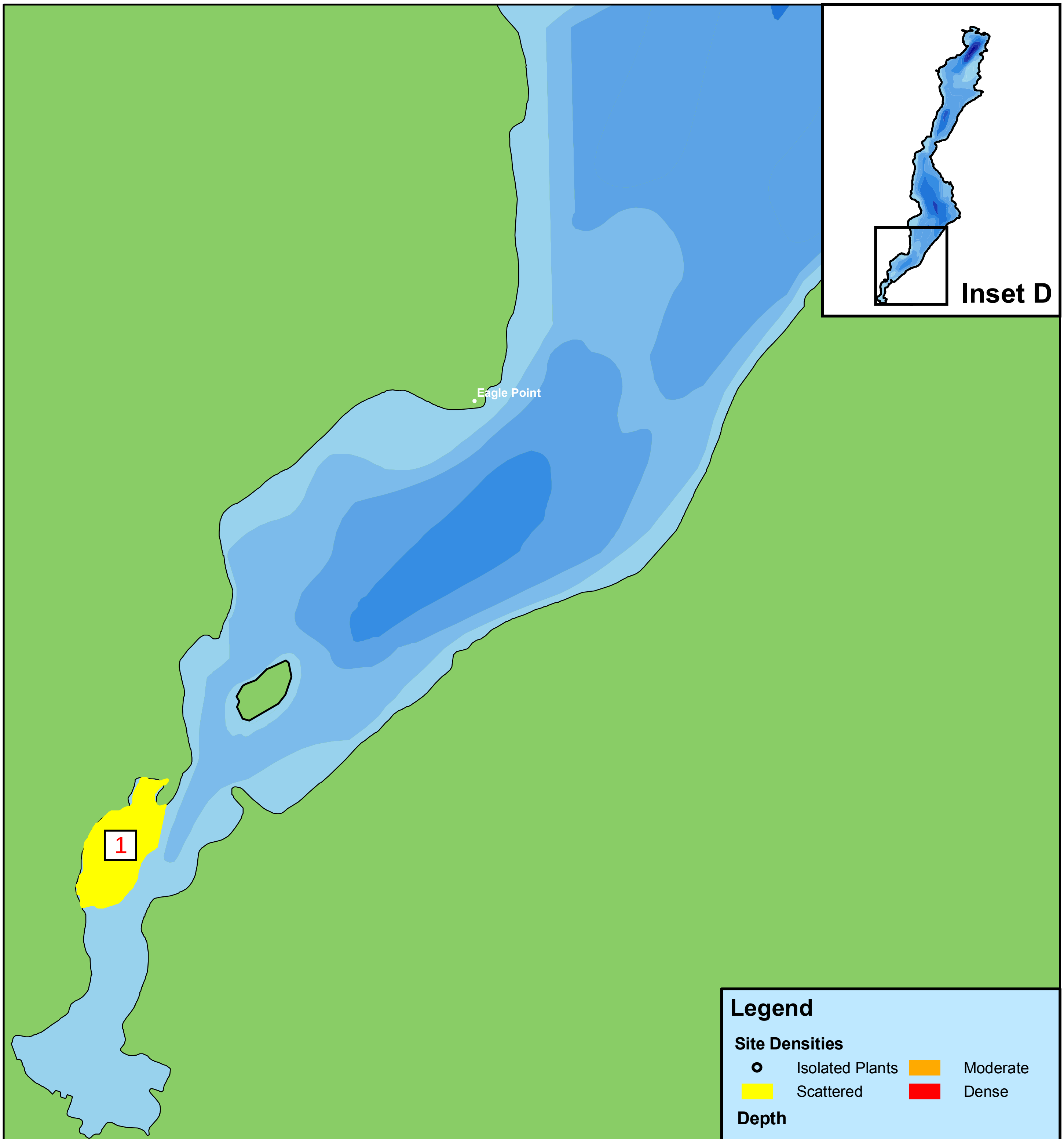


Distribution of Eurasian Milfoil (*Myriophyllum spicatum*)



Legend

Site Densities

- Isolated Plants
- Moderate
- Scattered
- Dense

Depth

0'-20'	61'-80'	111'- 120'
21'-40'	81'-100'	121'-140'
41'-60'	101'-110'	141'-150'

Meters: 0, 150, 300, 450, 600

1:18,500

Data Sources: USGS: Geographic Place Names (1981); NYS GIS Clearinghouse: National Hydrography Dataset (2007)

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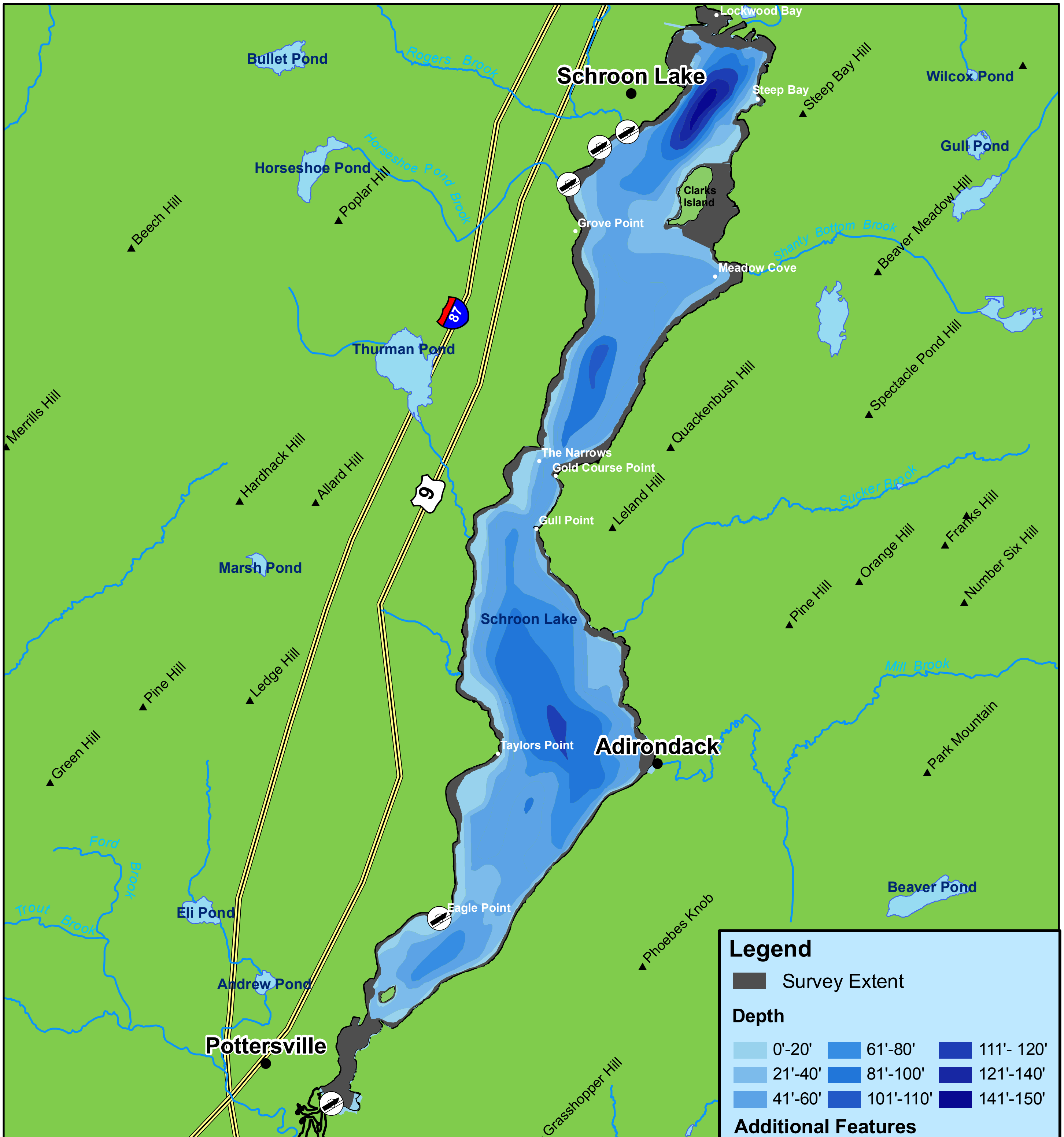
N

Extent of Schroon Lake Aquatic Vegetation Survey



Legend

Survey Extent

Depth

0'-20'	61'-80'	111'- 120'
21'-40'	81'-100'	121'-140'
41'-60'	101'-110'	141'-150'

Additional Features

Highway — Boat Ramp

0 0.75 1.5 2.25 3 Km

1:68,500

Data Sources: USGS: NCLD (1992), Geographic Place Names (1981); NYS GIS Clearinghouse: Accessible Recreation Destinations (2009), National Hydrography Dataset (2007), NYS Thruway Route System (2009)

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Appendix B

Site Descriptions

Outlet, Word of Life Ranch Shores (Site 1)- This site historically is very densely populated with milfoil. Upon our survey (following work by AE in 2011) we found scattered patches of milfoil throughout entire cove. Depths range from 4'-10', bottom of fine silt and sand. Other species present: *Elodea canadensis* and several native *Potemogeton spp*.

Adirondack Lodges Inland Marina (Site 2)- This site also dense to moderate with milfoil, however was worked just prior to our survey. We observed it to be moderately dense with milfoil. Depth from ca. 3'-6', water turbid with algae and re-suspended sediment (recent boat traffic). Marina densely populated by many *Potemogeton spp*. & *E. canadensis*. Likely receives significant nutrient input from lawn runoff.

Thurman Pond Tributary Delta (Site 3)- Scattered plants throughout entire stream delta area. Slope is flat to moderate (at edge of delta). Bottom of sand and fine silts. Depth from 6'-12'. *P. spp* and *V. americana* abundant.

West Shore north of Narrows and South of Grove Point (Site 4)- Site is a long narrow band from shore to ca. 12' deep. Bottom primarily of sand with fine silts. Milfoil largely in the 5'-12' depth range. Native *P. spp* throughout, also some native milfoil scattered. Two dense beds also exist within this larger area (4a and 4b).

Horseshoe Pond Brook Outlet (Site 5)- Site is entire bay/delta of Horseshoe Pond Brook. *M. spicatum* scattered as single plants and small clusters of plants through site. Additionally, there are four dense milfoil beds (5a & 5c-d) and one moderate milfoil bed (5b) within this site. Dense beds largely within the 6-8' depth range with moderate to dense native plant community throughout including sparse native milfoil throughout. 5b nearshore in sandy substrate in ca. 1-3' depths. Otherwise, bottom of silt on top of sand and cobble throughout bay. Slope generally flat to moderate in deeper areas.

Town Docks (Site 6)- Site extends from northern edge of town docks, northeast ca. 1000'. Moderate patch of milfoil in 2-3' of water just off NW corner of dock, larger dense bed northeast of docks in 6-8- of water. Moderate slope with bottom of silt, sand and cobble. V. Americana, native P. spp. and native milfoil scattered to common throughout most of site.

North of Schroon Lake Village (Fowler Ave.) (Site 7)- southern reaches of site primarily of silty substrate, northern reach more sand with light silt on top. Milfoil scattered throughout, but concentrated at 7a in a small bed. Slope flat to moderate, depths from shore to ca. 8'. *P. spp*. and *V. americana* common.

North of Schroon Lake Village (Wolters Way) (Site 8)- Milfoil scattered in small clustered throughout most of the bay not covered by floating plants (Nuphar sp., Nymphaea spp., and Brasenia spp.). Slope flat, depths from shore to ca. 5'. Bottom of sand overlain by silt several inches thick. Typically no other plant species present where milfoil is present.

Schroon Lake Marina (Site 9)- Milfoil scattered throughout marina channel. Depts from shore to ca. 6'. Bottom with silt, but commonly exposed sand (prop wash areas). Visibility poor to moderate, lots of native P. spp present. Difficult site to work due to boat traffic and low visibility.

Lockwood Bay (Site 10)- Visibility low, high density of native plant species present. Bottom of deep silt, margins lined by floating plants (*Nuphar spp*., *Nymphaea spp*., and *Brasenia spp*.). Milfoil observed scattered primarily along the southern shoreline of bay, but likely present throughout.

Steep Bay (Site 11)- Milfoil scattered in clusters along northern, rocky side of bay, scattered as individual plants in middle and southern side of bay. Bottom from steep rocky ledge to flat slope of silt/woody debris in ca. 10' depth. *V. americana* common and *Brasenia spp.* sparse.

East Shore south of Steep Bay (Site 12)– Scattered plants throughout with three moderate beds (12a-c). 12a and 12b are around a rocky, shallow point in ca. 6-8' of water with only sparse *P. spp*. and *V. americana*. 12c further south, on flat bottom with silt and scattered native P. spp. 12c is around and on approach to the channel markers. Generally, depths range from 6-10' with rocky substrates on the northern end and silty substrate on the southern end of the site.

NE Clark Island (Site 13)- Small but dense milfoil site at NE edge of Clark Island. Bottom of bedrock and cobble with thin layer of fine silt. Plants primarily growng around deadfall in 3' of water. Native plants present, but sparse. Slope is flat.

East Shore Clark Island (Site 14)- Very long and narrow area along eastern shore of Clark Island. Depths from shore to ca. 4' with milfoil scattered to moderate throughout and clusters of moderate growth found (usually associated with deadfall). Bottom of sand and silt overlaying bedrock and cobble. Native P. spp common along shore, some floating-leaves species present, but not abundant (*Brasenia spp., Nuphar spp*.).

SE Clark Island (Site 15)- Very dense site near the effluent of the Clark Island water treatment facility. Milfoil growth likely sustained by nutrient loading here. Slope flat with depths from shoreline to ca. 5'. Bottom bedrock overlain by silt and sand several inches thick. Native *P. spp* present, but milfoil bed likely displacing most native species here.

Southern End Clark Island (Site 16)- This site extends from small satallite island off southern end of Clark Is. East around southern shoreline and back toward W.O.L swim beach. Milfoil scattered in clusters throughout area with three well-defined dense beds (16b-d) and one moderate bed (16a). Slope varies from flat to moderate. Rocky bottom at all beds and flat bottom with silt in deeper areas. Milfoil growth in depths of 4-8’.

Meadow Cove North (Site 17)- This site is the Northern shore of Meadow Cove. Milfoil very sparse, but scattered along most of the length of the shore ranging in depth from ca. 3’ to 8’. Mixed bottom of silt and cobble with gentle slope from shore. P. spp scattered throughout deepers sections and floating-leaved species (e.g., Nuphar spp, Brasenia spp.) in the shallower sections toward the tributary.

Meadow Cove South (Site 18)- This is most of the open water areas of Meadow Cove. Milfoil clusters are sparse, but scattered throughout the bay—tending toward the shallower parts of the bay. Botom mixed with silt underlain by bedrock/boulder/cobble. *P. spp., V. americana* and *E. canadensis* common throughout bay.